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GEOLOGY OF THE MAGGIE DEPOSIT

By

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Abstract

The Maggie porphyry copper-molybdenum deposit was discovered in 1970 by percussion and diamond drilling of a till and alluvium covered area. Outcrops bordering the covered area contain anomalous copper values associated with strong pyrite mineralization and hydrothermal alteration. Drill holes on a 122 metre grid pattern indicated geological reserves of 181,440,000 tonnes grading 0.28 percent copper and 0.029 percent molybdenum.

The deposit is associated with the Maggie stock, an elongate, northwest trending intrusion of biotite quartz monzonite porphyry of Tertiary age. Economic minerals also occur, to a lesser extent, in adjacent strata of the Cache Creek Group.

Ore minerals are chalcopyrite and molybdenite. Relatively high grade mineralization is found in two core areas in the deposit which are surrounded by lower grade mineralization. Overlapping potassic-phyllic alteration assemblages are associated with higher grade mineralization, whereas phyllic-argillic alteration assemblages are associated with lower grade mineralization.

Pyrite, the most common sulphide present, varies from 1 percent in the central part of the deposit to over 10 percent in a well developed halo surrounding it. Weathering of the pyritic halo has produced striking gossans on the east and west sides of the deposit.

Location

The deposit is centered in the Bonaparte River valley at Lat. 50°55.4'N, Long. 121°25.2'W, N.T.S. 92I/14W. It is about 15 km north of the Village of Cache Creek along Highway 97. Colorful gossan areas on both sides of the highway mark the extent of the pyrite halo associated with the deposit.

In the vicinity of the deposit, the Bonaparte River valley floor lies at an elevation of approximately 520 meters and is relatively flat with a width of 0.8 km. To the west, moderately sloped valley walls rise to a maximum height of 1,300 metres. To the east, the valley is flanked by steep rocky slopes which moderate rapidly toward the east and gradually rise to heights between 1,500 and 1,675 metres.

History

Prospecting in the area dates back to the 1860s when miners travelling to the Cariboo investigated pyritic zones along the old Cariboo highway. This historic route passes over the western edge of the deposit and a number of test pits of unknown age are located in gossan adjacent to the road.

In 1907, underground exploration was undertaken to explore a narrow chalcopyrite-bearing shear zone located about 750 metres north of the porphyry deposit. The shear zone strikes northeast and dips steeply southeast. A shaft was sunk 56 metres below the adit level and three levels totalling 335 to 365 metres were driven. Some stoping was conducted on the No. 2 level and 45.4 tonnes of selected ore were shipped which yielded 8 percent copper, 62.5 gms. of silver per tonne but no gold. Attempts to reopen the workings in 1915 and 1930 were unsuccessful. These workings were referred to as the Maggie Mine.

In 1952, limited exploration, including some diamond drilling, was conducted in the vicinity of the Maggie Mine by Kennecott Explorations (Canada) Ltd. Results of this work were largely negative and the project was discontinued.

In 1955, claims in the area were acquired by Huestis, Reynolds and Associates. In 1964, Frobex Ltd. drilled four diamond drill holes to test part of a gossan area. Low copper values were intersected in some holes but the programme was discontinued.

In 1966, the claims were acquired by Bethlehem Copper Corporation Ltd. and in 1968 a relatively small area was tested by percussion drilling. Results of this work were negative.

In 1969, Bethlehem conducted limited geological mapping on the property and a single diamond drill hole tested the central part of the gossan. Copper values to a depth of 244 metres were about 0.05 percent copper but values averaging 0.25 percent were intersected in the lower part of the hole to a depth of 453 metres.

Following drilling of this deep hole, additional ground was acquired and further geological mapping and bedrock sampling were conducted. Copper values from 27 gossan samples ranged from 19 to 1,100 ppm and averaged 210 ppm. Background values beyond the gossan averaged less than 100 ppm copper.

In 1970, further percussion drilling followed by diamond drilling on a 122 metre grid pattern outlined a porphyry type deposit containing geological reserves of 181,440,000 tonnes grading 0.28 percent copper and 0.029 percent molybdenum.

Technical staff associated with the discovery included H. G. Ewanchuk, R. E. Anderson, D. C. Miller, R. J. Nethery, R. J. Savellieff and consultant, J. D. Lowell.

Geological Setting

The Maggie deposit comprises low grade chalcopyrite-molybdenite mineralization in an elongate zone trending N37°W and dipping steeply toward the southwest. The long dimension of the deposit is 1,280 metres and its maximum width is 365 metres. The deposit contains two deeply rooted core zones with relatively high grade mineralization which are surrounded by areas of shallower, lower grade mineralization.

