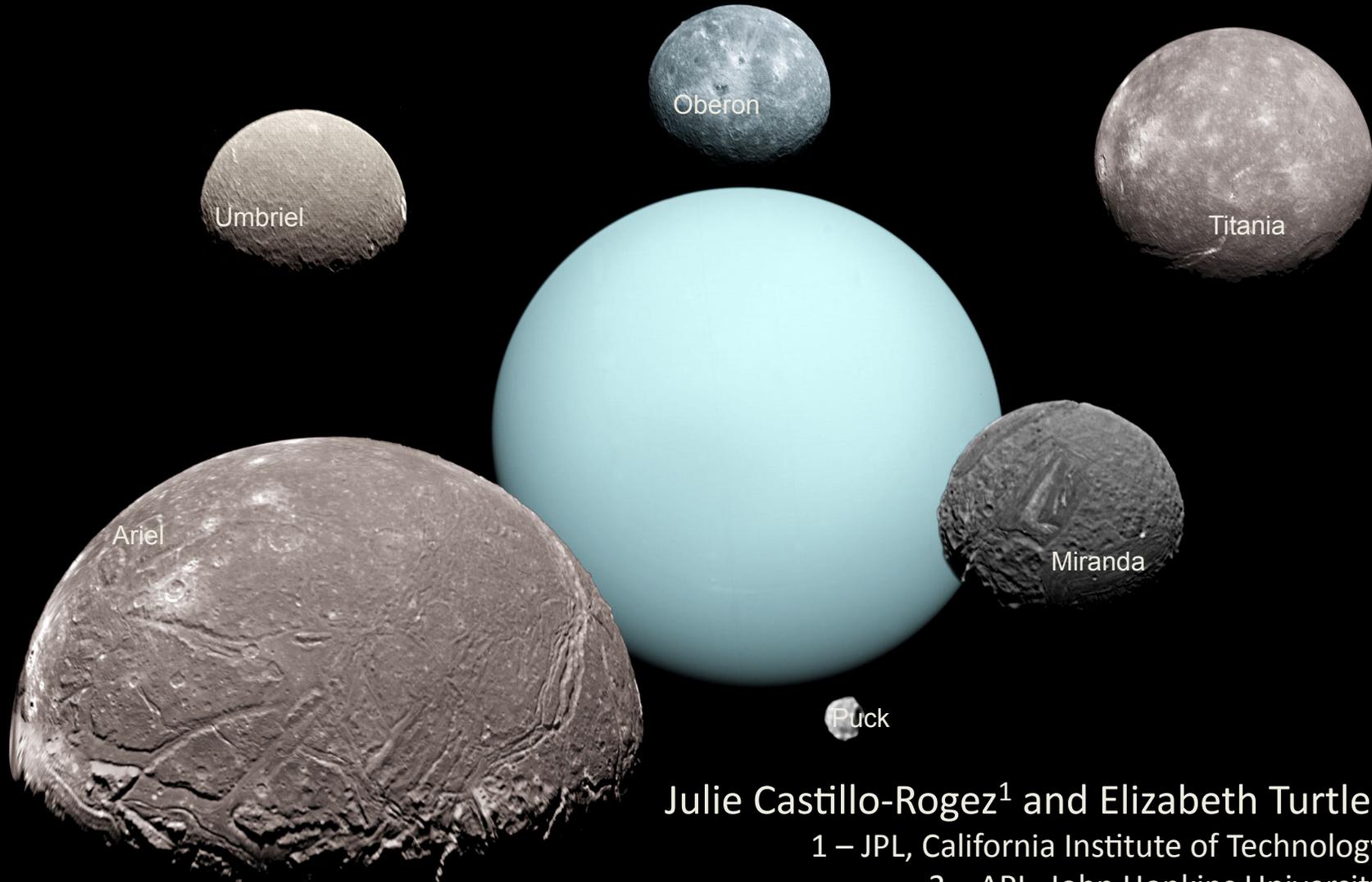


# Comparative Planetology between the Uranian and Saturnian Satellite Systems - Focus on Ariel



Julie Castillo-Rogez<sup>1</sup> and Elizabeth Turtle<sup>2</sup>

1 – JPL, California Institute of Technology

2 – APL, John Hopkins University

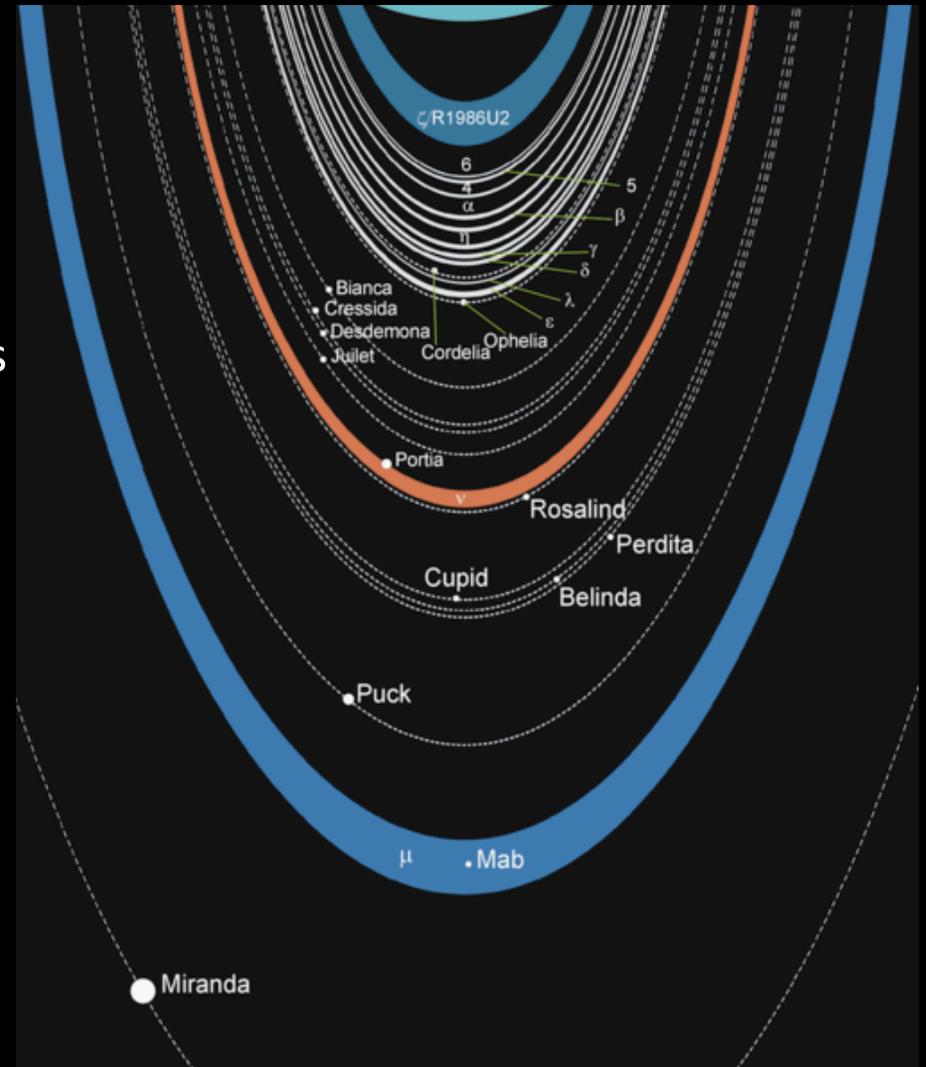
# Objectives

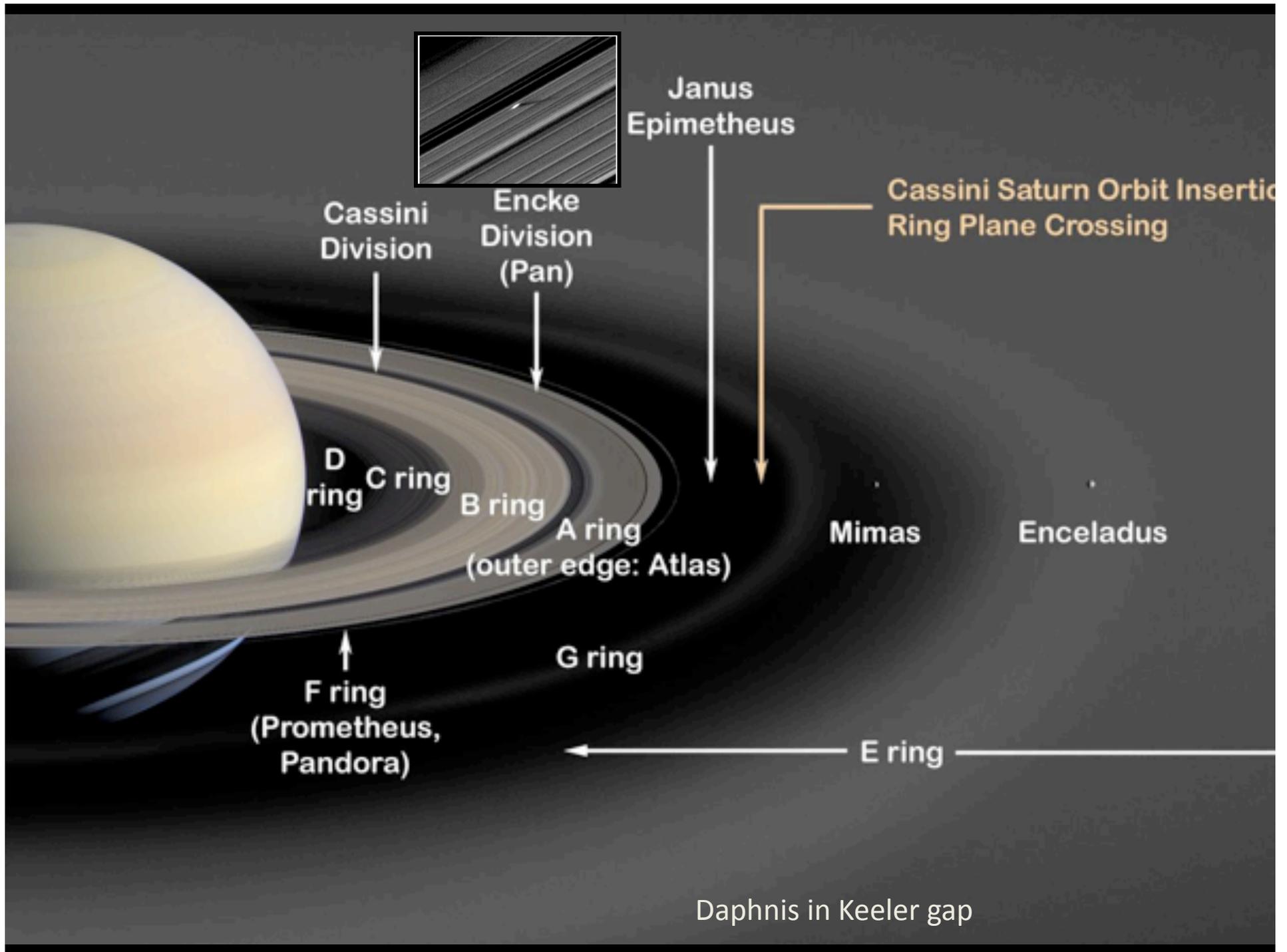
Revisit observations of *Voyager* in the Uranian system in the light of *Cassini-Huygens*' results

- Constrain planetary subnebula, satellites, and rings system origin
