HELLAS BASIN: WITNESS PLATE FOR DECONVOLVING THE GEOLOGIC AND CLIMATIC HISTORY OF MARS. B. D. Boatwright and J. W. Head, Dept. of Earth, Environmental, and Planetary Sciences, Brown University, Providence, RI 02912 USA (benjamin_boatwright@brown.edu).

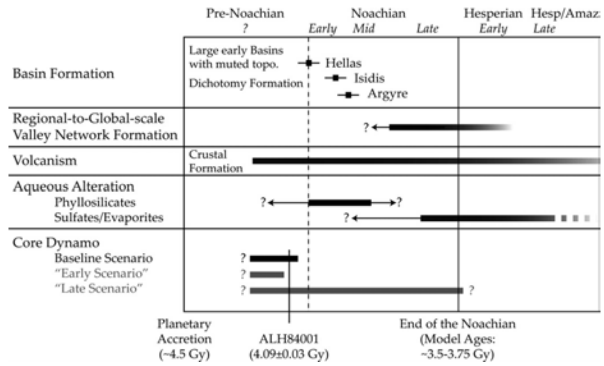

Fig. 1. Timing of early events in Mars geologic history, from [2].

Introduction: The impact that formed the ~2300 km diameter Hellas basin is one of the most influential events in early Mars history, defining the base of the Noachian period [1] and preserving a geological record of subsequent events throughout the entire Noachian, the transitional Hesperian, and the Amazonian (Fig. 1) [2]. Much attention is paid to the global geological history of Mars [3] with a particular focus on the northern lowlands and their margins, which virtually all geologically-driven landed missions to date have targeted.

In contrast, the Hellas basin is located in the southern hemisphere and forms a huge elliptical expanse consisting of the topographically lowest region of Mars, Hellas Planitia, surrounded by the Hellas basin rim, an annulus of the topographically highest regions in the southern hemisphere outside Tharsis, making up a combined ~5.6×10^6 km^2 (~4% of the surface of Mars) [4-5]. The combined Hellas basin and rim spans nearly half the range of martian global topography and the entire history of Mars subsequent to the Pre-Noachian. As such, Hellas provides a comparative "witness plate" to the geologic and climatic history of Mars relative to the standard history that is largely derived from outside it [1,3]. Any broad themes in the global geologic and climatic history of Mars must also be consistent and concordant with the major themes of the history of Hellas basin. Thus, the purpose of this analysis is to begin the construction of this alternate witness plate. Our first steps are: 1) to identify some of the major questions in the history of the Hellas basin; and 2) to begin the integration and analysis of some of the key geomorphic features that provide clues to the interpretation of geologic and climatic events (Fig. 2).

Major features of Hellas and opportunities for further investigation: The Hellas basin is thought to have been formed by an oblique impact event [6] whose structural uplift and ejecta created topography that defined the remaining geologic history of the southern hemisphere and significantly influenced the subsequent climate history. The event itself may have removed a significant part of the primary atmosphere [7] and induced a transient period of hot torrential rains and surface alteration of potentially global scale [8].

A rich and diverse geologic record is preserved from the period subsequent to the formation of Hellas [1,4-5]. *Noachian:* Potential deposits from the Early-Mid Noachian Isidis and Argyre impact events, Late Noachian formation of valley networks and crater basin lakes, and possible ocean-scale standing bodies of water [e.g. 9]. The deep topography of Hellas means that the floor is always one of the warmest places on Mars, and this has been cited to favor the presence of Noachian and Hesperian oceans [e.g. 10-13]. There is significant current debate surrounding the nature of the Late Noachian climate as either "warm and wet" [14-16] or "cold and icy" [17-20]. The Hellas basin, with its huge range of topography, serves as a laboratory to study the predicted effects of these two end-member models (erosion driven primarily by rainfall and runoff vs. melting of snow and ice). *Hesperian:* Widespread extrusive volcanism is preserved in regional plains on the Hellas basin rim (Hesperia and Malea Plana) with associated evidence for volcanic and fluvial resurfacing of the Hellas basin floor [1,4-5]. *Amazonian:* This period was largely one of very low mean annual temperature (MAT) and glaciation primarily associated with the eastern rim, an asymmetry attributed to the effect of Hellas on global atmospheric circulation patterns [21].

