What controls the explosive emplacement of the diamondiferous Diavik kimberlites? New insights from mineral chemistry and petrography of hypabyssal and pyroclastic samples

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Kimberlites are mantle-derived, CO_2 and H_2O rich magmas that entrain abundant mantle material, including diamonds during rapid ascent to the surface. Most kimberlite magmas that reach the upper crust either erupt explosively or are emplaced as shallow hypabyssal intrusions. Catastrophic volatile exsolution, local geology and stress regimes, and interaction with external water are suggested as possible controls of magma explosivity. A full understanding of the processes promoting the explosive emplacement of kimberlite magmas has been hindered by common alteration and crustal contamination of pyroclastic kimberlites (PK). To address this issue, we have undertaken a detailed petrographic and mineral-chemical study of fresh pyroclastic and hypabyssal kimberlites (i.e. dykes either cross-cutting or isolated from volcanic pipes) from the Diavik Diamond Mine (Lac de Gras, Canada). Diavik kimberlites feature the same olivine compositions regardless of emplacement style. The cross-cutting kimberlite dykes (xHK) and pyroclastic kimberlites also feature the same chromite (i.e. liquidus spinel) compositions, and spinel evolution to indistinguishable magnesian ulvospinel-magnetite compositions. These results demonstrate that primitive melt compositions, and early magmatic evolutionary trends are the same for kimberlite melts that erupt explosively or those that are emplaced as shallow intrusions. The magmaclasts in PKs contain higher abundances of phlogopite, and lower contents of carbonate than the groundmass of xHKs suggesting higher H_2O/CO_2 ratios in the magmas that erupt explosively. This finding highlights divergence of the PK and xHK parental melt compositions after late spinel formation, which underpins explosive CO_2 exsolution only in some magmas. While the causes of explosive volcanism remain uncertain, our study indicates that primitive melt composition has no significant influence on the emplacement style of kimberlites.