SEARCHING FOR SUBSURFACE ICE IN HELLAS PLANITIA USING SHARAD. C. W. Cook[1], A. M. Bramson[1], S. Byrne[1], D. Viola[1], J. W. Holt[2], M. S. Christoffersen[2], C. M. Dundas[3], [1]Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ 85721 (clairec@email.arizona.edu), [2]University of Texas Institute for Geophysics, Jackson School of Geosciences, University of Texas, Austin, TX 78758, [3]Astrogeology Science Center, U.S. Geological Survey, 2255 N. Gemini Dr., Flagstaff, AZ 86001

Introduction: The presence and nature of subsurface ice in the mid-latitudes of Mars has implications for the planet's climate history. Variations in obliquity and eccentricity drive changes in insolation that lead to transfer of water molecules around Mars [1]. Although water ice is currently unstable on the surface of Mars at the mid-latitudes, it's possible that ice deposited on the surface under previous orbital conditions currently resides in the subsurface [2], or that ice was deposited directly in the subsurface.

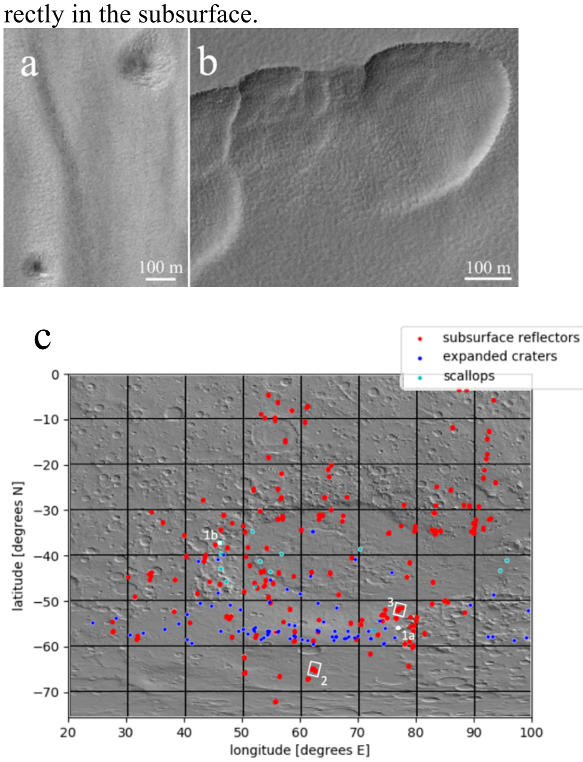

Figure 1: (a) Expanded craters and (b) scalloped depressions in Hellas Planitia. (c) Map of Hellas Planitia showing comparison of subsurface reflector locations to expanded crater and scalloped depression locations and locations of figures 1a, 1b, 2, and 3 marked in white.

Subsurface ice is correlated with thermokarst features such as expanded craters (figure 1a), which are thought to form by the sublimation of excess ice exposed by an impact [3, 4], and scalloped depressions (figure 1b). These features have been observed in the southern hemisphere of Mars [5, 6]. We are investigating Hellas Planitia, one region where these thermokarst features are concentrated, using the Shallow Radar (SHARAD) instrument on the Mars Reconnaissance Orbiter (MRO). We will examine 368 SHARAD tracks covering Hellas Planitia to determine whether there are subsurface dielectric interfaces in this area and, if possible, determine the dielectric constant of the associated material to constrain its composition. We will also observe whether these subsurface reflectors are correlated with the locations of expanded craters or scallops.

Methods: SHARAD is an orbital ground-penetrating radar with a 20 MHz center frequency and a bandwidth of 10 MHz, and a vertical resolution of 15 m in free space and $15\varepsilon_r^{-1/2}$ in a material with dielectric constant ε_r [7].

We are examining radargrams, which are plots of delay time versus distance along the track with the power returned at each pixel represented by its brightness. Reflections from off-nadir features (clutter) may appear at time delays similar to subsurface reflections. Therefore we are comparing the radargrams to simulations based on Mars Orbiter Laser Altimeter (MOLA) topography data [8].

When possible, we will determine the dielectric constant (ε_r) of the material causing the reflection using the thickness of the material (Δx), the delay time difference between the surface and subsurface interfaces (Δt), and the equation $\varepsilon_r=(c\ \Delta t/\Delta x)^2$ where c is the speed of light in vacuum. The thickness of the material is either measured directly using an associated geological feature or assumed based on context. After finding the dielectric constant, we will constrain the composition of the material using a model for the dielectric constant of a mixture.

Preliminary Results: We have examined 149 tracks so far and found 205 possible subsurface reflectors, with varying degrees of confidence. The presence of reflectors in the same area in adjacent tracks leads to higher confidence in a reflector. We have lower confidence in reflectors that are absent from the clutter simulation but are either contiguous with clutter or have characteristics like curvature that are common in clutter. We will produce clutter simulations using higher resolution topography data where available to verify ambiguous reflectors. We plan to present a completed mapping of reflectors in Hellas Planitia from the 368 tracks.

Figure 2 shows an example of possible reflectors. Two of the reflectors shown were beneath a pedestal crater examined in [9] so we have a high degree of confidence that those are real reflectors. We also found two additional reflectors along the track in the region, as well as several in the same area in adjacent tracks, leading to higher confidence in these reflectors as well.

