PRELIMINARY REGIONAL GEOLOGIC MAP OF UTOPIA PLANITIA IN THE POTENTIAL TIANWEN-1 LANDING REGION.

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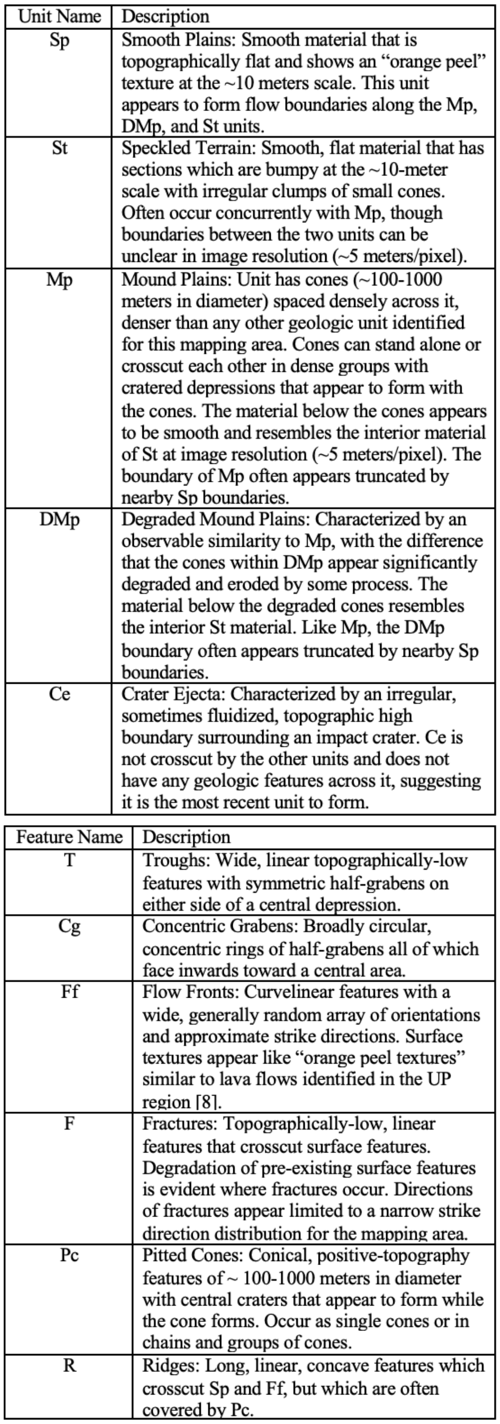
Introduction: A region in southern Utopia Planitia, Mars has been announced as the potential future landing site of the Tianwen-1 spacecraft lander and rover, sent to Mars by the China National Space Administration (CNSA) [1]. Given the possibility of *in situ* exploration at this site, understanding the local and regional geologic context is important. This is particularly of interest for any surface samples that are compositionally analyzed by the lander. Such compositions can help constrain what processes, such as volcanic or sedimentary, have been active in Utopia Planitia.

Utopia Planitia (UP), proposed as an ancient impact crater infilled with sediments, lava, and volatiles [2], exhibits a multitude of landforms, from lava flows near Elysium Mons that appear smooth on the scale of ~10-100 meters, to cratered conical features that have been proposed to be generated from volcanic or sedimentary eruptions [3]-[7], and glacial or periglacial landforms at higher latitudes. Some features, notably the observed cones, have had multiple origin hypotheses proposed, and geologic mapping is ongoing within UP to better constrain characteristics of features and the broad geologic trends [8]. UP has also been proposed as a site of vigorous and repetitive episodes of resurfacing, due to its low topographic plain-like features. The mud eruption hypothesis is of particular interest because it may have brought material from a habitable subsurface environment to the surface and exposed it [9].

Geologic Mapping: Our mapping focuses on a 4°x4° area in UP, ranging from 22°N-26°N and from 108°E-112°E. We use ArcGIS and map on a 4°x4° portion of the global Context camera (CTX) image map processed by the Bruce Murry Laboratory for Planetary Visualization at the California Institute of Technology [10]. Within this region, we map the major geomorphic units along with geologic features such as individual ridges, tectonic rifts, and cones.

Geomorphic Units. We have identified 5 unique geomorphic units in this mapping area. Units were defined based on observable surface morphologies at the resolution of CTX images (~5 meters/pixel). These morphologies included surface textures and sometimes depended on spatial boundaries of certain geologic features such as cones. The geologic units identified so far are: Sp (Smooth Plains), Mp (Mound Plains), DMp (Degraded Mound Plains), St (Speckled Terrain), and Ce (Crater Ejecta). A description of each unit is given in Figure 1a.



Unit Name	Description
Sp	Smooth Plains: Smooth material that is topographically flat and shows an "orange peel" texture at the ~10 meters scale. This unit appears to form flow boundaries along the Mp, DMp, and St units.
St	Speckled Terrain: Smooth, flat material that has sections which are bumpy at the ~10-meter scale with irregular clumps of small cones. Often occur concurrently with Mp, though boundaries between the two units can be unclear in image resolution (~5 meters/pixel).
Mp	Mound Plains: Unit has cones (~100-1000 meters in diameter) spaced densely across it, denser than any other geologic unit identified for this mapping area. Cones can stand alone or crosscut each other in dense groups with cratered depressions that appear to form with the cones. The material below the cones appears to be smooth and resembles the interior material of St at image resolution (~5 meters/pixel). The boundary of Mp often appears truncated by nearby Sp boundaries.
DMp	Degraded Mound Plains: Characterized by an observable similarity to Mp, with the difference that the cones within DMp appear significantly degraded and eroded by some process. The material below the degraded cones resembles the interior St material. Like Mp, the DMp boundary often appears truncated by nearby Sp boundaries.
Ce	Crater Ejecta: Characterized by an irregular, sometimes fluidized, topographic high boundary surrounding an impact crater. Ce is not crosscut by the other units and does not have any geologic features across it, suggesting it is the most recent unit to form.

