GEOMORPHIC MAPPING OF HALE CRATER, MARS. A. J. Philippoff[1], L. L. Tornabene[2], A. S. McEwen[2], V. R. Baker[3], H. J. Melosh[2], D. C. Berman[4], and the HiRISE Science Team, [1]Department of Geosciences, University of Arizona, Tucson AZ, 85721 (ajphil@arizona.edu), [2]Lunar and Planetary Laboratory, University of Arizona, Tucson AZ, 85721, [3]Department of Hydrology and Water Resources, University of Arizona, Tucson AZ, 85721, [4]Planetary Science Institute, 1700 E. Ft. Lowell #106, Tucson AZ, 85719.

Introduction: Hale crater, an exceptionally well-preserved crater on the northern rim of the Argyre Basin (323.6ºE, 35.7ºS), may be one of the youngest craters of its size (125 × 150 km) on Mars [1]. Hale possesses a relatively young channel system that emanates from its continuous ejecta blanket. The Hale-forming bolide impacted Uzboi Valles, part of the Uzboi-Ladon-Margaritifer outflow system [2]. Because Hale appears never to have filled with water or other fluids, Uzboi Valles is unlikely to have been active when Hale formed [3].

Hale is located near the current ice stability boundary [4], which fluctuates depending on orbit- and obliquity-induced climate changes. A meters-thick mantle of dust and perhaps ice [5] blankets much of the planet poleward of 60º latitude, becomes discontinuous with decreasing latitudes, and is generally absent below ~30º [6]. Ice was almost certainly stable at Hale's latitude in the relatively recent past during a period of higher obliquity [7]. Here we present a preliminary geomorphic map of Hale crater, highlighting the channels that may have been produced by surface runoff released from its potentially ice-rich target.

Approach: A geographic information system was constructed over a 20º × 20º region of Mars, centered on Hale, using data and images from the Mars Orbiter Laser Altimeter (MOLA), the Thermal Emission Imaging System (THEMIS) instrument [in visible, daytime, and nighttime infrared (IR)], the Mars Orbiter Camera (MOC), the Context Camera (CTX), and the High Resolution Imaging Science Experiment (HiRISE). A 1:500,000 THEMIS daytime IR mosaic, with a resolution of ~100 m/px [8], was used as the base map. Higher resolution imagery (MOC, CTX, HiRISE) allowed closer analysis of defined units, stratigraphic relations, and locations of contacts. HiRISE provides exceptionally high-resolution images of the Martian surface, at 25–32 cm/px [9]. Units apparently related to Hale have been mapped in some detail, though mapping is not complete for our region of interest at the time of writing (January 2009); see Figure 1.

Preliminary Results: Irregular crater clusters interpreted as Hale's secondary craters are found mainly north of the primary crater. This could be a result of target properties, the direction of travel of the projectile, a preservation issue (particularly on the steeper slopes and heavily-modified terrain in the south), or a combination of all three. The non-circularity of the crater and asymmetry of the ejecta blanket suggest a low-angle impact from the southeast.

The substrate north of Hale is much smoother than that to its south. Units are more difficult to distinguish to the south because of the pre-existing chaotic terrain on the margin of Argyre Basin. Additionally, a thicker mantle unit in lower areas masks ejecta (particularly thin, distal ejecta) and low-lying secondaries.

Small channels are found primarily in the southern to southwestern sector of Hale's continuous ejecta. Some channels carve through the ejecta blanket (Figure 2), some extend past the edge of the ejecta, and some begin just beyond the continuous ejecta boundary. There are also channels in the surrounding area that do not appear to have been formed or utilized by Hale. Closer analysis is required to determine the stratigraphic relationships between the channels. However, as some channels (or their coatings) show similar levels of degradation to those associated with Hale, it is possible that they may be coeval with Hale's channels. The channels not associated with Hale are distinguished from those that are as the unassociated channels do not flow away from the primary crater. Two hypotheses for their formation include impact-induced precipitation, as has been suggested to explain Mojave's alluvial fans (e.g. [10]), or remobilization of muddy ejecta. We favor the latter interpretation as there are no dense drainage networks that might be expected from precipitation. A suite of morphologies that we interpret as mudflows are also present (e.g. PSP_005609_1470).

Implications: Although Uzboi Valles was dry by the time of Hale's formation [3], it is possible that the Hale-forming impact was energetic enough to mobilize a significant volume of subsurface water or ice. As a consequence, the Hale-forming impact may have incorporated volatiles into its ejecta, which would have been released as surface runoff to form the channels within and emanating from Hale's ejecta blanket.

