FURTHER CONSTRAINTS ON THE HISTORY OF THE LUNAR DYNAMO FROM LUNAR PROSPECTOR MAGNETOMETER DATA.

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Introduction: Previous work has shown that lunar crustal magnetization has a combination of origins including shock remanent magnetization (SRM) in transient magnetic fields and thermoremanent magnetization (TRM) in a steady core dynamo magnetic field [1,2,3,4]. In particular, magnetic anomalies within the interiors of impact basins demonstrate that a core dynamo existed during the Nectarian epoch and provide the best available means using orbital data to constrain the history of the former dynamo [4,5]. This is because (a) the subsurface magnetization within basin interiors was almost certainly acquired via slow cooling in a steady magnetic field (as opposed to SRM in a transient field); and (b) the time of magnetization acquisition was the time of formation of the basin and is therefore determinable. Here, we build upon the work of [4,6] to analyze low-altitude Lunar Prospector (LP) MAG data to provide further constraints on the period of operation of a former core dynamo. Specifically, we investigate whether anomalies exist within younger late Nectarian- and Imbrian-aged basins that may imply persistence of the dynamo to later times.

Method of Analysis: For a series of selected lunar basins of late Nectarian and Imbrian age, all available orbit segments for altitudes < 40 km passing within 500 km of the basin rims were selected. Only those passes containing repeating signatures on successive orbits indicative of crustal fields were retained. Long-wavelength external fields were further minimized using a quadratic detrending procedure [4]. All field components (radial, east, and north) were examined. However, the radial component was examined first because (a) local (dominantly dipolar) field sources typically have stronger radial anomalies; and (b) the radial component is less affected by external fields. When possible, these field components were directly mapped on a surface defined by the slowly varying spacecraft altitude.

Results: As previously reported in [4], magnetic anomalies are present within the interiors of four Nectarian-aged basins that imply the existence of a core dynamo during this epoch (Moscoviense, Mendel-Rydberg, Humboldtianum, and Crisium). The anomalies were identified as genetically associated with the respective basins because they were either located at the basin center or were distributed around the basin center (Crisium). Moreover, one of the Crisium anomalies was modeled and was found to have a paleomagnetic pole position not far from the present rotational pole, consistent with expectations for a terrestrial-type core dynamo. In the present work, we have examined orbit segments for lunar basins younger than Serenitatis and excluding Bailly, which was studied in [4]. These include Serenitatis, Hertzsprung, Sikorsky-Rittenhouse, Imbrium, Schrödinger, and Orientale. In the case of Orientale and Imbrium, the two largest young basins, no detectable crustal signature was identified using available clean passes, which covered much of the basin interiors. In the case of Sikorsky-Rittenhouse, only partial coverage of relatively clean low-altitude passes was available so the existence of interior anomalies is uncertain. In the case of Hertzsprung, clean passes were available from July 1999 but the minimum altitudes (> 50 km) were too high to investigate weak central anomalies. In the cases of the late Nectarian basin Serenitatis and the Imbrian-aged basin Schrödinger, interior anomalies of crustal origin were identified.

Figure 1:

