

Chlorine depletion in the lunar mantle is problematic for a “wet” Moon

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Analyses of ultramafic volcanic glasses, olivine-hosted melt inclusions within volcanic glasses, and apatites within mare basalts all indicate that the mare source region is highly depleted in Cl compared to F and H₂O [1-3]. In contrast, apatites from crustal rocks are enriched in Cl relative to F or H₂O [3]. Furthermore, estimates of the volatile content of urKREEP (i.e., the last 1-2% of the global lunar magma ocean (LMO)) indicate that the abundance of Cl > F and Cl > H₂O [4].

Given the incompatible nature of F, Cl, and H₂O in nominally anhydrous silicates, the above observations imply that the volatile content of the mare source region is not representative of trapped interstitial residual liquid from the LMO because such a process would not efficiently fractionate F and H₂O from Cl. However, if the volatile content of the mare source region is controlled by the F, Cl, and H₂O partitioning relationships between nominally anhydrous minerals (NAM) and melt, the mare source would be enriched in F and H₂O relative to Cl because Cl is much more incompatible in NAM's than F and H₂O [5-8].

A mare source region controlled by NAMs poses a problem for estimates of a wet lunar mantle (>10 ppm H₂O) because it requires superchondritic abundances of F and Cl in the LMO liquid, which is inconsistent with overwhelming geochemical evidence for a volatile-depleted Moon. In fact, if the mare source region is controlled by NAMs, the bulk H₂O content of the lunar mantle is likely < 1 ppm.

Alternatively, experiments on the partitioning of F, Cl, and H₂O between nominally anhydrous minerals and melt have not been conducted under lunar *P-T-X-f_{O2}* conditions, and if the mineral melt partition coefficients are sufficiently high, a NAM controlled volatile budget for the lunar mantle could be reconciled with some of the terrestrial-like estimates for the H₂O content of the lunar interior.

[1] Saal et al., (2008) *Nature*, **454**, 192-195 [2] Hauri et al., (2011) *Science*, **333**, 213-215. [3] McCubbin et al., (2011) *Geochimica et Cosmochimica Acta*, **75**, 5073-5093 [4] McCubbin et al., (2015) *American Mineralogist*, 100, In Press [5] Beyer et al., (2012) *Earth and Planetary Science Letters*, **337**, 1-9 [6] Hauri et al., (2006) *Earth and Planetary Science Letters*, **248**, 715-734 [7] O'Leary et al., (2010) *Earth and Planetary Science Letters*, **297**, 111-120 [8] Tenner et al., (2009) *Chemical Geology*, **262**, 42-56.