KATIE – AN ALKALINE PORPHYRY COPPER-GOLD DEPOSIT IN THE ROSSLAND GROUP, SOUTHEASTERN BRITISH COLUMBIA (82F/3W)

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KEYWORDS: Economic geology, Katie, Jim, alkaline porphyry, copper, gold, silver, Rossland Group, Elise Formation, potassic alteration, propylitic alteration, sericitic alteration, mylonite, shear zone.

INTRODUCTION

The Katie deposit (49°08′00″, 117°19′50″, MINFILE 82FSW290) is located 7.0 kilometres southwest of the town of Salmo (Figure 2-1-1). Access to the property is via the 6-kilometre Hellroaring Creek logging road, which leaves Highway #3, 2 kilometres south of Salmo. Topography consists of gentle to moderately steep slopes ranging in elevation from about 1250 to 1700 metres. Outcrop on the property is sparse due to extensive glacial deposits which locally attain thicknesses of up to 50 metres.

Low-grade porphyry copper-gold mineralization is hosted by mafic to intermediate alkaline to subalkaline volcanic rocks of the Lower Jurassic Elise Formation of the Rossland Group. The rocks exhibit variable potassic and propylitic alteration associated with disseminated and stockwork pyrite, chalcopyrite and magnetite. This geological setting is similar to that of the alkaline suite of porphyry copper deposits as defined by Barr *et al.* (1976) and McMillan (1991), which includes Copper Mountain, Afton, Mount Milligan and Galore Creek. Katie is the most easterly significant example of this deposit class found to date in the Canadian Cordillera. Similar showings in the Rossland Group occur near Nelson and include the Star (Dawson *et al.*, 1989) and Shaft (Andrew and Höy, 1989).

Distinct but relatively minor gold and silver-bearing quartz-dolomite veins with minor pyrite, chalcopyrite, tetrahedrite, arsenopyrite and molybdenite crosscut the porphyry stockwork. Specular hematite has also been tentatively identified. These veins follow mylonitic shear zones which are altered to an assemblage of sericite, quartz and carbonate.

This paper presents a summary of the property geology and exploration results to date and details the results of core logging and petrography completed during 1992.

EXPLORATION HISTORY

Anomalous copper values in Hellroaring Creek stream sediments were first indicated by the 1977 National Geochemical Reconnaissance Survey (GSC Open File 514). The earliest recorded exploration work in the area was a geochemical survey completed on the Jim claims by Amoco Canada Petroleum Company Limited in 1980. This survey indicated "a zone of anomalous copper values in soils ... with values over 100 ppm over an area of 1200 m by 300-400 m" (MacIsaac, 1980). No further work was done and the claims were allowed to lapse. From 1982 onwards, exploration on the adjacent Gus, Swift, Elise and Lisa claims was focused on shear-hosted gold-silver targets (Andrew and Höy, 1990).

The Katie claim group (Figure 2-1-1) was staked by prospector Ken Murray in 1985 to cover the Amoco copper anomaly. Soil geochemistry carried out by Murray further defined the anomaly and established the presence of partially coincident gold anomalies (Murray, 1987). Balloil Lassiter Petroleum Limited optioned the property in 1988 and completed geological and geophysical surveys and drilled four diamond-drill holes totalling [illegible]05 metres in 1989. The best intersection, in hole KT-89-4, assayed 0.24 per cent copper and 0.20 gram per tonne gold over 6.0 metres (McIntyre and Bradish, 1990).

Yellowjack Resources Limited acquired Balloil's interest in 1990 and formed a joint venture with Hemlo Gold Mines Inc. and Brenda Mines Limited to explore the property. As operator, Noranda Exploration Company, Limited conducted further geological, geochemical and geophysical surveys and drilled 34 diamond-drill holes totalling 8260 metres (McIntyre and Bradish, 1990; McIntyre, 199[illegible]; Kemp, 1992). Yellowjack took over as operator in 1992 and drilled an additional 18 holes totalling 4477 metres.

The drilling has delineated three areas of low-grade porphyry copper-gold mineralization, named the "Main", "West" and "17" zones (Figure 2-1-2). To date, no mineral inventory figure has been released by the owners.

REGIONAL GEOLOGY

The Katie property is underlain mainly by mafic to intermediate volcanic rocks of the Lower Jurassic Rossland Group, the easternmost part of the Quesnel Terrane. Just a few kilometres south of the property the Rossland Group is juxtaposed against Paleozoic rocks of the Kootenay Terrane by the Waneta fault, a steep west-dipping thrust fault (Figure 2-1-1).

The Rossland Group in the Salmo area comprises a basal succession of fine and coarse-grained clastic rocks of the Archibald Formation, volcanic and epiclastic rocks of the Elise Formation and overlying fine-grained clastic rocks of the Hall Formation. These rocks have been well described by Little (1950; 1960; 1965; 1985), Frebold and Little (1962), Frebold and Tipper (1970), Höy and Andrew (1988; 1989a; 1989b; 1989c; 1990a; 1990b), Andrew *et al.* (1991) and Dunne and Höy (1992).

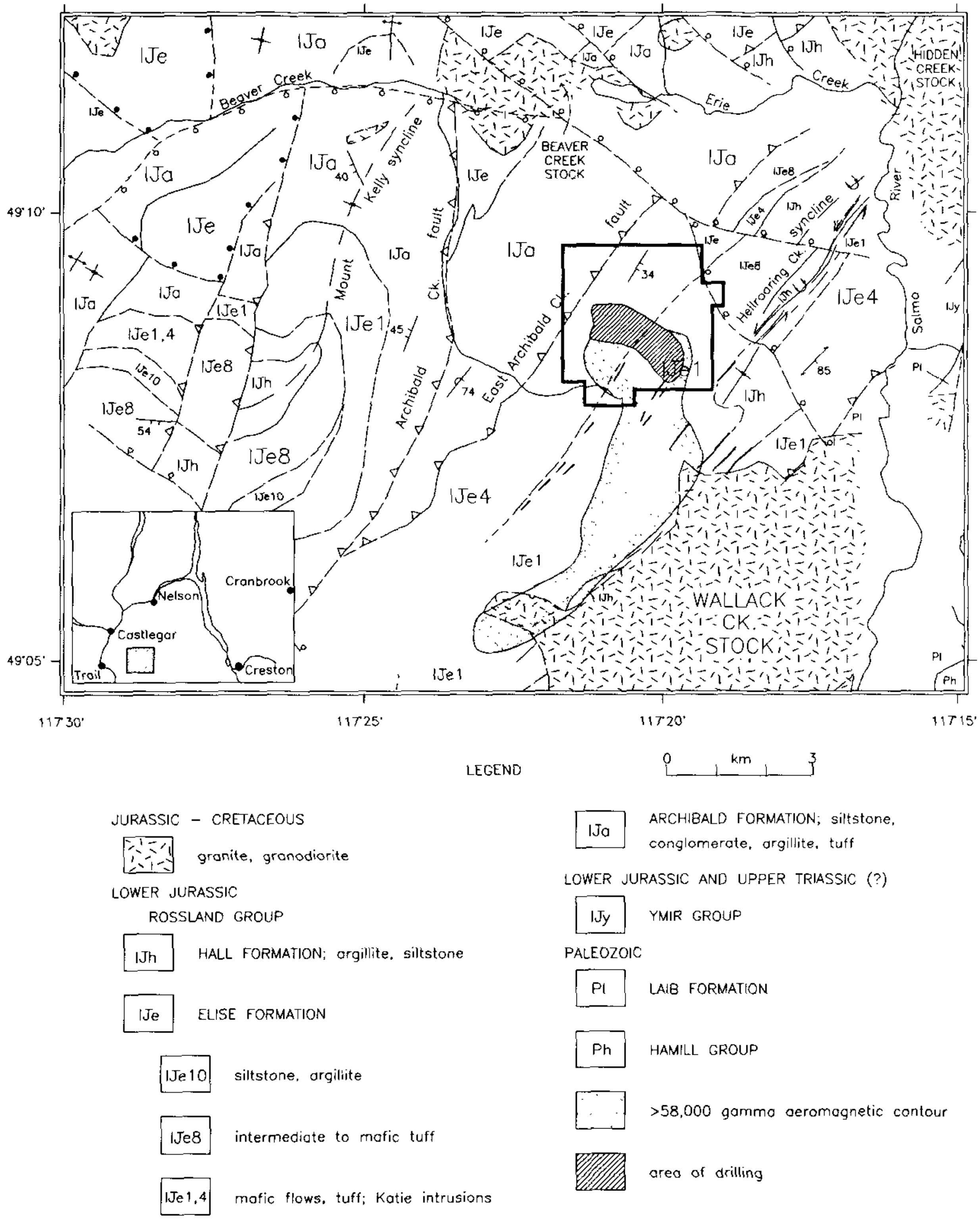

Figure 2-1-1. Location and regional geology map of the Katie property (after Höy and Andrew, 1990a). Katie claim group is shown by bold line. Magnetic data from GSC Map 8479G.

