SPECTRAL ANALYSIS OF DISTINCT GEOLOGICAL UNITS ON MERCURY. Rachel W. Gray[1] and Paul K. Byrne[1], [1]Planetary Research Group, Department of Marine, Earth, and Atmospheric Sciences, North Carolina State University, Raleigh, NC 27695, USA (rwgray@ncsu.edu).

Introduction: Our knowledge of Mercury has been transformed over the last decade by NASA's MErcury Surface, Space ENvironment, GEochemistry, and Ranging (MESSGENGER) mission, which returned global image and spectral data for the planet. Even so, the relationship between Mercury's surface geology and its spectral characteristics has yet to be fully understood. Although there are areas that appear spectrally distinct from one another across the planet, the extent to which those differences correspond to variations in geology (e.g., lithology) have yet to be determined. Here, we used MESSENGER data to analyze three different types of surface material—lava, impact melt, and the material that constitutes Mercury's "intercrater plains" (ICP), the oldest and most heavily cratered areas of Mercury—and compared their spectral characteristics.

Methods: We combined the global map of Mercury's smooth plains by Denevi et al. [1], and the global crater degradation database by Kinczyk et al. [2], with a newly created and categorized database of polygons of craters with interior volcanic units ($n = 98$), craters with impact melt (75), and craters within the ICP (98) (**Figure 1**). With these data, we found location, diameter, and assigned degradation state (as a proxy for age for crater-hosted impact melt and ICP materials) of each crater, and then extracted spectral data for the crater infill.

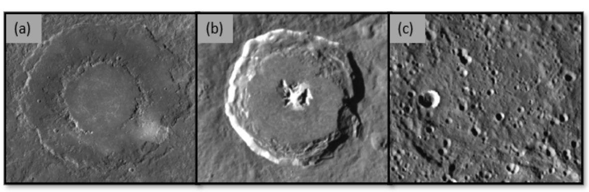

Figure 1. *(a) Rachmaninoff, a basin whose smooth plains infill is presumed to be of volcanic origin (e.g., [1]). (b) Degas, a crater presumed to have impact melt on its floor. (c) An unnamed crater in the ICP. (The original nature of this crater infill is unknown, but is mapped as ICP material.)*

Spectral data were taken from the MESSENGER Mercury Dual Imaging System (MDIS) enhanced color global mosaic, which comprises the 430, 750, and 1000 nm bands and places the second principal component, the first principal component, and the 430/1000 nm ratio in the red, green, and blue bands, respectively.

Pixel intensity values of 0–255 were used as a proxy for reflectance. These data were exported from ArcGIS Desktop and brought into Python for final analysis. A Jupyter notebook with the analysis is available at github.com/spacefalls/spectral_analysis_mercury.

The volcanic and impact melt deposits were manually selected—the volcanic deposits from the global map of Mercury's smooth plains [1], and the impact melt from a combination of the crater degradation database [2] and the newly created database of polygons. The presence of ghost craters and superposition relations were the primary identifiers for volcanic deposits [3]. Impact melt deposits were identified on the basis of interior pond morphology, crater superposition relations, and the presence of exterior deposits [4]. In particular, these melt-hosting craters frequently had smooth floors as well as wall terraces with ponded melt, and linear features within ponds were generally smaller than those seen within volcanic deposits.

ICP craters were selected from six regions of the planet considered to be of that unit type; we used the crater degradation database to randomly choose 100 craters greater than about 20 km in diameter. These craters were then manually reviewed to make sure none were situated within, nor hosted, local smooth plains deposits nor overlapped with either of the other categories.

Results and Discussion: No significant trends were observed between location, spatial extent, or degradation state (and thus emplacement age) and the spectral properties of select volcanic, impact melt, and ICP deposits across the planet (**Figure 2**).

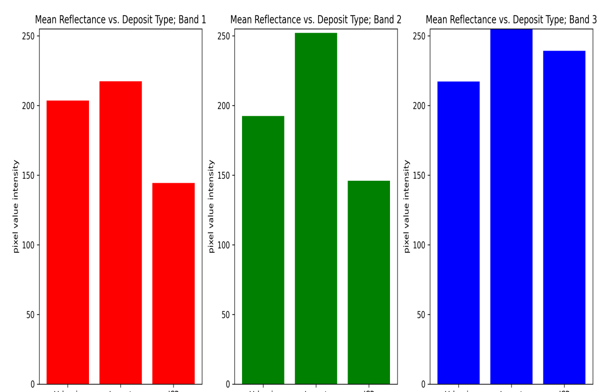

Figure 2. *Mean reflectance (shown here as pixel intensity, from a minimum of 0 to a maximum of 255) versus deposit type (ponded volcanic units, impact melt, and ICP) across the three color bands from which we extracted spectral data.*

The volcanic units' reflectance values are broadly similar across the three PCA bands, with no one band having considerably higher or lower reflectance than the other two.

There is more variation in the spectral values for the impact melt deposits within our study, however. These units appear to be slightly "less red" relative to volcanic deposits and the ICP, with higher pixel value intensities in bands 2 and 3 (the "green" and "blue" bands, respectively). There is a clear difference in degradation state between those craters that host impact melt deposits and those in which the volcanic and ICP units are situated, which is likely a result of impacts needing to be relatively recent for their impact melt units to remain unmodified by subsequent impact gardening (and so be included in this study). These deposits were also found to have greater reflectance overall, which is consistent with their being relatively geologically recent and as such have not been subject to space weathering for as long as other surface units [e.g., 5].

The ICP deposits are "bluer"—that is, they show higher reflectance in band 3 of the color mosaic we employed compared with volcanic and impact melt deposits. Again, this result is not surprising, as older material has been exposed to space weathering, and thus darkened, for longer than geologically younger units. The darker blue of ICP material is also indicative of a greater relative concentration of low-reflectance material (LRM) [6], material suggested to include remnants of Mercury's ancient, graphite-enriched flotation crust that has been exposed by the planet's extended history of impact bombardment [7].

The apparent lack of trend in location, deposit size, or age (where qualitatively assessed in terms of host crater degradation state) suggests that there is no obvious spectral characteristic that distinguishes smooth plains volcanic material from either impact melt or portions of the planet's oldest terrains. A chemically heterogeneous interior for Mercury has been proposed on the basis of geochemical measurements of the planet surface [e.g., 8,9]. It may be that that heterogeneity is reflected in the spectral properties of Mercury's volcanic and impact melt-derived crust, too, both spatially and temporally.

References: [1] Denevi, B. W. et al. (2013) *Journal of Geophysical Research Planets*, *118*, 891–907. [2] Kinczyk, M. J. et. al. (2016) *LPS*, *47*, #1573. [3] Byrne, P. K. et al. (2018) *Mercury: The View After MESSENGER*, pp 287–323. [4] Leight, C. et al. (2018) Lunar and Planetary Science Conference, 47, abstract 2553. [5] Murchie, S. L. et al. (2018) *Mercury: The View After MESSENGER*, pp 191–216. [6] Klima, R. L. et al. (2018) *Geophysical Research Letters*, *45*, 2945–2953. [7] Chapman, C. R. et al. (2018) *Mercury: The View After MESSENGER*, pp 217–248. [8] Weider, S. Z. et al. (2012) *Journal of Geophysical Research, 117*, E00L05. [9] Weider, S. Z. et al. (2015) *Earth and Planetary Science Letters*, *416*, 109–120.