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Stratiform Sedimentary Lead Sulfide Ores of Bonanza, Mine, Stevens County, Washington

Abstract

Previous views as to the probable origin (replacement vein) of the lead ores of the Bonanza mine of northeastern Washington are rejected. Recent review of old data and the gathering of new data, especially textural data obtained by the study of polished ore specimens using reflecting microscopy, establish the sedimentary-type stratiform massive sulfide nature of the original deposit and its subsequent metamorphism.

Purpose

The purpose of this paper is to demonstrate that the Bonanza mine ores are not vein or replacement deposits as has been previously proposed, but are stratiform strata-bound sedimentary sulfide deposits which have had their sedimentary aspect considerably modified by later deformation and subsequent annealing. This revision in our understanding of the mode of formation of this deposit requires a corresponding modification of our approach to exploration for its extension, as well as to the search for similar deposits elsewhere in northeastern Washington.

History

The Bonanza mine in the north half of sec 11, T37N, R37E, Stevens County, Washington, about 123 km NNW of Spokane, Washington (Figure 1), was discovered in 1885. Its production prior to 1907 was sporadic and presumably small. Production was continuous from 1907 through 1920, intermittent from 1920 to 1942, then continuous until 1952 when the mine closed. About 86 percent of the ore tonnage was mined during the 11 years preceding the closing. Total recorded production from 1907 to 1952 (Fulkerson and Kingston 1958) was 25 x 10^6 lbs of lead, 22 x 10^3 lbs of copper, and 239 x 10^3 ounces of silver, from 102 x 10^3 tons of ore. This corresponds to an overall grade of about 12.2 percent lead and 2.3 ounces of silver per ton. Ore was mined on six levels over a dip length of about 160 m and an elevation range of 107 m. Although the aggregate length of sulfide mineralization is not known, the mine level aggregate length, excluding the Gibbs crosscut, is 1.96 km. Since the mine closed in 1952, both shafts and the Gibbs access crosscut have collapsed so that all mine workings are inaccessible.

General Geology

The deposit underlines a low, grassy hill on which outcrops are scarce, small, and inconspicuous, probably constituting less than 1 percent of the surface above the mine workings. This, together with the lack of mine access, means that our knowledge of the

