THE GEOLOGY OF PIONEER MINE

by

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C O N T E N T S

	Page
Location	1
Areal Geology	1
Bridge River Sediments	1
Serpentine	2
Cadwallader Sediments	3
Augite-Diorite	4
Coast Range Intrusives	6
Late Dikes	6
Unconsolidated Deposits	7
Mine Geology	7
Relation of Main Rock Types to Productive Zone	7
Veins	10
A. Main Vein	10
(1) Ribbon Structure	11
(2) Sheeted Structure	12
B. Branch Veins	12
(1) Footwall Vein	13
(2) Hangingwall Vein	13
(3) "J" and "M" Veins	14
C. Parallel Vein	14
Mineralization	14
Ore Shoots	16
Faults	18
Lamprophyre Dikes	19
Methane	19

I L L U S T R A T I O N S

		Page
	Map of Cadwallader Creek Area	Insert
(Figure 1)	Geological Sketch of Cadwallader Creek Area	2(a)
(Figure 2)	Map Showing Location of Augite-Diorite Bodies	4(a)
(Figure 3)	Mine Cross-sections Showing Veins and Geology	7(a)
(Figure 4)	Mine Plans Showing Vein Structure and Geology	7(b)

P H O T O G R A P H S

	Page
A View of Part of the Pioneer Camp	1(a)
The Coast Range	1(a)
Soda-Granite and Greenstone Contact	7(e)
Competent Hangingwall	10(a)
Six Feet of Ore	10(b)
Ribboned Structure and Vertical Dip	11(a)
Typical Ribbon Structure	11(a)
Footwall Vein	13(a)
Showing "J" Vein	14(a)
Thrust Fault	18(a)
Striations	18(b)

Index to Suite of Ores

Number (1) Volcanic Ash

(2) Quartzite

(3) Serpentine

(4) Serpentine

(5) Greenstone

(6) Augite-diorite

(7) Soda-granite

(8) Quartz-diorite

(9) Felsite dike rock

(10) Lamprophyre dike rock

(11) Quartz crystals and encrusted sulphides

(12) Sulphides on ribboned planes of quartz

(13) Striations in banded quartz

(14) Free gold in massive quartz

(15) Mariposite

(16) Arsenopyrite

(17) Pyrite

(18) Pyrrhotite

(19) Stibnite

(20) Bornite

THE GEOLOGY OF PIONEER MINE

Location

The Pioneer Mine is in the Bridge River area, which lies on the eastern flank of the Coast Range, in the transition belt between the Coast mountains and the plateaux of the central interior system. It is situated on Cadwallader Creek - 52 miles by road from Shalalth station on the Pacific Great Eastern Railway, at an elevation of 4,000 feet.

Areal Geology

The main geological problems of the mine can probably be discussed more intelligently by first considering the geology of the district.

Bridge River Sediments

The oldest rocks in Cadwallader Creek area belong to the Bridge River series, which according to McCann, is composed of metamorphosed sedimentary rocks with interbedded volcanic rocks. The chief sedimentary member of the series is a bluish grey chert that grades into a banded, cherty quartzite in which the bands, one-half inch or more thick,

General View of Mill, Crushing Plant
Offices - Number 2 and 3 Head Frames
Looking Northwest

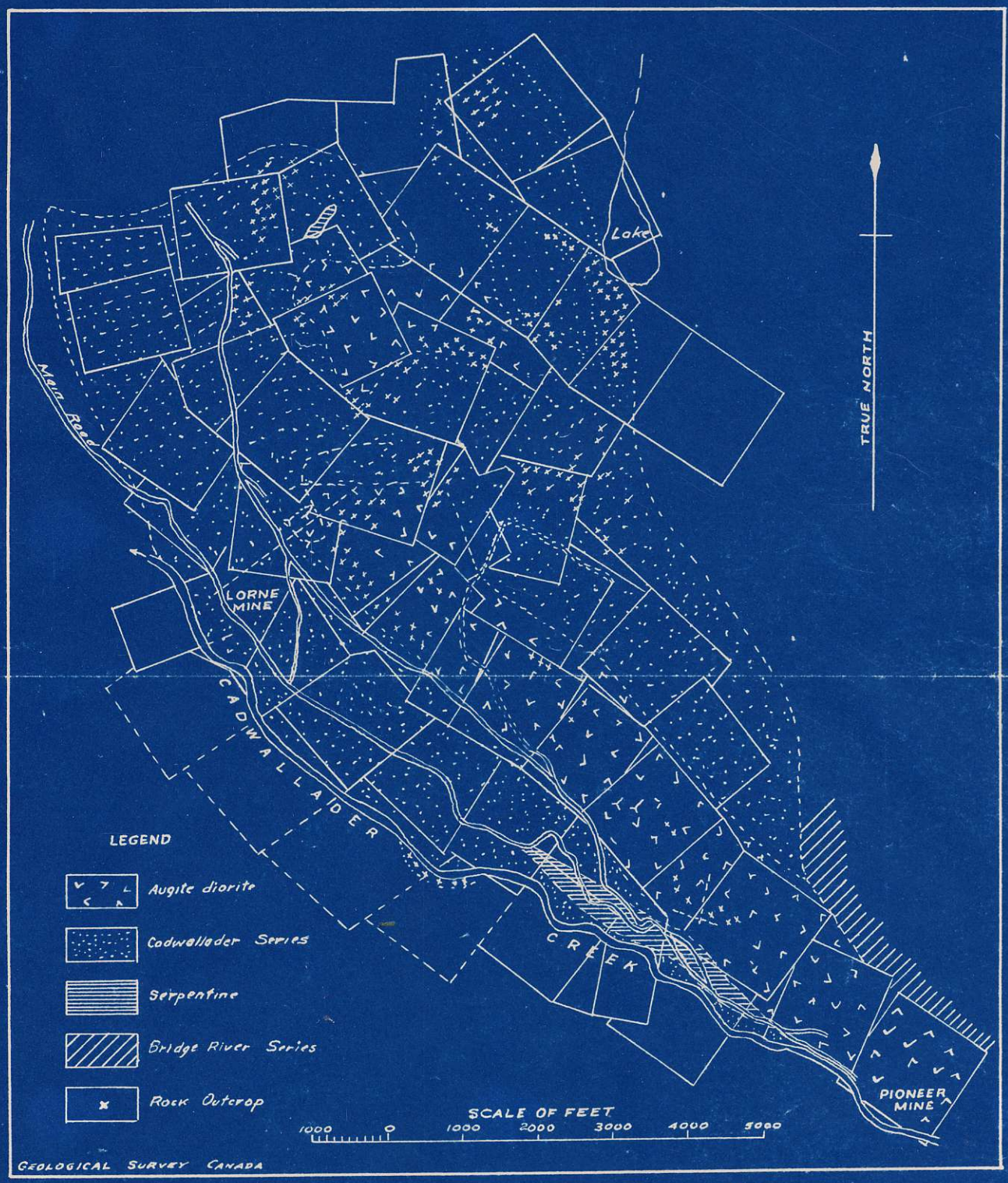
The Coast Range From the Old Townsite
Looking West

