ASCRAEUS MONS, MARS: CHARACTERISATION AND INTERPRETATION OF THE FAN-SHAPED DEPOSIT ON ITS WESTERN FLANK. R.L. Parsons and J.W. Head III, Department of Geological Sciences, Brown University, Providence, Rhode Island 02912, USA (Rebecca_Parsons@Brown.edu).

Introduction: Ascraeus Mons is one of the three Tharsis Montes shield volcanoes that are aligned along a N40°E trend on the crest of the broad Tharsis Rise. Although largely constructed of volcanic deposits, each of the Tharsis Montes has a distinctive and unusual fan-shaped deposit extending approximately north-west on their western flanks. Three major facies have been identified within the fan-shaped deposits of Arsia and Pavonis Mons [1-6]: (1) A ridged facies consisting of numerous ridges that trace the distal margin of the lobe, often cutting across flow features and craters without any obvious deflection. (2) A knobby-terrain facies characterized by a chaotic assemblage of equidimensional hills. (3) A smooth facies containing concentric ridges superposed on broad lobes.

For some years there has been a debate over the emplacement of these fan-shaped deposits. The problem is important because it contributes to an understanding of the environmental history of the Tharsis region and its place within a wider planetary context. Hypotheses for their origin have been primarily based on three major processes: mass movement [1,2,5,7,8], volcanism (pyroclastic flows and ash falls) [2,5,6], and glacial and periglacial activity [3,4,5,6,9].

The work presented here includes characterisation of the Ascraeus Mons fan-shaped deposit and an assessment of the plausibility of a cold-based glacial origin, which has been developed from studies of Arsia and Pavonis Mons [3,4].

Previous Modes of Origin: Early observations from Mariner and Viking images led to classification of these features as massive landslide deposits [1,8]. In this scenario, the knobby facies is thought to represent a chaotic mass of debris that detached from the western flank of the volcano, while the ridged facies is thought to form by deformation resulting from the drag of the slide over underlying terrain. Difficulties in reconciling a purely landslide origin with the great size and length of the deposits, as well as the lack of obvious source areas of sufficient volume has led to the proposal that pyroclastic activity may have contributed to the form of the fan-shaped deposits. Such activity is thought to be triggered by the slide events responsible for the initial emplacement of the deposits [2]. Although the evidence for pyroclastic activity has since been disputed, an origin of these features in terms of multiple processes is still favored by several authors [5,6,7].

Cold-Based Glacial Model: Building on early comparisons of the fan-shaped deposits with features characteristic of glacial depositional environments [5,6,9], the integration of MOLA, THEMIS and MOC data with depositional frameworks of polar glaciers in the Antarctic Dry Valleys, has provided evidence supporting an interpretation of these deposits as remnants of cold-based mountain glaciers [3,4]. Hence, the outer ridges are likened to drop moraines formed from lateral retreat of cold-based ice, the knobby facies forms from in-situ downwasting of the ice in a process analogous to sublimation till formation, and the smooth terrain represents relict features of rich debris-covered ice or rock glaciers.

The case for a cold-based glacial origin has often been disputed based on the elevations and equatorial location of the fan-shaped deposits. Atmospheric water vapor content in this area is currently extremely low, and thus suggests the existence of a very contrasting Martian environment in the relatively recent past [7]. The coupling of MGS observations with previous global climate models demonstrates the possibility that ice ages may have occurred on Mars as recently as 2.1 to 0.4 Myr ago [10]. These ice ages are characterised by increased insolation in the polar regions resulting in significant water vapor release from sublimating polar caps. Such losses increase the atmospheric water vapor content, and enhance its transport equatorwards. In a scenario similar to that on Earth, Martian ice ages are thought to be closely linked to variations in planetary orbital parameters. Over the past 10 Myr, the obliquity of Mars has varied chaotically between 14° and 48°. At high obliquities (>45°), models predict high rates of sublimation with subsequent growth and persistence of ice at the equator [11]. The formation of ice bodies on the western flanks of the Tharsis Montes may have been enhanced by orographic effects of wind circulation, in a process analogous to terrestrial rain shadows [4].

Ascraeus Mons Fan-Shaped Deposit: The Ascraeus fan-shaped deposit (Figure 1) is ~180 km at its widest point, and extends ~100 km from the shield base along a N82°W trend. Overall, the deposit covers an area of approximately 14,000 km^2, ranging in elevation from 1.5-5.5 km above the Mars datum. It contains four morphologically distinct units:

Ridged Facies. The ridged facies consists of at least seven near-continuous, elongated ridges that trace the distal edge of the deposit. Ridges are located at about 800 m intervals, but tend to converge towards the northern and southern portions of the deposit. The outermost ridge is the most prominent reaching heights of up to 80 m and extending for ~180 km with smaller (5-25 m) inner ridges concentric to this outer margin. Several of the ridges have asymmetric cross-profiles with steeper distal slopes. An additional set of small ridges can be observed ~20 km east of the outer ridge, at the base of an outer scarp that separates the distal ridges from the rest of the deposit by an elevation of between ~180-300 m. These ridges are much less prominent extending only ~20 km and with heights below 10m.

