

THE MEDUSAE FOSSAE FORMATION: GEOLOGICAL CHARACTERISTICS AND TOPOGRAPHIC AND STRATIGRAPHIC RELATIONSHIPS OF THE LOWER MEMBER ALONG SOUTHEASTERN ELYSIUM PLANITIA. S. M. McColley¹, J. W. Head, III¹, G. Neukum², and the HRSC Team. ¹Dept of Geological Sciences, Brown University, Providence, RI 02912. Shawn_McColley@brown.edu, ²Institut fuer Geologische Wissenschaften, Freie Universitaet Berlin, Germany.

Introduction: The Medusae Fossae Formation (MFF) is a long-standing enigma in the equatorial region of Mars. Mechanisms of formation for this unit are numerous [1] and include: ignimbrite flows [2,3,4], aeolian deposition [5], ancient polar deposits formed by polar wander [6], air fall from explosive volcanic eruptions [7,8], and deposition of ice, snow, and dust during periods of high obliquity or outflow channel formation [9]. The HRSC, MOC, THEMIS, and MOLA data sets provide the means to characterize all members (Aml, Amm, and Amu) included in the MFF at a variety of scales and to test the formational mechanisms listed above and to assess new ones. Specifically, quantitative and qualitative comparisons of features within the MFF will provide insight into the behavior of each member post-deposition. These observations coupled with past interpretations may provide an avenue to place tighter constraints on formational mechanisms. To this end, we are currently analyzing stratigraphic relationships and characterizing the variable terrain types within the lower member (Aml) of the MFF and its relationships to adjacent units.

Background: The MFF consists of three members, an upper (Amu), a middle (Amm) and a lower (Aml). Previous workers interpreted Aml as lava flows interbedded with eolian or pyroclastic deposits and observed that Aml is the most heavily eroded member of the three [4,5]. Amm was interpreted as moderately indurated eolian or pyroclastic deposits that had been eroded by wind along the margins [4,5]. The thick deposits of Amu were interpreted as eolian sediments or volcanic pyroclastic deposits with extensive wind erosion along the margin [4,5]. Based on crater counts, all units of the MFF have been determined to be Amazonian in age with the lower member extending well back into the period [4,5].

In an attempt to constrain better the type of material contained within Aml we use HRSC, MOC, and THEMIS in conjunction with MOLA to ask some specific questions about the lower unit of the MFF: a) What is the general nature of the lower unit? b) What are the topographic and stratigraphic relationships within the unit? c) Do subunits exist within the lower unit and if so, do they vary in age? d) What impact do these new observations have on current thinking regarding the nature, formation, and evolution of the MFF?

Description: Our study region is located at the southeastern edge of Elysium Planitia and is centered on 2°S and 174°E (Figure 1). Previously the area was mapped as two units [3], younger channel and flood plain unit undivided (Achu), embaying the lower member (Aml) of the MFF. Recently the northern hemisphere was remapped [10] including the northern portion of our area of investigation; the plains unit (Achu) was redesignated as AEC₃ ("flat-lying, broad flows with lobate margins"). The lower unit of the MFF (Aml) [3] was subdivided into two units, 1) AEC₁ (consisting of "patches of relatively high-standing plains-forming material...characterized by sets of arcuate fractures, lobate scarps, and depressions filled with knobs. Overlies and grades into Medusae unit."), and 2) The Medusae unit AAm (which "forms vast, discontinuous deposits...appears to be made up of sequence of layers..."). The latter unit (AAm) is interpreted [9] to be "volcanic ash deposits from local buried vents or other uncertain origin."

In this area the nature of the unit previously

designated as Aml [3] varies considerably. We have identified two distinct subunits (Figure 1), a semi-continuous subunit (Mmod in Figure 1) that appears to be minimally affected by erosional mechanisms and a heavily modified subunit (Hmod in Figure 1) that exhibits several types of modification including wind, mass wasting, collapse, and viscous flow. The Mmod subunit is predominately located in the eastern and southeastern areas of our study region. It is topographically high, standing approximately 250 m above the Hmod subunit to the northwest and between 500 m and 1000 m above the plains units to the northwest. The central portion of the study area contains several modes and levels of degradation of the Mmod material. This degraded area lies approximately 250 m above the plains unit to the northwest. All portions of the unit previously mapped as Aml [3] considered in this study lie on a general upward slope toward the southeast, however, definite topographic breaks are present within the lower member.

The Mmod subunit has a corrugated texture that is consistent with wind erosion of a friable substrate (Figure 2A, B). Small, parallel to subparallel, rounded ridges with wavelengths that range from 50 m to 100 m are pervasive in this portion of previously mapped Aml. Isolated patches of the Mmod subunit are observed within the more degraded area (Figure 2A) which tend to be topographically higher relative to adjacent degraded material, but topographically lower relative to the large concentration of Mmod in the southeastern portion of the study area (Figure 1).