are separated by thin layers of argillite. The cherty quartzite is very fine-grained, and ranges in color from black to nearly white. The series also includes thin-bedded, dark, argillaceous strata, highly siliceous in places with a tendency to pass into chert. A red-weathering arenaceous member occurs in places,and a number of lenses of crystalline limestone occur throughout the area of the Bridge River Series. The volcanic rocks included in the series are almost entirely dense, altered, dark basalts grading into andesites. The position of this series is indicated in Figure 1. The general strike of the beds is north-westerly, and the dip is to the northeast at high angles.

No fossils have been found in the Bridge River series, but on the basis of lithological and structural similarities itis correlated with the Cache Creek series considered to be Pennsylvanian to Permian in age.

Serpentine

The next rocks in age to the Bridge River series are a group of serpentine rocks which apparently have a porphyritic and a dense phase. The former appears to have been derived from such rocks as olivine gabbro porphyry or the porphyritic equivalent of a peridotite. These rocks when weathered are greyish brown with the more resistant pyroxene phenocrysts standing out in relief. The freshly broken surface, however, is dull bluish black. The dense serpentine rocks are more altered than the porphyritic, and were



PART OF CADWALLADER CREEK GOLD AREA – B. C.

GEOLOGICAL SKETCH

FIGURE 1

probably originally olivine basalts. The weathered surfaces are reddish brown to brownish yellow, except where the rocks have been crushed, in which cases the rock has been minutely sheared, the slip planes being covered with fine films of serpentine which gives to the rock a greasy feel.

Cadwallader Sediments

This series of sedimentary and volcanic rocks is indicated in Figure 1. They consist of argillites, conglomerate, sandstone and shales, with subordinate, thinly bedded limestone and dolomite, and in the lower part of the series great thicknesses of greenstones. The pebbles of the conglomerate vary in size from ¼ inch to 4 inches, and are principally quartzite; but some are limestone,and others are serpentine. The conglomerates are succeeded upwards by shale. The Cadwallader series have approximately the same strike as the Bridge River quartzites, but dip at steep angles in the opposite direction.

In regard to age, McCann concludes that the serpentine rocks were extruded over the eroded surface of the Bridge River series, before the rocks of the Cadwallader series were deposited. He points to the possibility, however, of the intrusion of the serpentine as sills along the contact of the Bridge River series and later formations, which would make the serpentine later than the Cadwallader series.

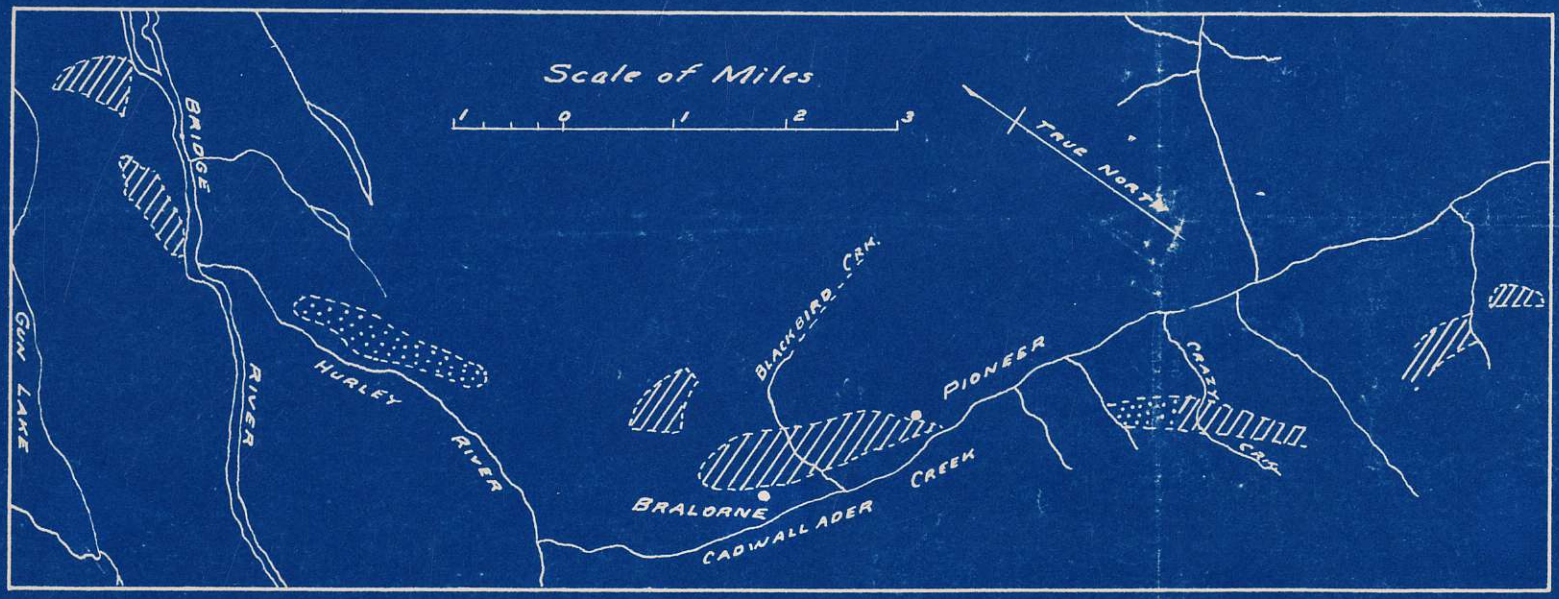
Fossils collected by McCann from the upper part of the series indicate that the Cadwallader may be referable to