If the Hale-forming impact released a significant amount of water, this could have major implications for early climate and landscape evolution [1, 11]: if a single moderate impact released enough water to form several channels, the combined release of water from all craters formed during the Noachian bombardment may have significantly contributed to the formation of valley networks without requiring a long-term, stable, warm and wet climate [12].

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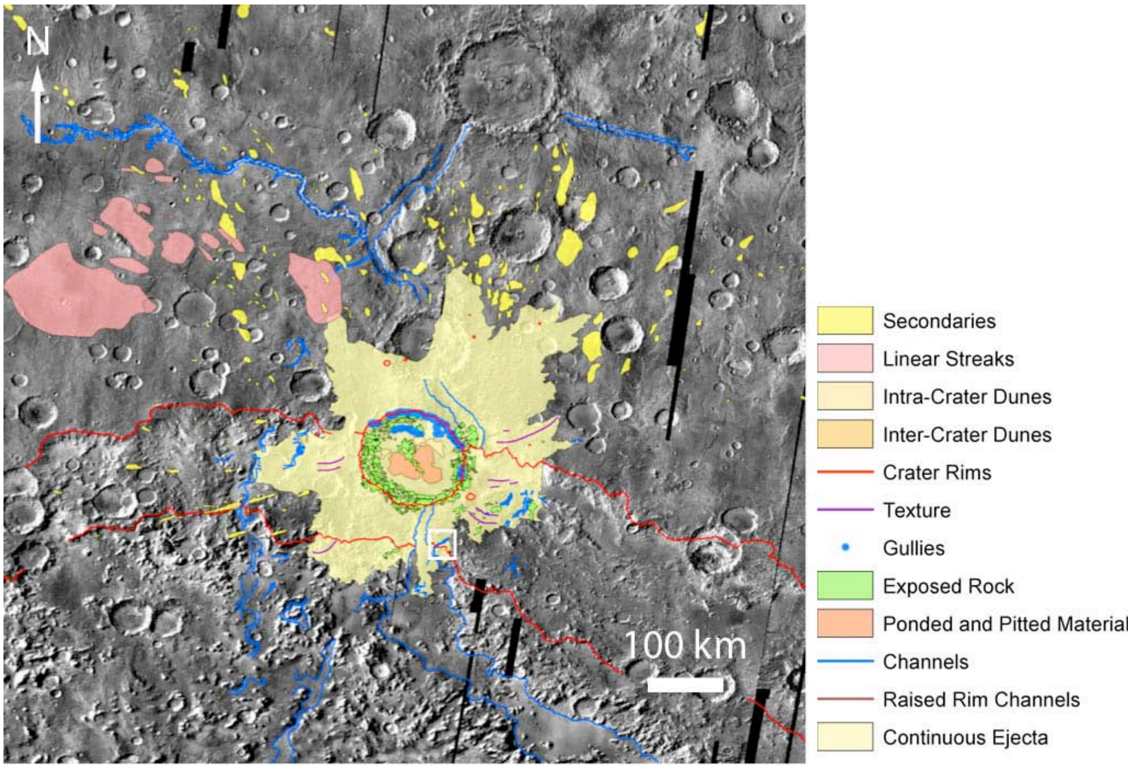

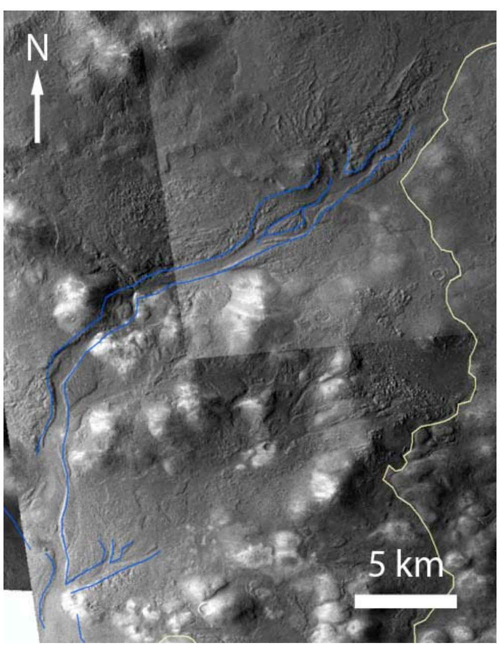

Figure 1. (above) Geomorphic map of Hale Crater, Mars. Units as of January 2009 are indicated on the right. Map was created at a scale of 1:500,000; base map is THEMIS daytime IR. The white rectangle at the southeastern edge of the continuous ejecta marks the location of Figure 2.

Figure 2. (left) Channels emanating from Hale's ejecta. Blue lines indicate channels; the beige line indicates the distal edge of the ejecta blanket. Location is indicated by the rectangle in Figure 1.