Úsvit trpasličích planet: Pluto a Ceres

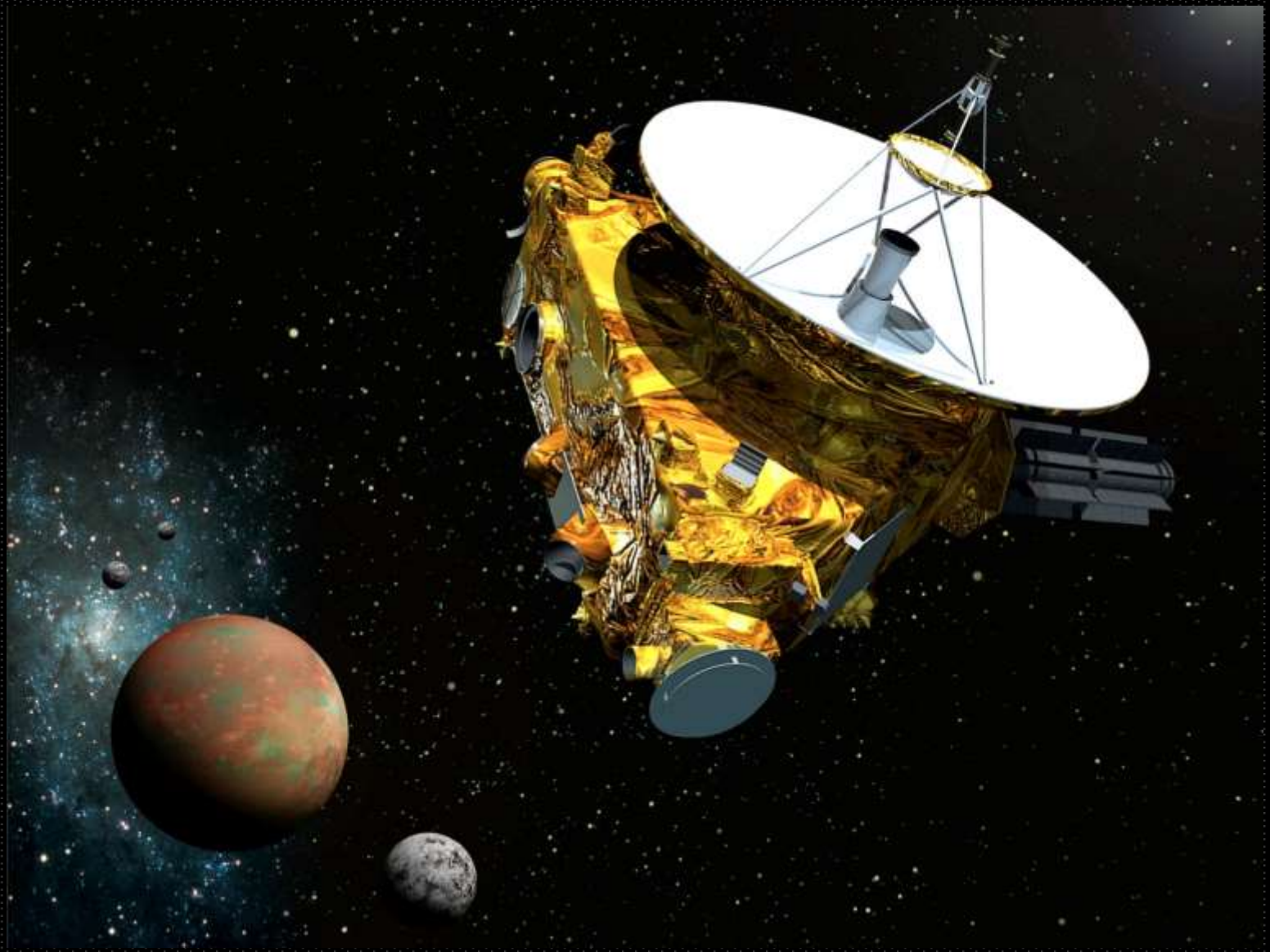
Petr Scheirich, Astronomický ústav AVČR

Hvězdárna Valašské Meziříčí, 8.11.2015

Dawn: přílet k Ceresu: 6. března

Dawn [dón]: úsvit

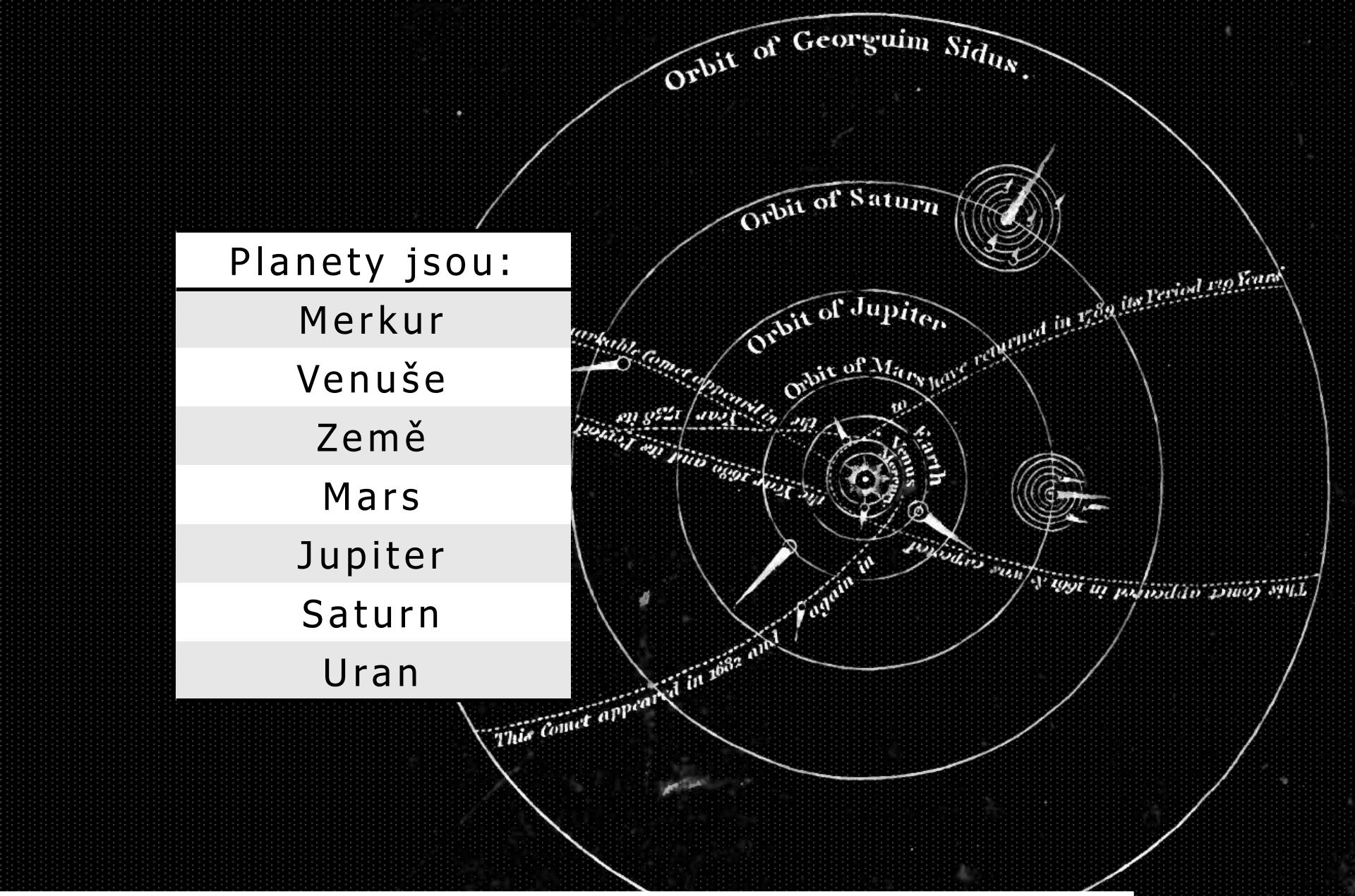
~~Down [daun]: dole~~



New Horizons: průlet okolo Pluta 14. července

Kde se vzaly trpasličí planety?

Planety jsou:
Merkur
Venuše
Země
Mars
Jupiter
Saturn
Uran



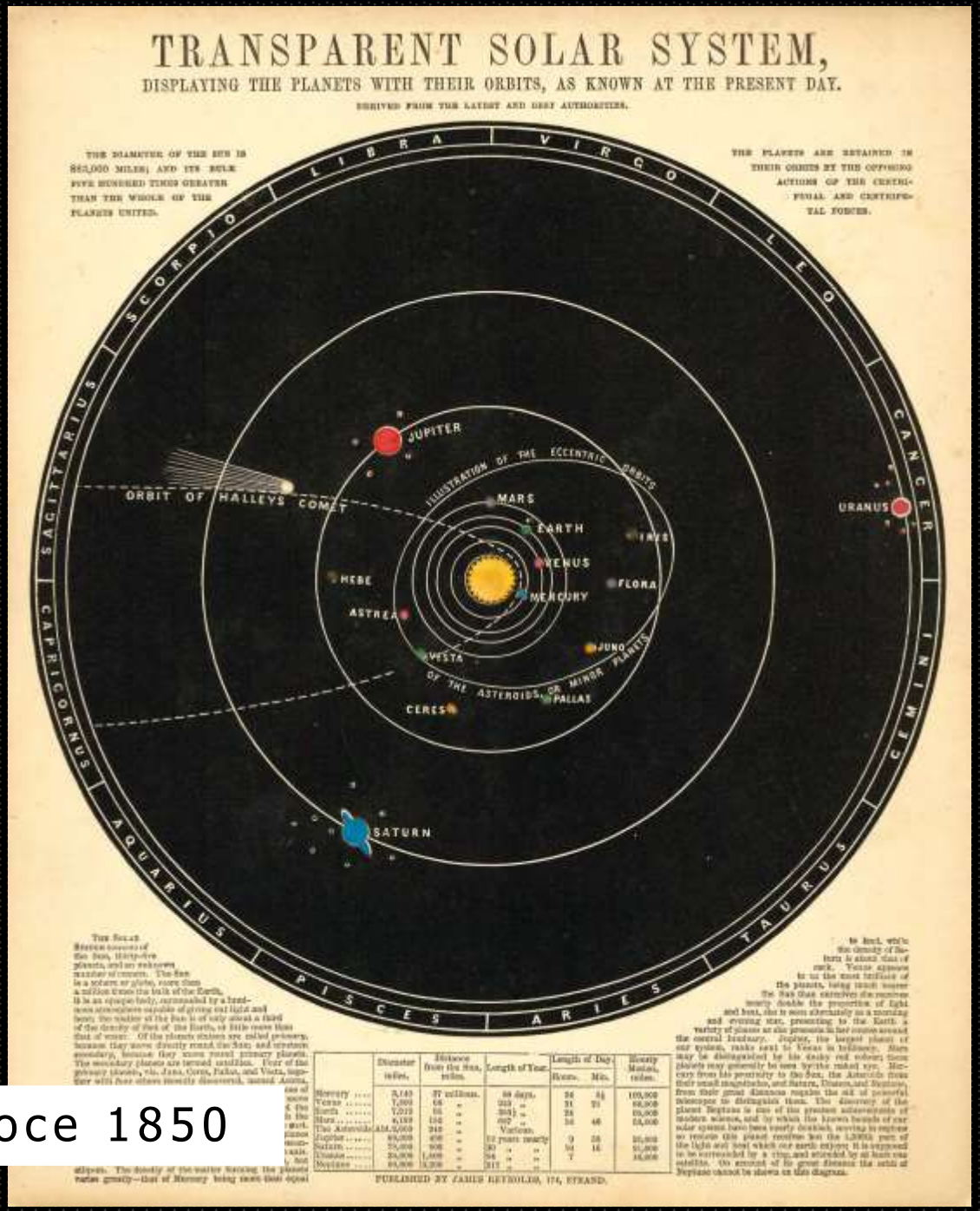
Sluneční soustava v roce 1800: Planety a komety

Planety jsou:
Merkur
Venuše
Země
Mars
Vesta
Juno
Ceres
Pallas
Jupiter
Saturn
Uran

Sluneční soustava v roce 1807

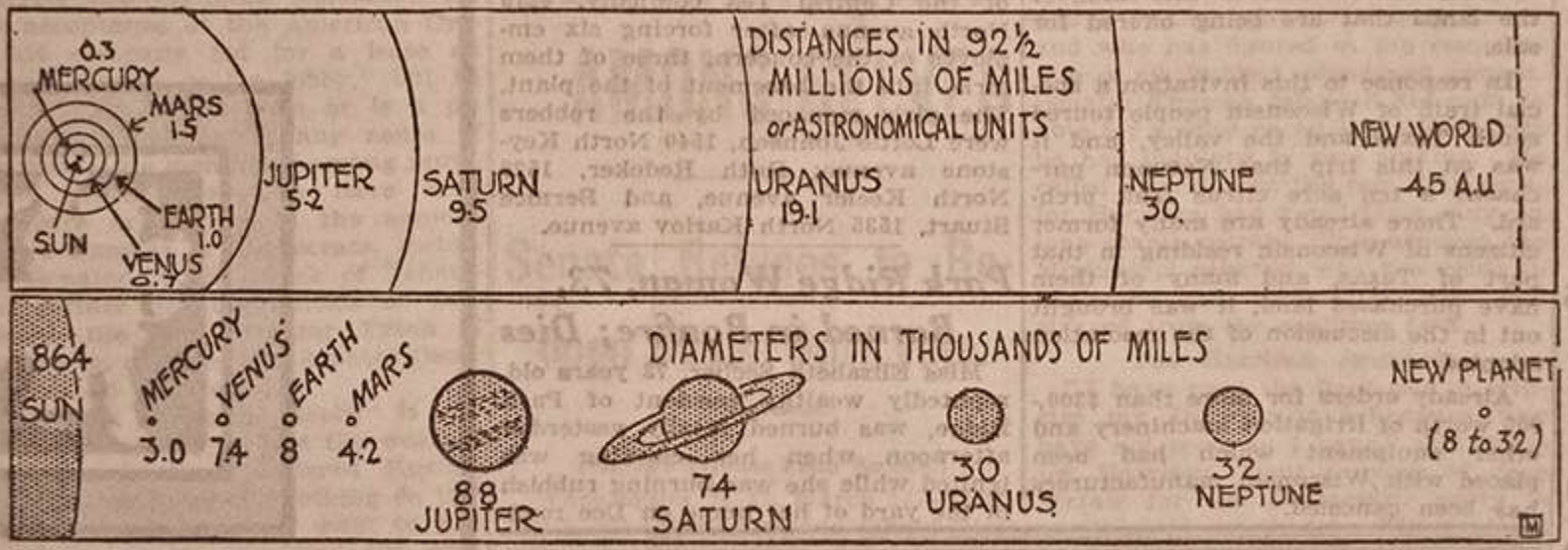
Desítky planet!

Nová kategorie těles: asteroidy (planetky; minor planets)



Sluneční soustava po roce 1850

LOCATE NEW PLANET OF SOLAR SYSTEM



The above diagram shows the distances of the planets from the sun, the distance of the earth from the sun being used as the unit of measure. The comparative sizes of the sun's satellites, including the newly discovered planet, are also shown.

complicated mathematical formula to plot the course of the hypothetical body.

His Calculations Disputed.

Dr. Lowell's calculations were confirmed by other astronomers, but in 1928 another Harvard astronomer, Prof. W. H. Pickering, calculated an-

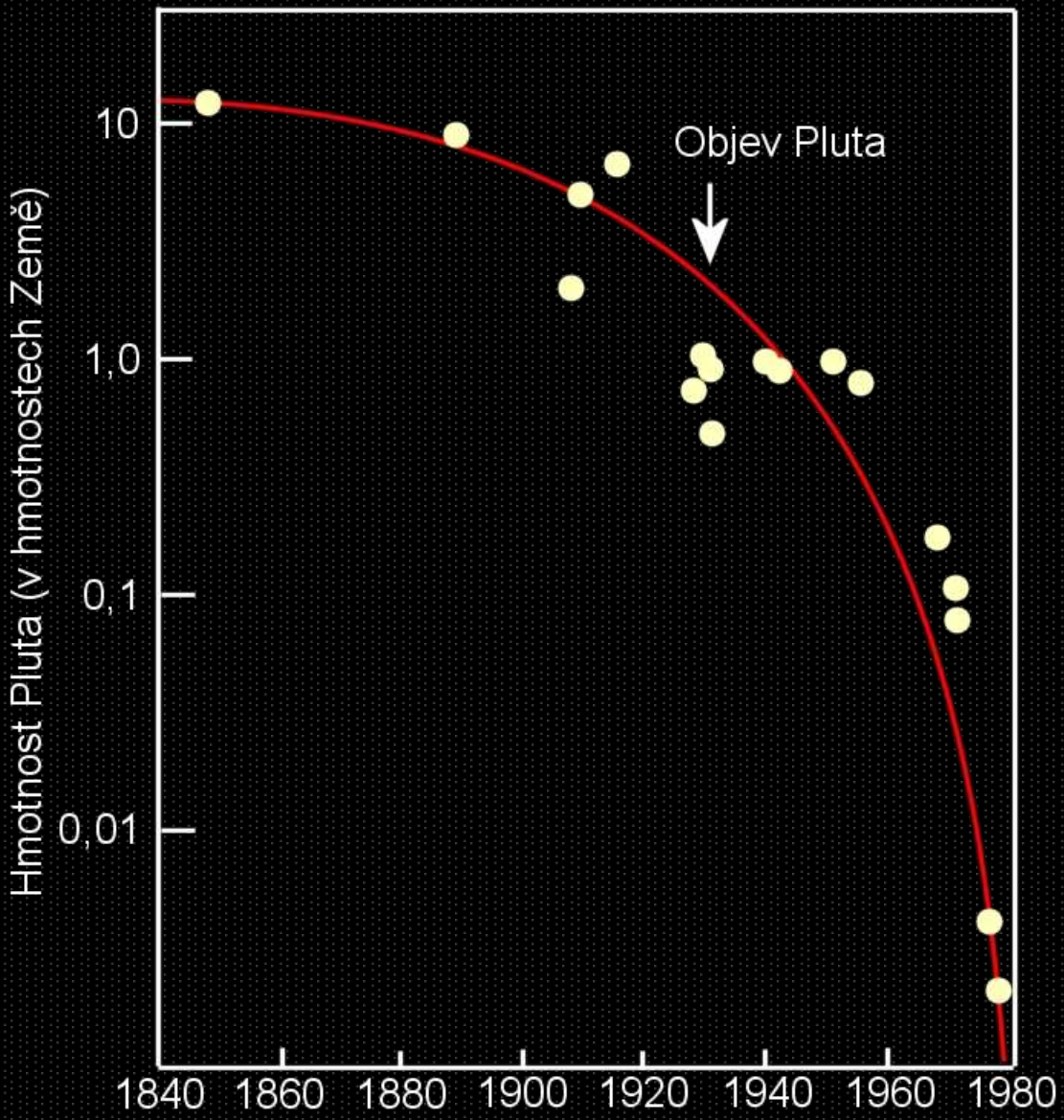
Adler planetarium now building on the lake front, yesterday hailed the discovery of the new planet as "a very fine thing—my congratulations to the astronomers."

The discovery was not wholly unexpected, Prof. Fox said, and referred to a paper written by the late Percival Lowell of Harvard university, who

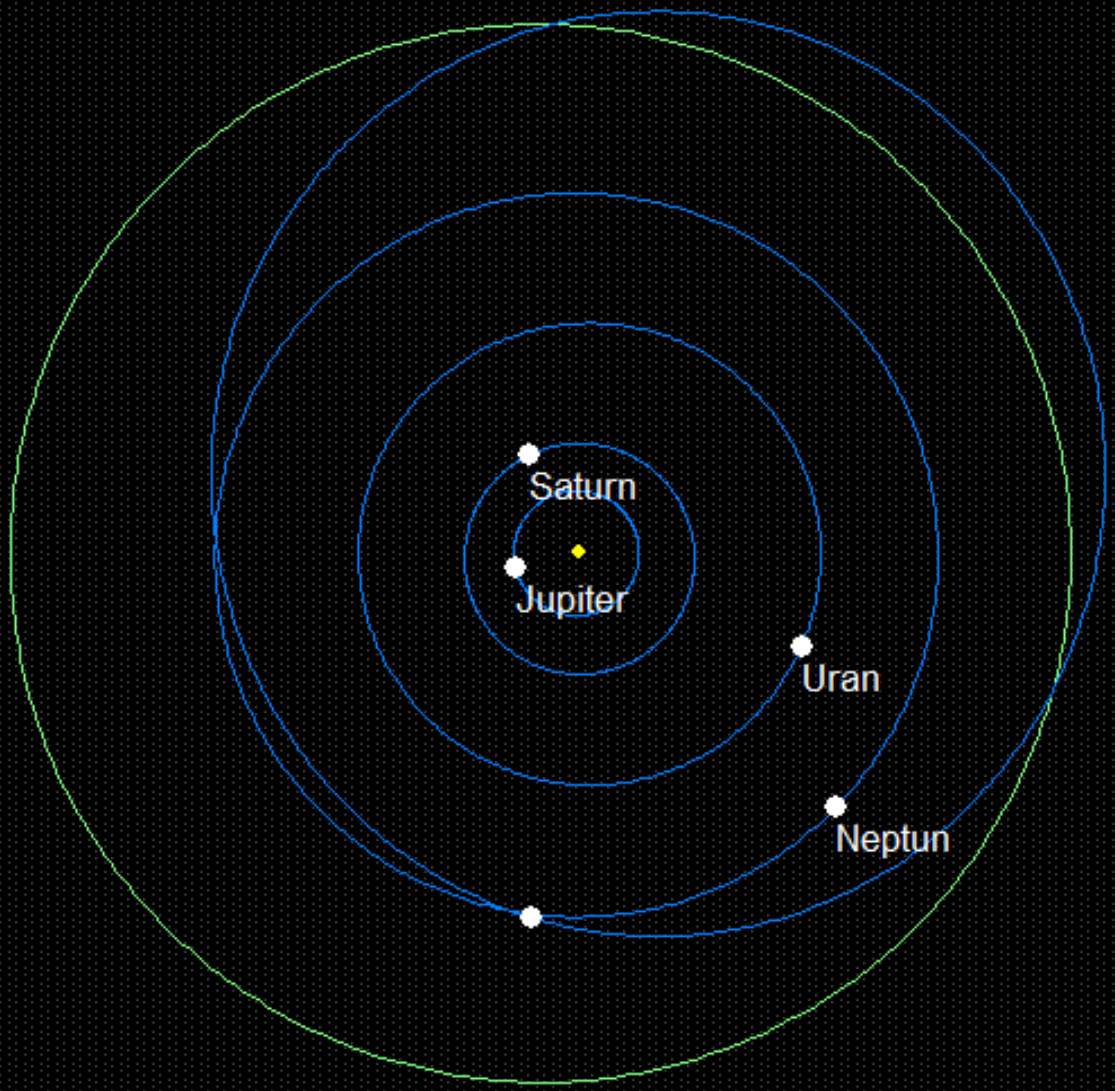
been discerned?" Prof. Cox was asked.

"O, surely," he replied, "there must be, but there is a limit to the distance that our system can hold them and when they get out far enough some other system gets hold of them. We know there are no big ones because of the perturbation, but there

1846: Neptun; 1930: Pluto



Vývoj hmotnosti Pluta



1992: 1992 QB1 Cubewano


Eris
2400 km
Disnomia
Pluto, Charon
2328 km
Nix
Hydra
Orcus
1600 km
Vanth
Makemake
1600 km
Sedna
1200-1600 km
Haumea
~1500 km
Namaka,
Hi'iaka
Quaoar
1260 km
Varuna
936 km

2005

Planeta Sluneční soustavy je těleso, které:

- obíhá okolo Slunce
- není měsícem
- má dostatečnou hmotnost, aby jeho vlastní gravitace překonala vnitřní síly pevného tělesa, takže dosáhne tvaru odpovídajícího hydrostatické rovnováze (přibližně kulatého)
- vyčistilo okolí své dráhy

Tělesa splňující pouze první tři body definice se označují jako trpasličí planety.

Nová definice

Trpasličí planety:
Ceres
Pluto
Makemake
Haumea
Eris

Současný oficiální (IAU) seznam trpasličích planet

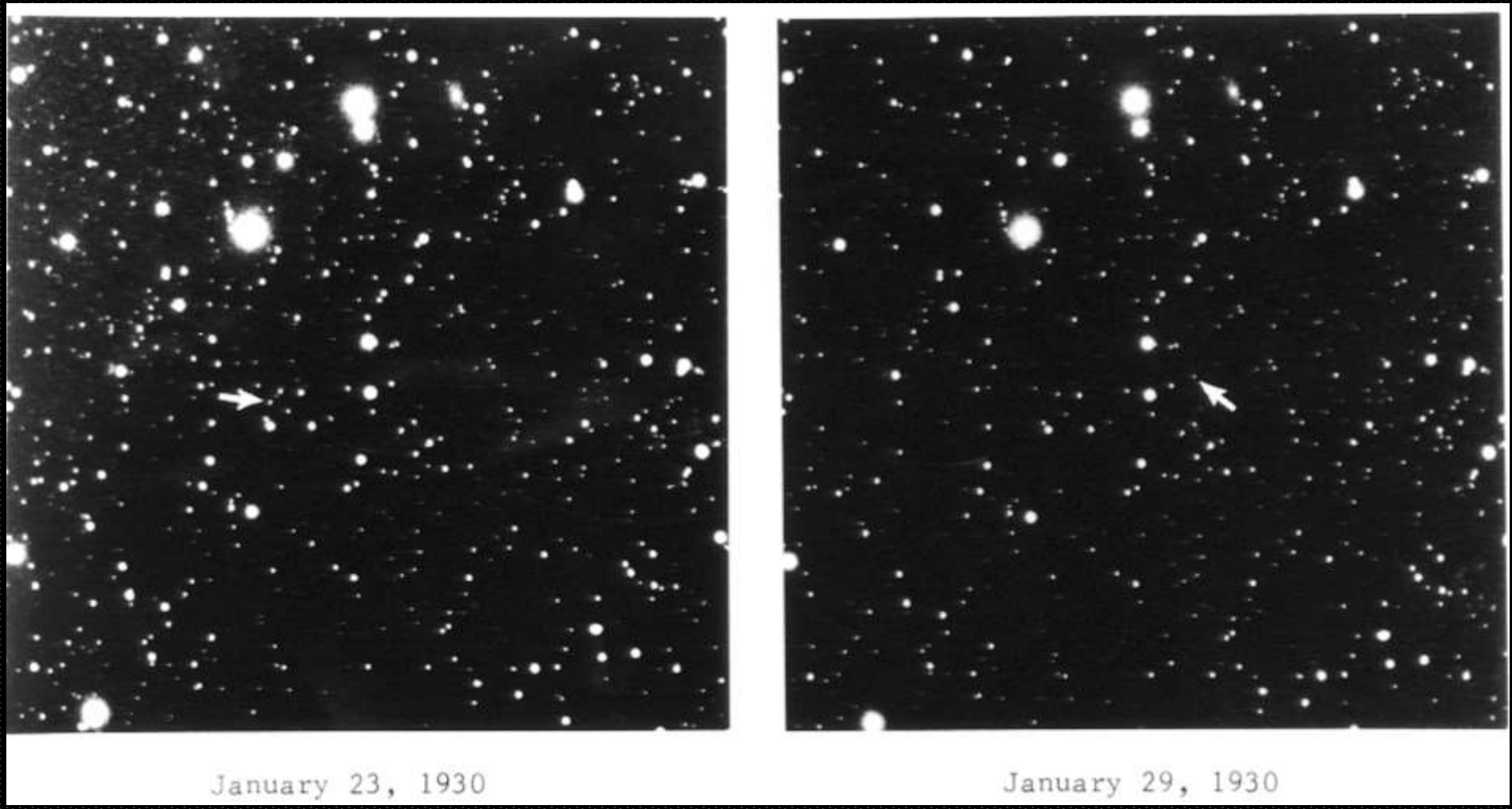
- má dostatečnou hmotnost, aby jeho vlastní gravitace překonala vnitřní síly pevného tělesa, takže dosáhne tvaru odpovídajícího hydrostatické rovnováze (přibližně kulatého)

Největší problém definice: stanovení tvaru tělesa vyžaduje poměrně detailní zobrazení!

