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G E O L O G Y   O F   T H E

A J A X - M O N T E   C A R L O   P R O P E R T Y

by

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B.A.Sc., University of British Columbia, 1965

A THESIS SUBMITTED IN PARTIAL FULFILMENT OF

THE REQUIREMENTS FOR THE DEGREE OF

MASTER OF APPLIED SCIENCE

in the Department

of

Geological Sciences

We accept this thesis as conforming to the

required standard

THE UNIVERSITY OF BRITISH COLUMBIA

June, 1973

ABSTRACT

The Ajax-Monte Carlo property is a small porphyry copper deposit located approximately six miles south of Kamloops, British Columbia on the south flank of the Iron Mask Batholith. The Batholith and successor intrusives were emplaced in a northwest-trending structural element named the Carabine Creek Lineament. Early phases of the batholith were basic and coarse-grained and form the core of the complex. Later phases, of intermediate to acidic composition, were emplaced along the structurally weak margins of the core.

Three stages of fracturing were recognized at the property. The earliest brecciated the coarse-grained phases prior to the emplacement of the fine-grained intrusions. The second stage of fracturing was synchronous with the alteration; the final stage created the stockwork in which the mineralization was concentrated.

The propylitic alteration facies developed at the property is typical of porphyry copper deposits except that only minor quantities of quartz are present. The potassic facies is distinctly different in that it lacks abundant red orthoclase and biotite.

Pyrite and chalcopyrite are the most abundant sulfides; and bornite is occasionally observed. Magnetite is a common accessory in the basic intrusives.

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CHAPTER I
INTRODUCTION

This thesis describes the Ajax-Monte Carlo Property, a small porphyry copper deposit on the southwest flank of the Iron Mask Batholith in its geological and structural setting.

LOCATION

The Ajax-Monte Carlo Property is located in the Kamloops Mining Division at Latitude 50° 30' N., Longitude 120° 22' W. The nearest centre is Kamloops, B.C., about 6 miles to the northwest. Access to the property is by good gravel roads via the small community of Knutsford.

SCOPE

The data for this study were gathered during the 1967 field session in conjunction with exploration work on the property. Because less than 5 percent of the surface is outcrop, most information was obtained by study of diamond drill core. Spatial relationships and distribution of lithologic units are inferred from drill hole intersections and therefore are subject to interpretation. This thesis encompasses a study of the mineralisation in relation to the paragenesis of igneous intrusion and the effects of regional and local structures.

PHYSIOGRAPHY

Much of the area occupied by the batholith is open grassland, with timber only on the higher slopes. Relief is moderate, and glacial action has created a topography of low, rolling hills. Light rainfall is reflected in the flora of the area. Sagebrush and cacti are abundant on the lower grassy slopes. Water is abundant in the spring in numerous small saline ponds and sloughs. In summer and fall, however, Jacko Lake is the only large body of water in the claim area.

PREVIOUS GEOLOGICAL WORK

General reconnaissance geology of the Iron Mask Batholith was first recorded by G.M. Dawson in 1877 and 1894 with additional work by R.A. Daly in 1911-12. Mathews (1941) studied the petrology of the major phases comprising the batholith and noted the peripheral distribution of copper deposits. Cockfield (1949) made the first systematic study of the numerous copper showings associated with the batholith and described them briefly in the Geological Survey of Canada Memoir 249. Continued exploration interest in the area resulted in two studies of the batholith and associated deposits by the B.C. Department of Mines. Carr (1956) separated the phases of the batholith into two categories based on textural and field relationships. These categories, each containing several varieties of intrusive rocks, were termed the coarse-grained suite and the fine-grained suite. Carr made an important contribution in suggesting a paragenetic sequence for the intrusives co mprising the batholith, and in relating the intrusive body to regional zones of structural weakness. In the second study of the batholith, Preto (1967) described several porphyritic younger varieties of the intrusive complex and recognized their close association with mineralisation.

HISTORY AND DEVELOPMENT

The original Ajax, Monte Carlo, Neptune and Sultan Crown-granted mineral claims were located in the early 1900's. During the next two decades, the owners sank numerous pits and shallow shafts on outcrops which were stained with copper carbonates or contained copper sulphides.

Cominco Ltd. optioned the claim group in 1928 and did approximately 5000 ft. of diamond drilling and minor underground development in the Monte Carlo adit. Berens River Mines Ltd. (Newmont) optioned the property in 1952 and drilled on a narrow high-grade shear zone on the Monte Carlo claim near the old adit. In 1954, Cominco again optioned the four original Crown grants together with adjacent crown-granted claims, staked additional claims and proceeded to carry out intermittent exploration programs up to the present time.

ACKNOWLEDGMENTS

The writer would like to acknowledge the guidance of J. Richardson and Dr. J.M. Allen of Cominco Ltd. while exploration work was being performed on the property. Discussions with Dr. V.A.G. Preto of the B.C. Department of Mines were invaluable in sorting out the numerous varieties of intrusive types, as well as the structure of the area. Thanks also are due to Cominco Ltd. for permission to publish this thesis and for bearing the cost of map reproduction, and certain of the photographs. The experience and knowledge of the area which the late Dr. J.A. Gower possessed were an invaluable resource to the author.

CHAPTER II

GENERAL GEOLOGY

REGIONAL GEOLOGY

The Iron Mask Batholith lies in the southeast corner of a large structural element known as the Quesnel Trough (Roddick et. al., 1967) and (Campbell and Tipper, 1970). Formation of the trough probably commenced at the close of the Paleozoic and an extensive system of structural weakness and faulting developed in the interior at this time (Douglas et. al., 1970). It seems probable that the ancestral fault system into which the Iron Mask Batholith and successor intrusives were emplaced was generated at this time. Subsidence of the trough began in the area in Upper Triassic time with the deposition of the Nicola Formation. Deformation, intrusion and uplift associated with the Inklinian orogeny (Douglas et. al., 1970) followed rapidly, commencing in the latest Triassic with the emplacement of a number of batholiths, including the Guichon Creek Batholith and it is postulated that intrusive activity in the Carabine Creek Lineament may have begun at this time as well with the emplacement of the earlier phases of the Iron Mask Batholith. Erosion during the Lower Jurassic unroofed the Guichon Creek Batholith. However, whether or not this stage was reached with the Iron Mask Batholith is unknown. Removal of superincumbent load progressed at least to the point where hypabyssal textures developed in

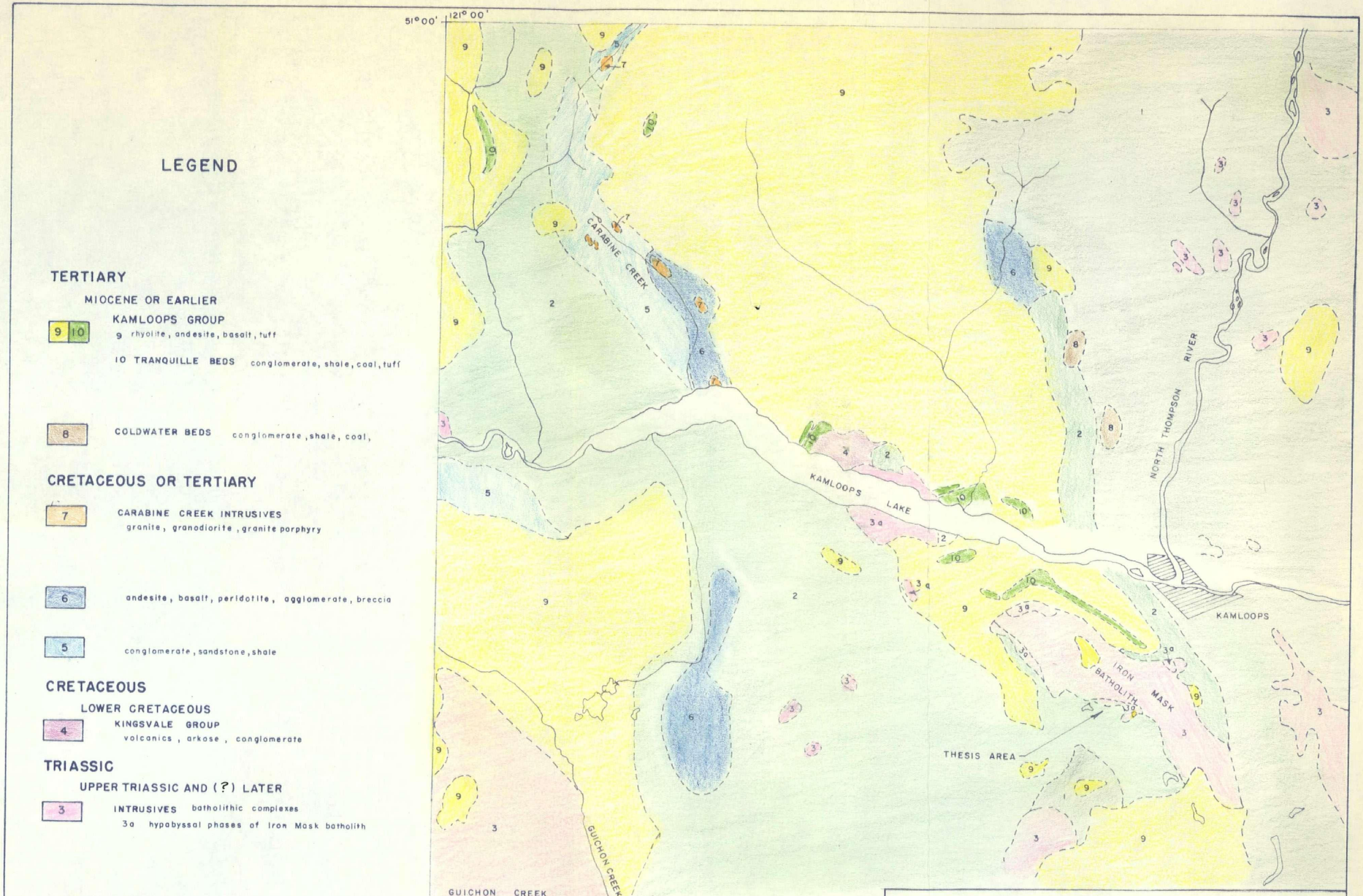


FIGURE 1

REGIONAL GEOLOGY

MODIFIED AFTER COCKFIELD AND PRETO

SCALE 1" = 4 MILES

the succeeding intrusive phases.

By Lower Cretaceous time the area to the southwest was emergent intermittently as evidenced by the continental clastics of the Kingsvale Group. In the northwest portion of the Carabine Creek Lineament, greenstones containing fragments believed to be derived from the Iron Mask Batholith are tentavely correlated with the Kingsvale Group by Cockfield (1947). Coarse clastic sediments of Upper Cretaceous (?) age are also localized in the northwestern Carabine Creek Lineament, as well as south of Kamloops Lake. Immediately overlying these conglomerates in the Carabine Creek area is a volcanic assemblage comprising basaltic breccias, tuffs, and augite porphyries with occasional bands and lenses of ultrabasic rock which are termed "picrite porphyry" (Cockfield, 1949). Cockfield's description of the picrite in this area very closely resembles the peridotite found on the Ajax-Monte Carlo property, and these occurrences are correlated on this basis by the present author. In addition, the relatively fresh augite porphyry (Jacko porphyry) found in the thesis area north of Jacko Lake is provisionally assigned to this group on the basis of lithologic similarity.

Small intrusive bodies of intermediate to acid composition were emplaced in late Cretaceous or early Tertiary time in the Carabine Creek Valley. These cut the coarse clastics and volcanic rocks mentioned above, and mark the cessation of igneous activity in the Carabine Creek Lineament.

The final major depositional event in the area was the extrusion of the Kamloops basalt over a substantial portion of the central interior, and the associated deposition of the Tranquille Beds and the Coldwater Beds in isolated continental basins.

REGIONAL STRUCTURE

The Carabine Creek Lineament, the dominant structure in the area, is a northwest-trending structural discontinuity about 30 miles long which extends from Shumway Lake in the southeast across Kamloops Lake and up the valley of Carabine Creek in the northwest (Figure 1). Evolution of the ancestral Carabine Creek Lineament may have begun as early as the close of the Paleozoic during the Cassiar orogeny when large northwest-trending breaks such as the Pinchi Fault system were generated, though intrusive activity along the lineament probably did not commence until late Triassic or early Jurassic time.

Intermittent tectonic activity along the lineament allowed intrusion of successively younger phases of the batholith culminating in the Tertiary with the intrusion of the small stocks in the Carabine Creek Valley. Carr (1956) believed that three zones of recurring fracture played an important part in localizing the batholith and were the loci of intrusive activity during the evolution of the batholith. Preto (1967) noted that the occurrence of the younger hypabyssal intrusive phases is restricted to Carr's fracture zones.

