INVESTIGATING YOUNG (<100 MILLION YEARS) IRREGULAR MARE PATCHES ON THE MOON USING MOON MINERALOGY MAPPER OBSERVATIONS. J. Grice[1], K. L. Donaldson Hanna[1], N. E. Bowles[1], P. H. Schultz[2], and K. A. Bennett[3], [1]Atmospheric, Oceanic and Planetary Physics, University of Oxford, Clarendon Laboratory, Oxford, UK (jonathon.grice@st-annes.ox.ac.uk), [2]Dept. of Earth, Environmental and Planetary Sciences, Brown University, Providence, RI, USA, and [3]School of Earth and Space Exploration, Arizona State University, Tempe, AZ, USA.

Introduction: The investigation and characterization of volcanism on a planetary surface provides the best insight into the composition, structure, and thermal history of its interior. The lunar maria, vast plains formed of basaltic flows, are limited to and cover 17% of the lunar near side [1]. Radiometric age dating of returned Apollo samples and crater counts from remote observations indicates that mare basaltic volcanism was active from ~4.2 to 0.8 Ga [e.g. 2-5].

Lunar-Orbiter/Apollo images and Clementine UVVIS observations identified four regions, including Ina, of small-scale, low relief patches of rubble with a maximum age of ~10 Ma [6]. Recent observations by the Lunar Reconnaissance Orbiter Camera (LROC) onboard NASA's Lunar Reconnaissance Orbiter (LRO) have expanded this list of unusual morphologic features by identifying similar features termed meniscus hollows [7] or irregular-bounded mare patches (IMPS) on the lunar near side with ages < 100 Ma [8]. The IMPs have two morphologically distinct deposits, uneven and smooth deposits [6-8]. The uneven deposits have a rough surface texture and contain a range of block densities, whereas the smooth deposits have a fairly uniform surface texture and almost no blocks. Most importantly, the boundary scarps have very low relief indicating recent formation. Two hypotheses for the origin of the irregular mare patches (IMPs) have been suggested: (1) recent, episodic outgassing from deep within the lunar interior [6] and (2) small basaltic eruptions that occurred after mare volcanism had ended [8].

These young volcanic features have implications for the cooling and volatile content of the lunar interior and may provide insight into the compositional evolution of magmatic materials over time. In this study we investigate the composition of the irregular mare patches in an effort to better understand the origin of these features and the evolution of lunar basalts over time. Compositional differences across each IMP as well as differences with surrounding mare materials are investigated using visible to near infrared (VNIR) observations from the Moon Mineralogy Mapper (M^3) instrument.

Data and Methods: M^3, an imaging spectrometer onboard the Chandrayaan-1 spacecraft, mapped the lunar surface across the VNIR (0.43-3.0μm) in 85 bands [9]. The focus of this initial analysis is on the two largest IMPs, Sosigenes (max length of 5 km) and Ina (diameter of 3 km). M^3 image cubes from single optical periods (OP) were used in this initial analysis of Sosigenes (M3G20090607T025544 from OP2C1) and Ina (M3G20090205T071411 from OP1B). VNIR reflectance spectra of mare basalts are typically dominated by absorption features near 1 and 2 μm owing to pyroxene. To investigate compositional differences between the IMPs and surrounding mare materials, spectral band parameters (band depths at 0.95 μm and 2.3 μm) were examined and reflectance spectra were extracted. In addition the optical maturity was calculated using the methods of Lucey et al. [10] to investigate optical maturity differences across the IMPs and with the surrounding mare.

Results: The M^3 observations of Sosigenes and Ina (spectral band parameters and OMAT) are shown in Figures 1 and 2 along with Lunar Reconnaissance Orbiter Camera (LROC) mosaics. The uneven deposits (the higher albedo regions) within Sosigenes (1) are less optically mature than the smooth deposits and surrounding mare, (2) have stronger 1 and 2 μm absorptions than the smooth deposits as seen in the band parameter map and in the extracted spectra in Figure 3, and (3) are similar in composition (spectra dominated by high-Ca pyroxene with similar band positions at 1 and 2 μm) to fresh craters in the surrounding mare. As

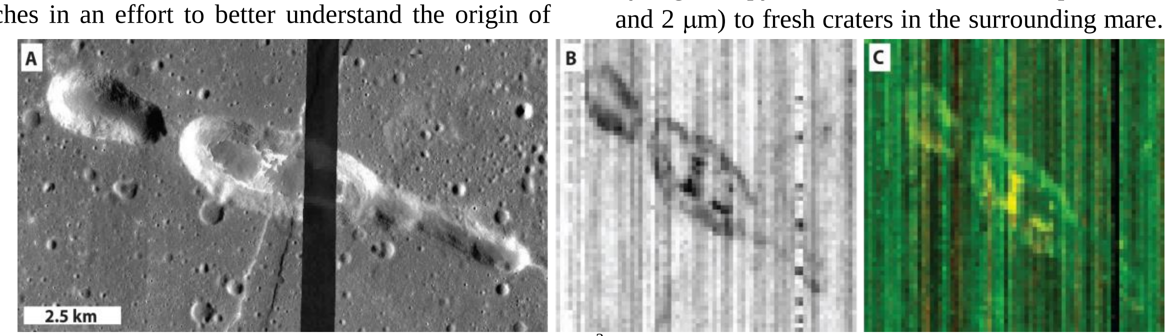

Figure 1. (A) LROC WAC and NAC mosaic of Sosigenes. (B) M^3 OMAT band parameter where black pixels indicate low values. (C) M^3 band parameter map where red = 0.95μm BD, blue = 2.3 μm BD, and green = reflectance at 1.578 μm.

