HYPERION: The Sponge Moon

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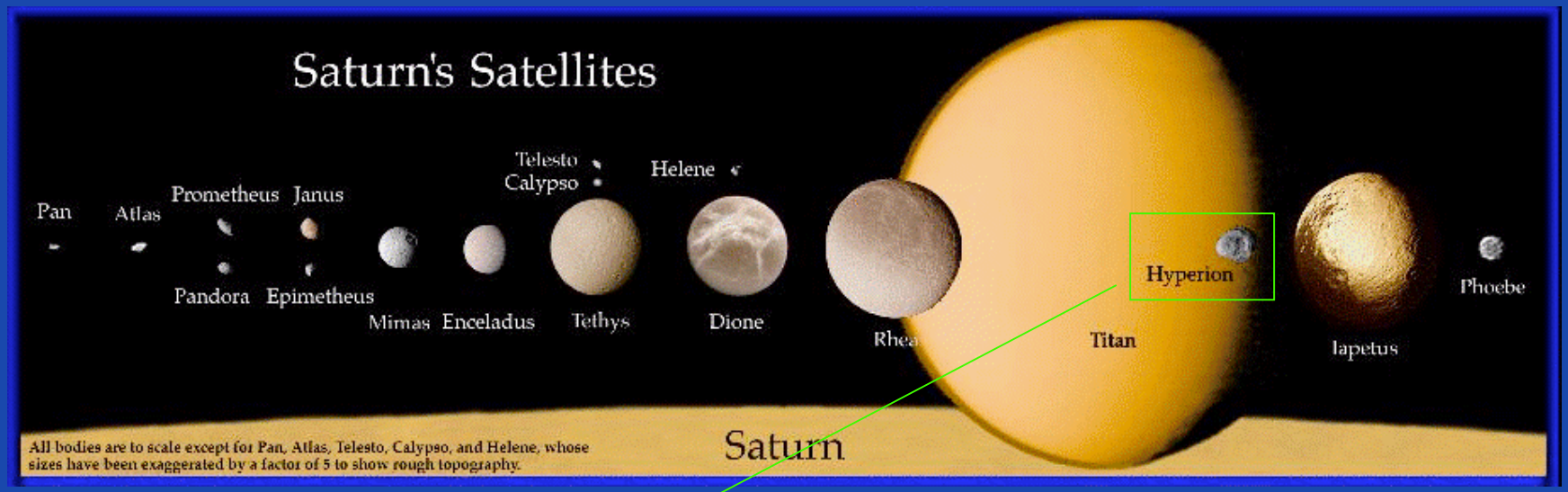
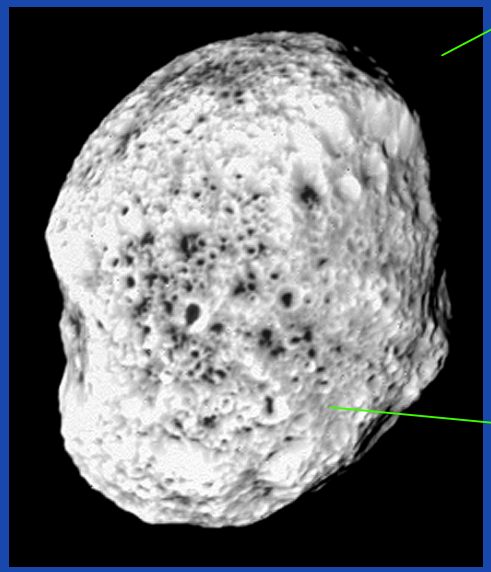
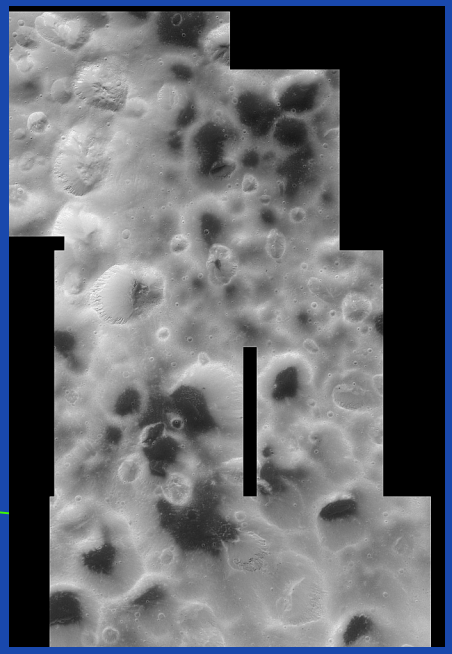
Hyperion & the Saturnian System

