



Skylight Astronomical Society

Probes to the Outer Solar System Past, Present and Future

Spotlight on: New Horizons

Terry P. Riopka, President of Skylight Astronomical Society - 2024

Probes to the Outer Solar System Past and Present

Launch
Date

1972 Pioneer 10

1973 Pioneer 11

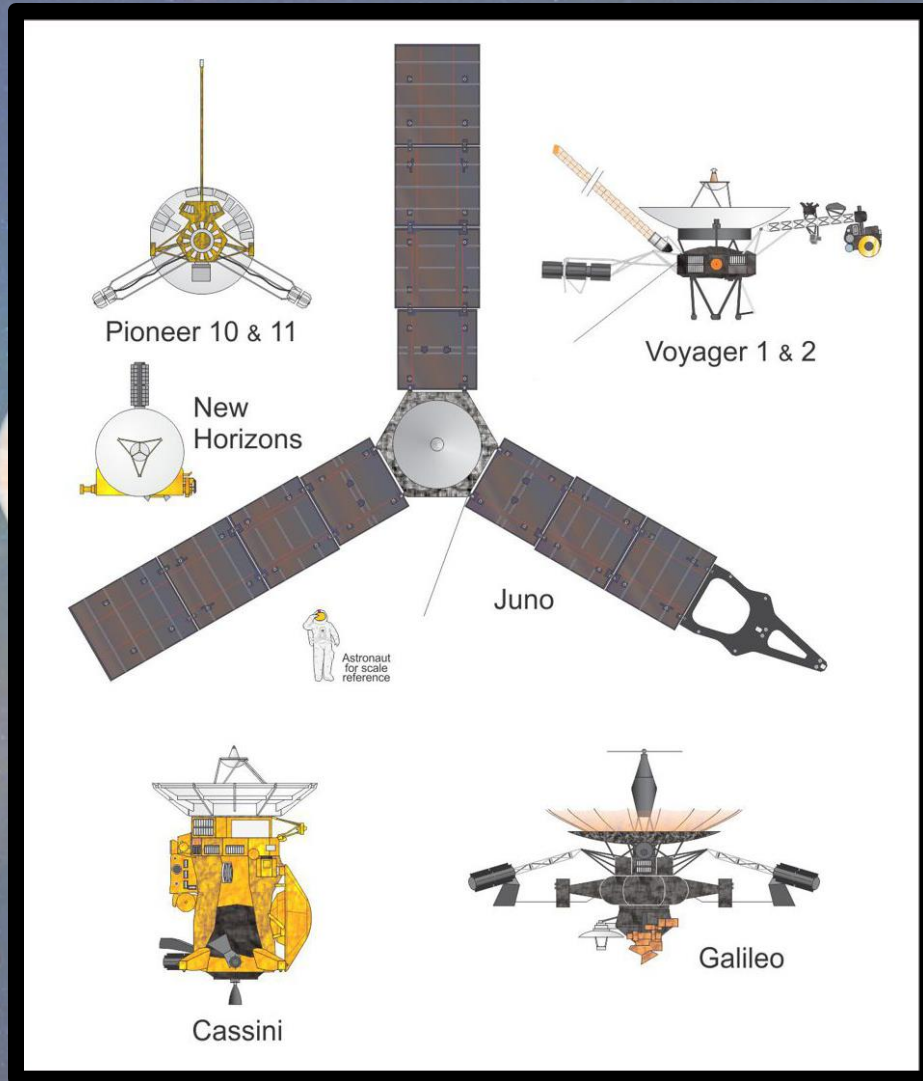
1977 Voyager 2
Voyager 1

1989 Galileo

1997 Cassini-Huygens

2006 New Horizons

2011 Juno



Probes to the Outer Solar System

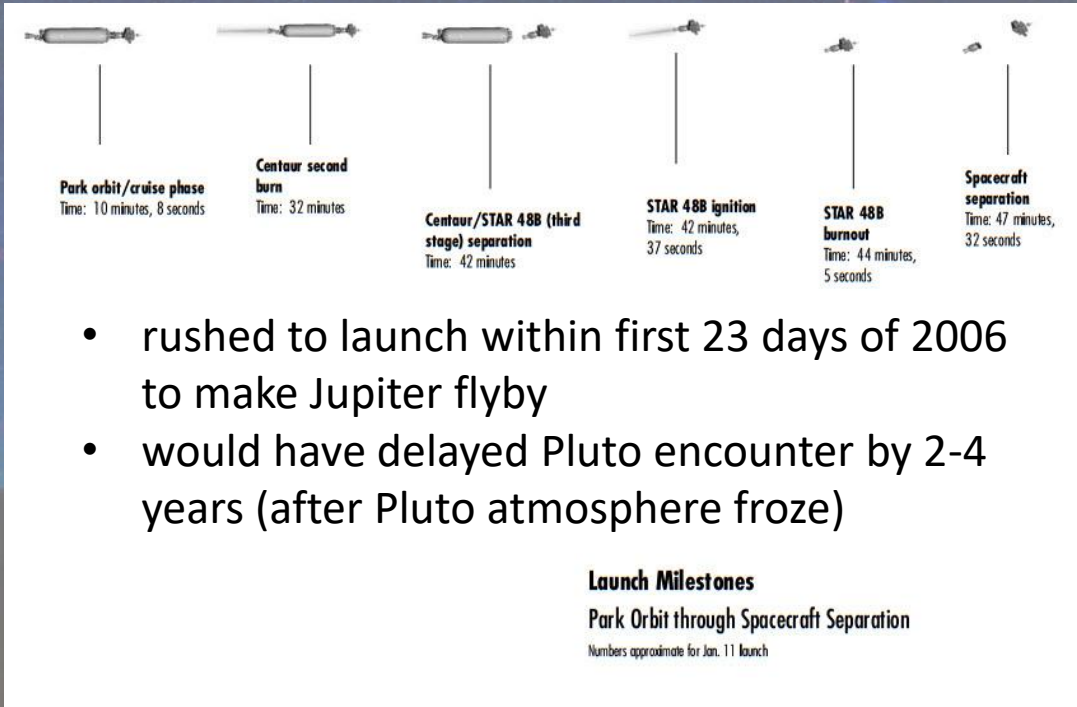
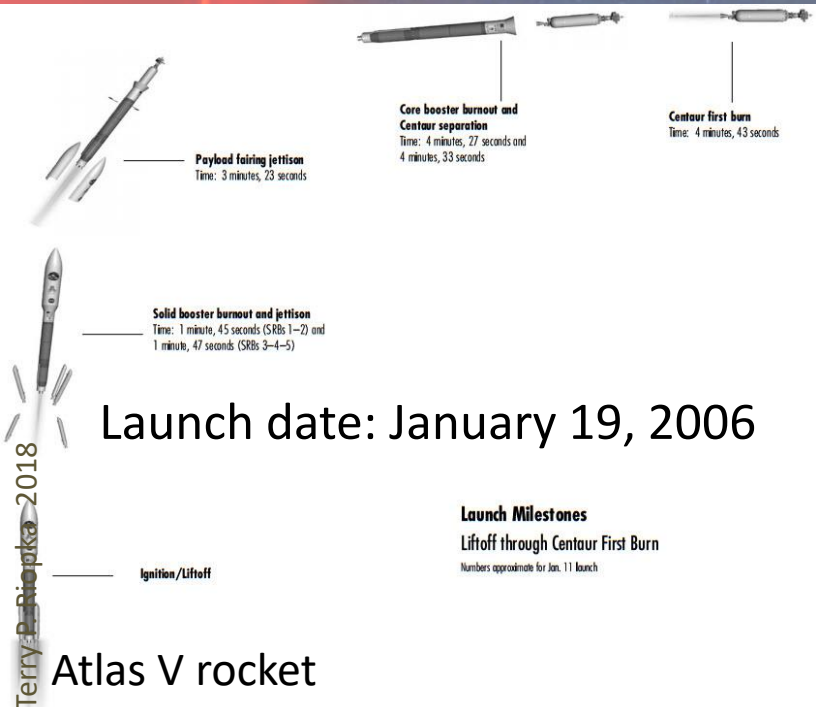
New Horizons

