MAGNETIC MODELING OF THE RIMA SIRSA LIS LUNAR MAGNETIC ANOMALY, J. E. McCoy (NASA/JSC, Houston, TX 77058), R. P. Lin, K. A. Anderson (Space Science Lab., U. of California, Berkeley, CA 94720).

One of the most intense regions of lunar surface magnetization yet discovered by the Electron Reflection Method (ERM) [1,2,3] is a narrow linear feature over 300 km in length, which appears to be associated with the long structural rille Rima Sirsalis [4]. The intensity of observed electron reflection indicates a magnetic field strength near the surface in excess of 100 nT (y), while direct measurement at PFS orbital altitudes of 155-187 km by the on-board magnetometer shows the field has decreased to less than ±2 nT at those altitudes. It was suggested that the rille is a structural feature, which has associated with it a net magnetic field exceeding by an order of magnitude that of the relatively non-magnetic areas adjacent. Such a feature might have either the form of intrusive magnetized rock, or else the form of a demagnetized gap in an otherwise rather uniformly magnetized layer of rock of large surface extent.

The usual simple dipole models of subsurface magnetization were clearly not applicable to a long narrow feature such as this. A reasonable initial approximation was obtained in [4] by using a model consisting of an infinitely long cylinder of magnetized material, centered a distance \( d \) below the surface. This model was used to show that the observed decrease in field from surface to orbit required a rather small radius for the cylinder, less than 4 km, with intensity of magnetization similar in magnitude to the NRM observed in the more highly magnetized breccias [5]. A model more applicable to probable physical cases such as a ribbon of magnetized rock intruded into a crack in the surface layers or the magnetically equivalent case of a layer of demagnetized (ground up) rubble along a dislocation of the otherwise uniformly magnetized crustal rock, requires calculation of the magnetic field configuration above a (rectangular prism) slab or ribbon of magnetized material of length \( L \), width (or gap) \( a \), and depth \( d \). An exact solution for any such model has been obtained by direct integration of the magnetic potential in three dimensions (rectangular coordinates).

\[
\mathbf{B} = -\nabla \phi
\]

where \( \phi = \frac{1}{4\pi} \iiint \mathbf{M} \cdot \nabla \left( \frac{1}{r} \right) \, dv' \)

The potential obtained is the sum of three components proportional to each of the three components of magnetization \( M_x, M_y, M_z \). The methods used are similar to those developed recently for use in...
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studies of seamount magnetic anomalies [6]; however, various simplifying assumptions commonly used there are not applicable to the lunar case. In particular, for use with ERM surveys of lunar surface magnetism, numerical integration of individual electron trajectories during scattering in an exact field solution is expected to be important for matching observed reflection coefficients with model predictions.

The most interesting solutions (relative to Rima Sirsalis) appear to be those involving vertical magnetization of a ribbon 200 km long, 1 km wide and 1 to 50 km deep. The field configuration of these solutions couples directly with a vertical external field of the same direction. Other relative orientations form a magnetic bubble above the magnetized region, with external field lines deflected around it. Electrons moving along these field lines will, therefore, be guided away from the most intense center of the magnetic anomaly, reducing the efficiency of scattering to be expected.

The results show maximum field strength obtained near the surface does not vary greatly with depth of the assumed anomaly, ranging from 90 to 200 nT as the model depth increases from 1 km to 50 km with intensity of magnetization $M_z$ taken to give a surface field of 100 nT for the infinite cylinder calculated in [4]. However, the rate of decrease in field strength with altitude drops rapidly with increasing depth $d$ of the magnetized ribbon. The field at 100 km due to an anomaly 1 km deep is only .02 nT (.02% of $B_{surface}$), while the 50 km depth gives a field at 100 km greater than 0.8 nT (.4% of $B_{surface}$). Thus, an assumed depth of 50 km or greater for the Rima Sirsalis Anomaly would not be consistent with the observed data. Assuming a narrower width (than 1 km) would not help. A source 50 km deep by only 100 meters wide would still give a field at 100 km of .5% of $B_{surface}$, while requiring a much stronger value of $M_z$ to obtain 100 nT at the surface. In fact, any magnetization extending deeper than 5 km ($B_{surface} = 110$ nT, $B_{100\ km} = .1\%$) would be unlikely to be consistent with the observed data.

The lateral extent (in x) of the observed reflection region along the orbit would also be difficult to reconcile with any model 50 km deep. "Fringing" fields of such a configuration near the surface fall off very slowly with increasing x, probably resulting in a much broader region (halo) of significant reflection than the sharply narrow one observed.

References:

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TABLE 1

<table>
<thead>
<tr>
<th>Magnetized Volume</th>
<th>B</th>
<th>Ratio</th>
<th></th>
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<tr>
<td>(ald)</td>
<td>surface</td>
<td>1 km</td>
<td>10 km</td>
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<tr>
<td>1 x 200 x 50</td>
<td>195</td>
<td>155</td>
<td>17</td>
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<tr>
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<td>150</td>
<td>110</td>
<td>8</td>
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<td>17</td>
<td>1.5</td>
</tr>
<tr>
<td>1 x 20 x 50</td>
<td>200</td>
<td>155</td>
<td>19</td>
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<tr>
<td>1 km dia. cylinder</td>
<td>160*</td>
<td>75</td>
<td>1.5</td>
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