Relationships of Widespread OH presence in the Lunar Surface Materials with Lunar Physical Properties. T. B. McCord[1], and J.-Ph. Combe[1], [1]Bear Fight Institute, P.O. Box 667, Winthrop WA 98862, tmccord @ bearfightinstitute.com[1], jean-philippe_combe @ bearfightinstitute.com[1]

Introduction: Absorptions in the 3-µm region of the lunar reflectance spectrum, first observed by the M^3 spectrometer on the Chandrayaan-1 spacecraft [1] and confirmed by two other spacecraft spectrometers [2,3], were interpreted as indicating widespread OH and perhaps H_2O in the lunar surface material. The sources of OH in the lunar surface materials were discussed and the dependence of these absorptions on various physical properties of the lunar surface were explored in some detail using the M^3 data; Solar-wind-proton-induced hydroxylation was identified as the most likely responsible process [4,5,6]. The analysis has continued in an effort to understand better the associated physical/chemical processes.

Complications: Although the M^3 data set is by far the most complete and highest quality spectra image data set ever obtained for the lunar surface, the measurement plan for M^3 was not completed, due to spacecraft failure, and thus the data set remains incomplete, with only the lower spectral and spatial resolution global data set obtained for the most part with a few higher resolution targeted image cubes acquired on small areas. A further complication is that many of the lunar surface properties are themselves correlated, such as maria concentrated at lower latitudes, and temperature (due to albedo) correlated with composition. Disentangling the various correlations completely requires an expanded data set, such as measurements of the same regions at different times of the lunar day and thus at different temperatures. These needed data can only come from flying another spectrometer about the Moon, which we strongly encourage be done.

Temperature and Thermal Emission: A most important complication is the tendency of thermal emission from the lunar surface to add radiation in the spectral region of the 3-µm region OH absorptions, which if not completely removed, will distort calculations of absorption strength [6]. Since temperature is very important in controlling the kinetics of many chemical processes, including OH formation and stability, identifying any dependence of absorption strength with temperature would be very important. The M^3 team has attempted thermal emission removal [7], but the lack of M^3 measurement longward of about 3 µm restricts any thermal emission removal to temperatures below about 250 K. Yet, there appears to remain some thermal emission effects on absorption-strength calculations for these lower temperatures [4]. Efforts are underway [8] to utilize independent temperature measurements, especially by the Diviner Lunar Radiometer Experiment (DLRE) on Lunar Reconnaissance Orbiter (LRO) [9], and some of these results are being used to study absorption dependences on physical properties [6].

Correlations: A focus has been attempting to determine behavior of the absorptions with respect to physical properties of the lunar surface [4,5,6]. These properties include composition, morphology, temperature, illumination and latitude. Actually, two different absorptions appear in the M^3 data, a narrow, well-defined absorption centered at about 2.8 µm, and a broader absorption centered beyond 3 µm, with only the short-wavelength band edge visible in the M^3 spectra as a downturn in the spectrum beginning at about 2.7 µm. These two absorptions are correlated in strength, suggesting that they are due to the same or related processes [Fig. 1]. Several lines of evidence were presented [6] suggesting that absorptions are related to composition, with more absorption for feldspathic materials [e.g., Fig. 2], and especially for small, fresh craters in such material. Only a small dependence of absorption-strength with temperature was found [6] for regions with temperatures >250 K, and attempts are underway to extend the analysis to lower temperatures [8]. The band strengths appear stronger for less well illuminated (shaded) regions and they seem to change as the illumination changes for the same lunar region [*e.g.* Fig. 3]. But, this may be due partly or entirely to unremoved thermal emission [Fig. 4].

Other Solar System Bodies: The discovery of lunar OH and the solar-wind related cause, suggest that OH may exist for other airless-body silicate surfaces in the Solar System, for example, for Vesta. The Dawn spacecraft is to orbit Vesta in July 2011, and the search for OH is now part of its science plan [10]. Mercury is another candidate, but the much hotter surface causes even greater thermal emission contamination observational problems than for the Moon.

References:

[1] Pieters C. M. et at. (2009) *Science, 326,* 568–572. [2] Sunshine J. M. et at. (2009) *Science, 326,* 565–568. [3] Clark R. N. (2009) *Science, 326,* 562–564. [4] McCord T. M. et at. (2010) *LPSC 41,* 1860. [5] McCord T. M. et at. (2010) *AGU,* P34A-04. [6] McCord T. M. et at. (2011) *JGR* in press. [7] Clark R. N. (2011) *JGR* in press. [8] Combe J. P. et at. (2011) *LPSC 42*. [9] Paige D. A. (2010) *Sp. Sci. Rev. 150,* 125–160. [10] McCord T. M. et at. (2011) *LPSC 42*.

