CRUSTAL MAGNETIC SCALE SIZES MEASURED AT APOLLO LANDING SITES

P. Dyal, NASA-Ames Research Center, Moffett Field, CA 94035
W. D. Daily, Eyring Research Center, Provo, UT 84061

Interaction of the remanent magnetic fields with the solar wind plasma has been used to study magnetization in the lunar crust at the Apollo 12, 15, and 16 landing sites. This magnetization results in local remanent fields of 38, 3, and 234 gammas measured by the three Lunar Surface Magnetometers (LSM). These surface fields diffuse into the solar wind plasma by a process theoretically described by Vanyan (1977). In this theory the crustal magnetization is modeled by a cos(my) dependence resulting in surface field components $B \propto e^{-qx} \cos(my)$. The horizontal (y) scale size is $L = 2\pi/m$ and the vertical (x) scale size is q^{-1} where q depends on L and the plasma density, N. This theory predicts that the remanent field distortion is proportional to the product $L\sqrt{N}$. The theortically predicted field-plasma interaction has been compared to the measured response at the Apollo 12 and 16 LSM sites. A measure of the distorted fields at these sites is calculated by subtracting the field external to the moon measured by lunar orbiting magnetometers (Coleman et al., 1973; Sonett et al., 1967) and the undistorted remanent field at each site from the total field measured by the surface magnetometers (Dyal et al., 1973). Solar wind plasma parameters were measured on the lunar surface by the Solar Wind Spectrometer experiments (Snyder et al., 1970). The vertical and horizontal components of the distorted remanent field at the Apollo 16 site are plotted as a function of plasma density in Figures 1 and 2 respectively. These data indicate that the horizontal scale size of the remanent fields is approximately 4 km. Corresponding analysis of the Apollo 12 data indicates a similar scale size of approximately 12 km at this site. These scale lengths are in accord with the gradient field measurements made by each LSM and the astronaut traverse field measurements at Apollos 14 and 16 (Dyal et al., 1973). We conclude that remanent fields over most of the lunar surface are probably characterized by spatial variations of a few kilometers which have not been resolved by the Particles and Fields Subsatellite mapping experiments. The measured field properties of the Apollo sites which can be obtained from this analysis will be useful as references for the Lunar Polar Orbiter field mapping experiments. Results of the remanent field-plasma interaction analysis imply that the scale size of crustal magnetization is as small as a few kilometers and this is further evidence that the processes responsible for the magnetization were local and not global in extent.

Electromagnetic sounding, remanent field mapping, and plasma interaction studies require accurate magnetic data from several orbiting and surface magnetometers. We have, therefore, undertaken thorough error analysis of the Apollo, Explorer, and Subsatellite magnetometer data. Direct comparison of simultaneous data shows gain and offset discrepancies between these instruments which are a function of time. For example, during the first four lunations of Apollo 12, the gains of the three magnetometers agree within approximately 2% except during sporatic intervals when the spin axis component measured by the Goddard Explorer 35 magnetometer indicates a gain difference of about 60% from the other instruments. During subsequent lunations the gain differences dramatically increase in all three axes of the two Explorer

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magnetometers from about 2% up to nearly 60%, implying a malfunction of one or both of the Explorer 35 magnetometers. We are now comparing this data with the Apollo LSM data to determine its validity. With the measured relative error between surface and orbiting magnetometers we can determine quantitative bounds on the accuracy of the lunar conductivity profile calculated from these data. To do this we have investigated the change in the conductivity profile resulting from a 3% relative difference in the magnetometer records from which the profile was calculated. Figure 3 shows the band which contains the profiles allowed by this difference. This band, therefore, indicates the limit in accuracy possible with the available data. It is evident that lunar conductivity studies using poloidal field analysis of available data is most accurate at depths from 200 to 1000 km. At depths below about 1000 km limitations on a highly conducting core are difficult to obtain due to limitations in data set length and accuracy. Work is in progress to determine the conductivity profile bounded by the errors inherent in the data.

