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MINERALOGY AND GEOLOGY OF THE ZGOUNDER SILVER DEPOSIT IN MOROCCO*

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Abstract

The Zgounder deposit, one of the few known silver deposits in Morocco, consists of mineralized pockets in sedimentary rocks and diabase. Silver is enriched at diabase-sediment and rhyolite dyke-sediment contacts. The pockets contain narrow, mineralized veins of chlorite, of quartz, of siderite, and of disseminated ore minerals. The ore minerals in the veins occur in five silver-bearing assemblages. Most of the silver occurs as native, mercurian silver (amalgam), but some is present as silver sulphides and sulphosalts, and some as minute inclusions, up to 0.1 micron in diameter, of an unidentified silver-copper-antimony mineral in galena. Some of the disseminated ore minerals in the sedimentary rocks are unrelated to the veins and are interpreted as products of contemporaneous deposition in a sedimentary horizon. The ore minerals in the veins are thought to have been mobilized from similar sedimentary horizons and redeposited in veins.

Introduction

The Zgounder deposit, one of the few known silver deposits in Morocco, is in the Anti-Atlas mountains about 200 km east of Agadir (Fig. 1). The deposit was exploited during the 12th and 13th centuries (Hatier 1967) and numerous pits and dumps from this operation are still evident. More recent exploration began in 1950 and has continued intermittently, but no silver has yet been mined. The deposit was studied by the author in 1973 under the auspices of the Canadian International Development Agency.

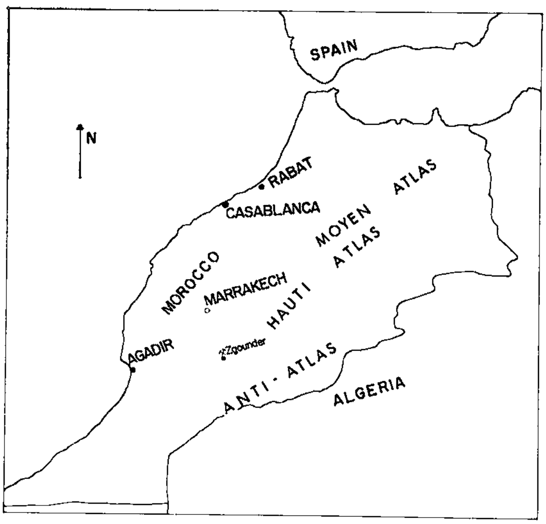


FIG. 1. Location of the Zgounder deposit.

General Geology

The area is underlain by a series of sedimentary and volcanic rocks intruded by diabase, gabbro, granite, granophyre, and rhyolite dykes (De Mange 1972) (Fig. 2). These rocks have been classified as Precambrian III (De Mange 1972). They occur as a window, 2.4 km wide, between younger cover rocks on the east and an undated granite on the west. The main rocks near the deposit are sediments, rhyolite, rhyolite dykes and diabase (Fig. 3A). The sediments, classified as the Brown Series, include pelite, quartzite, and greywacke and are enriched in quartz, chlorite, rutile, anatase, and leucoxene near fractures and in graphite near diabase. The sedimentary rocks strike east and dip steeply south.

The rhyolite occurs south of the Brown Series sediments and although their contact generally parallels the bedding, cross-sections indicate that it is irregular (Figs. 4A, 4B).

A rhyolite dyke in sediments, about 5 m wide, was found by company geologists at a diabase-sediment contact about 5 m from the rhyolite-sediment contact.

The diabase occurs as a sill-like body near and parallel to the rhyolite-sediment contact. On surface the diabase body is about 20 m wide and continues intermittently across the map-area but is offset in many places by cross-faults (Fig. 3A). In cross-section, it is approximately wedge-shaped and pinches out at 100 to 200 m below surface (Figs. 4A, 4B). The rock is composed of coarse-grained feldspar

*Mineral Deposits Contribution #13.

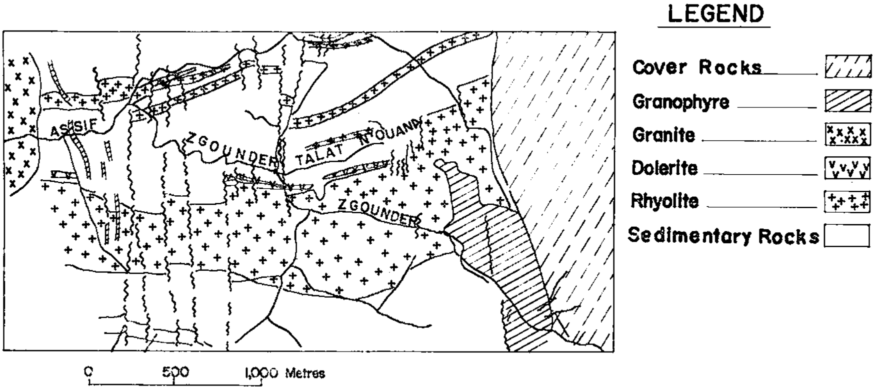


FIG. 2. Geological map of Zgounder area (from De Mange 1972).

laths with interstitial pyroxene. The proxene contains numerous small ilmenite grains, some partly replaced by pyrite. Near faults and in the mineralized zones the ilmenite is altered to anatase and the pyroxene and feldspar to chlorite, quartz, calcite, siderite and clay minerals.

This region is cut by a series of northerly faults which offset the rhyolite-sediment and diabase-sediment contacts, and by weaker easterly faults. Studies by BRPM geologists have shown that there is a correlation between the frequency of faults and silver mineralization, and that most of the native silver found to date occurs in the northerly faults. However, in sedimentary rocks much of the sulphide mineralization is in easterly faults (BRPM confidential reports).

CHARACTERISTICS OF THE DEPOSIT

Mineralized zones

Four mineralized zones are indicated by pits from the earliest mining operations. Three zones, referred to as Nos. 1, 2, and 3 in this paper, occur near the north diabase-sediment contact (Fig. 3A); a fourth (Zone 4) is in sedimentary rocks about 100 m north of the diabase. The presence of ore minerals has been confirmed in Zone 1, and the extent of the mineralized zone has been partly defined by underground workings and diamond drilling. Zones 2, 3 and 4 have not yet been explored, but some ore minerals were found in underground workings near Zone 2, and some in a drill hole near Zone 4. In addition, sporadic occurrences of ore minerals have been found by diamond drilling in sedimentary rocks between Zones 1 and 4 (Fig. 3B).

