EARLY HESPERIAN WARM-BASED GLACIATION IN ISIDIS PLANITIA, MARS. T. Guidat[1], S. Pochat[2], O. Bourgeois[2] and O. Soucek[3], [1]Trinity College, Dept. of Geography, Dublin 2, Ireland, [2]Laboratoire de Planétologie et Géodynamique de Nantes, CNRS UMR6112, Université de Nantes, 2 rue de la Houssinière, BP92208, 44322 Nantes Cedex 3, France, [3]Charles University in Prague, Mathematical Institute, Sokolovská 83, 186 75 Praha 8, Czech Republic.

Introduction: Isidis Planitia includes many landforms that result from paleo and contemporary climate regimes. These include the so-called Thumbprint Terrain [1], dating back from the early Hesperian, but the origin of which is still under discussion [2, 3, 4, 5, 6, 7, 8, 9]. Former studies have interpreted the origin of the Thumbprint Terrain without taking into account the potential important relationship with other landforms located on the floor of the basin. A new geomorphic mapping initiative that includes all landforms for the first time has been completed. The data elucidates on landforms inter-relationship and spatial organization. We build on the glacial interpretation of Lockwood et al and Kargel et al [1, 3] and, by using high resolution data, we reconstitute the precise dynamic of the corresponding ice sheet.

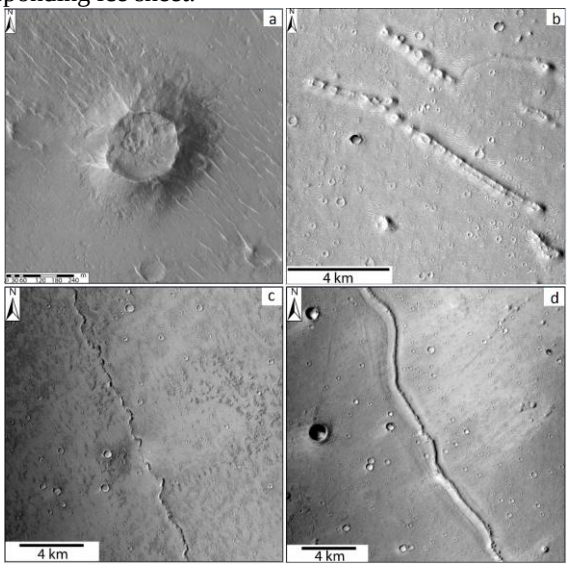

Figure 1: a) Cones (HiRISE); b) Arcuate Ridges (CTX); c) Simple Ridges (CTX); d) Simple Ridges on the floor of a Linear Depression (CTX)

Landforms: Isidis Planitia is composed of several different geological units identified by Ivanov et al [10]. All the landforms described in this study are located on 3 of these units: (1) *HApc* unit, i.e. plain with Thumbprint Terrains located in the center of the basin, (2) Hps unit, i.e. smooth plain surrounding *HApc* unit and (3) *Hmk* unit composed of knobby material located discontinuously on Hps unit.

Our five categories of Isidis Planitia landforms are 1) a *Geological Contact* between HApc and Hps units; 2) cones organized in three different ways (*Aligned Cones*, *Isolated Cones* and *Cones in Fields*); 3) *Arcuate Ridges* (fig.1); 4) *Simple Ridges* characterized by their sinuous shape (fig.1); 5) *Linear Depressions*. The latter two may be located on both sides of the geological contact but are absent in the center of the basin.

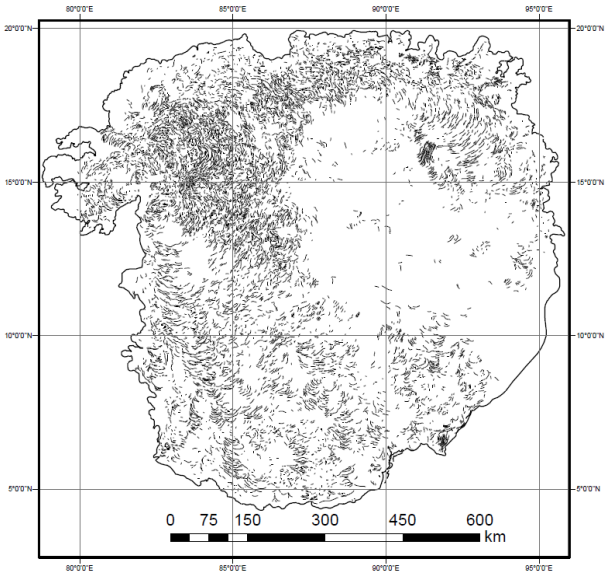

Figure 2: Map of the Arcuate Ridges and Aligned Cones. The delimited area is the HApc unit.

