GEOMORPHOLOGY OF FLUVIOGLACIAL FEATURES IN THE MARTIAN SOUTHERN MIDLATITUDES, NORTHEASTERN NOACHIS TERRA. D. E. J. Hobley[1], A. D. Howard[1], and J. M. Moore[2] [1]University of Virginia (Dept. of Environmental Sciences, Clark Hall, 291 McCormick Rd., Charlottesville, VA 22904; email: dan.hobley@virginia.edu), [2]NASA Ames Research Center (MS 245-3, Moffett Field, CA 94035).

Introduction: The martian midlatitudes (30-50°N/S) are the location of many post-Noachian to recent surface features thought to be mediated by ice or snow, e.g., gullies [1], lobate crater ejecta [2], LDAs [3], VFFs [4], and recurring slope lineae [5]. Throughout these latitudes are also found valley networks, termed midlatitude valleys (MLVs), which date to the post-Noachian [e.g., 6, 7]. These have also been variously hypothesized to result from ice and snow melt, but through poorly constrained mechanisms. This study looks at the quantitative geomorphology and distribution of channels around an area of southern Noachis Terra to better constrain the formation processes of the dense network of local MLVs.

Our study focuses on a 320x560 km area centered on 41.0°S 13.7°E, W and SW of Le Verrier Crater, in NE Noachis Terra. The area was selected due to remarkable density of MLVs visible in CTX, as well as availability of a local HRSC DTM. A small subset of features in this area have already been described by Fassett and colleagues as supraglacial and proglacial features, and Amazonian ages attributed to them [6]. The area also contains abundant VFFs at higher elevations inside crater rims (and less abundantly immediately outside the rims) and a number of large lobate flows on the larger crater floors. Local depressions in the area are often filled with a stipple-textured material reminiscent of ice-rich material [8]. Gullies [1] are not seen anywhere in the mapped area.

Channel Form: MLVs are defined as shallowly incised, narrow (<500 m) "fresh" valleys, with minimum degradation of their sidewalls and often sharp upper edges. This freshness indicates that almost by definition MLVs are post-Noachian structures. Two MLV end member types are found in the area: *Mode 1*. (Fig. 1A-C) Very narrow-floored, V- to slightly U-shaped, sharp-edged, sinuous valleys. Valley width is typically <50 m. Branching is uncommon. They start and end abruptly, or occasionally join mode 2 MLVs. *Mode 2*. (Fig. 1A) Rarer, wider valleys with distinct nearly flat floors. Margins are parallel and channels have low sinuosity. Floors may show faint longitudinal lineations interpreted as fluvial bars or low banks [7]. Both modes commonly form apparent chains across and between local highs in the landscape, though with no connections visible across the intervening lows. Modes may change along the chain. The longest chains exceed 12 km total length. Considering all MLVs seen, mean segment length is 660 m, though with frequent longer segments, up to a maximum of 6.9 km.

Rarely, mode 1 MLVs transition downslope into ridges, then into raised, irregularly pitted and cracked elongate mounds (Fig. 1C) [c.f., 6]. The whole sequence is seen only three times across the mapped area, though isolated mounds (rarely with associated ridges, but no MLV) are seen a further 60 times. These mounds are most commonly found in crater bottoms, immediately inside the lowest ring of VFFs.

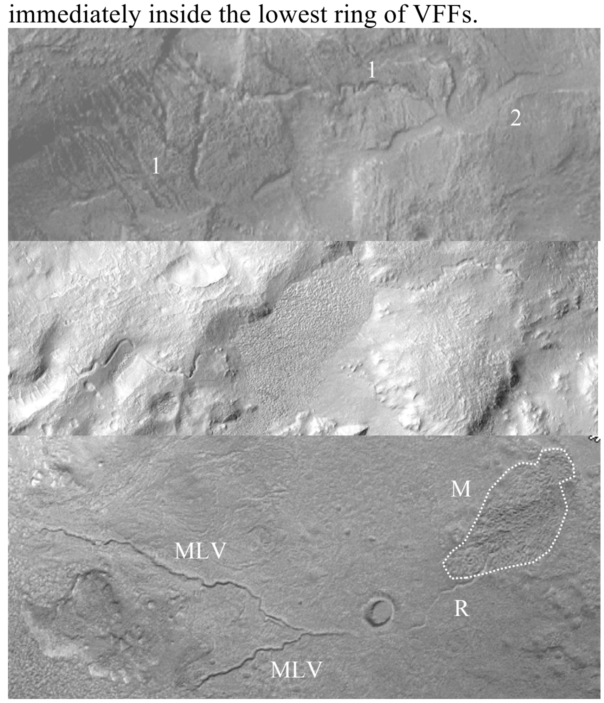

Fig. 1. A. Network of mode 1 MLVs meeting a mode 2. Seen on inner crater wall, dips c. 12° SE. FoV 4 km across. B. Chain of mode 1 MLVs crossing low gradient, hilly crater ejecta. FoV 7 km across. C. Rare mode 1 *MLV–R*idge–*M*ound sequence running S down crater wall dipping 5° to mound on crater floor (N is left). FoV 5 km across.