the upper Triassic.

Augite Diorite

Next in age to the Cadwallader series are dike like masses of augite diorite, probably "en echelon" intrusives into the sedimentary and volcanic rocks. One dimension of each intrusive is usually much greater than the other, and the long axis parallels the drainage lines, striking northwesterly in the upper part of Cadwallader Creek and more northerly along the Hurley and Bridge Rivers. (Figure 2)

The average diorite is a medium-grained gray rock in which feldspar and hornblende appear in the hand specimen to be the only two essential constituents. Microscopic examination showed that the rocks in general are made up of hornblende, augite, plagioclase, orthoclase and quartz, with chlorite, secondary hornblende, kaolin, zoisite, sericite and calcite as the alteration products. Accessory constituents include apatite, titanite and iron oxide. Some finer-grained varieties were observed lacking augite. The arrangement of the feldspar and hornblende gives the rock a characteristic salt and pepper texture; but probably the most characteristic feature of the series as a whole is the minute veining of the rocks by tiny veinlets of quartz and feldspar which crisscross the rock in a closed network. Variations in texture and composition within individual masses of the series are extreme. Coarse-grained gabbroic phases may vary within a relatively short distance to the normal, medium-



Bodies of Augite Diorite Tongues and small masses of Augite Diorite

Map showing location of augite diorite bodies in vicinity of the Bralorne and Pioneer mines. After W.E Cockfield and J.F. Walker of the Geological Survey of Canada.

FIGURE 2

grained diorite, and this to a quartz-bearing diorite and to fine-grained marginal phases which are identical in appearance to certain members of the greenstones. The most extreme variation in composition is to a light colored, moderately coarse-grained rock composed almost entirely of quartz and a very sodic plagioclase, together with a small amount of chlorite. This rock has been referred to as quartz-diorite, soda-granite; and in some of the earlier references it is apparently described as an albitite dike. Soda-granite would appear to be the most descriptive and appropriate name for the rock.

Large masses of soda-granite are found within the augite-diorite. In places the soda-granite cuts the diorite as a dike, but more frequently the contact relations are indefinite or gradational. This, together with the fact that the soda-granite is such a very definite part of the intrusives - and not found except with more typical phases of the augite-diorites - has led to the belief that the augite-diorites and soda-granite are differentiates of the same magma. Dikes of soda-granite cut adjoining greenstones, as do dikes of fine-grained, dense quartz porphyry. In the central section of the intrusives, masses of quartz porphyry cut the diorite in an irregular manner, and in several places a gradation to a soda-granite seems to take place. This would suggest a close relationship between certain phases of the diorite, soda-granite and quartz-porphyry.

Near its contacts with the enclosing rocks, the diorite is in many cases fine-grained, and contains numerous inclusions of the rocks into which it has been injected. The gradational character of the contact and the inclusions of argillite in the diorite indicate an intrusive and not a faulted contact.

McCann places the augite-diorite in the upper Jurassic.

Coast Range Intrusives

A local representative of the great complex of Coast Range batholithic rocks is the Bendor batholith, which is exposed two to three miles northeast of the Pioneer-Bralorne zone. It is principally quartz-diorite, and differs significantly from any phase of the augite-diorite group in that it contains the potash feldspar. The intrusive is of post-lower Cretaceous age, thus younger than the augite-diorite.

Late Dikes

Cutting the quartz-diorite and earlier rocks are a number of fine-grained porphyritic felsite dikes. These rocks are light grey, brown or red with phenocrysts of feldspar and occasionally of quartz. Microscopic examination has shown them to be made up largely of albite in small inter-locking grains penetrated by small crystals of sericite.

Dykes of diabase also occur in the rocks surrounding the augite-diorite.

Unconsolidated Deposits

Pleistocene and Recent unconsolidated deposits, including glacial and stream deposits cover a large part of the area, so that bedrock outcrops are relatively scarce.

