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Low-T sheared peridotites from the Kaapvaal-craton: Record of hydrous metasomatism during deformation

CATHARINA HECKEL[1], ANTHONY C WITHERS[2], ALAN B. WOODLAND[1], SALLY A. GIBSON[3] AND THOMAS LUDWIG[4]

[1]Goethe University Frankfurt
[2]Bayerisches Geoinstitut, University of Bayreuth
[3]University of Cambridge
[4]Universität Heidelberg

Presenting Author: c.heckel@em.uni-frankfurt.de

Low-T sheared peridotites from the cratonic lithospheric mantle potentially record snapshots of ongoing deformation processes in the mantle root at the time of entrainment but are rarely studied. We investigated the H_2O contents of 10 low-T sheared peridotites from the Kimberley and northern Lesotho clusters (Kaapvaal craton), derived from mid-lithospheric depths (3–4.5 GPa) at pre-deformation equilibrium temperatures of 850–1050°C. These are geochemically highly depleted (Fo = 92–94), and are known to have experienced heating and metasomatism during deformation[1,2]. The H_2O contents of olivine, orthopyroxene and clinopyroxene were determined using a combination of FTIR and SIMS analysis and give new insights into the nature of the deformation and concurrent metasomatism.

The H_2O concentrations of olivine range from 10–80 µg/g and are lower than in orthopyroxene (100–500 µg/g) and clinopyroxene (150–300 µg/g), and equilibrated during deformation. Overall, these high H_2O concentrations imply hydrous deformation conditions and are consistent with observed olivine fabrics (CPOs)[1,2]. However, the measured concentrations are higher, or in some cases lower, than that predicted from the fabric types. Thus, olivine fabrics are able to preserve earlier deformation conditions, while the measured H_2O concentrations reflect the youngest (metasomatic) event[3]. Two explanations for this discrepancy are possible: (i) Olivine fabrics record an older deformation event; or (ii) deformation conditions change over time, with low H_2O activities at the onset of deformation and higher at the end or vice versa. Both hypotheses support that rheological weakening(4) plays an important role in deformation processes in the mid-cratonic lithosphere. Probably early kimberlite pulses[5] led to the rheological weakening that triggered deformation. Furthermore, our results give evidence for metasomatic interactions ‘preparing’ the lithospheric mantle so that (i) subsequent kimberlite pulses may reach the surface[5] and (ii) metasomatized parts of the mantle are more likely to be repeatedly affected by metasomatic and deformation events.

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