UNDERSTANDING THE IMPACT PROCESS BY EXPLORING A NEWLY FORMED IMPACT CRATER.

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Introduction: Impact cratering is a fundamental geologic process that shapes terrestrial planets. Much of our insight into the impact process stems from small laboratory impact experiments, discharge of chemical explosives and nuclear test explosions, numerical models, as well as the examination of impact craters on Earth and other planetary bodies. However, remote analyses of impact craters formed in the last decade on the Moon reveal surface modification further from the impact site than previously anticipated. For example, a new 18 m impact crater that formed on 17 March 2013 [1] revealed two distal reflectance zones, one of which feathered out to 1-2 km or > 100 crater diameters away from the origin [2]. Additionally, a recent impact that created a 70 m diameter crater formed ray-like features extending 100 km away from the impact site. Furthermore, Robinson and coauthors [2] identified over 200 distal secondary disturbances, referred to as splotches, around the impact site of the 18 m crater. These splotches are thought to be the result of clustered secondary impacts [2,3]. By examining one or more of these recent impact sites, we can further our understanding and get new insights into this fundamental process that alters every terrestrial body.

Landing Areas: One advantage of studying recent impacts is that there are multiple sites across the Moon that are suitable for exploration. To date, the LROC team has identified over 500 newly formed impact craters within 50° of the equator [3]. Depending on the other payloads and science objectives, some impact sites may be enticing for a particular mission to address multiple science questions, including ones unrelated to impact processes.

The basic concept of operations includes landing in the distal ejecta region outside of the crater. From there, a rover would proceed out to traverse and acquire measurements of splotches associated with the impact event that were identified prior to launch with NAC temporal imaging. By carefully surveying the splotch(es) with detailed imaging, one could compare the morphology of these features with the raindrop texture reported on several Apollo EVAs. Next, the rover would traverse across the various reflectance zones associated with the impact event and analyze the photometric properties to examine how the surface characteristics and composition vary as a function of radial extent. Finally, the rover would examine the impact site itself and take compositional measurements to examine the stratigraphy of the impact site.

Science Objectives: Many high priority science and exploration questions could be addressed by this investigation. A majority of these questions have been recognized in community documents, such as the Scientific Context for Exploration of the Moon (SCEM) and Lunar Exploration Roadmap (LER):

- SCEM 1d: Assess the recent impact flux
- SCEM 1e: Study the role of secondary impact craters on crater counts
- SCEM 3d: Quantify the local and regional complexity of the current lunar crust
- SCEM 6c: Quantify the effects of planetary characteristics (composition, density, impact velocities) on crater formation and morphology
- SCEM 6d: Measure the extent of lateral and vertical mixing of local and ejecta material
- SCEM 7b: Determine physical properties of the regolith at diverse locations of expected human activity
- SCEM 7c: Understand regolith modification processes (including space weathering), particularly deposition of volatile materials
- LER Sci-A-7A: Determine and understand the stages of formation of simple and complex craters, and multi-ring basins.
- LER Sci-A-7B: Determine how impacts modify, redistribute, and mix materials.
- LER Sci-B-1D: Characterize the impact hazard to the Earth-Moon system.
- LER FF-C-1: Ability to operate on a geologic surface.

Required Capabilities: This mission requires the precise landing within the distal ejecta zone and near one or more splotches and the parent crater. A rover would be required to study the individual science sites around the crater and would need to move in such a manner that the small-scale morphology at the site is not disturbed prior to sampling/imaging. To examine the surface properties in detail, a robotic arm capable of positioning a high-resolution camera 1 m off the surface at a variety of angles would be needed to provide the necessary lighting and viewing geometries. Light on the rover could assist in collecting certain lighting angles not available during the short mission. The camera should be capable of acquiring images at multiple wavelengths (e.g., 750 and 950 nm) to measure immaturity variations across the reflectance zones. The lander/rover would not be required to survive the lunar night to address these science objectives as long as the rover would be capable of a kilometer traverse during mission.

References: [1] Suggs et al. (2014) Icarus, 238, p. 23-36. [2] Robinson et al. (2015) Icarus, 252, p. 229-235. [3] Speyerer et al. (2016) Nature, 538, p. 215-218.