GEOMORPHOLOGICAL MAPPING OF HARGRAVES EJECTA IN THE NILI FOSSAE TROUGH: INSIGHT INTO IMPACT PROCESSES AT POTENTIAL MARS 2020 LANDING SITE

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Background: The Nili Fossae region of Mars consists of a series of concentric graben structures radiating from the northwest of Isidis Basin and located north of Syrtis Major. These grabens are interpreted to have formed due to crustal stresses following the formation and subsequent infilling of Isidis Basin [1]. Nili Fossae Trough (NFT) is the longest of these grabens, approximately 600 km long and averaging 25 km wide.

Approximately 50 km to the east of the eastern wall of NFT is Hargraves Crater, a ~65 km diameter complex crater, which likely formed in the late Noachian or early Hesperian Period [2]. A portion of its distal ejecta blanket was deposited on the floor of the graben, and represents an important source of diverse target materials within the region. The ejecta blanket currently occupies over 50% of the landing ellipse for the proposed Mars 2020 NFT landing site. Other materials within the landing area include an ultramafic assemblage of pyroxene and olivine [3,4] and widespread clay-rich materials [5–7], as indicated by remotely sensed spectral data.

Methods: Using ArcGIS, eight images from the High-Resolution Imaging Science Experiment (HiRISE) aboard the Mars Reconnaissance Orbiter (MRO) [8] were chosen in order to map the study area at the greatest resolution possible. These images provide almost complete coverage of the study area, at ~0.25-0.50 m/px, offering detailed observations of surface morphology (*e.g.*, tonality, texture, structure, etc.). To cover the gaps between HiRISE and additional regional context, CTX images (~5-6 m/px) [9] were layered beneath the HiRISE images within the mapping area. Both image sets were layered over an 18 m/px THEMIS [10] global mosaic tile. All images were projected in the "Equirectangular_MARS" coordinate system in ArcGIS.

Results and Interpretations: We present a detailed morphological map of the landing ellipse and Hargraves ejecta blanket within NFT (Fig. 1). The map is sub-divided into two feature classes: Morphological Units, represented in colour, and Texture Facies, represented in texture overlays. Within the Morphological Units class there are 11 units, defined on the basis of tone, shape, and stratigraphic relationships with other units. All units additionally show some texture, but as texture is not necessarily exclusive to a single unit (such as brecciated materials), we decided to separate the property of "texture" into its own feature class. This allows us to show both continuous texture over discontinuous units, and multiple textures within a single unit or feature.

The Hargraves ejecta unit (shades of green) is subdivided into four sub-units on the basis of shade. This unit dominates the eastern and centre zones of the mapping area and is comprised predominantly of brecciated materials, with a lighter-toned, randomly-oriented, "fibrous" material containing various-sized clasts and blocks of a darker-toned material. This brecciated material is of particular interest in this study. Other notable units include the polygonally-textured material (shades of blue). CRISM analysis [7; 11-13] indicates that this material is likely clay-rich. Polygons in rocks can be formed through many processes [14], however they generally indicate some sort of volume change or dessication event, which is especially common in clays. Proximity to the ejecta blanket suggests that these clays may have formed as the result of some impact-induced alteration mechanism. Such alteration has been widely proven at other impact locations on Earth and Mars [5; 15-16]. Studies of Toro Crater [15] and Auki Crater [17] show a similar distribution of polygonal materials and phyllosilicate-bearing materials associated with ejecta materials and regional fracturing. We therefore hypothesize that the polygonally-textured material seen here may be the result of impact-induced alteration of the country rock.

Discussion and Conclusions: Other craters of similar size on Mars (*e.g.* Mojave) do not show such extensive exposure of breccias within their distal ejecta blankets, suggesting that this location has undergone erosion of its upper portions to expose the interior structure of the ejecta. This interior exposure offers the unique opportunity to study the internal structure of an ejecta blanket, providing insights into the impact process itself and the deposition of ejecta materials. The blanket exposure here also offers diverse material with easy, surface and near-sub-surface access for collection and study during the Mars 2020 mission. Based on our current understanding of the ejecta deposition process [16], it is likely that the ejecta contains materials from the Hargraves target site as well as trough floor material entrained during deposition, much of which was significantly altered. These materials, especially any preserved impact glass

both within the erosion-resistant ridges and hummocks and the breccia itself, have great implications for the study of astrobiology. Notably, impact glasses can offer both preservation of biosignatures in the original material, and habitat and subsequent trace fossilization of biosignatures in the emplaced ejecta [12–15].

