

**ORIGIN OF THE LIGHT-TONED SEDIMENTARY ROCKS IN JUVENTAE CHASMA, MARS.** Ranjan Sarkar<sup>1</sup>, Kenneth S. Edgett<sup>2</sup>, Pragma Singh<sup>1</sup>, Alok Porwal<sup>1</sup>, <sup>1</sup>Geology and Mineral Resources Group, CSRE, Indian Institute of Technology, Bombay, (ranjan.s@iitb.ac.in; ranjan888@gmail.com); <sup>2</sup>Malin Space Science Systems, Inc., P.O. Box 910148, San Diego, CA 92191-0148 USA, (edgett@msss.com).

**Introduction:** Equatorial Layered Deposits (ELDs) are a suite of sedimentary rocks occurring within  $\pm 30^\circ$  of the equator of Mars. These rocks are characterized by a stratified appearance arising from alternating bands of light and dark tone and are interpreted to be composed of hydrated sulfates, which makes these rocks potential targets to search for extra-terrestrial life. These rocks occur in a variety of geomorphic settings such as crater interiors, intercrater plains, and within canyons. The evidence for the sedimentary origin of these rocks include patterns of erosion idiosyncratic of sedimentary rocks, fine particle sizes, and absence of characteristic features attributable to volcanic rocks. A variety of mechanisms have been proposed for the formation of these deposits, such as deposition/chemical precipitation in volcanic, lacustrine, sub-ice volcanic settings; however, none is able to explain all geological features of these deposits. Moreover, higher resolution orbiter images (e.g., HiRISE) and ground data from rovers continuously reveal new features, making it necessary to regularly review the earlier held views and update them.

Interior Layered Deposits (ILDs) are a subclass of the ELDs that occur within the Valles Marineris. There are several chasms known to contain these deposits, namely Ius, Tithonium, Melas, Candor, Hebes, Coprates, Ganges, and Juventae. Understanding their geology, particularly the timing of their formation relative to the events which opened the Valles Marineris troughs and associated chasms and chaotic terrain, and created the large outflow channels to the north (Baker and Milton, 1974), is important for understanding the history of early (Noachian- 4.1 to 3.7 Ga to Hesperian-3.7 to 3.0 Ga) Mars.

**Objectives:** Through examination of Juventae Chasma, in this work addresses the following:

1. the tectonic evolution of the chasm,
2. the stratigraphic position of the light-toned sedimentary rocks with respect to the darker-toned wall rocks of the chasm,
3. the structural history of the light-toned mounds, and
4. the original depositional settings of the light-toned rocks.

**Study Area:** Juventae Chasma, a peripheral box canyon located northeast of the main Valles Marineris trough system, was selected as the study area because of the following reasons: Firstly, it contains four large exposures of light-toned rock units (Fig. 1), for which there is adequate orbital data coverage. Secondly, the

light-toned rock exposures are located in close proximity of the chasm walls, which makes it easy to understand the stratigraphic relation between the two. Thirdly, Juventae Chasma includes a chaotic terrain in its northern portion (Fig. 1), which can provide relevant clues to: 1) regional events such as chaos formation and its relation to canyon incision; 2) timing of light-toned rocks emplacement relative to canyon development; and 3) relation of canyon formation to regional tectonic events.

**Datasets and Methodology:** Data from the following instruments were used: HiRISE, CTX, MOC-NA, THEMIS Daytime-IR, HRSC, and MOLA. DEMs were generated using USGS ISIS and AMES Stereopipeline [1] and layer attitudes were measured with the Layer-Tools add-in for ArcGIS [2].

**Results and Discussion:** The major findings of the research are: (1) The light-toned rocks in Juventae Chasma are older than the chasm, as evidenced by the nature of contacts with the canyon wall rocks and floor [3]. (2) The opening and tectonic evolution of the Juventae chasm was partially controlled by regional tectonism in the adjoining plateau; some of these tectonic events are also imprinted on the light-toned rocks, indicating that they were existing before the chasm opened. (3) The stratal configuration of the light-toned rocks is best explained by an eolian (Fig. 2) (or lacustrine, in one particular case) depositional setting within isolated depressions (e.g., craters) that were buried by younger geological units, perhaps including lava flows.

**Conclusions:** A model for the evolution of Juventae Chasma and the light-toned rock exposures within it is presented in Figure 3. The timing of formation of light-toned materials has important implications for the relative timing of geologic events and episodes in the Martian past. A pre-chasm formation of light-toned rocks [4] would indicate that these rocks are considerably older than is generally believed, and therefore represent a record of earlier Martian environments (pre-dating the Hesperian-aged plains into which Juventae Chasma is cut) that favored the formation of rhythmically layered sedimentary rocks containing hydrated minerals, which, in turn, indicate the presence of large amounts of water. Therefore, the light-toned rocks of Juventae Chasma and other canyons of the Valles Marineris canyon system merit further detailed studies. This research points out several questions that future studies could aim at answering. It would not be exaggeration to say that a considerable record of the geological evolution of Mars is

hidden away in these light-toned layered rocks. The processes that led to the formation and the present structural and stratigraphic configuration of these rocks may, in many ways, differ, and in other ways resemble sedimentary and tectonic processes on Earth. The present knowledge of these rocks is mainly derived from orbital data which have significant limitations in terms of spatial and spectral resolutions; however, as more and more ground (Mars surface)-based data become available, the current understanding of these light-toned layered rocks is likely to be significantly revised.

