INSIGHT LANDING SITE: STRATIGRAPHY OF THE REGOLITH BENEATH THE LANDER AND IN ITS SURROUNDINGS, AND IMPLICATIONS FOR FORMATION PROCESSES. V. Ansan[1], E. Hauber[2], M. Golombek[3], N. Warner[4], J. Grant[5], J. Maki[3], R. Deen[3], F. Calef[3], C. Weitz[6], J. Garvin[3], S. Wilson[5], N. Williams[3], C. Charalambous[7], T. Pike[7], H. Lethcoe[3], M. Kopp[4], A. De Mott[4], S. Smrekar[3], B. Banerdt[3], and R. Lorenz[8]
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Introduction: On November 26, 2018, the InSight lander touched down at 4.50°N/135.62°E within Homestead hollow, a subdued and filled depression on Late Hesperian, highly cratered volcanic plains of western Elysium Planitia, Mars [1,2,3,4].

Surface Terrain: Both using the lander-mounted Instrument Context Camera (ICC) and the robotic arm-mounted Instrument Deployment Camera (IDC) [5], the terrain surrounding and beneath the lander was imaged, showing a smooth, sandy surface with additional >cm scale clasts, ranging from pebbles to very few cobbles [6,7,8] (Fig. 1). Close to the lander, pebbles and cobbles show two distinct types of materials: dark-toned, grey aphanitic one probably corresponding to a basaltic composition, and light-toned one with unknown composition and origin. Some particles are partially buried, showing that sedimentary processes are or were active after their deposition (i.e. sedimentation or aeolian erosion is very efficient at present-day).

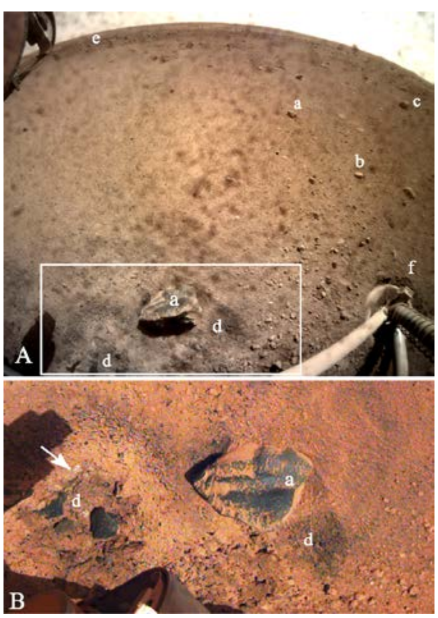

Fig. 1: A. South view of Homestead hollow, showing the flat sandy terrain covered by spaced sub-angular, pebbles and cobbles (a,b,c), and boulders (e) over the hollow. The right lander footpad (f) is partially buried in cohesionless, dark-toned, fine material, the "turtle" cobble consisting of ~20 cm in size, dark-toned material (probably mafic basalt), eroded by wind (deflation scour at its summit), lifted and pushed away by rockets during landing forming a shallow depression (d) consisting of <cm scale dark particles. ICC color image C000M004_596888328EDR _F0000_0461M1 obtained on sol 5. B. Detailed view in front of lander marked by white box in A, obtained by IDC, sol 14, (D001L0014_597774194CPG _F0909_0010M1), showing few cm-deep left pit which steep edges are irregular, composed of few mm thick, indurated, light-toned, fine-grained material (white arrow), and partially cementing cm-scale clasts locally, and covering a breccia composed of dark-toned, angular to sub-rounded pebbles poorly sorted in a very fine grained material.

Sub-surface terrain (~10 cm deep): The texture and near surface structure of regolith have been exposed by landing rocket-induced excavations under the lander (Fig. 2), showing a variety of clast sizes, arrangements and texture at horizontal meter-scale (distance between lander feet).

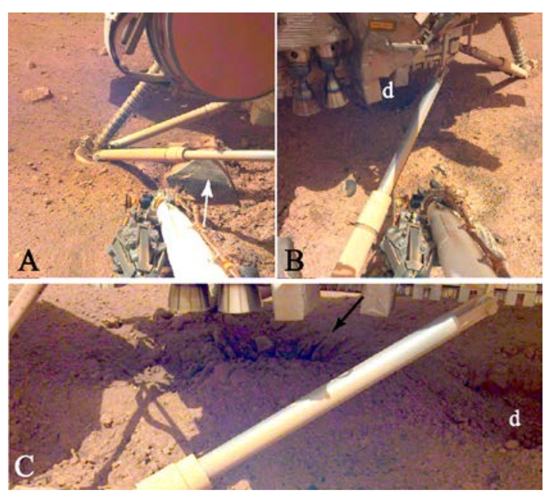

Fig. 2: A. B. Two footpads show evidence for slight sliding into place, creating a depression on one side and bulge in direction of travel, suggesting the sub-surface consists of

surficial dust mixed with thin, cohesionless, fine-grained material. White arrow shows the "Ace of Spades" cobble. IDC images acquired sol 18, D001L0018_598130765CPG_F0707_0010M1 and D002L0018_598131151CPG_F0707_0010M1. C. Zoom on pits under the lander (D001L0018_598131526CPG_F0606_0010M) showing a cm-scale deep, steep slope (greater than the angle of repose) composed of cemented soils, small angular gravels and pebbles indicating a cemented duricrust. Smaller clods and pieces of this material are littered within the pits and adjacent to the pits, showing imbricated texture (black arrow).