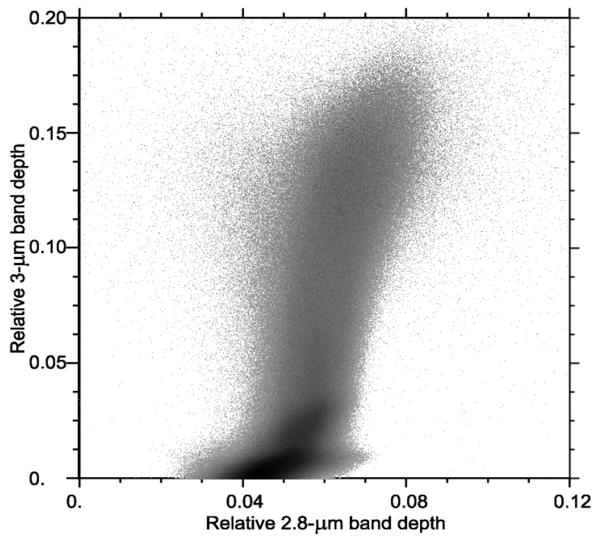

Fig. 1: Correlation of the two OH-related absorption strengths for the M^3 global lunar data set.

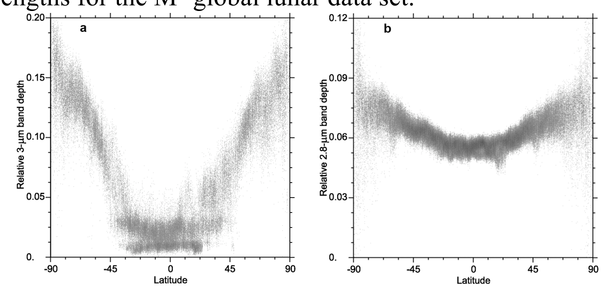

Fig. 2: Dependence of the two absorptions on lattitude for a section of lunar longitude containing Mare Orientale. Note the double horizonal clusters for the 3-µm band plot for lower latitudes: higher corresponds to highlands; lower corresponds to maria.

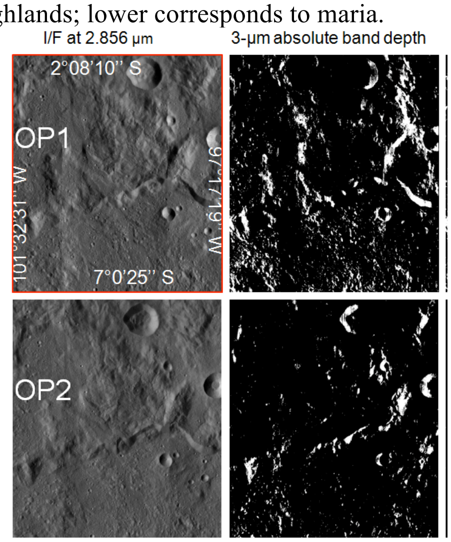

Fig. 3: The same lunar region under morning and afternoon illuminations. Note the crater at top-center (left) and how the band strength seems to change with illumination (right), being stonger for lower lighting.

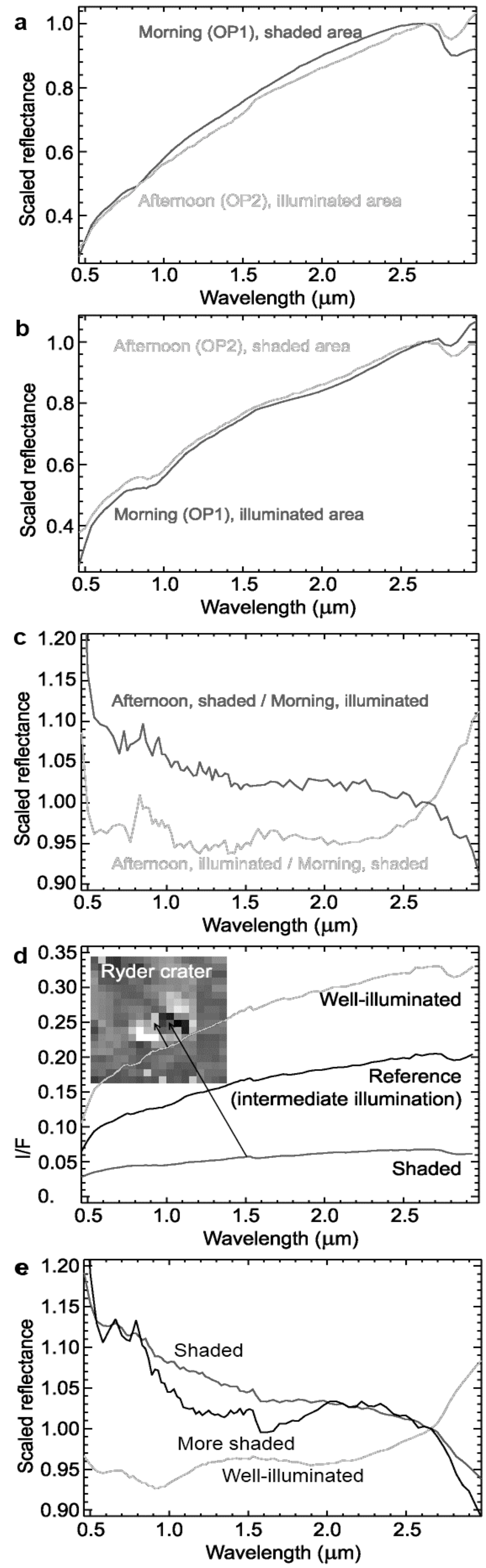

Fig 4: Spectra for the same or similar lunar regions under different illuminations. The ratios of these spectra show shapes consistent with differences in thermal emission (c) and in absorption strengths (e).