A STUDY OF THE VOLCANIC STRATIGRAPHY AND VOLCANOGENIC MINERALIZATION ON THE KAY CLAIM GROUP, NORTHWESTERN BRITISH COLUMBIA

by

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We accept this thesis as conforming to the required standard

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Frontispiece. One of several gossan stained bluffs which attracted prospectors attention to the area. The bluff is composed of massive rhyolite with pyritic stockwork mineralization.

Abstract

The Kay claim group, in northwestern British Columbia, is underlain by a succession of volcanic and volcaniclastic rocks of the upper division of the Jurassic Hazelton Group, dominantly rhyolitic flows or domes and related pyroclastics formed under marine conditions. A younger intrusive body related to the Skeena Intrusions and consisting of granodiorite porphyry, underlies a small portion of the thesis area.

Volcanogenic mineralization, stratigraphically and structurally controlled, occurs in two modes in the thesis area; (1) massive sulphides, predominantly galena, sphalerite and pyrite and (2) stockwork sulphides, mainly sphalerite and galena with varying amounts of jamesonite, tetrahedrite and polybasite.

The style and composition of the sulphide mineralization, coupled with the overall geologic setting, suggest that valid comparisons may be made with lead-rich massive sulphide deposits of the Japanese "Kuroko-type" and those of the Bathurst District of New Brunswick.

ACKNOWLEDGEMENTS

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INTRODUCTION

SCOPE AND PURPOSE

The Kay claim group, in northwestern British Columbia (Fig. 1), is underlain by a succession of eugeosynclinal volcanic flows and volcaniclastic rocks of the upper division of the Hazelton Group. The property was mapped by the author during the summer of 1975 for Texasgulf, Inc. The occurrence of sulphide mineralization within a volcano-sedimentary stratigraphy prompted laboratory study to determine:

1) lithology of units defined,
2) environment of deposition of the strata,
3) occurrence and composition of mineralization, and
4) paragenesis and environment of ore deposition.

LOCATION AND ACCESS

The Kay claim group (Fig. 2) is about 80 km north-northwest of Stewart, British Columbia, and lies on the east slope of the Prout Plateau about 4 km east of Tom MacKay Lake, between the Unuk and Iskut Rivers. Access to the property is by helicopter from Stewart or points along the Stewart-Cassiar Highway. Alternate routes would be by float equipped fixed-wing aircraft to Tom MacKay Lake and by "Cat" trail to the property. Ice on the lake until late July or early August limits the usefulness of this route.

Mandy (1932) reported that in 1902 some 64 km of wagon road were built along the Unuk River. The valley of this river was the first access route to the general area, but this route is impassible today.

Fig. I
LOCATION MAP
SCALE 1" = 140 Miles
(approx.)
ALASKA
YUKON
TERRITORY
DISTRICT OF
MACKENZIE
WHITEHORSE
SKAGWAY
WATSON LAKE
YELLOWKNIFE
BRITISH
COLUMBIA
KAY PROPERTY
FORT
NELSON
STEWART
B.C.R.
ALBERTA
FORT
St. JOHN
PRINCE
RUPERT
TERRACE
B.C.R.
C.N.R.
PRINCE
GEORGE
EDMONTON
C.N.R.
C.N.R.
C.P.R.
CALGARY
B.C.R.
KAMLOOPS
VANCOUVER
VICTORIA
U. S. A.

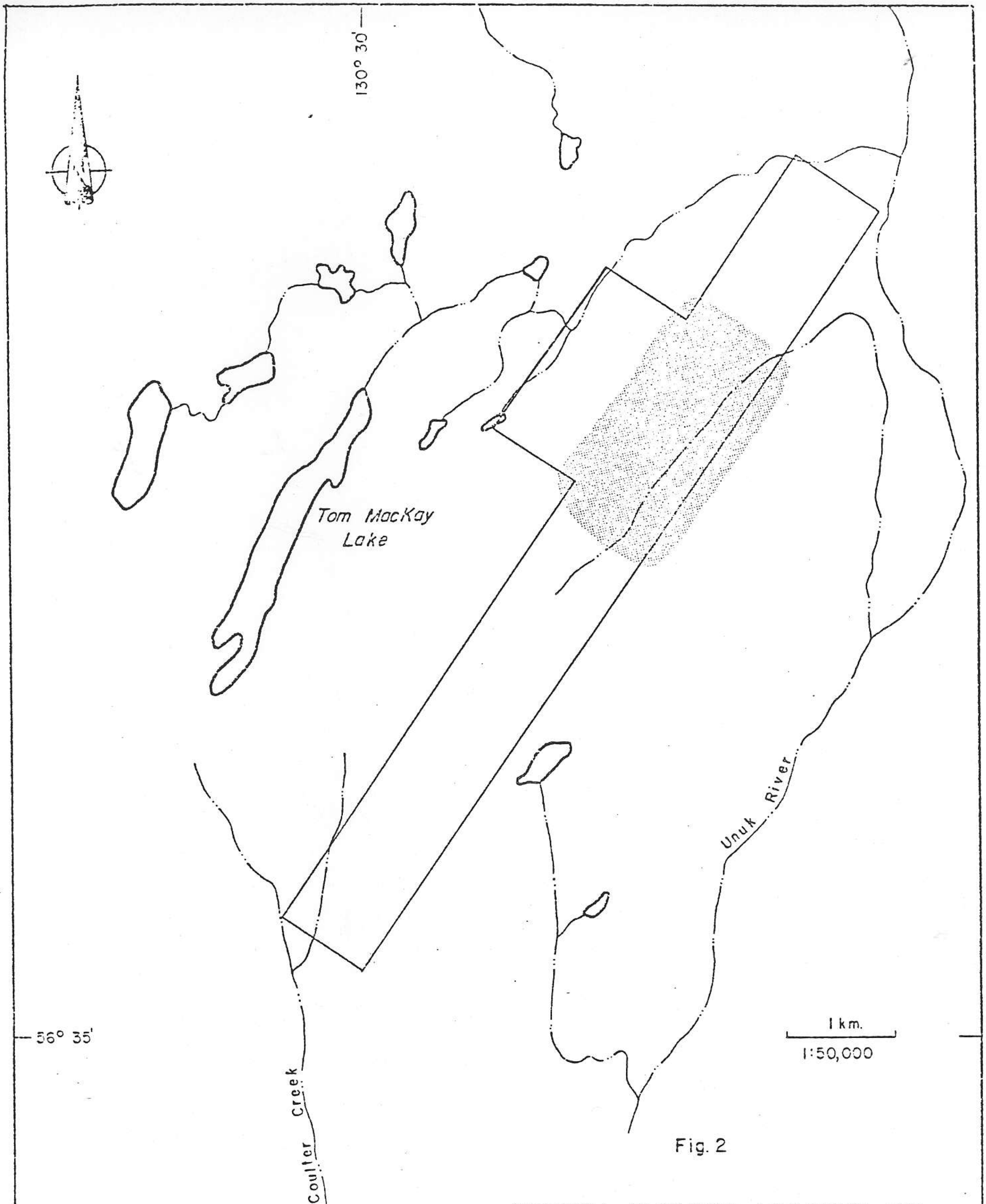

Fig. 2

SKETCH SHOWING LOCATION OF KAY PROPERTY AND AREA OF GEOLOGIC MAPPING

104 B / 9W

PHYSIOGRAPHY

The property lies within the so-called "Boundary Ranges" sub-division of the Coast Ranges as defined by Bostock (1970). In detail, the property is located on the northeastern edge of the Prout Plateau, which Mandy (1934) described as a sparsely timbered, indented and ridged terrain which trends north-south. This plateau is about 9.5 km wide and 12 km long and ranges in elevation from about 950 to 1200 m.

Within the thesis area, the topography slopes to the north-east. Alpine glaciation has modified the land surface to give a steep hummocky appearance, with some cliffs locally reaching 100 m in relief.

CLIMATE AND VEGETATION

The Prout Plateau occurs near the border between the West Coast Marine and Northern Interior climatic regions of British Columbia. Most of the weather systems originate off the coast and must rise above high topography in the area, resulting in heavy rainfall. Thus, the property probably receives in excess of 500 cm of precipitation every year.

Winters in the area are long and severe and summers tend to be cool and relatively short. The summers are characterized by mist and drizzle with rare clear, warm days. August is the best month for good weather and, therefore, for doing field work.

PLATE 1 Top: View south of Kay property showing typical hummocky topography. John Peaks in background.

Bottom: Portal of adit in rhyolite breccia.

Below 950 m elevation, the area is in the sub-alpine forest biotic region; above, it is in the alpine biotic region. Spruce, balsam fir, hemlock and ground alder, as well as many other shrubs and bushes, are common in the sub-alpine forest region. The flora of the alpine region varies from stunted conifers at its base to short grasses and heather in its upper regions.

HISTORY

Prospectors have worked in the general area since the late 1800's, when placer gold was found at the junction of the Unuk and South Unuk Rivers. The first geologist in the area was D'Arcy MacDonald who submitted a brief report in 1903 (Mandy, 1929). Since that time, the region has received limited study by the Geological Survey of Canada and the British Columbia Department of Mines because of its relative inacessability. J. T. Mandy (1932) produced the only geological sketch map of the area.

The property had an active history of exploration, by various interests, since its discovery in 1932 by T.S. MacKay and associates, (B.C.M.M. Annual Reports: 1933, p. A61; 1934, pp. B30-B33; 1935, pp. B9, B27; 1939, p. 65; 1946, p. 85; 1953, pp. 87-89 & fig. 4; 1963, p. 10; 1964, p. 20; 1965, p. 44; 1967, p. 30; 1970, pp. 64-65; 1971, p. 63). This work included a total of 320 m of underground work in two adits, a few thousand metres of diamond drilling, much surface trenching. A shipment, in 1971, of 1.5 tonnes of silver 'ore' yielded 8.5 g gold, 6,800 g silver, 29 kg lead and 42.6 kg zinc.

REGIONAL GEOLOGY

GENERAL STATEMENT

The Kay claim group is about 25 km east of the eastern margin of the Coast Crystalline Complex near the western edge of the Bowser Basin and, therefore, is within the Intermontane tectonic belts. The regional geology surrounding the property has recently been compiled at a scale of 1:1,000,000 by A.V. Okulitch (1974). The thesis area lies within a northwesterly trending belt of Lower Mesozoic eugeosynclinal sedimentary and volcaniclastic rocks, which parallels regional folding and faulting of the Canadian Cordillera.

Paleontologic and lithologic evidence presented in this thesis indicates that the rocks within the thesis area are correlative with part of the upper division of the Hazelton Group (Tipper, H., 1976, pers. comm.) and are intruded by granitic plutons of the Skeena Complex of probable Jurassic age (Grove, 1971, Fig. 1). Consequently, in order to understand the geological setting of the property a synthesis of the stratigraphy of the Hazelton Group, as adapted by the author, is presented below.

HAZELTON GROUP

The Hazelton Group consists of a sequence of volcanic and volcaniclastic sedimentary rocks with a total thickness of more than 3000 m. These rocks are exposed on the property in a northeasterly trending 3.5 km wide band. Generally, the strata dip to the northwest 40 to 60 degrees; dips are complicated locally by faulting.

Confusion exists over nomenclature and specific ages of Mesozoic units in northwestern British Columbia. Hanson (1935), working in the Portland Canal area (Fig. 3), used the name Hazelton Group to describe a thick, apparently conformable, package that included sedimentary and igneous, primarily volcanic, divisions. On the basis of fossil evidence he considered this group to be mainly Jurassic to Cretaceous in age.

