GEOLOGY OF THE INSIGHT LANDING SITE, MARS. M. Golombek[1], N. H. Warner[2], J. Grant[3], E. Hauber[4], V. Ansan[5], C. Weitz[6], N. Williams[2], C. Charalambous[7], S. Wilson[3], T. Parker[1], I. Daubar[1], E. Marteau[1], N. Mueller[4], W. T. Pike[7], A. DeMott[2], M. Kopp[2], H. Lethcoe-Wilson[1], L. Berger[1], R. Hausmann[1], M. Banks[8], M. Baker[9], and J. Garvin[8], [1]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, [2]SUNY Geneseo, NY, [3]Smithsonian National Air and Space Museum, Washington, DC, [4]German Aerospace Center (DLR), Berlin, [5]University of Nantes, [6]Planetary Science Institute, [7]Imperial College, London, [8]NASA Goddard Space Flight Center, Greenbelt, MD, [9]The Johns Hopkins University, Baltimore, MD.

Introduction: The Interior Exploration using Seismic Investigations, Geodesy and Heat Transport (InSight) spacecraft landed successfully on Mars on Nov. 26, 2018. Trajectory correction maneuvers targeted landing near the center of the E9 reference ellipse (130 km by 27 km) [1]. Images acquired by the High-Resolution Imaging Science Experiment (HiRISE) based on the initial radio tracking location on Dec. 6 and 11 show that the lander, is located at 4.502°N, 135.623°E at an elevation of -2613.43 m (Fig. 1) with respect to the Mars Orbiter Laser Altimeter (MOLA) geoid in the northwest-central portion of the landing ellipse [1] in western Elysium Planitia [2].

Since landing, a large number of color surface images from an arm-mounted camera have been acquired. These include stereo coverage at two resolutions (0.5-2 mm/pixel) of the instrument deployment workspace to select the locations to place the instruments, three complete stereo panoramas (morning, afternoon, and evening), and stereo images of the lander, its footpads, terrain under the lander, and the radiometer spots [3]. These surface images combined with orbital data [e.g., 1] provide information on the geology of the landing site.

Homestead Hollow Setting: The lander is located within a quasi-circular depression, interpreted to be a degraded ~20 m diameter impact crater, informally named *Homestead hollow* (Fig. 1), with a smooth pebble rich surface adjacent to a slightly rockier and rougher terrain (Fig. 2). Ten 1-10 m diameter impact craters can be seen within 20 m of the lander [4,5]. Some of these craters have very little relief and are filled with fine grained material. Farther afield, bright circular patches suggest soil filled, degraded craters are common (Fig. 3). At least one fresh crater has the characteristic bright ejecta of Corinto secondary craters (0.1-1 Ma and 2.5 Ma) that are omnipresent across the landing site [1] (Fig. 3). A slope to the north limits the horizon to about 50 m away; it is topped by three rocks (The Pinnacles), and eolian bedforms (Dusty ridge) near the southwest rim of a large degraded impact crater (Figs. 1-2). To the southeast (Fig. 3), the horizon extends about 400 m to the rim of a relatively fresh, ~100 m diameter impact crater (Sunrise) and large eolian bedforms on its rim (The Wave). A larger (460 m diameter), relatively fresh crater can be seen on the east-southeast horizon ~2.4 km away.

Terrains: The surface of Homestead hollow is made of smooth plains with few rocks; rock abundance is very low (1-2% for rocks >10 cm diameter) [6] and the resolvable particle size distribution is dominated by pebbles [7]. Cobble and pebble shape and form are equant to sub-equant and angular to sub-angular [7]. Some of the rocks closest to the lander have a dark grey color and appear aphanitic (Fig. 4), consistent with fine-grained, dark mafic rocks (basalts). Other rocks appear lighter as if covered by dust and/or weathering rinds. At least one rock appears fluted, suggesting eolian abrasion (ventifacts). The pebble-rich surface is similar to that at the Spirit landing site, which developed via eolian deflation of fines [8].

