Porphyry Copper Deposits of the American Cordillera

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The Helvetia Area Porphyry Systems, Pima County, Arizona

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ABSTRACT

The Helvetia area porphyry copper deposits occur within an extensive Laramide porphyry system located in the Santa Rita Mountains, Pima County, Arizona. The entire system consists of four separate centers of copper mineralization: Rosemont, Peach-Elgin, Broadtop Butte, and Copper World.

Mineralization and alteration are primarily of the contact pyrometasomatic type and hydrothermal alteration and zoning of sulfide mineral assemblages resemble those observed at the Twin Buttes Copper Mine located approximately 30 kilometers west of Helvetia. The stratigraphic sequence, ranging from Cambrian Bolsa Formation to Permian Rain Valley Formation, correlates well with sections developed in the Twin Buttes and Mission Mine areas. The Paleozoic section in the deposit area totals approximately 1,800 meters.

Two Tertiary intrusives penetrate the Paleozoic-Mesozoic stratigraphy in the region. One, a quartz-monzonite stock, occurs primarily in the western portion of the project area. The other, a hydrothermally altered quartz-litite porphyry, is mineralized locally and the copper mineralization in adjacent exoskarn is considered to be genetically related to it. Limestones in contact with the porphyry have been locally metasomatically altered to lime-silicate skarns, principally tactite. The tactite is, for the most part, grossularite or andradite garnet with varying amounts of diopside, tremolite, wollastonite, quartz, and vesuvianite. Occasional Tertiary lamprophyric dikes intrude the area and the immediate region is underlain by Precambrian granodiorite.

Ore mineralization was introduced during the later stages of pyrometasomatic hydrothermal alteration. Primary sulfide minerals include chalcopyrite, bornite, and pyrite with chalcopyrite and pyrite predominating. These occur principally as veins, coarse disseminations, blebs, and clots within irregular lenticular zones lying in and generally parallel to the lime-silicate areas. A limited tonnage of secondary chalcocite and covellite occurs irregularly throughout the deposit. In the oxidized zone, a substantial tonnage of copper occurs as chrysocolla, azurite, malachite, cuprite, and chalcocite. Minor amounts of silver, molybdenite, gold, sphalerite, and scheelite occur throughout the various mineral centers.

Post-ore faulting, principally high-angle normal and thrust faulting, terminates all four mineral centers. The Peach-Elgin mineral center lies within the Helvetia Klippe and is considered to be the offset upper segment of the Copper World mineral center.

Approximately 570 holes have been drilled in the area by various companies: Lewisohn Copper Corp., Banner Mining Company, Anaconda, Anamax, and ASARCO. The deposit is amenable to open pit mining and the metallurgical recoveries should be similar to those achieved at the Mission and Twin Buttes Mines.

INTRODUCTION

The Helvetia area copper deposits occur within a large Laramide porphyry system located in the Santa Rita Mountains, Pima County, Arizona. This porphyry copper system consists of four separate areas of copper mineralization — Rosemont, Peach-Elgin, Broadtop Butte, and Copper World — lying within a broad alteration zone in the northern segment of the Santa Rita Mountains. Mineralization and alteration are primarily contact pyrometasomatic, and zoning of hydrothermal alteration and sulfide mineral assemblages is similar to those observed at the Twin Buttes and Mission Copper Mines located approximately 30 kilometers west of Helvetia. ASARCO acquired the copper deposits within the Helvetia area porphyry systems in 1988 and has continued the exploration and development effort since then.

A considerable amount of excellent geological work has been completed on the Helvetia area porphyry systems but little information has been published on developments since the mid-1950s. The geology of the copper deposits as developed by numerous geologists over the past 75 years and the large, bulk-tonnage low-grade copper deposits outlined in recent years will be briefly reviewed in this paper.

LOCATION

The Helvetia area porphyry systems are located approximately 50 kilometers southeast of Tucson, Arizona, in the northern Santa Rita Mountains (fig. 1). They lie within the Basin and Range Physiographic Province at elevations ranging from 1,402 to 1,890 meters.

EXPLORATION AND MINING HISTORY

Copper mineralization may have been discovered in the Helvetia District prior to the Civil War, but no records are available for these early discoveries. The district has had a relatively small production of copper ore, principally from underground mines. In the late 1880s copper ore from the district was treated at the Columbia Smelter located on the west side of the Santa Rita Mountains, and the Rosemont Smelter located on the east flank of the same range near Rosemont Camp (Creasey and Quick, 1955). In 1903, the Helvetia Copper Company began operation and continued until 1911. Copper was produced almost continuously from 1915 to 1951. In the 1940s, some disseminated copper mineralization in skarns was mined from small open pits located in the Elgin area. Total production from the Helvetia District through 1950 totaled 227,300 tons of ore containing 17,290,000 pounds of copper, 1,097,980 pounds of zinc, and 180,760 ounces of silver (Schrader, 1915; Creasey and Quick, 1955).