Spacecraft	Instruction Memory	Imaging System	Data Rate	Data Storage
Pioneer	Up to 5 of 222 commands	2-color imaging photopolarimeter	16-256 bits/s	6144 bytes
Voyager	6 computers, total 32K RAM	800x800 slow-scan vidicon; 2 cameras each w/ 8 filters	160-115000 bits/s	64 Kb 8-track digital tape
Galileo	6 RCA1802 (comp to Apple II) 176K RAM	800x800 CCD with 8-position filter wheel	134000 bits/s (Actual: 160 bits/s with compression)	4-track 114MB digital tape
Cassini	2 MIL-STD-1750A	2 1024x1024 CCD cameras with 2x12 & 2x9 filters	166000 bits/s 2700 photos per month	2 1 Gbit solid state recorders
New Horizons	4 computers: MIPS R3000 CPU	1024x1024 12bit monochrome CCD, Alice, Ralph	1000-4000 bits/s	2 64 Gbit solid state recorders

New Horizon – Fun Facts

- powered using 1 RTG (21.5 lbs of plutonium)
- body mounted instrumentation to save on cost – entire spacecraft had to rotate to aim imaging instruments
- 12 watt signal emitted from New Horizons diminished to a millionth of a billionth of a watt by the time it reached the DSN on Earth
- 4.5 hours latency for data transmission
- required approximately 16 months to transmit the buffer load back to Earth
- total amount of data returned : 50 Gbits
- July 4, 2015, experienced a software anomaly and went into safe mode – resumed operations July 7 (7 days before closest approach!)
- Pluto was still a “planet” when New Horizons was launched

New Horizons Launch



Launch date: January 19, 2006

- rushed to launch within first 23 days of 2006 to make Jupiter flyby
- would have delayed Pluto encounter by 2-4 years (after Pluto atmosphere froze)



- fastest moving spacecraft to leave Earth to date (36 000 mph) - 9h vs. 3d for Apollo missions to cross Lunar orbit
- 9000 mph gravity assist from Jupiter

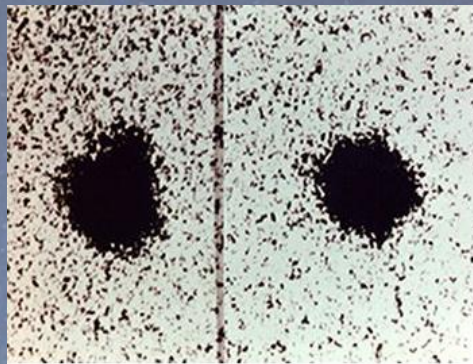


Terry DeBevoise 2018

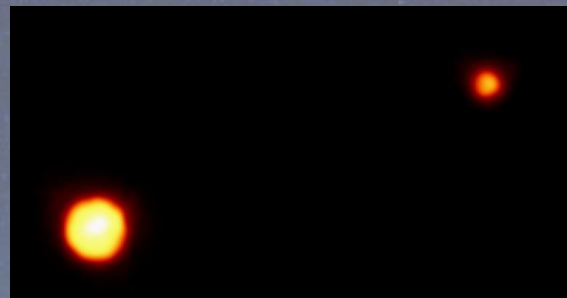
Pluto Before New Horizons



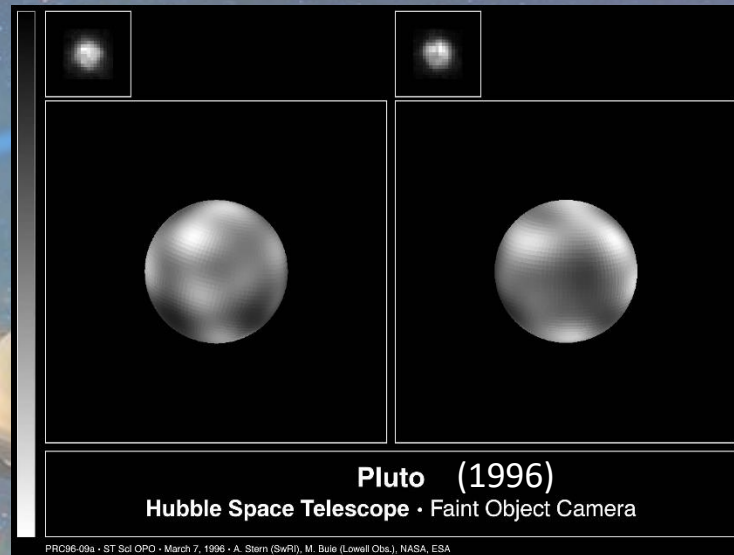
Clyde Tombaugh discovered Pluto (1930)



Charon discovered in 1978

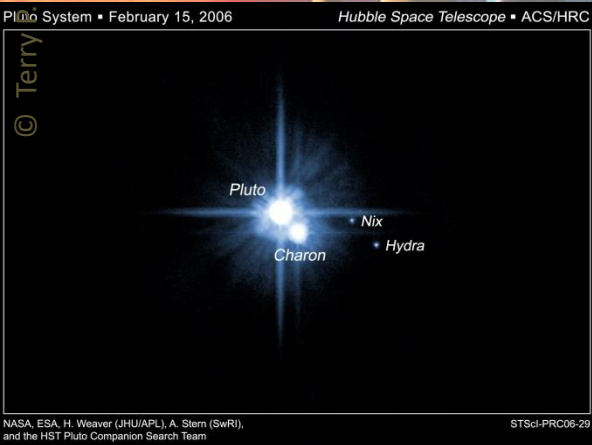


Pluto and Charon HST 1994

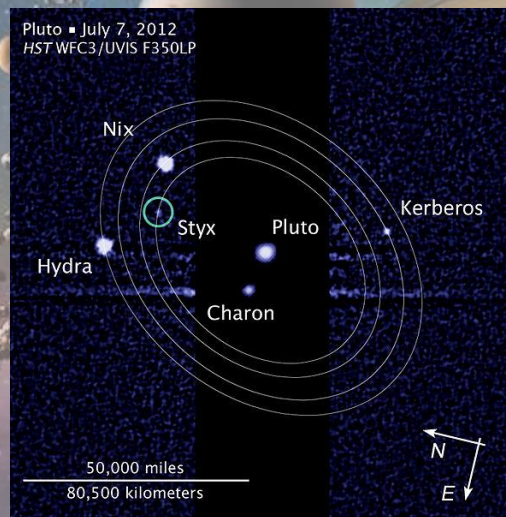


Pluto (1996)

