PERIGLACIAL PROCESSES IN UTOPIA PLANITIA, EVOLUTION OF SCALLOPED TERRAINS: NEW INSIGHTS FROM HIRISE OBSERVATIONS. A. Séjourné[1], F. Costard[1], J. Gargani[1], C. Marmo[1], F. Forget[2], J.-B. Madeleine[2], R. J. Soare[3]; [1]IDES, Univ. Paris-Sud XI, Orsay, France (antoine.sejourne@u-psud.fr) [2]LMD, IPSL, Paris, France [3]Dawson College & Concordia Univ., Montreal, Canada. Univ. of Western Ontario, London, Canada.

Introduction: In the last few years, evidence of Mars being an ice-rich planet has become increasingly abundant. The mid-latitudes of Mars show Earth-like periglacial landforms. These include polygonal networks [1], periglacial debris-flows [2], pingos-like mounds [3] and thermokarst-like scalloped terrains [4].

We have studied the western part of Utopia Planitia (80°-100°E, 40°-47°N) in order to understand the processes that have been acting to produce scalloped terrains and polygonal network. Indeed, scalloped terrains are assumed to be the result of thawing or sublimation of ice-rich regolith [4]. We focused on this region because there are numerous new high-resolution HiRISE images and climatic simulations [5].

Geomorphologic study of western Utopia Planitia

Scalloped terrains: They are depressions from few tens meters to kilometers width and dozens meters deep [3, 4, 6]. They typically show a N-S asymmetric profile: their N-facing slope is steeper than their S-facing slope [6, 7, 8]. Using laser shots of MOLA orbit tracks, we calculated that the slope of the N-facing is ~3° and the S-facing is ~1.2°. The bottom of the depression is close to the south edge and there seems to be a relationship between the scale and the depth of depression: large depressions are deeper than small ones with a depth ranging from 5 to 40 m. Also, they exhibit bright ridges on the floor presumed to be inner terraces or exposed layers [4, 9]. They possess a circular to elliptic shape with scallop edges [4, 10].

We performed a geomorphologic classification of scalloped terrains in order to understand their morphologic and geometric evolution and distinguished 3 classes of depressions (cf. fig. 2). 1) The first class corresponds to small depressions with crescent-shapes of few tens meters width; their mean elongation is 0.3 (max length/max width, number=33). 2) The second class is medium depressions with u-shapes of hundred meters size. They have a mean elongation of 0.8-1 (nb=38). Sometimes there are one or two inner ridges. 3) The third class represents large depressions with scallop-edges and three or more inner ridges. Their size varies considerably, from about hundred m to several km. Their elongation can be low (0.2-0.3) or high (1-1.2) (nb=29). Some large depressions exhibit clear marks of coalescence.

Polygonal network: There are two different types of polygonal network in western Utopia Planitia, a large network is present at the surface of the plain and a small one is observed inside scalloped terrains [6, 7, 11]. We have studied both network but we focus here on the one inside scalloped terrains. It's a network of hexagonal polygons of 5.79 m width (nb=104) (cf. fig. 1). They typically possess ridges (1 m width) at their edge. The network is stretched along the scarp of N-facing slopes. The appearance of polygons changes from the bottom of the depression to the top of S-facing slope, the ridges are less and less visible around polygons and the centre become higher than the edges.

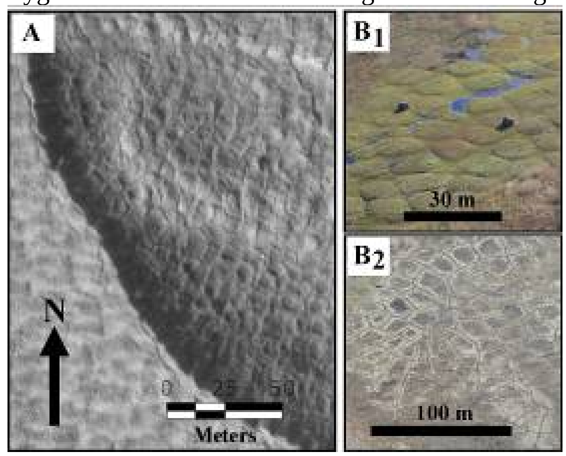

Fig. 1 : (A) Scalloped terrains in Utopia Planitia (PSP_002782_2230). (B1) High-centered polygons in Siberia (courtesy of A. Federov). (B2) Low-centered polygons in Canada (courtesy of R. Soare).

Periglacial processes on Earth: In periglacial environment on Earth, there are many thermokarst lakes in area of low topography with ice-rich and fine-grained permafrost [12]. They have a circular to elliptic-shapes with a diameter range from 300 m to 1-5 km for 2-10 m deep [12]. They are the result of the subsidence induced by the thawing of permafrost and the subsequent infilling by liquid water. If the subsidence is episodic, depressions could display a staircase appearance [10]. When the water is drained or evaporated, the depression is called an alas [12]. If sediments of the floor are still wet, there is a network of ice-wedge polygons inside alas. In periglacial landscape, a rapid temperature drop leads to a soil cracking, cracks could be fill subsequently by liquid water during seasonal thawing [12]. The freezing of this water produces an ice-wedge and small ridges around polygons. Polygons have a size from 15 to 40 m. The morphology and formation is the same for sand-wedge polygons with a filling of sand material. On well-drained uplands, the preferential water flowing along ice-wedges leads to the thawing of ice and formation of high-centered polygons [12].

