DEBRIS-COVERED GLACIERS WITHIN THE ARSIA MONS FAN-SHAPED DEPOSIT: IMPLICATIONS FOR GLACIATION, DEGLACIATION AND THE ORIGIN OF LINEATED VALLEY FILL. D. E. Shean[1], J. W. Head[1], and D. R. Marchant[2] [1]Brown University, Dept. of Geological Sciences, Providence, RI 02912 (David_Shean@Brown.edu), [2]Boston University, Dept. of Earth Sciences, Boston, MA 02215.

Introduction: Recent MOC and THEMIS data have shed new light upon intriguing flow-like features on Mars including viscous flow-like features [1], lobate debris aprons [2], concentric crater fill, lineated valley fill, and features interpreted as rock glaciers or debris-covered glaciers [3,4,5,6]. These features are distributed over low- to mid-latitudes and all appear to have experienced flow due to the presence of volatiles. Here we consider debris-covered glaciers – features that consist of a relatively pure glacier ice core covered by a thin (sub-m to m scale) layer of debris. A debris cover typically develops from rockfall or direct atmospheric dust deposition in the accumulation zone of the glacier and/or through sublimation of ice in the ablation zone, resulting in a surficial lag deposit of supraglacial and englacial debris. Using new data, we assess the origin of these features at Arsia Mons. We also consider how this interpretation may provide insight into processes of glaciation and deglaciation on Mars, and discuss its application to other areas containing candidate deposits of glacial origin.

Arsia Mons Smooth Facies: The Arsia Mons shield volcano has an 180,000-km^2 fan-shaped deposit present on its west-northwestern flank (Fig. 1). Our previous work suggests that this fan-shaped deposit represents the depositional remains of a large cold-based glacier that formed on the west-northwestern flank in the late Amazonian [5, 9]. One of the three main facies (smooth facies; Fig. 1) was interpreted as debris-covered rock glaciers [5]. These features consist of 20 to 100-km-long, broad, lobate plains, hundreds of meters thick with concentric ridges near the margins [5].

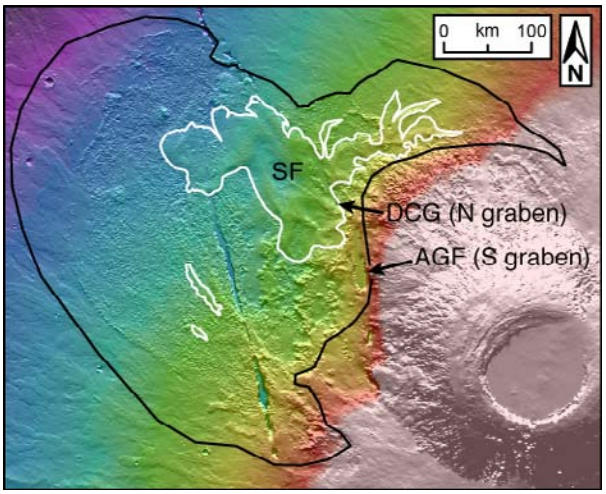

Figure 1: Arsia Mons fan-shaped deposit (black line) and smooth facies (SF, white line). The debris-covered glacier (Fig. 3) is labeled DCG and graben with arcuate graben fill (Fig. 4) is labeled AGF.

Similar features are well documented in the cold, hyperarid climate of the Dry Valleys in Antarctica [5,7,8]. Mullins Valley (Fig. 2) is of particular interest because it is occupied by a >5 km long, ~1 km wide, debris-covered glacier very similar in scale and morphology to those on Mars. As is characteristic of most debris-covered glaciers, Mullins displays a concentric ridged pattern. The debris cover (sublimation till) on Mullins (cm to <1 m thick) serves to insulate the underlying ice from the atmosphere, reducing sublimation to extremely low rates [10].

Recent THEMIS VIS images show some intriguing smaller-scale features near the eastern margins of the smooth facies at Arsia (Fig. 1). A distinctive flow-like feature (Fig. 3; ~12-15 km long, 2-4 km wide; >150-200 m thick in places) occupies a graben and does not have a "deflated" appearance like many flow-like features on Mars. In plan view, it consists of a proximal, steep-sided thinner section with marginal ridges that suggest previous occupation of a larger part of the valley. MOC data show a chevron-like pattern of lineations similar to terrestrial glaciers. To the NW, it expands into a wider, lobate series of concentric ridges (compare Figs. 2 and 3) and appears to fill depressions in previous topography (Fig. 3). We interpret this flow-like feature as a debris-covered glacier that may still contain a significant ice core and may represent the most recent phase of glaciation at Arsia. The marginal depressions suggest that the ice-rich upper part of the glacier may have been 'beheaded' during interglacials, followed by the formation of a new lobe when glacial conditions return.

An 8 to 15-km-wide graben cuts through the center of the Arsia fan-shaped deposit (Fig. 1, 4). This graben contains arcuate fill material that appears to originate at two cirque-like alcoves along the base of the scarp in the SE corner with concentric ridges indicating northward flow within the graben. Although the valley floor currently lies below the graben rim, the lobate and ridged deposits on the graben rim indicate that at one time, debris-covered flowing ice completely filled the graben, breached the walls, and extended an additional 5-8 km to the east and west of the graben (Fig. 4). Subsequent deglaciation then caused the down-wasting of the ice to produce the current topography; the material still appears to be a few hundred meters thick and is characterized by many concentric ridges suggesting substantial flow. On the basis of topography, the remaining material still appears to be ice-cored.

