Geologic Investigation of a Debris-covered Mountain Glacier in Argyre Basin, Mars: Implications for Past Climate and History of Non-Polar Ice. M.R. El-Maarry[1,2], X. Diot[3], [1]Birkbeck, University of London, Malet Street, department of Earth and Planetary Sciences, WC1E 7HX, London, UK, [2]University College London (UCL), London, UK. [3]Sogetrel Telecommunications, Nancy, France.

Introduction: Glacier-like forms (GLFs) are a particular class of ice-rich landforms that occupies the mid-latitudes of Mars [e.g., 1–4]. They appear to be concentrated around the 40º–55º latitude range in both hemispheres [3,4]. Within these latitudinal bands, GLFs are observed to occur primarily in regional clusters including the fretted terrain in Arabia, NE Tharsis and NE Elysium, circum Argyre (particularly northern Argyre), and circum Hellas (particularly east and west of the basin) [3]. Here we present results from an ongoing geological investigation of what we interpret to be a debris-covered mountain glacier in the Argyre basin. The glacier system displays 1) multi piedmont-like terminal lobes, 2) gullied cirque-like source regions, 3) flows reaching ~35 km with an elevation drop reaching nearly 2 km from source to terminus, and 4) periglacial modification of surface materials indicative of near-surface ice. A better characterization of this landform may provide clues regarding the formation and evolution of non-polar ice on Mars, particularly during periods of high obliquity.

Geologic Setting: The glacier is located along the inner eastern rim of Argyre basin, which suggests that the hosting mountain is an erosional remnant of the basin's rim materials [e.g., 5]. The mountain has an elevation of ~3250 m and rises ~4250 m above the surrounding terrains to the east, and more than 6000 m above the Argyre floor to the west. It displays a wide mesa-like flat top more than 20 km across along its longest axis with steep (22–30°) sides that have developed into cirque-like alcoves. Two prominent alcoves face NE and NW and their walls are highly dissected by narrow depressions resembling gullies. The mountain displays 3 distinct lobes that appear to flow from the base of the cirques trending NE, NW, and SW, among other minor flows, while a lobate debris apron extends to the SE. The lobes travel for tens of km gently sloping (generally 2–4°) downhill where they terminate with sharp lobate boundaries. Recent radar analysis of of the NE lobe is consistent with an internal ice-rich composition [6].

Observations: We created a CTX mosaic for the study region and georeferenced it to an HRSC DTM to extract morphometric information on flow directions and influence of surrounding topography. In addition, the glacier system is covered by a number of HiRISE images, which provide a spatial resolution of 0.25–0.5 cm/pixel. Below we present a number of notable observations.

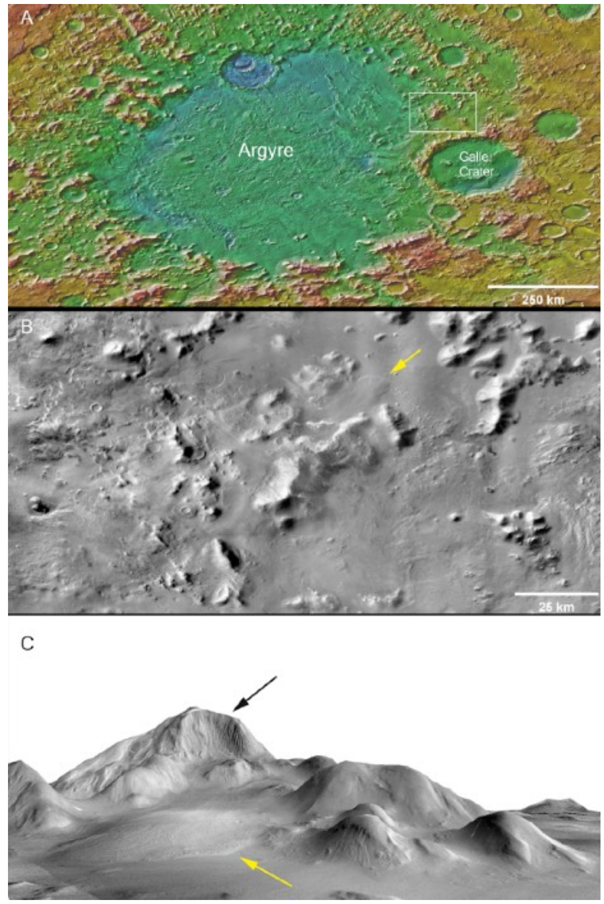

Fig. 1. Glacier-like landform (GLF) in Eastern Argyre. [A] Context view using THEMIS Day IR map with colorized MOLA elevation of Argyre basin overlaid. The study region is enclosed in a white box. [B] THEMIS Day IR mosaic of the GLF . Yellow arrow points to one of the prominent lobes as well as the approximate direction of the perspective view shown in panel C. [C] Perspective view from the east using an HRSC DTM with a vertical exaggeration of 3. Yellow arrow points to the prominent eastern lobe while the black arrow points to the large eastern cirque-like alcove with multiple narrow dissected depressions interpreted as gullies, and shown in Fig. 2 in more detail.