The ore minerals occur in narrow veins and as disseminated grains in the rock. Some parts of Zone 1 contain many mineralized veins plus a significant quantity of disseminated material, henceforth collectively referred to as "pockets". The rock between the pockets, though generally barren, does contain a few isolated mineralized veins. No pockets have been found in Zones 2, 3 and 4, but it is assumed these zones have characteristics similar to Zone 1 and do have pockets. Silver appears to be the only element of economic interest in the pockets although a wide variety of ore minerals in five different assemblages are present.

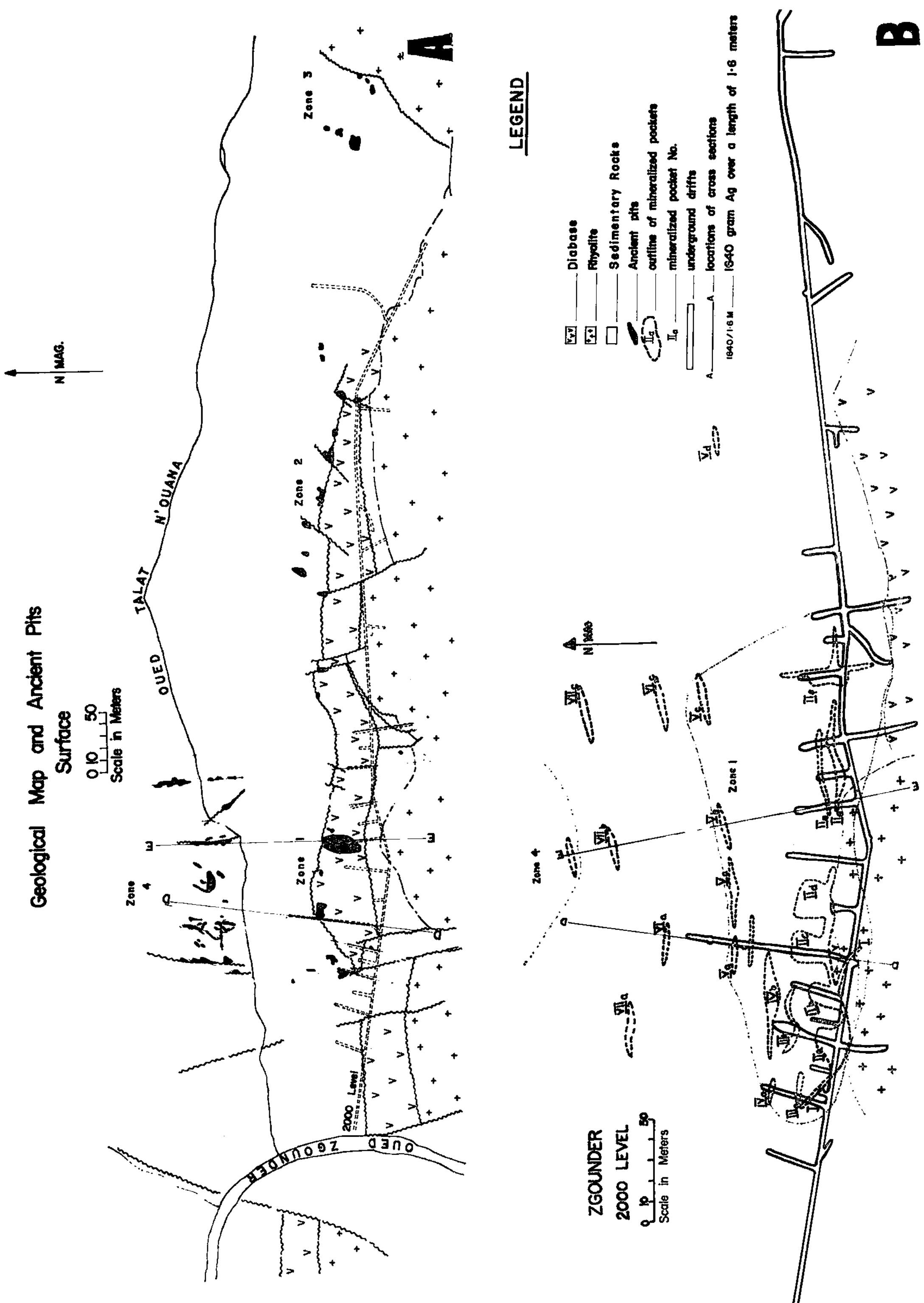
Mineralized pockets

The pockets occur in several geologic environments which include: (1) the diabase-sediment contact (2) a rhyolite dyke-sediment contact (3) sediments directly below the diabase (4) east-west faults in sediments and (5) north-south faults — in both diabase and sediments.

(1) Mineralized pockets, up to 30 m in diameter, occur intermittently along the diabase-sediment contact. They contain much native silver and form a high-grade silver ore which extends several meters into both the diabase and sediments. A sample collected from the 2100 level, 1 m from the contact, contained 1737 grams Ag/ton (50.66 oz/ton).

(2) A mineralized pocket at a rhyolite dyke-sediment contact is indicated by the occurrence of leaf silver on the 2000 level at 170 m from the adit portal and in drill hole S-2 (reported in BRPM drill hole logs) which followed the contact (Fig. 3B, pocket I, and Fig. 4A).

(3) Ore minerals in sediments directly below the diabase occur in a series of pockets aligned in an easterly direction and separated by barren rocks (Fig. 3B, pockets II_a to II_f, and Figs. 4A, 4B). These pockets, up to 15 m wide and



FIGS. 3A & 3B. Surface and 2000 level (modified from BRPM plans).

