Chromium isotopic homogeneity between the Moon, the Earth, and Enstatite chondrites

BERENGERE MOUGEL[1], FRÉDÉRIC MOYNIER[12], AND CHRISTA GÖPEL[1]

[1]Institut de Physique du Globe de Paris, Université Sorbonne Paris Cité, CNRS UMR 7154, Paris, France
[2]Institut Universitaire de France and Université Paris Diderot, Paris, France

Among the elements exhibiting non-mass dependent isotopic variations in meteorites, Cr has been central in arguing for an isotopic homogeneity between the Earth and the Moon, thus questioning physical models of Moon formation. However, the Cr isotopic composition of the Moon relies on two samples only[1], which define an average value that is slightly different from the terrestrial standard. Here, by determining the Cr isotopic composition of 17 lunar, 9 terrestrial and 5 enstatite chondrite (EC) samples, we re-assess the isotopic similarity between these different planetary bodies. While terrestrial and EC samples share similar ε^{54}Cr, lunar samples on the other hand show variable excesses of ^{53}Cr and ^{54}Cr compared to the Earth and EC. All the lunar samples plot on a straight line in a ε^{53}Cr and ε^{54}Cr diagram with a slope of ~2.62 (R^2=0.99), which suggests that the Cr isotopic composition of the Moon has been modified by secondary processes. Late arrival of meteoritic materials, solar wind implantation, or Galactic Cosmic Ray (GCR) irradiation are possible candidates that might generate Cr isotopic variations. We show that the Cr isotopic deviation of the lunar surface has a cosmogenic origin, and is controlled by neutron capture effect. This is different from previous lunar GCR model predictions[2], and observations in iron meteorites and other meteorites with high exposure ages[1], for which Cr isotopic shifts are exclusively controlled by the spallation of Fe. From the linear correlation between Cr isotopic ratios and ^{150}Sm/^{152}Sm ratios for lunar igneous bedrocks we deduced the pre-irradiation Cr isotopic composition of the Moon. The corrected ε^{54}Cr lunar value is indistinguishable from the terrestrial and EC materials. Thus, it reinforces the idea of a common and uniform reservoir origin in the proto-planetary disk for these objects[3], as well as it suggests either the involvment of an Earth/EC-like giant impactor, or a Moon mostly made of terrestrial material.

[1]Qin et al., (2010) GCA 74, 1122-1144; [2]Leya et al., (2003) GCA 67, 529-541; [3]Dauphas et al., (2014) EPSL 407, 96-108