UNDERSTANDING THE MAGNITUDE AND DURATION OF POTENTIALLY HABITABLE AQUEOUS ENVIRONMENTS ON MARS.
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Introduction: Each new mission continues to erode the Viking era conventional wisdom that Mars once had an early earth-like climate, but has maintained the current cold desert climate that we see today for much of its history. Higher resolution imagers, imaging spectrometers, and other instruments have revealed a much more dynamic planet that has experienced aqueous activity periodically throughout its history, perhaps even into the modern day. Determining the timing, duration and volumes of individual aqueous events is crucial to understanding whether any habitable environments could have persisted either in the past or in more recent times.

To address these issues, we have undertaken detailed geomorphic studies of several sites where water processes were repeatedly active early on, periodically throughout, and more recently in Mars history.

Navau Valles: Navua Valles are located on the inner NE slopes of Hellas basin and are adjacent to Dao Valles (located just to the SE) and to the SW of Hadriaca Montes and Tyrrhena Montes. These drainages have eroded into volcanic plains that were likely emplaced during the formation of Tyrrhenus and Hadriacus Montes, and terminate in Hellas basin.

We [1,2,3,4] have mapped, in detail, the drainages and surface terrains in this region and have documented at least five major episodes of fluvial activity at a confluence of channels within the Navua B system which intersect and erode into previous channels suggesting that significant periods had elapsed between each event [3]. Initial discharges in episode 1 were ~10^4 m^3/s and steadily increased through episodes 2-4 to a maximum ~5 x 10^5 m^3 /s before declining to several 10^4 m^3/s by episode 5. The terrains on which these channels episodically formed, range in age from the Noachian (3.7Ga) to the late Amazonian (~0.1Ga) [4].

Navua drainages formed discontinuous morphologic patterns similar to terrestrial fluvial systems in volcanic terrains. These patterns form a repetitive sequence from source to sink of V-shaped valleys eroding into bedrock, followed by broad channels and valleys in alluvial material. Drainages then transition into alluvial deposits where the flow presumably infiltrated into the subsurface only to reappear again downstream in a steeply sloping segment consisting of a narrow v-shaped shaped channel eroding into bedrock. This sequence repeats until the drainages terminate on the basin floor of Hellas. We have also identified several locations within the Navua Valles where water likely ponded forming possible paleolakes. We have identified ~13 paleolake locations within the Navau Valles with volumes ranging from 1.5 to 1356.5 km^3 and depths ranging from several 10s of meters to over 1 kilometer [5]. Given the long time span over which fluvial activity was periodically active, and the possible association of this activity to volcanic hydrothermal systems, these paleolakes may have provided localized areas of habitable environments that may have been connected by shallow subsurface aquifers throughout the Navua Valles drainage system.

Mars Tsunamis deposits: Using detailed geomorphic and thermal image mapping in the circum-Chryse and NW Arabia Terra regions of the northern plains, we identified deposits that are consistent with formation by tsunami waves early in Mars geological history [5]. We documented evidence for two enormous tsunami events possibly triggered by bolide impacts, and occurring perhaps a few million years apart. The tsunamis produced widespread littoral landforms, including run-up water-ice-rich and bouldery lobes, which extended tens to hundreds of kilometers over gently sloping plains and boundary cratered highlands, as well as backwash channels where wave retreat occurred on highland-boundary surfaces. As with terrestrial tsunamis, fossil and microbial communities potentially living in this northern ocean would have been swept up, transported landwards, incorporated, and preserved in the fine grained and icy lobes of the tsunami deposits. The preservation potential for near-surface evidence for ancient life makes these deposits a prime target for future astrobiological investigation.

Gullies and RSL: We have also been carrying out detailed mapping, morphologic and morphometric studies of integrated gully systems and spatially associated RSL using HiRISE DTMs (e.g., [7,8,9,10,11]). We find that these gullies are largely consistent with fluvial processes and that the spatially associated RSL may reflect either the last vestiges of water activity or could have played an integral role in gully formation.

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