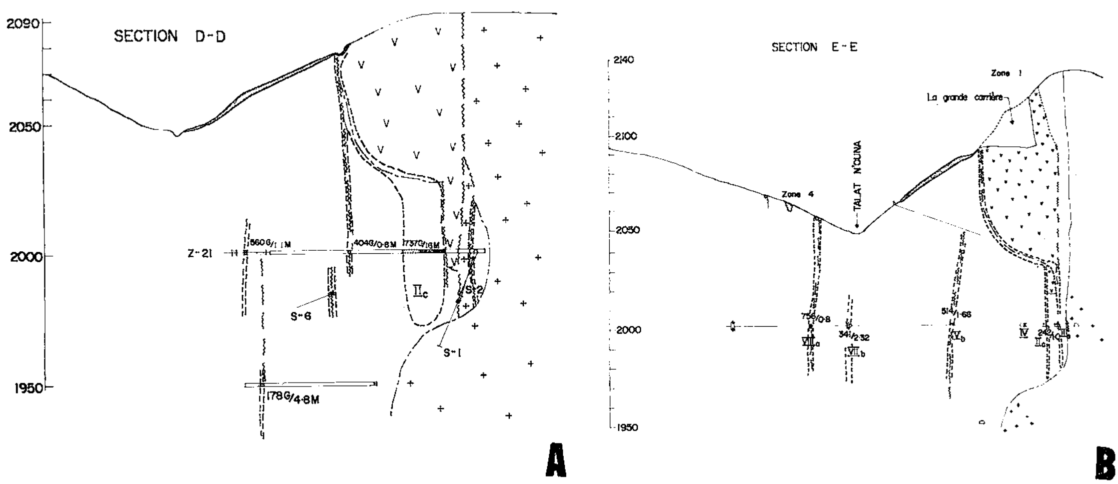


FIG. 4A. Cross-section D-D looking east. FIG. 4B. Cross-section E-E looking east.

50 m long, contain 400 to 1000 grams Ag/ton. It was observed that pockets II_b, II_c and II_e, which are rectangular in plan, contain several parallel east-west veins and disseminated ore minerals in the rock between the veins.

An understanding of the rectangular shape of these pockets is afforded by the polished surface of a drill core showing a series of veins parallel to the bedding of the rock and disseminated minerals between the veins (Fig. 5A). The veins end abruptly at mineralized cross-veins which follow small fractures. It may be interpreted that this polished surface is a small-scale representation of the mode of occurrence of the ore in the pockets, and that the pockets are blocks which contain a series of parallel east-west mineralized veins terminated by mineralized north-south veins.

(4) Pockets in sediments near vertical east-west faults are indicated from drill hole data and underground workings by an alignment of assay values into one plane (pockets V_a, V_b and V_c, Figs. 3B, 4B).

(5) One mineralized pocket was found in association with a northerly fault in diabase on the 2100 level and another in sediments on the 2000 level. These pockets contain mineralized veins and disseminated grains of ore minerals (Fig. 5B) up to 2 m from the fault. An assay of mineralized diabase 0 to 2 m from the fault on the 2100 level gave 2400 grams Ag/ton (70 oz/ton). The northerly faults are up to 10 cm wide and consist of fault gouge. The gouge from the fault in diabase contains 35% siderite, 30% chlorite, 30% quartz, and 5% feldspar, and trace amounts of chalcopyrite, sphalerite, pyrite, galena, bornite, and arsenopyrite.

Veins in mineralized pockets

The mineralized pockets contain a variety of veins along incipient fractures and bedding planes (Figs. 5A to 5D). These veins, which strike east, north, and northwest, are short and range from hair thickness to 4 cm in width, although most are 1 to 10 mm wide.

Several vein types, including those of chlorite, quartz, siderite, and ore minerals have been identified. Chlorite veins predominate and are generally barren. Some, however, contain ore minerals, and a few change along strike from barren chlorite to mineralized chlorite to ore veins. In addition, some chlorite veins have a quartz core and both the chlorite and quartz contain ore minerals.

Quartz veins are less common than chlorite veins but are wider. Some consist of barren quartz and some contain massive as well as disseminated ore minerals.

Siderite veins are narrow and contain disseminated grains of ore minerals.

The ore-type veins consist of masses of ore minerals distributed irregularly in a chlorite, quartz, and siderite matrix together with trace amounts of spinel, anatase, and talc. Some types can be classified as pyrite, others as sphalerite, still others as sphalerite-silver sulphides, and a few as native silver.

Ore-mineral assemblages in the veins

The ore minerals in the veins occur in five distinct assemblage: (1) pyrite-native silver (2) sphalerite-galena (3) sphalerite-galena-chalcopyrite-tennantite (4) silver sulphides and (5) native silver.

(1) The pyrite-native silver assemblage is the main one in diabase and a common one in sedimentary rocks. It consists essentially of pyrite with small amounts of arsenopyrite and contains most of the silver in the deposit. The pyrite occurs as either distinct pyrite veins or as pyrite

