

**PLAINS AND TRANSITIONAL TEXTURES ADJACENT TO LOBATE DEBRIS APRONS IN DEUTERONILUS MENSAE, MARS.** D. M. H. Baker<sup>1</sup>, J. W. Head<sup>1</sup>, and D. R. Marchant<sup>2</sup>; <sup>1</sup>Dept. Geological Sci., Brown Univ., Box 1846, Providence, RI 02912; <sup>2</sup>Dept. Earth Sci., Boston Univ., Boston, MA 02215 (david\_baker@brown.edu).

**Introduction:** Among the youngest features and modifiers of the dichotomy boundary on Mars are lobate debris aprons (LDA) (Fig. 1), which completely surround escarpment walls such as isolated plateaus and massifs in both the northern and southern mid-latitudes (~30° to 50°) of Mars [1]. LDA have been interpreted to result from the viscous flow of ice and debris [1,2,3], with recent evidence pointing toward a major role for Late Amazonian-aged debris-covered glacier flow [4]. Under the debris-covered glacier model, precipitated snow and ice likely accumulated on the tops of plateaus and in alcoves within the walls of plateaus during periods of higher obliquity [5]; compaction of this snow and ice produced glaciers that flowed away from the plateau and escarpment walls and into the surrounding plains to form integrated glacial systems extending for 10s of kilometers. The presently observed LDA are likely the stagnant remains of a once active glacial system, with ice protected under a <20-m-thick layer of sublimation till [6,7]. Outstanding questions involving the nature of LDA and mid-latitude glaciation remain, including: 1) What are the characteristics of the transition from LDA to adjacent plains? and 2) Is there evidence for former glacial maxima? We explored these questions by analyzing LDA and adjacent plains in Deuteronilus Mensae (39.6°N to 50.2°N and 13.6°E to 35.4°E) using image data from the Mars Reconnaissance Orbiter Context (CTX) camera at ~6 m/pixel resolution.

**Observations:**

*Plains units:* We identified two prominent plains units east of ~23.5°E in Deuteronilus Mensae. The first, an *Upper plains unit (Upl)*, covers much of the intermediate areas between plateaus and surrounding LDA north of ~43°N. The unit is relatively smooth at Viking resolution but is pockmarked at CTX resolution, with numerous muted, rimless, circular pits that resemble buried impact craters. Irregular fractures <20 m in width and isolated elongate pits with raised rims are also observed on much of the unit's surface. Where *Upl* is within proximity of LDA, surface fractures and elongated pits widen and link to form large grooves and sinuous pits that are <500 m in width and extend for 10s of kilometers (Fig. 1). Fracture patterns within *Upl* appear to be controlled by underlying structures, originating as *Upl* undergoes collapse. Collapse often occurs over buried craters, forming concentric ring fracture patterns and interior topographic depressions (Fig. 3a). Some of these collapse features (Fig. 3a) resemble ring-mold craters [6] which are unique to surfaces with ice-rich layers at depth such as LDA.

Underlying *Upl* is a *Lower plains unit (Lpl)* that covers the majority of the plains not overlain by *Upl*.

The unit exhibits multiple textures and albedos, but generally has rougher small- and large- scale textures than *Upl* with a greater number of knobs and erosional remnants of older terrain. Craters in *Lpl* are less subdued with raised-rimmed craters lacking ejecta and craters with ejecta that form platforms raised above the surrounding terrain. These raised crater ejecta are suggestive that material has been stripped away from *Lpl* and that the ejecta has created a more resistant substrate surrounding the crater or may be preventing sublimation from an otherwise unstable ice-cemented material at depth [e.g., 8]. Rounded, raised-rim craters lacking ejecta also commonly have interior mounds or remnant blocks of interior fill (Fig. 3b)