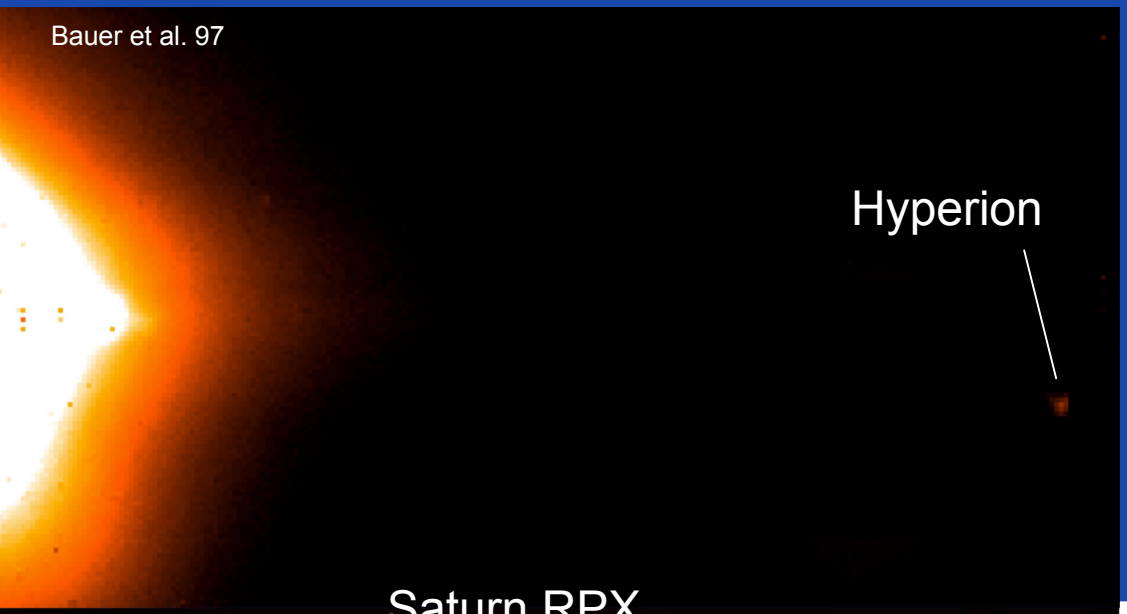




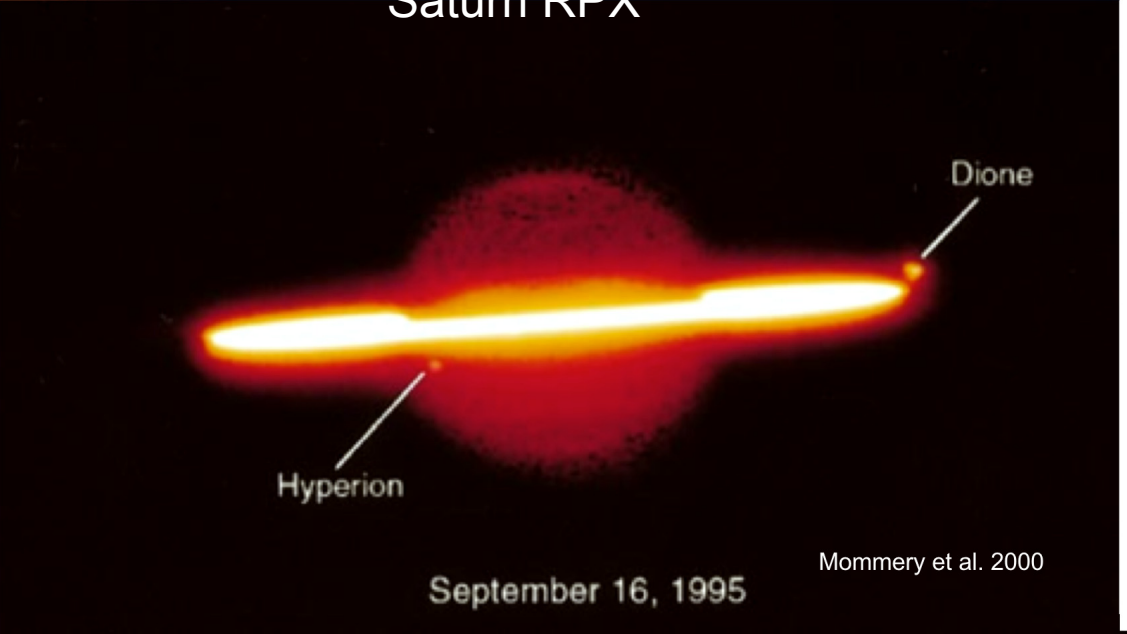


Hyperion from the Ground

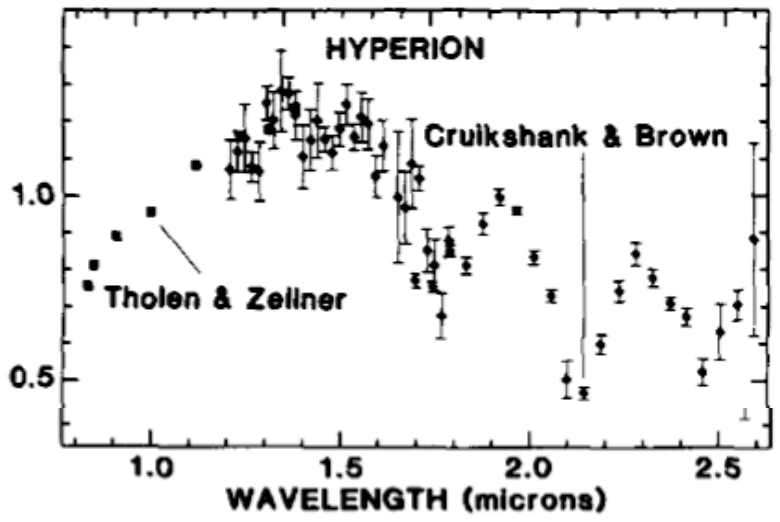
Bauer et al. 97



Saturn RPX

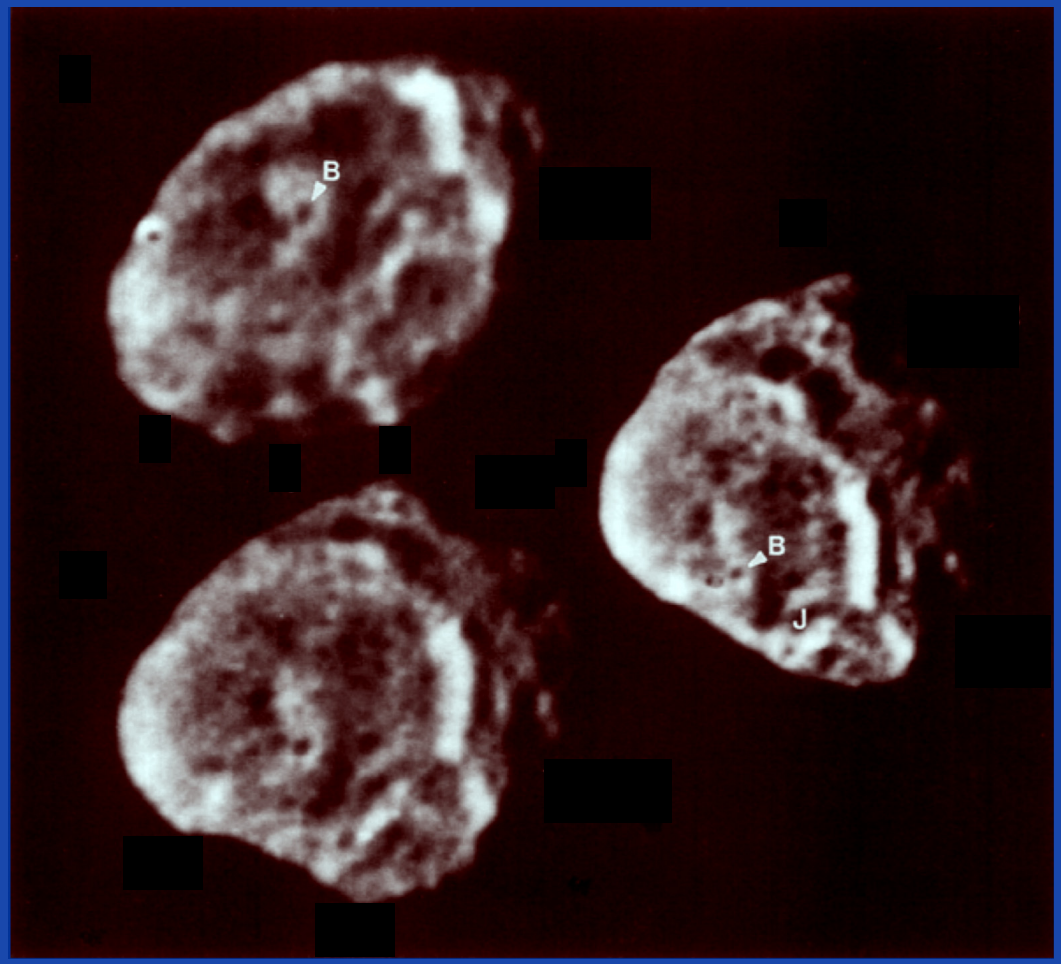


Mommery et al. 2000



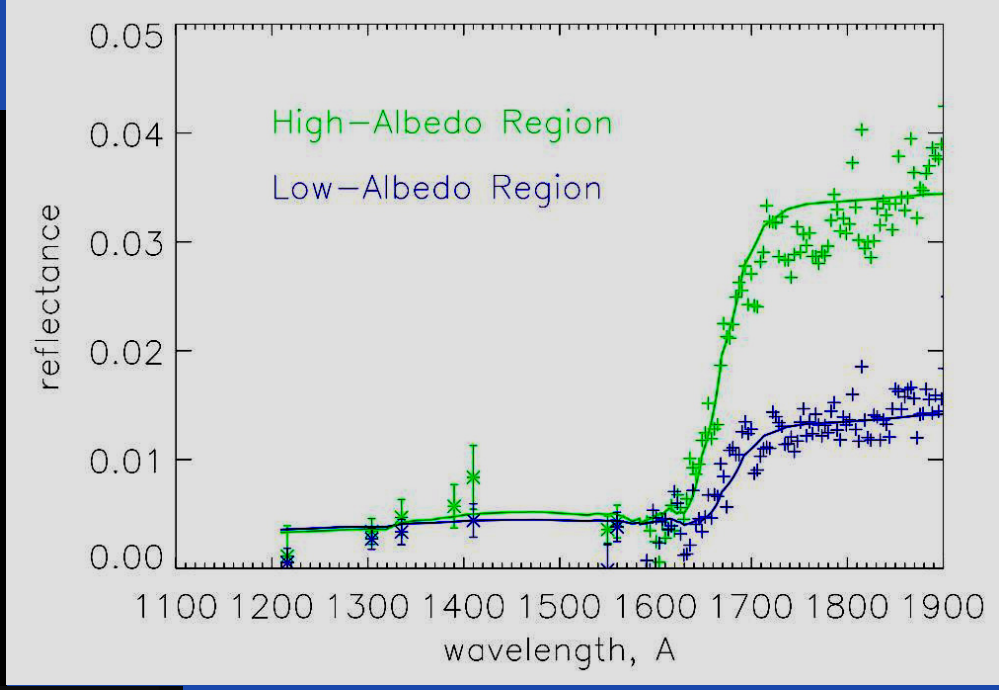
R. H. Brown 85

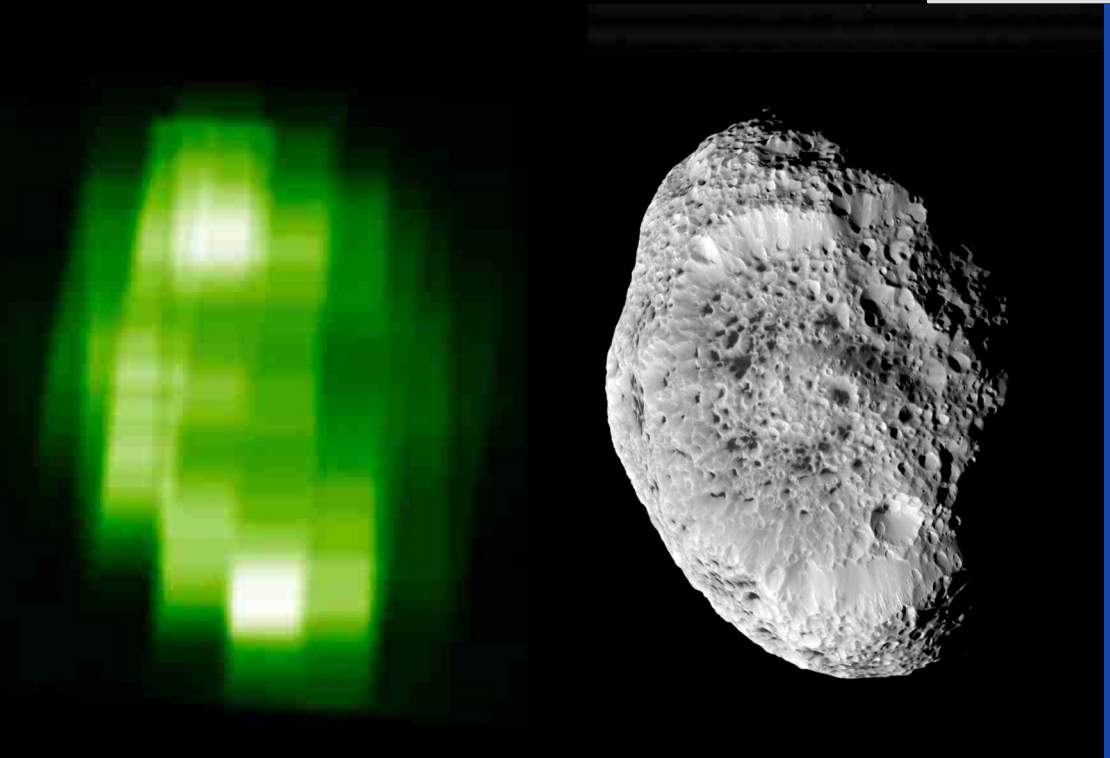
Hyperion & Voyager



Hyperion's Icy Surface

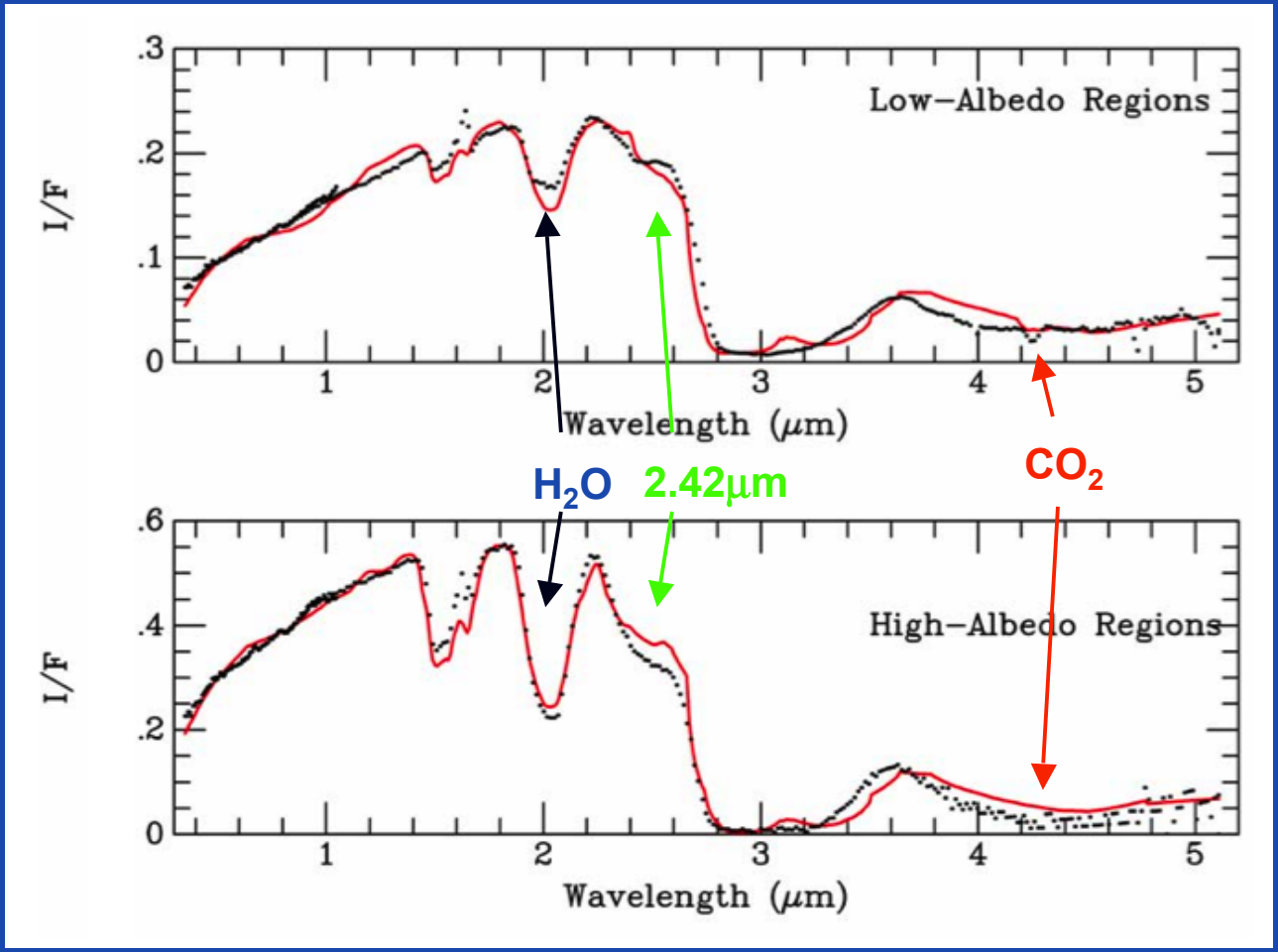
VIMS





Brightest regions are exposed water ice in the rim of the crater that dominates the hemisphere in view (Hendrix & Hansen, 2007).

