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SELCO MINING CORPORATION LIMITED

SOUTH BAY MINE

- A GEOLOGICAL UPDATE -

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SEPTEMBER 1979
CIM DIVISION IV
WINNIPEG

SOUTH BAY MINE - A GEOLOGICAL UPDATE

Abstract

South Bay Mine is located 50 miles east of Red Lake in the Uchi-Confederation greenstone belt.

The deposit was discovered in 1968 by airborne geophysics and went into production in early 1971. Production since that time has averaged 500 tons per day, from reserves of 1,600,000 tons (including past production) averaging 2.3% copper, 14.5% zinc and 3.5 oz./ton silver. These reserves extend to the 1500 foot level with underground exploration continuing at deeper levels.

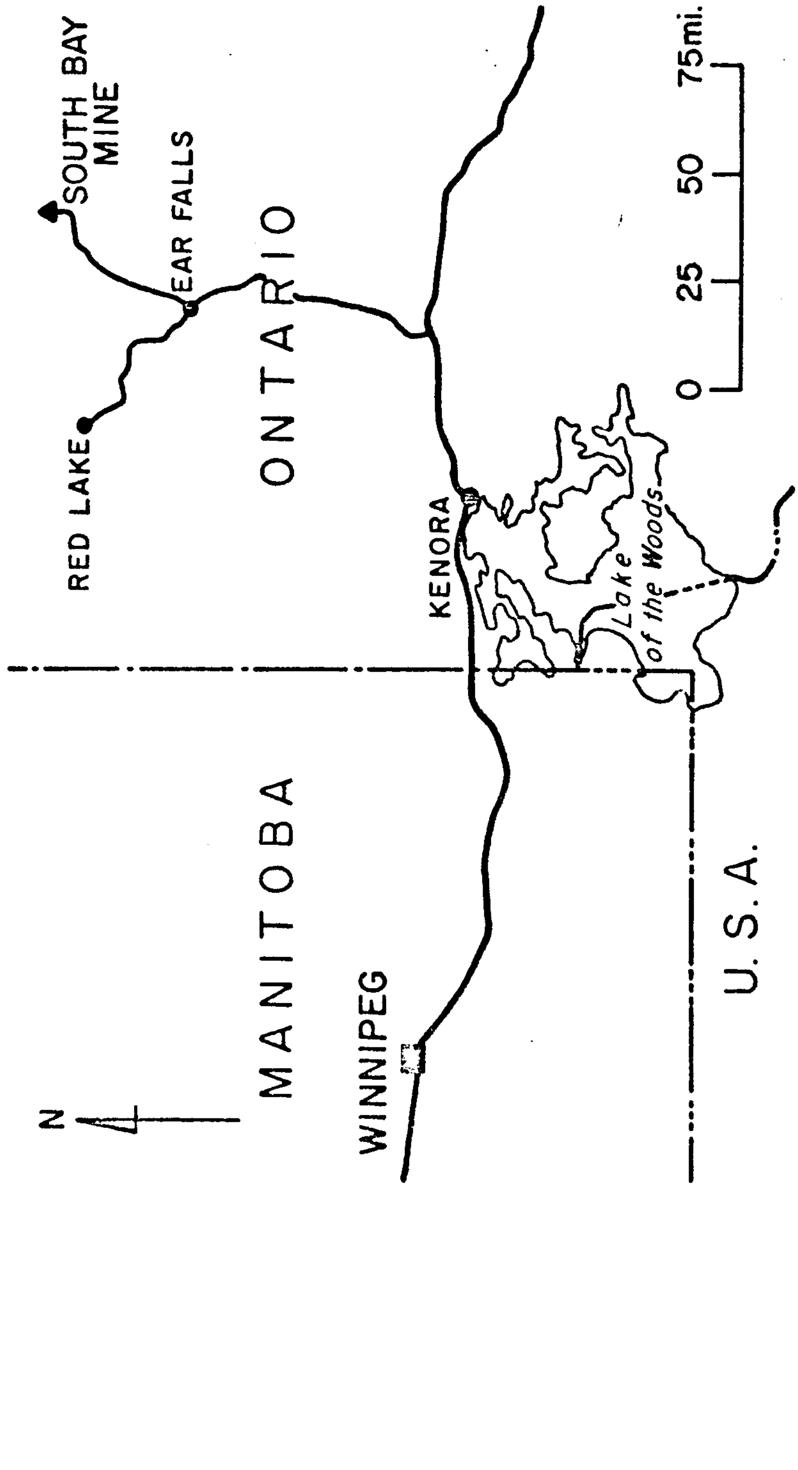
South Bay belongs to the family of stratiform base metals massive sulphide deposits associated with felsic volcanic rocks. It occurs near the top of the youngest of three mafic to felsic volcanic cycles identified in the area.

The ore horizon overlies quartz feldspar porphyry. The quartz feldspar porphyry thickens in the area of the mine where it probably formed the core of a rising felsic dome. The porphyry is believed to have intrusive and extrusive phases.

The ore lenses, 5-70 feet wide,contain massive fine pyrite, banded to interstitial chalcopyrite, and finely banded to coarse massive sphalerite. Sulphides constitute 70-95% of the ore, the balance being quartz, carbonate, chlorite, chert, and argillite. The highly irregular ore lenses occur along a strike length of up to 700 feet. The upper portions of some of the ore zones are zinc rich, reflecting original metal zoning. Argillite underlying and intercalated with these sulphide bodies indicate quiescent conditions of deposition. Elsewhere, preconsolidation slumping has destroyed any zoning. Primary textures of sphalerite and chalcopyrite have been largely destroyed by dynamic and thermal metamorphism.

The hanging wall consists of 70-300 feet of dacite breccia, in turn overlain by rhyolite. Irregular felsic dikes commonly intrude the ore zone and enclosing rocks. The dominant alteration consists of chloritization and brecciation of the quartz feldspar porphyry to depths of 50-300 feet below the ore, and chloritization in the hanging wall dacite breccia. It is believed that the wall rock alteration and mineralization resulted from the same event.

Fig. 1


SOUTH BAY MINE
EAR FALLS
RED LAKE
ONTARIO
KENORA
Lake of the Woods
MANITOBA
WINNIPEG
U.S.A.
N
0
25
50
75mi.

History

The initial orebodies were found in 1968, in following up a one-line airborne Input anomaly, under overburden. This was upgraded in drilling priority, since it occurred in a porphyry-rhyolite environment. A production decision was made, after delineation drilling, which allowed production to begin in early 1971. At this time, reserves were less than 500,000 tons, barely enough to return the capital costs. The production decision was decisively swayed by confidence in the on-going potential of the mine. Continuing exploration has increased the initial reserve to 1,600,000 tons, of which about 300,000 tons remain to be mined. Average overall grade is 2.3% copper, 14.5% zinc, and 3.5 oz./ton silver. Orebodies currently being mined extend to the 1500 foot level. Exploration is continuing to the 3000 foot level from an exploration drift at the 1950 level.

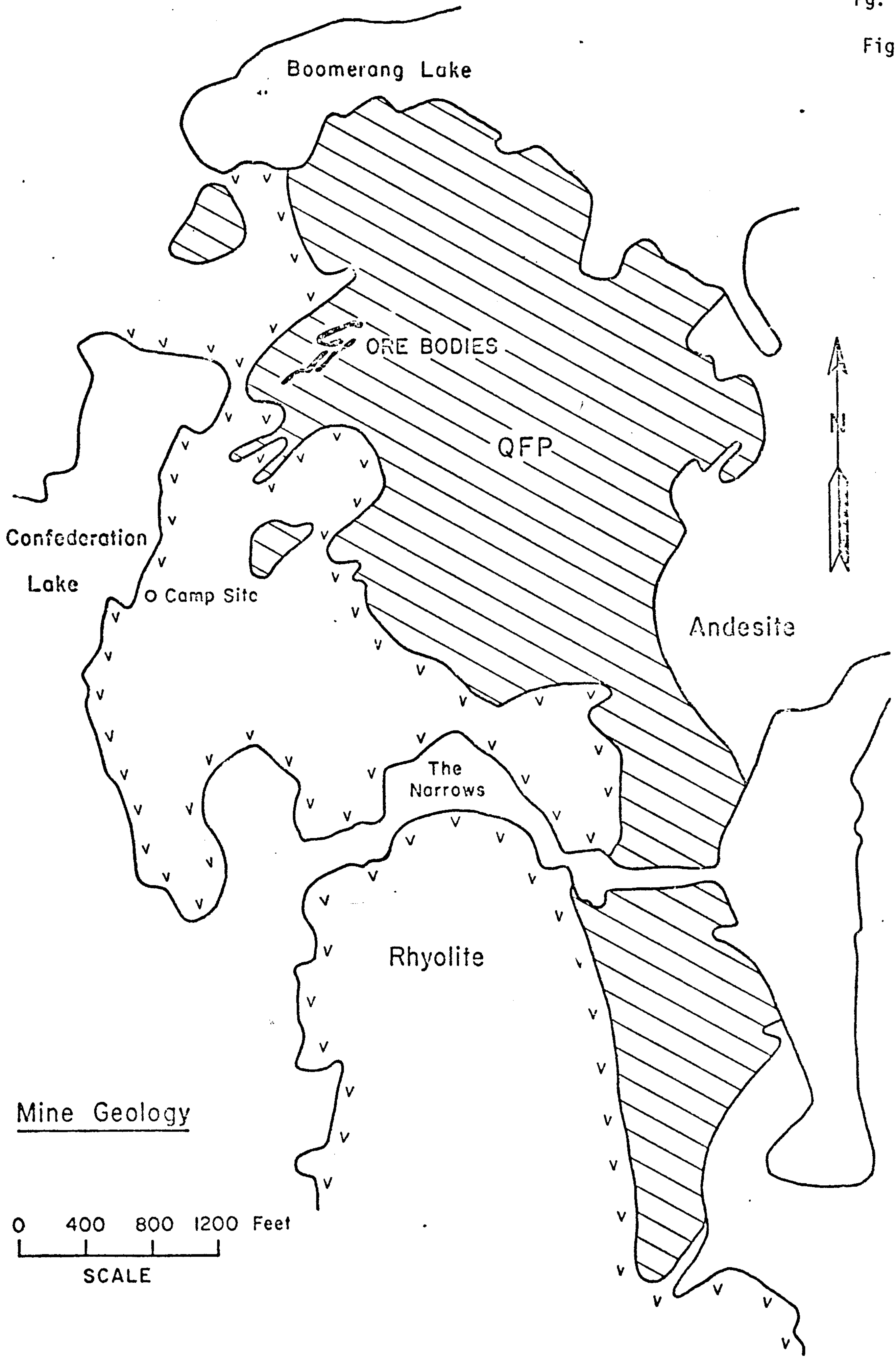
Regional Geology

The South Bay orebodies occur in the Uchi-Confederation greenstone belt which is a generally northerly trending belt, interrupted by diapiric granitic rocks. Basaltic to rhyolitic volcanic cycles and sediments are steeply folded and generally of lower green schist metamorphic facies. (Thurston and Jackson 1978). Two basaltic to rhyolitic cycles were originally recognized. A third older cycle was later recognized (Pryslak 1971). Zircon studies (Nunes and Thurston 1978) indicated an age difference between Cycle I and Cycle III rhyolites of 220 million years.

South Bay lies near the top of the third cycle on the western flank of a quartz feldspar porphyry sub-volcanic dome which measures 2½ miles by up to 1 mile wide. In part, and particularly in the mine area, the QFP appears to have been emergent in a submarine environment.

Mine Geology

The quartz feldspar porphyry (QFP) is the oldest rock unit in the mine and generally forms the footwall to the massive sulphide ores. Argillite locally occurs as an intervening layer between QFP and ore, but more commonly is a lateral equivalent of the sulphides. Dacite breccia and tuffaceous equivalents generally form the hanging-wall but


Boomerang Lake
ORE BODIES
QFP
N
Confederation
Lake
Camp Site
Andesite
The
Narrows
Rhyolite
Mine Geology
0 400 800 1200 Feet
SCALE

occasionally dacite breccia underlies the ore. Rhyolite tuffs, flows, and breccias overlay dacite breccia and the dacite-rhyolite contact represents the upper limit of known ore. Away from the mine area, rhyolites are usually directly overlying QFP.

Quartz Feldspar Porphyry (QFP)

This large unit is considered to be a high level intrusion with local extrusion, probably an endogenous rhyolitic dome. Near the ore-bodies, the QFP is generally altered to a highly chloritized shatter breccia which is mapped separately as QFP (2). Quartz Feldspar Porphyry (1) is a porphyritic rhyolite rock, with ubiquitous, rather evenly distributed quartz phenocrysts (~~25~~ 2-5 mm) which are clear or blue, rounded to subangular, and sometimes shattered. Feldspar (oligoclase) laths (up to 10 mm) show all gradations from incipient to total sericitization. The matrix is very fine grained, consisting mainly of quartz, sericite, and minor chlorite. The phenocrysts make up 30-40% of the total, about equally shared if the plagioclase is fresh. Silica content places the QFP in the rhyolite range but potassium and potassium/sodium are low for a typical rhyolite. It may therefore be termed a soda-rhyolite. Sericitization increases progressively as the QFP (2) alteration zone is approached with development of foliation. Carbonatization (ankerite) and bleaching and silicification are other alteration phases less closely associated with the ore-sulphides.

The QFP (2) generally occupies several hundred feet of QFP up to its contact with dacite, sulphides, or argillite in the mine area. Chlorite gradually increases until it forms a well-developed braided texture enveloping sub-rounded fragments of QFP (1) which are generally 0.5 - 1 ~~mm~~ cm and fairly uniform, but in local areas they are up to 5~~mm~~ cm. Chlorite content appears to be 10 - 30% but includes finely divided sericite which is not easily distinguishable. The iron-rich chlorite diabantite has been identified in most thin sections. (Koschal 1975).

Lightly scattered pyrite is rather ubiquitous throughout altered types of porphyry, but in QFP (2) local semimassive concentrations (a few inches to several feet wide) of fine grained pyrite are some- times seen, commonly with minor fine sphalerite. Elsewhere, galena has been noted in small concentrations, in fractures and quartz veins.

The QFP is seen in contact with massive ore, dacite tuff and breccia, cherty argillite and rhyolite units. Its interface is extremely irregular with embayments and bulges in dimensions up to several hundred feet. Sill-like extensions into the dacitic unit are not uncommon and display flow features.

Dacite Breccia and Tuff

This unit is the host rock to the ore and like the QFP (2) is heavily altered by dark chlorite. The fragments, from ash to breccia size (3 - 4 cm), are of felsic volcanic nature; QFP fragments have not been observed. Fragment size increases considerably toward nodes or thickened sections of breccias. In part, the fragmentation may be a steam-brecciation (if so, this would apply equally to QFP (2) and exotic fragments are rare. Of interest is the presence of fragments of massive pyrite (which may sometimes be rimmed by minor sphalerite) in the near hanging-wall of the massive sulphides. Whether these are true fragments or selective replacements of lithic fragments, has not been established. The absence of zinc, copper, or mixed massive sulphide fragments, plus sulphur isotope ratios suggests these fragments have not been derived from present ore-bodies. The dark chloritic alteration, which is the dominant characteristic of this unit, adjoins similar alteration in the QFP (2) as a complementary part of the alteration envelope. The dacite breccia has a strike length of 750 feet and a thickness from 50 to 200 feet.

Cherty Argillite

This sometimes laminated, siliceous sediment is developed in the lower levels where it ranges up to 75 feet thick and in rhyolite units adjacent to the dacite breccia. It is sometimes in contact with QFP, and overlain by dacite tuff/breccia. Sometimes mineralized, it lacks ore concentrations. The unit shows a close spatial relationship to massive ore in stope 24604 between 950 and 1200 levels. This is the only part of the mine where good metal zoning is developed with high grade (10 - 40%) zinc overlying lower grade zinc and copper ore.

Rhyolite Flows, Tuff and Breccia

Spheroidal and massive flows with subordinate tuff, chert and breccia characterize the siliceous rocks of the hanging wall. The rocks are weakly altered with carbonate, sericite and quartz as predominant phases.

