BLOCK DISTRIBUTION ANALYSIS OF IMPACT CRATERS ON MARS, INCLUDING THE THARSIS REGION AND ELYSIUM PLANITIA

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Introduction: Measurable block fields at impact craters are easily observable on planetary surfaces – Meteor Crater on Earth, Censorinus Crater on the Moon [1], and rayed craters on Mars (e.g. Figures 1 and 2). The distribution of ejecta surrounding these impact craters reveals clues about their formation, such as the impact angle and direction. As demonstrated by [1] with the investigation of Censorinus Crater on the Moon, block distribution patterns are both measurable and quantifiable, such as analysis of block size versus block distance from the crater and impact angle. Impact angle and direction may provide definitive evidence about whether an impact crater is a primary or secondary crater for ambiguous cases.

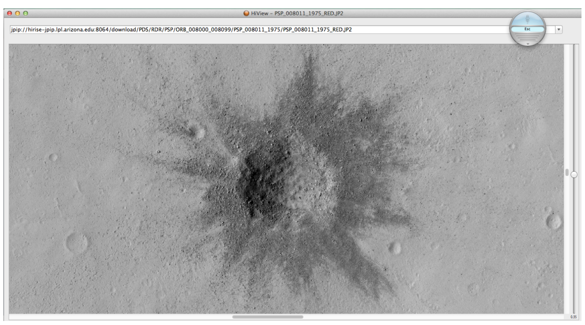

Figure 1. HiRISE image PSP_008011_1975 (Image Name: Very recent rayed crater in Tharsis region) of a rayed crater on Mars, referred to as “Impact Crater 1”. Location: 17.41°N, 248.75°E.

We have identified and analyzed two rayed impact craters on Mars with measurable block distributions. The first, referred to as “Impact Crater 1”, is located in the Tharsis region at 17.41°N, 248.75°E and is best observed in the HiRISE image PSP_008011_1975, as shown in Figure 1. It is considered a small rayed impact crater with a diameter of approximately 160 meters [2]. The second, referred to as “Impact Crater 2”, is located in Elysium Planitia at 0.51°N, 163.14°E and is best observed in the HiRISE image ESP_018352_1805, as shown in Figure 2. Given its proximity to Zunil Crater, it is speculated that Impact Crater 2 could be a secondary crater of Zunil Crater [3].

Using the Thermal Emission Imaging System (THEMIS) onboard the 2001 Mars Odyssey orbiter, Zunil Crater was the first rayed crater discovered on Mars [4]. [4] also investigated the approximately 10^7 probable secondary craters of Zunil Crater, some up to 1600 km away. [5] further investigated these probable secondary craters using images from the Mars Orbital Camera (MOC), with a resolution of 3.10 m/pixel, onboard the Mars Global Surveyor (MGS) [5]. The High Resolution Imaging Science Experiment (HiRISE) onboard the Mars Reconnaissance Orbiter, launched on August 12, 2005, has a resolution of approximately 0.3 m/pixel [4]. With the improved resolution of HiRISE images, we will be able to measure the blocks surrounding the impact crater, expanding upon the previous investigations of probable secondary craters of Zunil Crater.

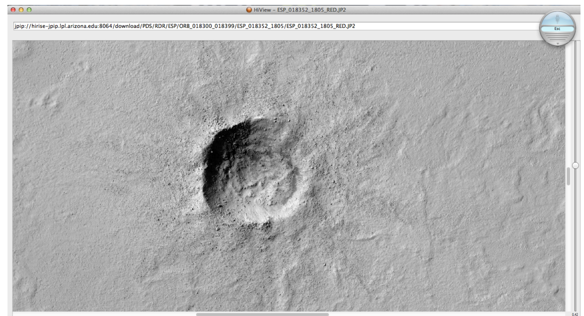

Figure 2. HiRISE image ESP_018352_1805 (Image Name: Rayed crater in Elysium Planitia) of a rayed crater on Mars, referred to as “Impact Crater 2”. Location: 0.51°N, 163.14°E.

