Ore Deposits of the Carrietown Silver-Lead-Zinc District, Blaine and Camas Counties, Idaho

Robert S. Darling¹

ABSTRACT

The Carrietown Ag-Pb-Zn district is located in the northern half of the Dollarhide Mountain 7.5-minute quadrangle, 35 km west of Ketchum and 30 km north of Fairfield. The district covers 25 square kilometers in the southwest part of the central Idaho black-shale mineral belt.

Ore deposits in the district are epigenetic, vein-type bodies containing galena, sphalerite, tetrahedrite, pyrite, arsenopyrite and chalcopyrite. Galena and tetrahedrite are the principal Ag-bearing phases. Localization of deposits is controlled by both structure and lithology. Ag-Pb-Zn mineralization is best developed in: (1) the Carrietown and Dollarhide metasedimentary units, and (2) the northeast-trending fault zones located in proximity to the Carrietown/Dollarhide thrust and close to contacts between the Carrietown and Cretaceous granodiorites. Temperatures of ore formation from several ore mineral pairs suggest a mesothermal environment. Field, thermal and mineralogical relationships are not consistent with Eocene mineralization related to Challis magmatism, but support mineralization related to Cretaceous igneous activity.

INTRODUCTION

The Carrietown silver-lead-zinc (Ag-Pb-Zn) district lies within an oval-shaped area of about 25 square kilometers, in the northern half of the Dollarhide Mountain 7.5-minute quadrangle. The quadrangle is located in the central Smoky Mountains, a north-south trending range that extends from Galena Summit on the north to the northern margin of the Snake River Plain near the town of Fairfield. The principal divide of the range forms the boundary between Blaine and Camas Counties (Fig. 1).

The old village of Carrietown is in the northern part of the Dollarhide Mountain quadrangle and was the principal settlement when mining operations flourished in the late 1800s. Today, however, the village is abandoned and only a few buildings remain. Carrietown can be reached via light-duty roads from the towns of Ketchum, 35 km to the east, and Fairfield, 30 km to the south (Fig. 1).

Ag-Pb-Zn deposits in the Carrietown area were described first by Umpleby (1915) and then Ross (1930). Umpleby (1915) believed the Carrietown ores were epigenetic and related to Cretaceous igneous activity. Later, the recognition of syngenetic Pb-Zn mineralization in Paleozoic rocks of central Idaho led to a renewed interest in the Carrietown deposits. The principal objectives of this research were to determine if the deposits had a syngenetic or epigenetic origin, and if epigenetic, was the mineralization related to Eocene or Cretaceous igneous activity.

GEOLOGIC SETTING

The Carrietown district is located on the southwest margin of the central Idaho black-shale mineral belt of...
Hall (1985), at the junction between allochthonous Paleozoic strata and Cretaceous intrusive rocks of the Idaho batholith.

In the northern half of the Dollarhide Mountain quadrangle, Permian Dollarhide Formation has been thrust over Paleozoic (?) Carrietown sequence (Fig. 2). In most locations, the thrust fault dips gently, but in the area southwest of Carrietown it dips about 65 degrees southeast. The Paleozoic units are preserved as large, almost completely isolated roof pendants in the Cretaceous intrusives (Fig. 2). In the southern part of the district, both Cretaceous intrusives and Paleozoic units are unconformably overlain by Eocene Challis Volcanics, which erupted between 51 Ma and 40 Ma (McIntyre and others, 1982). All of the above rocks are intruded by numerous Eocene hypabyssal dacite porphyry dikes and small stocks. The intrusives are coeval, subvolcanic equivalents of the Challis Volcanics. One dike 0.7 km west of Carrietown has been dated at $47.2 \pm 0.9$ Ma by K-Ar methods (Wayne Hall, unpublished report, 1978) (Fig. 2).

