4810 0002

February 3rd

TO DAN HART, U of Nevada - 1977
Home ph 786 6432
784-6067
cy. (Slemmons)

Dear Dan:

Thank you very much, indeed for passing your paper on the Big Mike minerology along to me. I think you have done a real fine job on the problem (though I'm not yet convinced that all of the mineralization is volcanigenic in origin) and I wish we had the benefit of your work when we were drilling the property. I'll be passing the paper along to Clair Chamberlain for his perusal soon.

There's a residential mine geology job opening up for a Jr. Geologist at Hawthorne very soon. If interested, give me a call.

Best regards,

Ward Carithers

4810 0002

270

Item 11

MINERALOGY AND PARAGENESIS OF THE ORES OF THE BIG MIKE MINE, PERSHING COUNTY, NEVADA

by
Daniel D. Hart

Geology 777
Ore Petrology
Dr. L. T. Larson
May 2, 1977

TABLE OF CONTENTS

INTRODUCTION

This project entailed the preparation and study of polished sections of ore specimens from the Big Mike Mine, Pershing County, Nevada. Ore specimens consisted of dump grab samples collected by Donald Hudson and Bruce Miller. A brief visit to the mine was also made. Historical and some geological information were obtained by verbal communication with Ward Carithers, a consulting geologist in Reno, Nevada. The purpose of this study was to identify the ore minerals present at Big Mike, describe their textural relationships, and determine their paragenesis.

LOCATION

The Big Mike Mine is located in Sec. 23, T31N, R39E, south of Winnemucca on the Grass Valley road. (See Figure 1.) It is situated at the west entrance to Panther Canyon between the southern end of the Sonoma Range and the northern end of the Tobin Range.

GENERAL GEOLOGY
(Refer to Figure 2)

Rocks in the vicinity of the Big Mike Mine are predominantly of Upper Paleozoic age. These consist of siliceous and volcanic eugeosynclinal rocks of the Western Assemblage. Deformation accompanied by thrusting of these rocks occurred during the Sonoma Orogeny of Late Permian age. Intrusion of granitics associated with Sierran plutonism

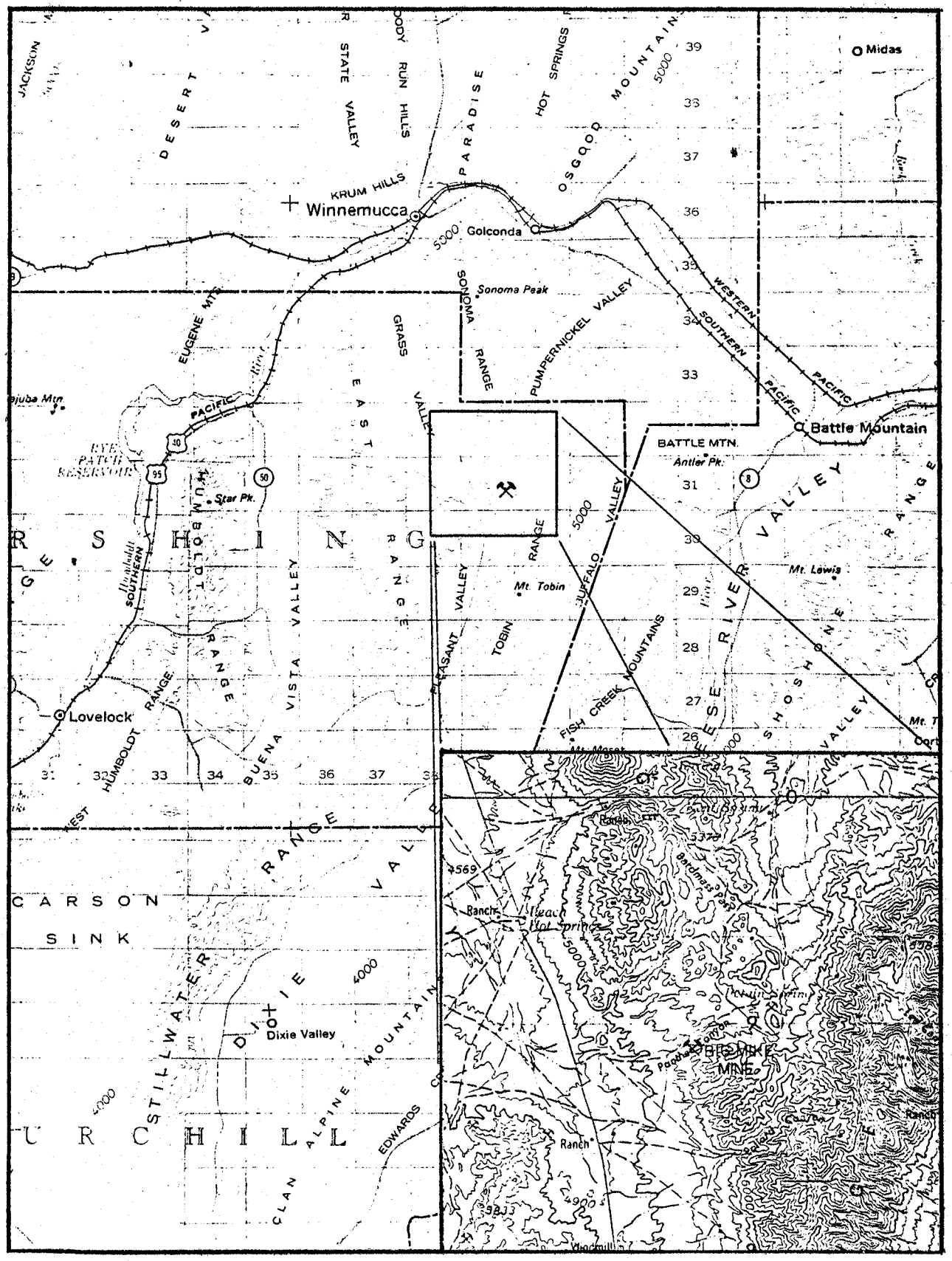


Figure 1: Location Map of Big Mike Mine, Pershing County, Nevada.

occurred in Late Jurassic or Early Cretaceous time. An erosional surface developed on these rocks was subsequently covered by Tertiary extrusives and sediments and subjected to Basin and Range faulting.

