STRUCTURAL GEOLOGY

of the

BRALORNE AND PIONEER MINES

Bridge River District, British Columbia

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Introduction

GOLD has been found in many parts of Bridge River district of British Columbia but it is from a relatively small area in the valley of Cadwallader creek that the bulk of production has come. This area, rectangular in shape, measures about one-half mile in width by three miles in length. In this area, here called for convenience the Cadwallader Gold Belt, are situated the Bralorne and Pioneer mines in addition to several prospects under development.

The gold of the Cadwallader Gold Belt occurs in quartz veins averaging about three feet in width. The ore contains about one-half ounce gold per ton. Except for a relatively small amount of silver, no other metals are produced from these veins. The productive veins occur in a variety of rocks. Vein-matter has filled reverse faults and modified tension structures. The fault structures are in some cases productive over lengths exceeding five thousand feet (28; p. 43). The Pioneer Main vein, the most deeply developed vein in the camp (1946), has been productive through a vertical distance of three thousand, seven hundred feet.

Production of the Bralorne Mine, from 1932 to 1945, is 996,383 ounces gold and 190,709 ounces silver. Production of the Pioneer Mine, from 1930 to 1945, is 777,588 ounces gold and 135,698 ounces silver. These mines, together, have distributed about twenty-five million dollars in dividends.

History

The earliest recorded reference to the occurrence of gold in the Bridge River area is to be found in the official reports of Government Agents to the Colonial Secretary[1] dated over a period from May 18th to October 27th, 1863. These communications describe the reported discovery of rich gold placer deposits on the Bridge River by Chinamen and the verification of these reports by John Cadwallader.

The lode showings that had given rise to these placers were not discovered until 1897 when, within the period of a few months, most of the veins of present importance in the Bridge River camp were found and staked.

Desultory development was carried on in the Cadwallader Gold Belt section from 1897 to 1928 when the Pioneer mine went into profitable production on a 100 to 150 ton per day basis, since increased to 350 tons. The Bralorne mine went into profitable production in 1932 on a 100 ton a day basis, since increased to 450 tons with a further increase now planned.

General Description of the Map Area

Location. The Bridge River mining area, in the southeast corner of which the Cadwallader Gold Belt occurs, lies approximately 100 miles north of Vancouver on longitude 123 degrees and latitude 50 degrees 10 minutes.

Accessibility. Access to the area from Vancouver is by car over a circuitous route through the Fraser Canyon; by a more direct boat, rail and car route 150 miles in length, or by pontoon-equipped aircraft. The boat-rail-car route, which requires about fifteen hours to cover, is the one most commonly used for passengers and freight. The chartered aircraft service, which covers the distance in one hour, has its terminus at Gun Lake, some fifteen miles by road from the mines.

Topography. Topographically the Bridge River area is an area of marked relief ranging abruptly from 2500 to 8500 feet above sea level.

The Cadwallader Gold Belt section forms a narrow, rectangular strip, conforming quite closely with the east-west trend of Cadwallader Creek valley. The Gold Belt ranges from 3,500 feet in elevation at its westerly end to 4,500 feet in elevation at its easterly end.

Immediately north and south of the Cadwallader Gold Belt the Bendor Batholith Range and Cadwallader Batholith Range, respectively, tower in a series of peaks up to 8,500 feet.

The Cadwallader Gold Belt is in part paralleled and in part crossed by Cadwallader Creek which is a typical mountain river showing large and rapid fluctuations in volume. It follows, in places, a canyonous course and is fed by several tributaries, several of which enter the main stream from hanging valleys.

Previous Published Work on the Area

From 1912 on, much reliable information has been published on the Bridge River area, including the Cadwallader Gold Belt section.

The most comprehensive stu[illegible] were those of W. S. McCann and [illegible] Cairnes, published in 1922 and 193[illegible] spectively. Cairnes' excellent bi[illegible]raphy, revised to date but wit[illegible]

1 Historical Archives, Parliament Bldgs. Victoria, B. C.

Presented as a thesis for registration to the Association of Professional Engineers of B. C. A summary of this paper was read before the Annual Meeting, C.I.M., Ottawa, January, 1947, and an abbreviated version will appear in the C.I.M. volume of Canadian Ore Deposits.

annotations, may be found at the end of this paper. It will be seen from this bibliography that most phases of Bridge River geology, with the seeming exception of the regional structural geology, have received attention prior to 1938. This paper is designed to summarize the progress of geological studies since that date with the emphasis on developments in the field of structural geology.

Acknowledgments

Those in charge of the Bralorne mine, the Pacific (Eastern) property and various prospects have all given generously of their information. Without this assistance and co-operation the composite regional study of the Cadwallader Gold Belt could not have been effected.

The writer is indebted to Howard T. James, M. M. O'Brien and Dr. F. C. Buckland, managing directors of Pioneer Mines, Bralorne Mines and the Quebec Gold Mining Corporation respectively, for permission to publish the data in this paper.

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For advice and constructive criticism the writer owes his thanks to Dr. C. Cleveland, Bralorne geologist.

Geological Table

The rock types of the Cadwallader Gold Belt are tabulated for brevity, in sequence of origin, in the geological table. For lithological and petrological details of individual rock types the reader is referred to the reports by Cairnes (24), Walker and Cockfield (16), and McCann (11). Most of the types mentioned in the above table will be further discussed under the sections on Primary and Secondary Geological Structure.

An important departure made in the table from previously published tables of formation on the Cadwallader Gold Belt area should be mentioned here. This change is the removal of the Noel sedimentary formation from the position previously given it (24; pp 15-16) as underlying the Pioneer greenstone, and the inclusion of the Noel with the Hurley sedimentary formation which definitely overlies the Pioneer greenstone. The writer believes that, at least on the Pioneer and Bralorne properties, these two sedimentary members are the same, duplicated in plan by close folding as illustrated in the structural cross-sections, Figs. 3 and 4. Such a stratigraphic relationship for the general area was suggested earlier by McCann (11; pp 22-28). The writer's reasons for this revision of sequence are, (a) the relative structural attitudes of the sediments and greenstone, (b) the general lithologic similarity between the Hurley and Noel formations and (c) the presence in both the Hurley and Noel formations of a local basal conglomerate containing pebbles of greenstone and the porphyritic rhyolite top member of the greenstone series.

Franc. R. (Francis Renault) Joubin was born in San Francisco, California, from which city he took his name. He is in his middle thirties, married and has a daughter of seven. He was educated in Victoria's public and high schools and in the University of British Columbia, receiving a bachelor's and master's degree in geology from the latter He has taken much post-graduate work in the University of "Hard-Knox."

He has served an apprenticeship as prospector, lessee, field and mine geologist. Is at present in charge of Pioneer's interests in Eastern Canada, with headquarters in Toronto. Managed to spend part of last winter in South America, which permits him to boast that he has worked with prospectors from "the Klondyke to the Amazon." Has published a number of technical and semi-technical papers, in the fields of geology and prospecting. Likes mining because "it takes you into the damndest corners where you meet the finest people in the world." He is a member of the Canadian and American Mining and Metallurgical Institutes and registered as a Professional Engineer in British Columbia and Ontario.

He prepared this paper two years ago, after a detailed study of the Cadwallader Gold Belt. A summary was presented to the C.I.M. Eastern Meeting in Ottawa, and another will appear in "A Symposium of Canadian Ore Deposits." The paper was accepted as a Thesis for Registration by the B. C. Engineers Association. Its present publication in full, containing a detailed description of the writer's original structural interpretations, may interest western readers familiar with the camp.

Structural Geology

A. Primary Structures

Introduction. In this section will be briefly discussed such physical features as the original form, size, internal structure and habit of occurrence of the intrusive, volcanic and sedimentary rock types. Much of this data is summarized in a column of the geological table but certain details are deserving of further description.

Fergusson Series. The basement complex of the Cadwallader Gold Belt, or the Fergusson Series, was formed as an extensively developed thin-bedded series of alternating argillite and chert, with, towards the top of the series, some lentils of limestone. The marked difference in the relative competency of the argillite and chert, and thinness of the beds, formed a rock series which was particularly susceptible to extensive small scale fracturing, mashing and crumpling under the stresses of regional deformation.

Pioneer Formation. The Pioneer greenstone of the Cadwallader Gold Belt appears in weathered outcrops as a homogeneous rock type of andesitic composition. Familiarity with freshly broken surfaces and in particular with diamond drill core of this rock makes it possible to distinguish between four types of different internal structure and different physical characteristics. The types present are amygdaloidal flows rarely exceeding one foot in thickness and in which the amygdule size variation commonly indicates the flow top; tuffs in which grain size variation is only occasionally perceptible; minor flow top breccias and locally distributed, fine-grained crystalline textured phases which are intrusive into the flows and tuffs. The intrusive type of greenstone is difficult to distinguish from the megascopically similar, coarser-grained tuffs.