**Stratigraphy**

The Carrietown sequence is an informal unit consisting of fine-grained, banded quartzites and quartz-biotite phyllites (Geslin, 1986; Darling, 1987). It lies structurally below the Dollarhide Formation and is intruded at its base by Late Cretaceous granodiorites of the Idaho batholith (Fig. 2). In the Carrietown area, the unit is about 1000 meters thick (Skipp and Hall, 1980), but only 176 meters are preserved in the Buttercup Mountain quadrangle, 10 km to the southeast (Geslin, 1986). The quartz-biotite phyllites are strongly foliated and locally contain staurolite, indicating regional metamorphism of the lower amphibolite facies (Geslin, 1986). Banded quartzites of the Carrietown sequence commonly contain fine-grained, locally stratiform pyritohite and minor chalcopyrite, presumably of syn-genetic or metamorphic origin.

The Permian Dollarhide Formation (2,000 meters thick) is a formal unit containing highly carbonaceous, fine-grained siltstones and argillites (upper member), and sandy limestone, calcareous siltstone and sandstone (lower member) (Hall, 1985; Wavra and others, 1986; Geslin, 1986). This subdivision follows that proposed by Link and others (1988, this volume). The lower member is characterized by synsedimentary folds, convolute bedding, load casts, and graded-, cross- and lenticular bedding (Wavra and others, 1986; Geslin, 1986). In the Carrietown area, the lower member forms the bulk of the outcrop. The Dollarhide Formation commonly contains abundant dark-colored tremolite which formed as a result of contact metamorphism (hornblende-hornfels facies) during intrusion of Cretaceous granodiorites (Darling, 1987).

**HISTORY AND PRODUCTION**

Mining in the Carrietown district began in the summer of 1880, but the activity was short lived and many operations ceased by the turn of the century (Umpleby, 1915). Since then, the district has remained essentially inactive, except for small-scale mining and annual assessment work. In the early 1980s, however, as silver prices soared, both local and major mining companies were exploring the district's potential for undiscovered base and precious metal deposits.

Umpleby (1915) reports that mines in the Carrietown area produced about $1,000,000 worth of silver, lead and zinc. Ross (1930) estimates a similar value of $1,200,000 and reports that mines in the Carrietown area produced 1,008,114 ounces of silver, 1,827,337 pounds of lead and 345,313 pounds of zinc; small amounts of gold were locally recovered as well. The average ore grade in the district ranged from 15 to 400 ounces of silver per ton (Umpleby, 1915), but local miners working in the area reported grades as high as 1,000 ounces per ton. Major mines in the Carrietown district and their production values are listed in Table 1. Refer to Ross (1930) for the amounts of metals produced from individual mines.

**ORE DEPOSITS**

Ore deposits in the Carrietown district are tabular, vein-type bodies that generally occupy northeast-trending
fault zones in both Paleozoic units. The mineralized shear zones dip moderately to steeply southeast and northwest, and are commonly positioned parallel to the bedding of their host rocks. Veins are generally located: (1) in or near the thrust fault that separates the Carrietown from the Dollarhide, and (2) near contacts between the Carrietown sequence and Cretaceous granodiorites (Fig. 2). Veins have an average width of 1 to 2 meters and extend into the country rock for several tens of meters. Within the veins, ore minerals occur in a series of irregular, lens-like pods that are positioned parallel to the vein walls. These pods commonly display open-space filling textures and show evidence of intense brittle deformation.

**Mineralogy**

The ore minerals include argentiferous galena, sphalerite, tetrahedrite, pyrite, arsenopyrite and chalcopyrite. Pyrrhotite, cubanite, temnantite, boulangerite and molybdenite occur in minor amounts. Quartz and siderite are the principal gangue minerals where the ore is hosted.
by the Carrietown sequence, but ores hosted by the Dollarhide Formation have a quartz-calcite gangue. A general paragenetic sequence for the mineralization is illustrated in Figure 3. This sequence is based on field observations and petrographic studies of seventy-four polished sections (Darling, 1987).