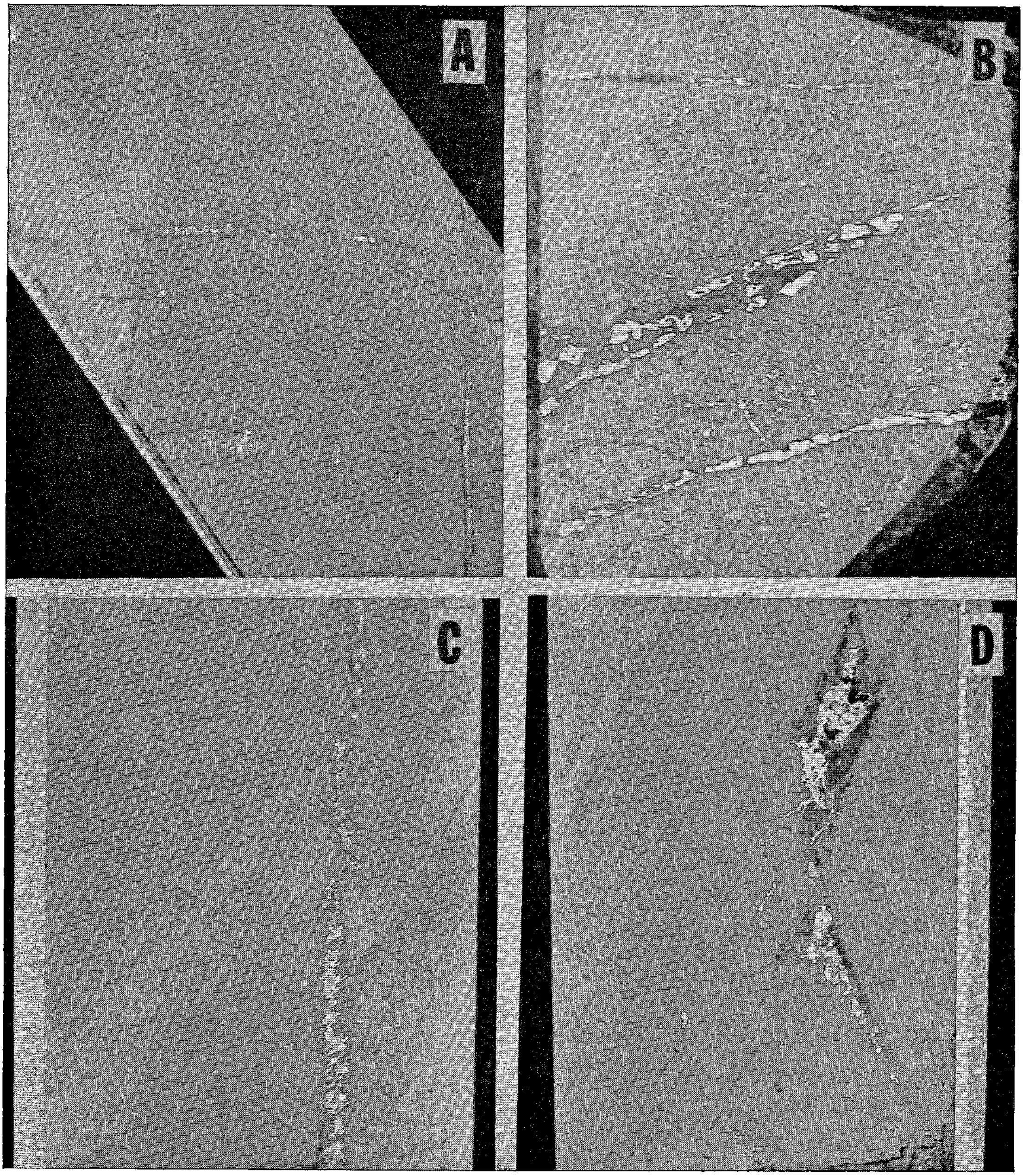


FIG. 5A. Polished face of a drill core (2.75 cm wide) showing mineralized bedding plane veins terminated by mineralized cross-veins.

FIG. 5B. Polished face of a hand specimen (5 cm high) showing mineralized veins and disseminated ore minerals in the diabase near the north-south fault on the 2100 level.

FIG. 5C. Polished face of a drill core (2.75 cm wide) showing a mineralized vein (sphalerite-galena assemblage in chlorite) at an angle to the bedding.

FIG. 5D. Polished face of a drill core (2.75 cm wide) showing a mineralized chlorite vein along a bedding plane, and mineralized veins in incipient fractures at an angle to the bedding plane.