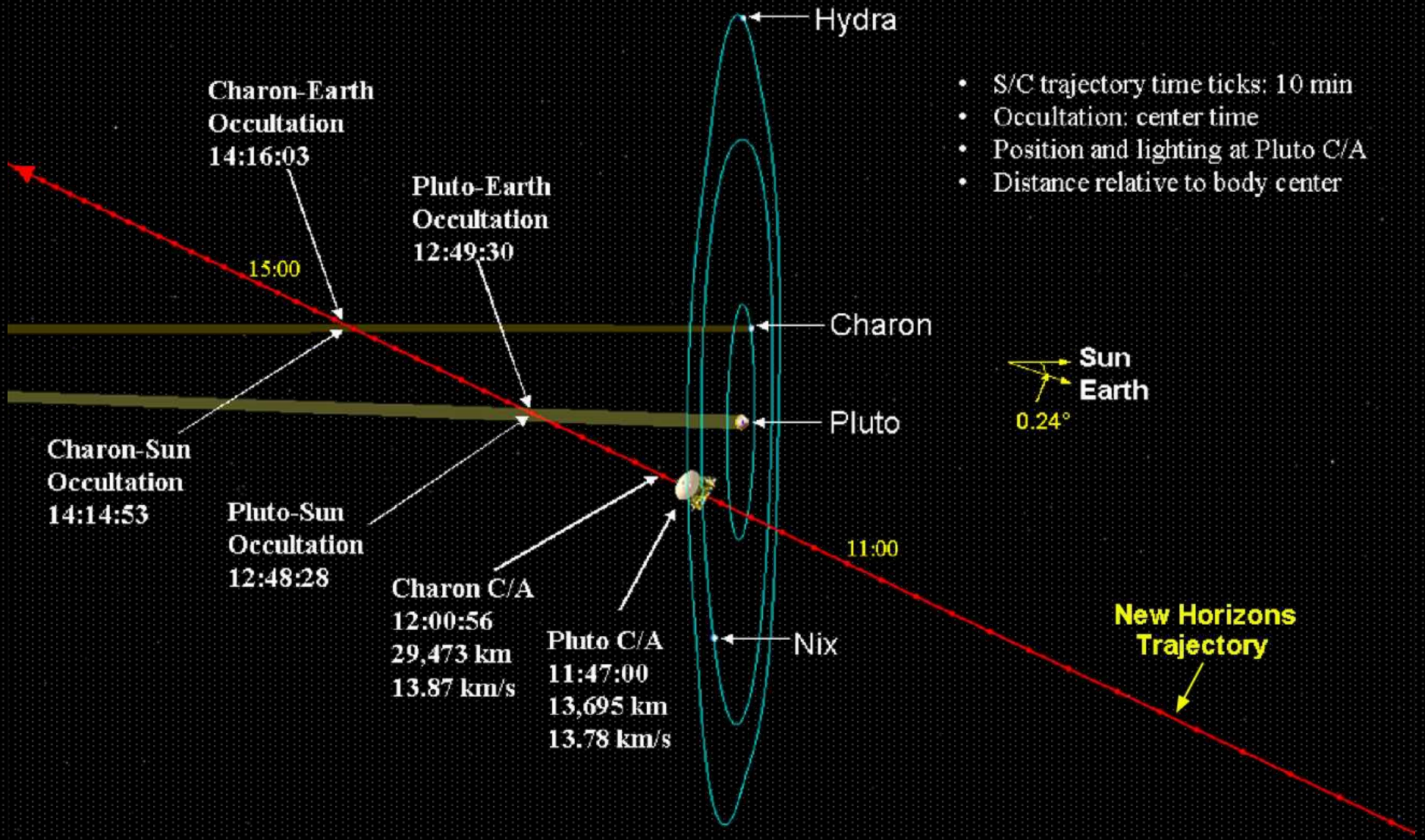
Problémy definice

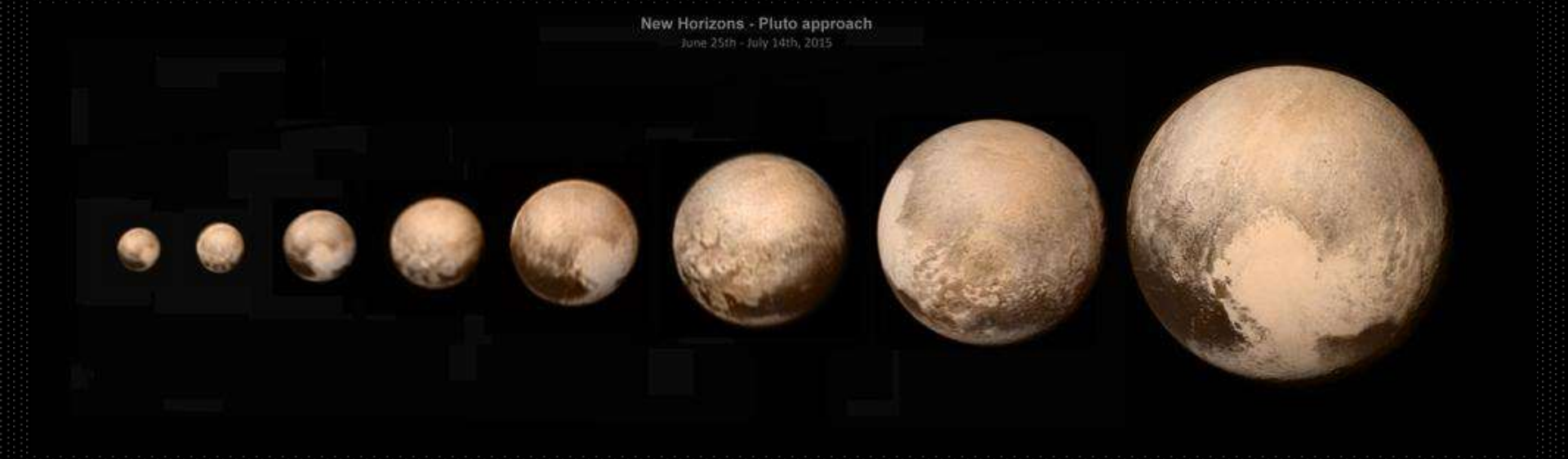
Pokud trpasličí planety v budoucnu skončí, pak jako pojem, ne jako tělesa!

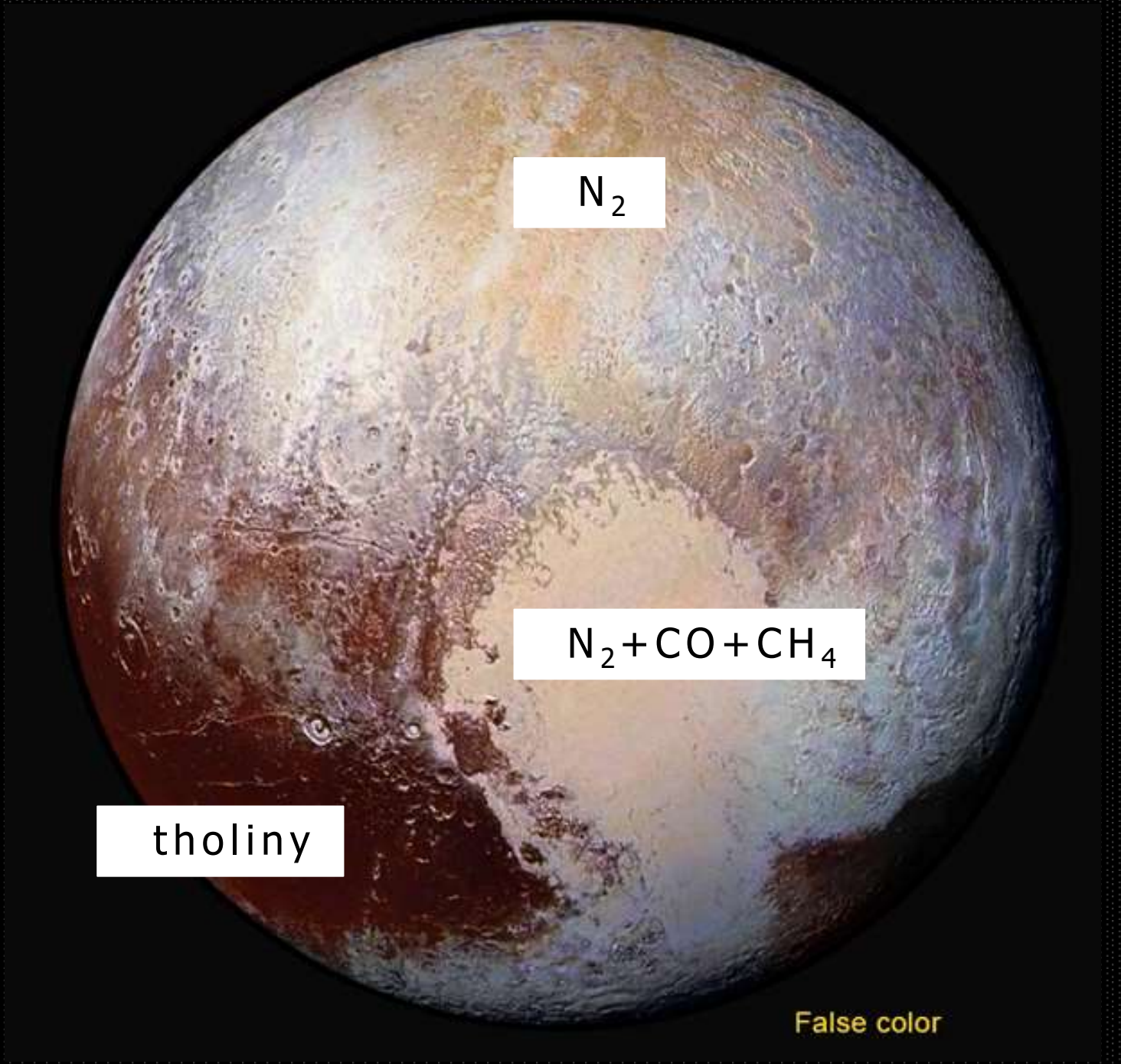
Pluto

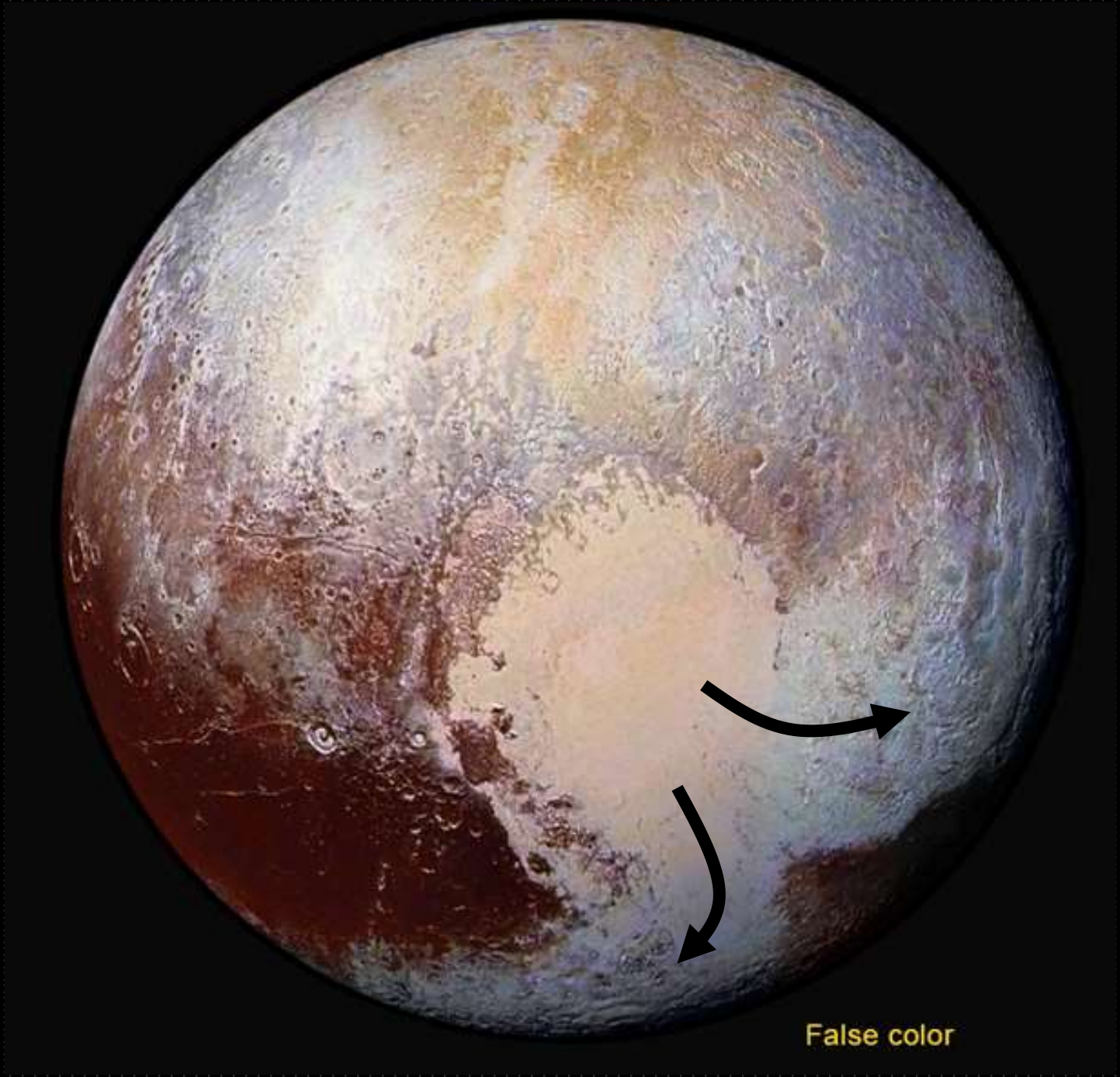


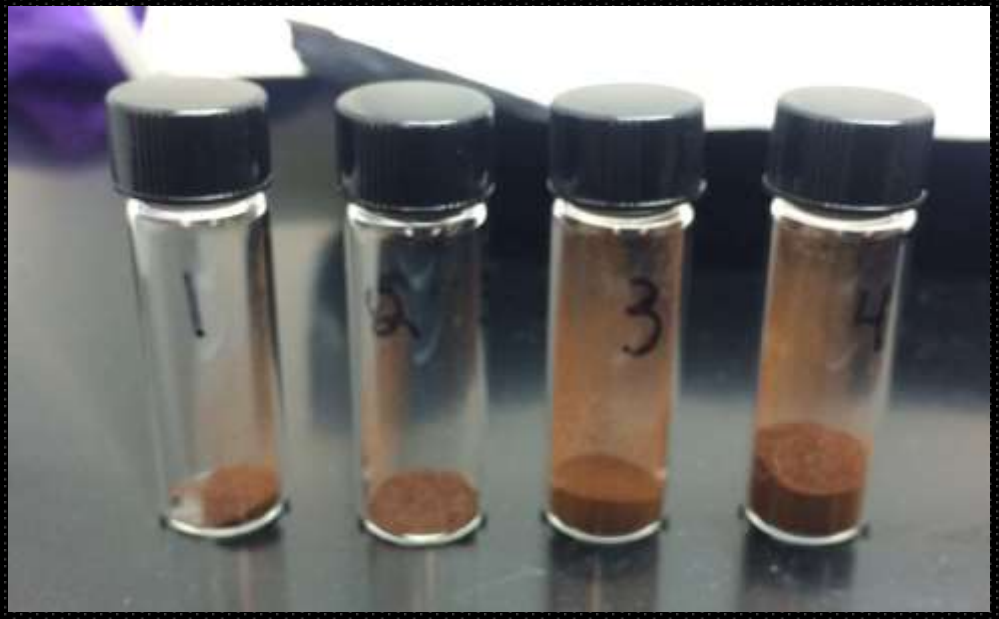
Objevové snímky

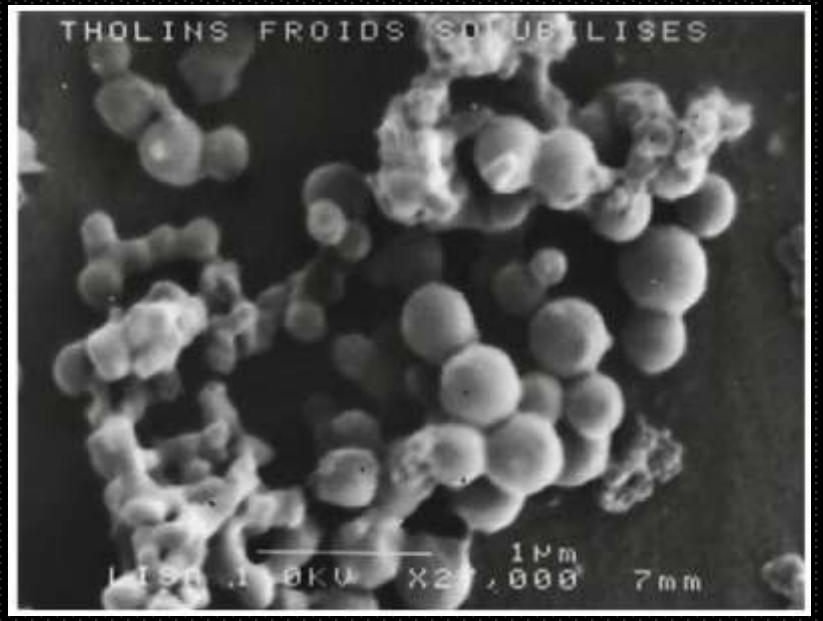

Hydra
Charon-Earth
Occultation
14:16:03
Pluto-Earth
Occultation
12:49:30
15:00
Charon
Pluto
Charon-Sun
Occultation
14:14:53
Pluto-Sun
Occultation
12:48:28
Charon C/A
12:00:56
29,473 km
13.87 km/s
Pluto C/A
11:47:00
13,695 km
13.78 km/s
Nix
11:00
New Horizons
Trajectory
Sun
Earth
0.24°
• S/C trajectory time ticks: 10 min
• Occultation: center time
• Position and lighting at Pluto C/A
• Distance relative to body center


New Horizons - Pluto approach
June 25th - July 14th, 2015


N_2
$N_2+CO+CH_4$
tholiny
False color

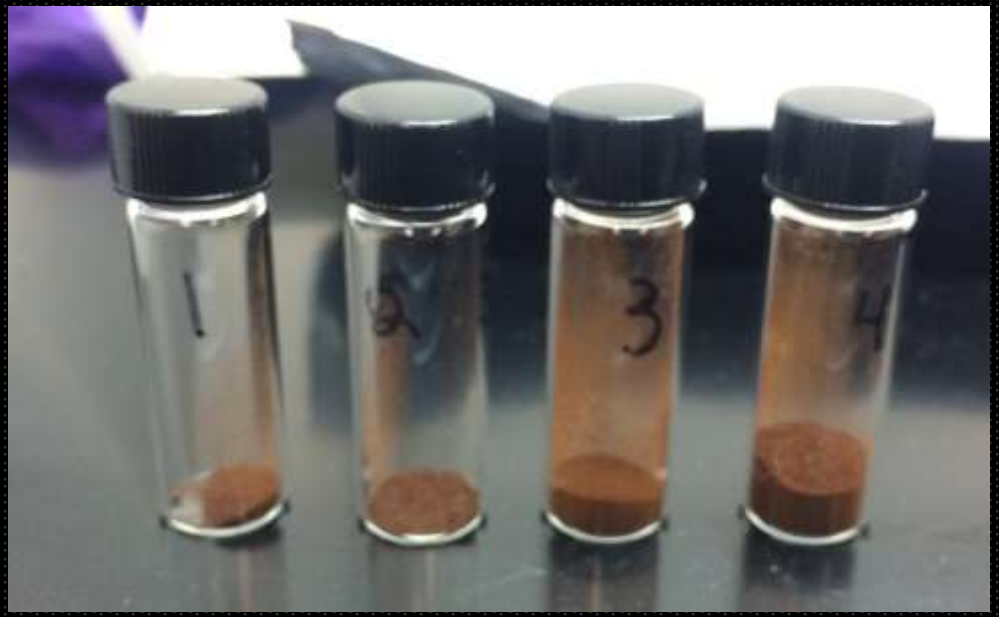

False color

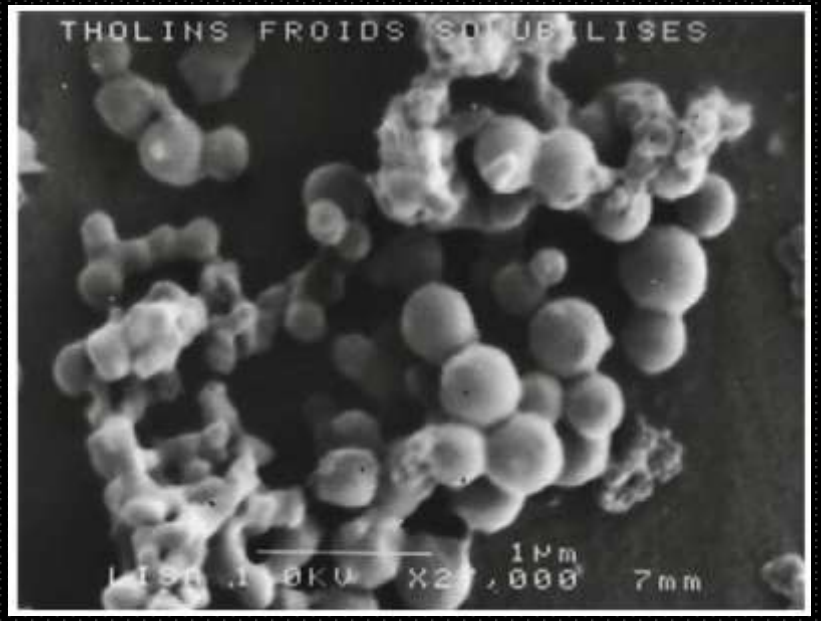




Tholiny (Triton, Titan, Pluto)
Tholos – „blátivý“ (Carl Sagan)

„sajrajt“ (gunk), „hnědý sajrajt“, „složitý organický sajrajt“



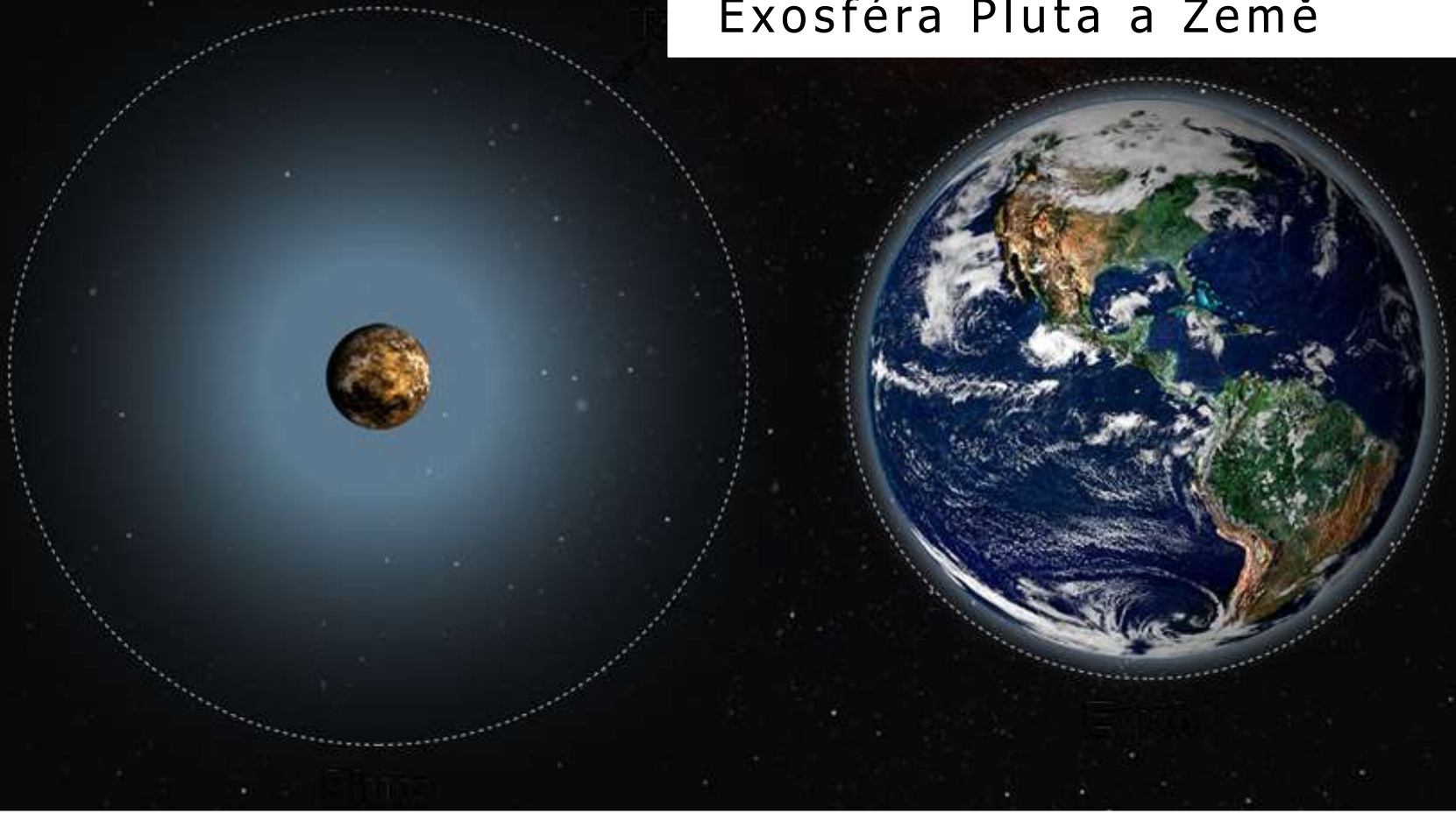


UV

UV

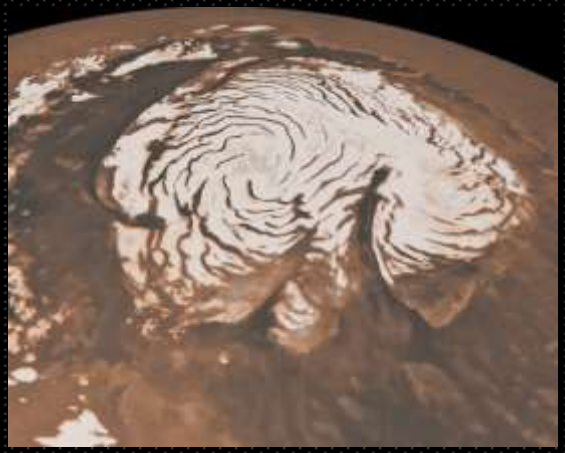
$CH_4 + N_2 \rightarrow$ etylén + acetylén $\rightarrow$ tholiny