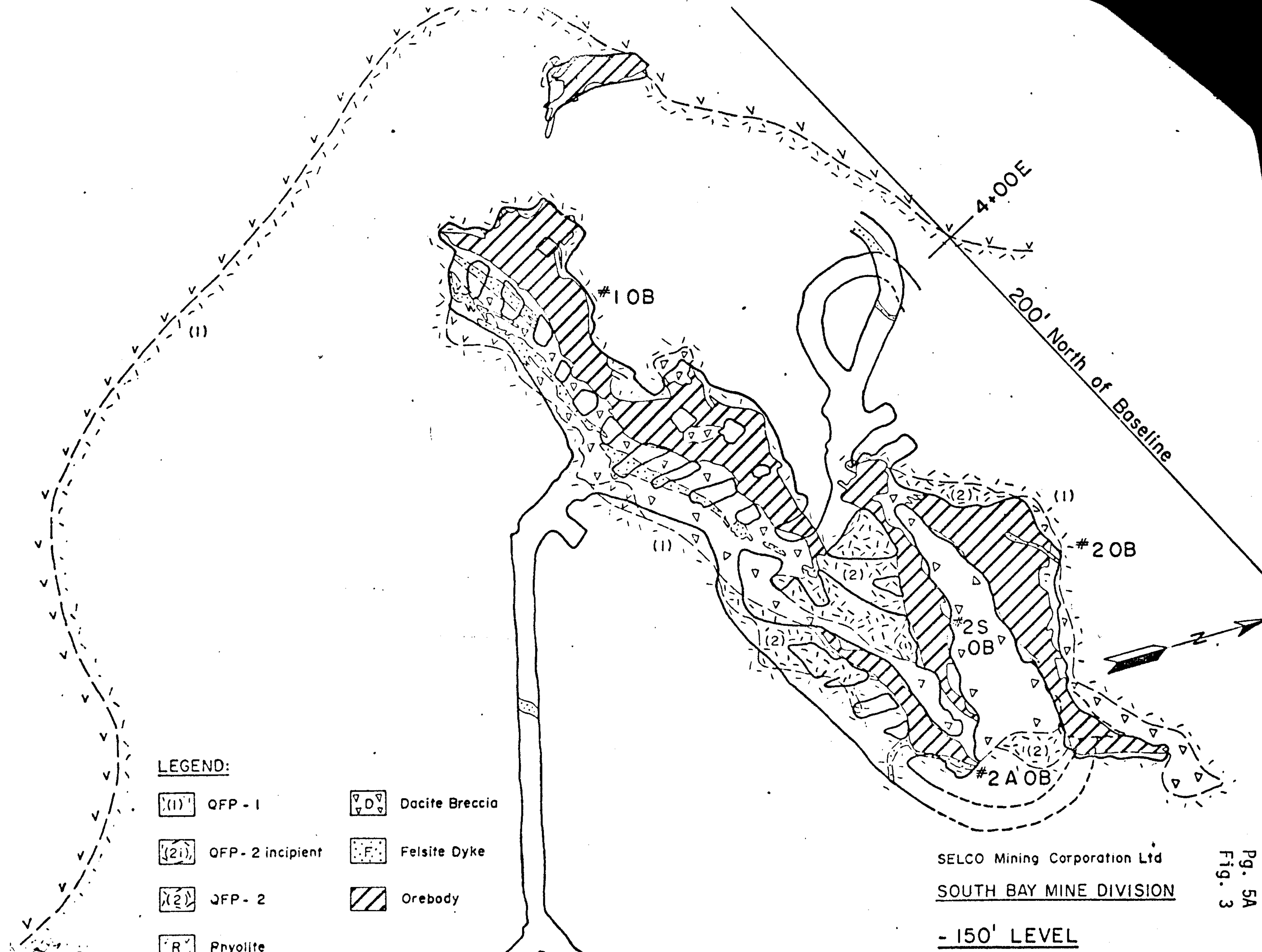
Spheroidal flow units are the most distinctive rocks noted in drill core and underground workings. In these flows tightly packed spheroids up to 8 mm long are present in a matrix of quartz, chlorite and sericite. The primary nature of the spheroids is best demonstrated by layering within individual flow units and (Parsons 1969) attributed these features to devitrification of glassy flows.

Asbury (1975) used spheroids along with other primary features as an indicator of strain which took place during deformation of the volcanic pile.

The spheroidal flows are interbanded with massive flows, breccias and tuff which overlie the main dacite breccia unit. In addition to colour and hardness, primary features such as spheroids, hyaloclastite and flow bands are used to distinguish the rhyolites from the underlying dacite breccia and flows.

Felsite Dikes

The felsite dikes intrude all rocks and the ore-sulphides, but are most common near the orebodies in the altered rocks (dacite and QFP (2). Here they are bulbous and irregular in shape. They are fine-grained unaltered rocks consisting mainly of quartz and oligoclase but with ubiquitous brown carbonate. Disseminated pyrite cubes are quite common. There is a grain size gradation from contact to centre, within thicker dikes having small feldspar $\pm$ quartz phenocrysts. Minor baking of the QFP wall has been observed. Most of the dikes are non-foliate, a feature that may reflect their high quartz-feldspar content.



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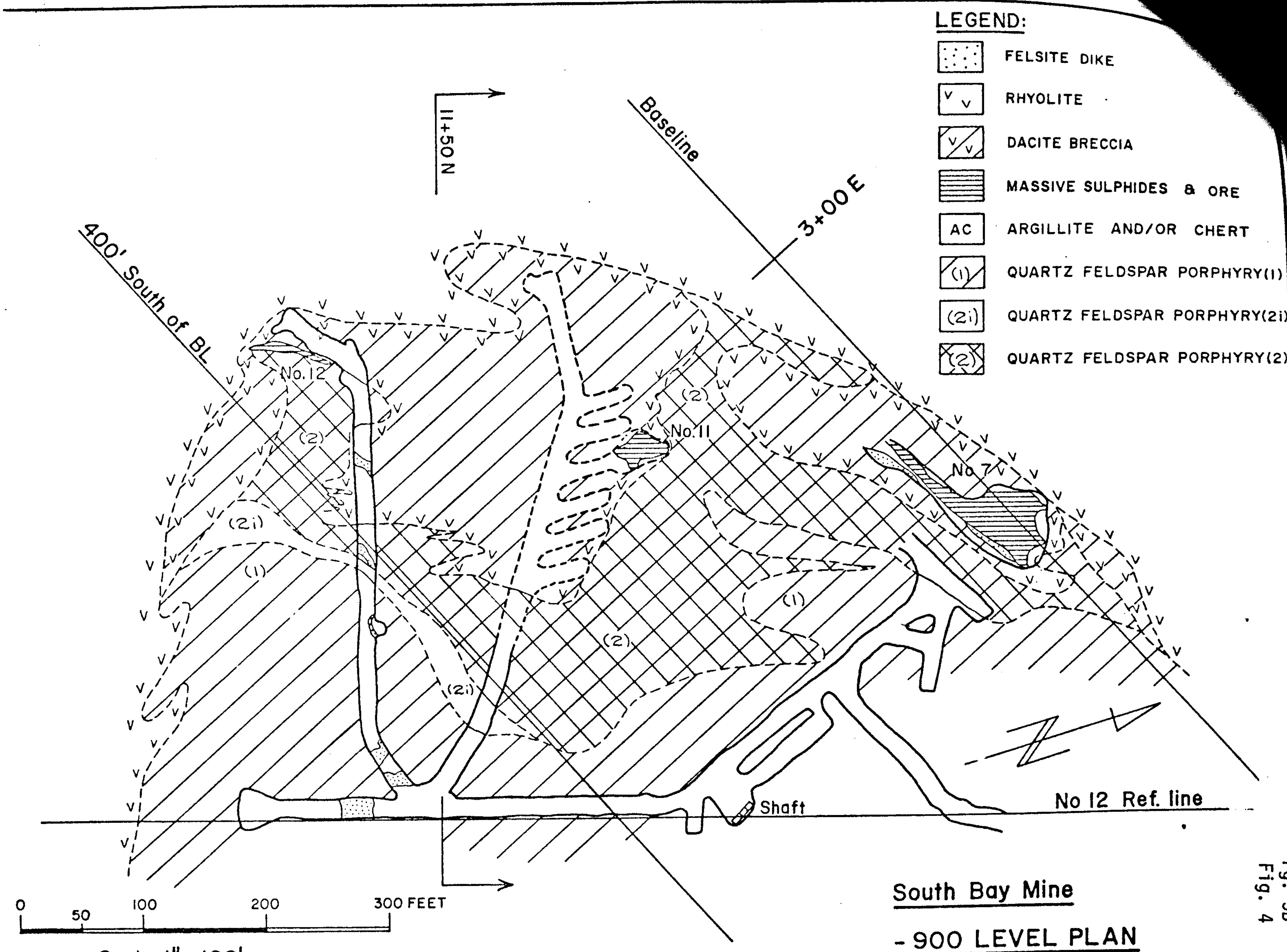
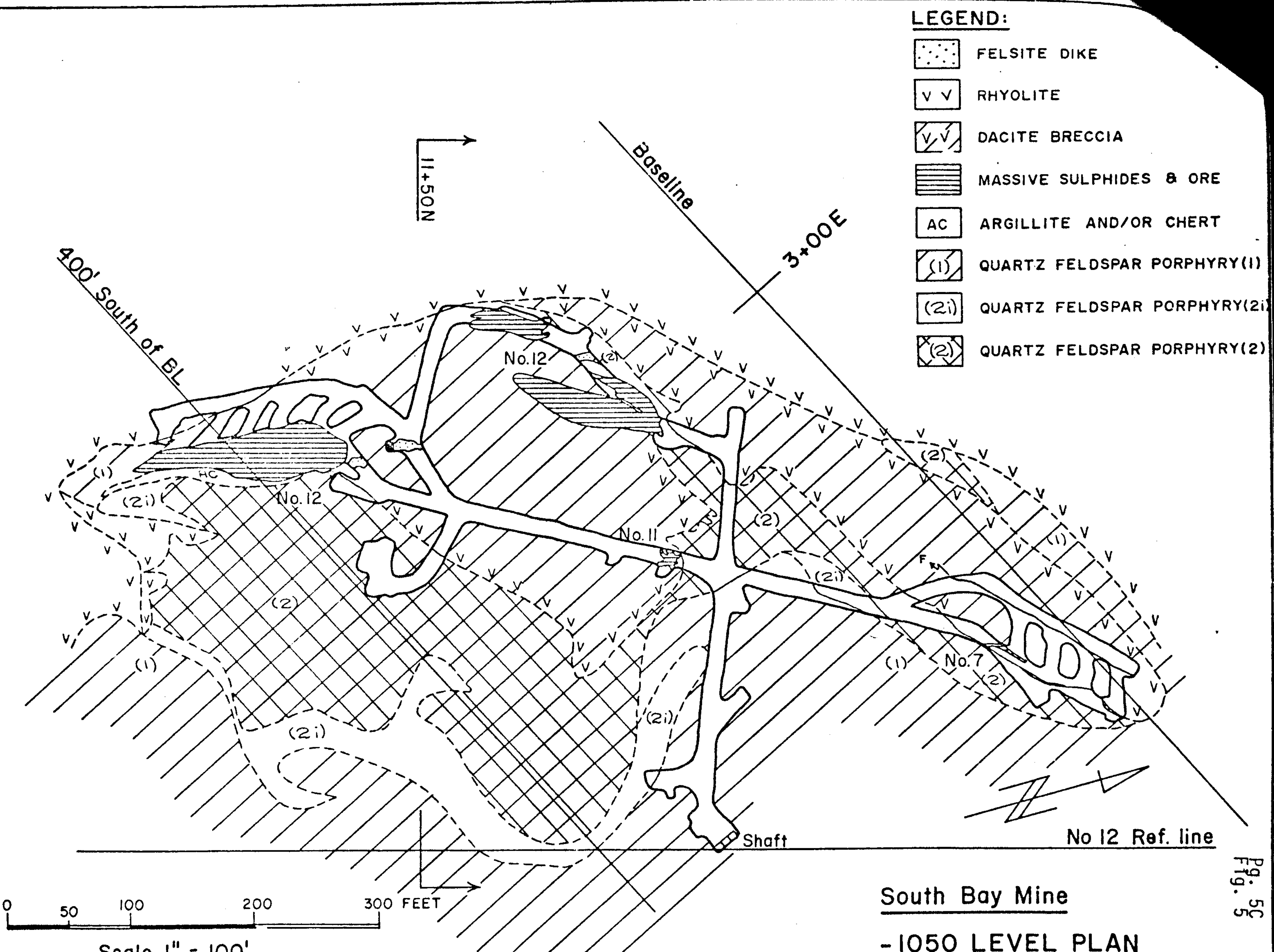
SOUTH BAY MINE DIVISION

