CENTRAL MAGNETIC ANOMALIES OF NECTARIAN-AGED LUNAR IMPACT BASINS: POSSIBLE EVIDENCE FOR AN EARLY CORE DYNAMO. Lon L. Hood, Lunar and Planetary Laboratory, University of Arizona , 1629 E. University Blvd., Tucson, AZ 85721, lon@lpl.arizona.edu.

Introduction: A long-standing issue of lunar science is whether the observed crustal magnetism requires a former core dynamo magnetic field. Direct laboratory paleointensity studies of returned samples have not yet resolved this issue [1,2] although one recent study of the oldest known unshocked lunar rock suggests that a core dynamo with a surface field of > 1 μT (0.01 G) existed at ~ 4.2 Gyr ago [3].

A prerequisite for applying orbital magnetic data to constrain the nature of lunar magnetizing fields is a knowledge of the sources of the orbital anomalies. Sample studies show that the main ferromagnetic carriers, microscopic metallic Fe grains, are concentrated in impact-produced materials (e.g., breccias) and are relatively rare in igneous materials (e.g., mare basalt). Consistently, Apollo surface magnetometer (MAG) data show that the strongest surface fields (> 330 nT) are found near the Apollo 16 landing site, which is dominated by basin ejecta materials such as the Cayley Formation. These observations led to the original hypothesis of D. W. Strangway et al. [4] that basin ejecta materials are the main sources of magnetic anomalies detected from lunar orbit. This hypothesis has been supported by a number of correlative studies of Apollo subsatellite and Lunar Prospector (LP) MAG and electron reflectometer (ER) data with surface geology [5,6]. Overall, the orbital data strongly suggest that basin-forming impacts played a major role in determining the gross distribution of lunar crustal magnetization. In particular, the largest concentrations of strong anomalies occur antipodal to the youngest large basins [7]. A model involving shock remanent magnetization (SRM) by impacting secondary ejecta in an amplified field antipodal to basin-scale impacts has been developed [8]. Most of the magnetization detected from orbit may be explained by the latter model. However, it is important to note that this model requires only an initial ambient field, e.g., a solar wind field. It neither requires nor precludes an initial core dynamo field.

Halekas et al. [9] applied LP ER data to show that central magnetic anomalies exist in many Nectarian-aged lunar basins but are nearly absent in younger basins such as Imbrium and Orientale. They interpreted these anomalies as ``due to thermal remanence in impact melt rocks and/or shock remanence in the central uplift.'' The former interpretation would require a long-lived, steady magnetizing field, consistent with a core dynamo, while the latter interpretation could in principle be explained by a transient field generated in

the impact. Similar central anomalies are present in terrestrial impact structures and are interpreted to be a consequence of remanent magnetization acquisition although the dominant mechanism (e.g., TRM or SRM) is unclear [10].

In this paper, LP MAG data are first applied to produce more detailed regional maps of central magnetic anomalies in a series of Nectarian-aged basins. The inferred magnetization distribution and directional properties within the basins are then considered to evaluate further the core dynamo hypothesis.

Data Selection and Mapping: We have re-examined all available MAG data during the low-altitude phase of the LP mission (Jan. – July, 1999) with coverage over a number of Nectarian-aged basins having central magnetic anomalies as identified by the ER technique. The mapping procedure follows that described in [11] and consists of a combination of (a) careful orbit selection and editing of individual orbits to minimize short-wavelength external fields; and (b) quadratic detrending to minimize longer-wavelength external fields within the edited orbit segments. Regional maps are constructed on the smoothly varying surface defined by successive orbit passes during a given lunation. Repetition of anomaly structures on adjacent orbit passes allows a direct empirical test of whether a given apparent anomaly is of crustal or external origin.

Results: The existence of central anomalies is confirmed within the Crisium, Moscoviense, and Mendel-Rydberg basins. No detectable central anomaly is present within Bailly at an altitude of ~ 35 km.