To the west of the lander, the surface is slightly rougher and rockier than the smooth plains (Figs. 1-3) [4] and it extends into the distance at most azimuths away from the lander. Rocky Field, nearby the lander (Fig. 1), has more cm to tens of cm size rocks and a rougher surface (Figs. 1-2). Rock abundance is about 2-3 times that on the smooth plains [6], but the soil is pebble rich and appears similar to the smooth plains.

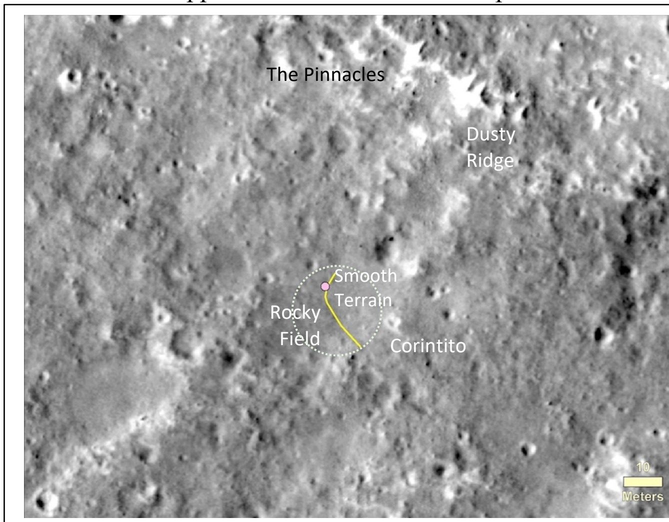

Figure 1: HiRISE image showing the location of the InSight lander (pink dot) in Homestead hollow (dotted) and surface features identified from the ground. Note smooth terrain to the east of the lander and slightly rougher and rockier terrain (Rocky Field) to the west (yellow line is the contact) and throughout much of the image. Bedforms (Dusty ridge) and three rocks (Pinnacles) are about 400 m away to the northeast.

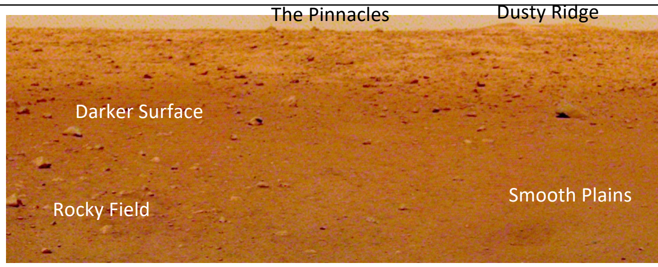

Figure 2. Portion of panorama to the north of the lander. Note darker surface where dust has been removed within 20 m of the lander, rockier surface to the west, and smooth plains to the east.

Near Surface Structure: The pulsed retrorockets disturbed the surface under and around the lander, providing views to the near surface stratigraphy. HiRISE images acquired roughly a week after landing show a large dark spot centered on the lander [9]. The dark spot extends around 20 m away from the lander to the north and is distinctly darker than the surrounding surface (Fig. 2), but is more gradational to the south. The inner 5 m of the dark spot in HiRISE is slightly brighter than the rest of the spot. In the workspace near the lander, the surface appears scoured, with multi-millimeter relief ridges and troughs that extend radially away from the lander [10]. Some pebbles and protrusions have tails extending away from the lander. One pebble hopped 0.8 m across the surface creating divots and elongated depressions. These observations are consistent with the pulsed descent rocket exhaust removing surficial fine-grained dust to create the dark spot and scouring loose sand and granules [9].