*Transition from LDA to plains units:* The transition from LDA to the plains units varies depending on the type of plains unit in contact with LDA. Where *Upl* contacts LDA, the transition is marked by a number of grooves [9] or sinuous pits within *Upl* that grade into LDA textures. The sinuous pits often mimic LDA planform shapes (Fig. 1a), suggesting that either stresses from LDA flow have induced fracturing of *Upl* or that fracturing of *Upl* is being controlled by underlying LDA-like structure. Sinuous pits and grooves with raised rims appear to form as collapse of *Upl* produces extensional stresses and fracturing along the edge of the collapsed area (Fig. 3a). Within several kilometers of the LDA terminus, the sinuous pits and grooves widen and lose their raised rims; this progression produces a topographic inversion, where the intermediate collapse areas become platforms that are raised above the surrounding LDA surface (Fig. 4). Platforms also take circular shapes with concentric patterns (Fig. 4, arrow) resembling “oyster-shell” craters described by [10]. Collapsed areas and platforms and widened pits often have LDA-like stippled textures that seamlessly grade texturally and topographically with the dominant LDA surface textures (Fig. 4). A topographic profile of the contact between LDA and *Upl* (Fig. 1b) suggests that *Upl* is stratigraphically above the LDA surface; raised scarps within *Upl* are common along the contact with LDA (Fig. 1a, b), indicating unit thicknesses of up to 75 m.

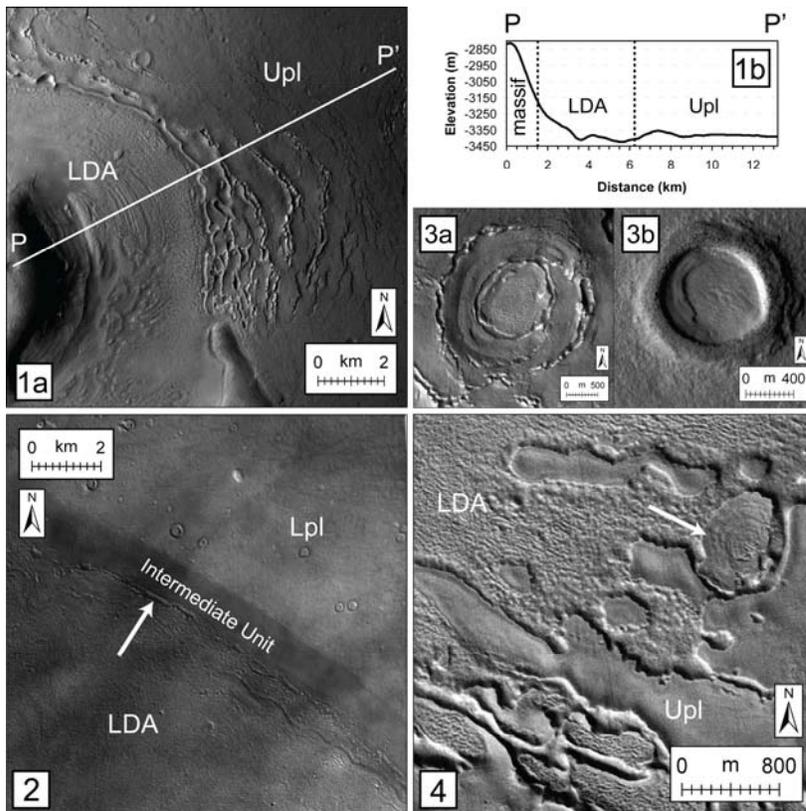
In contrast, contacts between *Lpl* and LDA are generally abrupt (Fig. 2), lacking the sinuous pit and groove texture typical of contacts between LDA and *Upl*. LDA often have arcuate elongate pits that contour the terminus of the LDA surface (Fig. 2, arrow). A smooth, low albedo intermediate unit between LDA and *Lpl* is also common (Fig. 2).

