

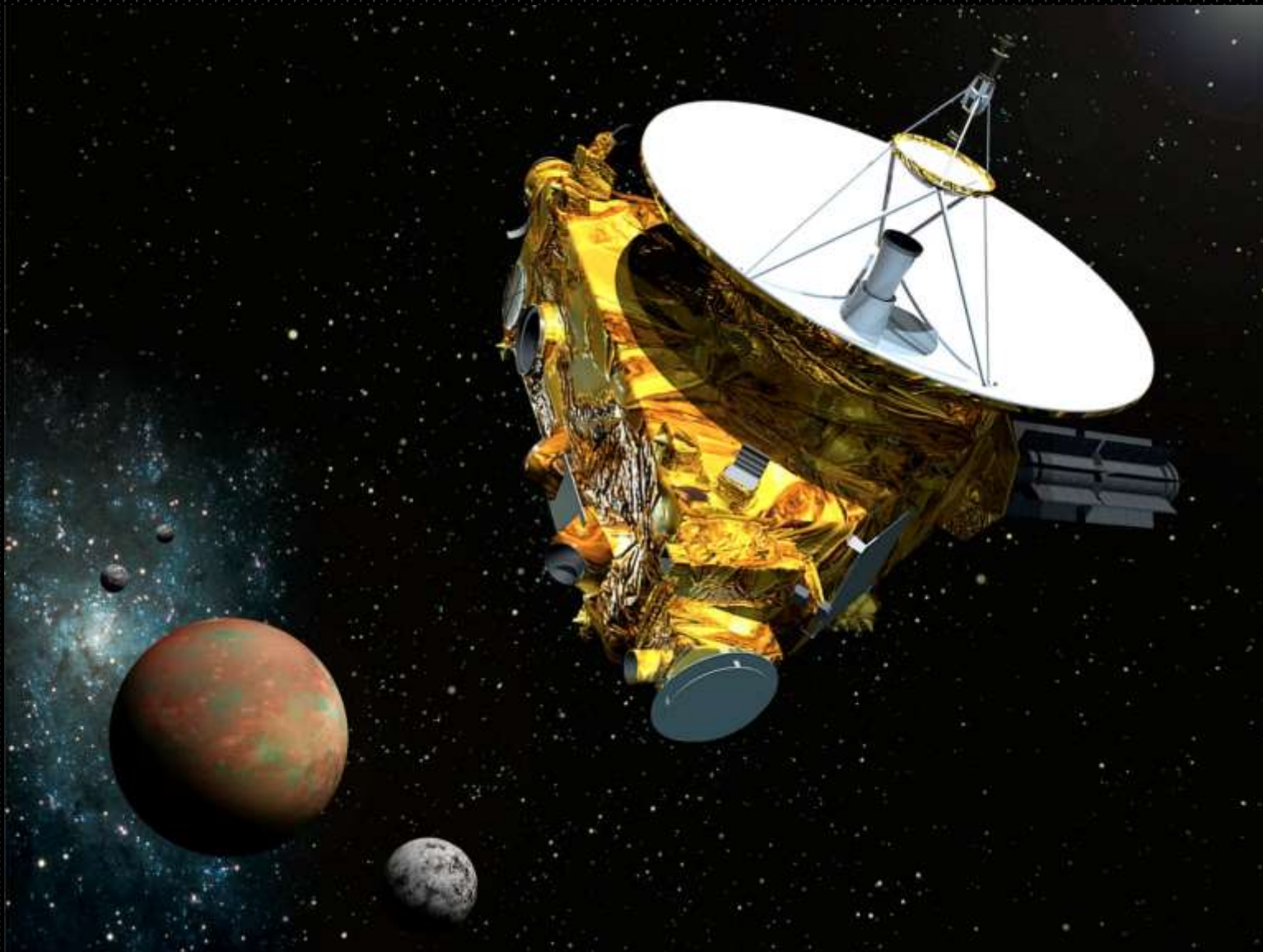
Úsvit trpasličích planet: Pluto a Ceres

Petr Scheirich, Astronomický ústav AVČR
Hvězdárna Valašské Meziříčí, 8.11.2015



Dawn: přílet k Ceresu: 6. března

Dawn [dón]: úsvit
~~Down [daun]: dole~~

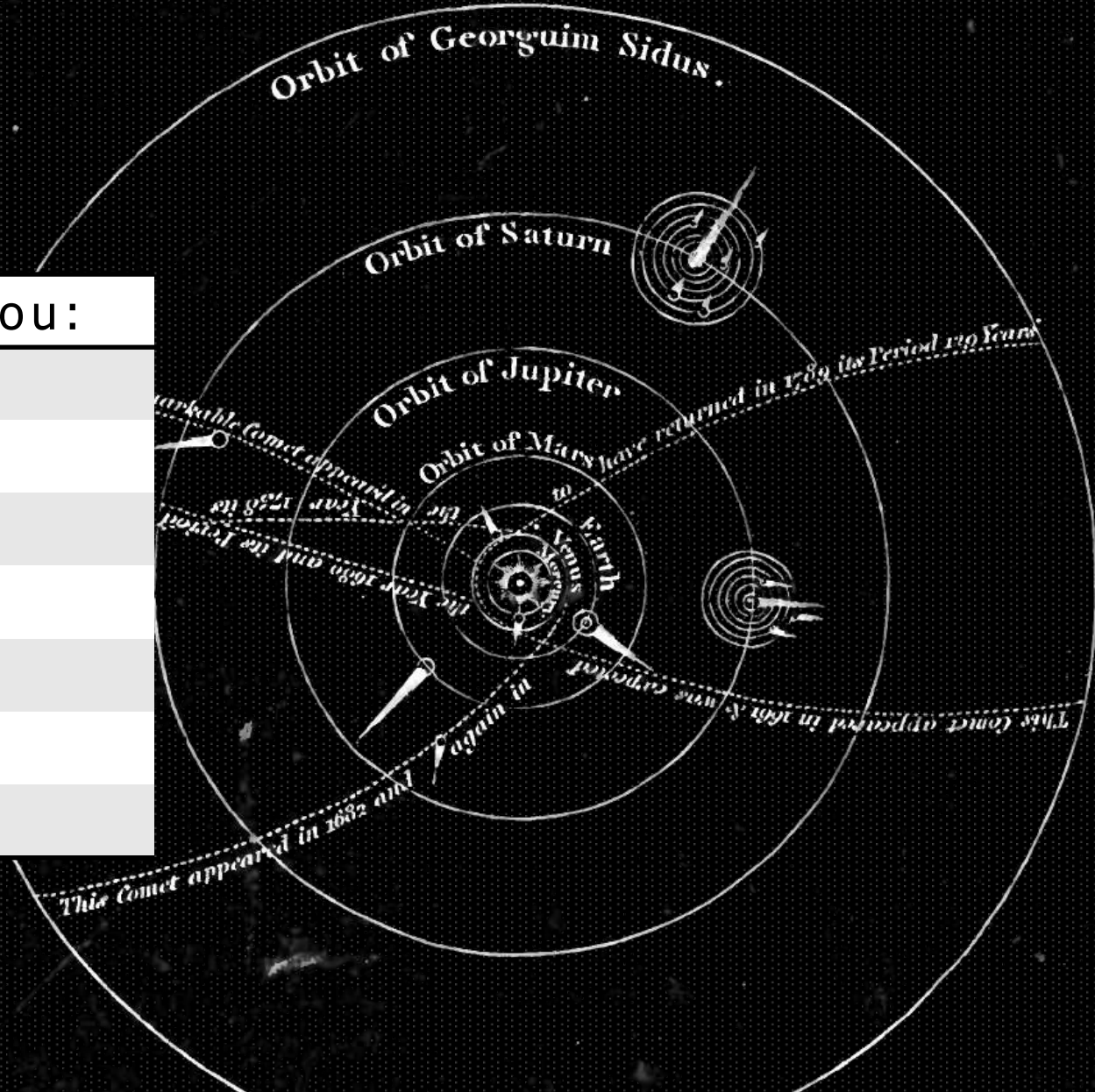


New Horizons: průlet okolo Pluta 14. července



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

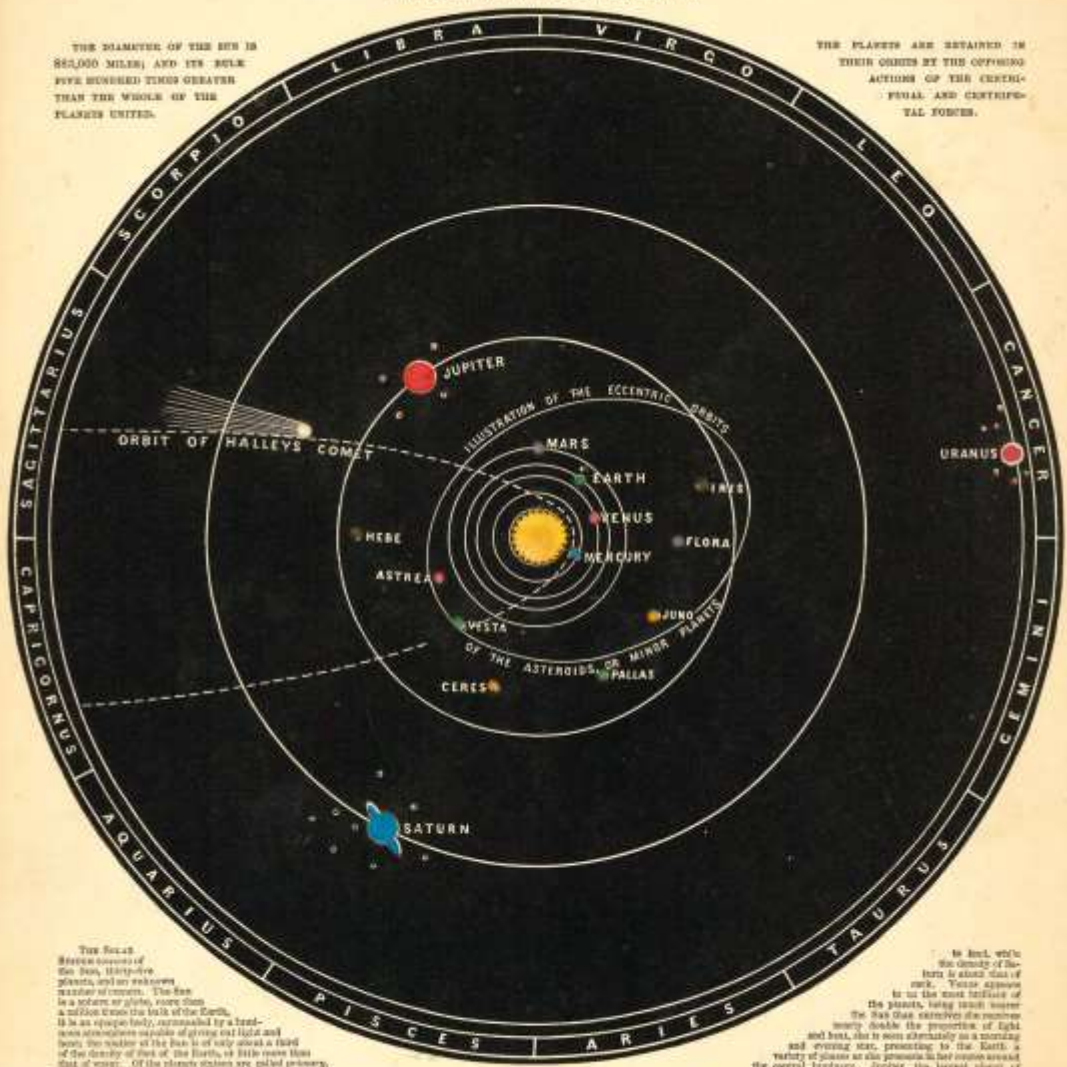
Desítky planet!
 Nová kategorie
 těles: asteroidy
 (planetky; minor
 planets)

TRANSPARENT SOLAR SYSTEM, DISPLAYING THE PLANETS WITH THEIR ORBITS, AS KNOWN AT THE PRESENT DAY.

DERIVED FROM THE LATEST AND BEST AUTHORITIES.

THE DIAMETER OF THE SUN IS 863,000 MILES; AND ITS MASS FIVE HUNDRED TIMES GREATER THAN THE WHOLE OF THE PLANETS UNITED.

THE PLANETS ARE RETAINED IN THEIR ORBITS BY THE OPPOSING ACTION OF THE CENTRIFUGAL AND CENTRIFUGAL FORCES.



The Sun
 Eighty times the mass of the Earth, and its volume 325,000 times greater. The Sun is a sphere of gas, with a surface temperature of 10,000 degrees Fahrenheit. It is an orange body, surrounded by a transparent atmosphere capable of giving out light and heat. The rays of the Sun are only about a third of the density of air at the Earth's surface, and are less than that of water. Of the planets Saturn is called primary, because it is the most distant from the Sun, and secondary, because they come round primary planets. The secondary planets are termed satellites. One of the primary planets, viz. Mars, Ceres, Pallas, and Vesta, together with four others recently discovered, named Astrea, Hebe, Juno, and Flora, are called asteroids, or minor planets.

to find, with the density of Saturn is about that of 1000. Venus appears to us the most brilliant of the planets, being much nearer the Sun than ourselves; the distance being double the proportion of light, and heat, she is seen alternately as a morning and evening star, presenting to the Earth a variety of phases as she presents to her moons around the central luminary. Jupiter, the largest planet of our system, ranks next to Venus in brilliancy. Stars may be distinguished by the dusky red colour; these planets may generally be seen by the naked eye. Mercury from his proximity to the Sun, the Asteroids from their small magnitude, and Saturn, Uranus, and Neptune, from their great distance require the aid of powerful telescopes to distinguish them. The discovery of the planet Neptune is one of the greatest achievements of modern science, and by which the known bounds of our solar system have been vastly extended, proving to require no longer the planet reckoned for the 12th, part of the light and heat which our earth enjoys. It is supposed to be surrounded by a ring, and situated by all hands as visible. No amount of its great distance the orbit of Neptune cannot be shown in this diagram.

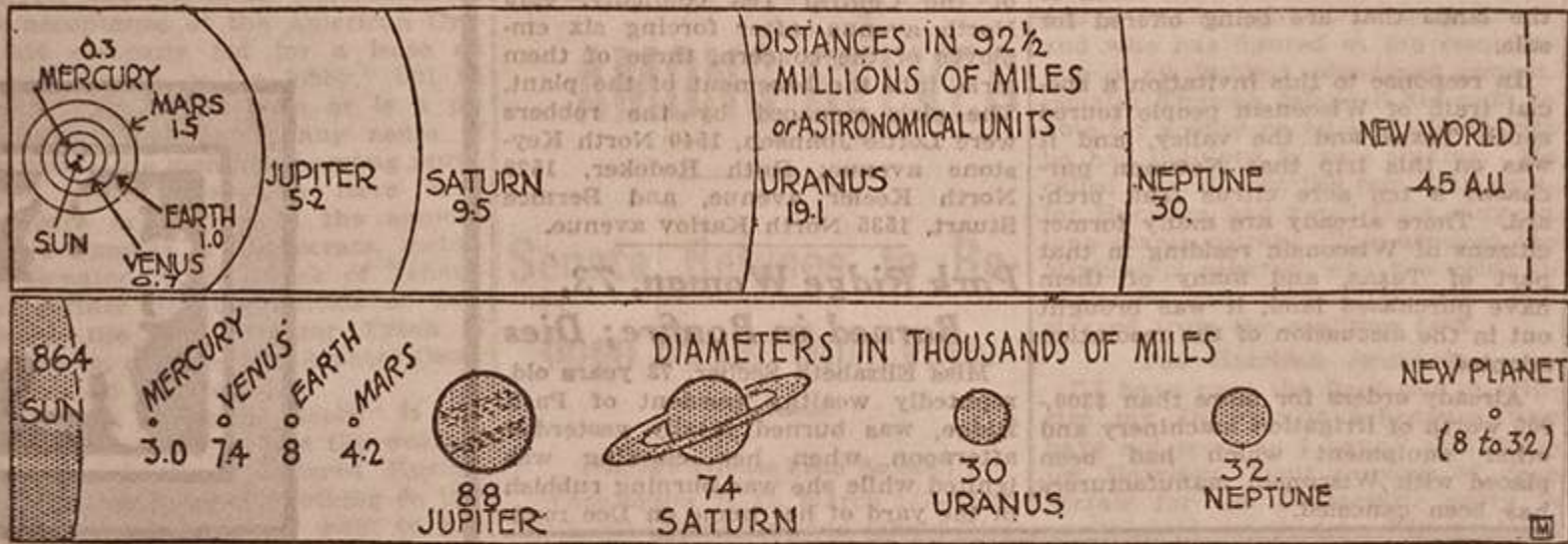
	Diameter Miles.	Distance from the Sun, miles.	Length of Year.	Length of Day.	Mean Density.
Mercury	3,100	37 millions.	88 days.	24 1/2	100,000
Venus	7,600	68 "	224 "	28 1/2	80,000
Earth	7,912	93 "	365 1/4 "	24	50,000
Mars	4,188	142 "	687 "	24 46	50,000
The Asteroids	100,000	210 "	Various.	0 25	10,000
Jupiter	86,000	495 "	12 years nearly.	10 16	50,000
Saturn	79,000	900 "	30 "	10 16	50,000
Uranus	31,000	1,780 "	84 "	10 16	50,000
Neptune	44,000	2,800 "	110 "	10 16	50,000

aligns: The density of Mercury being more than equal

PUBLISHED BY JAMES HENSHAW, 174, STRAND.

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-

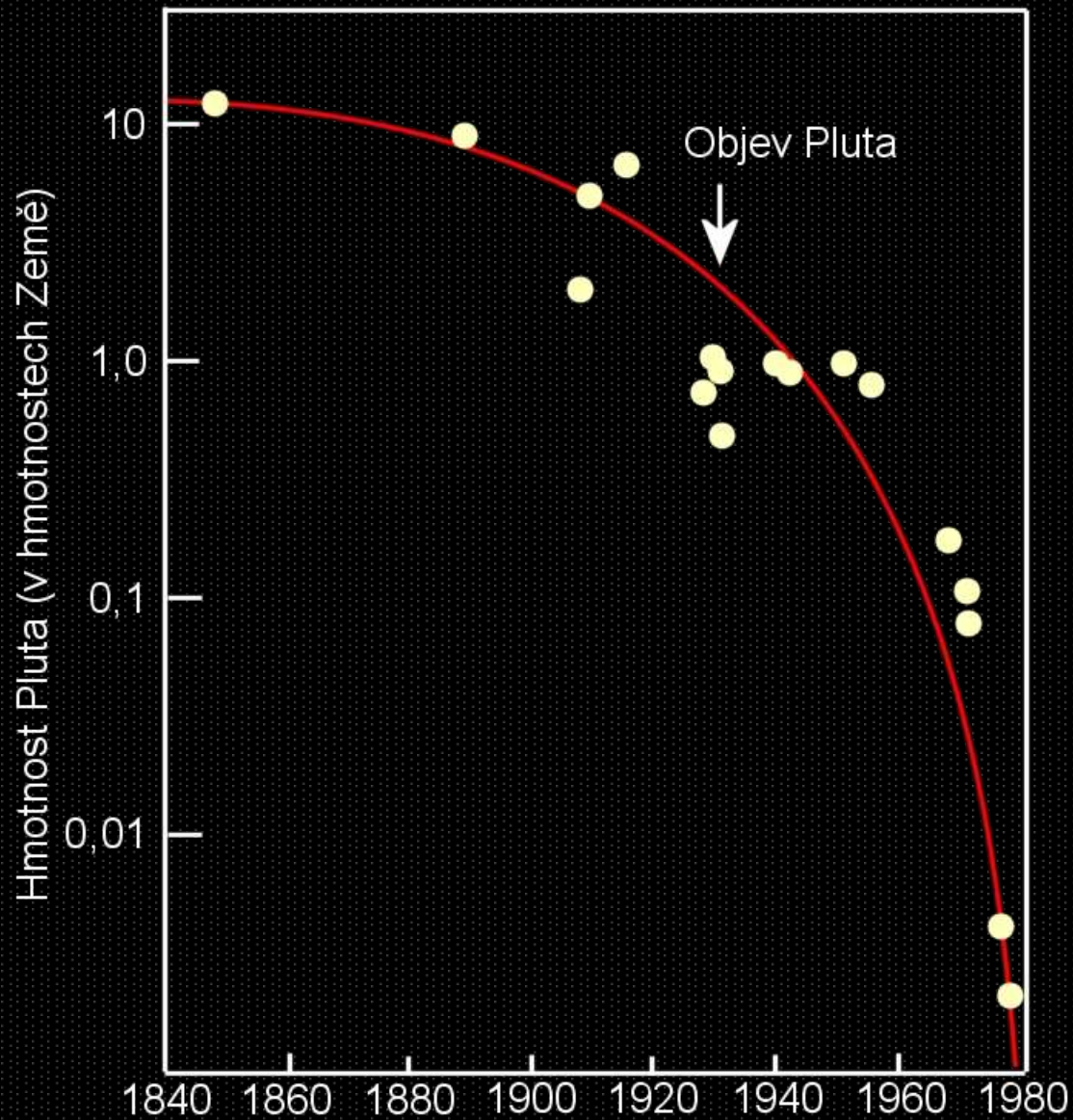
Adler planetarium now building on the lake front, yesterday hailed the discovery of the new planet as "a very fine thing—my congratulations to the astronomers."

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

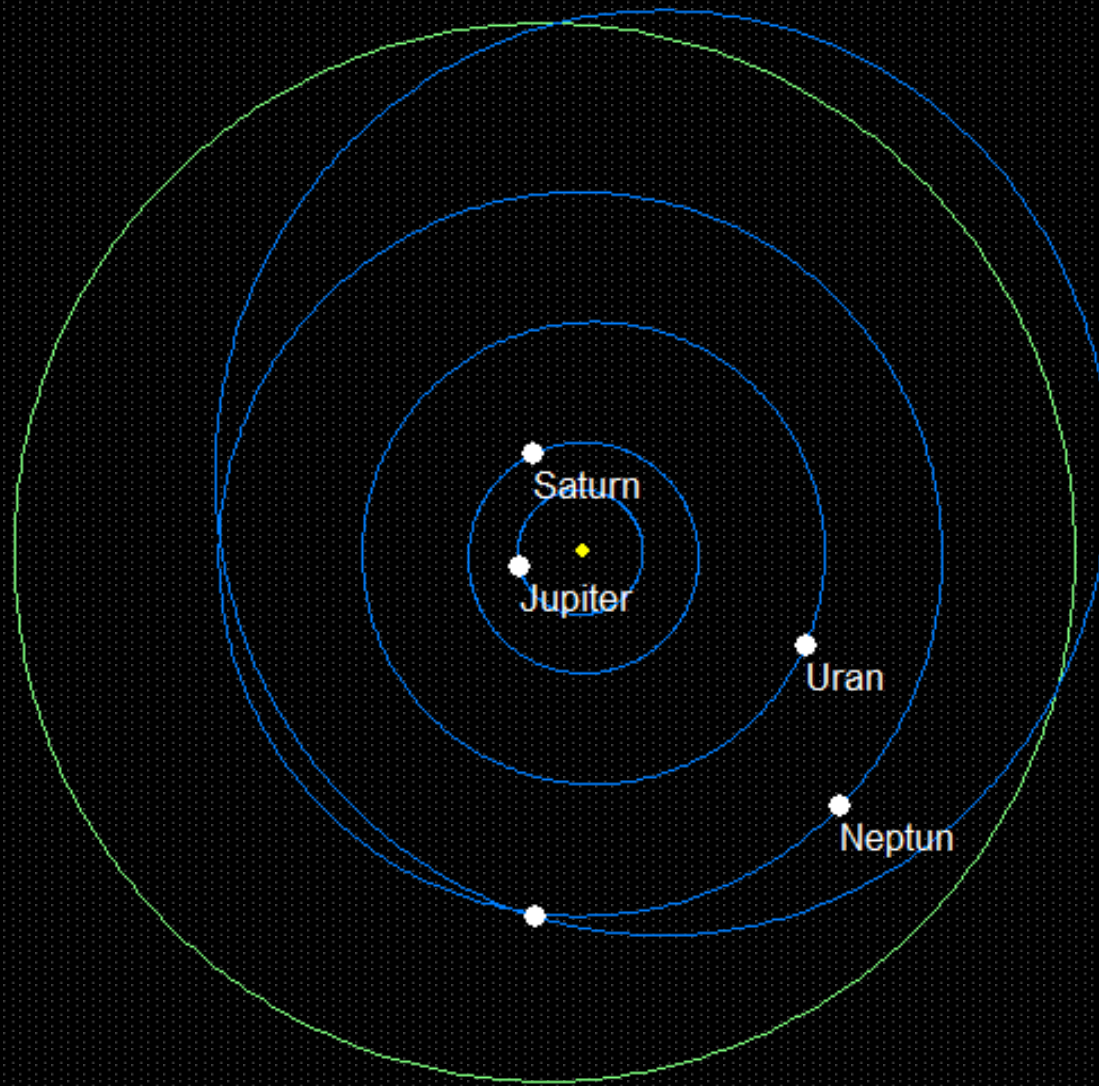
been discerned?" Prof. Cox was asked.

"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



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.

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)

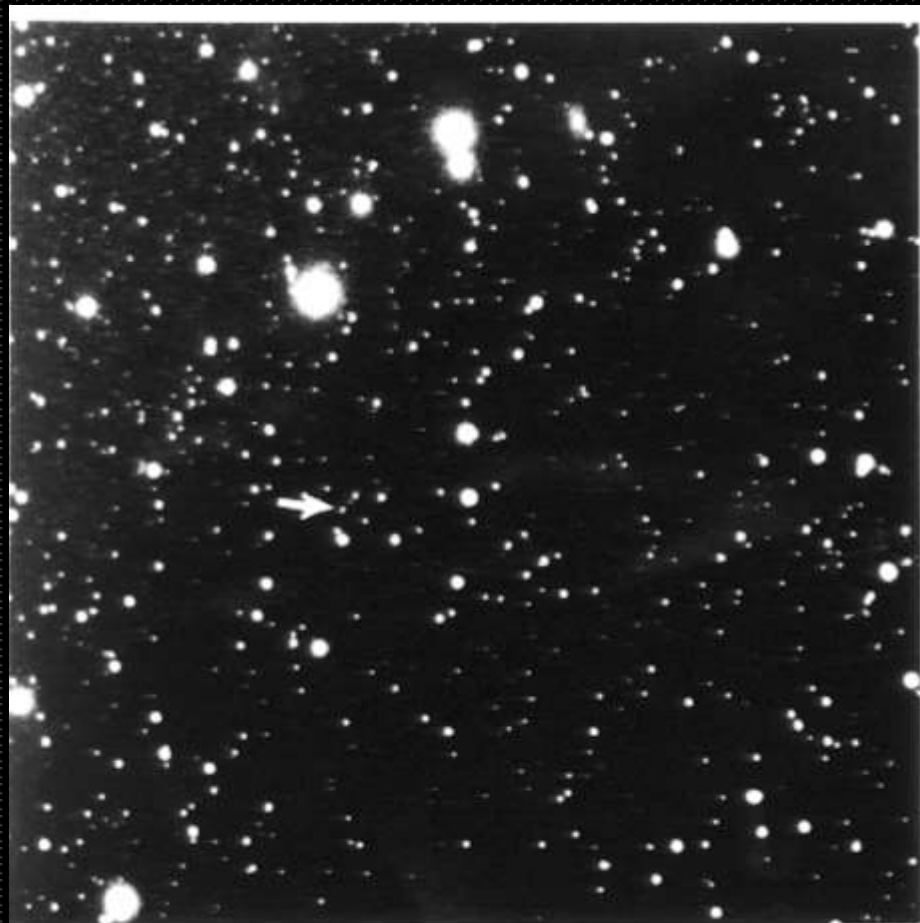
Největší problém definice: stanovení tvaru tělesa vyžaduje poměrně detailní zobrazení!



