LAYERED MANTLE DEPOSITS IN NORTHEAST ARABIA TERRA, MARS: I. OBSERVATIONS OF NOACHIAN-HESPERIAN SEDIMENTATION, EROSION AND TERRAIN INVERSION.

C. I. Fassett and J. W. Head, Dept. of Geological Sciences, Brown University, Providence, RI. 02912 (Caleb_Fassett@brown.edu).

Introduction and Background: Northeast Arabia Terra, west and north of Syrtis Major, has long been known to be characterized by significant terrain mantling and exhumation [1-3]. There are two widespread geological units at a scale of 1:15M [1]: *dissected terrain* (Npld; more highly dissected by valley networks (VN) than cratered unit; covers extensive area S and W of Syrtis Major, interpreted as cratered unit highly eroded by fluvial processes [1]) and *etched terrain* (Nple; similar to cratered unit but deeply furrowed by sinuous intersecting grooves producing etched or sculpted surface; craters and other depressions filled with smooth deposits; forms mesas; distributed in a band to the N of the dissected terrain, and N and W of Syrtis Major; interpreted as cratered unit partly mantled and dissected by fluvial processes, ground ice decay and minor fluvial activity [1]). The etched and dissected terrain are mapped as Noachian and laterally equivalent stratigraphically [1].

These units are marked by the widespread presence of a layered mantling material that fills the interior of craters and valleys and forms mesas in intercrater areas; geological relations show that the mantle has undergone stripping and removal of hundreds of meters of material [1,2,3]. In the etched unit this material commonly forms inverted topography – recognizable craters and valleys that now lie above the surrounding plains. It was recognized on the basis of Viking data that the formation of this inverted terrain requires an episode of both infilling of formerly low-lying regions (gradation) and preferential removal of the former surrounding topography (erosion) [2]. Viking observations [3] show that the fill material is regionally extensive and forms large, horizontal beds and largely mantles the preexisting topography rather than only filling depressions. The etched unit has a mapped extent of over a million km^2, and in many places have been extensively eroded; thus, it forms an excellent study area for consideration of erosion/exhumation processes on early Mars. We have been using new spacecraft data (e.g., MOLA, MOC, THEMIS, GRS/NS) to characterize these deposits and assess previous theories of origin. Here we present our observations, focusing on the transition region (centered at 50 °E, 15 °N) between the *dissected unit* and the *etched unit*; in a companion abstract [4], we discuss the implications of these observations for models of deposition and erosion of the mantle material.

General Observations and Regional Characteristics: Virtually all of NE Arabia Terra region has low thermal inertia (I<200 J/(K m^2 s$^{0.5}$)) at TES resolution [5], consistent with widespread surface dust or lightly indurated fines and./or minimal surface rock abundance. Neutron Spectrometer data show high abundances of water-equivalent hydrogen in the near-surface [6], which may be indicative of the presence of hydrated minerals [7].

Etched unit (Nple): High-resolution images of the etched unit reveal that it is pervasively layered (Fig. 1); layers appear approximately subhorizontal. MOLA data show that fill is locally of nearly constant thickness, but a range of thicknesses is observed (50-300 m) over the study area. Much of the surface is formed of flat deposits that appear smooth at 50-100 m resolution; these deposits are often extensive, covering hundreds to thousands of km^2, and can also weather into irregularly-shaped plateaus and mesas. At MOC scale, these mesas/filled surfaces are often rougher (and appear to be covered with surficial dunes). Edges of these plateaus and mesas are often highly irregular, almost cuspate, and are characterized by marginal aprons of erosional debris up to a few km wide (Fig. 2), characterized by dunes. However, some mesas are circular, suggesting that they represent exhumed craters (Fig. 2). In other locations, smooth deposits occupy the floors of craters which are not inverted, but occur over a wide variety of sizes and degradation states (Fig. 3). These craters in turn, show abundant evidence of stripping and terrain inversion, with central fracturing (Fig. 4), and pitting at the km-scale (Fig. 5). Areas between plateaus, mesas and crater fill are characterized by a distinctive knobby terrain (Figs. 2, 6) which consists of interspersed knobs tens of meters to several km in diameter. The knobs are clearly transitional to the mesas, as can be observed in Fig. 6, where larger knobs form small mesas, particularly where stabilized by fill of small partly exhumed impact craters. Craters that have their floors filled with smooth mantling material often have their walls and rims dissected and modified to knobby terrain (Fig. 3-5, 7). There are very few valley networks in the etched region, and those that are present tend to have been extremely modified (eroded, exhumed, or inverted).

