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In-Situ LA-ICP-MS Trace Elements and U-Pb Geochronometry of Melanite Garnet: The Eocene Mengya'a Skarn Pb-Zn Polymetallic Deposit in Gangdese Belt, Tibet of China

Xiaojia Jiang, Youye Zheng, Shunbao Gao, Xin Chen
China University of Geosciences, Wuhan, Wuhan, China

Ti-enriched garnet such as melanite occurs in a variety of geological environments, participating in Si-unsaturated igneous rocks, high-temperature metamorphic rocks, and contact-metasomatized skarns, and it is stable throughout a wide range of pressure-temperature conditions. Despite containing fair amounts of U, there is a lack of detailed research on its use as a U–Pb geochronometer. Abundant skarn Pb-Zn deposits in which ore-related pluton is not exposed have been discovered along the eastern Gangdese metallogenic belt, western China. The mineralization age of these skarn Pb-Zn deposits remains controversial. Therefore, the present paper first investigates the petrography, geochemistry, and in situ U-Pb geochronology of melanite coupled with the Re-Os geochronology of molybdenite. These data are then used to explore the potential of melanite dating and to constrain the age links between skarn alteration and mineralization.

Mengya'a Pb-Zn polymetallic deposit is one of the largest Pb-Zn deposits in Gangdese metallogenic belt. Its unique feature is that the ore-forming pluton is not exposed and the melanite is well developed. Therefore, the determination of the forming time of the melanite can build up the bridge and link for the diagenesis and mineralization of the Mengya'a deposit. The large Mengya'a Pb-Zn deposit is used as case study. Two melanite samples from the Mengya'a deposit are TiO_2-rich (mean of 3.47 wt %) and of brown-black color. They span wide ranges of Pb (0.02-4.40 ppm), Th (0.48-4.22 ppm), and U (0.60-6.43 ppm) contents and have U/Pb values between 0.57 and 81.82. Laser ablation inductively coupled plasma mass spectrometry dating showed that these melanites have a U-Pb age range of 54.9-53.8 Ma, which is consistent with the ages of two adjacent molybdenite Re-Os models (53.36-52.86 Ma). This indicates that skarn alteration occurred temporally, spatially, and genetically associated with a Pb-Zn mineralization event during main-collisional orogeny.

The positive linear Ti vs. Si, Ti vs. Fe^{3+}, REE vs. Y, and REE vs. U correlation indicate that Ti-enriched garnets may have high U content, and the incorporation of U and Ti is largely controlled by crystal chemistry of garnet in near closed system. Ti-rich garnets (e.g., melanite) are also widely distributed in Si-unsaturated alkaline rocks, carbonatite complexes, and high-temperature metamorphic rocks. Thus, this study confirms the reliability and accuracy of the U-Pb dating of melanite and highlights that Ti-rich garnets may have potential to become an invaluable geochemical and geochronological tool in magmatic, metamorphic, and hydrothermal mineral assemblages.