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BRIDGE RIVER GOLD CAMP

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Unique for vein deposits of the Canadian Cordillera, and even noteworthy among gold-bearing vein deposits of the world, is the great depth continuity of the Bridge River orebodies. Of equal interest are the structural controls of the Bridge River gold ore shoots; the controls are regionally, locally and megascopically specific and readily identifiable.

History

Placer miners, discovering gold concentrations up the Fraser then westward up the Bridge River, had been mining the bouldery gravels of the Bridge and one of its principal southern tributaries, Cadwallader Creek, for many years prior to 1897, when in situ gold-bearing quartz veins were discovered in the canyon of Cadwallader Creek on what was to become the Pioneer Property. Within a year the original lode claims had been staked and essentially all of the veins that would eventually be mined had been found. By 1912, gold worth approximately $55,000 (1912) had been recovered from the veins by crushing and panning the quartz from the surface exposures.

Access was made somewhat easier in 1915, and work in the district accelerated, when the PGE Railway reached Lillooet, from where supplies were hauled 60 miles on a tough road that followed the Bridge River from the Fraser to Cadwallader Creek. By 1920 some 3000 feet of underground drifts and crosscuts had been hand mined and the revenue from lode gold had doubled to $100,000.00. Eight more years of logistically hampered and seasonally governed gestation passed before a mine was born.

Pioneer Gold Mines Ltd. opened its 100 tpd mill in 1928. Lorne Amalgamated Mining Ltd. had developed many hundreds of feet of the principal near-surface veins on its property immediately northwest of Pioneer, but only small orebodies had been identified and the company went bankrupt in 1929. In 1931 Bralco Mining took over the property, then named Bralorne, and after additional development, opened a 100 tpd mill in 1932. By 1935 the capacity of the Pioneer mill had been increased to 400 tpd and the Bralorne to 475 tpd, and the camp was established for its 40-year run.

Pioneer ceased production in 1962, and was taken over by Bralorne, which ceased production itself in 1971.

The total production from the two mines was:

Pioneer	1.33 mill. oz. Au
Bralorne	2.82 mill. oz. Au
Total	4.155 mill. oz. Au and 0.95 mill. oz. Ag

The recoverable grade was 0.523 oz. Au and 0.12 oz. Ag. Of the 30 veins developed at Bralorne-Pioneer, six produced most of the gold and two of those veins, the Pioneer Main and the Bralorne 77, produced the majority of that quantity. Continuous production was obtained from the main ore-bodies on these two veins through vertical distances of 4000 feet and 4700 feet respectively, with both still in ore at the bottom levels. (Figure 3).

Regional Geological Setting

The Bridge River gold veins occur within the Cadwallader Fault Zone, a regional fault structure that is the westernmost of the two major fault zones that comprise the Fraser Fault System where it crosses the valley of the Bridge River, before becoming masked in the fields of Tertiary volcanics to the north, (Fig. 1). The Fraser Fault System is an ancient one of continental dimensions and no doubt its profound depth and complex history have had a major influence in the great depth, (+6000 feet), of the Bridge River veins and gold orebodies. The Cadwallader Fault Zone at Bridge River comprises anastomosing reverse, normal and strike faults that form a network of structural failures in a belt up to two miles in width, very similar in appearance to the exposures of the active San Andreas Fault Zone in California. Like the San Andreas transform fault, the Cadwallader has variously displaced a wide range of ages of rock formations and has been the locus of intrusions for many large and small bodies of igneous rocks that range in composition from ultrabasic (oldest) to granites (youngest).

This spatial coincidence of the Cadwallader Fault Zone with belts of intrusive granitic (lesser), dioritic and ultrabasic bodies, together with underground exposures, indicate that the intrusives were evidently introduced along an early regional fracture system which subsequently evolved into a continental transform fault zone which variously and repeatedly dislocated and embraced the various intrusive bodies. Thus the Cadwallader Zone is unique in that it contains, and is flanked by, a concentration of bodies of complexly fractured old and young intrusive rocks which are less common or non-existent in the terrain distant from the zone, (Fig. 2).

Within and beside this wide fault zone numerous ancillary shears and branching tension fractures have become hosts to the gold-bearing quartz veins.