On the contact between the Mmod and the Hmod, transitional areas are observed where the Mmod material is abutting and blending with Hmod material that generally lies topographically lower (Figure 2C). In these regions knobs and curvilinear troughs have developed a texture similar to that of fish scales (Figure 2D). Determining definite stratigraphic relationships in these transitional areas is difficult due to eroded material that is

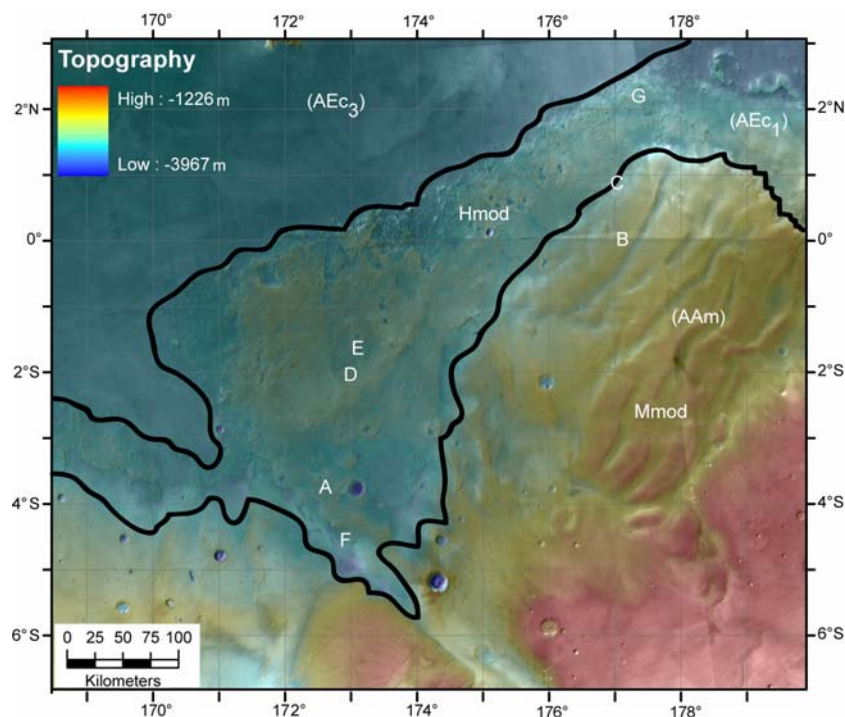


Figure 1. Context map of the study region. The letters mark the location of the thumbnail images discussed in the text and shown in Figure 2.

superposed on the contacts, but other relationships suggest that the Mmod material is overlying the Hmod material. Figure 2C shows a scarp of Hmod that appears to be dipping toward and emerging from beneath the large concentration of Mmod in the eastern portion of the study area. Also, the degree to which the Mmod deposit is disrupted decreases as the interior of the deposit is approached. The margins tend to be characterized by scarp-like features such as that in Figure 2C as well as shorter wavelength deformation that appears to be consistent with partially embayed troughs and fractures that are observed in the Hmod subunit. As the largest concentration of Mmod is traversed, and elevation is gained, surficial modification is limited to the corrugated texture described above and the large scale polar-like troughs suggesting that the deposit is increasing in thickness and that the short wavelength deformation of Hmod is completely veiled by the deposit.

The troughs found within the Hmod subunit that appear to be superposed by the Mmod subunit have variable widths (Figure 2D, E). Widths appear to be a function of several factors: modification age, underlying topography, and the formational mechanism. A narrow trough might indicate a very young modification age or it may suggest that the trough formation mechanism may not have operated as efficiently in some areas. Trough depths are variable as well. Individual MOLA tracks indicate that the troughs shown in Figure 2C, D, E range in depth from 10 m to 100 m, depending on the trough width and the amount of aeolian material that has been deposited on the floor of the trough.

Collapse features are prevalent in the degraded area as well (Figure 2D, F). Collapse can be identified on a variety of scales ranging from one to tens of kilometers. Figure 2D shows several stages of collapse across a 40 km wide section taken from an HRSC image. Some areas within the image have started to form troughs, but are still relatively flat-lying, with other regions showing blocks that are standing nearly vertical after the subsurface faltered (arrow Figure 2D). Figure 2F shows a much smaller scale collapse feature. Pit-like features such as this are distributed throughout the degraded region. They vary in depth depend-

ing on the amount of material deposited on the pit floor. Based on MOLA, the depth of the feature shown in Figure 2F is 30 m.

Other features of the degraded region include flow features that appear viscous in nature. Figure 2G shows a viscous-looking tongue of material that originates near the top of the trough. The feature appears to be propagating as a coherent unit down slope with some widening of the flow front as it reaches a less constricted area in the trough.

