RELATIVE ROLE OF GROUNDWATER VERSUS SURFACE WATER IN THE GALE CRATER REGION.

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Motivation: The advent of high-resolution imagery, topography, and spectroscopy has advanced our understanding of early Mars beyond the warm/wet and cold/dry scenarios, allowing for more detailed environmental histories using evidence from the geologic record. Early studies of valley networks suggest that most fluvial erosion on Mars occurred shortly after the heavy bombardment epoch (~3.7 – 4 Ga), with a monotonic decrease to Mars' current cold and dry climate [1], [2].

However, some have recognized the possibility of multiple periods of valley network development based on the presence of both degraded and pristine valley networks [3]. [4] and [5] suggested that the bulk of late valley network formation occurred at the Noachian/Hesperian boundary (~3.7 Ga), along with the formation of alluvial fans, deltas, and paleochannels (e.g., [6], [7]). A striking case for late fluvial erosion on Mars has been Gale Crater, a late Noachian to early Hesperian crater that has likely hosted several large lakes ([8], [9]) and is rimmed with preserved valley networks.

Through orbital data and the Curiosity rover, detailed geological and sedimentological studies have provided a deeper understanding of past hydrologic conditions in Gale, but the timing, source of water, and larger regional extent of aqueous activity is still poorly understood. As such, more detailed studies of nearby fluvially-modified impact craters are needed for a broader understanding of hydrologic conditions in post-Noachian Mars.

Our focus within this framework is on a more quantitative understanding of fine-scale valley networks in craters in the Gale region, with special focus on valley network terminations (VNTs). VNTs have been studied by [10] in the context of Tharsis shoreline deformation at the dichotomy boundary, but they have not been examined at fine scale in craters as a marker of past water activity.

Research question and hypotheses: Herein, we propose to address the following research questions: (1) How extensive was the water system that fed Gale Crater, (2) Was the water sourced predominantly from groundwater or surface water,

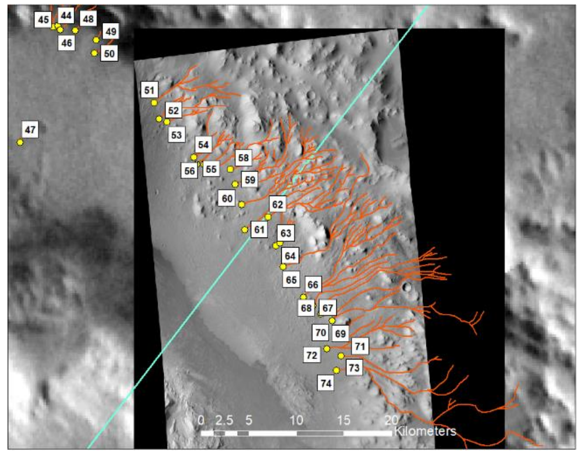

Figure 1: Mapped valley networks in Gale crater

and (3) Were there multiple periods of wetting and drying in this region. To address these questions, we are focusing on valley network features due to their utility as evidence of previous surface water flow and as potential markers for ancient lake levels. Based on initial results, as well as previous work, we hypothesize that Gale and neighboring craters were fed by a large groundwater system, but that a significant surface water component contributed to the craters as well. We also hypothesize that there were multiple periods of lake level rise and lowering, perhaps due to changing climate.