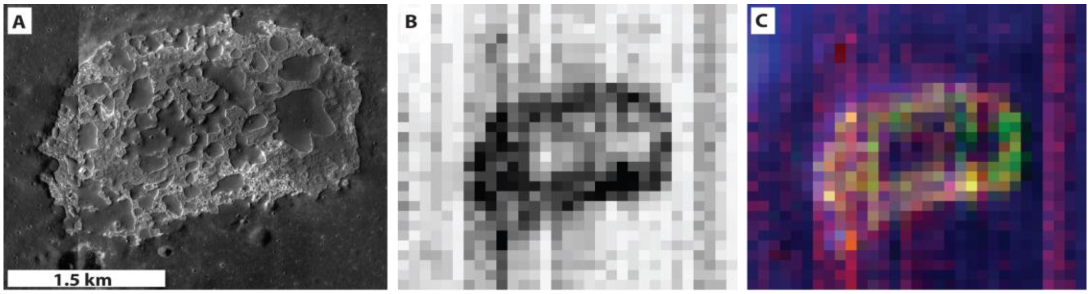

Figure 2. (A) LROC WAC and NAC mosaic of Ina. (B) M^3 OMAT band parameter where black pixels indicate low values. (C) M^3 band parameter map where red = 0.95 µm BD, blue = 2.3 µm BD, and green = reflectance at 1.578 µm.

seen in Figures 1 and 3 the smooth deposits within Sosigenes are less mature than surrounding mare and have spectra similar to surrounding mature mare soils (both have similar spectral slope and weak 1 and 2 µm absorptions).

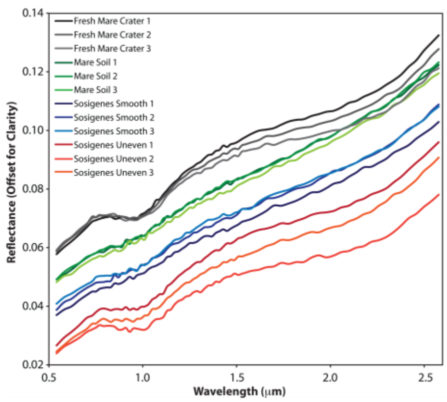

Figure 3. M^3 reflectance spectra extracted from the uneven and smooth deposits within Sosigenes and from fresh and mature mare materials surrounding Sosigenes. Spectra have been offset for clarity.

Similar results are seen in the uneven and smooth deposits within Ina. The uneven deposits, the higher albedo regions around the edge of Ina, are less mature than the smooth deposits and surrounding mare and have stronger 1 and 2 µm absorptions than the smooth deposits as seen in the band parameter map in Figure 2. However, unlike Sosigenes the uneven deposits are not similar in composition to the fresh craters in the surrounding mare except for one crater to the northwest of Ina. The smooth deposits within Ina are less mature than surrounding mare and have spectra similar to surrounding mature mare soils (both have similar spectral slope and weak 1 and 2 µm absorptions). These results corroborate earlier spectral analyses of the uneven and smooth deposits in Ina [6,11,12].

Discussion and Future Work: The smooth and uneven deposits in both IMPs analyzed in this initial study indicate that both units in each IMP have similar compositions, but with different degrees of space weathering. These spectral differences are likely due to the blockiness and exposure of fresh materials on the uneven deposits and the smooth surface texture and lack of boulders on the smooth deposits. The spectral signatures of the uneven and smooth deposits in Sosigenes are similar in composition to the mature soils and fresh craters exposed in the surrounding mare suggesting either no significant evolution of the magmatic materials over time or no exposure of mare units below the visible unit. However, differences are seen in the spectral signatures of the Ina uneven and smooth deposits with surrounding mare material suggesting either (1) a change in magma composition over time or (2) the exposure of a mare flow below the most recent flow [6,11].

Future work will include more detailed spectral analyses on IMPs large enough to spatially resolve within the M^3 dataset. This will allow us to better characterize the VNIR compositional trends within these young volcanic features and constrain any compositional differences between the IMPs and their surrounding mare units. In addition, thermal infrared (TIR) observations of the IMPs from the Diviner Lunar Radiometer Experiment on board the Lunar Reconnaissance Orbiter are also being analysed to investigate the compositional differences seen in a different wavelength regime. Combining VNIR and TIR data analyses will enable use to better constrain the compositional evolution of lunar mare materials.

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