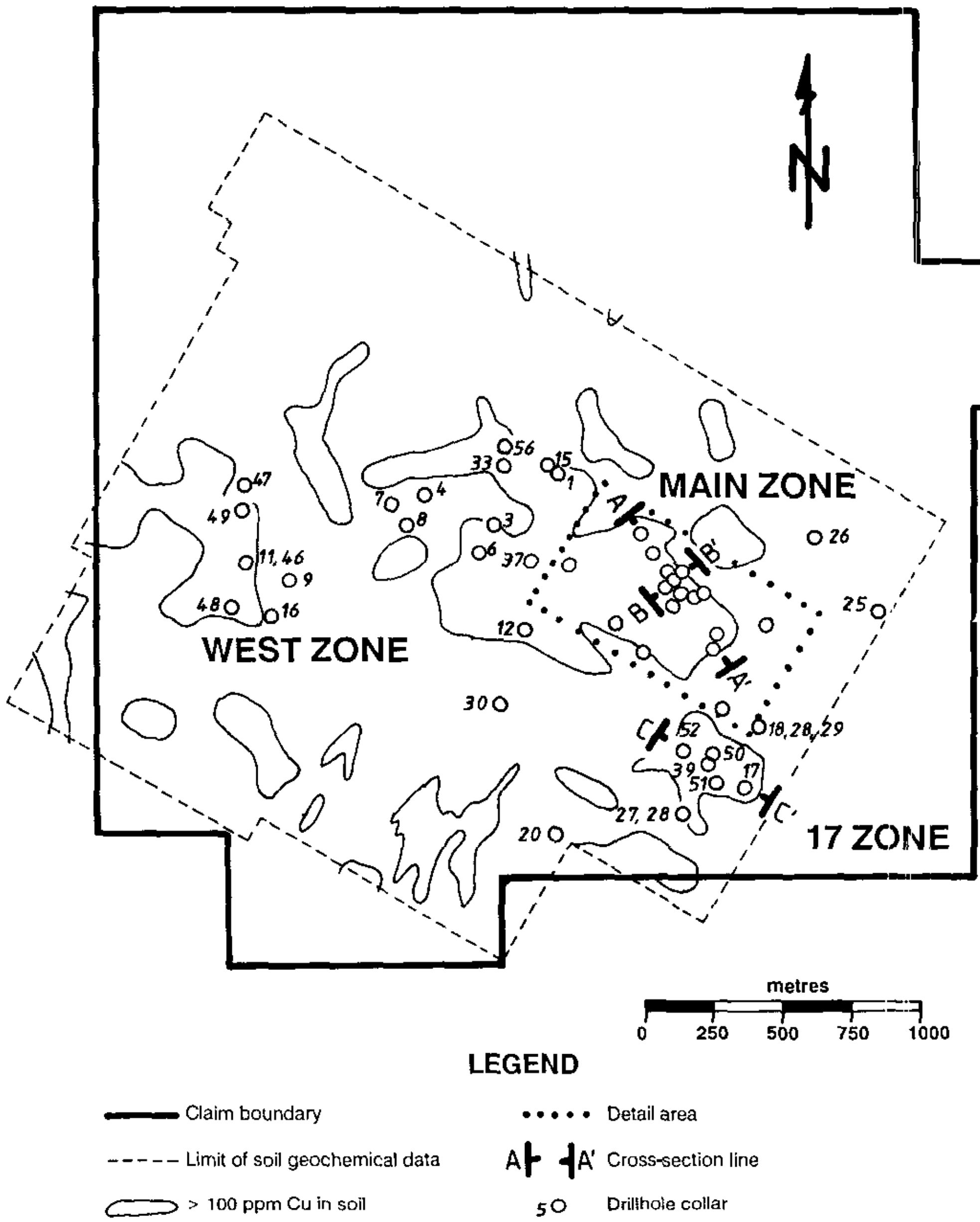

Figure 2-1-2. Drillhole plan for the Katie property. The location of Figure 2-1-3 is shown by the heavy dotted line. The locations of cross-section lines are also shown (*see* Figure 2-1-4).

Drill information from the Katie property indicates that the Elise Formation in this area is composed of mafic to intermediate volcanic rocks intruded by numerous subvolcanic gabbro to monzonite dikes and sills. These intrusive rocks, informally known as the "Katie intrusions", are assumed to be roughly syn-Elise in age. They are described in detail below.

The earliest structures in the Katie area (*ca.* 180 Ma) are tight folds, locally associated with a penetrative mineral foliation and intense shearing and thrusting (Höy and Andrew, 1990a). These structures are more pronounced and evident near the Waneta fault where the Hellroaring Creek syncline, an overturned, east-dipping syncline exposes Hall Formation in its core and sheared Elise Formation in its limbs. This syncline may be the southern extension of the Hall Creek syncline in the Nelson area (Höy and Andrew, 1990a).

To the south of the Katie claims, a number of northeast-trending shear zones formed during this early deformation event. Several of these can be seen in surface exposures and are characterized by intense carbonate-sericite-silica alteration (Andrew and Höy, 1990). Northwest-trending shear zones interpreted from Katie drill core may be the folded equivalents of these surface exposures.

North to northeast-trending, east-verging thrust faults post-date shearing along the Waneta fault. These include the steeply west dipping Archibald and East Archibald Creek faults on the west side of the Katie property (Figure 2-1-1).

The compressional structures are sealed by Middle Jurassic and Late Cretaceous intrusions such as the Beaver Creek, Wallack Creek and Salmo stocks (Figure 2-1-1). Late northwest-trending normal faults offset earlier thrust faults and cut both Jurassic and Cretaceous intrusions. These late faults are probably related to Eocene extensional tectonics (Parrish *et al.* 1988; Corbett and Simony, 1984).

Despite proximity to the tectonic boundary between Quesnellia and North America, Rossland Group rocks are relatively undeformed except within about 2 kilometres of the Waneta fault where they are penetratively deformed. Regional metamorphic grade of the Rossland Group is low in the Salmo area, but increases to the north in the Nelson area.

A strong (250 gamma), northeast-trending regional magnetic anomaly measuring 2 by 8 kilometres (Figure 2-1-1), overlies the property and probably reflects a magnetite-rich intrusion or volcanic unit (GSC Map 8479G).

ROCK TYPES

Outcrops on the property are rare and rock types are described mainly from drill core. Lithologies are described in order from oldest to youngest.

Lower Jurassic Rossland Group

UNIT lJev: ANDESITIC TO BASALTIC FLOWS AND TUFFS

The property is mainly underlain by variably altered volcanic rocks of the Lower Jurassic Elise Formation. They are medium to dark greenish grey in colour, weakly to moderately magnetic and generally massive to vaguely laminated. Although alteration has partially obscured the original textures, large pyroxene and feldspar phenocrysts are common and easily discernible in hand specimen. Pyroxene phenocrysts are subhedral to euhedral, range in size from 1 to 10 millimetres and average 2 to 3 millimetres. Feldspar phenocrysts are subhedral to euhedral and lath-like, average 2 to 3 millimetres in length and usually appear altered. The dominance of pyroxene and feldspar-phyric rocks suggests that most of this unit is part of the lower member of the Elise Formation (Höy and Andrew, 1988).

This unit is further subdivided into flow and flow breccia (lJe4), monolithic pyroclastic breccia (lJe2) and lapilli (lJe8l), crystal (lJe8x) and fine (lJe7f) tuff (Table 2-1-1) corresponding to the nomenclature of Andrew *et al.* (1991). Petrographically, flow units are distinguished from tuffs by trachytic alignment of feldspars, local calcite or quartz-filled amygdules and absence of broken crystals. Despite the apparent presence of pyroxene in hand sample, primary pyroxene phenocrysts are completely altered and replaced by actinolite, chlorite, epidote and biotite (Plate 2-1-1). Plagioclase varies from andesine to labradorite; the anorthite content is often obscured by saussuritization or sericitization of feldspar cores (Plate 2-1-2), replacement of rims by potassium feldspar or plagioclase zoning. Apatite is an accessory mineral in virtually all the Elise volcanic rocks. In tuffs, apatite phenocrysts are often broken (Plate 2-1-3).

UNIT lJga: KATIE INTRUSIONS

Intrusive rocks at the Katie property are generally pale green and grey spotted, moderately magnetic and medium to coarse grained. They range in composition from gabbro to monzonite and are composed of nearly equal proportions of anhedral to subhedral pale grey to greenish grey feldspar and subhedral dark green mafic minerals, mainly hornblende and lesser pyroxene. Grain size ranges from about 1 to 3 millimetres. In drill core, these intrusive lithologies alternate with volcanic rocks suggesting that they probably occur as thick sills or dikes. The rock often has a heterogeneous appearance with partially assimilated fragments of gabbroic or volcanic material: a texture that is more typical of a hybrid border phase than an intrusive breccia (V.A. Preto, personal communication, 1992).

In thin sections, intrusive rocks are mainly equigranular and granophyric (Plate 2-1-4), although porphyritic phases are also represented. They range from mafic to intermediate in composition. The mafic phases contain 15 to 40 per cent plagioclase (An_{50-65}) and lesser potassium feldspar (5 to 15%; Table 2-1-1). Primary quartz is generally absent. Pyroxene and hornblende are altered to actinolite, epidote, chlorite and carbonate. Feldspars are commonly sericitized (Plate 2-1-4) or saussuritized. Apatite occurs as an accessory mineral.

