

GEOLOGY AND ALTERATION OF THE MOUNT POLLEY ALKALIC PORPHYRY COPPER-GOLD DEPOSIT, BRITISH COLUMBIA (93A/12)

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INTRODUCTION

The Mount Polley deposit in south-central British Columbia (52°30'N, 121°35'W) is an alkaline porphyry copper-gold deposit (Hodgson *et al.*, 1976). The deposit, located 56 kilometres northeast of Williams Lake, is accessible from Highway 97 at 150 Mile House by 90 kilometres of secondary paved road.

Imperial Metals Corporation (Gorc *et al.*, 1992) has estimated geological reserves at 48.8 million tonnes grading

0.383 per cent copper and 0.556 gram per tonne gold in the proposed S19 open pit (Figure 2-8-1A).

Fieldwork was undertaken to study alteration zoning and its relationship to the various rock units. This was accomplished by detailed surface mapping, logging of eleven drill holes on a cross-section, and logging of 10-metre intervals from 105 drill holes at piercing points through the 1110-metre elevation, which is approximately 100 metres below the surface. Lithologies, hypogene alteration and associated mineralization are described. Preliminary statistical analyses and related plots are presented; these illustrate the spatial relationship of alteration mineral assemblages and rock types. Supergene characteristics are ignored in this paper.