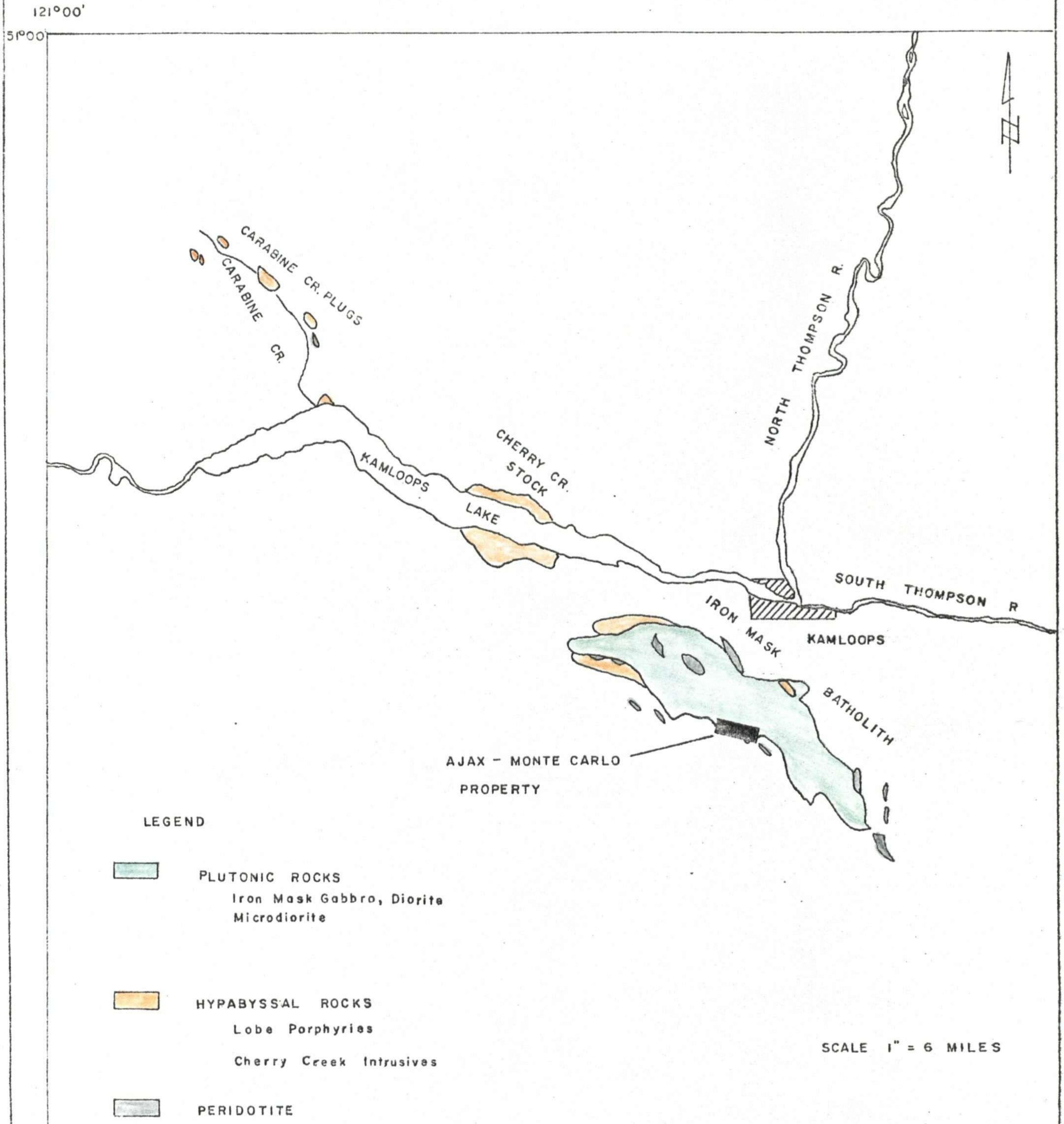


FIGURE 2

INTRUSIVE BODIES ALONG THE CARABINE CREEK LINEAMENT

Evidence suggesting the Nicola rocks were folded prior to emplacement of the early intrusive phases of the Iron Mask Batholith is described by Mathews (1941) and Jones (1957). Mathews, in describing the Nicola Group near the southeast-end of the batholith, states that the batholith has intruded the northeast limb of a syncline whose axis occurs near Edith Lake and trends northwesterly. Jones states that the Nicola rocks at the northwest corner of the batholith near Hughes Lake strike northwesterly parallel to the long axis of the batholith. Near the contact, dips are steep southwesterly but become flatter to the southwest, away from the batholith. From this, he infers a synclinal axis to the southwest of the batholith, which agrees with Mathew's conclusion that the batholith was emplaced discordantly into the northeast limb of a syncline.

CHAPTER III

LOCAL GEOLOGY

GENERAL INTRUSIVE HISTORY

The Ajax-Monte Carlo deposit occurs on the southwestern margin of the Iron Mask Batholith adjacent to the contact with the Nicola Group, but is entirely contained within the intrusive rocks of the batholith.

Intrusive activity is thought to have commenced during Upper Triassic or Lower Jurassic time during the Inklinian Orogeny. The first phases to be emplaced in the Carabine Creek Lineament were the gabbro, pyroxenite and diorite comprising the coarse crystalline suite of the Iron Mask Batholith. These early basic and coarsely crystalline varieties form the core of the batholithic complex. Continuing stress release along the lineament allowed the intrusion of successive phases along the structurally weak upper margins and crest of the rigid crystalline core. Emplacement of the younger hypabyssal varieties distributed along the upper margin and periphery of the plutonic core suggest firstly that the core rocks were crystalline and competent, and that unroofing of the complex has progressed to the stage where more rapid chilling of the magma took place, generating the porphyritic textures of the Sugarloaf suite and the potash-rich Cherry Creek porphyry. Intrusive activity along the lineament appears to have continued into Cretaceous or Tertiary time with the intrusion of the

Carabine Creek Stocks on the North side of Kamloops Lake. Late dikes and intrusions of probable Tertiary age mark the cessation of intrusive activity in the area.

On the Ajax property, intrusive varieties representing most of the stages of evolution of the batholith are present. Due to the limited exposure, however, little can be said regarding distribution, abundance and intrusive relationships beyond that information which is obtained from drill cores.

PETROLOGY

NICOLA GROUP

The rocks of the Nicola Group do not outcrop in the thesis area and consequently were not examined during the course of work on the property. Descriptions from the literature (Schau, 1964), Cockfield (1949) indicate the bulk of the Nicola Group is volcanic in origin with associated minor limestone, argillite and conglomerate. Lithologies of the volcanogenic members are diverse including amygdaloidal lavas, porphyries, breccias, agglomerates and tuffs. Material of andesitic composition predominates; basaltic or dacitic rocks are uncommon. Alteration is apparently widespread, with extensive development of chlorite, calcite and epidote. Uralitic alteration of pyroxenes is also common.

INTRUSIVE ROCKS OF THE IRON MASK BATHOLITH

Pre-Mineralization Assemblage (Coarse-Grained Suite)

Iron Mask Gabbro

This rock type is the oldest of the Iron Mask intrusive assemblage and, together with the Iron Mask Diorite, comprises the coarse-grained crystalline core of the complex. It is distributed along the northern edge of the Ajax-Monte Carlo property in breccia contact with the younger phases to the south.

In hand specimen, the gabbro is typically dark green in colour and is medium to coarse grained. No planar or linear fabric is discernable. The composition is quite variable and ranges from plagioclase-free pyroxenitic varieties to those containing approximately 50 percent plagioclase. Accessory magnetite is typically abundant, and occasionally is concentrated in lenses to 5 feet in length.

Augite, which is generally unzoned, occurs as large stubby subhedral crystals. Plagioclase, when present, is generally subhedral producing a texture which is sub-ophitic as can be seen in Plate I. Magnetite is interstitial.

Deuteric alteration is common, especially in plagioclase-rich varieties, and augite is altered to hornblende along crystal outlines and cleavage planes. Plagioclase is invariably riddled with hydromica which makes composition determinations impossible to obtain. Partial alteration of magnetite to ocherous hematite is also fairly common (Plate I).

Mode

(a) Typical gabbro (extensively altered):

Mineral	Percentage
Hornblende	71.6
Plagioclase	17.0
Pyroxene	1.0
Sericite	8.4
Accessories	1.0
Opaques (magnetite, hematite)	1.0

(b) Typical pyroxenite (unaltered):

Hornblende	1.0
Pyroxene	85.0
Opaques (magnetite)	14.0

Iron Mask Diorite

This species is less abundant than gabbro and from mutual contacts appears to have crystallized later than the gabbro. It is easily rocognized in the field being medium to coarse grained with long blades of hornblende to 2.5 cm. surrounded by subhedral plagioclase to 1.5 cm (Plate II). Linear or planar fabrics are generally absent except near contacts with the older gabbro where hornblende crystals occasionally are sub-aligned in trachytoid textures. Grain size is quite variable and commonly changes rapidly over distances as small as a few inches, which gives rise to the schleiric texture described by Mathews (1941). Contacts with the gabbro are generally sharp and exhibit little evidence of assimilation.

Under the microscope, hornblende occurs in long narrow blades. Colour is grey-green, and weakly pleochroic. Plagioclase occurs in anhedral crystals which are generally smaller than the hornblende. Albite twinning is common, and crystals are unzoned. Rounded quartz grains with undulatory extinction are present in trace amounts.

Alteration of the diorite is ubiquitous. Hornblende is extensively altered to chlorite along cleavages and crystal boundaries so that often only a few fragments of hornblende remain. Development of biotite after hornblende has been observed although this is relatively uncommon.

In the thin sections studied, plagioclase is seldom fresh, but shows extensive alteration to hydromica along twin planes and crystal boundaries. Crystals suitable to compositional determinations are very rare and the composition obtained, An_{70}, is based on one determination. Although several thin sections were studied, only one was suitable for determination of anorthite content (An_{70}).

Mode

Mineral	Percentage
Hornblende	51.8
Plagioclase	39.0
Biotite	2.3
Quartz	1.0
Opaques	5.8

Intra-Mineral Assemblage

Microdiorite

Fresh, medium grey microdiorite is fine to medium grained, allotrimorphic-granular. On the property, extensive propylitization has given it a buff to greenish white colour. The plutonic texture, even grain size and lack of foliation or lineation are characteristic of this species.

The bulk of the microdiorite on the property is restricted to the western area or Ajax Zone where it forms the host for most of the mineralization. The combination of lack of outcrop and intense alteration make it difficult to determine age relations with other intrusive varieties. However, it does postdate the Iron Mask Gabbro and Diorite because their mutual contact on the north edge of the property is a breccia zone, with fragments of the coarse-grained suite in a matrix of microdiorite. Other contact relationships are less conclusive and are discussed later.

Mode

Mineral	Percentage
Hornblende	39.5
Plagioclase	47.4
Biotite	4.0
Epidote	7.6
Opaques (sulphides)	1.4
Quartz	1.0
Augite	1.0

Hornblende occurs as stubby, ragged crystals which display a medium green to yellow-green pleochroism. Generally the hornblende is extensively replaced by chlorite and less commonly, by biotite. Augite is uncommon and exists as fragmentary remains only. Alteration of this mineral is not extensive and its destruction appears to have taken place as much by comminution as by chemical attack.

The plagioclase exists in small, unzoned anhedral grains with only a few displaying crystal outlines. It is invariably altered, either dusted with fine opaque material, or riddled with hydromica or epidote; and forms the bulk of the rock. The fabric is typically plutonic with a mosaic of interlocking grains of mafic minerals, plagioclase and trace amounts of quartz (Plate III).

Lobe Porphyries

This is an assemblage of microporphyritic rocks of intermediate to acid composition which on the east side of the property form a lobe-like salient from which the name is derived. The distribution of this group is restricted to the northwest corner and flanks of the batholith, and as noted by Preto, appear to have been emplaced along the fracture zones described by Carr. Although comprising a number of intrusive species of slightly different compositions and varying textures, they have been grouped as the Sugarloaf Intrusives by Preto because of their obvious spatial and genetic affinities. Sugarloaf diorite from the type locality on Sugarloaf Hill commonly contains stubby equant phenocrysts of hornblende in a fine-grained feldspathic matrix whereas the equivalent rock types in the thesis area contain long, bladed crystals of hornblende, and often euhedral grains of plagioclase. Because of the textural differences, it is thought that the Sugarloaf varieties present in the thesis area warrant the distinction of a separate name, the "Lobe Porphyries".

The two most important varieties are the Lobe diorite and the Lobe monzonite, each of which has numerous textural variants. Characteristic of this suite is the distinct hypabyssal texture which distinguishes it from the coarse crystalline suite, and from microdiorite.

Also included in this group is an assemblage of microporphyritic rocks which Preto has mapped separately as the Cherry Creek intrusives. These are similar texturally to the Sugarloaf suite but are characterized by an abundance of brick-red orthoclase. There has been some discussion among workers whether this variety is a separate intrusive phase or whether the unusually high concentration of orthoclase in the rock is the result of potassium silicate alteration of Sugarloaf or Lobe Porphyry.

Lobe Diorite

This species is medium green-grey coloured and is fine to medium grained. Fresh specimens show hornblende crystals to 1-2 mm. in length which are commonly ragged, fragmented and bent. The texture is not distinctly porphyritic but in some cases hornblende crystals reach 2 cm. in length (Plate VI). Preferred orientation is common as seen in Plate VII. The degree of crystallinity of the feldspars ranges from a mosaic of subhedral grains to distinctly euhedral crystals forming crowded feldspar porphyries (Plate VIII). The porphyritic nature of the rock is often masked by alteration which affects the plagioclase and leaves ghosts which are apparent only under the microscope. Altered varieties of this rock are thus easily confused in the field with microdiorite. Moderate alteration is almost always present and the most obvious effects observed in the field are frequent patches of epidote in the matrix.

The effects of alteration are much more apparent under the microscope. Hornblende, in long ragged crystals, commonly shows serrated terminations suggesting reaction with the melt phase. Oscillatory zoning of the larger crystals is frequently observed. Minor amounts of chlorite are present. Alteration of mafic minerals to tremolite-actinolite is also present in some sections.

Plagioclase occurs in euhedral to subhedral laths which rarely exceed 5 mm. in length and are invariably highly altered. Trachytoid texture is common, especially in the more porphyritic varieties. Unaltered specimens suitable for optical determination of composition are exceedingly rare. One determination obtained from a specimen from Sugarloaf Hill gave the composition An_{38}. In most of the sections studied, plagioclase is altered to a translucent cottony mass of sericite and a clay mineral (montmorillonite?). Highly altered plagioclase crystals may display a rim of unaltered feldspar. This material has positive relief, and therefore probably is an unaltered rim of a previously zoned crystal, rather than a rim of albite resulting from alteration.

In the groundmass, orthoclase is not abundant and generally occurs as small euhedral grains interstitial to the phenocrysts. Alteration is usually advanced to the stage where orthoclase is not readily identifiable in unstained slides, even though it is theoretically stable in both alteration facies present. Clinozoisite is common is disseminated granules and in larger poikilitic grains which pseudomorph hornblende. Calcite, tremolite, apatite, and chlorite are present in the matrix in small quantities. Quartz, which occurs in very small grains in the matrix, constitutes less than one percent of the rock.

Mode

Mineral	Percentage
Hornblende	9.5
Actinolite	7.9
Plagioclase (phenocrysts)	31.7
Plagioclase (matrix)	26.7
Orthoclase	13.1
Sericite	1.6
Accessories (quartz, calcite, sphene)	4.3
Opaques (magnetite, pyrite)	5.2

All porphyritic rocks of dioritic composition in the thesis area are grouped together under the name "Lobe Diorite". In hand specimen the most obvious lithologic variation is in the degree of crystallinity of the plagioclase (Plate VIII). This distinction is more apparent than real since under the microscope the type Lobe Diorite shows euhedral ghosts of plagioclase. Also apparent from the plates is the difference in habit of the hornblende. It is on this baiss that the Lobe Diorite is differentiated from the type Sugarloaf diorite.

Lobe Monzonite

Unaltered Lobe monzonite is a distinctly porphyritic rock containing abundant small phenocrysts of plagioclase in a matrix of orthoclase, quartz and minor hornblende. It is texturally similar to the Lobe diorite but is distinguished on the basis of somewhat lighter colour and a faint pinkish-orange hue due to more abundant orthoclase and lesser amounts of mafics.

It is not particularily abundant on the property. Known occurences are restricted to the eastern part of the property. Mineralized Lobe monzonite has been observed in core but in general it is not an important host of ore. Information regarding age relationships with other intrusive types is very limited because contacts are observed only in core. It obviously post-dates the coarse crystalline suite since it contains fragments of gabbro (Plate IX). In drill core from hole 52, it appears to have intruded the Lobe diorite and the contacts with it appear to be chilled.

