ANALYSIS OF MAGNETIC ANOMALIES INSIDE MARE CRISIUM: LUNAR PROSPECTOR MAGNETIC FIELD STUDY. K.-H. Kim¹, S.-M. Baek¹, H. Jin², and I. Garrick-Bethell¹², ¹School of Space Research, Kyung Hee University (1732, Deogyeong-daero, Yongin-si, Korea), ²Earth and Planetary Science, University of California, Santa Cruz (1156 High Street Santa Cruz, CA, USA)

Introduction: Mapping of the low-altitude Lunar Prospector magnetometer (LP-MAG) data shows that Crisium has two magnetic anomalies, which are distributed near the inner northern and southern edges inside the Crisium basin. The LP-MAG data obtained from an orbit passing over near the source of the northern Crisium anomaly (C NA) show that C NA has a bipolar perturbation in the northward (B N) component and a monopolar perturbation in the radial (B R) component. Unlike C NA, however, the southern Crisium anomaly (C SA) has magnetic field perturbations showing B N-bipolar/B R-monopolar (C SA1) in the area from 56°E to 58°E and B N-monopolar/B R-bipolar (C SA2) in the area from 59°E to 63°E, implying that C SA consists of two anomaly sources. Since the observed magnetic field signatures can be estimated from a single dipole source, we assume that the Crisium anomalies are associated with an isolated and dipolar source.

Using a dipole model for Crisium magnetic anomalies, we determine the dipole moment vector (M) and depth (d) of the dipole source from the lunar surface for each anomaly. The direction of M for the source of C NA is inferred to be oriented radially inward and inclined toward the south, and the predicted depth of the source is d = ~25–30 km. We find that the inferred M direction and source’s depth for C SA1 are very similar to those of C NA. However, the magnetization direction for C SA2 is horizontally southward, and the predicted depth of the C SA2’s source is d = ~50–55 km. Assuming that the age of the magnetization corresponds to the formation time of the Crisium basin and that the depth of the source of the magnetic anomaly corresponds to the age of the magnetization, we suggest that C SA2 was created earlier than C NA and C SA1. If our predictions are correct and the Crisium anomalies are magnetized by a core dynamo of the Moon, the core field was rotated ~90° from the age of C SA2 to the formation time of C NA and C SA1, implying the motion of the paleomagnetic pole. In addition, we compare the surface magnetic field strengths of the Crisium anomalies obtained from the electron reflectometer (ER) instrument on the LP spacecraft and estimated from our dipole model, and confirm that our model calculations describe LP-ER observations quite well.

Experiments and Data Set: In this study we use LP-MAG data obtained at low altitudes (~15-45 km) on 13-14 March 1999 to examine the Crisium magnetic anomalies. During this interval the Moon was in the solar wind. Only nightside MAG data were selected to minimize the effect of interplanetary magnetic field (IMF). The LP-MAG data have been rotated into local coordinates (LOC) to examine the characteristics of the anomalies. In this system, the three components (B E, B N, B R) of the vector magnetic field data indicate eastward, northward, and radially inward, respectively. In order to remove temporal magnetic field variations (i.e., IMF), the original 5-s LP MAG data have been filtered by removing 300-s running averages from each component. The residual magnetic fields are used to examine the characteristics of lunar magnetic anomaly in our study.

Observations of Crisium Magnetic Anomalies: Figure 1 shows the high-pass-filtered version of the magnetic field data in the LOC coordinates for nine successive orbits, separated by ~1° in longitude at the equator, passing over the Crisium basin as a function of selenographic latitude on 13-14 March 1999. The spacecraft longitude and ~8-min interval corresponding to ~25° pass from 5° to 30° in latitude are listed in each panel in Figure 1. The magnetometer data were obtained at spacecraft altitude ranged from ~18 to ~25 km above the mean lunar surface.

C NA and C SA, marked by vertical dashed lines, are clearly identified by repetition on consecutive orbit passes. C NA shows a monopolar (inward) perturbation in δB R and a bipolar (north-then-south) perturbation in δB N from 56°E to 60°E. δB E and δB N of C SA have the same polarity as those of C NA from 56°E to 58°E in longitude (CSA1), indicating that a dipole moment direction of C NA to the lunar surface is similar to that of C SA1. However, the δB N polarity changes to monopolar, and the δB R polarity changes to bipolar at 59°E. These field configurations of C SA extend to 63°E (CSA2). Thus we suggest that the southern Crisium anomaly consists of two dipole sources.

Dipole Model for Isolated Magnetic Anomaly: Using a dipole model for Crisium magnetic anomalies, we examine the dipole moment vector (M) and depth (d) of the dipole source from the lunar surface for each anomaly. Figure 2 shows the root-mean-squared (RMS) deviations of the observed data from the dipole field model for C AN with different depths from the lunar surface. The RMS deviation for each depth has a
minimum within a region of 21-21.5°N, and the minimum RMS deviation (~1.2 nT) in that region is obtained at \( d = 25-30 \) km. Thus, we suggest that the dipole source of \( C_NA \) is located at \( d = -25-30 \) km. The inferred direction of \( \mathbf{M} \) is radially inward and inclined toward the south. We find that the RMS deviations, the inferred \( \mathbf{M} \) direction, and source’s depth for \( C_{SA1} \) are very similar to those of \( C_{NA} \) (data not shown here). Thus, the sources of \( C_{NA} \) and \( C_{SA1} \) are similarly aged.

The magnetic polarities of \( C_{SA2} \) in \( \delta B_N \) and \( \delta B_R \) are not similar to those of \( C_{NA} \) and \( C_{SA1} \). That is, \( C_{SA2} \) shows a monopolar perturbation in \( \delta B_N \) and a bipolar perturbation in \( \delta B_R \) as plotted in Figure 3a. Figure 3b shows the RMS deviations of \( C_{SA2} \) for depths from 0 to 70 km. The RMS minimum value is ~0.5 nT, which is distributed in a region of 11-13°N. The predicted depth of the \( C_{SA2} \)’s source is \( d = 50-55 \) km, which is deeper than the source location of \( C_{NA} \) and \( C_{SA1} \). These different depths imply that \( C_{SA2} \) was created earlier than \( C_{NA} \) and \( C_{SA1} \).

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**Figure 1.** Magnetic field data measured on LP during the intervals crossing over the Crisium anomalies on 13-14 March 1999. Components are plotted in LOC coordinates. \( C_{SA} \) and \( C_{NA} \) indicate the south and north magnetic anomalies, respectively, in the Crisium (see the text for descriptions).

**Figure 2.** (a) The magnetic field data of \( C_{NA} \) in the LOC coordinates plotted as a function of selenographic latitude. (b) The RMS deviations of the observed data from the dipole field model for \( C_{NA} \) with different depths from the lunar surface.

**Figure 3.** The format is the same as that in Figure 2 except for \( C_{SA2} \).