- Evaluate satellites' potential for endogenic and geological activity

# Uranian Satellite System

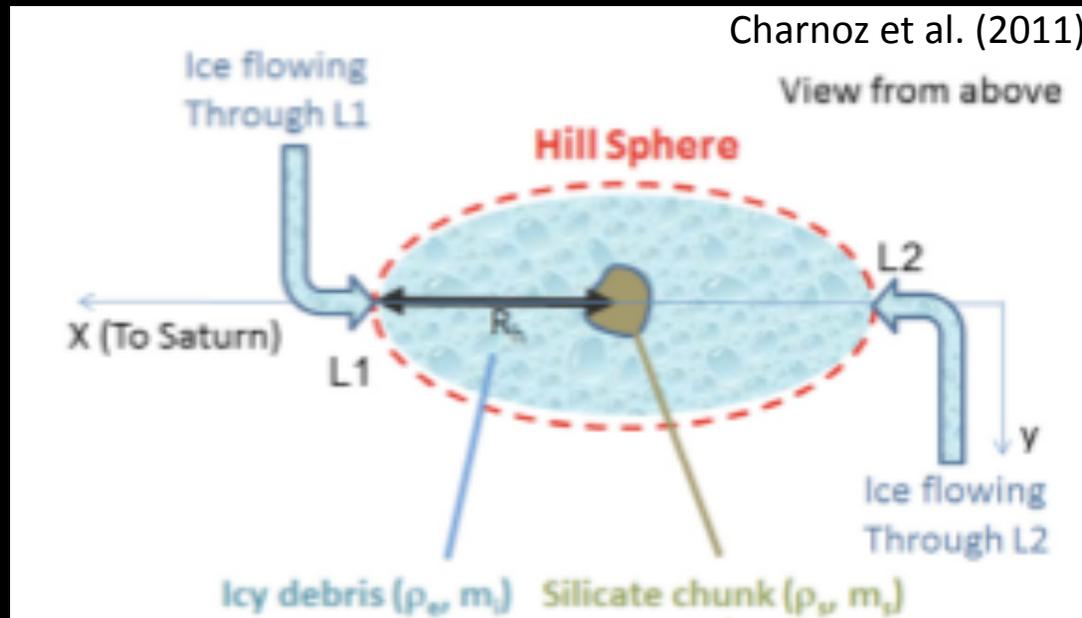
- Large population
- System architecture *almost* similar to Saturn's
  - “small” < 200 km embedded in rings
  - “medium-sized” > 200 km diameter
  - No “large” satellite
  - Irregular satellites
- Relatively high albedo
- CO<sub>2</sub> ice, possibly ammonia hydrates





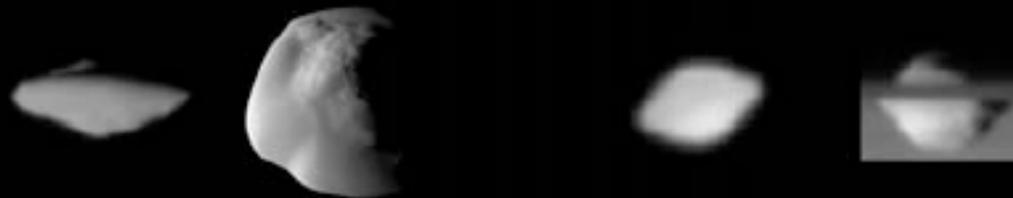
# Accretion in Rings?

Charnoz et al. (2011)



