RECONSTRUCTING THE SPATIAL AND TEMPORAL DISTRIBUTION OF GLACIAL AND PERIGLACIAL ACTIVITY IN UTOPIA PLANITIA AND SURROUNDING TERRAINS. Osinski, G.R., Capitan, R.D., Kerrigan, M., Barry, N., Blain, S. and Tornabene, L.L. Centre for Planetary Science and Exploration, Depts. Earth Sciences/Physics and Astronomy, University of Western Ontario, London, ON, Canada N6A 5B7 (gosinski@uwo.ca)

Introduction: There is growing and widespread evidence for glacial and periglacial activity in several regions of Mars. Head et al. [1] presented evidence for "dusty, water-ice mantling deposits that are layered, metres thick and latitude dependant, occurring in both hemispheres from mid-latitudes to the poles". They suggested that these deposits formed during a geologically recent Ice Age that occurred from ~2.1 to 0.4 Myr ago. Since then, a variety of landforms, possibly formed by late-Amazonian glacial activity (< 300 Ma), have been identified on Mars, including lineated valley fill (interpreted as debris-covered glaciers), lobate debris aprons, concentric crater fill, and morainal and esker-like features (e.g., [2-6] and references therein).

Utopia Planitia, in the northern plains, represents an area where there is a concentration of landforms (e.g., scalloped depressions interpreted as themorkarst features[7-10]; thermal contraction polygons [10, 11]) consistent with periglacial activity. This purpose of this contribution is to report on new mapping and dating of glacial and periglacial units in this region and understanding the stratigraphic relationships with other glacial units identified along the dichotomy boundary by other workers. We document the existence of lineated valley fill, lobate debris aprons and various relation landforms that are indicative of glacial processes. Our results suggest multiple periods of glacial and periglacial activity over the past ~100 Ma and continuing through the most recent ~20 Ma period. When taken together with impact crater landforms indicative of subsurface ice (e.g., the highest global concentrations of pedestal craters [12] and double layer ejecta craters [13]), this data points to the Utopia Planitia and surrounding regions as being a major depocentre and focus of glacial and periglacial activity on Mars.

Study Area and Previous Work: Utopia Planitia is a major topographic depression situated in the northern plains of Mars (Fig. 1). A wide variety of possible periglacial landforms, including shallow scalloped-depressions and polygons, have been documented in this region and discussed at length by multiple authors (e.g., [3, 8] and references therein). In contrast, the glacial record in Utopia Planitia remains less well studied. Concentric crater fill is common in this region and has most recently proposed to be of glacial in origin [3]. Pearce et al. [14] also presented further evidence for glaciation in the form of flow lobes, arcuate ridges, interpreted as eskers, and moraine-like deposits in central Utopia Planitia (Figs. 1, 2).

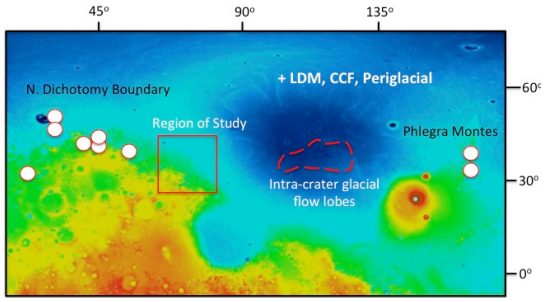

Fig. 1. Context map of Utopia Planitia (MOLA base image) showing the location of previously mapped glacial terrains (white dots; from [4]) and the study region.