Data and Methods: HiRISE images allow us to view and measure the blocks (greater than 1.0 m in diameter) that surround the Martian impact craters. Thus far, we have completed measurements and preliminary analysis at two impact craters (Figures 1-3) and have identified an additional 11 possible impact craters with measurable block fields. Using HiView (http://www.uahirise.org/hiview/), we manually measured the length and widths of blocks surrounding the impact craters. The measuring tools in HiView only allowed us to measure the length and width of the blocks in the north-south and east-west directions. Only in a few cases, the length and width of the block did not align with these directions. For the additional impact craters, we hope to increase the efficiency, both through time it takes to measure a single block as well as repeated measurements of a block, of measuring blocks by possible using a different software program, such as ArcGIS, or an automated block measuring program. In doing so, we will also be able to provide a comparison between these programs and HiView to determine the most

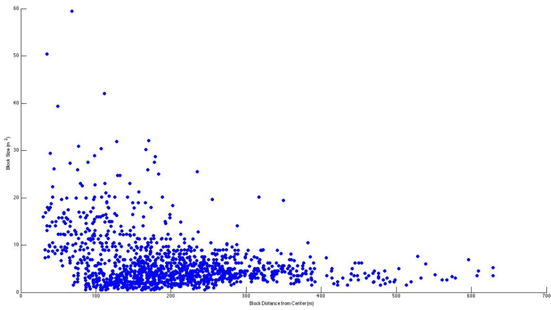

Figure 3. Block size (m^2) compared to distance from center of the crater (m) for Impact Crater 1. 1284 blocks were measured at Impact Crater 1.

accurate method for manually measuring blocks. We will use the already measured impact craters as case studies. For example, 1284 blocks were measured at Impact Crater 1. We will re-measure 10% of these blocks, sampling from all areas around the crater (on the crater rim to the farthest distance a block was measured from the center of the crater, ~600 m). These measurements will be compared to those from HiView. An automated measuring process would significantly increase our efficiency to measure blocks and allow us to easily measure blocks across the entire surface of Mars. A comprehensive block distribution analysis of impact craters would provide insight about the formation processes and allow for definitive identification of a primary or secondary crater. Our data from Impact Crater 1 and 2 will be used as ground-truth measurements in the development of the automated boulder measuring program MBARS [7] [LPSC by Hood et al., 2017]. Subsequently, we plan to use this program for block measurements.

For analysis of the block distributions of impact craters, we utilize similar methods as [1]. First, we calculated the area (m^2) of the blocks. Second, using the location of the blocks, we determined the distance from the center of the crater. A comparison between these two properties demonstrates block size as a function of distance from the center of the crater (Figure 3). Further analysis with these properties will allow us to determine the spatial variation of the block density population. In addition, we are able to calculate the impact direction by determining the b-value since the largest b-value is indicative of the impact direction [1]. [1] uses the equation to determine the b-value:

$N(a) = Ca^{-b}$, "where *N(a)* is a number of fragments or craters with a size greater than *a*, *C* is a constant, and *-b* is a power index (power-law slope). The block measurements not only provide observations about the impact craters but also insight about their formation processes.

Results and Discussions: Utilizing the block measurements, we seek to understand the geomorphological properties of impact craters, including rayed craters, with measurable ejecta fields. Thus far, we have completed measurements at two impact craters on Mars and completed preliminary analysis using methods described by [1]. Figure 3 shows the block size (m^2) as a function of distance (m) from the center of the crater for Impact Crater 1. Few blocks larger than 10 m^2 are found farther than 200 meters from the center of the crater. Within 200 meters, blocks up to 60 m^2 are observable. As expected, the smaller blocks traveled farther than the larger blocks. A similar pattern was observed at Impact Crater 2. We will further investigate these and the additional craters by analyzing the spatial variation of the block density population and determining the impact direction.

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