British Columbia Geological Survey
Geological Fieldwork 1992

GEOLOGY OF THE INEL DEPOSIT, ISKUT RIVER AREA, NORTHWESTERN BRITISH COLUMBIA (104B/11)

By David A. Rhys and Peter D. Lewis, Mineral Deposit Research Unit, U.B.C.

(MDRU Contribution 013)

KEYWORDS: Economic geology, Inel, Snip, Stonehouse, shear vein, potassic alteration, mesothermal gold.

INTRODUCTION

The Bronson Creek area (Figure 2-15-1) contains several significant mineral deposits and showings, including Snip, the largest currently operating gold producer in British Columbia, owned by Cominco Metals (60%) and Prime Resources Group Inc. (40%). These occurences underscore the importance of understanding controls on mineralization as a guide to further exploration. For example, the Snip, Johnny Mountain and Inel deposits are all examples of structurally controlled deposits spatially associated with syntectonic porphyry intrusions. Work by D. Rhys on the Snip deposit (Rhys and Godwin, 1992) and recent mapping by P. Metcalfe and James Moors (1993; this volume) is presently defining the stratigraphic and structural evolution of the entire western Iskut River area, and a comprehensive isotopic and geochemical examination of Mesozoic plutons in the area is in progress (Macdonald *et al.*, 1992).

The Inel property was originally staked by R.G. Gifford in 1969, and subsequently acquired by Skyline Explorations Limited. Surface exploration was carried out under option by Texasgulf Inc. in the mid-1970s, and later by Skyline. In 1987 the property was optioned, and later acquired by Inel Resources Ltd. Between 1987 and 1990, two adits were driven (AK and Discovery levels; Figure 2-15-1), and a total of 1200 metres of drifting and 11 500 metres of diamond drilling were completed (Gifford, 1991). During 1990, Inel Resources amalgamated with Gulf International Minerals Limited, which is now the sole property owner.

To better constrain the geological evolution of the Inel deposit and explore possible similarites with the nearby producing Snip and past-producing Johnny Mountain deposits, we examined the underground workings during the 1992 field season. The underground program included sampling and structural mapping at 1:500-scale through most of the two exploration drifts. Low oxygen levels at the end of the Discovery drift limited access.

GEOLOGICAL SETTING

The Inel property lies near the centre of the Snippaker map area within Intermontane Belt rocks just northeast of their boundary with Tertiary plutons of the Coast Plutonic Complex. Regional geologic maps (Lefebure and Gunning, 1989; Alldrick *et al.*, 1990) show the property to be underlain by a mixed volcanic and sedimentary succession, characterized by fine-grained marine sedimentary strata and mafic porphyritic flows and other volcanic rocks. Numerous intermediate to felsic dikes and stocks, associated with both Jurassic and Tertiary magmatism, intrude these rocks. Previous workers disagree on the age of the strata: Lefebure and Gunning (1989) suggest a Late Triassic age, and assignment to the Stuhini Group, whereas Alldrick *et al.*, (1990) prefer the Jurassic Hazelton Group. Recent mapping by P. Metcalfe (personal communication, 1992) indicates that rocks at Inel are lateral equivalents to strata exposed at Snippaker Peak, which contain Upper Triassic ammonites (Nadaraju and Smith, 1992).

The Inel property is on the southwestern flank of the south end of Snippaker Ridge, overlooking the Bronson Glacier. Jurassic strata on the upper part of Snippaker Ridge, and to the west on the upper part of Johnny Ridge, are flat lying to moderately tilted. Gold-bearing veins of the Stonehouse deposit at the Johnny Mountain gold mine occur in the lower part of this sequence. On Johnny Ridge, unconformably underlying Triassic sedimentary and volcanic strata are complexly folded and bedding attitudes range from flat lying to overturned. In contrast, the two packages are more nearly concordant on Snippaker Ridge, where Triassic strata are mostly flat lying to gently dipping. This folded Triassic sequence contains the Snip deposit at the base of Johnny Ridge.

Major structures in the Inel area include steep orthogonal fault sets striking northeasterly and northwesterly (Lefebure and Gunning, 1989; Alldrick *et al.*, 1990). These faults do not appreciably offset stratigraphic contacts, and displacements are probably a few hundred metres or less. Mappable folds are limited to tight, locally overturned, northwest-trending folds in the Triassic strata at Johnny Mountain, and to broad, upright open warps in the overlying Jurassic rocks.

