Mg-isotopes in terrestrial and extraterrestrial olivines.

O. ALARD[1], K.W. BURTON[1], P.A. BLAND[2] AND S.S. RUSSELL[3]

[1] Dept. Earth Science, The Open University, Milton Keynes MK7 6AA, U.K. (o.alard@open.ac.uk; k.w.burton@open.ac.uk).

[2] PSSRI, The Open University, Milton Keynes MK7 6AA, U.K (p.a.bland@open.ac.uk).

[3] Dept. Mineralogy, The Natural History Museum, London SW7 5BD, U.K. (sarr@nhm.ac.uk).

O-isotope studies of meteoritic materials have shown that the solar nebula was heterogeneous in composition, but also that some material as CAI and Ureilites have a non-mass dependant fractionation regime. Recent advances in MC-ICP-MS allow the investigation of other stable isotopic systems, and of particular interest are the 3-isotope systems of Fe and Mg (e.g. Zhu *et al*., 2001; Galy *et al*., 2000). Zhu *et al*. (2000) have shown that in a $^{56}Fe/^{54}Fe$-$^{57}Fe/^{54}Fe$ space terrestrial and extraterrestrial (chondrite and achondrite) materials plot on a single mass fractionation line, thus suggesting that the solar nebula was homogeneous in term of Fe-isotopes.

In this study Mg isotopes have been measured using MC-ICP-MS in terrestrial and extraterrestrial olivines, without chemical separation. Olivine has high Mg content, low minor/trace element contents, and is a rather ubiquitous phase. Analysis of Fe(Ni)-doped SRM-980 shows that there is no effect on the Mg isotopic composition. Furthermore, analysis of a number of mantle olivines (n=12; $\delta^{25}Mg=1.63\pm0.06$; $\delta^{26}Mg=3.07\pm0.08$, relative to SRM-980) shows a perfect agreement with the terrestrial mass fractionation line. Pallasite olivines have $\delta^{25}Mg$ ranging from 1.05 to 1.35 and show a mass dependant fractionation within error of the Terrestrial Fractionation Line (TFL). Ureilites show a wider range of Mg fractionation ($-0.30\leq\delta^{25}Mg\leq1.54$), however, they still define a mass dependant fractionation line, with a slope indistinguishable to that of the TFL.

Mg isotopes depict a contrasting view of the solar nebula heterogeneity to that shown by O isotopes. No difference is observed between the pallasites (Vesta line in O- space) and the Earth. Ureilites show a mass dependant fractionation line in Mg isotopes which strongly contrasts with their slope (ca. 1) in O-space, yet is in agreement with the CAI Mg-isotopic composition (Galy *et al*., 2000, Young *et al*., 2002). These data suggest that the process/es responsible for O isotope fractionation did not affect Mg isotopes, or did not affect them in the same manner.

Galy A., Young E.D., Ash R.D., O'Nions R.K. (2000) *Science* **290**, 1751-1753.

Zhu X.K., Guo Y. O'Nions R.K., Young E.D., Ash R.D. (2001) *Nature* **412**, 311-313.

Young E.D., Ash R.D., Galy A., Belshaw N. (2002) *Geochim. Cosmochim Acta* **66**, 683-698.

A Lu/Hf and Sm/Nd perspective on the early differentiation of the Earth, Moon, Mars, and EPB

F.ALBAREDE[1], J.BLICHERT-TOFT[1], AND M.BOYET[1]

[1] Ecole Normale Supérieure, 46 allée d'Italie, 69364 Lyon Cedex 7, France (albarede@ens-lyon.fr)

^{176}Lu-^{176}Hf and ^{143}Nd-^{144}Nd are the only two chronometric systems with long half-lives for which both the daughter and parent nuclides are refractory, lithophile, incompatible elements. The coupled Nd and Hf isotope systematics so far available for a large number of terrestrial and a few lunar samples [1,2] have now been extended to also include SNCs and eucrites [3,4]. Because the Earth, Mars, and the Moon all have post-formation histories, we consider the eucrite data together with data for these planets as chondrite-normalized source parent/daughter ratios.

On Earth, the coherence between Hf and Nd isotope ratios is strong with the mantle and the crust plotting in opposite quadrants of a $(Lu/Hf)_N$ vs $(Sm/Nd)_N$ plot. In most terrestrial basalts, Hf and Nd are more radiogenic than chondrites. Basaltic eucrites plot in the 'crustal' sector while cumulate eucrites plot in the 'mantle' sector. All lunar mare basalts plot in the 'mantle' sector: mildly radiogenic Hf and variable Nd for high-Ti basalts, and the opposite for low-Ti basalts. Finally, the most differentiated basaltic shergottites plot in the 'crustal' sector while the most cumulative shergottites fall in the mantle sector with relatively radiogenic Hf and variable Nd. The slope of the $(Lu/Hf)_N$ vs $(Sm/Nd)_N$ correlation increases in the order: Earth, Moon and Mars, eucrite parent body (EPB).

We believe that this relationship reflects the different thicknesses of the plagioclase stability field on the four planets. Terrestrial gravity is larger by factors of 3, 6, and, presumably, 40 with respect to Mars, the Moon, and the EPB, which gives a relative measure of the depth in the mantle that can produce plagioclase-saturated basalts. When compared with the Sm/Nd and Lu/Hf ratios of the major minerals that would crystallize from a chondritic magma ocean, we conclude that the mantle source of terrestrial basalts is controlled by equilibrium of melt with an olivine-clinopyroxene residuum. Plagioclase joins these two minerals in the source of SNCs and lunar mare basalts, notably the low-Ti basalts, and reaches a maximum in the mantle of the EPB. From Lu/Hf and Sm/Nd evidence only, it is unclear whether eucrites are small-degree melts from plagioclase-bearing cumulates or large-degree melts from a chondritic parent body. The low Ti contents and low Hf/Nd of cumulate eucrites and low-Ti lunar mare basalts indicate that either their parent magma or that of their mantle source lost substantial fractions of ilmenite. Cumulate eucrites therefore represent gabbros soaked by extremely differentiated melts.

References

[1] Unruh D.M. et al. (1984) *JGR 89*, B459-B477 [2] Beard B.L. et al. (1998) *GCA 62*, 525-544 [3] Blichert-Toft J. et al. (1999) EPSL 173, 25-39 [4] *id* (2002) this meeting.