White paper topic submitted to MEPAG 38 https://mepag.jpl.nasa.gov/meetings.cfm?expand=m38

A COMPARATIVE OVERVIEW OF GLACIAL AND PERIGLACIAL LANDFORMS ON EARTH AND MARS

Prepared for the Planetary Science Decadal Survey by:

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Synopsis and motivation:

Mars has remained a predominantly frozen world throughout most of its history, during which the formation, deposition, dynamics, and removal of ice has been a key agent in surface evolution, resulting in extensive glacial and periglacial landscape modification of Mars' mid- to polar-latitudes. The characterization and formal interpretation of this geomorphological record has seen a surge of discoveries in recent years, showing that Mars' surface evolved considerably after the so-called early Mars period, and presenting evidence that liquid water interacted with ice well into the Amazonian. Identifying the processes involved in icy landform formation and evolution is key to unraveling the climate and water history of Mars much beyond the early Mars period. It is also of primary interest for their potential to harbor extant or extinct life, as well as for the presence of in-situ resources for future human exploration.

Key questions:

The study of the Martian icy geomorphological record can help answer the following key questions:

- What are the characteristic landforms associated with the action of ice, including its formation, deposition, dynamics, and removal, and what processes drive their evolution? (MEPAG science goal 3)
- Can we reconstruct the Martian glacial/periglacial surface processes through the observation of reliable terrestrial analogue landscapes? (MEPAG goal 3)
- What terrestrial analogue sites best represent glacial and periglacial processes observed on Mars? (MEPAG goal 3)
- What is the climate, volatile, and orbital evolution of Mars inferred from the ice geomorphological record? (MEPAG goals 2 and 3)

- Is the presence of liquid water required to generate the glacial/periglacial landforms observed? If so, what are the implications? (MEPAG science goals 1,2, and 3)
- What is the likelihood that a prospective landing site provides in-situ resources for human exploration, given its geomorphological characteristics? (MEPAG science goal 4)

Recommendations

Expanding our understanding of the glaciological record on Mars as well as the underlying glaciological processes requires high-resolution observations, analogue studies, laboratory studies, and monitoring. Consequently, we extend the following recommendations for the Planetary Science Decadal Survey:

- Identification and formal investigation of terrestrial analogue sites that best represent past and present Martian conditions.
    - Earth analogues, informed with reliable data and physics-based scaling of Martian properties, remain the best way to understand surface evolution on Mars.
    - A formal definition of Earth analogues based on the correct scaling between Earth and Mars surface properties, aimed at the identification of dynamically relevant terrestrial analogues. This is also of importance to other planetary surfaces.
- High-resolution characterization of the Martian surface:
    - Continued imagery coverage from HiRISE, CaSSIS, or equivalent (new orbiter concept).
    - A new orbiter laser altimeter, to densify and improve the point coverage of MOLA.
    - High-resolution topographic data of periglacial terrains of interest, acquired through the deployment of an unmanned aerial vehicle (UAV) or a mobile LiDAR.
    - UAV-borne ultra-high-resolution imagery able to evaluate terrain roughness and small-scale topography.
- High-resolution characterization of the Martian near surface:
    - Deployment of a rover or UAV equipped with ground penetrating radar (GPR) for shallow ice characterization
- Improved understanding of ice distribution and characteristics
    - Mars Ice Mapper
    - Mars Orbiter for Resources, Ices, and Environments (MORIE)
    - COMPASS

Status of the white paper: tentative first draft and summary circulated among mentioned co-authors, seeking community feedback and members interested in co-authorship/ co-signers.