INVESTIGATING SOURCES OF MERCURY'S CRUSTAL MAGNETIC FIELD: FURTHER MAPPING OF MESSENGER MAGNETOMETER DATA.

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Introduction: A valuable data set for investigating crustal magnetism on Mercury was obtained by the NASA MErcury Surface, Space ENvironment, GEochemistry, and Ranging (MESSENGER) Discovery mission during the final year of its existence [1]. Altitude normalized maps of the crustal field covering part of one side of the planet (90^{o}E to 270^{o}E; 35^{o}N to75^{o}N) have previously been constructed from low-altitude magnetometer data using an equivalent source dipole (ESD) technique [2,3]. Results showed that the strongest crustal field anomalies in this region are concentrated around and within the 1550 km diameter Caloris impact basin. A second smaller concentration was mapped over and around Sobkou Planitia, which contains an associated older 770-km diameter impact basin. In general, anomalies over high-reflectance volcanic plains were relatively weak while anomalies over low-reflectance material that has been reworked by impact processes were relatively strong. Overall, these results suggested that at least some of Mercury's crustal sources consist of impact melt rocks within impact basins and in externally deposited ejecta, as has also been inferred from lunar studies [e.g., ref. 4]. Because of the long cooling time following a basin-forming impact, the strong anomalies within the Caloris rim were interpreted as implying the existence of a core dynamo at the time when this basin formed [3].

In this work, we report preliminary results of mapping low-altitude MESSENGER magnetometer data over part of the other side of the planet (270^{o}E to 90^{o}E; 35^{o}N to 75^{o}N). Initial objectives include: (a) investigating in more detail the occurrence of anomalies associated with impact basins/craters; and (b) identifying anomalies that are suitable for paleomagnetic pole position estimation with application to evaluating true polar wander.

Data and Methods: 106 relatively clean orbit passes from the last two months of the mission (March 16 to April 23) were selected. Only the measured radial field component was used for initial mapping because it is usually less affected by transient external fields. As described in more detail previously [2,3], the data were first processed by (a) filtering to minimize long-wavelength fields of noncrustal origin; (b) editing the residuals to minimize short-wavelength variations that do not repeat on successive orbit passes; and (c) two-dimensionally filtering the remaining data after sorting into 0.5^o latitude by 1^o longitude bins. Filtering along the orbit tracks was accomplished in two substeps. First, a cubic polynomial was least-squares fitted to the raw radial component time series for each orbit pass. Second, the deviation from 5^o running averages was calculated to eliminate wavelengths greater than about 215 km. At 60^{o}N, the spacecraft altitude decreased from 35 km on March 16 to 5.2 km on April 2 when an orbit correction burn occurred, increasing the altitude to 28 km. Several other orbit correction burns prevented the altitude at 60^{o}N from decreasing below 8.8 km during the period from April 2 to 23. The spacecraft altitude near 35^{o}N and 75^{o}N ranged up to about 100 km. Because of these large altitude variations and the strong altitude dependence of the crustal field, some form of altitude correction is necessary to produce a useful map. A "classical" ESD technique [2,3] was therefore applied in which the sources were assumed to consist of an array of vertically oriented magnetic dipoles separated by 1^o in latitude and 2^o in longitude on a spherical surface (3731 dipoles). The depth of the dipole array (20 km) was chosen to minimize the RMS misfit [2,3].

Results: Figure 1 plots the calculated crustal field magnitude at 40 km altitude according to the ESD solution after two-dimensional filtering as described above. Anomalies within a few degrees of the upper and lower boundaries should be regarded with caution due to the larger downward continuation of the modeled field. The contour interval is 1 nT and the field map is superposed onto a MESSENGER Laser Altimeter elevation map (G. Neumann, priv. comm., 2016). As seen in the figure, some anomalies appear to correlate with impact crater/basin locations. These include two relatively strong anomalies (numbered 1 and 2) over Rustaveli (200 km in diameter, centered at 83^{o}E, 52^{o}N) and Vyasa (300 km in diameter, centered at 275^{o}E, 50^{o}N). These anomalies have filtered amplitudes of about 6 nT at 40 km altitude. For comparison, the strongest anomalies at the same altitude near and within Caloris had filtered amplitudes of about 8 nT [3]. Several other smaller unnamed craters on the western side of the map (numbered 3, 4, and 5) also appear to have associated anomalies with amplitudes of 3 to 5 nT. On the other hand, some other named craters (e.g., Abedin and Hokusai, 116 and 114 km in diameter, respectively) have no associated anomalies. Similarly, several larger impact basins appear to have associated magnetic anomalies while others do not. Anomalies are re-

