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Interior Layered Deposits on Mars: Insights from elevation, image- and spectral data of Ganges Mensa

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Introduction

Interior Layered Deposits (ILDs) are exposed at various locations on Mars. They differ from their surroundings by their higher albedo, morphology, and fine layering. Their origin (sedimentary or volcanic) is well discussed [e.g. 1-3] but Fe-oxides and hydrated minerals such as sulfates [4-6] have been detected on ILD surfaces suggesting an aquatic environment.

Here we present some features of Ganges Mensa. We looked at HRSC elevation data [7], THEMIS brightness-temperature and CRISM data to understand differences in morphology and composition.

Ganges Mensa observations

This ILD shows sub-horizontal layering and mesa morphology (flat top and steep slopes). Its stair-stepped morphology is shown on Fig. 3 and does not appear in ILDs occurring in the eastern chaotic terrains (Iani, Aureum, Aram, and Arsinoes Chaos) but in other ILDs in Valles Marineris (e.g. Hebes).

Ganges Mensa features fresh-eroded light-toned layers appearing competent, forming steep scarps and having high surface temperatures as well as thermal inertia. The dark material corresponds to accumulations of wind-transported matter that covers flatter slopes and shows lower brightness-temperatures. Analyses of CRISM and image data (HRSC, MOC, HiRISE) indicate that there are differences in texture and mineralogical composition as well.

CRISM observations show that the lower sequence of the ILD (consisting of many layers) has a strong kieserite signature as observed by [8]. Exposed windblown dark material on its surface has no olivine, pyroxene, or ferric oxide spectral features. This unit comprises an approximate thickness of ~1.6 km out of 3.5 km for the whole ILD and is very rough and coarse looking. There, the surface temperatures (Fig. 2) as well as thermal inertia values are much higher which is in agreement with [8]. A transition zone characterized by a discrete layer at an elevation of about -1.9 km marks the beginning of the upper unit (Fig. 1-3). In the upper unit, weak polyhydrated sulfate (PHS) features are observed in the light-toned material while the dark dunes on top and in grooves show clinopyroxene (HCP).

The mineralogy might correlate with the steepness of the slopes observed by [8,10] for kieserite being exposed in steeper parts and polyhydrated sulfates in less steep parts. As the ILD is composed of alternating steep and less steep parts, less steep parts may possibly exhibit polyhydrated sulfates that are covered by windblown material.

We observe a higher thermal inertia in the lower, fresh eroded kieserite unit (400-600 SI) than in the upper unit that shows polyhydrated sulfate features (300-500 SI) which is not coincident to observations in West Candor Chasma ILD [11] but may be due to weak PHS signal or hydration state of PHS. The same is observed comparing kieserite exposed on steep exposures and PHS [12] in Capri Chasma.

ILDs observed in other regions

ILDs have various morphologies. They often appear as mounds or hills. Massive cap rock at their top and layering in lower parts is also very common. Material enclosing chaotic structures, terrace-like appearances, and knobs are visible. Varying surfaces (knobby, rough, fractured, grooved, cap rock) are widespread as well as talus exhibited on steep slopes. Yardangs and flutes on their surface as well as dunes located in surface fractures indicate that the material is highly affected by wind erosion and therefore weakly consolidated. The contact between ILD and chaotic terrain often is covered by dusty and/or fine-grained material, but few MOC-images [9] show the stratigraphic position of ILDs superposing chaotic terrain, and indicating a younger age.

Layering is observed at different elevations at MOC-scale reaching from -4.6 km up to -1 km, but mostly between -4.5 km up to -3 km and is absent in upper parts that are mostly cap rock. The vertical thickness of layered material is high in Ganges Mensa and low in other regions of Ganges or the chaotic terrains, e.g. Arsinoes. We discriminate between less than 16 layers and less than 7 layers we counted at MOC-scale. Apparently, there is no trend between the number of layering and topographic location. Even in regions where we see massive cap rock material, at HiRISE-scale, there is layering.

Summarizing, some ILDs show sulfate minerals while others do not, e.g. other ILDs in Ganges Chasma. There, no spectral signature is detectable by CRISM. That implies that their surface, which obviously is freshly eroded, apparently is not composed of iron-bearing and/or hydrated minerals. Nevertheless, these ILDs are interesting as well even if there are differences in the surface composition. These differences might have several reasons since the whole ILD must not be sulfate-rich and other evaporite minerals such as halite, sylvite or silica-rich minerals as plagioclase fit in the discussed hypotheses that formed ILDs. In the saliniferous-formation-cycle for instance, carbonates (calcite, dolomite) form first. Then sulphates (anhydrite, gypsum) and at last easy soluble sodium-, potassic- and magnesia salts (halite, sylvite, and carnallite) are formed. Additionally these spectrally neutral outcrops are strongly affected by erosion that may also explain the lack of CRISM sensitive mineral features. At least not all ILDs must have formed the same way. A correlation between ILDs may give clue to their formation processes.