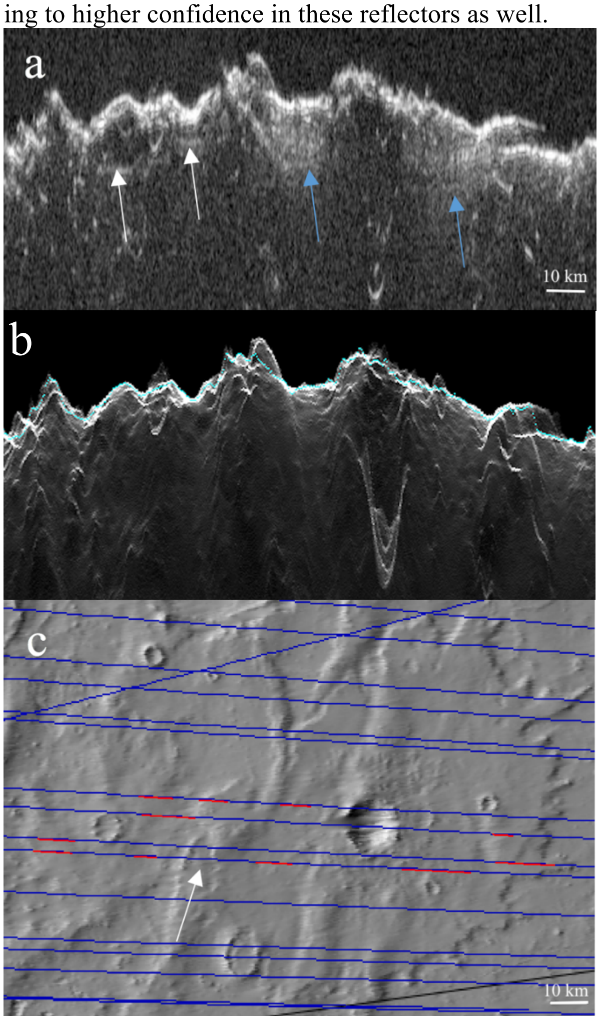

Figure 2: (a) Portion of the radargram for SHARAD track 669301. White and blue arrows mark subsurface reflectors; blue arrows mark reflectors at the base of a pedestal crater examined in [9] and white arrows mark additional subsurface reflectors along the same track. (b) Clutter simulation for same portion of the track. (c) MOLA image showing several tracks, with track 669301 indicated by the arrow. Red lines indicate subsurface reflectors.

Figure 3 shows another example of possible reflectors. No reflectors appear in adjacent tracks parallel to the first reflector on the left in figure 3a, so we have lower confidence in it, while the other reflectors have parallel reflectors in nearby tracks, so we have a higher confidence in those. The second reflector from the left in figure 3a, as well as the reflectors parallel to it, appear to be under a small pedestal crater, so finding the dielectric constant associated with these reflectors would constrain the pedestal's composition.

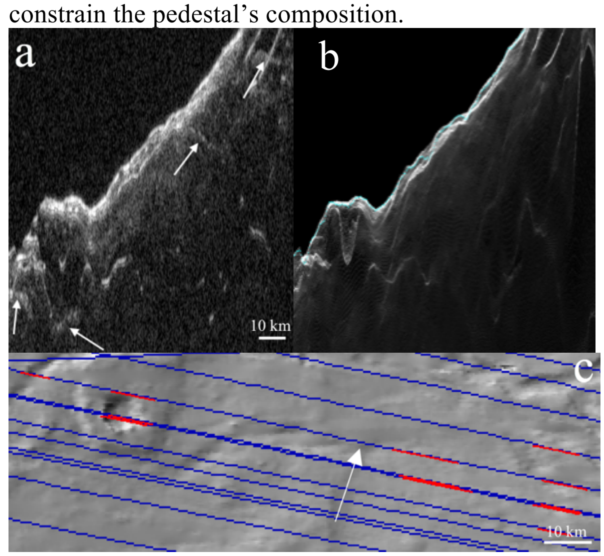

Figure 3: (a) Portion of the radargram for SHARAD track 1701701. Arrows mark subsurface reflectors. (b) Clutter simulation for same portion of the track. (c) MOLA image showing several tracks, with track 1701701 indicated by the arrow. Red lines indicate subsurface reflectors.

We will compare the spatial distribution of reflectors to that of the expanded craters in Hellas Planitia. Preliminary results (figure 1c) show that there is a concentration of expanded craters in a band near 60°S, where some subsurface reflectors are also present. It also shows a relative lack of expanded craters and reflectors in the northwest part of Hellas Planitia. We note that while not all of the tracks have yet been examined, those that have are distributed over the full area of the region, so this may be a real result. The correlation between current candidate reflectors and expanded craters or scallops is not strong but this may change as our understanding of the reflectors is refined.

References: [1] Head J. W. et al. (2003) *Nature 426*, 797-802. [2] Mellon M.T. et al. (2004) *Icarus, 169,* 324–340. [3] Viola D. et al. (2015) *Icarus, 248*, 190-204. [4] Dundas C. M. et al. (2015) *Icarus, 262*, 154-169. [5] Viola D. and McEwen A. S. (2018), *JGR*, DOI:10.1002/2017JE005366. [6] Zanetti M. et al. (2010) *Icarus, 206*, 691-706 [7] Seu R. et al. (2007) *JGR, 112*, E05S05. [8] Choudary P. (2016) *IEEE GRSL, 13*, 9, 1285-1289. [9] Nunes et al. (2011) *JGR, 116,* E04006.