GEOLOGY OF THE BRALORNE-PIONEER GOLD CAMP (92J/15)

By C. Leitch and C. I. Godwin
Department of Geological Sciences, The University of British Columbia

INTRODUCTION

The Bralorne-Pioneer gold camp produced more gold than any other camp in British Columbia (7 million tonnes of 18 grams per tonne gold or 4 million ounces of gold; Barr, 1980). It is the only vein camp in the Canadian Cordillera whose production approaches the major vein camps in the Canadian Shield, such as the Hollinger or MacIntyre mines which both produced more than 10 million ounces of gold (Bertoni, 1983). Hodgson (1982) notes similarities between the Bralorne camp and those of the Canadian Shield.

Remapping of both surface and the eighth level underground — from available outcrops, accessible workings, and intact drill core — was carried out in August and September 1985 by the senior author. Preliminary results, presented in Figures 47-1 and 47-2, include a synthesis of much old data combined with a re-interpretation of certain key lithologies.

REGIONAL GEOLOGY

The Bralorne-Pioneer gold camp lies within a fault-bounded slice of oceanic rocks called the Bridge River terrane by Tipper (1981). This "suspect" terrane is sutured between the larger accreted terranes of Wrangellia on the west and Stikinia on the east. The Bridge River terrane could represent ocean floor obducted onto and/or transported with the larger terranes.

Units within the Bridge River terrane (identified by Woodsworth, 1977) are Triassic, Permo-Pennsylvanian, and possibly Jurassic in age (Table 47-1). The base of the succession consists of a thick sequence of oceanic basalts, ribboned cherts, and argillites of the (?) Permo-Triassic Fergusson or Bridge River Group. This is overlain by the (?) Triassic-Jurassic Cadwallader Group, which from oldest to youngest is divided into the Hurley Formation of calcareous argillite, the Pioneer andesite, and the Noel argillite (Table 47-1). No fossils have been identified from these rocks.

Stratified rocks within the Bridge River terrane are intruded by the Bralorne intrusives and the Coast Range plutonics. All K/Ar data from the area yield Jurassic to Cretaceous dates and presumably represent only the Coast Range plutonic event. Hybrid contact relationships indicate that the Bralorne intrusives might be as old as the Triassic or Permian Pioneer andesites. Stevenson (1958), who mapped the Bridge River area surrounding the Bralorne-Pioneer camp at a scale of 1:7200, followed Cairnes' (1937) division of the Bralorne intrusives; this is, from oldest to youngest, the largely serpentinized President ultramafic, the Bralorne diorite, the soda granite, and albitite (quartz-plagioclase porphyry) dykes.

PROPERTY GEOLOGY

Detailed mapping was at 1:1200 on the surface and on the main adit level (eighth level, approximately 400 metres underground). Preliminary results, presented on Figures 47-1 and 47-2 show large areas with extensive glacial drift and little outcrop. Nevertheless, there is close correspondence between trends of dykes and contacts deduced at surface with those found underground. The geology of the eighth level is complex, but most data were derived from logging underground drill core (both the old Bralorne-Pioneer core and the recent core drilled by Mascot Gold Mines Ltd.) rather than from the underground workings. In some currently inaccessible areas, particularly in the old King mine workings, the map is drawn largely from old data.

TABLE 47-1
FORMATIONS IN THE BRALORNE-PIONEER CAMP SOUTHWESTERN BRITISH COLUMBIA
(Figures 47-1 and 47-2 show distribution of units.)

UNIT NO. MAP SYMBOL	DESCRIPTION
JURASSIC (?)	
10	Lamprophyre dykes
9	Green hornblende porphyry dykes
	Quartz veins (major, named)
8	Albitite (plagioclase porphyry) dykes
JURASSIC (?) BRALORNE INTRUSIVES	
7	Soda granite
6a	Hornblendite
6	Diorite
5	President ultramafics (serpentinite)
TRIASSIC-JURASSIC (?) CADWALLADER GROUP	
4	Hurley-Noel sediments (volcaniclastic)
3	Pioneer andesites
PERMO-TRIASSIC (?) FERGUSSON (BRIDGE RIVER) GROUP	
2	Sediments (ribbon chert, argillite)
1	Volcanics (basalt)

Principal lithologic units on Figures 47-1 and 47-2 match those mentioned in the section on regional geology and in Table 47-1. They are described following, from oldest to younger.

