The search for activity on the icy satellites

Bonnie J. Buratti,

Senior Research Scientist, Jet Propulsion Laboratory, Caltech

Summary

1. Review of discovery of activity (plumes) on Enceladus
2. Evidence for plumes on other icy satellites
3. The search for plumes on Mimas, Tethys, and Dione

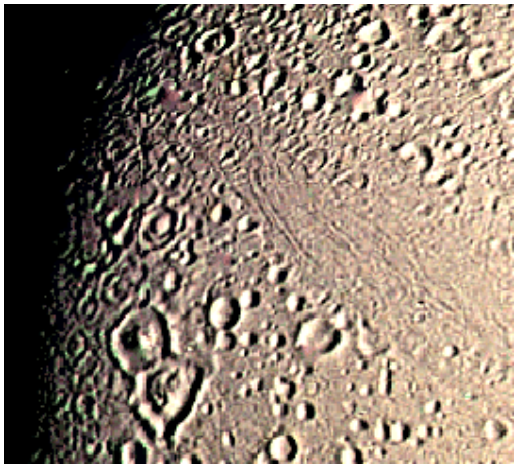
Outer Planet Satellites in Perspective

Properties of Enceladus

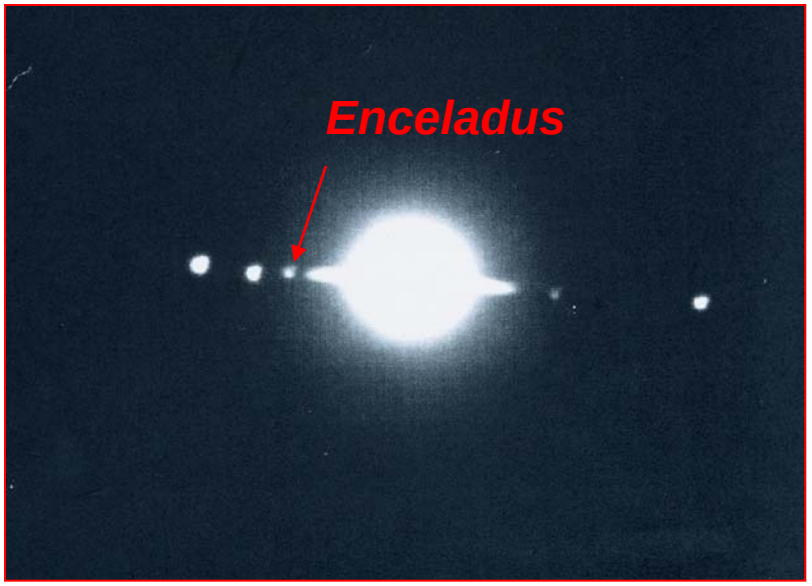
Distance from Saturn (10^3 km)	**238**
Period (days)	**1.37**
Radius (km)	**249**
i	**0**
e	**0.004**
Density (gm/cc)	**1.6**
Geometric albedo	**1.4 (the highest of anything!)**
Discovered	**1789 (Herschel)**
Composition	**Water ice (R. Clark et al.,1983)**

Enceladus during the ring plane crossing in 1997

- **Ground based studies of Enceladus (and Mimas) are extremely difficult because of scattered light from Saturn.**
- **Most discoveries prior to Voyager, and between Voyager and Cassini, were made during ring plane crossings**

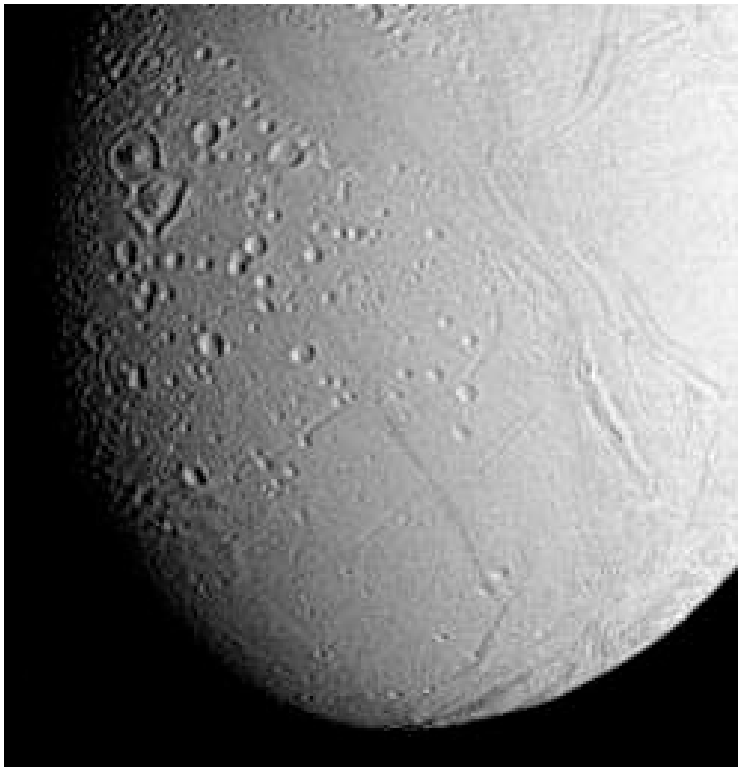


Enceladus From Voyager



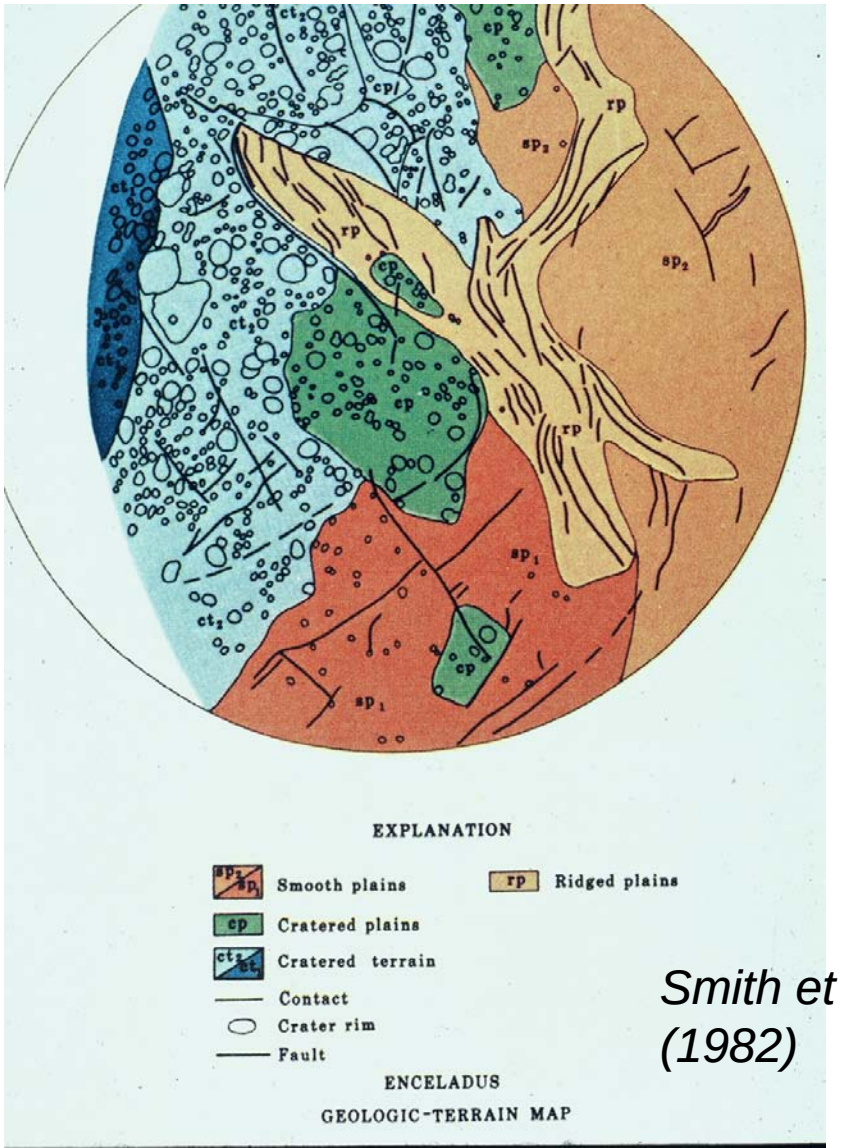
Saturn and its five inner medium sized satellites during RPX (1997) Image obtained on the Palomar 60-inch.

