

HEBES CHASMA, MARS: SLOPES AND STRATIGRAPHY OF INTERIOR LAYERED DEPOSITS. E. Hauber¹, K. Gwinner¹, A. Gendrin², F. Fueten³, R. Stesky⁴, S. Pelkey⁵, D. Reiss⁶, T. Zegers⁷, P. MacKinnon³, R. Jaumann¹, J.-P. Bibring², G. Neukum⁸, ¹Institute of Planetary Research, German Aerospace Center (DLR), Rutherfordstr. 2, 12489 Berlin, Germany (Ernst.Hauber@dlr.de); ²Institut d'Astrophysique Spatiale, CNRS, Orsay, France; ³Department of Earth Sciences, Brock University, St. Catharines, Canada; ⁴Pangaea Scientific, Brockville, Canada; ⁵Department of Geological Sciences, Brown University, Providence, USA; ⁶Institut für Planetologie, Univ. Münster, Germany; ⁷ESTEC, ESA, Noordwijk, The Netherlands; ⁸Institute of Geosciences, FU Berlin, Germany.

Introduction: Despite more than three decades of analysis, the origin of the Interior Layered Deposits (ILD) in the Valles Marineris (VM) trough system is still unknown. This study focusses on Hebes Chasma (HC) in the central VM, which is unique because it contains a huge mesa of ILD in a completely closed depression. It builds on an earlier study [1], where we mapped the distribution of sulfates identified by the imaging spectrometer, OMEGA, and where we also showed the layer geometry (strike and dip) on the main ILD deposit of Hebes Mensa. Here we present new results related to the stratigraphy of ILDs, their slopes, and structural deformation (faulting).

Data: We use high-resolution Digital Elevation Models (DEM) (Fig. 1) derived from HRSC stereo images [e.g., 2,3] for slope measurements, and new images from the Context Imager (CTX) on Mars Reconnaissance Orbiter (MRO) [4]. Unfortunately, at the time of writing only two images of Hebes Chasma taken by the HiRISE camera [5], also on MRO, were available, and these do not show significant details of Hebes Mensa and related ILDs.

Results: We present our results in two sections. First, we show the slope distribution on ILDs. Second, we present preliminary observations of the stratigraphic characteristics of ILDs.

Slope distribution. Surfaces slopes of ILDs display distinctly different values (Fig. 2). Shallower parts typically show slope values of 10-20°, while steeper parts can reach slopes of 30° and more. The steepest areas (>40°) are scars of landslides that developed on the flanks of Hebes Mensa. The steepness is often correlated with morphology. The shallower parts are characterized by finely layered units with layer thicknesses in the range of meters (when observed in CTX resolution of ~6m/pixel). In contrast, steeper parts and cliffs are often made up of visually more massive deposits, where no layering is visible in CTX or MOC resolution, but extremely fine layering is visible in HiRISE images (25-50 cm/pixel) down to the resolution limit (e.g., HiRISE image PSP_003975_1790, covering the SE corner of Hebes Mensa). Laterally, bands of comparable slope values can sometimes be traced over >>10 km, but typically, as in the case of their morphology, ILDs are extremely variable, and changes in

steepness are frequent in lateral direction. This corresponds to the observation that individual layers can rarely be traced over significant lateral distances.

Stratigraphy. The vertical sequence of ILDs shows distinct changes in their morphology, enhanced by the erosion patterns. In the eastern part of Hebes Mensa, the stack of ILDs is characterized (from top to bottom) by the following sequence, which is well exposed in a landslide scar (Fig. 3; labeled with letters): (a) top plateau of Hebes Mensa (\pm flat-lying), (b) material weathered into a spur-and-gully morphology (slope 35-40°), (c) a dark talus apron (25-30°), (d) an irregularly appearing unit characterized by massive hills and knobs (overall slope of <10°), (e) a unit weathered into very small yardangs (15-20°), (f) a unit weathered into coarser yardangs (20-30°). Nearby, exposed in another landslide scar, the vertical sequence (labeled with numbers) is very similar (*units 1-6*), but another unit (*unit 7*) is exposed beneath and separated by a putative unconformity (cf. Fig. 4). This lowermost unit displays finely layered material that is locally cut by NE-trending faults (Fig. 5). Importantly, only this lowermost unit was found to be associated with sulfates in this area. It can be traced around the western, northern, and eastern walls of a topographic depression which marks one of the deepest parts of Hebes Chasma.

Conclusions: The ILDs in Hebes Chasma display a variable morphology, which is reflected in variable surface slopes. Both vary not only in vertical, but also in horizontal (lateral) direction. It seems that a complex formation history has been responsible for their current appearance, including postdepositional tectonic deformation. The morphological variability is associated with a compositional variability, since OMEGA data show spectral evidence for hydrated sulfates only in discrete parts of the ILDs. In the study area of eastern Hebes Mensa, these sulfate-bearing layers correspond to the stratigraphically lowest parts of the ILDs. The results are still preliminary and do not allow an unambiguous interpretation of the geologic history. However, our model of ILD formation, developed in another study area (western Candor Chasma) [6], is in agreement with our results shown here, highlighting the importance of tectonic processes and including a formation of sulfates by groundwater circulation.

