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In-situ Major and Trace Elements Analysis for Garnets from the Xitian Orefield, SE China: Implications for Skarn-type Mineralization

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1 Introduction

The Xitian W-Sn polymetallic orefield is one of the most significant finds of tungsten–tin mineral resources in southeastern China, and the skarn orebodies have been considered to be the dominant mineralization type of the orefield (Zeng et al., 2005; Wu et al., 2011). The orefield lies at the intersection of the Qinzhou-Hangzhou Combined Zone (QCZ) and the Nanling Metallogenic Zone (Mao et al., 2011; Mao et al.,2013), comprising the Heshuxia, Goudalan, Longshang W–Sn deposits and Chaling Pb-Zn deposit. The Longshang W-Sn deposit and the Chaling Pb-Zn deposit situated in two sides of the Xitian Granite have skarn type mineralization developed. Garnet, as one of the most significant hydrothermal alteration minerals related to skarn-type mineralization, can be informative of the ore-forming fluid composition evolution during hydrothermal mineralization process, via implications from garnet geochemistry variations.

The features of garnet composition variations during the skarn-type mineralization process of the Xitian W-Sn polymetallic orefield are discussed in this paper, by interpreting geochemical messages printed on garnets. The major and trace elements of garnets from the Longshang W-Sn deposit and the Chaling Pb-Zn deposit were measured using electron probe microanalysis (EPMA) and laser ablation inductively-coupled mass spectrometry (LA-ICP-MS).

2 Geological Setting

The Xitian orefield is located in the central segment of the QCZ adjacent to the belt between the Yangtze and Cathaysia blocks (Mao et al., 2011; Mao et al., 2013). The sedimentary rocks and granite plutons of the Xitian orefield were cut by widespread large, complex, and grouped faults. A complex syncline with a NE–SW-trending axis was divided into two segments by the intrusion of the granites. In the northwestern part of the syncline, a wide variety of sedimentary rocks can be found, including Ordovician slate, feldspar–quartz sandstone, Devonian limestone, quartz sandstone and conglomerate, Carboniferous sandstone and shale with coal seams, Permian silicalite and concretionary limestone, and Cretaceous red conglomerate. All of these sedimentary deposits have been cut by the NE–SW-oriented fault system. The NNW–SSE-trending Xitian composite granite intrusion occur as a batholith and approximately 40 apophyses and stocks.

The Longshang W-Sn deposit and the Chaling Pb-Zn deposit are situated in the western and eastern sides of the Triassic Xitian Granite stock, respectively. The skarn-type tungsten-tin orebodies of the Longshang deposit occur in the endo- and exocontact zones between the Middle Devonian limestone of Qiziqiao Formation and the Triassic granite stock (Xiong et al., 2017). The stratiform lead-zinc orebodies of the Chaling deposit are hosted in the endo- and exocontact zones between the Upper Devonian limestone of Xikuangshan Formation and the granite stock.

3 Garnets Petrography

The garnets from the Longshang W-Sn deposit and the Chaling Pb-Zn deposit are predominatly grossularites and some are andradites. Coarse-grained garnets, being red-brown tetragonal trisoctahedron or rhombic dodecahedron, have euhedral and sub-euhedral textures with a grain size ranging from 1 to 2mm. Growth zoning can be clearly observed in garnets from the Longshang

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deposit. They were commonly found coexisting with diopside, tremolite, actinolite and chlorite, and some were metasomatic replaced by fine-grained diopside.

4 Chemical Composition of Garnets

The results of major element analysis by EPMA reveal that the garnets from the Longshang W-Sn deposit belong to the grossular-andradite solid solution ranging in composition from $And_{40.91}Gro_{55.35}$ to $And_{76.47}Gro_{21.82}$, commonly with Al-rich cores and Fe-rich rims. The garnets from the Changling Pb-Zn deposit also belong to grossular-andradite solid solution, but vary in composition at the range (close to the grossularites endmember) from $And_{9.96}Gro_{82.44}$ to $And_{14.29}Gro_{78.51}$, with relatively homogeneous rims and cores.

The results of trace element analysis by LA-ICP-MS show that the garnets from the Longshang W-Sn deposit are depleted in large ion lithophile elements (LILE), with negligible amounts of Cs and Rb, and with much lower concentrations of Ba and Sr than those of chondrites; they are enriched in high field strength elements (HFSE), especially Nb, Ta and Sc. They are depleted in heavy rare earth elements (HREE) and negative Eu anomalies. HFSE and REE show a consistent variation with major element geochemistry and petrographic observations. Generally, Al-rich cores are enriched in HFSE relative to Fe-rich rims which have small amounts of those elements.

The garnets from the Chaling Pb-Zn deposit are also depleted in LILE with the exception of Sr, and enriched in HFSE, yet with lower degree of enrichment than that for the garnets from the Longshang deposit. They have higher concentrations of ΣREE and LREE compared with the garnets from the Longshang deposit, as well as weak negative Eu anomalies. There tends to be a positive correlation between the total amount of REE^{3+} and the Al concentration in the garnets from the Chaling Pb-Zn deposit, whose chemical compositions are similar to those of grossularites.

5 Implications for Skarn-type Mineralization

The garnets from the two deposits are featured by LILE-depleted and HFSE-enriched patterns in different degree，and HFSE concentrations decrease from cores to rims of the garnets from the Longshang W-Sn deposit, indicating that the ore-forming fluids of them probably have similar origin, being involved with mantle-derived fluid, which has been supported by previous isotopic research on ferromagnesian xenoliths and fluid inclusion investigation (Liu et al., 2006; Xiong et al., 2017). The garnets from the Longshang W-Sn deposit exhibit HREE-enriched and LREE-depleted patterns and negative Eu anomalies, and the garnets from Chaling Pb-Zn deposit display HREE-depleted and LREE-enriched patterns and weak negative Eu anomalies, which suggest that the two deposits might have undergone different ways of metasomatism in fluid systems with different *W/R* ratios and fluid chemistry, in consideration of their geological setting and mineralization features (Gaspar et al., 2008; Xiong et al., 2017).

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