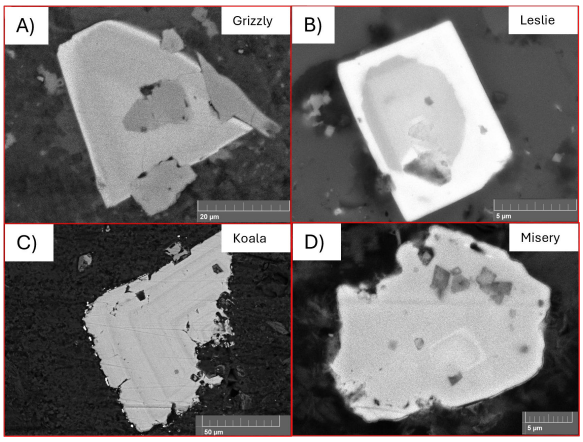
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REE and Nb systematics of perovskite in Lac de Gras kimberlites: implications for melt composition and evolution

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Kimberlites are volatile-rich, mantle-derived magmas best known for their diamond content, but they are also important carriers of rare earth elements (REE) and critical metals (e.g., Nb, Ni, Co). Perovskite is the principal REE host in kimberlite groundmass and provides key constraints on melt composition, crystallization sequence, volatile degassing, and magmatic evolution. However, the extent to which perovskite composition varies among kimberlite facies and the controls on REE content in perovskite remain poorly constrained. This study presents a comprehensive survey of perovskite and associated REE-bearing phases from seven kimberlites of the Lac de Gras (LDG) field, Canada, representing hypabyssal (Grizzly, Leslie, Boa) and volcaniclastic (Beartooth, Koala, Misery, Panda) facies, and compares them with global datasets to explain the nature of compositional trends shown by perovskite. Samples were examined using optical and scanning electron microscopy, and mineral compositions were obtained with electron microprobe analysis and laser ablation inductively coupled plasma mass spectrometry. Perovskite in hypabyssal kimberlites occurs as euhedral to subhedral zoned grains consistent with primary magmatic crystallization, whereas perovskite in volcaniclastic facies commonly shows embayed and fragmented morphologies reflecting resorption and breakage, and is associated with secondary REE-bearing phases, including monazite, ancylite, and apatite. Perovskite compositions show systematic variation in REE and Nb concentrations across the LDG kimberlites. Hypabyssal kimberlites contain more abundant perovskite and generally higher REE and Nb concentrations than volcaniclastic equivalents. Among the studied samples, perovskite from the hypabyssal Leslie kimberlite shows the highest REE, Nb, and Na concentrations, consistent with early crystallization from relatively primitive, alkali-rich melts prior to significant volatile loss, whereas lower Na contents in other studied kimberlites reflect more evolved and degassed melt conditions. Compared to global occurrences, Lac de Gras kimberlite perovskites are unusually enriched in REE and Nb indicating strong compositional control of the parental melt on trace element partitioning and highlighting the influence of melt composition and emplacement processes. The observed systematic variation in perovskite composition between kimberlite facies will be used to discuss differences in melt evolution, degassing, and emplacement processes, and the strong influence of parental melt composition on trace element enrichment.