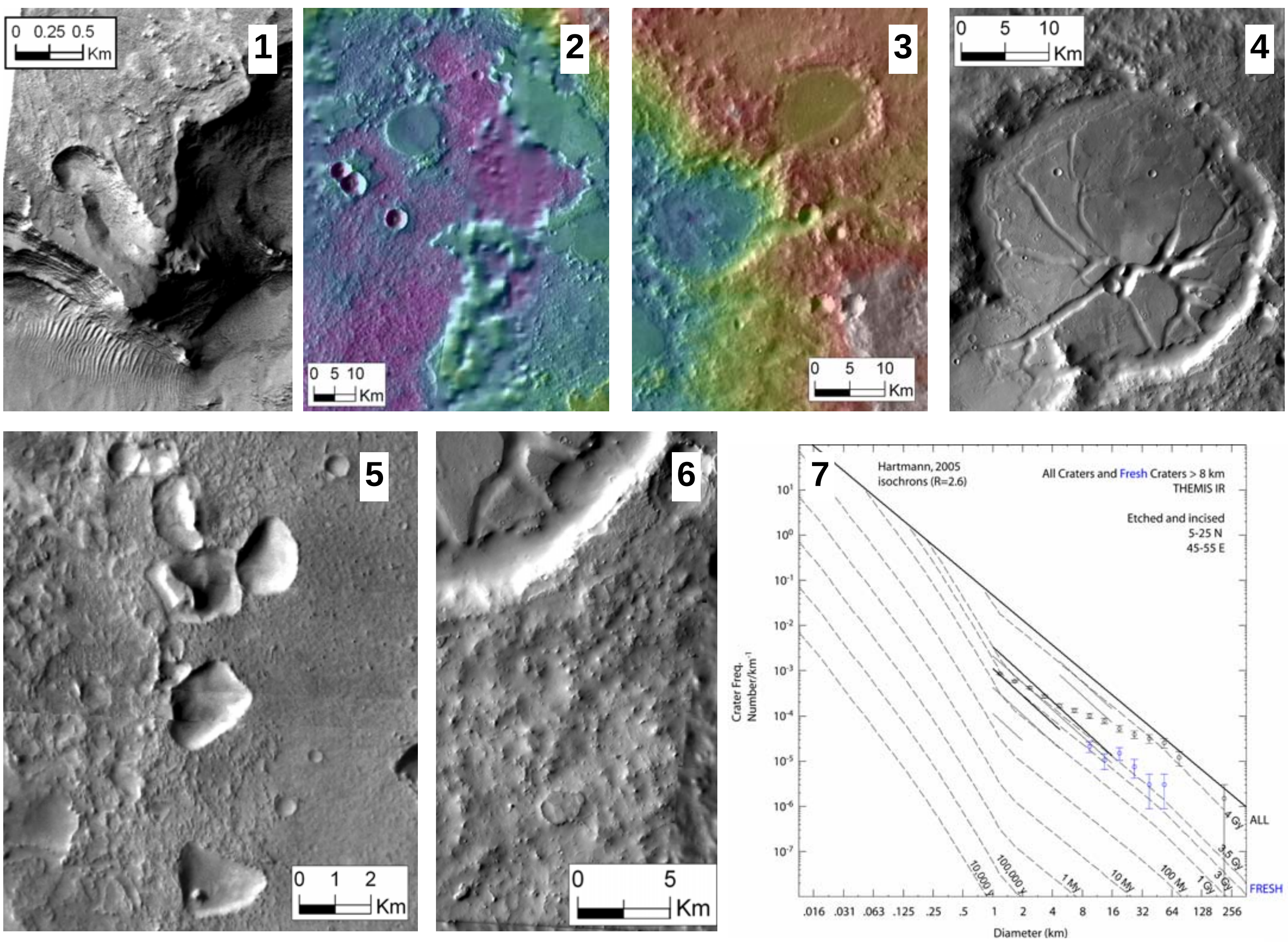
Dissected terrain: The dissected terrain is a crater highlands region incised by dendritic valley networks similar to those in other parts of the highlands [8]. Observations are consistent with 1) valleys incising the mantle material (contemporaneous or following its deposition) or 2) being exhumed from underneath the fill. Fill material is presently less widespread in the dissected terrain, where it is more commonly found filling craters than inverted above its surrounding. However, observations of linear ridges interpreted to be exhumed dikes [9] suggest that the fill material was more extensive in this region.

