SPECTRAL ANALYSIS OF LUNAR PYROCLASTIC DEPOSITS IN THE MONTES APENNINUS REGION. L.M. Pigue[1,2], K.A. Bennett[2], B.H.N Horgan[3], L.R. Gaddis[2,4]
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Introduction: Lunar Pyroclastic Deposits (LPDs) are the surface materials left on the Moon that have been produced by explosive eruptions. Spectral analyses of the composition and distribution of these volcanic deposits can reveal information about lunar formation and evolution because they are relatively pristine samples thought to be sourced from deep within the Moon. Their distribution in time and space captures information about changes in the composition, temperature, and structure of the lunar mantle and perched magma sources. In order to relate the surface expression of LPD compositions back to their source within the lunar interior, the degree and type of magmatic evolution prior to eruption and the style of eruption must be investigated.

We evaluated the mineralogy of LPDs (Table 1), sinuous rilles, irregular mare patches and other geologic features in the Montes Apenninus region. Spectra from the volcanic features were compared to adjacent mare and highland (specifically fresh exposures from recent impact craters) to examine potential compositional relationships. We used these data to constrain the eruption style of each LPD and compared compositions to determine whether the volcanic features in the study region share the same magmatic source.

Methods: We used data from the Moon Mineralogy Mapper (M^3) in its 85-band global mode [1] to spectrally map the Montes Apenninus region (0°N to 35°N and -10°E to 22°E, Figure 1). The data from the Planetary Data System were processed following the methods of [2] for spectral characterization, including suppression of the continuum due to factors including space weathering and smoothing the continuum to better evaluate spectral variations. We created spectral parameter maps designed to help identify key minerals (e.g., orthopyroxene, clinopyroxene and iron-bearing glass) and parameters to describe the position and shape of broad iron absorption features at 1µm and 2µm.

After data processing, we used ENVI to analyze spectra from Regions of Interest (ROIs) covering the 10 LPDs, as well as materials representing each LPD's geologic setting and other features of interest (e.g., nearby fresh craters, other volcanic terrains). The individual spectral parameter maps of targeted minerals were evaluated individually and were also overlaid on a Lunar Reconnaissance Orbiter Wide Angle Camera (LRO WAC) basemap in ArcMap. We also analyzed color composites of the spectral parameter maps and the 1µm band center and 2µm band depth (Figure 2).

Study Area: Montes Apenninus is a northeast-southwest trending chain of mountains that are part of the rim of the Imbrium basin. West of Montes Apenninus is the Apennine Bench Formation, a light plains unit determined to be older than the surrounding Mare Imbrium [3]. Ten LPDs have previously been identified within this study area, including examples classified by size as regional (>1000 km^2) and localized (<1000 km^2) [4].

LPD and identifier	Area (km^2)	Geologic Setting
1. Archimedes	<100	On a crater ejecta blanket
2. Beer	623	Apenninus bench
3. Hadley Cleft	898	Near sinuous rille
4. Mare Vaporum	4129	Mare
5. Mozart	589	Mare-filled valley
6. Rima Bode	6620	Near sinuous rille
7. Rima Fresnel	307	Highlands margin
8. S. Sinus Aestuum	10357	Mare margin
9. Sulpicius Gallus	4322	Mare margin
10. Mons Huygens	100	Highlands margin

Table 1: LPDs within the study area, their identifier in Figure 1a, area (in square kilometers, from [4]) and geologic setting within the region.

Results: The glass spectral parameter map shows increased absorption between 1.15 µm and 1.20 µm in most pyroclastic deposits that usually indicates increased glass signatures, but can also be due to olivine or feldspar; [2]), although the strength of the absorption varies between LPDs (Fig. 1). The variable glass signatures between LPDs could be consistent with variations in eruption styles and/or vigor [5]. This, along with variations in deposit mineralogy, roughness, and extent, could suggest that these LPDs came from magma sources that were different at the time of eruption or that the magma underwent different evolution during ascent.