Exosféra Pluta a Země

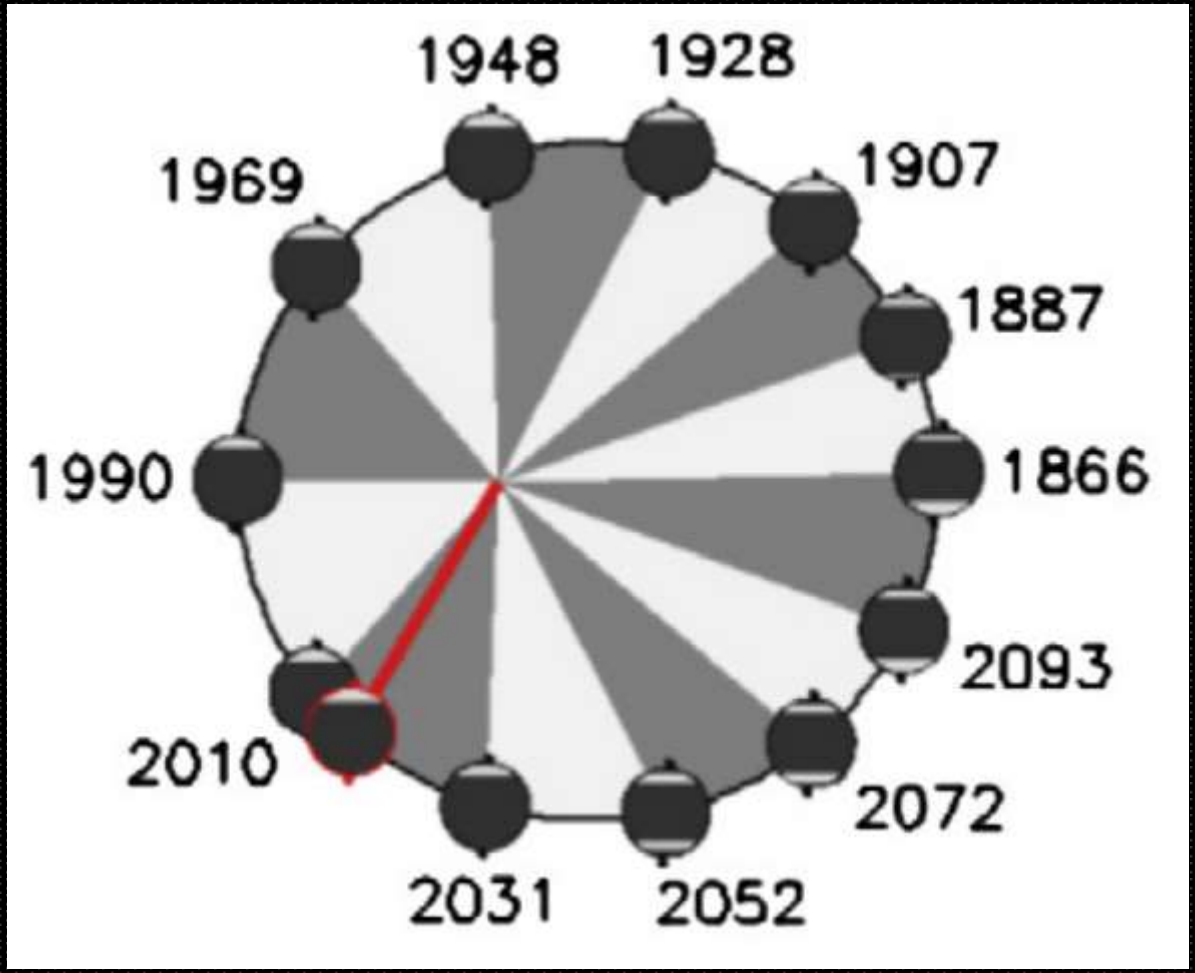


Tlak atmosféry na povrchu: 0,3 Pa (110 km na Zemi)

Teplota povrchu: -238°C až -213°C (35 K až 60 K)
Trojný bod dusíku: -210°C (63 K); 13 kPa
Trojný bod CO: -205°C (68 K); 15 kPa

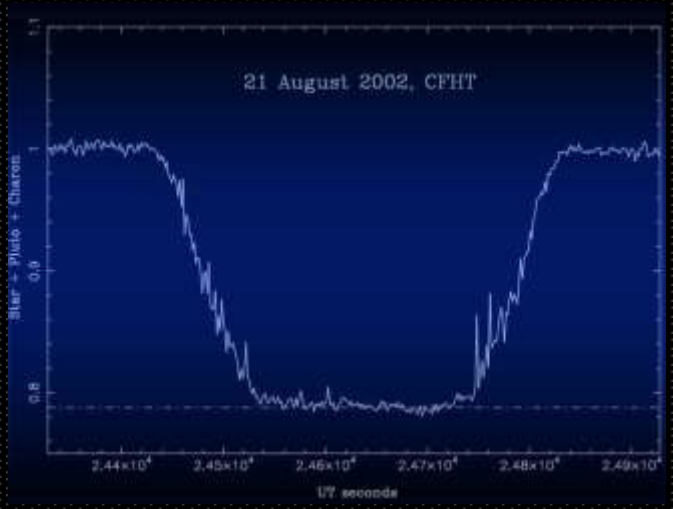


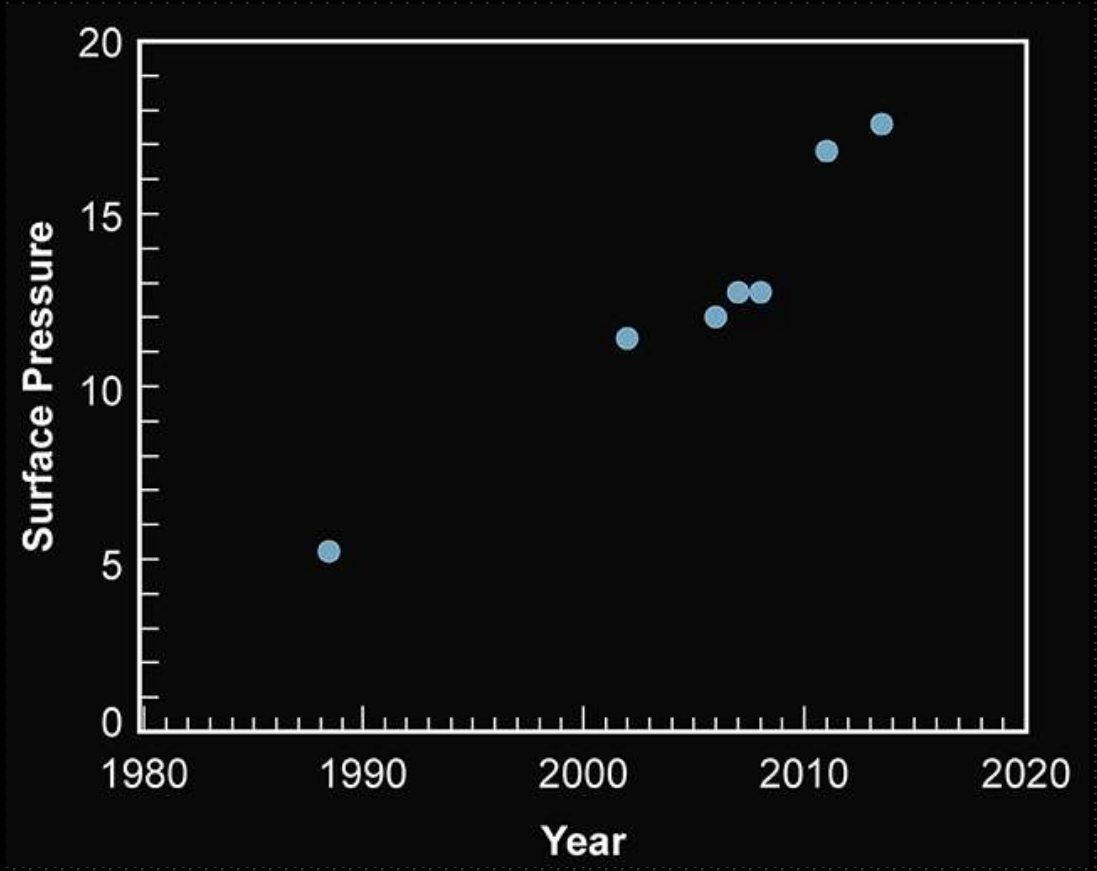
Povrch a atmosféra:
Země: H_2O (3 skupenství) + „skála“
Mars: H_2O + CO_2 (2 skupenství) + „skála“
Pluto: N_2 + CH_4 + CO (2 skupenství) + H_2O (skála)



Velké rozdíly ve vzdálenostech, sklon rotační osy.

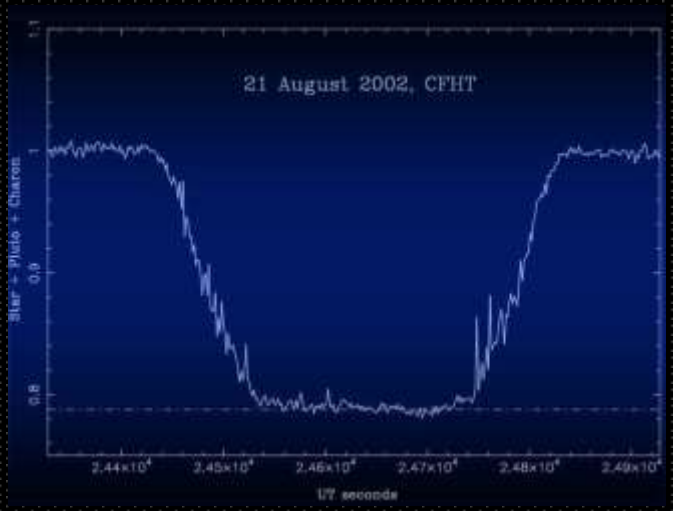
V roce 1987 se poprvé po 120 letech vynořil severní pól ze stínu.

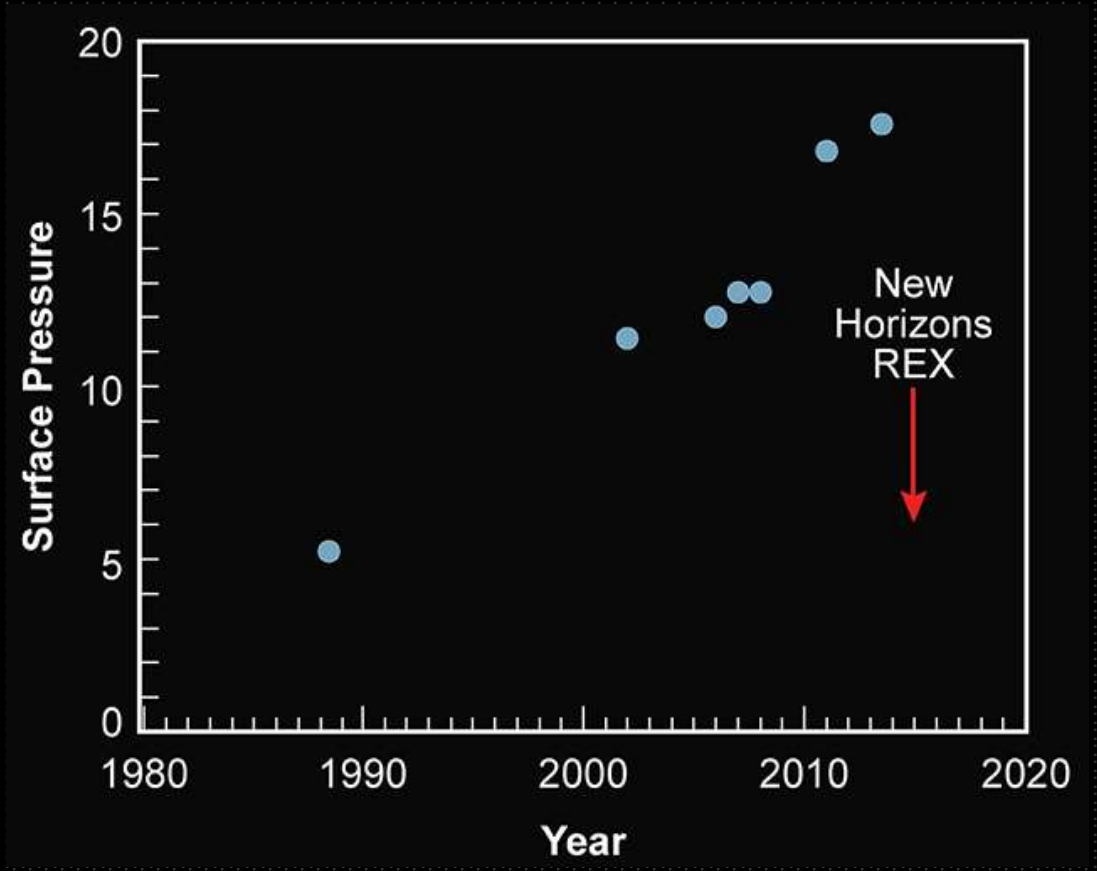




Pozemská detekce atmosféry ze zákrytů hvězd.

Pluto se vzdaluje od Slunce, proto by tlak měl klesat.
Ale polární čepička sublimuje, proto tlak narůstá.





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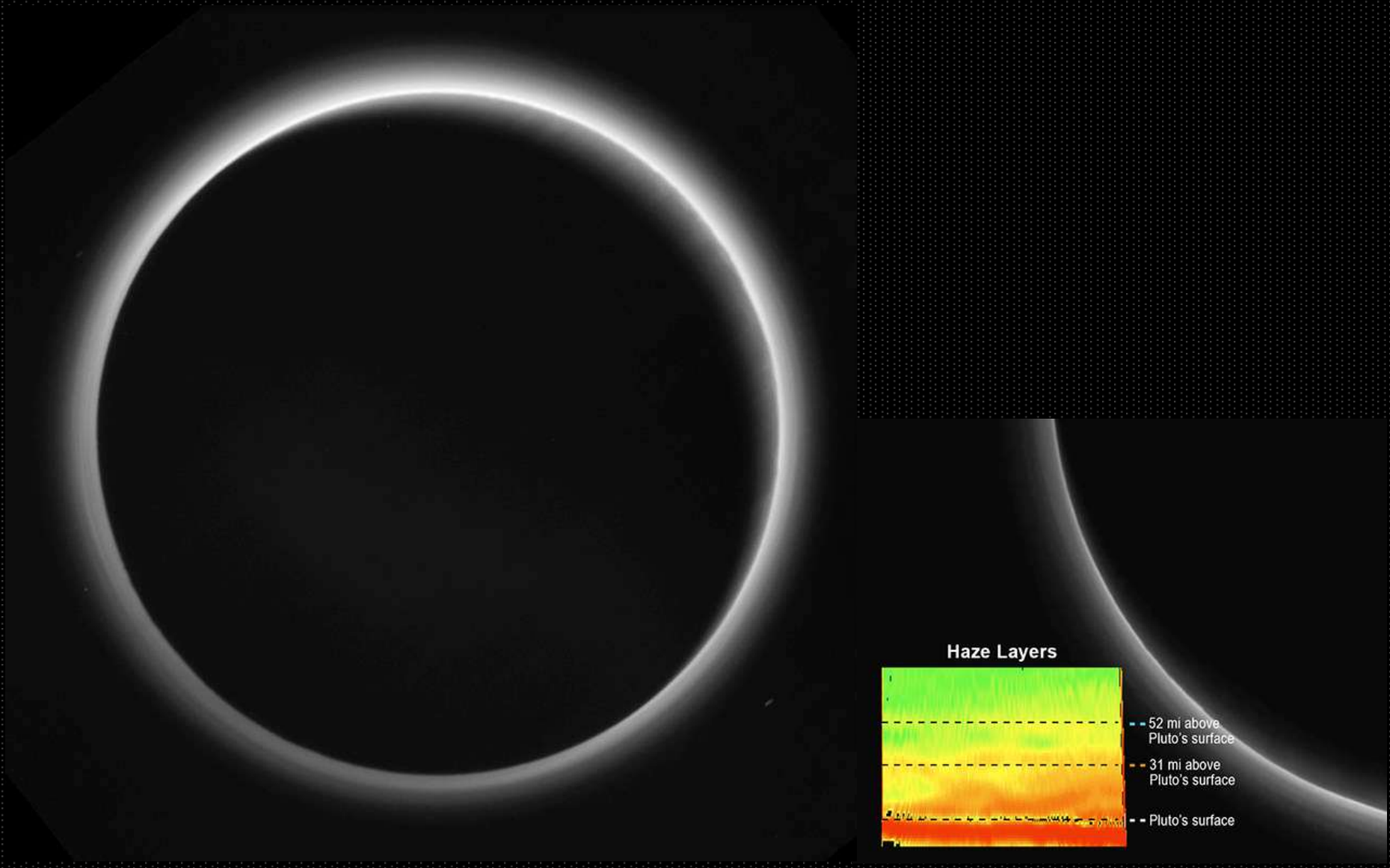
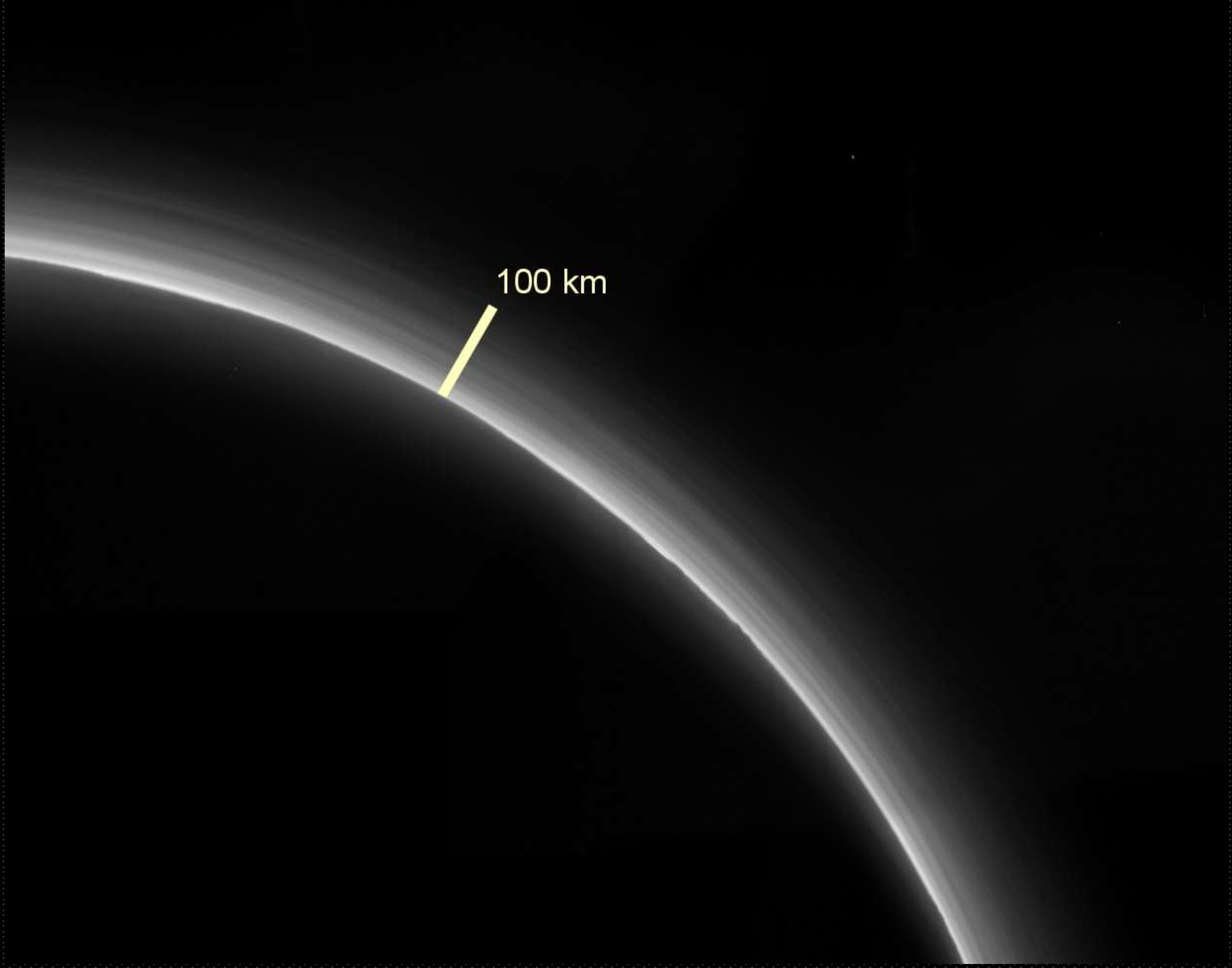
Ale polární čepička sublimuje, proto tlak narůstá.



Snímek atmosféry Pluta z kamery LORRI


100 km

Titan (Cassini) a Pluto (New Horizons)

Má Pluto modrou oblohu?

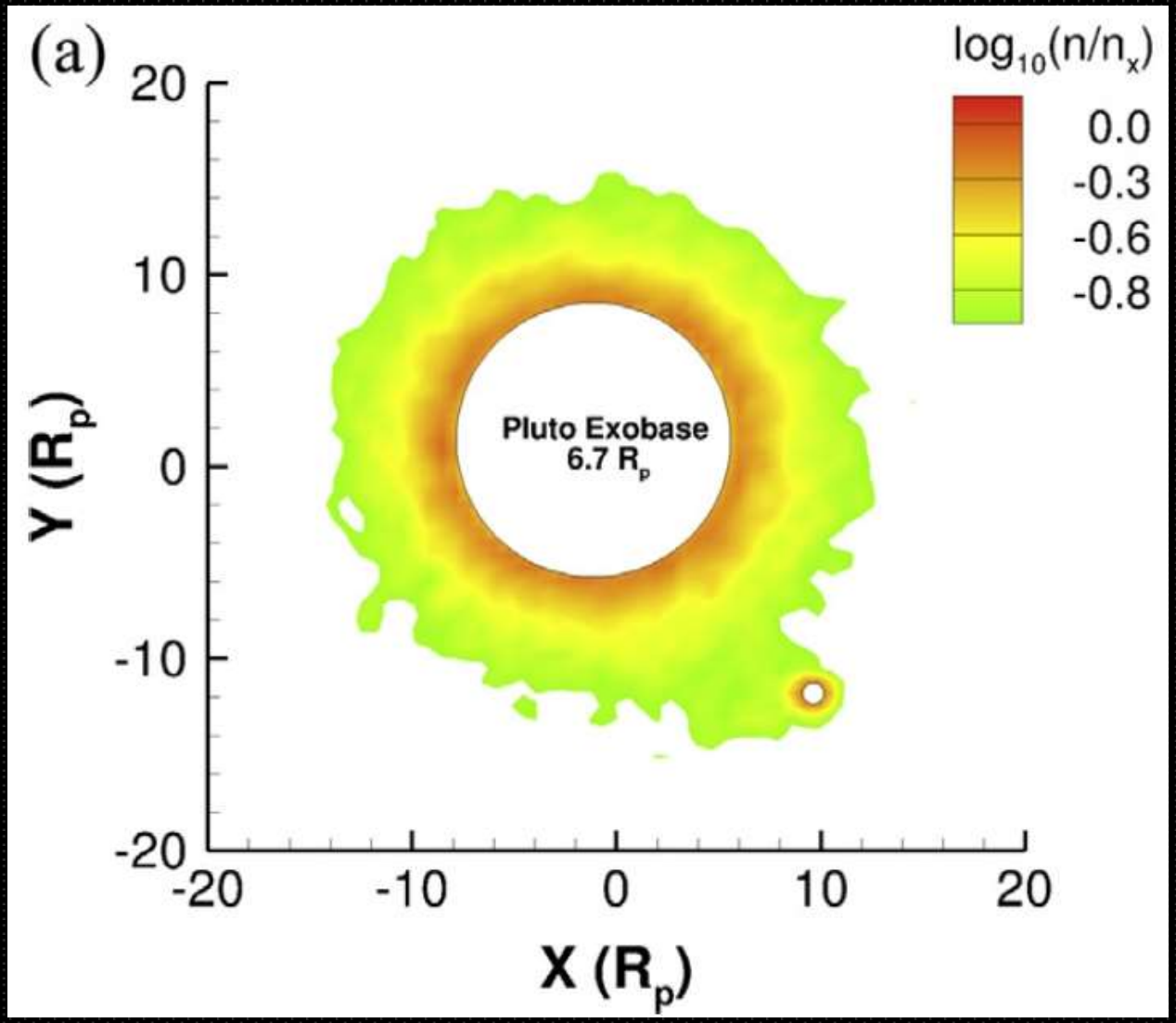
Pluto

Titan

Země

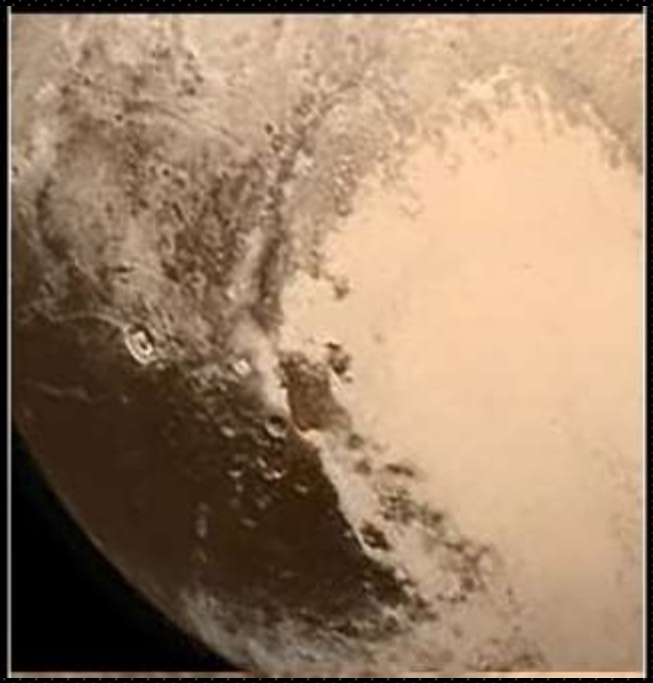
Mars

Má Pluto modrou oblohu?