Hubble Space Telescope • Faint Object Camera



Nix and Hydra ("N"ew "H"orizons) discovered by HST in 2005



Kerberos and Styx discovered by HST in 2011 and 2012 respectively



best Hubble pic 2010

New Horizons July 7, 2015

Riojka 2018

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NASA, ESA, H. Weaver (JHU/APL), A. Stern (SwRI), and the HST Pluto Companion Search Team

STScI-PRC06-29

PRC96-09a • ST ScI OPO • March 7, 1996 • A. Stern (SwRI), M. Bule (Lowell Obs.), NASA, ESA

New Horizons Approach to Pluto



NEW HORIZONS LORRI IMAGES OF PLUTO

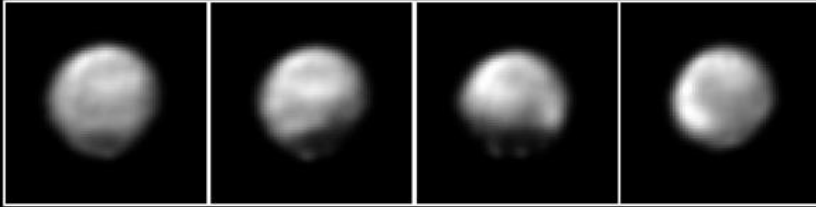
ROTATIONAL AXIS

JUNE 2, 2015

JUNE 1, 2015

MAY 31, 2015

MAY 29, 2015



PLUTO CENTRAL
LONGITUDE: 17°

PLUTO CENTRAL
LONGITUDE: 63°

PLUTO CENTRAL
LONGITUDE: 130°

PLUTO CENTRAL
LONGITUDE: 243°

DISTANCE: 50,500,000 KM
(31,000,000 MILES)

DISTANCE: 51,000,000 KM
(31,500,000 MILES)

DISTANCE: 54,000,000 KM
(33,500,000 MILES)

DISTANCE: 55,000,000 KM
(34,000,000 MILES)

ARRIVAL IN: 42 DAYS

ARRIVAL IN: 43 DAYS

ARRIVAL IN: 44 DAYS

ARRIVAL IN: 46 DAYS

Pluto



2015-06-22 00:47:00
Range: 26.8 million km
Lon: 332°



2015-06-23 04:04
Range: 25.4 million km
Lon: 268°



2015-06-25 05:37
Range: 22.9 million km
Lon: 152°



2015-06-27 05:32
Range: 20.6 million km
Lon: 39°



2015-06-29 05:03
Range: 18.2 million km
Lon: 288°



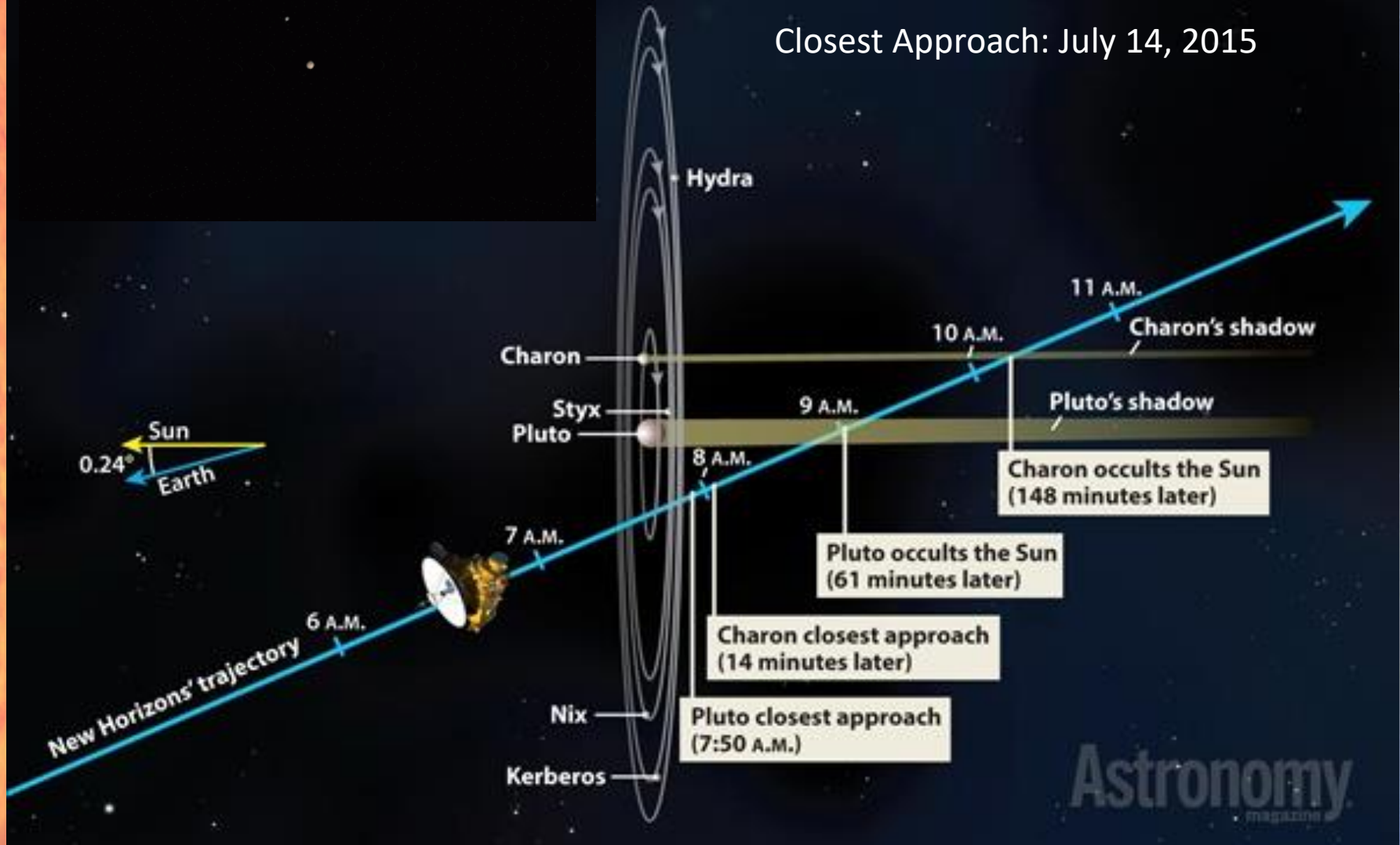
2015-07-01 04:17
Range: 15.9 million km
Lon: 177°



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New Horizons Arrives at Pluto

Closest Approach: July 14, 2015



Astronomy
magazine

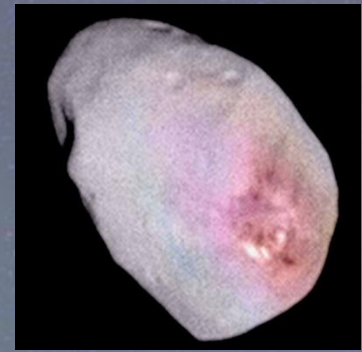
The Plutonian System

Charon (750 mi)

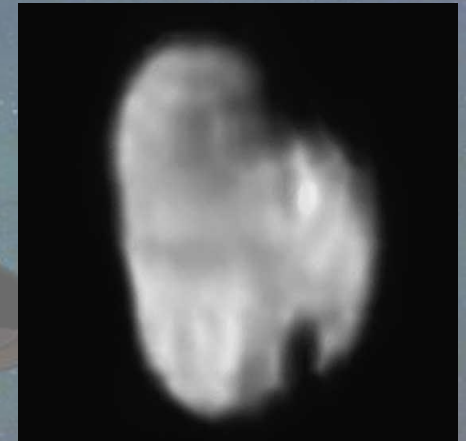


Pluto (1475 mi)

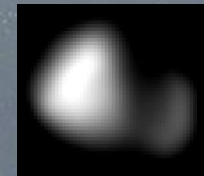
- orbits very close to circular, with Styx, Nix, Kerberos and Hydra fairly close to 3:1, 4:1, 5:1 and 6:1 mean-motion orbital resonances with that of Charon.



