Cassini's Coolest Results for Icy Moons during the Past Year

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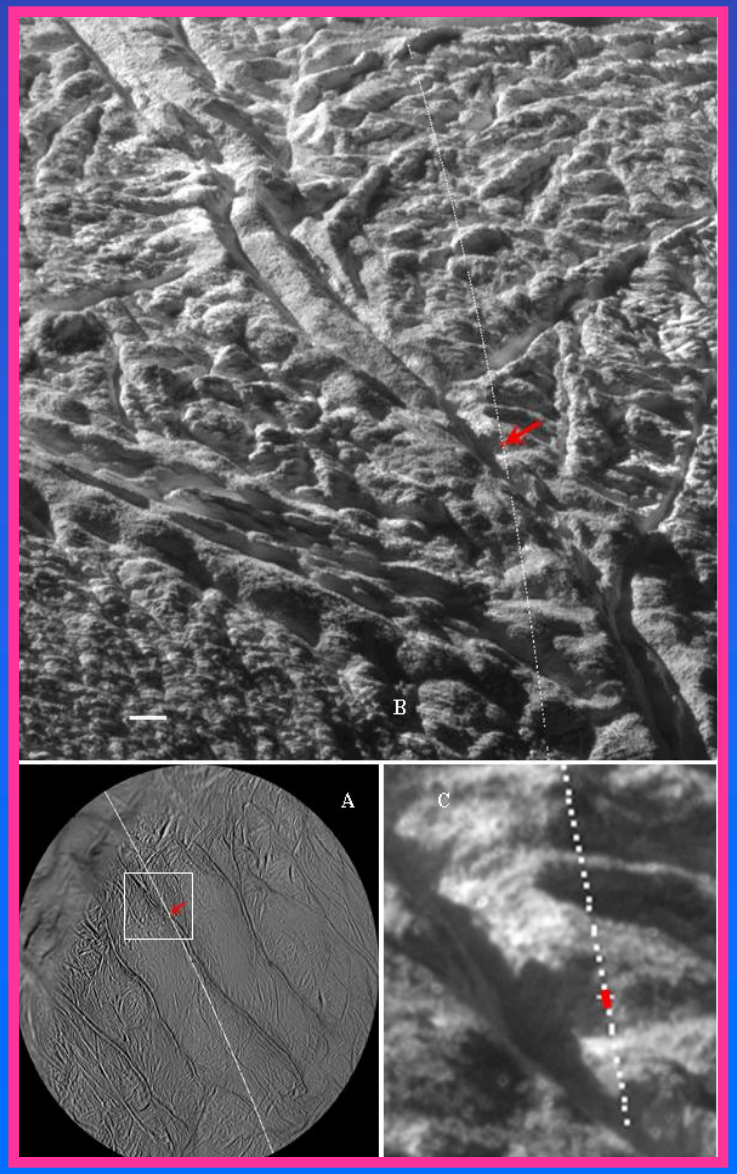
Overview of New Results

Published peer-reviewed papers
New observations

1. Plumes are emitted from small, hot regions in S. Pole of Enceladus
2. There is evidence for previous activity on Enceladus
3. Plumes of Enceladus are much brighter when it is farthest from Saturn
4. Hundreds of new plume observations were obtained
5. There is evidence for past – and perhaps even present – activity on Dione
6. New observations from the fourth targeted Rhea flyby show an unusual fault
7. The main moons of Saturn have roughly the same amount of ice, just varying amounts of contaminants.

Small, hot spots on Enceladus form plumes



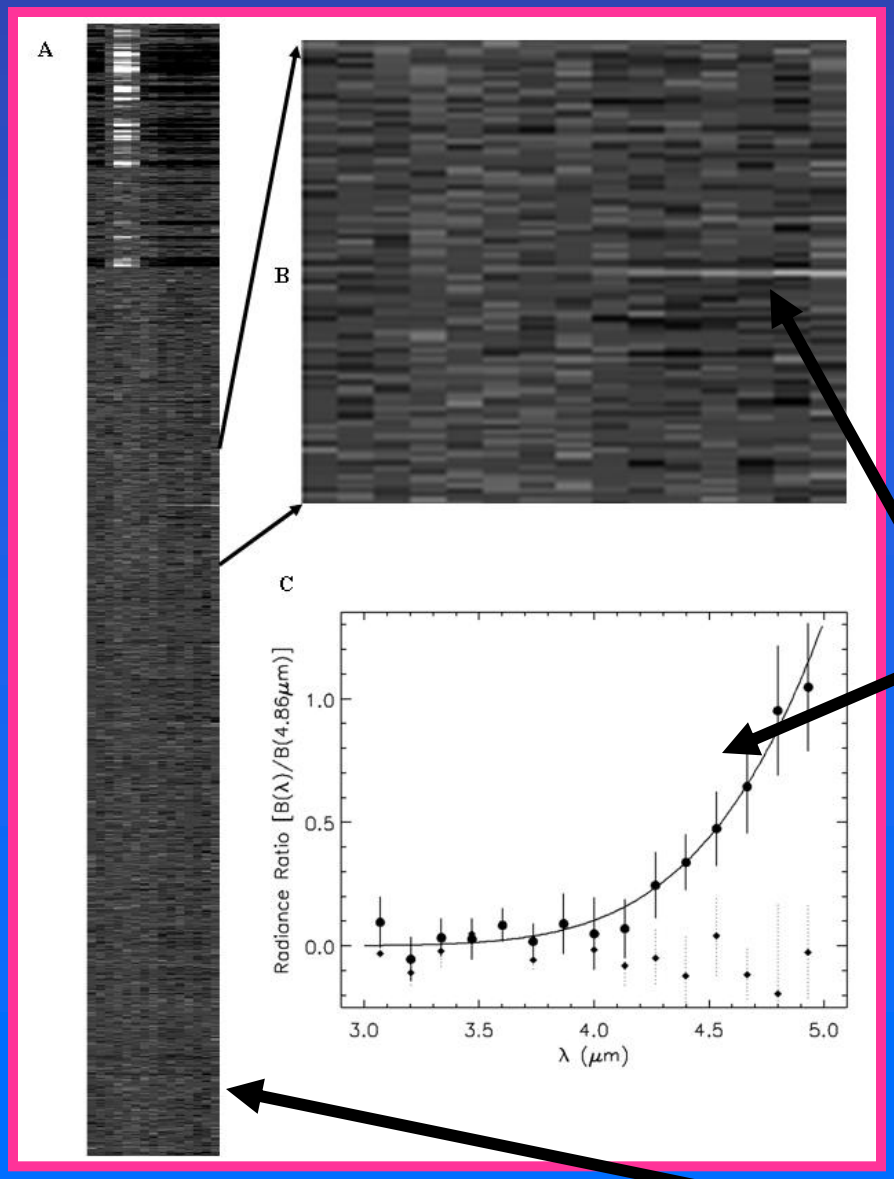
"The Temperature and Width of an Active Fissure on Enceladus Measured with *Cassini* VIMS during the 14 April 2012 South Pole Flyover"