GEOLOGY OF THE AK DRIFT

Rocks exposed in the AK drift (1650-metre mine level, Figure 2-15-2) are dominantly laminated to thinly bedded, graded siltstones and mudstones, with subordinate interbeds of matrix-supported cobble conglomerate and breccia up to 5 metres thick. Clasts within these coarser layers range from 0.5 to 60 centimetres in diameter and consist of rounded, massive medium-grained tonalite and angular mudstone. The clasts comprise between 5 and 30 per cent of the unit and are surrounded by a massive siltstone to mudstone matrix. Rare fining-upward beds within the laminated siltstone and mudstone sequence grade from a clast-rich basal conglomerate into massive mudstone. Isolated rounded tonalite to diorite clasts, 1 to 3 centimetres in diameter, are common throughout the siltstone and mudstone unit. Medium-grained, medium to thickly bedded greywacke occurs at the southeast end of the drift. Intrusive lithologies in the AK zone are limited to a medium to fine-grained

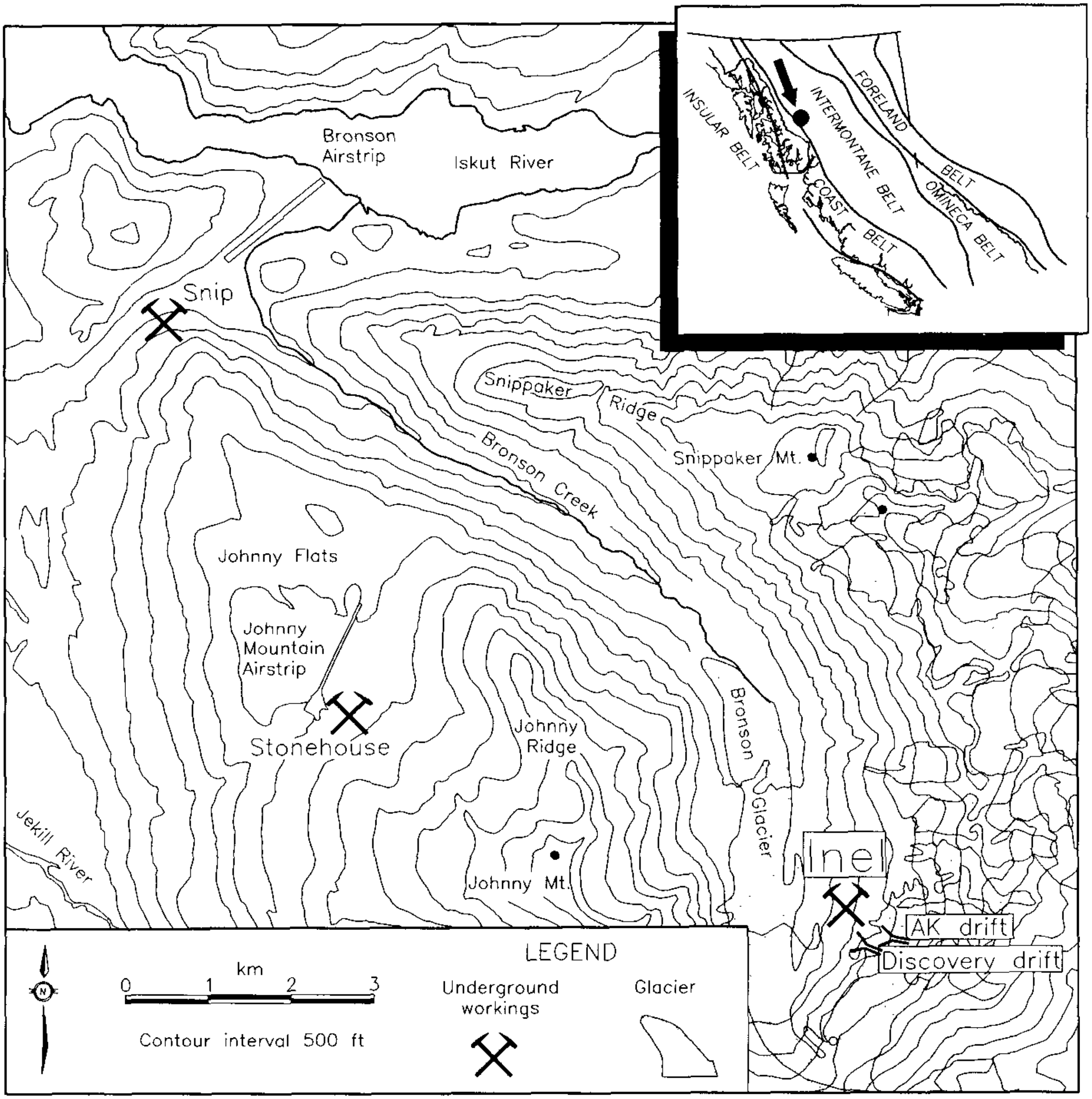

Figure 2-15-1. Location map of the Bronson Creek area, showing the locations of the Inel property, and the Snip and Stonehouse mines.

plagioclase-porphyritic stock which intrudes the siltstone and mudstone unit near the portal.

Rocks previously described as heterolithic intrusive breccias are exposed in the west end of the AK drift (Figure 2-15-2). These rocks have concordant contact relationships to mudstones underground, and a matrix composition similar to that in conglomeratic rocks observed elsewhere in the drift. Rounded massive to medium-grained tonalite to diorite clasts and angular mudstone to siltstone clasts occur in a medium to coarse-grained lithic greywacke matrix (Plate 2-15-1). The sedimentary clasts display variable degrees of pyrite alteration, and often have 1 to 4-millimetre bleached haloes. Surface exposures of this unit show it forming a tabular body discordant to bedding in enclosing strata, forming the basis for its suggested intrusive breccia origin (V. Jaramillo, K. Illerbrun; personal communication, 1992).

