GEOMETRIC PROPERTIES OF THE *MEREWETHER* STRUCTURE, NEWFOUNDLAND, CANADA

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Introduction: Detailed geometric properties of ultra-fresh (recent) impact events on Earth and on other planets provide a new class of boundary conditions for understanding the physics of hypervelocity cratering, as well as post-formation geomorphic modification. One of the potentially most recent impact events in Earth history is that which may have formed the ***Merewether*** "craterform" in Labrador (Newfoundland), Canada. Existing field observations largely from the 1950's field-work of V. B. Meen [1] suggest that the 200m lake-filled circular depression was formed within the past ~900 years in target materials dominated by till-covered crystalline rocks. Other than a brief field visit to *Merewether* in 1988 by Jean Pilon et al., there has been little consideration of this putative impact feature since the late 1950's. As a consequence of newly available topographic information about small martian impact craters made possible by MRO (i.e., HiRISE and CTX DEM's), as well as swath mapping lidar topographic observations of benchmark terrestrial craters, NASA acquired a geodetic-quality DEM for the *Merewether* region in collaboration with Canadian investigators in September 2007, as a piggyback on an aircraft remote sensing campaign to the Greenland ice-sheet. The resulting ~1m horizontal scale DEM offers 10cm vertical precision topographic information for what may be an extremely recent hypervelocity cratering event on Earth. As such, understanding the detailed geometric characteristics of a fresh simple crater on Earth in comparison with similar information for fresh simple craters on Mars offers new perspectives on relatively low-energy and minimally modified cratering events on both planets.

Here we summarize initial results of our detailed examination of the *Merewether* structure on the basis of the NASA geodetic topography dataset, and provide first-order comparisons with a small set of fresh martian simple craters as observed by MRO.

NEW LIDAR DATA: On September 25, 2007, a NASA P-3B aircraft equipped with differential GPS, laser-ring gyros, down-looking digital imaging systems, and a swath mapping lidar altimeter collected multiple swaths of cm-resolution ranging information covering the *Merewether* feature located at approximately 58N, 64E in Labrador, Canada. The dataset was processed into a 1m gridded topography dataset (DEM) with better than 10 cm (RMS) vertical precision. This 1m DEM is similar to stereogrammetric DEM's that are now being routinely produced from MRO HiRISE stereo images of Mars [2]. The *Merewether* DEM will ultimately provide 3-5 cm absolute vertical accuracy data on a 1 to 2 m grid. For comparison, NASA acquired a similar dataset for *Barringer* (Meteor) Crater in late 2005 as a benchmark for terrestrial impacts into sedimentary target rocks. A 10cm resolution nadir-viewing digital image dataset was acquired simultaneously with the lidar ranging data, and these data have been co-registered to the DEM (see Fig. 1).

GEOMETRIC ANALYSIS: Algorithms developed for use with gridded topography data for impact and volcanic landforms by the authors of this document have been modified to allow for derivation of primary geometric properties for features such as *Merewether*, as well as small craters on Mars and the Moon. In addition, cylindrical and annular harmonic analysis codes [3] have been utilized to develop simple "geometric amplitude spectra" for *Merewethe*r versus other reference craters as a means of addressing whether the topographic signature of the *Merewether* feature is consistent with an impact origin. A database of "reference" impact or explosion landforms has been compiled by the authors and includes: Meteor Crater (AZ), Ubehebe Maar (CA), Schooner nuclear explosion crater (NV), Victoria crater (Mars), a small 300m diameter simple crater in Taurus Littrow (Moon), a simple lunar-like crater in Amazonis on Mars we refer to unofficially as "Linne", and a fresh 1.7km simple crater at 44N on Mars that has been well "imaged" by MRO on orbit 5807. Geodetic DEM's for Merewether, Meteor Crater, Schooner, and Ubehebe maar were acquired by NASA using airborne swath mapping lidar instruments developed by NASA's Goddard Space Flight Center [4]. Combined MOLA topographic data and MRO imaging data were used to develop DEM datasets for some small martian craters using a new circular gridding algorithm. A DEM for *Victoria* crater was provided by the HiRISE science team on a 1m grid (from stereogrammetry).

MEASUREMENTS. Automated analysis of the DEM datasets was performed. For *Merewether*, the surface DEM was extended to include the full character of the underwater portion of the cavity using bathymetric profiles acquired by Meen in 1954 and co-registered with the inner cavity walls measured by the NASA airborne lidar. The resulting measurements indicate a very conical cavity with subdued rim-flank ejecta. Using a simple cavity shape function of the form : z = k r^(n), where n is a shape exponent for a least-squares regression fit to the cavity described by a dataset of the form (r,z), and k is a fit coefficient, we have measured the shapes of more than 2000 simple craters on Mars using MOLA data regridded using a circular gridding approach. This same approach was used for *Merewether*. Figure 1 illustrates the basic geometric properties of the *Merewether* "craterform", revealing its fresh-crater-like d/D (~ 0.26).