- 150' LEVEL



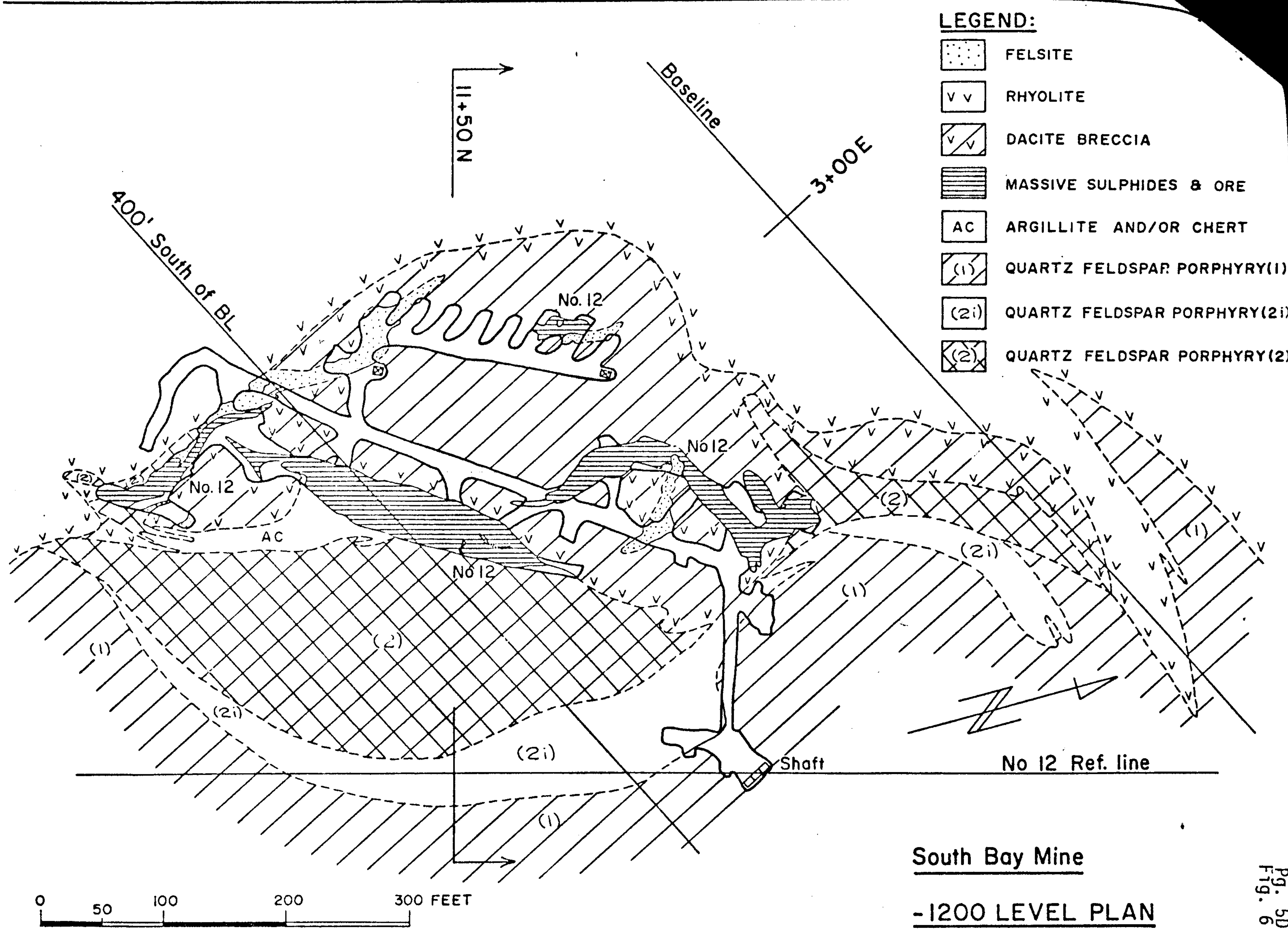
South Bay Mine

-900 LEVEL PLAN



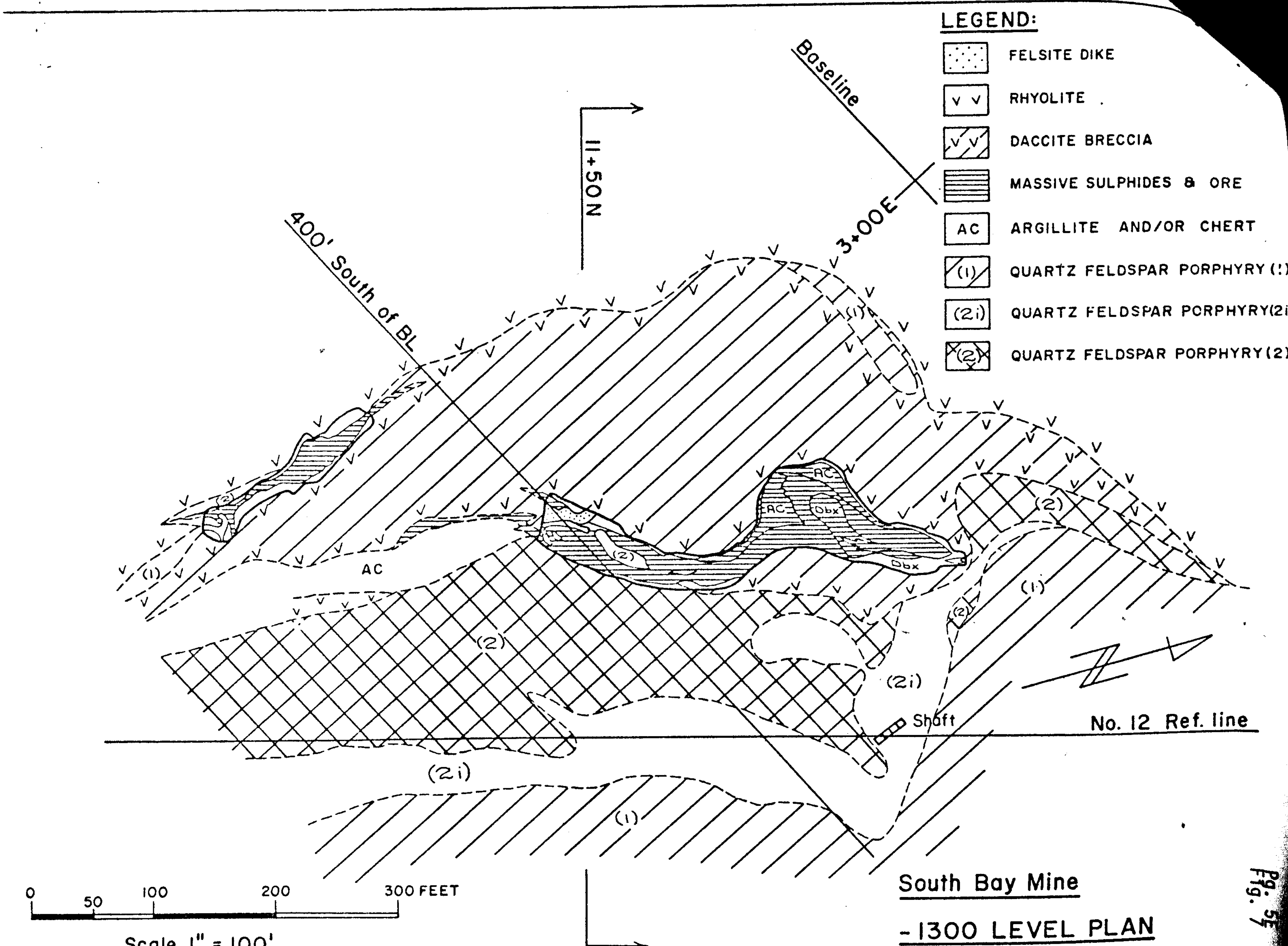
South Bay Mine

-1050 LEVEL PLAN



South Bay Mine

-1200 LEVEL PLAN

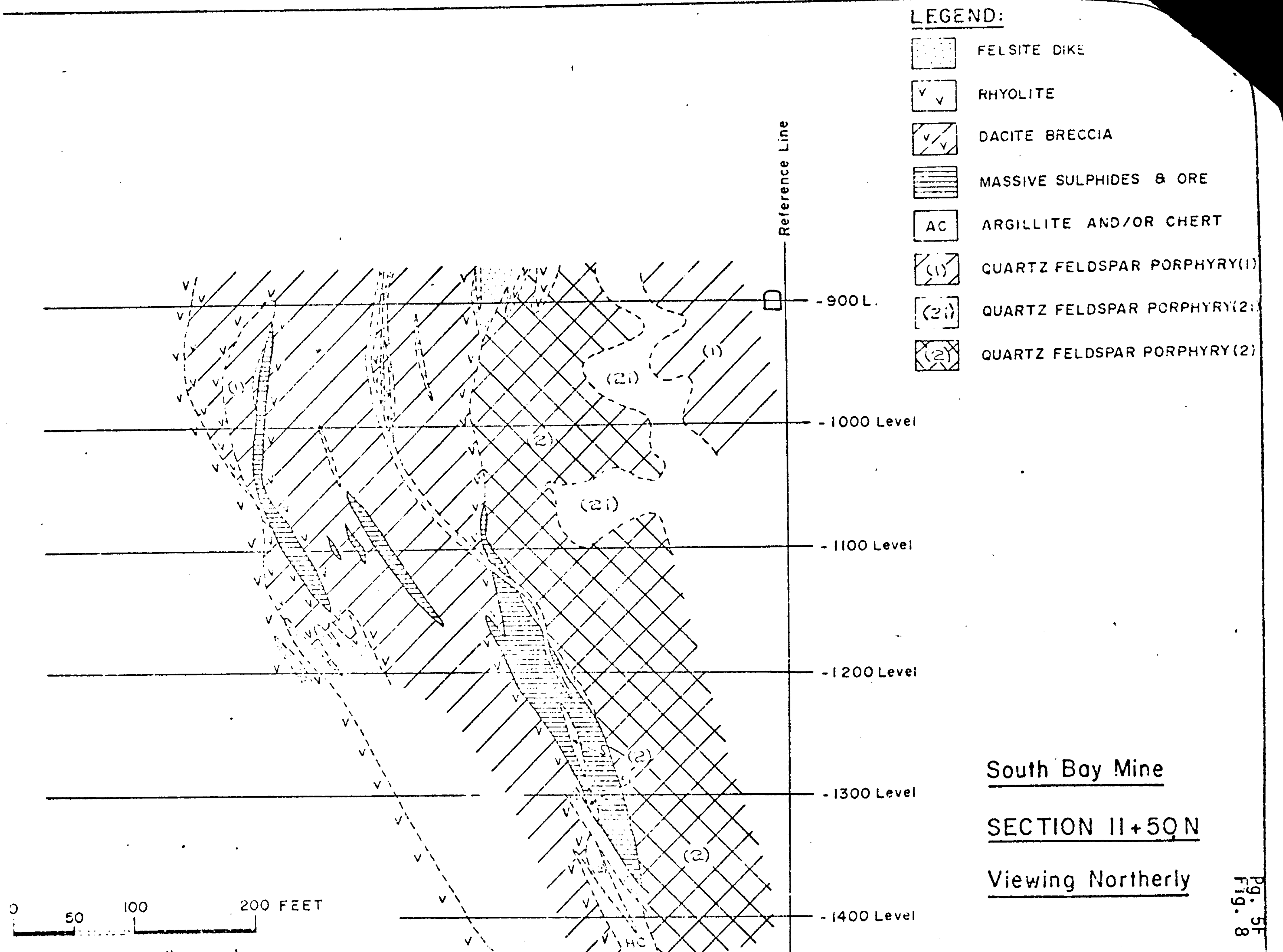


Scale 1" = 100'

South Bay Mine

-1300 LEVEL PLAN

Pg. 5E
Fig. 7


LEGEND:
FELSITE DIKE
RHYOLITE
DACITE BRECCIA
MASSIVE SULPHIDES & ORE
AC
ARGILLITE AND/OR CHERT
QUARTZ FELDSPAR PORPHYRY(1)
QUARTZ FELDSPAR PORPHYRY(2i)
QUARTZ FELDSPAR PORPHYRY(2)
Reference Line
-900 L.
-1000 Level
-1100 Level
-1200 Level
-1300 Level
-1400 Level
(1)
(2i)
(2)
0 50 100 200 FEET
South Bay Mine
SECTION 11+50 N
Viewing Northerly

Massive Sulphides

Massive sulphide ore lenses occur as generally bulbous, irregular bodies, up to 50 feet wide, 300 feet long and 500 feet high. They consist dominantly of pyrite (up to 80%) with sphalerite and chalcopyrite as the other principal sulphides. Pyrrhotite is rare in the upper levels but becomes significant between 900-1500 foot levels (up to 20%). Other minor sulphides are galena, arsenopyrite, and silver minerals. Cassiterite occurs in minor amount. Gangue, commonly 5% - 15% of the ore, is dominantly dacite and chert fragments plus quartz and carbonate (ankerite), with minor sericite and chalorite. The gangue material occurs in size ranges from chert to veinlets.

The ore ranges from very fine grained pyrite to coarse, nearly monomineralic light sphalerite, but is typically a finely banded series, the bands being respectively dominant in pyrite and sphalerite, with chalcopyrite as a remobilized phase.

Pyrite shows spheroidal textures, well seen when defined by contrasting chalcopyrite. These textures were noted and examined in polished section (Touborg 1971). Hard spheroids of pyrite have apparently been resistant to deformation, which has affected the more ductile chalcopyrite and sphalerite (Corkery 1977). The sulphides, as a whole, have thus behaved as an incompetent formation against quartz feldspar porphyry, as evidenced by scallop structures at the contacts. (Asbury 1975). An analysis of banding within the massive sulphide (Corkery 1977) has confirmed the stratabound nature of the deposit and defined two ages of pyrite which have reacted separately to stress. Early pyrite spheroids and fragments are representative of early layering while later pyrite and economic sulphide have developed a metamorphic fabric analogous to those developed in a metamorphosed sedimentary terrain.

The larger scale irregularities in the shape of the sulphide lenses are attributed largely to the original sea bed topography with the sulphide deposition constrained by hollows or basins in a trench or fissure, which also localized the presumed source vents of the hydrothermal solutions. There is evidence that the hydrothermal solutions travelled several hundred feet prior to sulphide deposition in #1 orebody which lies outside the alteration envelope with fresh wall-rocks. Movement of sulphides, probably by slumping, is also indicated by the metal zoning, particularly by sphalerite-rich zones. A good example is at the east ends of the parallel #2 and #2A lenses, where a northerly trending fault terminates the ore which is here a high-grade zinc zone with the metal zoning being transverse to the strike of the ore lens. It is inferred that later sphalerite-rich ore slumped over chalcopyrite pyrite-sphalerite ore and was constrained by an incipient fault-scarp. Quartz-chalcopyrite stringers sometimes extend for a few feet into the walls, and when in argillite, sometimes show slump structures. Felsite dikes are often boudinaged when they transgress a sulphide lens indicating post-dike movement in the sulphides with the wall-rocks unaffected.

Structure

The mine rocks have been steeply tilted by the regional folding and are now slightly overturned. There is considerable strike variation from ENE for the near-surface sulphide lenses, to northerly in the deeper lenses. The sulphides are believed to have been deposited along a linear structure on the sea bed. The northerly-trending regional folding has transgressed the original strike of the former linear structure. Present strike variations result from the intersection of the northerly fold axis and the variable geometry of QFP/ore interface. The original troughs or basins, into which the sulphides are inferred to have been deposited, have been further modified, in addition to steep tilting, by the regional compression.

Wallrock Alteration

Three phases of hydrothermal wallrock alteration have been recognized in the mine workings to date and a fourth "silicification" may also be related to the present ore zone.

Dark chlorite (diabantite) is the most prevalent hydrothermal phase and demonstrates a close spacial relationship to sulphide lenses. The mineral is most prevalent within the matrix of the dacite breccia and QFP (2) but similar chlorite fills fractures in felsite dikes and overlying rhyolite flows. (Koschal 1975) found that the intensity of chlorite alteration in QFP (2) increased with depth to the 600 foot level of the mine and underground mapping has shown that chlorite alteration is strongest within and adjacent to nodes or "thickened sections" of dacite breccia.

Sericite alteration is ubiquitous within the QFP (1) at the mine and shows an antipathetic spatial relationship to dark chlorite phases. Sericite is most strongly developed within the QFP (1) and flow rocks at the margins of the main chlorite zone but is also present along with chlorite in incipient phases of QFP (2). In addition to the matrix of breccia, sericite forms from the breakdown of plagioclase within the host rock.

In relation to both chlorite and sericite alteration, Koschal has noted the introduction of excess iron, magnesium, and potassium beyond that to be expected from alteration of ferromagnesians and potassic feldspar in the QFP and adjacent volcanics.

Ankerite has been identified as the main carbonate phase within the alteration halo (Koschal 1975). The mineral is most readily observed along with sericite in QFP (1) and massive flow rocks. Within the chlorite zone, carbonate is found disseminated within the breccia matrix and as fracture fillings of all rock types.

Silicification in the form of graphic texture and quartz over-growths is best observed in thin sections from bleached rock units. The spacial relationship of this alteration to sulphides has not been fully examined but evidence of silicification is found in foot- wall and hangingwall rocks.

Palagonite and clay minerals have been identified as alteration phases which occur with sericite and carbonate phases (Koschal 1975). More extensive thin section studies are required to ascertain the extent of these latter phases.

It must be emphasized that wall rock alterations and especially the chlorite phase of alteration has played a significant role in the search for ore at depth. In addition to increasing the size of target, the chlorite alteration phases show a sympathetic volume relationship to massive zinc-copper sulphide.

LIST OF FIGURES

Genetic Model

The QFP is believed to be a rhyolitic dome which became partly emergent in a submarine environment. A geothermal system related to the felsic volcanic centre was probably the source of the metal-rich solutions, with the QFP functioning as cap-rock and later as a host-rock to fracturing. (Hodgson and Lydon, 1977) Pervasive alteration (principally chloritization) of the footwall QFP to QFP (2) over stratigraphic thicknesses of up to 300 feet provide evidence of hydrothermal activity and its close relationship to the fissure or trench along which the ore sulphides were precipitated. Chloritization continued after ore deposition into the overlying dacite breccias. (Koschal 1975) and (Dykes 1979) have demonstrated significant compositional differences as between the 'alteration' chlorites and metamorphic chlorites. No massive ore-zones have been found below 1500 feet yet alteration increases in thickness and intensity from 1500 to the explored depth of 3000 feet. This raises the possibility of a vent at still greater depth.

The possibility that the known South Bay orebodies are distal deposits of the Norita type (MacGeehan and Bonenfant 1979) has been considered, mainly because of a complete lack of evidence for alteration pipes underlying the ore. Also, the near surface ore-bodies (which would be the furthest down slope on this interpretation) have overstepped the alteration envelope by several hundred feet. Against this we have the evidence of pervasive chloritization along the top of the QFP to form a stratiform alteration envelope. Probably therefore there were several centres of rising metal-rich solutions, along a linear feature resulting in distal deposition of sulphides. Lateral movement of the solutions from the exhalative centres may have been limited to a few hundred feet.

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We wish to thank Gunilla Andersson and Valerie Ayers for their valuable help in preparing this pre-print.

Five of the slides to be shown in the oral presentation are from photographs of mine rock types in a M.Sc. thesis by Shaun M. Dykes, use of which is gratefully acknowledged.

Finally, we cordially thank Selco Mining Corporation Limited for allowing us to make this presentation.

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5916.

VOLCANOLOGY AND MINERAL DEPOSITS OF THE UCHI - CONFEDERATION LAKES AREA NORTHWESTERN ONTARIO

P. C. Thurston, J. Wan, H.S. Squair, A.F. Warburton, and V.W. Wierzbicki

The Uchi-Confederation greenstone belt is a complex of metavolcanic and metasedimentary rocks with diapiric granites of Archean age within the Uchi subprovince of the Superior Province of the Canadian Shield (Ayres et al 1971) (Figure 1). This greenstone belt trends north for 84 km, is 32 km wide and has an estimated total stratigraphic thickness of 8500 to 11,240 m folded about a central syncline and an anticline on the east side of the belt. The belt is bounded to the south by the English River sub-province, a gneissic belt (Ayres *et al.* 1971; Beakhouse 1976; Breaks *et al.* 1974; 1975) and to the north, east and west by granitic rocks.

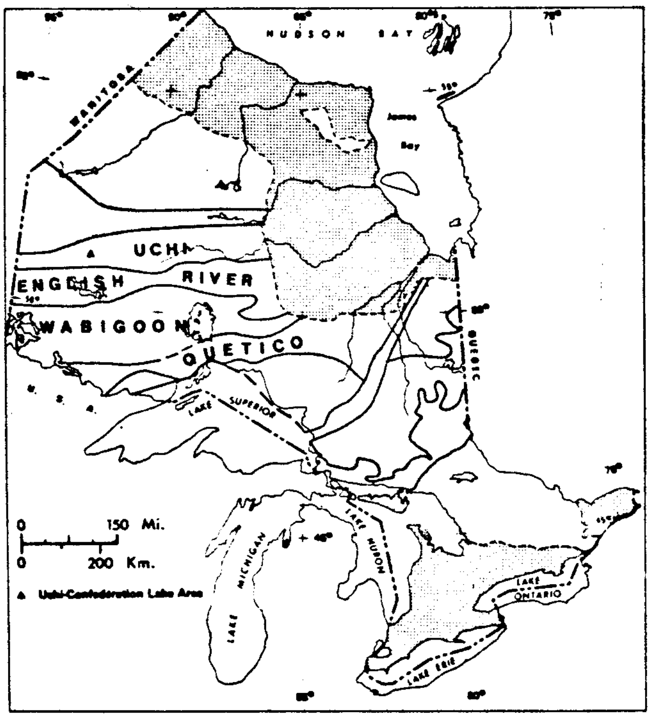


Figure 1 Key map showing location of the Uchi-Confederation Lakes area.

Goodwin (1967) divided metavolcanic rocks of the belt into two cycles; Lower and Upper Cycles with a mafic and a felsic member. These are now called Cycles II and III because a third and lowermost cycle was recognized by Pryslak in 1971 and called Cycle I on Figure 2 (Thurston 1978). Cycle I is the lowest unit in the homoclinal succession in the west limb of the central syncline and in the core of the Leg Lake anticline.

CYCLE I

Cycle I (Figure 3) on the west limb is 1) a basal dominantly pillowed basaltic unit 2200 m thick, overlain by a mixed unit of felsic pyroclastic and metasedimentary rocks forming a wedge 10 km by 1,500 m thick; 2) a second basaltic to intermediate flow unit overlies this followed by coarse intermediate subaqueous pyroclastic breccias of probable ash flow origin (Thurston in prep.); and 3) at the northwest end of the unit above the basalt is a small area of felsic vitric crystal tuff and lapilli tuff which is 2959 ± 3 m.y. old by the U/Pb method on zircons (Nunes and Thurston 1978). Volcanic rocks of Cycle I are overlain by 90 m of marble at the northwest end and sulfide facies iron formation and chert at the south end of the west limb of the synclinorium. Cycle I is also exposed on either flank of the Leg Lake anticline to the east. The upper felsic part of Cycle I on the east limb of the anticline is overlain to the south and east by the metasedimentary rocks of the Slate Lake Series (Bateman 1938) which persist southward into the gneissic English River sub-province (Breaks *et al.* 1975).

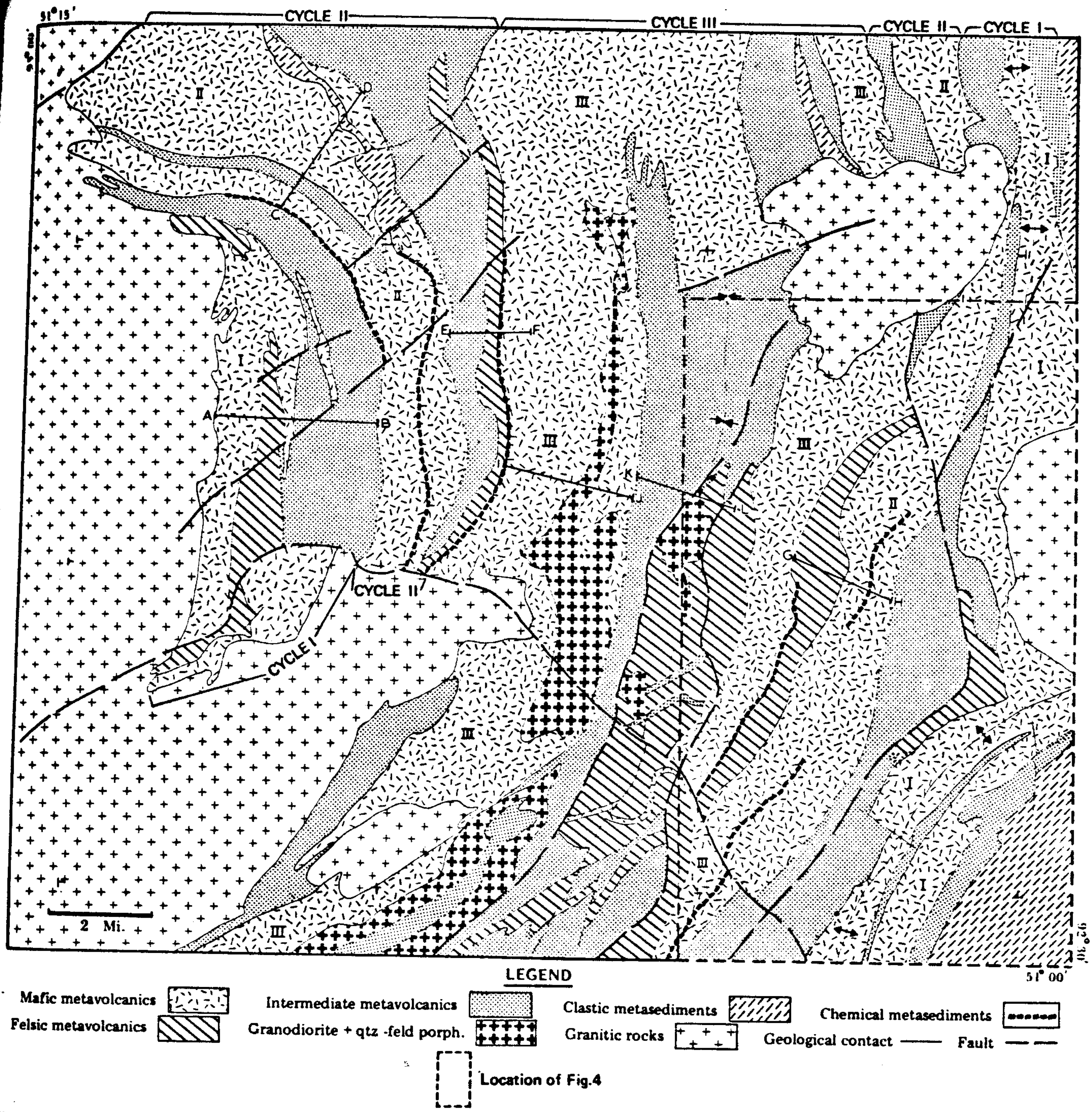


Figure 2. Geological Map of the Uchi-Confederation Lakes Area. Geology after Thurston and A. P. Pryslak ODM Prelim. Maps and unpublished material. Lines A - B etc. are locations of stratigraphic sections on Figure 3.