In terms of the official goals of the Mars 2020 mission, access to these materials is vitally important for determining if Mars ever supported life through objectives A., "Explore an astrobiologically relevant ancient environment on Mars to decipher its geological processes and history, including the assessment of past habitability."; and B., "Assess the biosignature preservation potential within the selected geological environment and search for potential biosignatures." [22] Therefore, we suggest that NFT is an ideal landing site for the Mars 2020 mission, due to the diversity and accessibility of these materials.

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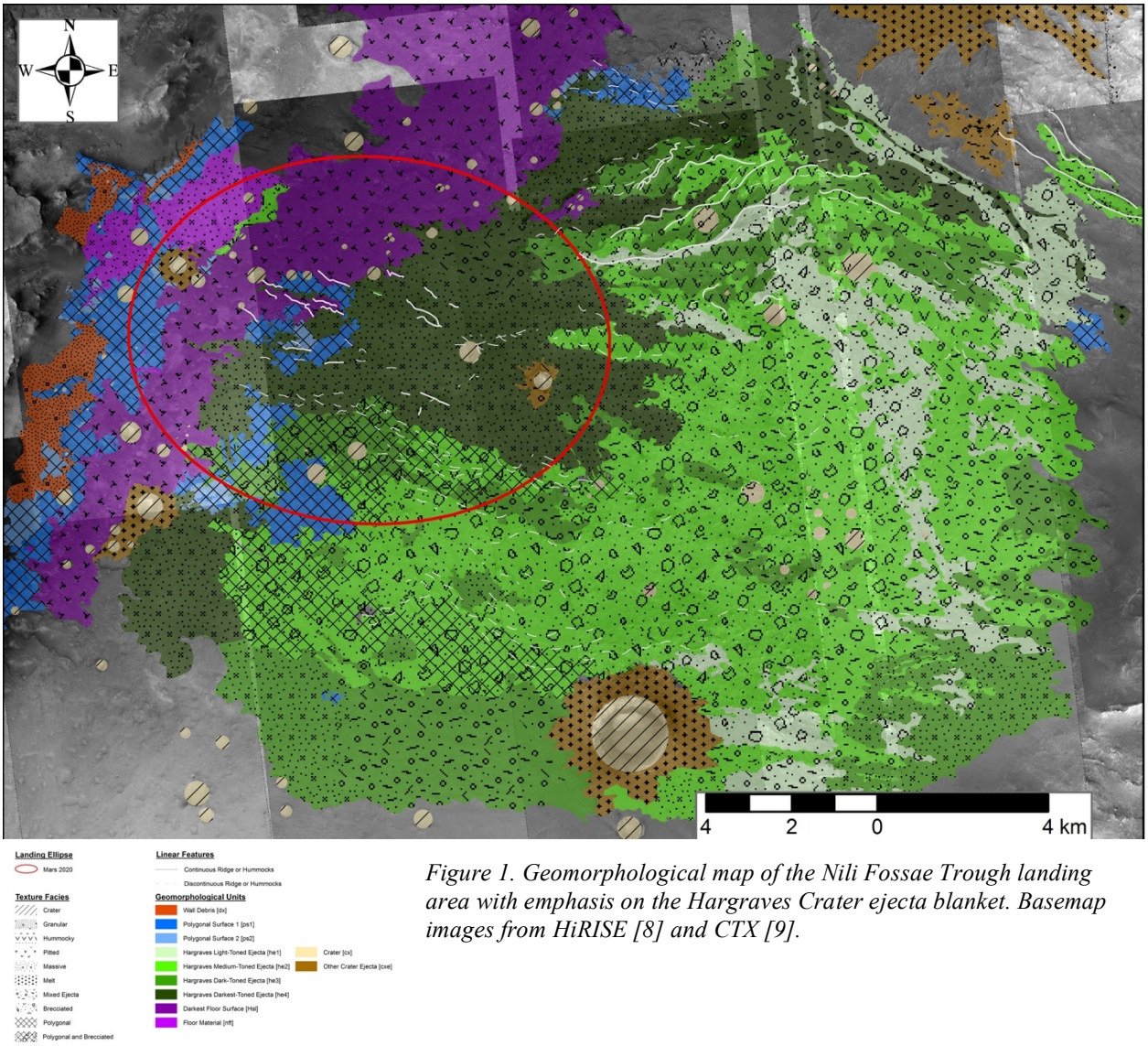

Figure 1. Geomorphological map of the Nili Fossae Trough landing area with emphasis on the Hargraves Crater ejecta blanket. Basemap images from HiRISE [8] and CTX [9].