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



Pluto

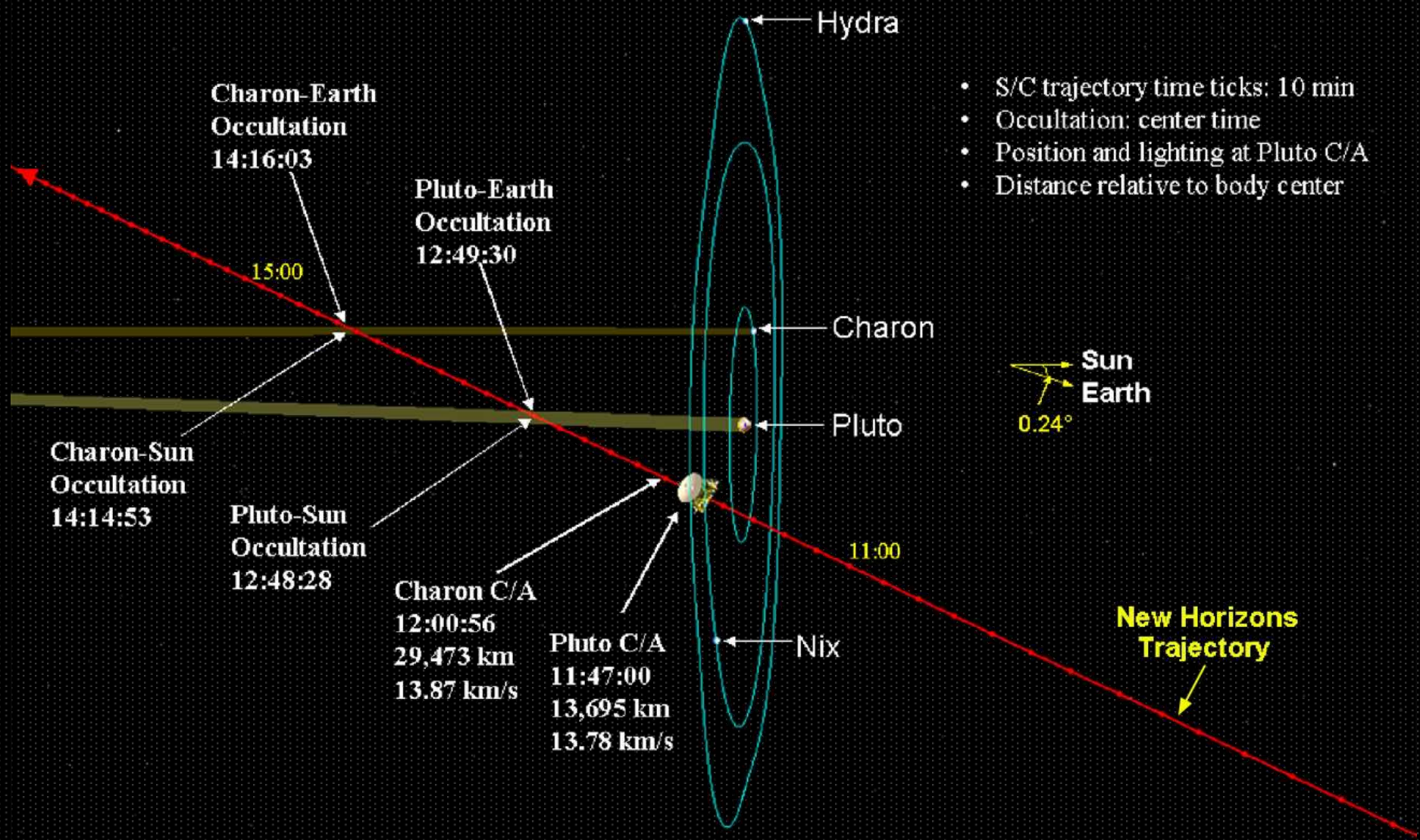


January 23, 1930



January 29, 1930

Objevové snímky



- S/C trajectory time ticks: 10 min
- Occultation: center time
- Position and lighting at Pluto C/A
- Distance relative to body center



New Horizons Trajectory

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

Charon-Earth Occultation
14:16:03

Pluto-Earth Occultation
12:49:30

Hydra

Charon

Pluto

Nix

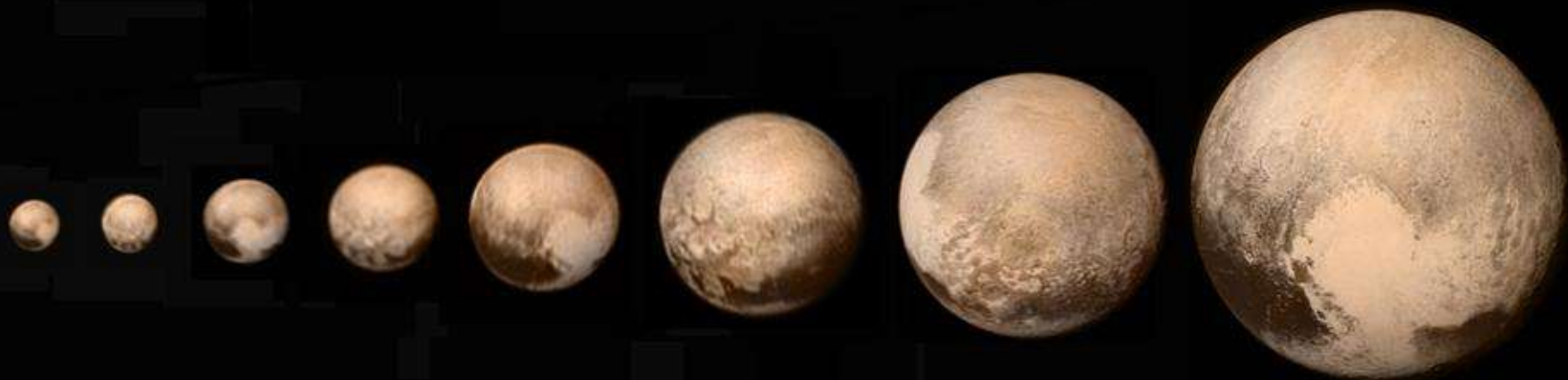
15:00

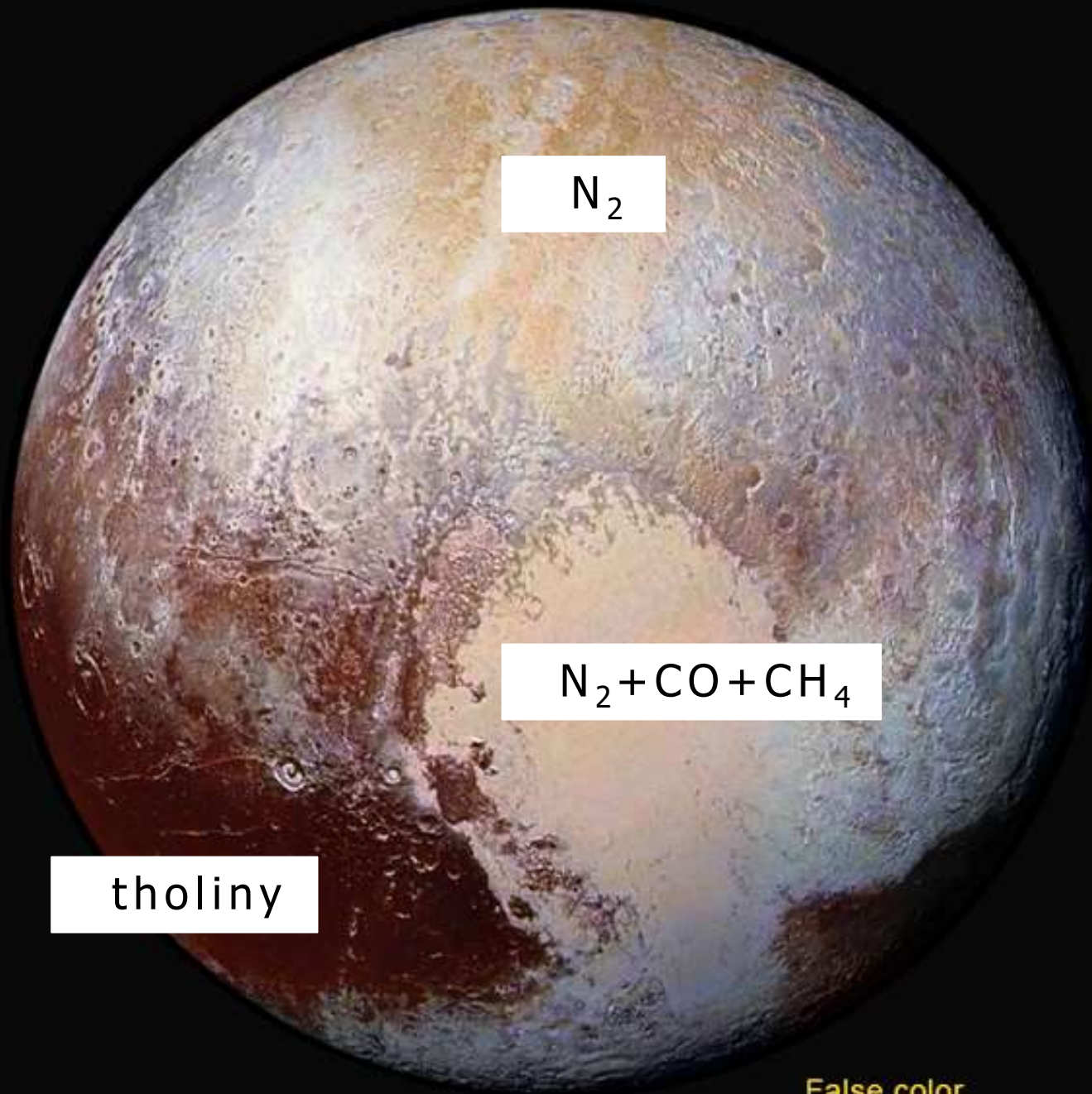
11:00



New Horizons - Pluto approach

June 25th - July 14th, 2015



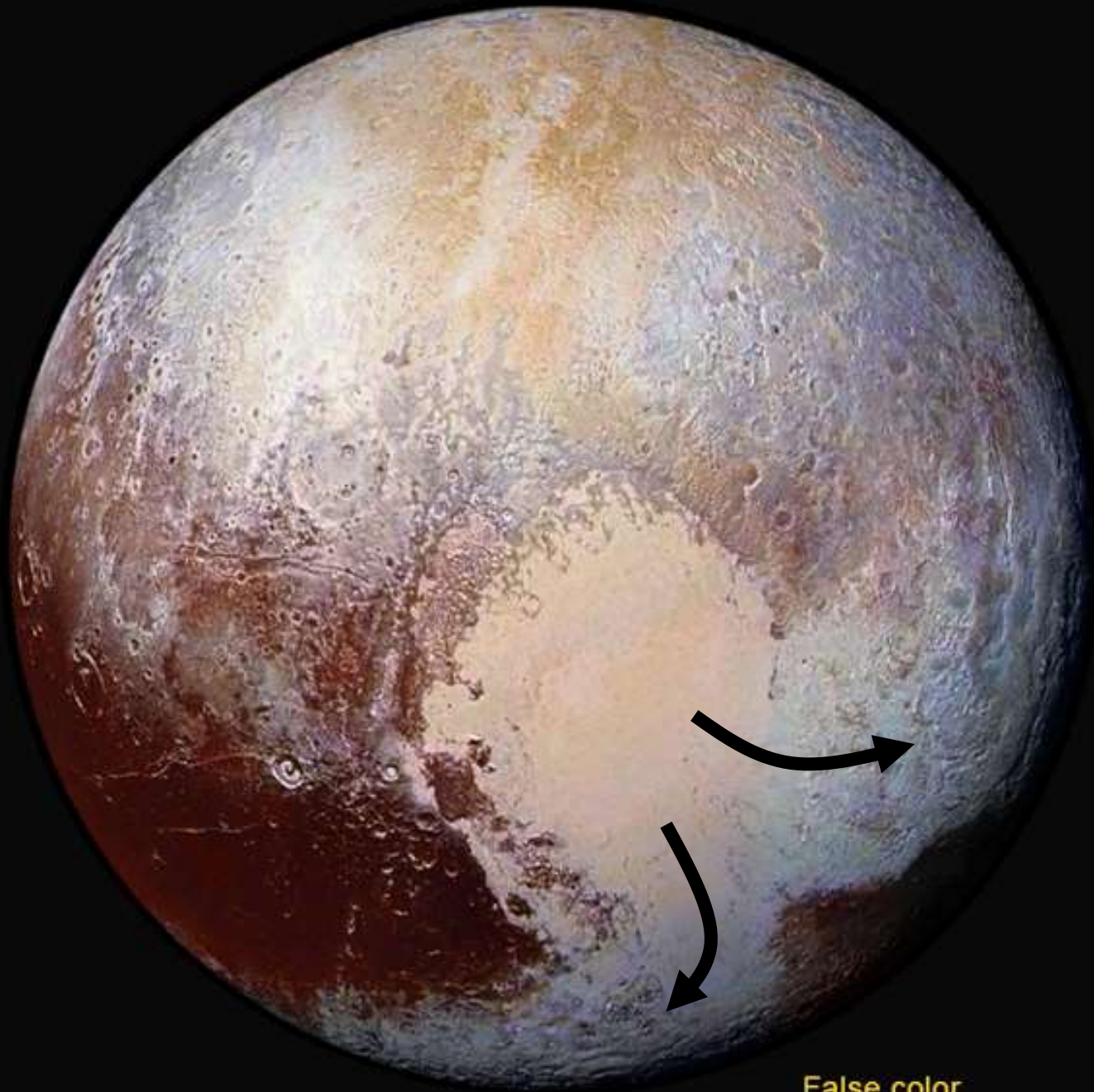


N₂

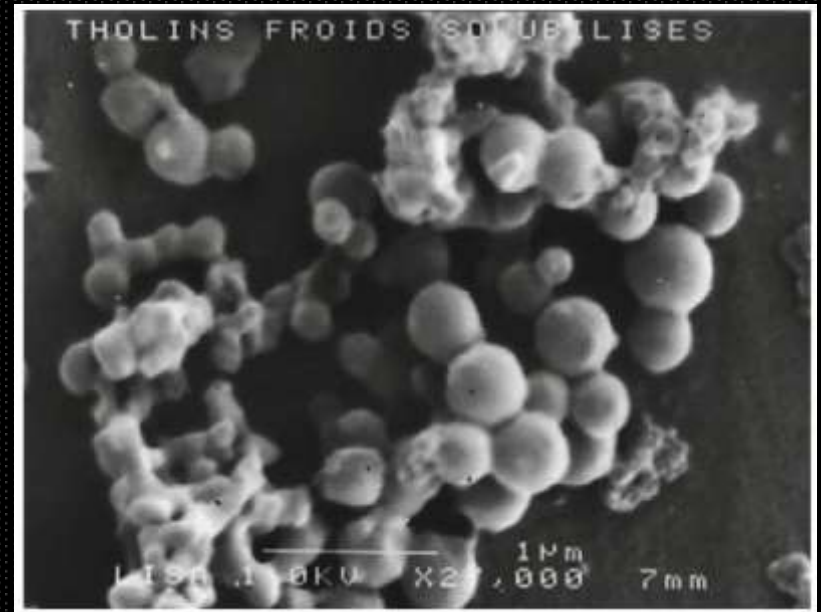
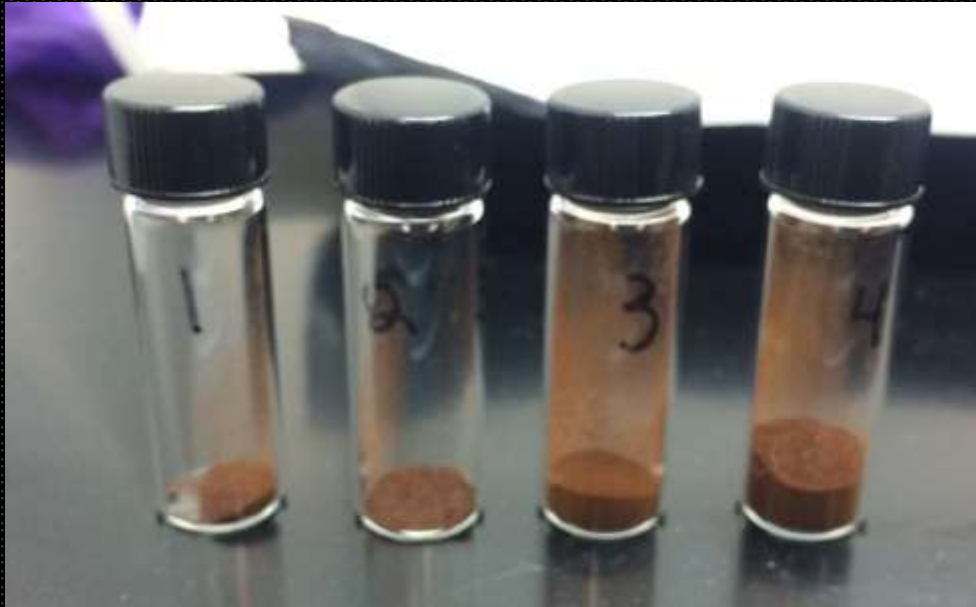
N₂+CO+CH₄

tholiny

False color

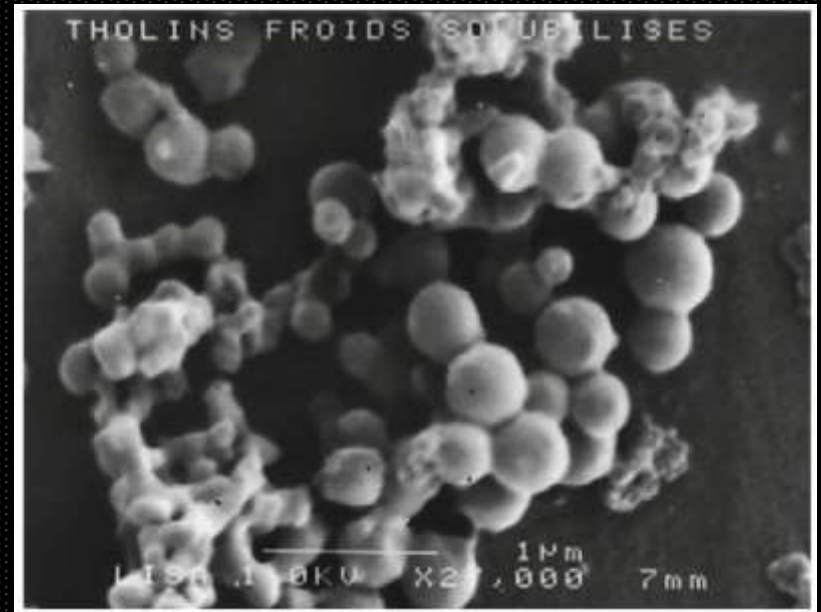
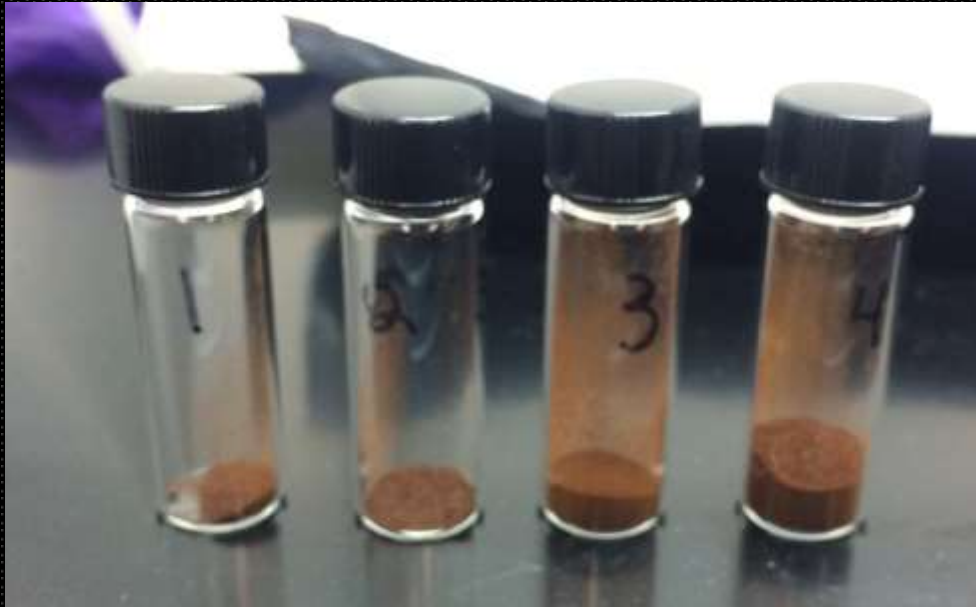


False color



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

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

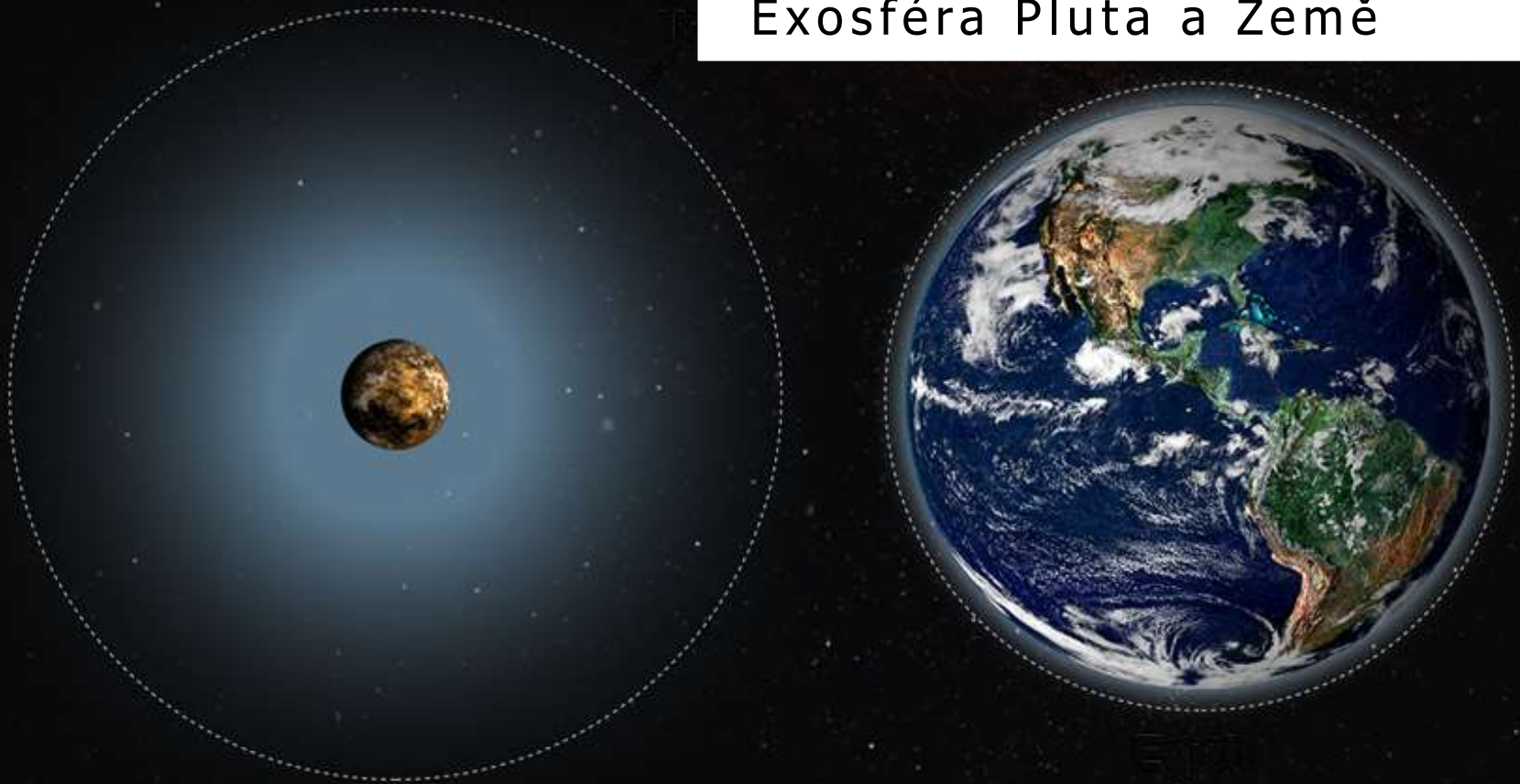


UV

UV



Exosféra Pluta a Země



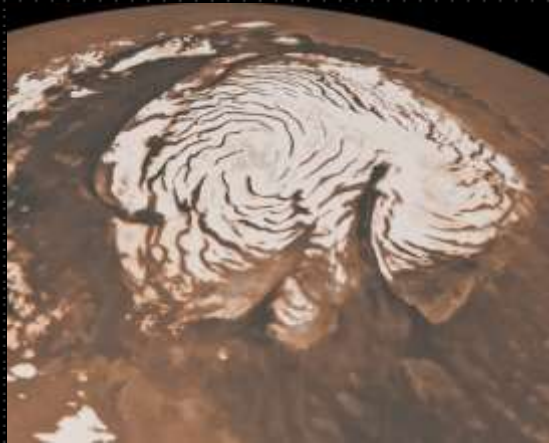
Tlak atmosféry na povrchu: 0,3 Pa (110 km na Zemi)

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

Average Ice Extent



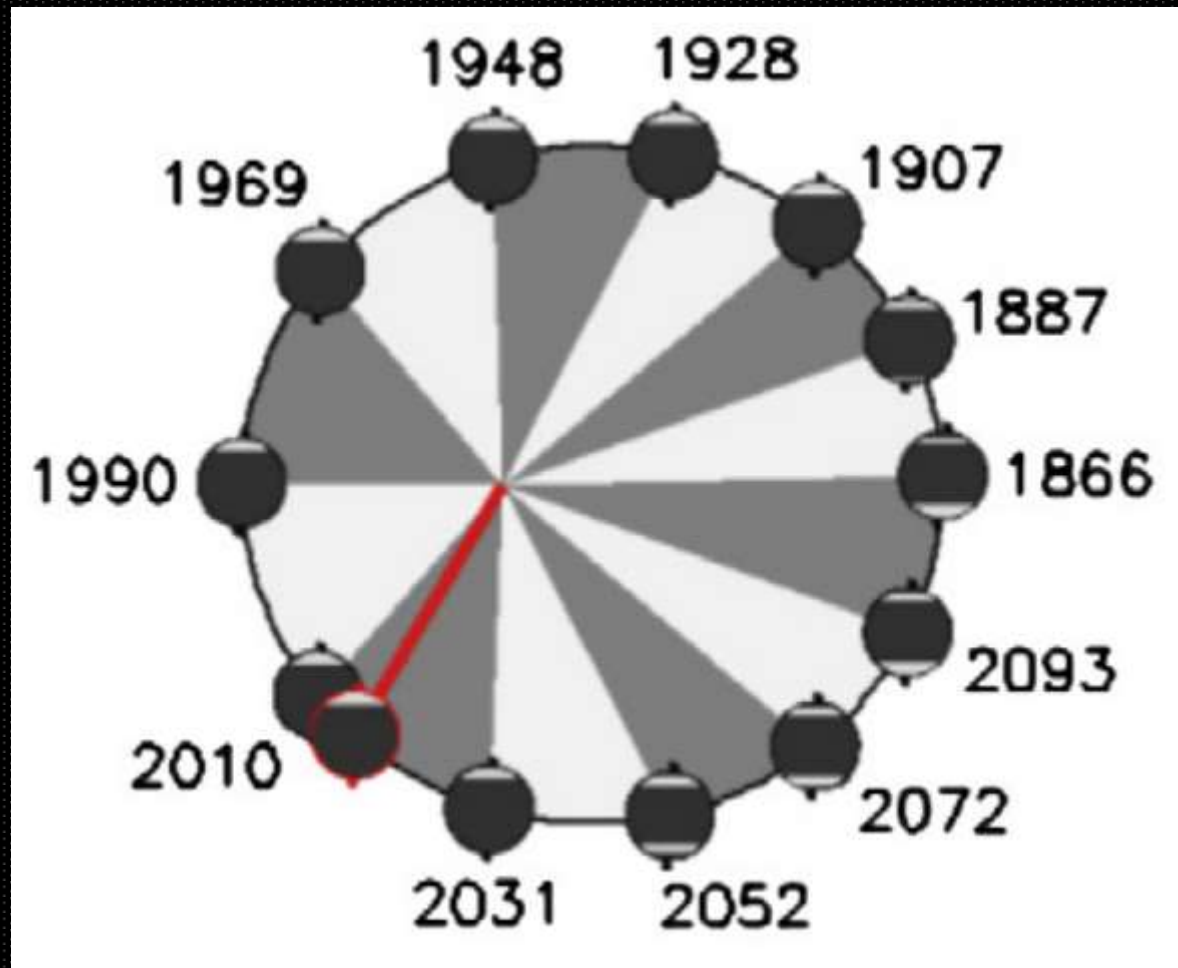
False color

Povrch a atmosféra:

