USING DIVINER DATA TO ANALYZE CHARACTERISTICS OF OVERLAPPING COLD SPOTS CAUSED BY A SERENDIPITOUS LUNAR IMPACT.

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Introduction: In March 2022, a rocket booster impacted the lunar surface about half way between the Michelson V and Hertzsprung D craters, creating two overlapping craters within an already existing cold spot[1]. Cold spots are formed by the disturbance of lunar regolith caused by an impact and are seen frequently around craters larger than ~70 meters[2]. Post-impact images [1] indicate the rocket booster body created a double crater about 28 meters wide. The east crater is 18 meters in diameter and overlies the 16-meter west crater, which may indicate a “dumbbell” shape of the rocket body. The rocket impact occurred within an existing cold spot formed by a ~1 kilometer crater, providing a natural experiment to understand how these unique initial conditions may affect cold spot formation

This study uses the data from NASA Lunar Reconnaissance Orbiter’s Diviner infrared radiometer to determine whether the March 2022 impact was large enough to form a cold spot within the existing cold spot. Due to the size and nature of this impact, this research can be used to determine the lower limit on crater diameter needed for cold spot formation and the characteristics of overlapping cold spots.

Data and Methods: In this study, we use infrared brightness temperature data from Diviner to analyze the changes in temperature caused by thermophysical disturbances of the lunar regolith on the Moon’s surface within a small region around the March 2022 impact site. We compare the brightness temperature data of a pre-impact surface with that of a post-impact surface to investigate possible cold spot formation.

The observational data are taken from Diviner’s channel 7 (25 – 41 µm) of an area of longitude -128˚ to -123˚ E and latitude 3˚ to 8 ˚ N between 4 to 5 AM. Diviner targeted the impact site at 4.42 hour local time on one orbit since impact on July 14th, 2022, which was the first nighttime observation of impact site since the March impact. We use these targeted data for the post-impact comparison. The pre-impact data set is taken from the same region around the impact during a similar local time between 2012 to 2022. Using the before and after impact data sets we produce difference maps to reveal any change in temperature in either direction.

Results and Discussion: Preliminary results a small, but potentially significant, increase in the nighttime brightness temperature from the post-impact surface compared to the pre-impact surface, within a region ~1 km (~50 crater radii) across, surrounding the impact site. We estimate this increase to be 3.29±0.31 K, relative to the background temperature of ~ 90 K at approximately 04:42 local time. Other anomalies outside the impact site showed changes generally < 2 K between the pre- and post-impact observations in both positive and negative directions. No systematic differences in pre- vs. post-impact brightness temperatures are observed across the whole region of interest, indicating that our 1-hr local time constraint on the pre-impact data was sufficiently narrow to eliminate systematic errors.

Comparison between post and pre-impact.

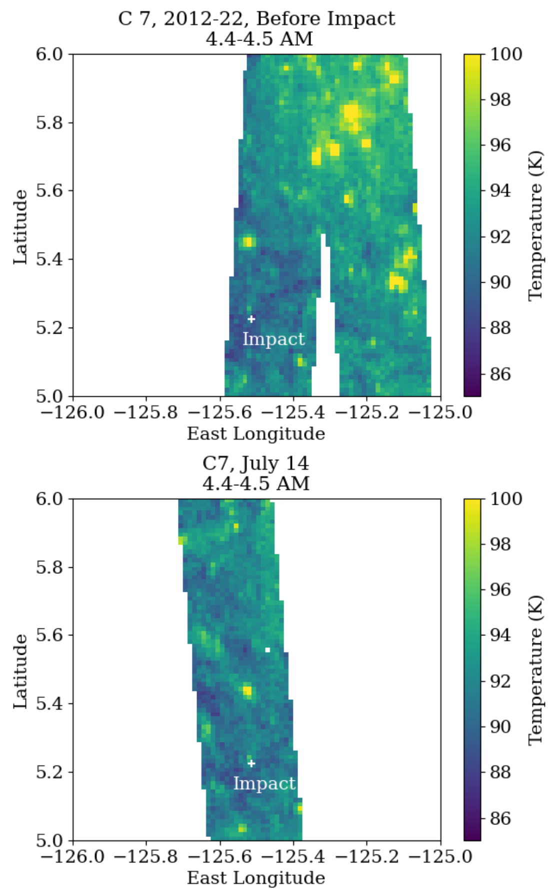

Fig 1. Pre-Impact data (above) and post-impact data (below) using 80 ppd (400 m) spatial binning.

