GEOLOGY OF THE "ISLAND COPPER" MINE, PORT HARDY, BRITISH COLUMBIA

by

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ABSTRACT

The Island Copper deposit at Port Hardy, approximately 200 miles northwest of Vancouver, B. C., consists of two ore zones with total reserves of 280,000,000 tons of 0.52 percent copper and 0.029 percent molybdenite. Ore zones occur in Jurassic andesitic rocks in the hanging wall and footwall of a quartz-feldspar porphyry dyke. Breccias with volcanic and intrusive fragments cap the dyke and occur along the margins. Chalcopyrite and molybdenite occur in all rocks, but ore grade concentrations are restricted to volcanic rocks and marginal breccias.

The rocks have been subjected to contact thermal metamorphism and to hydrothermal alteration. The metamorphic aureole can be subdivided into an inner zone, adjacent to the dyke, characterized by biotite and magnetite; an intermediate, transitional zone characterized by chlorite; and an outer zone characterized by epidote. The ore zone is associated with the inner (biotite) zone and the inner part of the intermediate (transitional) zone.

The hydrothermal alteration which occurs in volcanic rocks, breccias and the porphyry dyke is characterized by formation of sericite, pyrophyllite and a kaolin group mineral. Pyrophyllite is largely restricted to the breccia which caps the dyke. Sericite and the kaolin group mineral(s) occur in the marginal breccias and in sericite envelopes on quartz veins and open fractures cutting volcanic rocks and the porphyry dyke.

There are five stages of chalcopyrite deposition and three stages of molybdenite deposition. However, field evidence

supported by statistical study indicates that the first stage of copper deposition accounts for the bulk of metal in the orebody. Most of the chalcopyrite was deposited before the bulk of the molybdenite.

GEOLOG format proved a quick and effective method of recording wall rock alteration observed in drill core. Statistical study of correlation, between abundance of alteration minerals and copper and molybdenite grades, yielded information on the importance of different stages of sulphide deposition to the ore zone. However a knowledge of age relations of alteration and ore minerals was essential to an interpretation of the statistical results.

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Dr. A. Soregaroli assumed supervision of the completion of the study and his encouragement and advice contributed greatly to the study. Dr. K. C. McTaggart made suggestions for improvement of the original manuscript.

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CHAPTER 1: INTRODUCTION

LOCATION

The Island Copper mine is on Rupert Inlet approximately seven miles south of the town of Port Hardy on the northern part of Vancouver Island (Figure 1-1). The mine is accessible by public roads from Port Hardy or by sea through Quatsino Narrows into Rupert Inlet. Barge and freighter docks are at the mine site.

Elevations on the property range from sea level to 500 feet. The area is densely timbered and undergrowth is thick. Annual precipitation, which includes one or two feet of snow, normally averages seventy-five inches. Yearly temperature range is 20°F to 80°F.

PREVIOUS GEOLOGIC WORK

Dawson (1887) published the first maps of Northern Vancouver Island as part of a coastline reconnaisance carried out in 1886. More recently, O'Rourke (1962) described the geology and the ore deposits of the area in an unpublished study for Utah Mines Ltd. Muller (1970, 1973) mapped the area in the summers of 1968 and 1969 as part of the Geological Survy of Canada's mapping program. Northcote (1970, 1972, 1973) mapped an eight-mile-wide strip north of Rupert and Holberg Inlets at one mile to the inch (for the B.C. Department of Mines) during the summers of 1968, 1969 and 1970

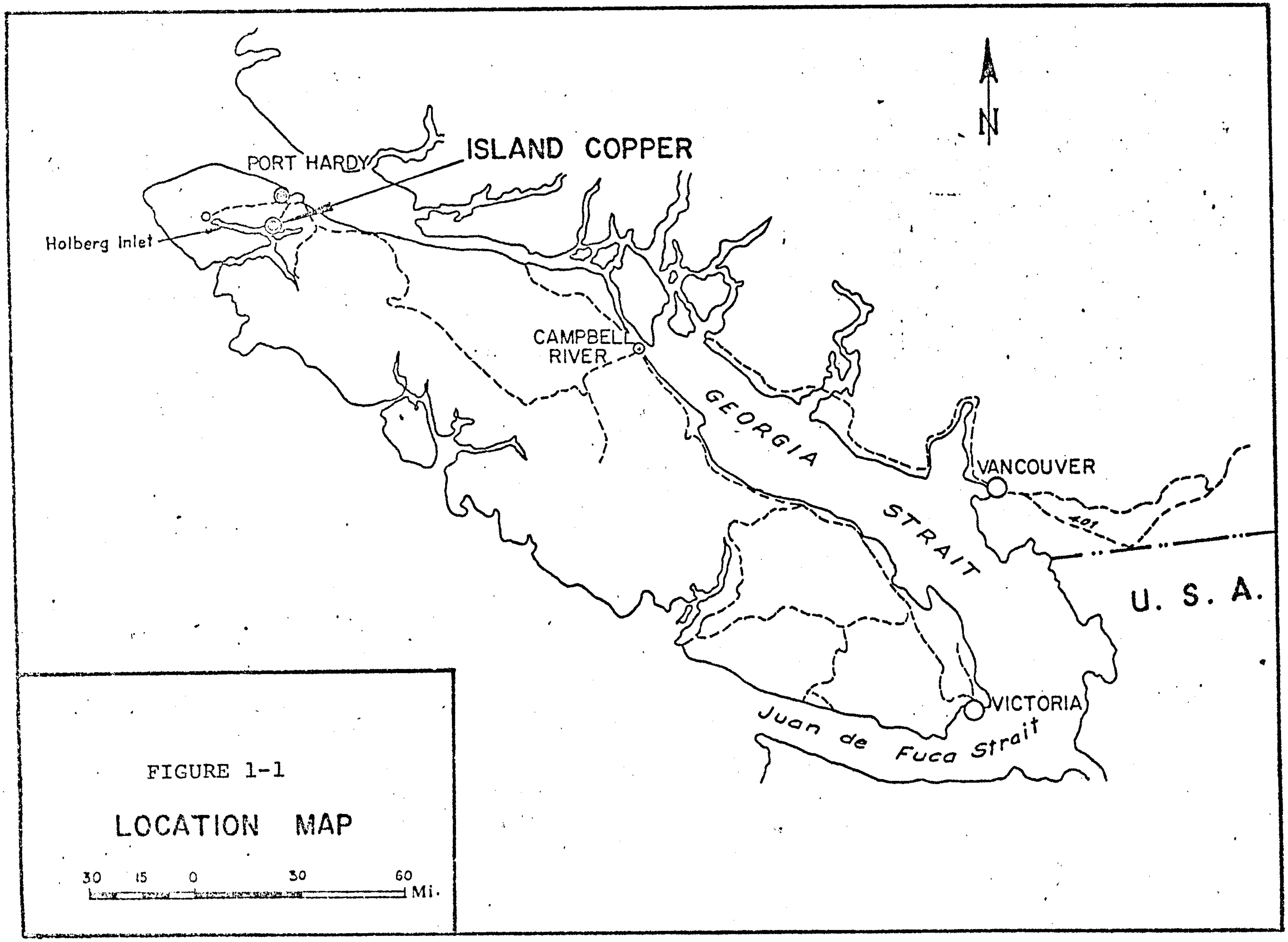


FIGURE 1-1

LOCATION MAP

and described the general geology and exploration history of the Island Copper deposit.

SCOPE OF THE PRESENT INVESTIGATION

The writer spent nine months on the Island Copper property during the summers of 1970, 1971 and 1972. During this time he mapped outcrops and pit exposures. In addition, he relogged approximately 40,000 feet of core in detail, using a modified "GEOLOG" format (Blanchet and Godwin, 1972). Apparently 70,000 feet of additional core were examined in less detail.

Mineralogy and temporal relations of the alteration minerals were established using thin-sections, polished sections and slabs, and X-ray diffraction techniques. During the course of the study 300 thin-sections, 65 polished sections and slabs, and approximately 550 X-ray diffraction patterns were examined.

A statistical study of the correlation between alteration, mineralogy, fracturing, colour index and copper and molybdenum grades was undertaken for that core relogged with the "GEOLOG" format.

CHAPTER 2: REGIONAL GEOLOGY

INTRODUCTION

Vancouver Island north of Holberg and Rupert Inlets is underlain by rocks of the Vancouver Group, which, as defined by Dawson (1887), include: the Karmutsen Formation, the Quatsino Formation, and the Bonanza Volcanics. Bancroft (1913) and Crickmay (1928) described two additional formations, Parson's Bay and Harbledown, as lying between the Quatsino Formation and the Bonanza Volcanics(Table 2-1 and Figure 2-1).

The Vancouver Group is intruded by rocks of Jurassic and Tertiary age and disconformably overlain by Cretaceous sedimentary rocks. The area is one of large-scale block faults with thousands of feet of displacement. These are offset by younger strike-slip faults with displacements up to 2500 feet.

Mapping is hindered by paucity of outcrop and dense forest cover. Exposures are limited to roads, streams, shorelines and rare cliffs. The absence of detailed stratigraphic information further complicates work in the area. There are no recognized marker units in volcanic rocks of either the Karmutsen Formation or Bonanza Volcanics which makes it extremely difficult to establish displacement on faults confined to these Units. This in turn makes it impossible to determine the stratigraphic thickness of the formations.

The present knowledge of the regional geology is shown in Figure 2-1. The geology is established on a small scale, but additional stratigraphic information and more exposure is essential for detailed interpretation.

Table 2-1

TABLE OF FORMATIONS

After Muller et al. (1973)

Period		Group or Formation	Lithology	Thickness (feet)
Tertiary		Eocene	Quartz diorite	
		Intrusive Contact		
Cretaceous	Upper	Nanaimo Group	Greywacke, siltstone, shale conglomerate, coal	400
		Disconformable Contact		
		Queen Charlotte Group	Greywacke, conglomerate, siltstone, shale, coal	1,000 - 3,500
		Disconformable Contact		
	Lower	Long Arm Formation	Greywacke, conglomerate, siltstone	200 - 1,300
		Unconformable Contact		
Jurassic	Lower Middle	Island Intrusion	Quartzdiorite, granodiorite, quartz monzonite, quartz-feldspar porphyry	
		Intrusive Contact		
		Bonanza Volcanics	Andesitic to rhyodacite lava, tuff, breccia	1,000 - 2,500
		Harbledown (1)	Greywacke, argillite, tuff	
Triassic	Upper	Parson's Bay	Calcareous siltstone, shale, greywacke, conglomerate, breccia	1,000 - 2,000
		Quatsino	Limestone	100 - 2,500
		Karmutsen (Includes in upper part intervolcanic limestone)	Basaltic lava, pillow lava, breccia Limestone	10,000 - 20,000

(1) Harbledown Formation is correlated with Bonanza Volcanics by Muller et al. (1973).

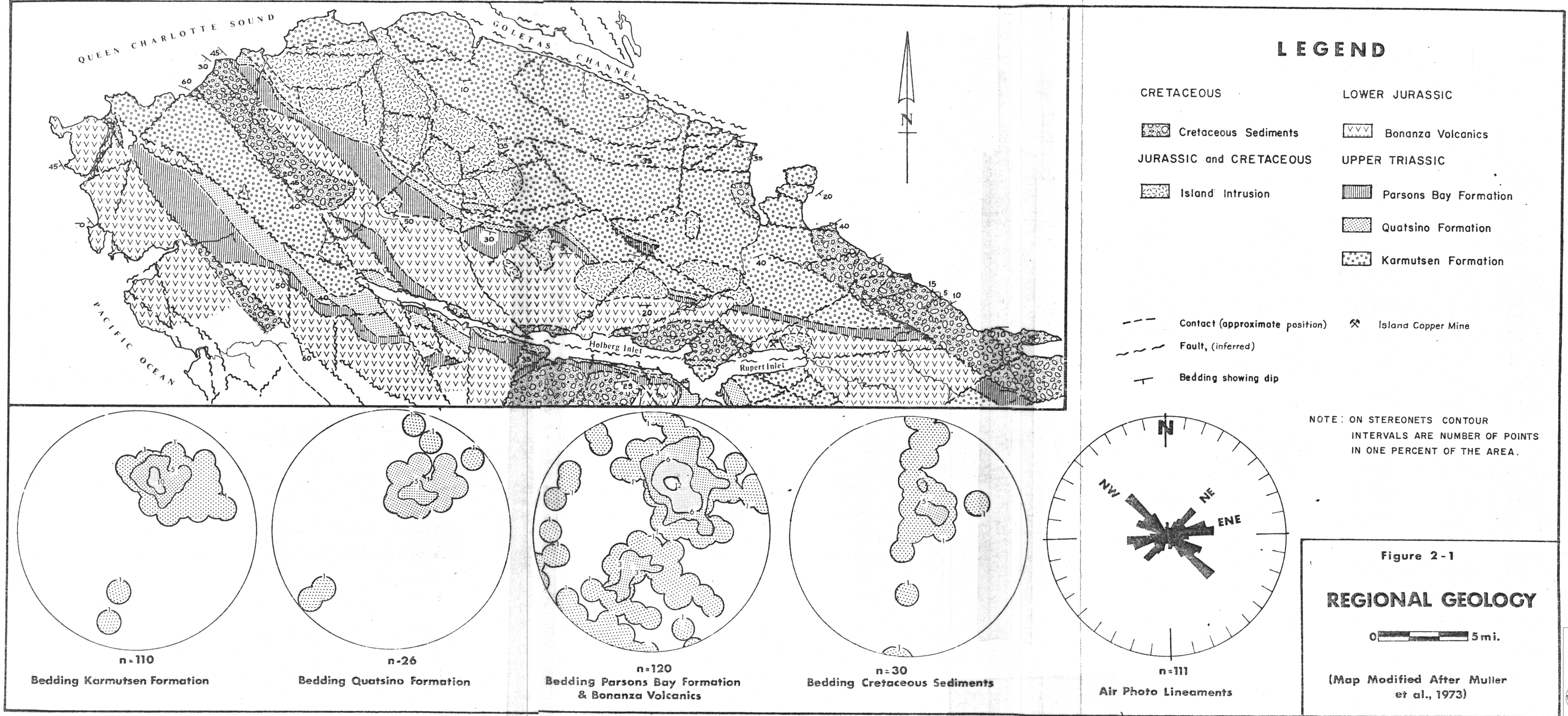


Figure 2-1

REGIONAL GEOLOGY

(Map Modified After Muller et al., 1973)

VOLCANIC AND SEDIMENTARY ROCKS

Karmutsen Formation

Upper Triassic Karmutsen Formation, the oldest rocks in northern Vancouver Island, underlie approximately fifty percent of the area (Figure 2-1). Although the stratigraphic thickness of the formation has not been measured in this area, Muller et al.(1973) estimate it to be 10,000 to 20,000 feet.

Rocks of the Karmutsen Formation are predominantly porphyritic and amygdaloidal basalt flows with rare units of pillow basalt, formational breccias and tuffs. Six chemical analyses reported by Muller (1971) suggest a range in composition between tholeiites and high alumina basalts. This agrees with results of more extensive analyses of Karmutsen rocks in the Buttle Lake Area (Surdam, 1967) and on Texada Island (Asihene, 1970).

Two thin bands of limestone occur near the top of the Karmutsen Formation. The distribution of limestone outcrops is erratic and suggests a series of lenses at the same general stratigraphic horizon rather than one continuous bed.

The lower contact of the formation has not been observed on the northern part of Vancouver Island. The upper contact with limestone of the Quatsino Formation generally is sharp and easily recognized, although limestones and basalt locally are interbedded over a narrow stratigraphic interval at this contact.

Low-grade metamorphism of the Karmutsen Formation rocks has resulted in pervasive chloritization and amygdules filled with epidote, carbonate, zeolite, prehnite, chlorite, and quartz.

Northcote (1970) reports pumpellyite, which places the rocks in the subgreenschist, pumpellyite-prehnite-quartz facies (Muller et al., 1973).

Basaltic rocks along contacts with intrusive stocks are in many places converted to dark-coloured hornblende hornfels. Skarn zones occur sporadically along these contacts, both in the inter-lava limestones and in the basalts.

Quatsino Formation

The Upper Triassic Quatsino Formation, defined by Dolmage (1919), paraconformably overlies the Karmutsen Formation. Distribution of this unit is shown on Figure 2-1.

Quatsino Formation consists of massive limestone with rare, thin (2 to 3 inches) interbeds of tuffaceous material. The unit ranges in thickness from 100 to 2500 feet. The upper contact with the overlying Parson's Bay Formation is gradational with limestones grading upward into carbonaceous argillites. Muller and Rahmani (1970) place the upper contact at the first influx of clastic material.

The rocks of the Quatsino Formation show little evidence of metamorphism except for contact metamorphic/metasomatic aureoles adjacent to intrusive stocks. Limestone near a few granitic intrusions is partly silicified.

Parson's Bay Formation

The Parson's Bay Formation of Upper Triassic age was established by Bancroft (1913) at Parson's Bay on Harbledown Island. The term was reintroduced by Muller et al. (1973) as a substitute for the Upper Triassic part of the sedimentary division of the Bonanza Group. The distribution of the formation is shown on Figure 2-1. Thicknesses range from 200 to 2,000 feet.

The Quatsino-Parson's Bay contact is gradational through a sequence of grey limestone characteristic of the Quatsino Formation, and black calcareous siltstones, shales, and limestones with shaley interbeds characteristic of the Parson's Bay Formation. Muller et al. (1973) define the contact as the lowest stratigraphic horizon where black limestone, shale and siltstone predominate over grey limestone. The upper contact between Parson's Bay Formation and Bonanza Volcanics is the lowest stratigraphic horizon where volcanic tuffs, breccias or flows occur.

The Parson's Bay Formation north of the mine consists of a basal black limestone grading upward into black calcareous shales and siltstones.

A black hydrocarbon with the appearance of tar occurs locally within the argillites as fracture fillings and along bedding planes. A few beds appear to be saturated with the hydrocarbon.

On a regional scale the rocks are unmetamorphosed. Contact effects adjacent to granitic intrusions have not been recorded.

Harbledown Formation

The Lower Jurassic Harbledown Formation was defined by Crickmay (1928) on the basis of mapping on Hanson, Harbledown and Swanson Islands. Muller et al. (1973) have reintroduced the term to designate the Lower Jurassic argillite-greywacke sequence on the islands in Queen Charlotte Sound. They have correlated these rocks with the Bonanza Volcanics of western

Vancouver Island.

The lithology of the unit in its type locality is dominantly argillite and is distinguished from rocks of the Parson's Bay Formation by its non-calcareous character.

Bonanza Volcanics

The name "Bonanza Subgroup" originally was applied to sedimentary and volcanic rocks overlying the Quatsino Formation on the west side of Bonanza Lake (Gunning, 1932). Muller et al. (1973) have restricted the term "Bonanza" to volcanic rocks overlying Lower Jurassic or Upper Triassic sedimentary rocks. The name "Bonanza Volcanics" is used for this formation. The distribution of the volcanic rocks is shown in Figure 2-1.

The base of the Bonanza Volcanics is the lowest lava or volcanic breccia overlying the Parson's Bay sediments (Muller et al. 1973). Bonanza Volcanics are overlain disconformably by Cretaceous sedimentary rocks.

Few outcrops and abundant faults make it extremely difficult to measure the thickness of this unit. The best available estimate, is 8,500 feet (Muller et al., 1973).

The Bonanza Volcanics formation consists of bedded and massive tuffs, formational breccias and rare amygdoloidal and porphyritic flows. Porphyritic dykes and sills intrude the lower part of the unit. Northcote (1970) reports the composition of the rocks, based on refractive indices determination of glass beads made by fusing powdered rock samples, to be basalt to andesite through the bulk of the section, with some rhyodacite in the upper part. This agrees with the results of nineteen chemical analyses for samples from an 8,500 foot section of the Bonanza Volcanics Formations reported by Muller et al. (1973).

Regional metamorphism within the Bonanza Volcanics is very low grade, possibly zeolite facies. Plagioclase commonly is albitized and saussuritized. Chlorite, epidote and laumontite occur within the matrix of volcanic breccias, in veinlets, and in amygdules. Coarse intraformational breccias locally are hematitized.

Biotite and amphibolite hornfelses occur adjacent to stocks which intrude the Bonanza Volcanics.

"Pyrobitumen", a black hydrocarbon erratically distributed within the Bonanza rocks, generally occurs as fracture fillings or in the centres of zeolite-carbonate veins. Its distribution is not related to the position of the intrusive stocks.

The Lower Jurassic age of the Bonanza Volcanics is established by fossils in interbedded sediments. In addition, potassium-argon whole rock dates reported by Northcote (1972), suggest a late Jurassic to early Cretaceous age. Northcote considered the whole rock ages as minimum ones and believes the volcanic rocks are slightly older than is suggested by these ages.

Lower Cretaceous Rocks

Lower Cretaceous rocks are divided into three units: Longarm Formation, Queen Charlotte Group and Suquash Formation (Muller et al., 1973). These units are described in detail by Muller.

Lower Cretaceous rocks lie disconformably on Bonanza Volcanics. They consist of well-indurated coarse conglomerates, siltstones, sandstones and greywackes with occasional small, discontinuous coal seams. Muller et al. (1973) believe that they formed during a molasse-type sedimentation cycle.

INTRUSIVE ROCKS

Stocks

A northwest-trending zone of intrusive stocks extends from the east end of Rupert Inlet to Queen Charlotte Sound (Figure 2-1). These stocks range in composition from diorite to quartz monzonite and display a wide variety of textures.

Potassium-argon age determinations reported by Northcote (1972), and Carson (1973) indicate that the stocks crystallized during the early to middle Jurassic time (179.5-148 m.y.)

Quartz-Feldspar Porphyry Dykes

Quartz-feldspar porphyry dykes occur along the south edge of the zone of stocks. Because they are narrow (less than 100 feet) and short (less than 500 feet), they are not shown in Figure 2-1.

Dykes are characterized by coarse, subhedral quartz and plagioclase phenocrysts set in a pink, very fine-grained, quartz and feldspar matrix. Phases within the stock at the east end of Rupert Inlet, which have textures similiar to the quartz-feldspar porphyry dykes, suggest that the dykes are apophyses from the stocks. Radiometric age determinations have not been made on the dyke rocks.

Felsic Dykes and Sills

Felsic dykes and sills occur around the margins of some intrusive stocks. They are less than five feet wide and two or three hundred feet long. These fine-grained, pink, felsitic rocks cut rocks of the Karmutsen Formation, the Quatsino Formation and the Bonanza Volcanics. Northcote (personal communication, 1971) has noted a similarity between these dykes and the rhyodacites occuring at the top of the Bonanza Volcanics. The dykes have had little effect on the rocks they intrude.

Andesite Dykes

Dykes of andesitic composition, which cut the Karmutsen Formation, the Quatsino Formation and the Parson's Bay Formation, were feeders for Bonanza volcanism. These dykes generally are less than ten feet wide. They are easily recognized in the Quatsino and the Parson's Bay Formations, but are difficult to identify in volcanic rocks of the Karmutsen Formation.

Basalt-Dacite Dykes

Tertiary basalt-dacite dykes are reported by Northcote (1970) as intruding lower Cretaceous sedimentary rocks. He also reports a small plug of similar composition intruding lower Cretaceous sediments.

REGIONAL STRUCTURE

The map area (Figure 2-1) is characterized by gently dipping beds offset by a complex pattern of faults. The trata, except for the gentle dip, are essentially undeformed. Folding and flexuring of bedding is observed only adjacent to major faults.

Bedding

Bedding is well developed within the Quatsino and Parson's Bay Formations. Bedding in volcanic rocks is poorly developed. All units are structurally conformable, with strikes slightly north of west and dips between 20° and 40° to the southwest. North-dipping beds invariably are adjacent to major faults and are the result of drag.

Faults

The area is one of block faults offset by younger faults with substantial strike-slip movements. Three prominent directions of faulting; norhtwest, northeast and east-northeast are recorded (Figure 2-1). Northwest-trending faults are most obvious and possibly most important. These faults cut Cretaceous and older rocks and cause repitition of large parts of the stratigraphic section. Although the stratigraphy is not established sufficiently to calculate displacements, the throws of many of these faults are several hundred to thousands of feet.

Northeast faults, of secondary prominence, offset the northwest set and have strike-slip displacements measuring hundreds of feet. The east-northeast faults are poorly developed and their age relative to other fault sets has not been established.

Mineral Deposits and Regional Alteration

Mines and mineral occurences shown in Figure 2-2 are divided into four groups:

Table 2-2

CLASSES OF METALLIFEROUS DEPOSITS
(After K. E. Northcote, in Muller et al., 1973)

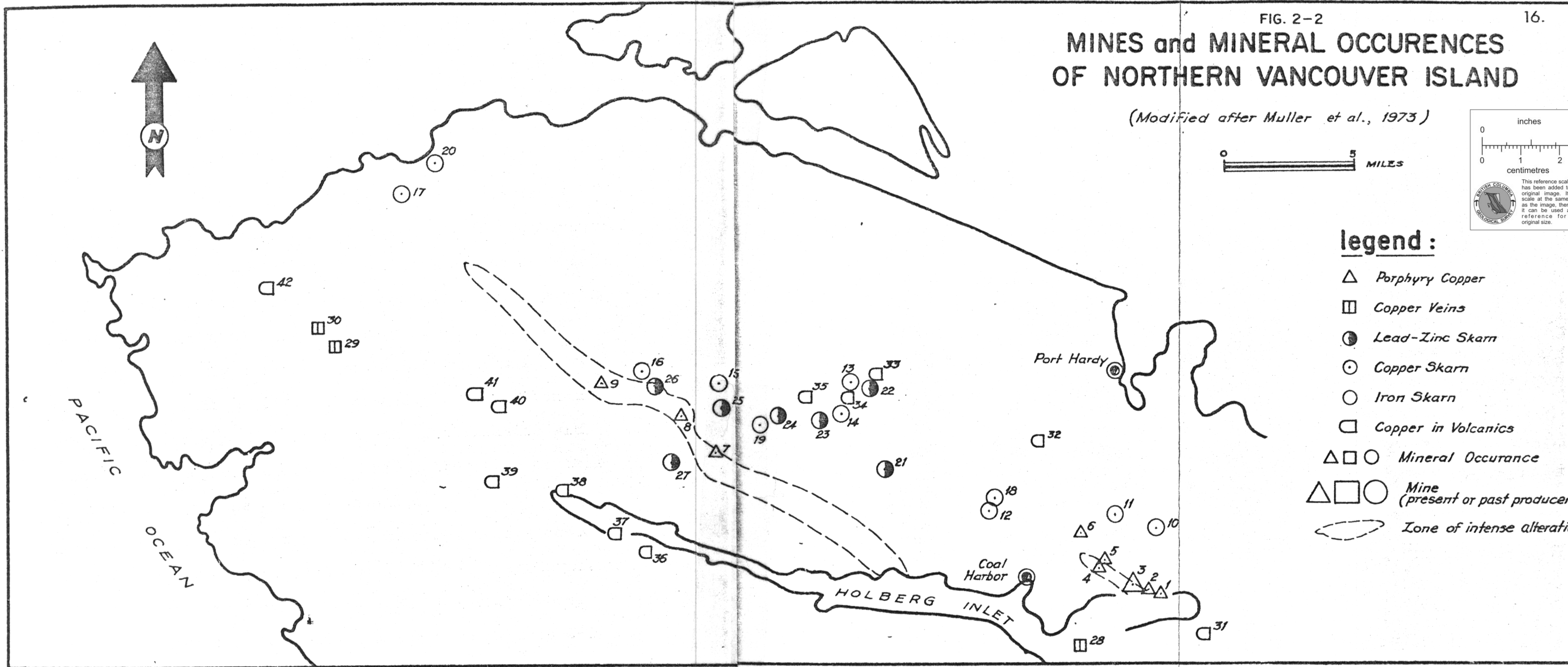
	Known or Probable Age	Class	Metal	Example	Mineralogy	Host and Associated Formation
1.	Mid Jurassic	Porphyry Copper	Cu 0.5% MoS_2 0.029%	Island Copper	Chalcopyrite, molybdenite, (bornite), magnetite, pyrite, hematite	Bonanza volcanics; pyroclastic rocks of andesite and basalt composition. To a lesser extent brecciated and altered quartz-feldspar porphyry
2.	Jurassic and Tertiary	Lead-Zinc Skarn or Replacement in Limestone	Pb, Zn, (Ag, Au)	H.P.H.	Sphalerite, galena	Limestone of Sicker Group, upper Karmutsen and Quatsino Formations
3.	Jurassic and Tertiary	Copper Skarns	Cu(Au, Ag, Fe)	Old Sport-Benson Lake	Chalcopyrite, bornite magnetite	Sicker Group limestone, in skarnified volcanic and sedimentary rocks at Quatsino-Karmutsen contact. Some deposits in Quatsino-Karmutsen limestones
4.	Jurassic and Tertiary	Iron Skarns	Fe (Cu)	Merry Widow	Magnetite, minor specularite and sulphides	Quatsino Formation and/or adjacent skarnified volcanic and intrusive rocks
5.	Upper Triassic	Copper in Basic Volcanics	Cu	Minnington, Rick	Chalcopyrite, bornite, native copper	Karmutsen Basalt, tuff and breccia
6.	Jurassic and Tertiary	Copper-Bearing Quartz Veins & Shear Zones	Cu (Mo/Ag Au, Zn)	Quatsino King	Chalcocite, chalcopyrite, (pyrite, pyrrhotite, molybdenite)	Karmutsen Formation, Bonanza Volcanics, granitic rocks

	Structural Control	Associated Alteration	Intrusive (Genetic-Spatial)
1.	Brecciation in and adjacent to quartz-feldspar porphyry intruding Bonanza rocks presumably following shear zones.	Epidote, chlorite, sericite, pyrite, biotite, silica, kaolin, pyrophyllite, dumortierite, carbonate, laumonite, pyrobitumen	Silicic stocks and quartz-feldspar porphyry complex.
2.	---------------------------	Silicification, skarn	Granitic to gabbroic and porphyritic intrusions
3.	Limestone-intrusive contacts folds, fractures, breccia zones and favourable horizons	Skarnification, epidote, garnet, various other calcium silicates including wollastonite, diopside, actinolite, hedenbergite, etc., and ilvaite.	Jurassic and Tertiary intrusive of varied composition
4.	Intrusive contacts, folds fractures, stratigraphic contacts, breccia zones	Skarnification as above	Jurassic and Tertiary intrusive of varied composition
5.	Amygdaloidal beds, fractures small shears in basic volcanic rocks	May or may not be associated with carbonate and/or quartz	None; thought to be generated within the volcanic rocks
6.	Narrow shear zones, large fractures, fracture zones near faults and contacts	Strong silicification and/or carbonatization may or may not be present	Granitic to gabbroic and porphyritic intrusions believed to be genetically related to these deposits

FIG. 2-2

MINES and MINERAL OCCURENCES OF NORTHERN VANCOUVER ISLAND

(Modified after Muller et al., 1973)



PORPHYRY COPPER DEPOSITS

1. Bay 29, 77, (Yankee Girl)
2. Road
3. Island Copper (Bay)
4. Bay 21
5. Bay 4
6. Bay 74
7. Expo #1
8. Hep
9. Red Dog

SKARN DEPOSITS

COPPER

10. Frances
11. Little Joe
12. Caledonia
13. Haw
14. Mor
15. North Shore, Lake, Jean
16. Mon, Ti
17. CS 1801, 1809, 1910

IRON

18. Caledonia
19. Sun, St. Claire
20. Ori

SKARN DEPOSITS

LEAD-ZINC

21. "A"
22. Haw 24
23. Rain, Main, #1
24. HPH, Main, #1
25. Norman, Contact Creek
26. Laury, Anon
27. Expo 81, Expo 202, Bowerman, Dictator

COPPER VEINS

28. Dem (Rupert)
29. CS 495
30. Aird

COPPER IN VOLCANICS

31. Har, Expo
32. Deb
33. Haw 26
34. Haw 15
35. Wit, Haw 34, Haw 44
36. Hol
37. Jay, Seal
38. Stuart
39. Millington, Stuart
40. AAA #48
41. Lois
42. CS 6422

(1) Porphyry copper deposits

(2) Skarn deposits

(3) Copper Mineralization in Volcanic Rocks

(4) Vein deposits

The system of classification is that used by Carson (1968).

Porphyry copper deposits on the north end of Vancouver Island are associated with bodies of quartz-feldspar porphyry which intrude the Bonanza Volcanics. All known porphyry copper showings are within a zone of hydrothermally altered Bonanza Volcanics approximately one mile wide and fifteen miles long (Figure 2-2). Northcote (1970) described the alteration in this zone as predominantly silicification and argillization with local bodies of pyrophyllitized breccia. Alteration of this type is restricted to the Bonanza Volcanics.

Skarn deposits of copper, iron and lead-zinc are associated with intrusive rocks cutting limestones of the upper Karmutsen Formation, the Quatsino Formations and the lower carbonate sequence of the Parson's Bay Formation (compare Figures 2-1 and 2-2). Skarns mostly occur along the limestone-intrusion contact, but at some skarn showings intrusive rocks are not exposed. Contact alteration consists of silicification of the limestone and formation of epidote-andradite-magnetite skarns locally accompanied by hedenbergite and ilvaite both in limestones and basalts. Chalcopyrite, pyrite, bornite, sphalerite and galena occur within these skarns (Table 2-2).

The copper showings in volcanic rocks are restricted to the Karmutsen Formation. Chalcopyrite, bornite and native copper occur in amygdules, fractures and small shears.

Associated alteration consists of minor amounts of carbonate and quartz.

Vein deposits occur in the Karmutsen Formation, the Bonanza Volcanics and granitic rocks (Figure 2-2). Chalcocite and chalcopyrite with pyrite, pyrrhotite, and molybdenite occur in shear zones, large fractures and fracture zones near faults. Intense silicification and carbonatization can be associated with the copper mineralization.

CHAPTER 3: MINE GEOLOGY

INTRODUCTION

Island Copper mine occurs in the volcanic section of the Bonanza Volcanics. Ore zones are in volcanic rocks in the hanging-wall and footwall of a quartz-feldspar porphyry dyke. The dyke contains minor amounts of chalcopyrite but very little ore-grade material.

A detailed knowledge of the stratigraphic position, lithology and structural history of a deposit is in many mineral deposits an obvious prerequisite to a study of the wall-rock alteration associated with the deposit. Stratigraphic position may give an indication of the depth at which the alteration formed and from this pressures can be interpreted. The lithology governs the initial chemical response of the rocks to hydrothermal conditions. Fractures and faults which existed at the time of formation of the deposit largely control the permeability of the rocks to hydrothermal solutions and thus control the extent, the intensity and the patterns of alteration.

STRATIGRAPHIC POSITION

Because of the absence of detailed stratigraphic knowledge of the Bonanza Volcanics, it is difficult to determine the exact stratigraphic position of the deposit. However, it is possible to estimate limits for the stratigraphic position.

First, the stratigraphic thickness of the Bonanza Volcanics must be established. Muller (1970) measured a section of 8,500 feet of Bonanza Volcanics and Jeletsky (1969) reports a section of 8,000 feet. These figures give an indication of the order of magnitude of the thickness of the unit. Considerable lateral thickening and thinning may be present in this volcanic section, but these cannot be estimated.

Assuming no repetition of the section due to faulting, the Island Copper deposit is, on the basis of geometry, about 5,000 feet stratigraphically above the lower contact with the Parson's Bay Formation. However, there is little outcrop between this contact and the mine area. Because three major northeast trending lineaments, which may represent faults, lie between the contact and the deposit, estimates of stratigraphic position based solely on geometry are extremely hazardous.

Surface diamond drilling at the deposit has penetrated 1,200 feet of the stratigraphic section without intersecting the Parson's Bay Formation. Assuming no repetition of section in the rocks drilled, part of the deposit formed at least 1,200 feet above the Parson's Bay Formation.

Limits to the deposit's depth of formation may be estimated from this data. Maximum depth would be 6,800 feet that is the entire thickness of the Bonanza Volcanic Formation (8,000 feet) less the 1,200 feet intersected by drilling. The minimum depth would be zero feet as the 1,200 feet of rock intersected by drilling could represent the entire thickness of the Bonanza Volcanics in the vicinity of the mine. A reasonable estimate lies between 1,000 and 5,000 feet. This estimate is supported by petrologic data discussed later.

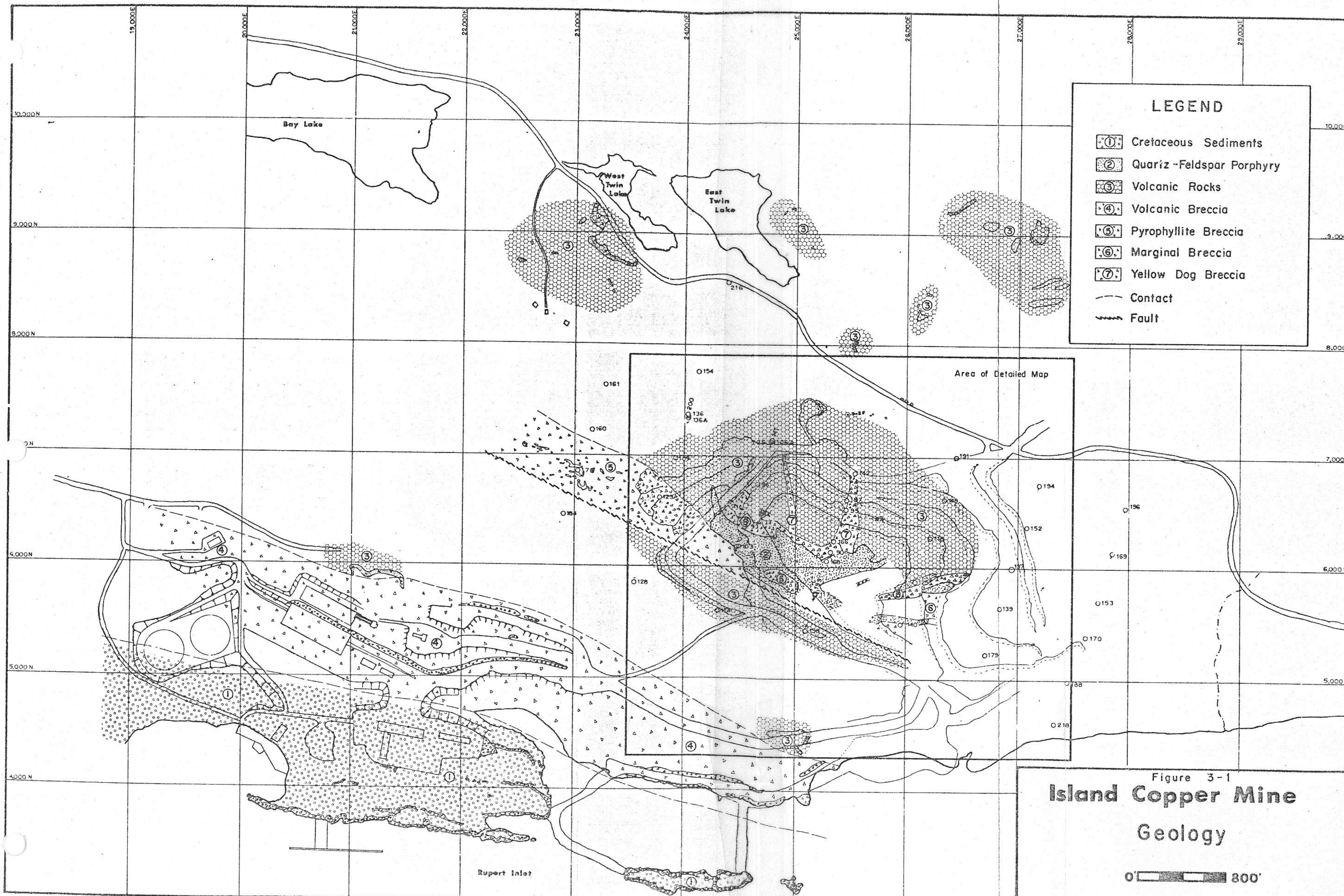
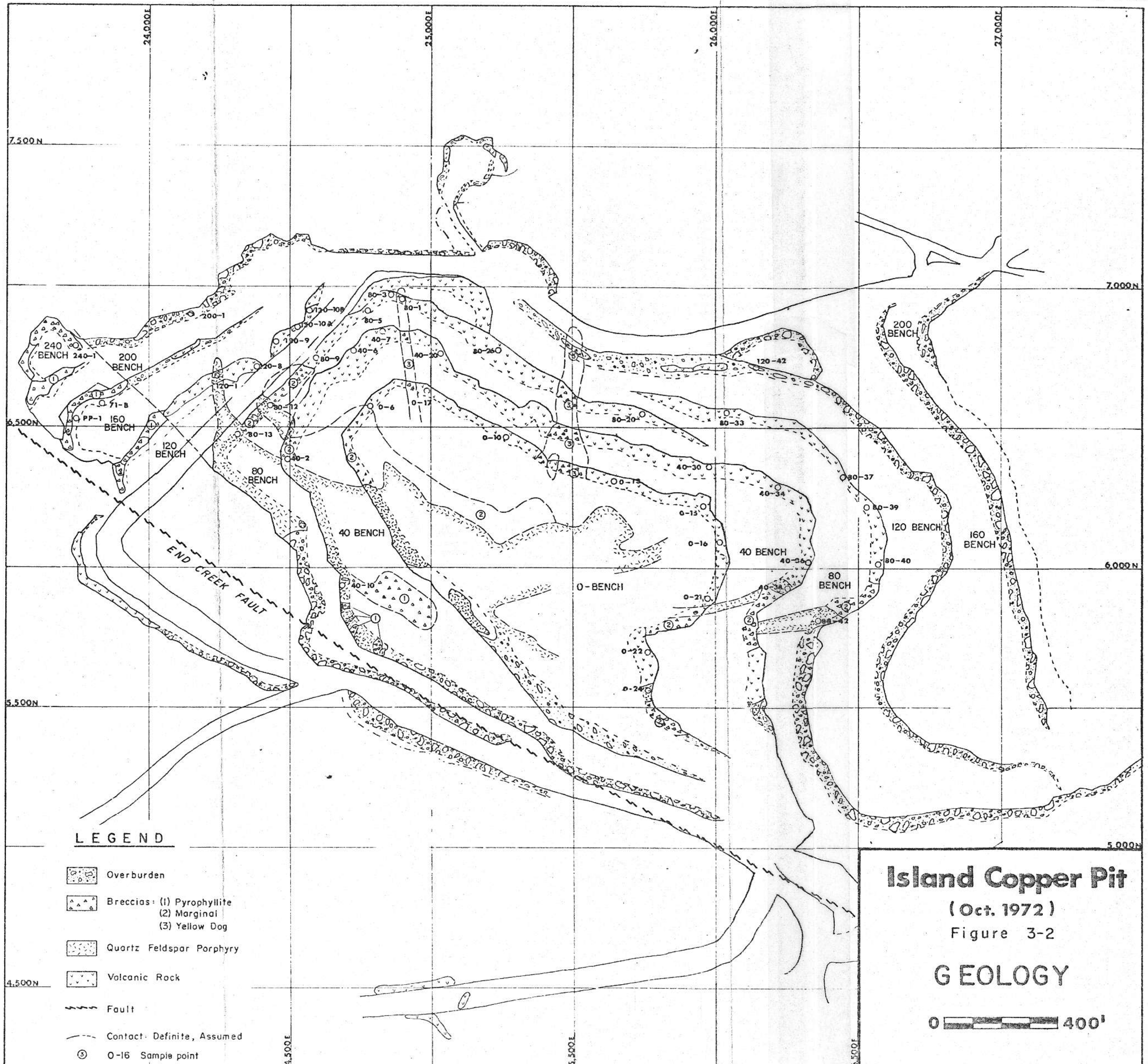


Figure 3-1
Island Copper Mine
Geology

Art Soregaroli



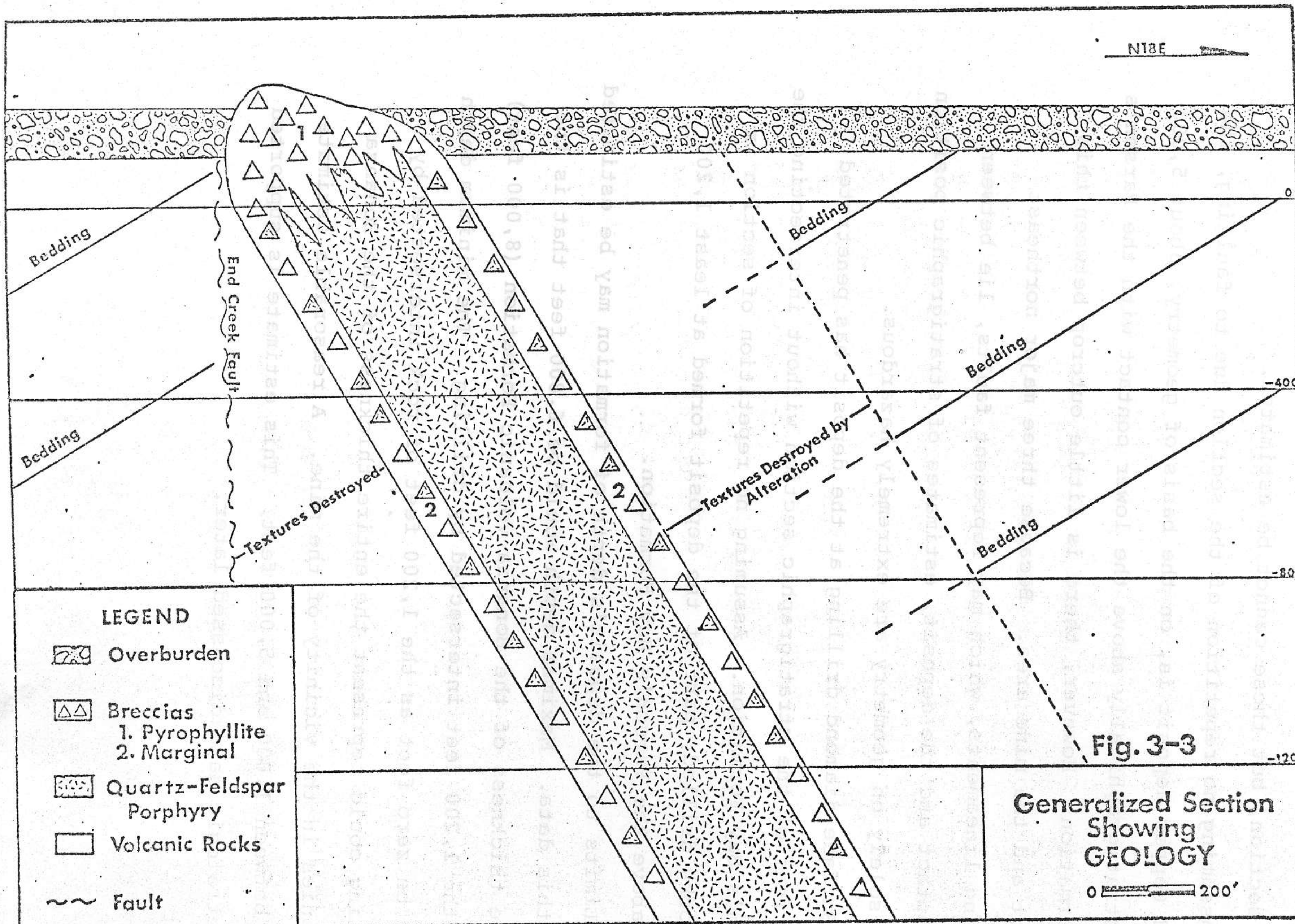


Fig. 3-3

Generalized Section Showing GEOLOGY

LITHOLOGY

Volcanic Rocks

The Bonanza Volcanics in the mine area are part of a pile of andesitic pyroclastic rocks with wide variations in texture. These rocks form a belt which strikes N70°W and dips 25° - 30° SW. Primary textures of the volcanic rocks are increasingly more vague as the dyke is approached and disappear within 400 feet of the dyke contact (Figure 3-3).