FERGUSSON (BRIDGE RIVER) GROUP

Unit 1, Basalts: Dark green, brown-weathering basalts outcrop along the northern edge of the mapped area (Fig. 47-1A and 1B). In outcrop, they are massive and fine grained; no pillows were observed in this area although elsewhere abundant pillows are present. The basalts are not seen in either the underground workings or in drill core.

Unit 2, Cherty Argillite: Black to grey, laminated to thin-bedded chert and cherty argillite are common in the Fergusson Group and make up thicknesses of several hundred metres. Due to its shattered nature, the argillites are generally poorly exposed close to the Fergusson thrust (Fig. 47-1) but form larger outcrops further northeast. These rocks were not seen in the underground workings.

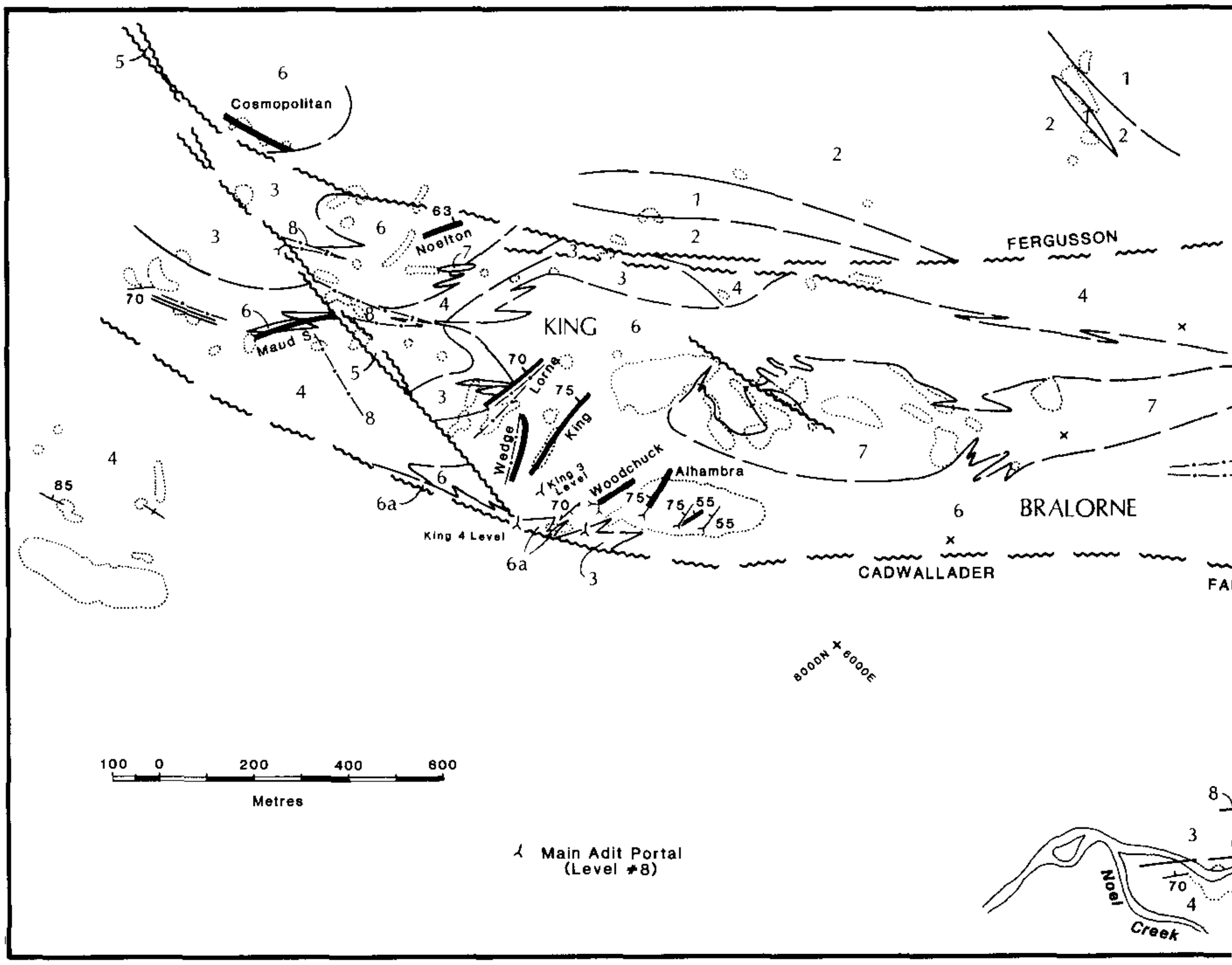

Figure 47-1. Surface geology of the Bralorne-Pioneer gold-quartz vein camp, Bridge River district, southwestern British Columbia. Units are defined in Table 47-1. *See* Figure 47-2 for eighth level underground plan.

