Afton

Major lithologies and alteration of the Ajax East orebody, a sub-alkalic copper-gold porphyry deposit, Kamloops, south-central British Columbia

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Abstract: The Ajax East pit, in the Afton mine district, on the southwestern side of the sub-alkalic Iron Mask batholith, was developed on copper-gold mineralization located 600 m east of the Ajax West pit. Porphyry-style mineralization, mainly pyrite and chalcopyrite, is located at the intersection of two dioritic phases of the Iron Mask pluton.

Pit mapping at 1:750 scale and logging of representative drill core sections in 1992 resulted in the recognition of nine major lithologies and a revised chronological order: (1) Nicola volcanics, (2) picrite, (3) hybrid diorite, (4) pegmatitic hybrid diorite, (5) Sugarloaf diorite, (6) pyroxene gabbro, (7) monzonite dykes, (8) syenite dyke and (9) quartz-eye latite dykes.

Intense albitization in the Sugarloaf diorite is related both spatially and temporally to mineralization. Potassic alteration is most intensely developed in the relatively mafic hybrid diorite and Nicola volcanic units and is also related to mineralization.

Résumé : Le puits de mine d'Ajax East, dans le district minier d'Afton, sur le versant sud-ouest du batholite subalcalin d'Iron Mask, a été installé sur une minéralisation cuprifère et aurifère située à 600 m à l'est du puits de mine d'Ajax West. Une minéralisation de style porphyrique, principalement en pyrite et en chalcopyrite, se situe à l'intersection des deux phases dioritiques du pluton d'Iron Mask.

La cartographie du puits de mine à l'échelle de 1/750 et la diagraphie, en 1992, de coupes représentatives des carottes de forage, ont permis d'identifier neuf lithologies principales et de réviser l'ordre chronologique: 1) roches volcaniques de Nicola, 2) picrite, 3) diorite hybride, 4) diorite hybride pegmatitique, 5) diorite de Sugarloaf, 6) gabbro à pyroxène, 7) dykes de monzonite, 8) dyke de syénite et 9) dykes de latite oeillée à quartz .

L'albitisation intense de la diorite de Sugarloaf est associée à la fois dans l'espace et dans le temps à la minéralisation. L'altération potassique atteint son degré maximum dans la diorite hybride relativement mafique et dans les unités volcaniques de Nicola et est également liée à la minéralisation.

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INTRODUCTION

The Ajax East orebody (50°37′N, 120°24′W) is one of a number of porphyry copper-gold deposits of the Afton mining district in the sub-alkalic Iron Mask batholith. This district is located 12 km west of Kamloops and 360 km northeast of Vancouver. Estimated open pit reserves in the Ajax East zone are 7 million tonnes, with a stripping ratio of 1.5:1, averaging 0.44% copper and 0.01 ounces of gold per tonne (Bond, 1987). Mining of the pit was halted in August 1991.

The Ajax East pit, situated on the southwestern side of the Iron Mask batholith at the intersection of two dioritic phases of the Iron Mask pluton, is located approximately 600 m east of the Ajax West zone (Fig. 1; Ross et al., 1992). Porphyry-style mineralization consists of pyrite and chalcopyrite with trace amounts of bornite, chalcocite and molybdenite in a gangue of calcite, albite, potassium feldspar and minor quartz. Due to the lack of feldspathoids, the Iron Mask Batholith has been reclassified as a sub-alkalic batholith (Stanley, 1992).

The objective of this study, a continuation of fieldwork started in 1991 on the Ajax West zone (Ross et al., 1992) was to determine the temporal and structural relationships of the rock units within the Ajax East pit, as well as to examine the alteration and mineralization related to these units. Mapping was conducted at 1:750 scale and core from approximately 50 drill holes was examined in detail. These data will be added to the Ajax West zone study in future descriptions of the mineralization and alteration patterns.

GEOLOGY

Pit mapping has delineated nine significantly different rock units (Fig. 2). Zircon U-Pb dating is currently underway on several of the major units. The current order, from oldest to youngest, is: Nicola volcanics, picrite, hybrid diorite, pegmatitic hybrid diorite, Sugarloaf diorite, pyroxene gabbro, monzonite dyke, syenite dyke, and quartz-eye latite dyke. Major and trace element whole rock analyses are underway. Previous field and petrographic work (Carr, 1956; Preto, 1968; Northcote, 1977; Bond, 1987; Kwong, 1987; Ross et al., 1992) is incorporated in the definition of the units. There has been a revision in the intrusive sequence; the hybrid diorite and pegmatitic hybrid diorite are mapped as older than the Sugarloaf diorite, rather than younger, as reported from the Ajax West pit (Ross et al., 1992).

