MAPPING OF FINE-SCALE VALLEY NETWORKS AND CANDIDATE PALEOLAKES IN GREATER MERIDIANI PLANUM, MARS: UNDERSTANDING PAST SURFACE AQUEOUS ACTIVITY.

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Introduction: One of the most common drainage features on Mars are valley networks and their presence in ancient terrains are frequently cited as evidence that past climatic conditions were conducive to surface water flow [1-2]. From Viking Orbiter data, valley networks (VNs) are typically negative relief, branching features that are a few kilometers wide and up to 200 km in length formed mostly (~70-90%) within the Noachian cratered highlands [1-3]. VNs may have also fed large bodies of water such as a northern lowlands ocean or shallow highland lakes [1-2]. Global mapping of VNs using Thermal Emission Imaging System (THEMIS) data at ~100 m/pixel has identified more of these features [4], but they are predominantly in the same areas where they were first mapped by [3].

A new group of VNs with varying preservation states have now been identified using meter-scale images [5-8]. These fine-scale VNs have a range of negative- and positive-relief forms that reflect a history of burial and erosion [5-11]. Other notable characteristics include branching or braided patterns, increasing width downstream, pronounced sinuosity, tributaries reaching drainage divides, and terminal deposits (e.g., some with a bulbous plateau, possibly inverted-relief lake deposits [6-7]).

Here we present the mapping of fine-scale VNs and candidate paleolakes in Context Camera (CTX) images that is focused on a portion of the greater Meridiani Planum region with a high density of these features (Figure 1). From geologic and geomorphologic maps of this region, there is a clear stratigraphic sequence of materials [6, 10] and specific units in which the VNs and candidate paleolakes occur within. Our goal is to determine the temporal relations and timing constraints of aqueous activity by identifying which material units our mapped VNs are associated with and how they fit within the time-stratigraphic history of the region [6, 10]. We report our results within the context of geologic units identified by [10]: (oldest to youngest) Noachian subdued cratered units (Nhc1 and Nhc2) superposed by etched units (NMe1, NMe2, HNMe3).

Data and Methods: THEMIS day IR global mosaics formed the basemaps used in this study. VNs were mapped on 154 CTX images that cover ~70% of the study region. Individual segments of VNs, whether a single feature or part of an expansive network, were mapped as line features using ESRI ArcGIS 10.2 software. Each valley segment was mapped continuously until it terminated or could no longer be identified with reasonable certainty. VN morphology, whether a single type or a combination of two or more types, was noted and stored as a geodatabase attribute. Other key attributes include group ID, length, Strahler stream order, MOLA elevation (mean and median), and geologic unit(s) from published maps [6, 10]. Candidate paleolakes were mapped as polygon features.

Valley Network Morphology: Four principle morphologies (and associated variations) are observed: troughs, pits, ridges, and knobs. Examples of the variations in ridges, including their cross-sectional forms, are described in [12]. Transitions between morphological types can occur within a single network (e.g., pits can be singular features, but often intersect with adjacent pits to form a long trough).

Mapping Results: We have mapped ~3600 km of VNs in >80 network systems within the study region. Ridges and pits are the most common morphological types. Most VNs occur within a geologic unit and those near unit boundaries are typically truncated reflecting possible burial. However, several lengthy VNs cross unit boundaries (Nhc1 and NMe1; Nhc1 and HNMe3; NMe1 and NMe2; Nhc1 and Nhc2), which may indicate reactivation of system.

The occurrence of VNs, their preservation state, planimetric pattern and network density varies as a function of stratigraphic position. In the lowest exposed unit, Nhc1, the density of VNs is the highest among all geologic units (~0.016 km/km^2). The stream order reaches as high as five, comparable to traditional VNs on this unit in the southern portion of the study region [10], and generally higher compared to VNs outside this unit. Pit and pit-trough are the dominant morphological types within Nhc1 and few pitted types are found outside of this unit suggesting that material properties have an influence on preservation state. Although unit Nhc2 shares similar attributes to Nhc1 and is inferred to be the same rock type [10], it has a noticeable paucity of VNs with the exception of pitted segments in the eastern section of the study area.

Within the sequence of etched terrains, most VNs are in the oldest (NMe1) and youngest (HNMe3) units, frequently as anabranching ridges. Both units have density values (~0.008 and ~0.004 km/km^2, respectively) that are considerably lower than Nhc1. The intermediate etched unit, NMe2, has little exposure, which may account for the small number of VNs. Several VNs in this unit cross into HNMe3 with the bulk of their extent in the younger unit.

Proceeding up section into the early Hesperian hematite-rich (HMh) and plains (Hp) units [10], the density of VNs drops to the point of little-to-no valley formation and(or) preservation.

