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Dunites from the Kaapvaal

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Garnet-bearing lherzolites are over-represented in the Kaapvaal database, while dunites are rarely studied, resulting in a biased data-base and estimate of the bulk composition and structure of the cratonic Sub-Continental Lithosphere Mantle (SCLM). Dunites, despite their common occurrence in kimberlite cargo, are seldom investigated because key minerals for geothermobarometry and geochemistry, such as garnet and cpx, are absent, rare or metasomatic. However, geophysical investigations suggest that the primitive Archean SCLM consists of a significant portion of buoyant and refractory materials: highly depleted dunite-harzburgites.

In this study, we investigate ≈20 chromite-bearing dunites from the Kimberley Dumps (Western Terrain, South Africa), no longer extant due to use of these xenoliths for diamond extraction. Garnet-bearing and metasomatised samples were systematically discarded as well as extensively serpentinised rocks. The investigated samples are mostly coarse-grained and contain 60 to 90% olivine, 10 to 35% orthopyroxene, and metasomatic phases make up less than 5%. Spinel (≈ 1%) is present as (sub)millimetric rounded grains or as symplectites, commonly interpreted as a retrograde pseudomorphic breakdown of garnet (decompression). Scarce relict garnets were found at the core of these symplectites and yield temperature estimates of ca 820±23ºC at 33±1 kbar, close to the estimated garnet-spinel transition conditions for depleted composition. Olivine-thermometers indicate temperatures between 780 and 925ºC.

Olivines have Fo% values ranging from 92.7 to 93.7%, and Cr# spinel varies between 0.47 and 0.67, consistent with the low CaO, Al_2O_3, TiO_2, and FeO content of the whole-rocks. Trace elements in the primary silicates are extremely low (4.3 ≤[Yb]opx< 8.0 ppb), while olivines exhibit severely depleted first-row transition element levels (e.g., [Cu] ≤ 0.01 ppm) and Yb contents between 0.23 and 0.46 ppb. All chemical indices allude to melt extraction of up to ≈40-45%. Os-isotope analyses of whole rocks and trace sulfides (heazelwoodite-pentlandite) indicate that the main melting events occurred around 2.5 to 3.2 Ga.