More intermediate phases comprise 15 to 40 per cent plagioclase (An_{10-45}) and 15 to 30 per cent potassium feldspar, including perthite (Plate 2-1-5). The abundance of potassium feldspar and perthite is probably due to potassic alteration. Hornblende is rarely partially preserved as ragged grains. Commonly chlorite, epidote and calcite replace primary amphibole and pyroxene. Sphene is often present as an accessory mineral; apatite is notably absent.

Based on primary mineral assemblages in thin section, the Katie intrusons are mainly gabbro to monzogabbro in composition with some more monzonitic varieties (Table 2-1-1). The variation, however, may be due to the increase in the potassium feldspar (and quartz) content in some specimens and could in part be an effect of the strong potassic alteration. Due to this alteration, discrimination of the protolith by whole-rock analysis is inappropriate.

The lack of sharp intrusive contacts and chilled margins, and the similar overall petrographic composition, suggest that the Katie intrusions were emplaced into the Rossland Group as synvolcanic intrusions. They incorporate partially assimilated gabbroic or volcanic phases and occur near a major regional structure (in the core of the Hellroaring Creek syncline). These features are characteristic of other complex subvolcanic intrusions in the Rossland Group including the Eagle Creek Complex (Dunne and Höy, 1992) and the Shaft gabbro (Andrew and Höy, 1989).

UNIT lJh: BLACK ARGILLITE AND SILTSTONE

Fissile black carbonaceous argillite and siltstone of the Lower Jurassic Hall Formation outcrops on the east side of the property (Höy and Andrew, 1990a). Similar black argillite and greywacke are also present in hole 25 to the northeast of the Main zone and are interpreted to be Hall Formation.

TABLE 2-1-1
PETROGRAPHIC CHARACTERISTICS OF THE LOWER JURASSIC ROSSLAND GROUP AT THE KATIE PROPERTY (082F/03W), SOUTHEASTERN BRITISH COLUMBIA

	Primary		Alteration		
Unit	**Phenocrysts%**	**Groundmass%**	**Replacement% (of phenocrysts)**	**Pervasive%**	**Vein%**
VOLCANIC ROCKS:					
andesite/basalt flow/flow breccia (lJe4)	plagioclase 10 apatite 1	opaques 2	sericite 10 chlorite 10 calcite 10	quartz 30 sericite 25	calcite 2 quartz 1 opaques 1
andesite/basalt lapilli tuff (lJe8l)	plagioclase 3 (An45-60) apatite 1-2	opaques 1-3	epidote 20-40 chlorite 5-10 actinolite 2-5 sphene trace	k-spar 10-20 quartz 10-15 chlorite 0-20 epidote 5-7	quartz 2 epidote 1-3 k-spar 1 biotite 1
andesite/basalt crystal tuff (lJe8x)	plagioclase 15-30 (An55-62) k-spar 2 apatite 1-2	hornblende 0-10 opaques 1-7	chlorite 1-15 albite 0-15 epidote 0-7 sericite 5 calcite 0-5 biotite 0-5 actinolite 0-5 k-spar 1-5	quartz 25-35 sericite 0-10	calcite 0-5 quartz 0-5 k-spar 0-1 opaques 1
latite fine tuff (Je7f)	plagioclase 20 (An45-60) k-spar 15-20 apatite 1	opaques 2-3	calcite 20 sericite 10 chlorite 10 biotite 0-5 albite 0-2	sericite 0-40 chlorite 0-15 quartz 2	

INTRUSIVE ROCKS:					
gabbro (lJmga)	plagioclase 15-25 (An 50) apatite 1	perthite 15 opaques 5	actinolite 25 quartz 5-15 k-spar 3-25 calcite 1-10 sericite 1-5	chlorite 40	calcite 1 opaques 1
monzogabbro (lJmga)	apatite 1	plagioclase 15-40 (An 55-60) k-spar 5-15 opaques 0-2	chlorite 15 sericite 10 leucoxene 1-7 calcite 2-3 actinolite 2 epidote 1-3 quartz 1	albite 1	epidote [illegible] calcite 1 quartz 1 opaques 1
monzodiorite (lJmga)		plagioclase 15-40 (An30-45) perthite 30 quartz 10 k-spar 3 opaques 0-5	chlorite 10 epidote 5 calcite 5 actinolite 0-20 leucoxene 3 sericite 1	chlorite 0-5	calcite 3 epidote 0-3 quartz 1
monzonite (lJmga)		plagioclase 20-30 (An10-30) k-spar 15-20 quartz 10 opaques 2	k-spar 30 actinolite 10 epidote 5 sericite 5 quartz 3-10 calcite 3 sphene 3	calcite 5 chlorite 2 quartz 1	calcite 2 epidote [illegible] quartz 1 calcite 1

1. Based on analyses of 20 thin sections from DDH 13, 39, 53 and 56 and private report for YellowJack Resources Ltd. by Getsinger (1992)
2. Table format after Ross (1992)

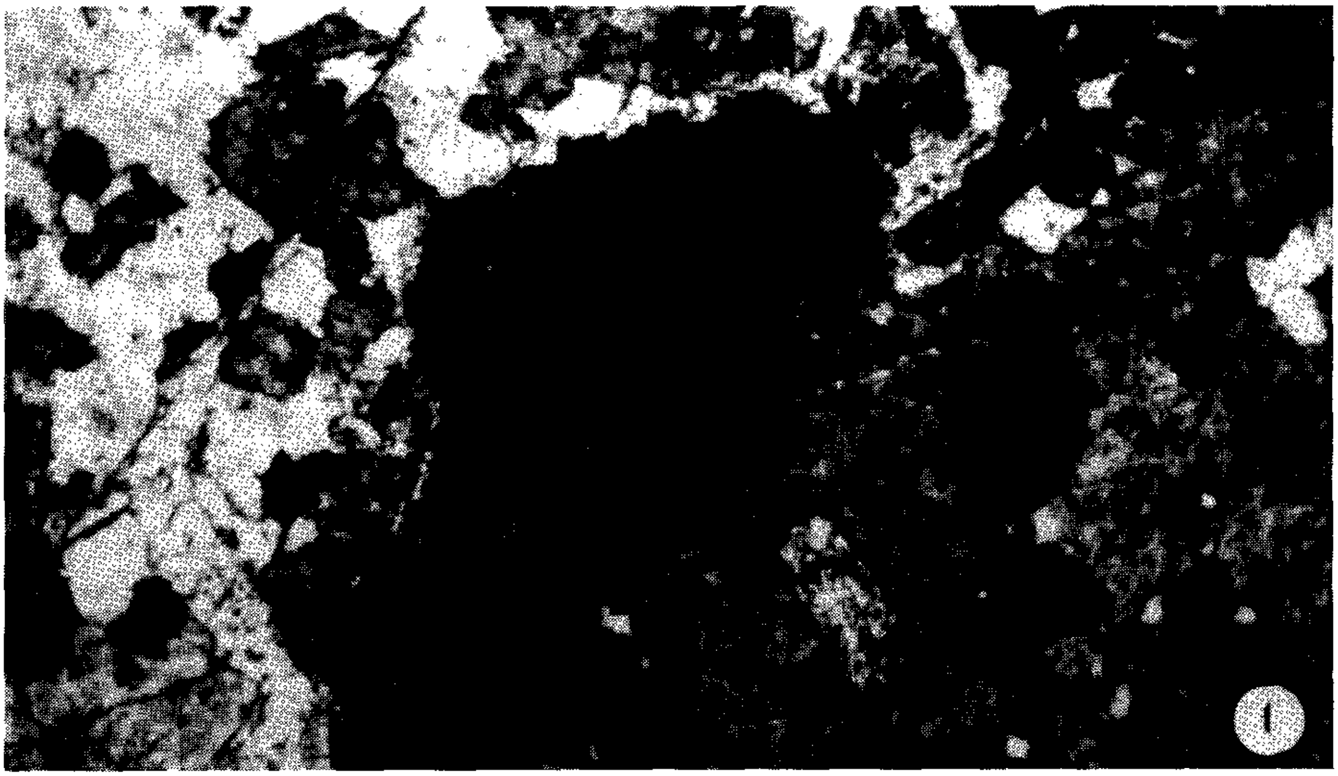

Plate 2-1-1. Pyroxene replaced by actinolite and carbonate in monzogabbro. Matrix dominated by potassium feldspar. Also note primary magnetite grains (dark grey) with needles of rutile. Katie DDH 41-176.7 metres (from McDonald, 1992; ppl + reflected light, field of view = 5.1 mm).

