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New insights into the control of visible gold fineness and deposition: A case study of the Sanshandao gold deposit, Jiaodong, China

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Abstract

Mineralogical distribution, textures, electron probe microanalysis of visible gold, laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) trace element analysis of pyrite, and LA-multicollector (MC-)ICP-MS sulfur isotope analysis of sulfide minerals are examined in an ore zone extending obliquely to –4 km depth in the Sanshandao gold deposit Jiaodong, China. We relate these results to the temporal and spatial ore-forming processes in the deposit to further elucidate the controls on the deposition of visible Au and fineness variation.

Two generations of Au mineralization are identified. The early generation is represented by beresitization and quartz-pyrite veins in which visible Au grains are associated with pyrite (Py1 and Py2) and are characterized by high fineness [729–961; fineness = 1000×Au/(Au+Ag)]. Py1 and Py2 are both enriched in Co, Ni, and Bi and depleted in As and Au. Texturally, gold and pyrite are pristine crystals, homogeneous in composition. These features are attributed to the sulfidation of the granitic wallrock (fluid/rock interaction) that effectively destabilizes Au in the ore-forming fluids during pyrite deposition. Fineness decreases continuously from 870 at –2650 m depth to 752 at –420 m depth. The Co and Ni contents of Py1 and Py2 decrease significantly from –4000 m to –420 m depth, whereas the As contents increase. The mean $\delta^{34}S$ values of Py1 increase from 10.5 to 11.8‰. The spatial variations are interpreted to be related to gradual cooling, decompression, and an enhanced degree of fluid/rock interaction with decreasing depth, which facilitated the initiation of visible gold mineralization at ca. –2700 m depth.

The late generation of Au mineralization is represented by quartz-polysulfide veins in which visible Au grains are associated with multiple sulfide minerals (Py3, galena, chalcopyrite, arsenopyrite, and sphalerite). It is characterized by low fineness (549–719), and heterogeneous textures with Ag-rich parts (218–421). Py3, occurring as the rim of pyrite grain, is interpreted to form by replacement via a dissolution-reprecipitation reaction. Py3 is distinctly enriched in As (median of 10 000 ppm) and Au (2.2 ppm), but depleted in Co, Ni, and Bi. The $\delta^{34}S$ values of the polysulfide minerals decrease sharply by 4 to 5‰ at depths from –1909 to –1450 m. These features are interpreted to be generated by significant decompression and phase separation of fluid, where most ore elements (e.g., Au, Ag, As, and base metal elements) are destabilized. Our study suggests that remobilization did not affect the generation of visible Au mineralization at Sanshandao.

Keywords: Visible gold grain, fineness, in situ pyrite trace elements, in situ sulfide sulfur isotope, Sanshandao gold deposit, Jiaodong