Geological analysis of Interior Layered Deposits from Gangis Chasma to Iani Chaos on Mars

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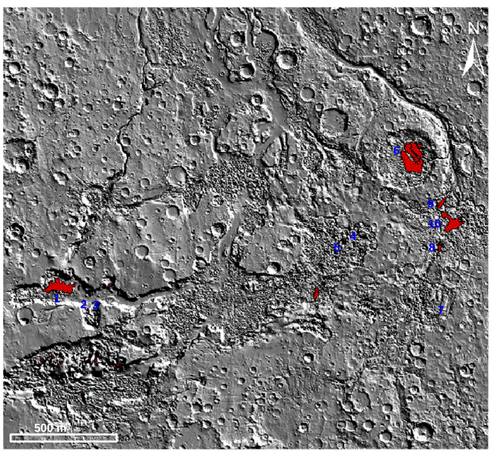
Introduction

Interior layered deposits (ILDs) have been analysed specially in the western part of the Valles Marineris (e.g. Hebes, Melas, Coprates, Juventae Chasmata). We concentrate on the layered deposits in the eastern part (Gangis, Eos/ Capri Chasmata) and in the chaotic terrains (e.g. Aureum, Iani Chaos) that are not so well-known and study their structure regarding elevation, stratigraphic position, thickness and geometry using HRSC- and high resolution MOC-data.
ILDs appear at different elevations and are of different morphologic character but a classification is possible.



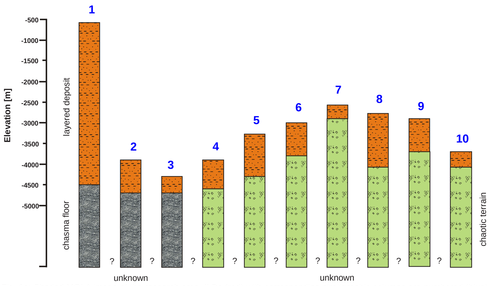


Fig. 1a: Shaded MOLA image of the research area. ILDs (red) with corresponding stratigraphic columns are numbered (blue). Fig. 1b: Stratigraphic columns of ILDs in chasmata and chaotic terrains from West to East. The stratigraphic ranges are inferred from elevation data (DTMs). The vertical extent of chasma floor and chaotic terrain respectively is not known yet. ILD 1 (Fig. 1a, Fig. 4, Gangis Chasma) shows the highest thickness, one of the lowest is found south of Margaritifer Chaos (ILD 7). The transitions to the underlying rock formation vary from -4700 to about -600 m.

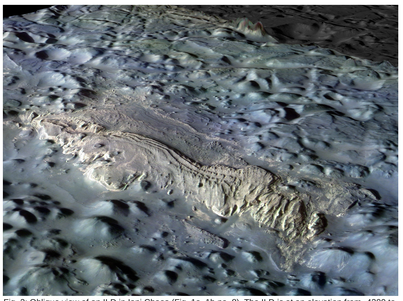
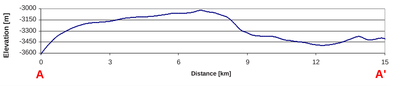


Fig. 2: Oblique view of an ILD in Iani Chaos (Fig. 1a, 1b no. 8). The ILD is at an elevation from -4200 to -2900 m and is of 35 km length. A rough surface and bedded structures are observed (Fig. 3).



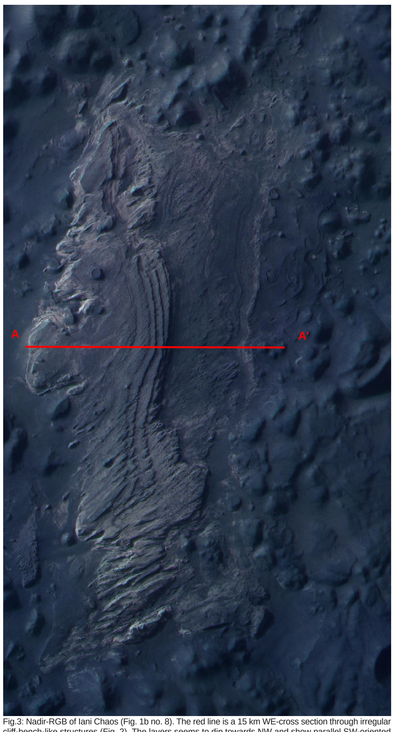


Fig.3: Nadir-RGB of Iani Chaos (Fig. 1b no. 8). The red line is a 15 km WE-cross section through irregular cliff-bench-like structures (Fig. 2). The layers seems to dip towards NW and show parallel SW-oriented lineations.