Země: H_2O (3 skupenství) + „skála“

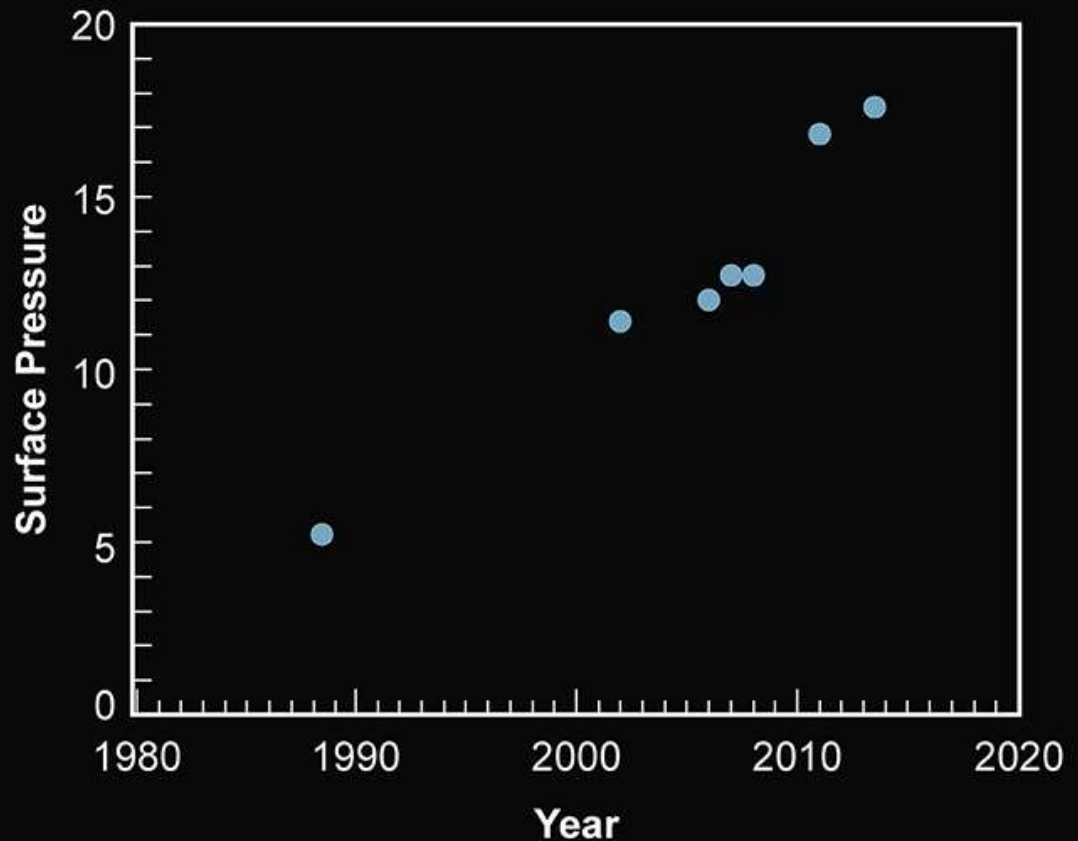
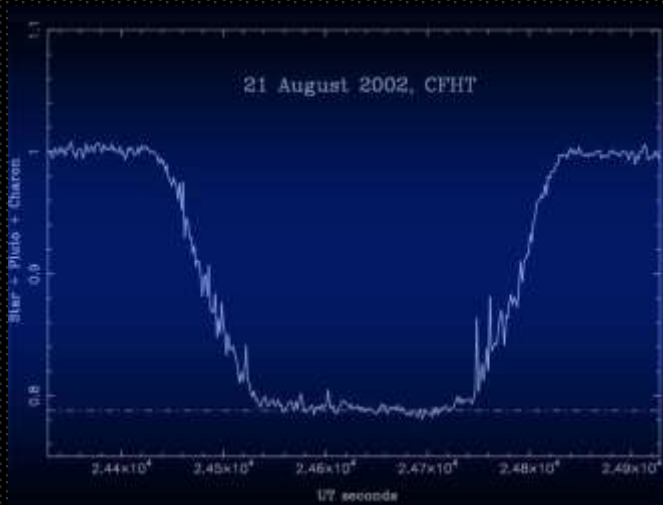
Mars: H_2O + CO_2 (2 skupenství) + „skála“

Pluto: N_2 + CH_4 + CO (2 skupenství) + H_2O (skála)



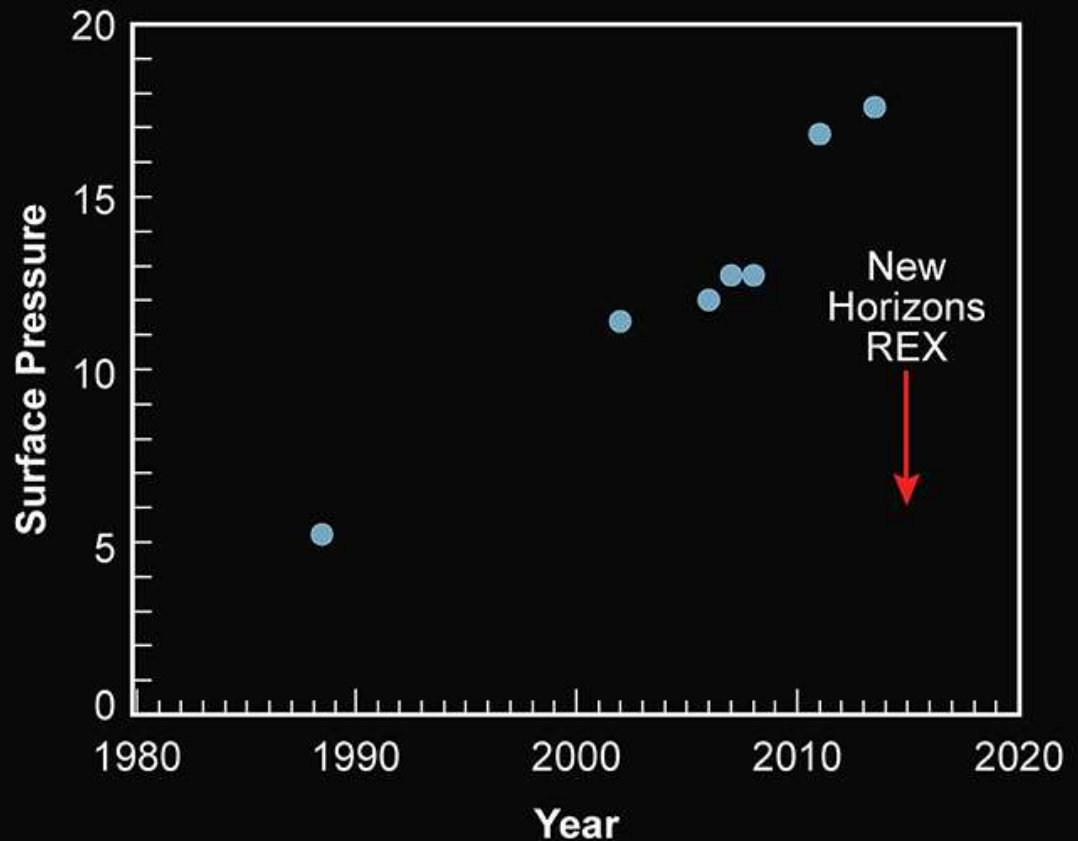
Velké rozdíly ve vzdálenostech, sklon rotační osy.

V roce 1887 se poprvé po 120 letech vynořil severní pól ze stínu.



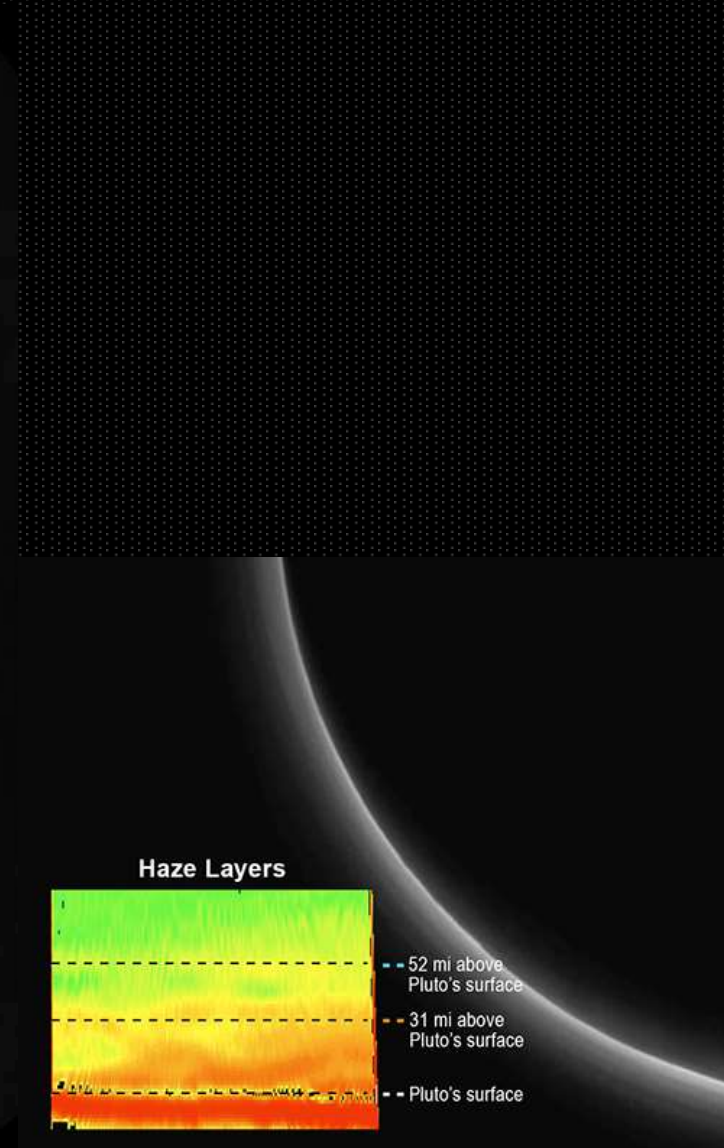
Pozemská detekce atmosféry ze zákrytů hvězd.

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

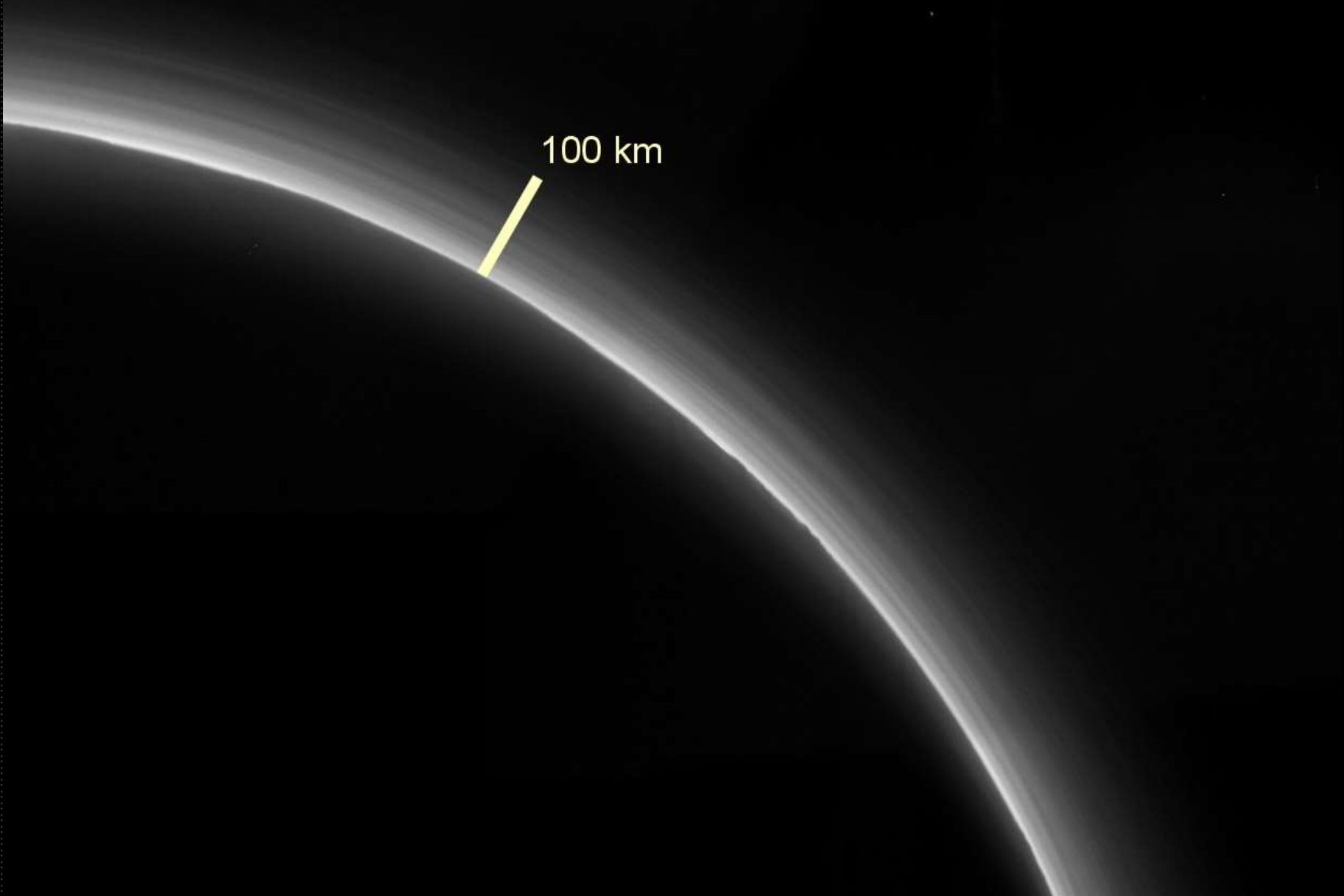


Pozemská detekce atmosféry ze zákrytů hvězd.

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



Snímek atmosféry Pluta z kamery LORRI



100 km

ALL THEIR SUNRISES AND SUNSETS



Left: Titan, Cassini, 2010. Right: Pluto, New Horizons, 2015. Phase angle about 165 degrees. Pluto image has been scaled to match size of Titan image.

Data: NASA / JPL / JHUAPL / SwRI. Comparison by Emily Lakdawalla.

Titan (Cassini) a Pluto (New Horizons)



Má Pluto modrou oblohu?



Pluto



Titan

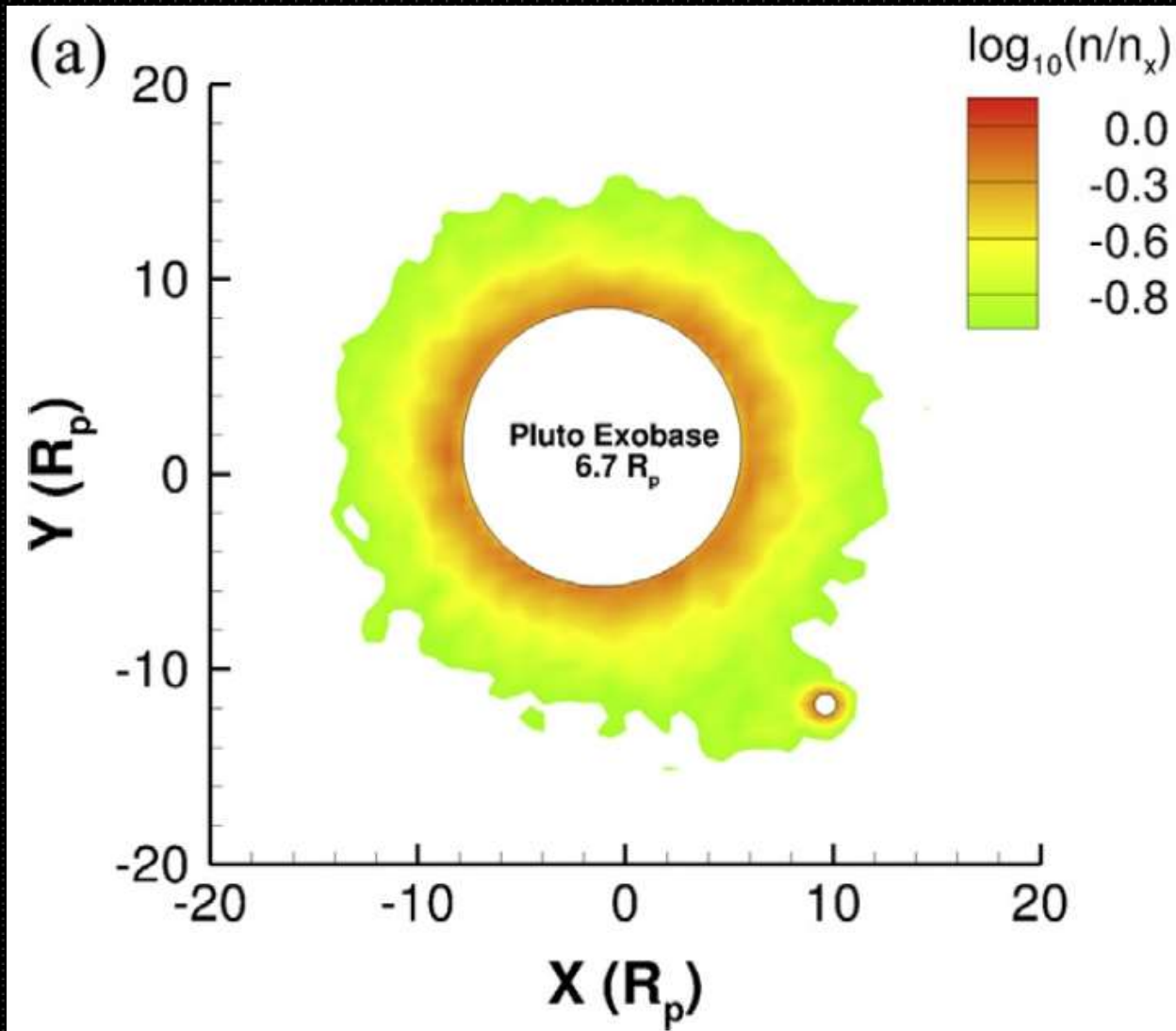


Země



Mars

Má Pluto modrou oblohu?



Atmosféra Pluta možná namrzá až na Charonu.



Povrch Pluta



Povrch Pluta



Povrch Pluta



Povrch Pluta



Povrch Pluta

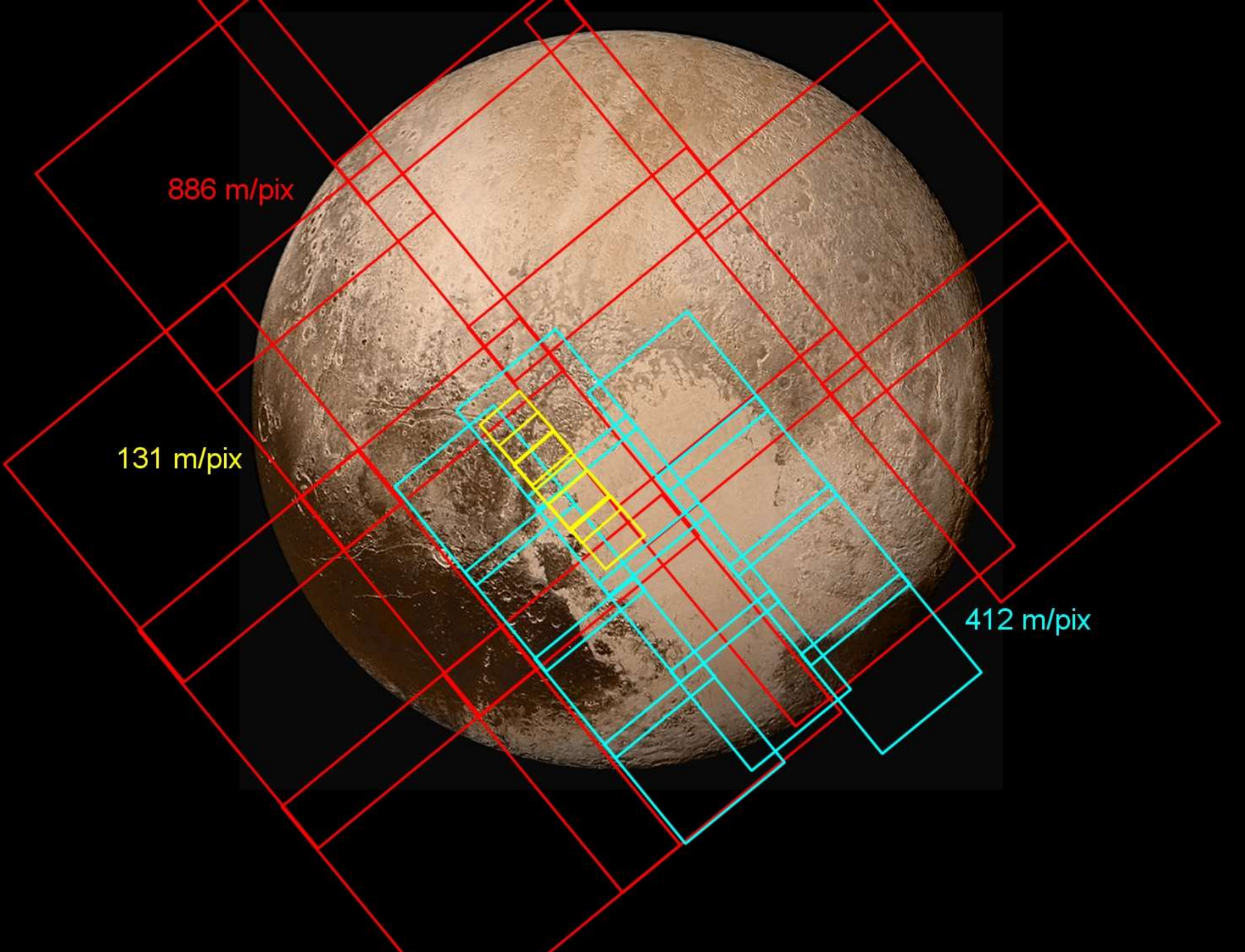


Povrch Pluta

886 m/pix

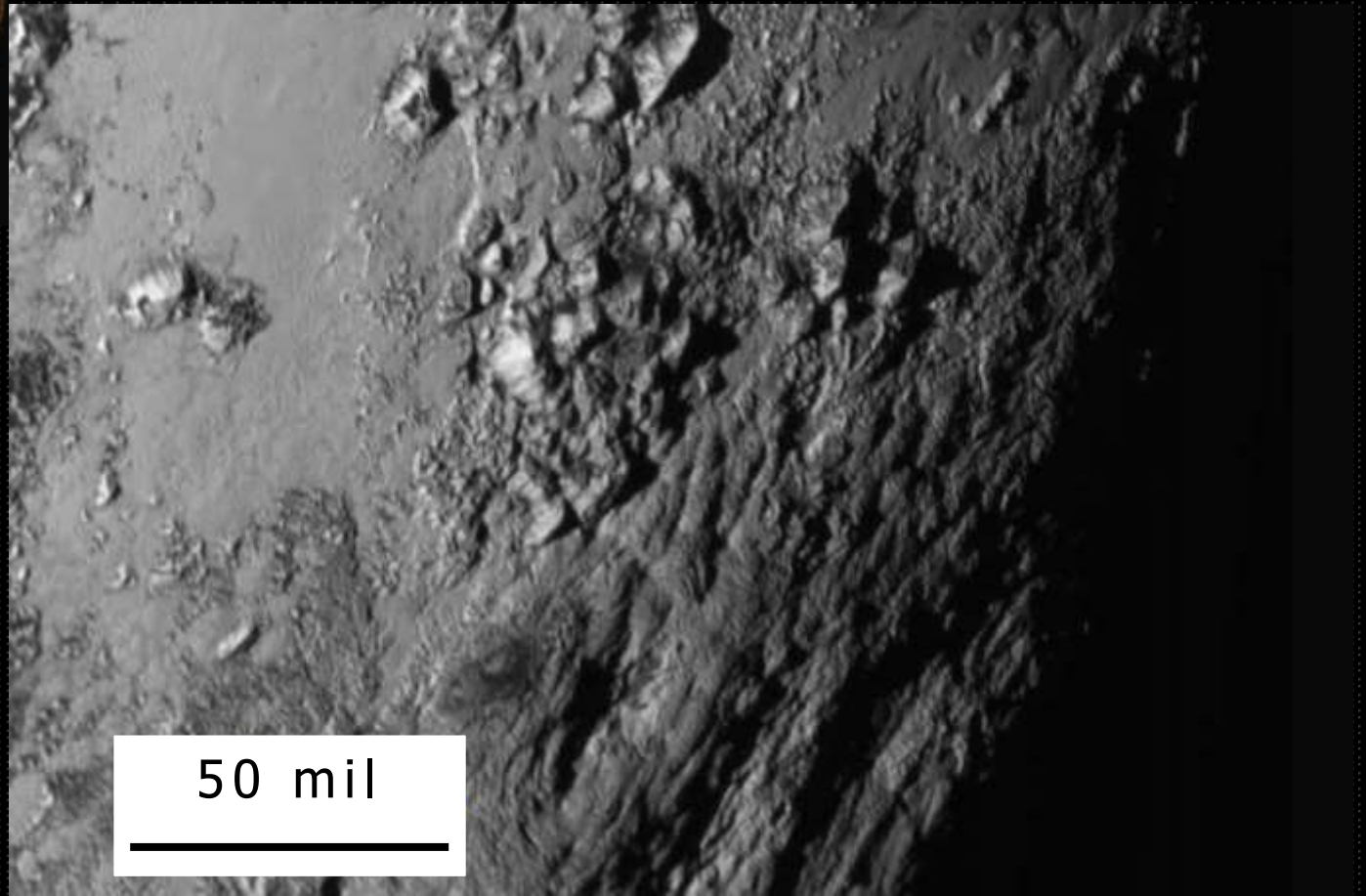
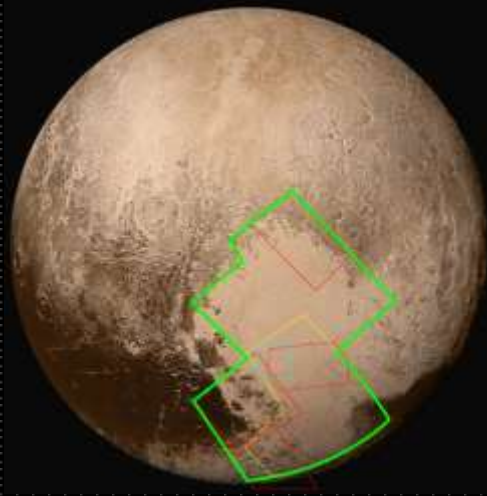
131 m/pix

