GAC Fieldtrip #9
May/83

675343

DAY 2: ISLAND COPPER

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INTRODUCTION

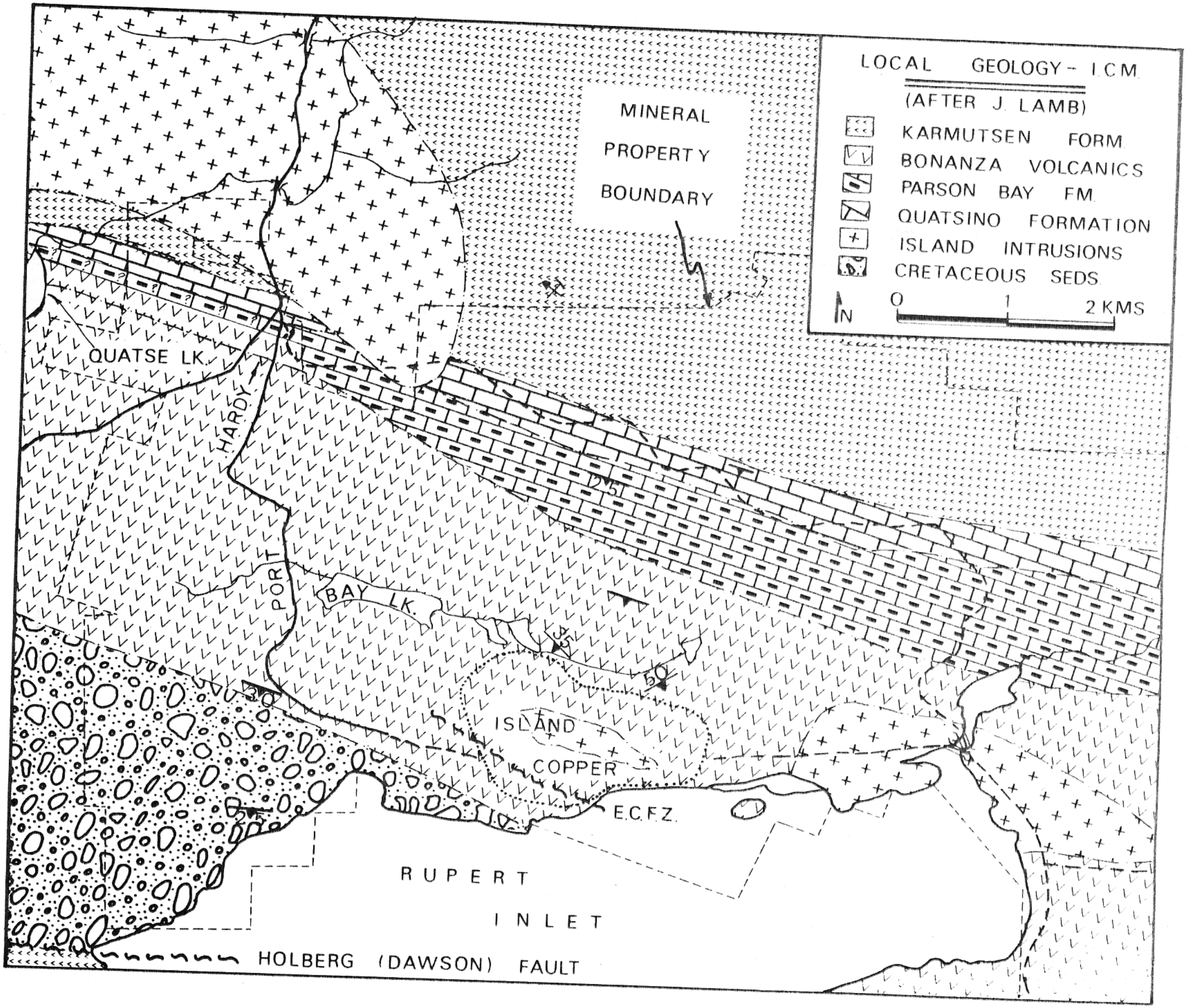
Location

The Island Copper Mine, controlled and operated by Utah Mines Ltd., is on the north shore of Rupert Inlet (50° 36'N, 127° 27'W), about 16 km south of Port Hardy, on northern Vancouver Island. The property consists of 245 contiguous claims and seven mineral leases extending 18 km east from Quatse Lake (Fig. 1).

History

In January 1966, Utah Mines Ltd. (then Utah Construction and Mining Co.) optioned a group of claims from Gordon Milbourne, a prospector, who had discovered high grade chalcopyrite in volcanic rocks immediately southwest of Bay (also called Frances) Lake. The ensuing exploration program consisted of geological mapping, ground magnetic and IP surveying, soil geochemistry and diamond drilling. In February 1967, hole number 82, drilled within a soil copper anomaly over the present pit, intersected mineralization grading 0.45 per cent copper over 88 m. By May 1969 more than 35,500 m of drilling had been completed in 128 holes, defining a 257 million tonne orebody that graded 0.52 per cent copper and 0.017 per cent molybdenum (Young and Rugg, 1971). The ore would be mined from an oval-shaped pit that would be ultimately about 2300 m long, 1050 m wide and 500 m deep, and extend almost 380 m below sea level, with an overall stripping ratio of 2.23 to 1.

The first shipment of copper concentrate was made in December 1971, less than five years after the option agreement was signed. Production to the end of 1982 has been approximately 135 million tonnes of ore and 395 million tonnes of waste rock and overburden. The present daily mine production is about 105,000 tonnes of waste rock and 40,000 tonnes of ore from which is produced 650 tonnes of copper concentrate grading 23 per cent copper, 6 ppm gold and 50 ppm silver. In addition, about 10 tonnes of molybdenum concentrate are produced daily grading 45 per cent molybdenum and containing 1100 to 1200 ppm rhenium.



DAY 2.

FIGURE 1 - GEOLOGY OF THE ISLAND COPPER PROPERTY.

REGIONAL AND LOCAL SETTING

The deposit occurs in and on the flanks of a Middle Jurassic quartz-feldspar porphyry dyke which intrudes pyroclastic volcanics forming part of a thick Upper Triassic and Lower Jurassic volcanic and sedimentary succession (Fig. 1). This succession, the Vancouver Group, has been subdivided into a basal sediment-sill unit, Karmutsen, Quatsino, Parson Bay and Harbledown formations, and the Bonanza Volcanics by Muller et al. (1974), on whose report the following summary of regional geology is based (Table 1).

The area north of Holberg and Rupert Inlets is underlain largely by the Karmutsen Formation porphyritic and amygdaloidal basalt flows with rare units of pillow basalt, formational breccia and tuff. Near the top of this thick volcanic pile are thin lenses of limestone similar to the overlying Quatsino Formation. The Quatsino Formation consists of limestone, thick-bedded to massive in the lower part and medium to thin-bedded in the upper part. Above and in gradational contact with this unit lies the Parson Bay Formation consisting of black calcareous siltstones, shales, and limestones with shaley interbeds. These Upper Triassic sediments are in places overlain by non-calcareous, argillaceous and arenaceous sediments of the Lower Jurassic Harbledown Formation.