Tipper (1959) studied Mesozoic beds in the Nechako River area (Fig. 3) and defined the lithologic characteristics and age of the Takla and Hazelton Groups. The Takla Group was subdivided into two units, a thick ($>$ 1500 m) volcanic unit characterized by augite porphyry and thick ($>$ 1000 m) red bed unit. He assigned an age of Late Triassic to Early Jurassic for this group on fossil evidence. The Hazelton Group was divided into three units:

1) the chert pebble conglomerate unit (of unknown thickness but up to 500 m), characterized by basal chert pebble conglomerate but comprised of greater than 50 percent andesitic and basaltic flows with related tuffs and breccias,

2) the Middle Jurassic unit (up to 1600 m thick), primarily a marine sedimentary unit with some interlayered andesite - rhyolite flow rocks, breccias and tuffs, and

3) the Upper Jurassic unit ($<$ 250 m), consisting of interbedded black calcareous shales and argillaceous limestones.

The above units of the Hazelton Group, therefore, varied in age from earliest Middle Jurassic to early Upper Jurassic.

The Takla project, undertaken in 1975 by the Geological Survey of Canada, redefined the Hazelton Group and limited its age, in the McConnell Creek map area (Fig. 3), from Lower Jurassic to lower Middle

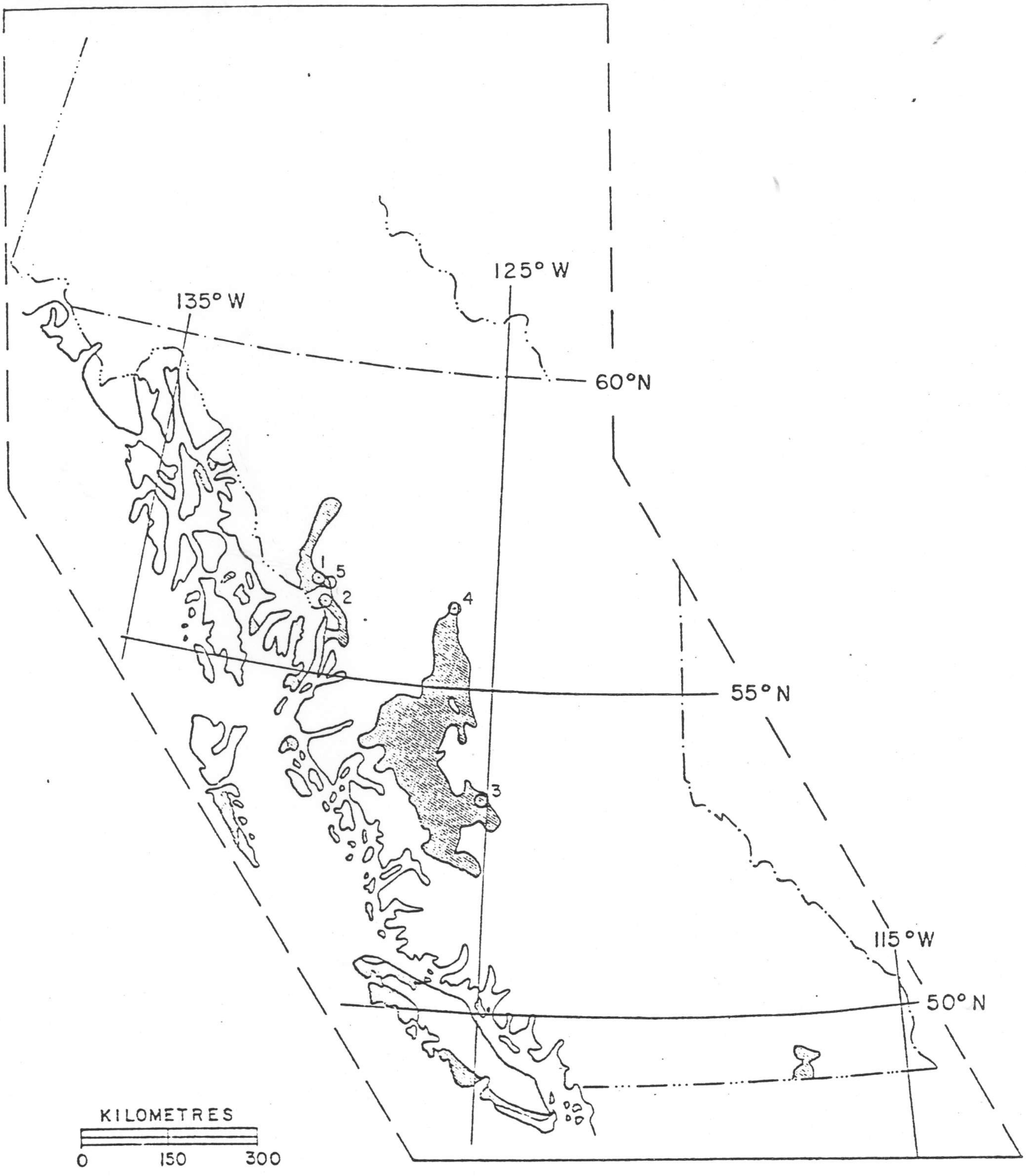

Fig. 3 Distribution of Lower & Middle Jurassic volcanic rocks in British Columbia and south eastern Alaska. Numbers define areas referred to in text: (1) Thesis area, (2) Portland Canal area, (3) Nechako River area, (4) McConnell Creek area, (5) Treaty Creek area.

Jurassic on the basis of biostratigraphic evidence (Geol. Surv. Can., 1975; Tipper, H., 1975, pers. comm.). The Hazelton Group (Table 1) is divided by Richards (1976) into a lower non-marine volcanic and volcaniclastic unit (> 1000 m in thickness) and an upper marine volcanic and sedimentary unit (> 500 m in thickness). The marine volcanic and sedimentary unit consists of four stratigraphic assemblages; from oldest to youngest these are:

1) a upper Sinemurian to lower Pliensbachian (Lower Jurassic) sedimentary assemblage of greywacke, argillite, limestone and minor amounts of red tuff,

2) a lower Pliensbachian to lower Toarcian (middle Lower Jurassic) assemblage of well bedded greywacke siltstone, arigllite, acidic tuff, limy argillite and minor amounts of basaltic breccia,

3) a middle to upper Toarcian (early Middle Jurassic) assemblage of black argillite, siltstone and tuff, and

4) an uppermost Toarcian to Bajocian (Middle Jurassic) assemblage of feldspathic greywacke, siltstone, argillite, ash fall tuffaceous rocks and tuffaceous sedimentary rocks.

Rocks of similar age and lithology to this upper marine volcanic and sedimentary unit crop out within the thesis area and will be described in detail on succeeding pages. These rocks resemble closely strata described by Kirkham (1963) near Treaty Creek, some 20 km east of the thesis area (Fig. 3).

SKEENA INTRUSIONS

The Skeena plutons (Grove, 1971) are small intrusive bodies of variable age, occurring mainly within but locally outside the Bowser basin. These plutons, of widely varying form, range in composition from quartz diorite to granite, and from diorite to syenite.

TABLE I

Formations from McConnell Creek

Map Area[a]

ERA	PERIOD	FORMATION (thickness)	CHARACTER
MESOZOIC	LATE JURASSIC (?)	Skeena Intrusions	quartz monzonite, granite, granodiorite, diorite, monzonite, syenite.
	LOWER MIDDLE JURASSIC to LOWER JURASSIC	Upper division of Hazelton Group (500 m)	Marine argillite, siltstone, greywacke, sandstone, tuff, tuffaceous sedimentary rocks, volcanic flow rocks, breccia, pillow basalt.
	LOWER JURASSIC	Lower division of Hazelton Group (1,000 m)	Nonmarine, red basalt to rhyolite calc-alkaline volcanic rocks, volcanic fragment conglomerate, sandstone, tuff, breccia.
	UNCONFORMITY		
	LATE TRIASSIC	Takla Group	Assorted volcanic and volcaniclastic sedimentary rocks.

a compiled from Monger (1976) and Tipper (1976)

LOCAL GEOLOGY

STRATIGRAPHY

The stratigraphic sequence of volcanic and volcaniclastic rocks, on the Kay claim group, is exposed as a series of northeasterly trending ridges. Dips are moderate to the northwest and the effect is to produce cuestas with northerly facing dip slopes and precipitous cliffs on the southerly facing slopes. This characteristic has been enhanced further by alpine glaciation.

Volcanic and volcaniclastic rocks in the thesis area make up a thickness in excess of 1000 m of what have been interpreted, by the author, as upper division Hazelton Group (upper Lower Jurassic to Middle Jurassic). Intrusive rocks were interpreted as part of the Skeena Intrusions (Late Jurassic?). The upper division Hazelton Group rocks consist predominantly of light grey acid volcanic flows or domes, varied pyroclastic rocks and some sedimentary strata.

In the thesis area, the upper division Hazelton Group has been divided, on the basis of lithology and textures, into four major units each consisting of one or more mappable rock types. The stratigraphically lowest unit observed is a thick ($>$ 600 m) pile of volcanic fragmental rocks (Fig. 5, Unit 1). This unit was only briefly examined in the field; only the uppermost rock types are described in detail. The upper part of this unit consists of crystal tuffs, lapillistones, and agglomerates believed to be acid in composition.[1] The nature of the base of the unit is unknown, but the top apparently represents an unconformity. The strata were intruded by a granodiorite plug or stock which locally metamorphosed the tuffs to produce irregular quartz-albite hornfels zones up to 20 m in apparent width (Fig. 5, Unit 1b).

Overlying this unit is a predominantly sedimentary package (approximately 130 m thick) comprised of three mappable rock subunits. The age of these strata was determined to be lower Jurassic (Table 2) from two fossil assemblages collected near the contact with the underlying unit. A primarily argillite subunit (Fig. 5, Unit 2a) is abundant throughout this package and is observed both stratigraphically above and below the other two subunits. The argillites are black, well bedded, fissile rocks with interbeds of tuffaceous sandstone and occasionally pebble conglomerate beds which exhibit graded bedding. Near the base, the strata contain numerous rounded calcareous concretions up to 15 m in diameter.

Contained within the argillite strata is a rhyolite breccia body (Fig. 5, Unit 2b) approximately 60 m in thickness, composed of light grey angular rhyolitic fragments in a dark grey siliceous and pyritic matrix. Lateral extent of this body is unknown to the southwest, but it terminates to the northeast within the thesis area.

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1 The author has adopted Walker's (unpublished) system of classification (Fig. 4) in naming the different pyroclastic rocks encountered. This system is the basis for a standard system of terminology at the Kidd Creek mine near Timmins, Ontario. Grain size limits adopted are those defined by Wentworth and Williams (1932).

TABLE 2

Ages[a] of Fossil Collections from the Kay property

LITHOLOGIC UNIT	FOSSIL IDENTIFICATION	AGE		REMARKS
		PERIOD	STAGE	
4	Stephanoceras, sp.	MIDDLE JURASSIC	MIDDLE BAJOCIAN	Fossil identification based on an ammonite collected in 1974 by R.J. Goldie
2a	(Paltarpites) sp. [abandoned name] Protogramoceras	LOWER JURASSIC	UPPER PLIENSBACHIAN	Fossil identification based on ammonites collected by author in 1975.
2a	Weyla, sp.	LOWER JURASSIC	TOARCIAN to HETTANGIAN	Fossil identification based on bioclastic bed containing the pectin; collected by the author in 1975.

a Ages determined by Dr. H.W. Tipper of the Geological Survey of Canada (Vancouver). Fossils are retained by Dr. Tipper.