Geologic terrains of Enceladus and albedo – first hint at true oddness



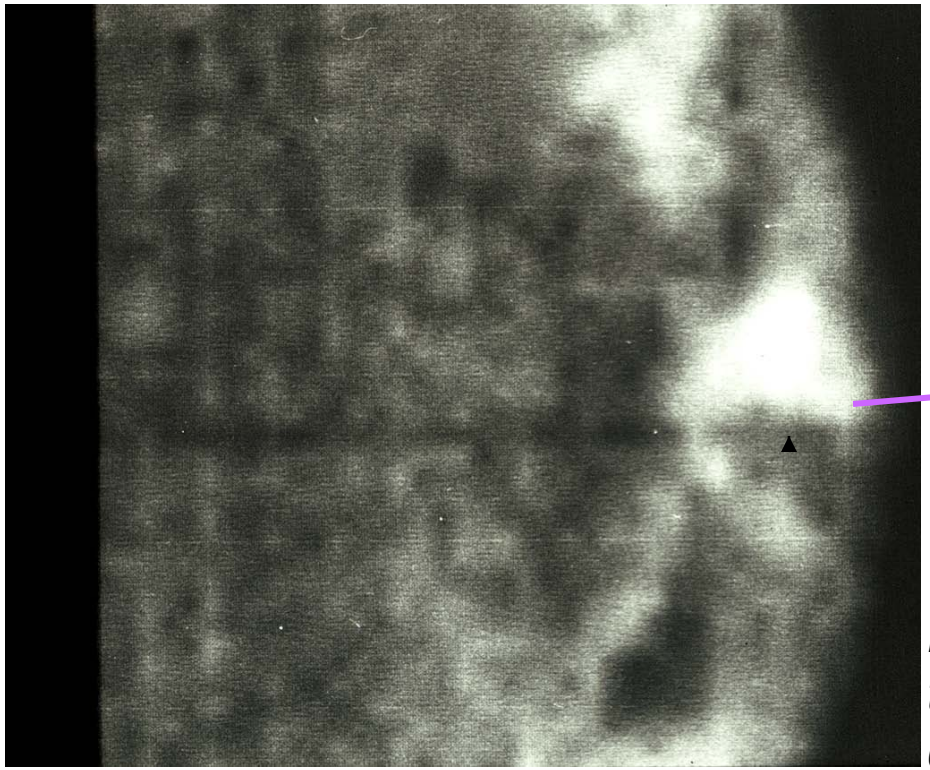
Terrain	*Age (BY)*	B_o
Smooth plains	<0.8	0.82 0.01
Cratered terrain	~3.9	0.84±0.02
Ridged plains	<0.8	0.84±0.01
Cratered plains	~3.6	0.84±0.01

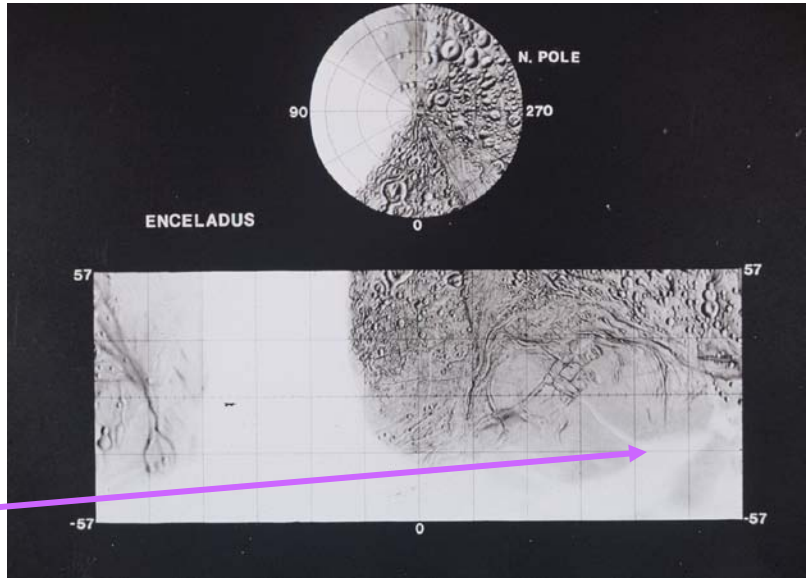
Buratti (1988)



Smith et al. (1982)

