**Geologic Mapping of Smooth Plains on Dione: Insights into Resurfacing Processes on Icy Bodies.** D. A. Bickham[1,2] and P. M. Schenk[1], [1] Lunar and Planetary Institute/USRA, Houston, TX 77058, [2]Sam Houston State University Department of Environmental and Geosciences, Huntsville, TX 77340.

**Introduction:** While not as well-studied as it's siblings Titan and Enceladus, Saturn's icy moon Dione is a geologically interesting and complex. One of the key features of Dione is its smooth plains, a relatively flat and lightly cratered region centered on its leading hemisphere [1][2][3]. This region is in stark contrast to the heavily cratered and more rugged trailing hemisphere. Among the hypotheses for this resurfacing are water-rich volcanism and pervasive relaxation by high heat flow. These plains thus offer additional opportunity examine resurfacing processes on icy bodies, in comparison to resurfacing on Ariel, Charon, Ganymede, Enceladus.

**Methods:** In order to test possible formation mechanisms, we first map both the potential extent of resurfacing as well as any geologic structures that exist in relation to it. We created new global mapping products for Dione not previously available. These include (Fig. 1) a 3-color global image mosaic at 250m/pixel, stereo-images, and a global DEM at 400m pixel scales that was made from the stereo-images (and tied to the global reference datum), a slope map, and a crater density map, all derived from Cassini data. These mosaics were then uploaded into ArcGIS for analysis.

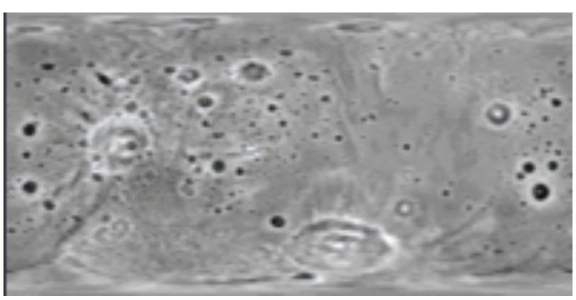
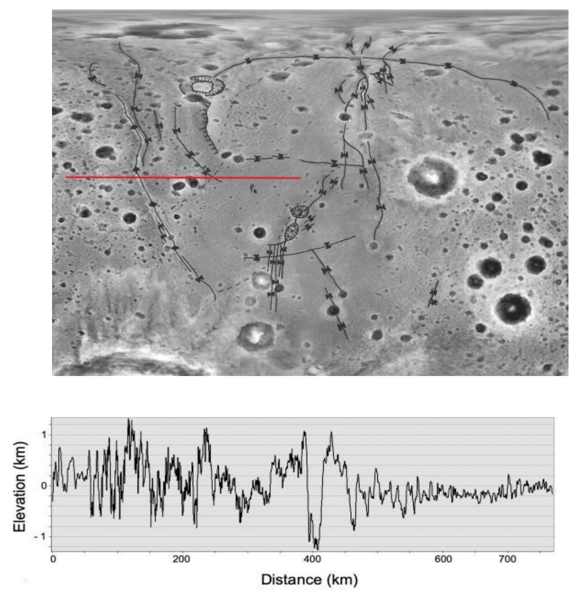


**Figure 1.** Global DEM of Dione at 400 m pixel scales in cylindrical projection.

While geologic maps of Dione exist or are in production, such as that made by Stephan et. al. [4], the mapping products used here were not available. As such, we have created an independent map of resurfacing features based on these new maps, especially our first high-resolution global registered topographic map.

**Results:** Our mapping of the leading hemisphere confirmed that Dione's smooth plains are a geologic complex and varied landscape (Fig. 2). With a few exceptions, the different features will be grouped together based on inferred relationship with each other and then discussed as a whole.

*Central Trough Belt:* One of the dominate features of the leading hemisphere plains is a series of roughly north-south aligned troughs that run from the north pole across the center of the hemisphere that ends in a horsetail-like trough network. This trough belt consists primarily of two parallel troughs with several secondary troughs either branching off or in close proximity to the primary troughs. The troughs in the belt range from ~300m to greater than 1500m deep, with the deepest lying in the north and the shallowest lying in the horsetail network.




(a)

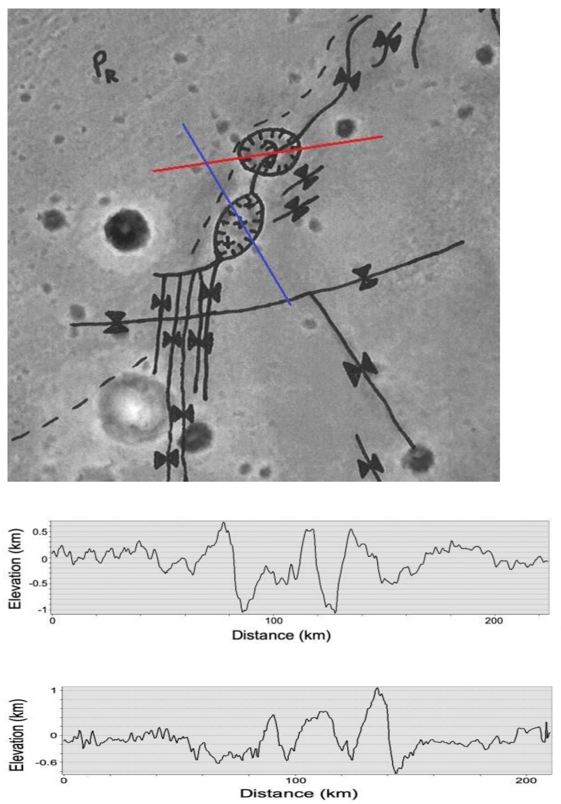
(b)