Local Stratigraphy

The oldest formation in the area is the Pumpernickle Formation of Early Pennsylvanian age which serves as the host for the Big Mike ores. It consists of greenstone, chert, and argillite with occasional interbeds of limestone. The greenstone varies from chlorite schist to andesitic pillow lavas and breccias. Interbedded sediments occur in the upper part of the formation and resemble those of the Havallah Formation. The Havallah Formation of Pennsylvanian and Permian age consists of discontinuous intertonguing beds of chert and quartzite, with minor limestone, slate, conglomerate, and sandstone. The Koipato Formation of Late Permian - Triassic age includes rhyolite, trachyte, and some andesite flows, breccias, tuffs, and minor clastic sediments. It unconformably overlaps older rocks.

Rocks of Triassic age include the China Mountain Formation, Prida Formation, Panther Canyon Formation, and Augusta Mountain Formation. The Triassic sequence overlies the Koipato Formation and other Paleozoic rocks with angular unconformity. They consist of conglomerate, shale, dolomite and limestone, and some volcanic flows. Some of the conglomerate pebbles have been identified as derivatives of the Koipato Formation.

Cenozoic rocks were deposited on a well developed erosional surface which formed after the Sierran Plutonism of Jurassic - Cretaceous age. Tertiary rocks include water-laid sediments, rhyolite, andesite and basalt flows which are, in part, contemporaneous with each other. Quaternary rocks consist of gravels of Pleistocene age, Recent alluvium, and hot spring sinter.

Structure

After deposition of the Pumpernickle Formation, there was an increase in orogenic activity in the source areas of clastics being supplied to the Permian sea. This is indicated by the sharp lithologic contrast between the Pumpernickle and Havallah Formations and slight unconformities seen between them elsewhere.

Extensive folding and thrust faulting associated with the Sonoma Orogeny took place in Late Permian time. The Pumpernickle and Havallah Formations occur in the upper plate of the Tobin Thrust, the major structure resulting from this period of deformation. The thrust fault shown on Figure 2 has been shown by later mapping (Silberling and Roberts, 1962) to be a normal fault.

Locally, the Havallah Formation has been removed entirely by erosion following the Sonoma Orogeny, and the Koipato Formation lies directly on the Pumpernickle Formation.

Cenozoic structure is mostly normal faulting related to the Basin and Range episode of faulting and is expressed in the present topography.

