A SEARCH FOR IMPACT CRATER-ASSOCIATED SURFACE MAGNETIC FIELDS IN MARE REGIONS, R. P. Lin, Space Sciences Lab., Univ. of California, Berkeley, CA 94720.

High spatial resolution (∿10 km) electron reflection measurements (1, 2) of lunar surface magnetic fields from the Apollo 15 and 16 subsatellites are analyzed to determine whether there are strong magnetic fields associated with craters in lunar mare. Such crater-associated fields could arise under the following circumstances:

(1) A large-scale magnetic field, if present during mare formation, would uniformly magnetize the mare basalts. Such a field might have arisen from a lunar dynamo or from an external source, e.g., terrestrial or solar fields. The surface field from a large, uniformly magnetized sheet such as a mare would be weak except at the edges. However, craters excavated by subsequent impacts in the uniformly magnetized basalt layer would show a strong magnetic signature equivalent to that of a plug of the crater dimensions with opposite magnetization. As illustrated schematically in Figure 1 the surface field will be stronger at the crater edge.

(2) If there was an ambient magnetic field present at the time of an impact, that field would be impressed into the crater material which was heated by the impact.

(3) There is a possibility that hypervelocity impacts could spontaneously generate strong magnetic fields which would then be imprinted into the hot crater material (3).

Thus the strength of crater-associated surface magnetic fields can give information on magnetization processes and the field strengths of lunar or ambient magnetic fields in the 3.2-3.9 b.y. mare formation period. Paleointensity measurements on returned lunar samples have been interpreted to imply that the ancient lunar field decayed from ∿1 Oe at ∿4 b.y. to ∿0.05 Oe at ∿3.2 b.y. (4). Also comparisons of mare fields with the age of the mare surface show a correlation with the older mare surfaces having the strongest average fields (5).

Analysis and Results

The measurements of the mare surface magnetic fields are obtained by the planetary electron reflection method (PERM) (1). PERM uses the principle of the "magnetic mirror." Basically charged particles tend to be reflected from a region of increased magnetic field strength. The moon is always threaded by the interplanetary or earth's magnetotail or magnetosheath magnetic fields which are typically 5-10 γ in strength. If no surface field is present, the charged particles are guided by the external magnetic field into the lunar surface where they are absorbed except for $\lesssim$ 5% which are Coulomb backscattered from surface material. If surface fields are present, the total field strength increases as the particles approach the region, causing a fraction of the particles to reflect back with an intensity that increases with the strength of the total surface field. The main advantages of the PERM technique are that it measures the field strength at the lunar surface with very high sensitivity and spatial resolution.

The 1/2 keV electron measurements from the Apollo 15 and 16 subsatellites,

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which cover ∿-30° to + 30° latitude, are used. These data provide spatial resolution of ∿10 km and sensitivity of ∿1γ. The mare regions were divided up for convenience into rectangular regions of ∿20 to 100 sq. degrees area. Every impact crater of 5 km size or larger in these regions was tabulated and the surface field over the crater is compared with the surrounding field (see Figure 1). A total of ∿1100 ¼ x ¼ degree crater resolution elements and ∿1500 elements surrounding craters were used. Figure 2 shows the average crater fields, plotted versus the surrounding fields for each region of the mare. The agreement with a 45° line drawn through the graph indicates that there is no increased field strength associated with craters. The average for all the data is 1.49 ± 0.06 γ (1 γ = 10^{-5} Oe) for the crater field compared to 1.53 ± 0.05 γ for the surrounding field. The same analysis was repeated with the surrounding elements replaced by all the mare elements, with essentially the identical results. Thus the data taken as a whole indicate that there is no crater-associated field. This result implies that the mare do not have a strong, large-scale homogeneous magnetization and therefore that any large-scale lunar magnetizing field at the time of mare formation must have been weak. Additionally, apparently no very strong fields were present at the times of impacts in the mare, nor do these impacts create strong fields spontaneously which can be imprinted into the crater material. Analyses are currently underway to provide quantitative limits on the ancient field strengths in mare formation periods.

References

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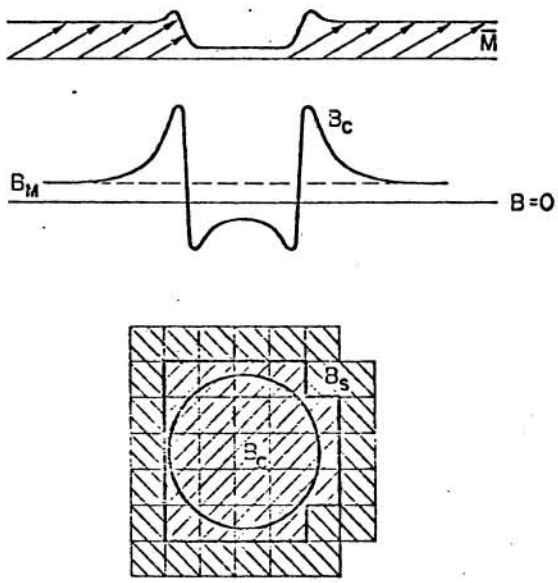

Fig. 1. The upper part shows a schematic cross-section of an impact crater in a uniformly magnetized mare basalt sheet. The middle portion is a schematic illustrating the surface field strength. The lower portion shows the choice of crater vs. surrounding resolution elements.

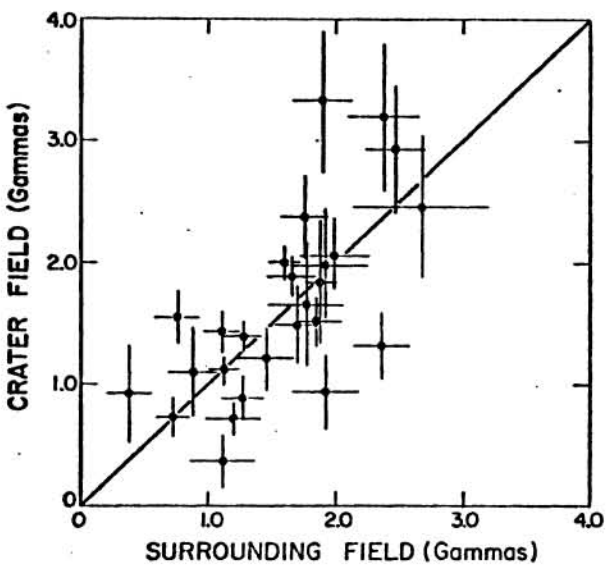

Fig. 2. Plotted here are the average field strengths for crater elements versus those for elements surrounding craters for 26 mare regions of ∿20 to 100 square degrees area.