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High Magma Differentiation Controls Rare Metal Mineralization: Traces by Tourmaline Major and Trace Elements, and Boron Isotopes

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Tourmaline is a common and crucial mineral in highly evolutional rocks due to being rich in boron. We research the structures, major and trace elements, and boron isotopic compositions of tourmalines in tourmaline-muscovite leucogranite, tourmaline leucogranite, barren pegmatite, beryl pegmatite, and spodumene pegmatite from the Rongxia-Qongjiagang area, greater Himalayan orogenic belt. All samples exhibit schorl characters and are divided into four groups by different host rock types. The tourmalines from the tourmaline-muscovite leucogranite exhibit obvious difference by the core-rim textures in a sample. The cores are characterized by highest $\delta^{11}B$ ratios (-10.04~-7.74‰), yet the rims exhibit high $\delta^{11}B$ ratios (-11.79~-10.49‰) close to another sample ($\delta^{11}B$ ratios are between -12.50~-12.06‰). All tourmaline-muscovite leucogranites exhibit higher MgO contents than other. The tourmaline leucogranite (-14.54~-13.88‰) and barren pegmatites (-14.02~-12.93‰) exhibit visible low $\delta^{11}B$ ratios. The beryl pegmatite is composed of lowest $\delta^{11}B$ ratios (-15.69~-14.28‰) with high B_2O_5 contents and slightly enriched Pb, Nb, Ta, and light rare earth elements. The spodumene pegmatite is composed of varied $\delta^{11}B$ ratios (-14.59~-10.25‰) with high Al_2O_3, B_2O_5, Pb, Nb, Ta, and light rare earth element contents, yet low SiO_2 contents. The structures, major elements, and B isotopes display the magmatic genesis of all tourmalines and record the magmatic differentiation process from early tourmaline-muscovite leucogranite to later mineralized pegmatite. Especially, the tourmaline core of tourmaline-muscovite leucogranite maybe generated in low-evolution magma conditions; the tourmaline of spodumene pegmatite may be affected by hydrothermal fluids, and the tourmaline formation records the independent enrichment of different rare metals. Thus, the tourmalines are useful tools to reconstruct the rare metal mineralization process controlled by high magma differentiation, not only in the Himalayan orogenic belt but also at other crucial metal mineralization belts.