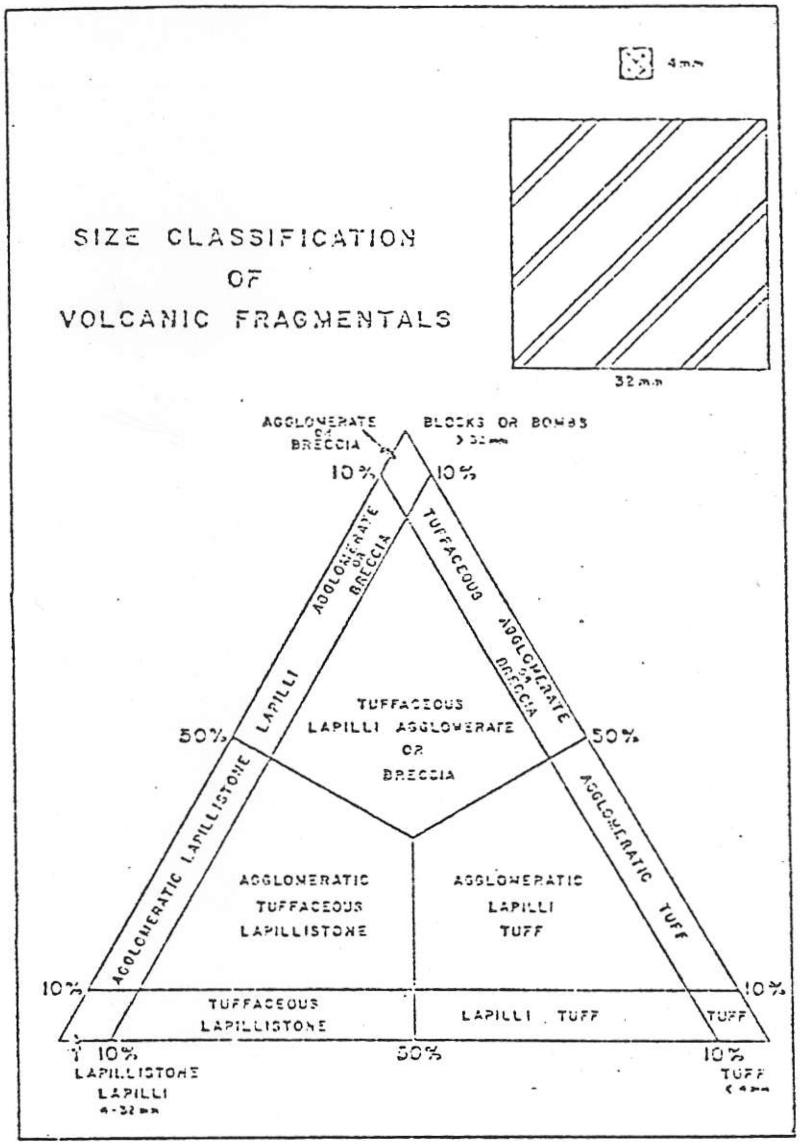
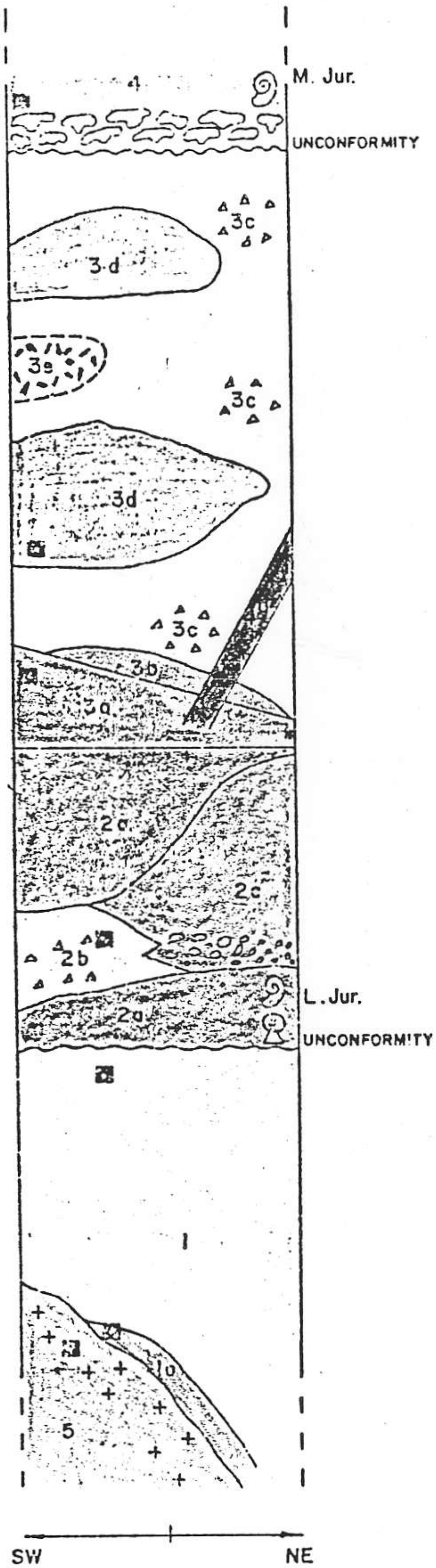


Figure 4. Size classification of volcanic fragmentals (after Walker, unpublished).



5	granodiorite porphyry
4	basaltic (?) pillow lavas, hyaloclastites, minor mudstone interbeds. Locally thin (0–3m) banded mudstone
4a	diabase dyke – probable feeders for unit 4
3e	brecciated rhyolite
3d	massive banded rhyolite-rhyodacite flows or domes at several horizons
3c	rhyolite breccia – pyritic, siliceous – includes minor amounts of tuff; encloses units 3d and 3e
3b	green to black tuffaceous lapillistone and lapilli tuff
3a	pale green lithic tuff or tuffaceous wacke, minor conglomerate lenses
2c	green tuffaceous wacke; conglomerate at base some lapillistone
2b	rhyolite breccia
2a	argillite with interbedded tuffaceous sandstone, minor amounts of tuff; calcareous concretions at base
1	acid to intermediate crystal tuffs, lapillistone, agglomerate and intercalated marine sedimentary rocks
1a	hornfels at contact with unit 5
■	hand-specimen and thin section location
(fossil symbols)	fossils – for details see Table 2

VERTICAL SCALE 1:5000

0 50 100 150 200 metres

modified from Peatfield, 1975

Fig. 5

STRATIGRAPHIC COLUMN FOR ROCKS ON THE KAY CLAIM GROUP NORTHWEST BRITISH COLUMBIA

Pale green tuffaceous sandstone (Fig. 5, Unit 2c), up to 140 m in thickness, lies conformably within the argillites. The base of this subunit consists of a cobble conglomerate from 4 to 10 m thick which contains scattered exotic fragments of pink cherty rock and many cobbles of acid tuff rocks. The relationship of the conglomerate to the rhyolite breccia is unknown.

The top of the sedimentary unit is arbitrarily taken as the top of the uppermost argillite beds and is overlain, apparently conformably, by an acid volcanic unit consisting of tuffs, breccias, and flows or domes. This unit is sub-divided into five mappable rock types distinguished by textures and clast size. The lowermost rock type is a pale green lithic tuff or tuffaceous wacke (Fig. 5, Unit 3a) which closely resembles the tuffaceous sandstone in the underlying unit (Fig. 5, Unit 2c). However, it overlies the argillite and has no marked conglomerate beds at the base. The rock is a lithic tuff with flattened glass shards and occasional 5 mm siliceous fragments set in a tuffaceous matrix. Some quartz grains and feldspar crystals are evident and the matrix was probably glassy but has since devitrified. The thickness of this subunit varies but averages about 45 m.

The lithic tuff grades upward into a thin (approximately 15 m) green to black tuffaceous lapillistone and lapilli tuff subunit (Fig. 5, Unit 3b) of limited lateral extent. These rocks contain dark wispy volcanic fragments, some black siliceous argillite chips and sparse angular felsic volcanic fragments. Locally, the rock is coarse enough to be termed an agglomerate.

Stratigraphically above the lapilli tuffs is a large heterogeneous subunit of rhyolite (?) breccia (Fig. 5, Unit 3c) with some thin beds of fine tuff. These rocks are difficult to separate from the massive rhyolitic rocks (Fig. 5, Unit 3d) because they are strongly silicified and often bleached on the weathered surface. The rhyolite breccias contain light grey angular fragments in a dark grey matrix; fragment size varies from 5 mm to greater than 8 cm. The tuffs are typically grey to black, well banded, with sparse angular fragments and abundant fine grained disseminated pyrite.

Within the rhyolite breccias are bodies of massive rhyolitic rock. As stated earlier these rocks are hard to distinguish in the field. The massive rhyolitic rocks are usually banded, very siliceous and generally free of phenocrysts. In some areas to the west (Fig. 10) the massive rhyolitic rocks have been brecciated on a large scale and contain 'stockworks' of polymetallic sulphide veinlets. These brecciated zones often contain large blocks (up to 20 m) of unbrecciated, banded rhyolitic rocks and were mapped as a separate subunit (Fig. 5, Unit 3e).

Unconformably overlying the acid volcanic unit is an undivided package of basaltic pillow lavas, pillow breccias or hyaloclastites, and associated thin mudstone beds (Fig. 5, Unit 4). Locally the base of the package is composed of 1 to 3 m of thinly banded mudstone.

Cross-cutting most of the rocks of the acid volcanic unit are dark green, fine grained diabase dykes (Fig. 5, Unit 4a), which are probably feeders for the mafic volcanic rocks of Unit 4 (Fig. 5 and 10).

Near the eastern boundary of the thesis area is a large outcrop of pale grey, medium grained, granodiorite porphyry (Fig. 5, Unit 5) which contains abundant 3 to 4 mm feldspar phenocrysts. This intrusive represents a plug or stock of Skeena Intrusive.

STRUCTURE

The volcanic and volcaniclastic rocks make up a simple stratigraphic sequence with beds dipping northwesterly 45 to 75 degrees. Steeper attitudes, where they occur, are interpreted as original dips on the edges or ends of acid flows or domes. Banding in the massive rhyolitic rocks is somewhat irregular but this is interpreted as an original depositional feature.

Folding is of minor importance within the thesis area. Such small folds as occur are generally drag folds associated with faults.

A localized but strong, nearly vertical schistosity or foliation is developed, parallel to the regional trend of the rock units. A few faults, as shown on the geologic map (Fig. 10), have minor offsets.

PETROLOGY

Thin section examination, especially of the extrusive and pyroclastic rocks, aided in identification and nomenclature for the rock types described in detail on the following pages.

Upper Hazelton Group Rocks

Feldspar crystal tuff (Unit 1)

Feldspar crystal tuff is characterized by euhedral and broken laths of plagioclase ranging from 0.1 mm to 0.75 mm, comprising 35 percent of the rock. The plagioclase has been albitized, with calcite and chlorite forming cores in many albite laths and chlorite outlining relic zoning in some of the albite crystals.

The very fine grained matrix makes up 40 to 45 percent of the rock and consists predominantly of devitrified glass dust, weakly to moderately replaced by chlorite.

Quartz-albite hornfels (Unit 1a)

Quartz-albite hornfels is a very fine grained dark grey rock formed by contact metamorphism of the lower tuff unit (Fig. 5, Unit 1) by the granodiorite intrusion. This rock is granoblastic, consisting of anhedral quartz grains (from 0.05 mm to 0.3 mm in diameter), anhedral to subhedral albite laths up to 0.5 mm long and minor amounts of completely chloritized biotite (?). Pyrite is ubiquitous as fine 'dust' and euhedral cubes (up to 0.5 mm across) that are rimmed by iron oxides. Albite is often rimmed by pyrite.

Rhyolite breccia (Unit 2b)

Rhyolite breccia is light grey and consists of fine grained fragments (from less than 5 mm to greater than 1 cm in diameter) in a dark grey pyritic matrix. The fragments are microporphyritic with albite phenocrysts (0.1 mm to 0.75 mm long), after plagioclase, making up 30 to 40 percent of the fragments. Chlorite outlines zones in altered plagioclase grains.

The breccia matrix consists of 34 percent indeterminable material, 25 percent chlorite, 15 to 20 percent albite laths, 10 to 15 percent anhedral quartz grains, 6 percent sericite and 2 to 5 percent subhedral to euhedral pyrite grains. Propylilization of this rock is strong to moderate.

