THE NATURE AND EXTENT OF AQUEOUS DEPOSITS RELATED TO THE HALE IMPACT CRATER ON MARS. J. A. Grant[1] and S. A. Wilson[1] [1]Center for Earth and Planetary Studies, National Air and Space Museum, Smithsonian Institution, 6th at Independence SW, Washington, DC, USA (grantj@si.edu).

Introduction: Hale (323.6°E, 35.7°S) is a 125 x 150 km-diameter crater formed by an oblique impact [1] near the time of the Amazonian-Hesperian boundary [2]. The Hale impact was responsible for a variety of widespread surface modifications [1] that included destruction of the probable head of the Uzboi-Ladon-Morava meso-scale outflow channel and blockage of the southern end of the Uzboi Vallis. Fluidized debris flows and channels extend well beyond the crater rim [3, 4] and mapping [5-9] reveals these water-driven flows extend considerably further north and east of the crater than previously recognized [3, 4] (**Fig. 1**).

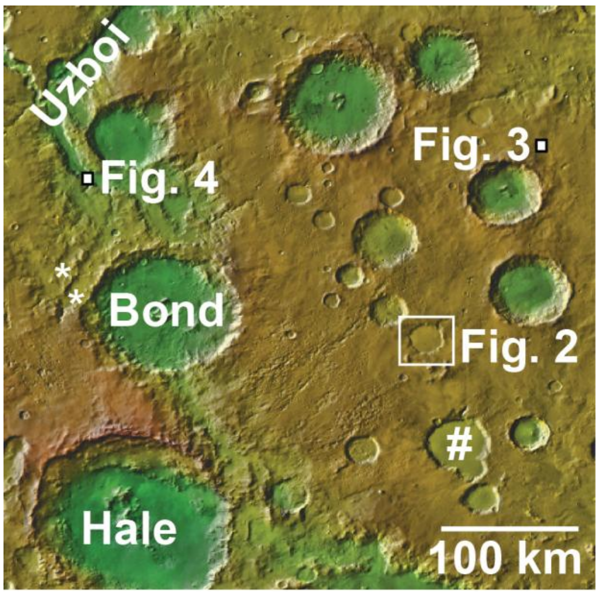

Figure 1. Hale crater is on the northern rim of Argyre basin in southern Margaritifer Terra (figure centered ~325.7ºE, 32.6ºS). West of Bond crater, Hale-related deposits locally form distinct lobes ("*") [6, 9, 10]. Similar deposits occur ~340 km NE of Hale (**Fig. 3**). Craters located ~170 km (**Fig. 2**) and ~140 km ("#") ENE of Hale are mostly infilled with material that may be Hale-related. MOLA over THEMIS day IR mosaic.

Background: Regional ice-bearing target materials were melted during the Hale impact and during emplacement of associated ejecta and impact melt [1, 3, 4]. Resultant water sourced deposits on the rim of Hale that flowed into pre-existing valleys, topographic depressions, and craters [2-4]. These deposits are mapped as a dark-toned Amazonian to Hesperian Smooth Unit [11], which is often darker-toned and smoother than bounding surfaces (at scales of 10s to 100s of meters). These deposits can occur as discrete lobes or crater fill [3], and embay secondary craters from Hale, thereby constraining the timing of emplacement [1, 6]. West of Bond crater (**Fig. 1**), lobes of the deposits occur downstream of topographic constrictions [3, 5, 8-10] and one is ~20-50 m thick based on MOLA shot points (see Fig. 3 in [**5**]). The deposits appear to thin with distance from Hale, but related material mostly fills two craters to the ENE (**Fig. 2**). Margins of the flows are mapped to ~400 km NE of Hale (e.g., **Fig. 3**) and they may have extended into Uzboi Vallis (**Fig. 4**).

