

THE PERMANENT AND INDUCED MAGNETIC DIPOLE MOMENT OF THE MOON, C.T. Russell, P.J. Coleman, Jr., B.R. Lichtenstein and G. Schubert, University of California, Los Angeles, 90024.

Data obtained with the fluxgate magnetometer on the Apollo 15 subsatellite have been used to measure separately the permanent and induced magnetic dipole moments of the moon. To measure the permanent dipole moment the fields were referenced to the 0° selenographic meridian, while to measure the induced moment the fields were referenced to the projection of the field in the orbit plane. The moments deduced for each tail lobe were then combined giving each equal weight and thus minimizing the contribution of the induced dipole to the measure of the permanent dipole moment and vice versa. Nearly complete orbits of data from 19 quiet passes in the north lobe and 10 from the south lobe of the geomagnetic tail were used in this study.

The magnitude of the permanent dipole moment in the orbit plane of the subsatellite is found to be less than our estimate of the noise level of $3 \times 10^{18} \text{ G-cm}^3$ in accord with earlier estimates¹. Thus, we conclude that if the moon ever possessed a dipole magnetic field, either from an internal dynamo or due to natural remanent magnetization, capable of magnetizing the lunar surface material to the extent observed, this field has effectively disappeared.

On the other hand, the induced dipole moment of $6 \times 10^{16} \text{ G-cm}^3$ per μG of external field is above the noise level of $2.2 \times 10^{16} \text{ G-cm}^3$ per μG . Somewhat surprisingly the induced dipole moment is diamagnetic within the 99.7% confidence level whereas the lunar material should be partially ferromagnetic or at least paramagnetic. In fact, Parkin et al.² have reported a ratio of the whole moon permeability to that of the tail lobes of 1.010 to 1.053 in contrast to our estimate of from .95 to .98. It is highly unlikely (0.3%) that our measurement is consistent with a permeability ratio greater than unity let alone with the Parkin et al. measurement. Thus, this difference must have some non-statistical cause. While it is possible that the Parkin et al. result is not a global measurement, or that there are calibration difficulties with their measurements, and therefore we might expect differences, these possibilities do not account for why our permeability ratio is less than unity. Thus, we are left with the conclusion that there is a significant low permeability layer below us, e.g., an ionosphere, when the moon is in the lobes of the geomagnetic tail. Indeed, a hot ionosphere has been observed with the Suprathermal Ion Detector Experiment³ but the ionospheric properties have been only roughly defined.

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This observation is cause for reevaluating Parkin et al. models. The ionosphere would shield the lunar surface from the full external field of the geomagnetic tail. Therefore, the whole body permeability estimates must be raised to compensate for the ionospheric effects. For example, assuming the ionospheric plasma fills the region between the subsatellite and the moon, an ionospheric permeability of $0.6 \mu_0$ and a whole moon permeability of $1.05 \mu_0$ would be consistent with the subsatellite data. However, ionospheric shielding would reduce the apparent permeability deduced from surface measurements to $1.02 \mu_0$. We conclude that while magnetic measurements can provide important constraints on lunar thermal and compositional models, these measurements must go hand in hand with an accurate measurement of the lunar plasma environment.

¹Russell C.T., Coleman P.J., Jr., Lichtenstein B.R., Schubert G. and Sharp L.R. (1973), Subsattellite measurements of the lunar magnetic field, Proc. Fourth Lunar Sci. Conf. Geochim. Acta Suppl. 4, Vol. 3, 2833-2846, MIT Press.

²Parkin C.W., Dyal P., and Daily W.D. (1973), Iron abundance of the moon from magnetometer measurements, Proc. Fourth Lunar Sci. Conf. Geochim Cosmochim. Acta Suppl. 4, Vol. 3, 2947-2962, MIT Press.

³Lindeman R., Freeman J.W., Jr., and Vondrak R.R. (1973), Ions from the lunar atmosphere, Proc. Fourth Lunar Sci. Conf. Geochim. Cosmochim. Acta Suppl. 4, Vol. 3, 2889-2896, MIT Press.