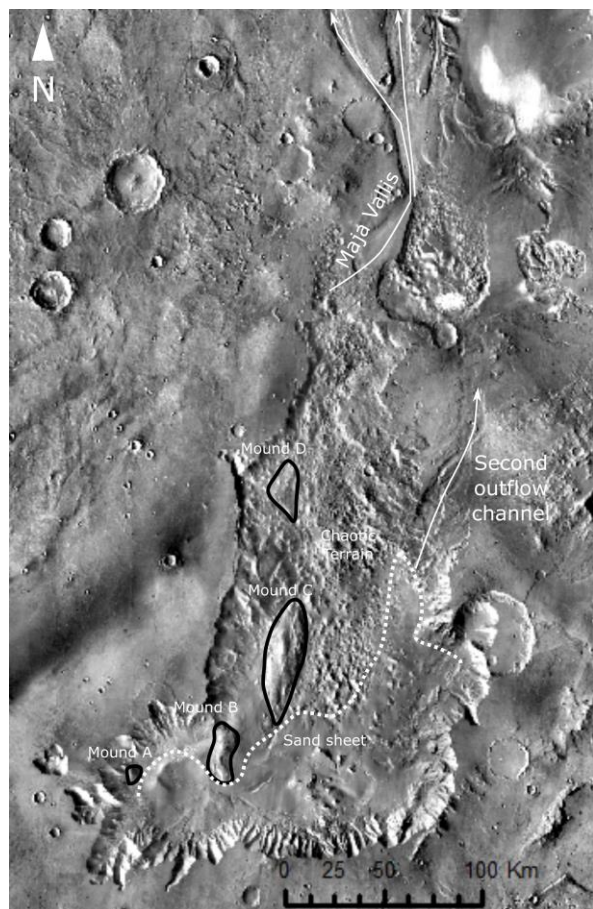


Fig. 1. The light-toned mounds are outlined in black. The white dotted line separates the sand sheet in the south from the chaotic terrain in the north. The two outflow channels, one of which is Maja Vallis, are also marked.

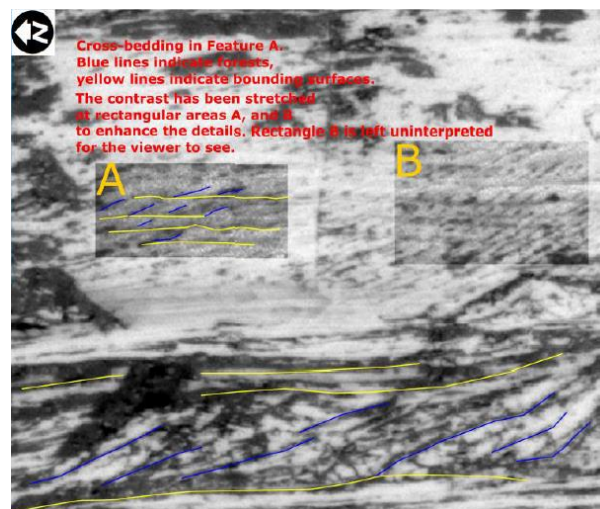


Fig. 2. Cross-beds and bounding surfaces within the light-toned rocks.

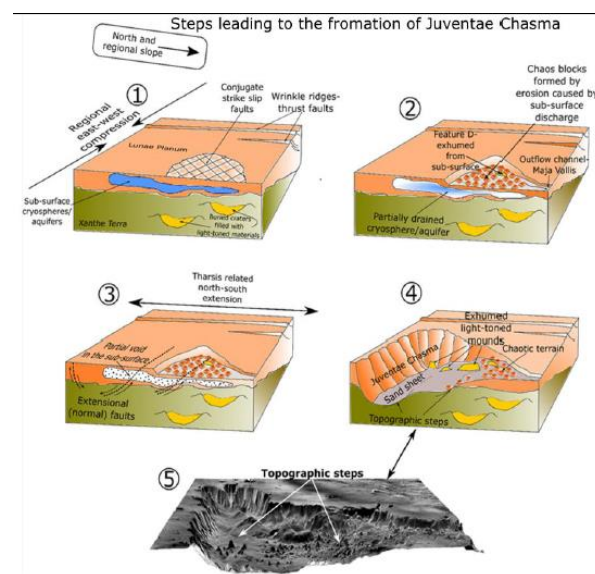


Fig. 3. A model for the evolution of Juventae Chasma.

**References:** [1] Bayer, R. A., et al., (2017) *NeoGeographyToolkit*. [2] Kneissl, T. et al., (2010), LPSC Abstract# 1640. [3] Sarkar, R., et al. (2018) *Icarus*, 112, 7–35. [4] Malin, M. C. and Edgett, K. S. (2000) *Science*, 290, 1927–1937.