

The replacement of chalcopyrite by bornite under hydrothermal conditions

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ABSTRACT

We report the replacement of chalcopyrite by bornite under hydrothermal conditions in solutions containing Cu(I) and hydrosulfide over the temperature range 200–320 °C at autogenous pressures. Chalcopyrite was replaced by bornite under all studied conditions. The reaction proceeds via an interface coupled dissolution-reprecipitation (ICDR) mechanism and via additional overgrowth of bornite from the bulk solution. Initially, the reaction is fast and results in a bornite rim of homogeneous thickness. Reaction rates then slow down, probably reflecting healing of the porosity, and the reaction proceeds predominantly along twin boundaries of the chalcopyrite.

The composition of the bornite product is generally Cu-rich, corresponding to the bornite-digenite (Cu₅FeS₄-Cu₉S₅; Bn-Dg) solid solution (*bdss*). The Cu and Fe contents were controlled principally by temperature, with solution pH having only a small effect. The percentage of Cu in *bdss* decreased and the percentage of Fe increased with increasing reaction temperature: at 200 °C a composition of Bn₄₇Dg₅₃ was obtained; at 300 °C the composition was Bn₉₀Dg₁₀ and at 320 °C it was near-stoichiometric bornite. The influence of temperature rather than solution chemistry on the composition of *bdss*, as well as the homogeneity of the bornite product grown both via replacement of chalcopyrite and from the bulk solution as overgrowth, are interpreted to reflect buffering of the bornite activity in *bdss* via solids (e.g., reaction chalcopyrite + 2 chalcocite = bornite).

Only the end-member compositions of the *bdss* are found in nature, indicating that the products obtained are metastable, and illustrating the importance of reaction mechanism for controlling the chemistry of the mineral product. The unique features of the chalcopyrite to bornite reaction investigated here are related to interaction between a solution controlled ICDR reaction with solid-state diffusion processes driving porosity healing.

Keywords: Chalcopyrite, bornite, mineral replacement reaction, diffusion, hydrothermal, bornite-digenite solid solution