

MAPPING OF LUNAR VOLATILES: A CHALLENGING PROBLEM. J.-Ph. Combe¹, T. B. McCord¹, P. O. Hayne² and D. A. Paige³. ¹Bear Fight Institute, 22 Fiddler's Road, Winthrop, WA, USA. ²Caltech, Pasadena, CA. ³UCLA, Los Angeles, CA. (Contact: jean-philippe_combe @ bearfightinstitute.com),

Introduction: Uncertainties in the interpretation of spectral signatures of volatiles.

Background: Spectral signatures of hydroxyl and/or water molecules have been observed at 2.8 and 3 μm by the Moon Mineralogy Mapper (M^3) onboard the Chandrayaan-1 spacecraft [1-3], and confirmed by the Epoxi mission [4] and Cassini Visual and Infrared Mapping Spectrometer (VIMS) [5]. If those volatiles are endogenic, their identification would have implications for the understanding of lunar interior geological processes. If OH and/or H_2O result of surficial processes, they are likely related to the space environment and surface properties of the Moon, one hypothesis being the interaction of solar wind particles with minerals of the lunar soil [2].

Problem: Measurements of the position, strength and shape of the absorption bands are essential for the interpretation of the type of volatile, its distribution, and dependence on lunar physical properties. However, these measurements have significant uncertainties [2]. Thermal emission contributes significantly to the lunar radiance in the 3- μm region above 250 K [6, 7]: It fills and distorts the absorption bands of volatiles, and it is correlated to illumination (latitude, local slope, surface roughness and time of day), surface albedo and composition [2, 8]. The accuracy of thermal removal based on reflectance spectra [6, 7] is affected by the broad 2- μm band of pyroxenes and the presence of the 3- μm band of volatiles. Photometric properties of the lunar soils have also significant spectral effects.

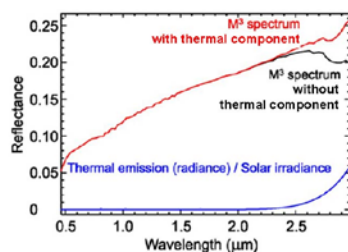


Figure 1. Example of M^3 spectrum with and without thermal emission in it, for surface temperature of 350 K.

The main objectives in our study are 1) the interpretation of the OH-bearing composition, which is based on the position of the bands, 2) quantifying the components, which is partly related to the depth of the bands, 3) monitoring temporal variations of the volatile distribution, which is a way to determine if the volatiles are endogenic or at the topmost surface, and 4) determining the association of various types of volatiles to different mineralogical compositions, which may provide insights on geological processes, or how the minerals interact with solar wind particles. We are first focusing

on thermal emission removal because it has the strongest effects on the absorption bands.

Spectral analysis and results: Thermal emission removal and monitoring temporal variations.

We use M^3 reflectance spectra with thermal emission correction based on the data themselves [6, 7, 8]. We use also brightness temperature measured by the Diviner Lunar Radiometer Experiment [9] on Lunar Reconnaissance Orbiter (LRO), where data are available at the same lunar local time of day than M^3 observations. Both methods so far lead to an incomplete thermal emission removal [8]. Qualitatively, the variability of the 3- μm band depth observed as function of the composition after incomplete removal of the thermal contribution is sensitive to the actual dependence to the composition. Quantitatively, this dependence is likely underestimated. The band shape estimate of the 3- μm absorption band is sensitive to the diversity of volatiles. However, since the thermal emission is not completely corrected, and since this incompleteness varies from place to place, and also between observations of the same scene under different geometries of illumination, it is not yet possible to reach firm conclusions. Variations with time of day seem also to indicate an increase of the 3- μm absorption band depth when the sun is lower above the horizon. However, thermal removal uncertainties are also higher when shadows are mixed in the scene. We are currently working on improving the temperature modeling from Diviner data in order to account for surface roughness, and therefore reduce some of the uncertainties.

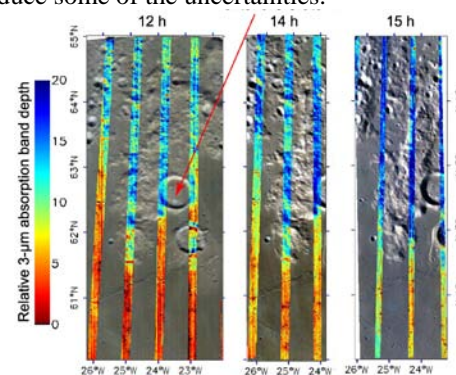


Figure 2: 3- μm absorption band depth near Fontenelle Crater D (red arrow) for three times of day after thermal removal using Diviner brightness temperature measurements at 8 μm .

References: [1] Pieters et al., Science 326, 2009. [2] McCord et al., JGR, in press. [3] Clark et al. JGR, in press. [4] Sunshine et al., Science 326, 2009. [5] Clark, Science 326, 2009. [6] Clark et al., Icarus 40, 1979. [7] Clark et al. submitted to JGR. [8] Combe et al., LPSC abstract 2573. [9] Paige et al. Science 330, 2010.