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Isotopes and formation of the Earth's core

A.N. Halliday, R.B. Georg, S. Nielsen and H.M. Williams

Department of Earth Sciences, Oxford University, Parks Road, Oxford, OX1 3PR, U.K. (alexh@earth.ox.ac.uk / +44 1865 272969)

The mechanisms and timescales for accretion in the inner solar system are now thought to be reasonably well understood and provide evidence that the first planetary embryos underwent metallic core formation in $< 10^6$ years. How the Earth's core then developed is less clear although stable isotope fractionations and radiogenic systems that undergo major metal-silicate, parent / daughter element fractionation have the potential to supply powerful new constraints that complement experimental and bulk chemical evidence. In particular, new high precision silicon (Si) isotopic data provide evidence that the bulk silicate Earth (BSE) has a fractionated composition that is heavy relative to both chondrites and achondrite meteorites that come from Mars and Vesta. A viable mechanism for this is isotopic fractionation during metal–silicate differentiation, providing evidence that Si is a light element in the Earth's core. Assuming the core contains $<$7 wt % Si it has an isotopic composition that is $>$1 ‰ amu^{-1} lighter than the bulk earth assuming a chondritic – BSE difference in δ^{30}Si of 0.3 ‰. This is consistent with the stiffness of Si-O bonds. The partitioning of Si is dependent on temperature and pressure, which provides some explanation for the absence of such an effect in smaller planets. Lithium and Mg, elements with a similar volatility to that of Si, show no resolvable isotopic differences between the silicate reservoirs of the Earth, Mars and Vesta. Therefore, a mechanism that relates to accretion seems less likely as an explanation. Iron (Fe) does show a hint of a similar effect and this may also relate to high pressure core formation. In the case of both Si and Fe, high pressure experimental isotopic data are needed to confirm this. The Si and Fe isotopic compositions of normal lunar basalts are similar to those for the Earth. This provides evidence in support of the recent proposal that there was mixing and at least partial isotopic equilibration between the material in the silicate Earth and proto-lunar disk during the Giant Impact (Pahlevan K. and Stevenson D.J. (2005) The oxygen isotope similarity between the Earth and Moon – source region or formation process? *Lunar*

and Planetary Sciences XXXVI, 2382) This being the case the isotopic compositions of lunar samples provide new constraints on the state of the Earth at the time of the Giant Impact. For example, there is evidence that W did not equilibrate between the impactor's core and the silicate Earth, consistent with previous conclusions based on the W isotopic composition of the present day BSE.