Throughout the AK workings, beds dip gently easterly to northeasterly, except in locally disrupted areas. Structural features superimposed on these strata include stockwork veinlet systems, thick sulphide veins, localized folds and brittle faults. Zones of potassium feldspar - sericite alteration bleach the laminated siltstones and are spatially associated with a pyrrhotite-sphalerite stockwork. Feldspar staining indicates that potassium feldspar occurs irregularly in this altered zone, and is absent from some strongly bleached samples. The veinlets have both moderate southeast and shallow north-northeast bedding-parallel dips. Several steep southwest-striking pyrite + calcite + sphalerite ± biotite ± chlorite veins, up to 40 centimetres wide, are associated with potassium feldspar alteration. Some of these steep veins are folded about flat-lying axial surfaces. Gouge-filled faults, locally with rusty bleached envelopes and thin calcite vein fill, cut all other structures. These have variable orientations, but most commonly dip moderately to steeply to the northwest. Slip direction and amount for these late structures could not be determined from available exposures.

Galena from a thin sulphide veinlet at the southeast end of the AK drift returned an Early Jurassic Pb-Pb relative age (Godwin *et al.*, 1991).

Near the east end of the exploration drift, bedding is deformed by disharmonic, overturned minor folds with variably oriented axial surfaces. A phyllitic bedding-parallel foliation is developed locally within this zone.

Exploration drilling from the AK drift intersected a southwest-dipping orthoclase-porphyritic dike 7 to 15 metres wide, 50 metres northeast of the drift (Figure 2-15-2 inset; compiled from Gifford, 1991). This dike is not exposed in the workings. An altered, mineralized heterolithic breccia or conglomerate, 5 to 12 metres thick, in its immediate footwall, known as the AK zone, strongly resembles the "intrusive breccia" at the west end of the AK drift. It consists of tonalite, diorite and siltstone/mudstone clasts in a sandy matrix and has contacts discordant to bedding in surface exposures. Drill-core samples often have a porous to pyritized matrix. Areas of highest pyrite content carry subeconomic copper, lead and zinc values associated with significant gold content. On the basis of current drilling information, a resource of 57 600 tonnes with an average grade of 11.7 grams per tonne gold has been calculated for this zone (Gifford, 1991).

