Source of Water, Salt, Volatiles, and Metal in Carlin-like Deposits of the Golden Triangle, Southwest China: Implications for Genetic Models

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The ~120,000 km^2 Golden Triangle in SW China contains the greatest concentration of Carlin-like gold deposits outside of Nevada and has a total proven reserve of > 800 t Au. The largest deposits are hosted in folded and faulted Permian shallow-marine limestone and fluvial volcaniclastic rocks (e.g., Shuiyindong 270 t Au, Nibao 97 t Au) and Triassic deep-marine siliciclastic and carbonate rocks (e.g., Lannigou 167 t Au, Yata 21 t Au). As yet, there is no consensus on the source of ore fluids, age of the deposits (85, 135, or 200 Ma), or their relation to the geotectonic evolution of the region. New isotopic and fluid inclusion data from Shuyindong, Nibao, and Yata together with data from previous studies are used to constrain the principal sources of ore fluid components.

Calculated $\delta^{18}O_{H2O}$ and δD_{H2O} values for dickite and $\delta^{18}O_{H2O}$ values for quartz (220°C) and calcite (150°C) and δD_{H2O} values of fluid inclusions extend between three end members: metamorphic (± magmatic) waters (14‰, -15‰), organic water (14‰, -135‰), and meteoric water (-10‰, -72‰). Most of the calculated $\delta^{13}C_{CO2}$ values for calcite (150°C) and measured $\delta^{13}C_{CO2}$ values of fluid inclusions are within the range of their carbonate host rocks (-7 to +6‰) as well as mantle C (-3 to -7‰); some extend to lower values (-10‰) that may be due to oxidation of organic C. Helium extracted from fluid inclusions in quartz, calcite, As-pyrite, realgar, and fluorite generally has Rc/Ra values between 0.01 that is typical of crust and 0.3 that corresponds to 4% mantle He (R/Ra = 8); the exception is Yata quartz with Rc/Ra up to 2 and 25% mantle He. Inclusion fluid extracted from quartz, calcite, and realgar have high Na/Cl and low Cl/Br ratios that extend from basinal brine into the metamorphic field. Extracts from 2 fluorite and 2 milky quartz samples have low Na/Cl and high Cl/Br ratios typical of a magmatic source. In-situ S and Pb isotope data on Au-bearing As-pyrite mimic those of the most abundant type of pre-ore pyrite in host rocks, which may be evidence for As-metasomatism of pre-ore pyrite. These results demonstrate that local host rocks exerted a remarkably strong control on the isotopic compositions of hydrothermal minerals. Only H, O, and He isotopes and halogens provide clear evidence for fluid input from deep metamorphic or magmatic sources.

The Golden Triangle is inboard from three Mesozoic orogens: Yanshanian subduction-related, Indosinian island arc-continent collision, and Qinling continent-continent collision. Lateral flow of hot fluids over large distances (200-400 km) from one or more of these orogens with up-flow in the Golden Triangle is one explanation for the concentration of Carlin-like gold deposits. Although no 200 Ma igneous rocks have been found in the Golden Triangle, a few lamprophyre dikes provide evidence for mafic magmatism at 135 and 85 Ma. Advective transfer of heat to shallow levels from concealed mafic sills at middle to lower crustal levels is another plausible explanation for Au mineralization in this

region.