Constraining the ice-content and timing of deposition of ice-rich deposits in Utopia Planitia: SHARAD, stratigraphy and crater counting. A. Séjourné(1)(antoine.sejourne@u-psud.fr), F. Costard(1), A. Losiak(2), Z.M. Swirad(3), I. Smith(4,5), M.R. Balme, S.J. Conway, C. Gallagher, E. Hauber, A.E. Johnsson, C. Orgel, C., J.D. Ramsdale, J.D., D. Reiss, J.A. Jr. Skinner, S. Van Gasselt; (1)Univ. Paris-Sud 11, Laboratoire GEOPS, Orsay, France. (2)Institute WildFIRE Lab, University of Exeter, Exeter, UK,. (3)Department of Geography, Durham University, Durham, UK. (4)York University, Toronto, Ontario, Canada. (4)Planetary Science Intitute, Denver, Colorado

Introduction: The northern plains of Mars, topographically lower than the "cratered highlands" of the southern hemisphere, comprise several large overlapping basins that are filled by sediments. Different ice-related landforms demonstrated the presence of ground-ice even at mid-latitudes [e.g., 1-2]. However, there is no consensus about the nature of ground ice and formation of the planetary permafrost. The spatial distributions of ice-related landform at broad-scale and control by regional geology or climate is still not constrained. Improving the geological context of the northern plains will help constrain outstanding questions about martian geological evolution.

An International Space Science Institute team project has been convened to the distribution of ice-related landforms in targeted areas in the northern plain of Mars: Acidalia Planitia, Arcadia Planitia, and Utopia Planitia [3-6].

In Utopia Planitia, we used the distribution and morphotypes of these landforms along a strip from 30°N to 80°N to understand the permafrost cryolithology and its past evolution in relation to climate [3]. Two ice-rich deposits were distinguished over the latitude of the region :

- Between 47°N and 78°N, the assemblage is composed of mantled deposits, textured terrains 30 m diameter polygons [3]. This assemblage is related to the young (<10 Ma) ice-rich debris-covered latitude-dependent mantle [2].
- From 38°N to 47°N, the assemblage is comprised of large scallops, 100 m diameter polygons, pits and mantled deposits [3]. This assemblage of landforms is related to with a deposit of 80 m in thickness containing excess-ice. This high volume of ground ice was sublimated forming km-scale scalloped depressions at the mid-latitude of Utopia.

Here, we describe our study of the stratigraphy, crater counting and SHAllow RADar (SHARAD) detections of the mid-latitude deposit in western Utopia Planitia. The goals are to: (i) constrain the ice-content; (ii) crater retention age of the deposit.

Methods: Following our mapping and distinction of the mid-latitude and high-latitude assemblages of landforms, identification of possible deposits that are associated with the assemblages of landforms were investigated to determine possible geomorphological units. Context Camera images (CTX; 6 m/pixel) and Mars Orbiter Laser Altimeter (MOLA) PEDRs laser shots analysis (vertical uncertainty of about ~1 m, horizontal precision ~100 m) were used for detailed local topographic analysis of stratigraphy.

We performed a crater counting using CTX images to provide an age estimate for the different geomorphologic units in Utopia Planitia. All visible impact craters (>50 m in diameter) were measured except the aligned secondary clusters and rays within the CTX resolution limit. Relatively fresh craters (bowl-shaped with shallow interior) were selected and distinguished from sublimation pits

We analyzed observations from the SHARAD instrument that cross the Utopia Planitia swath. The aim was to detect radar reflections that represent an interface between contrasting materials: air-regolith; regolith-ice; regolith-basement.

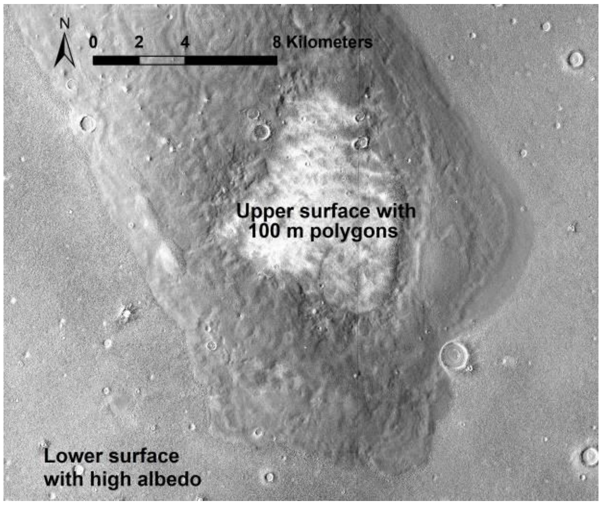

Figure 1: Mid-latitude ice-rich deposit with a polygonized surface of 100 m polygons