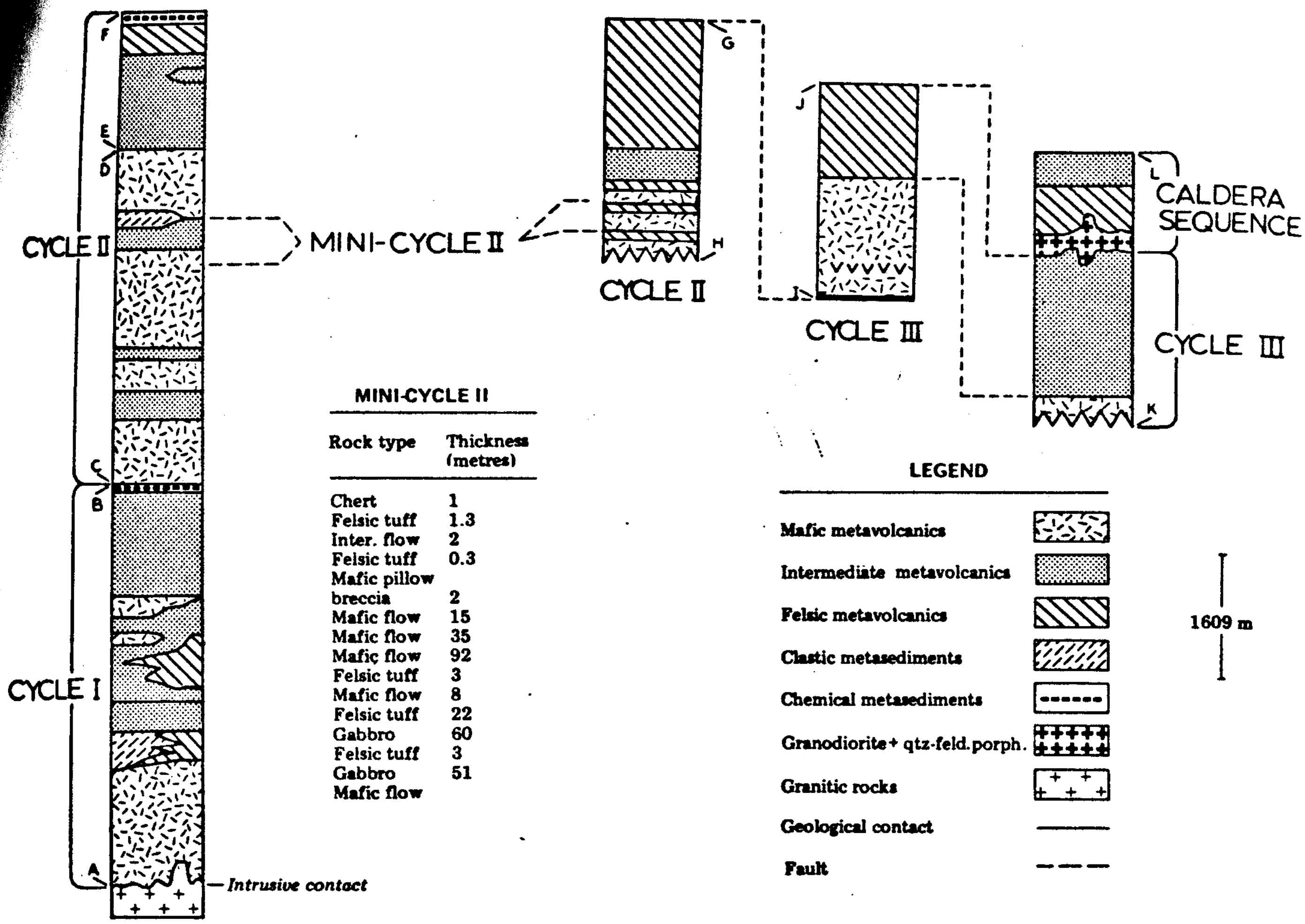


Figure 3. Stratigraphic Section Uchi-Confederation Lakes. See Figure 2 for location of sections.

CYCLE II

Cycle II has a base of amygdaloidal pillowed basaltic flows 2,300 m thick which overlie the marble topping Cycle I (Figure 3). A 60 m thick band of oxide-facies iron formation occurs midway through the basalts of Cycle II on the west limb of the syncline. This correlates with a chert unit on the east limb of the syncline. Four basalt to rhyolite minor cycles (Anhaeusser, 1971) each about 200 m thick underlie the chert on the east limb (Figure 3). Basalts overlain by subaqueous pumice-rich pyroclastic rocks of intermediate composition which form several fining-upward pumice flows (Yamada 1973) or subaqueous ash flows (Parsons 1969), and are in turn overlain by felsic tuffs, lapilli tuffs and 300 m of eutaxitic textured felsic tuff (Savory 1976) indicative of local subaerial volcanism. A U/Pb radiometric age on zircons from the felsic part of Cycle II has an age of crystallization of 2800 ± 12 m.y. (Nunes and Thurston 1978). Felsic volcanic rocks are overlain, on the west limb of the fold, by a stromatolitic marble indicating extremely shallow water depths (Playford and Cockbain 1976).

CYCLE III

The basaltic base of Cycle III is 400 m of pillowed flows followed by 90 m of "massive" variolitic flows (terminology after Gelinas *et al.* 1976) (Figure 3). This is succeeded, with no evidence of an unconformity, by a further 1000 m of pillowed basalts and hyaloclastite with minor andesite flows toward the top. These basalts and andesites are overlain by quartz and feldspar phyric flows of intermediate composition spherulitic partially welded tuffs, and lapilli tuffs and minor rhyolite and rhyolite tuff. The upper part of Cycle III is interrupted by a fault-bonded graben within which dominantly felsic and intermediate volcanic rocks called the Mine Series (Sopuck 1977) have a northeasterly structural trend rather than the northerly trend of the surrounding rocks. The graben, on the basis of l) the dominantly felsic volcanic lithologies and 2) its fault-bounded character is assumed to be a caldera-like structure (Smith and Bailey 1978; Lambert 1978). A U/Pb radiometric age on zircons from a quartz and feldspar phyric rhyolite flow on Fly Lake is 2738 ± 5 m.y. (Nunes and Thurston 1978).

MINERALOGY AND PETROLOGY

The Uchi-Confederation Lakes area is in the lower greenschist facies of regional metamorphism described as a low grade Abukuma type (Thurston and Breaks 1978). Mineralogy is almost entirely secondary. Basaltic rocks are saussuritized plagioclase laths in a matrix of tremolite-actinolite and chlorite; amygdules and veinlets consist of quartz, carbonate, biotite, and stilpnomelane with accessory magnetite, ilmenite and sphene. The intermediate and felsic rocks contain relict glass as shards, plates or matrix of very fine masses of epidote, chlorite, quartz albite and pumiceous and lithic clasts of sussuritized plagioclase, tremolite-actinonlite, white mica, chlorite, biotite and quartz. Accessory minerals include sphene, zircon, stilpnomelane and magnetite with secondary carbonate, quartz, and epidote confined largely to fractures.

STRUCTURAL GEOLOGY

North trending rocks of the Uchi-Confederation belt are folded about a central syncline with trace of the axial plane in the upper part of Cycle III (Figure 4). West of the synclinal axis lithologies form a homoclinal sequence, with Cycle I basalts at the base, succeeded upwards by the rocks of Cycle II and III (Figure 4). East of the synclinal axis the rocks of Cycle III face west, Cycle II rocks face west in the area of Lost Bay. To the east, the rocks of Cycle II are complexly isoclinally folded between Lost Bay of Confederation Lake and Uchi Lake where they are cut by the north trending Uchi Lake fault. East of this, Cycle I volcanic rocks are exposed in the core of the Leg Lake anticline.

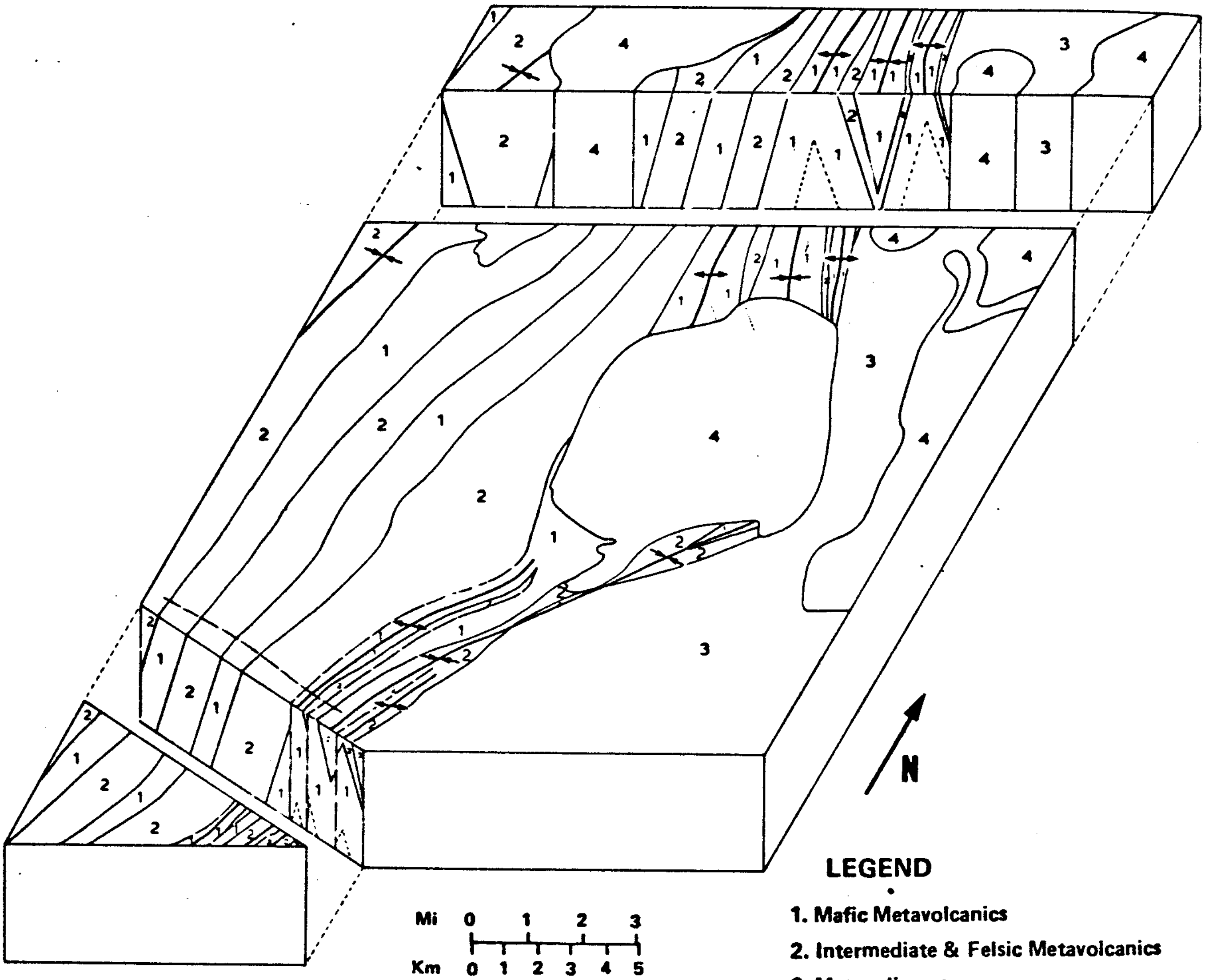
The major fault in the area is the Uchi Lake fault, a branch of the Sydney Lake fault zone (Stone 1976; Thurston and Breaks 1978). Movement on this fault is both strike-slip; (Thurston and Breaks 1978; Stone 1976; McRitchie and Weber 1971) and vertical with a long history of movement (Thurston and Breaks 1978).

Other major fault systems include the graben bordering the Mine Series (Sopuck 1977) felsic volcanic rocks of Cycle III and, the Bear Lake fault (Thurston 1976). The graben developed nearly synchronously with early Cycle III volcanism and was filled with Cycle III rhyolites with a northeasterly trend. The Bear Lake fault offsets all metavolcanic units and post-dates volcanism except for the Mine series.

TECTONICS

The predominantly volcanic lithologies of the Uchi-Confederation portion of the Uchi subprovince grade southward into the predominantly metasedimentary lithologies of the Northern Supracrustal Domain of the English River subprovince (Breaks and Bond 1977). Metamorphic grade increases from greenschist facies assemblages of the Uchi subprovince to amphibolite and granulite facies assemblage of the English River subprovince abruptly at the Sydney Lake fault zone (Thurston and Breaks 1978; Breaks *et al.* 1976). The isograds parallel the fault for substantial distances to the south of the main fault and east of the Uchi Lake fault. This suggestion of vertical movement along the fault system, the presence of the marginal anticlines in the Uchi-Confederation belt (Thurston 1976), the fact that supracrustal lithologies are about 3 km deep based upon gravity modelling (V. Gupta, personal communication), the presence of hematite along the fault system (Beach and Fyfe 1972), the presence of mantled gneiss domes north of the fault west of the Uchi-Confederation area (Thurston and Breaks 1978) and the anticlinal nature of the Red Lake belt all suggest that the Sydney Lake fault system is a thrust fault. Similar structures have been described by Coward *et al.* (1976) and Stowe (1974) in the Rhodesian Shield.

This sort of a deformation pattern is an example which conforms to the largely theoretical model proposed by Gorman *et al.* (1978), in which dense (S.G. 2.9-3.0) mainly basaltic rocks close to the Uchi-Confederation volcanic centre were laid upon a combination of sialic basement (S.G. 2.7) and metasedimentary distal facies material of similar density. Deformation by gravity because of the density inversion caused a central down-sag where basaltic rocks were abundant, producing a central syncline. Lateral transport at the edges of the synclinorium produced bedding-plane thrusts (Figure 5). If the initial, pre-deformation, interface between the dense basaltic rocks and the surrounding metasedimentary rocks and sialic basement (Krogh *et al.* 1976; Harris and Goodwin 1976) had a dip of greater than 25^{o},model studies of Talbot (1974) predict that eccentric pleurotoid nappes would result (Figure 6) producing allochthonous metavolcanic fragments such as the Red Lake belt which Thurston and Breaks (1978) have suggested is the anticlinal nose of a nappe. Allochthonous fragments would form the supracrustal mantle of the gneiss domes south of Red Lake (Table I).



LEGEND

1. Mafic Metavolcanics
2. Intermediate & Felsic Metavolcanics
3. Metasediments
4. Granitic Rocks

Figure 4. Block diagram of Earngey, Birkett, Agnew and Costello Townships.

TABLE 1 METAMORPHIC AND DEFORMATIONAL EVENTS IN THE UCHI AND ENGLISH RIVER SUB-PROVINCES (AFTER McRITCHIE AND WEBER 1971).

		S_0	Original sedimentary and volcanic fabric.
D_1			Isoclinal folds in volcanic sequences and nappes in the Red L.—Bee L. areas.
	M_1	S_1	Development of planar fabric preserved as inclusion trains in staurolite, biotite, and almandine, and andalusite.
	M_1 A		Main regional metamorphic event-development chlorite, biotite, hornblende, muscovite, cordierite, almandine, sillimanite. Migmatization of metasediments in English River subprovince probably commenced during this event.
D_2			Regional folding, rotation of M_1 porphyroblasts associated with emplacement of granitic intrusions in uchi volcanic sequence.
	M_2	S_2	Matrix corasening and development of main axial plane schistosity of biotite and muscovite parallel to D_2 folds. Further migmatization of metasediments in English River subprovince; minor volumes of mobilizate controlled by axial surfaces of mesoscopic D_2 folds.
D_3			Large scale folds.
	M_3	S_3	Muscovite parallel to D_3 axial planes, pinitization of cordierite and andalusite.
D_4		S_4	Late stage development of mylonite on strike slip faults.
	M_4		Retrograde muscovite and chlorite in shear zones of D_4.
D_5		S_5	Late transcurrent faulting, bear L. fault.
	M_5		Minor recrystallization assoc. with D_5.

