MELTING MOUNTAINS ON MARS? – SHEET DEPOSITS IN A MONTANE ENVIRONMENT. M. Voelker[1], E. Hauber[2], L. Parro[3], A. Cardesín-Moinelo[1], P. Martin[1], [1]European Space Agency, European Space Astronomy Center, Camino Bajo del Castillo s/n, Villanueva de la Cañada, E-28692 Madrid, Spain (martin.voelker@esa.int), [2]German Aerospace Center (DLR), Institute of Planetary Research, Rutherfordstr. 2, D-12489 Berlin, Germany, [3]Departamento de Geodinámica, Estratigrafía y Paleontología, Universidad Complutense de Madrid, E-28040 Madrid, Spain.

Introduction: During an extensive grid-mapping campaign in the southern highlands of Mars [1], we detected sheet deposits flowing down the tectonically evolved Dryas Mons, which is a part of the South Tharsis Ridge Belt (Fig. 1) [2]. Their surface is characterized by faint parallel lineations (Fig. 2,3), and their margins show distinctive flow fronts. The lengths of the flows can exceed 100 km. The sources of these deposits are often located at the base of multi-layered outcrops in the high-elevation parts of the mountain (Fig. 2). Unique on Mars, the study area is characterized by the highest internal heat flux [3,4,5] and strong remnant magnetic fields [6,7]. This work addresses the question if these flow deposits are of magmatic or volatile-based origin, and whether their formation is related to the unique environment.

Methods: We mapped the distribution of the sheet deposits (Fig. 1) based on CTX imagery [8], measured their thickness using MOLA single shot profiles [9], and determined their age by crater counts [10-14]. Based on these results we reconstructed the stratigraphy of the deposits and their relation to viscous-flow features (VFF) and gullies. We calculated the surface heat flow considering the average of surface heat production (caused by radioactive elements), the crustal heat flow (assuming a crustal density of 2,900 kg·m^3) [3,4], and the mantellic contribution derived from [3].

Results: Many sheet deposits (blue units, Fig. 1) start at steep scarp crests (Fig. 2), and often occur in parallel with VFF (grey units, Fig. 1) and gullies; both landforms are assumed to involve volatiles in their formation [15,16]. In contrast to the sheet deposits the VFF extend only several kilometers in length.

On their way down the former sheet flows converge into small channels and diverge into small basins afterwards (Fig. 3). All flows originating from the mountain emanate into two separate basins to the north where they terminate. Each of these basins contains a small, possibly volcanic edifice surrounded by thick flows [17] (red units at Fig. 1).

The thicknesses of the sheet deposits range from 5.6 to 31.7 m (based on 9 measurements), while the thicknesses of VFF range from 39.6 to 89.1 m (7 measurements). The possibly volcanic flows in the basins have thicknesses of 85.3 to 103.8 m (3 measurements).

The potential volcanic flows have an age of ~1.2 Ga, the sheet deposits have ages of ~100-190 Ma, and the VFF ~37 Ma. The average surface heat flow totals 22.6 mW·m^2 [3].

Discussion: The distinct flow fronts and the faint lineations of the sheet deposits indicate a certain minimum viscosity of the flow material, and hence, a (probably laminar) slow emplacement. A very low viscosity would result in turbulent flows, preventing the formation of lineations and sharp flow fronts [18]. A relatively high viscosity is either found in lava flows (with high SiO_2-content [19]), glaciers [20], or debris flows with a low volatile content [18].

Dryas Mons itself is lacking clear volcanic morphologies. The origin of the sheet deposits at a scarp is uncommon for volcanic flows (neither volcanic craters nor fissures are visible).

As the flows extend very long down to the basins, without significantly changing their lineated surface texture (e.g. by a cooled, solidified crust), the atmospheric temperature must have been similar to the temperature of the flow itself. While the temperature difference between the atmosphere and volcanic flows can be several hundred degrees (causing a rapid cooling; e.g., on Mars basalts at ~1,400°K begin to solidify after ~125 seconds [21]), the difference to a debris flow is much smaller allowing the flows to be (meta)stable for a longer amount of time. This enables long flow lengths with a continuous morphology.

Similar deposits have been described before [22,23], but such finely-lineated flows are not typical for Mars. Usually, lava flows appear rugged, as their surface is solidifying quickly due to rapid cooling and repetitive rupturing [24]. If the flows consist of volatiles and solids it may be no coincidence that they occur in parallel with VFF and gullies at their sources.

It remains unknown yet if the volatiles originate from outcropping volatile-rich layers, from debris-covered glaciers [25], or from the latitude-dependent mantle [26]. In all cases, the high heat flux could have triggered or enhanced the mobilization of volatiles. Future work will determine if the calculated heat flux is sufficient to melt near-surface volatiles.

