

THE FORMATION OF WATER IN SILICATES. C. J. Bennett^{1,2}, C. Ennis², and R. I. Kaiser^{1,2}, ¹NASA Astrobiology Institute, Institute of Astronomy, 2680 Woodlawn Drive, University of Hawai'i at Manoa, Honolulu, HI 96822, USA, cjbennet@hawaii.edu; ralfk@hawaii.edu ²Department of Chemistry, University of Hawai'i at Manoa, 2545 McCarthy Mall, Honolulu, HI 96822, USA. Ennisc@hawaii.edu

Introduction: Since the Apollo missions returned lunar samples from the moon, there has been fierce debate as to whether or not water is, or was present on the moon. The recent results of the NASA LCROSS mission as well as those of the NASA M³ (moon mineralogy mapper) instrument onboard the Indian Chandrayaan-1 Spacecraft have established that low-levels of water are indeed present [1,2].

However, the precise chemical nature of lunar water has yet to be established. Similarly, the question of where this water may have originated from has not been determined. There are two leading theories as to the origin; i) water may be brought to the lunar surface by an exogenous source, such as comets [3], or ii) Energetic protons are carried into the silicate material which constitutes the moon by the solar wind and are here able to – *through a series of events* – react with oxygen atoms to form water or hydroxyl (-OH) groups [4]. The problem with the first hypothesis however, is that the solar wind causes water to sublime rapidly from the surface. To be stable for long periods of time, it must migrate towards permanently shaded regions – while this is certainly viable [5], we are here investigating the second hypothesis.

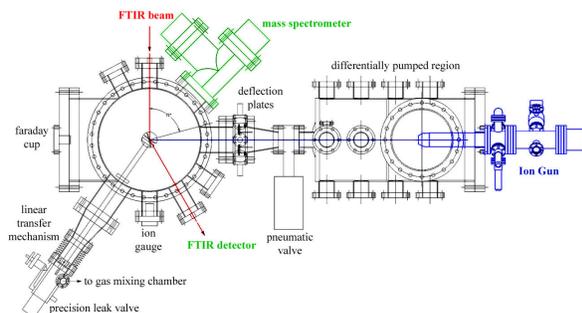


Fig. 1: Top view of the experimental apparatus.

Experimental Method: The experiments were carried out in an the ultra-high vacuum surface scattering experimental set-up held at the University of Hawai'i, which is depicted in Fig.1 and described in detail elsewhere [6]. The solar wind is simulated by an ion source which is used to generate 1 keV H⁺ ions and irradiated over the target area of just under 1 cm². We used 3 different types of target to simulate the lunar surface; i) thin slabs of pure minerals less than 1 mm thick, ii) finely powdered nanoparticles of pure minerals and heavy-metal oxides are pressed onto our target, and iii)

laser ablation is used to directly deposit silicate layers around 10 microns thick. The production of water can be measured during the irradiation of the sample *in-situ* using absorption-reflection-absorption (ARA) FTIR spectroscopy, while desorption of water from the sample can be detected upon heating the sample can be detected by residual gas analysis *via* a Quadrupole mass spectrometer. Additional infrared spectra were taken using diffuse-reflectance of the samples before and after irradiation. An example of the infrared spectra taken of olivine powdered nanoparticles on our target prior to irradiation is shown in Fig. 2.

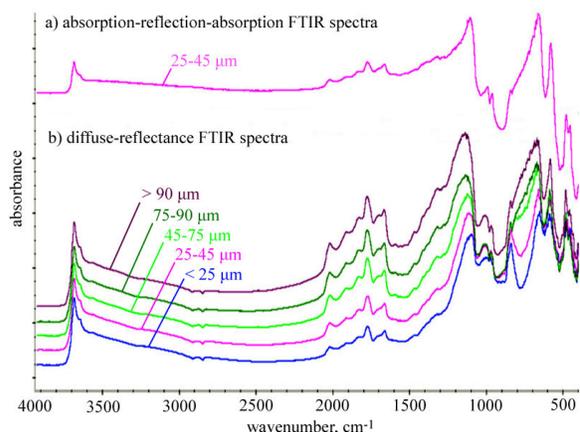


Fig. 2: FTIR spectra of olivine nanoparticles taken using a) absorption-reflection-absorption, and b) diffuse-reflection.

Results & Discussion: The preliminary findings from these experiments will be presented, and a discussion as to the likely formation processes within our samples will be presented. The implications of our results for the case of lunar water will be discussed.

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References: [1] NASA (2009, November 13). LCROSS impact analysis indicates water on Moon [2] Pieters, C. M. et al. (2009), *Science* 24 September (10.1126/science.1178658). [3] Ong, L. et al. (2006) *LPS XXXVI*, Abstract #2450 [4] Zeller, E. J. et al. (1970) *Modern Geology* 1, 141-148 [5] Schorghofer, N and Taylor, G. J. (2007), *JGR* 112, E02010. [6] Bennett, C. J. et al. (2004) *PCCP* 6, 735-746.