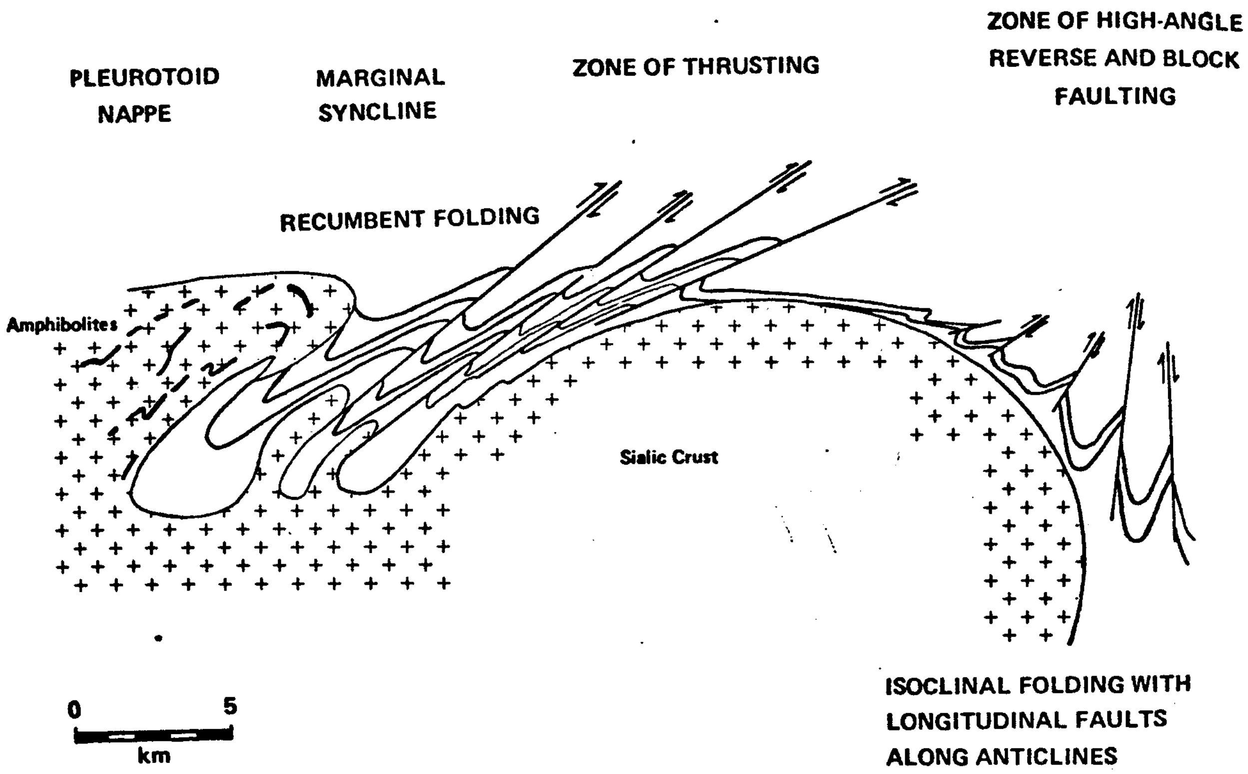


Figure 5. Development of thrust faults in greenstone belts during gravitationally driven deformation (after Gorman *et al.* 1978).

GEOCHEMISTRY

Approximately 235 whole and partial analyses of metavolcanic rocks in the Uchi-Confederation Lakes area have been made by previous workers (Goodwin 1967; Lalor 1970; Birnie 1972; Pryslak, pers. comm. 1975; Johns 1976; and Thurston 1978). In addition, the author has 122 additional analyses of major and trace elements including a suite of 73 analyzed for major, trace and rare earth elements (Thurston and Fryer 1978). The principal conclusions of this latter work are summarized in the following pages.

The credibility of the following section is dependent upon the isochemical nature of the metamorphism and any early halmrolysis. Accordingly, the basaltic rocks were plotted on the CaO vs. MgO diagram of Humphris and Thompson (1978) which shows that Mg has been added to the chloritic basalts and Ca to epidote-rich basalts. Miyashiro's (1975) plot of Na_2O/K_2O vs. Na_2O+K_2O illustrates profound disturbance of the alkalies in the basaltic rocks.

The presence of igneous trends involving fractionation or crystallization of recognized igneous mineral species on AFM diagrams and other plots is taken as evidence of lack of gross chemical change. Where possible, major element trends are confirmed by use of relatively immobile trace elements such as Ti, Zr, Nb, Y, Cr, Ni, Ba etc. (Floyd and Winchester 1978).

Basalts of Cycle I are olivine normative tholeiites based upon the AFM plot and the Jensen plot (Jensen 1976). Cycle II basalts are quartz normative tholeiites by the same classification (Figure 7). The basalts of Cycle III are quartz normative high alumina tholeiites. There is not a coherent relationship between FeO^*/FeO^*+MgO and Cr or Ni, therefore percent TiO_2 has been used as a measure of differentiation in the basaltic rocks. Using this parameter, Cycle II basalts for example, has two Fe enrichment trends. Each Fe enrichment trend is marked by increasing Fe, Ti, and P; decreasing Mg, Cr, and Ni, AL, Ca, and Sr (Figure 8). The ratio Ti/Nd is relatively constant throughout. This pattern is interpreted as olivine and plagioclase fractionation with no spinel phase involved. At peak of each Fe enrichment cycle Sc and V contents suddenly increase indicating some clinopyroxene accumulation presently seen as 5-10 mm amphibole phenocrysts. The basalts evolve in composition from cycle to cycle i.e. from Ol normative to quartz normative but in addition, Cycle I is low in Zr and Y both of which increase in abundance slowly relative to Ti. In Cycle II a low Zr and Y trend relative to Ti and a high Zr and Y trend relative to Ti or Fe can be discerned. In Cycle III only the high Zr and Y trend appears in the basaltic rocks.

Andesites of Cycle 1 have a continuous variation in Si content. Increasing Si is correlated with decreasing Fe, Mg, Ca, Sc, and V at constant Al and Ti. The pattern is interpreted as representing some Plagioclase fractionation with more extensive clinopyroxene fractionation. This trend is not accompanied by decreasing Cr and Ni; these rocks are richer in Zr than the most fractionated basalts of the cycle. Therefore, we have appealed to O'Hara's (1977) open system crystal fractionation model for its origin. Andesite intercalated with Cycle II basalts on the west limb of the fold are high in Cr, Ni, and have low variable Zr content, and lower Ree abundances than the basalts. Again O'Hara's model of fractionation is suggested. The basaltic andesites of mini Cycle II are enriched in Ti, Fe, and Zr with Y constant to

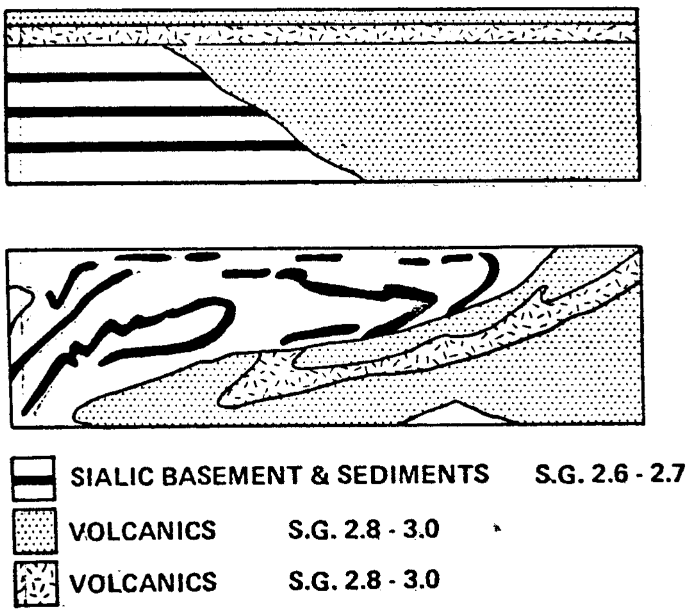


Figure 6. Development of pleurotoid nappes during gravitationally driven deformation (after Talbot 1974).

decreasing in abundance. Zr increases like Y then keeps increasing as Y levels off and P decreases. This pattern is interpreted as fractionation of olivine, plagioclase, and apatite (Zielinski 1975).

Felsic rocks of Cycle I are calc-alkaline dacites (62-67 percent SiO_2 anhydrous), low Si rhyolites (67-75 percent SiO_2 anhydrous) and high Si rhyolites. As a group they are low K trondjemites based upon normative feldspar composition. The high Si rhyolites are possibly related to the other groups by fractionation of quartz, plagioclase, and biotite. A plot of Zr vs. SiO_2 (Figure 9) shows 1) a scarcity of intermediate rocks 2) that the felsic rocks are not related to the mafic rocks by fractional crystallization.

The felsic metavolcanic rocks of the east limb of Cycle II and the internal cycles are calc-alkaline DSV (Condie 1976) with high Cr and Ni in the dacites and low Si rhyolites. With increasing Si, Al, Fe, Ti, Ca, and P decrease, Cr and Ni decrease, Ba has irregular scatter Sr decreases and Na and Ti increase. Zr is generally minor, large abundances correlate with abundant Y. This pattern is a function of fractionation of plagioclase, an oxide phase, and apatite (Zielinski 1975). The minor Zr etc. suggests origin of the group by liquid immiscibility rather than fractional crystallization which yields greater abundances of LIL elements.

On the west limb where there are eutaxitic rhyolites with abundant fiamme (Savory 1976), high K and low Na and P are thought to represent a combination of subaerial leaching and chemical changes upon devitrification. (Lipman 1967; Scott 1971). The remainder of the west limb rhyolites are Na rich trondhjemitic rhyolites similar to the east limb.

The high alumina basalts and andesites of Cycle III have variolitic textures through a 60-90 m interval 1/3 of the way through the unit. Chemical trends indicative of liquid immiscibility are found in the major elements (Figure 10) (Roedder and Weiblen 1970) (Gelinas et al. 1976) and the trace elements (Watson 1976) at the variolitic unit and toward the top of the basaltic unit where there are high Fe (19 percent Fe_2O_3) basalts. It is suggested that basalts of Cycle III evolved by fractionation of olivine and plagioclase to an andesitic composition at which point they split into a two liquid system, one represented by the high Fe basalts, the other the dacites and rhyolites derived therefrom. Extremely large abundances of the LIL elements occur in the associated felsic rocks suggesting volatile transport (Collerson and Fryer 1978; Fryer and Edgar 1977).

The geological significance of South Bay being placed in Cycle III is based on high LIL element abundances (Zr, Y, Th, etc.) and Ree patterns (flat) with high abundances in the felsic rocks. This suggests that volatile transport, in the sense of Collerson and Fryer (1978) and Fryer and Edgar (1977), was active. The implication is that a large scale hydrothermal system modified the

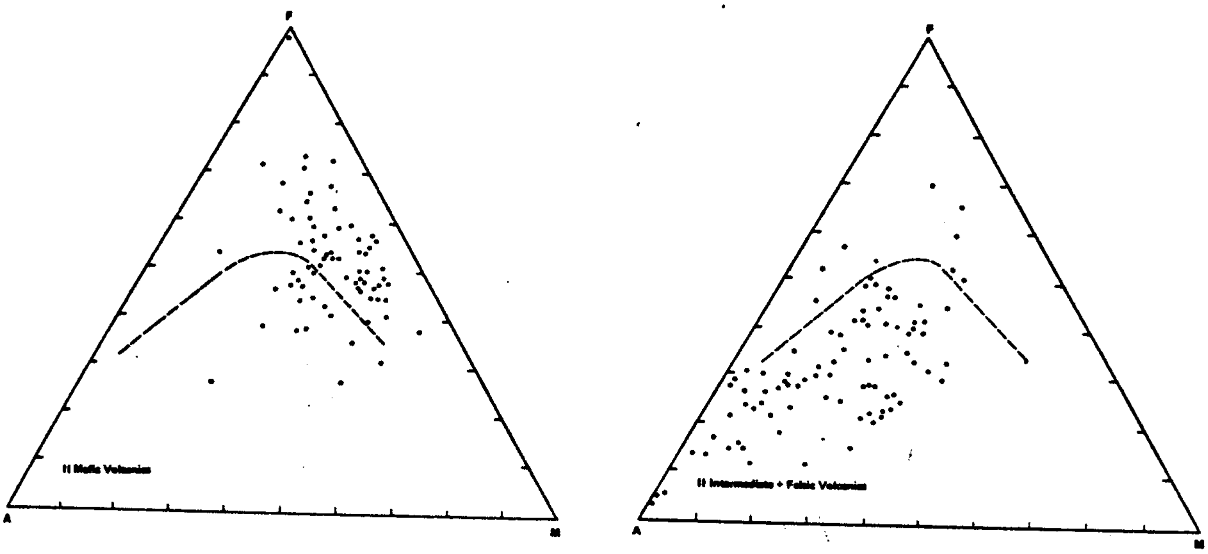


Figure 7. AFM plot cycle II metavolcanic rocks. Line separating tholeiites and calc-alkaline rock after Irvine & Baragar (1971).

chemistry of Cycle III felsic volcanics and was also probably responsible for concentrating the base metals.

REE CHEMISTRY

The REE pattern of the Cycles I and II basalts are essentially flat. Cycle III basalts below the variolites are fractionated, whereas above, they are flat. The felsic volcanic rocks of Cycle I have strongly fractionated REE trends indicative of clinopyroxene and plagioclase fractionation. Andesites associated with the basalts of Cycle II on the west limb of the syncline have lower REE abundances than the basalts, but similar flat patterns. The felsic volcanic rocks of Cycle II and the internal cycle are strongly fractionated with patterns similar to Cycle I. Cycle III felsic rocks have almost flat patterns with little fractionation. Coupled with the large LIL abundances, volatile transport of heavy REE is the most plausible alternative.

SOUTH BAY MINE

South Bay mine is comprised of a series of stacked orebodies consisting of massive sulphides yielding copper zinc, and silver. The deposit was first indicated by an airborne Input survey in 1968 and reached production early 1971(Auston 1969; Reed and Auston 1973).Copper zinc-silver ore is mined at the rate of 500 t.p.d. and the mill produces two concentrates - copper-silver which is shipped to Noranda, and zinc which is shipped to Western Europe.

At January Ist, 1978, undiluted ore reserves (including those already mined) from surface to the 1500 foot level, totalled 1,600,000 tons averaging 2.3% copper, 14.5% zinc and 3.5 oz./ton silver.

DISCOVERY: The deposit was indicated in an airborne Input survey as a single line anomaly. Although the orezone was nowhere exposed, the presence of rhyolitic and quartz feldspar porphyry outcrops in the close vicinity, led to early diamond drilling and discovery of ore-grade

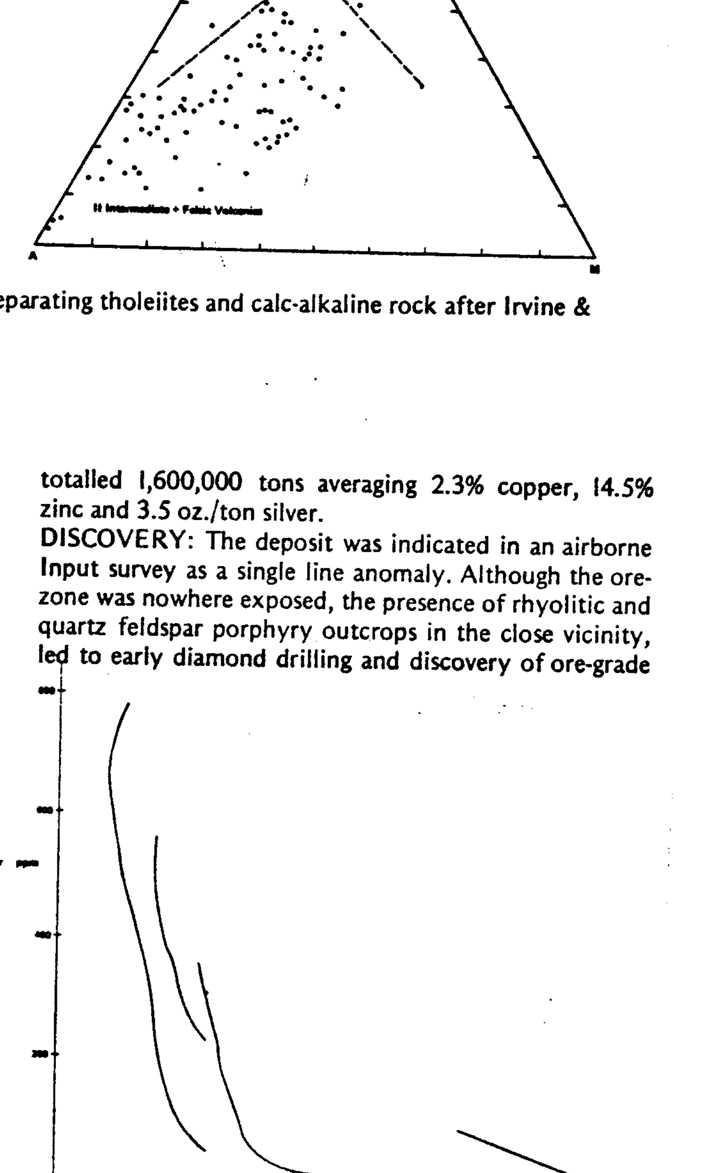


Figure 8. Cycle II basalts Cr vs. TiO_2 . Trend lines join samples in approximately stratigraphic order defining Ti enrichment and Cr depletion curves. The above trends suggest episodic replenishment of the Magma chamber with high Cr, low TiO_2 magma at intervals in the basaltic stratigraphy.