Stratigraphy of regolith: From these observations, stratigraphic sequences are proposed as following from top to bottom (Fig. 3): i) a cm-scale thick layer consisting of light-toned, cohesionless, <mm-scale grain sizes ranging from clay to fine sand. It was partially removed by the rocket blast as shown by cm-scale erosive streaks and divots around the lander [6,7]; ii) a mm-to cm scale thick, light-toned layer, consisting of indurated material "duricrust", easily fragmented in flat polygons by lander feet. This duricrust shows lateral variations of textures, from fine-grained (i.e. <mm scale) to coarse-grained material (i.e. composed of poorly-sorted, angular to sub-rounded clasts, ranging from granule to cobbles with a majority of pebbles contained in fine-grained cement; iii) a cm-scale thick, cohesionless, granular material comprised of either dark-toned sand or poorly sorted material with sub-angular, dark-toned pebbles showing a weakly developed sub-horizontal planar layering, containing in a fine-grained matrix.

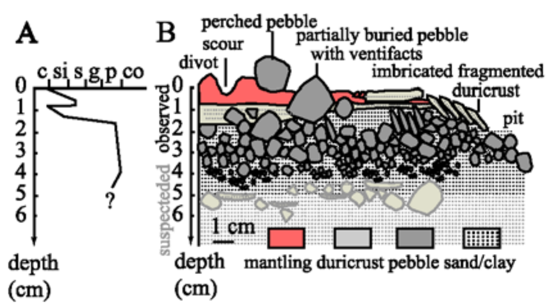

Fig. 3: A. Granulometry (c: clay, si: silt, s: sand, g: granule, p: pebble, co: cobble). B. synthetic cross-section of regolith beneath and in surroundings of InSight lander.

If we extrapolate this at meter-scale, an idealized geologic cross-section would show the distribution of fragmented-rocks with depth (Fig. 4), due to impact gardening, before reaching Hesperian lava flows a few meters deep.

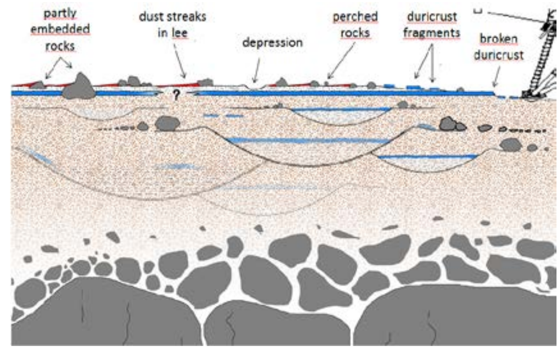

Fig. 4: Idealized geologic cross-section in Homestead hollow. Lander foot at right side.

Discussion: This stratigraphic succession is quite similar to what was seen at the other Martian landing sites [9,10,11], notably if compared to the regolith in Gusev crater which consists of similar Hesperian volcanic host material: There is a cohesive duricrust near the sub-surface. It differs by a greater thickness (cm-scale).

The stratigraphy of regolith in Homestead hollow suggests that several processes modified the Late Hesperian/Early Amazonian lava flows of western Elysium Planitia into this clastic regolith during the last 3 billion years: impact gardening as the origin of clasts; aeolian erosion, transport and sedimentation, filling impact craters and intercratered plains, though the small excavations beneath the lander do not display sand cross-bedding; weathering as the change of clast shape (e.g. wind abrasion) and the cementation to form duricrust.

References: [1] Golombek et al., this issue. [2] Golombek et al. (2018) SSR. [3] Warner, N., et al., this issue. [4] Parker, T., et al., this issue. [5] Maki, J., et al., this issue. [6] Grant et al., this issue. [7] Weitz, C., this issue. [8] Charalambous et al., this issue. [9] Arvidson et al. (2006) *Journal of Geophysic Res.*, 111, E02S01, doi:10.1029/2005JE002499. [10] Herkenhoff et al. (2008) The Martian Surface: Composition, Mineralogy, and Physical Properties, Cambridge University Press. [11] Golombek et al. (2008) The Martian Surface: Composition, Mineralogy, and Physical Properties, Cambridge University Press.