MAGNETIC FIELDS NEAR THE MOON, Paul J. Coleman, Jr.,
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The Apollo 15 subsatellite was launched into a lunar orbit
with an average altitude of 110 km and an inclination of 28° to
the moon's equatorial plane. The subsatellite is spin stabi-
lized and the spin axis is essentially parallel to the moon's
axis. The spin rate is 12 rpm.

The subsatellite magnetometer is a two-axis fluxgate. The
sensor is mounted at the end of a six foot boom. The two sensor
elements are oriented parallel and transverse to the spin axis
of the spacecraft. The measured variables that define the vec-
tor field are $B_p$, the parallel component, $B_T$, the absolute value
of the transverse component, and $\phi$ the angle between the trans-
verse component and the component of the sun-spacecraft vector
transverse to the spin axis. Measurements of $B_p$ and $B_T$ only
were available for use in the preliminary analysis reported upon
here. The subsatellite carries a data storage unit that records
field measurements on the far side of the moon for playback when
the subsatellite is in view from the earth.

Remnant Magnetization. At times of relatively low levels
of geomagnetic activity, the magnetic field in the geomagnetic
tail is quite constant. Our preliminary analysis of the quick-
look data recorded during the first traversal of the geomagnetic
tail revealed the existence of measurable levels of remnant
magnetism over much of the subsatellite orbit.

The major features of the structure of the measured remnant
field are apparently associated with large craters. The most
obvious feature is that apparently associated with the crater
Van de Graff, which produces a 1 $\gamma$ variation in the field as the
satellite sweeps past it. Van de Graff is approximately 9°
across and its center is located about 8° from the satellite
ground track. Other prominent features of the data are tenta-
tively associated with the craters Hertzsprung, Korolev, Ga-
garin, and Milne.

The magnetic field measurements used in this preliminary
analysis do not include the final pre-flight calibrations. Thus
although the measured variations are accurate, the absolute values of $B_p$ are not necessarily correct. Further, the data processing performed to date has been done entirely by hand and this precluded our determining the orientation of the component perpendicular to the satellite spin axis.

The measurements suggest that the remnant field is smoother and possibly weaker on the near side than on the far side and that most of the major craters produce measurable fields at 110 km altitude. This near side/far side asymmetry leads us to the speculation that the remnant field observed is due to irregularities in a magnetized crust. This crust has been disturbed over a broad region of the near side, possibly by the processes that created the ringed maria, but disturbed primarily by more localized crater formation on the back side.

Samples returned from the Apollo 11 and 12 sites show remnant magnetization as great as $10^{-2}$ emu/cm$^3$. If one takes this value as an upper limit on the magnetization of lunar material, then the minimum scale size of a spherical body magnetized at this level and producing a 1 γ variation at the subsatellite orbit is approximately 10 km. The field at the surface of such a region, and therefore the maximum field that could be produced by such a region on the surface of the moon, is roughly 1000 γ. Such a volume would have a magnetic dipole moment of approximately $10^{16}$ gauss cm$^3$. For a more typical remnant magnetization of $10^{-5}$ emu/cm$^3$, the scale size would be 100 km and the surface field would be about 10 γ for this dipole moment. The data also indicate that any lunar centered magnetic dipole must have a magnetic moment less than $4 \times 10^{19}$ gauss cm$^3$ corresponding to a surface field strength in the range 1.5 to 3 γ.

These preliminary results show that we will be able to obtain a detailed map of lunar remnant magnetization. This will provide additional information on the ancient magnetizing field and the history of the magnetized material subsequent to its magnetization.

Electrical Conductivity. Information on the electrical conductivity of the moon's interior has been obtained through an analysis of simultaneous magnetic field measurements at the Apollo 12 site and at the lunar orbiting satellite, Explorer 35. The results already obtained include a radial conductivity profile that has been interpreted in terms of models of mantle-core stratification, the mantle temperature, the near-surface
Magnetic Fields Near the Moon
Paul J. Coleman, Jr.

Data recorded at the lunar subsatellite during several successive orbits when the moon was in the solar wind show that there is greater variability of the magnetic field on the day side or upstream side of the moon. This behavior suggests that the magnetic field measured at the subsatellite when the moon is in the solar wind includes a component due to lunar induction. The presence of this component indicates that data from the subsatellite magnetometer, along with simultaneous data from the lunar surface magnetometers and Explorer 35 magnetometer, can be used to produce a detailed, three-dimensional model of the interior conductivity. Alternatively, the effect could be caused by ionized components of gases emitted from the moon.

Boundary Layer Studies. Observations of the magnetic field and plasma obtained with the lunar orbiter, Explorer 35, have revealed that a so-called diamagnetic cavity exists behind the moon, or downstream from the moon, when the moon is in the solar wind. The essential magnetic feature of this cavity is an interior magnetic field stronger by about 1.5 \gamma, on the average, than the exterior field. At the boundary of this cavity, there is a sharply localized decrease in the field magnitude approximately coincident with the boundary of the moon's optical shadow. The preliminary analysis of the data from the subsatellite magnetometer indicates that a diamagnetic increase also appears at the lower altitude of the subsatellite.

Data from Explorer 35 have also revealed the existence of sporadic field disturbances adjacent to the rarefaction wave at the boundary of the diamagnetic cavity. Studies of these disturbances have shown that they occur in the solar wind flow across the limbs when certain regions of the lunar surface are at the limbs. The greatest concentration of disturbance sources was found to be in a 15° square near the crater Gagarin.

Our preliminary analysis of the subsatellite magnetometer data indicates that strong disturbances, or limb effects, are present most of the time and, thus, over near-side as well as far-side regions. Thus, on the one hand the detection of relatively strong remnant fields in the vicinity of Gagarin is consistent with the earlier suggestion that the limb effects detected at Explorer 35 are caused by localized regions of enhanced magnetic fields. On the other hand, an indication that the limb disturbances are present more often than not, and that they are just as great when many other regions are at the limb, suggests that further study is required to establish their causes.