Stratigraphy: Over the area of the mid-latitude assemblage of landforms, the 100 m polygons are present over the surface continuously until its southern limit at about 38°N (Fig. 1). The southern limit of the polygonized surface takes the form of a deposit with clear gently-sloping limits whithout scallops suggesting no degradation (Fig. 1). The deposit covers a surface that is lower in altitude. The deposit having thermal-contraction polygons of 100 m, this deposit is a permafrost. The estimated thickness of the deposit is about 80-100 m based on different MOLA laser tracks along the limit.

Ice-content: The widespread presence of numerous scalloped depressions formed by sublimation over the mid-latitude of Utopia Planitia indicates a high ice-content of the deposit (excess-ice which is the amount of ice exceeding the natural pore water content in a non-frozen state) [6-9]. However, it is difficult to have a precise estimation of the volume of ice. This deposit is highly similar to ice-rich permafrost in the Arctic on Earth [6-9]

However, SHARAD can help to constrain the ice-content. On several radargram (39°–45°N), we found detection interfaces where we estimated the thickness of the deposit. These detections were compared with a simulated radargram to remove artefact. We found a thick deposit of material that corresponds to the ice-rich zone highlighted by our mapping. By using the estimated thickness of 80–100 m, we determined that the material has a dielectric constant between 3.4 and 5.3 [3]. These values are consistent with a material that is primarily ice (~50–85% by volume) with some lithic component. Previous SHARAD studies suggested the presence of an ice-rich layer of about 100 m in thickness (estimated to be 50–85% water ice by volume) in a zone (70°–90°E and 40°–48°N) at the southwest of our study area [10]. Here, we improve the confidence of the estimation of ice-content by selecting a zone where no extensive sublimation occurred and where there is a better estimation of the maximum thickness of the deposit.

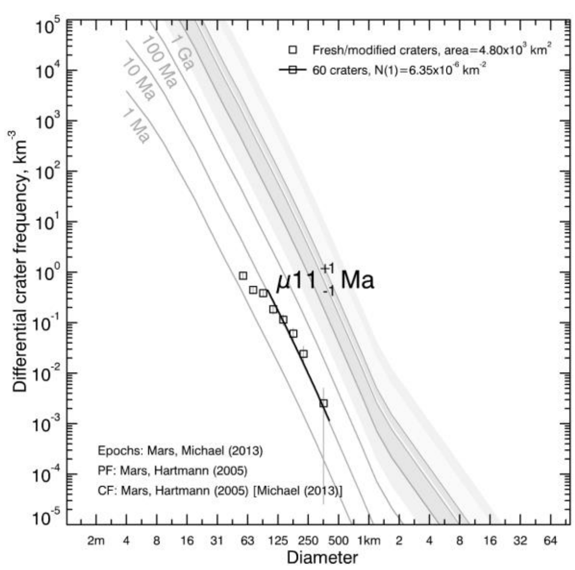

Figure 2: Crater size-frequency distributions of the mid-latitude deposit at 42°N

Crater counting: For the mid-latitude polygonized surface, the crater count of relatively fresh impact craters shows a step between the 1 Ma and 10 Ma isochron (Fig. 2). The craters with diameter >100 m are aligned along the 10 Ma isochron and give a best fit age of 11 ±1 Ma [3]. They correspond to the last major deposition in the zone. For craters smaller than 79 m (bin edge), a resurfacing event occur after 11 Ma partially removing them.

Discussion: On Earth, the formation of arctic ice-rich permafrost are related to the last glaciation. Therefoire, a formation related to the Late Amazonian extensive mid-latitudes glacial landsystems along Deuteronilus-Nilosyrtis Mensae [11] has been suggested [9, 10, 12]. The crater retention ages of these glacial features ranges between ~60 Ma and 1 Ga [11, 13, 14]. The difference in crater retention age between these features and the youngest last deposition in UP dismisses a related origin. With MOLA laser shot profile, the ice-rich mid-latitude deposit seems to cover several Viscous Flow Features along Nilosyrtis Mensae.

Conclusion: Our stratigraphic analysis, crater counting and SHARAD detections highlight a mid-latitude ice-rich deposit similar to ice-rich permafrost in the Arctic. The deposit is of 80 m in thickness containing excess-ice (~50–85% by volume) and of about 11 Ma age. More crater countings and SHARAD detections in different areas of the mid-latitudes are currently being done.

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