GEOLOGY OF THE INSIGHT LANDING SITE, MARS: INITIAL OBSERVATIONS. 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], W. T. Pike[7], A. DeMott[2], M. Kopp[2], H. Lethcoe-Wilson[1], L. Berger[1], M. Banks[8], J. Garvin[8], [1]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, [2]SUNY Geneseo, NY, [3]Smithsonian National Air and Space Museum, Center for Earth and Planetary Studies, [4]German Aerospace Center (DLR), [5]University of Nantes, Laboratory of Planetary and Geodynamics, [6]Planetary Science Institute, [7]Imperial College, London, Department of Electrical and Electronic Engineering, [8]NASA Goddard Space Flight Center, Greenbelt, 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 -2613.426 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 including stereo coverage at two resolutions of the instrument deployment workspace to select the locations to place the instruments, a 290° azimuth stereo panorama (320° to 250° azimuth), stereo images of the lander, its footpads, terrain under the lander, and the far radiometer spot [3]. These surface images and their setting in orbital data [e.g., 1] provide information on the geology of the landing site.

Homestead Hollow Setting: The lander is located within a degraded impact crater, dubbed *Homestead hollow*, with a smooth pebble rich surface adjacent to a slightly rockier and rougher terrain (Fig. 2) with a concentration of rocky ejecta craters nearby [4, 5]. Eight 1-10 m diameter impact craters can be seen within 20 m of the lander. Some like Homestead hollow have very little relief and are filled with fine grained material. Farther afield, bright circular patches suggest soil filled craters are common (Fig. 3). At least one fresh crater (between 0.1-1 Ma and 2.5 Ma) has the characteristic bright ejecta of Corinto secondary craters that are omnipresent across the landing site [1] (Fig. 3). A slope to the north, which limits the horizon to about 50 m away, 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 to 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).

Terrains: The surface of Homestead hollow is made of smooth plains with few rocks; rock abundance is very low (1-2% for diameters >10 cm) [6] and 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, which is consistent with an origin via fragmentation [7]. Some of the rocks closest to the lander (e.g., the Ace of Spades) 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 (also similar to those on the Gusev cratered plains). At least one rock (Turtle) appears fluted, suggesting eolian abrasion (ventifact). 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 [4]. This rougher and rockier terrain extends into the distance in most azimuths away from the lander. Rocky Field, nearby the lander has more cm to tens of cm size rocks and a rougher surface. 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.

Near Surface Structure: The pulsed retrorockets disturbed the surface under and around the lander, providing views to the near surface structure. HiRISE images acquired roughly a week after landing shows a

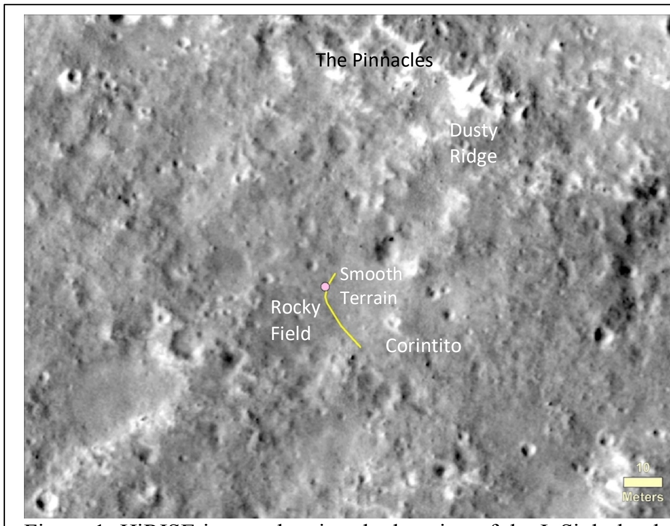

Figure 1: HiRISE image showing the location of the InSight lander (pink dot) in Homestead hollow and surface features identified from the ground. Note smooth terrain to the east of the lander and slightly rougher and rockier terrain (Rocky Field) to the west (yellow line is the contact) and throughout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