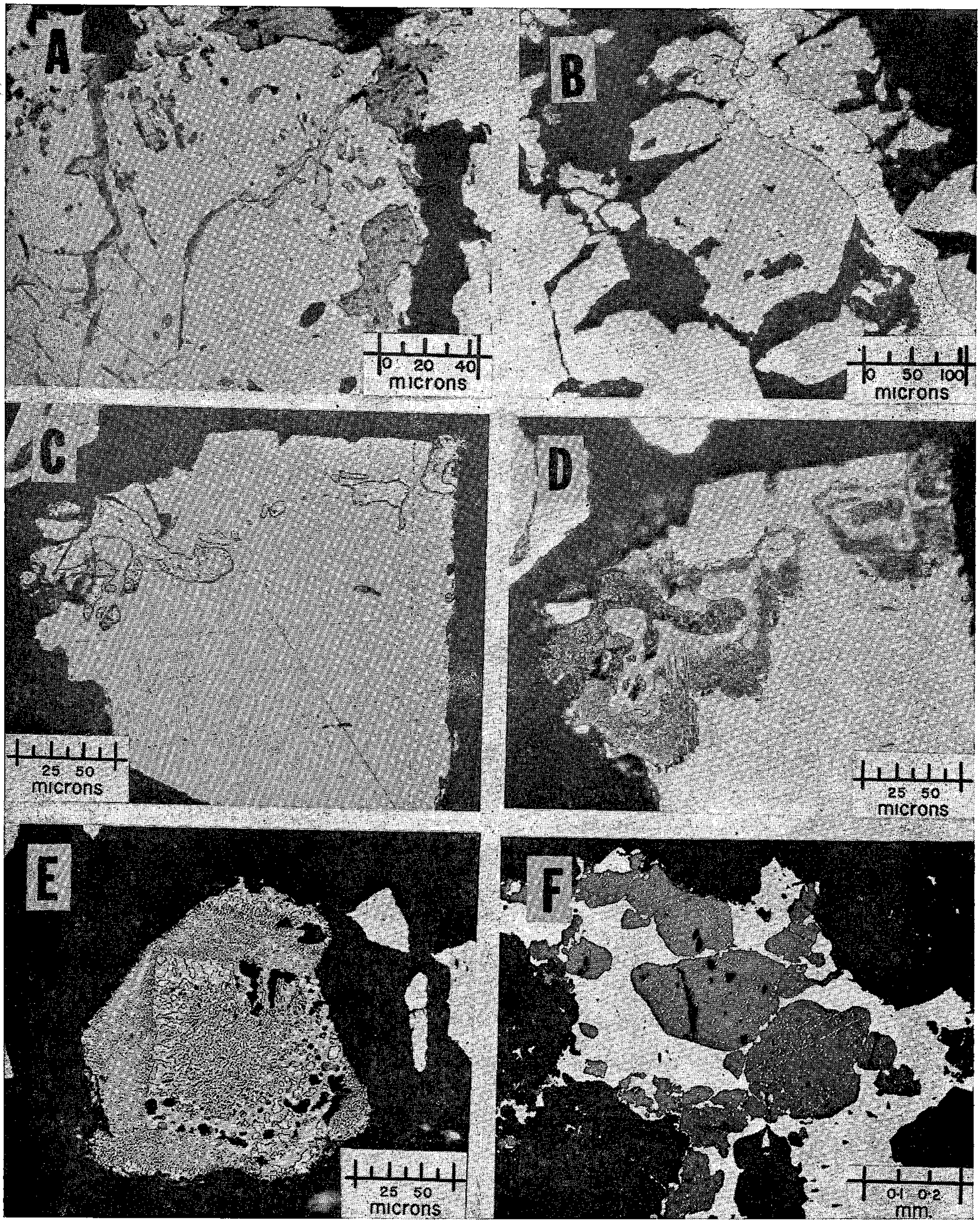


FIG. 6A. Acanthite (grey) and galena (light grey) in pyrite and arsenopyrite (white, unresolved on this photograph).

FIG. 6B. Native silver veinlet cutting pyrite.

FIG. 6C. Inclusions of native silver in pyrite.

FIG. 6D. Tarnish (grey) on pyrite adjacent to native silver inclusions (dark grey) in pyrite (white).

FIG. 6E. Worm-like inclusions of native silver in pyrite (myrmekitic-like texture).

FIG. 6F. Galena (white) and sphalerite (grey). The sphalerite contains minute chalcopyrite inclusions.

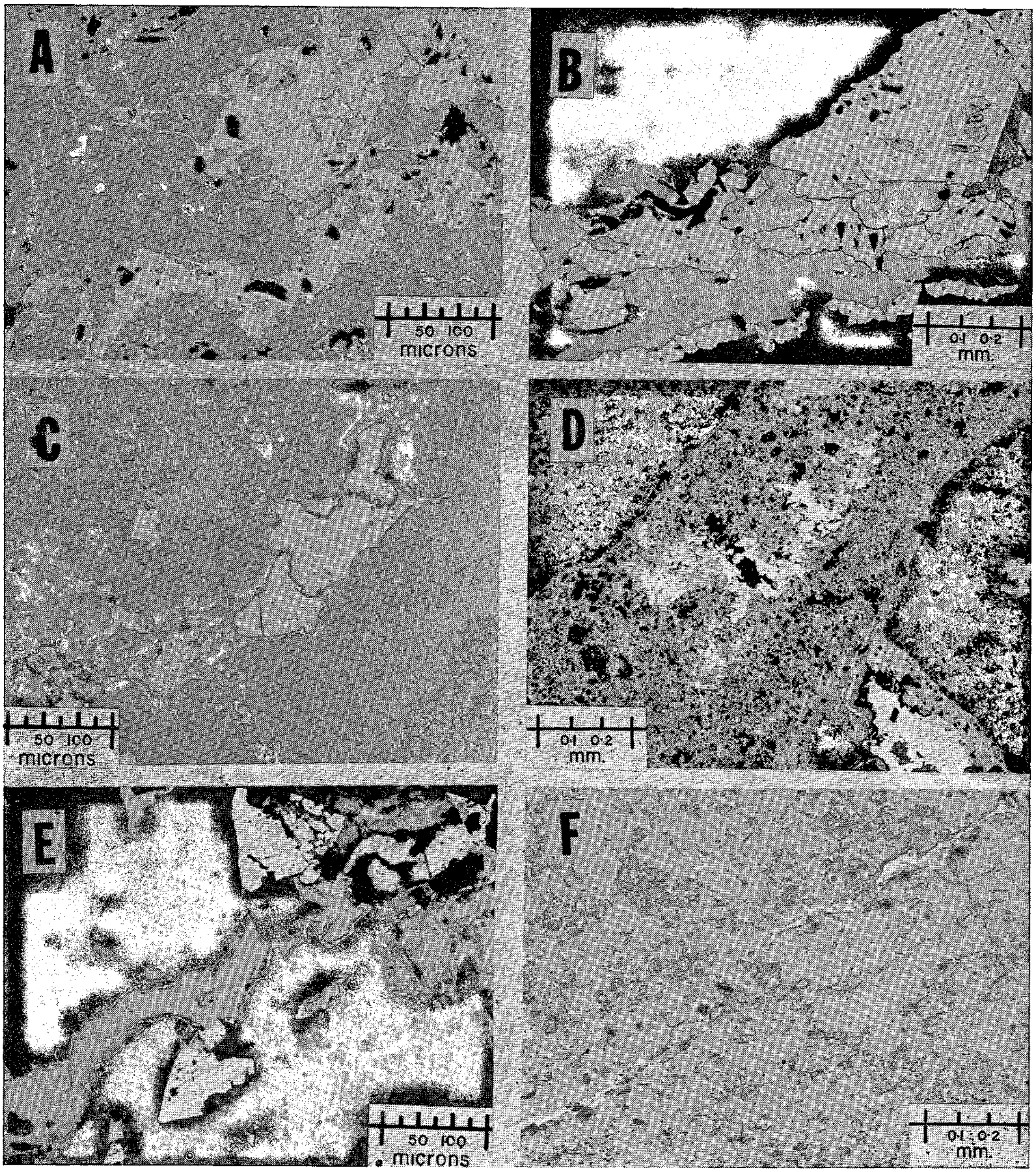


FIG. 7A. Tennantite (medium grey) and chalcopyrite (light grey) veinlets and intergrowths in sphalerite.

FIG. 7B. A sphalerite-chalcopyrite-galena-tennantite vein with an inclusion of pyrite (white, upper right part of photograph) and a pyrite veinlet at the sphalerite wall rock boundary (white, bottom part of vein). The sphalerite is grey; galena, white with triangular pits; and chalcopyrite (light grey) occurs as minute grains in pyrite.

FIG. 7C. Acanthite grains (light grey) at each end of a sphalerite grain (grey) in a siderite vein (dark grey, well-polished). The wall rock (dark grey, mottled) is visible on each side of the siderite vein. Other grey areas represent complex mixtures of silver sulphides.

FIG. 7D. Acanthite, pearceite, pyrite and sphalerite (unresolved) in a siderite vein. The pearceite is in the lower right corner of the photograph and occurs as a hair veinlet in siderite around an acanthite grain.

