CRATER RETENTION AGES AT THE INSIGHT LANDING SITE: IMPLICATIONS FOR THE DEGRADATION HISTORY OF HOMESTEAD HOLLOW.

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Introduction: The Interior Exploration using Seismic Investigations, Geodesy, and Heat Transport (InSight) mission landed in western Elysium Planitia, Mars. Elysium is a relatively smooth, Hesperian-age [1], basaltic lava plain that is capped by a meters-thick, granular regolith [2-4]. InSight landed in a ~25 m-diameter, quasi-circular, topographic depression that is informally known as "Homestead hollow" [5] (**Fig. 1**). The hollow is characterized by a smooth, pebble-rich surface that is adjacent to slightly rockier and rougher terrain [6]. This transition in roughness is apparent in the color images from the High Resolution Imaging Science Experiment (HiRISE) [7], where the surface of Homestead hollow appears more "bluish" relative to the darker, rougher surrounding terrain (**Fig. 1**). Despite the lack of an apparent crater rim, Homestead hollow appears to be a very degraded and infilled impact crater [5, 8].

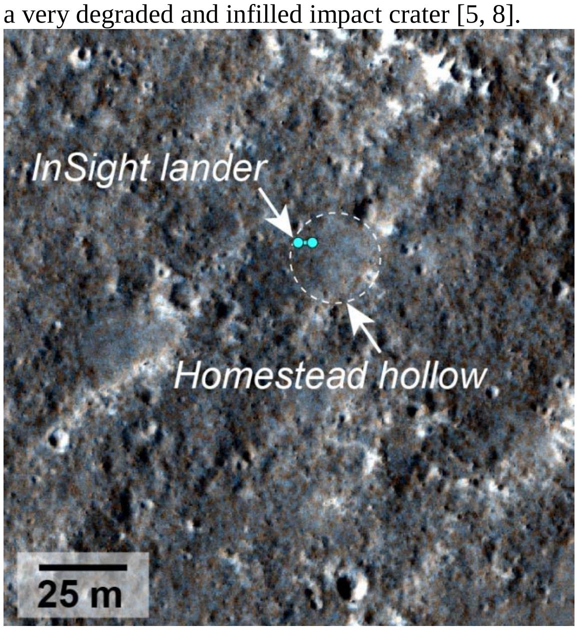

Figure 1. The InSight lander (aqua) in Elysium Planitia (4.502384°N, 135.623447°E; planetocentric coordinates based on HiRISE location georeferenced to MOLA [9]) landed near the margin of the ~25 m-diameter quasi-circular topographic depression (dashed line) known as Homestead hollow. Subframe of HiRISE color ESP_036761_1845 (0.25 m/pixel). North is towards the top.

Background and Motivation: The morphology of impact craters within the region of the InSight landing ellipse follow a degradational continuum from pristine, bowl-shaped craters (Class 1) to nearly completely filled, quasi-circular hollows (Class 6) [10]. As estimated by [10], a 100 m-diameter scale Class 1 crater would degrade to a Class 6 crater in ~1.7 Ga, whereas smaller craters would follow the same degradational trend an order of magnitude faster. Assuming Homestead hollow is a nearly completely filled "Class 6" [10] crater, we aim to estimate its maximum age based on the retention age of 20 to 30 meter-diameter craters.

Methods: Crater statistics were compiled using CraterTools [12], a plug-in software for ArcGIS. Craters, excluding obvious secondary clusters, were counted using images from HiRISE and the Context camera (CTX) on board the Mars Reconnaissance Orbiter in a ~1 km^2 region centered around the InSight lander in HiRISE image ESP_037262_1845 (0.25 m/pixel) (**Fig. 2**), and a 3,750 km^2 region in CTX image F09_039135_1843 (5.42 m/pixel; the etched terrain [2, 4] in the southern portion of the CTX image was excluded).

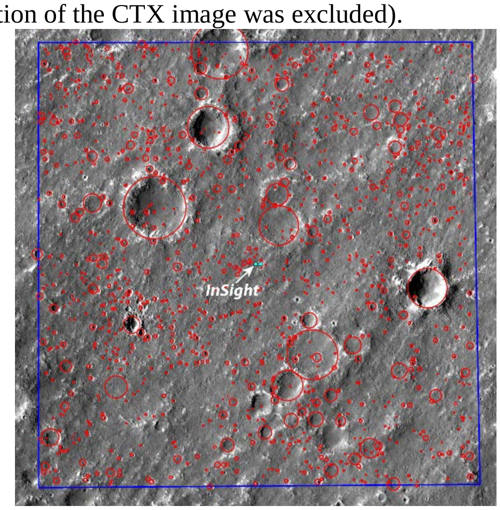

Figure 2. Craters (red circles) counted within the 1 km × 1 km area (blue box) centered around the InSight lander (aqua) used to produce a portion of the cumulative size frequency distribution plot (**Fig. 3**). Subframe of HiRISE ESP_037262_1845 (0.25 m/pixel). North is towards the top.

Relative and absolute ages were interpreted from reverse cumulative histograms using pseudo log bins and Craterstats software [12] based on the Mars chronology function of [13], the Hartmann "2004 iteration" production function of [14], and the Hartmann equilibrium function [14] (**Fig. 3**).

Results: The cumulative size frequency distribution (SFD) for the preliminary mapping of 1,323 craters in the ~1.17 km^2 area surrounding the InSight lander using HiRISE data (**Fig. 2**), and 733 craters in the 3,750 km^2 area using CTX data, are shown in **Figure 3**.