Plagioclase phenocrysts (An_{35}) show little variation in size and are generally .5 cm. or less in length. They are usually euhedral and albite twinning is common. Phenocrysts are more abundant and closely packed than in the diorite porphyries, and trachytoid texture is common. Zoning of the phenocrysts is present, though frequently masked by alteration, and compositional variations across the crystals are unobtainable. Euhedral crystals of hornblende generally are altered to tremolite-actinolite.

Interstitial to the euhedral phenocrysts of plagioclase is a fine-grained mosaic of anhedral quartz and orthoclase. Quartz grains range from about .25 mm. to 1 mm. and have rounded boundaries, whereas orthoclase is sub-poikilitic in grains to 1mm. Alteration of the cores of the orthoclase grains to a clay mineral (montmorillonite?) is frequent. The matrix contains small amounts of granular clinozoisite, apatite, sphene, calcite, and euhedral pyrite.

Mode

Mineral	Percentage
Plagioclase	29.7
Orthoclase	22.9
Quartz	14.0
Tremolite - actinolite	7.3
Chlorite	13.4
Accessories (epidote, calcite)	9.9
Opaques (magnetite, sulphides)	2.8

Aside from small changes in the amount of phenocrysts, little variation in composition or texture has been observed.

Micromonzonite

Texturally this rock is similar to the microdiorite, in that it is fine-grained hypidiomorphic-granular and lacks the hypabyssal appearance of the Lobe porphyries. In general it is leucocratic; however, some varieties contain minor hornblende. Its pinkish-grey colour and characteristic texture make it easy to recognize in the field.

The main body of micromonzonite on the property occurs in the north-central area where it has intruded microdiorite and rocks of the coarse crystalline suite. Elsewhere on the property, small bodies of micromonzonite have a dike-like aspect, and contain fragments of Lobe diorite and Lobe feldspar porphyry. Carr (1956) in describing an occurrence of micromonzonite within a body of serpentinized peridotite in hole 23 inferred that the micromonzonite has intruded the peridotite. Examination of the core by the author did not result in any definitive evidence regarding the relative ages of the rocks in question. From this, it appears that the micromonzonite was emplaced later than the Lobe porphyries and as such represents a departure from the general trend from older plutonic-textured basic rocks to younger prophyritic acidic phases.

Plagioclase, the most abundant mineral species, occurs as a mosaic of stubby laths and crystals. Albite twinning is common, but the crystals are unzoned and are not preferentially oriented. As implied in the name, the size of the crystals is small, averaging about 2.5 mm. in length. Alteration is moderate with development of hydromica along twin planes and crystal boundaries. The cores of some crystals are clouded with an amorphous aphanitic material which is probably montmorillonite. Optical determinations indicate a composition of An_{30} to An_{35}.

Orthoclase occurs in anhedral grains which may partly enclose plagioclase laths in a sub-poikilitic texture. In plane light, the crystals have a dusty appearance which is perhaps due to inclusion of finely divided hematite. Quartz is present in small quantities as rounded equant grains to 2 mm.

Hornblende is present in small amounts in subhedral unzoned crystals displaying light tan to green pleochroism. No alteration was observed. Clinozoisite, apatite and calcite comprise the accessory minerals.

Mode

Mineral	Percentage
Hornblende	26.1
Plagioclase	44.9
Orthoclase	2.5
Sericite	8.9
Epidote	14.4
Quartz	1.6
Opaques (pyrite, chalcopyrite)	1.6

The dike-like distribution, relatively weak alteration and lack of mineralization associated with this rock type suggest that it was intruded subsequent to the mineralization and alteration on the property, but conclusive evidence is not available.

Jacko Porphyry

This intrusive variety outcrops on the western edge of the property and forms the low bluffs to the north of Jacko Lake. Its contact relationships with other intrusive types are sufficiently obscure to reduce an estimation of its relative age to a matter of speculation. Near the eastern side of Jacko Lake, however, a small test pit has been excavated to expose a narrow fracture containing pyrite, chalcopyrite and calcite. No other mineralization has been observed in this species, however. It is provisionally included with the intra-mineral intrusive assemblage.

As evidenced by the name, the rock is porphyritic, with small (1 cm.) equant phenocrysts of hornblende in a fine-grained granular matrix. On a weathered surface, the porphyritic nature is particularly apparent, and it was on this basis that field identification was made. Preferred orientation of phenocrysts is not present, although scattered throughout the rock are occasional narrow (5 cm.) irregular streaks of fine-grained granular material which is devoid of phenocrysts. The colour of the rock on a fresh surface is a dark greenish-grey due to the predominance of hornblende.

Phenocrysts are bimineralic, with cores of augite and rims of secondary hornblende. The nucleii often show oscillatory zoning, and extensive alteration has produced a sieve-texture especially near the rims of the augite crystals.

Hornblende is the most abundant mineral species and occurs as alteration rims as mentioned above and as mats of stubby crystals, commonly with a preferred orientation. Pleochroism is distinct and colours are yellow to green. The crystals are fresh and unaltered, which is in marked contrast to plagioclase. The presence of plagioclase is indicated only by lath-shaped ghosts of hydromica.

Small amounts of biotite, calcite, and traces of magnetite are also present.

Mode

Mineral	Percentage
Hornblende	60.2
Sericite (after plagioclase)	29.1
Pyroxene	5.3
Chlorite	3.2
Quartz	1.3
Accessories & opaques	1.0

It should be noted that other workers have not mapped the Jacko porphyry as a separate intrusive phase and have presumably included it with rocks of the Coarse crystalline suite since there is a marked resemblance to some of the more pyroxenitic varieties of Iron Mask Gabbro. The limited exposures and lack of diamond drill holes in this area make it difficult to come to a definite conclusion. However, the writer has provisionally classified these rocks as a separate intrusive type because of its distinct hypabyssal texture, lack of mineralization, and absence of accessory magnetite.

Post-Mineralization Intrusives

Peridotite

Small lenticular bodies of peridotite have been mapped by Carr along the Carabine Creek lineament, and several occur on the property. Most are strongly sheared and serpentinized, but one outcrop of fresh material occurs about one-quarter mile southeast of the property. The close spatial relationship between the peridotite bodies and the major breaks in and adjacent to the batholith was noted by Carr and Preto, but a genetic relationship has not been proposed.

On the property, peridotite is distributed along the southern edge of the property and appears to underly the Lobe diorite on the eastern side of the Monte Carlo zone. In fresh specimens, it is dark green and dense, commonly with greenish ovoid remnants of olivine crystals to 1 cm. in a dark aphanitic matrix. Some of the serpentinized material displays a glomeroporphyritic texture with clusters of phenocrysts in a dark grey serpentinized matrix (Plate IV).

A specimen of fresh peridotite from the locality one-quarter mile from the property was studied in thin section since unaltered material does not occur on the property. It has large (1 cm.)

closely-packed ovöid crystals of olivine in varying degrees of serpentinization. Typically, the olivines are fractured and veined with serpentine, and are rimmed with selvages of antigorite and magnetite. The phenocrysts show no preferred orientation. Some olivine crystals in advanced stages of serpentinization have antigorite rims with associated coarse euhedral grains of magnetite, whereas the centres of the crystal sites have been reduced to felted mats of chrysotile with disseminated, very fine-grained magnetite.

The groundmass consists of a granular aggregate of small (0.1 mm.), euhedral pyroxene crystals, identified by Mathews (1941) as pigeonite, in a glass matrix. This glass is generally fresh and unaltered and only occasionally is it cloudy and semi-opaque. Spherulitic cracks are uncommon as is strain birefringence. Serpentine was not observed in the matrix. Spinifex textures are absent.

Specimens from the property show vestiges of olivine with abundant serpentine and magnetite in phenocryst sites (Plate V). The groundmass is completely altered to a fine-grained mat of serpentine, magnetite and talc (?). Directional textures are occasionally visible, presumably generated by shearing.

Mode

Mineral	Percentage
Olivine	30.7
Serpentine	27.0
Augite	25.5
Talc	4.7
Opaques (magnetite)	12.1

Rhyolite

A branching dike of rhyolite traverses the property in a north-easterly direction. Thickness is less than 40 feet but it has been traced in drill holes for a strike length in excess of 3000 feet. Rhyolite intrudes mineralized Lobe porphyries, microdiorite and also micromonzonite, but it is completely barren and unaltered, and so was emplaced after the mineralization and alteration. Chilled margins suggest the intrusive complex had completely cooled prior to the intrusion of the rhyolite. Its fine grained sub-porphyritic texture and distinctive orange-brown colour on both fresh and weathered surface make it easily recognizable in the field.

Quartz and euhedral sanidine crystals are commonly distributed about the rims of the vesicles. The centres are filled with calcite and rarely an unidentified mineral in radiating clusters (Plate XI).

The groundmass makes up about 90 percent of the rock and is composed of an aggregate of fine-grained sanidine, hornblende, plagioclase and quartz. The small (less than 1 mm) sanidine crystals are subhedral to anhedral. In thin section they are commonly brownish and dusty due to minor alteration. Hornblende is found as ragged crystal remnants to 1 mm. In thin section, the texture is decussate, and the hornblende is in most cases extensively altered to actinolite-tremolite, and occasionally to chlorite.

Plagioclase (An_8) occurs in small laths generally less than 1 mm. in length. Alteration has been negligible and the crystallites have no preferred orientation. In addition to filling vesicles, calcite occurs as small irregular veinlets and patches associated with epidote.

Pyrite and rare chalcopyrite, which constitute less than one percent of the rock, comprise the opaque minerals. They occur as very small grains evenly disseminated throughout the rock.

Mode

Mineral	Percentage
Hornblende (Actinolite)	27.0
Plagioclase	20.9
Sanidine	19.0
Quartz	7.6
Chlorite	12.2
Calcite, epidote	11.0
Accessories	1.0
Opaques	1.0

The vesicular nature and chilled margins of this dike suggest emplacement at a relatively high level, and at a time when the batholithic complex including the porphyries had crystallized and cooled. The relative abundance of quartz and acidic composition suggest an affinity to the intrusives in the northwest end of the Carabine Creek Lineament which Cockfield suggests are post-Cretaceous.

EXTRUSIVE ROCKS

Kamloops Group

Olivine Basalt

On the extreme eastern edge of the property basalt is exposed in a small bluff. Its contacts are not exposed but it appears to overlie peridotite and altered Lobe porphyries.

The rock is aphanitic, dense, with a conchoidal fracture. It is black on a freshly broken surface but weathers to a characteristic medium brown colour. It is distinctly porphyritic with rounded crystals and crystal aggregates of light brown to greenish-yellow olivine. Single phenocrysts rarely exceed 2 cm. but aggregates 5 cm. or more in diameter are common. Amygdules are rare but where present, are usually filled with white chalcedony.

The rock is quite fresh with little evidence of alteration. The olivine crystals are subangular to subrounded, moderately fractured and weakly serpentinized. Plagioclase microlites are abundant and develop trachytoid textures around the olivine phenocrysts. The composition of the plagioclase is labradorite-bytownite (An_{70}).

Pyroxene occurs in very small grains and fragments and comprises most of the matrix. It is slightly altered and this, together with the small grain size, makes optical determinations difficult. The material filling the vesicles has botryoidal or rounded outlines, and under crossed nichols occurs as a cockscomb aggregate. The colour is a pale brown and the relief and bire-fringence are low. On the basis of these properties, the mineral is identified as chalcedony.

Mode

Mineral	Percentage
Olivine	16.0
Plagioclase	32.0
Pyroxene	35.0
Chalcedony	3.0
Opaques	14.0

The composition and lack of alteration indicate that this small occurrence is in all probability Kamloops basalt of Miocene age.

ALTERATION

In recent years significant emphasis has been placed on alteration of wallrock in porphyry copper deposits and numerous systems of classification have been proposed. All systems assume an excess of silica. Most intrusive species in the thesis area contain trace amounts of quartz with the exception of peridotite which is quartz deficient. Modal quartz in excess of trace amounts is present in only a few of the younger microporphyries. With this exception, the model to which the Ajax-Monte Carlo deposit may best be compared is that developed by Creasey (1966), which is based in part on ideas developed by Burnham (1962), that is, alteration facies are defined on the basis of mineral assemblages which reflect in part leaching or metasomatic addition of basic cations.

Two discernable alteration facies are present in the thesis area; a propylitic phase and a potassic phase. The propylitic phase is the earliest and most widely distributed. Intensity of propylitic alteration varies between broad limits ranging from weak, in which the only effects are joint coatings of pyrite, epidote and calcite, to intense, where the original texture of the rock is destroyed.

Within the propylitic zone are two smaller areas of potassic alteration. These zones are characterized by small veinlets and fractures containing potash feldspar with trace amounts of biotite, and correspond to zones of highest sulphide concentrations.

PROPYLITIC ALTERATION

The two zones of propylitic alteration (fig.14, pocket) are distinguished on the basis of alteration intensity. The eastern half of the property (designated the Eastern Zone) has been only weakly affected by the alteration processes, whereas the western half (Ajaz Zone) has been intensely altered and the igneous texture of the rocks has been largely obliterated. The boundary between the intense and weak alteration is gradational and occurs at about 12,000 E. in a region penetrated by only a few drill holes.

Eastern Zone

This area is underlain by rocks of intermediate to acidic composition comprising the Lobe diorite and microporphyries and some peridotite, all of which have been weakly propylitized. Although pervasive, the alteration is not immediately apparent until observed under the microscope. In hand specimen, the diagnostic characteristics are dull white feldspars, minor concentrations of epidote near mafic minerals and coatings of epidote, pyrite and calcite on joint planes. Fracture density in the rocks, which is weak to moderate with one to ten planes per foot does not seem to have been a factor in localizing the alteration. The propylitization is pervasive and mineral gradients are not established within the altered rock adjacent to fractures.

Peridotite in this area has been extensively altered to serpentine and talc but whether or not this is the result of propylitization has not been established. The presence of fresh peridotite one-quarter mile southeast of the property suggests that these small bodies were altered subsequent to emplacement.

Microscopic examinations of the Lobe porphyries from the eastern half of the property show that hornblende is altered in varying degrees to chlorite and plagioclase is altered either to extremely fine-grained sericite or to a clay mineral, probably montmorillonite. In addition, the matrix contains small irregular grains of epidote, probably formed from plagioclase. Calcite rarely is seen in thin section, though as mentioned previously, is ubiquitous in joints and fractures and suggests that the composition of the altered rocks falls in the calcite-chlorite-epidote field of the ACF diagram of Creasey (1966) (Fig.3).

