INSIGHT ROCK SIZE-FREQUENCY DISTRIBUTIONS ON MARS. A. Trussell[1,2], M. Golombek[1], N. Williams[1], H. Abarca[1], N. H. Warner[3], M. Deahn[3], C. Charalambous[4], J. Grant[5], and E. Hauber[6], [1]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, [2]California Institute of Technology, Pasadena, CA, [3]SUNY Geneseo, NY, [4]Imperial College, London, [5]Smithsonian National Air and Space Museum, Washington, DC, [6]German Aerospace Center (DLR), Berlin.

Introduction: The size-frequency distribution of rocks on Mars is important for understanding the geologic and geomorphic history of the surface, for determining the aerodynamic roughness important for eolian processes, for quantifying the hazards for landing spacecraft, and for evaluating the trafficability for roving. Rock counts have been made by all the landers or rovers on the surface of Mars and they have been related to rock counts made in High-Resolution Imaging Science Experiment (HiRISE) ~30 cm/pixel orbital images using an exponential model that defines the size-frequency distribution (SFD) of rock diameter versus cumulative fractional area (or cumulative number/m^2) for any total fractional rock coverage [1,2].

The InSight mission (Interior Exploration using Seismic Investigations, Geodesy, and Heat Transport) landed within a quasi-circular depression, interpreted to be a degraded ~20 m diameter impact crater, informally named *Homestead hollow*, with a smooth pebble-rich surface adjacent to a slightly rockier and rougher terrain [3]. The broader surface appears modified by impact, eolian and mass wasting processes with craters in various stages of degradation.

Prior to landing, orbital estimates of rock abundance in the landing ellipse indicated a surface with very low average rock abundance [4]. In HiRISE, the average cumulative fractional area (CFA) covered by rocks away from rocky ejecta craters is ~1%. For all rocks within the ellipse, including sparse rocky ejecta craters, a CFA of ~6% is obtained. These low rock abundances are consistent with thermal differencing estimates of rock abundance (<5%) and are generally comparable with rock distributions measured at the Phoenix and Spirit landing sites [4].

After landing, initial rock counts were performed in a number of small (1-7 m^2) areas around the lander that had stereo coverage [1,5]. This abstract, presents the rock counts and SFD in the nearly complete panorama digital elevation model (DEM) and so covers more area and is a better representation of the rock abundance around the lander. We also compare the distributions around the lander to those measured in the area around the lander in HiRISE.

Panorama DEM and Rock Measurements: IDC stereo images (283) acquired on Sols 12-160 were mosaicked to create the panorama DEM and orthoimage shown in Fig. 1. Image resolution varied from 0.12 cm/pixel to 2.8 cm/pixel with increasing distance and the DEM has elevation postings every 5 mm. The panorama orthomosaic has been bundle adjusted [6], except for the west region, which does not overlap with the rest of the panorama.

Because InSight is on a shallow slope down to the east [7], stereo definition is more limited in distance in this direction than others (Fig. 1). The orthoimage and DEM was divided into four subareas. The total area is 220.3 m^2 in which 854 rocks with diameters >3 cm were included in the SFD. A total of 2069 rocks >0.6 cm were counted to be sure all larger rocks were included, but the SFDs are cut off at 3 cm diameter.

Rock edges were digitized as polygonal outlines in orthorectified images using ArcMap. For each digitized rock, a convex hull was calculated using the DEM. This method provides a minimum axis from the shortest distance between any two vertices of each polygon and a maximum axis from the longest distance between any two vertices of each polygon. Minimum and maximum axes are averaged to yield the mean diameter for each rock. The CFA and cumulative number of the rocks are then normalized over the count area as functions of diameter.

Size-frequency Distributions: The rock abundance around the InSight lander varies from <1% to 5% (Fig. 2). The least rocky, pebble-rich surface of *Homestead hollow* to the east of the lander, falls on a model

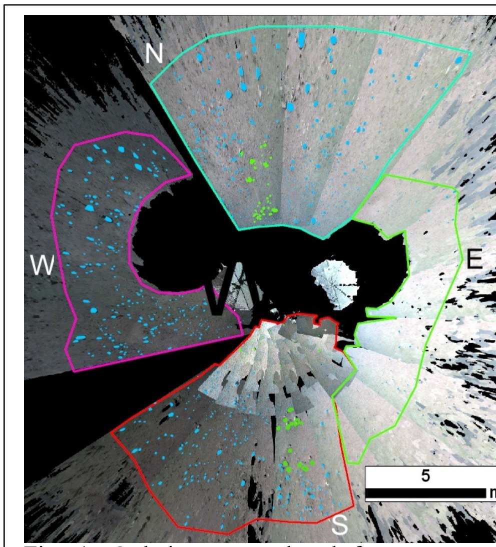

Fig. 1. Orthoimage, produced from panorama digital elevation model, of the four areas around the InSight lander in which rocks (blue and green) were counted (North, South, East, West). The area to the north is 75.3 m^2 in which 328 rocks 0.03-0.44 m diameter were counted. The area to the west is 41.2 m^2 in which 215 rocks 0.03-0.3 m diameter were counted. The area to the south is 60.1 m^2 in which 266 rocks 0.03-0.19 m diameter were counted. The area to the east is 30.7 m^2 in which 45 rocks 0.12-0.03 m diameter were counted.