The term "Bonanza Volcanics" refers to the Jurassic rocks overlying the Parson Bay or Harbledown sediments. The formation consists of bedded and massive tuffs, formational breccias, amygdaloidal and porphyritic flows of andesitic and basaltic composition, and rhyodacite flows. The lower part of the unit is cut by porphyritic dykes and sills. The Lower Jurassic age of the Bonanza Volcanics has been established by fossils in interbedded sediments. A Bajocian age has been suggested for rocks in the Island Copper pit from which a shell fossil was identified as Myophorella taylori (Poulton, 1980).

Middle Jurassic granitic stocks (Island Intrusions), cutting the Vancouver Group, extend in a belt northwest from the east end of Rupert Inlet to Queen Charlotte Sound. The intrusives range in composition from diorite to quartz-monzonite. Most of the metalliferous deposits on the North Island are related to the intrusive activity either in association with the stocks or with associated porphyry dykes.

Unconformably overlying the Vancouver Group are sediments of the Lower Cretaceous Longarm Formation and the Upper Cretaceous Queen Charlotte and Nanaimo Groups. These rocks consist mainly of coarse conglomerates, siltstones, sandstones and greywackes, with some coal seams.

The structure of the area is characterized by strong northwest trending faults defining the edges of major fault blocks with downthrown, moderately dipping, generally undeformed strata. The faults cut the Cretaceous and older rocks causing repetition and loss of parts of the stratigraphic section. These faults are cut and offset by less prominant, northeast trending fault sets. The Island Copper deposit is in the Nahwitti fault block bound to the south by the large Holberg Fault. The strata dip about 35° to the south-southwest in the vicinity of the deposit.

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TABLE 1 - FORMATIONS IN MINE AREA
(After Muller et al, 1976)

Period			Group or Formation	Lithology
Cretaceous	Upper		Nanaimo Group	Greywacke, siltstone, shale, conglomerate, coal
			— Disconformable Contact —	
			Queen Charlotte	Greywacke, conglomerate, siltstone, shale, coal
			— Disconformable Contact —	
	Lower		Longarm Formation	Greywacke, conglomerate, siltstone
			— Unconformable Contact —	
Jurassic	Middle		Island Intrusions	Quartz diorite, granodiorite, quartz monzonite, quartz-feldspar porphyry
			— Intrusive Contact —	
	Lower	VANCOUVER GROUP.	Bonanza Volcanics	Andesitic to rhyodacitic lava, tuff, breccia
			Harbledown	Greywacke, argillite, tuff
Triassic	Upper		Parson Bay	Calcareous siltstone, shale, greywacke, conglomerate, breccia
			Quatsino	Limestone
			Karmutsen (Includes in upper part inter-volcanic limestone)	Basaltic lava, pillow lava, breccia Limestone

MINE GEOLOGY

Introduction

The Island Copper deposit (Fig. 2) has the shape of an inverted "U" draped over a quartz-feldspar porphyry dyke intruding bedded and massive Bonanza Volcanics andesitic tuffs. The dyke strikes N 70°W, sub-parallel to the regional strike, and dips approximately 50° to the north-northeast, almost perpendicular to the Vancouver Group units. In plan the orebody has the shape of an attenuated ellipse. In longitudinal section both the ore boundary and the dyke plunge at the ends with fingers of porphyry extending outwards and upwards.

A similar porphyry dyke has been intersected in drill holes to the east of Red Island where it is in close proximity to the west flank of the granodioritic Rupert Stock. The genetic relationship between the Island Copper dyke and the stock has not been established. The Rupert Stock has been dated by K-Ar analyses at 154±4 m y (Northcote and Robinson, 1973).

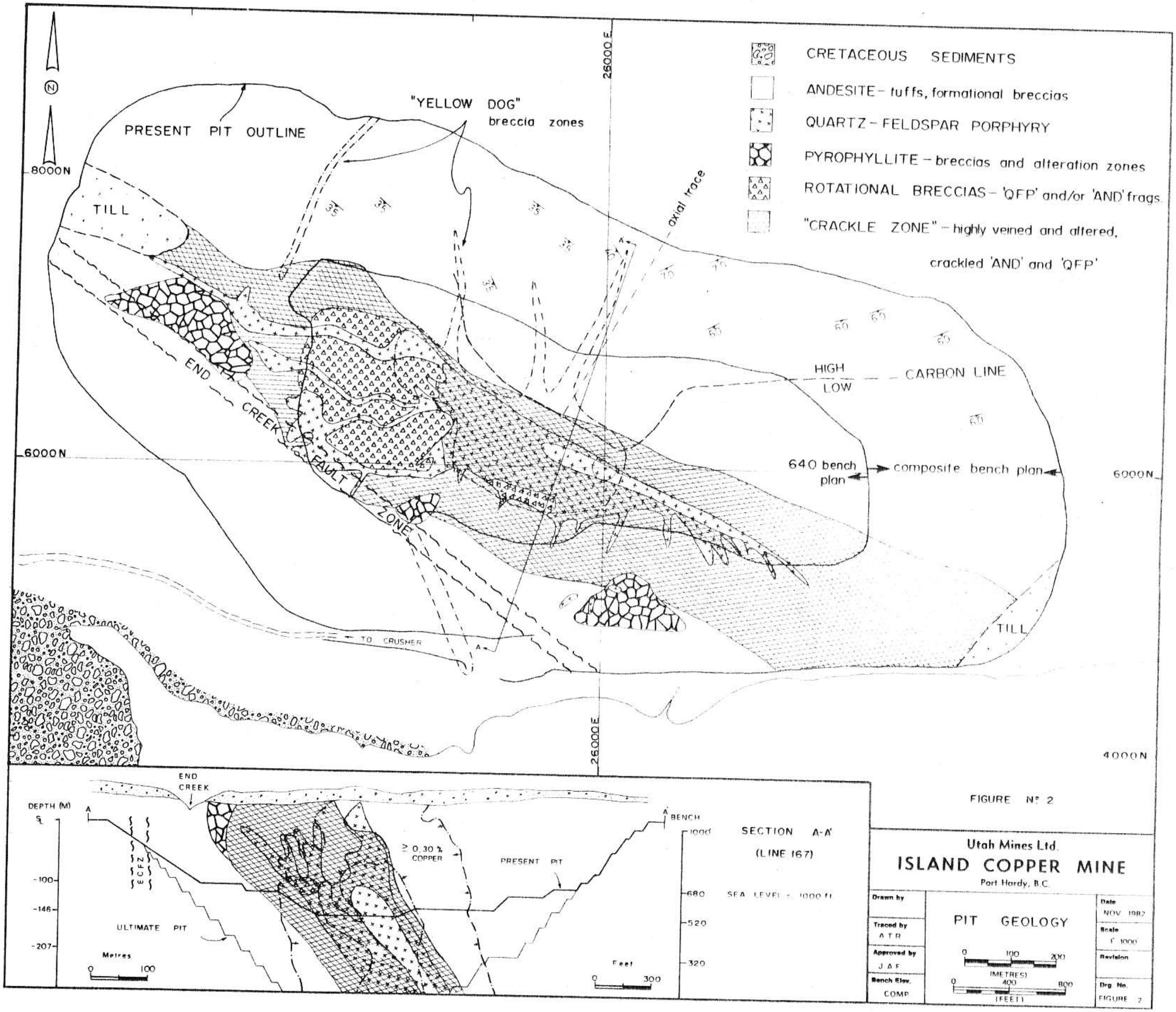
The margins and parts of the interior of the Island Copper dyke are complexly brecciated, shattered, healed, veined and altered. These rocks are classified into marginal breccias with (rotational breccia) and without (crackle breccia) mixing and/or rotation of fragments, a capping breccia (pyrophyllite breccia) and a late stage fracturing and veining (Yellow Dog Breccia). The crackle breccias and the highly altered (hybrid?) rocks are shown (Fig. 2) as a separate zone (Crackle Zone), although all the breccias have been crackled.