412 m/pix





Pluto time
16:35 SEČ

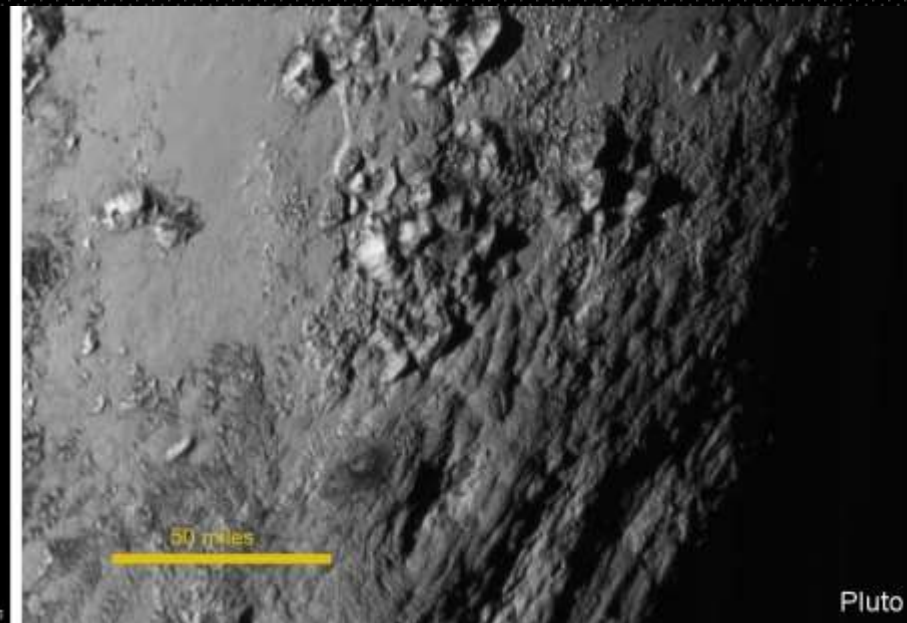


První snímek s vysokým rozlišením



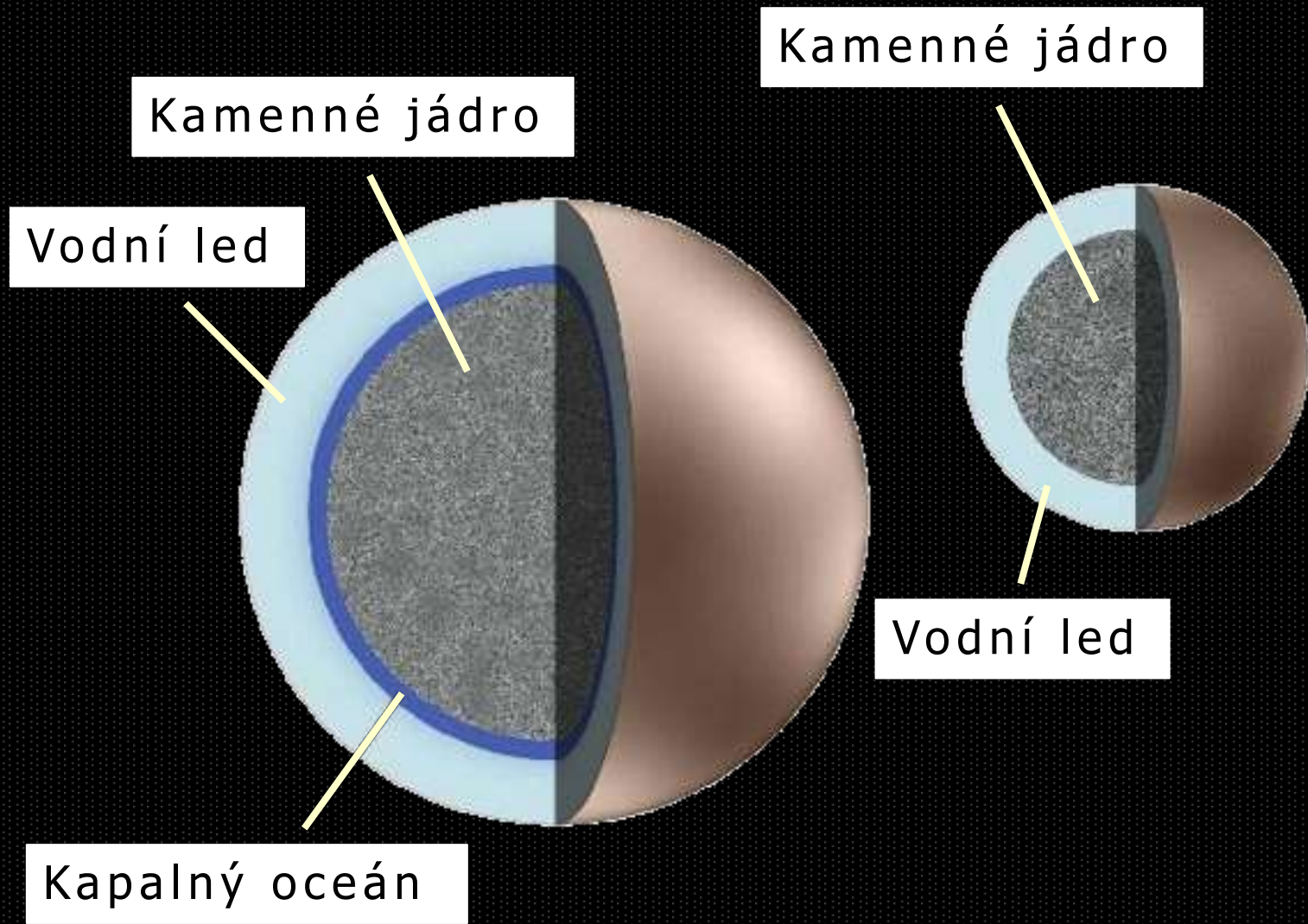
Ceres

Foto: NASA
Úprava: Petr Scheinich

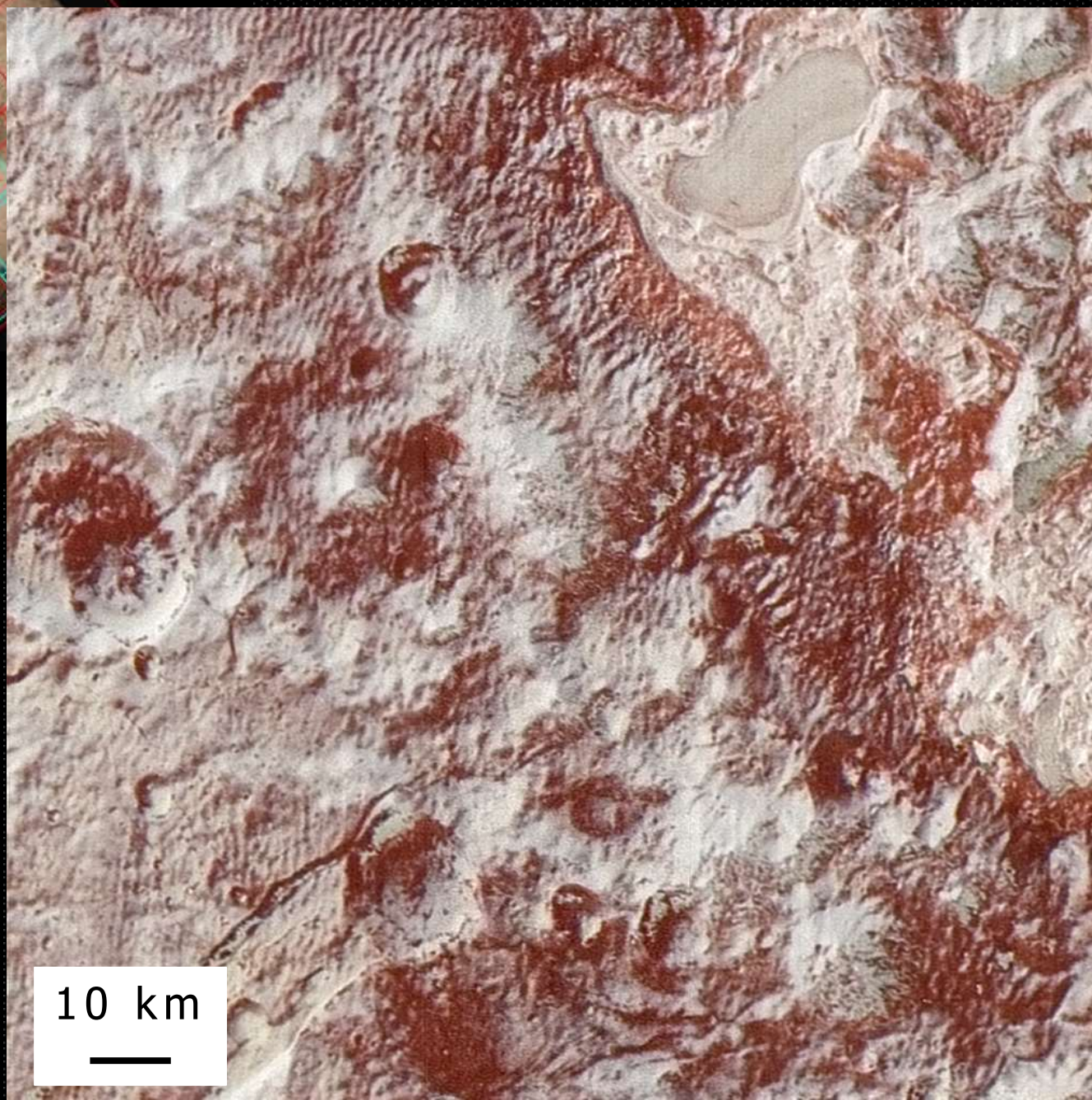
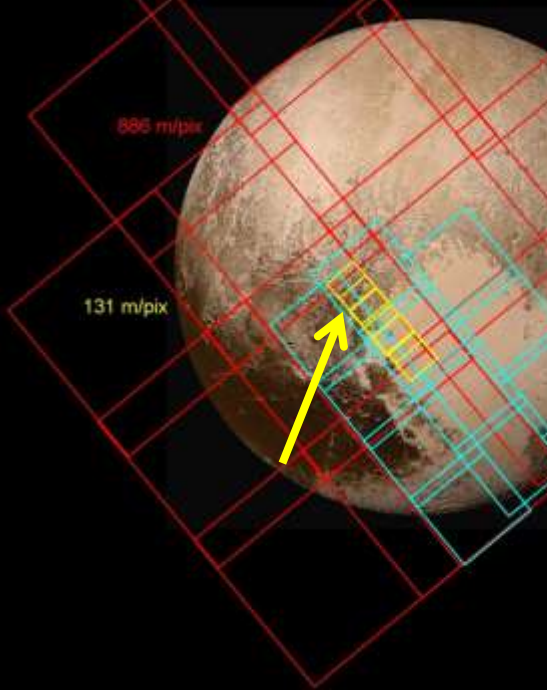


Pluto

Málo kráterů – geologicky mladý povrch.



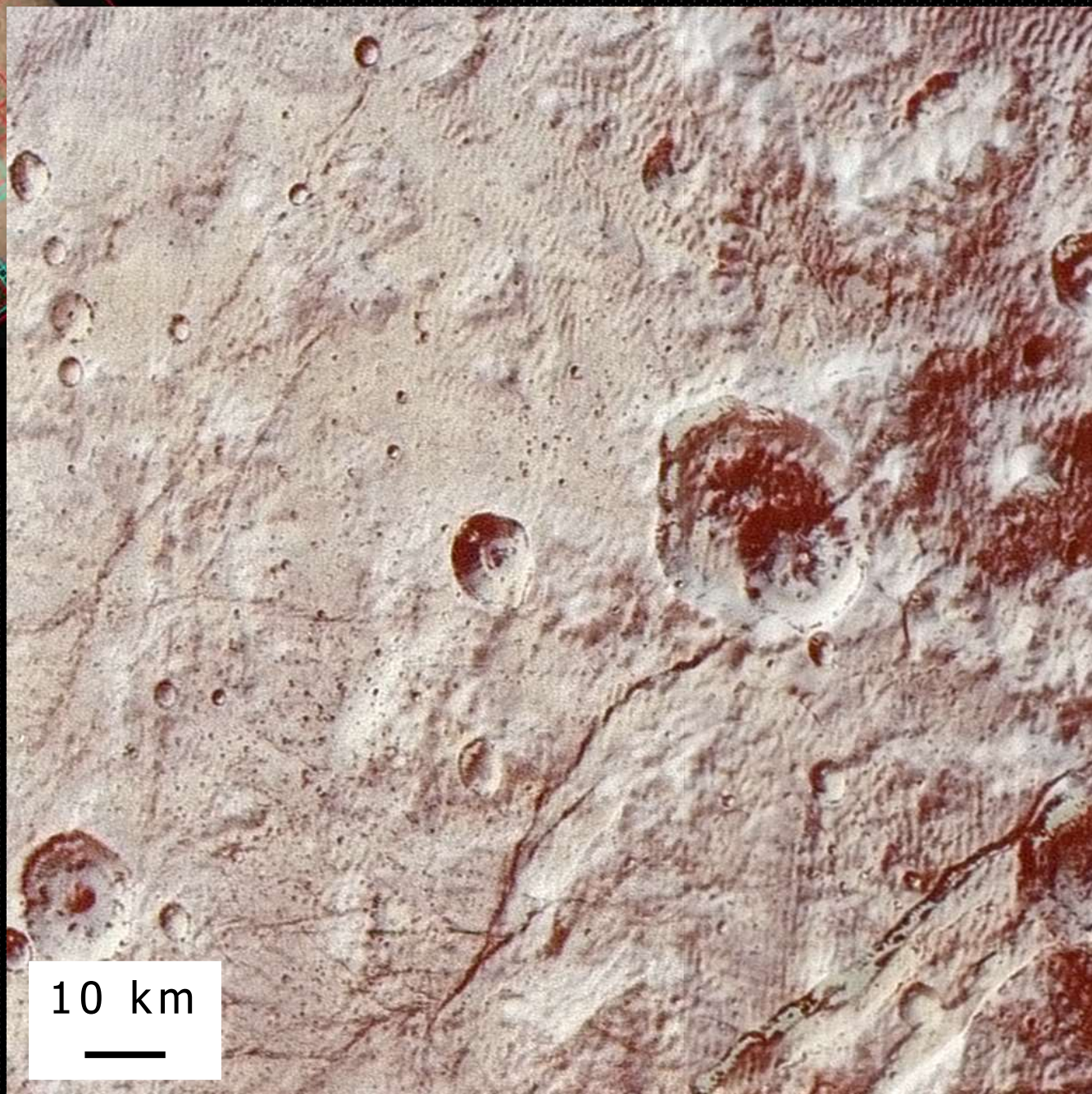
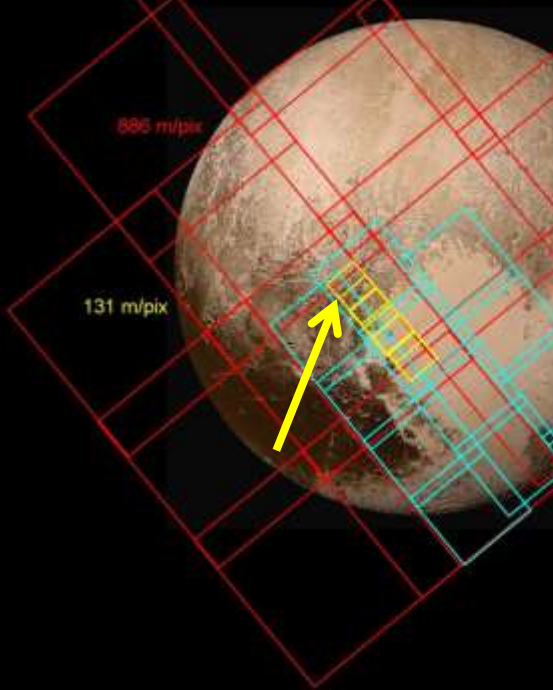
Vnitřní uspořádání Pluta a Charonu



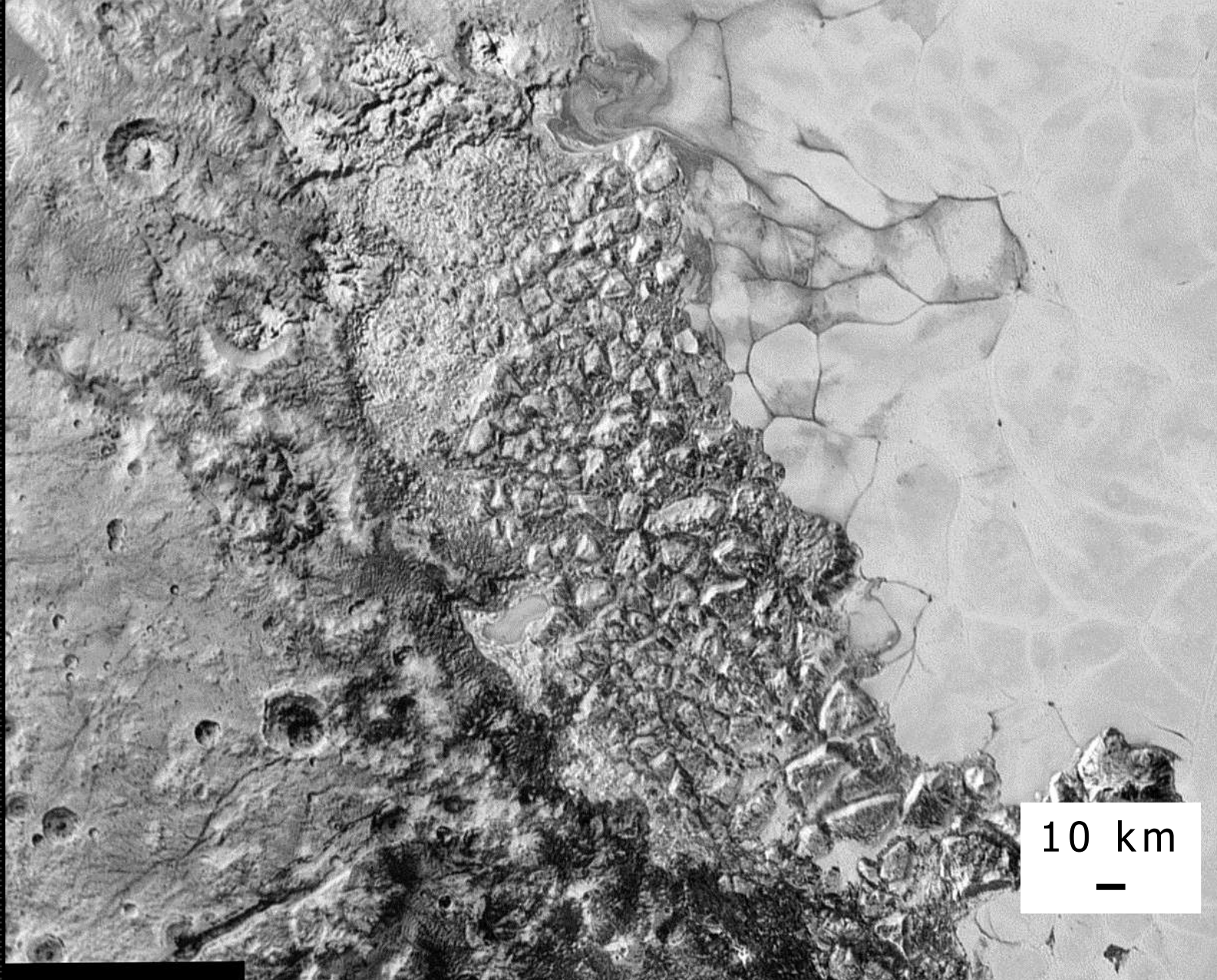
Duny

10 km





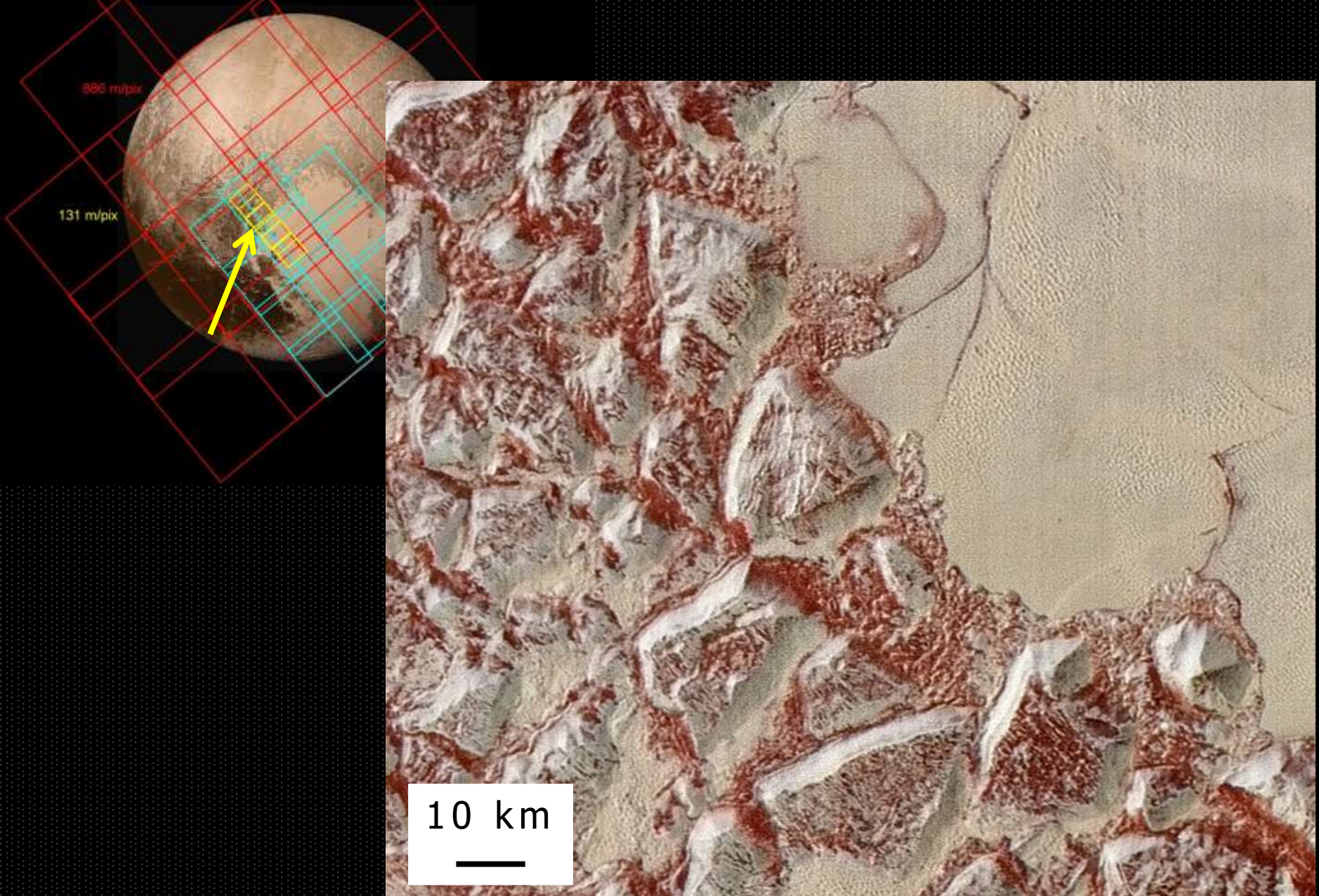
„Řečiště“?



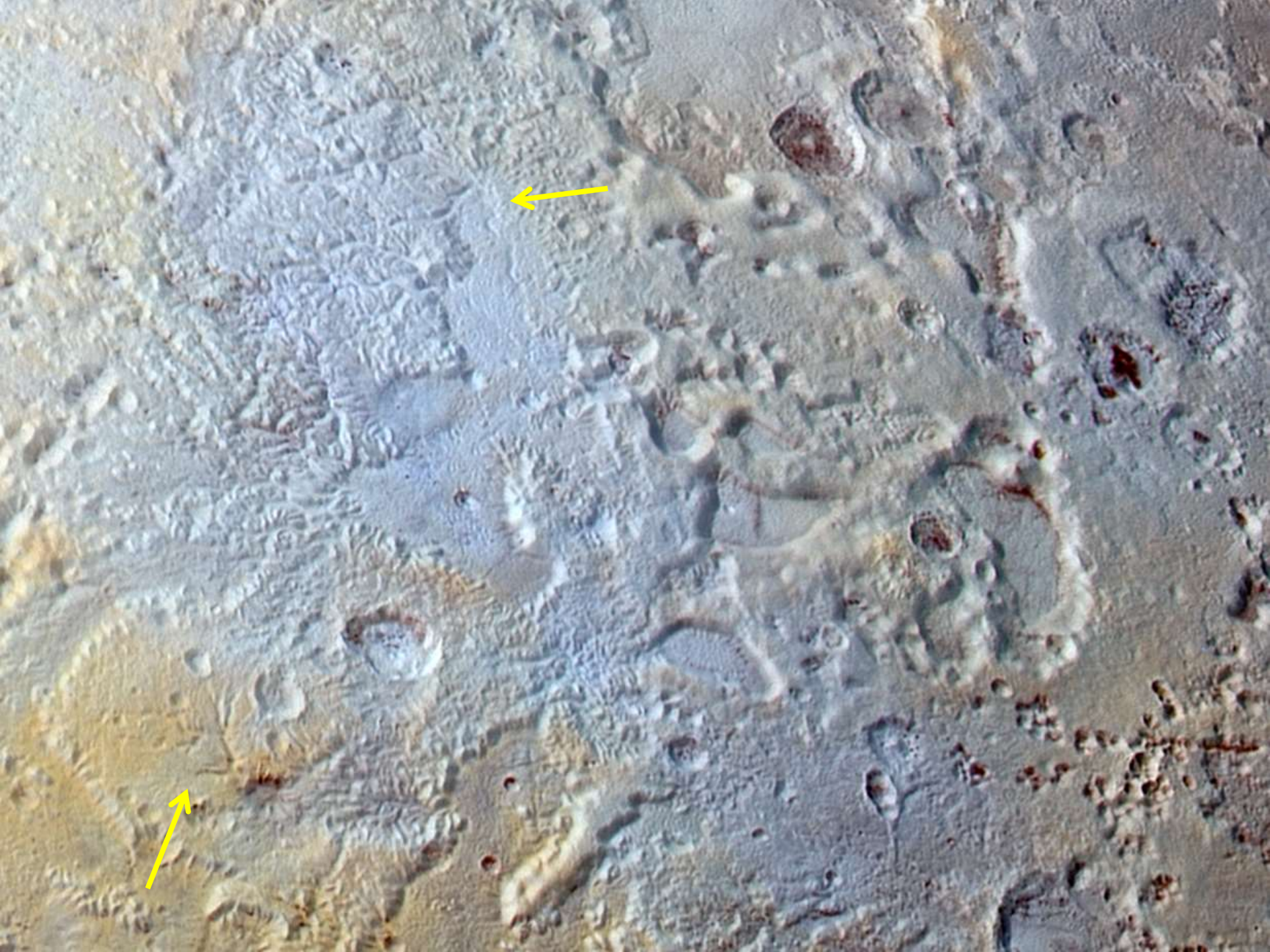
10 km



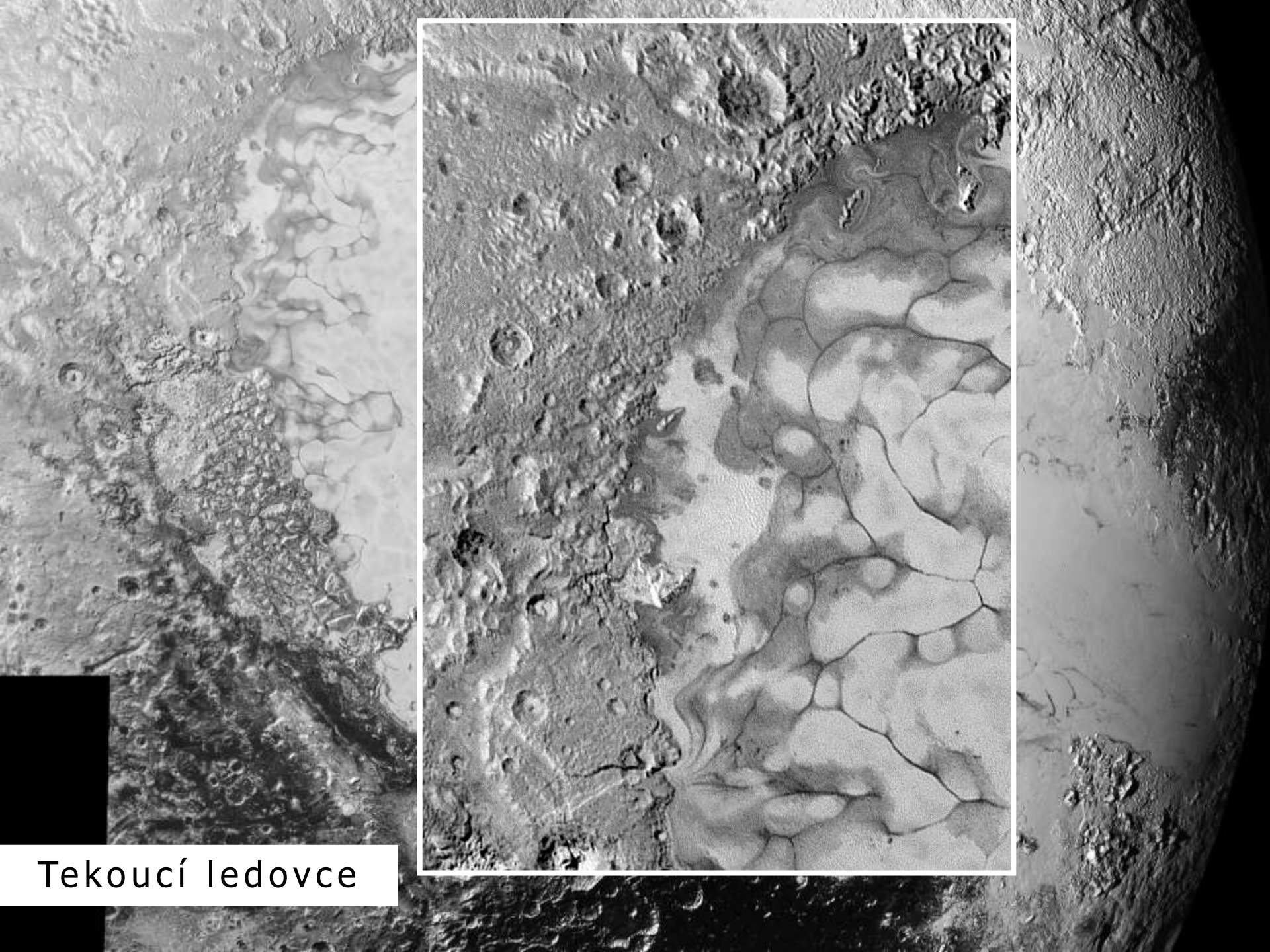
Duny, „řečiště“, konvektivní cely, tekoucí ledovce



