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LATE-STAGE EFFUSIVE VOLCANISM ON MERCURY: EVIDENCE FROM MANSURIAN IMPACT BASINS.

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Introduction: The globally extensive smooth plains of Mercury are believed to be mostly volcanic in origin [1]. Widespread effusive volcanism on Mercury is thought to have ended by ~3.5 Ga due to secular cooling of the planet's interior, and contraction of its lithosphere [2]. As the planet cools and contracts, melt should be produced at a slower rate and in smaller volumes, so it will stall deeper and its escape routes will close. 3.5 Ga corresponds roughly with the end of Mercury's Calorian system. Smooth plains younger than this have been reported, but are restricted to the interiors of impact basins, such as Rachmaninoff [3]. If widespread effusive volcanism on Mercury ceased in response to cooling and contraction during the Calorian, then Mansurian impact basins are good places to search for late-stage effusive volcanism. Effusive volcanism should be favoured in impact basins, because they remove overburden, promote uplift, temporarily reset the preexisting stress regime, propagate fractures and deposit heat [2]. If cooling and contraction were the main factors that controlled the decline of widespread volcanism on Mercury, then post-impact volcanism should similarly become less voluminous throughout the Mansurian. Smaller basins should have less post-impact volcanism because they produce shallower pathways for melt. Post-impact volcanism should also become less common throughout the Mansurian as Mercury continues to cool.

Considering these expectations, we are conducting a global survey of Mansurian impact basins to study how effusive volcanism on Mercury waned as a consequence of global cooling and contraction.

Methods: For our initial study, we include all Mansurian basins >100 km in diameter (n=43) [4]. We are examining the smooth infill of each basin to ascertain if it was emplaced as post-impact volcanism or impact melt. We will also determine the relative ages of these basins if possible to test if post-impact volcanism becomes rarer through the Mansurian.

Some of the smooth infill of Rachmaninoff was determined to be post-impact volcanism on the basis of its resolvably younger crater size-frequency distribution compared to the rest of the basin material. The smooth infill also has a sharp colour boundary with the surrounding basin material, suggesting a volcanic, rather than an impact, provenance [3].

We will not use crater size-frequency statistics to determine relative ages for basin formation and infill emplacement. This is because the crater statistics for Rachmaninoff are probably dominated by secondary impacts [5]. Furthermore, Rachmaninoff is the largest basin in our study. All the other basins will have smaller count areas and fewer superposing craters, making ages derived from crater statistics more uncertain and probably indistinguishable.

Instead, we will search for geological evidence that the smooth basin infill is a result of post-impact volcanism using the following criteria.

Ghost craters. If ghost craters are visible within the basin fill, then it cannot be impact melt (Fig. 1). This is because impact craters must have had sufficient time to form on the basin floor before flooding in order to become expressed as ghost craters.

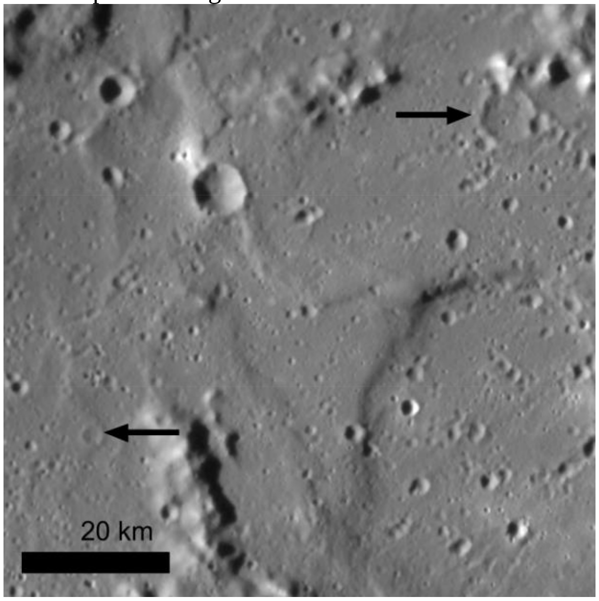

Fig. 1. *The interior of Steichen (~190 km diameter peak-ring basin). The peak-ring is breached by smooth plains material. The smooth plains contain evidence of tectonic deformation in the form of wrinkle ridges. The black arrows indicate probable volcanically buried impact craters ('ghost craters').*

Infill thickness. Many Mansurian basins have such a thickness of infill that their peak elements are partly or entirely obscured. Such deep burial is unlikely to be possible with impact melt alone [6]. Furthermore, characteristic systems of grabens observed in a few Mansurian basins are thought to have formed in response to flooding by thick lava units: models of impact melt fill geometries do not reproduce the observed pattern of grabens [7]. We will quantify the thickness of the infill by measuring depth/diameter (d/D) ratios for each basin. Basins which contain an additional thickness of post-impact volcanism should be anomalously shallow compared to basins containing only impact melt [8]. Ghost craters can also be used to constrain the thickness of the lava unit [9].

