MAGNETIC ANOMALIES WITHIN THE SCHRÖDINGER IMPACT BASIN: ORBITAL EVIDENCE FOR PERSISTENCE OF THE FORMER CORE DYNAMO INTO THE IMBRIAN EPOCH. L. L. Hood[1], H. Tsunakawa[2], and P. D. Spudis[3], [1]Lunar & Planetary Lab, 1629 E. University Blvd., Univ. of Arizona, Tucson, AZ 85721, USA; lon@lpl.arizona.edu, [2]Dept. of Earth & Planetary Sciences, Tokyo Institute of Technology, Tokyo, Japan, 152-8551, [3]Lunar & Planetary Institute, 3600 Bay Area Blvd., Houston, TX 77058.

Introduction: Laboratory analyses of returned samples indicate that the lunar core dynamo persisted at least until ~ 3.7 Gyr [1,2]. However, orbital measurements can potentially provide a macroscopic corroboration of this important constraint on lunar internal evolution. Specifically, magnetic anomalies within the rims of large impact craters or basins are useful indicators of the existence or absence of a core dynamo at the times of their formation [3,4,5]. The source materials of such anomalies, which probably consist of solidified impact melt beneath the visible surface, must have formed via slow cooling (TRM) because the subsurface within large crater rims was heated to high temperatures and required long periods (up to 1 Myr) to cool through the Curie blocking spectrum. Formation of these anomaly sources therefore required a steady, long-lived magnetizing field, i.e., a core dynamo field.

Previous work has shown the existence of central magnetic anomalies in a number of Nectarian-aged basins [3,5] and in several pre-Nectarian basins and large craters [6,7]. However, no such anomalies have previously been reported in younger (Imbrian-aged or younger) basins or craters. Of the three Imbrian-aged basins (Orientale, Schrödinger, and Imbrium), significant detectable anomalies are virtually absent within Imbrium and Orientale. This does not necessarily conflict with laboratory results because both of these basins have experienced extensive mare volcanism which could have thermally erased any pre-existing central anomaly magnetization.

In this paper, we report more detailed mapping of Kaguya (KG) magnetometer data [8] obtained in 2009 at low altitudes over the Schrödinger impact basin in the lunar south polar region. Using an improved equivalent source dipole mapping technique as well as examinations of individual orbit passes, the existence of detectable anomalies within the basin rim is confirmed.

Data and Mapping: Figure 1 shows plots of the radial field component along individual Kaguya orbit passes at altitudes ranging from 19 to 24 km over Schrödinger (centered at 75°S, 133°E). Repeating positive and negative anomalies with amplitudes of order 1 nT are present within the basin rim as indicated by the red arrows.

It is not possible to construct an accurate map of the magnetic field magnitude over Schrödinger directly from the KG data because the horizontal field components are significantly contaminated with high-frequency external field noise. However, it is possible to construct such a map using an equivalent source dipole (ESD) technique [9,10,11]. For this purpose, the sources in the vicinity of Schrödinger were assumed to consist of an array of 41 by 31 radially oriented magnetic dipoles on a spherical surface at some depth below the mean lunar radius. The dipoles were spaced 0.5° apart in latitude and 2° apart in longitude covering latitudes from 65°S to 85°S and longitudes from 100°E to 160°E. Dipole moment amplitudes were iteratively adjusted positively or negatively depending on the difference between the observed and model field above the location of a given dipole. Convergence to a solution occurred after about 50 iterations. Although the ESD solution is non-unique (because of the assumed dipole orientations), it allows a calculation of the three vector field components and the field magnitude on a constant-altitude surface based only on the measured radial field component at the spacecraft altitude.