Atmosféra Pluta možná namrzá až na Charonu.

Povrch Pluta



Povrch Pluta

Povrch Pluta

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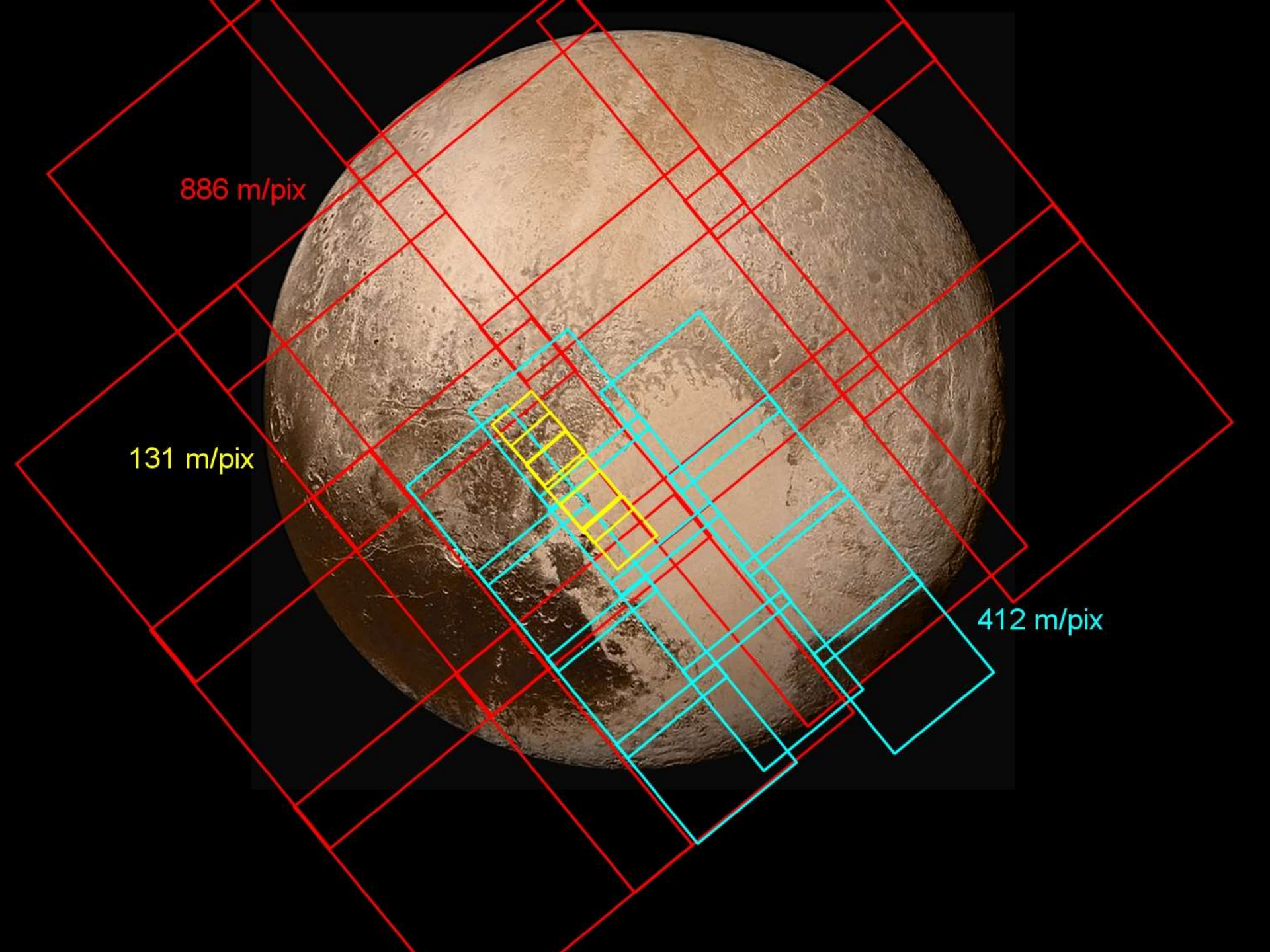
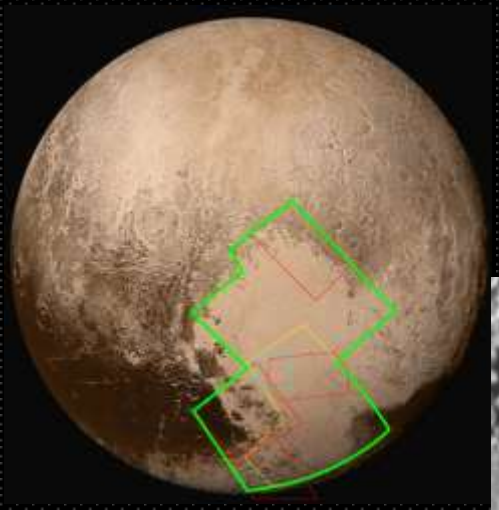
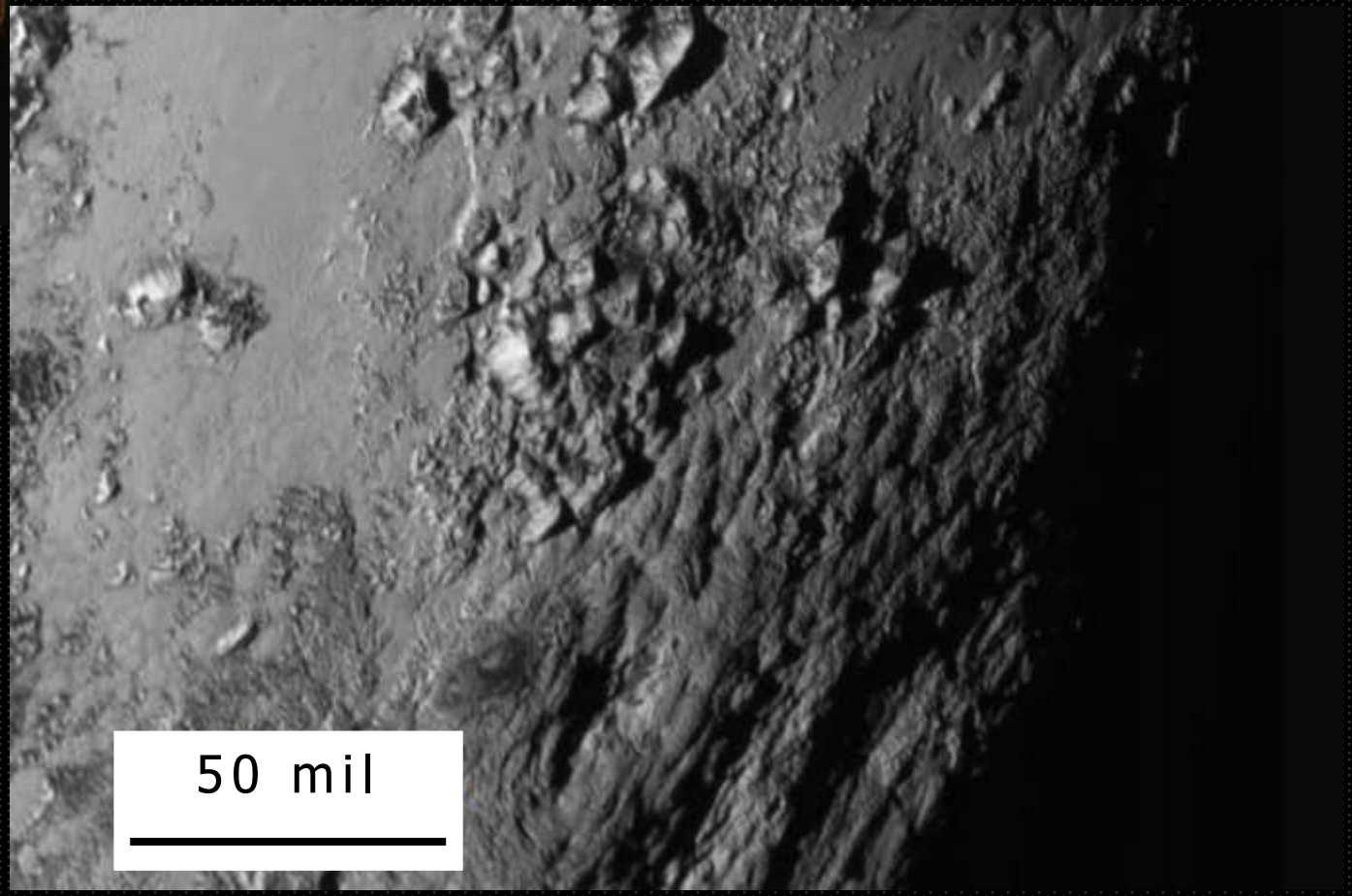
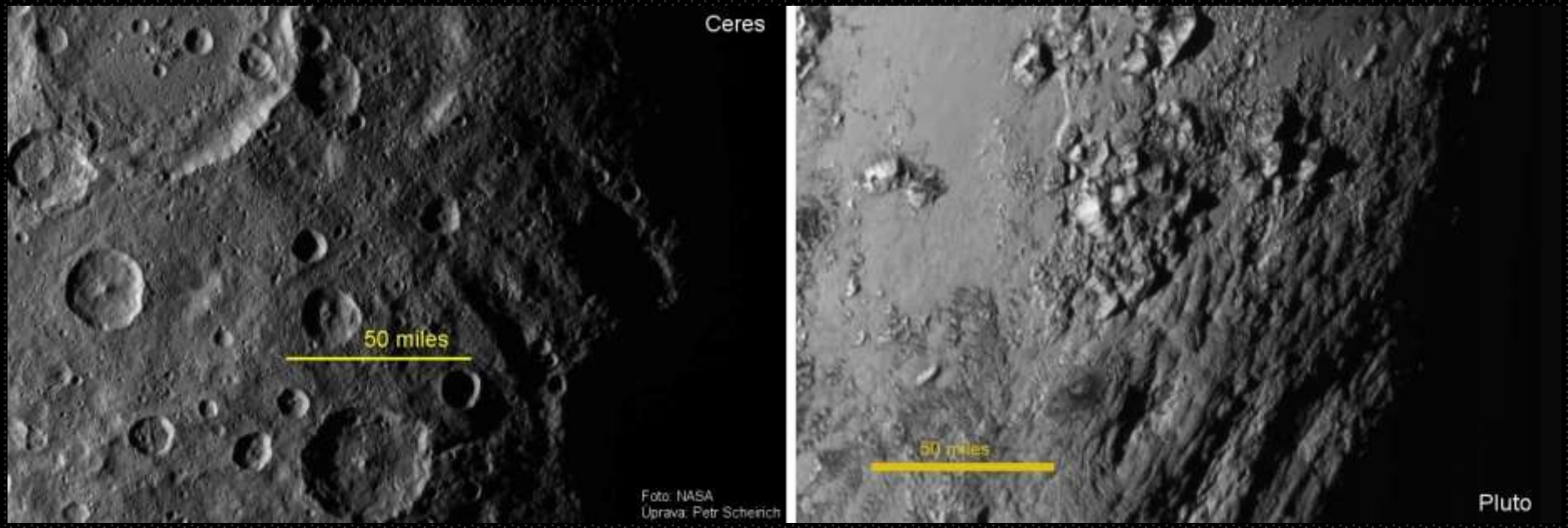

886 m/pix
131 m/pix
412 m/pix

Pluto time
16:35 SEČ

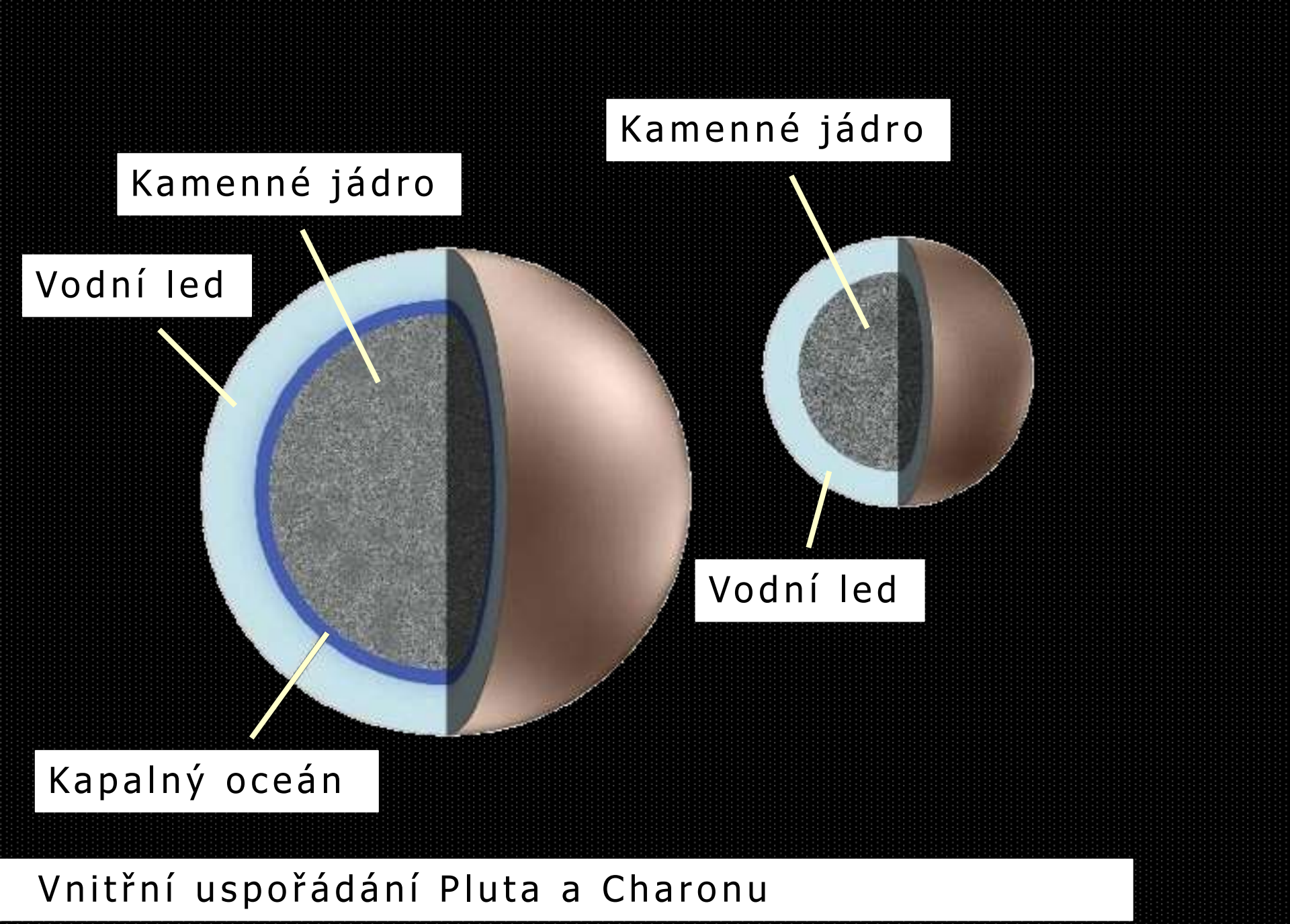




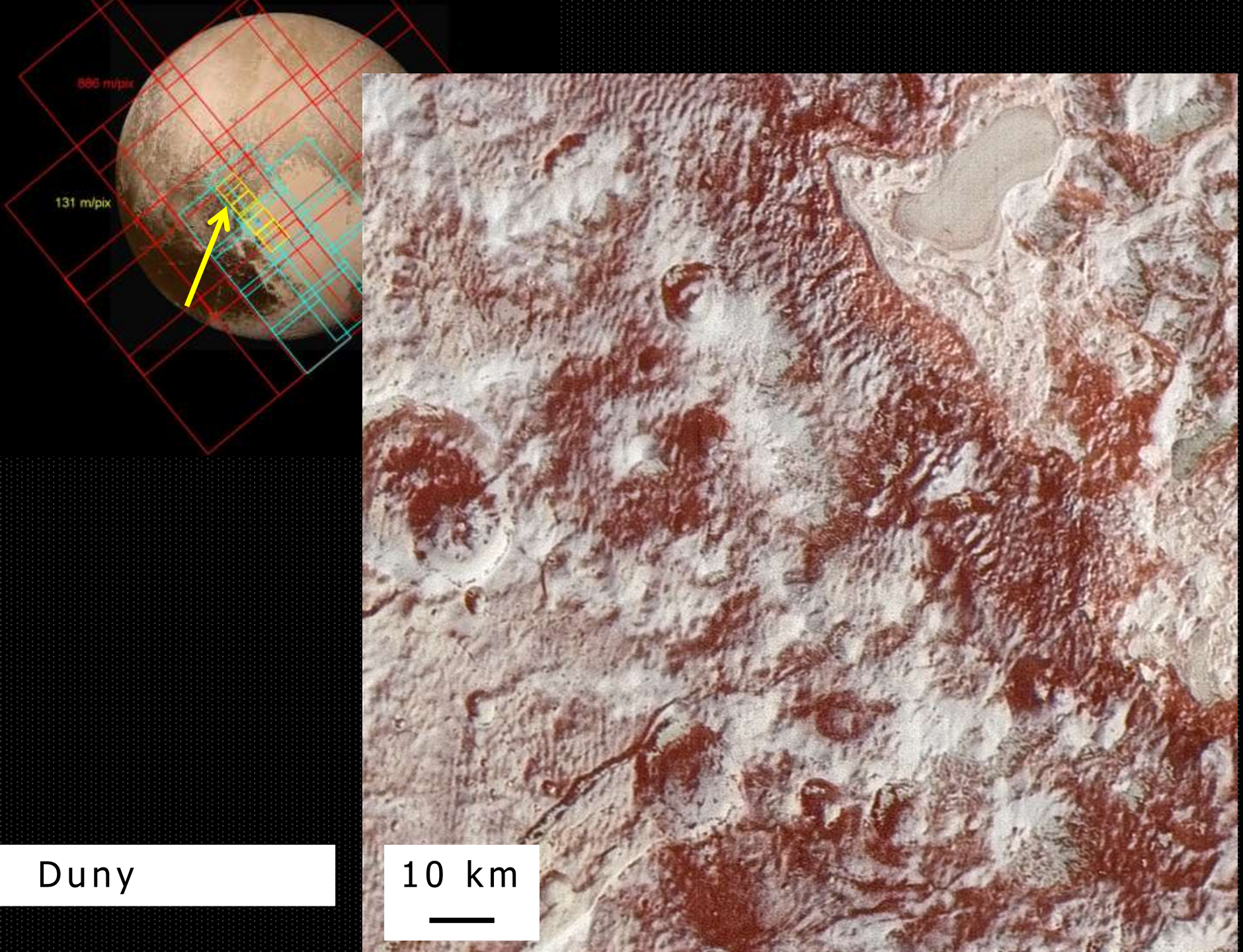
První snímek s vysokým rozlišením

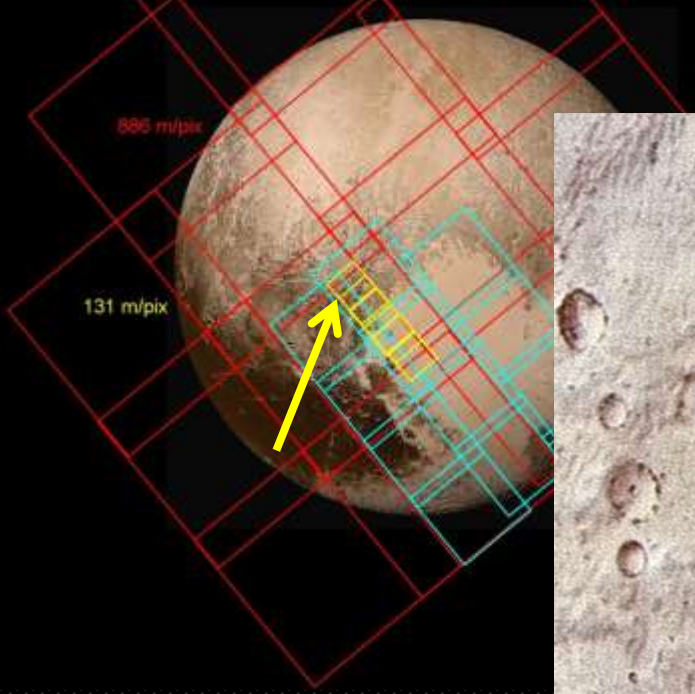


Málo kráterů – geologicky mladý povrch.



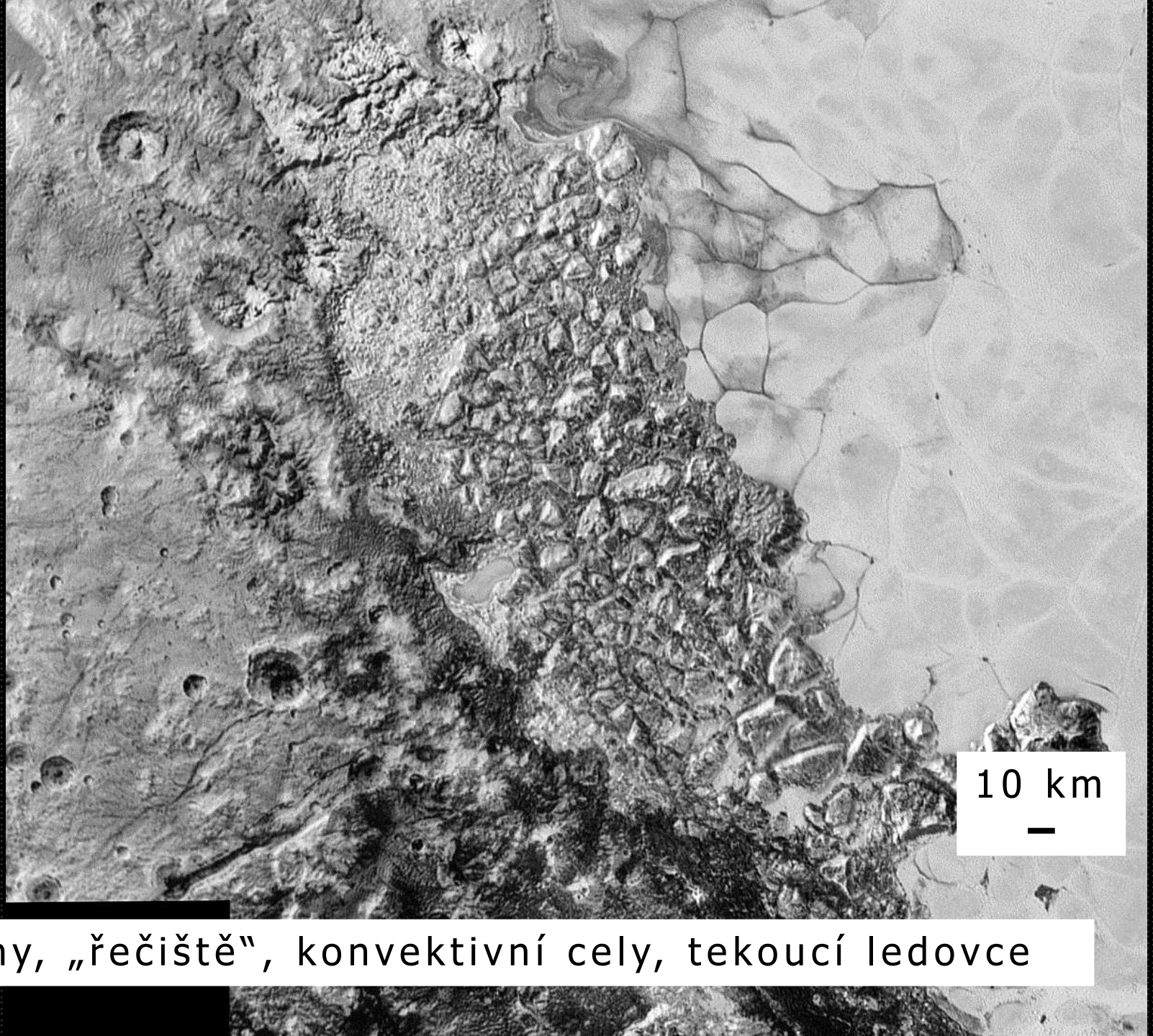
Vnitřní uspořádání Pluta a Charonu


886 m/pix
131 m/pix
Duny
10 km

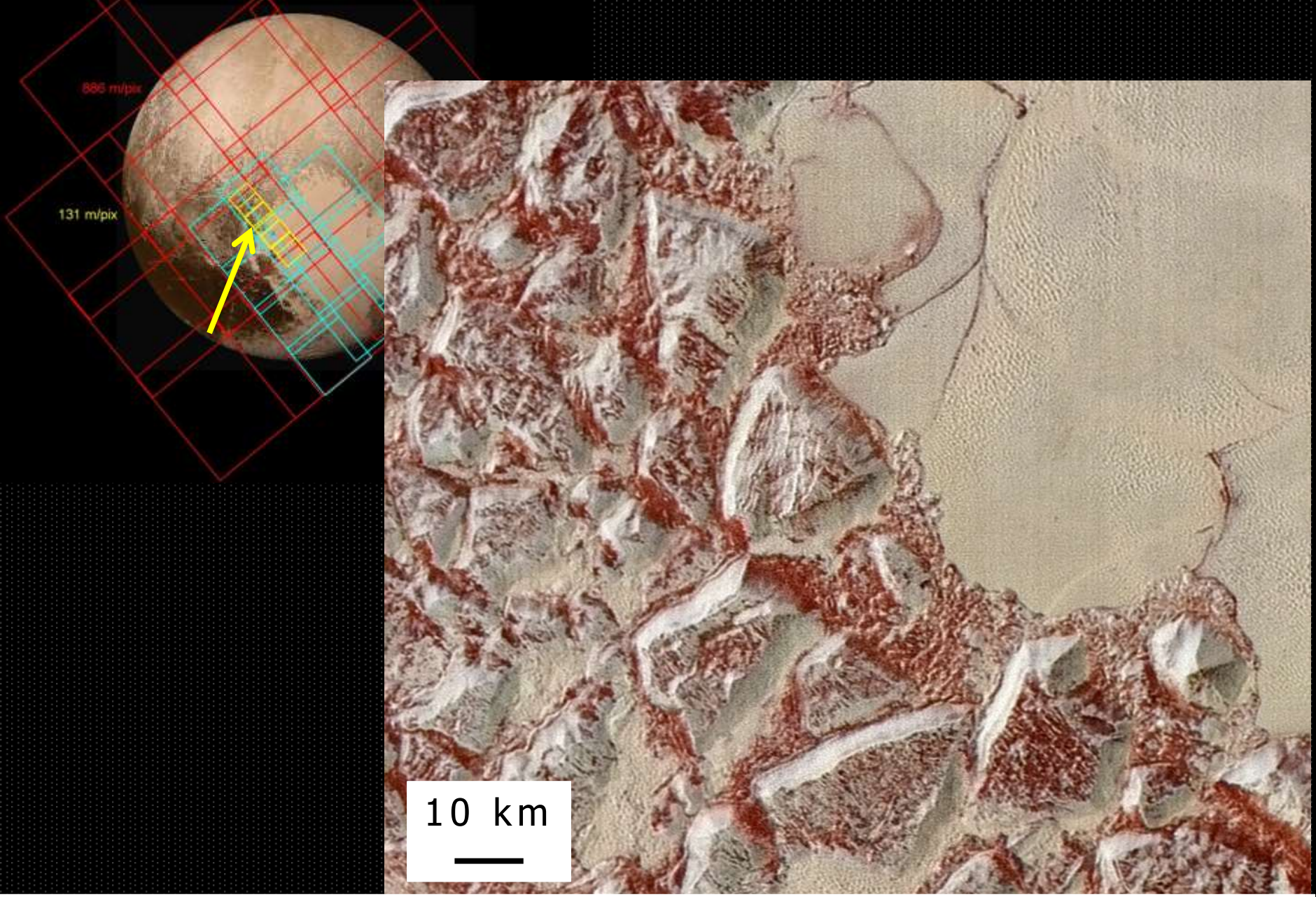


„Řečiště“?

