EPSC Abstracts,
Vol. 4, EPSC2009-555, 2009
European Planetary Science Congress,

Episodic Floodings at Maja Valles and Juventae Chasma

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Introduction:

Juventae Chasma is located at the northern side of the Valles Marineris. It stretches for approximately 150 km east-west and 250 km north-south. The smooth, sand filled basin floor shows a depth of 5 km and more below the surrounding surface. Juventae Chasma comprises several light-toned layered deposits (LLD). The four most prominent ones have been labeled from south to north A-D by [1]. To the north lies the adjacent Maja Valles, a 50 km to 150 km wide, ramifying channel system extending for 1600 km northward and discharging into the Chryse Planitia plains, the landing site of Viking 1 in 1976. The floor of the channels shows giant ripple marks and streamlined islands pointing to heavy erosion by tremendous flooding events.

We investigate the age relationship of Juventae Chasma to the adjacent Maja Valles in order to gain a feasible explanation for the formation and evolution of rhythmic light-toned layered deposits (LLD). Starting from Juventae Chasma and following the valleys in northward direction, a number of cross-cutting channels can be observed. One of our goals is to determine the number of outflows in that area and to constrain their age relationships to the episodic history of Mars.

Previous work:

Various investigations of several authors have been carried out on this subject in the past, but the formation of the LLD in Juventae Chasma is still poorly understood. The formation theories range from a volcanic origin as the result of sub-ice volcano eruptions [1], lake deposits, delta-deposits [2] to spring deposits [3]. A very different hypothesis for the formation of the sulfates is deposition from airfall. This could happen as dry deposition from the atmosphere or in co-precipitation with icy materials such as snow crystals or dust particles. This phenomenon is observed at the poles of Mars, where rhythmic layerings occur, showing high similarities to the sulfate deposits in Juventae Chasma. The light-toned materials in the chasma show a spectral signature indicative of kieserite in the outcrops A, C and D and in the lower part of B, whereas the upper part of B was described as gypsum [4]. Wendt et al. [5] identified different mineral assemblages in the cap-rock of mount B, using the CRISM instrument and the Multiple-Endmember Linear Spectral Unmixing Model (MELSUM).

Techniques:

HRSC and OMEGA (Mars Express), MOC (Mars Global Surveyor) as well as HiRise and CRISM (Mars Reconnaissance Orbiter) data was used for generally mapping the target area. The dating of the planetary surfaces in the regions of interest by impact crater size-frequency distribution was carried out using HRSC and CTX images. For better understanding of the complex layered sulphate mounds in the chasma, HiRise Anaglyphs were produced. In order to calculate volumes and the relief, a Digital Terrain Model (DTM) mosaic was produced (Fig. 1).

HRSC-DTM:

The Digital Terrain Model (DTM) mosaic (see Fig. 1) was derived from 11 HRSC orbits at approximately -7° S to 8° N and 295° to 301° E with a ground resolution of 100 m per pixel and an orthoimage mosaic with a ground resolution of 12.5 m per pixel. The main processing tasks for the DTM derivation are first a pre-rectification of image data using the global MOLA- based DTM, then a least-squares area based matching between nadir and the other channels (stereo and photometry) in a pyramidal approach and finally, DTM raster generation. Improved orientation data are necessary for high-resolution digital terrain models and ortho-image mosaics. For this purpose,

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new exterior and interior orientation data, based on tie-point matching have been used. The bundle adjustment approach for photogrammetric point determination with a three-line camera is a least squares adjustment based on the well known collinearity equations [6]. The construction of the HRSC-DTM is the basis for further investigation of the masses and volumes, transported from Juventae Chasma through Maja Valles.

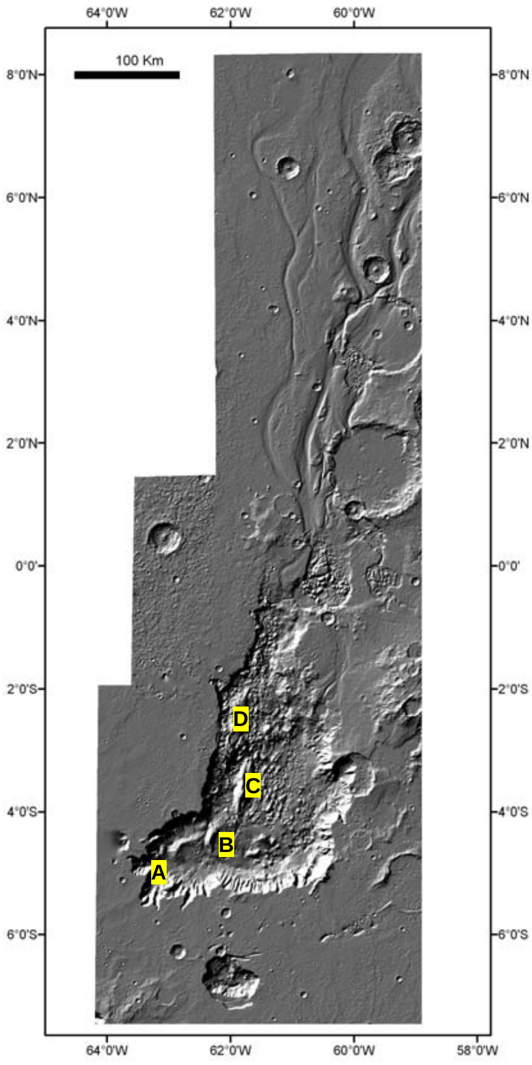

Figure 1: HRSC-DTM of the Juventae Chasma and Maja Valles-Area. The sulphate deposits are labeled A, B, C and D. The different streams of the outflow channel can be clearly identified above the equator-line.

Results:

Our age determinations for Juventae Chasma indicate an age of 3.33 Ga, measured at the bottom of sulphate-mound B on a cratered rock terrace cropping out of the surrounding dune fields.
The results of the determinations of the impact crater size-frequency distributions in Maja Valles show different ages within an area close to the pour point of Juventae Chasma. An age of 1.22 Ga (+/- 0.16 Ga) was calculated for the western part of the Maja Valles channel, whereas the south-eastern channel (close to the streamlined island) is showing much older ages of 3.68 Ga (+0.08/-0.17 Ga) and 2.18 Ga (+/- 0.31 Ga). This clearly indicates, that multiple flooding events took place in the area.

Conclusion

Juventae Chasma has a formation age of at least 3.33 Ga. The investigated sites at Maja Valles clearly show evidences for multiple outflow events. Some of these events took place before the formation of the sulfate deposits in Juventae Chasma. Our datings are also showing, that different and presumably non-continuous colossal floods occurred, carving the Maja Valles channel network into the Martian plains. Further age determinations and mapping, as well as the expansion of our HRSC-DTM in north- and in eastward direction will be carried out to obtain a chronology of events of this highly interesting area in the equatorial regions of Mars.

Acknowledgements

This research has been supported by the Helmholtz Association through the research alliance “Planetary Evolution and Life” and by the German Space Agency (DLR) in the context of the Mars Express project.

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