Iron isotope compositions of lunar highland rocks and mare basalts

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The Fe isotope composition of the bulk Moon remains largely unknown. An early study on lunar basalts found that they are isotopically heavier than terrestrial basalts, invoking evaporative loss of Fe as a mechanism for concentrating heavy Fe isotopes on the Moon [1]. Subsequent studies noted a dichotomy in the Fe isotope compositions of low- and high-Ti basalts with low-Ti basalts being similar to terrestrial basalts whereas high-Ti basalts are systematically heavier by ~0.1‰ in δ^{56}Fe [2]. Rocks from the Mg-suite have been used to estimate δ^{56}Fe of the bulk Moon [3]. They concluded that the bulk Moon has the same δ^{56}Fe as bulk silicate Earth. One concern with this approach is that the petrogenesis of Mg-suite rocks is complicated. It involves interactions between early-formed Mg-rich LMO cumulates, plagioclase, and KREEP, which formed after ilmenite crystallization [4]. This complexity makes Mg-suite rocks potentially unsuitable for estimating δ^{56}Fe of the bulk Moon [5].

To elucidate the processes that control Fe isotope fractionations between lunar reservoirs, we obtained major and trace element compositions alongside MC-ICPMS iron isotope data for low- and high-Ti basalts, Mg-suite highland rocks, and ferroan anorthosites (FANs). These new results reinforce the dichotomy that exists between low- and high-Ti basalts, and confirm that ilmenite crystallization controls δ^{56}Fe of mare basalts [6]. As FANs formed before ilmenite crystallization in the LMO [7], their δ^{56}Fe is unfractionated by this process. A chemically pristine ferroan anorthosite displays an δ^{56}Fe of 0.044 ± 0.027‰, which is identical to the two Mg-suite rocks we measured. This suggests that the Fe isotope composition of the Mg-suite is controlled by components that formed before ilmenite crystallized in the LMO and that KREEP is not a signifance source of Fe for these rocks. Thus, bulk Moon δ^{56}Fe is most likely ~0.044‰, which is identical to the bulk silicate Earth.

[1] Poitrasson et al., 2004. EPSL 223, 253-266. [2] Weyer et al., 2005, EPSL 240, 251-264. [3] Sossi and Moynier, 2017. EPSL 471, 125-135. [4] Shearer et al., 2015. Am Min 100, 294-325. [5] Elardo et al., 2019. EPSL 513, 124-134. [6] Craddock et al., 2010. LPSC Abstract #1230. [7] Snyder et al., 1992. GCA 56, 3809-3823.