ERUPTIVE VOLCANISM ON SATURN'S ICY MOON DIONE. P. M. Schenk[1] and J. M. Moore[2], [1]Lunar and Planetary Institute, Houston TX 77586 (schenk@lpi.usra.edu), [2]NASA Ames Research Center, Moffett Field CA 94035 (jeff.moore@nasa.gov).

Introduction: Although Enceladus has garnered the greatest attention, Saturn's other icy moons also betray a diverse range of phenomenon (e.g., Rhea's ring, Iapetus' ridge, Tethys' fracture). Even in Voyager's limited global mapping, some cryptic evidence of resurfacing was evident [e.g., 1, 2]. Global mapping by Cassini reveals that a large resurfaced terrain covers much of the leading hemisphere of Dione. In addition, Cassini magnetic field observations [3] indicate that Dione is losing mass to space at a rate greater than can be explained by sputtering, although only a fraction of the rate observed at Enceladus' plumes. It is not clear whether Dione's excess plasma material emanates from a discrete internal source or from the global surface via sputtering or bombardment. We focus our attention here on Dione's geologic history in an effort to determine the degree and style of resurfacing.

Methods: In addition to global mapping at 1 km resolution and regional mapping at 400 m and better (Fig. 1), near global topographic mapping using stereo techniques, supplemented with photoclinometric modeling of large areas, has been completed (Fig. 2). Crater counts have been done for parts of Dione and are in progress for other areas [4].

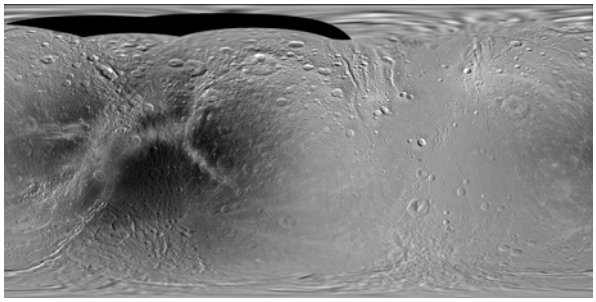

Figure 1*: Global image mosaic of Dione from Cassini imaging data. Base resolution is 400 m/pixel.*

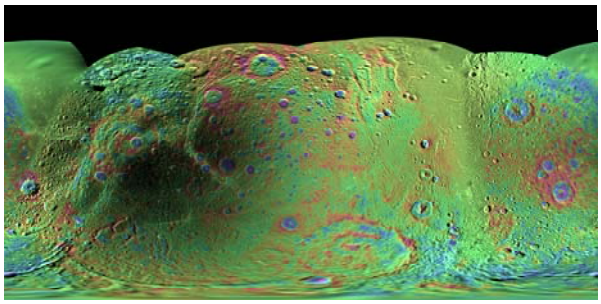

Figure 2*: Global topographic map of Dione. Color-coded topographic map has been merged with global mosaic. Red is high and blue is low. Total dynamic range of topography is 5 km.*

Results: Dione's smooth plains have low crater densities [4], indicating possible relative age of 2 to 4.5 Gyr, and were initially interpreted to be related to endogenic resurfacing [1, 2], then proposed to be volcanic (the lava being water or ammonia-water on this low density ice-rich moon). Our data confirm that high, steep volcanic edifices are absent, indicating that volcanism, if present, was dominated by low-viscosity lava emplacement. Numerous enigmatic arcuate to sinuous rilles or chasmata are apparent, including a set of ridges along the northwestern margin of the terrain.

A prominent set of relaxed impact craters, featuring prominent uplifted center peaks [5], is associated with the resurfaced plains of Dione. Roughly half of all craters are relaxed, consistent with prolonged persistent elevated heat flows across this terrain after formation. Modeling in progress suggests that high heat flow in these terrains, while necessary, may not be sufficient to account for relaxation. Residual impact heat may also be necessary [e.g., 5].

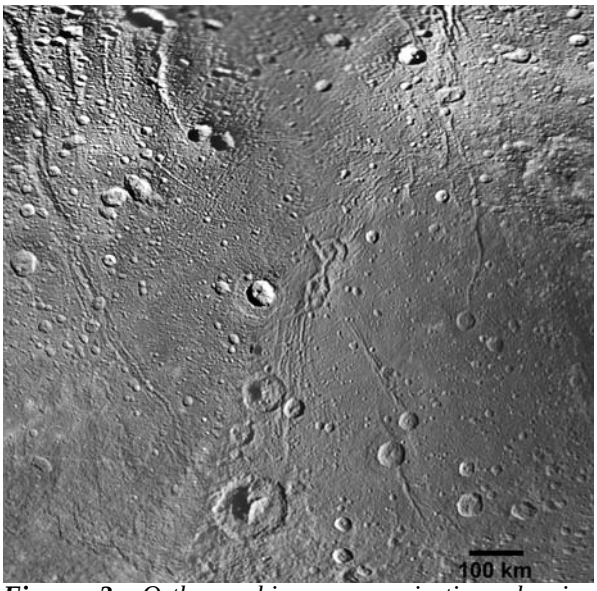

Figure 3*: Orthographic map projection showing smooth plains on leading hemisphere of Dione. A pair of adjacent oblong craters lies at the center of these plains and at the center of a radiating network of fissures and chasmata.*

We have also identified two unusual scarp-bounded depression complexes, one near the equator, one near the north pole, that may have been centers of

volcanism of Dione. The equatorial feature consists of two adjacent depressions (Fig. 3). The northern depression is in fact a pair of offset nested depressions 53 by 48 km and 31 km across each, the smaller of which features a 1 km high central dome. The second (oblong) depression is 69 by 42 km across, also featuring a 1 km high offset central dome. A distinguishing feature of these "craters" is that their floors are at the level of and have no depth with respect to the regional ground plain (Fig. 4).