References: [1] Hauber et al. (2006) *LPS XXXVII*, Abstract #2022. [2] Gwinner et al. (2008) *PERS*, *subm.* [3] Scholten et al. (2005) *PERS*, 71(19), 1143-1152. [4] Malin, M. C. et al. (2007) *JGR*, 112(E5), CiteID E05S04, doi: 10.1029/2006JE002808. , Abstract #1402. [5] McEwen, A. S. et al. (2007), *JGR*, 112(E5), CiteID E05S02, doi: 10.1029/2005JE002605. [6] Fueten et al. (2008) *JGR* (*in review*).

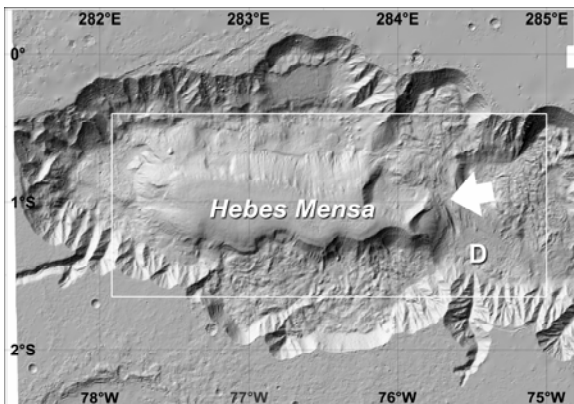


Fig. 1. Shaded representation of DEM derived from HRSC data. White box outlines Fig. 2. White arrow indicates viewing direction in Fig. 4. “D” shows depression bounded by finely layered sulfate material.

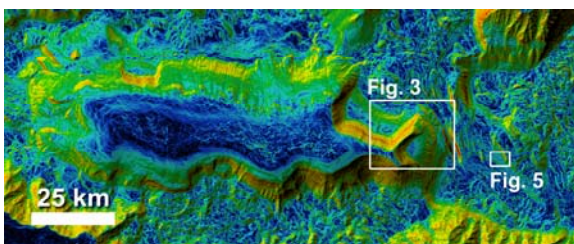


Fig. 2. Slope map. Approximate colour scheme: Blue 0-10°, green 10-20°, yellow: 20-35°, red: >35°. Note the vertical and horizontal variability of slopes.

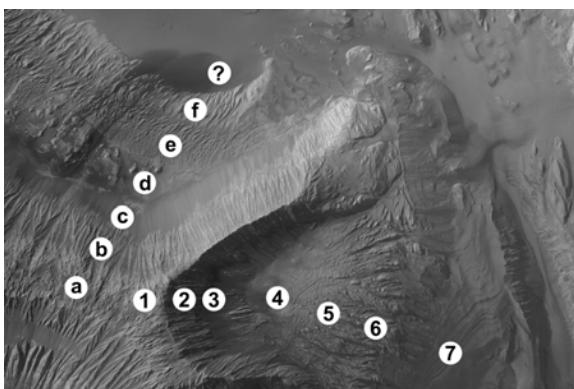


Fig. 3. Detail of CTX mosaic with labeled units discussed in text. “?”: Stratigraphically lower ILDs (equivalent to unit 7) covered by eolian material???

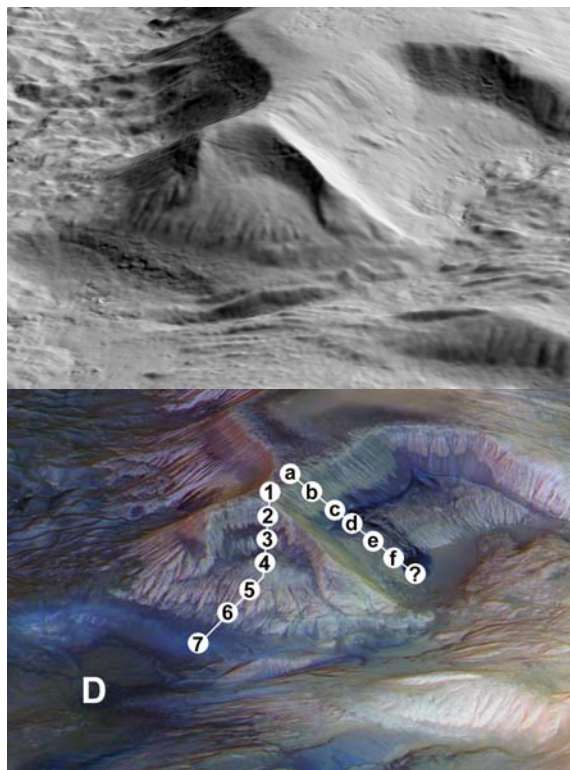


Fig. 4. Simulated 3D-views of eastern Hebes Mensa. Top: Shaded DEM. Bottom: False colour HRSC image. Labeling as in Fig. 3 and text. “D” shows depression bounded by finely layered sulfate material. The 3D-views show the diverse character of the ILDs. Next steps will involve the comparison of the stratigraphy found here with ILD stratigraphy in other parts of Valles Marineris.



Fig. 5. Detail of CTX image, showing finely layered units that exhibit spectral evidence for hydrated sulfates. Note the NW-trending faults cutting the ILD material. Similar faults were observed to cut ILDs in western Candor Chasma [6] and are evidence for widespread post-depositional deformation of ILDs by regional faulting.