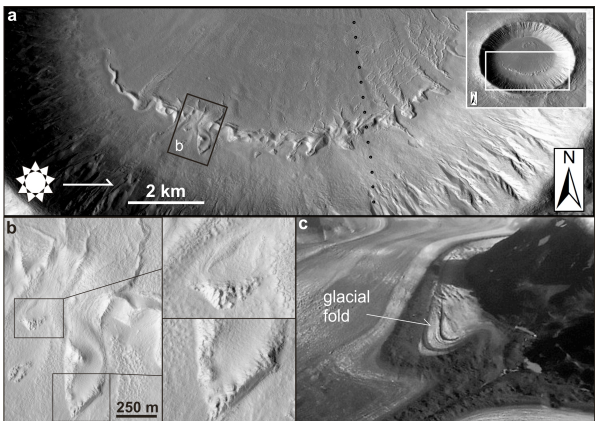

Fig. 2. Glacial flow lobes from Pearce et al. [14].(a) Series of arcuate ridges in an 11.5 kilometre impact crater at 105° E, 39° N (CTX P01_001357_2198). (b) Flow features that have overridden arcuate ridges from HiRISE PSP_001357_2200. (c) Glacier folds that form under constricted flow from an Alaskan glacier that resemble features in (b). Photo courtesy of Don McCully.

The presence of a variety of potential "ice-rich mantles" or the Latitude Dependant Mantle (LDM) of <2 Ma have also been proposed in this region (e.g., [1, 15]). There also exists abundant evidence for debris covered glaciers and lobate debris aprons to the west at Deuteronilus, Protonilus, and Nilosyrtis Mensae ~25–40°N, 15–75°E) (see [2] for an overview) and to the east in Phlegra Montes (Fig. 1) [16]. The relationship,

if any, between these various landforms and deposits, however, remains unknown.

Here we focus our observation on a region located between the western periphery of Utopia Planitia and Astapus Colles and eastern side of the fractured terrain of Nilosyrtis Mensae, known stratigraphically as boundary plains 1 and 2 [17] (Fig.1).

Evidence for Glaciation: Systematic mapping of this region is ongoing and has resulted in a preliminary new geological map (Fig. 3) [18]. We have identified 3 distinct terrains that exhibit evidence for glaciation ("glacial units 1–3" in Fig. 3).

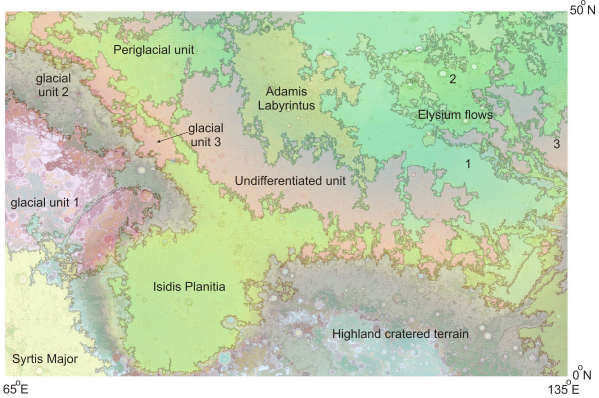

Fig. 3. Preliminary new geological map of Utopia Planitia (see [18] for further details) outlining "glacial units 1–3".

Glacial Units 1 and 2 – Fretted Terrain, Lineated Valley Fill and Lobate Debris Aprons: These regions comprise isolated areas of high topography bounded by channels and troughs (Figs. 4,5). Along the entire contact with higher elevated terrain to the west, this terrain develops within circular or oval areas and alcoves. Parallel arcuate ridges extend downslope from many of these alcoves and the the troughs display limeations parallel with the walls. Based on the criteria developed by Head et al. [2], this system of landforms conforms to the definition of lineated valley fill (LVF) (Fig. 5). Lobate debris aprons (LDA) are also common. As such, we interpret these regions to represent networks of debris-covered glaciers consistent with interpretations of the fretted terrain further to the west along the dichotomy boundary, the closest example being in the Nilosyrtis Mensae region [19]. Glacial Unit 1 appears to be more akin to these other regions along the dichotomy boundary, whereas Glacial Unit 2 posseses some of the traits of Glacial Unit 3 desribed below.

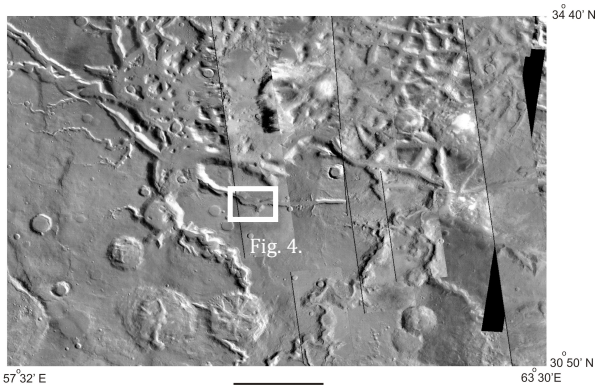

Fig. 4. Mosaic of CTX and THEMIS images showing the typical appearance of Glacial Unit 1. The inset shows the location of Fig. 4.