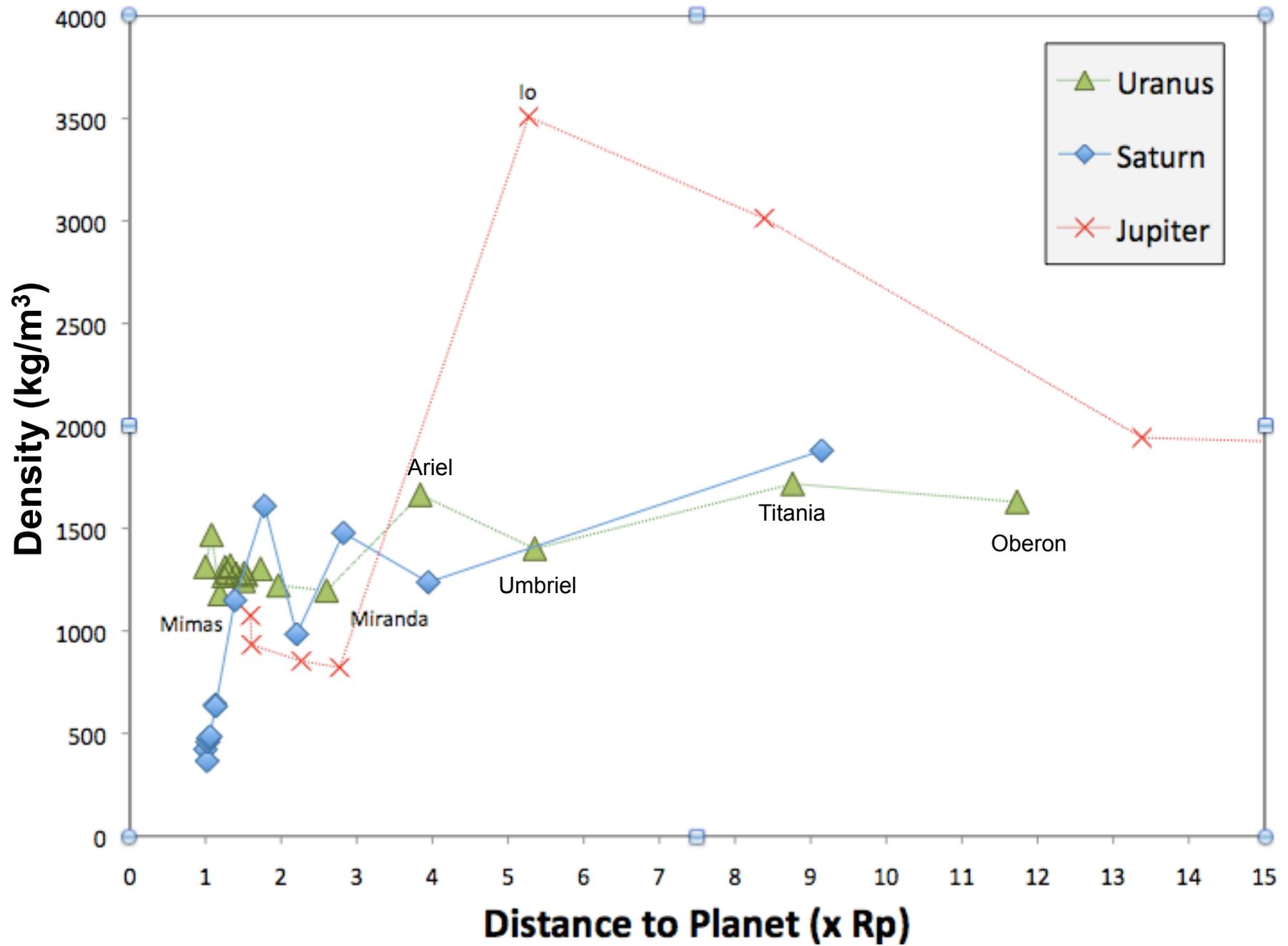
Atlas

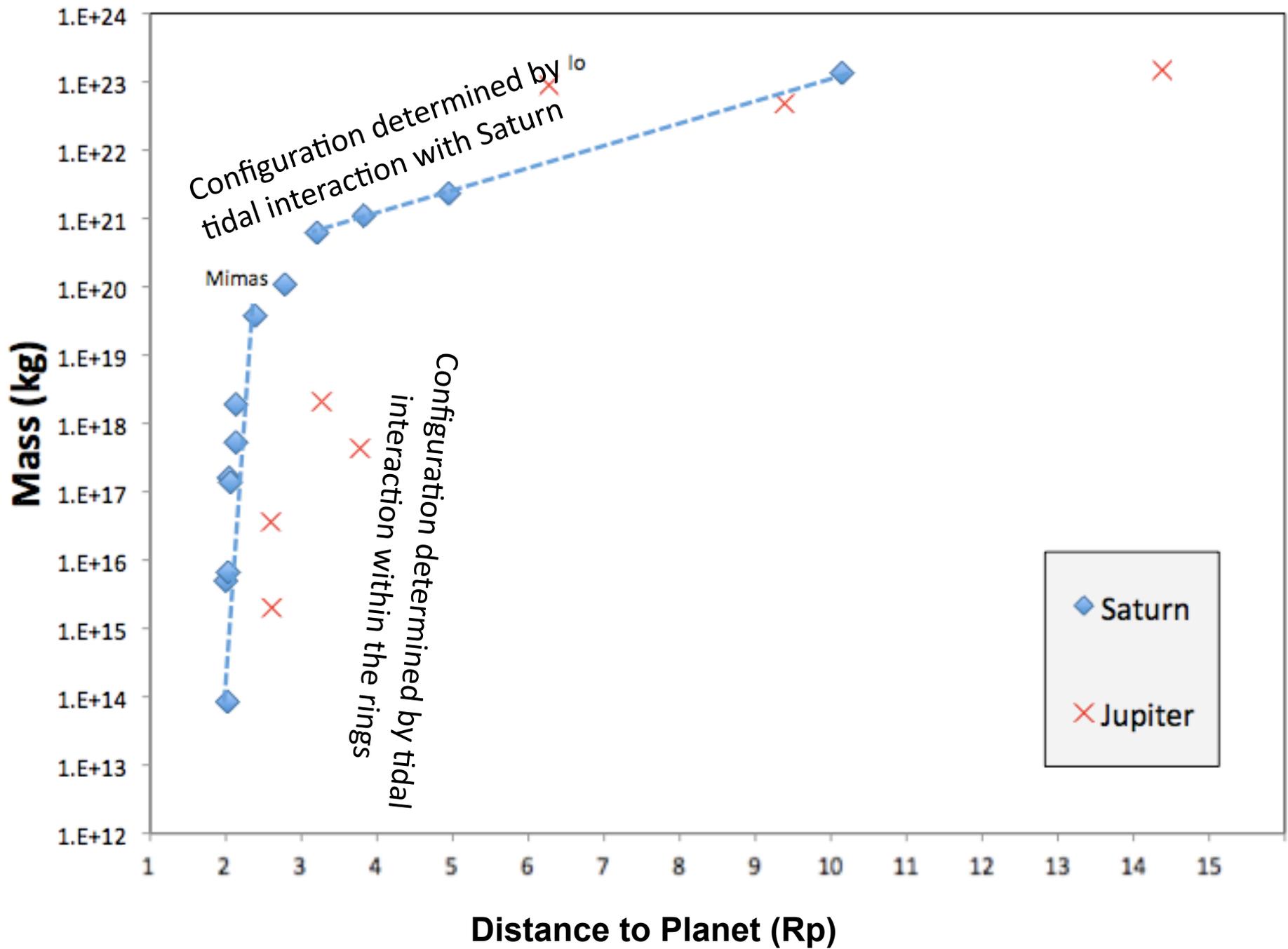
Pan

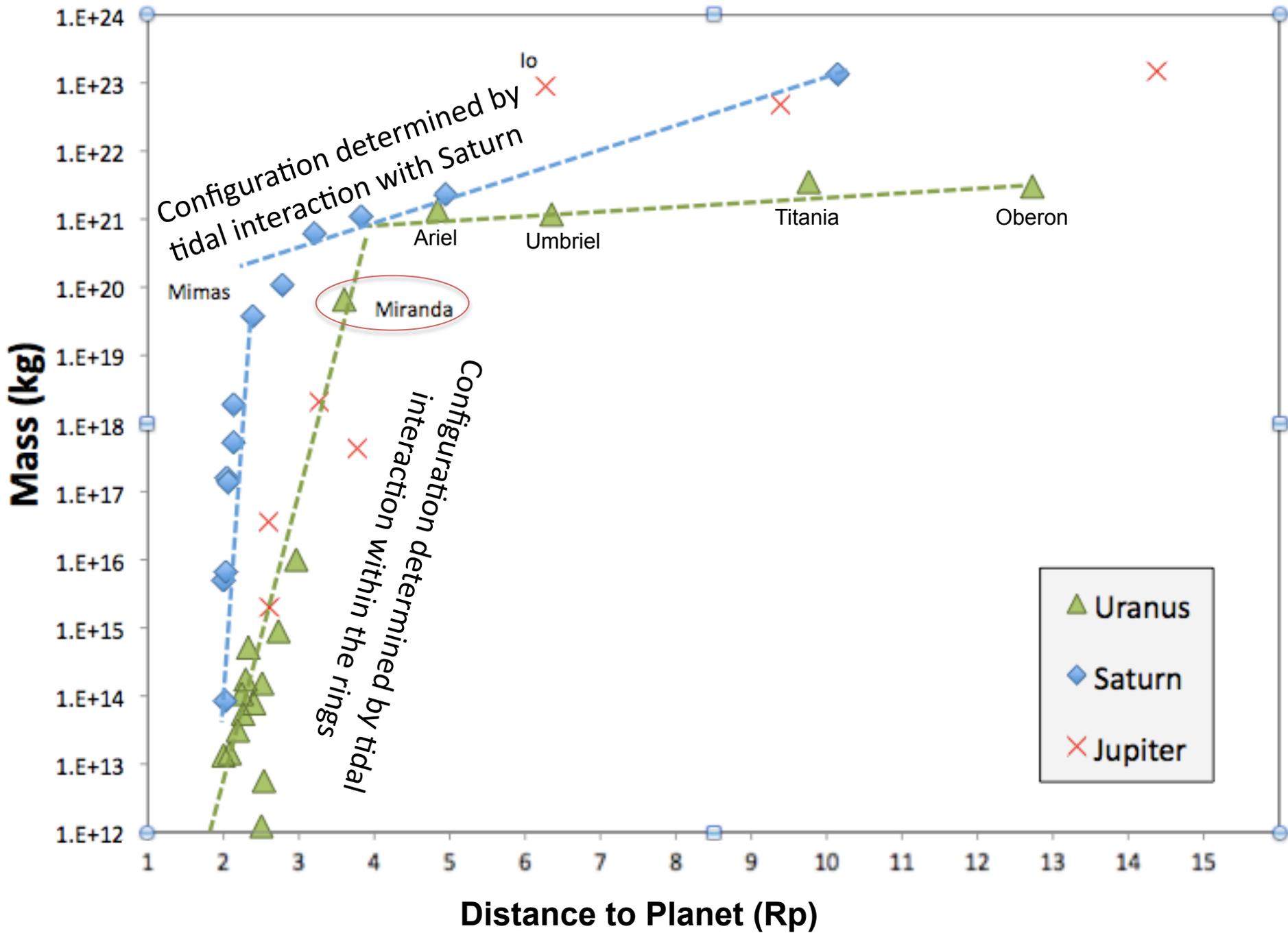


20 km

Porco et al. (2007)