Nix (31 x 22 x 21 mi)



Hydra (48 x 28 x 16 mi)

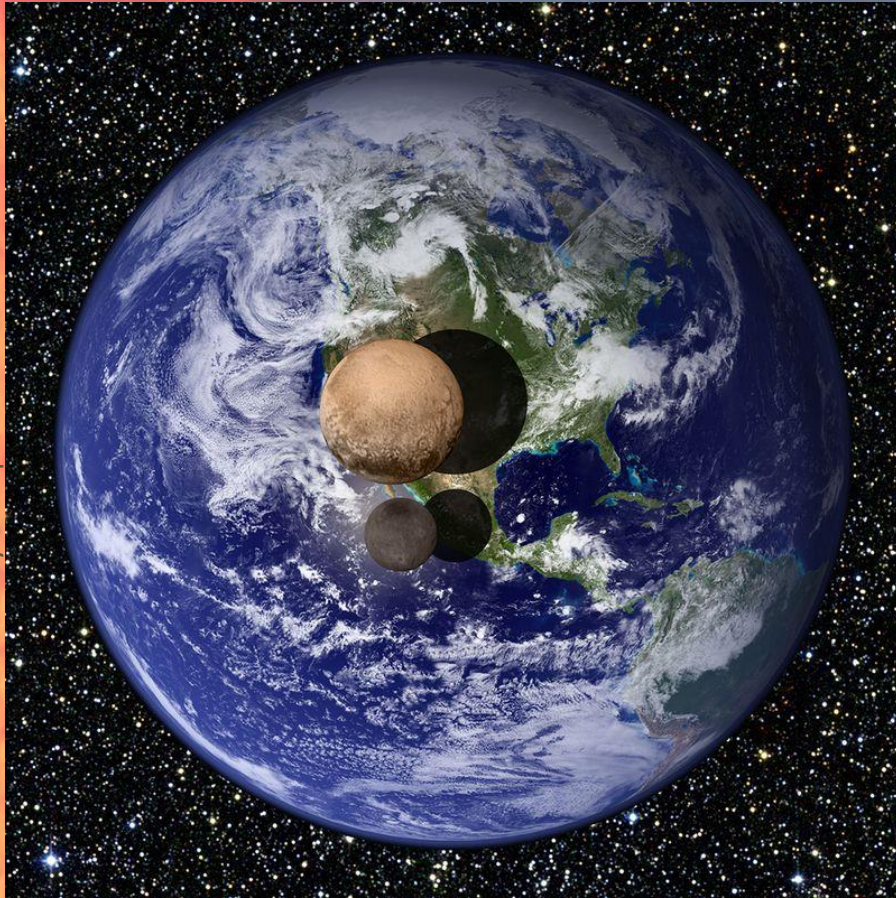


Kerberos
(12 x 7 x 6 mi)



Styx
(10 x 6 x 5 mi)

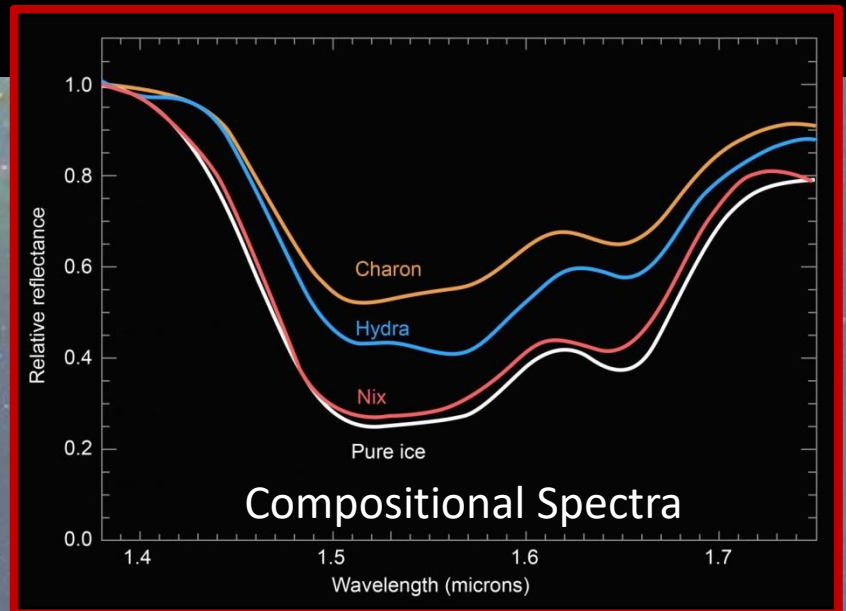
The Plutonian System



Pluto and Charon in Comparison to Earth

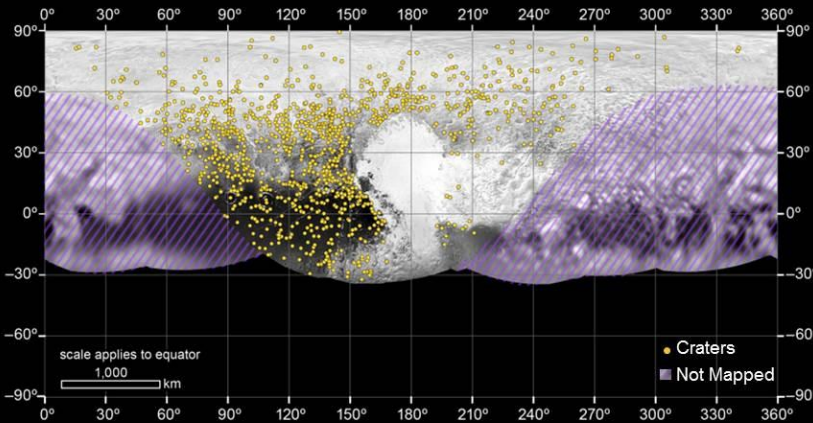
Merged Bodies?

At least two and possibly all four moons are the result of mergers between smaller bodies. Pluto may have had many more moons in the past.