Enceladus and its environment

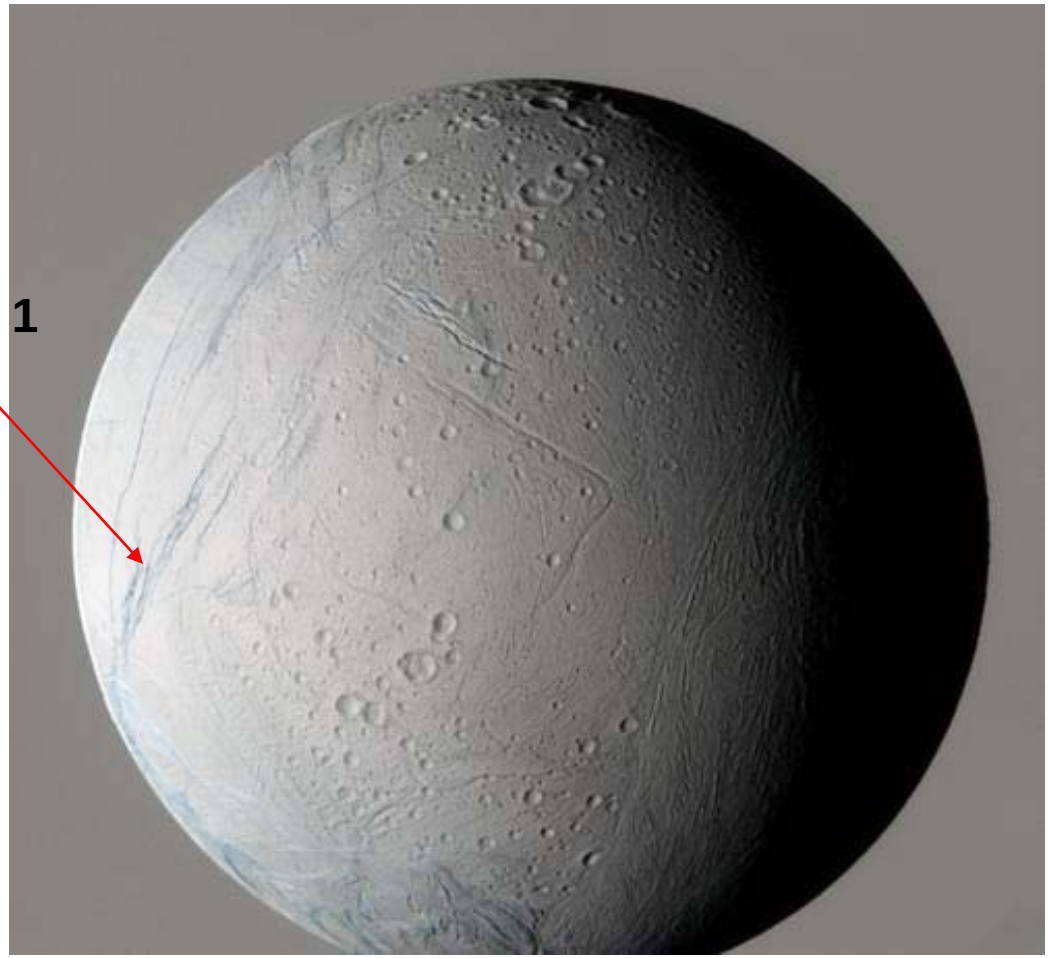




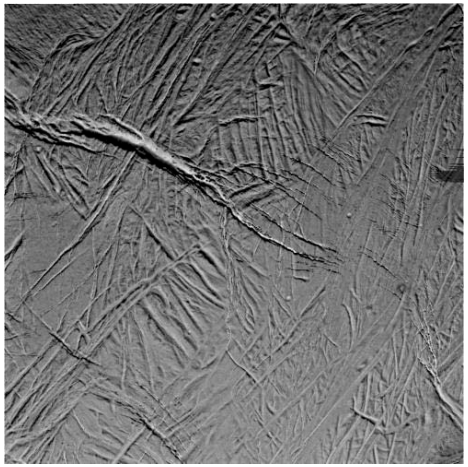
Do particles from the E-ring interact with the other satellites (cf. sulfur and sulfur dioxide from Io; exogenic particles on Iapetus)?

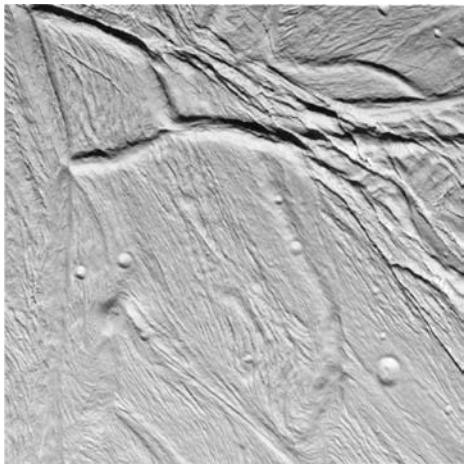
Is the feature above evidence for activity???
Is Enceladus the source of the E Ring?

Enceladus at 94,000 km

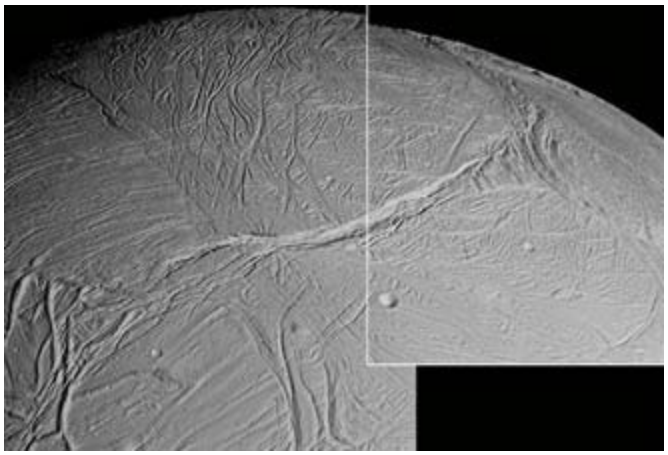


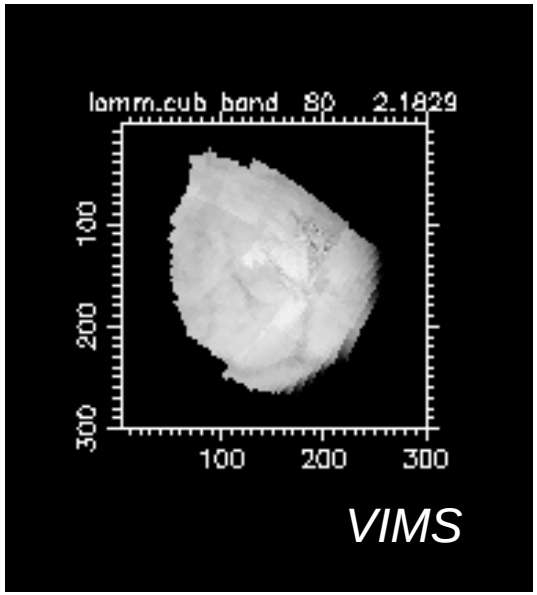
EN 003 – Highlights





Extensional and compressional faults; small craters in plains area; water ice only component identified; particle environment probed; no active ice volcanism detected.