Two main stages of alteration have been defined (Cargill et al., 1976). Contact metamorphic alteration zones occur in the wall rocks parallel to the dyke (biotite, transition and epidote zones). Second stage, small volume, wall-rock alterations (chlorite-sericite, sericite, pyrophyllite and "Yellow Dog"), closely related to fracturing and brecciation, are superimposed on the porphyry and the wall rocks.

The ore minerals are chalcopyrite and molybdenite occurring primarily as fracture fillings and smears on fractures and slips, respectively. Over 40 per cent of the ore is in the crackle zone and rotational breccias with the remainder primarily in the hanging-wall and footwall volcanic rocks.

Lithology

Volcanic Rocks. The volcanic rocks in the mine area, part of the Bonanza Volcanics Formation, are massive and bedded, andesitic, fine grained, lithic and lapilli tuffs, and formational breccias. Chert beds, black argillite, thin beds of accretionary lapilli and a large lens or wedge of rhyodacitic lapilli tuff (large, light coloured patch on the north wall) have been observed. A hematized volcanic breccia that occurs south of the End Creek Fault has been intersected in drill holes and is well exposed along the edge of the crusher haul road.



DAY 2. FIGURE 2 - PLAN, COMPOSITE PLAN AND SECTION OF GENERALIZED PIT GEOLOGY.

Quartz-feldspar porphyry dyke. The dyke, as exposed in the pit, is about 1500 m long and up to 200 m thick. The central intrusive zone consists of massive, readily identifiable porphyry and complexly brecciated, quartz veined, sericitized and quartz-magnetite altered porphyry, porphyritic (hybrid?) and porphyry bearing rocks.

The massive, typically white to light green, porphyry prominent in the pit is medium to coarse-grained with resorbed quartz (5-15 per cent) and plagioclase (20 to 30 per cent) phenocrysts and occasional mafic minerals pseudomorphed by chlorite (5 to 10 per cent) set in a fine-grained quartzo-feldspathic matrix (Cargill et al., 1976). This rock is generally poorly mineralized. A variety, typically with distinct tan feldspar phenocrysts and smokey quartz eyes set in a dark green, reddish and black quartz-magnetite rich matrix, has become more abundant with depth, as has a variety with a salmon-pink matrix. Porphyry with a reddish matrix, found at depth in the core of the dyke, may represent the least altered variety of porphyry. Apophyses of porphyry that extend out from the body of the dyke, cutting earlier porphyries, have, in some cases, recognizable chilled margins. Porphyry also occurs as a breccia matrix and in a vague replacement mode (hybrid?). More than one phase of porphyry is represented in the deposit and some of the dyke rocks may be of post-ore age.

A northward dipping quartz-feldspar porphyry dyke, intersected in drill holes north of Red Island, and a dyke 580 m below the surface immediately north of the pit are similar to the Island Copper dyke. They support the model of a system of more or less vertical dykes, emanating from a larger and deeper source, intruding volcanic rocks that were later block faulted downward to the south, giving the dykes steep dips to the north. Northcote and Muller (1972) see the Island Intrusions and the Bonanza Volcanics as comagmatic with the dykes as feeders for the dacites and rhyodacites in the upper part of the Bonanza.

Epigenetic breccias. Three associated breccia types have been recognized in the deposit (Cargill et al., 1976); pyrophyllite breccia, marginal breccias and Yellow Dog breccia. Rarely, narrow dykes (pebble dykes) with rounded fragments of porphyry and andesite, have been recognized. The mechanisms of brecciation and the genetic relationships of the breccias are not clearly established. Intrusion brecciation, volcanic explosion brecciation and/or multiple intrusion brecciation (Cargill, 1975), and autobrecciation with possible fault brecciation (Fahey, 1979) are suggested mechanisms. Fahey does not include the Yellow Dog rocks with the breccias.

Pyrophyllite breccia is a coarse breccia that occurs as a cap over the quartz-feldspar porphyry dyke at the west end of the deposit. It has been traced over 1100 m to the west along strike with a width of up to 150 m. The breccia zone thickens to the west and pinches out on the footwall side of the dyke. Zones of intense pyrophyllite alteration also occur to the east, but without the brecciation. The pyrophyllite breccia contains fragments of quartz-feldspar porphyry and highly altered, fine-grained volcanic (?) rocks in a fine-grained, grey and tan pyrophyllite matrix. Blue to lilac dumortierite occurs both as pervasive alterations of the fragments and as cross-cutting veins.

The breccia is bounded on the south by the End Creek Fault and to the north by a zone of intense, pervasive sericite alteration that extends along and down the north boundary, thinning with depth. The bottom of the breccia grades into the west end marginal breccias with the pyrophyllite decreasing in intensity.

The marginal breccia occurs along and overlapping the margins of the quartz-feldspar porphyry dyke as rotational and crackle breccias typically shattered and healed with quartz and porphyritic material with concomitant quartz, sericite and magnetite alterations. At least two periods of brecciation and two periods of shattering have occurred. The composition of the breccias varies from predominantly volcanic fragments to predominantly porphyry fragments as the dyke is approached. The breccias follow the dyke to at least 400 m below the surface as determined from deep drill holes.

The crackle breccias show little or no fragment rotation, with the breccia texture due to the quartz healed fractures or vein stockworks. The complex around the dyke of crackled rocks and rocks with original textures largely obliterated by alterations and veining, with vague porphyritic textures (hybrid?) or flooded with quartz veins are grouped into a "Crackle Zone" (Fig. 2).

