TERRAIN MAPPING OF THE INSIGHT LANDING REGION: WESTERN ELYSIUM PLANITIA, MARS.

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Introduction: InSight is a NASA Discovery Program mission that is designed to determine the interior structure of Mars. The payload includes a seismometer, a heat flow probe, and a precision tracking station. Engineering constraints for landing are dominantly controlled by elevation and latitude. This has limited the suitable landing area for InSight to only western Elysium Planitia [1]. Sixteen ellipses were initially defined in this region based on THEMIS images that revealed smooth and flat terrains combined with thermal differencing rock abundance estimates of <10%. Since this initial effort, the area has been extensively targeted for imaging by the Mars Reconnaissance Orbiter (MRO) CTX and HiRISE cameras. This has allowed for better definition of terrain types across the region. This abstract discusses the mapping of terrains in the InSight ellipses as a result of this imaging campaign.

Methodology: The initial 16 InSight landing sites were placed in western Elysium Planitia within an area bounded by 5°N-2°S and 134°E-145°E. Ellipses occur on relatively smooth Hesperian ridged plains, and are bounded by Noachian highlands to the south and west, are divided by a ridge of Early Amazonian Medusae Fossae Formation in the center, and are bordered to the east by Late Amazonian lava flows [2].

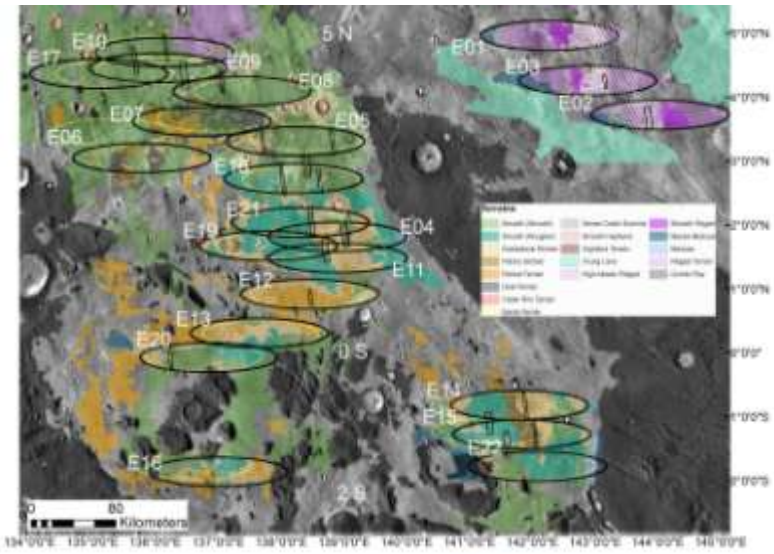

Figure 1: THEMIS (100 m pixel^{-1}) daytime mosaic displaying the mapped terrain types across 22 InSight ellipses and HiRISE image outlined acquired by late summer 2013.

Terrains were mapped during two phases. Initial mapping was done using a near complete 6 m pixel^{-1} MRO CTX image mosaic and four previously acquired HiRISE images at 25 cm pixel^{-1}. This first phase concentrated on calculating the areal extent of Etched Terrain, defined as the most hazardous surface type in the landing region [3]. Initial HiRISE observations of the Etched Terrain revealed a relatively high concentration of meter-sized boulders and aeolian bedforms that are hazardous to landing [4].

For the second phase of mapping, additional HiRISE images were targeted to characterize other terrain types and to correlate HiRISE-scale morphology with lower resolution CTX observations. By the late summer of 2013, ~20 HiRISE images had been acquired. This allowed for comparative validation of almost all terrain types between HiRISE and CTX. Furthermore, by mapping regions between the 16 ellipses, 6 new potential ellipses were identified, bringing the total number of candidates to 22.

The current terrain map (Fig. 1) was constructed across all 22 landing ellipses in ArcGIS at a scale of 1:40,000 using the near complete CTX image mosaic. All terrain types within the ellipses are shown. The terrains were defined based on their thermal characteristics, observed texture, crater density, presence of aeolian bedforms, and rock abundance.

Primary Terrain Types: The five most aerially extensive and most relevant terrain types for the landing site safety assessment are: (1) Smooth, (2) Rougher Smooth, (3) Etched Terrain, (4) Gradational Etched, and (5) Patchy Etched. Slope hazards (crater rims and highland scarps) and dense crater rays/clusters were also mapped and are hazards for landing.

Smooth Terrain is a muted, moderate albedo surface in CTX and HiRISE images. It is relatively bright (warm) in daytime THEMIS. Smooth Terrain exhibits a very low rock abundance (<1%) and low regional/local slopes making it the safest landing surface in the region. A rougher variant of the Smooth Terrain (Rougher Smooth) has a similar albedo and daytime THEMIS signature but is more textured, exhibiting numerous low relief arcuate scarps that likely represent degraded impact crater rims.

Etched Terrain is the most hazardous terrain type in the region [4]. It exhibits a relatively high albedo, corresponding with bright bedforms and sun-lit sloping surfaces, and has a dark (cool) daytime thermal signature. Its rougher surface texture at the ~10 m scale is

related to well-defined arcuate and linear ridge-like landforms that are a combination of aeolian bedforms superimposed on degraded impact crater rims. Etched Terrain has the highest rock abundance of all terrain types in the region (>20%), excluding the rocky ejecta blankets of fresh impact craters that occur uniformly throughout the landing region.