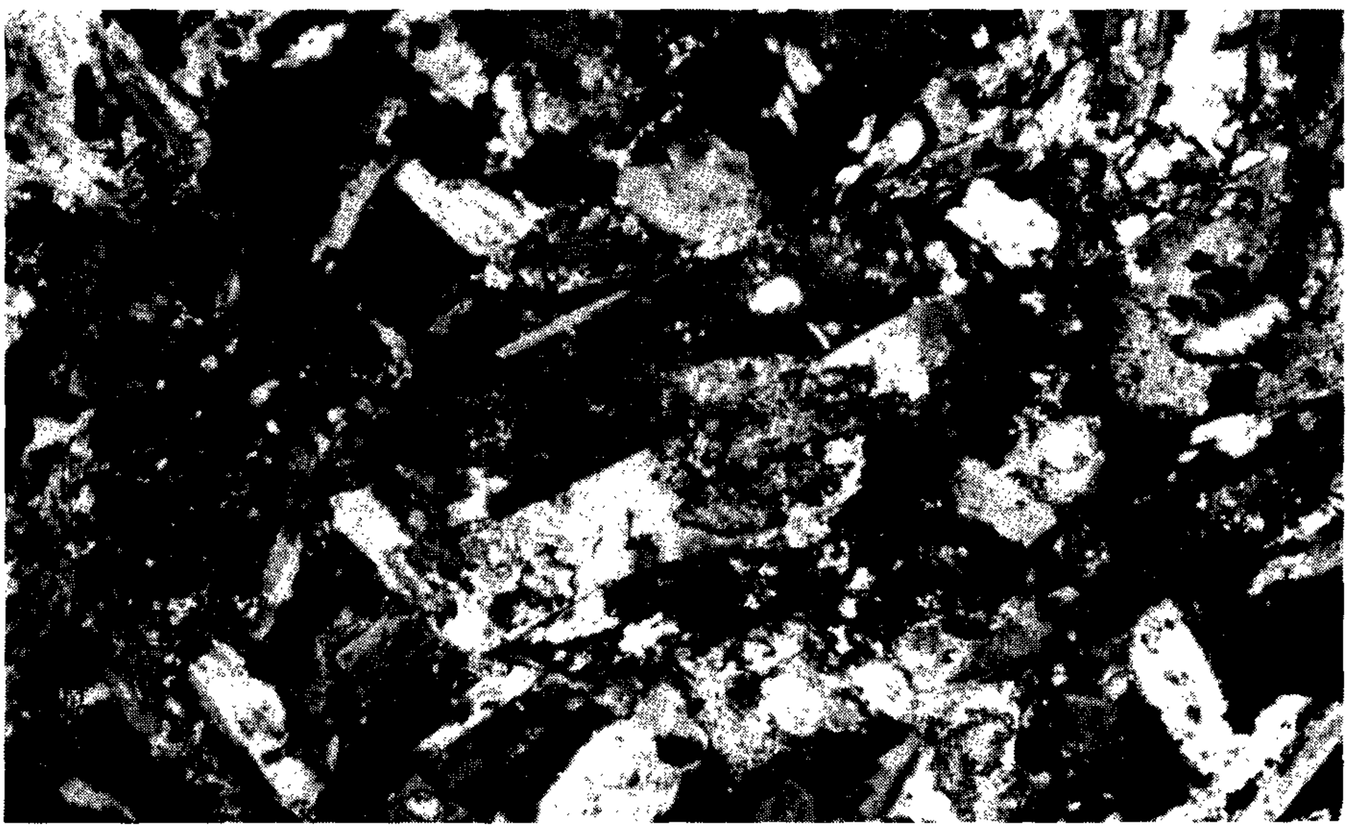

Plate 2-1-2. Saussuritized albite in plagioclase-augite crystal tuff; albite phenocryst in centre of photo is 0.7 millimetre long. Katie DDH 53-223.5 metres (xp, field of view = 1.3 mm).

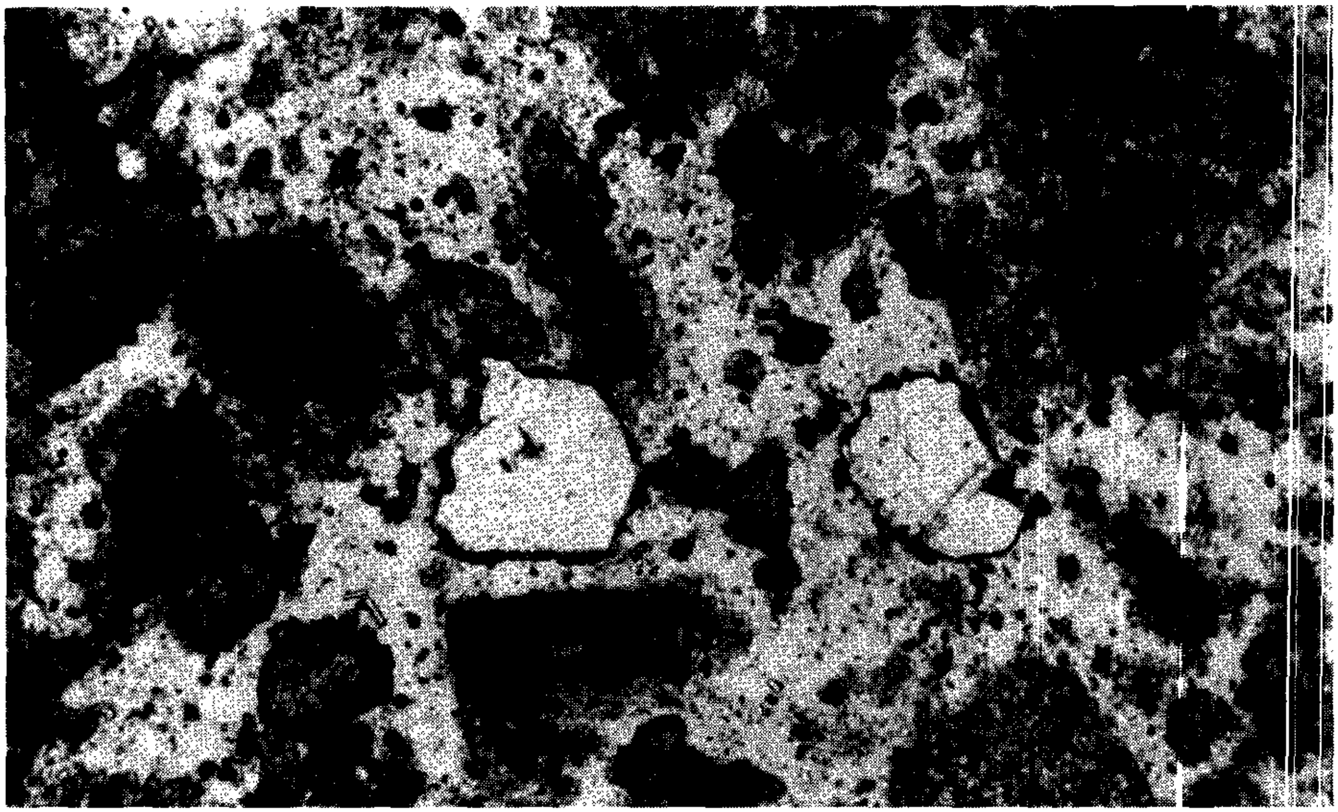

Plate 2-1-3. Broken apatite phenocrysts in crystal tuff; apatite crystals are 2 millimetres in diameter. Katie DDH 53-109.2 metres (ppl, field of view = 1.3 mm).

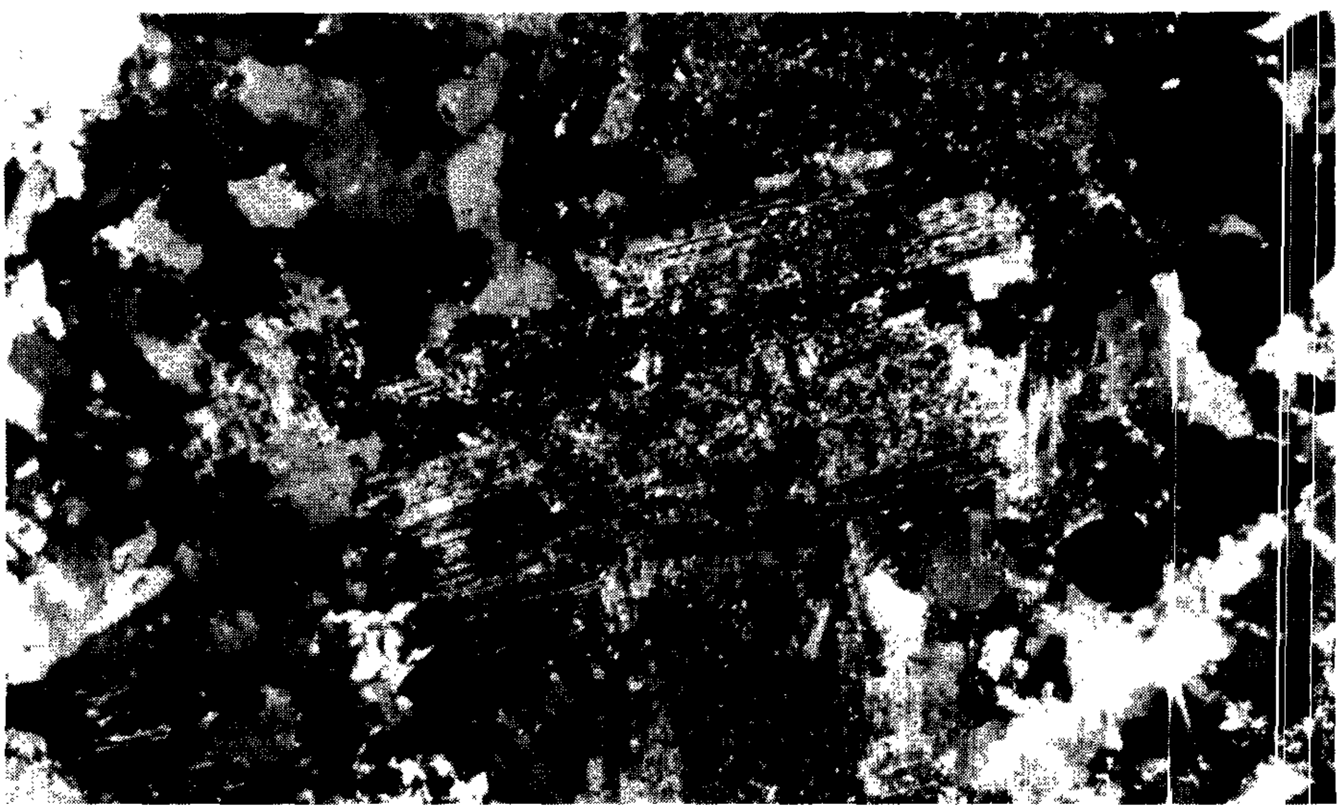

Plate 2-1-4. Sericitized plagioclase phenocryst in granophyric monzonitic matrix, Katie DDH 53-90.3 metres (xp, field of view = 2.6 mm).