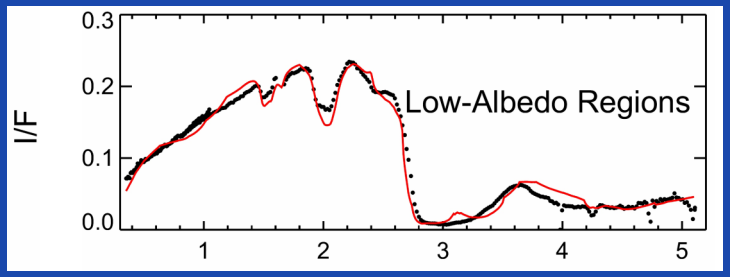
Spectra of bright and dark regions

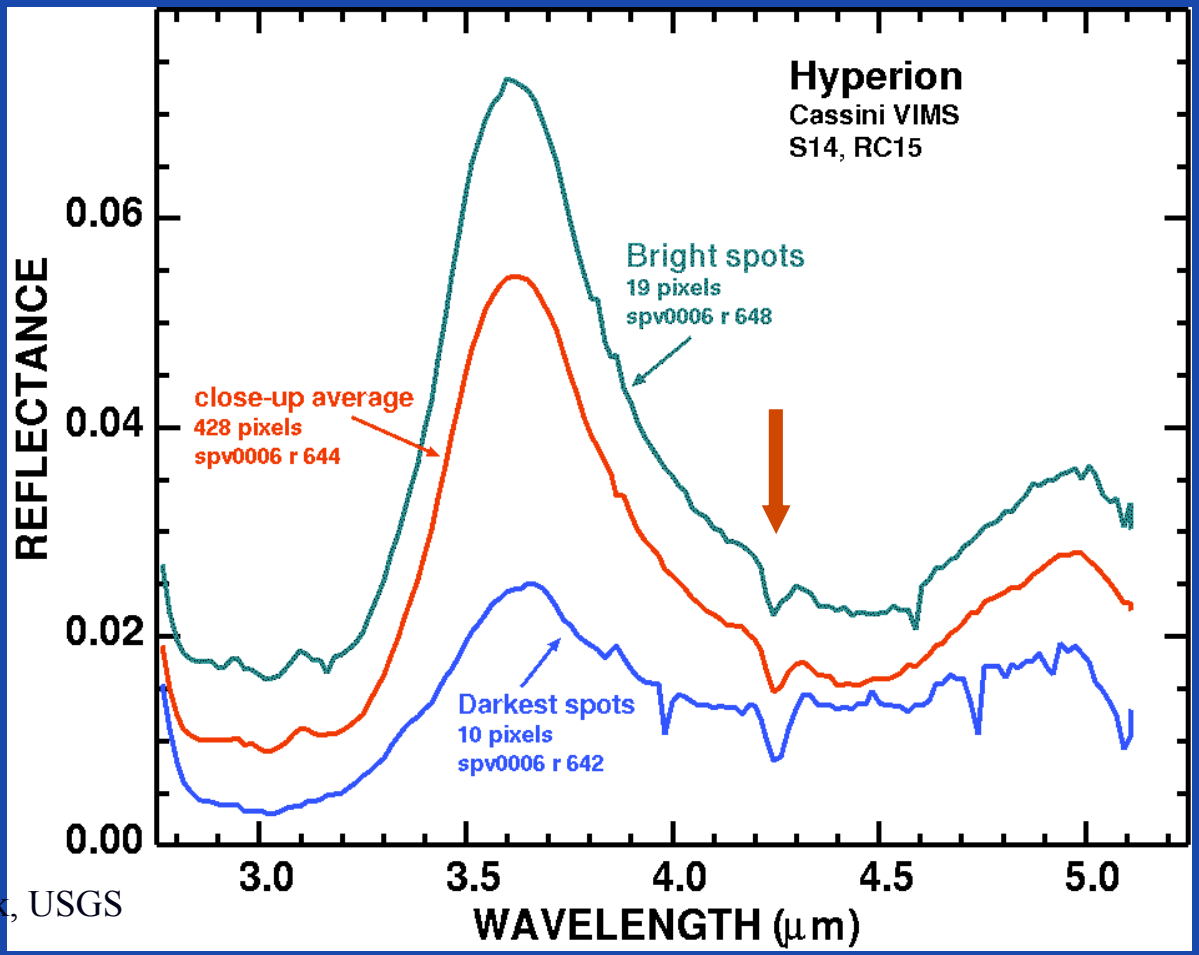


CO_2 on high- and low-albedo regions of Hyperion

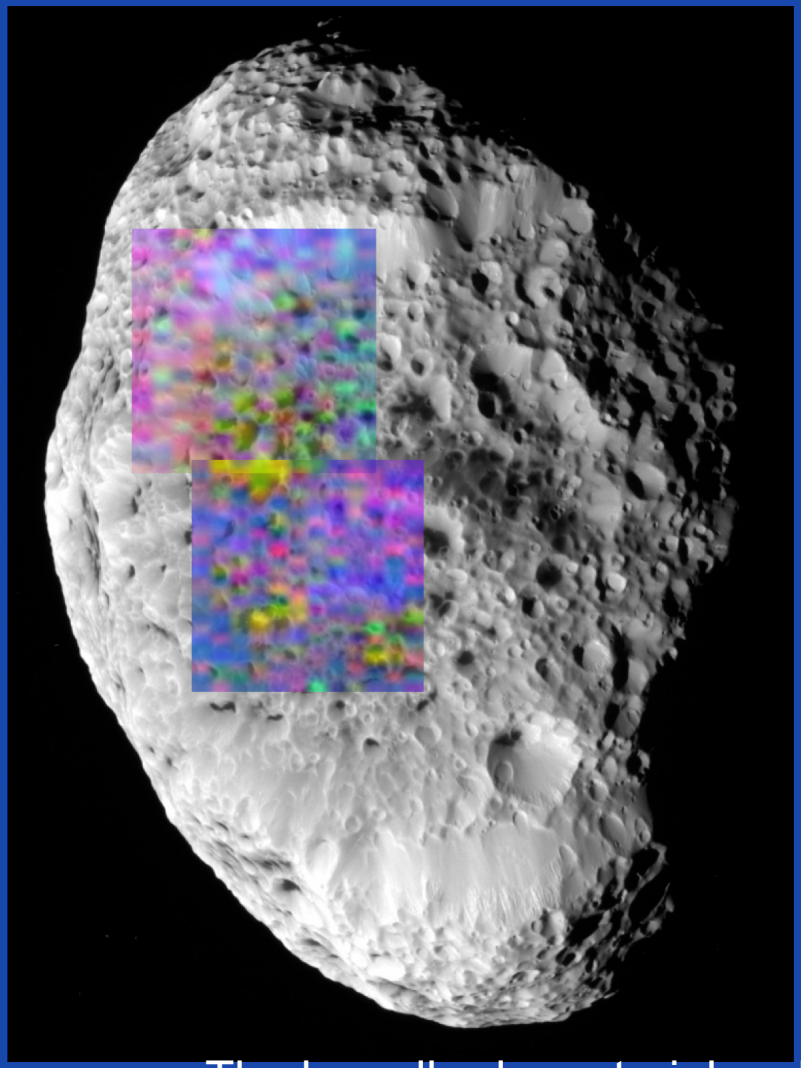
R. Clark, USGS

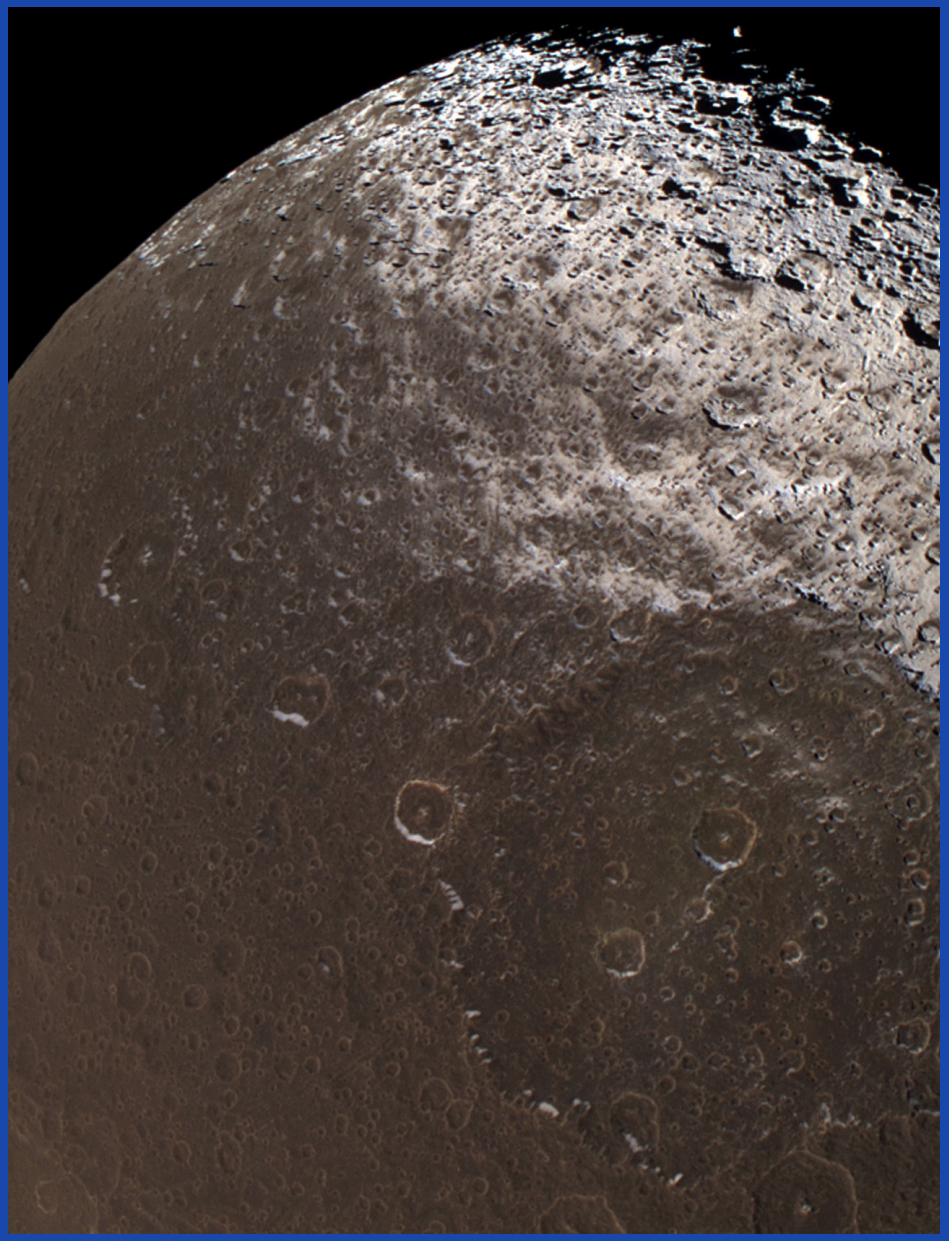
Full spectrum with model, Cruikshank et al. 2007





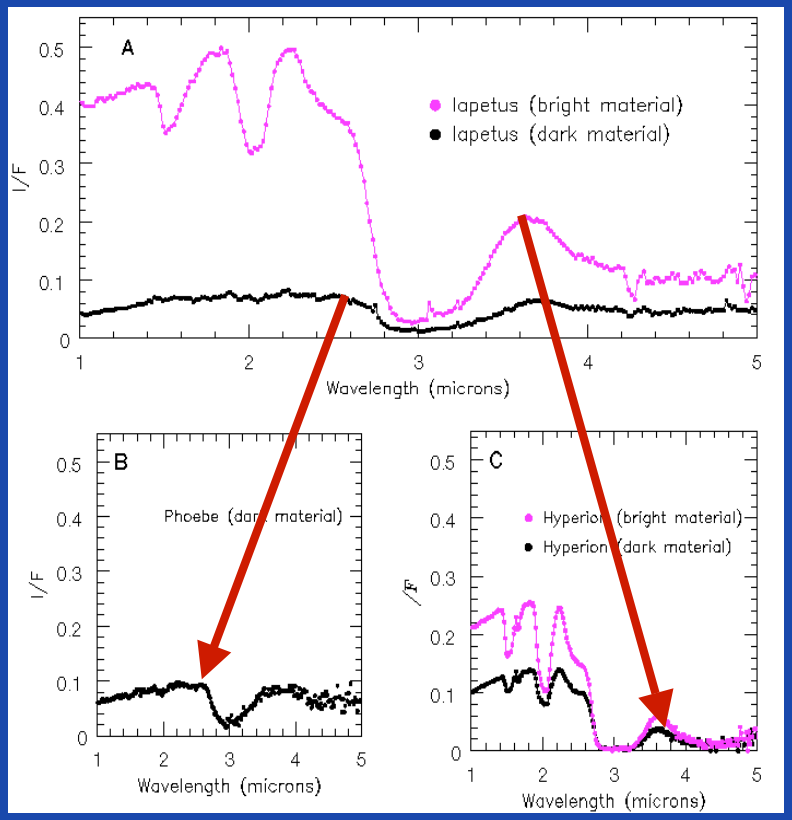
Compositional maps of Hyperion

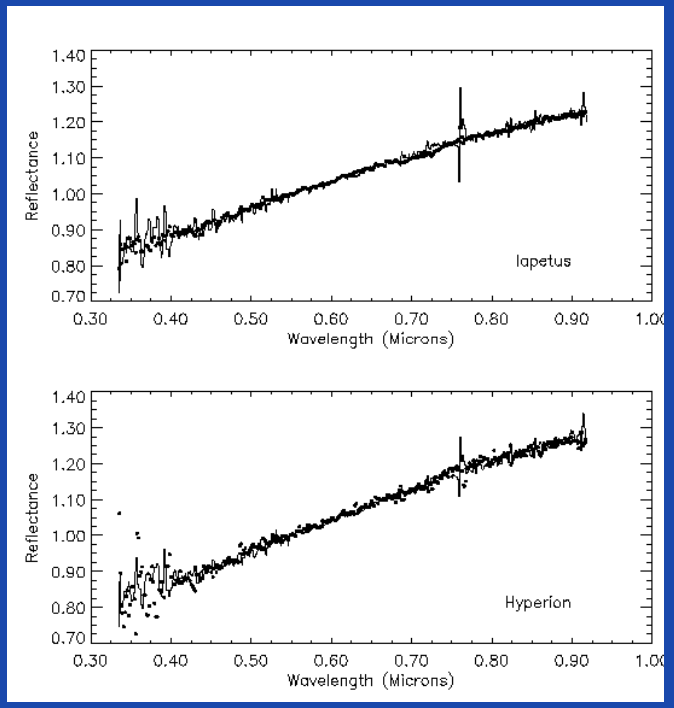


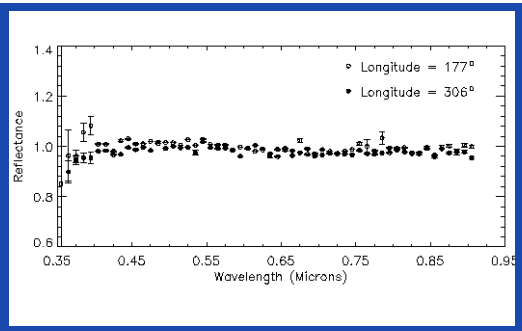


The low-albedo material on Hyperion (in the craters) appears to be The same as that on Saturn's other satellite, Iapetus.