**Figure 2.** Geologic map of Dione showing major features (a) and topographic profile showing change in ruggedness from cratered plains to smooth plains from left to right (red line, b). Geologic map is on the global DEM of Dione. North is top. Largest Crater is ~175 km across.

The central trough belt shows an en echelon in the network just north of the equator. This pattern suggests that these troughs are most likely a part of one system that formed at the same time.

*Central Patera:* The central trough belt also intersects two distinct paterae in the southern section, Metiscus and Murranus Patera (Fig. 3). These paterae are situated in the center of the plains and are the dominate feature of this area. The paterae are characterized by raised rims, shallow floors, and non-circular shapes. Although the raised rims and shallow floors could indicate relaxed craters, the odd shapes of the two paterae, as well as their spatial association with the central trough belt suggests an endogenic origin.

The northern patera is the more circular of the two but has a nested smaller patera within it offset to the southwest. The southern patera has an oval shape with three mounds ~1000m high, aligned through its long axis. Both paterae also sit within a localized shallow depression ~500m deep. Although not conclusive, the shapes and morphologies of the paterae and their association with the troughs suggests a volcanic origin.




(a)

(b)

(c)

**Figure 3.** Close up view from Fig. 2 of central paterae and troughs on Dione's smooth plains (a) with topographic profile of northern patera (red line, b) and southern patera (blue line, c). Map is on global DEM of Dione.

*Northwestern Ridge and Trough Belt:* To the northwest of the central trough is a zone that consists of a singular ridge and several troughs, all north-south trending. The ridge is the only one found on Dione [5], is ~750km long and ~1500m tall. The ridge is also flanked on either side by several troughs.

*Ridged Plains:* Between the northwestern ridge and trough belt and the central trough belt, the low relief resurfaced plains are characterized by a series of parallel, close-spaced ridges. These ridges are only a few hundred meters high. Elsewhere, the smooth plains lack a ridged morphology. While the cratered plains are on the order of ≥~4 Ga old, the ridged and smooth plains may be as young as ~1.5 Ga [6].

**C*omparisons:*** We compared resurfacing on Dione wither other ice bodies, namely Ganymede, Charon and Triton. Although Dione's resurfaced plains share some common features (patera, plains, troughs), these bodies are distinctly different in their patters, morphologies and sequences of features. For example, no paterae have been recognized on Charon, but the trough system on Dione appears more "organized" into two north-south trending systems than those on Charon [7]. Paterae on Dione are closed and not associated with bands of bright terrain as on Ganymede.

*Mechanism:* The two possible hypotheses to explain the formation of the smooth/ridged plains on Dione are: burial by water lava or a vast series of such flows, or a hemispherical "hotspot" that either fully softened melted the region. While both hypotheses can explain the resurfaced plains, neither do so in a fully satisfactory way.

The lava flow hypothesis is based around the existence of the paterae and associated troughs in the center of the plains. Whether in numerous smaller bursts or as a few large ones, the lava would extend over the entirety of the plains, filling in the preexisting craters. However, in this case, one would expect relic crater rims from craters that were not fully filled in, especially towards the outer edge of the plains where resurfacing was less. Not only is this gradient of fully filled craters, relic crater rims and partially filled craters absent, no partially filled relict craters are observed at all.

Alternatively, there could have been a regionalized increase in thermal energy that would have heated the surface. This heating would have to have relaxed the craters to the point of disappearing completely. In the context of crater relaxation, there will be a decreasing heat flow from the center and a gradual increase in the number of relaxed craters and decrease in the magnitude of crater relaxation. There are relaxed craters that form in a globally nonuniform pattern [8], but their distribution does not match the outlines of the smooth terrains. Since neither hypothesis fully survive their tests, a hybrid model featuring both hemispherical "hotspot" hypothesis and resurfacing by lavas, or a third mechanism, may be required.

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**References:** [1] Moore J. M. (1984) *Icarus, 59,* 205-220. [2] Plecia J. B. (1983) *Icarus, 56,* 255-277. [3] Schenk P. M. et. al. (2018) *Enceladus and the Icy Moons of Saturn,* 237-265. [4] Stephan K. et. al. (2009) *Icarus, 206,* 631-652. [5] Hammond N. P. et. al. (2013) *Icarus, 223,* 418-422. [6] Kirchoff M. R. and Schenk P. M. (2015) *Icarus, 256,* 78-89. [7] Beyer, R., 2017, Icarus, 287, 161-174. [8] White et. al. (2017) *Icarus, 288,* 37-52.