Dacitic lithic tuff (Unit 3a)

Dacitic lithic tuff is comprised of 45 to 50 percent lithic fragments in a fine grained chlorite-sericite altered matrix. Lithic fragments are made up mainly of accessory angular tuff fragments, with some accidental argillite chips and minor amounts of devitrified glass fragments. The rock contains 5 to 10 percent euhedral and subhedral crystals of albite, orthoclase and composite anhedral grains of quartz.

Rhyodacite (Unit 3d)

Rhyodacite is microporphyritic with quartz, plagioclase and orthoclase phenocrysts (0.08 mm to 0.25 mm in diameter) making up 42 percent of the rock. Orthoclase occurs as weakly to moderately sericitized anhedral grains and comprise 16 percent of the rock.

Albite laths make up 8 percent of the thin section, are unzoned, euhedral to subhedral and weakly to moderately altered to chlorite and sericite. Quartz occurs as anhedral grains, up to 0.08 mm in diameter or clots of anhedral grains, up to 0.25 mm in diameter. Matrix makes up 58 percent of the rock and consists of quartz, feldspar, chlorite, sercite and pyrite.

Basaltic pillow breccia (Unit 4)

Basaltic pillow breccia is a dark greenish-grey aphanitic rock which occurs both as pillow lava and pillow breccia. The texture is spilitic with subradiating microlites of albite, ranging from less than 0.1 mm to 0.5 mm in length, making 54 percent of the rock. Groundmass consists of calcite, chlorite and devitrified glass.

Augite diabase (Unit 4a)

Augite diabase contains characteristic ophitic augite crystals (greater than 2 mm in diameter) which make up 15 percent of the rock. Augite is weakly to strongly replaced by chlorite and calcite. Small euhedral laths of albite (0.1 mm to 0.35 mm in length) are contained within the augite crystals and also occur in the groundmass. Albite laths make up 48 percent of the rock and are 'dirty' with inclusions of augite and very fine disseminations of unknown material. Matrix consists of intersertal chlorite, calcite and penninite.

Skeena Intrusive (Unit 5)

Granodiorite porphyry is characterized by 36 percent euhedral to subhedral grains of plagioclase (up to 1 mm long), ranging in composition from An_{25} to An_{30} and partially to completely replaced by chlorite-sericite. Zoning is rare and when observed is usually relic with chlorite outlining the zones.

Orthoclase, occurring as subhedral grains up to 1 mm in diameter, makes up 8 percent of the rock and is locally altered to sericite. Quartz occurs as corroded anhedral grains up to 0.3 mm in diameter and makes up 11 percent of the rock. Mafic constituents in the rock have been completely replaced by chlorite with pyrite rimming the relic crystals. All of the above are set in a fine grained quartz-feldspar matrix comprising 29 percent of the rock.

ENVIRONMENT OF DEPOSITION

Upper Hazelton Group strata, typically marine according to Richards (1976), are represented in the thesis area primarily by pyroclastic rocks. Graded bedding observed within some of the pyroclastic rocks is a further indication of subaqueous deposition. These graded beds are poorly sorted and do not exhibit the doubly-graded characteristics described by Fiske and Matsuda (1964) as being evidence of deep water deposition. Cross-bedding, ripple marks, or cut and fill structures characteristic of shallow marine environments were not observed in the thesis area.

McBirney (1963), considering factors governing the nature of submarine volcanism, states that the depth at which explosive eruptions can occur is primarily a function of the water content of the magma and, therefore, ash formation is unlikely at depths greater than 500 m for basalts with greater depths for rhyolite only if the water content is greatly enriched (eg. 2000 m with 3 percent water content). Therefore, the tuffaceous nature of some of the volcanic rocks, plus marine fossils from a neritic water environment, are criteria suggesting that the strata examined were deposited in a submarine environment (probably less than 500 m water depth).

SULPHIDE MINERALIZATION

OCCURRENCE OF MINERALIZATION

Polymetallic mineralization occurs, predominantly in acid volcanic and pyroclastic rocks, as pods of massive 'ore' (> 50% sulphides) and as stockwork 'ore'. Massive sphalerite, galena and pyrite occur associated with rhyolite breccia as pods which range in thickness from 0.6 to 1.5 m. Stockworks contain primarily galena and/or sphalerite with varying amounts of tetrahedrite, jamesonite and polybasite. Some veinlets contain vuggy quartz.

There are two main zones of mineralization presently known within the acid volcanic rocks. The first occurs near the adit (Fig. 10) and is of the stockwork type in brecciated rhyolite (Unit 3e). The second occurs 1000 m northeast of the adit and is a 1.5 m thick pod of massive sulphides consisting mainly of galena, sphalerite and pyrite.

A third, but minor, zone of mineralization was observed near the northeast boundary of the thesis area. It consists of a number of small irregularly shaped pods of semimassive (30 to 40% total sulphides), coarse grained pyrite, galena and sphalerite associated with the granodiorite porphyry - hornfels contact (Fig. 10).

Massive 'Ore'

Study of polished sections representative of massive 'ore' indicates the presence of the following opaque minerals in approximate order of decreasing abundance:

Pyrite	FeS_2
Sphalerite	$(Zn,Fe)S$
Galena	PbS
Chalcopyrite	$CuFeS_2$

One very small lens consists entirely of fine granular pyrite.

Pyrite occurs as anhedral to euhedral crystals and fragments 0.75 mm across forming, in aggregate, massive sulphide 'ore' which is locally fragmented. Much of the massive sulphide mineralization consists of a mosaic of fine grains of sphalerite and/or galena. Sphalerite also occurs as atolls in some pyrite grains and appears to have replaced pyrite along fractures. Galena forms atolls in sphalerite, caries in pyrite and has replaced pyrite and sphalerite along fractures. Chalcopyrite, occurring in trace amounts in one section, forms very fine exsolution bodies in sphalerite.

Stockwork 'Ore'

Study of two polished sections of stockwork 'ore' indicate the presence of the following opaque minerals in approximate order of decreasing abundance:

Galena	PbS
Sphalerite	$(Zn,Fe)S$
Jamesonite	$Pb_4FeSb_6S_{14}$
Tetrahedrite	$(Cu,Fe)_{12}Sb_4S_{13}$
Polybasite	$(Ag,Cu)_{16}Sb_2S_{11}$
Pyrite	FeS_2
Covellite	CuS
Arsenopyrite	$FeAsS$
Gold	Au

The stockwork mineralization consists mainly of a mosaic of fine grains of sphalerite and/or galena. Galena also occurs as atolls in sphalerite and appears to have replaced sphalerite along fractures. Jamesonite, tetrahedrite and polybasite occur in lesser amounts in the stockworks. Jamesonite occurs as a mosaic of fine grains forming mutual boundaries with galena and irregular boundaries with sphalerite and pyrite. It appears to have replaced sphalerite and pyrite along fractures. Tetrahedrite and polybasite are intimately associated, with laths and irregular bodies of polybasite oocurring in a mosaic of fine grains of tetrahedrite. These minerals form irregular boundaries with and have replaced sphalerite along fractures. Covellite, occuring in trace amounts as small mosaics of fine grains forming, most commonly, near sphalerite - tetrahedrite boundaries, is probably the result of supergene alteration of tetrahedrite. Also occurring in trace amounts are pyrite, arsenopyrite, and gold. For a more detailed description of the mineralogy and modes of occurrence see Appendix II.

PARAGENESIS AND ORE DEPOSITION

(1) Massive 'Ore'

A representative paragenesis for the massive mineralization is shown in the Vandeveer diagram of figure 6 and the line diagram of figure 7. The lack of primary features such as framboidal and colloform textures suggests the sulphide minerals have probably recrystallized due to regional metamorphism and, therefore, the paragenesis diagrams represent the last recrystallization. However, certain conclusions may be drawn from the mineralography and field observations.

Massive 'ore' occurs as banded stratiform pods in the acid pyroclastic rocks near the flanks of what have been interpreted by the author (Fig. 10 and 10a) as acid volcanic domes or flows. This stratiform nature suggests that these sulphide bodies are probably volcanogenic in origin.

(2) Stockwork 'Ore'

Paragenesis of the sulphide minerals for the stockwork mineralization is shown in the Vandeveer diagram of figure 8 and the line diagram of figure 9. As with the massive 'ore', these diagrams probably represent recrystallization due to regional metamorphism.

Stockwork mineralization clearly cross-cuts the stratigraphy of massive acid volcanic and pyroclastic rocks and is, therefore, epigenetic. However, these stockworks could be feeders for massive 'ore' and, therefore, equivalent in time. Spatial relationships of the showings, though, do not confirm this and further investigations of the property would be required.

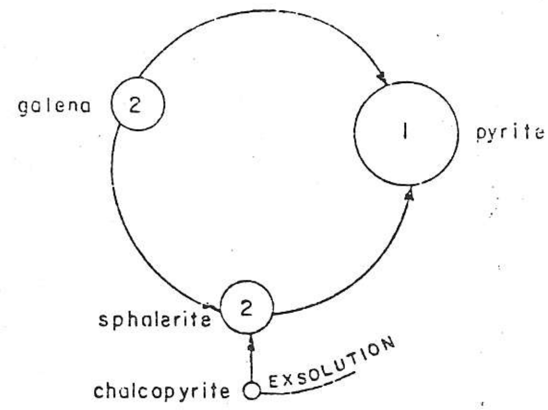


Figure 6 Vandeveer diagram showing paragenesis of opaque minerals associated with massive "ore". Numbers indicate order deposition; size of circle indicates replacement and dashed lines represent minerals which touch but relation is not certain.

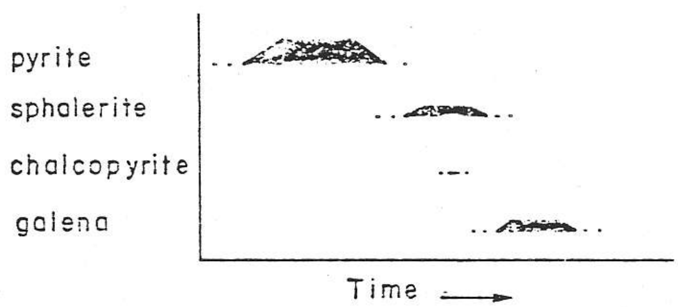


Figure 7 Line diagram showing paragenesis of opaque minerals associated with massive "ore." Thickness of bar represents relative amounts.

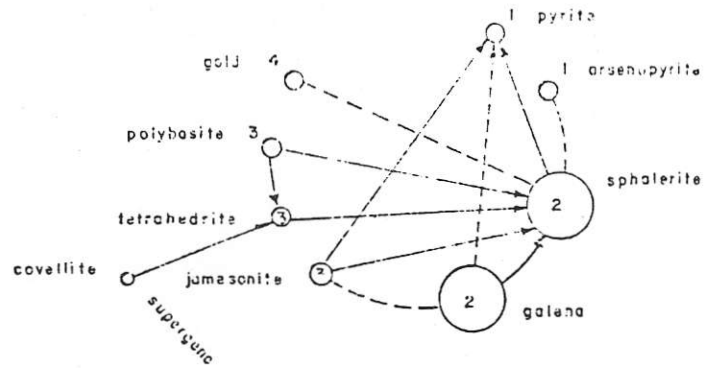


Figure 8 Vandeveer diagram showing paragenesis of opaque minerals associated with stockwork "ore". Numbers indicate order deposition; size of circle indicates relative amounts; arrows indicate replacement and dashed lines represent minerals which touch but relation is not certain.

