Distribution and Evolution of Cold-Climate Landforms in a Subpolar and Hyperarid Environment, Hellas Planitia, Mars

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Located in the mid-latitudes of the southern highlands of Mars, Hellas Planitia is the second-largest confirmed impact basin on the planet, having a diameter of 2,300 kilometers. The basin also contains the lowest elevated parts of Mars, and hence, the highest atmospheric pressure on the planet of up to 11 millibar. Temperatures vary by season from 150 to 300 K. Thus, this vast depression is one of the atmospherically most active regions of Mars. This is also shown by the seasonal dust storm activity in Hellas Planitia. More than 90% of the basin's floor is covered with so-called Latitude-Dependent Mantling deposit (LDM); a several meters-thick layer draping the surface. It is believed to consist of a mixture of dust and ice falling out of the dusty atmosphere. It is unclear if this process is still active on Mars. However, according to crater-size frequencies, it deposited on geologically recent times (0.1 – 1 Ma). At certain environmental conditions LDM appears to get deformed or eroded into several morphologies, Layered Remnant Deposits in crater (LRD) or a scalloped terrain.

Results are based on a newly developed method for planetary mapping called grid-mapping **[Ramsdale, 2015]**. This is a useful method for analyzing the geospatial distribution of pre-defined landforms over a large area, by using high spatial resolution datasets. By using this method, the whole study area is separated into 20,000 grids, each with a size of 20×20 kilometers. Mapping has been carried out in a GIS environment on the basis of CTX images (Context Camera onboard the spacecraft Mars Reconnaissance Orbiter) at a scale of 1:30,000. Because of the huge size of the study area, only every second grid has been mapped (approx. 10,200 in total).

Our mapping results have shown that there is a significant elliptical gap of LDM in the NE part of Hellas, measuring 800×200 kilometers. The rest of the basin is covered by LDM. However, the more south the LDM is, the less it is textured and eroded, and appears to be young and smooth.

Scalloped terrain is referred to rimless and often axisymmetric depressions, formed by subsurficial loss of ice and/or volatiles; like it is assumed to be contained in the LDM. They always show a steep pole-facing rim at their northern side, and a gentle equator-facing rim at their southern side. It is assumed that their topography and development is linked to solar insolation and latitude. Although there is an almost completely closed LDM cover in Hellas, scalloped terrain only appears in scattered places south of 35°S. However, there is no obvious distribution pattern recognizable.

North of 37°S there is an increased prevalence of LRD within smaller craters (0.1 – 3 kilometers in diameter). They usually occur on the southern parts of the crater interiors, and are hence exposed to the Sun. High-resolution images of the HiRISE camera (also on board of the Mars Reconnaissance Orbiter) have shown that LRD consists of a brittle material cracked into polygons.

We hypothesize that lack of LDM in NE Hellas may be the result of wind circulations within the basin. According to **Howard et al. [2012]**, wind currents rotate clockwise in Hellas. Cold polar winds enter the basin at a gap in the rim in SW Hellas, draining down from the south polar highlands toward the north. When they reach the northern parts of Hellas at a latitude of 30°S they are likely to warm up, and begin to move south again. Thus, they may have either sublimed the LDM material in NE Hellas or prevented an atmospheric deposition as the winds have become too dry at that place. This observation supports theories of a high amount of volatiles within LDM.

The evolution of LRD remains much more enigmatic. We hypothesize three different scenarios. (1) *Eolian processes* might have caused sublimation. But wind does not explain the strict location of the CCF in the southern half of the crater bowls over such a huge area. (2) *Volcanic ashes*, transported over wide distances, like the Medusae Fossae Formation along some equatorial regions on Mars, are also a possibility. They can explain the uniform orientation of the LRD's. However, there is no known volcanic feature northwest of Hellas. However, climate modeling by **[Kerber, 2012]** suggests that a dispersal of volcanic ashes is possible, but only originating from volcanoes northeast and southwest of Hellas. (3) *Solar insolation*, and hence thermal sublimation, could explain the uniform location of these remnants over a big area. Moreover, this could explain the latitude-dependence of this landform, as they predominantly occur north of 37°. But this does not explain why the LRD-layers consistently "survived" in that part of craters that receives the most intense solar radiation. This theory would be conclusive if LRD's were located in the shaded northern half of a crater. However, we assume this scenario as the most likely. Because of Mars' permanently changing obliquity of up to 47° within the last 20 Ma, it is also possible that the northern parts of the crater interiors once received a high amount of solar insolation even at these latitudes. Thus, the volatile-rich material could have been removed there. If LRD is or was rich in volatiles, it is likely that it is composed of the same material like LDM. Another explanation for this paradoxical location might be that the LRD's are a result of an inverted relief.

Despite scalloped terrain is latitude-dependent, it does not appear continuously south of 35°S, although there is a complete LDM cover. A possible reason for this scattered pattern might be a varying amount of volatiles within the LDM blanket.

On basis of grid-mapping, it was possible to analyze the geospatial distribution of cold-climate landforms in Hellas. Thereby, an extensive elliptical gap of LDM in NE Hellas became apparent; probably caused by clockwise wind circulations within the impact basin, causing either prevention of LDM deposition or sublimation of a pre-existing LDM layer. The exact evolution of Layered Remnant Deposits (LRD) is still poorly understood. However, it appears likely that these deposits were eroded by a process controlled by solar insolation (i.e. sublimation), which means they contained, or still contain, certain amounts of volatiles like ice. Hence, our observations support existing theories of a volatile-rich layer in the Martian mid-latitudes, typically termed LDM. Detailed statistical evaluations of our grid map will test, i. a., if there is a correlation between landforms and their elevation, aspect, and slope. Thus we will be able to derive further information about atmospheric conditions and layering within Hellas as well as the influence of obliquity cycles.

References:

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