The Earth accreted dry and its ocean rains into the mantle

FRANCIS ALBARÈDE AND JANNE BLICHERT-TOFT

Ecole Normale Supérieure, 69007 Lyon, France
(albarede@ens-lyon.fr)

Mars and the Moon are dry and inactive deserts. Their interiors came to rest within one billion years of accretion. Venus, although internally very active, has a dry inferno for a surface. In contrast, the Earth is tectonically active and largely covered by a deep ocean. The strong gravity field of large planets allows for an enormous amount of gravitational energy to be released, causing the outer part of the planetary body to melt (magma ocean), thus helping retain water on the planet. The relationship between terrestrial element abundances and condensation temperatures shows that the Earth accreted dry. The analysis of K/U and $^{87}Sr/^{86}Sr$ ratios in planetary objects further demonstrates that the Inner Solar System lost up to 95% of its K and Rb. Planets in such an environment cannot contain much water (~20 ppm). Buoyant serpentines produced by reactions between the dry terrestrial magma ocean and icy impactors received from the outer Solar System isolated the magma and kept it molten for ~30 million years. Subsequent foundering of this wet surface material gradually softened the terrestrial mantle, transporting water to depth and set the scene for the onset of plate tectonics which currently lets the ocean rain into the mantle. The very same processes may have acted to remove all the water from the surface of Venus 500 My ago and added enough water to its mantle to make its internal dynamics active and keep the surface young. In contrast, because of the smaller radius of Mars compared to that of the Earth, not enough water could be drawn into the Martian mantle before it was lost to space and Martian plate tectonics never began.

W isotope study of natrocarbonatites from Oldoinyo Lengai, Tanzania

A. ALI[1,2]*, S. NAKAI[2], K. BELL[3] AND Y. SAHOO[2]

[1]University of Toronto, Toronto, Ontario, M5S 3B1
(*correspondence: ali@geology.utoronto.ca)
[2]University of Tokyo, Tokyo 113-0032, Japan
(snakai@eri.u-tokyo.ac.jp, yuvin@eri.u-tokyo.ac.jp)
[3]Carleton University, Ottawa, Canada (kib@magma.ca)

We contribute to the debate of core-mantle interactions by providing W isotope ($^{182}W/^{183}W$) analyses of natrocarbonatite lavas collected in 1993 from the only known active carbonatite volcano Oldoinyo Lengai (OL), Tanzania. The ^{182}Hf-^{182}W system is well-suited to constrain the timing of core formation because Hf and W behave differently when metal segregation occurs. W is a moderately siderophile, incompatible, and refractory element that preferentially partitions into the Earth's core during core formation. Hf, on the other hand, is a lithophile, so its abundance in the core is low. Most deep-seated rocks are difficult to analyze because of their low W contents. Therefore we chose to analyze OL lavas because earlier Nd-Sr-Pb isotopic studies [1] had shown that they are derived from a mantle source with an isotope signature that reflects a mixture of HIMU and EM1-like mantle components. Moreover they have unusually high W contents of 41-116 ppm [2]. A recent study [3] of C-O isotopes is also consistent with a mantle origin for the natrocarbonatites. We analyzed 7 lava samples for W isotopes using MC-ICPMS. Because the carbonatite lavas of OL contain Pb with distinct mantle isotopic signatures, the high W contents of the natrocarbonatites cannot be the result of crustal contamination. The W isotope compositions from the carbonatite lavas are relatively uniform. The εW ($([^{182}W/^{183}W]_{Sample}/[^{182}W/^{183}W]_{NIST\text{-}SRM3163} - 1)\times10^4$) values range from -0.12±0.50 to 0.12±0.54 and are similar to those from other terrestrial materials. The εW value of silicate Earth by definition is equal to zero, while that of chondritic meteorites is -1.9 [4]. If it is assumed that the bulk Earth composition is chondritic, the εW of the core calculated using mass balance equations is about -2 [5]. However, the new □W values from OL are equivocal. Either: i. there is no contribution from the core into the source of OL lavas, or ii. there might be overprinting by the addition of W from an enriched mantle source region, or iii. analytical methods at present are unable to resolve isotopic differences brought about by small contributions from the core.

[1] Bell & Simonetti (1996) *JP* **37**, 1321-1339. [2] Simonetti *et al.* (1997) *JVGR* **75**, 89-106. [3] Keller & Zaitsev (2006) *Can. Min.* **44**, 857-876. [4] Kleine *et al.* (2002) *Nature* **418,** 952-955. [5] Scherstén *et al.* (2004) *Nature* **427**, 234-237.