

Multistage Metasomatism and Mineral Growth of Cratonic Mantle Recorded by a Glass-bearing Garnet Lherzolite Xenolith from Letseng-la-Terae, Lesotho

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Introduction

The Kaapvaal craton is currently >1 km above sea level implying extensive modification of the subcontinental lithospheric mantle (SCLM) during the last 200 Ma. The aim of this study is to determine the extent of post-Archaean SCLM modification, with particular emphasis on the timing and nature of metasomatism.

Results

We present major and trace element data on a relatively fresh, typical coarse garnet-lherzolite from Lesotho that comprises 5% phlogopite, 10% clinopyroxene, 10% garnet, 25% orthopyroxene and 50% olivine. Two generations of clinopyroxene can be identified: (1) large single grains (cpx1, 0.5–2 mm), often with very irregular grain boundaries, and (2) smaller "fingers" and veinlets (cpx2). Notably the sample also contains 1% low silica-highly magnesian glass. It is mostly found in contact with euhedral phlogopite, but also occurs in thin (<10 µm) veins. Glass contains microphenocrysts of spinel, titanites, phlogopite, clinopyroxene, and ~ 100 µm vugs filled with serpentine.

Garnet and orthopyroxene porphyroclasts in this rock are homogeneous in major element composition, while clinopyroxene, phlogopite and spinel are strongly zoned. Clinopyroxene compositions vary widely. Cpx1 have mg# equal to olivine and orthopyroxene (0.93), and contain up to 2.9 wt% Na₂O and 0.1 wt% TiO₂. The composition changes towards the rims to mg# 0.91, 1 wt% TiO₂ and 1.2 wt% Na₂O. More extreme clinopyroxene compositions are found in cpx2. Phlogopite is zoned in the same elements. Calculation of pressures and temperatures using combinations of several geothermo- and barometers consistently yield 1100 C and 4.5 GPa for mineral cores, placing it close to a typical cratonic geotherm.

The high-Mg (35 wt% MgO) glass in LET64 has a distinct composition compared to most reported glass occurrences from xenoliths. It has between 39 and 44 wt% SiO₂, 7–10 wt% Al₂O₃, up to 5.5 wt% TiO₂ and moderate alkali contents (<4

wt% K₂O, <0.1 wt% Na₂O). In contrast, most glasses described from other localities have high Si, Al and alkali contents (Draper and Green, 1997, for a review).

Representative REE compositions obtained by LA-ICP-MS are presented in figure 1. Glasses are strongly REE enriched with distinct negative Sr anomalies but may have negative or positive Eu anomalies. All clinopyroxenes record LREE enrichment. Cpx1 rims and cpx2 are more LREE enriched than cpx1 cores, and have a small negative Eu anomaly. Extended trace element diagrams show that cpx1 rims and cpx2 have, compared to cpx1 cores, markedly higher Ba, Th, Nb and Ta contents and a negative Sr as well as a negative Zr anomaly. Phlogopite rims are enriched in LREE by a factor of 100 and have much less pronounced negative Th anomalies compared to phlogopite cores. A clear positive Sr anomaly present in the cores is absent or even reversed in the highly enriched rims.

LET64 has an initial ¹⁸⁷Os/¹⁸⁶Os ratio of 0.1093 and relatively high Re/Os ratio (0.1). These data equate to a Re depletion age of 2.7 Ga but a future Re-Os model age.

Interpretation

Together the petrography and geochemical data imply that a peridotite protolith, possibly a harzburgite, underwent a hydrous metasomatic event that introduced more clinopyroxene and/or enriched existing clinopyroxene in REE. At the same stage, phlogopite was formed (which has low LREE). Minerals had sufficient time to achieve chemical equilibrium. Later a melt rich in incompatible trace elements infiltrated the peridotite and partially reacted with the pre-existing assemblage. The high-Ti and trace element content of LET64 glass implies formation of clinopyroxene and phlogopite rims from this melt. Chemical and textural disequilibrium between freshly grown phases, preservation of glass and the high Re/Os ratio indicate that melt infiltration occurred only very shortly before eruption of the host kimberlite. The glass composition is similar to kimberlite but has been modified by melt-rock interaction and crystallization of microphenocrysts.

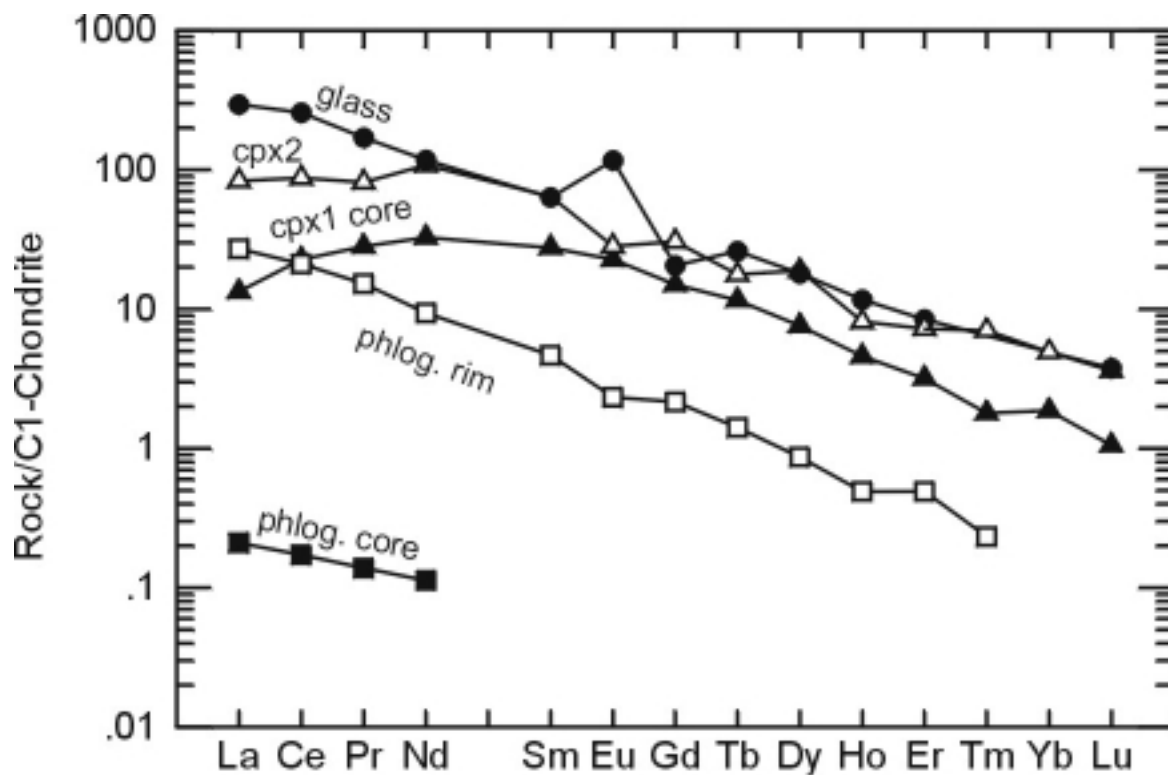


Figure 1: REE pattern of LET64 glass (dots), cpx1 core (filled triangles), cpx2 (open triangles), and phlogopite core (filled squares) and rim (open squares).

Draper DS & Green TH, *J. Pet.*, **38**, 1187-1224, (1997).