MODELING EJECTA DISTRIBUTION AND MODIFICATION AT MONTURAQUI CRATER, CHILE: A MULTI-SOURCE APPLICATION OF ARCGIS.

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Introduction: Monturaqui Crater is a small, well-preserved, simple crater located near the southern edge of the Salar de Atacama basin in northern Chile (23°55'41" S, 68°15'42" W). The crater is sub-circular with a preferential NW-SE elongation (370 m E-W, 350 m N-S, 34 m average depth) and the southern rim is 10-15 m higher than the northern [1].The target is comprised of Ordovician granitic basement cut by several 1 – 2 m wide mafic dikes and overlain by thin (0 – 5 m), discontinuous Pliocene Tucucaro ignimbrite [2]. Granite and ignimbrite are both exposed in the crater walls. Ejecta consist of unshocked and shocked granite and ignimbrite with small volumes of dark impact melt rich in Fe and Ni. Previous field mapping collected GPS locations for the dark impact melt, which is preferentially located on the southern and eastern flanks of the crater and is discontinuous [3]. The impact event that formed Monturaqui 663 ± 90 kya [4] restructured pre-existing drainage patterns and the ejecta blanket has been subsequently dissected by numerous channels that are currently inactive. Although located within the hyperarid part of the Atacama Desert, the area is subjected to infrequent and low-volume precipitation events that facilitate erosion [5]. Monturaqui is of interest due to its uneven distribution of granitic and dark impact melt ejecta. The distribution could be a primary remnant of the impact event or a result of preferential erosion. Field observations suggest much of the ejecta have been removed [3] although this has yet to be confirmed by studying the stratigraphic profile at the site. The objective of this study is to digitize and combine existing data to assess the evolution of ejecta distribution around Monturaqui since its emplacement.

Data and Methods: Due to the isolated nature of the field area, a remote sensing approach was combined with field-based data previously collected. Multispectral and panchromatic imagery at 1-m and 4-m resolution were acquired from IKONOS for use as a base map and to digitize geographic features. The global 10-m resolution digital elevation model (DEM) and multiple thermal infrared (TIR) images from the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) onboard Terra were obtained to model topography and map surface ejecta. A 2-m resolution DEM of the local area was generated by digitizing contours in ArcMap from existing maps and calculations of original ejecta thickness were made following the equations of Melosh [6] assuming a flat pre-impact surface and circular crater morphology. In order to qualitatively estimate paths of material removal, hydrology tools in ArcMap were used in conjunction with the 2-m DEM, and erosion rate estimates from various peer-reviewed sources were applied to assess a minimum value for eroded volume. Estimates of erosion rates in the Atacama Desert vary, but a commonly cited figure is <0.1 m Myr^{-1} [e.g., 7].

Distribution and modification of ejecta: Use of the ASTER TIR and IKONOS images for mapping ejecta beyond the rim area was ultimately impractical due to their low resolution. However, it is likely that most of the granitic fragments within the continuous ejecta blanket is granitic ejecta. Samples collected beyond the rim show evidence of shock metamorphism [8] and a few samples of ignimbrite from the surrounding area exhibit a frothy texture not commonly seen elsewhere in the Tucucaro. Field mapping in proximity to the rim shows distinct populations of granite and ignimbrite. The 2-m DEM generated in this project shows that most areas of higher elevation are comprised of granite. This also corresponds to higher albedo areas in IKONOS imagery. Dark impact melt occurs only on the SE flank of the crater. It has been hypothe-

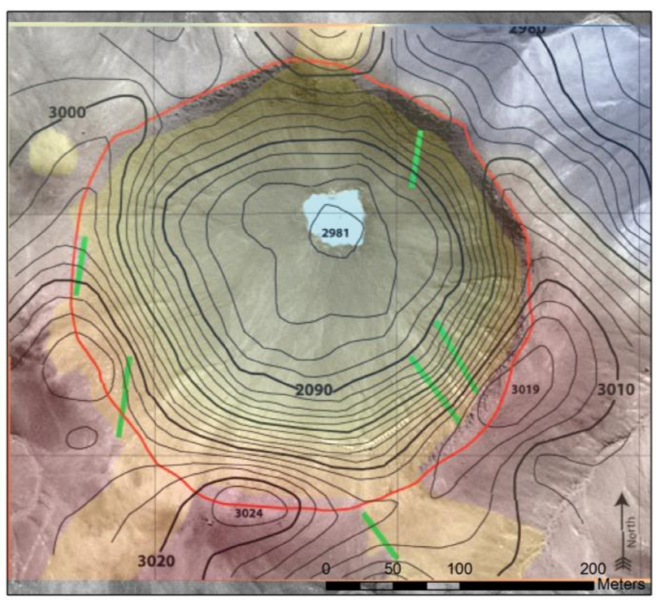

Fig. 1. Lithologies at Monturaqui superimposed on a 2 m DEM of the site. Warmer colors are higher in elevation than the blues. On top, pale yellow is granite, bright green is the mafic dikes, the red line denotes the crater rim, and uncolored areas are ignimbrite. After Cukierski [9].

sized that this could be directly related to the trajectory of the projectile [3].