CADWALLADER GROUP

Unit 3, Pioneer Andesites: Although commonly called "greenstones" in mine usage, the Pioneer Formation consists mainly of andesitic volcanic and volcaniclastic rocks. In drill core the andesites vary from fine-grained, massive, amygdaloidal flows and medium-grained dykes, to coarse lapilli tuffs and breccias. The constant colour index suggests little compositional variation. A paler, possibly dacitic phase is rarely seen and quartz-eye porphyry fragments were observed in the Pioneer No. 2 shaft dump. This unit grades stratigraphically upward into the Hurley-Noel sediments.

Unit 4, Hurley-Noel Sediments: The Hurley Formation comprises green volcanic wacke and dark argillite, while the Noel Formation consists of black argillite. Interlaminations of the green wacke and argillite are common as is characteristic in much of the Jurassic Hazelton Group near Stewart (Tipper and Richards, 1976). The Hurley and Noel Formations were not separated in this study; the Hurley-Noel rock sequence lacks ribbon chert, which distinguishes it from the Fergusson Group. Volcanic wackes grade stratigraphically into volcaniclastic rocks of the Pioneer Formation (Table 47-1).

BRALORNE INTRUSIVES

Unit 5, President Ultramafic: The President ultramafic largely comprises serpentinite; it lies along the Cadwallader fault zone (Figs. 47-1 and 47-2) that bounds the south side of the rocks hosting the gold veins. Some serpentinite was also mapped on surface by previous workers near the north end of the Fergusson fault. Where unserpentinized (for example, near the King workings), this unit includes distinct, network-textured hornblendite cut by dykes of the Bralorne diorite. However, it is sometimes difficult to distinguish this hornblendite from amphibolitized diorite (unit 6a) and greenstone. A repeated interlayering of hornblendite, diorite, and ultramafic(?) is seen in drill core as the serpentinite contact is approached. Further work is needed to understand this unit.

Unit 6, Bralorne Diorite: Bralorne diorite underlies much of the area and interfingers in a complex manner with the Pioneer andesite on the south side of the Bralorne intrusives. The diorite is typically dark grey-green, medium to coarse grained, and contains equal amounts of plagioclase and amphibole; it is commonly foliated parallel to its northwest-striking margin, and is commonly cut by a stockwork of late deuteric pale green quartz-epidote veinlets which may contain prehnite (Stevenson, 1958). Similar but sparser quartz-epidote veinlets also cut the soda granite which is described follow-