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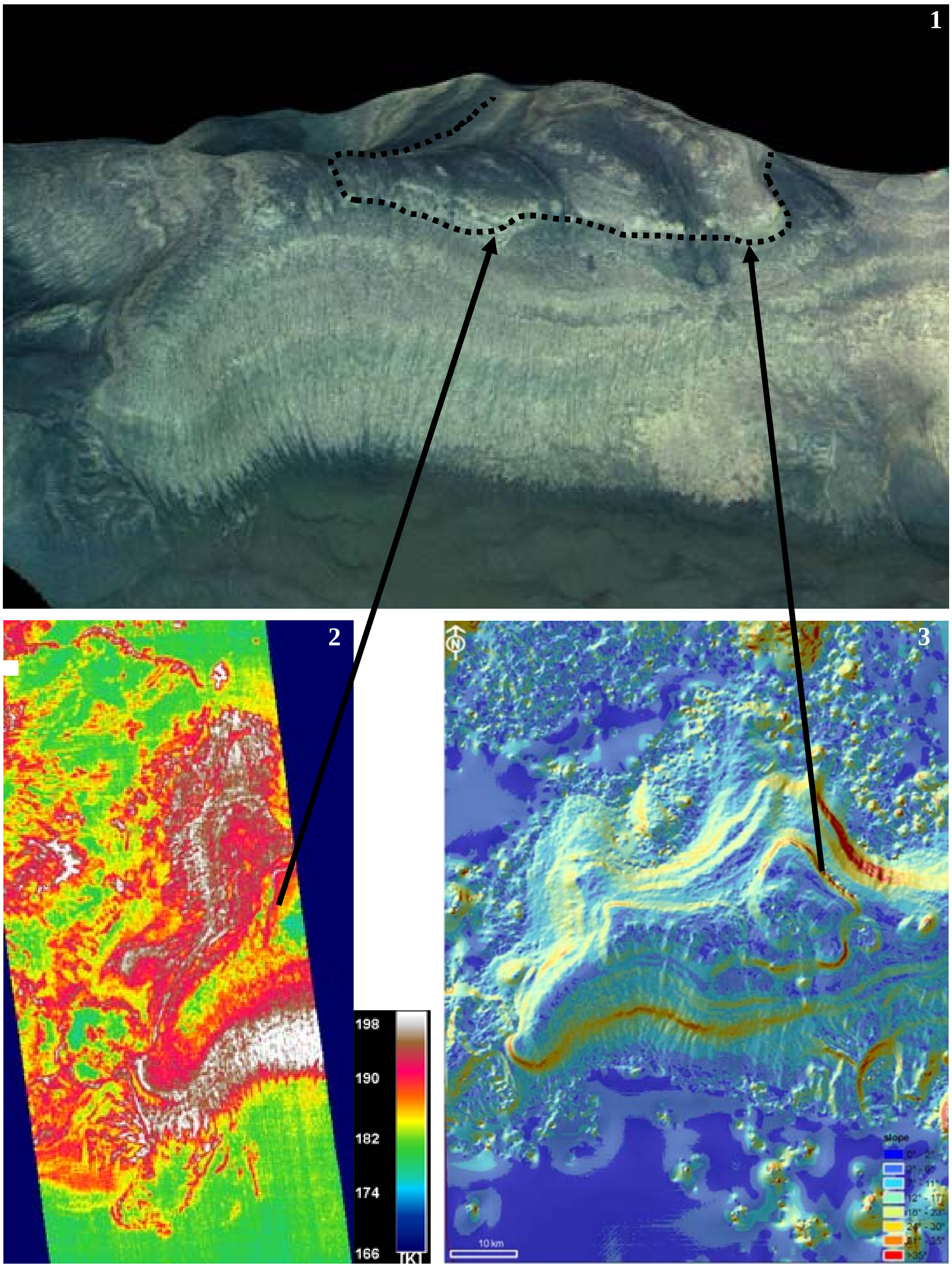

Fig. 1-3: Ganges Chasma ILD showing different mineralogical features in lower and upper part, transition zone marked by arrows and dotted line (HRSC perspective h2211_0000). Fresh eroded regions having higher surface temperatures (THEMIS BT I01706003) and steeper slopes (>25°) corresponding to yellow and red colors (HRSC slope map h2211_0000).