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KRAIN

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TABLE OF CONTENTS

ABSTRACT

The Krain porphyry copper prospect, located 10 km north of the Bethlehem mine, has been explored intensively over the past 20 years. Reserves of 14 million tonnes grading 0.56 percent copper are indicated, and little hope remains for discovery of additional tonnage.

Krain is unique in the district in that it is partly covered by post-mineral volcanic rocks beneath which an oxidized cap is preserved. Although primary sulfides are deeply and totally oxidized, very little chalcocite enrichment has resulted. Precipitation of copper appears to have been achieved primarily within the oxidizing zone, such that the cap is slightly enriched in copper. This is inferred to result from rapid neutralization of acid solutions by reaction with calcite, a common mineral of the hydrothermal alteration assemblage.

At Krain there are clear genetic and spatial ties between zonal patterns of mineralization, alteration, and fracturing, around a quartz diorite stock which resembles the Bethlehem phase of the Guichon Creek Batholith.

Post-mineral faulting is significant.

LOCATION

The Krain property is located on the east flank of North Forge Mountain about 10 km north of the Bethlehem mine in Highland Valley district (Lat. 50° 35' N, Long. 120° 58' W, NTS 92I/10W, Elev. 1750 m).

HISTORY

The earliest history at Krain is unknown except that by 1907 a 5 m adit already existed on the property which was then called the Keystone Group. Little more was done until development of the Bethlehem mine commenced in 1955, and prospects in the district began to attract the attention of mineral exploration companies. Operators at Krain since 1955 have included Beaver Lodge Uranium, Far West Tungsten, Kennecott, North Pacific, Canex, Shulman, Noranda, Quintana and Getty; total exploration costs have exceeded one million dollars.

Several companies recognized that part of the mineralized area at Krain was deeply oxidized and lay beneath Tertiary volcanic cover where supergene enriched copper mineralization might exist. Determined efforts were made to explore this potential, as well as to develop tonnage in the primary sulfide zone. Regional and detailed geological mapping and sampling were supplemented by geochemical, magnetometer and induced polarization surveys, and considerable bulldozer trenching. Extensive diamond and percussion drilling have been done throughout the years.

The most recent operators, Quintana and Getty, in 1971-72 jointly explored extensions of mineralization beneath covered areas to the north and south. In 1973 Getty continued efforts to develop deeper extensions to the south and southwest, but since then the property has been idle.

In 1972 tonnage and grade estimates were made at Krain, including all areas of mineralization that could be recovered from a single open pit 250 m deep, using a 0.3 percent copper cutoff grade. The calculations indicated a total reserve of 14 million tonnes grading 0.56 percent copper. Of this total, about 9.1 million tonnes averaging 0.53 percent copper contain primary sulfides, and 4.9 million tonnes grading approximately 0.64 percent copper contain secondary copper carbonates and oxidation products.

Overall molybdenum content was estimated to average close to 0.01 percent molybdenum although short intercepts near the centre of the deposit contain as much as 0.03 percent molybdneum.

GEOLOGY

The Krain prospect lies on the southern boundary of an extensive area of post-mineral cover consisting of continental volcanic and interbedded sedimentary rocks of the Early Tertiary Kamloops Group. These rocks cover the northern half of the mineralized zone, and have protected an older oxidized cap as much as 100 m thick. Hypogene sulfides within this cap have been totally destroyed. In contrast, sulfides occur at surface within the southern part of the deposit where Pleistocene glaciation has removed most of the oxidized zone.

Mineralization at Krain occurs within quartz diorites of the Highland Valley phase (Guichon variety) of the Guichon Creek Batholith, as defined by Northcote (1969), and within younger anastomosing dykes and small stocks. These dykes and stocks exhibit textures ranging from porphyritic to hypidiomorphic-granular, more equigranular varieties closely resembling quartz diorites of the Bethlehem phase of the batholith (Northcote, 1969).

The mineralized porphyry system at Krain occurs within a broad northwesterly trending zone that also contains the Trojan (South Seas) prospect, a breccia-pipe 3 km south of Krain, and the Bethlehem deposits some 7 km further south. This broad zone is characterized by numerous sub-parallel northwest trending porphyry dykes, as well as by prominent fracture related but non-pervasive chlorite-epidote-chalcopyrite-±pyrite-±bornite hydrothermal vein and fracture selvage assemblages. Smaller zones of pervasive chlorite-clay alteration, some containing strong chalcopyrite mineralization, occur frequently at the margins of porphyry dykes. Extensive trenching and drilling were carried out by prospectors and exploration companies within and around many of these small showings.

At Krain mineralization and alteration are closely associated with an elongate 1000 m x 200 m dyke-like stock which is unroofed within a small area at the centre of the deposit (Figures 1 & 2). The unroofed portion appears to be an abrupt cupola-like projection which developed above the stock. To the northwest and southeast along strike the apex of the stock plunges gently away from the high point at Krain, and the lateral contacts dip about 70° southwestward (Figure 2).

Fracturing, brecciation, alteration and mineralization are all most strongly developed in and around the central cupola-like core, and along the upper surface of the stock.

PRIMARY MINERALIZATION AND ALTERATION

Well defined zonal patterns of primary sulfide mineralization and silicate alteration have been recognized around the core area. Within the core and near the contacts of the stock, chalcopyrite-bornite assemblages are found associated with molybdenite-bearing quartz veinlets. Peripheral to this mineralization, chalcopyrite-pyrite assemblages occur in fracture stockwork fillings in which pyrite becomes more abundant outwards, both within the wall rocks and the stock. Maximum total sulfide content is about 5 percent and this occurs in a zone approximately coincident with the outer limit of 0.1 percent copper grades.