The amygdaloidal type occurs most commonly as a repeated succession of thin flows, followed by successions of thin tuff beds. Individual flow or tuff

Era	Period	Formation	Lithology	Thickness (in Feet)	Primary Structure
Cenozoic	Recent		Stream deposits; volcanic ash; slide debris and soil.	± 300	Forming bars, low benches and a generally thin surface mantle.
Cenozoic	Pleistocene		Fluvioglacial, glacial and stream deposits.		Originally partly filling valleys, now forming high and low benches along valley sides.
			Erosion—Nonconformity		
Mesozoic	Upper (?) Jurassic	Bralorne Intrusives	Lamprophyre dykes. Ore deposition. Albitite and quartz-albitite.		As dykes, lenses, irregular masses and "soaking material."
Mesozoic	Upper (?) Jurassic	Bralorne Intrusives	Soda granite (albite feldspar).		As an elongated stock of somewhat sill-like habit.
Mesozoic	Upper (?) Jurassic	Bralorne Intrusives	Quartz- and feldspar-"porphyries."		As isolated or swarms of sill-like masses; in part intrusive, in part "pseudo-porphyry" after tuffs or sediments.
Mesozoic	Upper (?) Jurassic	Bralorne Intrusives	Quartz-diorite.		As small plug-like bosses.
Mesozoic	Upper (?) Jurassic	Bralorne Intrusives	Diorite and greenstone-diorite. Gabbro and hornblendite. Peridotite ? (All in part serpentinized.)		As a lenticular, stock-like mass with gradational, sub-parallel zoning into more basic phases, along one flank where the hornblendite and gabbro phases in part "soaked" greenstones to form hybrid greenstone-diorite.
Mesozoic			Intrusive Contact		
Mesozoic	Upper (?) Triassic	Hurley (–Noel)	Argillaceous, tuffaceous and minor cherty sediments; conglomerate and agglomerate beds; locally limy and fossiliferous; minor intercalated andesitic ("greenstone") flows.	± 1200	Forming banded to laminated beds with little grain size variation. Conglomerate as lenses, at or near the base of the formation.
Mesozoic	Upper (?) Triassic	Structurally Conformable			This contact, on basis of local basal conglomerate, may be disconformable.
Mesozoic	Upper (?) Triassic	Pioneer	Green, massive, amygdaloidal or finely crystalline, regionally metamorphosed andesites ("greenstones") and some associated instrusive phases. Minor local rhyolitic flows and breccia at top of the series.	+ 1000	Mainly flows, tuffs and breccias with dyke-like and irregularly shaped generally fine-grained, intrusive phases. Top determinations of flows occasionally possible by amygdule size variations.
	Structurally Conformable				This contact may be disconformable. Its original nature is now masked by basic sill-like intrusives, generally sheared and faulted, serpentinized and locally carbonated.
Paleozoic			Mainly green-colored andesitic to basaltic lavas and minor associated limestone with some local thin beds of oolitic jasper.		These lavas occur as amygdaloidal pyroclastics, pillows and flows with (probably) fine-grained intrusive phases. Stratigraphically they overlie, except where they intrude, the Fergusson sediments; structurally they are now commonly infolded in the latter. These lavas are probably the basal member of the Triassic Pioneer greenstones.
Paleozoic	Permian	Fergusson Series	Chert, quartzite and graphitic argillites.		Extensively developed as relatively thin, interbedded argillite, quartzite and chert.

horizons cannot be correlated laterally with any reasonable degree of certainty.

The flow top breccias are of erratic occurrence, except towards the top of the greenstone series where they rapidly increase and gradually change into a type called for convenience "amygdaloidal pyroclastic." The latter is composed of sub-angular to rounded volcanic fragments, of acidic composition and amygdaloidal structure, in a more basic fine-grained matrix. Locally the actual top of the greenstone series, where underlying the sediments and so spared from erosion, consists of one or more massive, acidic, (rhyolite or dacite), sometimes porphyritic, flows.

The flow and tuff types of greenstone, which probably comprise eighty per cent of the volcanic series, react differently to stress. The flow type becomes somewhat schistose with soft chloritic films on the parting surfaces giving the rock a "greasy" feel, while the tuffs are more prone to fracture into angular fragments with abrasive-like surfaces.

All types of the greenstone series are relatively competent rocks which, under certain conditions, form a favorable host for much of the ore.

Greenstone-Diorite. This is a hybrid rock quite common in the Cadwallader Gold Belt. In places it presents a breccia-like appearance and may be composed of mixed sub-angular blocks of greenstone and dioritic material; or adjoining sub-angular blocks of dioritic material of different granularity and crystallinity; or simply fractured dioritic material. Commonly the divisions between blocks of different types are marked by narrow felspathic stringers. In places the breccia-like structure of the greenstone-diorite is absent and instead the complex consists of greenstone with small to large, irregularly shaped patches, which have been seemingly replaced or saturated with dioritic magma. In this type of the greenstone-diorite, contacts between the greenstone and intrusive material are gradational.

Distribution of the greenstone-diorite in the Cadwallader Gold Belt is confined to certain general zones and as these zones are closely related to the regional folding and shearing, they will be further discussed under the heading of Secondary Structures.

Hurley-Noel Formation. These sediments, including argillaceous, tuffaceous and conglomeratic types, are generally thin-bedded. Grain size variation or other top determination criteria are poorly developed. No dependable horizon marker, other than a zone of conglomerate lenses, is known to the writer.

The conglomerate mentioned occurs in lens-like masses rarely more than twenty feet in thickness, and commonly much less. These lenses occur at, or close to, the contact of the sedimentary formation with the Pioneer greenstone. In places the conglomerate is formed of well-rounded pebbles of chert (of Fergusson Series origin?) or porphyritic, felsitic rock (of uppermost Pioneer formation acidic flow origin?) and other unidentifiable material. In other sections the conglomerate will include, in addition to the above, the conspicuous presence of rounded to angular pebbles and cobbles of limestone and granitic material.

Since the conglomerate observed is believed to occur in the basal zone of the sedimentary formation adjoining the Pioneer greenstone and includes in part pebbles of material resembling the uppermost volcanic flows of the Pioneer formation, the conglomerates are regarded in the main as basal conglomerates.

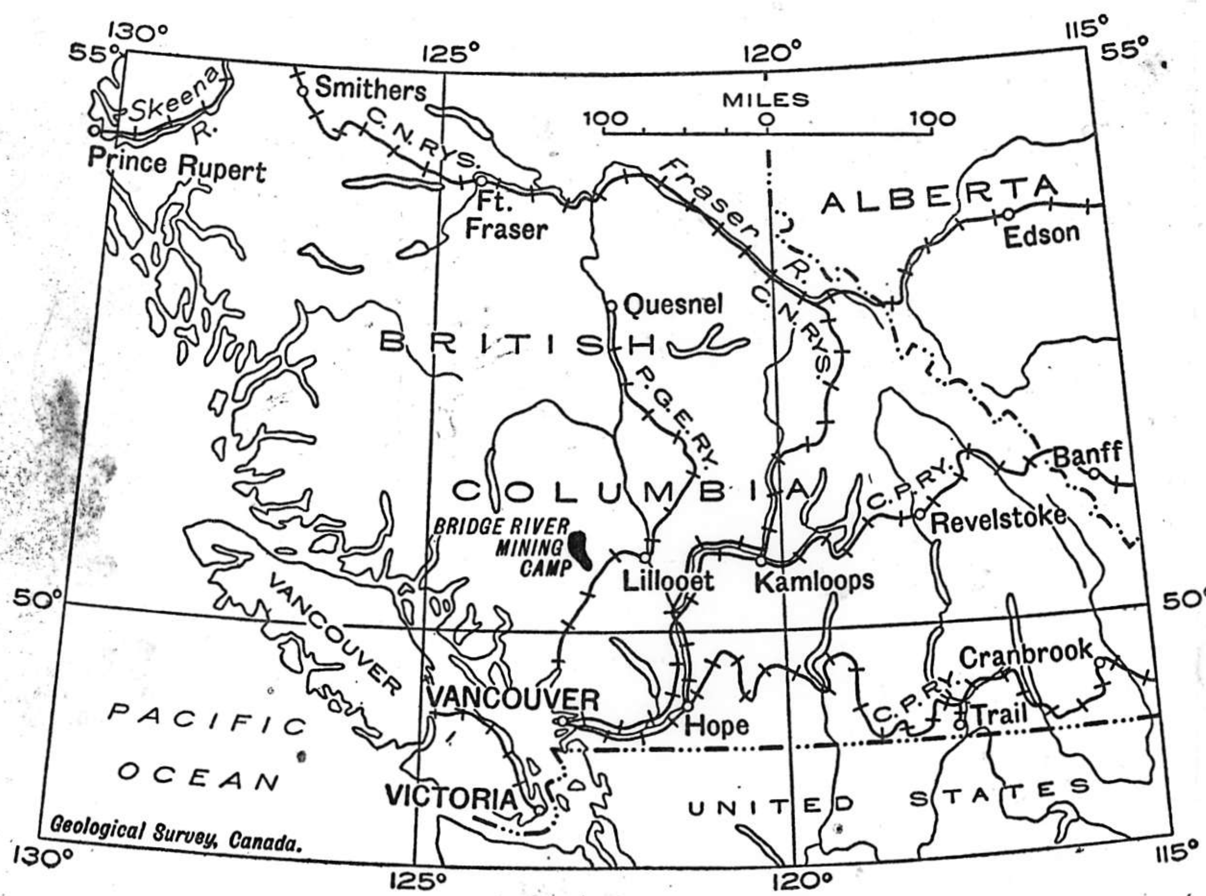

Figure 1. Index map showing position of Bridge River mining camp.

