

THE REINER GAMMA ALBEDO MARKING ON EARTH'S MOON: OLD OR YOUNG?. J. B. Nicholas¹, M. E. Purucker² and T. J. Sabaka², ¹Washington International School (3100 Macomb St. NW, Washington, DC 20008), ²Raytheon at Planetary Geodynamics Laboratory, NASA Goddard Space Flight Center, Greenbelt, MD 20771, (Code 698, purucker@geomag.gsfc.nasa.gov).

Summary: One of the largest lunar magnetic features is closely associated with the Reiner Gamma albedo feature. Explanations for this coincidence posit a recent cometary impact, or differential space weathering of a much older feature. Using magnetometer data from Lunar Prospector, we find that the minimum magnetization necessary to explain the observations varies from 100 A/m for a 10 m thick layer, to 1 A/m for a 1 km thick layer. Magnetic sources appear to be magnetized in a north-south direction, and be shallow, within a few km of the surface. The strength of the magnetization is spatially related to the albedo of the feature. The magnetic results point towards an origin of the albedo feature as a consequence of retarded ageing under the umbrella of the Reiner Gamma mini-magnetosphere. In this interpretation, the magnetic field signal is ancient, possibly due to basin impact ejecta.

Introduction: Reiner Gamma (Figure 1) is a swirl, an albedo marking that characteristically exhibits winding or sinuous patterns

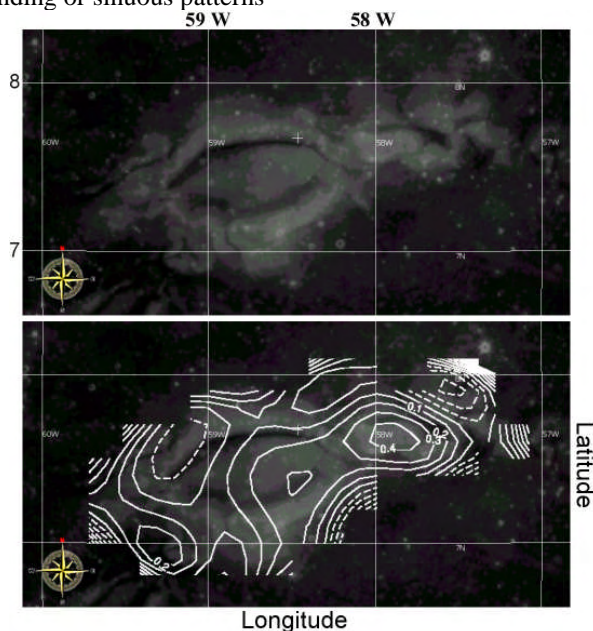


Figure 1. Gray-scale image showing the main part of Reiner Gamma. The overlay in the lower part of the figure shows the magnitude of the magnetization, on the assumption that the magnetization lies in the N-S plane. Solid lines are positive, dashed lines are negative. Contours lines are at 0.1 A/m intervals.

There are two models for the origin of the albedo markings, as the relict of a recent (<1 Myr old) cometary impact [1],[2], or related to the deflection of the solar wind [3],[4].

Data: The magnetometer data were selected from the six quietest days, 5 in the lunar wake, and 1 in the earth's geomagnetic tail lobe. The data is the same as [5], who characterized the mini-magnetosphere over Reiner Gamma. The electron reflectometer data [6] confirm the location and strength of the Reiner Gamma anomaly, but are not used here.

Model:

External magnetic field. A simple model of the external field, that of a uniform field over each satellite half-orbit, was removed from the observations. The resulting vector fields are shown in Figure 2. Note that fields of internal origin appear on multiple passes because of the spacing of adjacent passes, and their altitude above the surface.

