FLUVIAL AND HYDROTHERMAL DEPOSITS IN THE CIRCUM-HELLAS REGION

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Introduction: The Hellas basin, arguably the largest well-preserved impact structure on Mars, is thought to have formed during the late heavy bombardment [1] as a consequence of a massive impact. The basin, centered near 42°S, 70°E, spans across ~25 degrees of latitude and ~50 degrees of longitude, covering a vast portion of the mid-latitudes. The surrounding terrain, known as the circum-Hellas region, contains a wide assortment of geologic terrains that exhibit evidence for subsequent modification by diverse depositional and erosional processes [2-7]. These processes are thought to have occurred during different portions of martian history and therefore the associated terrains provide a record of geological processes from much of the planet's history.

Of particular interest to the question of habitability is the possibility that a variety of aqueous systems, in particular marine/lacustrine [8-9] and hydrothermal systems [10], may have formed in the region after the Hellas impact. Spectroscopic evidence for aqueous activity in the greater region has been presented [11-12] and more recently, phyllosilicates and sulfates have been identified on and near the rim of Hellas in association with multiple geological features [13-15].

In addition to lacustrine activity, the circum-Hellas region may have also hosted extensive hydrothermal activity. An impact of the magnitude of the one that formed the Hellas basin is thought to have deposited enough energy to support hydrothermal conditions for a prolonged period [10]. Observations by [14] identify potential hydrothermal alteration products occurring on the plains units near Hellas and studies performed here show evidence for hydrothermal alteration products in multiple other locations in the circum-Hellas region [15].

The goal of this investigation is to constrain the mineralogy and geological setting of aqueous minerals in the circum-Hellas region and if possible, their spatio-temporal relationship to the Hellas impact in order to understand how the geological setting of aqueous environments in the region changed over time.

Datasets: In this investigation, we build on the work performed by [11] by extending the region of study to include more of the Hellas rim over a broader latitude range, and also to extend further into the highlands (out to ~1.5 crater radii from the rim of Hellas). Our analysis includes the use of CRISM, HiRISE, and CTX datasets, as well as stereo digital elevation models from HiRISE image pairs. Topographic data can be used to evaluate outcrop bedding and stratigraphy.

Results:

Spectroscopic analyses Spectroscopic studies of the NW Hellas region have revealed a broad suite of hydrous alteration products including Fe/Mg smectites, Al-phyllosilicates (including kaolin-group minerals), polyhydrated sulfates, chlorites, smectite/chlorite mixed-layer phyllosilicates, and prehnite (carbonate presence has been inconclusive thus far). Often, the spectra of these materials bear a broad, concave-up absorption centered around 1-1.2 µm, which is consistent with Fe^{2+} and may suggest partial alteration of mafics. In some cases, units exhibiting spectra with only the Fe^{2+} absorption and no hydration occur adjacent to these units.

The observed mineralogies can be correlated to photogeologic units. Hydrothermal alteration products, such as prehnite, chlorite, and illite assemblages, are associated with the hilly units previously mapped by Tanaka and Leonard (1995) as uplifted terrain from the Hellas impact. The presence of prehnite is of particular importance because it is a transitional metamorphic grade between the zeolite and greenschist facies, forming under specific conditions: 2-7 kbar, 200 – 350°C, and XCO_2< 0.004 (Blatt and Tracy, 1995). Hence, its presence indicates that a relatively low temperature hydrothermal environment was present at the time of its formation. In contrast, the material forming the pitted plains and pitted craters exhibits spectra consistent with a chlorite/smectite mixed-layer material, suggesting a sedimentary origin followed by low-grade metamorphism.

Geomorphic analyses A number of interesting features and relationships are revealed in the intercrater plains and on the floors of some craters. These plains are the materials in which large pits form north and northwest of Hellas basin. The pits vary in size and shape and exhibit varying forms of structural control (Fig. 1), but have the same overall morphology. Plains-forming materials retreat to form irregularly shaped pits that are in some cases elongated in a roughly north-south orientation. Layers exposed along the walls of the pits vary in thickness. Remnants of the plains and underlying strata are preserved within the pits as flat-topped mesas, rounded knobs, and fields of low-relief knobs (Fig. 2). The floors of pits are generally flat and contain low- to high-albedo materials that could represent lithified materials or sediments redistributed within the pit. From MOLA data, pits are roughly similar in depth, ranging from 100 to 380 m deep. One pit located in the large crater adjacent to

Niesten has a depth of ~1300 m, which is similar to pit depths observed in Terby crater [8].

