

Neodymium stable isotope variations in the Solar System: The effect of sulfide during differentiation?

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Radiogenic neodymium (Nd) isotopes have been widely used in studies of planetary accretion to constrain the timescales of early planetary differentiation [1]. Whereas stable isotope variations allow constraints to be placed on the processes occurring during planet formation. Experimental work suggests that the Earth's core contains a significant proportion of sulfide [2], and under reducing conditions sulfide can incorporate substantial quantities of refractory lithophile elements [including Nd; 3]. If planetary embryos also contain sulfide-rich cores, Nd stable isotopes have the potential to trace sulfide segregation in highly reduced environments, because there is a significant contrast in bonding environment between sulfide and silicate, where heavy isotopes should be preferentially incorporated into high force-constant bonds involving REE³⁺ (i.e. the silicate mantle).

Here we present ¹⁴⁶Nd/¹⁴⁴Nd ($\delta^{146}\text{Nd}$) values, obtained using a double spike TIMS technique, for a range of planetary bodies formed at variable oxidation states including samples from the Moon, Mars, the asteroid 4Vesta and the Angrite and Aubrite parent bodies. Analyses of chondritic meteorites and terrestrial igneous rocks indicate that the Earth has indistinguishable $\delta^{146}\text{Nd}$ from chondrites [4,5]. Eucrites, Lunar and Martian meteorites also have compositions within uncertainty of the chondritic average, although some variability is observed in meteorites with low Nd concentrations consistent with magmatic processes. In meteorites formed under more reduced conditions heavier $\delta^{146}\text{Nd}$ is observed. Analyses of sulfide leachates and sulfide-silicate melting experiments confirm the prediction that light Nd isotopes preferentially partition into the sulfide phase. Together these observations provide evidence for the removal of light Nd to a sulfide phase in the interior of highly reduced planetesimals.

References

[1] Boyet & Carlson (2005) *Science* 309, 576-581; [2] Labidi et al. (2013) *Nature* 501, 208-211; [3] Wohlers & Wood (2015) *Nature* 520, 337-340; [4] McCoy-West et al. (2017) *EPSL* 480, 121-132; [5] McCoy-West et al. (2021) *GCA* 293, 575-597.