

Apatite geochemistry provides insights into the late magmatic evolution of kimberlites

ASHTON SOLTYS^{1*}, ANDREA GIULIANI¹, DAVID PHILLIPS¹,

¹Kimberlites and Diamonds (KiDs), School of Earth Sciences, The University of Melbourne, Australia.

*correspondence: soltysa@student.unimelb.edu.au

The late evolution of kimberlite magmas, i.e., during and following emplacement into the upper crust, remains a controversial aspect of kimberlite petrogenesis. Likewise, it is unclear whether or not there is a link between melt composition and the emplacement mechanism of intrusive kimberlites (i.e., planar dykes/sills vs. irregular intrusions in the root zone of pipes). Resolving these issues is hampered by the absence of comparative studies of late-magmatic kimberlite phases (e.g., apatite, monticellite, mica) in dykes, sills, and root-zone intrusions from the same locality.

Here we report petrographic and mineral-chemical results for groundmass phases in samples of dykes, sills, and root zone intrusions from the Kimberley kimberlites (South Africa). Early crystallised phases (e.g., olivine, spinel) in dykes/sills and root-zone intrusions have indistinguishable compositions, and hence crystallised from similar primitive melts. Conversely, apatite major element compositions are variable and can discriminate dykes/sills (i.e., low and constant Sr, with increasing Si) from root zone intrusions (high but variable Sr, low and constant Si). The Sr depletion in root zone apatite is interpreted to represent fractional crystallisation of earlier apatite, perovskite, and calcite from a broadly similar parental melt. Silica enrichment of apatite from dykes/sills may be attributed to the coupled incorporation of CO_3^{2-} and Si into the apatite structure, reflecting higher CO_2 contents in the melts that formed dykes/sills. CO_2 enrichment in the dykes/sills is consistent with petrographic observations. Dykes/sills are enriched in carbonates, may contain dolomite, and are depleted in mica and monticellite compared to the groundmass of root-zone kimberlites. This suggests the melts parental to dykes/sills have a higher $\text{CO}_2/\text{H}_2\text{O}$ ratio compared to those parental to root zone intrusions. These two distinct melt evolution paths cannot be due to crustal contamination before emplacement because the Sr-isotope compositions of late-crystallised carbonates are indistinguishable in dykes/sills and root-zone intrusions. We speculate that CO_2 is better retained in dykes/sills due to a higher confining pressure (i.e., lack of breakthrough to the surface).