



H₂O Paradox and its Implications on H₂O in Moon

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The concentration of H₂O in the mantle of a planetary body plays a significant role in the viscosity and partial melting and hence the convection and evolution of the planetary body. Even though the composition of the primitive terrestrial mantle (PTM) is thought to be well known [1-2], the concentration of H₂O in PTM remains paradoxical because different methods of estimation give different results [3]: Using H₂O/Ce ratio in MORB and OIB and Ce concentration in PTM, the H₂O concentration in PTM would be (300×1.5) ppm; using mass balance by adding surface water to the mantle [3-4], H₂O concentration in PTM would be (900×1.3) ppm [2-3]. The inconsistency based on these two seemingly reliable methods is referred to as the H₂O paradox [3]. For Moon, H₂O contents in the primitive lunar mantle (PLM) estimated from H₂O in plagioclase in lunar anorthosite and that from H₂O/Ce ratio in melt inclusions are roughly consistent at ~ 110 ppm [5-6] even though there is still debate about the volatile depletion trend [7].

One possible solution to the H₂O paradox in PTM is to assume that early Earth experienced whole mantle degassing, which lowered the H₂O/Ce ratio in the whole mantle but without depleting Ce in the mantle. The second possible solution is that some deep Earth reservoirs with high H₂O/Ce ratios have not been sampled by MORB and OIB. Candidates include the transition zone [8] and the D" layer. The third possible solution is that ocean water only partially originated from mantle degassing, but partially from extraterrestrial sources such as comets [9-10]. At present, there is not enough information to determine which scenario is the answer to the H₂O paradox. On the other hand, each scenario would have its own implications to H₂O in PLM.

If the first scenario applies to Moon, because degassed H₂O or H₂ would have escaped from the lunar surface, the very early lunar mantle could have much higher H₂O [11] than that obtained using the H₂O/Ce ratio method. The second scenario is unlikely on Moon because there was unlikely plate tectonics, and because there is no similar H₂O-rich transition zone or D" layer due to the much lower maximum pressure in Moon. In the third scenario, volatiles from an extralunar source would likely be lost from the high vacuum environment of the lunar surface, meaning that it would not impact on the H₂O content estimation.

[1] McDonough & Sun (1995) *Chem. Geol.* **120**, 223. [2] Palme & O'Neill (2014) *Treatise on Geochemistry* **3**, 1. [3] Zhang (2014) *Treatise on Geochemistry* **6**, 37. [4] Zhang & Zindler (1989) *JGR* **94**, 13719. [5] Hui et al. (2013) *Nature Geosci.* **6**, 177. [6] Chen et al. (2015) *EPSL* **427**, 37. [7] Albarede et al. (2015) *MPS* **50**, 568. [8] Sobolev et al. (2016) *Nature* **531**, 628. [9] Chyba (1987) *Nature* **330**, 632. [10] Hartogh et al. (2011) *Nature* **478**, 218. [11] Hui et al. (2016) *Goldschmidt Conf. Abstr.*