ILD classes

The ILDs are divided into classes. In Gangis Chasma and in the chaotic terrains they sometimes show light and dark layering (A). Most of them are eroded into yardangs with rugged surfaces, steep slopes (Fig. 2, 3), slump structures, fractures, and fine layering in the lower parts massive material in the upper parts (B; Fig. 1a; 1b no. 2; Fig. 5; 8). Debris fans exist on nearly every slope. In Aram and Aureum Chaos plate-like ILDs with smooth to coarse surfaces are detected (C; Fig. 6), the layering seems to be horizontal to subhorizontal (slope$_{\text{Aram crater ILD}}$ ~15°). In Aurorae Chaos some ILDs show fan-like morphologies with heavily fractured and rugged surfaces indicating flow directions (D; Fig. 7) from the north (in contrast to the indicated flow direction in Juventae Chasma). Flow-like structures are also observed in Iani Chaos were the ILDs embay mounds of chaotic terrain.

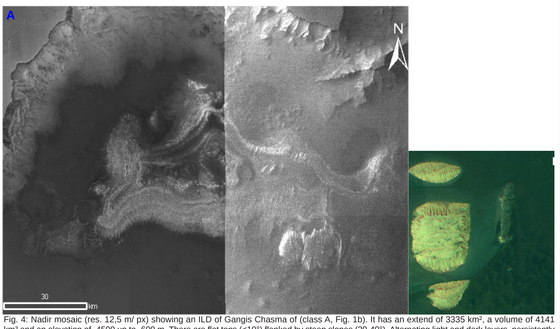


Fig. 4: Nadir mosaic (res. 12,5 m/ px) showing an ILD of Gangis Chasma of (class A, Fig. 1b). It has an extend of 3335 km², a volume of 4141 km³ and an elevation of -4500 up to -600 m. There are flat tops (<10°) flanked by steep slopes (20-40°). Alternating light and dark layers persistently crop out around the complex.
Fig. 5: Nadir-RBG of a layered deposit in Gangis Chasma (Fig. 1a) showing ILD class B (Fig. 1b, no. 2; Fig. 8). The block in the centre extends to 4 km width; north toward top. At the margins faults planes are exposed.

Fig. 6: Nadir-RGB of Aureum Chaos. The occuring deposit has a plate-like structure (Fig. 1a, 1b class C). The width of the structures is ~5 km; north toward top.

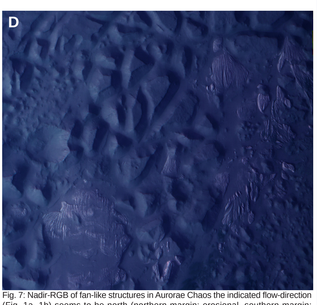


Fig. 7: Nadir-RGB of fan-like structures in Aurorae Chaos the indicated flow-direction (Fig. 1a, 1b) seems to be north (northern margin: erosional, southern margin: frayed). The rough, fractured surfaces show a parallel orientated NS-trending lineation. Streamlined islands may be explained by fracturing; north toward top.

Hypotheses for the formation of ILDs:

For more than 30 years, ILDs have been known and analysed but their origin remains uncertain. Many authors studied their formation processes. Following hypotheses concerning their origin are considered:

- eolian [1] and

- lacustrine deposition [2],

- pyroclastic volcanism in subaerial [3,4,5,6] or

- sub glacial environments [7,8].

These hypotheses imply that the ILDs are younger than the troughs in which they formed. Another aspect is that the ILDs are ancient deposits exhumed due to uplift of the basement [9,14].

Various morphologies of ILDs may be related to different formation processes.

However, the knowledge about these deposits still grows as sulfates were detected in chasmata and chaotic terrains by OMEGA [10]. Sulfates probably point on aquatic conditions as phyllosilicates elsewhere on Mars [11,12]. Sulfates generate by:

- hydrothermal alteration of volcanic material
- evaporation by decreasing water availability

In Aram Chaos water-indicating minerals like hematite were observed in the layered deposits. Therefore, [10] assume a lacustrine origin.

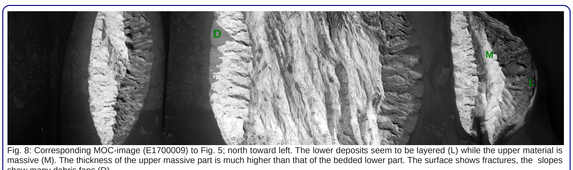


Fig. 8: Corresponding MOC-image (E1700009) to Fig. 5; north toward left. The lower deposits seem to be layered (L) while the upper material is massive (M). The thickness of the upper massive part is much higher than that of the bedded lower part. The surface shows fractures, the slopes show many debris fans (D).

Conclusions

The ILDs have various morphologies and show different weathering patterns which may point to different rock material. All ILDs in the research area lie beyond the surrounding level of the canyon rims (from about -600 m to -6000 m at least). Therefore, a lacustrine origin as in Juventae Chasma (compared to Hebes Chasma) is not excluded. They show a young erosional age (hardly cratered) and superimpose the chaotic terrains. Debris fans and a lack of boulders at the base of the ILDs may also point to loose to partly consolidated sedimentary rocks.

Further working aspects

Orion structural analysis software along with high-resolution DTMs is applied to get information about the internal layer geometry (the layers' strike and dip) to reconstruct the tectonic history. Furthermore, the mineralogy may lead to the processes concerning the ILD formation and discriminate between hypotheses concerning their origin. If a same stratigraphic pattern within the layering is found a correlation is possible and a common origin can be assumed.

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