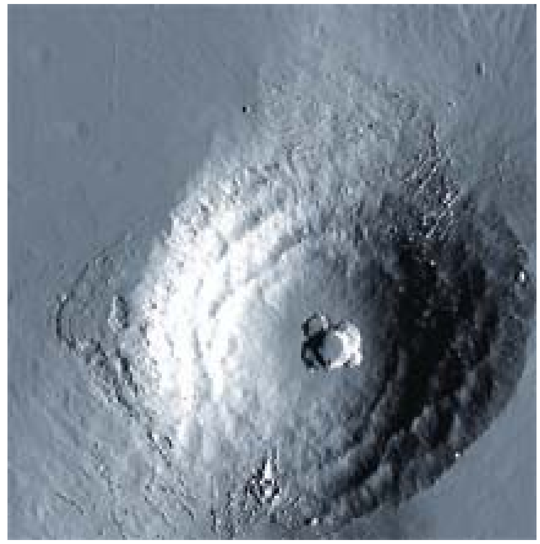
Knobby Facies. The knobby facies forms one continuous deposit covering an area of approximately 1800 km^2. This unit consists of numerous rounded to sub-rounded hummocks, several km in diameter and tens of km in height. Some of these hummocks appear elongated, typically in a N40°W direction. In the southern part of the deposit, hummocks are particularly dense and extend from the shield base of Ascraeus to an inner scarp representing an abrupt ~100 m drop in elevation. Hummocks are less numerous to the north, but extend further westwards to the base of the outer scarp.

Mountainous Region. Small, isolated "mountainous regions" [2] are located adjacent to the north and south edges of the knobby facies. Hummocks in these regions are morphologically distinct from those of the knobby facies, but appear to be elongated in a similar north-northwest direction. They are 2-7 km long, 1-2 km wide, and exhibit steep slopes. Comparable units are also observed in the central region of the deposit, extending from the distal edge of the knobby facies and across the outer scarp. Hummocks within these two areas appear to superpose underlying distal ridged facies.

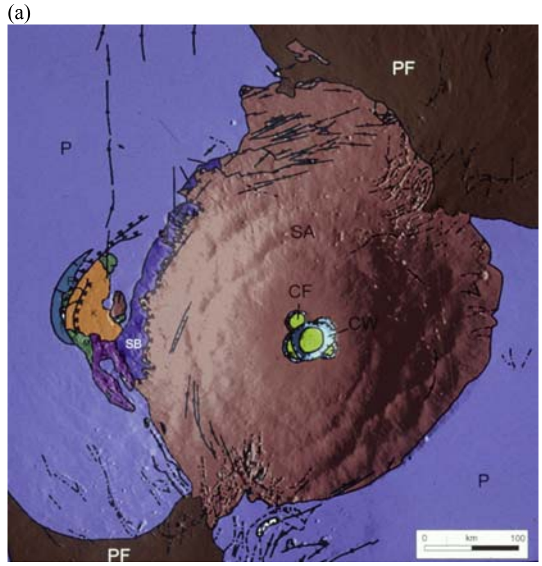
Flow-like Feature. "Lobate flows" [2], covering an area of approximately 1500 km^2, are concentrated in the southeast part of the deposit. This feature consists of a broad, steep sloped, elevated plateau of >500m, which forms two leveed channels that extend southwards. The upslope (southern) end of the feature is truncated by lava flows originating from troughs parallel to the shield base of Ascraeus [2]. Morphologically similar flow-like features have been identified within the Pavonis fan-shaped deposit [4,6]. Scott et al [6] have described several possible explanations for their formation including eskers formed by sedimentary deposition beneath or within a wasting ice sheet, and unique lava flows. In contrast, Shean and Head [4] have argued that the steep scarps and leveed edges of these flows are more consistent with subglacial lava flows.

Discussion and Conclusions: The fan-shaped deposit on the western flank of Ascraeus Mons provides significant evidence that could be used in support of a cold-based glacial origin. Contained within this deposit are the ridged and knobby facies identified at Arsia and Pavonis, and reported to bear a striking similarity to features formed by recession and downwasting of cold-based ice in the Antarctic Dry Valleys [3,4]. Furthermore, the superposition of hummocks on the ridged facies may indicate two separate ice recession and deposition events. However, the Ascraeus fan-shaped deposit also displays several distinct and unique aspects. Its area is approximately a fifth of that covered by the Pavonis deposit, which is itself less than half the area of the deposit associated with Arsia. This deposit also appears to lack any unit comparable to the smooth facies observed within the other Tharsis Montes fan-shaped deposit, an observation that is consistent with previous studies [2].

It has been noted that any successful explanation for the origin of these deposits must address their morphologic similarities and differences, approximately equal Upper Amazonian age, and location on the western flanks [7]. Hence, a critical test for the cold-based glacial model will be how well it can explain the contrasting aspects of the Ascraeus fan-shaped deposit. Differing elevations of the deposits have been used to question a regional climate, and thus glacial, origin of these deposits [12]. Conversely, terrestrial glacial research has highlighted the non-linearity of the response of glaciers to climate change. In this respect, it will be important to assess how non-climatic factors may have influenced the formation, behavior and persistence of ice bodies. For example, differences in the structural evolution and styles of eruption between the three volcanoes [13], as well as the pre-existing topography surrounding each volcano [14] may have served to modify the response exhibited by glaciers associated with each. In a wider context, it is important to consider possible variance in the local climate experienced by each volcano as a result of the interaction of regional topography with general atmospheric circulation.



(a)



(b)

Figure 1: (a) MOLA topography of Ascraeus Mons and its associated fan-shaped deposit. (b) Geologic sketch map of western Ascraeus Mons (modified from [2]) superposed on a MOLA topographic gradient map, highlighting ridged facies (R-blue), knobby facies (K-yellow), isolated mountains (M-green), and lobate flows (L-purple).

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