SEARCHING FOR IMPACT MELT IN THE EJECTA OF OCCATOR CRATER, CERES. A. J. Blance[1,2], H. M. Meyer[1], J. D. Stopar[1], and P. M. Schenk[1]. [1] Lunar and Planetary Institute, Universities Space Research Association, Houston, TX 77058, USA. [2] School of Earth and Environmental Sciences, University of Manchester, Manchester, M13 9PL, UK.

Introduction: Previous studies of Occator crater, a relatively fresh complex crater on Ceres (92 km diameter, ~1.6 to 63.7 Ma [1]), suggest that morphological features within the crater interior are indicative of impact melt deposits [2,3]. For example, Occator crater contains lobate-textured fill material reminiscent of the impact-melt-rich floor materials found within lunar complex craters [2]. Occator's fill material is abundant within the crater interior, where it exhibits flow margins and embays the crater's rim terraces. The material has a lack of recognizable source vents but has extensive coverage, including perched, isolated units in the crater terraces, supporting an impact melt model of formation over post-impact volcanism [2,3].

Ceres' crustal layers are thought to be primarily composed of phyllosilicates, carbonates, salt, and water ice [4-7]. Thus, Ceres provides a unique opportunity to study how the impact process is affected by target composition, distinct from the Earth's Moon or the icy outer satellites. Impacts on Ceres are on average lower in velocity (~5 km/s) [8] when compared to the inner Solar System, so they generally induce insufficient shock heating to melt silicates [9]. Any melt generated by an impact on Ceres will therefore be liquid water, as water ice is a more volatile melt source than silicate minerals. The melting of water ice at Ceres' surface and shallow subsurface is expected to result in an "impact mud", a mixture of liquid water with dissolved solid particles and suspended debris [2,3,9].

In contrast to Occator crater's interior, there has been limited study of Occator's continuous ejecta for possible melt morphologies, a location where impact melt is frequently found at lunar craters [e.g., 10-14]. Thus, the objective of this study is to investigate whether any morphologies around Occator crater are suggestive of impact melt, and to determine whether impact melt on Ceres can be used to disentangle the effects of target composition in the impact process.

Method: This study utilizes the Dawn mission's high resolution images of Ceres (pixel scales down to ~3 to 15 m [15]). To assess potential impact melt features on Ceres, we compare observed morphologies found within Occator's ejecta to the interior deposits [2] and to lunar impact melt [10]. Observed differences between the morphologies on each body are then used to investigate the role of composition (and other planetary differences) in the production, distribution and preservation of impact melt on Ceres.

The Dawn Low Altitude Mapping Orbit (LAMO) clear filter mosaic (~35 m/pixel) [16] was used as a basemap, in conjunction with a LAMO-derived regional DEM (~32 m/pixel horizontal, 1.5m vertical accuracy) [16]. A slope map was derived from the DEM over a 3-pixel baseline (~96 m). The highest resolution images available for Occator are from XM2 (~3-15 m/pixel) [15] and were used for detailed observations of Occator's continuous ejecta. This data was used in ArcGIS to conduct a detailed assessment of our study area, beginning at the rim of Occator and extending outwards to ~1 crater radii, beyond which image resolution decreases dramatically to ~35 m/pixel to the east and west.

Observations: Using the criteria defined for the Moon [10] as a guide, we identified morphologies reminiscent of lunar melt features within Occator's continuous ejecta, but we find no perfect analogues. The suggestive morphologies include: lobate flows, smooth and flat (2-6°) topographically confined deposits, and a regional relatively smooth surface material draping the region near Occator's rim. The putative impact melt features are located up to ~0.5 crater radii from the rim.

Lobate Flows. In addition to the lobate fill material identified in Occator's floor, we observe lobate features in the ejecta, which appear to flow downslope and exhibit distinct margins (Fig. 1). These features are reminiscent of lunar impact melt flows; however, channel morphologies are not observed, and often the lobes appear to be gradational with ejecta deposits.

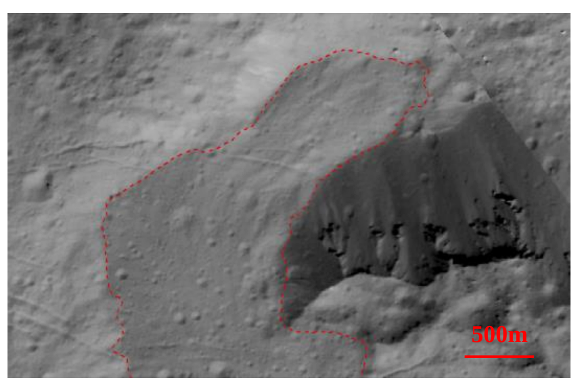

Figure 1 – An example image of a lobate flow in Occator's ejecta. Inferred boundary shown by red dashed line.

