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Photogeologic map of the Hellas basin floor, Mars: Nature, origin, and sequence of major infill units

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Abstract

Based on all state-of-the-art datasets and USGS-mapping guidelines [1,2], we produced a comprehensive photogeological map of the Hellas basin floor and its immediate surroundings (scale 1:2,000,000; Fig. 1). We compiled a self-consistent geologic history of the area, incorporating absolute and relative dating of identified units, as well as insights gained by previous investigations in and around the Hellas basin [e.g., 3-5]. Based on their ages, derived approximate volumes, as well as other characteristics, we suggest potential circum-Hellas source regions for specific basin floor units. Large deposits and erosional units in the basin show ages very similar to those of volcanic units in and around Hellas (~3.7 Ga), which is in agreement with certain volcanic outgassing models enabling liquid water runoff during that time.

1. Wrinkle-ridged plains

Wrinkle-ridged plains (units $Npwr_{1/r}$ and $Hpwr_2$) are exposed on a third of the Hellas basin floor and embay and partially superpose layered sequences along the basin rim. Morphometric analyses of the wrinkle ridges imply an average thickness D of the "wrinkled" layer of ~2 km (D ≈ 0.3 ridge width [6]), and, thus, a combined volume of ~1.7 x 10^6 km³ (~4 x Deccan traps, Earth).

The lower wrinkle-ridged plains ($Npwr_1$) show a crater-size frequency distribution-based apparent model age (AMA) of 3.78-3.82 Ga. Gamma Ray Spectrometer (GRS) data shows higher average K, Th, and Si concentrations than $Hpwr_2$ indicating a formation by "lesser evolved" basalts (i.e., from a not well differentiated mantle relatively rich in incompatible elements [7]). Plausible sources are Malea and Tyrrhena Paterae, which both have AMAs [8-10] and Th-abundances similar to $Npwr_1$. Although Thyrrena Patera is located ~1,500 km away, ancient lava flows have been shown to reach the Hellas basin floor [11].

The upper wrinkle-ridged plains ($Hpwr_2$) have an AMA of 3.63-3.74 Ga. Their spatial extent correlates well with a low-K / low to mid-Th /low to mid-Si area in GRS data indicative of "evolved" basalts derived from an already well-differentiated mantle depleted in incompatible elements [7]. Plausible sources are Hadriaca and Amphitrites Paterae, which both show very similar ages [8,9] and elemental abundances.

2. Interior formation ("Alpheus plateau")

Approximately one fifth of the entire basin floor is covered by highly degraded, hummocky material (mainly units Hih and Hik) superposing the wrinkle ridged plains amongst others. Hih's AMA of 3.67-3.74 Ga overlaps that of the underlying $Hpwr_2$ as well as of other dissected rim units (Hd_M and Hd_P). Numerous, up to ~300 m thick buttes and pedestal crates, likely composed of Hih-material, indicate a once complete coverage of the basin floor, implying a volume of ~1.1 x 10^6 km³. The volume of material removed from Hesperia Planum and the area between it and Hellas Planitia has been suggested to be on the order of 0.5- 1.5 x 10^6 km³ [12], thus being a plausible main source for Hih. Large-scale lava-ice interactions on Hesperia Planum around the AMA of Hih have been suggested as the source of huge amounts of meltwater [13], and might account for the erosion and transport of such a large volume of material. An interpretation of the interior formation containing mafic materials transported from the adjacent volcanic provinces into the Hellas basin by fluvial activity, is also in agreement with the detection of low-Ca pyroxene by OMEGA (southwestern Hih) as well as hydrous minerals by CRISM (northeastern Hih) [7,9,14,15,16].

