THE FIRST HIGH-RESOLUTION SAR OBSERVATION OF ENCELADUS BY CASSINI RADAR.

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Introduction: On November 6th, 2011, Cassini RADAR had its first and probably only opportunity to image a non-Titan icy world at close-range, ~500 km. The results include a high-resolution, ~24 km wide Synthetic Aperture RADAR (SAR) swath of southern latitudes down to ~66° S (Fig. 1a). Azimuth (along-track) resolution is ~200 m, and range (across-track) resolution is ~50 m. The unusual aspect ratio is due to the high speed (~7.4 km/s) fly-by, at ~500 km altitude. Further details on the technical aspects of this fly-by are provided by R. West et al. (this meeting). We present the data and some initial interpretations, demonstrating the utility of Cassini RADAR in studying the surface of non-Titan icy satellites, yielding image resolution comparable to optical images but with a sensitivity to different surface properties.

Observations: As previously revealed by optical images, the south polar region of Enceladus appears to RADAR to be dominated by a complex tectonic network. RADAR reveals the grooves in fine detail, especially in the range (across-track) direction. The side-looking nature of the instrument means that parallax can be used to measure their local depths and slopes with greater precision than single optical images, assuming a symmetric cross-section; Those measured to date indicate a typical groove slope of ~30º.

Different backscatter domains exist in this scene, typically associated with changes in tectonic regime (distribution and orientation of grooves), and are tectonically bounded. Resolved faults rarely cross between these backscatter domains, and those that do are fine-scale features.

The darkest domains (annotated R1 and T3 in Fig. 1b, with characteristic backscatters of ~1-2 dB), which occur towards the ends of the swaths, are more rectilinear. Here, ~2-km-scale grooves dominate, although the lack of fine-scale grooves may be at least partly due to poorer resolution and steeper incidence angles.

The brightest domains (prefixed B and T) are dominated by narrower grooves, and tend to be slightly more arcuate and jagged. They correlate with areas shown to be spectrally similar to other areas interpreted as covered with proximal plume ejecta. The westernmost edge of the first of these (B1, with characteristic brightness of ~6 dB) is bounded on one side by Mosul Sulci, part of a tectonic complex than runs roughly perpendicular to the active "tiger stripe" structures nearer the pole, and on the other side by an unusually smooth block of terrain of unknown origin (T1a). A similar but less well defined block (T2b) is observed on the eastern edge, along with a fault. A second bright area (B2, and associated T2) is similarly bright (~5 dB) and tectonically bounded.

Tiger-stripes: Several of the observed grooves appear to be bear a relationship with the active "tiger stripe" structures observed by optical instruments closer to the south pole. Alexandria, Cairo, Baghdad and Damascus Sulci have all been shown to contain active eruptive vents, and their similar orientations and spacing suggest a causative relationship. This RADAR swath shows portions of two adjacent structures with similar morphologies and orientations to the tiger stripes, neither of which have exhibited signs of ongoing eruptive activity, but it is plausible that they might have in the past. However, no backscatter anomalies indicative of proximal deposits are observed. The wide, bright (~6 dB) groove (T2) at the edge of the easternmost bright region (B2) is the eastern part of the trough adjascnet to Dasmascus Sulcus. A groove near the center of the swath (marked as "unnamed sulcus") is the next in the spatial sequence. In addition, Mosul Sulci may well also be related.

Bright units: The high RADAR brightnesses in all areas, T and B units in particular, are likely due to structure at scales comparable with RADAR's wavelength of 2.17 cm, although high dielectric constant materials may also provide a partial explanation. They are so extremely bright (*cf.* sea-ice at typically <4 dB) that they are comparable to reflective paint used on roads, or to cat's eyes. At present, we model such bright surfaces, on the basis of radiometry and scatterometry elsewhere, as low-loss inhomogeneneous media that lead to multiple scattering and depolarization of incident radar signals. What this means in terms of actual surface structures is difficult to know. 1-10 cm spheroids would produce a similar reflectivity, but are hard to account for; Organised corner-reflectors may be more reasonable. On the pixel scale (~100 m), the RADAR-bright units appear to be rougher than RADAR-dark surfaces, implying that the surface is roughly fragmented across a wide range of scales.

The different backscatter properties of mapped units might be due to different degrees of plume depositional resurfacing (hence age), modification by space weather, different chemistry, or a local process (such as heating) that caused modification of the physical structure and hence backscatter properties. We favor hypotheses in which RADAR brightness is a function of surface maturity; Specifically, we find plume depositional resurfacing over different age units most compelling. This hypothesis is consistent with the relative lack of larger-scale tectonics in the RADAR-bright areas, which presumably are smoothed and brightened by plume material over time, with the smaller-scale tectonic feautures being only preferentially preserved.