After 1950, activities consisted mainly of exploration and development drilling. The Lewisohn Copper Company conducted a drilling program in the Peach-Elgin area in 1955 and in
1956 outlined a possible open pit copper deposit in the Peach Hill area (fig. 3). Drilling in 1956 by American Exploration and Mining Co. in the Ingersoll breccia area, located southeast of Broadtop Butte, failed to outline an economic deposit. In the late 1950s the Helvetia area porphyry systems were acquired by the Banner Mining Company, and a modest exploration drilling program was conducted in the area. During this Banner program, drill hole G-33 penetrated the first significant porphyry copper mineralization in the Rosemont area of the Helvetia area porphyry systems. This hole contained a 300-meter intercept of greater than 0.90 percent copper mineralization. Anaconda Mining Company acquired the property in 1963 and carried out an extensive mapping and drilling program. The vast majority of the modern information on the Helvetia area porphyry systems was developed by Anaconda and Anamax personnel. Their efforts resulted in the delineation of the Rosemont Porphyry Copper Deposit, a major North American copper resource. The property was incorporated into the Anamax Mining Co. when Amax joined Anaconda in a partnership in 1973. Anamax sold the property to a real estate company in 1986 which in turn sold it to ASARCO in 1988.

GEOLOGY

The four Helvetia area porphyry copper systems occur within a series of moderate to steeply dipping Paleozoic and Mesozoic sedimentary rocks that have been intruded by Laramide igneous rocks. Mineralization and alteration are primarily contact pyrometasomatic (Creasey and Quick, 1955), and hydrothermal alteration and zoning of sulfide mineral assemblages are similar to those found at ASARCO's Mission Mine and Cyprus Mining Company's Twin Buttes Mine. The Paleozoic stratigraphic sequence, ranging from the Cambrian Bolsa Quartzite to the Permian Rain Valley Formation, corre-

lates well with the stratigraphic sections of the Twin Buttes and Mission Mine areas. The Paleozoic rocks are chiefly limestone, dolomitic limestone, and quartzite; the Mesozoic rocks, primarily Cretaceous in age, consist of shales, sandstone, arkose, and impure limestone (Creasey and Quick, 1955). The thickness of the Paleozoic stratigraphic section in the deposit area totals approximately 1,828 meters (fig. 6) (McNew, 1981).

Two Paleocene intrusives cut the Paleozoic-Mesozoic strata in the region. One, a quartz-monzonite stock (QM), is found primarily in the western portion of the project area (fig. 2). The other, a moderate to strongly altered quartz latite porphyry (QLP), is closely associated with copper mineralization. The quartz latite porphyry is locally mineralized and strong copper mineralization in adjacent skarns is considered to be genetically related to this porphyry. The principal alteration features in the quartz-latite porphyry are sericite and clay alteration of the feldspars, partial destruction of the mafics, and varying degrees of silicification. Limestones in contact with the quartz latite porphyry have locally been metasomatically altered to lime-silicate skarns. Heyman (1958) and McNew (1981) have classified one of the principal components of the skarn as garnet actitite, composed primarily of grossularite and andradite garnet with varying amounts of quartz, diopside, tremolite, serpentine, wollastonite, and vesuvianite. Endoskarn alteration is occasionally observed in the quartz latite porphyry. Garnet is the predominant endoskarn mineral, vesuvianite is locally abundant, and epidote occurs in small amounts at intrusive contacts (Heyman, 1958; McNew, 1981). Occasional Tertiary lamprophyric dikes penetrate the area and the general region is underlain by Precambrian granodiorite (fig. 2).

MINERALIZATION

Sulfide mineralization is considered post-contact pyrometasomatic alteration and occurs in all of the altered sediments. While all of the altered sediments are mineralized to some extent, higher grade copper mineralization tends to favor certain skarn horizons indicating that the original rock type and stratigraphy exerted considerable control over ore deposition. Drilling to date in the Rosemont area indicates that the Horquilla and Colina Formations were far more receptive to copper mineralization than the other sedimentary formations in the Helvetia area porphyry systems (fig. 4). Primary sulfide minerals include chalcopyrite, bornite, molybdenite, and pyrite with chalcopyrite and pyrite predominating. Sulfides occur principally as veinlets, coarse disseminations, blebs, and clots within irregular lenticular zones lying in and generally parallel to the lime-silicate areas. Magnetite in varying amounts is found throughout the skarn zone. In the oxidized zone a considerable tonnage of copper occurs as chrysocolla, azurite, malachite, cuprite, and chalcocite. Minor amounts of molybdenite, sphalerite, galena, and scheelite occur throughout the deposit with trace amounts of silver and gold being noted in the area.

The total sulfide content of the deposit is relatively low, seldom exceeding 3 percent in the altered Paleozoic rocks. The sulfide content of the Mesozoic sequence is somewhat higher due primarily to an increase in pyrite content.