The rotational breccias have evident mixing and/or rotation of fragments and are shown separately where recognized. The largest expanse of the breccia is at the west end in a large circular zone cut by fingers of quartz-feldspar porphyry. These breccias are no less shattered, veined and altered than the crackle breccias. They tend to yield above average copper grades (commonly above one per cent copper) and up to double the average gold content of 0.22 ppm. The west end area also has zones of anomalous lead and mercury concentrations.

The Yellow Dog breccia was named for the characteristic rusty-brown colour imparted to the rock by a network of ferroan-dolomite (Cargill et al., 1976) or ankerite veins (O. Arancibia, Personal Communication, 1979). The veins occur primarily in the center of the deposit in the breccias and the dyke with branches extending north into the hanging-wall andesites, south through the dyke and on the south side of the End Creek Fault. The Yellow Dog rocks are typically sericite altered. On the upper benches the limbs of Yellow Dog contained mixed porphyry and andesite fragments that extended north beyond the main breccia boundary. Current exposures show the ferroan-dolomite/ankerite as late-stage veins and fracture fillings. It is not clear whether the Yellow Dog veins are tied to a phase of intrusion related brecciation or were controlled by late-stage structures.

Structure

Bedding within the Bonanza Volcanics defines a broad, asymmetrical, anticlinal structure (Fig. 2) with an axis trending S 34°W and plunging 30° south. The beds in the west limb dip 25° to 40° southwest while dips in the east limb are steeper at about 60° southeast. The structure probably results from faulting and/or folding. The absence of small scale folds, and the presence of minor displacements of strata and rotation of small blocks between faults and shears suggest a mechanism of brittle deformation. This would be consistent with the regional structural style of block faulting with limited amounts of folding. The alignment of the axis with the Yellow Dog zone indicates that the two may be related to the same period(s) of deformation.

There are two main fault sets in the pit and at least five weaker sets. Most of the faults have some associated breccias, gouge, veins and/or alterations. Coarse crystals of calcite and well developed zeolite crystals found suggest that structures were open at least part of the time. The magnitude and directions of offsets are not generally known. Most structures other than the few strong faults are discontinuous due to the multiple, small offsets by cross-cutting structures.

The most prominent faults strike west-northwest and dip moderately to steeply to the northeast. These structures are aligned with the axis of the deposit and the strongest regional fault set. They may have effected some control on emplacement of the dyke and mineralization.

The End Creek Fault, located on the south side of the pit, is the most prominent structure associated with the deposit. It is a zone of faults, shears, crushed rock and clayey gouge, about 60 m thick, that strikes N 60°W and dips vertically to steeply to the northeast. It cuts off part of the south edge of both the pyrophyllite breccia zone and the orebody. At least some of the movement was, therefore, post-mineralization. The Yellow Dog streak on the south side of the fault zone indicates that either little lateral movement was involved or that the fault pre-dated the Yellow Dog veining.

The second prominent set of faults and shears strikes northeast and dips moderately to steeply to the southeast. A strong, central, northeast striking fault zone (November Fault Zone) that was found on the upper benches has not been traced to depth.

The fracture density of the rocks varies from low to very high depending on rock type, structures and proximity to the margins of the dyke, although the overall fracture density of the deposit is high. The lowest fracture densities occur in the unbrecciated dyke and the pyrophyllite breccia, while the highest levels occur in proximity to strong faults and shears, and in the marginal breccias.

Alteration and Veining

Alterations have been classified into two main stages (Cargill et al., 1976); contact metamorphism (hornfelsic) of the andesite associated with the intrusion of the quartz-feldspar porphyry dyke and superimposed wall-rock (metasomatic) alterations of the dyke and wall rocks.

The first stage developed mineral assemblages zoned parallel to and grading outward from the dyke from one zone to the next (Fig. 3). The principal alteration minerals are biotite, chlorite and epidote. These define the biotite, transition and epidote zones, respectively, with the biotite zone closest to the dyke. On the hanging-wall side of the dyke the biotite

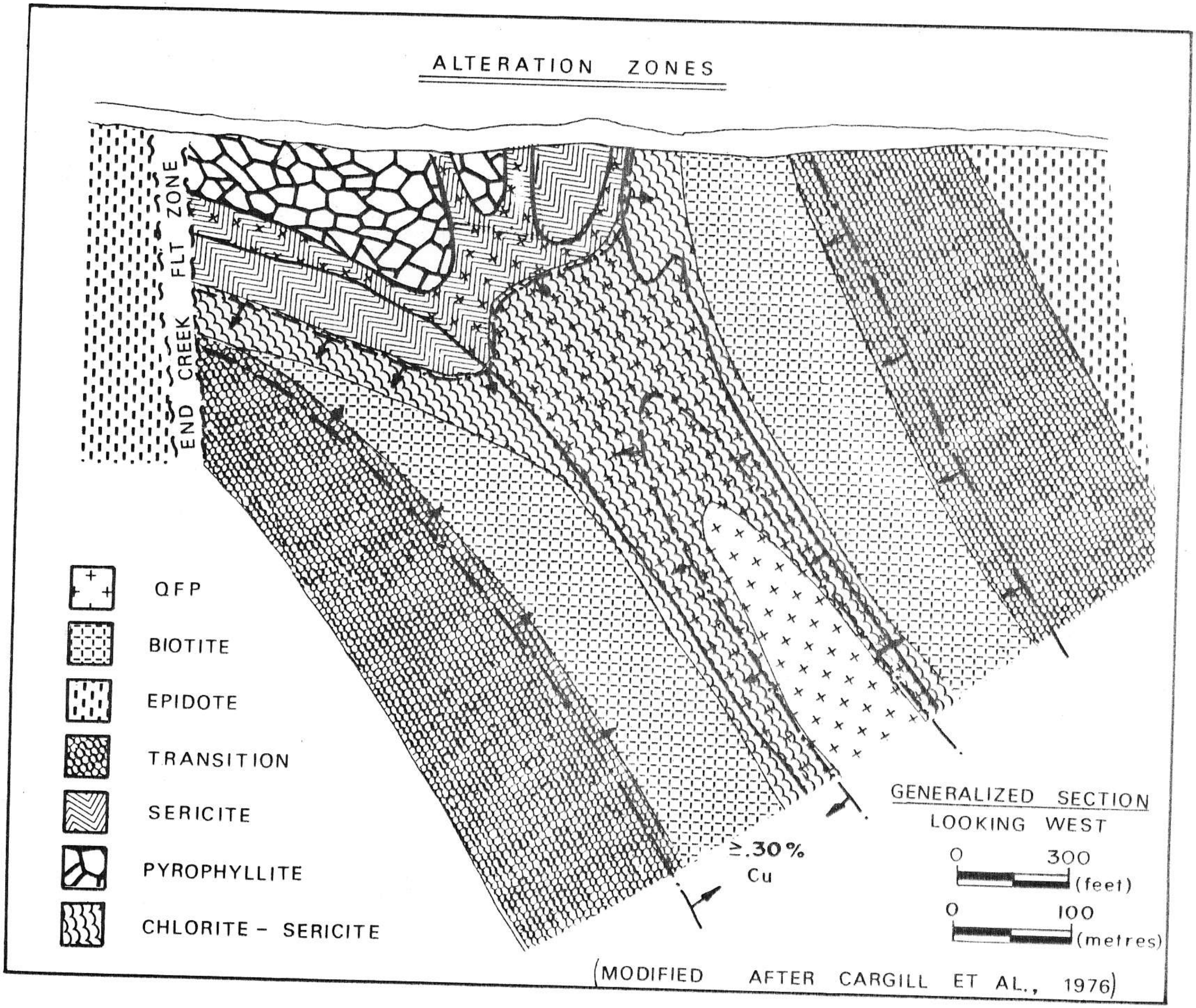


FIGURE 3 - GENERALIZED SECTION, SHOWING ALTERATION ZONES.

