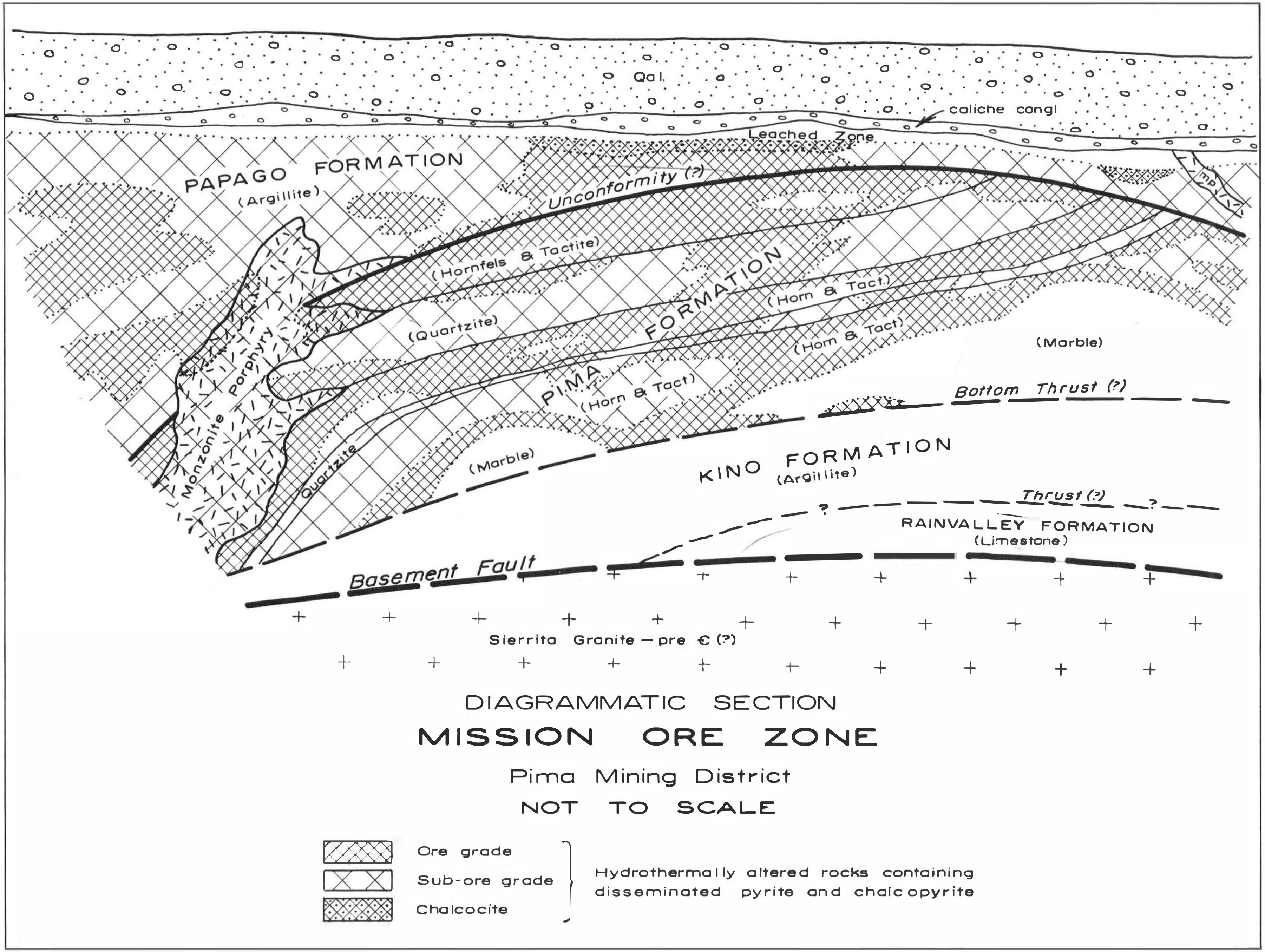

FIGURE 43. Diagrammatic geologic cross section through the Mission development, East Sierrita area (fig. 44), Arizona.

SOME GEOLOGIC FEATURES OF THE MISSION COPPER DEPOSIT

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INTRODUCTION

The Mission ore zone, formerly called East Pima, is situated in the Pima mining district just south of the San Xavier Indian Reservation and 16 airline miles south-southwest of Tucson (fig. 55). Its center is three-fourths of a mile northeast of the Pima open-pit mine.

