POSSIBLE GLACIO-FLUVIAL LANDFORMS IN SOUTHERN ARGYRE PLANITIA, MARS: IMPLICATIONS FOR GLACIER THICKNESS AND DEPOSITIONAL SETTINGS H. Bernhardt[1], H. Hiesinger[1], D. Reiss[1], M. Ivanov[2], G. Erkeling[1], [1]Institut für Planetologie, Westfälische Wilhelms-Universität, Wilhelm-Klemm-Str. 10, 48149 Münster, Germany (h.bernhardt@uni-muenster.de), [2] Vernadsky Institute, Russian Academy of Sciences, Kosygin St. 19, 119991 Moscow, Russia.

Introduction: The southern rim of the Argyre basin on Mars between -52°S/-59°S and 310°E/322°E shows several landforms of likely glacio-fluvial origin [e.g., 1,2,3]. Our study presents new insights into possible formation mechanisms and glacio-fluvial implications of previously identified esker-like sinuous ridges on layered terrain [2,3,4]. Based on detailed morphologic analyses and comparisons with terrestrial analogues, we interpret the ridges and their surroundings to be eskers on glacio-fluvial sediments. We propose the formation of northward trending degraded ridges to have involved back- and downwasting ice near the glacier rim, whereas eastward trending, more pristine ridges likely formed beneath a ~2 km thick ice sheet before its stagnant retreat. Glacier-like viscous flows in the nearby highlands, however, are likely more recent features and thus not related to these landforms.

Mapping: We compiled a new a detailed geomorphologic map of the study area (Fig. 1). Its general division into highland- and lowland units can be related to older, Viking-based mappings of that region [5]. The southern half of our study area consists of the heterogeneous Charitum Montes highland terrain (blocky; mountainous; smooth upland terrain: UTb; UTm; UTs), representing the southern rim of the Argyre basin. The northern half represents the southern basin floor (unstratified; layered basin floor: BFu; BFl). The highlands are characterized by broad, often U-shaped, valleys and mesa-like plateaus with numerous cirque-like, semicircular embayments [1,2]. The basin floor consists mostly of rough, layered terrain (BFlr), slowly changing to intermediate and smooth terrain (BFli, BFls) within a ~100 km wide zone circumferential to the Charitum Montes. Sinuous, layered and branching ridges, up to 300 km in length and 160 m in height can be seen on the basin floor with their apparent vertices being located close to the mouth of Surius Vallis (Channel: Cha).

Morphologic and stratigraphic analyses: Absolute model ages based on crater counts on units HTm and HTs indicate that the U-shaped valleys and cirques were formed ~3.7 – 3.5 Gyr ago. Crater counts on unit BFl suggest a simultaneous formation of the esker-like ridges along with an at least ~340 m thick suite of layered sediments on the floor of the Argyre basin. The unstratified basin floor is exposed in a ~1 km deep V-shaped depression ca. 70 km north of the mouth of Surius Vallis. On the basis of the braided pattern and

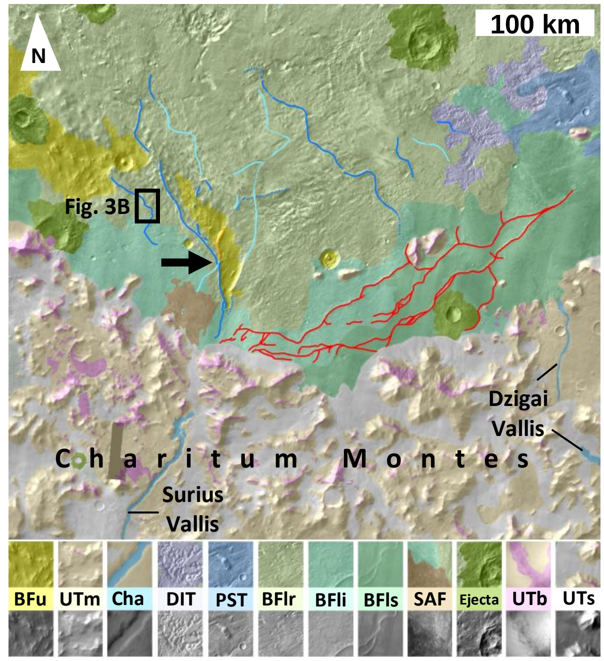

Fig. 1. Geomorphologic map of southern Argyre Planitia (background THEMIS-IR Day). Units are explained in the text.

state of degradation of the sinuous ridges, we subdivided them into two populations, which could in turn reflect changing conditions of glacial retreat:

- Population I (Fig. 1, red lines) consists of northeast trending ridges that show patterns of multiple branching and braiding and appear less degraded
- Population II (Fig. 1, blue lines) consists of northward trending, solitary, and more degraded ridges, with layers extending into the adjacent terrain

Based on the analysis of crest shapes of the more pristine ridges of population I and their surrounding surface gradients, we used the transition method and the oblique path method [6,7] to compute four ice surface gradients of the glacier (Fig. 3, blue bars) under which they might have formed. According to this reconstruction, the ice sheet reached a thickness of ~2 km if a conservative glacial terminus near the end of the easternmost ridge is applied (Fig. 3). This would imply at least ~100,000-150,000 km³ of ice on the southern floor of the Argyre basin during the time the population I-ridges were deposited.

