MARS SUBSURFACE WATER ICE MAPPING (SWIM): RADAR SUBSURFACE REFLECTORS.

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Introduction: The Subsurface Water Ice Mapping (SWIM) in the Northern Hemisphere of Mars, 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 from 0º to 60ºN in four longitude bands: "Arcadia" (150–225ºE, which also 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 (https://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 meters 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 echos.

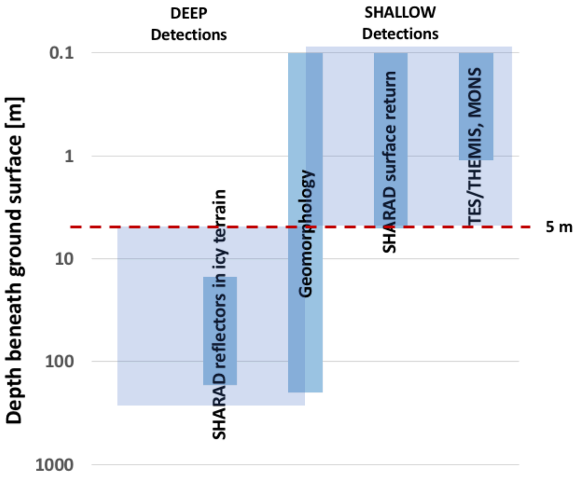

Figure 1: Various depth resolutions of the data sets/surface features used in the SWIM project to search for ice within the Martian subsurface. SHARAD subsurface reflections focus on depths of ~10s–100s meters.

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 subsurface returns associated with deep 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), Bain et al. (surface reflectivity), and Putzig et al. (geomorphology).

Methods: The Mars Reconnaissance Orbiter Shallow Radar (SHARAD) is a sounder that transmits a signal swept from 25 to 15 MHz, corresponding to a wavelength in free space of 15 meters [1]. The data returned by the instrument are typically presented in the form of "radargrams", which are images of returned radar power (represented by pixel brightness) with time delay along the vertical axis and along-track distance along the horizontal axis. When the radar wave encounters a contrast in the material dielectric properties (e.g., atmosphere to surface or layering in the subsurface), a portion of the radar wave is reflected back, causing an increase in power returned at that delay time. In locations where the depth to a reflecting interface can be estimated from topographic measurements, the thickness of the unit and the time delay measured with SHARAD can be used to constrain the relative dielectric constant of the material through which the radar signals have traveled.

Bandwidth extrapolation (super-resolution processing) [2] can improve the vertical resolution of the standard radargrams by a factor of 3, permitting a better identification and tracking of buried structures (Figure 2). Radar echoes from the surface also contain a wealth of information, see Bain et al. [this LPSC].

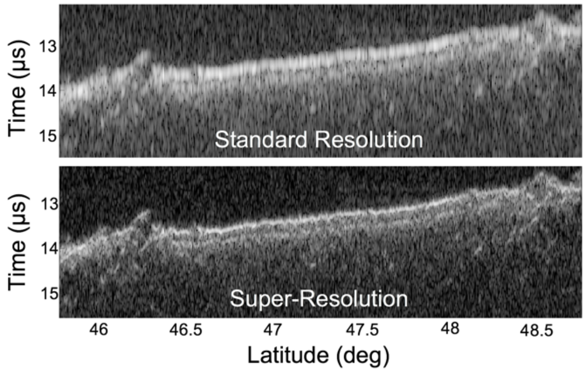

Figure 2: SHARAD track 1329301 demonstrating the improvement in resolution offered by bandwidth extrapolation techniques (bottom) compared to the standard processing (top).

Preliminary Results: Here, we provide some preliminary SHARAD subsurface mapping results. At the 50th LPSC, we intend to present new results, including maps of the ice consistency values based on the subsurface interfaces and dielectric constants.