Origin of dark material?

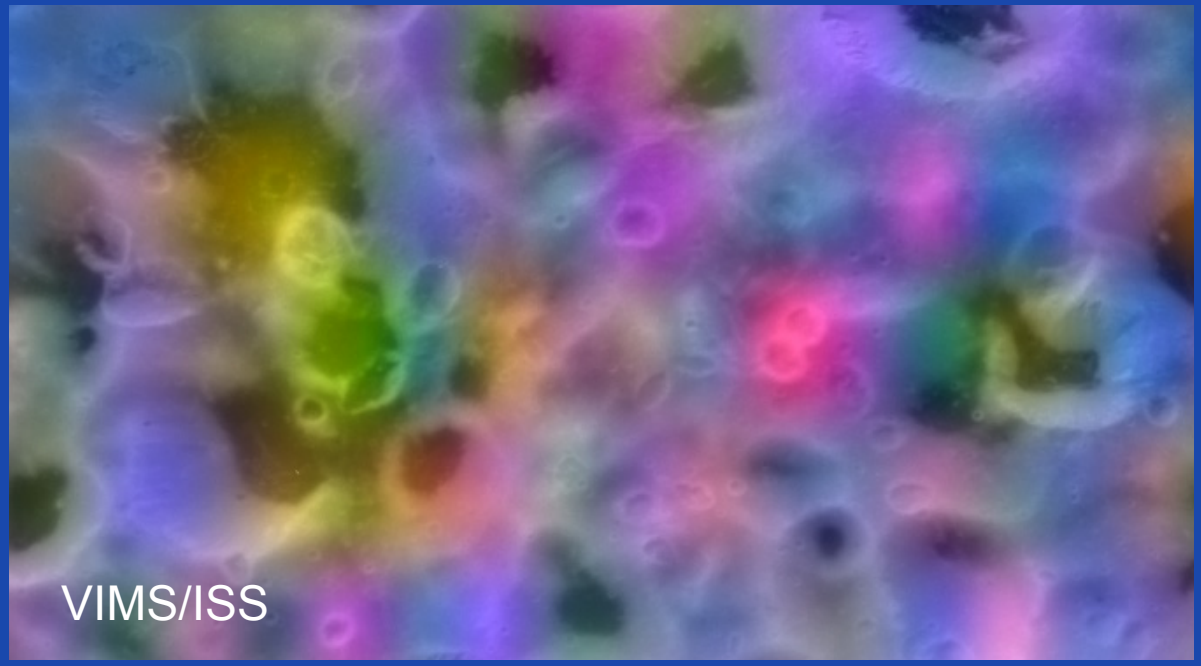


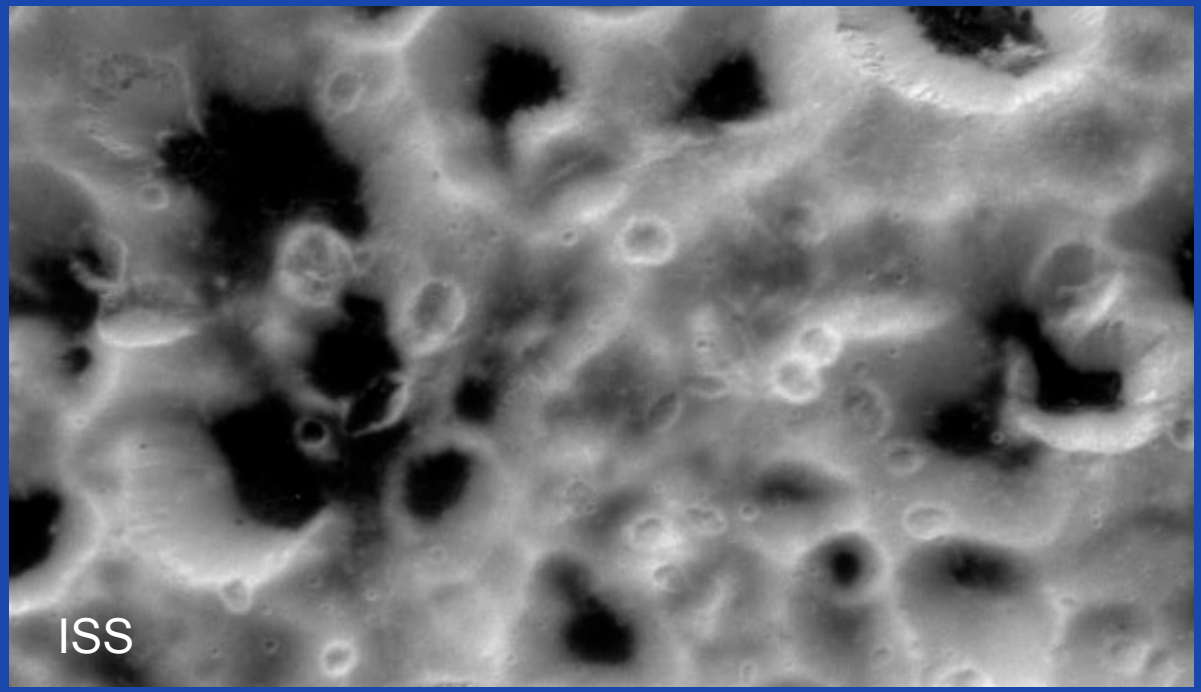




The IR spectra show that Phoebe dark material is similar to Iapetus dark material, but the visual spectra show that Hyperion and Iapetus are more similar.

Buratti et al., 2001, *Icarus*
(200-inch Hale telescope)





Hyperion Composition Map

Color code:

Blue = H_2O band depth

Red = CO_2 band depth

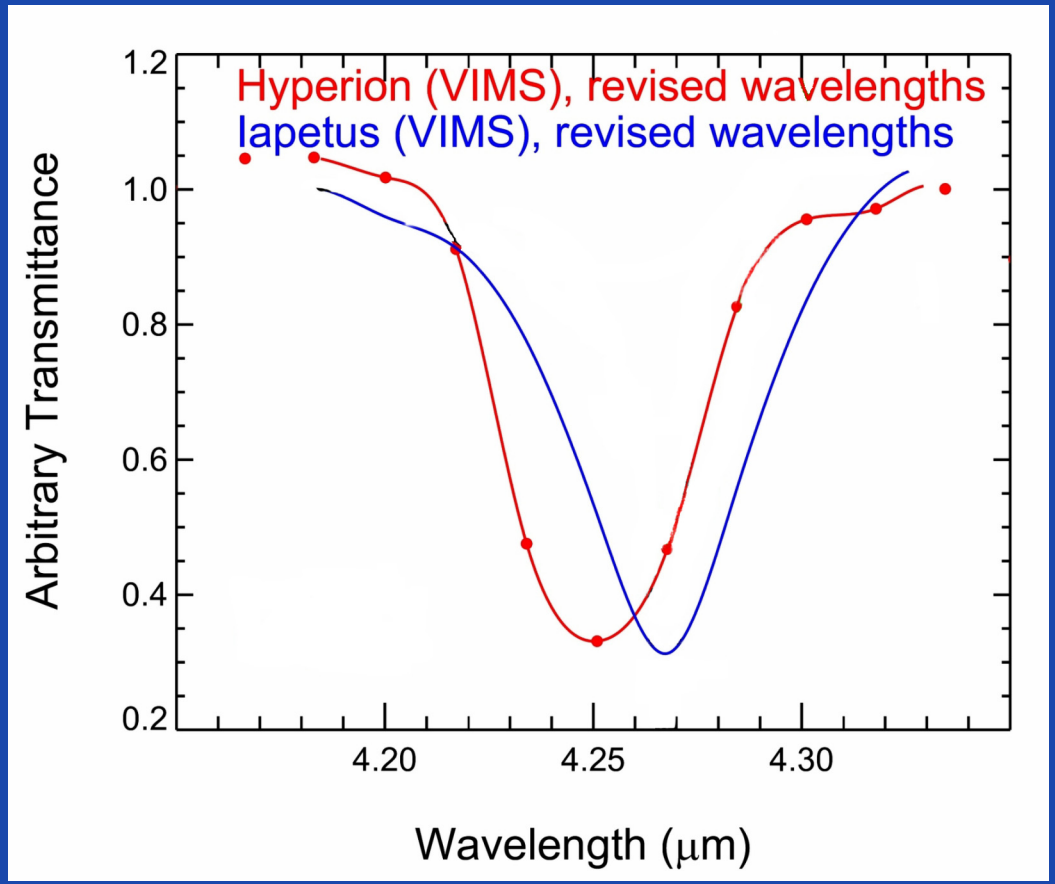
Green = 2.42 μm band

Yellow = CO_2 + 2.42 μm

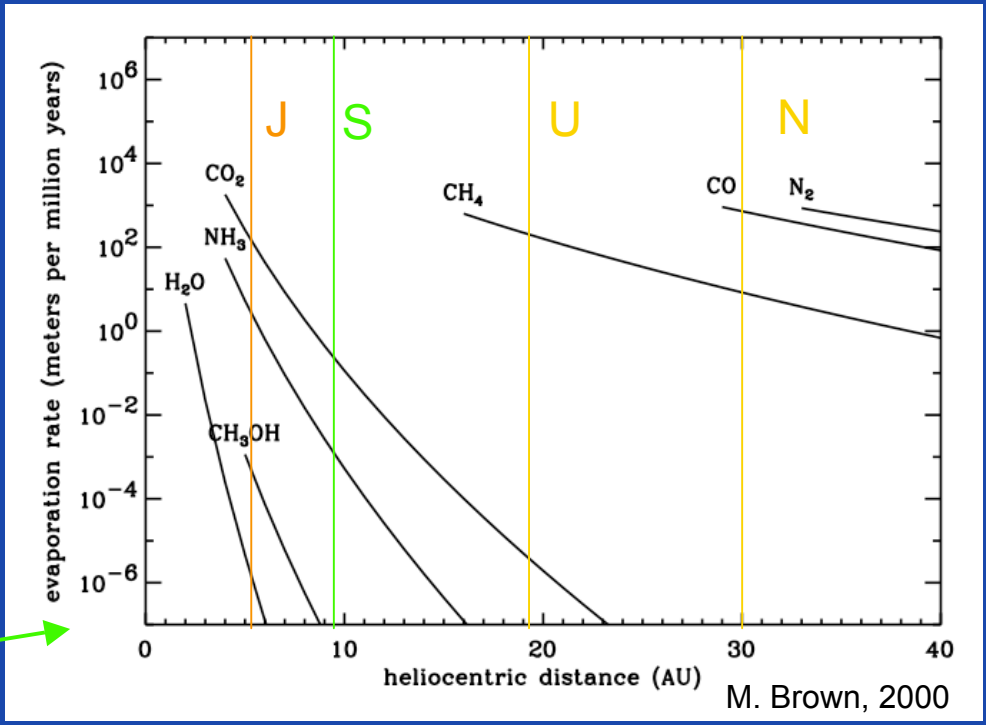
Magenta = H_2O + CO_2

Map by B. Dalton

CO_2 bands on Iapetus and Hyperion compared. The shift of the Hyperion's CO_2 band center toward shorter wavelengths indicates that the CO_2 molecules are somehow combined with, or attached to, other materials (possibly water ice molecules).