Associated zoned silicate alteration is pervasive and diminishes outwards from sericite-clay-chlorite[1] assemblages in the core, through clay-chlorite, and chlorite assemblages in the chalcopyrite zone, to chlorite-epidote assemblages in the pyrite zone. Beyond the approximate outer limit of 0.05 percent copper, silicate alteration is no longer pervasive although chlorite-epidote assemblages form pronounced fracture selvage halos which gradually diminish to fracture coatings over transition zones as much as 1000 m wide.

1. Identification of sericite and clay-bearing mineral assemblages is based on physical properties and knowledge of x-ray determined mineralogy of similar rocks from the Bethlehem mine (McMillan, W. J., 1974, personal communication).

OXIDIZED ZONE

An oxidized cap as much as 100 m thick, has been preserved beneath Early Tertiary cover at Krain (Figure 2). The overall average oxide copper grade is about 20 percent higher than the overall average hypogene copper grade suggesting that copper enrichment has occurred within the cap. Malachite is the most abundant copper mineral but chrysocolla and a black waxy copper oxide of dendritic habit (neotocite? copper-manganese?) are common. These minerals form very prominent fracture coatings, some of which are botryoidal, and also fill cavities previously occupied by sulfides. Minor cuprite and disseminated native copper are found most commonly in the outer parts of the deposit.

Chalcocite occurs in minor amounts as thin coatings on corroded grains of sulfide within a narrow zone, extending through the lower metre of oxidized rock to the upper few metres of the primary sulfide zone. Chalcocite is not sufficiently abundant to contribute appreciably to the grade of the deposit, and does not account for the slight enrichment of the oxidized zone over primary grade.

Disseminated calcite forms as much as 5 percent of the more highly altered and better mineralized rocks at Krain, and is believed to have greatly influenced the migration of copper at the time of oxidation. The presence of calcite within the system likely resulted from the destruction of calcic plagioclase during the hydrothermal stage. Calcite under later oxidizing conditions probably reacted to neutralize cupriferous acid solutions formed from hypogene sulfides, precipitating copper before much vertical migration could take place. However some net downward migration of copper must have occurred as the processes of weathering, oxidation, and leaching progressed, if the apparent enrichment of the cap truly indicates secondary enrichment.

A possible alternate explanation for the higher oxide copper grade at Krain is second cycle oxidation of a pre-existing chalcocite blanket, but no substantiating textural relationships such as partially oxidized chalcocite relicts, or hematitic limonites were noted. Further, the chalcocite observed forms coatings on sulfide grains near the base of the oxidized zone, a site and mode of occurrence common in first cycle chalcocite blankets. It is interpreted therefore that at Krain, because of the retarding influence of carbonate mineralogy on downward migration of copper, only small amounts of copper reached the groundwater table where first cycle chalcocite could form.

STRUCTURE

Fractures and faults are prominent features at Krain, and the areas of highest fracture density which are adjacent to the stock, are also the zones of best mineralization.

Sets of steeply dipping northeasterly and northerly trending faults are shown on Figure 1. Pre-mineral existence of a few of these faults which contain sulfides is evident in the field, but a post-mineral age appears likely for most. Early Tertiary Kamloops Group rocks are restricted almost entirely to downfaulted blocks, where vertical offsets have been substantiated in several instances by drill data. It has not been possible to measure net movement on any of these faults, nor are the time relationships fully understood between mineralization, episodic minor faulting, and the development of the major regional Highland Valley and Lornex Faults.

SUMMARY

Krain is a well-explored porphyry copper deposit which forms part of a much larger hydrothermal sulfide system. Reserves of 14 million tonnes averaging 0.56 percent copper and 0.01 percent molybdenum are known, but potential is low for discovery of additional tonnage near surface.

Unlike most copper deposits within the Guichon Creek Batholith, Krain displays a strong genetic relationship with a small stock which in this instance intrudes Guichon quartz diorite. Texturally the stock resembles the Bethlehem phase of the batholith, and a cupola-like part of it forms a core about which are developed strong zonal patterns of fracture intensity, sulfide and hydrothermal silicate mineralogy, and copper grade.

Mineralized rocks at Krain were deeply oxidized prior to burial during Early Tertiary time. Despite total destruction of sulfides within a thick oxidized cap, very little secondary chalcocite enrichment resulted. Conversely, the oxidized cap itself appears to have become enriched in copper to the extent that oxide grade exceeds primary grade by about 20 percent. This enrichment is interpreted to result from the reaction of available hydrothermal calcite to precipitate copper from acid solutions produced during the oxidation process. Downward migration of copper was thereby retarded and, ultimately, with continued weathering and oxidation the oxidized zone became slightly enriched. Northern parts of the Krain deposit lie protected beneath Early Tertiary cover, but the oxidized cap within southern parts of the deposit, has all but been destroyed by Pleistocene glaciation.

The present distribution of Early Tertiary Kamloops Group is strongly influenced by faults, and at Krain most of these rocks occur in downthrown fault blocks.

REFERENCES

Northcote, K. E. (1969): Geology and Geochronology of the Guichon Creek Batholith, B. C. Dept. of Mines and Petroleum Resources, Bull. No. 56.

BIOGRAPHY

James Stanley Christie was born in Toronto, Ontario and moved west to study geology at the University of British Columbia. After completing a detailed study of structure, metamorphism and igneous intrusion within part of the Shuswap Metamorphic Complex of south-central British Columbia, supported by a National Research Council of Canada Scholarship, he graduated with a Ph.D. in 1973. Jim joined the Vancouver staff of Quintana Minerals Corporation in 1972 and has been engaged in mineral exploration projects focused principally on the Guichon Creek Batholith of British Columbia, and the Aleutian Island - Alaska Peninsula region of Alaska.