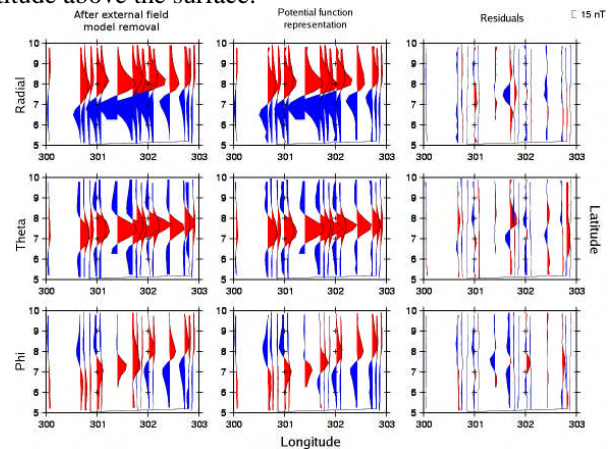


Figure 2. Stacked profile plots showing (left) the actual magnetic field after external field model removal, (middle) the modeled internal component, and (right) the remaining unfit field. The RMS values for the Radial, Theta, and Phi residuals are 1.99, 2.43, and 1.65 nT, respectively.

Minimum magnetization. Ideal body analysis [7] systematizes the process of placing bounds on the distribution of magnetization via the minimization of the infinity norm of the magnetic intensity within the source region. Figure 3 shows the minimum magnetization required for a given layer thickness, irrespective of the magnetization direction.

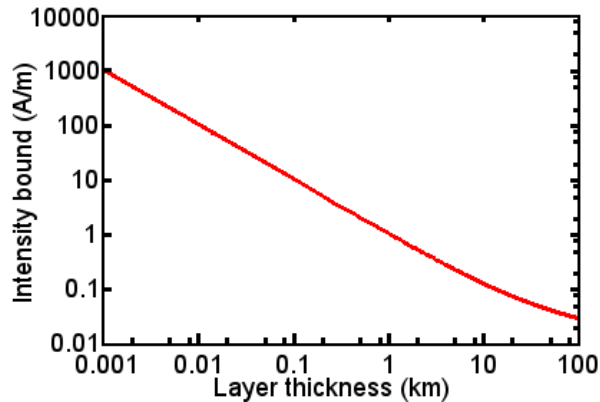


Figure 3. Minimum source magnetization required to explain a field magnitude of 49.078 nT at an altitude of 18.52 km

Magnetic directions and depth to source: As shown in Figure 2, the magnetic field is horizontal over the center of Reiner Gamma, and bounded to the north and south by steeply dipping fields. This feature is most simply interpreted in terms of a body with a horizontal, N-S oriented magnetization approximately coincident with the Reiner Gamma feature. The depth to the magnetic source was calculated by varying the depth of a grid of dipoles, and finding the minimum in a plot of RMS misfit vs depth below the surface. The radial component data yields a calibrated depth to source of 1 km below the surface. The radial field has the highest signal/noise ratio as shown in Figure 2, and is unaffected by magnetic boundary effects often seen in the horizontal components.

Discussion: The shallow source is consistent with previous studies [5] using different approaches. The shallow source is most simply explained as a near-surface ejecta layer, perhaps from Imbrium [9], or as a cometary impact. An ejecta layer would require magnetizations of 1 A/m if it were 1 km in thickness, or 10 A/m if it were 100 m in thickness. The dominant magnetic remanence carriers on the moon are native iron-bearing alloys, and such magnetization strengths have been reported in previous studies [10]. The spatial relationship of the inferred magnetization strength (Figure 1) with albedo is suggestive of an origin related to ageing in the solar wind. The minimum magnetization required to explain the feature argues most strongly for an ageing origin. Magnetizations in excess of 1000 A/m would be required to explain a realistic thickness of cometary debris, say 1 m in thickness. Such strong magnetizations have never been encountered in nature over such a wide area.

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Additional Information: Further information can be found at our web page http://geodynamics.gsfc.nasa.gov/personal_pages/purucker/purucker.html and in a GRL paper [8] in press