GEOLOGIC MAPPING AND CHARACTERIZATION OF NICHOLSON CRATER, MARS. A. C. Pascuzzo[1], J. F. Mustard[1], and R. M. Newton[2], [1]Dept. of Earth, Environmental, and Planetary Sciences, Brown University, Providence, RI, 02912 (alyssa_pascuzzo@brown.edu) [2]Department of Geosciences, Smith College, Northampton, MA, 01063

Introduction: Craters hosting central mounds of sedimentary material occur in various locations across the Martian surface and provide insight into Mars' diverse geologic history [1]. Although these interior crater deposits are a global occurrence, the mound formation process may vary between individual and clusters of craters [2].

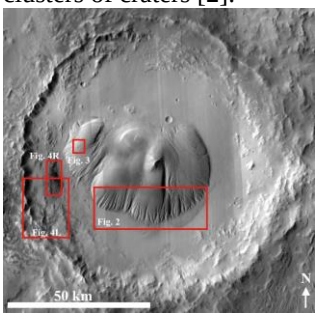

***Figure 1**. Nicholson crater (0º N, 165º W), a 102 km diameter impact crater, and its central mound (CTX).*

Nicholson crater (Fig. 1), a 102-km diameter complex impact crater with a 3.6km thick central mound located at the Martian equator (0º N 165º W), resides on the western edge of Eumenides Dorsum, Medusae Fossae Formation (MMF) - a pyroclastic and volcanic ash deposit[3]. Nicholson's mound is unique compared to the 50 total craters identified with having a central mound deposit [2] due to its striking similarity in mound morphology and size to Gale crater's mound, Mt. Sharp. Despite, their uncanny resemblance, Mt. Sharp's formation from lacustrine and aeolian processes differ greatly from Nicholson. Detailed observations at the highest spatial resolution helps to clarify the geologic history of the crater and formation of the mound that separates Nicholson from the rest, as well as assist in determining the regional processes responsible for the various clusters of central mound craters [2].

Methods: Basemaps for Nicholson crater were made using Mars Orbiter Laser Altimeter (MOLA) topography [4] and Thermal Emission Imaging System (THEMIS) daytime infrared global mosaic [5]. Morphologic mapping of varying geologic units within the crater was performed using high-resolution images from High Resolution Imaging Science Experiment (HiRISE) [6] and the Context Camera (CTX) [7] aboard the Mars Reconnaissance Orbiter (MRO), in addition to THEMIS nighttime infrared images [5].

Key Observations & Interpretations: The following subsections will cover the major morphologic units and landforms in Nicholson crater including features on the mound, on the crater floor and along the crater wall.

Central mound. Nicholson's sedimentary mound is centered in the middle of the crater, elongated east and west, and surrounds a central peak uplift (Fig. 1). Layering of the mound can be seen on highly abraded and deflated surfaces (e.g. crescentic scour features). The entire mound exhibits a unique combination of aeolian erosional patterns, which are also observable in Eumenides Dorsum and Lucus Planum (MMF regions). These patterns include, but are not limited to, the erosion of material into small-scale and larger-scale bidirectional and unidirectional yardangs (Fig. 2), etched and faceted terrain, crescentic and half crescentic scour features (Fig. 3), and pedestal craters.

Unlike the crater floor, the mound does not exhibit small diameter impact craters. Lack of craters on the mound suggests the mound material is extremely friable in nature, allowing for wind erosion to play a dominate role in the young appearance of the mound [8,9].

Yardangs. The large unidirectional yardangs are concentrated on the southwestern face of the mound (Fig. 2a) The southern end of the yardangs have wide heads ranging between ~300-600 m wide with tapered tails (~6-8 km long) as mound slope increases northward. The orientation of these yardangs are consistent with the average yardang orientation in Eumenides Dorsum [3]. The shape and perpendicular orientation to the base of the mound suggests erosion by strong slope-winds from the south. This suggests that the wind patterns in craters are linear and perpendicular to the crater rim as it moves across the crater floor, rather than a circular motion [10]. Such winds likely cause the isolation and central location of the mound [10].

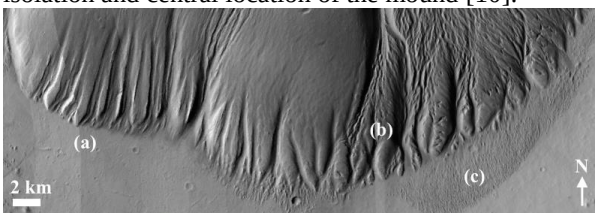

***Figure 2**. South face of Nicholson's mound. (a) Large unidirectional yardangs on the SW face. (b) Tapered fluvial/aeolian erosional features on the S/SE face. (c) Wind eroded, layered, mound-skirting unit limited to S/SE perimeter of the mound. (CTX)*

The south and southeastern faces of the mound also display landforms with a tapered morphology (Fig. 2b), however the flute and landform orientation and morphology differ slightly from the yardangs on the southwest face. The landforms on the southeastern face flu-

vial gully like morphology. In addition, at the base of the mound, to the southeast there is a fan-like mound-skirting deposit (Fig. 2c) that has been heavily reworked by wind.