In summary, the Hellas basin offers an unprecedented opportunity to assess geomorphic changes as a function of extreme elevation changes over short baselines (Hellas floor to rim) and to compare their areal and temporal distribution. Here we focus initially on a range of geomorphic features with potential fluvial or glacial origins dating to the Late Noachian–Early Hesperian climate transition (candidate ocean shorelines, predicted equilibrium line altitudes, and a range of climate-related features) (Fig. 2).

Initial integration of Hellas basin geomorphic features: We mapped and studied the distribution of crater basin lakes from four different studies [22-25], alluvial fans [26], valley networks [27], pitted crater floors [28], and chloride deposits [29] in reference to the predicted equilibrium line altitude (ELA) of Noachian highland glaciation [18] and various predictions for Hellas ocean shorelines [9,11]. Among our initial findings were: 1) most mapped features are located equatorward of ~40°S, despite global coverage of some mapping surveys; 2) valley networks are primarily associated with Hesperian-aged volcanic deposits but are otherwise sparse; 3) the mapped features as a whole occupy a wide altitude distribution not closely matching any predicted Hellas ocean shoreline or glacial ELA.

Recent analyses suggest that the NW rim of Hellas was the site of Late Noachian cold-based glaciation [30] followed by top-down melting [31] and late-stage wet-based activity [32-33]. These suggest a potential evolution in the Late Noachian ambient climate toward higher MAT over time [34].

References: [1] Tanaka K.L. et al. (2014) USGS SIM 3292; [2] Fassett C.I., Head J.W. (2011) Icarus 211; [3] Carr M.H., Head J.W. (2010) EPSL 294; [4] Leonard G.J., Tanaka K.L. (2001) USGS I-2694; [5] Bernhardt H. et al. (2016) Icarus 264; [6] Leonard G.J., Tanaka K.L. (1993) LPSC 24; [7] Melosh H.J., Vickery A.M. (1989) Nature 338; [8] Palumbo A.M., Head J.W. (2018) MAPS 53; [9] Moore J.M., Wilhelms D.E. (2001) Icarus 154; [10] Baker V.R. et al. (1991) Nature 352; [11] Head J.W. et al. (1999) Science 286; [12] Clifford S.M., Parker T.J. (2001) Icarus 154; [13] Di Achille G., Hynek B.M. (2010) Nat. Geos. 3; [14] Craddock R.A., Howard A.D. (2002) JGR 107; [15] Ramirez R.M., Craddock R.A. (2018) Nat. Geos. 4; [16] Ramirez R.M. et al. (2020) JGR 125; [17] Forget F. et al. (2013) Icarus 222; [18] Wordsworth R. et al. (2013) Icarus 222; [19] Wordsworth R. et al. (2015) JGR 120; [20] Palumbo A.M., Head J.W. (2018) GRL 45; [21] Forget F. et al. (2006) Science 311; [22] Fassett C.I., Head J.W. (2008) Icarus 198; [23] Goudge T.A. et al. (2015) Icarus 260; [24] Hargitai H.I. et al. (2018) Astrobio. 18; [25] Zhao J. et al. (2020) JGR 125; [26] Wilson S.A. et al. (2021) GRL 48; [27] Hynek B.M. et al. (2010) JGR 115; [28] Moore J.M., Howard A.D. (2005) LPSC 36; [29] Osterloo M.M. et al. (2008) Science 319; [30] Fastook J.L., Head J.W. (2015) PSS 106; [31] Boatwright B.D., Head J.W. (2021) PSJ 2; [32] Bouquety A. et al. (2019) Geomorph. 334; [33] Bouquety A. et al. (2020) Geomorph. 350; [34] Fastook J.L., Head J.W. (2022) LPSC 53.

