LUNAR HYDRATION AND THE PLASMA ENVIRONMENT: WHAT CAN WE LEARN FROM LUNAR TRANSITS THROUGH THE EARTH'S MAGNETOTAIL?

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Introduction: Observations from the Chandrayaan-1 Moon Mineralogy Mapper (M3), Cassini Visual and Infrared Mapping Spectrometer, and the EPOXI (Deep Impact) High-Resolution Instrument infrared spectrometer have shown adsorbed water and hydroxyl spectral absorptions around 3 µm [1,2,3] across the surface of the Moon. Data from all three spacecraft demonstrate a strong latitudinal distribution of the absorption feature, with increasing water or hydroxyl at higher latitudes [1,2,3]. Additionally, the presence and strength of the various absorption features vary with the lunar day, generally characterized by a minimum around lunar noon [1,2,3].

Among the considered sources for the hydration, solar wind chemical alteration of oxygen-bearing minerals is investigated [4]. The results from EPOXI are largely attributed to the interaction of H+ from the solar wind [2]. The exact mechanism for this to occur is unknown, although theoretical studies based on laboratory data have predicted this type of interaction for many years.

In stark contrast, however, a recent laboratory investigation determined that ion bombardment as expected from the solar wind led to dehydration of lunar analog materials [5]. This suggests that the favored mechanism for hydration by solar wind might be wrong.

Solar Wind vs. Earth's Magnetotail: The solar wind generates a significant hydrogen ion flux across a range of velocities and energies; as the solar wind flows past the Moon, the ions impact the Moon and generate a wake that extends for a significant distance. Table 1 summarizes average properties of the Solar Wind (SW).

For six days of its orbit, however, the Moon is immersed within the Earth's magnetosphere. The Earth's magnetosphere exhibits a significantly different ion population (Table 2). In particular, because the Moon's orbital and rotational periods are locked into a 1:1 resonance around the Earth, the near side of the Moon is repeatedly subjected to the maximum impact of the magnetotail every lunar day. The regions of the magnetosphere that interact with the Moon include the magnetosheath, magnetotail lobes (north and south), plasma-sheet boundary layer, and central plasma sheet. Table 2 summarizes the average properties of the Lobe (L) and central Plasma Sheet (PS) portions of the magnetotail.

We will demonstrate the differences between these plasma population (ie Table 3) and propose some simple tests for examining their relative effects with respect to lunar geography.

References: [1] Pieters C.M. et al. Sci, 326, 568 (2009). [2] Sunshine J.M., et al., Sci, 326, 565 (2009). [3] Clark, R. N. Sci, 326, 562 (2009), [4] Arnold J.R. (1979) JGR, 84, 5659. [5] Burke D.,et al. Icarus, in press.(2010). [6] Kivelson M.G., Russell C.T. (1995) Introduction to Space Physics, book. [7] Phillips T. NASA Science News, webpage. (2008)

Table 1.Average Solar Wind (SW) Properties [6].

proton flux density:	3.0e8 cm^-2/s^-1
proton density:	6.6 cm^-3
proton temp:	1.2e5 K
velocity:	400 km/sec
magnetic field:	7 nT

Table 2. Average Magnetotail (Lobes & Plasma Sheet (PS)) Properties [6].

PS proton density:	0.3 cm^-3
Lobe proton density:	0.01 cm^-3
PS proton temp:	48.7e6 K
Lobe proton temp:	3.48e6 K
PS magnetic field:	10 nT
Lobe magnetic field:	20 nT

Table 3. Comparison of ion gyroradii with respect to the size of the Moon. *

Lunar radius: 1700 km
SW proton gyroradius: 50 km
PS proton gyroradius: 700 km
Lobe proton gyroradius: 90 km

- Charged particles move in a circular orbit in a uniform magnetic field (no electri field) given by the gyroradius.

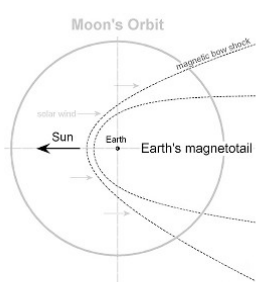

Fig. 1. Top view of the passage of the Moon's orbit between solar wind and magnetosphere plasma populations [7].