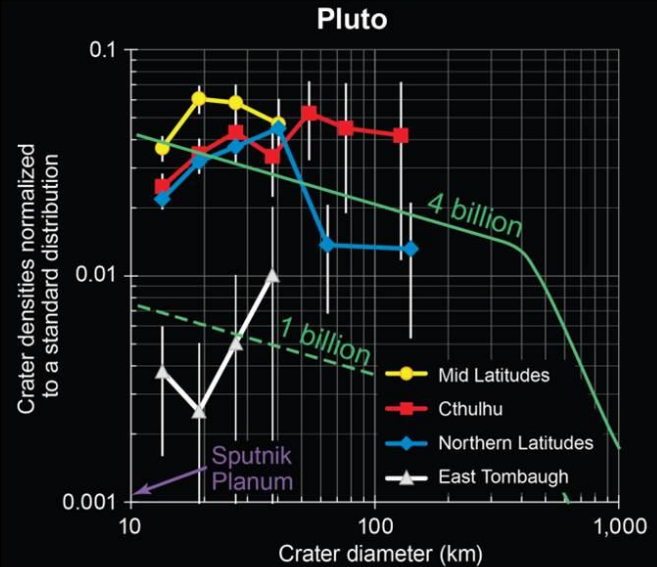
Pluto Geology

Pluto Crater Map



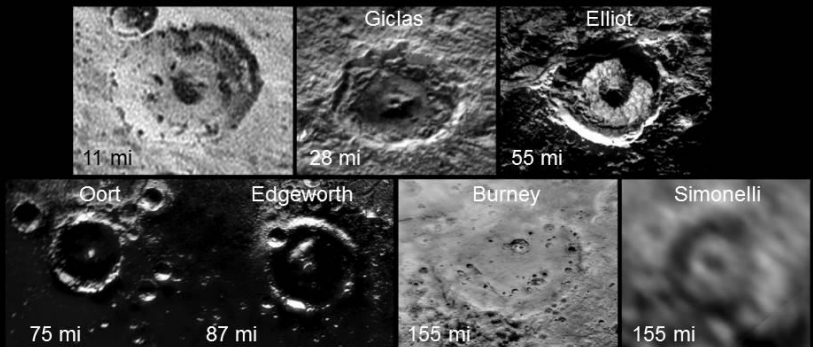
- 1,070 craters on encounter hemisphere mapped so far
- Mapped at a consistent resolution of ~ 900 m/px

Terrain Ages

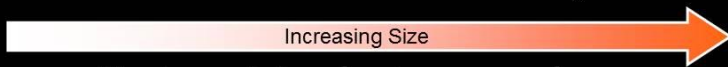


Indicates a range from ancient to extremely young surfaces

Pluto's Craters



approximate crater diameters

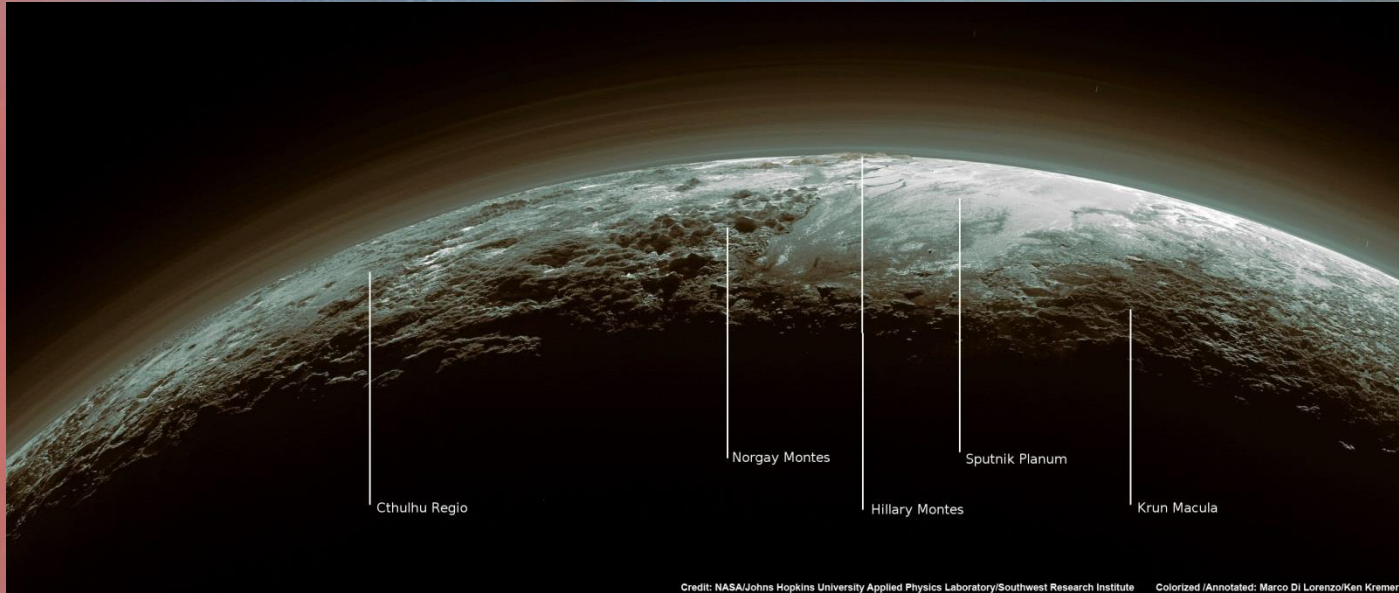
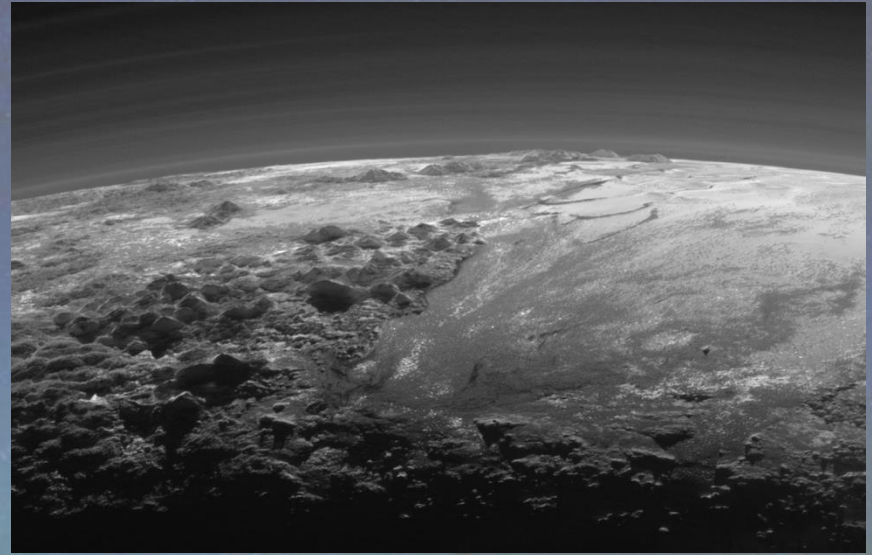
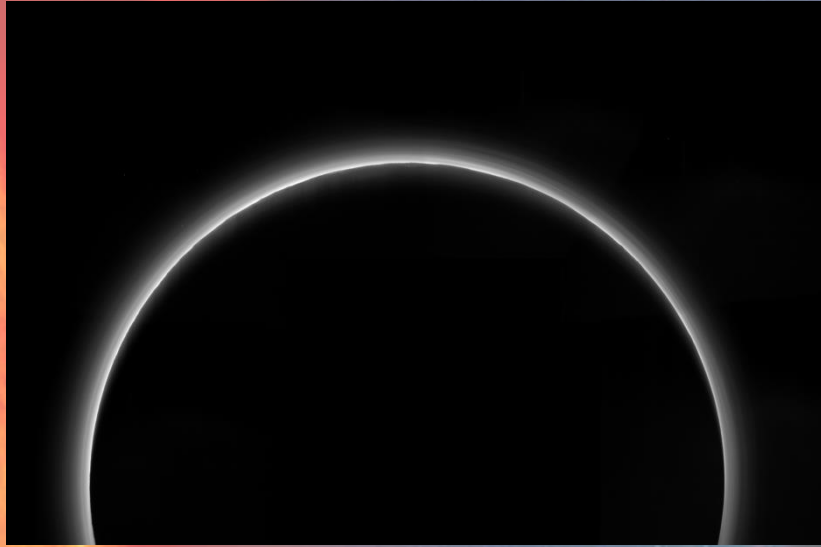


Number and size of craters = proxy for age

Note: All feature names are informal.

