DETERMINING EROSIONAL/DEPOSITIONAL HISTORY OF DEUTERONILUS MENSAE, MARS USING CATEGORIZED CRATER SIZE-FREQUENCY DISTRIBUTIONS.

Daniel C. Berman, David A. Crown, and Emily C.S. Joseph, Planetary Science Institute, 1700 E. Ft. Lowell Rd., Suite 106, Tucson, AZ 85719; bermandc@psi.edu.

Introduction: Crater size-frequency distributions (SFD) of small craters (~25 m – 1 km diameter) on Mars can provide new insights into the erosional and depositional histories of geologic units as well as refinements of formation ages. The Deuteronilus Mensae region along the dichotomy boundary exhibits a variety of geologically young, ice-related features, including ice-cemented mantling deposits, lobate debris aprons, concentric crater fill, and lineated valley fill that are key indicators of climate conditions. Categorized crater size-frequency distributions derived using Mars Reconnaissance Orbiter Context Camera (CTX; ~5 m/pixel) images on the lobate debris aprons, the ejecta blanket of Cerulli crater (32.2°N, 22.0°E), and surrounding plains units are presented here.

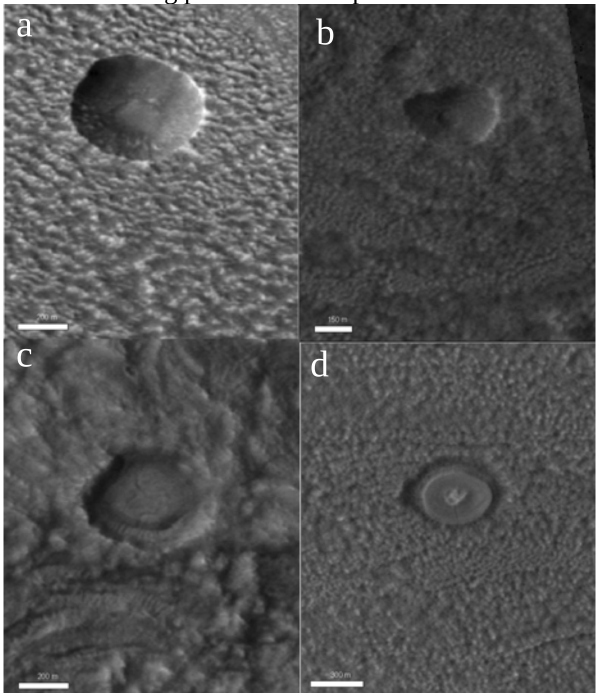

Fig. 1. Examples of: (a, from CTX image P19_008441_2247) a fresh crater; (b, from CTX image P14_006582_2214) a degraded crater; (c, from CTX image P05_002890_2205) a flat floored crater; and (d, from CTX image P19_008441_2247) a filled crater.

Crater Count Methodology: Crater size-frequency distribution statistics have been compiled using established methodologies [1-4]; all impact craters (primaries and isolated secondaries) on a given surface in a specific diameter range are counted while avoiding areas of obvious secondary chains or clusters. These data are then plotted on the isochrons defined by [2-4] to assess relative age (Martian time-stratigraphic age) and estimate absolute age. Deviations from isochron shape over specific crater size ranges, along with classification of crater type (fresh, filled, degraded, or flat-floored), provide further information on erosional and depositional processes affecting the surfaces of interest.

Potentially ice-rich surfaces can be geologically complex given uncertainties in ice content and distribution, and mantling and degradational history. In mid-latitude zones, surfaces may have undergone multiple cycles of mantling. We assume fresh (bowl-shaped, Fig. 1a) craters superpose even the youngest of these and that filled craters (Fig. 1d) are filled with mantling deposits and thus indicate a formation age of the landform/surface that has been mantled. Layered mantling deposits on the floors of craters, as well as degradational textures resembling mantle materials on filled crater surfaces support this interpretation. Degraded and flat-floored craters (Fig. 1b,c) may have formed before the most recent mantling episode, but have not yet accumulated much fill.