zone is about 100 m wide, the transition zone about 200 m wide and the epidote at least 300 m wide. Alteration assemblages on the footwall side of the dyke are partially obliterated by the broad, irregular, footwall zone of wall-rock alterations and are cut-off by the End Creek Fault. Biotite alterations have been intersected by drill holes at depth on the footwall of the dyke.

Second stage (wall-rock) alterations have been classified as chlorite-sericite, sericite, pyrophyllite and "Yellow Dog" (Cargill et al., 1976) based on their mineral assemblages. The wall-rock alterations (excluding "Yellow Dog") occur as zoned envelopes about quartz-molybdenite veins and fractures with the alteration intensity proportional to the degree of veining and fracturing. The alterations affect all rock types in the orebody, but are strongest in the breccias with an intensification of the alterations up the section. Cargill et al. (1976) apply the theory of hydrogen-ion metasomatism (Hemley and Jones, 1966) to the system whereby the progressive leaching is due to the freshest hydrothermal fluids causing the strongest alterations.

Wall-rock alterations in the quartz-feldspar porphyry are typically broad, zoned envelopes on thin fractures and in the andesites are narrow, zoned envelopes about quartz-molybdenite veins. An early period of pervasive sericite alteration is postulated to explain some of the macroscopic paragenetic relationships observed.

Silicification and quartz veining occur in all parts of the orebody, but are strongest in the crackle zone and rotational breccias, often with almost complete replacement of the original minerals by silica. An early period of strong silicification was followed by possibly five periods of quartz veining, some with associated magnetite and sulphides. One set, found mainly in the marginal breccias, contains coarse chalcopyrite that yields small volumes of ore grading over two per cent copper. Swarms of quartz veins, typically fracture or fault controlled and with soft alteration envelopes, are most abundant in the crackle zone, but also extend out into the less altered andesites.

Carbonate and zeolite occurring as late-stage veins are widespread through the deposit. A more pervasive calcite, probably due to propylitic alterations, is also present. Orange zeolite (laumontite) locally stains the altered feldspar phenocrysts of some of the porphyry a bright orange. Sphalerite and galena, pyrite and chalcopyrite also occur with these veins, particularly on the periphery of the deposit. A black pyrobitumen, called gilsonite, believed to originate in the Parson Bay Formation, occurs in late-stage fractures in an area north of a line called the "carbon line" on the north side of the deposit. J. Lamb (Personal Communication, 1974) suggests that the boundary demarks a thermal front related to the dyke beyond which the gilsonite did not pass.

Ore Zone

Geometry. In section, the copper orebody (greater than or equal to 0.30 per cent copper) has the shape of a thick "U" inverted over and dipping parallel to the quartz-feldspar porphyry dyke (Fig. 2). It averages about 350 m from the hanging-wall to the footwall ore boundaries. A 30 m to 200 m, irregular, weakly mineralized central zone extends down from about 60 m below sea level separating the hanging-wall and footwall ore limbs. The mineralized limbs have been traced to a maximum depth of 425 m below sea level and are not closed off. Bench composite copper grades do not weaken with depth.

In plan the orebody is elongate with a maximum length of about 900 m along a N 70°W axis. The hanging-wall and footwall ore limbs, at depths greater than approximately 120 m below sea level, are linked at the east end and open at the west end with the north limb extending up to 300 m further west than the south limb. The north ore boundary is sharp and continuous along the length of the deposit. The other ore boundaries are more irregular, reflecting the greater complexity of the system closer to and south of the dyke. The orebody is slightly concave to the north. Additionally, in longitudinal section, the orebody crests in the middle and plunges 15° to 25° to the northwest and 5° to 10° to the southeast. These forms, if linked to the antiform on the north wall, suggest post-ore deformation.

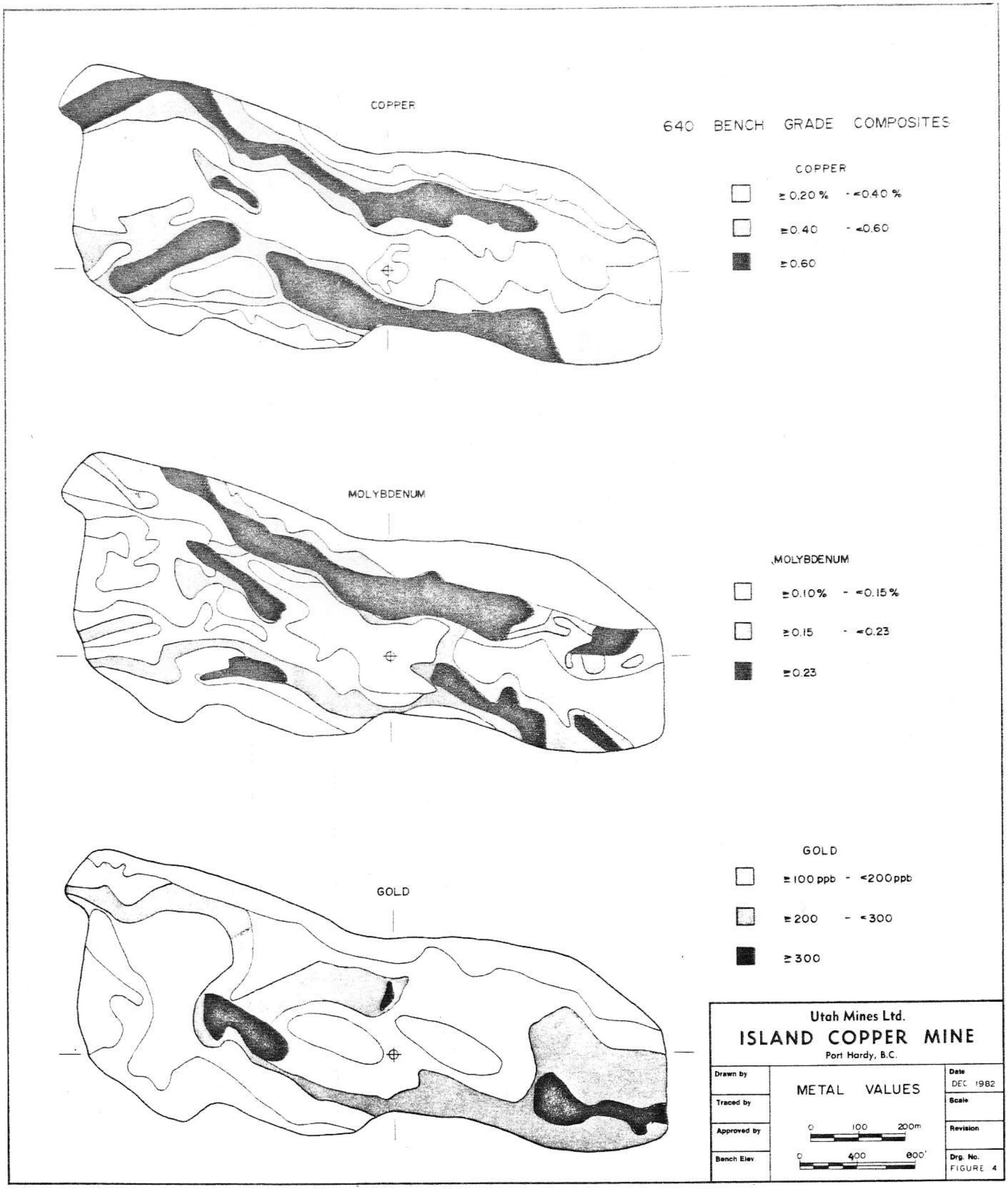
About half of the ore grade mineralization occurs in the biotite and transition zone andesites. The remainder of the ore is in the crackle zone, the rotational breccias and the dyke. The massive, light green to white porphyry and the pyrophyllite altered rocks, chacterized by low fracture densities and a high degree of fracture infilling, have weak to negligible copper mineralization.

