**HELLAS AS A POSSIBLE SITE OF ANCIENT ICE-COVERED LAKES.**

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We propose the hypothesis that the interior of Hellas held ice-covered lakes early in Mars history. Morphologic, stratigraphic, and topographic evidence imply that water-laid, then later ice-rich, sediment dominates the geology of the Hellas interior. Sediment was transported to the basin interior by water released by volcanism and other geothermal activity from the Martian crust, then delivered via channels principally east and south of the central basin, perhaps as well as by seepage within the basin. Layer thicknesses within the observed deposits suggests a high proportion of sediment load to water, perhaps some inundations were more like water-rich low-viscosity mudflows than like terrestrial river discharges. The water bodies would have immediately developed ice carapaces several hectometers thick, assuming that the Martian climate then was similar to that of today. Eventually, as the ice cover was lost to sublimation, ice-rich, multiply layered deposits were all that remained. The grounding of the ice carapaces in some locations (units r and h, Fig. 1) formed casts in the initially still-soft sediment resulting in textures similar to kame and kettle terrains on Earth. Along the basin periphery, the ice margins left their marks upon the surface mainly in the form of scarps and marginal deposits. At least one, and possibly several, stands are inferred from marginal modifications and sedimentary unconformities occurring at the same topographic elevation all around the basin.

Recently acquired data from the Mars Orbiter Laser Altimeter (MOLA) aboard MGS have allowed a test of our hypothesis. The best support comes from the correlation of landforms and deposits along the basin periphery at the ~-5.8 km contour. The discontinuous though extensive annular band of rugged material (unit r), which we interpret as an ice-lake marginal deposit, lies along this contour. So does the outer north and south contacts of unit p, which are recognized by abrupt changes in texture beyond them. The ~–5.8 km contour passes along the scarp separating the change in morphology of the large eastern channels, Dao and Harmakhis Valles, from sharp and exposed above to muted and diminished and partly buried by unit p below. Indeed these muted reaches resemble terrestrial marine channels beyond the mouths of large rivers. Taken together, the observed stratigraphic relations, unit morphologies and arrangements, all occurring at a constant elevation, are consistent the presence of a body of ice-covered water that once filled the Hellas Basin interior to the ~-5.8 km elevation. Alternatives, such as aeolian, pyroclastic, or effusive volcanic activity are less likely to have created this set of relations.

Though the evidence for an ice-coverd lake stand at the ~-5.8 km level is strongest, there are indications of other stands as well. Due to the limitations of this abstract format, an early large putative ~-3.1 km stand will not be discussed. However, we will briefly mention a smaller, shallower, and later stand of water postulated to be the deposition medium of the belt of honeycomb terrain along the north west periphery of the plateau of Alpheus Colles. Honeycomb terrain materials (unit h) appear to be superposed on unit p. The problematic criterion of crater density also suggests that the honeycomb materials postdate unit p. The honeycomb material occupies the lowest points in Hellas Planitia (and therefore on Mars), below –6.9 km elevation.

Tanaka and Leonard[1] concur with Moore and Edgett's[2] thermal inertia analysis which concluded that the materials within the basin are fine grained and relatively unindurated. Thus, those studies, as does this one, reject the continental glaciation hypothesis of Kargel and Strom[3] on the grounds that such glaciation should have produced large clasts that would be subsequently concentrated on the surface by currently active wind erosion within Hellas.[2] Moreover there is the considerable problem with the absence of evidence elsewhere on Mars for a vigorous hydrologic cycle needed to support continental style glaciation. The landforms seen at Viking resolution Kargel and Strom attributed to scour along the southern periphery of the basin (the Axius Valles region) do not appear to be glacially eroded in MOC images. Thomson and Head also disfavor a glacial origin for Hellas landforms.[4] Both Moore and Edgett and Tanaka and Leonard tended additionally to disfavor blocky lava flows and boulder-laden catastrophic flood outwash. Also, effusive lava flows, while certainly capable of producing deposits with constant-elevation contacts, would also produce level plains, which are not seen in the MOLA data. Pyroclasic deposits, while often exhibiting layering and a susceptibility to wind erosion, are not known to show a strong constant elevation control on their limits, especially over thousands of kilometers. Also, because wind direction is generally not orthogonal to local surface slope gradients, landforms due solely to wind erosion generally do not parallel surfaces of constant elevation, whereas the bases of scarps within Hellas at the ~-5.8 km (and ~-3.1 km) elevations do; in some cases for over a thousand kilometers.

The principle objection raised by Tanaka and Leonard to non-aeolian origins for the basin-filling materials was that they imagine other processes incapable of transporting sufficient quantities of material to emplace the volume of material necessary. They assumed that only material from or within the landform-defined basin rim (~2300 km wide) was available for non-aeolian deposition, and "by default the majority of the (interior) deposit must therefore originate from beyond the rim of Hellas, which requires aeolian transport."[1] However, the greater Hellas depression, as revealed by MOLA[5], is a region defined by a topographic divide at the ~+1.0 km elevation that forms a rough circle some 4000 km in diameter, encompassing an area of ~12 × $10^6$ $km^2$. Material could be transported by water down gradient within this larger "drainage" basin, and could potentially have provided sediment to the Hellas Planitia. Material was also transported by water out of the eastern volcanic field by Harmakhis, Reull, Dao, and Niger Valles into the central basin. Tanaka and Leonard point out that the volcanic materials along the southern periphery of Hellas are deeply and extensively dissected by sinuous valleys (e.g., the Axius Valles region). In addition to the channels related to the volcanic field, many small sinuous channels cut the northern and western landform-defined basin rim, which presumably carried material to the basin interior. Manifestations of older erosion and drainage may well lie buried under the volcanics of the southern and eastern fields. Given the extent of "late" resurfacing (mostly by volcanics) of large areas just outside the landform-defined rim but within the greater Hellas depression, it is not possible to quantify all the sources of the interior deposits, though Tanaka and Leonard (their Table 5) were able to set minimum volumes for the best exposed (and hence most recent). However, the correlation of deposit contacts and circumferential landforms with constant elevation is a strong indicator of a process that operates exclusively at and below an equipotential level, thus favoring sedimentation and modification from water inundation over air-fall mantling.

**References:** [1] Tanaka K. L. and Leonard G. J. (1995) *JGR*, *100*, 5407–5432. [2] Moore J. M. and Edgett, K. E. (1993) *Geophys. Res. Lett.*, *20*, 1599-1602. [3] Kargel J. S. and Strom R. G. (1992) *Geology*, *20*, 3–7. [4] Thomson B.J. and Head J.W. (2001) *LPS XXXII*, #1374, this issue, [5] Smith D. E. et al. (1999) *Science*, *284*, 1421-1576.

**Fig. 1.** Simplified geologic map of Hellas. Units are: undifferentiated ancient terrain - **u**, mantled material - **m**, plateau material - **pl**, volcanic material - **v**, rugged material - **r**, plains material - **p**, channel material- **c**, sinuous ridges - **e**, honeycomb material - **h.** Unit stratigraphic correlation shown in insert.