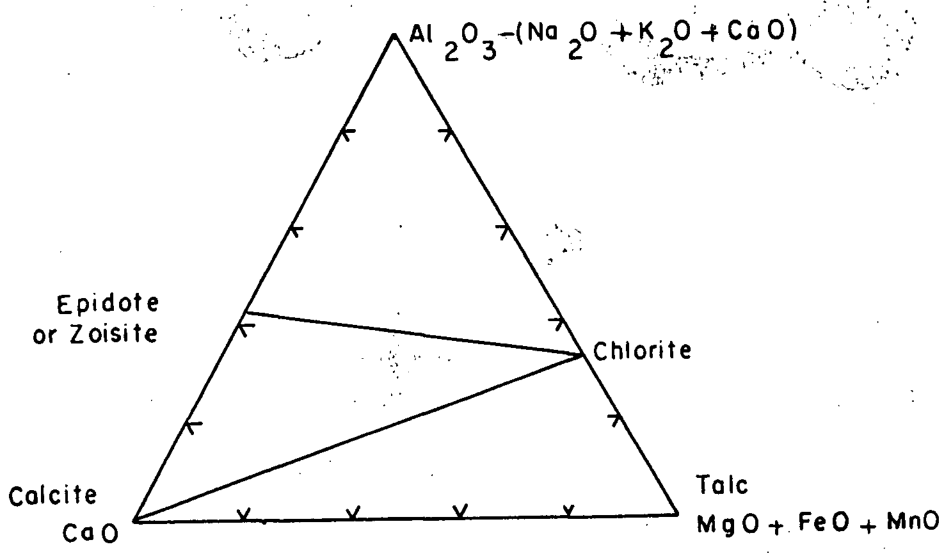


FIGURE (3) Compatibility diagram for propylite alteration with high CO_2 pressure, silica and water in excess. From Creasey (1966)

Ragged remnants of hornblende generally have been preserved but plagioclase has been completely altered and only the crystal outlines remain.

In the Lobe Monzonite, plagioclase is completely altered to sericite, but primary orthoclase is unaltered. Minor epidote is present as small granules within relict plagioclase as well as in small intergranular patches. Small quartz stringers rarely occur in the Lobe monzonite where there is modal quartz and are not observed in the other Lobe varieties. These small quartz stringers probably resulted from remobilization of quartz during alteration and not from metasomatic addition of SiO_2.

Ajax Zone

The propylitic alteration of the Ajax zone differs in intensity and mineral assemblage from the Eastern zone. The altered area, which is about 3000 feet by 1000 feet, extends from Jacko Lake to the middle of the property. The boundaries of the propylite halo about the Ajax deposit have not been defined because alteration extends into covered areas and areas untested by drill holes. The composition of the rocks prior to alteration often is difficult to establish because of intensity of alteration, but for the most part, the rocks appear to have been microdiorite with small quantities of the younger porphyries.

Characteristically, the propylitized rocks of the Ajax zone are fine grained and massive. Destruction of primary mafic minerals has resulted in a general bleaching of the rock and the obliteration of igneous texture so the colour now is light cream, occasionally with a pale greenish cast. Brecciation of the microdiorite prior to propylitization is indicated by numerous specimens which show the irregular outlines of less altered fragments enclosed in a matrix of completely propylitized material.

The mineral assemblage developed by this phase of alteration is sodic plagioclase, commonly with sericite developed along (010) planes; epidote, ubiquitous in ragged grains and small granules; calcite, rarely in dissemminated patches but most often occurring in fractures with a selvage of epidote; and minor tremolite developed from hornblende and sphene. The presence of tremolite rather than chlorite in this zone suggests possible leaching of ferromagnesian ions concomitant with destruction of the primary mafic minerals. Quartz is rarely observed.

Discussion

The propylitic assemblage at the Ajax-Monte Carlo is typical of those described in the literature with the significant exception that silica, although present, is not one of the major constituents in the assemblage. Burnham (1962) states that epidote is the mineral diagnostic of the propylitic subzone, and in the Creasey model, metasomatic addition of CaO (and other basic cations as well) defines the propylitic zone. These criteria are abundantly fulfilled in the thesis area.

As shown in Figure (4) the maximum temperature for epidote stability ranges between 400°C at low $P(H_2O)$ to greater than 600°C at high $P(H_2O)$. An accurate estimate of the pressure conditions prevailing during alteration cannot be made but the hypabyssal textures of the porphyries indicates that it was probably fairly low. The extensive alteration of peridotite to serpentine suggests a prevailing temperature below 500°C (Fig. 4), though Creasey (1966) suggests the experimental data from which this curve is derived may be inaccurate.

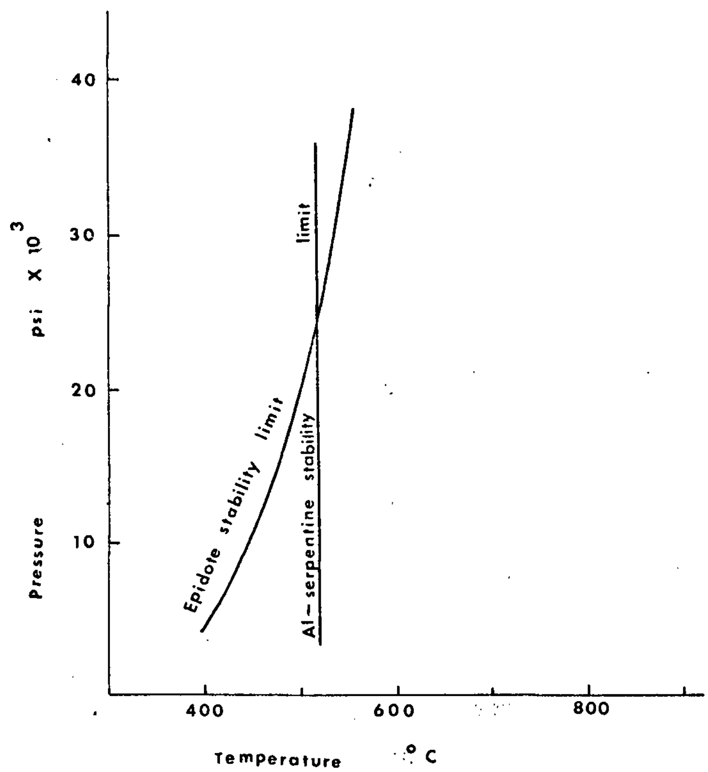


FIGURE (4) Univariant equilibrium curves for epidote and Al-serpentine. From Creasey (1966).

The alteration of plagioclase to epidote-sericite in some areas and to a clay mineral (montmorillonite?) in different areas within the propylitic zone is somewhat anomalous. All three minerals have been reported in propylitic alteration zones, but there is some doubt that the association montmorillonite (or kaolinite) - epidote is a stable assemblage (Creasey, 1966, Burnham, 1962).

Little mention is made in the literature of the stabilities of mafic minerals in the propylitic facies beyond pointing out that chlorite commonly is produced at the expense of biotite. Reference to tremolite in propylitic assemblages has not been seen by the author, but as a calcium silicate its chemical composition is consistent with the requirements of this facies. Brief mention is made by Hemley (1969) of "amphiboles" present in the chloritic alteration typical of some propylitic facies and it is assumed that the presence of tremolite is inferred.

POTASSIC ALTERATION

Two zones of potassic alteration were mapped on the property (Fig. 14, pocket). The largest, the Ajax Zone, is centred on the Ajax mineral claim and will be described in some detail. The smaller, less well-defined Wheal Tamar Zone will be briefly described.

Ajax Zone

The potassic alteration halo around the Ajax zone, on the western side of the property, is about 3500 feet in length and 1000 feet in width. In contrast to the pervasive propylitic alteration, the potassic facies is restricted to small veinlets, stockworks and fracture fillings. Its presence was not immediately apparent in the field because the orthoclase is nearly always white; and biotite is absent from the assemblage.

Potassic alteration is restricted to fractures in the propylitized rock and to envelopes up to 2 cm. wide adjacent to these fractures, and thus post-dates the propylitization.

Microscopic examination of the veinlets reveals potash feldspar in a mosaic of fine interlocking grains with significant amounts of tremolite. Pyrophyllite sometimes occurs as a selvage along fracture walls and, less commonly, in the wallrock immediately adjacent to the fractures. Minor amounts of chlorite and calcite have been noted in one specimen, and their relationship to the potassic facies is not clear, but are perhaps contained within fragments of unaltered wallrock. Microcline, with its characteristic polysynthetic twinning and perthitic exsolution texture, together with pyrophyllite is not an uncommon constituent in the veinlets. Biotite is absent from the assemblage.

Wheal Tamar Zone

Potassic alteration in the Wheal Tamar zone is weak. The well-developed veinlets of the Ajax zone are not present but concentrations of fine grains of orthoclase occur along fractures and shears (Plate XII). Biotite, pyrophyllite and quartz are absent from this zone.

Discussion

The potassic alteration facies displayed at the Ajax-Monte Carlo property is distinctly different from the facies described by Creasey (1966), Hemley (1969) and Burnham (1962) as typical of porphyry copper deposits. The most obvious differences are the virtual absence of biotite and the lack of abundant red or pink potash feldspar on the property. The presence of pyrophyllite is fairly common at this property though it is seldom recognized in the hydrothermally altered rocks associated with other porphyry copper. At Island Copper, on Vancouver Island, Young and Rugg (1971) mention the association of pyrophyllite with silica in fault breccias near the orebody but does not describe the assemblages developed. Creasey (1966) suggests that pyrophyllite may not be developed in a number of deposits due to high concentrations of K^+ ion (Fig. 5).

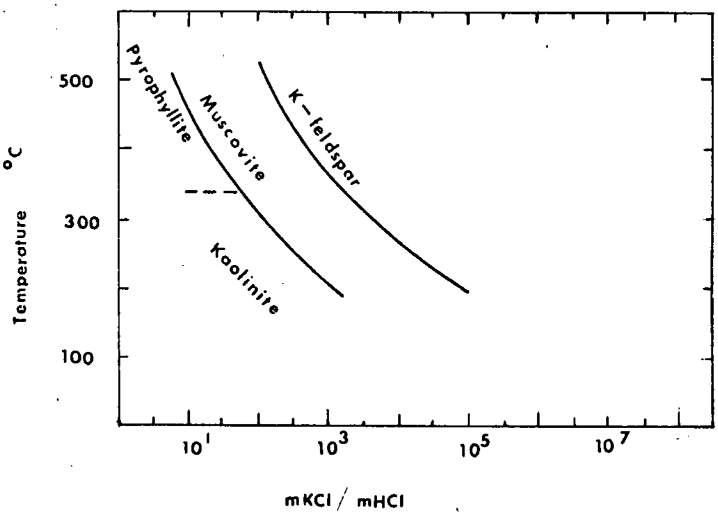


FIGURE (5) Some stability relations in the system $K_2O - Al_2O_3 - SiO_2 - H_2O$ at 15,000 psi total pressure. From Hemley (1959)

The association pyrophyllite - orthoclase, which occurs in some of the veinlets in the potassic zone in the thesis area, and the absence of muscovite constitutes a non-equilibrium assemblage. Rapid fluctuations in the concentration of K^+ ion in the solution may have been the cause.

The presence of perthite associated with potassic alteration is uncommon. Analysis of the perthite was not performed, hence it is not possible to state a minimum temperature at which the veinlets were deposited. However, the pyrophyllite-kaolinite dehydration curve, which is independent of pressure, (Fig. 6) suggests prevailing temperatures were in excess of 350°C.

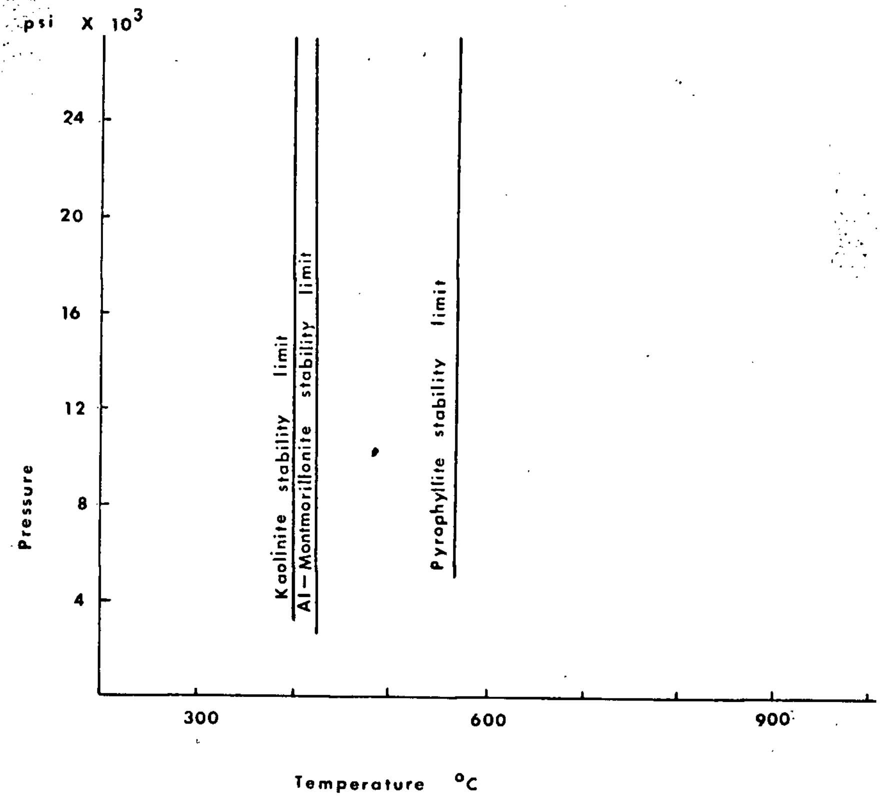


FIGURE (6) Experimental dehydration curves for the stability limits of kaolinite, Al-montmorillonite, and pyrophyllite. From Creasey (1966)

STRUCTURE

The phases comprising the Iron Mask Batholith may have been emplaced intermittently along the Carabine Creek Lineament. Recurring tectonic adjustment and concomitant passive emplacement of magma at depths which became increasingly shallower as the emplacement of the batholith proceeded are suggested by the field relationships of the various phases.

After the coarse-grained phases had crystallized, extensive brecciation occurred along a zone on the northern margin of the property. At least one and possibly two episodes of fracturing preceeded the rock alteration and mineralization was emplaced along still later sets of fractures.

Carr (1956) states that the peridotite body at the Iron Mask Mine is fault-bounded, and infers similar relationships for other peridotites associated with the batholith. Peridotites at the Ajax-Monte Carlo property are not sufficiently exposed to permit comment on their boundaries with adjacent rocks.

Three phases of fracturing have been observed on the property. The earliest formed a breccia zone which developed prior to the emplacement of the microdiorite. The second, involving the rocks of intermediate composition was synchronous with the alteration of these rocks and provided the necessary permeability for alteration. The final phase developed the stockwork within the altered rock in which the sulphides and associated gangue minerals were deposited.