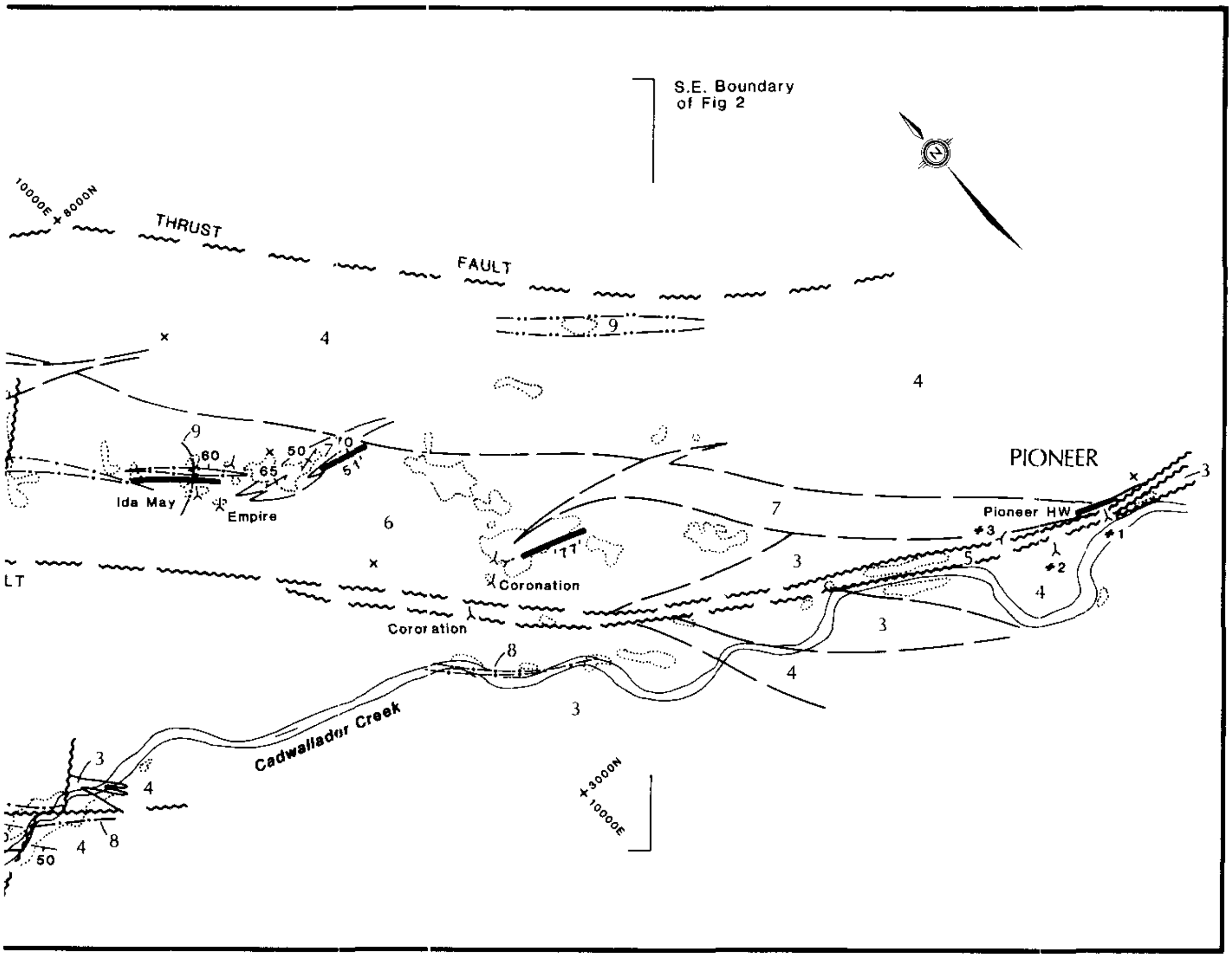

Figure 47-1. Surface geology of the Bralorne-Pioneer gold-quartz vein camp, Bridge River district, southwestern British Columbia. Units are defined in Table 47-1. *See* Figure 47-2 for eighth level underground plan.

ing. Near the large quartz vein systems the diorite is altered to either a dark green, chloritic facies or a buff-coloured carbonate-rich facies; these facies may alternate over a few metres.

Unit 6a, Hornblendite: Hornblendite commonly exhibits an apparent gradational contact with the Bralorne diorite.

Unit 7, Soda Granite: The major mass of soda granite lies along the north side of the Bralorne intrusives (Figs. 47-1 and 47-2); its northern contact with the Pioneer andesite and Hurley-Noel sediments is relatively sharp. In contrast, its contact with the diorite is generally gradational over a 200-metre distance; this is partly due to numerous, small, irregular masses of soda granite within diorite giving the rock a migmatitic appearance. However, dykes of soda granite with sharp contacts against diorite are also common. Soda granite is pale, medium grained, and distinguishable from the diorite by the presence of quartz and its lighter colour due to a lower percentage of chloritized mafics. Nevertheless, altered, bleached diorite can look very similar. Stevenson (1958) notes that the plagioclase is albite in the soda granite and andesine in the diorite. The origin of the complex relationship between the diorite and the soda granite is not understood; it could result from either anatectic partial melting of the diorite with subsequent remobilization (favoured by Godwin), or differentiation and intrusion of soda granite following formation of still plastic diorite (favoured by Leitch).

Unit 8, Albitite Dykes (Intra-mineral): Most albitite dykes are 1 to 10 metres in thickness, except near the centre of the Bralorne intrusive where they reach 30 metres thick (Figs. 47-1 and 47-2). Contacts against diorite or soda granite can be sharp, chilled, and flow banded, but usually are sheared and/or veined. These pale buff to greenish intra-mineral dykes cut the Bralorne intrusives but rarely extend into surrounding rocks. They are very fine grained, have quartz and/or plagioclase phenocrysts, and are compositionally similar to the soda granite. A few albitite dykes contain relict hornblende, commonly marked by pyrite blobs. Altered diorite and soda granite resemble albitite, but the two are distinguishable by the aphanitic texture of the dykes; this caused early workers on the property to erroneously map highly altered quartz-carbonate rock as albitite. Albitite dykes commonly have gold-bearing veins parallel to their margins, but are rarely cut by these veins.