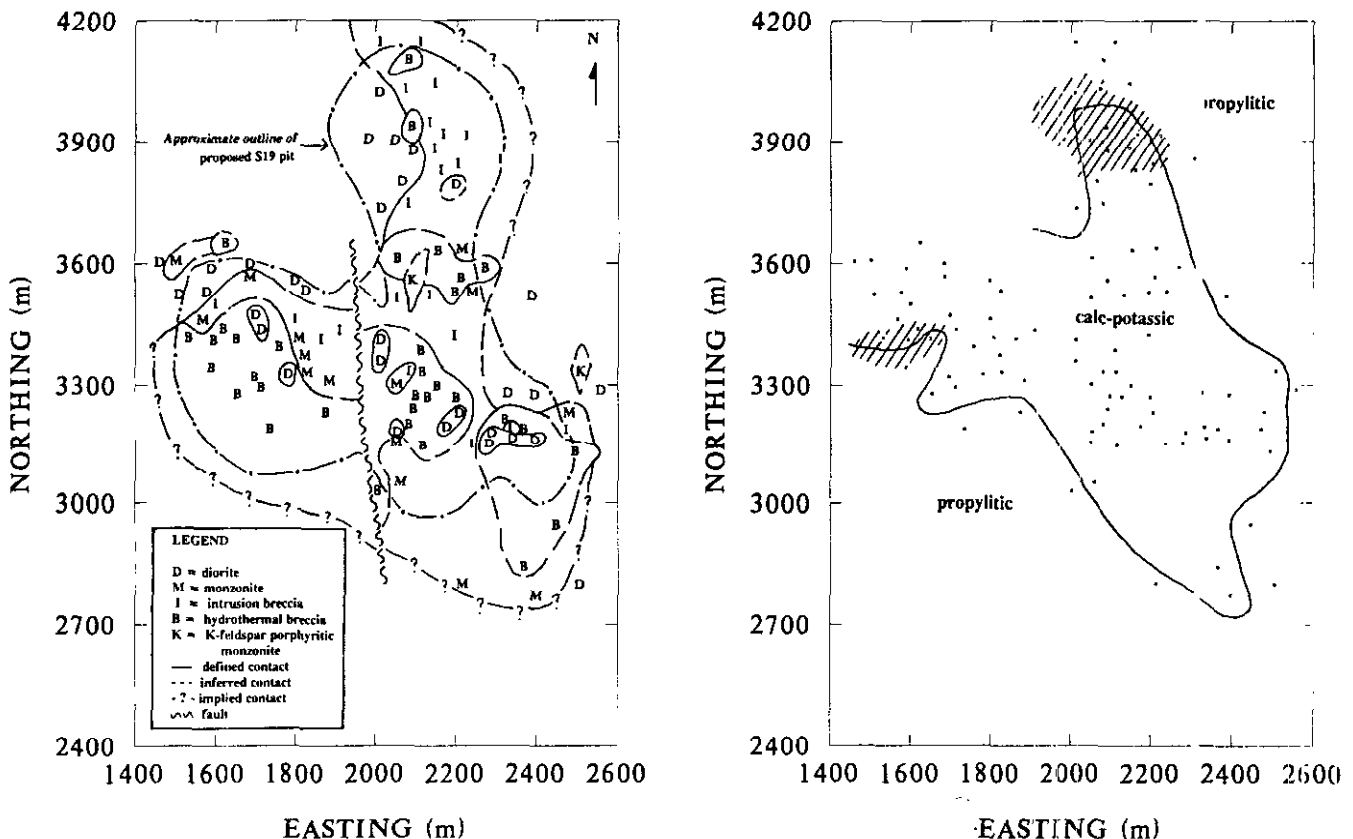


Figure 2-8-1. Geology and alteration at the 1110-metre plan level, Mount Polley, south-central British Columbia. This level is about 100 metres below the surface. (A) Rock units are plotted at drill-hole piercing points. Post-mineral dikes have been removed. Diorite outside the pit boundary may contain minor volcanic screens. (B) Distribution of the calc-potassic and propylitic alteration zones. The core of the system is characterized by a copper-gold (chalcopyrite±bornite), potassium feldspar, magnetite, diopside±albite assemblage. A peripheral propylitic zone defines a pyrite, epidote and albite assemblage. Hatched areas represent regions of overlap. The dashed-dot line is the surface outline of the proposed S19 pit.

EXPLORATION HISTORY

Copper showings were first documented at Mount Polley in 1964 during investigation of an aeromagnetic anomaly by Mastodon - Highland Bell Mines Limited and Leitch Gold Mines Limited. From 1966 to 1972 Cariboo - Bell Copper Mines Limited drilled 215 holes and conducted geophysical surveys, mapping, geochemistry and trenching. In 1979 Teck Corporation drilled six percussion holes. During 1981 and 1982, E & B Explorations Inc. confirmed and expanded the tonnage of low-grade copper-gold mineralization by drilling 42 additional holes, following ground geophysical and soil geochemistry surveys. E & B was joined by Imperial Metals Corporation in a joint venture that drilled a further 22 holes and conducted magnetometer, induced polarization, VLF-EM and soil geochemistry surveys (Imperial Metals Corporation, 1989). Imperial Metals Corporation acquired the Mount Polley property in 1988, and conducted an extensive diamond drilling program over 1988 and 1989 that totaled 238 holes. Six bulk samples were collected from surface trenches for metallurgical testing. A total of 528 drill holes (61884 metres) have been completed since 1964 (Gorc *et al.*, 1992).

REGIONAL GEOLOGY

The deposit is located within Quesnellia on the eastern margin of the Intermontane Belt. This part of Quesnellia consists of a sequence of volcanic units that dip east to northeast 5 kilometres west of the property, and dip predominantly to the west or southwest 4 kilometres east of the property (Bailey, 1987). The volcanic rocks include flows, breccias and tuffs. Volumetrically the most important are augite-porphyrific basalts to trachybasalts that locally form pillowed units. Less common are purple and maroon poly-mictic volcanic breccias, and green crystal and lapilli tuffs. An analcite-bearing flow and flow breccia are interpreted to be the youngest volcanic units in the area (Bailey, 1987).

