MODIFICATION OF THE ANCIENT HIGHLAND PLATEAU ALONG THE DICHOTOMY BOUNDARY, DEUTERONILUS MENSAE, MARS. Frank C. Chuang and David A. Crown, Planetary Science Institute, 1700 E. Fort Lowell Rd., Suite 106, Tucson, AZ 85719 (e-mail: chuang@psi.edu).

Introduction: Deuteronilus Mensae, a gradational zone along the dichotomy boundary in the northern mid-latitudes of Mars, includes the transition from the rugged cratered highlands of Arabia Terra to the northern lowland plains of Acidalia Planitia. Here, polygonal mesas are prominent along with features diagnostic of Martian 'fretted' terrain, including lobate debris aprons, lineated valley fill, and concentric crater fill [1-3]. Lobate debris aprons surround and extend beyond the bases of mesas, escarpments, knobs, and crater rims. Fretted valley floors are covered by lineated valley fill and debris aprons. Many aprons have multiple lobes, surface lineations, and margins that deflect around small obstacles, indicating downslope flow. Debris aprons and valley fill are geomorphic indicators of ground ice [4-8] and their occurrence may be related to Martian climate change. The morphologic and topographic characteristics of the Deuteronilus Mensae region record a diverse geologic history [9-10], with significant modification of the ancient highland plateau and resurfacing of low-lying regions. Recent geologic mapping of Deuteronilus Mensae [11-12] and regional studies of lobate debris aprons and other ice-rich flow features [13] have revealed insights into highland plateau degradation, including the significance of surface collapse. Here we present a synthesis of this recent work that highlights our mapping results, discusses collapse of plateau materials, and preliminary reconstruction modeling of apron and valley fill materials.

Geologic Mapping: Deuteronilus Mensae was first mapped at 1:5M scale using Mariner 9 data and later at 1:15M scale with Viking Orbiter data [14-15]. At 1:15M scale, the region was divided into Noachian highland units, Hesperian ridged plains, older channel materials, and young slide materials. Recent detailed mapping of 4 MTM quadrangles identified a complex sequence of resurfacing within the high-standing older terrains with a major erosional event between the mid-Noachian and mid-Hesperian, resulting in formation of fretted valleys and fretted terrain [10].

We are currently mapping 3 Mars Transverse Mercator (MTM) quadrangles (35337, 40337, and 45337; 32.5-47.5ºN, 20-25ºE) that transect the dichotomy boundary in Deuteronilus Mensae [11-12]. We have identified 17 geologic units, which can be grouped into 4 material types (from oldest to youngest): plateau, plains, impact crater, and surficial materials. Within the plateau materials, which include the northernmost extent of the continuous highland plateau and the adjacent polygonal mesas, 4 units are defined: *plateau (pl), dissected plateau (pld), upper mesa (mu), and lower mesa (ml)*. Both the *pl* and *pld* units exhibit numerous impact craters and contain several large elongated depressions. Unit *pl* has depressions that contain irregularly-shaped blocks or knobs of the original surface. We interpret this unit to be ancient highland plateau modified by impact cratering, minor fluvial activity, and surface collapse above volatile-rich zones. Units *mu* and *ml* consist of polygonal mesas with flat upper surfaces above the surrounding plains and debris apron materials. From our analysis of surface morphologies and MOLA elevations, we find that mesas closest to the continuous plateau margin are similar to highland surfaces, and are thus mapped as unit *pl*. Mesas further north have muted or textured surfaces and their elevations generally decrease towards the north-northwest. These mesas are divided into upper and lower units, with unit *mu* clearly positioned above unit *ml* from their surface elevations. We interpret both mesa units to be in-situ remnants of ancient highlands beyond the continuous highland plateau. Our mapping results suggest that collapse of highland terrains may lead to the subsequent development of fretted valleys, mesas, and knobs.

Collapse in the Highland Plateau: Within the highland plateau, three prominent large, elongated, closed depressions 300-500 m deep contain numerous polygonal blocks and rounded knobs. The blocks do not appear to be rotated and some have sloped upper surfaces dipping in toward the depression floor. The top surfaces of some blocks are at an elevation that is similar to, or higher than, the surfaces surrounding the depressions, which suggests that parts of the original surface surrounding the blocks have collapsed. We interpret the blocks and knobs to be in-situ remnants of plateau materials that have subsided and/or been degraded over time.

