SPECTROPHOTOMETRIC ANALYSIS OF PYROCLASTIC MANTLES ASSOCIATED WITH LUNAR DOMES AND RILLES. W. H. Farrand[1]. [1]Space Science Institute, Boulder, CO, farrand@spacescience.org.

Introduction: The detection of low circular polarization ratio (CPR) values over several domes and lunar rilles from Earth-based radar studies [1-3] is indicative of those features being covered by mantles of loose, disaggregated materials such as pyroclastic ash. Analysis of several of these features using a variety of lunar orbital remote sensing datasets provides support to the hypothesis that these are pyroclastic mantles. However, properties detected by remote sensing indicate variability between the features. The features discussed here include the Menelaus domes and Tacquet formation of southern Mare Serenitatis, the Manilius-1 and Yangel-1 domes of Mare Vaporum, the Rima Calippus rille in Mare Serenitatis, and the Cauchy-5 dome in Mare Tranquilitatis.

Data Examined: Characteristics that are potentially indicative of the presence of pyroclastic materials include mineralogy, chemistry, and physical state (e.g., surface roughness, grain size, degree of induration). Imaging spectrometer data from the Moon Mineralogy Mapper (M^3) was used to assess mineralogy and potential hydration, optical measures of chemistry (FeO and TiO_2 abundance) were obtained from respectively Kaguya Multiband Imager (MI) and LROC Wide Angle Camera (WAC) data. A measure of surface roughness is also obtainable from multi-phase angle WAC data.

FeO and TiO_2: Lunar glasses returned by Apollo have FeO wt. % values > 16 wt.% [4] and glass can be a major constituent of pyroclastic mantles. Thus, higher FeO is a potential indicator for pyroclastic deposits. TiO_2 content in those glasses had a wider spread, from 0.26 to 16.4 wt.% and would not be a unique indicator of pyroclastics; however, since pyroclastic deposits represent a composition that is potentially distinct from surrounding materials, it could be an indicator of compositional distinctness.

Table 1 shows wt. % FeO, as derived from Kaguya MI data after the approach of [5] for the features considered here.

Feature	*Wt. % FeO from MI*
Menelaus-1	19.1
Yangel-1	18.4
Manilius-1	18.5
Rima Calippus mantle	15.3
Cauchy-5	20.4

Table 1. Wt. % FeO from MI over study areas.

M^3 Mineralogy: An indication of a glass-rich composition is a broad "1 μm" band centered longer than 1 μm and often longer than the "1 μm" band center of high-Ca pyroxenes predominant in mare basalts. Correspondingly, glasses have a relatively weak "2 μm" band centered shorter than high-Ca pyroxene "2 μm" band centers. Using a band center mapping program [6] these band center positions were determined and can be graphically observed as in **Fig. 1** looking at a subsection of a M^3 scene over Rima Calippus.

Table 2 shows that some of the examined areas show this longer 1 μm / shorter 2 μm pattern, but others do not.

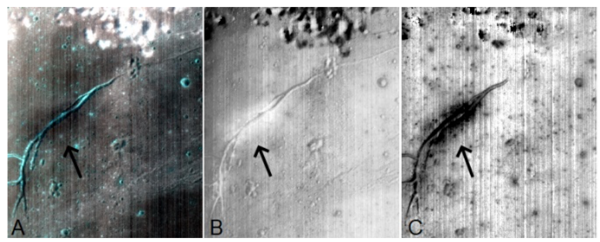

Fig. 1. A. Color composite with Rima Calippus and dark mantle in left center. **B.** 1 μm band center position, note longer 1 μm band centers (brighter area) corresponding to the dark mantle. **C**. 2 μm band center position, note lower values indicating shorter 2 μm band center positions.

Feature	*1 μm center relative to mare*	*2 μm center relative to mare*
Menelaus-1	Longer	Shorter
Yangel-1	Longer	Longer
Manilius-1	Longer	Shorter
R. Calippus	Longer	Shorter
Cauchy-5	Longer	Same

Table 2. 1 and 2 μm band center positions relative to surrounding mare.

Hydration: The best approach to perform thermal correction of M^3 data is not a fully agreed upon topic. The thermal correction of [7], which is incorporated into reflectance data released on the PDS, has been cited as underestimating surface temperatures [8,9]. The empirical approach of [8] provides an alternative as do approaches that seek to incorporate models of surface roughness [9-11]. Given uncertainty in the thermal correction approach, data corrected through both that of [8] and [11] were used here with the OH Integrated Band Depth (OHIBD) metric of [10] used to gauge potential hydration.