Rocks of this sedimentary formation are relatively incompetent but under special conditions have served as a host for productive veins.

Bralorne Intrusives. These consist of a succession of intrusive types including, possibly, peridotite and pyroxenite, together with gabbro, hornblendite, diorite[2] (hornblende and augite), quartz diorite, soda granite and related hypabyssal types. The peridotite and pyrozenite are doubtfully included in this group. Although evidence for the probable genetic and age relationship of the remainder of the group is obtainable, the ultrabasic rocks are commonly sheared, serpentinized and sometimes carbonated to a degree which masks their genetic and age relationship in the intrusive sequence. They are placed where they are in the Geological Table principally because of their very common spatial relationship with the gabbroic and dioritic rocks of the Cadwallader Gold Belt. There is some evidence in the Pioneer mine pointing to a post-soda-granite age for small amounts of ultra-basic rocks.

The gabbro, hornblendite and diorite (also greenstone-diorite) appear closely related genetically and spatially. They form sub-parallel bands with gradational contacts, across a zone which varies from twenty to fifteen hundred feet in width.

The diorite and greenstone-diorite of this series are competent rocks which form hosts for much of the ore. The more basic types are incompetent and are commonly schistose and serpentinized.

The primary structure and the origin of the "porphyries" is not yet clear. They are in general lens-shaped or tabular-shaped masses, from one to twenty feet wide, with commonly one well defined wall and the other wall showing replacement characteristics. They appear in part to be dyke or sill-like intrusions while microscopic thin section studies (9) indicate that they are at least in part "pseudo-porphyries" after tuffs or sediments.

These "porphyries," common in the greenstone of the Pioneer mine, occur in sub-parallel swarms and are of some significance in connection with the vein structures. The "porphyries" are brittle rocks and fracture or shatter rather than fissure. They appear to be decreasing in number but increasing in size as depth is gained. The "porphyries" appear to be the siliceous forerunners of the soda granite.

The soda granite appears to be a late differentiate of the gabbro-diorite magma and its occurs in all cases within or adjoining these more basic phases. The contacts of the soda granite and diorite are commonly gradational across a patchwork-like zone of hybrid type; the contacts between the soda granite and greenstone are sharply defined with local shearing of the greenstone. In form, the soda granite is a lens-like mass. Its long axis conforms to the trend of regional folding. The westerly nose of the granite mass, occurring on the Bralorne property, is somewhat blunt and it plunges steeply to the northwest (3; p. 41). The south-easterly "nose," occurring on the Pioneer property, consists of a rapid narrowing of the granite accompanied by a fingering-out of the mass until only one relatively narrow but persistent dyke remains, to extend south-easterly along the Cadwallader Gold Belt towards the Pacific Eastern property. The south-easterly "nose" appears to plunge at about 45 degrees to the southeast.

Noteworthy features of the noses of these soda granite masses are that they are both seemingly soaked with sodic plagioclase, carbonate and conspicuous amounts of hydrothermally introduced quartz. The productive veins of the King mine on the Bralorne property and the Pioneer Main ("A") vein on the Pioneer property are situated on the west and east noses respectively of the soda granite.

In the Pioneer mine and west of the east nose of the intrusive mass and at deeper levels, the soda-rich phase is still present but rather than soaking or replacing the granitic mass, it forms a narrow, relatively well defined border or crust associated with spur and dyke-like masses quite often of porphyritic texture. Such small, commonly less than ten-foot-wide dykes, form the albitite or albitite porphyry which is often closely associated with the vein structures.

The albitites are competent rocks and they maintain remarkably persistent vein structures. The albite-soaked granite is also a competent rock but, more brittle than the albitite, it tends to shatter rather than fissure.

At depth, where the surplus of albite has been segregated as dykes from the soda granite proper, the latter rock, which is quite coarsely crystalline, has a strong tendency to shatter rather than fissure. For this reason the soda granite proper, away from its albite-rich border, does not long maintain a single continuous fissure.

B. Secondary Structures

Introduction. In this section will be discussed the folding and fracturing of the rock types of the area. It has been pointed out by others (19,24; p 42) that the structural problems of the Cadwallader Gold Belt are complex. The nature of the contacts between formations are commonly masked by the introduction of sill-like basic intrusions, now sheared and serpentinized and making the determination of attitudes and stratigraphic succession difficult.

To complicate the problem of stratigraphic succession further, there is close folding and duplication of the formations.

The linear sill-like injections of basic material and commonly associated shearing are, in general, parallel to the formational strike and so provide no offsetting criteria to aid in learning if such shear zones mark zones of faulting. To add to the difficulty of structural interpretation, rock outcrops are few since the Cadwallader Gold Belt occupies a topographic trough largely overburden-filled.

Data relied on for the writer's structural interpretation of the folding were found on surface and in the underground workings of the Pioneer mine and Pacific (Eastern) property. Although the latter workings were flooded and inaccessible (1945-6), maps, notes, specimen suites, drill logs and drill core were available to the writer and these, together with relatively plentiful and critically located surface outcrop data over the section of the Pacific (Eastern) working, provided data bearing on the probable cross-sectional structure of the Cadwallader Gold Belt. This interpretation of the cross-sectional structure (figure 4) was projected east and west, through the Pacific (Eastern) and Pioneer properties respectively and with minor modifications, was substantiated by all additional surface and underground data obtained.

Folding. In the central section of the Cadwallader Gold Belt, or the Pioneer mine area, the nature of the folds in the Pioneer greenstone and Hurley-Noel sediments is believed by the writer to be as illustrated in plan figure and cross-sectional figures 3 and 4.

The structure of the Hurley-Noel sediments, northwest of Noel creek, on the Bralorne property, has not been studied beyond the recording of a few observed attitudes, nor has the structure of the Pioneer greenstone and Hurley-Noel sediments southeast of

2 Cleveland's albitic syenite; (26; pp. 28-29).

Extension creek on the Pacific (Eastern) property been studied by the writer.

The Fergusson Series, which form the northeast boundary of the Cadwallader Gold Belt, dip in general from 45 to 65 degrees to the northeast. The Fergusson Series, which form the southwest boundary of the Cadwallader Gold Belt, dip (at the two isolated points observed) at about 60 degrees to the northeast. Between these two Paleozoic boundaries, the Mesozoic volcanics and sediments are believed to be symmetrically close-folded in the manner shown in figures 3 and 4.

The most south-westerly band of Mesozoic sediments (Cairnes' Hurley formation; 24); provides a relatively large number of outcrops, offering many dip[3] and strike observations. The southwest limb of this structure is masked by a large, sill-like basic intrusive, now serpentinized, as is also in part at least, the northeast limb of the structure. Along the approximate position of the northeast limb and contact with the greenstone, on the south boundary of the Pioneer property, "float" of apparently Hurley-Noel basal conglomerate is strewn. Similar material was also found at one point on the southwest limb. No convincing top determination of individual beds could be made in this synclinal structure but a general and consistent transition of coarse to fine material, ranging through conglomerate, pebbly coarse sandstone, and sandstone to argillite members, is discernible from the limbs inward towards the axis. The synclinal structure appears to plunge to the northwest at a small angle which is exaggerated in plan by a flattening of dip on the north limb, as it continues north-westerly. The southwest limb of this structure is steep-dipping, averaging between 70 and 80 degrees, while the northeast limb appears to be 20 degrees flatter.

Little is known, on the basis of direct evidence, concerning the structure of the Pioneer greenstone to the northeast of the syncline described, but its position between two indicated synclines, its stratigraphic position beneath the sediments, the dip of its contacts and the form of its massif (widening on depth as indicated in figure 4), also some direct evidence that a similar band of greenstone to the north is an anticline, all suggest that this band, called locally the South Greenstone Band, forms an anti-clinal structure.

The sedimentary band between the two greenstone bands is poorly exposed at surface. A few outcrops are present near the west boundary of the Pioneer property, but unfortunately these occur in the greatly disturbed vicinity of the Cadwallader shear. Near the east boundary of the Pioneer property, in the bed of Extension creek, outcrops are quite numerous and the attitude there suggests the steep-dipping, south flank of a synclinal structure.