**Evidence for former glacial maxima and directions for further study:**

Where *Upl* occurs in Deuteronilus Mensae, it masks a significant portion of the underlying plains,

likely making it difficult to recognize depositional and erosional landforms of former glacial maxima that are typical for glacial landystems [11]. The presence of fractures in *Upl* that mimic the planform shapes of LDA and which form ring-mold crater-like patterns [6], however, suggest that LDA surrounded by *Upl* may be at least several kilometers more extensive than implied by the present termini of LDA surface textures. Additional analysis of the spatial extent and age of the *Upper plains unit* will help to improve characterization of the unit's origin and relationship with apparently young features such as LDA. Also, further analyses of the plains surrounding LDA throughout the northern mid-latitudes on Mars will help to place the present analysis in context and to improve understanding of the nature and full extent of northern mid-latitude glacial episodes on Mars.

**References:** [1] Squyres, S.W. (1979) *J. Geophys. Res.*, 84, 8087-8096. [2] Squyres, S.W. (1978) *Icarus*, 34, 600-613. [3] Lucchitta, B.K. (1984) *J. Geophys. Res.*, 89, 409-418. [4] Head, J.W., Marchant, D.R., Dickson, J.L., Kress, A.M., Baker, D.M. (2009) *Earth Planet. Sci. Lett.*, in press doi:10.1016/j.epsl.2009.06.041. [5] Madeleine, J.-B., Forget, F., Head, J.W., Levrard, B., Montmessin, F., Millour, E., (2009) *Icarus*, in press, doi:10.1016/j.icarus.2009.04.037. [6] Kress, A.M., Head, J.W. (2008) *Geophys. Res. Lett.*, 35(23), L23206, doi:10.1029/2008GL035501. [7] Plaut, J.J., Safaenili, A., Holt, J.W., Phillips, R.J., Head, J.W., Seu, R., Putzig, N.E., Frigeri, A. (2009) *Geophys. Res. Lett.*, 36, L02203, doi:10.1029/2008GL036379. [8] Kadish, S.J., Head, J.W., Barlow, N.G., and Marchant, D.R., (2008) *Geophys. Res. Lett.*, 35, L16104, doi:10.1029/2008GL034990. [9] McGill, G.E. (2002) USGS Misc. Geologic Invest. Series, Map I-2746. [10] Mangold, N. (2003) *J. Geophys. Res.*, 108, 8021, doi:10.1029/2002JE001885. [11] Evans, D.J.A. (ed.) (2003) *Glacial Landystems*, Edward Arnold, London, 532 pp.



**Fig. 1.** (A) Transition from LDA to the *Upper Plains unit (Upl)*. The transition is marked by sinuous pits within *Upl* that parallel the planform shape of LDA. (CTX image P20\_008665\_2239.) (B) Topographic profile across the line of transect in Fig. 1A. *Upl* begins as a scarp raised ~75 m above the LDA surface and continues outward from the LDA at fairly constant elevation. (Elevation data from HRSC DTM 1450.)

**Fig. 2.** Transition from LDA to the *Lower plains unit (Lpl)*. The contact is abrupt, lacking the sinuous pits typical of contacts with *Upl*. An elongate pit (arrow) contours the terminus of the LDA. A low albedo intermediate unit is also commonly observed. (CTX image P13\_006160\_2252.)

**Fig. 3.** (A) Collapse feature in *Upl* formed of concentric fracture patterns and interior depressions; the pattern resembles ring-mold craters which are common on LDA surfaces. (CTX image P13\_006160\_2252.) (B) Typical crater in *Lpl*. The crater lacks ejecta, has a rounded rim that is raised above the surrounding terrain, and has remnants of fill material occupying its interior. (CTX image P02\_001993\_2238.)

**Fig. 4.** Platforms and pits within *Upl* in contact with LDA. The platforms are raised above the LDA surface but also have LDA-like textures that appear to grade seamlessly with the dominant texture of LDA. Platforms of *Upl* also have circular shapes (arrow) that resemble “oyster-shell” craters of [10]. (CTX image P13\_006239\_2240.)