- size and density of craters used to estimate ages of terrain
- can be related to amount of geological activity

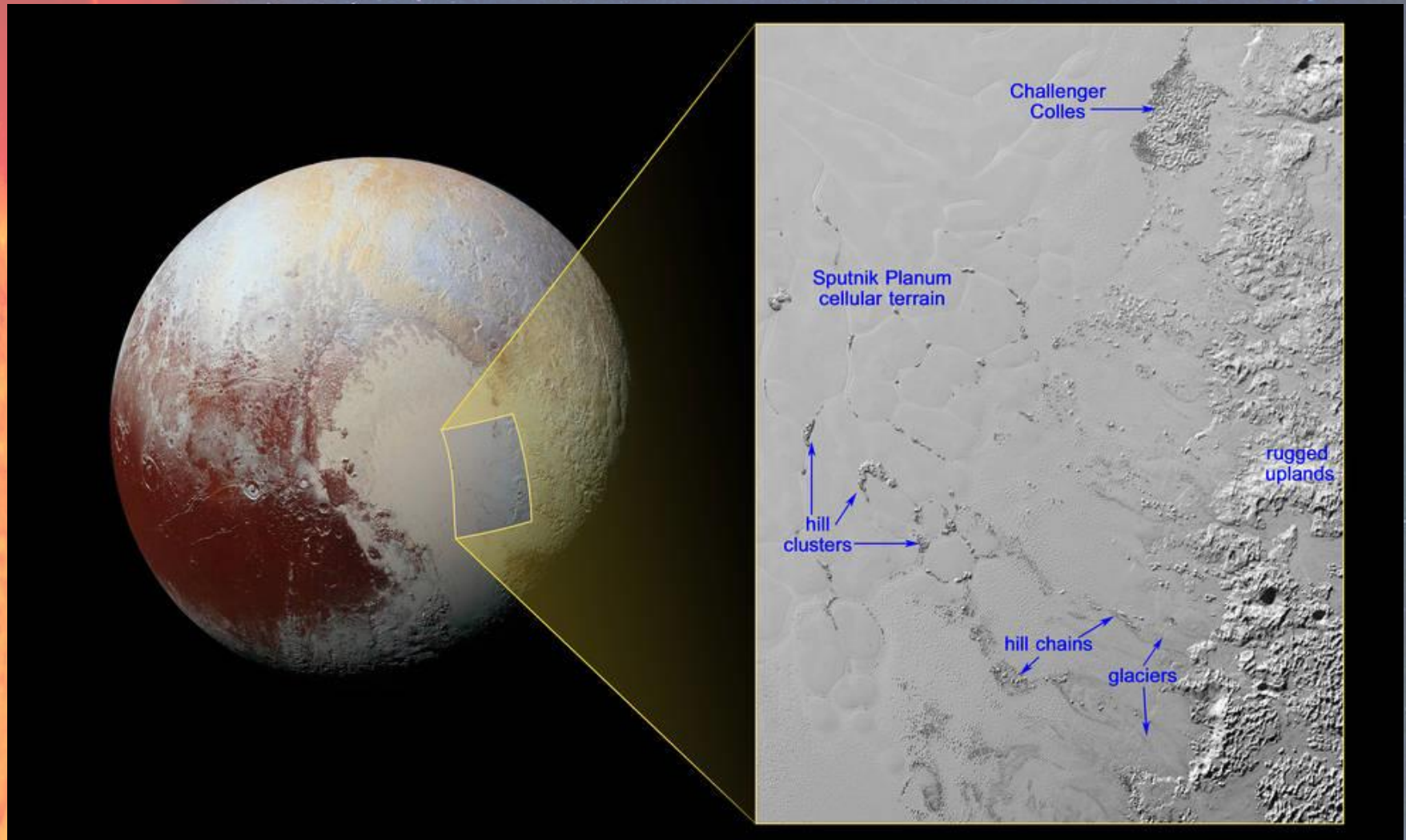
Plutonian Atmosphere



Credit: NASA/Johns Hopkins University Applied Physics Laboratory/Southwest Research Institute Colorized /Annotated: Marco Di Lorenzo/Ken Kremer

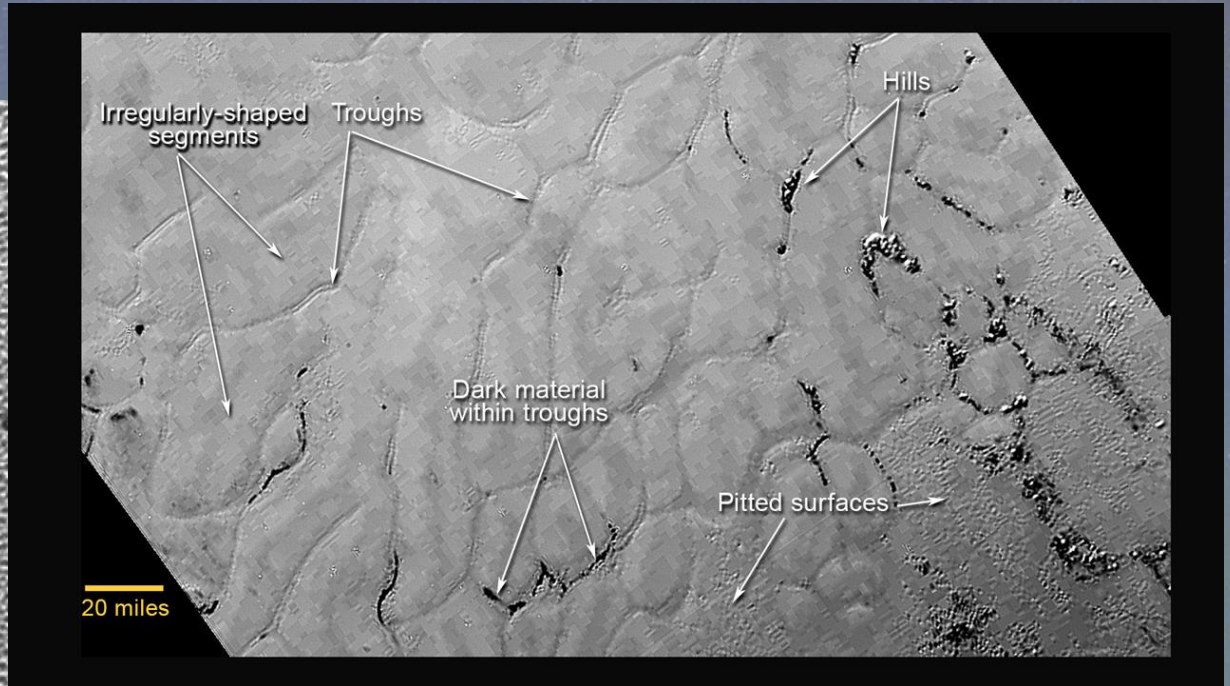
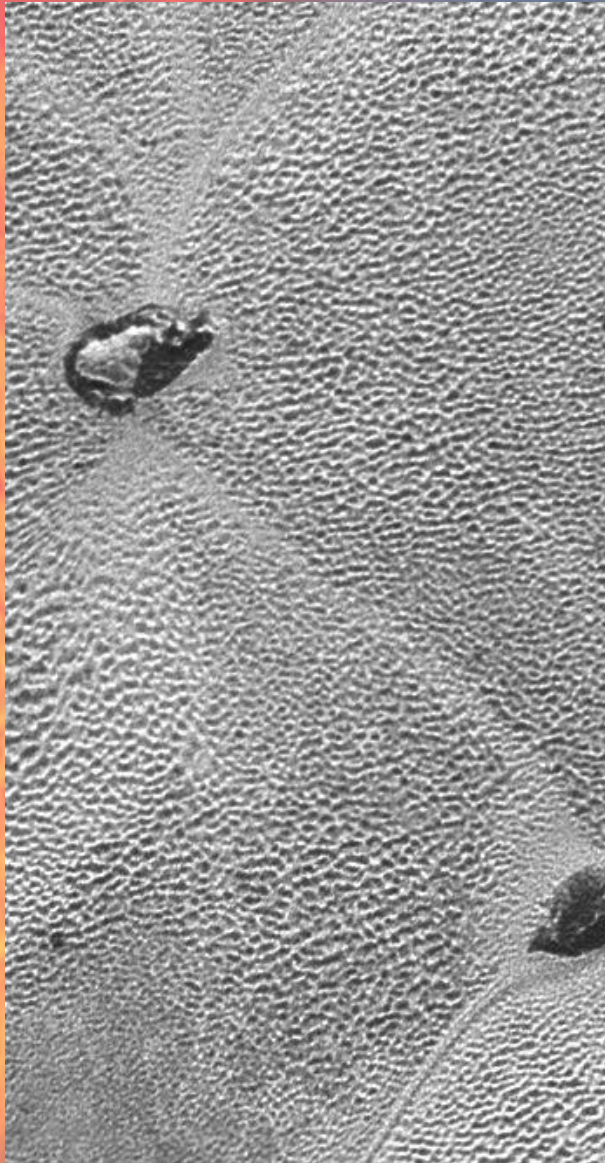
- primarily nitrogen, with 0.25% methane, and even less carbon monoxide
- pressure 100,000 times less than Earth
- 40-60K on surface, increases to 110K 20mi high, then decreases again