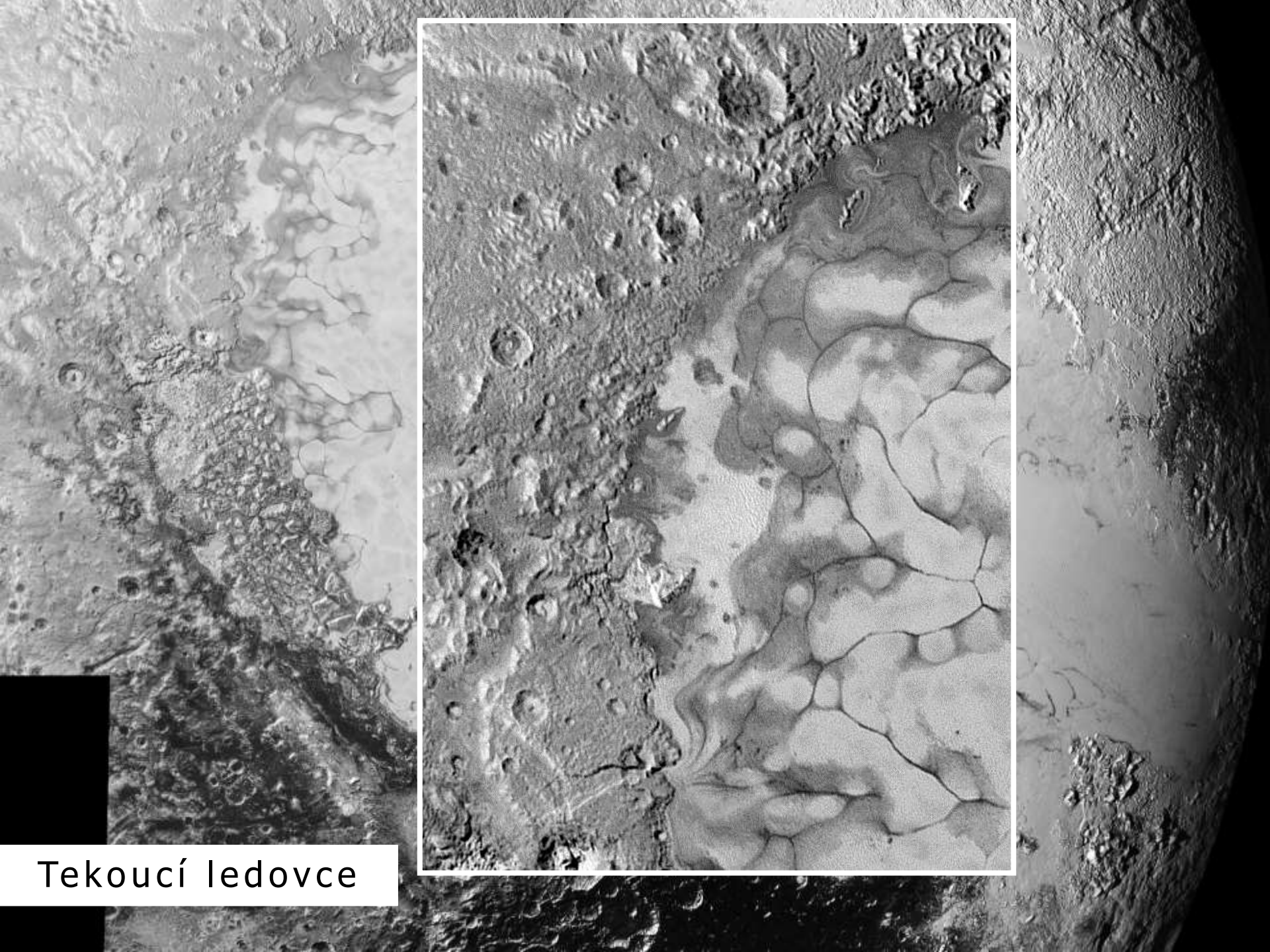
10 km



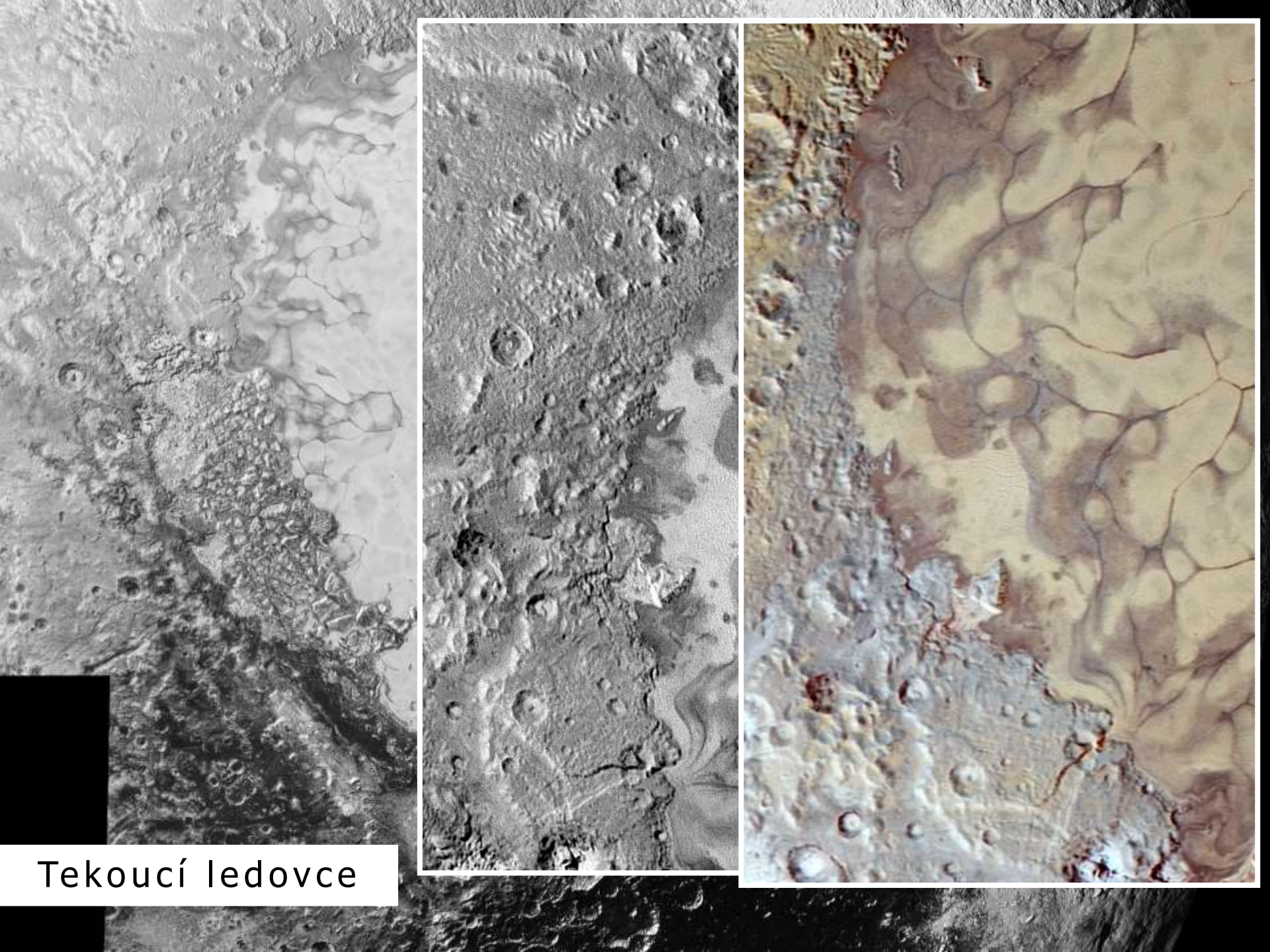
Duny, „řečiště“, konvektivní cely, tekoucí ledovce



Zakousnutá „ledovcová“ údolí na okraji Tombough Regio, duny



Tekoucí ledovce

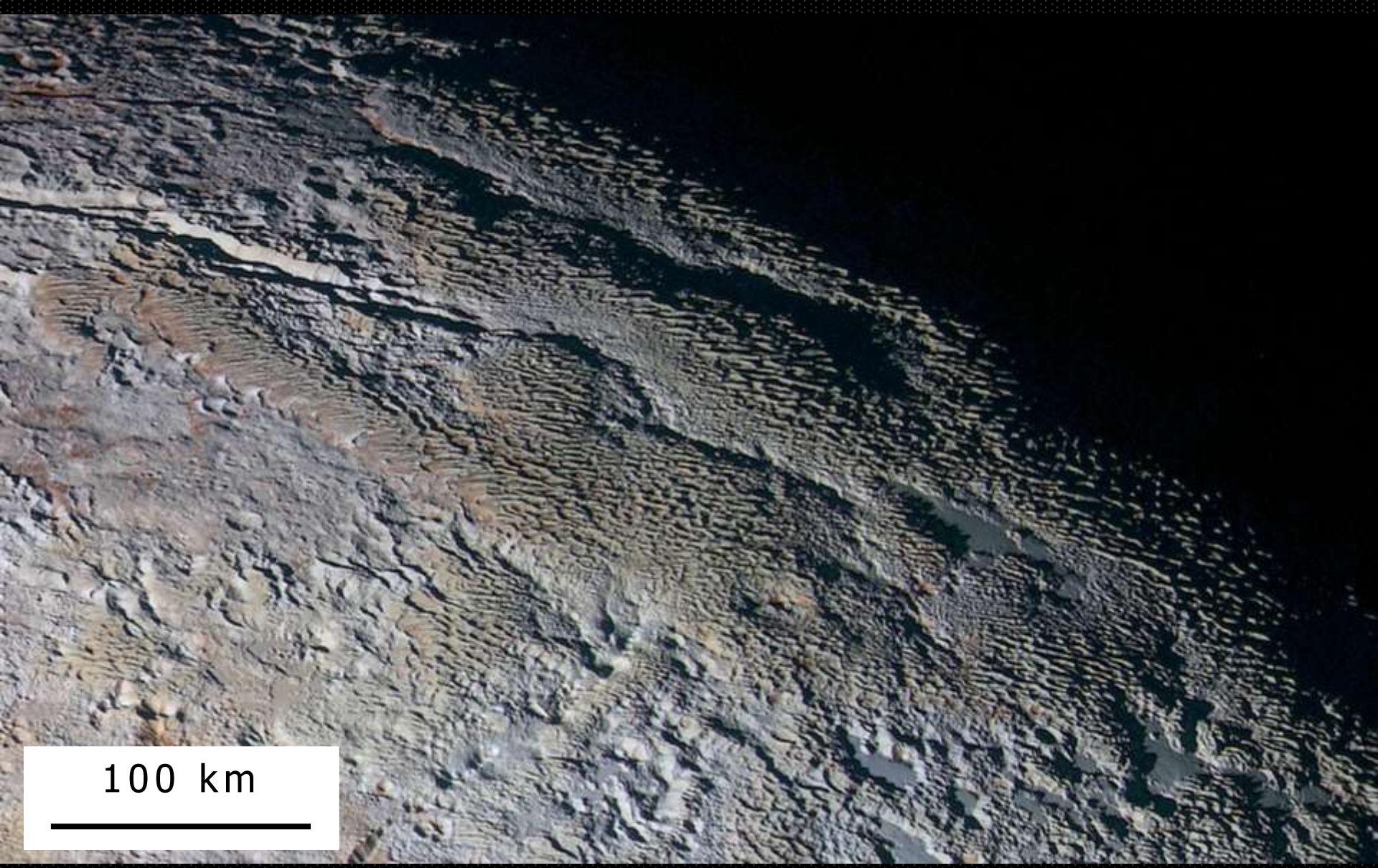


Tekoucí ledovce

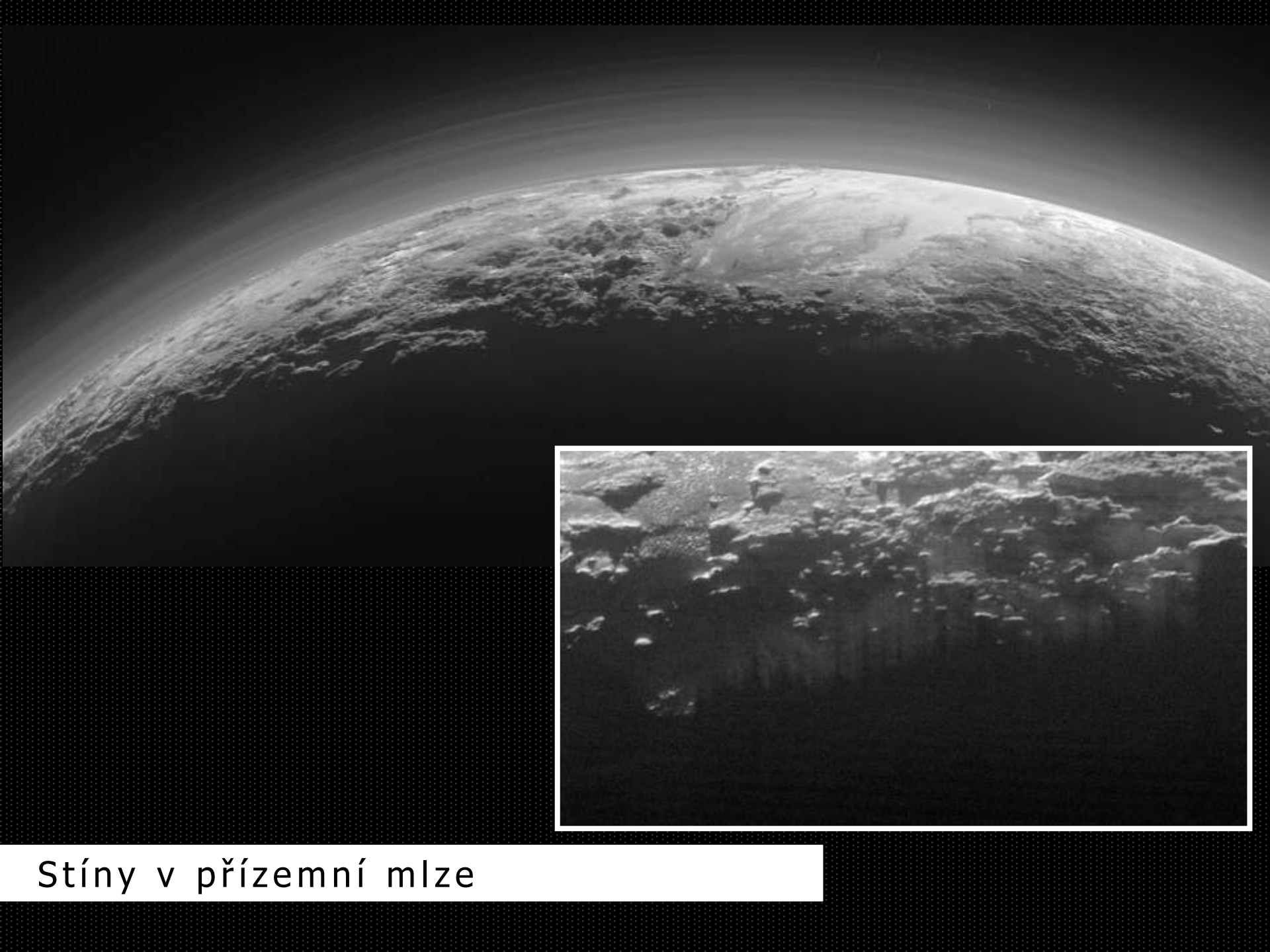
Působení větru?
Dvojitá údolí mezi konvektivními buňkami

Působení větru?
Dvojitá údolí mezi konvektivními buňkami

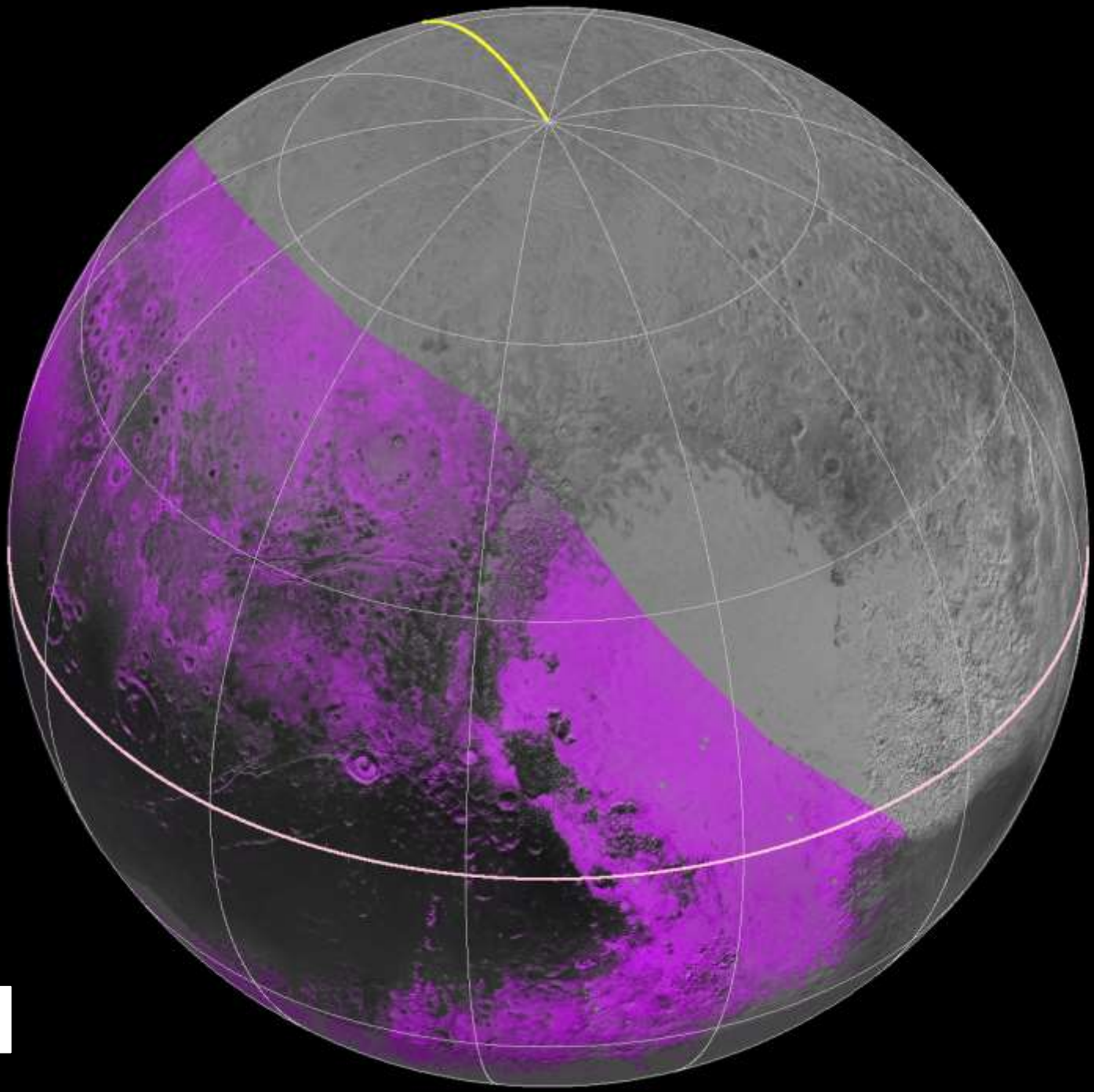
Eroze – ostré „mysy“ a oblé „zálivy“.

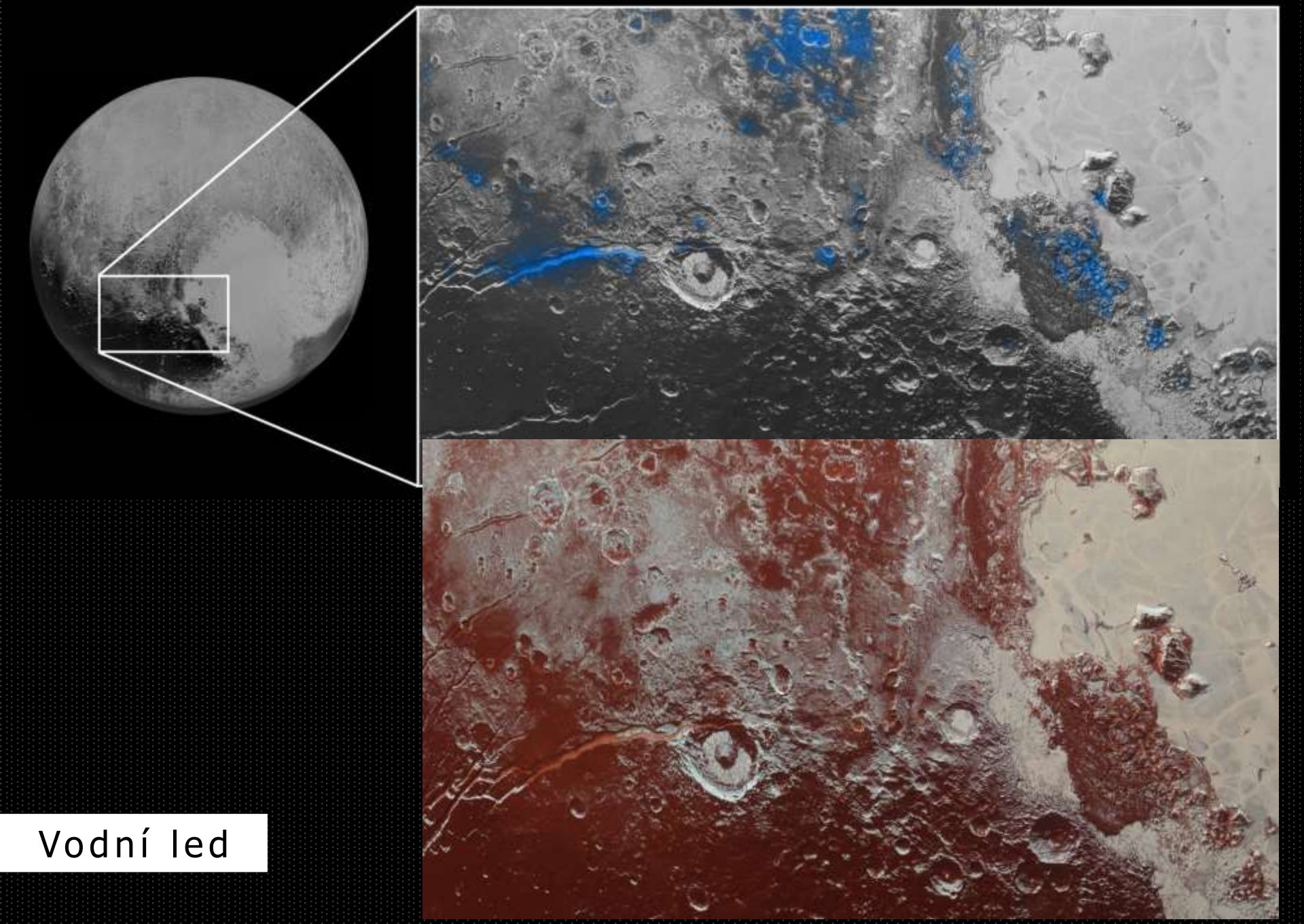


Sublimace nebo kondenzace?

