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# Geochemical Modeling of ZnS in Biofilms: An Example of Ore Depositional Processes

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## Abstract

The precipitation of nearly pure, nanocrystalline zinc sulfides (primarily sphalerite and wurtzite) within a biofilm dominated by sulfate-reducing bacteria of the family *Desulfobacteriaceae* has been observed in the flooded tunnels of an abandoned mine in southwestern Wisconsin. ZnS accumulations are limited to biofilms growing on old mine timbers. ZnS deposits, which comprise about 20 percent of the volume of the biofilm, formed in less than 30 yr from solutions containing only a few milligrams per liter (mg/l) $Zn^{2+}$. A model is proposed wherein sulfate reduction is followed by the formation of aqueous metal-sulfide clusters that aggregate to form 1- to 3-nm–diameter crystals that are transported and agglomerate to form micron-scale aggregates. Geochemical modeling shows how reduction of sulfate leads to exclusive precipitation of ZnS until most of the $Zn^{2+}$ is consumed. The model also predicts a series of discrete metal-sulfide precipitation events that may be used to interpret sulfide mineral paragenesis of low-temperature Cu-Pb-Zn ore deposits. For example, the paragenesis of essentially monomineralic and mixed sulfide layers in Mississippi Valley-type, strataform, and strata-bound Pb-Zn-Cu, and SEDEX deposits can be predicted thermodynamically if the rate of aqueous sulfide generation does not outstrip the flux of metals into the system. Based on the characteristics of ZnS produced by sulfate-reducing bacteria, features of ore deposit minerals consistent with a biogenic origin can be identified. These include microstructures formed by coarsening of nanophase materials, the presence of micron-scale spherical aggregates in organic-rich microenvironments, and spatially heterogeneous patterns of sulfide mineral distribution, consistent with local variations in redox potential and activity of sulfate-reducing bacteria.