Several LPDs are located along the outside perimeter of the mare basin (i.e. those identified in Table 1 as being on a mare margin), consistent with prior observations [6, 7]. These deposits typically exhibit stronger glass signatures than other LPDs and tend to be larger than the other deposits identified in this

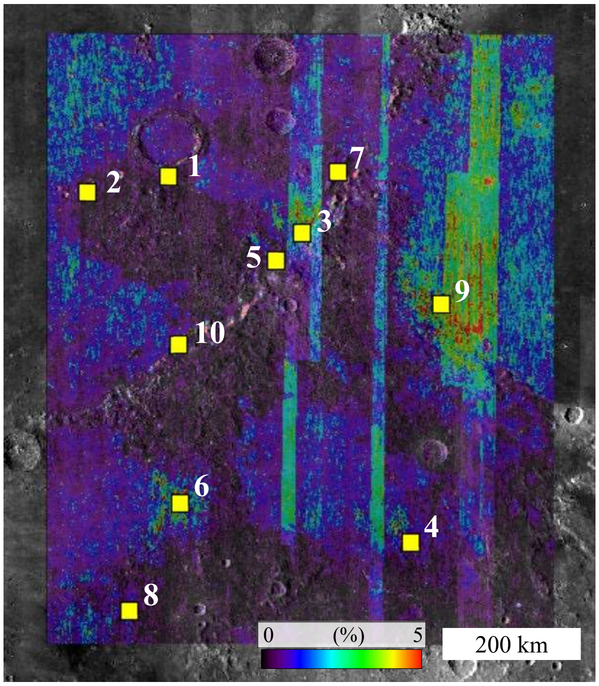

Fig. 1: Glass band parameter map mosaic (percent is glass band depth %) from M³ overlaid on LRO WAC mosaic basemap. Yellow squares are lat/lon positions of LPDs (identified in Table 1). The position of the point is either the deposit centroid or eruptive vent.

region (e.g., Beer and Archimedes). This observation is of interest as the stratigraphic and eruptive relationships between mare lavas and LPDs are complex; few deposits are identified in the interior of mare basins and few mare margin deposits are of a localized size classification [8]. Rima Bode LPD, on the margin of Sinus Aestuum, is superimposed by lava flows from the Rima Bode rille (Fig 2), and Sinus Aestuum lavas. This indicates Rima Bode LPD predates at least some of the mare fill.

Reevaluating LPDs in Montes Apenninus: Our investigation suggests there are previously unidentified LPDs in the study area and that some previously reported LPDs may not be composed of glass-rich pyroclastic materials. Spectral analysis of the Kathleen crater depression (the apparent "cobra head" vent of Mozart rille [9]; #5 in Fig 1) is consistent with an LPD, in addition to other depressions along Mozart rille.

Two previously identified LPDs do not have mineralogy consistent with typical pyroclastics: Archimedes and Mozart [10]. Archimedes is located south of the rim of Archimedes crater on a thick ejecta deposit (LPD #1 in Fig 1); no dark mantling is observed in this region in LRO WAC images and spectral characterization of this area is not consistent with an LPD; it lacks a glass signature and has a weak 2 µm absorption. Mozart LPD is identified as a "dark mantled valley" [10] (LPD 5 in Fig 1), however this region had a weak glass signature and did not contain other characteristic pyroclastic indicators (e.g. strong 2 µm band absorption).

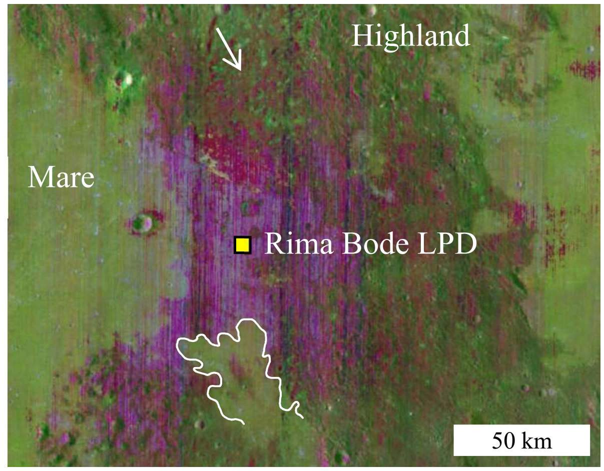

Fig. 2: RGB composite of spectral maps of Rima Bode LPD (yellow square, LPD #6 in Fig 1): R=1µm band center, G=2µm band center, B=glass band parameter. White arrow indicates pyroclastic (pinkish) mantling mixing with highland (dark green) materials; white boundary indicates lava flow margin associated with Rima Bode and smaller rille.

Interpretations and Future Work: With noted exceptions detailed here, LPDs analyzed in this region had high glass signature and were observed to have a lower albedo than the surrounding surface. Many of the LPDs in the study region were associated with rilles, but the relationship between the explosive volcanism of the LPD and the effusive volcanism of the rille varied between deposits. Detailed analysis of individual LPDs and the immediate surrounding area is ongoing to determine the extent of deposits, variations in mineralogy within a deposit, and eruption dynamics of volcanism in this region. Further analysis of volcanic features in the region is being conducted to understand the regional geology, relationships between various features, and determine igneous provenances of the LPDs and other volcanic features.

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