

Fluid Inclusions and C-H-O-S Isotope Systematics of the Suyunhe Porphyry Mo Deposit, West Junggar, NW China

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The Suyunhe molybdenum deposit, located in the West Junggar terrane, Xinjiang, China, is a typical low-fluorine porphyry-type deposit with a proven reserve of 0.57 Mt at an average Mo grade of 0.05–0.09%. The formation of the ore deposit is associated with Early Permian granitic rocks, which were emplaced into the volcano-sedimentary sequences of the Middle Devonian Barluk Formation.

The following four metallogenic stages are identified at Suyunhe. Stage I is marked by quartz+magnetite+K-feldspar veins associated with potassic alteration that formed under high temperatures ($>481^{\circ}\text{C}$), from high salinity fluids (58.60–65.18 wt %), and at relatively high oxygen fugacity conditions within the NaCl-H₂O-CO₂ system. Stage II is the main metallogenic stage and developed numerous quartz-molybdenite±pyrite veins associated with muscovite-chlorite alteration that formed under medium-high temperatures (210°–427°C), from medium-high salinity fluids (43.36–49.90 wt %), and at relatively low oxygen fugacity conditions within the NaCl-H₂O-CO₂-CH₄-C₂H₆ system. After the main Mo-mineralization, quartz-polymetallic sulfide veins associated with quartz-sericite alteration were formed by fluids under medium-low temperatures (116°–348°C) and from low salinity fluids (1.03–8.50 wt %) during stage III. Stage IV mainly consists of quartz±calcite and calcite veins that formed at low temperatures (100°–185°C) and from low salinity fluids (1.05–7.16 wt %) within the NaCl-H₂O system.

Interpretation of $\delta^{18}\text{O}_{\text{‰}}$ values indicates that ore fluids during stages I and II in the Suyunhe Mo deposit are dominated by magmatic water, whereas stages III and IV are dominated by meteoric water. The $\delta^{34}\text{S}$ values of sulfides vary from $-7_{\text{‰}}$ to $+4.6_{\text{‰}}$, indicating that sulfur is mainly magmatic in origin. The decrease in redox potential of the ore fluids can play an important role in molybdenum mineralization as demonstrated by sulfur isotopic compositions and increased content of reducing gases in stage II. Most of the CH₄ from fluid inclusions has $\delta^{13}\text{C}_{\text{CH}_4}$ values in a narrow range of -28 to $-23.2_{\text{‰}}$ and relatively low CH₄/C₂H₆ ratios of 0 to 20, indicating a typical characteristic of thermogenic gases; whereas a few samples have higher $\delta^{13}\text{C}_{\text{CH}_4}$ values of -14.6 to $-8.5_{\text{‰}}$, suggesting abiogenic gases. Therefore, the $\delta^{13}\text{C}_{\text{CH}_4}$ values suggest that CH₄ in the ore fluids mainly is derived from carbonaceous country rocks, and partly derived from magma. However, $\delta^{13}\text{C}_{\text{CO}_2}$ values suggest that CO₂ of the ore fluids mainly originates from magma, and minor contributions come from wall rocks and meteoric water.

A CH₄ component is widely recognized in ore fluids from porphyry ore deposits (e.g., Baogutu, Suyunhe, Hongyuan) in the West Junggar terrane. In contrast, CH₄ is not common in porphyry deposits elsewhere in China and worldwide. Its presence here can be ascribed to the fact that the volcano-sedimentary strata in the West Junggar terrane contain organic matter as identified by scanning electron microscope and energy spectrum, carbon isotopes, and organic carbon content analyses. The organic matter in the strata will break down, producing abundant hydrocarbons

(e.g., CH₄ and C₂H₆) when the magmatic-hydrothermal system provides heat. In addition, the minor abiogenic CH₄ is compatible with the low oxygen fugacity ($f_{O_2} < FMQ+1$) of the magma as demonstrated by mineral chemistry analyses of hornblende, biotite, apatite, and Fe-Ti oxides.