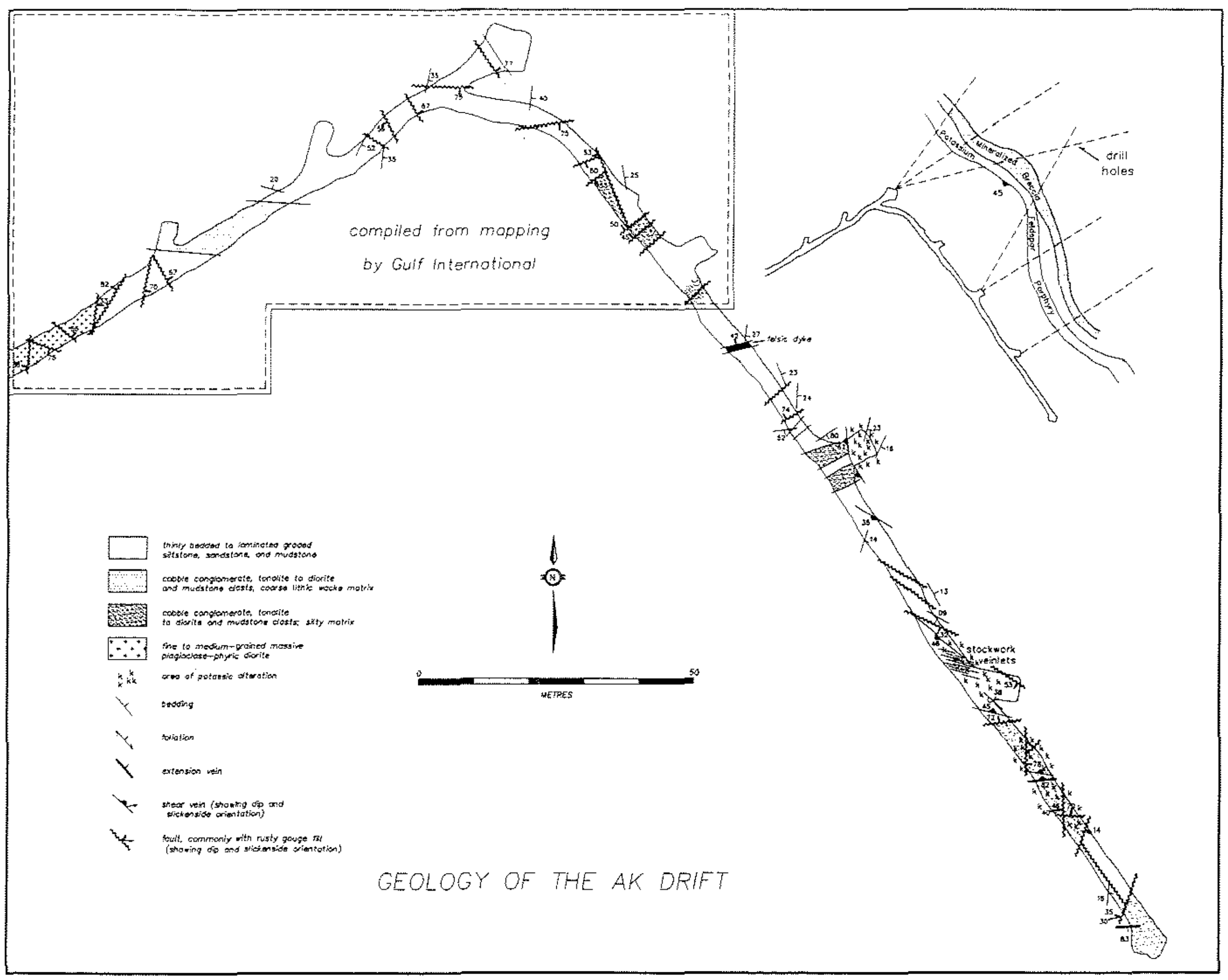

Figure 2-15-2. Geology of the AK drift, based on 1992 underground mapping.

GEOLOGY OF THE DISCOVERY DRIFT

The Discovery drift (1510-metre mine level; Figure 2-15-3) contains many of the same lithotypes present in the AK drift. Bedded to laminated siltstones and greywackes, generally coarser grained than equivalent units in the AK drift, are the dominant rock types. Greywackes in the Discovery drift are massive to medium bedded and generally poorly sorted, and contain scattered siltstone interbeds. Local coarser grained layers contain granule-sized angular mudstone fragments and well-rounded quartz grains.