Fresh, unaltered rocks are lithic tuffs, crystal tuffs, lapilli tuffs and formational breccias (Plate I,, A,B,C,D, E; and Plate IV., A,B) with rare beds of chert. These units have very limited lateral extent, which makes it impossible to correlate most individual units between sections 200 feet apart. However, an exception is a unit of hematitized breccia, which is exposed in core, along the shore of Rupert Inlet south of the pit and in the excavations for foundations of the mill building. It has been traced more than 6,000 feet along strike on the south side of the deposit.

Bedding and graded-bedding are observed in good exposures of tuffs and lapilli tuffs. Breccias locally show bedding but tend to be massive.

Few of the volcanic rocks have retained their original textures. Textures are preserved in lithic lapilli tuffs, lithic and crystal tuffs and formational breccias. Lithic fragments generally are porphyritic sometimes with a trachytic matrix. Many porphyritic fragments are crystal tuffs.

In volcanic rocks near the orebody, alteration is so intense that it is difficult to determine the original mineralogy of the rocks. Plagioclase phenocrysts are invariably albitized. Mafic

PLATE I

OUTCROPS AND HAND SPECIMENS

A. Bonanza Volcanics - Formational Breccia
Matrix and many fragments are colored box-car red by pervasive hematite. Scale on outcrop is one inch.

B. Bonanza Volcanics - Lithic Tuff
Intricate sedimentary and post-diagenetic structures are shown by some of pyroclastic rocks. Scale on outcrop is one inch.

C. Bonanza Volcanics - Lithic Lapilli Tuff
This sample is typical of volcanics on the north wall of the pit. Bedding is difficult to discern but fragmental nature of rock is apparent.

D. Bonanza Volcanics - Lithic Lapilli Tuff
A thin section of C showing Lithic nature of fragments

E. Bonanza Volcanics - Formational Breccia
Fragments are coloured box-car red by pervasive hematite. Matrix is coloured chalky white by zeolite (laumontite).

F. Quartz-Feldspar Porphyry
Phenocrysts of quartz, plagioclase, and chlorite pseudomorphing mafic minerals are clearly visible.

G. Cretaceous Conglomerate
A sample of conglomerate from Cretaceous outcrops south of mill buildings.

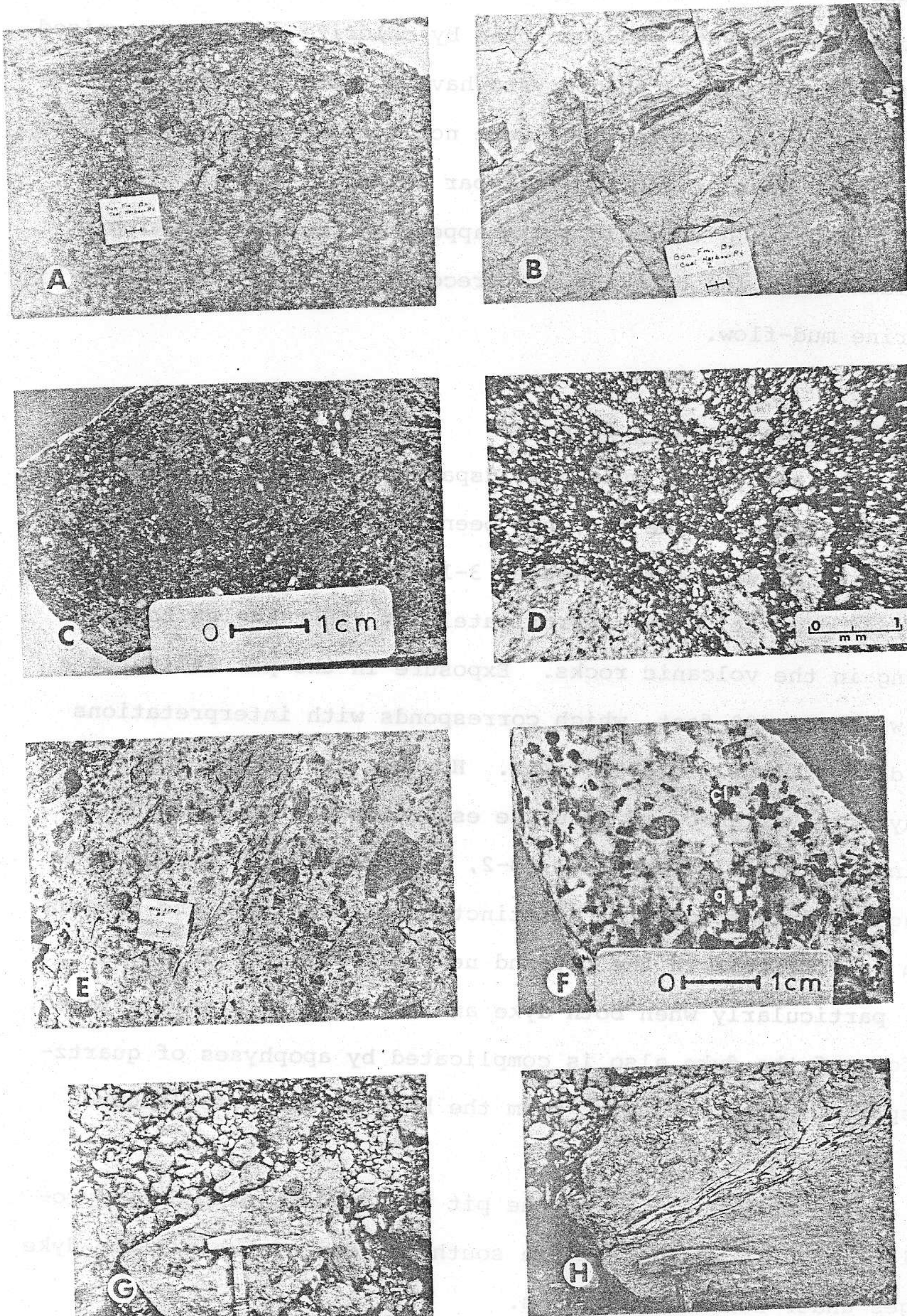
H. Cretaceous Sedimentary Unit
Discontinuous coal seams in the Cretaceous strata.

Abbreviations Used on the Plate

q - quartz

cl - chlorite

f - plagioclase feldspar


A
B
C
0 1cm
D
0 1 mm
E
F
0 1cm
G
H

minerals are almost invariably chloritized, but pyroxene and amphibole phenocrysts pseudomorphed by chlorite can be recognized in some cases. Quartz phenocrysts have not been recognized. The matrix of the few samples that were not totally altered is a very fine-grained mass of albitic feldspar laths.

Finer-grained volcanic rocks appear to be a combination of waterlain tuffs and graywackes. Breccias may have been formed by submarine mud-flow.

Quartz-Feldspar Porphyry Dyke

A tabular dyke of quartz-feldspar porphyry, 2,400 feet of which is exposed in the pit, has been traced by drilling for more than a mile along strike (Figures 3-1, 3-2). The dyke strikes N70°W and dips at 50°NE, approximately at right angles to the bedding in the volcanic rocks. Exposure in the pit indicates a true width of 400 feet, which corresponds with interpretations from diamond drill intersections. However the actual width of the dyke is variable and accurate estimates are hampered by a marginal breccia (Figures 3-1, 3-2, 3-3) containing a high percentage of dyke fragments. Distinction between dyke and breccia often is difficult in the pit and nearly impossible in drill core, particularly when both dyke and breccia are highly altered. The form of the dyke also is complicated by apophyses of quartz-feldspar porphyry extending from the body of the dyke (Figure 3-2).

At the northwest end of the pit the dyke is capped by pyrophyllite breccia whereas at the southwest end of the pit the dyke plunges under Bonanza Volcanics.

Intense alteration of most of the dyke makes it difficult to define clearly the original composition. However, the central portion of the dyke, which shows the least alteration, is granodiorite. Less-altered bodies of quartz-feldspar porphyry beyond the map area also are granodiorite (Muller et al., 1973).

The porphyry consists of phenocrysts of quartz (5-15%), plagioclase (20-30%), and occasional mafic minerals, pseudomorphed by chlorite (5-10%) (Plate I., F, and Plate V., A,B,C) set in a fine-grained matrix of quartz (15-20%), plagioclase (10-25%) and potash feldspar (15-25%).

Quartz phenocrysts are the most characteristic features of the rock. They are large (4-5mm.), subhedral and show moderate to strong embayment along the margins. Quartz phenocrysts are resistant to alteration and persist through all types and degrees of alteration.

Plagioclase phenocrysts are slightly smaller (2-3mm.) than quartz phenocrysts. They generally occur in glomeroporphs. The crystals are mostly unzoned or normally zoned; but some complex zoning was noted. Composition of the plagioclase is difficult to determine because the phenocrysts generally are altered to sericite (Plate VI.,H). In the few specimens where the plagioclase is relatively unaltered, compositions of An 5 to 15 were obtained. However, these grains everywhere are associated with altered plagioclases and it is difficult to establish whether these represent average compositions or compositions which are more resistant to alteration.

Mafic phenocrysts are altered, either to chlorite, epidote, carbonate, magnetite and leucoxene, or to white mica, clay minerals, pyrite, and leucoxene (Plate V., B,C,D,E). Rare patches of chlorite are clearly pseudomorphs of euhedral amphiboles, but most are anhedral.

Most of the fine-grained matrix of the dyke is highly altered. However, where relatively unaltered, it consists of a micrograpnitic assemblage of equant quartz, subhedral plagioclase (albitic) and anhedral orthoclase. Orthoclase generally is more altered than plagioclase, even in "fresh" rocks, but its presence was confirmed by etching and staining both hand specimens and thin sections.

Magnetite, leucoxene and pyrite are associated with chlorite pseudomorphs and probably formed as by-products during the alteration of the original mafic minerals.

The dyke exhibits many characteristics of an epizonal pluton as outlined by Buddington (1959). It is porphyritic, discordant, and exhibits contact metamorphic/metasomatic effects. The fine-grained chilled margins of the dyke are now fragments in the marginal breccia. Northcote (1970) suggested that the intrusions with which it is associated are closely related to extrusive rocks in the upper part of the Bonanza Volcanics, suggesting that they are feeders for the later stages of the volcanism. The dyke is flanked by contact breccias and capped by an explosion breccia. All of these characteristics suggest shallow emplacement.

Radiometric age determinations have not been made on the dyke. However it is believed contemporaneous with the granodiorite stock at the end of Rupert Inlet which has been dated by K-Ar on biotite at 154 ± 6 M.Y. (Muller et al., 1973).

Intrusive Breccias

Pyrophyllite Breccia

Pyrophyllite breccia occurs as a tabular body capping the porphyry dyke on the northwest end of the deposit (Figures 3-1, 3-2, 3-3). The breccia zone is approximately 350 feet wide and was traced more than 3,600 feet along strike. The breccia is wedge-shaped, thickening to the northwest.

The breccia is open textured, with fragments separated by matrix (Plate VII., A,B). Average size of the rounded fragments is six inches in diameter with size ranges from one-half inch to eighteen inches. Fragments consist of both quartz-feldspar porphyry recognizable because of the large quartz phenocrysts, and fine-grained massive material, presumably completely altered volcanic rocks. The middle part of the breccia contains a higher proportion of porphyry fragments than the borders.

The original texture of the altered porphyry fragments is largely preserved. Quartz phenocrysts are unaltered and plagioclase and mafic phenocrysts pseudomorphed by patches of fine-grained white mica and quartz. Volcanic fragments consist of quartz grains completely surrounded by white mica (Plate VII.,H).

The matrix of the breccia is similar to the volcanic fragments, except that the quartz and white mica grains are of finer grain.

Marginal Breccias

Marginal breccias are tabular bodies which roughly parallel the contacts of the quartz-feldspar porphyry dyke (Figures 3-1, 3-2, 3-3). All breccias occuring between dykes of unbrecciated porphyry are also included in this group.

The width of the marginal breccias is extremely variable. In most places there are 50 to 100 feet of breccia between the porphyry dyke and the volcanic rocks on the hanging wall of the dyke; but locally the entire width of the dyke is brecciated.

These breccias continue to at least 1,800 feet below the ground surface without apparent change. However, knowledge of the breccias at depth is based on very few drill holes. Recognition of this type of breccia is difficult both in core logging and pit mapping, making location of the contacts difficult.

Marginal breccias are less distinctly open textured than the pyrophyllite breccia because the fragments usually are separated by vein quartz. Fragment composition ranges from 100 percent volcanic near the volcanic contact to 100 percent porphyry near the dyke contact and with mixtures of varying proportions in between. Breccias surrounded by unbrecciated quartz-feldspar porphyry consist entirely of porphyry fragments. Where volcanic and porphyry fragments are mixed, the breccia is a true breccia, with fragment movement and rotation. However, as the contacts are approached, the breccia resembles a "crackle breccia" with little fragment movement or rotation. Because there are no beds retaining distinctive characteristics near the contact of the breccias, it is not possible to determine direction of movement of fragments within the marginal breccias.

Yellow Dog Breccia

The Yellow Dog Breccia derives its name from characteristic rusty-brown, ferroan dolomite which occurs as tiny veinlets. Tabular breccia bodies range from 50 to 200 feet in width and widen with depth. They are exposed for approximately 800 feet along their length. The bodies trend north and northeast and dip steeply (Figure 3-1, 3-2). The breccias consist of fragments of highly altered volcanic rocks separated by several ages of quartz and carbonate veins (Table 3-1). Because the fragments do not appear rotated, the breccia resembles a "crackle breccia" more than an intrusive breccia (Plate VIII., A,B,C).

At present, mining development along the south wall of the pit is not adequate to reveal the relationship between the marginal breccia, the "Yellow Dog Breccias" and the porphyry dyke.

Formation of Intrusive Breccias

Breccias associated with ore deposits are subjects of a voluminous literature. The poorly exposed breccias at the Island Copper mine do not lend themselves to detailed investigation at present. As mining operations continue, more detailed study may add information to help establish the origin of these breccias. At present only a few comments are possible.

Marginal breccias adjacent to the quartz-feldspar porphyry dyke probably are formed by upward drag of the intruding dyke. The distribution of fragments, quartz-feldspar porphyry near the dyke, and volcanic near the outer margin of the breccia, supports this theory. Unfortunately the absence of recognizable units within the volcanic rocks adjacent to the breccias makes it impossible to demonstrate direction of movement of fragments in the breccia.

The pyrophyllite breccia, which caps the porphyry dyke, is more typical of intrusive breccias associated with porphyry copper deposits. There are many theories which attempt to explain the formation of this type of breccia. The more popular ideas include:

1) Volcanic Explosion Brecciation (Norton and Cathles, 1973) caused by gas accompanying a magma which shatters the overlying rocks;

2) Collapse Brecciation (Perry, 1961)
caused by the collapse of overlying rocks into an emptied magma chamber;

3) Fault Brecciation (Kennedy and Nordlie, 1968)
caused by movement on single faults or by movements on one or more intersecting faults;

4) Multiple Intrusion Brecciation (Johnston and Lowell, 1961)
caused by repeated intrusion and recession of a body of magma;

5) Shock Brecciation (Godwin, 1973)
caused by a shock wave passing through a body of rock to surface;

6) Chemical Brecciation (Sawkins, 1969)
caused by hydrothermal alteration of the rock involving large changes in volume;

7) Impact Brecciation (Dietz, 1961)
caused by the impact of celestial bodies on the earth's surface.

A number of these theories are rejected as improbable for the Island Copper examples. The tabular nature of the breccia does not fit the impact breccia theory. Collapse breccias imply a net downward movement, while the porphyry fragments in the pyrophyllite breccia suggest a net upward movement. Shock breccias imply a source for the shock waves which is not evident.

Intense hydrothermal alteration within the Pyrophyllite Breccia makes the chemical brecciation theory attractive at first. However, field studies at Conception Bay, Newfoundland (Buddington, 1916) show that volcanic beds can be traced through a zone of pyrophyllite alteration with no change in thickness and that the volcanic textures are obscured but not obliterated by the pyrophyllitization. This suggests little change in volume.

Fault brecciation is another attractive hypothesis, if one assumes that the dyke is intruded into a pre-existing fault zone. However a fault breccia approximately 400 feet wide implies a major fault and there is no evidence of great displacement between the two sides of the dyke.

The field of speculation seems thus narrowed to two hypotheses: volcanic explosion or multiple intrusion, or some combination of the two.

The volcanic explosion theory is very attractive when the extremely fine-grained nature of the matrix in the dyke and the shallow depth of emplacement are considered. Upward flow of volatiles could also explain the intense alteration in the breccia. Northcote and Muller (1972) favour this hypothesis.

The multiple intrusion theory is another attractive hypothesis. Later pulses of magma related to the dyke could account for the internal brecciation of and possibly for the "crackling" of the ore zone.

Unfortunately, while present evidence suggests one of these hypotheses, it is not sufficient to decide between them or to even completely eliminate some of the other ideas.

The formation of the "Yellow Dog" breccias is another major problem. Because of their attitude at right angles to other major structural elements and the ore zone, they were not thoroughly investigated in the drilling program. From their geometry within the pit, widening with depth, Lamb (personal communication, 1972) suggest that they may be cappings on dykes.

Cretaceous Sedimentary Rocks

Cretaceous sedimentary rocks of the Queen Charlotte Group (Muller et al., 1973) disconformably overlie formational breccias of the Bonanza Volcanics on the southeastern part of the Island Copper property (Figures 3-1, 3-4). The Cretaceous rocks are coarse conglomerates with interbedded sandstones and siltstones and occasional thin, poor-quality coal seams (Plate I., G,H). Most cobbles within the conglomerate are coarse-grained granodiorite. Occasional cobbles of fresh quartz-feldspar porphyry have been noted. Cretaceous sediments are well indurated but not metamorphosed. Hydrothermal alteration and mineralization are absent.

STRUCTURAL GEOLOGY

Bedding

Bedding within the Cretaceous sedimentary rocks is well-defined and easily measured. Bedding within the Bonanza Volcanics near the deposit is difficult to recognize and primary structures have been destroyed within the ore zone. Bedding along the north wall of the mine pit generally is poorly defined, but bedding in some outcrops beyond the northern edge of the pit is well-defined. Good exposures of volcanic breccias with well-defined bedding were exposed during the excavation for the mill buildings.

Attitudes of bedding are shown on stereonets in Figure 3-4. Although relatively few points are shown they appear to form significant clusters. From Figure 3-4, it is apparent that bedding within Cretaceous sediments and Bonanza Volcanics is structurally conformable with strikes around 100° and dips near

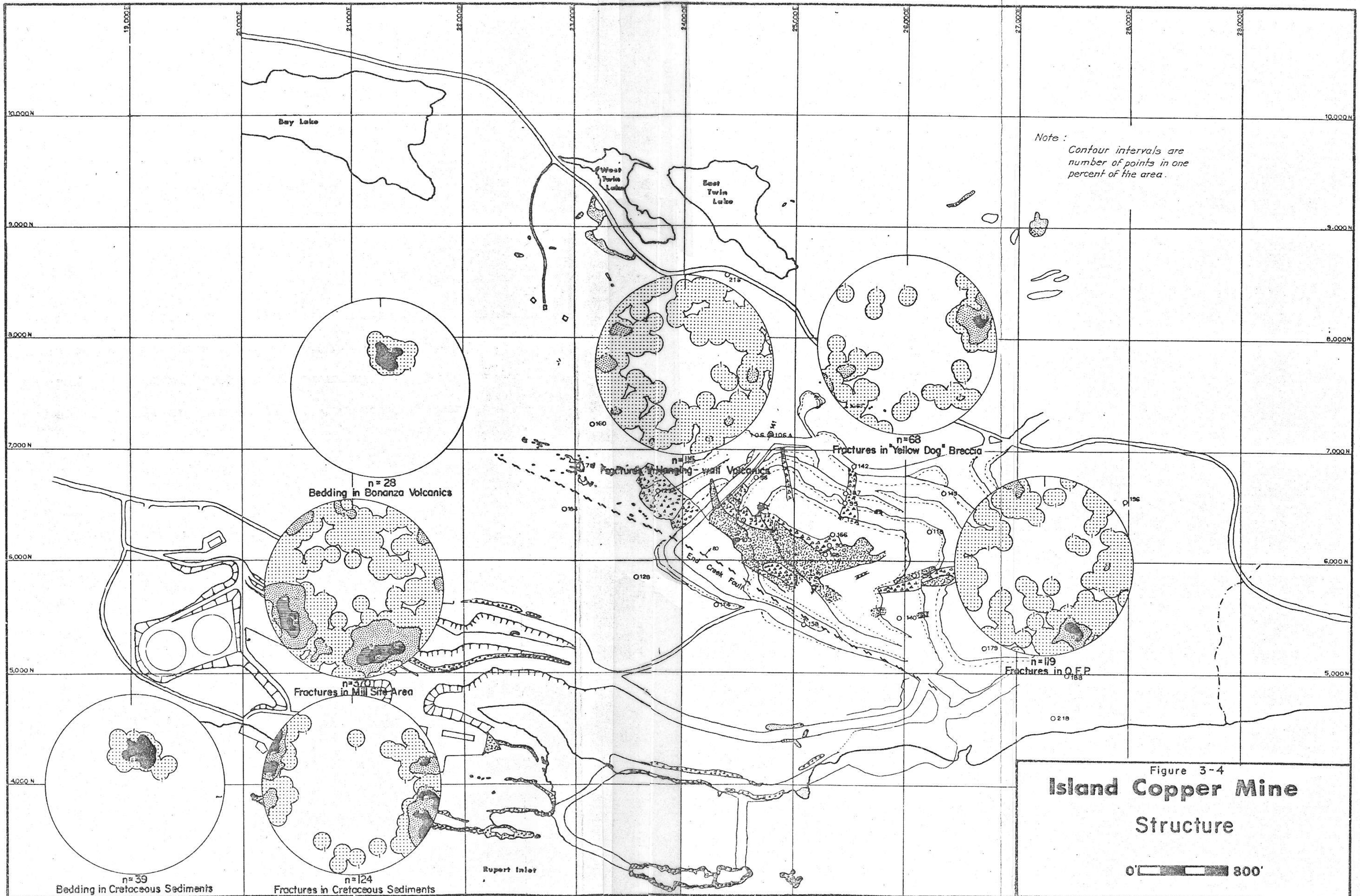


Figure 3-4

Island Copper Mine

Structure

30° southwest. If the beds were deposited roughly horizontally, then the thirty degree southwesterly dip of the dip of the volcanics is the result of post-Cretaceous adjustment. Further, because the porphyry dyke is pre-Cretaceous and roughly at right angles to the bedding, it was intruded as a vertical body.

This 30 degree southwest tilt of the layered rocks in the vicinity of the Island Copper mine is apparently the result of movement along a fault in Rupert Inlet.

Fractures

Fracture patterns in the vicinity of the Island Copper mine are complex. The complexity appears to come from the superposition of several periods of intense fracturing. An attempt to categorize the fractures on the basis of geometry (Figures 3-4, 3-5) failed to yield reasonable data.

Faults

Recognition of faults in the vicinity of the Island Copper deposit is hampered by lack of outcrop and lack of detailed stratigraphic knowledge.

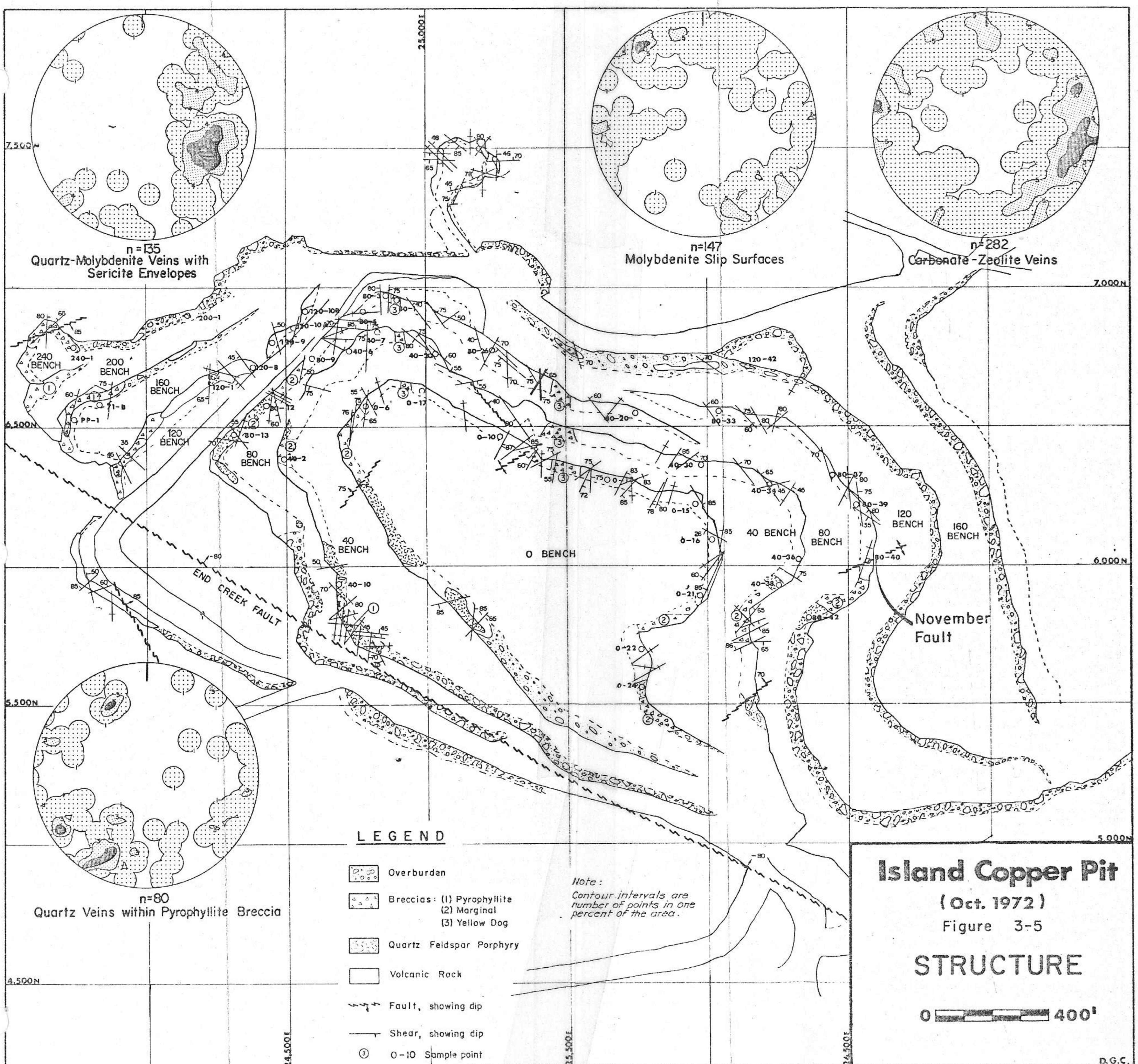
Airphoto interpretation, described by Rugg and Young (1970), indicates photo linear trends at:

1) E to N 70° W

2) N 70°E

3) N 40° - 60°W)
)   Subordinate Trends
4) N 20° W   )

The first three trends correspond to regional trends described by Northcote (1970) (Figure 2-1). The fourth trend (N20°W) has not been recognized on a regional scale.



n=135
Quartz-Molybdenite Veins with Sericite Envelopes
n=147
Molybdenite Slip Surfaces
n=282
Carbonate-Zeolite Veins
n=80
Quartz Veins within Pyrophyllite Breccia
240 BENCH
200 BENCH
160 BENCH
120 BENCH
80 BENCH
40 BENCH
O BENCH
40 BENCH
80 BENCH
120 BENCH
160 BENCH
END CREEK FAULT
November Fault
7,500N
7,000N
6,500N
6,000N
5,500N
5,000N
4,500N
25,000E
24,500E
25,500E
26,500E
LEGEND
Overburden
Breccias: (1) Pyrophyllite
(2) Marginal
(3) Yellow Dog
Quartz Feldspar Porphyry
Volcanic Rock
Fault, showing dip
Shear, showing dip
0-10 Sample point
Note:
Contour intervals are number of points in one percent of the area.
Island Copper Pit
(Oct. 1972)
Figure 3-5
STRUCTURE
0 400'
D.G.C.

Within the part of the pit developed to November 1972, there are two prominent fault zones. One is the End Creek Fault, which corresponds to the third set of air-photo linears (Young and Rugg, 1971) and to Northcote's (1970) third regional set. It strikes N55°W and dips steeply to the northeast (Figures 3-3, 3-4). The fault is expressed as a zone of crushed rock 50 to 100 feet wide. In the pit, the End Creek Fault forms the south boundary of the porphyry dyke which it apparently offsets. However at depth the fault plane and dyke diverge (Figure 3-3). Offset of alteration assemblages suggests normal movement along the fault plane (Figure 5-2).

Because the End Creek Fault cuts off the ore zone and the alteration patterns, it is concluded that movement was post-mineralization. Copper mineralization is not locallized along the fault, which suggests that the fault was not a prominent feature at the time of formation of the orebody.

A second prominent fault zone within the pit, the November Fault, trends northeast and dips very steeply. The fault zone is from 100 to 200 feet wide. The position of the porphyry on the northwest side of the fault suggests a dextral strike-slip movement. Amount of displacement, if any, is unknown. Drilling data suggest that the End Creek Fault displaces the November Fault.

Veins

A tentative correlation between the veins found in the various parts of the ore deposit is given in Table 3-1. Because the veins are too short and irregular to follow from one zone to another, correlation is based on mineralogic similarity.

TABLE 3-1

TENTATIVE VEIN CORRELATION

Set	Ore Zone	"Yellow Dog" Breccia	Marginal Breccia	Pyrophyllite Breccia	Quartz-Feldspar Porphyry
(1)	--	Silicification	--	Quartz	--
(2)	Quartz (Smoky) Pyrite	Quartz (Smoky) Pyrite	Quartz Pyrite	Quartz	Quartz Pyrite
(3)	Quartz (Milky) Chalcopyrite Pyrite minor Molybdenite	Quartz Chalcopyrite Pyrite	Quartz Chalcopyrite Pyrite	Quartz minor Chalcopyrite minor Pyrite	Quartz minor Chalcopyrite Pyrite minor Molybdenite
(4)	Quartz Molybdenite Pyrite minor Chalcopyrite (Sericite Envelopes)	--	Quartz Molybdenite	Quartz Molybdenite Pyrite	--
(5)	Quartz Pyrite	--	Quartz	--	--
(6)	"Slips" Molybdenite minor Chalcopyrite minor Pyrite	--	"Slips" Molybdenite minor Chalcopyrite minor Pyrite	--	"Slips" Molybdenite minor Chalcopyrite minor Pyrite
(7)	--	--	--	Dumortierite	--
(8)	--	Buff Dolomite	--	--	--
(9)	Carbonate Zeolite Pyrite minor Sphalerite Hematite Chalcopyrite	Carbonate Pyrite	Carbonate Pyrite minor Sphalerite	Carbonate	Carbonate Zeolite Pyrite minor Sphalerite
(10)	Chalcopyrite Pyrite	Quartz Pyrite minor Chalcopyrite	--	--	--

Set 1 "veins" are silicification of the matrix in the Yellow Dog Breccia and quartz veins in the Pyrophyllite Breccia. Veins belonging to this set were not recognized in the Ore Zone, the Marginal Breccia or the porphyry dyke.

Veins of set 2 occur in all parts of the deposit. In the Ore Zone and the Yellow Dog Breccia, they are smoky quartz veins which have been shattered and recemented with material from the third set of veins (Figure 3-6A). In the Marginal Breccia, the Pyrophyllite Breccia, and the porphyry dyke, there are quartz veins containing minor amounts of pyrite.

Quartz-chalcopyrite-pyrite veins of set 3 occur in all parts of the deposit (Figure 3-6 A, B, C, E). They are thin, almost hairline veins and do not have a well-developed uniform orientation. In the Ore Zone they are very closely spaced, but in the other parts of the deposit they are more erratically distributed. Trace amounts of molybdenite occur in these veins in the Ore Zone and quartz-feldspar porphyry.

Quartz-molybdenite-pyrite veins of set 4 occur in the Ore Zone, the Marginal Breccia and Pyrophyllite Breccia. In the Ore Zone they are characterized by alteration envelopes rich in sericite (Figure 3-6, B, C, D, E, F; Figure 3-5).

Quartz and quartz-pyrite veins of set 5 are only recognized in the Ore Zone and the Marginal Breccia. In the Ore Zone they are quartz-pyrite veins (Figure 3-6, C, E); in the Marginal Breccia they are quartz veins. The relationship between these veins and the Molybdenite "slips" of set 6 is obscure, but set 5 are tentatively considered older.

Molybdenite "slips" constitute set 6 "veins". These are fracture surfaces coated with molybdenite (Figure 3-5). The

Figure 3-6

SKETCHES ILLUSTRATING AGE RELATIONS OF VEINS WITHIN THE ORE ZONE

A. Set 2 quartz vein within biotitized volcanics (indicated by stippling) crosscut by set 3 fracture filling chalcopyrite, pyrite and quartz, crosscut by a set 4 quartz and molybdenite vein, crosscut by a set 9 carbonate vein.

B. Biotitized volcanics (stippled) crosscut by set 3 fracture filling chalcopyrite, pyrite and quartz, cross-cut in turn by a set 4 quartz-molybdenite vein with a sericite envelope cross-hatched) which is cut in turn by a set 9 carbonate vein.

C. Biotitized volcanics (stippled) crosscut by set 3 fracture filling chalcopyrite, pyrite, and quartz which are cut in turn by a set 4 quartz-molybdenite vein with an inner quartz-sericite envelope and an outer bleached zone. Both the quartz-molybdenite vein and the alteration envelopes are crosscut by a set 5 barren quartz vein.

D. A highly altered fragmental volcanic, clots of chlorite in a silicified matrix, is crosscut by a set 4 quartz-molybdenite vein with a sericite envelope, which is crosscut by a set 6 molybdenite slip surface which is cut in turn by a set 9 carbonate vein.

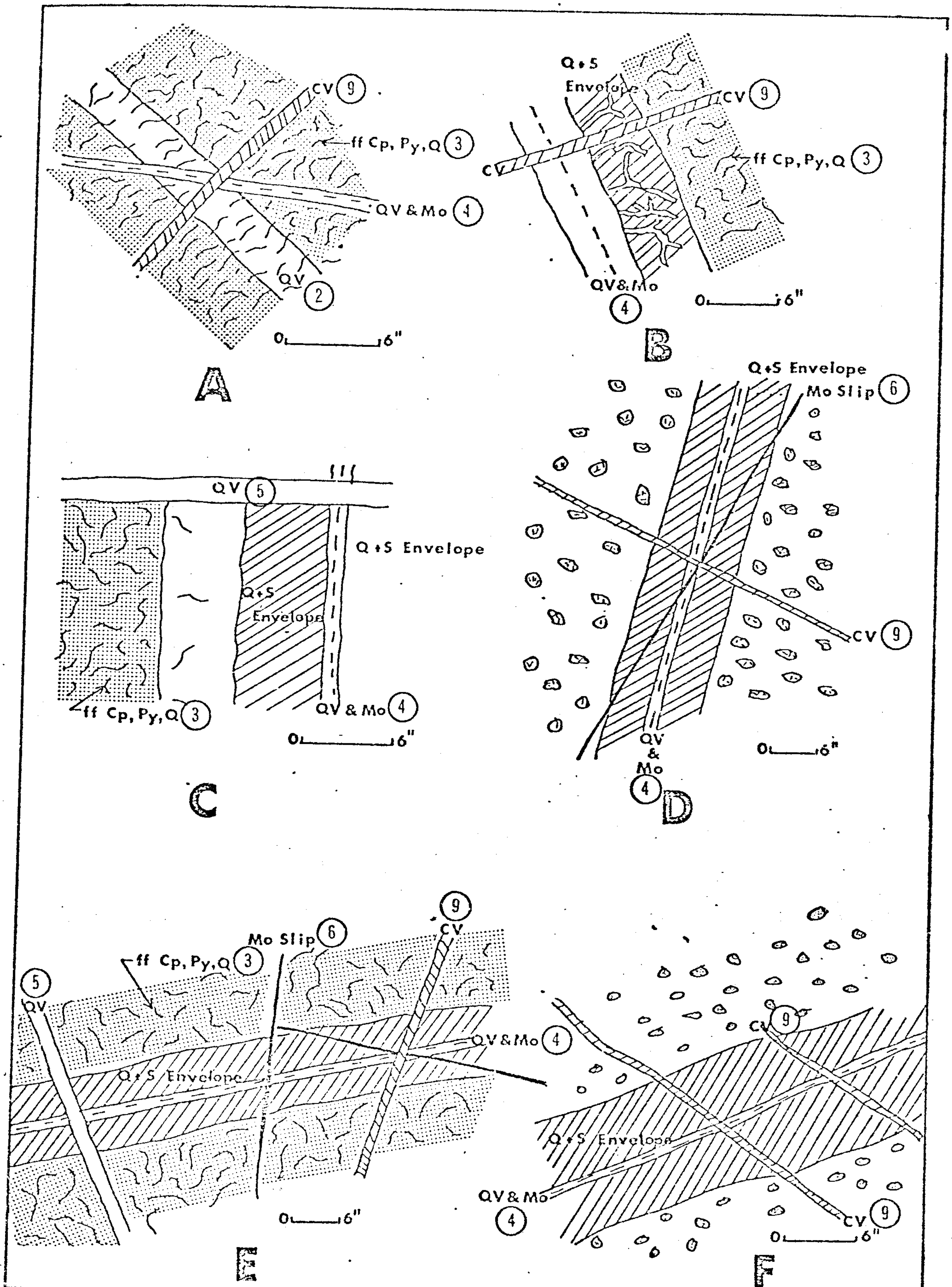
E. Biotitized volcanics (stippled) are crosscut by set 3 fracture filling quartz, chalcopyrite and pyrite, which is crosscut in turn by a set 4 quartz and molybdenite vein with a sericite envelope which is cut by both a set 5 barren quartz vein and a set 6 molybdenite slip surfaces. The molybdenite slip surface is cut by a set 9 carbonate vein.

F. A highly altered fragmental volcanic consisting of chloritized and biotitized fragments in a siliceous matrix crosscut by a set 4 quartz and molybdenite vein with a sericite envelope which is cut in turn by two set 9 carbonate veins.

Abbreviations

QV Quartz vein
CV Carbonate vein
ff fracture filling
Q Quartz
Mo Molybdenite
Cp Chalcopyrite
Py Pyrite
S Sericite

1 Number indicates vein set outlined in Table 3-1


CV 9
ff Cp, Py, Q 3
QV & Mo 4
QV 2
0 6"
A
Q+S Envelope
CV 9
CV
ff Cp, Py, Q 3
QV & Mo 4
0 6"
B
QV 5
Q+S Envelope
Q+S Envelope
ff Cp, Py, Q 3
QV & Mo 4
0 6"
C
Q+S Envelope
Mo Slip 6
CV 9
QV & Mo 4
0 6"
D
9 CV
Mo Slip 6
ff Cp, Py, Q 3
5 QV
QV & Mo 4
Q+S Envelope
0 6"
E
CV 9
Q+S Envelope
QV & Mo 4
CV 9
0 6"
F

most recent movement on these surfaces, indicated by slickensides on the molybdenite, fits into the relative position shown in Table 3-1. However the age of deposition of the molybdenite is not known. Many molybdenite "slips" occur in Marginal Breccia and the Ore Zone and a few were noted in the porphyry dyke.

Set 7 and set 8 of veins are restricted to the Pyrophyllite Breccia and the Yellow Dog Breccia respectively. Their relative positions within these zones is clearly established. However, because they cannot be correlated across the other parts of the deposit, they are treated as separate sets.

Carbonate veins (set 9) are found in all parts of the deposit (Figures 3-5, 3-6). These are predominantly carbonate veins but locally contain considerable amounts of zeolite, pyrite and hydrocarbon. Minor amounts of sphalerite, hematite and chalcopyrite have been noted.

Veins of set 10 are recognized only in the Ore Zone and Yellow Dog Breccia. In the Ore Zone they are pyrite-chalcopyrite veins whereas in the Yellow Dog Breccia they are quartz-pyrite-chalcopyrite veins.

Stereonet plots of some of the vein sets are given on Figure 3-5. Attempts to relate veining geometrically to other structural elements were unsuccessful. Present knowledge of the structural history of the deposit is too fragmentary to allow the various ages of veins to be fitted into a detailed picture.

