

GEOMORPHOLOGY OF BARNARD CRATER, MARS: A STRATIGRAPHIC MARKER FOR SOUTHERN HELLAS. Daniel C. Berman¹, David A. Crown¹, Hannes Bernhardt², and David A. Williams², ¹Planetary Science Institute, 1700 E. Ft. Lowell Rd., Suite 106, Tucson, Arizona 85719 (bermandc@psi.edu); ²School of Earth & Space Exploration, Arizona State University, Tempe, AZ.

Introduction: The ~2000 km-across Hellas basin (Fig. 1) exhibits diverse rim terrains that preserve a complex record of Martian geologic history, including both emplacement of ancient units and multiple cycles of modification [e.g., 1-3]. The volcanic plains of Malea Planum extend across the southern rim of Hellas basin and contain a series of degraded volcano-tectonic centers (including Amphitrites, Malea, Peneus, and Pityusa Paterae) [4-6]. Recent studies describe geologically young, ice-rich mantling deposits that cover the region and partially obscure the underlying geology [7-10]. As part of a new study focused on understanding the evolution of southern Hellas landscapes and the formation and degradation of volcanic landforms, we present initial results regarding the geology of Barnard Crater, whose interior rim and floor morphologies provide important insights into recent degradational processes in the region.

Data sets: This investigation utilizes image and topographic data sets from the THEMIS, MOLA, CTX, HiRISE, and HRSC instruments.

Geomorphology of Barnard Crater: Barnard (61.06°S, 61.59°E) is a 121.1 km diameter impact crater with a central peak and terraced inner rim located adjacent to the summit of Amphitrites Patera. Hummocky deposits in the plains surrounding Barnard appear to be remnants of its degraded ejecta blanket. Recent studies by Bernhardt and Williams [11] map Barnard ejecta out to 300 km from its rim and determine a 3.6 to 3.7 Ga age, making Barnard an important regional stratigraphic marker. Barnard is also important because it impacted into Amphitrites Patera and should have exposed volcanic materials within its rim materials (i.e., mafic signatures are present in CRISM data of a semicircular landform along the northern wall; FRT00007EFC_07_IF163L_MAF1, although these might also be more recent airfall deposits [11]). The crater floor is a confined depositional sink and its inner rim slopes are the steepest local topography in the region. The geologic characteristics of Barnard may thus provide important information to help constrain regional degradational processes including the deposition, preservation, and mobilization of ice-rich materials.

CTX images show that Barnard's inner rim and floor are highly irregular, with widespread mantling deposits in various states of preservation, arcuate ridges, pedestal craters, and numerous dust devil tracks. Our observations of Barnard's floor show the presence of a

partly buried central peak and an adjacent irregular depression with significant infill. The inner crater wall displays an annulus of material that appears to result from the coalescence of numerous flow lobes extending toward the crater floor. In addition, numerous sinuous ridges extend down the inner wall slopes of Barnard crater (Fig. 2). In some cases, these appear to occur in sets of individual features and in others ridges appear to form immature parallel "networks." Potential formation mechanisms for these ridges include glacial (moraines, eskers) and fluvial or volcanic (as inverted landforms).

Geomorphic Mapping: We are using ArcGIS to conduct geomorphic mapping and analyses of Barnard crater with a focus on mantling and crater infill deposits, pedestal craters, arcuate ridges, lobate flows, and sinuous ridges (Fig. 2). We are using the THEMIS-based map of [11] as a starting point, refining contacts and adding detail afforded by the larger scale of our CTX-based map.

Linear features mapped to date include sinuous ridges, arcuate ridges, fluvial channels, scarp crests, depression margins, and crater rims. We have mapped 136 individual sinuous ridges with an average length of 5 km; 21 arcuate ridges with an average length of 5.1 km; and 6 fluvial channels with an average length of 5.1 km. Map units are yet to be determined, but will include lobate flow materials, central peak materials, dune materials, and floor materials. Lobate flows have ridged upper surfaces with degradational pitting, and HiRISE images reveal their surfaces to be highly polygonalized (Fig. 3). We have mapped the margins of four pedestal craters on the floor of Barnard. Floor materials include multiple scarps and depressions indicating an erosional environment. Ice-rich mantling deposits are observed in various states of preservation across the crater.

Topographic Analyses: Integrated with geomorphic mapping of Barnard crater and its interior deposits and features are a series of topographic analyses. We will use HRSC and CTX topography to assess the gross morphology of Barnard crater (e.g., diameter, depth, variability of rim height and floor depth, inner and outer rim slopes) and to estimate the thickness of the crater interior deposits. We will use topographic profiles across the Barnard crater rim to evaluate suites of features identified and make comparisons to those found in southern hemisphere mid-latitude regions (e.g., sequences from top to bottom include gullies, lobate flows, arcuate ridges on rims covered with mantling deposits [12-13]). We will

examine correlations between both individual features and suites of features to elevation/elevation range and rim slopes.

