GRID-MAPPING PHLEGRA MONTES, MARS: NEW INSIGHTS INTO THE DISTRIBUTION, GEOMORPHOLOGY, AND DICHOTOMY BOUNDARY OF GLACIAL-PERIGLACIAL LANDSYSTEMS.

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Introduction: Mars is a permafrost world where water ice is abundant at, near, and under the surface. Radar studies performed to date have substantiated the existence of shallow ground ice and have confirmed the existence of debris covered glaciers on Mars [1-4]. Although there is speculative classification that terrestrial periglacial regions are often marginal to active glacial regions, there is no consensus, and it is unknown if glacial meltwater also plays a role in shaping or "feeding" subsurface ice within permafrost landforms. Thus, if Martian morphologies are glacial and/or periglacial in origin, then these features and transitional areas would act as useful climate and geomorphological markers for sites where there may be seasonal advance/freeze-thaw cycles.

The main objective of this research is to better understand and differentiate ice-rich (periglacial) vs icy (glacial) landforms using a combination of datasets [5, 6]. The results will have implications on future mission planning and on our understanding of the habitability of Mars. Specifically, we aim to produce a grid-based map of the Phlegra Montes region on Mars to build a database of associated glacial-periglacial landforms

Methods: Phlegra Montes (25-50° N) is a mountain range system of eroded Hesperian- and Noachian-aged alpine and massif terrain in the mid-latitudes of the northern lowlands of Mars. The Phlegra Montes system divides the lowland plains of Utopia Planitia (west) and Amazonis Planitia (east).

In this study, the region of interest is enclosed within a 1500 x 500 km area, which is further divided into 20 x 20 km grids using CTX mosaic images [8] similarly done by [7]. These 20 x 20 km grids were overlain on various datasets **(Fig. 1)** to verify the presence of ice in more localized regions **(Fig. 1C).** Each grid was surveyed for icy and ice-rich landforms and categorized based a multicriteria classification scheme. Datasets such as SWIM 2.0 Geomorphology [9], SHARAD Surface Power Return [9], and MOLA/HRSC [11] **(Fig. 2B)** were used.

Multicriteria Classification: To delineate a general geomorphologic trend within the study region, multiple

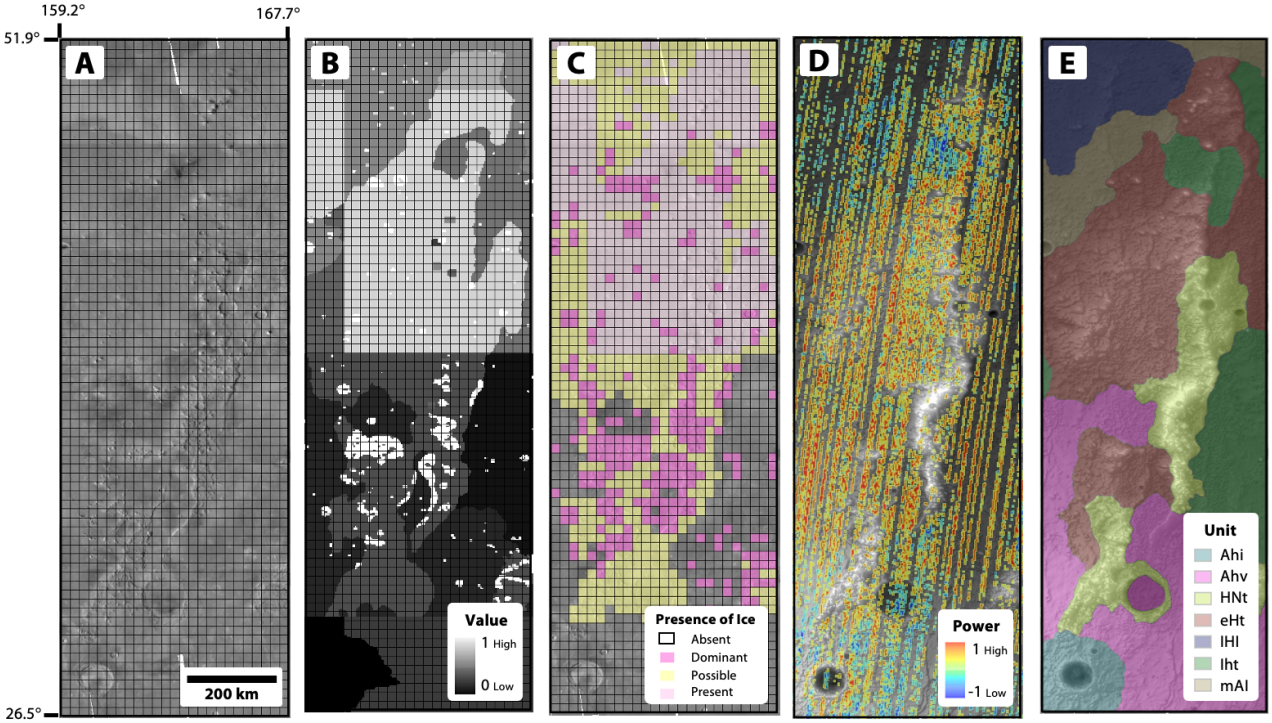

Figure 1. Preliminary grid maps (20 x 20 km) of the Phlegra Montes region on Mars (25°N-50°N). Maps are showing a **(A)** Gridded CTX Global Mosaic basemap of the study region [8]. **(B)** SWIM project's geomorphology ice consistency map generated using new and previous mapping of periglacial and glacial features. **(C)** A manually mapped grid of the presence of ice-rich (periglacial) and icy (glacial) landforms using several datasets. **(D)** SWIM project's radar surface power return from SHARAD measured and corrected for surface topography using a combination of MOLA and SHARAD surface roughness data [9] **(5)** Geology map of the study region composed of seven geologic sections [10].

