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, amphibole-montebasite, 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+3, Al+3O[O]^3-2(OH)], and Al[X]^3(R3+Na), (where R3+ = Fe2+/Mg2+2+/Mn3+2+/Zn2+), 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 ([Li]3Al3[Li]3(Al3[Li])3). Later, during the crystallization of the core zone, this exchange vector combined with the substitution ([X]3Al3[Li]3(Na)3(Li)3). Finally, the gemmy tourmalines from the pockets show a deprotonation related to the exchange vector AlO3[O]^3 Li, (OH)], 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 amphibole-montebasite 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.

INTRODUCTION

Pegmatites are common in the Central Maine Belt of the United States. Many of them are barren bodies, however, rare-element-bearing pegmatites, showing a well-developed internal zoning, are also widespread in this region. The Berry-Havey pegmatite (Androscoggin County, Maine, U.S.A.), is a highly evolved, rare-element pegmatite enriched in Li, F, B, Be, and P. It belongs to the Oxford pegmatite field, located in the western portion of the state of Maine, within the Sebago migmatite terrain (Solar and Tomascak 2009). In this field, pegmatites have been mined for more than a century for gem tourmaline. The first gem tourmaline was discovered at this pegmatite in 1910. Tourmaline occurs in all pegmatite zones and shows a continuous and well-defined chemical evolution from the outer to the inner zones. Previous studies of pegmatic tourmaline have shown the relationship of tourmaline chemistry to the evolution of the host pegmatite. (e.g., Jolliff et al. 1986; Selway et al. 1999; Keller et al. 1999; Novak 2000; Tindle et al. 2002; Roda-Robles et al. 1995, 2004, 2011). This study investigates the relationship of tourmaline chemistry of the Berry-Havey pegmatite to help decipher the petrogenesis of the Berry-Havey pegmatite and to contribute to the understanding of other pegmatites in the Oxford field that share some features with this pegmatite.

This study deals mainly with the paragenesis, textural characteristics, and compositional variation of tourmaline in the different zones of the Berry-Havey pegmatite. The possible substitution mechanisms accounting for the compositional variation.