A LACK OF SPIN-ORBIT SIGNAL IN THE MORPHOLOGY OF MERCURY'S LARGE CRATERS. J. W. Conrad[1] and C. I. Fassett[1], [1]NASA Marshall Space Flight Center, Huntsville, AL 35805. (jack.w.conrad@nasa.gov)

Introduction: The spatial structure of Mercury's thermal lithosphere depends on the balance between internal heat and surface temperature as controlled by solar insolation. For bodies not in a spin-orbital resonance, observed spatial temperature variations are due to internal heating variations. However, for Mercury's present 3:2 spin-orbit coupling a notable difference of ~150 K exists for the sub-skin depth temperature of the crust as a function of longitude (Fig 1B.; [1,2]). Mercury's longitudinal "hot poles" and "cold poles", in addition to the standard poles (i.e. North and South), have large temperature contrasts that could lead to systematic differences in crater size, morphology, or morphometry, especially for large impacts. Warmer lithospheric temperatures should produce craters that are wider and shallower [3], due to lower effective shear strengths [4].

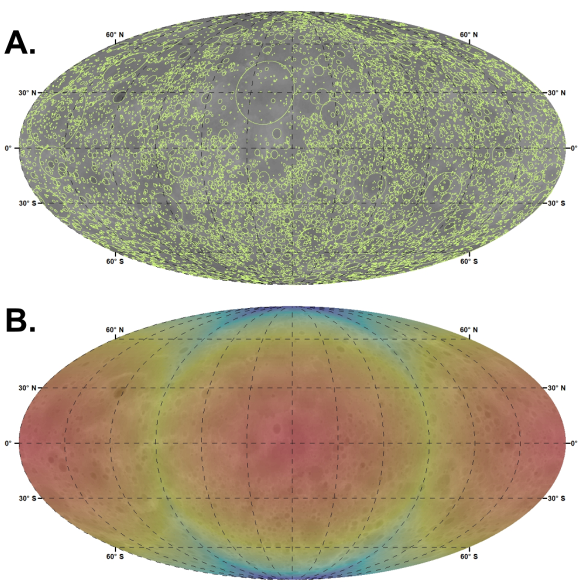

Figure 1: Maps of Mercury to centered on 180 degrees E/W. **A.** (top) Craters larger than 5 km from [5]. Note the Caloris basin (top center). **B.** (bottom) Mean surface temperature [1]. Temperatures range from 150 to 435 K.

Methodology: In order to determine if systematic differences exist in crater metrics exist on Mercury, we use a variety of datasets and check for correlations between them. For craters we use [5]'s cratering database (>20 km) as a starting point, and cross-reference it with [6]'s crater degradation state database. [6] put a lower limit of 40 km on their analysis, which we adopt with our analysis. Larger craters are expected to be more sensitive to the crustal thermal gradient and if there is signal then we should determine at what crater size (in different regions) does the signal dissipate. [6] places craters into 6 discrete degradation categories that we use to code and refine our crater analysis.

Mean surface temperature data come from [1]. This is a globally gridded dataset with 2x2 degree cells (Fig. 1B). We interpolate the temperature for specific craters to the crater center and use that value for our analysis (Fig. 2).

A Lack of Signal: We chose to plot the relationship between surface temperature and crater diameter (Fig. 2). In addition, we checked for correlations within each of [6]'s degradation categories and found no relationship between degradation state and individual temperature poles.

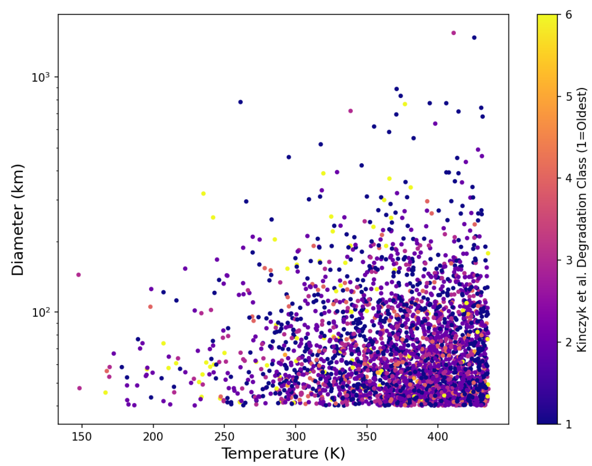

Figure 2: Mercury craters greater than 40 km diameter at the crater's center mean modeled surface temperature. Color is [6]'s degradation category (brighter = younger).

While there is a lack of large craters near the coldest regions (i.e. the North and South pole), this can be explained simply as a function of decreased surface area in the cooler regions as a function of latitude. We can correct for this slightly by applying a latitudinal correction to the mean surface temperature to produce a temperature anomaly (Fig. 3B). The other issue to consider is the sensitivity of impact crater to crustal temperature as a function of their diameter. On the Moon, the nearside-farside dichotomy in crater diameters are only observed in basin-class impacts [3]. To ensure that we are investigating more sensitive craters, we cut off craters smaller than 200 km in diameter (Fig. 3).