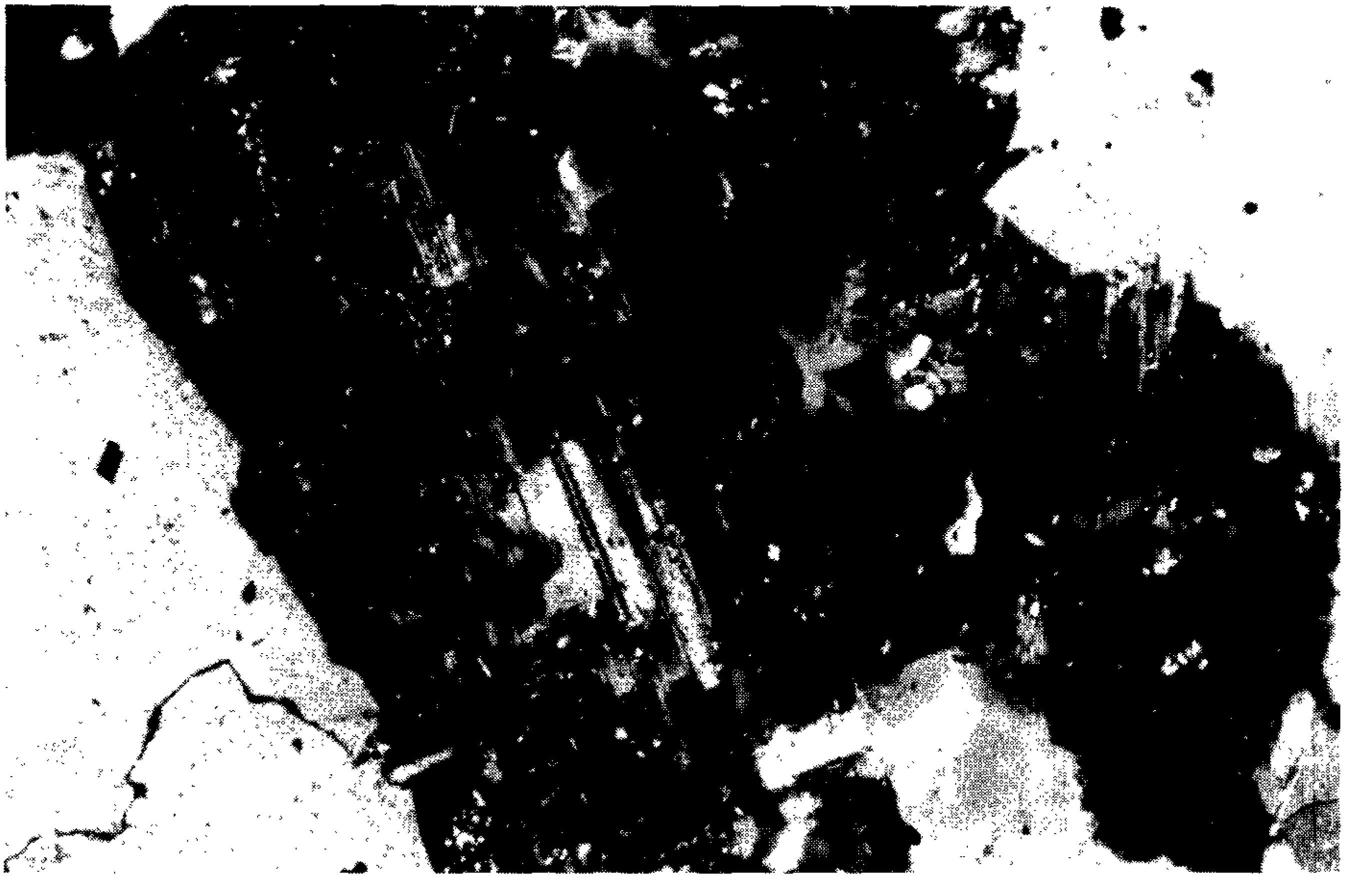

Plate 2-1-5. Perthitic texture of plagioclase in potassium feldspar. Alternatively, this may be potassium feldspar replacing a primary plagioclase phenocryst. Katie DDH 53-90.3 metres (xp, field of view = 0.65 mm).

UNIT lJsk? FELDSPAR PORPHYRY

Pale grey and greenish grey plagioclase porphyry is occasionally present in the drill core. In hand specimen it is generally foliated and mottled in appearance, with 5 to 7 per cent subhedral to euhedral feldspar phenocrysts 6 to 10 millimetres in size in a medium to dark greenish grey groundmass. Chloritized hornblende laths 1 to 2 millimetres long comprise 5 to 15 per cent of the rock. In thin section, sericitized labradorite phenocrysts are seen in a groundmass of plagioclase, potassium feldspar and quartz; hornblende needles are virtually all altered to chlorite. Several per cent magnetite grains show a poikiolitic texture. The protolith for this rock was probably a dacite. It is similar in appearance to the post-Elise (*ca.* 186 Ma) Silver King porphyry near Nelson (Höy and Andrew, 1988) but may be a synvolcanic dike rock. It contains 1 to 2 per cent pyrite but has only background levels of copper and gold; this infers that it is a post-mineral intrusion.

LATE DIKES

Late dikes of lamprophyre, microdiorite and feldspar porphyry are minor but ubiquitous; they are generally unmineralized and unaltered or only weakly altered. None of these dikes has been dated at Katie or in the immediate area, but they are post-mineralization and may be related to the Nelson (Middle Jurassic) or Coryell (Middle Eocene) plutonic suites.

UNIT mJnmd?: PLAGIOCLASE MICRODIORITE, HORNBLENDE MICRODIORITE

Narrow dikes of fine-grained porphyritic microdiorite are common in the drill core. These dike rocks are spotted light and dark grey, are nonmagnetic to moderately magnetic and contain 0.5 to 2-millimetre pale green or grey, anhedral to subhedral phenocrysts of feldspar and 0.5 to 1-millimetre needles of black hornblende.

UNIT mJfp?: FELDSPAR PORPHYRY

Fine to medium-grained, nonmagnetic to weakly magnetic, beige-grey to pale beige feldspar porphyry dikes are locally present. This unit is distinguished by 0.5 to 2-millimetre subhedral to anhedral phenocrysts of white to pale green feldspar in a greenish beige aphanitic groundmass.

UNIT mEL?: BIOTITE LAMPROPHYRE, BIOTITE-HORNBLENDE LAMPROPHYRE

Lamprophyre dikes or sills up to 15 metres thick, but generally less than 3 metres thick, are locally present in drill core. They are dark grey, relatively fresh and nonmagnetic to weakly magnetic. These dikes have a fine-grained groundmass with 3 to 5 millimetre biotite phenocrysts, less common hornblende phenocrysts and angular to subrounded, grey, fine-grained rock fragments up to 5 millimetres in diameter. Fine-grained chilled margins are usually evident. Staining shows that this unit contains 10 to 20 per cent potassium feldspar in the groundmass and that the rock fragments contain no potassium minerals.

STRUCTURAL GEOLOGY

The Katie property is within a generally northeast-trending, southeast-dipping panel of lower Elise rocks on the western limb of the Hellroaring Creek syncline. Lack of outcrop hinders more detailed structural interpretations. Bedding is difficult to recognize in the volcanic rocks, partially because of pervasive alteration. Correlation of bedding contacts in the Main zone suggests they strike northwest and dip northeast. A weakly developed foliation is recognizable in drill core as chloritic partings along microfractures.

Several zones of sheared and mylonitic rocks have been recognized in the Main zone. These shears are 5 to 20 metres wide and appear to crosscut porphyry-stage alteration and mineralization. Their relationship to post-mineral dikes is not known and their attitude and distribution are unclear. Some drillhole correlations suggest that they may have a predominantly northwest strike and northeast dip (Figures 2-1-3 and 2-1-4).

