Reassessment of pre-eruptive water content of lunar volcanic glass based on new data of water diffusivity

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For long the Moon was unanimously thought to be dry with H_2O content below ng/g level which is consistent with the giant impact hypothesis accounting for the formation of the Earth-Moon system. Lunar volcanic glasses associated with mare basalt magmatism experienced significant degree of degassing, and to retrieve their initial water contents requires data of water diffusivity. We have carried out diffusion experiments at 0.5 GPa and 1703–1903 K in piston cylinder apparatus for two synthesized lunar basaltic melts with compositions corresponding to Apollo green glass and yellow glass. The water diffusivities extracted from diffusion profiles, measured by FTIR spectroscopy, through error-function fitting are 0.5–1 order of magnitude greater than those of terrestrial basaltic melts. Hydroxyl, instead of molecular H_2O or H_2, is not only the dominant H species but also the major carrier of H with respect to diffusion. Modeling of previously reported profiles of volatile loss in Apollo green glass bead [1] using the new water diffusivity data indicates average cooling rate of 1–2 °C/s and initial water content of 120–260 μg/g. With the assumption of limited degassing before magma fragmentation and the consideration of the bulk partition coefficient of water between the residual solid and the melt (~0.006), the lunar mantle source is inferred to contain 7–15 μg/g H_2O with 5% partial melting. Due to the imcompatible behavior of water in magmatic processes, it is with high confident that the initial water content of lunar magma ocean was higher than that of the source of lunar volcanic glass. The previous argument [2] that the bulk silicate Moon is only moderately less hydrous than the bulk silicate Earth therefore appears to be correct.

[1] Saal *et al*. (2008) *Nature* **454**, 192-195. [2] Hauri *et al*. (2015) *EPSL* **409**, 252-264.