Jay D. Goguen, Bonnie J. Buratti, Robert H. Brown, Roger N. Clark, Phillip D. Nicholson, Matthew M. Hedman, Robert R. Howell, Christophe Sotin, Dale P. Cruikshank, Kevin H. Baines, Kenneth J. Lawrence, John R. Spencer, David G. Blackburn

***Icarus*, online July 24, 2013**

During a close (74 km) flyby of Enceladus in April 2012, the Visual Infrared Mapping Spectrometer (VIMS) measured spectra between 3 and 5 μm during a passage of the active regions ("tiger stripes"). This area was dark, but a thermal signal was detected.

Small hot spots, cont'd.



VIMS
detected a thermal signature of
197 +/- 20K (with a spot size of 9 m).
The VIMS detector size was 38 X 214 r

Thermal emission spectrum from small hot spot on Baghdad Sulcus (a tiger stripe), seen as brightest spectrum.

Goguen et al., 2013

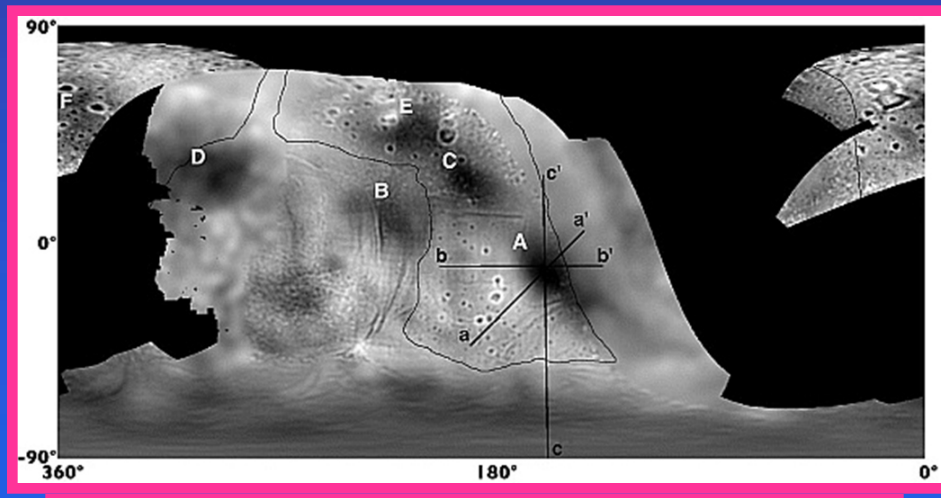
Ground track with spectrum at each point

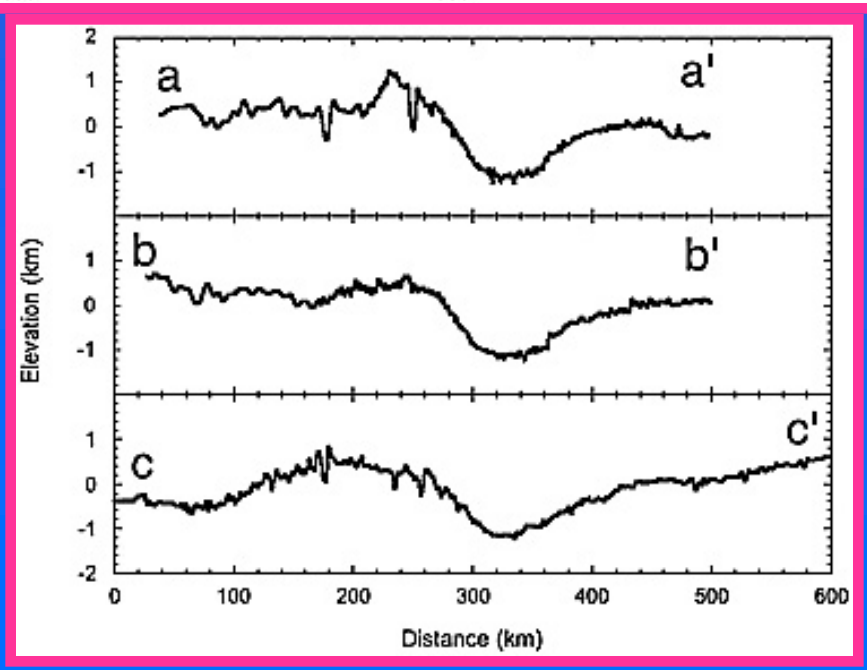
Previous activity on Enceladus?

"Convection-driven compaction as a possible origin of Enceladus's long wavelength topography," Besserer et al. J. G. R. , (2013)

