RECENT CHANNEL SYSTEMS EMANATING FROM HALE CRATER EJECTA: IMPLICATIONS FOR THE NOACHIAN LANDSCAPE EVOLUTION OF MARS. L. L. Tornabene[1, 2], A. S. McEwen[1], and the HiRISE Team[1], [1]Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ 85721, [2]livio@lpl.arizona.edu

Introduction: Impact cratering is a fundamental geologic process that dominated the distant geologic past of the terrestrial planets. Thereby, impacts played a significant role in the formation and evolution of planetary crusts in the form of impact effects and byproducts (e.g., ejecta, breccias, impact melts, etc.). On Mars, impacts may have liberated subsurface volatiles that, in the form of liquid water, modified both surface morphology and composition (e.g., phyllosilicates [e.g., 1]), and possibly influenced early habitable environments. Although such an interaction has been inferred by studies of crater morphology [e.g., 2] and impact models [e.g., 3], direct evidence for the release of liquid water or other volatiles by Martian impacts was lacking [4]. This has likely been a consequence of image resolution, signal-to-noise and sampling, but also due to the fact that most large craters on Mars are degraded.

Detailed observations from instruments onboard the Mars Reconnaissance Orbiter (MRO) of the freshest large (D > 1 km) craters such as Hale, Tooting and the Martian rayed craters [*including our recent discovery of the largest currently recognized rayed crater (D ~15 km) on the Elysium Mons rise (141.7°E, 16.9°N)] have revealed evidence of extensive landscape modification via impact melting and fluvial activity. This previously led us to the reinterpretation of the well-developed alluvial fans in Mojave. Essentially, Mojave was formed as a recent impact into an ice-rich target [5, 6], and that its size and youthful preservation is somewhat unique, but not necessarily its origin as suggested by [7].

Here we present a brief summary and discussion of our observations, which are primarily derived from the Thermal Emission Imaging System (THEMIS), and two MRO-based instruments: the meter-resolution High Resolution Imaging Science Experiment (HiRISE) and the decameter-resolution Context Imager (CTX). These observations suggest that not only is Hale crater relatively young (possibly the youngest crater of its size-class), but that it was responsible for recent fluvial activity.

Background and Observations: Hale is a large (D ~125x150 km) and complex crater situated on the northern terrace complex of the Argyre impact basin (323.6°E, 35.7°S). The ejecta extends to the NW, SW, and SE but not to the NE, indicating an oblique impact from the NE. Hale has been previously interpreted as late Hesperian or early Amazonian in age [8]. An ongoing systematic survey for the freshest craters on Mars [5, 6] reveals that the crater maybe the freshest of the ~100-200 km size class (likely Amazonian), but new crater counts are needed based on better images (i.e., CTX and HiRISE). The youthfulness of this crater is indicated, most notably, by the thermal contrast that the crater and its ejecta exhibits in nighttime THEMIS infrared images. A mosaic of these images also shows that aeolian materials were streamlined into linear elements that do not appear to be typical crater rays, but like rays lie radial to Hale (e.g., 315°E, 32°S; 323.6°E, 35.7°S). Further, Hale has pristine morphologic features at the decameter scale such as a sharp but complexly terraced rim, a prominent central peak and only small (<1 km) and few superimposed craters. The ejecta and secondaries from Hale are superimposed over surrounding terrains covering a large expanse of Mars, with one swath of secondaries spanning >500 km wide. Hale also possesses ponded materials and channelized flows, which is an indication of the presence of impact-melt bearing materials, as well as a testament to the youthfulness and excellent state of preservation of the crater [5].

Several channel systems occur in the circum-Hale region, which emanate from the ejecta. Fig.1 shows a sketch map created on a THEMIS daytime IR with a CTX mosaic superimposed. A close inspection of CTX and HiRISE images reveal that the channels originate from breaks in topography and slope within or at the outskirts of Hale ejecta materials.

Discussion: Based on the apparent relative youthfulness of Hale crater, Hale ejecta may possess some of the most recent large-scale fluvial modification on Mars associated with cratering. The reoccurrence of such features [5, 6], although scaled down and less extensive at other fresh craters [5], suggests that cratering may have played a significant role with respect to the extensive fluvial modification during the Noachian [9], as suggested by [3] and others. This does not preclude a significant contribution from volcanic activity as suggested by recent observations from MRO of Athabasca Valles [10].

It is important to note that unlike the channels in Mojave [5, 6], these features appear to both emanate and cross-cut Hale ejecta. Therefore, fluvial activity may not have only been triggered, but continued for some time after the crater formed. However, some Hale channels are underdeveloped with respect to Mojave (i.e., lower order), which may suggest that multiple pulses of activity fed the channels and formed the alluvial fans in Mojave. One possible scenario is that water was released by the interaction of superheated impact melt-bearing deposits interacting with colder ice-rich target materials.