Paleo-accumulation regions: The source region for many of the flows appears to be the central mountain. Near the top, large cirque-like structures are visible that show extensive networks of gullies of variable widths and cross cutting relationships suggesting multiple, and varying, erosion cycles through time. Many of the drainage systems appear to originate from quasi-linear ridges, which are closely aligned with each other at the top of the mound (Fig. 2). We interpret these ridges to be the paleo-boundaries (possibly ancient till deposits) between the drainage systems and past ice deposits at the mountain top, which contributed to the drainage systems.

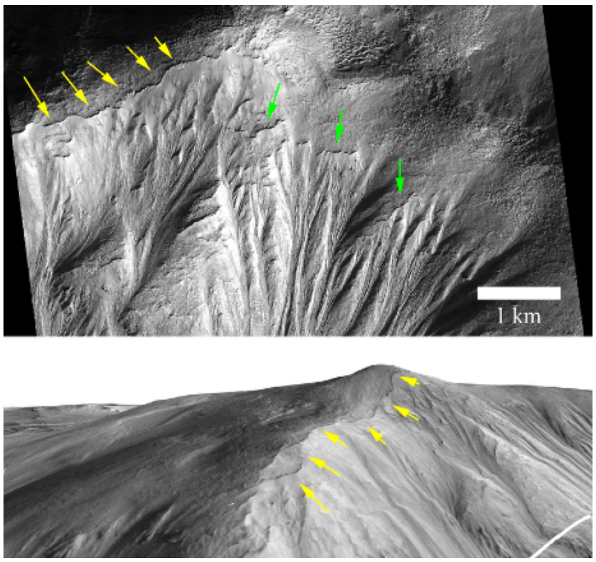

Fig. 2. [Top] HiRISE image covering the top of the eastern cirque shown in Fig. 1c. Extensive gullies are visible in this image with many appearing to originate from narrow linear ridges (arrows). Yellow arrows point to a prominent set shown in perspective view in the bottom panel. Green arrow point to other isolated examples. [Bottom] Perspective view covering the top of the eastern cirque (no vertical exaggeration). Yellow arrows show the ridges shown in the top panel that are aligned with the cliff top and mark the regions where many of the gullies in the eastern alcove appear to originate from.

Fractures and gullies: On the western slopes of the central mountain, a number of distinctive gullies show deep alcoves, terminal fan-shaped deposits, and transverse fractures that cut through the gully system (Fig. 3). This type of transverse fractures that are quasi normal to the general slope suggest long-term modification following the gullies formation, which could be a result of periglacial modification, volatile loss, slowly flowing ice, or a combination of these processes.

Surface periglacial modification: High resolution images covering multiple locations in the glacier system show that the surface is pervasively modified showing patterned grounds, which we interpret to be

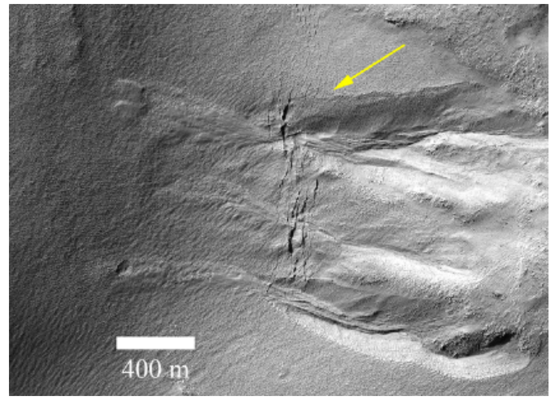

Fig. 3. Part of a HiRISE image showing a well-defined gully system with wide alcoves, fan shaped deposits, and transverse fractures dissecting the system.

seasonal thermal contraction polygons. In areas of pronounced slopes, surface patterns appear to be additionally aligned with these slopes with fractures that are transverse to the slope direction showing preferential widening (Fig. 4). Such locations are likely preferential zones for volatile loss. We plan to present these findings, among others, in the meeting in more detail and discuss implications to past climates and history of non-polar ice on Mars.

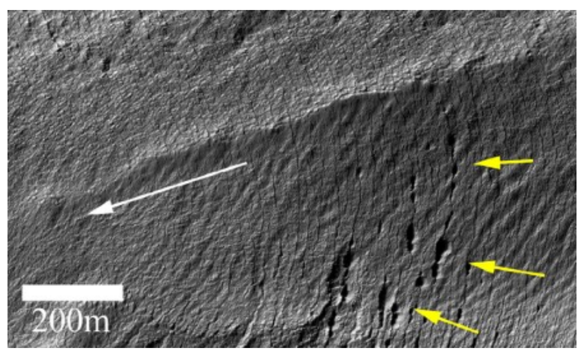

Fig. 4. Part of a HiRISE image covering the surface of one of the western lobes of the glacier system showing the pervasive patterned ground indicative of near surface ice. Note the preferred orientation of the surface pattens in response to the local slopes. White arrow shows the direction of the regional downslope. Yellow arrows show examples of widening troughs.

References: [1] Arfstrom, J., and Hartmann, W.K., (2005), *Icarus, 174*, 321–335. [2] Head. J.W. et al. (2010), *EPSL*, 294, 306–320. [3] Souness, C. et al. (2012). *Icarus, 217,* 243–255. [4] Hubbard, B. et al. (2014), *Cryosphere, 8,* 2047–2061. [5] Dohm, J.M. et al. (2015), *Icarus,* 253, 66–98. [6] Berman, D.C. et al. (2018), LPSC abstract #1544.