Discussion and Summary: 1) Debris-covered glaciers are valuable morphological indicators of climate change on Earth and Mars. 2) We interpret these features in the smooth facies at Arsia to represent the latest phases of glacial activity associated with the fan-shaped deposit. 3) These data also provide insight into both glaciation and deglaciation processes here and elsewhere on Mars, showing examples of advance (Fig. 3), overflowing of valley margins (Fig. 4), retreat during deglaciation (decapitation, Fig. 3; down-wasting, Fig. 4), and readvance (Fig. 3). 4) The elongate graben (Fig. 4) shows abundant evidence of being filled with debris-covered ice, overflowing the margins, and then retreating during deglaciation. This provides an excellent analog for the nature of lineated valley fill (LVF) [11], and a) how it can form on portions of valley interiors and flow along the long axis of the valley, b) how it can fill valleys and overflow onto the valley margins [12], and c) how LVF can form in closed valleys of limited areal extent.

References: [1] Milliken R.E. et al. (2003) *JGR, 108(E6)*, 5057. [2] Mangold N. (2003) *JGR, 108(E4)*, 8021. [3] Head J.W. et al. (2005) *Nature*, in press. [4] Neukum G. et al. (2004) *Nature, 432*, 971-979. [5] Head J.W. & Marchant D.R. (2003) *Geology, 31*, 641-

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Figure 2: Aerial photograph of Mullins valley debris-covered glacier, Antarctica. Note the distinctive concentric ridges.

Figure 3: THEMIS VIS mosaic of flow-like feature within northern graben, interpreted as a debris-covered glacier.

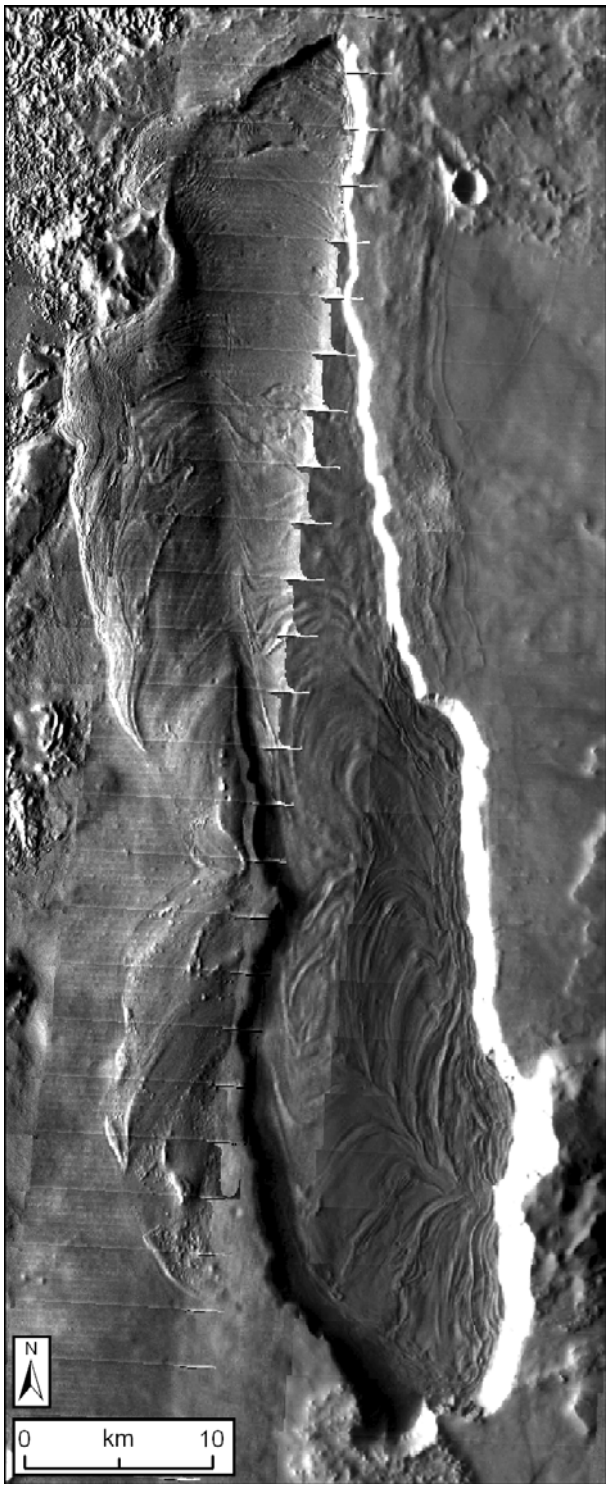

Figure 4: THEMIS VIS and IR mosaic of arcuate fill material in southern graben at Arsia. Note the material to the west and east of the graben walls and the concentric ridges that appear to originate at the two cirque-like alcoves on the southeastern wall.