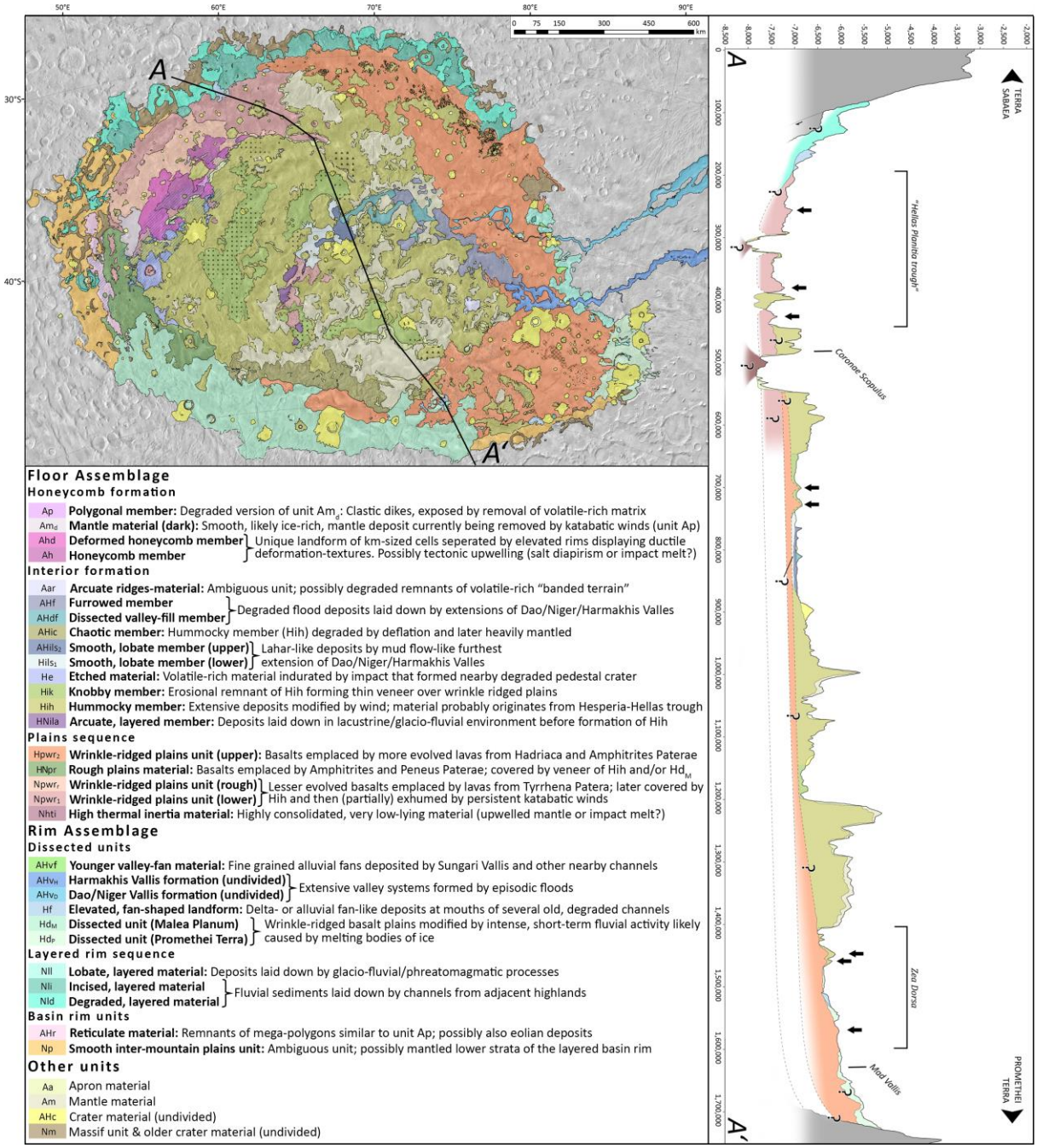

Figure 1: Simplified version of our photogeologic map of the Hellas basin floor (orthographic projection centered at 43°S, 69°E; background: THEMIS-IR Daytime 100 m Global Mosaic version 11.6) with highly condensed interpretations of all units. On the right is a MOLA DTM-based profile illustrating our stratigraphic model of the basin floor (path shown in (A)). Black arrows mark wrinkle ridges. Period extents for units labels based on [17].

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