Regional Ore Control - The Cadwallader Zone

The principal member of the Cadwallader Fault Zone is a fault structure, ranging in width from 50 feet to 1,000 feet, comprising gouge-covered shear planes that bound and interlace tabular bodies of slickensided serpentine. This fault structure dips vertically to steeply to the west and southwest. Hangingwall branches are relatively uncommon but major and minor shears, faults and fractures are widespread on the footwall side for a distance of a mile or more along Cadwallader Creek. The net displacement along the Cadwallader zone is difficult to determine because the zone trends parallel to the surrounding formations; however, Permian formations on the east side of the fault have been thrust over younger formations on the west. In addition, there are numerous indications of normal displacements within the zone. The great lateral extent of the fault, measured in hundreds of miles, together with its relatively straight strike, its steep dip and the ubiquitous presence in it of serpentine bodies, are characteristics of a crustal transform fault, along which internal local thrust and normal displacements commonly accompany vertical adjustments during the continuing lateral movement on the break.

Where it is exposed along Cadwallader Creek and across the Bridge River the Cadwallader Fault Zone is essentially straight and uninterrupted for 8 miles southeast from Pioneer and over 7 miles north from Bralorne. At Bralorne-Pioneer the strike of the fault zone changes sharply from northwest to north. Quartz veins developed within otherwise favourable rock formations along the portions of the zone north and south of Bralorne-Pioneer have all proven to be discontinuous shear veins, only locally and sporadically mineralized with gold, (Figure 2). The only known economic gold-quartz veins along the Cadwallader Fault Zone occur where the zone changes direction from a northwest to a north strike.

At this bend in the structure, as in such bends in all transform faults, stresses set up in the adjacent wallrocks have been such that fractures have been induced which tend to close the interior angle formed by the bend. In the case of the change of direction of the Cadwallader Fault Zone this stress produced a major failure known as the Fergusson Thrust. This east-dipping fault leaves the Cadwallader Shear about a mile southeast of Pioneer and rejoins it a mile and a half north of Bralorne, thus enclosing a lense of rock which measures 3.5 miles in length and a half mile in maximum width and which, because of the diverging dips of the enclosing faults, widens and lengthens with depth. All of the known productive economic gold-quartz orebodies in the Bridge River area occur within this structural lense.

Because of the varied stresses imposed at various times by transform movement upon the rocks within the Fergusson-Cadwallader fault lense, the enclosed rocks failed further by tangential fractures which diverged from the Cadwallader Shear at low angles and, trending southeastward across the lense, tended to join the Fergusson Thrust at larger angles. This set of shear fractures was supplemented by northeast-southwest tensional fractures which opened as irregular gash veins. This system of fracture sets was adjusted and reopened repeatedly, as evidenced by the many ages of sheared and fractured quartz existing within the fractures.

All of the productive gold-quartz veins at Bralorne and Pioneer are confined between the Cadwallader Shear and the Fergusson Thrust which form the lense-shaped block at the bend of the Cadwallader Fault Zone. The tensional stresses imposed on the rocks within this lense have fractured and opened particular rocks to permit the formation of quartz veins and the mineralization by gold. The chances of finding economic gold-quartz veins outside of this lense are not good. Even the otherwise favourable

Pioneer Greenstone lying on the southwest side of the Cadwallader Shear, directly opposite the productive veins that occur in greenstone within the structural lense, contains no worthwhile veins because it lies beyond the focus of tensional fracturing. (This area was thoroughly drilled from the surface and upper levels at Pioneer.)

There is an interesting comparison to be made between the Bridge River camp and the Mother Lode camp in California. The two camps not only have striking similarities in ore, vein mineralogy, wallrock alterations and wallrocks, but also are remarkably similar in the association of the ore veins with a major fault along a belt of elongate serpentine bodies that flank the margin of a granitic batholith. In addition, the Melones Fault Zone, an active transform fault along which the quartz veins are distributed in the Mother Lode camp, changes strike direction sharply from northwest to north just south of Placerville and it is in the area of this broad change in strike, some 60 miles in length, that most of the productive veins occur. This is analogous to the Cadwallader Focus of ore veins on a much larger, more regional, scale.

