

Modification of harzburgite to K-rich dolomite-bearing peridotite from the Kaapvaal craton, South Africa: Evidence of metasomatism by carbonate-silicate incipient melts

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Geochemical proxies, experimental studies, and thermodynamic models have been applied to make inferences about the stability of mantle carbonates and their role in the deep carbon cycle and the evolution of the lithospheric mantle. Despite extensive searches in kimberlite-derived mantle xenoliths from the Kaapvaal lithospheric mantle, evidence for carbonates remains rare. To date, direct evidence of their occurrence is limited to inclusions in olivine and ilmenite [1,2], with reports of discrete carbonates restricted to calcite [3,4], and not dolomite or magnesite as would be expected for equilibrium with peridotite.

Using Raman spectroscopy, we present the first direct evidence of discrete dolomite and associated phases in an atypical K-rich carbonated peridotite sampled by the Bultfontein kimberlite. Dolomite occurs as fine (up to 100 μm), discrete, euhedral grains in tandem with calcite. The carbonate grains occur in patches interpreted as carbonate-rich melt domains, and occasionally show spatial association with fluorapatite. The carbonate-rich domains are segregated from silicate-rich domains defined by the initial mineralogy (orthopyroxene, olivine) and modally metasomatized (clinopyroxene, phlogopite) silicate phases. Serpentinized quenched residual silicate melts occupy the boundaries between both domains [5]. Phases in the carbonate-rich domains are partially replaced by oxides (chromite, magnetite with hematite inclusions) and the oxides show partial replacement by sulphides.

These textures and mineralogy are interpreted to have formed from a reaction between a harzburgite and a carbonate-silicate incipient melt [6]. Dolomite is absent or occurs only as an accessory phase in kimberlite. It is, therefore, unlikely that the observed textures represent a late-stage reaction between the kimberlite magma and the xenolith *en-route* to surface. A more plausible explanation is that the carbonates crystallized in the mantle at pressures consistent with the base of the lithospheric mantle in the range 4.5 - 6 GPa, prior to entrapment in the kimberlite [5,6].

[1] Sharygin, et. al., 2021. *Journal of Raman Spectroscopy* 1-17.

[2] Giuliani et al., 2013. *Chemical Geology*, 353, 4-18.

[3] Berg, 1986. *Nature*, 324 (6092), 50-51.

[4] Howarth et al., 2019. *Geochimica et Cosmochimica Acta*, 266, 258-273.