TESTING THE REGIONAL ICE-SHEET COLLAPSE MODEL: EVIDENCE OF GLACIAL MODIFICATION OF PLAINS UNITS IN DEUTERONILUS MENSAE, MARS. David M. H. Baker and James W. Head; Dept. of Earth, Environmental and Planetary Sciences, Brown University, Box 1846, Providence, RI 02912; (david_baker@brown.edu).

Introduction: Lobate debris aprons (LDA) (Fig. 1) surround steep escarpments such as the walls of isolated plateaus and massifs in the northern and southern mid-latitudes (~30° to 50°) on Mars and are Middle to Late Amazonian in age [1]. Much evidence supports the formation of these features by flow of ice and debris in a manner similar to glacial systems on Earth [1-9]. Additional evidence has suggested that this glaciation may have been more extensive in the past [10-11] and recent modeling [12] supports the hypothesis that LDA are the preserved, debris-covered remnants of the retreat and down-wasting of a much more regional ice sheet.

To test the regional ice-sheet collapse model, we investigated the morphology and topography of plains units distal to LDA in Deuteronilus Mensae (39.6°N to 50.2°N and 13.6°E to 35.4°E) [see also, 13] using image data from the Mars Reconnaissance Orbiter (MRO) Context (CTX) camera at ~6 m/pixel resolution and topographic data from High Resolution Stereo Camera (HRSC) digital terrain models (DTMs). We find evidence of a unique plains unit ("Upper plains unit") at the distal areas of LDA that exhibits characteristics indicative of a former glacial extent.

Regional Ice-Sheet Model Predictions: Model results [12] show that LDA could not have historically attained temperatures near or above the ice melting point and retained their current shape. As a result, geomorphic evidence of former glacial maxima is most likely to resemble cold-based glacial landsystems and not wet-based landsystems such as those associated with many temperate glaciers on Earth. Glacial retreat and down-wasting will therefore be largely driven by sublimation of ice. On Earth, cold-based glaciation can produce a number of geomorphic features, including drop moraines, lateral moraines, sublimation tills, and lateral melt-water channels [14]. Other unique landforms can be produced from the retreat and deposition of glacial sediments over down-wasting, buried glacial ice. Such landforms include controlled and hummocky moraines, with the details of moraine topography being largely related to the spatial pattern, distribution, and concentration of englacial and supraglacial debris concentrations over stagnant glacial ice at the glacier's terminus [15].

Plains Units Morphology and Stratigraphy: An Upper plains unit (Upl) covers much of the intermediate areas between plateaus and surrounding LDA north of ~43°N in Deuteronilus Mensae (Fig. 1). The unit is relatively smooth at Viking and CTX image resolution but is pockmarked with numerous muted impact craters and depressions formed by surficial collapse. Irregular fractures <20 m in width and isolated elongate pits with raised rims are also observed in Upl. Some fractures widen and form concentric and radial patterns, appearing to be controlled by the underlying terrain (Fig. 1). Topographic measurements of Upl indicate a unit thickness of approximately 100 m.

The stratigraphic relationship between Upl and LDA is complex. Within proximity to LDA, surface fractures and elongated pits within Upl widen and link to form large, irregular troughs with raised rim (Fig. 1). The troughs are most prominent and form parallel to complex spatial patterns where multiple LDA meet. Toward the LDA terminus, the troughs within Upl further widen and lose their raised rims. Widening of the troughs suggests removal of material from Upl, possibly fines or volatile-rich material. This progression produces isolated patches or platforms of Upl that can appear raised above the surrounding LDA surface or seamlessly grade texturally and topographically with the dominant LDA surface textures (Fig. 1). Large-scale (kilometers long) collapse-like depressions within Upl are also observed near the distal margins of LDA (Fig. 1).

The Upl and LDA are superposed on an older Lower plains unit (Lpl), which exhibits a variety of textures and albedos with erosional remnants of older terrain. The contact between LDA and Lpl is generally sharp, with the steep convex-upward topography of the LDA termini abruptly transitioning to the flatter Lpl at lower elevations. The contact between Upl and Lpl is similarly sharp; the margins of Upl also have convex-upward profiles transitioning to a flatter Lpl.

Unit Ages: Crater size-frequency distributions on Upl using CTX images and all craters >100 m in diameter yield a best-fit age of ~520 Ma (Middle Amazonian, Hartmann [16] isochron). For comparison, a best-fit age of ~470 Ma was determined for nearby LDA, although with a less well-defined isochron that reflects removal of small crater sizes and effects of impacts into ice-rich substrates [17].

