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A reassessment of the volcanic history of western South Pole-Aitken Basin based on geologic mapping

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Abstract

Geologic mapping of west South Pole-Aitken (SPA) indicates a larger area covered by volcanic deposits; and a greater diversity in mode of emplacement of volcanic deposits than reported in previous work. Understanding the nature and stratigraphy of lunar volcanic activity will ultimately provide constraints on models of lunar volcanic generation and evolution.

1. Introduction

Constraining physical and mechanical models of lunar volcanic processes requires a full inventory, characterization and stratigraphic analysis of volcanically-produced surface materials. To this end, we are constructing a 1:2,500,000-scale map of Planck Quadrangle or Lunar Quadrangle 29 (Figure 1), which includes west SPA. Previous maps of the region [1, 2] were based on Lunar Orbiter images, which in most cases were oblique, low-resolution images and in every case did not contain mineralogical or elemental information. In this investigation, we document the stratigraphy, extent and characteristics of west SPA by incorporating regional morphology, composition, topography, elevation and elemental abundance data.

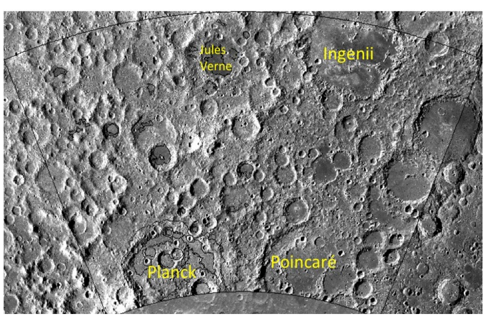

Figure 1: Planck Quadrangle (outlined in black) with large impact structures noted.

2. Geologic setting

West SPA is dominated by the western portion of the pre-Nectarian South Pole-Aitken Basin. This basin is the largest recognizable impact structure in the Solar System, as well as being the oldest and deepest [e.g., 3]. The basin floor is dominated by multiple, overlapping impact structures from sizes below resolution to over 600 km across.

Previous work [1, 2] identified mare deposits as the primary volcanic product in the region. These mare deposits were dated as Imbrian-aged and mapped as discrete, non-contiguous deposits [4] occurring exclusively within or breaching the rims of craters or basins (areas of low crustal thickness). Based upon assessment of the morphology and subsequent compositional analysis, the composition of these ponds was interpreted as likely basaltic, similar to the nearside maria, but low in mafic material such as Fe and Ti (possibly due to vertical or lateral mixing of non-mare soils beneath these thin, areally small deposits). Potential pyroclastic deposits were mapped only in basins such as Poincaré. Cryptomare material (patches of basaltic material buried or mixed into the regolith as a result of impact activity) does not appear in previously-published geologic maps of the region [1, 2].

3. Data sets and methodology

In this mapping study, morphology was determined using ~100 m/pixel Lunar Reconnaissance Orbiter Camera (LROC) images as the basemap (Figure 1). Clementine multispectral data was also utilized to extract compositional information. Coverage includes ultraviolet/visible (UVVIS; 5 bands between 415 and 1000 nm) and near-infrared (NIR; 6 bands between 1100 and 2780 nm) data. We examined the 750/950 nm, 750/415 nm, and 415/750 nm band ratios. The 750/950 nm ratio indicates FeO content; the deeper the absorption feature, the greater the FeO content. The other band ratios measure the “continuum slope;" the younger the soil, the flatter the slope. Data acquired by the Lunar Orbiter Laser Altimeter (LOLA) yields topographic data at 100 m/pixel. This topographic dataset represents the most refined spatial and vertical (~1 m/pixel) resolutions acquired for the Moon.

Volcanic deposits were identified based on albedo, texture, morphology and spectral signature. Smooth, low-albedo surface materials with relatively sharp boundaries and elevated mafic content were mapped as mare deposits. Rougher surface deposits with very low albedo, diffuse or irregular boundaries, and elevated mafic content were mapped as pyroclastic deposits. Areas of heightened mafic content that otherwise showed little or no morphologic indication of volcanic origin were considered potential candidates for cryptomare materials and were tagged for further study.

4. Results

Using these data sets, we identified ~40 potential volcanically-emplaced surface deposits. This total includes 22 smooth, low-albedo, higher-Fe deposits we interpret to be mare deposits or ponds, and ~18 rougher, very low-albedo, higher-Fe materials with irregular, diffuse boundaries, that we interpret to be pyroclastic materials. The uncertainty in the number of pyroclastic materials stems from the diffuseness of the boundaries of the majority of these deposits; it is not always clear whether a deposit should be divided into multiple discrete deposits. Several candidate areas for the presence of cryptomare materials were also identified, including small patches in Planck.

We confirm the previous identification of most mare units based on morphologic characteristics, though we have refined the boundaries of some of these deposits using higher resolution morphologic data, Clementine compositional data, and LOLA-derived topographic data.

However, in the work presented here we have identified additional mare materials, as well as several previously unmapped pyroclastic deposits. For traditional mare materials, our mapping indicates that 5% should be added to the previous areal total, due to the refining of boundaries and redefining of 1-2 smooth plains deposits as mare deposits. Additionally, we preliminarily add 3,000-5,000 km^2 of areal coverage to the volcanic inventory in the form of pyroclastic deposits. A greater surface area of west SPA is thus covered with volcanics than previously mapped. This increased area implies a higher volcanic flux.

Higher resolution also reveals finer features than were previously identifiable, that may inform volcanic history. These include potential individual flows, wrinkle ridges, and fractures associated with pyroclastic deposits.

5. Summary and Conclusions

A larger area than previously indicated is covered by volcanic deposits; this would potentially place new constraints on our understanding of the global lunar thermal budget. We are refining crater frequency-derived ages to determine whether the period of volcanic activity in this area may be extended in time as well as space.

We infer from the broader morphologic range of identified and mapped volcanic products that mode of emplacement of volcanic deposits (an indication of conditions at depth) was more diverse in west SPA than previously assumed. Association of fractures with low-albedo deposits interpreted to be pyroclastic deposits might indicate a tectonic mechanism for emplacement, such as near-surface dike emplacement.

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References

[1] Stuart-Alexander, D.: Geologic map of the central far side of the Moon, U.S. Geol. Surv. Map, I-1047, 1978.

[2] Wilhelms, D. et al.: Geologic map of the south side of the Moon, U.S. Geol. Surv. Map, I-1162, 1979.

[3] Wilhelms, D.: The Geological History of the Moon, U.S. Geol. Surv. Prof. Pap., 1348, 302 pp., 1987.

[4] Yingst, R. A., et al.: Volumes of lunar lava ponds in South Pole-Aitken and Orientale basins: Implications for eruption conditions, transport mechanisms, and magma source regions, JGR, 102, 10909-10931, 1997.