The Ore Veins

The ore veins at Bralorne-Pioneer occupy tension fractures that obliquely traverse the structural lense between the Cadwallader and Fergusson faults. Most of the veins strike eastward and dip steeply north; however, a less numerous set, productive in the Pioneer Mine, strikes northeastward and dips steeply west. The veins are displaced to the right by occasional north-south faults. The veins commonly anastomose (branch and split) and "double veins", (a rib of barren rock a few feet in width between veins), are not uncommon in the mines.

The vein material is massive white quartz, commonly ribboned with dark sulphide bands, particularly in the ore shoots. Accessory vein minerals are siderite, scheelite and mariposite, all very minor but the distinctive blue-green mariposite is visually striking and frequently indicative of gold mineralization. Up to 3 percent of the ore-bearing veins are made up of pyrite and arsenopyrite, the latter of which is commonly associated with gold, generally occurring in fine ribbon fractures parallel to the vein walls.

The gold in the ore is commonly visible, frequently coarse and 83 percent of it was recovered in the jigs and on blankets. The gold is concentrated along both the dark banding fractures parallel to the walls of the quartz veins, as well as on faint cross fractures at right angles to the walls. Clearly, the percolation of the gold-bearing solutions through the quartz veins was dependent on a stress condition whereby some fractures in specific places on particular quartz veins were opened at the time of the introduction of the solutions. The evidence in the mine exposures suggests that this condition was probably one of relaxation of compressive stress at right angles to the dip of the fault zone (veins). This could have been affected by either a normal displacement on the faults (veins) or a left lateral displacement.

The ore shoots are ten times more persistent vertically than laterally and have generally sharp lateral cut-offs in gold values. Average stoping widths ranged from 3 to 5 feet, with stopes widening to as much as 20 feet at vein junctions. Some orebodies had high grade nucleii, one of which on the Pioneer Main Vein was 250 feet in length and averaged 5 oz. Au/t across 3.5 feet, but generally the values were fairly consistent within the orebodies. There has been no change in vein mineralization over a vertical range of 6000 feet.

Wallrock alteration consists predominantly of argillization, with major biotization and carbonitization components, that softens the rock and lightens its colour for widths ranging from a few inches to several feet beyond the veins. It is most extensive where sulphides are most abundant in the veins and it is post-quartz and possibly contemporary with the gold in age.

Local Ore Controls - The Wallrocks

The belt of rocks through which the Cadwallader Fault Zone passes at Bridge River comprises faulted and contorted sedimentary and volcanic rocks ranging in age from Permian, (Fergusson Series argillities east of the fault), to Jurassic, (Hurley-Noel Formations of intercalated volcanics and sediments, of which the Pioneer Greenstone is a thick unit of recrystallized flows and pyroclastics). These older formations have been invaded, particularly along the Cadwallader Fault Zone, by three suites of intrusive rocks, the oldest of which is the President Intrusive series comprising large and small bodies of extensively serpentinized ultrabasic rocks. The serpentine in the main Cadwallader Fault Zone may be related to these intrusives. The second oldest intrusives are the Bralorne Diorites which occur as plugs and elongate lenses near and within the Cadwallader Fault Zone. The diorite is a crystalline augite-amphibole metadiorite that is both intrusive and gradational into the Pioneer Greenstone, suggesting that it was derived from the same magmatic source at different times. It appears that the Bralorne Diorite was intruded after the Cadwallader zone had deformed the Hurley-Noel rocks but before it had assumed its present form. The final intrusive phase is represented by the Bralorne Soda Granite, which occurs as a vertical dike-like body 1.5 miles in length and 2000 feet in width within the lense encompassed by the Cadwallader and Fergusson faults. It is an albite granite that commonly grades into aplite dikes.

Some of the above-described rock types sustained open fractures within the Bralorne-Pioneer structural lense, and hence were mineralized with quartz, whereas other rocks did not and hence are not host to quartz veins. No veins were formed within the (incompetent) serpentine of the Cadwallader Zone and only occasional ones were formed within the predominantly argillaceous rocks of the Hurley-Noel Series. The remaining rock formations within the lense all sustained open fractures, but to different degrees.

The Bralorne Diorite and the Pioneer Greenstone are much alike in mechanical characteristics in that they are both generally homogeneous masses of considerable competency but are varied enough in internal structure to provide sites for changes in fracture characteristics. Because of the relative competency of these rocks most of the fissures in them are simple structures which opened with the shifting stresses on the lense, thus permitting the passage of hydrothermal solutions and the deposition of quartz.