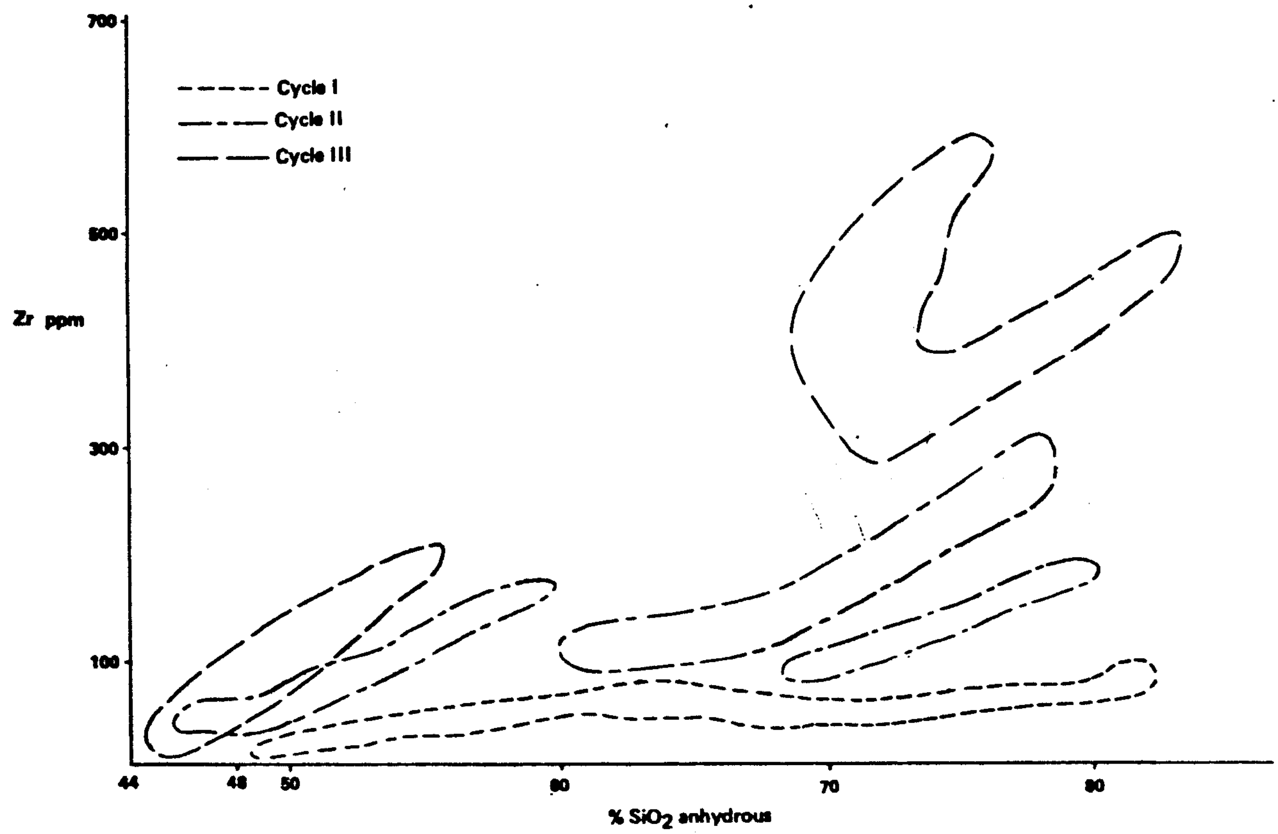


Figure 9. Zr vs. SiO_2. The various cycles are defined hereon as areas.

massive sulphides under about 20 feet of glacial overburden.

GEOLOGICAL SETTING The orebodies are hosted by felsic pyroclastic rocks, (Pryslak 1970 a, b) near the top of the acid phase of Cycle III of the Uchi metavolcanics. The volcanic sequence here faces northwestwards, a little east of the trace of the (faulted) axis of a synclinorium. From east to west, the sequence consists of:-

(a) Quartz feldspar porphyry. (QFP)
(b) Cherty argillite. Locally developed.
(c) Dacite breccia and tuff.
(d) Rhyolite tuffs, breccias, flows with argillite.
(e) Later felsite dikes, and less commonly, andesite dikes intrude all the above.

Massive and Minor Disseminated Sulphide.

Extensive alteration, which generally envelopes the massive sulphides, may be the same age as the felsite dikes.

Structural attitudes are sub-vertical and the trends swing from northerly in the south to north-easterly in the north, with much variation determined in large part, by the irregular intrusive QFP/volcanic flow interface (Asbury 1975)(Figure 11).

QUARTZ FELDSPAR PORPHYRY (QFP): This large unit is considered to be a high level intrusion, probably an endogenous rhyolitic dome (Pollock *et al.* 1972). We lack observed chilled contacts and wall-rock inclusions in the mine area, but its boundary geometry, uniform and isotropic nature (except where later foliated or altered) leads us to this conclusion. Near the orebodies, the QFP is generally altered to a highly chloritized shatter breccia which is mapped separately as QFP (2)(Squair 1973). Quartz Feldspar Porphyry (1) is a porphyritic rhyolite rock, with ubiquitous, rather evenly distributed quartz phenocrysts (2-5 m.m.) which are clear or blue, rounded to subangular, and sometimes shattered. Feldspar (oligoclase) laths (up to 10 mm.) show all gradations from incipient to total sericitization. The matrix is very fine grained, consisting mainly of quartz, sericite, and minor chlorite. The phenocrysts make up 30-40% of the total, about equally shared if the plagioclase is fresh. Silica content places the QFP in the rhyolite range but potassium and potassium/sodium are low for a typical

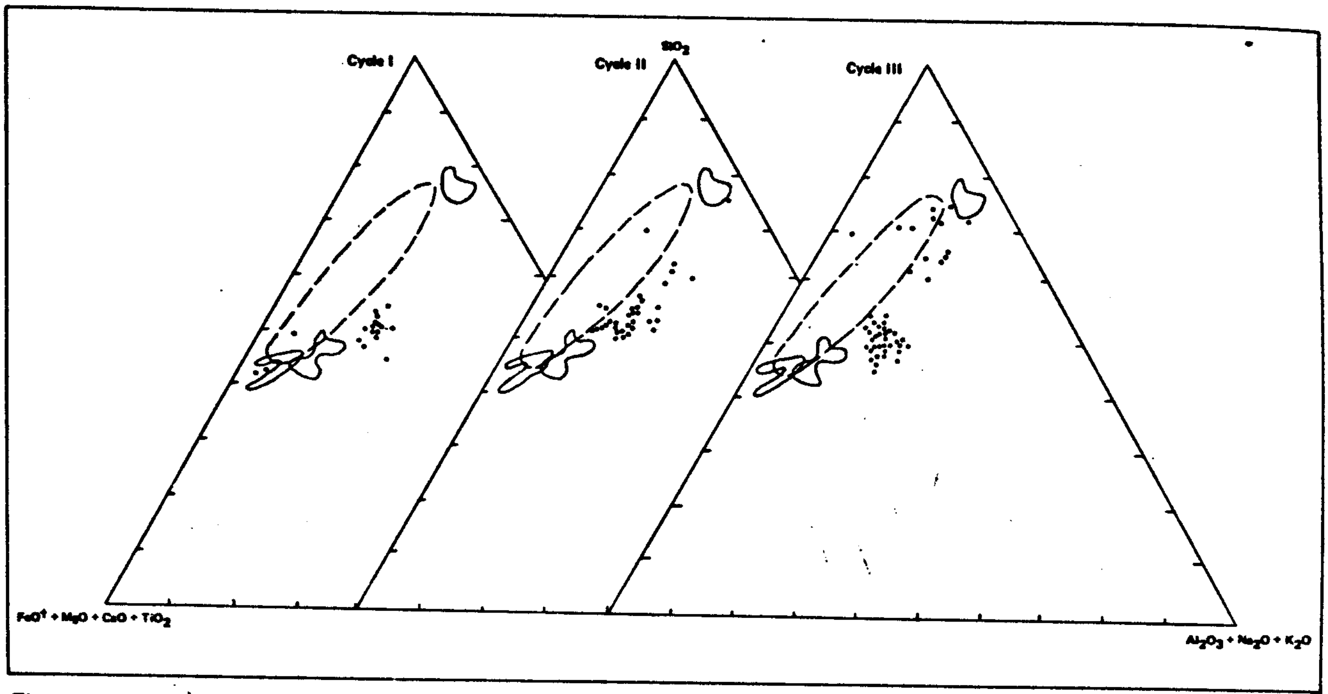


Figure 10. $FeO^+ + MgO + CaO + TiO_2$ vs. $Al_2O_3 + Na_2O + K_2O$ vs. SiO_2; a pseudoternary system after Greig (1927). The dashed area defines proposed region of liquid immiscibility. Outlined areas are lunar immiscible basalts after Roedder and Weiblen (1970).

rhyolite. It may therefore be termed a soda-rhyolite. Sericitization increases progressively as the QFP (2) alteration zone is approached with development of foliation. Carbonatization (ankerite) and bleaching and silicification are other alteration phases less closely associated with the ore sulphides (Squair 1973; Koschel 1975).

The QFP (2) generally occupies several hundred feet of QFP up to its contact with dacite, sulphides, or argillite in the mine area. Chlorite gradually increases until it forms a well-developed braided texture enveloping subrounded fragments of QFP (1) which are generally 0.5 - 1 m.m. and fairly uniform, but in local areas they are up to 5 m.m. Chlorite content appears to be 10 - 30% but includes finely divided sericite which is not easily distinguishable. The iron-rich chlorite diabantite has been identified in most thin sections (Koschal 1975).

Lightly scattered pyrite is rather ubiquitous throughout altered types of porphyry, but in QFP (2) local semi-massive concentrations (a few inches to several feet wide) of fine grained pyrite are sometimes seen, commonly with minor fine sphalerite. Elsewhere, galena has been noted in small concentrations, in fractures and quartz veins.

The QFP is seen in contact with massive ore, dacite tuff and breccia, cherty argillite and rhyolite units. (Figure 12). Its interface is extremely irregular with embayments and bulges in dimensions up to several hundred feet. Sill-like extensions into the dacitic unit are not uncommon and display flow features (Parsons 1969).

DACITE BRECCIA AND TUFF: This unit is the host rock to the ore and like the OFP (2) is heavily altered by dark chlorite. The fragments, from ash to lapilli size (3 - 4 cm.), are of felsic volcanic nature; QFP fragments have not been observed. Fragment size increases considerably toward nodes or thickened sections of breccias. In part, the fragmentation may be a steam-brecciation (if so, this would apply equally to QFP (2)) and exotic fragments are rare. Of interest is the presence of fragments of massive pyrite (which may sometimes be rimmed by minor sphalerite) in the near hanging-wall of the massive sulphides. Whether these are true fragments or selective replacements of lithic fragments, has not been established. The absence of zinc, copper, or mixed massive sulphide fragments, plus sulphur isotope ratios (Seccombe 1973) suggest these fragments have not been derived from present ore-bodies. The dark chloritic alteration, which is the dominant characteristic of this unit, adjoins similar alteration in the QFP (2) as a complementary part of the alteration envelope. The dacite breccia has a strike length of 750 feet and a thickness from 50 to 200 feet (Figures 13 and 14).

CHERTY ARGILLITE: This sometimes laminated, siliceous sediment is developed in the lower levels where it ranges up to 75 feet thick and in rhyolite units adjacent to the dacite breccia. It is sometimes in contact with

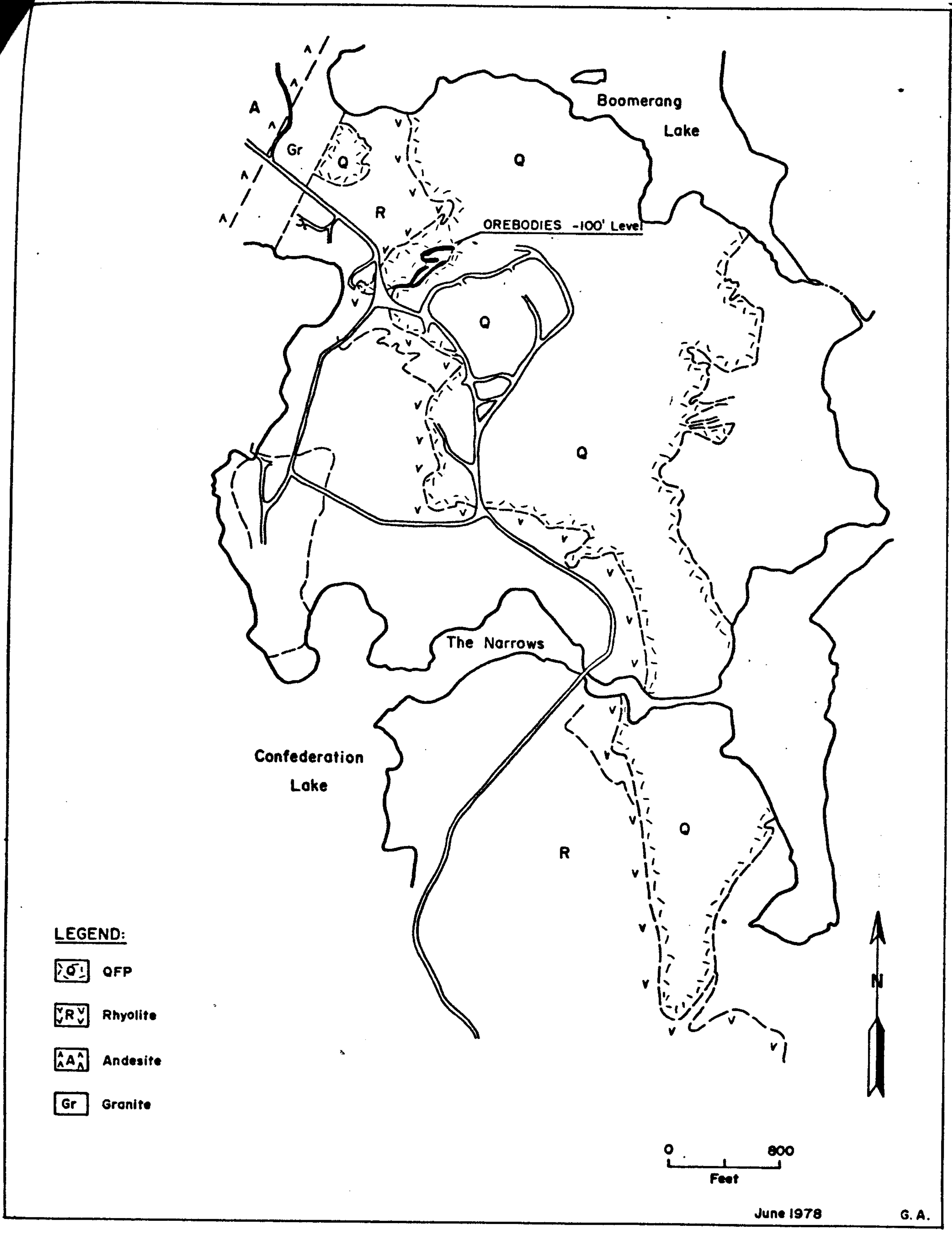


Figure 11. Surface plan of South Bay Mine, Selco Mining Corporation Limited.

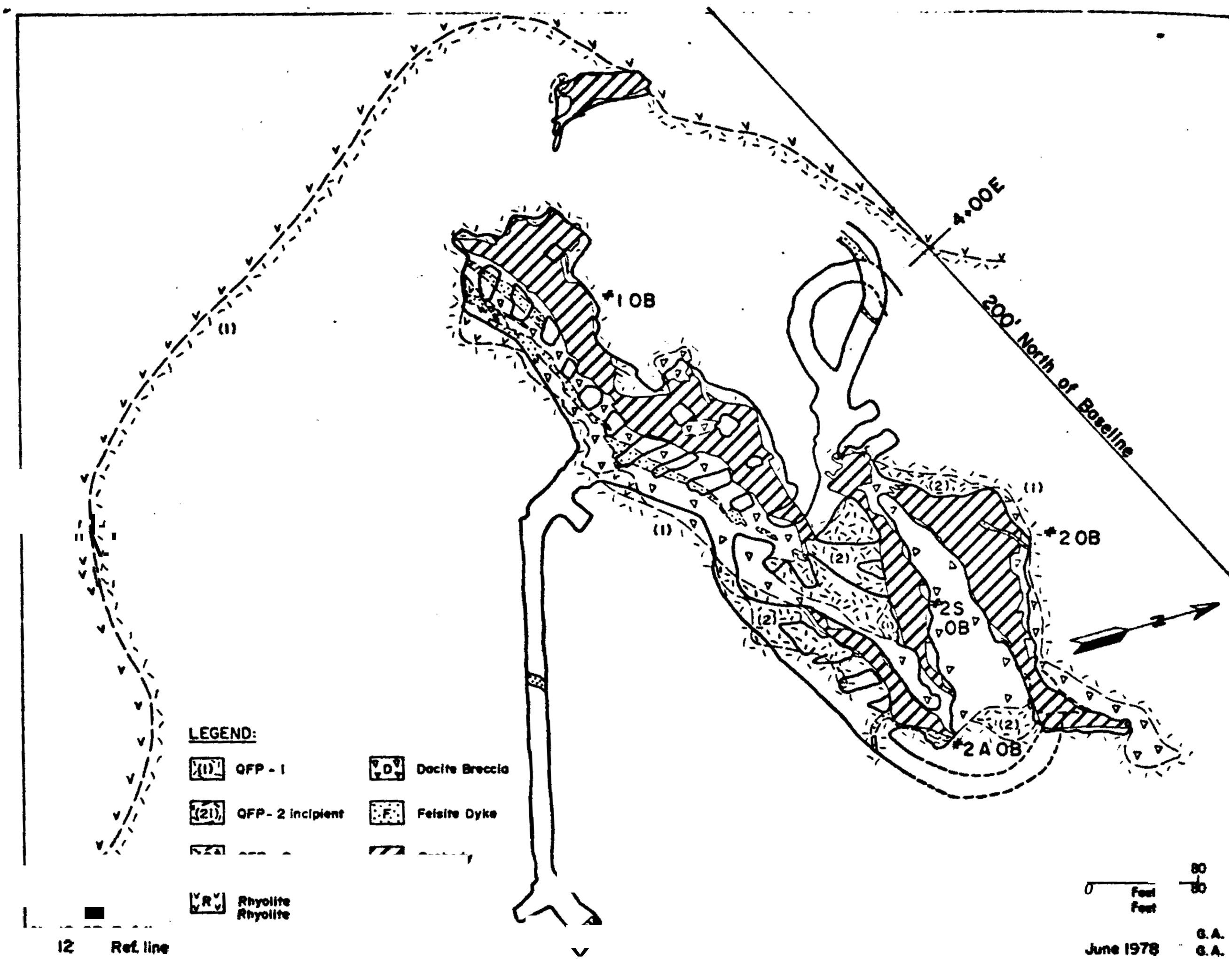


Figure 12. 150-foot level of South Bay Mine, Selco Mining Corporation Limited.

