The source of water for 4-Vesta is likely carbonacous chondrites

A. R. SARAFIAN[1]*, S. G. NIELSEN[1], H. R. MARSCHALL[1], F.M. MCCUBBIN[2] AND B. MONTELONE[1]

[1]Woods Hole Oceanographic Institution, Woods Hole, MA 02543
(asarafian@whoi.edu)
[2]Institute of Meteoritics, University of New Mexico, Albuquerque, NM 87131

Water is one of the most important molecules in the Solar System. It is vitally important for life, geologic processes, and human exploration of the Solar System. Determining the timing, provenance and timing of water delivery to the relatively dry inner Solar System is crucial to understand the volatile evolution of the terrestiral planets. Hydrogen isotopes (D/H) can be used as a source signature for water, because the D/H of planetary materials have a large variation.

We used the mineral apatite in the basaltic meteorite group eucrites to determine the source of water for the eucrite parent body, presumed to be the asteroid 4-Vesta. The large radius ion microprobe at the Woods Hole Oceanographic Instution was used to measure D/H and water concentrations of apatite simultaneously. After minor corrections for hydrogen released from the sample surface, apatites displayed a wide range of water contents with little variation in hydrogen isotopic composition. The hydrogen isotopic ratio of nine measured apatites yielded a $\delta D = -126 \pm 40$ ‰. We adopt this value for bulk Vesta because there is little variation between apatites in different meteorites, fractional crystallization will not effect the D/H, and isotopic fractionation between apatite and melt should be less than analytical precision. Our bulk Vesta estimate is within error of the the accepted bulk Earth value and close to the estimated Moon value for D/H (*1, 2*).

Combining D/H data with previously published nitrogen isotope data for Earth, Moon, and Vesta, it is evident that carbonacous chondrites are the most likely source of volatiles for these three bodies. The crystallization age of eucrites is ~4565 Ma (*3*), and the Earth, Moon and Vesta have the same inferred source of water. We, therefore, conclude that volatiles were present in the inner Solar System at a very early stage, and that water was not delivered from a foreign source later during the accretion process.

(1) A. E. Saal, *et al Science* **340**, 1317 (2013). (2) F. Robert, Earth. *Science* **293**, 1056 (2001). (3) A. Trinquier, *et al Geochim. Cosmochim.* **72**, 5146 (2008).