EXPLORING THE SURFICIAL PROCESSES ON LOW-MID LATITUDINAL MARS USING PLANETARY DATASETS AND TERRESTRIAL ANALOGUES

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ABSTRACT

This research explores the surface evolutionary processes of Mars, with a particular focus on understanding the interplay between endogenic and exogenic mechanisms that have shaped the low-mid latitudinal Martian landscape over time. Leveraging orbital remote sensing data from various Martian exploratory missions, the study investigates Martian processes including glaciation, mineralogical compositional variations, and impact cratering dynamics during pivotal epochs of Martian history. The findings illuminate a complexity of geological processes, shedding light on the evolutionary trajectory of our neighboring planet. From the rugged terrains of Eos Chaos of eastern Valles Marineris to the glacial expanses of Xanthe Terra, the research sheds light on certain processes in Martian history and the transformative forces molding its landscape.

The research begins with an exploration of the western reaches of Eos Chaos within Valles Marineris, where degraded impact craters bear witness to the erosive forces of fluvial, aeolian, and tectonic processes. Through meticulous analysis of morphological features and comparative studies with other regions of Valles Marineris, insights emerge into the complex geological evolution of this sub-region, offering a glimpse into the broader history of Martian trough systems. Our findings reveal the significant influence of various geological processes, including fluvial, tectonic, and aeolian activities, on shaping the landforms under study. The presence of channels along the slope of the wall, characterized by a mean v-index of 0.2, suggests a fluvial origin for these features. Despite significant degradation, the chaotic mounds within the study area exhibit clear signs of past aeolian and fluvial processes. Additionally, the presence of eroded inselberg peaks above the maximum ponding level of eastern Valles Marineris (-3560 m) indicates the combined effects of aeolian and fluvial processes in the denudation of the impact crater. The morphological and thermal inertia characteristics of the landforms in Eos Chaos closely resemble those observed elsewhere in Valles Marineris. Through our study,

we classify the impact crater of Eos Chaos as a sub-region of Valles Marineris, preserving evidence of various geological processes over time. A model developed based on potential chronological markers provides insight into the evolutionary history of the Eos Chaos impact crater and its integration into Valles Marineris.

Continuing the quest for understanding, the investigation turns to Eos Chaos' potential glacial processes, unraveling the morphological signatures indicative of past ice-related activities. We have identified a range of geomorphological features indicative of diverse geological processes, with glacial activity prominently represented. These glacial processes are evidenced by various morphological features, including tongue-shaped lobate flows, alternating dark and light strata (~10-15 m thick), fragmented sediments with light tones, kettle lake-like structures, surface striations, sublimation hollows, and pit and knob structures. The evolution of these features is delineated into three distinct stages: developing (~0.3 km length), intermediate size (1.5 km length), and mature (~15 km length). Through our observations, we have developed a model illustrating the evolutionary trajectory of the glacial landforms in the region, based on these morphological characteristics. Our findings suggest that these glacial landforms formed during periods of increased planetary spin axis obliquity in the late Amazonian epoch.

This investigation expands to Adamas Labyrinthus, where the presence of a blue-white tint in HiRISE images suggests the existence of water ice deposits, hinting at glacial activity in mid-latitudes. This observation is further corroborated by the presence of brain terrains, chevron textures, and concentric fills nearby, all indicative of glacial processes in the area. The preservation of water-ice deposits across various regions is vital for sustaining long-term assessments of global water-ice resources in future human exploration endeavors. These findings underscore the variability of Mars' climate and the possible distribution of essential water resources on the planet. These revelations regarding glacial occurrences at mid-latitudes on Mars offer valuable insights into the planet's historical climate and the distribution of water resources. Understanding the extent and characteristics of these ice-related exposures within Adamas Labyrinthus will be essential for strategic planning of future human missions to exploit Martian resources. Ongoing investigation and analysis of glacial and periglacial features on Mars will continue to enrich our understanding of the planet's geological history and its potential to support future missions.

Venturing further into the Martian landscape, the study focus into an unnamed impact crater located within Xanthe Terra, discovering compelling evidence of both fluvial and glacial activity. Through meticulous geomorphological analysis and spectral characterization, a dynamic environment shaped by water and ice processes comes into focus, offering tantalizing glimpses into Mars' geological past and the potential for ongoing environmental dynamics. Through meticulous examination of diverse landforms, including theater-head valleys, stratified terrains, fans, meandering ridges, and viscous flows, we have discerned compelling indications of both fluvial and glacial action within the crater. These observations point to a dynamic landscape sculpted by water and ice processes, likely influenced by an impact event approximately 3.5 billion years ago. The existence of Amazonian fan deposits dating back roughly 750 million years further emphasizes the ongoing activity of fluvial processes in the area. Our investigation significantly enhances our comprehension of Mars' geological development and underscores the imperative of additional research to elucidate the intricate history of the planet's mid-latitudinal regions and its evolving climatic conditions over time.

In parallel, the thesis also investigates into the mineralogical composition of Martian analogues, with a focus on the Salem Ultramafic Complex. The serpentine-magnesite assemblage holds significance in astrobiology due to the serpentinization process's known role in forming simple organic molecules like methane from inorganic precursors. This specific assemblage is prevalent in the Salem Ultramafic Complex (SUC) in Southern India, and our study utilized hyperspectral, Laser Raman, and Fourier-transform infrared (FTIR) techniques for characterization. The visible and near-infrared (VNIR) spectra of serpentine samples exhibit a distinct absorption feature at 1.4 μm and a profound feature at 2.35 μm. Magnesite samples, on the

other hand, display broad and strong features at 1.4 μm, 2.3 μm, and 2.5 μm. Comparisons with Martian counterparts were made using the Mars Reconnaissance Orbiter-Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) type spectral library. Raman spectroscopy helped differentiate serpentine polymorphs, with antigorite being the major polymorph in the area. It exhibited specific Raman peaks, and magnesite's presence was confirmed by distinctive Raman peaks. FTIR spectra from serpentine samples revealed characteristic absorption features, while diagnostic features of magnesite were also identified, contributing to a comprehensive understanding of the mineral assemblage. Spectral analysis of olivine-serpentine-magnesite assemblages not only enriches our understanding of Martian surface processes but also holds implications for future missions, aiding in instrument calibration and astrobiological investigations into the origins of life.

As this research concludes, the thesis contemplates the broader implications of its discoveries, underscoring the importance of ongoing exploration and interdisciplinary collaboration in unraveling the enigmas of Mars. Each revelation peels back the layers of Martian history, unveiling a planet sculpted by diverse forces and providing hints for our comprehension of the cosmos.