Non-chondritic magnesium and the origins of the inner terrestrial planets

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Our solar system is chemically heterogeneous with the volatile-poor, rocky terrestrial planets dominating its innermost portions. The silicate reservoirs as sampled from the Earth, Mars, the Moon and the HED parent body (thought to be Asteroid 4 Vesta), as well as the various chondritic meteorite groups, exhibit large apparent differences in volatile element budgets, but also in other respects such as Mg/Si and refractory element contents e.g. [1]. The origin of this chemical heterogeneity and the causes of differences between differentiated objects and chondrites have been controversial. Here we present Mg isotope data to address this issue.

New high-precision magnesium (Mg) isotope data obtained using a large geometry high resolution MC-ICPMS are reported for 9 carbonaceous and ordinary chondrites, 9 eucrites and diogenites generally considered to originate from Asteroid 4 Vesta, together with 4 martian meteorites, and a variety of terrestrial and lunar materials. The variation in Mg isotopic composition found for ultramafic rocks and minerals (δ^{25}Mg≈-0.03‰) is smaller than reported previously and are fractionated to slightly heavy values relative to those of chondrites (δ^{25}Mg≈-0.15‰). Data for the Earth, Mars and Vesta display no systematic Mg isotopic differences despite large variations in the level of depletion in moderately volatile elements.

The compositions of these major silicate reservoirs of differentiated objects are broadly similar and display no relationship with indices of volatile element depletion or differences in proposed accretion mechanisms. More strikingly, all differentiated planets and planetesimals, as sampled, have Mg that is on average isotopically heavy compared with most chondrites analyzed thus far. Chondrules also are heavy in terms of Mg, so this might reflect sorting of material in the proto-planetary disk. Such an explanation would be similar to one previously proposed [2] to explain the non-chondritic Si/Mg of the Earth. Chondrules also yield heavy Mg isotopic compositions, so the compositions of the differentiated planets may reflect sorting of material in the proto-planetary disk. The isotopically heavy Mg isotopic compositions of the Earth and its possible "chondrulitic" origin have important implications for Earth's bulk composition and putative hidden reservoirs.

References

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