Origin of the CO_2

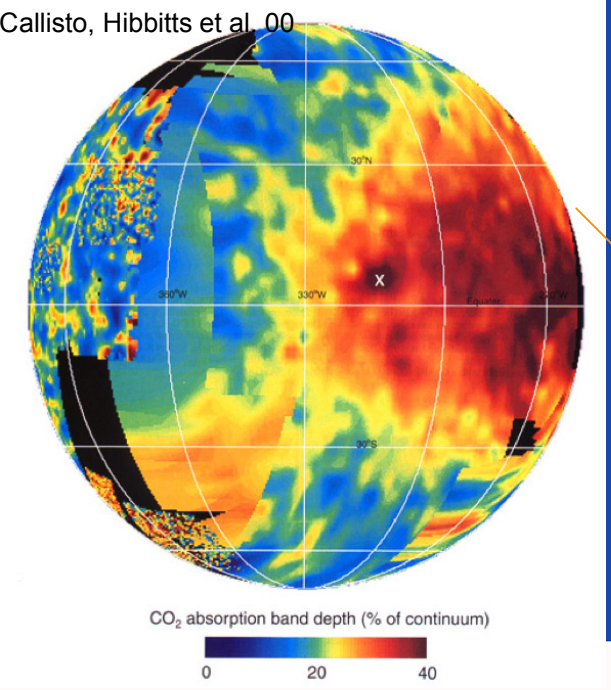


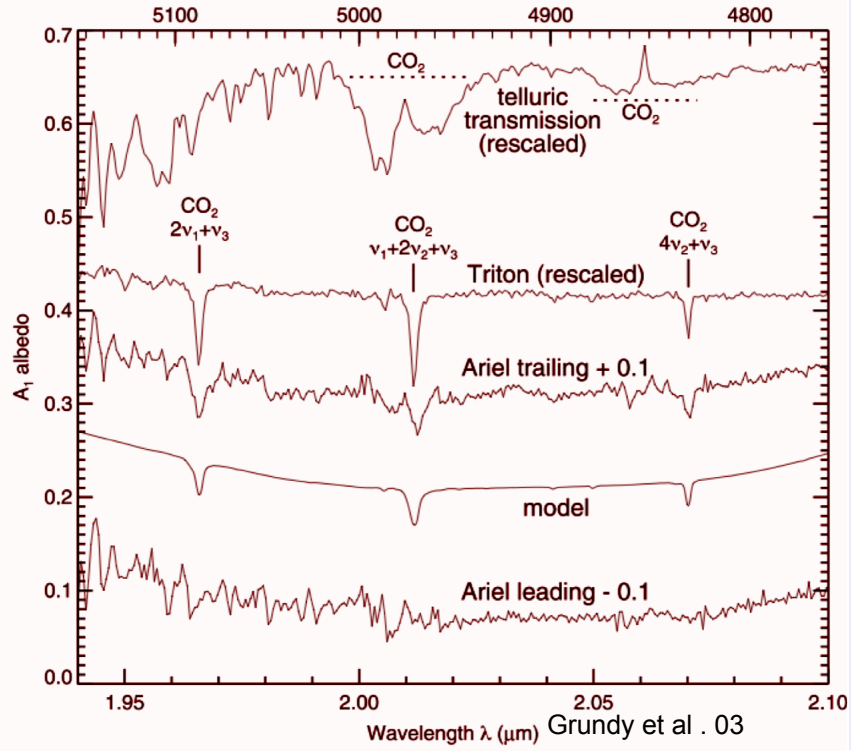
- Original – ~~requires re-~~ supply to surface
- Converted CO: $CO \leftrightarrow CO_2$ (Moore, Hudson, et al.)
- Product of H_2O + carbonaceous material with UV
- Impact or shock-induced chemistry, e.g., $H_2O + CH_3OH \rightarrow CO_2$ … (Naa Mvondo et al. 2007)

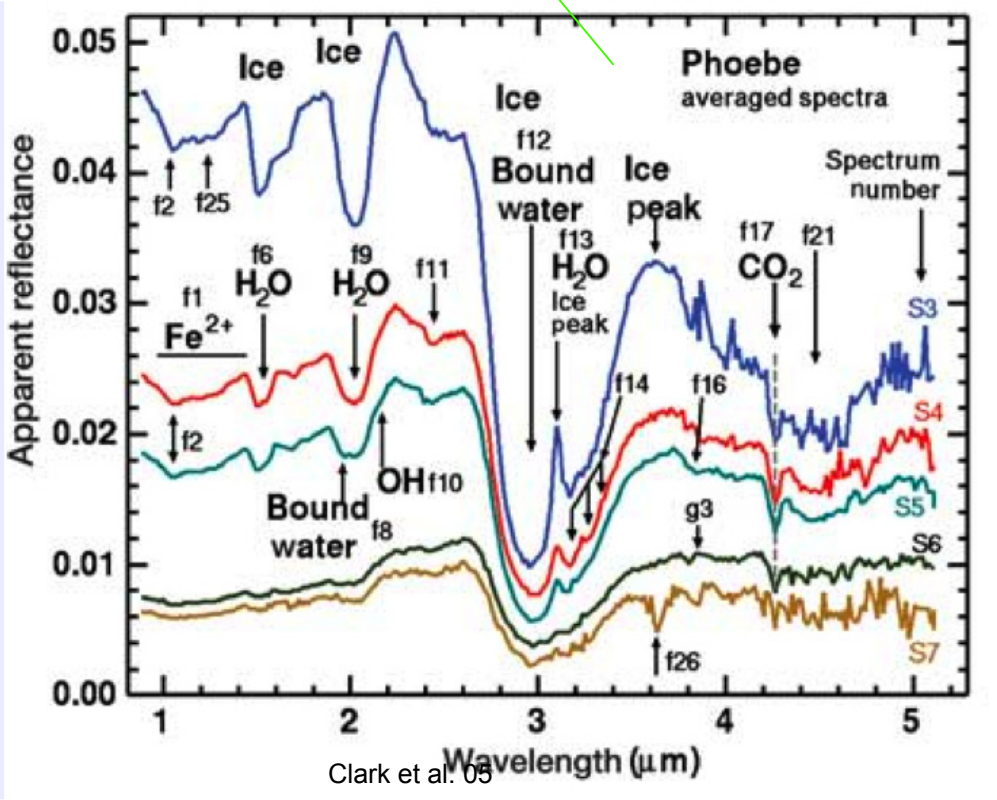
- Why is Hyperion's CO_2 complexed (when CO_2 ~~on other satellites~~ is not) ?

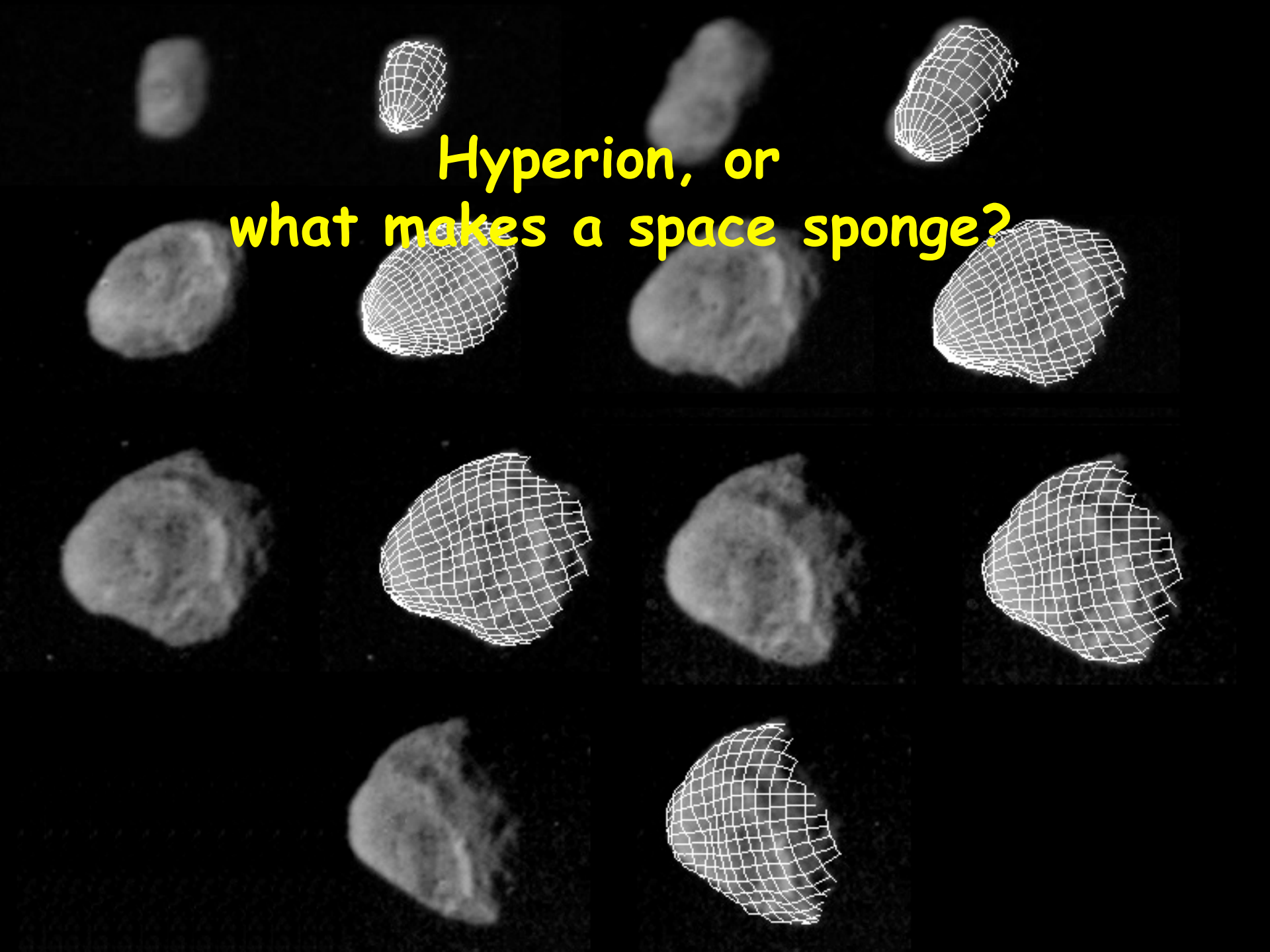
Ubiquitous CO2?

CO2 appears to be present on many outer Solar System surfaces including moons of Jupiter, Neptune & Uranus, and Saturn





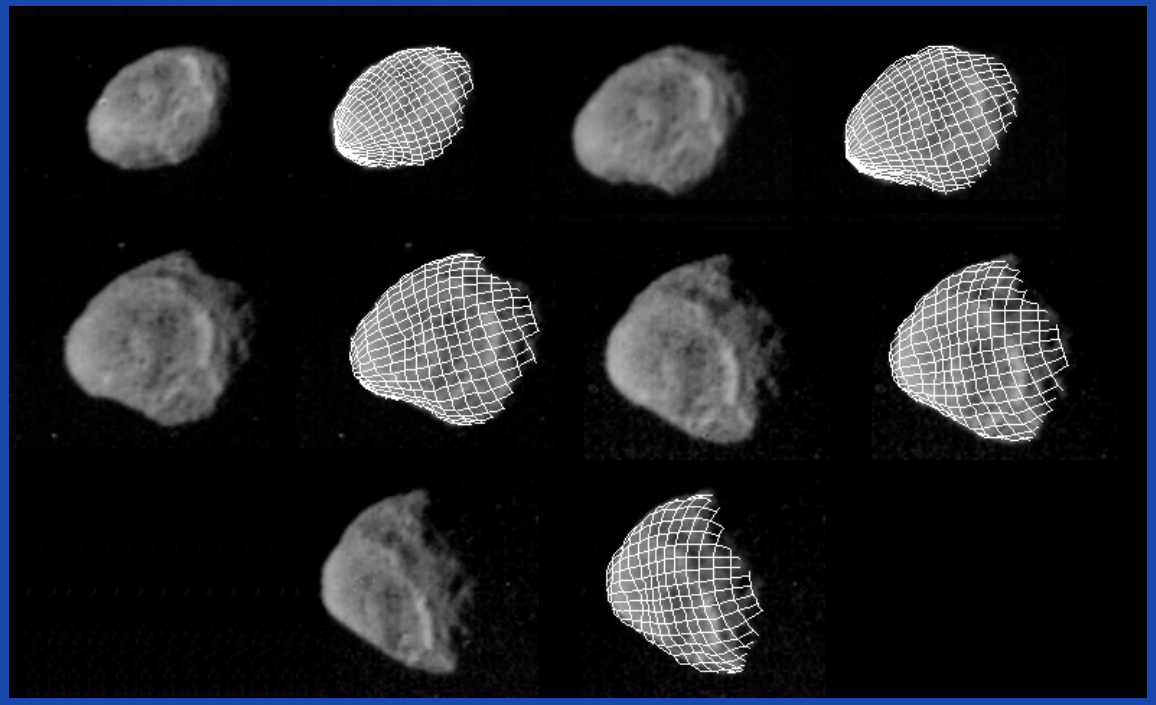



Hyperion, or
what makes a space sponge?

