DICHOTOMY BOUNDARY AT AEOLIS MENSAE, MARS: FRETTED TERRAIN DEVELOPED IN A SEDIMENTARY DEPOSIT.

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Introduction: The origin of fretted and knobby terrain on Mars has remained uncertain since the landforms were first described by Sharp in 1973 [1]. Subsequent studies have focused primarily on the fretted terrain in northern Arabia Terra, where investigators generally agree that ground ice has been important in modifying knobs and fretted valleys [2-5]. The initial processes isolating mesas from the high-standing terrain are less certain. Some fretted channels exhibit characteristics that suggest origin by fluvial erosion, despite their poorly developed drainage networks [5]. Other proposed mechanisms include crustal extension and structural control of groundwater sapping [6].

Situated near the martian equator at the crustal dichotomy boundary, Aeolis Mensae (Fig. 1) provides a pristine example of fretted terrain development without the younger landforms attributed to ice. We examined an area bounded by 10°S, 10°N, 120°E, and 150°E, adjacent to the cratered and dissected area described by Irwin and Howard [7]. Here we present evidence for a compositional difference between the Aeolis Mensae and the adjacent highland crust, and we discuss the interaction of fluvial valley networks with the dichotomy boundary in this region. Our observations indicate that Aeolis Mensae fretted terrain developed in a thick sedimentary deposit. Sedimentary layers were emplaced and eroded as fluvial activity declined, with minimal influence from highland valley networks.

Distinguishing highland bedrock from sedimentary deposits: The extensive degradation of Aeolis Mensae relative to the adjacent cratered highlands, where 20–50 m deep valley networks are preserved [7], suggests either that the mensae are composed of different materials than the highland crust, or that geomorphic proceses were concentrated along the dichotomy boundary [1]. Malin and Edgett [8] describe criteria for distinguishing sedimentary deposits on Mars from highland bedrock. These criteria include step-like exposures of horizontal sedimentary layers, fluting or yardangs, and an absence of boulders in talus slopes. Where thick sequences occur, a massive (or perhaps layered at sub-meter resolution) deposit overlies the thinner stair-stepped sequences. Mars Orbiter Camera (MOC) images suggest that knobs and mesas in Aeolis Mensae include the same stratigraphy and landforms as sedimentary deposits in other regions on Mars [8] (Fig. 2).

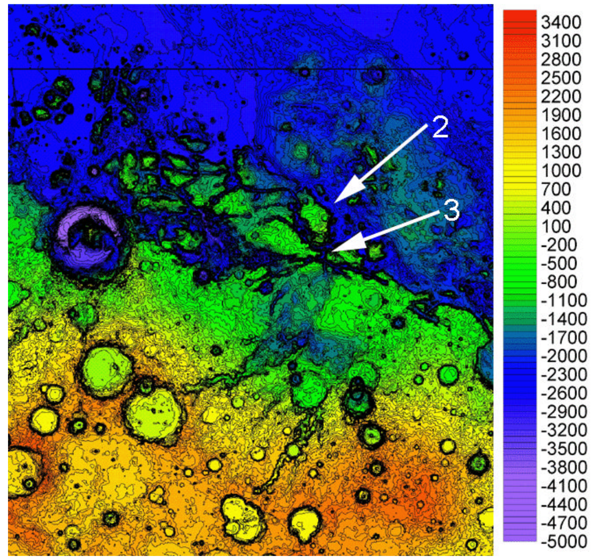

Fig. 1. Mars Orbiter Laser Altimeter contour map of part of the study area in eastern Aeolis Mensae, bounded by 2°N, 15°S, 135°E, and 150°E, 889 km across. The fretted terrain mesa materials appear to be emplaced at a higher topographic level than the termini of wide theater-headed valleys. Gale crater (left-center) contains thick sediments, higher than the crater rim, that may be of similar origin to layers in the fretted unit. Locations of Figs. 2 and 3 are indicated by arrows.

Relationships with highland valley networks: The dichotomy boundary in the study area consists of a steep scarp dropping into elongated open and closed basins (Fig. 1). The density of valley networks on this north-facing scarp is low relative to degraded crater rims in the adjacent highlands. The few valley networks crossing the boundary commonly steepen abruptly near the scarp [7], consistent with a base-level reduction or southward advancement of the boundary scarp [7,9]. These valley networks do not appear to continue into the multibasinal lowland knobby terrain.

The Aeolis Mensae materials appear to stratigraphically overlie or "dam" highland valley networks that drain toward the dichotomy boundary (Fig. 1). The mesas and knobs are not dissected by valley networks as are slopes in the adjacent highlands (Fig. 2). It is therefore likely that erosion of Aeolis Mensae occurred in the absence of abundant precipitation, during a time when activity of highland valley networks was waning.

Very limited fluvial activity continued after material was stripped to form the knobby and fretted terrain. Crater counts [11,12] and the activity of highland drainage basins can be used to constrain the emplacement and erosion of the Aeolis Mensae to the late Noachian and Hesperian periods.

Possible emplacement and erosional processes: Sedimentary materials could have been transported into the Aeolis Mensae region from the highlands by fluvial activity, or they could have originated from either the highlands or lowlands as an airfall deposit. For their present appearance and erosion, the mesas must have disaggregated entirely to grain sizes that are transportable by wind, so emplacement mechanisms should be consistent with this sorting requirement.

A more durable cap rock outcrops in many flat-topped mesas (Fig. 2). Erosion of these knobs may have been limited by the backwasting or disaggregation of the capping unit. Transport of disaggregated sedimentary materials into the lowlands could have been accomplished by wind, water, or ice. Yardangs, etched terrain, absence of continuous flow paths, and the temporal relationships with valley networks favor wind as the transport medium.

Regional and planetary correlations: Malin and Edgett [8,10] described sedimentary mantles covering substantial areas of low-standing ground. These layered units showed no obvious relationship to highland valley networks. One possibility is that layered deposits in Terra Meridiani, Arabia Terra, Valles Marineris, and along the dichotomy boundary may share a common origin, as fine-grained sedimentary deposits were stripped from low-standing settings and transported to their current locations by wind.

Fig. 2 (left). MOC image E05-01183 (3 km across) of mesas in Aeolis Mensae. Mass wasted deposits on the mesa slopes (bottom) are free of large boulders even at full resolution (5.8 m/pixel). Between mesas a layered deposit has been partially stripped in the upper part of the image. An indurated layer caps the mesa.

Fig. 3 (right). Subframe of Mars Odyssey THEMIS daytime infrared image I00957001 (32 km across). Aeolis Mensae fretted terrain (top) formed in an etched sedimentary layer (center), which overlies cratered terrain and valley networks. A higher-inertia layer is exposed between knobs at the top of the image. In MOC images, this high-inertia material underlies a largely stripped, thin layer, which itself underlies the thick mesa-forming unit.

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