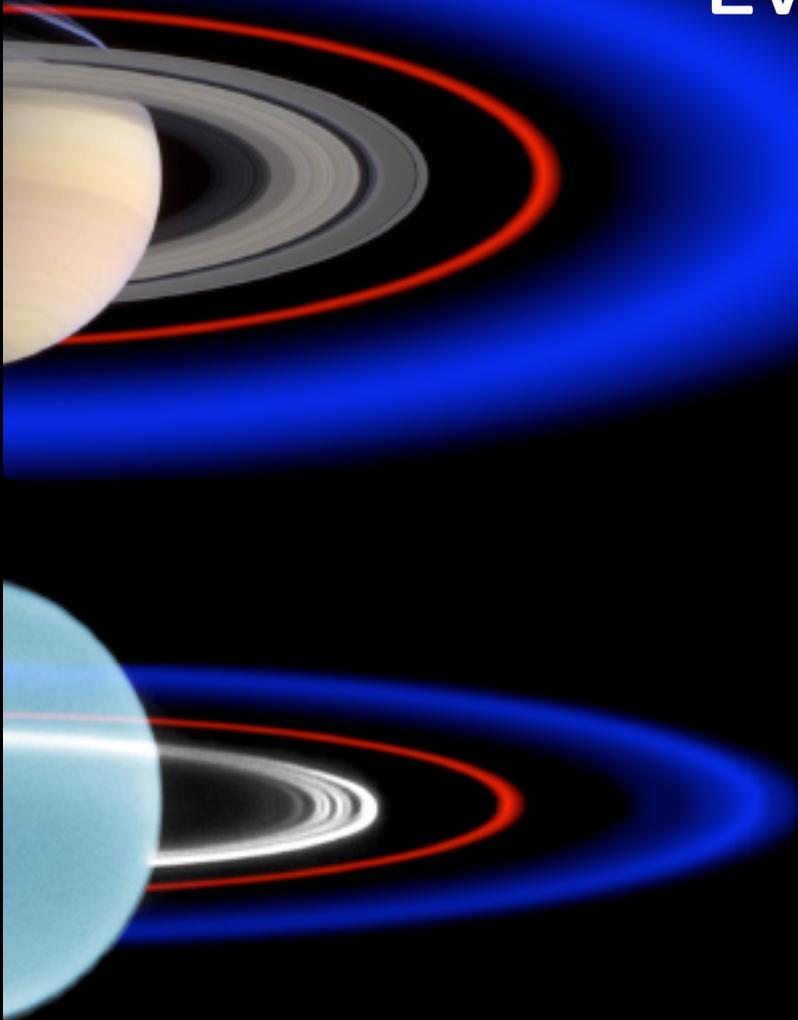
# Evidence for Activity?

“Blue” ring found in both systems

- ❖ Product of Enceladus’ outgassing activity
- ❖ Associated with Mab in Uranus’ system, but source if TBD

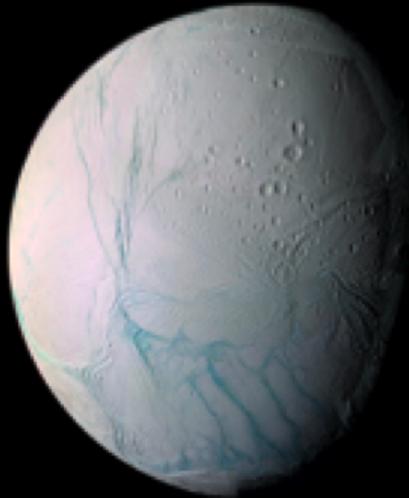
Evidence for past episode of activity in Uranus’ satellite?

Saturn’s and Uranus’ rings systems – both planets are scaled to the same size (Hammel 2006)

