THE PERIGLACIAL LANDSCAPE OF UTOPIA PLANITIA; GEOLOGIC EVIDENCE FOR RECENT CLIMATE CHANGE ON MARS. M. C. Kerrigan[1], G. R. Osinski[1], and M. Van De Wiel[2], [1]Dept. of Earth Science, Western University, London, ON, Canada N6A 5C2. [2]Dept. of Geography, Western University, London, ON, Canada N6A 5B7. (mkerrig@uwo.ca)

Introduction: The northern plains of Utopia Planitia, Mars, hosts an abundance of potential periglacial landforms. We present here a revised geologic map of the region. We define a new Periglacial Unit and have developed a model for the formation and evolution of the periglacial landscape by assessing the use of scalloped depressions as indicators of climate change, and combining our geologic evidence with recent climate model predictions.

Study Area: Utopia Planitia is a large topographic depression centred at 49.7°N and 118°E, approximately 3,300 km in diameter. The study area is in the west of the region, shown in Figure 1. There are scalloped depressions and other periglacial landforms present in other regions of the northern hemisphere (e.g.,[1], [2]) and some occurrences in the southern hemisphere [3], but none in the quantity that is seen in Utopia Planitia. This would suggest that Utopia Planitia has some unique feature(s) that encourages the development and preservation of these landforms.

Methodology: The area investigated stretches from approximately 20 to 60°North and 70 to 140°East. Thermal Emission Imaging System (THEMIS), Mars Orbiter Camera (MOC) and Mars Reconnaissance Orbiter Context Camera (CTX) images for this area were examined. There are challenges in identifying unit contacts accurately and precisely due mainly to data quality and coverage and also from the geology of the region itself. The proximity of visually very similar units means that the contacts between them can be quite subtle. The types of deposition in the region have also resulted in units not having sharply defined edges but rather they dissipate out over a large area. We have classified the unit contacts as either "certain", "approximate", or "inferred", depending on the level of confidence in the accuracy and precision of the placement of the line.

Periglacial Landforms as Climate Indicators: The significance of periglacial landforms lies in their diagnostic value as environmental indicators, both on regional and localized scales [5]. The occurrence and morphology of periglacial landforms are determined by a complex combination of geologic and climatic conditions. As such, the study of an ancient periglacial landscape is useful in reconstructing the past environmental conditions. It must be noted that in doing this assumptions are made on the process-form relationship between the environmental conditions and the landforms but whose validity can be strengthened on the basis of additional evidence, such as climate models.

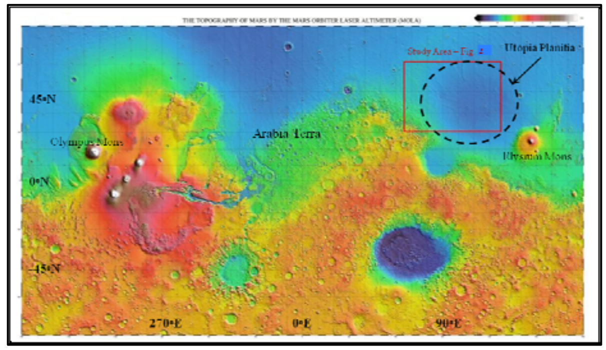

Figure 1. Global topographic map of Mars.Study area shown by red box. Image credit: MOLA Science Team

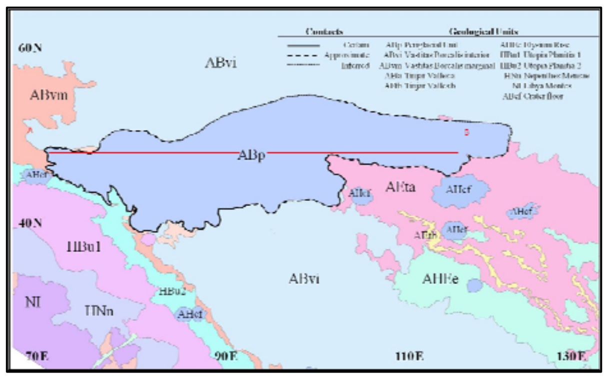

Figure 2. Revised geological map of study area in Utopia Planitia, showing the extent of the Periglacial Unit (ABp). Other units are based on the map produced by [4] and detailed descriptions can be found therein. Red line A to B indicates cross section as seen in Figure 4.

Results and Interpretations: *New Periglacial Unit:* This unit was identified by the abundance of scalloped depressions, in the area. In order to define the area of scalloped depressions the furthest extent of their occurrence was examined in all directions. A boundary for this area was drawn following the methodology for contact types as outlined above. The revised geology of the study area is shown in Figure 2 with the newly defined Periglacial Unit shown to be stratigraphically younger than the volcanic units of Elysium Rise (AHEe) and Tinjar Valles (AEta, AEtb) in the east, the glacial-like units in the west, and the Vastitas Borealis units (ABvi) in the north and south of the area. Examples of contacts between units can be seen in Figure 3.