Mineralization. Chalcopyrite and molybdenite are the only sulphide minerals recovered. Minor amounts of bornite and pyrrhotite have been seen, however. Cargill (1975) identified five stages of chalcopyrite and three stages of molybdenite deposition. Stage one deposition of chalcopyrite as fine fracture fillings and lesser dissemination and stage three deposition of molybdenite as skins on slip surfaces account for the bulk of the copper and molybdenum mineralization. The molybdenum ore contours (Fig. 4) show a strong overall similarity to the copper contours, although locally the correlation between the two is poor. The 0.010 per cent molybdenum contour falls consistently within the 0.30 per cent copper boundary on the north limb, but elsewhere irregularly overlaps the copper boundary.

Pyrite is ubiquitous, occurring as veinlets and disseminations, and in chloritized mafic minerals with magnetite a common association. The pyrite content of the rocks is generally two to five per cent.

Magnetite is the most abundant oxide in the deposit, although earthy-red hematite is not uncommon. The magnetite occurs with chlorite replacing mafic minerals in the transition and biotite zones and in the marginal breccias as veinlets and pervasive disseminations with silica in amounts increasing with depth. Magnetic susceptibility studies in the pit substantiate the strong spatial magnetite-copper association recognized in the area. Intense quartz-magnetite alteration occurs in a zone about 15 m to 50 m wide on the north margin of the dyke, producing a distinctive, black, brittle rock, and extends increasingly into the dyke with depth.

Gold concentrations above 0.010 ppm occur mainly within the copper ore boundary (Fig. 4) with the distribution paralleling the axis of the orebody. The gold distribution has a relationship to copper similar to that of moly-



DAY 2. FIGURE 4 - DISTRIBUTION OF COPPER, MOLYBDENUM AND GOLD ON THE 640 BENCH.

bdenum. There is an overall good correlation between the two, but locally they do not match. Gold emplacement is evidently tied to the intrusive system, but at least some of the gold was not emplaced at the same time or in the same place as the chalcopyrite. The highest gold values recorded to date (up to 0.51 ppm) are from the quartz-magnetite altered rotational breccias and the highly altered rocks in the crackle zone to the southeast. A gold-quartz-magnetite association, also evident for the quartz-magnetite altered breccias found on Red Island, has been noted in scanning electron microscopy research on samples from the deposit (J.W. Gabelman, Personal Communication, 1981).

Weathering and Supergene Characteristics

The deposit shows little evidence of weathering and supergene alterations. A thin (two cm thick) zone of iron and copper oxides occurred in the center of the deposit (Cargill et al., 1976). There is no secondary enrichment of the orebody.

Ore Formation

Cargill et al. (1976) describe a tentative three step model of formation of the Island Copper deposit as follows: 1) early, pervasive, contact metamorphic alterations related to the intrusion of the dyke with associated fracturing and brecciation, lateral migration of fluids and convective transfer of heat with no mass transfer effects; 2) progressive, small volume, wall-rock alterations by base leaching related to the upward migration of hydrothermal fluids along the margins of the dyke and into the dyke and wall rocks along fractures, driven by a heat source deeper than the dyke. Copper and molybdenum mineralization accounting for the bulk of the ore were deposited very early and very late, respectively, in this step, on fractures and slip surfaces; 3) late-stage, fracture and fault controlled emplacement of carbonate and zerolite veins from low-temperature, alkaline, hydrothermal solutions with a down-ward displacement of the zone of superimposed alterations.

Northcote (1973) suggests that at least one and possibly several episodes of explosive brecciation or gaseous streaming and several periods of fracturing produced the complex breccia and fracture system flanking the dyke that was variously permeated by hydrothermal solutions and mineralized quartz (-feldspar) porphyry differentiates.

Fracturing and the chemistry of the rocks and fluids were undoubtedly important ore controls. The relationships between them and the source of the copper have yet to be determined.

ACKNOWLEDGEMENTS

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DAY 3: IRON HILL (ARGONAUT MINE)

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INTRODUCTION

The Iron Hill property, known locally as the Argonaut mine, is located 28 kilometres southwest of Campbell River at Upper Quinsam Lake (49° 47' N, 125° 32' W; N.T.S. 92F/13E).

Magnetite outcropping over a considerable area on Iron Hill was discovered early in the century. It received sporadic exploration prior to 1948 at which time it was acquired by Coast Iron Company Limited. They did some diamond drilling and shipped a small quantity of ore. The property was optioned in 1949 by the Argonaut Company Ltd., a subsidiary of Utah Construction Company Ltd. of San Francisco (now Utah International Inc.). The Argonaut Company operated it as an open pit mine from August 1951 until December 1956. During that period, approximately 4 million tonnes of iron ore were mined. There has been no work done on the property since early 1957. The mineral rights are presently owned by Head Mining Corporation of Campbell River. Intention to reopen in 1982 held up by claim dispute exploration in 1982-83. New name Iron Hill Mines Ltd.