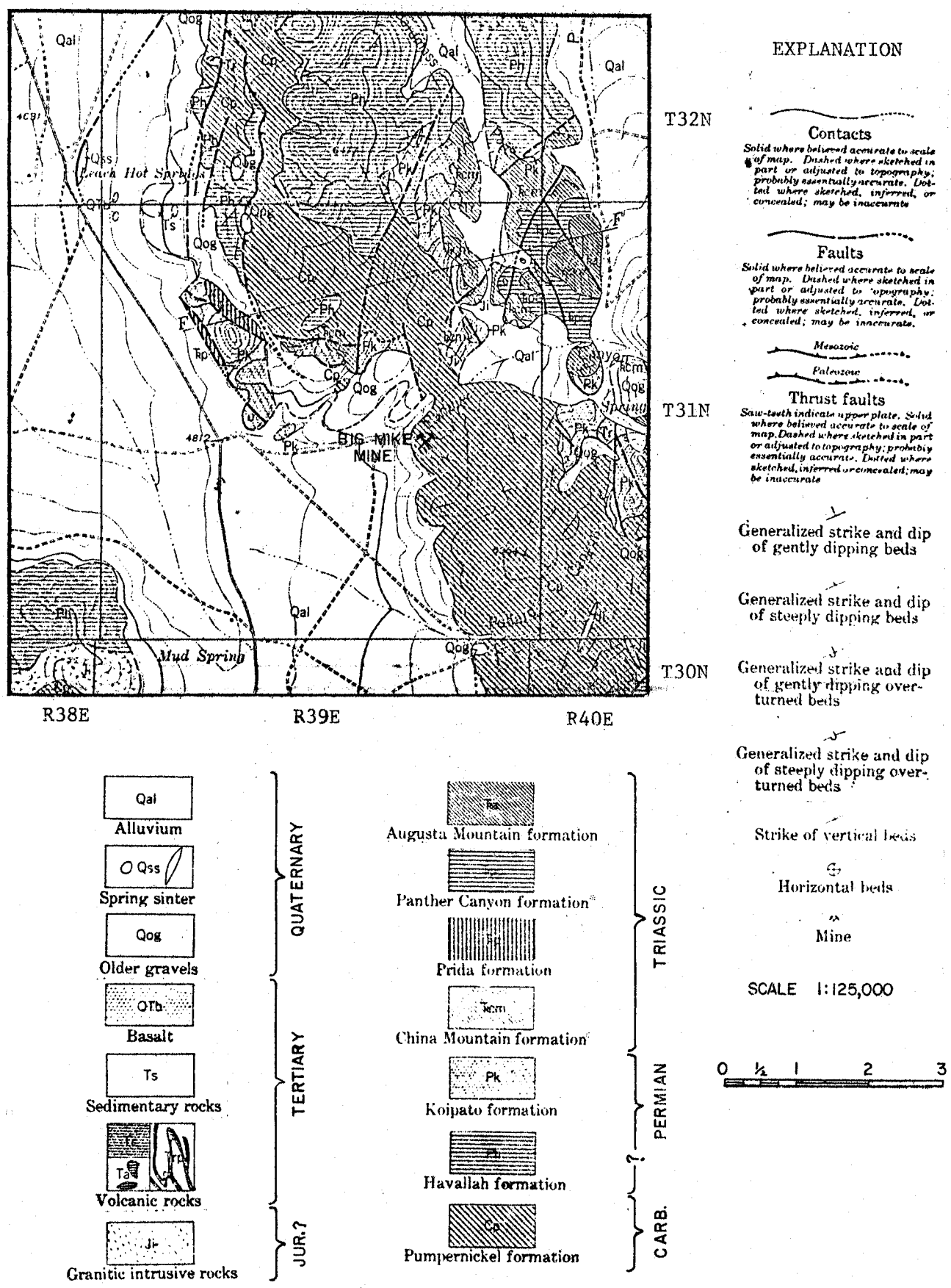


Figure 2: Geologic Map of Big Mike Mine Area. After Ferguson, et. al., 1951, USGS GQ-11.

THE BIG MIKE MINE

Geology

The orebody at the Big Mike Mine is a steeply dipping (approx. 45° NE) elongate lens of massive iron and copper sulfides. It occurs entirely within the Pumpernickle Formation. Specifically, it lies at the interface between andesitic pillow lavas and breccias and overlying chert, shale, and minor black shale. Drill data indicate the presence of limey sediments beneath the pillow andesites. A thin veneer of hot spring sinter occurs above the gossan. A northeast dipping normal fault with small displacement transects the orebody. Several smaller faults intersect the pit at various angles. A near-vertical, approximately north-striking dacite (?) dike cuts the east side of the pit. Both the faulting and the dike appear to be unrelated to the mineralization. (Ward Carithers, personal communication).

History and Production

The first claim staked on the site of the Big Mike Mine was by Willard O. Zilkey of Winnemucca for a gold show. Clair C. Chamberlain, an engineer in the employ of Goldfield Consolidated, recognized the potential for mineralization on the site. He leased the prospect from Zilkey in 1966 and formed the Big Mike Corporation, consisting of nine claims. Chamberlain outlined the area of secondary copper mineralization by air track drilling. He mined some ore from a small pit in 1966 and 1967.

Cerro Corporation leased the property from Chamberlain in late 1967 and performed geochemical and geophysical surveys of the property. In the spring of 1968 Cerro hired Ward Carithers to guide a drilling program. By mid-1969, a small orebody of massive sulfides had been delimited. The core data indicated approximately 75,000 tons of 12% (ave.) copper and 38,000 tons of 3% copper from mixed oxide and sulfide ore. Cerro, after making feasibility studies for a mill, preferred a somewhat larger deposit and sold it to Rancher's Exploration and Development Company in late 1969.

Dravo Corp. mined the property for Ranchers during 1970. The high grade sulfide ore was shipped to a smelter in West Germany. About 300,000 tons of ore were stockpiled at the mine site, and 300,000 tons remained to be mined at the end of 1970. The U.S. Bureau of Mines records indicate 9682 short tons of copper were produced in Pershing County for that year, almost all of which came from the Big Mike mine.

Rancher's built a cement copper plant in 1971 and produced 66 short tons (USBM records) of copper from 164,000 tons of stockpiled ore that year. Production figures for 1972 and 1973 are 603 and 682 short tons respectively. Rancher's is continuing the leach operation within the pit at the present time.

MINERAL DESCRIPTIONS

Thirteen polished sections of the Big Mike ores were prepared and studied. The ore mineralogy consists entirely of sulfides. Primary sulfides are pyrite, chalcopyrite, and sphalerite. Secondary sulfides are digenite, covellite, and melnikovite-pyrite.

Pyrite (FeS_2) - Pyrite is the most abundant mineral occurring in the Big Mike ores. It appeared in all sections varying from 100 to about 15 percent of total sulfides. Crystal shape varies from euhedral to anhedral. There appear to be three types of pyrite, based on morphology and internal structure.

One type tends to form larger phenocrysts and is clear of flaws and inclusions, except for occasional inclusions of chalcopyrite. This type also displays much better crystallinity than the other types, sometimes forming perfect crystal outlines. It has been brecciated subsequent to its formation. Figure 3 is an example of the breccia texture showing later veining and cementation by covellite. This texture is best developed where the pyrite is the dominant sulfide. Many of the pyrite grains have inclusions of chalcopyrite which show no apparent connection with the outside of the pyrite grain. In some instances, pyrite occurs as veins in chalcopyrite (See Figure 4) which even later has been fractured and veined with digenite.

The second type almost never displays good crystal faces. Colloform growth banding can be seen in some grains. (See Figure 5.) The banding

