Cr isotope composition of the Earth-Moon-Enstatite chondrite system

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Among the catastrophic events that happened at the onset of the Earth's formation, a giant impact between the proto-Earth and a Mars-sized object has been proposed for the origin of the Moon formation [1]. However, physical models are difficult to reconcile with geochemical observations mainly because the Earth and Moon have similar isotope compositions for some elements that display clear isotopic anomalies in meteorites (e.g., Ti, O)[2][3]. Recently, very high precision $\Delta^{17}O$ measurements [4] suggest that it is possible to detect small isotopic variations that exist between the Earth, the Moon and enstatite chondrites, but this observation was later contested [3]. Chromium isotope system has also been used to argue for the isotopic homogeneity between the Earth and the Moon. However, while there is a large database for Cr isotope compositions in meteorites [5], only 2 lunar samples have been analyzed so far [6]. In addition, Cr isotopic data for terrestrial samples are scarce, with the common assumption that they are strictly identical to the reference standard. We will discuss the degree of homogeneity between the Moon, the Earth and enstatite chondrites, and present the Cr isotopic composition of lunar samples including basalts, anorthosites, a norite, and a dunite collected during the Apollo missions. We also re-evaluate the Cr isotope signature of the Earth by measuring terrestrial basalt, andesite and peridotite samples, and provide new data for enstatite chondrites. Our preliminary results show that some lunar samples have anomalously high $^{53,54}Cr$ isotope values that can be attributed to cosmogenic irradiation effects, consistent with their high exposure ages. Excluding these samples, isotopic homogeneity between the Earth and the Moon is observed at the 10-ppm level. Enstatite chondrites exhibit slightly higher ^{53}Cr and lower ^{54}Cr values than the Earth and the Moon, but overlap within error. Finally, we observe a small but systematic positive offset in ^{54}Cr between terrestrial samples and the NIST SRM 3112a Cr standard.

[1]Canup RM. (2012) Science 338, 1052-1055; [2]Zhang et al. (2012) Nat. Geosci. 5, 251–255; [3]Young et al. (2016) Science 6272:493-496; [4] Herwartz et al. (2014) Science 344, 1146–1150; [5]Göpel et al. (2015) Geochim. Cosmochim. Acta 156, 1-24; [6]Qin et al. (2010) Geochim. Cosmochim. Acta 74, 1122-1145.