The Iron Hill deposit is representative of a large number of contact metasomatic magnetite deposits which occur on the islands fringing the coast of British Columbia. At least 14 of these deposits have produced iron (± copper) on Vancouver Island, the Queen Charlottes, and Texada Island since the 1940's. Production peaked in the early 1960's and, at present, only one of these deposits is still producing (Tasu on Moresby Island). Tasu will close in Oct/83

GEOLOGY OF THE DEPOSIT TYPE

The contact metasomatic magnetite deposits of coastal British Columbia characteristically occur in Upper Triassic rocks, at or near the contact between mafic Karmutsen volcanics and Quatsino Limestone or their correlatives (e.g. Kunga Fm. on the Queen Charlottes). The majority have replaced folded and brecciated Karmutsen rocks adjacent to the limestone, a few occur within

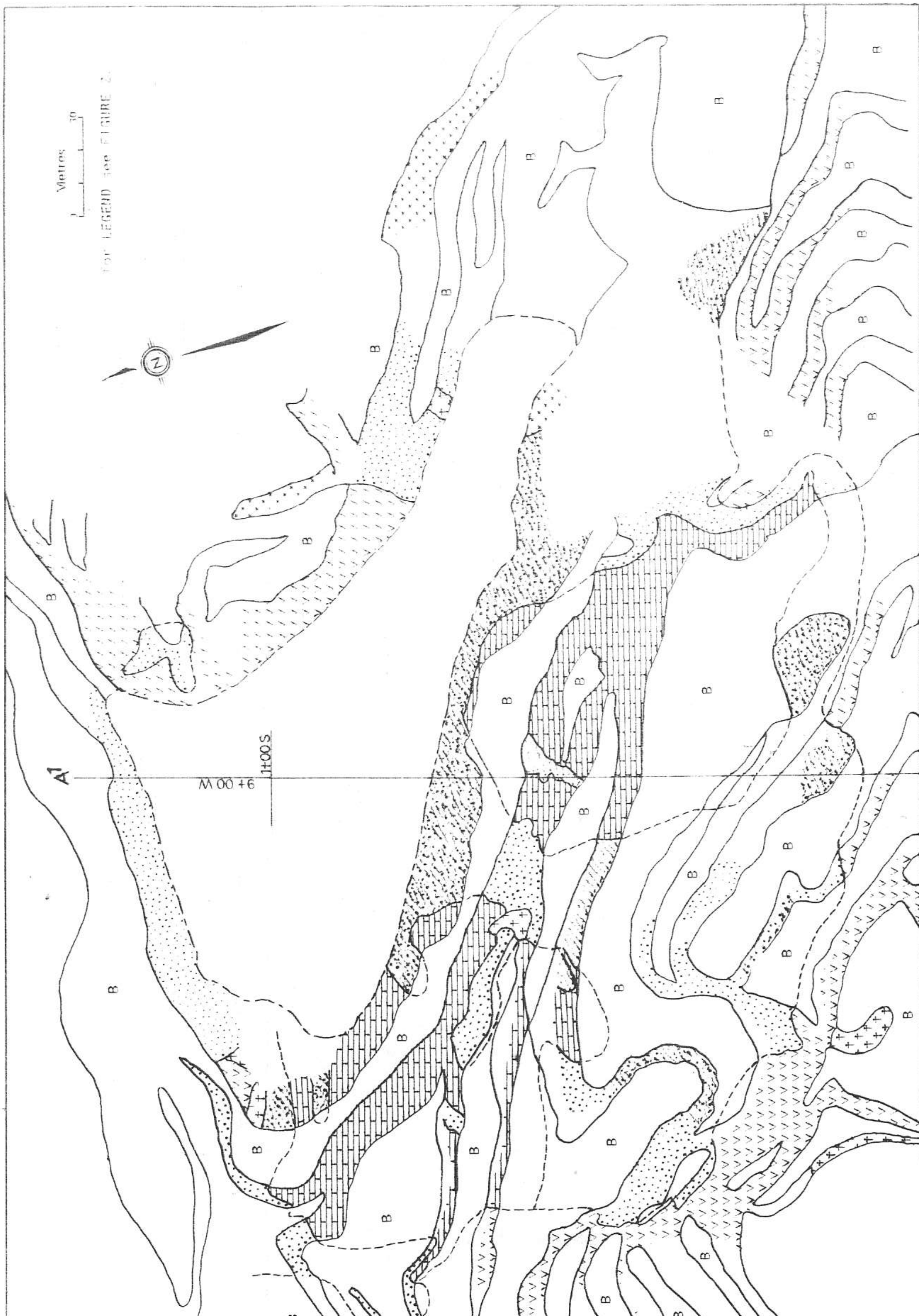

FIGURE 1. Plan of Open Pit, June 1961, Iron Hill Deposit

DAY 3.

