Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.36618

Ultra Depleted but orthopyroxene rich peridotites from Kaapvaal

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Garnet-bearing lherzolites are over-represented in the Kaapvaal database, while spl-bearing harzburgites are rarely studied, resulting in a biased estimate of the bulk composition and structure of the cratonic Sub-Continental Lithosphere Mantle (SCLM).

In this study, we investigate ≈20 chromite-bearing harzburgites from the Kimberley Dumps (Western Terrain, South Africa). The investigated samples are mostly (but not only) coarse-grained and contain 60 to 90% olivine (Ol), 10 to 35% orthopyroxene (Opx), 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 P-T conditions ca 820±23ºC at 33±1 kbar, close to the estimated garnet-spinel transition conditions for depleted composition.

These samples are characterised by high Opx abundances, with microstructures marked by curvilinear, interlobate, and interpenetrating boundaries between Ol and Opx, as well as vermicular Opx extensions. Together with elevated Opx/Ol ratios (0.2–0.9), high for the observed Fo contents (92.7–93.7%) and Cr# values in spinel (0.47–0.67), these textural features strongly suggest that the Opx formed through melt–rock reaction rather than representing primary residues of melting.

Despite this, the olivines preserve extremely depleted first-row transition element signatures (e.g., Cu ≤ 0.01 ppm) and very low heavy rare-earth element concentrations (Yb = 0.23–0.46 ppb). Complementary Os-isotope systematics from whole-rock and sulfide analyses (heazlewoodite–pentlandite) indicate that the principal depletion events occurred between ~2.5 and 3.2 Ga, consistent with the broader Kaapvaal peridotite record.

A particularly striking characteristic is the spoon-shaped, normalised REE patterns in Opx, which exhibit exceptionally steep HREE slopes ($(Ho/Lu)_N < 0.01$). On first inspection, such geochemical signatures would imply melt extraction of up to ~40% (approaching dunite-like residues), a conclusion that contrasts sharply with the microstructural evidence for significant melt–rock interaction. These distinctive REE systematics therefore point to highly specific melting and melt–reaction regimes and provide critical constraints for understanding the processes driving Opx enrichment in portions of the Archean cratonic mantle.