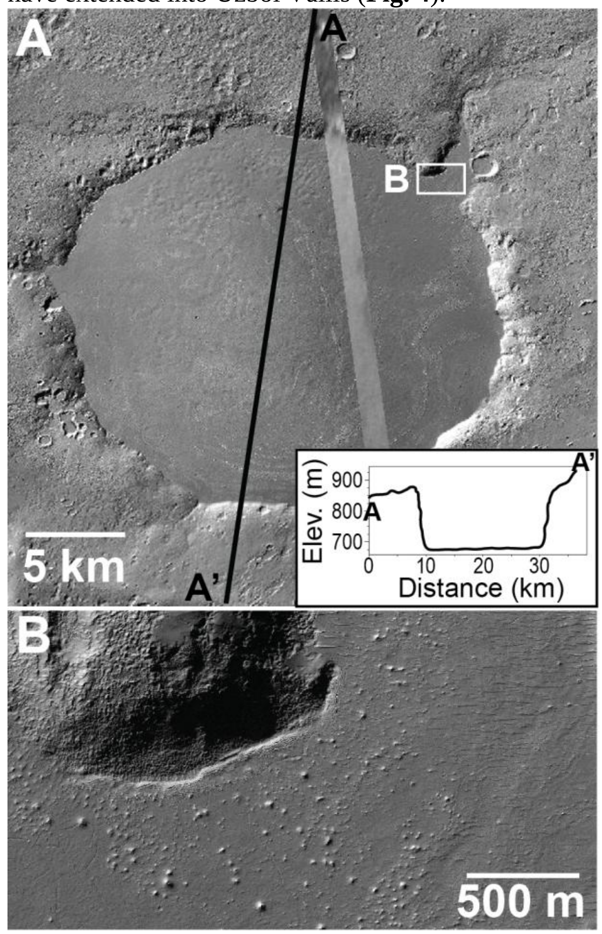

Figure 2. (**A**) Crater ~170 km NE of Hale is filled with deposits likely associated with the Hale impact [3]. Similar deposits occur in crater ~60 km to the south (see "#" in **Fig. 1**). Black line shows transect A to A' from MOLA profile 8582, corresponding profile shown in inset. CTX B19_017133_1471 and B18_016777_1461 (~6 m pixel scale). (**B**) Surface of the crater contains meter-scale relief but is smooth at scales of 10s to 100s of meter length scales. HiRISE ESP_034908_1465 (51 cm pixel scale).

Aqueous Deposits Northeast of Hale: Fluidized ejecta and impact melt from Hale melted additional ice on impact [1, 3, 4], collectively sourcing deposits that filled craters northeast of impact site (**Figs. 1 and 2**). Flows into a 22 km-diameter crater near the distal edge of Hale's continuous ejecta occupied pre-existing channels [3], the largest of which breaches the NE rim of the crater. MOLA profiles indicate the crater floor is flat and the rim-to-floor depth is ~200 m (**Fig. 2**). The predicted original depth of a crater this size is ~1.5-2.2 km [12], indicating the Hale-related fill could be up to 1-2 km thick (assuming no other fill is present). Similar deposits occur in a ~44 km-diameter crater 60 km to the south (**Fig. 1**). This crater is also near the edge of Hale's ejecta [3] and may have captured water draining from the ejecta [3] and released by more distal secondary impacts [1, 3]. Presently ~750 m deep, this crater was likely ~2-4 km deep when formed [12], indicating deposition of up to ~1-3 km of Hale-related fill.