The northerly greenstone band, called for convenience the North Greenstone, is the important member in which the Pioneer Mine is situated. Although only two outcrops of the North Greenstone are present on the Pioneer and Pacific (Eastern) properties, the member is well outlined by the underground workings. The North Greenstone has been studied in detail in the Pioneer mine where it forms the host rock for much of the ore. Here, on the basis of many observations of amygdule size variation in flows, it appears folded into a tight, roughly symmetrical, anticlinal structure. The North Greenstone band appears to be narrower towards the southeast but it is not known whether this indicates a southeast plunging fold or is the result of "slicing" by the Cadwallader shear.

To the north of the North Greenstone is a narrow band of sheared and contorted sediments of the Hurley-Noel type. There are just two isolated outcrops of this member but it has been

3 Although these sediments are now generally fissile, convincing evidence is locally present to indicate that the fissility conforms in attitude to the bedding, hence, attitude observations on fissility are used in part on the structural plan, together with direct observations on obvious bedding.

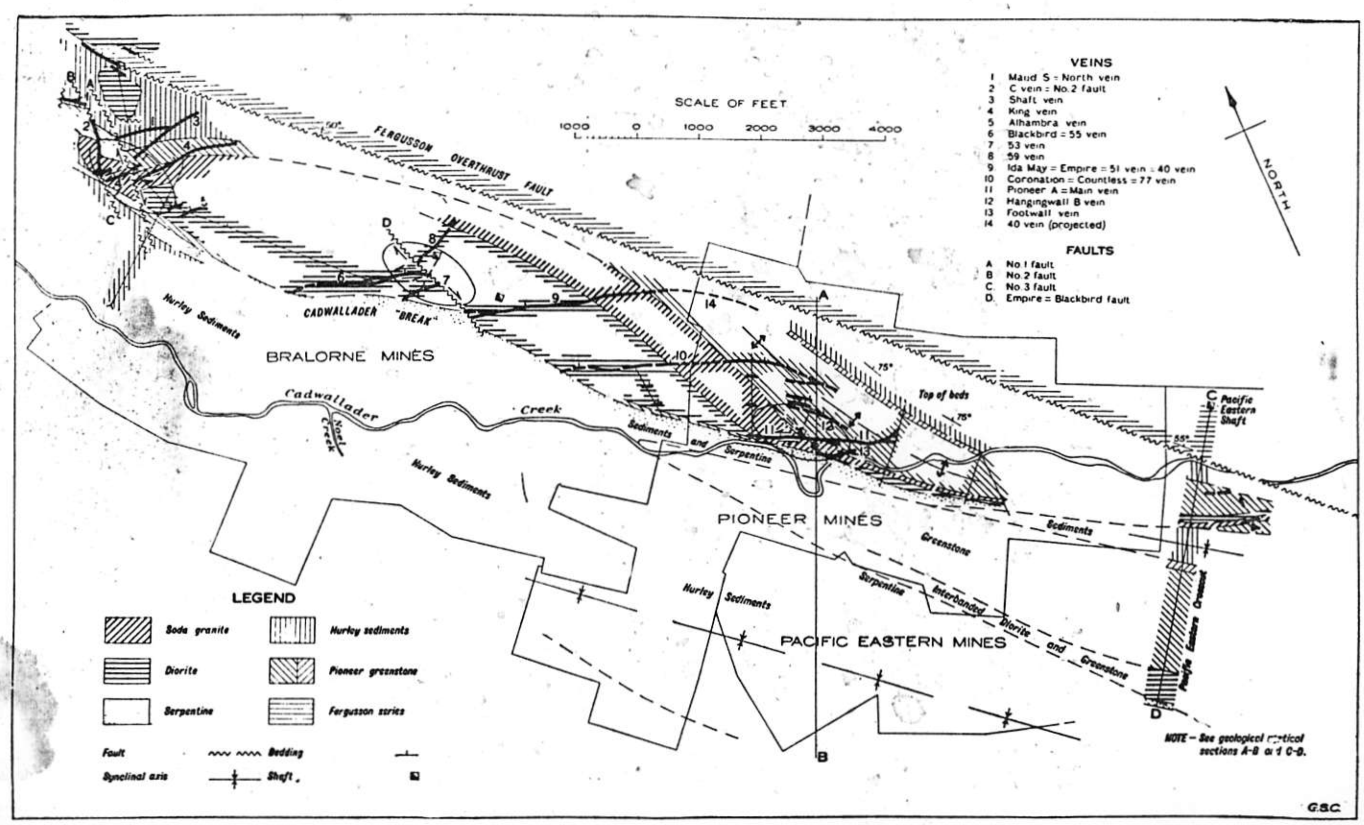

Figure 2. Geological Plan, Cadwallader Gold Belt.

exposed in underground workings and diamond drilling on both the Pioneer and Pacific (Eastern) properties. The south contact of this formation with the Pioneer Greenstone dips steeply (70 to 80 degrees) north and at several points along this contact a basal conglomerate is present. The band exposed appears to be the south flank of a synclinal structure but the nature of the complete fold is unknown, since the northerly position of it has been sheared and sliced by the Fergusson Overthrust fault.

Shearing and Faulting. The position of the Cadwallader shear is shown in figure 2. This regional structure is known to be at least three miles in length and it forms the present southwest boundary of the productive veins of the Cadwallader Gold Belt. Its average strike is about north 45 degrees west and it dips from 70 degrees southwest to vertical with local steep reverse dips. Its course follows closely the southwest contact, or basic side, of the differentiated intrusive complex, even where this narrows down (as it does to the southwest of the Pioneer mine) to widths of 50 feet or less. The extension of the Cadwallader shear zone northwest of the King mine (Bralorne) appears to lose its identity in a zone of north-south faults which occur roughly parallel to, and mainly to the west of, the Hurley River canyons. The extension of the Cadwallader shear zone southeast of the Pioneer mine has been located only at widely spaced points. Pacific (Eastern) geologists believe that the Cadwallader shear zone can be correlated with a fault structure in their underground workings and shown in cross-sectional figure 4.

The Cadwallader shear is a zone of moderately to intensely schistose rock, averaging in the few places crossed about 200 feet in width. The schistose rock of the zone is characteristically a serpentinized basic intrusive whose identity is locally recognizable in occasional massive fragments. Locally bordering the shear zone, and across relatively narrow widths, the Pioneer greenstone may be intensely sheared with sometimes small to very large, relatively unbroken, hornblende crystals present.

The serpentine of the Cadwallader shear zone is very rarely talcose, carbonated, silicified or mineralized. It appears noteworthy that where the serpentine is so altered, such sections are usually the intersection area of the Cadwallader shear zone with one of the northerly-striking faults related to the vein-fault pattern of the camp.

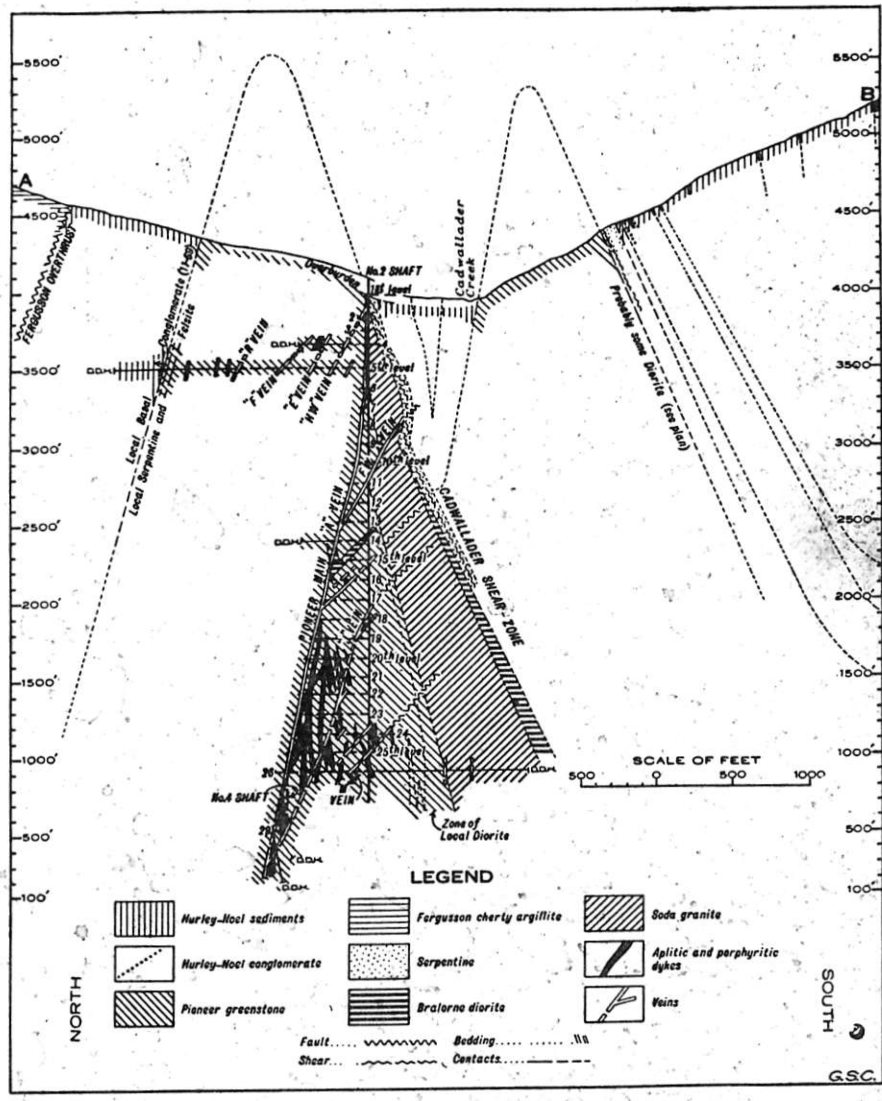

Figure 3. Geological Section A-B, Cadwallader Gold Belt.

