A Plethora of Planetary Processes in Southern Hesperia Planum, Mars: Water, Ice and Mass Wasting.
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Introduction: Possible glacial features have been interpreted to exist in the mid-latitude belts (30°-60° N and S) on Mars and radar data reveals the presence of ice in the eastern Hellas region [1,2]. We present a 6° x 6° map of a portion of southwestern Hesperia Planum, located northern Reull Vallis Region (centered at 36° 50' S, 102° 50' E) (Fig.1). This area appears to have been reworked by tectonic, impact, fluvial, and mass wasting events and therefore presents significant implications for the presence of water in Mars' past [3]. Our study area is composed of ancient, heavily cratered highland material, smooth to rugged massifs, plains materials, and surficial deposits.

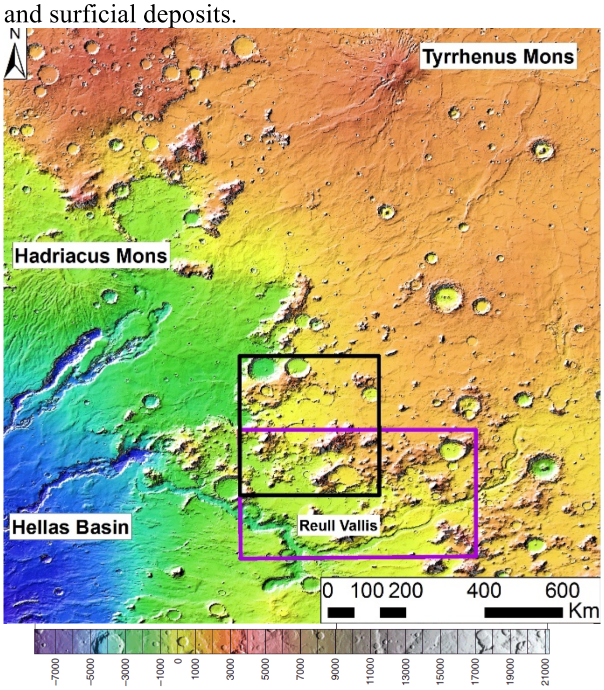

***Figure 1**: Our study area (black) and [4] map area (purple) on* Mars Orbiter Laser Altimeter (MOLA) [5] C*olorized Hillshade. MOLA scalebar in meters. Centered on 32°30'S, 102°30'E.*

Background: The Mest and Crown [4] geologic map of the Reull Vallis region of Mars overlaps the southern region of our map (Fig. 1). Using Viking Orbiter images, they identified the following units within our map area:: Debris apron material (Ada), Intermontane basin fill (HNbf), Basin-rim unit (Nh 1), Mountainous material (Nm), and Crater fill material (AHcf). They presented a geologic history beginning with the Hellas impact event resulting in uplifted mountainous material and basin-rim units, with subsequent erosion and volcanic resurfacing through the Late Noachian to the Early Hesperian Periods. Volcanic and and fluvial processes apparently dominated resurfacing in the Hesperian Epoch, with mass wasting and deposition of debris aprons occuring in the Late Hesperian and continuing into the Amazonian Periods. Eolian processes modified all units through the Amazonian Epoch.

Methods: We mapped on a Thermal Emission Spectrometer (THEMIS) daytime infrared (IR) mosaic [6] 100m resolution basemap in ArcGIS and Java Mission-planning and Analysis for Remote Sensing (JMARS) [7]. MOLA [5], Context Camera (CTX) [8] and THEMIS nighttime IR [6] were used to support identification of units and features. Units were identified on the basis of morphological and topographic expression as well as albedo and thermal differences. Absolute model ages calculated from crater counts have not yet been determined for the units, but based on previous mapping efforts, approximate ages were determined.

Results: We identified the following units in our mapping area: Noachian mountainous material (Nm), Noachian incised mountainout material (Nmi), Hesperian incised plains material (Hpi), Hesperian smooth plains material (Hp) (Fig. 2), Hesperian highland plains material (Hph), Amazonin lineated crater fill material (Acl) (Fig. 3), Amazonian lobate material (Al) (Fig. 4) and crater floor material (cf). They broadly correspond to previously mapped units [4]. Additionally, units were subdivided into different plains units to account for morphological differences when mapped at higher resolutions.

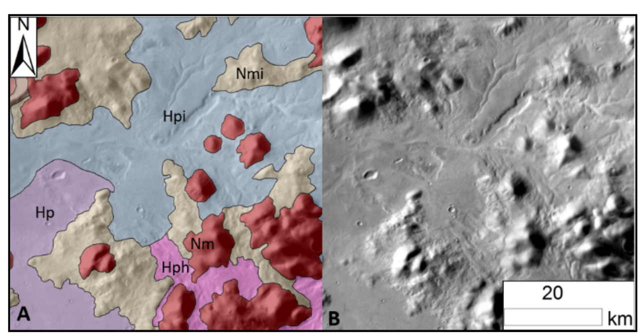

***Figure 2:** A) geologic map; B) THEMIS Dayime IR of same area shown in (A). THEMIS image courtesy of ASU/JPL/NASA. Centered at 38°31'S, 101°11'E.*

Discussion: The geologic history of our map area is broadly in agreement with previous work [4]. Noachian mountainous materials were likely formed from the impact that generated Hellas Planitia, and the area was subsequently degraded via fluvial and aeolian erosion; incised Noachian mountainous materials are interpreted to be degraded Nm materials. Crater counts [4] show an age for similar units to be Early to Middle Noachian and Middle which supports the interpretation of reworking of Nm to form Nmi. Incised plains materials (Hpi) were probably deposited by volcanic or fluvial processes, which resurfaced much of the map area. We infer that Hesperian plains material is a depositional unit most likely sourced from the erosion of the highlands during the emplacement of Hpi.