Unit 9, Green Hornblende Porphyry Dykes (Post-mineral): These dykes cross the easterly striking contacts of the earlier intrusives, and commonly intrude and taper into the post-mineral faults. They are relatively fresh, lack veining, and have sharp, flow-banded and chilled contacts. The relationship between the green dykes and the albitite dykes is generally unclear due to shearing near the margins of the former; however one large outcrop of green dyke includes blocks of apparent albitite dykes, confirming the older age

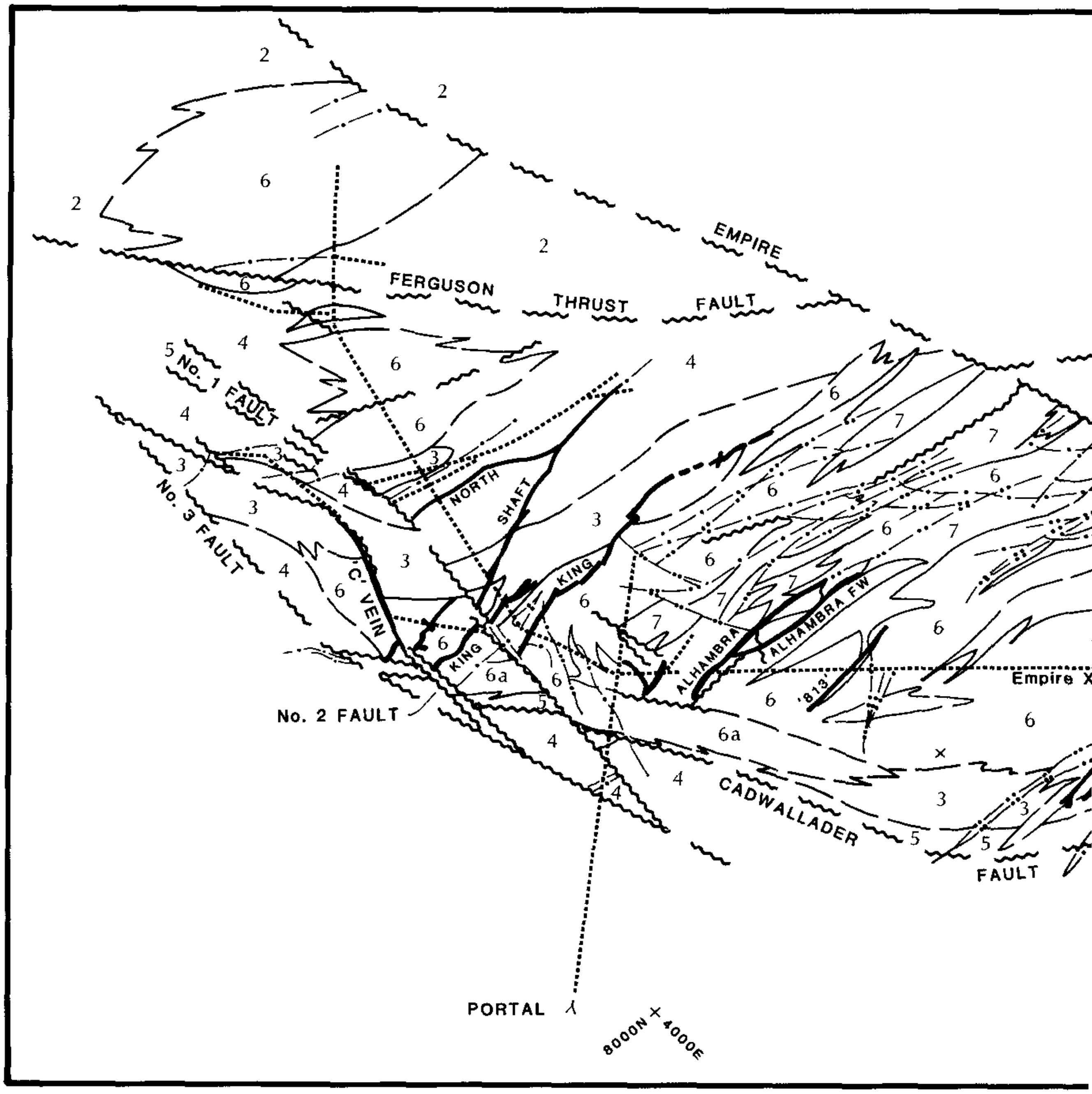

Figure 47-2. Eighth level underground plan (about 400 metres below the surface) of the Bralorne-Pioneer gold-quartz vein camp, Bridge River district, southwestern British Columbia. Units are defined in Table 47-1. Surface geology is on Figure 47-1.

of the albitite. Common hornblende and lesser plagioclase (never quartz) phenocrysts in an aphanitic groundmass characterize this unit.