References

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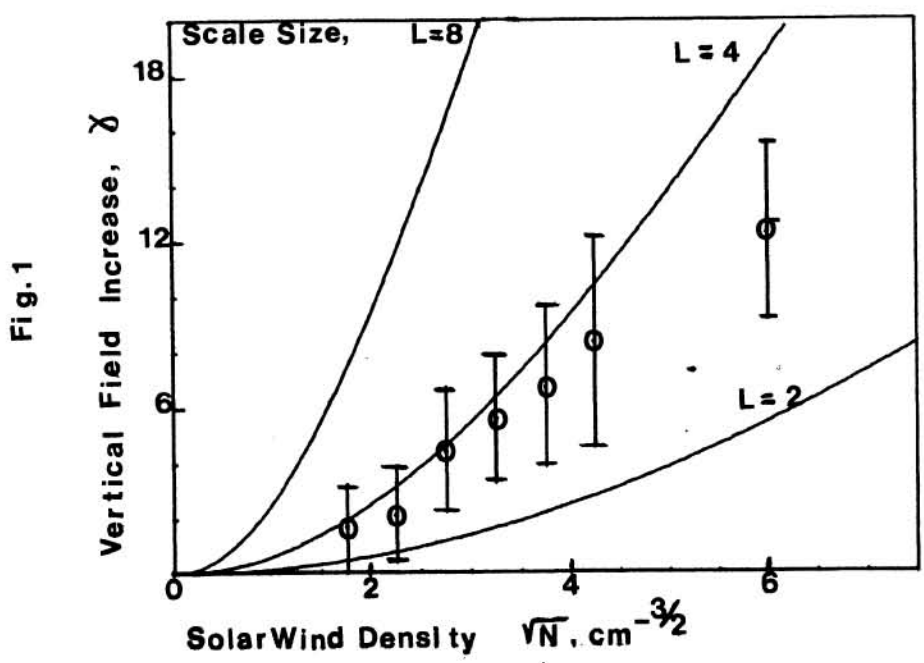

Fig. 1

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Fig. 2

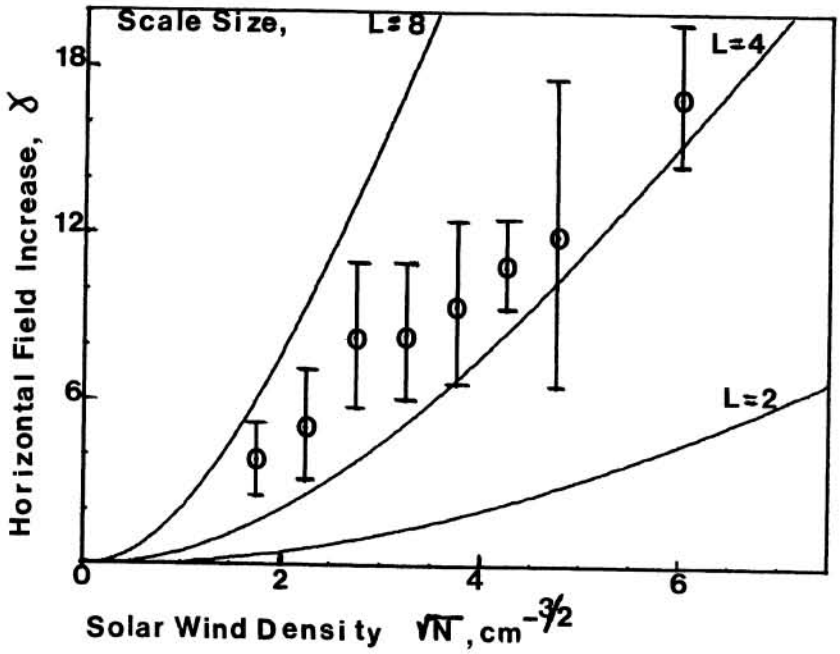

Fig. 3