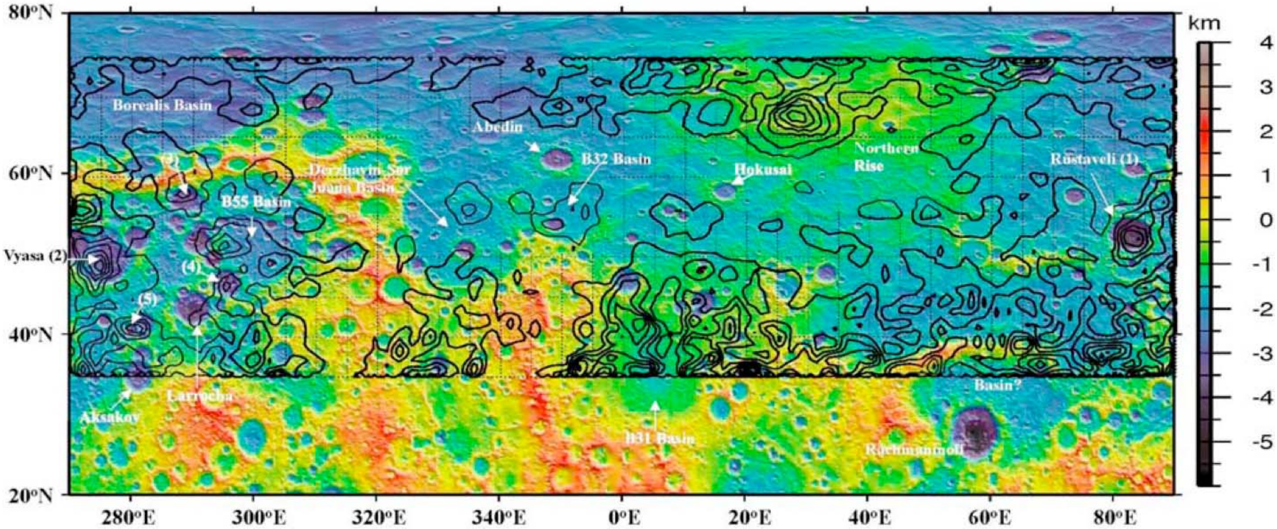

Figure 1: Calculated crustal field magnitude at 40 km altitude according to the ESD solution after two-dimensional filtering. The contour interval is 1 nT and the field map is superposed onto a MESSENGER Laser Altimeter elevation map (G. Neumann, priv. comm., 2016).

latively strong near and within the probable B31 basin (770 km in diameter, centered at 4°E, 37°N [5]). Anomalies also appear to be concentrated circumferential to an unnamed quasi-circular feature with a possible partial outer rim visible in the topography centered at about 60°E, 32°N. However, only weak anomalies are found in the probable Derzhavin-Sur Juana basin (580 km in diameter, centered at 332°E, 52°N [5]) and the probable B32 basin (370 km in diameter, centered at 349°E, 56°N [5]). Relatively weak anomalies are present over the northern lowlands, most of which has been volcanically resurfaced [6]. Anomalies are, however, present over the northern rise. This includes a relatively strong (> 6 nT) and broad magnetic anomaly centered at about 28°E, 67°N. Smith et al. [7] report that the northern rise has a nearly uncompensated strong gravity anomaly (~ 150 mgal) centered at approximately the same location (~ 33°E, 68°N). Possible origins for the northern rise include a region of uplift into a rigid lithosphere resulting from purely internal processes (e.g., a mantle plume) or a central bulge of a giant impact basin. The observation that the northern rise is surrounded by relatively low-lying terrain [8] is consistent with the latter possibility; however, the absence of radial or concentric extensional structures (e.g., grabens), usually associated with large basin central bulges, makes this interpretation challenging.

Discussion: The occurrence of anomalies associated with some impact basins/craters but not others is a new observation that must be explained by any successful crustal magnetic source model. For example, if crustal sources consist primarily of impact melt rocks, then differences in impactor composition or subsurface target composition are needed. Since basin/crater associated magnetic anomalies occur over a variety of terrains, differences in impactor composition, e.g., a larger metallic iron content, are most likely. Such an interpretation has previously been proposed as a possible explanation for magnetic anomalies along the northern rim of the South Pole-Aitken basin on the Moon [9]. Alternatively, antipodal deposition of iron-enriched ejecta from young basin-forming impacts on the lunar near side (Imbrium, Orientale, Crisium) could also explain the anomalies north of SPA [4]. In either case, the magnetic anomalies would have implications for impactor composition. The Mercury results may therefore provide insights into the interpretation of lunar crustal magnetism, which remains incompletely understood. Finally, several of the basin/crater associated anomalies (especially those over Rustaveli and Vyasa) are relatively isolated and may be well suited for paleomagnetic pole estimation, assuming that the anomalies are primarily remanent rather than induced. Arguments favoring a remanent interpretation have been presented by Johnson et al. [1].

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