The depressions contain blocks or knobs of different sizes and abundances, indicating progressive stages of degradation in the plateau, providing a potential formation mechanism for the polygonal mesas and fretted valleys in the region. The following describes these stages: 1) formation of fractures and pits at the surface in plateau regions with subsurface discontinuities or voids, 2) fractures and collapse pits enlarge, possibly intersecting with neighbors to form larger depressions with remnant in-situ material forming blocks or knobs, 3) continued destabilization of plateau materials by removal of subsurface support causes subsidence and larger-scale collapse, isolating and destroying some blocks and knobs, 4) mass wasting and collapse along escarpments at margins of depressions or fractures results in fretted valley formation, 5) downslope movement of debris, presumably mixed with ice, from fretted valley walls and mesas forms lineated valley fill and lobate debris aprons, 6) further degradation of depression blocks and knobs forms hummocky floor deposits. Our sequence is consistent with a previous study that determined mesas and knobs are being formed at the expense of plateau materials by mass wasting [16].

A fundamental issue regarding the origin of the depressions is removal of subsurface support that allows collapse to occur. The significant sizes of the depressions and lack of apparent outlets argues against removal by fluvial processes. Winds have the ability to remove and/or redistribute some surface materials; however, a growing surface depression may also trap eolian deposits. It is unlikely that wind alone could remove hundreds of km^3 of material to form these depressions. Assuming volatiles are present in plateau materials, sublimation of ice could remove some of the total volume from near the surface, but its likely to be only a small fraction if the ice is interstitial or trapped at significant depths. In general, the depressions indicate that significant void space and/or volatile-charged zones were once, or still are present in the plateau. Although the Deuteronilus Mensae region has been recently modified by ice-rich mass wasting producing fretted terrain, we suggest that collapse has played an important early role in the overall degradation of this region. Collapse has also been recognized in other highland regions of Mars such as southern cirum-Chryse [17-18] and eastern Hellas [19].

Debris Aprons and Plateau Reconstruction: To further explore the styles of collapse that may occur in Deuteronilus Mensae, the observed debris aprons and valley fill deposits may be used to estimate the amount of displaced material from the slopes of valley and mesa walls. We extracted 128 pxl/deg MOLA elevations across several apron/valley fill deposits and their source areas along profiles roughly parallel to the apparent flow direction. The elevations were then used to construct a simplified geometric model of the profile with the following assumptions: the walls of the source area have constant slope, walls extend below the apron/valley fill head at the base of the wall, the apron/valley fill base is horizontal with zero slope, and the elevation at the outermost edge of the apron/valley fill is the base elevation. The apron/valley fill area can be approximated to a scalene triangle and this material can be added back to the wall as a parallelogram-shaped area.

To date, we have extracted elevations from three profiles, two across different parts of Mamers Valles (Valley1 and Valley2) where deposits from both walls abut one another on the valley floor, and one across a mesa escarpment near the continuous plateau margin (Escarpment). For the Valley1, Valley2, and Escarpment cases, we estimate that the apron/valley fill deposits represent lengths of the plateau of 3.2 km and 0.6 km, 0.95 km and 0.90 km, and 3.2 km, respectively (Table 1). These amounts represent 13.5%, 6.4%, and 13.9% of the total width; where for Valley 1 and 2, it is the distance from one side of the valley to the other, and for the escarpment, the distance from the top of the slope to the edge of the apron lobe. All of our estimates are minimum values as there could be more material below the base level that is not visible. These results suggest that the observed apron/valley fill deposits in Deuteronilus Mensae account for only a small fraction of the material removed in the formation of fretted terrain. Future work will examine mechanisms for debris removal, including the potential for multiple cycles of apron and valley fill formation.

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Table 1. Measurements from Plateau Reconstruction

Profile	Apron Length	Wall Height	Wall Extension[1]
Valley1	16.9 km	0.8 km	3.2 km, 11.4%
	11.1 km	1.1 km	0.6 km, 2.1%
Valley2	7.3 km	0.9 km	0.95 km, 3.3%
	10.3 km	1.0 km	0.9 km, 3.1%
Escarpment	19.7 km	1.7 km	3.2 km, 13.9%

[1] Percent values are relative to the total width. See text.