SIZE AND GEOMETRY OF THE ORE ZONE

The ore zone at the Island Copper mine contains reserves of 280 million tons of 0.52 percent copper and 0.029 percent

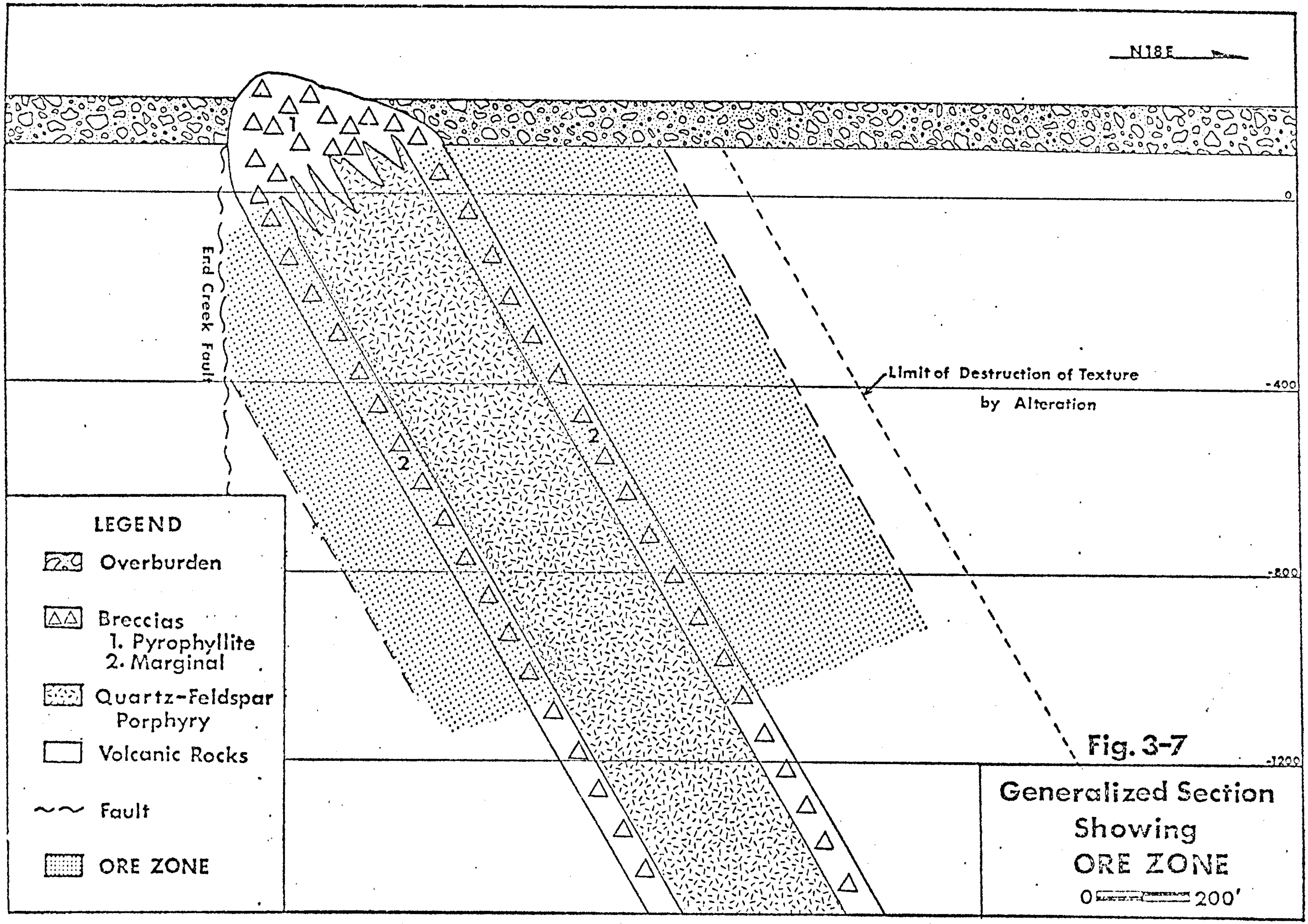


Fig. 3-7

Generalized Section Showing ORE ZONE

MoS_2 (Young and Rugg, 1971). It consists of two parts, one on each side of the porphyry dyke. The bulk of the ore is in volcanic rocks on the hanging wall of the porphyry dyke (Figure 3-7). This part of the ore zone is a roughly tabular body 400 to 600 feet wide and approximately 5,500 feet long which continues essentially unchanged to a depth of 1,000 feet below the ground surface. The zone apparently continues beyond this depth. At the ends of the planned pit the top of the ore zone plunges deeper below the ground surface. It is not known whether this doubly plunging zone is a primary structural characteristic of the ore zone or was superimposed by subsequent tectonism.

The second part of the ore zone is in the footwall volcanic rocks (Figure 3-7) adjacent to the porphyry dyke and is smaller than the hanging wall section. It has been displaced by normal movement on the End Creek Fault. Because it is farther from surface than the hanging wall part, it is not as well defined by diamond drilling.

A minor amount of ore occurs within the dyke. However ore-bearing quartz-feldspar porphyry is restricted to dykes or blocks faulted from the main dyke (Figure 3-7). The main dyke locally contains minor amounts of copper sulphides along its contacts but the rock is for the most part unmineralized.

Boundaries of ore zones are assay walls. Mineralization continues beyond these assay boundaries into the volcanic rocks and porphyry dyke so that the orebodies are enclosed by a halo of lower grade copper mineralization in the volcanic rocks.

SULPHIDE AND OXIDE MINERALOGY

Introduction

Chalcopyrite and molybdenite are the only sulphide minerals recovered at the Island Copper mine. Pyrite, the only other major sulphide mineral makes up two to five percent of the ore. Sphalerite occurs erratically in carbonate veinlets both within and outside of the ore zone.

The most abundant oxide mineral is magnetite. Other oxide minerals include hematite, which is almost invariably formed from the oxidation of magnetite, and leucoxene, which is associated with chloritized mafic minerals.

Chalcopyrite

Chalcopyrite occurs as veinlets, as disseminations and on slip surfaces. Most chalcopyrite is in set 3 veins (Plate II., A, B, C) which are 0.1mm. thick. Field observations suggest that set 3 veins (Table 3-1) contain the bulk of the copper in the ore zone.

Chalcopyrite also occurs in smaller amounts with the quartz-molybdenite veins (set 4); on slip surfaces (set 6); with sphalerite in carbonate-zeolite veins (set 9); and as late chalcopyrite-pyrite veins (set 10). These occurrences of chalcopyrite, although locally spectacular, do not contribute much copper to the ore zone.

Molybdenite

Molybdenite occurs in quartz veins and on fracture "slip" surfaces. There were three stages of molybdenite mineralization.

First-stage molybdenite, a quantitatively minor stage of

PLATE II

POLISHED SECTIONS

A A set 3 chalcopyrite vein cutting across a matrix containing disseminated magnetite.

B A set 3 chalcopyrite and quartz vein cutting a matrix containing disseminated magnetite.

C A set 3 chalcopyrite and quartz vein cutting a matrix of disseminated magnetite.

D Molybdenite and pyrite in the centre of a set 4 vein.

E Magnetite core in a subhedral pyrite crystal.

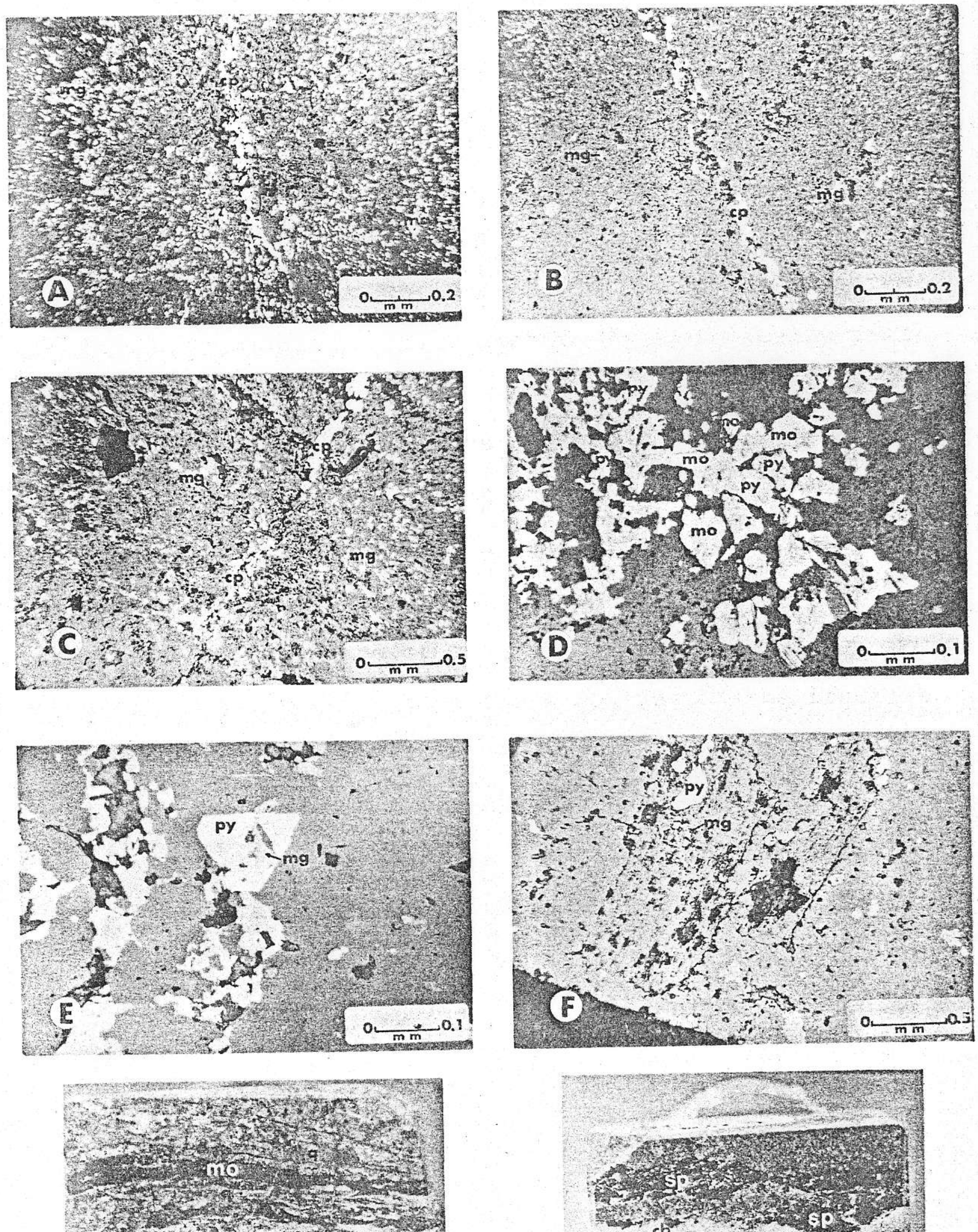
F Pyrite and magnetite within a chloritized mafic phenocryst.

G A set 4 molybdenite-quartz vein.

H A set 9 carbonate-sphalerite vein in chloritized tuff.

Abbreviations used on the plates

cp - chalcopyrite
py - pyrite
mg - magnetite
mo - molybdenite
sp - sphalerite
q - quartz
cb - carbonate



A
mg
cp
0 mm 0.2
B
mg
cp
mg
0 mm 0.2
C
cp
mg
mg
cp
0 mm 0.5
D
py
mo
mo
mo
py
py
mo
0 mm 0.1
E
py
mg
0 mm 0.1
F
py
mg
0 mm 0.3
G
mo
0 1cm
H
sp
sp
cb
0 1cm

molybdenite mineralization, is associated with chalcopyrite and pyrite and quartz veinlets (set 3). It occurs as small (<0.05mm) subhedral crystals (Figure II, D).

Second-stage molybdenite occurs in Set 4 quartz veins with sericite envelopes (Plate VI., A,B,C). Molybdenite occurs as a mass of tiny subhedral crystals forming veins 0.1 to 2 cm. thick (Plate II.,G). Minor amounts of pyrite and chalcopyrite occur with the molybdenite. This also is an economically minor stage of molybdenite mineralization.

Third-stage molybdenite occurs on "slip" surfaces (set 6 veins). Field observations suggest that most of the molybdenum in the ore zone was deposited during this stage. The molybdenite has been smeared into a thin (<1 mm.) film by movement on the fractures. The relative age of movement on the fracture surfaces can be determined, but the age of the sulphides on the fracture surface is difficult to establish.

Molybdenite at Island Copper has a high rhenium content. Molybdenite concentrate contains between 1,800 and 2,400 ppm (0.18% and 0.24%) rhenium calculated to 100% MoS_2. This is rich relative to most porphyry copper deposits (Table 3-2). The relation between the different stages of molybdenite and rhenium has not been studied.

Pyrite

Pyrite is ubiquitous within the deposit and accompanies at least five sets of quartz veins (Table 3-1). Pyrite content ranges from 2 to 5 percent and locally is up to 15 percent.

Pyrite within the ore zone is associated with chalcopyrite and molybdenite in veinlets and within chloritized mafic minerals

Table 3-2

RHENIUM CONTENT OF SOME PORPHYRY COPPERS

(expressed in ppm on 100% MoS_2)

(after Sutulov 1963, 1974)

North America		South America	
McGill	1,600	Chuquicamata	230
San Manuel	1,000	El Teniente	440
Chino	800	El Salvador	570
Cities Service	600	Andina	380
Twin Buttes	600	La Disputada	350
Pima	600	Toquepala	325
Mission	600	Argentinian porph.	170
Bagdad	200	Communist World	
Esperanza	200	Kounrad	510
Sierrita	180	Almalyk	290
Mineral Park	60	Kadzharan	300
Island Copper	2,000	Aigedzor	1,000
Brenda	80	Dastakert	80
Cananea	700	Medet	125
Bingham	300		

(Plate II., D,E,F). Outside the ore zone, pyrite is disseminated in the porphyry dyke as an accessory mineral. Pyrite also occurs in volcanic rocks far removed from the ore zone.

Most pyrite is in the form of euhedral cubes (0.5 - 2mm.) but rare pyritohedrons have been noted.

Sphalerite

Dark brown to black sphalerite occurs in carbonate-zeolite veins (set 9; Table 3-1) both inside and outside the ore zone (Plate II.,H). The small (to 1 mm.) subhedral sphalerite crystals are associated with pyrite and more rarely chalcopyrite and specular hematite. Galena is very rare. Minute crystals have been reported, with sphalerite.

Magnetite

Magnetite is found both in volcanic rocks and quartz-feldspar porphyry. In volcanic rocks it occurs primarily as fine (<.1 mm.) disseminated grains and with chlorite pseudomorphs of mafic phenocrysts. Locally it is in fracture fillings and quartz veins (Plate II., A,B,C). The magnetite-rich (to 10%) part of the volcanic rocks closely corresponds to the ore zone. In polished sections of magnetite-rich volcanic rocks, magnetite is invariably older than the associated pyrite and chalcopyrite. Molybdenite does not show clear age relations with the magnetite.

In the porphyry dyke, magnetite is found with chlorite pseudomorphs of mafic minerals.

Hematite

Hematite occurs in two forms; first as masses of small (<1 mm.) dark specularite plates in late carbonate veins and second as the alteration product of magnetite near fractures. This hematite appears to be hypogene because there is no obvious relation between the hematite and the depth below the present ground surface. However it cannot be clearly correlated with any hypogene mineralization or alteration events.

Leucoxene

Leucoxene is a general name applied to very fine-grained secondary titanium minerals. It is associated with masses of chlorite and/or white mica which form pseudomorphs after mafic phenocrysts (Plate V., E,F). Leucoxene is found both in the quartz-feldspar porphyry and the volcanic rocks.

Leucoxene provides a useful method to distinguish mafic from feldspar phenocrysts when both have been altered to white mica. Once leucoxene has formed, it apparently is stable and is unaffected by subsequent alteration.

CHAPTER 4: COMPUTER ANALYSIS

INTRODUCTION

The "GEOLOG" computer input format was used in this study for three reasons: (1) to attempt to minimize bias in collection of data by using a standardized format; (2) to record the data in a format where statistical as well as graphical tests of the correlation between copper and molybdenum grades and alteration could be made; (3) to test the efficiency of the computer format logging system in a deposit other than a "classic" porphyry copper deposit.

40,000 feet of drill core, which represent one-third of the core obtained during exploration of the deposit, were logged using computer input format. This core represents forty-two diamond drill holes along seven sections spaced at 800-foot intervals across the ore body (Figure 4-1). This quantity of core is believed large enough to allow statistical tests of correlation.

DATA COLLECTION

Basic data sheets were modified from original "GEOLOG" sheets described by Blanchet and Godwin (1972). Details of the modifications are discussed in Appendix A. In these modifications, the number of hydrothermal minerals was increased and those features of "classic" porphyry copper deposits not observed at Island Copper were omitted. Data collection included: sample location, rock type, colour, fracture density, and amount and mode of occurence of twelve silicate alteration minerals, three iron oxide minerals and

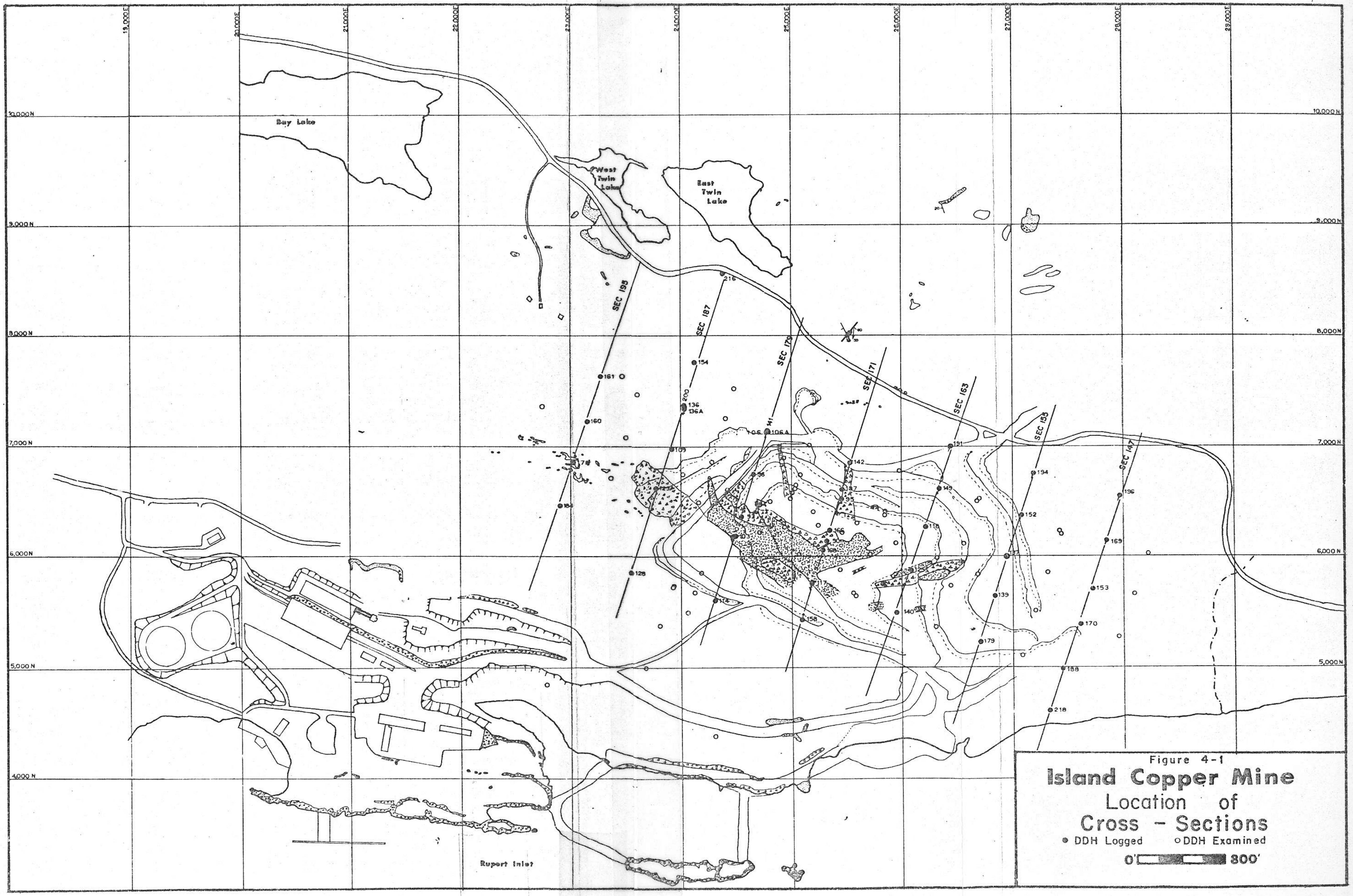


Figure 4-1
Island Copper Mine
Location of
Cross - Sections
● DDH Logged ○ DDH Examined
0' 800'

five sulphide minerals.

To use the forms, assuming there is one rock type within an assay interval, rock type is recorded and then all other parameters are recorded. If there is a change of rock type within the interval, the footage of the contact is recorded along with all data for the first rock type, data for the second rock type are recorded at the regular assay interval. Assay values are assumed constant for the entire sample interval. Fracture density data were obtained from original drill logs by Utah Exploration geologists, because useful fracture density data is difficult to obtain from split core.

DATA TREATMENT

To obtain the maximum spatial information, data for drill holes on each section were analysed independently. To consider the two rock types, data for each section were further divided into three parts; the hanging-wall of the dyke, the dyke and the footwall of the dyke (Figure 4-2). The three divisions of each of seven sections gave twenty-one separate batches of data for statistical treatment.

Data cards from each division were computer processed to test three correlations:

(1) Copper grade versus molybdenum grade.

(2) Copper grade versus fifteen separate parameters.

(3) Molybdenum grade versus the same fifteen parameters.

Details of programming and statistics used in the treatment of the data are presented in Appendices B and C.

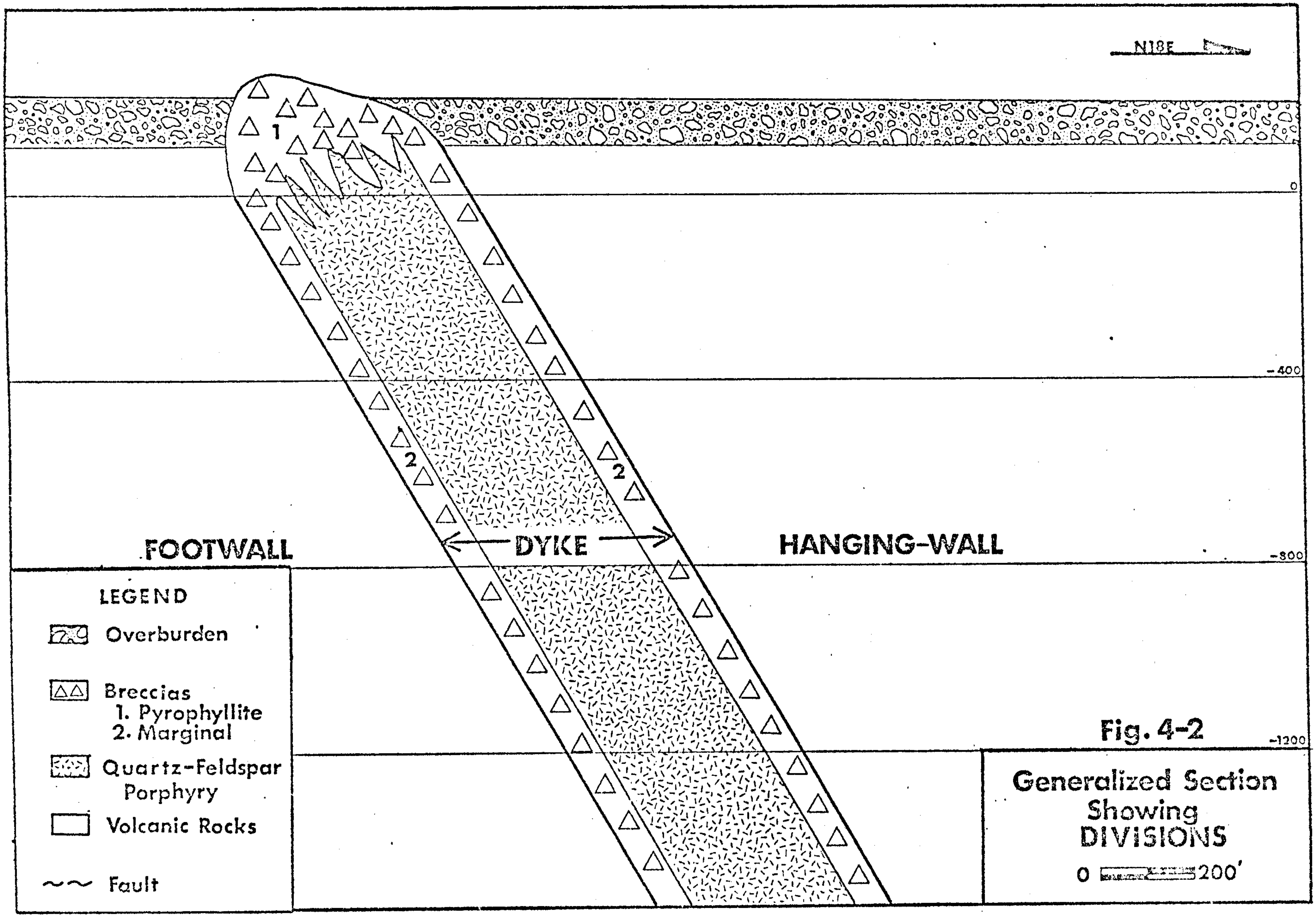


Fig. 4-2

Generalized Section Showing DIVISIONS

RESULTS

Results of the statistical study are presented in Table 4-1. The table is designed to present correlations between each independent variable measured and copper and molybdenum grades in adjacent columns for easy comparison. Columns marked "CORR" are correlation coefficients. As this value approaches unity, the degree of correlation increases.

Columns labelled "PROB" are the probability of obtaining the corresponding amount of correlation from random numbers. The smaller the value in this column, the stronger the probability of a correlation between the two variables. Values of less than 0.1000 in the "PROB" column indicate good correlations.

Dashed lines in the table indicate invalid correlations. These result from a complete absence of data for one of the variables; that is, either there are no assays, or the independent variable was not recognized in this part of the section. Data presented in Table 4-1 are summarized in Table 4-2.

INTERPRETATION OF RESULTS

The results of this form of data treatment lend themselves to a number of interpretations.

Correlation Between Grade of Mineralization and Other Parameters

The object of statistical examination of "GEOLOG" data is to examine the correlation between ore grades and alteration as well as other parameters throughout the orebody. This approach is used in an attempt to establish empirically those parameters, other than grade, that would be most useful in defining the orebody.

TABLE 4-1

CORRELATION BETWEEN GRADE AND ALTERATION INTENSITY

	FOOTWALL				DYKE				HANGING WALL			
	CU GRADE		MO GRADE		CU GRADE		MO GRADE		CU GRADE		MO GRADE	
	CORR	PROB	CORR	PROB	CORR	PROB	CORR	PROB	CORR	PROB	CORR	PROB
	INDEPENDENT VARIABLE QUARTZ											
147	0.0610	0.5402	-0.0621	0.6061	0.1023	0.1662	0.0081	0.8782	0.2257	0.0002	-0.0936	0.1361
155	-0.1877	0.1262	-0.2743	0.0243	0.4060	0.0000	0.3436	0.0002	0.3297	0.0000	0.3897	0.0000
163	-0.3451	0.0028	0.1869	0.1079	0.2466	0.0206	-0.2018	0.1779	0.5947	0.0000	0.5204	0.0000
171	0.2351	0.0007	0.0865	0.2077	-0.0135	0.8553	0.1871	0.9863	0.2038	0.0029	0.1093	0.1064
179	0.5851	0.0005	------	------	0.4227	0.0000	0.2811	0.0000	0.2751	0.0000	0.2237	0.0011
187	-0.2428	0.3360	------	------	0.5800	0.0000	------	------	0.3375	0.0000	0.3425	0.0000
195	0.2014	0.0021	0.2320	0.0005	0.5148	0.0000	0.4638	0.0000	-0.0668	0.5914	0.0690	0.5760
	INDEPENDENT VARIABLE "ARGILLIC"											
147	0.1563	0.1694	-0.0621	0.6051	-0.2444	0.0025	0.1983	0.0136	0.0219	0.7725	-0.0478	0.5554
155	-0.4954	0.0009	-0.2411	0.1084	-0.4926	0.0006	-0.3696	0.0003	-0.0337	0.6423	0.0276	0.7001
163	-0.1955	0.1237	-0.0586	0.6549	-0.2553	0.0196	-0.2614	0.0901	0.1237	0.2718	0.0306	0.7769
171	-0.2955	0.0001	-0.2676	0.0003	-0.2970	0.0001	-0.1489	0.0505	0.0988	0.1662	0.0617	0.3964
179	0.8211	0.0001	------	------	-0.0941	0.2634	-0.1815	0.0292	-0.4412	0.0000	-0.1569	0.0648
187	-0.4067	0.3848	------	------	-0.4704	0.0000	------	------	-0.2807	0.0000	-0.0973	0.2120
195	-0.0082	0.8886	0.1357	0.1229	-0.2836	0.0006	-0.3444	0.0000	-0.2082	0.0930	0.1355	0.2822
	INDEPENDENT VARIABLE SERICITE											
147	0.3480	0.0184	-0.3189	0.0573	-0.1031	0.3105	-0.0974	0.3389	-0.2200	0.0124	-0.2132	0.0155
155	-0.4812	0.0004	-0.3892	0.0039	-0.2910	0.0044	-0.1804	0.9765	-0.1304	0.1136	-0.0931	0.2645
163	-0.1017	0.4915	0.4701	0.0009	-0.1907	0.1623	-0.2444	0.2349	0.0593	0.6665	-0.0406	0.7589
171	-0.2952	0.0002	-0.3633	0.0000	0.2854	0.0092	0.1871	0.0863	0.1637	0.0782	0.0769	0.4202
179	------	------	------	------	-0.2942	0.0167	-0.2307	0.0487	-0.2450	0.0112	-0.2157	0.0309
187	------	------	------	------	-0.6069	0.0000	------	------	-0.1592	0.0107	0.1127	0.2147
195	0.1316	0.1012	0.1357	0.1229	-0.2836	0.0006	-0.3444	0.0000	-0.0215	0.8357	0.0748	0.5406
	INDEPENDENT VARIABLE K-FELDSPAR											
147	------	------	------	------	0.1070	0.3860	0.1928	0.1099	------	------	------	------
155	------	------	------	------	-0.2252	0.3594	-0.1123	0.6504	------	------	------	------
163	------	------	------	------	------	------	------	------	------	------	------	------
171	0.6242	0.0130	0.1372	0.5960	-0.2978	0.3992	0.0365	0.8810	0.3198	0.0610	0.5310	0.0021
179	------	------	------	------	------	------	------	------	------	------	------	------
187	------	------	------	------	-0.0466	0.8173	------	------	0.2264	0.2103	0.7352	------
195	------	------	------	------	------	------	------	------	------	------	------	------
	INDEPENDENT VARIABLE PYROPHYLLITE											
147	-0.2337	0.1806	-0.2675	0.1525	------	------	------	------	-0.1651	0.6266	-0.1508	0.6561
155	------	------	------	------	0.1791	0.6328	0.2134	0.5700	-0.2291	0.0612	-0.2610	0.0332
163	------	------	------	------	------	------	------	------	------	------	------	------
171	-0.3026	0.0124	-0.2219	0.0654	-0.5914	0.0000	-0.2666	0.0212	-0.3867	0.0057	-0.2799	0.0435
179	------	------	------	------	-0.2574	0.4385	-0.2011	0.5474	-0.3381	0.1805	------	------
187	------	------	------	------	-0.7709	0.0000	------	------	-0.2943	0.0006	-0.2067	0.0611
195	-0.2605	0.0890	-0.0225	0.8566	-0.4505	0.0000	-0.4565	0.0000	-0.2816	0.0546	0.2461	0.0939

TABLE 4-1 (Cont)

	FOOTWALL				DYKE				HANGING WALL			
	CU GRADE		MO GRADE		CU GRADE		MO GRADE		CU GRADE		MO GRADE	
	CORR	PROB	CORR	PROB	CORR	PROB	CORR	PROB	CORR	PROB	CORR	PROB
INDEPENDENT VARIABLE DUMORTIERITE												
147	------	------	------	------	------	------	------	------	------	------	------	------
155	------	------	------	------	------	------	------	------	------	------	------	------
163	------	------	------	------	------	------	------	------	------	------	------	------
171	-0.3233	0.3355	-0.1865	0.5843	-0.4563	0.0456	-0.3155	0.1670	------	------	------	------
179	------	------	------	------	------	------	------	------	-0.3839	0.1282	------	------
187	------	------	------	------	-0.7636	0.0000	------	------	-0.2216	0.4900	-0.1537	0.6488
195	-0.2605	0.0890	0.1468	0.5767	-0.3505	0.0000	-0.3694	0.0001	-0.1744	0.5676	0.2461	0.0939
INDEPENDENT VARIABLE CARBONATE												
147	-0.1538	0.1238	0.1888	0.1182	0.4059	0.0000	0.2881	0.0006	-0.1157	0.0809	0.0263	0.6987
155	0.4072	0.0038	0.4104	0.0036	0.4702	0.0001	0.5419	0.0000	-0.1543	0.1069	-0.2154	0.0019
163	0.0831	0.5709	0.2819	0.0451	0.1346	0.3265	0.3564	0.0357	-0.2184	0.0030	-0.0436	0.5626
171	0.0469	0.4918	0.1323	0.0456	0.0624	0.4769	0.1590	0.0615	-0.1986	0.0078	0.1425	0.0548
179	-0.3083	0.0855	------	------	0.0138	0.8024	0.0289	0.6335	0.4200	0.0000	0.2059	0.0044
187	0.2225	0.2877	------	------	0.5529	0.0000	------	------	0.1435	0.0044	0.1304	0.4134
195	-0.0528	0.4546	-0.0225	0.8566	0.4556	0.0000	0.4760	0.0000	0.2251	0.0525	-0.1246	0.2929
INDEPENDENT VARIABLE ZEOLITE												
147	-0.3462	0.0017	0.1939	0.2267	-0.0031	0.9322	0.0836	0.5853	0.1924	0.0219	0.3634	0.0000
155	------	------	------	------	------	------	------	------	-0.1543	0.1069	0.1299	0.1768
163	------	------	------	------	------	------	------	------	-0.4087	0.0000	-0.2890	0.0009
171	-0.5143	0.0000	-0.4454	0.0000	------	------	------	------	-0.5942	0.0000	-0.4208	0.0008
179	-0.1031	0.5664	------	------	-0.2460	0.0032	-0.2235	0.0072	0.1424	0.2448	0.0802	0.5453
187	-0.4504	0.0318	------	------	0.2653	0.1702	------	------	-0.0468	0.6228	0.1304	0.4134
195	0.0848	0.4658	-0.0230	0.8221	------	------	------	------	-0.2332	0.1574	-0.2761	0.0923
INDEPENDENT VARIABLE CHLORITE												
147	-0.3230	0.0023	-0.0349	0.7733	0.1311	0.0973	0.0515	0.5285	-0.1687	0.0083	-0.1246	0.0514
155	0.3929	0.0028	0.3115	0.0179	0.2909	0.0030	0.0873	0.3834	-0.1139	0.0623	-0.1780	0.0040
163	0.0752	0.5658	-0.2334	0.0635	-0.0143	0.8688	0.3096	0.0505	-0.1381	0.0518	-0.0575	0.4312
171	-0.3710	0.0000	-0.3490	0.0000	-0.0213	0.8103	0.0337	0.7269	-0.1899	0.0095	-0.1323	0.0693
179	-0.6127	0.0000	------	------	-0.2473	0.0000	-0.1465	0.0118	0.1811	0.0055	0.1021	0.1485
187	0.0097	0.9155	------	------	0.3110	0.0016	------	------	0.1869	0.0001	0.1137	0.0627
195	0.0338	0.6218	-0.0624	0.3574	0.0150	0.8465	0.0117	0.8682	0.2862	0.0134	-0.1297	0.2715
INDEPENDENT VARIABLE EPIDOTE												
147	-0.4655	0.0001	-0.2878	0.4638	0.4499	0.0469	0.0780	0.7322	-0.5619	0.0000	-0.3227	0.0005
155	0.6181	0.1127	0.2473	0.5409	------	------	------	------	-0.6898	0.0000	-0.5484	0.0000
163	-0.2090	0.0594	-0.1522	0.1725	------	------	------	------	------	------	------	------
171	-0.3813	0.0002	-0.3101	0.0018	------	------	------	------	-0.3185	0.3546	-0.2538	0.4648
179	-0.6307	0.0010	------	------	-0.3847	0.0000	-0.3316	0.0002	-0.1221	0.3753	-0.1275	0.3688
187	-0.6968	0.0015	------	------	0.4162	0.0009	------	------	-0.2756	0.0000	-0.2838	0.0038
195	0.0360	0.7103	-0.1043	0.2814	-0.1957	0.2797	-0.2374	0.1861	-0.2160	0.1497	-0.2966	0.0462

TABLE 4-1 (Cont)

	FOOTWALL				DYKE				HANGING WALL			
	CU GRADE		MO GRADE		CU GRADE		MO GRADE		CU GRADE		MO GRADE	
	CORR	PROB	CORR	PROB	CORR	PROB	CORR	PROB	CORR	PROB	CORR	PROB
					INDEPENDENT VARIABLE HEMATITE							
147	-0.4060	0.0029	------	------	0.1025	0.5740	0.0780	0.7322	0.1254	0.4127	0.2255	0.1323
155	------	------	------	------	-0.1826	0.1877	-0.2144	0.1200	-0.0112	0.9122	-0.1135	0.6061
163	0.1371	0.6052	0.1162	0.6595	0.2733	0.1739	0.0854	0.7275	------	------	------	------
171	0.1503	0.1083	0.2234	0.0172	0.3295	0.0005	0.1974	0.0343	0.1147	0.2438	-0.2073	0.0331
179	------	------	------	------	0.1455	0.1431	0.0734	0.4724	0.0910	0.6481	0.1696	0.4039
187	------	------	------	------	-0.1383	0.5126	------	------	-0.1372	0.3531	-0.1855	0.2657
195	-0.2164	0.5311	-0.2920	0.3936	------	------	------	------	------	------	------	------
					INDEPENDENT VARIABLE MAGNETITE							
147	0.1659	0.1094	0.2981	0.0130	0.1423	0.0957	0.0437	0.6202	0.2229	0.0012	0.1462	0.0312
155	0.3228	0.0178	-0.2452	0.0731	0.1809	0.0778	0.0120	0.8749	0.1627	0.0116	0.1017	0.1142
163	0.1802	0.0165	0.2387	0.0017	0.4038	0.0012	0.2455	0.1493	0.4946	0.0020	-0.3534	0.0273
171	0.2210	0.0016	0.1726	0.0124	0.3948	0.0011	0.4146	0.0006	0.1201	0.1724	-0.0130	0.0273
179	0.1237	0.5565	------	------	-0.1593	0.0089	0.0742	0.2247	0.1535	0.0291	0.1330	0.0786
187	0.0417	0.8329	------	------	0.3634	0.0023	------	------	0.1366	0.0110	0.1529	0.0277
195	0.1571	0.0430	0.2106	0.0071	0.9043	0.0000	0.7693	0.0000	0.1352	0.3148	-0.1896	0.1527
					INDEPENDENT VARIABLE MOLYBDENITE							
147	0.4793	0.0000			0.4489	0.0000			0.5320	0.0000		
155	0.4374	0.0002			0.7266	0.0000			0.6746	0.0000		
163	0.7295	0.0000			0.1970	0.1763			0.0644	0.5873		
171	0.6670	0.0000			0.5365	0.0000			0.4978	0.0000		
179	------	------			0.5625	0.0000			0.5097	0.0000		
187	------	------			------	------			------	------		
195	0.5742	0.0000			0.8188	0.0000			0.4668	0.0000		
					INDEPENDENT VARIABLE FRACTURE DENSITY							
147	0.2758	0.0062	0.4472	0.0002	0.1397	0.1029	0.1154	0.1805	-0.1539	0.0138	0.0936	0.1363
155	0.6089	0.0000	0.6252	0.0000	0.2923	0.0032	0.2653	0.0073	-0.1736	0.2550	0.1310	0.0405
163	-0.1236	0.3292	0.0757	0.5566	0.2352	0.1321	0.2964	0.0646	-0.2540	0.0009	-0.1285	0.0597
171	0.5974	0.0000	0.6188	0.0000	0.2035	0.0665	0.4390	0.0000	0.0039	0.9109	0.1246	0.0770
179	-0.6044	0.0005	------	------	0.2275	0.0002	0.2085	0.0005	0.0003	0.9449	0.2491	0.0041
187	-0.2056	0.3516	------	------	0.0499	0.6342	------	------	0.1830	0.0002	0.3199	0.0000
195	0.4162	0.0000	0.4360	0.0000	0.4953	0.0000	0.5101	0.0000	0.0595	0.6145	0.4288	0.0002
					INDEPENDENT VARIABLE GRAYNESS							
147	0.0320	0.7600	-0.2043	0.0957	-0.1843	0.0158	-0.0461	0.5594	-0.0601	0.3410	-0.0172	0.7758
155	-0.3834	0.0058	-0.1389	0.3316	0.1316	0.1850	0.3305	0.0009	-0.0090	0.8563	0.0378	0.5515
163	-0.4828	0.0001	0.1662	0.1991	-0.2587	0.0187	-0.1382	0.4064	0.2382	0.0009	0.1729	0.0141
171	-0.1864	0.0055	-0.2094	0.0020	-0.4330	0.0000	-0.2395	0.0026	0.0220	0.7537	0.1430	0.0434
179	0.5028	0.0022	------	------	0.0734	0.2003	-0.0475	0.4166	-0.2984	0.0000	-0.1970	0.0048
187	0.1737	0.4883	------	------	-0.2235	0.0323	------	------	-0.1145	0.0176	0.0277	0.6691
195	0.0592	0.4070	0.0679	0.3388	0.1462	0.0890	0.0313	0.7193	-0.1511	0.2318	0.0891	0.4906

TABLE 4-1 (Cont)

	FOOTWALL				DYKE				HANGING WALL			
	CU GRADE		MO GRADE		CU GRADE		MO GRADE		CU GRADE		MO GRADE	
	CORR	PROB	CORR	PROB	CORR	PROB	CORR	PROB	CORR	PROB	CORR	PROB
INDEPENDENT VARIABLE BLEACHING												
147	0.0331	0.7584	-0.1892	0.1345	-0.1635	0.0490	-0.0005	0.9434	-0.1108	0.0916	-0.0172	0.7758
155	-0.3871	0.0074	-0.1094	0.4670	0.1752	0.0830	0.3649	0.0004	0.0161	0.7940	0.0205	0.7506
163	-0.3306	0.0273	0.2700	0.0723	-0.2164	0.0696	-0.1053	0.5383	0.2741	0.0002	0.2115	0.0040
171	------	------	------	------	------	------	------	------	------	------	------	------
179	------	------	------	------	------	------	------	------	------	------	------	------
187	0.2809	0.2213	------	------	-0.2395	0.0252	------	------	-0.0768	0.1304	0.1342	0.0405
195	-0.0075	0.8822	0.0144	0.8244	0.1749	0.0522	0.0849	0.3568	-0.2295	0.0881	0.1089	0.4324

TABLE 4-2

SUMMARY OF CORRELATION RESULTS

		Footwall		Dyke		Hanging-Wall	
		Cu Grade	M_0S_2Grade	Cu Grade	M_0S_2Grade	Cu Grade	M_0S_2Grade
Alteration Minerals							
1.	Quartz	0	0	+	+	++	++
2.	"Argillic"	0	0	--	-	0(-)	0
3.	Sericite	0	0	--	0	-	0
4.	K-Feldspar	0	0	0	0	0	0
5.	Pyrophyllite	-	-	-	-	-	-
6.	Dumortierite	-	0	-	-	-	0
7.	Carbonate	0	0	0	+	0(-)	0
8.	Zeolite	0	0	0	0	0	0
9.	Chlorite	0	0	0	0	0	0
10.	Epidote	-	-	0	-	-	-
11.	Hematite	0	0	0	0	0	0
12.	Magnetite	++	0	++	0	++	0
Other Parameters							
13.	Cu Grade		++		++		++
14.	MoS_2 Grade	++		++		++	
15.	Fracture Density	0	++	++	++	0	++
16.	Bleaching	0	0	0	0	0	0

+ Positive Correlation

++ Strong Positive Correlation

\- Negative Correlation

-- Strong Negative Correlation

0 Indefinite Correlation

Note: Material logged in the field as "Argillic" was identified as sericite by X-Ray diffraction

The requirements of a useful correlation are strength and consistency. An alteration mineral which shows a strong positive correlation with grade in one section and a strong negative correlation in another section is of little use. Although changes in correlation with rock types are expected, the ideal correlation is the same in the volcanics of both hanging-wall and footwall. This is not considered a vital point, because the geometry of the deposit (Figure 3-7) has permitted much better examination of the hanging-wall ore zone than the footwall zone.

Table 4-2 illustrates that the strongest positive correlations for copper grade in volcanic rocks are with magnetite and high molybdenite grades. Quartz has a strong positive correlation with copper grades in the hanging-wall volcanics but not in the footwall. Minerals least associated with copper (negative correlations) are pyrophyllite, dumortierite and epidote. Sericite has a negative correlation with copper grade in the hanging-wall volcanic rocks, but not in the footwall.

In the quartz-feldspar porphyry, magnetite, quartz, high molybdenite grades, and high fracture densities characterize samples with high copper grades. "Argillic" and sericite have strong negative correlations with copper grades where as pyrophyllite and dumortierite have weak to moderate negative correlations.

Copper and high fracture density have strong positive correlations with molybdenite grades in volcanic rocks. Quartz has strong positive correlation with molybdenite in the hanging-wali volcanics, but not in the footwall. Pyrophyllite and epidote have negative correlations with molybdenite in volcanic rocks as well as in the quartz-feldspar porphyry.

In the quartz-feldspar porphyry, copper and fracture density have a strong positive correlation with molybdenite, and quartz and carbonate have moderate positive correlations. Pyrophyllite, dumortierite, epidote, and argillic alteration have negative correlations with molybdenite.