Many of the above minerals are very coarse-grained and are easily recognized in hand sample; however, cubanite, boulangierite and tennantite are microscopic. Common ore textures are: (1) chalcopyrite blebs in sphalerite, (2) cubanite exsolution lamellae in chalcopyrite, (3) pyrite and arsenopyrite intergrowths, (4) comb-structured quartz and siderite; (5) crustiform siderite, (6) deformed galena, (7) tetrahedrite inclusions in galena and (8) spindle shaped deformation twins in chalcopyrite.

Umpleby (1915) reports that galena and tetrahedrite are the principal silver-bearing phases in the Carrietown district. Tennantite and boulangierite (although volumetrically insignificant) could be additional silver-bearing phases. The manner in which silver occurs in galena is not known, but microscopic tetrahedrite inclusions are a possible source. The silver-bearing phases (galena-tetrahedrite-tennantite-boulangerite) were deposited relatively late in the mineralization sequence (Fig. 3).

**DISCUSSION**

In recent years, much attention has been focused on the occurrence of stratiform, syngeneic ore deposits in the black-shale belt. Ore deposits of syngeneic origin have been described in the Triumph mine (Triumph-Parker mineral belt) and in the Hoodoo and Livingston mines (Slate Creek district) (Hall, 1985). In the Carrietown district, however, the orebodies appear to have an epigenetic origin. This interpretation is supported by strong structural control of the deposits and open-space filling textures.

**Structural and Lithologic Controls on Deposition**

The localization of deposits is controlled by both structure and lithology, as they are best developed in moderately to steeply dipping, northeast-trending fault zones in both Paleozoic units.

**Structural Controls**

The prominent northeast trend of the veins suggests they may have formed in steep northeast-trending structures related to Eocene extension. However, localization of deposits could also be controlled by bedding-parallel faults. This explanation is supported by: (1) bedding in both host rocks commonly strikes north-northeast and dips moderately to steeply northwest and southeast, and (2) the veins are commonly positioned parallel to the bedding of their host rocks. Because many of the deposits are located in proximity to the thrust, it is likely that the present orientation was controlled not by Eocene extension but rather by earlier Mesozoic thrusting.

Some of the larger deposits (Carrie Leonard, Silver Star and Horn Silver mines) are located where the thrust fault is steepest (about 65 degrees). This spatial relationship also occurs in the Buttercup Mountain quadrangle. There, the Buttercup mine (the chief producer in the Willow Creek district) is located on the Carrietown/Dollarhide thrust, which dips about 50 degrees eastward (Geslin, 1986). This relationship suggests that the thrust fault and its imbricated splays acted as a principal pathway for hypogene ore fluids.

**Lithologic Controls**

The deposits are partly controlled by lithology, since most Ag-Pb-Zn mineralization is hosted by Paleozoic metasedimentary rocks. These rocks could have provided a reducing environment for the deposition of metals, an environment not normally expected in Cretaceous intrusive rocks. Also, trace-element signatures of both Paleozoic metasedimentary units are similar to average black shales and would provide an excellent source for metals (Darling, 1987).
Thermal Conditions of Mineralization

Howe and Hall (1985), in an isotopic study of the black-shale belt, performed sulfur isotope analyses on six samples in the Carrietown district, two of which were used to calculate ore-forming temperatures. The two analyses yielded 269 ± 45 degrees C from the sphalerite-galena pair, and 375 ± 45 degrees C from the pyrite-galena pair (Howe and Hall, 1985, p. 192). In polished section, both sulfide pairs commonly exhibit mutual grain boundaries, suggesting that isotopic equilibrium was established and that the calculated temperatures are reliable.