The descriptions of alteration are based on field observations. A statistical study of the alteration is in progress on the data gathered from drill core samples systematically collected at two plan sections at the 860 and 940 m level, and a cross-section striking 60 degrees northwest (Fig. 2, 3). This part of the study will be supported ultimately by microprobe analyses of representative samples.

(Unit 1) Nicola volcanics, is a strongly foliated hornfelsed screen which strikes north 40 degrees east and occurs along the hybrid diorite/Sugarloaf diorite contact throughout the length of the pit (Fig. 2, 3). The volcanics are nonmagnetic, augite phyric. Much of the augite is replaced by pale green amphibole surrounded by red-brown biotite. The Nicola is mineralized with chalcopyrite and pyrite, as foliation parallel disseminations and as veinlets crosscutting foliation. Sugarloaf diorite intrudes the screen as numerous dykes and dykelets. The hornfelsing was probably generated initially by intrusion of the hybrid diorite and later by intrusion of the Sugarloaf diorite. K-feldspar-calcite ± epidote veins crosscut the foliation.

(Unit 2) Picrite, as designated by Cockfield (1948) and Carr (1956), is characterized by serpentinized olivine phenocrysts, relict clinopyroxene phenocrysts and up to 25% secondary magnetite (Kwong, 1987). It occurs in the northeast corner of the pit where it is in contact with Sugarloaf diorite (Fig. 2) and is also apparent as fault slices within the screen of Nicola volcanics (Fig. 3).

In hand sample picrite is a dark grey, aphanitic rock with rounded inclusions of olivine partially replaced by serpentine and magnetite. On sheared surfaces, waxy serpentine is characteristic. In thin section the corroded, serpentinized, coarse grained olivine phenocrysts are in a groundmass of aphanitic grey serpentinite and tremolite.

Disseminated pyrite and chalcopyrite occur one to two centimetres from contacts with the Sugarloaf diorite. Xenoliths of picrite within the Sugarloaf diorite appear to be affected by albite alteration.

(Unit 3) Hybrid diorite, a fine- to coarse-grained intermediate unit, with mafic to ultramafic phases, characterized by abundant disseminated magnetite, occurs on the northwestern side of the pit (Fig. 2, 3). The medium- to coarse-grained phases predominate in the East pit.

In hand sample the rock is typically dark grey to green, composed of medium- to coarse-grained pyroxene, feldspar (An_{35}) and magnetite. Foliated, mineralized xenoliths of Nicola are incorporated in the unit. Chlorite and biotite replace pyroxene. The hybrid unit is only locally affected by strong albitization, but potassic alteration, characterized by hydrothermal biotite, is strongly developed. Hydrothermal biotite occurs pervasively throughout the unit and as selvages on K-feldspar-calcite-diopside ± epidote ± albite? veins. Pervasive and selvage biotites may differ compositionally. Propylitic alteration assemblages are intensely developed in sheared zones.

(Unit 4) Pegmatitic hybrid diorite consists of medium- to very coarse-grained pyroxene, plagioclase and magnetite. The coarse grained phase predominates, but appears to be consanguineous with the medium grained phase. Coarse grained mafic clasts occur in a finer grained more felsic matrix. This complex agmatitic unit occurs in the Ajax East pit as very localized patches of clasts in felsic matrix. However, the unit occurs in large areas north of the Ajax West and East pits (Fig. 1). Epidote alteration is common.

