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Tourmaline and zircon trace the nature and timing of magmatic-hydrothermal episodes in granite-related Sn mineralization: Insights from the Libata Sn ore field

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Abstract

The Bin Yauri-Libata polymetallic ore district is a Sn and Au ore-bearing district in the Zuru schist belt, Northwestern Nigeria. The Libata Sn ore field is characterized by a set of cassiterite-bearing hydrothermal veins associated with Neoproterozoic Pan-African granites affected by deformation and low-grade metamorphism. The hydrothermal alteration associated with cassiterite-bearing quartz veins in the Libata deposit includes silicification, albitization, chloritization, and potassic alteration. In this study, geochemical and geochronological data from tourmalines and zircons from Sn-bearing lodes, unmineralized and altered granites is applied to reveal the timing, fluid composition, and source of ore-forming materials for tin mineralization in the Libata ore field. Zircon trace element and Hf isotopes [εHf(t) = +4.37 to +10.85] reveal a mantle-derived source with some crustal contribution for the melts forming the Libata Sn-bearing granites. LA-ICP-MS zircon U-Pb dating constrains the magmatic and hydrothermal ages to 650–646 and 649–646 Ma for the Libata granites. Overlapping zircon εHf(t) and $^{176}Hf/^{177}Hf$ but distinct $^{176}Lu/^{177}Hf$ and $^{176}Yb/^{177}Hf$ ratios from magmatic and hydrothermally altered zircons reveal a magmatic source for the hydrothermal fluids which triggered cassiterite deposition in the Libata ore field. Major element chemistry constrain tourmalines from the Libata ore field as schorls that show high alkalis, low-Ca contents, and moderate □ values (where □ is x-site vacancy). High Li, Zn, and Sn concentrations in tourmaline as well as Li/Sr and Ca-Fe-Mg ratios demonstrate that the tourmaline formed from granite-sourced fluid likely derived from the host Libata granites. Measured $\delta^{11}B$ values from the Libata tourmaline range from –15.7‰ to –14.1‰. The $\delta^{11}B$ of the mineralizing fluid is estimated to be –13.1 to –11.9‰ for the Libata tourmalines at 400–500 °C and overlaps with averages from fractionated granites worldwide. Therefore, our data show that tourmaline and zircon are useful tracers of magmatic-hydrothermal evolution in rare-metal-bearing granite systems.

Keywords: Tourmaline chemistry, Sn mineralization, hydrothermally altered zircons, Pan-African granites, B isotopes, Libata