STRONG MAGNETIC ANOMALIES ON THE LUNAR NEAR SIDE. J. S. Halekas, D.L. Mitchell, R. P. Lin, S. Frey, *Space Sciences Laboratory, Berkeley, CA 94720, USA*, M. H. Acuna, *NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA*, L.L. Hood, *Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ 85721, USA*, A. Binder, *Lunar Research Institute, Tuscon, AZ*

Since entering a polar orbit around the Moon in January 1998, the Lunar Prospector (LP) spacecraft has returned the first new data on lunar magnetic fields in 26 years. The Magnetometer/Electron Reflectometer (MAG/ER) experiment on LP measures remanent magnetic fields in the lunar crust by observing the magnetic reflection of electrons from the Moon's surface (Lin 1979). The LP electron reflection data set is ~50 times larger than the Apollo data set, and because of LP's polar orbit, these data are globally distributed.

One measure of the surface magnetic field strength is the electron reflection coefficient, which is the ratio of the reflected flux to the incident flux. This quantity can be reliably used to measure the surface magnetic fields stronger than about ~5 nT (1 nT = 10^{-5} Gauss). The accurate measurement of weaker fields is complicated by the fact that the lunar surface can charge up, and the resulting electric field can also reflect electrons. Since electrostatic reflection is energy dependent whereas magnetic reflection is not, we can separate these two effects by comparing reflection data at several different energies. The corrected data set provides an accurate measure of surface magnetic fields as weak as ~0.2 nT; however, it is four times smaller than the uncorrected reflection coefficient data set, resulting in significant undersampling over much of the lunar surface. Thus, despite its limitations, the uncorrected reflection coefficient provides the best means of investigating the fine scale structure of magnetic anomalies stronger than ~5 nT. A reflection coefficient map of the lunar near side is shown in Figure 1.

Apollo and Lunar Prospector measurements have shown that the largest regions of strong crustal fields are located diametrically opposite (antipodal) to the Imbrium, Orientale, Serenitatis, and Crisium impact basins. Meanwhile, the

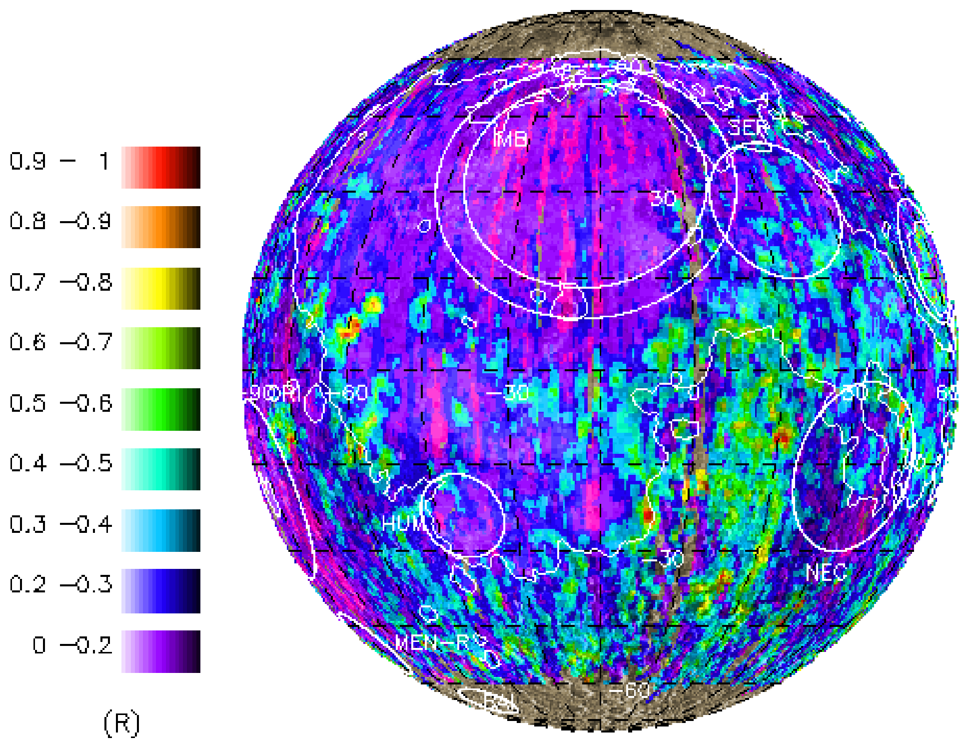

Figure 1. The reflection coefficient for 520 eV electrons is mapped over the lunar near side in an orthographic projection. These measurements are uncorrected for electrostatic reflection and other effects. Consequently, artificial features are apparent in low-field regions, such as the north-south linear stripes in Mare Imbrium. However, the high data volume (400,000 points) provides nearly complete sampling over most of the Moon, revealing the fine scale structure of moderate (>5 nT) and strong field regions. The circles show the locations of large impact basins, and the white albedo contour separates mare regions from the lunar highlands.