datasets were used to create an original map comparing geology, elevation, radar surface return, and more. Our morphologic classification grows from a more simple classification scheme [5]. Categories of sorting or classification **(Fig. 2A)**:

(1) Glacial-dominated. A glacial landsystem is a region that is often dominated by glacier flow, basal ice processes, and various glacial landforms [12] (i.e. presence of eskers, glaciofluvial landforms, viscous flow features (VFFs), and glacier-like forms (GLFs) [5]

(2) Periglacial-dominated. A periglacial landsystem is a region of ground that has been frozen (<0°C) perennially for two or more consecutive years dominated by freeze-thaw processes, thermal contraction, frost, and mass movement [12]. Dominant landforms include scalloped topography, patterned ground, and polygonal networks [5].

(3) Mixed. This category is the most notable area for this study, as they depict the interplay between two ice-rich and icy environments that have been previously speculated to have no relationship. These may be intermediary glacial-periglacial landforms that have undulating or non-distinct forms found in areas where ice is *Present* and *Possible.* The *Mixed* landsystem also exhibits features that exist simultaneously between glacial and periglacial (i.e. numerous glacial-periglacial landforms and morphologies are present in a 20 x 20 km grid region).

Discussion: By correlating the grid maps in **Fig 1C** and **Fig 2A**, we are able to show that areas where the presence of ice is *Dominant* are where *Glacial-dominated* landsystems exist, while areas where the presence of ice is *Possible* or *Present* tend to host the *Periglacial-dominated* and *Mixed* landsystem types.

The presence of icy and ice-rich landsystems in Phlegra Montes is substantial. However, to understand the surficial and subsurface processes, the transitional margins between glacial-dominated, mixed, periglacial-dominated must be distinguished. We hypothesize that this *glacial-periglacial dichotomy* may be a continuum that has various phases of interactivity influencing climatic and surface processes in the region.

Future Work: The continued research of Martian (peri)glacial environments through comparative geology, geophysics, and geomorphology is largely relevant for the future of a sustainable Mars exploration. Further, high-detail landform mapping and the addition of more detailed datasets (i.e. stereo images, HiRISE and SHARAD) lead to more comprehensive grid maps, which is crucial to this overarching study.

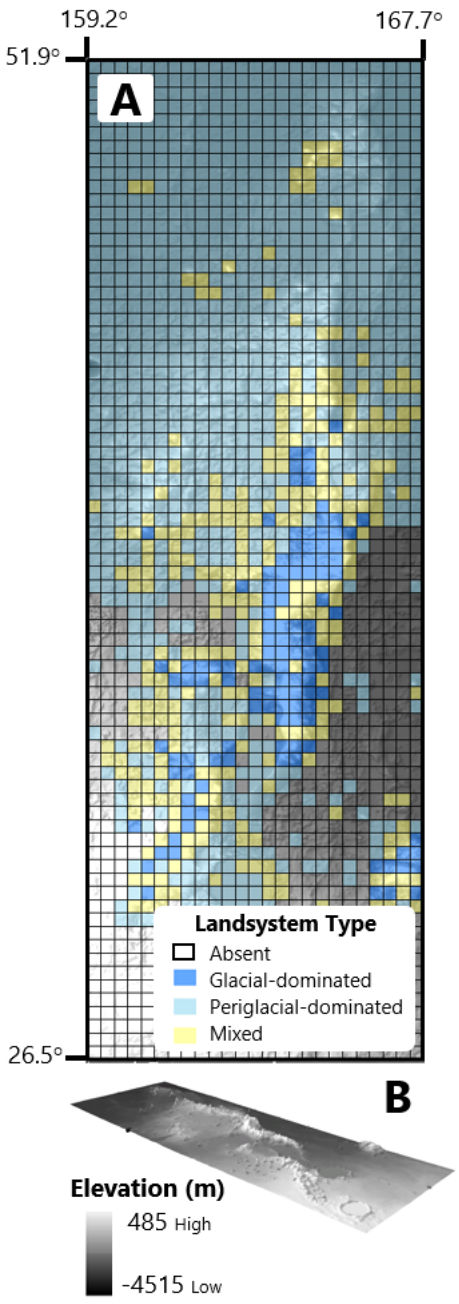

Fig. 2. (A) Final grid map of the Phlegra Montes region differentiating three distinct landsystem types: Glacial-dominated, periglacial-dominated and mixed, *(manually mapped and derived from Figure 1C).* **(B)** 3D digital elevation model (DEM) of the Phlegra Montes mountain range with 0 km as the base level [11].

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