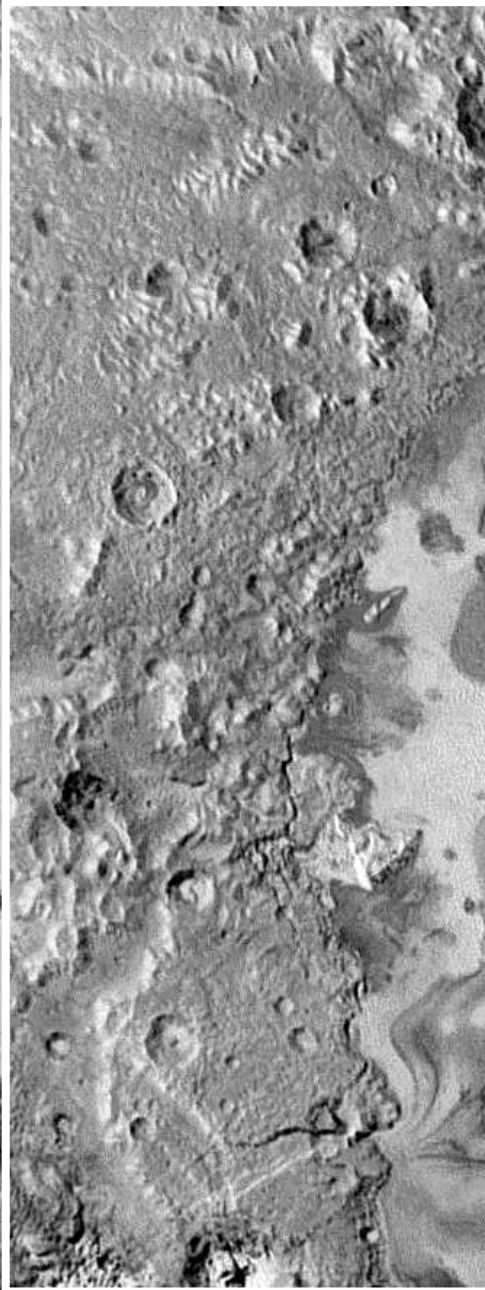
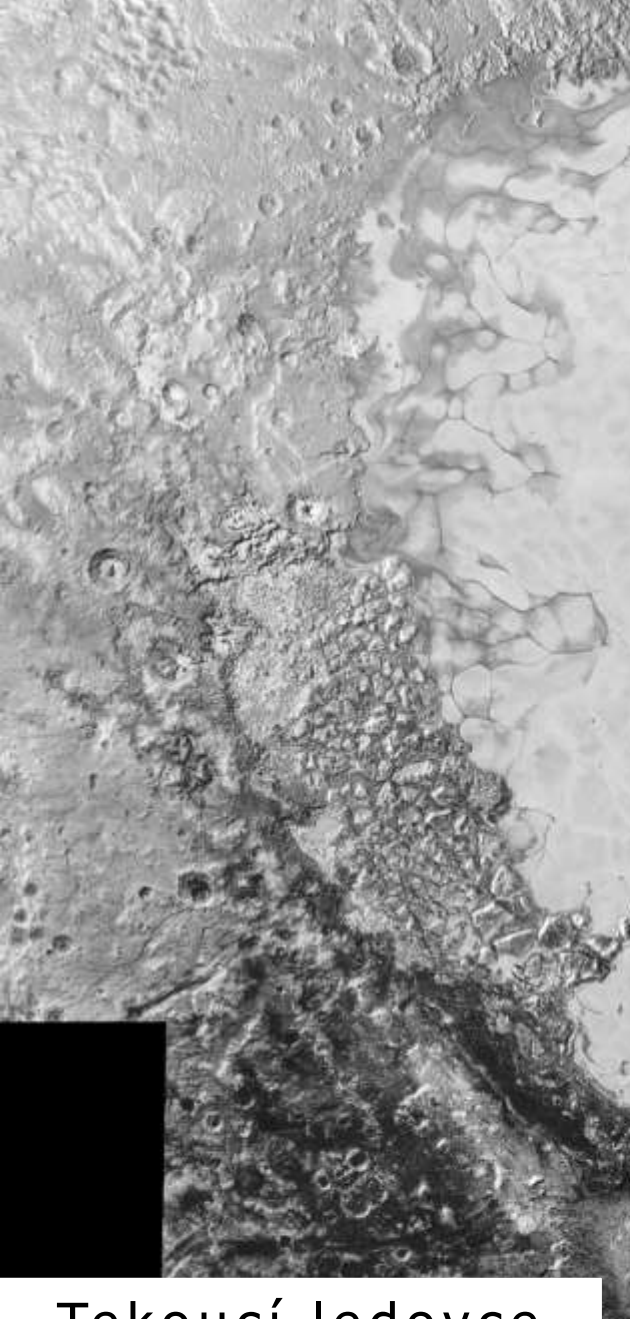
Zakousnutá „ledovcová“ údolí na okraji Tombough Regio, duny



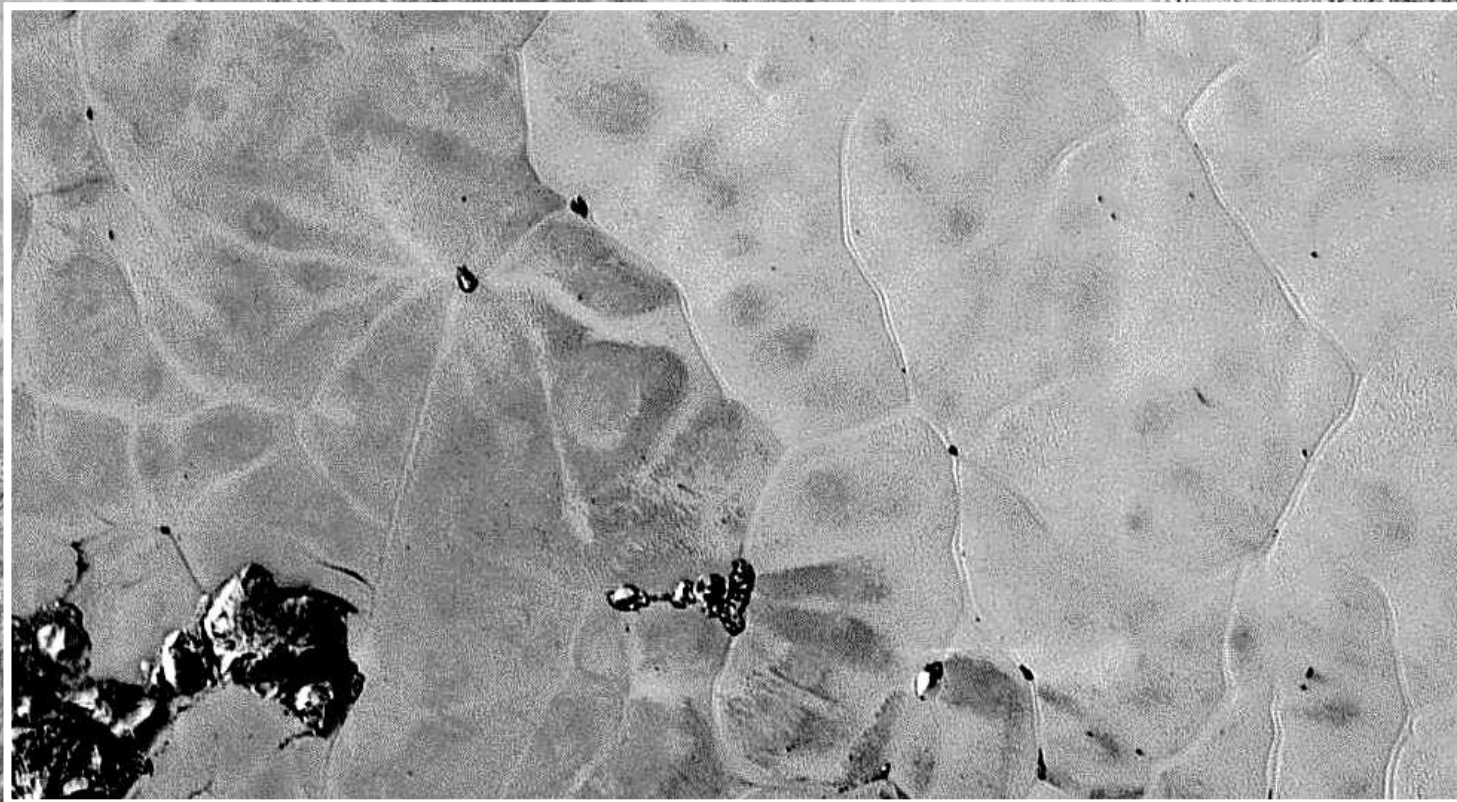




Tekoucí ledovce



Tekoucí ledovce



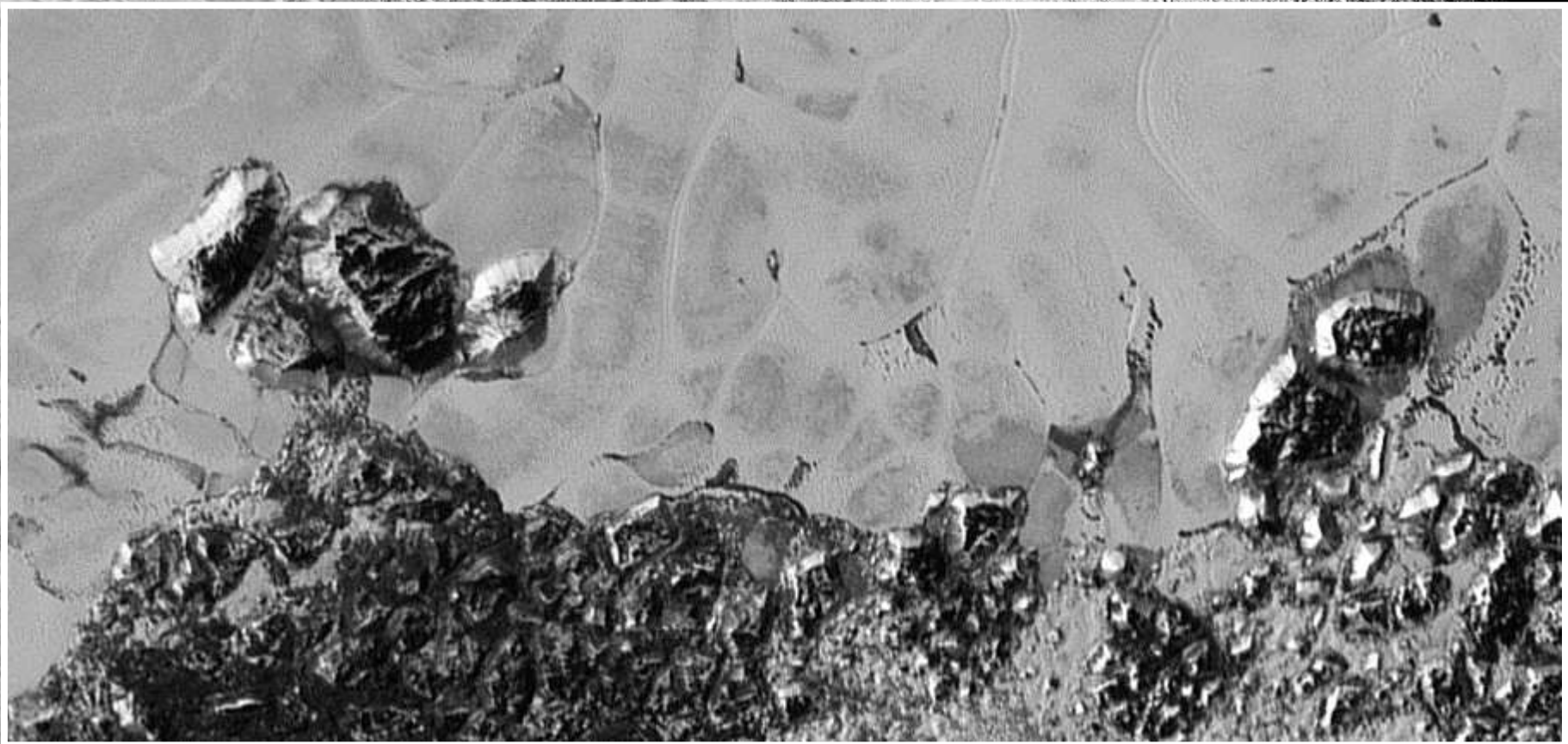
Působení větru?
Dvojitá údolí mezi konvektivními buňkami



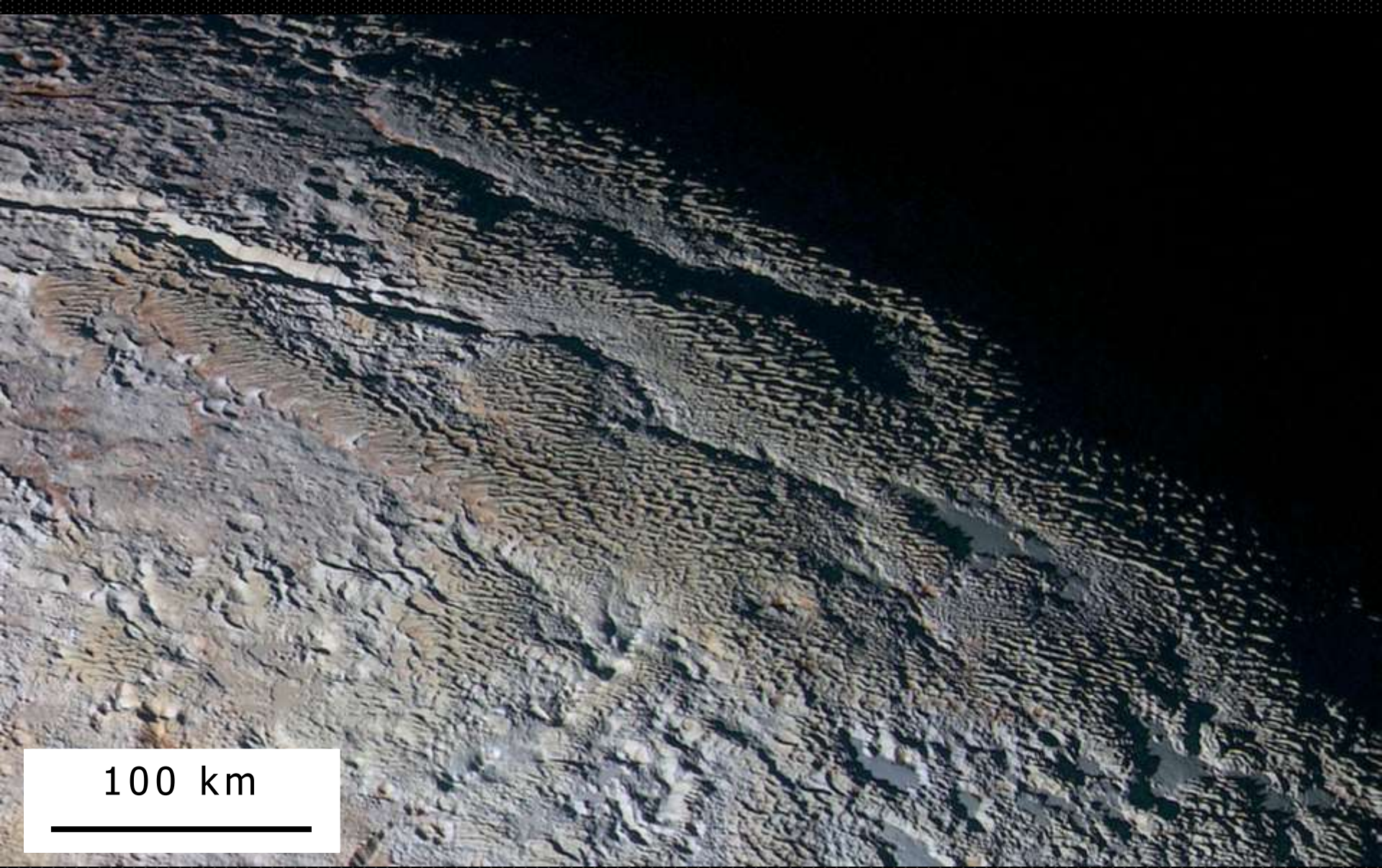
10 km



Působení větru?
Dvojitá údolí mezi konvektivními buňkami

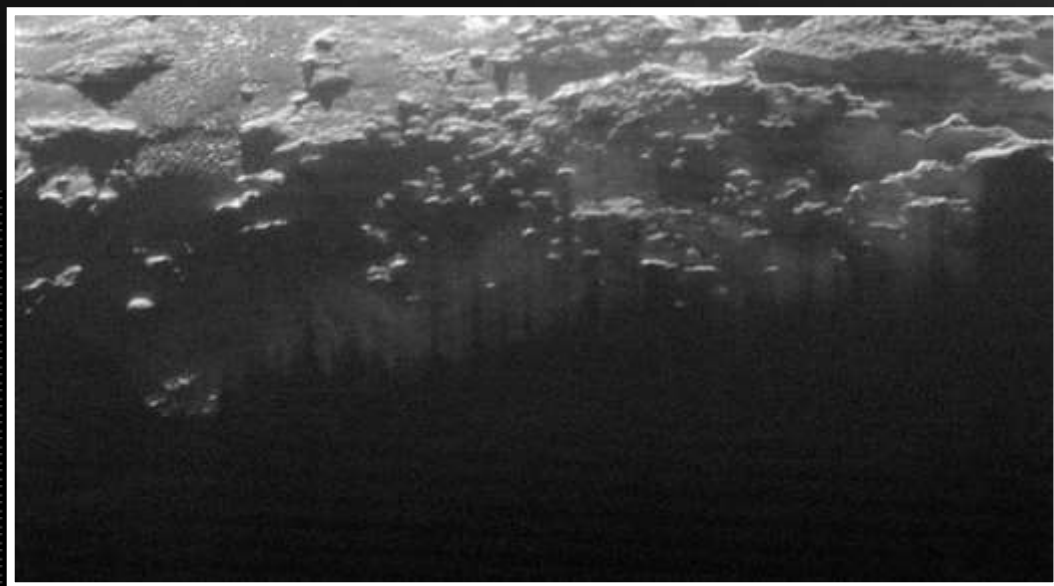
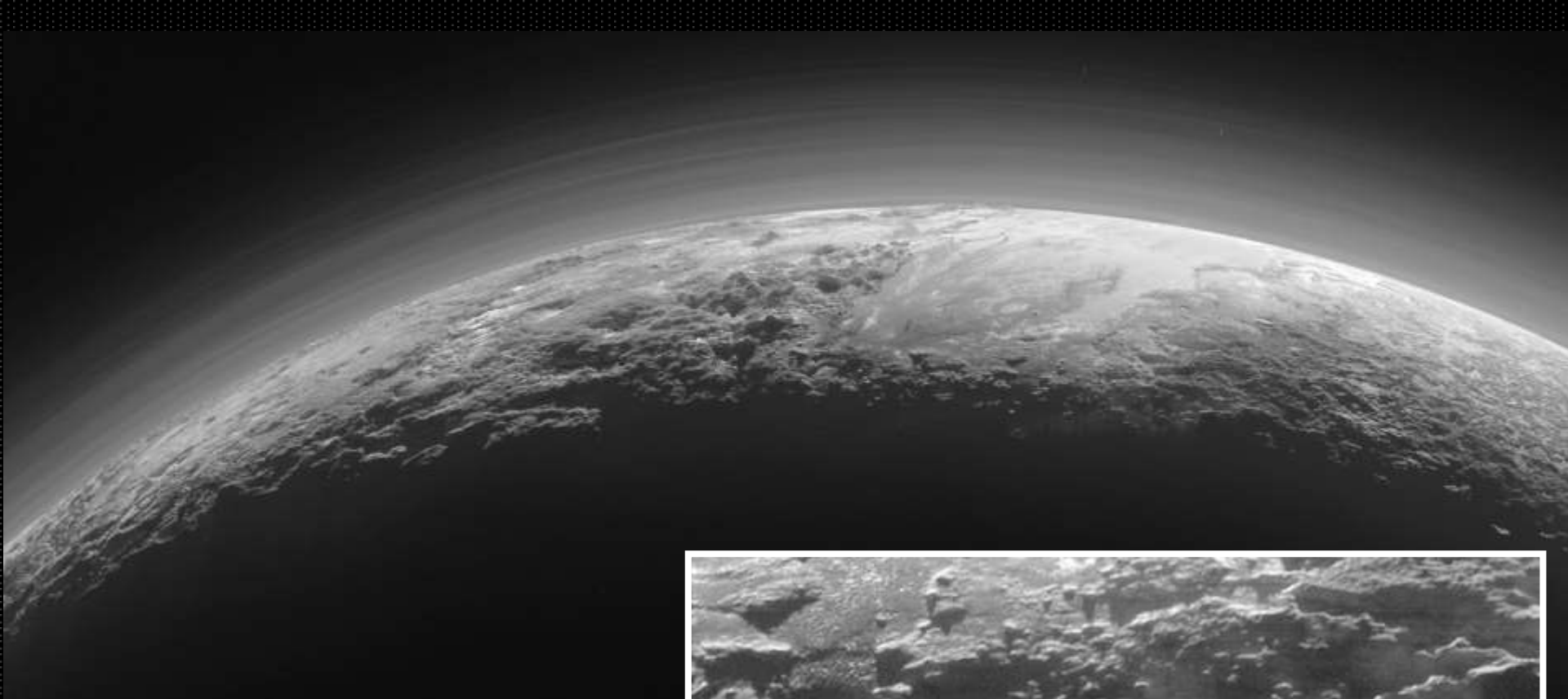


Eroze – ostré „mysy“ a oblé „zálivy“.

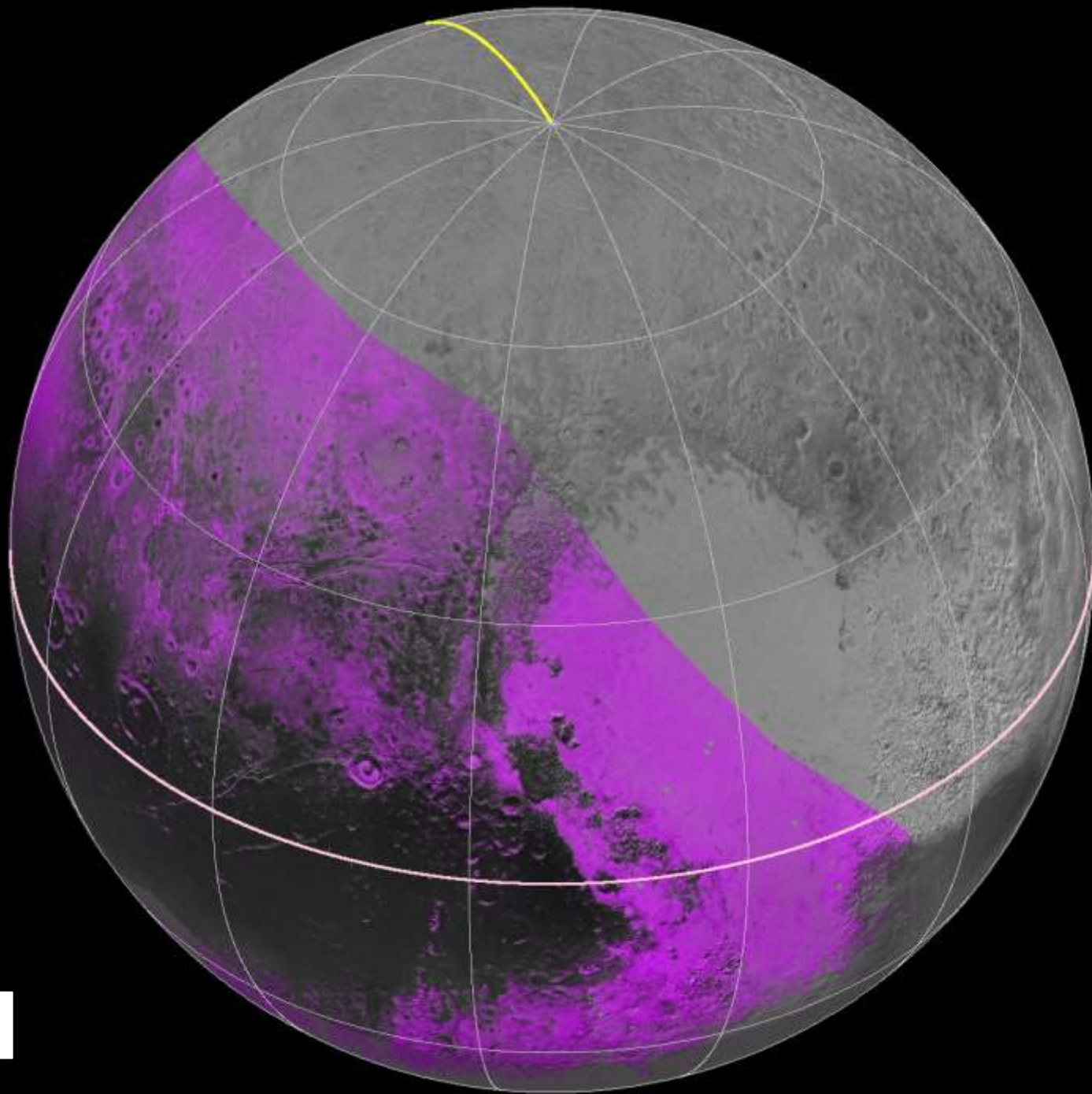


100 km

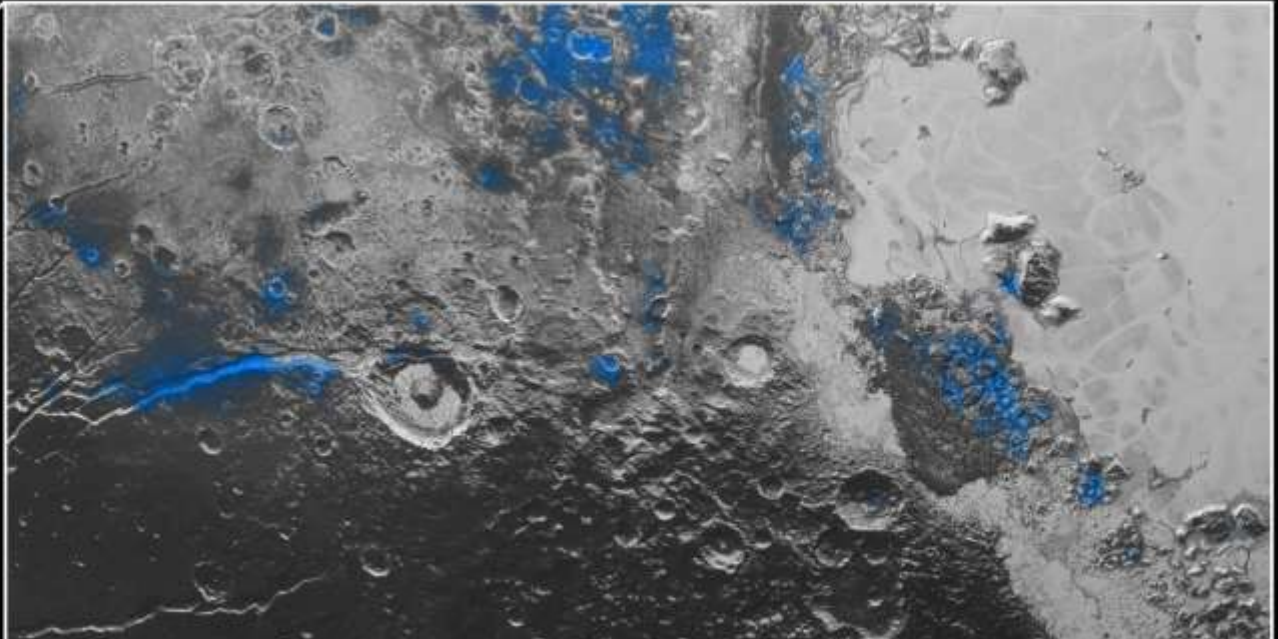
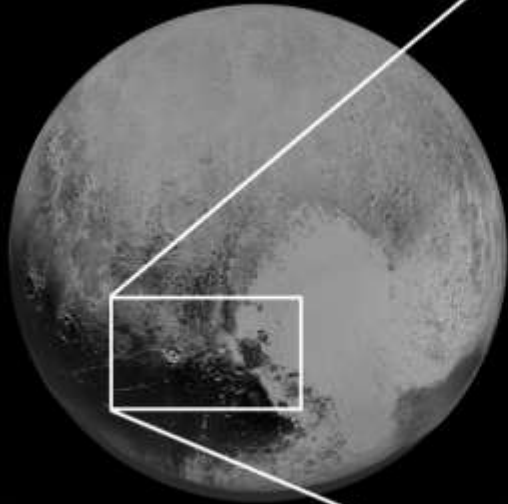
Sublimace nebo kondenzace?