An extensive intermediate to alkaline intrusive complex is exposed in the Bootjack - Polley Lakes area, more or less at the centre of the synclinorium that defines Quesnellia in this region. The complex is divisible into two major bodies both of which intrude a variety of volcanic rock types. A diorite intrusion, with lesser monzonite and pyroxenite, forms the hills between Polley and Bootjack lakes. This body hosts the Mount Polley deposit (Figure 2-8-1A). Three kilometres south of the deposit the diorite is intruded by a large alkaline stock. This body varies upwards, west to east, from pseudoleucite syenite porphyry through crowded orbicular syenite porphyry to granophyric syenite. The orbicules consist of pseudoleucite cores with concentric overgrowths of potassium feldspar and range up to 4 centimetres in diameter. Granophyric syenite partially overprints orbicular textures. This, combined with the concentration of granophyre in the upper part of the intrusion, apparently reflects fluid build-up during late crystallization. The granophyric syenite contains xenoliths of diorite. Thus, the granophyre is closely related in age to mineralization. It may be a source for hydrothermal fluids.

DEPOSIT GEOLOGY

The Mount Polley deposit lies within the diorite intrusive complex between Bootjack and Polley lakes. It is hosted largely by breccias of various types and related intrusive phases. Breccias and mineralization are cut by post-mineral intrusions, the most prominent being a swarm of augite porphyry dikes. Veinlet copper-gold mineralization is concentrated within the breccias and the associated alteration zone. Figure 2-8-1 represents the generalized geology and distribution of units at the 1110-metre elevation. Post-mineral dikes have been removed. A prominent north-striking fault (Hodgson *et al.*, 1976) separates the deposit into two zones, the west and central zones of the proposed S19 pit. Rock types are described from oldest to youngest.

Diorite is homogeneous, equigranular, medium to dark grey and fine grained. It consists of up to 70 per cent plagioclase and varying percentages of biotite, green pyroxene and finely disseminated magnetite. Xenoliths of volcanic country rock occur locally. Peripheral to the deposit, the diorite is relatively fresh with only minor (<5%) crosscutting albite veins with potassium feldspar envelopes. Within the deposit, diorite is characteristically pervasively flooded with potassium feldspar (up to 25%) and amphibole-diopside-magnetite veinlets with pink potassium feldspar envelopes.

Monzonite and intrusion breccia are complexly related and intrusive into the diorite. They occupy the centre of the proposed pit. The intrusion breccia has a monzonite matrix and is dominated by rounded to subangular fragments and blocks of diorite that range from 3 centimetres to 12 metres in diameter. Fragments of volcanic rock occur locally. The breccia is matrix supported and locally contains up to 35 per cent clasts. The monzonite is characterized by 40 per cent rounded plagioclase phenocrysts, about 1 millimetre in diameter, in a fine-grained matrix dominated by pink potassium feldspar with lesser pyroxene and magnetite, and traces of biotite. In the strongly brecciated areas, the matrix of the monzonite is interpreted to be largely secondary with intense pink potassium feldspar alteration. Larger areas of homogeneous monzonite are pinkish grey in colour and plagioclase has a seriate texture.

Hydrothermal breccia occurs in three main areas at the plan level. These are generally at the contact between diorite and monzonite or intrusion breccia. The breccia is polyolithic and is characterized by clasts of diorite, monzonite and intrusion breccia. It is therefore younger than the intrusion breccia. Hydrothermal breccia weathers recessively because of intense alteration and is poorly exposed at surface. In drill core, more compact phases of the breccia are mottled with potassium feldspar and pale albite. This obliterates primary textures and clast boundaries. Hydrothermal breccia is characteristically vuggy and porous. Coarse-grained secondary biotite, prismatic albite crystals (up to 1.5 cm long), and fine-grained magnetite and diopside commonly fill vugs.