Fig. 5. Close-up of terrain interpreted as Lineated Valley Fill (LVF). Image is ~10 km across, north is up. CTX image P16_007385_2149_XN_34N300W.

Glacial Unit 3 – Smooth Terrain: There is no abrupt morphological transition to the smooth plain that lays to the east and to the front of the fretted terrains described above (Fig. 6). The smooth deposits cover and subdue may of basement craters and engulf the peripheral fretted morphologies. Larger craters that are superposed on the smooth terrain display brain terrain morphology, and the smallest ones internal mounds. All major craters are breached or covered. There are relatively few superposed craters, which suggests this unit is Late Amazonian in age, possibly <100 Ma. Dating using crater counting techniques is being conducted. Our preliminary interpretation of this unit is that it represents a remnant ice sheet overlain by a mantle of aeolian-derived till generated by sublimation of the uppermost portion of the potentially still buried ice.

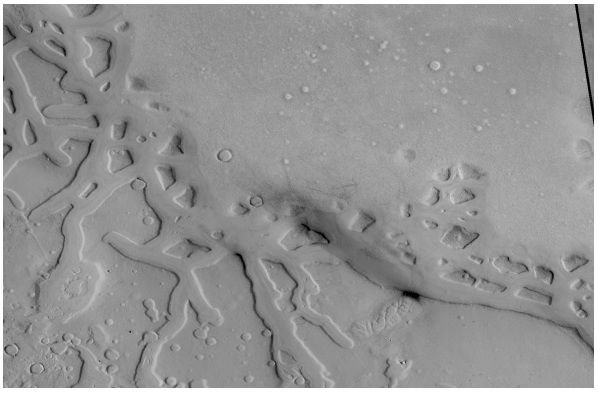

Fig. 6. Image showing the transition from glacial unit 2 (fretted terrain to south) to 3. Image is ~10 km across, north is up. CTX image P19_008505_2218_XN_41N285W.

Evidence for Periglaciation: Unlike glacial activity, numerous workers have documented evidence for periglacial activity in Utopia Planitia. This evidence includes scalloped depressions, interpreted as themorkarst features [7-10], thermal contraction polygons [10, 11]), and possible ico-cored mounds or pingos [20]. Most recently, at this workshop, Kerrigan et al. [21] presented an overview of evidence for periglacial activity in Utopia Planitia. One of the most important conclusions is that the scalloped depressions define a new periglacial unit in this region. The nature and origin of the ice-rich substrate (or mantle) in Utopia Planitia is believed to be the result of periodic atmospheric deposition of an ice and dust mixture driven by changes in Mars' obliquity. Kerrigan et al. 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 Utopia Planitia. 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.

Synthesis and Discussion: The morphologic area under scrutiny is located at the distal periphery of the dichotomy boundary of Nilosyrtis Mensae, a region characterized by fractured lineated valley fill and fretted terrains that were presumably formed by and extended glacial period in tropical latitude of Mars under specific environmental conditions (cf., [1]). Our preliminary studies have revealed a large and integrated glacial system extending from high elevations in the heaviliy cratered highlands eastwards into Utopia Planitia. This may represent the largest such preserved glacial system on Mars and suggests the action of glaciers akin to continental ice sheets on Earth over a large expanse of the northern plains and dicohotomy boundary. Dating of these geological units is ongoing but based on the presence of similar terrains to the west (e.g., [19]), we suggest this period of glaciation occured <100 Ma ago. We note that this morphological evidence for glaciation in Utopia Planitia is consistent with climate models [22], which predict large accumulations of ice in this region during periods of high obliquity, and glacial flow models [4], which predict build up of ice sheets up to 4 km thick in 600 Ka. Further work is planned to constrain the spatial and temporal extent of these glacial and periglacial deposits.

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