Arcadia (150–225ºE): To date, most work has been focused on the Arcadia pilot-study region, 188–208ºE. We examined 193 SHARAD tracks across the pilot region. We extended the reflector mapping of [3], increasing its southern extent from 38°N to 35.6°N (Figure 3). We also revised the estimate of real dielectric permittivity above the shallow reflector (Figure 4) upward from 2.5 to 5.0 (ranging from 3–6), using 23 topographic features: the four terraced craters in [3] and an additional 19 features that includes mesas, hills, valleys, domes, and pedestal craters. This result is consistent with larger fractions of non-ice materials than that suggested by [3], offering an explanation for the high dielectric losses calculated by [4].

Acidalia (290–360ºE): We have inspected radargrams in ~5º spacing across the region. So far, we have not found any significant subsurface radar reflectors in Acidalia, consistent with [5], though there is a considerable amount of radar clutter in Acidalia making identification of subsurface reflectors difficult.

Onilus (0–70ºE): We have analyzed 517/1938 radargrams across the region, expanding the study of [6]. We have found four regions of interest associated with reflectors.

Utopia (70–150ºE): We have analyzed 445/1402 radargrams across the region, identifying five regions of interest associated with reflectors, including the area previously mapped by [7]. Two of these regions with reflectors are likely to be associated with lava flows, however.

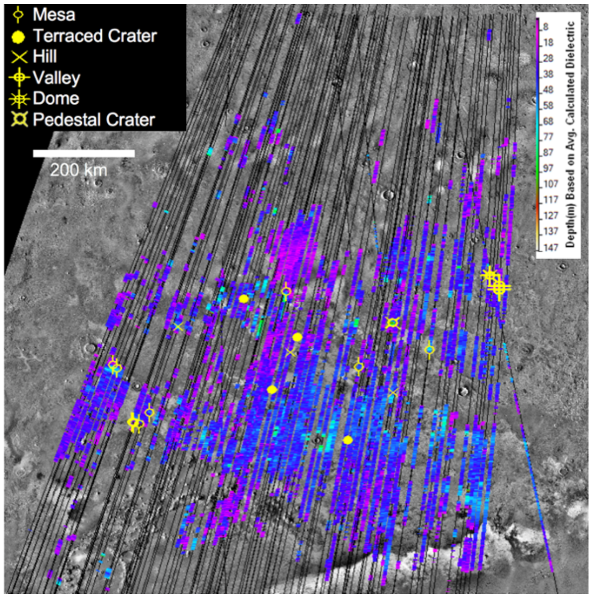

Figure 3: Locations of subsurface reflectors mapped for the pilot study across Arcadia Planitia (figure centered on 196ºE, 47.25ºN). Yellow symbols represent geologic features used to calculate the dielectric values (Fig. 4).

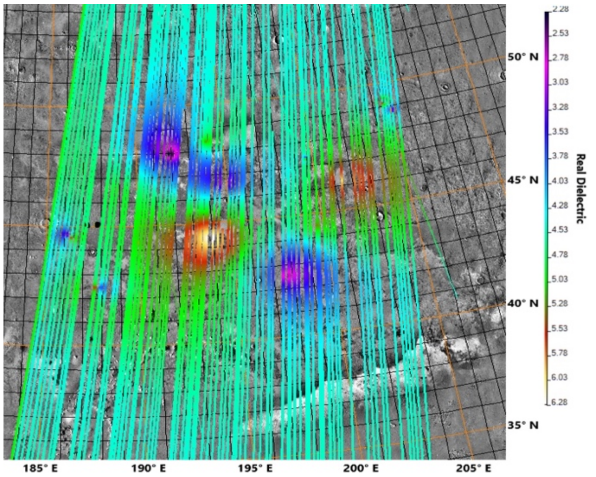

Figure 4: Interpolated and extrapolated real dielectric constants from the topographic and radar delay time measurements made at sites shown in Figure 3.

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References: [1] Seu et al. (2007) *JGR, 112,* E05S05. [2] Raguso et al. (2018) *5th IEEE Intern. Workshop on Metrology for AeroSpace.* [3] Bramson et al. (2015) *GRL, 42*, 6566–6574. [4] Campbell & Morgan (2018) *GRL, 45*, 1759–1766. [5] Orgel et al. (accepted) *JGR.* [6] Petersen et al. (2018) *GRL, 45,* 11595–11604. [7] Stuurman et al. (2016) *GRL, 43*, 9484–9491.