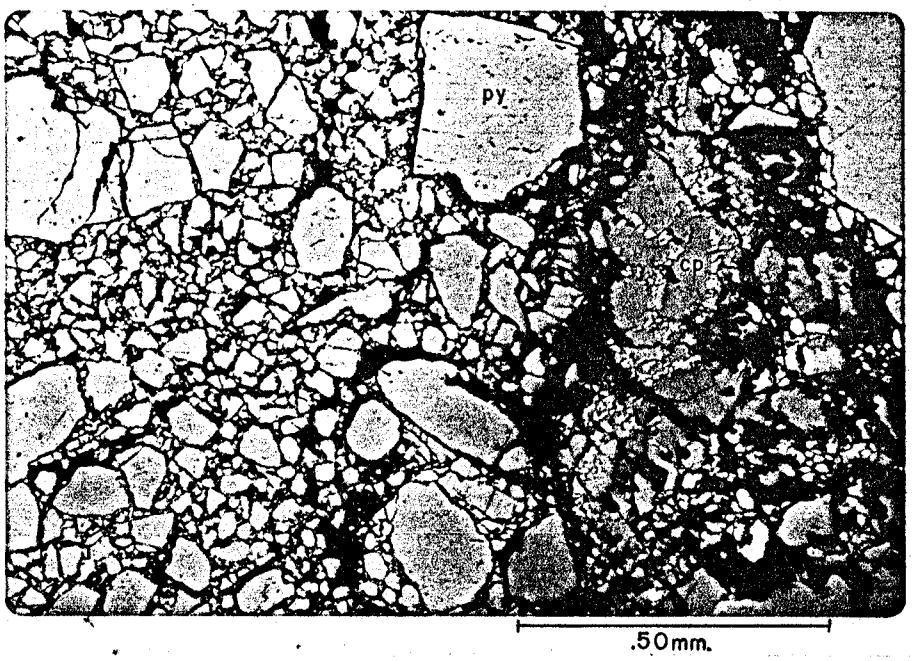


Figure 3: Breccia texture in pyrite. Veining and cementation by covellite.

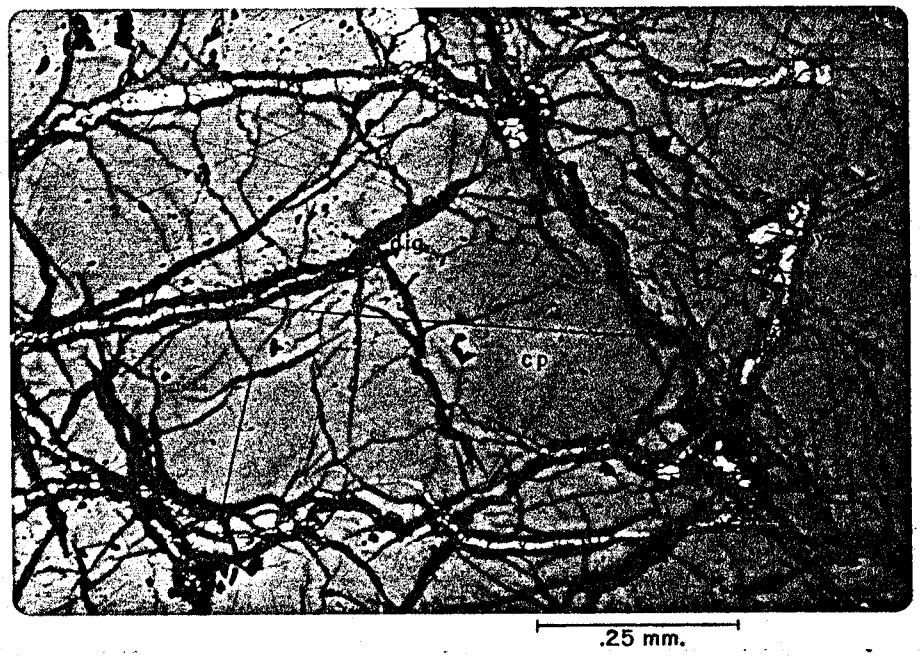


Figure 4: Chalcopyrite veined by pyrite. Digenite veining along the earlier pyrite vein.

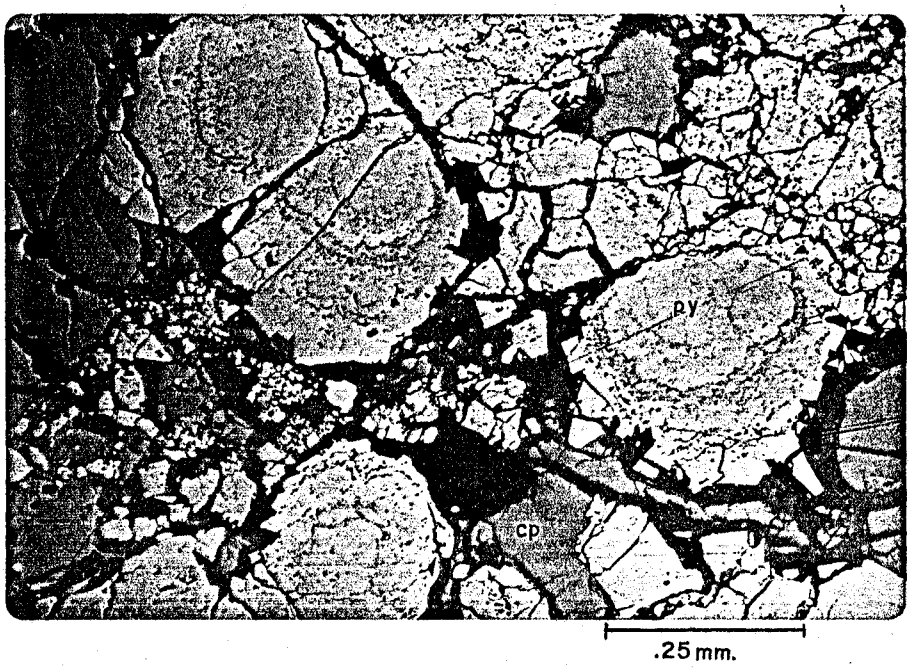


Figure 5: Colloform growth banding in pyrite.

appears to be due to minute unidentifiable inclusions and/or pores. In a few instances chalcopyrite was seen incorporated in the growth bands. This could either be due to simultaneous deposition or to penetration of the chalcopyrite into the pores after the pyrite had already crystallized. This type of pyrite also shows fracturing and cementation by later sulfides. Textural relations with gangue suggest simultaneous deposition and continued deposition of pyrite after crystallization of the gangue was complete. Some of the inclusions in the growth bands of the pyrite may be gangue. The pyrite may also have preceeded the gangue slightly. Pyrite can also be seen as fine overgrowths rimming the "clean", apparently earlier pyrite, accompanied by a little corrosion of its faces. This texture grades outward into the gangue as finely dispersed infiltrations, possibly along shrinkage cracks or replacement along crystal surfaces. It is also seen as a rim texture on the gangue. (See Figure 6.)

