MARS SUBSURFACE WATER ICE MAPPING (SWIM): RADAR SURFACE REFLECTIVITY.

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Introduction: The Subsurface Water Ice Mapping (SWIM) in the Northern Hemisphere of Mars project supports an effort by NASA's Mars Exploration Program to determine *in situ* resource availability. We are performing global reconnaissance mapping as well as focused multi-dataset mapping to characterize the distribution of water ice from 0º to 60ºN in four longitude bands: "Arcadia" (150–225ºE, which contains our pilot-study region), "Acidalia" (290–360ºE), "Onilus" (0–70ºE, which covers Deuteronilus and Protonilus Mensae), and "Utopia" (70–150ºE). Our maps are being made available to the community on the SWIM Project website (swim.psi.edu) and we intend to present final results at the next Human Landing Site Selection workshop, expected to occur in the summer or fall of 2019. Follow us on Twitter @RedPlanetSWIM for project news and product release information.

The SWIM Datasets: To search for and assess the presence of shallow ice across our study regions, we are integrating multiple datasets to provide a holistic view of the upper 10s of m of the Martian subsurface (Figure 1). The individual datasets we consider include neutron-detected hydrogen maps (MONS), thermal behavior (both TES and THEMIS), multiscale geomorphology (HiRISE, CTX, HRSC and MOLA), and SHARAD radar surface and subsurface echoes.

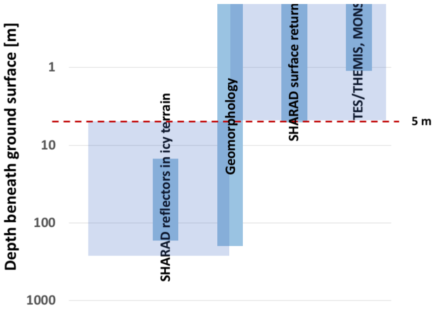

Figure 1. Depth resolution of the data sets, surface features used in the SWIM project to search for ice within the Martian subsurface. SHARAD surface returns analyze the upper ~5m.

Consistency Mapping: To enable a quantitative assessment of how consistent (or inconsistent) the various remote sensing datasets are with the presence of shallow (<5 m) and deep (>5 m) ice across these regions, we introduce the SWIM Equation. Outlined in detail by Perry et al. [this LPSC], the SWIM Equation yields consistency values ranging between +1 and -1, where +1 means that the data are consistent with the presence of ice, 0 means that the data give no indications of the presence or absence of ice, and -1 means that the data are inconsistent with the presence of ice. Here, we focus on our mapping of ice consistency values for radar surface returns associated with shallow ice. For more information regarding the project and its various techniques and datasets, visit our website and see the other SWIM Project abstracts for this LPSC: Morgan at al. (overview), Hoover et al. (thermal analysis), Perry et al. (SWIM infrastructure), Bramson et al. (radar subsurface reflectors), and Putzig et al. (geomorphology).

Methods: SHARAD was designed to study the subsurface structure of Mars through the detection of reflections originating from boundaries between underground layers with contrasting dielectric properties. Indeed, Bramson et al [this LPSC] provides a full description of how the SWIM project uses SHARAD data for this very purpose in order to search for buried ice-rich layers. However, echoes returned from the surface of Mars also contain a wealth of useful information, including surface roughness and near-surface Fresnel reflectivity.

Fresnel reflectivity provides a measure of the density of the near surface. As ice is a low density material, especially in comparison to the regolith and rock that make up most of the Martian surface, measuring reflectivity offers a strategy to search for ice rich deposits. Within this context, the 'surface' is defined by the SHARAD central wavelength (15 m) and actually refers to the upper ~5 m of the subsurface. Consequently, the bulk density over this range can be constrained. As every SHARAD measurement includes a value of the surface power returned, we can generate density estimates across the planet and use them to search for regions of low power that can be indicative of shallow ice.