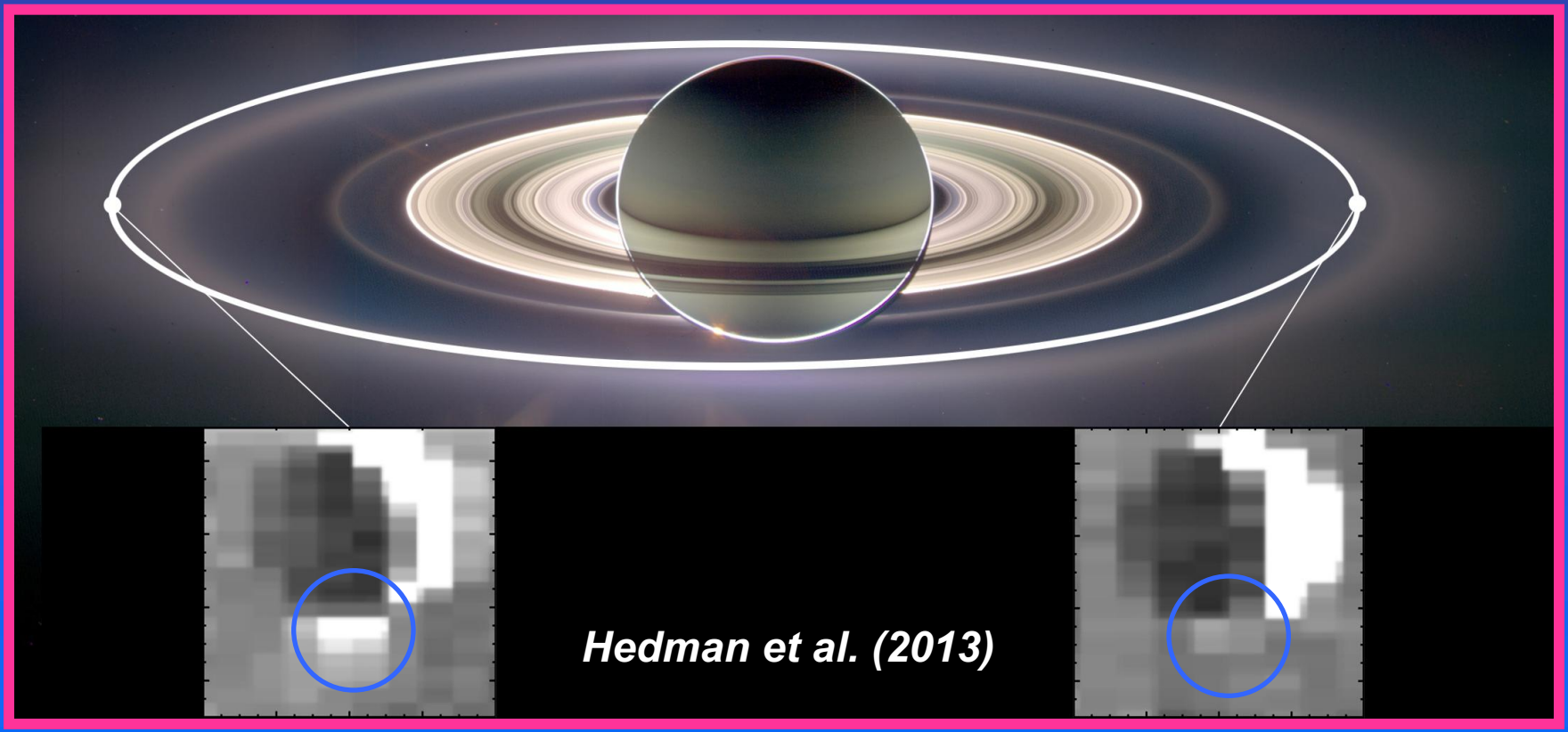
Depressions in the older terrain of Enceladus (northern hemisphere) may be due to previous episodes of activity and subsequent compaction as the surface cooled and sank.

Figures at right show that these basins are nearly 1 km in depth.





The plumes of Enceladus



Cassini **Visual Infrared Mapping Spectrometer (VIMS) observations of Enceladus obtained when it is farthest from Saturn (apoapse, at left) are about 4 X as bright) as when it is closest (periapse, right). This result can be explained by having the fissures that are the source of the plumes get "squeezed" together by tidal forces when the moon is closest to Saturn.**

Rhea 4: Radio Science Gravity Targeted Flyby

March 9, 2013; 1000 km

Radio science results from the first Rhea flyby suggest partial differentiation and the possibility of a non-equilbriumfigure, perhaps from the impact crater Tirawa, which may not be gravitationally compensated.

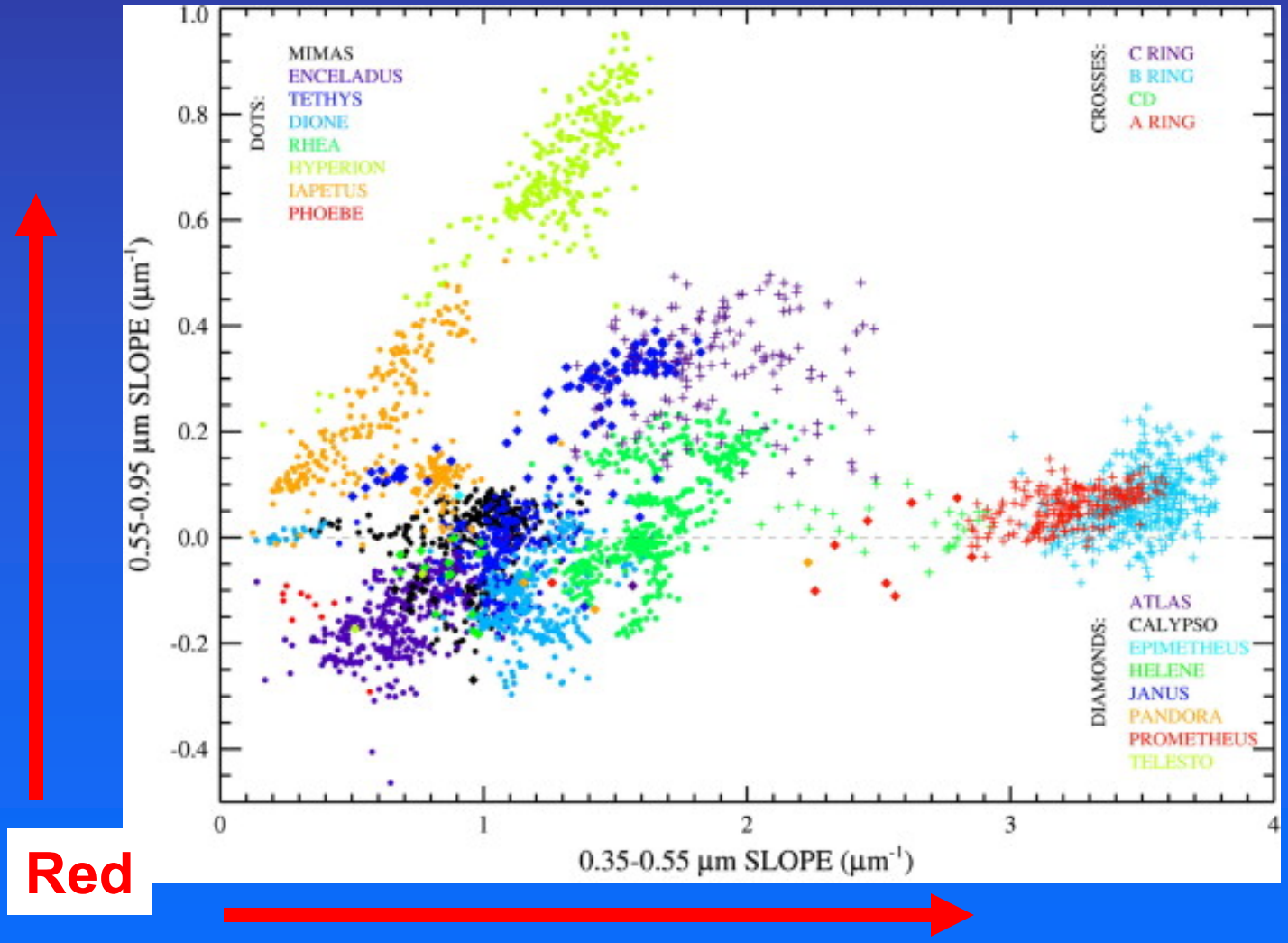
The goal of this fourth Rhea flyby was to determine: 1. the figure of Rhea and to what extent it is in equilibrium; and 2) the internal structure of Rhea in more detail. Fields and particles instruments were in ridealong mode to determine the source and amount of the exterior dust flux into the system (Rhea is a gravitational focuser).