Alluvium everywhere overlies the bedrock formations in the Mission deposit area (fig. 44). This block of ground is separated from the nearest exposed rocks, in the vicinities of the Pima mine and Daisy mine, by faults below the alluvium. Geological interpretations are based on examination of core from a large number of diamond drill holes, spaced at intervals of 150 to 300 feet. The core studies are supplemented by observations made in a few hundred feet of lateral workings from the Mission shaft, which is located in the eastern part of the ore zone. As a result of the limitations, descriptions and opinions expressed herein are confined to generalizations from which more questions than answers may seem to arise. Some of the geologic features, however, are sufficiently unusual to warrant the following preliminary comments. The accompanying section (fig. 43) illustrates the principal relationships of stratigraphy, structure, and mineralization.

STRATIGRAPHY

The original character of the sedimentary rocks is either obliterated or obscured by recrystallization and metasomatism and correlation of formations is uncertain. The Permian "Rainvalley" formation is recognized on fossil evidence, but the "Rainvalley" block is structurally isolated. For working purposes all other pre-mineral sedimentary rocks are grouped into three formations: "Pima," "Papago," and "Kino." These three formations cannot be correlated with other known formations at this time and may, in whole or in part, represent units that have not been recognized heretofore.

"Pima Formation"

The "Pima formation" is composed of quartzite and marble, the latter largely altered to tactite. A sequence of two quartzite units, separated by a unit of tactite, suggests possible correlation with the Permian Scherrer formation. The overlying tactite-hornfels may be the equivalent of the Permian Concha limestone, except that it contains silt and gypsum. The underlying tactite-hornfels may be the equivalent of the Pennsylvanian Horquilla and Permo-Pennsylvania Andrada, except that the characteristic gypsiferous beds of the Andrada formation are missing. These and other apparent discrepancies may eventually be explained by faulting or overturning, whose pattern is not presently recognized from drill cores. At the present time, the Pima formation is tentatively considered to be of Paleozoic age.

"Papago Formation"

The "Pima formation" is apparently truncated below the overlying "Papago formation" (fig. 43). The contact is considered to be an unconformity because no evidence of faulting on this contact is found in the drill cores. The "Papago formation" consists of a substantial thickness of massive argillite. Conglomeratic and arkosic facies and a few thin, lenticular, garnetized limestone beds are recognized, but these comprise only a small part of the formation. There is no basal conglomerate.

Although the "Papago formation" lies above presumed Paleozoic rocks, it is not considered to be Cretaceous because it lacks the alternation of thin-bedded sandstone and mudstone which characterizes Cretaceous rocks elsewhere in the region. The "Papago formation" possibly may be of early Tertiary age, but no correlation with any known Tertiary formation is suggested.

"Kino Formation"

The "Kino formation" underlies the "Pima formation" but the contact is a fault. The "Kino formation" is dominantly conglomeratic with intercalated beds of argillite, arkose, and some graywacke and pyroclastic(?) material.

Lithologically the "Kino formation" in general resembles the "Papago formation" and, although they may be parts of a single sequence of deposits, the two units cannot be correlated at this time. Like the "Papago," the "Kino" lacks the alternation of thin beds which is characteristic of most Cretaceous rocks.

IGNEOUS ROCKS

In addition to Precambrian(?) Sierrita granite which forms the basement rock, three igneous formations occur within the deposit. These are pre-ore monzonite porphyry and felsite porphyry, and post-ore andesite. The felsite porphyry and andesite are in the form of dikes; the monzonite occurs in sill-like bodies and in small, irregular stocks.

STRUCTURE

A nearly flat fault separates the "Rainvalley" and "Kino" formations from the underlying Precambrian (?) Sierrita granite. Little is known of the nature of this structure, although it probably is a continuation of the low-angle thrust which crops out a short distance west of the San Xavier mine.

Largely due to the lack of visible bedding within units, structure is not understood in detail. However, gross patterns are apparent. The quartzite beds are moderately folded and dip at low to intermediate angles. Several low-angle faults, such as the "Bottom thrust (?)," are traced through parts of the mineralized zone and some of these faults are associated locally with repetition and thickening of stratigraphic units. As a group, these faults appear to show thrust relationships. Several high-angle, normal faults of appreciable displacement also are recognized, although none of these is shown on the section.

Most of the thrust and normal faults are probably of pre-mineral origin because breccia along most of the faults is locally mineral-healed. However, the faults usually are marked also by post-mineral gouge and breccia, and the relative magnitudes of the pre- and the post-mineral movements are not known. The ore zone is traversed by numberless faults and slips of definite post-mineral age and of diverse, apparently unsystematic orientation. The displacement and continuity of most of these faults are probably insignificant. A few of them may have importance that is not now apparent within the limitations of the data on hand.

In the Mission deposit, the number of veins and veinlets of quartz, sulphide, feldspar, and calcite that are more than an inch in thickness is small compared to the number present in most other disseminated sulphide deposits. Veinlets of one-fourth inch and smaller width seldom have continuity of more than a few inches. Microscopic veinlets, however, are locally abundant, particularly in the siliceous formations. A system of parallel veinlets is exposed in a part of the underground workings, but it is unlikely that such systems are common within the deposit as a whole.