Phase I Fracturing - The Ajax Breccia

The dominant structural feature is a breccia zone on the northern edge of the property which occupies the position of the contact between the coarse crystalline rocks of the Iron Mask Batholith to the north and the finer grained younger intrusive types to the south. Gabbro or pyroxenite and rare diorite fragments are cemented by a matrix of microdiorite. The character of the breccia changes over a distance of about 1000 feet from predominantly fragments (95%) on the north in the coarsely crystalline rocks of the batholith to predominantly matrix (95%) with occasional isolated fragments of gabbro to the south (Fig. 15). In most cases, there has been little, if any, assimilation of the fragments, but occasionally there are zones within the breccia in which the fragments have been partially digested and outlines of individual fragments are difficult to discern (Plate II).

Most fragments are angular to sub-angular. In one outcrop near the eastern corner of the Ajax claim the fragments are sub-rounded to well-rounded and exhibit little or no evidence of assimilation (Plate XIV). The chronological time of brecciation may be placed with accuracy relative to the rock types involved. The coarse-grained rocks were emplaced and solidified before brecciation and intrusion of microdiorite. It seems probable that continued stress along this portion of the Carabine Creek lineament was released along the approximate contact between the coarse-grained rocks of the batholith and the Nicola volcanics. Dilation of the breccia zone allowed the emplacement of microdiorite which forms the breccia matrix, and the Lobe porphyries. Absence of fragments of Nicola rocks in the breccia suggest the brecciation occurred entirely within the batholithic rocks.

Phase II Fracturing - Synchronous with Alteration

Subsequent to the intrusion and crystallization of the microdiorite and Lobe diorite, another episode of fracturing occurred which opened channels for the altering solutions. Intermittent stress releases throughout the alteration history are indicated by wispy, ghost-like fragments of moderately propylitized microdiorite in a matrix of porcelaneous "albitite". Occasionally, the fragments have sharp boundaries with the albitite which suggests fracturing during the propylitic alteration episode.

Fracturing following propylitization is indicated by the development of potassic alteration minerals in openings in propylitized rock. Veinlets containing minerals of the potassic assemblage invariably cut propylitized microdiorite and Lobe porphyries. Sulphides are absent from the Phase II fractures.

Phase III Fracturing - The Sulphide-Bearing Stockwork

Fractures of the Phase III group cut Phase I and Phase II fractures. Sulphides and calcite, the dominant minerals in the assemblage which fills Phase III fractures weather readily making the fractures easily recognizable in outcrop. Copper carbonates and limonite are common at or near surface in the Ajax, Monte Carlo and Wheal Tamar zones, but away from these mineralized areas, pyrite, epidote and calcite are typical fracture fillings.

The intensity of Phase III fracturing is greatest within the Ajax Zone where locally the altered rock as been shattered into 1 inch fragments. The stockwork of fractures appears to be centred about the zone of most intense alteration in the vicinity of the underground workings, which suggests that the alteration rendered the rock more susceptible to brittle failure, or that this zone was a focus of intermittent stress release.

A plot of 182 poles to Phase III fractures on a Schmidt equal-area stereonet shows that the fractures occur in three steep-dipping sets. The direction of the dominant set is 002° and subordinate sets occur at 130° and 147°.

The chronology of fracturing is difficult to establish within the Phase III group because of the intensity of fracturing, and results are ambiguous. In the Ajax south adit (Fig. 8), the earliest fractures trend northeasterly and dip moderately to the northwest (A') or southeast (A). These are cut by a set which trend northwest and dip moderately northeast (B), which in turn are post-dated by fractures which trend north-south and dip easterly (X) and by a set of fractures which trend northwesterly and dip steeply to the northeast or southwest (Y). Secondary mineralization appears to be concentrated in the earlier fractures (A, A' and B).

In the Ajax north adit (Fig. 9) the chronology of fracturing is similar, with the oldest sets trending northeast with moderate

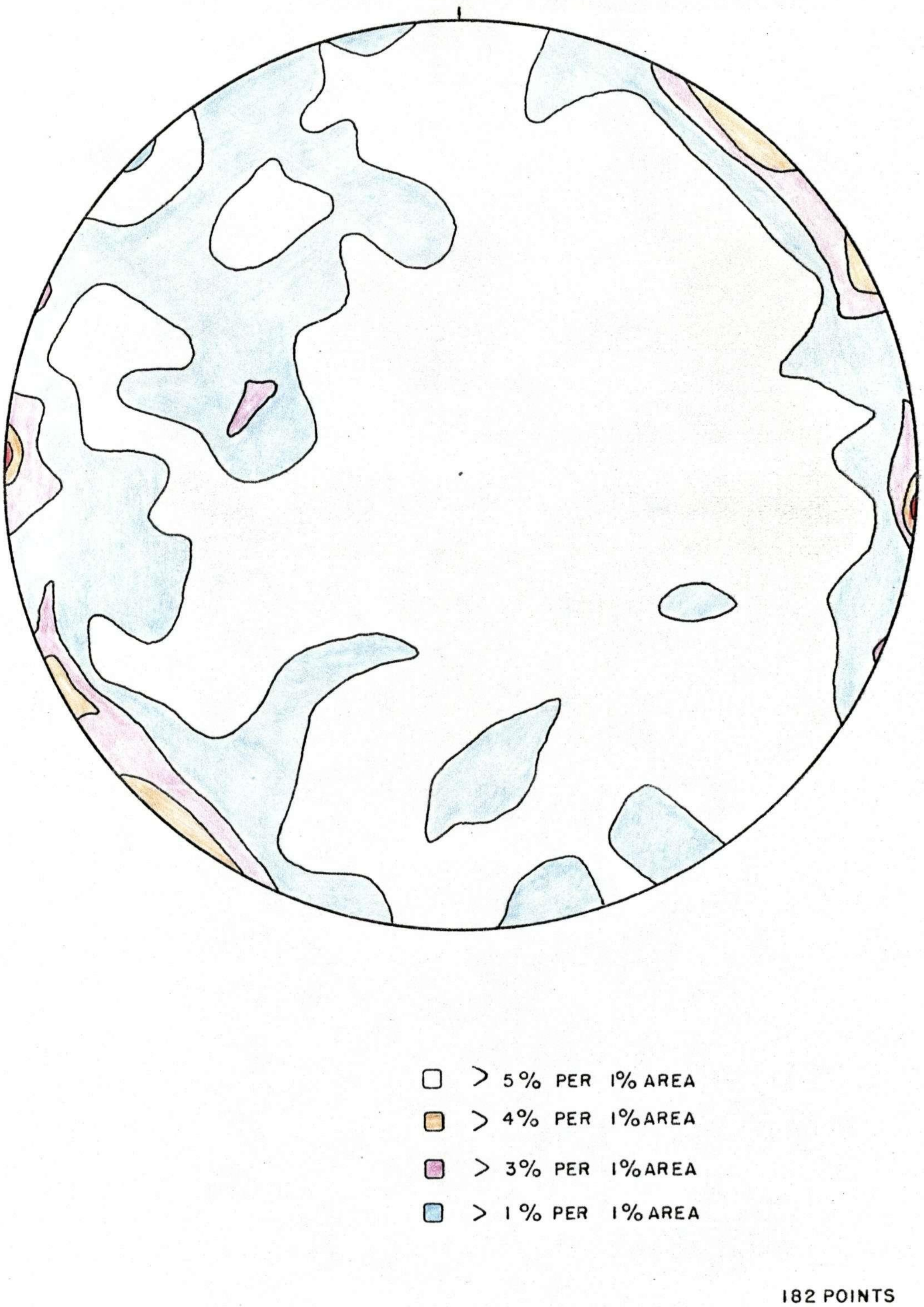


FIGURE 7

POLES TO PHASE III FRACTURES

LOWER HEMISPHERE PROJECTION

northwestward dips (A') and trending northwest with moderate north-easterly dips (B). Cutting these are east-west striking, north dipping fractures (D), steep north striking fractures (E).

In the pit over the south Ajax adit (Fig. 10), early northeast-trending fractures (A and A') contain secondary mineralization and are cut by a north dipping, north-west striking set (F) and a north-south set (X).

The shallow shaft on the Wheal Tamar zone (Fig. 11) permite the only three dimensional look at the structure in this area. The earliest Phase III fractures displayed here are steep-dipping and strike northerly (E) or slightly east of north (A?, A). These are related to the dominant set of fractures in figure (7). Sets striking northeasterly with steep (A?) or moderate (C) southeast dips are displaced by the steep northwest trending shear (Y). Fractures (A, A?, C) of the dominant set, then, appear to predate fractures (Y) of a subordinate set.

The Monte Carlo shear zone (Fig. 12) was explored in the 1920's by a shallow adit, test pit, and by three drill holes. The adit is caved and the information presented herein was derived from the original records. The zone intersected in the crosscut consists of three shears each 10 to 15 feet wide. Drilling and test pitting to the south has established that the shears strike northerly and dip steeply westward. As such, they are the same attitude as the dominant set of Phase III fractures in figure 6.

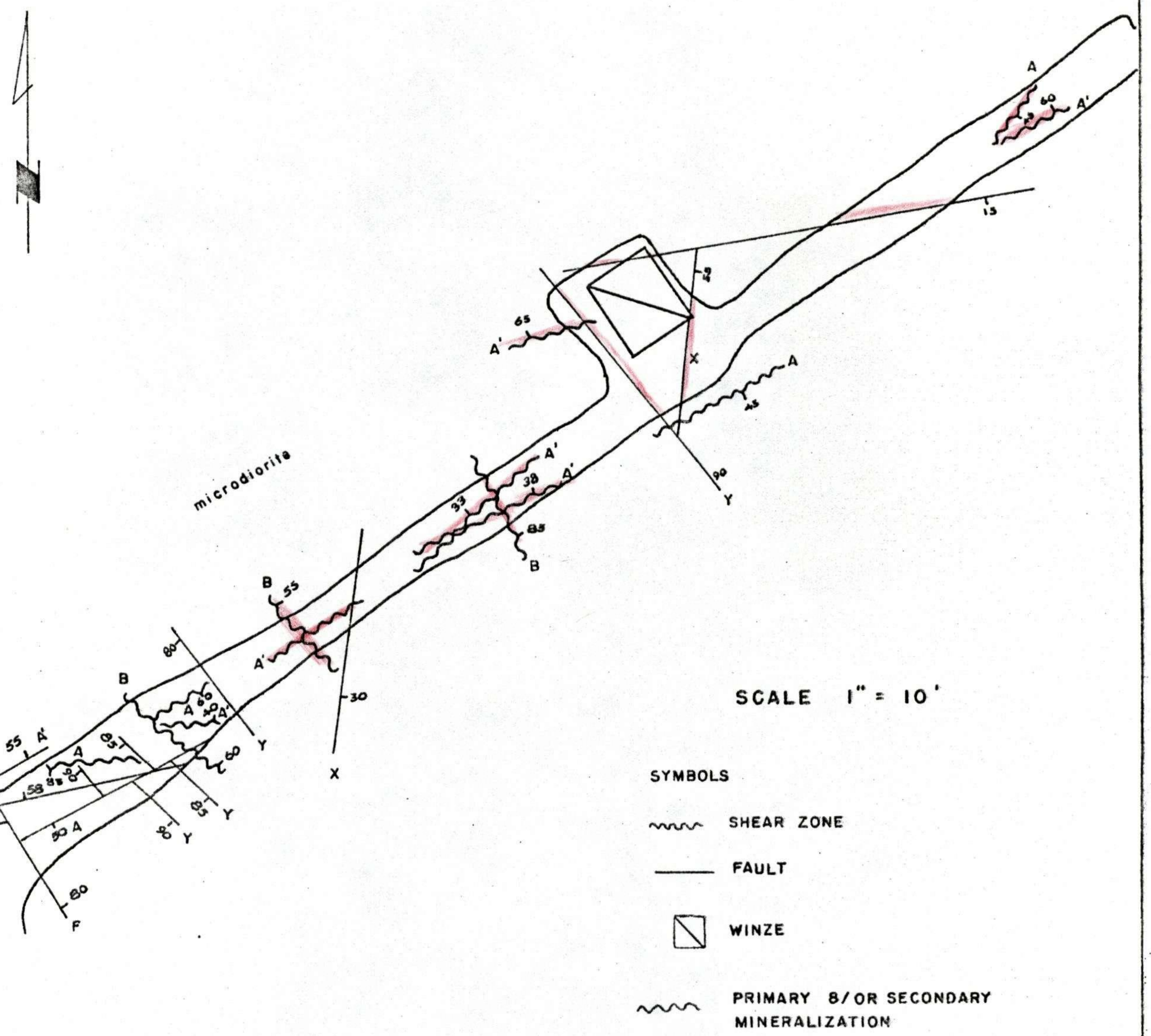
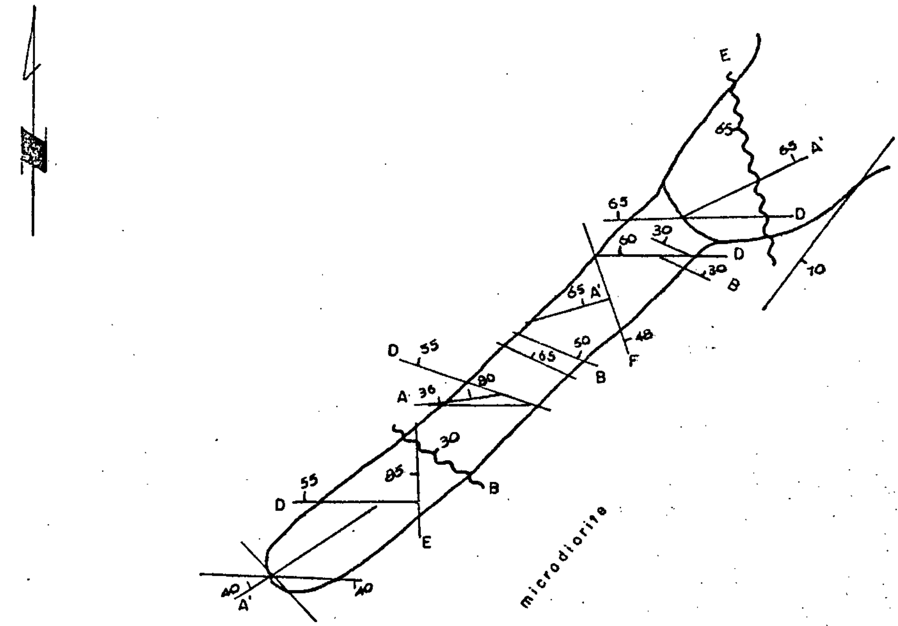


FIGURE 8

SOUTH ADIT

AJAX ZONE

LAT 8880 LONG 10 220



SCALE 1"= 10'