The hydrothermal breccia is syn-mineral and is strongly stockworked with chalcopyrite + diopside + magnetite ± amphibole veinlets. The matrix also contains finely dissemi-

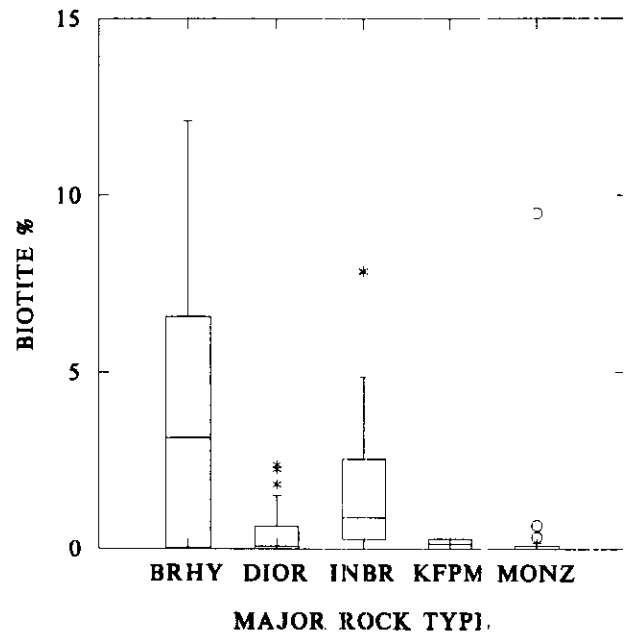
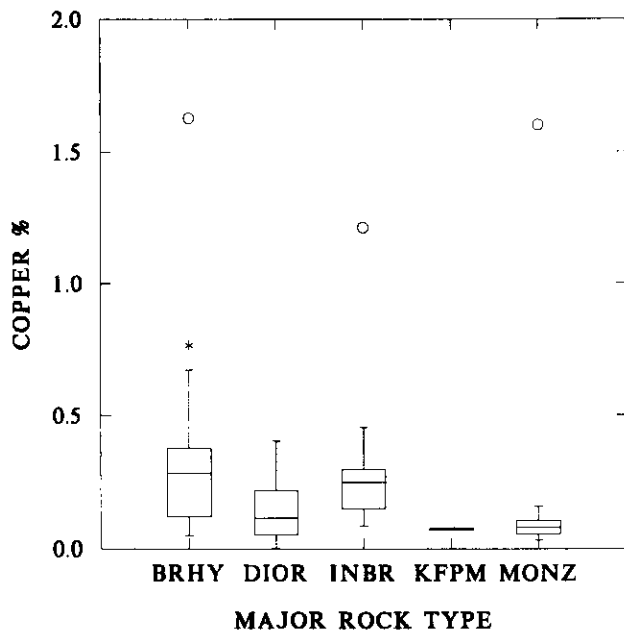


Figure 2-8-2. Box plots of total copper assay value and biotite versus major rock type. BRHY = B (in Figure 2-8-1) = hydrothermal breccia, DIOR = D = diorite, INBR = I = intrusion breccia, KFPM = K = potassium feldspar porphyritic monzonite, PLPP = P = monzonite. (A) Highest copper assays are in the hydrothermal and intrusive breccias. (B) Secondary biotite is rock specific. It is well developed in the hydrothermal breccia, and to a lesser degree, in the intrusive breccia.

