

**ULTRAVIOLET RADIATION INDUCED DESORPTION OF WATER FROM MARTIAN SOIL.** A. S. Yen,<sup>1</sup> B. C. Murray,<sup>1</sup> G. R. Rossman,<sup>1</sup> and F. J. Grunthner,<sup>2</sup> <sup>1</sup>Caltech, 150-21, Pasadena, CA 91125 (ayen@gps.caltech.edu), <sup>2</sup>Jet Propulsion Laboratory, 302-306, Pasadena, CA 91109.

The composition and pressure of the martian atmosphere allows solar ultraviolet photons as short as 190 nm to penetrate to the surface. The effects of UV photons on the hydration state of minerals has been investigated in the past with mixed results. *Andersen and Huguenin* [1977] proposed that photons with wavelengths shorter than 280 nm release water from goethite by ejecting OH<sup>-</sup> groups which subsequently combine with H<sup>+</sup> from nearby lattice sites. However, *Morris and Lauer* [1981] repeated the experiments and found no UV dehydration effects on goethite or lepidocrocite in exposures equivalent to 10 to 100 years on the martian surface.

We have developed a new series of experiments that offer 5 to 6 orders of magnitude greater sensitivity than previous studies of UV catalyzed dehydration of martian minerals. We use a quadrupole mass spectrometer in a ultrahigh vacuum (UHV) chamber to monitor the gaseous species as samples of Mars-analog soils are illuminated with a mercury vapor lamp (peak flux at 254 nm). This lamp is external to the chamber and periodically radiates the sample through an Al<sub>2</sub>O<sub>3</sub> window. The ambient pressures inside the chamber are approximately 10<sup>-10</sup> torr.

Recent results from the Mars Pathfinder camera [*Smith, et al.*, 1997] indicate that iron oxyhydroxides might be responsible for the 930 nanometer absorption in some soils. The magnetic properties experiment onboard Pathfinder further suggests that maghemite,  $\gamma$ -Fe<sub>2</sub>O<sub>3</sub>, could be present at 1 to 7 weight percent in the soil [*Hvidt, et al.*, 1997]. Understanding the origin of this maghemite could significantly advance our understanding of the weathering processes at the martian surface. One method of producing maghemite is through the dehydration of lepidocrocite ( $\gamma$ -FeOOH), and we explore the possibility that ultraviolet radiation is responsible for this transformation.

Raw data collected from a lepidocrocite sample as the UV lamp is cycled on and off with a 2 hour period is shown in figure 1. The downward trend in the partial pressure of water is due to the gradual decrease in the total pressure as the ion pump continues to trap the free molecules in the chamber. Once the instrumental noise in the data is reduced by averaging and the DC bias is removed, the remaining AC signal (see figure 2) can be analyzed for frequency content correlated to the cycles of the UV lamp. The application of a Fourier transform to the data clearly shows that the power in the signal corresponds to a two hour period (figure 3). The mercury vapor line source that we use in our experiments has a surface temperature less than the bakeout temperatures used prior to UV illumination. Thus, the effect that we observe is not due to sample heating. We therefore conclude that the

release of water from FeOOH samples is induced by ultraviolet radiation.

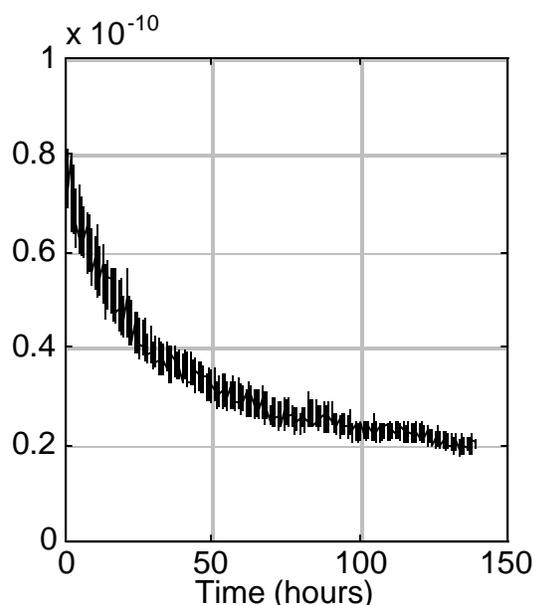
In order to determine the source of the water (which was deemed not to come from the chamber itself by running suitable blanks), we compare the results from FeOOH to the data obtained from the anhydrous counterpart: Maghemite. The process used in the preparation, baking, and data collection from the FeOOH was carefully repeated for the Fe<sub>2</sub>O<sub>3</sub> samples. A Fourier transform result for the anhydrous phase is plotted in comparison to the hydrated one in figure 3. These spectra indicate that there is no significant difference between the amount of water released from lepidocrocite as compared to maghemite.

