HARGRAVES-TYPE EJECTA ON MARS: IMPLICATIONS FOR IMPACT EJECTA PROCESSES. L.E. Sacks[1], L.L. Tornabene[1], G.R. Osinski[1], R. Sopoco[1], A.S. McEwen [1] Centre for Planetary Science and Exploration/Department of Earth Science, University of Western Ontario, London, Ontario, Canada (lsacks4@uwo.ca), [2]LPL, Univ. of Arizona, Tucson, AZ.

Introduction: The prevalence of impact craters throughout the solar system correlates with their importance in the study of planetary surface processes, providing insights into the nature of: surface materials, crustal structures, surface age, and stratigraphy. In contrast to the Moon, the presence of an atmosphere and volatile-rich target rocks make Mars a comparable analogue to Earth impact studies. Numerous well-preserved craters and extensive high-resolution image coverage augment the value of studying impacts on Mars. A prominent feature of impact craters through the solar system is the presence of ejecta deposits within and around the host crater (e.g., [1, 2]). High Resolution Imaging Science Experiment (HiRISE) images (25-30 cm/px) of Hargraves Crater on Mars provide detailed meter-scale observations of one of the best-exposed and well-preserved ejecta blankets on Mars (initially noted in [3]). Hargraves ejecta characteristically preserve exposures of materials consistent with melt-bearing and lithic breccia-bearing deposits [4]. Previous studies of impact craters and ejecta emplacement [e.g. [1, 2]] indicate that the preserved and exposed nature of the ejecta seen at Hargraves is indicative of some erosion but minimal post-impact deposition. The exposure of the preserved layers of the Hargraves ejecta blanket, unlike many ejecta blankets on Mars, permits an excellent means to study the deposition and emplacement processes of ejecta.

In this work, we present the results of a detailed analysis of the Hargraves ejecta blanket with the HiRISE [5]. This study starts with the morphologic and general morphometric characterization of the features seen in ejecta to the south of the crater rim, in order to complement and expand on earlier studies of the ejecta deposited within the Nili Fossae “trough” to the west of Hargraves [4].

Hargraves Crater: Hargraves Crater is located in the Nili Fossae region of Mars at 20.76°N 284.36°W. The crater is ~68 km in diameter with a central uplift indicative of a complex morphology. Ejecta are deposited radially from the center of the crater, including into other nearby pre-existing structures where they are

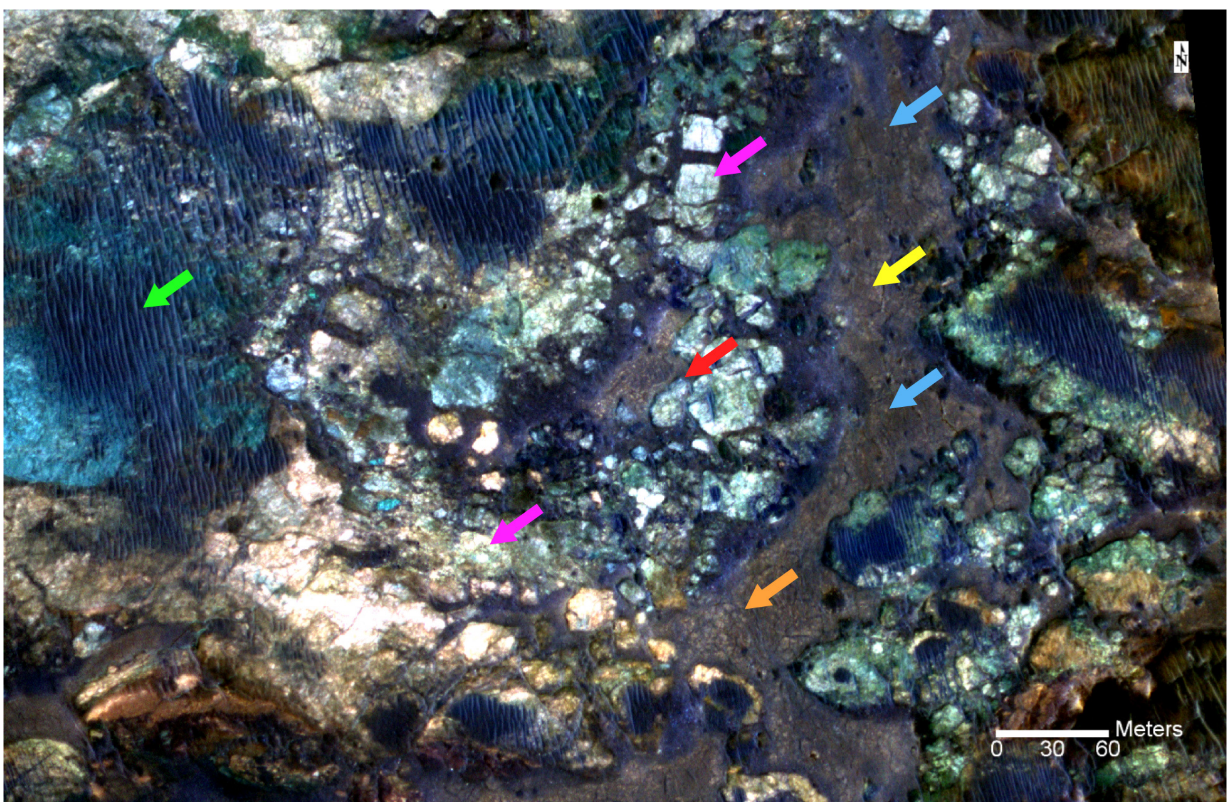

Fig. 1. A portion of HiRISE image ESP_044161_2005 with optimal image stretch. Yellow arrow: smooth unit. Green arrow: blue linear features. Magenta arrows: fragmental unit. Red arrow: smooth unit underlain by fragmental unit. Blue arrows: brighter pixels in smooth unit. Orange arrow: cooling-contracting texture. Courtesy of NASA /JPL/University of Arizona.

