**Origin of high-Ag fahlores from the Galena Mine, Wallace, Idaho, U.S.A.**

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**ABSTRACT**

Tetrahedrite fahlores from the Galena Mine of the Coeur d’Alene Mining District (Wallace, Idaho) have been found to be enriched in Ag by the Ag-Cu exchange reaction:

\[
\frac{1}{10} \text{Cu}_{10}(\text{Zn,Fe})_2\text{Sb}_4\text{S}_{13} + \text{AgSbS}_2 + \text{PbS} = \text{CuPbSbS}_3 + \frac{1}{10} \text{Ag}_{10}(\text{Zn,Fe})_2\text{Sb}_4\text{S}_{13}
\]

Cu-fahlore in galena galena bournonite Ag-fahlore

which occurred during cooling following fahlore mineralization. This solid-state reaction produced a distinct population of high-Ag fahlores found in galena-rich samples, quantitatively removed Ag (in an AgSbS2 component) from galena, and accounts for all of the bournonite mineralization. This reaction has produced the most argentian fahlore yet found [molar Ag/(Ag + Cu) = 0.443] in the district, and forms a secondary overprint on any primary fahlore zoning that may have existed. The results obtained here indicate that the galena and fahlore-siderite stages of mineralization were virtually synchronous, as this reaction has produced the same result despite the opposite relative age relationships of these mineralization stages exhibited in two of the mines studied. Multiple lines of evidence suggest a temperature between 320 and 350 °C for this “stage.” Based on the Ag/(Ag + Cu) of fahlores and Fe-Zn partitioning between fahlore and sphalerite, we estimate that fahlore compositions were frozen in by about 235 °C, roughly 40 °C above corresponding temperatures obtained for the Gold Hunter vein of the Lucky Friday Mine. This result and the absence of readily detectable diaphorite (~Pb2Ag3Sb3S8) in the Galena Mine sample containing the highest Ag fahlore indicate a faster cooling rate for the terrane in the vicinity of the Galena Mine.

**INTRODUCTION**

The Coeur d’Alene mining district, northern Idaho, has produced in excess of one billion ounces of Ag (e.g., White 1998) and is one of the most extensively studied Ag districts in the world. Mineralization is of Cretaceous age (Fleck et al. 2002), and includes the extensive Ag-Pb-Zn orebodies exploited by most of the recently active mines, and gold-quartz veins currently being evaluated and mined by the New Jersey Mining Company (NJMC). Lead isotopic data indicate that the respective sources of these ores are rocks of the Proterozoic Belt Supergroup and granitic rocks possibly underlying or nearby the district (Fleck et al. 2002; Sack and Brackebusch 2004). Ag-Pb-Zn ore is concentrated in narrow, steep, west- to northwest-trending veins in deformed argillites and quartzites of the Middle Proterozoic Belt Supergroup, and is found in mineral belts immediately north and south of a major right-lateral, strike-slip fault (Osburn fault) that has some 25 km of post-mineralization displacement. Ag-Pb-Zn ore mineralization occurred during a dip-slip tectonic event accompanied by localized greenschist-facies metamorphism (e.g., White 1989, 1998; Wavra et al. 1994) and proceeded in stages that include early silicate, Fe-carbonate (e Hobarte), and Fe-oxide, followed by sulfide stages dominated by sphalerite, the sulfosalts tetrahedrite-tennantite fahlore, and galena (e.g., Fryklund 1964; Mitcham 1952). Other sulfides/sulfosalts reported in the Ag-Pb-Zn ores include minor bournonite, chalcopyrite, and arsenopyrite; trace amounts of boulangerite, pyrargyrite, polybasite, stibnite, chalcocite, and gersdorffite (e.g., Fryklund 1964); and recently discovered diaphorite and matildite (Sack et al. 2002).

In this paper, we report microprobe analyses of tetrahedrite-tennantite fahlores and associated sulfides/sulfosalts from the Galena Mine (Wallace, Idaho) and analyze our findings in light of the recently developed thermochemical database for sulfides/sulfosalts (Sack 2000, 2005). This database is the product of over 20 years of experimental, theoretical, and petrological studies focused on characterizing the thermodynamic properties of tetrahedrite-tennantite fahlore [a complex solid-solution series typically approximating the chemical formula (Cu,Ag)10(Zn,Fe)12(Sb,As)6S39] and the sulfides and sulfosalts with which it coexists.

Fahlores approximating this simplified formula may be displayed in a cube (Fig. 1) whose vertices correspond to the