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Textural, fluid inclusion, and in-situ oxygen isotope studies of quartz: Constraints on vein formation, disequilibrium fractionation, and gold precipitation at the Bilihe gold deposit, Inner Mongolia, China

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Abstract

Bilihe is a porphyry gold deposit located in the northern margin of the North China Craton (NCC), Inner Mongolia, China. Different stages of quartz are well developed at this deposit. To document the history of quartz deposition, the fluid evolution and gold precipitation events of the deposit and the detailed oxygen isotope signatures of quartz from Bilihe were studied using high-resolution secondary ion mass spectroscopy (SIMS), then integrated with scanning electron microscope-cathodoluminescence (SEM-CL) and fluid inclusion microthermometry. The SEM-CL features show that the hydrothermal veins at Bilihe have a complex growth history, with multiple generations of quartz developed in each set of veins. Fluid inclusions in different quartz stages yield variable homogenization temperatures, ranging from 178 °C to above 600 °C. These quartz stages exhibit variable $\delta^{18}O$ values of 3.5–15.4‰, corresponding to $\delta^{18}O_{fluid}$ ranging from –8.7 to 12.0‰. There are two abnormal peaks of $\delta^{18}O_{quartz}$ and $\delta^{18}O_{fluid}$ values occurring in a sub-generation of A type veins and auriferous-banded quartz veins, suggesting that the vein quartz may have experienced sporadic disequilibrium oxygen fractionation with water when crystallizing, thus resulting in local ^{18}O-enrichment. The overall $\delta^{18}O_{fluid}$ values, which show a gradual decrease from early to late stages, suggest a progressive decrease in the proportion of magmatic hydrothermal fluids. The relationship between quartz textures and gold occurrence shows that gold precipitated twice at Bilihe. The first precipitation in the UST quartz may have resulted from rapid cooling and indicates that the addition of meteoric water was not necessary for gold precipitation, whereas the progressive incursion of meteoric water probably had a significant effect on the second gold precipitation event.

Keywords: Porphyry gold deposit, quartz, cathodoluminescence, in situ oxygen isotopes, magmatic-hydrothermal evolution, disequilibrium fractionation