Importance of Sulphide Mineralization Stages to the Ore Zone

It is possible to examine the importance of the different stages of deposition of chalcopyrite and molybdenite to the ore zone using statistical correlation data. This is approached by examining correlations between grades and intensity of individual alteration minerals associated with different stages of sulphide mineralization. A strong correlation between grade and an alteration mineral associated with a particular stage suggests that the stage is an important contributor to the ore zone.

There are four stages of copper mineralization within the deposit. First-stage chalcopyrite mineralization is represented as tiny veinlets closely associated with biotite and magnetite (Plate II, A and B). The strong positive correlation between copper grades and magnetite supports the field observation that this is the most important phase of copper mineralization. Biotite was not recognized in the core at the time it was logged on the "GEOLOG" format.

Second-stage copper mineralization occurs as chalcopyrite with quartz-molybdenite veins. Because these veins are characterized by argillic envelopes, the importance of this stage of copper to the ore zone can be examined by observing the degree of correlation between "argillic" and sericite alterations to ore grade. Table 4-2 shows that in the hanging-wall ore zone the values range from zero to negative for "argillic", but are negative for sericite. This suggests that copper associated with this stage of mineralization does not constitute a major portion of copper in the ore zone.

Third-stage copper mineralization is associated with molybdenite on slip surfaces. Indefinite correlation between copper grade and fracture density in volcanic rocks as opposed to a strong positive correlation between molybdenite grade and fracture density suggests that this stage of copper is not a major contributor to the ore zone.

Fourth-stage copper mineralization is associated with late carbonate-zeolite veins. In the hanging-wall ore zone there is an indefinite correlation between copper and zeolite and a correlation ranging from positive to negative for carbonate. This suggests that while locally there may be a contribution to the ore zone, by this stage of mineralization, it is of limited importance.

There are three stages of molybdenum mineralization in the ore zone. First, molybdenite occurs with copper in the magnetite-rich zone. The indefinite correlation between magnetite and molybdenite grade suggests a minor contribution to the molybdenum ore.

Second-stage molybdenum is in quartz-molybdenite veins with sericite envelopes. Indefinite correlation between molybdenite grades and intensity of argillic and sericitic alteration suggest that this stage of molybdenum also is a minor contributor to the ore zone.

Third-stage molybdenum occurs on slip surfaces. The strong correlation between molybdenite grade and the fracture density supports the field observation that this is the major contributor of molybdenum to the ore zone.

In summary, field observations that stage-one copper mineralization and stage-three molybdenum mineralization are the stages of sulphide mineralization which made the major contribuitions to the ore zone are supported by the statistical study.

Importance of the Copper-Molybdenum Correlation

Stong correlation between copper and molybdenite grades is another result of the statistical study. As outlined in the previous section, field evidence, supported by much of the statistical evidence, suggests that copper and molybdenum were deposited at distinctly different times. However, correlation between copper and molybdenite grades is one of the strongest correlations obtained in the study.

This appears to be a paradox where two parameters which have a strong mathematical correlation are not, in fact, directly related. In the case of the copper and molybdenite grades, the mutual variable(s) are unknown. It may be a spatial, (e.g. proximity to dyke) instead of a direct temporal relationship. They are genetically related in that they are both part of the same ore-forming system.

This problem with correlation between copper and molybdenite grades illustrates one of the fundamental drawbacks of using correlation analysis. Merely because two sets of data have a strong mathematical correlation does not establish a direct relationship to each other. Statistical correlation, while it is a powerful technique for examining data, should not be used as the sole criteria for determining the relationship between parameters.

Efficiency of "GEOLOG" Logging

For the purpose of this study, the "GEOLOG" format proved much faster than conventional core logging methods. However, during this logging, neither graphic logs nor grade estimates were made. It is estimated that logging with "GEOLOG" format accompanied by a graphic log and grade estimates requires approximately the same amount of time as conventional core logging.

The advantage of the "GEOLOG" format is in the amount and type of data which are recorded and the speed with which they can be treated and recovered. Using this format, one obtains "quantitative, specific, and consistent data" (Blanchet and Godwin, 1972) for each assay interval. It also results in collection of data generally omitted during routine logging.

In terms of data treatment, data recorded on the "GEOLOG" format is amenable to many types of computer treatment as outlined by Blanchet and Godwin (1972). The usual descriptive logs cannot be satisfactorily coded for this type of treatment.

"GEOLOG", even when used without a computer, provides a good way of using and retrieving data. All parameters recorded can be examined in terms of assay intervals. The single column devoted to each parameter lends itself to making a colour-coded, strip log parallel to the lithic or graphic log. This allows visual comparison of different variables and lithology or grade.

CHAPTER 5: HYDROTHERMAL ALTERATION

INTRODUCTION

Discussion of hydrothermal alteration at the Island Copper deposit is divided into five parts:

1. Discussion of alteration stages.
2. Description of alteration types.
3. Discussion of the relations between ore zone and alteration types.
4. Brief review of the relative importance of hypogene and supergene alteration processes in development of alteration.
5. Discussion of the formation of alteration zones.

ALTERATION STAGES

Several problems arise when determining relative ages of alteration minerals:

1. The time-transgressive nature of hydrothermal alteration. Minerals alter in response to their chemical environment, which is not necessarily the same in all parts of a deposit at the same time.
2. The formation of the same minerals at different times in the sequence of hydrothermal alteration. For example, hydrobiotite in the biotite zone could be a metastable phase created by progressive alteration, a phase created by regressive alteration which partialy destroyed biotite, or a mixture of both.
3. Distinquishing alteration envelopes which cut earlier pervasive alteration, from coalescing zoned alteration envelopes. As Hemley and Meyer (1967) observe, the problem is "to avoid mistaking geometric plausibility for geometric fact".
4. The correlation of events in different rock types.

Alteration at the Island Copper deposit is divided into two main stages on the basis of cross cutting relations as well as the mineralogical, texture and chemical nature of the assemblages. Contact metamorphism by the quartz-feldspar-porphyry dyke produced alteration of the biotite, transition and epidote types. These types of alteration are characterized by:

1. Mineral assemblages characteristics of contact metamorphism (Winkler, 1967);
2. Pervasive distribution of the alteration minerals;
3. Little chemical variation between different types of altered rocks or altered and fresh rocks (Figure 5-7).

Superimposed wall-rock alteration resulted in alteration of the chlorite-sericite, sericite, pyrophyllite and "Yellow Dog" types. These types of alteration are characterized by:

1. Mineral assemblages characteristic of wall-rock alteration (Hemley and Meyer, 1967);
2. Spatial distribution controlled by fractures and breccias;
3. Marked chemical variation between different types of altered rocks and between altered and fresh rocks (Figures 5-8, 5-13).

The contact metamorphism and the wall-rock alteration will be referred to as stage one and stage two respectively.

ALTERATION ZONES

Alteration at the Island Copper Mine is divided into seven types on the basis of criteria recognizable in hand specimen. Mineral assemblages characteristic of the types

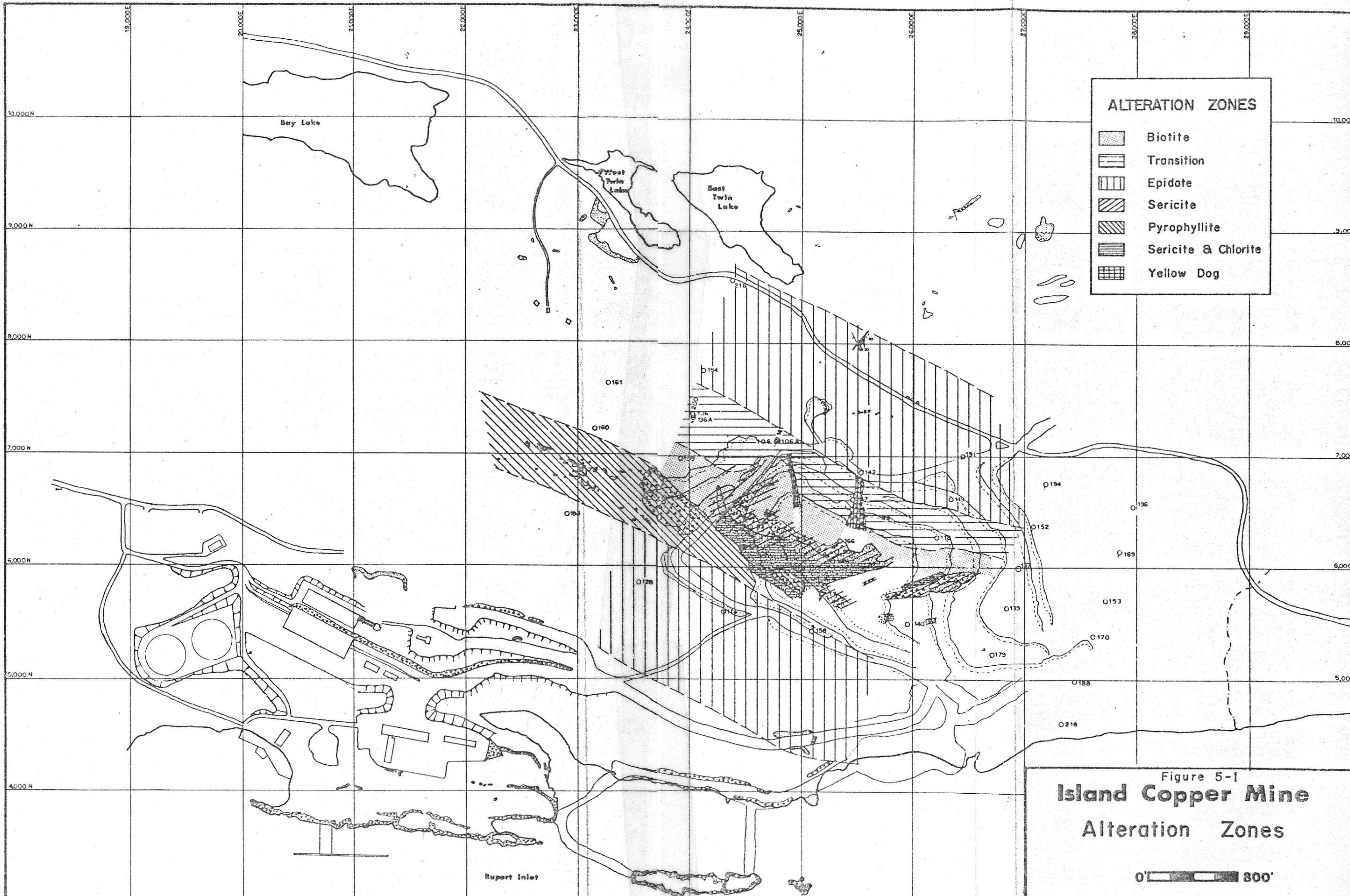


Figure 5-1
Island Copper Mine
Alteration Zones

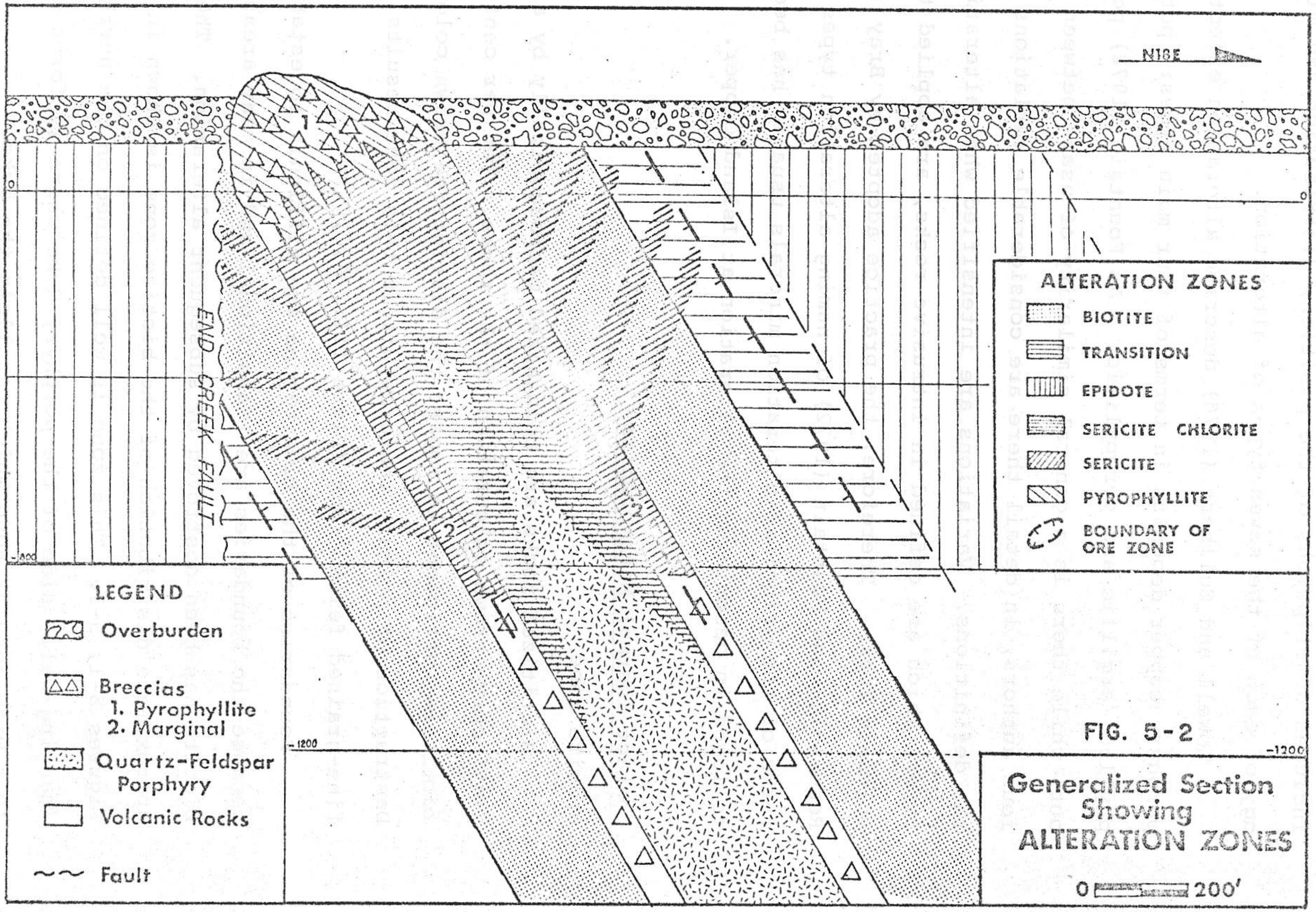


FIG. 5-2

Generalized Section Showing ALTERATION ZONES were established by subsequent laboratory study. This section includes descriptions of the position, distribution and mineralogy of each of the seven types of alteration.

Lowell and Guilbert (1970) describe alteration effects in porphyry copper deposits in terms of four main types: potassic, phyllic, argillic and pyropylitic. As Fountain (1972) points out, while there is a general similarity of usage between various authors, in detail there are considerable variations in the definitions. Variations are intensified when alteration types, which are defined in intrusive rocks, are applied to volcanic rocks. Therefore, the practice adopted by Bray (1969), Rose(1970) and Fountain (1972) of naming alteration types in terms of the principal alteration minerals usually has been followed in describing the alteration at Island Copper.

Contact Thermal Metamorphism

Biotite Zone

Biotitized rocks are recognized macroscopically by a distinctive brown colouration of the rocks. Ten per cent biotiteis sufficient to impart the distinctive brown colour. Destruction of primary textures within this zone results in a fine-grained felted rock (Plate III., A,C,D.).

Boundaries of the biotitezone are difficult to establish because the boundaries are transitional and in many areas biotite has been destroyed by subsequent alteration. The approximate distribution of the biotite zone is shown in Figures 5-1, 5-2. This zone is well defined on the northeast (hanging-wall) side of the porphyry dyke where is forms a 350-foot wide tabular zone which parallels the dyke.

PLATE III

BIOTITE ALTERATION ZONE

A. Polished slab from the biotite alteration zone shows the absence of primary volcanic textures in this zone. The specimen is cut by a quartz vein which is cut in turn by a carbonate vein.

B. Thin section of relatively coarse-grained biotite and magnetite, possibly after an amphibole.

C. Thin section with a biotite veinlet cutting across containing abundant disseminated biotite. The opaque mineral grains are magnetite.

D. Thin section of a patch of biotite and quartz with magnetite and leucoxene.

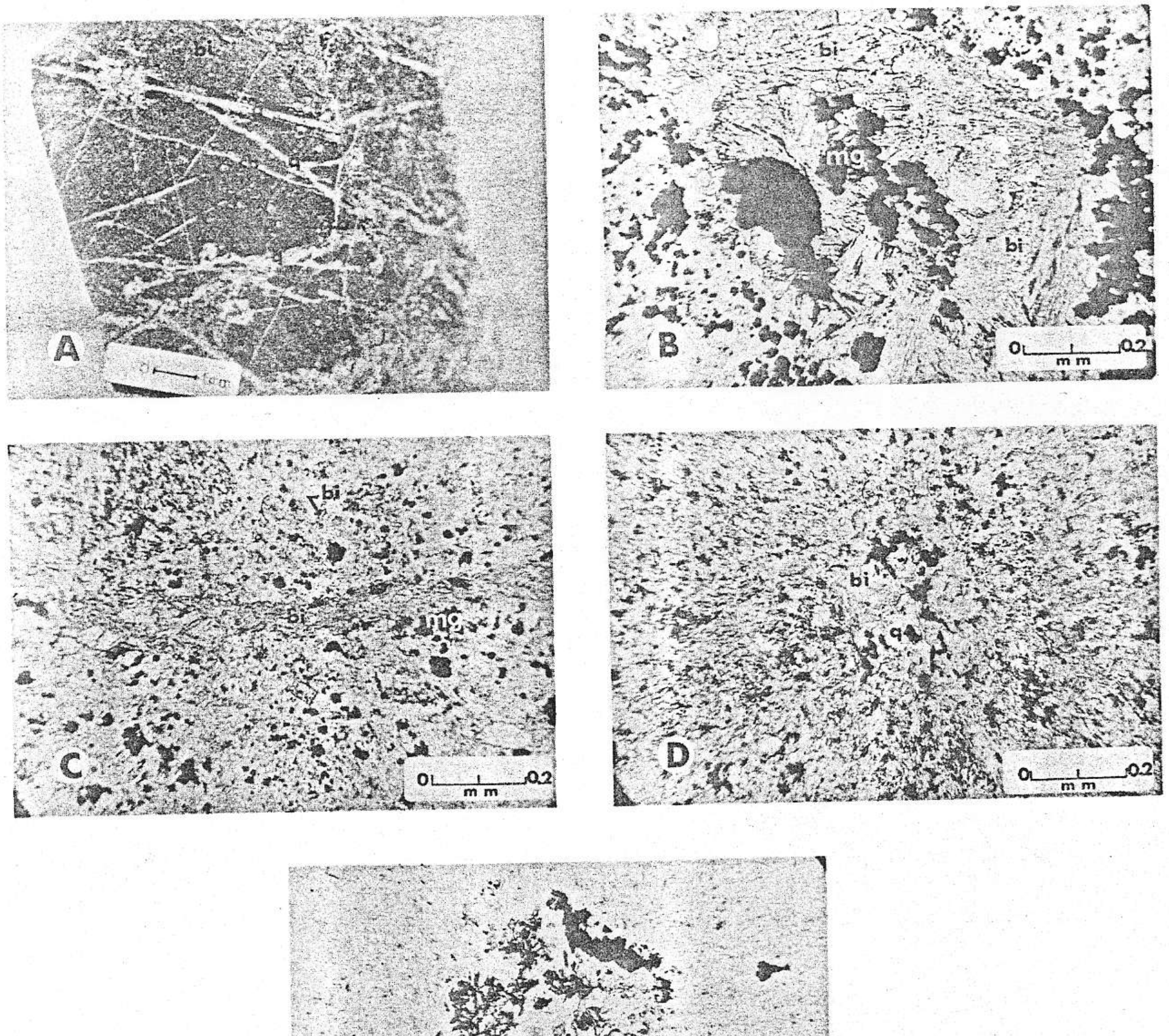
E. Thin section of a patch of chlorite containing some grains of biotite in the centre. Peripheral material is epidote.

F. Thin section showing chlorite and magnetite along a fracture crossing a matrix containing abundant biotite. The chlorite envelope is offset on a carbonate filled fracture.

G. Thin section with chlorite on a fracture crossing a matrix containing abundant biotite.

Abbreviations used on the plate

bi - biotite
cb - carbonate
q - quartz
cl - chlorite
mg - magnetite


A
bi
B
bi
mg
bi
0 mm 0.2
C
bi
bi
mg
0 mm 0.2
D
bi
q
0 mm 0.2
E
bi
cl
0 mm 0.2
F
bi
bi
0 mm
G
bi
cl
bi
0 mm 0.2

On the southeast (footwall) side of the porphyry, the zone is less well defined. Normal movement on the End Creek Fault has displaced the biotite zone in the upper parts of the deposit and it has been removed by erosion (Figures 5-1,5-2). However, the biotite zone reappears at depth where the fault plane diverges from the dyke (Figure 5-2).

Examination of thin sections of biotite zone rocks reveals a vague relict porphyritic or fragmental texture with phenocrysts of plagioclase and mafic minerals in a fine-grained matrix. Table 5-1 lists some mineral assemblages from the zone.

Plagioclase phenocrysts are small ($<$ 4mm) with ragged, corroded margins. It is difficult to determine their compositions, because they are both zoned and altered. Where compositions could be determined, they range between An 5-25. Phenocrysts generally have sericitized or saussuritized centres with relatively unaltered margins. The intensity of alteration is highly variable.

Mafic phenocrysts generally are pseudomorphed by ragged patches of chlorite, biotite, epidote, carbonate and actinolite. Crystal outlines of both amphibole and pyroxene locally have been preserved.

The matrix consists of plagioclase (An 20), biotite, chlorite, and minor muscovite, actinolite, hydrobiotite/ vermiculite, quartz and carbonate.

X-ray diffraction indicates the presence of small amounts of hydrobiotite and vermiculite in the biotite zone. The relationship between these minerals and biotite has not been determined, because they are extremely difficult to distinquish optically from biotite.

Table 5-1

MINERAL ASSEMBLAGES - BIOTITE ALTERATION ZONE
(from thin sections and X-ray Diffractions)

	00-6	00-10	00-13	00-16	00-24	40-2	40-6	40-7	40-30C	80-5	80-37	196-1025	194-866	118-400	191-989	191-1021	191-1072	191-1090	158-430	103-690	103-970	103-565
Plagioclase An<25	X	x	x	x	X	X	x	x	-	-	X	X	-	x	x	x	x	x	x	x	x	x
Sericite	x	x	x	x	x	x	x	x	x	x	X	x	-	x	x	x	x	x	x	X	-	x
Epidote	x	x	x	x	x	-	-	-	-	-	x	-	x	x	-	-	x	-	x	-	-	x
Calcite	x	-	-	x	x	-	-	x	-	-	-	x	-	x	-	x	x	-	-	-	-	x
Quartz	x	-	-	x	x	x	x	x	X	X	x	x	X	x	x	x	x	x	x	X	x	X
Biotite	X	X	X	x	-	X	x	X	x	X	-	x	X	X	x	x	X	X	X	X	X	X
Green Biotite	-	x	-	x	-	x	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-
Chlorite	-	X	X	X	x	X	x	x	X	x	X	x	x	X	X	X	x	x	-	X	X	x
Apatite	x	-	-	-	-	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Hydrobiotite	-	-	-	-	x	-	-	x	-	-	x	x	x	-	-	-	-	-	-	-	-	-
Actinolite	-	-	x	-	-	-	-	-	-	-	-	-	-	-	x	-	X	x	-	-	-	-
Magnetite	x	x	x	X	x	-	X	-	-	-	x	-	-	x	-	x	x	x	x	x	x	x

X Abundant
x Present
- Absent

Opaque minerals associated with this zone are magnetite and minor amounts of hematite and leucoxene. Magnetite occurs as fine-grained disseminations, with altered mafic phenocrysts and as narrow-fracture fillings (Plate II., A,B,C,E). Hematite is present near fractures and leucoxene is associated with chlorite pseudomorphs of mafic minerals.

Transition Zone

The transition zone is characterized macroscopically by the presence of chlorite, and the obliteration of primary textures. This zone is transitional between an inner biotite zone, which is adjacent to the porphyry dyke, and an outer epidote zone. Boundaries are gradational and difficult to define.

The zone is well exposed on the northeast (hanging-wall) side of the porphyry dyke. It is approximately six hundred feet wide and parallels the biotite zone (Figures 5-1, 5-2). On the southwest (footwall) side of the dyke, the transition zone is not well defined. Normal movement on the End Creek Fault has displaced the zone, but it reappears at depth where the fault plane diverges from the dyke (Figure 5-2).

Thin sections of rocks from the transition zone reveal vague porphyritic and fragmental textures. There are plagioclase phenocrysts and mafic phenocrysts and fragments, replaced by chlorite, in a fine-grained matrix. Mineral assemblages observed in the zone are outlined in Table 5-2.

Plagioclase phenocrysts generally resemble those of the biotite zone. Mafic phenocrysts are replaced by chlorite, epidote, actinolite, minor carbonate and sericite. The matrix

Table 5-2

MINERAL ASSEMBLAGES IN THE TRANSITION ZONE
(From thin sections and X-ray Diffractions)

	163-193	203-782	203-237	201-856	203-903	204-245	201-773	201-775	00-15	00-17	00-21	40-20	40-30C	40-36
Plagioclase (An 20)	X	X	X	X	X	X	X	X	X	x	-	x	-	x
Muscovite	x	x	X	x	x	x	x	x	x	x	x	x	X	x
Epidote	-	-	x	x	-	-	x	x	x	x	-	-	-	x
Carbonate	x	-	x	x	-	-	-	-	x	-	-	x	-	x
Quartz	x	-	x	-	x	X	X	-	X	X	X	x	X	x
Chlorite	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Laumontite	-	x	-	-	-	-	-	-	-	-	-	-	-	-
Actinolite	-	x	-	x	-	-	x	X	-	X	-	-	-	-
Leucoxene	-	-	-	-	-	-	-	-	-	-	-	x	x	-
Magnetite	X	-	-	-	x	-	X	x	x	-	-	x	x	x

X Abundant
x Present
- Absent

consists of plagioclase(An 20), which is weakly to moderately altered to sericite, and chlorite, actinolite and minor amounts of quartz.

X-ray diffraction shows that the sericite noted in the thin sections is muscovite with minor amounts of hydromica (hydromuscovite?).

Opaque minerals within this zone are magnetite and leucoxene. Magnetite is restricted to the inner part of the zone which is within two hundred feet of the biotite zone. It occurs disseminated through the matrix of the rocks and with chlorite pseudomorphs of mafic minerals. Leucoxene occurs only with chlorite pseudomorphs of mafic minerals.

Epidote Zone

This zone is recognized macroscopically by abundant pistachio-green epidote. Primary textures of the volcanic rocks are easily recognized within the zone (Plate IV., A,B,C).

Epidote has a relatively uniform distribution throughout the zone and shows no obvious relation to fractures or veins (Plate IV., B, C). The zone is well exposed on the northeast (hanging-wall) side of the dyke. The inner boundary, which is gradational with the transition zone, is approximately eight hundred feet from and parallel to the quartz-feldspar porphyry dyke-volcanic contact (Figures 5-1, 5-2). The position of the outer boundary is not well defined because of lack of exposure, however, the inferred width of the zone is 1,200 feet.

On the southwest (footwall) side of the quartz-feldspar porphyry dyke, the epidote zone is well defined. The inner boundary is the End Creek Fault (Figures 5-1, 5-2). The

Table 5-3

MINERAL ASSEMBLAGES IN THE EPIDOTE ZONE
(From thin sections and X-ray Diffractions)

	Thin Sections						X-ray Diffractions (Matrix Material)				
	11A	11B	201-989	183-185	173-335	183-519	GC-20	GC-21	GC-22	GC-23	GC-27
Plagioclase (An<20)	X	X	X	X	X	X	x	x	x	-	-
Saponite	-	-	-	-	-	-	x	x	x	?	?
Sericite	x	x	x	x	x	x	x	-	x	x	?
Epidote	X	X	-	X	X	X	-	-	-	-	-
Carbonate	-	-	-	x	x	x	-	-	-	x	-
Quartz	-	-	-	x	x	-	-	-	x	-	-
Chlorite	x	X	X	x	x	X	X	X	X	x	X
Laumontite	-	-	-	x	-	x	X	X	x	X	X
Actinolite	-	-	-	-	x	-	-	-	-	-	-

X Abundant
x Present
? Questionable Identification
- Absent

PLATE IV

EPIDOTE ZONE

A. Outcrop north of the pit showing finely bedded tuff with epidote developed along the bedding planes. The scale on the photo is one inch.

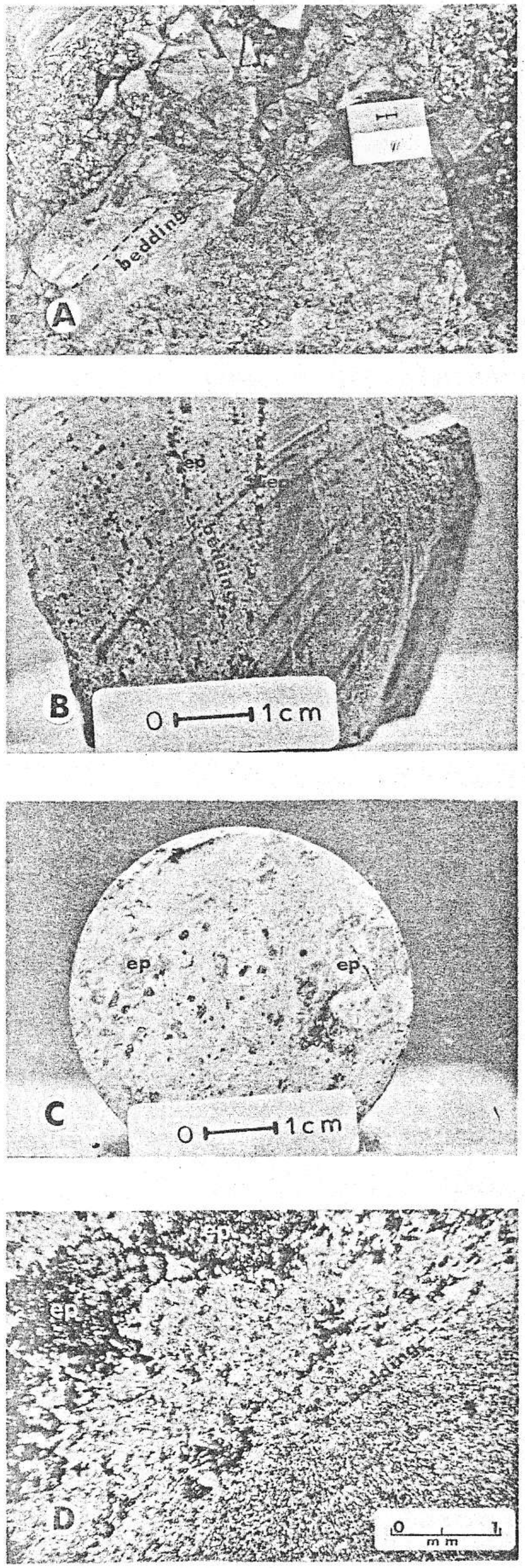
B. Hand specimen from the outcrop shown in "A", showing the development of epidote along the bedding planes.

C. Drill core showing patches of epidote in a lapilli tuff.

D. Thin section showing epidote developed in a tuff.

Abbreviations used on the plate

ep - epidote


bedding
A
ep
ep
bedding
B
0 1cm
ep
ep
C
0 1cm
ep
ep
bedding
D
0 1
mm

outer boundary is parallel to the fault and approximately 1,200 feet to the south.

Thin sections of rocks from the zone show that they are tuffs and lithic lapilli tuffs (Plate IV., D) with patches, veinlets, and disseminated grains of epidote (Plate IV., A,B, C,D). Mineral assemblages observed in the zone are listed in Table 5-3.

Plagioclase phenocrysts usually are moderately saussertized. Composition of the plagioclase, where possible to measure, is sodic (An 5-20). Zoned plagioclase grains commonly have saussuritized centres and albitic rims. Mafic phenocrysts are altered totally to chlorite and epidote with minor amounts of carbonate, actinolite and leucoxene.

The matrix of the rocks consists of plagioclase (An 20), sericite, and very fine-grained material, probably devitrified glass. X-ray diffraction studies of the matrix indicate:

(1) The sericite noted in thin section is muscovite, and

(2) The presence of a smectite group clay mineral, possibly saponite. The saponite may be part of the very fine-grained material, but could not be distinguished optically.

Pyrite is the only opaque mineral noted in this zone. Small ($<$2mm) subhedral cubes of pyrite are disseminated through the matrix.

<u>Wall-rock Alteration</u>

Sericite and Chlorite Zone

The sericite and chlorite zone is recognized by chlorite pseudomorphs of mafic minerals and sericite pseudomorphs of plagioclase phenocrysts. Although it occurs both in the

TABLE 5-4

MINERAL ASSEMBLAGES IN THE CHLORITE-SERICITE ZONE
(From thin sections and X-ray Diffractions)

	Quartz-feldspar porphyry										Volcanic Rocks	
	40-38	80-12	80-13	80-42	120-1B	139-850	125-542	103-661	103-781	103-784	120-10A	40-5B
Plagioclase (An 10)	-	-	-	-	-	-	x	-	x	-	-	x
Kaolin Group Clay	-	-	-	x	-	x	-	X	x	x	-	-
Sericite (Muscovite)	x	X	X	X	X	X	x	x	x	x	X	x
Epidote	-	-	-	x	-	-	-	-	-	-	-	-
Carbonate	x	x	-	-	-	x	x	x	x	-	-	-
Chlorite	X	X	X	X	X	X	X	X	X	X	X	x
Quartz	X	X	X	X	X	X	X	X	X	X	X	X
Leucoxene	x	x	x	-	-	x	x	-	-	x	-	-
Magnetite	-	x	-	-	-	x	x	x	-	-	-	x
Pyrite	-	x	x	x	x	-	x	-	x	x	x	x
Chalcopyrite	-	-	-	-	-	-	-	-	-	x	-	-
Molybdenite	-	-	-	-	-	-	-	-	-	-	x	-
Quartz Veins	-	-	-	-	-	X	-	-	-	-	x	X
Carbonate Veins	x	-	-	-	-	x	x	-	-	-	x	x

X Abundant
x Present
- Absent

quartz-feldspar porphyry dyke and volcanic rocks, it is more extensive in the dyke. In the volcanic rocks, it is restricted to the outer part of alteration envelopes on set 4 quartz-molybdenite veins (Table 3-2, Figures 5-3, 5-4).

A.) Quartz-Feldspar Porphyry

Chlorite-sericite alteration within the porphyry dyke is easily recognized macroscopically by the dark green pseudomorphs of mafic minerals and the pale green pseudomorphs of plagioclase (Plate V. A). This pervasive chlorite-sericite alteration shows no clear relation to fractures of veins in the porphyry exposed in the pit. However, it tentatively is regarded as large outer envelopes on the narrower sericite envelopes. The "pervasive" alteration in the porphyry exposed in the pit is believed due to coalescence of these envelopes.

Examination of thin sections confirmed that the plagioclase phenocrysts are moderately to intensely altered. Alteration products as determined by X-ray diffraction, are muscovite, with minor amounts of hydromica (hydromuscovite), calcite and a kaolin group clay mineral. Mafic phenocrysts are altered to chlorite with minor amounts of epidote, carbonate and opaques (Plate V., B,C,D).

The matrix is a fine-grained mixture of quartz, sericite (muscovite) and minor amounts of chlorite, epidote, sodic plagioclase and opaque mineral. K-Feldspar in the matrix which forms up to 15 per cent of the rock in unaltered porphyry is destroyed in this zone.

Opaque and semi-opaque minerals within the chlorite-sericite zone are magnetite, and leucoxene. Magnetite and

PLATE V

CHLORITE-SERICITE ALTERATION ZONE

A. Polished slab of quartz-feldspar porphyry showing the texture of the rock. The quartz "eyes", sericitized plagioclase and chloritized mafic phenocrysts are evident.

B. Thin section showing chloritized mafic minerals, probably amphiboles, with magnetite and leucoxene.

C. Thin section showing a chloritized mafic phenocryst with pyrite and leucoxene. The subhedral opaques are pyrite and and the lath-shaped opaques leucoxene.

D. Thin section shows a mass of chlorite altering to white mica. The two large opaque grains are pyrite and the smaller ones are leucoxene.

E. Thin section showing a mass of white mica with laths of leucoxene. This is apparently a mafic phenocryst which has altered to chlorite and then to white mica leaving the leucoxene unaffected.

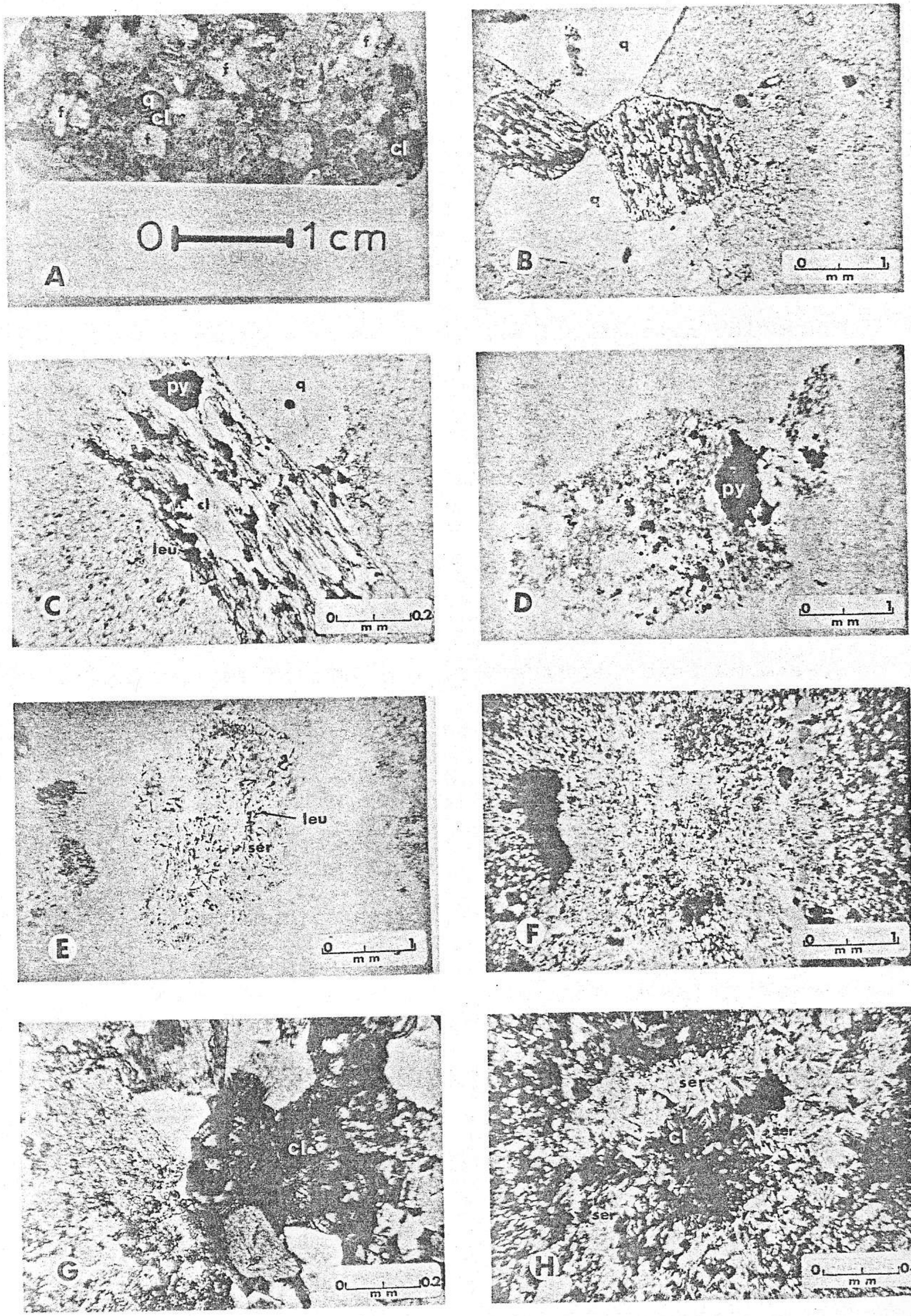
F. The same thin section as "E" with the nicols crossed.

G. Thin section showing rosettes of chlorite.

H. Thin section showing a mass of chlorite surrounded by white mica.

Abbreviations used on the plate

q - quartz
f - plagioclase feldspar
leu - leucoxene
ser - sericite (white mica)
cl - chlorite
py - pyrite


f
f
q
cl
f
cl
0 1cm
A
q
q
B
0 1
mm
py
q
cl
leu
C
0 0.2
mm
py
D
0 1
mm
leu
ser
E
0 1
mm
F
0 1
mm
cl
G
0 0.2
mm
ser
cl
ser
ser
H
0 0.2
mm

leuocoxene are associated with chlorite pseudomorphs of mafic phenocrysts (Plate V., B,C,D).

B.) Volcanic Rocks

Within volcanic rock, chlorite-sericite alteration is restricted to the outer part of sericite envelopes around quartz veins (Plate VI., D: Figure 5-4). This alteration is distinguished macroscopically by its light green colour which contrasts with the chalky white colour of the sericite envelopes.

Thin section study indicates that there are patches of chlorite replacing mafic phenocrysts, as well as rosettes of secondary chlorite (Plate V.,G). The chlorite patches occasionally are rimmed by sericite (Plate V., H).

Plagioclase grains have been intensely altered to muscovite, hydromica (hydromuscovite), and a kaolin group clay mineral.

The matrix consists of quartz, sericite (muscovite), a kaolin group clay mineral, chlorite, magnetite and leucoxene. Magnetite and leucoxene usually are associated with chlorite pseudomorphs of mafic minerals.

Sericite Zone

The sericite zone occurs both in quartz-feldspar porphyry and volcanic rocks where it is recognized macroscopically by the chalky white colour of the rocks caused by the total alteration of chlorite to sericite.

Table 5-5

MINERAL ASSEMBLAGES IN THE SERICITE ZONE
(From thin sections and X-ray Diffractions)

	Volcanic Rocks									Quartz-feldspar porphyry					
	40-30A	80-9A	80-9B	120-9A	120-9B	120-10B	40-4	40-5	160-1B	80-13	120-1A	80-42	103-970	173-925	40-3B
Sericite (Muscovite)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Kaolin Group Clay	-	-	-	-	-	x	-	x	-	x	x	x	x	x	-
Pyrophyllite	-	-	x	-	x	-	-	-	-	-	-	?	-	-	-
Quartz	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Pyrite	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Chalcopyrite	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Molybdenite	-	x	x	-	x	-	-	-	-	x	-	-	-	-	-
Quartz Veins	X	x	x	x	X	X	X	X	X	-	-	-	-	-	x
Carbonate Vein	-	-	x	x	-	-	-	-	-	-	-	-	-	x	-

X Abundant
x Present
? Doubtful Identification
- Absent

Figure 5-3

SCHEMATIC DIAGRAM OF SERICITE ENVELOPES IN THE QUARTZ-FELDSPAR PORPHYRY

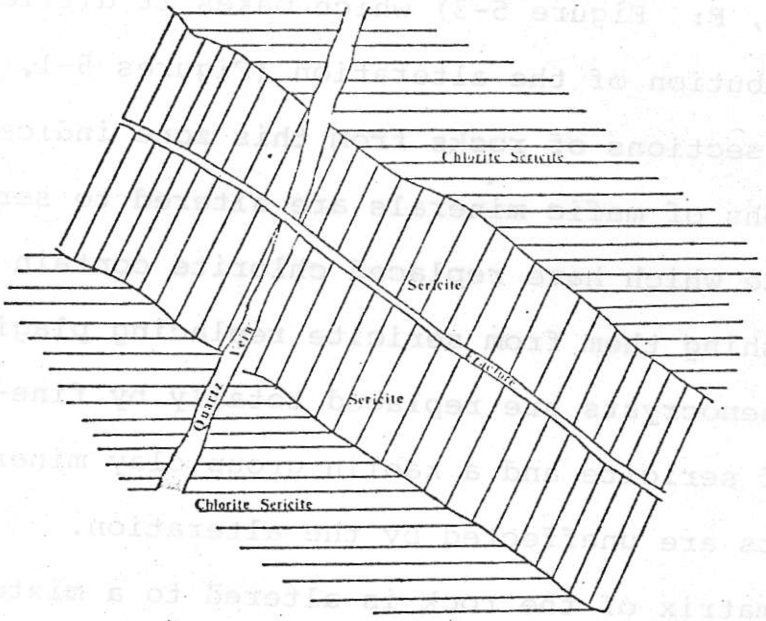
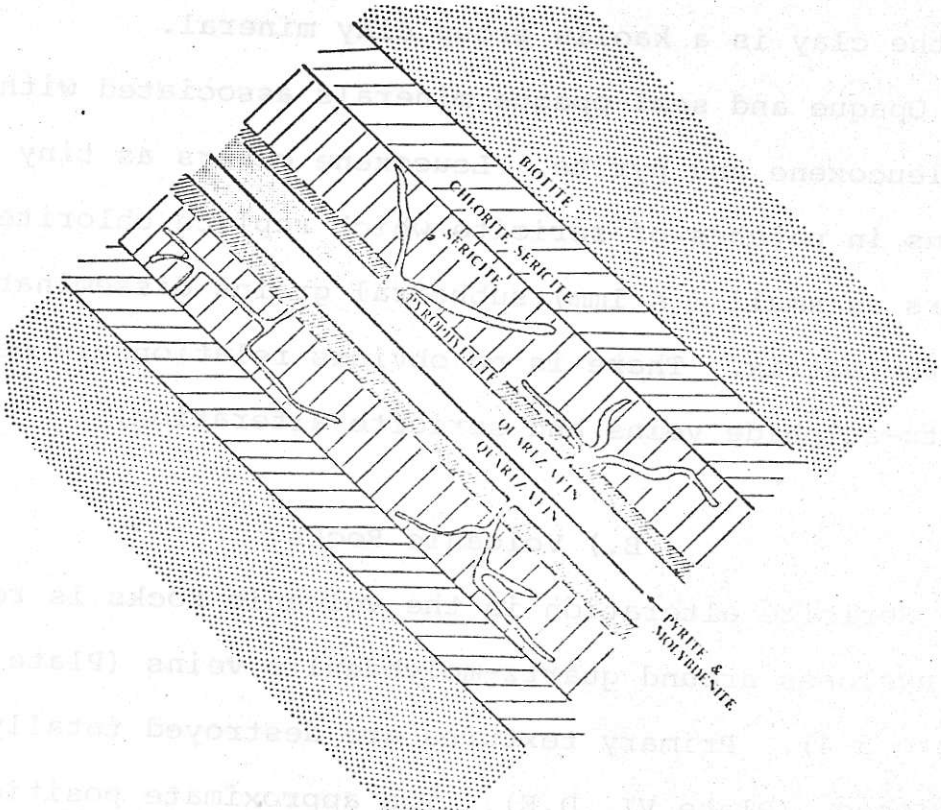


Figure 5-4

SCHEMATIC DIAGRAM OF A SERICITE ENVELOPE IN VOLCANIC ROCKS



A.) Quartz-Feldspar Porphyry

Sericite alteration occurs as envelopes on fractures (Plate VI., F: Figure 5-3) which makes it difficult to define the distribution of the alteration (Figures 5-1, 5-2).

