

Sulfur- and alkali-rich metasomatism in the cratonic, lithospheric mantle: Insights from phlogopite-bearing mantle xenoliths from Kimberley (Kaalpvaal craton, South Africa)

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Phlogopite-bearing mantle xenoliths from the cratonic, lithospheric mantle are direct evidence of alkali-, volatile-rich metasomatism related to lamproite and kimberlite magmatism^[1]. Those carbonated-silicate melts are not only responsible for e.g. phlogopite crystallization^[1] but also cause enrichment of the cratonic root in sulfur^[2]. We investigate major to trace element analysis of silicates and sulfides of 13 phlogopite-bearing xenoliths from the Kimberley kimberlite cluster (Kaalpvaal craton) in order to evaluate a possible connection of silicate and sulfide metasomatism.

The xenoliths consist of phlogopite ±olivine, orthopyroxene, clinopyroxene, garnet, spinel, ilmenite, zircon and amphibole, with various amounts of sulfides. Estimated *PT* conditions are ~2.1 to 5.7 GPa and 620 to 1280°C. The sample suite is split into three groups: Peridotites in Group I are geochemically depleted with Mg# >90 in olivine and phlogopite. They have <10 vol% phlogopite. Xenoliths in Group II are enriched with Mg# <90 in olivine and phlogopite and modal abundances of phlogopite <30 vol%. High modal abundances (>30 vol%) of enriched (Mg# <90) phlogopite are present in the olivine-free Group III. Group II and III are geochemically similar to MARID xenoliths. Group II xenoliths contain large sulfide grains (up to ~800 µm; median = 26/thin section) often associated with ilmenite and/or phlogopite. Group I has low amounts of sulfides (8/t.s.) and Group III is almost sulfide-free (0/t.s.).

First results indicate that contrasted melt/rock ratios resulted in different metasomatic assemblages: Group III (MARID) xenoliths formed at high melt/rock ratios in an oxidized environment (occurrence of ilmenite), which prevented the crystallization of sulfides. At moderate melt/rock ratios, the metasomatic agent interacted with peridotites (drop in *f*O₂?), causing the crystallization of sulfides and enrichments of silicates (Group II). Group I xenoliths (low melt/rock ratios) interacted with the remaining, depleted agent, resulting in the crystallization of lower amounts of sulfides and less enrichments than Group II.

Trace elements in silicates and sulfides, which are currently measured, should shed more light on these processes and their possible interconnections.

[1] Gregoire et al. (2003). *JPet* 44, 629-657.

[2] Chen et al. (2025). *Nature* 637, 615-621.