Iron isotopes on Mars linked to the formation of the terrestrial planets

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Iron isotopes (δ^{57}Fe) fractionate by Fe exchange in different valence states and bear witness to the redox history of early solar system bodies. Although δ^{57}Fe differences between terrestrial and Martian (SNC) basalts have been proposed [1], recent analytical advances and a refined δ^{57}Fe value for Earth's mantle [2] call for a re-assessment of this difference. We report Fe isotope analyses of 17 Martian whole rocks and 5 mineral separates obtained in Canberra and Toulouse.

All Martian meteorites correlate with indices of magmatic differentiation. Nakhlites and evolved shergottites have δ^{57}Fe≈0.05±0.03‰, while the MgO-rich rocks are lighter (δ^{57}Fe≈-0.01±0.02‰). Lighter δ^{57}Fe of pyroxenes than whole-rock nakhlites causes a co-variation of δ^{57}Fe with fO_2, where both increase in the melt as in terrestrial magmas.

If SNCs are representative of Martian magmatism, they are distinctly lighter than MORB. Extrapolation of the δ^{57}Fe SNC trend to a putative Martian mantle yields a value lighter than its terrestrial counterpart, but close to chondrites. If the Earth and Mars accreted from similar material, this disparity arose post-accretion (given the constancy of δ^{57}Fe in chondrites). As MORBs are more oxidised (≈FMQ) than Martian shergottites (FMQ-2.5), a process that increased the fO_2 and δ^{57}Fe of the BSE is required.

Possible mechanisms include evaporation of light isotopes during a Moon-forming giant impact [1], addition of an oxidised ^{57}Fe-enriched impactor, or disproportionation and extraction of Fe^0 in equilibrium with perovskite with large $\Delta^{57}Fe_{mantle\text{-}core}$ [3,4] but not on the smaller body, Mars [5].

[1] Poitrasson et al., 2004, EPSL, 223, 253-266 [2] Craddock and Dauphas, 2013, EPSL, 365, 63-76 [3] Polyakov, 2009, Science, 323, 912-914 [4] Williams et al., 2012, EPSL 321-322, 54-63 [5] Poitrasson et al., 2009, EPSL, 278, 376-385