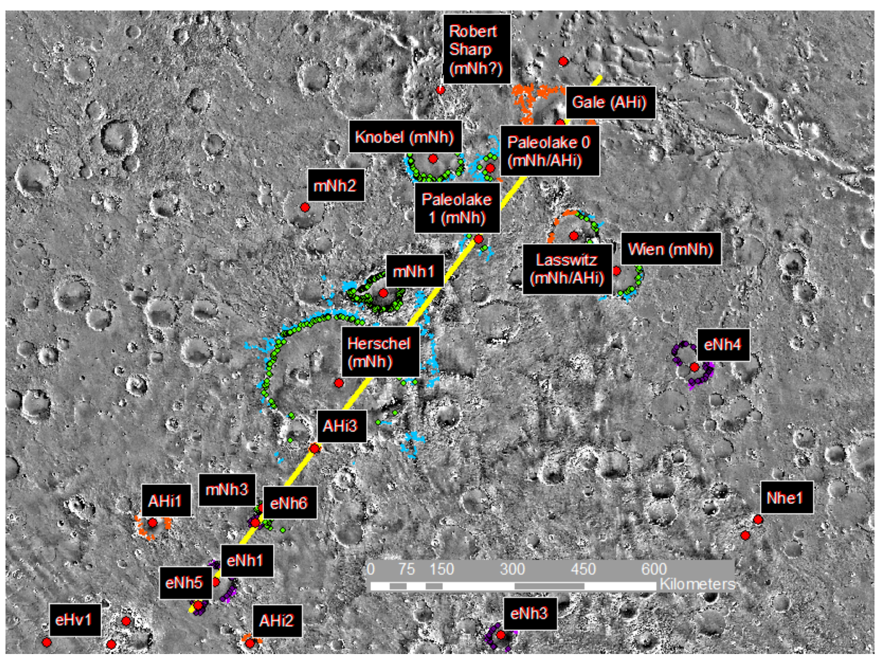

Figure 2: Mapping area, with transect line spanning nine craters shown in yellow

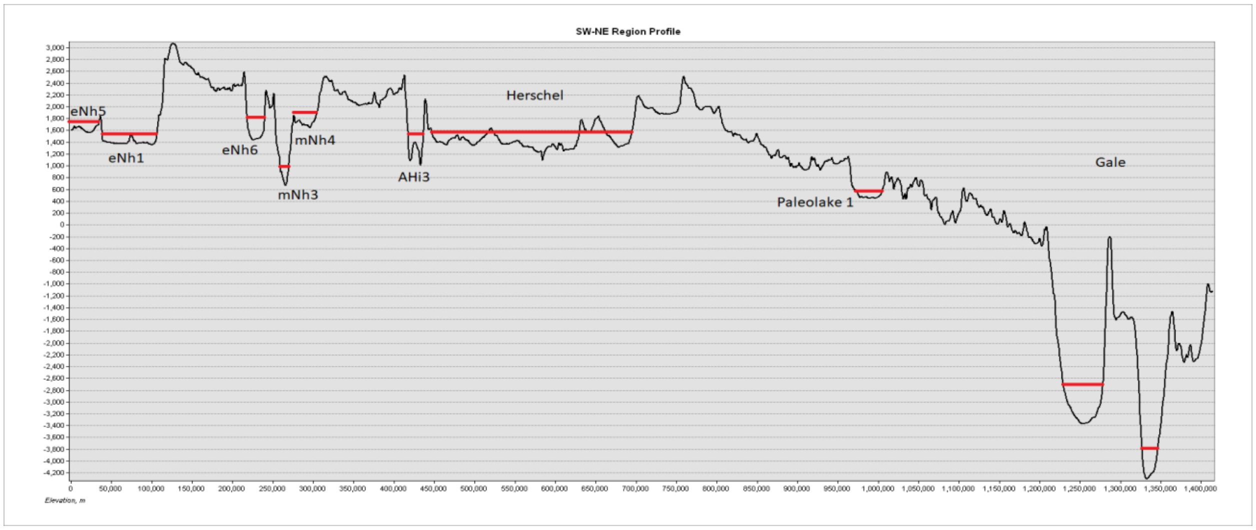

Figure 3: Topographic profile of 9-crater transect (see Fig. 2). Average VNT elevation for each crater is marked in red.

Methods: We used 6 m/pixel-resolution CTX imagery to map valley networks. To measure the elevation of valley network mouths, we first mapped the valley networks around the rims (e.g, **Fig. 1**) of 9 craters along a SW-NE transect, ending at Gale Crater (**Fig. 2**, **Fig. 3**). We then visually identified the terminal end of each valley network. Then, using the planet-wide DEM from MOLA, we recorded the elevation value at each termination point.

As part of our geomorphic analysis, we also created DEMs from CTX imagery using ISIS3 and the Ames Stereo Pipeline in 8 of the 9 craters in the study area. Stereo pairs were selected using USGS PILOT.

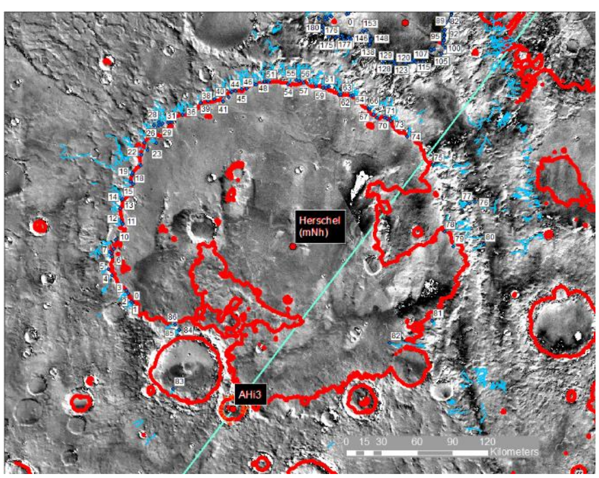

Figure 4: Herschel Crater, with mapped valley networks (blue) and average VNT elevation of the crater (red).

Results: In mapping and measuring valley networks, we have found that their elevations tend to be approximately consistent around the crater (**Fig. 4**). Gale crater has two distinct VNT elevations, which is consistent with observed deltaic features within the crater [9]. This suggests that either the VNTs fed into a standing water level at this elevation or that the valley networks were affected by a consistent morphological constraint of the crater walls at these elevations.

However, preliminary examination of crater topography with MOLA and CTX data does not indicate a topographical constraint that would cause the valley networks to preferentially terminate at a constant elevation. This suggests that the elevation points are indicative of paleolake levels in these craters.

Further work: To expand upon my results, I plan to compare my paleolake elevation values with groundwater models to better understand past water activity in this region. Initial comparisons with modeled results from [11] suggests that the elevations of several of our mapped VNTs are consistent with an aridity index of 1.5. Future work will focus on better constraining the climate and relative contribution of ground versus surface water in the Gale region on Mars.

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