The deposit is associated with a Tertiary biotite quartz monzonite porphyry stock that intrudes weakly metamorphosed sedimentary and volcanic rocks of the Upper Paleozoic Cache Creek Group. Economic minerals are largely confined to the stock but also extend into bordering Cache Creek rocks. The stock is approximately 1,500 metres long and 425 metres wide, but does not crop out. It is covered by 45 to 120 metres of till and alluvium. The stock is cut by a number of pre-mineral latite porphyry dykes. Some distance from the stock, several light colored, porphyritic dykes and small intrusions varying in composition from quartz latite to diorite intrude Cache Creek rocks (Figure 1). A satellite intrusion immediately west of the stock is comprised of quartz diorite. The contact zone between this intrusive and the stock is not exposed; however, it is interpreted that the quartz diorite intrusion is cut by the stock (Figure 2).

The Cache Creek Group in this area comprises chert, argillite, limestone and intermediate to basic volcanic rocks. Because of poor exposure and deformation, the stratigraphy of the Cache Creek Group is not yet fully understood (Duffell and McTaggart, 1951). The Cache Creek rocks are cut by a number of small ultramafic intrusions which are thought to have been emplaced during Permian or Triassic time. The ultramafic bodies are cut by the Maggie stock or occur as large inclusions within it.

Tertiary volcanic rocks, which are younger than the Maggie stock, crop out east of the Maggie deposit where they are in fault contact with rocks of the Cache Creek Group and down dropped with respect to the block containing the Maggie. Tertiary volcanic rocks comprise basaltic to andesitic flows and breccias.

Pre-porphyry Host Rocks

Cache Creek Group

Cache Creek Group on the property include interbedded chert and argillite, andesitic to basaltic volcanic rocks and limestone. Chert and argillite beds occur as thick sections of dark flaggy carbonaceous argillite, thinner sections of interbedded chert and argillite and narrow sections of dark argillaceous to relatively pure light grey chert. Volcanic rocks are commonly medium to dark green and range in texture from nearly massive to strongly foliated. Original features such as breccia fragments and pillow structure are preserved locally. The most common variety of volcanic rock near the deposit is brown weathered with a speckled appearance caused by fine grained mafic phenocrysts. Limestone is light to dark grey, massive to banded. It is nowhere intersected by the Maggie stock. Correlation of various Cache Creek Group units is difficult because of poor outcrop and deformation.

Ultramafic Rocks

Small bodies of ultramafic rocks, intrusive into Cache Creek rocks, crop out in several locations and were intersected by various drill holes. Where exposed, they are dark green fine grained, resinous-looking rocks which weather to a distinctive greenish powder.

They are strongly magnetic and crop out as small bodies which are arranged in linear patterns, apparently along old fault zones. In drill hole intersections, ultramafic intrusions occur as sill-like bodies apparently dipping nearly parallel to bedding in Cache Creek rocks. They seem to resist assimilation by the later Maggie stock and occur as large inclusions within it. In drill cores, faults commonly mark the contact zone between ultramafic bodies and other units.

Ultramafic rocks within the deposit are weakly mineralized with chalcopyrite but are of much lower grade than adjacent porphyry. They normally contain 0.20 percent nickel, mainly as fine grains of pentlandite. Nickel of this order of magnitude is also present in ultramafic bodies some distance from the deposit.

Ultramafic rocks were originally composed of olivine with minor pyroxene. Subsequently, they were pervasively serpentinized and later partially altered to talc-carbonate mineral assemblages.

Petrology of Porphyry System and Related Rocks

The principal host of chalcopyrite-molybdenite mineralization is the altered biotite quartz monzonite porphyry of the Maggie stock. To a lesser extent, economic minerals occur in related intrusions, dykes, Cache Creek Group rocks and small ultramafic intrusions adjacent to the stock. Inclusions of older rocks and dykes cutting the stock are also mineralized.

Biotite Quartz Monzonite Porphyry

Porphyry typically comprises altered plagioclase and biotite phenocrysts, commonly 1 to 5 mm in size, in a finer grained matrix of K-feldspar, quartz and plagioclase. Accessory minerals include apatite, zircon and magnetite. Quartz commonly occurs as matrix grains, and less commonly as quartz phenocrysts to 3 mm size, as well as in secondary quartz veinlets. Fragments and inclusions of Cache Creek Group and ultramafic rocks are common near the borders of the stock.

