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Cerium-Nd isotope evidence for an incompatible element depleted Moon.

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The Moon is the best example of a planetary body that has formed after a collisional impact event. A better understanding of its bulk composition can provide new constraints on its building blocks and can help clarifying whether the Earth-Moon system is chondritic in its lithophile trace element composition or not. A recent study revealed that Earth has a higher ^{142}Nd/^{144}Nd composition than would be expected from pure s-/r-process variations[1]. This can be explained, if Earth has accreted from material with a higher p-process component[1], or if Earth has lost an early enriched reservoir[2]. To provide new constraints whether and possibly when Earth has lost an enriched reservoir, we have applied the long-lived ^{138}La-^{138}Ce and ^{147}Sm-^{143}Nd systems to 30 lunar samples, covering the most important lunar petrological rock types (low and high Ti basalts, KREEPs, and ferroan anorthosites). Present day and initial Ce-Nd lunar isotope arrays do not intersect the chondritic value, arguing for a non-chondritic composition of the Moon. Trace element and isotope modelling of lunar magma ocean crystallization[3] further imply that a slightly depleted bulk Moon composition is required to match the observed data, although the degree of depletion must be smaller compared to previous estimates of a super-chondritic Earth composition[2]. When comparing previously reported Ce-Nd isotope data of 3.3±0.25 Ga Archean rocks from the Kaapvaal[4] and Pilbara Craton[5] with a subset of contemporaneous lunar rocks from this study, both arrays define a Ce-Nd intersect that is indistinguishable from our modeled lunar intersect at that time. We take this as evidence that the terrestrial mantle and the lunar mantle are non-chondritic but may share a common, slightly depleted incompatible trace element depleted composition. Considering that the Moon is predominantly formed by terrestrial material, our finding of a non-chondritic Moon imply that this feature was inherited from an already differentiated proto-Earth that must have already lost parts of an enriched reservoir prior to the giant impact.

[1] Saji et al. (2020) GCA, 281.[2] Caro & Bourdon (2010) GCA, 74.[3] Snyder et al. (1992) GCA, 56.[4] Tusch et al. (2021) unpubl. prepr. DOI 10.1002/essoar.10507464.1.[5] Hasenstab et al. (2021) EPSL, 553.