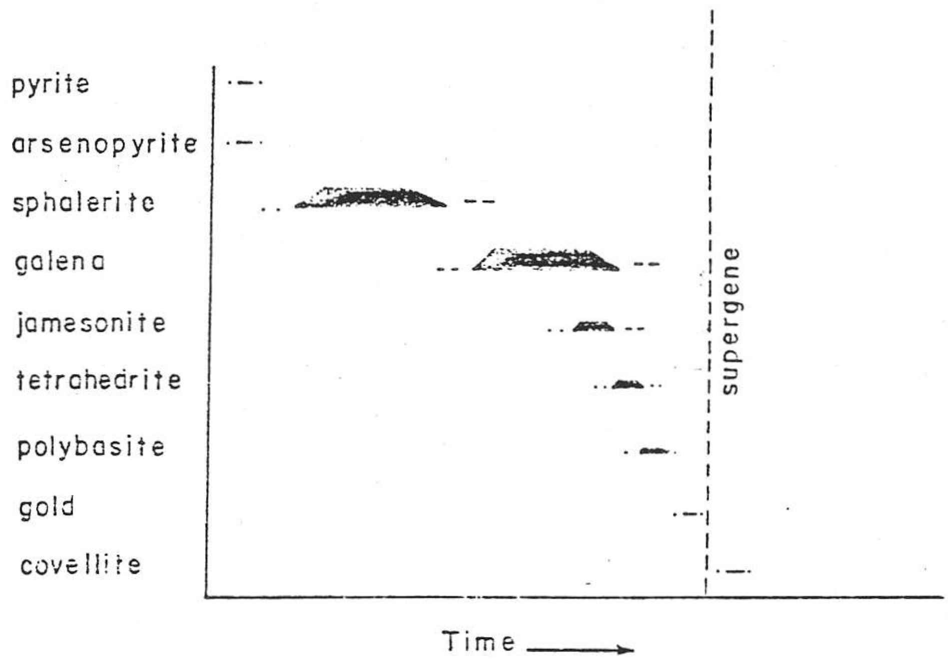


Figure 9 Line diagram showing paragenesis of opaque minerals associated with stockwork "ore". Thickness of bar represents relative amounts.

SUMMARY AND DISCUSSION

Results of field investigations, research and laboratory examinations are:

(1) Upper Mesozoic volcanic and volcaniclastic rocks exposed in the thesis area are correlative with the upper division of the Hazelton Group.

(2) The upper division of the Hazelton Group can be divided into four major units in the thesis area; from oldest to youngest these are:

- (a) an undivided volcanic fragmental unit,
- (b) a sedimentary unit,
- (c) an acid volcanic unit, and
- (d) a mafic volcanic unit.

(3) Mineralization occurs primarily in the acid volcanic unit and consists of stockwork and massive stratiform sulphide zones. This mineralization is of the volcanogenic type.

The volcanogenic massive sulphide and stockwork zones in acid volcanic and pyroclastic rocks exposed in the thesis area resemble in some aspects other volcanogenic deposits, notably (1) the "Kuroko" type deposits in Japan as described by Matsukuma and Horikoshi (1970) and Kajiwara (1970), and (2) the Ordovician deposits in the Bathurst District, New Brunswick (Hutchinson, 1973). However, there are differences between the showings in the thesis area and the Kuroko and Bathurst deposits.

The main difference is age; Kuroko deposits are younger (Tertiary) and the Bathurst deposits are older (Ordovician). Hutchinson (1973) attempted to classify volcanogenic massive sulphides on the basis of minerology and age; his findings are summarized in Table 3. It appears that the showings in the thesis area correspond to the lead - zinc - copper - silver type of Triassic to Tertiary age. The principal differences between the Kay property sulphide zones and Hutchinson's type deposits are the lack of the commonly associated barite and gypsum, and the apparent absence of significant amounts of copper in the massive mineralization.

In conclusion, the author recommends further detailed mapping in the area of the showings and a more exhaustive mineralographic study of all the sulphide bearing zones. These studies would help to determine the relationships between massive 'ore' and stockwork 'ore'. Also, detailed geological mapping of the volcanic terrain immediately south of the thesis area should be carried out because deposits of this type are small, and are easily hidden.

TABLE 3

Comparative Chart: Some Geological Characteristics of Different Volcanogenic Sulphide Deposits[a]

BASE METAL TYPE	PRECIOUS METAL ASSOCIATION	ASSOCIATED VOLCANIC ROCK TYPES	TYPE OF VOLCANISM	TYPE OF SEDIMENTATION	TECTONISM	AGE	EXAMPLES
(1) Zn-Cu-pyrite	both Au (with high Cu) and Ag (with high Zn)	-fully differentiated suites of intermediate bulk composition(?); -tholeiitic to calc-alkaline -basalt-andesite-dacite-rhyolite, etc.	-initial deep, subaqueous mafic platform, with differentiation toward felsic volcanism, building domical centres	-chemical; cherts, iron formations -clastic; immature, first cycle, volcanogenic greywackes, volcanoclastics	-early eugeosynclinal-orogenic stage, -major subsidence	Archean Proterozoic(?)	Timmins, Ont Noranda, Que United Verde, Ariz
Zn-Cu-pyrite	ditto	ditto	ditto	ditto	ditto; early subduction	pre-Ordovician mid-Devonian	Rambler, Nfld W Shasta, Calif
(2) Pb-Zn-Cu-pyrite	mainly Ag	-intermediate to felsic calc-alkaline volcanic suites, -andesite-dacite-rhyolite-porphyry-crystal tuff, etc.	-felsic centres of explosive, pyroclastic and ignimbritic activity, subaqueous to subaerial	-epiclastic predominates; immature volcanogenic greywackes, manganiferous shales, graphitic shales and argillites, siltstones -chemical minor, cherts, iron formations -sulphate gangues common	-later eugeosynclinal-orogenic stage; infilling with uplift balances subsidence(?)	Proterozoic Ordovician	Mt. Isa, Queensland Errington, Vermilion, (Sudbury Basin) Bathurst, New Brunswick
Pb-Zn-Cu pyrite	ditto	ditto	ditto	ditto	ditto, later subduction	Triassic Tertiary	E Shasta, Calif. Kuroko, Japan
(3) Cu-pyrite	mainly Au	-poorly differentiated mafic-ultramafic(ophiolitic) suites, -tholeiitic -basaltic pillow lavas, serpentinite, etc.	-deep subaqueous, quiescent fissure eruptions	-chemical predominates; cherts, ironstones, mangastones -clastic insignificant	-early stage of continental plate rifting; tension, separation, graben	l-Ordovician u-Cretaceous Jura-Cretaceous Cret.-Eocene	W Newfoundland Cyprus Island Mountain, California Phillipines

a from Hutchinson (1973)

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APPENDIX I

Hand Specimen and thin section descriptions

SAMPLE NUMBER SK75-18

Hand Speicmen Description:

Fine grained brownish grey fragmental rock. Fragments are obscured by alteration. Type of fragments is difficult to discern but appear to be mainly plagioclase crystals up to 4 mm.

Field Rock Name: Basal tuff

Thin Section Description:

Albite	-35%; after plagioclase -twinned euhedra 0.1 to 0.75 mm in length -zoning outlined by chlorite
Calcite	-15%; after plagioclase
Chlorite	-3%; after plagioclase and glass -after mafic mineral (biotite ?)
Lithic fragments	-2%; comprised of tuff and some pumice fragments 0.8 to 3 mm in diameter
Pyrite	-1%; after mafics and glass
Matrix	-40%; devitrified glass dust

Rock Name: Feldspar crystal tuff

SAMPLE NUMBER SK75-44

Hand Specimen Description:

Very fine grained rock with some quartz (?) fragments and rounded vugs lined with euhedral pyrite cubes. Rock is dark in colour, hard and weathers whiteish-grey with some limonite staining.

Field Rock Name: Hornfels

Thin Section Description:

Texture is fine grained granoblastic. Due to grain size modal estimates were not attempted minerals observed in order of relative abundance are:

Quartz	-anhedral grains up to 0.3 mm in diameter -occurs as veinlets -clots of composite anhedral grains
Albite	-negative relief -forms anhedral to subhedral laths up to 0.5 mm -exhibit reaction rims with opaques outlining grains
Opaques	-consists largely of pyrite and iron oxides -occurs as very fine dust and euhedral cubes often rimmed by iron oxides -up to 0.5 mm across
Chlorite	-after biotite
Sericite	-occurs in matrix
Epidote (?)	-very small (< 0.05 mm) tabloids, high relief, low birefrignence

Rock Name: Quartz-albite hornfels

SAMPLE NUMBER SK75-32

Hand Specimen Description:

Light grey, very fine grained rock which weathers brownish-grey. Fragments vary in size from < 5 mm to > 1 cm. Matrix is dark grey and strongly pyritic. Pyrite is ubiquitous but is concentrated around fragments. Crystals are not discernable in fragments. A vein 1.5 cm across of mainly galena and sphalerite is present.

Field Rock Name: Rhyolite breccia

Thin Section Description:

Fragments	-35%; consists of 30 to 40% albite -albite after plagioclase, euhedra 0.1 to 0.75 mm in length -chlorite outlines zoning in albite laths
Breccia Matrix	-65% of rock
Albite	-12 to 15%; after plagioclase
Quartz	-10 to 13%; fine anhedral grains < 0.1 mm in diameter
Chlorite	-25%; after biotite -after amphibole (?)
Sericite	-6%; after plagioclase and potassium feldspar (?)
Pyrite	-2 to 5%

Rock Name: Rhyolite breccia

SAMPLE NUMBER SK75-46

Hand Specimen Description:

Coarse, green lithic tuff consisting of about 40% fragments and 60% matrix. Fragments consist of numerous argillite chips, felsite and tuff.

Field Rock Name: Lithic tuff

Thin Section Description:

The texture is somewhat foliated with the alignment of the long axis of the fragments.

Fragments	-44%; size varies from 0.1 to 4 mm -90 to 95% lithic fragments -accessory tuff fragments -accidental argillite chips -some devitrified glass fragments
Albite	-8% of fragments -subhedral to euhedral laths after plagioclase, 0.1 to 0.5 mm in length -also occurs in tuff fragments
Quartz	-2%; composite anhedral grains 0.1 to 0.2 mm in diameter
Matrix	-56%; made up of very fine grained chlorite, sericite and euhedral pyrite after glass (?)

Rock Name: Dacitic lithic tuff (because of modal quartz the author feels the rock is at least this acid)

SAMPLE NUMBER SK75-65

Hand Specimen Description:

Light grey aphanitic siliceous rock with 2 to 3% pyrite. Few phenocrysts are obvious and appear to be mainly feldspar.

Field Rock Name: Rhyolite

Thin Section Description:

Quartz	-18%; anhedral grains up to 0.08 mm -clots of composite anhedral grains up to 0.25 mm
Orthoclase	-16%; anhedral grains up to 0.08 mm -partially altered to sericite
Albite	-8%; negative relief, after plagioclase (?) -partially altered to chlorite and sericite -alteration weak to moderate
Chlorite	-after plagioclase and mafics
Sericite	-after plagioclase and orthoclase
Pyrite	-2%; euhedral cubes up to 0.08 mm
Matrix	-40% quartz-feldspar -16% chlorite-sericite
Iron Oxides	-occur in fractures

Rock Name: Rhyodacite

SAMPLE NUMBER SK75-C92A

Hand Specimen Description:

Dark greenish-grey aphanitic rock with few mafic (?) clots. Weathers light brownish-grey to brown.

Field Rock Name: Pillow breccia

Thin Section Description:

Texture is radiating laths of sodic plagioclase in a calcite-chlorite matrix similar to spilite texture.

Plagioclase	-54%; unzoned, negative relief -composition An_0 to An_{10} -needle like laths up to 0.1 mm -weakly to moderately altered to chlorite
Calcite	-22%; anhedral blebs and clots in matrix
Chlorite	-1 to 2%; occurs in plagioclase microlites -as clots in matrix up to 0.1 mm in diameter -after glass
Matrix	-22%, comprised of devitrified glass, chlorite and calcite

Rock Name: Basaltic pillow breccia

SAMPLE NUMBER SK75-40

Hand Specimen Description:

Fine grained dark green rock weathers grey-brown. It consists of fine crystals (< 0.05 mm) of plagioclase and pyroxene (?) in a green matrix.

