MOUNTAIN GLACIERS ON MARS?: WESTERN ARSIA MONS FAN-SHAPED DEPOSIT SMOOTH FACIES AS ROCK GLACIERS; James W. Head1 and David R. Marchant2, 1Dept. Earth Sciences, Boston University, Providence, RI 02912 USA, 2Dept. Geol. Sci., Brown Univ., Providence, RI 02912 USA, Microsymposium 36, MS103, 2002

Introduction and Background: Arsia Mons contains a distinctive and unusual lobe, or fan-shaped deposit on its western flank [1,2] that displays three facies: 1) An outermost ridged facies, consisting of a broad thin sheet characterized by numerous ridges, 1->10 km in length, and spaced a few hundred meters to several kilometers apart, that extend over topographic barriers without obvious deflection. 2) A knobby facies, which forms an extensive area of chaotic terrain that consists of subrounded several-kilometer-diameter hills; some hills are elongated downslope, and others form chains that are parallel to subparallel to the ridges in the ridged facies. 3) A smooth facies, which contains arcuate lineations and diffuse to lobate margins; the smooth facies appears to overlie areas of the knobby facies. Here we focus on the nature and origin of the ridged facies.

Smooth Facies Description: Scott and Zimbelman [1] described the smooth facies of the fan shaped deposit (Fig. 1) as consisting of "smooth surfaces with arcuate lineations and diffuse to lobate margins. [It] overlies large areas of knobby facies...[and]...partly fills and appears to be extruded from faulted collapse depressions."

The setting of the major occurrence of the smooth facies can be seen in Fig. 1, and details of the lobate nature of the structures can be seen in Figs. 2 and 3. The lobate parts of the facies appears to have originated near the vicinity of the large linear depression, a location that caused Scott and Zimbelman [1] to interpret them as volcanic (pyroclastic) lobes emanating from the fissure (see also [2]), or possibly as a lahar. On the basis of the MOLA topography, we found that the lobes tended to be located on highs and to descend into adjacent lows. They are characterized by a series of concentric ridges tens of meters high superposed on a broad lobe hundreds of meters thick. Some of the lobes have depressions in their centers. In other places (Fig. 3) these lobes appear at the margins of the hummocky terrain and appear to be closely related to both the ridged facies and the knobby facies.

Smooth Facies Interpretation: Scott and Zimbelman [1995] interpreted the smooth facies to have originated as a viscous flow from two large fault-bounded depressions and to be formed by ash-flow tuffs or lahars. They point out that "the margins of the smooth facies appear to be spread out and feather-edged, and thus the material more nearly resembles an ashflow."

On the basis of the lobate characteristics of these deposits as revealed in the MOLA data and their very close association with the ridged and knobby facies, we have explored glacial analogs for these features. We find that rock glaciers provide a very compelling analog for these lobate features [3,4]. Rock glaciers are lobate debris-covered deposits commonly found in alpine environments and range from ice-rock mixtures to thin, debris covered glaciers where ice might be preserved for considerable periods of time due to the insulating effects of the debris.

Summary and Synthesis of the Fan-Shaped Deposits on Western Arsia Mons: The unusual Amazonian-aged, fan-shaped deposit covers ~180,000 km2 of the western flank of Arsia Mons. It consists of three components: 1) an outermost ~60-90 km wide distal zone of over 100 parallel raised ridges; 2) a medial ~80-300 km wide zone of rough, hummocky topography, 3) A proximal zone up to ~150 km wide abutting the upper flanks of Arsia and consisting of arcuate and lobate flow-like deposits. Upfllank are several sinuous outward-facing scarps, rough near-summit topography, and pits and elongate troughs. Within the fan shaped deposit are NNW-striking, graben-like elongate depressions. The distal ridged deposits are superposed on lava flows and a large impact crater and underlying lava flows can be traced back underneath the medial hummocky unit to the graben structure.

Using new MGS data and Earth analogs appropriate for Mars, we explored the hypothesis that the deposit is the remnant of a mountain glacier formed on the western flank of Arsia Mons (e.g., [1]). Conditions during the recent geological history of Mars suggest that glacial ice should commonly be below the pressure melting point, and thus analogous to polar glaciers, which are frozen to underlying beds (cold-based), and move by internal deformation, producing no record of basal scour or extensive meltwater features. Glaciers in the Antarctic Dry Valleys may be most appropriate terrestrial analogs, and we find many similarities between them and the western Arsia fan-shaped deposits.

We interpret the outer parallel ridge zone to be distal dump moraines formed from the lateral retreat of a cold-based glacier, and the hummocky facies to be proximal hummocky moraines resulting from the sublimation, decay and downwasting of the ice sheet (a sublimation till). The arcuate structures in the proximal zone are interpreted to be rock glaciers, formed by lobate flow deformation of debris-covered ice surfaces; some rock glaciers may still be ice-cored. We find little evidence for melting features in association with the deposit, and thus conclude that it was predominantly cold-based throughout its history. In summary, we find abundant evidence to support the interpretation that the fan-shaped western Arsia Mons deposit was formed by a cold-based mountain glacier. Similar deposits are seen on Pavonis and Ascraeus Montes.

Stratigraphic relations show that the medial hummocky unit partly overlies the distal parallel ridged unit; we interpret this to mean that there was at least one phase of readvance following retreat of a significant part of the cold-based glacier. Contemporaneous volcanic eruptions suggest that tephra may be the main non-ice component of the glacial deposits. If the glacial interpretation is correct, this means that at some time during the Amazonian conditions were conducive to the accumulation of ice on the western flanks of the Tharsis Montes, and that subsequently the ice largely disappeared. Possible causes of ice accumulation could be 1) extremes in orbital parameters, which could result in sublimation of polar deposits and deposition in equatorial regions, or 2) locally increased water supply to the atmosphere, perhaps coincident with Amazonian-aged catastrophic outflow in nearby Elysium and Amazonis Planitia, orographic upwelling, and deposition. The
presence of rock glaciers suggests that some ice may still exist in the shallow subsurface, and may preserve a record of the Amazonian atmosphere and Tharsis Montes tephrochronology.


Figure 1. Setting for the smooth facies of the fan-shaped deposit on Western Arsia Mons. Viking Orbiter images.

Figure 2. Enlargement of fan-shaped deposits in the smooth facies. See Figure 1. Viking Orbiter images.

Figure 3. Enlargement of fan-shaped deposits in the smooth facies. Viking Orbiter images.