In contrast to the diorite and the greenstone, the remaining rock formation within the lense, the Soda Granite, is a far more homogeneous and competent rock and, as are most young granitic intrusives, it is brittle. It has not sustained single, wide continuous fissures upon failure but rather has failed by tight, braided fractures along which movement in many places has been taken up to some extent by the prevalent joint system. Thus, the quartz veins tend to become narrow, dispersed and erratic in trend where they traverse the soda granite. Gold orebodies are rare within the soda granite.

The major ore control on the veins within the Bralorne-Pioneer lense is then, that the orebodies are restricted to those portions of the veins within the Bralorne Diorite or the Pioneer Greenstone at or near the contact of a rock type of markedly different competency; i.e., the soda granite. This is best illustrated by the longitudinal section showing most of the orebodies in the camp, (Fig. 3). At these contacts the vein structures are buckled or refracted so that there is a marked change in strike and/or dip crossing from one rock type to the other. Generally the veins steepen at the soda-granite contact and tend to deflect along it.

Ore Shoot Control

In detail the veins are both horizontally and vertically broken into segments which follow one or two fracture directions. The length of these segments in any one direction ranges from 300 to as much as 1000 feet depending on the type of vein. The shear (southeast, east) veins tend to be in long and merging segments whereas the tension (northeast) veins are broken into short segments which may not merge with one another. (Five main segments make up 27 vein, three occurring between the 21st and the 26th levels). The vein segments are generally in echelon to one another in that the end of one tends to curve away from the end of the next. The ends of adjacent segments are most generally interconnected by tangential shears and/or cross-over fractures both of which pass from the hanging wall of one segment to the footwall of the next, or vice-versa, and any of which may or may not be mineralized with quartz, but seldom with gold.

From a point of view of ore controls the segmented structure of the veins is noteworthy because the steep portions of the vein segments are generally more richly mineralized with gold than are the flatter portions, and also, laterally, the ore shoots in most places terminate at direction changes within or at the ends of vein segments.