Field Rock Name: Gabbro

Thin Section Description:

Texture is ophitic with intersertal devitrified glass.

Plagioclase	-48%; negative relief -composition An_0 to An_{10} -euhedral laths 0.1 to 0.35 mm -contain inclusions of augite and other fine grain material
Augite	-15%; ophitic grains > 2 mm in diameter -partially to wholly replaced by chlorite and calcite
Chlorite	-15%; after augite and glass
Opaques	-4%; after augite
Calcite	-3%; after augite
Penninite	-1%; after augite and glass
Devitrified glass	-3%; intersertal between plagioclase laths -altered to chlorite

Rock Name: Augite diabase

SAMPLE NUMBER SK75-43

Hand Specimen Description:

Medium grained, grey, feldspar porphyry. Feldspars appear slightly altered with some having cores of sericite (?). Mafics have been altered to chlorite (?).

Field Rock Name: Feldspar porphyry

Thin Section Description:

Plagioclase	-36%; positive extinction -unzoned euhedra up to 1 mm -composition An_{25} to An_{30} -partially to completely replaced by chlorite-sericite
Quartz	-11%; corroded anhedral grains up to 0.3 mm in diameter
Orthoclase	-8%; no twinning, negative relief -subhedral grains up to 1 mm -partly replaced by sericite
Chlorite	-6%; after plagioclase and mafic minerals
Sericite	-2 to 4%; after orthoclase and plagioclase
Opaques	-4%; pyrite and iron oxides after mafic minerals -rim replaced mafic minerals
Penninite	-minor amounts after mafic minerals
Sphene	-minor amounts

Rock Name: Granodiorite porphyry

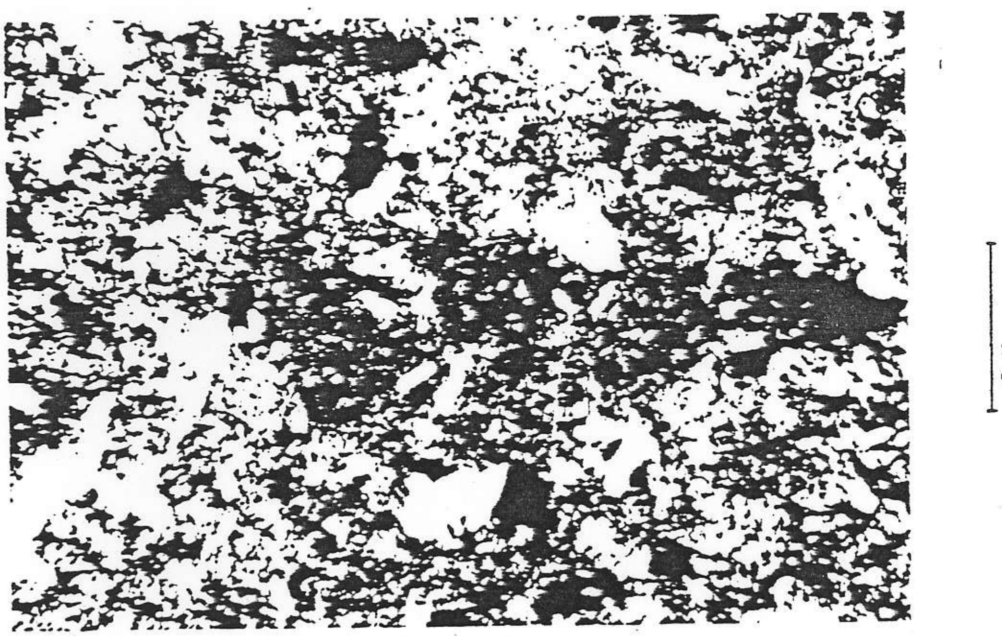
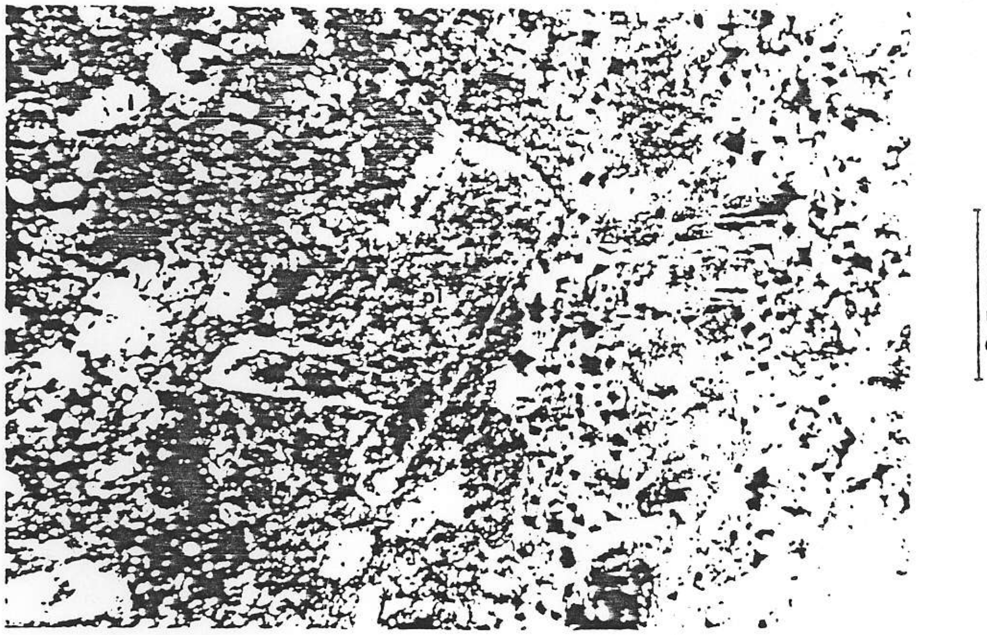


PLATE II Top: Photomicrograph of feldspar crystal tuff (unit 1). Crystals of albitized plagioclase (ab) and pyrite (py) in a very fine matrix of devitrified glass dust (X-Nichols, 12.5X)

Bottom: Photomicrograph of quartz-albite hornfels (unit 1a). Relic fragment is seen in center of picture surrounded by very fine grain quartz and albite. (X-Nichols, 12.5X)



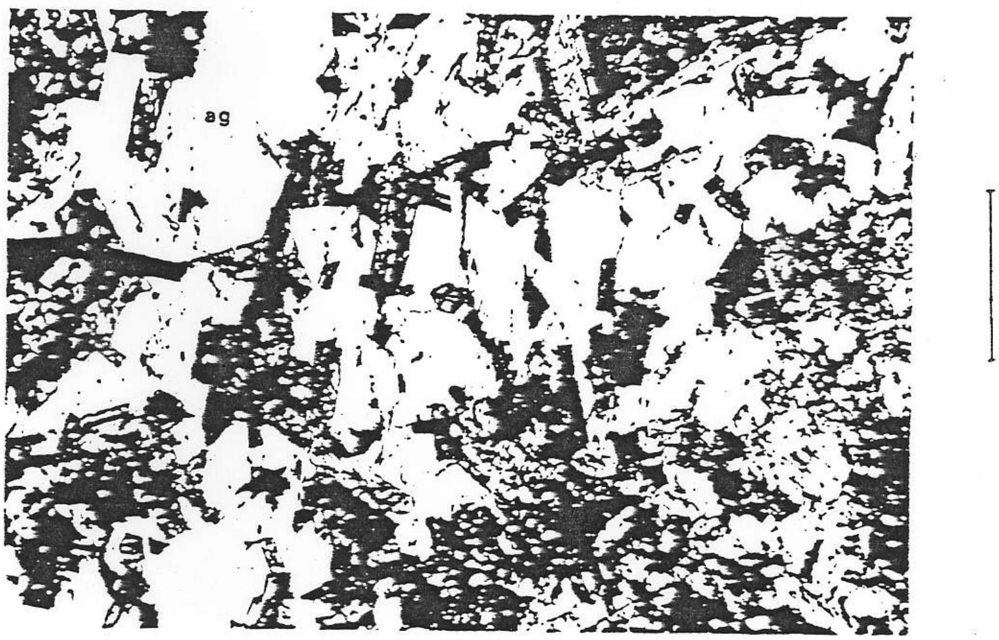
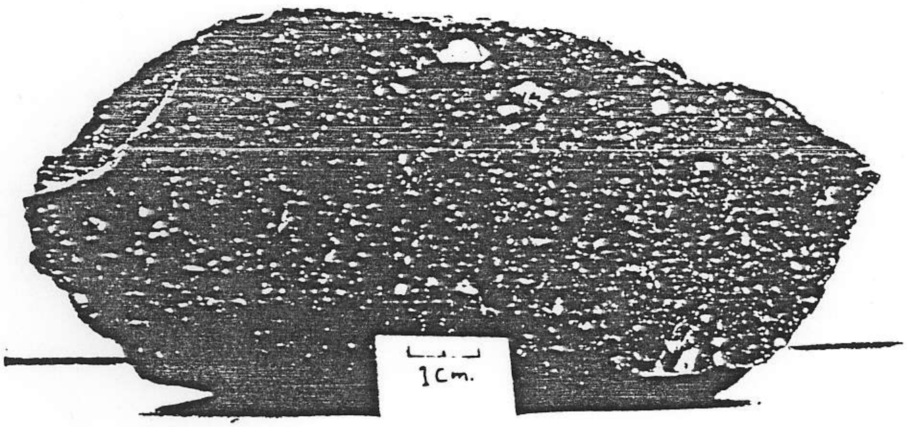


PLATE III Top: Photomicrograph of rhyolite breccia (unit 2b). Fragment on right,sericite, pyrite and chlorite matrix on left. Chlorite outlines zoning in plagioclase (pl) in fragment. (X-Nichols, 12.5X)

Bottom: Photomicrograph of augite diabase (unit 4a). Large ophitic augite (ag) enclosing small laths of sodic plagioclase. (X-Nichols, 12.5X)



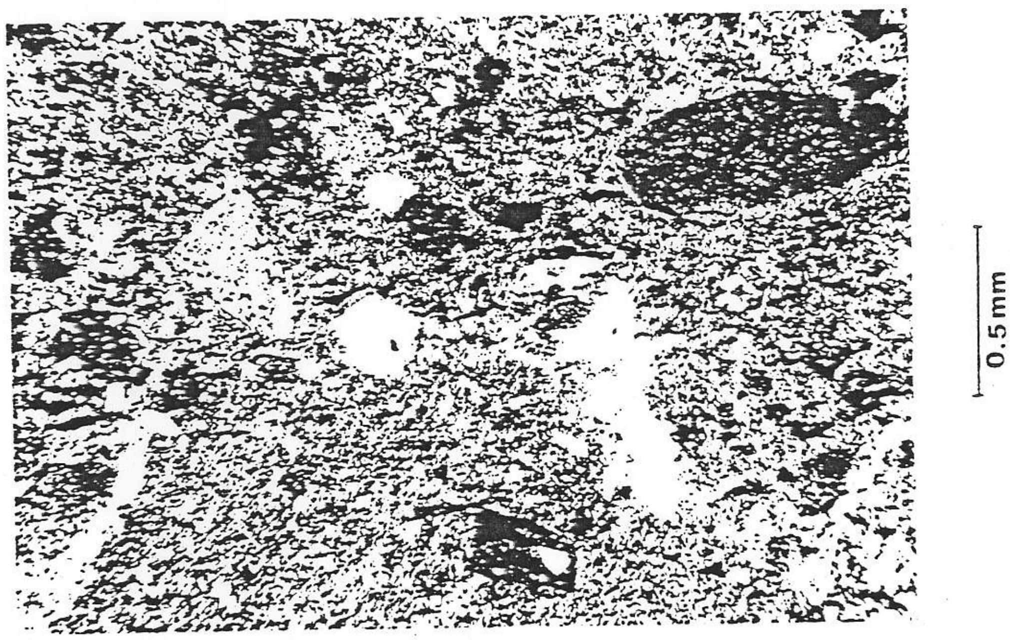


PLATE IV Top: Hand Specimen of dacitic lithic tuff (unit 3a). Recognizable fragments include argillite chips and felsic volcanic rock.

