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FISH LAKE
PORPHYRY COPPER DEPOSIT
TASEKO LAKES AREA, BRITISH COLUMBIA

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INTRODUCTION

LOCATION

The Fish Lake copper-gold porphyry deposit is located at 51° 28' N, 123° 38' W, (NTS 92O/5E), 130 km southwest of the city of Williams Lake and about 10 km north of Taseko Lakes. Fish Lake is 1 km south of the deposit at elevation 1420 m. The area is in the physiographic division known as Fraser Plateau (Holland, 1965), an upland of low relief (500 m). Local relief about the deposit is 90 m (Figure 1).

HISTORY

In the early 1930's, prospectors E. Calep and C. M. Vick followed float to exposures of narrow pyrite, chalcopyrite and gold bearing zones associated with diorite or feldspar porphyry dykes some 1 km east and 0.5 km north of the deposit (O'Grady, 1935).

The porphyry copper potential of the area was recognized in 1960 by D. C. Malcolm of Phelps Dodge Corporation. Early drilling results were not encouraging and Phelps Dodge allowed the ground to lapse. In 1969, Taseko Mines Ltd., directed by C. Dansey, L. Ross and J. Whist acquired the ground, drilled several critical holes in areas of little or no exposure and discovered better grade copper. G. A. Dirom and R. Seraphim acted as consultants. The property was optioned first to Nittetsu Mining Company Ltd. and then in 1973 to Quintana Minerals Corporation who in that year and in 1974 drilled about 6000 m in 23 core holes to test and delimit the better grade area. The deposit is now known to contain several tens of millions of tons of material grading approximately 0.3 percent copper and 0.5 g per tonne gold.

GEOLOGY

STRATIGRAPHIC AND TECTONIC SETTING

The Fish Lake prospect is near the northeastern erosional edge of rocks forming part of the Tyaughton Trough (Jeletsky and Tipper, 1968) and lies at the east end of a belt of east trending folds, faults and feldspar porphyry dykes (Tipper, 1963). The Tyaughton Trough, a mid-Jurassic to Late Cretaceous successor basin, contains both marine and non marine sedimentary and volcanic rocks. The last major marine transgression occurred in Aptian and Albian time (Tipper, 1968). During the remainder of the Cretaceous, continental sedimentation and volcanism were dominant, accompanied by transcurrent movement on the northwest trending Yalakom fault. Structures related to the Yalakom fault may have provided controls important in the localization of the Fish Lake prospect, the Poison Mountain prospects 75 km to the southeast

(Seraphim and Rainboth, this volume) as well as for some prospects near Relay Mountain 50 km to the southeast. Wall rocks to the porphyry intrusive complex include greywackes and shales, with variable dips and northerly strikes, together with overlying gently dipping pyroclastic rocks that are correlated with the Upper Cretaceous Kingsvale Group (Roddick and Okulitch, 1973). Flat-lying basaltic lavas of Pliocene and Miocene age overlie the southwest corner of the deposit and extend far beyond the borders of the property to the southeast and east. (Figure 1 and Tipper, 1963).

Local geology is interpreted mainly from drill cores but also from a few peripheral outcrops and trenches. The most strongly altered rocks are not exposed.

As shown in Figure 2, the deposit lies in a north trending embayment in the northern contact of a fine grained porphyritic quartz diorite. The embayment is occupied by altered pyroclastic and sedimentary rocks and by a younger small, stock and dyke complex of coarse grained porphyritic quartz diorite. Mineralization occurs in fine and coarse grained plutonic to hypabyssal rocks, as well as in hornfels.

PETROLOGY OF PORPHYRY INTRUSIVE COMPLEX

Four units of the porphyry intrusive complex, three of which are shown on Figure 2, are distinguished on the basis of feldspar and quartz phenocryst textures. The older, fine grained porphyritic quartz diorite (Unit 2) is composed of 20 percent to 40 percent euhedral plagioclase phenocrysts (1 x 2 mm) and 10 percent hornblende phenocrysts in a fine grained matrix of plagioclase, quartz and 1 to 5 percent biotite. This rock contains a few partially resorbed quartz phenocrysts 1 mm in diameter. The plagioclase is typically reverse zoned from An 40 to An 45, with some late An 50 overgrowths. Minor apatite and magnetite are ubiquitous.

Two younger, pre-mineral porphyry phases are recognized. One phase of younger quartz diorite porphyry (Unit 3), consists of 30 percent to 50 percent stubby euhedral plagioclase phenocrysts 2 mm to 4 mm in diameter, 10 percent hornblende phenocrysts, and less than 5 percent quartz phenocrysts 1 mm in diameter. This rock type has only been identified in an area of intense alteration, hence the composition of the original groundmass and of the feldspar phenocrysts was not determined. The hornblende is now completely replaced by chlorite or sericite.