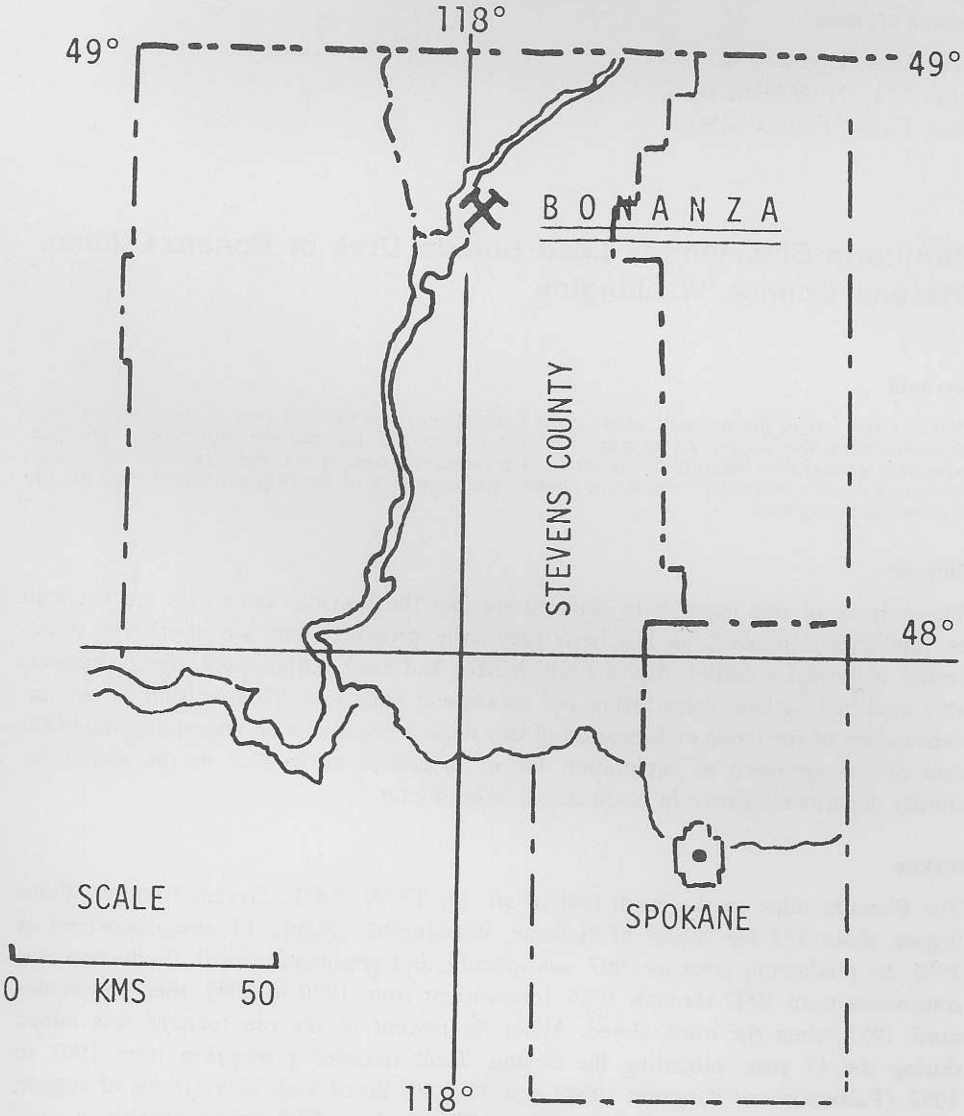

Figure 1. Location map of the Bonanza Mine.

geologic setting of the ore body is limited to brief descriptions provided by early authors (Bancroft 1914, Weaver 1920, Patty 1921, Hunting 1956), unpublished data of Washington State's Division of Geology and Earth Resources, and data gathered by the author from surface outcrops and mine dump specimens.

The geologic setting of the ore deposit is one of a gently north-plunging upright antiform, with associated minor folds, in argillite and phyllitic argillite. Ore sulfides are conformable with the bedding of the host rocks and both are folded. Furthermore, both are cut, drag folded, and displaced by major north-striking faults dipping moderately steeply to the west in the central part of the mine workings and to the east on the eastern mine workings. The age of the strata is probably Ordovician to Devonian (Las-

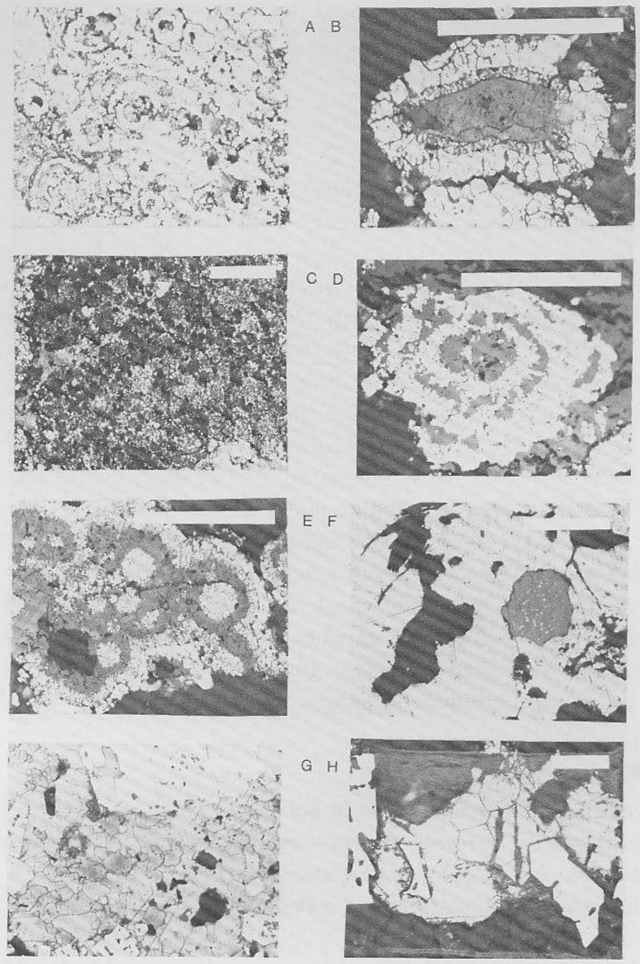

Figure 2. Length of white bar in each figure represents 0.10 mm. Dark gray to black areas are non-reflecting gangue (host rock silicates, quartz, siderite).
A through E: textures diagnostic of sedimentation.
F and G: textures diagnostic of metamorphism, including annealing.
A: Atoll texture in ultra-fine grained pyrite (light gray; etched*) and pyrrhotite (gray).
B: Atoll texture in pyrite (outer double layer; white and light gray; etched) and sphalerite (core; gray).
C: Composite mass of framboidal pyrite (etched).
D: Atoll texture in pyrite (white) and sphalerite (light gray).
E: Composite pyrite-sphalerite body with a 2-layer pyrite rind consisting of an outer fine grained layer and an inner ultra-fine grained layer, surrounding a core of sphalerite (gray) containing several spherical pyrite framboids (etched).
F: Sub-spherical sphalerite (dark gray) with speckles of exsolved(?) chalcopyrite, surrounded by galena (light gray) and gangue (black).
G: Porphyroblasts of pyrite (white) with inclusions of galena (light gray; etched**) surrounded by intergrown polygonal galena (light gray; etched) and pyrrhotite (gray).
H: Granoblastic polygonal galena (light gray; etched) and porphyroblastic pyrite (white) with inclusions of galena (dark gray; etched).