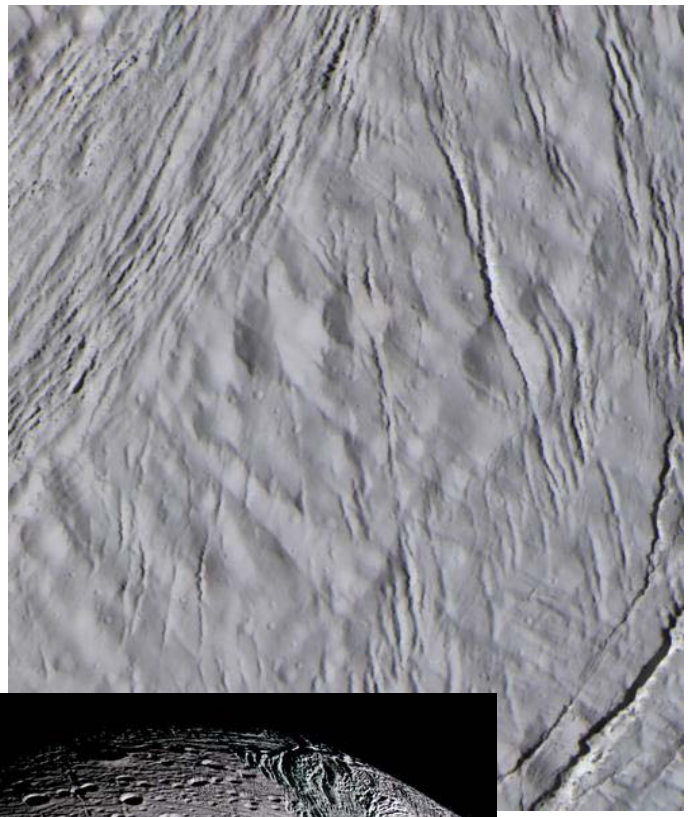


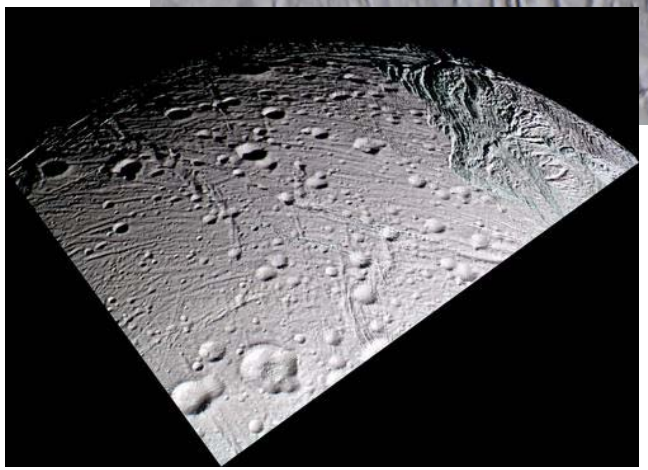


Snowy, cracked Enceladus

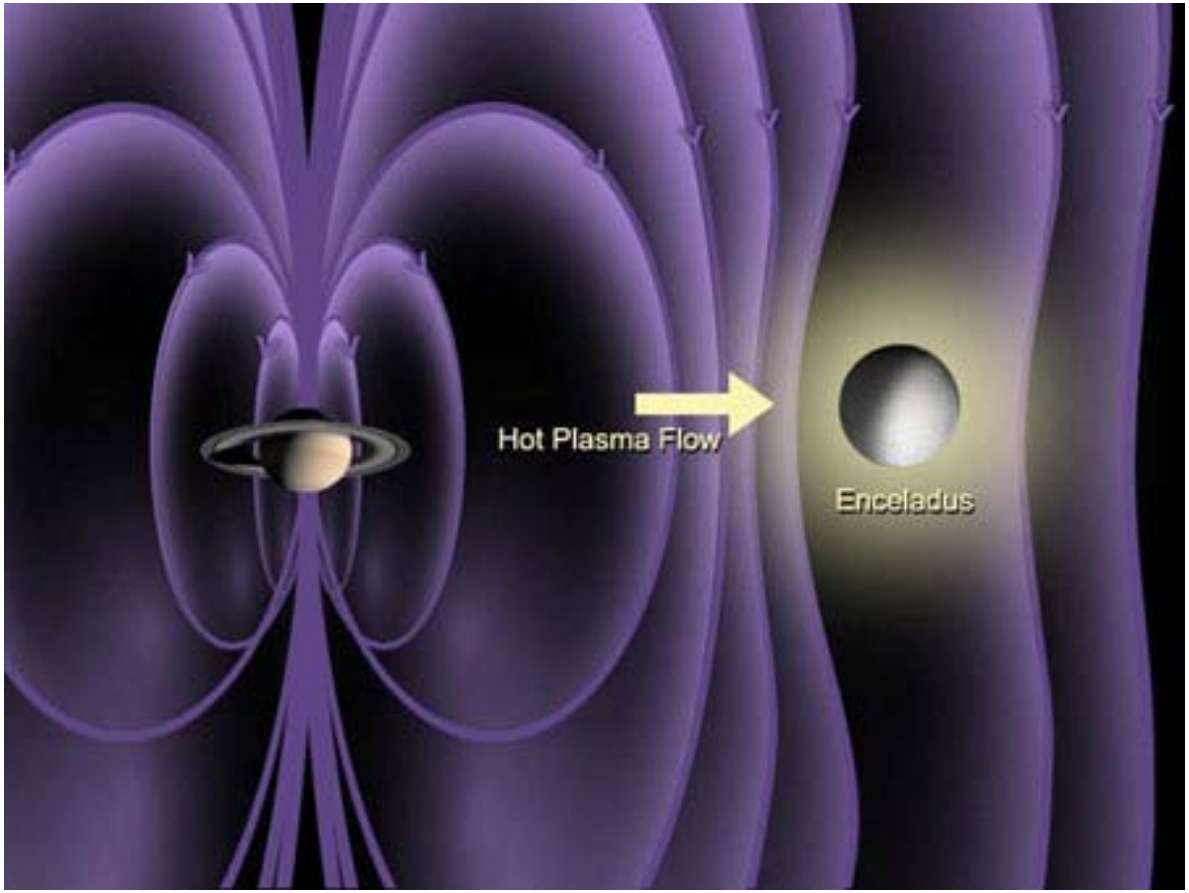
Rev 003 and 004 showed no activity on Enceladus. However, the satellite looks as if it were coated in snow.

Puzzling: only ice detected. How does it melt? Does the moon's high density imply radioactivity?





Atmosphere on Enceladus?



The Cosmic Dust Analyser found evidence for an atmosphere. There was also evidence for a magetic field on the satellite. To further explore this astounding possibility, the Project agreed to lower the altitude on EN 11 to 175 km!!