SYMBOLS

SHEAR ZONE

FAULT

PRIMARY & / OR SECONDARY MINERALIZATION

FIGURE 9

NORTH ADIT

AJAX ZONE

LAT 9030 LONG 10,380

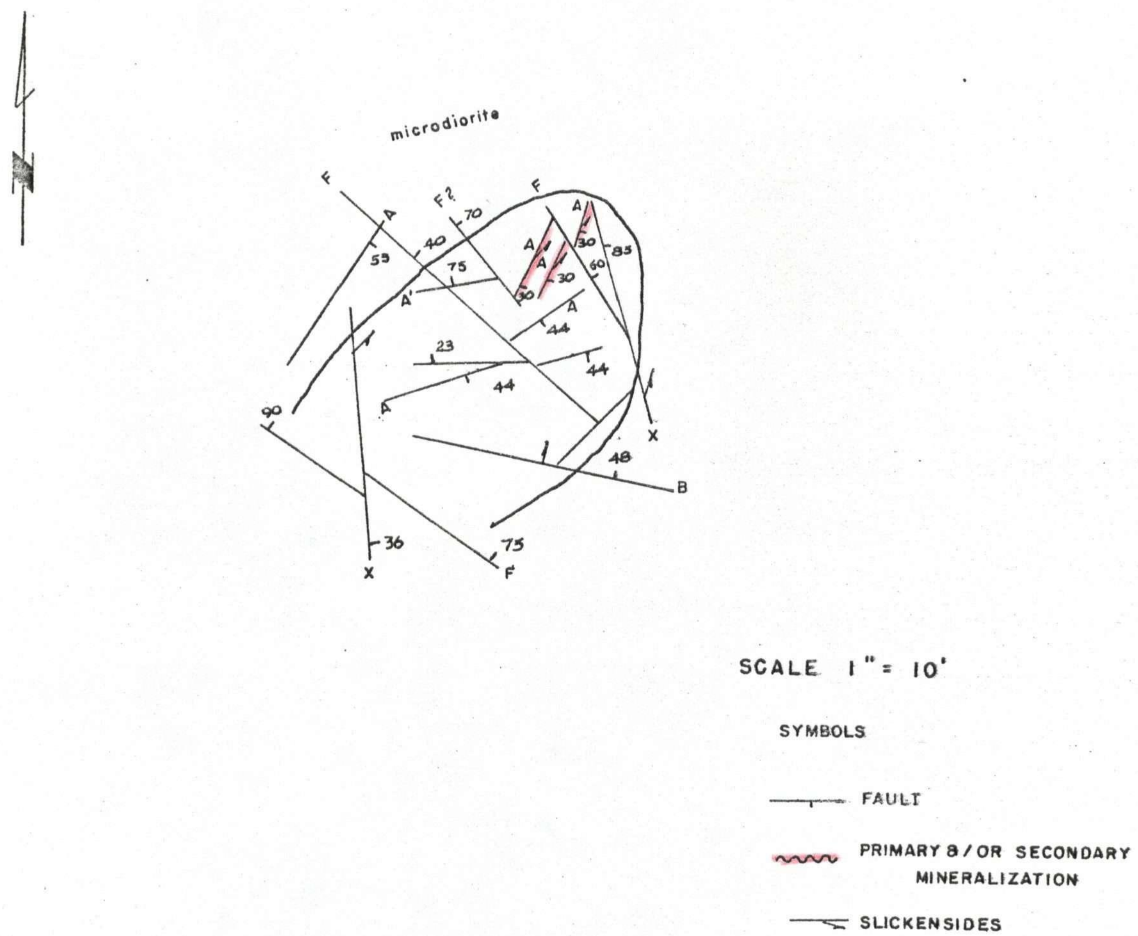
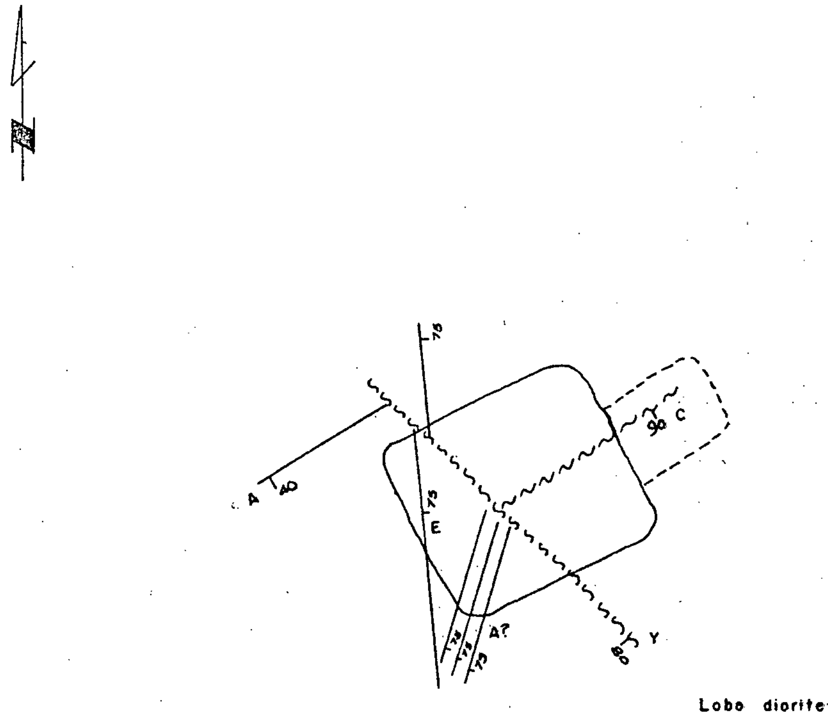


FIGURE 10

PIT OVER SOUTH ADIT

AJAX ZONE

LAT 8880 LONG 10,220



SCALE 1" = 10'

SYMBOLS

SHEAR ZONE

PRIMARY & / OR SECONDARY MINERALIZATION

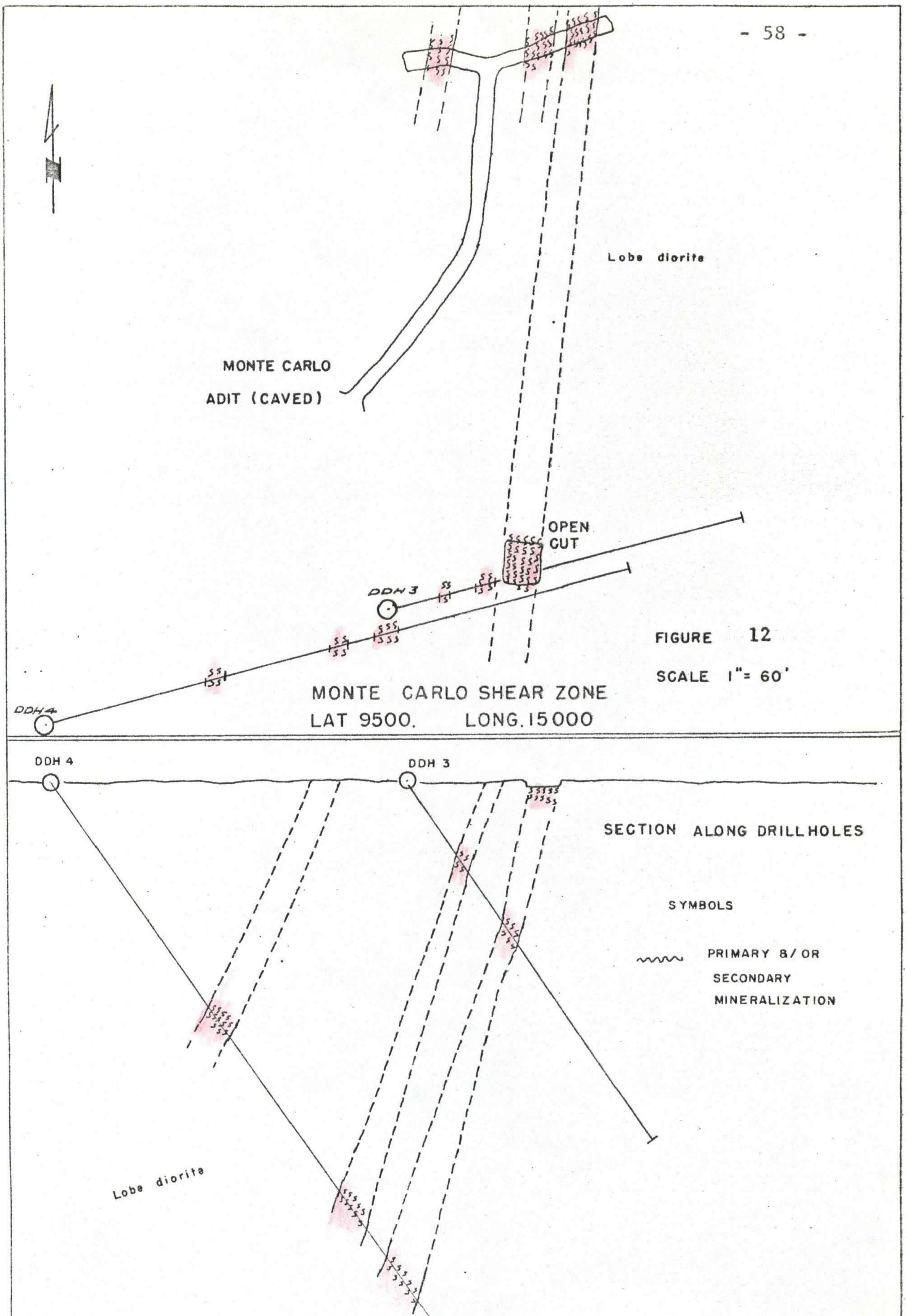
FAULT

FIGURE 11

WHEAL TAMAR SHAFT

LAT. 9920 LONG. 13580

The limited exposures on the property do not permit an accurate picture of the chronology of fracturing to be developed beyond the general and somewhat ambiguous ideas presented here. It is evident, however that fractures of the Phase III group were not generated simultaneously in a simple stress field.


Lobe diorite
MONTE CARLO
ADIT (CAVED)
OPEN
CUT
DDH 3
DDH 4
FIGURE 12
SCALE 1" = 60'
MONTE CARLO SHEAR ZONE
LAT 9500. LONG. 15000
DDH 4
DDH 3
SECTION ALONG DRILLHOLES
SYMBOLS
PRIMARY &/OR
SECONDARY
MINERALIZATION
Lobe diorite

MINERALIZATION

The main concentration of mineralization occurs in the Ajax Zone with lesser amounts in the Wheal Tamar Zone and in the Monte Carlo shear. The Ajax mineralization is localized within zones of anastomosing fractures belonging to the Phase III group which form short, irregular shoots. Minor amounts of sulfide occur as disseminations throughout the rock in the Ajax Zone but most is restricted to the stockwork of narrow fractures and veinlets.

The Wheal Tamar mineralization is restricted mainly to shear zones. Minor amounts of sulfides are disseminated throughout the rock, usually as replacements of mafic minerals.

Shear zones are all steeply dipping, and have no discernable preferred orientation. Diamond drill evidence suggests that the zones are short and discontinuous, or have been displaced along post-mineral faults, because of a lack of correlation between drill holes two hundred feet or so apart.

The Monte Carlo shear is a well-defined, though short zone, which dips steeply westwards and strikes northerly. Underground workings which intersected the shear zone indicate a width of 60 feet. Three mineralized shoots, each about 10 feet wide and grading about one percent copper, occur within the shear zone. Because the adit is caved, further information regarding the nature of the mineralization is not available.

PRIMARY MINERALS

The mineralogy of the mineral deposits is very simple, with only a few species present. They are described in order of abundance.

Magnetite

Magnetite, the only primary oxide mineral on the property, occurs as an accessory mineral in disseminated grains and patches to 1 cm. in the Iron Mask Gabbro. Generally magnetite constitutes less than 10 percent of the rock, but rarely it is localized in lenses a few feet long and a few inches wide in shears in highly altered gabbro. In peridotite it occurs as small euhedral grains in a matrix of serpentine adjacent to remnants of crystals of olivine.

The Lobe monzonite also contains trace amounts of magnetite, in euhedral grains to 0.1 mm.

Pyrite

Pyrite is typically found in the younger intrusive rocks on the property, the most common hosts being microdiorite and Lobe diorite. It seldom occurs in concentrations exceeding 3 percent and, in contrast to other porphyry copper deposits, which have pyrite-rich zones or aureoles, it is evenly distributed throughout the property. In the Ajax Zone, it occurs as anhedral to irregular grains up to 1 mm. in diameter in phase III fractures, accompanied by chalcopyrite. In the eastern half of the property, where chalcopyrite is absent, pyrite occurs as small subhedral or euhedral grains with epidote and calcite in Phase III fractures.

Chalcopyrite

Chalcopyrite is the dominant copper mineral found in the map area. The highest concentration is in the Ajax Zone where it occurs predominantly in Phase III fractures in altered microdiorite and Lobe diorite. Polished section study reveals chalcopyrite in small interstitial grains and extremely irregular patches within fractures, and often as disseminated grains (0.01 mm.) along hairline fractures and mafic mineral-feldspar grain boundaries in the adjacent rock.

In the Wheal Tamar Zone, chalcopyrite occurs in shear zones with bornite but without the usual gangue minerals calcite, epidote and chlorite. Texturally it is similar to the chalcopyrite in the Ajax Zone, except for a tendency towards orientation along shear direction in deformed mafic patches.

Bornite

Traces of bornite have been observed in polished sections of cores from the Ajax Zone in close association with chalcopyrite in Phase III fractures. Where observed, the bornite has been in contact with chalcopyrite and may be an exsolution product. However, definitive textures have not been observed.

Bornite is relatively more abundant in narrow shears in the Wheal Tamar Zone, but nowhere on the property does it reach concentrations of economic importance.

Gold

Persistent assays of gold in the order of 0.01 oz. per ton are obtained from oxide zones in the Wheal Tamar, Ajax and Monte Carlo mineralized areas. Free gold has not been seen in hand specimens or polished sections.

SECONDARY MINERALS

Although weathering has been extensive, expecially in the more highly fractured and permeable Ajax, Monte Carlo and Wheal Tamar Zones, leaching and removal of copper has been minimal. Abundant calcite rapidly fixed copper ions as malachite and azurite.

These stable carbonates, together with abundant limonite constitute the bulk of the secondary mineral suite. Because the region is semi-arid and because of the tendency for copper to become rapidly fixed as carbonates, a leached capping is poorly developed and there is virtually no zone of supergene enrichment. Consequently minerals typical of the oxide and supergene zones such as native copper, cuprite and chalcocite are not found on the property.

The depth of surface weathering is a function of the permeability and thus of the fracture density. In some of the weakly mineralized zones on the property the rock is oxidized to a depth of 25 feet to 30 feet, but on the Ajax Zone, where Phase III fracturing is intense, limonite and copper carbonates have been observed in cores at depths of 250 feet.