Degradation of ice-rich regolith on Mars:

The fact that scalloped terrains share morphology and size with thermokarst lakes and the presence of martian polygonal network support the thermokarst hypothesis. Though, we don't see marks of drainage or run-off inside or outside scalloped terrains. On Mars, it's still difficult to evaluate if they are formed by sublimation or by thawing of an ice-rich regolith.

Evolution of inner polygonal network: The polygons at the bottom of scalloped terrains have the same morphology and size as terrestrial thermal contraction polygons (cf. fig. 1). However on Mars, we still don't know whether the filling of wedges is by water ice or by material. We think that the network was formed shortly after the depressions because it is stretched along the N-facing scarps. High-centered polygons at the top of S-facing slopes have a similar morphology as sublimation polygons of Antarctica Dry Valleys [13] or terrestrial high-centered polygons (cf. fig. 1). We think that they are older than the low-centered polygons of the bottom of scalloped terrains.

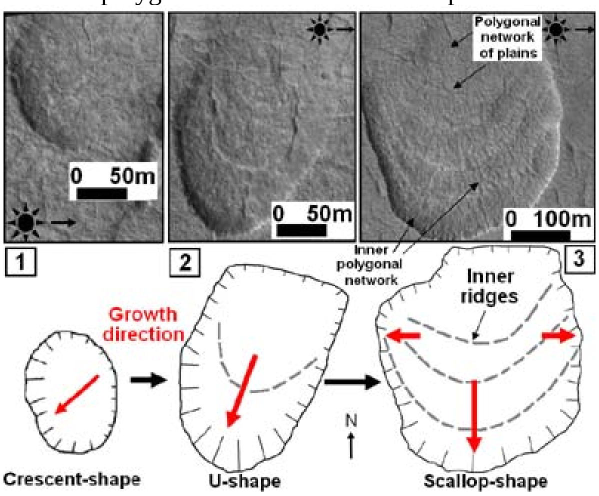

Fig. 2 : Evolution sequence of scalloped terrains.

Evolution of scalloped terrains: We recognized a sequence of evolution of scalloped terrains from small u-shape depressions to large scallop-edge depressions (cf. fig. 2). We propose that the growth is principally N-S because the elongation increases (0.3 to 1). There is also a laterally growth which could induce the coalescence between two depressions, this is underlined by the resulting small elongation (bigger width than length). The large plain network is less and less visible from the top of the S-facing slopes to the bottom of depressions. The southward deepening of the depression cuts off cracks of this network. The small inner network evolves from low-centered polygons to high-centered polygons. Our interpretation is that the southern part of depressions is younger than the northern part. Thus, the growth direction of depression may be southward.

A cyclic sublimation controlled by obliquity? Assuming tropical water source [14], the simulations of Global Climate Model (GCM) predict the deposition of ice and dust in western Utopia Planitia during periods of 35° obliquity [5]. The model also predicts sublimation of this ice-rich mantling during higher obliquity (45°) [15]. This is compatible with the martians morphologies observed. Moreover, at an obliquity of 45°, pole-facing slopes receive more insolation from the sun during summer than equator-facing slopes [2]. With the analogy of asymmetrical periglacial valleys on Earth produced by the difference in insolation [12] and in addition to our hypothesis of southward growth, we propose that N-facing slopes of scalloped terrains receive maximum insolation and thus undergo maximum sublimation. Thereby, the disappearance of ice leads in turn to a collapse. The latter could be more important on N-facing slopes, producing steeper slopes. Then, the sublimation being still more important on this slope, the growth of depressions is southward. With the analogy of terraces inside alas showing the gradual subsidence, we suggest that inner ridges inside scalloped terrains could be markers of past cycle of sublimation on Mars. However, we can't exclude the hypothesis of inner ridges as exhumed stratification [4].

Conclusion: We produced a geomorphologic study of landforms in western Utopia Planitia with HiRISE images. This allowed us to identify an evolution sequence of scalloped terrains from small u-shapes to large scallop-edges depressions. We also found that the polygonal network inside depressions is similar to terrestrial thermal contraction network. But we cannot know the nature of material filling the wedges. We observed an evolution of polygons morphology from low-centered to high-centered. The simulations of GCM predict accumulation of ice and dust precisely in western Utopia Planitia at 35° obliquity, followed by sublimation of this ice-rich mantling under 45° obliquity. Thus, assuming a more important insolation that leads to a higher sublimation on N-facing slopes, the growth of scalloped terrains may be southward.

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