LAYERED DEPOSITS AND PITTED TERRAIN IN THE CIRCUM HELLAS REGION.

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Introduction: Much of the southern highlands has been mantled since the Noachian, including a general blanket of possibly airfall-derived sediment that softens the landscape [1,2,3,4], the Electris mantle [5] including knobby 'chaos' in several basins [6], and a variety of deposits that are the subject of this study that share the common characteristics of being generally confined to basins and crater floors and that manifest irregular interior depressions. Many of these features occur in a zone surrounding Hellas (Fig. 1). These deposits share the general characteristics of having fairly smooth, nearly planar surfaces and abrupt scarps bordering interior and marginal depressions. Despite these common characteristics, a wide range of morphologies occurs. Several end-members are discussed below.

End-Member Landforms: Pitted crater floors in the Hellas rim zone At least 33 craters surrounding the Hellas basin exhibit irregular pitting (Fig. 1), most of which occur near the center of an otherwise smooth crater floor (e.g., Fig. 2, P in Fig. 1). The abrupt scarps bordering the pits generally surround a nearly flat-floored inner basin. Apparent layering is exposed on some scarps (although not in Fig. 2). Pitted craters west of Hellas are generally associated with smooth, undulate, and sparsely channeled crater rims. The 'softened' crater rims may have been formed either by selective airfall deposition or by non-linear creep processes [2]. The temporal and process relationship between the pitting and the smoothed, channeled crater walls is uncertain but under investigation.

Layered Deposits of Terby and Other Craters A thick sequence of layered deposits occurs on the northeast margin of Terby Crater (T in Fig. 1). Apparent remnants of the top of the deposit slope southward from the northern rim of Terby as broad plateaus, but much of the deposit has been eroded by deep troughs incised up to 2.5 km below the plateau surfaces. The most complete erosion has occurred at the southern portion of the deposit, creating a moat-like depression. Similar, but thinner deposits occur in a number of large crater basins north and east of Hellas, including Millochau Crater, as discussed by [7] (M in Fig. 1).

Gorgonum Chaos Platforms Flat-surface benches ring a central depression about 100-150 m lower in the center of the Gorgonum Chaos Basin. The bench planforms are very irregular, with long, branching reentrants, enclosed depressions, flat-topped guyot-like mesas within the central depression, and rings around older mesas of the Gorgonum 'Chaos' [8]. The platform edges drop as abrupt, 50-100m scarps into interior depressions. The scarps exhibit apparent tensional fractures along their top margin, but show little collapse or slumping. [8] explored a number of hypotheses for the origin of these features and tentatively conclude that they originated by deformation of sediments beneath an ice-covered lake. Similar, but generally less extensive planar benches and interior depressions occur within a number of crater basins in mid southern latitudes (as is possibly seen within the crater shown in Fig. 2). Exposed layering is not obvious.

Common and Disparate Characteristics: Do they have a Similar Composition and Origin? The landform suites described above share the characteristics of smooth upper surfaces and abrupt scarps bordering interior and, sometimes, marginal depressions. They also generally occur in mid-southern latitudes. Most occur in depressions and some expose layering at the scarp edges. Most appear to be post-Noachian in age. They may share a common origin or there may be two or more distinct environments and geologic history. The following paragraphs briefly explore the possible materials beneath the flat surfaces, the origin of the pits and erosional features, and overall scenarios for the origin of the landforms.

Possible Composition of Deposits: 1). Ice and Dust: The scenario proposed by [9,10,11] suggests that the deposits in the pitted Cavi Angusi and Cavi Sisyphi in the south-polar region are ablated analogs of the more recent polar layered deposits (PLD). The deposits, however, do not exhibit the intricate layering of the modern PLD nor the topography of steps and troughs that characterize the PLD. The well-developed layering of the Terby-type deposits are more suggestive of PLD deposits, and their apparent banking against one side of the crater basins that contain them argues against fluvial or lacustrine sedimentation [12]. 2). Fluvial or Lacustrine Sediments: The restriction of most of the deposits to basins is consistent with fluvial or lacustrine deposition. The top surface of many of the deposits is nearly flat-lying, consistent with a strong gravitational control during the formation of the deposits. However the deposits in general do not have obvious connections to source regions supplying sediment. In addition, the landform surfaces, while nearly planar, often have subtle (strong in the case of the Terby deposits) slopes across the basin in which they occur, as in the Gorgonum Chaos benches [8]. 3). Airfall Deposits of Aeolian or Volcanic Origin: Both volcanic ash/ignimbrite or aeolian loess deposits might accumulate locally to form thick massive or layered deposits, as was recognized by [5,13]. The flatness of the top surface and well-defined edges of the landform suite may be inconsistent with a primary landform origin through airfall deposition, although the deposits may have preceded development of the surficial landforms of benches and pits. 4). Volcanic flows: The lack of association with volcanic sources, absence of flow features, and abrupt, steep scarp edges weigh against this composition.