The ejecta blanket has been dissected by new drainage patterns in the past 663 kyr that seldom reactivate due to the hyperarid nature of the Atacama. All of the fine-grained ejecta at the surface has been blown away although fine-grained material is present a few centimeters below the surface [3]. It is uncertain if this material is impact-related or not and further analysis must be done to confirm its origin. Modeling of flow paths in ArcMap suggests larger material may have been removed via two primary channels on the NW and SE sides of the crater, although this only represents paths of highest probable flow accumulation and is only an approximation since it is based on a DEM. Numerous smaller channels that originate on the crater flanks are clearly visible in satellite images. The northern channel dissects an area with little granite but granite is abundant in the area of the southern channel. It remains unclear whether the uneven distribution of granitic ejecta is a primary artifact or the result of preferential erosion.

Assuming there were approximately 4 – 5 m of ejecta deposited within the continuous ejecta zone, several meters of ejecta could still persist given the Atacama's extremely low rates of erosion, and particularly concerning the granitic fragments. If the <0.1 m Myr^{-1} rate represents a minimum value, and not accounting for grain size distributions, <7 cm depth of material, or ~54,000 m^3, could have been removed from the continuous ejecta blanket alone. Future work should generate a larger field map of the ejecta and determine its actual thickness and distribution.

Conclusions: The uneven distribution of granitic ejecta cannot be easily explained without further study. Dark impact melt is present only on the SE flank but this is more likely related to the trajectory of the projectile preferential than erosion. Previous field observations of ejecta thickness do not agree with calculated estimates and further work must be done to accurately map ejecta distribution and measure its actual thickness.

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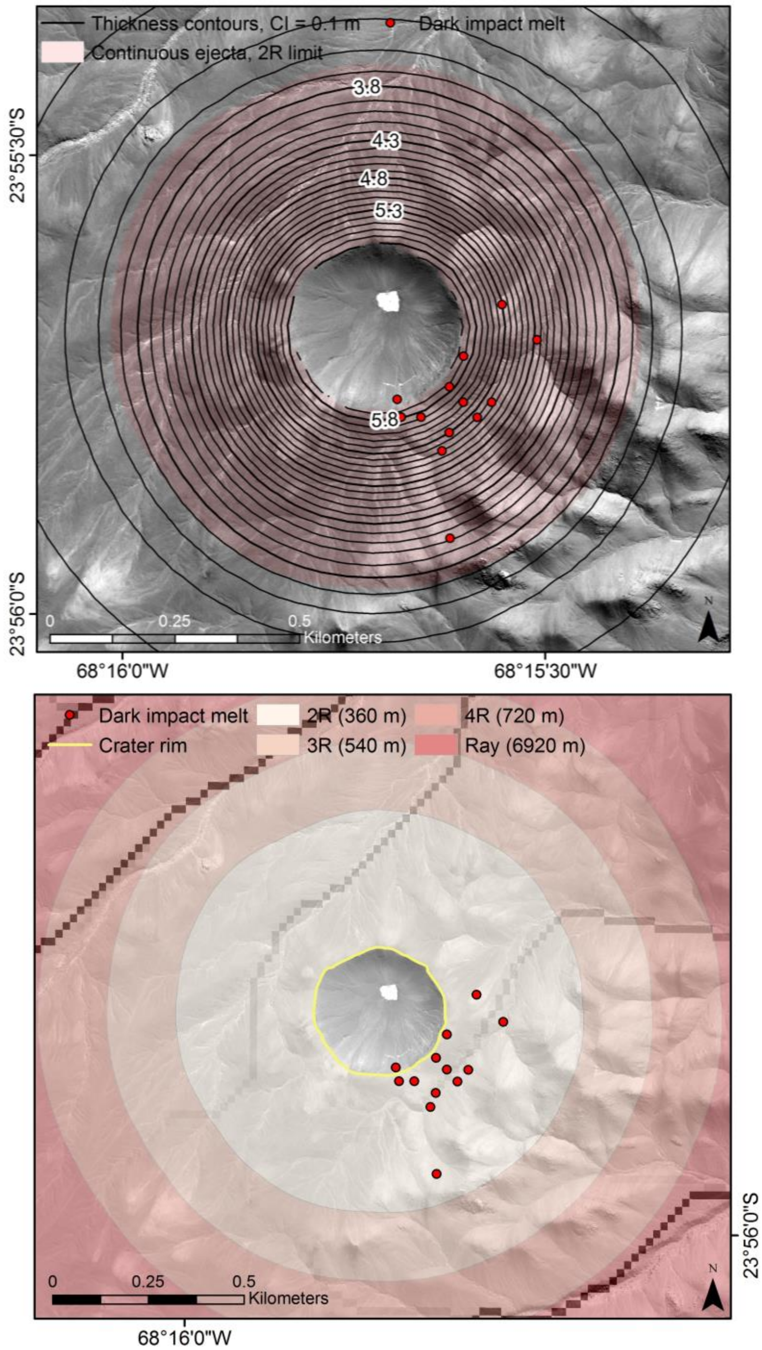

Fig. 2. (top) Ejecta thickness contours calculated after Melosh [6] and modeled in ArcMap. The current model does not account for topography or the lithologic distribution of ejecta. (bottom) A Flow Accumulation model from ArcMap superimposed on calculated ejecta zone limits. Darker lines represent areas of higher probable flow accumulation.