Epidotized volcanic breccia at the eastern end of the mapped Discovery workings contains angular porphyritic fragments with black, biotite-altered mafic phenocrysts and epidote spots. The fragments are typically 0.5 to 3 centimetres in diameter, with highly angular, pitted margins that commonly interlock with adjacent fragments. The breccia matrix is a fine-grained mixture of epidote, calcite, and locally, potassium feldspar. A drill-hole intersection of this unit clearly shows that the epidote-calcite matrix material has replaced a fine to medium-grained mafic rock along fractures, indicating that the texture observed has probably resulted from intense alteration of a fractured basaltic protolith.

Two intrusive bodies are exposed at the southern end of the workings, outside the mapped area (Figure 2-15-3, inset map). A steeply southwest-dipping orthoclase-porphyritic dike, 6 metres wide, is exposed at the far southern end. This dike contains 5 to 10 per cent, 0.3 to 3-centimetre potassium feldspar crystals in a chloritic, medium-grained plagioclase-rich matrix (Plate 2-15-2). It is texturally and compositionally similar to the dike associated with the AK zone mineralization, of which it may be an offset extension. Five metres north of this dike, a parallel medium-grained massive, plagioclase-porphyritic dike, 10 metres wide, intrudes the greywackes. The fine-grained matrix of the dike is moderately to strongly potassium feldspar altered. In addition, medium-grained plagioclase-porphyritic diorite dikes intrude the north-central portion and the southeastern portion of the mapped workings.

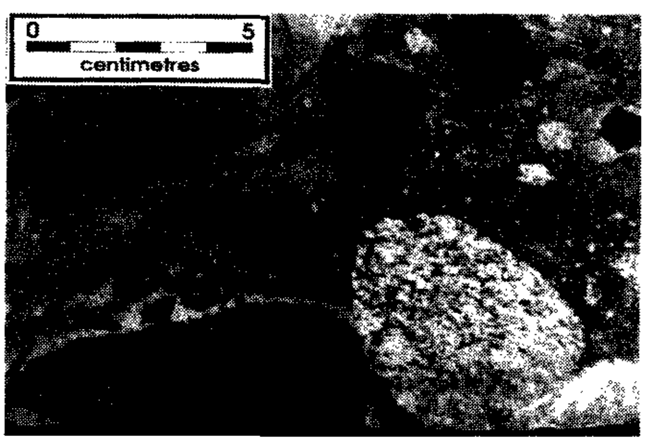

Plate 2-15-1. Cobble conglomerate with tonalite to diorite and siltstone clasts, from the west end of the AK drift. Note the bleached alteration haloes around some siltstone clasts.

Bedding in the mapped portion of the Discovery drift is upright and has shallow to moderate northeasterly and southeasterly dips that define two broad, west-trending upright folds. Mesoscopic structural features in this area include sheeted shear veins, faults, foliation and extension veins. Shear veins are most common and generally have moderate southwest, northeast and southeast dips. There are two main varieties of vein infillings: calcite-chlorite veins, with subordinate quartz, biotite, pyrite and sphalerite; and massive pyrite-calcite-quartz veins with lesser chlorite and biotite. Calcite-chlorite veins are the most abundant, and range up to 40 centimetres in thickness. These commonly have a laminated fill of alternating chlorite and calcite-rich layers (Plate 2-15-3) and rarely have narrow biotite alteration envelopes. Massive pyrite veins are mostly thicker (up to 2.0 m) and commonly have biotite alteration envelopes 0.2 to 1.5 centimetres wide. Pyrite veins strike 090° to 110°, and are locally cut by calcite-chlorite veins, which usually strike 120° to 140°. Calcite-chlorite veins often contain a subhorizontal internal foliation oblique to vein walls. This foliation also occurs in adjacent footwall rocks, but rotates to steeper dips along the vein-footwall contact. In one vein, pyrite grains have well-developed pressure shadows aligned on the flat foliation surface. In several veins, the layered vein-filling material is disrupted by asymmetric, down-dip verging folds with shallow fold axes. Slickenside lineations on chlorite foliation surfaces in the veins mostly record dip-slip movement. Offset markers are rare; one southwest-dipping pyrite-rich calcite-biotite-chlorite vein, 15 centimetres wide at the southeast corner of the mapped area offsets one of the potassium feldspar altered dioritic dikes by 1.5 metres in an apparent normal sense. A sample of galena collected from a 1-metre quartz-sulphide vein at 46.95 metres in Discovery drillhole U-87 (Figure 2-15-3) returned an Early Jurassic Pb-Pb relative age (A. Pickering, personal communication, 1992).

