GEOMORPHOLOGY AND ORIGIN OF HOMESTEAD HOLLOW, THE LANDING LOCATION OF THE INSIGHT LANDER ON MARS. N. H. Warner[1], M. P. Golombek[2], J. Grant[3], S. Wilson[3], E. Hauber[4], V. Ansan[5], C. Weitz[6], C. Charalambous[7], T. Pike[7], N. Williams[2], F. Calef[2], T. Parker[2], A. DeMott[1], M. Kopp[1], H. Lethcoe[2], L. Berger[2]
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Introduction: The Interior Exploration using Seismic Investigations, Geodesy, and Heat Transport (InSight) mission to Mars landed successfully at 4.502° N, 135.623° E in Elysium Planitia [1,2]. Pre-landing orbital investigations of the landing ellipse indicated a smooth, basaltic plain that is capped by a meters-thick regolith [3-5]. The plains here have been previously mapped as the Early Hesperian transitional unit (eHt) [6]. The most obvious geomorphic features on this landscape, visible from CTX (Context Camera) and HiRISE (High Resolution Imaging Science Experiment), are 10 to 100-m-scale rocky (RECs) and non-rocky ejecta (NRECs) impact craters [7].

Prior to landing, significant attention was paid to the morphology and degradation history of impact craters in the landing ellipse to evaluate local surface processes [7]. The craters exhibit a degradational continuum that begins with a pristine, bowl-shaped crater (Class 1) and ends with a nearly completely filled, quasi-circular hollow (Class 6) (Fig. 1) [7]. From orbital observations of craters in an intermediate state of degradation (Class 2 to 5), the hollows were suggested to be infilled by eolian materials, limited airfall dust, material from slope modification of the interior, and possibly ejecta from other craters. The maximum time period over which craters transition from Class 1 to 6 was estimated at ~1.7 Ga for 100-m-scale craters [7]. Smaller craters degrade an order of magnitude faster [8]. InSight landed in a 25-m-diameter quasi-circular depression dubbed "Homestead hollow" that may represent one of these degraded, Class 6 craterforms (Fig. 1) [also see 9]. This analysis describes the morphology of the hollow and implications for the observed surface characteristics and soil properties.

Observations: InSight was fortunate to have landed within the extent of a 1 m HiRISE DEM (Digital Elevation Model) produced for the landing site evaluation [10]. From the DEM, the maximum depth of Homestead hollow is ~0.8 m (Fig. 1). The hollow has no expression of an elevated rim.

Color HiRISE shows that the lander straddles a transition between a smooth surface of near constant color variation to one with a rougher, mottled appearance (Fig. 1). A panorama, taken from the Instrument Deployment Camera (IDC), confirms that InSight landed on a boundary between two surface types (Fig. 2). To the south and east of the lander, in the direction

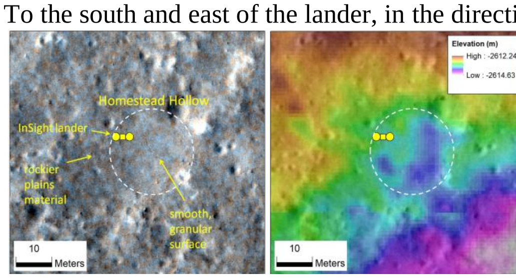

Fig. 1: HiRISE color image ESP_03761_1845 (left) at 25 cm pixel^{-1} and a 1 m HiRISE DEM (right) showing the location of InSight within Homestead hollow (dashed circle)

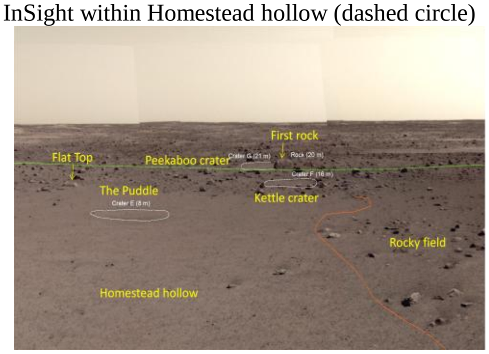

Fig. 2: Portion of the IDC panorama looking south showing the transition between the Rocky field and the granular surface of Homestead hollow. Green line marks the extent of InSight's blast zone. Partially buried rocks are visible on the margin of the hollow (red line).

towards the center of the hollow, the surface is dominated by sand to pebble-size particles with few cobbles. To the north and west of the lander, at the edge of the hollow, the surface exhibits abundant 10-cm-scale, cobble-size clasts that are surrounded by soils that have a similar grain-size to the hollow interior ("Rocky field", Fig. 2). Boulder-size clasts are rare, although a few are evident in the IDC panorama beyond the hollow (e.g. "First rock"). The larger rocks at the edge of the hollow are either perched on top of the finer soils or are partially buried by the soils. The large rocks in the landing site are likely sourced as ejecta from nearby 100-m-scale RECs and more far-field impacts.