Models of Formation: The similarity in crater retention ages between LDA and Upl and the complex, often gradual transition from LDA to Upl point toward a link in the processes that formed or modified these two units. Based on the age similarity and observed geomorphic characteristics, including evidence of sublimation textures and collapse features, we interpret the occurrence of Upl to be glacially modified sediments with contributions from deformation by glacio-tectonic stresses under cold-based conditions [14]. The large spatial extent and relatively smooth texture of Upl suggests that the sediment comprising this unit is unlikely to have originated from erosion of the plateaus alone and that other sediment supply mechanisms such as regional dust and tephra deposition was likely important during glaciation. Collapse features within Upl are interpreted to result from the sublimation of subsurface ice, possibly related to stagnant ice remaining from the retreat of a much larger glacial extent. The mapped restriction of troughs in Upl to areas with steep surface gradients proximal to LDA (Fig. 1) suggests that differential ice flow may also be important in forming the unique surface textures in Upl. Further, traditional wet-based glacial depositional and erosional landsystems [14] are not observed in the plains surrounding LDA, consistent with a history of cold-based glaciation in the region.

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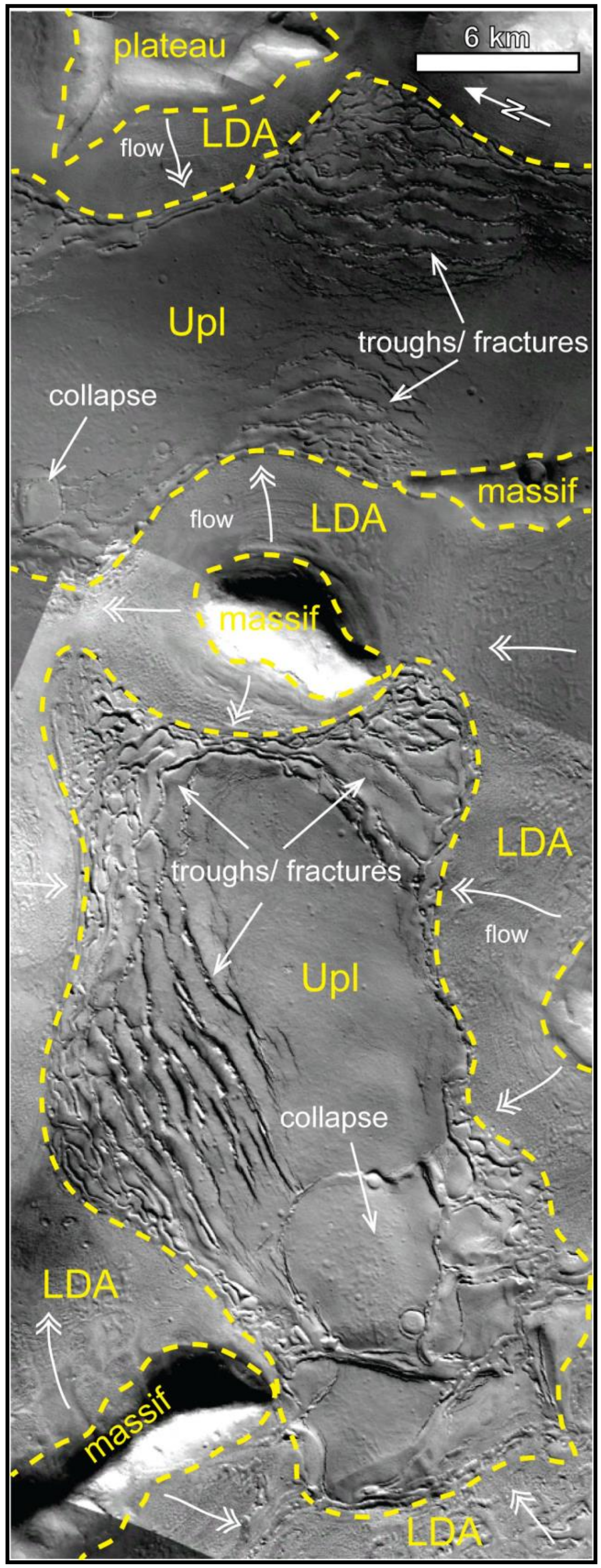

Fig. 1. Morphology and relationship between lobate debris aprons (LDA) and the Upper plains unit (Upl) in Deuteronilus Mensae. Interpreted paleo-flow directions of LDA are indicated with double arrows. Within proximity to LDA, brittle fractures in Upl widen to form troughs with raised rims toward the LDA terminus. Troughs are most prominent near the convergence of multiple LDA. Further widening of the troughs produces isolated patches of Upl. Kilometer-scale collapse features, possibly related to sublimation of subsurface ice, are also observed within Upl. The image is a mosaic of multiple CTX images and is centered at approximately 44.01°N, 25.40°E.