MORPHOLOGY AND TEMPORAL EVOLUTION OF THE EJECTA OF HALE CRATER IN THE ARGYRE BASIN, MARS: RESULTS FROM HIGH RESOLUTION MAPPING. M. R. El Maarry[1] J. M. Dohm[2], G. Michael[3], and N. Thomas[1], [1]Physikalisches Institut, Bern Universtät, Sidler Str., 5, 3012, Berne, Switzerland. [2]Department of Hydrology and water resources, University of Arizona, Tucson, AZ, USA. [3]Department of Earth Sciences, Freie Universitaet Berlin, Berlin, Germany.

Introduction: Various lines of evidence point to recent hydrological, periglacial, and glacial activities at several locations on Mars [1–6]. In this study, we investigate one such region in the Nereidum Montes, north of Argyre basin, including Hale crater and its ejecta (Fig. 1). In particular, we concentrate on the distal part of the ejecta as mapped by [7]. [7] published a geomorphological map of the region surrounding Hale crater that characterizes the behavior of the distal part of the ejecta as being fluid-like. Additionally, they mapped a number of valleys associated with these deposits, interpreting them to be carved by impact-generated meltwater from ice-rich terrain. We use recently acquired images from the HiRISE camera, among other datasets, to perform detailed study of these deposits. We concentrate on a region west of Hale crater that includes a 38-km-wide impact crater, recently named Moanda, cut by a well-developed valley system (hereafter referred to as MCVS).

MCVS setting: Most of the study region, as well as the rest of the Nereidum Montes, comprises smooth material nestled among the rugged crater ejecta deposits. The smooth materials, which are relatively featureless at low spatial resolution [8], are marked by a dearth of impact craters, as well as numerous filled or semi-buried impact craters that point to recent resurfacing. Our investigation, which includes mapping, crater-size frequency analysis of the region and modeling of ejecta behavior using well-known scaling laws, corroborates the hypothesis of [7] that the material filling the MCVS is genetically related to the ejecta deposits of Hale crater, distinct from other smooth deposits in the Nereidum Montes region.

High-resolution mapping: While concentrating on the MCVS, we evaluate other localities in order to assess whether the MCVS deposits are ejecta from Hale crater, as well as the overall properties of the ejecta deposits both inside and outside of Argyre basin. *Knobby/pitted terrains*: The terrain is complex with various interrelated textures and flow fronts. The texture forms a continuum ranging from knobby to pitted, subdued in places by a dusty mantle pointing to extensive erosion including eolian activity (Fig. 2).

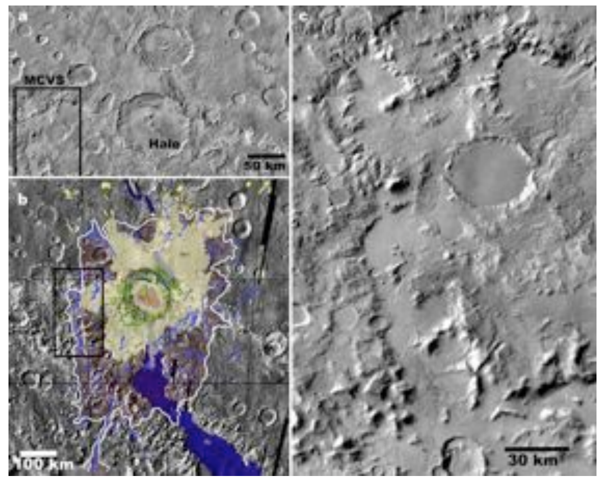

Fig.1. [a] Daylight IR mosaic of Hale crater and its surroundings. The Moanda cater-valley system (MCVS) can be seen west of Hale crater (black box). [b] Geomorphological map of Hale crater and its ejecta adapted from [7]. White boundary was added to highlight the extent of the distal ejecta deposits (red dots). [c] Day IR mosaic of the MCVS. North is up in all images.

Valleys dissecting the ejecta: CTX images reveal narrow valleys (Fig. 2b) dissecting the ejecta within the MCVS, suggesting further and possibly continued erosion of this deposit. The narrow (a few meters wide) valleys occasionally exhibitg meandering, braided, and/or tear-drop-shaped morphologies. Some of these channels are observed in great detail through HiRISE images, appearing to have been dissected in turn by local fractures (Fig. 2b).

Fractures: Many HiRISE images display multiple linear and quasi-linear troughs with lengths ranging from 50 to 350 meters and widths 2-3 meters. These troughs, which occur along distal parts of the deposits (Fig. 2a), are perpendicular to local flow directions and parallel to the flow fronts. Some of the fractures cut the dune-like material as well as numerous valleys. This not only suggests that that the hydrological activity predates the formation of at least some of the troughs or fractures, but that the fracture development is long-term, and possibly even continuous.

Mounds and fractured rises: Several 50–250 m-wide mounds, some with fractured tops, and some associated with linear troughs are evident in the images (Figs. 3a). Another distinct feature is the widespread presence of fractured rises and plateaus (Figs. 3b) that show distinct systems of fractures oriented with their margins, consistent with inflation features of Earth. The terrains surrounding the mounds and rises occasionally display flat features with similar fracture patterns that may mark circular extensional fractures or collapse features of previously elevated mounds.