STRUCTURE

The structure of the Helvetia area porphyry systems is
highly complex. The rocks are cut by numerous faults including thrust faults, high-angle normal and reverse faults, and tear faults. Folding of the sediments is commonly observed throughout the area. A complex assemblage of thrust faults, high-angle normal faults, and tear faults follows the crest line of the Santa Rita Mountains in the Helvetia deposit area. This complex structural zone is known locally as the “Backbone Fault”. The Backbone Fault zone forms the western edge of the east dipping block of Paleozoic sediments that include the Rosemont Copper Deposit. Post-ore faulting, principally high-angle normal and thrust faulting, has had substantial effects on all four mineral areas (McCurry, pers. commun., 1991).

The Peach-Elgin is the most structurally complex of the four copper deposits. It is described in the literature as part of the Helvetia Klippe (Schrader, 1915; Creasey and Quick, 1955; Heyman, 1958; Drewes, 1972). The entire Peach-Elgin deposit is underlain by a thrust fault that places Paleozoic and Mesozoic sediments and Laramide quartz-latite porphyry over Precambrian granodiorite (fig. 3). The Helvetia Klippe is considered by some to be the offset upper segment of the Copper World mineral area (fig. 2). The Copper World area is itself strongly affected by numerous faults (fig. 5; Schrader, 1915).

Schrader (1915), Creasey and Quick (1955), Heyman (1958), and Drewes (1972) have described the geology and structural environment of the Helvetia region and the reader is directed to these publications for additional geological information.

RESERVES

Approximately 570 drill holes have been drilled throughout the Helvetia area. The Rosemont porphyry system has been tested by approximately 130 vertical and angle diamond drill holes. Based on this drilling a computer-generated reserve estimate was completed for the Rosemont area porphyry system by
Figure 3. Cross section through the Peach-Elgin portion of the Helvetia Klippe showing the location and orientation of drill holes with +0.30 percent copper intercepts shown in black (after Schrader, 1915). Location of cross section shown on figure 2.

Figure 4. Cross section through Rosemont area showing location and orientation of drill holes with +0.30 percent copper intercepts shown in solid black. Location of cross section shown on figure 2.
Figure 5. Cross section through Copper World area (after Schrader, 1915, and Drewes, 1972). Location of cross section shown on figure 2.

Figure 6. Stratigraphic column of the Helvetia area porphyry systems (after McNew, 1981).
Anamax in 1977. This estimate outlined a geological reserve of 328 million tonnes of sulfide mineralization assaying 0.61 percent copper, 0.019 percent molybdenum, and 8.5 grams per ton silver based on a 0.30 percent copper cutoff. In addition, 60 million tonnes of copper oxide mineralization assaying 0.53 percent copper was estimated. ASARCO is continuing to explore and define the Rosemont Copper Deposit, and there is little doubt that the ultimate copper resource will exceed these preliminary estimates. The ultimate waste-to-ore ratio will depend on the cutoff grade and pit design selected. Based on the preliminary Anamax data, the waste to ore ratio is approximately 3:1.

The Peach-Elgin area has been penetrated by 81 churn and diamond drill holes. Based on a 0.40 percent copper cutoff, a hand-drawn geological reserve of 21 million tonnes averaging 0.76 percent total copper has been delineated. Approximately 60 percent of this mineralization occurs as sulfides. If a 0.30 percent copper cutoff is used, the tonnage doubles and the grade is approximately 0.58 percent copper. The waste to ore ratio at Peach-Elgin is less than 3:1 (Anzalone and Brown, 1992).

The current drill hole spacing in the Broadtop Butte and Copper World areas is too wide to accurately define a geological reserve. Opportunities to outline additional mineralization in these areas appear good. Additional drilling will be required before a minable ore reserve and pit plan can be developed for the entire deposit. Based on current evidence, it appears that the Helvetia area porphyry system contains a geological reserve of copper mineralization in excess of 500 million tonnes.

**METALLURGY**

A limited amount of metallurgical testing has been completed on samples from the Rosemont area. This testing indicates that the sulfide mineralization is amenable to concentration by standard flotation methods. These tests produced a copper concentrate assaying 33.5 percent copper with payable precious metal credits (Barter, pers. commun., 1987). The sulfide mineralization from the other copper deposits should react to treatment in a similar fashion. A considerable tonnage of oxide copper mineralization is present throughout the deposit. The minimal test work completed so far suggests that much of the oxide material should be amenable to treatment by solvent extraction-electrowinning methods.

**CONCLUSION**

The Helvetia area porphyry system ranks as a major skarn-type porphyry copper occurrence. It is amenable to open pit mining methods, and metallurgical recoveries should be similar to those achieved at ASARCO’s Mission Unit. A significant percentage of the copper oxide mineralization present will be amenable to heap leaching and solvent extraction-electrowinning recovery.

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