Iron isotopes track planetary accretion or differentiation?

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The heavier Fe isotopic composition of the Moon relative to that of the Earth by 0.1‰ δ^{57}Fe, itself heavier by 0.1‰ than other rocky solar system components has been interpreted as tracking planetary accretion processes [1]. More recently however, it has been suggested that planetary differentiation could be an other explanation for these variable isotopic signatures [2]. We thus need to assess to what extent Fe isotope variations can be produced by mantle-core differentiation or crust extraction.

Studies of pallasites, chondrites and iron meteorites [3], combined with new HT-HP metal-silicate partitioning experiments suggest that mantle-core differentiation should not generate significant Fe isotope fractionation if this process occurred at equilibrium.

On the other hand, to evaluate whether crust extraction can produce Fe isotope fractionation [2], it is first necessary to estimate the bulk Fe isotope signature of the terrestrial mantle. This task is complicated by the isotopic heterogeneity recently found in bulk mantle rocks [4], also observed with new intraplate peridotite xenolith analyses (Kerguelen), which now extend the δ^{57}Fe range to 1.2‰ for the mantle. Only the determination of the possible causes of these isotopic variations (e.g., melt extraction, metasomatism or redox variations [4,5]) will lead to a correct estimate of a bulk mantle δ^{57}Fe value.

However, given our current understanding of the high temperature geochemistry of iron isotopes, the simplest and most straightforward interpretation of the heavy Fe isotope composition observed for the Earth and the Moon is that it tracks contrasted accretion mechanisms.

References

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