Unit 10, Lamprophyre Dykes: Pieces of late stage black, mafic, biotite-bearing lamprophyre dykes are seen both in core and on the dump at the Bralorne portal; however, these late-stage intrusive dykes have not been seen underground. Their location on Figure 47-2 is from old Bralorne-Pioneer maps.

STRUCTURE

Outstanding features of the Bralorne-Pioneer veins are their great length (6 kilometres) and depth (1.5 kilometres), and also their parallelism to the Cadwallader and Fergusson faults, the long axes and contacts of the intrusives, the dykes, foliation, bedding, and shearing directions. Veins are ribboned, with quartz layers separated by thin, black septa of crushed and sheared auriferous sulphide. Repeated episodes of vein filling by a crack and seal mechanism may account for the alternating layers of quartz and gold-bearing sulphide. Striations along the sheared sulphide-rich surfaces plunge about 45 degrees east and indicate reverse fault movement along the veins which strike about 110 degrees and dip north at 70 degrees. Joubin (1948) considered the veins to follow planes of shear failure.

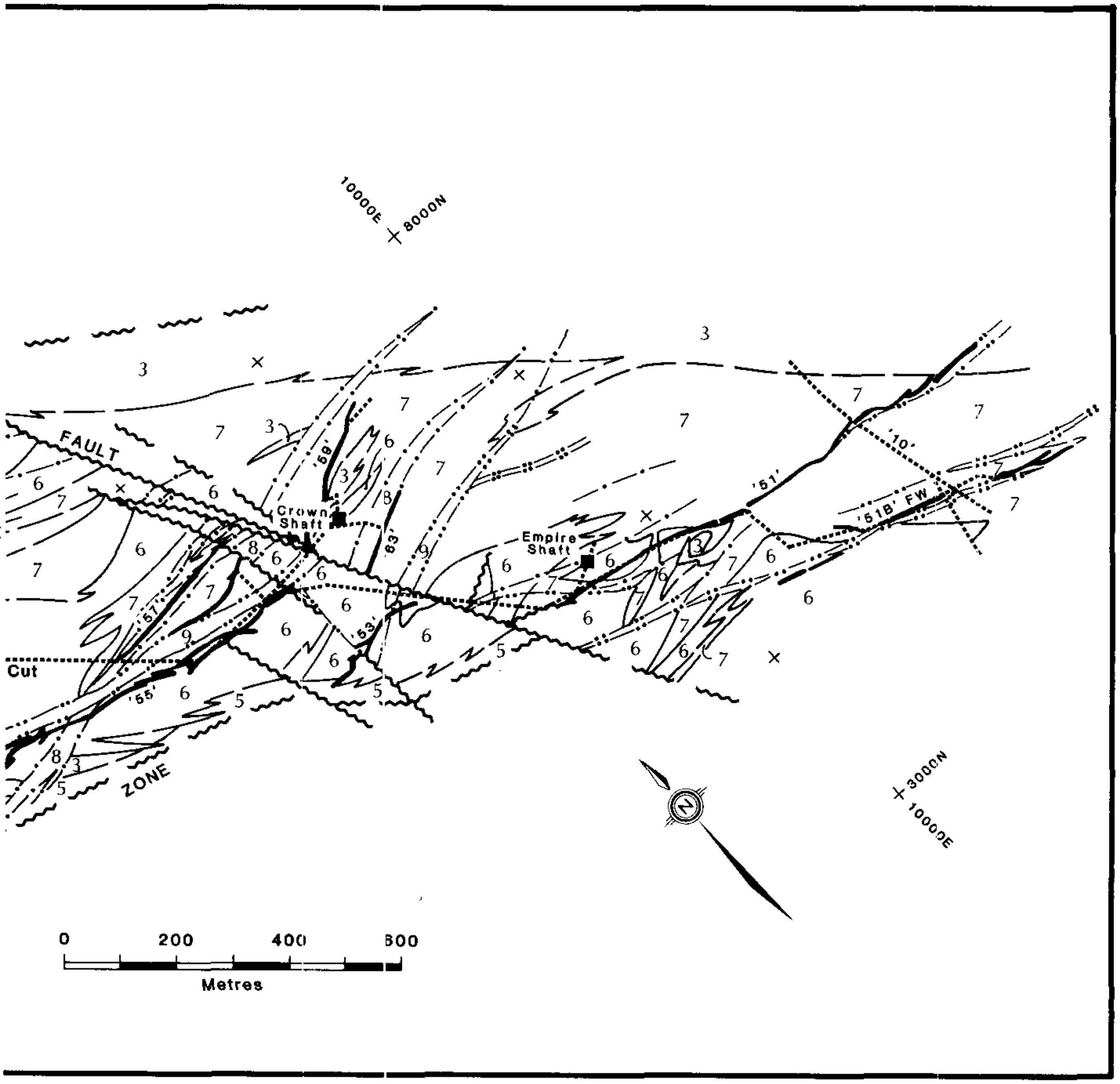

Figure 47-2. Eighth level underground plan (about 400 metres below the surface) of the Bralorne-Pioneer gold-quartz vein camp, Bridge River district, southwestern British Columbia. Units are defined in Table 47-1. Surface geology is on Figure 47-1.

ALTERATION

Hydrothermal alteration is developed as wide envelopes around the veins; these may coalesce to form pervasive alteration envelopes extending tens of metres away from major veins. Pyrite may also extend for several metres from the larger veins. A characteristic zonation toward the veins hosted in diorite are: (1) green chloritization of the hornblende, (2) buff carbonatization of the hornblende with intact granitic texture, (3) intense brown quartz-carbonate alteration, which destroys the granitic texture and is commonly foliated from shearing, and (4) cream-coloured, paper-like, intensely sheared quartz-carbonate schist, with local fuchsite and common disseminated pyrite, adjacent to major veins.

MINERALIZATION

Gold is concentrated in the sulphide septa of the ribboned quartz veins. Most of the sulphide is pyrite, but arsenopyrite laths up to 1 millimetre long are common. Where sheared the sulphides are powdered, but visible native gold is locally present on striated smears. Sphalerite and galena are reported by Cairnes (1937) but only noted on the King 4 level adit dump and in core from the Pacific Eastern Gold property southeast of the Pioneer mine.

CONCLUSIONS

