SHARAD REFLECTORS IN UTOPIA PLANITIA, MARS CONSISTENT WITH WIDESPREAD, THICK SUBSURFACE ICE. C.M. Stuurman[1], G.R. Osinski[1], T.C. Brothers[2], J.W. Holt[2], M.Kerrigan[1],[1]Centre for Planetary Science and Exploration/Dept. of Earth Sciences, University of Western Ontario, London, ON, Canada [2]University of Texas Institute for Geophysics, University of Texas at Austin, Austin, TX, USA

Introduction: Characterising the extent and distribution of sub-surface ice in the middle latitudes of Mars is an ongoing endeavour, with applications to both paleoclimate and future missions. Utopia Planitia has been posited as a potentially ice-rich area by climate models [1], gamma-ray spectrometer results suggestive of high hydrogen concentrations [2], and due to the high density of putative periglacial and glacial landforms [3-4].

The SHAllow RADar (SHARAD) instrument on the Mars Reconnaissance Orbiter is a radar sounder which transmits a 15-25 MHz chirped pulse. The data is recorded in the time delay and can be used to map and characterize Mars' subsurface through analysis of relative dielectric constants at depth [5].

SHARAD has identified several features in the mid-latitudes of Mars that are indicative of ice-rich subsurface material. Analysis of lobate debris apron features in the mid-latitudes revealed a dielectric constant consistent with nearly pure water ice, both in the northern and southern hemispheres [6-7]. Pedestal craters in the mid-latitudes have also yielded results suggestive of water ice composition [8]. A massive, radar-transparent layer in Arcadia Planitia has also been discovered, and results suggest the composition of material overlying the reflecting interface is nearly pure water ice [9].

This study represents part of an ongoing SHARAD investigation linked to mapping of potential periglacial and glacial landforms in Utopia Planita. We present the discovery of a subsurface reflecting interface in SHARAD data over western Utopia Planitia. The interface spans approximately 400,000 square kilometers. This work discusses the plausibility of an ice-rich composition for the material overlying the reflectors using dielectric analysis and morphological evidence.

Utopia Planitia: The Utopia Planitia region is a circular depression ~3,300 km in diameter centred at 49.7^{o} N and 118.0^{o} E, thought to be the result of an impact event early in Mars' history. Motivated by obliquity-driven atmospheric deposition, the depression has acted as a depocentre for infill material composed of a mixture of ice and dust [9].

Recently, a revised map of Utopia Planitia has been proposed. This work identifies a new unit ABp which is characterized by the presence and dominance of periglacial landforms such as polygonal terrain, scalloped depressions, and debris flow features [10]. Nearly all reflectors found in this work are contained within periglacial unit ABp (Figure 2). An outlier occurs within Vastitas Borealis marginal unit ABvm.

SHARAD Observations: The mapped interface is located in southwestern Utopia Planitia, and spans from 75^{o}-90^{o} E in longitude and 40-50^{o} N in latitude. Several hundred SHARAD tracks were analyzed, and a total of 88 tracks exhibited verifiable reflectors. Some reflecting interfaces were anomalously far from the bulk of the reflectors, and coverage bias in SHARAD may, in part, explain the gaps in the reflecting unit. Noise in the data and geological variation are also possible explanations for the gaps.

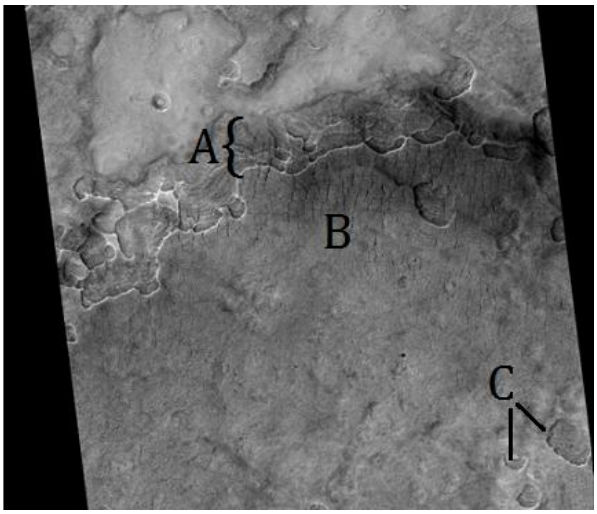

Figure 1: HiRISE image ESP_026385_2225. A scarp within unit ABp exhibiting (A) layering, (B) large polygons, and (C) scalloped depressions. Many similar features were found in SHARAD reflecting unit; reflections often terminate at edge of scarps. HiRISE image is 6 km wide.

Many layered scarps (Figure 1) are found within the reflecting unit; however, some regions are more continuous than others. In cases where reflections are found in the vicinity of a scarp, they consistently terminate where scarps expose a lower unit. This suggests that the layered deposits are the source of the SHARAD reflectors. The heights of the scarps range from 85 to 110 m relative to their bases. Using time delays derived from SHARAD radargrams, relative dielectric constants of 3 to 4.5 have been calculated for these thicknesses. These dielectric values are consistent

with pure to relatively pure water ice. This interpretation is supported by the prevalence of periglacial morphologies throughout the region [10].