CONCLUSIONS

The intrusive history of the property reflects the large scale events which have characterized the development of the Carabine Creek Lineament and the Iron Mask Batholith. Development of the intrusive complex was initiated by the emplacement of the plutonic-textured core rocks comprising the Iron Mask gabbro and diorite in folded Nicola Group volcanics. Uplift and unroofing then followed. Tectonic adjustments were accommodated by zones of weakness along the contacts between the rigid core and the enclosing country rock, creating the Ajax breccia and allowing the emplacement of the microdiorite, micromonzonite and porphyritic species. Intermittent stress releases of small magnitude continued along the predefined zones of weakness resulting in brecciation of the microdiorite and Lobe porphyries to create the Phase II stockwork.

Development of the alteration zones was synchronous with the Phase II fracturing. Propylitization was pervasive and predates the potassic alteration which was restricted to fractures in the propylitized rock. The propylitic assemblage developed at the property is characterized primarily by chlorite, calcite and epidote and except for a lack of abundant silica, is typical of porphyry copper deposits. By comparison, the potassic alteration assemblage is distinctly different from those described in the literature. Biotite and red orthoclase are both rare, and the facies is characterized by pyrophyllite, white orthoclase with minor perthite and quartz. The relative scarcity of quartz reflects the low concentrations of free silica in the host rocks.

Fracturing of the altered rock to form the Phase III mineralized stockwork does not appear to have been the result of a single episode of dislocation. The chronology of Phase III fracturing was not established, however it does appear that the earliest fractures are north-dipping and strike north easterly or northwesterly. These are cut by younger fractures of various attitudes. Statistically, steep north-striking fractures dominate the Phase III stockwork, however, as shown on the stereonet plot of Phase III fractures. Displacement of the mineralized shears by subsequent faults is indicated by relationships in the Ajax south adit. As a consequence, the size, shape and spatial relationships of the mineralized zones is indeterminate from the available data.

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PLATES

PLATE I IRON MASK GABBRO (x-6)
Note the ophitic texture, and hematite (red) after magnetite.

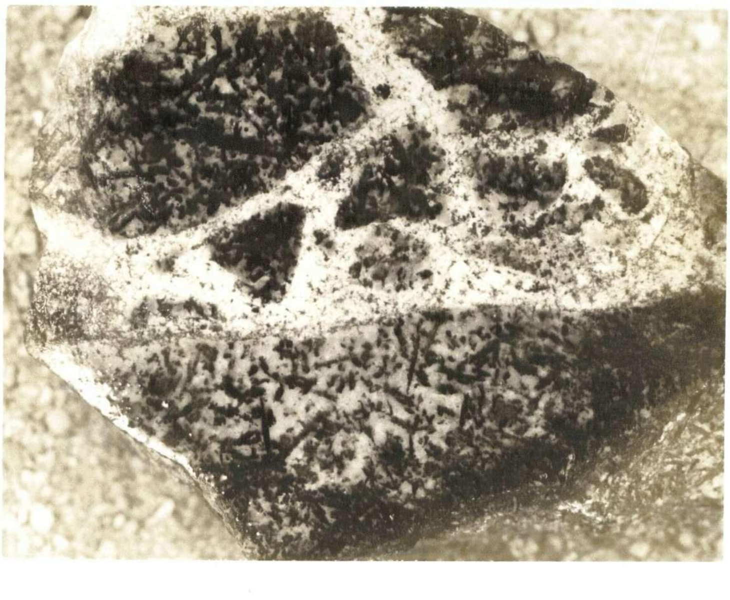


PLATE II AJAX BRECCIA (X-½)
Fragments of Iron Mask Diorite in Microdiorite matrix.

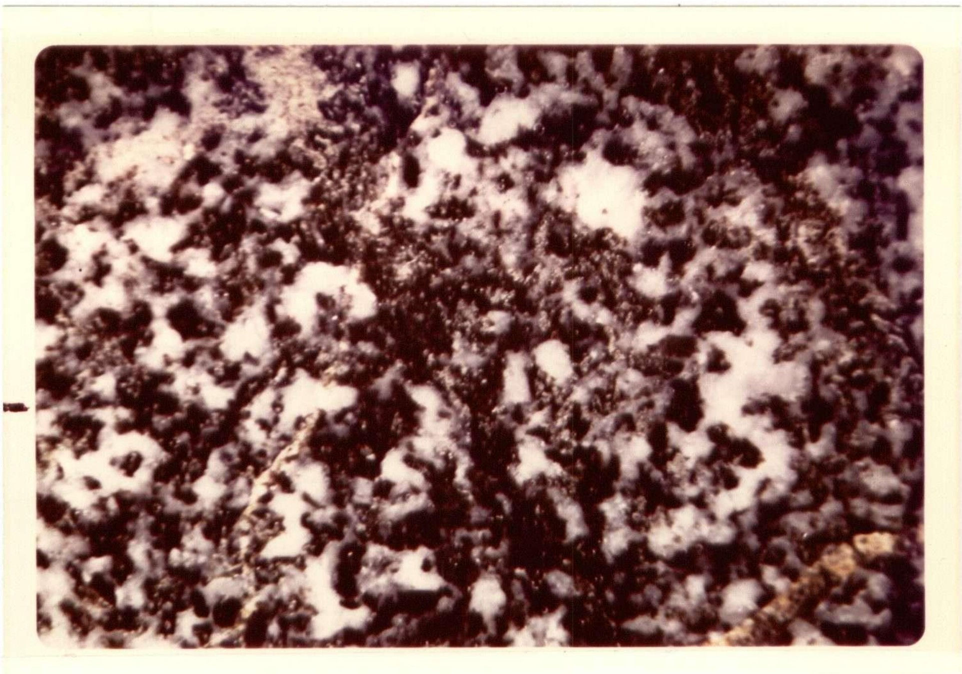


PLATE III MICRODIORITE (X-6)

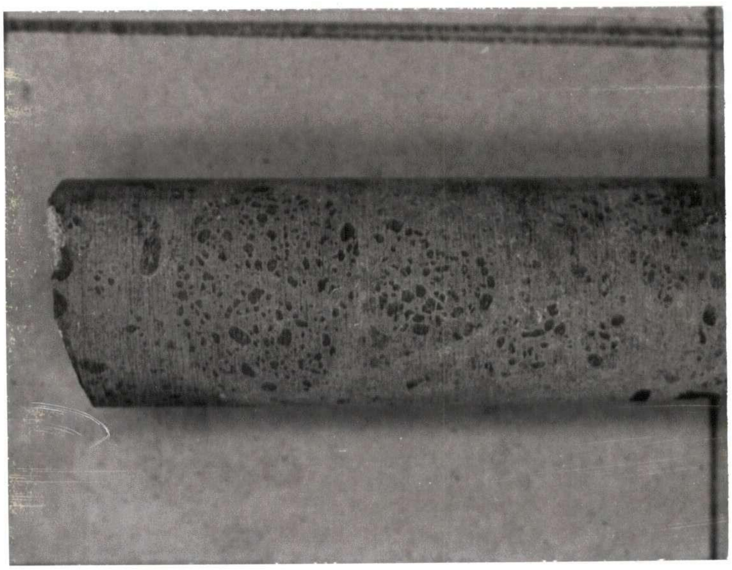


PLATE IV PERIDOTITE (X-1)
Core speciman displaying fragments of porphyritic material in a finer groundmass.

PLATE V PERIDOTITE (X-15)
Vestigal Olivine (ol) crystals in an aureole of serpentine (s). Euhedral magnetite and pigeonite (p) in glass matrix.

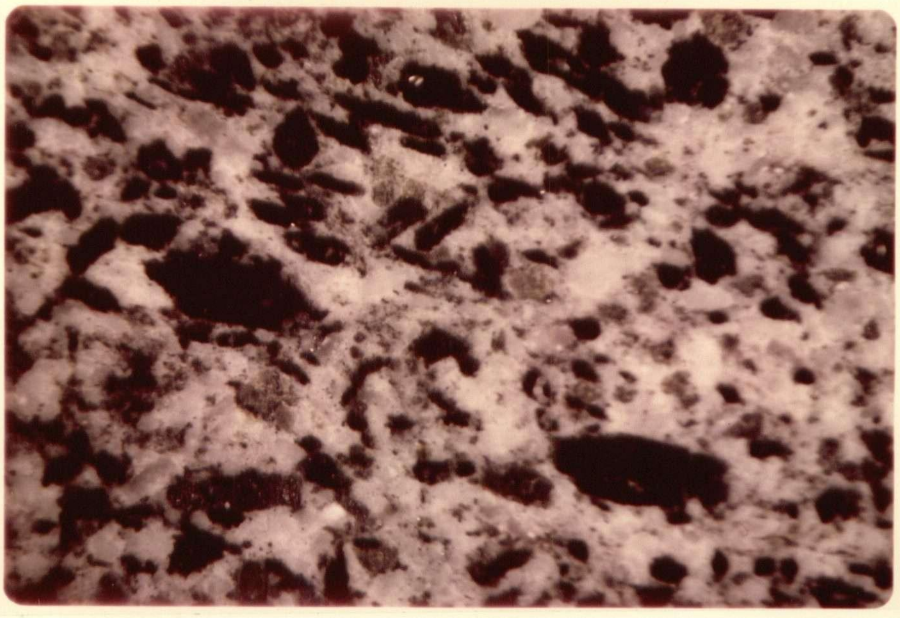


PLATE VI LOBE DIORITE (X-6)

PLATE VII LOBE DIORITE PORPHYRY (X-6)
Subtrachytoid texture.

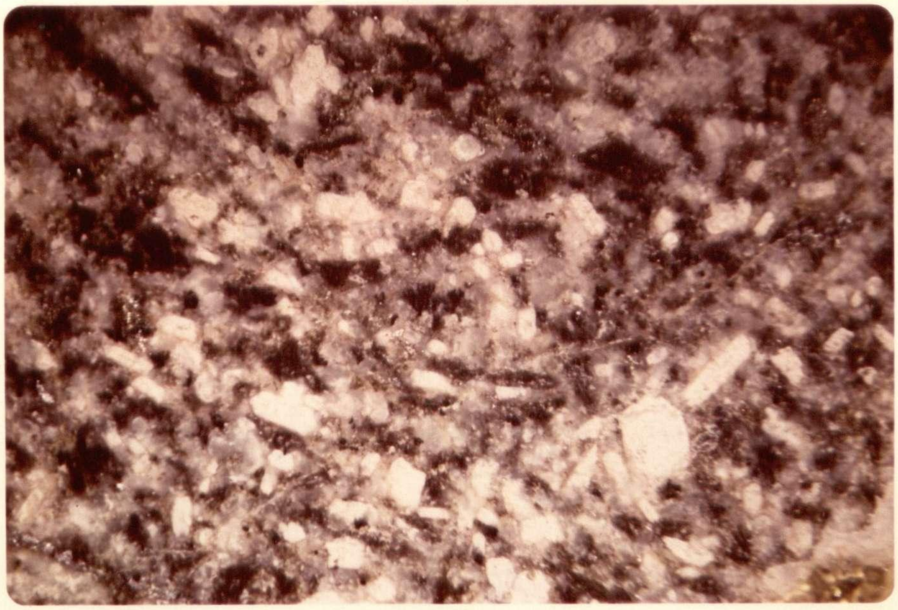


PLATE VIII LOBE DIORITE PORPHYRY (X-6)

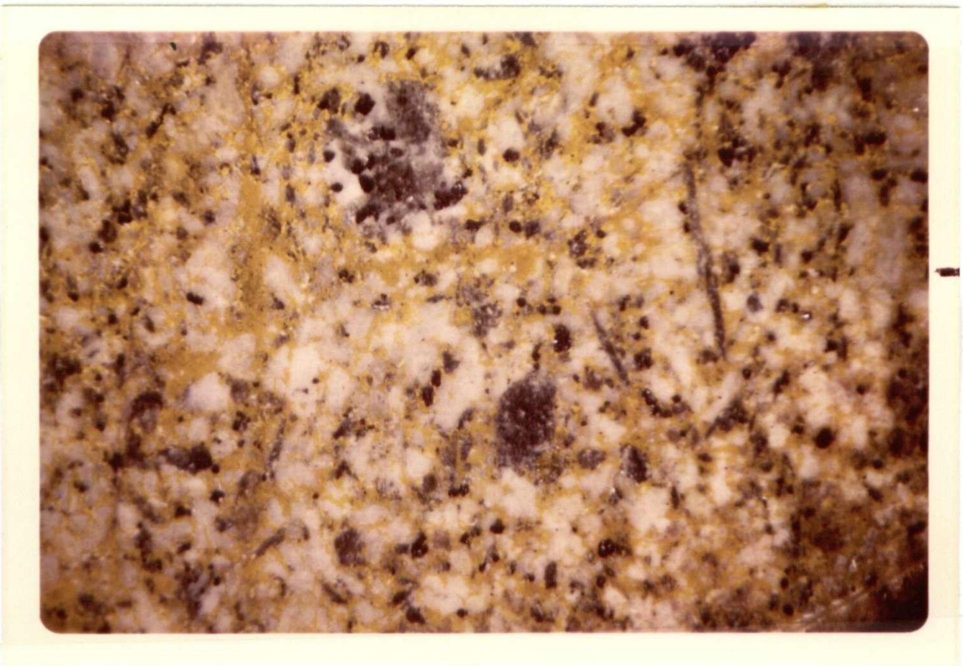


PLATE IX LOBE MONZONITE (X-6)
Specimen has been stained with cobaltinitrate.
Note fragments of Microdiorite and Lobe Diorite.

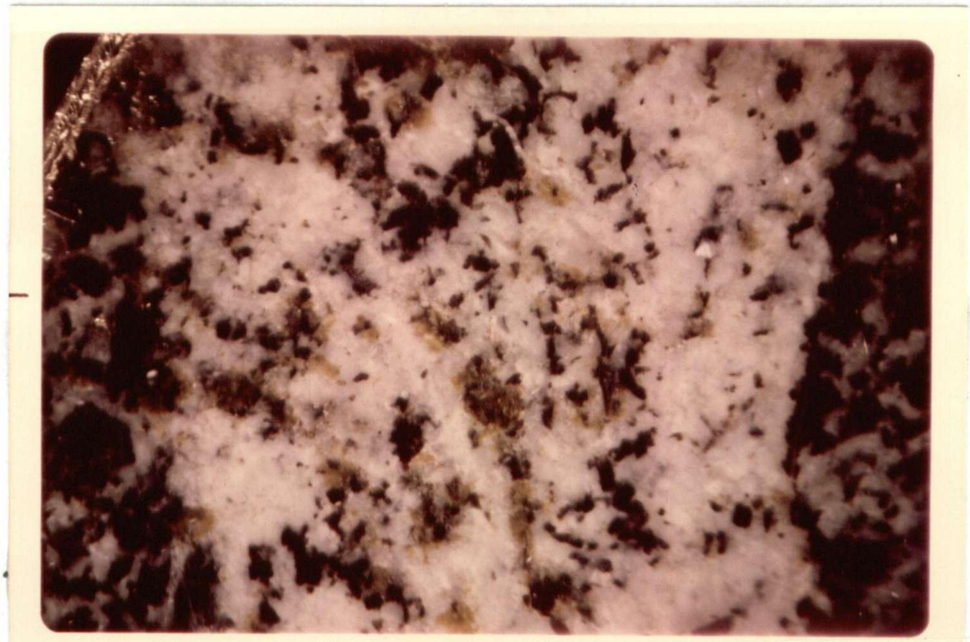


PLATE X MICROMONZONITE (X-6)
Specimen is a small dike intruding Microdiorite.

