MAGNETIC FIELDS OF LUNAR IMPACT BASINS AND THEIR USE IN CONSTRAINING THE IMPACT PROCESS.
J.S. Halekas, R.P. Lin, *Space Sciences Laboratory, University of California, Berkeley CA 94720 (email: jazzman@ssl.berkeley.edu).*

Measurements by the Magnetometer/Electron Reflectometer instrument on the Lunar Prospector spacecraft, which completed its mapping mission in 1999, have been used to construct the first completely global maps of lunar crustal magnetic fields. Now, for the first time, we have a data set with global coverage and a sensitivity and resolution which allow us to investigate the magnetic fields of lunar impact basins and craters. As on the Earth, impact sites have a variety of magnetic signatures associated with them, ranging from nearly complete demagnetization to strong central magnetic anomalies. Observations of the magnetic fields of terrestrial basins have been used to make inferences about the impact process, and we wish to show that lunar observations can also provide valuable constraints.

It is clear that we can not achieve the same kind of magnetic field data coverage of lunar basins with measurements from orbit that we can for terrestrial basins using ground magnetometer or aeromagnetic data. Furthermore, lunar missions have only returned a limited number of samples of actual magnetized crustal rocks, while on the Earth we can study as many samples as one could wish. Therefore, one might wonder why lunar data should be used at all, when terrestrial data has these clear advantages. However, the Moon has several key advantages over the Earth for this type of study. First and foremost, the Moon currently has no global magnetic field. This means that we do not have to subtract off a huge global field when measuring local crustal fields, nor do we need to deal with induced magnetic fields. Instead, we can be sure that the signal we measure is purely due to remanent magnetization in the local crustal rocks. Furthermore, on the Earth impact basins formed in the presence of a strong ambient magnetic field. On the Moon, on the other hand, at least the younger basins and craters appear to have formed with no significant ambient magnetic field present. This means that we can more easily determine the demagnetization effects of these impacts.

Studies of terrestrial impact basins have revealed many basin-associated magnetic anomalies [1]. These range from short-wavelength anomalies with a radial extent of a fraction of the transient cavity radius (e.g. Manicougan [2]), to larger groups of anomalies which fill most of the transient cavity region (e.g. the outer ring of anomalies in the Chicxulub basin [3]). The more localized anomalies have generally been ascribed to shock remanence (SRM) or other processes in the central uplift region, while more extensive anomalies have been interpreted as thermal remanent magnetization (TRM) in impact melt rocks. Many lunar basins and craters also display central magnetic anomalies, with the older large (> 200 km in diameter) craters and basins having the most significant anomalies. These anomalies roughly fill the transient cavity region, and therefore by analogy with terrestrial basins, may be due to TRM in impact melts. If this is the case, these anomalies indicate the location of the most substantial amounts of impact melt in lunar basins. On the other hand, if they are instead due to SRM in uplifted materials, they could be used to delineate central uplift structures in multi-ring basins.

Earlier work has shown that many lunar impact craters and basins, especially the youngest ones, are demagnetized with respect to their surroundings [4]. This is also true of many smaller terrestrial craters [1,5]. However, for younger lunar impact sites, demagnetization is especially clear, probably because there were no strong ambient magnetic fields present at the time of these impacts. The demagnetization of lunar craters and basins has been found to extend well beyond the main rims of these structures, which provides strong evidence that impact-generated shock is mainly responsible for demagnetizing the crustal rocks [4].

The physical mechanism of shock demagnetization is still not particularly well understood. However, laboratory measurements of shock demagnetization of both lunar and terrestrial rocks have been performed [6,7,8]. The degree of demagnetization is, in general, dependent on the peak shock pressure and on the remanent coercivity of the crustal magnetization, and laboratory experiments have roughly quantized this relationship for terrestrial basalts [6]. The returned lunar samples show a wide variety of magnetic coercivity spectra. However, lunar breccias tend to carry the strongest remanence, and we have therefore constructed average coercivity spectra for various sets of breccias [9,10]. By combining coercivity spectra with impact demagnetization data and experimental shock demagnetization results, we have attempted to derive the radial peak shock pressure attenuation. Our preliminary results imply peak shock pressures at the transient cavity rim of 2 Gpa and power law attenuation with a power of -2 to -3. These results are consistent with modeling [11] and shock pressure reconstructions from terrestrial basins [12].

We believe that the magnetic fields of lunar impact craters and basins can provide important information about the impact process. Though performing this work with lunar rather than terrestrial data has some drawbacks, there are also clear advantages. So far, our results are encouragingly consistent with terrestrial observations and modeling.

REFERENCES: [1] Pilkington and Grieve, *Rev. Geophys., 30*, 161-81, 1992. [2] Coles and Clark, *J. Geophys. Res., 83*, 2805-8, 1978. [3] Pilkington and Hildebrand, *J. Geophys. Res., 99*, 13147-62, 1994. [4] Halekas *et al., Geophys. Res. Lett., 29, 10.1029/2001GL013924*, 2002. [5] Scott *et al., Meteorit. Planet. Sci., 32*, 293-308, 1997. [6] Pohl *et al., J. Geophys., 41*, 23-41, 1975. [7] Cisowski and Fuller, *J. Geophys. Res., 83*, 3441-58, 1978. [8] Cisowski *et al., Proc. Lunar Planet. Sci. Conf., 6*, 3123-41, 1975. [9] Gus'kova *et al., Cosmic Research, 12*, 680-8, 1974. [10] Fuller, *Rev. Geophys., 12*, 23-70, 1974. [11] Ahrens and O'Keefe, in *Impact and Explosion Cratering* ed. Roddy, Pepin, and Merrill, 639-56, 1977. [12] Robertson and Grieve, in *Imp. and Exp. Crat.*, 687-702.