Scour features. The scour features on the western and eastern side of the mound are unique in their crescentic and half-crescentic morphology (Fig. 3). The inverted-barchan-dune-like morphology of the scours are observed and limited to Nicholson's mound and the MFF. The larger crescentic scours (2 km wide) of Eumenides Dorsum are oriented pointing SW, while the smaller scours (700 m wide) point either E-SE. All of the scours in Eumenides Dorsum are limited to topographic highs as a result of the nature of the MFF material. The scours on Nicholson's mound are ~600-700 m wide and exhibit the same E-SE orientation as the smaller scours in Eumenides Dorsum.

The scours are thought to be proto-yardangs [9]. Deflation around the slopes of the rounded topographic highs and curvature of the mound can cause vortex pits to form from the saltation of grains [11], which could initiate the formation of the crescentic scours.

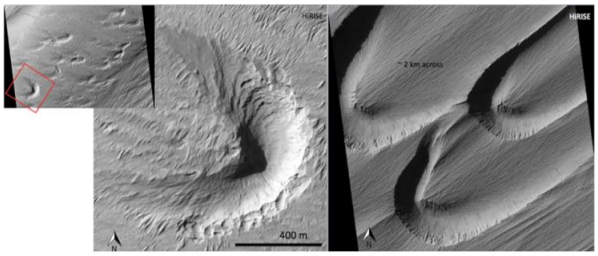

***Figure 3**. Left - crescentic scour on west lobe of Nicholson's mound (HiRISE img. ESP_016874_1800). Right - (HiRISE image ESP_038341_1810) E-SE oriented scours in Eumenides Dorsum.*

Alcoves, channels, fans, and polygons (ACFP). Along the southwest to northwest rim and crater floor are a series of alcoves, channels, and fan deposits (Fig. 4). The alcoves are concentrated along the crest of the western crater rim their bowl shapes resembling glacial cirques on Earth. Fan-like deposits start at the apex of the fans where they meet the alcove. HiRISE images (Fig. 4) reveal the fans in the southeast quadrant of the crater superimposing the channels, indicating the channels occurred prior to the emplacement of the fans. Longitudinal ridges in the mound-adjacent-basin curve around the perimeter of the central mound indicating the formation of this system post-dates the emplacement and primary erosion of the central mound.

A concentration of crater floor polygons (CFPs) appears between and within the channels (Fig. 4). The CFPs in Nicholson range between ~15-30 m in diameter. Each polygon is elevated in the center and drop into troughs around their perimeter resembling terrestrial desiccation cracks [11].

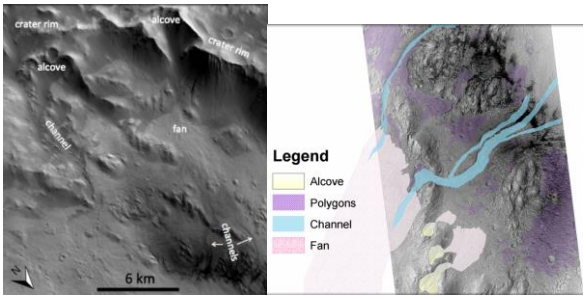

***Figure 4**. Left - shows an oblique view, to the SW, of Nicholson's crater wall. The southern base of the central mound is at the bottom of the image out of frame. The mapped HiRISE image (ESP_016096_1800) – right - shows the relationship between the alcoves, polygons, channels and fans.*

The ACFP system suggests recent liquid flowed from the crater wall. Multiple fan fronts, and the non-meandering behavior of the channels suggest episodic melt release causing short lived mass wasting and fluvial events. Such an event could have occurred from the melting of surface or subsurface ice. Oversaturation of the rim and mass wasting of the material would have resulted in the formation of the alcoves and fans [12]. As the drier and cooler climate returned [13, 14] CFPs formed from the desiccation of the floor material.

Lobate debris ridges. Small lobate ridges or tongues, commonly thought to be rock glaciers, which move by permafrost creep [15], are the youngest feature in the crater. These features are observed occasionally intercepting fans where they meet with the alcove on the western base of the crater wall.

Conclusions: The erosion styles and friable nature of the mound material suggests that the origin of the central mound is not lacustrine or fluvial, but is volcanic and aeolian, based on similar erosional patterns observed in the MFF, in addition to its proximity and placement at the edge of the MFF. Although water did not contribute to the mounds' formation the ACFP system on the crater floor suggests a transition from a wet to dry environment and episodic equatorial melt activity between the deposition of the mound and the recent Amazonian.

References: [1] Malin & Edgett (2000) *Science, 290*, 1927-1937 [2] Bennett & Bell (2015) *Icarus, 264*, 331-341 [3] Mandt et al. (2009) *Icarus, 204*, 471-477 Zimbelmann & Scheidt [4] Smith et al. (2001) *JGR, 106*, 23,689-23,722 [5] Edwards et al. (2011) *JGR, 116*, E10008 [6] McEwen et al. (2007) *JGR, 112*, E05S02 [7] Malin et al. (2007) *JGR, 112*, E05S04 [8] Kerber & Head (2010) Icarus, *206*, 669-684 [9] Rodriguez et al., (2014) *Icarus, 242*, 202-210 [10] Kite et al. (2013) *Geo., 41*, 543-546 [11] Bishop (2011) *Geomorph. 125*, 558-568 [12] El Maarry et al. (2010) *JGR, 115*, E10 [13] Laskar et al. (2004) *Icarus, 170*, 343-364 [14] Head et al. (2006) *EPSL, 241*, 663-671 [15] Mahaney et al. (2006) *PSS, 55*, 181-192