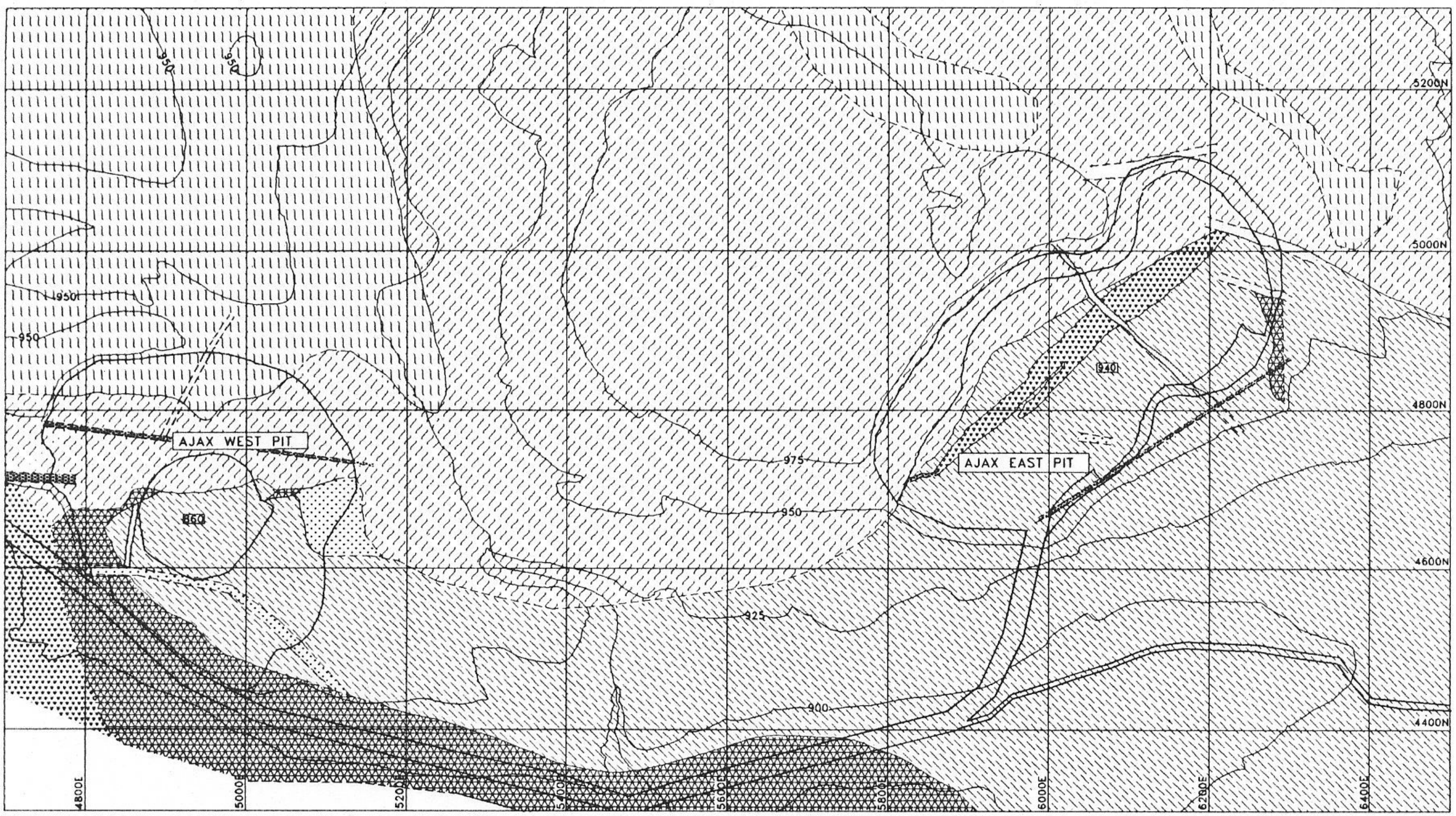


Figure 1. Regional geology and location of the Ajax East and West pits (see Fig. 2 for legend).

