

MAFIC ANOMALY IN PTOLEMAEUS CRATER. J. L. Whitten¹, J. W. Head¹, C. M. Pieters¹, and W. M. Vaughan¹. ¹Department of Geological Sciences, Brown University, Providence RI 02912 USA (*jenifer_whitten@brown.edu*).

Introduction: Before the Apollo 16 mission to the central highlands, many believed that the Imbrium smooth light plains deposits (the Cayley Formation) were volcanic in origin [e.g., 1-5], possibly extrusive lava flows, ash-fall tuff or tephra [2, 4]. These plains have an intermediate albedo, reflecting a non-mare composition, are observed in topographic lows (e.g., crater floors), and generally appear to be as smooth as lunar mare in images [4]. Following the landing of Apollo 16, observations by Astronauts John Young and Charles Duke [6], and analysis of returned samples, it was clear that most of rocks were impact breccias [e.g., 7]. This revelation, coupled with experimental data, inspired the hypothesis that the smooth light plains were ponded fluidized basin impact ejecta [8], a hypothesis which has been called on to explain almost all the light smooth plains deposits on the Moon. In addition, many analyses have shown that impact crater and basin ejecta can cover up older mare deposits to produce cryptomaria [e.g., 9-11]. These are readily recognizable by their mare basalt-like soils and superposed dark-halo craters.

It is also known that magmatic activity occurred prior to the formation of mare basalts and cryptomaria; these include the Mg-rich suite, low-potassium Fra Mauro and KREEP basalts [12]. Could there have been multiple formation processes that produced light smooth plains deposits, both impact related and extrusive volcanic in nature?

Several non-mare/non-cryptomare smooth plains regions on the Moon have been identified as mafic-rich, including a region north of the Imbrium basin [13] and parts of the interior of South Pole-Aitken basin

[14]. There are several hypotheses that could explain an anomalously high mafic signature, including inherent crustal heterogeneities, impact ejecta/melt and volcanic activity. We have identified an additional region with an enhanced mafic spectral signature, on the floor of Ptolemaeus crater to the northeast of Mare Nubium in the central highlands (Fig. 1). Could this ~150 km wide deposit represent early highlands effusive non-mare volcanism?

Study Region: The western edge of the south-central highlands has four large craters, Ptolemaeus (158 km), Alphonsus (110 km), Albategnius (131 km) and Hipparchus (144 km), all with Imbrian plains mapped as their floor deposits [5]. In this area, just south of the Imbrium impact basin, the plains deposits have been interpreted to be fluidized ejecta emplaced during the Imbrium basin impact [8]. This hypothesis is supported by their rims having linear grooves radial to Imbrium. The floors of each of these craters vary in albedo, with the Ptolemaeus floor deposits having the lowest albedo (Fig. 1, red circle), followed by Alphonsus and Albategnius, and Hipparchus having sequentially higher albedo floors.

Methods: Moon Mineralogy Mapper (M³) data [15] from optical period 1B are analyzed to determine the composition of the anomalous low albedo deposits in Ptolemaeus crater. We use level 2 reflectance data with the ground truth correction applied. Initially, parameter maps were used to identify potential mafic anomalies and to then use spectra to determine if the anomaly is noritic (short 1 μ m absorption) or basaltic (long 1 μ m absorption). Parameters such as the integrated band depth at 1 μ m and 2 μ m, the 1 μ m band

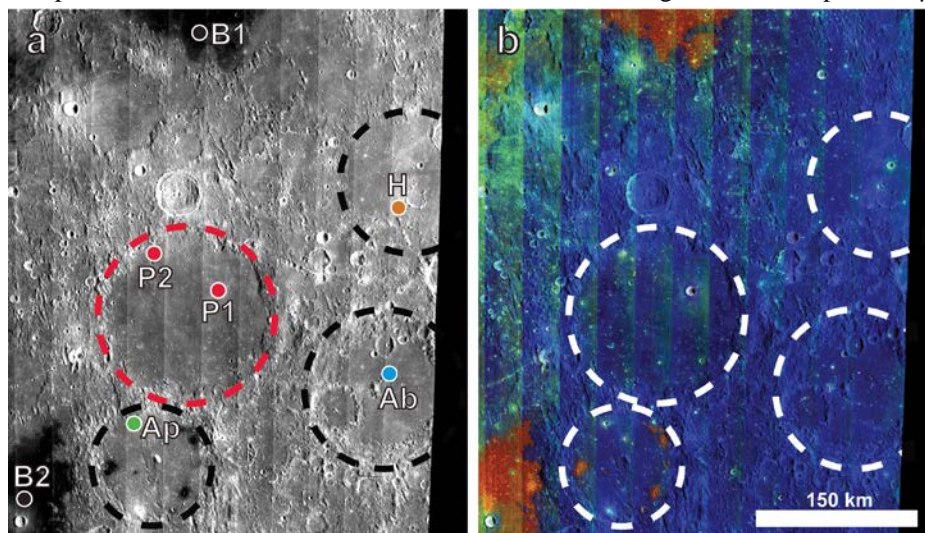


Figure 1. Study region of archetypical Cayley Plains deposits, including the craters Ptolemaeus (red), Alphonsus, Albategnius and Hipparchus. a) M3 OP1B 1489 nm (band 46), comparing the lower albedo of Ptolemaeus' floor deposits with the higher albedo floors of Alphonsus, Albategnius and Hipparchus. Colored dots represent the locations of spectra in Fig. 2. b) M3 mafic color composite (R: 1 μ m integrated band depth, G: 2 μ m integrated band depth B: reflectance at 1849 nm) showing the enhanced mafic signature of the floor of Ptolemaeus (green color).

strength, and band depths at various wavelengths (e.g., 950 nm, 1050 nm, 1900 nm and 2300 nm) are used in our analysis. Spectra were collected from small craters superposed on the floor of the four craters in question.