A total of 11 candidate paleolakes were mapped within units Nhc1, NMe1 and HNMe3 (see Fig. 1). The paleolakes range in size from ~0.11 km^2 to ~19.3 km^2. These features are generally at the termini of lengthy VNs, but also occur in the central portion of a network.

Discussion and Implications: Differences in the preservation state, pattern, and density of VNs within the stratigraphic sequence provides insight into environmental transitions during the critical Noachian to Hesperian transition period. A key observation in this study is the change from dendritic VNs, reflecting relatively mature systems at the base of the section, to anabranching VNs in the younger superposed etched units, indicating variable flow conditions [13]. In addition, there are individual geologic units (Nhc2, NMe2, NMh) that are largely devoid of surface runoff interleaved in the stratigraphic sequence. We note that our interpretations of VNs and their locations within the etched units are still under development at this time and that we will further scrutinize their stratigraphic relationship in future work. Paleolakes occur in several Noachian units, indicating that there may have been sufficient aqueous activity to feed and pool water into lakes throughout the early to late Noachian. Taken together, our results currently support episodic aqueous periods rather than a monotonic decline in climate conditions over time.

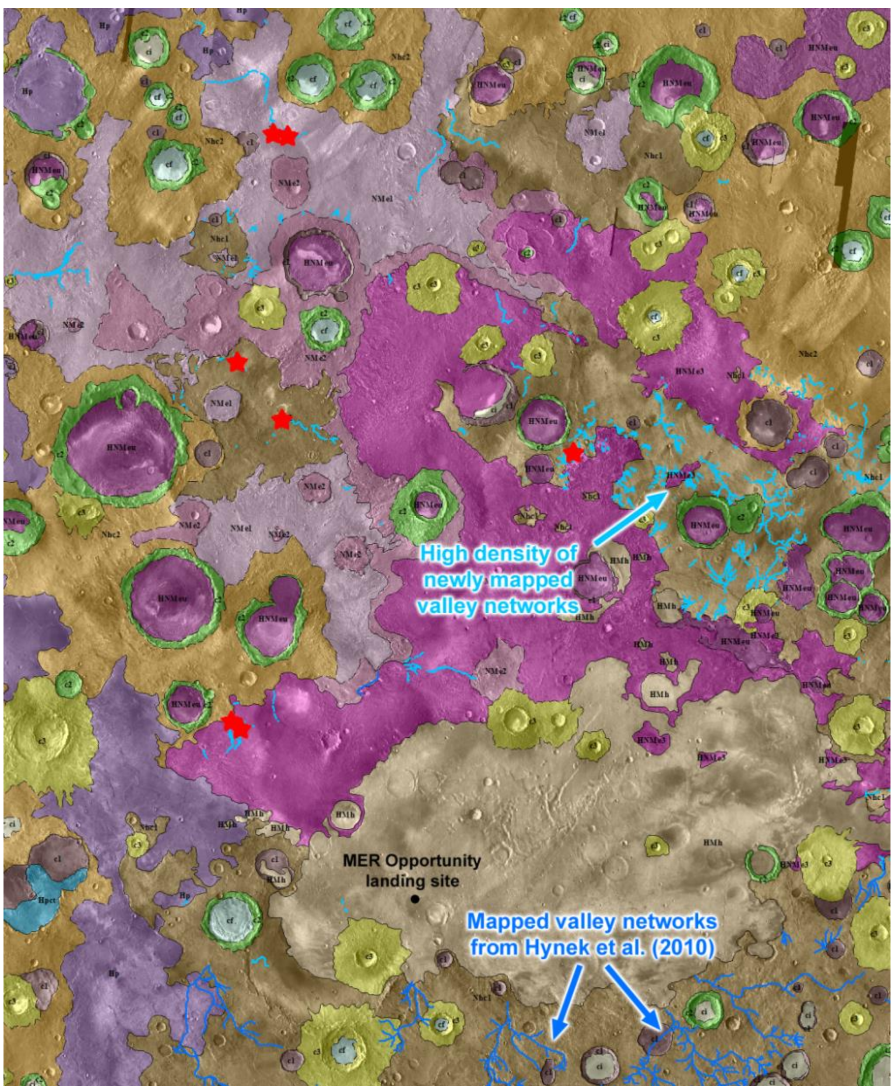

Figure 1. Greater Meridiani Planum study region (348°E-2°E, 5°S-12°N) with newly mapped VNs in light blue, traditional VNs [4] in dark blue, and candidate paleolakes denoted by red stars. Basemap is 100 m/pixel THEMIS day IR mosaic in simple cylindrical projection overlain with geologic map units from [10]. Etched units, shown in shades of pinks and purple, superpose ancient cratered terrain, shown in brown and orange.

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