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Fluid Chemistry and Depositional Mechanism of the Epigenetic, Discordant Ores of the Proterozoic, Carbonate-Hosted, Zawarmala Pb-Zn Deposit, Udaipur District, India

JAWAHAR KUMAR TALLURI, H. S. PANDALAI,† AND G. N. JADHAV

Department of Earth Sciences, Indian Institute of Technology (Bombay), Powai, Mumbai 400,076, India

Abstract

The Proterozoic, carbonate-hosted, Zawarmala Pb-Zn deposit has stratiform, banded pyrite-sphalerite ore, as well as discordant, sphalerite-galena veins and rich massive galena ore shoots. The mechanisms of deposition of discordant vein and massive ores have been studied using speciation and solubility calculations based on ore fluid characteristics and physical parameters inferred from petrography, fluid inclusion studies, and leachate analysis.

Massive galena ore, which is the economic ore type, cuts across the earlier, F_2-related, vein-type ore and is distinct from the vein-type ore in terms of mineralogy, texture, and fluid inclusion characteristics. Fluid inclusions in quartz associated with the ores show that fluids forming vein-type ore are low-salinity (4.3–14.7 wt% NaCl equiv) H_2O-NaCl fluids. The trapping temperature of vein-type ore fluid was estimated to be in the range of 395° to 290°C at a pressure of about 1,450 bars. Fluids associated with massive galena ore are H_2O-CO_2-NaCl fluids of lower salinity (about 3–4 wt % NaCl equiv). The wide variation in X_{CO2} of fluid inclusions that occur in close proximity to each other within the same sample of massive ore suggests heterogeneous entrapment of the low-salinity H_2O-CO_2-NaCl fluids. From the intersection of isochores of local, homogeneously entrapped CO_2 and aqueous biphase fluids of unmixed CO_2-H_2O-NaCl fluid, trapping temperature fluid was estimated to be between 250° and 150°C at pressures of 2,000 to 750 bars. Despite the low salinity of the ore fluids, speciation studies show that chloride complexes are dominant over most of the temperature range of interest in both ore fluids. The only bisulfide complex of importance is $Pb(HS)_2$, which is dominant below 175°C in fluids associated with massive galena ore.

Data from fluid inclusions and solubility calculations reveal that cooling is the important mechanism of vein-type ore deposition. In contrast, physicochemical data indicate that an increase in reduced sulfur, by mixing a regional, high metal content, low sulfur fluid with a local, high sulfur fluid at the site of deposition, was the mechanism for massive galena ore deposition. The difference in oxidation state (and therefore also in metal content) of the two fluids is inferred to be a significant factor that caused differences in the modes of deposition of the two ore types and the relatively high value of X_{CO2} (0.2033) in fluids associated with massive galena ore.