Keeke Sun and Bin Chen

1Key Laboratory of Orogenic Belts and Crustal Evolution, School of Earth and Space Sciences, Peking University, Beijing 100871, China
2School of Resources and Environmental Engineering, Hefei University of Technology, Hefei 230009, Anhui, China

Abstract

The Shimensi deposit (South China) is a newly discovered W-Cu-Mo polymetallic deposit with a reserve of 0.76 million tones WO₃, one of the largest tungsten deposits in the world. We report elemental and Sr-Nd isotopic data for scheelites from the giant deposit, to determine the source region and genesis of the deposit. Scheelite is the most important ore mineral in the Shimensi deposit. Trace elements (including REEs) and Nd-Sr isotopic compositions of scheelites were used to constrain the origin of the mineralizing fluids and metals. Our data reveal that the REEs of scheelite are mainly controlled by the substitution mechanism 3Ca²⁺ = 2REE³⁺ + □Ca, where □Ca is a Ca-site vacancy. Scheelites from the Shimensi deposit show negative Eu anomalies in some samples, but positive Eu anomalies in others in the chondrite-normalized REE patterns. The variation of Eu anomalies recorded the ore-forming processes. Considering the close spatial and temporal relationship between the mineralization and porphyritic granite, we think the negative Eu anomalies were inherited from the porphyritic granite and the positive ones from destruction of plagioclase of country rock during fluid-rock interaction. The variation of cathodeluminescence (CL) color of a single scheelite from red to blue and to yellow was likely associated with the increase of REE contents. The scheelites hosted in the Mesozoic porphyritic granite with negative Eu anomalies formed in a primitive ore-forming fluid, whereas the scheelites hosted in Neoproterozoic granite with positive Eu anomalies precipitated in an evolved ore-forming fluid. The high Nb, Ta, LREE contents, and LREE-enriched REE patterns of scheelites from the Shimensi deposit reveal a close relationship with magmatic hydrothermal fluids. The scheelites from the Shimensi deposit are characterized by low εNd(t) values (–6.1 ≈ –8.1) and unusually high and varied initial ⁸⁷Sr/⁸⁶Sr ratios (0.7230~0.7657). The εNd(t) values of scheelites are consistent with those of the Mesozoic porphyritic granite, but the Sr isotopic ratios are significantly higher than those of the granites, and importantly, beyond the Sr isotopic range of normal granites. This suggests that the ore-forming fluids and metals cannot be attributed to the Mesozoic porphyritic granites alone, the local Neoproterozoic Shuangqiaoshan Group schists/gneisses with high Rb/Sr ratios and thus radiogenic Sr isotopic compositions should have contributed to the ore-forming fluids and metals, particularly, in a later stage of ore-forming process, by intense fluid-rock interaction. This is different from a commonly accepted model that the ore-forming fluids and metals were exsolved exclusively from the granite plutons.

Keywords: Scheelite, trace element, REE, Sr-Nd isotopes, Shimensi

Introduction

Scheelite is one of the two tungsten ore minerals, being exploited mainly in skarn deposits, and effectively is an important ore mineral in many other ore deposits such as porphyry-type, quartz vein-type, and some metamorphic type deposits (Allen and Folsinsbee 1944; Xu 1957; Noble et al. 1984; Liu and Ma 1987; Zhang et al. 1990; Uspensky et al. 1998; Peng et al. 2003; Wang et al. 2008; Song et al. 2014). Scheelite has a simple crystal structure with tetrahedral [WO₄]²⁻ groups and irregular dodecahedral [CaO₄]¹⁺ groups, and can accommodate high concentrations of rare earth elements (REEs), Y, Sr, and Pb in substitution for Ca (Cottrant 1981). It is of particular interest to ore geologists because it has the potential to provide important information on the genesis of ore minerals and related deposits (Zhang et al. 1990; Brugger et al. 2008). The REE abundances of scheelite can be used to infer the origin of ore-forming fluids, source characteristics and mineralization conditions (Tomschi et al. 1986; Brugger et al. 2008). Scheelite is one of the few minerals characterized by high Sm/Nd ratios and is therefore potentially useful for Sm/Nd dating and Nd isotopic study (Kempe et al. 2001; Peng et al. 2003; Roberts et al. 2006). In addition, the scheelite lattice can accommodate small amounts of Sr but reject Rb (Deer et al. 1966) and thus the radiogenic ⁸⁷Sr from ⁸⁷Rb decay has a negligible effect on Sr isotope compositions of scheelite (Bell et al. 1989). The Sr and Nd isotopic compositions of scheelite have been extensively used to constrain the origin of the mineralizing fluids and solutes in Archaean gold deposits.