The third type of pyrite is melnikovite-pyrite (or colloform pyrite. See Figure 7.) The color tends toward brownish shades. It is much softer than pyrite and can be as soft as galena, according to Ramdohr. It always displays colloform texture which can sometimes be seen to consist of radiating fibrous aggregates. It is usually seen around gangue. High magnification is required to see the internal structure. According to Edwards (1974, p. 21) it is precipitated as colloidal ferric hydroxide which has been converted to hydrous ferrous sulfide in the presence of H_2S, and later dehydrated to form pyrite. He states that it is a supergene product deposited from cold (?) aqueous solutions in pore spaces, but

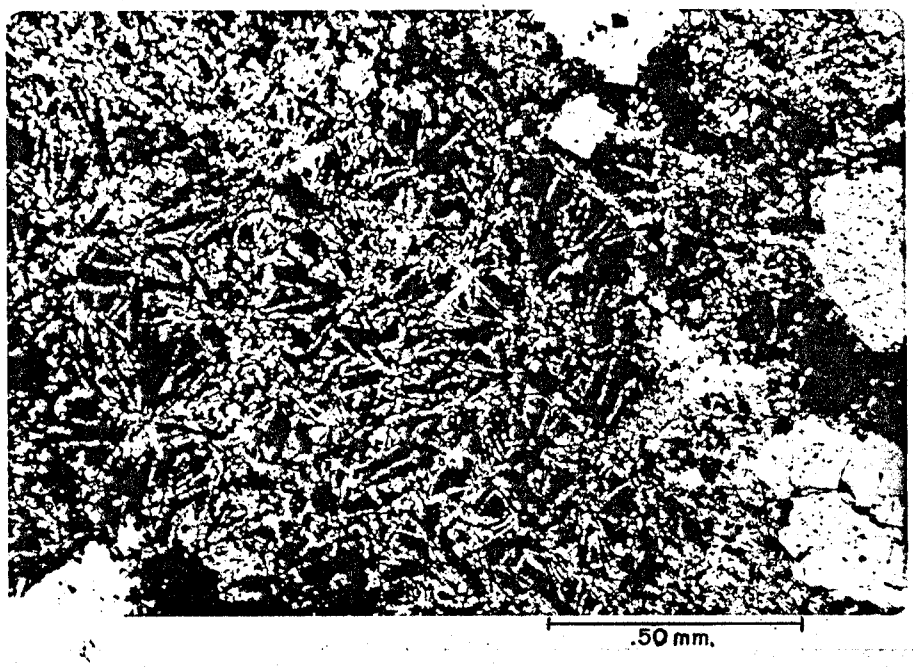


Figure 6: Finely dispersed pyrite infiltrations along shrinkage cracks or replacement along crystal surfaces of gangue grading into rim textures.

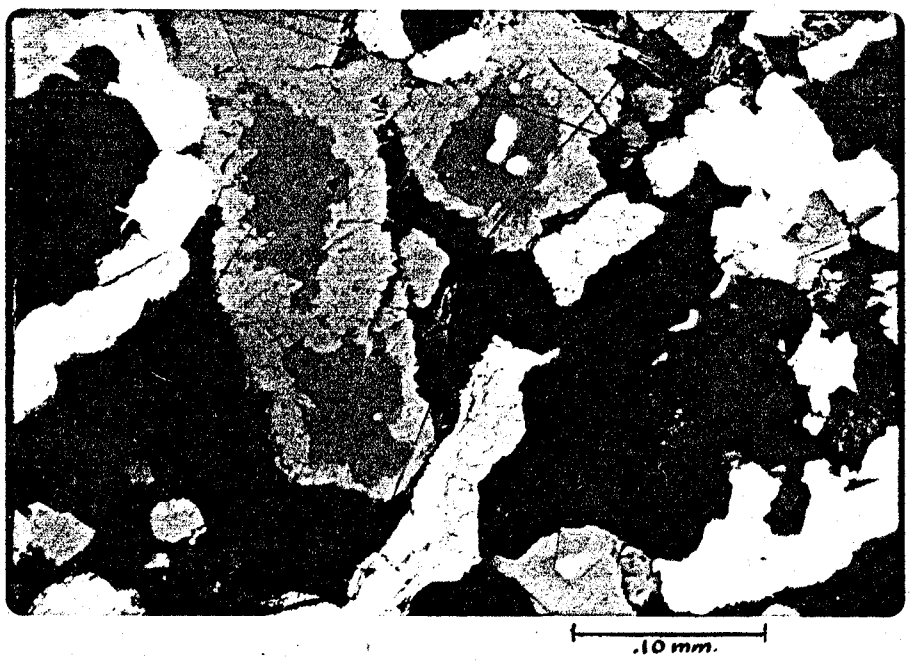


Figure 7: Melnikovite - pyrite.

may replace gangue. In these polished sections, it is obviously the latest mineral present. It is never seen deformed, veined, or replaced.

Chalcopyrite ($CuFeS_2$) - Chalcopyrite is the second most abundant sulfide in the ore. In polished section it constitutes up to 30 percent of total sulfides. It never shows good crystal faces and no twinning was observed.