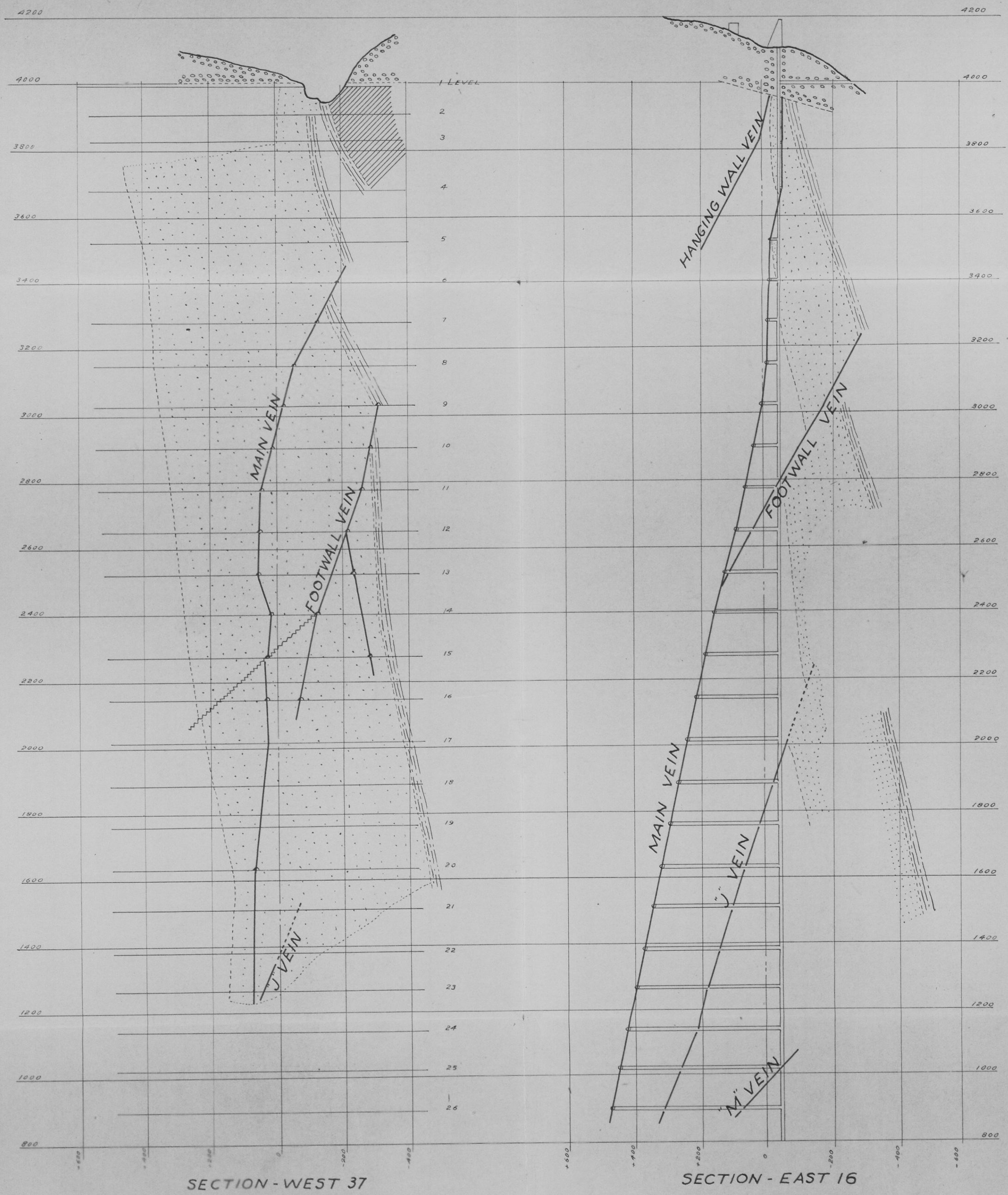
Mine Geology

Relation of Main Rock Types to Productive Zone

The distribution of the main rock types and the relation of the principal veins to them in the Pioneer Mine is shown in the sections East 16 and West 37 and the plans of 10 and 23 levels. (Figures 3 and 4)

On the south side of the known productive zone is a band of serpentine, striking north-westerly and dipping to the southwest at an angle of 70 to 75 degrees. This band is exposed in the canyon below the Pioneer camp, where it is about 100 feet wide and is overlain on the south by a thick series of argillites.

North of the serpentine, at the east end of the mine, is the greenstone series which contains most of the ore deposits. This series is approximately 1,200 feet wide and consists of amygdaloidal and massive andesites, and at one



SECTION - WEST 37

SECTION - EAST 16

PIONEER GOLD MINES OF B.C. LTD.