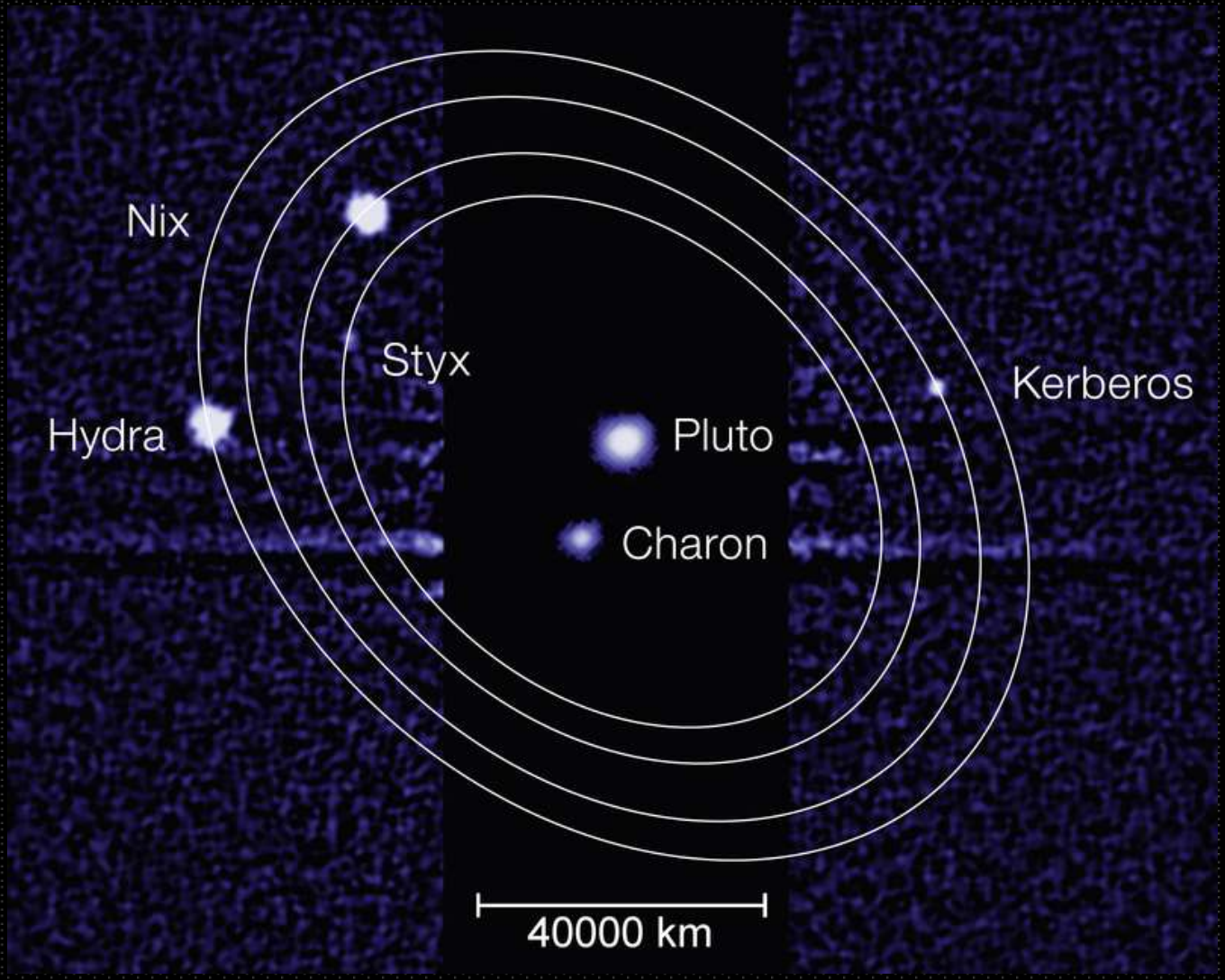


Stíny v přízemní mlze

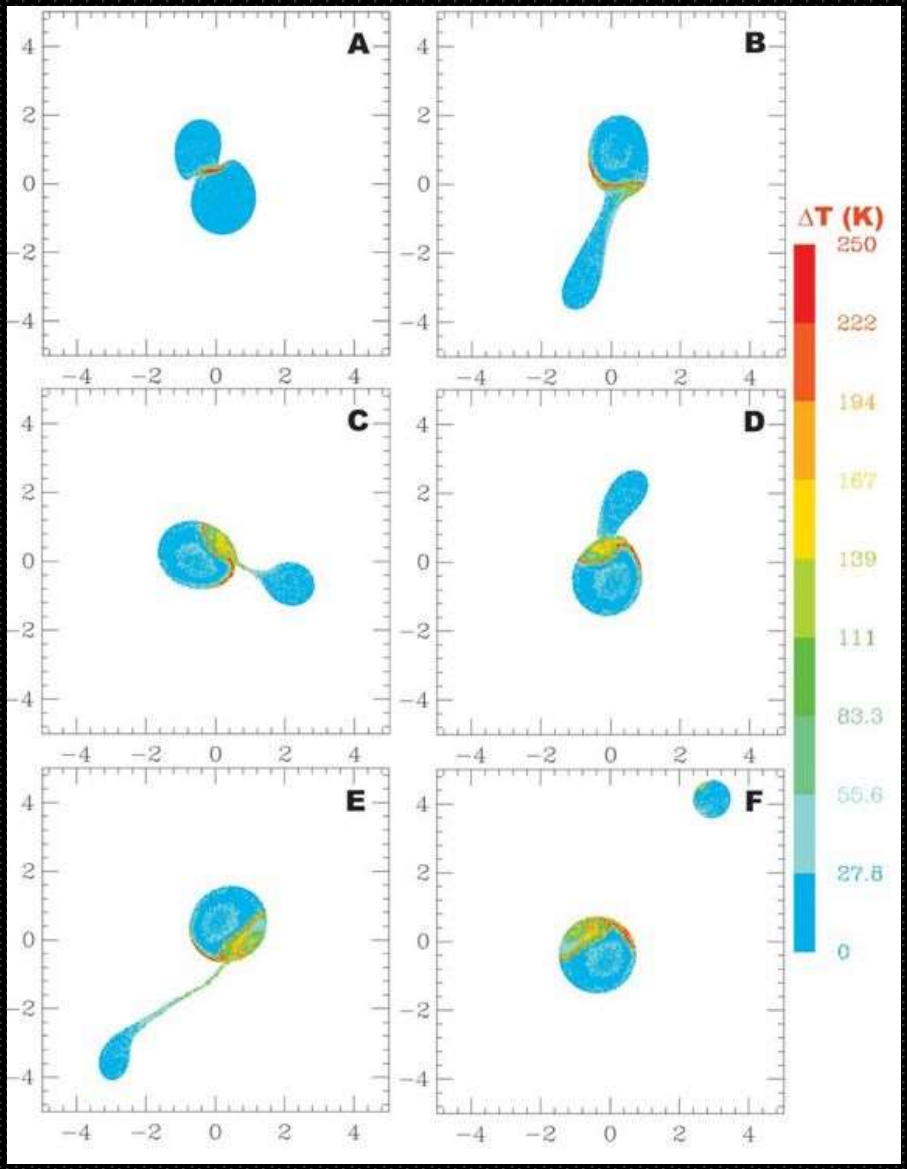

Metan



Vodní led

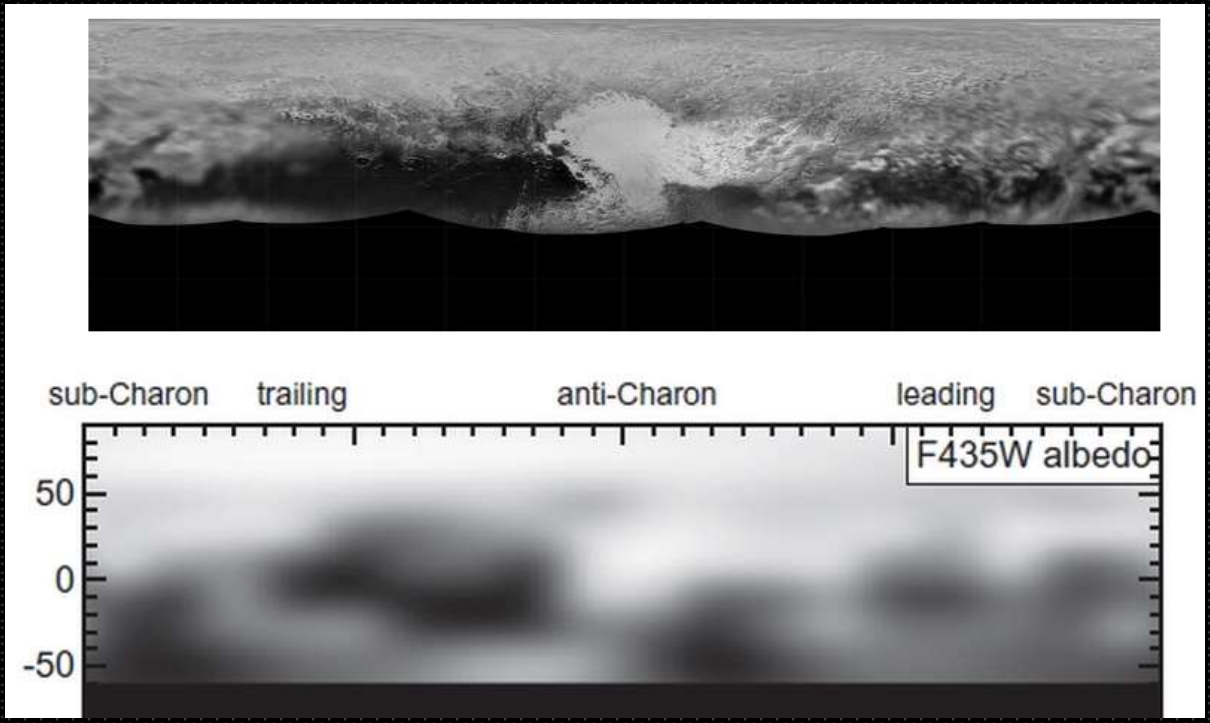


Měsíce Pluta

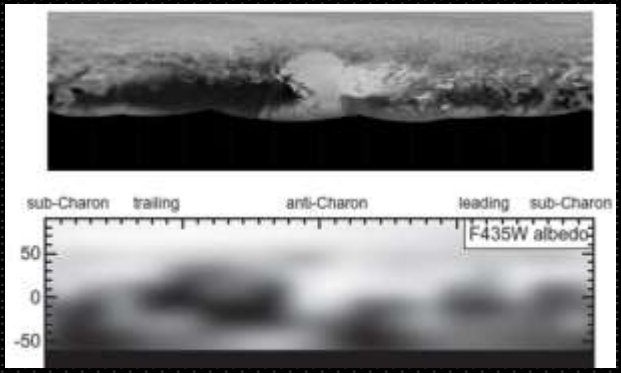


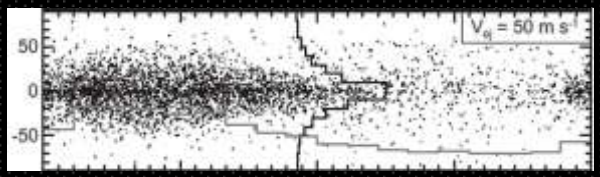
Měsíce Pluta – vznik při velké srážce

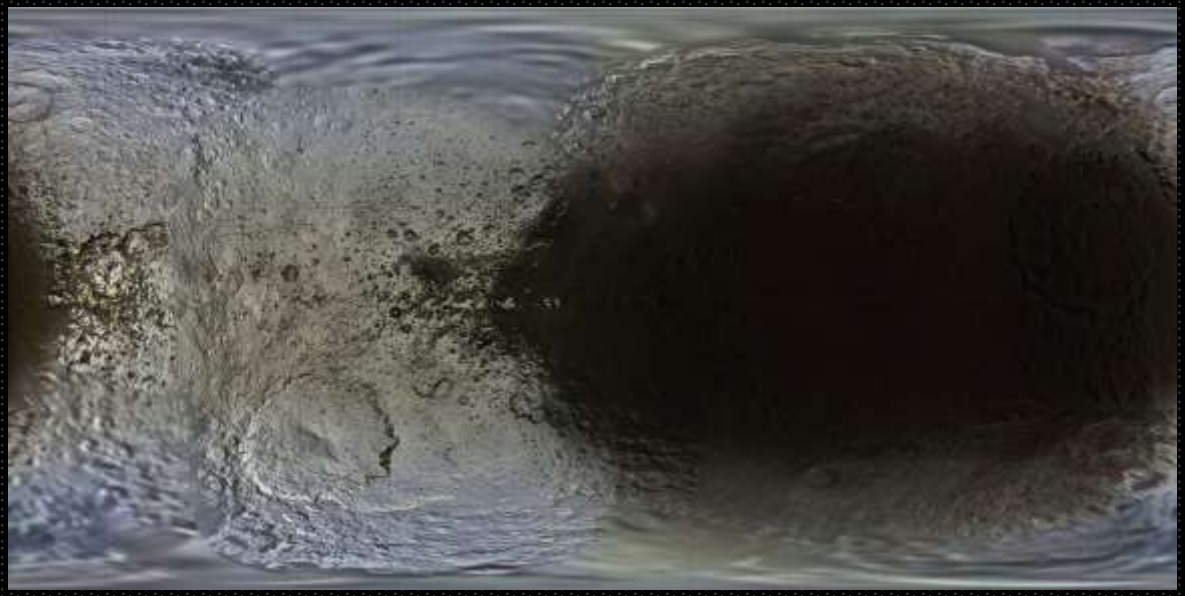
Malé měsíce Pluta



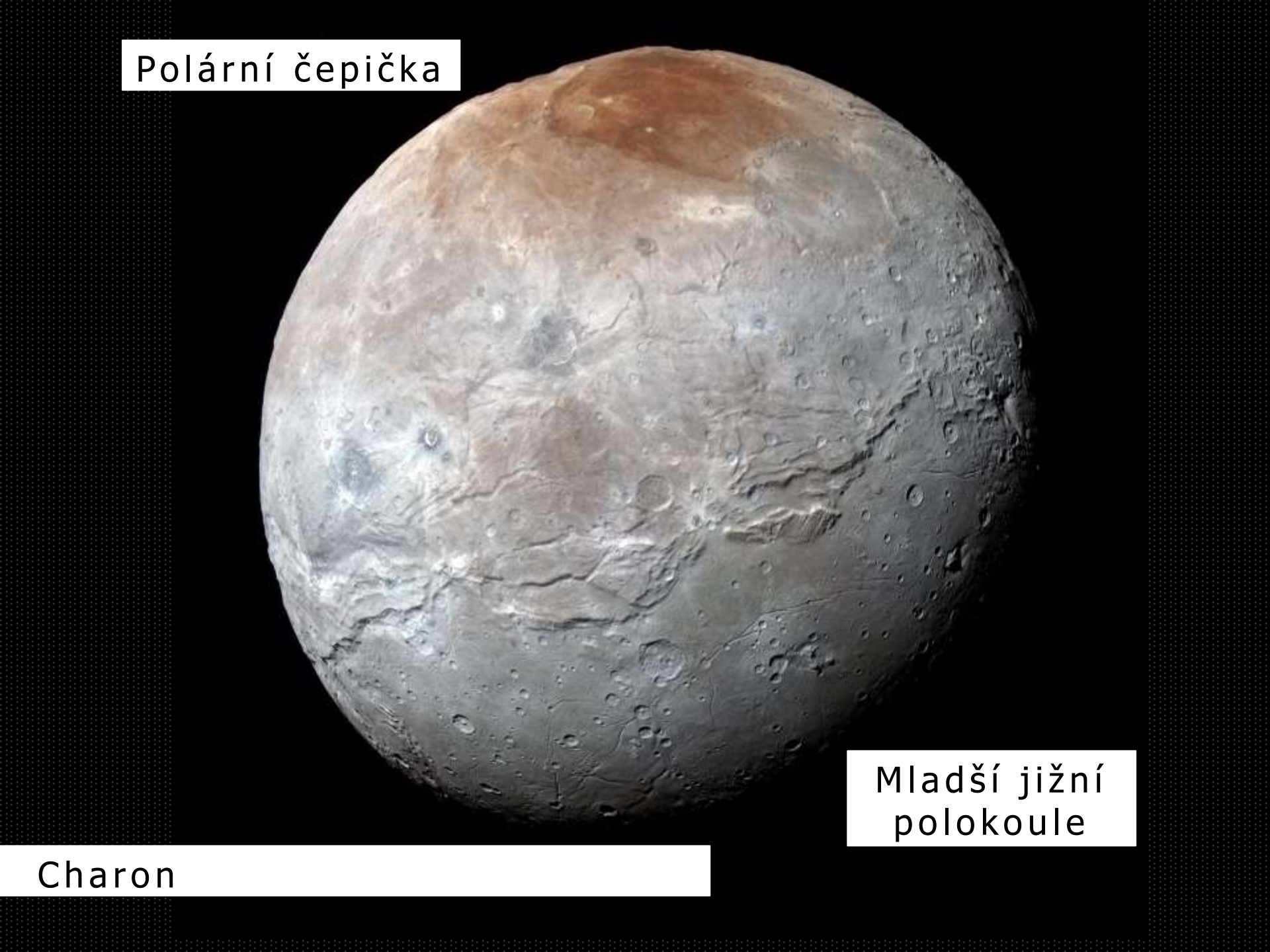
Prach z měsíce Nix na povrchu Pluta



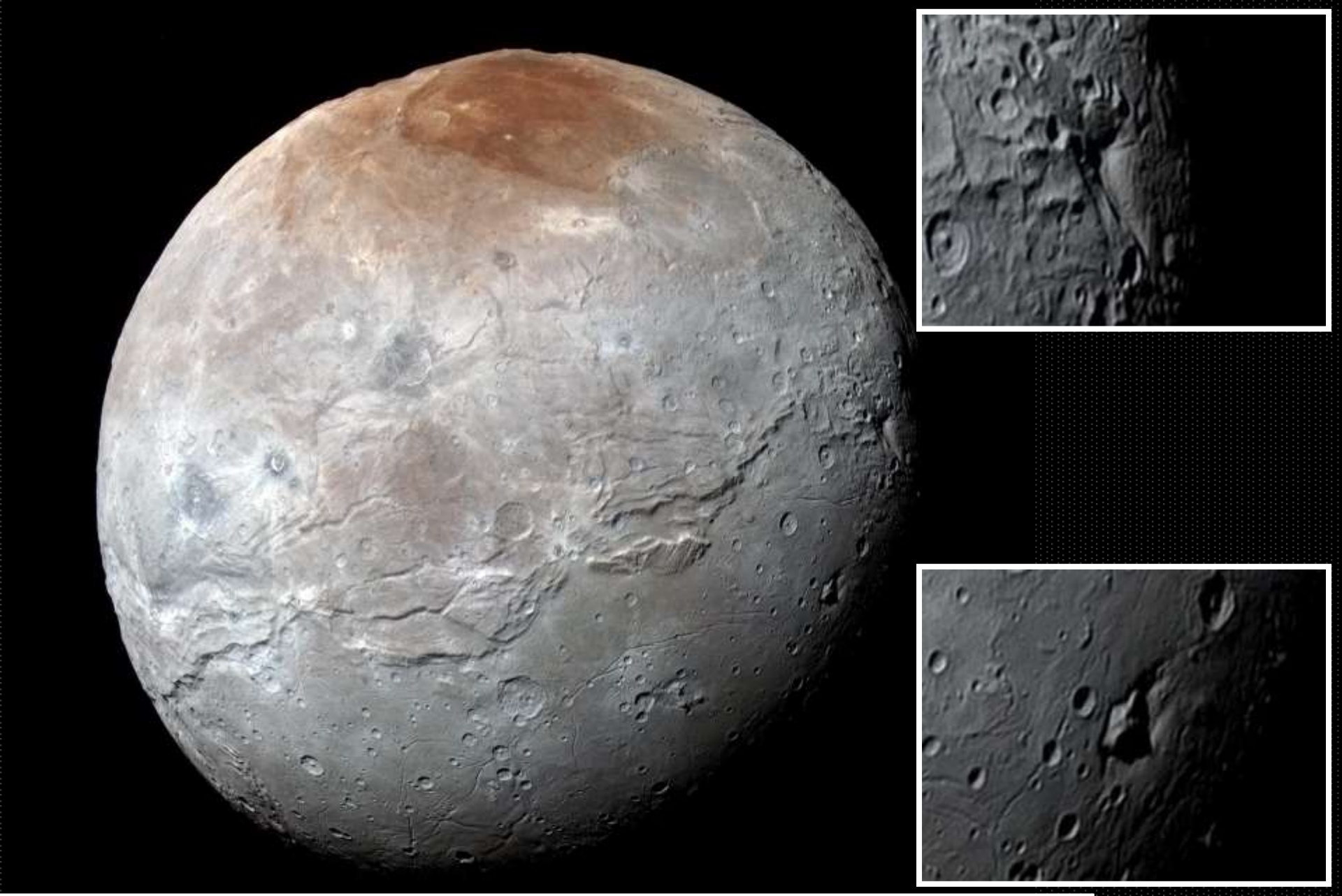




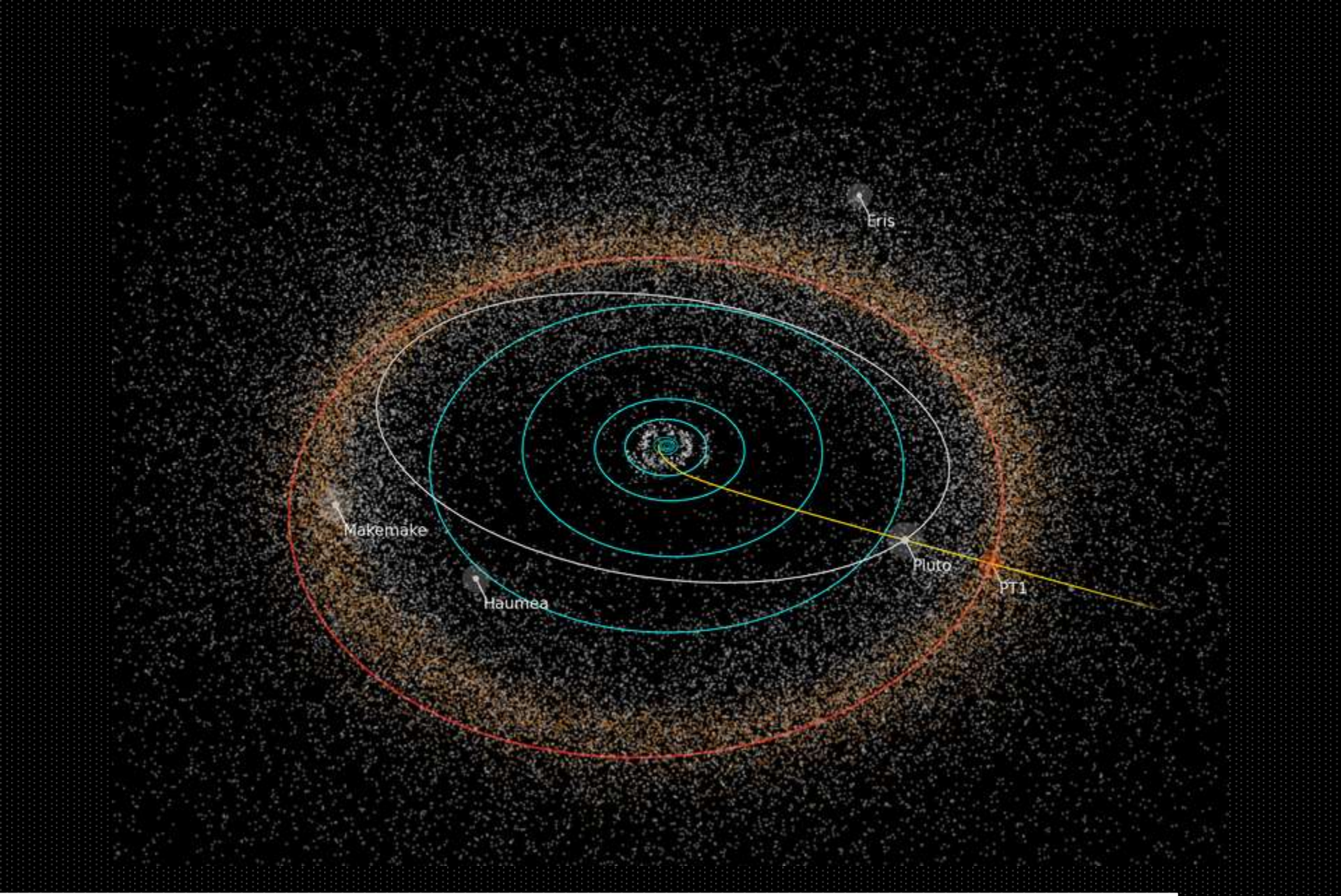
Japetus a prach z Phoebe


Polární čepička
Mladší jižní polokoule
Charon

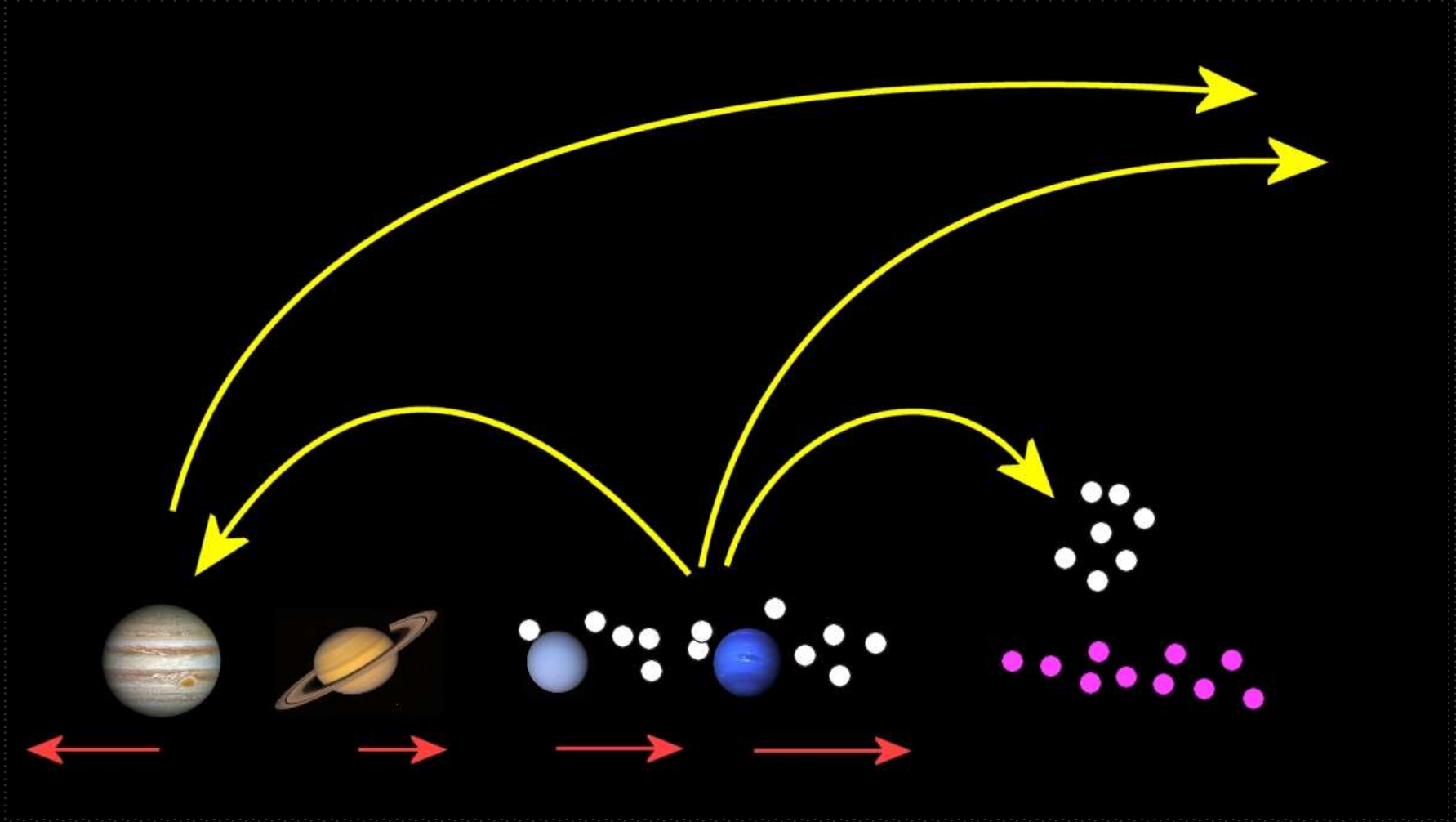

Tethys
Dione
Umbriel
Oberon
Ariel
Foto: NASA
Koláž: Petr Scheirich



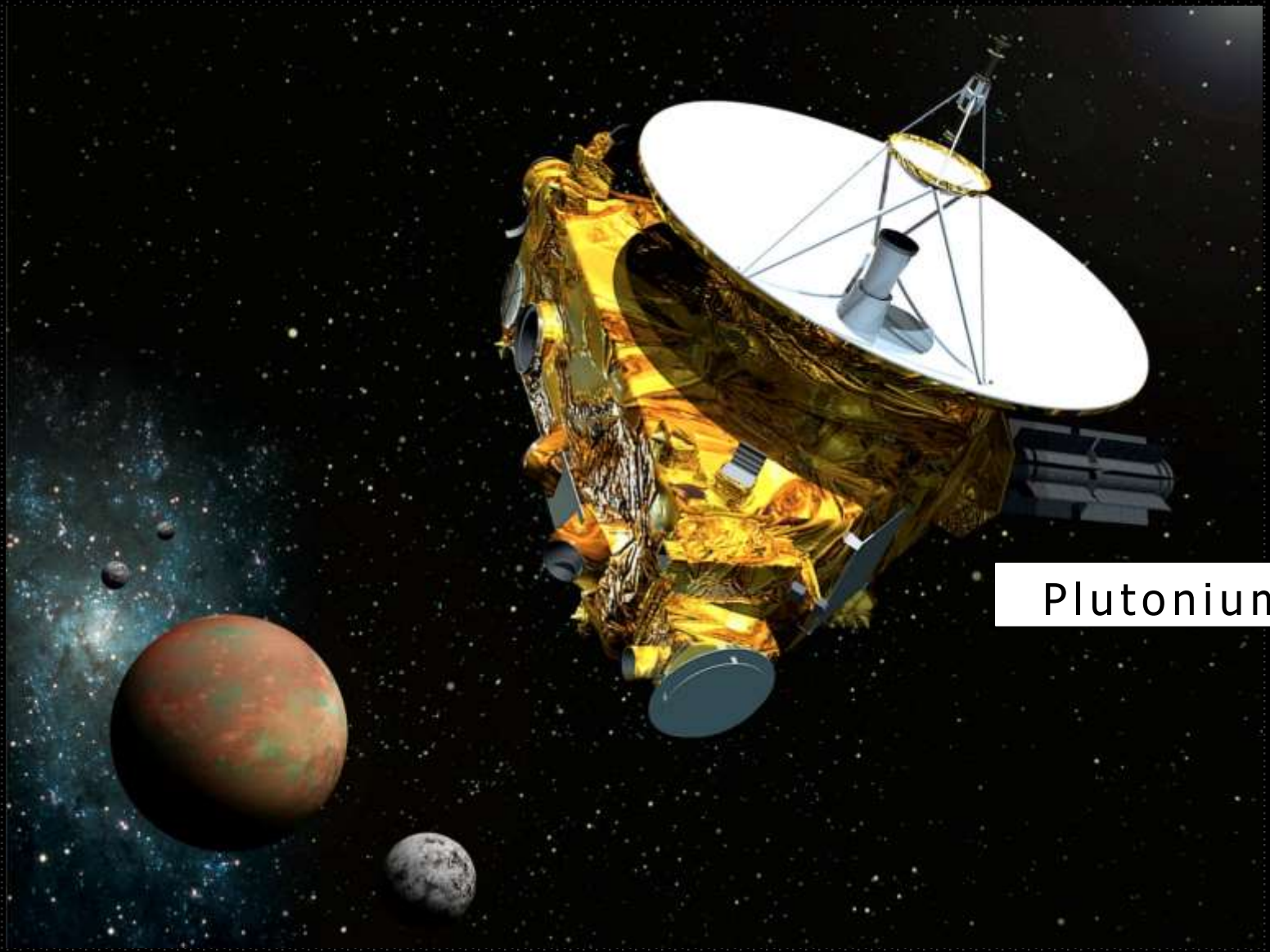
Leinhardt a kol., 2008:
Impakty, při nichž se impaktor nerozpadl.