Colour boundaries. If the smooth infill of a basin is formed only of impact melt, then it is expected to have an approximately uniform colour. However, colour variation can occur if the impact exhumes materials with different spectral properties or if young, superposing impacts deposit bright crater ejecta. Volcanic flows are another potential source of sharp colour boundaries, since these can have very different compositions from the material exhumed by the impact (Fig. 2).

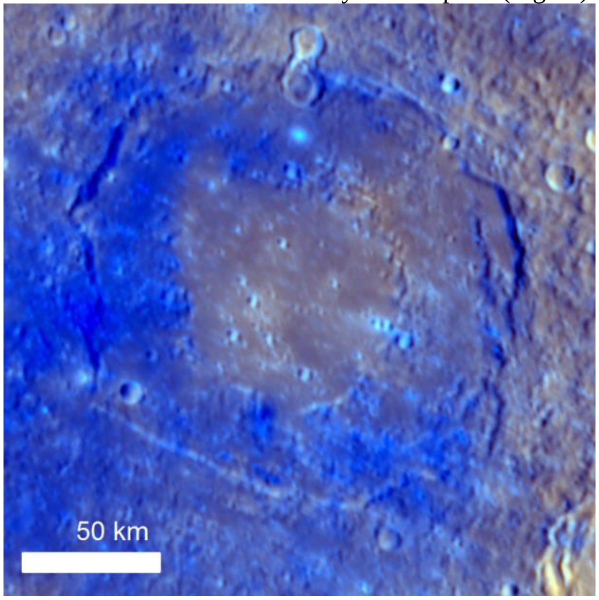

Fig. 2. *An enhanced colour view of Nabokov, a ~170 km diameter basin. Similar to Rachmaninoff [3], the smooth plains within the peak-ring have a higher reflectance and a redder colour than the annulus material, suggesting these result from post-impact volcanism with a different composition. They are restricted to within the peak-ring, except in the east where it appears to have been breached.*

Pyroclastics. Red spots are attributed to putative sites of explosive volcanism on Mercury. Mercury's history of explosive volcanism is believed to have extended into the more recent past due to volatile-rich magmas being more buoyant and therefore more able to overcome Mercury's compressive stress regime [10]. If pyroclastic deposits are found within the smooth infill of Mansurian basins then the same volcanic plumbing system may have supplied an earlier phase of effusive volcanism. We discuss this possibility in [11].

Relative age dating. It is possible to determine the relative order in which Mansurian basins formed by observing superposition relationships of distal ejecta. Secondary crater chains (catenae) are useful for this (Fig. 3) [12]. In the absence of clear superposition relationships, we can compare the degradation states of the basins to group them approximately by age.

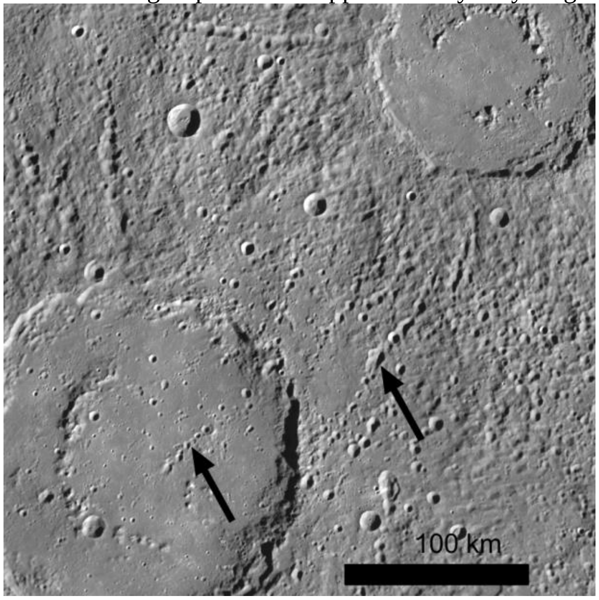

Fig. 3. *Strindberg (SW, ~190 km) and Ahmad Baba (NE, ~126 km). Black arrows indicate Ahmad Baba secondary chains demonstrating this basin is younger than the smooth infill of Strindberg.*

Future Work: We intend to compile each of these lines of evidence for post-impact volcanism in Mansurian basins and assess if there is a relationship to basin size and age. If there is no apparent relationship between the presence of volcanism, basin size and age, then cooling and contraction of Mercury's interior must not be the only control on effusive volcanism. For example, it is possible that post-impact volcanism occurs in regions of thin crust, hence we will plot sites of post-impact volcanism on a map of crustal thickness [13].

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