The mylonitic rocks have an intense penetrative fabric, are wavy banded, pale beige and greenish beige, strongly slickensided and may grade into chlorite-sericite schist. In thin section, the cataclastic fabric is marked by rounded feldspar boudins and rotated sulphide grains with quartz pressure shadows (Plate 2-1-6). Compositionally, the mylonite comprises over 70 per cent sericite as pervasive alteration and replacement of feldspar, 10 per cent quartz, 10 per cent sulphides, 2 to 3 per cent carbonate (possibly ankerite) and several per cent leucoxene. Folded and sheared quartz-dolomite-sulphide veins, which are described below, are also present.

Drillhole 25 intersected a fault in the northeast part of the property which juxtaposes andesites of the Elise Formation against black argillite of the Hall Formation. This is probably a steeply dipping northwest-trending fault mapped by Höy and Andrew (1990b).

MINERALIZATION AND ALTERATION

At least two stages of mineralization are present; an alkalic porphyry copper-gold stage and a later, shear-hosted gold-silver-copper-antimony-arsenic stage.

ALKALINE PORPHYRY STAGE

Porphyry-stage mineralization is simple, consisting mainly of pyrite and lesser chalcopyrite (Plate 2-1-7). Traces of bornite, pyrrhotite, sphalerite and tetrahedrite have been noted and chalcocite has been tentatively identified in drillhole 37. Total sulphide content ranges from 1 to 10 per cent and averages about 2 per cent. The sulphides occur as subhedral disseminations in the volcanic and intrusive rocks or in narrow veinlets with quartz, calcite, potassium feldspar, chlorite and epidote. Chalcopyrite also occurs locally with pyroxene which is commonly altered to actinolite (McDonald, 1992). Good correlation of copper and gold analyses suggests that gold occurs mainly in chalcopyrite. Limonite, malachite and azurite are common on fractures high in drillholes; in some holes partial oxidation extends to depths of over 100 metres.

In terms of metal content, the altered volcanic and intrusive rocks contain a maximum of about 1 per cent copper and 0.5 gram per tonne gold. Copper content is rarely less than 400 ppm, except in late dikes which generally contain less than 100 ppm. Other elements, such as silver, lead, zinc, arsenic and antimony, are relatively low.

Up to several per cent magnetite is present in most rock types. The main exception to this is strongly potassium feldspar altered zones which are often nonmagnetic. Magnetite occurs mainly as rounded and corroded primary (?) grains 0.1 to 2.0 millimetres in diameter (Plate 2-1-1), or as secondary grains to 50 microns, veins, irregular aggregates and breccia fillings (Plate 2-1-8; McDonald, 1992). Narrow zones of coarsely crystalline secondary magnetite are locally well developed, especially above mineralized intervals (Figures 2-1-3 and 2-1-4). Locally these contain up to 50 per cent magnetite (Plate 2-1-8). A slightly oxidized surface sample of this material returned analyses of 14 200 ppm copper and 2800 ppb gold. Other trace accessory minerals include rutile, sphene, ilmenite and leucoxene. These are generally associated with magnetite (Plate 2-1-1) and ferromagnesian minerals, although rutile is also found locally in veins carrying chalcopyrite (Getsinger, 1992; McDonald, 1992).

Alteration mineral assemblages in the Katie area are consistent with both propylitic alteration and greenschist facies metamorphic grade. However, as the regional metamorphic grade is low in the Salmo area and penetrative deformation of the volcanic rocks is generally lacking on the property, propylitic alteration is more likely. On the Katie property, this alteration is characterized by saussuritization of feldspars to a greenish grey mixture of chlorite, epidote, sericite and calcite. Pyroxene grains have been altered to chlorite, sericite and actinolite. Albite is locally developed adjacent to sulphides (Getsinger, 1992). In addition, calcite, epidote and chlorite-pyrite stringers crosscut the rock, although many of these appear to be later than the main stage of mineralization.

Pervasive potassic alteration is locally well developed (Figures 2-1-3 and 2-1-4) and is characterized by a grey, green, pink and purplish brown mottled, vaguely granular rock composed of potassium feldspar, plagioclase and lesser quartz, biotite and chlorite. Petrography indicates that potassium feldspar has replaced the groundmass and forms rims on primary plagioclase grains (Getsinger, 1992). Coarse secondary biotite is also locally present. In some places, potassium feldspar may be confined to narrow (1 to 5 cm) veins, quartz vein selvages, or irregular flooded zones associated with quartz, pyrite and chalcopyrite (Plate 2-1-9).

A late, retrograde, hydrous alteration appears to overprint the prograde alteration types. Sericite replaces plagioclase

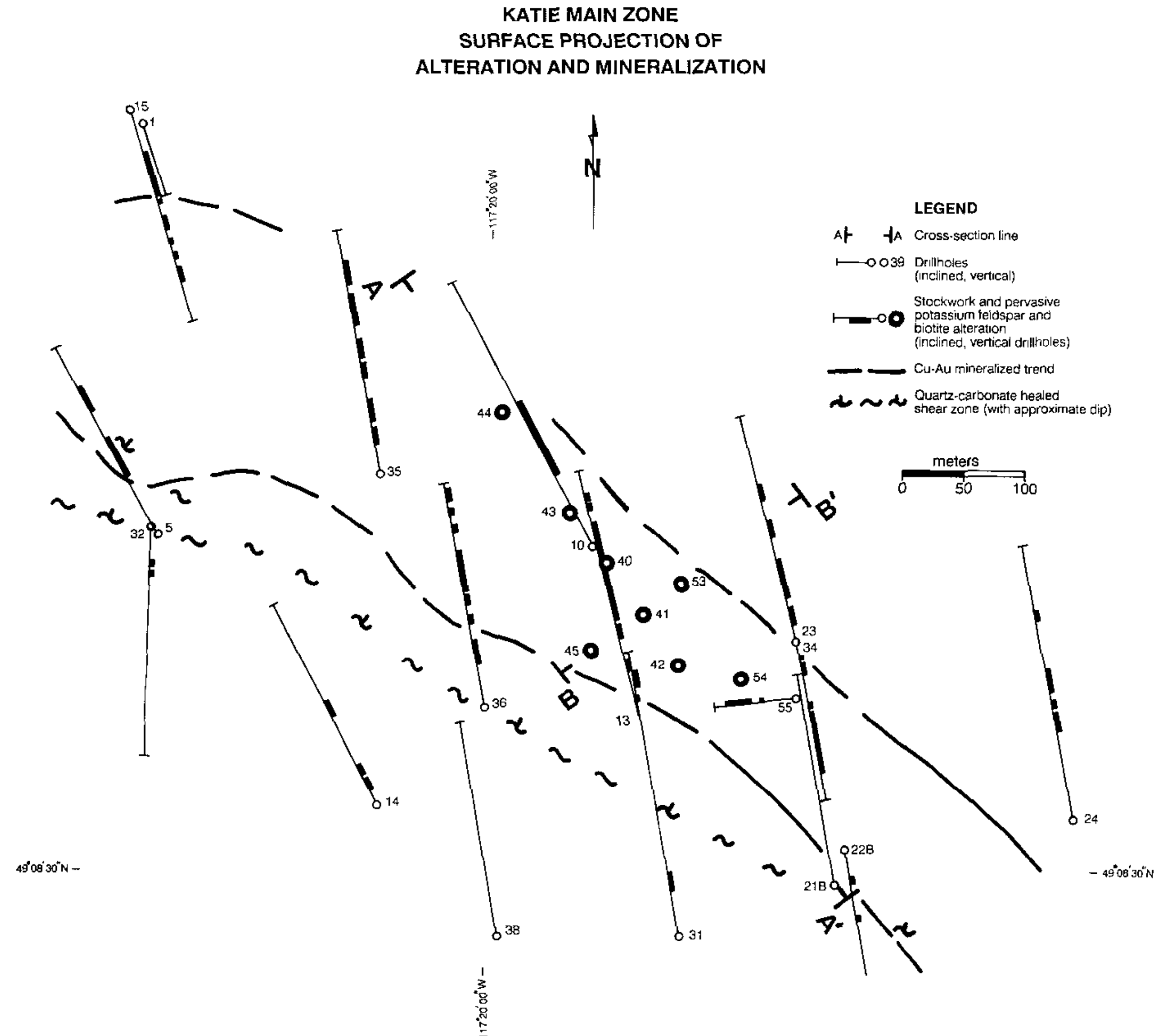

Figure 2-1-3. Drillhole plan for the Main zone, Katie property. Drillhole traces and the extent of alteration zones and mineralization are shown projected to surface.

and secondary potassium feldspar and chlorite replaces secondary biotite and amphibole (Getsinger, 1992). The abundant late calcite, epidote and chlorite-pyrite stringers mentioned above crosscut the potassic alteration and may also be part of this late retrograde stage.

Shear-related Au-Ag-Cu-Sb-As Stage

Although not common, mylonitic shear zones carry significant gold values (1 to 3 ppm), silver (10 to 60 ppm) and copper (up to 1 per cent) and anomalous levels of arsenic and antimony. These sheared rocks are pervasively altered to an assemblage of quartz, sericite and carbonate and contain weakly to strongly contorted quartz-dolomite-sulphide veins. The veins contain minor but locally abundant concentrations of pyrite, chalcopyrite, tetrahedrite and arsenopyrite and traces of molybdenite. Specular hematite has been tentatively identified.

