

Thermal Activated Water Formation on the Moon. B. M. Jones¹, A. Aleksandrov¹, M. D. Dyar², C. K. Hibbitts³, T. M. Orlando^{1,4}, ¹School of Chemistry and Biochemistry, Georgia Institute of Technology, Atlanta, GA 30332, ²Planetary Science Institute, Tucson, AZ, ³John Hopkins Applied Physics Laboratory, Laurel, MD ⁴School of Physics, Georgia Institute of Technology, Atlanta, GA 30332, (thomas.orlando@chemistry.gatech.edu).

Introduction: The existence of physisorbed water (H₂O) [1] or the water equivalent in the form of solar wind implanted hydroxyls (-OH) [2] in lunar surface soils and rocks has been postulated over decades. In general, the sources of lunar water widely accepted by the community include: primordial water, water delivered via comets and meteorites, released/formed during an impact event, and implantation from solar wind. However, we propose that an additional source term of water is prevalent during impact and occurs on a daily basis on the lunar surface. Here, a detectable amount of molecular water is formed thermally (either diurnally or from an impact event) from recombinative desorption of -OH defects that were made by implantation of solar wind protons.

Experimental Details: Second order (water formation) recombinative desorption activation energies of highland Apollo sample 15221 were determined utilizing temperature program desorption (TPD) studies. The sample analyzed was Apollo 15 lunar sample 15221 and is considered a highland reference. Sample 15521 is considered mature with an I_s/FeO = 63. Briefly, sample 15221 has an average grain size 54 μm with olivine and pyroxene as the dominate minerals with a large percentage (37%) of agglutinate glass. Signal from the grain/vacuum interface yielded the second order desorption activation energies and site probability distributions.

Results: Activation energies assuming second order recombinative desorption of water and hydrogen from solar wind implanted hydroxyl defects of Apollo lunar sample 15521 were determined by TPD experiments conducted under ultra-high vacuum conditions. Desorption at the grain/vacuum interface

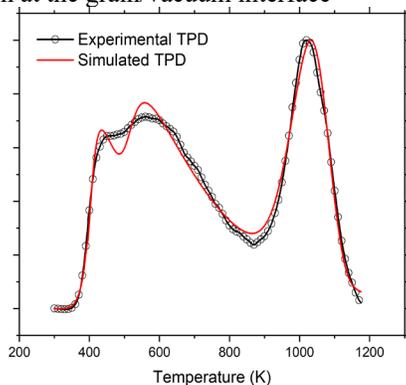


Figure 1. Experimental molecular water TPD signal (black circles) from a 5 mg of Apollo sample 15221 with the simulated TPD (red line).

with re-adsorption as water transports through the porous medium and activated sub-surface diffusion/penetration were found to reproduce the experimental TPD signal (Fig. 1). Signal from the grain/vacuum interface yielded the second order desorption activation energies and site probability distributions. Water production via recombinative desorption has coverage dependent activation energies. Water from highland sample 15521 exhibited a broad distribution of binding site energies peaking at 120 kJ mol⁻¹ extending at to 300 kJ mol⁻¹ at zero coverage limit with an onset of 100 kJ mol⁻¹ at full coverage corresponding to an onset temperature of 350 K (Fig. 2).

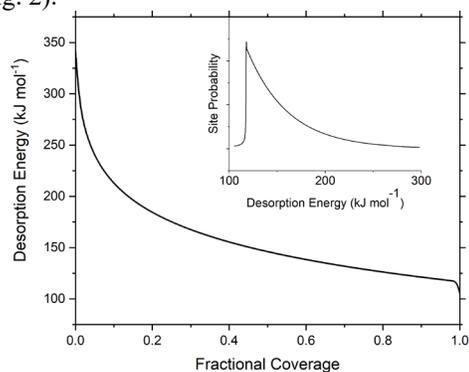


Figure 2: Recombinative desorption energies for Apollo Sample 15521. Inset displays site probability distribution.

Summary: Our results suggest that water originating from recombinative desorption contributes a minor amount during normal diurnal thermal excursions and may contribute to the water inventory in the polar regions. In addition, this process should produce water during meteorite and micrometeorite bombardment events and contribute to the observed mass in the LCROSS impact event.

References: [1] Housley, R. M., et al. (1973) *LPS, IV*, 2737-2749. [2] Zeller, E. J., et al. (1966). *JGR*, 20, 4855-4860. [3] Taylor, S. R. (2016). Lunar science: A post-Apollo view. [4] Pieters, C. M., et al. (2009), *Science* 326, 568-572. [5] Clark, R. N. (2009). *Science*, 326, 562-564. [6] Sunshine, J. M., et al. (2009). *Science*, 326, 565-568.

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