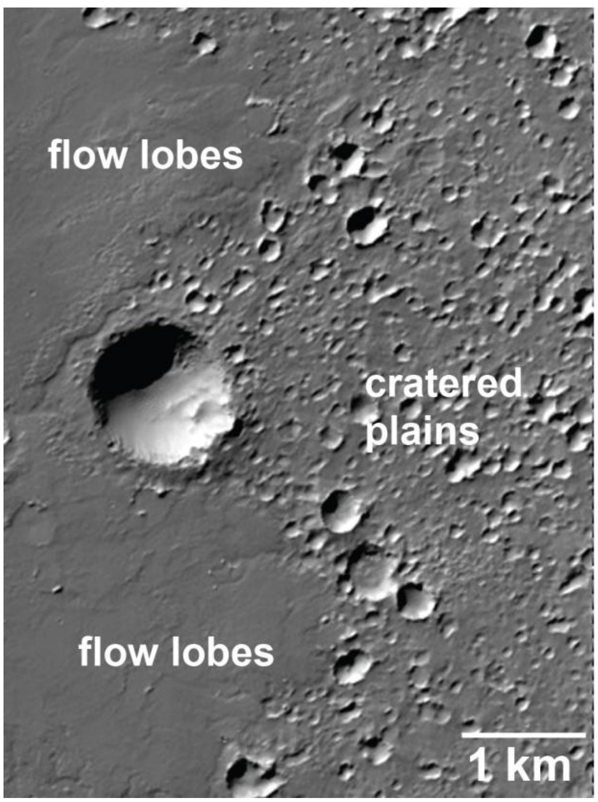

Figure 3. Example of smooth, dark-toned Hale flow deposits ~340 km northeast of Hale. HiRISE ESP_043941_1490 (~ 50 cm scaled pixel width).

Approximately ~340 km NE of Hale (**Fig. 1**), additional smooth, dark-toned material forming distal lobes is sourced near the northern rim of a large crater (**Fig. 3**). These and other deposits are found up to ~400 km from Hale and occur within the region affected by impact melt from the crater [1], but beyond the crater's continuous ejecta [3]. Hence, melting of local ground ice via secondary impacts and impact melt may have contributed more to these flows than those closer to Hale. Regardless, transport rates of several meters/second [5] indicate emplacement could have occurred at this range within 1-2 days of the Hale impact.

Possible Hale-Related Aqueous Deposits in Uzboi Vallis: Possible de-watering of the Hale-related lobe deposits west of Bond crater (**Fig. 1**) may have transported material roughly ~60 km to the north, modifying the southern reaches of Uzboi Vallis via pre-existing tributaries. These deposits on the floor of Uzboi appear thin, lack obvious indicators of flow, and are difficult to map, possibly due in part to later erosion in some locales (**Fig. 4**). They are dark-toned, infill low-lying topography, have distinct margins, and it is possible that they are Hale deposits or related to the modification of impact melt from Hale [1]. It does not appear that water related to the deposits caused significant ponding within Uzboi based on their limited occurrence relative to relief within the channel. The appearance of the deposits in Uzboi is somewhat similar to widespread indurated dark-toned mantling deposits seen elsewhere, so further investigation is warranted before positively associating them with the Hale-related aqueous activity.

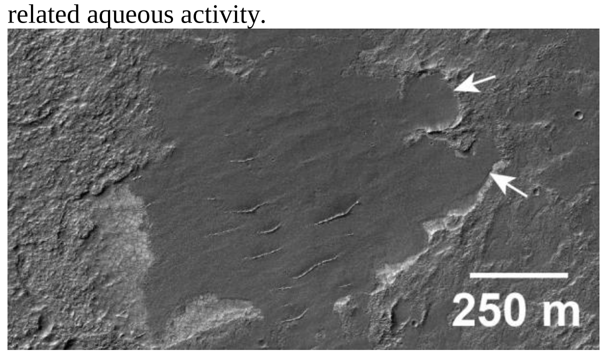

Figure 4. Smooth, dark-toned material on the floor of Uzboi Vallis with distinct margins (arrows). Material is near a large tributary valley and fills low-lying topography. HiRISE ESP_034328_1485.

References: [**1**] Schultz, P. H., and Wrobel, K. E. (2012), *JGR*, 117, E04001. **[2]** Cabrol et al., 2001, *Icarus*, 154, 98–112,. **[3]** Jones et al. (2011), *Icarus*, 211, 259-272. **[4]** El-Maarry, M. R., et al. (2013), Icarus, 226, 905-922. [**5**] Grant, J. A., and Wilson, S. A. (2015), *LPSC* Abst. 2538. [**6**] Wilson et al., (2013), *Abst. Ann. Mtg. Planet. Geol. Mappers*, Washington, DC. **[7]** Wilson et al. (2013), *LPSC* Abst. 2710. **[8]** Wilson et al., (2014), *Abst. Ann. Mtg. Planet. Geol. Mappers*, Flagstaff, AZ. **[9]** Wilson et al. (2015), LPSC Abst. 2492. **[10]** Wilson S. A. et al. (2015), *Abst. Ann. Mtg. Planet. Geol. Mappers*, Honolulu, HI. **[11]** Wilson, S. A., and Grant, J. A. (2016), LPSC Abst. 2505. **[12]** Grant, J. A., et al. (2015), *Icarus*, in press.