Mantle fluid indicator for the poly-metallic mineralization in the south margin of North China Craton: Evidences from fluid inclusion and He-Ar isotopes

MINGTIAN ZHU AND LIANCHANG ZHANG

Key Laboratory of Mineral Resources, Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing 100029, China

Dozens of poly-metallic deposits distributed in the south margin of North China Craton (SMNCC). They share some similar features in the occurrences and metal assemblages. Here we focus on their porphyry±skarn Mo and veined pyrite mineralizations to distinguish their ore-forming microthermometry and sources by fluid inclusions and He-Ar isotopes. (1) In the porphyry quartz, the boiling feature is very obvious, with homogenization temperatures of 335–420 °C and salinities of 4.7–49.6 wt. % NaCl equiv and its $^{3}He/^{4}He$ ratio are relatively uniform, ranging from 1.39 to 1.78 Ra ($Ra=1.39\times10^{-6}$ for air), corresponding to 16–22 % mantle ^{4}He contribution. This relatively constant range represents the actual helium isotopic composition of the fluids emanating from the cooling intrusions at depth; (2) Pyrite in the veined mineralization only hosts liquid-rich biphase inclusions, with homogenization temperatures of 260–350 °C and salinities of 6.0–21.3 wt. % NaCl equiv. The range of $^{3}He/^{4}He$ ratios is wide, varying from 0.16 to 5.26 Ra, corresponding to 1–65 % mantle ^{4}He. Significant variation in the microthermometry and $^{3}He/^{4}He$ ratios reflects mixing between two fluids. These data indicate that there are two distinct fluid sources and separate evolutionary processes for the porphyry and vein mineralizations and support a multi-stage mineralization model. The porphyry molybdenite mineralization was induced by the boiling and associated cooling of a magma-sourced fluid that emanated from intrusions at depth. The pyrite mineralization may be attributed to the influx of a dominantly mantle-derived fluid with high $^{3}He/^{4}He$ ratio, which is most likely related to a later, more mafic magmatic event. The precipitation of the most economically important pyrite resulted from the mixing and diluting of this mantle-derived fluid with a surface-derived fluid. Additionally, the high $^{3}He/^{4}He$ ratios indicate a strongly extensional setting, which is most likely related to the Late Jurassic to Early Cretaceous lithospheric modification and thinning of the SMNCC.

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