Future Work: In order to better understand the relationship between Hale crater and these channels, we will be mapping the Hale and its surroundings in further detail. We are working on constraining a more precise age estimate on Hale using CTX and HiRISE images for crater counts. We will also estimate the volume of water released from Hale, the extent of modification, the area affected by modification; and investigate if these parameters might scale with crater diameter.

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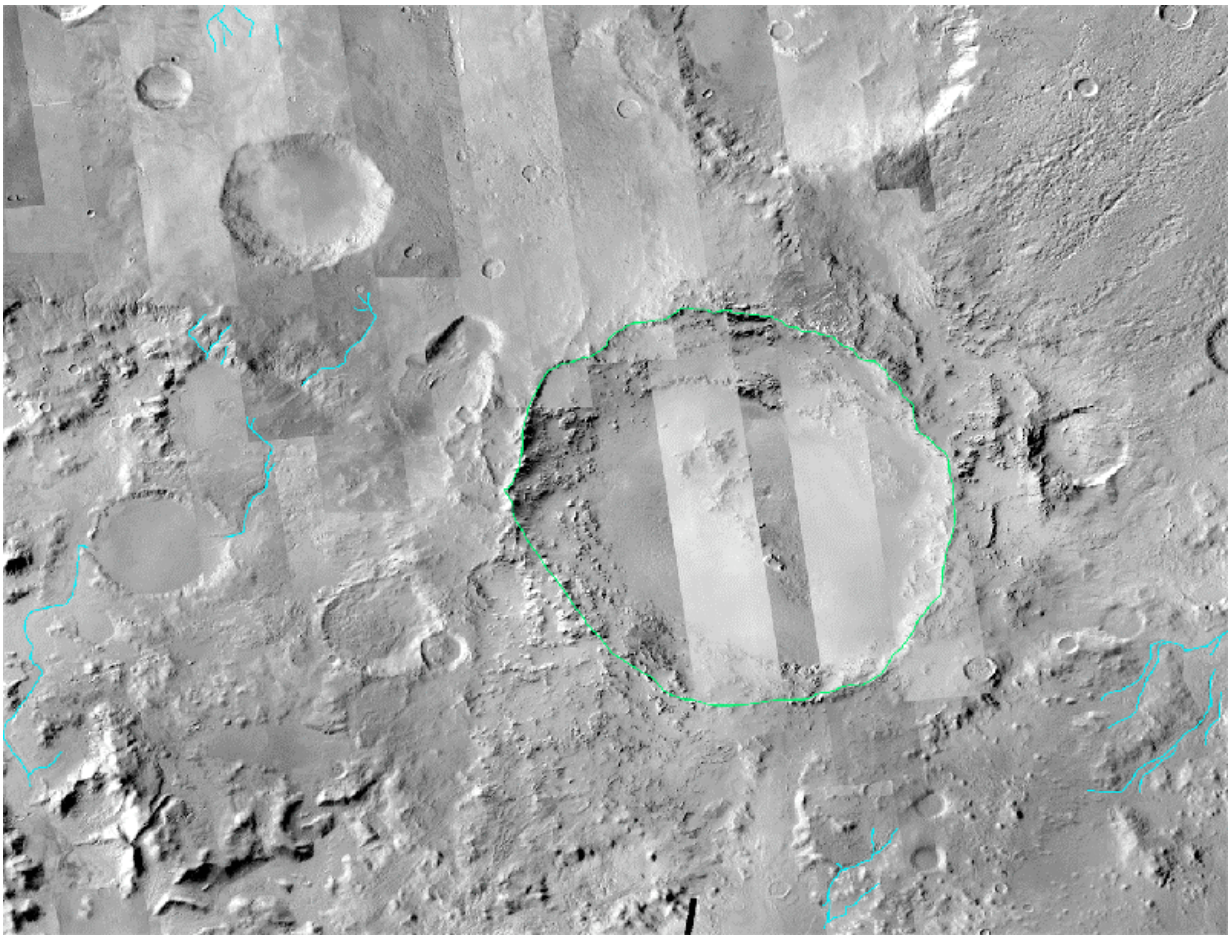

Fig 1. A sketch map of crater Hale using THEMIS daytime IR as a base map with CTX images superimposed. North is up and the CTX swath with is ~ 30 km for scale. The outline of the crater rim can be seen in green with some of the largest channels associated with Hale ejecta outlined in blue. (Below left) HiRISE image from just south of Hale of a fluvial channel within hummocky ejecta materials. Massif towards the bottom of image is older preexisting terrain. Scale bar is 500 m. (Bottom right) HiRISE image (PSP_006677_1405) of channels NW of Hale exhibiting scoured floors and tear-drop shaped streamlined islands. The width of the image is ~3 km.