Topographically Confined Deposits. The topographically confined deposits around Occator are characterized by smooth, flat surfaces that occur in topographic lows close to the crater rim (Fig. 2). Some examples of these features have distinct margins, but many exhibit gradational boundaries. These features may be analogous to lunar impact melt ponds, which are defined as relatively low-albedo, topographically confined, low-lying features with a flat surface that is smooth at the meter scale. Ponds are thought to form from the settling of melt into topographic lows, where melt can reach an equipotential surface before it solidifies, a process which is feasible for the "impact mud" of Ceres. However, some of the criteria for identifying lunar melt ponds were not identified in the features around Occator, including albedo contrasts, distorted craters, and tension fractures. The surface slopes of the deposits (2-6°) are not as flat as for lunar melt ponds (<1-3°), but are distinctly less rugged than the surrounding ejecta (avg. ~12°). Despite these inconsistencies with lunar melt ponds, for a deposit so compositionally different from silicate melts, their overall appearance is remarkably similar to lunar melt ponds.

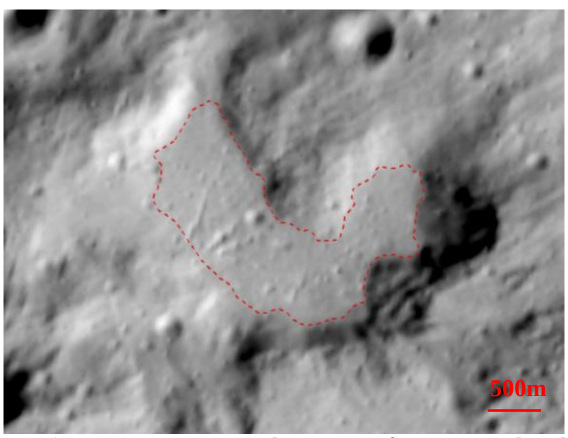

Figure 2 – An example image of a topographically confined deposit in Occator's ejecta. Inferred boundary shown by red dashed line.

Surface Draping. The continuous ejecta of Copernican lunar craters are often draped by veneers of impact melt, which are low-albedo and smooth at the meter scale and mantle the underlying topography. Veneers likely form from thin sheets of melt that solidify to hard rock. Veneers were not conclusively identified around Occator crater; however, areas close to the crater rim display a smooth surface covering, in contrast to rougher distal surfaces, which have more prominent linear features suggestive of ballistic emplacement.

Conclusions: We have identified several morphological features that are highly suggestive of impact melt in Occator's ejecta, but without robust body-specific identification criteria, they cannot be conclusively defined as such. However, when considered in conjunction with observations of Occator's interior, an impact melt origin is favored. The significant differences between the morphologies of crater deposits on the Moon and Ceres likely result from the differences in the target materials. Features on Ceres generally display more gradational or ambiguous boundaries and an overall subdued appearance relative to lunar features. This may be related to Ceres' volatile content, where weaker ice-rich target materials [17,4,6] make features on Ceres more prone to surface degradation. The relationship between impact melt and ejecta may also be less distinct on Ceres, where melt is not clearly separated from the ejecta due to the ability of ice-rich ejecta to flow [18]. This is unlike lunar craters, where melt features are generally clearly distinguishable from ejecta and where morphological evidence suggests flow of melt long after the ejecta was emplaced [12]. More work is needed to define criteria that identifies impact melt on Ceres, specifically which takes into account the significant compositional differences between putative melt on Ceres with silicate melt.

References: [1] Neesemann, A. et al. (2019). *Icarus*, *320*, 60-82. [2] Schenk, P.M. et al. (2019). *Icarus*, *320*, 159-187. [3] Scully, J.E. et al. (2019). *Icarus*, *320*, 7-23. [4] Bland, M.T. et al. (2016). *Nat. Geosci.*, *9*(7), 538. [5] Fu, R. et al. (2017). *Earth Planet Sci. Lett.*, *6*, 153-164. [6] Schmidt, B.E. et al. (2017). *Nat. Geosci.*, *10*(5), 338. [7] Rivkin, A.S. et al. (2006). *Icarus*, *185*(2), 563-567. [8] Farinella, P. and Davis, D.R. (1992). *Icarus*, *97*(1), 111-123. [9] Bowling, T.J. et al. (2019). *Icarus*, *320*, 110-118. [10] Howard, K.A. and Wilshire, H.G. (1975) *J. Res. US Geol. Surv.*, *3*, 237-251. [11] Hawke, B.R. and Head, J.W. (1977) *Impact and explosion cratering*, 815-841. [12] Bray, V.J. et al. (2010). *GRL*, *37*(21). [13] Denevi, B.W. et al. (2012). *Icarus*, *219*(2), 665-675. [14] Stopar, J.D. et al. (2014). *Icarus*, *243*, 337-357. [15] Roatsch, T. et al. (2018) *AGU Fall Meeting Abstracts*, P33D-3869. [16] Roatsch,T. et al. (2016) *NASA PDS*. [17] Schenk, P.M. (2015). *AGU Fall Meeting Abstracts*, P53E-2186. [18] Hughson, K.H. et al. (2019). *JGR: Planets*, 124.