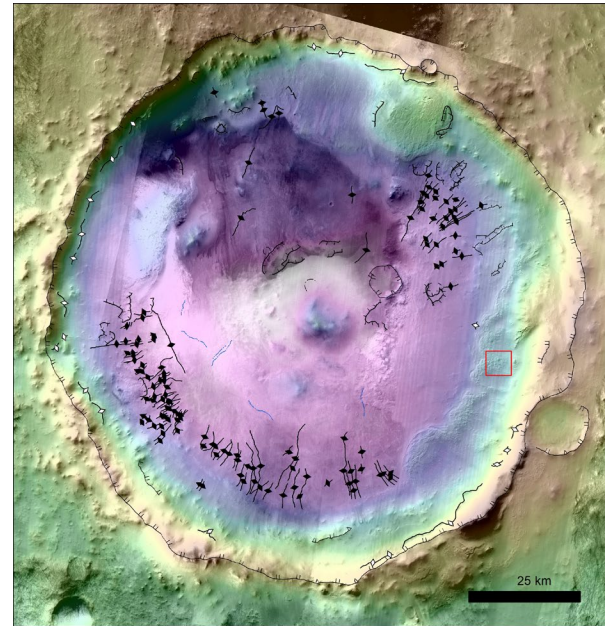
Geologic History: Our preliminary crater counts on the ejecta blanket of Barnard crater show agreement with [11] for the age of the crater (3.7 ± 0.1 Ga). Crater size-frequency distributions for exposed floor materials give a model crater retention age of 2.6 ± 0.6 Ga. Crater size-frequency distributions for lobate flows give a model age of 320 ± 220 Ma.

Conclusions: Studies of the morphology, evidence of infilling, and modification/degradation processes at Barnard crater will provide important information for assessing environmental conditions in the mid to high latitudes in the southern hemisphere. Detailed morphologic and topographic studies of Barnard crater will help assess the distribution, preservation, and mobilization of ice-rich surface materials and help to interpret the modification of adjacent volcanic features.

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(2010) *Icarus*, 206, 691-706. [10] Willmes M. et al. (2012) *Planet. Space Sci.*, 60, 199-206. [11] Bernhardt H. and Williams D.A. (2021) *Icarus* 366: 114518. [12] Berman D.C. et al. (2005) *Icarus*, 178, 465-486. [13] Berman D.C. et al. (2009) *Icarus*, 200, 77-95.



Linear Features

- channel (fluvial)
- - - crest of buried crater
- crest of crater rim
- depression margin
- sinuous ridge
- arcuate ridge
- scarp crest

Figure 2. MOLA color hillshade (128 pxl/deg) of Barnard crater with linear features mapped. Red box shows location of Fig. 3. Elevation range -1063 – 2338 m.

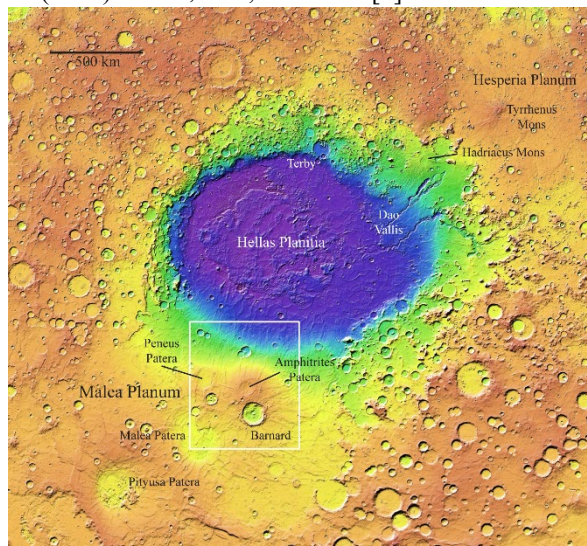


Figure 1. MOLA color hillshade (128 pxl/deg) of Hellas showing feature locations and Amphitrites/Barnard study region (outlined in white). Mercator projection; 60°E center longitude; -8033 - 4070 m elevation range.

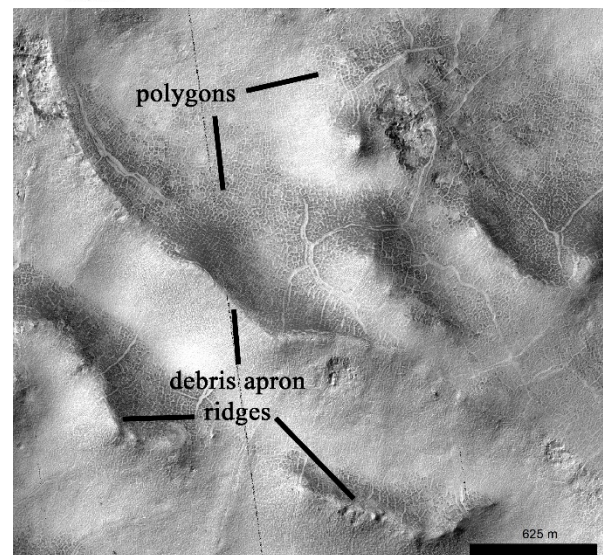


Figure 3. HiRISE image ESP_055502_1185 showing small polygons and ridges on the surface of the lobate debris apron extending from the eastern crater wall.