As further evidence, we find that the visual colors of the lepidocrocite samples are not altered by exposure to ultraviolet radiation. We, therefore, conclude that the water released by the incident UV photons in these experiments with iron oxides does not originate from the OH bound in the crystal structure. Due to the similarities in the water profiles obtained from the hydrated and anhydrous forms of this iron oxide, we believe that the origin of the observed water is from H<sub>2</sub>O molecules adsorbed on the surfaces of the mineral grains that were not completely removed by baking.

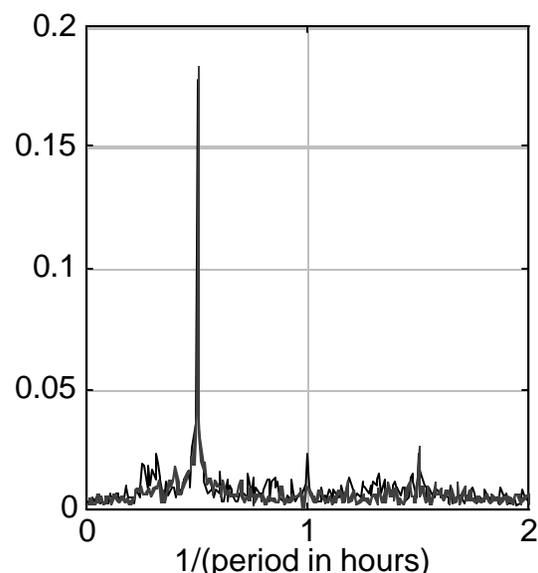
In an "order of magnitude" calculation which accounts for the differences between the martian and laboratory environmental parameters (including pressure, temperature, radiation flux, and quantity of adsorbed water), we estimate that a square meter of the martian surface could, in diurnal cycles, evolve up to a milligram of water during daytime exposure to UV photons.

A similar calculation indicates that a minimum exposure time of 10<sup>8</sup> years (as set by the sensitivity limits of our experiment) is required to completely remove the OH bound in the uppermost layer of soil at the martian surface. Dust suspended in the martian atmosphere is exposed to a larger radiation dose and has a minimum dehydration time an order of magnitude shorter. The actual required exposure time, however, could be much longer and possibly irrelevant to the weathering processes on Mars.

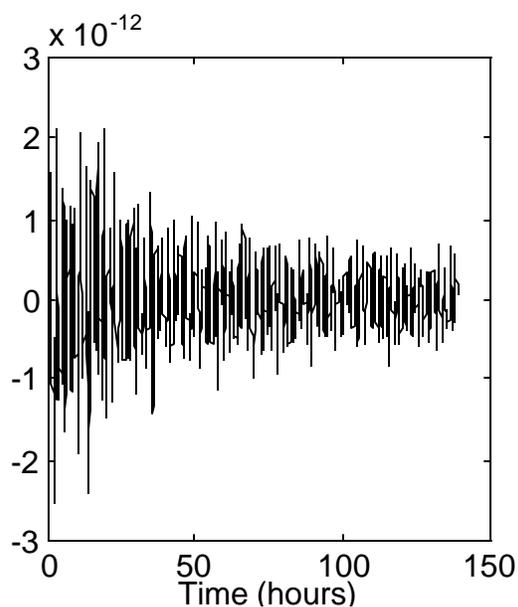
In conclusion, we find: (a) No evidence that ultraviolet radiation is capable of removing bound OH from iron oxides ( $\alpha$ - or  $\gamma$ -FeOOH), and (b) UV radiation can eject water from the surfaces of mineral grains and can impact the diurnal cycles of near surface water on Mars.

**FeOOH (Raw)**

**Figure 1:** Raw mass spectrometer data from atomic mass unit 18 measured from lepidocrocite which was baked for 24 hours at 100°C. The UV lamp was cycled on/off (1 hour each) while these data were collected. Similar results were obtained for goethite.

**Frequency Content**

**Figure 3:** Fourier transform of the data in figure 2 (lepidocrocite - solid line) and for a similar data set collected for maghemite (dashed line). The spike at a period of 2 hours corresponds to water released from the samples while the lamp is on. The lack of a significant difference between the hydrated and anhydrous forms of this iron oxide indicate that adsorbed water was the source of the signal.

**FeOOH (Processed)**

**Figure 2:** Filtered version of the signal shown in figure 1 with the trend removed.

**References:** Andersen and Huguenin, *Bull. AAS*, 9, 449, 1977; Hvidt et al., *Science*, 278, 1768-1770, 1997; Morris and Lauer, *JGR*, 100, 10893-10899, 1981; Smith et al., *Science*, 278, 1758-1765, 1997.