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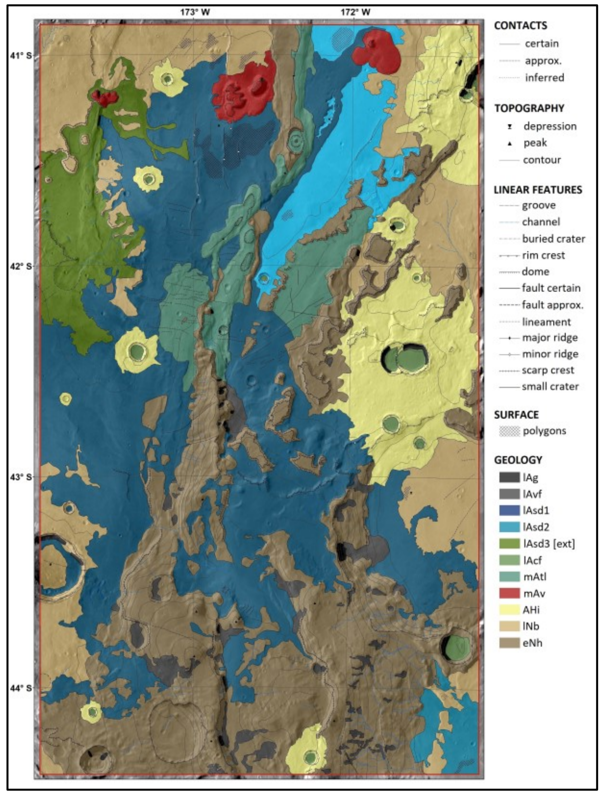

Fig. 1. *Geologic map of Dryas Mons in Terra Sirenum (basemap THEMIS).*

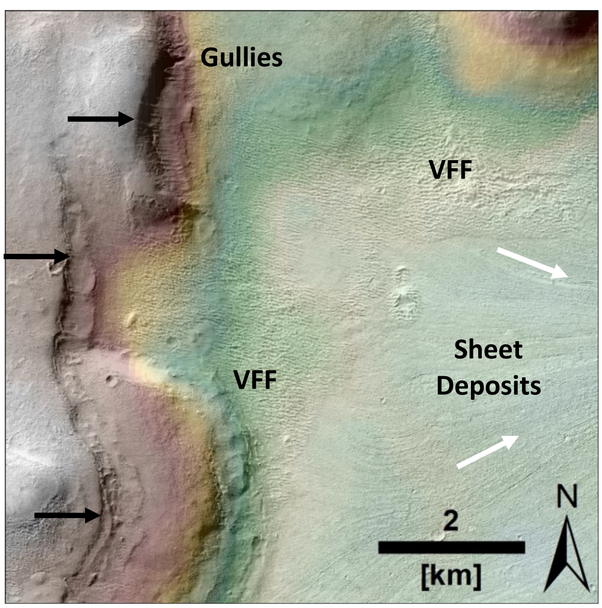

Fig. 2. *Source region of sheet deposits. Note the faint lineations of the sheet deposit (white arrows indicate the direction of flow), and the multiple geologic layers (black arrows). Often, the transition zone between layered outcrops and sheet deposits is covered by younger VFF (basemap CTX, HRSC-DEM, centered at 43.8°S 172.8°W).*

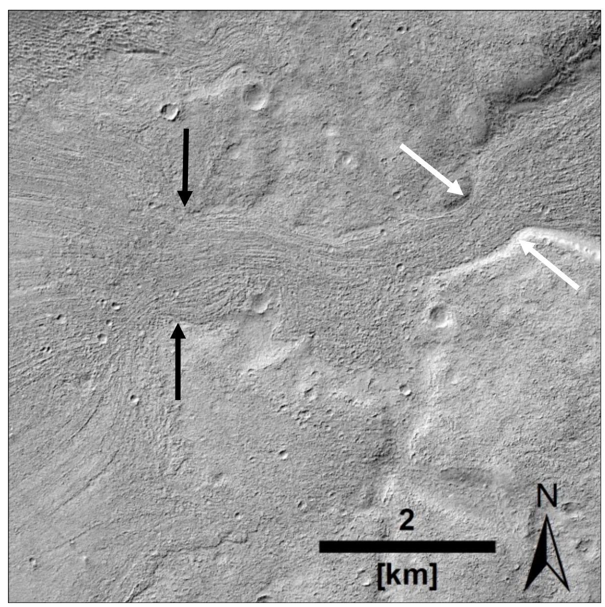

Fig. 3. *Close-up view of a sheet flow. Direction of flow is from left to right. Note the convergence (black arrows) and divergence (white arrows) of the flow (basemap CTX, centered at 43.8°S 172.6°W).*