CROSS SECTIONS

SHOWING VEINS AND GEOLOGY

GREENSTONE

ARGILLITES

SODA GRANITE PHASE

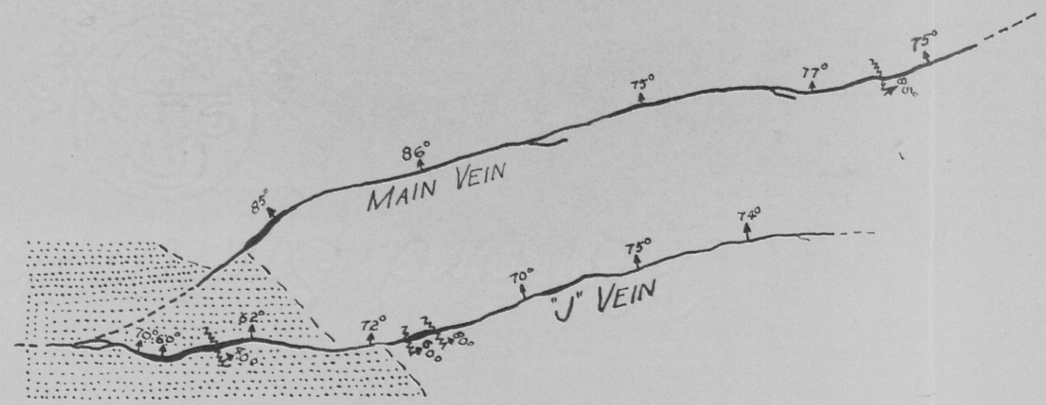
AUGITE-DIORITE INTRUSIVE

SERPENTINE

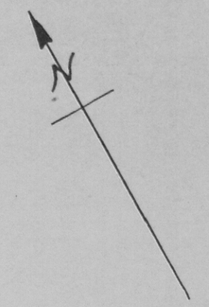
100 50 0 100 200 300

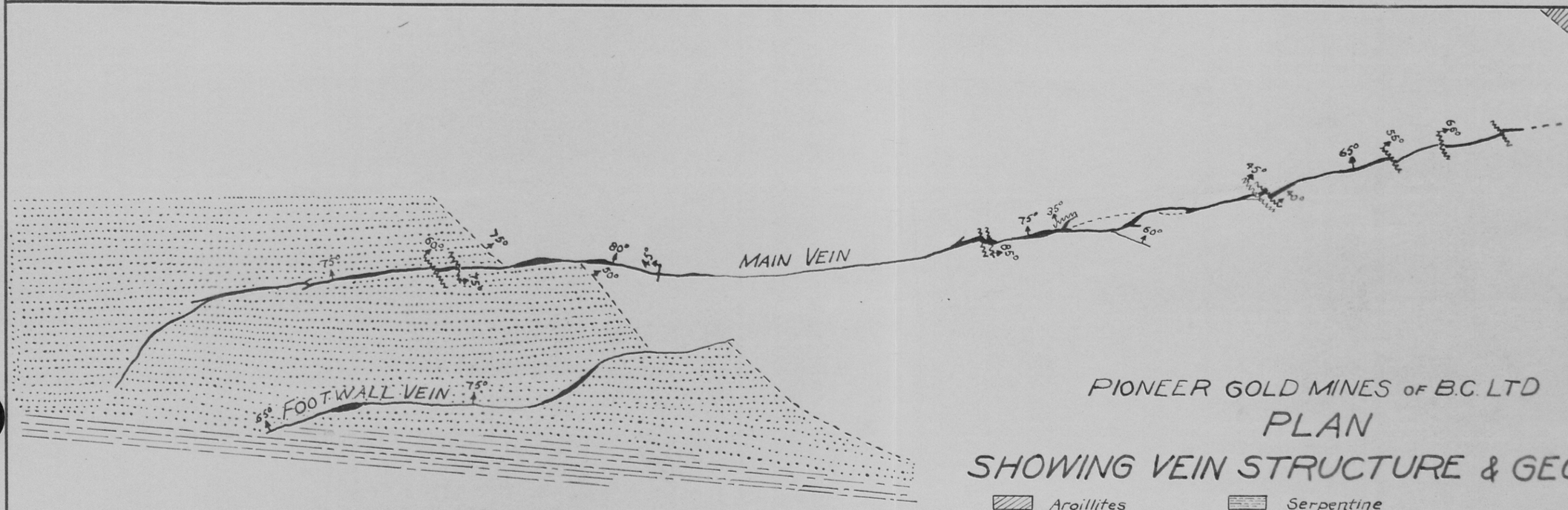
SCALE IN FEET

TRACED BY W.L.



23 LEVEL





10 LEVEL

PIONEER GOLD MINES OF B.C. LTD

PLAN

SHOWING VEIN STRUCTURE & GEOLOGY

Argillites
Greenstones
Serpentine
Soda Granite phase of Augite Diorite Intrusives

Scale in feet
100 50 0 100 200

inches
0 1
0 1 2
centimetres

Showing Soda Granite on Hangingwall
And Greenstone on Footwall
Main Vein - 16 Level - 54 Stope

point underground there is a small amount of finely banded material which appears to be a tuff. Within the greenstone band intrusive andesites are found and a certain amount of fine-grained diorite material resembling the augite-diorite.

North of the greenstone and dipping north, which is opposite to the dip of the serpentine, is a thick series of finely bedded quartzites, with some argillite and a few bands of volcanic rock resembling the mine greenstones. These quartzites are known as the Bridge River series, described in the areal geology.

The Cadwallader series, also previously mentioned, is south of the serpentine band and consists of a great thickness of argillites.

The hundred-foot band of serpentine between the argillite and greenstones is a very fine-grained dense black rock, sheared and serpentinized near the greenstone contact. Because of this shearing, it is not possible to determine definitely the exact contact of the two rocks underground, nor to discover the age relations of the two. McCann correlates the serpentine with the Shulap Volcanics, and describes them as basic volcanic flows extruded on the upturned and eroded Bridge River quartzites followed by the deposition of the Cadwallader, in which there is an appreciable amount of interbedded volcanic material.

At the west end of the Pioneer property and on the strike of the mine greenstone is an elongated dike-like mass of augite-diorite; one of several such masses strung out along

the Cadwallader valley, and would seem to be intrusive into the sedimentary and volcanic rocks. The mass at the northwest end of the Pioneer is one of the largest in the area, being about 11,000 feet long and 1,500 feet wide, and is of particular interest in that the Pioneer Mine is situated at one end of the mass and the Bralorne at the other. The Bralorne veins are largely within the augite-diorite, while the Pioneer veins are found chiefly in the greenstone or in a quartz-diorite. This quartz-diorite is a light coloured, moderately coarse-grained silicious intrusive, consisting of sodic plagioclase and quartz with a little chlorite.

Dikes of quartz-diorite have been found cutting the augite-diorite, but at other points the contact between the two is indefinite and the areas of quartz-diorite somewhat irregular in outline. Evidently the Pioneer quartz-diorite is later than the augite-diorite, but there is not a little to suggest that it may be a differentiate of the same magma.

The Pioneer quartz-diorite and earlier rocks are cut by light coloured felsite dikes up to several feet in width, which weather to a buff color. They are frequently sheeted, and in several places throughout the mine have quartz veins associated with them, either along the walls or within the dike.

