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Tourmaline as a petrogenetic monitor of the origin and evolution of the Berry-Havey pegmatite (Maine, U.S.A.)

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Abstract

The Berry-Havey pegmatite (Oxford pegmatite field, Androscoggin County, Maine, U.S.A.), enriched in Li, F, B, Be, and P, is intruded in hornblende-rich amphibolite, with minor biotite or diopside. The pegmatite has a complex internal structure, with four texturally and compositionally different zones that show an increasing degree of evolution inward: wall zone, intermediate zone, core margin, and core zone. The main minerals are quartz, feldspars, Al-micas, tourmaline, with minor Fe-micas, garnet, beryl, amblygonite-montebrasite, Fe-Mn phosphates, and apatite. Tourmaline is present in all zones of the pegmatite, showing different textures: black anhedral crystals in the wall and intermediate zones; black prisms of up to 40 cm in length in the intermediate zone; black tapered prisms, surrounded by a pseudo-graphic intergrowth of quartz or albite with black ± green/bluish tourmaline, and constituting a continuous layer under the core zone; multicolored and "watermelon" zoned crystals in the core zone; and gemmy deep green and color-zoned "watermelon" tourmaline prisms, up to 15 cm length, inside the pockets. A complete chemical evolution from Mg-rich schorl in the wall zone to elbaite with an important deprotonation in the pockets inside the core zone is observed. The most plausible exchange vectors for this chemical evolution are $FeMg_{-1}$, $^{Y}Al^{W}O[^{Y}R^{2+W}(OH)]_{-1}$ and $Al[X]^{X}(R^{2+}Na)_{-1}$ (where R^{2+} = Fe^{2+}+Mg^{2+}+Mn^{2+}+Zn^{2+}), for the tourmalines from the wall and intermediate zones. In the core margin, tourmaline composition evolves from schorl toward Li-rich species through the substitution ($^{Y}Al^{Y}Li^{Y}R^{2+}_{-2}$). Later, during the crystallization of the core zone, this exchange vector combined with the substitution ($[X]^{Y}Al_{0.5}{}^{X}Na_{-1}{}^{Y}Li_{-0.5}$). Finally, the gemmy tourmalines from the pockets show a deprotonation related to the exchange vector $^{Y}Al^{W}O_{2}{}^{Y}Li_{-1}{}^{W}(OH)_{-2}$ and may be classified as darrellhenryite. These substitutions may reflect an increase in oxygen fugacity and a decrease in Li and F related to the crystallization of lepidolite and amblygonite-montebrasite in the core zone adjacent to or within the pockets. The crystallization of these minerals would reduce the availability of Li and F for the very latest tourmaline crystals, growing inside the pockets, where the deprotonation becomes important. Chemical and textural variation in tourmaline is consistent with a fractional crystallization process for the internal evolution of the Berry-Havey pegmatite. Crystallization of the tourmaline layer under the core zone may be related to the exsolution of the fluid phase implied in the formation of pockets.

Keywords: Tourmaline, pegmatites, mineral chemistry, Maine, U.S.A.