

Characterizing the variation of kimberlitic apatite within kimberlite bodies

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Kimberlites are well known for being the primary source of diamonds, although they are poorly understood when it comes to the processes involved in their formation due to their highly complex nature. Kimberlites are volatile-rich magmas which in combination with their diverse composition, volatile loss during emplacement, alteration, and composition of volatiles – does not allow for them to be well constrained in terms of their formation. The mineral apatite is highly sensitive to the behaviour of trace elements and volatiles due to its crystal structure. It can therefore be indicative of the processes and conditions involved in the stages of evolution of a kimberlite body. While apatite is known to vary between different kimberlite bodies, little is known about the variation that occurs within any one kimberlite body. This study examines variations in the presence, textures, and composition of apatite with depth in kimberlite pipes filled with both magmatic and volcanoclastic kimberlite lithologies.

Samples have been collected from boreholes in Boa and Leslie kimberlites (Ekati Mine, Canada) and BK1 and AK15 kimberlites from Orapa cluster (Botswana). We examined 23.7–234.6 m-depth range in magmatic (coherent) Leslie kimberlite, 30–84.8 m depth range in Kimberly-type pyroclastic and magmatic facies from Boa pipe, 56.16–151.7 m-depth range in magmatic (coherent) AK15 intrusion, and in three drill holes (2 of which have known depth ranges, 36.7–54.33 m and 8.64–124.41m) in two coherent and one Kimberly-type pyroclastic facies from BK1 kimberlite pipe. We observed notable variation in groundmass apatite textures forming irregular and radially aggregates composed of fine apatite crystals. Discrete euhedral to subhedral crystals are also observed with zoning. Poikilitic texture is common with inclusion within both clusters and discrete apatite crystals. Electron microprobe and LA-ICPMS analytical methods are used to characterize the chemical variations.

The features of kimberlitic apatite will help to constrain the behavior of volatiles through the erupting kimberlite column and shed more light on the eruption mechanism of kimberlite magma and the origin of different facies within the same pipe. This study aims to correlate apatite and its implications for the history of kimberlite evolution.