

## Characterizing Fe-rich dunite xenoliths as cumulates of Phanerozoic and Archaean flood basalt magmatism

TATJANA REHFELDT<sup>1</sup>, STEPHEN F. FOLEY<sup>1</sup>,  
DORRIT E. JACOB<sup>1</sup>, RICHARD W. CARLSON<sup>2</sup>

<sup>1</sup>Johannes-Gutenberg Universität Mainz, Institut für  
Geowissenschaften, Becherweg 21, 55099 Mainz,  
Germany; (rehfeldt@uni-mainz.de)

<sup>2</sup>Carnegie Institution of Washington, Department of Terrestrial  
Magnetism, Washington, DC 20015, USA

Fe-rich dunite xenoliths occur amongst a large abundance of mantle xenoliths, in the kimberlites of the Kimberley cluster, but their origin has been unclear. On the basis of texture, major and trace elements, as well as Re-Os isotope characteristics, we interpret these dunites as cumulates of flood basalt magmatism related to the ~183 Ma Karoo and the ~2.7 Ga Ventersdorp events in southern Africa.

The Fe-rich dunites mainly comprise olivine neoblasts with subordinate olivine porphyroclasts and parallel-oriented needles of ilmenite, which enclose spinel in some samples. Olivines have lower forsterite and NiO contents than mantle peridotite xenoliths (Fo87-89 versus Fo93-95 and 1300-2800 ppm versus 2200-3900 ppm, respectively), which rules out a restitic origin. Cr-rich spinels are remnants of the original cumulate mineralogy that survived a late stage metasomatic overprint related to the production of the host kimberlite, producing ilmenite and phlogopite in some samples. Olivine porphyroclasts and neoblasts have different trace element compositions, the latter having higher Ti, V, Cr and Ni and lower Zn, Zr and Nb contents, indicating contrasting origins for neoblasts and porphyroclasts. The dunites have high <sup>187</sup>Os/<sup>188</sup>Os ratios (0.11-0.15) indicating young (Phanerozoic) model ages for most samples, whereas three samples show isotopic mixtures between Phanerozoic neoblasts and ancient porphyroclastic material. Most Fe-rich dunite xenoliths can be interpreted as cumulates of fractional crystallization of Karoo flood basalt magmatism, whereas the porphyroclasts are interpreted to be remnants from the much earlier Archaean Ventersdorp magmatic episode.

The calculated parental magma for olivine neoblasts in Fe-rich dunites corresponds to low-Ti Karoo basalts, whereas olivine porphyroclasts had a parental magma with higher MgO contents similar to Archaean high-Mg and komatiitic rocks. Modelling the crystal fractionation of the parental magmas with pMELTS yields element fractionation trends that mirror the element variation of primitive low-Ti Karoo basalts and the basal section of the Ventersdorp Klivriviersberg Group.

## Volcanic Outgassing and the Tl Isotope Composition of the Oceans

M. REHKÄMPER<sup>1,2</sup>, R.G.A. BAKER<sup>1,2</sup>, S.G. NIELSEN<sup>3</sup>,  
T.K. HINKLEY<sup>4</sup> AND J.P. TOUTAIN<sup>5</sup>

<sup>1</sup>Department of Earth Science and Engineering, Imperial  
College, London SW7 2AZ, UK

<sup>2</sup>Department of Mineralogy, The Natural History Museum,  
Cromwell Road, London, SW7 5BD, UK

<sup>3</sup>Department of Earth Science, Parks Road, Oxford OX1 4BH

<sup>4</sup>US National Ice Core Laboratory, USGS, Denver CO 80225

<sup>5</sup>LMTG, Université de Toulouse, CNRS, IRD, OMP, 14 Av.  
E. Belin, F-31400 Toulouse, France

Thallium is a conservative element in seawater with a marine residence time of ~20 kyr [1]. It is thus unsurprising that the present oceans have a nearly constant Tl isotope composition of  $\epsilon^{205}\text{Tl} = -6 \pm 1$  [2-4]. This uniformity is also expressed in the recent growth surfaces of hydrogenetic ferromanganese (Fe-Mn) crusts, which incorporate seawater-derived Tl by adsorption and display  $\epsilon^{205}\text{Tl} = +13 \pm 1$  [2]. Time-series analyses of six Fe-Mn crusts from the Atlantic, Indian and Pacific Oceans revealed nearly constant Tl isotope compositions over the last 30 Myr. In contrast, it was also shown that the  $\epsilon^{205}\text{Tl}$ -values of Fe-Mn crusts changed dramatically from about +6 at 60 Ma to +13 at about 30 Ma [5]. This change has been confirmed by a recent high-resolution time-series study of the Pacific Fe-Mn crust CD29-2 [6].

Given these systematics, it is not unreasonable to assume that the time-series data reflect a change in the Tl isotope composition of seawater. Of particular interest is the possibility that the trend was generated by larger fluxes of Tl derived from subaerial volcanism in the early Cenozoic. This interpretation is in accord with observations that (i) volcanic emissions presently provide ~30% of the global input flux of Tl into the oceans [1], and (ii) such emissions may display low  $\epsilon^{205}\text{Tl}$  due to isotope fractionation by partial degassing. The increase of  $\epsilon^{205}\text{Tl}$  from 60 to 30 Ma may furthermore be essentially synchronous with the decrease of atmospheric CO<sub>2</sub>, as inferred from B isotope data [7], and a 5‰ shift in the S isotope composition of seawater sulfate [8]. It has been proposed that both of these changes could reflect decreasing rates of volcanic outgassing during the early Cenozoic [7, 8].

Preliminary Tl isotope data show that volcanic gases have  $\epsilon^{205}\text{Tl}$ -values as low as -8, and this demonstrates that changes in volcanic inputs may indeed alter the Tl isotope composition of the oceans. To further investigate this possibility, we will acquire Tl isotope data for a larger suite of volcanic emanations from Etna, Kilauea, Merapi, Vulcano and White Island.

### References

- [1] Rehkämper and Nielsen, (2004) *Mar. Chem.* **85**, 125. [2] Rehkämper *et al.*, (2002) *EPSL* **197**, 65. [3] Nielsen *et al.*, *Chem Geol.* (2004) **204**, 109. [4] Nielsen *et al.*, (2006) *EPSL* **251**, 120. [5] Rehkämper *et al.* (2004), *EPSL* **219**, 77. [6] Nielsen *et al.*, *this volume*. [7] Pearson and Palmer (2000), *Nature* **406**, 695. [8] Paytan *et al.* (1998). *Science* **282**, 1459