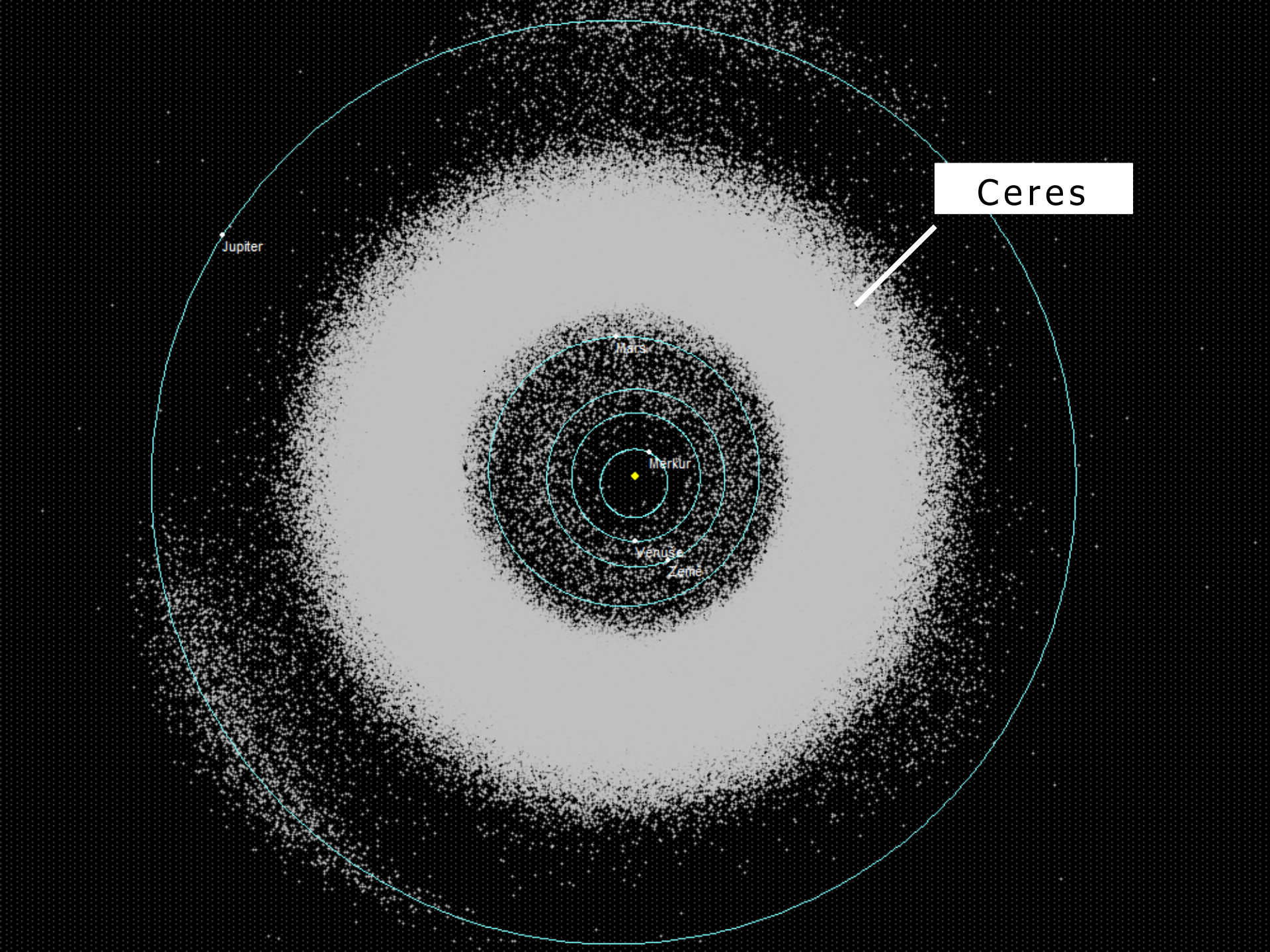
Další cíl sondy New Horizons: 2014 MU69
(40 km, 1.1.2019)

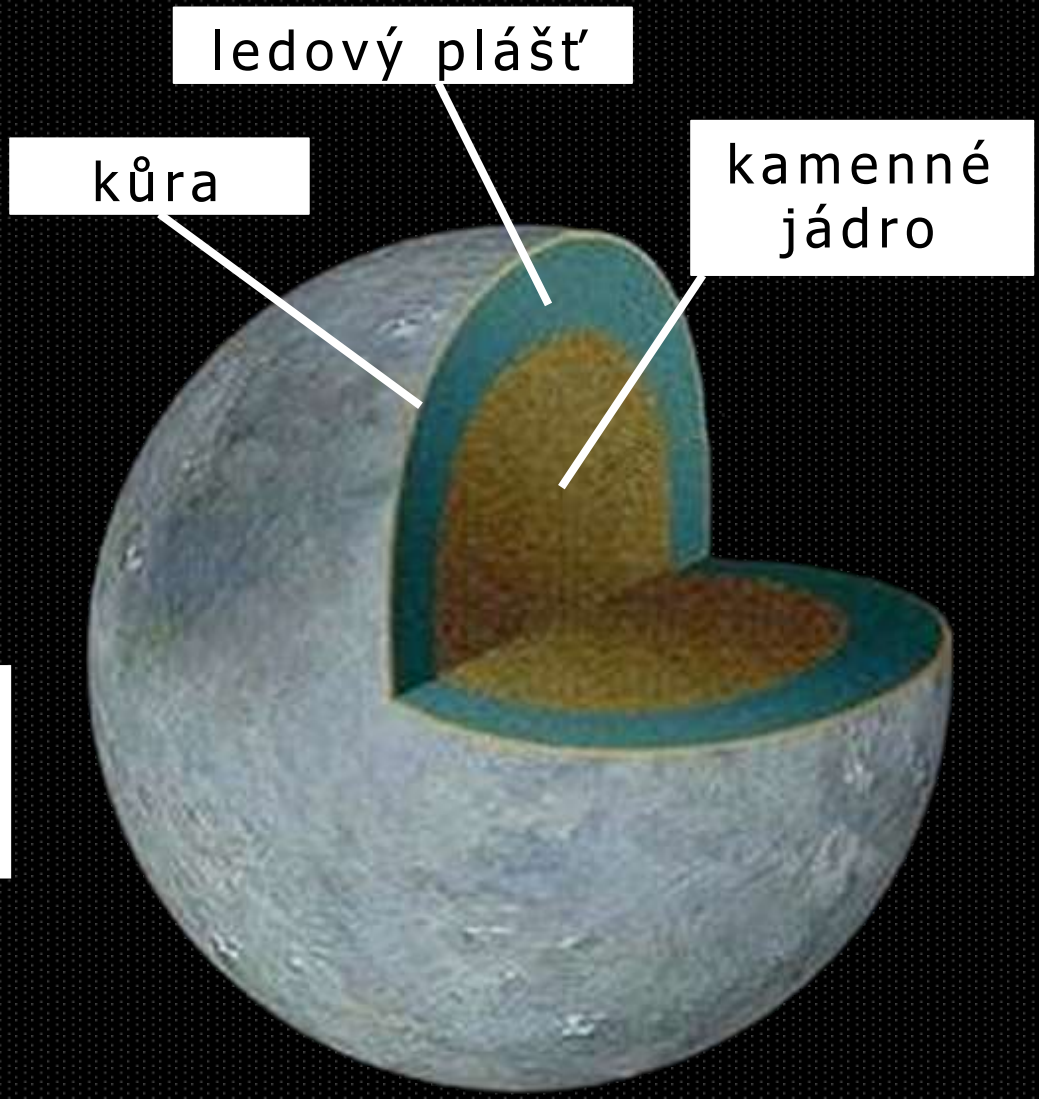


Zástupce „klasického Kuiperova pásu“.


Plutonium

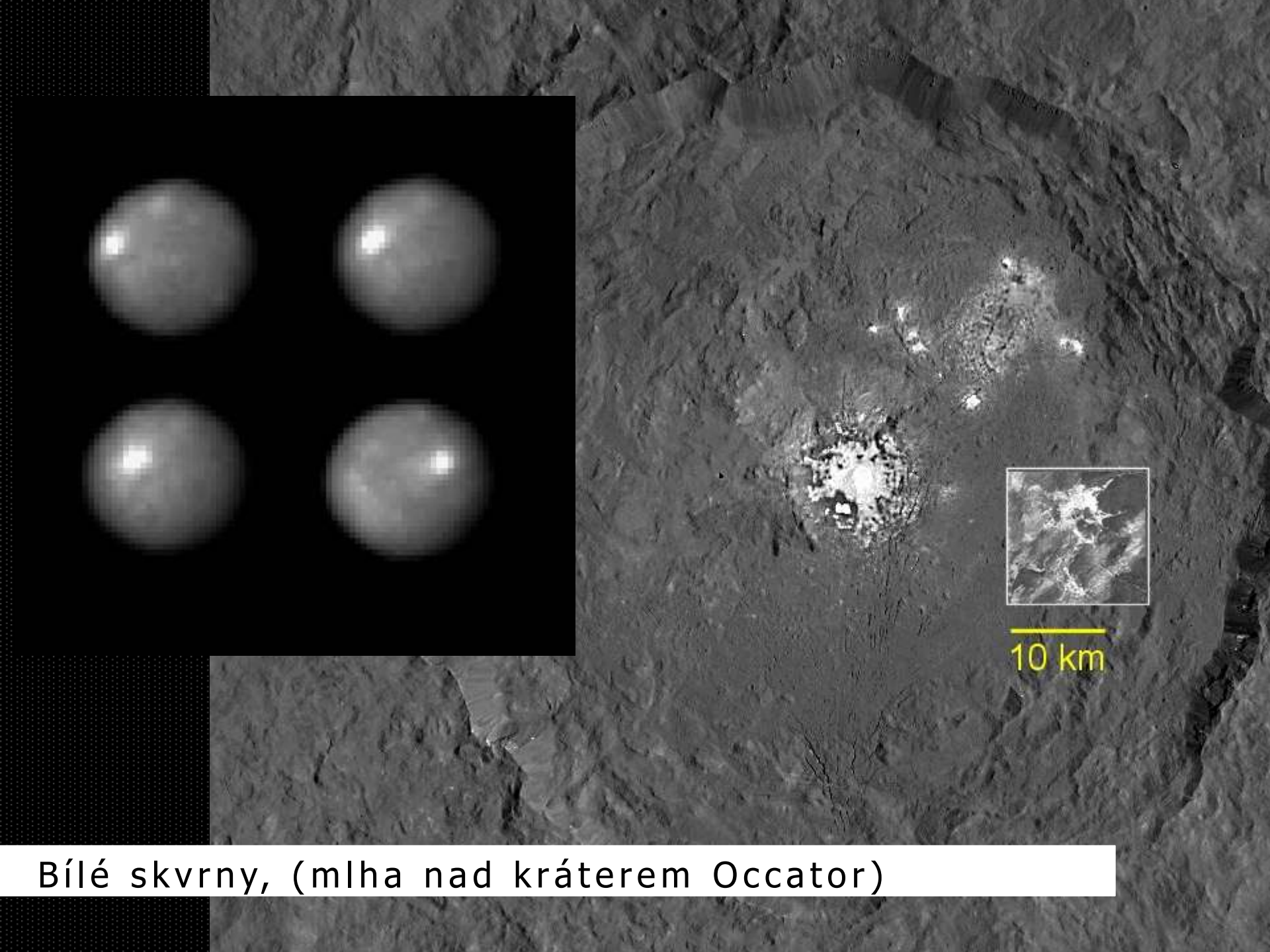
Ceres


Ceres
Jupiter
Mars
Merkur
Venuše
Země

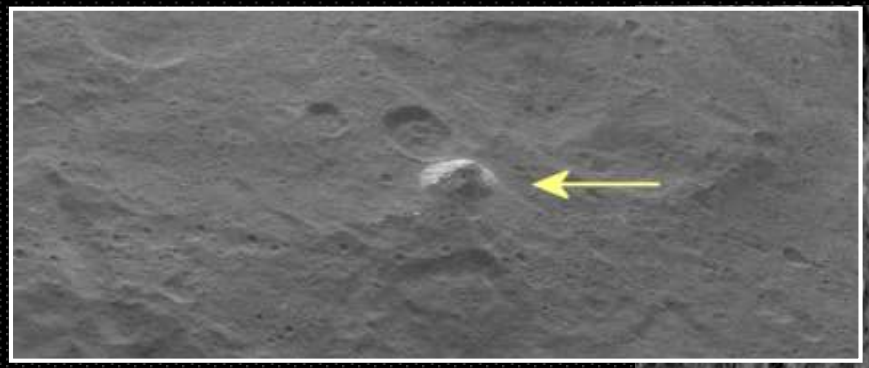


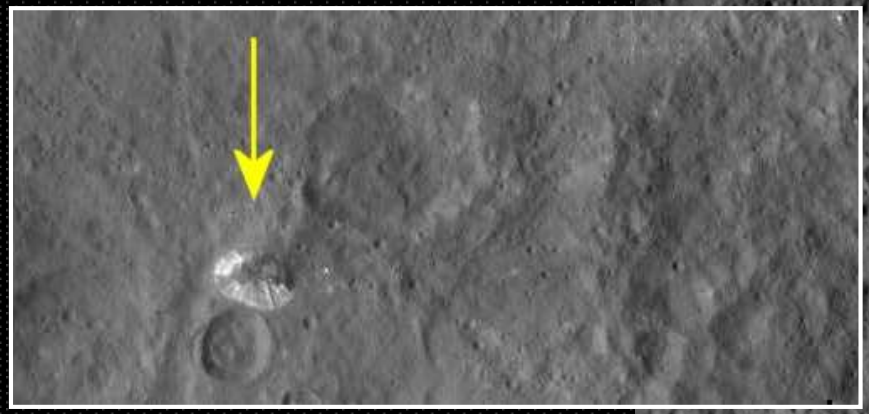
- Diferencované těleso
- Aktivita (vodní páry)

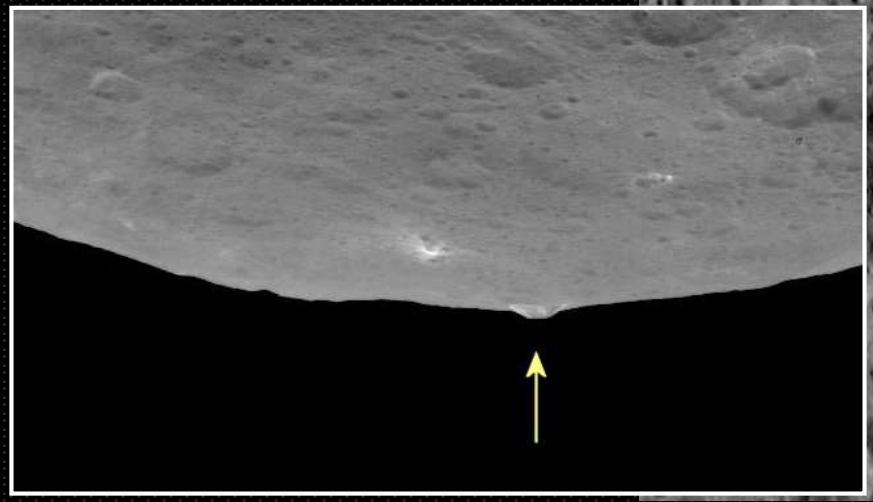
Ceres



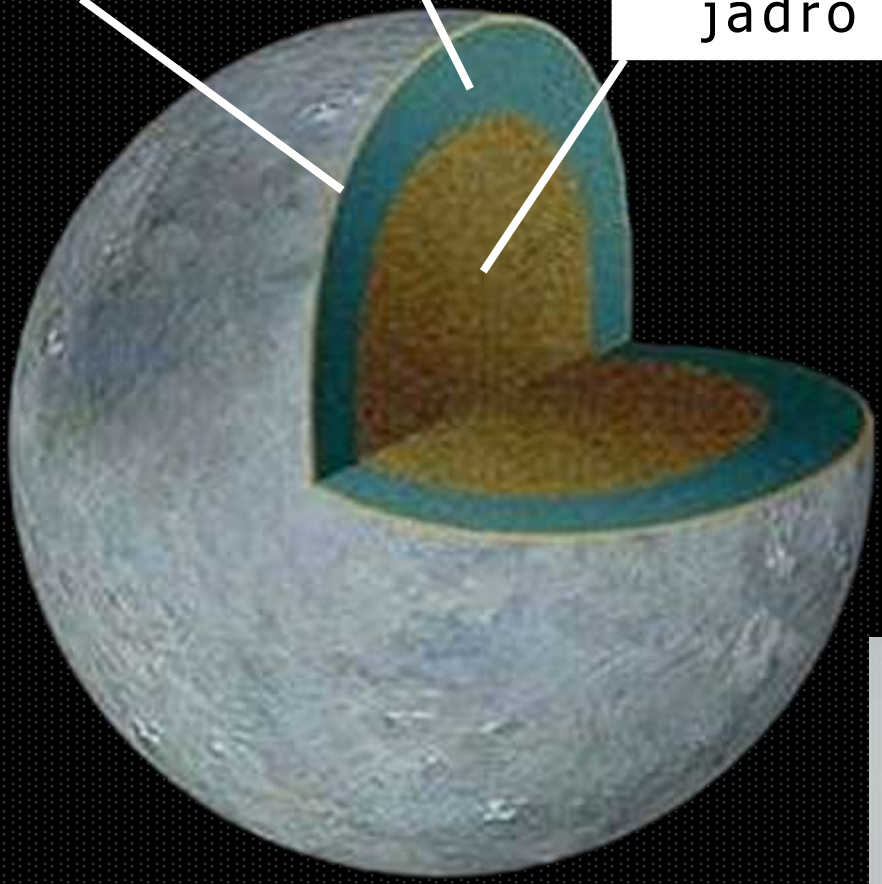
Bílé skvrny, (mlha nad kráterem Occator)





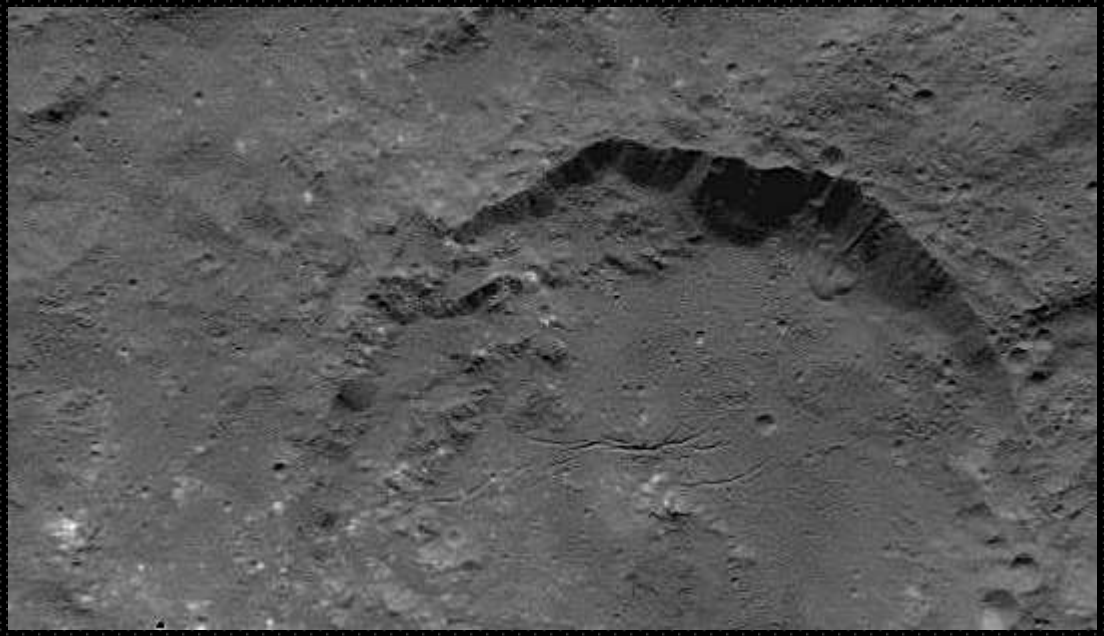


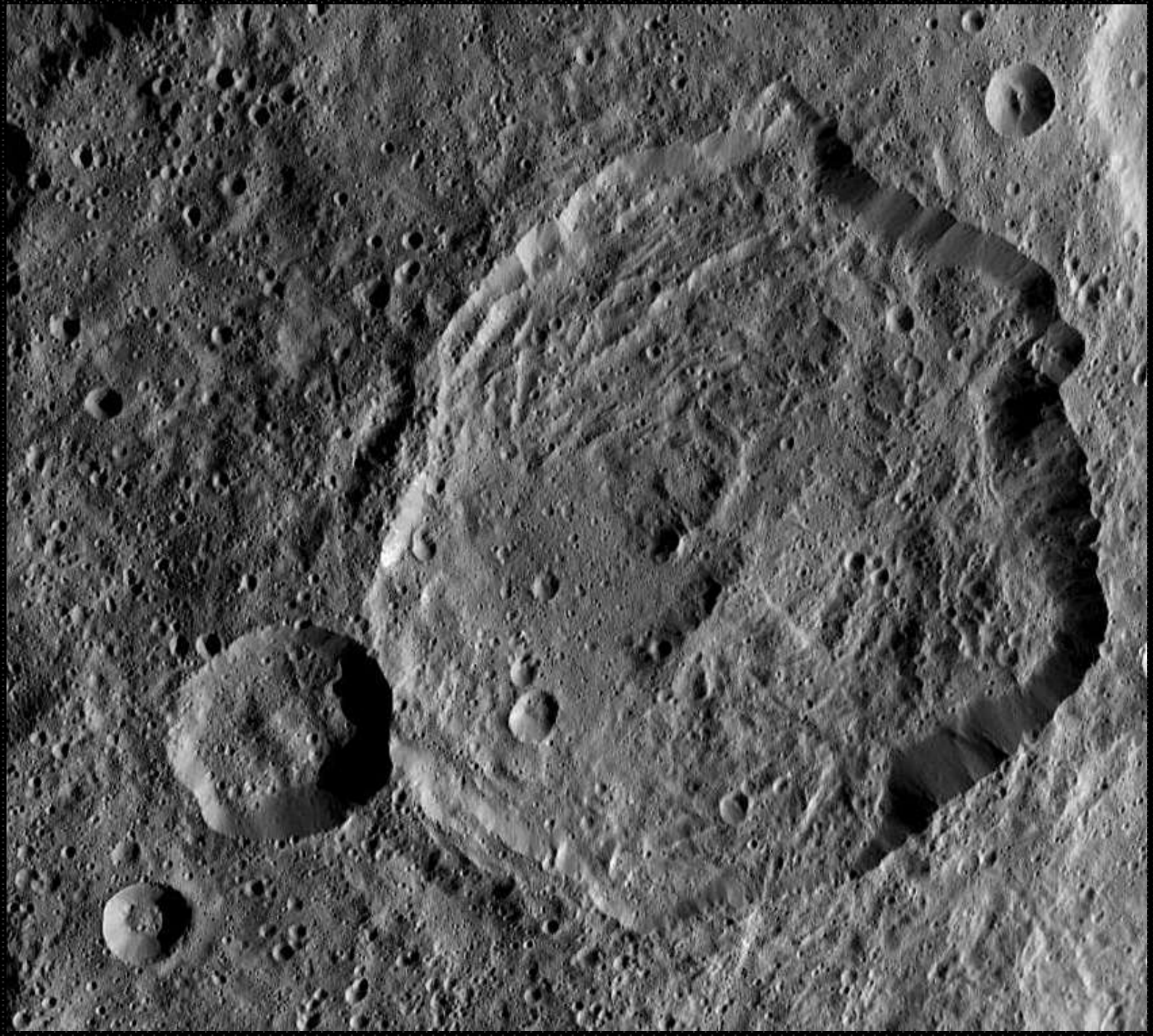
Diapír?