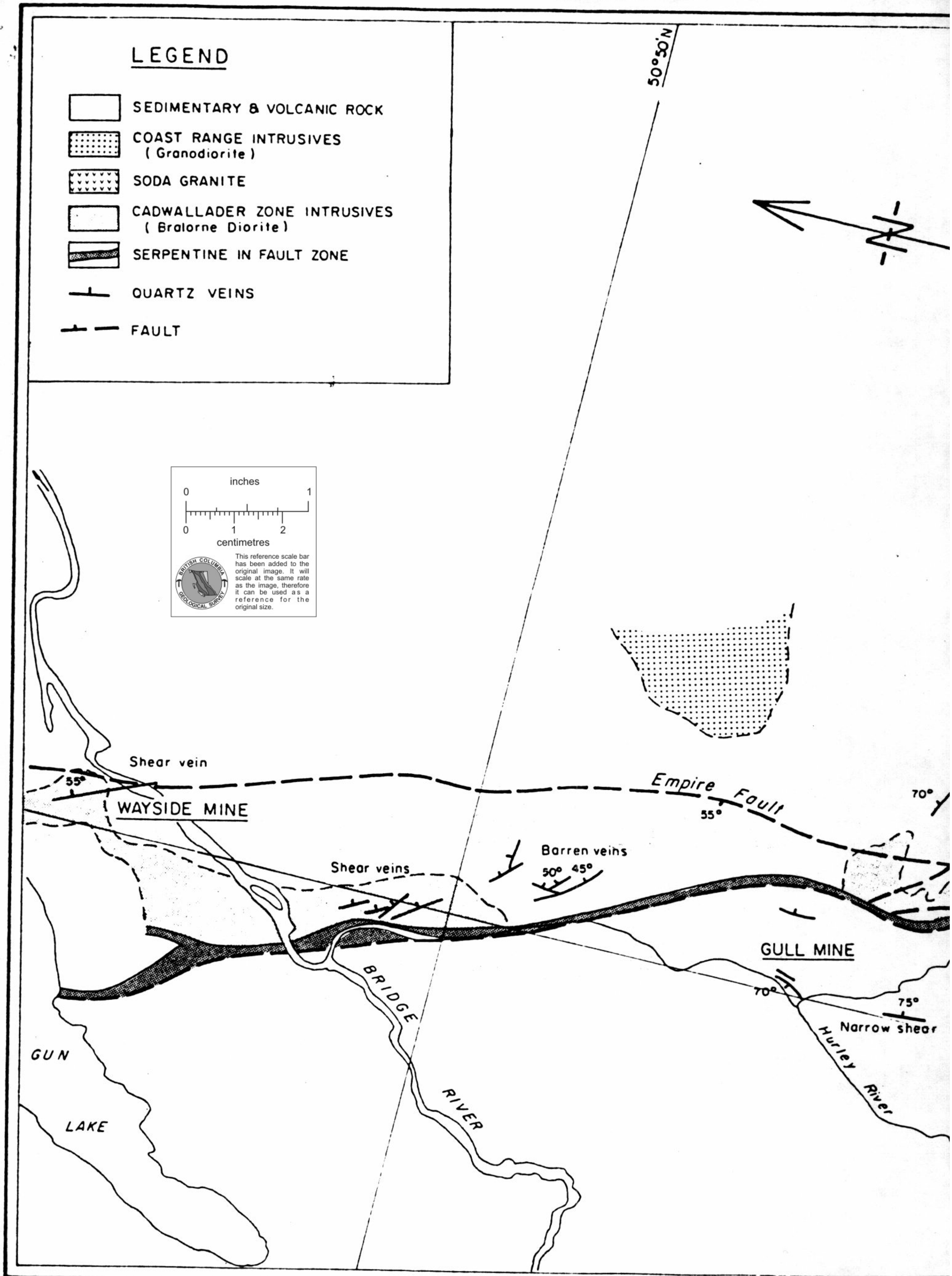
en echelon

Enriched mineralization at steep sections is a very common characteristic of vein-type ore deposits and may result in either an increased amount of overall vein material (quartz) being deposited in the steep portions, and/or an opening up of fractures within the steep portions of existing veins to permit introduction of new material. It is evident that the latter process was dominant at Bralorne-Pioneer. All of the orebodies on the Bralorne 77 and 79 veins and on the Pioneer Main and 27 veins, i.e., all of the major orebodies, occur on steep portions of the veins. Spot checks of a few lesser orebodies reveal the same relationship. Other structural controls such as branch junctions, segment junctions and lenses also resulted in ore sites in different veins and different parts of veins in the two mines, but these controls are subsidiary to the "steep and flat" control. This then is the primary control of orebodies at Bralorne and Pioneer and it pertains most commonly where the vein structures have been deflected passing from diorite or greenstone into soda granite, with the steep portions occurring in the former rocks at the contact.

The effect of tension or gravity relaxation on dipping veins and fracture systems is that the steeper portions of the structures tend to open, whereas flatter portions tighten and close. Hydrothermal solutions, originating at depths of high pressures and temperatures, carry metal salts in solution so long as the required pressure-temperature relationship is maintained. Drops in pressure result in a decrease of vapour pressure and a drop in temperature and possible resultant precipitation of metals. In the case of the Bralorne-Pioneer orebodies it is suggested that solutions saturated in gold salts arose along the more open, (quartz vein), members of the available plumbing system under vapour pressures high enough to keep the gold salts in solution. On suddenly encountering portions of the veins relatively more open than the preceding portions the vapour pressure would drop and gold would be precipitated until equilibrium was reestablished within the system. Thus the open, steep, low pressure, portions of the veins would be host to gold mineralization in successively ascending order as each steep section was reached. Obviously there is some depth below which pressures were so high that even a very appreciable drop in pressure would not precipitate the gold, thus there is an ultimate bottom to this type of orebody.

To date there is no indication that the ultimate bottom of the orebodies has been reached at Bralorne-Pioneer. The ore shoot on the bottom level of the 77 Vein in Bralorne is 530 feet in length, 7 feet in width and averages 1.0 oz. Au/ton, and has been verified to a further depth of 300 feet by diamond drilling. However, the rock temperature at this level (6200 feet) is 135°F and mining can only be accomplished with costly refrigeration to the working faces.

Other ore possibilities exist in the unexplored geologically favourable portions of the structural lense, particularly in the mid-upper levels of both mines. Unfortunately, practical access to these areas can only be from underground, requiring very extensive rehabilitation and development.


