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Boron isotope variations in tourmaline from hydrothermal ore deposits: controlling factors and insights for mineralizing systems

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Boron is a fluid-mobile element whose isotopic composition reflects many factors that are relevant to understanding mineralizing processes, including fluid source(s), fluid-rock interaction, and mineralization temperature. The most important host of boron in hydrothermal mineral deposits is tourmaline, which is fortuitous because this is a very stable and chemically resistant mineral with a wide compositional range.

We have compiled published B-isotope data of tourmaline from 110 hydrothermal deposits worldwide (>2210 analyses) organized into seven groups: porphyry Cu-Mo-Au deposits, granite-related Sn-W deposits, IOCG deposits, orogenic Au deposits, stratabound VMS and SEDEX deposits, and sediment-hosted U deposits (Mendeley Data, V4, doi: 10.17632/tv5y7xt9fb.4).

The total range of $\delta^{11}B$ values for all deposits is -26.8 to +35.0 ‰. Four deposit types (granite Sn-W, orogenic Au, stratabound VMS and SEDEX) have median $\delta^{11}B$ values close to the continental crustal average of ca. -10 ‰, whereas the median values for IOCG and porphyry Cu-Mo-Au deposits are higher (-3.9 ‰ and -2.1 ‰, respectively); the median for sediment-hosted U deposits is distinctly higher (+25.3 ‰). Importantly, each deposit type displays a considerable range of $\delta^{11}B$ values, the smallest being 18 ‰ for granite Sn-W deposits and the largest (48 ‰) for IOCG deposits.

These boron isotope ranges are suggested to reflect three levels of controlling factors. The primary one is the composition of the boron source; secondary effects relate to fluid-tourmaline fractionation (equilibrium or Rayleigh). There are commonly also tertiary factors that depend on evolution of the specific deposit, which include fluid mixing, changing water-rock ratio and/or depositional temperature, influences of other boron-bearing minerals, and where relevant, post-ore metamorphism. Separating the effects of these factors is rarely possible from boron isotopes alone, as selected case studies illustrate. However, multi-isotope studies of tourmaline, and approaches that combine isotopic and chemical variations in tourmaline can potentially overcome this limitation.