Thin sections of rocks from this zone indicate that chlorite pseudomorphs of mafic minerals are altered to sericite. Patches of sericite which have replaced chlorite contain leucoxene distinguishing them from sericite replacing plagioclase. Plagioclase phenocrysts are replaced totally by fine-grained intergrowths of sericite and a kaolin group clay mineral. Quartz phenocrysts are unaffected by the alteration.

The matrix of the rock is altered to a mixture of white mica, quartz, minor clay and opaques. Quartz grains within the matrix are separated completely from each other by the white mica and clay.

X-ray diffraction indicates that the sericite is muscovite and the clay is a kaolin group clay mineral.

Opaque and semi-opaque minerals associated with this zone are leucoxene and pyrite. Leucoxene occurs as tiny ($<$ 0.1mm) grains in patches of sericite which replace chlorite. Pyrite occurs as small ($<$ 1mm) subhedral grains disseminated throughout the matrix. There is no obvious relationship between quartz-sulphide veins and sericite alteration.

B.) Volcanic Rocks

Sericite alteration in the volcanic rocks is restricted to envelopes around quartz-molybdenite veins (Plate VI.,A,B,C,: Figure 5-4). Primary textures are destroyed totally within the envelopes (Plate VI.,D,E). The approximate position of the

PLATE VI

SERICITE ZONE

A. Sericite envelopes on quartz veins cutting biotitized volcanic rocks. The scale of the photo from the bottom to the sky-line is approximately forty feet.

B. A closer view of a sericite envelope (white band behind the hammer handle) cutting biotitized volcanics.

C. A smaller sericite envelope associated with a quartz vein containing molybdenite. The rock is a lapilli tuff with chloritized fragments in a silicified matrix.

D. A polished slab of a typical sericite envelope in volcanic rocks.

E. A polished slab from the inner part of a sericite envelope in volcanic rocks.

F. Sericite envelope in the quartz-feldspar porphyry. The envelope is locallized along a fracture.

G. A polished slab of a transition from chlorite-sericite zone to sericite zone in the porphyry. Scale is on the chlorite-sericite zone.

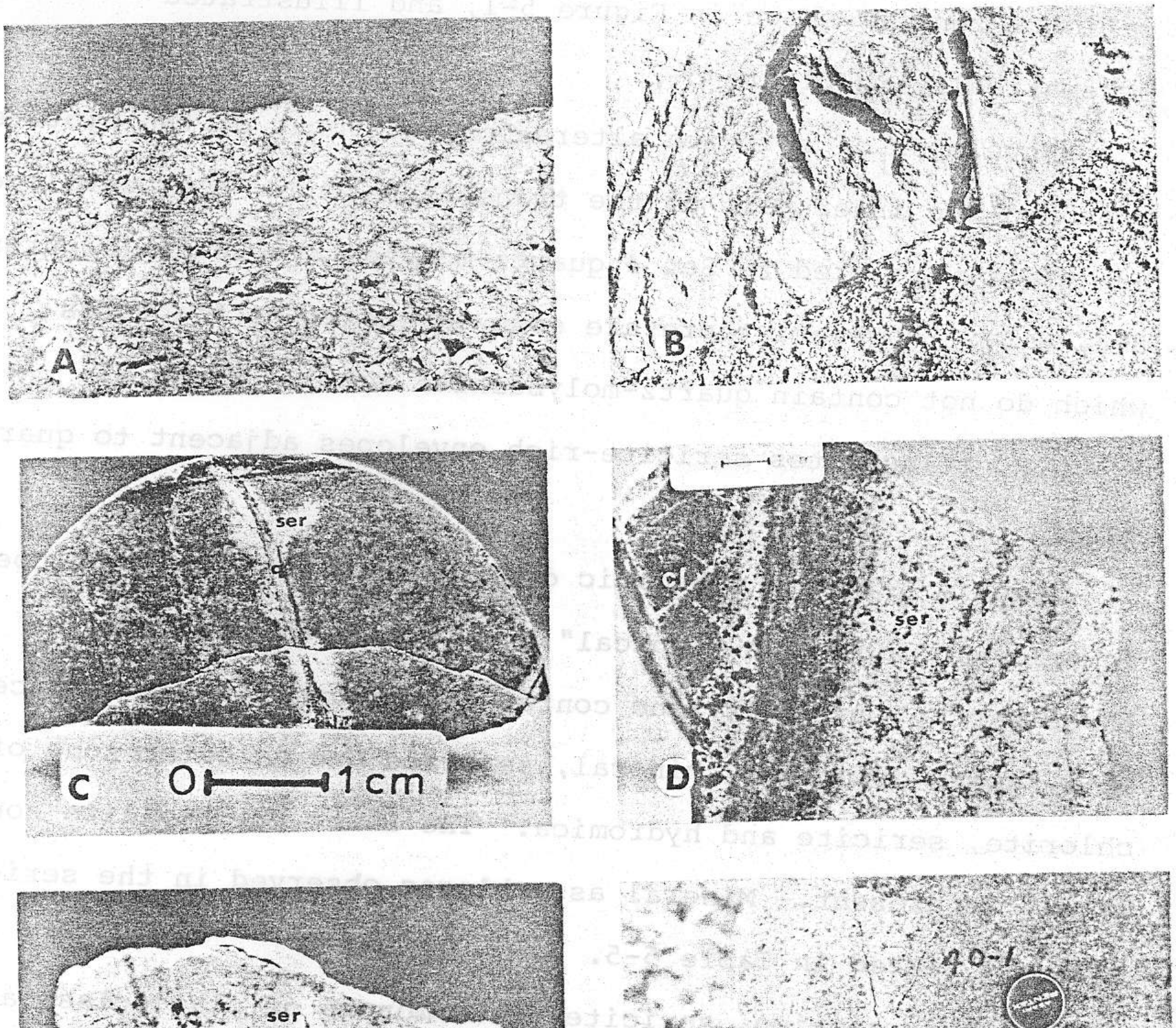
H. A polished slab of sericitized quartz-feldspar porphyry.

Abbreviations used on the plate

q - quartz

ser - sericite

cl - chlorite


A
B
ser
q
C
0 1cm
cl
ser
D
ser
q
q
0 1cm
E
40-1
F
q
f
f
q
f
0 1cm
G
q
f
f
q
H
0 1cm

sericite zone is shown in Figure 5-1, and illustrated schematically in Figure 5-2.

Envelopes of sericite alteration cut rocks of the biotite zone and the inner part of the transition zone. Most envelopes are clearly related to Set 4 quartz-molybdenite veins (Figures 3-5, 3-6). However, there are some envelopes on fractures which do not contain quartz-molybdenite veins. Plate VI, A, B,C,D,E, illustrates sericite-rich envelopes adjacent to quartz veins.

Figure 5-4 is a schematic diagram of a sericite envelope in volcanic rocks. A "typical" envelope is divided into three parts: an inner zone containing pyrophyllite and traces of a kaolin group clay mineral, sericite and an outer zone of chlorite, sericite and hydromica. The inner pyrophyllite zone rarely is present. Mineral assemblages observed in the sericite zone are listed in Table 5-5.

In thin section, sericite pseudomorphs of plagioclase and mafic phenocrysts can be distinguished from the matrix only because they contain slightly coarser-grained sericite. Pseudomorphs of mafic minerals in places can be identified by the presence of leucoxene, a mineral not formed with pseudomorphs after plagioclase.

Most of the "white mica" noted in thin sections is sericite. However pyrophyllite, a kaolin group clay mineral and hydromica (hydromuscovite) were identified by X-ray diffraction.

Pyrophyllite Zone

Most phyrophyllite alteration occurs in a breccia which caps the quartz-feldspar porphyry dyke on the northwest end

Table 5-6

MINERAL ASSEMBLAGES IN THE PYROPHYLLITE ZONE

	Thin Sections						X-ray Diffractions														
							Fragments						Matrix								
	121-206	240-1A	40-10A	C 71 B	P-1	160-210	C 71 A	160-123	160-282	C-71 E	C-71 C	C-71 D	C-71 D1	C-71 A1	160-210A	178-70	123-35	C-71 B1	C-71 C1	C-71 E1	160-135A
White Mica	X	X	X	X	X	X															
Pyrophyllite							X	X	X	X	X	X	X	X	-	X	X	X	X	X	X
Muscovite							-	X	x	-	-	-	-	-	X	-	-	-	-	-	-
Kaolin Group Clay							-	X	x	-	-	-	-	-	X	-	-	-	-	-	-
Dumortierite	x	x	-	x	X	x	-	-	-	-	-	-	X	X	x	X	-	-	x	X	-
Quartz	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Leucoxene	-	-	x	x	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pyrite	x	x	x	x	x	x	X	-	-	-	-	-	-	-	X	-	-	-	-	-	-
Quartz Veins	x	-	x	x	-	-															
Carbonate Veins	x	-	-	-	-	-															

X Abundant
x Present
- Absent

of the deposit (Figures 5-1, 5-2).

The pyrophyllite zone is characterized by pyrophyllite and dumortierite. Pyrophyllite is identified macroscopically by its extreme softness and soapy feel. Dumortierite is recognized by its diagnostic blue to mauve colour.

The breccia is a tabular body capping the dyke. It is approximately 350 feet wide and has been traced 3,600 feet along strike. It is wedge shaped, thickening as the quartz-feldspar porphyry dyke plunges to the northwest.

Within the breccia, volcanic fragments, porphyry fragments and matrix have been pyrophyllitized. Primary textures of volcanic fragments are completely destroyed (Plate VII.,B), but the texture of the quartz-feldspar porphyry fragments is unchanged.

Thin sections of volcanic fragments show that they consist of tiny quartz grains isolated in very fine-grained ($<2\mu$) white micas and clays. It is difficult to distinguish volcanic fragments from matrix in thin section.

Thin sections of quartz-feldspar porphyry fragments show that plagioclase and mafic phenocrysts are totally altered to white micas and clay. White mica pseudomorphs of mafic minerals can still be recognized by the presence of leucoxene (Plate V.,E, F). Quartz phenocrysts appear unaffected by the alteration. Matrix of porphyry fragments consists of quartz grains surrounded by white micas and clay (Plate VII.,H).

X-ray diffraction of material from volcanic and porphyry fragments and breccia matrix (Table 5-6) indicates that most of the white mica is pyrophyllite, rarely accompanied by muscovite, and a kaolin group clay mineral.

Dumortierite occurs as rosettes in the matrix (Plate VII., D) and as veinlets (Plate VII.,E,F,G,) that locally have colloform

PLATE VII

PYROPHYLLITE ALTERATION ZONE

A. Outcrop of pyrophyllite breccia. The quartz-feldspar porphyry fragments are apparent; the volcanic fragments are difficult to see.

B. The same outcrop of pyrophyllite breccia from a slightly greater distance to show the texture of the breccia.

C. A hand specimen of a quartz vein within the pyrophyllite breccia. The vein appears to cut the breccia, but thin section examination shows pyrophyllite growing into the vein.

D. Dumortierite rosettes in a pyrophyllite matrix.

E. Dumortierite veining matrix of pyrophyllite breccia.

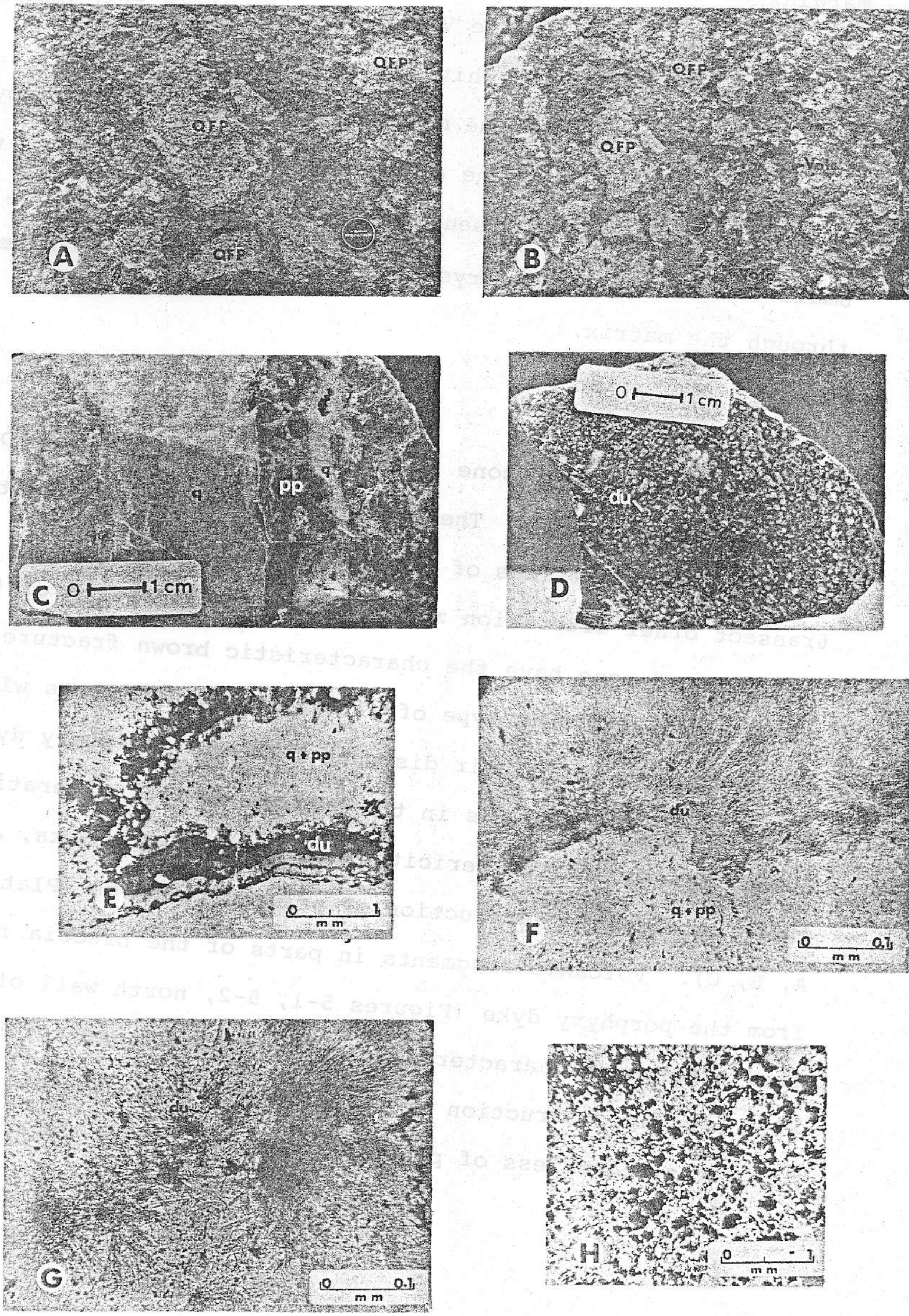
F. A closer view of the dumortierite vein shown in "E". The upper part of the photograph consists of needles of dumortierite. The lower part is quartz and pyrophyllite.

G. A mass of dumortierite needles in a quartz and pyrophyllite matrix.

H. Typical matrix in the pyrophyllite breccia. Quartz grains are surrounded and separated by white mica, mostly pyrophyllite.

Abbreviations used on the plate

pp - pyrophyllite
du - dumortierite
q - quartz
QFP - quartz-feldspar porphyry
Volc - Volcanic


QFP
QFP
QFP
A
QFP
QFP
Vol
B
pp
q
q
C
0 1 cm
0 1 cm
du
D
q + pp
du
E
0 1
mm
du
q + pp
F
0 0.1
mm
du
G
0 0.1
mm
H
0 1
mm

texture (Plate VII E). Tiny needles of dumortierite along the margins of these veinlets extend into grains of quartz and into flakes of white mica (Plate VII.,F,G) suggesting that dumortierite postdates quartz and white mica.

Opaque and semi-opaque minerals associated with the pyrophyllite zone are leucoxene and pyrite. Leucoxene occurs within masses of white mica pseudomorphs of mafic phenocrysts. Small ($<$ 2mm) subhedral crystals of pyrite are disseminated through the matrix.

"Yellow Dog" Zone

The "Yellow Dog" zone is restricted to the "Yellow Dog" breccias (Figure 5-1). The zone is characterized by rusty-brown fracture fillings of ferroan dolomite (Table 5-7), which transect other alteration zones. Although all parts of the "Yellow Dog" zone have the characteristic brown fracture-filling material, the type of alteration of fragments within the breccia varies with their distance from the porphyry dyke. Near the dyke, fragments in the breccia exhibit alteration characteristic of the sericite zone in volcanic rocks, and there is complete destruction of primary textures (Plate VIII., A, B, C). Volcanic fragments in parts of the breccia farthest from the porphyry dyke (Figures 5-1, 5-2, north wall of pit) show alteration characteristic of the chlorite-sericite zone with partial destruction of primary textures. Breccia matrix is quartz regardless of position relative to the dyke.

TABLE 5-7

MINERAL ASSEMBLAGES IN THE "YELLOW DOG" ZONE
(From X-ray Diffractions)

	80-1A	YD-1	YD-2	YD-3	YD-4	YD-5	YD-6	YD-7	YD-8	Clay Size Fraction Separate 1A	Clay Size Fraction Separate 1B
Quartz	X	X	X	X	X	X	X	X	X	X	X
Plagioclase (An 10)	-	-	-	-	-	-	-	-	-	x	x
Sericite (Muscovite)	X	-	X	X	X	X	X	-	X	X	X
Kaolin Group Clay	X	X	X	X	X	-	-	X	X	x	X
Pyrophyllite	-	-	-	-	-	-	-	-	-	-	-
Chlorite	-	?	?	-	-	?	-	-	-	-	-
Calcite	-	-	-	-	-	-	-	-	-	-	-
Ferroan Dolomite	X	X	X	X	X	X	-	X	X	-	-
Pyrite	X	?	X	-	X	-	-	X	-	-	-

X Abundant
x Present
? Doubtful Identification
- Absent

PLATE VIII

"YELLOW DOG" ZONE

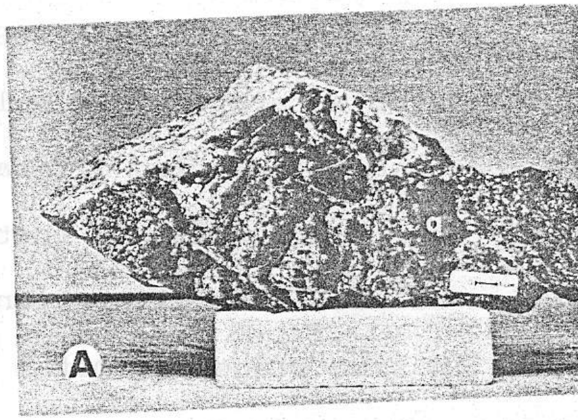
A. A polished slab of breccia showing the extent and intricacy of quartz veining within the breccia.

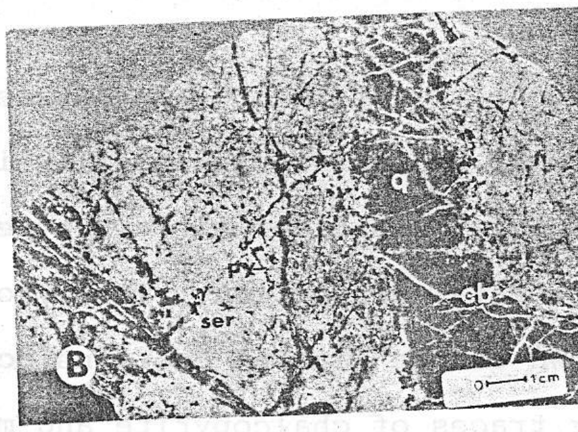
B. A polished slab showing quartz veins, dark gray, cutting sericite alteration which contains extensive fracture-filling pyrite. The quartz veins are cut by later carbonate veins.

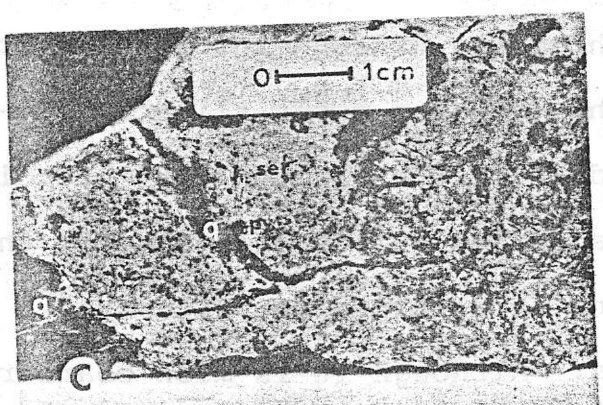
C. A polished slab showing quartz veining cutting a sericitized volcanic fragment.

Abbreviations used on the plate

q - quartz
cb - carbonate
ser - sericite
py - pyrite


q
A


q
py
ser
cb
0 1cm
B


0 1cm
ser
q
py
C

RELATIONS BETWEEN ALTERATION TYPE AND SUPHIDE DEPOSITION

Two stages of alteration and multiple stages of metal deposition complicate relating alteration type to sulphide deposition. The relationship is further complicated by the superposition of wall-rock alteration on contact metamorphism. This results in some stages of metal deposition being spatially, but not temporally related to a certain type of alteration. This section is divided into discussions of spatial and temporal relations between alteration types and stages of sulphide deposition.

The spatial relationship between the ore zone and the alteration zones is shown schematically in Figure 5-2. Figure 5-5 shows spatial relations between types of alteration and each stage of metal deposition. The pyrophyllite breccia which is not shown on the diagram contains no ore grade material. However traces of chalcopyrite and molybdenite occur in quartz veins tentatively believed set 3 and set 4 veins (Table 3-1).

The "Yellow Dog" breccia cuts all zones of contact metamorphism and extends into the unaltered rocks. The boundary of the ore zone moves slightly (20-30 feet) further away from the dyke in the "Yellow Dog" breccia relative to the adjacent volcanic rocks. Chalcopyrite in the breccia occurs as coarse grains in veinlets and with traces of molybdenite in quartz veins. Although it is much coarser grained than in adjacent volcanic rocks it is tentatively correlated with them.

Temporal relationships between metal deposition and alteration type are outlined in Table 5-8. The problem with the "Yellow Dog" alteration type is shown by the table. While the bulk of the alteration within the breccia is sericite,

Figure 5-5

SPATIAL RELATIONS BETWEEN ALTERATION TYPE AND SULPHIDE DEPOSITION

	INTRUSIVE ROCKS		VOLCANIC ROCKS			
	QUARTZ-FELDSPAR	MARGINAL BRECCIA	CONTACT METAMORPHISM: BIOTITE ZONE	CONTACT METAMORPHISM: TRANSITION ZONE	CONTACT METAMORPHISM: EPIDOTE ZONE	UNALTERED
	SW.	ORE ZONE	ORE ZONE	ORE ZONE		NE.
WALL-ROCK ALTERATION						
Sericite Envelopes	XXXXXXXX	XXXXXXXXXX	X X X X X	X X X X		
METAL DEPOSITION						
1.) Copper						
Stage one (3)		X X X	XXXXXXXXXXXXXX	XXXXXXX X		
* Stage two (4)		XXXXXXXXXX	X X X X	X X X		
Stage three (6)		X X X	X X X X	X X X		
Stage four (9)	X	X X	X X	X X X	X X	X
Stage five (10)		X	X X	X		
2.) Molybdenum						
Stage one (3)		X X	X X X X X	X X X		
Stage two (4)		X X X	X X X X X	X X X		
*Stage three (6)	X X	XXXXXXXXX	XXXXXXXXXXXXXX	XXXXXXXXX		

Notes

(1) Numbers in parentheses refer to vein sets (Table 3-1).

(2) Stage two - copper and stage three - molybdenum are the major contributors of metal to the ore zone.

Legend

XXX - Abundant

X X - Always Present

X X - Present Locally

Table 5-8

TEMPORAL RELATIONS BETWEEN STAGES OF ALTERATION AND SULPHIDE DEPOSITION

VEIN SET (Table 3-1)	STAGES OF METAL DEPOSITION: Copper	STAGES OF METAL DEPOSITION: Molybdenum	ALTERATION TYPE
-	---------	---------	Contact Thermal (Biotite, Transition and Epidote Types)
3	Stage One	Stage One	----------------------
4	Stage Two	Stage Two	Wall-rock Alteration (Pyrophyllite, Sericite, and Chlorite-Sericite Types)
6	Stage Three	Stage Three	----------------------
8	--------	--------	"Yellow Dog" Orange ferroan dolomite
9	Stage Four	--------	----------------------
10	Stage Five	--------	----------------------

formed during the stage of wall-rock alteration, the orange ferroan dolomite which gives the zone its name is formed later.

SURFICIAL ALTERATION

At many ore deposits, a major problem in the study of hydrothermal alteration is distinguishing and separating supergene from hydrogene effects. Surficial effects at the Island Copper deposit are minimal and have not obscurred hydrothermal alteration.

Two conditions at the Island Copper deposit indicate the absence of surficial effects. First, there is an absence of abundant iron oxides and copper oxides in the upper part of the deposit. In the central part of the pit, the subcrop surface has a zone of iron and copper oxides approximately one inch thick. This contrasts with other mineral showings on the north end of Vancouver Island which commonly are covered by gossans exceeding 100 feet in thickness.

Second, there is a lack of secondary enrichment of the ore body. Secondary copper sulphide minerals have not been observed in hand specimen or polished section. There is no relation between copper grade and distance below the suberop surface, as would be expected with secondary enrichment of an ore zone.

A study which gives some insight into surficial effects was made on core samples from drill hole no. 216 (Figure 4-1), a vertical hole. Clay-sized material ($\angle$ 2 microns) was separated from 13 samples from this hole to test for differences in the mineralogy of the clay-sized fraction near the bedrock surface compared with the deeper parts of the hole. The mineral assemblages for the different samples are tabulated

Table 5-9

MINERAL ASSEMBLAGES IN CLAY SIZE RANGE

DDH. C-216

Depth from collar	Quartz	Feldspar	Sericite	Chlorite	Kaolinite	Monmorillite	Pyrite
48'	X	X	-	X	?	-	-
77'	X	-	-	X	-	-	x
120'	X	X	-	X	?	-	-
205'	X	x	x	x	X	-	-
224'	X	-	x	x	X	-	-
257'	X	-	X	x	-	?	-
455'	X	-	X	-	X	-	-
745'	X	-	-	X	-	-	-
767'	X	-	X	X	-	-	-
782'	X	-	X	-	X	-	-
800'	X	-	X	X	-	-	-
804'	X	-	X	x	x	-	-
813'	X	-	X	x	x	x	-

Notes: 1/ X major phase
x minor phase
? questionable identification
- absent

2/ Vertical hole

3/ 20' of overburden

in Table 5-9. There is no increase in variety or amount of clay minerals in the samples from the upper parts of the hole indicating that the effects of surficial alteration are very minor.

FORMATION OF THE ALTERATION ZONES

Introduction

This section reviews available data on the environment of formation and discusses the formation of: 1.) Stage 1, Contact Metamorphism 2.) Stage 2, Wall-rock Alteration.

Environment of Formation

The Island Copper deposit is related spatially to the quartz-feldspar-porphyry dyke. Intrusive bodies of this nature are believed coeval with and probably feeders for extrusive rocks in the upper part of the Bonanza Volcanics. Stratigraphic data (Chapter 3), the porphyritic texture of the dyke, and its accompanying brecciation, suggest the deposit formed in a near-surface, low pressure environment.

Temperatures of formation of alteration zones have not been determined. Preliminary studies of samples from many different ages of quartz veins indicate fluid inclusions too small for determining temperatures with available equipment. Indirect methods of estimating temperatures by comparing mineral assemblages with those formed experimentally proved inconclusive. While experimental data give upper limits for temperatures of formation of some minerals present in natural assemblages, they do not indicate lower limits.

Diamond drilling shows that the ore zone is in a constant position relative to the dyke and has the same mineralogy and grade through 1,200 feet of stratigraphic thickness. While data at extreme depths is scanty, alteration patterns seem little changed with depth, except for variations in the mineralogy of the superimposed alteration.

Contact Thermal Metamorphism

Contact metamorphic effects are summarized in Table 5-10. Distribution of mineral assemblages characteristic of this stage are shown schematically in Figure 5-6.

The biotite and transition zones are a hornfels. Chemical analyses of thirteen samples of Bonanza Volcanics (Muller, 1970) a relatively complete sampling of the rock types, were plotted on an ACF diagram of the Albite - Epidote Hornfels Facies (Winkler, 1967) to determine which mineral assemblages could be expected (Figure 5-7). Eleven of thirteen samples plotted in the chlorite-epidote-tremolite field. This corresponds with minerals assemblages found in the biotite, transition and epidote zones (Table 5-10). Lack of mineralogic data for analysed rocks makes it impossible to calculate where the analyses would plot on an A'KF diagram.

A problem remaining in whether or not abundant biotite in the biotite zone represents metasomatism in addition to contact metamorphism. Analyses for potassium, sodium, magnesium and calcium are presented in Figure 5-8. Because only a few analyses are available only arithmetic means and range are plotted.

The arithmetic mean of potassium in biotite zone samples is slightly higher than that from transition and epidote zone samples, but is below the mean and within the range of potassium analyses from fresh rocks. Magnesium analyses are essentially the same in fresh rocks, transition, epidote and biotite zones.

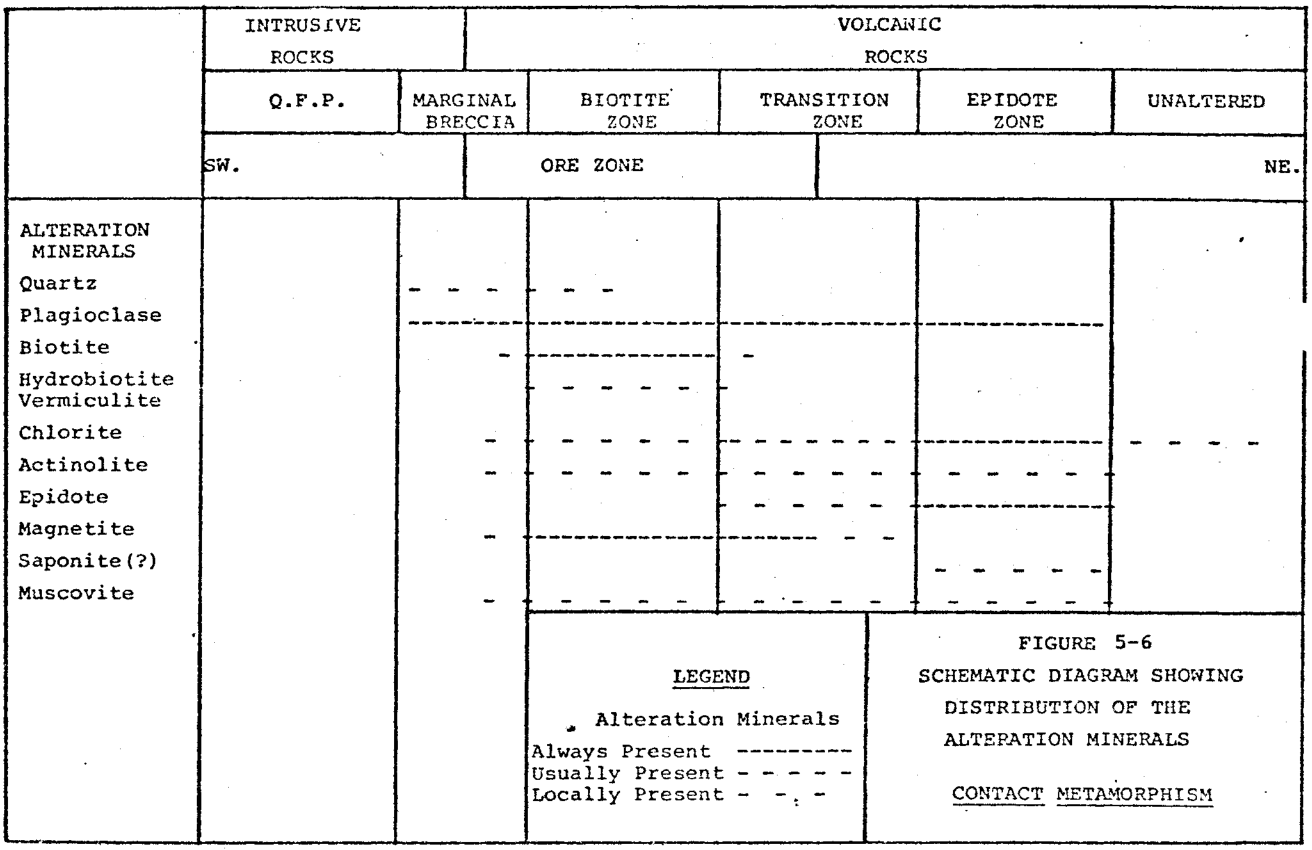


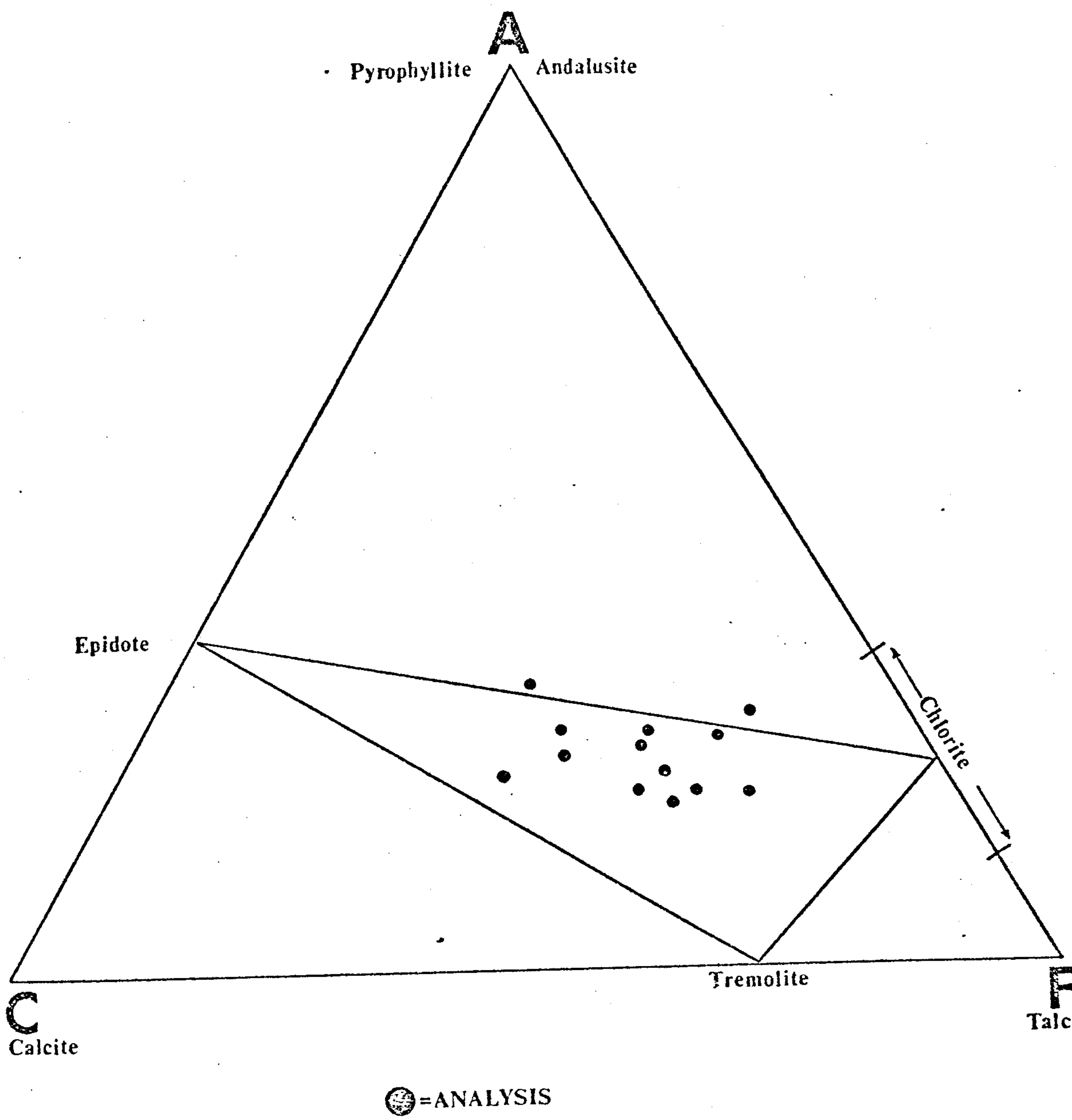
FIGURE 5-6
SCHEMATIC DIAGRAM SHOWING
DISTRIBUTION OF THE
ALTERATION MINERALS

CONTACT METAMORPHISM

FIGURE 5-7

Thirteen Analyses of Bonanza Volcanic Rocks on an ACF Projection of the Albite-Epidote Hornfels Facies

(ACF Projection After Winkler, 1967)
(Analyses Published by Mueller, 1970)



These data suggest that formation of biotite involved little metasomatism.

Analyses for sodium and calcium, which show essentially no variation between samples of fresh rocks and those from contact metamorphic zones support the suggestion that little metasomatism is involved in the formation of these zones. Manganese is slightly depleted in biotite zone samples relative to samples from fresh rocks, transition and epidote zone samples, but the mean value is within the range of analyses from samples of fresh rocks.

Contact metamorphism of a similar nature is reported from several other porphyry copper deposits where much of the ore is in andesitic wall rocks adjacent to an intrusive or breccia. Panguna (Fountain, 1972), El Tiente (Howell and Molloy, 1960), Safford (Robinson, 1966) and Mess Creek (Sutherland Brown, 1970) are the best documented examples. Figure 5-9 is a schematic diagram comparing the distribution of the early alteration zones at Island Copper to Panguna, El Tiente, and Safford. The distr-bution at Mess Creek is too complex for this type of diagram.

Figure 5-9 shows that the hornfels (biotite, transition, epidote zones) at Island Copper is relatively narrow compared with alteration zones described at the other deposits. This may be a function of the width of the intrusive. At Island Copper it is relatively narrow (400 feet) while it is much wider at the other deposits.

The close spatial correlation between biotite and copper mineralization at Panguna and El Tiente is also illustrated on the diagram. Biotite at El Tiente and Safford is clearly a pre-ore feature, while at Panguna and Mess Creek, the exact age relations have not been established.