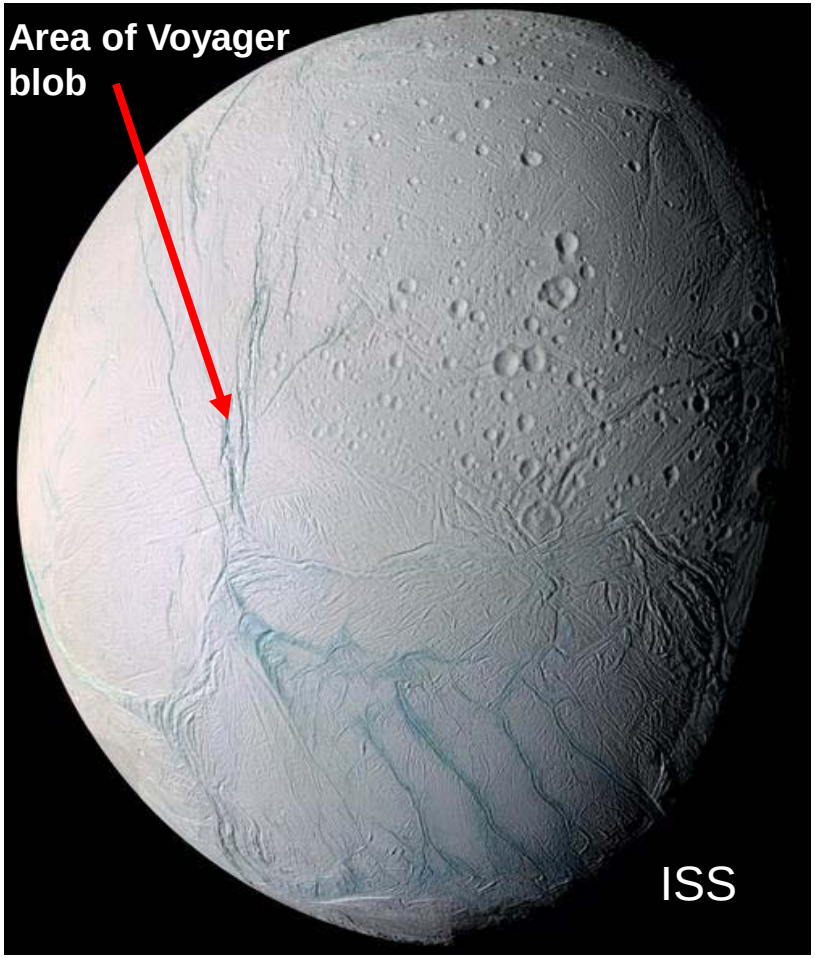
Mysterious telescopic observations

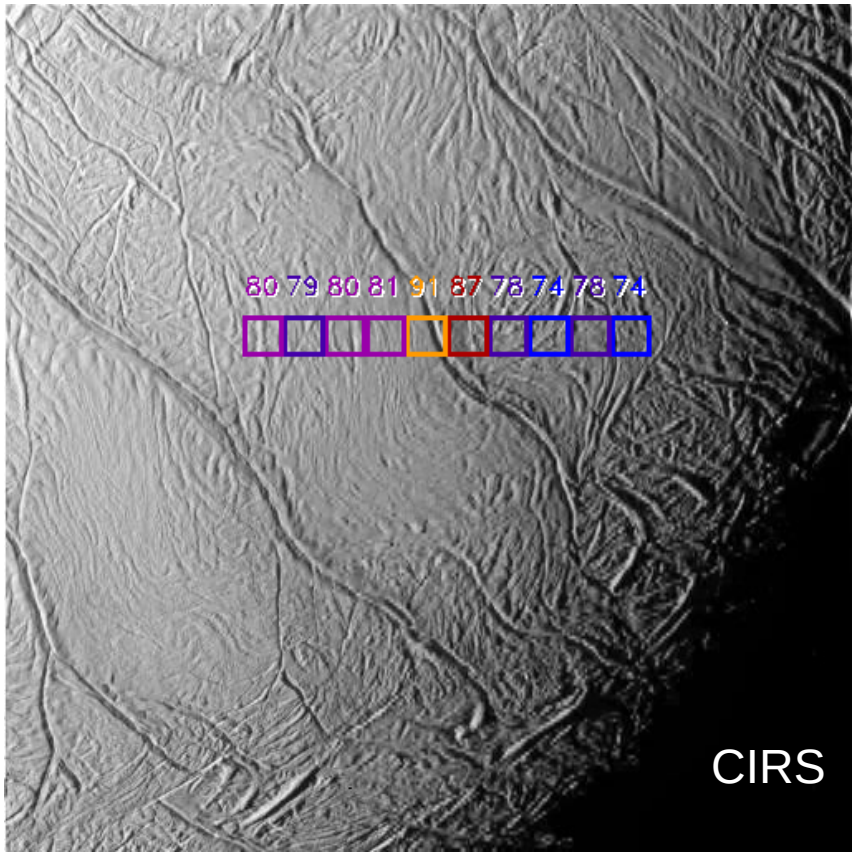
Lowell (left) and the 24-inch Clark refractor at Lowell Observatory (right).

Observations by P. Lowell and E. C. Slipher in 1913-1914 showed a 0.3 magnitude increase in the brightness of Enceladus at western elongation (the trailing side) when the subobserver latittude was -32º

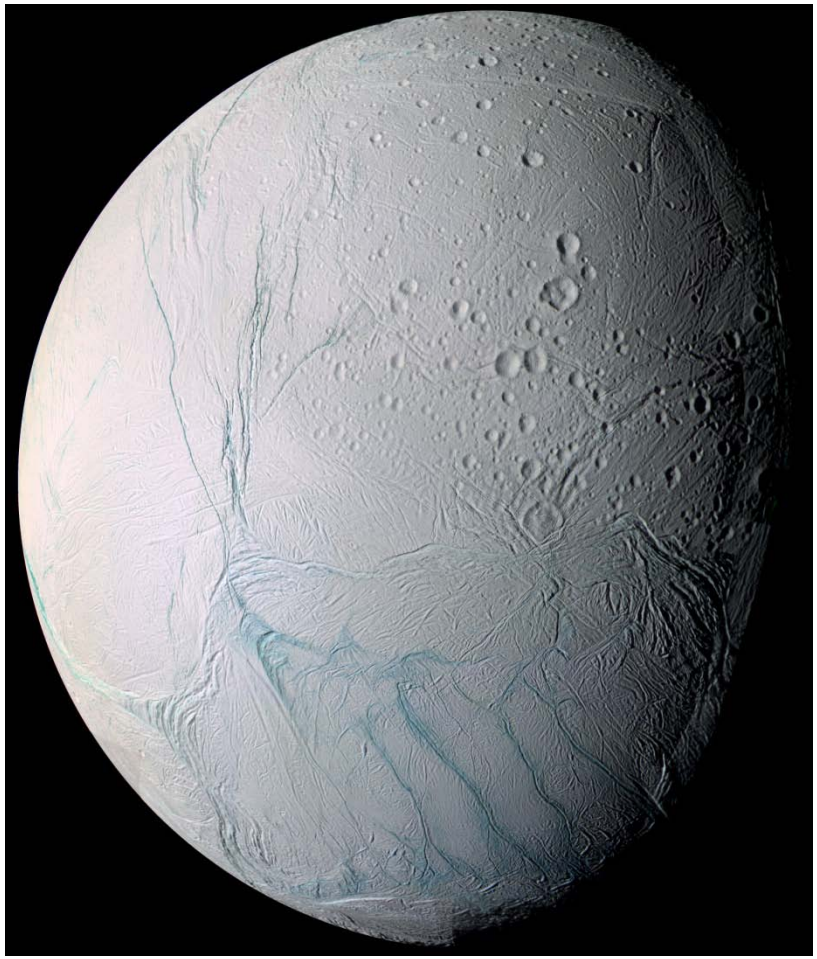
Similarly, in 1972-73, O. Franz and R. Millis observed a brightening of 0.3 magnitudes at western elongation when the subobserver latitude was -30º

