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GEOLOGY OF THE BATOPILAS MINING DISTRICT, CHIHUAHUA, MEXICO

VOLUME I

by

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DISSERTATION

Presented to the Faculty of the Graduate School

The University of Texas at El Paso

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for the Degree of

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GEOLOGY OF THE BATOPILAS MINING DISTRICT,

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Chemical assays were performed by St. Joe American Mining Company (180 samples) and Southwest Assay Labs (210 samples). Dr. Kenneth F. Clark is responsible for obtaining a K/Ar age determination of the Dolores Formation. Dr. Robin Hoffer and Dr. Paul Orajaka assisted with the x-ray fluorescence major oxide geochemical analyses. Sandy Figuers assisted with the generation of computer pole plots of structural data.

The dissertation area and problem was first proposed by Dr. Philip Goodell who has overseen the project from its inception in 1978.

ABSTRACT

The Batopilas mining district of southwestern Chihuahua is structurally simple and mineralogically unique. The rocks of the district are granodiorite, fine-grained quartz diorite, and dacite intrusives which have been overlain by at least three distinct flow breccias. The silver deposits are irregularly shaped pods of massive native silver or wire silver in calcite, which occur along fissures and are connected by unmineralized fractures or silver-barren calcite veinlets. The veins formed along north-south and northeast-southwest trending fractures and faults. Maximum vertical displacement on these faults is probably less than 394 ft (120 m), and maximum horizontal displacement is probably less than 1,640 ft (500 m).

The geologic history of the district is summarized as follows: (1) intrusion of the Pastrana Dacite (Phases I, II and III) into pre-existing Cretaceous? sediments and igneous rocks; (2) intrusion of the Dolores Micro-Quartz Diorite; (3) minor faulting; (4) intrusion of the Las Tahonas Granodiorite and development of a porphyry copper mineralizing system; (5) minor faulting; (6) erosion; (7) extrusion of the El Arenal Flow Breccia; (8) erosion; (9) extrusion of San Jose Flow Breccia; (10) minor faulting; (11) erosion; (12) deposition of the Cinco de Mayo

Conglomerate; (13) erosion; (14) extrusion of Casas Coloradas Flow Breccia; (15) erosion; (16) extrusion of the Yerbanis Formation (ignimbrites and interbedded andesite flows); and (17) minor faulting; (18) intrusion of rhyolite and andesite dikes.

The native silver ore bodies are generally less than 100 ft (30.5 m) in length and vary in width from a few inches up to 15 ft (0.01 to 3 m) and average 2 to 3 ft (0.6 to 1.0 m) in width. The ore bodies terminate abruptly in both vertical and horizontal directions, and are connected both vertically and along strike by up to 300 ft (91.5 m) of unmineralized fractures or vein stringers of calcite which can be less than 1/8 inch (0.32 cm) wide.

Most of the accessible ore bodies in the district are hosted by Pastrana Dacite (Phase I) or Pastrana Dacite Porphyry (Phase II), but a few ore bodies are hosted by Las Tahonas Granodiorite or by andesite dikes. Only one small galena-calcite ore body was observed in the district hosted by Dolores Micro-Quartz Diorite. Native silver-bearing veins are not known to exist in any of the flow breccia units (El Arenal, San Jose and Casas Coloradas formations) or in the Yerbanis ignimbrites. A few quartz-galena veins were found in the El Arenal and San Jose flow breccias.

Structural controls are associated with some ore bodies. Many ore bodies formed at flexures in the dip or strike of vein-forming fractures and other ore bodies are

clearly associated with cross-fractures. There are many other ore bodies, however, which are completely devoid of apparent structural controls and their localization cannot be explained by structural controls alone. Furthermore, brecciated zones near ore bodies are often not mineralized. Ground preparation was adequately developed in many unproductive portions of the vein systems, and yet deposition of neither calcite nor silver occurred there. It appears that for many of the ore deposits, some as yet poorly understood physio-chemical event induced the nucleation of native silver pods at irregular intervals along the vein fractures.

There are four types of wall rock alteration in the district: (1) chlorite-actinolite alteration, (2) silicification, (3) pyrite alteration, and (4) gossan formation. Type 1 alteration is also associated, locally, with dark green chloritization and gray and green argillization. Type 1 alteration is often, but not always, associated with ore bodies, and is best developed in Pastrana Dacite and in andesite dike host rocks.* Silicifacation occurs in dike-like masses within the Pastrana as well as Dolores Formations. The silicified zones are generally less than 30 ft (9.2 m) wide.

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*In this report the term "altered" is meant to be understood as Type 1 alteration.

Pyritization is characteristic of the Pastrana Dacite and is common in the Las Tahonas Granodiorite. Pyritization was also experienced by portions of the Dolores Micro-Quartz Diorite. The degree of pyritization of the Dolores is less than that of the Pastrana and Las Tahonas intrusives. The flow breccias are not pyritized or altered. The Los Corralitos Gossan formed from the limonitization of pyrite and argillization of plagioclase and orthoclase in the pyrite-rich portions of the Pastrana and Las Tahonas formations.

Samples of host rocks which have experienced chlorite actinolite and silica alteration are enriched in Cu, Pb, Zn and possibly Ag. The base and precious metal content of unaltered host rocks appears to be a function of their pyrite content. The Los Corralitos Gossan is weakly mineralized, but the degree of base and precious metal mineralization is uneconomic. It represents a pyritic halo of a porphyry copper system which may be economic at depth.

The Batopilas ore deposits consist of native silver in calcite with lesser amounts of galena and sphalerite. The native silver may be massive or occur as wire silver in calcite. The wire silver often occurs in a geometric mesh which follows the cleavage directions of calcite. The calcite and silver in these ores formed contemporaneously and probably at relatively low temperatures (less than 250° C). The gold content of the silver ores is negligible.

Cobalt-nickel arsenides and ruby silvers reported in previous investigations were not observed during this study. Galena and sphalerite are the major sulfide minerals, and pyrite is generally absent from the ores.

The Batopilas native silver-calcite ore bodies could have formed by four different processes. They could be primary hypogene hydrothermal deposits or they may have formed by lateral secretion. A third possibility is that they formed from supergene activity. In this model, supergene solutions leached silver from overlying pre-existing precious/base metal deposits which formed as a direct consequence of intrusion of the Las Tahonas Granodiorite. The silver was remobilized downward along faults and fractures and deposited at favorable locations and under changing physio-chemical conditions within the Pastrana and Las Tahonas Formations. This model accounts for the high Ag/Au ratio of the ores as well as some of the relationships of alteration to silver mineralization. A fourth possibility is that the native silver-calcite mineralization was produced by circulating connate waters which were associated with the formation of the Las Tahonas porphyry copper system. Of these four models of ore genesis, the connate water-porphyry copper hypothesis is currently favored.

There is a fairly well developed pattern of mineralogical zoning with the district. The mineral

zonation is concentric around the Las Tahonas porphyry copper system (Los Corralitos Gossan). The zone nearest the Los Corralitos Gossan is barren, but may contain quartz-galena veins. The second zone contains calcite-native silver veins. The third zone outward from the gossan contains quartz as the primary gangue mineral with galena and a smaller proportion of pyrite.

The only potentially economic ore deposits existing in the Batopilas district are the classic native silver ore bodies. The non-native silver bearing portions of the veins may contain a few percent base metals and a few grams of silver per ton, but the tonnages are too low and the grade of mineralization too inconsistent for profitable mining. Suggestions are made for the future exploration for native silver ore bodies in the district.

TABLE OF CONTENTS

Chapter | Page

Chapter | Page