TABLE 5-10

SUMMARY OF THE CHARACTERISTICS OF THE ALTERATION ZONES IN VOLCANIC ROCKS

	CONTACT METAMORPHISM			WALL-ROCK ALTERATION			
ZONES	BIOTITE	TRANSITION	EPIDOTE	CHLORITE SERICITE	SERICITE	PYROPHYLLITE	"YELLOW DOG"
DEFINING MINERALS	Biotite	Chlorite	Epidote	Chlorite& Sericite	Sericite	Pyrophyllite & Dumortierite	Rusty Orange Dolomite
TEXTURES	Destroyed	Partially Destroyed	Distinct	Partially Destroyed	Destroyed	Destroyed	Partially Destroyed
PLAGIOCLASE PHENOCRYSTS	Albitic (An 5-25) Slight to moderate sericitization and saussuritization	Albitic (An5-25) Slight to moderate sericitization and saussuritization	Albitic (An5-25) Moderate saussuritization	Altered to: Muscovite Minor Kaolinite Hydromica	Altered to: Muscovite Kaolinite	Altered to: Pyrophyllite Muscovite Kaolinite	Moderately altered to: Muscovite Kaolinite
MAFIC PHENOCRYSTS	Altered to: Biotite Chlorite Epidote Carbonate Actinolite	Altered to: Chlorite Epidote Actinolite Carbonate Sericite	Altered to: Chlorite Epidote Carbonate Actinolite	Altered to: Chlorite Muscovite Carbonate	Altered to: Muscovite Minor Kaolinite	Altered to: Pyrophyllite Muscovite Minor Kaolinite	Altered to: Chlorite Muscovite
MATRIX	Plagioclase Biotite Chlorite Muscovite Actinolite Hydrobiotite Vermiculite Carbonate Quartz	Plagioclase Muscovite Chlorite Quartz Actinolite Hydromica	Plagioclase Chlorite Muscovite Glass Saponite(?)	Muscovite Kaolin Chlorite Quartz	Quartz Muscovite Kaolinite	Quartz Pyrophyllite Kaolin Muscovite Dumortierite	Quartz Sericite Carbonate Plagioclase
OXIDES	Magnetite Leucoxene Hematite	Magnetite Leucoxene	Leucoxene	Magnetite Leucoxene	Leucoxene	Leucoxene	Leucoxene
SULPHIDES	Pyrite Chalcopyrite Molybdenite	Pyrite Chalcopyrite Molybdenite	Pyrite	Pyrite Minor Chalcopyrite Molybdenite	Pyrite	Pyrite	Pyrite Chalcopyrite Molybdenite

CHEMICAL VARIATIONS BETWEEN ALTERATION ZONES IN THE VOLCANIC ROCKS

FIGURE 5-8

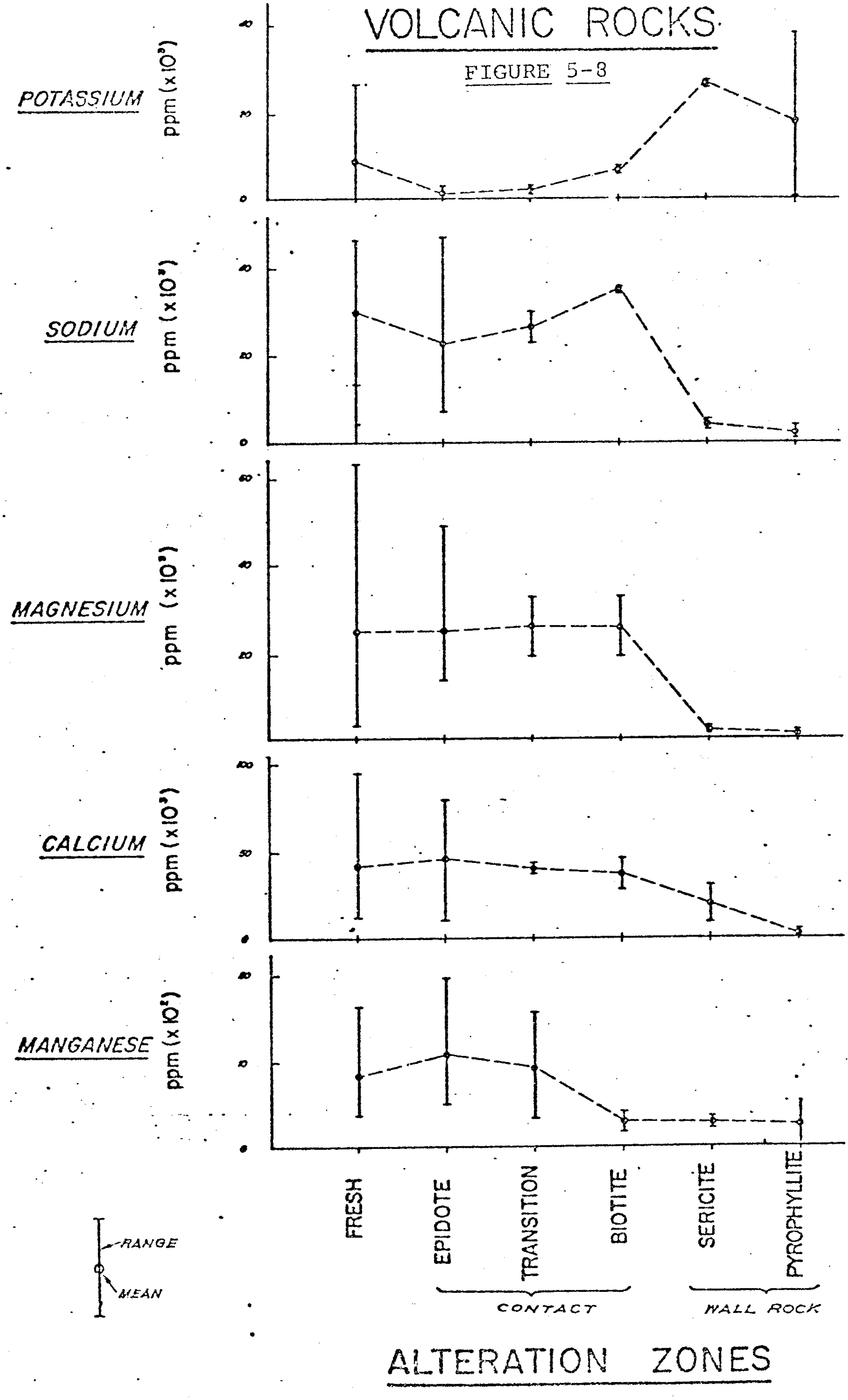
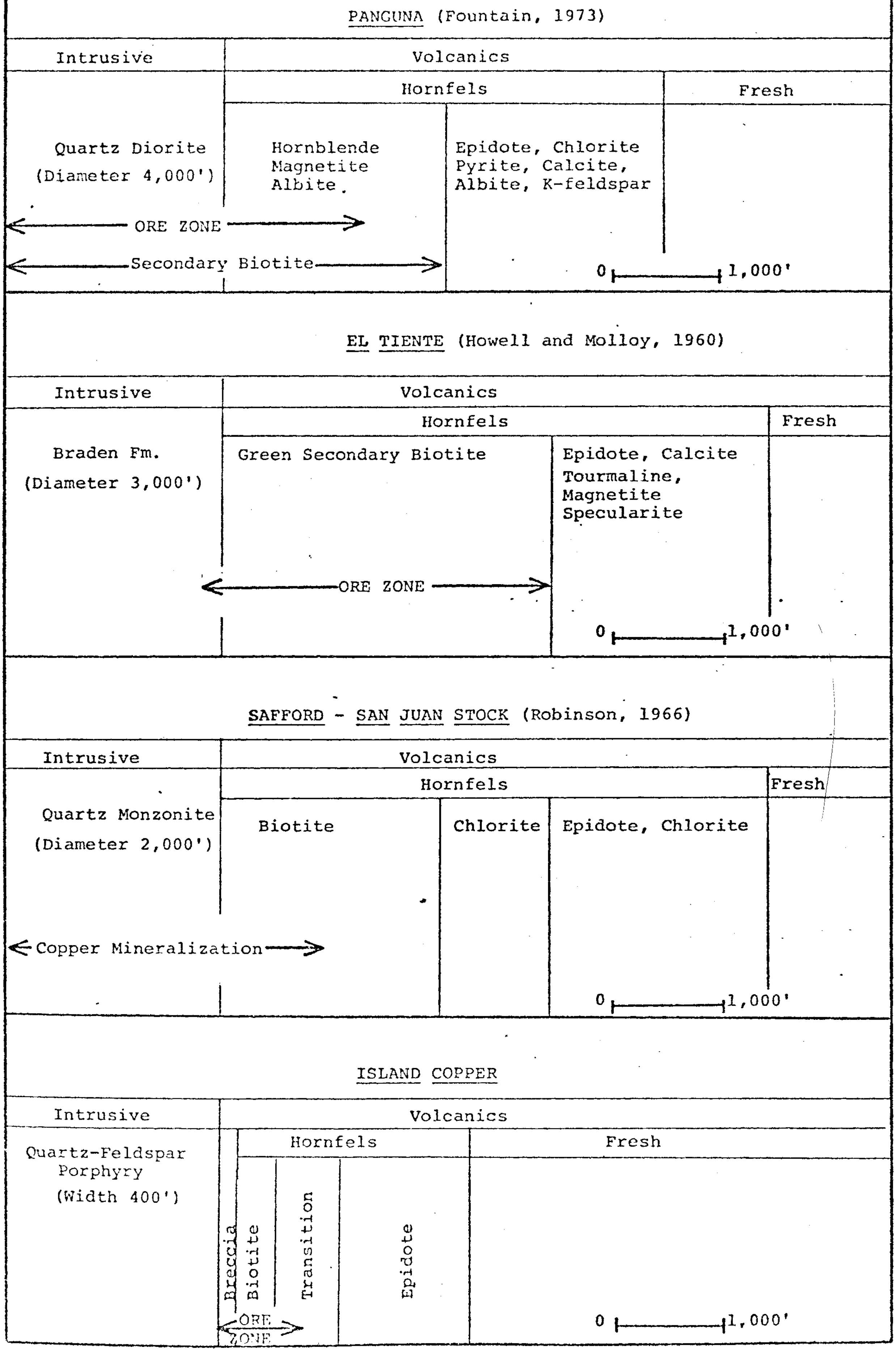


FIGURE 5-9

SCHEMATIC DIAGRAM OF EARLY ALTERATION ZONES



Wall-rock Alteration

Stage 2 alteration is characterized by the formation of sericite, kaolinite and pyrophyllite. Sericite, as used in this discussion, refers to fine-grained potassium mica (muscovite). Polytypes of the mica were not determined. Kaolinite refers to a Kaolin group mineral or minerals. Pyrophyllite is a misture of the 1T and 2M polytypes in approximately equal proportions.

These minerals occur in: 1) envelopes of alteration on quartz-molybdenite veins and fractures cutting volcanic rocks and quartz-feldspar porphyry respectively, and 2) in breccias containing fragments of both volcanic rocks and quartz-feldspar porphyry. Mineral assemblages are summarized in Tables 5-10 and 5-11 and their distributions are shown schematically in Figures 5-10 and 5-11. Distribution of these minerals produces zones on the scale of: 1) and envelope and 2) the whole deposit.

Figures 5-3 and 5-4 are schematic diagrams of mineral zoning within sericitic envelopes in quartz-feldspar porphyry and volcanic rocks. In volcanic rocks, envelopes consist of progressive zones grading from an inner pyrophyllite-kaolinite and minor sericite assemblage adjacent to the vein, through an intermediate assemblage of sericite and minor kaolinite, to an outer sericite and chlorite assemblage.

Envelopes in quartz-feldspar porphyry, are somewhat different from those in volcanic rocks and consist of a relatively narrow inner zone of sericite and kaolinite and a broad outer zone of sericite and chlorite. Pyrophyllite is not found in these envelopes.

Pervasive sericitic (sericite and kaolinite) alteration of rock fragments in the maginal breccias is due to coalescing of

TABLE 5-11

SUMMARY OF THE CHARACTERISTICS OF THE ALTERATION ZONES IN QUARTZ-FELDSPAR PORPHYRY

ZONES	BIOTITE	TRANSITION	EPIDOTE	CHLORITE SERICITE	SERICITE	PYROPHYLLITE	"YELLOW DOG"
DEFINING MINERALS				Chlorite Sericite	Sericite	Pyrophyllite & Dumortierite	Rusty Orange Dolomite
TEXTURES				Distinct	Distinct	Distinct	Distinct
QUARTZ PHENOCRYSTS				Unchanged	Unchanged	Unchanged	Unchanged
PLAGIOCLASE PHENOCRYSTS				Altered to: Muscovite Carbonate Kaolinite	Altered to: Muscovite Kaolinite	Altered to: Pyrophyllite Minor Muscovite Kaolinite	Altered to: Muscovite
MAFIC PHENOCRYSTS				Altered to: Chlorite Minor Epidote Carbonate	Altered to: Muscovite Kaolinite	Altered to: Pyrophyllite Muscovite Kaolinite	Altered to: Chlorite Sericite
MATRIX				Quartz Muscovite Chlorite Epidote Plagioclase	Quartz Muscovite Kaolinite	Quartz Pyrophyllite Kaolinite Muscovite	Muscovite Kaolinite Quartz Plagioclase
OXIDES				Magnetite Leucoxene	Leucoxene	Leucoxene	Leucoxene
SULPHIDES				Pyrite Chalcopyrite	Pyrite	Pyrite	Pyrite

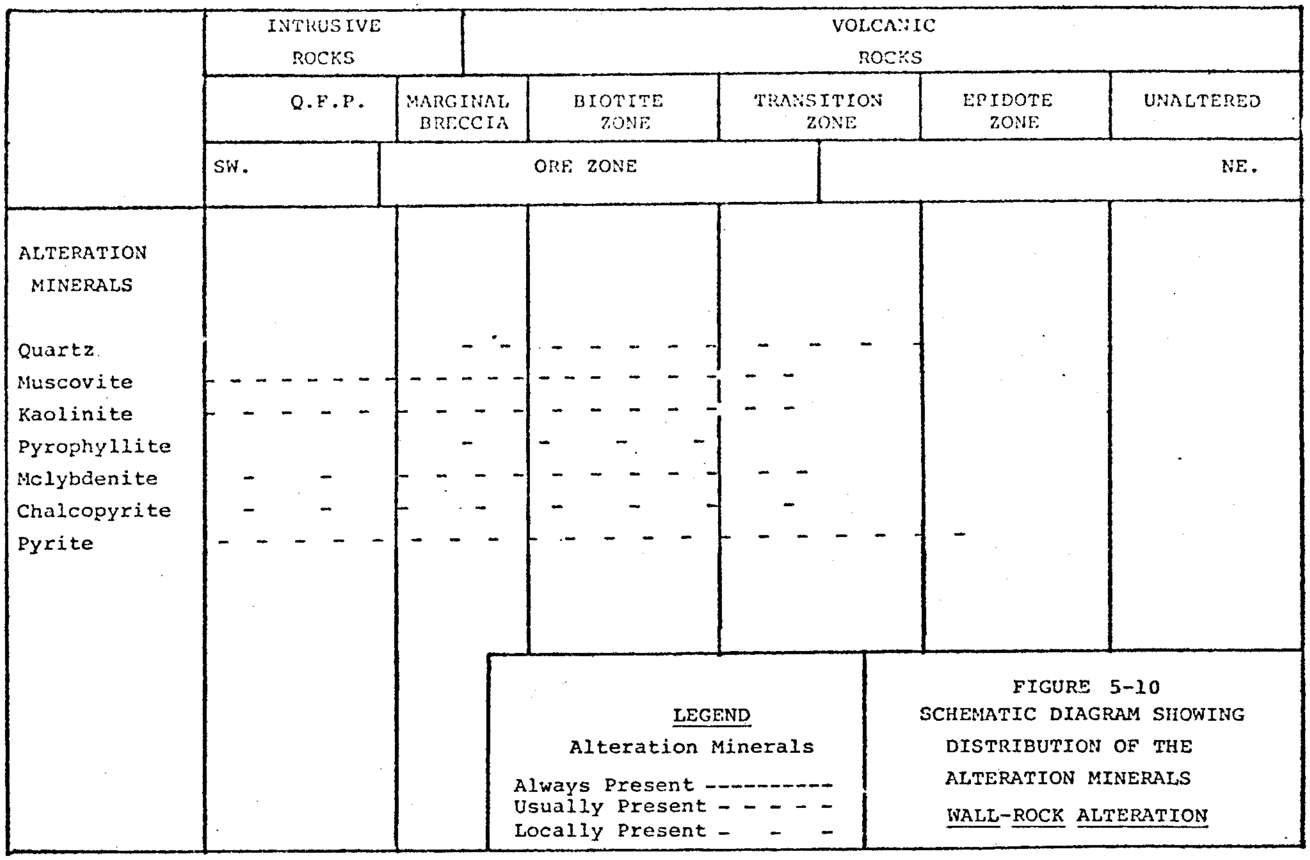


FIGURE 5-10
SCHEMATIC DIAGRAM SHOWING
DISTRIBUTION OF THE
ALTERATION MINERALS
WALL-ROCK ALTERATION

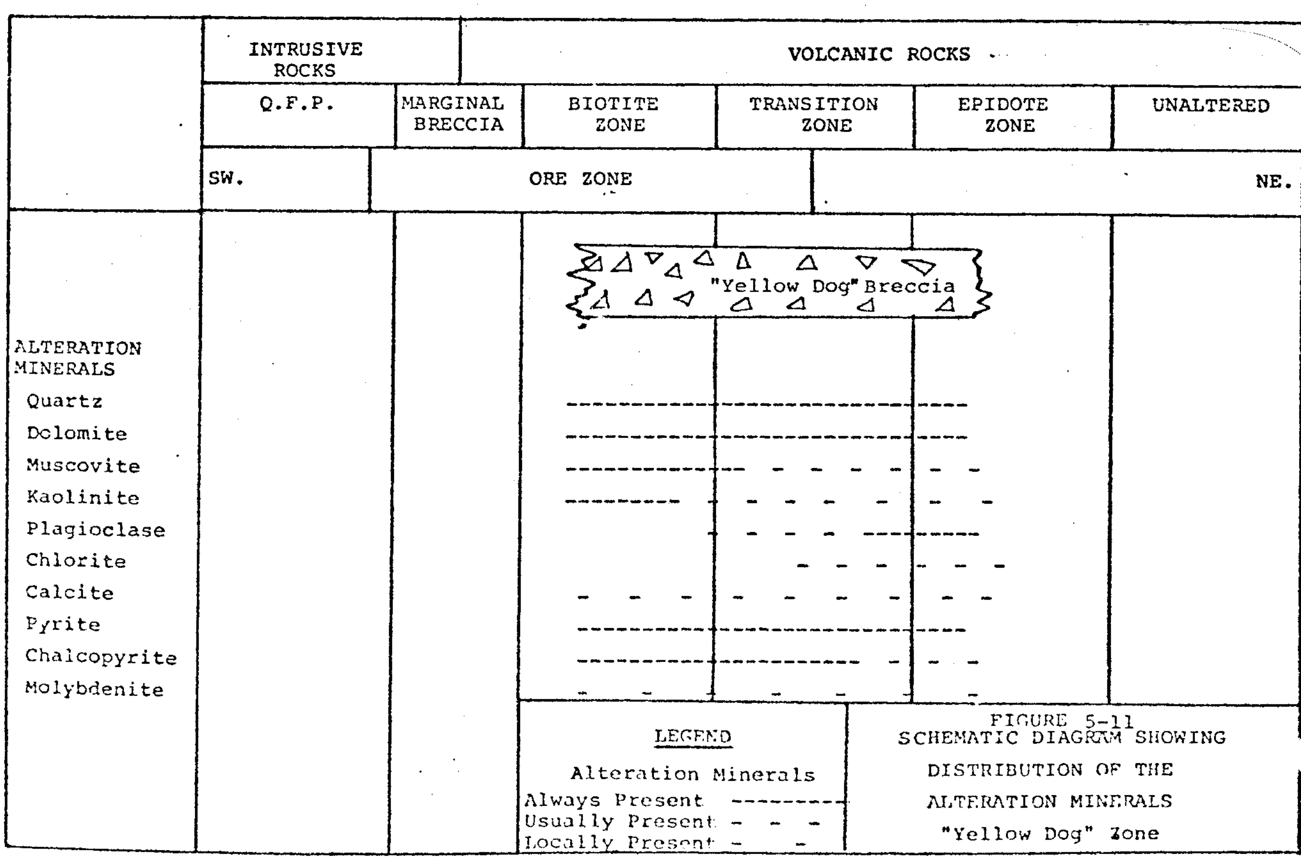


FIGURE 5-11
SCHEMATIC DIAGRAM SHOWING
DISTRIBUTION OF THE
ALTERATION MINERALS
"Yellow Dog" Zone

the inner parts of sericitic envelopes. However, as the marginal breccias grade into the capping "pyrophyllite" breccia (Figure 5-2) the mineral assemblage changes to pyrophyllite and kaolinite with minor sericite.

In the "Yellow Dog" breccia, rock fragments are altered pervasively. Near the quartz-feldspar porphyry dyke, the mineral assemblage is sericite and kaolinite. Away from the dyke, the assemblage is sericite and chlorite. This pervasive alteration is tentatively believed due to coalescing alteration envelopes around fractures.

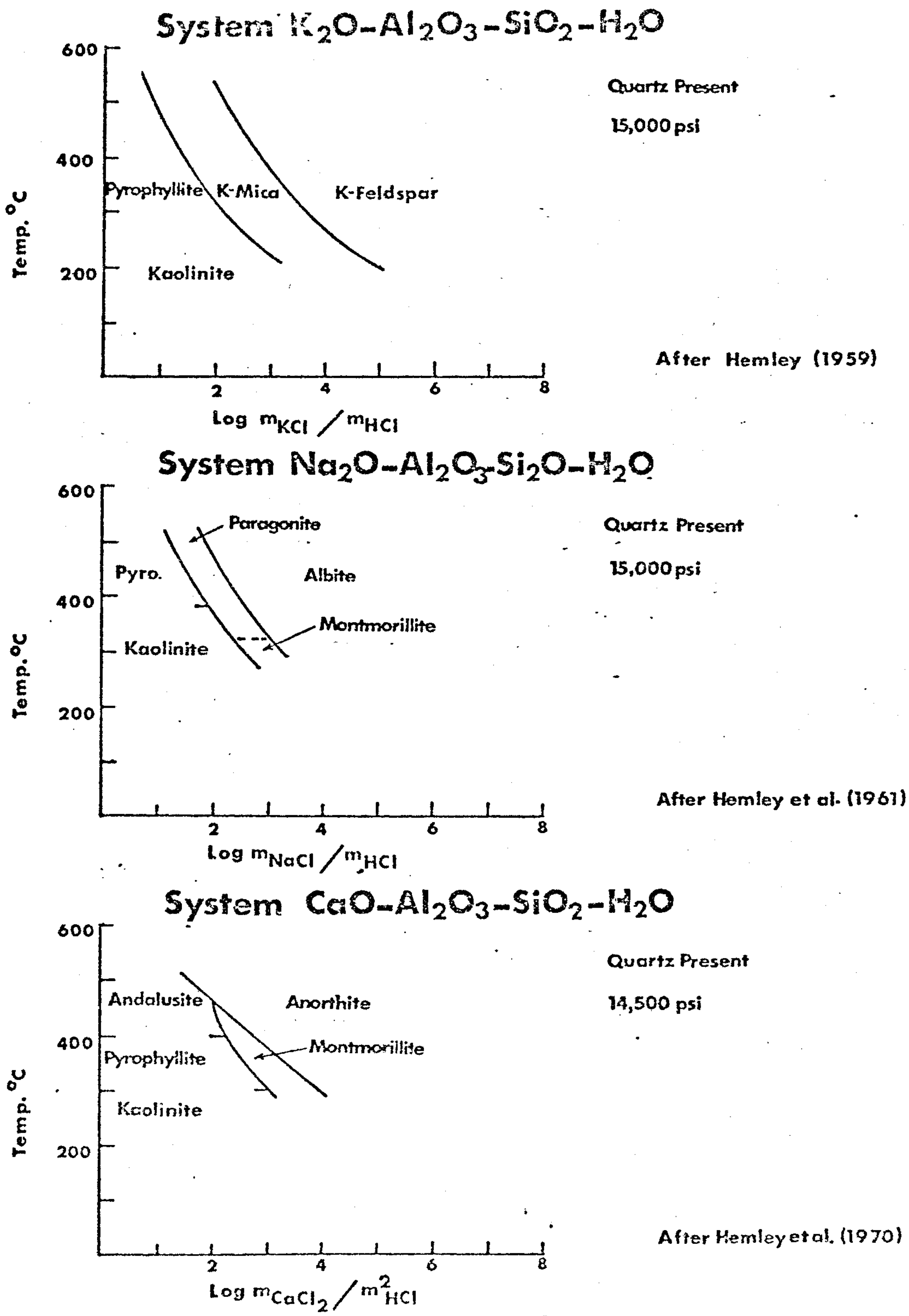
Development of the different mineral assemblages in the superimposed alteration can be explained by hydrogen ion metasomatism (Hemley and Jones, 1966). This process requires that hydrothermal solutions be rich in hydrogen ions and these solutions hydrolize silicate minerals causing release of metal cations into solution. Resulting ratios of metal ions are the principal factor in determining stability of minerals in contact with solution. However, the net effect of these reactions is the removal of metal cations and the ultimate alteration product is quartz.

Figure 5-12 shows results of experimental studies (Hemley et al., 1959, 1961, 1970) to investigate effects of different ratios of metal cations to hydrogen ions on mineral stabilities in simple systems. The diagrams show ratios of metal ions to hydrogen ions plotted against temperature.

These diagrams give considerable insight into the process of hydrogen ion metasomatism. Figure 5-12A represents a rock composed of K-Feldspar and quartz. If a hydrothermal solution at 250°C containing hydrogen ions is introduced into this rock along a fracture, potassium feldspar adjacent to the fracture

FIGURE 5-12

EXPERIMENTAL STUDIES RELATING TO HYDROTHERMAL ALTERATION



will be altered to K-mica (sericite). If more hydrothermal solution is added to the rock, alteration of K-feldspar to K-mica will move outward from the crack and K-mica adjacent to the crack will alter to kaolinite. Thus, two alteration zones are developed adjacent to the crack by one hydrothermal fluid.

Figure 5-12B illustrates what would happen for rocks consisting of sodium feldspar and quartz and Figure 5-12C for rocks consisting of calcium feldspars and quartz.

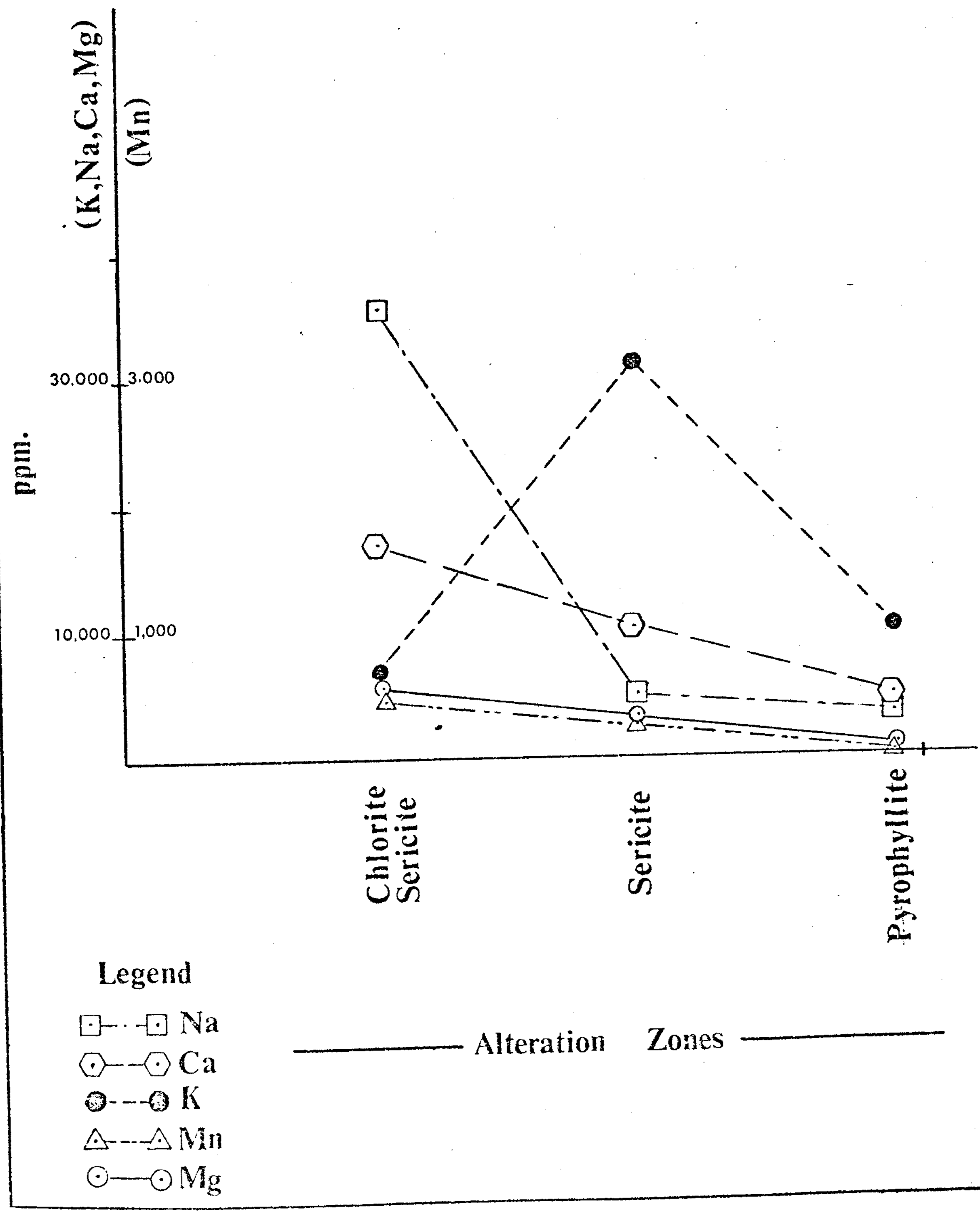
Mineral zoning within sericite envelopes cutting volcanic rocks can be explained by the theory of hydrogen ion metasomatism. The inner pyrophllite-rich zone represents intense base leaching. The intermediate sericite and kaolinite zones represent partial leaching of bases and perhaps potassium enrichment. The outer chlorite-sericite zone represents base leaching from the feldspars, but not the mafic minerals.

This interpretation is supported by the chemical data, in the case of Island Copper (Figure 5-8). Samples from the sericite zone contain less sodium, calcium, magnesium and manganese than samples from either fresh rocks or biotite, transition and epidote zones. Potassium content is high relative to other alteration zones and fresh rocks. Samples from the pyrophyllite zone (those shown on the figure are from the pyrophyllite breccia) indicate further depletion of all metals including potassium.

In sericitic envelopes cutting quartz-feldspar porphyry, the zonation is not as well developed. However, inner sericite-kaolinite part of the envelopes indicates a greater degree of base leaching than the outer chlorite and sericite zone. This is supported by chemical analyses (Figure 5-13). There is less sodium, calcium, magnesium and manganese in the sericite zone

Figure 5-13

CHEMICAL VARIATIONS BETWEEN ALTERATION ZONES IN QUARTZ-FELDSPAR PORPHYRY



than in the chlorite and sericite zone, but potassium is higher in the sericite than in the chlorite-sericite zone.

Formation of the sericite-kaolinite assemblage within rock fragments in the marginal breccia corresponds to the formation of the inner parts of the sericitic envelopes. The entire breccia represents an area of intense base leaching.

Formation of the pyrophyllite breccia with its assemblage of pyrophyllite and kaolinite and minor (relict?) sericite is by extreme base leaching. That is the removal of potassium as well as the other metals (Figures 5-8 and 5-13 . This vertical zonation with the zone of most intense leaching above zones of less intense leaching is well documented in the literature. Butte, Montana (Meyer et al., 1968) Silverton, Colorado (Burbank and Luedke, 1961; Luedke and Hosterman, 1971), Usuga, Japan (Iwao, 1962) and Snedogarian Zone, Bulgaria (Randonova and Velinova,1970) are particularly well-described examples.

In terms of the theory of hydrogen ion metasomatism, this zoning can be explained by an increase in concentration of hydrogen ions as solution moves upward. Hemley and Meyer (1967) suggest that increased production of hydrogen ions is due to more dissociation of stronger inorganic acids at lower temperatures and possibly production of strongly ionized sulphuric acid by oxidation of H_2S as hydrothermal solutions mix with oxygenated meteoric water. The remaining problem is why pyrophyllite forms so abundantly instead of kaolinite. A satisfactory explanation has not been found.

Distribution of the alteration zones comprising the superimposed alteration (Figure 5-2) offers considerable insight into movement of hydrothermal solutions during this stage of alteration. The most intense leaching is in the marginal breccias while there are zones of leaching adjacent to fractures in volcanic rocks and quartz-feldspar porphyry. This suggests fresh hydrothermal fluids flowed upward through the marginal breccias and outward into both the porphyry and volcanic rocks. The bulk of the fluid probably continued up through the marginal breccias into the pyrophyllite breccias and eventually to surface.

CHAPTER 6: FORMATION OF THE ISLAND COPPER DEPOSIT

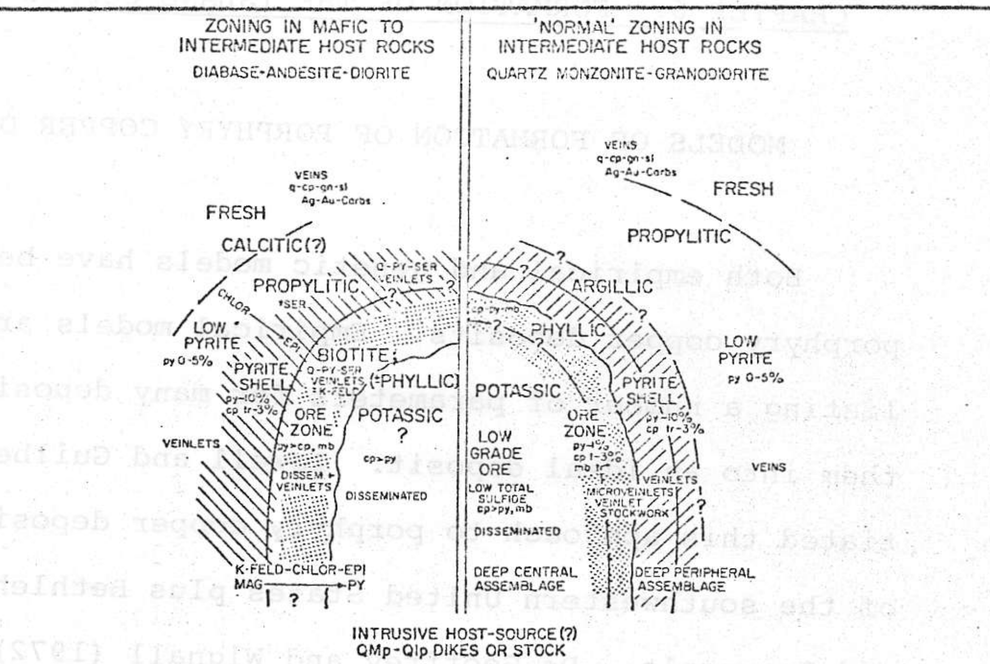
MODELS OF FORMATION OF PORPHYRY COPPER DEPOSITS

Both empirical and genetic models have been proposed for porphyry copper deposits. Empirical models are constructed by listing a number of parameters for many deposits and integrating them into an ideal deposit. Lowell and Guilbert (1970) initiated this approach to porphyry copper deposits using deposits of the southwestern United States plus Bethlehem, El Salvador and Toquepala. De Geoffrey and Wignall (1972) expanded the model to include many of the deposits of the Canadian Cordillera. In 1974, Guilbert and Lowell re-examined their model and developed subclasses to explain variations in zoning. Figure 6-1A is the revised Guilbert and Lowell model of alteration zoning in mafic and intermediate rocks. Similarities between alteration zones predicted by the model and those found at the Island Copper deposit (Figure 5-2) include:

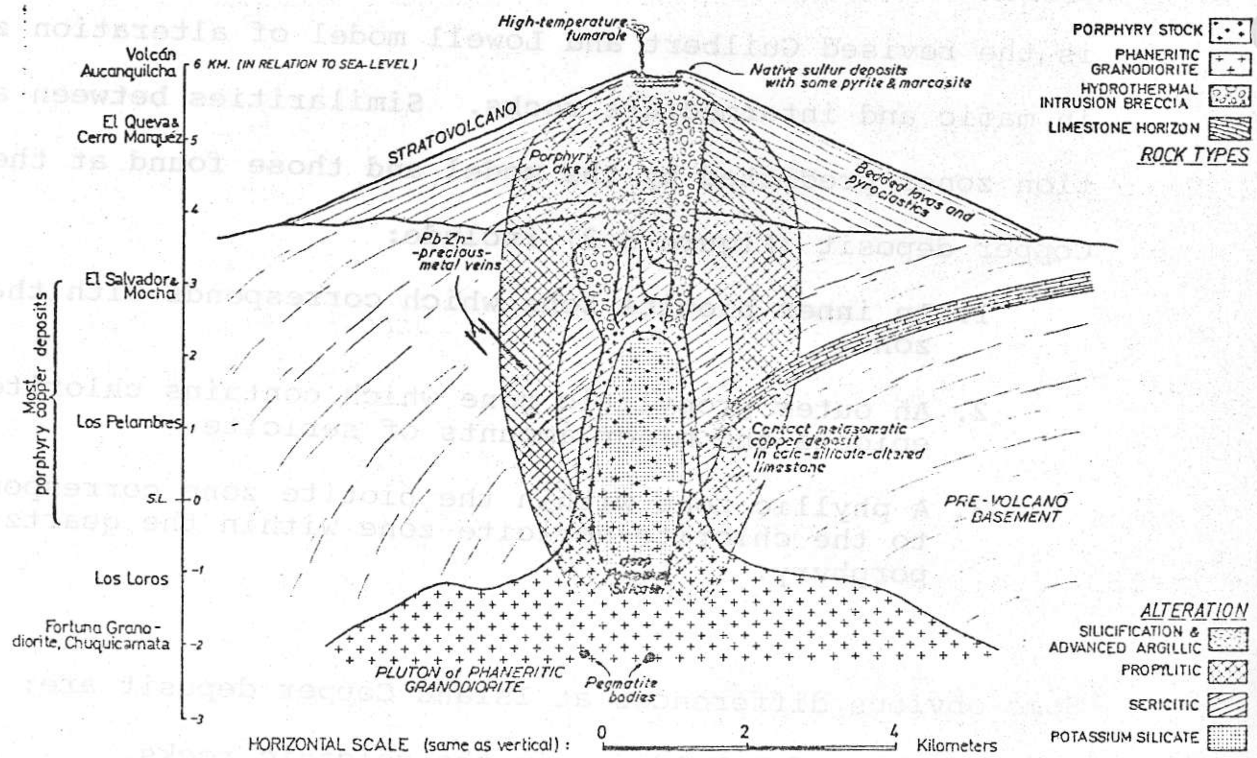
1. An inner biotite zone which corresponds with the ore zone.
2. An outer propylitic zone which contains chlorite, epidote and minor amounts of sericite.
3. A phyllic zone within the biotite zone corresponding to the chlorite-sericite zone within the quartz-feldspar porphyry.

Some obvious differences at Island Copper deposit are:

1. Lack of K-Feldspar in the volcanic rocks.
2. Lack of a pyrite-rich shell surrounding the ore zone.
3. Reversal of chlorite and epidote-rich portions in the propylitic zone.
4. Veinlets of calcite cutting all alteration zones.



A. Schematic comparison of alteration and mineralization in mafic and intermediate rocks (After Guilbert and Lowell, 1974)



B. Idealized cross section of a typical, simple porphyry copper deposit showing its position at the boundary betwe[en] plutonic and volcanic environments. (After Sillitoe, 1973)

FIGURE 6-1

5. Sphalerite occurs throughout the deposit.

6. Pyrite exceeding chalcopyrite in the Inner zone (quartz-feldspar porphyry).

7. Alteration patterns which are much more complex in the Inner zone (quartz-feldspar porphyry).

9. Pyrophyllite forming a major alteration zone.

Another problem with attempting to fit the Island Copper deposit into the Guilbert and Lowell (1974) model is that the model is entirely spatial. The implicit assumption is that alteration zones formed in one system which grew outward from the center. This concept does not fit the evidence at the Island Copper deposit.

The second type of model, the genetic model is constructed by fitting different deposits together into an ore-forming system. Sutherland Brown (1969) initiated this approach with prophyry copper deposits in the Canadian Cordillera. James (1971), using southwest U.S. deposits and El Tiente in Chile, expanded the idea. Hutchison and Hodder (1972) expanded it further to include strataform massive sulphide deposits in the system. Sillitoe (1973) has again expanded the model (Figure 6-1B) to fit porphyry type deposits with coeval volcanism.

Sillitoe followed the Lowell and Guilbert (1970) pattern for lateral alteration zoning, but introduced vertical variation in the alteration. The Sillitoe model is a better approximation of the situation at the Island Copper deposit particularly if Guilbert and Lowell's (1974) revised zoning patterns for mafic and intermediate rocks are used.

A TENTATIVE MODEL FOR THE FORMATION OF THE ISLAND COPPER DEPOSIT

Models discussed in the previous section consider alteration patterns of a number of deposits and explain them in terms of one ore-forming system. This approach ignores the time relations between the different alteration patterns and the possibility of a system evolving over a period of time. The following model is proposed for development of the Island Copper deposit.

Step One

Intrusion of the porphyry dyke is the first major structural event. These porphyry dykes are coeval with Bonanza volcanism and probably are feeders for acid volcanic rocks in the upper part of the formation. Although the exact mechanism of their formation is not known, the marginal breccias and the pyrophyllite breccia were formed contemporaneously with intrusion of the dyke. Fracturing of volcanic host rocks also accompanied dyke emplacement.

A contact metamorphic aureole in the volcanic rocks marked by biotite, transition and epidote zones developed adjacent to the quartz-feldspar porphyry dyke. These zones are much wider than metamorphic aureoles predicted from Jaeger's (1957) calculations for aureoles formed by conductive heat transfer. This suggests lateral heat transfer by circulating water as well as conduction. Water could be either formational water trapped during depositon of volcanics or meteoric water which penetrated the volcanic pile. This type of hydrothermal system would be relatively short lived (a few hundred years) as the dyke would cool rapidly.

Step Two

Step two in formation of the deposit is marked by changes in flow patterns and nature of the hydrothermal solutions. During step one, hydrothermal solutions moved laterally to form contact alteration zones on each side of the dyke. These solutions aided cooling of the dyke by convective transfer of heat, but do not appear to have affected the chemical compositions of the wall rocks.

Flow patterns of hydrothermal solutions during step two are shown by distribution of superimposed alteration (Figure 5-2). Hydrothermal solutions moved upward through marginal breccias and pyrophyllite breccia and laterally through fractures into both quartz-feldspar porphyry and volcanic rocks.

This change in the pattern of hydrothermal flow is due to a change in the position of the heat source driving the system. The primary heat source is no longer the dyke, which is cooling rapidly, but a deeper magma chamber which feeds the dyke. Figures 2-1 and 2-2 show distribution of intrusive and altered volcanic rocks on this part of Vancouver Island. Northcote (1970) suggested that this entire area was underlain by an intrusive of batholithic dimensions. A large intrusive mass such as this would provide a long term heat source.

There are two distinct phases to this hydrothermal system: 1) Copper deposition and 2) Molybdenum deposition.

Although some copper was deposited in quartz-feldspar porphyry, volcanic rocks and breccias, copper in ore grade quantities is confined to volcanic rocks, the marginal and "Yellow Dog" breccia. In volcanic rocks, copper is deposited as fracture fillings in tiny closely spaced fractures. In marginal and "Yellow Dog" breccias, it occurs in relatively large quartz veins. Variation in mode of occurence is due to variation in the size of fractures available to fill. Although minor amounts of molybdenite are associated with this chalcopyrite, it is predominantly a stage of copper deposition.

Locallization of ore grade quantities of copper in volcanic rocks and the marginal and "Yellow Dog" breccias is due primarily to physical controls of ore deposition. Volcanic rocks adjacent to the quartz-feldspar porphyry dyke are intensely fractured as a result of dyke intrusion, and the breccias contained abundant void space. Copper deposition was an early event in this system. If the porphyry dyke were still warm there would be a lateral geothermal gradient pushing hydrothermal solutions away from the dyke into available permeable zones, crackled volcanics and breccias. Chemical controls, while they may be equally important, are not obvious.

Although some molybdenite occurs in quartz-feldspar porphyry, volcanic rocks and breccias, recoverable amounts are confined to marginal breccias, volcanic rocks and the "Yellow Dog" breccia. Molybdenite occurs in quartz veins with envelopes of sericitic alteration and on fracture surfaces (molybdenite slips) which cut these envelopes. Although movement on these fractures occurred after development of sericite envelopes, the time of molybdenite deposition is unknown.

Molybdenite deposition is related to the later part of this stage of hydrothermal activity when the solutions were highly acid. The reasons for the restricted areas of molybdenite deposition is probably due to availability of fractures for the solutions to move through. Molybdenite deposition on the fracture surfaces which do not have accompanying sericitic alteration tentatively is believed formed as the last event in this system.

Step Three

Formation of carbonate-zeolite veins is the last step in the formation at the deposit. Distribution of these veins in all rock types and cutting all alteration zones indicates a change in the flow patterns of the hydrothermal solutions. The marginal and pyrophyllite breccias are not the principal conduit for hydrothermal activity as they were during step two.

Mineralogy of the veins and lack of associated wall-rock alteration suggest a change in the nature of the solutions. Veins consist of carbonate (principally calcite) and zeolite (laumonite) with minor amounts of pyrite, sphalerite, hematite, and pyrobitumen. This mineral assemblage suggests deposition from low temperature alkaline hydrothermal solutions.

In the Wairakei geothermal system (Steiner, 1953) zeolite veins superimposed on a zone of argillized rock are believed formed by alkaline-rich waters at the end of the hydrothermal system. That is, they began as acid rich water and lost their hydrogen ions through reactions (base leaching) with the wall rocks. If the system at Island Copper were similar, the zone of superimposed alteration by base leaching has moved downward. This is a more reasonable explanation than postulating a change from an acid to an alkali hydrothermal system.

CHAPTER 7: CONCLUSIONS

The following conclusions are drawn from this study:

1) The copper-molybdenum deposit of Utah Mines Ltd. formed in volcanic rocks adjacent to a coeval porphyry dyke in a near-surface environment.

2) Ore and alteration zones formed symmetrically on both sides of the dyke.

3) Alteration assemblages are divided into seven zones, which can be mapped on the basis of megascopic characteristics.

4) Alteration assemblages formed during two stages:

   (i) Pre-ore contact alteration comprising the biotite, transition and epidote zones.

   (ii) Wallrock alteration comprising the chlorite-sericite, sericite, pyrophyllitic and "Yellow Dog" zones.

5) Pre-ore contact alteration is a contact metamorphic aureole on both sides of the dyke. Little metasomatism is involved in the formation of this aureole.

6) Wallrock alteration formed after the dyke was largely cooled in a hydrothermal system locallized in breccias around the margins of the dyke.

7) The bulk of the copper was deposited prior to deposition of molybdenum.

8) The copper ore zone is closely spatially related to the inner part of the contact metamorphic aureole rich in biotite and magnetite. However, deposition of copper mineralization post-dates contact metamorphism.

9) Although copper and molybdenum are spatially closely related, the bulk of the molybdenum deposition post-dates copper mineralization. Deposition of molybdenum is closely related temporally to the formation of superimposed alteration.

10) The "GEOLOG" format is an efficient method of

logging core in this type of deposit. It yields a core log amenable to either computer or visual interpretation.

11) Statistical correlation studies between abundance of alteration minerals and ore grade yields data on relations between ore grade and formation and distribution of alteration assemblages. However, correct interpretation of statistical studies requires additional data on age relations between alteration assemblages and ore minerals.

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APPENDIX A

"GEOLOG"

The development and use of the "GEOLOG" format for recording drilling data is described by Blanchet and Godwin (1972). The system used for recording drilling data at Island Copper is a modified form of one of the earlier "GEOLOG" formats (Figure A-1) which was loaned to the writer in the spring of 1971. Early core logging at Island Copper indicated that limonite was negligible and that very little fracture data could be obtained from the split core; therefore, these sections were removed from the data sheets for this study. Copper and molybdenum assays were added to the "GEOLOG" sheet instead of being recorded on a separate "ASSAYLOG" sheet. The resultant format used for core logging at Island Copper are shown in Figure A-2. Coding sheets for the "GEOLOG" data sheets are illustrated as Tables A-1, A-2.