After we apply the corrections and limits to the data, we can test the trend in diameter as a function of the surface temperature. The data is set into 6 bins and we calculate two percentiles in each bin (80^{th} and 95^{th}) to see if either of those values increases with increasing temperature. We find, however, that in the standard surface temperature (after we remove craters smaller than 200 km) there is a very minor trend (~2km/K for the 95^{th} percentile). Certainly, there is not a Moon-like dichotomy. When we apply the latitudinal correction and compare craters diameters (>200 km) to the anomalous temperature, the minor trend disappears in exchange for a sharp uptick in the final bin (20-25 K). This sharp uptick is entirely explained by the existence of the Caloris and proposed "b30" [7, 8] impact basins. When these are removed, the signal disappears.

There is precedent to remove these basins, South Pole-Aitken is often ignored in Lunar studies on the basis that it constitutes another class of impact structure or that it is a stochastically large impact event. Two such structures on Mercury still fall within a stochastic regime. As such, there is no global thermal signal in crater diameters.

Future Work: While there is no conclusive signal in [6]'s degradation categories or in the trends of crater diameters, we want to state that our study is not yet exhaustive. We want to investigate if a signal could exist in other morphometric properties (i.e. depth to diameter ratio) and how resurfacing mechanisms could mute a possible signal.

In addition, we need to determine the temperature gradient that would cause an observable difference in crater morphology. This could be achieved with numerical impact and relaxation modeling. If those results show that the modern 3:2 spin-orbit insolation pattern would drive an observable signal, and we do not observe that signal, then the 3:2 spin-orbit configuration of Mercury was not the ancient configuration. This result would have implications for the spin-orbit evolution of Mercury [9].

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References: [1] Vasavada, A. R. et al. (1999) *Icarus, 141,* 179-193. [2] Williams, J. P. et al. (2011) *JGR: Planets, 116.E1* [3] Miljkovic, K. et al. (2013) *Science, 342,* 724-726. [4] Ohnaka, M. (1995) *GRL, 22,* 25-28. [5] Fassett C. I. et al. (2011) *GRL, 38(10).* [6] Kinczyk, M. J. et al. (2020) *Icarus, 341,* 113637. [7] Preusker, F. J. et al. (2011) *Planet. Space Sci., 59,* 1910-1917. [8] Fassett, C. I. (2012) *JGR: Planets, 117,* E12. [9] Knibbe, J. S. and Westrenen W. (2017) *Icarus, 281,* 1-18.

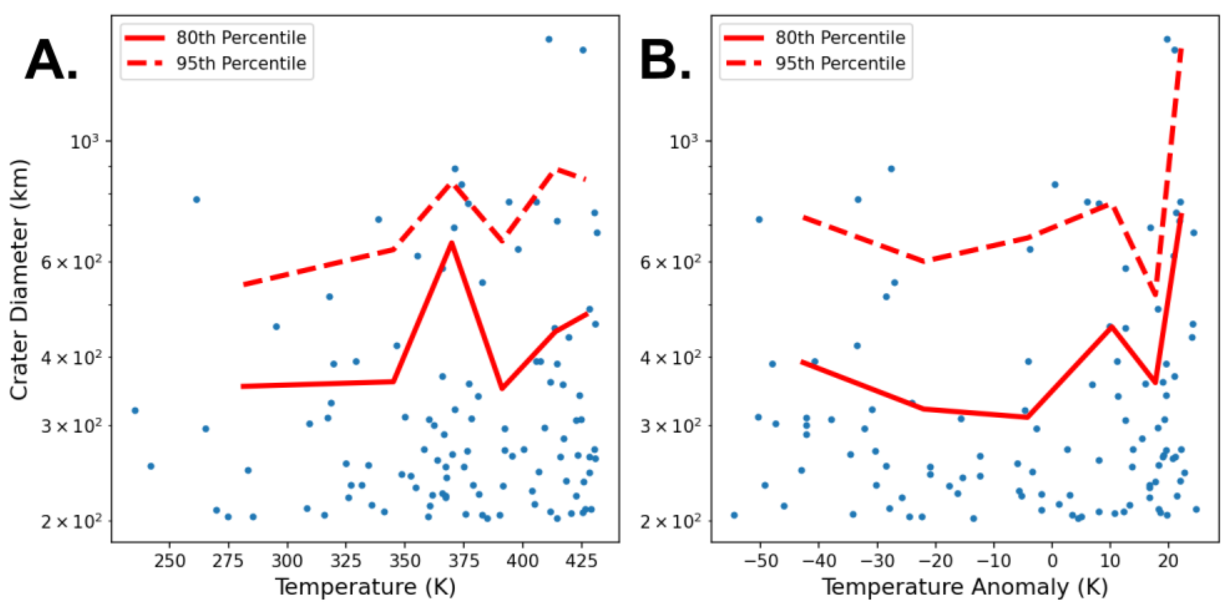

Figure 3: Mercurian craters larger than 200 km in diameter plotted by (**A.**) the mean surface temperature and (**B.**) latitudinally corrected temperature anomaly. 80^{th} and 95^{th} (dashed) percentile are plotted in red. Note, like in Fig. 2, that the crater diameter is plotted with on a $\log_{10}$ scale.