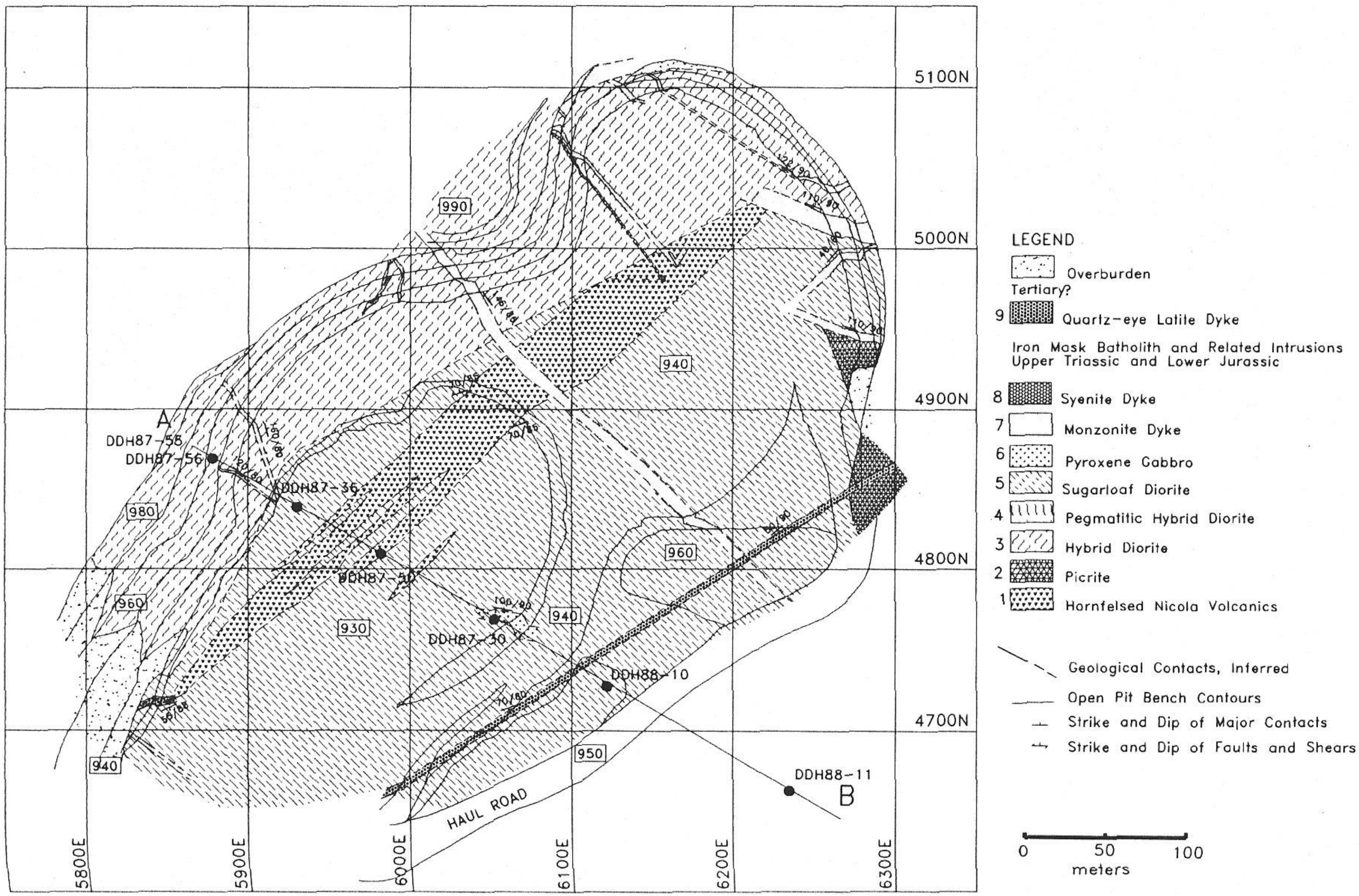


Figure 2. Geology of the Ajax East pit with location of cross-section A-B (see Fig. 3). Nine major rock units have been identified. The units are presented from youngest to oldest in legend. This order is based on field relationships.

