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Tourmaline growth in the border and wall zones of the Emmons pegmatite (Maine, U.S.A.): Evidence for disequilibrium crystallization and boundary layer formation

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ABSTRACT

The anisotropic textures, including unidirectional solidification textures and graphic intergrowths, characteristic for pegmatites, are interpreted to result from disequilibrium crystallization at high degrees of undercooling. Experimental studies have revealed the existence of thin boundary layers surrounding the rapidly growing crystals. Here, tourmaline-bearing samples from the outer zones of the Emmons pegmatite (Maine, U.S.A.) are used to examine if a boundary layer can also occur in natural samples. Crystal morphology is linked with geochemistry to understand the evolution of pegmatite melts and to constrain disequilibrium conditions at large degrees of undercooling. Petrographic studies and semiquantitative micro-X-ray fluorescence element mapping were conducted to identify crystal morphology and zonation, complemented with electron microprobe analyses to determine major and minor element compositions and LA-ICP-MS analyses of selected trace elements. Three textural groups were identified: comb-like tourmaline, quartz-tourmaline intergrowths, and radiating tourmaline. The intergrowths are optically coherent and are split into three different morphologies: central, second tier, and skeletal tourmaline. Most tourmaline is schorl, but chemical variation occurs on three different scales: between textural groups, between different morphologies, and intracrystalline. The largest scale geochemical variation is caused by the progressive evolution of the melt as it crystallized from the borders inwards, while the intracrystalline variations are attributed to sector zoning. A model is suggested where the systematic variation of Mg, Mn, and Fe within individual intergrowths is proposed to be the result of crystallization from a boundary layer, rich in water and other fluxing elements (e.g., Li, P, B), formed around the rapidly growing central tourmaline. Here, we show the first examples of boundary layers in natural pegmatites. Furthermore, the results bring into question whether boundary layer tourmaline can be used as a bulk melt indicator in pegmatitic melts.

Keywords: Tourmaline, graphic intergrowths, pegmatite, boundary layer, µXRF, EMPA