A strong spaced cleavage in siltstones in the north-central section of the workings is defined by closely spaced (0.3, 3 cm) bedding-parallel chlorite-calcite>pyrite+quartz+biotite veinlets and stringers.

Blocky quartz-calcite extension veins occur rarely in all rock units. The veins have various orientations; a well-developed moderately southeast-dipping set occurs at the central east end of the mapped area. Some extension veins crosscut shear-vein fabrics, but are also offset along them.

Rusty gouge-filled faults cut all other structures and form northwest and northeast-striking sets. Faults of both sets dip moderately to steeply to both sides and rarely have down-dip slickensides. Sense and amount of displacement, and relative chronology of fault sets could not be determined from the mapped exposures.

Several zones of potassium feldspar alteration that affect the siltstones are spatially associated with stockwork veinlets of pyrite, chlorite, biotite and calcite. In the southeastern part of the mapped area (Figure 2-15-3), four bedding-parallel altered zones range from 0.2 to 2.5 metres thick, and have common southwest-dipping veinlet orientations. A similar alteration style surrounds the two dikes at the south end of the Discovery drift, and is coincident with several thick pyrite veins. This alteration cuts bedding and

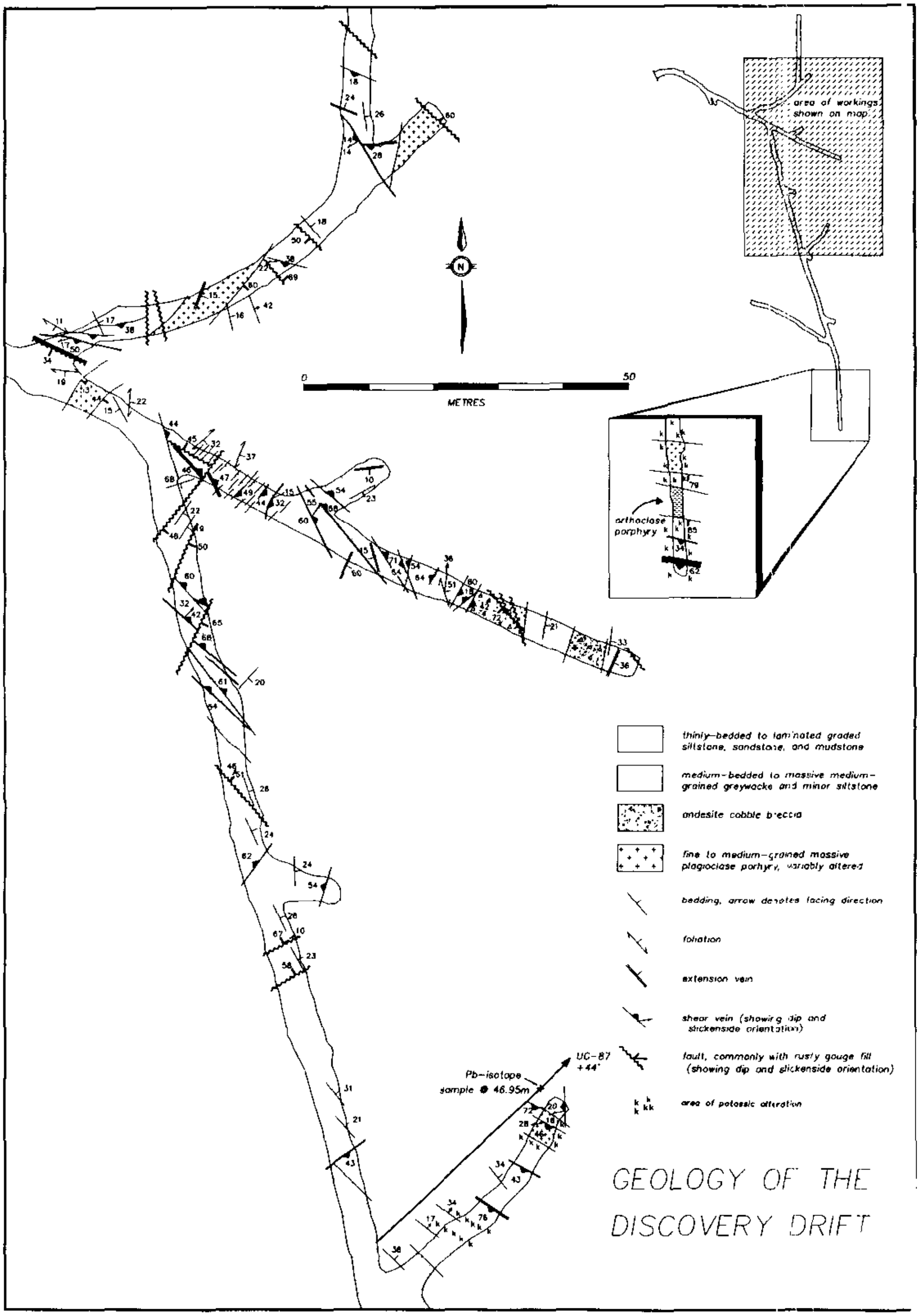

Figure 2-15-3. Geology of the Discovery drift, based on 1992 underground mapping.