The Cadwallader shear zone has been described as a fault zone. The early evidence to support this was based on the assumption that there was a single greenstone band and the further assumption of displacive overlap to account for the local presence of two greenstone bands. The assumed overlap was taken to indicate the presence and direction of horizontal offset of a large fault. Subsequent work underground on the Pacific (Eastern) property and diamond drilling on the Pioneer property indicates two separate, parallel greenstone bands and not a single faulted and overlapping one as previously assumed.

No certain evidence of displacement along the Cadwallader shear zone is known to the writer to occur on the Pioneer property other than minor and local movement of the shear zone to adjust itself to the intersecting offsets of later cross-faults. As the Cadwallader shear zone conforms closely in position to formational and intrusive contacts, masked by injected sill-like masses of basic intrusive, it can be seen that fault displacements could be present yet not apparent. Some evidence that might bear on the question of possible displacement is shown in Cairnes' mapping (Mem. 213, Map 431A) by the unexplained presence of two or three very small outcrops of Fergusson-like rocks along the strike and within the Cadwallader shear zone. Additional evidence is reported[4] to be accumulating on the Pacific (Eastern) property to indicate that the Cadwallader shear may prove to be a major normal fault, with marked horizontal offset in a direction opposite to that assumed by earlier investigators.

Fergusson Overthrust. This structure was first described by Cairnes as one of "principal" northeasterly-dipping faults" (24; p. 43). The Fergusson Overthrust, now so named because all exploration to date points to a single major structure, is a reverse fault which has resulted in the late Paleozoic

4 Dr. F. Buckland. Personal communication.

(Fergusson Series) rocks being thrust against and over the Mesozoic Series. Forming as it does the fault contact between unlike rock types, it can be traced at intervals along the three or four miles of the Cadwallader Gold Belt and continues to the southeast for a probable eight miles more. To the northwest of the Bralorne mine the course of the Fergusson Overthrust becomes involved and obscure, as does the Cadwallader shear to the south, with probably later, northerly trending, westward dipping cross-faults, that parallel the general course of the Hurley River canyons.

The Fergusson Overthrust is roughly parallel to the Cadwallader shear zone, striking about north 45 degrees west, but it dips more flatly (averaging about 60 degrees) in the opposite direction or to the northeast. The course of the Fergusson Overthrust is subparallel to the formational trend in strike and dip and it slices along the contact of the north Greenstone Band and Hurley-Noel sediments, being in the main just within the latter.

The Fergusson Overthrust has been cut through or closely approached in the Taylor Bridge River workings of the Bralorne mine; the 51-east drifts of the Empire mine, the 40 vein workings in the Pioneer mine, the vertical diamond drill hole on the Holland property (due north of the Pioneer mine), and the underground workings and surface drilling on the Pacific (Eastern) property. Where exposed, the Fergusson Overthrust consists of a zone of intensely sheared serpentinized rock, at least 100 feet in width. Where approached from the south as in the Bralorne 51-east workings, the foot-wall greenstone of the Fergusson Overthrust becomes increasingly schistose and incompetent. The origin of the serpentine and talcose material in the Fergusson Overthrust poses an interesting problem. On the Pioneer property in the 40-vein hangingwall diamond drilling, it appears to have been derived, at least in part, from serpentinization of the basal conglomerate of the Hurley-Noel sediments.

The Fergusson Overthrust contains little vein-matter, that best known being the quartz lenses explored underground north of the Bralorne mine on the former Taylor Bridge River property. Although this vein-matter resembles that of the productive veins, it has to date produced no ore.

The time of formation of the Cadwallader shear and the Fergusson Overthrust is still uncertain but they appear to be of approximately the same age. The Fergusson Overthrust is known to be later than the quartz diorite intrusions on the basis of Cairnes' mapping (24; fig. 2). On the basis of other fragmentary but corroborative evidence these two structures appear to be not later and probably earlier than the vein-fault fracture pattern of the Cadwallader Gold Belt. Some evidence of this is the offsetting of the Cadwallader shear zone by the northerly striking faults of the Bralorne mine, the offsetting of the Cadwallader shear zone by footwall branches of the Pioneer Main vein and the presence of quartz veins in the Fergusson Overthrust (24; fig. 2). The presently available evidence points to a pre-fracture-pattern age for the Cadwallader shear and a possibly later but still pre-quartz age for the Fergusson Overthrust.

Fracture Pattern

Diagrammatic Presentation. The fracture pattern of the Cadwallader Gold Belt may be advantageously studied in the diagrammatic setting of the conventional strain ellipsoid of figure 5 following:

If the ellipsoid is oriented in plan on the basis of the probable directions of

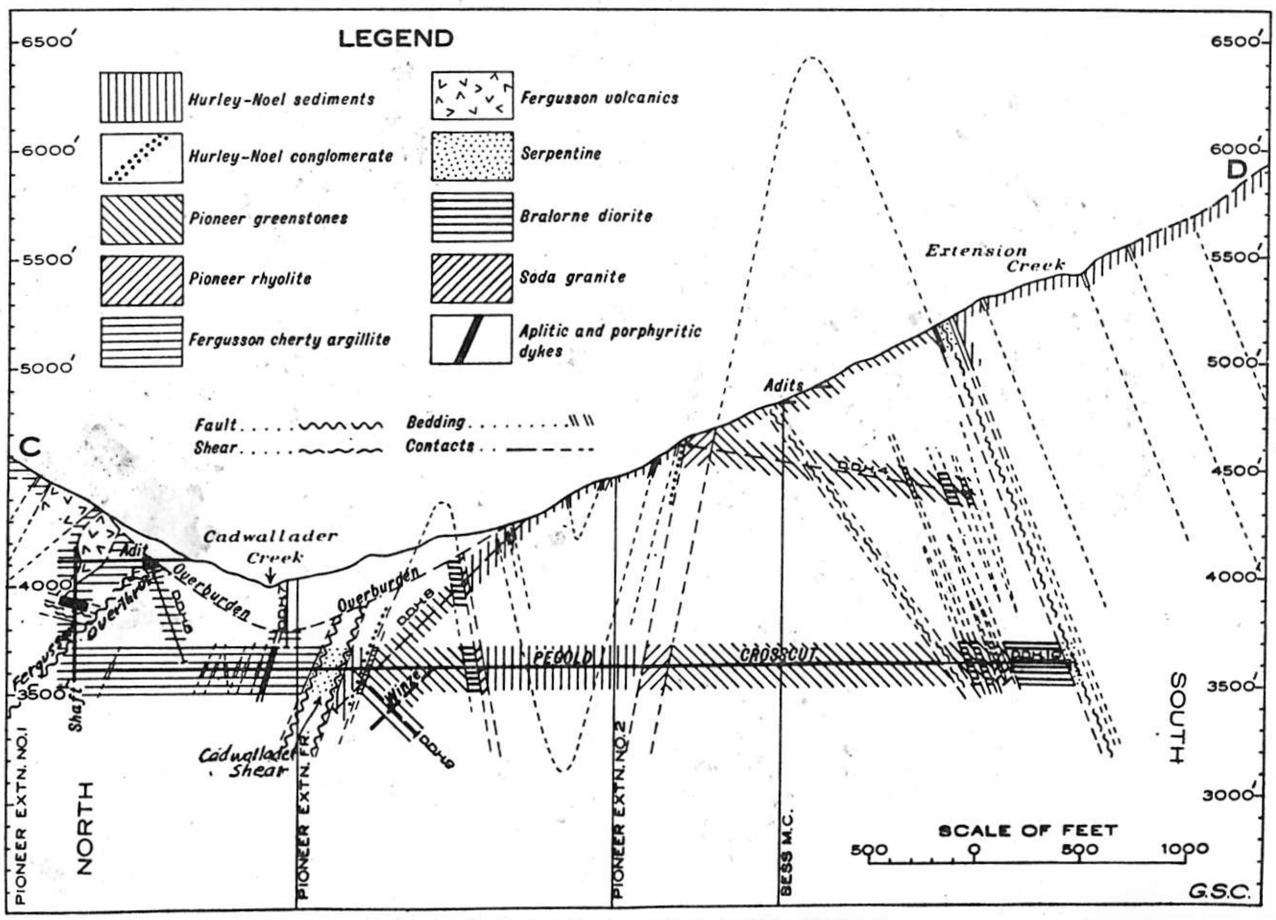

Figure 4. Geological Section C-D, Cadwallader Gold Belt.

maximum regional compression as evidenced by the parallel close folding, the regional shear zone and regional overthrust fault, then it will be seen that the composite fracture pattern of the Gold Belt agrees closely with the theoretical pattern to be expected.