LEGEND
SEDIMENTARY & VOLCANIC ROCK
COAST RANGE INTRUSIVES (Granodiorite)
SODA GRANITE
CADWALLADER ZONE INTRUSIVES (Bralorne Diorite)
SERPENTINE IN FAULT ZONE
QUARTZ VEINS
FAULT
50°50'N
inches
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BRITISH COLUMBIA GEOLOGICAL SURVEY
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Shear vein
55°
WAYSIDE MINE
Empire Fault
55°
70°
Barren veins
50°
45°
Shear veins
GULL MINE
70°
75°
Narrow shear
Hurley River
BRIDGE
RIVER
GUN
LAKE

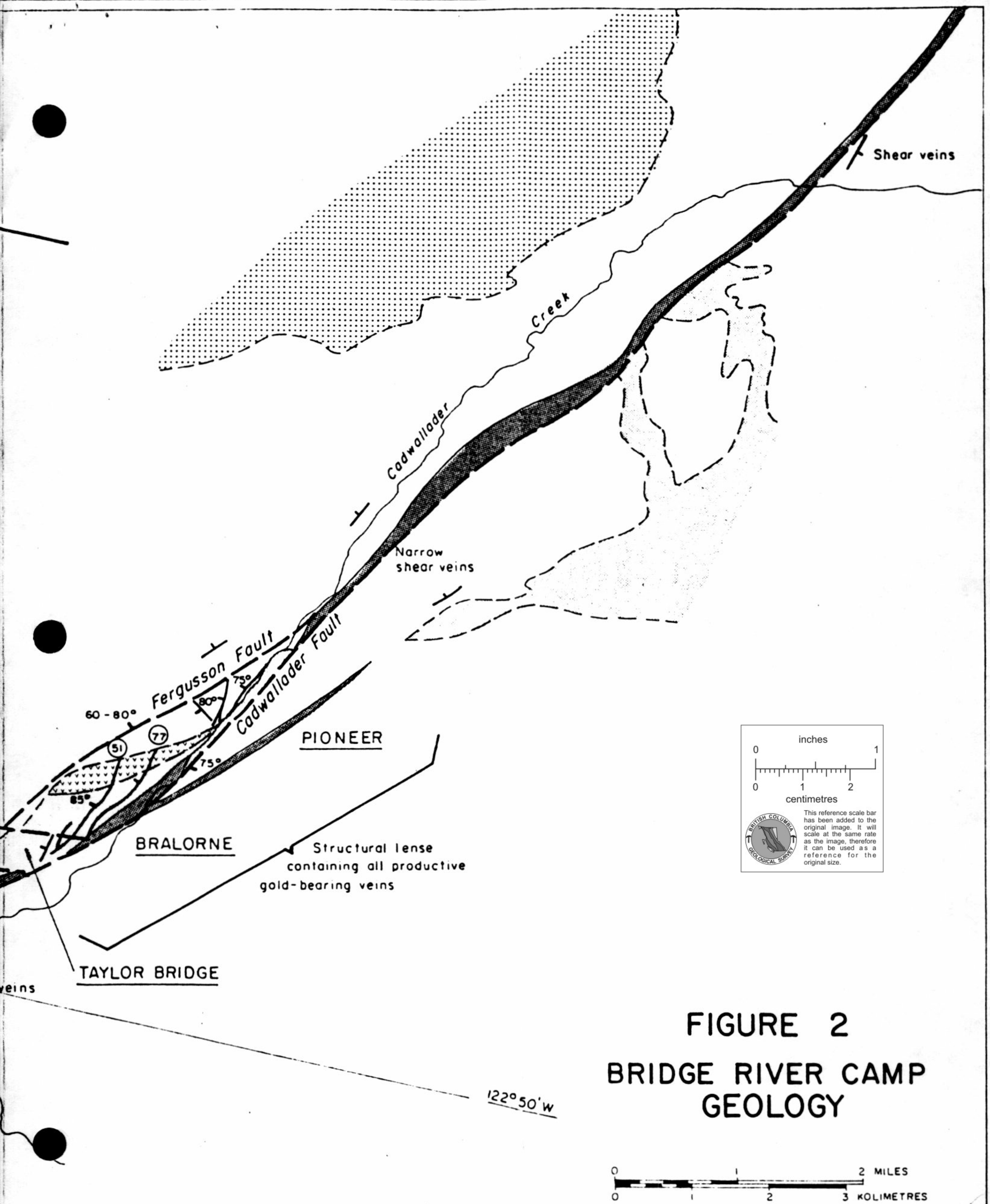