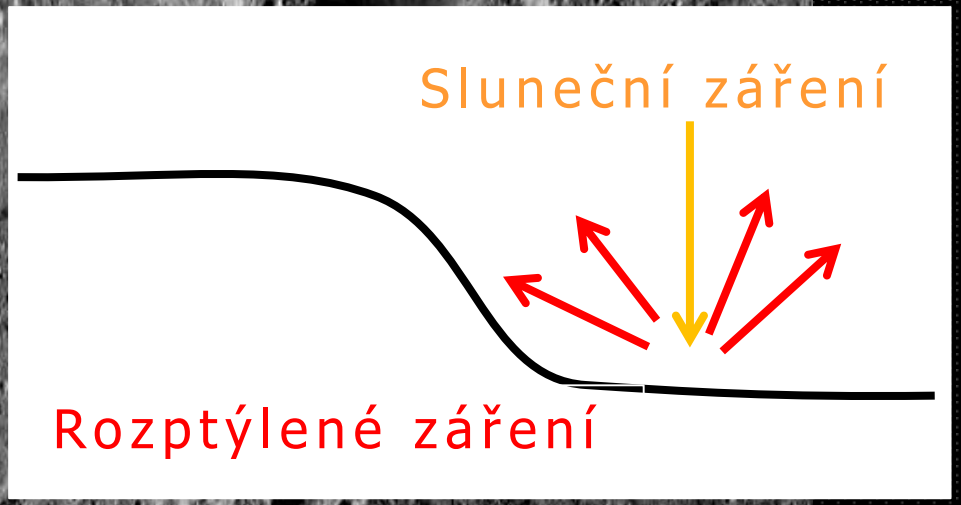


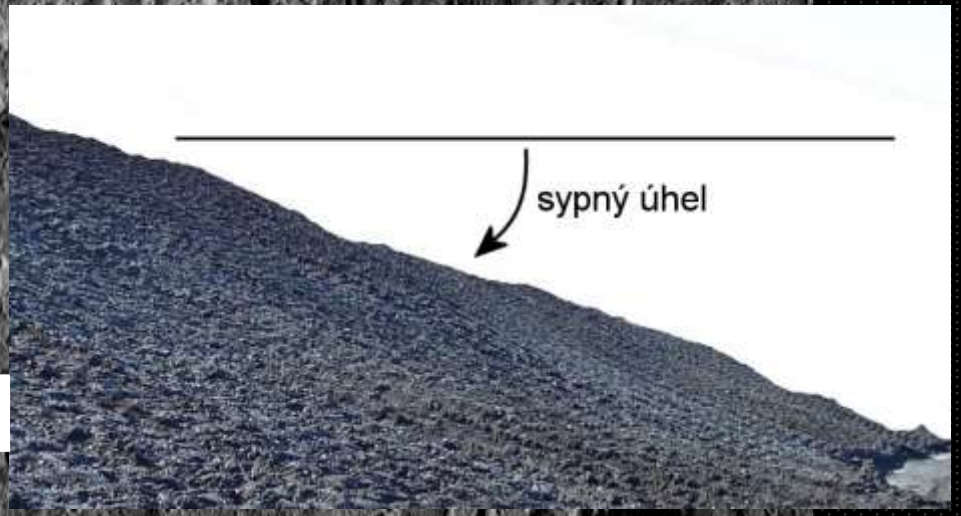
Rayleigh-Taylorova nestabilita

„Oblé zálivy a ostré mysy“

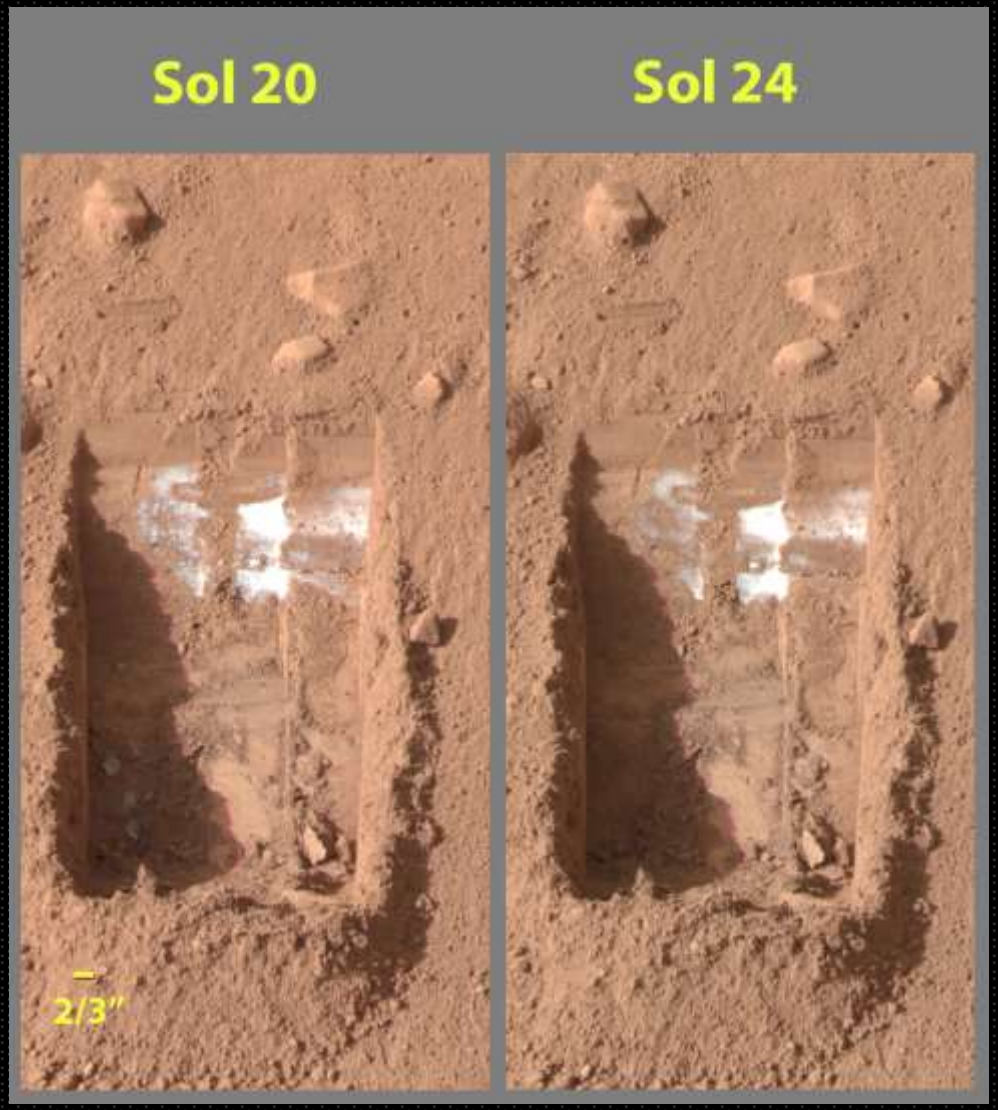






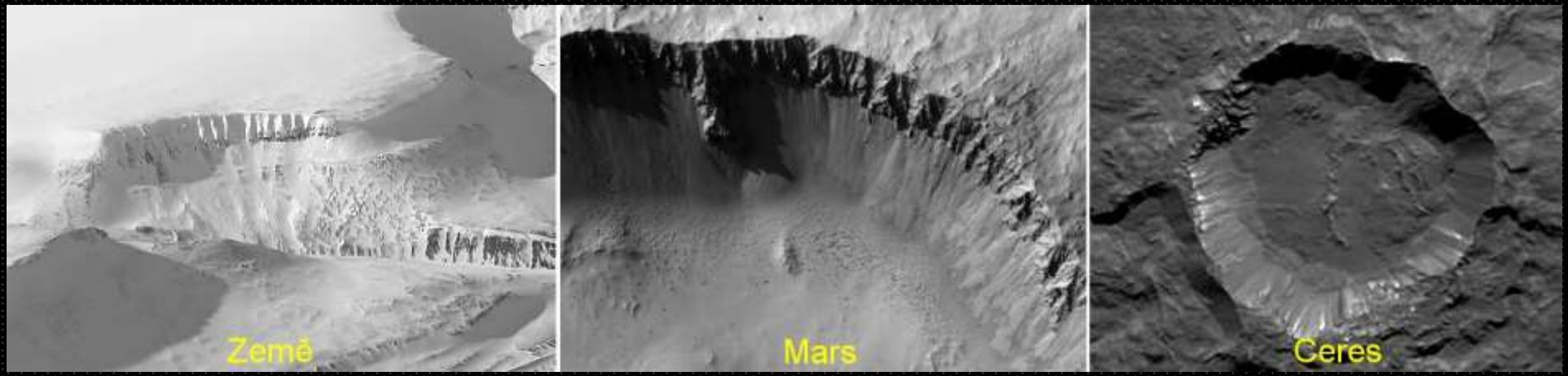


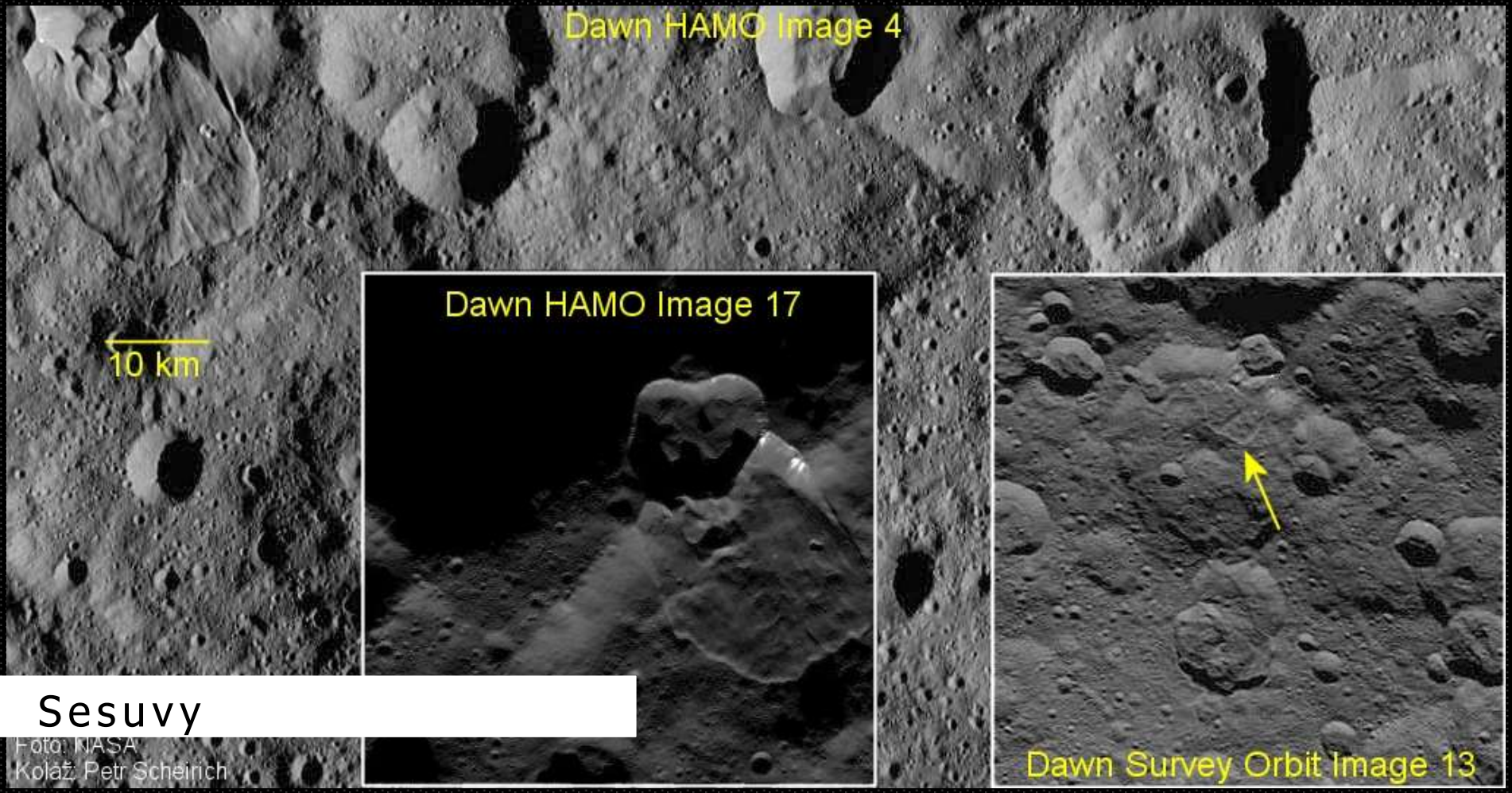
Sublimace + sypný úhel



Mars Polar Lander

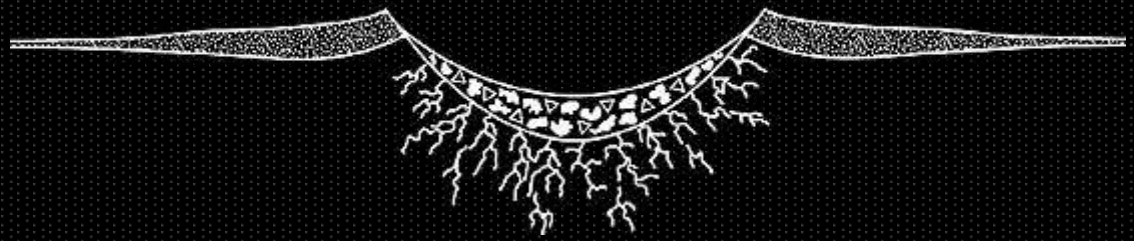
Jen několik cm regolitu stačí k izolaci ledového podloží.


Země
Mars
Ceres



Sesuvy

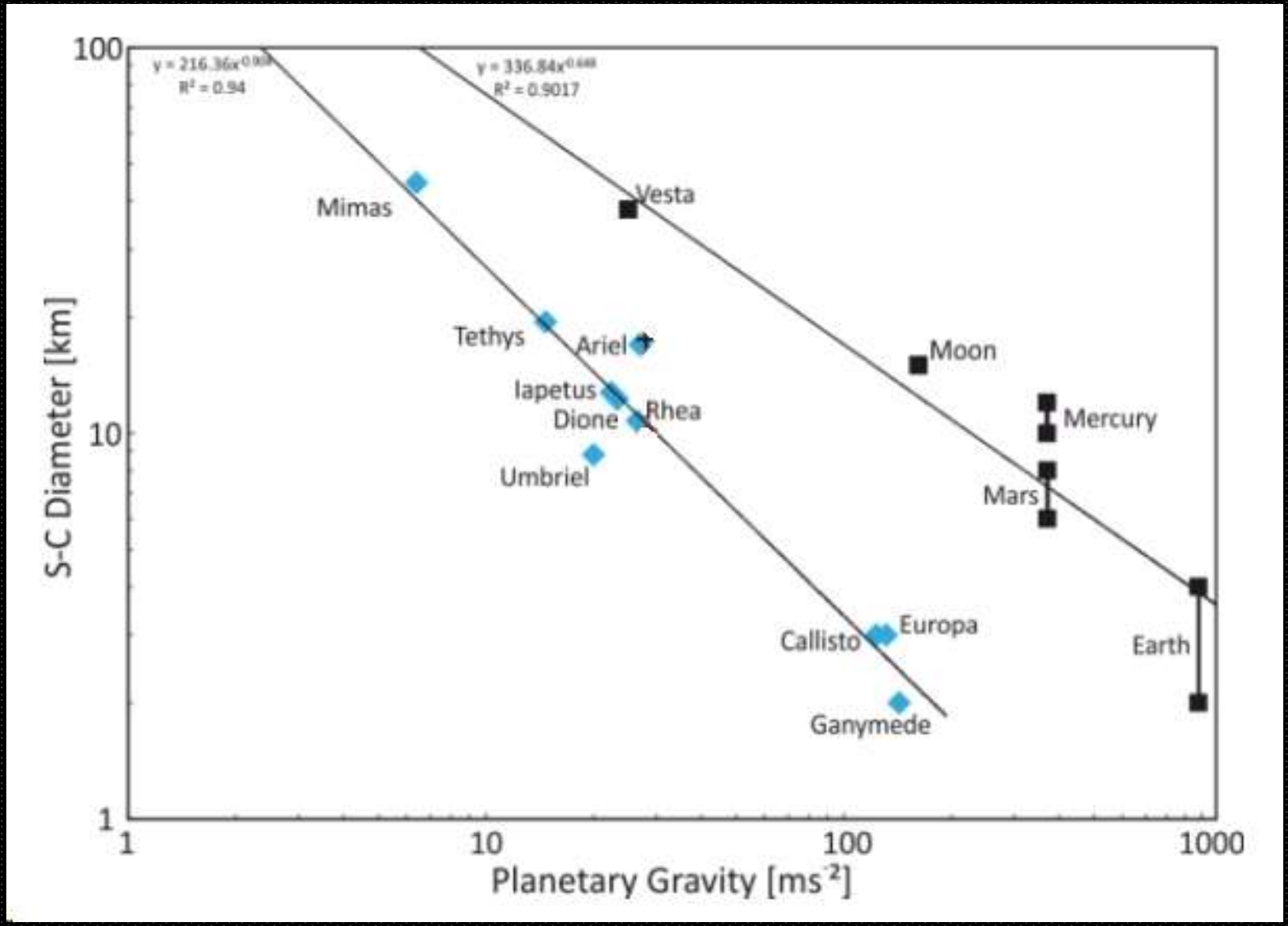
Foto: NASA
Kolaž: Petr Scheirich



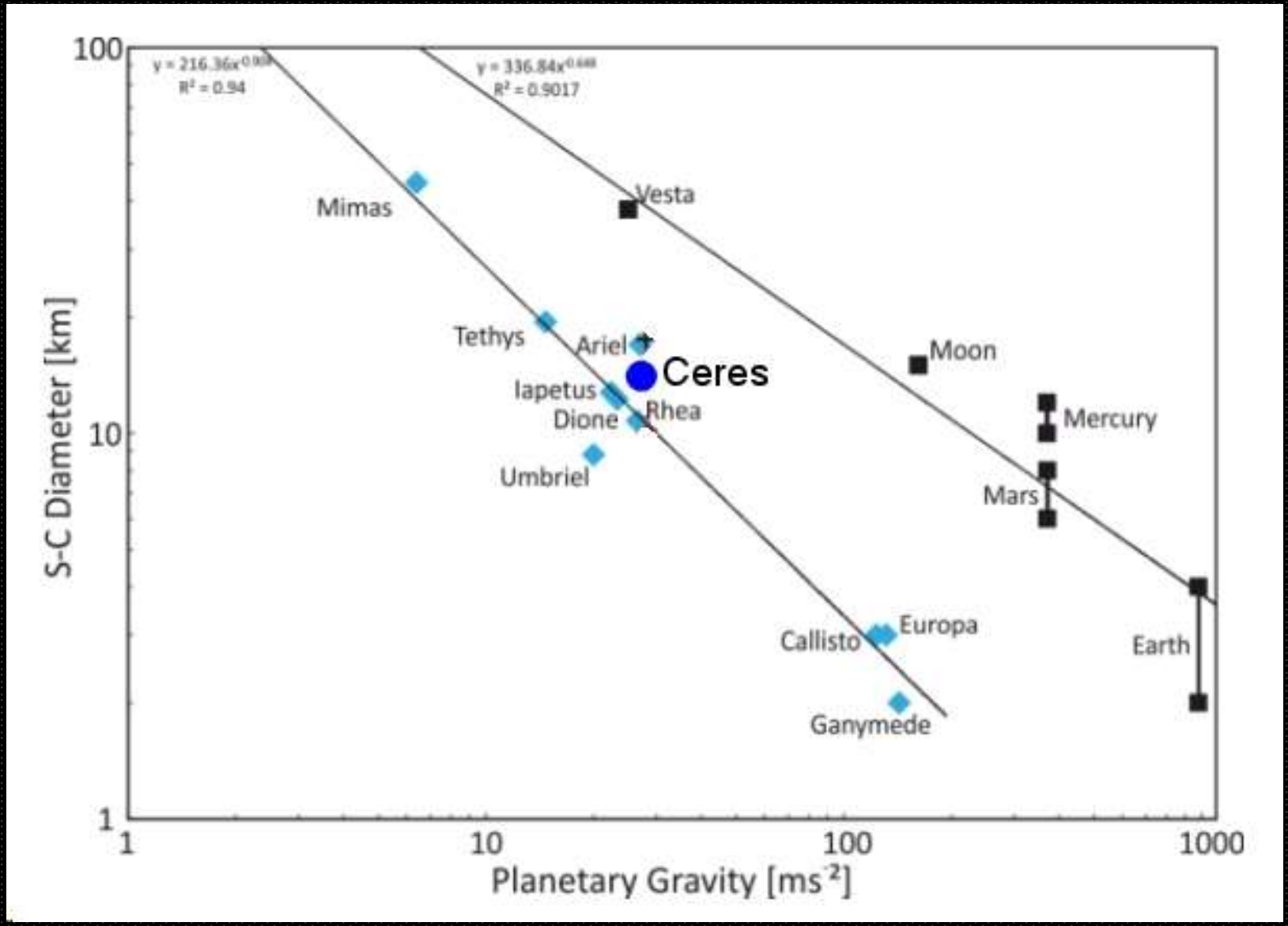
jednoduchý kráter

komplexní kráter

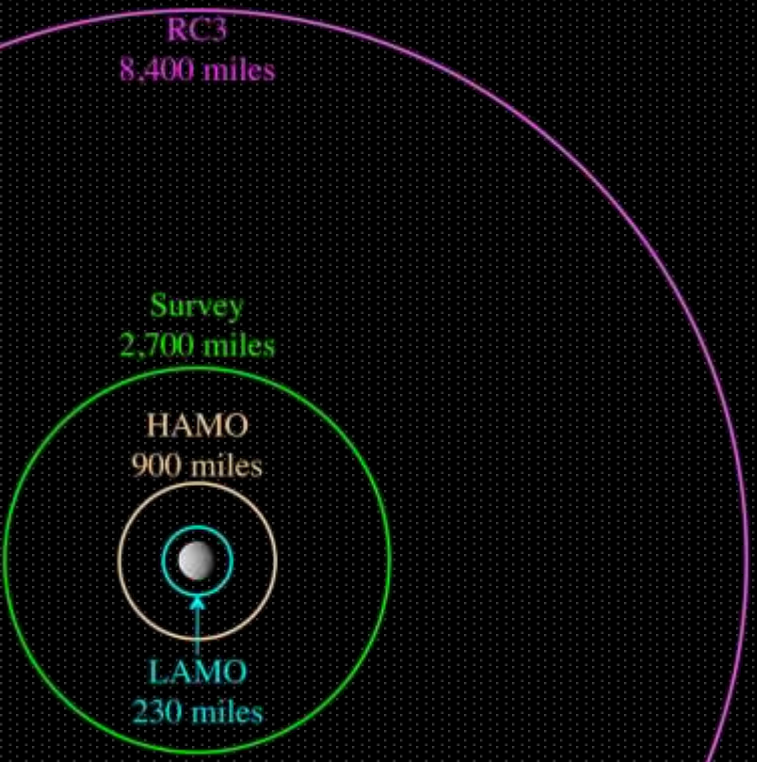
Jednoduché/komplexní krátery

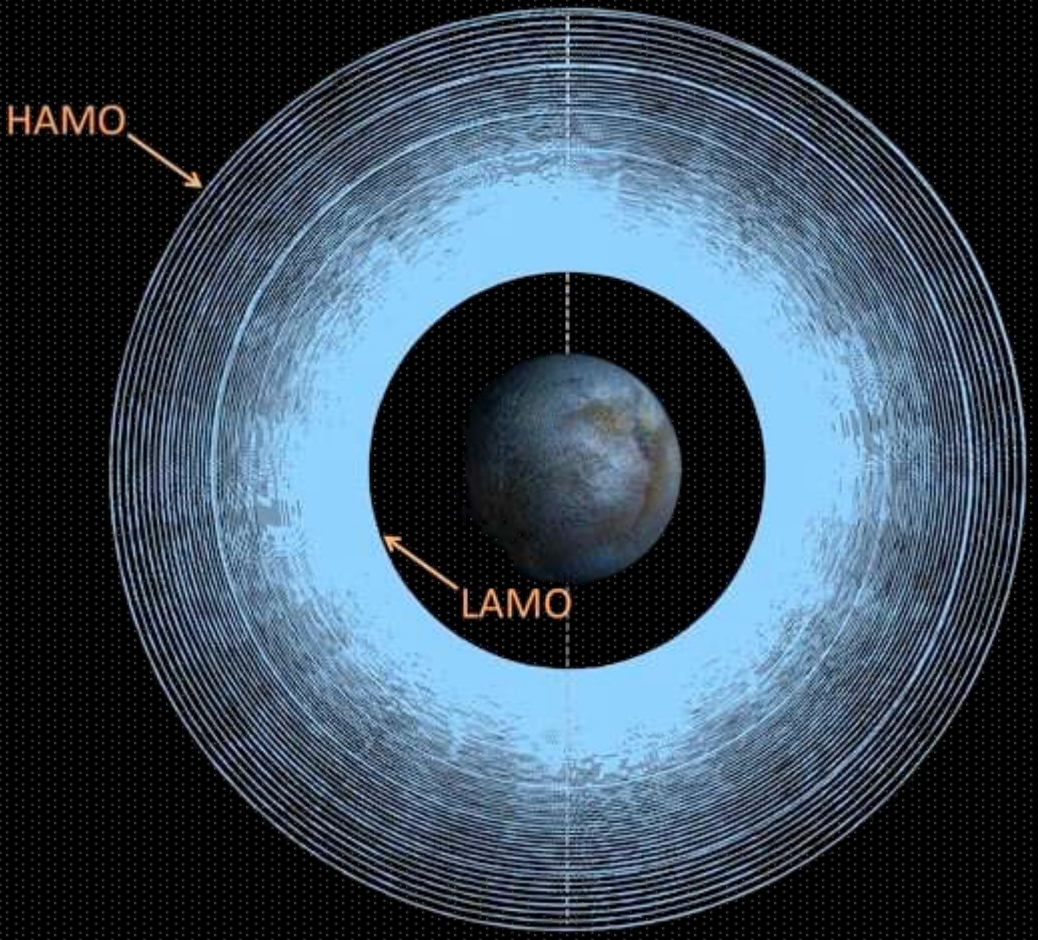


Jednoduché/komplexní krátery



Jednoduché/komplexní krátery





6 týdnů spirálování ze survey orbit na HAMO (1470 km), kde stráví 2 měsíce. V závěru roku 2 měsíce spirálování na LAMO (375 km).