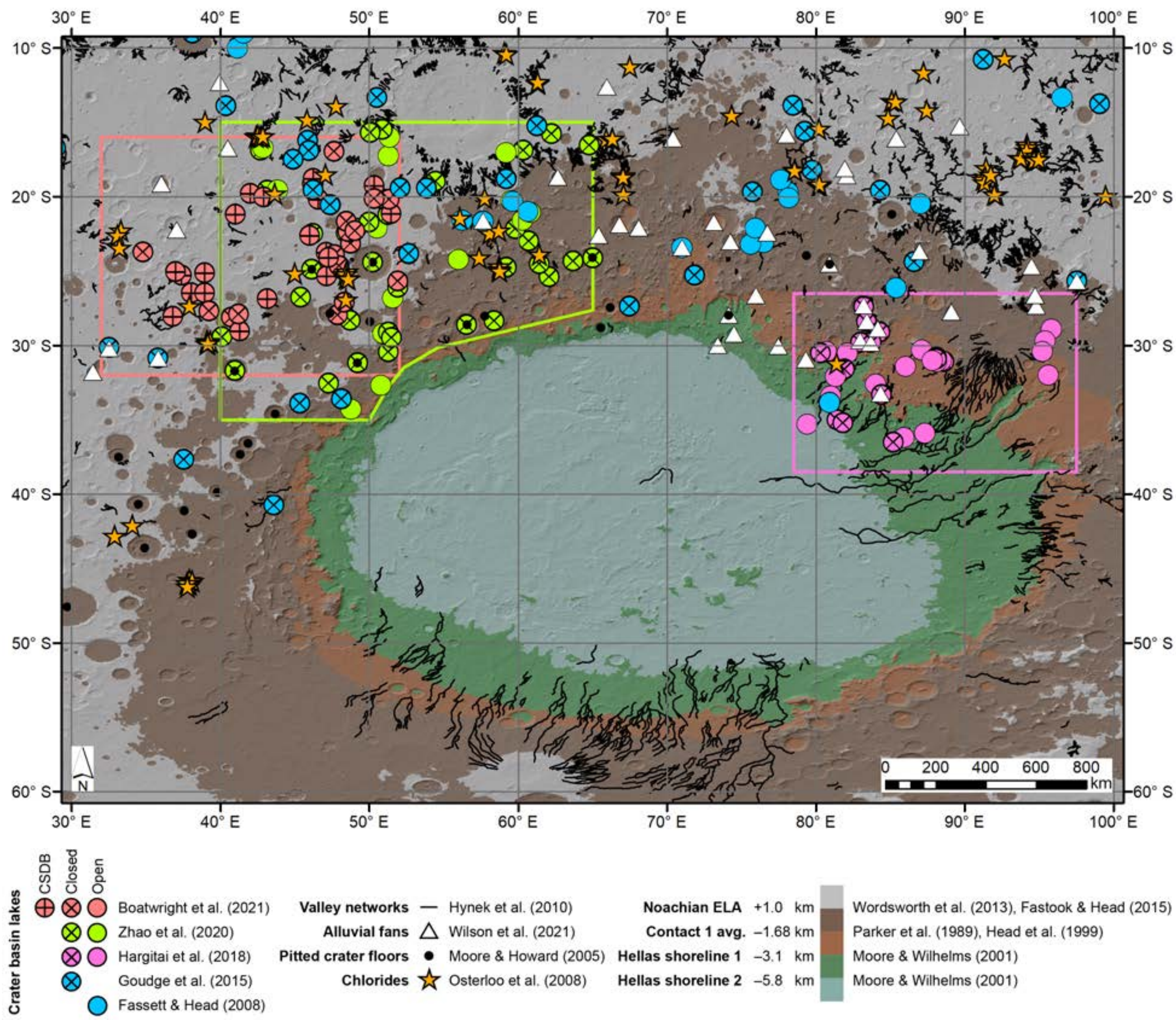

Fig. 2. Map of the Hellas basin showing distribution of various geomorphic features and predicted altitudes of glacial ice stability and Hellas ocean shorelines. Polygons correspond to study area boundaries for symbols of the same color.