Infrared and optical instruments obtained measurements including global color maps of the North Pole.

Rhea

Image obtained on March 9, 2013 at 2779 km showing a very odd fault.

The colors of the Icy Moons (Filacchione et al. 2012; 2013)



Red

Work over the past year that accumulated all the VIMS observations from the mission shows that the colors of the moons differs. However, if the coloring contaminant (nano-iron? organics?) is subtracted from the surface, the moons are remarkably similar in the amount of ice on their surfaces.

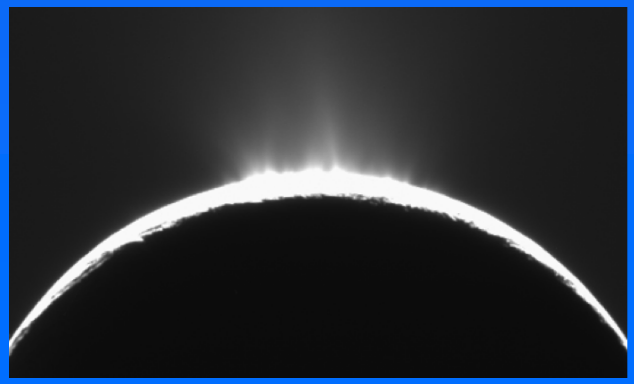
Enceladus Plume Observations

Why so many plume observations?

1. To obtain different viewing geometries which better characterize plume shape, particle size, and the relationship between plumes and surface features and thermal sources. Specific jets are mapped to specific locations. In addition, large distances are required for context and to understand the relationship of the plumes to E-ring.

2. To understand the variability of geologic activity on Enceladus. The same viewing conditions at different times are required.

3. To understand what causes the jets. Is it tidal? Do the jets come from a liquid source?



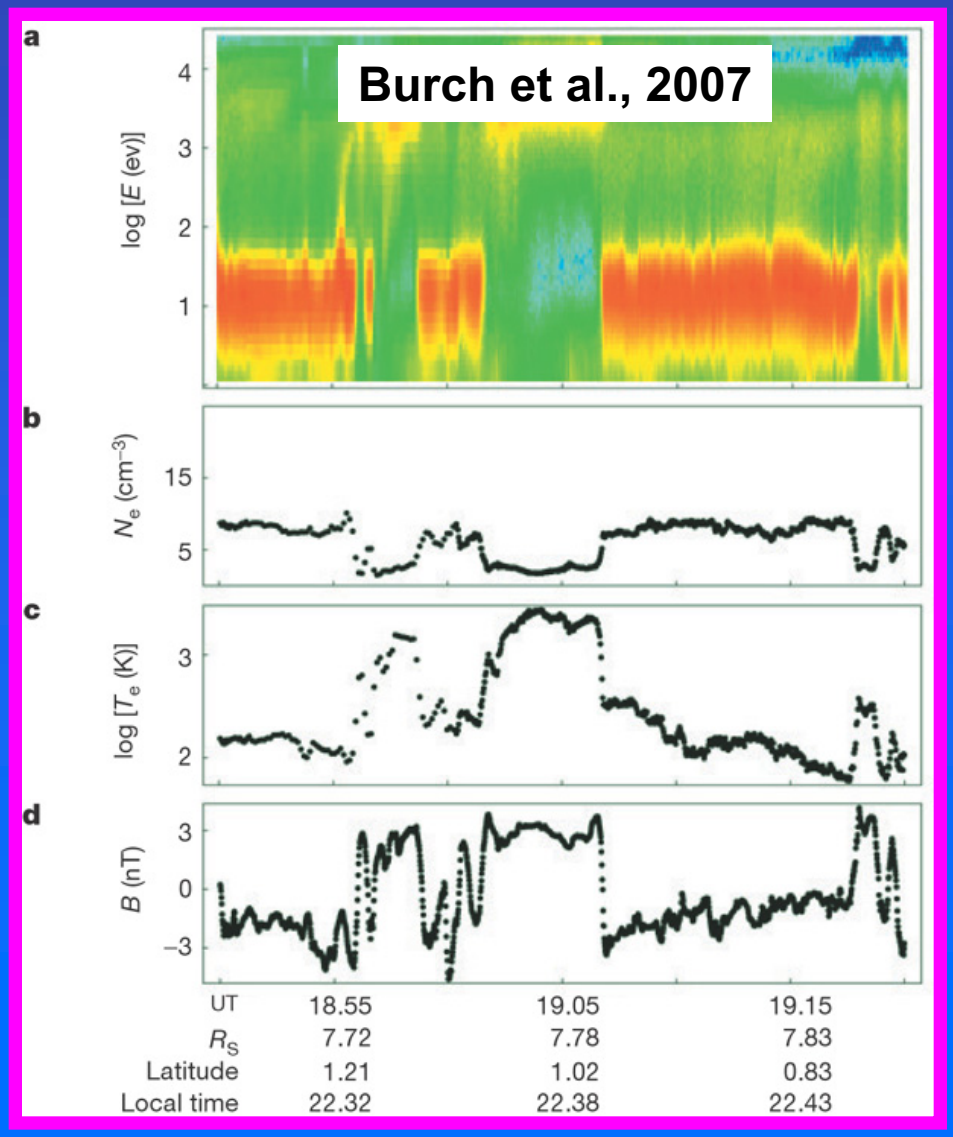
Dione: is it active?