QFP, and overlain by dacite tuff/breccia. Sometimes mineralized, it lacks ore concentrations. The unit shows a close spatial relationship to massive ore in stope 24604 between 950 and 1200 levels. This is the only part of the mine where good metal zoning is developed with high grade (10 - 40%) zinc overlying lower grade zinc and copper ore. These features are similar to those found in the Kuroko ores of japan.

MASSIVE SULPHIDES: Massive sulphide ore lenses occur as generally bulbous, irregular bodies, up to 50 feet wide, 300 feet long and 500 feet high. They consist dominantly of pyrite (up to 80%) with sphalerite and chalcopyrite as the other principal sulphides. Minor sulphides are pyrrhotite, galena, arsenopyrite and silver minerals (Bridge 1972). Gangue, commonly 5 - 10% of the ore is dominantly dacite and chert fragments plus quartz and carbonate, with minor sericite and chlorite. The gangue minerals occur variously as disseminated dust to veinlets.

The ore ranges from very fine grained pyrite to coarse, nearly monomineralic light sphalerite, but is typically a finely banded series, the bands being respectively dominant in pyrite and sphalerite, with chalcopyrite as a remobilized phase.

Pyrite shows spheroidal textures, well seen when defined by contrasting chalcopyrite. These textures were noted and examined in polished section (Toubourg 1971). Hard spheroids of pyrite have apparently been resistant to deformation, which has affected the more ductile chalcopyrite and sphalerite (Corkery 1977). The sulphides, as a whole, have thus behaved as an incompetent formation against quartz feldspar porphyry, as evidenced by scallop structures at the contacts. (Asbury 1975). An analysis of banding within the massive sulphide (Corkery 1977) has confirmed the stratabound nature of the deposit and defined two ages of pyrite which have reacted

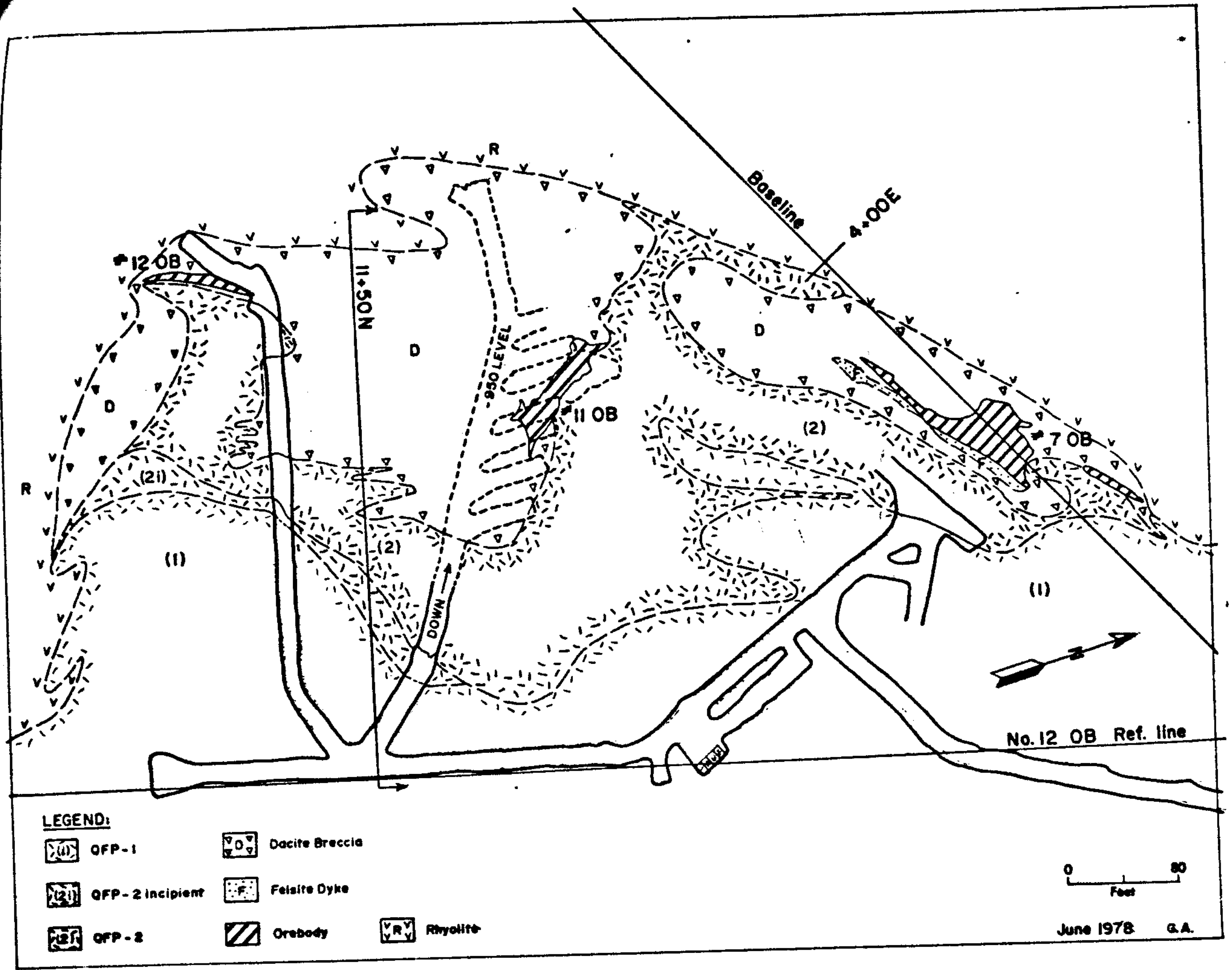


Figure 13. 900-foot level of South Bay Mine, Selco Mining Corporation Limited.

separately to stress. Early pyrite spheroids and fragments are representative of early layering while later pyrite and economic sulphide have developed a metamorphic fabric analogous to those developed in a metamorphosed sedimentary terrain.

RHYOLITE FLOWS, TUFF AND BRECCIA: Spheroidal and massive flows with subordinate tuff, chert and breccia characterize the siliceous rocks of the hanging wall. The rocks are weakly altered wi 1 carbonate, sericite and quartz as predominant phases.

Spheroidal flow units are the most distinctive rocks noted in drill core and underground workings. In these flows tightly packed spheroids up to 8 m.m. long are present in a matrix of quartz, chlorite and sericite. The primary nature of the spheroids is best demonstrated by layering within individual flow units and Parsons(1969) attributed these features to devitrification of glassy flows.

Asbury (1975) used spheroids along with other primary features as an indicator of strain which took place during deformation of the volcanic pile.

The spheroidal flows are interbanded with massive flows, breccias and tuff which overlie the main dacite breccia unit. In addition to colour and hardness, primary features such as spheroids, hyaloclastite and flow bands are used to distinguish the rhyolites from the underlying dacite breccia and flows.

FELSITE DIKES: The felsite dikes intrude all rocks and the ore-sulphides, but are most common near the orebodies in the altered rocks (dacite and QFP (2)). Here they are bulbous and irregular in shape. They are fine-grained unaltered rocks consisting mainly of quartz and

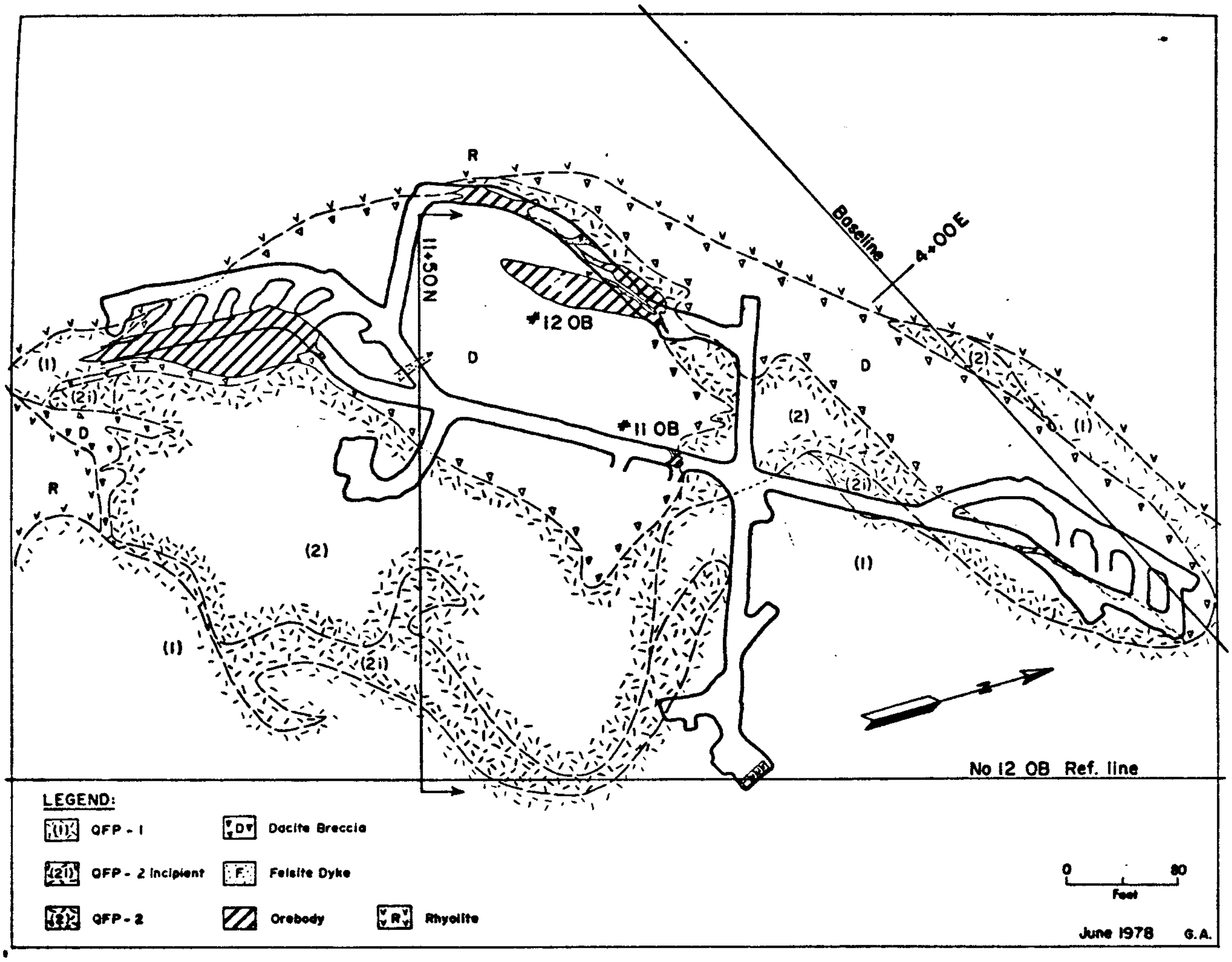


Figure 14. 1050-foot level of South Bay Mine, Selco Mining Corporation Limited.

oligoclase but with ubiquitous brown carbonate. Disseminated pyrite cubes are quite common. There is a grain size gradation from contact to centre, with thicker dikes having small feldspar + quartz phenocrysts. Minor baking of the QFP wall has been observed. Most of the dikes are non-foliate, a feature that may reflect their high quartz-feldspar content.

WALLROCK ALTERATION: Three phases of hydrothermal wallrock alteration have been recognized in the mine workings to date and a fourth "silicification" may also be related to the present ore zone.

Dark chlorite (diabantite) is the most prevalent hydrothermal phase and demonstrates a close spatial relationship to sulphide lenses. The mineral is most prevalent within the matrix of the dacite breccia and QFP (2) but similar chlorite fills fractures in felsite dikes and overlying rhyolite flows. Koschal(1975) found that the intensity of chlorite alteration in QFP (2) increased with depth to the 600 foot level of the mine and underground mapping has shown that chlorite alteration is strongest within and adjacent to nodes or "thickened sections" of dacite breccia.

Sericite alteration is ubiquitous within the QFP (1) at the mine and shows an antipathetic spatial relationship to dark chlorite phases. Sericite is most strongly developed within the QFP (1) and flow rocks at the margins of the main chlorite zone but is also present along with chlorite in incipient phases of QFP (2). In addition to the matrix of breccia, sericite forms from the breakdown of plagioclase within the host rock.

In relation to both chlorite and sericite alteration, Koschal has noted the introduction of excess iron, mag-

nesium and potassium beyond that to be expected from alteration of ferromagnesians and potassic feldspar in the QFP and adjacent volcanics.

Ankerite has been identified as the main carbonate *phase within* the alteration halo (Koschal 1975). The mineral is most readily observed along with sericite in QFP (I) and massive flow rocks. Within the chlorite zone carbonate is found disseminated within the breccia matrix and as fracture fillings of all rock types.

Silicification in the form of graphic texture and quartz overgrowths is best observed in thin sections from bleached rock units. The spatial relationship of this alteration to sulphides has not been fully examined but evidence of silicification is found in footwall and hangingwall rocks.

Palagonite and clay minerals have been identified as alteration phases which occur with sericite and carbonate phases (Koschal 1975). More extensive thin section studies are required to ascertain the extent of these latter phases.

It must be emphasized that wall rock alterations and especially the chlorite phase of alteration has played a significant role in the search for ore at depth. In addition to increasing the size of target, the chlorite alteration phases show a sympathetic volume relationship to massive zinc-copper-sulphide.

CONCLUSION: While South Bay is classified as a volcanogenic massive sulphide orebody in felsic volcanic rocks, it shows several variant characteristics. The footwall QFP has been considered a high-level intrusive

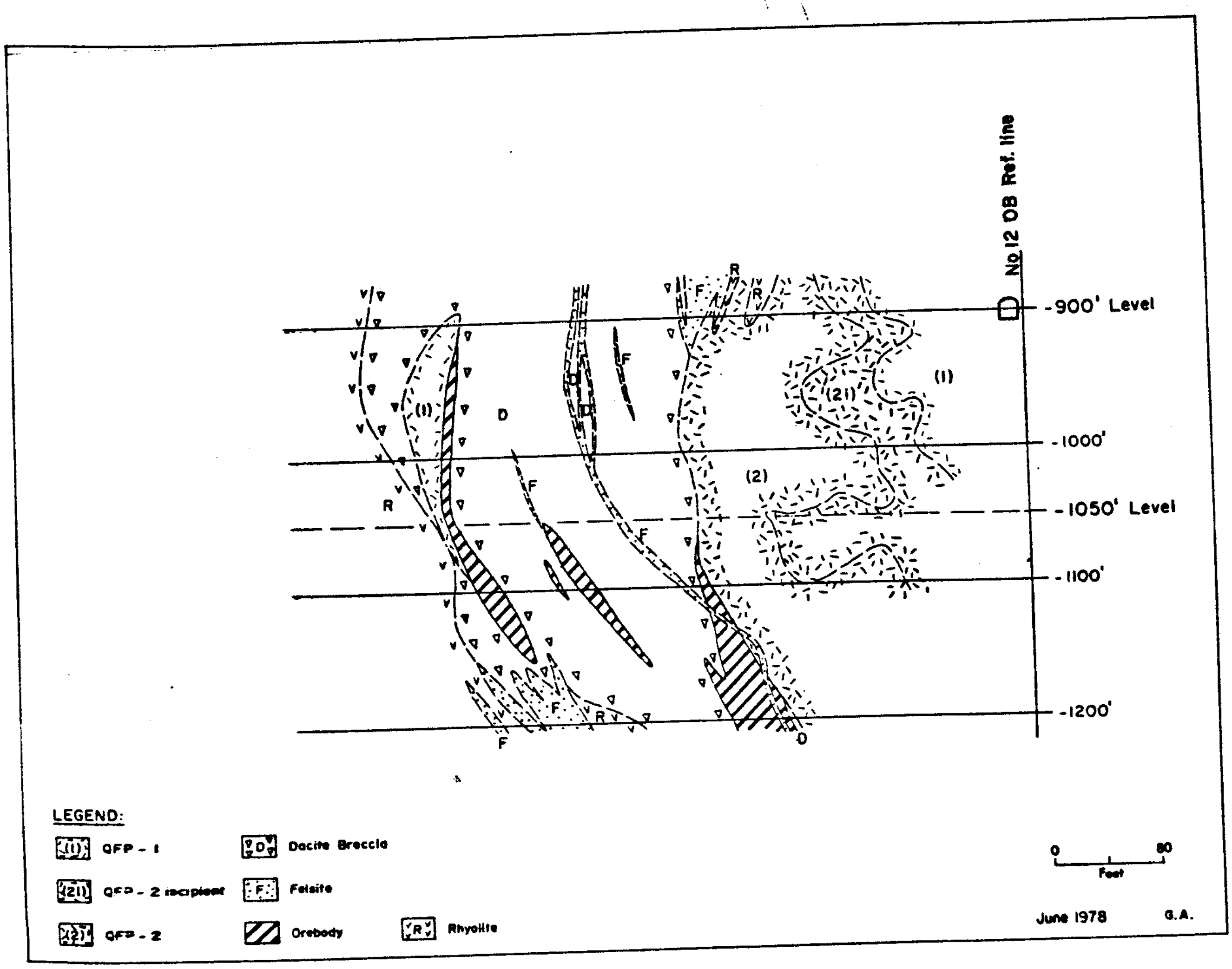


Figure 15. Section 11 + 50N (look north), No. 12, Orebody, South Bay Mine, Selco Mining Corporation Limited.

phase although it is likely that some of the sill-like protuberances are local extrusive phases. The orebodies are very sympathetically situated in relation to its contact, embayments and protuberances. The sulphides, at times, display sedimentary-type textures (spheroidal, fine pyrite) and Kuroko-type zoning conformable to underlying argillite/cherty sediments. Elsewhere, there has been plastic deformation of the chalcopyrite and sphalerite bearing bands, but apparently not of the harder pyrite.