Channel Distribution: We have systematically mapped 761 distinct channel segments across 66,000 km^2 of CTX imagery (501 km total length) within the study area. The segments are unevenly distributed across the landscape. They are most strongly concentrated inside and around an 80 km terraced late Hesperian [6] crater to the west of center of the mapped area. However, significant concentrations also exist inside the most proximal walls of neighbouring rimless, older craters, and also in a second 70 km crater of similar morphology 130 km away to the SSE. Lower densities also appear around craters and occasionally on inter-crater plains at the far eastern end.

Very rarely, channels are spatially associated with the VFFs and lobate flows [c.f., 6]. Channels are found either immediately outside or inside the ridged and ruckled margins of these features, orientated parallel to VFF flow (i.e., regionally downslope). However, most channels are not associated with extant glacial features. Channels are not restricted to the ejecta blankets, or to any one terrain type. They are never found on the stippled material.

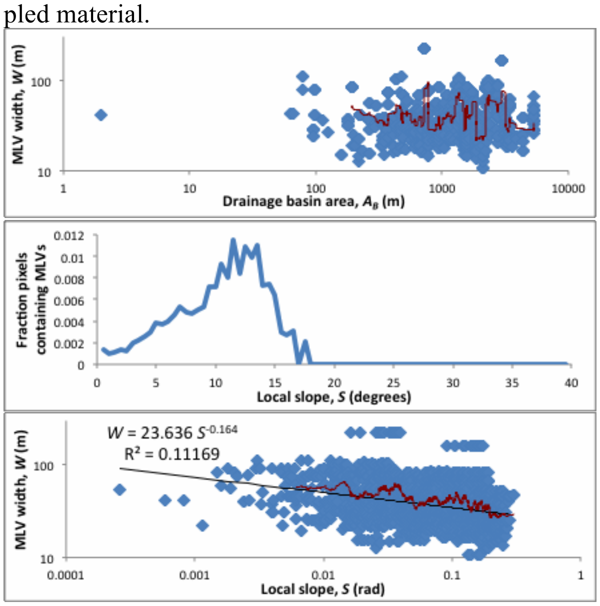

Fig. 2A-C. Quantification of MLV scaling and distribution. In A and C, red lines are moving averages through data clouds.

Channel Analysis: We have overlayed the mapped channels onto the HRSC DTM to examine distribution and width scaling. Topographic flowpaths were extracted within the closed basins across the landscape; some the longer MLVs run close to derived drainage pathways, but do not perfectly coinceide. However, many others do not mimic the drainage pattens, and frequently chains and segments of MLVs cross the divides between basins. We also examine local channel relationship to drainage area by plotting MLV valley width, W (n=3741) against the enclosing drainage basin area, A_B (Fig. 2A) (as channels do not perfectly coincide with the extracted drainage, simple extraction of underlying drainage accumulation is not viable). No relation between width and contributing area is observed. However, channels are affected by local slope, S. If we contrast the slopes of pixels containing channels with the slope distribution across the whole landscape (Fig. 2B), we see a strong preference for slopes 11-14°. MLVs do not appear on slopes >18°, and are progressively less common but still present on slopes <11°. Similarly, we may examine the relation of valley width to local slope (Fig. 2C). We find weak but robust correlation, $W \sim S^{-0.164}$. We note that on Earth, it has been suggested based on channel bed roughness scaling that $W_{channel} \sim S^{-0.188}$ [9].

Interpretation: Significant numbers of these channels are seen to cross drainage divides, i.e., flow uphill must occur. This demands that the flow through the channels is subject to pressurization, and thus isolated from the atmosphere (this also would increase vapour phase partial pressure and help stabilize liquid water). Whatever this cap may have been, it is clearly no longer present; a cap of ice is the most parsimonious solution, i.e., these are tunnel valleys. To produce the required hydrostatic pressures, this ice cover must extend across significant areas of this landscape, not just form a shell over each channel. The lack of MLV width response to basin drainage area (Fig. 2A) also fits this interpretation, since discharge through each channel should not correspond to the local subaerial drainage area. The channel patterns seen are also qualitatively consistent with terrestrial sub-glacial flow patterns – channels sometimes run across the noses of spurs, cut more deeply into local highs, and run parallel to but displaced away from the lows of saddles (e.g., Fig. 1). However, we do not envision thick (>>100m), uniform ice cover, for several reasons: 1. This landscape has not been carved by wet-based flowing ice; lower thicknesses will suppress glacial motion. 2. Channel widths and distribution do respond to local slope on the meso-scale (Figs. 2B,C); this means that the ice surface slopes (which are around 10 times as important as bed slopes in controlling flow) must still reflect the underlying topography. 3. The mounds (Fig. 1C) are commonly found in lines, in plausible ice-marginal positions, and can be interpreted as sediment-rich aufeis (we thus interpret the associated ridges as eskers, deposited as water pressure falls towards the ice margins). It is possible a subset of these features are not formed under ice, but rather over or proximal to ice [c.f., 6]. However, we consider that considered as a set, our interpretation is more parsimonious.

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