Veins

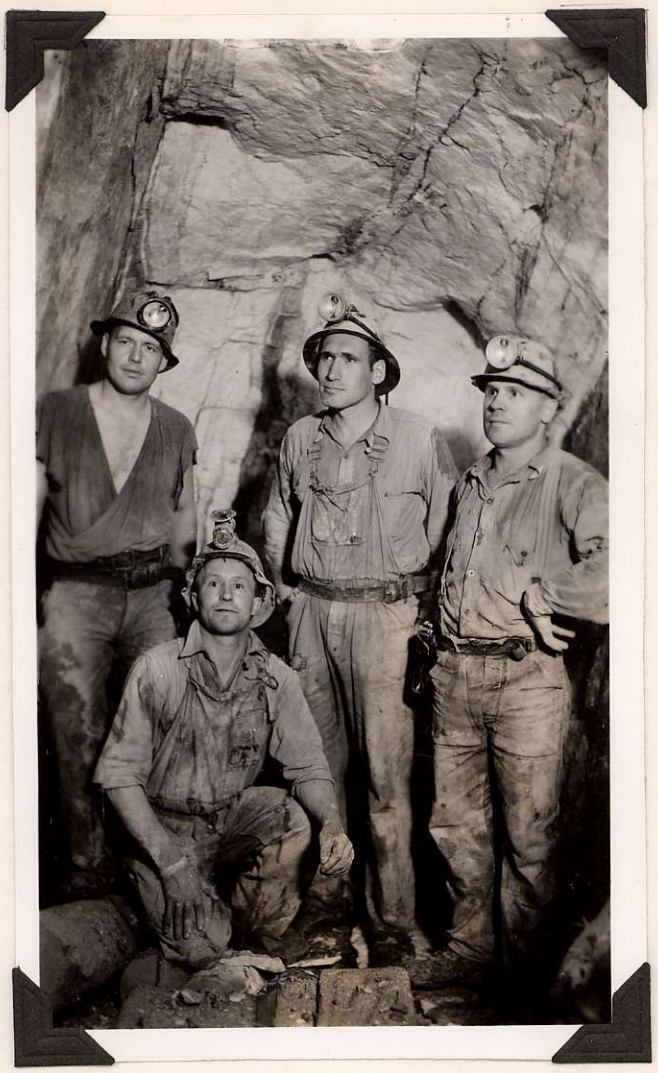
Apparently the next phase of igneous activity in the district was the development of the quartz veins. These are widely distributed, being found in the quartzites, argillites, greenstone, augite-diorite and quartz-diorite. They are quite numerous in the sediments, particularly the argillites, but with few exceptions commercial ore has been found only in the igneous rocks. The relationship of the principal Pioneer veins is illustrated in sections West 37 and East 16. (Figure 3)

A. Main Vein

The main vein is a quartz filled fissure varying from a mere crack to 9 feet of quartz, but averaging about 3 feet. It strikes north 60 to 70 degrees west, except at the extreme west end, where the vein swings sharply to the south before pinching out in the serpentine. The average dip is to the north at 75 to 80 degrees, although in places the dip is vertical and between 13 and 14 levels and 15 and 17 levels is reversed,as shown in section West 37. (Figure 3) The length as developed to date is about 4,000 feet.

It may be observed on the plan (Figure 4) that towards the west end of 10 level, at a point where the main vein turns sharply to the south, a strong branch vein continues approximately along the strike of the main fissure. From a structural standpoint this branch vein should really be considered the main vein, but commercial ore follows

Showing Competent Hangingwall
of Main Vein
17 Level - 24 Stope



Six Feet of Ore - 15 Level - Main Vein
East End of 40 Stope

around in the swing to the south and this has come to be regarded as the main vein.

(1) Ribbon Structure

One feature of the main vein which is well and characteristically developed throughout most of its length is the ribbon structure. This is the result of the development of parting planes in the quartz, parallel to the walls of the vein, due to movement during vein formation. These are particularly well developed in the east, or greenstone end of the mine, where the ribbons may number several to the inch, but average about one to the inch. Generally speaking, the ribbons in the west or quartz diorite end are less numerous than in the east, and appreciable lengths of massive white quartz are not uncommon. The faces of the ribbons are invariably striated, and these plunge east at an angle of 45 to 65 degrees. It is on these faces that most of the sulphide and an appreciable amount of visible gold is found. Obviously the sulphides and much of the gold found access to the vein which had been fractured since it was formed. Very often the faces are slickensided and the sulphides pulverized, suggesting a later movement. It is also true that very commonly the fine needles of arsenopyrite and cubes of pyrite, with which the faces are sprinkled, are not broken and show no signs of having been disturbed since they were formed.

Ribboned Structure and Vertical Dip
Main Vein - 17 - Level - West Drift

Typical Ribbon Structure

Although there is no direct relation between the number of ribbons per foot and the values, it is generally true that the ribboned quartz is higher grade than the massive quartz. Exceptions are common,and heavy free gold is frequently found in massive white quartz and occasionally highly ribboned quartz is disappointingly low grade.

(2) Sheeted Structure

A sheeted structure, similar to the ribbon structure, is developed in some places in the mine; but it is a later development associated with strike faulting. While both structures are basically the same, being due to a movement in the vein, there is a significant differency in that one was developed during mineralization, while the other is a post ore development. The direction of striations on the ribbon faces corresponds very closely to the actual displacement of the vein walls. While it is not to be inferred that any more than a small amount of total movement is represented in the ribbons, it is suggested that the forces which were responsible for the development of the original fault may have been active during vein formation.

B. Branch Veins

Branch veins are numerous, and these take off from both the foot and hanging wall, going both east and west. Occasionally the two parts of the vein come together again in anything from a few feet to a hundred feet, and either or both branches may contain commercial values. The majority of

the branch veins leave the main vein entirely and appear to pinch out within a few hundred feet of the intersections. It must be admitted that in most cases exploration on branch veins has ceased at the first discouraging signs, whereas, under similar conditions on the main vein, work would continue with the assurance of improvement within a very short distance. Good ore shoots have been developed in several instances on these veins, and two are known to be long and persistant fractures carrying good widths of quartz with sections of commercial values.