The cnlorite alteration zone is essentially transgressive to the sequence, and may define a fissure, trench, or other zone of weakness, along which vents (now indicated by alteration nodes) were developed as a result of volcanic breccia extrusion, mineralization and alteration fluids. Coeval with the chlorite alteration, with its excess iron and magnesium was the intrusion of felsite dikes depleted in those metals. The dikes intrude all rocks, including the ore (Sopuck 1977, McConnell 1976).

ROAD LOG

DAY 1

Transport from Toronto to Dryden via Transair. Meet bus at Dryden airport.

Drive 60 km. west on highway 17 to Vermilion Bay then north on highway 105 for 112 km to Ear Falls. The highway 17 leg of the trip crosses metavolcanic and metasedimentary rocks of the Wabigoon subprovince. As we turn north along highway 105 we traverse a major part of the English River subprovince. If time permits, 2 unscheduled short stops will be made either northbound or on our return to the Dryden airport. Arrival scheduled in Ear Falls at about 8:30 P.M.

DAY 2

Turn left from Trillium Motel onto highway 105 for about 0.2 km then left onto highway 657 to Goldpines. After 1.5-2 km turn left onto the South Bay Mine Road. Continue for 77 km to the South Bay Mine gatehouse. Check in at gatehouse. All visitors must:

1) have company permission to enter property.
2) Log in and out at gatehouse.
3) Wear hard hat, safety glasses and safety boots.

For details of Mine, refer to South Bay Mine section of this field trip guide.

The visit will take the whole morning. Re-assemble at the bus after completion of the mine visit for surface tour conducted jointly by J. Wan and P. Thurston.

Outcrops in mine area

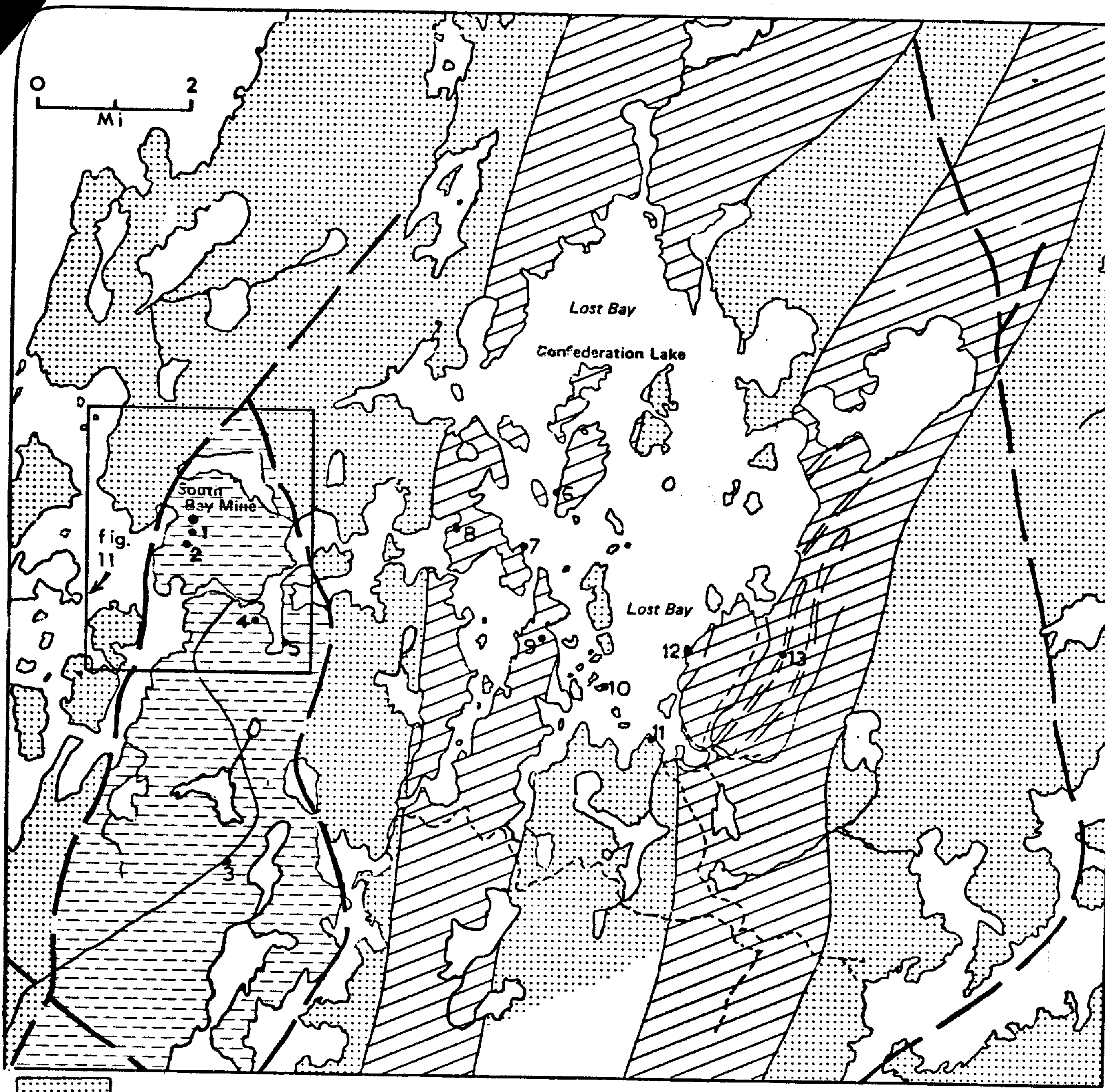
Note: This is an area with much vehicular traffic - walk facing traffic off the travelled portion of the road and stay away from the maintenance garage.

STOP 1 About 90 m WSW of the headframe, on the north side of the road to the mine store. This outcrop extends about 30 m north of the road and should be examined on the weathered surface about 20 m north of the road. At this point the outcrop consists of alternating poorly defined northeast striking bands. Detailed inspection shows some bands up to 0.3 m thick of aphanitic felsic matrix containing up to 20-30 percent 5-10 m spherulites. The spherulites have a turbid light green to clear core surrounded by a milky white rim. The spherulite rich bands alternate with irregular patches and blebs 0.3-0.6 m thick of crackle brecciated felsic aphanitic massive rock. Fragments in the breccia can be re-assembled into larger fragments.

The outcrop is interpreted as a rhyolitic flow. The interior part of relatively thin flows have developed devitrification type spherulites (Lofgren 1971) consisting of radiating needles of albite. Saussuritization is more intensely developed on the exterior of the spherulites rendering them white on the periphery such that they bear a resemblance to accretionary lapilli. Development of spherulites implies some degree of proximity to a heat source as spherulite development requires on the order of 350^0 C of supercooling for about 48 hours in this instance (Lofgren 1971; Kesler and Weiblen 1968). The heat source is most probably the subjacent endogenous dome of mine porphyry the probable feeder for the Cycle III felsic rocks (Pollock *et al.* 1972; Asbury 1976). Steam fracturing has produced this crackle type breccia (Parsons 1969).

STOP 2 Walk 50 m ESE down the road past the maintenance garage and proceed uphill toward the water tower. About halfway up the hill a 10 x 5 m area of massive rhyolite is exposed. The outcrop weathers white and has blocky fractures. Irregular joints defining polygonal blocks about 0.1-0.3 m on a side cut the outcrop. The joints are filled with minor chlorite. The rock is a massive aphanitic rhyolite flow with occasional quartz and feldspar phenocrysts.

STOP 3 Proceed from the mine site by bus 2.4 km southeast from the bridge crossing the Narrows of Confederation Lake. At this point the bus will discharge passengers. Please stay off the road. Outcrops on both sides of the road for a distance of about 300 m to the northeast will be examined. The rocks here are rhyolitic pyroclastic rocks of the upper part of Cycle III. They are immediately south of the mine porphyry and may be thought of as the ejecta from that dome. The unit varies from fine 1-3 mm ash to lapilli sized lithic and crystal fragments in a tuffaceous matrix defining poorly sorted beds 0.3-10 m thick to lapilli tuff and tuff breccia. The coarser pyroclastic rocks are also rhyolitic in composition. Worthy of note is the lack of sorting, lack of bedding, preponderance of lithic fragments and ash. Many of the fragments were obviously hot and deformed. They can only have the shape of ribbon and cow dung bombs (Macdonald 1972). The pumiceous nature of many of the fragments suggests shallow water (less than 1600 m, Rittman 1962). Partial welding textures in the intermediate to felsic tuffs to the north suggest sub-



Felsic & Intermed. Volcanic Rocks

Mafic Volcanic Rocks

Mine Series Felsic Volcanic Rocks

Figure 16. Geological map showing field stops.

aerial origin to some but recent discussions by Frances and Howells, (1973) indicate that submarine welding does occur. If so, deformed ribbon bombs etc. are possible submarine also.

Return to Trillium Motel Ear Falls.

DAY 3

Travel by bus to MNR campsite at mile 47 on South Bay Mine road and enter boats.

STOP 4 The mine porphyry is an intrustive rhyolite spatially associated with the cycle III felsic metavolcanic rocks. The principal features of the unit are abundant (20-40 percent) quartz phenocrysts and subordinate amounts (10-15 percent) plagioclase phenocrysts of similar size in a white to grey weathering massive to foliated rock. The unit forms, in plan view, a domical mass in SE Dent Township (Pryslak 1970). This body is 800 by 2000 m and by virtue of its two dimensional shape, intrusive contacts, fine grained marginal zones, inclusions of wall rocks, and a poorly developed foliation parallel to the margin, has been termed an endogeneous dome by Pollock *et al.* (1972). Numerous sill-like offshoots of the main dome occur (Pryslak 1970; Thurston 1978).

In thin section, the quartz-feldspar porphyry consists of 20-40 percent 2-4 mm diameter rounded quartz phenocrysts, 10-20 percent 1-3 mm diameter sericitized albite phenocrysts in a matrix of fine grained quartz, albite and minor sericite .006-.02 mm in size. Scattered grains of epidote occur throughout the matrix. Sericitization of feldspar phenocrysts and the matrix is more intense as the orebody is approached.

On this outcrop a faint regional foliation can be discerned. The foliation is a function of the alignment of phenocrysts. Other than this the "mine porphyry" is massive. On the north edge of the outcrop "ghost breccia" consisting of poorly defined subangular blocks up to 0.1 m. on a side can be discerned. They are distributed irregularly through the unit and may mark the existence of extrusive phases of the body. The "ghost breccia" fragments on this outcrop can only be seen from a boat as they occur on a vertical face.

STOP 5 This outcrop lies at the top of the hill 30 m east of the shore at the locality marked on Figure 16. It lies about 914-1220 m beneath the orebody. It is part of a unit of dacitic pyroclastic rocks spatially associated with the mine porphyry. Several outcrops on the hill side have been stripped of moss and the shoreline examined in vain for evidence of bedding. The unit consists of pumiceous or scoriaceous blocks and lapilli of dacitic composition forming 60-80 percent of the outcrop in an aphanitic ash matrix. The lack of bedding, lack of crackle brecciation, homogeneity of clast types, lack of contrast in composition of matrix and clast and limited lateral extent of the unit suggest it is a vent breccia using the criteria of Parsons (1969).

STOP 6 The next three outcrops are intended to show a sequence of events in the development of pillow breccia in cycle III mafic flows. Here both pahoehoe toes with a roughly circular cross-section and concentric cracks and pillows with radial cooling cracks are present. Careful examination of the pillow margins reveals the presence of small (less than 1 mm) plagioclase phenocrysts and spherulites. The interpillow space is in several instances filled with relict glass with flower-like patterns which has spalled off the pillows. This represents the first stage in the formation of pillow breccia.

The unusual grey-green color of this basalt is an early stage in the development of the white basalts which are very common in the upper portion of cycle III. As the alteration is often concentrated at pillow rims it is perhaps evidence of early hydrothermal activity which perhaps led to the unusual LIL enrichment pattern of the overlying rhyolites of Cycle III. The alteration assemblage consists of carbonate, tremolite-actinolite ± chlorite and coarse-grained epidote.

STOP 7 Here white weathering amoeboid masses of basalt forming 20-30 percent of the rock sit in a dark weathering matrix of metabasaltic glass. The unit is completely chaotic with no evidence of bedding. As no pillow selvages can be seen the outcrop is not a convincing example of hyaloclastite. If it is, the amoeboid masses ("pillows"?) must have been plastic and not confined by surrounding material so as to develop the irregular shapes observed.

STOP 8 This outcrop, still within the cycle III basalts, represents a more classical view of the broken pillow breccia type of Carlisle (1963). Along the north edge of the outcrop, several fractured pillows about 0.1-0.2 m in the long dimension with selvages around a portion of their periphery can be observed. The matrix is hyaloclastic debris with straight edges vs the curved edges seen in pyroclastic fragments. In this instance less vesicular plates of glassy basaltic debris have fractured forming relatively straight edged fragments typical of hyaloclastite (Honnorez 1972).

At other localities, isolated pillows in a calcareous matrix are interpreted as pillows expelled onto calcareous muds in a shelf environment.

STOP 9 Bobjo Point is the site of an old gold prospect (Thomson 1938). Therefore watch for old trenches, pits, etc. Proceed east to crest of hill (60 m) then south for about 120 m past derelict cabins to clearing.

This outcrop represents a variolitic andesite. The unit is about 60-90 m thick and extends for about 10 km along strike. It occurs about 1/3 of the way up into the basalts of cycle III. The varioles are concentrated in bands 0.1 m thick consisting of separate and coalesced varioles, separated by comparatively variole-free bands. No pillows have been observed in the unit. Accordingly the unit is suggested to be a massive variolitic flow after the terminology of Gelinas *et al.* (1976). The varioles have been concentrated into the variole-rich body by flow differentiation (Gelinas *et al.* 1976).

The preferred process for origin of this unit is liquid immiscibility as many of Bowen's (1928) criteria for liquid immiscibility are met: 1) Two glasses of different composition occurred in the rock, a low K rhyolite and a high Fe andesite: 2) Identical crystals of relict quench olivine or pyroxene occur in both glasses: 3) The felsic varioles are observed in several different size ranges (Philpotts 1977) and are often observed to coalesce. Many of the major element criteria for immiscibility discussed by Philpotts (1977); Gelinas *et al.* (1976) and Watson (1977) are met; i.e. P_2O_5, the rare earth elements, Cu, Cr, Ti, Mn, Zr, Mg, Sr and Ba preferentially enter the mafic phase. (See samples 449, 450, 451 and 452 matrix-variole pairs from this unit: 449 and 451 are matrix and 450 and 452 varioles).

Other possible origins include spherulitic crystalliz - tion (Kesler and Weiblen 1968) and metasomatic movement of elements (Hughes 1977).

STOP 10 We begin here the examination of the pyroclastic rocks of cycle II. This outcrop lies about 400 m below the top of cycle II. The next 3 stops represent various facies of an assemblage of subaqueous pyroclastic flows. The flows show both in a single bed on a single outcrop and in a gross stratigraphic sense over an interval of 60-600 m or overall fining upward and fining outward aspect similar to that described by Yamada (1973). The proximal facies consists of coarse angular unsorted poorly-bedded chaotic conglomerate with a high proportion of pumiceous clasts in a matrix of ash and broken crystals. This facies occurs on Uchi Lake to the east. Outward from the vent pumiceous lapilli tuff with smaller fragments, more matrix and better development of bedding occurs. This unit is succeeded upward by sandy pumice tuff with interbedded fine tuff and lapilli tuff, followed upward by finely bedded tuff.

On this outcrop we examine sandy pumice tuff with 80-90% angular rhyolitic lapilli in a fine tuffaceous matrix. Beds are 5-8 cm thick and graded in both a normal and a reverse fashion. The lithic lapilli are pumiceous in nature. In Yamada's scheme (1973) the units represent the parallel laminated pumice tuff unit about midway through the fining upward sequence. This outcrop is part of several of these subaqueous pyroclastic flows forming the Cycle II pyroclastic rocks on the east limb of the fold.

On the west limb this unit is correlative with eutaxitic textured fiamme bearing rhyolites with a subaerial origin (Savory 1976).

STOP 11 In Yamada's sequence this outcrop represents the parallel laminated fine tuff unit toward the top of Yamada's (1973) fining upward cycle. It consists of occasional subangular rhyolitic pumice fragments (2 cm) in a fine sandy tuffaceous matrix. The matrix consists of broken quartz and feldspar phenocrysts and fine ash. Convoluted bedding of the Bouma C division is present as well as a massive unit of the A division.

STOP 12 This land is the property of the Mackinaw Rod and Gun Club of the South Bay Mine and as private property must be respected.

The outcrop here forms the basal part of the first of several fining upward subaqueous pyroclastic flows. In Yamada's (1973) scheme it would be termed the massive graded division. Subangular pumiceous dacitic clasts (2-5 cm) predominate with occasional lithic clasts in a matrix of occasional pea-sized sulphide clasts, broken crystals, small lithic fragments and ash. The proportion of clasts varies from 20-80%. The unit is massive over a thickening of 60 m with occasional sandy pumice tuff interbeds. One finer-grained bed can be seen at the southwest edge of the outcrop.

STOP 13 Dock at end of road to Uchi Lake, proceed southeast for 400 m to the Grasset shaft (Thomson 1938). From the shaft proceed about 400 m south on the road, then due east for 40-50 m to the large stripped outcrop.

The Hill-Sloan-Tivey (HST) vein of Thomson (1938) is considered to be a chert horizon because of its great length (2950 m) its generally conformable nature and the fact that it sits above a rhyolite in the upper part of one of four so-called mini-cycles within Cycle II. The chert exhibits a laminated structure defined by carbonate and;or muscovite-rich interbeds; gold mineralization is associated with the chert (Thomson 1938; Baker 1976; Thurston 1978). The underlying metavolcanic rocks form a minicycle consisting of pillowed basaltic andesite dacite and rhyolite. Features to be seen on this outcrop underlying the chert include rhyolitic tuff exhibiting cyclical graded bedding and rhyolitic flow top breccia. Above the chert on an outcrop 60 m north intermediate hyaloclastic debris consisting of isolated and broken pillow breccia (Carlisle 1963) with occasional jaspilitic iron formation clasts are observed.

Proceed by boat to MNR campsite to board bus for return to Ear Falls.

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