While much of the stock is homogeneous, a second phase is recognized in certain drill holes along margins of the stock. In this quartz diorite border phase, porphyritic texture is poorly developed, K-feldspar is lacking, and the rock is relatively fine grained. A small quartz diorite intrusion which occurs west of the deposit is similar in composition to this border phase and may be an extension of it.

Dykes

A wide latite porphyry dyke cuts the southeast part of the Maggie stock and outcrops near highway 97. It strikes northwesterly and dips approximately 60° southwestward. Although this dyke is pre-ore, it carries much lower copper values than adjacent porphyry. The dyke consists of 2 percent quartz phenocrysts, 25 percent altered plagioclase phenocrysts, and 5 percent altered biotite and hornblende phenocrysts that are all evenly distributed in an aphanitic plagioclase and K-feldspar matrix. Several smaller dykes of similar composition and texture were intersected in drill holes elsewhere in the stock.

A number of small, light colored porphyritic dykes of intermediate composition intrude Cache Creek rocks on the property. The relationship of these dykes to the Maggie stock is uncertain but it is presumed that they are offshoots from it.

Radiometric Age

One drill core sample from the contact zone that contained secondary biotite was submitted for whole rock potassium-argon analysis. An age of 61.1 $\pm$ 2 million years was obtained by J. E. Harakal at the University of British Columbia (McMillan, 1971).

Structure

Structural information in the Maggie area is obtained from sparse outcrops and diamond drill cores. Cache Creek strata exposed along the walls of the Bonaparte River valley strike mainly northwest and less commonly northeast and dip both east and west at moderate to steep angles. Near the deposit drill cores indicate Cache Creek rocks are dipping at moderate angles. An anticlinal structure over the Bonaparte River valley is suspected with the Maggie stock lying to the west of the anticline's axial plane (Figure 2).

Two prominent structural directions, northwest and northeast, are evident from visible shearing and elongation of intrusive bodies. The Maggie stock and several dykes follow the northwesterly trend with average strike N37°W and dip 60° to 75°SW. The Maggie Mine shear zone, parallel zones and a number of small ultramafic bodies follow a northeast trend and dip steeply southeast or northwest. Some ultramafic bodies strike northwest and dip about 30° southwest.

Within the Maggie stock, numerous faults and three prominent sets of quartz veins are apparent in drill core. Because of wide drill hole spacing, these features cannot be projected between holes.

Post-ore Tertiary volcanic rocks east of the Maggie stock are in fault contact with Cache Creek strata. Diamond drilling indicates these volcanic rocks are down-faulted several hundred feet with respect to the Cache Creek rocks.

In a relatively small area east of the stock, a landslide has occurred which transported relatively unaltered Cache Creek rocks westward. Small exposures, which could be interpreted erroneously as outcrops, actually overlie glacial and alluvial deposits.

Metamorphism

Prior to intrusion of the Maggie stock, Cache Creek strata were deformed and had sustained low rank regional metamorphism with the formation of argillites and, locally, foliated volcanic rocks.

Deformation of these strata is considered to have commenced in Lower or Middle Triassic time (Campbell and Tipper, 1969). Upper Triassic Nicola strata near Ashcroft and some 20 km south are much less deformed.

During the final stages of intrusion of the Maggie stock, bordering Cache Creek strata were modified by contact metasomatism while contemporaneous hydrothermal alteration was occurring within the stock.

Mineralization and Alteration

Ore minerals comprise generally fine grained chalcopyrite and molybdenite with average grain sizes ranging from 0.05 to 0.3 mm. These minerals occur in three principal associations:

(1) as fine disseminations in quartz veins;

(2) as fine disseminations throughout the host rock;

(3) as fine veinlets within or bordering quartz or, less commonly, calcite veins.

The first two associations are about equally common while the third is less common and typically occurs near the edges of the deposit.

Both copper and molybdenum grades decrease outward from two higher grade central areas. Similarly, the vertical distribution of these minerals is related to the two central cores. Within the core regions, mineralization persists to depth whereas in adjacent zones mineralization is relatively shallow.

Pyrite is the most common sulphide associated with the deposit and varies in content from 1 to 3 percent in the central part of the deposit to over 10 percent in a well developed peripheral halo. In the central zone, pyrite is disseminated throughout the host rock and, to a lesser extent, occurs in veins. On the margins of the deposit, however, pyrite in veinlets is as prominent as it is disseminated. The pyrite halo contains 1 to 14 percent pyrite over widths of 450 to 750 metres east and west of the deposit and extends even greater distances north and south of it. Small intrusions, not exposed but indicated by float, may affect its distribution northwest of the stock.

