

EVIDENCE FOR LOCAL, VOLCANISM-INDUCED WET-BASED GLACIAL CONDITIONS IN THE AMAZONIAN ARSIA MONS FAN-SHAPED DEPOSIT. K. E. Scanlon¹, J. W. Head III¹, and D. R. Marchant²,
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Introduction: The Arsia Mons Fan-Shaped Deposit (FSD) covers an area of ~166,000 km² on the western flank of the Arsia Mons shield volcano and formed during the Late Amazonian era [1,2]. Like the other Tharsis Montes FSDs, it has been interpreted to be of glacial origin, because the units in the deposit are similar in appearance and spatial association to terrestrial cold-based glacial landforms [3-6] and because climate models indicate that the western flanks of the Tharsis Montes would have been sites of preferential snow accumulation during high-obliquity periods in the Amazonian [7].

The interaction between this glacial ice and Arsia Mons lava flows resulted in numerous distinctive glaciovolcanic landforms in the FSD, including pillow mounds, hyaloclastite mounds, a tuya, and several steep-sided ridges and scarps [6,8,9]. On Earth, observations indicate that both the elevated geothermal heat and direct lava-to-ice heat transfer associated with subglacial volcanism can lead to enhanced ice flow speed and local wet-based behavior in otherwise cold-based glaciers [e.g. 10-12]. Several features that we interpret as characteristic wet-based glacial landforms are present in the Arsia Mons FSD; we document these landforms and their relationship to glaciovolcanic features in the deposit.

Outflow channels and streamlined knobs: At the western edge of the deposit (**Fig. 1**) lies a steep-sided, ~17 km long by ~15 km wide, ~140 m high plateau, interpreted as a subglacially constructed volcanic edifice [6,8,9]. Directly downslope of this plateau, a braided, ~35 km fluvial channel emerges from the outermost moraine, indicating that a substantial volume of water (generated by volcano-ice interactions) drained out from beneath the glacier. Between the plateau and the channels, a field of aligned knobs, streamlined and elongated in the downslope direction, indicate sculpting by a glacier moving along its bed.

Ribbed moraine: The Lobate Facies of the Arsia Mons FSD is dense with steep-sided flows and evidence of phreatomagmatic eruptions. At the contact between the Lobate Facies and Knobby Facies (interpreted as a glacial sublimation till) within the FSD lies a ~17 km wide field of sharply defined, commonly asymmetric, regularly spaced, concentric or anastomosing ridges up to 30 km long (**Fig. 2**). On the basis of this morphology, their regular size and spacing, their occurrence in a large field aligned with bulges in the moraines farther

downslope, their orientation transverse to the downslope direction, and the fact that they do not appear to gently drape underlying topography as the drop moraines in the ridged facies do, we interpret these ridges as ribbed moraines. The mechanism by which ribbed moraines form on Earth is incompletely understood, but they are widely thought to form subglacially [e.g. 13] and to be diagnostic of wet-based or polythermal glaciers [14]. Furthermore, some researchers have suggested that strong horizontal gradients in ice flow velocity (such as those that would have been present at the boundary between wet-based and cold-based portions of the Arsia Mons glacier) are always a crucial factor in their formation [e.g. 15]. In addition to the ribbed moraine between the lobate and knobby facies, morphology and stratigraphic relationships suggest that some parallel ridges near glaciovolcanic edifices in the northern and western parts of the FSD may be washboard moraines, which also may form subglacially in regions of extension [e.g. 16].

Thrust-block moraine: Near the northern edge of the deposit lies a steep-sided, ~400 m high, ~53 km long ridge that we interpret as an ice-confined lava flow [6]. Directly downslope of this large glaciovolcanic edifice, the outermost moraine in the FSD is markedly wider than it appears anywhere else in the deposit, and is ridged in appearance (**Figure 3**) and topography. This appearance and profile are consistent with an imbricate stack of thrust slabs, suggesting that thrust-block moraine (sometimes known as composite or push moraine; cf. [17]) may have developed in this part of the deposit. On Earth, such moraines may form when high stresses (e.g. from a steeply sloping glacier edge) act on weak subglacial sediments or bedrock. High pore water pressure, often due to the presence of a permafrost-confined aquifer beneath the glacier, is generally the major factor weakening the substrate in terrestrial cases [e.g. 17-19].

Discussion: While the Arsia Mons glacier was cold-based through much of its spatial and temporal extent [1], volcano-ice interactions appear to have induced local wet-based behavior in several regions of the deposit. The basal sediments of terrestrial wet-based glaciers support a diverse array of microbial life [e.g. 20-21], and along with other aqueous environments created by glaciovolcanism in the deposit [6], wet subglacial sediments may have presented an unusually hospitable environment in the Amazonian for any martian life that may have existed to colonize it.