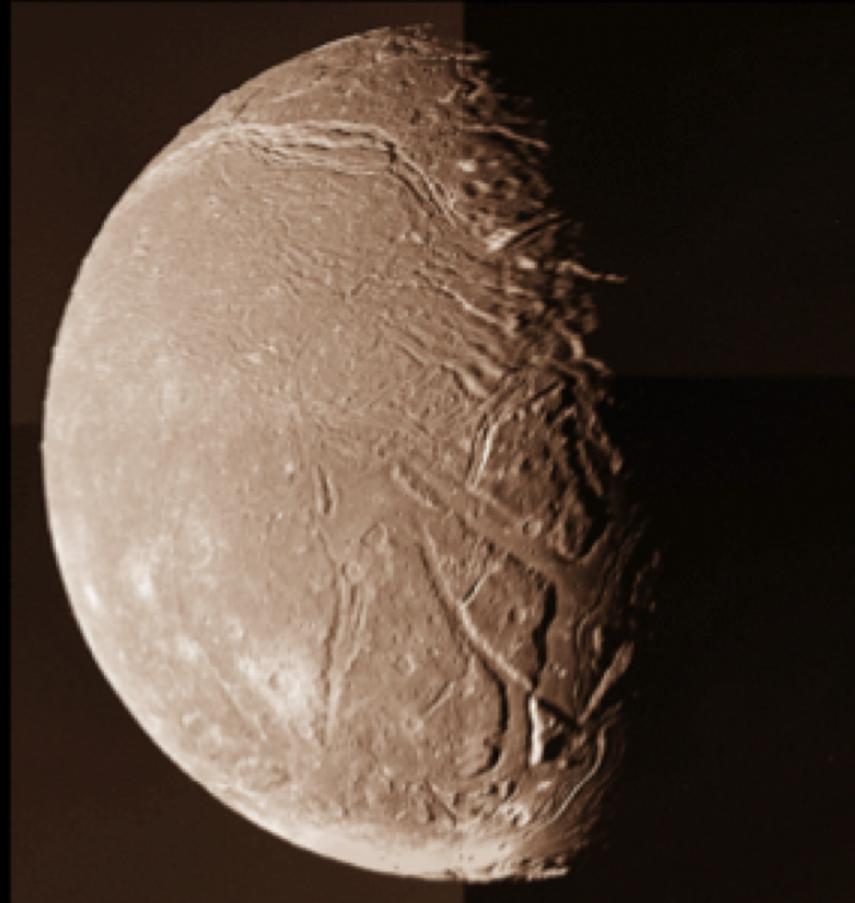


ENCELADUS

$$\rho = 1607 \text{ kg/m}^3$$
$$x_s = 0.57$$



ARIEL



MIRANDA

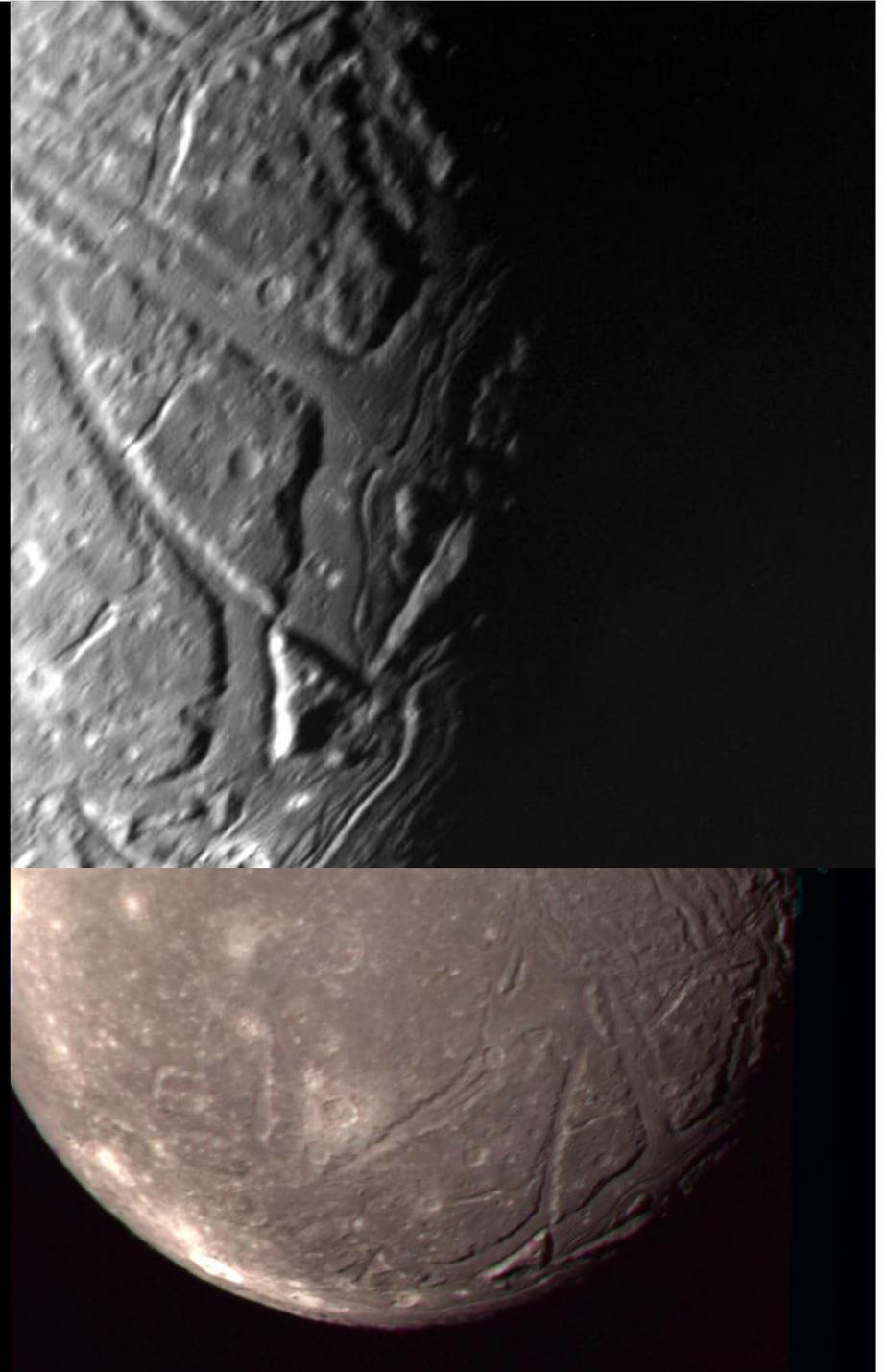
$$\rho = 1201 \text{ kg/m}^3$$
$$x_s = 0.38$$
$$\frac{dE}{dt}_{\text{mir}} \sim \frac{dE}{dt}_{\text{enc}}$$

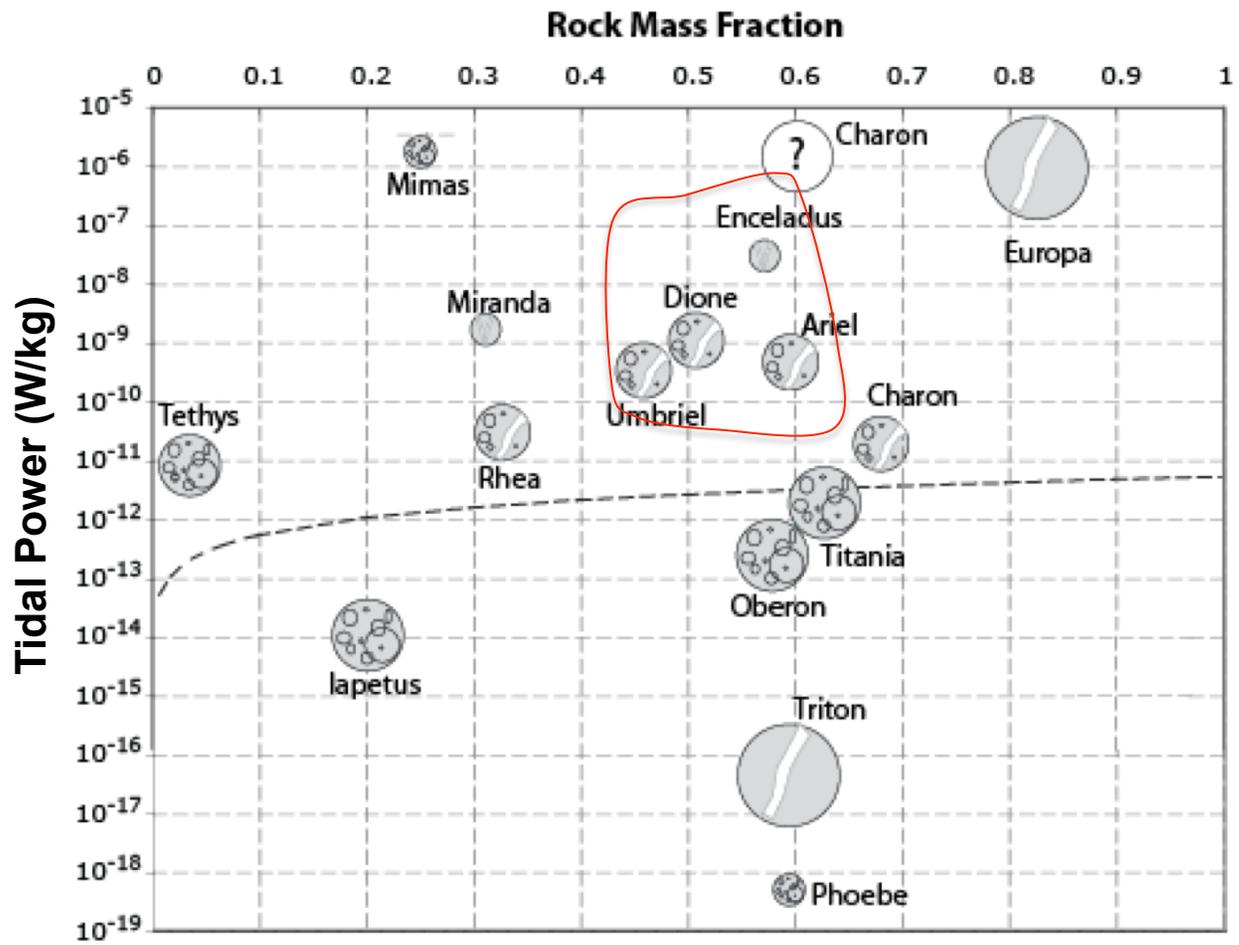


$$\rho = 1665 \text{ kg/m}^3$$
$$x_s = 0.62$$
$$\frac{dE}{dt}_{\text{ari}} \sim 5 \frac{dE}{dt}_{\text{enc}}$$

# Ariel

- Comparatively low crater density
  - Deficient in 100-km craters
- Extensional tectonics
  - Graben
  - Tilted blocks
- Cryovolcanic units
  - Convex valley floor units with marginal troughs 1-2 km deep (extend past ends of canyons)
  - Flows override craters
  - 100s m to kms thick
- Multiple stages of tectonism and volcanism are interleaved, causally related?