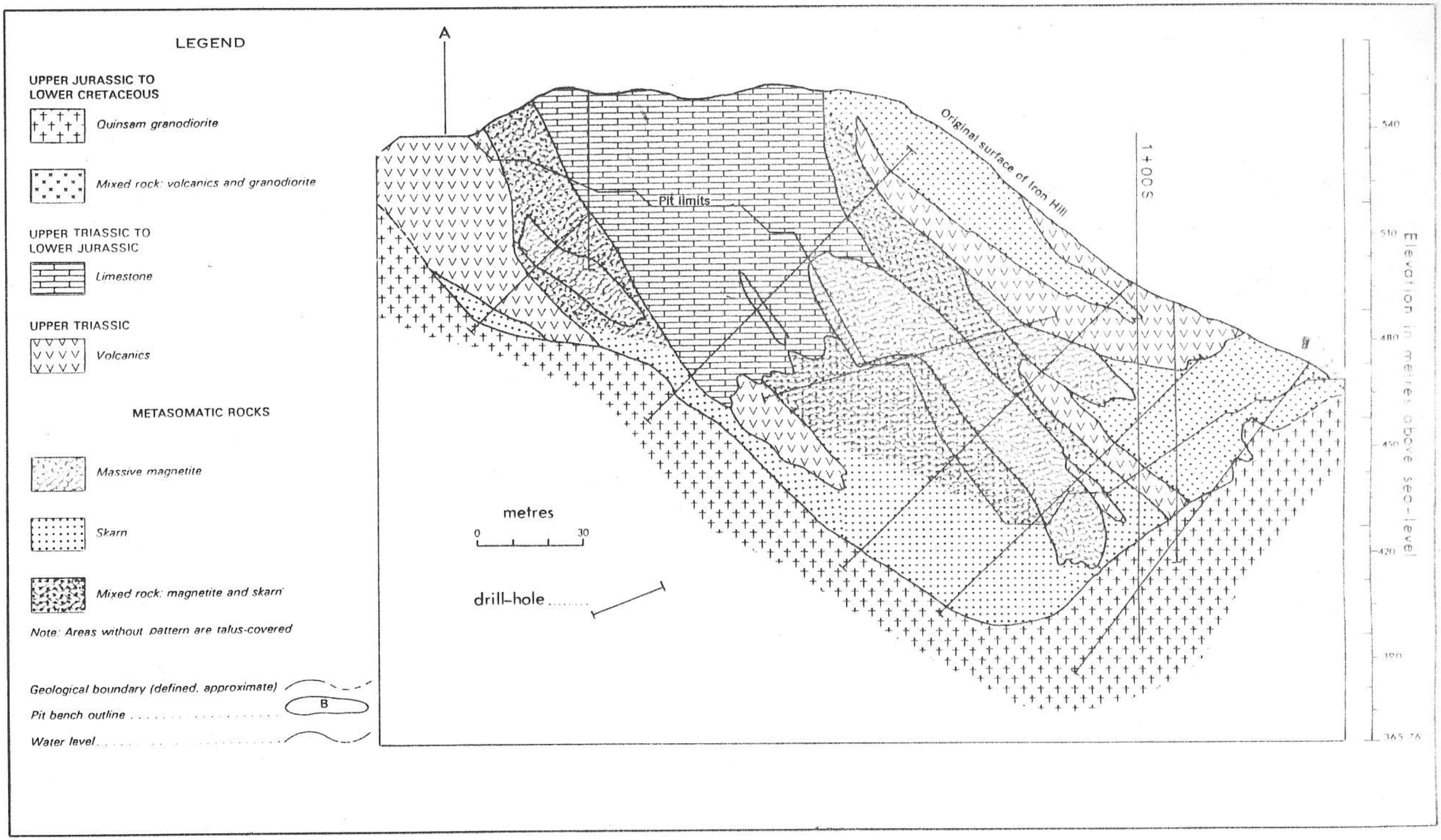

FIGURE 2. Diagrammatic Section A-A'. Iron Hill Deposit (from Sangster, 1969)

the limestone, and a small number in Bonanza volcanics stratigraphically above the Quatsino limestone. Furthermore, the deposits are all found adjacent to Jurassic plutons of intermediate composition which have intruded and metamorphosed the Triassic rocks.

The gangue in all cases is a skarn assemblage dominated by yellowish-brown garnet (andradite-grossularite) with abundant pyroxene (diopside-hedenbergite) and epidote. Magnetite is the major metallic mineral, chalcopyrite is locally abundant, and pyrite, pyrrhotite, sphalerite, and arsenopyrite frequently occur in minor amounts. Many of the ore zones contained up to 60% Fe, as much as 2% Cu (e.g. Coast Copper), and traces of Au, Ag, Ni, Co, Mo.

For a more complete description of the contact metasomatic magnetite deposits of southwestern British Columbia, and of the Iron Hill deposit specifically, the reader is referred to Geological Survey of Canada Bulletin 172 by D.F. Sangster (1969), and to earlier reviews by Sutherland Brown (1962) and Eastwood (1965).

Eastwood and Sangster both concluded that the immediate source of the iron was the intermediate pluton with which each deposit is invariably associated, and that the ultimate source was the Karmutsen volcanics which had been partly assimilated by the advancing magma. Sangster made the following additional generalizations:

> " Iron is considered to have been ......carried to the sites of deposition as aqueous supercritical solutions of iron chloride. Magnetite was precipitated from the ore-forming fluid by an increase in pH brought about by reaction with limestone."

and:

> " The most favourable sites of deposition were along contacts between limestone and volcanic rock, particularly where local folding had brecciated the more brittle igneous rocks. Brecciated volcanic rock, relatively more permeable to ore-forming fluids and having a relatively large surface area, was a particularly favourable site of ore deposition."

GEOLOGY OF THE IRON HILL DEPOSIT

In addition to the general reviews cited above, the reader is referred to an excellent description of the Iron Hill deposit published by Black in 1952 when the Argonaut mine had been in production for only one year. The figures included in this guidebook report are derived from figures published by Sangster in 1969. They show the surface geology of the open pit at the conclusion of mining (Fig. 1) and a diagrammatic cross section of the deposit (Fig. 2).

The Iron Hill deposit occurs within a pendant of Upper Triassic rocks preserved in a saucer-like embayment in the Quinsam intrusion. The Quinsam intrusion is 7 miles long in a northwesterly direction and 3 miles wide, consists of medium-grained, massive granodiorite containing euhedral hornblende crystals, and is believed to be a Jurassic pluton. The Triassic rocks in the pendant comprise an overturned syncline, the axial plane of which strikes northwesterly (parallel to the long axes of both the Quinsam intrusion and the elliptical pendant) and dips moderately to the northeast.

A roughly elliptical body, 270 metres by 80 metres in plan, of Quatsino limestone sits on the axis of the syncline and is surrounded and underlain by Karmutsen andesites. The limestone is characterized by alternating grey and white beds and is completely recrystallized to a medium-grained marble. The andesites are generally fine-grained, dark green and locally are distinctly porphyritic with star-shaped clusters of feldspar crystals. Between the limestone and the volcanic rocks an irregular zone of magnetite and garnet skarn was developed.

Skarn obscures most of the limestone-volcanic contact, but, according to Sangster, company records show that most of the ore occurred as a replacement of volcanic rocks rather than of limestone. Black concluded, and Sangster concurred, that "during deformation the greenstone became closely fractured whereas the limestone merely flowed and recrystallized. Because the fractured greenstone was more permeable to mineralizing fluids than limestone and offered larger surface areas for reaction, it was preferentially replaced by ore minerals."

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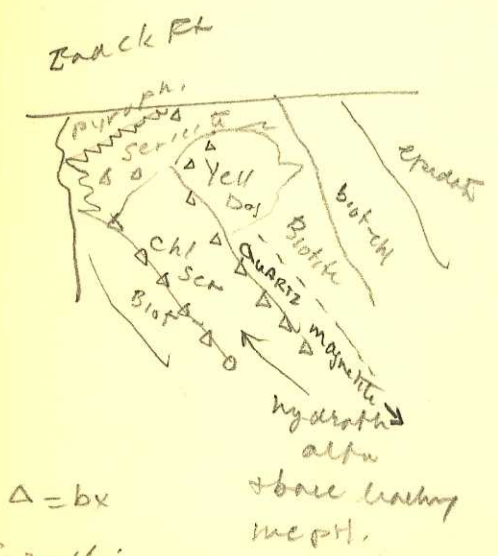
Alteration



Δ = bx

Coyell:
porph: broad chl-ser alt
andesite: narrow alt zn
margins of dyke are porph.
conduits of fluids.

Goldeman: 3 periods faulting,
5 periods Au depn.

Coyell: 5 periods cpy +
3 sets Mo veins
(phases)

Au ① follows dyke system,
② within Cu orebody
③ correlates well with Cu, not 100%. May be free Au in small cavities, hard to recover.

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qtz-magnetite alt intensifies with depth + actinolite
— looks like Red Island type min - could be high Au
— concentrate on HW of porphyry dike.

180 Ma on Island Cu dike porphyry Rb/Sr

154 Ma of KA on Rupert Stock at E end of Rup Inlet.
Kassel may be younger than dyke - problem.