

Linking kimberlite magmatism, transition zone diamonds, and subduction processes

S. TAPPE^{1,2*}, D.G. PEARSON¹, B.A. KJARSGAARD³,
G.M. NOWELL⁴ AND D. DOWALL⁴

¹University of Alberta, Edmonton, Canada

²De Beers Group Exploration, Johannesburg, South Africa
(*sebastian.tappe@debeersgroup.com)

³Geological Survey of Canada, Ottawa, Canada

⁴Durham University, Durham, United Kingdom

The presence of diamonds with transition zone (TZ) inclusion parageneses in a growing number of kimberlites worldwide is generally considered evidence for an ultradeep origin of kimberlites. However, combined geochemical and experimental evidence, including mantle redox constraints, suggests that kimberlite magma formation is best explained by volatile-fluxed melting of refertilized depleted upper mantle domains.

We analysed the Sr-Nd-Hf isotope compositions of fresh hypabyssal kimberlites from the 75-to-55 Ma Lac de Gras (LDG) field of the central Slave craton that contains TZ diamonds. The LDG kimberlites show the most extreme Nd-Hf isotope decoupling reported from global kimberlites. Isotopic modelling suggests that the steep-angled array in Nd-Hf isotope space is best explained by mixing of convecting upper mantle-derived CO₂-rich melt with minor amounts of alkali silicate melt derived from an isolated mantle reservoir with extremely unradiogenic Hf. Our data indicate that OIB-type material stored in the transition zone for >2 Gyr can be the source of the alkali silicate melt component. Given that the nearby 170 Ma Jericho kimberlites contain neither TZ diamonds nor anomalously unradiogenic Hf, we suggest that onset of fast and steep subduction along the western margin of North America at 100 Ma caused significant entrainment of ancient TZ material into the upper mantle beneath the region. Recycled ancient OIB-type material partially melted during the subduction-triggered upward mantle flow, and locally refertilized the depleted convecting upper mantle. Subsequent CO₂- and H₂O-fluxed redox melting of refertilized domains gave rise to kimberlite magma formation beneath the thick cratonic lid in the LDG area starting at 75 Ma. Model calculations indicate that ancient TZ diamonds could have been brought to the Slave craton base by vigorous mantle flow near a subduction zone within <25 Myr, such that they were available for sampling by the ascending upper mantle-derived LDG kimberlite magmas at 75 Ma [1].

[1] Tappe *et al.* (2013), *EPSL*, Vol. **371-372**, 235-251

A Possible Route to K⁺-Enriched Aqueous Solutions on Early Earth

O. TARAN,^{*1} H. LANGE¹ AND G.M. WHITESIDES^{1,2}

¹ Department of Chemistry and Chemical Biology, Harvard University, Cambridge, MA 02138, USA.

² Wyss Institute for Biologically Inspired Engineering, Harvard University, Cambridge, MA 02138, USA.
(correspondence: otaran@gmwhgroup.harvard.edu)

All known living organisms have a K⁺-rich intercellular medium, while usually existing in a Na⁺-enriched environment [1]. High K⁺ concentrations are required for the proper function of numerous essential enzymes and ribozymes [2]. This difference between cation concentrations is translated to potential difference used for energy storage and signalling. Most of the natural terrestrial environments are known to be enriched in Na⁺ due to its higher abundance and high solubility of its salts. The Na⁺/K⁺ mole ratio inside living cells varies around 1/10, which is roughly the opposite ratio of these ions in seawater (47/1). In this work we show that one of the processes leading to the enrichment of groundwaters in K⁺ can occur during acid weathering of Aluminium rich clays and zeolites and the fractional secondary precipitation of alunite and Na-alunite

Zeolites and montmorillonites were treated by acidic (0.1-1M H₂SO₄) solutions (K⁺/Na⁺ mole ratio 1/5) at temperatures 20°-50°C. The clay/acid mixtures were left to evaporate. During the drying process octagonal crystals were formed from coalecent brines on the surface of the clays. The crystals were identified by X-ray diffraction and ICP analysis as KAl(SO₄)₂. The remaining interstitial brine was enriched in Na⁺ and close to saturation with respect to NaAl(SO₄)₂. Fast washing from the final mixture surface leads to the enrichment of K⁺ in the formed solution by orders of magnitude depending on pH, temperature and a mineral type.

This proposed scenario leads to environments rich in potassium and can also be applied for accumulation of other prebiotic components, such as phosphate and small organic molecules. We suggest that acid weathering could be a process to accumulate essential components for the chemical origin of life.

[1] Williams, R. (1970).. *Q. Rev. Chem. Soc.*, 3.[2] Mulkey, A., *et al.* (2012) *PNAS*, 109:E821-E830.