INTEGRATED ANALYSIS OF GANGES MENSA, MARS.
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Introduction: Images from the Mariner 9 and Viking missions show thick, horizontally layered, irregularly shaped mesas scattered throughout Valles Marineris, Mars. These interior layered deposits (ILDs) are of Hesperian to Amazonian age [1]. Proposed formational processes of the ILDs are lacustrine deposition, subaqueous/sub-ice volcanism, or combinations of processes [2-8]. Using Viking, MOLA (Mars Orbiter Laser Altimeter), and MOC (Mars Orbital Camera) data, a detailed stratigraphic analysis was done on Ganges Mensa, an ILD in Ganges Chasma (-7.5 N, -49.0 W) in eastern Valles Marineris (Fig. 1). The Mensa is 100 x 50 km and rises 4 km above the chasma floor. A geomorphic column was identified for the SW slope of the Mensa. The units were correlated to the rest of the Mensa to investigate layer boundaries, continuity, consistency, thickness, slope, weathering styles, and other characteristics.

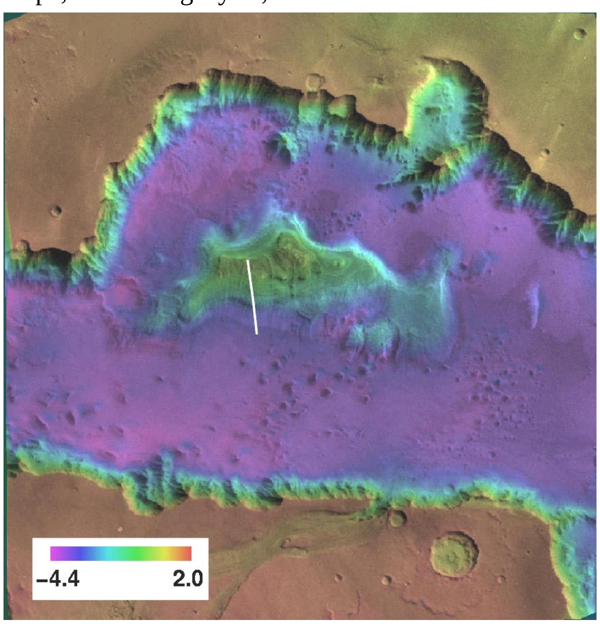


Fig. 1. MOLA topography of Ganges Chasma showing ILDs and location of profile in Fig. 2. Image is 235x240 km.

Data coregistration procedure: 1) Grid MOLA Data. Individual MOLA footprints released through June, 2001, were gridded using a standard TIN (triangulated irregular network) approach. The resulting grid had ~1.5m vertical accuracy, ~300 m N-S resolution, and ~2 km W-E resolution. 2) Coregister Viking imagery and MOLA altimetry. Within ArcInfo the Viking-derived Mars Digital Image Mosaic (MDIM, 233 m/ pixel resolution) was manually shifted for best fit over the gridded MOLA topography. 3) Coregister MOC images with the MDIM. There are 13 narrow-angle MOC swaths crossing Ganges Mensa with 1-10 m/pixel resolution. We warped the MOC swath (maintaining proper image size) to match the MOLA footprints corresponding to the recorded start and end times for the MOC image. The image was then manually shifted to best overlay the Viking MDIM.

Image analysis and unit mapping: We used the MOC and MOLA data to identify distinct geomorphic units, and the MDIM was used to correlate the units between narrow-angle swaths. Units are defined by albedo, slope angle, erosional style and unique geomorphic properties. MOC swath m400323 was used as a type section, and units were correlated to adjacent swaths m702620 and m903505.

Southeast. The southeast section of Ganges Mensa is dominated by two ~10-km wide blocky massifs. MOLA data show that they are separated from the main Mensa by a steep v-shaped valley, and are not slump blocks leaning against the Mensa [8]. The valley floor is level with the surrounding Chasma floor.

North facing slope. The steep north face of Ganges Mensa has subtle slope breaks that, unlike the south face, do not correlate with any apparent layers. Dark sands, also seen on the Mensa top and southern floor, are more abundant on the north face despite its steeper slope. The layers of the north face are marked by contrasting albedo changes and have highly reflective, fine, subparallel layers seen in ~100 m packages that form waves and rough semicircles, but have no apparent large-scale pattern. The layers are not adequately visible to correlate with those on the south face.

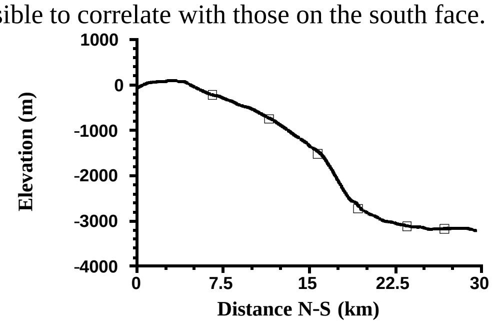
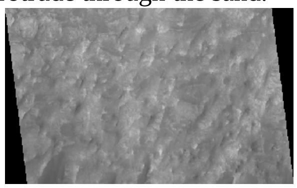


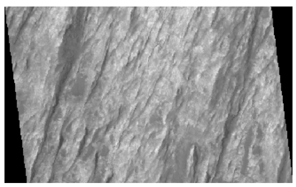
Fig. 2. MOLA profile through SW Ganges Mensa and along MOC swath m400323 . Unit contacts shown as squares.