We find relationships between all categories of landforms. The most clearly define is the relationship between Aligned Cones (AC) and Arcuate Ridges (AR) that have similar morphometry (height, width, summit depression) and are located only on HApc unit. In addition, these landforms are arranged in a similar region-scale whorl-shape that suggests a pattern around the center of the basin and end facing the geological contact (fig.2). AR are absent from the central area (fig.2) which contains only cones organized in dense fields.

The geological contact (GC) between HApc and Hps units has a lobe-shaped morphology where flat mounds of Hmk unit can be found at the inter-lobes (fig.3).

Simple Ridges are perpendicular to the pattern formed by AC and AR as well as to the geological contact when SR are on HApc unit (fig.3), on Hps and Hmk units they have the particularity to link flat mounds of the Hmk unit between each other (fig.3).

Finally, Linear Depressions (LD) in Isidis Planitia are sometimes filled with a SR when inside the GC and are simple depressions outside where they appear to interconnect each other creating an anabranching network in one case.

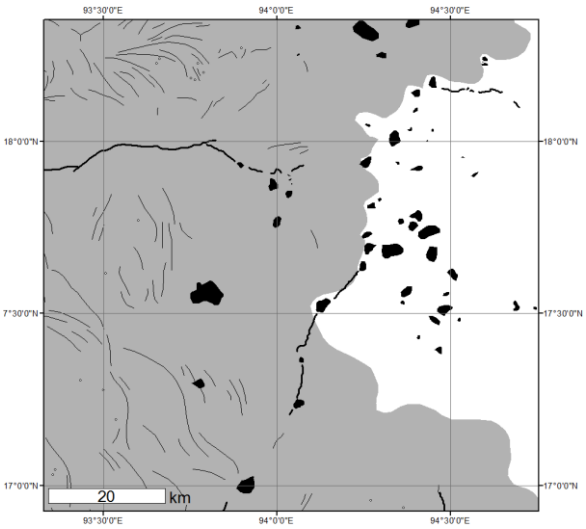

Figure 3: Map showing relationship between Isidis Planitia landforms. AR and AC are represented in thin black lines; SR are represented in bold black lines; mounds are represented by black polygons; HApc unit is in grey and Hps unit in white.

Interpretation: The pattern of periodic alternating arcuate shape is similar in form and scale to ribbed moraines identified on Earth. Ribbed moraines are subglacially formed transverse ridges [11]. Movement of the ice sheet is a glacial process that reworks preexisting sediments into ridges and implies a warm-based ice sheet [11]. Ribbed moraines are generally characterized by arcuate-downslope shapes, regular spacing and similar dimension to neighboring ridges and located on large flat area of deformable bed material as AR and AC. Also, they can be formed in proximity to other landforms such as eskers.

SR have characteristics similar to eskers on Earth: 1) sinuous in planform and rounded in cross section, 2) located at the periphery of the geological contact and organized perpendicular to the front flow direction, 3) trend uphill in some places, 4) some SR link mounds to each other, others originate from arcuate ridges or are found in the bottom of LD. The eskers are associated with other potential glacial features such as mounds (potential kames) and moraines. The potential esker features may extend from them or from depressions interpreted as Tunnel Valleys [1, 12, 13].

Linear depressions share characteristics with terrestrial Tunnel Valleys. They have constant widths along their profiles, occasionally organize in anabranching networks, have termination at or near former ice margins, have undulating long profiles and eskers can be located on their floors [13].

Conclusion: The presence of these landforms assemblages in Isidis Planitia and especially their relationship to each other suggest a glacial origin specifically a wet-based ice sheet. Indeed all these landforms require melt water for their formation. The detection of an ice sheet is consistent with climate models [14] that show snow accumulation in the NW area of Isidis, precisely where the whorl-shape pattern starts. This would permit the sustainability of an ice sheet at different obliquities.

The ice flow pattern starts in the NW and deflects around the basin center where no arcuate shapes are mapped. We interpret the morphology of the basin centre to suggest the presence of a stagnant part of the former ice sheet. We suggest that this stagnating part of the ice sheet results from a negative thermal anomaly located at the center of Isidis Planitia [15] that cooled the base of the ice sheet. Around this anomaly, the base of the ice sheet alternated between wet and dry allowing the accumulation of sediment (i.e. ribbed moraines) in arcuate shapes.

This interpretation of Isidis landform assemblages implies the presence of an equatorial large-scale warm-based ice sheet in Isidis Planitia.

References:

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