The transition from Nple to Npld: The transition between dissected and etched terrain is characterized by a gradational change in the density of the fill material and a transition from common inverted topography (Nple) to its rare occurrence (Npld). Where valleys cross the transition region, there are valley-to-ridges transitions over relatively short distances.

Ages: New counts of the study region (Nple and Npld) (Fig. 7) show that the basement material is very ancient. Counts of all craters (including the large degraded craters) give an Early Noachian age using Hartmann's [10] recently published isochrons. In contrast, however, the fresh crater population (undegraded rims & ejecta) over the whole region gives an early Hesperian age. The fresh population on the inverted surfaces gives a Hesperian age that is indistinguishable from the knobby intermesa terrain. This suggests that both the deposition of the fill material and most of its erosion occurred largely in the Hesperian and that minimal modification has occurred since that time. These new results are consistent with earlier counts on Viking data [2]. Furthermore, following [2], we also observe a striking divergence in the total crater (degraded and fresh) population from the Early Noachian production function at crater sizes less than 40 km. This observation is consistent with a scenario in which the surface was considerably reworked in Early Noachian time; the remnants of the ancient surface we see in the exhumed terrain are likely exhumed relicts of this older surface that was substantially modified after that time, as seen by the divergence from production at smaller diameters.

Synthesis of observations: In the etched and dissected terrain, an areally-extensive mantle material was deposited during the Noachian. It was subsequently eroded significantly enough to lead to the formation of inverted topography and exhumation of older underlying material. Our observations suggest that this erosion (and possibly deposition) took place in a relatively short amount of time. In the companion to this abstract [4], we discuss hypotheses for this mantle's deposition and erosion based on the observations given here.

References: [1] Greeley, R. and Guest, J.E. (1987) *Geologic Map of the E. Equat. Reg. of Mars*, I-1802-B; [2] Grant, J.A., and Schultz, P.A. (1990) *Icarus, 84*, 166-195; [3] Moore, J.M. (1990) *JGR, 95,* 14,279-14,289. [4] Fassett, C.I. and Head, J.W. (2005) *LPSC XXXVII*, this conf. [5] Putzig, N.E. et al. (2005) *Icarus, 173*, 325-341. [6] Feldman, W.C. et al. (2003), *JGR, 109*, E09006. [7] Feldman, W.C. et al. (2004), *GRL, 31*, L16702. [8] Carr, M.H. (1996) *Water on Mars*. [9] Head, J.W. et al. (2006), *Geology*, in press. [10] Hartmann, W.K. (2005) *Icarus, 174,* 294-320.



See discussion of figures in text. Top Row (left-to-right), Fig 1. MOC E0200362; Fig 2-3. THEMIS IR Mosaic on MOLA false color, Fig 4. THEMIS VIS images V05703012 & V04954006. Bottom Row: Fig 5. V02632006; Fig. 6. V04954006; Fig 7. Crater counts on the isochrons of [10].