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Magnetization Distribution for the Schlüter P. Lunar Magnetic Anomaly

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Abstract

Using magnetic field data measured during three low altitude passes of the ARTEMIS P1 probe over the same region of the Moon, we are able to identify and characterize a weak magnetic anomaly in the vicinity of the Schlüter P. crater. The measurements are done in quiet solar wind conditions on the night side of the Moon while the second ARTEMIS spacecraft is used to simultaneously monitor the variations of the interplanetary magnetic field. The measured magnetic field is then compared with the terrain elevation from Lunar Reconnaissance Orbiter and with the gravitational field derived from the GRAIL spacecraft observations. We find that the magnetic field variations show a dependence on the terrain elevation and also on both the free air and the Bouger gravitational anomalies. This indicates that the surface magnetization follows the terrain and that the layer just below the terrain is characterized by patchy magnetization closely related with the density variations.

1. Introduction

Even though the first measurements of the lunar crust magnetization were done in the Apollo era [11, 6] and in the last two decades high resolution mapping of the lunar surface field was realised based on Lunar Prospector [4] and Kaguya [8] data [12, 9], the relation between the lunar crust magnetization and the surface features remained elusive. The concentration of strong magnetic anomalies at the antipodes of large impact basins [7] can be explained by compression of the pre-existing ambient magnetic field by the plasma cloud created by the impact converging towards the antipode. The impact basins themselves exhibit low magnetization, as do in general the smaller impact craters too [12].

Comparing crustal magnetization models with the Lunar Prospector data shows that the magnetized sources in the lunar crust can be represented by a magnetized layer with the thickness of about 30 km and average magnetization of 30-40 mA/m [5]. The distribution of the magnetized material within this layer is less known. On one hand, large scale magnetic anomalies, observable from the orbit, require the presence of strong coherent remnant magnetization sources. On the other hand, fields measured by the Apollo surface magnetometers have shown a great variety in strength and orientation on km scales, suggesting localized sources close to the surface [6]. We show that - for the Schlüter P. magnetic anomaly - there is a correlation between the elevation of the Moon's surface and the magnetic field measured on orbit. This proves that the near-surface magnetization contributes to the large scale magnetic anomaly. We also show that deeper magnetized sources, associated with density variations bring a comparable contribution to the Schlüter P. magnetic anomaly.

2. Data

After the initial phase of the THEMIS mission [1] was completed in 2009, two of the five spacecraft were sent to the Moon to form the ARTEMIS mission [2]. In this work we use magnetic field data measured by the FGM instrument [3] onboard these probes. Due to their highly elliptical equatorial orbits, the low altitude segments of the orbits were grouped only in four areas in the equatorial region. Up to now, we counted only 47 orbits having a periselene lower than 45 km AGL. To be able to separate the magnetic field originating from the crust from external fluctuations, we select only the intervals when the Moon was in the pristine solar wind and the measurements were done on the night side. This leaves us with only 16 orbit segments. Three of them, illustrated in Fig. 1 show high correlation between the measured magnetic fields.

The Lunar Reconnaissance Orbiter Camera [10] data obtained from the NASA Planetary Data System

(PDS) was used for the surface elevation. The lunar gravitational field data, also obtained from PDS, was delivered by the Gravity Recovery and Interior Laboratory (GRAIL) mission [13]

3. Schlüter P. magnetic anomaly

In the vicinity of the Schlüter P. crater, located on the equator, north of Mare Orientale we identified a weak magnetic anomaly revealed by the correlation between the measured magnetic field along three orbit segments with the closest approach of 12, 20, and 29 km AGL, respectively. The maximum peak to peak variations of the measured magnetic field were in the order of 4 nT. From measurements at different altitudes, if we assume a cubic decay of the field intensity, we can associate the strongest field variation with an equivalent dipole buried 13 km below the surface and producing a surface field of about 36 nT. The magnetization corresponding to a magnetized sphere centred on the dipole and touching the surface would be about 80 mA/m.

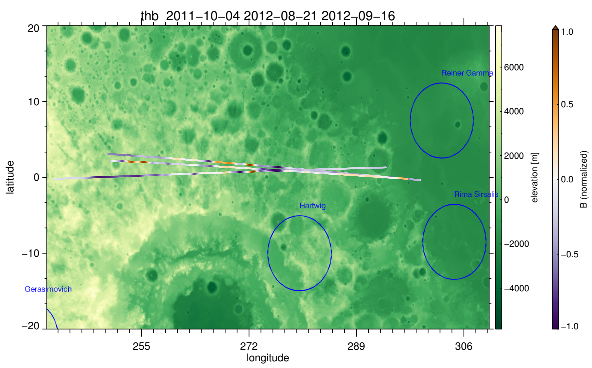

Figure 1: ARTEMIS orbit segments below 100 km over the Schlüter P. magnetic anomaly. The background image shows the terrain elevation from LRO data, The orbit colour represents the measured magnetic field, and the blue markings show known magnetic anomalies

4. Magnetization distribution

One way to obtain information on the distribution of the magnetized material below the lunar surface is to establish if there is a relation between the magnetic field measured on orbit and variations in the terrain elevation and in the lunar gravitational field. This can be done by analysing the phase difference between the measured magnetic field and the quantities named above. We obtained the time and frequency dependent phase shift from the cross-spectrum between the magnetic field and the elevation and gravitational field variations, respectively. We found that, far from being random as expected for un-related quantities, the phase shift was consistently close to the same value for the three tested orbit segments for all relevant frequencies. This holds true for the elevation, free air and Bouger gravitational anomalies.

By comparing our results with possible combinations of uniform and patchy distributions of the subsurface magnetized material and density, we are able to show that near-surface magnetization has a significant contribution to the overall magnetic anomaly. At the same time, magnetized sources correlated with density variations in deeper layers generate much of the magnetic anomaly field.

5. Summary and Conclusions

A new magnetic anomaly close to the Schlüter P. lunar crater was identified from ARTEMIS magnetic field data. The anomaly is rather weak, with surface fields in the order of 30 nT.

The magnetic field variations are correlated with the terrain elevation, with the free air gravitational anomaly, and with the Bouger gravitational anomaly.

The sources of the Schlüter P. magnetic anomaly are distributed both near the lunar surface, following the terrain, and in the depth, where the magnetization is closely related with the crust density variations.

References

[1] Angelopoulos, V. *Space Sci Rev*, pp. 47–+, 2008
[2] Angelopoulos, V. *Space Sci Rev*, pp. 114–137, 2010
[3] Auster, H. U., et al. *Space Sci Rev*, pp. 73–+, 2008
[4] Binder, A. B. *Science*, 281:1475, 1998
[5] Carley, R. A., et al. *JGR Plan*, 117(E8), 2012. E08001
[6] Dyal, P., et al. *Science*, 169:762, 1970
[7] Hood, L. L. and Vickery, A. In *Lunar Plan. Sci. Conf. Proc.*, vol. 15, pp. C211–C223. 1984
[8] Kato, M., et al. *Space Sci Rev*, 154:3, 2010
[9] Richmond, N. C. and Hood, L. L. *JGR Plan*, 113:E02010, 2008
[10] Robinson, M. S., et al. *Space Sci Rev*, pp. 81–124, 2010
[11] Runcorn, S. K., et al. *Geochimica et Cosmochimica Acta Supplement*, 1:2369, 1970
[12] Tsunakawa, H., et al. *JGR Plan*, 120:1160, 2015
[13] Zuber, M. T., et al. *Space Sci Rev*, pp. 3–24, 2013