A second radial complex lies to the north at ~ 73°N, 64°W (Fig. 5), where at least two major linear trough systems radiate from a central complex. Here, the central complex was observed only obliquely at low resolution, making comparison with the equatorial complex difficult. Nonetheless, this extensive pattern, including one braided/anastomosing fracture network ~600 km long, appears to have formed a second similar independent feature on Dione.

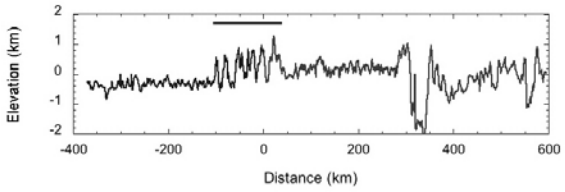

Figure 4*: North-south topographic profile of anomalous craters near Dione's equator (see Figure 3). Horizontal bar marks location of the two adjacent craters, noteworthy for their prominent raised rim and lack of deep floors. Note large crater in southern (right-hand) portion of profile.*

The morphology of these depression complexes is highly unusual for icy satellites. The similarity and proximity of the two depressions indicates they formed simultaneously or by the same processes. Two impact related interpretations are first considered. The odd morphology may reflect the impact of an odd or highly oblique pair of impactors. The distorted shape of the depressions is not unlike oblique crater pairs on the Moon but radiating fractures are not. Alternatively, the impactors may have been unique. The most likely impactor would be sufficiently loose or unconsolidated to interfere with impact excavation. Unconsolidated disrupted comets have impacted on Ganymede and Callisto [6] but these craters have normal impact morphologies, including well-formed central peaks. Hence, a very unusual impactor would be required to explain the morphologies observed on Dione.

Discussion: The Dione equatorial depressions are associated with troughs radiating from the northern and southern ends of the two craters. The southern troughs splay out from the crater rim. A set of troughs also extends radially to the southeast for at least 400 km. Also unusual is the linear trough connecting both craters. Impact craters of this size do not form extended fracture networks elsewhere on other icy satellites.

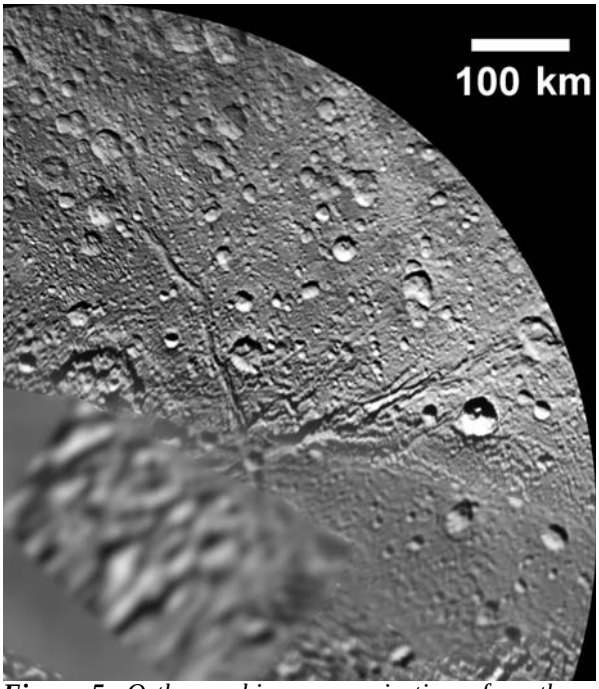

Figure 5*: Orthographic map projection of northern regions of Dione. Radial network of chasmata indicates possible location of source vents within poorly imaged north polar region.*

These troughs also breach the crater rims without crossing the crater floors and appear have formed simultaneously with the crater. This is consistent with a volcano-tectonic origin, perhaps involving energetic (possibly pyroclastic) volcanic crater formation and regional fracturing of the icy outer shell due to upwarping or localized intrusive penetration. The nested double depression, and the oblong central mounds would be interpreted as resurgent volcanic eruption or collapse, followed by viscous extrusion up the central vent. Regardless of the mechanism, smooth plains volcanism, possibly centered on several large volcanic craters, and associated with chasmata formation and viscous relaxation, appears to be an integral part of Dione's evolution. These features, including completion of north polar mapping, should be a priority target during future close encounters with Dione.

References: [1] Plescia, J., Icarus, 56, 255, 1983. [2] Moore, J., Icarus, 59, 205, 1984. [3] Leisner, J et al., Lunar Planet. Sci. Conf. 38, abstr. 1425, 2007. [4] Kirchoff, M. and Schenk. P., Lunar Planet Sci. Conf. 40, submitted, 2009. [5] Schenk, P. and Moore, J., Lunar Planet Sci. Conf. 38, abstr. 2305, 2007. [6] Schenk, P. et al., Icarus, 121, 249, 1996.