DO BOULDER DISTRIBUTIONS ON LOBATE DEBRIS APRONS INDICATE REGIONAL-TO-GLOBAL SYNCHRONICITY IN GLACIAL FLOW RATES?: SEDIMENT COVER PATTERNS RESULTING FROM MARTIAN GLACIATION. J. S. Levy, C. I. Fassett, M. Tebolt. Colgate University, 13 Oak Ave., Hamilton, NY, jlevy@colgate.edu, NASA Marshall Space Flight Center, Huntsville, AL.

Introduction: Landforms including lineated valley fill (LVF), lobate debris aprons (LDA), and concentric crater fill (CCF) are the dominant debris-covered glacial landforms on Mars, covering ~7 x 10^11 km^2 of the martian surface between ±30-50° latitude [1], representing a global water-equivalent layer 0.9-2.6 m thick [1,2]. These landforms represent an important component of the Amazonian [3] water ice budget, however, because small craters (diameter D≤ 0.5-1 km) are poorly retained on the surface of CCF, LDA, and LVF, and, since the glacial landforms are geologically young, it is challenging to reliably constrain individual ages in order to determine how quickly the glaciers accumulated [15]. Modeling investigations of ice flow under martian conditions suggest that LDA could accumulate and flow to their full extent in as little as ~500 kyr [4] or could require over 100 Myr [5]. A fundamental question for individual glaciers is whether ice deposition and flow occurred episodically during a few, short instances, or whether glacial flow was quasi-continuous over a long period. Because glaciation is thought to be controlled largely by obliquity excursions [6,7], a larger question is whether glacial deposits on Mars exhibit regional to global characteristics that can be used to infer synchronicity of flow or degradation.

Because rocks exposed on Mars' surface are known to breakdown and weather to a finer grained regolith, we hypothesize that observable boulder size may decrease as a function of position down-glacier, with age increasing with distance between the accumulation zone and the glacier, with age increasing with distance between the accumulation zone and the glacier. Boulder breakdown thus could act as a “ticker tape” advancing out of the accumulation zone such that boulder population on the debris surface is sensitive to the episodicity and intensity of glaciation as a function of time. Alternatively, if the boulder breakdown timescale is long compared to glacial flow rates, or if boulders are mostly entrained englacially, no such signal may be observed.

Methods: We mapped boulder size-frequency distribution over 16 LDA and CCF landforms. Boulders were mapped manually on 25 cm/px HiRISE images along a flow-line determined through observations of CTX and HiRISE stereo DEMs generated for each site using ASP [8-10]. Boulder measurement sites are widely distributed over the martian surface, and include examples in Protonilus/Deuteronilus, eastern Hellas, and Mareotis Fossae.

Results & Discussion: Boulder size is more strongly correlated with density than with distance down glacier (Fig. 1). Boulder size, both median and 95th percentile (in 50 m distance bins) are consistently variable, with large clasts appearing not only at the upper end of the glacial landform.

Intriguingly, the most notable signal observed between sites is the persistence of ~1-5 concentrations or “bands” of boulders, which are apparent in plots of boulder distribution with distance down-glacier (Fig. 2). The presence of zones of dense boulder cover banding in lobate debris aprons separated by thousands of km suggests the possibility that these LDA are recording a regional or larger-scale climate signal associated with...
ice deposition and flow and/or geological weathering rates. Such bands of dense clast cover could emerge from periods of slow ice flow (little accumulation), or periods of rapid erosion.

One intriguing implication of the absence of a monotonic boulder size reduction with distance down-glacier is that it suggests that englacial flow of debris [11] may be responsible for transporting large clasts through the glacier with minimal weathering or comminution. Although internal radar reflectors are not directly observed in LDA [12], the emergence of large, uncommminated clasts near the base of the glaciers is consistent with a sublimation lag origin for at least part of the debris layers, rather than continuous conveyor-style movement of rocky lag downslope from headwall mass wasting. If concentrated boulder bands are associated with englacial debris bands intersecting the surface of the glacier, they may reflect accumulation of debris during periods of reduced ice accumulation [13,14], providing a regional link between glaciation and obliquity.

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Fig. 2. Down-glacier profiles of boulder location (x-axis) and distance from the profile centerline (y-axis) for 15 LDA and/or CCF sites across martian mid-latitudes. Boulder “bands” are present at all locations, and commonly are present at or near similar length-scaled locations along the profile (i.e., LDA are of variable length, but have been placed on a common scale to permit site-to-site comparison). Gray eye-guides have been added to each column of plots, and should not be interpreted to reflect precise band locations. Rather, they highlight that even arbitrarily grouped boulder profiles share notable similarities in the spacing of boulder concentrations.

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