EPSC Abstracts
Vol. 6, EPSC-DPS2011-1561-2, 2011
EPSC-DPS Joint Meeting 2011

Mare, Cryptomare, and Nonmare Plains Units in the South Pole-Aitken Basin Interior

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Abstract

The interior of South Pole-Aitken basin has a distinctive geochemical signature discovered from orbital compositional measurements. The deep basin interior contains extensive plains deposits, some of which are clearly volcanic and others that are deposits from large impact craters that penetrated into the SPA basin substrate. Image data from the Lunar Reconnaissance Orbiter Cameras and digital terrain models generated from the image data are used to distinguish areas of mare and cryptomare from impact-generated plains deposits. We find that compositional data are a poor discriminator of these different types of deposits, which supports the likelihood that crater ejecta deposits are mafic and reflect the substantial contribution of SPA impact-melt rocks to the regolith.

2. Introduction

Although MoonRise [1] was not selected by NASA for the New Frontiers 3 opportunity, returning a sample from the South Pole-Aitken (SPA) basin remains a high priority for planetary exploration in the decade 2013-2022 according to the US National Research Council Decadal Survey [2]. It is therefore important to continue work investigating the nature of SPA Basin deposits, looking ahead to future opportunities. The driving science objective of MoonRise was to sample the SPA impact-melt complex and to determine the age of the SPA event, and thereby test and constrain the “cataclysm hypothesis” [3] by determining the age of the oldest recognized lunar impact basin. This test has significant implications for early Solar System history and evolution, including early formation of crusts on the terrestrial planets and moons of the giant planets, migration of the giant planets, and effects on early, potentially habitable environments at a time when life may have been beginning to take foothold on Earth and possibly elsewhere in the Solar System.

To ensure the collection of SPA-generated crystalline impact melt, MoonRise targeted sites in the deep interior of the SPA basin where the geochemical signature of the basin is strong, i.e., mafic. Here, we investigate the source of the compositional signature. Recent image data provides a new look at the basin interior deposits, especially mare basalt and cryptomare, i.e., buried, ancient lavas. At issue is the question of how much of the mafic signature is a result of these volcanic deposits as opposed to impact-ejected rocks that represent the original SPA basin formation.

2. Elevation Data

The LRO Wide Angle Camera (WAC) [4] has imaged SPA at multiple incidence angles and provided stereoscopic measurements to derive a digital terrain model (DTM), useful for investigating surface morphology and deposit thicknesses. Here, we focus on topography related to mare lavas, cryptomare, and nonmare plains deposits. We use the 100 m grid LROC WAC stereo DTM (GLD100) [5]) to compare topography associated with these deposit types [see 6] and to assess plains deposit thicknesses.

Examples of elevation profiles for regions of interest (ROI) where surface features indicate (1) mare, (2) cryptomare, and (3) by inference, plains deposits that are neither (1) nor (2) are shown in Fig. 1. Mare ROIs include small areas such as those filling craters and low terrain N-NE of Bose Crater, as well as S-SW of Bose. Areas of cryptomare include extensive regions NE of Bhabha Crater and N of Stoney Crater. Profiles of elevations in mare deposits are very flat and smooth. In several profiles, regional slopes are evident, but these involve smooth elevation changes of typically only 200 m or less over distances on the order of 50 km. Profiles across areas mapped as cryptomare are smooth in image views, but they are not as visibly dark as the more recent surface mare flows. When viewed in profile, their elevations are more variable than the mare surfaces. Plains areas, mapped neither as mare nor cryptomare on the basis

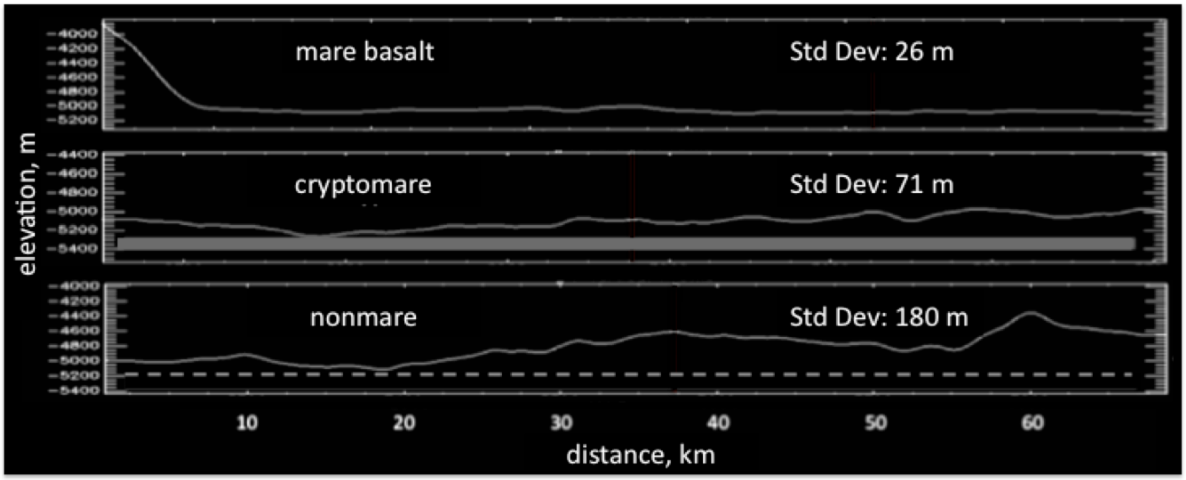

Figure 1: Example profiles for the three deposit types. Note different scales. Gray bar in cryptomare profile and dashed line in nonmare profile represent hypothetical cryptomare levels.

of morphology are characterized by more irregular topography. Elevation profiles indicate that these areas have deposit thicknesses ranging up to 500 m or more over the elevation where cryptomare would be if it extended beneath these deposits (Fig. 1).

3. Compositional Data

Clementine UV-VIS [7] and Lunar Prospector gamma-ray spectrometer data (LP-GRS) [8] indicate the SPA basin interior has typical FeO concentrations that lie between known basin impact-melt rocks (8-10 wt.% FeO) and typical mare basalts (17-22 wt% FeO). LP-GRS data do not distinguish the three surface types probably owing to the large footprint

	Mean		Std Dev		95% Conf	
	LP-GRS	Clem UV-VIS	LP-GRS	Clem UV-VIS	LP-GRS	Clem UV-VIS
Mare	11.20	15.00	0.38	1.25	11.9-10.5	17.5-12.6
Cryptomare	11.80	13.30	0.57	0.92	12.9-10.7	15.1-11.5
Nonmare	10.30	13.00	0.56	1.08	11.4-9.2	15.1-10.9

Table 1: Compositional data for the three different deposit types

and broad spatial response function. Clementine-derived compositions discriminate mare units as having the highest FeO, as expected, but do not discriminate areas of cryptomare from non-mare plains deposits (Table 1). This comparison indicates that although plains deposits may have a component of mare basalt mixed in the regolith, the nonmare deposits are themselves mafic and are not simply dominated by basaltic materials.

4. Conclusions

Understanding the distribution of cryptomare and the thickness of nonmare plains deposits is important in assessing the mixture of materials likely to be in the regolith. The deep, central part of SPA contains a significant area covered by ancient mare flows, probably more than was appreciated before the recent remote sensing missions. However, plains ejecta deposits from many large impact craters that excavated through the volcanics have produced deposits of hundreds of m thickness over much of the region and these are composed of a substantial proportion of mafic SPA-derived impact materials.

Acknowledgements

We thank the LROC science and operations team for data acquisition and processing, and the LRO Project, NASA and DLR for support.

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