Lines of evidence from several Cassini instruments suggest that Dione is active. Another paper published earlier this year added to the evidence. First, a review of the previous work.

1. Evidence: MAPS data for Dione

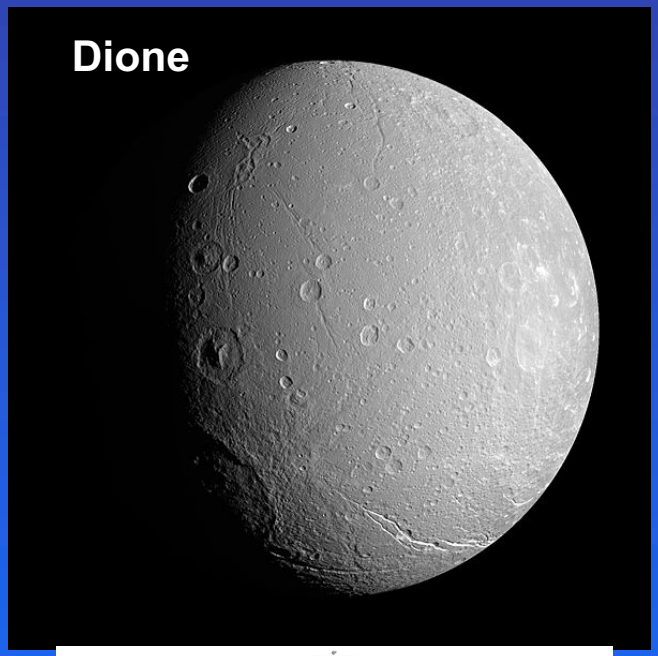
Dione and Tethys are associated with the best evidence for activity, in the form of plasma transported from their surfaces (Burch et al., 2007; see figure). Double peaked "butterfly" pitch-angle distributions representing both high and low energy electrons were found in Saturn's inner magnetosphere. A model of this distribution assuming a dipole magnetic field for Saturn shows that the two plasma streams originate separately from Dione and Tethys, forming plasma tori at the locations of their orbits. (See A. Rymer GRL, 2011 for a counter explanation)

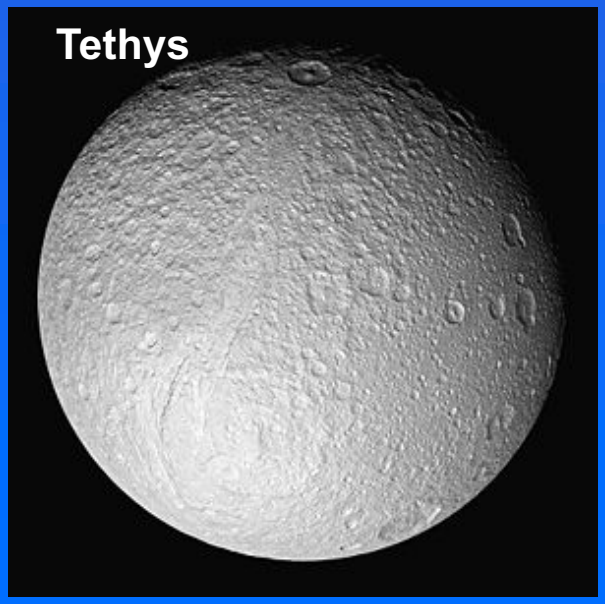
K. Khurana also presented Mag data that are consistent with a mass loading of 0.72 kg/s neutrals from Dione (Enceladus is 200-300 kg/s)

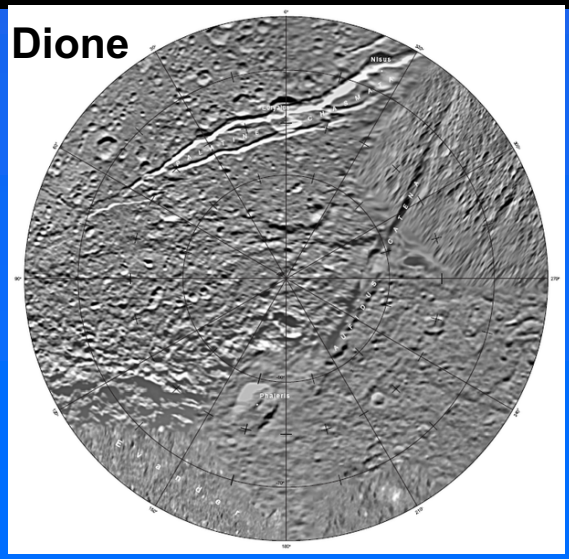


2. Evidence: Geological

Geologic features on Dione (and Tethys) show extensive faulting and resurfacing with possible associated outgassing (Smith et al. 1982; Roatsch et al. 2008; 2009)



