**SEARCHING FOR THE SHALLOWEST MARTIAN MIDLATITUDE ICE: THERMAL CONTRACTION CRACK POLYGON MAPPING.** Gareth A. Morgan,[1] Colin Dundas,[2] Matthew Chojnacki,[1] Megan Russell,[1] David M.H. Baker,[2] Nathaniel E. Putzig,[1] and the Mars SWIM Team. [1]Planetary Science Institute. Contact: gmorgan@psi.edu. [2]U.S. Geological Survey. [3]NASA Goddard Space Flight Center.

**Introduction:** Driven by insolation, the Martian climate system evolves through the flux (and phase change) of volatiles between the subsurface, the surface, and the atmosphere. Cataloguing the full array of ice deposits is therefore imperative to our understanding of the contemporary Martian system and to unlocking the climate history. The recently renewed interest in sending humans to Mars provides a complementary focus on midlatitude ice deposits. The extraction and decomposition of shallow $H_2O$ ice offers a source of fuel to support operations on the ground as well as a return trip to Earth.

Outside of the polar regions, perennial ice is restricted to the subsurface, significantly limiting our ability to investigate and map out the full extent of Martian ice reservoirs. Fresh, ice-exposing impacts identified using HiRISE data [1–3] provide valuable direct confirmation of the presence of buried ice, but only over highly restricted areas. To extrapolate the presence of ice beyond the limited locations of the icy impacts, we undertook geomorphic analysis of the landscape surrounding the craters in HiRISE data. As icy-impacts represent locations of known buried ice, the aim of the study was to assess whether a common assemblage of landforms was present across all of the sites. Small-scale polygons (meters to 10s of meters in diameter), interpreted to be an expression of the thermal contraction of near-surface ice [4], were revealed to be prevalent at virtually all icy impact sites, although many are subtle features [3] (**Figure 1**).

Through the Mars Subsurface Water Ice Mapping (SWIM) project, we are undertaking a broad HiRISE survey of polygons within the midlatitudes of both hemispheres to better constrain the presence of shallow ice.

**SWIM Project**: Taking a different approach from previous ice-mapping efforts, the SWIM project has applied data synthesis techniques to integrate all available relevant orbital datasets – including neutron spectrometer, thermal, image, and radar data – to map out the near surface distribution of ice on Mars [5-6] (See [7], for an overview of the SWIM project). The SWIM project consists of three main components: (1) improving/developing five ice-characterizing techniques, (2) undertaking mapping efforts using the individual ice- characterizing techniques, and (3) applying data integration to generate congruent maps representative of the presence of ice. We received three phases of NASA funding through JPL subcontracts (SWIM 1.0: FY19, SWIM 2.0: FY20 and SWIM 4 MIM: FY22) to develop the approach and apply multi-depth (<1 m, 1-5m and >5 m) mapping between 60°N and 60°S.

The HiRISE-based polygon mapping we will present at the 53rd LPSC will represent the highest resolution geomorphic mapping and will be applied to improve our <1 m depth map products. Mapping results from that work will be available on the SWIM Project website (https://swim.psi.edu).

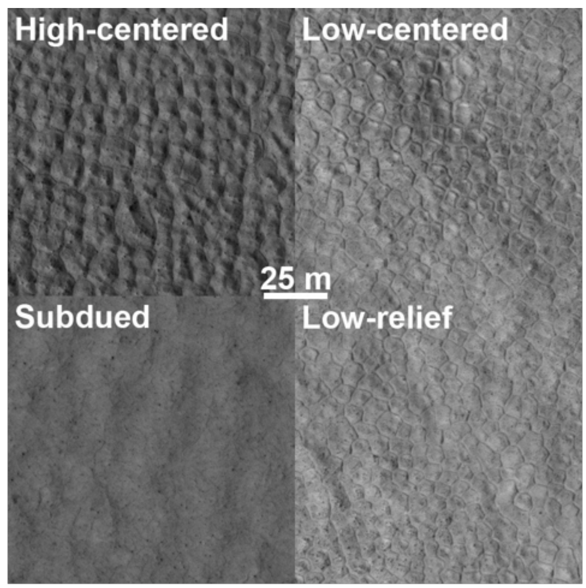


***Figure 1. Examples of different polygon morphology observed in HiRISE coverage near fresh ice-exposing impacts. We are actively surveying these polygon types as part of the SWIM project.***

**Polygons:** Multiple investigations of Martian polygonal terrain have been undertaken using HiRISE data, though the most extensive survey [8] was published over a decade ago. The polygons surveyed at the ice-exposing impact sites did not clearly correspond to the global classification scheme developed by [8], and thus we have established a new, simpler polygon classification system. Under this scheme we divide polygons into high- and lowcentered, low-relief, and subdued (**Figure 1**). We also note potential irregular polygons.