The Discovery

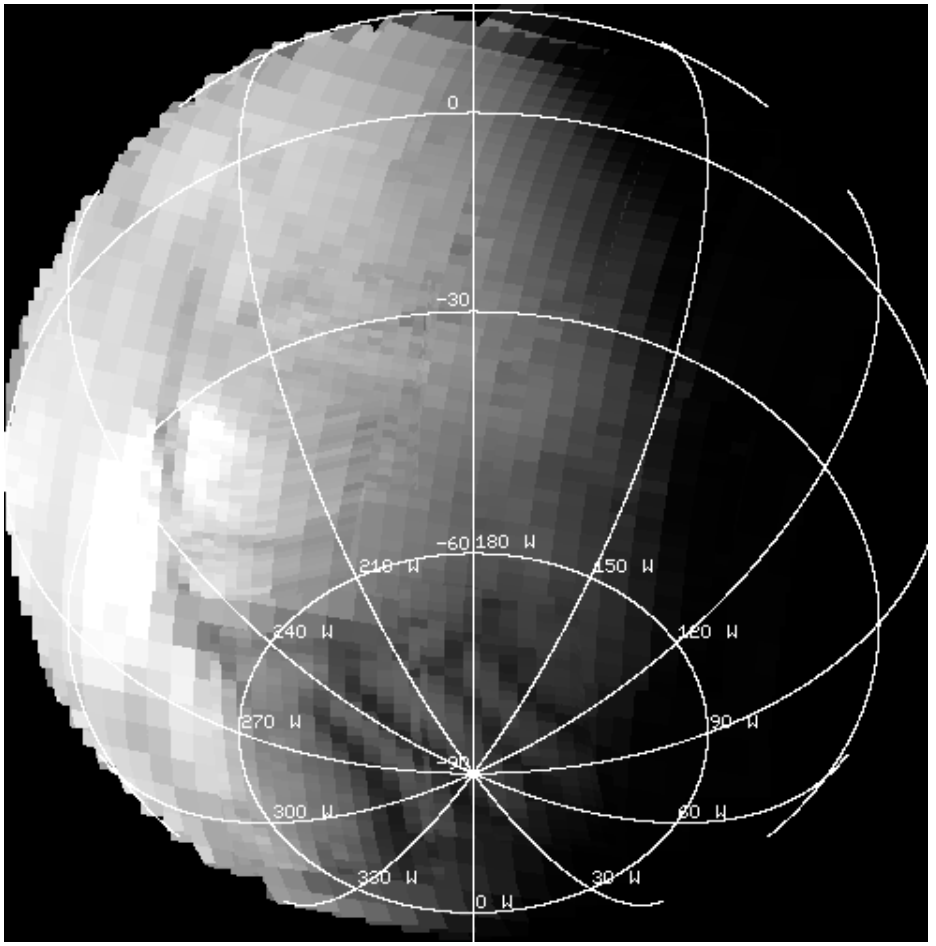




The tiger stripes

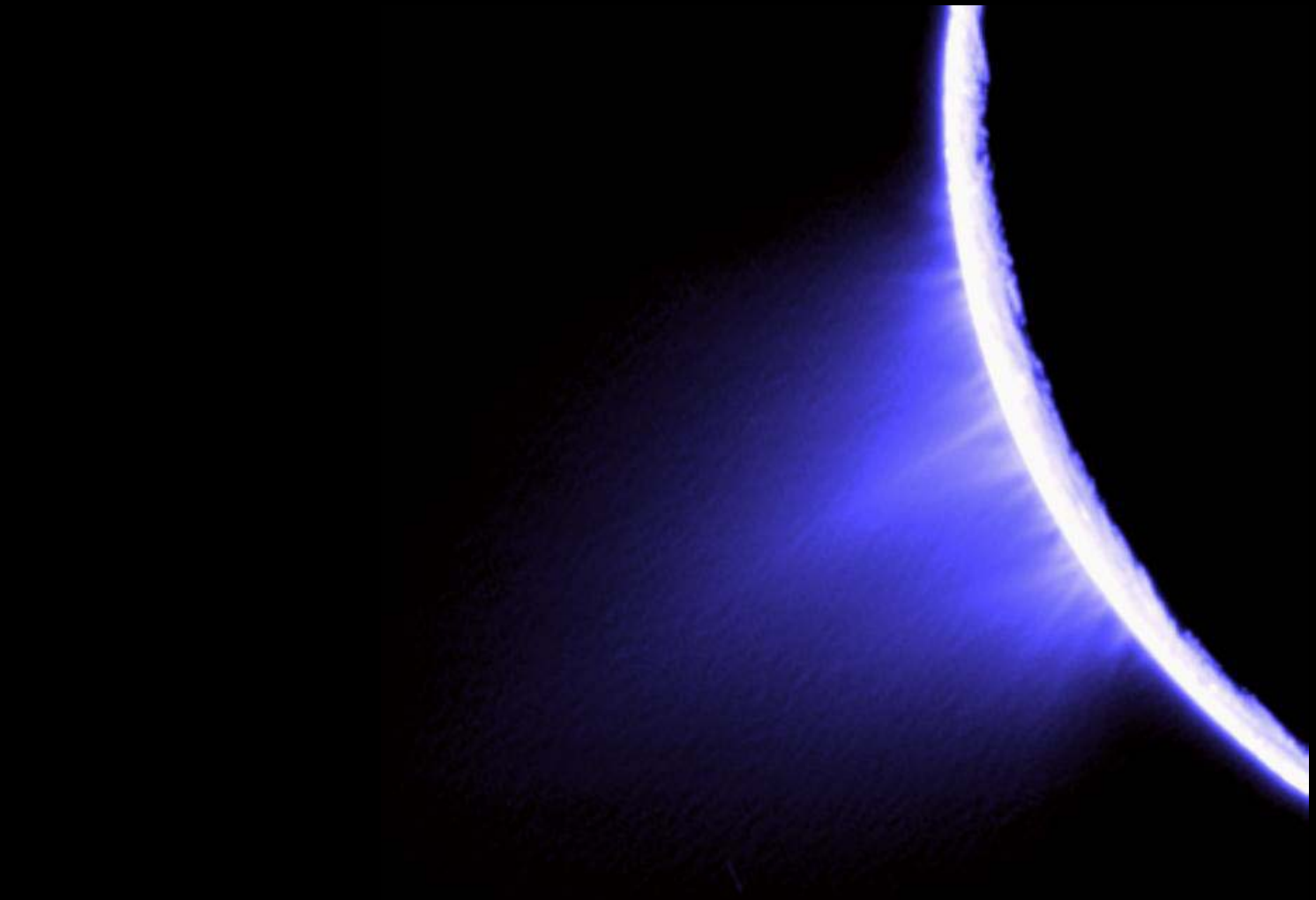


ISS mosaic

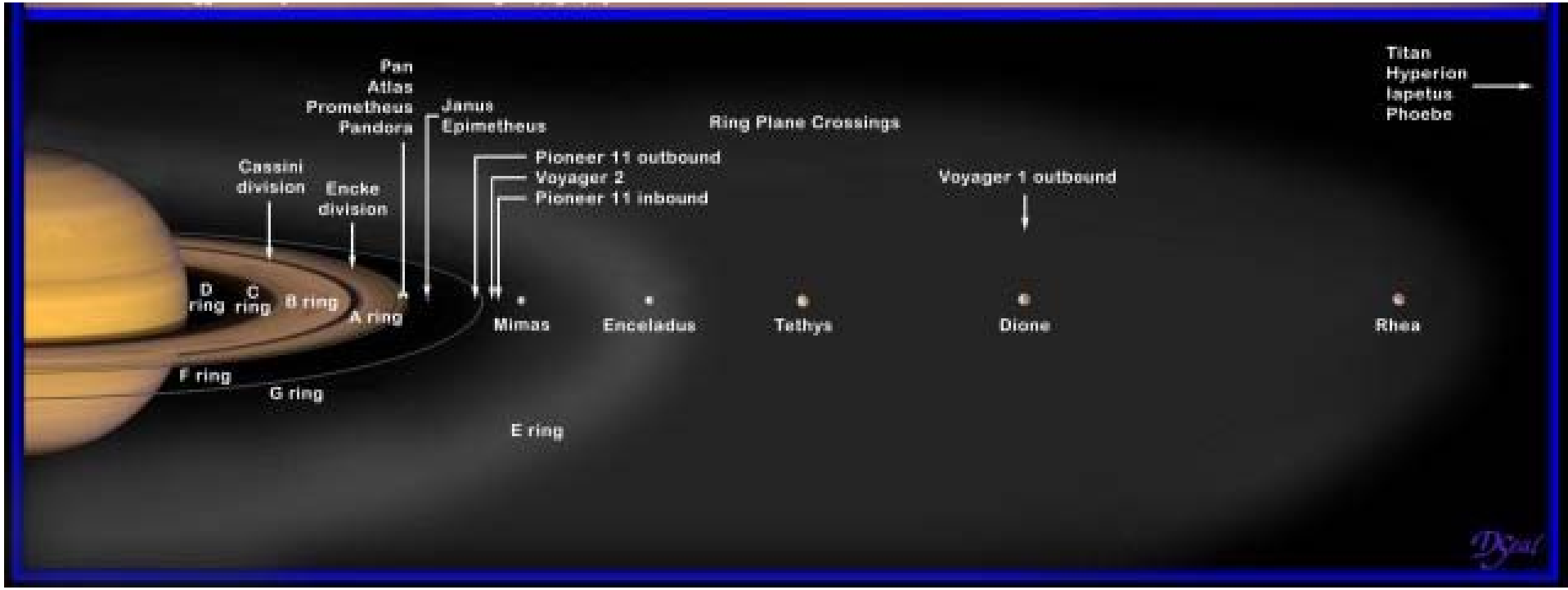


VIMS 2.01 μm mosaic

The smoking gun



Saturn’s satellites and the rings



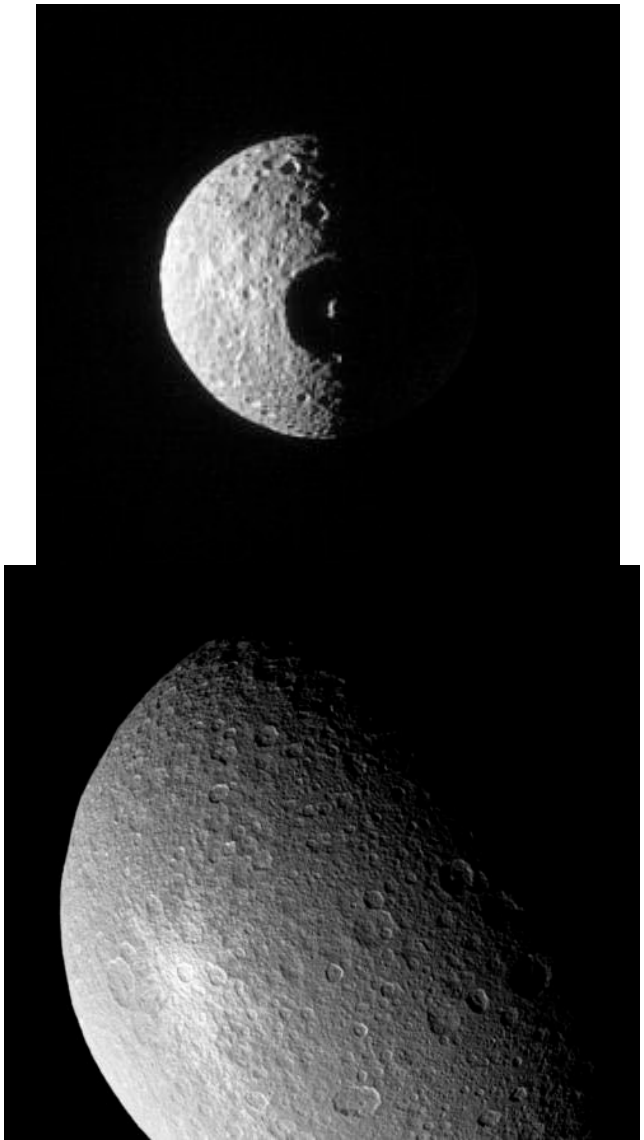
Which other satellites might be active?

Dione and Tethys:

Dione and Tethys are associated with the best evidence for activity. They exhibit signatures similar to those exhibited by Enceladus prior to the discovery of its plume, in the form of plasma streams transported from their surfaces (Burch et al., 2007). The best model for the plasma entails two streams that originate