Discussion: In order to explain the transition of layers from the ridges into their surroundings, subglacial cavities in contact with subice channels have previously been proposed [3] as depositional environ-

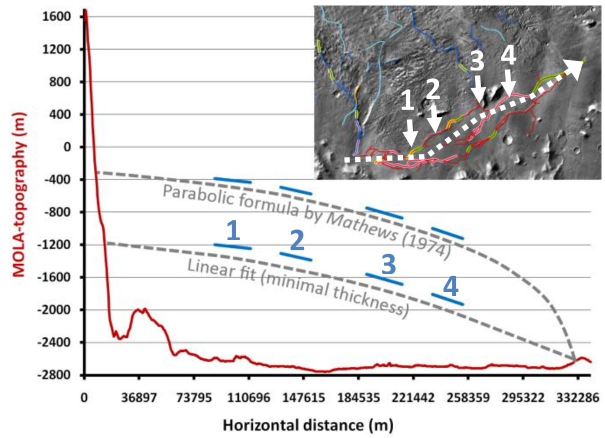

Fig. 2. Reconstructed glacier surfaces along the population I-ridges (map inlet). The curves are extrapolated from four ice surface gradients computed via the transition- and oblique path methods [6,7].

ments. However, due to the vast extent of the population II-ridges on terrain with visible layering (over 40.000 km²), such a scenario seems problematic, as subglacial cavities are spatially limited features. A more suitable scenario can be observed at the Piedmont-style Malaspina Glacier, Alaska [9], and was also proposed for terraced landscapes around Pleistocene eskers in Canada [10]: A glacial retreat involving backwasting of stagnant ice lying beneath fresh outwash sediments (Fig. 3), thereby creating a degraded and layered lag around the emerging eskers. If outwash sediments were fed by the same drainage source as an esker, sections of layers can extend from the ridge into the surrounding deposits. Therefore, we propose that the different direction and better preservation of the population I-ridges represent a change of the subglacial drainage direction coupled with diminished downwasting, possibly due to a decreased deposition of outwash sediments.

After sedimentation during this proposed glacial period had ceased, a distinct period of fluvial activity, indicated by the following observations, likely occurred in southern Argyre Planitia:

- A ~2.500 km² large possible alluvial fan at the mouth of Surius Vallis (Surius alluvial fan: SAF) deposited on top of the BFl
- Cleia Dorsum, the largest of the esker-like ridges, is dissected by a channel-like trough originating from the SAF (Fig. 1, black arrow)
- Streamlined terrain associated with Pallacopas Vallis (Pallacopas streamlined terrain: PST, deeply incised terrain: DIT) carved into the BFl

Aside from the discussed glacio-fluvial landforms, glacier-like viscous flows are present in the Charitum Montes (unit HTs), which show crevasse-like fissures and are lacking any visible craters. Although we cannot rule out their nature as remnants of an earlier glacial period, our observations are consistent with the hypothesis [11] that they are young "recently" active (Amazonian) "dust glaciers" [12]. As proposed by other authors, such flows may be fed by dust-ice accumulations from atmospheric volatiles mobilized due to cyclic changes in orbital obliquity [11,13,14]. Therefore, viscous flows in the Charitum Montes might currently be stationary, but activated by enhanced inflow of volatiles during phases of higher obliquity [13].

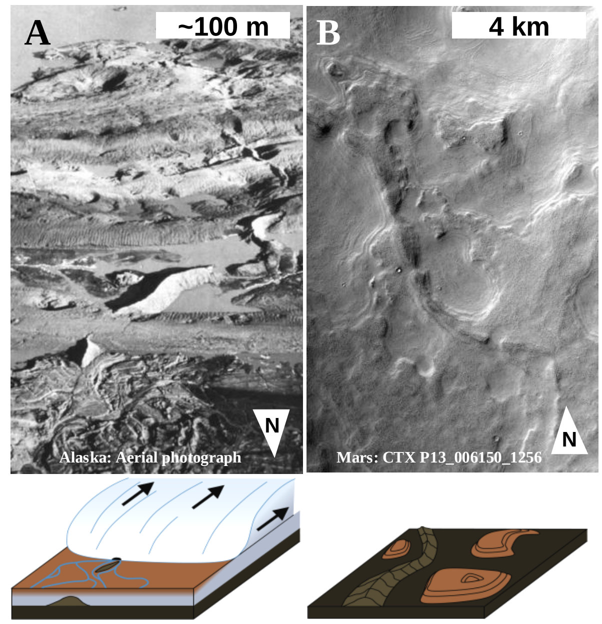

***Fig. 3.** (A) A ~15 m high, degraded esker at the southern margin of Malaspina Glacier, Alaska, sitting on ~100 m thick ice. The outwash-fan in the foreground was fed by the same drainage tunnel that formed the esker [9,10]. Down- and backwasting of a stagnant ice sheet (drawings below) could produce landforms similar to (B), showing a ~50 m high ridge of population II among degraded, terraced terrain (shown on Fig. 1).*

Conclusions: The results of this study suggest, that southern Argyre Planitia experienced an extended period of glacial and fluvial activity throughout the Hesperian and possibly until the early Amazonian. Large amounts of water, possibly supplied by the Dorsa Argentea Formation via Surius, Dzigai and Pallacopas Vallis, caused the formation of an at least ~2 km thick glacier. Its marginal environment involved down- and backwasting of ice and outwash sediments and could thus have been comparable to terrestrial Piedmont-style glaciers like Malaspina Glacier in Alaska.

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