

Two-stage magmatism and tungsten mineralization in the Nanling Range, South China: Evidence from the Jurassic Helukou deposit

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ABSTRACT

The Helukou deposit, with proven reserves of 33 752 t WO₃, is one of the newly exploited medium-scale tungsten (W) deposits in the Guposhan ore field, Nanling Range of South China. Skarn-type and less abundant altered granite-type tungsten orebodies were identified in this deposit. The ore mineralization in this district was a product of two-stage magmatism, as shown by LA-ICP-MS U-Pb dating of zircons and Re-Os dating of molybdenite. The former yielded U-Pb ages of 184.0 ± 3.6 Ma (MSWD = 0.15) and 163.8 ± 1.5 Ma (MSWD = 0.41) for fine-grained biotite granite and muscovite granite, respectively, as well as a U-Pb age of 181.5 ± 2.1 Ma (MSWD = 0.75) for zircon grains from altered granite-type tungsten ore. The latter yielded molybdenite Re-Os ages of 183.5 ± 2.8 Ma (without MSWD owing to a limited number of samples) and 163.4 ± 2.8 Ma (MSWD = 0.71) for altered granite-type and skarn-type tungsten deposits, respectively. Thus, two separate tungsten mineralization events occurred during the Early Jurassic and Middle Jurassic. Trace-element compositions suggest that scheelite I was controlled by the coupled substitution reactions of 2Ca²⁺ = Na⁺ + REE³⁺ and Ca²⁺ + W⁶⁺ = Nb⁵⁺ + REE³⁺, whereas scheelite II was controlled by the coupled reactions of 2Ca²⁺ = Na⁺ + REE³⁺ and 3Ca²⁺ = □Ca + 2REE³⁺ (where □ is a site vacancy). High Mo and low Ce³⁺ contents suggest that both scheelite I and scheelite II were precipitated from oxidizing magmatic-hydrothermal fluids. Based on the mineral assemblage of the altered granite-type ores and geochemical characteristics of scheelite I [i.e., negative Eu anomalies (0.02–0.05; mean = 0.03 and STD = 0.01), and high ⁸⁷Sr/⁸⁶Sr ratios (0.70939–0.71932; mean = 0.71345 and STD = 0.00245)], we infer that fluid-rock interaction played an important role in modifying Early Jurassic ore-forming fluids. Scheelite II exhibits a geochemical composition [i.e., ⁸⁷Sr/⁸⁶Sr ratios (0.70277–0.71471; mean = 0.70940 and STD = 0.00190), Eu anomalies (0.14–0.55; mean = 0.26 and STD = 0.09), and Y/Ho ratios (16.1–33.7; mean = 27.9 and STD = 2.91)] similar to that of the Middle Jurassic Guposhan granites, suggesting inheritance of these features from granite-related magmatic-hydrothermal fluids. These results provide new insights into the two-stage magmatic and metallogenic history of the Nanling Range during the Jurassic Period.

Keywords: scheelite, Re-Os dating, U-Pb dating, W-Sn mineralization, Guposhan