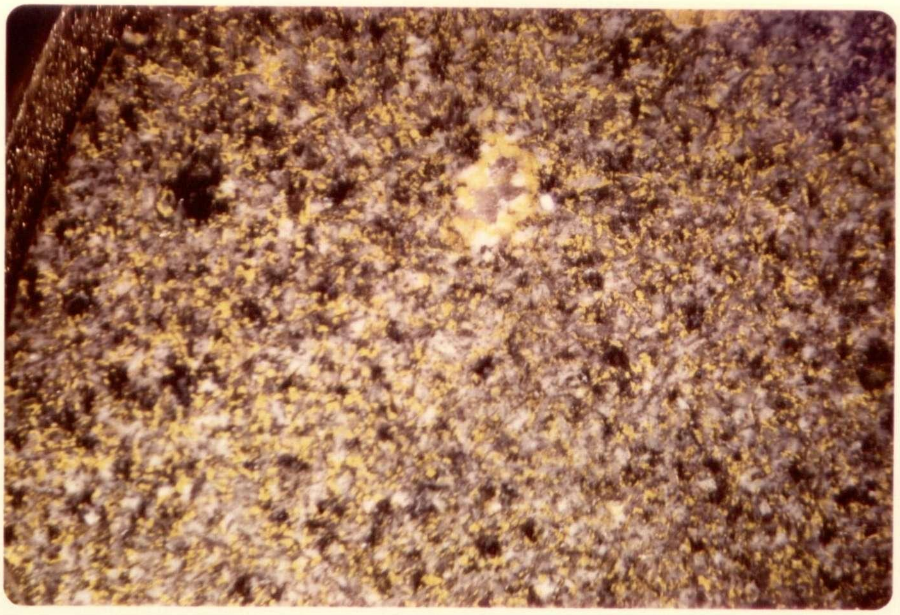


PLATE XI RHYOLITE (X-6)
Specimen has been stained with cobaltinitrate.

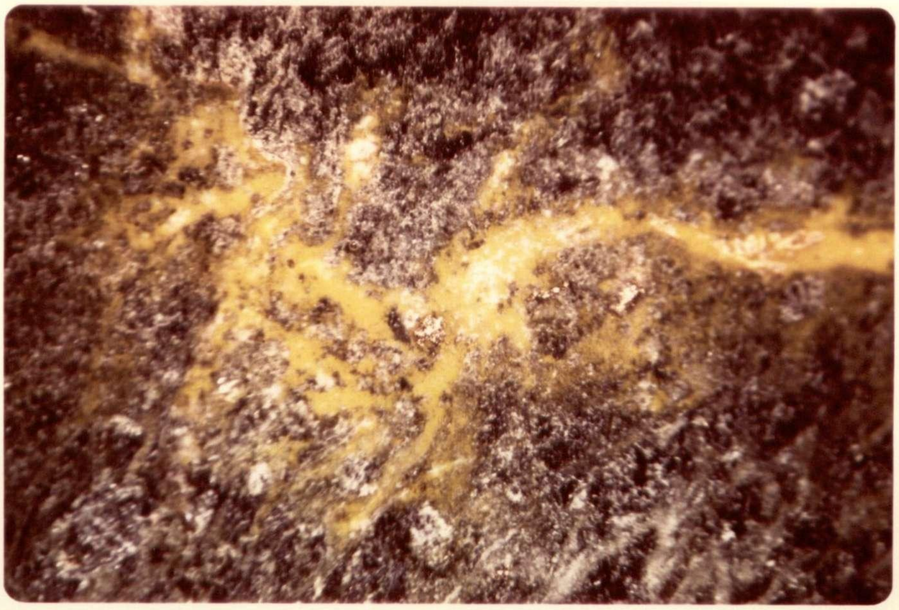


PLATE XII POTASSIC ALTERATION - WHEAL TAMAR ZONE (X-6)
Specimen has been stained with cobaltinitrate to reveal small fracture.

PLATE XIII AJAX BRECCIA
Fragments of Iron Mask Gabbro in Microdiorite.
Ajax Zone. Knife in photo centre for scale.

PLATE XIV AJAX BRECCIA (X-1)
Fragment of Iron Mask Gabbro in strongly propylitized Microdiorite.

PLATE XV WHEAL TAMAR ZONE
Looking westwards toward Ajax Zone behind Lone Pine Hill.

PLATE XVI AJAX NORTH ADIT


9000 E
9500 E
10000 E
10500 E
11000 E
11500 E
12000 E
12500 E
13000 E
13500 E
14000 E
14500 E
15000 E
15500 E
16000 E
10000 N
9500 N
9000 N
8500 N
8000 N
JACKO LAKE
AJAX ZONE
WHEAL TAMAR ZONE
MONTE CARLO ZONE
PETERSON CREEK
A
B
SYMBOLS
OUTCROP
INTRUSIVE CONTACT - DEFINITE
INTRUSIVE CONTACT - ASSUMED
DIAMOND DRILL HOLE
SHAFT
TRENCH
ADIT
DUMP
SWAMP
STREAM
PROPERTY BOUNDARY
AJAX BRECCIA
LEGEND
POST-MINERAL
INTRA-MINERAL
PRE-MINERAL
POST INTRUSIVE ROCKS
10 KAMLOOPS GROUP
INTRUSIVE ROCKS
9 RHYOLITE
8 PERIDOTITE, SERPENTINITE
7 JACKO PORPHYRY
6 MICROMONZONITE
SUGARLOAF PORPHYRIES
5 LOBE DIORITE, LOBE MONZONITE VARIETIES
4 MICRODIORITE
COARSE CRYSTALLINE SUITE
3 IRON MASK DIORITE
2 IRON MASK GABBRO
PRE INTRUSIVE ROCKS
1 NICOLA GROUP
FIGURE 13
GEOLOGY
AJAX - MONTE CARLO . COPPER PROPERTY
BRITISH COLUMIA
SCALE 1" = 300'
0 200 400
TO ACCOMPANY THE THESIS "GEOLOGY OF THE AJAX - MONTE CARLO COPPER PROPERTY"
BY WM P ARMSTRONG 1973

FIGURE 14

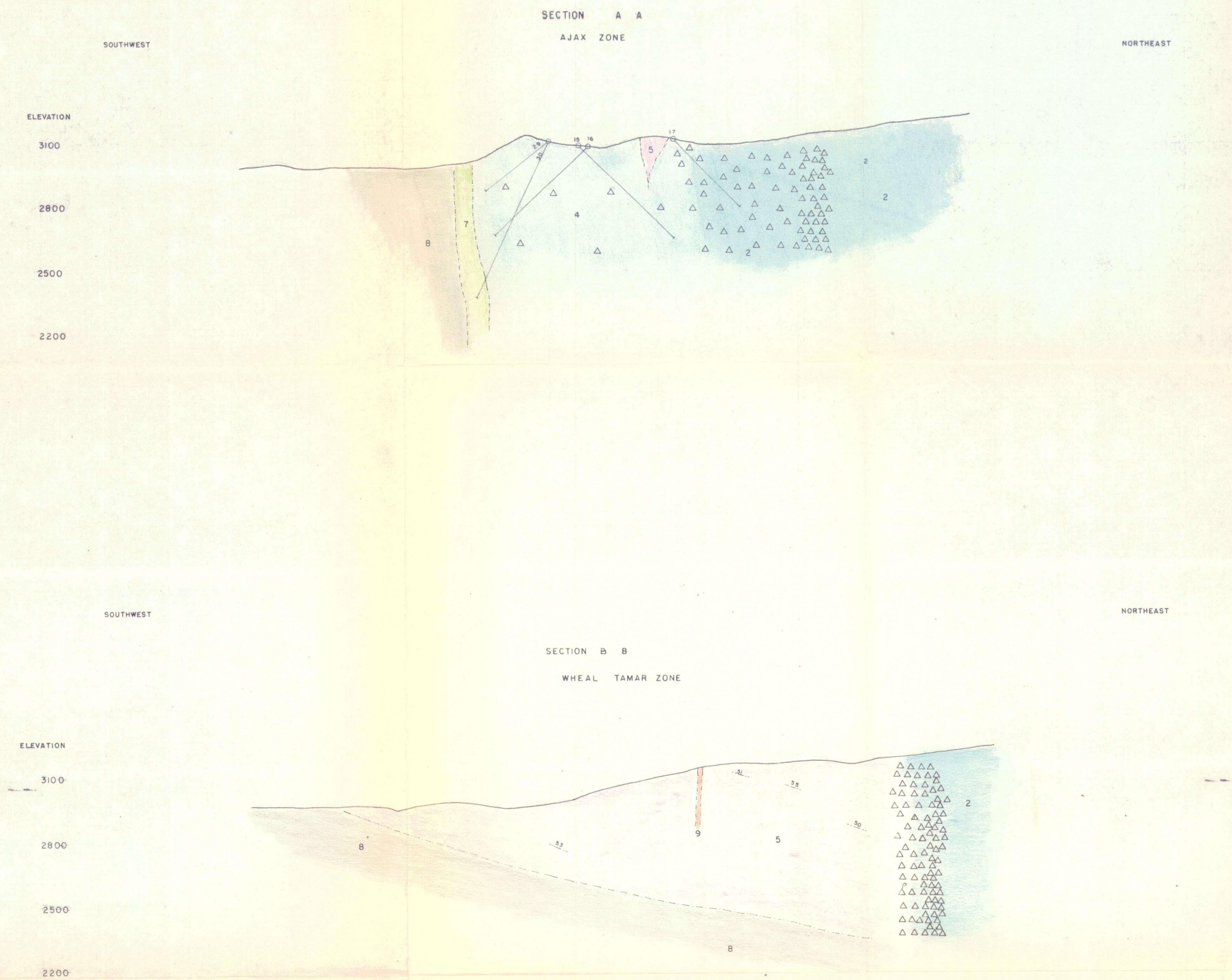
ALTERATION

AJAX – MONTE CARLO COPPER PROPERTY

BRITISH COLUMIA

TO ACCOMPANY THE THESIS "GEOLOGY OF THE AJAX – MONTE CARLO COPPER PROPERTY"

BY WM P. ARMSTRONG 1973



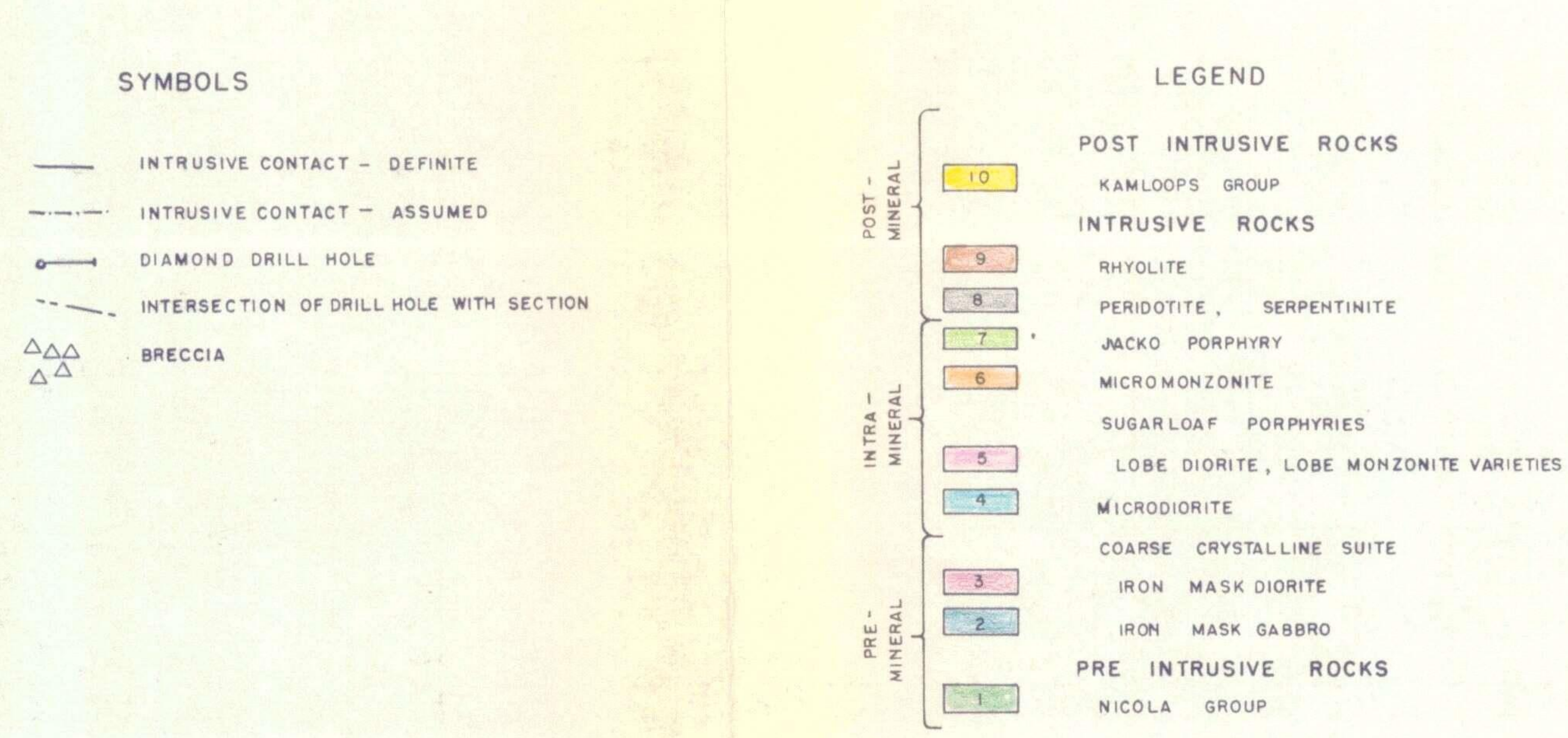


FIGURE 15

SECTIONS A A and B B

AJAX MONTE CARLO COPPER PROPERTY

BRITISH COLUMBIA

SCALE 1" = 300'

TO ACCOMPANY THE THESIS " GEOLOGY OF THE AJAX MONTE CARLO COPPER PROPERTY "

BY WM. P. ARMSTRONG 1972