Gradational Etched Terrain is defined as a terrain type that is transitional in morphology and thermal characteristics between Smooth and Etched terrains. It is uniquely defined by the gradational change in the observed albedo, surface texture, and rock abundance. Patchy Etched Terrain by comparison is a transitional terrain that exhibits small patches of rocky Etched Terrain (<1 km) within a smoother surrounding surface. The presence and density of rocks identified in each of the five main terrains varies from extremely sparse for Smooth, and progressively increases for Rougher Smooth, Gradational Etched, Patchy Etched and Etched, with the latter likely around 20% rock abundance.

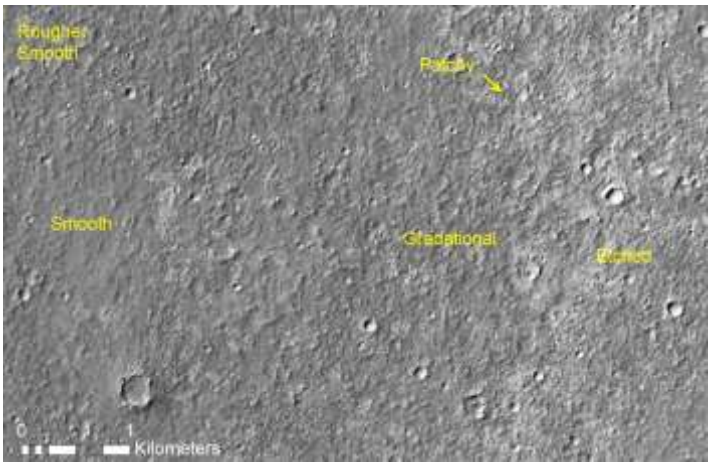

Figure 2: CTX image displaying all five of the major terrain types in the InSight landing region.

Terrains with slopes that exceed 15° represent a hazard for the InSight landing. These terrains were identified using along-track MOLA elevation points spaced at 307 m [4]. Highland scarps and interior walls of large craters have slopes that exceed 15° and were mapped on the CTX mosaic.

Finally, fresh secondary crater rays are evident in select locations across the entire landing site region [4]. From detailed mapping, these rays can be traced to both the young Corinto and Zunil craters. Corinto is about 1000 km north of the landing site region and Zunil is 1700 km to the east-northeast. The dense secondary rays have high concentrations of small craters (<30-40 m diameter) that cover >25% of the area within a ray. HiRISE images reveal no rocks associated with the vast majority of these fresh secondary craters and so are considered to be mostly a slope hazard with interior wall slopes that likely exceed 15° [4].

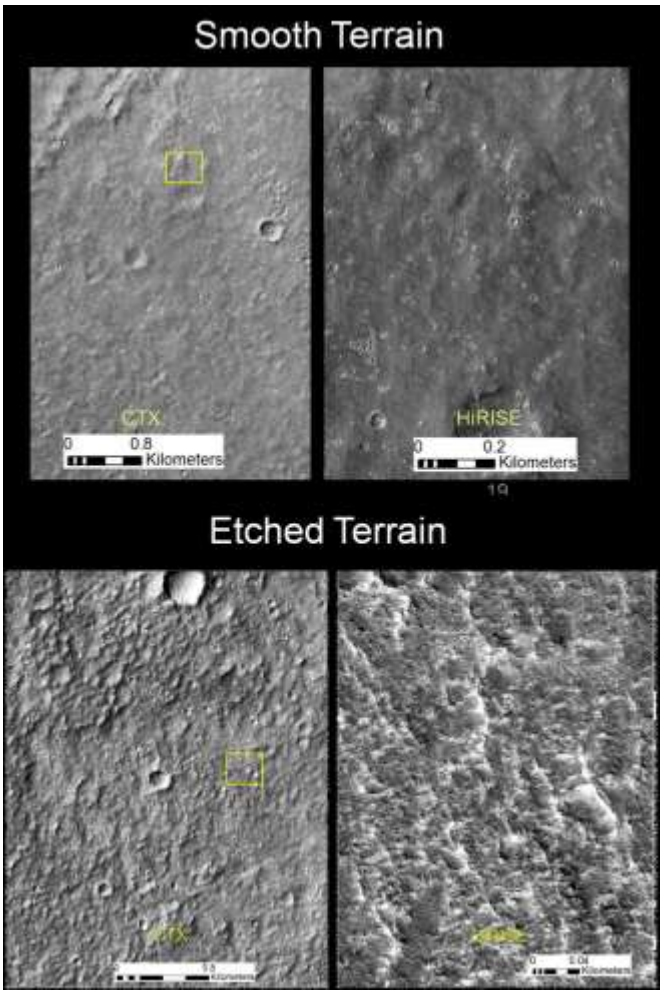

Figure 3: Images displaying Smooth and Etched Terrain at CTX and HiRISE resolutions.

Conclusion: Twenty-two candidate landing ellipses for the InSight mission were mapped in the western Elysium Planitia region using a near complete CTX mosaic with ~20 available HiRISE images. Of the 5 major identified terrain types Etched Terrain and the transitional terrains pose a significant hazard for spacecraft landing due to high rock abundance. In addition, areas with slopes >15° are hazardous. Combining the terrain and slope hazards by area within each ellipse indicates that the northern ellipses are generally the least hazardous. Of the northern ellipses, E9, E8, E17, and E5 appear the safest landing sites [4] because they are dominated by Smooth Terrain and lack of slope or rock hazards.

References: [1] Golombek, M. et al. (2013) *44th LPS* abs #1691. [2] Tanaka, K. et al. (2005) *USGS SIM 2888*. [3] Golombek, M. et al. (2013) *44th LPS* abs #1696. [4] Golombek, M. et al. (2014) this volume.