Feature Name	Description
T	Troughs: Wide, linear topographically-low features with symmetric half-grabens on either side of a central depression.
Cg	Concentric Grabens: Broadly circular, concentric rings of half-grabens all of which face inwards toward a central area.
Ff	Flow Fronts: Curvelinear features with a wide, generally random array of orientations and approximate strike directions. Surface textures appear like "orange peel textures" similar to lava flows identified in the UP region [8].
F	Fractures: Topographically-low, linear features that crosscut surface features. Degradation of pre-existing surface features is evident where fractures occur. Directions of fractures appear limited to a narrow strike direction distribution for the mapping area.
Pc	Pitted Cones: Conical, positive-topography features of ~ 100-1000 meters in diameter with central craters that appear to form while the cone forms. Occur as single cones or in chains and groups of cones.
R	Ridges: Long, linear, concave features which crosscut Sp and Ff, but which are often covered by Pc.

Figure 1: (a) A description of each mapped geomorphic unit in our mapping area. (b) A description of each mapped geologic feature in our mapping area.

Geologic Features. We have identified 6 unique types of geologic features in this mapping area. Features were defined based on size, shape, and other observable parameters at CTX image resolution (~5 meters/pixel). The geologic features mapped are: T (Troughs), Cg (Concentric Grabens), Ff (Flow Fronts), F (Fractures), R (Ridges), and Pc (Pitted Cones). Descriptions of the features are listed in Figure 1b. The preliminary version of our geologic map is shown in Figure 2a, with the legend and scalebar shown in Figure 2b.

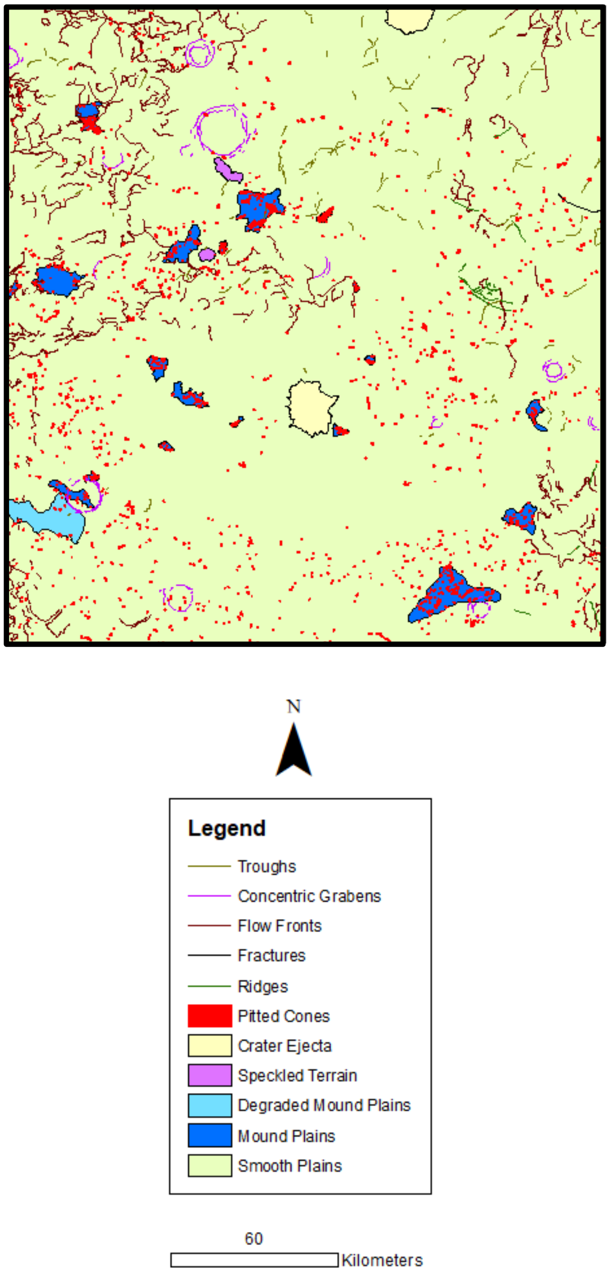


Figure 2: (a) Our preliminary geologic map for this region with (b) the corresponding legend for units and features, a north arrow, and a scale bar.

Results: In this region of UP the dominant unit is Sp, which appears to be relatively safe for landing. The majority of our mapping area consists of low, flat topography that appears lightly textured at the ~10 meters scale. This unit also exhibits many flow-like features, here called flow fronts, which could be lava flow or mud flow boundaries. Also evident are several examples of concentric ringed grabens which have been interpreted to be buried impact craters, further supporting the model of infill and resurfacing in UP [11]. Within this region, there are landing hazards such as cones (~100-1000 meters in diameter) and infilled craters with uneven topography (~100 km in diameter). The cones create a more local landing hazard than the grabens, which have relatively flat and smooth (at the ~10 meters scale) central areas. Our mapping returns a population of cones that are more densely correlated within certain units, such as Mp and DMp. There are local places where cones appear to be less numerous or dense. These places, which are predominantly located in Sp, would be good choices for landing because there are less cones presenting landing hazards, although landing near a cone would be of scientific interest. However, there are still uneven flow fronts and trough-like features within Sp that may need to be avoided for a successful landing.

Finally, we note from our spatial mapping of cones that some cones appear to commonly form along flow front lines and also along boundaries between Mp and Sp. Further study is needed into the cone spatial trends, particularly regarding flow features and unit boundaries.

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