Fluid-Rock Interaction Recorded in Apatite: Implications for Source and Evolution of Ore-Forming Fluids in the World-Class Jiaodong Gold Deposits, China

Liang Zhang[1], Shu-Qi Yang[1], Gui-Ying Li[1], Li-Qiang Yang[1], Jing Zhang[1]
[1]State Key Laboratory of Geological Processes and Mineral Resources & School of Gemmology, China University of Geosciences, China

The giant Jiaodong gold province, with >5,700 tons of proven gold resources, is the largest in China. However, the source of auriferous fluids and the gold mineralization process remains debated. Traditional C-H-O-S-Pb isotope data have failed to resolve this issue. Apatite, commonly found in gold-hosting granites, records fluid–rock interactions during alteration, offering a potential tracer for ore-forming fluid sources and evolution. In this study, we analyzed textural features, in-situ trace elements, and oxygen isotope compositions of unaltered, altered, and hydrothermal apatite from host granites and syn-gold diorite beneath major orebodies using CL, LA-ICP-MS, and SHRIMP.

Magmatic apatite in granites is typically subhedral to euhedral with yellow-green CL. Altered apatite shows fractures with purple-gray CL in altered zones. Rare hydrothermal apatite displays oscillatory zoning and commonly overgrows or crosscuts earlier apatite. Chondrite-normalized REE patterns of magmatic apatite are relatively flat with strong negative Eu anomalies. During alteration, fluids preferentially leached LREE and HREE, while MREE remained. Breakdown of feldspars released Eu, producing hydrothermal apatite with positive Eu anomalies and depletion in LREE and HREE. These changes, alongside a hydrothermal assemblage of muscovite, quartz, pyrite, polymetallic sulfides, and gold, suggest a transition from oxidizing to reducing conditions.

In syn-gold diorite, magmatic apatite shows brown CL and a right-leaning REE pattern with a slight negative Eu anomaly, whereas its altered zones show green CL, reduced Cl and S contents, and inclusions of monazite and celestite, suggesting an oxidizing fluid. Although mixing with the dominant reducing auriferous H2O–CO2–NaCl±CH4 fluid may have aided gold deposition, the limited oxidizing dolerite fluid cannot be the main gold source.

Oxygen isotope data from syn-gold hydrothermal apatite from granite overlap with values from oceanic crust altered by high-temperature melts/fluids, pointing to a Paleo-Pacific Plate contribution to the Jiaodong gold mineralization.

Supported by National-Key-Research-Program (2023YFC2906902) and National-Natural-Science-Foundation (42272071).