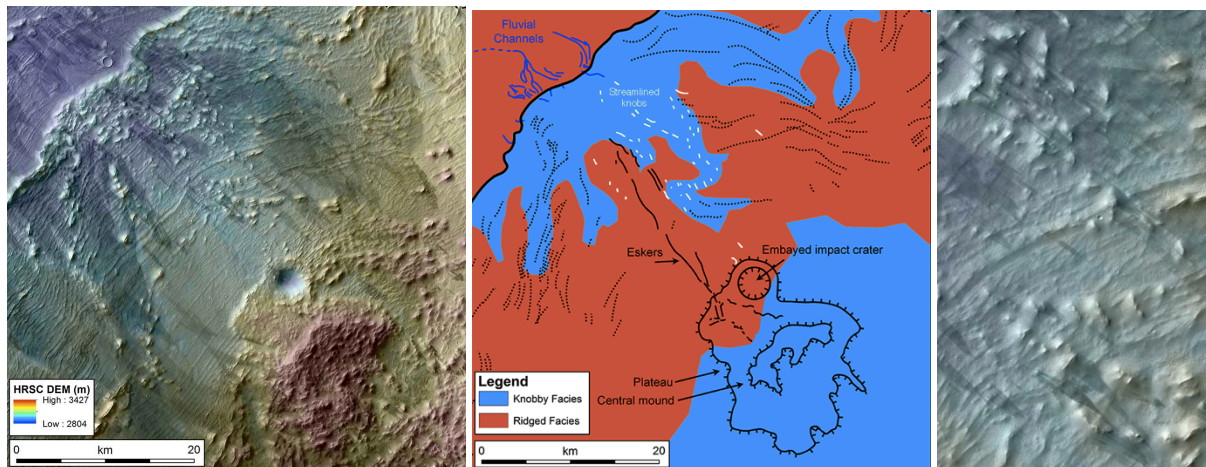


Fig. 1: (left) Plateau, interpreted as subglacial, and surrounding landforms. (center) Sketch map showing locations of fluvial channels (dark blue) and streamlined knobs (green). (right) Close view of streamlined knobs.

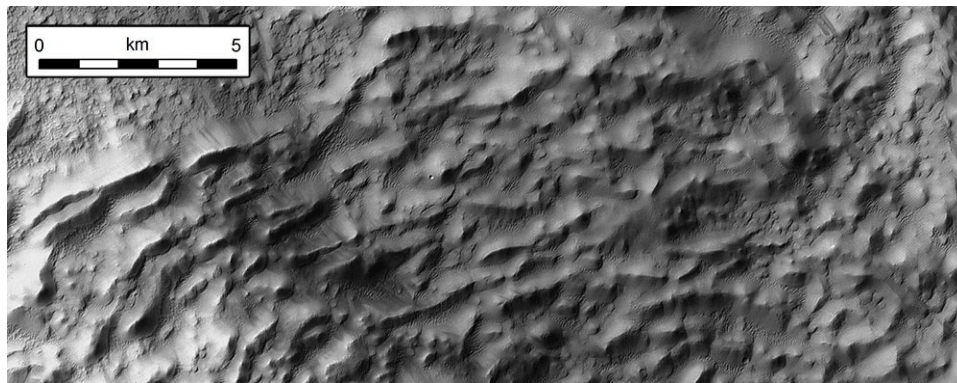


Fig. 2: Concentric, sharp, evenly spaced ridges, interpreted as ribbed moraines, at the contact between the lobate facies and the knobby facies.

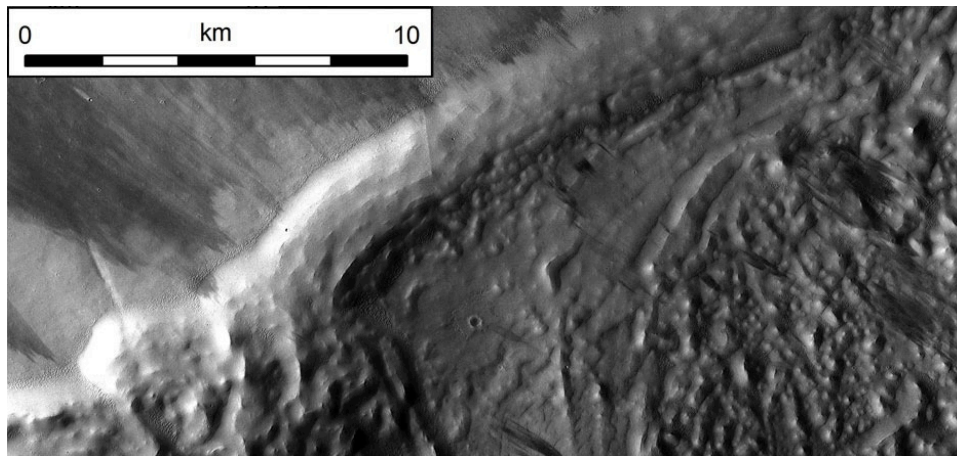


Fig. 3: Thick, ridged terminal moraine downslope of a large ice-confined lava flow.

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