Bottom: Photomicrograph of dacitic lithic tuff. Fragments are set in an altered matrix of chlorite, sericite and pyrite. (X-Nochols, 12.5X)

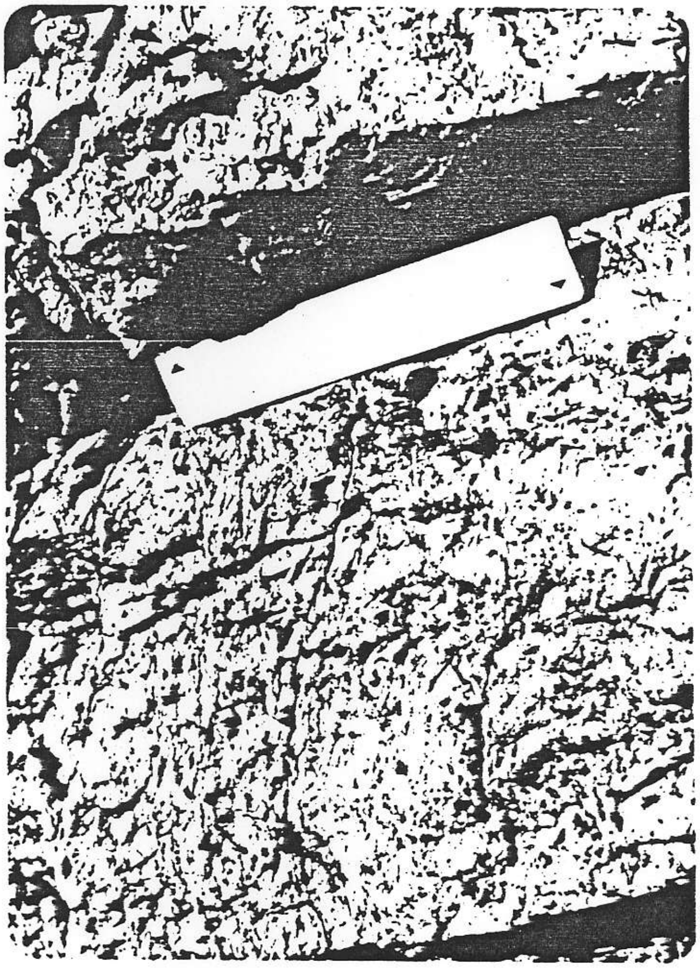


PLATE V Rhyolite breccia (unit 3c)

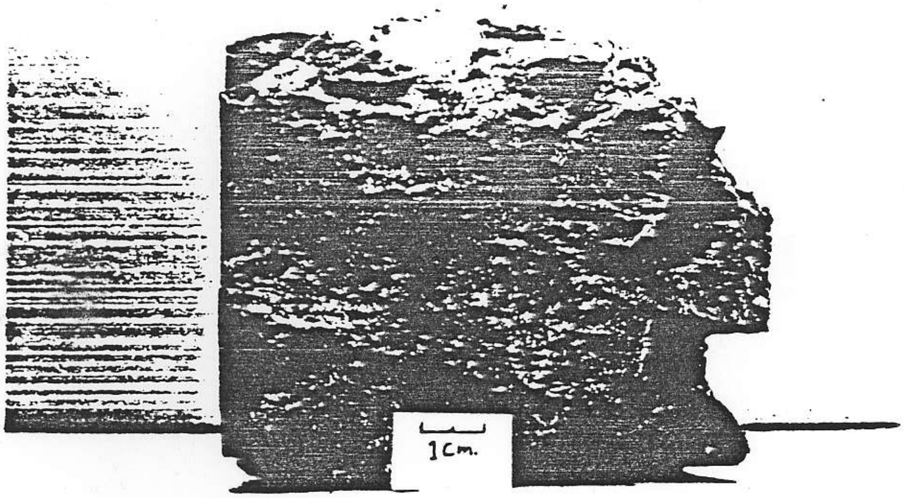


PLATE VI Top: Hand specimen of massive rhyolite (unit 3d)

Bottom: Photomicrograph of rhyodacite (unit 3d) showing altered plagioclase (pl), orthoclase (or), and anhedral quartz (q) in a quartz, feldspar and sericite matrix (note some feldspars are almost completely replaced by sericite; X-Nichols, 50X).

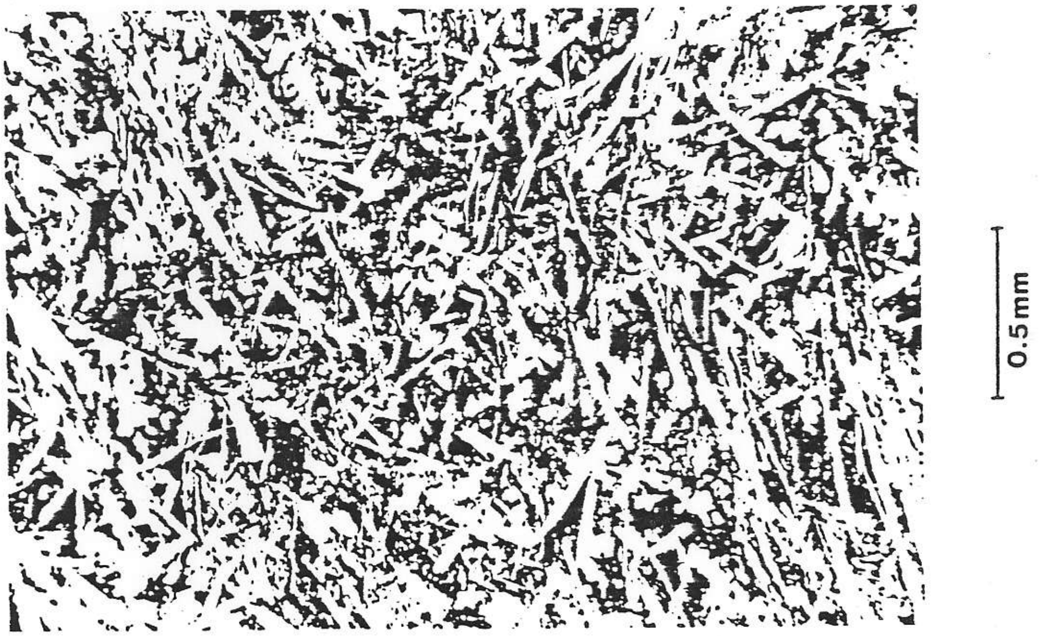


PLATE VII Top: Brecciated pillow basalts of unit 4.

Bottom: Photomicrograph of brecciated pillow basalt showing microlites of sodic feldspar in calcite-chlorite matrix. (X-Nichols, 12.5X)

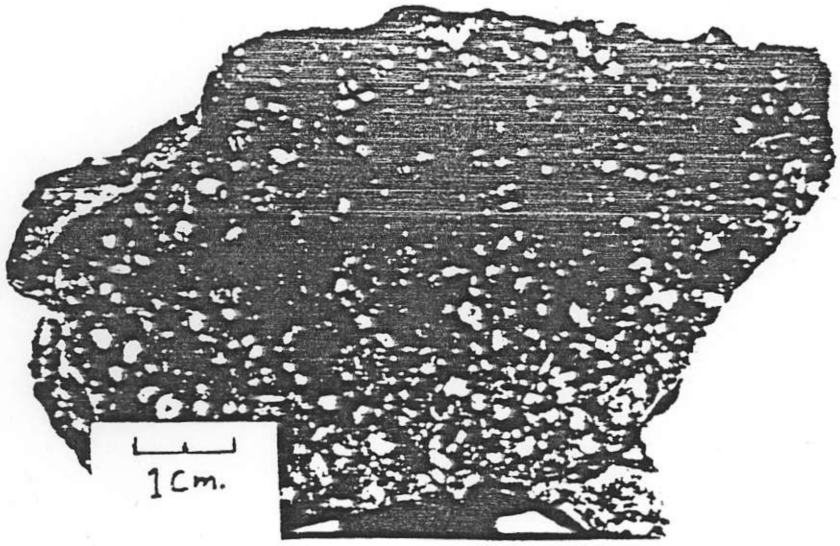


PLATE VIII Top: Hand specimen of granodiorite porphyry (unit 5).

Bottom: Photomicrograph of granodiorite porphyry showing phenocrysts of plagioclase (pl) and orthoclase (or). Large relic phenocryst of chlorite-sericite (cl-ms) after plagioclase. Upper right corner of photomicrograph relic biotite (?) crystal completely replaced by chlorite and sericite (cl-ms). (X-Nichols, 12.5X)

APPENDIX II

Polished Section Descriptions

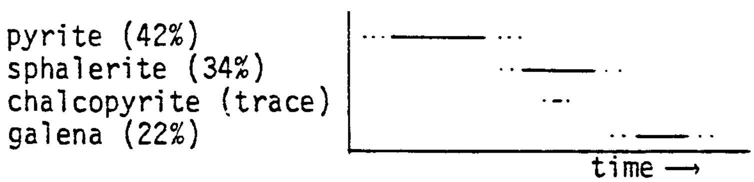
SAMPLE NUMBER SK75-AS

Hand Specimen Description:

Massive banded sulphides with some angular acid volcanic fragments. Bands average about 5 to 8 mm and consist of mainly fine to medium grain pyrite rich bands alternating with mainly fine grained sphalerite and galena.

Polished Section Description:

Opaques 93% of polished section



pyrite:
occurs as subhedral to anhedral crystal fragments up to 0.75 mm with most about 0.2 mm. Exhibits mutual boundaries with sphalerite and galena. Some grains have cores of sphalerite.

sphalerite:
occurs as a massive fine mosaic of grains and as atolls in galena. Exhibits mutual boundaries with pyrite and galena and forms caries in galena. Appears to have replaced pyrite along fractures in grains.

chalcopyrite:
occurs as fine exsolution bodies in sphalerite.

galena:
occurs as fine mosaic of grains and as atolls in sphalerite. Exhibits mutual boundaries with pyrite and sphalerite. Forms in fractures in sphalerite and has replaced sphalerite.

SAMPLE NUMBER SK75-N5

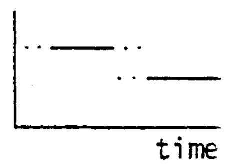
Hand Specimen Description:

Massive galena and sphalerite with pyrite recognizable gangue. Sphalerite appears brecci filling fractures.

Polished Section Description:

Opaques 99% of polished section

pyrite (23%)
sphalerite (36%)
galena (41%)



pyrite:
occurs as massive fine grain crystal euhedral to subhedral grains (to 0.2 is fragmentary and appears to be rep and galena.

sphalerite:
occurs as a massive fine mosaic of g in galena. It forms mutual boundari galena.

galena:
occurs as a massive fine grain cryst atolls in sphalerite. Forms mutual caries in sphalerite and pyrite and replaced these minerals.

SAMPLE NUMBER SK75-N21

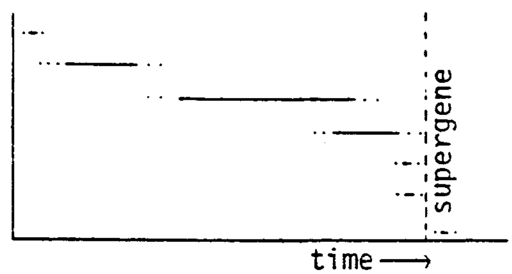
Hand Specimen Description:

Sulphide veinlet about 4 cm wide and made up of mainly massive galena with some sphalerite.

