LUNAR REGOLITH SURFACE FEATURES AS INDICATORS OF VOLATILE RELEASE. J. J. Gillis-Davis[1], K. K. Ohtaki[2], R. C. Ogliore[1] H. A. Ishii[2], and J. P. Bradley[2], [1]Washington University in St. Louis, Department of Physics and the McDonnell Center for the Space Sciences, One Brookings Dr., St. Louis, MO, 63130; [2] Hawai'i Institute of Geophysics and Planetology, 1680 East-West Road, University of Hawai'i at Mānoa, Honolulu, HI 96822, USA (j.gillis-davis@wustl.edu).

Introduction: We use micro-analyses of Apollo 11 (10084) regolith grains, <1 mm, in order to understand space weathering at the nm-scale dimensions over which it takes place. We compare and contrast textures and chemical compositions of features at/near the surface of these grains with the aim of linking particular surface features with volatile release processes.

Results & Discussion: The following surface features were observed in SEM backscatter electron (BSE) and secondary electron (SE) images: three types of pits, discoid or circular/ellipsoidal melt deposits (CEMD), two types of splash melt, adhered particles, blistering, iron metal blebs, conchoidal fracturing, abrasion/impression features, and zap pits. Due to length restrictions, only pits and CEMDs are describe in this abstract.

Pits are small holes of non-impact origin and are categorized in three main types. The distinguishing features of *Type I* pits are: found exclusively on agglutinitic glass and splash melt, exhibit no floor, generally have raised and/ thickened rims, and circumferences are circular to elliptical (Fig. 1). The diameter of these pits ranges from 0.1 to 1 µm. Cross sections into surfaces containing these pits reveal vesicular internal texture of the glass. On the basis of these characteristics, we suggest these pits formed as the result of volatile release—with gas escaping from the glass or from the substrate on which the hot melt landed. Where bubbles intersect the melt surface but the melt viscosity was too high for the hole to close. The thickened rim formed when the bubble ruptured and the edges viscoelastically rebounded back onto the surface. These pits are abundant on lunar agglutinitic glass and found in a melt splash on an Itokawa grain by [1,2]. These pits might be mistaken for impact craters in low–magnification SE images because of their raised rims [2,3].

Type II pits are found on impact melt beads that are associated with micro-impact craters [4]. The pits are found approximately antipodal to impact craters and along the portions of the crater rim. These bowl shaped, rimless pits are circular with a uniform diameter that averages ~2 µm. The pits appear generated by shock and heating related to the micrometeorite impact event. This formation mechanism was suggested for pits formed in ion and laser irradiation experiments [5].

Type III pits occur on glassy grain surfaces—both impact melt glass and amorphous rims. These pits are the smallest of all three pit types with average size of ~0.5 µm. Another difference from the previous two pit types is that the rims of these pits are not sharp. We infer that these pits once exhibited a sharp, crisp morphology but their form has degraded with weathering.

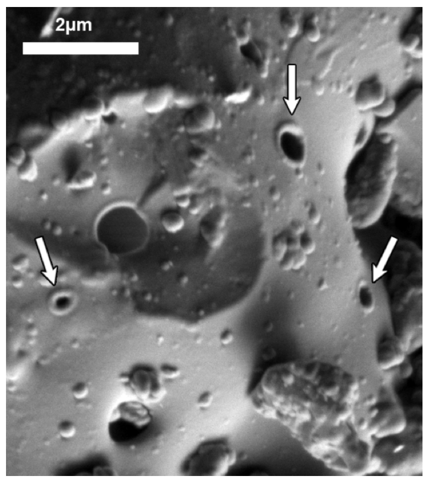

Fig 1. SE image of pits with raised rims, which are formed in agglutinitic glass.

Circular/ellipsoidal melt deposits are raised circular features found on many grain surfaces. They are a common feature on lunar grains [6] but found infrequently on asteroid grains [1]. CEMDs exhibit a pancake-like width-to-height aspect ratio. For lunar grains, this aspect ratio is approximately 30:1, and the ratio still needs to be measured for asteroidal grains. The diameter of these melt deposits on lunar samples ranges from 0.3 µm to 6 µm. On the basis of EDS mapping of one CEMD, we can confirm that these melt deposits are not part of the original grain but splashes of molten material [5,7]. The CEMD contains 33% less Si, double the amount of Ti, and 50% more Ca and Mg relative to the grain that it is superposed on.

Conclusions: All of the pits discussed here (Fig 1) suggest volatile loss from the regolith. Impact heating is the proposed catalyst for volatile release in Type I and II pits. Further study of Type III pits is needed to determine their origin. CEMDs looked analogous to popped vesicle lids reported by [5], however, EDS compositional mapping indicates the discoid features are accretionary objects as suggested by [1,6]. Hence, classifying grain morphologies may serve to untangle mechanisms of volatile release from planetary regoliths.

References: [1] Dobrică, E., Ogliore, R., 2016. *Earth, Planets and Space* **68**, 21; [2] Nakamura, E., et al., 2012. *PNAS* **109**, E624; [3] Schneider, E., et al., 1975. *4th LPSC*, 3277; [4] Gillis-Davis et al., 2019, EPSC Abstracts Vol. 13, EPSC-DPS2019-61-2; [5] Zhu, C., et al., 2019. PNAS, **116**, 23, 11165; [6] Morrison, D. A., et al., 1976. *4th LPSC*, 3235; [7] Matsumoto, T., et al., 2018. *Icarus* **303**, 22-33.