JULES VERNE MARE SOILS AS REVEALED BY CLEMENTINE UVVIS DATA. R. A. Yingst[1] and J. W. Head[2], [1]Lunar and Planetary Laboratory, University of Arizona, P.O. Box 210092, Tucson, AZ, 85721, yingst@lpl.arizona.edu; [2]Box 1846, Brown University, Providence, RI, 02912.

Introduction: The thermal evolution of the lunar interior is best revealed by the morphology and composition of the volcanic products of that evolution — the lunar mare deposits. Based upon laboratory and telescopic reflectance spectra [e.g. 1,2] and recent reflectance data provided by Clementine [e.g. 3,4], these deposits are revealed to be essentially basaltic, containing high-Ca pyroxene and olivine [5]. However, a recent examination of 21 discrete mare deposits in South Pole-Aitken (SPA) basin [6,7] has revealed six deposits whose multispectral signatures may be interpreted to be dominated by low-Ca pyroxene rather than high-Ca pyroxene. If this interpretation is correct, it would signal the identification of a unique lunar volcanic mineralogy, a result that would have a profound impact on theories of volcanic petrogenesis and thus lunar internal evolution. To determine the nature of this anomalous multispectral signature, we undertake an in-depth analysis of a representative of these deposits, that associated with Jules Verne crater.

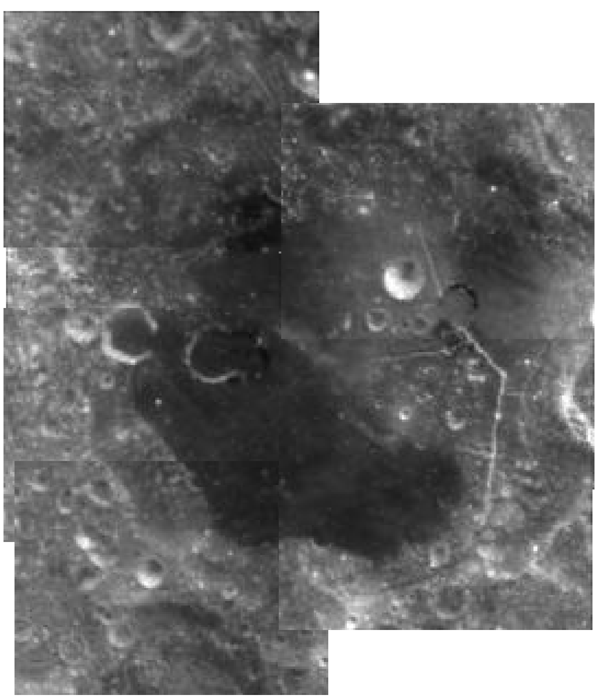

Figure 1. Mare deposit associated with Jules Verne crater shown at 0.750 µm. North is up in this mosaic. The mosaic has not been geometrically corrected.

Approach: Mare soils in Jules Verne (shown in Figure 1) were examined using multispectral information gathered by the Clementine UVVIS camera, which yielded reflectance values at 0.415, 0.750, 0.900, 0.950 and 1.0 µm wavelengths. The two shorter wavelength bands defined the strength of the continuum slope (related to soil maturity) while the three longer wavelength bands revealed the presence and nature of any Fe^{2+} absorption band associated with mafic minerals. Determination of mafic mineralogy was based upon three factors: 1) albedo as estimated by reflectance values at 0.750 µm; 2) the 0.750/0.950 µm ratio indicating the presence of a 1.0 µm Fe^{2+} (mafic) absorption band [8]; and 3) the depth and wavelength position of that band's minimum value. Deposit regions with very low albedo and a strong 0.750/0.950 µm ratio signal were assumed to be areas of most unadulterated, uncontaminated mare soil. Within these regions spectral samples were taken from non-mature soils excavated by the youngest impact craters. The depth and wavelength of the 1.0 µm band minimum was then measured using methods introduced by [9] and utilized in [7]. Spectra with minima at longer wavelengths (around 1.0 µm) are consistent with a high-Ca pyroxene (typically basaltic) component, while spectra showing a shorter wavelength minimum are more consistent with a low-Ca pyroxene (noritic) composition [3,5].

These data may be influenced by several factors, including the extent of contamination by non-mare soils lying near the mare boundary, and the number of very young craters available for sampling non-mature soil spectra. Thus we focused our efforts on Jules Verne, the deposit in the study area [6,7] with the largest areal extent and therefore the least likely to be affected by such processes. Each sampled spectrum was chosen to avoid regions most likely affected by vertical or lateral mixing, or other contamination by non-mare soils. As an independent confirmation of this, we searched for any correlation between the wavelength of the 1.0 µm absorption band minimum and the location of the sample. Such a correlation would indicate other factors such as mixing are responsible for the shorter wavelength signature. The result of these studies was an updated summary of the morphology and general mineralogy of the Jules Verne deposit.