Lineated crater fill material (Acl) may have formed from mass wasting processes, but some of these outcrops are likely to be ice-rich aprons, or lobate debris flows (LDF) covered in debris and dust due to viscous flow and sublimation features observed in THEMIS and CTX [2].

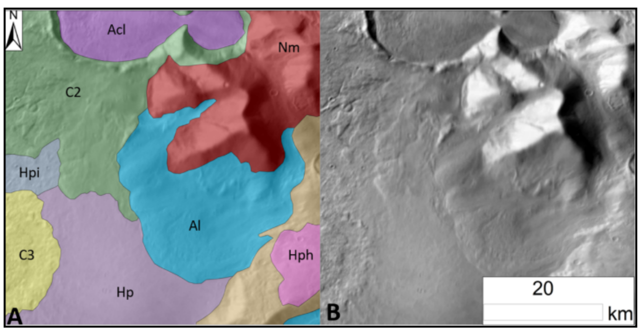

***Figure 3**: A) geologic map (labled with units); B) THEMIS Dayime IR of same area shown in (A). THEMIS image courtesy of ASU/JPL/NASA. Centered at 39°22'S, 102°53'E.*

Lobate material (Al) is morphologically similar to concentric crater fill (CCFs), defined by concentric lineations with a fretted texture described as "brain terrain" and a convex-up profile within a crater [9]. The location of these features correspond to the same latitudinal bands that ice deposits are expected to exist on Mars today [1,2,9]. Although it is possible that these lobate materials formed from an ice-rich deposit that covered the surface and is preferentially preserved within closed impact craters, lobate materials are not uniformly found in craters of similar stratigraphic age throughout the map area and the morphology of the material suggests flow rather than a uniform deposit (Fig. 4).

Extensive mapping of glacial landforms [10], including CCFs, LDFs and lineated valley fill (LVF), show that these features are variably abundant in the 30°-50° latitude range, and all are present in the region east of Hellas Planitia. Estimates of the ice volume, accumulation rates, and geographic distribution of these glacial landforms suggest a middle to late Amazonian origin [10].

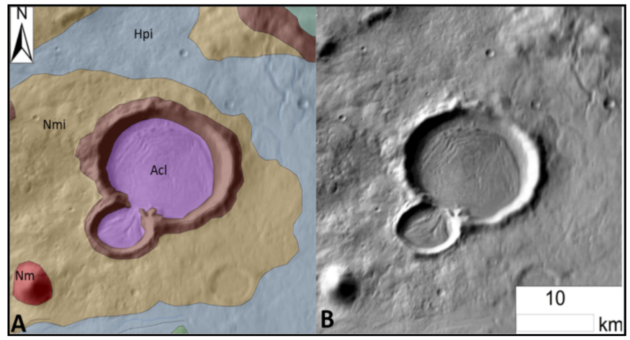

***Figure 4**: 4A is the interpreted geologic map; 4B is THEMIS dayime IR. THEMIS image courtesy of ASU/JPL/NASA. Centered at 38°15'S, 102°44'E.*

The abundance of of CCFs and LDFs in our mapping area was anticipated due the the geographic location and previous mapping efforts, but relationships with the surrounding plains and highland materials will aid in better constraining climate conditions in the Hesperian and Amazonian Epochs.

Future Work: Crater-size frequency distributions will be used to contratin the timeline of volcanic and fluvial resurfacing and glacial feature formation. SHAllow RADar (SHARAD) [11] data will examined for evidence of ice in the Acl and Al materials, although specific features in our mapping area may not be resolved by the instrument.

References: [1] Squyres, S. W. (1979), JGR, 84(B14), 8087–8096. [2] Holt, J. W., et al. (2008) Science, 322(5905), 1235-1238. [3] Mest S. C., Crown D. A. (2001), Icarus, 153(1), 89-110. [4] Mest S. C., Crown D. A. (2003), USGS Misc. Inv. Series I-2763. [5] Zuber et al. (1992) JGR, 97(E5), 7781-7798. [6] Christensen et al., (2004), SSR, 110(1-2), 85-130. [7] Christensen et al., JMARS – A Planetary GIS [8] Malin et al. (2007) JGR, 112, E05S04. [9] Levy, J. S., et al. (2010), Icarus, 209(2), 390–404. [10] Levy, J. S., et al (2014), JGR, 119(10), 2188–2196. [11] Seu et al. (2007) JGR, 112, E05S05.