Assessment of this data is still on-going; however, OHIBD images over Manilius-1 and Yangel-1, corrected through the approach of [8] are shown in **Fig. 2**. These present a contrast with Manilius-1 showing increased OHIBD levels relative to the background and Yangel-1 not showing any such rise.

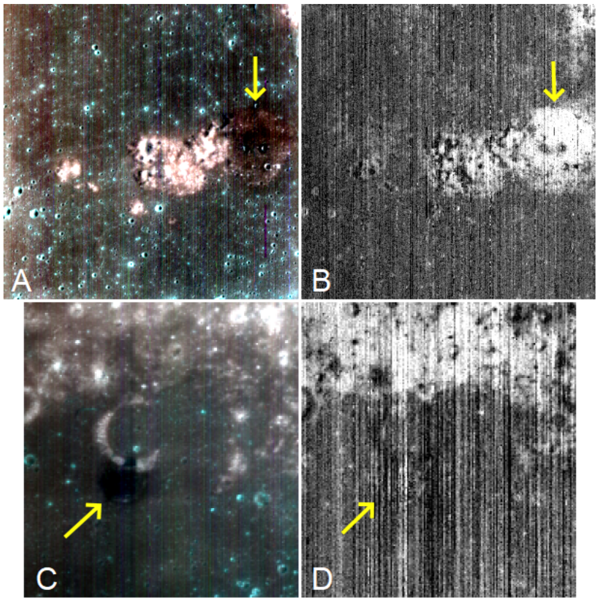

Fig. 2. A. M^3 color composite over Manilius-1 dome (right center, indicated by arrow). **B.** OHIBD image showing higher hydration band depth over dome. **C.** M^3 color composite over Yangel-1 dome (indicated by arrow). **D.** OHIBD image showing no increase in hydration band depth over dark mantle.

Photometry: An approach for assessing the photometric character of the lunar surface was adapted from that used for Mercury by [12] based on a combined photometric model from separate work by Kaaslainen [13] and Shkuratov [14]. A parameter related to roughness, labeled μ in [12] was calculated. **Fig. 3**. Shows a subsection over the Menelaus-1 dome from 6 phase angles of WAC data. This indicates lower roughness over the top of the dome, but greater roughness in an annular ring around the dome. Work on the photometric character of the other areas discussed here is on-going.

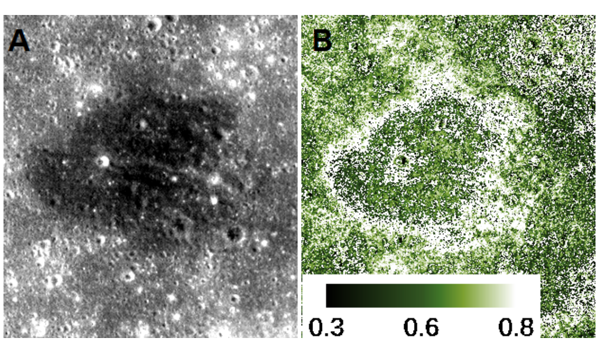

Fig. 3. A. WAC 415 nm band 40° phase angle over Menelaus-1 dome. **B.** μ roughness parameter.

Discussion: Compositional variability in both regional and localized LPDs has been amply demonstrated in numerous studies. The low CPR regions associated with domes and rilles that are examined here are potential pyroclastic deposits, and similarly show heterogeneity in their compositional and photometric character. Relatively high FeO wt. percents are observed for all but the Rima Calippus mantle as listed in **Table 1**. All but Yangel-1 and Cauchy-5 show 1 µm band centers longer than the surrounding mare and 2 µm band centers shorter than the surrounding mare. These two areas also do not show increased OHIBD in the data thermally corrected through the methodology of [8] while the others do show higher OHIBD values relative to surroundings.

Conclusions: These results indicate that mantles associated with some lunar volcanic domes and some rilles represent a previously unrecognized subset of localized lunar pyroclastic deposits. Behavior of 1 and 2 µm band center positions and increased OHIBD band depth are consistent with glass-rich compositions over all but the Yangel-1 and Cauchy-5 dome mantles. Yangel-1 also indicates an optically immature surface and Cauchy-5 has an associated irregular mare patch (IMP) hypothesized to be geologically young [15] possibly indicating a change in pyroclastic eruption styles over time.

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