HYDROXYLATION OF LUNAR SOIL BY SOLAR WIND PROTONS. L-H. Yeo[1], J.L. McLain[1], and R.M. Killen[1]; [1]NASA Goddard Space Flight Center

Introduction: The discovery of widespread OH/H_2O on the lunar surface [1] has spurred questions about the production and distribution of hydrogen-bearing resources on the moon. Solar wind protons continuously strike the lunar surface, which consists of silicates and other oxygen-rich minerals. This presents an opportunity for hydroxylation - the creation of OH/H_2O on lunar soil [2]. It is important to understand how space weathering contributes to the production and proliferation of volatile resources such as hydrogen and water within the lunar environment [3], as this affects exploration, long-term habitation, and in-situ resource utilization activities.

OH/H_2O shows a distinct absorption feature in the infrared (IR) at ~3μm^{-1} that can be readily studied. Diffuse Reflectance Infrared Fourier Transform Spectroscopy (DRIFTS) is a fast and accurate way to detect changes in the IR spectra of lunar soil. Previous studies have examined the changes in IR spectra of amorphous silica and olivine [4], as well as lunar soil [5] before and after hydrogen irradiation. However, the evolution of the OH band and other IR features has not been studied during proton implantation itself. It is especially important to not expose the samples to terrestrial air, which will contaminate the samples with water.

Method: In a high-vacuum chamber, we perform DRIFTS on two Apollo-era soil samples (LS73131 and LS78421) while simultaneously irradiating them with a high energy (~keV) hydrogen plasma beam, similar to the solar wind. LS73131 is an unusually immature sample obtained from South Massif, while LS78421 is a mature sample from Wessex Cleft. Samples are first prepared by baking under high vacuum to drive off any surface water. Samples are also brought through thermal cycling and heated to 400 K (lunar dayside maximum temperature) in-situ, and changes in their DRIFTS spectra are reported.

Results: Broad and distinct growths in the 2.7-3.4 μm^{-1} absorption band during irradiation of lunar samples are observed compared to a sharper peak for SiO_2. These findings are in line with observations by the Moon Minerology Mapper. Since the samples are not exposed to terrestrial water during measurements, the hydroxylation observed is due to proton implantation. We note that variations in the overall band shape, possibly stemming from significant differences in maturity of these two samples, can result in varying degrees of inhomogeneous broadening of the OH band.

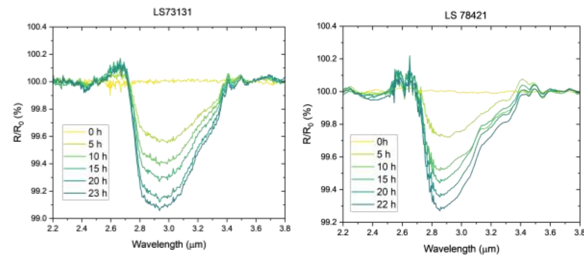

Fig. 1. DRIFTS spectra of Apollo samples LS73131 and LS78421 as they are being irradiated by a high energy hydrogen plasma beam. Broad features near 3 µm are observed. Total fluence is ~2×10^{20} ions/cm^2.

We will also report evidence of hydrogen diffusion into the lunar soil samples. When samples are heated to 400 K for 24 h, their OH band diminishes. This is likely due to the escape of some hydrogen atoms at elevated temperatures. Subsequent hydrogen irradiation produces OH bands that are measurably deeper than before. This is evidence that hydrogen atoms have migrated into deeper regions of the soil sample, freeing up sites closer to the surface for further hydrogen implantation, which occurs only in the top 10s of nm. In comparison, the IR beam is sensitive to the upper ~10 µm of the sample.

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