Preliminary Interpretations: The preliminary model age fit of craters in the 20 m-diameter bin (n=10), 25 m-diameter bin (n=10), and 30 m-diameter bin (n=10) is ~340 Ma, ~500 Ma, and ~657 Ma, respectively. This implies that a crater comparable in size to Homestead hollow would likely have a retention age on the order of 100s of millions of years (results will become refined with further analyses that increase the area and associated crater counts).

The cumulative SFD of small-diameter craters (black triangles in **Fig. 3**) in the range of ~20 to 150 meters appear to follow the -2 power law slope of Hartmann's equilibrium function (**Fig. 3**). This is consistent with other areas within the landing ellipse [10], and indicates that the production of craters below ~ 200 m in diameter is in equilibrium with geomorphic processes that are eroding them. Thus, craters that are < ~200 m in diameter provides a "crater retention" age of the surface, rather than the formation age of the landscape, which is reflective of surface processes and rates. By contrast, craters > 200 m in diameter follow a production curve, which suggests there may have been a regional, Early Amazonian resurfacing event that covered the Early Hesperian, km-size population of craters.

The model age fit to craters 0.2 to 0.6 km in diameter based on the crater counts from the CTX data is approximately 1.7 (± 0.06) Ga, indicating an Early Amazonian retention age for 100 meter-scale craters (**Fig. 3**). This result is consistent with a ~1.7 Ga age from an analysis of a much larger area of the Smooth Terrain [2, 3] within the InSight landing ellipse prior to landing [10]. Larger diameter craters (0.6 to 1.7 km) based on the counts from the CTX data have a best model age fit of ~2.94 (+0.29/-0.53) Ga (**Fig. 3**).

The present depth of Homestead hollow is approximately 0.8 m [5]. The 25-m-diameter hollow is a degraded and infilled impact crater [3, 8], and would have had an initial depth of ~3.8 m [5]. Given the average crater retention rate of ~ 500 Ma based craters 20 to 30 m in diameter estimated above, this yields a depth-related degradation rate of ~0.006 m/Myr, which are similar to crater degradation rates in [10]. The initial rate of rim degradation following formation of Homestead hollow was likely greater due to early deflation and gravity-driven slope processes [5, 10], that then slowed and became limited by weathering of rim rocks and slow production of fines [8].

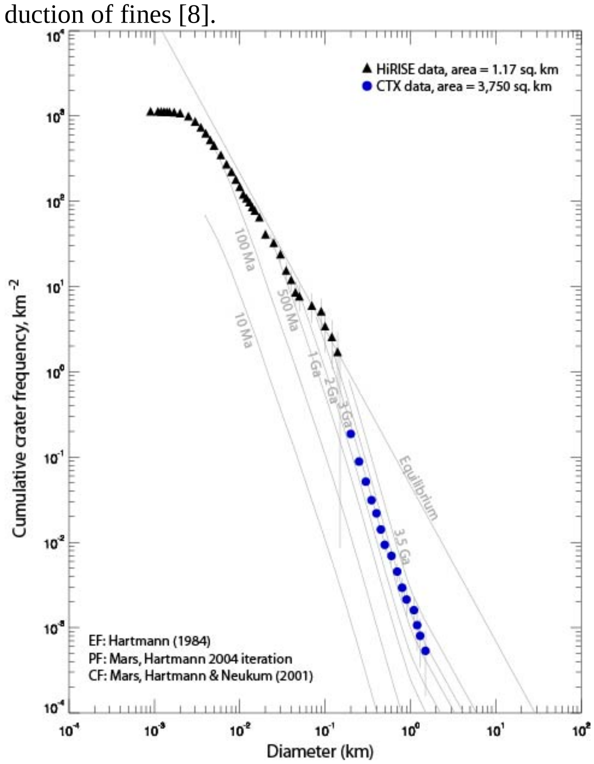

Figure 3. Cumulative size frequency distribution (SFD) plot for all craters mapped using in HiRISE (black triangles) and CTX (blue circles) data. The model age fit to craters comparable in size to Homestead hollow (20-30 m diameter range) is ~500 Ma. The model age fit to craters with diameters 0.2 to 0.6 km in diameter is ~1.7 (± 0.06) Ga (675 craters); the model fit age to craters with diameters 0.6 to 1.7 km is of ~2.94 (+0.29/-0.53) Ga (26 craters).

References: [1] Tanaka, K., et al. (2014), *USGS Sci. Invest. Map*, 3292 [2] Golombek, M., et al. (2017), *SSR*, 211, 5-95 [3] Warner, N.H. et al. (2017), *SSR*, 211, 147-190 [4] Golombek, M. et al. (2018), *SSR*, 214, 84 [5] Warner, N. et al. (2019), *50th LPSC*, this issue [6] Golombek, M. et al. (2019), *50th LPSC* this issue [7] McEwen et al. (2007) *JGR*, https://doi.org/10.1029/2005JE002605. [8] Grant et al. (2019), *50th LPSC*, this issue [9] Parker, T., et al. (2019), *50th LPSC*, this issue [10] Sweeney, J., et al. (2018), *JGR*, 123, 2732-2759 [11] Kneissl, T., S. van Gasselt, & G. Neukum (2011), *Planet. Space Sci.*, doi:10.1016/j.pss.2010.03.015 [12] Michael G., Neukum G. (2010), *Earth & Planet. Sci Letts*., doi:10.1016/j.epsl.009.12. 041 [13] Hartmann W.K., Neukum G. (2001), *Space Sci. Rev*., 96, 165-194. [14] Hartmann (1984), *LPSC XV*, 348-349.