If, in vertical section, the southeast end of the axis of maximum elongation of the ellipsoid is depressed about 45 degrees, the close agreement between the actual fracture pattern and theoretical pattern extends to all details such as agreement in dips of structures, directions of fault offsets, attitude of the widespread slicken-sidings and of other physical criteria characteristic of the individual shear or tension structures.

The individual fractures making up the pattern are discussed in greater detail below.

Type A. Structures of the type indicated as "A" in the ellipsoid diagram are recognizable on the geological plan (see fig. 2) as the north-striking faults, which are, with one important exception (C-vein No. 2 fault), unmineralized. Three or more of these faults are clustered at the northwest extremity of the Cadwallader Gold Belt (King mine workings of the Bralorne), with two others at from 1,500 to 2,000 foot intervals to the southeast. None are known to occur on the northwest corner of the Pioneer property exposed by the Pioneer mine workings. A large fault of similar attitude that may belong to this same set has been inferred by Pacific Eastern geologists in the Plutus-Twinturn Creeks area on the Pacific Eastern property.

The faults of this set strike from due north to north 20 degrees west and dip from 45 to 70 degrees west, with one example, the Bralorne No. 1 fault, dipping 80 degrees to the east. The faults of this set are all thrust or reverse faults with both vertical and horizontal components of movement. The horizontal component of movement for each fault is roughly the same and between 200 and 300 feet, except for the Empire fault where the aggregate movement for three separate downward converging near-surface faults totals about 700 feet for the single fault structure resulting below the 3,200 foot horizon. The horizontal displacement along these faults is as shown in the diagrammatic ellipsoid or right-handed.

In detail there appears to have been hinged or rotational displacement along this north fault set. In the King mine, Bralorne property, vein dips increase in flatness for each successive

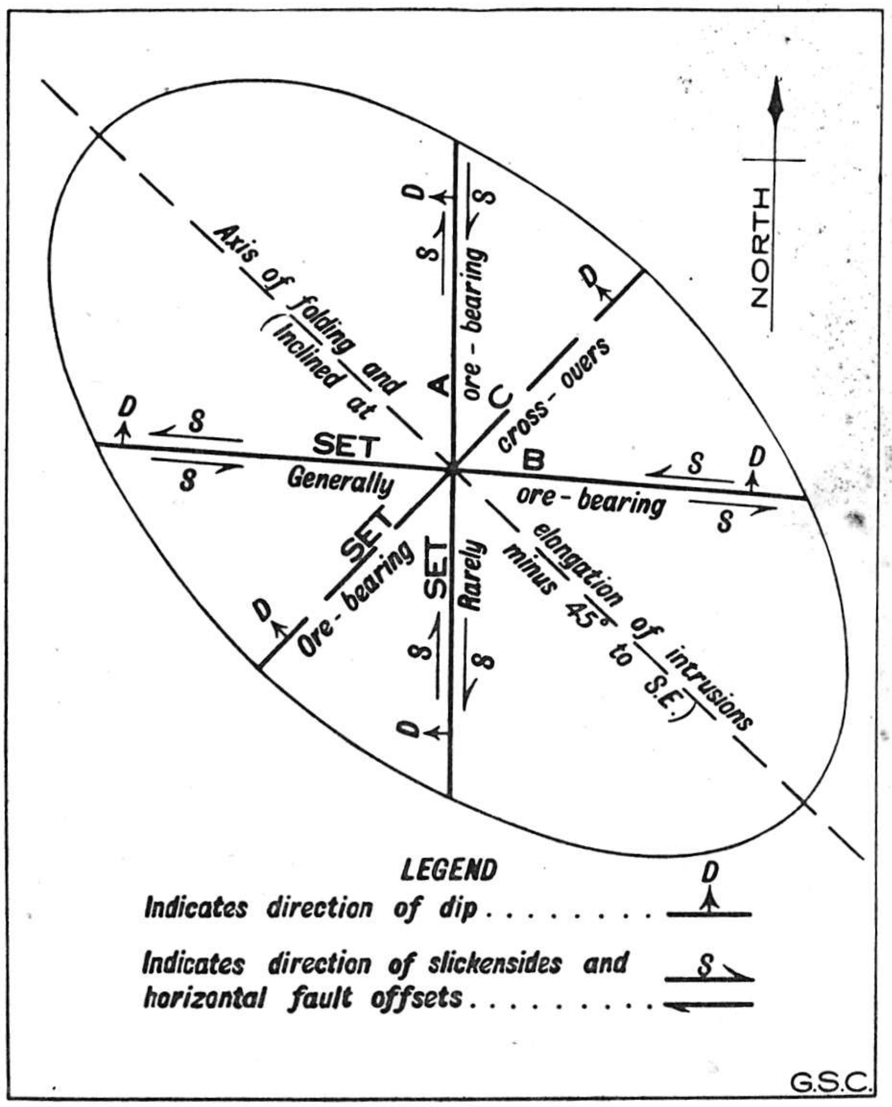

Figure 5. Strain Ellipsoid Diagram.

fault block westwardly. Similar evidence of rotational movement is present in the Empire fault structure.

The individual faults of this set are known to be at least 1,500 feet in length and in all probability they extend at least across the full width of the intrusive complex.

They follow in general a straight course except for the ore-bearing No. 2 fault (also called C vein) which is gently sigmoidal in plan.

The fault structures are filled with from one to fifty feet of schistose rock and gouge. In the case of the partly quartz-filled and ore-bearing No. 2 fault (C vein) the vein-matter consists of "discontinuous, rudely lenticular bodies of more or less fractured quartz between heavy gouge walls ... with a re-cemented quartz breccia frequently evident" (21; p 258). Hedley (21; 530-1) has summarized evidence to prove that this set of north-striking faults was active before (?) during and after the introduction of vein-matter.

Type B. Structures of the type indicated by "B" in the ellipsoid diagram are recognizable on the geological plan (see fig. 2) as the westerly-striking fault set, commonly quartz-filled and mineralized to form the "Main" veins of the Cadwallader Gold Belt. The more important members of this set and their manner of distribution are shown on the geological plan.

These vein-filled faults, complementary to the type "A" faults of the ellipsoid diagram (fig. 5), strike between 15 degrees north and south of west and dip from 55 degrees north to vertical, with locally (in the Bralorne King vein and Pioneer Main vein), a steep reverse dip.

The vein structures of this set appear to be all thrust or reverse faults with both vertical and horizontal components of movement. The horizontal component of movement for these vein-faults is between 80 and 150 feet and in all cases the displacement is left-handed. The vertical component of movement is not accurately measurable but it is estimated to be as a rule slightly in excess of the horizontal component.

Extensive uniform development of slickensides and mullion structure show the hangingwall blocks to have thrust-ridden over the footwall blocks at an angle averaging 55 degrees from the horizontal. If the vein-filled faults of this general east-west set are regarded as fault segments of originally single east-west structures, now offset by the north-south fault system, then the original type "B" structures must have ranged from 2,500 to over 5,000 feet in length, or in other words extended across the full width of the igneous complex.

The vein-filled fault structures of this set, although they conform closely in general direction of dip and strike, have in detail individual characteristics. These individual characteristics appear to have been determined to a large degree by the relative competency of the rocks cut. Individual structures commonly split into diverging branches on approaching less competent types (such as serpentine, sediments or schistose greenstone) and commonly such branches curve to make the largest possible angle of intersection with the less competent rock.

In the Bralorne diorite the individual fault structures usually show minor irregularities in dip and strike with many branching "splits." These "splits" are often quartz-filled and occasionally ore-bearing. Less often, as in the Blackbird vein, the "splits" leave and re-join the main structure to form a closed or braided pattern which may be entirely quartz-filled with a resultant repetition of ore-shoots. In detail, this set of ore-bearing fault structures. where they occur in diorite, may be described as irregular in form.

