

## **Texture and geochemistry of multi-stage hydrothermal scheelite in the Dongyuan porphyry-type W-Mo deposit, South China: Implications for the ore-forming process and fluid metasomatism**

**JIA-XIANG DONG<sup>1,2</sup>, XIAO-FEI PAN<sup>2,\*</sup>, SHAO-YONG JIANG<sup>1,\*</sup>, ZENG-QIAN HOU<sup>3</sup>, YAN-SHEN YANG<sup>2,4</sup>, SUO-FEI XIONG<sup>1,†</sup>, AND YONG-PENG OUYANG<sup>5</sup>**

<sup>1</sup>State Key Laboratory of Geological Processes and Mineral Resources, School of Earth Resources and Collaborative Innovation Center for Exploration of Strategic Mineral Resources, China University of Geosciences, Wuhan 430074, China

<sup>2</sup>State Key Laboratory of Deep Earth and Mineral Exploration, Institute of Geology, Chinese Academy of Geological Sciences, Beijing 100037, China

<sup>3</sup>State Key Laboratory of Deep Earth and Mineral Exploration, SinoProbe Laboratory, Chinese Academy of Geological Sciences, Beijing 100037, China

<sup>4</sup>University of Science and Technology Beijing, Beijing 100083, China

<sup>5</sup>State Key Laboratory of Geological Processes and Mineral Resources, and School of Earth Sciences and Resources, China University of Geosciences, Beijing, 100083, China

### **ABSTRACT**

Scheelite in the Dongyuan porphyry-type W-Mo deposit, South China, occurs both in porphyritic biotite granite and lamprophyre. Three types of scheelite (Sch<sub>A</sub>, Sch<sub>B</sub>, and Sch<sub>C</sub>) were identified in the porphyritic biotite granite, whereas two types (Sch<sub>a</sub> and Sch<sub>b</sub>) were recognized in the lamprophyre. The incorporation of rare earth elements (REE) into scheelite occurs mainly via the substitution mechanism represented by  $2^{[VIII]}Ca^{2+} = [VIII]REE^{3+} + [VIII]Na^{+}$ , and additionally by  $3^{[VIII]}Ca^{2+} = 2^{[VIII]}REE^{3+} + Ca\Box$  (where Ca $\Box$  denotes a Ca-site vacancy). The REE patterns of Sch<sub>A</sub> are similar to those of the porphyritic biotite granite, suggesting that Sch<sub>A</sub> inherited its REE composition directly from the porphyritic biotite granite. Complex textures in scheelite and the similar geochemical signatures of Sch<sub>B1</sub> and Sch<sub>B3</sub> imply repeated injections of ore-forming fluids into the porphyritic biotite granite during Sch<sub>B</sub> formation. The evolution of ore-forming fluids, coupled with the precipitation of apatite and early scheelite (Sch<sub>A</sub> and Sch<sub>B</sub>), led to Sch<sub>C</sub> with more intense enrichment in middle rare earth elements (MREE). Sch<sub>a</sub> and Sch<sub>b</sub> share identical REE patterns, indicating precipitation from the same ore-forming fluids. Prior precipitation of zoisite caused a sharp decline in MREE and heavy rare earth element (HREE) concentrations in Sch<sub>B</sub> relative to Sch<sub>A</sub>. The europium anomaly in scheelite reflects an initial rise in oxygen fugacity, followed by a slight decrease from Sch<sub>A</sub> to Sch<sub>B</sub> and Sch<sub>C</sub>. Notably, the most oxidizing conditions are recorded in Sch<sub>a</sub> from the lamprophyre. A binary plot of V vs. As in scheelite from the porphyritic biotite granite mirrors the oxygen fugacity trends inferred from the europium anomaly, suggesting that the V vs. As relationship may serve as a potential fingerprint for oxygen fugacity in scheelite. The decline in the Y/Ho ratio from early to late scheelite stages likely results from self-precipitation of earlier scheelite, considering that REE-Eu (mol) and Y (mol) are incorporated into scheelite at a 2:1 ratio. Calcium necessary for scheelite formation is sourced from sericitization of calcic plagioclase in the porphyritic biotite granite and biotitization of mafic minerals (e.g., hornblende) in the lamprophyre. This study demonstrates that different host rocks significantly influence the evolutionary pathways and physicochemical properties of ore-forming fluids. Water-rock interactions are crucial at multiple stages of scheelite precipitation in the Dongyuan deposit.

**Keywords:** Scheelite, major and trace elements, porphyry-type W-Mo deposit, porphyritic biotite granite, lamprophyre, Dongyuan