A second phase of younger quartz diorite porphyry (Unit 4) mapped as quartz feldspar porphyry, is texturally similar to the above described rock with the exception of the quartz phenocrysts. In quartz feldspar porphyry, partially resorbed quartz phenocrysts about 4 mm in diameter make up more than 5 percent of the rock volume. This rock type has a fine grained matrix of quartz, plagioclase and biotite. Plagioclase phenocrysts show oscillatory zoning ranging from An 40 to An 45. None of these rocks contain potassium feldspar. Minor apatite and magnetite are ubiquitous. Age relation between the porphyritic quartz diorite and the quartz feldspar porphyry is not known, although both are thought to be genetically associated with mineralization.

Another, still younger, phase of quartz diorite porphyry, (not shown on the accompanying figures), texturally similar to Unit 3, occurs as narrow dykes cutting all other intrusive types. Alteration in these dykes consists of probably deuteric chloritization with weak clay-carbonate alteration of plagioclase phenocrysts. These phenocrysts show either no zoning or weak oscillatory zoning about a mean composition of An 50. These dykes are texturally and compositionally similar to phases closely related to mineralization although they are clearly younger than copper mineralization. However the dykes do contain traces of disseminated pyrite and are cut by barren carbonate veinlets.

The younger pre-mineral phases (Units 3 and 4) probably form a small stock and dyke complex, trending easterly and dipping steeply to the south, as shown in Figures 2 and 3. It is clear from Figure 2 that the

0.15 percent copper contour is centered on a body of younger quartz diorite porphyry (Unit 3), but no such relationship is obvious for the 0.25 percent copper contour.

RADIOMETRIC AGE

A sample of hornfels containing 40 percent secondary biotite was obtained from 120 m in Hole 73-12 for age determination by J. E. Harakal at the University of British Columbia. A whole rock age of 77.2 $\pm$ 2.8 million years was obtained. No significant potassium bearing mineral species other than biotite are present. As there are biotite-sulfide veinlets present, as well as matrix biotite coexisting with quartz-sulfide veinlets, the radiometric age is considered to be the date of mineralization. This age, Upper Cretaceous, is similar to the presumed age of the intruded rock.

STRUCTURE

Pyroclastic rocks within the altered area dip about 20° with unknown strike. Morphology of the older quartz diorite porphyry (Unit 2) is unknown, younger quartz diorite porphyry (Unit 3) and quartz feldspar porphyry (Unit 4) bodies dip steeply and trend eastward. Post-mineral quartz diorite porphyry dykes too small to show on Figure 2 dip steeply and trend northeastward where seen on surface. Some alteration zone boundaries are elongate easterly. Although many core holes show considerable steep dipping post-mineral shearing, no significant offsets of either alteration or lithologic units are evident.

METAMORPHISM

There is no significant regional metamorphism. Hornfelsed pyroclastic rocks locally were raised to biotite facies by a pre-mineral thermal event probably related to older quartz diorite porphyry (Unit 2). Remnants of what was probably a widespread, pervasive zone of biotitization are present in hornfels altered to chlorite zone by the later hydrothermal event.

MINERALIZATION

Primary metallic mineralization on the Fish Lake property consists of pyrite, chalcopyrite, bornite, magnetite, hematite and rare molybdenite. Trace amounts of galena, sphalerite, tennantite and gold are present. Gangue minerals include sericite, chlorite, quartz, gypsum or anhydrite, and iron-bearing carbonate.

These minerals were introduced in 8 stages separable by mineral assemblage and by crosscutting relationships. Table 1 shows these stages from youngest (8) to oldest (1).

Zoning of metallic mineralization is marked. Table 2 indicates changes in some parameters from central to peripheral zones.

Hematite typically occurs with sericite bearing alteration zones, while magnetite is seen with secondary biotite and with chlorite or epidote.

ALTERATION

The distribution of alteration minerals shown in Figure 4 is based mainly on 20 power hand lens examination of core and of hand specimens from peripheral outcrops and is not precise. The boundaries shown in Figure 4 are the outer limit of the occurrence of secondary biotite, pervasive sericite, together with the inner limit of epidote. Thin section study of 25 specimens generally confirmed these boundaries. In detail, biotite occurrence is more widespread than shown, as is the occurrence of minor amounts of sericite. Sericite is here used to mean minerals with approximately the optical properties of muscovite.