Retrorockets excavated three pits ~10 cm deep beneath the lander (Fig. 4). In one pit, the subsurface material is poorly sorted with pebbles and cobbles. Two pits have steep slopes (greater than the angle of repose) composed of small rocks and pebbles cemented in a finder-grained matrix (duricrust). Smaller clods and pieces of this material are scattered within the pits and adjacent to the pits. One footpad appears buried by the material excavated from the pit. Two footpads show evidence for slight sliding into place, creating a depression on one side and a bulge in the direction of travel. These observations suggest a near surface stratigraphy of surficial dust over thin cohesionless sand, underlain by a variable thickness (cm) duricrust, with poorly sorted, cohesionless sand and rocks beneath [11]. Orbital [1] and lander radiometer [12] measurements of thermal inertia are consistent with a surface dominated by very fine sand size particles. This is consistent with the cohesionless fines and the low rock abundance of the site. The cohesive strength of the duricrust estimated from the stability of the pit slopes indicate very low cohesion (<<1 kPa), similar to other weak soils on Mars [13].

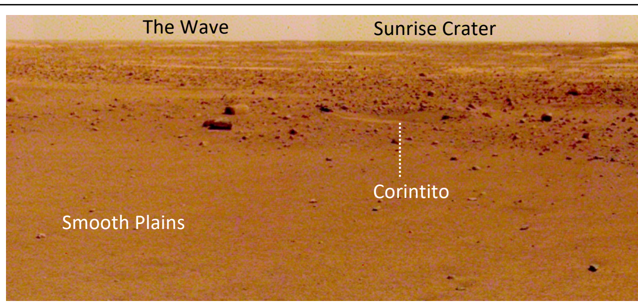

Figure 3. Portion of panorama to the southeast of the lander showing smooth plains to the edge of Homestead hollow and rougher and rockier terrain beyond. Note fresh Corinto secondary crater (Cointito) on the edge of the hollow, circular soil filled depressions (hollows) in the distance, and eolian bedforms (The Wave) and Sunrise crater rim on the horizon about 400 m away.

Geologic Processes and Origin: The observations described in this and companion abstracts [4-7,11] portray a surface modified by impact, eolian and mass wasting processes. The terrains and surface features in view of the lander include craters in various stages of degradation [4,5] and dusty eolian bedforms (suggesting relative inactivity). Based upon the origin and modification of Homestead hollow and adjacent impact craters, slow mass wasting and eolian processes are those dominantly modifying the surface [4,5]. No outcrop or bedrock has been observed.

These observations are consistent with expectations made from remote sensing data prior to landing [1,13]. Orbital investigations indicated a surface composed of >3 m thick impact-fragmented regolith overlying Hesperian basalt flows that would be similar to the Spirit landing site [1,14,15]. Observations from the lander show impact craters in various stages of degradation and eolian bedforms. The terrains observed and the materials present at the site are consistent with a surface formed dominantly by impact, mass wasting, and eolian processes that created an impact-generated regolith composed dominantly of sand-sized particles with some pebbles, cobbles and boulders.

References: [1] Golombek et al. (2017) SSR. [2] Parker, T. et al., 50th LPSC. [3] Maki, J. et al., 50th LPSC. [4] Warner, N. et al., 50th LPSC. [5] Grant, J. et al., 50th LPSC. [6] Charalambous, C. et al., 50th LPSC. [7] Weitz, C. et al. 50th LPSC. [8] Golombek, M. et al. (2006) JGR [9] Williams, N. et al., 50th LPSC. [10] Garvin, J. et al., 50th LPSC. [11] Ansan, V. et al., 50th LPSC. [12] Mueller et al., this issue. [13] Golombek et al. (2018) in The Martian Surface, Cambridge. [12] Wilson, S. et al., 50th LPSC. [13] Golombek et al., 50th LPSC. [14] Golombek et al. (2018) SSR. [15] Warner, N. et al. (2017) SSR.

Fig. 4. Image under the lander showing struts, retrorockets, excavated pits (~10 cm deep), dark gray aphanitic rocks (basalt) and duricrust. Note steep pit walls of soil and clasts indicating cemented duricrust and clods and fragments that litter the pits and surface.