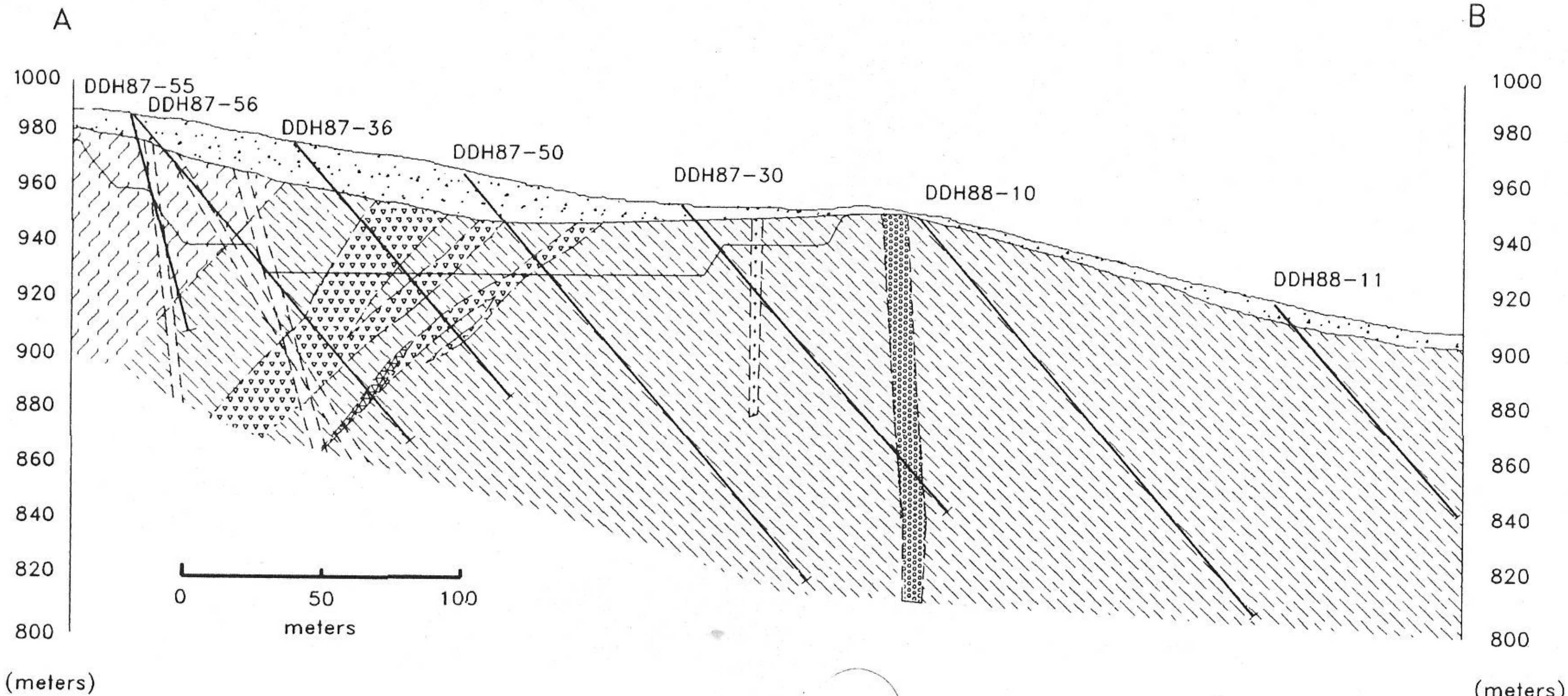


Figure 3. Cross-section A-B, Ajax East pit, striking 40° northwest and looking northeast (see Fig. 2 for location and legend).

(Unit 5) Sugarloaf diorite, a fine- to medium-grained porphyry, with characteristically elongate hornblende and plagioclase phenocrysts that are enclosed in a medium grey matrix. This unit, that has been mapped on a regional scale (Preto, 1968), occurs on the southeastern side of the Ajax East pit (Fig. 2, 3). This unit displays considerable textural variation, ranging from fine grained, weakly porphyritic to a medium grained crowded (phenocryst-rich) porphyry, commonly with trachytic texture.

In thin section the unit contains olive green, strongly pleochroic hornblende as prismatic crystals and needles. Feldspar makes up 55% of the rock, either as sericitized, ghostly, equant to tabular phenocrysts or as an aphanitic, sericitized ground mass.

Albitization is intensely developed and is commonly associated with mineralization. Alteration assemblages grade from weak propylitic to intense albitic. Pervasive epidote and chlorite after hornblende occur in weakly propylitized rock. Disseminated pyrite content varies from absent to several per cent. Albite envelopes are developed outward from veins containing albite-diopside-epidote. As albitization intensity increases, the envelopes coalesce to form a uniformly textured fine grained white rock. Albite-diopside-anhydrite veinlets also occur. K-feldspar-calcite-diopside ± epidote ± albite? veins with chlorite (after biotite?) envelopes occur within both intensely albitized rock and propylitically altered rocks. The composition of the various types of plagioclase alteration and their zonal distribution is under investigation.

(Unit 6) Pyroxene gabbro is a medium- to coarse-grained amphibole- and pyroxene-phyric unit with a dark grey matrix that occurs as a dyke within the Sugarloaf diorite (Fig. 2, 3). It has very limited exposure in the East pit and its orientation is uncertain.

