

LAYERING ATTITUDES IN SOUTHWESTERN CANDOR CHASMA FROM HRSC IMAGE DATA AND STEREO-DERIVED DTM R. Stesky¹, F. Fueten², P. MacKinnon², E. Hauber³, K. Gwinner³, F. Scholten³, T.E. Zegers⁴, G. Neukum⁵ and the HRSC Co-Investigator Team, ¹ Pangaea Scientific, Brockville, Ontario, Canada (rstesky@pangaeasci.com), ² Department of Earth Sciences, Brock University, St. Catharines, Ontario, Canada, ³ Institute of Planetary Research, German Aerospace Center (DLR), Berlin, Germany, ⁴ Faculty of Geosciences, Utrecht University, Netherlands, ⁵ Remote Sensing of the Earth and Planets, Freie Universität, Berlin, Germany

Introduction: Layered deposits occur widely within the chasmata of Valles Marineris, but their origin and mechanism of formation are uncertain [1, 2]. They may form distinct mounds or may be more widely distributed, and often show signs of post-depositional modification, largely by wind erosion. Recent geochemical soundings by the OMEGA instrument on Mars Express [3] indicate the presence of sulfates in some of the deposits.

Less is known about their internal geometry and structural setting, properties that may give clues to their formation process. Recent high resolution imagery and stereo-derived digital terrain models (DTMs) from the High Resolution Stereo Camera (HRSC) experiment on the Mars Express orbiter can provide this information, by allowing the attitudes of observed layering to be calculated at various locations throughout the image.

Geological Setting: This study focused on the deposits in southwestern Candor Chasma where they are associated with a linear ridge that lies parallel to the chasma wall. Mapping by Lucchitta [4] defined a number of units of Hesperian or Amazonian age, based on their morphology and surface appearance, including mottled, layered and resistant. Prominent in the area is a mound of strongly layered material, unconformably capped by a resistant dark unit situated on the west side of the mound. The surface of many of the units show winnowing erosional structures and fields of dark dunes, attesting to strong and persistent wind erosion.

Data and Methodology: The multispectral image and DTM were calculated from HRSC data collected during orbit 2116. The image has a spatial resolution of 12.5 m and the DTM, 50 m, significantly higher than was used in our previous work in this area [5, 6]. Fig. 1 shows an oblique 3-dimensional view of part of the region, including the mound and distant chasma wall.

Pangaea Scientific's software ORION was used to sample the image and calculate the layering attitudes. The method was described in detail by Fueten et al. [7]. Briefly, points are chosen along the observed layering contact deemed to be planar, while Orion computes the best-fit plane to the 3-dimensional points using multilinear regression. The repeatability of orientation measurements of nearby layers suggests that the results are reasonably reliable and accurate.

Measurements and Results: The layer dips are generally low (less than 30°, typically) and tend to be in the direction of the local topographic slope (Fig. 2), as we found earlier [6] and as is also observed in other ILDs [8, 9, 10].

In some areas, such as immediately to the east of the

mound, the dips show marked changes in direction and angle within relatively short distances, yet nearby layers give very similar attitudes. The topographic surface shows little apparent variation to account for the dip changes.

The resistant cap rock on the mound shows the same unconformable relation with the underlying strata as observed previously and gives a consistent westward dip of about 8°.

New to this work is the measurement of fine layers in the deep part of the chasma in the northeastern part of the image area. The layers are subhorizontal, similar to the attitudes found for deep layers in nearby Ceti Mensa [10] and in Hebes [8] and Ophir [9] chasmata.

Discussion: As we concluded earlier [6], the pattern of dip angles and directions is most likely the result of the strata draping over an irregular basement topography. The basement likely consists of fault blocks that formed during the initial opening of the chasma and then were rotated and downdropped with continued opening and collapse of the chasma. The fact that the linear ridge in this area is parallel to the chasma wall suggests that this interpretation is reasonable. In a number of places, outcrops of more resistant units, visually similar to wallrock, appear surrounded by younger layered strata, suggesting that they are basement blocks that were never buried or have subsequently been exhumed by erosion. The regions showing marked dip variations unaccounted for by topography, may contain buried basement blocks that lie just below the present surface, close enough to have affected the deposition attitudes of the overlying strata.

Our draping model, if correct, suggests that deposition must have occurred under low energy conditions. High energy situations such as fluvial or subglacial deposition are unlikely. Subaerial or deep water conditions are more likely, suggesting either pyroclastic ash fall or the presence of a deep ocean (in this case, at least 6 km deep). We tend to favor the former, as proposed by Hynek et al. [11].

References: [1] Nedell S.S. et al. (1987) *Icarus* 70, 409-441, [2] Lucchitta, B.K. (2000) *LPSC XXXI* #1139, [3] Gendren A. et al. (2005) *Science*, 307, 1587-1591 [4] Lucchitta, B.K. (1999) *U.S. Geol. Survey Map I-2568* [5] Fueten F. et al. (2005) *LPSC XXXVI* #1498 [6] Fueten F. et al. (2006) *Geophys. Res. Lett.* (in review) [7] Fueten F. et al. (2005) *Icarus*, 175, 68-77 [8] Hauber E. et al. (2006) *this conference*, [9] Zegers T. et al. (2006) *this conference*, [10] Gaddis, L.R. et al. (2006) *this conference*, [11] Hynek B.M. et al. (2003) *J. Geophys. Res.* 108(E9), 5111-5127.

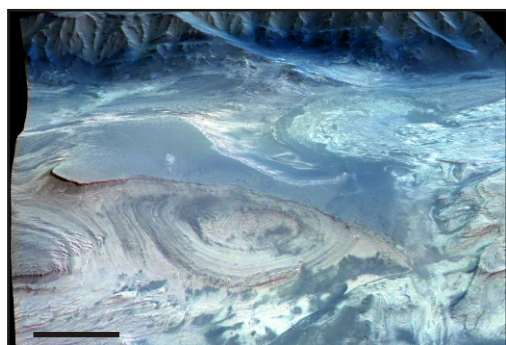


Figure 1. (Left) Oblique false-colored 3-dimensional view of the southwestern Candor Chasma, seen from the north-northeast. The layered mound in the center is unconformably capped by a west-dipping resistant unit. The chasma walls are in the distance. The scale bar is approx. 5 km.

Figure 2. (Below) The image area of orbit 2116. The layering attitude measurements are shown as standard strike/dip symbols, with the dip angle shown. A colored topographic map underlies the image. Note how the layer dips tend to be in the down-slope direction. The chasma wall is at the southwest corner of the image; wall strata show shallow dips into the chasma.

