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Fluid Inclusion and Multiple Isotope (H, O, S, Pb) Studies of the Sandaowanzi Epithermal Au-Ag-Te Deposit, NE China

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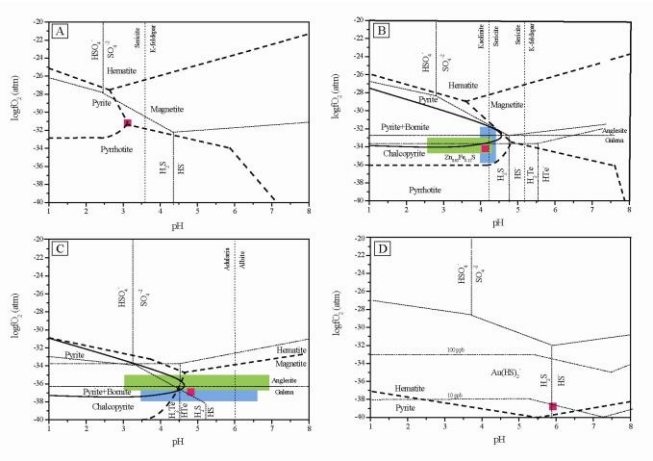
Although numerous epithermal deposits contain tellurides, only a few contain the majority of their gold and silver within telluride minerals. The Sandaowanzi gold deposit, which is a typical gold-telluride deposit in NE China, has a total reserve of ≥25 tonnes Au and an average grade of 15 g/t. The deposit has attracted broad attention mainly because (1) it is the first reported case of a dominantly Au-(±Ag)-telluride deposit in NE China, and (2) exploration investigations discovered abundant bonanza Au- and Ag-telluride ores. In this study, new analytical results of mineralogical, stable (O, H and S) and Pb isotope and fluid inclusion are presented. This integrated fluid inclusion and isotope geochemical study covers a suite of samples from different mineralization stages, ore types and mining levels within the ore system to constrain the origin of ore fluids and metals, and to infer the mechanisms that trigger widespread precious metal-bearing telluride deposition.



Fluid inclusion data reveal that the Sandaowanzi ores precipitated from moderate-temperature (225° to 265 °C) and low to moderate salinity (0.2 to 14.2 wt.% NaCl equiv.) hydrothermal fluids. The $\delta^{34}S_{H2S}$ (-2.2 to -0.2 ‰) values indicate a leached sulfur by meteoric water from the host volcanic rocks and the $\delta^{18}O_{H2O}$ (-13.6 to -7.6 ‰) and δD_{H2O} (-127 to -96 ‰) values consistently determine significant amounts of meteoric waters in hydrothermal fluid. The lead isotopes of sulfides suggest a mantle or magmatic origin for Pb, which was isotopically inherited from the host volcanic rocks by fluid-rock interactions.

Figure 1: Physicochemical constraints for the ore fluids

In *situ* LA-ICP-MS analyses of different quartz generations show that Ti contents in later veins successively decrease, implying that the temperature of the hydrothermal fluids decreased through time during the evolution of the system. Physicochemical conditions for deposition of tellurides (Fig. 1) are

pH = 3.01 to 5.95, $fS_2 = 10^{-14.1}$ to $10^{-9.3}$, $fO_2 = 10^{-38.8}$ to 10^{-31} and $fTe_2 = 10^{-11.6}$ to $10^{-7.0}$. The transport and deposition of Au and Ag in solution can be summarized as the following two reactions:

$2Ag(HS)^-_{2(aq)} + HTe^-_{(aq)} = 4HS^-_{(aq)} + Ag_2Te_{(s)} + H^+_{(aq)}$

$Au(HS)^-_{2(aq)} + 2HTe^-_{(aq)} + H_2O_{(l)} + H^+_{(aq)} = 2HS^-_{(aq)} + AuTe_{2(s)} + 0.5O_{2(g)} + 2.5H_{2(aq)}$

An increase of $\alpha_{HTe^-_{(aq)}}$ coupled with pH neutralization ($\alpha_{H^+_{(aq)}}$ decrease) could favor hessite precipitation, and coupled with fO_2 decrease could have also promoted calaverite deposition. Accordingly, we propose that a pH and $\alpha_{HTe^-_{(aq)}}/\alpha_{HS^-_{(aq)}}$ increase coupled with a fO_2 decrease due to episodic boiling and subsequent condensation are plausible mechanisms for precipitation of the abundant Au- and Ag-telluride ores.