A 250-300 degree C minimum temperature of mineralization is suggested by the presence of cubanite exsolution lamellae in chalcopyrite (Ramdohr, 1980, p. 639). Clark (1960) shows that the equilibrium assemblage of arsenopyrite + pyrite reacts to form pyrrhotite + liquid at 491 ± 12 degrees C (at 1 bar), up to 528 ± 10 degrees C (at 2,070 bars). Thus, the pyrite + arsenopyrite intergrowths establish a maximum mineralization temperature at 491 to 528 degrees C (if P_T is less than 2,070 bars). Thermal constraints imposed by the fixed-point geothermometers agree well with the calculated sulfur isotope temperatures and are generally consistent with a "mesothermal" (200-300 degrees C) environment. The thermal information gathered from ores in the Carrietown district, although scant, is generally consistent with that established for similar deposits in the Wood River District, 30 km to the east (Hall and Czamanske, 1972; Hall and others, 1978).

Age of Mineralization

Because the ore deposits have an epigenetic origin and are partially hosted by granodiorite at the Silver Crown mine, the deposits are no older than late Cretaceous. Furthermore, the principal mineralized structure in the Dollarhide mine is cut by a dacite porphyry dike (Uempleby, 1915; Darling, 1987), indicating the deposits are no younger than Eocene (47.2 Ma). Because the ore deposits formed at elevated temperatures, it seems safe to assume that mineralization is related to either Cretaceous or Eocene intrusive activity.

The spatial relationship of some ore deposits to Cretaceous granodiorites suggests a Cretaceous age. A similar spatial relationship is used by Hall and Czamanske (1972) to argue for Cretaceous mineralization in the Wood River district, 30 km to the east.

The thermal data and field relations previously discussed may help to constrain the age of mineralization. Ore deposits in the Dollarhide, Silver Star, Stormy Galore and King of the West mines are located less than 150 meters vertically below the unconformable contact between the Dollarhide Formation and overlying Eocene Challis Volcanics. Because the volcanics show neither hydrothermal alteration (Gehlen, 1983), nor do they host sulfide mineralization, it is believed that the mineralization is prevolcanic. If the mineralization is prevolcanic, but still related to Eocene intrusive activity, then ore deposits in the above mines must have formed at depths of 150 meters below the Eocene paleosurface. This inferred shallow ore-forming environment conflicts with a number of mineralogical, thermal and field relations, including:

1) The "mesothermal" mineral assemblage is not characteristic of very shallow depths of formation (rather, we would expect an "epithermal" mineral assemblage).

2) Minimum temperatures of 250-300 degrees C would not be expected at 150 meter depth (this would require an unusually high geothermal gradient).

3) Minimum temperatures of 250-300 degrees C at 150 meter depth suggest that water would exist as vapor (however, the observed primary inclusions indicate that the fluid was not boiling).

4) There is no evidence of acid-sulfate (near-surface) alteration occurring in or above the deposits.

It should be noted that Eocene igneous activity lasted for about 10 million years (McIntyre and others, 1982). The deposits could therefore have formed during early Challis magmatism (~31 Ma), could have subsequently been eroded to deep levels, and then covered by younger Challis Volcanics (~40 Ma). However, this interpretation conflicts with the observation that dacite porphyry dikes (dated at 47.2 Ma) intrude many of the volcanics, indicating that the extrusives probably represent early phases of Challis volcanism.

From the observations listed above, mineralization of Eocene age is highly unlikely. The deposits probably formed during or soon after the emplacement of the Cretaceous intrusive rocks.

SUMMARY AND CONCLUSIONS

Ore deposits in the Carrietown Ag-Pb-Zn district are tabular, vein type bodies composed dominantly of Ag-galena, sphalerite, tetrahedrite, pyrite, arsenopyrite and chalcopyrite. The localization of deposits appears to be controlled by both structure and lithology. The deposits are generally restricted to: (1) the Carrietown and Dollarhide metasedimentary rocks; and (2) northeast-trending shear zones located in or near the thrust fault, and near contacts between the Carrietown and Cretaceous intrusive rocks. The strong structural control and open-space filling textures support an epigenetic origin for the deposits. Field relations, geothermometry and mineralogical information are not consistent with an Eocene ore-forming environment, but support a Cretaceous age of mineralization.

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