Debris Apron SFD: The distribution of all craters superposed on a series of debris apron surfaces in Deuteronilus Mensae shows one segment that follows the isochrons (~500 m - 2+ km), indicating a formation age of less than 1 Gy during the Early Amazonian Epoch (range Late Hesperian-Middle Amazonian). The distribution of filled craters mimics that for all craters but the depletion of small crater sizes (relative to the isochrons) is greater, consistent with mantled debris apron surfaces. The distribution of degraded and flat-floored craters matches the isochrons from 250 m - 1 km diameters, giving an age of ~100 My. The distribution of fresh craters shows a segment that follows the isochrons (~60 - 500 m), consistent with the several-My age estimates of obliquity-driven Martian mid-latitude mantling deposits [5]. We interpret the filled craters to have predominantly formed on the Early Amazonian surfaces of the debris aprons and the fresh craters to have formed on Late Amazonian mantling deposits that have covered the debris aprons, with the degraded and flat-floored craters forming in between. The various potential mantling/resurfacing ages estimated from debris aprons can be attributed to a combination of highly mobile surface materials, the presence of ice and the degradational effects of loss of ice, and a complex history of erosion and mantling [6].

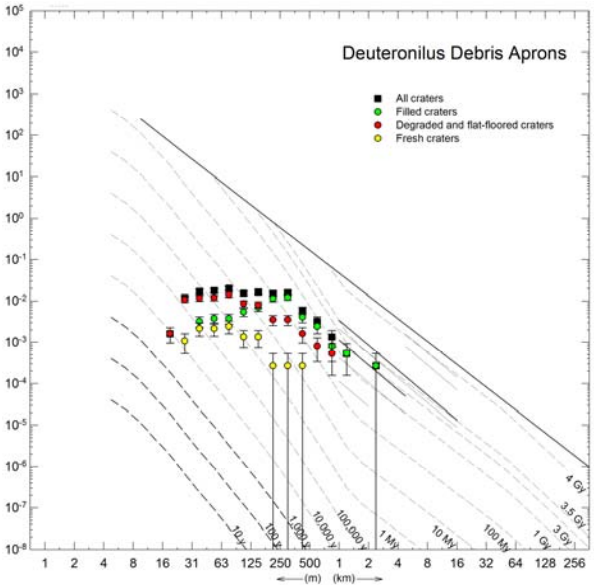

Figure 2. Crater size-frequency distributions for lobate debris aprons. N_{all}=411, N_{filled}=151, $N_{degraded/flat}$=159, N_{fresh}=24, A=3513 km^2.

Plains SFD: The distribution of all craters on the plains (Figure 3) matches the isochrons above 500 m in diameter, and falls off below, giving ages of ~1 Gy, in the Late Hesperian/Early Amazonian. Filled craters give the same age, but fall off much more sharply at small diameters. Degraded and fresh craters follow the isochrons down to 125 m and give ages of 100 My, or Late Amazonian, again consistent with recent mid-latitude mantling.

