SEG 2017 Conference

Pyrite zonation and gold distribution in the Haopinggou deposit, southern North China craton: Constraints from LA-ICP-MS and EBSD analyses

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Texture and trace-element content of pyrite from the Haopinggou deposit were studied to reveal the Au enrichment mechanism in metamorphic rock-hosted gold veins. The Haopinggou deposit is located in the Xiong'ershan district, southern margin of the North China craton. It comprises numerous gold-bearing pyrite-quartz veins and silver-bearing Pb-Zn-sulfide veins hosted in metamorphic rocks of the Late Archean to early Paleoproterozoic Taihua Group. The mineralized veins are surrounded by alteration halos ranging from 10 cm to 2 m in width. The alteration assemblages consist mainly of sericite, quartz, chlorite, and carbonate, with minor disseminations of sulfide minerals. The pyrite-quartz veins formed earlier than the Pb-Zn-sulfide veins due to field crosscutting relationships. Metallic minerals in the pyrite-quartz veins are dominated by pyrite, with minor to trace amounts of chalcopyrite, pyrrhotite, arsenopyrite, galena, sphalerite, and gold minerals.

Petrographic observations of acid-etched thin sections, back-scattered electron imaging, and laser ablation-inductively coupled plasma-mass spectroscopy (LA-ICP-MS) spot analysis and elemental mapping revealed three generations of pyrite (Py1 to Py3) in the gold-bearing pyrite-quartz veins. Py1 is coarse-grained pyrite with abundant fine-grained inclusions of quartz, chalcopyrite, and galena. It is enriched in lots of trace elements including Co, Ni, Ag, Pb, Cu, Sb, and Bi, but has low Au. Py2 consists of subhedral to euhedral pyrite overgrowths on Py1. Py2 has much higher contents of As and Au, but other trace elements are generally very low compared to Py1. Py3 typically occurs as overgrowths of Py1 and Py2, and is also present as discrete subhedral to euhedral grains. Py3 is enriched in As, Au, Ag, Pb, Bi, Sb, Cu, Co, and Ni. Gold occurs as invisible gold in pyrite or visible gold minerals including native gold, electrum, and kustelite in the pyrite-quartz veins. Invisible gold mostly occurs as lattice-bound Au in Py2 (up to 92 ppm Au) and Py3 (up to 127 ppm Au) and has a close relationship with As. Gold minerals are present in Py3 and surrounding minerals, and likely resulted from mobilization and reprecipitation of the invisible gold previously locked in the precursor pyrite. This view is supported by extensive plastic deformation of pyrite as revealed by electron backscatter diffraction (EBSD) analysis. The plastic deformation could have generated lattice dislocations and orientation boundaries that caused intragrain diffusion through fast pathways and fluid-mediated liberation of invisible gold. The remobilized gold can be efficiently scavenged by deformation-related fluids and reprecipitated as particles within microfractures of pyrite grains or included in overgrowths surrounding the parental grains and nearby gangue minerals. Our study demonstrates that gold could be remobilized and enriched during pyrite deformation process in gold-bearing veins hosted in the metamorphic rocks.