The Bralorne-Pioneer gold camp has an igneous and hydrothermal system that exceeds 6 kilometres in strike length. The virtual restriction of the gold-bearing quartz veins to the Bralorne intrusives is similar to some of the deeper level "plutonic" porphyry copper-molybdenum systems in British Columbia (Sutherland Brown, 1969). These porphyry systems have elongate rather than circular intrusives; mineralization is sometimes in ribbon veining, but contains molybdenite and chalcopyrite rather than pyrite-arsenopyrite and gold; and intra and post-mineral dykes are common to both.

The petrogenesis, age, and relationship of a number of units remain obscure, particularly the andesite, ultramafic, hornblendite, diorite, soda granite, and albitite dykes. Understanding the relationships between gold veining and the various intrusive events could enhance our understanding of this major gold camp. Age dating of intrusive and altertion events, possibly by U/Pb of $^{39}Ar/^{40}Ar$ methods could also clarify the geological history of the area.

ACKNOWLEDGMENTS

We thank the management and staff, particularly John Bellamy, of Mascot Gold Mines Ltd., Vancouver, for permission to visit and sample the underground workings, to examine the voluminous drill core from current and past programs, and to view data from their development of the property. Brad Cooke of Cooke Geological Consultants Ltd., Vancouver, helped orient our study. The open assistance and discussions with Gary Nordin and Rick Barclay of Amir Mines Ltd., Vancouver, are gratefully acknowledged. Core from their 3 500-metre drill program on the Pacific Eastern Gold property, adjoining the old Pioneer mine to the southeast, was made available.

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WOLF EPITHERMAL PRECIOUS METAL VEIN PROSPECT CENTRAL BRITISH COLUMBIA (93F/3W)

By Kathryn P. E. Andrew and C. I. Godwin
Department of Geological Sciences
The University of British Columbia
and
Robert M. Cann
Rio Algom Exploration Inc.

INTRODUCTION

The Wolf epithermal precious metal vein prospect (Fig. 48-1) is near latitude 53 degrees 12 minutes north and longitude 125 degrees 26 minutes west in central British Columbia, about 6 kilometres southeast of Entiako Lake approximately 185 kilometres southwest of Prince George. Access is by helicopter or floatplane to one of several nearby lakes. The Wolf claims were located in 1983 by Rio Algom Exploration Inc., Vancouver, as a result of anomalous silver values in lake sediments. Preliminary mapping and sampling of soil and rock in 1983 and 1984 indicated epithermal mineralization within Tertiary Ootsa Lake Group rhyolites (Cann, 1984). A silicified zone was trenched in 1984. Drilling and additional trenching were undertaken in 1985; the main area of drilling is shown on Figure 48-1. Mapping and ongoing studies of the Wolf area by Andrew form the basis for an M Sc. thesis.