Southwest. MOC imagery suggests that the narrow subparallel crests visible in the MDIM are yardangs. The south-facing slope of this portion of the Mensa is divisible into distinct geomorphic units. For convenience the units are named for tributaries of the Ganges river. A topographic profile along MOC swath m400323 (Fig. 2) shows that generally the geomorphic units correspond to slope breaks in the topography.

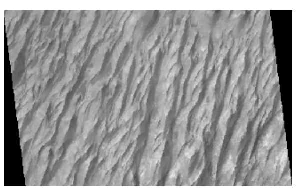
Floor – The floor of Ganges Chasma adjacent to the south face of the Mensa is dark and relatively horizontal. Smooth dunes are formed most likely from fine-grained, sand sized material [9] that may have originated from the Mensa itself. The mounting or descending sand covers deeper deposits that occasionally protrude through the sand.



Gandak Unit– At the base of the Mensa, the medium albedo Gandak Unit is overlain by the dark sand. The Gandak is composed of thin layers, each of which is exposed over 10s of meters. Its sub-horizontal topography has mesas and ridges separated by longitudinal dunes of medium albedo sand.



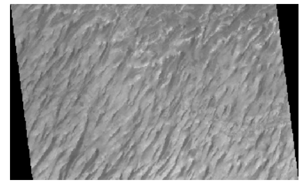
Brahmaputra Unit– High albedo with thin, kilometer-long yardangs trending NE-SW. Between the widely spaced yardangs are rounded troughs that often have sand dunes of medium albedo. The overall topographic slope of the Brahmaputra is ~10°. Within the Unit itself, several subtle layers appear to be horizontal. The Gandak Unit laps onto the Brahmaputra indicating the latter underlies the former.



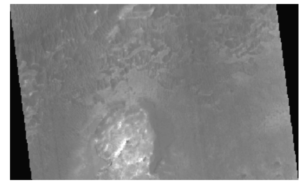
Tista Unit – Shorter yardangs (100s of meters) that are more closely spaced than the underlying Brahmaputra's. The overall topographic slope of the Tista is ~20°. Previously identified as the 'dark layer' that is tilted and truncated [8], the Tista Unit's upper and lower contacts appear conformable and horizontal. Sand cover or other mantling deposit could give the semblance of an angular unconformity [10]. The lower contact has subtle layers and the upper contact is marked by an abrupt break in slope with a few small, widely spaced yardangs (10s of meters) separated by medium albedo, E-W longitudinal dunes.

Yamuna Unit – Smaller, shorter yardangs than the Tista that are sand filled. From bottom to top of the Yamuna, yardangs become shorter and sparse as the amount of sand increases. Some sections show E-W trending ridges similar to the Gandak's.

Gomti Unit – Long, thin, widely spaced yardangs trending NE-SW with sand dunes of medium albedo in the troughs. At the top of the unit the yardangs lessen and eventually fade out.



Top – The Mensa top has large spans of dark longitudinal dunes and linear and circular features. From the top to halfway down the Mensa, two prominent linear, low albedo features run perpendicular to the units.



Conclusions: The units' slopes are consistent with the paleolake hypothesis and benches are potentially ancient shorelines [11]. The layers' alternating albedos, horizontality, lateral continuity, and thickness can be seen as evidence for both the lacustrine deposition and the subaqueous/sub-ice volcanic hypotheses. Circular/semi-circular features on the Mensa top are suggestive of vent structures. However, like studies of other deposits, no features are distinctly volcanic. Conceivably, these structures are immature vents buried by mass wasting [4,7]. The uniform thicknesses of the units would require volcanic activity in a semi-confined area, either provided by water or ice pressure. Subaqueous or sub-ice eruptions could create the massive and fine layering observed and produce materials for the dark sand dunes. Two linear ridges in the center of the Mensa are potential dike structures.

The Mensa's distinct layers may indicate breaks in deposition; change in depositional environment, and/or change in deposit composition [8]. Slope breaks generally correspond to unit contacts. The differential weathering and slope change is evidence for different lithologies.

The Gandak Unit overlying the Brahmaputra implies that there were at least two cycles of deposition on Ganges Mensa. The first cycle would form the majority of the structure (Brahmaputra, Tista…etc.), then either a break in deposition or erosion. A second cycle deposited the Gandak and was followed by erosion.

References: [1] Lucchitta, B.K., (2001), *LPS XXXII*, abs. 1359. [2] Lucchitta, B.K., et al., (1992), in *Mars*, Uof A Press, 453-492. [3] Lucchitta, B.K., et al., (1994), *JGR, v. 99*, 3783-3798. [4] Chapman, M. G., (2000), *LPS XXXI*, abs. 1256. [5] Geissler, P.G., et al., (1990), *JGR, 95*, 14,399-14,413. [6] Murchie, S.L., et al., (1992), *LPS XXIII*, 945-946. [7] Nedell, S.S., et al., (1987), *Icarus, 70*, 409-441. [8] Komatsu, G., et al., (1993), *JGR, 98*, 11,105-11,121. [9] Lucchitta, B. K., (2000), *LPS XXXI*, abs. 1139. [10] Waggoner, J.A., et al., (2000), *LPS XXXI*, abs. 1765. [11] Komatsu, G., et al., (2001), *LPS XXXII*, abs. 1048.