is parallel to dike contacts. In contrast, no alteration is associated with the diorite dike in the northern part of the Discovery workings.

DISCUSSION

New underground mapping at Inel highlights some important similarities to other deposits in the Bronson Creek area. The mine sequence is dominantly sedimentary, with the possible exception of an altered volcanic breccia in the Discovery drift. The AK zone breccia or conglomerate is enigmatic, and requires further investigation to determine its origin. The clast type, abundance, and texture are identical to that of siltstone-mudstone matrix sedimentary conglomerates in the AK drift. If this unit is truly discordant to bedding, it may have an origin similar to the pebble dikes described in some copper porphyry systems (*e.g.*, El Salvador; Gustafson and Hunt, 1975). Mineralization overprints this unit, and the spatially associated orthoclase-porphyritic dike probably intruded synchronous with both mineralization and alteration on the AK and Discovery levels.

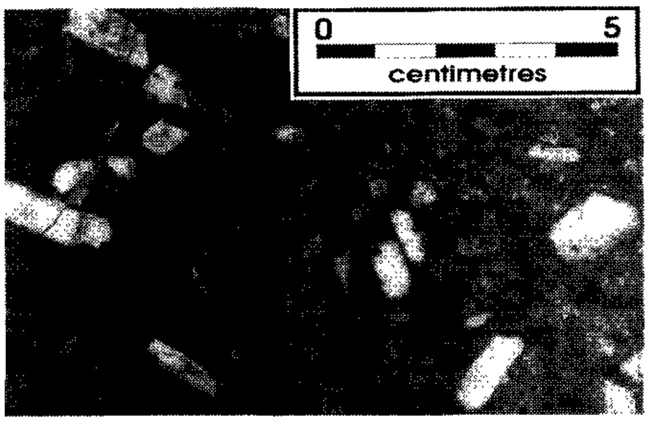

Plate 2-15-2. Porphyritic dike, from the south end of the Discovery drift. Coarse orthoclase phenocrysts are enclosed in a chloritic medium-grained plagioclase-phyric groundmass.

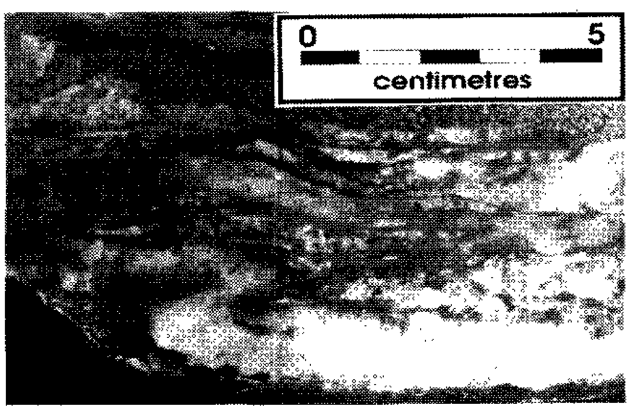

Plate 2-15-3. Laminated calcite-chlorite-pyrite-quartz vein from the northeastern Discovery drift, with an asymmetric fold outlined by a quartz vein. A massive pyrite band runs through the top of the picture, beside the scale bar.

