THE DISTRIBUTION AND STRATIGRAPHY OF PERIGLACIAL LANDFORMS IN WESTERN UTOPIA PLANITA, MARS. M. C. Kerrigan[1], G. R. Osinski[2], R. D. Capitan[2], N. Barry[2], S. Blain[2] and M. Van De Wiel[1]. [1]Dept. of Geography, University of Western Ontario, London, ON, Canada, [2]Centre for Planetary Science and Exploration, Depts. Of Earth Science and Physics and Astronomy, University of Western Ontario, London, ON, Canada. (mkerrig@uwo.ca)

Introduction: Periglacial landforms, in particular polygons and scalloped depressions, have been documented in Utopia Planitia by numerous workers (e.g., [1-3]). The distribution trends of periglacial landforms in this region offer indications to the stratigraphy and climatic history of the area. We suggest that these landforms represent a complex arrangement of multiple discrete periglacial units rather than just superficial surface modifications of existing geological units. These previously undefined periglacial units can be identified through the observation of the various geomorphologic landforms present on the surface and their spatial relationships to one another. This study focuses on the largest periglacial unit identified in the area and aims to introduce a clearer understanding of the large-scale geographical context of the multiple episodes of periglacial activity in Western Utopia Planitia.

Study Area and Methodology: We have carried out an extensive survey of periglacial-like landforms in Western Utopia Planitia. The study area extends from approximately 70 to 140 degrees east and 20 to 60 degrees north. Thermal Emission Imaging System (THEMIS), Mars Orbiter Camera (MOC) and Mars Reconnaissance Orbiter Context Camera (CTX) images for this area were examined. With hundreds of images analysed, this represents the most detailed study of this area to date. High Resolution Imaging Science Experiment (HiRISE) images were also studied to facilitate distinguishing between certain landforms. Figure 1 shows the distribution of scalloped depressions and small-scale polygons identified from these images over a morphometric map of the region [4]. Also noted was whether a feature was in or associated with a crater or in the surrounding flat terrain.

Distribution of Periglacial Features: Western Utopia Planitia contains a melange of many and varied periglacial landforms across its full extent. With the mapping of these landforms some trends in their distribution emerge. There is a distinct band of scalloped depressions highlighted at the top of the map region (Fig. 1). This includes individual scalloped depressions as well as more degraded areas where depressions have coalesced. In addition, in this area are small-scale polygons although they are also found in areas outside of the boundary on the map where scalloped depressions are not found. Also of note is the spatial separation of gullies and scalloped depressions in Western Utopia Planitia, an anomaly not previously noted in this debate and discussed further in [4].

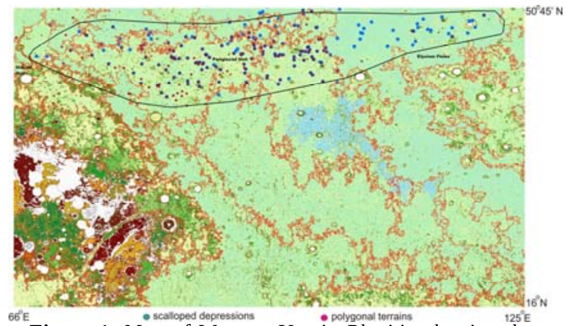

Figure 1. *Map of Western Utopia Planitia showing the distribution of periglacial landforms and the boundaries of the previously undefined Periglacial Unit. (see [4] for more on this map).*

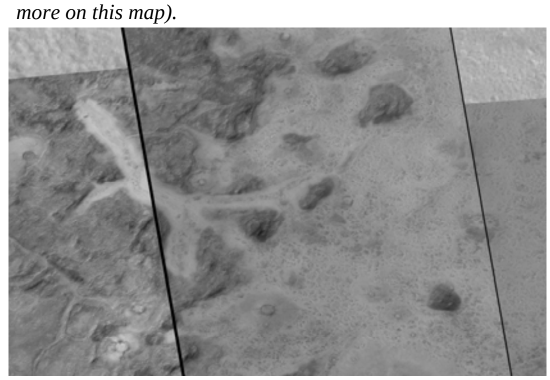

Figure 2. *CTX mosaic, centred on image B17_016442_2252_XI_45N257W showing contact between Periglacial Unit (low albedo) and Elysium Flows (high albedo).*

