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VALLEY COPPER DEPOSIT

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ABSTRACT

The Valley Copper porphyry deposit is located in the Highland Valley of B.C., about 370km northeast of Vancouver, B.C. Reserves are 790 million tonnes of 0.48 percent copper.

The rocks which host this deposit are mainly porphyritic Bethsaida phase granodiorites, the most central and youngest phase of the 198 m y old Guichon Creek batholith. Minor dyke phases include: pre-mineralization granodiorite and quartz diorite porphyries and aplite, syn-mineralization Tan felsite porphyry and post-mineralization lamprophyres.

Localization of the deposit is related to the formation of a zone of intense fracturing near the intersection of the northerly trending Lornex fault and the easterly trending Highland Valley fault. Predominant orientations of faults, fractures and quartz veinlets in the deposit are parallel to these two regional faults.

The alteration types recognized are: propylitic, pervasive sericitic and kaolinitic, vein sericitic, K-feldspathic, biotitic, silicic and post-mineralization veining (principally gypsum). K-feldspathic alteration is dominant in the central, deeper part of the deposit, where it is intimately associated with and enveloped by an extensive zone of moderate to strong vein sericitic and pervasive sericitic and kaolinitic alteration, which grades outward into a zone dominated by weak to moderate pervasive sericitic and kaolinitic alteration. This latter zone, in turn, grades outward into a zone with areas of weak to moderate propylitic alteration and areas with no hydrothermal alteration. A well developed silicic zone (in the form of barren quartz veinlets) occurs in the southeastern part of the deposit. Elsewhere quartz veinlets (principally mineralized but some barren) are only moderately developed within the deposit. The age of hydrothermal alteration, calculated by averaging several potassium-argon analyses of hydrothermal sericites, is 191 m y.

The sulfides present in the deposit are, in order of relative abundance: bornite, chalcopyrite, digenite, covellite, pyrite, pyrrhotite, molybdenite, sphalerite, galena and gudmundite (FeSbS). The greater part of the copper mineralization is associated with areas of abundant vein sericitic alteration and quartz veinlets. Bornite is the dominant sulfide in this sericitic association, whereas chalcopyrite is the dominant sulfide accompanying K-feldspathic alteration. Bornite/chalcopyrite ratios show highest values in the central part of the deposit, where they exceed 3 to 1 and decrease away from the core to the fringes of the deposit where chalcopyrite predominates. The deposit has a weakly developed pyrite halo.

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Geochemical patterns related to hydrothermal alteration show a decrease in CaO, Na₂O, MgO, Sr, Ba and Mn and a corresponding increase in K₂O, SiO₂, Rb and TiO₂ from the periphery to the centre of the deposit. Patterns related to mineralization show that the deposit (as defined by copper values exceeding 0.30 percent) is roughly oval in plan, with a broad halo of lower copper grades around it. Molybdenum and zinc form annular, geochemically enriched zones around the deposit.

Sericite stabilities and fluid inclusion compositions as well as sulfur, oxygen and hydrogen isotopic data, suggest both that sulfur in the sulfides is of sub-crustal or magmatic derivation and that the deposit was formed at a shallow depth from saline, hydrothermal fluids. The fluids had the following range in characteristics during the alteration sequence:

$$T = 260 \text{ to } 480^{\circ}\text{C}$$

$$\text{pH} = 1.7 \text{ to greater than } 4.0$$

$$-\log f_{\text{S}_2} = 1.5 \text{ to } 4.5$$

$$-\log f_{\text{O}_2} = 21.6 \text{ to } 23.4$$

The main period of copper mineralization occurred at about 400°C from a solution of about pH 2.2 to 3.1 which exhibited -log fugacities of oxygen and sulfur of 21.8 to 23.0 and 1.8 to 2.7 respectively. The controlling factor in the deposition of sulfides was apparently an increase in the sulfide ion concentration. Mixing of magmatic water and seawater probably occurred throughout the various stages of hydrothermal alteration and is estimated to be about 25 percent SMOW (Standard Mean Ocean Water) during the main period of mineralization.

GENETIC SYNTHESIS

The copper-rich magma of the Guichon Creek batholith was probably derived from a subcrustal source with the ore metals and hydrothermal fluids probably derived from it by processes of differentiation. It is likely, however, that seawater was contributed to the magmatic hydrothermal system.

