FORMATION OF RHYOLITIC RIDGES ON MARTIAN BASALTS. T.K. Porter and P.H. Schultz, Dept. of Geology, Brown University, Providence, RI 02912

Introduction: Martian lava flows centered at approximately 3° N, 140° W are characterized by steep, thick flow fronts, large areal extents, and distinctive textures. These flows are strikingly different from other martian flows (see Figures 1a and b). The texture has been interpreted as festoon or pressure ridges [1] like those on terrestrial pahoehoe basalts - yet the martian ridges are the same scale as those on terrestrial rhyolite flows [2]. As discussed in [3], the height and spacing of the ridges is controlled by the thickness of the chilled upper margin of the flow and the viscosity ratio (the viscosity of the chilled crust of the flow vs. the viscosity of the flow interior). A thick crust and high viscosity ratio are conditions that favor the formation of high ridges with long wavelengths. Here, analytical modeling and preliminary experimental results suggest that the martian flows could not have developed a crust sufficiently thick to form the observed ridges if the flows were emplaced subaereally, and that instead the flows may have been emplaced under a unit of ice-rich dust.

Viscosities of Martian Flows: We used high resolution Viking Orbiter photographs to determine an average ridge spacing of 175.5m and an average ridge height of 13.9m. These dimensions are one to two orders of magnitude greater than the ridge dimensions of typical terrestrial basalts and are similar to ridge dimensions found on terrestrial rhyolites ([2], [3]). They are unlike any lunar basalts. We inserted the values found in Table 1 into analytical models ([1], [2], [3]) to obtain viscosities (Table 2). The lower viscosities are high for terrestrial basalts ([1], [4]) while the larger viscosity values approach the terrestrial rhyolite viscosities [2]. But these flows are undoubtedly basaltic: observed lava channels and abundant evidence for tube-fed flow are distinctive characteristics of basalts [5]. The long flow distances (up to $6000km^2$) over low gradients combined with the large areal extent of these flows (1000 to $4000km^2$) indicate a low-viscosity lava; paradoxically, the steep flow fronts, ridge dimensions and analytical models suggest a high-viscosity lava [6]. Recent experiments with molten carbowax [7] indicate that ridge creation is favored if the flow rate is "sufficiently slow" and the ambient temperature is "sufficiently low." Therefore, forming a thick chilled crust on the martian lavas may impart a high-viscosity appearance to a low-viscosity flow. A low-viscosity lava can form steep, thick flow fronts if the flow cools quickly enough. Icelandic table mountains, for example, are basalts that erupted subglacially, producing steep-sided, flat-topped mountains ([8], [9]). The slopes of the steeper terrestrial table mountains are approximately 32° [8]. For comparison, we derive flow front slopes of about 36° for the martian lavas (see Fig. 1a.), in contrast to the thickest lunar flows which have flow front slopes of about 14°.

Apparent High Viscosity from Low Viscosity Flows: The high-viscosity appearance of the martian flows might be produced by quickly and efficiently cooling the surface of a low-viscosity flow. Rapid cooling of the flow surface could be achieved by emplacing the flow under a material with high heat capacity and high thermal diffusivity This would create a thick chilled crust and, by exerting a downward force, could increase the drag component on the surface; both conditions enhance ridge formation. Many of the observed flows are surrounded by easily eroded deposits and the surfaces of some flows exhibit heavily eroded impact craters indicating differential removal of a friable surface deposit at least 300m thick. Models of the rate of cooling of terrestrial lava flows [7] permit calculating the thermal diffusivity of the boundary environment for the martian flows. Using this model and the parameters in Table 1, and then solving for the thermal diffusivity yields a value that is a hundred times too high for air, water or ice and is a hundred times too low for most rock. An ice-rich dust may produce the appropriate thermal diffusivity.

Preliminary experimental results suggest that overburden pressure on the lava flow may play an important role in creating the observed textures. By simulating lava flows with molten carbowax, we have found that efficient cooling alone is not enough to produce the large-scale ridge texture and the steep flow fronts at this scale. To determine the first-order trends of ridge formation, we have emplaced the molten wax in varying conditions such as: subaeral with ambient temperatures varying from -2° to 20° C; under water varying from 0° to 25° C; under powdered dry ice, snow and foam to simulate a material with high heat capacity but low thermal diffusivity. Cooling the wax flows with dry ice or 0°C air is not as efficient at producing large ridges and steep flow fronts as is cooling the flows with ice water - even though the thickness of the chilled margin is roughly the same in all cases.

Conclusion: The observed martian flows have large areal extents and flow lengths, indicating a fluid basalt; the same flows paradoxically have steep flow fronts and a long ridge wavelength, indicating a highly viscous (almost rhyolitic) lava. A low-viscosity basalt may resemble a high-viscosity lava if the flow cools quickly and efficiently enough to produce a thick surface crust, and if thereby exerting drag force on the crust once formed. Preliminary experimental results suggest that overburden pressures also may be important to ridge formation. If emplaced under a mantle of ice-rich dust, then the martian flows could have cooled quickly and have been sujected to sufficient overburdon pressure

References: [1] Theilig and Greeley (1986) *Proc. LPSC XVII*. [2] Fink (1980) *Geology*, **8**. [3] Fink and Fletcher (1978) *Jour. of Volc. and Geotherm. Res.*, **4**. [4] *Basaltic Volcanism Study Project* (1981). [5] Greeley (1980)

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Parameter	Number of Samples	Avg. Value
Ridge spacing	1840	175.5m
Ridge height	8	13.9m
Flow thickness	16	62.5m
Flow front slope	8	36°

Table 1. Parameters obtained using high-resolution VO photographs.

Model	Viscosity in Pa•s	
	Interior	Exterior
Fink and Fletcher (1978)	$5.4 * 10^4 - 8.7 * 10^6$	$3.4 * 10^5 - 5.5 * 10^8$
Fink (1980)	$1.5 * 10^6 - 2.3 * 10^8$	$9.7 * 10^6 - 1.5 * 10^9$
Theilig and Greeley (1986)	$1.4 * 10^7 - 2.3 * 10^9$	$1.5 * 10^8 - 2.5 * 10^{10}$

Table 2. Viscosities obtained from the parameters in Table 1 and the models in [1], [2] and [3].

1a. 1b.

Figures 1a. and b. Fig. 1a is a mosaic of 731A03 and 731A04; INA = 75.4°. Note relief and spacing of ridges and steep flow fronts. Fig. 1b. is a portion of 387B13; INA = 72.0°. Here, note flow fronts with less abrupt termini and absence of texture. Scale bar is 10 km for both figures.