Relative to the northern and northeastern circum-Hellas highlands, the northwestern and western circum-Hellas highlands display sparse evidence for volatile movement. Some areas within the intercrater plains are dissected by narrow channels or broad, shallow valleys that terminate in fan deposits both on the plains and within the pits (Fig. 3), and which may have contributed to the sediments that form these plains. However, these rarely form well-integrated networks that drained larger portions of the highlands. Some rugged peaks and crater rims/walls are incised with narrow gullies, but further investigation using HiRISE images reveal that these gullies are incised within mid-latitude mantling mantling material, which likely post-dates the emplacement of plains-forming materials and the formation of the pits.

Relative timing: The relationships established thus far suggest a transition from a hydrothermal environment associated to the uplifted blocks of the Hellas impact to a cooler depositional environment associated to the embaying plains-forming units. The units that develop pits in the intercrater plains are, compositionally and morphogically, similar to the pitted intracter deposits. The timing and genesis of the pits is still not completely understood. However, depositional fans have been identified within some of the pits, indicating that limited fluvial activity and sedimentation did occur after the initial formation of the pits. This suggests that plains and pit formation may have been concurrent, perhaps indicating intermittent wet periods.

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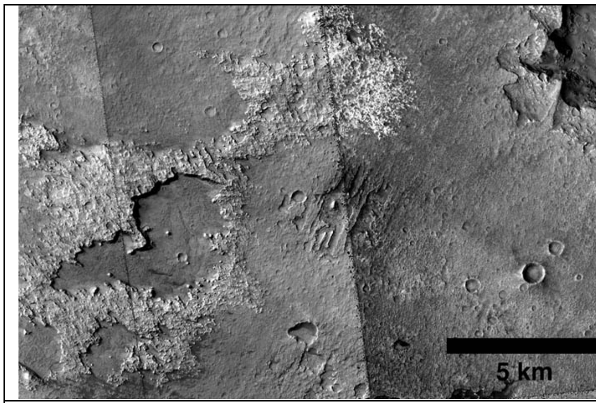

Figure 1. CTX mosaic of a portion of the central pit in Schaberle crater. Note the structural control of erosion resulting in SW-NE trending ridges in darker material and SE-NW trending rigdes in lighter-toned material. North is up, sun is from the upper left.

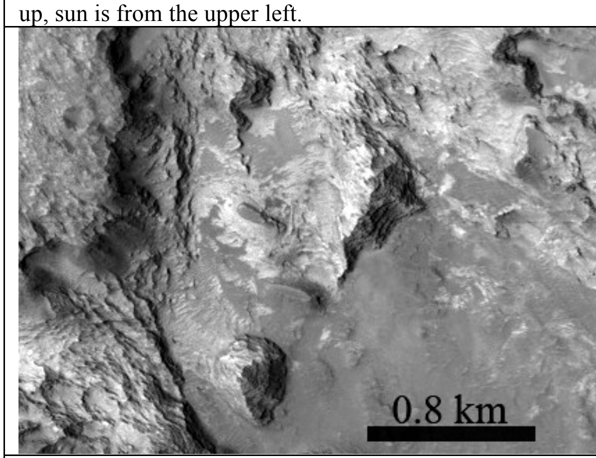

Figure 2. HiRISE image of layered buttes in pit of plains. The material composing these units erodes into yardangs and buttes, and does not shed boulders. North is up, sun is from the upper left.

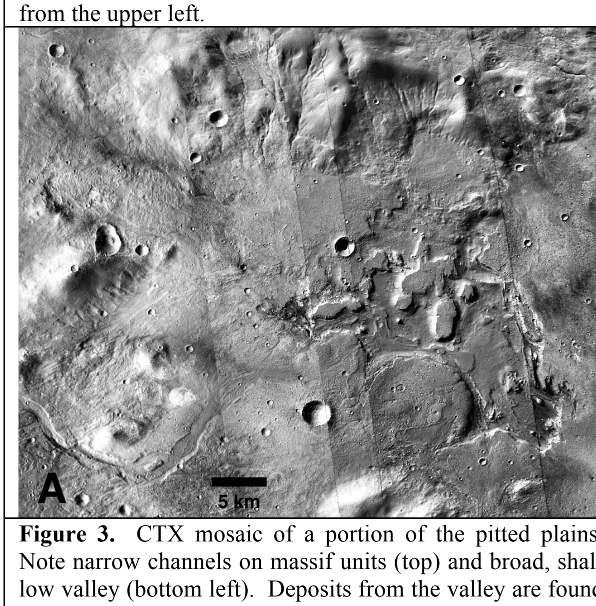

Figure 3. CTX mosaic of a portion of the pitted plains. Note narrow channels on massif units (top) and broad, shallow valley (bottom left). Deposits from the valley are found within the pit. North is up, sun is from the upper left.