Dating mantle samples: examples from the Re-Os system in eclogites and diamonds

S.B. SHIREY[1], M.D. SCHMITZ[1,2], K.J. WESTERLUND[3], S.H. RICHARDSON[3], U. WIECHERT[4], D.G. PEARSON[5], R.W. CARLSON[1] AND J.W. HARRIS[6]

[1]Carnegie Institution of Washington, DTM, 5241 Broad Branch Road NW, Washington, DC, 20015, USA (shirey@dtm.ciw.edu, carlson@dtm.ciw.edu)
[2]Department of Geosciences, Boise State University, 1910 University Drive, Boise, ID 83725-1535 (markschmitz@boisestate.edu)
[3]Department of Geological Sciences, University of Cape Town, Rondebosch 7701, South Africa (karl.westerlund@hifab.se, shr@geology.uct.ac.za)
[4]Institute of Isotope Geology, ETH Zentrum, Zurich, 8092 Switzerland (wiechert@erdw.ethz.ch)
[5]Department of Geological Sciences, Durham University, South Rd, Durham DH1 3LE, United Kingdom (d.g.pearson@durham.ac.uk)
[6]Division of Earth Sciences, Gregory Building, University of Glasgow, Glasgow, G12 8QQ, United Kingdom (jwh@earthsci.gla.ac.uk)

Absolute age determinations on mantle samples using radiogenic isotope systems such as Rb-Sr, U-Pb, and Sm-Nd have been difficult because of issues of metasomatic overprints, host contamination, and blank. The Re-Os system over the last 15 years has shown wide applicability both on the single grain and whole-rock scales. Combination with opportunistic U-Pb and Lu-Hf in zircon, garnet and whole-rock provides a comprehensive tool to understand, with increasingly precise chronological constraints, the petrogenesis of the lithospheric mantle beneath cratons.

Re-Os isotopic ages of individual eclogitic sulfide inclusions in diamonds compared to the Re-Os model ages on depleted harzburgites supports a process whereby the Kaapvaal craton was created and then assembled from 3.1 to 2.9 Ga by Archean subduction. Independent corroboration of this model comes from two sources: Re-Os, U-Pb, O, and trace elements on Kaapvaal craton eclogite suites which allow for the reconstruction of an older than 3.04 Ga Archean ocean floor section preserved within the lithosphere; and metasomatic signatures in 3.57 ± 0.15 Ga Slave craton peridotitic sulfide inclusions in diamonds that suggest subduction can be key to forming the earliest cratonic nuclei.

Diamonds beneath an ancient continental rift: The Star kimberlite, South Africa

M.D. SCHMITZ[1,2], S.B. SHIREY[2] AND R.W. CARLSON[2]

[1]Department of Geosciences, Boise State University, Boise, ID 83725 (markschmitz@boisestate.edu)
[2]Department of Terrestrial Magnetism, Carnegie Institution of Washington, Washington, DC 20018 (shirey@dtm.ciw.edu, carlson@dtm.ciw.edu)

The Group 2 Star Mine kimberlite dike of the central Free State province of South Africa intruded at 144 Ma across a key region of the southern African Kaapvaal craton for testing the effects of ancient cratonic rifting on the subcontinental lithosphere. An apparent paradox exists in the mutual presence at the Star Mine of: 1) abundant diamonds necessitating a thick cold mantle keel, and 2) ultrahigh-temperature lower crustal xenoliths formed at 2.71 Ga during deep crustal metamorphism in an apparent response to severe lithospheric thinning during Ventersdorp rifting (Schmitz and Bowring, 2003). We initiated a geochemical and geochronological study of the Star Mine diamonds in order to constrain the thermal history of the deep lithosphere and unravel this paradoxical lithospheric assemblage.

Optical microscopy and cathodoluminescence imaging on polished plates of the dominant population of white octahedral diamonds reveals abundant discordant diamond nuclei, thick mantles of oscillatory zoned octahedral growth and a major resorption surface followed by an outer rim of octahedral diamond. FTIR measurements yield relatively low nitrogen contents with a median IaB aggregation of 10% in the oscillatory zoned mantle, with lower nitrogen and degree of aggregation in the outer rims. These compositional variations have guided in situ carbon and nitrogen isotopic analyses, yielding typical mantle-like compositions. Chromite, olivine, rare harzburgitic garnet, and more abundant sulfide are present as inclusions in the diamonds. The targeted sulfides will facilitate geochronological and tracer isotopic investigations of diamond growth through ID-TIMS Re-Os and Pb isotopic measurements.

Reference

Schmitz M.D. and Bowring S.A., (2003), *Geol. Soc. Am. Bull.* **115**, 533-548.