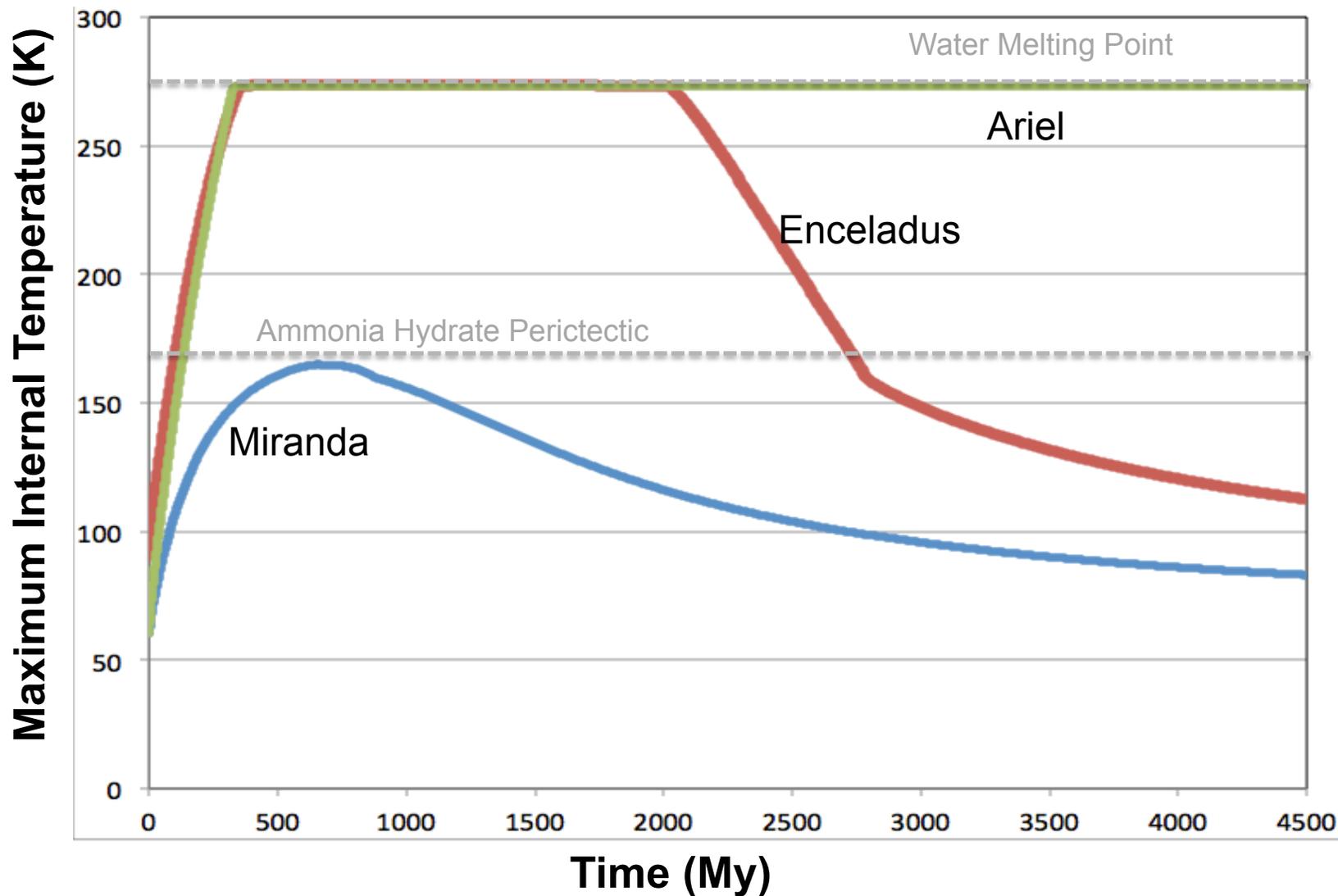
Castillo-Rogez and Lunine (2012)

**OBJECT RADIUS**

**SURFACE STATE**

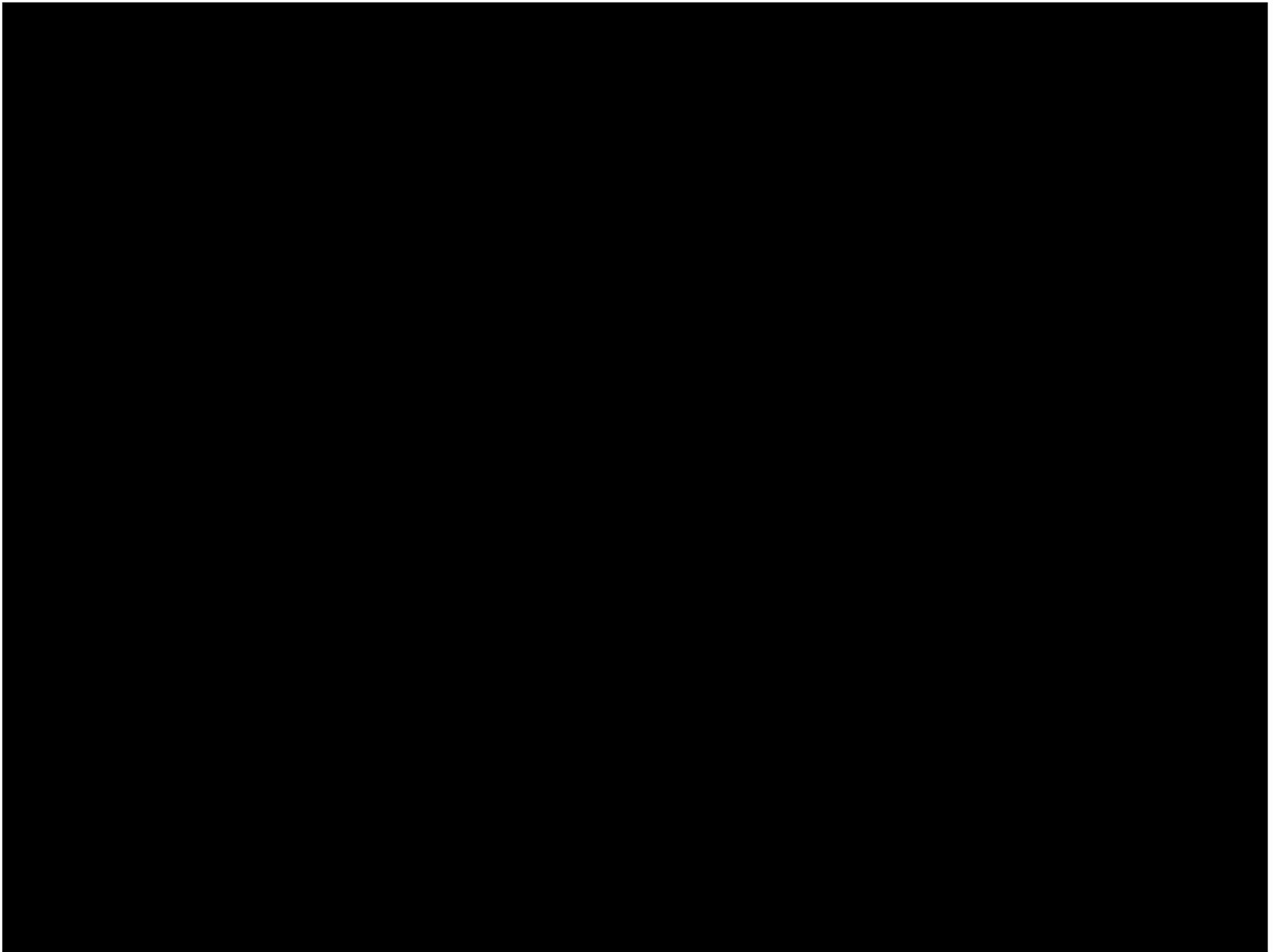
# Maximum Temperature

Does not include resonances



# Preliminary Conclusions

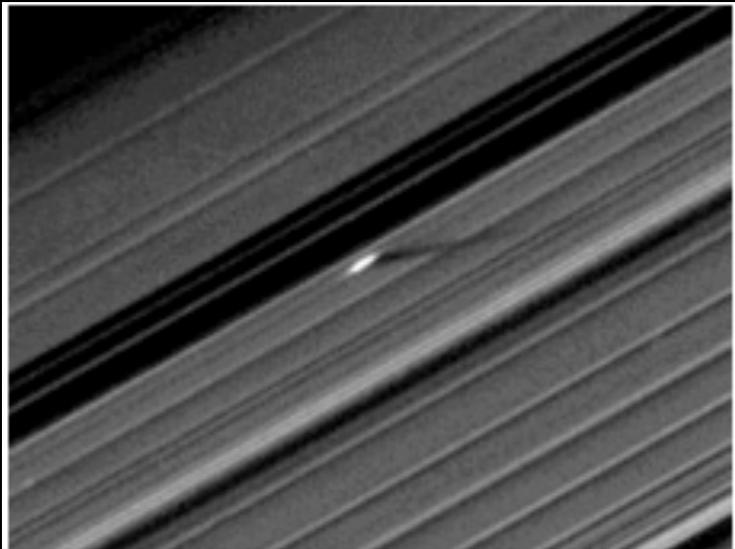
- Uranus satellite system may have formed in the rings
  - Strong resemblance with Saturn system
  - Full model needs to be developed
- Ariel offers high potential for *recent* endogenic activity
  - Depends on detailed orbital evolution (resonances)
  - If Ariel formed from rings then could have had episodes of activity while migrating outward



