Calcium isotopes, the Moon's origin and magmatic evolution

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The isotopic ratios of many terrestrial and lunar samples are identical for many elements when corrected for mass-dependent fractionation (e.g., O, Cr, and Ti). This is potentially a serious problem for the giant impact model for the origin of the Moon because most simulations predict the Moon to be primarily made of material derived from a Mars-sized impactor, which likely had a different isotopic composition from that of the Earth. One of the options to resolve this problem is to re-equilibrate the post-giant impact Moon-forming disk and Earth in a silicate vapor atmosphere [1]. The recently proposed model of impact on a fast spinning proto-Earth predicts a continuous mantle-atmosphere-disk that extends well beyond the Roche limit where the Moon's material condenses out of a homogeneous vapor disk [2]. In such models the Earth and Moon, forming from an isotopically identical material, may bear small but measurable mass-dependent fractionation effects (0.1-0.2‰) for some elements [3] [4].

To further test the giant impact hypothesis, we have made high-precision Ca isotopic analyses of lunar samples using a TIMS instrument and a ^{43}Ca-^{48}Ca double spike technique. Our current data include high- and low-Ti basalts, ferroan anorthosites, and plagioclase separated from troctolite 76535. They show a total variation of about 0.3‰, with anorthosites being lighter than basalts. Despite this variation, the average Ca isotopic composition of these samples ($\delta^{44/40}Ca_{SRM915a}$ of 0.92 ± 0.09 (2σ)) is in the range reported for the Earth's mantle [5]. We are measuring additional lunar samples to understand Ca isotope fractionation during the crystallization of the lunar magma ocean and to get a firmer constraint on the Ca isotope composition of the Moon. We are also measuring non-mass dependent Ca isotope variations and will discuss them in the conference.

[1] Pahlevan K. and Stevenson D. J. (2007) *EPSL* **262**, 438–449. [2] Lock S. et al. (2015) *LPSC* #2193 [3] Pahlevan K. et al. (2011) *EPSL* **301**, 433–443. [4] Huang S. et al. (2104) *LPSC* #2246. [5] Huang S. et al. (2010) *EPSL* **292**, 337-344.