Morphology and Mineralogy: Jules Verne is a 120 km diameter impact crater lying on the northwestern edge of SPA basin. It contains a 5830 km^2 volcanic (effusive) deposit estimated to be approximately 8745 km^3 in volume [10]. On the basis of morphology this deposit was originally estimated to be a single eruptive phase [10,11]. However, two distinct and sharply divided regions of soil color (0.415/0.750 µm) and mafic band strength suggest that at least two mare flows are represented in this region. Northeastern spectra are characterized by a lower mafic component than spectra from the southwestern portion, and are more "red". In addition, spectra of fresh soils in the southwestern portion of the pond show a more basaltic signature than those in the northeastern portion. Finally, improved spatial resolution of this region afforded by Clementine shows that the northeastern portion of the mare deposit has a higher albedo than the southwestern portion and is blanketed by ejecta from the prominent crater to the northwest. This suggests that the northeastern portion of the mare deposit in Jules Verne crater is older than the southwestern portion, which appears to postdate the prominent northwestern crater.

Areas of these separate flows were calculated to be 4200 km^2 and 1630 km^2 for the older and younger flow respectively, assuming that the older flow does not underlie the younger. If such is the case, the calculated area for the younger flow must be considered a minimum value. Similarly, the improved spatial resolution for these two regions allowed increased accuracy in flow thickness estimates to be made for these deposits. Specifically, the thickness of this pond was originally estimated using a method in which the depths of craters excavating highland material [12,13] are used as indicators for maximum thickness values. For this method, then, it is crucial in determining the non-mare nature of the ejecta to utilize only those craters that are both relatively young and optically mature. Using multispectral data provided by Clementine allows a clearer picture of the optical maturity of highland-excavating craters. Based upon this updated thickness assessment, the larger, older flow is estimated to be 2940 km^3, while the younger flow is estimated to be 2120 km^3.

Several dark regions can be seen in the northwestern and eastern edges of the mare pond in the Clementine images, making up a third, youngest, geologic unit. The eastern patch is a small region of dark soil associated with the scarp system that dominates this portion of the crater. The larger northwestern patch is associated with an east-west trending fracture, as well as a circular feature at the eastern terminus of the fracture that may be a vent. Such fractures and rilles associated with dark deposits have been interpreted to be dark mantle deposits emplaced pyroclastically. Spectra here are "redder" than the surrounding regions, and this, combined with the darkness of the soils and the diffuseness of the boundary, suggests that these patches are pyroclastic [14]. When compared to the Aristarchus region dark mantle deposits [15], spectra of Jules Verne dark soils are consistent with an interpretation of dark mantle deposits.

Nature of the 1000 nm Mafic Band: A total of 16 regions in Jules Verne were spectrally sampled . Of these, ~40% showed long wavelength signatures consistent with a high-Ca pyroxene (basaltic) composition [3], while ~60% displayed a shorter wavelength signature consistent with a predominantly low-Ca pyroxene (noritic) composition. Soils show this signature apparently regardless of location within the deposit. A general shorter wavelength 1.0 µm band signature occurs within a region of low albedo, large areal extent and significant estimated thickness. Such characteristics would indicate that the effects from various mixing processes would be less dominant. In addition, although a prominent impact crater has mantled much of the northeastern portion of the deposit with ejecta, the southwestern region, which appears relatively unmantled, displays similar shorter wavelength spectra. Although these observations do not rule out contamination processes or scattered light issues, they suggest the possibility that a unique type of mare material is represented by lava ponds in Jules Verne that is either dominated by low-Ca pyroxene or is a mixture of low-Ca and high-Ca pyroxene.

Conclusions: The noritic signature displayed by five of the mare deposits examined in SPA [6,7] can plausibly be attributed to various mixing processes, without resorting to a unique mineralogical classification of farside mare deposits. However, these explanations are insufficient for the spectral signatures returned from Jules Verne. An assessment of 16 spectral sample regions shows no correlation between location or distance from the deposit boundary and the position of wavelength minima, suggesting that mixing processes play a minor role if any in the position of the 1.0 µm absorption band. We are currently exploring more closely the contribution of scattered light and other systematic factors that may influence these results [14].

References: [1] Adams, J. B. [1968] *Science*, *159*, 1453. [2] McCord, T.B. et al. [1981] *JGR*, *86*, 10,883-10,892. [3] Pieters, C. M. et al. [1997] *GRL*, *24*, 1903-1906. [4] Pieters, C. M. et al. [1993] *JGR*, *98*, 17,127–17,148. [5] Pieters, C. M. [1993] *Remote Geochemical Analysis*, Cambridge Univ. Press, NY. [6] Yingst, R. A. and Head, J. W. (1997) *LPSC XXVIII*, 1609–1610. [7] Yingst, R. A. and Head, J. W. [1999] *JGR*, in review. [8] Burns, R. G. [1993] *Mineralogical Applications of Crystal Field Theory*, Cambridge Univ. Press, NY. [9] Tompkins, S. [1997] *Ph.D. Thesis*, Brown Univ., RI. [10] Yingst, R. A. and Head, J. W. [1997] *JGR*, *102*, 10,909-10,931. [11] Stuart-Alexander, D. E. [1978] *USGS Map I-1047*. [12] Stöffler, D. et al. [1975] *JGR*, *80*, 4062-4077. [13] Pike, R. J. [1977] *PLPSC*, *VIII*, 3427-3436. [14] Gaddis, L. R. et al. [1985] *Icarus*, *61*, 461-489. [15] Weitz, C. M. et al. [1997] *LPSC*, *XXVIII*, 1533-1534. [16] Gaddis, L. R. et al. [1995] *JGR*, *100*, 26,345-26,355.