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Magmatic sulfur source for the Hatu gold deposit, West Junggar, NW China: Evidence from in situ sulfur isotope

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West Junggar is a major part of the Central Asian Metallogenic Domain. The Hatu deposit with gold reserves of more than 50 tons is the largest gold deposit in west Junggar, however, its genesis is still controversial. Different workers have suggested a basaltic volcanic-related, granite-related, or orogenic gold deposit type classification.

The Hatu gold deposit is controlled by the ENE-trending Anqi fault and its secondary faults in Early Carboniferous volcanic-sedimentary rocks. The major wallrocks are basalt, with small amounts of tuffaceous siltstone and tuff. Carbonaceous tuffaceous siltstone layers containing framboidal pyrite are common in the tuffaceous siltstone. The framboidal pyrite (5-30 μm) displays a texture of microscopic spheroidal pyrite clusters. A chlorite-sericite-pyrite assemblage is widespread in altered basalt. The pyrites (50-350 μm) are euhedral to subhedral, and intergrown with chlorite. The orebodies are composed of quartz veins and altered wallrock types. The former is mainly distributed in shallow parts of the deposit (0-400 m) and is controlled by NE-trending faults, while the latter is only found in deeper parts of the deposit (>400 m) and is hosted in E-W-trending faults. The hydrothermal assemblages were divided into five stages: anhedral pyrite microcrystal aggregate (Py1)-albite-quartz vein (stage I); fine-grained euhedral pyrite (Py2)-albite-quartz vein (stage II); fine-grained subhedral to euhedral pyrite (Py3)-arsenopyrite-quartz-carbonate vein (stage III); microgranular subhedral pyrite (Py4)-chalcopyrite-carbonate vein (stage IV); and calcite vein (stage V). Native gold occurs as inclusions and fracture fillings in Py2, Py3, and arsenopyrite.

In-situ sulfur isotope analyses were conducted on different pyrite grains from Hatu. The framboidal pyrite grains have an extremely large range of $\delta^{34}S$ values from -26.71 to +53.98‰ (26 analyses). Pyrite grains intergrown with chlorite in basalt have negative $\delta^{34}S$ values ranging between -26.73 to -12.10‰, with an average of -20.55‰ (14 analyses). Hydrothermal pyrite grains in different veins have a rather narrow range of $\delta^{34}S$ values near zero (-0.74 to 1.45‰). Py1 grains have positive $\delta^{34}S$ values of 0.66 to 1.45‰ (mean=1.08‰; 11 analyses). The $\delta^{34}S$ values of Py2 are -0.24 to 1.24‰ (mean=0.61‰; 13 analyses), and those for Py3 are -0.66 to 0.83‰ (mean=0.27‰; 20 analyses). Py4 grains have negative $\delta^{34}S$ values of -0.74 to -0.12‰, with an average of -0.30‰ (6 analyses). The change of $\delta^{34}S$ values from stage I to stage IV pyrite may reflect a gradual change from an originally reducing hydrothermal fluid to slightly more oxidized conditions. The sulfur isotopic compositions of pyrite in host rocks and hydrothermal veins exclude the possibility that the host rocks were one of the sulfur sources, but indicate that the Hatu gold deposit has a mantle sulfur source. The very narrow range of $\delta^{34}S$ values of Hatu is different from orogenic gold deposits, which tend to show $\delta^{34}S$ values that are extremely variable and are also distinctly different from pyrite in basalt. Thus, we propose that the Hatu gold deposit is probably a granite-related gold deposit.