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*Pyrite etchant: 98 parts concentrated nitric acid to 2 parts methanol. Apply at room temperature for 15 seconds to 4 minutes.

**Galena etchant: 1 part concentrated HC1 to 3 parts thiourea solution (100 grams per liter). Etch time is 1 to 2 minutes at approximately 80°C.

kowski 1982). Folding and faulting are probably early Cretaceous and post-Cretaceous, respectively, in conformity with structural data applicable to similar strata in neighboring parts of northeastern Washington.

Geology of Ore Horizon

Overall, the ore horizon strikes northeasterly and dips 30 to 55 degrees northwesterly in the western mine workings; about east-west with dips of 10 to 35 degrees northerly in the central part; and northwest with dips from 25 to 55 degrees easterly in the eastern mine workings. Wide divergences from these general attitudes occur wherever the strata and sulfides are involved in minor folds. Ore is localized along the contact of chlorite-sericite phyllite below (footwall) and black graphitic argillite above (hanging wall), conforming to beds and bedding. Sulfide horizon thickness ranges from a few cms to 6 m, most commonly in the range of 2 m to 2½ m. The greatest thicknesses are at fold hinges. It is reported (in the unpublished data files of Washington Division of Geology and Earth Resources) that in the eastern part of the mine the ore mineralization grades laterally into the host rock argillite and that the margins of the sulfide bodies contain a higher proportion of quartz and pyrite than do the central parts.

Mineralization is very fine-grained galena with about equal amounts of pyrite, several percent of pyrrhotite, and very little sphalerite. Gangue minerals include the rock-forming minerals of the argillite host together with siderite, quartz, barite, and a little calcite. Typical sulfide-rich hand specimens are strongly banded owing to the changing proportions of the various sulfides and gangue minerals.

Ore Petrography

Textures observed in hand specimens and in polished sections using the reflecting microscope are of two distinctly different origins—sedimentary and metamorphic.

Observed textures indicative of sedimentation include:

(1) thin interbedding of sulfides and rock-forming silicates common in hand specimens and in polished section
(2) nodular, colloform, and framboidal textures (Figures 2A, 2C, 2E)
(3) atoll textures in pyrite, sphalerite and galena (Figures 2B, 2D)

Observed textures indicative of metamorphism and annealing* are:

(1) crumples in bedding of sulfides and silicates
(2) thickening of galena layers in fold hinges
(3) numerous pyrite porphyroblasts (Figures 2G, 2H)
(4) granoblastic polygonal galena (Figures 2G, 2H)
(5) annealing twins in sphalerite

Conclusions

Most previous authors have concluded that the Bonanza ore body is a vein deposit formed by the replacement of host rocks within a shear zone. The present writer was the first to suggest that the deposit may be a massive sedimentary sulfide deposit (Mills 1977, p. 48). During the present review of old data and the gathering of new data,

*For the benefit of the reader who may not be familiar with the recognition and interpretation of metamorphic textures in lead-zinc ores, the following references will be helpful: McDonald 1970; Davis 1973; Mills 1976; Pederson 1980; Frizzo, Mills, and Visonà 1982.

little or nothing was found that is compatible with, or diagnostic of, a replacement origin. On the other hand, data both compatible with, or diagnostic of, a primary sedimentary forming of the ores and their subsequent metamorphism are abundant and compelling. The data discussed and detailed in this paper, such as the stratiform and stratabound nature of the ores, the folded character of both the ore horizon and the graphitic host rocks, the simple ore mineralogy, and especially the textures of the ores, are abundant evidence of their primary sedimentary origin modified by subsequent metamorphism.

Mineral deposits exploration plans and procedures are based on implicit or explicit understanding of how such deposits were formed. Clearly, the chances of success in the search for extensions of the Bonanza mine ores, or for finding similar deposits elsewhere in northern Washington, are much greater when it is appreciated that the Bonanza ore body is a marine sedimentary deposit, not a hydrothermal vein deposit.

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