ABSOLUTE MODEL AGES AND STRATIGRAPHIC RELATIONSHIPS OF GULLIES IN THE NORTHWESTERN ARGYRE BASIN, MARS.

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Introduction: We selected a study region in the northwestern Argyre basin (44° – 49.5°S and 306° – 312°E) because it shows a high density of gullies and earlier studies reported evidence for glacial and fluvial activity [1,2] in this area. On the basis of High Resolution Stereo Camera (HRSC) and Context Camera (CTX) imagery, we produced a new detailed morphologic map. In addition, we analyzed seven different morphologic units with CTX and the High Resolution Imaging Science Experiment (HiRISE) images to constrain the relative ages of the formation of gullies in this region. We also measured crater size-frequency distributions to determine absolute model ages to further constrain the stratigraphic relationships of gullies.

Units: Within the study region, seven geomorphologic units have been identified and mapped.

Bedrock: The blocky and rough surface (coverage: 6.36%) has no or little dust cover and is only exposed on hilltops. In some areas striation marks are visible, probably caused by glacial flow [2].

Dust/ice mantle: The dust/ice mantle (coverage: 14.1%) is a smooth and flat unit, which occurs in protected depressions or on southern, pole-facing slopes that today receive less insolation. In many cases a sharp boundary to adjacent units is visible. This unit has been interpreted as a young, ice-containing mantle [3].

Viscous flow features: Viscous flow features (coverage: 1.35%) were formed when the dust/ice mantle was deformed by creep. Like elsewhere on Mars [4], the viscous flow-features in our study region are mostly located in front of gully aprons.

Dissected mantle material: This unit (coverage: 54.84%) is smoother than the bedrock and more blocky than the dust/ice mantle. It has been interpreted as an eroded dust/ice mantle [3,5,6].

Large dark dunes (LDDs): The aeolian dunes (coverage: 2.69%) represent the darkest material in the study region and often occur on southeastern mountain slopes or within impact craters.

Transverse aeolian ridges (TARs): Transverse aeolian ridges (coverage: 16.87%) are a dune form with variable shape. Often these ridges are parallel to each other. They occur on flat plains, such as valley floors, or in craters.

Gullies: In the study region, gullies occur on the dust/ice mantle and on viscous flow features. On the basis of our detailed map, we found that the gullies only erode into these units, but not into the underlying bedrock [7]. Stratigraphic investigations revealed that gullies on Mars, first identified by [8], are the most likely evidence for very recent fluvial activities on Mars. Some gullies on Mars are very young, possibly less than ~3 Ma [9,10]. They are most likely formed by processes, which require the involvement of liquid water (fluvial and/or debris flow processes) [11].

Stratigraphy: Large parts of the study region are covered by the dust/ice mantle, which is draped over the pre-existing topography. The dust/ice mantle shows a smooth transition to the dissected mantle material and has been deformed by viscous flow features. The occurrence of gullies on the dust/ice mantle and on viscous flow features indicates a relative younger age than the mantle units. The observerd gullies in the study region preferentially occur on N- to E-facing slopes. 65% of all gullies occur on equator-facing slopes and 45% between N and E (Figure 1). This exposition is typical in these latitudes [12,13].

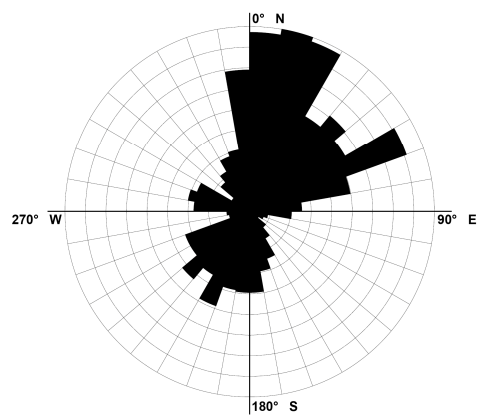

Figure 1. Rose diagram of all gullies in the study region (n=1289).

The dust/ice mantle is relative intact on pole-facing slopes. However, the morphology of the gullies is different: On pole-facing slopes the gullies have wide and well developed alcoves, relative small channels and commonly large aprons. The gullies on equator-facing slopes have long channels and small aprons/alcoves, which are often coalesced. An explanation for this might be that the formation of gullies on equator-facing slopes at these latitudes is related to an increased erosion of the dust/ice mantle caused by enhanced insolation, whereas the sheltered dust/ice mantle on pole-facing slopes remained more intact. The aeolian units (LDDs, TARs) are very young; no craters are visible

and they are superposed on all other units, except the gullies. Some gully aprons are superposed on dunes, indicating a younger age of these gullies [9]. In places, small aeolian ripples, which are superposed on all other aeolian features as well as gully fans, were later cut by small and even younger gully channels, indicating very young fluvial activity (Figure 2).