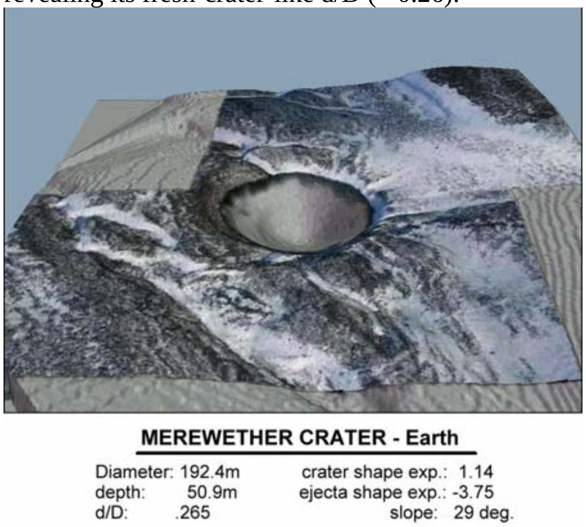

Figure 1: NASA 1m DEM of Merewether Crater with 10cm/pixel image superimposed (from NASA swath imaging lidar flown on P-3B aircraft) with measurements.

This new topographic information supports the hypothesis that *Merewether* is a minimally-modified impact crater with extremely fresh crater characteristics, but with extremely subdued ejecta topology and thickness characteristics. A fresh-appearing simple impact crater at 44N on Mars, with a diameter of 1.7 km (MRO orbit 5807) exhibits similar cavity parameters to those of *Merewether*, as do several sub-km simple craters on the Moon for which high resolution topography is available. While these findings appear to suggest a uniquely impact origin for Merewether, they cannot serve to "prove" the 200m feature was formed via hypervelocity impact.

ANALYSIS: Using cylindrical harmonic model (CHM) analysis of the *Merewether* DEM vs the others, we have examined the amplitude spectra to investigate whether there are signatures indicative of an impact origin. Figure 2 illustrates the CHM spectra of *Merewether* vs. other reference craters.

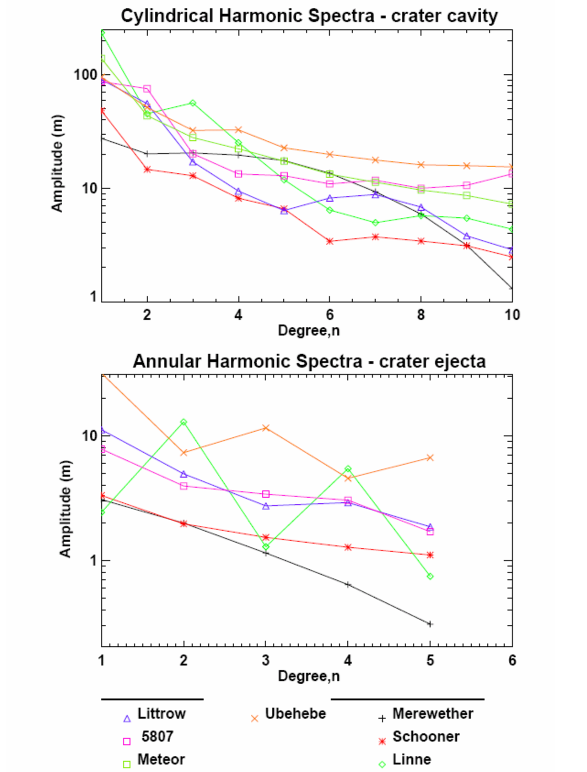

Figure 2: CHM amplitude spectra for craters (cavities at top, and ejecta at bottom); Ubehebe maar included (x)..

Merewether most resembles the fresh 300m lunar simple crater and the martian crater (5807). We believe that the combination of the cavity geometry properties with the CHM spectra uniquely support a recent impact origin for *Merewether*. The implications of this assertion are many. First, if *Merewether* is an extremely recent impact event, then its properties may be relevant to fresh near-polar impacts on Mars where rubble-covered surfaces are common. In addition, if detailed topographic signatures can be used to convincingly verify impact origins for landforms on Earth and other planets, then the topographic information being acquired by MRO and soon-to-be collected for the Moon via NASA's LRO will contribute to an improved understanding of the hypervelocity impact process across the inner solar system. *{We gratefully acknowledge the support of NASA HQ SMD (Garvin's MSSE activities for the MEP), and the NASA GSFC IRAD program}.*

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