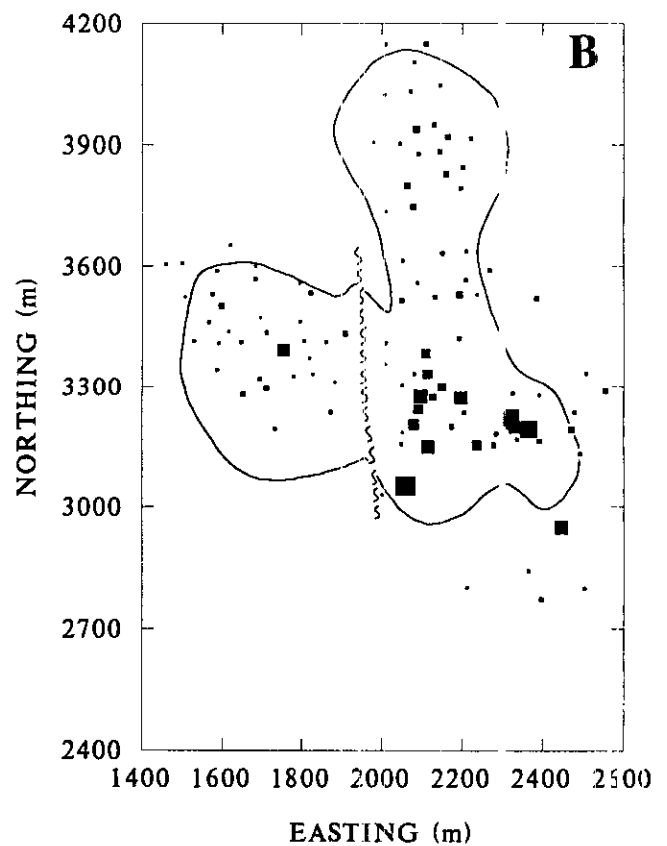
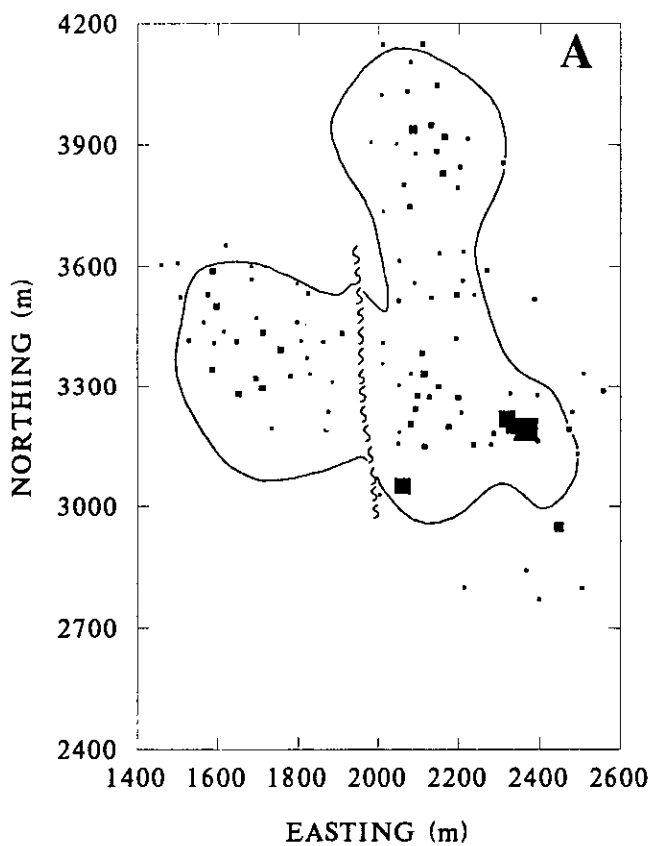


Figure 2-8-3. Bubble plots of total copper assay value and gold (ppb) at the 1110-metre plan level, Mount Polley. (A) The highest copper grade is in the south-central zone of the pit. Bubble size is proportional to percentage; largest bubble = 2.33%, and smallest bubble = 0%. (B) The highest gold grade is in the south-central zone of the pit and correlates with copper. Bubble size is proportional to grade; largest bubble = 2560 ppb, and smallest bubble = 0 ppb. The solid line is the surface outline of the proposed S19 pit.

nated chalcopyrite. Generally the highest copper and gold assays can be correlated with these breccias (Figures 2-8-2 and 2-8-3).

Potassium feldspar porphyritic monzonite occurs as dikes and pods in the centre of the proposed pit area. This unit is weakly altered and probably late-mineral. Hostrock xenoliths are found at the margins of these intrusive bodies. About 20 per cent of the porphyritic monzonite is trachytic with zoned, euhedral potassium feldspar phenocrysts that average 6 millimetres long by 1 millimetre wide. Locally, these phenocrysts have dimensions up to 2 centimetres by 2 millimetres. The potassium feldspar phenocrysts in less altered rock are translucent to beige; more altered specimens have opaque, pink to white phenocrysts. The groundmass consists of 50 per cent subhedral plagioclase laths, approximately 1 by 0.5 millimetre, with minor disseminated magnetite and augite.

