New insights into planetary formation from Os stable isotopes

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Osmium (Os) displays a number of characteristics that are of geochemical interest; it is highly siderophile and redox sensitive, and displays compatible behaviour during mantle melting. These properties have made Os a key tool in studies of planetary differentiation and mantle recycling, mainly through the use of the ^{187}Re-^{187}Os and ^{190}Pt-^{186}Os radioactive decay systems. Recent studies of high-mass stable isotope systems (such as thallium and uranium, e.g. [1], [2]) indicate the presence of significant and systematic stable isotope variations in both meteorites and Earth's mantle-derived rocks. The potential, therefore, also exists for significant Os stable isotope fractionation, which could in principle be used to constrain redox processes that take place on meteorite parent bodies or during Earth's early accretion and differentiation. We have developed a method for high-precision measurement of stable Os isotope compositions in geological samples, by both plasma source (MC-ICP-MS) and thermal ionisation mass spectrometry (TIMS), using an Os double-spike. Precision on single measurements is ca. 0.020‰ on δ^{190}Os (95% c.i.), where δ^{190}Os is the per mil deviation in the measured ^{190}Os/^{188}Os ratio relative to the DROsS Os standard [3].

Preliminary results on ordinary and enstatite chondrites, including all sub-groups and covering a range of petrological types, show no detectable variation with δ^{190}Os of 0.115 ± 0.007 (95% c.i., *n=28*). This implies Os stable isotope homogeneity of the solar nebula, but further analyses are required to confirm this hypothesis. Terrestrial mantle samples display stable Os isotope compositions (δ^{190}Os of 0.134 ± 0.016, 95% c.i., *n=5*) similar to that obtained for ordinary and enstatite chondrites. This suggests that, if any stable isotope fractionation occurred as a result of metal-silicate segregation during core formation, it was completely overprinted by a subsequent late veneer (assuming the latter had an Os stable isotope composition similar to our current chondrite record). Future work will focus on exploring stable Os isotope variations in other meteorite groups and terrestrial mantle samples.

[1] Nielsen et al (2006) *Geochim. et Cosmochim. Acta **70**(10), 2643-2657*. [2] Brennecka et al (2010) *EPSL **291**, 228–233*. [3] Nowell et al (2008) *Chemical Geol. **248**, 363-393*.