Density variations derived from the range in substrate geology expected to exist on Mars (water ice to dense basalt) should account for ~ 6 dB in return power. However, SHARAD was not calibrated to specifically measure surface power, and multiple factors external to surface reflectivity influence the return power measured by the antenna. Hence, individual SHARAD measurements cannot be directly converted into density estimates. Nevertheless, it is possible to narrow the power distribution measured by SHARAD and thereby better constrain the influence of density. To achieve that, we broadly follow a similar methodology first attempted with MARSIS data [1], while taking into account the higher frequency of SHARAD.

First, to limit the ionosphere effects we exclude all daytime tracks. Next we normalize the power for surface roughness using the SHARAD roughness parameter developed by [2]. To further account for topographic effects at longer baselines, we correct for the loss of power due to regional slope using the median MOLA slope value over a Fresnel zone. Finally to account for additional MRO influences (spacecraft role, solar panel configuration), we take the median value of corrected SHARAD returns sampled over 1/12° bins.

Preliminary Results: At the time of the abstract submission, we had completed our initial analysis of the Arcadia Pilot study region (Figure 2). The most distinct region of low surface power within the pilot study area consists of an east-west oriented band centered at 33ºN. North of this band, SHARAD largely measures higher surface power returns, though isolated regions of anonymously low power do exist.

The 33ºN low-power band corresponds to a known region of active dust upwelling and dust devil formation that has been monitored since the Mars Global Surveyor Mission [3]. It is therefore likely that a locally thick dust cover is responsible for the lower-power SHARAD returns.

Image analysis of some of the isolated patches of low-power returns reveal the presence of periglacial features consistent with large ice concentrations. For example, the white circle in Figure 2 highlights one such low power anomaly centered on Erebus Montes where features morphologically similar to glacial lobate debris aprons [4] are present, suggesting ice is responsible for the low-power return in this area. See Than et al [this LPSC] for more detail on the corresponding morphology.

Determining the cause of the lower power demonstrates the strength of the SWIM Project approach. By incorporating multiple datasets that also probe the shallow near surface of Mars, such as thermal data [see Hoover et al., this LPSC] and geomorphologic analysis [see Putzig et al., this LPSC], ice detections of high confidence can be distinguished from likely 'false positives' through the SWIM equation [see Perry et al., this LPSC].

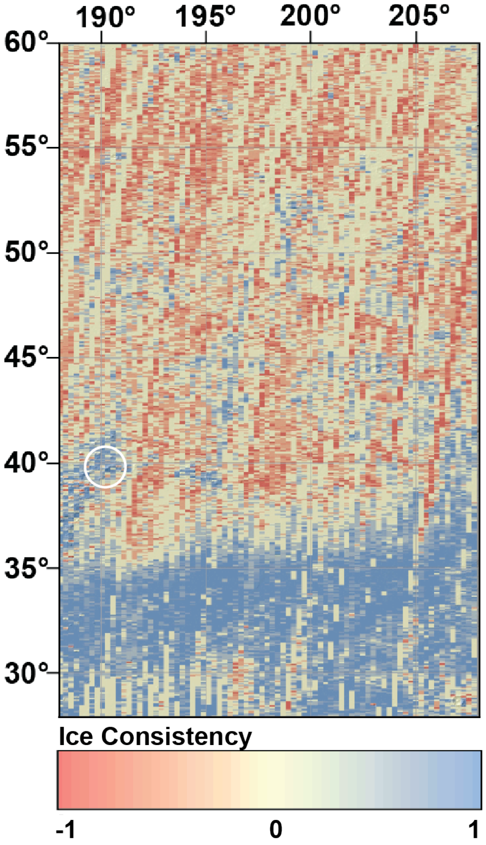

Figure 2. Ice Consistency values derived from SHARAD surface reflectivity across the Arcadia Pilot region. See Putzig et al. [this LPSC] for details of the periglacial morphology highlighted by the circle.

During the 50th LPSC, we will display our completed results for all of our northern hemisphere study regions, including maps of the ice consistency values based on the Fresnel reflectivity.

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