MINERALIZATION

All rocks above the marble of the "Pima formation" are pervasively altered by hydrothermal processes of metasomatism and recrystallization and contain disseminated sulphides. Calcareous sedimentary rocks have been converted to aggregations of various lime-silicate minerals and sulphides. For working purposes, the metamorphosed calcareous rocks are grouped into two principal types, tactite and hornfels. In places, these two types reflect the original lithology of different stratigraphic units, but elsewhere, the two types grade into each other through irregular and structureless zones within what appear to be single stratigraphic units. The tactite is composed predominantly of coarse-grained garnet with small amounts of diopside, tremolite, and other silicates and its texture is granoblastic. The hornfels has a fine-grained granoblastic texture and its principal mineral is diopside, with tremolite, garnet, wollastonite, quartz, and calcite present in small amounts. Irregular zones consisting almost entirely of quartz and feldspar occur occasionally in the tactite and hornfels.

Siliceous rocks such as argillite, arkose, and quartzite are altered to rocks composed of quartz, feldspar, sericite, clay, and sulphides. These rocks have very fine-grained granoblastic textures.

The original minerals of the monzonite are altered in part to quartz, sericite, and clay, and appreciable amounts of hydrothermal quartz and orthoclase also are present. Disseminated sulphides occur throughout.

In the lower part of the "Pima formation," hornfels and tactite locally have sharp, crosscutting contacts with a rather pure marble. Here it is evident that formation of the lime-silicate minerals involved the exchange of a considerable amount of material. It is difficult to determine from drill cores the extent to which this replacement process was controlled by fractures and it is believed that the metasomatism was accomplished mostly by diffusion.

Pyrite and chalcopyrite are the preponderate sulphides. Molybdenite is sparse and erratically distributed, and sphalerite, bornite, and galena occur in places. Under the microscope, textural relationships suggest sulphide replacement of the silicate gangue and a slightly younger age for the sulphide minerals. The age association probably is close, because the silicates and sulphides developed without the intervention of extensive structural disturbance. Sulphide deposition may be considered an end-stage phase of recrystallization and silicate metasomatism.

A large part of the sulphides occur as discrete grains and small blebs -- the remainder, as veins and veinlets plus a few sizeable pods of rather massive sulphides. Sizeable zones exist which contain sulphides only in the form of grains and blebs. In the underground workings, there is no concentration of sulphide grains adjacent to any one veinlet and the abundance of sulphides does not seem to depend on the concentration of veinlets.

Some of the pre-mineral zones of fracturing undoubtedly have acted as local channelways. This is evidenced by an occasional substantial vein-like concentration of sulphides and by the pods of massive sulphides. The forms and attitudes of the sulphide pods are not clearly known but the pods are confined to originally calcareous rocks and usually occur adjacent to pre-mineral faults. Individually, the pods are typical replacement ore bodies related to pre-mineral breaks. Collectively, though, they are constituents of a large zone of disseminated sulphides.

All formations within the zone of hydrothermal alteration contain copper, but some contain more than others. As an average, the originally calcareous rocks, tactite, and hornfels, carry the most copper per unit volume; argillite has less; and quartzite and monzonite have the least. Bedding contacts, particularly between tactite-hornfels and quartzite, often mark a sharp change in copper content.

Leaching and enrichment of copper are confined to a thin layer at the top of bedrock (fig. 43). The amount of supergene copper present is trivial as compared to the amount of chalcopyrite which once must have existed in the eroded part of the mineralized zone.

Although the tactite-hornfels is of the type commonly termed contact metamorphic or pyrometasomatic, the mineralogical variations in this deposit show no particular spatial relationship to the monzonite. The monzonite is also hydrothermally altered by the same processes which altered the sedimentary rocks. The inference is drawn that the mineralization process is hydrothermal-metasomatic rather than pyrometasomatic, and is unrelated to any specific contact action of the monzonite. Hydrothermal-metasomatism is envisioned here as involving two mechanisms: (1) Transportation of materials in fluids circulating along faults and fractures; and (2) transfer through unfractured rock by ionic diffusion. The latter may have functioned extensively.

The Mission deposit contains many of the principal geological elements of the socalled porphyry copper-type of deposit. It differs only in the magnitude of certain features. For example, the monzonite porphyry body is small in proportion to the size of the mineralized zone, and the amount of ore in the hydrothermally altered sedimentary rocks is large in proportion to that in porphyry. Disseminated sulphide ores in altered sedimentary rocks similar to those of the Mission deposit are components of a number of porphyry copper ore bodies -- Ely, Morenci, Santa Rita, and Bingham Canyon, for examples.

Acknowledgments

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