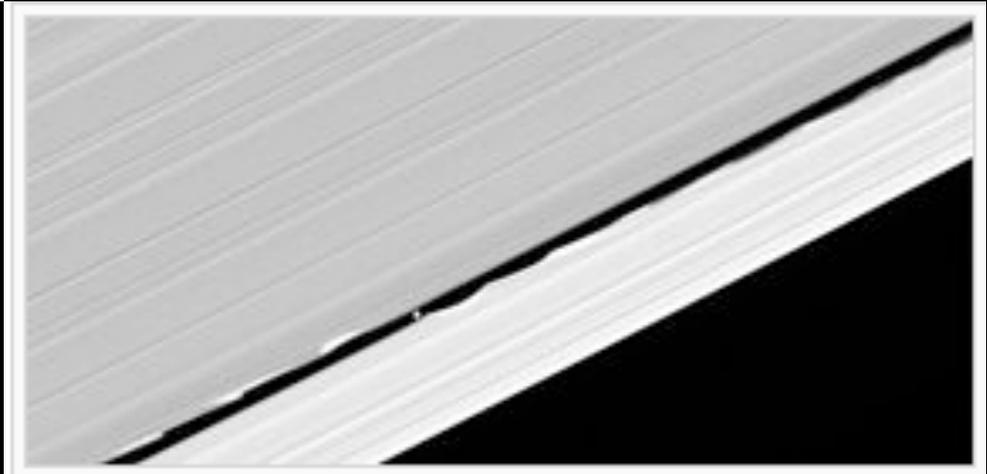
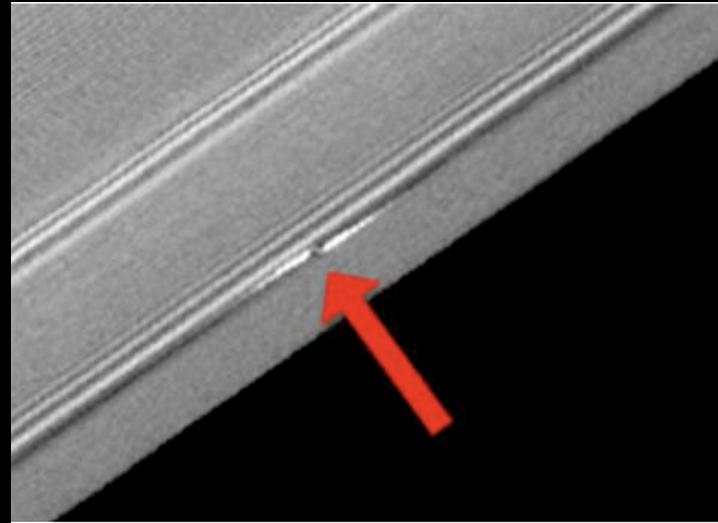
# Accretion in Rings

- Chunks of silicates accrete an ice shell
- Proto-moons migrate outward by tidal interaction with the rings
- Ice-dominated satellites formed at the ring outer edge (beyond Roche limit)
- Final silicate mass fraction is a function of chunk size and collision between rock-rich and ice-dominated proto-moons prior exit

# Moonlets

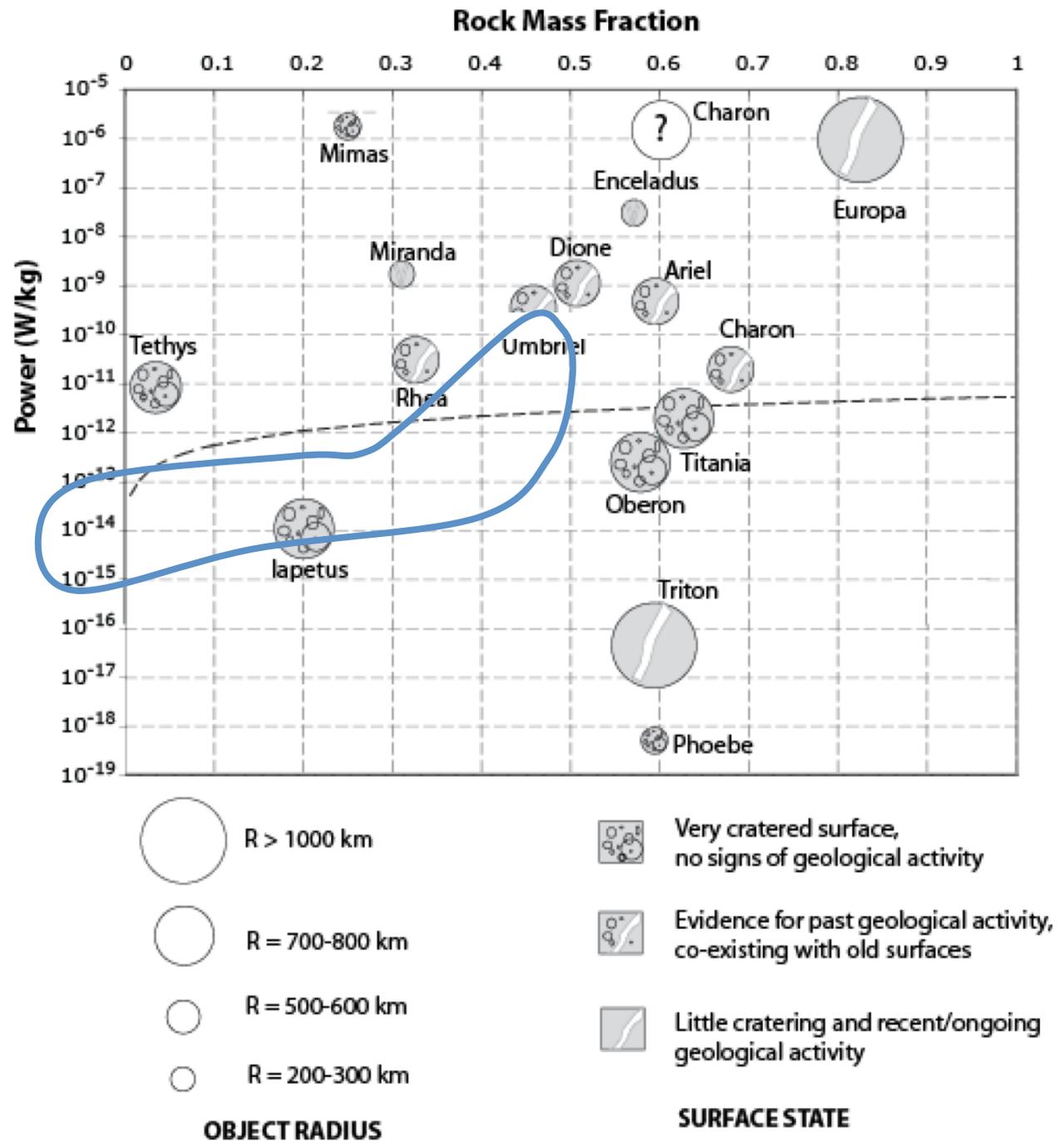


Propeller near Encke gap



Daphnis in Keeler gap

Castillo-Rogez and Lunine, CUP, in press.