Augite porphyry dikes are unaltered and clearly post-mineral. They occur as swarms throughout the deposit, striking north and dipping steeply to the east, with an average thickness of 4 metres. On surface, the dikes are continuous along strike for at least 100 metres.

Chilled margins of most dikes are up to 15 centimetres in width and are aphanitic, dark reddish brown, with approximately 3 per cent very fine grained plagioclase laths aligned parallel to the contact. Trace augite phenocrysts are occasionally present in the chilled margin. The visual appearance of the dikes varies with groundmass composition; two end members are prominent. The first has 40 per cent fine grained euhedral augite phenocrysts, 1 per cent disseminated magnetite and rare plagioclase laths in a dark grey, very fine grained groundmass. The second has 55 per cent augite phenocrysts, 3 per cent disseminated fine-grained magnetite, and a felsic groundmass consisting of fine-grained plagioclase with sparse subhedral plagioclase phenocrysts.

Intermediate dikes are numerous, friable, grey-green to yellow, fine grained and locally vesicular. They are concentrated in the western part of the pit. The dikes vary from biotite lamprophyre to andesite or dacite in composition and are probably of Tertiary age. Their orientation is similar to the augite porphyry dikes.

ALTERATION AND MINERALIZATION

Visual estimates of the percentages of alteration minerals were made during core logging of intervals on the 1110-metre level. Statistical analysis is restricted to data from this level. SYSTAT-SYGRAPH software (Wilkinson, 1990), was used to analyse and display this data. Two distinct alteration suites are defined: a copper-gold bearing calc-potassic alteration zone that is centred on intrusive and hydrothermal breccias, and a peripheral propylitic zone with low levels of copper and gold. An inferred contact between the calc-potassic and the propylitic zones is shown in Figure 2-8-1B; hatched areas represent areas of overlap. The propylitic zone is peripheral to the deposit but its lateral extent is poorly defined due to a lack of drill holes outside the proposed S19 pit. Post-mineral anhydrite and calcite veins are a widespread component of both alteration zones. The

alteration pattern is a refinement of that presented by Hodgson *et al.* (1976). Future analysis will investigate the detailed relationship of alteration to different lithologies, particularly breccias, and the spatial distribution of all alteration minerals.

CALC-POTASSIC ALTERATION

Calc-potassic alteration, coincident with copper-gold mineralization, is concentrated within the proposed pit area. It is dominated by chalcopyrite, pervasive potassium feldspar, biotite, diopside, albite and magnetite.

Copper and gold assay values are closely correlated and are highest in the hydrothermal and intrusion breccias (Figure 2-8-2A). Copper and gold distributions on the plan level are shown in Figure 2-8-3. The highest copper and gold grades occur in the southern part of the central zone in the eastern part of the proposed pit. Copper occurs dominantly as chalcopyrite with traces of bornite. The most common vein assemblage consists of chalcopyrite, magnetite and diopside with or without pyrite. Chalcopyrite also occurs as fine-grained disseminations in the matrix of hydrothermal breccia, and rarely as breccia cement. Bornite is rare, but is found in chalcopyrite-rich areas. Gold is not macroscopically visible, but may be contained within chalcopyrite because of the close copper-gold association (Figure 2-8-3).

Potassium feldspar is present throughout the deposit but is concentrated in the breccias. This alteration is pink, fine grained and usually pervasive. Visually estimated percentages vary from 15 to 70. Minor potassium feldspar occurs as vein envelopes. Potassium feldspar correlates poorly with other alteration minerals; this may reflect the difficulty of distinguishing primary from secondary potassium feldspar.

Biotite is abundant, averaging 5 per cent in vugs in the hydrothermal breccia. Flakes from 1 millimetre to 1 centimetre in width are common. The association of visible secondary biotite with the hydrothermal breccias is illustrated by Figure 2-8-2B. Secondary biotite has developed to a lesser extent within the intrusion breccia, possibly due to its more competent nature. Secondary biotite coincides with the spatial distribution of breccia; concentrations are generally higher in the central zone than the west zone.