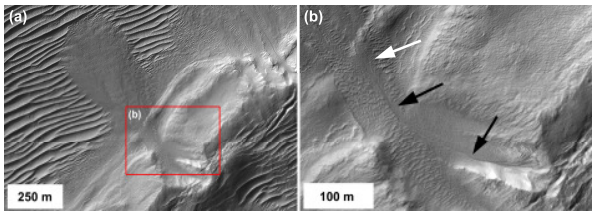

Figure 2. (a) Example of the stratigraphic relationship between a gully on the edge of a viscous flow feature and a dune field, (b) detail of (a), a young channel cuts through very young ripples (black arrows), the apron (white arrow) shows no ripples (Part of HiRISE-Image PSP_009156_1335).

Absolute Ages: Due to the lack of craters on TARs (e.g., Fig. 2), it was not possible to derive absolute model ages from crater size-frequency. However, we were able to measure the frequency of four different areas of the dust/ice mantle. These measurements revealed absolute model ages of about 5 to 50 Ma (Figure 3). Because the gullies are incised into the dust/ice mantle, we interpret them to be younger than 5-50 Ma.

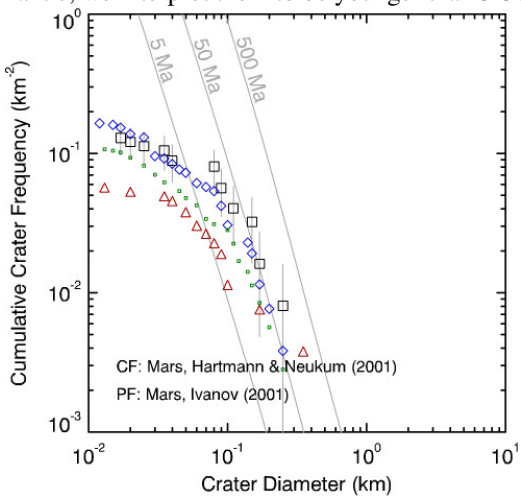

Figure 3. Crater count measurements of the dust/ice mantle. The approximate ages vary between 5 and 50 Ma.

Discussion and Conclusions: On the basis of our geomorphologic map we conclude that glaciation in the Argyre region was areally more widespread than previously thought by [8]. Our stratigraphic investigations indicate that this glaciation was followed by fluvial activity (gullies). The gullies only emanate from the dust/ice mantle or viscous flow features and the different morphologies and expositions on pole- and equatorward slopes point to a climatically driven formation by higher insolation on equator-facing slopes.

The absolute model ages range between 5 and 50 Ma years for the dust/ice mantle. The viscous flow features and the dissected mantle material have to be younger because they consist of deformed or eroded dust/ice mantle material. These ages are generally younger than glaciation ages of about 2.3 – 0.25 Ga [8] and ~0.4 Ga [2] in the Argyre basin. Aeolian features (TARs, LDDs) mostly cover all other units and are therefore younger than these (Figure 4). However, some TARs are superposed by gullies, indicating a younger age of these gullies. Our ages are in agreement with ages for dune-superposing gullies, which show ages younger than ~3 Ma [9], and with the age of a ~1.25 Ma old gully [10] in other regions on Mars. Based on absolute model ages for the dust-ice mantle and the stratigraphic relationships to all other units, the gullies represent the youngest features in our study region.

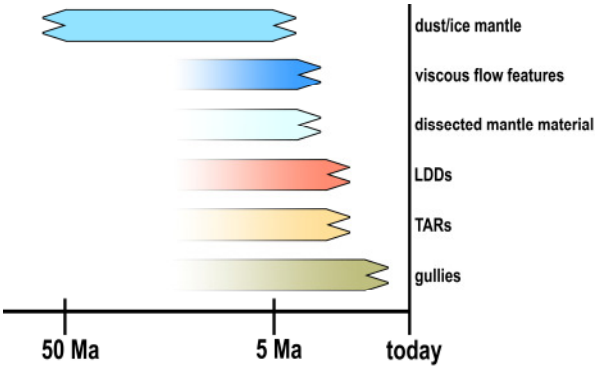

Figure 4. Stratigraphic model with absolute model ages of the seven different units in the mapping area

References: **[1]** Hiesinger, H. and Head, J. W. (2002) PSS, 50, 939-981. **[2]** Banks, M. A. et al. (2008) JGR, 113, doi:10.1029/2007JE002994. **[3]** Mustard, J. F. et al. (2001) Nature, 412, 411-414. **[4]** Milliken, R. E. et al. (2003) JGR, 108, doi:10.1029/2002JE002005. **[5]** Kreslavsky, M. A. and Head, J. W. (2002) GRL, 29, doi:10.1029/2002GL015392. **[6]** Head, J. W. et al. (2003) Nature, 426, 797-802. **[7]** Raack, J. et al. (2010) LPSC 41, abstr. 1998. **[8]** Kargel, J. S. and Strom, R. G. (1992) Geology, 20, 3-7. **[9]** Reiss, D. et al. (2004) JGR, 109, doi:10.1029/2004JE002251. **[10]** Schon, S. C. et al. (2009), Geology, 37, 207-210. **[11]** Malin, M. C. and Edgett, K. S. (2000) Science, 288, 2330-2335. **[12]** Heldmann, J. L. and Mellon, M. T. (2004) Icarus, 168, 285-304. **[13]** Berman et al. (2005) Icarus, 178, 465-486.