TERRAIN ANALYSIS OF THE METEOR CRATER EJECTA BLANKET

Garvin, J. B.*, J. L. Bufton*, B. A. Campbell**, and S. H. Zisk**; *NASA/GSFC, Greenbelt, MD 20771, and ** Planetary Geosciences, Hawaii Instit. Geophys., Honolulu, HI 96822

Only youthful impact craters on Earth with "simple" morphologies have well-preserved ejecta blankets, and of those that have been studied to date, the *Meteor Crater* (aka *Barringer*) structure displays the best preserved continuous ejecta blanket [1,2]. In an effort to investigate the ways in which ejecta blankets are eroded or degraded on planetary surfaces, we have focused on what can be learned about such processes from various airborne remote sensing datasets, including airborne laser altimetry (ALA), multipolarization imaging radar (MIR), and thermal infrared emission imagery (TIMS). In this preliminary report of our findings the emphasis is on the textural characteristics of the ejecta deposit within one crater radius (600 m) from the Meteor Crater rim crest as described by a set of multidirectional ALA topographic profiles. Comparisons of terrain characteristics derived from the ALA data with the results of a polarimetric radar scattering model developed by Campbell et al. [3] for MIR data are in progress (for L and P bands). The primary objective in this work has been to analyze azimuthal variations in local terrain properties of the ejecta as it extends to a distance of one crater radius from the rim.

We have explored the statistical properties of local slopes, slope curvature, RMS relief, and topographic variance within this near-rim ejecta zone, as well as the radial decay of meter-scale relief. These terrain properties can be derived from a variable azimuth set of 3 m horizontal resolution ALA profiles (with < 1 m vertical precision) using traditional "sliding" boxcar filtering techniques. Power-law relationships for each of the terrain properties (in terms of mean values) as a function of horizontal baseline (Δx) have been established for baselines from 10 to 250 m. These relationships permit reasonable estimation of 0.1-10 m scale properties of interest in polarimetric radar scattering models by simple extrapolation. The power laws are of the form: Mean{property} = k Δx**b, where b is the power-law exponent. ALA topographic profiles for the E, W, SW, NE, and S regions of the ejecta blanket have been analyzed. Of all of these, the SW ejecta is the most consistently anomalous with the largest variations in local slope and RMS relief, suggesting a fundamental modification of the pristine ejecta deposit in this sector.

The first order characteristics of any impact crater ejecta blanket are adequately described in terms of the radial decay of local topography (and hence thickness) with range from the rim crest [4]. It is instructive to investigate how well the McGetchin et al. [4] model for the radial decay of ejecta thickness as a function of azimuth applies to a canonical crater such as Meteor Crater. McGetchin et al. [4] suggest that the thickness t of the ejecta decays from the rim with a power law exponent of -3.5 for simple craters, and in general for all craters at -3.0. The general power law they developed was of the form: (t/T) = k (r/R)**B, where t is the ejecta thickness, T is the maximum thickness, r is radial distance from the crater center, R is the crater radius, k is a constant, and B is the power law slope. We have assumed that the normalized thickness (t/T) can be approximated by z/Z, where z is the local topography as a function of radial distance (in terms of r/R) and Z is the height of the rim crest above an assumed ground zero level (the local relief at 2 crater radii from the crater center). This assumption should be valid if the ejecta blanket has not been highly modified, as suggested by [2]. Thus, we have explored power law relationships of the form: (z/Z) = k (r/R)**B for five different sectors of the ejecta using ALA topographic profiles that extend from the crater center to at least two crater radii. The resulting power law exponent values B are as follows:

East B=-5.6, *West* B=-6.7, *Southwest* B=-2.7, *Northeast* B=-4.8, and *South* B=-5.8.

The range of these B values clearly demonstrate the azimuthal variability of the ejecta blanket at Meteor Crater. Only the SW ejecta sector appears to follow the McGetchin et al. [4] model for the radial decay of ejecta thickness (B ~-3). Given the sub-meter precision of the ALA profiles, it is unlikely that the B-values derived from these data are in error. Several working hypotheses can be constructed to explain the extreme azimuthal variation in the ejecta thickness and terrain properties. A first hypothesis would suggest a preferred directional distribution of the ejecta due to an oblique impact. However, several workers have explored this possibility [1,2] and have concluded that the Meteor

Crater impact event was not anomalously oblique. Given the flat-lying, layered nature of the sedimentary target at Meteor Crater, there is no reason to believe that target characteristics would strongly influence ejecta distribution and hence thickness. The variation in the power law B values from -2.7 to -6.7 (with a mean value of -5.0) demonstrates an ejecta blanket asymmetry that appears to be due to the pattern of erosional processes which have acted in the Meteor Crater region over the past 49,000 yrs. It appears that the SW sector of the ejecta has been the most severely modified since emplacement by local weathering processes which include eolian mantling (which are obvious in the TIMS imagery of this region). The prevailing southwesterly winds appear to have deflated the SW ejecta and encroaching eolian deposits in the form of dunes have covered some of the primary ejecta beyond 1.4 crater radii. However, the locally severe fall-off in ejecta relief at ~ 1.4 crater radii in the SW appears to be anomalous as well, and may relate to a previous erosional episode in which the ejecta in this region was downcut by fluvial(?) processes. This topographic variation may also be related to the regional monocline on which the crater is superimposed [1,2].

The best preserved ejecta (to the East and NE) displays a radial decay of thickness (and hence relief) that follows a power law with an exponent B of -4.8 to -6.7, with an effective mean value of -5.0. Such behavior is not in agreement with data from nuclear explosion craters nor is it consistent with estimates for simple lunar maria craters [4]. This rapid decay of apparent ejecta thickness relative to previously reported values [4] appears to suggest several explanations. First, the near-rim ejecta at Meteor Crater may be more extensively modified than previously believed, with superimposed eolian drift deposits that have significantly affected the meter-scale relief. Alternately, the previous estimates of ejecta thickness for simple craters as a function of radial range [e.g., 4] could be in error, and the preserved ejecta around simple craters in layered sedimentary targets may follow a power law decay with B=-5 instead of B=-3. This rapid decline in ejecta thickness qualitatively agrees with observations of simple lunar maria craters [5]. It should be noted, however, that the analysis presented herein is exclusively for the ejecta within one crater radius from the rim crest; power law B values nearer to -3 or -4 would be expected if the analysis were extended to > 2 crater radii.

This work suggests that the radial behavior of ejecta topography (and hence thickness) within one crater radius of the rim crest follows a power law with a typical B value of -5. This behavior has apparently not been quantified to adequate precision for other fresh terrestrial simple craters such as Lonar, New Quebec, Shunak, Talemzane etc. Data reported in [4,6] for nuclear explosion craters (B=-3.5) appears to suggest a fundamentally different ejecta blanket character. High precision and spatial resolution topographic profiles of fresh ejecta blankets for simple craters on the Earth, Moon, and Mars appear to be required to adequately describe and analyze ejecta blanket development as a function of target type, gravity, kinetic energy of impact, and angle of impact. Airborne laser altimeter profiles of nuclear explosion craters could help address this problem in the future. {Research supported by NASA/GSFC DDF 88-04}.

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