Silicon isotopes in achondrites and clues to planetary differentiation

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Core formation is a major event during planetary differentiation, but the conditions during core formation on planetesimals are not well understood. However, the partitioning of elements between metal and silicate during core-mantle differentiation may induce condition-dependent isotopic fractionations. Silicon is one element that shows such isotopic fractionation, exhibing light isotope enrichment in the metal phase under distinctive conditions of pressure, oxygen fugacity and temperature. Recent studies have observed heavy Si isotope enrichments in basalts from both Earth [1, 2] and the asteroid 4-Vesta [3], which were interpreted as evidence for the incorporation of isotopically light Si into the cores of these bodies.

Here we present new high-precision Si isotope data for a suite of achondrites, including angrites, ureilites, and lodranites. The ureilites and lodranites have chondritic Si isotope compositions, indicating that processes during the accretion and differentiation of their respective parent bodies did not fractionate Si isotopes. In contrast, angrites exhibit among the largest Si isotope fractionations observed to date in basaltic materials (on average $\delta^{30}Si = -0.33 \pm 0.06$ ‰), with Si isotope compositions similar to terrestrial basalts.

Angrites are among the oldest and most volatile-depleted differentiated rocks in the solar system. There are two major parent body processes that could have resulted in the observed Si isotope composition of angrites: (1) loss of isotopically light Si during the devolatilization event or (2) partitioning of isotopically light Si into the metal phase during core formation. If metal-silicate differentiation is the cause of the light Si isotope enrichment in angrites, this implies that the angrite parent body experienced core formation under highly reducing conditions with a subsequent oxidation of its shallow mantle.

[1] Fitoussi et al. (2009), *EPSL*
[2] Georg et al. (2007), *Nature*
[3] Pringle et al. (2013), *EPSL*