observed to be the best exposed in: 1) a segment of the Nili Fossae graben system [see [4]] located to the northwest of Hargraves; and 2) an older ~38 km degraded crater immediately to the south of Hargraves. The southern ejecta outcropping (within ~10 km of the rim) is less distal to Hargraves then the deposits on the floor of the "trough" (within ~30 km of the rim) and shows differences in preservation state and more color and morphologic diversity.

Observations: Our mapping and analysis delineates two main units within the ejecta blanket.

Smooth unit. Smooth and relatively homogenous darker-toned areas shown in Fig. 1 (yellow arrow) are classified as the smooth unit. The edges of the unit are darker and are observed to drape and superpose the underlying fragmental unit. The unit is also characterized by shallow polygonal fractures (orange arrow). A close analysis of the smooth unit also shows brighter pixels that vary in colour in a fashion similar to the colours observed in the fragmental unit (blue arrows).

Fragmental unit. The HiRISE image shown in Fig. 1 shows a morphologically complex portion of the ejecta. The most colour-varied portions (magenta arrows) are classified as the fragmental unit, ranging in size from tens of meters to hundreds of meters. Fragments vary in color, with bright whites, blues, greens, and oranges, but are not homogenous in their colouration. This colouration may be related to either the unit itself or to partial obscuration. The fragmental unit is visible in "windows" where the smooth unit is thin or absent (red arrow). Some areas are highly fractured with similar colored areas proximally located, potentially indicating one large fractured clast. In some areas, the fragmental unit is overlain and partially obscured by the blue linear features, and by the smooth unit.

Blue linear features. Bluish *en echelon* linear features appear to overlay the fragmental units exclusively. This relationship is best observed where these linear features are the least densely concentrated (green arrow). The blue linear features are consistently present in the topographically low areas. The features are oriented NNW-SSE and are most consistent with aeolian bedforms, which are abundant across Mars [6].

Discussion: Within this HiRISE image (Fig. 1) we observe two distinct types of crater ejecta: the fragmental unit and the smooth unit. In the center of Fig. 1, the smooth unit can be seen overlaying the fragmental unit (red arrow). The Ries and other terrestrial structures provide a framework for interpreting our observations at Hargraves. Similar to Hargraves, Ries shows layered ejecta deposits comprising an underlying lithic-breccia unit, the Bunte Breccia, and an overlying impact-melt bearing breccia unit [1, 2]. The lowermost fragmental breccia unit at Hargraves is composed of large lithic blocks such as those seen in the ballistically emplaced Bunte Breccia [1, 2]. We see no evidence for flow or cooling fractures suggestive of impact melt. The overlying smooth unit is smooth and drapes the topography. Together with the polygonal fracturing representing cooling-contraction texture (orange arrow), this is consistent with a melt-rich unit. Similar to Ries melt-bearing breccia [1, 2], it has small bright pixels consistent with the smaller clasts expected in these melt-bearing deposits. Thus, at Hargraves, we generally interpret the fragmental unit as ballistic ejecta and the corresponding smooth unit as the overlying impact melt-bearing deposits, consistent with [1, 2].

Further analysis of the smooth unit indicates evidence of erosion, likely of aeolian origin. The darker toned edges of the smooth unit give way to exposure of the fractured unit below as "windows." This partial enclosure gives the material a false sense of polygonal shape as seen in the bottom right of Fig. 1. Similarly, the smooth unit, or impact melt-bearing unit of Hargraves now stands at a topographically higher level. Assuming correct interpretations, this indicates that the unit originally bordering the smooth unit was less competent and more susceptible to erosion. These units, likely comprised of the fragmental breccia, were eroded away, leaving the more competent and once lower-standing melt-bearing deposits as topographic highs. This is consistent with a melt-bearing body structure on Earth and another crater on Mars [7, 8].

Conclusions: The use of HiRISE images to study ejecta processes is proving to be effective and necessary. The resolution offered by HiRISE and extent of exposure and preservation of ejecta on Mars allows individual blocks of brecciated ejecta and discrete melt-bearing bodies to be resolved at Hargraves. The relationship between the units seen here represent observational evidence of a two-stage emplacement detailed by [1] of ballistic sedimentation of the fragmental breccia unit followed by the emplacement of the smooth unit as melt-rich flows. HiRISE images of a few other craters have since shown similar features thus, we define "Hargraves-type" ejecta as ejecta with excellent exposure and moderately high-preservation, where abundant breccia and some melt-bearing deposits may still be discerned. Morphometric constraints on the clasts resolved in these images will provide detailed insights into ejecta deposition and emplacement processes on solid bodies in the Solar system.

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