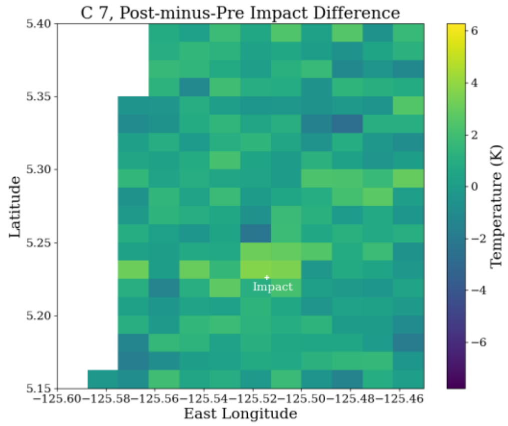

Fig. 2. Post-minus-pre impact brightness temperature data (-125.6° to -125.45°E longitude, 5.15° to 5.4° latitude) using the same spatial binning as in Fig. 1.

Restricting the observational area to the four bright pixels close to the impact site and indicates the temperature of this proximal region roughly falls within the expected trend during nighttime hours and is within 1 standard deviation of the pre-impact data (Figure 3). However, comparison with the map in Figure 2 indicates that at least a portion of this region showed systematically lower brightness temperatures post-impact. Therefore, further analysis is required to resolve the discrepancy, including all available spatial information.

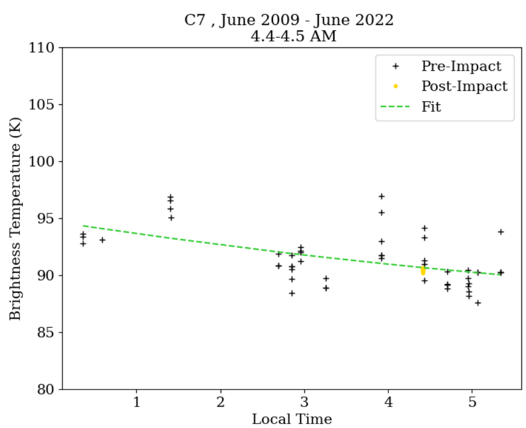

Fig 3. Plot of degree-2 polynomial fit to channel 7 brightness temperature vs local time from 4 pixel box near impact site (-125.525° to -125.505° Long, 5.231° to 5.250° Lat).

Next Steps. Further work is needed to validate the observed nighttime temperature changes at the site of the rocket booster impact. For example, we intend to properly account for Diviner's detector field-of-view and spacecraft motion in order to deconvolve the spatial and temporal data [3]. This approach is expected to both sharpen the images and improve the noise statistics significantly. Our investigation of cold spot formation for smaller impact diameters and cold spot overlap will answer the question of whether an impact within a pre-existing cold spot would make lunar regolith even fluffier resulting in an even colder cold spot. Since cold spots appear to be ubiquitous among lunar impacts, our results will improve understanding of the process of crater formation generally and the proposed ballistic sedimentation or granular flow mechanisms for cold spot formation [4]. We also intend to search the Diviner dataset for on data on naturally produced small cold spots overlapping pre-existing cold spots.

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References: [1] Robinson, M. S. et al. (2022), … LROC. [2] Powell, T. M. et al., UCLA. [3] Williams, J.-P. et al., (2017), *Icarus*, *283*, 300-325. [4] Bandfield, J. L. et al. (2014), *Icarus*, *231*, 221-231.