The mylonitic shears appears to be younger than the porphyry stage and may displace porphyry mineralization in some places. As outlined above, the attitude of these structures is not well known, although at least one set appears to strike northwest and dip northeast (Figures 2-1-3 and 2-1-4).

EXPLORATION RESULTS

Ground geophysical surveys and soil geochemistry have detected numerous anomalies on the Katie claims. Geophysical surveys include a 28 line-kilometre pole-dipole induced polarization survey (a = 50 m, n = 1 to 5, line-

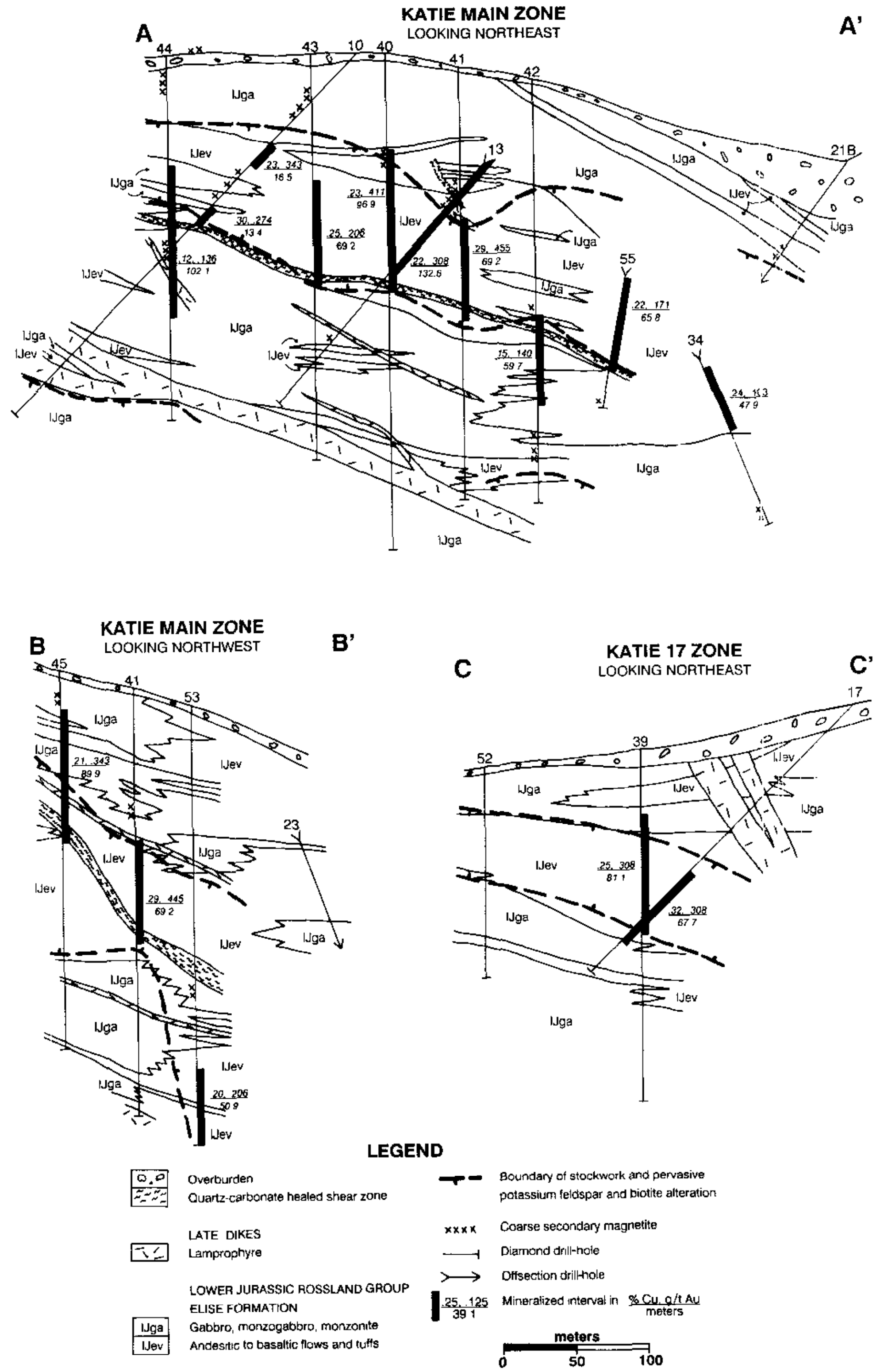

Figure 2-1-4. Cross-sections through the Main and 17 zones, Katie property. The locations of cross-section lines are shown on Figures 2-1-2 and 2-1-3.

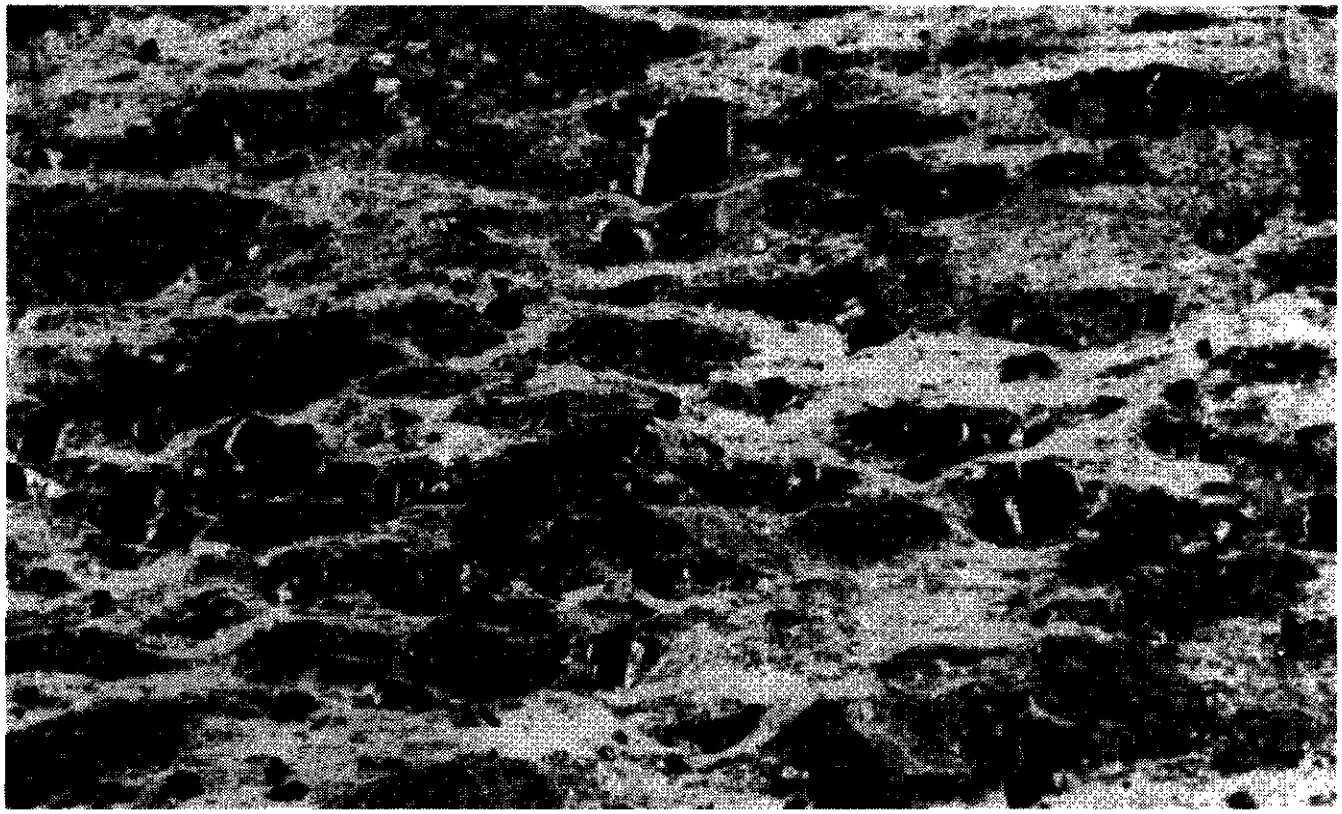

Plate 2-1-6. Protomylonite. Note rotated sulphide grains with quartz pressure shadows and replacement of feldspar by sericite and carbonate. Katie DDH 13-100.4 metres (ppl. field of view = 5.1 mm).

Plate 2-1-7. Matrix chalcopyrite and lesser pyrite (both white) in quartz-albite alteration replacing sericitized plagioclase. Katie DDH 41-124.2 metres (from McDonald, 1992; ppl + reflected light, field of view = 5.1 mm).