Discussion/Future work: The reflecting interface strongly correlates with recent ice accumulation models from [1] (Figure 3). Results from this model suggest that Utopia Planitia has the highest ice accumulation budget of the northern hemisphere, and the reflectors found in this work lie within the 10-14 mm/yr range.

Dielectric analysis, morphological analysis, and ice accumulation models consistently support the hypothesis that the material overlying the Utopia Planitia SHARAD reflector is composed of pure to nearly pure water ice.

By creating a database of scarp elevations across the reflecting unit and the associated radargram time delays at each location, a simple inversion for the average relative dielectric constant should be possible. This will help to constrain the dielectric constant in a comprehensive and quantitative manner.

Possible relationships between the reflecting interface found in this work and the expansive reflecting unit found in Arcadia Planitia will be investigated further. More mapping to the east and west of the reflecting unit is to be completed, as there is evidence that the reflectors extend further than what is currently mapped.

References: [1] Madeleine, J.B. et al. (2009) *Icarus*, *203*, 390-405. [2] Boynton, W.V. et al. (2002) *Science*, *297*, 81–85. [3] Lefort, A et al. (2009) *JGR*, *114*, E04005 [4] Séjourné, A. et al. (2011) *Planetary and Space Science*, *59*, 412-422. [5] Seu, R. et al. (2007) *JGR*, *112*. [6] Holt, J.W. et al. (2008) *Science*, *322*, 1235. [7] Plaut, J.J. et al. (2009) GRL 36, L02203. [8] Nunes, D.C. et al. (2011) *JGR*, *116* [9] Head, J.W. et al (2003) *Nature*, *426*, 797-802. [10] Kerrigan, M.C. (2013) *MA thesis, U of Western Ontario -- Electronic Thesis and Dissertation Repository*. 1101.

Acknowledgements: This work was supported by the Natural Sciences and Engineering Council of Canada.

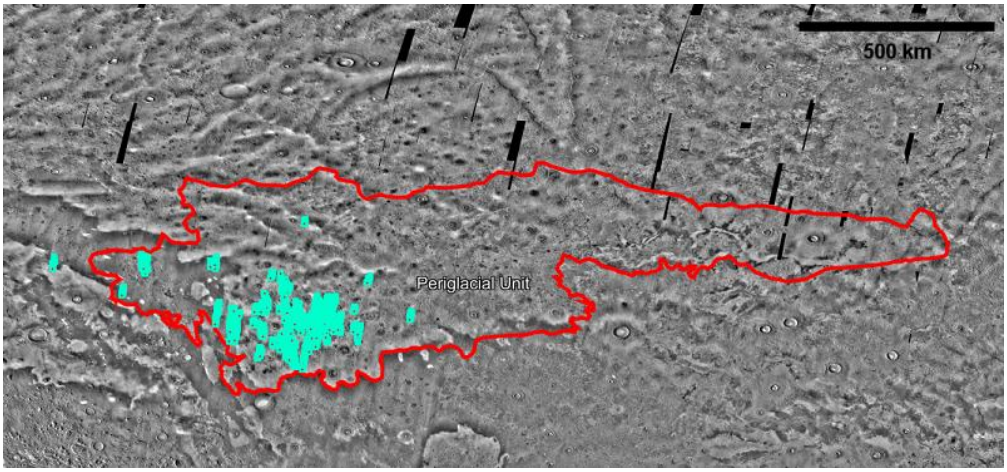

Figure 2: Map of reflector locations (blue) over Kerrigan's (2013) periglacial unit ABp on a THEMIS daytime IR mosaic basemap.

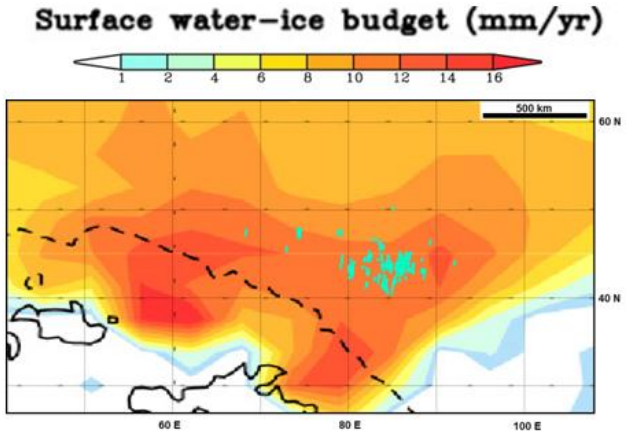

Figure 3: Correlation of reflecting unit locations (blue) with ice accumulation model results. Modified from [1].