A new look at diamonds from the Koffiefontein Mine using *in situ* techniques for trace element and stable isotope analyses

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The Koffiefontein kimberlite is one of the classic locales on the Kaapvaal Craton and best known for being the first locality where very deep diamonds were recovered. Koffiefontein diamonds were last studied in 1980s and, based on major advances in micro-analytical techniques, here we revisit the mine to provide improved inclusion-based geothermobarometry. Currently, ~70 peridotitic diamonds have been studied with ~150 olivine, Cr-rich pyrope garnet, enstatite, and diopside inclusions liberated. So far, the inclusions were analysed (EPMA) for their major element compositions. The peridotitic inclusion suite is dominated by a highly-depleted harzburgitic association: olivine Mg-number ranges between 93 and 95, harzburgitic garnets contain $\leq$ 3.00 wt % CaO, and 14 % of garnet inclusions are lherzolitic in paragenesis.

Conventional mineral exchange geothermobarometry on non-touching inclusion pairs reveals that diamonds with harzburgitic inclusions derive from close to the base of the lithosphere (1143-1283 °C and 55-65 kbar; 12 diamonds) whilst much rarer lherzolitic inclusions last equilibrated in the upper portion of diamond stable lithosphere (983-1158 °C and 47-52 kbar; 5 diamonds). Both associations fall along a 39 mW/m^2 reference geotherm (Hasterok and Chapman, 2011), implying a total lithosphere thickness of ~200 km at 90 Ma. To expand our geothermobarometry data beyond rare garnet-opx associations we conducted high-precision trace element analysis of Al and Ca in olivine inclusions via EPMA. Using long count times (300 sec on peak and each background) and a 200 nA beam current, detection limits of 8 ppm for Al and 6 ppm for Ca were achieved. This technique allowed for trace element analysis of olivine inclusions as small as 20 μm in diameter. Based on these high-precision Al analyses, the updated Al-in-olivine thermometer of Bussweiler et al (2017) extrapolated to a 39 mW/m^2 geotherm yielded temperatures of 1124-1278 °C (30 diamonds).

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