The purpose of this part of the paper is to summarize the sequence of major events leading to formation of the Valley Copper deposit. They are believed to have been as follows:

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1. The Bethsaida granodiorite was intruded in Upper Triassic time about 198 ± 8 m y ago.
2. Movement on the Lornex and Highland Valley faults initiated a zone of intense fracturing in Bethsaida granodiorite near the fault intersection.
3. Pre-mineralization aplite, granodiorite and quartz diorite porphyry dykes were injected along northerly and easterly trends.
4. Hot, saline fluids moved upward in the zone of fracturing and mixed with downward percolating seawater to produce a fluid with a temperature of about 260°C , pH about 1.7 and $-\log f\text{S}_2$ of about 4.5. This fluid reacted with and leached Na_2O and CaO while adding K_2O and H_2O to the wall rocks. This stage of alteration produced extensive pervasive sericitic and kaolinitic alteration with associated trace amounts of pyrite and chalcopyrite.
5. A continued influx of magmatic hydrothermal fluids and seawater gave rise to a hydrothermal fluid with a temperature about 400°C , slightly higher pH of 2.2 to 3.1, and a lower $-\log f\text{S}_2$ of 1.8 to 2.7. These fluids reopened many of the access channelways used by previous hydrothermal fluids and produced vein sericitic alteration. Deposition of main stage copper mineralization occurred during this stage, probably as the result of increased sulfur ion concentration.

Tan felsite dykes, of syn-mineralization age, were also intruded at this time.

6. In the main part of the deposit a further influx of fluids again reopened the old channelways and formed quartz veinlets containing vugs lined by or filled with bornite and chalcopyrite.
7. Continued fracturing of the rock mass occurred along with formation of quartz veinlets with disseminations and envelopes of secondary K-feldspar. The pH of the hydrothermal fluid at this stage probably continued to increase to about 4.0 while $-\log f\text{S}_2$ probably increased slightly to about 3.5. Mineralization of this stage was limited to minor amounts of chalcopyrite, probably as a result of further decreased sulfur fugacity. Chemically, this stage is characterized by a pronounced increase of K_2O and SiO_2 and a marked decrease of H_2O , relative to zones with pervasive and vein sericitic alteration.

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8. Further fracturing occurred followed by deposition of essentially barren quartz veinlets from hydrothermal fluids of still further increased pH and $-\log fS_2$.
9. In close spatial association with previously formed secondary K-feldspar fractures were re-opened and gypsum deposited. The hydrothermal solutions were rich in seawater sulfate.
10. Lamprophyre dykes were intruded about 132 ± 3 m y ago.
11. During subsequent uplift and erosion the overlying rocks and the upper part of the deposit were removed and an oxidized zone and weak supergene blanket developed. Glaciation followed by glaciofluvial deposition and continued erosion produced the present day surface.