Possible Origin(s) of Pits and Erosional Features: 1). Primary Features (Never Infilled): The pits and depressions might be areas that never accumulated the deposits found beneath the adjacent flats. This could be because the deposits accreted laterally from the edges and were never able to totally infill the basin or that the depressions were sites of dissimilar deposits that have subsequently disappeared (e.g. ice). 2). Basal Melting: This mechanism, involving basal melting of ice-rich deposits was suggested for the formation of polar pitted terrains by [9,10]. In the features studied here, absence of obvious fluvial drainage and the location within enclosed depressions do not favor this mechanism. 3). Slumping or Collapse: The basins might be structural collapse features from removal of materials at depth by, e.g., solution or melting. This is distinct from the basal melting because the material removed is not the same as the deposits beneath the flats. [8] disfavor this hypothesis for the Gorgonum Chaos because of the generally smooth floors of the depression and paucity of collapse morphology in the scarp edges. 4). Aeolian Erosion: This was suggested in an early analysis of the south polar cavi [14]. Many of the depressions are very deep with steep walls, making effective wind scour questionable. Most show no obvious directional alignment, as might be expected from a prevailing wind direction. Selective aeolian deflation would presumably require a resistant caprock and possibly a basal friable layer. 5). Mass Wasting and Scarp Retreat: Erosion of layered rock generally produces a landform of plateaus on the resistant units and scarps where these are undercut by erodible layers. Scarp backwasting requires transport mechanisms to remove debris from the scarp face. On Earth these are generally slumping or rockfall aided by weathering and fluvial transport. With local exceptions, the Martian scarps show little evidence of slumping, debris piles at the base of scarps, or evidence of lateral transport of debris away from the scarp face. Enclosed depressions clearly pose a difficulty for the hypothesis of scarp retreat. Scarp retreat could occur if the majority of the deposits under the scarps were soluble or volatile. [8] argue that the planimetric form of scarps in Gorgonum Chaos is inconsistent with development through scarp retreat.

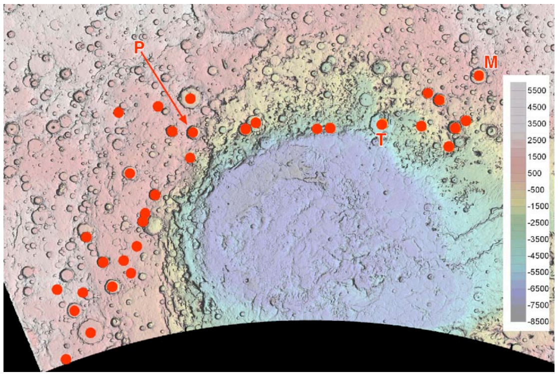

Fig. 1. Map of the northern Hellas Basin region showing locations of craters with pitted floors (red dots). (P) is location of crater shown in Fig. 2; (T) is location of Terby Crater; (M) is location of Millochau Crater studied by [7]. Map width about 3400 km.

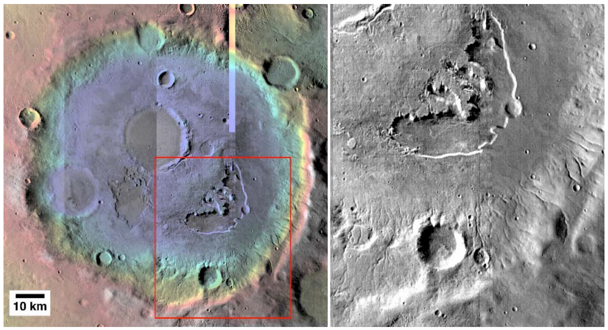

Fig. 2. 100-km diameter crater on the Hellas Basin Rim (at 28.5°S, 310°W). Elevation cueing from MOLA data. Detail at right shows abrupt scarps separating nearly flat crater floor from interior depression. Note the complicated, cumulate planform of the scarps, possibly similar to those reported in [8]. The crater walls show the smooth crater rims characteristic of mid-southern latitudes that might have resulted from preferential sedimentation or non-linear creep [2]. Shallow channels draining the rim appear to have deposited thin fan-like deposits at the base of the crater wall whose age relationship to the central pits is uncertain.

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