Magnetite occurs as fine-grained disseminations, up to 5 per cent, and in veinlets throughout the deposit; it also forms the matrix to some breccias. The distribution of vein magnetite (Figure 2-8-4A) is erratic, and is less specific to rock type than biotite. Veinlet assemblages commonly consist of: magnetite + diopside ± amphibole ± chalcopyrite, diopside + magnetite + chalcopyrite ± pyrite and magnetite + chalcopyrite ± pyrite.

Diopside is a ubiquitous alteration mineral and occurs as fine-grained disseminations (5%) within the hydrothermal and intrusion breccias. It typically occurs as diopside + magnetite ± chalcopyrite ± amphibole + albite veinlets, usually with potassium feldspar envelopes.

Albite (field term) is an important alteration mineral, with concentrations up to 30 per cent. It is particularly abundant in the west zone where it causes pervasive bleach-

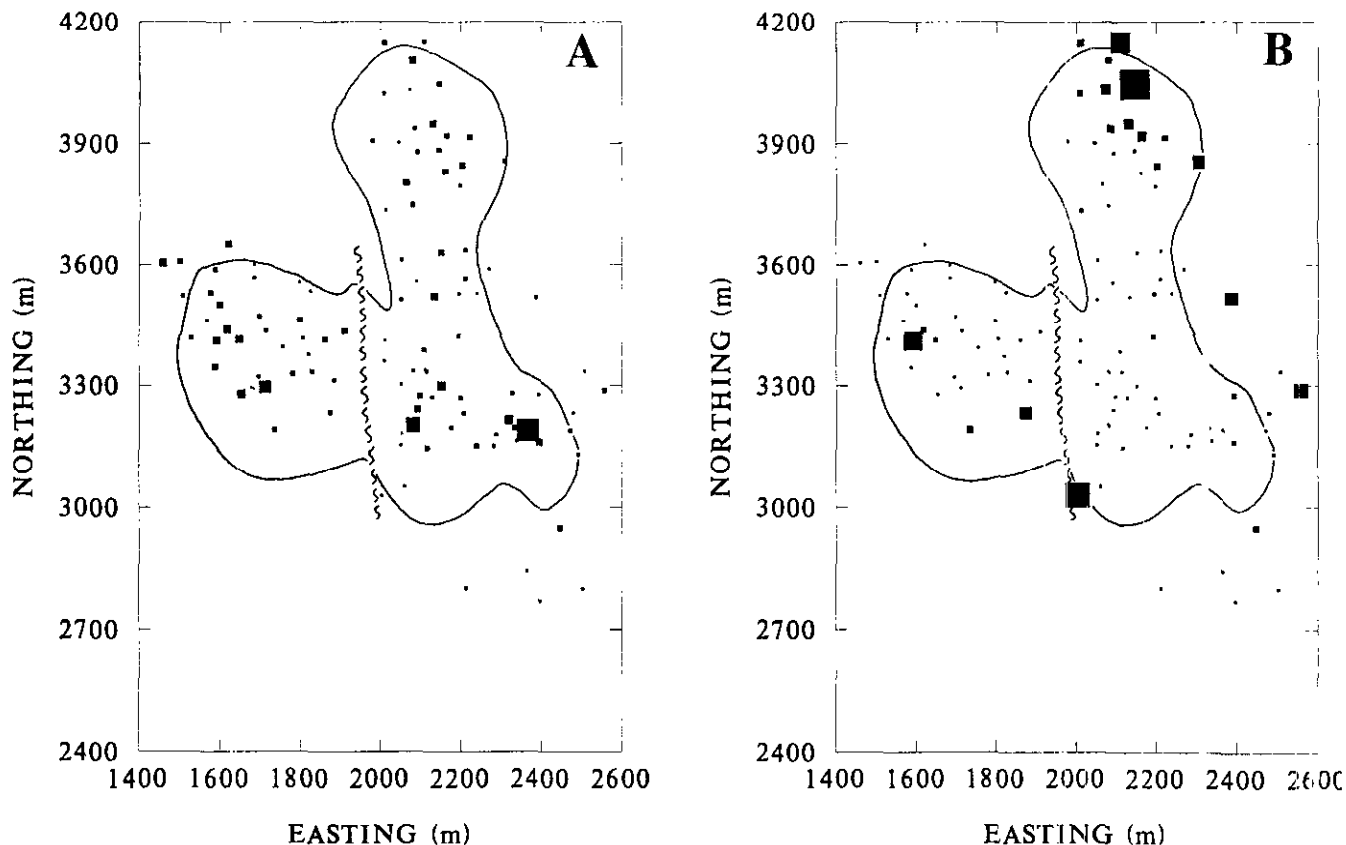


Figure 2-8-4. Bubble plots of visually estimated secondary magnetite and pyrite at the 1110-metre plan level, Mount Polley. (A) The distribution of magnetite is irregular, and is not rock specific. Magnetite veining is present in all rock units. Bubble size is proportional to percentage; largest bubble = 13.63%, and smallest bubble = 0%. (B) Pyrite is peripheral to the deposit and marks the propylitic assemblage. There is some overlap on the calc-potassic zone. Bubble size is proportional to percentage; largest bubble = 4.2%, and smallest bubble = 0%. The solid line is the surface outline of the proposed S19 pit.

ing. Vugs in hydrothermal breccias in both the central and west zones contain euhedral albite. Albite also occurs in the propylitic zone.

PROPYLITIC ALTERATION

Propylitic alteration, peripheral to the calc-potassic alteration zone, is developed outside the proposed pit area. Generally, the rocks are weakly altered compared with the calc-potassic zone. Pyrite, epidote and albite dominate most assemblages.

