LVF/LDA STRATIGRAPHY IN NILONSYRTIS MENSAE, MARS: EVIDENCE FOR MULTI-STAGE GLACIAL ACTIVITY. J. L. Levy1, J. W. Head1, D. Marchant2 Brown University, 324 Brook Street, Providence, RI, 02906. joseph_levy@brown.edu 2Boston University, 675 Commonwealth Ave. Boston, MA, 02215

Introduction to LVF/LDA: In order to more completely understand the geological history of the martian dichotomy boundary, it is essential to first understand the erosional and modification processes which have acted on the boundary, producing the present topography and features [1-6]. Lineated valley fill (LVF) and lobate debris aprons (LDA) are some of the most common modification features present on the dichotomy boundary. Recent analyses of LVF in northern Arabia Terra [3, 7] show local sources for LVF in valley-wall alcoves, down-valley flow, merging of flow into trunk valleys, and terminal valley lobate-shaped deposits; these features are similar to terrestrial valley glacier systems [8, 9]. Likewise, analyses of LDA features indicate flow of ice and rocky debris material with interstitial pore ice in a manner analogous with terrestrial debris-covered glaciers and rock glaciers [10-12].

Among dichotomy boundary fretted terrain outcrops, the Nilonysrtis Mensae region is distinctive, as it provides evidence of overprinting of ancient landscapes by a suite of glacial features, providing a composite view of the variety of glacial modification processes which can occur during martian ice ages. We interpret stratigraphic, topographic, and textural relationships between lineated valley fill (LVF) and lobate debris apron (LDA) morphological units in the Nilonysrtis Mensae region of the martian dichotomy boundary as evidence of multiple stages of glacial overprinting during the recent Amazonian. We document regional integration and flow of LVF material as well as LVF degradation. We document stratigraphic relationships between LVF units, LDA, and high-relief lobate features. These are the first observations which suggest multiple episodes of mid-latitude valley glacier overprinting. These observations are consistent with surface units in northern Arabia Terra interpreted as glacially modified landforms, suggesting the possibility of glacial deposits extending over ~70° of longitude within the past hundreds of millions of years.

Above-Derived, Regional LVF (R-LVF): R-LVF is present in many of the Nilonysrtis Mensae valleys and is commonly lineated along the axis of the valley (Fig. 1, 2). Some cross-valley lineations are present, commonly as part of a lobate lineation structure [14]. Tracing lineations in MOC images, most R-LVF is sourced in valley-head alcoves at a variety of elevations, where it embays the lower valley wall slopes. The R-LVF has a pit-and-butte surface texture, suggesting modification of the surface by sublimation subsequent to flow, which is consistent with a lack of significantly deformed craters on the R-LVF surface [10, 14]. At locations where the R-LVF abuts smooth, topographically lower terrain, which has been interpreted as deflated R-LVF (LVF residue) [15], thickness measurements using MOLA point data yield a minimum thickness of ~50 m. If the smoothed, lower terrain represents partially dessicated R-LVF, it is possible that preserved R-LVF is considerably thicker, depending on ice content and porosity. R-LVF is locally integrated, with several R-LVF lineation systems showing indications of confluence of flow, folding, and ultimate stagnation and sublimation in local topographic minima.

Valley-Wall LDA: Lobate debris-aprons (LDA) form along valley walls in the Nilonysrtis Mensae study area. Valley wall LDA lie stratigraphically above the R-LVF (Fig. 1). LDAs are present along valley walls and alcove walls, overlying R-LVF, with a sharp contact commonly visible between the two units. The LDA has a pit-and-butte texture similar to the R-LVF, however, LDA lineations are commonly parallel to the surface strike, rather than parallel to surface dip (as in the case with most LVF) [10]. The transition from R-LVF to LDA along MOLA point profiles is marked by a rapid increase in thickness and slope, from the relatively gentle (~1-1.5°) slopes of the R-LVF to strongly convex-up LDA slopes (up to ~5°).

Superposed LVF (S-LVF): In some locations (Fig. 2), axially-lineated and lobate features are present in small (10s-100s of meters wide and commonly less than 1-2 km) valleys which debouch into larger Nilonysrtis Mensae region valleys. These features commonly overlie R-LVF or patchy material interpreted as R-LVF sublimation residue present in the larger trunk valleys. These lobate features are commonly strongly positive in relief, and support relatively steep marginal slopes. Broader lobes of lower-relief superposed S-LVF have similar topographic profiles to valley floor R-LVF, but are interpreted as overlying R-LVF and R-LVF residue (Fig. 2). The lobes enter larger valleys, and expand over the valley floor, strongly suggesting flow. The superposed and high-relief features are never integrated into a larger R-LVF system.

Stratigraphic Interpretations: We interpret the stratigraphic relationships between the Nilonysrtis R-LVF, S-LVF, and LDA—the presence of LDA along valley walls and in valley-head alcoves; the sharp contact, suggesting over-riding of valley floor LVF by LDA; the enhanced relief of the LDA compared to the largely flat and low-angle R-LVF; and the over-printing of R-LVF by S-LVF—as evidence of multiple periods of glacial activity in the Nilonysrtis Mensae region. If the stratigraphic relationship between LDA and R-LVF is actually conformable, the abrupt changes in morphology still strongly suggest multiple periods of activity, suggesting several
phases of glacial modification of the Nilosyrtis Men-sae region of the dichotomy boundary within the past ~100 My. These relationships and interpretations are consistent with recent GCMs that predict regional northern mid-latitude glaciation in the Amazonian [16].


Figure 1. (Above) Valley-wall LDA in contact with R-LVF. (Below) Sketch map detailing the sharp contact between R-LVF and LDA. M denotes mesas.

Figure 2. (Top) MOLA point profile down a steep, convex-up S-LVF lobe onto flat-lying R-LVF surface. (Middle) MOC image of S-LVF in contact with R-LVF. Note expanding S-LVF lobe-front and valley-axial R-LVF lineations. (Bottom) Sketch map detailing contact between S-LVF and R-LVF. Note concentric, expanding S-LVF lineations cross-cutting valley-axial R-LVF lineations.