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The architecture of the northern Kaapvaal craton root: insights from mantle-derived xenocrysts from the Marsfontein kimberlite, South Africa

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Mantle-derived xenoliths entrained by ultramafic potassic magmas provide unique insights into the composition and architecture of the mantle, providing means to constrain the melt depletion and enrichment processes recorded by the SCLM in its evolution from Archaean to recent times. A significant percentage of this type-magmatism within sub-Saharan Africa is hosted on the Kaapvaal craton, which despite being studied, still proves complex. We present the first xenolith data for the relatively understudied diamondiferous Marsfontein kimberlite, a Mesozoic Group-II deposit located in the north-western region of the ca. 2056 Bushveld Complex, located on the north-western edge of the Kaapvaal craton.

The clinopyroxenes classify as Cr-diopsides ($Wo_{(26-42)}En_{(35-55)}Fs_{(1-7)}$), showing compositions broadly similar to those from metasomatized peridotite xenoliths. REE patterns evolve along “normal” enrichment trends, with segregated classification into Group-I and Group-III clinopyroxenes with the latter evolving along high LREE-enrichment trends. The garnets show high Mg# (72 – 89) and low Ca# (9 – 15) and are classified according to their Cr_2O_3 (<1 – 5 wt%) and CaO (3 – 6 wt%) contents. REE patterns dominantly evolve along “normal” enrichment trends, with minor “sinusoidal” trends. The incompatible element systematics show multiple episodes of metasomatism, with garnets evolving along Zr/Hf and Ti/Eu ratios consistent with both carbonatite- and silicate-dominated metasomatism, while Y contents dominantly between 10 – 30 ppm and Zr ranges between 10 – 80 ppm, provide evidence for high temperature melt metasomatism.

Single-grain P-T estimations were performed on both clinopyroxenes and garnets. The clinopyroxenes yielded average equilibration conditions of 49,7 Kbar at 1162 °C, which plot along the 40 mW/m^2 geotherm. $T_{(Ni)}$ for the garnets yielded an average temperature of 1148 °C at pressures of 50,9 Kbar when projected along the clinopyroxene geotherm. These estimates agree well with each other, estimating the LAB to be at depths of ~215 – 230 km. We observe the P-T data of clinopyroxenes to show two distinct varieties: high-PT and low-PT groups, with no clinopyroxenes occurring between ~50 – 55 Kbar, and interpret this to suggest a layered SCLM structure, with melts originating from a mixed peridotite mantle source which has seen enrichment by different melts.