Results and Discussion: Analysis of the study region with M³ data reveals that the floor of Ptolemaeus crater is characterized by an enhanced noritic signature in the floor soils. Small craters (<10 km diameter) superposed on the plains on the floor of Ptolemaeus, such as Ammonius, show strong noritic absorption features (Fig. 2). A comparison with regional mare basalt spectra reveals short wavelength pyroxene absorption features. The Ptolemaeus crater rim does not show any indication of the same enhanced mafic signature (Fig. 1b). The other three craters, Alphonsus, Albategnius and Hipparchus, also have small floor craters with noritic signatures (Fig. 1a, 2), but the crater floor soils do not have a mafic-rich signature. Lunar Prospector data of the region show an enhanced thorium signature on the floor of Ptolemaeus (Fig. 3). What could cause there to be a concentration of noritic soils and a thorium enhancement on the Ptolemaeus floor, but not these other three adjacent craters?

Of the three main formation hypotheses (e.g., crustal

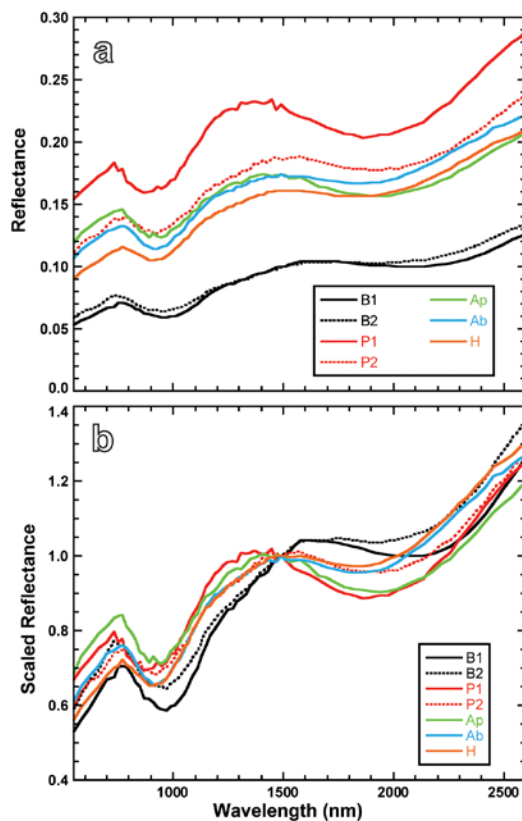


Figure 2. a) Spectra collected from locations identified in Figure 1a. Note that the colored spectra have a short 1 μ m band center compared to the black spectra. b) Spectra from part a scaled to 1489 nm to better see the difference in the position of the 1 μ m band centers.

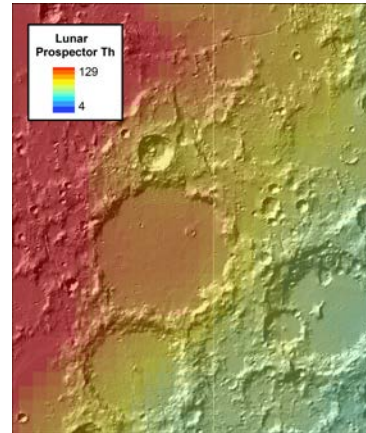


Figure 3. Lunar Prospector thorium map of the study region with an enhanced thorium signature in Ptolemaeus crater, compared to Alphonsus, Albategnius and Hipparchus craters.

tal heterogeneities, impact ejecta and volcanism) we suggest a plausible option is volcanic activity. If this region was characterized by subsurface crustal heterogeneities, such as plutons, or was affected by Imbrium impact ejecta of a unique local composition, then the mafic anomaly would be expected to cover a broader, more random area. Instead, the mafic anomaly (Fig. 1) corresponds closely to the crater floor, consistent with what would be expected from extrusive volcanic activity embaying the crater interior and walls. The enhanced thorium anomaly in Ptolemaeus is consistent with volcanic rock types [16]. Therefore, we propose that extrusive volcanism is a plausible explanation in this scenario. This candidate extrusive noritic unit on the floor of Ptolemaeus crater was subsequently covered with Imbrium basin ejecta. Vertical mixing of these two units then caused the observed characteristic mafic-rich soils.

Could Mg-suite derivative magmas erupt onto the lunar surface? Separate analyses have shown that, unless the source region of the parental melt is shallow (10-20 km below the crust-mantle boundary) such magma would be expected to erupt [17]. Therefore, the presence of extrusive non-mare volcanics provides one plausible explanation for the spectral observations in Ptolemaeus crater.

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