FIG. 7E. A border of the unidentified Ag-Cu sulphide (white) around sphalerite (grey). The other white areas are pyrite.

FIG. 7F. A vein of native silver in dolerite.

veinlets* within chlorite or quartz veins. About 1 to 5% of the pyrite contains veinlets and inclusions of native silver, acanthite (Fig. 6A), galena, unidentified Ag-Cu sulphides, sphalerite, chalcopyrite, tennantite, and pyrrhotite. The main silver minerals is native silver (Figs. 6B, 6C, and 6E). An analysis of a concentrate from a pyrite-native silver vein gave 21,148 grams Ag/ton or about 2% silver.

(2) The sphalerite-galena assemblage, probably the most common in veins in sedimentary rocks, also occurs in veins in diabase. It consists of sphalerite-galena masses (Fig. 6F) which contain minor amounts of pyrite, chalcopyrite, pyrrhotite, tennantite, and acanthite. A chemical analysis of a concentrate from this assemblage gave (wt %) 43.75 Pb, 30.35 Zn, 0.48 Cu, and 5567 grams Ag/ton. Quantimet image analysis of the same concentrate gave 50% galena, 48% sphalerite and 1.5% chalcopyrite. Microprobe and microscope studies show that most of the silver is present as minute inclusions of an unidentified Ag-Cu-Sb mineral, <0.1 micron in diameter, in galena.

(3) The sphalerite-galena-chalcopyrite-tennantite assemblage is also common in veins in sedimentary rocks. Minerals of this assemblage occur as intergrowths and veinlets in sphalerite (Fig. 7A). Also present in the assemblage are remnants of pyrite and inclusions of native silver, unidentified Ag-Cu sulphides, pearceite, and acanthite (Fig. 7B). In some veins massive sphalerite occurs in one part and chalcopyrite intergrown with galena and tennantite in another.

(4) The silver-sulphide assemblage consists largely of acanthite, unidentified Ag-Cu sulphides, and pearceite. The assemblage occurs as veinlets and minute inclusions in other assemblages (Figs. 7C, 7D and 7E). The veinlets frequently change along strike from silver sulphides to native silver to chalcopyrite.

(5) The native silver veins are narrow (Fig. 7F) and are most abundant near the diabase-sediment and rhyolite dyke-sediment contacts. The veins occur along incipient fractures and along bedding planes in the rock. They cut across pyrite and arsenopyrite but rarely across sphalerite veins. Where the rock breaks along native silver veins, the silver is exposed as leaf silver. Adjacent to the native silver veins the rock contains numerous minute inclusions, up to 10 microns in diameter, of native silver and a few of pearceite and chalcopyrite.

*The term "veinlet" as used in this report refers to fissure fillings within veins.

Disseminated ore minerals in mineralized pockets

The mineralized pockets contain significant amounts of ore minerals disseminated in the wall rock, some associated with veins and some unrelated to them. The ore minerals associated with veins are the same as those in the veins, the quantity and grain size of the ore minerals merely decreasing outward into the rock (Fig. 8A).

The ore minerals unrelated to veins occur in sedimentary rocks and are uniformly distributed in specific beds. The ore minerals in these beds are the same as those in the five ore mineral assemblage described above but occur as grains less than 10 microns in diameter. An assay of a mineralized sedimentary rock gave 181 grams Ag/ton (5.3 oz. Ag/ton).

Some mineralized beds unrelated to veins are pyritic. The pyrite varies from 1 to 200 microns in diameter and contains numerous minute inclusions of silicate minerals which give it a spongy appearance (Fig. 8B). A small amount of arsenopyrite is present in the pyritic beds. The arsenopyrite contains minute inclusions of galena, chalcopyrite, acanthite and unidentified Ag-Cu sulphides.

DETAILED ORE MINERALOGY, ZONE 1

Native silver (amalgam)

Native silver is the main silver-bearing mineral. It occurs as veins, veinlets and disseminated grains in wall rock, pyrite, arsenopyrite, quartz, siderite, sphalerite, acanthite, and chalcopyrite (Figs. 6B, 6C, 6E and 7F). The disseminated native silver in quartz and siderite veins is commonly associated with and surrounded by acanthite which, in turn, is surrounded by either unidentified Ag-Cu sulphides or pearceite. Microprobe studies show that the native silver in veins cutting diabase contains 11.9 to 30% Hg and hence is amalgam.

Acanthite

Acanthite, the low-temperature form of Ag_2S, is the main silver sulphide. It occurs in veins and as disseminated grains in sediments and dolerite. Acanthite in veins is present as irregular grains and veinlets in chlorite, siderite, quartz, pyrite, arsenopyrite (Fig. 6A) and sphalerite. Some large acanthite grains are intergrown with unidentified Ag-Cu sulphides, and some are bordered by pyrargyrite and pearceite. Some acanthite surrounds native silver, sphalerite (Fig. 7C), galena and chalcopyrite.

Unidentified Ag-Cu sulphides

The ore contains some material that occurs as narrow veinlets with minute acanthite inclusions (Fig. 7E). This material has the optical properties of stephanite but microprobe analyses show that its composition by weight varies from Ag 67.9%, Cu 12.4%, and S 14.7%, total 95.0% ($Ag_{3.04}Cu_{0.96}S_{2.20}$) to Ag 60.5%, Cu 22.7% and S 16.2%, total 99.4% ($Ag_{1.22}Cu_{0.78}S_{1.10}$). These formulae approximate the compositions of jalpaite and mckinstryite respectively. Locally this material contains up to 18.5% sulphur, which is more than can be accounted for by jalpaite, mckinstryite, and acanthite. Without *x*-ray data, therefore, the mineralogy of this material cannot be defined.

Pearceite

Pearceite, a common silver mineral in quartz veins in sediments north of the diabase, occurs as disseminated grains and veinlets in sphalerite, as borders on acanthite, and it contains minute acanthite inclusions. Microprobe studies show that the composition of a pearceite grain near arsenopyrite diabase is Ag 67.1%, Cu 10.0%, As 7.1%, S 16.8%, total 101.0 wt % ($Ag_{12.78}Cu_{3.22}As_{1.95}S_{10.76}$). *X*-ray diffraction studies show that this is the large-cell polymorph, pearceite 2-2-2 in the terminology of Harris *et al* (1965).

