

Experimental constraints on HSE fractionation during basalt genesis

JAMES M BRENNAN

Earth Sciences, University of Toronto,
(brenan@es.utoronto.ca)

Terrestrial basalts are characterised by CI-normalised depletions in the highly siderophile elements (HSE), as well as moderate to large interelement fractionation within the group; the IPGE (Os, Ir, Ru) are relatively depleted compared to the PPGE (Rh, Pt, Pd), Au and Re. The overall low abundance of the HSE in basalts is attributed to core formation, whereas the origin of the fractionation within the HSE group has been less certain. Experiments and empirical observations indicate that Ir, Ru and Rh are compatible in olivine, as is Ru in ferric-iron-poor chromian spinel, and both phases strongly reject Pt, Pd, Re and Au. It is expected, but unproven, that cpx and opx will exhibit broadly similar partitioning behaviour as olivine. This sense of fractionation is correct for terrestrial basalts, but the magnitude of partition coefficients is too low to account for the overall depletion levels.

Residual sulfide, either as liquid or crystalline MSS, has a significant impact on basalt HSE levels, owing to large sulfide-silicate partition coefficients. Crystalline MSS can be stable with silicate melt if the silicate liquidus is suppressed by water. Based on known MSS-sulfide melt partitioning, MSS-silicate melt partitioning can impose a strong inter-HSE fractionation, whose sense and magnitude is similar to terrestrial basalts. With the exception of Au, however, direct measurements of MSS-silicate melt partitioning of the HSE have not been done. If melting occurs at higher temperatures, MSS is replaced by sulfide liquid. Experiments show that Re and Au are significantly less compatible than PGE in sulfide liquid at moderately oxidised conditions, accounting for the relative enrichment of Re and Au in terrestrial basalts. It is not clear, however, if sulfide liquid can impose IPGE/PPGE fractionation on silicate melt, as partition coefficients for these elements are currently too imprecise.

Recent measurements indicate sulfide-silicate partition coefficients for the PGE are on the order of 10^6 or larger. Since the mass fraction of sulfide liquid decreases during melting, this implies that the PGE content of residual sulfide could reach 1000s of ppm, leading to saturation in the less soluble PGE, such as Os, likely alloyed with Ir and Ru. The HSE content of terrestrial basalts might therefore be controlled by a combination of metal solubility and sulfide-silicate partitioning. Detailed modelling of this behaviour is considered by Mungall [this session].

Evidence for supernova injection into the solar nebula and the decoupling of *r*-process nucleosynthesis

G.A. BRENNECKA¹, L.E. BORG¹ AND M. WADHWA²

¹Lawrence Livermore National Laboratory, Livermore, CA, USA 94550 (brennecka2@llnl.gov)

²School of Earth and Space Exploration, Arizona State University, AZ, USA 85287

Variations in the non-radiogenic isotope abundances of meteoritic materials have long been interpreted as nucleosynthetic signatures resulting from the input of distinct materials produced from *p*-, *s*-, and *r*-processes [e.g., 1-8]. Previous studies of the Solar System's first solids, calcium-aluminum-rich inclusions (CAIs), have demonstrated that isotopic compositions of various elements differ from terrestrial compositions and may be modeled using addition or subtraction of different nucleosynthetic components [6-8]. However, these studies did not determine the isotopic compositions of multiple elements spanning a large mass range in the same CAIs. We present for the first time an integrated study of Sr, Mo, Ba, Nd, and Sm isotope compositions determined on multiple coarse- and fine-grained CAIs from the Allende CV3 chondrite.

The data demonstrate that the isotopic compositions of these elements in CAIs are uniform and yet distinct from the average Solar System, necessitating that CAIs were formed in a homogenous and isotopically distinct reservoir. Taken in whole, the observed mass-independent anomalies cannot be explained by: (1) presence of presolar components, (2) simple addition/subtraction of *r*-process nuclides, (3) incomplete digestion of the sample, (4) nuclear field shift fractionation, or (5) neutron capture. Relative to terrestrial standards, CAIs contain positive *r*-process anomalies in isotopes $A < 140$ and negative *r*-process anomalies in isotopes $A > 140$. Previous work has suggested that multiple supernova sources are required to account for the proportions of short-lived isotopes in the early Solar System [9]. The fundamental difference in the isotopic character of CAIs around mass 140 is consistent with [9] and necessitates (1) the existence of multiple sources for *r*-process nucleosynthesis, and (2) the injection of supernova material into a reservoir untapped by CAIs.

[1] Hidaka *et al.* *EPSL* **214**, 455 (2003) [2] Andreasen & Sharma *Science* **314**, 806 (2006) [3] Carlson *et al.* *Science* **316**, 1125 (2007) [4] Andreasen & Sharma *ApJ* **655**, 874 (2007) [5] Qin *et al.* *GCA* **75**, 7806 (2011) [6] Burkhardt *et al.* *EPSL* **312**, 390 (2011) [7] Moynier *et al.* *ApJ* **758**, 45 (2012) [8] Schönbachler *et al.* *EPSL* **216**, 467 (2003) [9] Qian *et al.* *ApJ* **494**, 285 (1998).