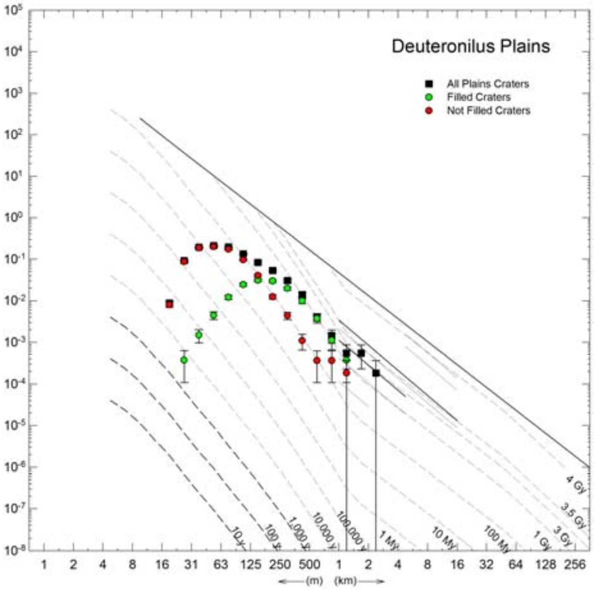

Figure 3. Crater size-frequency distributions for portions of the smooth plains unit. N_{all}=5591, N_{filled}=748, N_{other}=4425, A=5442 km^2.

Cerulli Crater SFD: The crater-size frequency distribution for craters superposed on part of Cerulli crater's ejecta blanket was compiled using two CTX images covering ~15% of the total ejecta (Fig. 1). The distribution of all craters superposed on the ejecta blanket shows one segment (650 m - 3+ km) that follows the isochrons with a departure at sizes smaller than ~650 m. The formation age of Cerulli crater is interpreted to be ~3.5 Gy or slightly older, during the Late Noachian or Early Hesperian Epoch (uncertainty Late Noachian-Late Hesperian). Fresh craters reveal two populations, one at diameters between ~500 m and 4 km showing an age of ~1-3 Gy, and another (~63 m – 250 m) showing an age of 10 My, with a depletion of craters smaller than 63 m.

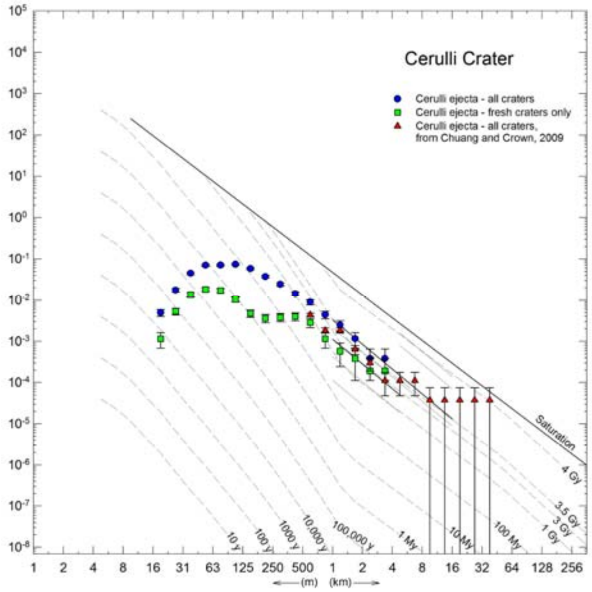

Figure 4. Crater size-frequency distributions for the ejecta blanket of Cerulli crater. N_{all}=2270, N_{fresh}=459, A=4358 km^2.

Conclusions: CTX images of surfaces in the Deuteronilus Mensae region reveal populations of both superposed and partially buried/modified craters, consistent with mantling episodes at various times in the Amazonian Period, some of which may represent Late Amazonian obliquity-driven climate change [e.g., 5-8]. Additional crater counts and refinement of ages for this region can be found in [9].

References: [1] Berman, D.C. and Hartmann, W.K. (2002) *Icarus, 159,* 1-17. [2] Hartmann, W.K. (2005) *Icarus, 174,* 294-320. [3] Hartmann, W.K. (2007) *7th Intl. Conf. on Mars, Abstract 3318.* [4] Hartmann, W.K. (2007) *Icarus, 189,* 274-278. [5] Mustard, J.F. et al. (2001) *Nature 412*, 411-414. [6] Mangold, N. (2003) *J. Geophys. Res.*, 108. [7] Costard, F. et al. (2002) *Science*, *295*, 110-113. [8] Forget, F. et al. (2006) *Science*, 311, 368-371. [9] Joseph, E.C.S. et al. (2011) *Lunar Planet. Sci. Conf.* 42, this conference.