The northeast and southwest-dipping orientations of shear veins on the Discovery level may represent a conjugate array. The normal sense of motion for both sets is consistent with this interpretation. Minor, southeast-dipping shear-veins are parallel to bedding, suggesting rheologically controlled failure and movement along bedding surfaces during formation of the conjugate vein sets. Crosscutting relationships show the massive pyrite veins predate the calcite-chlorite veins.

The irregularity of fold axes and axial planes, and the presence of internally folded siltstone and mudstone clasts in conglomerates of the AK drift suggest that soft-sediment deformation may have been occuring during or slightly after deposition. Later folding of sphalerite-pyrite veins about subhorizontal axial surfaces is kinematically consistent with and may be linked to formation of the shear veins.

Two styles of alteration are developed in both mine levels: bedding parallel to discordant zones of predominantly potassic alteration associated with sulphide-chlorite-calcite stockwork veins; and biotite - potassium feldspar - chlorite-silica envelopes developed around shear veins. Both styles occur together, but the broad, stockworked alteration zones may slightly predate the shear veins in some places, as demonstrated by their local offset by shear veins. The broad alteration zones may represent a channeling of fluids along permeable rock units that were superceded by flow along the shear veins once they developed. The spatial association of the orthoclase porphyry dike with alteration and mineralization implies that it may be a potential source of fluid and/or heat for at least part of the hydrothermal system. Dioritic dikes in the Discovery workings are offset by shear veins and are potassium feldspar altered, indicating that they predate the mineralizing event.

COMPARISON WITH THE SNIP AND STONEHOUSE DEPOSITS

The geology of the Inel deposit contains notable similarities to published descriptions of the Snip and Stonehouse deposits. Structures at both Snip and Inel are dominated by shear veins with layered calcite, chlorite and biotite fill hosted by probable Triassic sedimentary rocks (Rhys and Godwin, 1992). Kinematic indicators in both locations indicate a large component of down-dip simple shear associated with vein formation. In contrast, the Stonehouse deposit consists of a set of parallel, tabular, extensional quartz-sulphide veins cutting Jurassic volcanic and volcaniclastic strata (Britton *et al.*, 1990).

At all three deposits, porphyritic intrusions are co-spatial with alteration and mineralization. At Snip, the Red Bluff porphyry, a potassium feldspar megacrystic quartz monzonite to monzodiorite body, intrudes footwall sandstones approximately 1 kilometre from the ore deposits of the Twin zone. At Stonehouse, two-feldspar porhyry dikes (Britton *et al.*, 1990) cut the volcaniclastic sequence, and are in turn cut by mineralized veins. Our descriptions above note the occurrence of altered potassium feldspar megacrystic and dioritic dikes within the mine sequence at Inel. Isotopic data are consistent with intrusion broadly coeval with mineralization. Uranium-lead analyses for the Red

Bluff porphyry (195±1 Ma, Macdonald *et al.*, 1992), the Inel stock (190±3 Ma, Macdonald *et al.*, 1992), and the Stonehouse two-feldspar porphyry dikes (194±3 Ma, M-L. Bevier, personal communication, 1992) are consistent with Early Jurassic galena Pb-Pb ages from all three deposits (Godwin *et al.*, 1991).

Finally, potassic alteration is widespread at Stonehouse, Snip and Inel. Biotite envelopes are common around veins at Snip and Inel, as are wide zones of potassium feldspar alteration associated with sulphide-calcite-chlorite stockwork veining. Mineralized veins at Stonehouse are enveloped by potassium feldspar alteration zones 5 to 10 metres thick, and this alteration hosts well-developed pyrite-quartz-chlorite-calcite veins and veinlets.

ACKNOWLEDGMENTS

This contribution has benefited greatly from discussions with V. Jaramillo and R.G. Gifford of Gulf International Minerals Ltd., Cominco geologists N. Callan and T. Hodson, D. Yeager of Skyline Gold Corporation, and with P. Metcalfe, J. Moors and J. Macdonald at The University of British Columbia. P. Carter and R.G. Gifford of Gulf International are thanked for permission to visit the property, and for logistical help. Cominco Metals provided accomodation at the Snip mine. A. Pickering analysed the Discovery drift galena Pb-Pb sample at the U.B.C. Geochronology Laboratory. Funding for this study is provided by the Science Council of British Columbia and Natural Sciences and *Engineering Research Council of Canada under the Mineral* Deposit Research Unit project "Metallogenesis of the Iskut River Area".

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