Quartz veining is prominent throughout the deposit and commonly constitutes 5 to 20 percent of the rock. Calcite veining is less common and is generally restricted to the margins of the deposit.

The Maggie stock and bordering Cache Creek rocks have been pervasively modified by hydrothermal alteration. Because the stock is largely of one rock type, alteration assemblages within it are considered separately from those in heterogeneous bordering rocks. Thin section studies were conducted on drill cores cutting an imaginary plane some 210 metres below surface, or at an elevation of 305 metres above sea level. The alteration descriptions which follow are based largely on this study. Alteration terms potassic, phyllic, and argillic follow as closely as possible the usage of Lowell and Guilbert, 1970. Potassic alteration implies secondary biotite-K-feldspar-quartz-sericite assemblages; phyllic alteration implies quartz-sericite-pyrite assemblages; and argillic alteration implies quartz-kaolinite-sericite-illite assemblages.

Overlapping potassic-phyllic alteration assemblages are associated with two northwest trending core zones in the deposit. Within these zones, plagioclase is almost completely altered to sericite, K-feldspar and kaolinite; K-feldspar is partly altered to biotite, sericite, and secondary K-feldspar; and biotite is altered to secondary biotite, sericite and rutile-leucoxene aggregates. The best grade chalcopyrite-molybdenite mineralization is found within these core zones.

Outward from the core zones, alteration zones are complex and do not fall into simple annular patterns. Various overlapping phyllic, argillic and potassic alteration assemblages are present and associated chalcopyrite-molybdenite mineralization is relatively low grade.

Argillic alteration is well developed in a northwest trending area between the two core zones. In this area, plagioclase is almost completely altered to kaolinite, sericite-illite and minor K-feldspar. Primary K-feldspar is virtually unaltered and biotite is altered to secondary biotite and sericite.

Strong phyllic alteration is associated with the western border phase of the Maggie stock. Plagioclase and biotite are completely altered to sericite and K-feldspar is absent or present in minor amounts. The lack of K-feldspar probably reflects a low original K-feldspar content further modified by alteration. Strong quartz-pyrite veining and very sparse chalcopyrite-molybdenite mineralization, mainly in quartz veins, are present.

Outward from the stock, bordering Cache Creek rocks and small felsic intrusives have sustained variable degrees of alteration. Drill cores indicate strong alteration occurred laterally a distance of about 90 metres beyond the stock, then decreased gradually to almost nothing about 600 metres from the stock. Bordering the stock, argillites have been converted to rocks composed essentially of interlayered biotite and quartz; cherts to quartz-sericite aggregates; volcanic rocks variably replaced by biotite, chlorite, epidote, sericite, quartz, calcite and other minerals; and small felsic intrusives have been affected by quartz-sericite-biotite alteration. In the outer part of the contact zone, important alteration minerals are chlorite, epidote and calcite.

Weathering and Supergene Characteristics

Surrounding the Maggie deposit, extensive gossans have developed from the oxidation of the pyritic halo. In addition to pyrite this gossan contains an average of 300 ppm copper. Weathering leached most of the sulphides from gossan zones to a depth of about two metres and copper values in leached rock are about half of those obtained in rock below the zone of weathering.

Over the deposit, the oxidized zone was destroyed by glaciation and the scoured surface was buried beneath a thick glacial mantle which effectively prevented further oxidation. No zone of supergene enrichment exists above the deposit.

Synthesis

Geological events associated with the formation of the Maggie deposit are summarized as follows:

(1) In Permian to Triassic? time ultramafic bodies were emplaced along deep-seated faults into late Paleozoic Cache Creek rocks.

(2) Deformation of Cache Creek strata probably began in early Triassic and ended before late Triassic time. Nearby rocks of the Upper Triassic Nicola group are much less deformed than Cache Creek strata.

(3) In late Paleocene time the Maggie stock and associated small intrusions were emplaced along zones of weakness which may also have controlled emplacement of earlier ultramafic intrusions.

Fracturing, alteration and sulphide deposition in the Maggie stock and bordering strata took place during the final stages of cooling of the intrusion.

(4) Following emplacement of the stock, Middle Eocene basalts and andesites were extruded over a large area which includes the Bonaparte River valley. Post-volcanic block faulting occurred immediately east of the deposit and the western block which contains the Maggie deposit was uplifted with respect to the eastern block.

(5) In Quaternary time the Maggie deposit was eroded and possibly unroofed by glaciation and subsequently covered by thick deposits of till and alluvium. In the latter part of this period, a small landslide, which obscures part of the alteration halo of the deposit, occurred along the east side of the Bonaparte River valley.

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