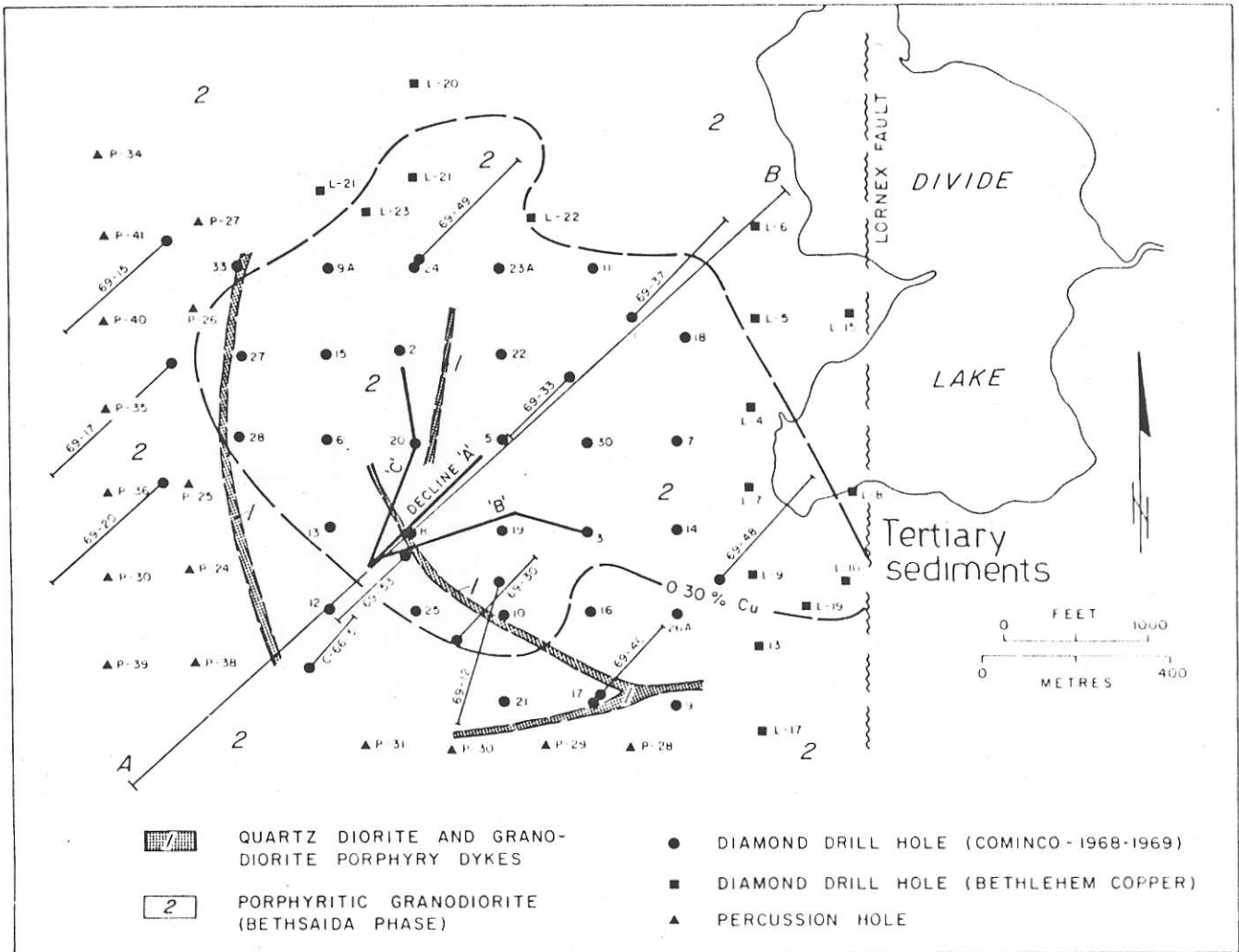


Figure 1. Geology of the Valley Copper deposit, showing distribution of drill holes studies, location of underground workings and location of vertical section A-B.

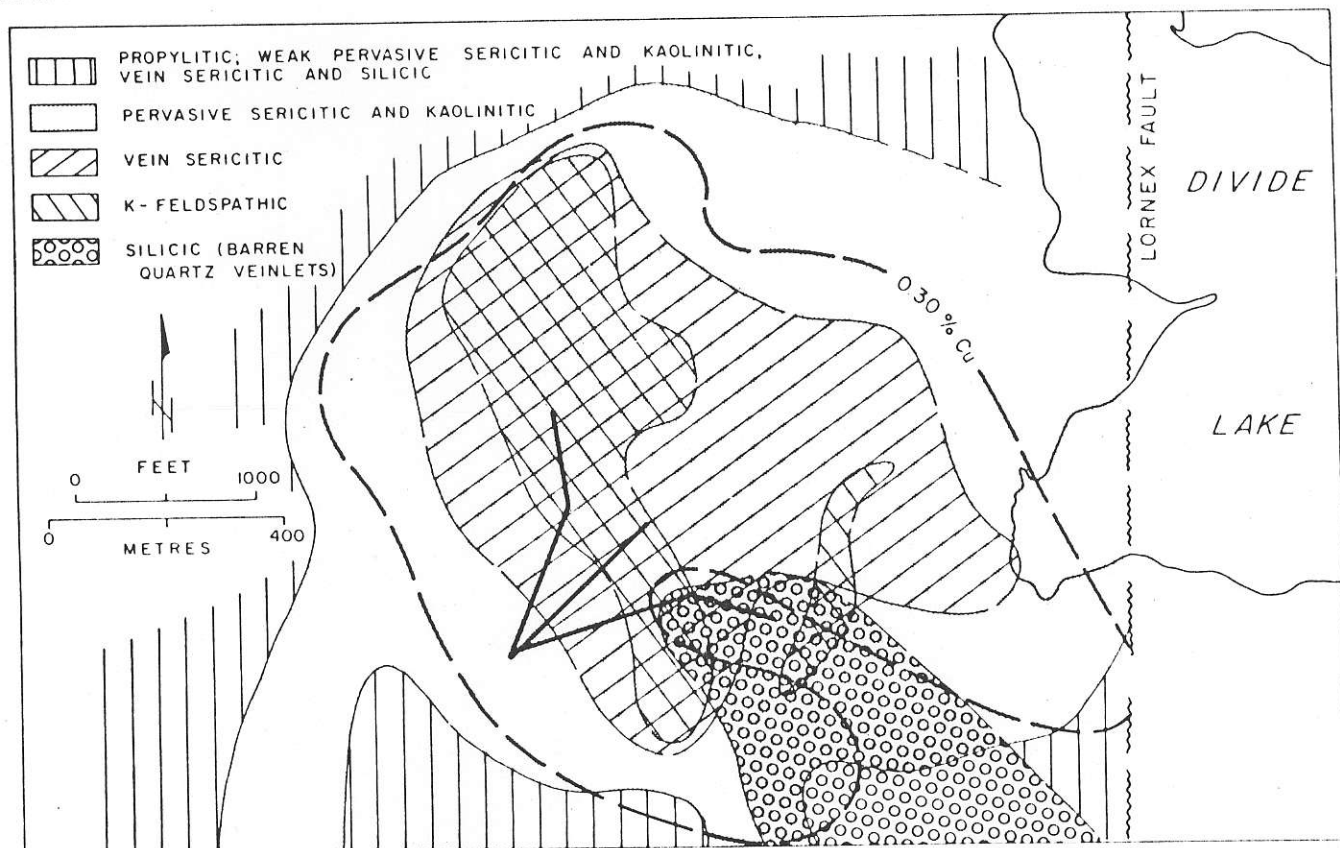


Figure 2. Map of dominant alteration types on the 1097m level.