Icebergs on Pluto (?)

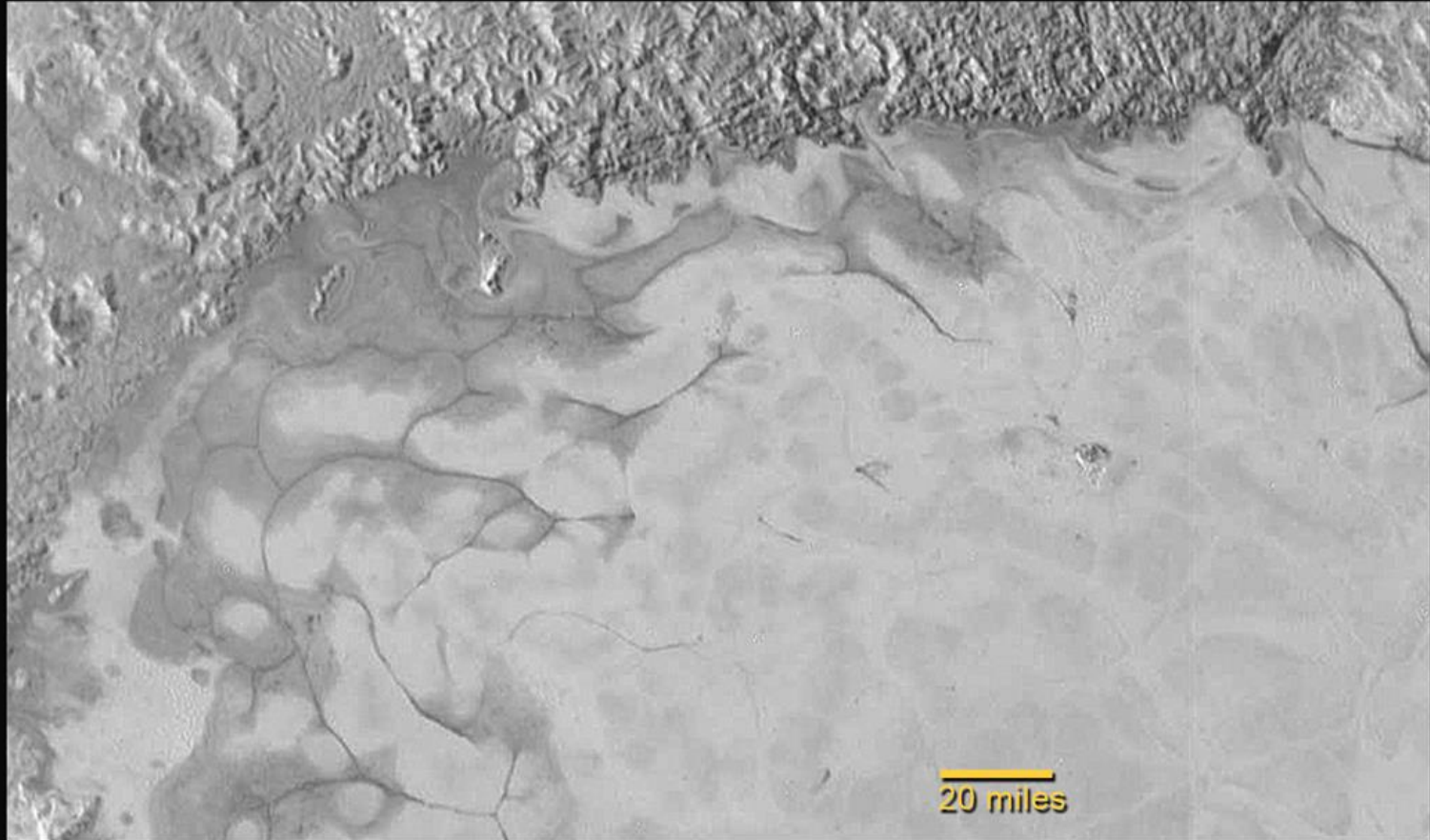


- because water ice is less dense than nitrogen-dominated ice, hill clusters are thought to be icebergs floating in a sea of frozen pliable nitrogen
- covered with icy, convective "cells" 10-30 miles across, and less than a million years old , "churning" at a rate of a few centimeters a year

Icebergs on Pluto (?)



