Experimental Determination of Water Binding Energies on Lunar Regolith. B. M. Jones[1], A. Aleksandrov[1], M. Darby Dyar[2], Charles K. Hibbitts[3], T. M. Orlando[1,4], [1]School of Chemistry and Biochemistry, Georgia Institute of Technology, Atlanta, GA 30332, [2]Planetary Science Institute, Tucson, AZ, [3]John Hopkins Applied Physics Laboratory, Laurel, MD, [4]School of Physics, Georgia Institute of Technology, Atlanta, GA 30332, (thomas.orlando@chemistry.gatech.edu).

Introduction: Solar wind implantation is generally accepted as the source for formation of chemically bound hydroxyls in lunar regolith grains [1] while impacts are responsible for delivery of water and other volatiles [2, 3]. Understanding how water interacts with lunar regolith allows for simulation of water migration and transport. Despite the importance of understanding the chemisorbed states of water on lunar regolith, only one study thus far has measured the binding energies of actual lunar material [4]. Here, we present direct measurement and analysis of binding energies and site distribution profiles of chemisorbed water on two additional lunar materials: highland reference sample 14163 and mare reference sample 10084.

Experimental Details: Desorption activation energies of highland Apollo sample 14163 and mare Apollo sample 10084 were determined utilizing temperature program desorption studies. Signal from the grain/vacuum interface yielded the desorption activation energies and site probability distributions. Sample 14163 is considered sub-mature with an I_s/FeO = 57 while sample 10084 is considered mature with I_s/FeO = 78. Briefly, sample 10084 has an average grain size of 51 microns. The composition is dominated by glass and minerals, Ca-plagioclase, pyroxene, olivine and ilmenite. Sample 14163 has an average grain size 73 µm with a large percentage of agglutinate glass as well as feldspar, olivine, and pyroxene.

Results: TPD signals of each sample were decomposed into two main components, desorption at the grain/vacuum interface and desorption/transport of water though the porous medium taking into consideration re-adsorption. Highland sample 14163 exhibited a broad distribution of binding site energies peaking at 60 kJ mol^{-1} while mare sample 10084 exhibited a narrower distribution of binding site energies peaking at 65 kJ mol^{-1} with approximately 30% of the total binding sites in comparison to the highland sample. Simulated water desorption matches with spacecraft data assuming ~1% submonolayer coverage only if photon stimulated desorption (PSD) is ignored. If PSD is active,there must be an additional diurnal recurring source of water.

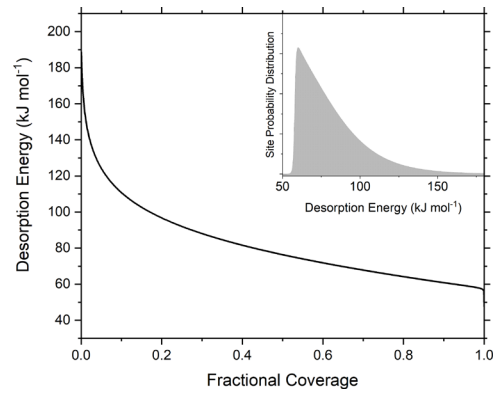

Figure 1: Binding Energies of highland sample 14163 with site probability distribution (inset)

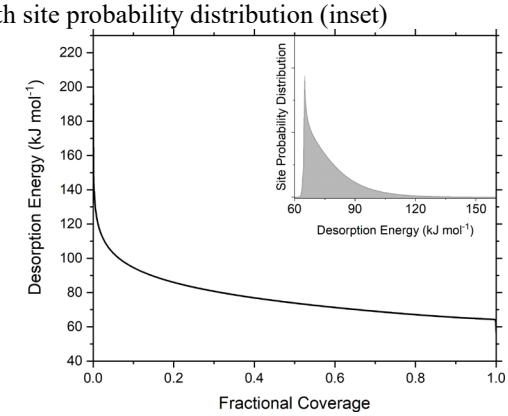

Figure 2: Binding Energies of Mare Sample 10084 with site probability distribution (inset).

Summary: The desorption activation energies for water molecules chemisorbed on Apollo lunar samples 14163 and 10084 were determined by TPD experiments conducted under ultra-high vacuum conditions. Water desorption from the lunar surface over a typical lunar day was simulated with the measured coverage dependent activation energies of the mare and highland samples.

References: [1] Stephant, A. and F. Robert, PNAS, 2014. 111(42), 15007-15012 [2] Barnes, J.J., et al., Nature Comm., 2016. 7(1), 11684 [3] Lawrence, D.J., JGR Planets 2017, 122(1), 21-52 [4] Poston, M.J., et al., Icarus, 2015, 255, 24-29

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