Titania



1500 km

Rhea



Oberon

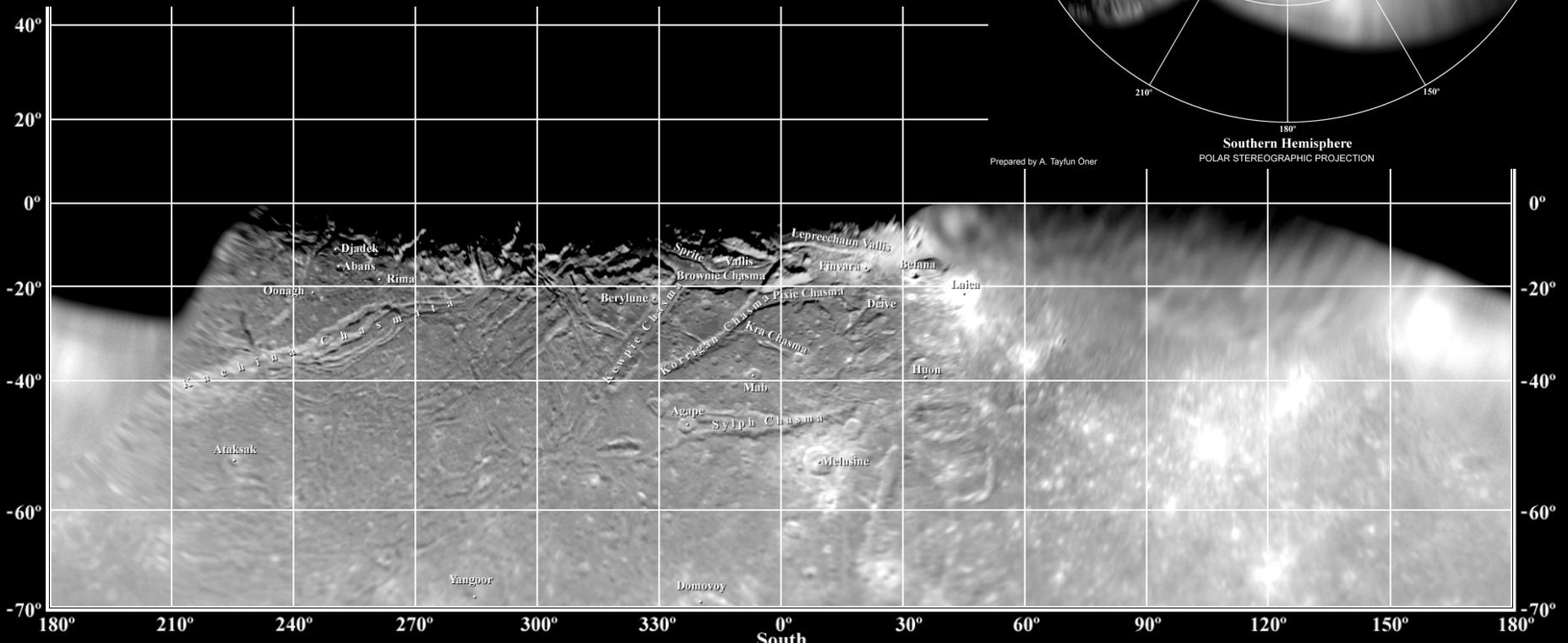
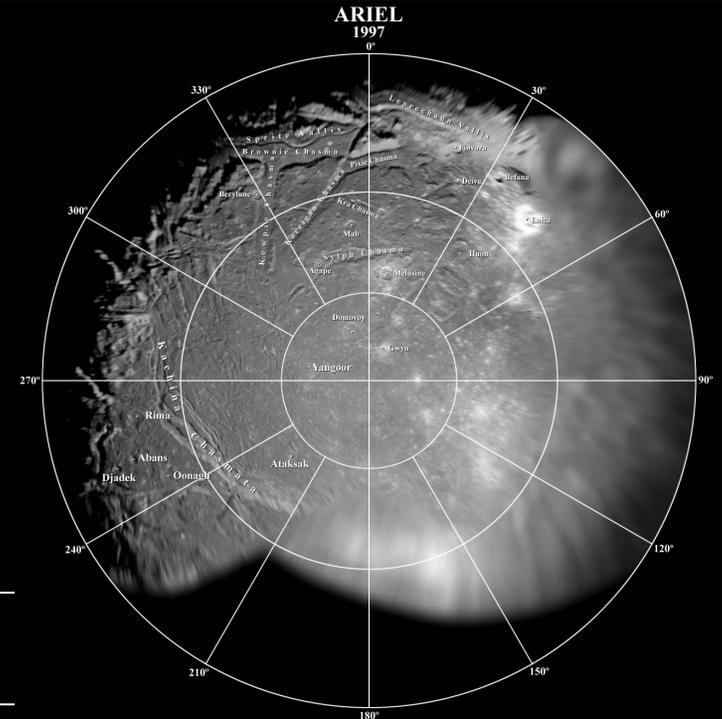


# Ariel, R = 579 km

best resolution ~300 m

triaxial shape consistent with hydrostatic equilibrium (581x578x578)

topographic features up to 4 km



Prepared by A. Tayfun Öner

Southern Hemisphere  
POLAR STEREOGRAPHIC PROJECTION

Trailing Hemisphere

Uranus Facing Hemisphere  
Scale 5 Pixel/Degree at 0° Latitude  
MERCATOR PROJECTION

Leading Hemisphere

# 27 Uranian Satellites

Satellite	Distance (000 km)	Radius (km)	Mass (kg)	Discoverer	Date
• Cordelia	50	13	?	Voyager 2	1986
• Ophelia	54	16	?	Voyager 2	1986
• Bianca	59	22	?	Voyager 2	1986
• Cressida	62	33	?	Voyager 2	1986
• Desdemona	63	29	?	Voyager 2	1986
• Juliet	64	42	?	Voyager 2	1986
• Portia	66	55	?	Voyager 2	1986
• Rosalind	70	27	?	Voyager 2	1986
• Cupid (2003U2)	75	6	?	Showalter	2003
• Belinda	75	34	?	Voyager 2	1986
• Perdita	76	40	?	Voyager 2	1986
• Puck	86	77	?	Voyager 2	1985
• Mab (2003U1)	98	8	?	Showalter	2003
• Miranda	130	236	6.30e19	Kuiper	1948
• Ariel	191	579	1.27e21	Lassell	1851
• Umbriel	266	585	1.27e21	Lassell	1851
• Titania	436	789	3.49e21	Herschel	1787
• Oberon	583	761	3.03e21	Herschel	1787
• Francisco	4281	6	?	Holman	2003
• Caliban	7169	40	?	Gladman	1997
• Stephano	7948	15	?	Gladman	1999
• Trinculo	8578	5	?	Holman	2001
• Sycorax	12213	80	?	Nicholson	1997
• Margaret	14689	6	?	Sheppard	2003
• Prospero	16568	20	?	Holman	1999
• Setebos	17681	20	?	Kavelaars	1999
• Ferdinand	21000	6	?	Sheppard	2003

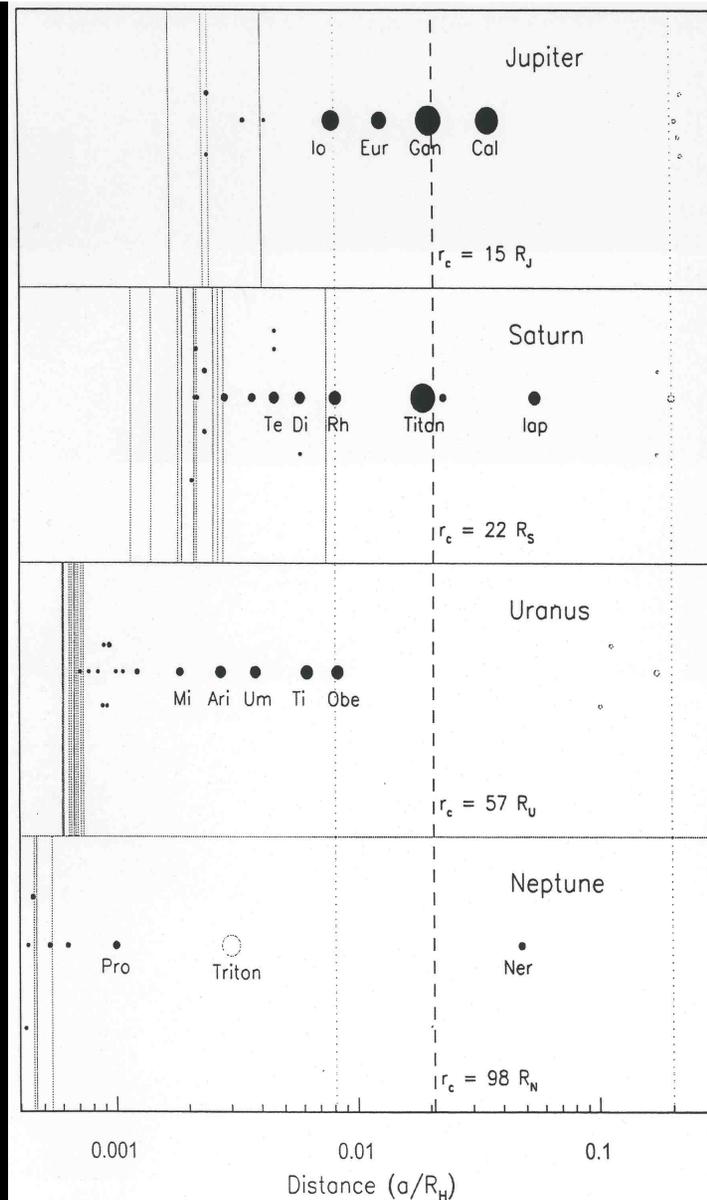


Fig. 1 Moons of the giant planets. The (logarithmic) horizontal axis gives the relative distance from the planet. In contrast to the irregular satellites (empty dots), the regular satellites (solid dots) formed within circumplanetary gas and dust disks.

# Ariel, $R = 579$ km

- best imaging 1.3 km/lp
- deficient in 100-km craters, comparatively low crater density
- possible population of degraded or buried ancient craters
- shallow – intrusive or extrusive cryovolcanism or relaxation?
- high-albedo ejecta (related to flow material?)

