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Mapping Mars' Northern Plains: Origins, Evolution and Response to Climate Change - An Overview of the Grid Mapping Method and Results from Arcadia Planitia.

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1. Introduction

As part of an International Space Science Institute (ISSI) team project studying the northern plains of Mars we use geomorphological mapping to compare ice-related landforms in the three northern plains basins: Arcadia Planitia, Acidalia Planitia [1], and Utopia Planitia [2]. The main questions are:

1) *"What is the distribution of ice-related landforms in the northern plains, and can it be related to distinct latitude bands or different geological or geomorphological units?"*
2) *"What is the relationship between the latitude dependent mantle (LDM) and (i) landforms indicative of ground ice, and (ii) other geological units in the northern plains?"*
3) *"What are the distributions and associations of recent landforms indicative of thaw of ice or snow?"*

Increased coverage of high-resolution images of the surface of Mars enables identification of increasing numbers and varieties of small-scale landforms which can form the observational basis for understanding the history of an area. The combination of improved spatial resolution with near-continuous coverage increases the time required to analyse the data. This becomes problematic when attempting regional or global-scale studies of metre-scale landforms. Here, we present an approach for mapping small features across large areas that was formulated for the ISSI project and the results from Arcadia Planitia (Fig. 1).

2. Assessment of the Method

Rather than traditional mapping with points, lines and polygons, we used a grid "tick box" approach to determine where specific landforms are. The mapping strips were divided into a 15×150 grid of 20 km squares. In an ArcGIS shapefile, a new column attribute was added for each landform/surface type. CTX and THEMIS daytime images were then viewed systematically for each sub-grid square and the landforms were recorded as "present", "dominant", or "absent" in each sub-grid square. Where relevant, each square was also recorded as "null" (meaning "no data") or "possible" if there was uncertainty in identification (but where the mapper felt that there was some evidence to suggest that the landform was present). The result is a series of coarse-resolution "rasters" showing the distribution of the different types of landforms across the strip. The Grid mapping (Table 1) is efficient: for each sub-grid, only the presence or absence of a landform needs to be ascertained, and no detailed digitising is needed removing an individual's decision as to where to draw boundaries and improving repeatability.

Pros	Cons
Rapidity, ensures all areas are covered, actively marking negative results. At full CTX resolution.	If a landform needs to be added later, it would require going back over the whole dataset.
Reproducible and scalable with group efforts. Transitions between colleagues are easier than traditional mapping.	Hard to discriminate between a single dominating landform in a sub-grid, and many landforms covering perhaps 25% of the sub-grid.
Allows large datasets to be published in a series of smaller maps.	Tedious to implement.
Comparable data for several strips across an area.	
Several landforms can be mapped at once.	
Only basic mapping and GIS skills needed.	

Table 1. Pros and Cons of the grid mapping method.

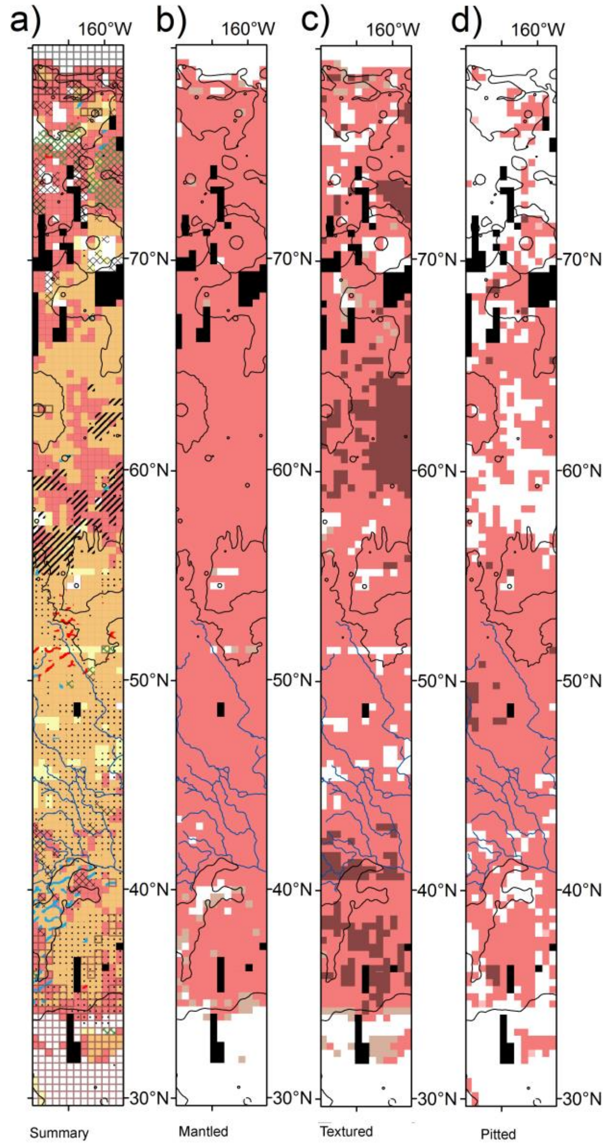

Fig. 2. Summary and example data from Arcadia Planitia grid-mapping. a) summary of all landforms and surface types, b) "mantled" designation, c) "textured" morphological type terrain, and d) "pitted" morphological type terrain. Background map takes simplified contacts from [3] and additional mapping (e.g., of channel-like features) from this study.

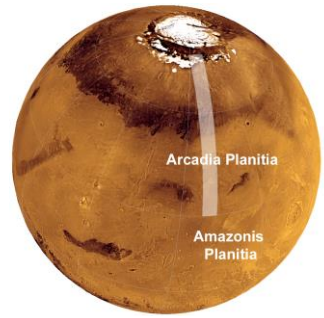

Fig. 1 Arcadia Planitia Study area. The swath is 300 km wide and extends from 30° to 80° N.

3. Results

Fig. 2 shows summary results from Arcadia Planitia; results of particular note are 1) "textured" surfaces are ubiquitous down to about 35°N, and match the distribution of a topographic mantle. 2) Small pits are common in the south and middle of the swath, but become less common in the north. 3) 100m-scale polygons are found mainly near the north of the study area, in contrast to results from Utopia [3]. Also, unlike Utopia, there are very few scalloped depressions. 4) Small mounds – morphologically similar to erosional remnants – correlate with albedo and relief patterns that form a branching network between 40° and 50°N. This could suggest that there was once an extensive, erosional fluvial system in this region.

4. Conclusions

Grid mapping provides an efficient and scalable approach to collecting data on large quantities of small landforms over large areas and has produced a rich dataset. Future studies will compare the landform maps with roughness, elevation, slope, geological, sub-surface RADAR, and climate data. Also, the three mapped strips will be contrasted with one another in order to assess whether the dominant control on landform/surface type is latitude (i.e. climate or insolation strength) or substrate.

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References: [1], Hauber et al., (2015) *LPSC XLVI*, Abstr. #1359 [2] Séjourné et al., (2015) *LPSC XLVI*, Abstr. #1328, [3] Tanaka, K. L., et al., (2005) Geologic map of the northern plains of Mars.