In the soda granite these structures behave differently. Where the granite is coarse-grained, homogeneous, and contains a minimum of excess albite, it appears to have been over-competent or brittle. In this granite the fault structure loses its simple, single plane or narrow zone identity and is present as a wider, quartz-filled fracture zone, generally inhospitable to ore. Where the granite is finer grained with excess albite, a combination usually found in its contact zone, the rock is sufficiently competent to fracture and maintain faults of this set as simple uniform structures suitable for ore disposition.

The conduct of these type "B" faults in Pioneer greenstones depends on several factors. Where the greenstone is massive, the members cut at a relatively large angle and where the assemblage has been given rigidity by swarms of "porphyry" dyke-like bodies, this rock is competent to a very favorable degree. An east-west ore-bearing fault of the set discussed (the Pioneer "A" vein) cuts rock of this type and the resulting quartz and ore-filled structure is probably the most uniform in dip, strike, width and simplicity of all examples in the Bralorne-Pioneer mines. Where the greenstone formation differs from the ideal above described the fault structure suffers and may be quite inhospitable to ore.

Faults of this "B" or ore-bearing set occur in the Mesozoic sediments but only under a certain general condition do they retain a simple structure and are quartz-filled and ore-bearing. This is where the fault zone has been cemented by an early dyke (commonly albitic) and subsequent movement been localized to the wall(s) of such a dyke as in the Bralorne North and (in part) the King veins.

Other general characteristics of this set of faults will be discussed under veins.

"C" Type Structures. Structures indicated by type "C" in the ellipsoid diagram have their recognizable counterparts in the Cadwallader Gold Belt but only one such structure (Bralorne 59 vein) is shown on the geological plan (fig. Z), because with few exceptions, structures of this set are best developed only in the deeper levels or those below the 3,000 foot horizon. Below this horizon several modified structures of this set (locally called "cross-over" veins) are productive, important examples being the Bralorne 59, 73, 75 and 79 veins and, probably, the Pioneer 27 vein.

The tension or cross-over structures illustrated diagrammatically as the "C" set strike north-easterly with moderate northwesterly dips. Some of the "C" set cross-over structures are steeper-dipping and some flatter-dipping than the "B" or main vein structures.

The tension or cross-over structures make an average angle of 45 degrees to the "B" or main vein set of faults and these two sets show a great variety of form at their points of junction. In general the tension structures curve tangentially as they approach the fault structures. In detail a tension structure may curve and join the fault structures to form a clean-cut junction; elsewhere the tension structure may curve, approach close to and parallel the fault structure with stringer connections between the two, while elsewhere the tension structure, on approaching the fault structure, may lose its identity in an intersection area of irregular fractures. Commonly the tension structures terminate where they join a set "B" fault structure but in rare cases they form intersecting relationships.

Tension structures may be as little as 80 to 100 feet apart (Bralorne 73 and 75 veins) but again may be widely separated. Their length is largely determined by the distance separating the pair of limiting vein-faults.

The origin of the tension structures appears to have been contemporaneous with the set "B" fault structures.

Miscellaneous Structures. The three set system of structures above described form the basic structural pattern of the Cadwallader Gold Belt. There are in addition to the above, less well defined structures which are of some economic significance. These include a set of flat-dipping thrust-faults (active during and after mineralization) and a set of probably post-ore strike and transverse faults.

The flat (25 to 45 degree) dipping thrust faults are reported in the Bralorne mine (Blackbird section) and are present in the Pioneer mine. In strike, they vary from roughly east-west in the upper levels to north-easterly trends in the lower levels. The dips are to the north and northwest. These structures are observed as flatter-dipping strike faults along the east-west vein faults in the upper levels, curving in strike and steepening on dip to become strike faults along the north-easterly tension structures in the lower levels. These flat fault structures are believed by the writer to have contributed much to the structural development ("strength") of the tension structures where, at lower levels, their planes have coincided. One of the best exposed of several such structures is the "Q" vein-fault of the Pioneer mine. The net vertical component of movement along these flat faults, where measurable, is between five and twenty feet.

Other minor structures are strike and cross faults apparently post-ore in age and of small displacement. The strike faults are present on both the Bralorne and Pioneer properties. They are characterized by short overlaps and discontinuities of the vein matter.

The cross-faults are of small horizontal offset, rarely exceeding drift width; with movement right-handed and dip to west. Such cross-faults appear more generally distributed in the Bralorne mines than in the Pioneer mine. In the Pioneer mine they appear localized to the near-contact zone with incompetent rocks such as the sediments or serpentine. In the Bralorne mines they show some localization by, and conformity to, the north-south fault system.

Ore Deposits

Vein Matter. The vein matter of the Cadwallader Gold Belt, also its paragenesis and mesothermal characteristics, are described by McCann (11), Dolmage (18), James (19) and Cairnes (24). Briefly, it consists of milky white quartz, commonly ribboned and of several ages, with very minor amounts of erratically distributed ferruginous carbonates, scheelite, mariposite and locally (in late tension fractures cutting the Pioneer 27 vein), appreciable quantities of black tourmaline.

The sulphides, comprising from 2 to 3 per cent of the vein-matter, consist of pyrite and arsenopyrite, generally distributed and the most plentiful sulphides; sphalerite, galena and tetrahedrite, generally distributed but in very small amounts, important however as "high-grade indicators"; pyrrhotite and chalcopyrite, erratically distributed as local pockets, occasionally associated, together or separately, with high gold values; stibnite and marcasite, erratically distributed in the Pioneer mine along or close to post-ore faults or fractures; telluride and gold, the former apparently very rare and reported only by McCann (11; p 54), the latter generally and sparsely distributed with, also, occasional erratically deposited "pockets" up to nine hundred pounds in weight composed of 45 per cent gold.

There is no recognizable zoning of sulphides in the Cadwallader Gold Belt but certain unusual features of sulphide and gangue occurrence in various of the modified tension ("cross-over") structures are noteworthy. These are the unique occurrence of stibnite in the Bralorne 59 vein, the observed occurrence of tetrahedrite in only one of the Pioneer veins (the "27") and that only below 19 level, and the first appearance of tourmaline in the same tension structure and at about the same horizon. Also in the "27" vein (a probable tension structure modified by minor thrust faulting) there is a unique condition present on the 25 level, about 3200 feet below the present surface. Here the characteristic ribboning in the quartz is widely spaced and locally between the slickensided ribbon planes there are lenses of drusy to coxcomb-structured quartz. Sulphides here consist of a coarsely crystalline coxcomb filling, or forming small sphalerite-pyrite (and gold) rosette-like clusters.

Wallrock Alteration. The subject of wallrock alteration in the Bralorne and Pioneer mines is described by McCann (11; p 62) and Cairnes (24; p 61) as being predominantly carbonatization.

Deep development in the Pioneer mine, particularly in recent years, has shown that biotization is important as a form of wallrock alteration in the greenstone section of this mine. The biotite[5] is considered to be of hydrothermal origin. It is reported by James[6] to have also been present in the upper, now inaccessible levels, in the east or greenstone section of the Pioneer mine.

Wallrock alteration of carbonatization and biotization appears entirely post-quartz in age. Locally the hydrothermal solutions causing the rock alteration followed fractures other than the quartz-filled structures, but in general these channels coincided.

Ore Shoots—General. Ore shoots in the Cadwallader Gold Belt may individually exceed 1500 feet in length. Commonly the ore shoots are more persistent vertically than they are horizontally. They usually have a steep rake determined, in part at least, upon one or more of the structural controls described below.

Ore shoots may contain their gold erratically distributed, a not uncommon habit in ore shoots near serpentine, or very uniformly distributed. In other instances the gold may be so distributed in an ore shoot as to increase gradually from all boundaries to form a "high-grade" nucleus. Some of these nuclei are large and rich; one in the Pioneer Main vein being 245 feet in length, 3.5 feet in average width and averaging 5 ounces gold per ton.

5 Microscopic identification by J. S. Stevenson.
6 Personal communication.

It is noteworthy that practically all of the productive vein structures in the Cadwallader Gold Belt, that have been developed through a vertical range exceeding 1500 feet from surface, have encountered, commonly at some point between the 8 and 14 level elevations, a non-commercial, roughly horizontal horizon, below which ore of excellent grade was again developed. It is noteworthy also, that it is only at or below this critical horizon, that the several increasingly important ore-producing tension ("cross-over") structures appear.

Probable Structural Controls. The form and size of ore shoots in the Cadwallader Gold Belt are determined by either physical or assay limits. Physical boundaries to the ore, such as vein structure termination, are definite and obvious. Less definite and obvious are the controls that have determined the concentrations of precious metal deposited (assay limits) in certain select sections of a large structure.

The environmental factors considered by Cleveland (25), Hedley (21), James (19), Poole (28), Cairnes (24) and the writer to have exerted some control on the presence, size and form of the ore shoots are as folows:

(a) The serpentine contact. The control here appears to have been a "daming" and, locally where the contact is suitably inclined, as is most commonly the case, also a "capping" influence exerted by the incompetent and

Looking down Cadwallader Creek from the Pacific (Eastern) mine.
—Photo by L. Packard

impervious serpentine. Not only are ore shoots of substantial size found in this locale but it is also the favoured environment for small "bonanza pockets" of almost-massive gold.

