

CONSIDERATIONS FOR EXTRACTING ADSORBED WATER AND HYDROXYL FROM THE LUNAR REGOLITH. C. A. Hibbitts¹, T.M. Orlando², G. Grieves², M. Poston², M.D. Dyar³, and A. Johnson², ¹Johns Hopkins University Applied Laboratory, 11100 Johns Hopkins Rd., Laurel, Md., 20723, karl.hibbitts@jhuapl.edu, ²A School of Chemistry and Biochemistry, Georgia Institute of Technology, 901 Atlantic Drive, G209C, Atlanta, Ga 30332, ³Department of Astronomy, Mt. Holyoke College, S. Hadley, MA 01075.

Introduction: The H₂O and hydroxyl discovered on the illuminated portion of the Moon by three independent spacecraft [1,2,3], and the excavated water ice from within a permanently shadowed crater (LCROSS homepage), may represent reservoirs of accessible H₂O and OH. Understanding the distribution, stability, and abundances of water and hydroxyl represented by these potential reservoirs requires understanding the processes that control the adsorption, migration, and desorption of both water and OH on lunar grains.

The water and hydroxyl-related infrared absorption bands on the illuminated Moon likely represent ~ a monolayer, dominated by OH at mid to lower latitudes and by water for some (cooler) polar regions [1,2,3]. The abundance, while only ~ monolayer, represents ~1000 ppm because of the fine granularity and roughness of the soil [4]. Distributed throughout a regolith, concentrations are significantly greater than currently-mined disseminated metal deposits on Earth [e.g. 5], and could be extracted with less energy.

Results & Discussion: The surface of the Moon contains a wide range of materials of various compositions and surface properties and will differ in adsorbing water and OH.

Lunar Agglutinates. The lunar soils have a significant component (~ 40%) of agglutinate glass, formed from the finest size fraction of the soil. In our experiments, lunar agglutinates are simulated with a very low water content lunar basaltic glass analog. Dosed with water at 110K, water desorbs very quickly at ~ 170K, consistent with sublimation of ice. There is no evidence for adsorption of water or OH, though high surface roughness may increase adsorption for all lunar materials [6].

Nanophase Iron. Associated with agglutinates, *npFe⁰* is ubiquitous in mare soils but is also found on highland grains. Native metal is not expected to strongly adsorb water or OH because of the lack of a strong electronic attraction.

Silicates. Olivine, pyroxene, and plagioclase are major components of the lunar soil. Crystal structure and the presence of any unsatisfied bonds, such as created through rock fracturing, micrometeoroid bombardment, and even solar wind bombardment, would affect the adsorptivity. Desorption experiments show that the lunar mare simulant (JSC1A) desorbs water over a continuum of temperatures relevant to the illuminated Moon, from 200K to 400K [7].

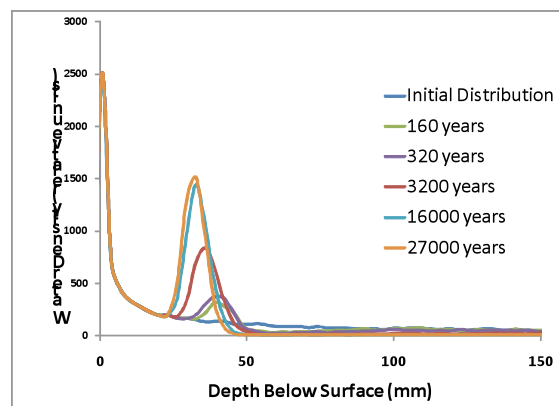


Figure 1. Model result of H₂O desorbing from grains to escape to space (not shown) but also to migrate into the regolith until cold trapped at about 30cm beneath the surface

Migration of H₂O and OH. Water will become mobile and migrate at temperatures below which it desorbs [6]. Additionally, OH may become mobile to combine with nearby OH or hydronium to then desorb as H₂O. This mobility can result in the diffusion of water (including recombinant OH) into and out of the regolith (Figure 1).

Implications: The thermal mobility of water and hydroxyl will possess a compositional as well as thermal dependency. Hydroxyl created through solar wind implantation may potentially mobilize at lunar temperatures to desorb as water with a portion accumulating both within the regolith as well as in local cold-traps or PSRs. These would likely be disseminated deposits. Observed diurnal variations in the depth of the 3- μ m band [2] may represent desorption and migration of this water. Compositional dependencies, including maturity effects, may further affect the abundance of adsorbed water and OH. This water and OH is weakly bound compared to mineralic OH or O, and may represent an accessible volatile resource.

References: [1] Pieters, C. et al., (2009), *Science*, 326, 568-572. [2] Sunshine et al., (2009), *Science*, 326, 565-568. [3] Clark, R.N. (2009), 0.1126/ science.1178105. [4] Dyar, M.D. et al. (2010), *Icarus*, 208, 425-437. [5] Gonen, N. (2003), *Hydrometallurgy*, 69, 169-176. [6] Grieves et al. (2010), *LPSC XLI*, #1533. [7] Hibbitts et al., (2010), *LPSC, XLI*, #2552.