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The solubility of gold in sulfur-bearing fluids at 600 ^{o}C and 200MPa: A synthetic fluid inclusion study

LINBO SHANG[1], YUN-HE ZHOU[1], CHEN CHEN[2], ZI-QI JIANG[1] AND I-MING CHOU[3]

[1]Institute of Geochemistry, Chinese Academy of Sciences
[2]Chengdu University of Technology
[3]Institute of Deep-sea Science and Engineering, Chinese Academy of Sciences

Hydrothermal fluids serve as critical carriers for transporting ore-forming metals, in which ligands such as chloride (Cl^-) and hydrosulfide (HS^-) have long been recognized as key agents for gold mobilization. Recent spectroscopic evidence has identified the trisulfur ion (S_3^-) as a potentially significant ligand in crustal fluids[1], yet its quantitative role under porphyry-type conditions remains poorly constrained. This study experimentally investigates gold solubility in S_3^--bearing aqueous fluids using synthetic fluid inclusion and LA-ICP-MS analysis methods[2]. Experiments were conducted in rapid-quench cold-seal vessels with Au capsules at 600 °C and 200 MPa, with various initial $K_2S_2O_3$ concentrations to control sulfur content.

Experimental results reveal a strong positive correlation between total sulfur content and gold solubility, which increased dramatically from 50 ± 18 ppm in 0.05 *m* (mole/kg H_2O) $K_2S_2O_3$ solution to 3532 ± 314 ppm in 0.75 *m* $K_2S_2O_3$ solution. Upon reheating of the inclusions, S_3^- became detectable by Raman spectroscopy above 200 °C. Gold concentration increases with the calculated concentrations of both S_3^- and HS^-. Based on the approximate 1:1 dependence of logarithm of Au solubility on logarithm of S_3^- and HS^- concentrations, we interpret gold solubility to be controlled by the formation of the mixed-ligand complex $Au(HS)S_3^-$. The high solubilities observed indicate that S_3^--bearing species are exceptionally effective ligands for gold transport at elevated temperatures, consistent with previous spectroscopic studies[3]. These findings highlight the importance of incorporating S_3^- speciation into genetic models of hydrothermal ore formation alongside conventional Cl^- and HS^- complexes to better understand gold mobility in complex geological fluids.

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