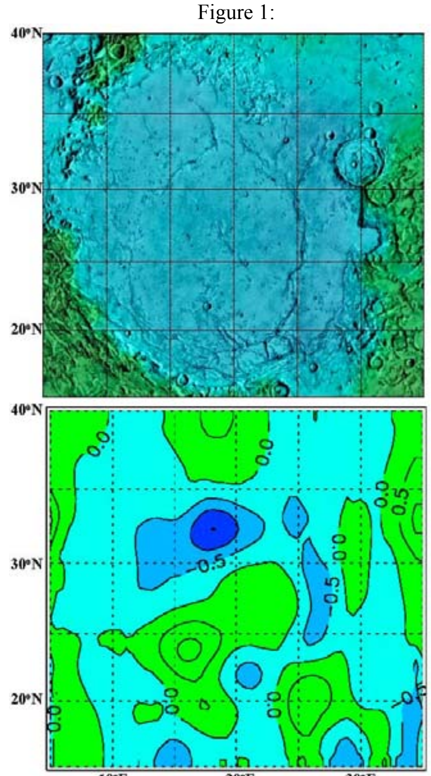
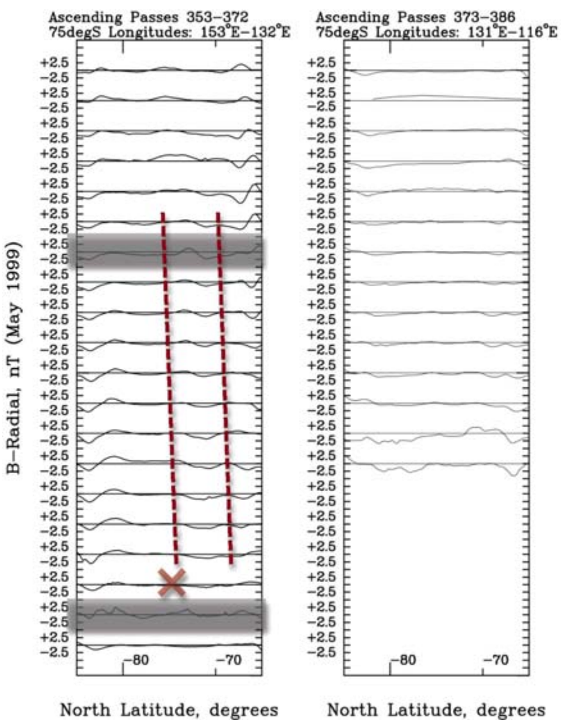


Figure 1 compares a Clementine LIDAR shaded relief map of the Serenitatis region to a preliminary map of the radial field component measured on a series of passes from May 1999 at the LP altitude (smoothly increasing from ~ 34 to 40 km from left to right across the map). The contour interval is 0.5 nT and negative values are shaded blue. The 2D smoothed maximum field amplitude for these anomalies is ≤ 1.5 nT, which is weaker than that of other observed interior basin anomalies [4]. The anomalies are confirmed as lunar in origin by repetition on successive orbit passes. They resemble those within Crisium in that there is no single anomaly at the basin center; rather, they are distributed around the basin center.

Figure 2:



The Schrödinger basin is centered in the south polar region near 75°S, 134°E. It is considered to be slightly younger than Imbrium according to [7]. The main rim extends from ~ 70°S to 80°S and from ~ 120°E to 150°E. Figure 2 shows a series of low-altitude passes over this basin using LP data from May 1999. At 75°S, the altitude is ~ 23 km. The two vertical lines bracket a small negative anomaly that is centered near 73°S, 137°E. The X symbol marks the approximate center of the basin. Thus, these anomalies lie well within the basin rim but are offset somewhat to the east of the center. A preliminary map of the field components over this basin will be presented at the conference.

Conclusions and Discussion: Anomalies located within large basins likely have a thermoremanent origin owing to high subsurface temperatures reached at the time of impact [4]. The anomalies therefore require a long-lived, steady magnetic field to explain their magnetization. Of the six late Nectarian and Imbrian-aged basins investigated here, two (Orientale and Imbrium) have no detected interior field signatures, two (Hertzsprung and Sikorsky-Rittenhouse) have incomplete coverage of high-quality and/or low-altitude measurements so that results are inconclusive, and two (Serenitatis and Schrödinger) have clearly detected interior anomalies. As discussed in [4], the absence of anomalies over Imbrium and Orientale does not necessarily imply the absence of a core dynamo because other factors besides ambient field intensity determine whether interior magnetization is produced. For example, relatively large basin-forming impacts such as these may have completely removed all potential remanence carriers from the interior. However, the clear detection of interior anomalies within Serenitatis and Schrödinger probably implies that a core dynamo existed when these two basins formed. Since Schrödinger is comparable in age to Imbrium and Orientale according to [7], it follows that the lunar dynamo probably persisted into the Imbrian epoch. This provisional conclusion can be tested further by analyzing anomalies over craters larger than 100 km in diameter, many of which are Imbrian or younger in age.

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