Clay minerals occur in all alteration zones except with epidote and biotite, but they were not specifically identified, as only optical methods were employed. Disseminated carbonate is widespread and makes up more than 10 percent of the rock except in the biotite and pervasive sericite zones. Typically, abundant clay and carbonate occur in the fracture controlled sericite zone.

No fresh plagioclase or hornblende exist within the limits of fracture controlled sericite.

It is clear that all of the fracture controlled alteration zones discussed here are of different ages, even though they appear to be distributed about a common center. It seems obvious that most biotite and much pervasive sericite is related to quartz feldspar porphyry (Unit 4), while pervasive and fracture controlled sericite alteration is also related to the quartz-poor younger quartz diorite porphyry (Unit 3). Relationships between alteration types described in the preceding section on mineralization suggest that quartz feldspar porphyry (Unit 4) may be older.

The correspondence between the 0.15 percent copper contour and the limit of fracture controlled sericite is good, but the 0.25 percent contour is offset eastward with respect to the biotite zone. The fact that some drill holes collared in +0.25 percent copper, east of the biotite zone, penetrate biotite alteration at depth suggests that the biotite zone plunges to the east, and that the apparent offset of the 0.25 percent copper contour reflects this plunge.

WEATHERING AND SUPERGENE MINERALIZATION

Locally, iron oxides, malachite, and copper bearing brown oxides are present near surface. Chalcocite was reported by Dirom (1969) and the profile of assay values in DDH 69-2, 69-3, and PDH-6 suggest secondary enrichment in the upper 15 m on the east end of the deposit. Brown oxide material which precipitates copper on iron in a sulfuric acid medium was examined by x-ray diffraction. No chalcocite was identified.

SYNTHESIS ~~AND GENESIS~~

The Fish Lake copper-gold porphyry prospect is associated with a mid-Upper Cretaceous quartz diorite stock and dyke complex. It is possible that the intrusive is related to volcanic rocks of the intruded Kingsvale Group. Concentric alteration zones, defined by the disappearance of epidote, and by the appearance of fracture controlled sericite, pervasive sericite and pervasive secondary biotite are centered on two quartz diorite porphyry bodies (Units 3 and 4) of stock or dyke form. Although particular sulfide-silicate mineralization assemblages are of different ages, and although the centers of distribution of particular assemblages are probably spatially separate from each other, the net result is a fairly classic zonation of both silicate and sulfide minerals. Copper distribution is closely related to the younger quartz diorite porphyry (Unit 3) and quartz feldspar porphyry (Unit 4) bodies, as well as to higher grade alteration zones. Gold distribution is very similar to that of copper, although weak gold/copper zoning is apparent (Table 2).

Whole rock chemical analyses were not obtained, therefore data are lacking on the nature of the possible compositional changes, with time, of the quartz diorite porphyry phases. The oldest phase (Unit 2) acted essentially as a wall rock and apparently did not contribute copper or gold to the system. Most copper-gold is related to the quartz feldspar porphyry (Unit 4), with some economic mineralization related to the younger quartz diorite porphyry (Unit 3). The association between copper-gold and these two late phases strongly suggests a genetic link. These two phases must certainly have acted as a heat source, and may also have been a source of metal, and of at least some of the hydrothermal water.

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TABLE 1: SULFIDE-SILICATE ALTERATION ASSEMBLAGES

Relative Age		Assemblage
Youngest	(8)	Carbonate veinlets with no sulfides.
	(7)	Gypsum (after anhydrite?) and anhydrite veinlets with little or no sulfide.
	(6)	Quartz, carbonate, minor pyrite, chalcopyrite veinlets.
	(5)	Pyrite (chalcopyrite), quartz, sericite envelope veinlets.
	(4)	Pyrite, chalcopyrite, bornite, (MoS_2) quartz veinlets with chlorite or sericite flakes.
	(3)	Pyrite, chalcopyrite hairline fracture fillings.
	(2)	Chalcopyrite, pyrite, bornite (MoS_2) with quartz, chlorite, magnetite (hematite) veinlets.
Oldest	(1)	Pyrite, chalcopyrite, bornite, and magnetite disseminated; typically with clots of mafics or sericite.

TABLE 2: CHANGES IN SOME ZONING PARAMETERS FROM CENTRAL TO PERIPHERAL AREAS

PARAMETER	VALUE	
	Central	Peripheral
pyrite/chalcopyrite	1/3 to 3/1	3/1 to 10/1
total sulfide	2 percent to 5 percent	2 percent to 7 percent
proportion of Cu in fractures	50 percent	90 percent
proportion of Cu as bornite	5 percent to 30 percent	0 percent
total Cu	0.3 percent	0.15 percent
Cu ppm/Au ppm	variable about 4000:1	variable about 6000:1

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