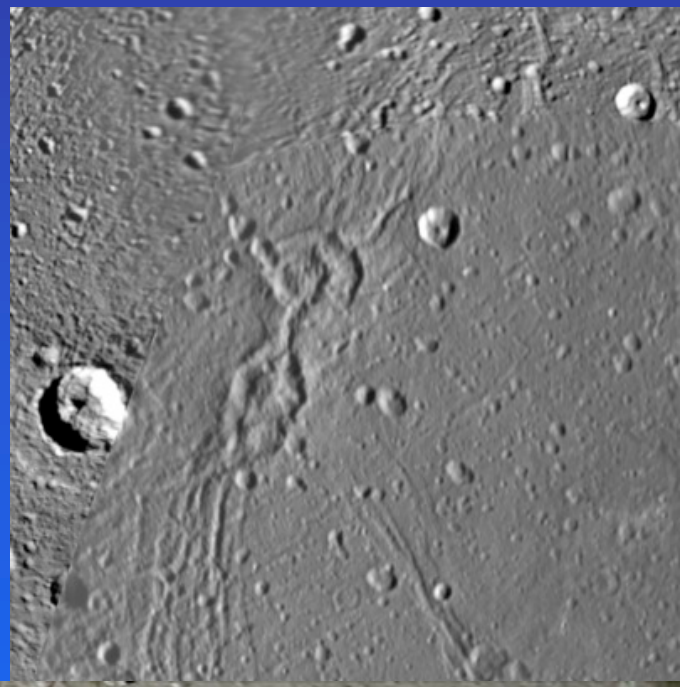


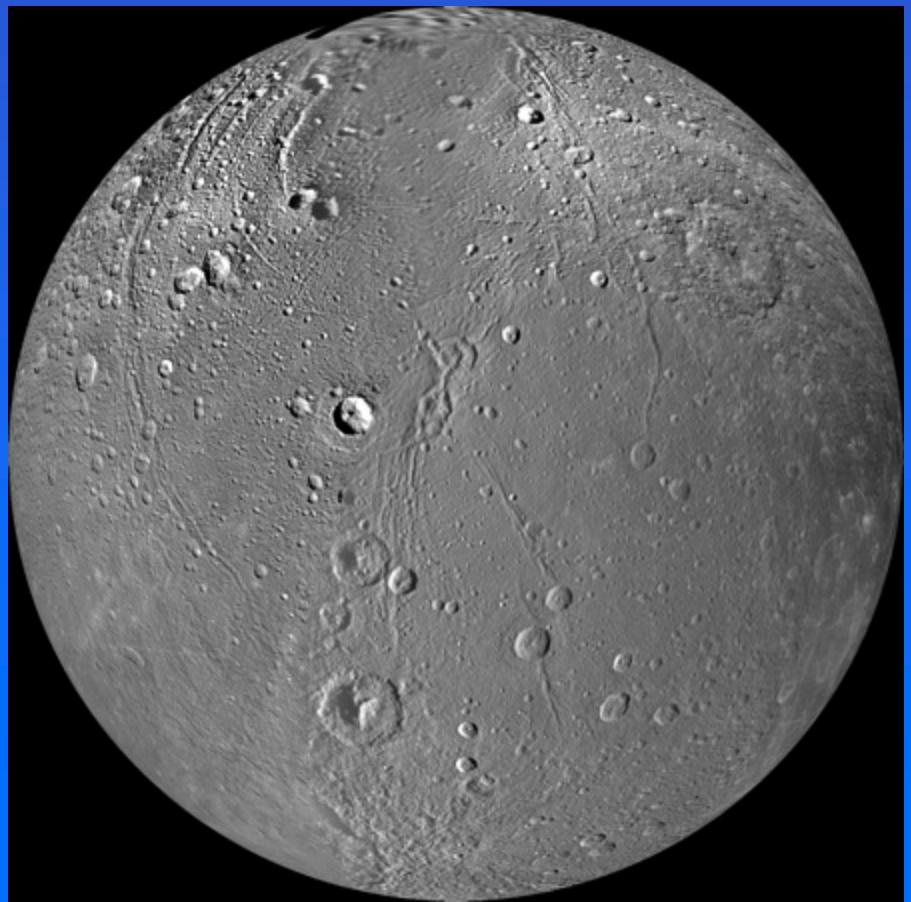


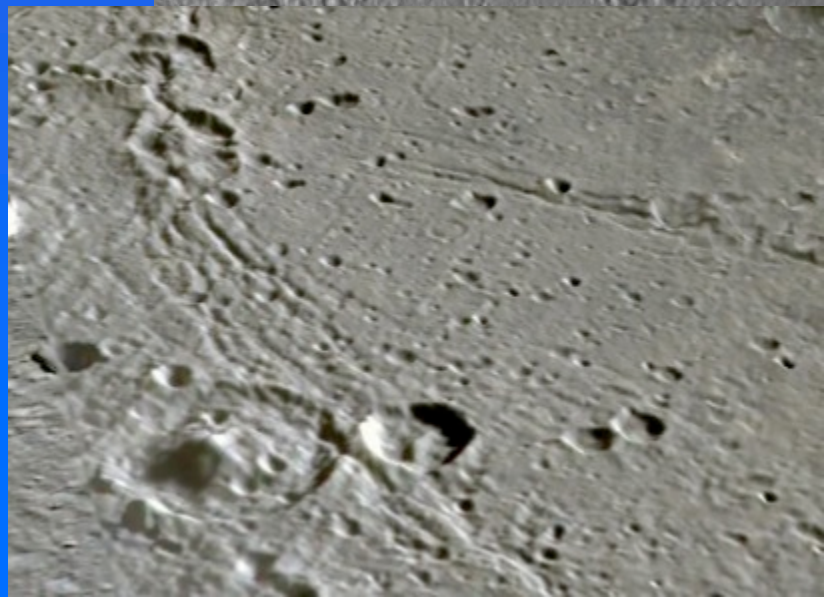
3. Paul Schenk: Volcanism

Smooth plains on Dione

- Lower crater density
- Linear grooves and scarps
- Rampart craters
- Anomalous crater pair: Possible volcanic vent!