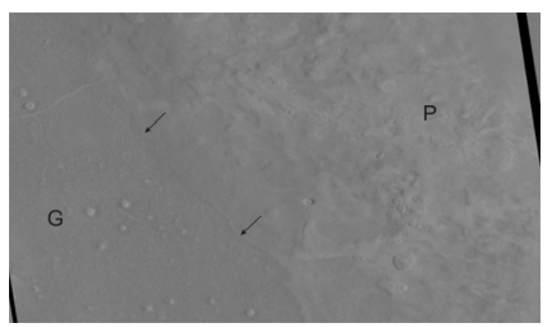

Figure 3. *CTX image B 19_016944_2254_XI_45N282W showing contact between Periglacial Unit (P) and Glacial Unit (G).*

Defining a new Periglacial Unit(s): The presence of periglacial landforms on Earth is indicative of an ice-rich substrate and the same is thought to be true on Mars [5]. In Western Utopia Planitia this substrate is of varying thickness, possibly up to many hundreds of meters [6]. The nature and origin of this ice-rich substrate (or mantle) is still a matter of debate but 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 [7]. It has been suggested however that these periglacial landforms are not present in this ice-rich substrate but are in a unit underlying it [8]. This was concluded through the observation of scalloped depressions with possible mantle deposits on their floors. Alternatively, it may be that rather than the scalloped depressions being filled in with mantle deposits, they have extended down through their unit to expose an underlying, older unit of ice-rich mantle material. Although this ice-rich substrate is usually (albeit not always explicitly) referred to as a single unit, it has been proposed that multiple distinct layers of this substrate are present in the area [9]. We suggest that there is evidence from the periglacial landform distribution trends investigated here to support the related idea of multiple episodes of periglacial activity represented by separate units in Western Utopia Planitia.

Extent and stratigraphical relations of the Periglacial Unit: This study has defined the boundaries of the large periglacial unit for the first time (Fig. 1). The unit covers an area of approximately 1,150,000 km^2. It overlies the Elysium Flows on its eastern extent and the Glacial Unit to the west (see [10] for details of this glacial unit). To the north and south the unit dissipates gradually and as such the boundaries here are difficult to accurately determine. Combining the visual datasets with altimetry data, however, has allowed these boundaries to be better estimated than with visual information alone [4]. Figure 2 shows an area along the contact between the periglacial and Elysium units. The lower albedo material is part of the periglacial unit and small 'islands' of this material is seen within the higher albedo Elysium unit. We suggest that at this farthest eastern extent of the Periglacial Unit it is quite thin and has degraded variably to expose the underlying Elysium unit. Figure 3 shows a section of the contact between the Periglacial Unit and the Glacial Unit to the west. This clear divide between the Periglacial on the right of the image and the Glacial on the left can be followed quite readily due to the high density of CTX images in this area.

Discussion: Rather than polygon terrain and scalloped depressions being thought of as periglacial modifications to pre-existing non periglacial units (e.g., Vastitas Borealis Formation), we propose here that they are landforms diagnostic of distinct and previously undefined periglacial units. These landforms vary in size and morphology throughout the region and we suggest units representing multiple episodes of periglacial activity can explain morphological differences as well as the discrepancies between areas where, for example, scalloped depressions appear to post-date gullies and other areas where they pre-date gully formation.
Concluding that all instances of periglacial geomorphology are representative of a single occurrence of periglacial activity is to underestimate the vastness of Utopia Planitia both spatially and temporally. It is worth remembering that the area surveyed spans almost 6,500,000 km^2, an area 6 times the size of the Canadian High Arctic where a complex geologic and climatic history is recorded in the stratigraphical relationships between numerous distinct units.

This study has shown that by using observations of the landforms present on the surface of Western Utopia Planitia and investigating how they relate to each other a clearer understanding of the area as a whole and the history of its landscape can be attained. While geological mapping of Utopia Planitia will always be somewhat limited when confined to imagery and satellite data, the high resolution imagery and the increasing coverage of the region now available is allowing a start to be made on constructing the most detailed stratigraphical history of Utopia Planitia to date.

References: [1] Costard F. M. and Kargel J. S. (1995) *Icarus* 114:93-112. [2] Soare R. J., et al. (2008) *Earth Planet. Sci. Lett.* 272:382-393. [3] Lefort A., et al. (2008) *J Geophys Res.* 114:E04005. [4] Capitan R. D., et al. (2012) *LPSC XLIII*, this conference. [5] French H. M. (2007) *The Periglacial Environment*, Wiley, West Sussex, England. [6] Madeleine J. –B., et al. (2009) *Icarus* 203:390-405. [7] Head J. W., et al. (2003) *Nature* 426:797-802. [8] Soare R. J., et al. (2012) *Planetary & Space Science* 60:131-139. [9] Head J. W., et al. (2011) *LPSC XLII* 1315 [10] Osinski G. R., et al. (2012) *LPSC XLIII*, thisconference.