In thin section this unit is a medium grained, crowded porphyry. Hornblende phenocrysts make up to 30% of the assemblage and may be after pyroxene. The groundmass of microcrystalline secondary hornblende and sericitized aphanitic feldspar apparently is affected locally by the albitization.

(Unit 7) Monzonite dyke, is a fine grained porphyry with hornblende and plagioclase phenocrysts in a feldspar matrix with approximately 2% disseminated magnetite. This unit was grouped with the Cherry Creek suite (Ross et al., 1992), but probably belongs with the Sugarloaf diorite suite. The petrographic affinity will be investigated in conjunction with a larger study on the Iron Mask units (Snyder and Russell, in progress). A major dyke traverses southeastward across the Ajax East pit, cutting the Nicola volcanics, the hybrid diorite and Sugarloaf diorite (Fig. 2). A second large dyke separates the Sugarloaf and hybrid diorites on the northeastern wall of the Ajax East pit, and a third dyke partially separates the screen of picrite in the northeastern corner of the pit from the Sugarloaf diorite. Numerous smaller dykes occur within the hybrid diorite on the northwestern wall of the pit. The dykes are typically fine grained, blue-grey to pinkish with characteristic grains of magnetite, and commonly, a pervasive epidote alteration. The pinkish colour is due to pervasive K-feldspar alteration that occurs sporadically in some dykes and is absent in others. Disseminated chalcopyrite and pyrite occur in trace amounts. Unmineralized calcite veins crosscut mineralization.

In addition to epidote alteration in the larger dykes, and localized pervasive K-feldspar alteration, many of the smaller dykes appear to have been albitized. One dyke in particular is totally albitized though the primary texture is preserved.

(Unit 8) Syenite dyke, occurs parallel to a monzonite dyke (Fig. 2). Only one dyke has been noted. It is medium grained and consists dominantly of pink potassic feldspar. Mineralization is not apparent in hand sample.

(Unit 9) Quartz-eye latite dyke, is hornblende, potassium feldspar and quartz phyric. These dykes cut the Sugarloaf diorite and the picrite (Fig. 2). The largest dyke is approximately 5 m wide and can be traced along the entire length of the southeastern side of the pit. A second large dyke occurs at the contact between the hybrid and the Sugarloaf diorites in the southwest corner of Ajax East pit, but could not be traced beyond the pit wall. These dykes postdate alteration, mineralization and many of the faults. Similar dykes are reported in the Afton pit (Kwong, 1987) and Ajax West pit (Ross et al., 1992).

In hand sample this unit is a uniform, fine grained porphyritic, brownish pink rock with hornblende needles, characteristic quartz and K-feldspar phenocrysts and minor amounts of disseminated pyrite. Quartz veining, accompanied by bleaching and silicification of the host rock, is associated with these dykes.

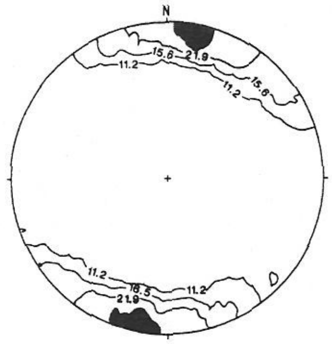
Magnetite-rich dykes (unit not defined) occur at several localities in both the Sugarloaf and hybrid diorites. These discontinuous dykes, less than a metre in width, are too small to appear on the map.

STRUCTURE

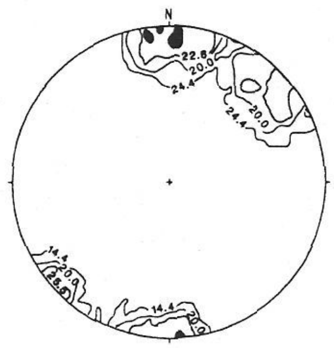
Attitudes of both mineralized and unmineralized structures in Ajax East orebody are predominantly EW/90°, oblique to principal intrusive contacts that strike northeast and dip moderately northwest. Contoured stereogram plots of poles to Ajax East mineralized and unmineralized structures are given in Figures 4 and 5 respectively. Average structural trends are given in Table 1. Intrusive contacts between older units, i.e. Nicola volcanics, picrite, Sugarloaf diorite and hybrid diorite, commonly are loci of subsequent faulting and mineralization. In contrast to Ajax East, attitudes of structures in Ajax West orebody (not illustrated) shift significantly from early, mineralized (NE/75°NW) to late, unmineralized (SE/65°SW) and moderately to shallowly dipping structures predominate. Unmineralized faults in both Ajax orebodies are concordant with the dominant southeast to east-southeast strike of regional faults, and represent a Late Mesozoic to Early Tertiary structural overprint on pre-mineralization northeast and east-west-striking structures.