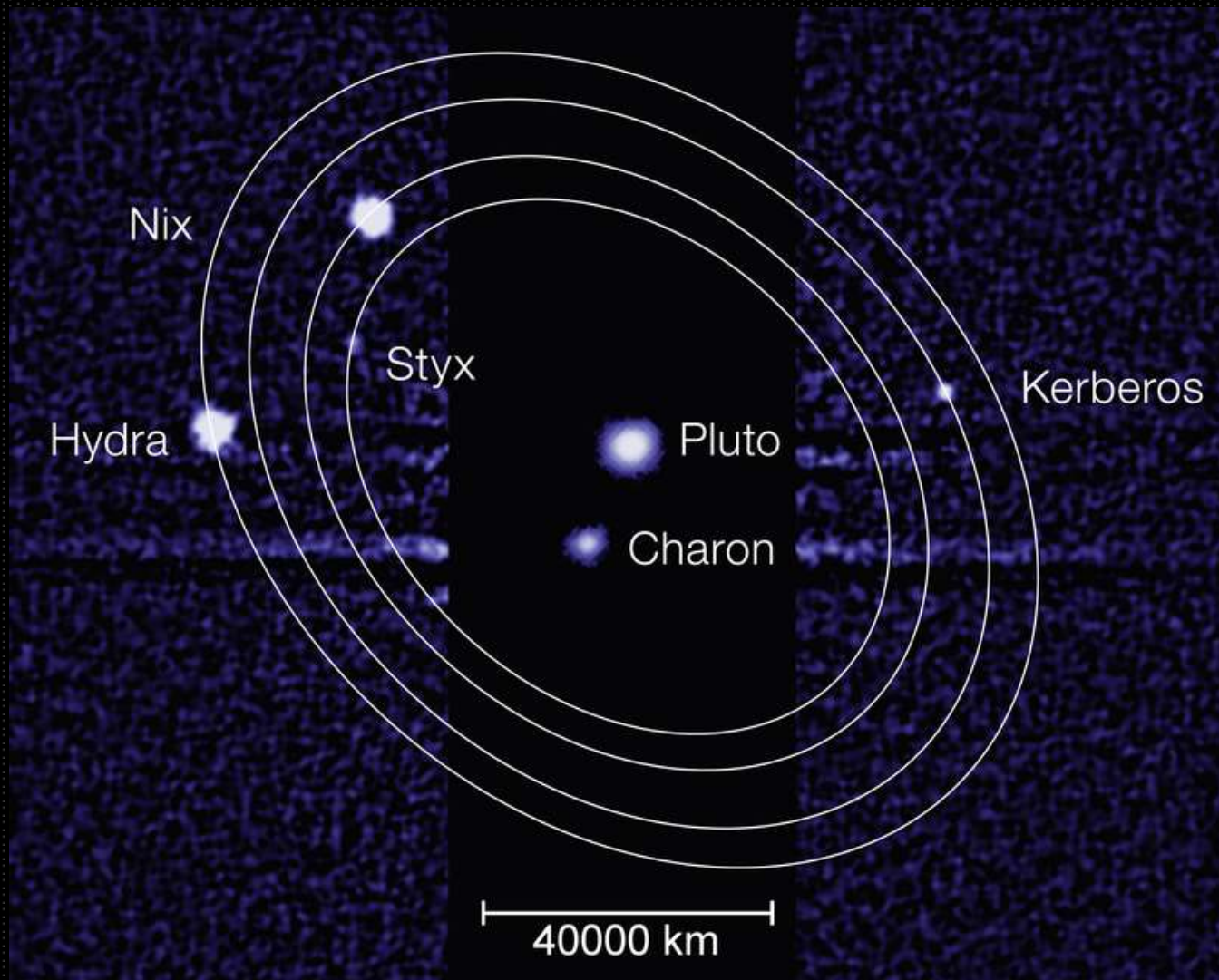
Stíny v přízemní mlze



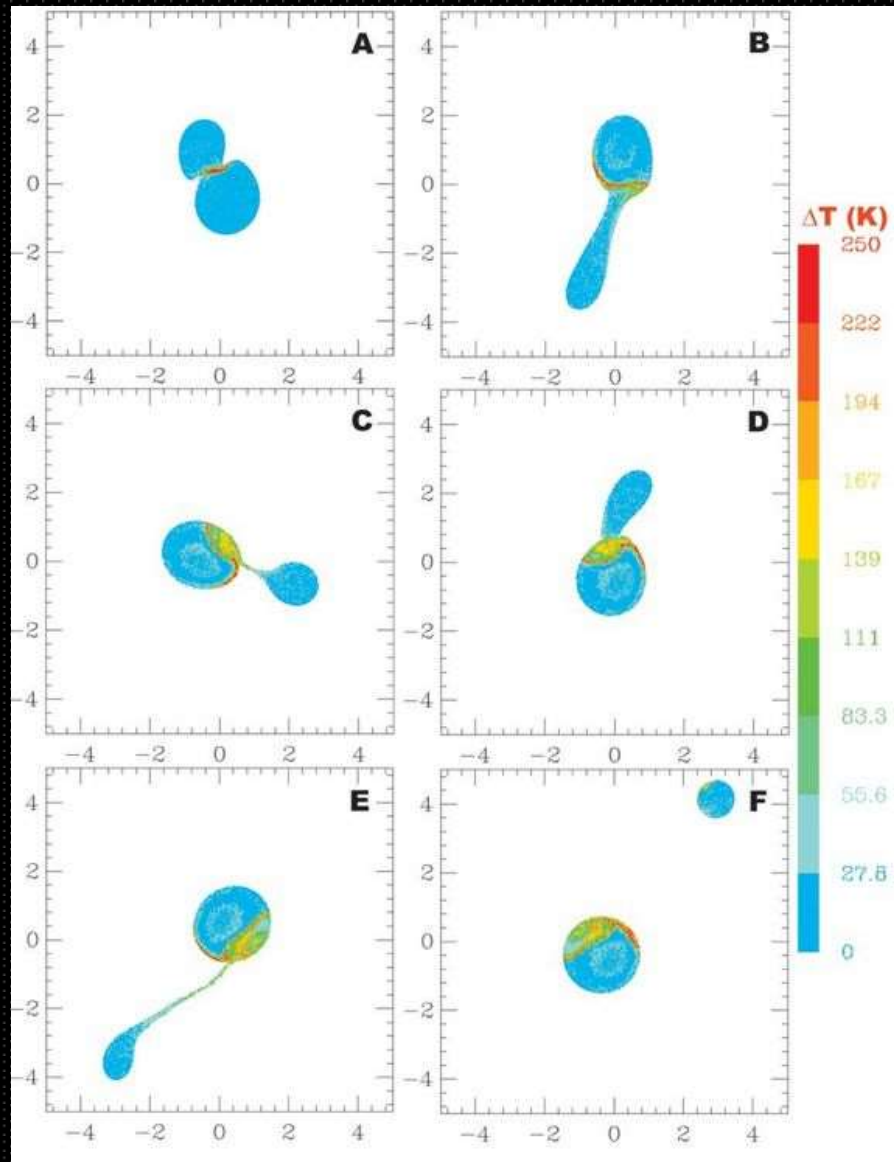
Metan



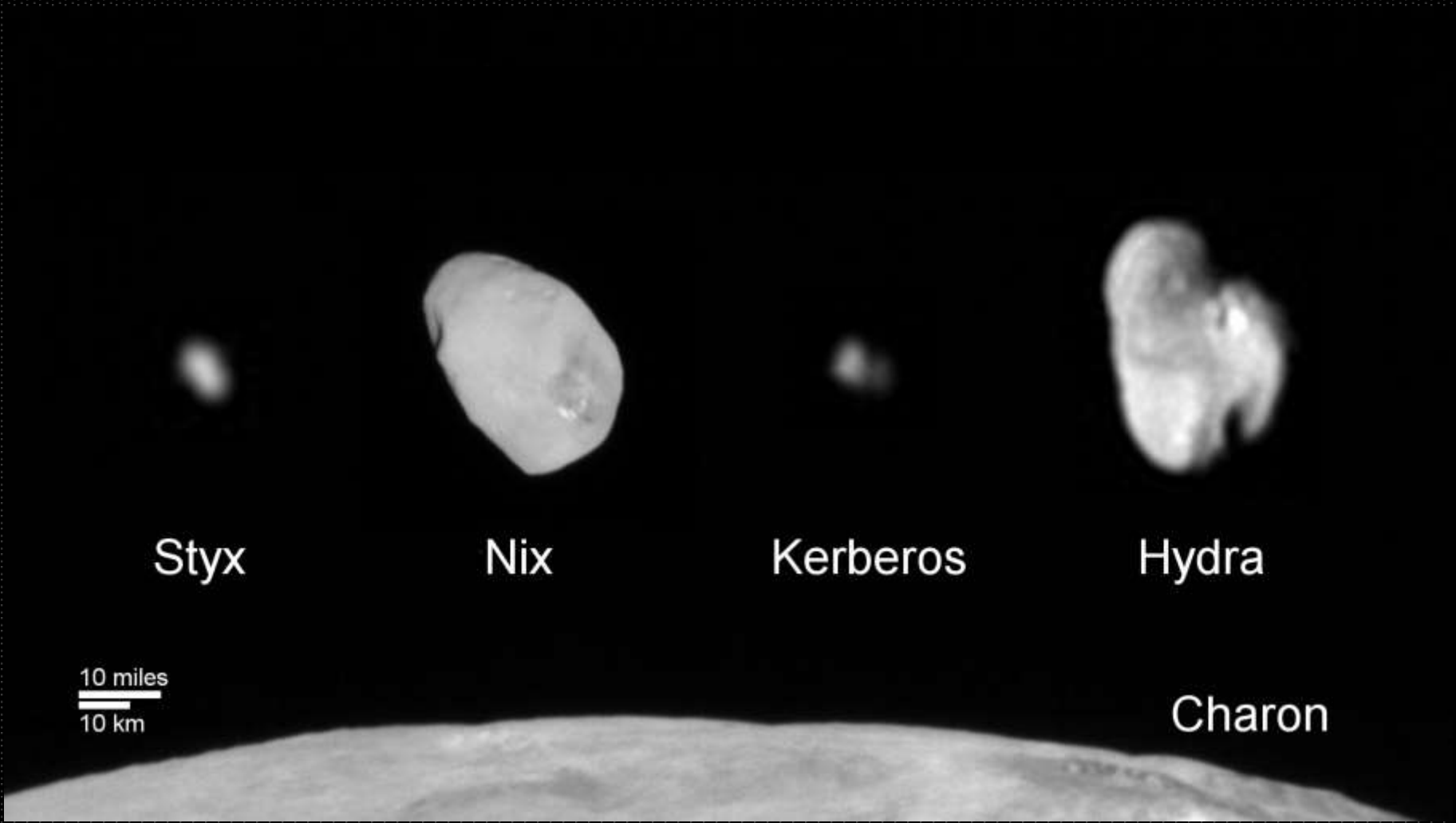
Vodní led



Měsíce Pluta



Měsíce Pluta – vznik při velké srážce



Styx

Nix

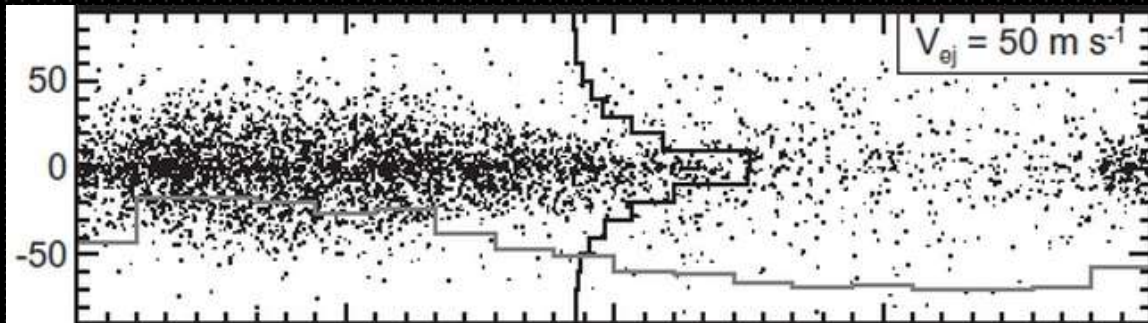
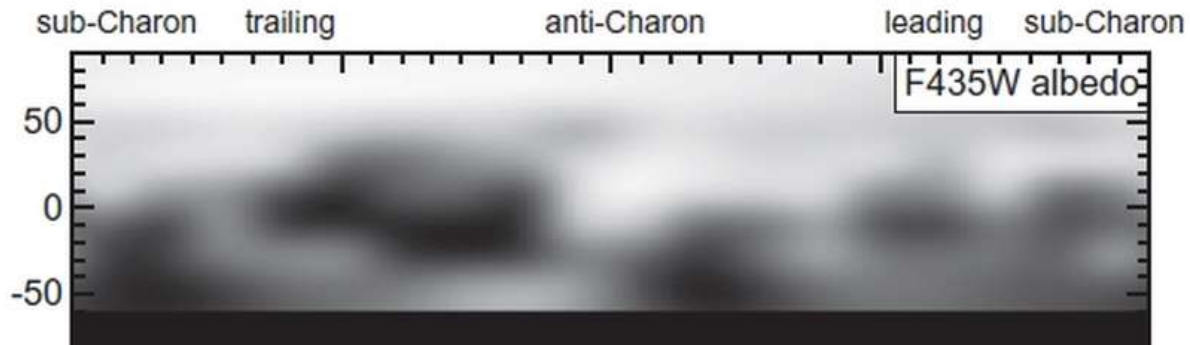
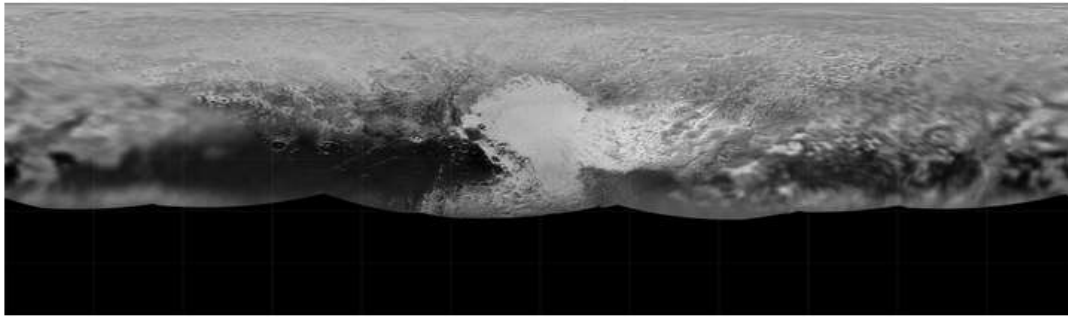
Kerberos

Hydra

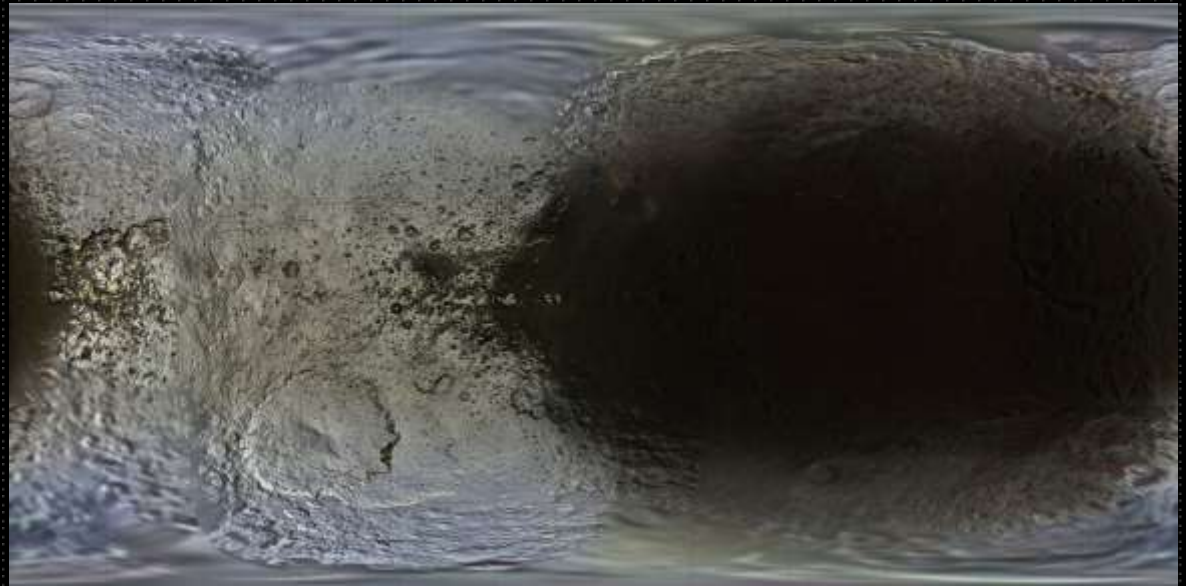
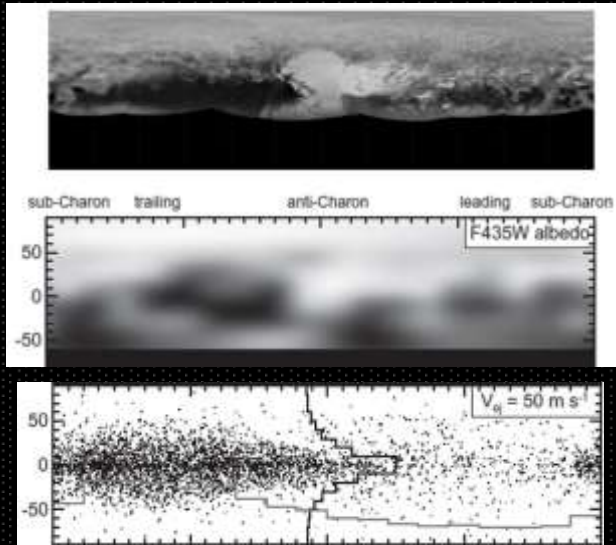
Charon