FIGURE A-1

"GEOLOG" Format

After Blanchet and Godwin, (1972)

GEOLOG

DRILL HOLE GEOLOGIC LOG

CW&G CHAPMAN, WOOD AND GRISWOLD LTD.

COMPANY: PROPERTY: LOGGED BY: DATE:

HOLE NUMBER ______

PAGE ____ OF ____

CW&G. FORM TI-03

CIP ____ AZIM. ____ CORE

TYPE OF HOLE: DDH / RDH / PDH

NORTHING

EASTING

COLLAR ELEVATION

STRUCTURE AND/OR ALTERATION	HOST ROCK	ZONE		PRINC. ZONES & CONTACTS, FAULTS & DYKES	DEPTH TO BOTTOM OF INTERVAL DESCRIBED	HOST ROCK	FRACTURES	ALTERATION ASSEMBLAGES	LIMONITES	MINERALIZATION
			ESTIMATES & ASSAYS ELEMENTS OR MINERALS	1 2 3	4 5 6 7	ROCK TYPE USE 4-LETTER CODE (8–11); TYPE MODIFIER (12); COLOUR CODE M N S L OR NORMAL COLOUR VALUE (13–16); QUALIFYING MINERAL (17–18); TEXTURE (19); GRAIN SIZE (20)	ALL FRACS: Fracture Density, % with Sulphides, % Fault Zone Matter (21–23); ANGLE TO AXIS: GP1 <30°, GP2 30–60°, GP3 >60°: Fracture Density, % with Sulphides (24–29)	MODE OF OCCURRENCE / % (VOL.) OF MINERAL: QZ QUARTZ, KF K-SPAR, BI BIOTITE, MS SERICITE, CY CLAY, CL CHLORITE, EP EPIDOTE, CB CARBONATE (MODE, %; 30–45); OTHER ALTERATION MINERALS — NAMES GIVEN ON NAMES CARD OR ON EACH CODE LINE (MODE, %; 46–51); FACIES (52); ALTERATION INTENSITY (53)	MODE OF OCCUR. OF OXIDE SULPHIDES; FACTOR; GANGUE REACTIVITY; COLOUR CODE M N S L OR JAROSITE, GOETHITE, HEMATITE, % OTHER; INTENSITY OF OXIDIZED SULPHIDES; OTHER MINERALS WHEN BELOW CAP USE 2-LETTER CODES 1 2 3 4 (54–61); LIMONITE INTENSITY (62)	MODE OF OCCUR. / % (VOL.) OF MINERAL — NAMES OF RIGHT 4 MINERALS TO BE GIVEN ON NAMES CARD OR ON EACH CODE LINE. LEFT 4 AS SHOWN OR OVER-RIDDEN BY SPECIFYING ON NAMES CARD: PY, CP, DO, MO, —, —, —, — (MODE, %; 63–78); 79 80
				SCALES →						
				NAMES →						

← COMMENTS TO BE KEYPUNCHED AFTER REMARK — FOR COMMENTS WHICH WILL NOT BE KEYPUNCHED →

SAMPLE NUMBER

VISUAL ESTIMATES

ACTUAL ASSAYS

SAMPLE NUMBER

VISUAL

ACTUAL

SAMPLE NUMBER

VISUAL

ACTUAL

SAMPLE NUMBER

VISUAL

ACTUAL

SAMPLE NUMBER

VISUAL

ACTUAL

SAMPLE NUMBER

VISUAL

ACTUAL

FIGURE A-2

Modified "GEOLOG" Format Used at Island Copper

Contacts, Faults, Dykes	Depth to Bottom of Interval Described	HOST ROCK						FRAC.			ALTERATION MINERALS																			MINERALIZATION					ASSAYS	
		Rock Type	Type Mod	Colour Code	Quality Mineral	Texture	Grain Siz	Density	% Min	% Fault	QZ	ARGL	KA	MM	MS	KF	PP	DU	CB	ZE	CL	EP			.	HEM	MG	LI	PY	CP	MO	BN	PR		CU ASSAY	MO ASSAY
1–3	4–7	8–11	12	13–16	17	18–19	20	21	22	23	24–25	26–27	28–29	30–31	32–33	34–35	36–37	38–39	40–41	42–43	44–45	46–47	48–49	50–51	52–53	54–55	56–57	58–59	60–61	63–64	65–66	67–68	69–70	71–72	73–77	78–80

TABLE A-1

Coding Data for the Modified "GEOLOG" Sheet

1 2 3

INTERVAL

CNT	Contact
OVB	Overburden
CAP	Capping
SUP	Supergene
TRN	Transition
FLT	Fault
DYK	Dyke
FRX	Fresh Rocks
REM	Remarks

8 9 10 11

ROCK TYPE

4 letter rock name from Table A-3

Open for local name characteristic etc.

13 14 15 16

COLOUR CODE

13

SHADE

-	No Comment
9	White
7	Light Gray
5	Medium Gray
3	Dark Gray
1	Black

14

BLEACHING

-	No comment
L	Lighter
N	Normal
D	Darker

15 16

COLOUR

R	Red(ish)
Ø	Orange(ish)
Y	Yellow(ish)
G	Green(ish)
B	Blue(ish)
P	Purple(ish)
T	Tan(Brownish)

17 18

DEFINING MINERAL

2 letter mineral code, if applicable (from Table)

19

TEXTURE OR STRUCTURE

1. IGNEOUS ROCK
   a. Porphyry

Groundmass Texture	Estimated % Phenocrysts 10%	10-40%	40-60%	60%
Phaneritic	1	2	3	4
Aphanitic	5	6	7	8

   b. Non Porphyritic

E	Equigranular	D	Diabasic
I	Inequigranular	V	Vesicular
H	Graphic	A	Amygdaloidal
#	Miarolitic	S	Spherulitic
Ø	Ophitic	P	Poikilitic

2.	SEDIMENTARY ROCK	3.	METAMORPHIC ROCK
L	Laminated	Q	Porphyroblastic
N	Thin Bedded	L	Lineated
U	Medium Bedded	F	Foliated
K	Thick Bedded	G	Granulose
XX	Cross Bedded	Y	Slaty
B	Bioclastic	M	Migmatic
F	Fissile	J	Spare
T	Clastic	Z	Spare
R	Oolitic		

20

GRAIN SIZE

Sediment		Igneous Rock (phenos if Pfy)
9	Boulder	Megapeg
8	Cobble	Peg
7		
-	Pebble	Coarse
6		Medium
5	Granule	
4		
-	Sand	
3		Fine Grained
2	Silt	Aphanitic
1	Clay	Glassy

21 22 23

FRACTURES

21

Fracture Density

L = low

A = above medium

F	= Fair	H	= high
M	= Medium	X	= Extreme

22 / 23

Percent with Sulphides/Percent with Fault Material

0	2.5 ± 2.5	5	50 ± 5
1	10 ± 5	6	60 ± 5
2	20 ± 5	7	70 ± 5
3	30 ± 5	8	80 ± 5
4	40 ± 5	9	90 ± 5

ALTERATION ASSEMBLAGES

24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60

Mode of Occurence

0	No Comment	5	Envelopes
1	Veins	6	Pervasive cut by Envelopes
2	Veins Envelopes	7	Pervasive cut by Veins
3	Veins = Envelopes	8	Pervasive replacement of one mineral
4	Veins Envelopes	9	Pervasive

25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57 59 61

Amount (Percent)

0	2.5 ± 2.5	5	50 ± 5
1	10 ± 5	6	60 ± 5
2	20 ± 5	7	70 ± 5
3	30 ± 5	8	80 ± 5
4	40 ± 5	9	90 ± 5

MINERALIZATION

63 65 67 69 71

Mode of Occurence

1	Veins	6	Moderate veinlets and disseminations

2	Veins, veinlets, fracture fillings and minor disseminations	7	Disseminations and some veinlets
3	Veins and some disseminations	8	Disseminations and minor veinlets
4	Veinlets and moderate disseminations	9	Disseminations
5	Veinlets = Disseminations		

64 66 68 70 72

Amount (Percent)

0	0	5	3 ± 1
1	$.13 \pm .13$	6	6 ± 2
2	$.37 \pm .13$	7	12 ± 4
3	$.75 \pm .25$	8	24 ± 8
4	$1.5 \pm .5$	9	More than 34

TABLE A-2

LETTER ROCK TYPE CODE

IGNEOUS ROCKS

General Types

dyke	- DYKE
igneous	- IGNS
plutonic	- PLNC
volcanic	- VLCC
porphyry	- PPRY

Dyke Rocks

alaskite*	- ALSK
aplite	- APLT
diabase (dolerite)	- DIAB
lamprophyre	- LAMP
pegmatite	- PEGM

Plutonic Rocks

alaskite*	- ALSK
breccia	- BRPL
diorite	- DRIT
gabbro	- GBBR
granite	- GRNT
granodiorite	- GRDR
monzonite	- MONZ
quartz diorite (tonalite)	- QZDR
quartz gabbro	- QZGB
quartz monzonite (adamelite)	- ZQMZ
syenite	- SYEN
trondhjemite	- TRDJ

Ultramafic Plutonic Rocks

anorthosite	- ANRS
dunite	- DNIT
hornblendite	- HBLD
norite	- NORT
peridotite	- PRDT
pyroxenite	- PRXN
serpentinite	- SRPN

Feldspathodial Plutonic Rocks

feldspathoidal diorite	- FDDR
feldspathoidal gabbro	- FDGB
feldspathoidal monzonite	- FDMZ
feldspathoidal syenite	- FDSY

Miscellaneous Plutonic

carbonatites	- CRBN

Volcanic Rocks

andesite	- ANDS
basalt	- BSLT
breccia	- BRVL
dacite	- DCIT
diabase (dolerite)	- DIAB
feldspathoidal andesite	- FDAN
feldspathoidal basalt	- FDBS
feldspathoidal latite	- FDLT
latite	- LTIT
phonolite	- PNLT
quartz basalt	- QZBS
quartz latite	- QZLT
rhyodacite	- RYDC
rhyolite	- RYLT
trachyte	- TRCT

METAMORPHIC ROCKS

Progressive Metamorphism

amphibolite	- AMPB
gneiss	- GNSS
granofels	- GRFL
granulite	- GRNL
greenschist	- GRSC
greenstone	- GRSN
lit-par-lit gneiss	- LTGN
migmatite	- MGMT
mixed gneiss	- MXGN
orthogneiss	- ORGS
paragneiss	- PRGS
phyllite	- PHYL
quartzite	- QZIT
schist	- SCHS
serpentine	- SRPN
slate	- SLTE

Contact Metamorphic Rocks

cale-silicate rock	- CLCC
hornfels	- HRFL
marble	- MRBL
pyroclasite	- PRCL
pyroxenite	- PRXN
skarn	- SKRN
tactite	- TCTT

TABLE A-2

LETTER ROCK TYPE CODE

CONTINUED

Cataclastic Metamorphic Rocks	
augen gneiss	- AUGN
cataclasite	- CCLS
mylonite	- MLNT
SEDIMENTARY ROCKS	
Detrital & Epiclastic Rocks	
argillite	- ARGL
arkose	- ARKS
breccia	- BRCC
claystone	- CLSN
conglomerate	- CGLM
greywacke	- GRWK
mudstone	- MDSN
quartzose sandstone	- QZSS
sandstone	- SNDS
shale	- SHLE
siltstone	- SLSN
Chemical-biogenic Rocks	
carbonaceous rocks	- CRBC
chert	- CHRT
clastic limestone	- CLLS
coquina	- COQN
dolomite	- DOLM
evaporite	- EVPR
ironstone	- IRNS
limestone	- LSTN
oolitic limestone	- OOLS
phosphorite	- PSPR
Pyroclastic Rocks	
agglomerate	- AGLM
breccia	- BRPC
ignimbrite	- IGMB
tuff	- TUFF
BRECCIAS, Unspecified Origin	
Undivided	- BRXX
Mainly Angular Fragments	- BRA
Mainly Rounded Fragments	- BRR
- with 4th character 0-9, giving % of matrix to total rock	

APPENDIX B

DATA PROCESSING

The computer program described in Blanchet and Godwin's (1973) paper was not used in the treatment of data from Island Copper. The object of this study was to relate hydrothermal alteration to ore rather than to build a basic geologic picture of the deposit, which the Blanchet system was designed to achieve. Data from each cross-section were divided into three portions: hanging wall, dyke and footwall, to obtain the maximum amount of spatial data from the core.

Data selected as amenable to computer processing are: grayness, bleaching, fracture density, amount of the twelve alteration minerals and copper and molybdenum grades.

Quantity of all variable, except grades, was recorded using a semi-quantitative scale. On reflection, it was considered to be closer to ordinal data than to interval data and was treated accordingly. Grade values are interval data.

Data processing was done at UBC Computing Centre using library program UBC-CORR programed by A. Floyd and J.H. Bjerring (1969). This program is designed to compute correlations between different pairs of variables and to perform significance tests of the results. The program can handle nominal, ordinal and interval variables and will calculate correlations between variables of the same or different sizes.

The correlation between copper grade and molybdenum grade, both interval variable, use the standard Pearson's Coefficient of Correlation (Pearson's r). The significance is determined by an F-test of the significance of "R".

Correlations between grades and other variables are mixed correlations between interval and ordinal data and the statistical test used is Jaspen's Coefficient of Multiserial Correlation. This uncommon test is described by Freeman (1965). Once again, the significance of the correlations is determined by F-tests.

"Listing" of a typical input

```
********************************** LISTING **********************************

$LIST

*****************************************************************************

$SIGNON CARG T=100 P=20 C=0
CARG
$RUN *WATFIV 6=-TDATA
$COMPILE
      DIMENSION X(20),XX(20)
      DATA BLANK/' '/
    5 READ(5,1,END=2)X,XX
    1 FORMAT(12X,F1.0,3X,F1.0,4X,F1.0,1X,2(1X,F1.0),4X,8(1X,F1.0),6X,2(1
     1X,F1.0),2X,F1.0,F1.0,1X,F1.0,10X,F3.2,1X,F3.3,T1,12X,A1,3X,A1,4X,A
     21,1X,2(1X,A1),4X,8(1X,A1),6X,2(1X,A1),2X,A1,A1,1X,A1,10X,A3,1X,A3)
      DO 3 I=4,15
      IF(XX(I).NE.BLANK) X(I) = X(I) +1.0
    3  X(I)=X(I)+1.0
      WRITE (6,13) (X(I),I=1,20)
      GO TO 5
   13   FORMAT(1X,18F3.0,F6.2,F6.3)
    2 CONTINUE
      STOP
      END
$DATA
       60ZMZ 9N  5 24L1 9481              91  81            93 93        15 005
      120ZMZ 9N  5 24L1 92            10  91  82            73 91        21 007
      240ZMZ 9N  5 24L1 92            10  91  82            73 91        15 011
      330ZMZ 9N  5 24F2 1282                  71            94 91        18 004
      410ZMZ 9N  5 24M3 9182                  81            94 90        19 004
      560ZMZ 9N  5 24L1 9182                  81            93           47 005
      610ZMZ 9N  5 24L1 72            10      81            93           16 015
      720ZMZ 7L  9 25L1 7382          10      10            95           25 014
      820ZMZ 7L  9 25L1 9881                                92 92        21 004
      940ZMZ 7L  9 25L1 82                    80            94 91        21 004
     1000ZMZ 7L  9 25L1 97                    82            55 1210      21 004
     1023RXX 7L  9 25L1 7693                  90            96 9210      70 014
     1053RXX 7L  9 25L1 98            10      91            55 51        70 014
     115ANDS 3NG 5 25L1 90            10      10      9290     91        45 010
     121ANDS 3NG 5   L1 71            11  92            90  72 91        47 026
     135ANDS 3NG 5   L1 92      81    10                    95 94        68 025
     143ANDS 3NG 5  3L1 75                92          9291  54 93        52 016
     1500ZMZ 7N  5 24L1   80                  90            55 34        52 016
     1510ZMZ 7N  5 24L1 7181          10      91            95 11        31 007
     1630ZMZ 7N  9 24L1 94                              91  94 93        40 007
     1780ZMZ 7N  9 2443 9371                  91            94 92        50 007
     1880ZMZ 9L  9 2443 7183                  90            92           26 006
     1900ZMZ 9L  9 2443 7182                  90            94           26 005
     2050ZMZ 9L  9 2443 7183                  10            23           19 005
     2140ZMZ 9L  9 2443 7183          10                    95           52 008
     2240ZMZ 9L  9 2443 7183          10      10            95 92        27 009
     2500ZMZ 9L  9   43 7183                  11            75 11        55 016
     2410ZMZ 9L  9   A4 7332                                             44 015
     2550ZMZ 9L  9   A4 7333                  10            95           12 028
     2640ZMZ 9L  9   A4 7383          10      10            92 91        05 038
     2730ZMZ 9L  9   A4 7483          10      10            94 93        10 011
```

157.

52	282JZMZ 9L	9 24A4 9283							55 93	22 052
53	291JZMZ 9L	9 24M3 9582							55 9391	74 021
54	302JZMZ 9L	9 24M3 7584					10		95 93	59 047
55	312BRXX 9L	9 24M3 76				10			97 93	22 009
56	322JZMZ 9L	9 24M3 9583				10			94	34 015
57	333JZMZ 9L	9 24M3							93 94	33 011
58	344JZMZ 9L	9 24M3 7183			10		81		95 93	37 009
59	353JZMZ 9L	9 24M3 9584					80		94	37 [illegible]
60	300ZMZ19L	9 24 1 9693							93	04 [illegible]
61	400ZMZ19LO	9 24 1 9594					10		93 91	05 014
62	500ZMZ19L	9 24 1 9593		91			10		94	01 004
63	560ZMZ19L	9 24 1 9593		91			10		94	03 011
64	630ZMZ19L	9 24 1 9594		90			10		94	03 011
65	700ZMZ19L	9 24 1 9594		90			10		93	13 004
66	733RVL35L	9 1 96				91			94 91	10 007
67	803RVL35L	9 1 72				92	91	91	95 92	10 007
68	903RVL35NG	5 1 74			11	93			94 91	08 [illegible]
69	953RVL35NG	5 1 74			11	93			94 91	07 [illegible]
70	1003RVL37LG	9 1 91			11	94	1093		94 91	07 [illegible]
71	1033RVL37LG	9 1 91			11	94	1073		94 91	04 011
72	107JZMZ17L	9 1 9594			11				95	04 011
73	110JZMZ17LO	9 1 9592			11		11		95	04 011
74	112JZMZ17LO	9 1 9692			11		11		95	04 005
75	120JZMZ17LG	9 1 7591	92		11				95	04 005
76	1253RVL37LG	9 1 7591	92		11				95	03 [illegible]
77	1303ROM17LG	0 1 9493		90					95	03 005
78	140JZMZ17LG	9 1 9493	90	91					94	01 007
79	150JZMZ17LG	9 24 1 9484							94	01 006
80	160BROM17LO	9 24 1 9584		9090			11		74	05 004
81	170BROM17LG	9 24 1 9583		90		90	11		94 91	11 004
82	180BROM17LT	9 24 1 9483		92			11		94 91	02 [illegible]
83	190BROM17LT5	9 24 1 7384		92			10		94	06 010
84	200BRXX27LG	9 3 1 7482		92	10		10		94	03 011
85	204JZMZ17L	9 34 1 7582		919010					92	03 006
86	206BROM17L	9 34 1 7582		91	10		11		92	03 006
87	210JZMZ17L	9 34 1 7582		919010					92	03 006
88	220JZMZ17LG	9 24 1 9444		90					93	05 006
89	223JZMZ17LG	9 24 1 9484		90					93	12 007
90	20JZMZ99L	9 24 1 7483							91 91	01 005
91	30BROM99L	9 24 1 7493							52 91	03 004
92	40JZMZ55NO	5 24 1 9482					8092		94 90	09 007
93	50JZMZ55NO	5 24 1 9482					8012		92 92	12 004
94	603RVL95LO	7 3 1 7542				90	80129291			11 007
95	70ANDS55NG	5 F3 1 9281				92	90	9291	94 91	03 [illegible]
96	74ANDS55NG	5 F3 1 9281				92	90	9291	94 91	10 007
97	80ANDS97LO	9 F4 1 7282						9391	74 91	16 007
98	90BRVL97L	9 3 2 9394					109190		95 91	08 006
99	100BROM97L	9 24 6 9282		92		90			92 91	01 006
100	110BRXX97LT	9 4 9492		93		90			92	01 014
101	120BRXX97LT	9 2 9292		95		90			74 92	11 017
102	123BRXX97LT	9 1 9292		95		90			94 92	21 006
103	130BRXX55NO	5 1 7392				90	73		75 95	21 [illegible]
104	140BRXX99L	9 3 7494	90	90					93 90	05 014
105	150BRXX99LT	9 3 7493	90	91		90			95 91	12 015
106	160BRXX97L	9 3 3 7393							95 93	1[illegible] 012
107	170BRXX97L	9 3 3 9594							93 90	01 [illegible]
108	180BRVL97LO	9 3 5 93					109291		74 91	25 012
109	190BRVL97LO	9 1 73				10	109391		74 93	13 009
110	195BRVL55NG	5 1 12				91	100292		74 95	21 014
111	200JZMZ55N	5 24 1 9781	81				10		95 92	21 [illegible]

112	208JZMZ55N	5	24	1	9781	81				10		95 92	25 038
113	217BRXX55NU	5	24	4	93					13		95 93	34 038
114	230JZMZ97L	9	24	1	9283							54 91	28 012
115	240BRXX55NU	5		1	11					109571		93 92	26 012
116	250JZMZ55NG	5	24	1	9730	81				10		94 91	34 037
117	251JJUJ97LG	9		4	39								29 010
118	270BRQM55NG	5	24	3	9182					10		94	62 013
119	280JV 99L	9		3	79								27 016
120	27JBRVL55NG	5		3	9180					10	91	94 9390	45 012
121	300BRXX97LG	9	3	4	9194					8110		93 91	41 025
122	310BRVL55NU	5		1	9191			11	92	109390		92 93	56 017
123	320BRVL55N0G	5		3	7281				81	109251		93 12	37 016
124	329JV 99C	9		1	99								57 020
125	336ANDS55NU	5		1	73					14		95 92	69 056
126	343BRXX55NT	5		5	7180		97			10		91	15 031
127	357BRQM55NG	5		1	9582					8110		92 91	29 023
128	346JZMZ 7L	9	24M3		9483			10			11	95 93	45 039
129	354ANDS 7LR	9		3M3	7292			10		11	91	55 54	35 011
130	351ANDS 7LR	9		3M3	7292			10		11	9191	55 54	3. 038
131	356ANDS 7L	9		3M3	7393			10		10		55 54	33 019
132	358JZMZ 7NU	5	2443		9382			10		11	11	35 34	33 010
133	371BRQM 5N	5	24		7381			10		82	91	44 34	45 015
134	380JZMZ 7L	9	4		7494			10		11	91	54 34	40 016
135	385BRQM 5N	5			7395			10		90	90	75 23	30 010
136	393BRQM 5NT	6	3		7395			10		10	9190	55 23	27 043
137	405JZMZ 5N	5			74			10	10	10	90	56 92	15 065
138	413BRQM 7L	9			7532			10		10	91	25 93	37 011
139	415BRVL 5NG	5			73			10		90	9090	34 33	40 006
140	425BRQM 7L	9	24		7533			10			90	85 83	24 012
141	435BRQM 7L	9	24		7533			10		90	90	75 5511	56 019
142	442BRQM 5N	5	24		9581					10	1090	26 54	44 026
143	450BRQM 7L	9	24		9582							86 53	46 015
144	460BRVL 5L	9			7584			10		10		45 43	31 028
145	470BRQM 5L	9	3		9584			10		10	9090	55 53	26 013
146	480BRXX 7L	9	24		7533			10		10	90	55 33	34 020
147	483BRXX 7L	9	24		7533			10		10	9091	55 33	34 019
148	490BRQM 7L	9	24		7534			10		10		55 33	34 010
149	500JZMZ 7L	9	24		7233	80		10		10		55 92	14 012
150	510JZMZ 7L	9	24		7383	80		10		10		75 53	37 020
151	520JZMZ 7L	9	24		7483	80		10		10		75 53	28 013
152	530JZMZ 7L	9	24		7333			10				35 53	33 015
153	540JZMZ 7L	9	24		7383			10				55 53	36 012
154	545JZMZ 7L	9	24		7383			10		10		55 5391	24 012
155	550JZMZ 7L	9	24		7383			10				9055	24 012
156	560JZMZ 7L	9	24		7333					10	90	94	16 017
157	570JZMZ 7L	9	24		9582	80				10		95 93	32 010
158	580JZMZ 7LO	9	24		9581	81				10	90	95 94	57 019
159	590BRQM 7L	9	24		7583	80						95 9392	33 023
160	600BRQM 7L	9	24		7484	80		10		10		96 94	44 030
161	610BRQM 7L	9	24		7584	81		10		10		95 94	57 019
162	620JZMZ 7L	9	24		7682			10				26 25	36 035
163	630JZMZ 7L	9	24		7534							24 23	55 021
164	635ANDS 5N	5	3		97			10		91	92	94	56 018
165	640JZMZ 5N	5	24		97			10		91	91	91 94	66 018
166	650ANDS 3D	1	3		9781				90		9191	55 54	53 017
167	655ANDS 3D	1	3		97			10	90		9191	92 96	106 017
168	658JZMZ 5N	5	24		93	82						91 54	100 017
169	663JZMZ 5N	5	24		93	82		10		92	90	91 92	33 015
170	665JZMZ 5N	5	24		93	82		10	90		90	94 91	33 015
171	675ANDS 5N	5	24		95				91		93	95 94	70 017

```
      530JZMZ 5N  5 24   9580                 91                    54 92        70 019
      685JZMZ 5NJ 5 24   9332   80      10         11               74 93        56 024
      871JZMZ 5NU 5 24   9280           10         82     91        74 94        105 051
      595JZMZ 5N  5 24   9280           10         82     90        93 95        105 051
      700ANDS 30  1  3   94                               9090      93 55        105 031
      705JZMZ 5N  5 24   9331                                       56 54        60 041
      710ANDS 5NG 5        82                 92          92        53 52        60 041
      720JZMZ 5N  5 24   9381   81      10    90                    12 13        38 017
      730JZMZ 5N  5 24   9331   80      10    80                    94 72        21 020
      740JZMZ 5N  5 24   9381           10         82     11        95 93        53 004
      750JZMZ 5N  5 24   9481           10         81               92 93        35 005
      760JZMZ 5N  5 24   9580           10         82     90        93 92        21 012
      765BRVL 5N  5                     13    92                    92 91        23 019
      770JZMZ 5N  5 24   9281           10                          73 91        23 009
      780JZMZ 5N  5 24   9880                      82               92 9390      23 007
      790JZMZ 5N  5 24   9330                      80               92 9390      23 009
      800JZMZ 5N  5 24   9782           10                          92 91        14 007
      810JZMZ 5N  5 24   9782           10         82               92 93        21 009
      820BRDM 5N  5 24   9582                      81     9191      54 53        52 017
      824JZMZ 5NG 5 24   9182                 11                    93 92        54 019
      835BRVL 5NG 5 24   93             10    92          92        93 94        78 034
      840BRVL 5NG 5 24   1293   91                                  52 53        78 034
      850BRVL 30G 1      94             10    90          9211      73 54        78 035
      860BRVL 5NG 5      97             10    90                    34 54        52 030
      865BRVL 5NG 5      97             10    90          9092      34 54        36 030
      870JZ   5N  6      99             10                          92 93        38 050
      879JZ   5N  5      99             10                             9211      29 038
      883BRVL 70  1      95             10                93        91 53        58 045
      892BRXX 5LG 9      98             10    90                    93 92        31 033
      905BRVL 5LG 9      77             10    91          91        93 94        74 057
      914JZMZ 5NG 5 24   72     94      10    81                    93 54        87 05.
      924BRXX 5NG 5      7392   92      10                          93 92        120 050
      933BROM 5N  5 24   7491           10                90        34 55        105 050.
      937BROM 5NG 5 24   7491 . 91      10                          92 93        105 044
   $STOP
   $ENDFILE
   $RUN *CORR 3=-TDATA
    20 191111
    2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 4 4
    9 3 61111111111111111111111 9 9 9 0 0
       GRAYS  DK--LT  NO.FRA      QZ    ARGL       MS      KF       PP      OU      C8
          ZE       CL       EP      HEM     MAG PY-MODE      PY CP-MODE  CU-GRD  MD-GRD
   (1X,18F3.0,F6.2,F6.3)
       SECTION 171  -  DYKE COMPLEX
     4 201
   $SIGNOFF
 1.817 SEC. CPU TIME
20.273 SEC. ELAPSED TIME
```

Typical Computer Output

```
CATA XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

RES NO. 776157              UNIVERSITY OF B C COMPUTING CENTRE   MTS(CC141)            13:29:53    FRI DEC 17/71   163

******************** THIS JOB SUBMITTED THROUGH FRONT DESK READER ********************
$SIGNON CARG
**LAST SIGNON WAS: 13:27:57   FRI DEC 17/71
 USER "CARG" SIGNED ON AT  13:30:04 ON FRI DEC 17/71
$RUN *WATFIV 6=-IDATA
EXECUTION BEGINS
```

```
      $COMPILE
            DIMENSION X(17),XX(17)
            DATA BLANK/'    '/
      5     READ(5,1,END=2)X,XX
      1     FORMAT(12X,F1.0,3X,F1.0,4X,F1.0,1X,2(1X,F1.0),4X,8(1X,F1.0),6X,2(1
           1X,F1.0),16X,F3.2,1X,F3.3,T1,12X,A1,3X,A1,4X,A1,1X,2(1X,A1),4X,8(1X
           2,A1),6X,2(1X,A1),16X,A3,1X,A3)
            DO 3 I=4,15
            IF(XX(I).NE.BLANK) X(I) = X(I) +1.0
      3      X(I)=X(I)+1.0
            WRITE (6,13) (X(I),I=1,17)
            GO TO 5
      13     FORMAT(1X,15F4.0,F6.2,F6.3)
      2     CONTINUE
            STOP
            END

      $DATA

CORE USAGE      OBJECT CODE=      824 BYTES,ARRAY AREA=      136 BYTES,TOTAL AREA AVAILABLE=  102400  BYTES

COMPILE TIME=      0.14 SEC,EXECUTION TIME=      7.14 SEC,   WATFIV - VERSION 1 LEVEL 2 AUGUST  1970      DATE=  12-17-71
```

```
$STOP
EXECUTION TERMINATED


$RUN *CCFR 3=-TDATA
EXECUTION BEGINS
```

SECTION 163 -- HANGINGWALL VOLCANICS

DEPENDENT VARIABLE = CU-GRD TYPE = 4

KF; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
FP; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
CU; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE

VARIABLE	NUMBER OF OBSERVATIONS	VARIABLE TYPE	CORR CODE	CORRELATION	TEST CODE	PROB	
GRAYS	232	2	5	0.2382	6	0.0009	
CK--LT	233	2	5	0.2741	6	0.0002	
NO.FRA	233	2	5	-0.2540	6	0.0003	
QZ	233	2	5	0.5947	6	-0.0	
ABCL	233	2	5	0.1237	6	0.2718	
FS	233	2	5	0.0593	6	0.6665	
KF	233	2	5	0.0	6	0.0	INVALID
FP	233	2	5	0.0	6	0.0	INVALID
CU	233	2	5	0.0	6	0.0	INVALID
CB	233	2	5	-0.2184	6	0.0030	
ZE	233	2	5	-0.4087	6	0.0000	
CL	233	2	5	-0.1381	6	0.0518	
FP	233	2	5	-0.2090	6	0.0594	
HEM	233	2	5	0.1371	6	0.6052	
MAG	233	2	5	0.1802	6	0.0165	
MO-GRD	233	4	6	0.7295	7	-0.0	

DEPENDENT VARIABLE = MC-GRD TYPE = 4

KF; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
PP; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
CU; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE

VARIABLE	NUMBER OF OBSERVATIONS	VARIABLE TYPE	COEF CODE	CORRELATION	TEST CODE	PROB	
GRAYS	232	2	5	0.1729	6	0.0141	
DK--LT	233	2	5	0.2115	6	0.0040	
NO.FRA	233	2	5	-0.1285	6	0.0597	
CZ	233	2	5	0.5204	6	-0.0	
ARGL	233	2	5	0.0306	6	0.7769	
MS	233	2	5	-0.0406	6	0.7589	
KF	233	2	5	0.0	6	0.0	INVALID
PP	233	2	5	0.0	6	0.0	INVALID
CU	233	2	5	0.0	6	0.0	INVALID
CB	233	2	5	-0.0437	6	0.5626	
ZE	233	2	5	-0.2890	6	0.0009	
CL	233	2	5	-0.0575	6	0.4312	
FP	233	2	5	-0.1522	6	0.1725	
HEM	233	2	5	0.1162	6	0.6595	
MAG	233	2	5	0.2387	6	0.0017	
CU-GRD	233	4	6	0.7295	7	-0.0	

DICTIONARY OF CODES

CORRELATION CODES

1. GUTTMANS SYMMETRIC COEFFICIENT OF PREDICTABILITY (LAMDA)
2. KEEFMANS COEFFICIENT OF DETERMINATION (THETA)
3. GOODMANS AND KRUSKALS COEFFICIENT OF RANK ASSOCIATION (G)
4. CORRELATION RATIO (ETA)
5. JASPENS COEFFICIENT OF MULTISERIAL CORRELATION (M)
6. PEARSONS COEFFICIENT OF CORRELATION (R)

SIGNIFICANCE TEST CODES

1. PEARSONS CHI-SQUARED TEST WITH YATES CORRECTION
2. MANN-WHITNEY U-TEST
3. PEARSONS CHI-SQUARED TEST
4. SIGNIFICANCE TEST FOR G
5. ANALYSIS OF VARIANCE
6. F-TEST OF SIGNIFICANCE OF M
7. F-TEST OF SIGNIFICANCE OF R

STOP 0
EXECUTION TERMINATED

$SIGNOFF

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CNTR XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

RES NO. 776157              UNIVERSITY OF B C COMPUTING CENTRE   MTS(EC141)            13:29:53    FRI DEC 17/71


                        USER: CARG
                        DEPARTMENT: GEOL

                        **** ON AT  13:30:04
                        **** OFF AT 13:31:19
                        **** ELAPSED TIME         74.323  SEC.
                        **** CPU TIME USED        25.243  SEC.
                        **** STORAGE USED        971.786  PAGE-SEC.
                        **** CARDS READ          267
                        **** LINES PRINTED       126
                        **** PAGES PRINTED         7
                        **** CARDS PUNCHED         0
                        **** DRUM READS           97
                        **** RATE FACTOR           1.0
                        **** APPROX. COST OF THIS RUN  C$2.91