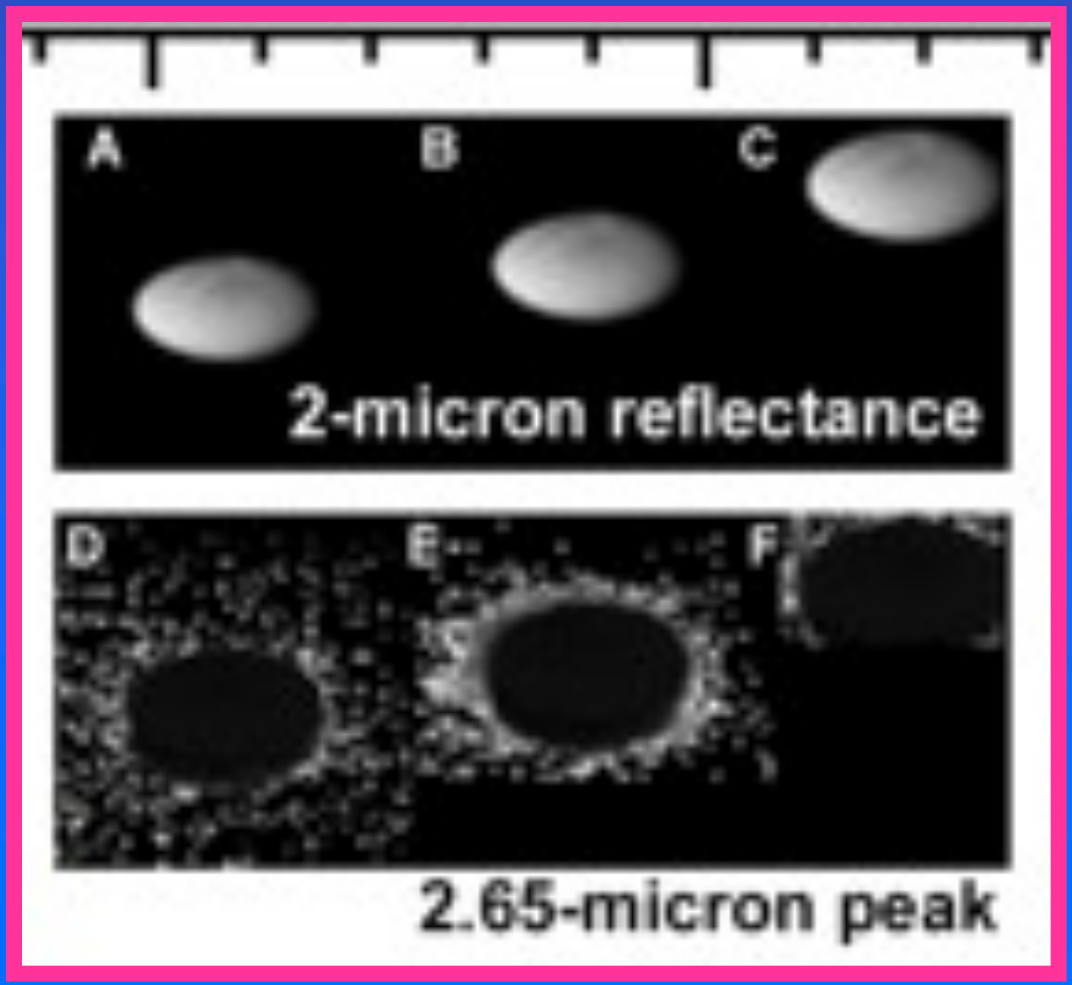






4. Transient atmosphere

Clark et al., 2008



4. Transient atmosphere-cont'd

"Data from 16DI [Oct. 11, 2005] show a weak field perturbation in the upstream region, indicative of a tenuous atmosphere around the satellite" according to Simon et al., 2011. The signature was not seen on 129DI (April 7, 2010).

Then, Tokar et al. (2012) discovered a thin atmosphere of O_2^+ with CAPS during the close (500 km) flyby on April 7, 2010. Density is ~0.01-0.09 particles/cm^3

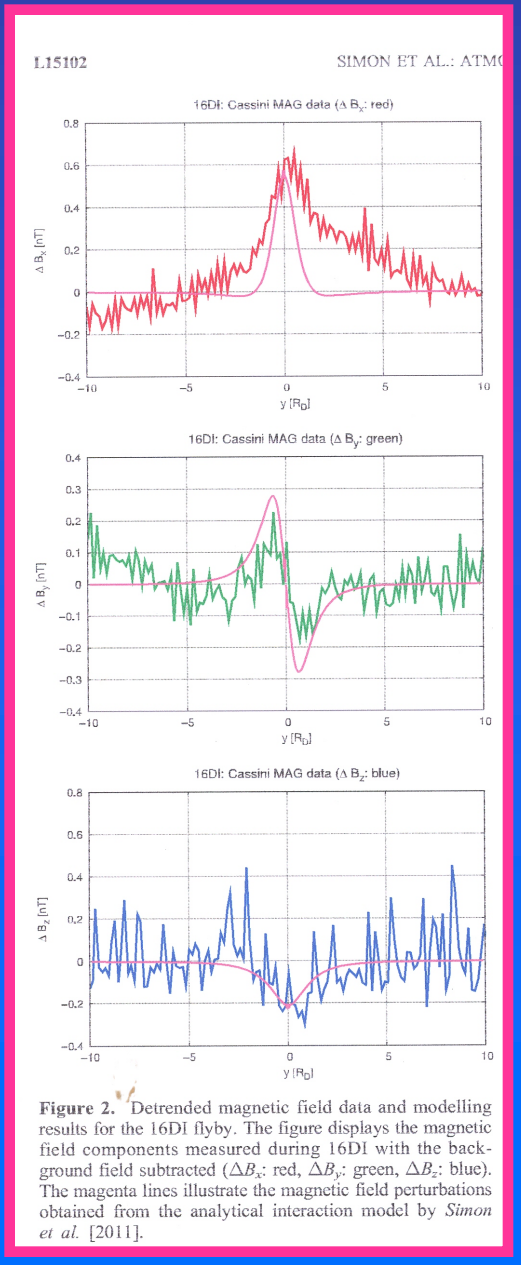
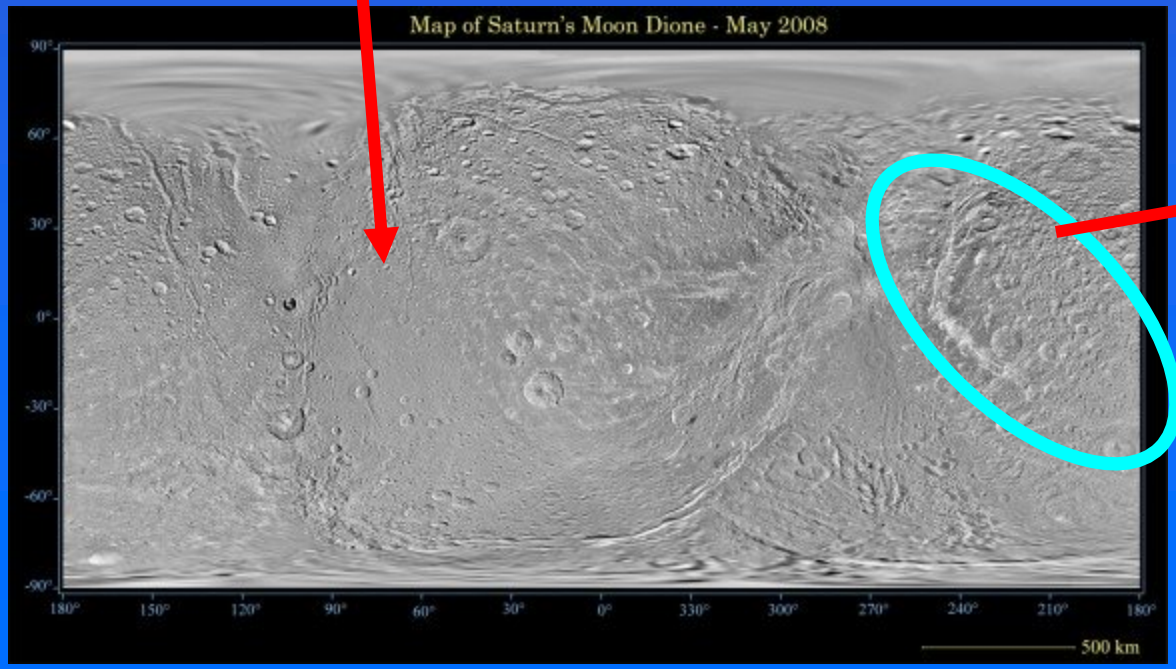