InSight's pulse rockets also revealed the near surface stratigraphy of the material within the hollow by excavating cm-deep holes beneath the lander. The ejected debris includes dark-gray, sub-angular pebbles and clods of light reddish-brown material that suggest a weakly indurated surface crust (duricrust) [11].

Interpretations: The quasi-circular nature of Homestead hollow and its generally lower elevation relative to the surrounding terrain argues for an impact origin. Other hollows are located nearby the landing site, many of which show a more obvious circular morphology. These hollows exhibit a similar smooth floor appearance and color characteristics in HiRISE.

The primary processes involved in crater degradation at the InSight landing site include diffusional slope modification, which leads to rim degradation and infilling, and eolian deposition in the crater interiors [7]. Near-pristine craters exhibit abundant bedforms (ripples and dunes) in the ejecta and on crater floors. Bedforms are largely absent on the plains between craters suggesting that the impact process is responsible for the production of sand-sized material [12].

Ejecta around a fresh crater is out of equilibrium with the local wind regime and sand is preferentially entrained here, ultimately migrating across the landscape [9]. HiRISE images of the landing region reveal that crater rims, ejected rocks, and crater floors are natural sediment traps for migrating sand (Fig. 3). Meter-tall bedforms occur on the horizon to the north and east of the landing site, trapped against the rims of degraded impact craters. The observed crater morphology in HiRISE also indicates an important transition between younger craters that have bedforms on their floors and older craters whose floors are now smooth (Fig. 3). Smoothing may be due to accumulation of dust that buries the bedforms or slope modification that degrades the topographic expression of bedforms after they stabilize. In either case, the smooth material shows evidence of induration. Small impact craters are well preserved on the infill, and in some instances, the infill forms a well-defined scarp at the edge where it only partially covers the crater floor (Fig. 3)

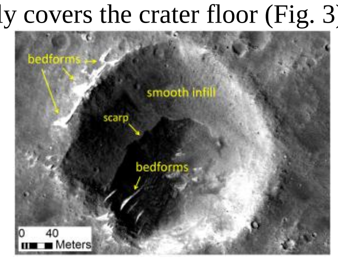

Fig. 3: HiRISE image from the InSight landing region (final ellipse E9) showing an older Class 4 impact crater [7]. The crater contains smooth infill with a margin that is defined by an escarpment, possibly suggesting induration.

The overall grain-size characteristics, granular nature, and weak induration of the soils within Homestead hollow are entirely consistent with trapping of fines including transported sand and likely some component of airfall dust. Furthermore, the partially buried appearance of cobble to boulder-size rocks at the edge of the hollow and beneath the lander indicates that the rockier material that is evident on the surrounding landscape continues at relatively shallow depths beneath the finer material. While it is possible that some component of the fines in the hollow have been stripped (this is suggested by the pebble rich surface in the hollow), significant exhumation is not obvious. The presence of a duricrust is also consistent with stabilization of infill by diffusional exchanges of water vapor between the atmosphere and near-surface soils [13].

Assuming an impact origin for Homestead hollow, a pristine crater that is 25 m in diameter should be ~3.8 m deep given the depth (d) to diameter (D) ratio for simple craters in the landing site (d=0.15D) [7]. Diffusional modeling and observations from [7] revealed that craters here fill with externally-derived materials (e.g. likely wind-blown sand) at roughly the same order of magnitude rate (10^{-3} m Myr^{-1}) as the rims degrade by slope processes. This infill was also found to account for ~30 to 40% of the total amount of depth-related degradation [7]. With an initial depth of 3.8 m and accounting for the current depth of the hollow at 0.8 m, there has been a total of ~3 m of depth-related change. A maximum estimate for the component of externally-derived infill is therefore ~0.9 to 1.2 m. Shallower infill is possible near the margins of the crater, at the location where InSight straddles the edge of the hollow.

Conclusions: The InSight lander rests within a small topographic depression that may represent a highly degraded, 25-m-diameter impact crater. This feature has served as a sediment trap for migrating eolian materials, accounting for up to ~0.9 to 1.2 m of sand infill. HP^3, the percussive mole, will pass through this material during its descent before encountering the coarser, impact-gardened regolith beneath.

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