

The origin of silica-rich Kaapvaal lithospheric mantle

G.R. DAVIES¹, L. WASCH¹, F. VAN DER ZWAN¹,
M.L.A. MOREL¹, O. NEBEL¹, W. VAN WESTRENNEN¹,
D.G. PEARSON² AND E.W.G. HELLEBRAND³

¹Department of Petrology, Vrije Universiteit Amsterdam, NL.

²Department of Earth Sciences, Durham Universiteit, UK.

³SOEST - University of Hawaii, USA.

The Archaean Kaapvaal lithospheric mantle is residual after extensive melt removal but is characterised by high silica content and is often enriched in incompatible trace elements [1]. The timing and nature of the silica enrichment process is not understood partly because interpreting the temporal evolution of mantle xenoliths is complicated by recent interaction with kimberlite. Here we report a combined petrology and in situ major and trace element and mineral Sr-Nd-Hf-Os isotope study of extremely silica-rich and undeformed xenoliths from Kimberley, S.A. Silica enrichment is manifested in two forms: i) orthopyroxene (opx)-rich clots (75% opx, 15% garnet (gnt), 10 % olivine) and veins (5-20 cm) that have mutual gnt and opx exsolution; ii) gnt-rich clots (80% gnt, 15% opx, 5 % ol). Some samples appear recently metasomatised. This process is manifested by clinopyroxene (cpx) and is associated by LREE enriched whole rock patterns with $Yb_N \sim 2$, $Nd_N \sim 15$. All minerals are in chemical equilibrium and the rocks have isotopic systematics indicating interaction with the host kimberlite. In contrast, Opx and Gnt-clots have "S" shaped REE patterns with $Yb_N \sim 0.5$, $Nd_N \sim 10$, $La_N \sim 0.1$ with a maximum at Sm or Nd. Opx-clots have time integrated low Lu/Hf, down to $\epsilon_{Hf} -15$ but variable Sm/Nd ratios, whereas the gnt-clots have time integrated LREE depleted isotopic signatures ($\epsilon_{Hf} + 10$). The combined trace element and isotopic data are used to formulate a model for the nature and timing of the silica addition to the Kaapvaal lithosphere.

References

[1] Simon *et al.* 2007, *J. Petrol.* **48**, 589-625.

The ion nanoprobe: A new instrument for isotopic and chemical analysis at the few-nanometer scale

A. M. DAVIS^{1,3}, I. V. VERYOVKIN^{2,3}, M. J. PELLIN^{2,3} AND
M. R. SAVINA^{2,3}

¹Department of the Geophysical Sciences and Enrico Fermi Institute, University of Chicago, Chicago, IL 60637
(a-davis@uchicago.edu)

²Materials Science Division, Argonne National Laboratory, Argonne, IL 60439 (verigo@anl.gov; pellin@anl.gov; msavina@anl.gov)

³Chicago Center for Cosmochemistry

A variety of techniques have been developed or are under development to study the properties of materials at the nm scale, including transmission electron microscopy (TEM) and nm-size x-ray beams. These techniques are unsurpassed for studying the distribution and local environment of atoms on this scale, but are unable to measure isotopic composition. At the μm scale, the secondary ion mass spectrometer (SIMS), commonly known to geochemists as the ion microprobe, is widely used to measure isotopic compositions. The most advanced SIMS instruments can produce isotopic images with 100 nm resolution.

The increase in spatial resolution from the earlier generation SIMS instruments such as the Cameca ims-3f to the latest Cameca NanoSIMS-50 led to important new discoveries, such as the discovery of isotopically anomalous ~ 500 nm presolar silicates. We plan to build a new instrument that will take another substantial leap forward in spatial resolution, to 5–10 nm. This is perhaps the last such leap, as there are so few atoms in a few-nm analysis spot (a 5 nm diameter sphere of SiC contains only 3200 atoms). In order to make isotopic and trace element analyses at this spatial scale, very high sensitivity is essential. The ionization efficiency in SIMS is typically 10^{-3} , but can be higher for selected elements. The useful yield (ions detected per atom consumed) in SIMS can exceed 1% in only a very few cases. We have developed techniques for laser postionization of ion-sputtered or laser-desorbed/laser-ablated neutral atoms that have much higher ionization efficiency, which results in a remarkably high useful yield (exceeding 20% in the latest generation instrument built by us) and approaching the atom-counting limit. The new instrument will combine a recently developed high resolution liquid metal ion gun, tunable solid state lasers, and an improved time-of-flight mass spectrometer. By analogy with the ion microprobe, a common name for SIMS, we dub the new instrument the "ion nanoprobe". Development of this instrument will fill a major gap in analytical capability between chemical composition at the nm scale and isotopic composition at the μm scale.

The ion nanoprobe is perhaps best suited to analysis of interstellar and cometary dust returned by the Stardust mission as well as presolar grains in meteorites, where large isotopic variations occur on very fine scales, but a wide variety of applications are envisioned.