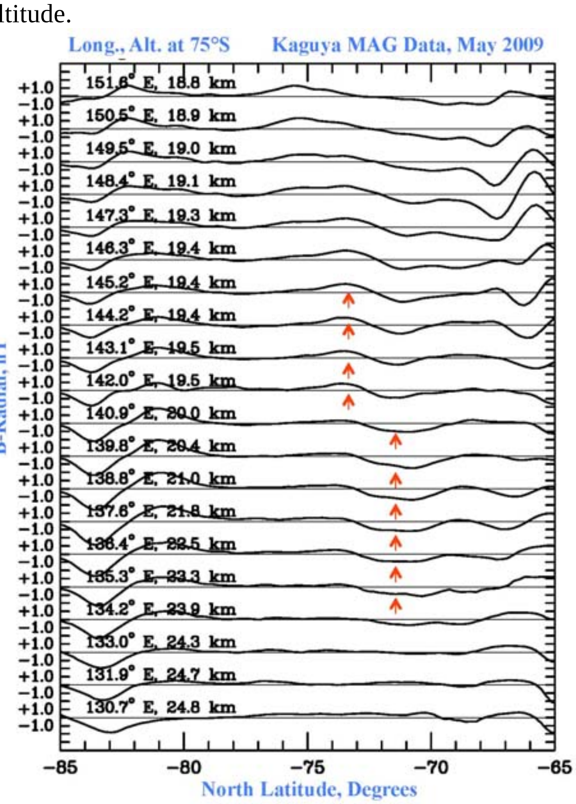

Figure 1

Results are not sensitive to the assumption of a radial orientation of the dipole array. Alternate calculations using a dipole orientation tilted 45^o from the vertical yield similar results [11]. Repeating the calculation for a series of assumed depths of the dipole array, a minimum RMS deviation of ~ 0.4 nT was obtained for a depth of 5 km. The final correlation coefficient between the modeled and observed radial field component along the spacecraft orbit tracks within the basin rim was 0.975.

Figure 2 shows the field magnitude map evaluated at an altitude of 15 km over Schrödinger. This altitude is somewhat less than the KG observations but is not so low that the map is affected appreciably by amplification of residual external field noise. As expected from the individual orbit passes in Figure 1, significant anomalies are present within the basin rim. They are distributed in a semi-circular arc about the center of the basin. A minimum field intensity (0.3 nT) is found on the southeast side of the basin (upper left in the figure).

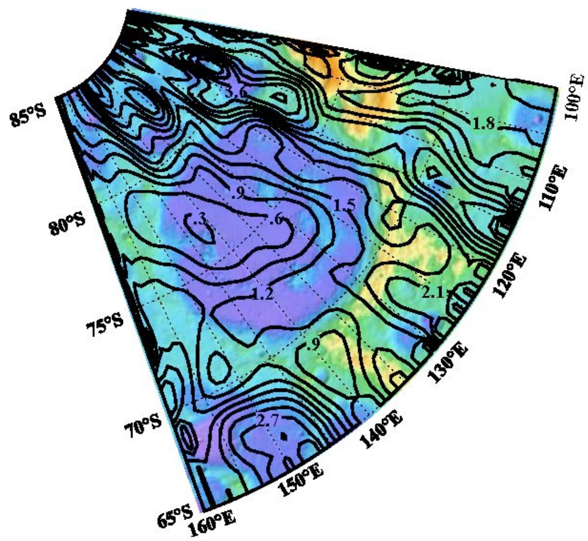

Figure 2

Interpretation: The results presented here confirm that magnetic fields of crustal origin are detectable within the rim of Schrödinger. The sources most probably consist of impact melt beneath the visible surface. The interior anomalies of Schrödinger are asymmetrically distributed with stronger fields on the western and northern sides. There is also a minimum near the basin center. It is noteworthy that the topographic map shows a partial inner ring that is also visible mainly on the western and northern sides of the basin. The weakness of the field on the southeastern side suggests that some process has acted to weaken the original interior field. A likely possibility is the volcanic intrusion episode that produced the interior mare surface at some time after Schrödinger formed.

Thermal demagnetization of pre-existing central anomalies by magmatic intrusions may have been important for basins/craters of all ages, but could have been most important for those that formed during the Imbrian and Eratosthenian epochs when mare volcanism was most widespread. As noted in the Introduction, the virtual absence of anomalies within Imbrium and Orientale could be a consequence of magmatic thermal demagnetization. The asymmetry of the anomalies within Schrödinger suggests that magmatic activity was strongest in the southeastern part of the basin. The tendency for central anomalies to be weak or non-existent in the three Imbrian basins while they are generally much stronger in Nectarian-aged basins is consistent with this interpretation.

In any case, the detection of anomalies within the rim of Schrödinger provides the first macroscopic evidence for the persistence of the core dynamo into the Imbrian epoch as has been inferred from sample studies.

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