weakest crustal field regions tend to be associated with large impact basins themselves. This magnetization pattern dominates the large scale lunar crustal magnetic field, suggesting that physical processes associated with large impacts are capable of magnetizing and demagnetizing the lunar crust.

The near side map (Fig. 1) is dominated by the low fields of Mare Imbrium and Oceanus Procellarum. The partially demagnetized Nectaris, Serenitatis and Humorum impact basins are also visible, as is part of the Orientale basin on the western limb. However, there are also a number of strong magnetic sources visible around these weak-field regions. On the southwestern side of Oceanus Procellarum three strong magnetic anomalies are visible. The Reiner Gamma (60 W, 7 N) and Rima Sirsalis (58 W, 13 S) anomalies were originally discovered by the Apollo 15 and 16 subsatellites. A previously unmapped anomaly lies at 80 W, 10 S.

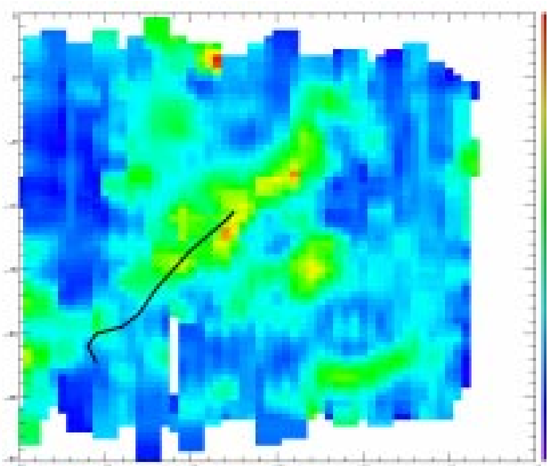

Figure 2. The reflection coefficient is mapped over the Rima Sirsalis region (30 S to 5 N in latitude, 70 W to 40 W in longitude). The black line marks the Rima Sirsalis rille. The strong feature at the top of the map is the southern extent of the Reiner Gamma magnetic anomaly.

Lunar Prospector data show an elongated magnetic feature (Fig. 2, above) that is nearly aligned with the Sirsalis rille, which confirms Apollo electron reflection data (Anderson et al. 1979). If one assumes that this signature is caused by a leakage field from a crack in a magnetized crustal layer or by a magnetized subsurface dike (Srnka et al. 1979), then a steady magnetizing field would be required while a large mass of rock (> 5 km wide, tens of km deep) cools through its Curie point. Transient fields that might be produced during impacts would be too short lived; thus, a lunar dynamo appears to be a necessary component of such models. This view is supported by the fact that magnetometer measurements have shown the polarity of the two strongest magnetic features to be roughly the same. However, the Lunar Prospector data show that the strongest magnetic feature (58 W, 13 S) is not directly over the rille, and moreover, the southwest part of the rille extends beyond the magnetic feature. Are the rille and magnetic signature physically related? An alternate hypothesis is that the magnetic signature is associated with impact ejecta, which is plausible given that the feature is radially aligned with the center of the Imbrium basin, as is the Reiner Gamma anomaly. In addition, the strongest magnetic feature is closely associated with a patch of material identified as Imbrian ejecta. Furthermore, we have thus far been unable to find any other clear associations between rilles and magnetic features

To the east of Rima Sirsalis and Reiner Gamma, an arc of magnetized crust borders southern Imbrium, suggesting an association with the Fra Mauro formation. Further east and south, between the Imbrium and Nectaris impact basins, a number of strong anomalies exhibit a close (but not one-to-one) correlation with the Cayley and Descartes formations. Both the Fra Mauro and Cayley formations are believed to have been produced by Imbrian primary and/or secondary ejecta, while Descartes is most likely Nectarian ejecta (Stoffler et al. 1985, Spudis 1984, Wilhelms 1984). This suggests that magnetization effects from basin-forming impacts are not confined to the antipode.

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