FIGURE 2

BRIDGE RIVER CAMP GEOLOGY

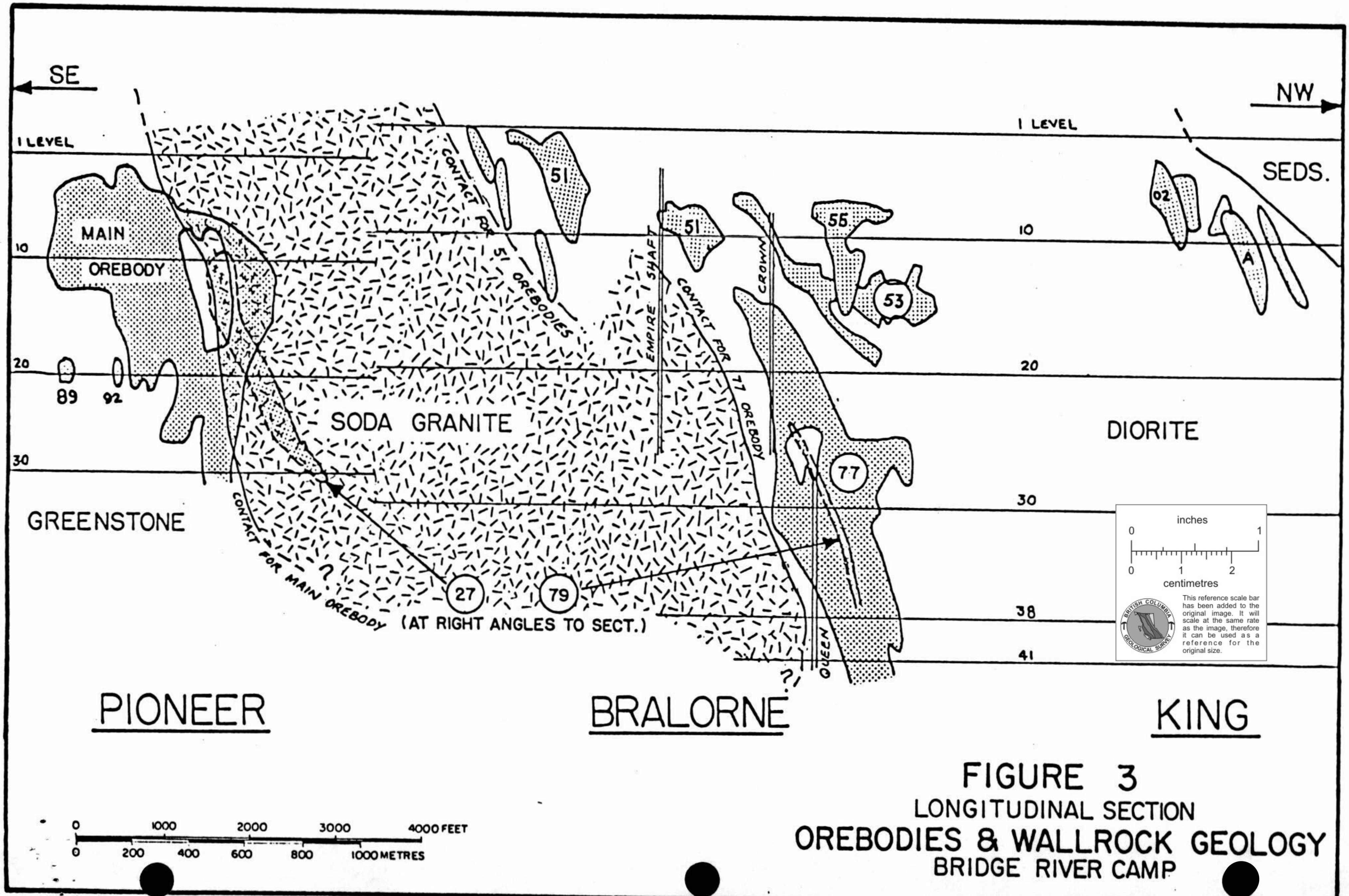

FIGURE 3
LONGITUDINAL SECTION
OREBODIES & WALLROCK GEOLOGY
BRIDGE RIVER CAMP

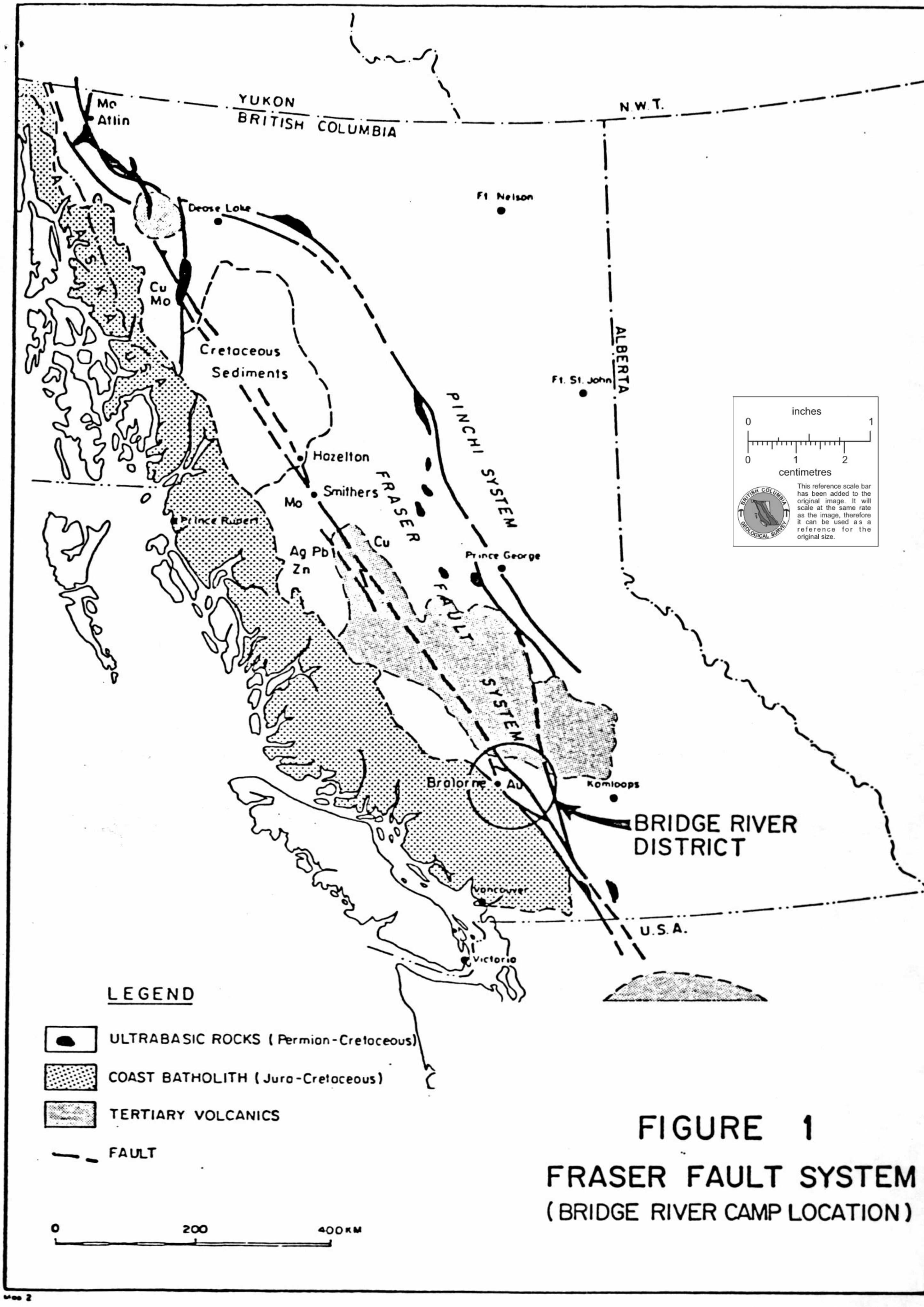

FIGURE 1

FRASER FAULT SYSTEM
(BRIDGE RIVER CAMP LOCATION)