Chalcopyrite occurs as inclusions and veins in pyrite, as exsolution and unmixing textures in sphalerite, and as a dominant mineral with inclusions of pyrite and sphalerite. Chalcopyrite as inclusions and veins in pyrite is discussed in the section on pyrite. Excellent exsolution textures of chalcopyrite with sphalerite are shown in Figure 8. The chalcopyrite has been exsolved along cleavage planes of the sphalerite. The larger blebs may be the result of unmixing of the two phases. Figure 9 shows mutual boundary texture between chalcopyrite and sphalerite.

A larger scale feature which may be difficult to spot under magnification is a crude mineralogical banding of the primary ore minerals, especially chalcopyrite and pyrite. This is shown in Figure 10. In slices of ore specimens and one polished section the banding is readily apparent. Bands can be seen deformed, more or less severely, into small folds. In Figure 10, a string of euhedral to subhedral pyrite roughly parallels the band of chalcopyrite. This indicates simultaneous deposition of the two minerals, or alternating periods of dominance of one phase over the other.

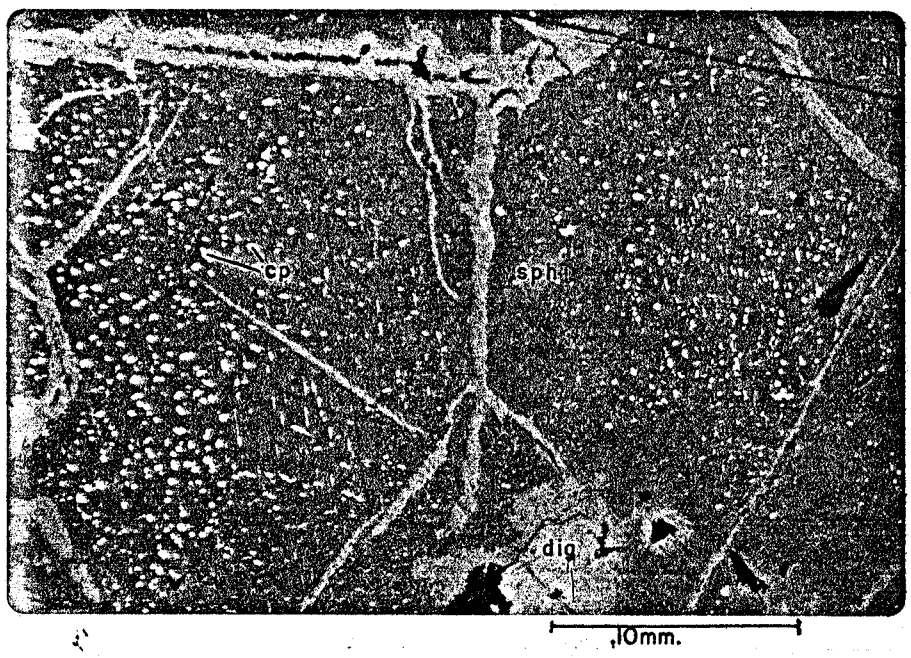


Figure 8: Exsolution of chalcopyrite along cleavage planes of sphalerite.

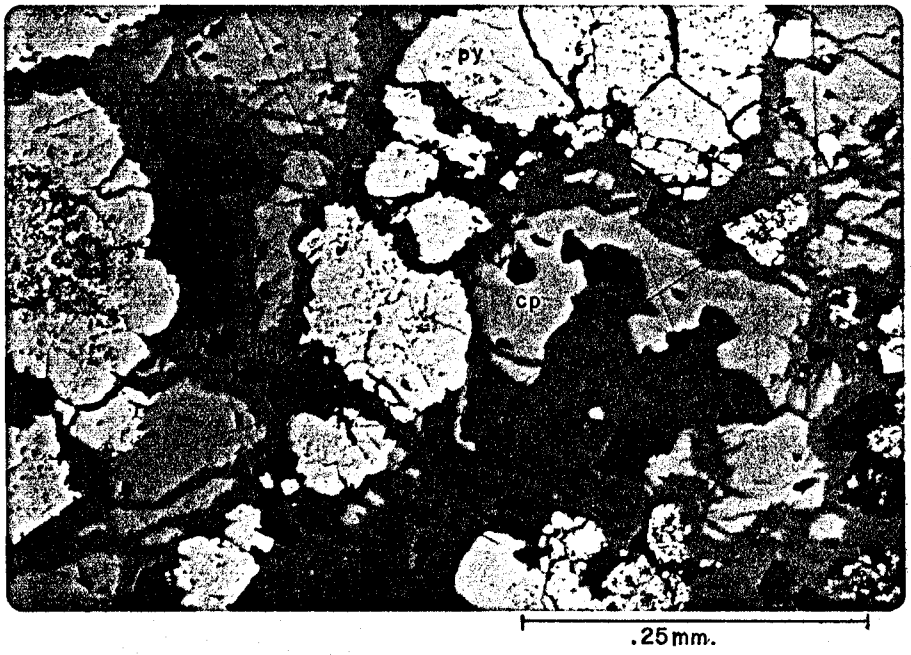


Figure 9: Mutual boundary texture between sphalerite and chalcopyrite. Pyrite, chalcopyrite, and sphalerite veined by digenite.

