Project EARTH-16-STFC-JW1: Heavy Mantles – evaporating space rock?

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Recent studies of the differentiated planetary bodies suggest they are isotopically heavy with respect to Si, with some authors suggesting that HED parent body, for instance, records sequestration of Si into its core during formation. Although there has been significant disagreement in the literature as to the magnesium isotopic content of the differentiated terrestrial bodies, there is a developing consensus that they are all broadly isotopically heavy and elementally depleted in both Si and Mg. However, the small, oxidised nature of the HED parent body make it unlikely that core formation or high-pressure silicate phases are the culprit for the isotopic and elemental depletions of both elements.

The other explanation is that of element volatility – under highly reducing conditions such as those found in the proto-planetary disc, both magnesium and silicon are volatile. The residual silicate will evolve to become depleted in both and, assuming evaporation at low-pressures, isotopically heavy in both. Support for this process occurring in nature is found in the calcium-aluminium inclusions (CAI's) found in primitive meteorites. These highly refractory components, thought to have been processed in the early proto-planetary disc, are depleted in the both Si and Mg and exhibit large variations in their respective isotopic contents. These observations suggest an enticing hypothesis – is volatility under reducing conditions responsible for both the isotopic and element depletion in the Earth? Does the Mg isotope content of the Earth reflect addition of a reduced component during planetary formation, rather than the presence of a so far un-sampled mantle component?

The project will use experiments to explore the role of silicate composition upon elemental and isotopic fractionations, and compare these to CAI's contained within meteorites. The project will make extensive use of experimental techniques as well as microbeam (electron probe, LA-ICPMS and nanoSIMS) together with high precision isotopic analysis to characterise both experimental and natural samples.