Interesting because it has chaotic rotation,
is the largest irregularly-shaped satellite seen to date,
Voyager hinted at spotty albedo distribution.

Cassini made close flyby 26 September 2005, and
Several passes <500000 km at other times.

Voyager views
of Hyperion

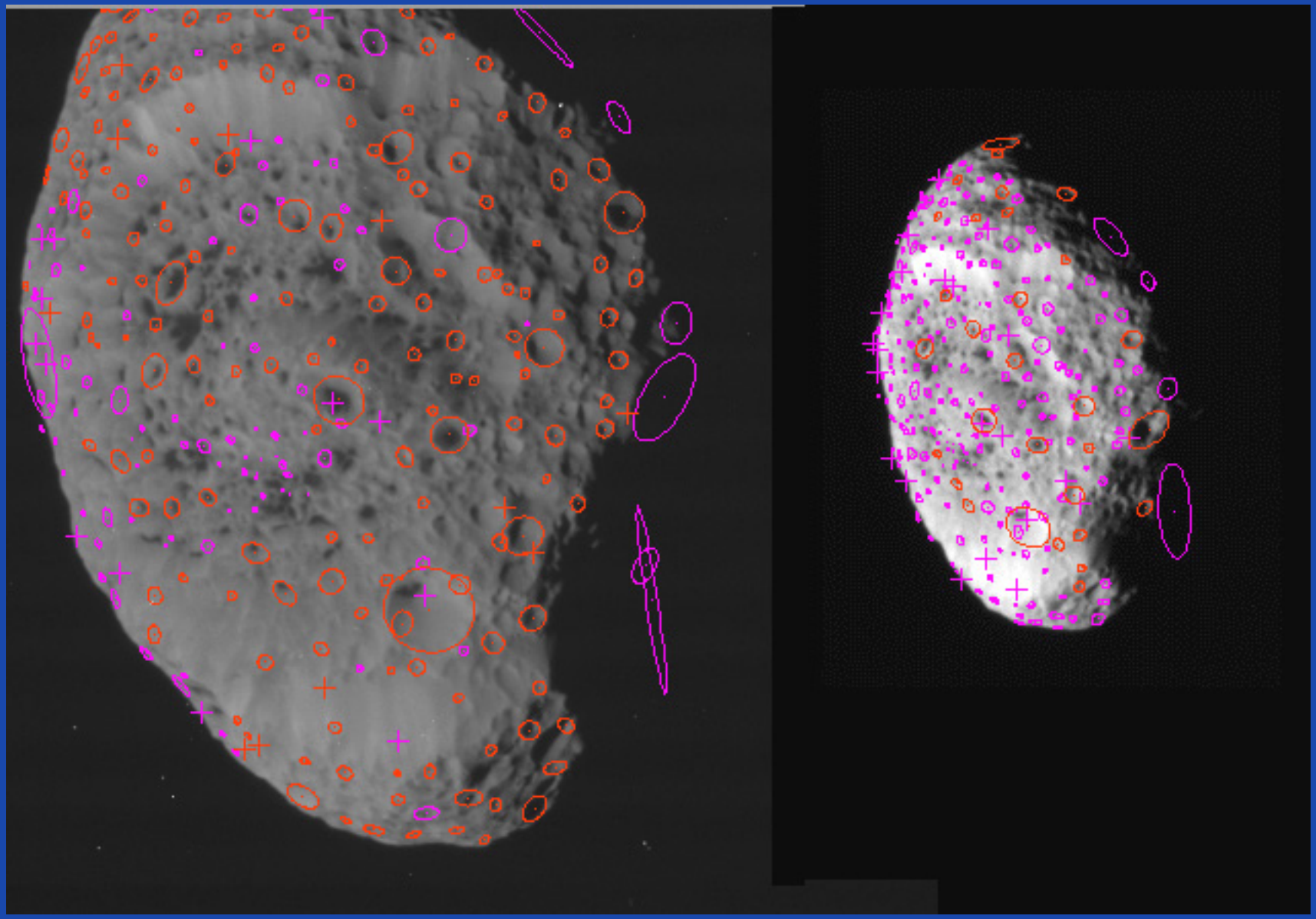


Hyperion: the numbers

Because of chaotic and slow rotation, the generation of the shape model required stitching data from several encounter together.

Mean radius: 135 ± 4 km
Range of diameters: 195 – 349 km
Mean density 540 ± 50 km m^{-3}
(mass from NAV and RSS teams)
Surface gravity ~ 2cm s^{-2}

Spin found from observing "control" points



Hyperion: more numbers

Instantaneous spin pole solutions:

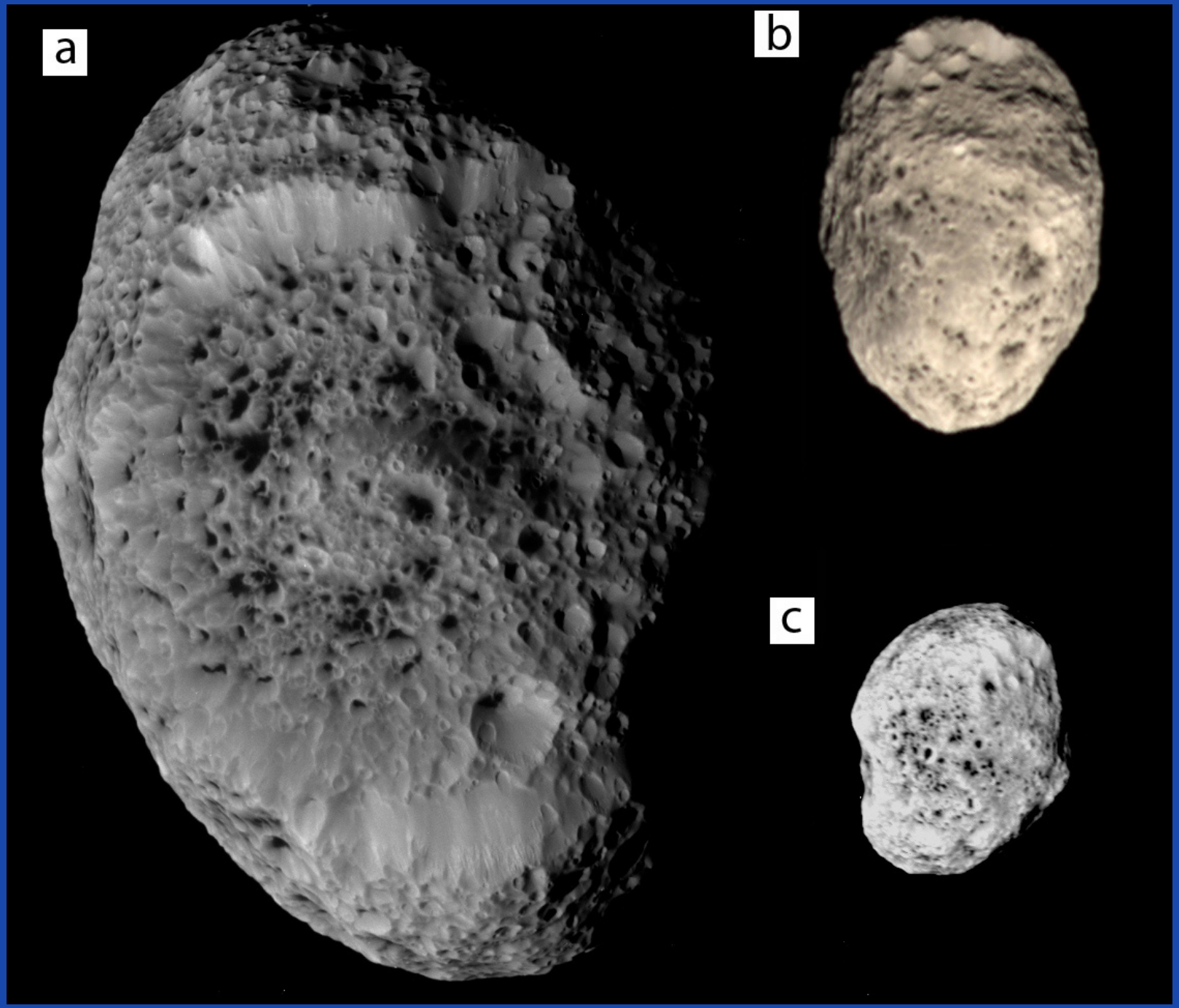
UTC range	RA	Dec	rate	SS lat
2005,160/18:10:05 - 161/09:58:38	208.4,	35.3	75	-14.1
2005,161/16:43:20 - 162/15:22:01	210.8,	39.3	75	-13.3
2005,228/01:46:59 - 228/20:16:46	271.3,	35.6	72	27.0
2005,228/22:16:13 - 229/12:15:23	266.7,	39.1	72	22.1
2005,268/04:29:06 - 268/17:20:16	315.1,	56.6	72	13.3
2005,268/17:20:16 - 269/02:18:20	299.8,	58.7	72	11.3
2006,179/02:24:03 - 180/04:15:09	184.5,	34.8	72	-43.7

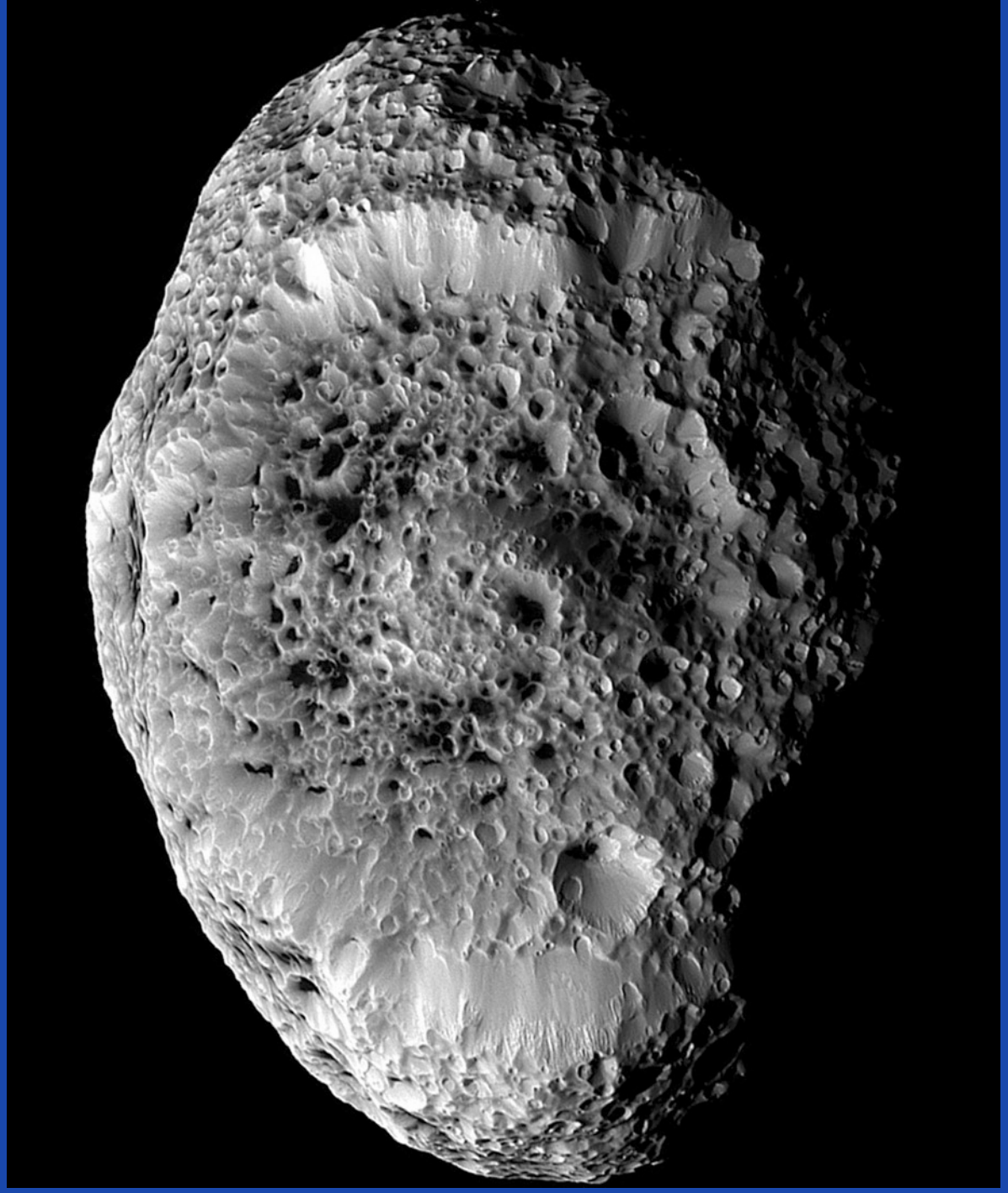
Rate: spin rate in degrees per day
SS lat = sub solar latitude: note drastic changes

Hyperion: the numbers mean what?