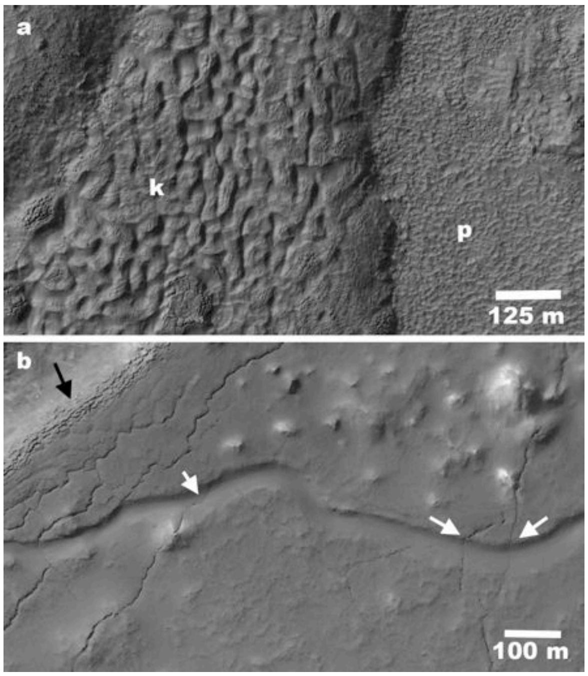

Fig.2. [a] HiRISE image showing ejecta in MCVS with surface textures ranging from knobby (k) to pitted (p). Deposits may appear featureless at times due to mantles of dust. [b] HiRISE image showing valleys dissecting the ejecta. Also visible are fractures that occur on the margins of the flows (black arrow) and cut the valleys (white arrows).

Summary and conclusions: We have used high resolution images, particularly from the HiRISE camera, morphometric techniques, crater-size frequency analysis, and well-known scaling laws to characterize the distal part of Hale crater's ejecta, defined as He2 unit by [7], in terms of its morphology, morphometry, physical properties, and flow behavior, and to assess its evolution since emplacement. Our analysis shows that the ejecta display unique morphologies such as inflation features and fractured rises. We attribute these landforms to periglacial modification due to their volatile-rich composition, which in turn is responsible for the viscous behavior of the ejecta and onset of fluvial activity in the vicinity of Hale crater. The presence of various linear and quasi-linear fractures within the ejecta which cut some of the superposed channels, as well as dust deposits, indicate that the ejecta deposits were actively moving, albeit in a slow, highly viscous manner for a long time, exceeding the period of fluvial activity.

The ejecta deposits, which may yet contain significant amounts of volatiles beneath a thick layer of dust or sublimation lag, appear to be friable, as they appear to be highly eroded (except in topographic traps) with low crater retention ages. The ejecta may be interspersed with with glacial deposits that occur in the lowlands, enhancing their viscous behavior and rendering them more durable to weathering in such locations. Morphometric analysis suggests that the MCVS could have been formed by glacial and/or fluvial processes prior to the emplacement of the ejecta deposits.

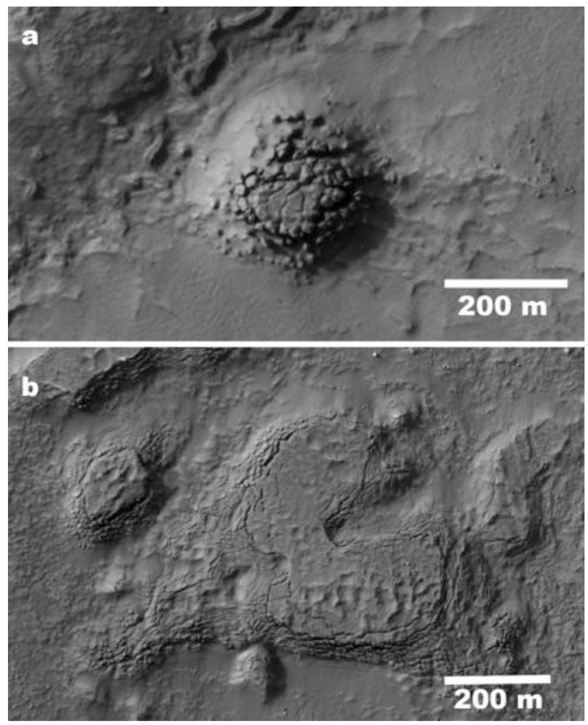

Fig.3. (a) HiRISE image highlighting one of the mounds in the MCVS. Shadow analysis suggests a height of about 30–40m. (b) fractured rises that are common in the ejecta deposits of Hale crater. These features could be indicative of periglacial modification.

References: [1] Malin, M.C., Edgett, K.S., (2000), *Science 288*, 2330–2335. [2] Head, J. W., et al. (2005), *Nature*, *434*, 346–351. [3] Basilevsky, A. T. et al., (2006), *Geophys. Res. Lett.*, 33,. [4] Dohm, J.M. et al., (2008), *Planet. & Space Sci. 56*, 985–1013. [5] Dickson, J.L. et al., (2009), *Geophys. Res. Lett.*, 36,. [6] Fassett, C. I., et al. (2010), *Icarus*, *208*, 86–100. [7] Jones, A.P., et al (2011), *Icarus*, 259–272. [8] El Maarry et al., (2013), this meeting.