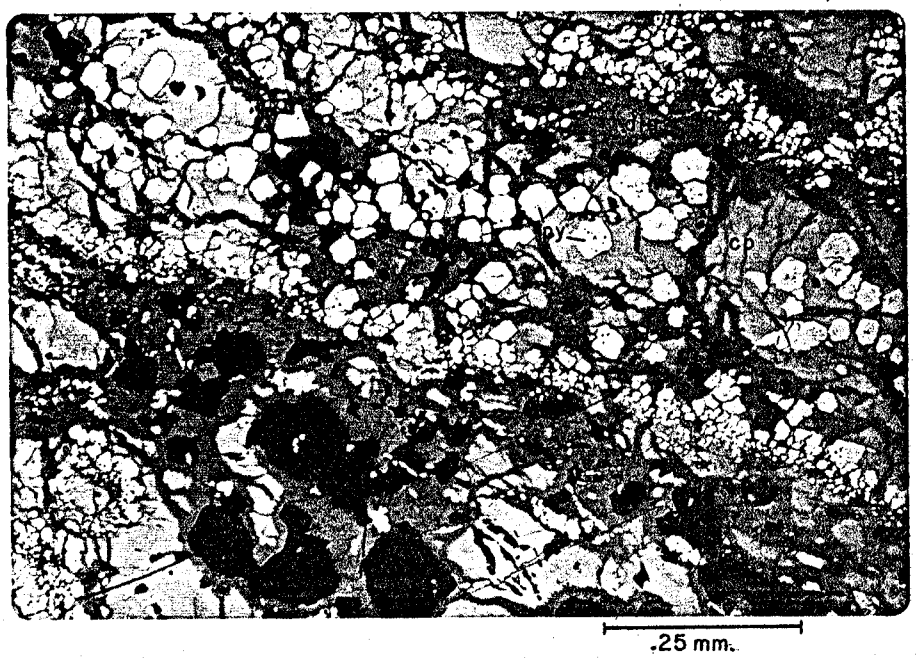


Figure 10: Crude mineralogical banding of pyrite and chalcopyrite.

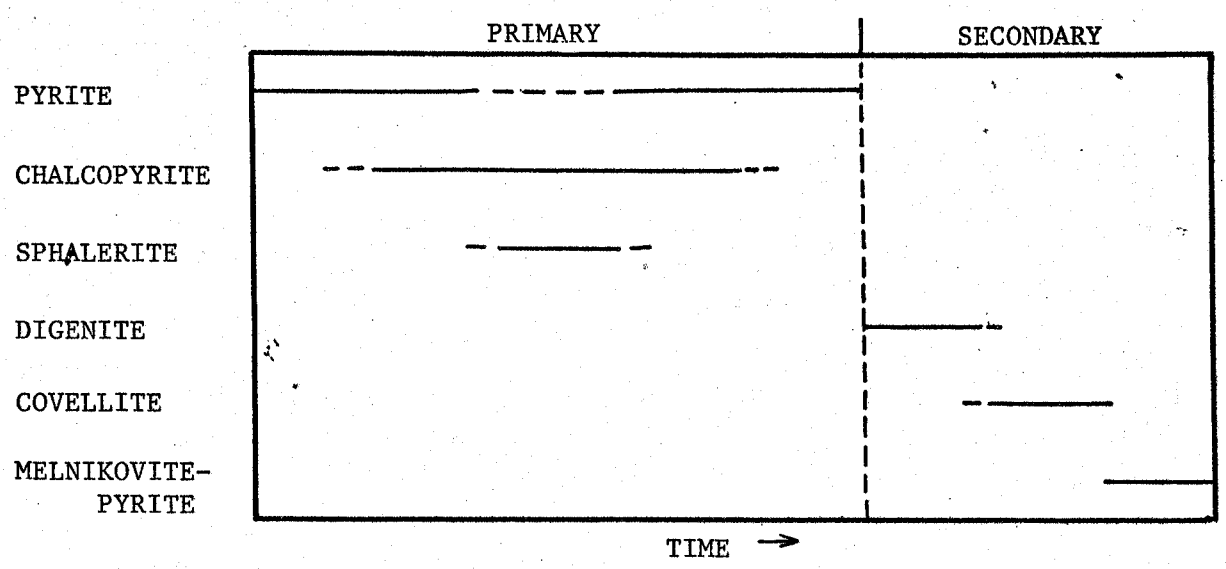
Sphalerite (ZnS) - Sphalerite is the least abundant primary sulfide. It constitutes up to 3 to 5 percent in selected specimens, but over the whole orebody is negligible. Sphalerite is seen as granular allotriomorphic grains and often displays mututal boundary texture with chalcopyrite (Figure 9). This texture indicates simultaneous deposition of the two phases. It is also seen to exsolve chalcopyrite along its cleavage planes as discussed earlier. In very few instances is sphalerite seen to enclose pyrite grains.

Digenite (Cu_9S_5) - Digenite, distinguished from chalcocite (Cu_2S) by a bluer color in reflected light and by its X-ray powder diffraction pattern, makes up most of the secondary sulfide mineralization. It reaches a maximum total sulfide percentage of about 25 percent in the polished sections. Digenite is clearly of secondary origin as it veins all of the primary sulfide minerals. Figure 9 shows veining of all three primary sulfides by digenite in a cementation texture. Digenite is also seen replacing chalcopyrite along cleavage planes in some areas. Replacement of pyrite has been minimal. Slight rounding of some grains was observed, however. This may have occurred during brecciation.

Covellite (CuS) - Covellite was seen in only a few of the polished sections (Figure 3). It appears to be later than the digenite since it can be seen as an apparent alteration of the digenite in a nondescript texture. In some places the digenite has been completely altered to covellite.

PARAGENESIS

The paragenesis of the Big Mike ores, determined from previously mentioned textures, is as follows:



Because of the large and near perfect grains of pyrite which are often included in chalcopyrite, it is interpreted to be the first sulfide to begin crystallization. Fracture fillings of chalcopyrite in pyrite indicate that chalcopyrite is later than the pyrite. However, occurrences of pyrite veins in chalcopyrite suggest a subsequent deposition of pyrite. Two stages of deposition or continuous deposition of pyrite are possible and will be discussed further in the conclusions.

Sphalerite was deposited simultaneously with chalcopyrite, as indicated by the exsolution textures and mutual boundaries. The general lack of pyrite inclusions in sphalerite (with exceptions) could indicate that pyrite was not deposited at the same time. However, it is felt that because of the small quantity of sphalerite, and its generally small size,

it is simply a statistical problem.

