Elbaite from the Himalaya Mine, Mesa Grande, California

Andreas Ertl (andreas.ertl@a1.net)[1], George R. Rossman[2], John M. Hughes[3], Ying Wang[2], Julie O'Leary[2], M. Darby Dyar[4], Stefan Prowatke[5], and Thomas Ludwig[5]

[1]University of Vienna, Austria; [2]Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena; [3]Miami University, Oxford, Ohio; [4]Mount Holyoke College, South Hadley, Massachusetts; [5]University of Heidelberg, Germany

Detailed chemical, Mössbauer, infrared, and structural data were obtained on 12 crystals from gem pockets in the Himalaya mine, San Diego County, California, which is a source for pink and multicolored gem tourmaline. Some of these tourmalines varied strongly in composition. One crystal (sample I) had increasing Ca content (liddicoatite component) and decreasing Zn content (up to ~1 wt.% ZnO) from the Fe-rich core to the Al- and Li-rich rim. The black core (zone 1) was an Al-rich, Mn-bearing schorl. The outer core (zone 2) was a dark yellowish green, Fe- and Mn-bearing elbaite with ~4 wt.% MnO. A yellowish green, intermediate Mn-rich elbaite zone (zone 3) contained a relatively high Mn content of ~6 wt.% MnO. Next there was a light pink elbaite zone (zone 4) with essentially no Fe and <100 ppm Mn^{3+} that was responsible for the color. The near-colorless elbaite rim (zone 5) had the highest Li content and ~1 wt.% MnO. Mössbauer studies of 20 mg samples from the different color zones within this crystal showed that the relative fraction of Fe^{3+} increased continuously from the Fe-rich core to the Fe-poor rim, reflecting the increasing fugacity of oxygen in the pegmatite pocket. Within the core of the crystal, the Si site contained ~0.3 apfu (atoms per formula unit) Al whereas in the rim it contained ~0.2 apfu B, consistent with the average Si-O distances. The intermediate zones contained mixed occupancies of Si, Al, and B.

A near-colorless, late-stage elbaite (sample II) from the Green Cap pocket (extracted in 1998) had ~2 wt.% MnO, ~2 wt.% FeO, and surprisingly ~0.3 wt.% MgO (dravite/uvite component), which is unusual in late-stage elbaite. This sample contained 1.6 wt.% CaO, the highest Ca content of the tourmalines in this study.

A gem-quality, light pink elbaite crystal (sample III) had the highest boron concentration (~0.3 apfu B) at the Si site (which produced a lower Si-O distance) of the three samples; it also contained the highest Al_2O_3 content (~43 wt.%) and essentially no Fe and only small amounts of Mn.

Analysis of water in elbaites is problematic because the crystals often contain fluid inclusions. Thus, conventional methods that extract water from a bulk sample may give erroneous values. Methods such as IR spectroscopy, which allow the distinction between structural OH and fluid inclusions, offer advantages for future tourmaline analyses.