Conclusions: The lower MFF member (Aml) [3] found in our study region is composed of two subunits, a subunit that has experienced minimal modification (Mmod) and a subunit that is heavily modified (Hmod). Although stratigraphic relationships are not definite between the two subunits, other evidence suggests that Mmod overlies Hmod in our study area. Several features found in the degraded subunit are not consistent with erosional modification by wind. Both large- and small-scale collapse resulting in a fish scale-like texture and pits respectively indicate the removal or movement of material beneath the overlying substrate. Viscous flow features such as that shown in Figure 2G suggest the presence of a volatile component within the degraded subunit. Several questions arise as a result of these findings: 1) What was the source of the volatiles in the degraded subunit? 2) Are volatiles limited to the Hmod subunit or was there exchange between Hmod and Mmod? 3) To what degree did compaction by the overlying Mmod play a role in the evolution of Hmod? Currently we are analyzing several other areas in detail to determine if the volatile component is limited to a layer within Aml or if evidence for volatiles is present throughout the lower member of the MFF.

References: 1) J. Zimbleman et al., LPSC 30, #1652, 1999; 2) Malin, NASA Conf. Pub., 2072, 54, 1979; 3) D. Scott and K. Tanaka, USGS Map I-1802 A, 1986; 4) D. Scott and K. Tanaka, JGR, 87, 1179, 1982; 5) R. Greeley and J. Guest, USGS Map I-1802 B, 1987; 6) P. Schultz and A. Lutz, Icarus, 73, 91, 1988; 7) Hynek, B. et al., JGR, 108, 10.1029/2003JE002062, 2003. 8) Bradley, B. A. et al., 107, 10.1029/2001JE001537, 2002. 9) J. Head and M. Kreslavsky, LPSC 35, #1635, 2004. 10) K. Tanaka, J. Skinner, and T. Hare, Geologic Map of the Northern Plains, USGS Atlas of Mars, 2004.

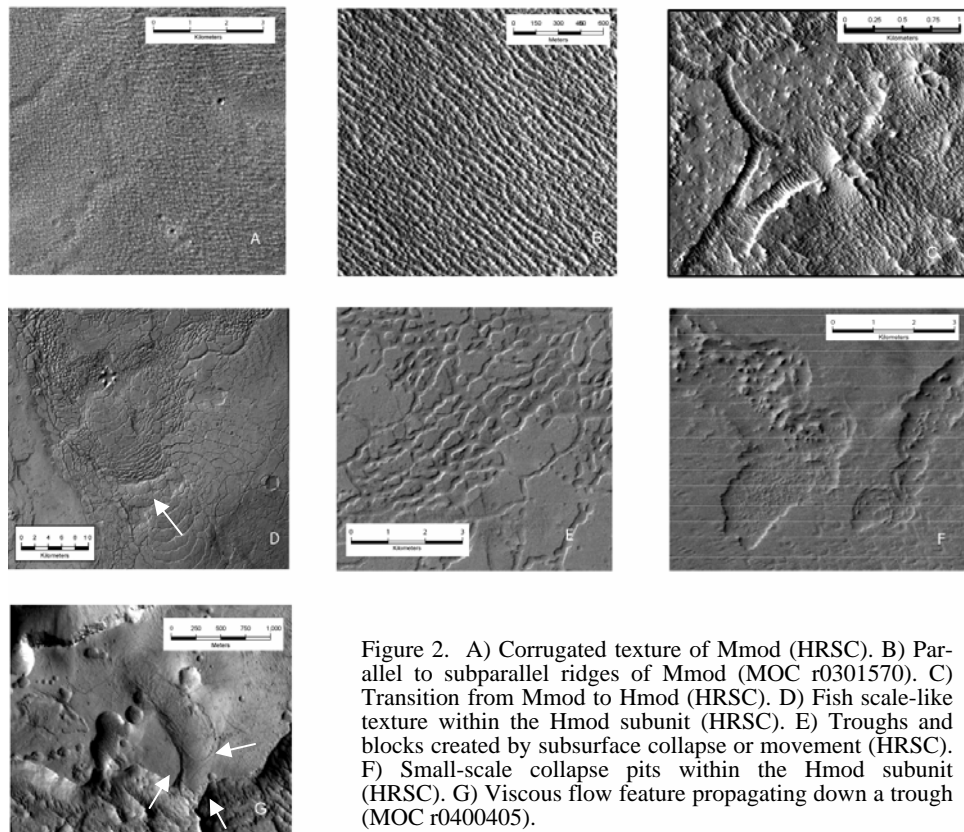


Figure 2. A) Corrugated texture of Mmod (HRSC). B) Parallel to subparallel ridges of Mmod (MOC r0301570). C) Transition from Mmod to Hmod (HRSC). D) Fish scale-like texture within the Hmod subunit (HRSC). E) Troughs and blocks created by subsurface collapse or movement (HRSC). F) Small-scale collapse pits within the Hmod subunit (HRSC). G) Viscous flow feature propagating down a trough (MOC r0400405).