Digenite is seen in all instances to be conclusively secondary to the three primary sulfides. Its occurrence as fracture fillings indicates some deformation or crushing of the orebody prior to deposition of the digenite which is probably a supergene enrichment.

Covellite appears to be later than the digenite and may be the result of changing Eh-pH conditions.

The melnikovite-pyrite is believed to be the latest sulfide deposited. It is never seen to be deformed, veined, or replaced. Since it is almost always seen associated with a piece of gangue, it may be a replacement of the gangue. Ramdohr (p. 796) suggests that its low temperature of formation restricts its occurrence to sedimentary deposits, or to low-temperature thermal springs. Geochemical maps around the orebody indicate mercury anomalies whose locations and trends are closely associated with young faults. In fact, the mercury anomalies continue along structure to the range front at Leach Hot Springs, only one mile distant. This evidence and the thin veneer of sinter over the gossan suggest that the melnikovite-pyrite is a product of recent hot spring activity.

CONCLUSIONS

This study has outlined several characteristics of the Big Mike Mine which bear strong similarity to the classic volcanigenic massive sulfide (pyritic) ore deposit. Recent summaries on the subject of pyritic ore deposits are by Smirnov (1970), Kinkel (1966) and Tatsumi (1971).

The particular similarities of the Big Mike Mine with those documented in the literature are as follows: (1) regional geologic setting; (2) shape and attitude of the orebody; (3) ore mineralogy and textures; and (4) consanguineous associations.

Pyritic deposits which are cited in the literature as having a volcanigenic origin tend to occur at the top of thick volcanic eugeosynclinal piles. The Pumpernickle Formation, which is the host for the Big Mike ores, is known to have been deposited in an eugeosyncline of Permian age. Specifically, the ore body is overlain by cherts, shales, and black shales, which is characteristic of the upper part of the formation.

Virtually all orebodies cited as examples are lenticular in shape and most are strataconformable. This is especially true of the Big Mike.

Pyrite is recognized by all workers as the main sulfide mineral of volcanigenic massive sulfide deposits. Other common ore minerals are found to be chalcopyrite, bornite, sphalerite, and sulfosalts in varying amounts. Textures found in the Big Mike ores supportive of volcanigenic origin are the breccia texture, colloform pyrite and mineralogical banding.

Smirnov suggests three stages exist in the formation of pyritic ore. Stage 1 is pre-ore preparation of the host rock by high-temperature acid and gaseous solutions. Stage 2 is accumulation of pyrite accompanied by porosity increases. Between stages 2 and 3 is a time gap in which metamorphism and brecciation of the pyrite may take place. Stage 3 is deposition of the primary economic minerals. Textural evidence from the Big Mike ores does not clearly indicate two separate stages of primary sulfide accumulation

separated by a period of deformation. Rather, continuous deposition of sulfides is indicated with a possible lull in pyrite accumulation during the main stage of chalcopyrite and sphalerite accumulation. If the Big Mike is indeed a volcanigenic massive sulfide which formed at or near sea bottom, crushing and compaction of the ore body during deposition as a result of increasing sedimentary (or volcanic) load could account for all of the textures displayed between pyrite and chalcopyrite.

Bilibin (1967), Kinkel (1966), and Smirnov (1970) find that, consanguineous with pyritic deposits, are deposits of barite, manganese and iron hydroxides, and jasper of exhalational-sedimentary origin. This is again confirmed, in the case of the Big Mike, by manganese deposits apparently syngenetic with their host. (Ferguson, 1951). Nine miles north of the Big Mike Mine is the Black Diablo manganese mine. Its host is chert, argillite, and intercalated greenstones of the Pumpernickle Formation. Other manganese occurrences are in Pollard and Grand Trunk Canyons on the west side of the Tobin and Sonoma Ranges and the Black Diamond Mine just north of the Black Diablo Mine. These all occur in the Pumpernickle Formation.

The evidence gathered herein indicates that the Big Mike is a volcanigenic massive sulfide deposit. Further study of the wall rock alteration and gangue minerals may lend further support to this conclusion.

BIBLIOGRAPHY

Edwards, A. B., 1974, Textures of the Ore Minerals and their Significance: Australian Institute of Mining and Metallurgy (Inc.), Melbourne.

Ferguson, H. W. et. al., 1951, Geology of the Winnemucca Quadrangle: U. S. G. S. Geol. Quad. Map- GQ-11, 1:125,000.

Kanehira, Keichiro and Tatsumi, Tatsuo, 1970, Bedded Cupriferous Iron Sulfide Deposits in Japan: in Volcanism and Ore Genesis, Univ. of Tokyo Press, Tokyo.

Kinkel, A. R., 1966, Massive Pyritic Deposits Related to Volcanism and Possible Methods of Emplacement: Econ. Geol. v. 61, p.673 - 694.

Maucher, A. and Rehwald, G., 1960, Bildkartei der Erzmikroskopie (Card Index of Ore Photomicrographs): Umschau Verlag, Frankfurt, Germany.

Minerals Yearbook, U. S. Dept. of the Interior, Bureau of Mines, 1967 - 1973.

Ramdohr, P.,1969, The Ore Minerals and their Intergrowths: Pergamon Press, 1174 p.

Silberling, M. J. and Roberts, R. J., 1962, Pre-Tertiary Stratigraphy and Structure of Northwestern Nevada: G. S. A. Spec. Pap. 72.

Smirnov, V. I., 1970, Pyritic Deposits - Part 1: Int. Geol. Rev. v. 12, #8, p. 881 - 908.

_____, Pyritic Deposits - Part 2: Int.Geol. Rev., v. 12, #9, p.1039-1052.