REGIONAL GEOLOGY

Duffell (1959) named the Ootsa Lake group and noted that it unconformably overlies Hazelton Group rocks above a basal conglomerate near Whitesail Lake, about 100 kilometres northwest of the Wolf property. In the vicinity of the Wolf prospect, Geological Survey of Canada Map 1424A shows the Eocene (?) Ootsa Lake group to unconformably overlie the Jurassic Hazelton Group. Tipper (1963) postulated that much of the Ootsa Lake Group occupies depressions in pre-Tertiary valleys. He also subdivided the Ootsa Lake volcanics into two units: rhyolite and andesite. The Wolf prospect lies within the rhyolite unit that is composed of rhyolite, trachyte, dacite, with minor andesite and basalt, and related breccias and tuffs. Sedimentary rocks of Ootsa Lake Group are not abundant and generally occur as poorly consolidated, soft, friable stream gravels and sands along major valleys. In the Wolf area outcrops of sedimentary rock are rare. The recessive weathering sedimentary rocks were only encountered in drill core.

LOCAL GEOLOGY

Field relations on the property and petrographic observations define 12 map units within the Ootsa Lake major rhyolite unit. They are shown on Figure 48-1 and described in detail following. The map units can be divided into four assemblages: a basal package (units 1, 2, and possibly 3), a pyroclastic package (units 4 to 7), a dome and vent breccia package (units 8 and 9), and a late-stage and intrusive package (units 10 to 12). Sedimentary rocks underlying unit 8, the rhyolite, do not outcrop and were only intersected in drill holes. The rocks are not described here; they might occur in the valleys — note that outcrop, as shown on Figure 48-1, is sparse. Figure 48-2 schematically illustrates the stratigraphic relationships.

BASAL PACKAGE (1)

Unit 1, volcanic conglomerate, crops out in a creek on the northwest side of the property (Fig. 48-1). It is matrix supported with 30 per cent well-rounded granodiorite clasts (5 to 50 centimetres in diameter), 10 per cent angular andesite clasts (up to 15 centimetres in diameter), and 5 per cent subrounded aplite clasts (20 to 30 centimetres in diameter). The tuffaceous matrix has up to 60 per cent quartz. The quartzose matrix, granodiorite, and aplite clasts indicate a predominantly granitic, as well as a volcanic, provenance.

Unit 2, felsic lapilli tuff, has a pale grey to green aphanitic groundmass which supports various amounts of clasts, 1 to 10 millimetres in size. The unit crops out in the same creek as unit 1 on the northwest side of the property (Fig. 48-1). In two outcrops clay-altered clasts show alignment with an indicated strike of 175 degrees and a steep dip.

Unit 3, porphyritic andesite and andesite breccia, is restricted to the eastern edge of the property (Fig. 48-1). It is dark green to black, has plagioclase phenocrysts, and is locally propylitically altered. The andesite breccia contains up to 5 per cent calcite-rich clasts. This unit might be part of the Hazelton Group because of the porphyritic nature of the andesite, its association with calcite-bearing breccias, and its proximity to known Hazelton Group rocks.

PYROCLASTIC PACKAGE (2)

Unit 4, grey-green lithic crystal tuff, has an aphanitic groundmass that supports 10 per cent quartz and orthoclase crystals and 25 per cent lithic fragments ranging in texture from flow-banded to agglomeratic. The tuff crops out in the southwestern part of the property forming the basal unit of a shallowly westward-dipping pyroclastic sequence (Fig. 48-1). Quartz veinlets, 1 to 2 centimetres in width are common.

Unit 5, cream aphanitic ash tuff, is generally massive but locally contains up to 2 per cent smoky quartz crystals, 1 millimetre in size. The unit appears to lie conformably above unit 4 in the southwestern part of the property (Fig. 48-1). Spherulites are seen in thin section. Shallow, southwestwardly dipping quartz veinlets 2 centimetres in width are characteristic in this unit.

Unit 6, maroon K-feldspar-quartz porphyry, is a locally columnar-jointed flow extending over much of the southwestern portion of the property (Fig. 48-1). Quartz and orthoclase phenocrysts, each up to 5 per cent by volume, are suspended in a cryptocrystalline groundmass. No hydrothermal alteration is evident in this unit.

Unit 7, grey-maroon crystal tuff, marks the top of the pyroclastic package and crops out over much of the west-central part of the property (Fig. 48-1). This unit is near map units 9 and 11