Volatile content of 4-Vesta: evidence from unequilibrated eucrites

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Eucrites are a class of basaltic meteorites that, along with the howardites and diogenites, likely derive from the asteroid 4-Vesta. This asteroid is depleted in moderately volatile elements relative to the Earth and carbonaceous chondrites. Extrapolation of this depletion trend predicts that bulk silicate 4-Vesta (BSV) contains at most 250–1000 μg/g H_2O (Sarafian et al., 2017), which is approximately a factor of two lower than the H_2O content of Earth (Marty, 2012).

To obtain more accurate H_2O and F estimates for BSV, we examined four unequilibrated antarctic meteorites, Yamato(Y)-793548, Y-82210, Y-75011, and Y-74450, by EPMA and SIMS. Pyroxenes contain MgO-rich cores and FeO-rich rims, consistent with primary magmatic zoning. Volatile concentrations generally follow patterns expected for growth zoning with lower values in the cores and higher in the rims. These features indicate that thermal metamorphism and other post-crystallization processes did not significantly perturb the volatile contents of these unequilibrated eucrite pyroxenes. We used these data to derive best estimates for the BSV H_2O and F content based on experimentally determined pyroxene-melt partition coefficients and models for magma generation on Vesta.

In addition, we measured D/H in the early crystallizing pyroxenes and late crystallzing apatites. We find that the D/H of pyroxene and apatite are within error of one another as well as previous measurements of apatite in equilibrated eucrites (Sarafian et al, 2017). These results imply that degassing was minimal or did not fractionate D/H. Degassing may have been limited if eucrites were shallowly emplaced sills or dykes, or the total H_2O content of the magmas was too low for vapor saturation. An alternative mechanism for limited D/H fractionation is that degassing did occur, but the H_2/H_2O of the exsolved vapor was approximately 15:85, as predicted from experiments (Hirschman et al 2012).

References: Hirschman et al (2012) *EPSL* 345, 38-48. Marty (2012) *EPSL* **313**, 56–66. Sarafian et al (2017) *EPSL* **459**, 311–319