The fault-bounded nature of the mapped units strongly supports a tectonic resurfacing origin. Cryovolcanic resurfacing would result in diffuse or lobate margins, which are not observed. The lack of contiguous tectonic structures between the broader units suggests a highly destructive resurfacing process; however, and we see no evidence for the kind of jigsaw-puzzle-like surfaces observed on Europa where complete lateral displacement and spreading have occurred.

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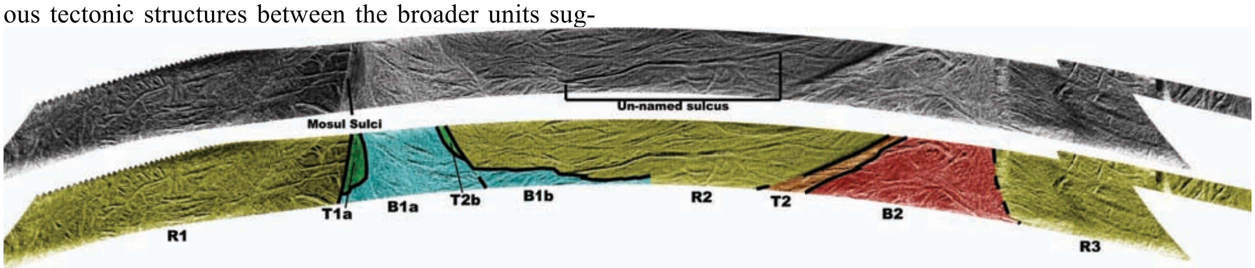

Figure 1: (top) Cassini RADAR E16 SAR swath. Azimuthal (along-track) resolution is ~200 m, and range (across-track) resolution is ~50 m. The unusual aspect ratio is due to the high speed (~7.4 km/s) fly-by at ~500 km closest approach. As a result, features aligned along the direction of motion are better resolved than those across. Image swath width at center is ~24 km. (bottom) Geological map of the observed area, with regions defined by differences in RADAR backscatter and tectonic domain. Dashed lines represent greater uncertainty in the unit contact. Difficulty in distinguishing among B1a, B1b, R2 and T2 along the southern edge may be due to problems with the predicted ephemerides, so those contacts should not be considered final.

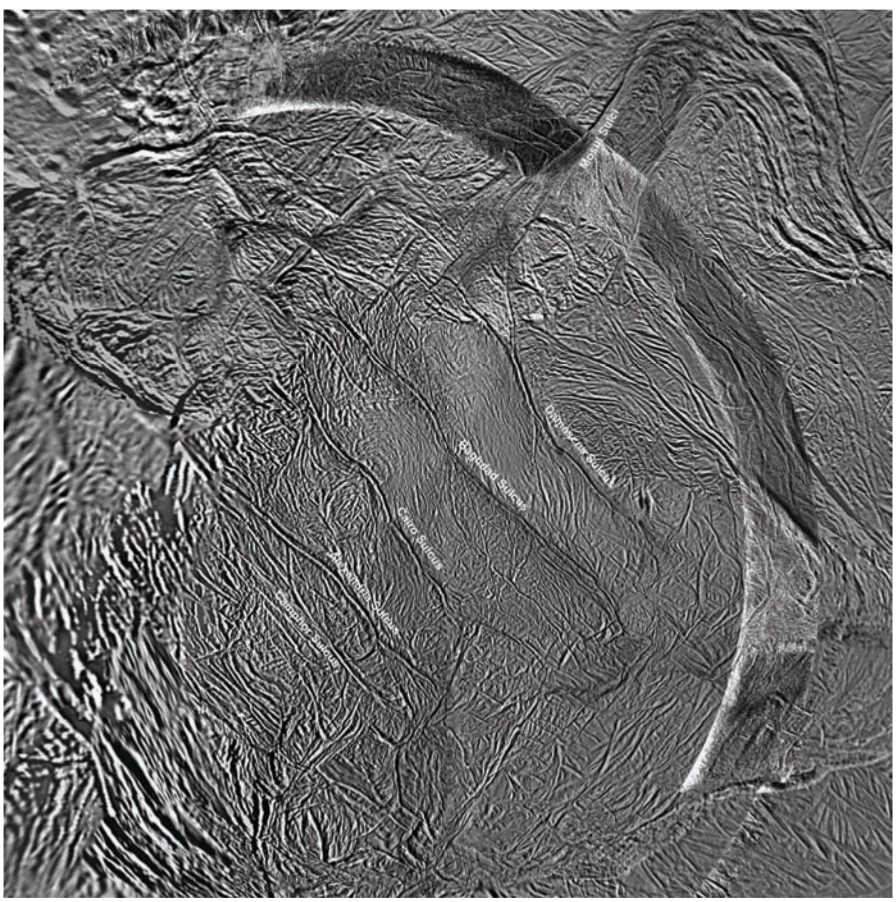

Figure 2: Polar stereographic projection of an ISS image mosaic (NASA/JPL/SSI), out to ~50º N (at center of each side), with the Cassini RADAR E16 SAR swath superimposed. Swath width at its center is ~24 km. Formally named sulci are annotated.