Pyrargyrite

Small amounts of pyrargyrite were found in the veins in diabase. The pyrargyrite occurs as borders on sphalerite, as inclusions in sphalerite, and as veinlets with unidentified Ag-Cu sulphide at pyrite-wall rock boundaries. The mineral is commonly surrounded by unidentified Ag-Cu sulphides.

Proustite

A small amount of proustite, identified optically on the basis of strong red internal reflection and confirmed by *x*-ray diffraction, was found as inclusions in galena that surrounds acanthite-pearceite grains.

Unidentified Ag-Cu-Sb mineral

Numerous inclusions, up to 0.1 micron in diameter, of a silver-copper-antimony-bearing mineral with the optical properties of tetrahedrite are uniformly distributed in the massive

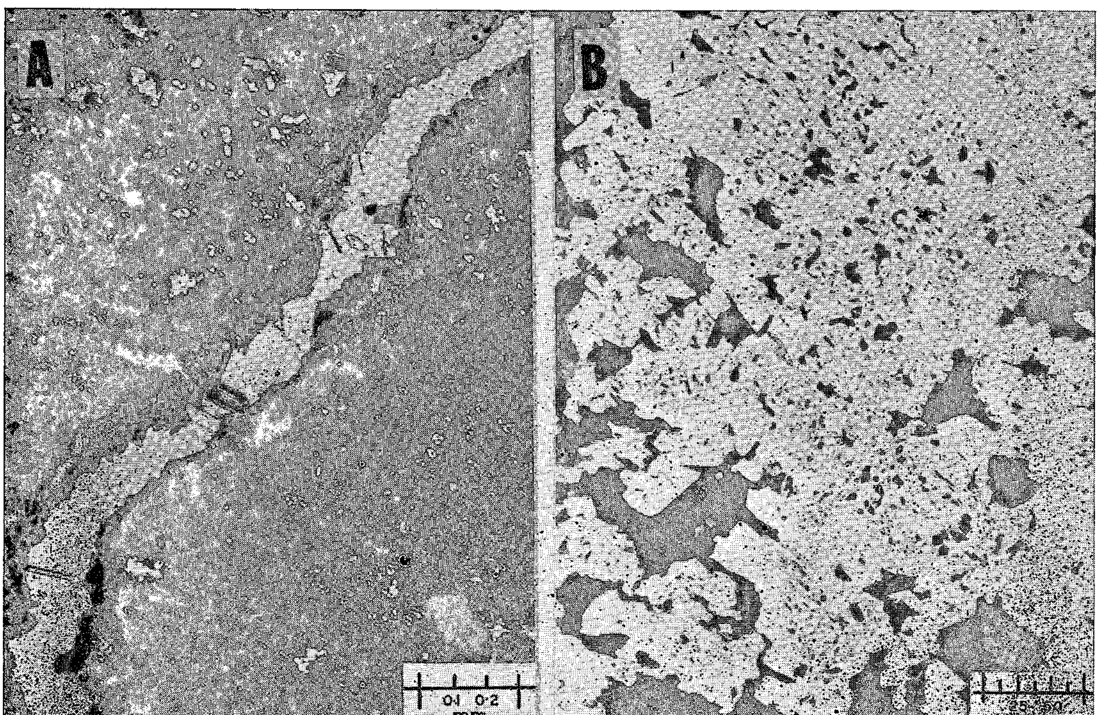


FIG. 8A. Large grains of ore minerals disseminated in sedimentary rock near an ore minerals vein. The ore minerals vein consists of pyrite along the middle and sphalerite with small amounts of chalcopyrite and galena at the edges.
FIG. 8B. Sponge-like pyrite in sediments.

galena intergrown with sphalerite. These inclusions are so small that they were observed only with a 100× oil immersion objective on a Zeiss research microscope and could not be analyzed with an electron microprobe. Microprobe analyses (in wt %) on random spots on the galena gave nearly constant values of 0.11% Ag, 0.07% Cu, and 0.14% Sb. It is interpreted that these elements are present in an unidentified Ag-Cu-Sb mineral.

Sternbergite

A mammillary-textured brown material, intergrown with fine-grained acanthite and pyrite and surrounding a large pyrite grain, was found in a vein in sediments. The intergrowth is so complex that the individual phases could not be *x*-rayed or analysed. Microprobe analyses (in wt %) on this intergrowth detected only Fe, Ag, and S and yielded from 9.6 to 35.6 Ag, 25.3 to 38.1 Fe, and 32.0 to 45.0 S. Obviously the spots analysed included either pyrite or acanthite impurities, but the presence of all three elements in every spot analysed indicates that the brownish mammillary-textured material is an iron-silver sulphide, probably sternbergite.

Tennantite

A significant amount of tennantite was found in the sphalerite-galena-chalcopyrite-tennantite veins in the sediments and as disseminated grains in the sediments. That in veins occurs as veinlets, as masses in sphalerite (Fig. 7A), as inclusions in galena, and as intergrowths with, and remnants in chalcopyrite. The mineral also occurs as veinlets in the pyrite-native silver assemblages. Electron microprobe analyses of three different tennantite masses are given in Table 1.

Galena

Galena occurs in the veins and as minute disseminated grains in the sediments. The galena in the veins is present as masses, as intergrowths with sphalerite, chalcopyrite, and tennantite, and as inclusions in pyrite and arsenopyrite. It contains inclusions of chalcopyrite, tennantite, pyrrhotite, an unidentified Ag-Cu-Sb mineral, and remnants of pyrite. Three modes of occurrence were found — the first as intergrowths with sphalerite (Fig. 6F), the second associated with chalcopyrite and containing tennantite and chalcopyrite inclusions (several microns in size), and the third as small masses surrounding pearceite and containing proustite inclusions.

