Os isotope and PGE evidence for major disruption and addition to the lithospheric mantle: A study of peridotites from the Premier Mine, Kaapvaal craton, SA

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Determining the processes responsible for modification of sub continental lithospheric mantle (SCLM) is key to understanding early crust formation and stabilisation. The Kaapvaal SCLM, as a residue from partial melting, is characterised by depletion in basaltic melt components, but contains high silica and incompatible trace element contents indicative of a complex melt-fluid enrichment history (Griffin *et al*., 2003).

Tomographic studies have establish that Kaapvaal SCLM forms a thick buoyant lithospheric root except for a region in Central Kaapvaal where a marked seismic anomaly coincides with the region of a major magmatic activity that formed the Bushveld Province at 2.05Ga.

This study aims to establish the effect of this major magmatic event on the SCLM through a study of mantle xenoliths from the Premier kimberlite pipe that occurs in the centre of the seismic anomaly. The specific goal is to determine if new SCLM was formed at 2.05 Ga or if there was a major modification of existing SCLM. A combined petrology, major and trace element and Hf-Os isotope study will be reported. Peridotites range from highly depleted spinel and garnet harzburgites to garnet lherzolites. The Premier suite is characterised by two distinct PGE patterns. Group 1 is characterised by fractionated I-PGE to P-PGE patterns typical of residua from high % partial melting ($Pd_N/Ir_N<0.4$) while Group 2 has $0.3<Pd_N/Ir_N<1.6$. Os model ages of Group 1, are generally Archaean whereas Group 2 clusters at ca. 2.0 Ga. A model will be presented to explain the observed depth vs. age of melt depletion relationships which will constrain amount of new vs. modified SCLM beneath Premier.

References

[1] Griffin *et al*. 2003, Lithos 71, 215-241.

2-D diffusion modelling – extracting timescales and crystal histories from BSE images

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Modelling of diffusion profiles within phenocrysts from igneous systems has become more common in recent years. Initial modelling was conducted from linear traverses across crystals measured quantitatively by electron microprobe. Use of Back-Scattered Electron (BSE) imaging allows us to improve the spatial resolution to that of a focused electron beam, at less than a micrometre per pixel, and also to work with two-dimensional images rather than simple traverse lines. When calibrated against electron microprobe analysis, such images can, for certain elements in certain minerals, be used as high-resolution compositional maps.

Combination of imaging with other techniques such as Electron Back-Scatter Diffraction (EBSD) and U-stage measurements allows us to account for many of the geometric uncertainties that exist in diffusion, with crystal orientation (and hence diffusional anisotropy), and boundary orientation being measurable. This presentation introduces a simple finite-difference model (FINDIF) that can incorporate diffusional anisotropy, compositional dependence of both diffusion coefficients and trace element activity coefficients, and elemental partitioning between different crystal phases and liquids (modelled as infinite buffers). Initial states can be read in from TIFF files created with standard image manipulation software, allowing the direct modelling of BSE images that are frequently captured in this format. Multiple grains of multiple minerals can be considered simultaneously, allowing the modelling of polymineralic aggregates.

The program can model the degree of fit between modelled values and an input value within specific pre-defined regions of interest, allowing separate treatment of different regions of interest within the same field of view.

The results indicate that diffusion processes in phenocrysts are actually rather complex even within single crystals and are intimately tied into the dynamic processes of growth, cracking and dissolution to which a crystal is subject during magmatic residence.