10 miles
10 km

Malé měsíce Pluta



Prach z měsíce Nix na povrchu Pluta



Japetus a prach z Phoebe

Polární čepička



Mladší jižní
polokoule

Charon

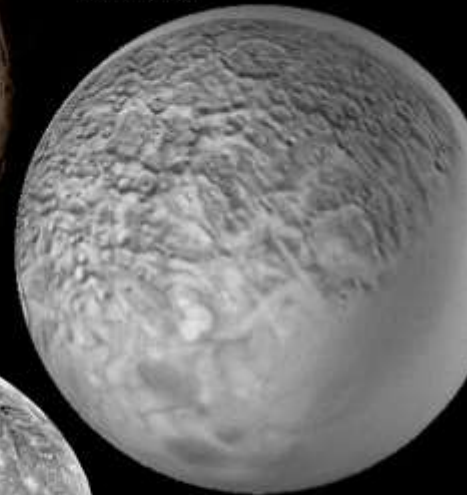
Tethys



Dione



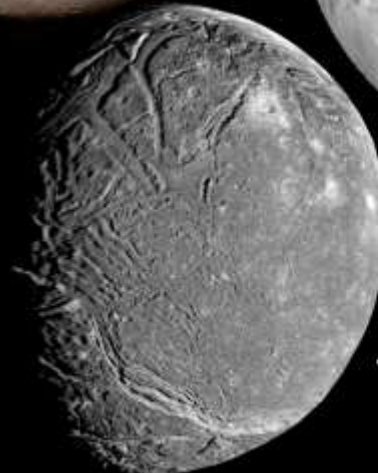
Umbriel

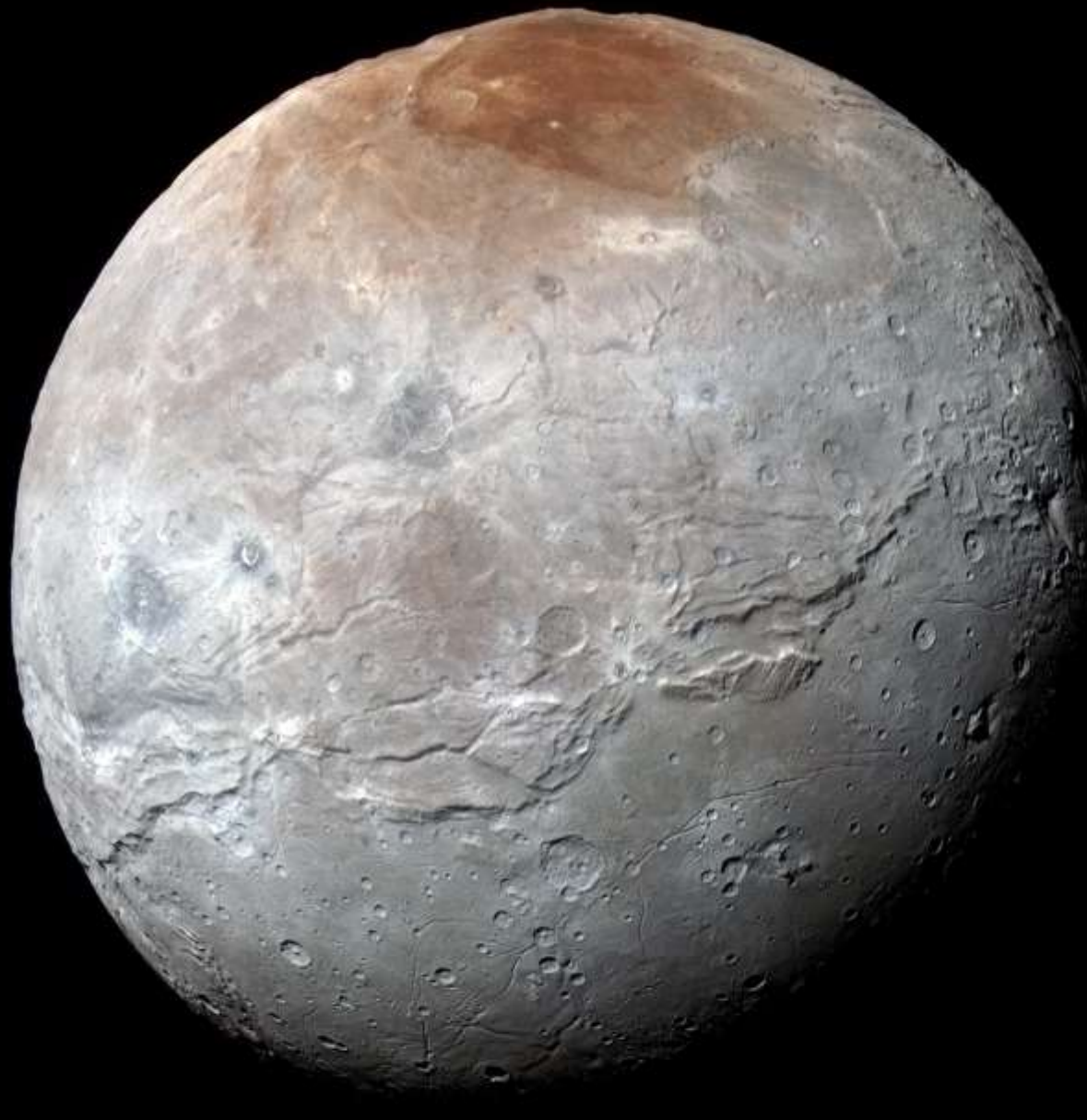


Oberon

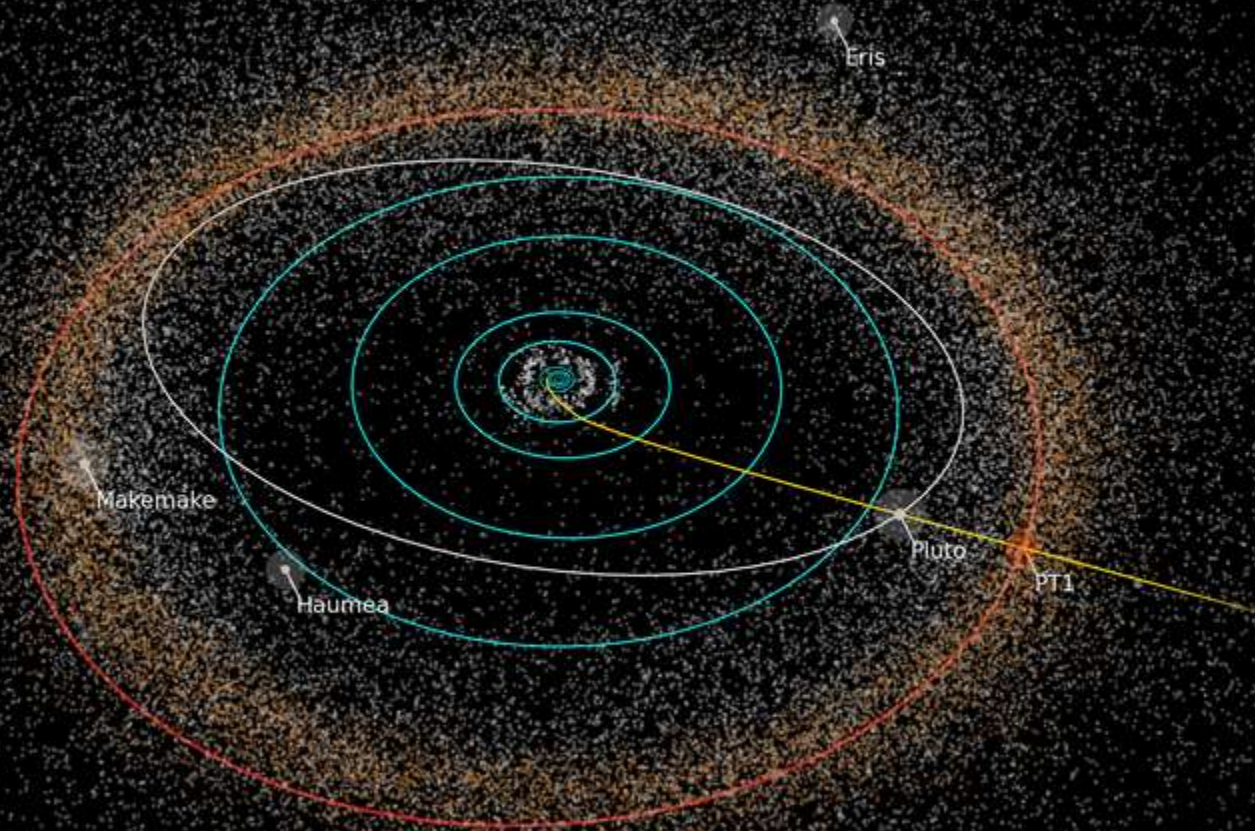


Ariel

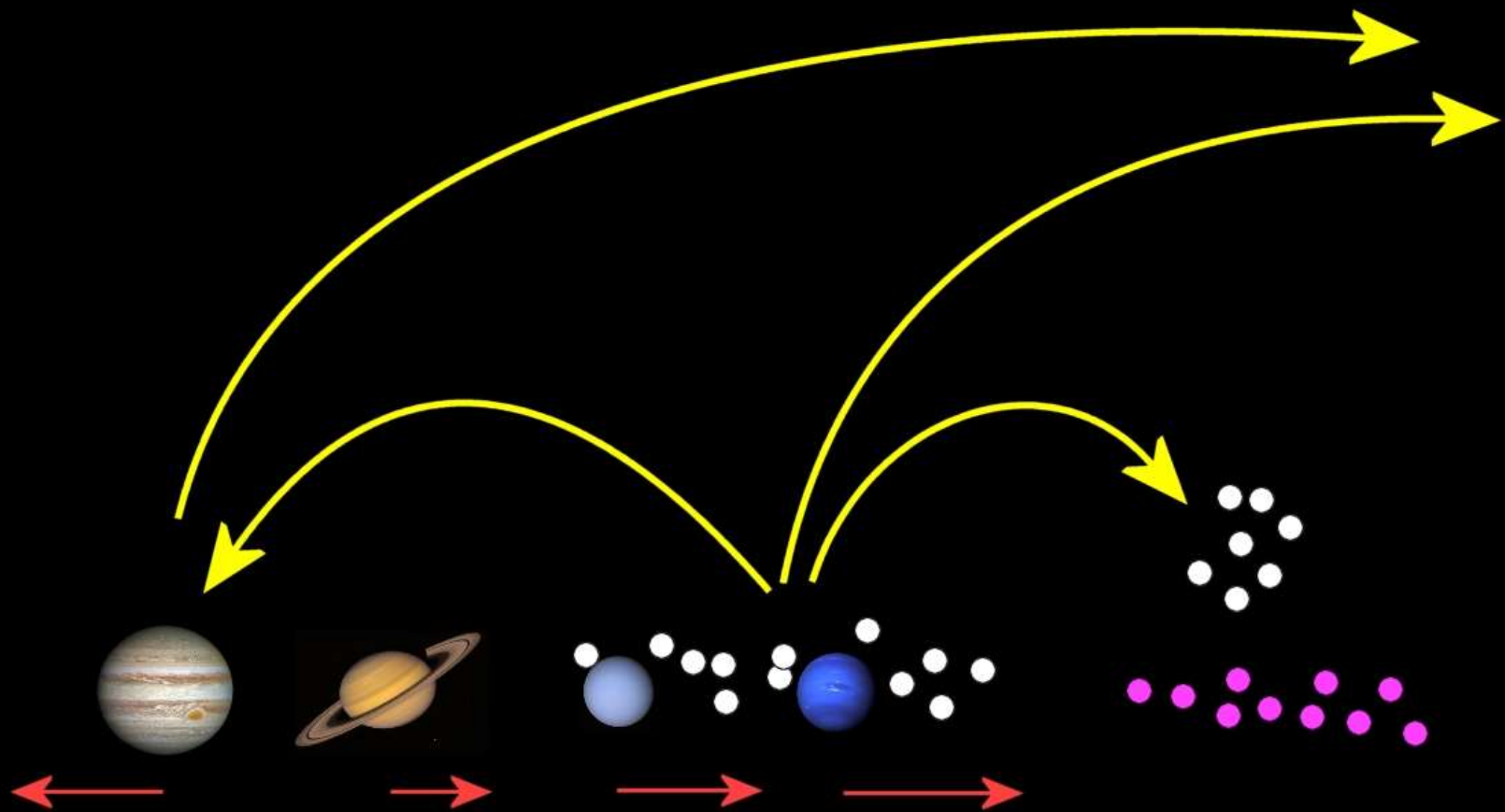




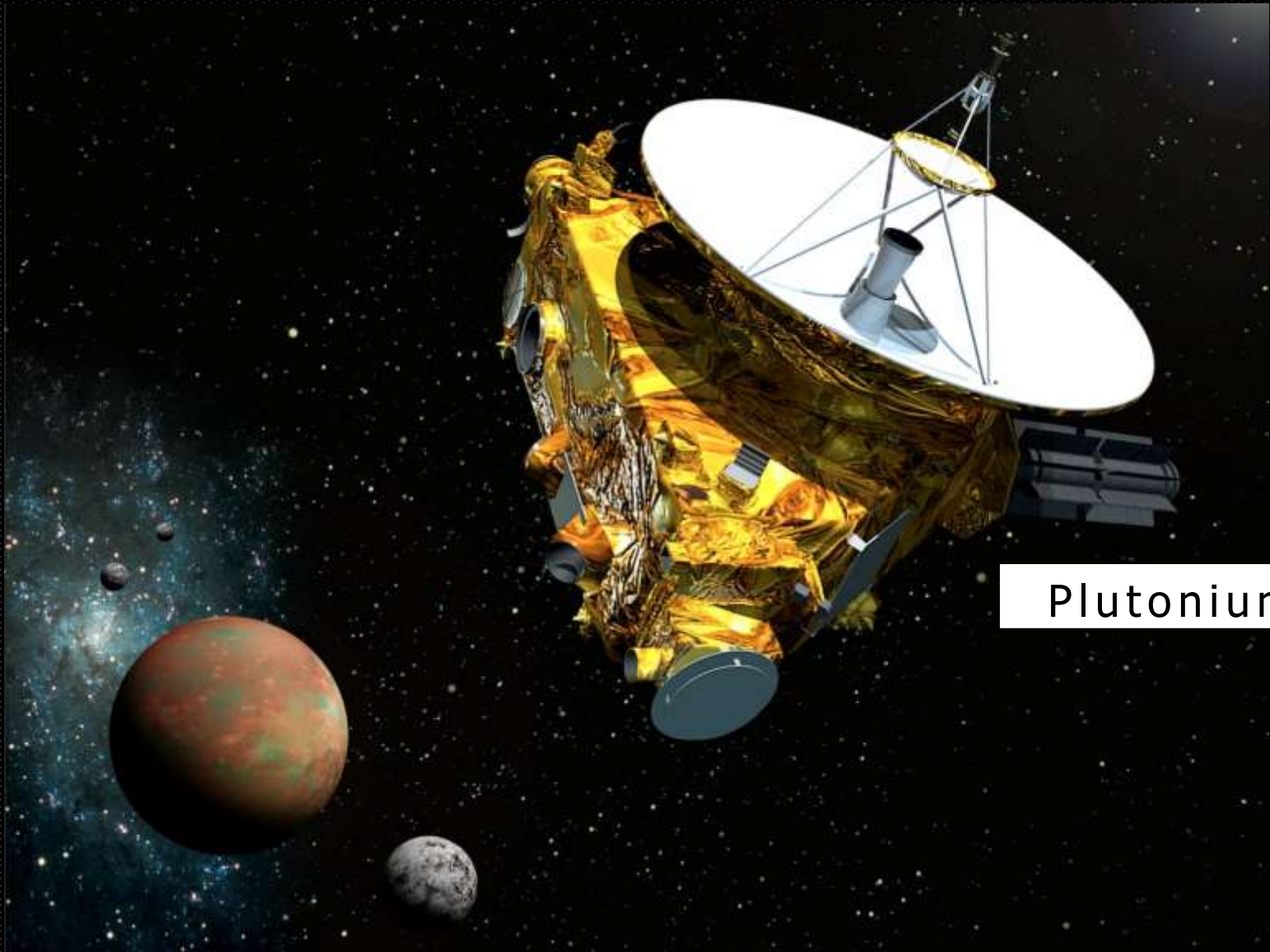
Leinhardt a kol., 2008:
Impakty, při nichž se impaktor nerozpadl.



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



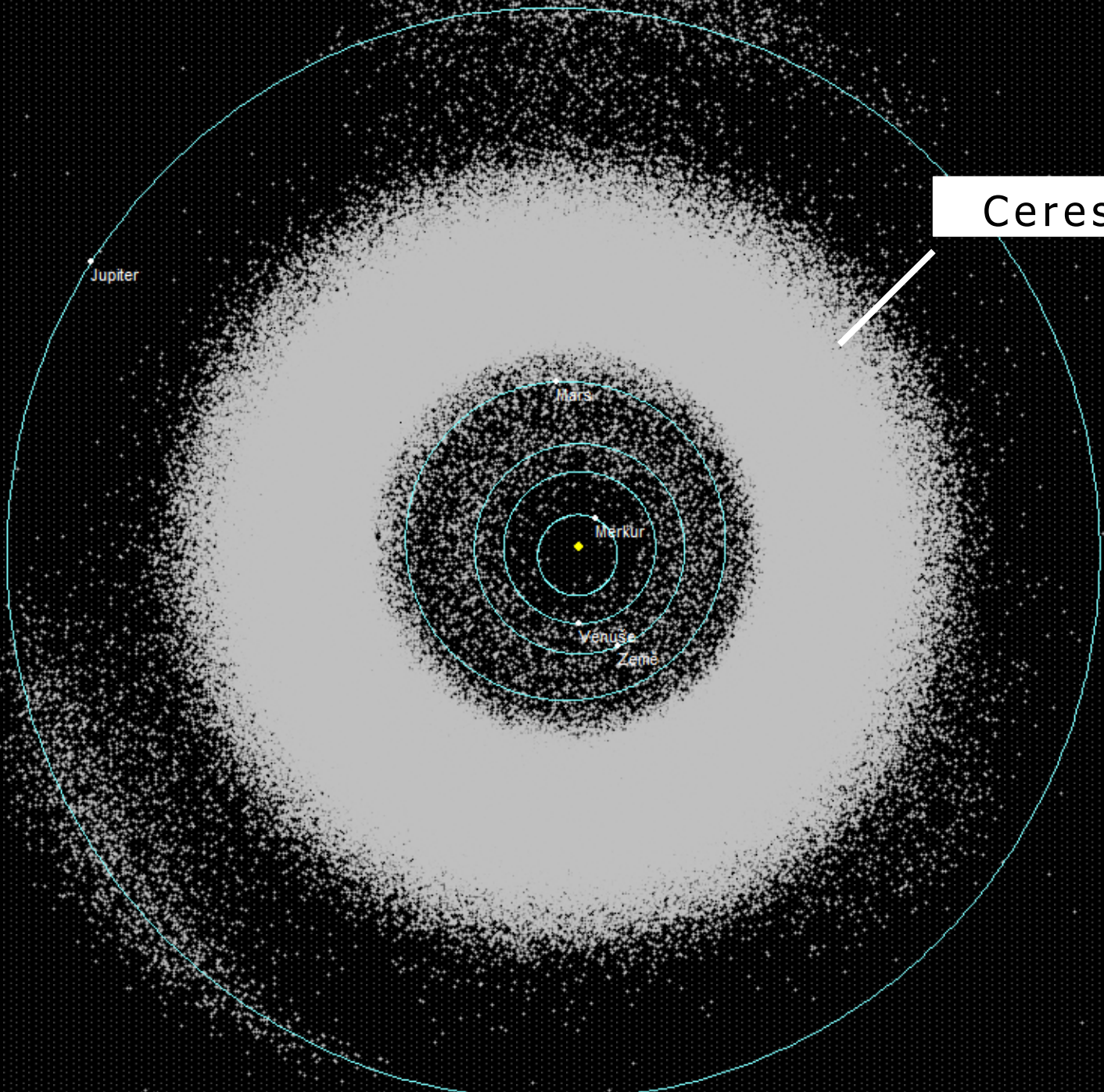
Zástupce „klasického Kuiperova pásu“.



Plutonium



Ceres



Jupiter

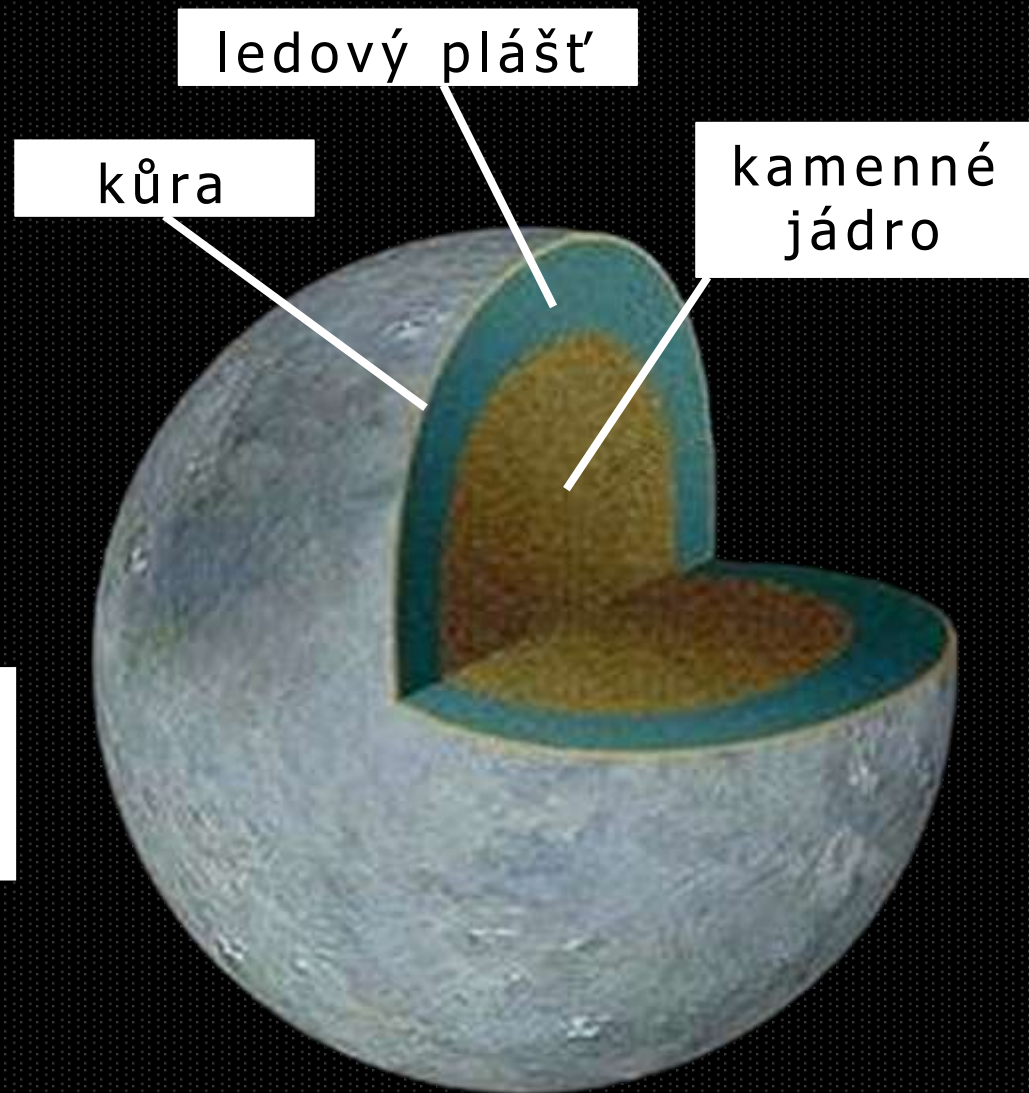
Mars

Merkur

Venus

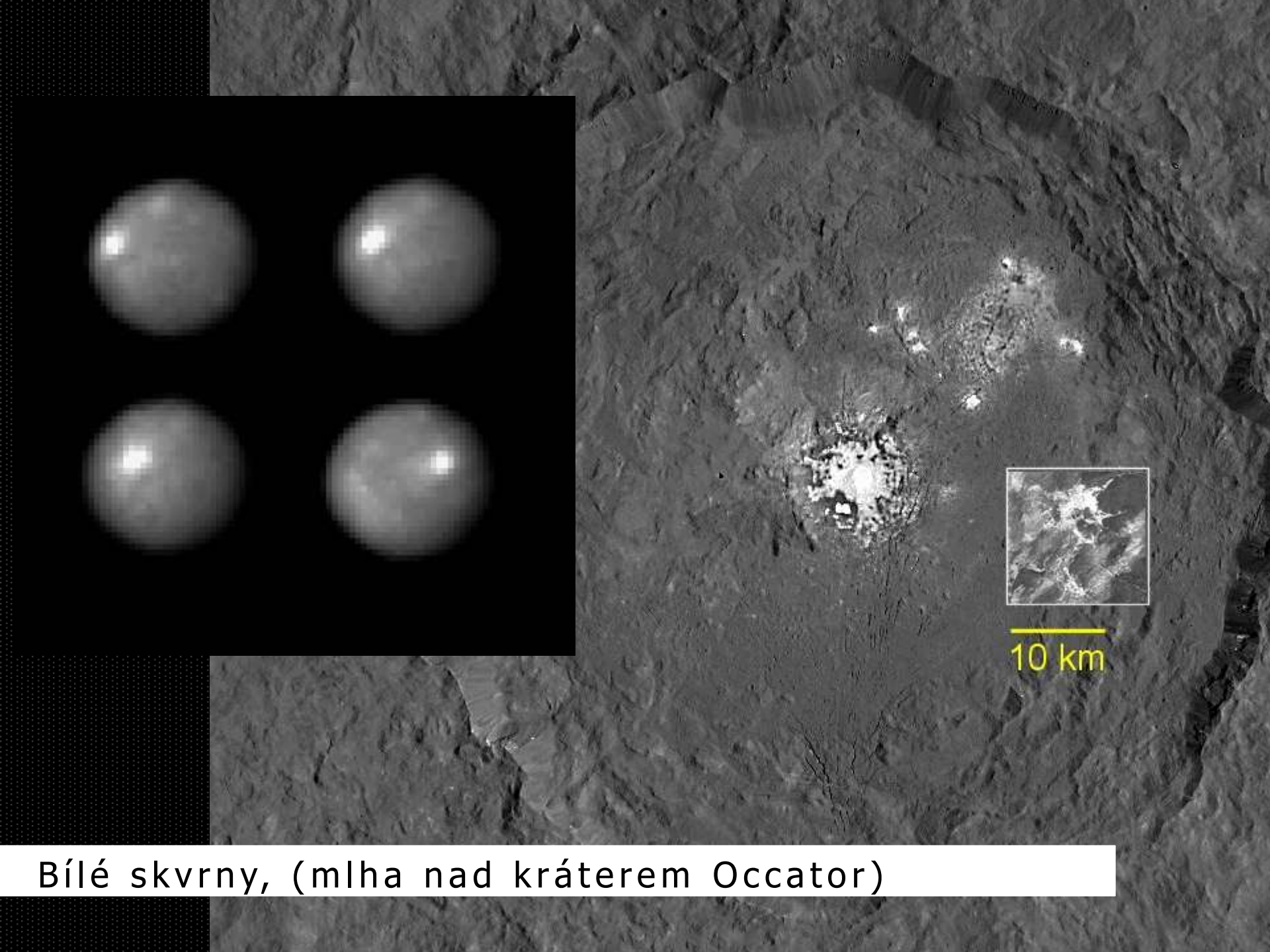
Erde

Ceres

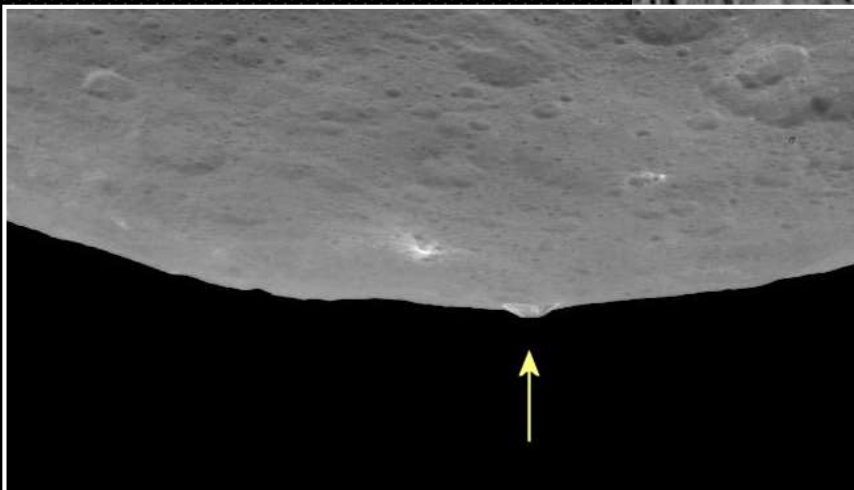
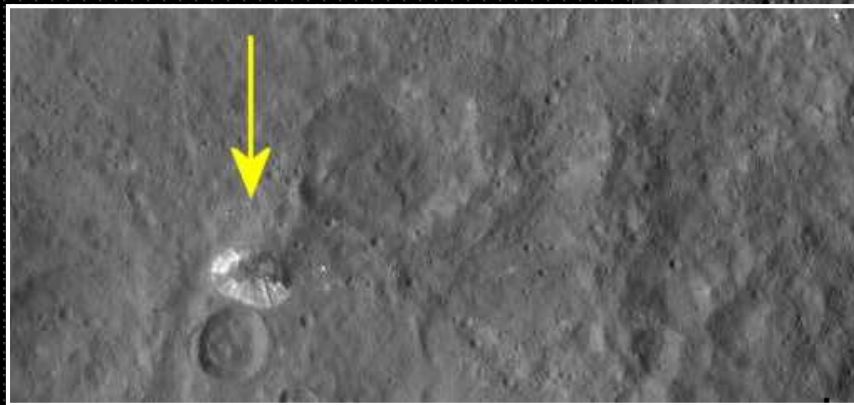
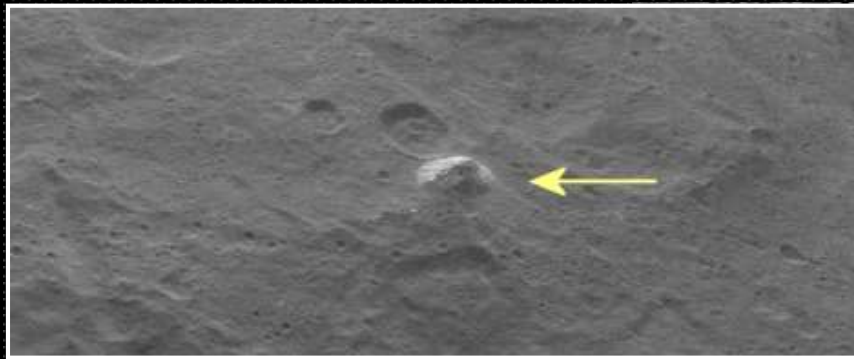


- Diferencované těleso
- Aktivita (vodní páry)

Ceres



Bílé skvrny, (mlha nad kráterem Occator)

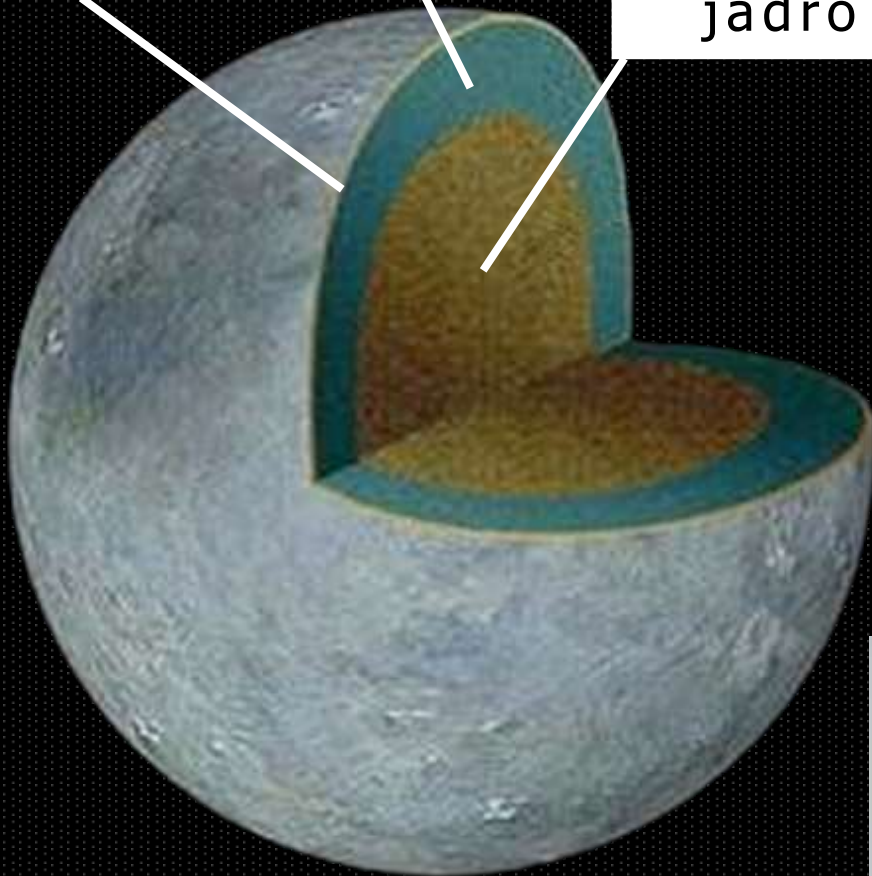


Diapír?

ledový plášť

kůra

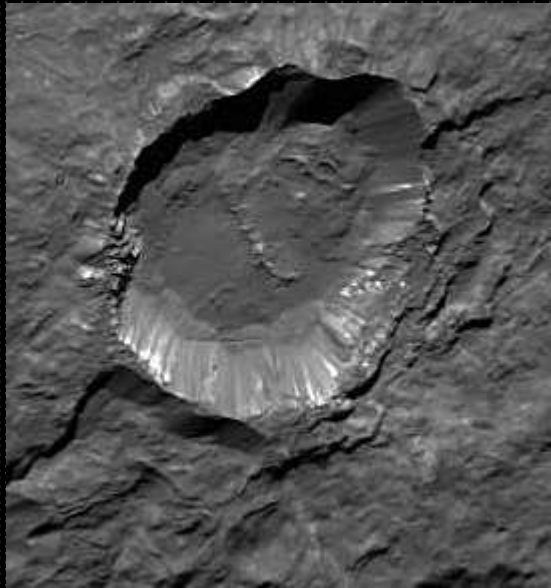
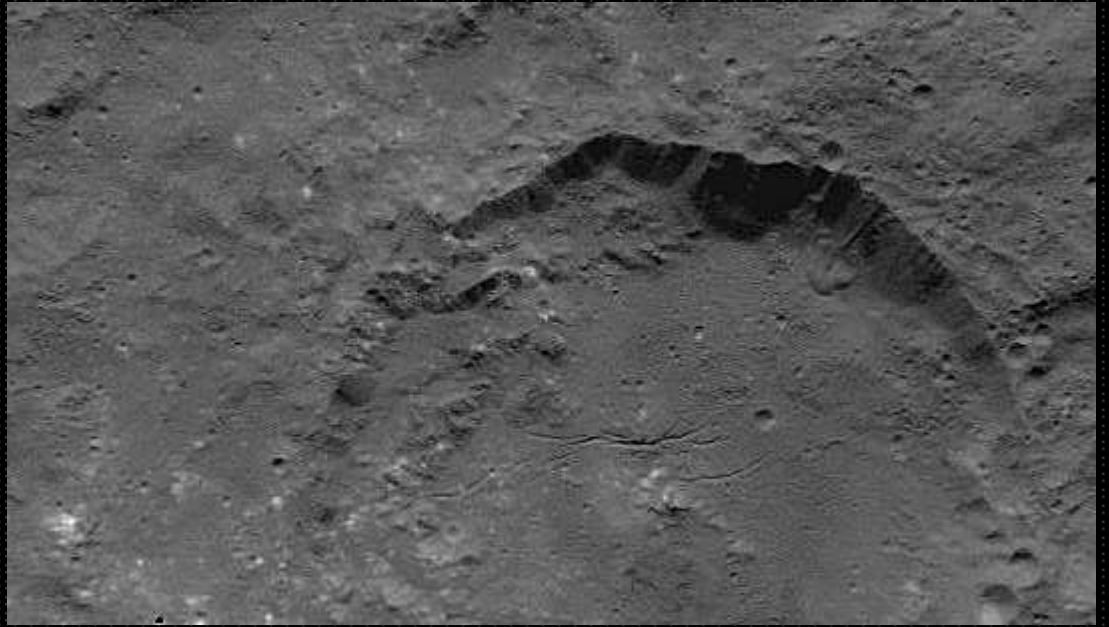
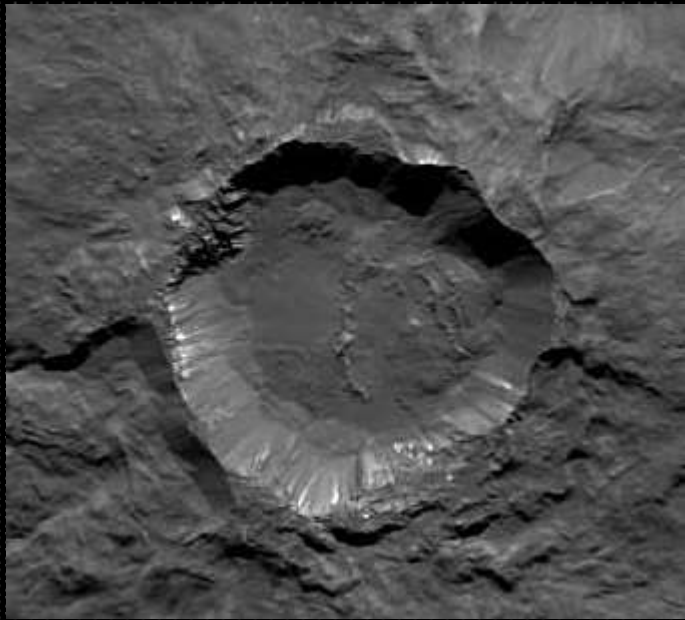
kamenné
jádro