Mean density of 540 kgm-3, combined with probabililty of a lot of water ice, mean porosity is >40%. If there are Denser components, porosity is even higher.

Very small ring-related satellites have even lower densities.

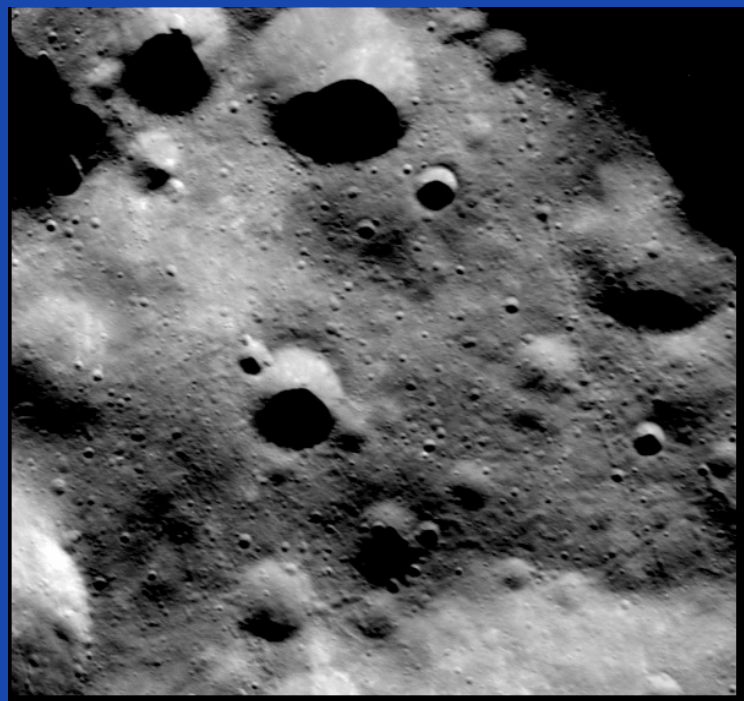

a
b
c



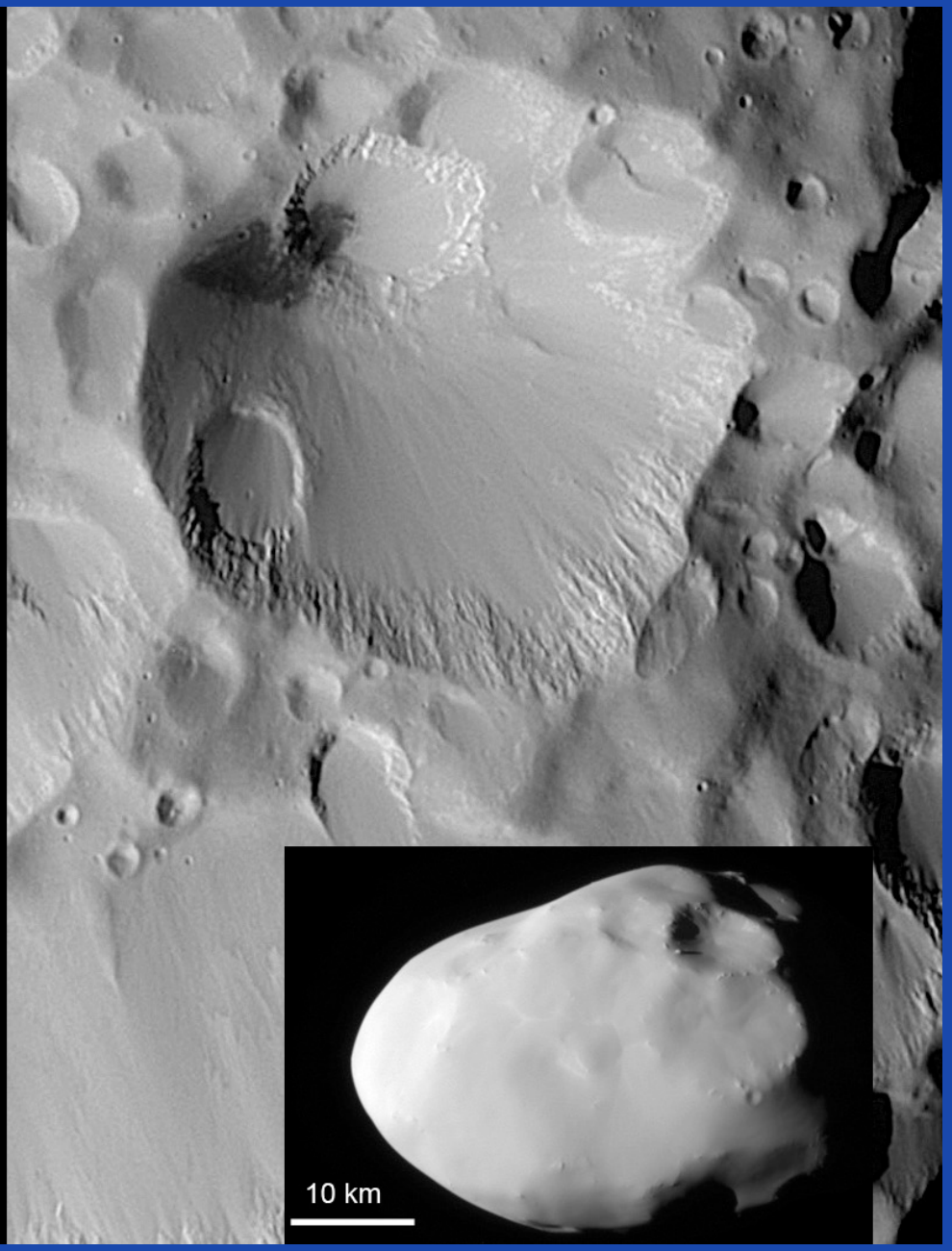
The
Sponge

Count obvious craters; then, what's left?