(1) Footwall Vein

At the present time, the most important of the branch veins would seem to be the footwall vein, which was first discovered just below 13 level. In drifting east on 14 level along this vein, a 100-foot ore shoot was opened up and a similar length of ore has been developed on 10 level west of the shaft.

(2) Hangingwall Vein

The second strong branch vein is the hangingwall vein. It has not been developed below 5 level; but in the early days ore was mined from this vein on the two upper levels, and 160 feet of ore shoot has been opened up on 5 level.

Showing Flatter Dip and Competent
Hanging Wall - Footwall Vein
10 Level

(3) "J" and "M" Veins

While crosscutting from number 2 shaft to intersect the main vein on the lower levels, a very strong vein - the "J" vein - has been disclosed and also the "M" vein on levels 25 and 26 only. (Figure 3) These two veins will probably intersect the main vein at lower levels. Very little drifting has yet been done on these veins. The grade of the ore so far developed in the branch veins is below the average of the main vein. It is yet to be determined how important branch veins will become.

C. Parallel Vein

The principal known parallel vein is the Countless vein, from which a small amount of ore was taken in the early days. It is in albitite at the west end of the mine and has not yet been developed by underground workings.

Mineralization

All veins on the property consist essentially of quartz with only minor amounts of other gangue minerals and sulphides. Gangue minerals, other than quartz, are calcite, ankerite, mariposite, scheelite, chlorite and sericite. Where calcite occurs in the veins it is usually along the walls. Calcite is also found at the outer end of branch veins or in pinches in the main vein.

On 14 level west, flat veins of calcite and quartz with a high percentage of scheelite were found cutting the

Showing "J" Vein - 23 Level - West Drift

main vein.

Metallic minerals in addition to gold represent about 2 to 3 per cent. of the ore, and consist of arsenopyrite, pyrite, sphalerite, pyrrhotite, chalcopyrite, stibnite and marcasite, in order of relative importance.

Arsenopyrite and pyrite are the most common sulphides, and as a rule are the only ones found in the vein. They occur in the quartz and on the ribbons and, to a variable extent, in the wallrock. Bunches of arsenopyrite are occasionally found at the west end near the serpentine, and invariably they are associated with high-grade gold values. Pyrite is more rarely found massive, but gold values are not necessarily high in concentrations of this mineral.

Small stringers and scattered grains of sphalerite are occasionally found at the west end near the serpentine and more rarely in other parts of the mine. High gold values are again invariably associated with this sulphide.

Galena has been found in small quantities with the sphalerite at the serpentine end of the vein.

Chalcopyrite and pyrrhotite are rare, particularly the former, which has been observed in only one or two instances. The writer also found some bornite, which has never been previously mentioned.

Marcasite was identified by Dr. Dolmage in specimens collected on 14 level from the west end of a high-grade ore shoot. It occurs with pyrite in a massive form, a foot or so in diameter. This is the only known occurrence in the

mine.

Stibnite has been found at one point where a fault crosses the vein on 7 level east, but its relationship to the main period of mineralization is not known.

Gold is the only mineral of economic importance except for a slight silver content, which amounts to about five cents a ton. Most of the gold occurs as the native metal. The visible part is usually found on the ribbon faces or in the quartz close to the ribbon. High grade pockets are also found in massive white quartz at the west end of the mine near the serpentine.

Ore Shoots

A satisfactory explanation of the variation of the gold content has not been found. Values occur in definite ore shoots. Some generalizations can be made regarding the distribution of these shoots. The fault fissure crosses from greenstone to quartz-diorite to augite-diorite without interrruption, but on entering the soft serpentine quickly "pinches" down and disappears. Because of the relative attitude of the vein and serpentine contact, the vein becomes progressively longer on the lower levels. Down to 8 level, the line of this intersection of the vein and serpentine rakes west of about 45 degrees. Below 8 level the rake is nearly vertical, because the vein changes its strike towards the west end on the lower levels and meets the serpentine more quickly than it would have done had it continued on its

usual course. (Figure 4) The west end ore shoot extends back from the serpentine for several hundred feet. On the upper levels the ore shoot rakes westerly in line with the rake of the vein-serpentine intersection and becomes about vertical on the lower levels. The hangingwall of this ore shoot is quartz-diorite, and the footwall above 9 level changes from quartz-diorite to augite-diorite and finally to serpentine, on going west. Generally speaking, the gold "pockets" are found about where the serpentine comes in as the footwall rock. Below 8 level both walls are quartz-diorite.

The west ore shoot may be divided into two sections, the westerly being lower grade than the easterly portion. In the lower grade section, from 6 level down the vein is entirely within the quartz-diorite, and values in this are quite uniform until 13 level is reached, where in the centre section values increase materially, and on 14 level in the centre of the block is an 80-foot stretch of about 7-ounce ore.

The other main ore shoots are entirely within the greenstone. The first of these unites with the west ore shoot above 6 level to form one continuous ore shoot. A section of the vein on either side of the point where it crosses from greenstone into quartz-diorite is generally low grade, but does contain one or two short ore shoots. The lack of values here is due in part to a lesser gold content of the quartz and in part to a pinching of the veins. Ths two greenstone ore shoots are separated by variable lengths of narrow vein. Their general plunge is easterly, although

sections are vertical and on the two lower levels the first ore shoot is lengthening with one end plunging east and the other west. The second ore shoot has not been explored on the lower levels.

Although the westerly half of the west ore shoot is rich and contains exceptionally high-grade "pockets", the eastern or greenstone end of the mine in general contains the most valuable ore shoots.