**Methodology:** To undertake our survey we are exclusively using the highest resolution, bin 1 HiRISE images (0.25 m/pixel) to fully resolve polygon morphology. For each HiRISE image we note the presence of each polygon type as well as the presence of non-polygonal textures (such as "brain-terrain") and rocks. As the central focus of our mapping is to support human landing site studies, our survey is concentrated over the lowest latitudes at which we expect shallow ice to be present. To establish these latitudinal bands we are using the SWIM CTX-based grid mapping of periglacial features as a guide (see [9] at this conference). Under this approach we use the boundary between the presence and absence of periglacial features (at a given longitude) as our guiding latitude and then survey all bin 1 HiRISE images 5º equatorward and 10º poleward of that latitude (**Figure 2**).

HiRISE images are not uniformly distributed across the surface of Mars and are also clustered over targeted regions of high scientific importance. To extract a subset of HiRISE images with which to survey, we have divided the survey area (derived from the CTX mapping) into a grid of 1ºx1º cells (**Figure 2**). Where present, a bin 1 HiRISE image is then selected from each cell to be surveyed. As was done for the previous CTX-based mapping, we are excluding areas above +1 km of elevation where the first human landing sites are unlikely to be chosen.

**Anticipated Results:** Different polygon types may relate to subsurface variations in ice states, we therefore anticipate there to be latitudinal/regional differences in polygon populations that we can compare with the other SWIM data sets. Overall, we expect the results of the polygon survey to better delineate the equatorward extent and prevalence of the shallowest ice in both hemispheres.

**Additional LPSC 53 Presentations:** The SWIM team will also present an overview of the entire project [7] as well as detailed ongoing results pertaining to improved CTX-based geomorphic mapping [9].

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**References:** [1] Byrne, S. et al. (2009) *Science* 325, 1674–1676. [2] Dundas, C.M. et al. (2014) *GRL* 119, 109–127. [3] Dundas, C.M. et al. (2021) *JGR Planets*, 126, e2020JE006617. [4] Mellon, M.T. (1997), *JGR Planets,* 102, 25,617-25,628. [5] Morgan, G.A. et al. (2021) *Nature Astronomy*. [6] Putzig, N.E. et al. (in press) Ch. 16 of Badescu et al., eds., *Handbook of Space Resources,* Springer. [7] Putzig, N.E. et al. (2022) *LPSC* 53 (this conference). [8] Levy, J.S. et al (2009) *JGR Planets, 114,E01007*. [9] Baker, D.M.H. et al. (2022) *LPSC* 53 (this conference).

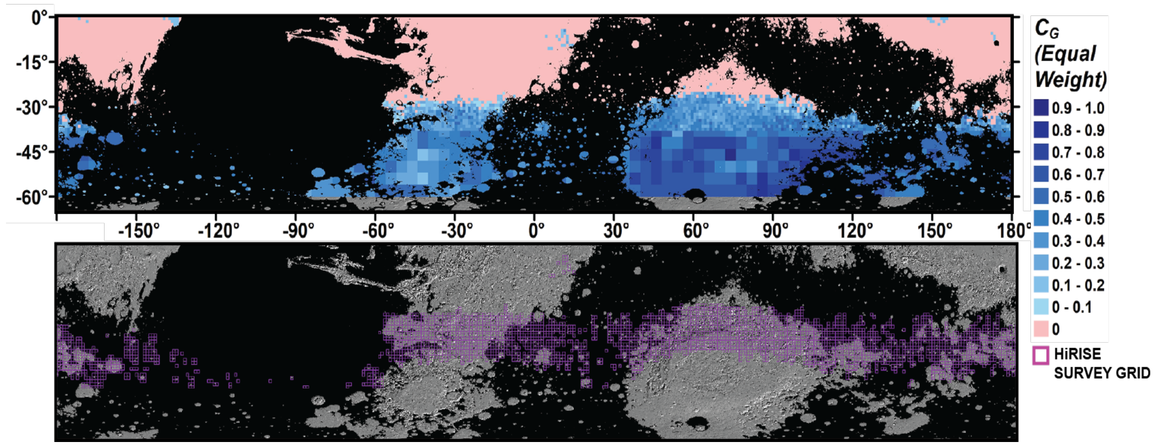


**Figure 2.** HiRISE based polygon survey region within the southern hemisphere. (top) Results of CTX based SWIM geomorphology mapping across the southern hemisphere [7,9]. (bottom) 1º x 1º HiRISE survey grids derived from the CTX results. Note: a similar survey will be undertaken of the northern hemisphere once the corresponding CTX survey [9] is completed there.