Gold in Porphyry Copper Deposits: Experimental Determination of the Distribution of Gold in the Cu-Fe-S System at 400° to 700°C

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Abstract

Experiments in the system Au-Cu-Fe-S were carried out at temperatures of 400° to 700°C to determine how much gold could be accommodated by bornite and chalcopyrite, the two most common ore minerals in porphyry copper-gold deposits. Our results show that for all temperatures bornite contains one order of magnitude more gold than chalcopyrite (or intermediate solid solution (iss), its high-temperature equivalent). The range of gold concentrations in bornite and chalcopyrite (or iss) decreases with decreasing temperature from 1,280 to 8,200 ppm Au in bornite and 100 to 125 ppm Au in iss at 600°C, to 235 to 364 ppm Au in bornite and 5 to 16 ppm Au in chalcopyrite (or iss) at 500°C, and to 13 to 80 ppm Au in bornite and 2 to 4 ppm Au in chalcopyrite (or iss) at 400°C. The amount of gold in bornite is also strongly dependent on the composition of bornite, being highest in ''stoichiometric'' bornite compositions (Cu_5FeS_4), and decreasing toward Cu-rich and Cu-poor compositions.

Phase equilibrium constraints for solutions with geologically reasonable reduced sulfur contents indicate that high-temperature porphyry copper-gold deposits will contain bornite and magnetite, whereas lower temperature deposits (whether primary or overprinted by phyllic alteration) will contain chalcopyrite and pyrite. If gold is present in the ore-forming solutions, more of it will be deposited in high-temperature porphyry copper-gold deposits where it will be closely associated with bornite. Coexisting magnetite in these deposits should generate magnetic anomalies. Lower temperature deposits will contain less gold, which is hosted by pyrite as well as chalcopyrite, and will lack magnetic anomalies. Comparison of the amount of gold hosted by natural porphyry copper-gold ores to that hosted by bornite and chalcopyrite in our experiments suggests that significant amounts of gold can be lost from these deposits into surrounding hydrothermal systems.