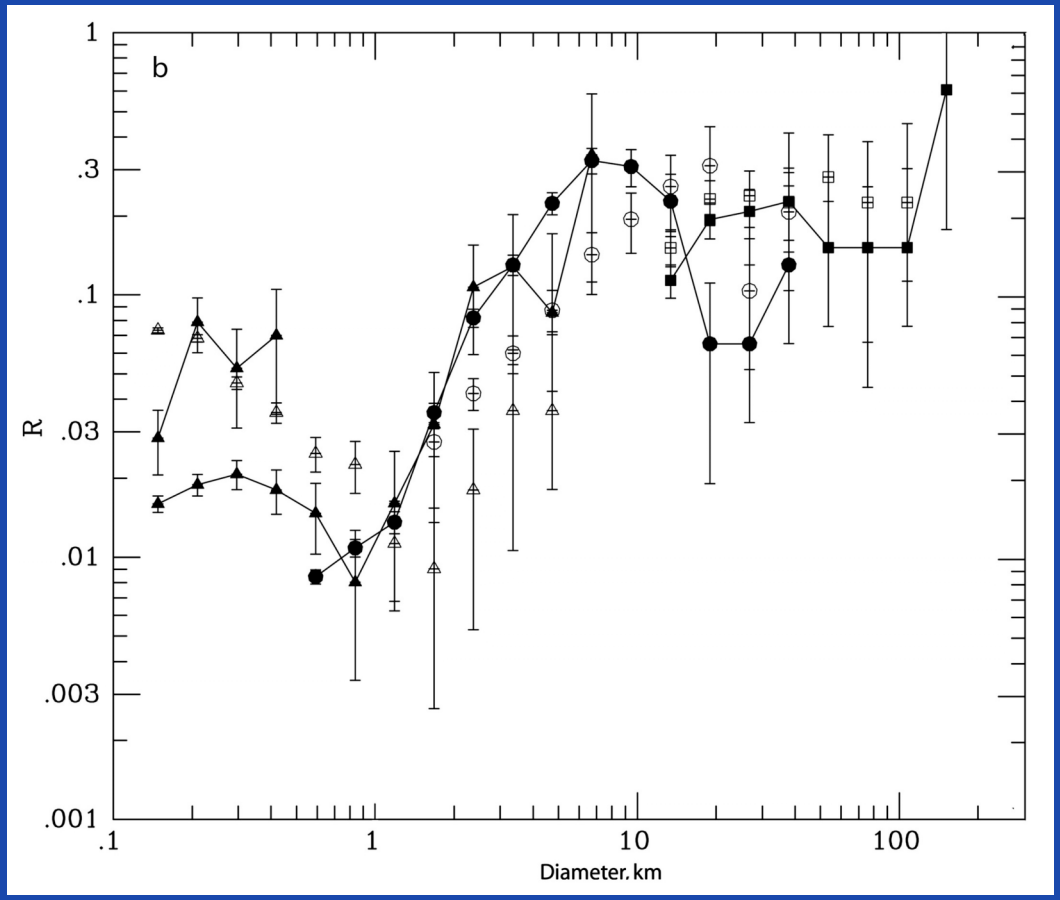
Not much



Phoebe, Hyperion Telesto at similar scale



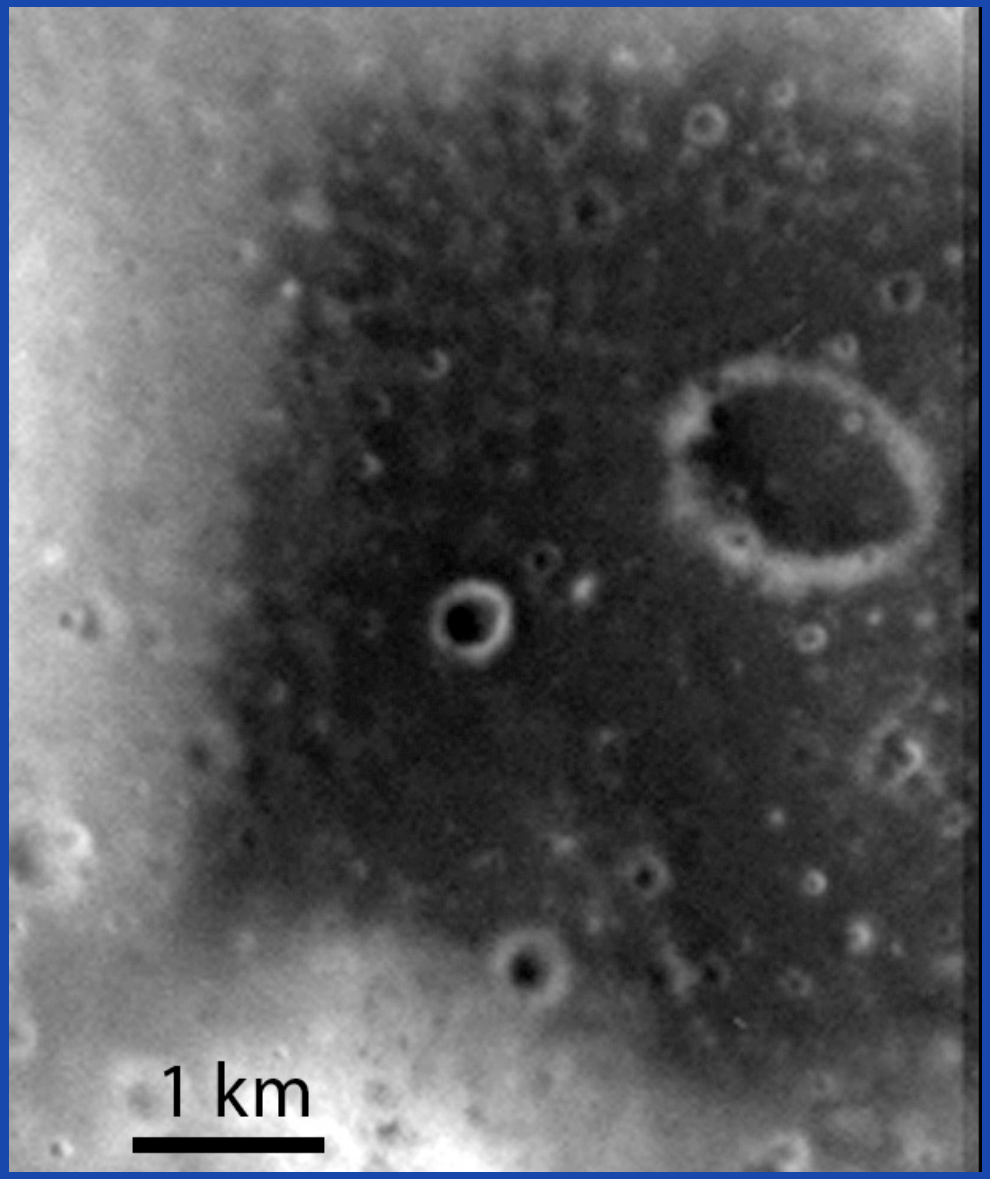
Craters on Hyperion and Phoebe



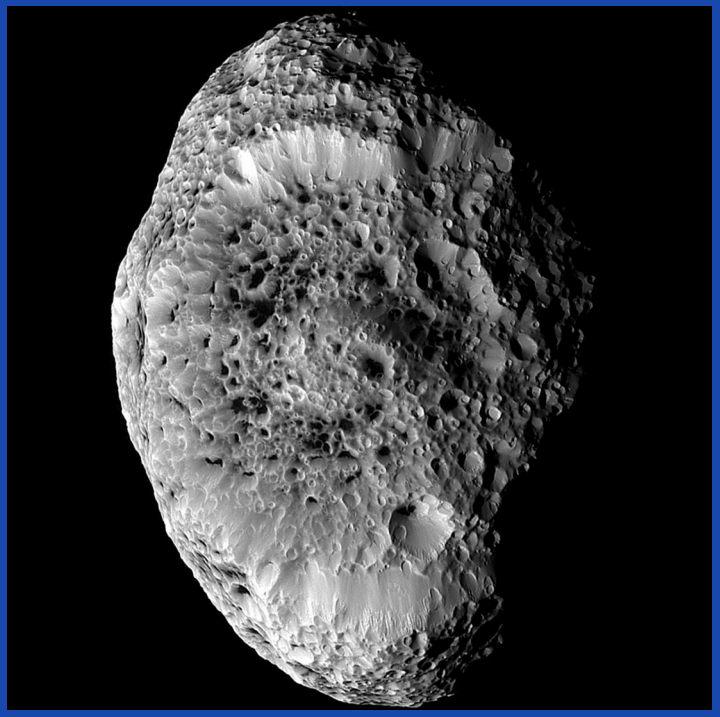
Between 2-10 km,
2x craters on Hyperion
as Phoebe.

>10 km Saturated

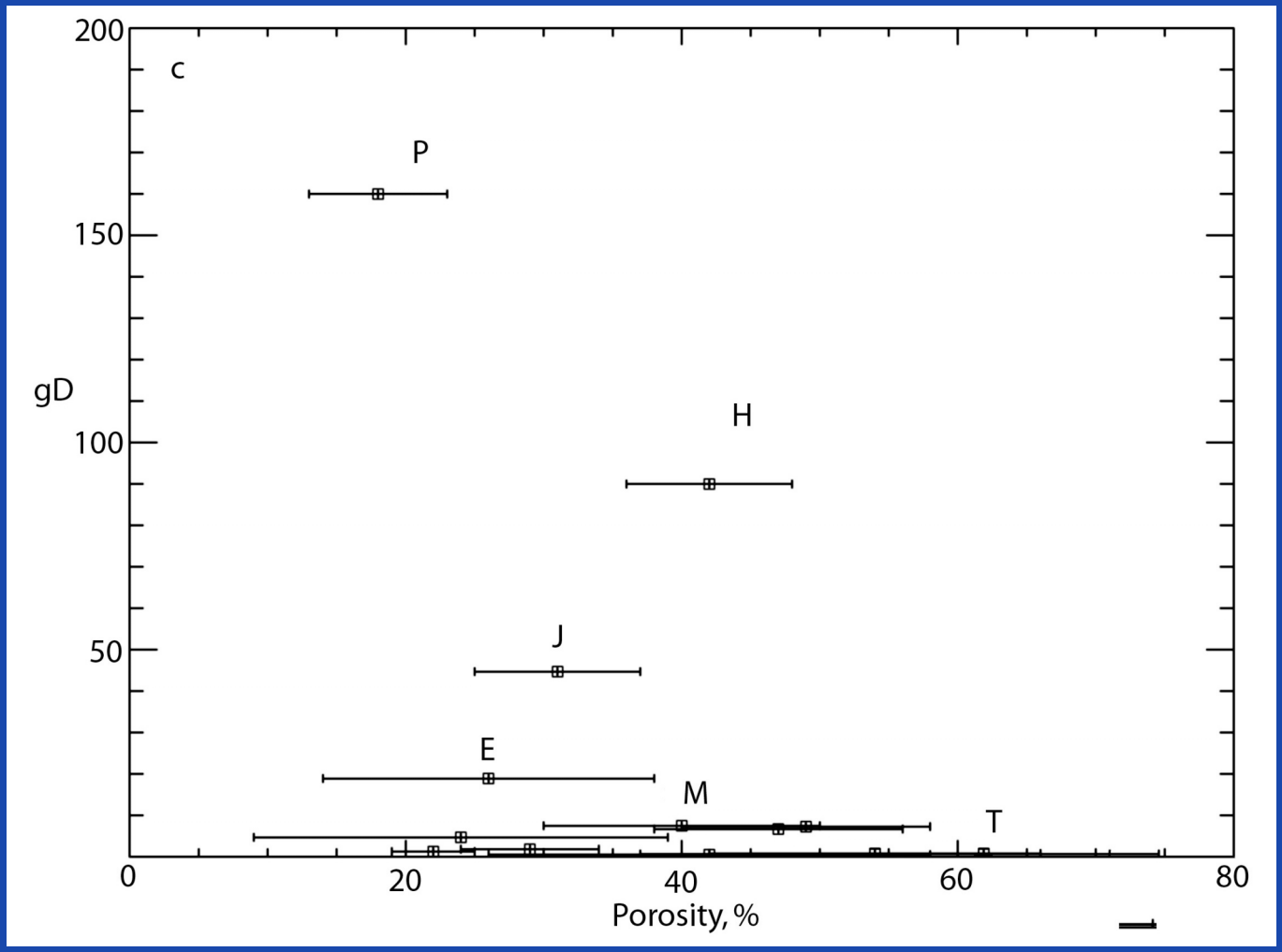
Small: more on Phoebe?



Little fill or erosion in old craters.
Little sublimation
Little ejecta fill

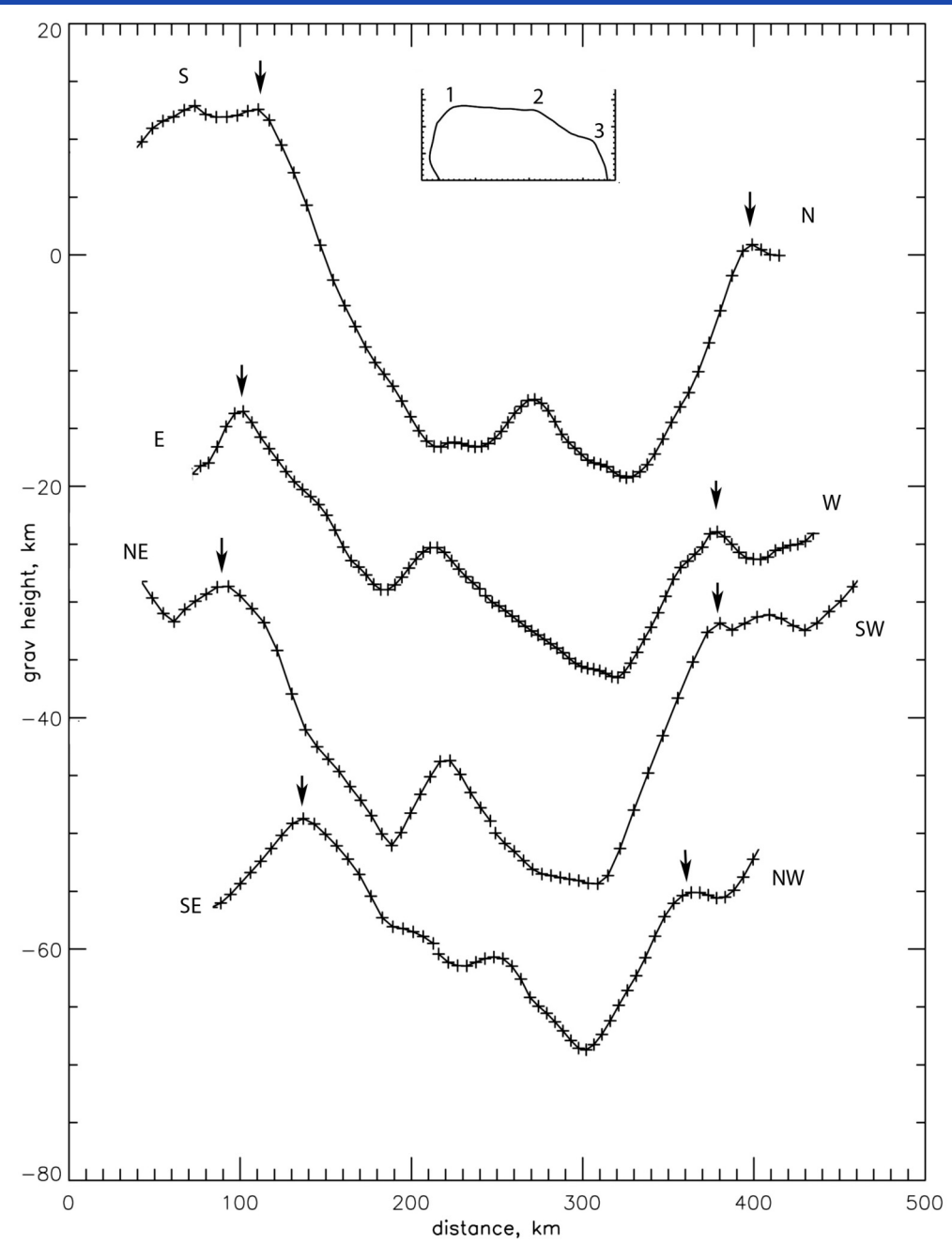


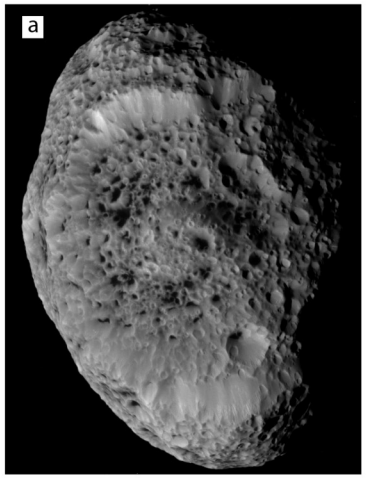
Role of porosity?
Housen and Holsapple, 2003 suggest
Less ejecta for porosities >30%;
and proportional 1/gD

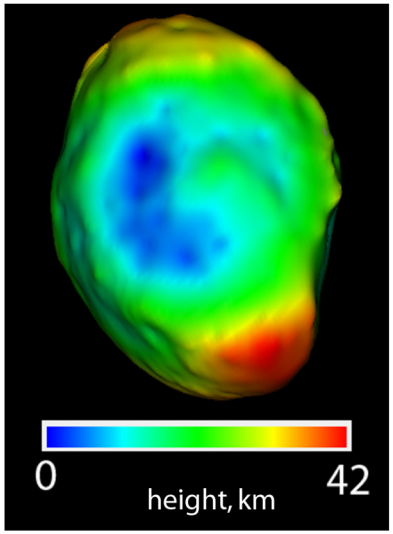


Very plausible, if…

Effects of big impacts?







Geology

Central peaked crater?

Barely…

Hyperion

Sponge-like appearance from lots of 2-10 km craters with good rim preservation.
No suncup role.
Scant evidence of ejecta, and some evidence for relative lack of ejecta.

Dark material concentrated by downslope motion and/or some sublimation

Porosity effects on craters?