separately from Dione and Tethys. Also, the satellites have evidence for recent resurfacing. Finally, VIMS saw a possible atmosphere on Dione (Clark et al., 2009).

Which other satellites might be active?, cont'd

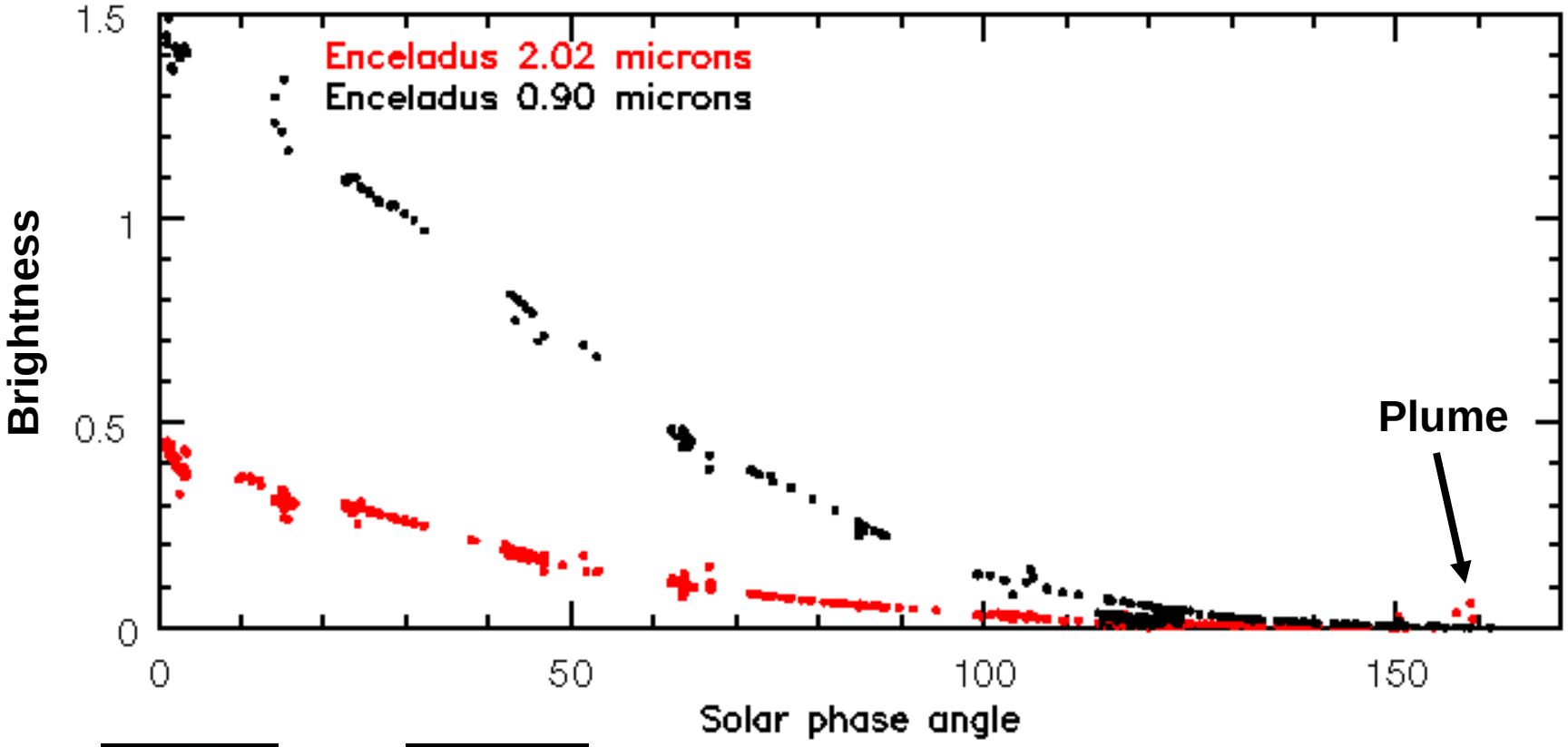
- Mimas may have tidal forces acting on it (the main source of heat for Enceladus)
- Rhea appears to be dead from all evidence (see Pitman et al., 2008).



Ways to detect activity

- Heat
- Direct observation of plume (images)
- Direct observation of plume when the moon is in its crescent phase
- Observation of atmosphere (directly or through occultations)
- Observation of effects of plume on plasma around Saturn.