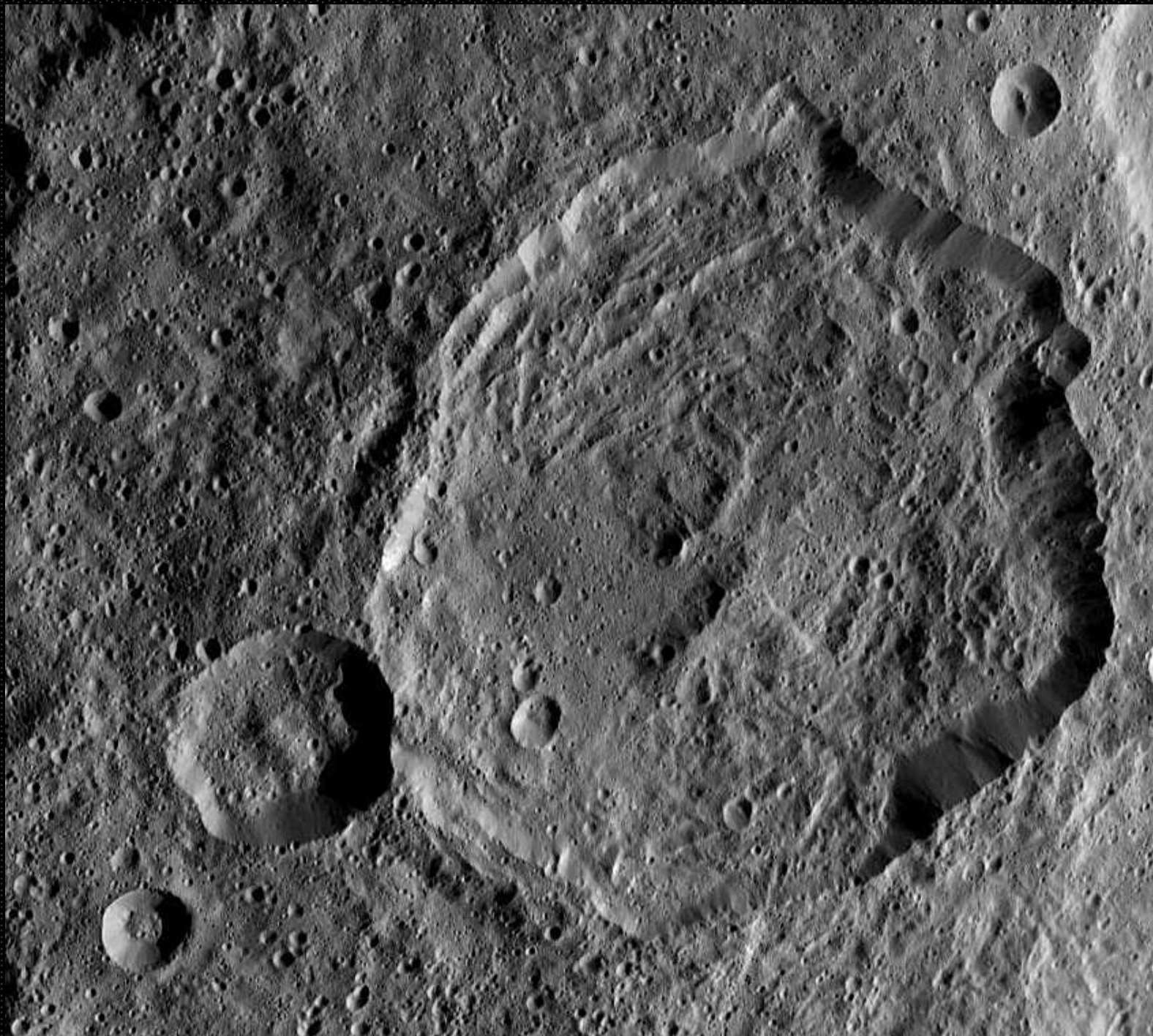


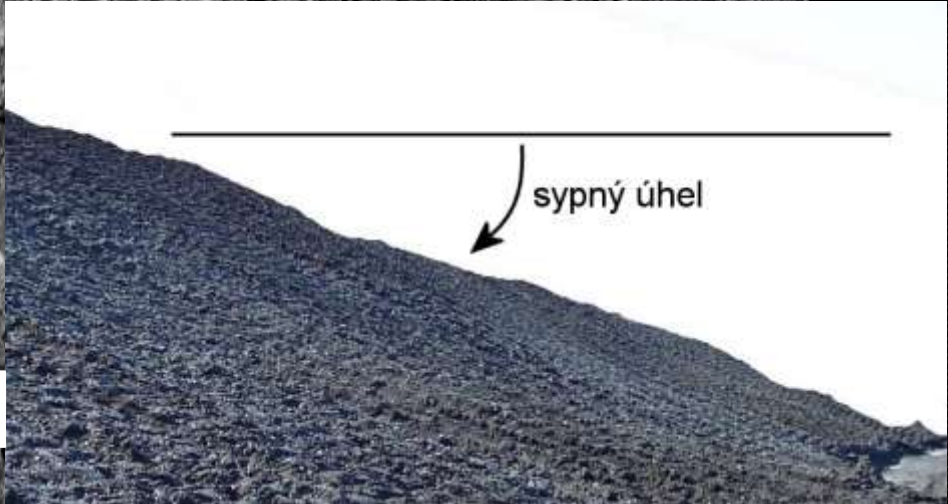
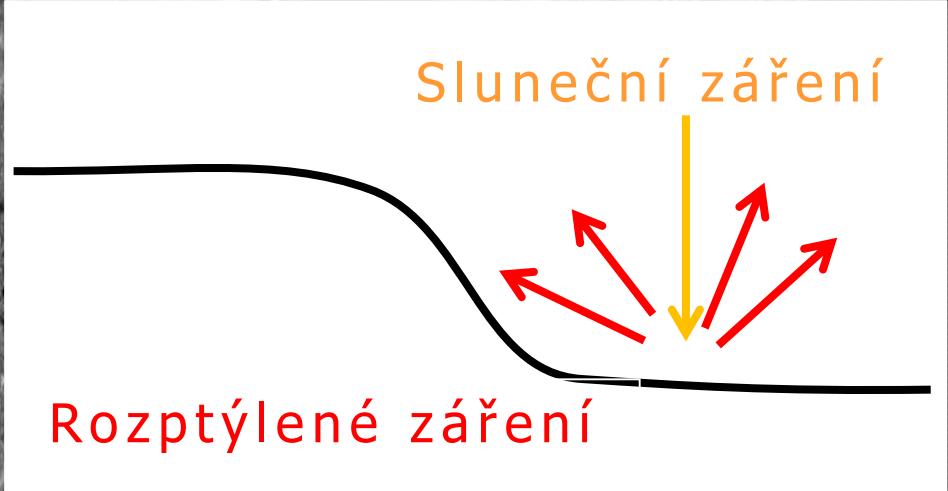
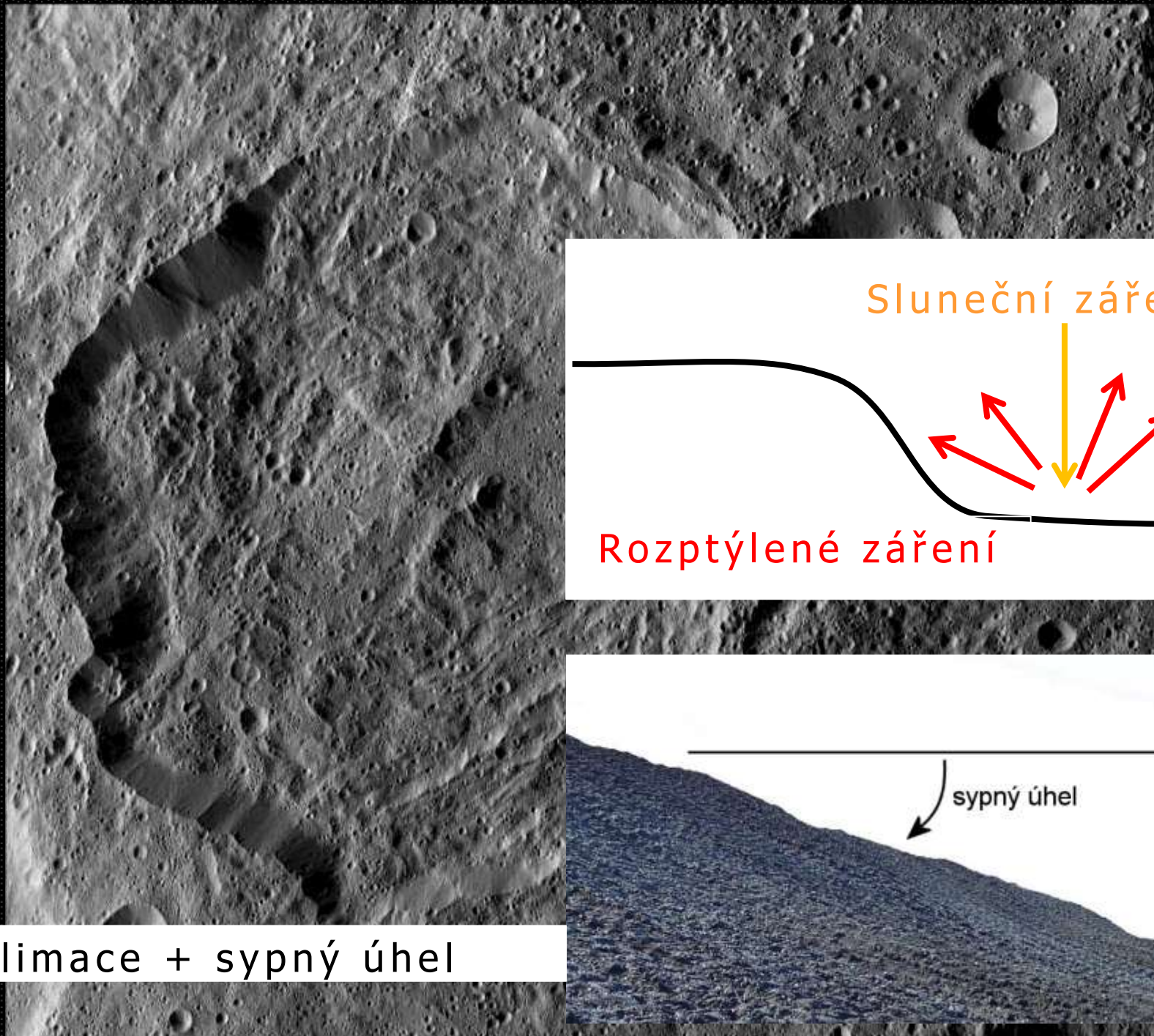
Rayleigh-Taylorova nestabilita



„Oblé zálivy a ostré mysy“



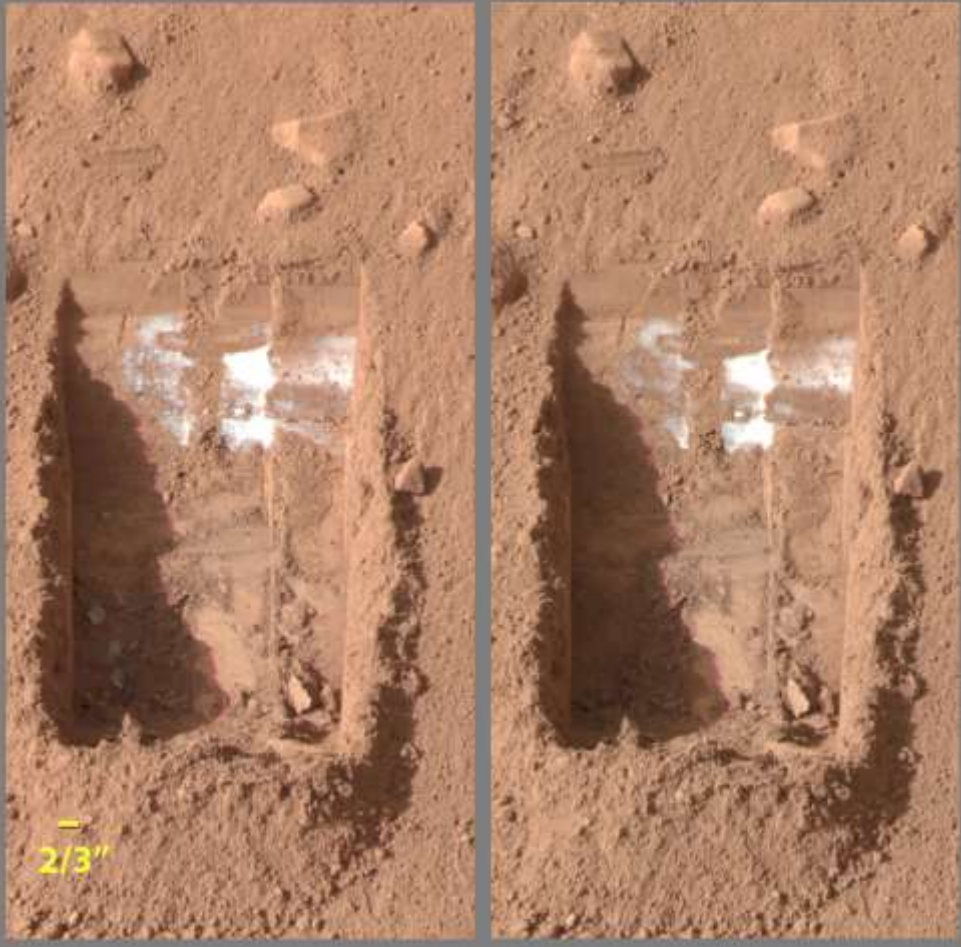




Sublimace + sypný úhel

Sol 20

Sol 24

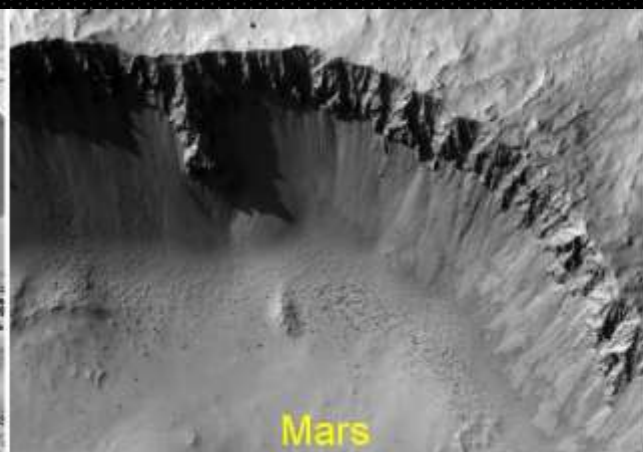


Mars Polar Lander

Jen několik cm regolitu stačí k izolaci ledového podloží.



Země



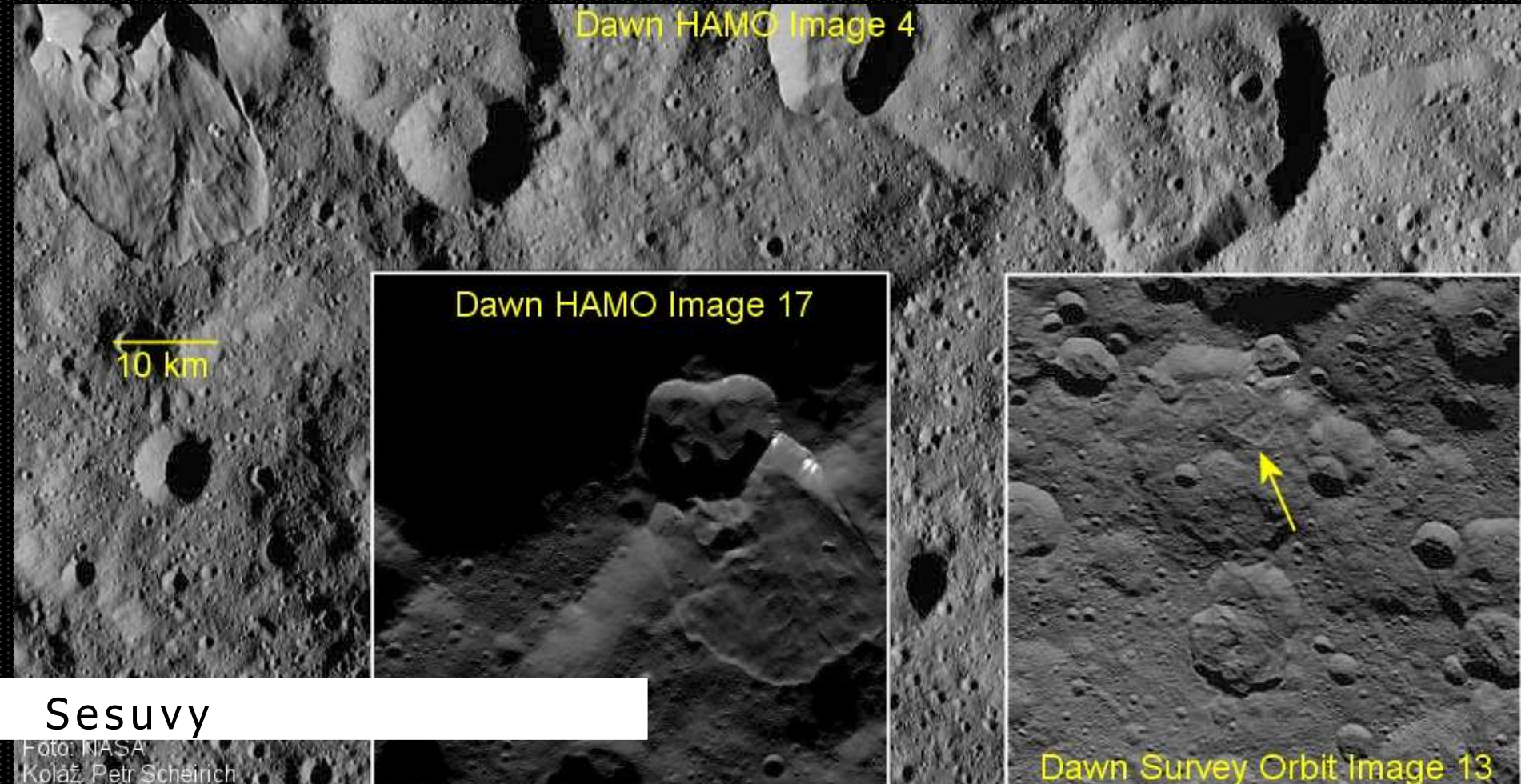
Mars



Ceres

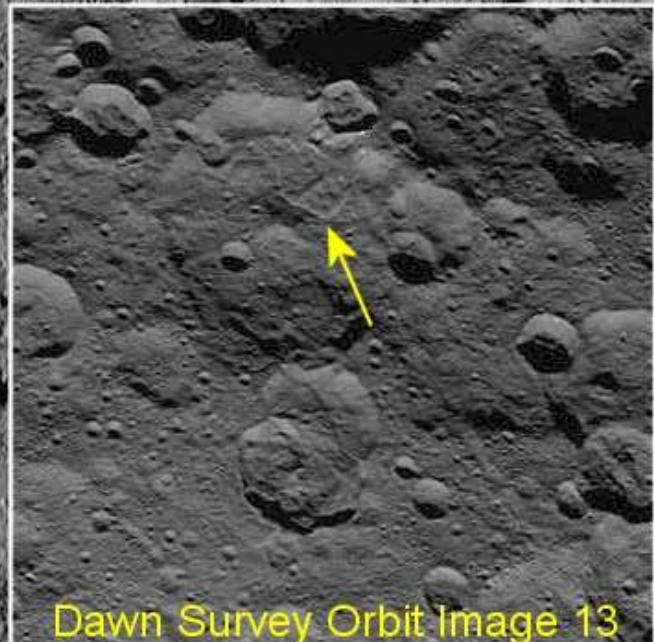


Dawn HAMO Image 4



Dawn HAMO Image 17

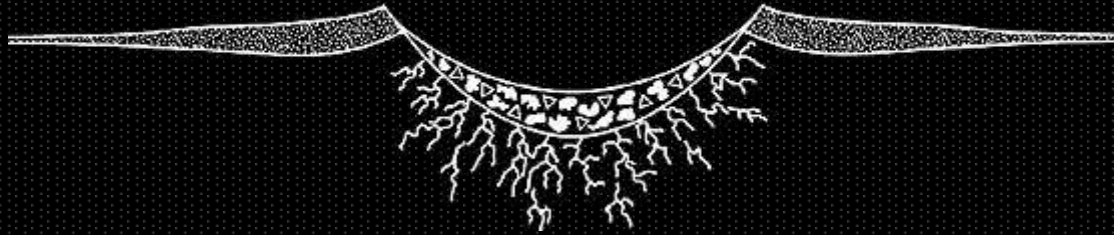
10 km



Dawn Survey Orbit Image 13

Sesuvy

Foto: NASA
Koláž: Petr Scheirich

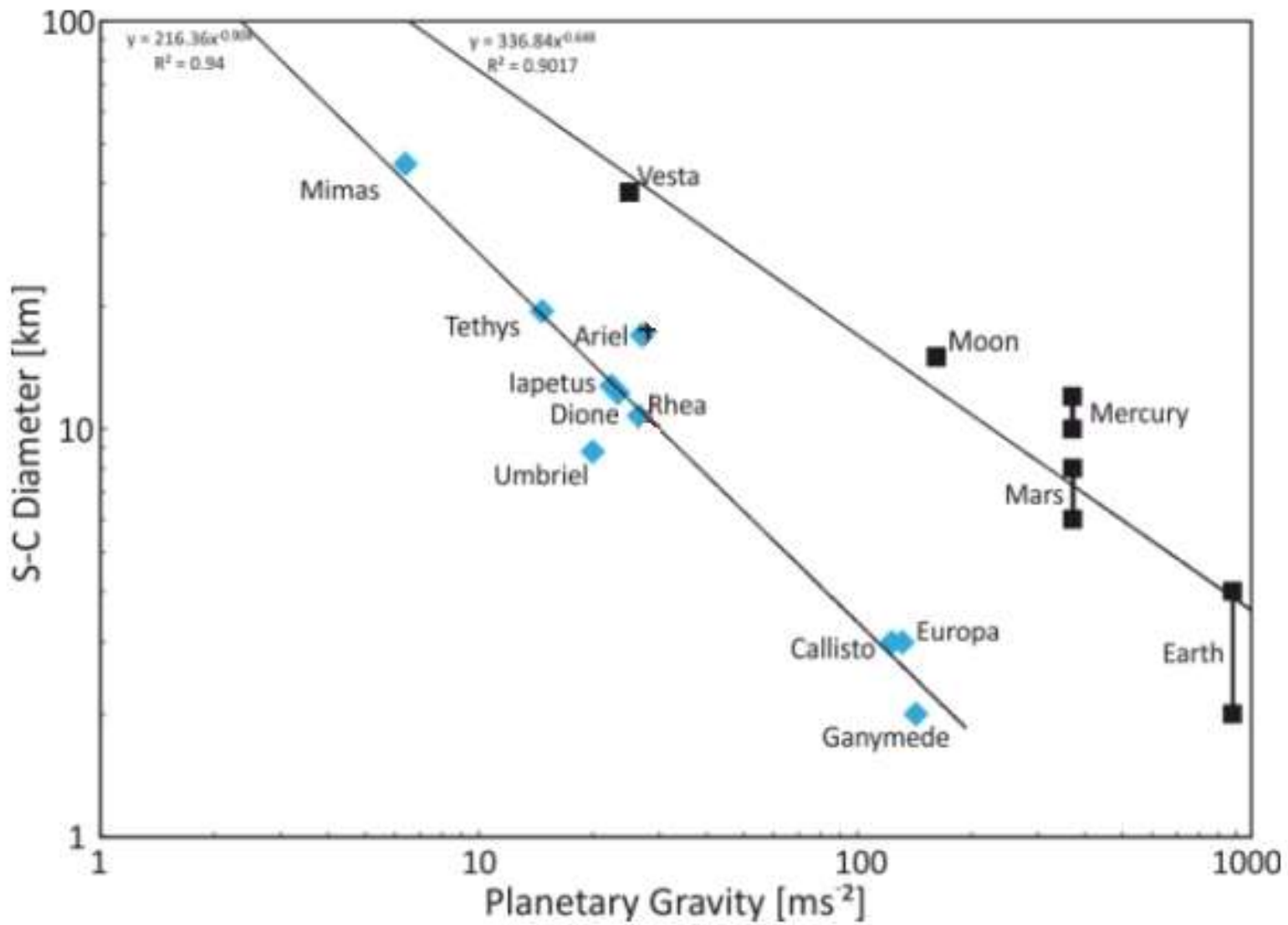


jednoduchý kráter

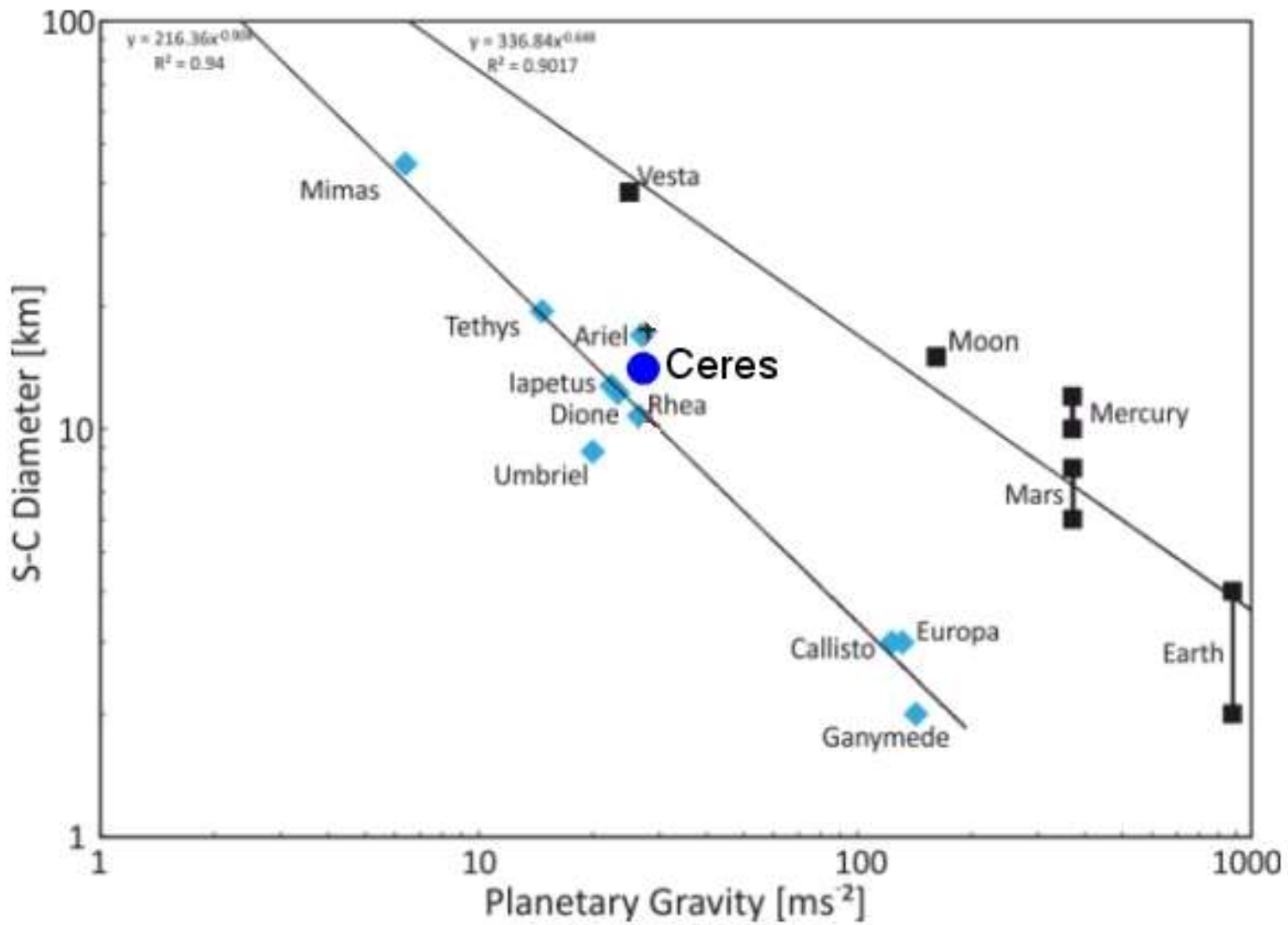


komplexní kráter

Jednoduché/komplexní krátery



Jednoduché/komplexní krátery



Jednoduché/komplexní krátery