Figure 4.

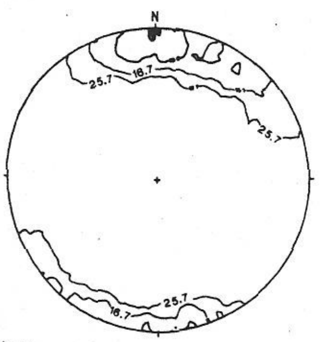
Contoured poles to planes, Schmidt projection, mineralized structures at Ajax East pit, Afton mine.



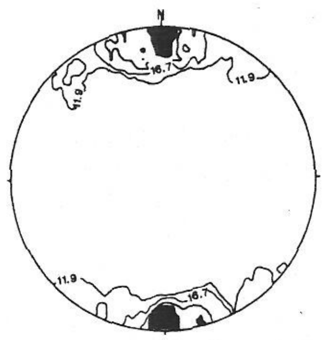
Ajax East : All Mineralized Structures; n=169



Ajax East : Mineralized Faults, Shears; n=30



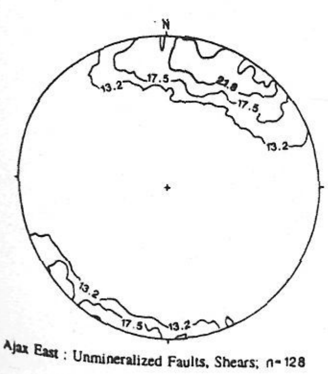
Ajax East : All Unmineralized Structures; n=205



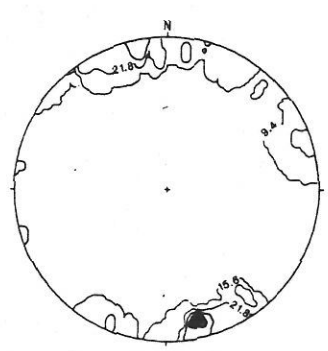
Ajax East : Unmineralized Joints, Fractures; n=45

Figure 5.

Contoured poles [illegible] projection, unmin[illegible] Ajax East pit, Afton [illegible]



Ajax East : Unmineralized Faults, Shears; n=128



Ajax East : Unmineralized Dyke Contacts; n=32

Table 1. Average attitudes of structures in and adjacent to Ajax East and Ajax West pits, Afton mine

	Ajax East		Ajax West		Regional	
	mineralized	unmineralized	mineralized	unmineralized	cut Iron Mask, Nicola	cut Iron Mask, Nicola, Kamloops
Faults, shears	085/90 *140/85SW n=30	108/75SW 135/80SW n=128	062/70NW 00/55W n=75	153/75NW 030/60 NW n=55	strike 135 n=18	strike 102 n=64
Veins, fractures	115/90 105/90 n=113	090/90 n=45	145/85SW 075/85SW n=51	135/45SW n=24		
Dyke contacts	115/90 n=26	078/90 100/85S n=32	083/85N n=15	090/85N n=10		
Average of all structures	100/90 n=169	090/90 115/85S n=205	070/75NW 017/65W n=141	155/65SW 160/90 n=89		
Nicola Group volcanic, sedimentary bedding					145/70NE n=125	
* second attitude is secondary structural trend in each case						

CONCLUSIONS

Detailed mapping of the Ajax East pit has delineated nine major rock units. The relative ages of these units is provisionally defined by contact relationships exposed in the pit and in drill core. Lithogeochemical trends and zircon dating of the units may refine compositional and age relationships.

Albitization is spectacularly developed within the Sugarloaf diorite and is spatially and temporally related to mineralization. Potassic alteration is more intensely developed in the relatively mafic hybrid diorite and Nicola volcanic units and may also be closely related to mineralization. Future statistical analysis of data, supported by microprobe work will help define alteration and mineralization zonation patterns.

The dominant EW/90° attitude of both mineralized and unmineralized Ajax East structures differs from that of Ajax West and regional rocks.

ACKNOWLEDGMENTS

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