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Xenocrystic and magmatic olivines in kimberlites tell a complex story of precipitation, dissolution and renewed crystallisation during magmatic uprise

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Kimberlites are magmatic ultramafic rocks with variable abundances of mantle debris xenocrysts, with cpx, grt, opx, ol and ilmenite megacrysts and with olivine phenocrysts set in a groundmass of mostly carbonate, serpentine and perovskite. Olivines are commonly serpentinized but examples with exceptionally fresh olivines occur in most kimberlite fields. These were the aim a few recent studies on the origin of the olivines and the nature of a kimberlitic magma (Kamenetsky et al. 2008, Arndt et al. 2010, Brett et al. 2009, Moore 2012).

These authors distinguished two populations from the olivine sizes and morphology and differentiated them further on textural and geochemical grounds. Large, rounded and homogeneous olivines are either megacrysts or from disaggregated mantle xenoliths. The latter have deformation and dislocation structures and may also be polycristalline and have high, but variable forsterite contents. The former generally should have lower forsterite contents.

The other type of olivines are smaller, mostly euhedral and are regarded as phenocrysts. They show complex zoning and arguments exist whether they are cognate phases to the magma or if only the outermost rims were precipitated from the magma and formed the euhedral shapes.

In order to gain more insight into these questions we have investigated fresh olivines from a Group I (former basaltic) kimberlite from the Kenilworth dump in Kimberley (material stems from the "Big hole") and a Group II (former micaceous) kimberlite from the Roberts Victor mine (50 km NW of Kimberley). We determined the major and trace elements by electron microprobe and LA ICP MS and the Li-isotopes of Xenocryst-, Megacryst- and Phenocryst separates by MC ICP MS.

Sofar, Li-isotopes have only been determined for Roberts Victor kimberlite whole rock (Li $>$ 60 ppm, δ^7 Li of +3.4$\%_o$), Xenocrysts (Li = 0.8-1.3 ppm, δ^7 Li of +3.4 to +6$\%_o$) and Phenocrysts (Li = 2.3-3.2 ppm, δ^7 Li of +1.8$\%_o$).

The rounded mantle debris olivines have Mg-values of more than 90 while the large, also rounded megacrysts individually vary between 87 and 89. The small euhedral olivines have a stepwise zonation pattern with the larger central parts showing a continous zonation from a core with megacryst composition to the rim with Fo_{84}. This is overgrown by olivines with $Fo_{82-83.}$

The stepwise zonation is especially pronounced in trace elements like Ni, Mn and Ca. From this we envisage an uprise of the magma in steps which involves the incorporation of disintegrated mantle material and crystallisation of the megacrystic olivines at stable conditions. The residual liquid with its load moved upwards into a zone where olivine was not stable anymore. Dissolution started and changed the liquid somewhat back to a Mg- and Ni-richer composition. Olivine crystallisation occurred again at lower P,T conditions and magmatic zoning developed. Volatile saturation may be reached eventually by a further surge upwards which led to fast precipitation of the Ca-rich olivine rims.

Arndt et al., 2010, JPetrology, **51**, 3, 573-602

Brett et al., 2009, Lithos, **112S**, 201-212

Kamenetsky et al., 2008, JPetrology, **49**, 4, 823-839

Moore, 2012, Lithos, **128-130**, 1-10