On the iron isotope heterogeneity of lunar highlands

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Despite over a decade of focused investigations, the Fe isotope composition of the Moon remains controversial. Whereas its δ^{57}Fe was initially considered twice as high as that reported for the Earth, irresolvable δ^{57}Fe between the Earth and the Moon was also suggested. It has even been advocated that the Earth and the Moon are isotopically lighter than previously thought, with δ^{57}Fe composition indistinguishable from chondrites. This diversity of estimates has severe impacts on the constraints on lunar accretion modes and/or differentiation processes.

We report a compilation of 73 bulk-lunar rock δ^{57}Fe values, including 33 unpublished data. These new data reinforce a significant dichotomy between high-Ti and low-Ti mare basalts, yielding δ^{57}Fe = 0.274 ± 0.020‰ and 0.127±0.012‰, respectively. Assuming lunar basalts mirror the Fe isotope composition of their respective mantle sources, this indicates a lunar upper mantle composition of δ^{57}Fe=0.14±0.03‰. A large scatter of the new and published data at δ^{57}Fe=0.09±0.12‰ found for Ferroan Anorthosites (FANs), Mg-suite rocks and a KREEP basalt imparts more complexities for the global Fe isotope view of the Moon. This large scatter is stressed by the observation that different aliquot allocations of some highland rocks yield significantly different δ^{57}Fe values despite the general consistency of Fe isotope determinations performed on terrestrial silicate rock reference materials from different laboratories.

This is likely the result of the coarse-grained nature of most highland rocks that may contain mineral phases with potentially different Fe isotope systematics. Given the limited sample aliquots size available, it is only through in situ determination of δ^{57}Fe in diverse mineral phases of highland samples that it will be possible to provide more robust estimates of the bulk rock Fe isotope composition of these coarser-grained lithologies. From there, a more reliable assessment of the Fe isotope composition of the lunar crust will likely be provided.