Pyrite

Pyrite is the main ore mineral present. It occurs in veins and as disseminated grains in diabase and sediments. Pyrite in veins is present as large grains that contains veinlets and inclusions of native silver, sphalerite, galena, acanthite, and chalcopyrite. Most of the pyrite is barren of silver, but grains that are silver-bearing contain either several rounded native silver inclusions or clusters of worm-like native silver (Figs. 6B, 6C and 6E). The pyrite adjacent to these native silver (amalgam) grains tarnishes quickly, whereas pyrite farther away does not (Figs. 6D and 6C). Microprobe analyses show that the pyrite does not contain detectable amounts of silver in its crystal structure, and that the tarnish is due to the deposition of native silver (amalgam) on the pyrite surface. The microprobe analyses also detected up to 0.05% Ni. 0.06% Co and 0.47 wt % As in the pyrite.

Pyrite in sediments occurs as disseminated grains near ore veins and in pyrite beds. That in

TABLE 1. *Composition of Tennantite*

Element	Analysis 1 wt %	Analysis 2 wt %	Analysis 3 wt %
Ag	0.4	0.4	0.4
Cu	43.8	43.6	43.5
Fe	7.2	2.3	2.3
Zn	—	5.5	5.5
As	21.0	17.8	20.6
Sb	—	4.5	0.1
S	28.2	28.2	28.5
Total	100.6	102.1	100.9

Analysis 1 — $Cu_{10.01}Ag_{0.05}Fe_{1.87}As_{4.07}S_{12.77}$
Analysis 2 — $Cu_{10.07}Ag_{0.05}Fe_{0.61}Zn_{1.24}As_{3.49}Sb_{0.54}S_{12.82}$
Analysis 3 — $Cu_{10.05}Ag_{0.05}Fe_{0.61}Zn_{1.24}As_{4.04}Sb_{0.01}S_{13.06}$

pyritic beds, as well as in some veins in sediments, contains a few inclusions of anatase, ilmenite, acanthite and galena, and numerous inclusions of a gangue mineral that gives the pyrite a sponge-like texture (Fig. 8B).

Marcasite

Small amounts of secondary marcasite are associated with the pyrite in the veins.

Pyrrhotite

Pyrrhotite is rare. It occurs as lamellae in sphalerite, as minute inclusions in galena, as intergrowths with chalcopyrite, and as borders on chalcopyrite. Pyrrhotite-chalcopyrite intergrowths commonly occur as minute inclusions in pyrite.

Arsenopyrite

Arsenopyrite is present in the veins in diabase and sediments and as large euhedral grains disseminated throughout the diabase. It occurs as integrowths with pyrite, as overgrowths on pyrite, and as separate euhedral crystals. It contains minute inclusions of galena, sphalerite, chalcopyrite, native silver, and acanthite, as well as remnants of pyrite.

Sphalerite

Sphalerite is present in the veins and as disseminated grains in sediments. That in veins occurs as masses, irregular grains, and intergrowths with galena and chalcopyrite. It contains droplets and lamellae of chalcopyrite and pyrrhotite, veinlets and irregular grains of chalcopyrite, galena, tennantite, acanthite, native silver, and pearceite, and remnants of pyrite. The sphalerite in one sample occurs at the core of a concentrically layered grain, with layers progressing outward from sphalerite to chalcopyrite to pyrrhotite to galena with tennantite inclusions. In another vein the sphalerite is partly replaced by chalcocite surrounded by clusters of minute kidney-shaped bornite grains. In still another the sphalerite is surrounded and partly replaced by bornite altered to covellite.

Chalcopyrite

Chalcopyrite is a common ore mineral in the veins but some is also present as disseminated grains in sedimentary rocks. That in veins is present as small masses, irregular grains, and veinlets. Some grains contain irregular inclusion of sphalerite, galena, tennantite, and unidentified Ag-Cu sulphides, and some are altered to covelite. A small rounded inclusion in pyrite consists of chalcopyrite intergrown with pyrrhotite. In one place in sediments a small chalcopyrite grain contains rounded bornite grains up to 3 microns in diameter.

Bornite

A few minute bornite grains were found as replacements of sphalerite and chalcocite (i.e. as borders and veinlets at edges of sphalerite and chalcocite grains), as minute grains in a silver-bearing vein, and in chalcopyrite.

Chalcocite and covellite

Chalcocite was found in one place surrounding a sphalerite grain and surrounded by kidney-like bornite grains. Covellite was found in a few places as borders and veinlets at the edges of sphalerite, chalcopyrite, galena and bornite grains.

INTERPRETATION OF THE NATURE OF THE DEPOSIT

The deposit consists of mineralized veins and disseminated ore minerals in sedimentary rocks and diabase, with silver enrichment at the diabase-sediment contact and at a rhyolite dyke-sediment contact. The disseminated ore minerals in the wall rock occur in association with the veins, and in beds of the sedimentary rocks unrelated to the veins. The ore minerals unrelated to veins consist of subhedral to euhedral pyrite grains uniformly disseminated in some beds and of minute grains of a variety of ore minerals uniformly disseminated in other beds. These textures and distributions of the ore minerals suggest they were formed contemporaneously with the sediments. Thus it is interpreted that the mineralized and pyritic beds represent original mineralized and pyritic sedimentary horizons.

The ore minerals in the veins are the same as those in the mineralized and pyritic beds, and the main non-metallic minerals in the veins is chlorite which is an alteration product of the sedimentary rocks and diabase. These mineralogical features suggest that the metals were mobilized from the sedimentary rocks and redeposited as ore minerals in zones of weakness (fissures, minor faults, and bedding planes). It is further interpreted that some of the ore minerals, particularly the silver-bearing ones, were concentrated at the diabase-sediment and rhyolite dyke-sediment contacts, probably by the heat of intrusion of the diabase and rhyolite dyke, as well as by minor subsequent faulting.

Systematic geochemical studies have not been done on the sedimentary rocks to confirm this interpretation for the origin of the deposit.

The textures and distributions of the ore minerals in the veins are distinct enough to show that silver is an early mineral and is associated with pyrite; the sphalerite, galena, chalcopyrite and tennantite were deposited next; these were followed by the silver sulphides (acanthite, unknown Ag-Cu sulphides, etc.). Chalcocite, bornite, covellite, and marcasite are secondary minerals.

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