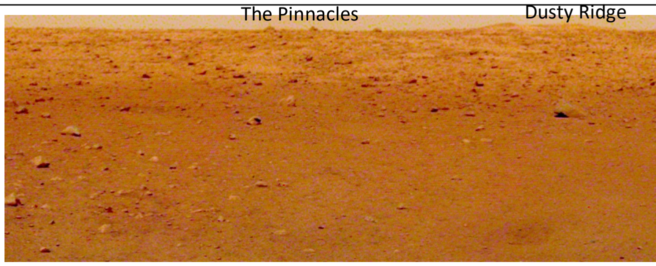

Figure 2. Portion of panorama to the north of the lander. Note darker surface where dust has been removed within 20 m of the lander.

large dark spot centered on the lander [9]. To the north, the dark spot extends around 20 m away from the lander and is distinctly darker than the surrounding surface (Fog. 2). To the south, the dark spot extends farther from the lander and gradually lightens. 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. At least one round pebble (Rolling rock) rolled 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 sculpting loose sand and granules to create the scours [9].

More surface alteration occurred near the lander by the footpads and rockets that excavated three pits 10-20 cm deep beneath the lander (Fig. 4). In one pit, the subsurface material is poorly sorted with pebbles and cobbles. Another pit has a steep slope (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] thermal inertia measurements are consistent with a surface dominated by sand size particles. This is consistent with the cohesionless fines and the low rock abundance of the site. The cohesive strength of the duricrust must be very low because the 2 cm high spikes below the flat flanges of the seismometer feet have fully penetrated into the ground.

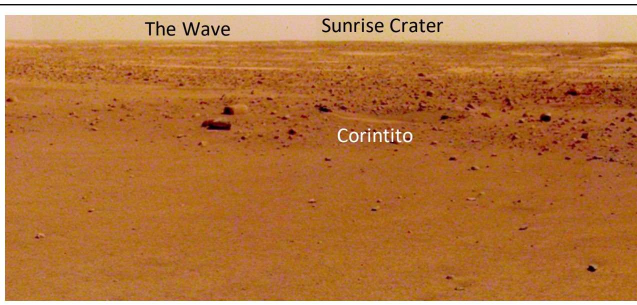

Figure 3. Portion of panorama to the southeast showing smooth plains to the edge of Homestead hollow and rougher and rockier terrain beyond. Note fresh Corinto secondary crater (Cointito) on the edge of the hollow, circular soil filled depressions (hollows) in the distance, and eolian bedforms (The Wave)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

Geologic Processes and Origin: The observations described in this and companion abstracts [4, 5, 6, 7, 11, 12] 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 eolian bedforms. The origin and modification of Homestead hollow and adjacent impact craters identify mass wasting and eolian processes as those dominantly modifying the surface [4, 5]. Finally, no outcrop or bedrock has been observed.

These observations are consistent with expectations made from remote sensing data prior to landing [1, 13]. The investigations made as part of the landing site selection effort indicated a surface composed of 3-17 m thick 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 size particles with decreasing abundance of pebbles, cobbles and boulders.

References: [1] Golombek et al. (2017) SSR 211, 5-95. [2] Parker, T. et al., this issue. [3] Maki, J. et al., this issue. [4] Warner, N. et al., this issue. [5] Grant, J. et al., this issue. [7] Weitz, C. et al. this issue. [6] Charalambous, C. et al., this issue. [8] Golombek, M. et al. (2006) JGR 110, E02S07. [9] Williams, N. et al., this issue. [10] Garvin, J. et al., this issue. [11] Ansan, V. et al., this issue. [12] Wilson, S. et al., this issue. [13] Golombek et al., this issue. [14] Golombek et al. (2018) SSR 214: 84. [15] Warner, N. et al. (2017) SSR 211, 147-190.

Fig. 4. Image under the lander showing struts, retrorockets, excavated pits (10-20 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.