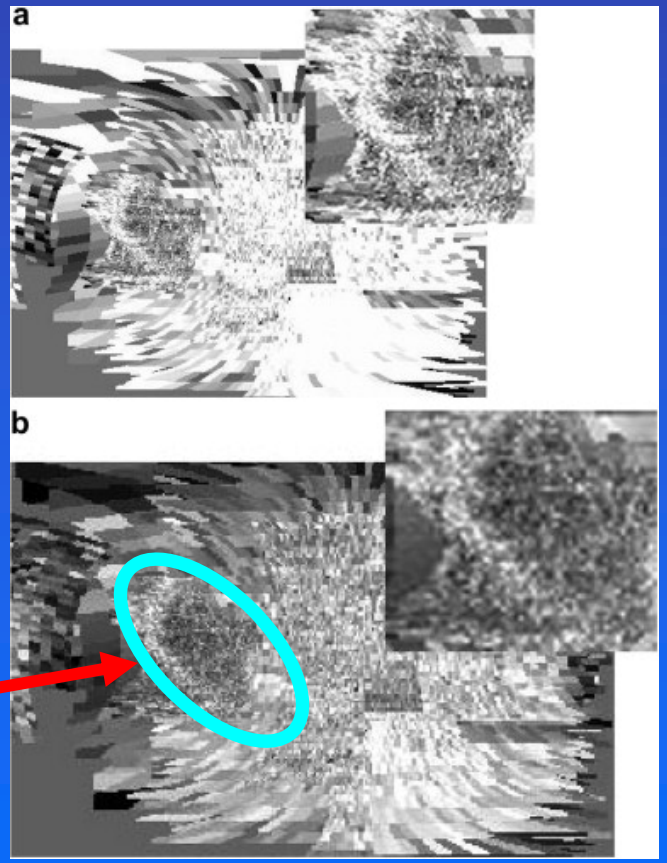
Figure 2. Detrended magnetic field data and modelling results for the 16DI flyby. The figure displays the magnetic field components measured during 16DI with the background field subtracted (ΔB_x: red, ΔB_y: green, ΔB_z: blue). The magenta lines illustrate the magnetic field perturbations obtained from the analytical interaction model by *Simon et al.* [2011].

5. Amorphous ice?

Newman et al, 2009

Crystallinity maps of Dione (Newman et al., 2009): Lighter shades pertain to a higher crystallinity factor. The "smooth" region is more crystalline. Does this observation imply heating and recrystallization?





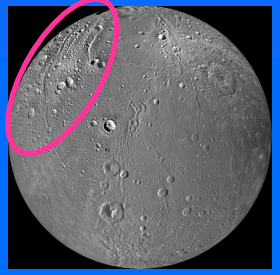
6. New Evidence

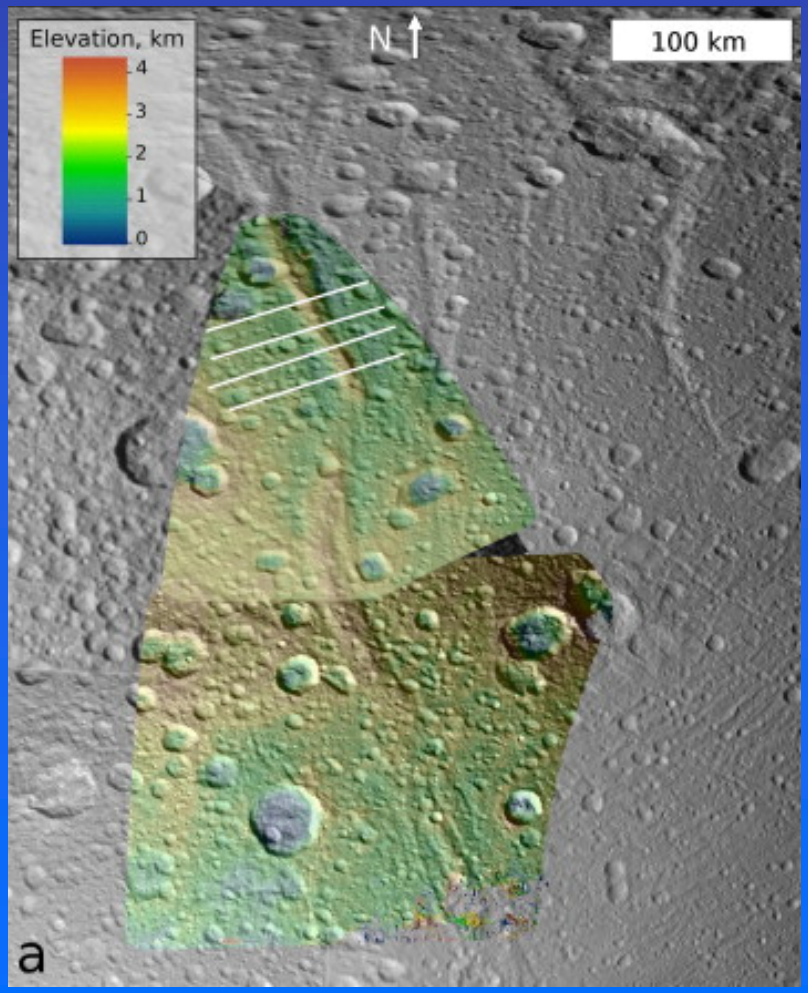
Hammond et al. (2013) *Icarus*:

Abstract:

Estimate of an effective elastic thickness of Dione's crust of 3.5 ± 1 km. This local estimate is in good agreement with global values derived from long wavelength topography.

"Corresponding heat fluxes of 25–60 mW/m2 are much greater than those expected for a body heated solely from radioactive decay. It would be possible to generate our inferred heat flux values via tidal heating at close to the current orbital eccentricity of Dione, but only if a subsurface ocean were present at the time of flexural deformation."





Digital elevation model of Janiculum Dorsa, located at 150° W 45° N.

Upcoming events

For nearly two years, there are no significant upcoming events, because *Cassini* is in an inclined orbit to study the rings and the polar regions of Saturn.

But scientists will be busy studying the treasure-trove of data we already have. Keep tuned for new results.