Polished Section Description:

Opaques 95% of polished section

pyrite (trace)
sphalerite (24%)
galena (58%)
jamesonite (18%)
tetrahedrite (trace)
polybasite (trace)
covellite (trace)



pyrite:
occurs as small fragments of fine mosaic of grains replaced along fractures by sphalerite and jamesonite.

sphalerite:
occurs as a fine mosaic of grains somewhat fractured and fragmented. Forms mutual boundaries with galena and jamesonite and caries in galena.

galena:
occurs as fine grain crystal aggregates and as atolls in sphalerite. Forms mutual boundaries with jamesonite and caries in sphalerite. Appears to have replaced sphalerite along fractures.

jamesonite:
occurs as fine mosaic of grains with a fractured (?) texture. In places it is intimately associated with galena. Forms irregular mutual boundaries with sphalerite and appears to have replaced sphalerite.

tetrahedrite:
occurs with polybasite as atolls in sphalerite. Forms mutual boundaries with jamesonite.

polybasite:
as for tetrahedrite

covellite:
occurs as very fine needle shaped crystals usually in gangue. Probably formed from supergene alteration of tetrahedrite.

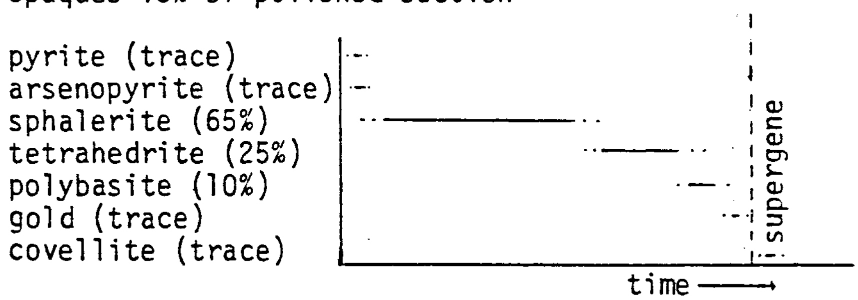
SAMPLE NUMBER SK75-N22

Hand Specimen Description:

Fine grain brecciated rhyolite with stockwork of sulphide minerals.

Polished Section Description:

Opaques 15% of polished section



pyrite:
occurs as subhedral crystal fragments (up to 0.1 mm) in gangue

arsenopyrite:
occurs as euhedral to subhedral crystals in gangue and sphalerite.

sphalerite:
occurs as a fine mosaic of grains and as atolls in gangue. Forms irregular boundaries with tetrahedrite and polybasite and caries in tetrahedrite. Texture is somewhat fragmentary with tetrahedrite and polybasite surrounding and replacing sphalerite fragments.

tetrahedrite:
occurs as fine mosaic of grains intimately associated with polybasite. Forms microveinlets in sphalerite.

polybasite:
occurs as laths and irregular shaped bodies in tetrahedrite. Forms near tetrahedrite - gangue boundaries and tetrahedrite - sphalerite boundaries and appears to have replaced tetrahedrite. Also forms microveinlets in sphalerite.

gold:
occurs in trace amounts as small (< 0.01 mm) blebs in sphalerite and tetrahedrite.

covellite:
occurs as small fine mosaics of grains in sphalerite. Forms most commonly near sphalerite - tetrahedrite boundaries and is apparently a supergene alteration of tetrahedrite.

SAMPLE NUMBER SK75-P85

Hand Specimen Description:

Massive fine grain pyrite, texture is somewhat fragmentary with felsic gangue fragments included.

Polished Section Description:

Pyrite was very friable and epoxy was used to bind the minerals.

Opaques 99% of the polished section

pyrite (100%):
occurs as very fine mosaic of grains and as small ($<$ 0.5 mm) euhedral to subhedral grains in a finer grain pyrite matrix. Appears highly fractured and friable making polishing difficult.

SAMPLE NUMBER SK75-IC

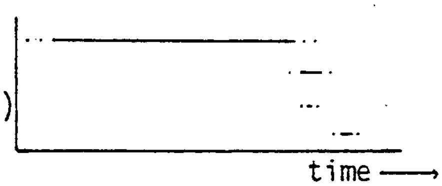
Hand Specimen Description:

Semimassive sulphide minerals comprised of medium grain (2 - 3 mm) crystal aggregates of pyrite (up to 12 mm) in a dark grey fine grain matrix of gangue.

Polished Section Description:

Opaques 42% of polished section

pyrite (93%)
sphalerite (5%)
chalcopyrite (trace)
galena (2%)

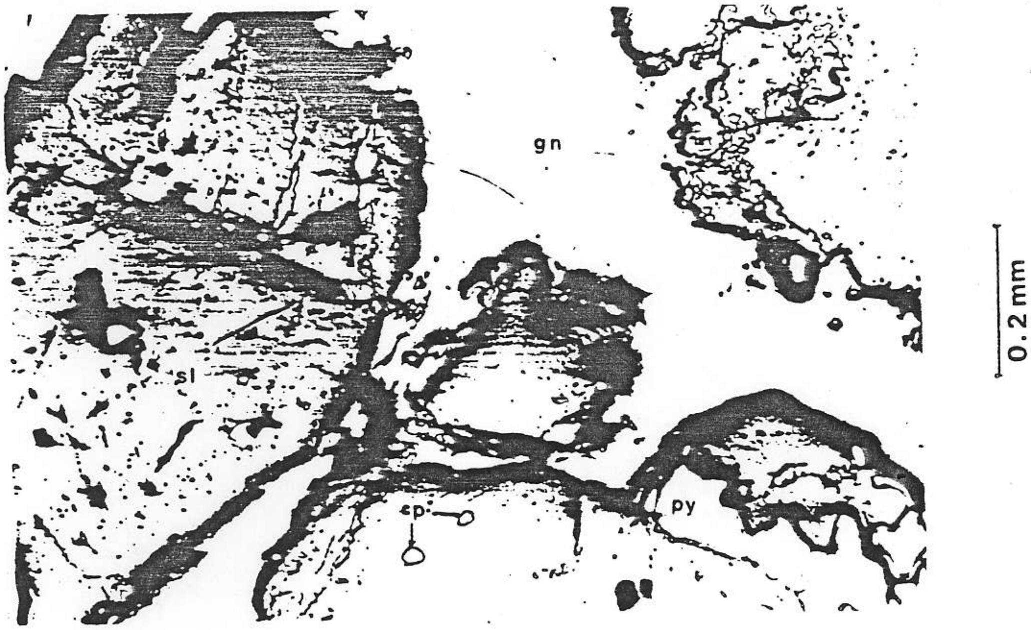


pyrite:
occurs as mosaic of euhedral to anhedral grains often fragmented. Grain size varies from less than 0.01 mm to greater than 2 mm.

sphalerite:
occurs as fine mosaics of grains and as atolls in pyrite. Forms in voids between pyrite and gangue.

chalcopyrite:
occurs as fine exsolution blebs in sphalerite and as atolls in pyrite.

galena:
occurs as fine mosaic of grains and as atolls in sphalerite and pyrite. Forms mutual boundaries and caries in sphalerite and appears to have replaced pyrite.



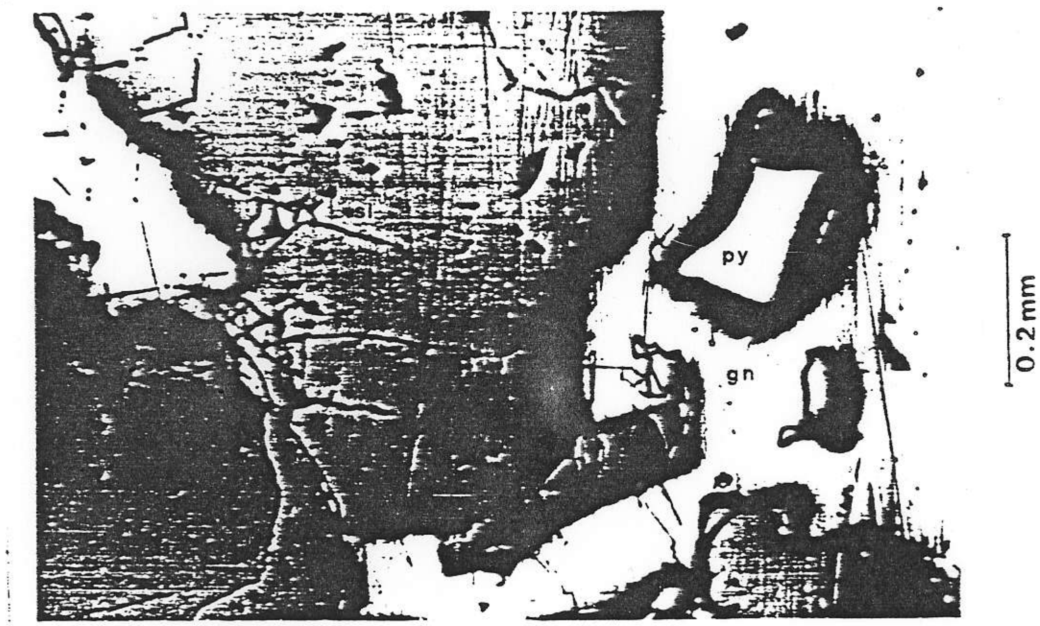


PLATE IX Top: Galena (gn) and sphalerite (sl) with chalcopyrite (cp) exsolution blebs in sphalerite. Pyrite (py) also present. (SK75-AS in plane light X32).

Bottom: Galena (gn), sphalerite (sl) and pyrite (py) (SK75-N5 in plane light X32).

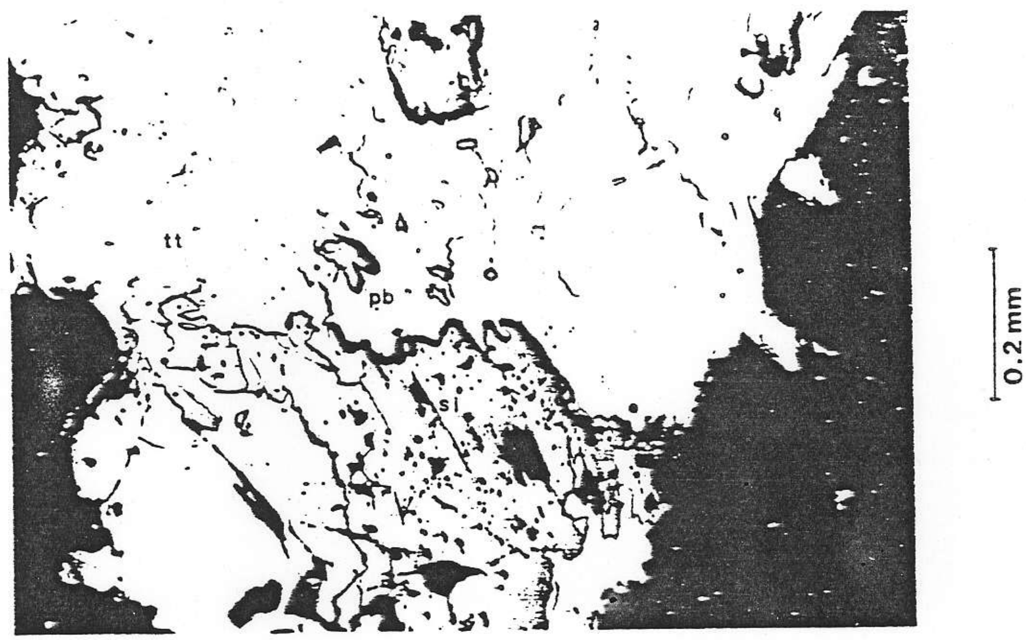


PLATE X Top: Jamesonite (ja), sphalerite (sl) and galena (gn) (SK75 - N21 in plane light X32).

Bottom: Tetrahedrite (tt), polybasite (pb) and sphalerite (sl) (SK75 - N22 in plane light X32).