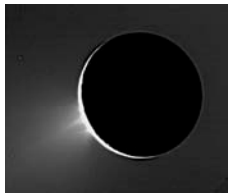
The plume at crescent phase



Full moon

Gibbous moon

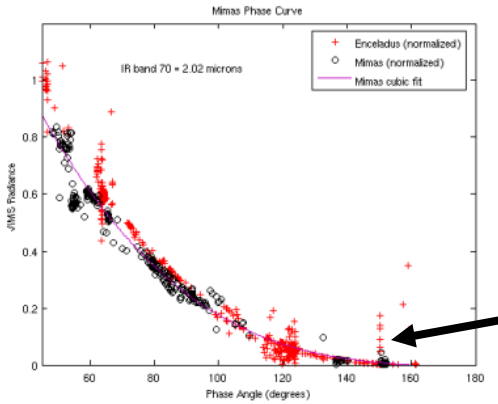
Quarter moon

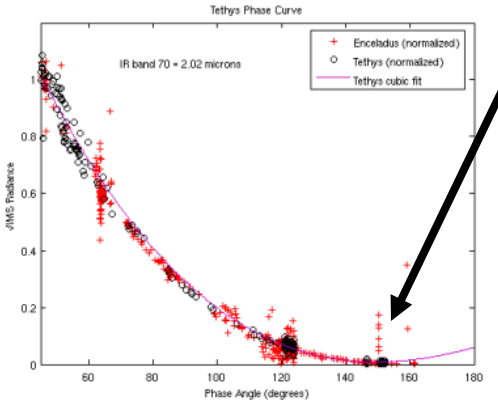


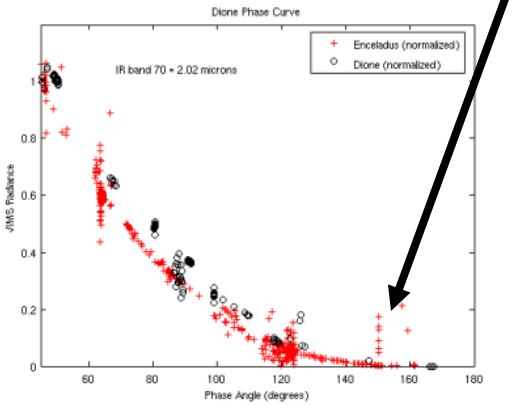
Crescent moon

The other Moons that have possible activity: data from the Visual Infrared Mapping Spectrometer (VIMS) data.

No plumes at large solar phase angles:
No evidence for activity
At least 2 orders of magnitude below activity on Enceladus





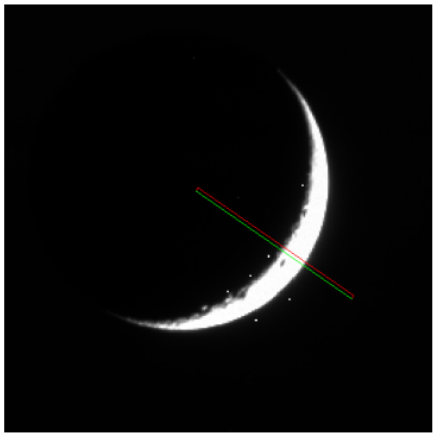


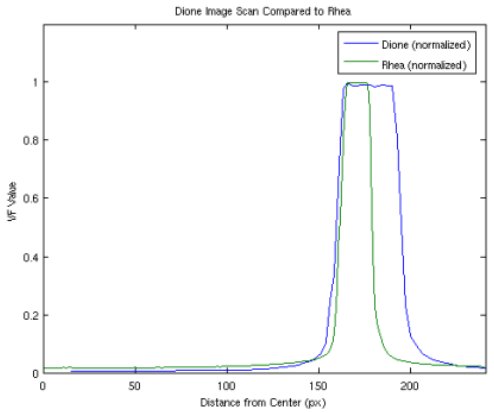
Enceladus Plume

Imaging: best seen at large solar phase angles

Dione / Rhea Image Ratio

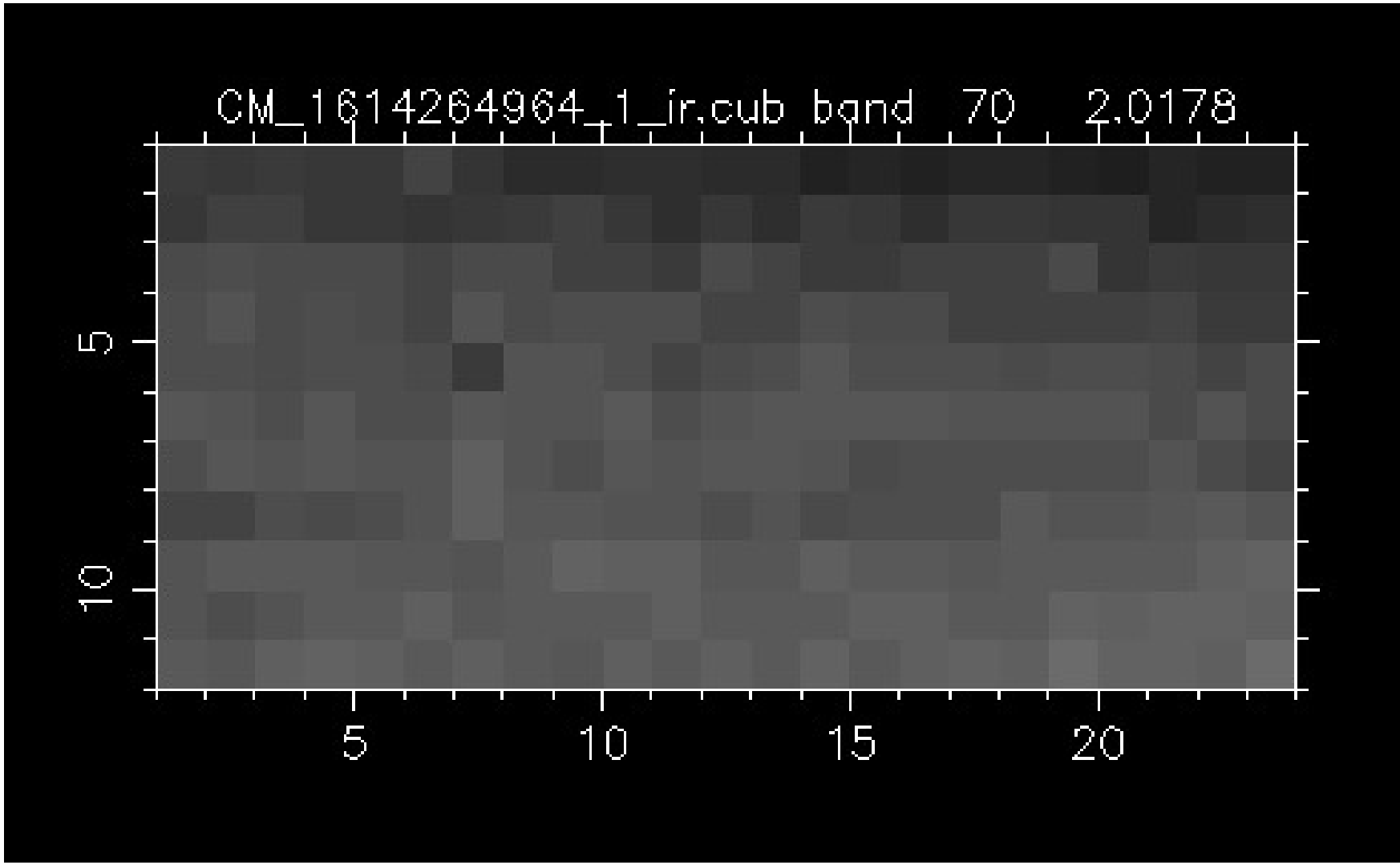
Dione ISS Image





No evidence for activity

Dione VIMS image (165º)



Summary

- All evidence (so far) shows Rhea is dead.
- MAPS evidence for Tethys and Dione.
- No evidence for Tethys, Dione, and Mimas in the VIMS data.
- No evidence in the ISS data for Dione
- Tethys and Mimas still being looked at
- Activity may be sporadic