                        **** FILE STORAGE             PG-HR.     .00

                        **LAST SIGNON WAS: 13:27:57   12-17-71
```

APPENDIX C

STATISTICAL DATA FOR:

Section 195

Section 187

Section 179

Section 171

Section 163

Section 155

Section 147

SECTION 195 -- FOOTWALL VOLCANICS

DEPENDENT VARIABLE = CU-GRD TYPE = 4

KF; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE

VARIABLE	NUMBER OF OBSERVATIONS	VARIABLE TYPE	CORR CODE	CORRELATION	TEST CODE	PROB	
GRAYS	241	2	5	0.0592	6	0.4070	
DK--LT	245	2	5	-0.0075	6	0.8822	
NO.FRA	245	2	5	0.4162	6	-0.0	
QZ	245	2	5	0.2014	6	0.0021	
ARGL	245	2	5	-0.0082	6	0.8886	
MS	245	2	5	0.1316	6	0.1012	
KF	245	2	5	0.0	6	0.0	INVALID
PP	245	2	5	-0.2605	6	0.0890	
DU	245	2	5	-0.2324	6	0.3709	
CB	245	2	5	-0.0528	6	0.4546	
ZE	245	2	5	0.0648	6	0.4658	
CL	245	2	5	0.0338	6	0.6218	
EP	245	2	5	0.0360	6	0.7103	
HEM	245	2	5	-0.2164	6	0.5311	
MAG	245	2	5	0.1571	6	0.0430	
MO-GRD	245	4	6	0.5742	7	-0.0	

DEPENDENT VARIABLE = MC-GRD TYPE = 4

KF; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE

VARIABLE	NUMBER OF OBSERVATIONS	VARIABLE TYPE	CORR CODE	CORRELATION	TEST CODE	PROB	
GRAYS	241	2	5	0.0679	6	0.3388	
DK--LT	245	2	5	0.0144	6	0.8244	
NO.FRA	245	2	5	0.4360	6	-0.0	
QZ	245	2	5	0.2320	6	0.0005	
ARCL	245	2	5	0.1357	6	0.1229	
MS	245	2	5	0.2710	6	0.0009	
KF	245	2	5	0.0	6	0.0	INVALID
PP	245	2	5	-0.0225	6	0.8566	
DU	245	2	5	0.1468	6	0.5767	
CB	245	2	5	-0.2243	6	0.0013	
ZE	245	2	5	-0.0230	6	0.8221	
CL	245	2	5	-0.0624	6	0.3574	
EP	245	2	5	-0.1043	6	0.2814	
HEM	245	2	5	-0.2920	6	0.3936	
MAG	245	2	5	0.2106	6	0.0071	
CU-GRD	245	4	6	0.5742	7	-0.0	

SECTION 195 -- DYKE COMPLEX

DEPENDENT VARIABLE = CU-GRD TYPE = 4

KF; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
ZE; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
HEM; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE

VARIABLE	NUMBER OF OBSERVATIONS	VARIABLE TYPE	CORR. CODE	CORRELATION	TEST CODE	PROB	
GRAYS	169	2	5	0.1462	6	0.0890	
DK--LT	169	2	5	0.1749	6	0.0522	
NO.FRA	170	2	5	0.4953	6	-0.0	
QZ	170	2	5	0.5148	6	-0.0	
ARGL	170	2	5	-0.2836	6	0.0006	
MS	170	2	5	-0.2513	6	0.0076	
KF	170	2	5	0.0	6	0.0	INVALID
PP	170	2	5	-0.4505	6	0.0000	
DU	170	2	5	-0.3505	6	0.0002	
CB	170	2	5	0.4556	6	0.0000	
ZE	170	2	5	0.0	6	0.0	INVALID
CL	170	2	5	0.0150	6	0.8465	
EP	170	2	5	-0.1957	6	0.2797	
HEM	170	2	5	0.0	6	0.0	INVALID
MAG	170	2	5	0.9043	6	-0.0	
MO-GRD	170	4	6	0.8188	7	-0.0	

DEPENDENT VARIABLE = MU-GRD TYPE = 4

KF; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
ZE; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
HEM; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE

VARIABLE	NUMBER OF OBSERVATIONS	VARIABLE TYPE	CORR CODE	CORRELATION	TEST CODE	PROB	
GRAYS	169	2	5	0.0313	6	0.7193	
DK--LT	169	2	5	0.0849	6	0.3568	
NO.FFA	170	2	5	0.5101	6	-0.0	
QZ	170	2	5	0.4638	6	0.0000	
ARGL	170	2	5	-0.3444	6	0.0000	
MS	170	2	5	-0.1895	6	0.0428	
KF	170	2	5	0.0	6	0.0	INVALID
PP	170	2	5	-0.4565	6	0.0000	
DU	170	2	5	-0.3694	6	0.0001	
CB	170	2	5	0.4760	6	0.0000	
ZE	170	2	5	0.0	6	0.0	INVALID
CL	170	2	5	0.0117	6	0.8682	
FP	170	2	5	-0.2374	6	0.1861	
HEM	170	2	5	0.0	6	0.0	INVALID
MAG	170	2	5	0.7693	6	-0.0	
CU-GRD	170	4	6	0.8188	7	-0.0	

SECTION 195 -- HANGINGWALL VOLCANICS

DEPENDENT VARIABLE = CU-GRD TYPE = 4

KF; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
HEM; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE

VARIABLE	NUMBER OF OBSERVATIONS	VARIABLE TYPE	CORR CODE	CORRELATION	TEST CODE	PROB	
GRAYS	84	2	5	-0.1511	6	0.2318	
DK--LT	86	2	5	-0.2295	6	0.0881	
NO.FRA	86	2	5	0.0595	6	0.6145	
QZ	86	2	5	-0.0668	6	0.5914	
ARGL	86	2	5	-0.2082	6	0.0930	
MS	86	2	5	-0.0215	6	0.8357	
KF	86	2	5	0.0	6	0.0	INVALID
PP	86	2	5	-0.2816	6	0.0546	
BU	86	2	5	-0.1744	6	0.5676	
CR	86	2	5	0.2251	6	0.0525	
ZE	86	2	5	-0.2332	6	0.1574	
CL	86	2	5	0.2862	6	0.0134	
FP	86	2	5	-0.2160	6	0.1497	
HEM	86	2	5	0.0	6	0.0	INVALID
MAG	86	2	5	0.1353	6	0.3148	
MO-GRD	86	4	6	0.4668	7	0.0000	

DEPENDENT VARIABLE = MO-GRD TYPE = 4

KF: OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
HEM: OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE

VARIABLE	NUMBER OF OBSERVATIONS	VARIABLE TYPE	CORR CODE	CORRELATION	TEST CODE	PROB	
GRAYS	84	2	5	0.0891	6	0.4906	
DK--LT	86	2	5	0.1089	6	0.4324	
NO.FRA	86	2	5	0.4288	6	0.0002	
CZ	86	2	5	0.0696	6	0.5760	
ARGL	86	2	5	0.1355	6	0.2822	
MS	86	2	5	0.0748	6	0.5406	
KF	86	2	5	0.0	6	0.0	INVALID
PP	86	2	5	0.2461	6	0.0939	
CU	86	2	5	-0.1124	6	0.7075	
CB	86	2	5	-0.1246	6	0.2929	
ZE	86	2	5	-0.2761	6	0.0923	
CL	86	2	5	-0.1297	6	0.2715	
EP	86	2	5	-0.2966	6	0.0462	
HEM	86	2	5	0.0	6	0.0	INVALID
MAG	86	2	5	-0.1896	6	0.1527	
CU-GRD	86	4	6	0.4668	7	0.0000	

SECTION 187 -- FOOTWALL VOLCANICS

DEPENDENT VARIABLE = CU-GRD TYPE = 4

MS; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
KF; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
PP; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
DU; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
HEM; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
MO-GRD; NO OBSERVATIONS

VARIABLE	NUMBER OF OBSERVATIONS	VARIABLE TYPE	CORR CODE	CORRELATION	TEST CODE	PROB	
GRAYS	28	2	5	0.1737	6	0.4883	
DK--LT	28	2	5	0.2809	6	0.2213	
NO.FRA	28	2	5	-0.2056	6	0.3516	
CZ	28	2	5	-0.2428	6	0.3360	
APGL	28	2	5	-0.4067	6	0.3848	
MS	28	2	5	0.0	6	0.0	INVALID
KF	28	2	5	0.0	6	0.0	INVALID
PP	28	2	5	0.0	6	0.0	INVALID
DU	28	2	5	0.0	6	0.0	INVALID
CB	28	2	5	0.2225	6	0.2877	
ZE	28	2	5	-0.4504	6	0.0318	
CL	28	2	5	0.0097	6	0.9155	
FP	28	2	5	-0.6968	6	0.0015	
HEM	28	2	5	0.0	6	0.0	INVALID
MAG	28	2	5	0.0417	6	0.8329	
MO-GRD	0	4	0	0.0	0	0.0	INVALID

DEPENDENT VARIABLE = MO-GRD TYPE = 4

GRAYS; NO OBSERVATIONS
DK--LT; NO OBSERVATIONS
NO.FRA; NO OBSERVATIONS
QZ; NO OBSERVATIONS
ARGL; NO OBSERVATIONS
MS; NO OBSERVATIONS
KF; NO OBSERVATIONS
PP; NO OBSERVATIONS
DU; NO OBSERVATIONS
CB; NO OBSERVATIONS
ZE; NO OBSERVATIONS
CL; NO OBSERVATIONS
FP; NO OBSERVATIONS
HEM; NO OBSERVATIONS
MAG; NO OBSERVATIONS
CU-GRD; NO OBSERVATIONS

VARIABLE	NUMBER OF OBSERVATIONS	VARIABLE TYPE	CORR CODE	CORRELATION	TEST CODE	PROB	
GRAYS	0	2	0	0.0	0	0.0	INVALID
DK--LT	0	2	0	0.0	0	0.0	INVALID
NO.FRA	0	2	0	0.0	0	0.0	INVALID
QZ	0	2	0	0.0	0	0.0	INVALID
ARGL	0	2	0	0.0	0	0.0	INVALID
MS	0	2	0	0.0	0	0.0	INVALID
KF	0	2	0	0.0	0	0.0	INVALID
PP	0	2	0	0.0	0	0.0	INVALID
DU	0	2	0	0.0	0	0.0	INVALID
CB	0	2	0	0.0	0	0.0	INVALID
ZE	0	2	0	0.0	0	0.0	INVALID
CL	0	2	0	0.0	0	0.0	INVALID
FP	0	2	0	0.0	0	0.0	INVALID
HEM	0	2	0	0.0	0	0.0	INVALID
MAG	0	2	0	0.0	0	0.0	INVALID
CU-GRD	0	4	0	0.0	0	0.0	INVALID

SECTION 187 -- DYKE COMPLEX

DEPENDENT VARIABLE = CU-GRD TYPE = 4

MO-GRD; NO OBSERVATIONS

VARIABLE	NUMBER OF OBSERVATIONS	VARIABLE TYPE	CORR CODE	CORRELATION	TEST CODE	PROB	
GRAYS	117	2	5	-0.2235	6	0.0323	
DK--LT	117	2	5	-0.2395	6	0.0252	
NO.FRA	117	2	5	0.0495	6	0.6342	
QZ	117	2	5	0.5800	6	-0.0	
ARGL	117	2	5	-0.4704	6	0.0000	
MS	117	2	5	-0.6069	6	0.0000	
KF	117	2	5	-0.0466	6	0.8173	
PP	117	2	5	-0.7709	6	-0.0	
DU	117	2	5	-0.7636	6	-0.0	
CB	117	2	5	0.5529	6	-0.0	
ZE	117	2	5	0.2653	6	0.1702	
CL	117	2	5	0.3110	6	0.0016	
EP	117	2	5	0.4162	6	0.0009	
FEM	117	2	5	-0.1383	6	0.5126	
MAG	117	2	5	0.3634	6	0.0023	
MO-GRD	0	4	0	0.0	0	0.0	INVALID

DEPENDENT VARIABLE = MO-GRD TYPE = 4

GRAYS; NO OBSERVATIONS
DK--LT; NO OBSERVATIONS
NO.FRA; NO OBSERVATIONS
QZ; NO OBSERVATIONS
ARGL; NO OBSERVATIONS
MS; NO OBSERVATIONS
KF; NO OBSERVATIONS
PP; NO OBSERVATIONS
DU; NO OBSERVATIONS
CB; NO OBSERVATIONS
ZE; NO OBSERVATIONS
CL; NO OBSERVATIONS
EP; NO OBSERVATIONS
HEM; NO OBSERVATIONS
MAG; NO OBSERVATIONS
CU-GRD; NO OBSERVATIONS

VARIABLE	NUMBER OF OBSERVATIONS	VARIABLE TYPE	CORR CODE	CORRELATION	TEST CODE	PROB	
GRAYS	0	2	0	0.0	0	0.0	INVALID
DK--LT	0	2	0	0.0	0	0.0	INVALID
NO.FRA	0	2	0	0.0	0	0.0	INVALID
QZ	0	2	0	0.0	0	0.0	INVALID
ARGL	0	2	0	0.0	0	0.0	INVALID
MS	0	2	0	0.0	0	0.0	INVALID
KF	0	2	0	0.0	0	0.0	INVALID
PP	0	2	0	0.0	0	0.0	INVALID
DU	0	2	0	0.0	0	0.0	INVALID
CB	0	2	0	0.0	0	0.0	INVALID
ZE	0	2	0	0.0	0	0.0	INVALID
CL	0	2	0	0.0	0	0.0	INVALID
EP	0	2	0	0.0	0	0.0	INVALID
HEM	0	2	0	0.0	0	0.0	INVALID
MAG	0	2	0	0.0	0	0.0	INVALID
CU-GRD	0	4	0	0.0	0	0.0	INVALID

SECTION 187 -- HANGINGWALL VOLCANICS

DEPENDENT VARIABLE = CU-GRD TYPE = 4

VARIABLE	NUMBER OF OBSERVATIONS	VARIABLE TYPE	CORR CODE	CORRELATION	TEST CODE	PROB
GRAYS	492	2	5	-0.1145	6	0.0176
DK--LT	498	2	5	-0.0768	6	0.1304
NO.FRA	498	2	5	0.1830	6	0.0002
QZ	498	2	5	0.3375	6	-0.0
AR CL	498	2	5	-0.2807	6	0.0000
MS	498	2	5	-0.1592	6	0.0107
KF	498	2	5	0.2264	6	0.2103
PP	498	2	5	-0.2943	6	0.0006
DU	498	2	5	-0.2216	6	0.4900
CB	498	2	5	0.1435	6	0.0044
ZE	498	2	5	-0.0468	6	0.6228
CL	498	2	5	0.1869	6	0.0001
EP	498	2	5	-0.2756	6	0.0000
HEM	498	2	5	-0.1372	6	0.3531
MAG	498	2	5	0.1366	6	0.0110
MU-GRD	296	4	6	0.4886	7	-0.0

DEPENDENT VARIABLE = MO-GRD TYPE = 4

VARIABLE	NUMBER OF OBSERVATIONS	VARIABLE TYPE	CORR CODE	CORRELATION	TEST CODE	PROB
GRAYS	290	2	5	0.0277	6	0.6691
DK--LT	296	2	5	0.1342	6	0.0405
NO.FRA	296	2	5	0.3199	6	0.0000
QZ	296	2	5	0.3425	6	0.0000
ARGL	296	2	5	-0.0973	6	0.2120
MS	296	2	5	-0.1127	6	0.2147
KF	296	2	5	0.7352	6	0.0002
PP	296	2	5	-0.2067	6	0.0611
DU	296	2	5	-0.1537	6	0.6488
CB	296	2	5	0.0659	6	0.3146
ZE	296	2	5	0.1304	6	0.4134
CL	296	2	5	0.1137	6	0.0627
EP	296	2	5	-0.2838	6	0.0038
HEM	296	2	5	-0.1855	6	0.2657
MAG	296	2	5	0.1529	6	0.0277
CU-GRD	296	4	6	0.4886	7	-0.0

SECTION 179 -- FOOTWALL VOLCANICS

DEPENDENT VARIABLE = CU-GRD TYPE = 4

DK--LT; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
MS; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
KF; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
PP; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
DU; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
HEM; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
MO-GRD; NO OBSERVATIONS

VARIABLE	NUMBER OF OBSERVATIONS	VARIABLE TYPE	CORR CODE	CORRELATION	TEST CODE	PROB	
GRAYS	39	2	5	0.5028	6	0.0022	
? → DK--LT	6	2	5	0.0	6	0.0	INVALID
NO.FRA	39	2	5	-0.6044	6	0.0005	
QZ	39	2	5	0.5851	6	0.0005	
ARGL	39	2	5	0.8211	6	0.0001	
MS	39	2	5	0.0	6	0.0	INVALID
KF	39	2	5	0.0	6	0.0	INVALID
PP	39	2	5	0.0	6	0.0	INVALID
DU	39	2	5	0.0	6	0.0	INVALID
CB	39	2	5	-0.3083	6	0.0855	
ZE	39	2	5	-0.1031	6	0.5664	
CL	39	2	5	-0.6127	6	0.0001	
EP	39	2	5	-0.6307	6	0.0010	
HEM	39	2	5	0.0	6	0.0	INVALID
MAG	39	2	5	0.1237	6	0.5565	
MO-GRD	0	4	0	0.0	0	0.0	INVALID

DEPENDENT VARIABLE = MC-GRD TYPE = 4

GRAYS; NO OBSERVATIONS
DK--LT; NO OBSERVATIONS
NO.FRA; NO OBSERVATIONS
QZ; NO OBSERVATIONS
ARGL; NO OBSERVATIONS
MS; NO OBSERVATIONS
KF; NO OBSERVATIONS
PP; NO OBSERVATIONS
DU; NO OBSERVATIONS
CB; NO OBSERVATIONS
ZE; NO OBSERVATIONS
CL; NO OBSERVATIONS
EP; NO OBSERVATIONS
HEM; NO OBSERVATIONS
MAG; NO OBSERVATIONS
CU-GRD; NO OBSERVATIONS

VARIABLE	NUMBER OF OBSERVATIONS	VARIABLE TYPE	CORR CODE	CORRELATION	TEST CODE	PROB	
GRAYS	0	2	0	0.0	0	0.0	INVALID
DK--LT	0	2	0	0.0	0	0.0	INVALID
NO.FRA	0	2	0	0.0	0	0.0	INVALID
QZ	0	2	0	0.0	0	0.0	INVALID
ARGL	0	2	0	0.0	0	0.0	INVALID
MS	0	2	0	0.0	0	0.0	INVALID
KF	0	2	0	0.0	0	0.0	INVALID
PP	0	2	0	0.0	0	0.0	INVALID
DU	0	2	0	0.0	0	0.0	INVALID
CB	0	2	0	0.0	0	0.0	INVALID
ZE	0	2	0	0.0	0	0.0	INVALID
CL	0	2	0	0.0	0	0.0	INVALID
EP	0	2	0	0.0	0	0.0	INVALID
HEM	0	2	0	0.0	0	0.0	INVALID
MAG	0	2	0	0.0	0	0.0	INVALID
CU-GRD	0	4	0	0.0	0	0.0	INVALID

SECTICN 179 -- DYKE COMPLEX

DEPENDENT VARIABLE = CU-GRD TYPE = 4

DK--LT; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
KF; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
DU; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE

VARIABLE	NUMBER OF OBSERVATIONS	VARIABLE TYPE	CORR CODE	CORRELATION	TEST CODE	PROB	
GRAYS	337	2	5	0.0734	6	0.2003	
DK--LT	52	2	5	0.0	6	0.0	INVALID
NO.FRA	308	2	5	0.2275	6	0.0002	
QZ	338	2	5	0.4227	6	-0.0	
ARGL	338	2	5	-0.0941	6	0.2634	
MS	338	2	5	-0.2942	6	0.0107	
KF	338	2	5	0.0	6	0.0	INVALID
PP	338	2	5	-0.2574	6	0.4385	
DU	338	2	5	0.0	6	0.0	INVALID
CB	338	2	5	0.0138	6	0.8024	
ZE	338	2	5	-0.2460	6	0.0032	
CL	338	2	5	-0.2473	6	0.0000	
EP	338	2	5	-0.3847	6	0.0000	
HEM	338	2	5	-0.1455	6	0.1431	
MAG	338	2	5	-0.1593	6	0.0089	
MO-GRD	336	4	6	0.5625	7	-0.0	

DEPENDENT VARIABLE = MO-GRD TYPE = 4

DK--LT; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
KF; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
DU; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE

VARIABLE	NUMBER OF OBSERVATIONS	VARIABLE TYPE	CORR CODE	CORRELATION	TEST CODE	PROB	
GRAYS	336	2	5	-0.0475	6	0.4166	
DK--LT	52	2	5	0.0	6	0.0	INVALID
NO.FPA	307	2	5	0.2085	6	0.0005	
QZ	337	2	5	0.2811	6	0.0000	
ARGL	337	2	5	-0.1815	6	0.0292	
MS	337	2	5	-0.2307	6	0.0487	
KF	337	2	5	0.0	6	0.0	INVALID
PP	337	2	5	-0.2011	6	0.5474	
DU	337	2	5	0.0	6	0.0	INVALID
CB	337	2	5	-0.0289	6	0.6335	
ZE	337	2	5	-0.2235	6	0.0072	
CL	337	2	5	-0.1465	6	0.0118	
EP	337	2	5	-0.3316	6	0.0002	
HEM	337	2	5	0.0734	6	0.4724	
MAG	337	2	5	0.0742	6	0.2247	
CU-GRD	336	4	6	0.5625	7	-0.0	

SECTION 179 -- HANGINGWALL VOLCANICS

DEPENDENT VARIABLE = CU-GRD TYPE = 4

DK--LT; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
KF; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE

VARIABLE	NUMBER OF OBSERVATIONS	VARIABLE TYPE	CORR CODE	CORRELATION	TEST CODE	PROB	
GRAYS	271	2	5	-0.2984	6	0.0000	
DK--LT	63	2	5	0.0	6	0.0	INVALID
NO.FRA	202	2	5	0.0003	6	0.9449	
QZ	272	2	5	0.2751	6	0.0000	
ARGL	272	2	5	-0.4412	6	-0.0	
MS	272	2	5	-0.2450	6	0.0112	
KF	272	2	5	0.0	6	0.0	INVALID
PP	272	2	5	-0.3381	6	0.1805	
DU	272	2	5	-0.3839	6	0.1282	
CB	272	2	5	0.4200	6	-0.0	
ZE	272	2	5	0.1429	6	0.2448	
CL	272	2	5	0.1811	6	0.0055	
EP	272	2	5	-0.1221	6	0.3753	
HEM	272	2	5	0.0910	6	0.6481	
MAG	272	2	5	0.1535	6	0.0291	
MO-GRD	228	4	6	0.5097	7	-0.0	

DEPENDENT VARIABLE = MO-GRD TYPE = 4

DK--LT; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
KF; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
PP; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
DU; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE

VARIABLE	NUMBER OF OBSERVATIONS	VARIABLE TYPE	CORR CODE	CORRELATION	TEST CODE	PROB	
GRAYS	228	2	5	-0.1970	6	0.0048	
DK--LT	63	2	5	0.0	6	0.0	INVALID
NO.FRA	158	2	5	0.2492	6	0.0041	
QZ	228	2	5	0.2237	6	0.0011	
ARCL	228	2	5	-0.1569	6	0.0648	
MS	228	2	5	-0.2157	6	0.0309	
KF	228	2	5	0.0	6	0.0	INVALID
PP	228	2	5	0.0	6	0.0	INVALID
DU	228	2	5	0.0	6	0.0	INVALID
CB	228	2	5	0.2059	6	0.0044	
ZE	228	2	5	0.0802	6	0.5453	
CL	228	2	5	0.1021	6	0.1485	
FP	228	2	5	-0.1275	6	0.3688	
HEM	226	2	5	0.1696	6	0.4039	
MAG	228	2	5	0.1310	6	0.0786	
CU-GRD	228	4	6	0.5097	7	-0.0	

SECTION 171 - FOOTWALL VOLCANICS

DEPENDENT VARIABLE = CU-GRD TYPE = 4

DK--LT; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE

VARIABLE	NUMBER OF OBSERVATIONS	VARIABLE TYPE	CORR CODE	CORRELATION	TEST CODE	PROB	
GRAYS	279	2	5	-0.1864	6	0.0055	
DK--LT	16	2	5	0.0	6	0.0	INVALID
NO.FRA	231	2	5	0.5974	6	-0.0	
QZ	280	2	5	0.2351	6	0.0007	
ARGL	280	2	5	-0.2955	6	0.0001	
MS	280	2	5	-0.2952	6	0.0002	
KF	280	2	5	0.6242	6	0.0130	
PP	280	2	5	-0.3026	6	0.0124	
BU	280	2	5	-0.3233	6	0.3355	
CB	280	2	5	0.0469	6	0.4918	
ZE	280	2	5	-0.5143	6	0.0000	
CL	280	2	5	-0.3710	6	-0.0	
EP	280	2	5	-0.3813	6	0.0002	
HEM	280	2	5	0.1503	6	0.1083	
MAG	280	2	5	0.2210	6	0.0016	
PY-MODE	261	2	5	-0.1203	6	0.1016	
PY	260	2	5	-0.2763	6	0.0000	
CP-MODE	157	2	5	0.0804	6	0.4013	
MO-GRD	280	4	6	0.6670	7	-0.0	

SECTION 171 - FOOTWALL VOLCANICS

DEPENDENT VARIABLE = MO-GRD TYPE = 4

DK--LT; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE

VARIABLE	NUMBER OF OBSERVATIONS	VARIABLE TYPE	CORR CODE	CORRELATION	TEST CODE	PROB	
GRAYS	279	2	5	-0.2094	6	0.0020	
DK--LT	16	2	5	0.0	6	0.0	INVALID
NO.FRA	231	2	5	0.6188	6	-0.0	
QZ	280	2	5	0.0865	6	0.2077	
ARGL	280	2	5	-0.2676	6	0.0003	
MS	280	2	5	-0.3633	6	0.0000	
KF	280	2	5	0.1372	6	0.5960	
PP	280	2	5	-0.2219	6	0.0654	
DU	280	2	5	-0.1865	6	0.5843	
CB	280	2	5	0.1323	6	0.0456	
ZE	280	2	5	-0.4454	6	0.0000	
CL	280	2	5	-0.3490	6	0.0000	
EP	280	2	5	-0.3101	6	0.0018	
HEM	280	2	5	0.2234	6	0.0172	
MAG	280	2	5	0.1726	6	0.0124	
PY-MODE	261	2	5	-0.1140	6	0.1211	
PY	260	2	5	-0.3385	6	0.0000	
CP-MODE	157	2	5	-0.1087	6	0.2497	
CU-GRD	280	4	6	0.6670	7	-0.0	

SECTION 171 - DYKE COMPLEX

DEPENDENT VARIABLE = CU-GRD TYPE = 4

DK--LT; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
ZE; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
EP; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE

VARIABLE	NUMBER OF OBSERVATIONS	VARIABLE TYPE	CORR CODE	CORRELATION	TEST CODE	PROB	
GRAYS	185	2	5	-0.4330	6	0.0000	
DK--LT	5	2	5	0.0	6	0.0	INVALID
NO.FRA	112	2	5	0.2035	6	0.0665	
QZ	185	2	5	-0.0135	6	0.8353	
ARGL	185	2	5	-0.2970	6	0.0001	
MS	185	2	5	0.2854	6	0.0092	
KF	185	2	5	-0.2978	6	0.3992	
PP	185	2	5	-0.5914	6	0.0000	
DU	185	2	5	-0.4536	6	0.0456	
CB	185	2	5	0.0624	6	0.4769	
ZE	185	2	5	0.0	6	0.0	INVALID
CL	185	2	5	-0.0213	6	0.8103	
EP	185	2	5	0.0	6	0.0	INVALID
HEM	185	2	5	0.3295	6	0.0005	
MAG	185	2	5	0.3948	6	0.0011	
PY-MODE	177	2	5	-0.1442	6	0.1156	
PY	177	2	5	0.0133	6	0.8414	
CP-MODE	144	2	5	-0.2892	6	0.0045	
MO-GRD	185	4	6	0.5365	7	-0.0	

SECTION 171 - DYKE COMPLEX

DEPENDENT VARIABLE = MO-GRD TYPE = 4

DK--LT; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
ZE; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
EP; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE

VARIABLE	NUMBER OF OBSERVATIONS	VARIABLE TYPE	CORR CODE	CORRELATION	TEST CODE	PROB	
GRAYS	185	2	5	-0.2395	6	0.0026	
DK--LT	5	2	5	0.0	6	0.0	INVALID
NO.FRA	112	2	5	0.4390	6	0.0001	
QZ	185	2	5	0.0294	6	0.6962	
ARGL	185	2	5	-0.1489	6	0.0505	
MS	185	2	5	0.1871	6	0.0863	
KF	185	2	5	0.0365	6	0.8810	
PP	185	2	5	-0.2666	6	0.0212	
DU	185	2	5	-0.3155	6	0.1670	
CB	185	2	5	0.1590	6	0.0615	
ZE	185	2	5	0.0	6	0.0	INVALID
CL	185	2	5	0.0337	6	0.7269	
EP	185	2	5	0.0	6	0.0	INVALID
HEM	185	2	5	0.1974	6	0.0343	
MAG	185	2	5	0.4146	6	0.0006	
PY-MODE	177	2	5	-0.1514	6	0.0983	
PY	177	2	5	-0.0345	6	0.6648	
CP-MODE	144	2	5	-0.1466	6	0.1500	
CU-GRD	185	4	6	0.5365	7	-0.0	

SECTION 171 - HANGINGWALL VOLCANICS .

DEPENDENT VARIABLE = CU-GRD TYPE = 4

DK--LT; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
DU; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE

VARIABLE	NUMBER OF OBSERVATIONS	VARIABLE TYPE	CORR CODE	CORRELATION	TEST CODE	PROB	
GRAYS	226	2	5	0.0220	6	0.7537	
DK--LT	4	2	5	0.0	6	0.0	INVALID
NO.FRA	226	2	5	0.0039	6	0.9109	
QZ	226	2	5	0.2038	6	0.0029	
ARGL	226	2	5	0.0988	6	0.1662	
MS	226	2	5	0.1637	6	0.0782	
KF	226	2	5	0.3198	6	0.0610	
PP	226	2	5	-0.3867	6	0.0057	
DU	226	2	5	0.0	6	0.0	INVALID
CB	226	2	5	-0.1986	6	0.0078	
ZE	226	2	5	-0.5942	6	0.0000	
CL	226	2	5	-0.1899	6	0.0095	
EP	226	2	5	-0.3185	6	0.3546	
HFM	226	2	5	0.1147	6	0.2438	
MAG	226	2	5	0.1201	6	0.1724	
PY-MODE	215	2	5	0.1405	6	0.0539	
PY	214	2	5	-0.0216	6	0.7536	
CP-MODE	174	2	5	0.1159	6	0.1606	
MO-GRD	226	4	6	0.4978	7	-0.0	

SECTION 171 - HANGINGWALL VOLCANICS

DEPENDENT VARIABLE = MO-GRD TYPE = 4

DK--LT; OBSERVATIONS IN CNLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
DU; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE

VARIABLE	NUMBER OF OBSERVATIONS	VARIABLE TYPE	CORR CODE	CORRELATION	TEST CODE	PROB	
GRAYS	226	2	5	0.1430	6	0.0434	
DK--LT	4	2	5	0.0	6	0.0	INVALID
NO.FRA	226	2	5	0.1246	6	0.0770	
QZ	226	2	5	0.1093	6	0.1064	
ARGL	226	2	5	0.0617	6	0.3964	
MS	226	2	5	0.0769	6	0.4202	
KF	226	2	5	0.5310	6	0.0021	
PP	226	2	5	-0.2799	6	0.0435	
DU	226	2	5	0.0	6	0.0	INVALID
CB	226	2	5	0.1425	6	0.0548	
ZE	226	2	5	-0.4208	6	0.0008	
CL	226	2	5	-0.1323	6	0.0693	
EP	226	2	5	-0.2538	6	0.4648	
HEM	226	2	5	-0.2073	6	0.0331	
MAG	226	2	5	-0.0130	6	0.8558	
PY-MODE	215	2	5	-0.0120	6	0.8462	
PY	214	2	5	-0.1538	6	0.0270	
CP-MODE	174	2	5	-0.0942	6	0.2580	
CU-GRD	226	4	6	0.4978	7	-0.0	

SECTION 163 -- FOOTWALL VOLCANICS

DEPENDENT VARIABLE = CU-GRD TYPE = 4

KF; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
PP; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
DU; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
ZE; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
EP; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
HEM; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE

VARIABLE	NUMBER OF OBSERVATIONS	VARIABLE TYPE	CORR CODE	CORRELATION	TEST CODE	PROB	
GRAYS	76	2	5	-0.4828	6	0.0001	
DK--LT	76	2	5	-0.3306	6	0.0273	
NO.FRA	76	2	5	-0.1236	6	0.3292	
QZ	76	2	5	-0.3451	6	0.0028	
ARGL	76	2	5	-0.1955	6	0.1237	
MS	76	2	5	-0.1017	6	0.4915	
KF	76	2	5	0.0	6	0.0	INVALID
PP	76	2	5	0.0	6	0.0	INVALID
DU	76	2	5	0.0	6	0.0	INVALID
CB	76	2	5	0.0831	6	0.5709	
ZE	76	2	5	0.0	6	0.0	INVALID
CL	76	2	5	0.0752	6	0.5658	
EP	76	2	5	0.0	6	0.0	INVALID
HEM	76	2	5	0.0	6	0.0	INVALID
MAG	76	2	5	0.4946	6	0.0020	
MO-GRD	76	4	6	-0.0644	7	0.5873	

DEPENDENT VARIABLE = MC-GRD TYPE = 4

KF; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
PP; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
DU; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
ZE; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
EP; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
HEM; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE

VARIABLE	NUMBER OF OBSERVATIONS	VARIABLE TYPE	CORR CODE	CORRELATION	TEST CODE	PROB	
GRAYS	76	2	5	0.1622	6	0.1991	
DK--LT	76	2	5	0.2700	6	0.0723	
NO.FRA	76	2	5	-0.0757	6	0.5566	
Q7	76	2	5	0.1869	6	0.1079	
ARGL	76	2	5	-0.0586	6	0.6549	
MS	76	2	5	0.4701	6	0.0009	
KF	76	2	5	0.0	6	0.0	INVALID
PP	76	2	5	0.0	6	0.0	INVALID
DU	76	2	5	0.0	6	0.0	INVALID
CB	76	2	5	0.2819	6	0.0451	
ZE	76	2	5	0.0	6	0.0	INVALID
CL	76	2	5	-0.2334	6	0.0635	
EP	76	2	5	0.0	6	0.0	INVALID
HEM	76	2	5	0.0	6	0.0	INVALID
MAG	76	2	5	-0.3534	6	0.0273	
CU-GRD	76	4	6	-0.0644	7	0.5873	

SECTION 163 -- DYKE COMPLEX

DEPENDENT VARIABLE = CU-GRD TYPE = 4

KF; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
PP; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
DU; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
ZE; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
EP; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE

VARIABLE	NUMBER OF OBSERVATIONS	VARIABLE TYPE	CORR CODE	CORRELATION	TEST CODE	PROB	
GRAYS	91	2	5	-0.2587	6	0.0187	
DK--LT	91	2	5	-0.2164	6	0.0696	
NO.FRA	47	2	5	0.2352	6	0.1321	
QZ	91	2	5	0.2466	6	0.0206	
AFGL.	91	2	5	-0.2553	6	0.0196	
MS	91	2	5	-0.1907	6	0.1623	
KF	91	2	5	0.0	6	0.0	INVALID
PP	91	2	5	0.0	6	0.0	INVALID
DU	91	2	5	0.0	6	0.0	INVALID
CB	91	2	5	0.1346	6	0.3265	
ZE	91	2	5	0.0	6	0.0	INVALID
CL	91	2	5	-0.0143	6	0.8688	
EP	91	2	5	0.0	6	0.0	INVALID
HEM	91	2	5	0.2733	6	0.1739	
MAG	91	2	5	0.4038	6	0.0012	
MO-GRD	48	4	6	0.1970	7	0.1763	

DEPENDENT VARIABLE = MC-GRD TYPE = 4

KF; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
PP; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
DU; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
ZE; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
EP; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE

VARIABLE	NUMBER OF OBSERVATIONS	VARIABLE TYPE	CORR CODE	CORRELATION	TEST CODE	PROB	
GRAYS	48	2	5	-0.1382	6	0.4064	
DK--LT	48	2	5	-0.1053	6	0.5383	
NO.FRA	47	2	5	0.2864	6	0.0646	
QZ	48	2	5	-0.2018	6	0.1779	
ARGL	48	2	5	-0.2614	6	0.0901	
MS	48	2	5	-0.2444	6	0.2349	
KF	48	2	5	0.0	6	0.0	INVALID
PP	48	2	5	0.0	6	0.0	INVALID
DU	48	2	5	0.0	6	0.0	INVALID
CB	48	2	5	0.3564	6	0.0357	
ZE	48	2	5	0.0	6	0.0	INVALID
CL	48	2	5	0.3096	6	0.0505	
EP	48	2	5	0.0	6	0.0	INVALID
HEM	48	2	5	0.0854	6	0.7275	
MAG	48	2	5	0.2455	6	0.1493	
CU-GRD	48	4	6	0.1970	7	0.1763	

SECTION 163 -- HANGINGWALL VOLCANICS

DEPENDENT VARIABLE = CU-GRD TYPE = 4

DK--LT; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
KF; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
PP; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
DU; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE

VARIABLE	NUMBER OF OBSERVATIONS	VARIABLE TYPE	COEF CODE	CORRELATION	TEST CODE	PROB	
GRAYS	232	2	5	0.2382	6	0.0009	
DK--LT	41	2	5	0.0	6	0.0	INVALID
NC.FRA	233	2	5	-0.2540	6	0.0003	
QZ	233	2	5	0.5947	6	-0.0	
ARGL	233	2	5	0.1237	6	0.2718	
MS	233	2	5	0.0593	6	0.6665	
KF	233	2	5	0.0	6	0.0	INVALID
PP	233	2	5	0.0	6	0.0	INVALID
DU	233	2	5	0.0	6	0.0	INVALID
CB	233	2	5	-0.2184	6	0.0030	
ZE	233	2	5	-0.4087	6	0.0000	
CL	233	2	5	-0.1381	6	0.0518	
EP	233	2	5	-0.2090	6	0.0594	
HEM	233	2	5	0.1371	6	0.6052	
MAG	233	2	5	0.1802	6	0.0165	
PY-MODE	231	2	5	0.1019	6	0.1387	
PY	231	2	5	0.0185	6	0.7789	
CP-MODE	177	2	5	0.1431	6	0.0723	
MO-GRD	233	4	6	0.7295	7	-0.0	

SECTION 163 -- HANGINGWALL VOLCANICS

DEPENDENT VARIABLE = MO-GRD TYPE = 4

DK--LT: OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
KF; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
PP; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
DU; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE

VARIABLE	NUMBER OF OBSERVATIONS	VARIABLE TYPE	CORR CODE	CORRELATION	TEST CODE	PROB	
GRAYS	232	2	5	0.1729	6	0.0141	
DK--LT	41	2	5	0.0	6	0.0	INVALID
NO.FRA	233	2	5	-0.1285	6	0.0597	
QZ	233	2	5	0.5204	6	-0.0	
ARGL	233	2	5	0.0306	6	0.7769	
MS	233	2	5	-0.0406	6	0.7589	
KF	233	2	5	0.0	6	0.0	INVALID
PP	233	2	5	0.0	6	0.0	INVALID
DU	233	2	5	0.0	6	0.0	INVALID
CB	233	2	5	-0.0436	6	0.5626	
ZE	233	2	5	-0.2890	6	0.0009	
CL	233	2	5	-0.0575	6	0.4312	
EP	233	2	5	-0.1522	6	0.1725	
HEM	233	2	5	0.1162	6	0.6595	
MAG	233	2	5	0.2387	6	0.0017	
PY-MODE	231	2	5	-0.0559	6	0.4278	
PY	231	2	5	-0.0601	6	0.3894	
CP-MODE	177	2	5	-0.1169	6	0.1438	
CU-GRD	233	4	6	0.7295	7	-0.0	

SECTION 155 -- FOOTWALL VOLCANICS

DEPENDENT VARIABLE = CU-GRD TYPE = 4

KF; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
PP; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
DU; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
ZE; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
HEM; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE

VARIABLE	NUMBER OF OBSERVATIONS	VARIABLE TYPE	CORR CODE	CORRELATION	TEST CODE	PROB	
GRAYS	70	2	5	-0.3834	6	0.0058	
DK--LT	70	2	5	-0.3871	6	0.0074	
NO.FRA	70	2	5	0.6089	6	0.0000	
QZ	70	2	5	-0.1877	6	0.1262	
ARGL	70	2	5	-0.4954	6	0.0009	
MS	70	2	5	-0.4812	6	0.0004	
KF	70	2	5	0.0	6	0.0	INVALID
PP	70	2	5	0.0	6	0.0	INVALID
DU	70	2	5	0.0	6	0.0	INVALID
CB	70	2	5	0.4072	6	0.0038	
ZE	70	2	5	0.0	6	0.0	INVALID
CL	70	2	5	0.3929	6	0.0028	
EP	70	2	5	0.6181	6	0.1127	
HEM	70	2	5	0.0	6	0.0	INVALID
MAG	70	2	5	0.3228	6	0.0178	
MO-GRD	70	4	6	0.4374	7	0.0002	

DEPENDENT VARIABLE = MO-GRD TYPE = 4

KF; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
PP; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
DU; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
ZE; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
HEM; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE

VARIABLE	NUMBER OF OBSERVATIONS	VARIABLE TYPE	CORR CODE	CORRELATION	TEST CODE	PROB	
GRAYS	70	2	5	-0.1389	6	0.3316	
DK--LT	70	2	5	-0.1094	6	0.4670	
NO.FRA	70	2	5	0.6252	6	0.0000	
QZ	70	2	5	-0.2743	6	0.0243	
ARGL	70	2	5	-0.2411	6	0.1084	
MS	70	2	5	-0.3892	6	0.0039	
KF	70	2	5	0.0	6	0.0	INVALID
PP	70	2	5	0.0	6	0.0	INVALID
DU	70	2	5	0.0	6	0.0	INVALID
CB	70	2	5	0.4104	6	0.0036	
ZE	70	2	5	0.0	6	0.0	INVALID
CL	70	2	5	0.3115	6	0.0179	
EP	70	2	5	0.2473	6	0.5409	
HEM	70	2	5	0.0	6	0.0	INVALID
MAG	70	2	5	-0.2452	6	0.0731	
CU-GRD	70	4	6	0.4374	7	0.0002	

SECTION 155 -- DYKE COMPLEX

DEPENDENT VARIABLE = CU-GRD TYPE = 4

DU; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
ZE; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
EP; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE

VARIABLE	NUMBER OF OBSERVATIONS	VARIABLE TYPE	CORR CODE	CORRELATION	TEST CODE	PROB	
GRAYS	119	2	5	0.1316	6	0.1850	
DK--LT	120	2	5	0.1752	6	0.0830	
NO.FRA	120	2	5	0.2923	6	0.0032	
QZ	120	2	5	0.4060	6	0.0000	
ARGL	120	2	5	-0.4926	6	0.0000	
MS	120	2	5	-0.2910	6	0.0044	
KF	120	2	5	-0.2252	6	0.3594	
PP	120	2	5	0.1791	6	0.6328	
DU	120	2	5	0.0	6	0.0	INVALID
CB	120	2	5	0.4702	6	0.0001	
ZE	120	2	5	0.0	6	0.0	INVALID
CL	120	2	5	0.2909	6	0.0030	
EP	120	2	5	0.0	6	0.0	INVALID
HEM	120	2	5	-0.1826	6	0.1877	
MAG	120	2	5	0.1809	6	0.0778	
MO-GRD	120	4	6	0.7266	7	-0.0	

DEPENDENT VARIABLE = MO-GRD TYPE = 4

DU; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
ZE; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
EP; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE

VARIABLE	NUMBER OF OBSERVATIONS	VARIABLE TYPE	CORR CODE	CORRELATION	TEST CODE	PROB	
GRAYS	119	2	5	0.3305	6	0.0009	
DK--LT	120	2	5	0.3649	6	0.0004	
NO.FRA	120	2	5	0.2653	6	0.0073	
QZ	120	2	5	0.3436	6	0.0002	
ARGL	120	2	5	-0.3696	6	0.0003	
MS	120	2	5	-0.1804	6	0.0765	
KF	120	2	5	-0.1123	6	0.6504	
PP	120	2	5	0.2134	6	0.5700	
DU	120	2	5	0.0	6	0.0	INVALID
CB	120	2	5	0.5419	6	0.0000	
ZE	120	2	5	0.0	6	0.0	INVALID
CL	120	2	5	0.0873	6	0.3834	
EP	120	2	5	0.0	6	0.0	INVALID
HEM	120	2	5	-0.2144	6	0.1200	
MAG	120	2	5	0.0120	6	0.8749	
CU-GRD	120	4	6	0.7266	7	-0.0	

SECTION 155 -- HANGINGWALL VOLCANICS

DEPENDENT VARIABLE = CU-GRD TYPE = 4

KF; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
DU; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE

VARIABLE	NUMBER OF OBSERVATIONS	VARIABLE TYPE	CORR CODE	CORRELATION	TEST CODE	PROB	
GRAYS	293	2	5	-0.0090	6	0.8563	
DK--LT	292	2	5	0.0161	6	0.7940	
NO.FRA	291	2	5	-0.0736	6	0.2550	
QZ	293	2	5	0.3297	6	0.0000	
ARGL	293	2	5	-0.0337	6	0.6423	
MS	293	2	5	-0.1304	6	0.1136	
KF	293	2	5	0.0	6	0.0	INVALID
PP	293	2	5	-0.2291	6	0.0612	
DU	293	2	5	0.0	6	0.0	INVALID
CB	293	2	5	-0.1983	6	0.0040	
ZE	293	2	5	-0.1543	6	0.1069	
CL	293	2	5	-0.1139	6	0.0623	
EP	293	2	5	-0.6898	6	-0.0	
HEM	293	2	5	-0.0112	6	0.9122	
MAG	293	2	5	0.1627	6	0.0116	
MO-GRD	292	4	6	0.6746	7	-0.0	

DEPENDENT VARIABLE = MC-GRD TYPE = 4

KF; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
DU; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE

VARIABLE	NUMBER OF OBSERVATIONS	VARIABLE TYPE	CORR CODE	CORRELATION	TEST CODE	PROB	
GRAYS	292	2	5	0.0378	6	0.5515	
DK--LT	291	2	5	0.0205	6	0.7506	
NO.FRA	290	2	5	0.1310	6	0.0405	
QZ	292	2	5	0.3897	6	-0.0	
ARGL	292	2	5	0.0276	6	0.7001	
MS	292	2	5	-0.0931	6	0.2645	
KF	292	2	5	0.0	6	0.0	INVALID
PP	292	2	5	-0.2610	6	0.0332	
DU	292	2	5	0.0	6	0.0	INVALID
CB	292	2	5	-0.2152	6	0.0019	
ZE	292	2	5	-0.1299	6	0.1768	
CL	292	2	5	-0.1780	6	0.0040	
EP	292	2	5	-0.5484	6	0.0000	
HEM	292	2	5	-0.1135	6	0.6061	
MAG	292	2	5	0.1017	6	0.1142	
CU-GRD	292	4	6	0.6746	7	-0.0	

SECTICN 147 -- FCOTWALL VOLCANICS

DEPENDENT VARIABLE = CU-GRD TYPE = 4

KF; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
DU; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE

VARIABLE	NUMBER OF OBSERVATIONS	VARIABLE TYPE	CORR CODE	CORRELATION	TEST CODE	PROB	
GRAYS	118	2	5	0.0320	6	0.7601	
DK--LT	118	2	5	0.0331	6	0.7584	
NO.FRA	118	2	5	0.2758	6	0.0062	
QZ	118	2	5	0.0610	6	0.5402	
ARCL	118	2	5	0.1563	6	0.1694	
MS	118	2	5	0.3480	6	0.0184	
KF	118	2	5	0.0	6	0.0	INVALID
PP	118	2	5	-0.2337	6	0.1806	
DU	118	2	5	0.0	6	0.0	INVALID
CB	118	2	5	-0.1538	6	0.1238	
ZE	118	2	5	-0.3462	6	0.0017	
CL	118	2	5	-0.3230	6	0.0023	
EP	118	2	5	-0.4655	6	0.0001	
HEM	118	2	5	-0.4060	6	0.0029	
MAG	118	2	5	0.1659	6	0.1094	
MO-GRD	83	4	6	0.4793	7	0.0000	

DEPENDENT VARIABLE = MO-GRD TYPE = 4

KF; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
DU; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
~~HEM; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE~~

VARIABLE	NUMBER OF OBSERVATIONS	VARIABLE TYPE	CORR CODE	CORRELATION	TEST CODE	PROB	
GRAYS	83	2	5	-0.2043	6	0.0957	
~~DK-LT~~	~~83~~	~~2~~	~~5~~	~~-0.1892~~	~~6~~	~~0.1345~~	
NO.FRA	83	2	5	0.4472	6	0.0002	
QZ	83	2	5	-0.0621	6	0.6061	
ARGL	83	2	5	-0.3273	6	0.0128	
MS	83	2	5	-0.3189	6	0.0573	
KF	83	2	5	0.0	6	0.0	INVALID
~~PP~~	~~83~~	~~2~~	~~5~~	~~-0.2675~~	~~6~~	~~0.1525~~	
DU	83	2	5	0.0	6	0.0	INVALID
CB	83	2	5	0.1888	6	0.1182	
ZE	83	2	5	0.1939	6	0.2267	
CL	83	2	5	-0.0349	6	0.7733	
EP	83	2	5	-0.2878	6	0.4638	
~~HEM~~	~~83~~	~~2~~	~~5~~	~~0.0~~	~~6~~	~~0.0~~	~~INVALID~~
MAG	83	2	5	0.2981	6	0.0130	
CU-GRD	83	4	6	0.4793	7	0.0000	

SECTION 147 -- DYKE COMPLEX

DEPENDENT VARIABLE = CU-GRD TYPE = 4

PP; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
DU; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE

VARIABLE	NUMBER OF OBSERVATIONS	VARIABLE TYPE	CORR CODE	CORRELATION	TEST CODE	PROB	
GRAYS	188	2	5	-0.1843	6	0.0158	
DK--LT	188	2	5	-0.1635	6	0.0490	
NO.FRA	167	2	5	0.1397	6	0.1029	
QZ	188	2	5	0.1023	6	0.1662	
ARGL	188	2	5	-0.2444	6	0.0025	
MS	188	2	5	-0.1031	6	0.3105	
KF	188	2	5	0.1070	6	0.3860	
PP	188	2	5	0.0	6	0.0	INVALID
DU	188	2	5	0.0	6	0.0	INVALID
CB	188	2	5	0.4059	6	0.0000	
ZE	188	2	5	-0.0031	6	0.9322	
CL	188	2	5	0.1311	6	0.0973	
EP	188	2	5	0.4499	6	0.0469	
HEM	188	2	5	0.1025	6	0.5740	
MAG	188	2	5	0.1423	6	0.0957	
MO-GRD	188	4	6	0.4489	7	-0.0	

DEPENDENT VARIABLE = MO-GRD TYPE = 4

PP; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
DU; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE

VARIABLE	NUMBER OF OBSERVATIONS	VARIABLE TYPE	CORR CODE	CORRELATION	TEST CODE	PROB	
GRAYS	188	2	5	-0.0461	6	0.5594	
DK--LT	188	2	5	-0.0005	6	0.9434	
NO.FRA	167	2	5	0.1154	6	0.1805	
GZ	188	2	5	0.0081	6	0.8782	
ARGL	188	2	5	-0.1983	6	0.0136	
MS	188	2	5	-0.0974	6	0.3389	
KF	188	2	5	0.1928	6	0.1099	
PP	188	2	5	0.0	6	0.0	INVALID
DU	188	2	5	0.0	6	0.0	INVALID
CB	188	2	5	0.2881	6	0.0006	
ZE	188	2	5	0.0836	6	0.5853	
CL	188	2	5	0.0515	6	0.5285	
EP	188	2	5	0.0780	6	0.7322	
HEM	188	2	5	0.0700	6	0.6967	
MAG	188	2	5	0.0437	6	0.6202	
CU-GRD	188	4	6	0.4489	7	-0.0	

SECTION 147---HANGINGWALL VOLCANICS

DEPENDENT VARIABLE = CU-GRD TYPE = 4

KF; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
DU; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE

VARIABLE	NUMBER OF OBSERVATIONS	VARIABLE TYPE	CORR CODE	CORRELATION	TEST CODE	PROB	
GRAYS	285	2	5	-0.0601	6	0.3410	
DK--LT	285	2	5	-0.1108	6	0.0916	
NO.FRA	286	2	5	-0.1539	6	0.0138	
QZ	286	2	5	0.2257	6	0.0002	
ARGL	286	2	5	0.0219	6	0.7725	
MS	286	2	5	-0.2200	6	0.0124	
KF	286	2	5	0.0	6	0.0	INVALID
PP	286	2	5	-0.1651	6	0.6266	
DU	286	2	5	0.0	6	0.0	INVALID
CB	286	2	5	-0.1157	6	0.0809	
ZE	286	2	5	0.1924	6	0.0219	
CL	286	2	5	-0.1687	6	0.0083	
EP	286	2	5	-0.5619	6	-0.0	
HEM	286	2	5	0.1254	6	0.4127	
MAG	286	2	5	0.2229	6	0.0012	
MO-GRD	283	4	6	0.5320	7	-0.0	

DEPENDENT VARIABLE = MO-GRD TYPE = 4

KF; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE
DU; OBSERVATIONS IN ONLY ONE CATEGORY OF THE NON-INTERVAL VARIABLE

VARIABLE	NUMBER OF OBSERVATIONS	VARIABLE TYPE	CORR CODE	CORRELATION	TEST CODE	PROB	
GRAYS	282	2	5	-0.0172	6	0.7758	
DK--LT	282	2	5	-0.0487	6	0.4735	
NO.FRA	283	2	5	-0.0936	6	0.1361	
QZ	283	2	5	0.1976	6	0.0012	
ARGL	283	2	5	-0.0478	6	0.5554	
MS	283	2	5	-0.2132	6	0.0155	
KF	283	2	5	0.0	6	0.0	INVALID
PP	283	2	5	-0.1508	6	0.6561	
DU	283	2	5	0.0	6	0.0	INVALID
CB	283	2	5	0.0263	6	0.6987	
ZE	283	2	5	0.3634	6	0.0000	
CL	283	2	5	-0.1246	6	0.0514	
EP	283	2	5	-0.3227	6	0.0005	
HEM	283	2	5	0.2255	6	0.1323	
MAG	283	2	5	0.1462	6	0.0312	
CU-GRD	283	4	6	0.5320	7	-0.0	