Origin of the Houxianyu Paleoproterozoic borate deposit (NE China): Constraints from chemical and boron isotopic compositions of tourmalines

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The Houxianyu borate deposit in NE China is hosted in the Paleoproterozoic meta-volcanic and sedimentary rocks (the Liaohe Group, with protolith age of 2.2-2.0Ga and metamorphic age of 1.9Ga) that show high boron concentrations. The borate ore-body has intimate spatial relationship with Mg-rich carbonates/silicates of the Group. The presence of abundant tourmalinites and tourmaline-rich quartz veins in the borate orebody provides an opportunity to study the origin of boron and ore-forming fluids, and possible mineralization mechanism. We report chemical and boron isotopic compositions of zoned tourmalines from the borate deposit and the tourmaline-bearing meta-volcanic rocks to discuss the issues above. Tourmalines from the meta-volcanic rocks are chemically homogeneous, showing relatively high Fe and Na and low Mg, with $\delta^{11}B$ values ranging from +1.2‰ to +2.6‰. Tourmalines from the tourmaline-rich rocks, however, commonly show compositional zoning, with an irregular detrital core and a euhedral overgrowth, and have significantly higher Mg, REEs, V and Sr than those from the meta-volcanic rocks. They show varied B isotope values ranging from +4.5‰ to +12.4‰, which plot intermediate between those of the terrigenous sediments and arc rocks with low boron isotope values and those of marine carbonates and evaporates with high boron isotope values. In addition, the rim of the zoned tourmaline shows notably higher Mg, Ti, V, Sn, and Pb, and REE, but lower Fe, Co, Cr, Ni, Zn, Mn, and lower $\delta^{11}B$ *values than the core*. These data suggest that (1) the sources of boron of the borate ore-body are mainly from the Paleoproterozoic meta-volcanic and sedimentary rocks that were formed in a continental arc setting, and (2) the ore-forming fluids should be the high temperature metamorphic fluids related to the amphibolite-facies metamorphism of the foldbelt during a process of arc-continental collision at ca. 1.9Ga, which leach boron from the boron-rich meta-volcanic and sedimentary rocks, and the boron-rich metamorphic fluids subsequently interacted with the marine Mg-rich carbonates and evaporates, forming the borate deposits.