The Moscoviense and Mendel-Rydberg anomalies consist of single maxima in the field magnitude with scale sizes of ~ 5° (150 km) and with peak intensities located within a few degrees of the basin centers. The Moscoviense anomaly (Figure 1) has a peak amplitude of ~ 2.8 nT at an altitude of ~ 29 km while the Mendel-Rydberg anomaly has a somewhat higher amplitude of ~ 4.0 nT at an altitude of ~ 34 km. Since these anomalies maximize near the basin centers, their sources could be either the shocked central uplift or impact melt rocks. No firm constraint on the nature of the magnetizing field is immediately implied.

However, as shown in Figure 2, the Crisium anomalies are not located at the basin center but consist of two elongated maxima that are distributed in a semi-circular arc about the basin center. It is unlikely that the sources consist of ejecta from a later basin-forming impact that happened to be covered by mare

fill because (a) both maxima occur within the inner topographic rim of the basin; and (b) there are no anomalies of comparable magnitude within 15° of the basin. Moreover, the semi-circular pattern of the anomalies suggests a genetic relationship to the basin. A possible interpretation is that the sources consist of impact melt, which would tend to concentrate in a trough around the central uplift. The vector information in the MAG data indicate that the two maxima consist primarily of negative peaks in the radial field component. Initial modeling is consistent with a single direction of magnetization that is close to radially inward. Thus, the Crisium anomalies may be most easily explained as due to TRM of impact melt surrounding the central uplift. The inferred nearly parallel directions of magnetization for the two source maxima suggest a large-scale, steady magnetizing field.
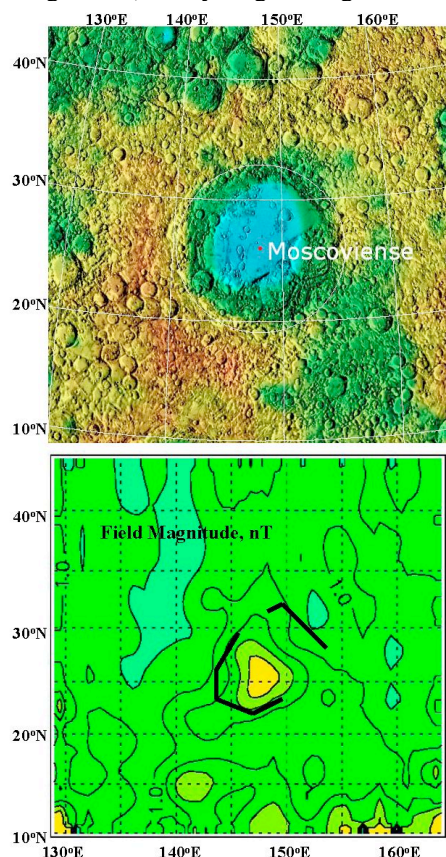

Figure 1. Top: Clementine LIDAR shaded relief map of Moscoviense region (http://lpod.org). Bottom: Field magnitude in nT (C.I. = 0.5 nT) at altitudes ranging from ~26 km near 10° N to ~32 km near 45°N. The dark lines outline several ring structures within the basin.
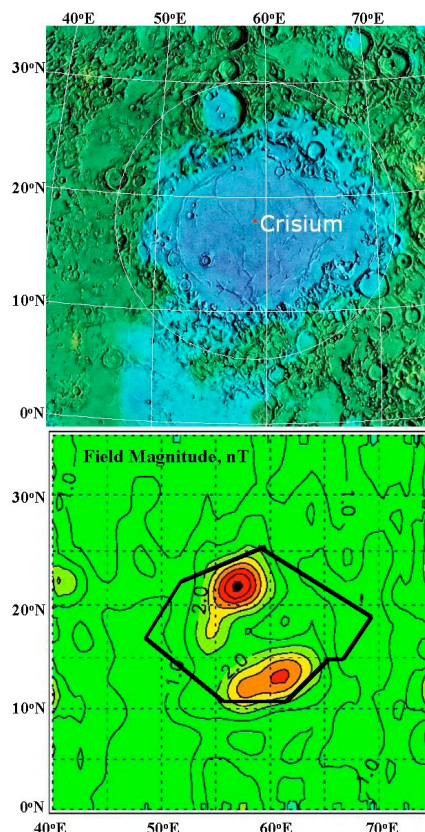

Figure 2. Same format as Figure 1 but for the Crisium basin region. The altitude of the field magnitude map ranges from ~35 km near 0°N to ~40 km near 35°N.

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