(b) Contacts between rocks of different competency. The control operating here appears to have been an impeding influence exerted where the vein structure passes, with physical variations in its nature (changing width, dip, strike, splitting, etc.), from a competent to less competent rock, as from diorite to schistose greenstone or massive greenstone to fissile argillite respectively. The distinction between this case and the first is that in this case the vein structure (and sometimes the vein filling of quartz) persists, but values are limited to the more competent side of the contact.

(c) Branching and intersecting structures. Apparently exerting some control on the presence, size, attitude and form of some ore shoots are the intra-mineralization-aged faults of the north-south set, either where these occur singly, as in the Bralorne Empire section, or where they occur as upward converging groups as in the Bralorne Lorne-King section. In addition to these faults, the presence and traces formed by the junction of branching structures has, apparently, exerted some control.

The effects produced by these fault structures have been several. The north-south faults probably determined the areas of more intensive quartz fracturing prior to the deposition of metallics, and their commonly gougy, impervious nature later provided "dams," "caps" and, under certain conditions (as in the King vein, "A" Block) complete roof-like "traps" for the later auriferous hydro-thermal solutions. The subsidiary branching structures appear to have operated as active tensional components to the east-west vein faults, commonly resulting in abnormal widening of the quartz with an increase in grade, in the junction areas.

In summary, the presence and habit of ore shoots in the Cadwallader Gold Belt appears to depend upon such physical features as the relative competency of the host rock (in turn dependent on several variable factors even where the rocks are of the same composition) and the relationship of the fractures to each other.

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A BRIGHT FUTURE FOR PIONEER

"Development Results are Exceptionally Good"

IN the face of most difficult operating conditions for all Canadian gold mines, Pioneer Gold Mines of B. C., Ltd., is staging a remarkable comeback. Marketwise, the balance sheet and profit and loss statement for the year ended March 31st do not offer much cause for optimism, but minewise a vastly different picture is presented. Excellent results as to grade of ore and width have been obtained in the 27 vein. Ore reserves, including unofficially estimated reserves in the 27 vein on the 20- to 25- levels approximate 500,000 tons or better, with every indication that there will be substantial additions to this estimated figure.

Financial

From 53,715 tons treated during the year, production of gold bullion was valued at $783,619.79. Miscellaneous income was $18,765.69. Production costs were $815,463.93, of which $515,010.92 was for mining and development. The net loss before provision for depreciation, depletion, and exploration and prospects was $13,078.45. After provision for these items, net loss for the fiscal year was $156,793.44, bringing the deficit account at that date to $265,518.45.

The Pioneer balance sheet shows current assets of $483,654.60 as against current liabilities of $130,501.23.

Prospects for resumption of dividend payments are considered as very good, managing director Dr. H. T. James told the annual meeting of shareholders. No probable date was forecast, but he said the amount would naturally depend on the relationship between costs and the price of gold.

Pioneer Mine Operation

The crew at the mine has been increased from 130 in April, 1947, to a maximum of 267 in January, 1948. During the early months of the year the usual exodus to farms, logging and construction jobs, reduced the crew by the end of March to 250. This represents the entire personnel at the mine, including the mine office, general store, cookhouse and hospital staffs, the logging and sawmill crews, the usual complement of men for shop, mill and surface, in addition to the actual underground employees. The number of men employed underground at the end of March numbered 142.

Accommodation is provided at the mine for 94 families and 180 single men. This is not sufficient for a full scale operation but would be adequate for the present programme if a steady crew of this size could be maintained. Plans have been prepared for additional accommodation for both married and single men but construction has been deferred until construction costs, or conditions for gold mining, show some signs of improvement. Three cottages were built during the year from material on hand.

Dr. H. T. James

The objective at the mine this year has been to develop as much ore as possible on the 27 vein and to start preparations for economical mining. An effort has also been made to recover sufficient ore from available remnants of the main vein to carry the operation. This ore has been expensive to mine because it is in scattered blocks and heavy ground conditions developed during the idle period of the war. The value of our output has been about equal to operating costs but has not been sufficient to provide for capital expenditures and write-offs. Current costs include a great deal of retimbering and other maintenance work, but the mine workings are now back to a reasonably satisfactory condition.

The year's development footage of 8067' is the greatest since 1938. It is made up of 3379' of drifting on 27 vein, 264' of drifting on 40 vein, 455' of slashing and miscellaneous workings, 2238' of crosscutting, 1489' of raising and 242' of shaft. In addition, 3595' of diamond drilling was completed during the year. The development results on 27 vein are exceptionally good, as the following tabulation will show. The percentage of ore on the various levels is uniformly high and the grade is better than could have been expected. Of the four levels on which work was done during the year 25 level only has reached the limit of the vein. Total drift length on this level is now 2001' of which 1374' is ore averaging 0.70 oz. per ton over a width of 5.0'. Additional drifting remaining to be done on 22, 23 and 24 levels is estimated at 1500' to 2000' in all.

Diamond drilling to the east of 27 vein on 25 level located an east-west vein which is referred to as 29 vein. Three intersections on this level at 160, 270 and 480 feet east of 27 vein assayed as follows: 0.58 oz. over 3.6'; 0.12 oz. over 4.2'; and 0.10 oz. over 3.6'. The vein in a down-hole assayed 0.06 oz. per ton. Some drifting will be done on the vein, but it cannot be regarded at this time as an important prospect.

The only other vein on which work has been done during the year is the

27 Vein Development for Year

Level	Advance	Ore Length	% Ore	Exposed Vein Width	Grade oz. per ton
22	1311.2	851.8	64.9	4.1'	0.79
23	856.2	482.3	56.33	5.4'	0.75
24	655.3	457.7	69.8	5.1'	0.68
25	556.2	368.6	66.3	3.8'	0.76
Total	3378.9	2160.4	63.9	4.55'	0.75

40 vein off the Taylor tunnel. In 264' of drifting 55' of ore was found.

While development work on the veins, and crosscutting towards the veins, has advanced at a satisfactory rate, shaft sinking and other work in waste is not as far advanced as had been hoped for. With a smaller crew than required for the complete program, ore development was favored until such time as a certain minimum amount of ore was definitely assured. By the end of the year only 242 feet of shaft had been completed, but since getting started the shaft is progressing at a very satisfactory rate.

Ore Reserves

Ore reserves as carried on the records at the mine, as of the end of the year, amount to 118,524 tons, grading 0.467 oz. per ton. This includes 20,306 tons of broken reserves, and 10,800 tons of ore in a section of 27 vein on which a short stope has been started. Much of the remainder is in the shaft pillar section of the main vein. The indicated tonnage in 27 vein is very much greater than the tonnage included above but detailed estimates are not being made until more information has been ...bout minable widths and ...r number of raises have been driven through the v... However a reasonably close estim... of the tonnage indicated can be m... from the fact that the total length... ore developed on 20 to 25 levels... date is just over 4800'. Assumin... reasonable dilution factor, the tonn... between these two levels is appro... mately 350,000 tons having a mina... grade of about half an ounce per t... The additional drifting remaining... be done on 22, 23 and 24 levels will a... to this tonnage and may alter ... grade somewhat. Total tonnage abo... 25 level is up to expectation and t... grade of the ore is higher than a... ticipated.

Cost Factors

Costs are abnormally high. The ... crease in wage rates of 50% to ... since the beginning of the war, and ... major items of supply, except explo... ives, from 30% to 90% is responsib... for a large part of the increase. Bu... added to these are a number of othe... items of expense which have accumu... lated during the war, or are a result o... the present shortage of labor. One o... the most serious is the heavy labo... turnover. No operation can be carrie... on effectively with a crew which i... changing constantly, especially whe... many of the men are not familiar wit... the work. This condition will correct itself as labor becomes more settled, but in the meantime it adds to costs by reducing the average output per man. Community services, such as medical and hospital plan, cookhouse and bunkhouse operation, group insurance and general aid to the community have increased from a pre-war average of less than $6000 per year to slightly more than $50,000 for the past year. Other increases have been added by legislation. For example, the minimum added cost of the 44-hour week, on the present scale of operation, is $12,000 to $15,000 per year. This is under the most favorable circumstances of being permitted to work a 48-hour week and paying overtime for hours worked in excess of 44 hours in the week. The added expense represents pay for hours not worked. Should the Company be denied a permit to continue working 48 hours a week, production will be reduced by 8% and carrying charges for the time which the plant would be idle would approximate $25,000 per year. A short work week is a well recognized means of pr... ing more jobs when labor is pl... but during a labor shortage a legislated short week is an absurdity. The Holidays with Pay Act requires the payment of a holiday bonus to an... ne working more than one week. Some means of providing for holidays is an excellent idea and a plan was put in