SFD curve for 0.6% CFA. The SFD of the highest rock abundance area to the west of the lander falls on a model 5% CFA for diameters <10 cm, but drops to a ~2% model curve for larger diameters. The SFD of the area to the north includes the largest rock counted (44 cm) and rises from ~3% CFA for the largest rocks to ~4% for diameters <30 cm. The area to the south of the lander rises from ~1% CFA at 20 cm diameter to 3% CFA for diameters <1 cm. The SFD of all areas are generally parallel to the exponential model curves at diameters <10-30 cm, but fall below the models for larger diameters, indicating a relative deficiency in large rocks. The entire area together has a SFD that is close to the exponential 3% model SFD for diameters <30 cm.

These SFDs are generally similar to initial counts obtained over smaller areas [3,5], except the range in rock abundance is greater and the SFDs are clearly curved on the log-log plot and more closely resemble the curved exponential model SFDs than the initial smaller area counts. *Homestead hollow* has the lowest rock abundance (0.6%) and the area to the north and west have the highest (4-5%). The lower rock abundance within the hollow likely reflects a real paucity of fragments within the fill as compared to exterior surfaces with varying fragment burial by infilling sediments [8]. The average rock abundance for the entire area counted is ~3%, which is between the ~2% at the Phoenix and 5% at the Spirit landing sites. The rockier areas to the north and west (4-5%) are more representative of the area around the lander that includes rocky ejecta craters [5], compared with the rock-poor area of *Homestead hollow*.

HiRISE Rock Distributions: During InSight landing site selection, measurements of rocks in HiRISE images utilizing the rock shadow segmentation, analysis, and modeling method used for Phoenix and Mars Science Laboratory [1,2] was used to measure the rocks in the landing ellipse [4]. To compare the rock counts made from orbit to those made from the lander, all rocks detected in a 1 km sided square centered on the lander were plotted. However, because detections included false positives (scarps, hills, eolian bedforms) that were generally >2.25 m, the estimate of rock abundance in 150 m by 150 m square areas was based on rocks 1.5-2.25 m diameter [2,4]. We selected detections that were confirmed by a human who mapped rocks, craters and eolian bedforms in a HiRISE orthoimage and DEM. Rocks were distinguished by their being illuminated in the up Sun direction and casted a shadow in the down Sun direction. One hundred seventy-two confirmed rocks between 40 cm and 2 m are plotted in Fig. 2. The majority of these rocks are around three rocky ejecta craters [3,5].

The SFD for rocks >1.6 m to 2 m diameter is parallel to the 5% exponential model distribution. The SFD for rocks 1.6-1.2 m diameter is parallel to the 4% exponential model distribution. The SFD of rocks smaller than 1.2 m diameter shallows relative to the exponential model curves similar to most HiRISE counts which has been attributed to a resolution roll off in which rocks with fewer than 5 pixels are detected less frequently [1,2].

The 4-5% rock abundance indicated by the HiRISE detections from orbit matches the 4-5% of the rockier somewhat stripped of fines and better exposed areas viewed to the north and west (4-5%) of the lander, which are more representative of rock abundance of the general area around the lander that includes rocky ejecta craters. As a result, the rock abundances observed from orbit falls on the same exponential model rock abundance curves as those viewed from the surface. Therefore, InSight joins Viking Lander 1 and 2, Mars Pathfinder, Phoenix and Spirit where rock counts in HiRISE images fall on the same exponential model curve as those seen from the surface [1,2]. The SFD measured from both the lander and orbit also agrees with the fragmentation theory predictions made prior to landing [4]. The measurements further strengthen the use of HiRISE images to measure rocks >1.5 m diameter, fitting these rocks to an exponential SFD model, and extrapolating along the model to predict the number of rocks smaller than 1.5 m that could be potentially hazardous to landing spacecraft [1,2,4].

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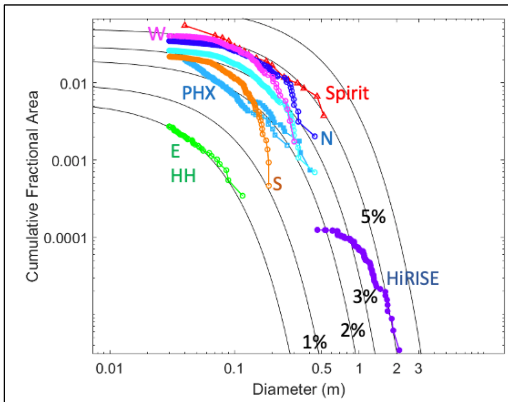

Fig. 2. Cumulative fractional area versus diameter plot of rocks around the InSight lander to the North, South, East (*Homestead hollow*), West and all areas combined (light blue). Also shown are the Phoenix [9,2], the Spirit landing site [10] rocks and exponential model curves for 0.6, 1, 2, 3, 5 and 10% rock abundance [1,2]. Confirmed HiRISE rocks measured in a 1 km^2 area around the lander are also shown [4].