Recent Climate History of Utopia Planitia: The nature and origin of the ice-rich substrate resulting in this periglacial landscape is still a matter of debate. However, the commonly held theory is that it is the result of periodic atmospheric deposition of an ice and dust mixture driven by changes in Mars' obliquity [6]. Combining evidence for the timing in obliquity changes in the recent past [7], evidence for the potentially significant warming affect of clouds [8], and evidence for the changes in wind and aeolian deposition patterns [9] with the mapping carried out in this study, we have developed a model for the formation of the periglacial landscape in Utopia Planitia.

Recent work [10] identified an area to the west of the Periglacial Unit that shows evidence of recent glaciation. The large volume of ice required to form glaciers and ice sheets would likely be deposited during periods of very high obliquity when ice would be transported from the poles. Jet streams from Arabia Terra would decelerate over the topographic low of Utopia [9] and deposit ice and dust into this region (Figure 4a). As obliquity gradually decreases, so does the amount of ice in the atmosphere and the amount of deposition in Utopia Planitia. Thinner layers of dust with less ice content are laid down, burying the remains of former ice sheets beneath them (Figure 4b). When obliquity drops below approximately 30°, deposition slows enough to allow the formation of periglacial landforms (Figure 4c) as the ground ice begins to be lost to the atmosphere and is eventually deposited back at the poles. In present day conditions, the ice is lost through sublimation directly to the atmosphere. During the past 5 million years, as obliquity has lowered, the atmospheric conditions may have been suitable for thaw to occur and possibly for liquid water to pool on the surface. During periods when obliquity is approximately 35°, Utopia Planitia is a region of above average cloud coverage [9]. This would also mean above average temperatures [8].

Conclusions: The Periglacial Unit (ABp) is a distinct geologic unit identified by its assemblage of scalloped depressions. In defining its extent, contacts, and stratigraphical relationships with surrounding units we concluded that it is the youngest geologic unit in Utopia Planitia and that the scalloped depressions are representative of the most recent phase of periglacial activity in the region.

This research also developed a model for the formation and evolution of the periglacial landscape in Utopia Planitia which suggests that regional conditions are such that they could allow for the presence of water on the surface in the geologic past, if only for brief intervals. It is concluded that in the past Utopia Planitia has experienced an intensified regional climate and dynamic, evolving landscape that has recorded the changing climate on Mars.

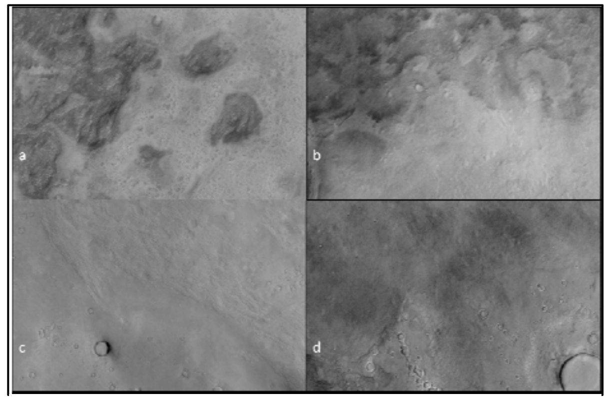

Figure 3. Contacts between scalloped depression terrain (SDT) and surrounding terrains. a) SDT on the left with a lower albedo than the brighter volcanic terrain on the right. B17_016442_2252_XI_45N257W. b) SDT at the top of the image. P18_008188_2228_XN_42N268W. c) The southern edge of the polygon dominated terrain in the south west of the area. P20_008676_2186_XI_38N274W. d) SDT on the top right of the image. B18_016575_2255_XN_45N288W Images are 10 km wide, North at top.

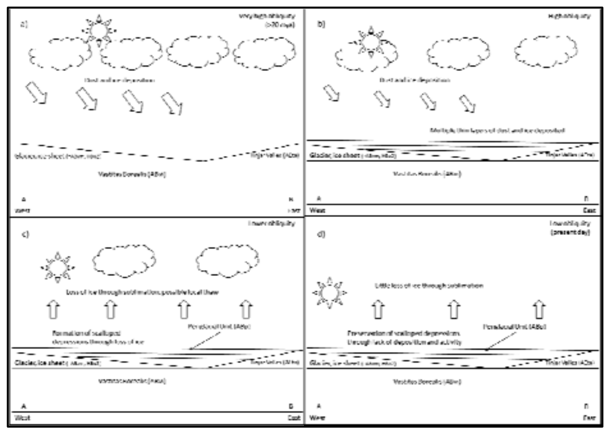

Figure 4. The deposition and formation of the Periglacial Unit (ABp) in Utopia Planitia (not to scale). a) very high obliquity, deposition of dust and ice, accumulation of glacier/ice sheet in west, dissipates towards east b) high obliquity, deposition of dust and ice in thin layers c) lower obliquity, loss of ground ice, formation of scalloped depressions d) present day low obliquity, stable conditions.

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