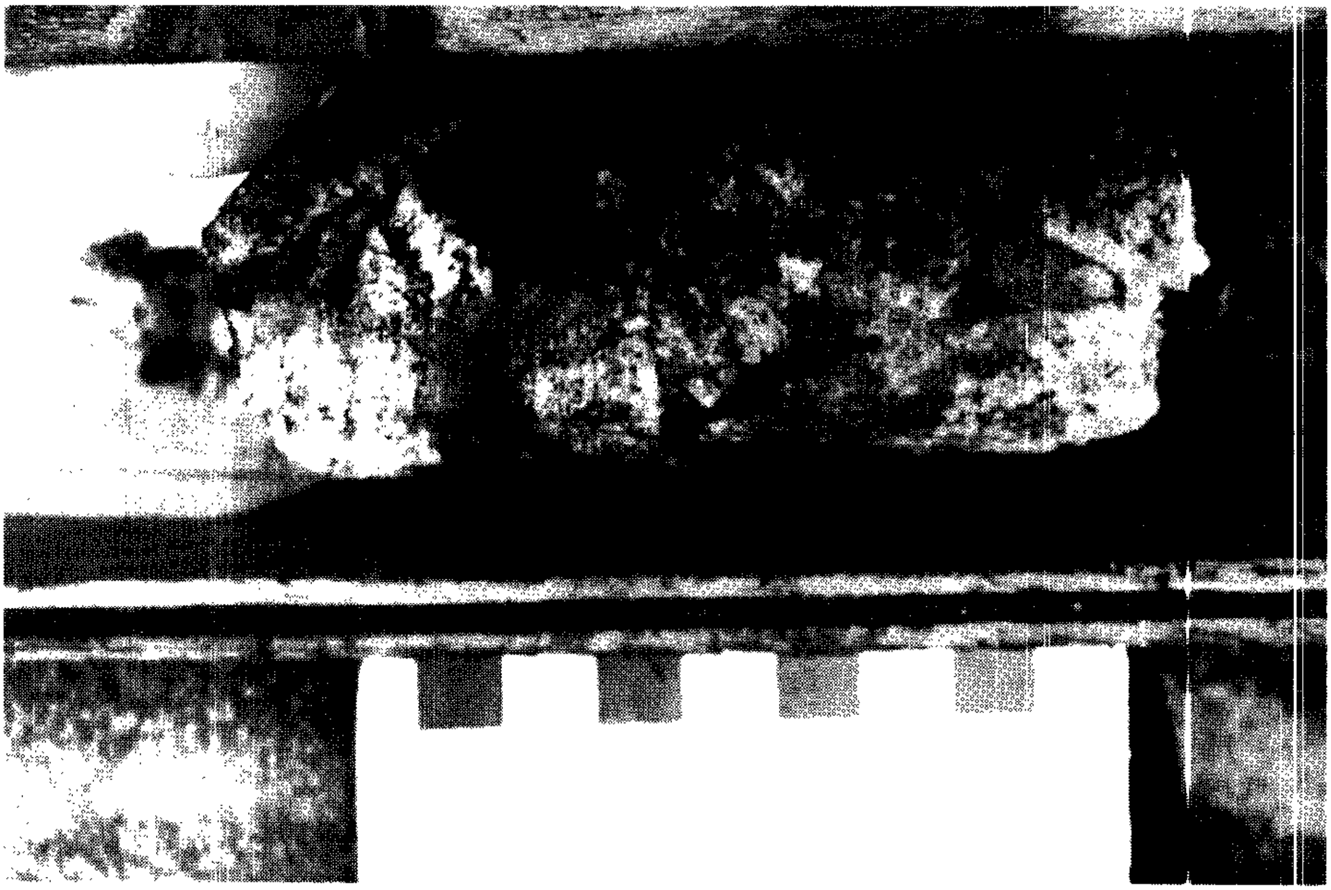

Plate 2-1-8. Coarse-grained magnetite-cemented breccia. Fragments are 2 to 3 centimetres in diameter. Katie DDH 40-77.0 metres.

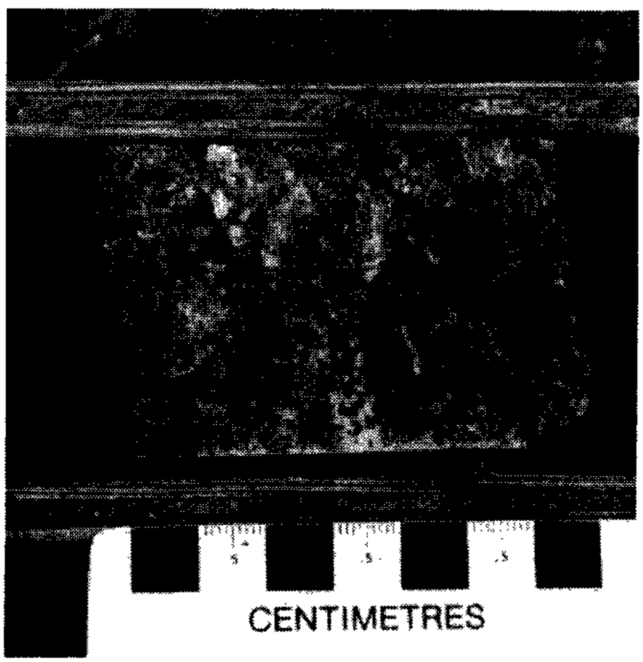

Plate 2-1-9. Pinkish brown mottled potassic alteration comprising fine-grained potassium feldspar and biotite with 1 to 2-centimetre quartz-chalcopyrite stringers and patches. Katie DDH 41-103.8 metres.

spacing = 200 m) and a 41 line-kilometre magnetometer survey (25 m stations, line spacing = 100 m). In addition, a total of 36 line-kilometres of soil sampling (100 x 100 m grid) has been carried out but was hindered somewhat by thick overburden. Several large areas of anomalous copper (100 ppm) have been outlined (Figure 2-1-2). There are no large contiguous gold anomalies, although spot highs 10 ppb) are coincident with the copper zones. Details of the geophysical and geochemical work can be found in McIntyre and Bradish (1990) and McIntyre (1991)

Three anomalous zones were identified by the ground geophysics and extend over an area of at least 1800 by 500 metres. An anomaly over the Main zone consists of coincident high chargeability, moderate resistivity and moderate to strong magnetic responses. The true dimensions of this geophysical anomaly were not ascertained because its stratigraphic and mineralized trends strike subparallel to the grid lines. A roughly coincident copper-gold soil anomaly (Figure 2-1-2) is also present. Drilling has shown that the Main zone strikes northwest, has an apparent true thickness of 70 to 135 metres and is at least 500 metres long (Figures 2-1-2, 2-1-3, 2-1-4). It has been intersected in drillholes to 350 metres below surface. Copper-gold enrichment is mainly confined to intensely potassically altered andesitic volcanic rocks (for grades *see* Figure 2-1-4). Local enrichments in gold and silver are associated with late mylonitic shear zones as previously described.

The 17 zone anomaly is located 670 metres south of the the Main zone, has a strong magnetic response but is outside the area of induced polarization coverage. It is geologically similar to the Main zone, with copper-gold mineralization associated with intense potassium feldspar and biotite alteration. Limited drilling has outlined an altered and locally mineralized area measuring at least 300 by 100 metres (Figure 2-1-4). The zone appears to strike northwest and dip at a low angle to the northeast (Figures 2-1-2 and 2-1-4). It may be a faulted extension of the Main zone.

The West zone anomaly is 1.6 kilometres west of the Main zone and comprises a north-trending zone of high resistivity, high chargeability and locally high magnetic responses. Potassic alteration is not as well developed in this area although one drillhole, NKT-89-9, cut a 170.3 metre intercept grading 0.16 per cent copper and 0.171 gram per tonne gold.

CONCLUSIONS

- The Katie property hosts low-grade, alkaline porphyry copper-gold mineralization within variably potassic and propylitically altered intermediate to mafic volcanic rocks and gabbro to monzonite synvolcanic intrusions of the Lower Jurassic Elise Formation. Drilling to date is insufficient to close off the area of mineralization and alteration but it measures at least 1800 by 500 metres.
- The early porphyry-stage mineralization is mineralogically simple, consisting mainly of pyrite and chalcopyrite with traces of bornite, pyrrhotite, molybdenite, tetrahedrite and sphalerite. Highest copper grades are associated with zones of potassium feldspar and biotite alteration and potassium feldspar-quartz-calcite-sulphide veining. Strong positive correlation between copper and gold suggests that gold probably occurs in chalcopyrite. The potassic alteration zones are surrounded by a much wider area of pervasive propylitic alteration. Zones of coarse secondary magnetite cemented breccia are locally present and occur most commonly above mineralized intervals. Late calcite, epidote and chlorite-pyrite veins transect the prograde alteration assemblages and may be part of a late, hydrous, retrograde alteration phase.
- A later, relatively minor stage of Au-Ag-Cu-Sb-As mineralization crosscuts the porphyry mineralization and is at least partially controlled by northwest-striking, northeast-dipping mylonitic shear zones. These shear-hosted zones result in local enrichments in gold and silver.
- The Katie porphyry deposit has numerous similarities to other alkaline porphyry deposits in volcanic arc terranes in the Cordillera (Copper Mountain, Afton, Mount Milligan, Galore Creek); specifically with respect to its Jurassic age, calcalkaline to alkaline hostrocks, potassic and propylitic alteration and relatively high gold and magnetite content.
- The mineralized area lies within a 2 by 8 kilometre, northeast-trending, 250 gamma aeromagnetic anomaly, which probably reflects magnetite-rich intrusive or volcanic rocks. Exploration for similar deposits in the Rossland Group should focus on coincident magnetic, chargeability, resistivity, copper and gold anomalies, as well as the recognition of characteristic alteration assemblages and synvolcanic gabbro to monzonite intrusions.

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