On 5 level the second ore shoot is over 500 feet long, and averages 4 ounces of gold per ton over a stoping width of 3.3 feet, for a length of 375 feet.

Faults

The quartz vein fissures themselves are fault structures. The remaining principal fault structures are those striking in a north-south direction, and are for the most part truly post-mineral in character. The distribution of these faults is over the central and particularly the western limit of the augite-diorite intrusion.

On all major faults there has been both a horizontal and vertical component of movement. Each of the faults is considered as a thrust from the southwest, with a hinge motion in each fault block. As a result of the hinge motion, the dips of the veins are not the same on opposite sides of the fault, and the horizontal offset therefore varies from level to level. Usually the displacement is only a few feet, often

Showing Thrust Fault of Small Displacement
Main Vein - 11 Level - 39 Stope

Striations on Hangingwall - Showing
Movement - But No Displacement of Vein
4 Level - 58 Stope

just the width of the vein. (Figure 4) Most of the faults cross the vein at about 90 degrees, and dip either east or west at angles of from 30 to 90 degrees.

A few faults strike approximately parallel with the main fissure and dip in the same direction, but at flat angles. These are invariably reverse faults. One of these is shown in Figure 3 between 14 and 17 levels. It has a junction with the footwall vein at 14 level, dips 45 degrees north and crosses the main vein, displacing it some 18 feet to the north on 15 level.

Lamprophyre Dikes

The last to consolidate of the igneous deposits known are lamprophyre dikes. One such dike cuts all other rocks including the veins, on the lower levels, and is considered to be of the kersantite minette group of mica dikes.

Methane

A description of the Pioneer geology would not be complete without some mention of its most unusual product, methane. This gas was first struck on 14 level, which is 1,600 feet below bed-rock,and has since been found in nearly all sections of the mine. It occurs in pockets with water, and on the upper levels the odor of hydrogen sulphide was distinctly noticeable. The greatest flow of gas was from a flat dipping water course in the vein, which drained out in a few days.

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HON. W.A. GORDON, MINISTER; CHARLES CAMSELL, DEPUTY MINISTER.

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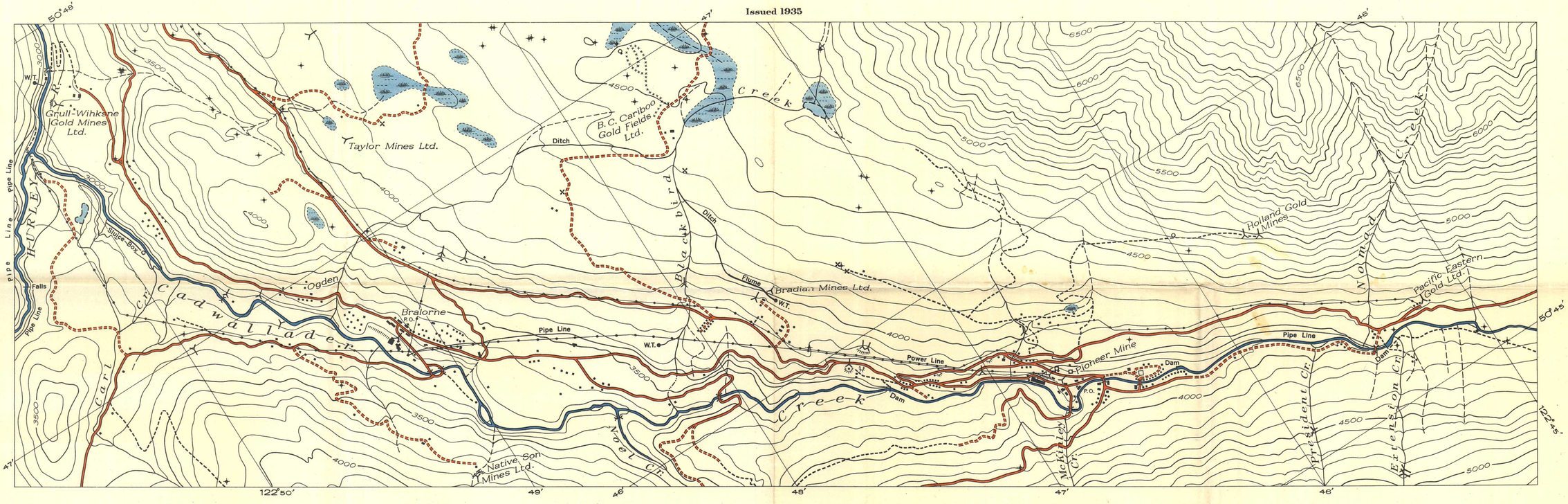
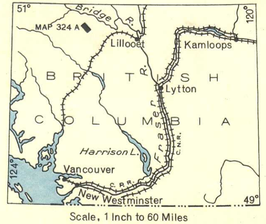
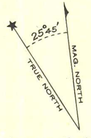
GEOLOGICAL SURVEY

Issued 1935







Approximate magnetic declination, 25°45' East.

MAP 324 A
(PUBLICATION NO. 2386)

CADWALLADER CREEK AREA

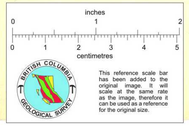
LILLOOET DISTRICT

BRITISH COLUMBIA

SCALE, 1/12,000 or 1 INCH TO 1,000 FEET

1000 0 1000 2000 3000 4000
Feet

Contour interval 100 feet.
Datum, Mean sea-level.



LEGEND

Road and buildings	Prospect
Road not well travelled	Shaft
Trail	Claim post
Bridge	Water tank W.T.
Power line	Trench
School	Mine dump
Post office	Intermittent stream and lake
Mine tunnel	Marsh

Surveys and topography by the Topographical Division, Bureau of Economic Geology, Department of Mines.