Pyrite forms veinlets up to 2 millimetres wide and averages approximately 1 per cent of the rock volume. Pyrite distribution is not rock specific and occurs as veinlets in both breccias and the diorite. The highest concentrations of pyrite are on the northeast and southwest margins of the calc-potassic alteration zone (Figure 2-8-4B), suggesting the development of a pyrite halo within peripheral propylitic alteration.

Epidote is present in minor quantities and occurs as fine-grained disseminations throughout all syn-mineral units. It characteristically occurs in veinlets with calcite. The spatial distribution of epidote correlates closely with that of pyrite on the periphery of the mineralized zones. This relationship was noted by Hodgson *et al.* (1976).

Albite, often associated with diopside, occurs locally as minor veins accounting for less than 2 volume per cent of the altered diorite.

CONCLUSIONS

The alkalic porphyry copper-gold system at Mount Polley is associated with a series of intrusions and breccia bodies. The intrusive suite that hosts the deposit ranges from pyroxenite to monzonite and is dominated by diorite. Breccias are divisible into intrusion breccias with an igneous monzonitic matrix, and hydrothermal breccias with a porous and vuggy matrix. The emplacement of the monzonite, formation of the intrusion breccia and alteration probably represent a continuum of orthomagmatic processes. Specifically, hydrothermal breccias containing a calc-potassic vug-filling alteration assemblage probably are of orthomagmatic origin. Hydrothermal breccias are also the major host for better grade mineralization, which consists of disseminated and stockwork chalcopyrite, bornite and magnetite.

The calc-potassic alteration zone dominates the core of the deposit. Pervasive potassium feldspar commonly obliterates primary textures. Disseminated magnetite, diopside-amphibole-chalcopyrite veinlets and coarse biotite in hydrothermal breccias are characteristic. Peripheral pro-

pylitic alteration overlaps the outer margin of the potassic zone and is prominent outside the proposed S19 pit. The assemblage consists of pyrite veinlets, epidote disseminations and albite-diopside veins.

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