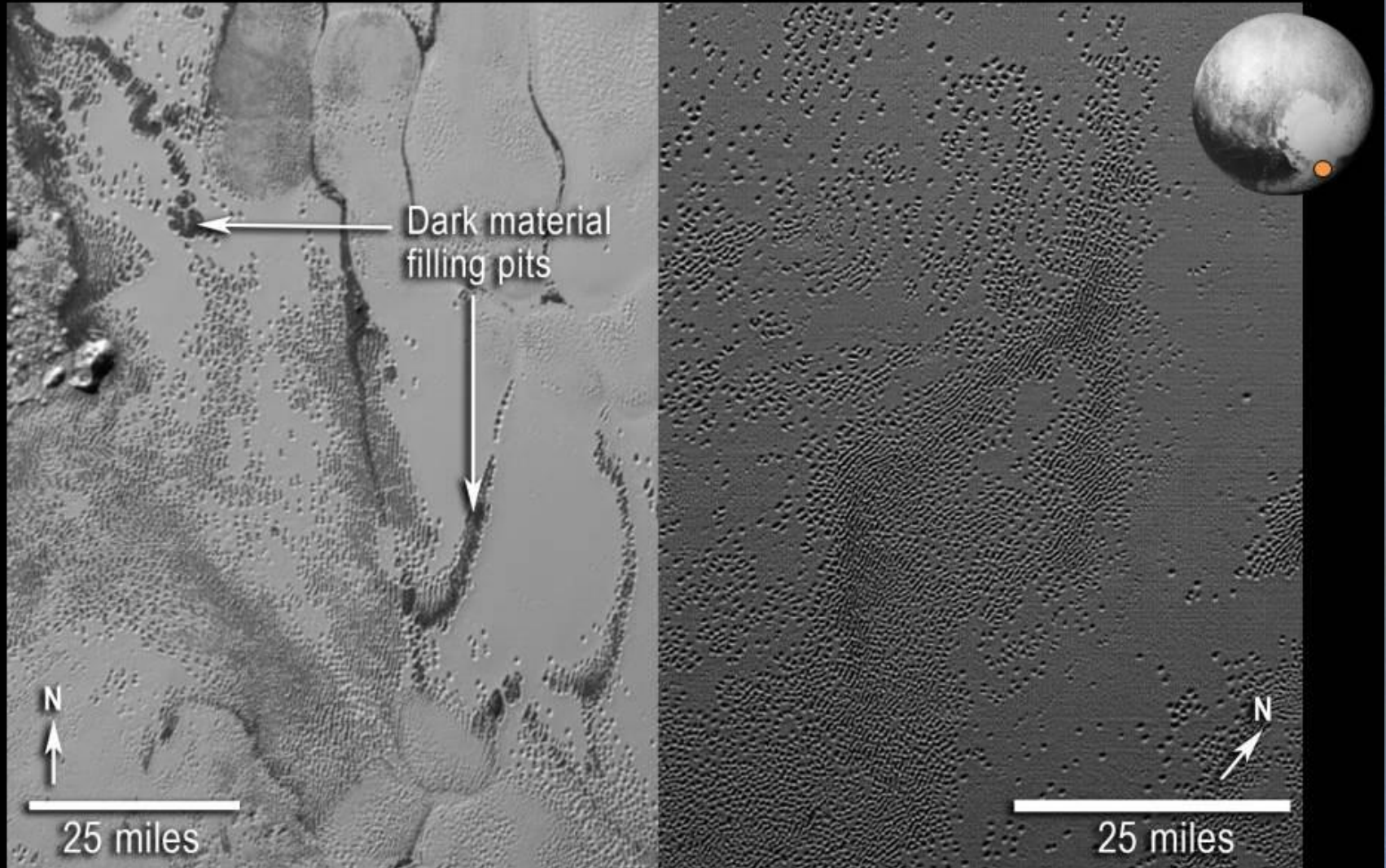
Nitrogen Ice Flows



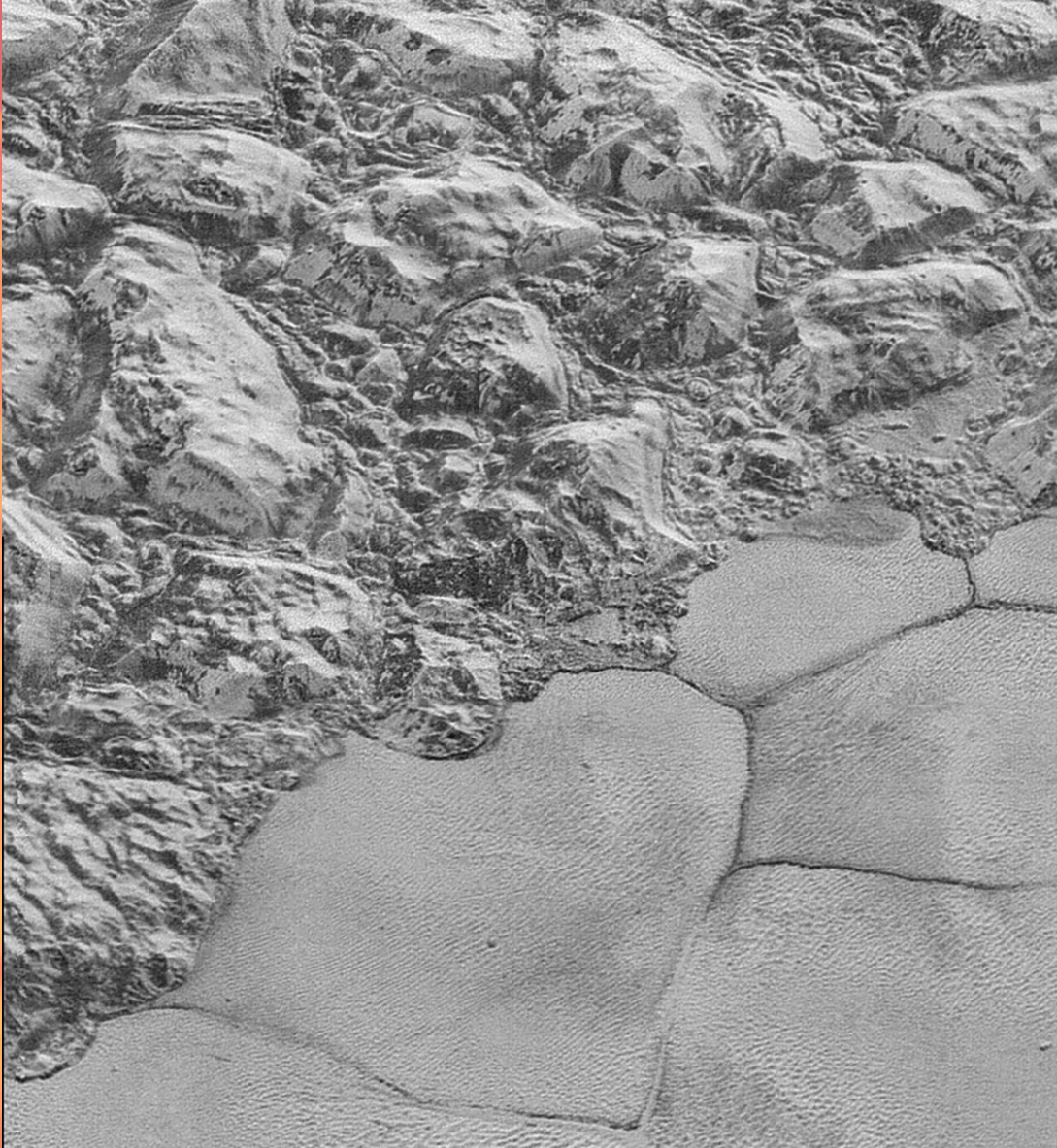
20 miles

Swarms of Pits in Southern Sputnik Planum

Pits may form through a combination of sublimation and ice fracturing.



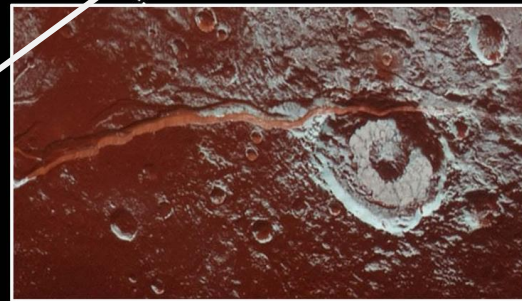
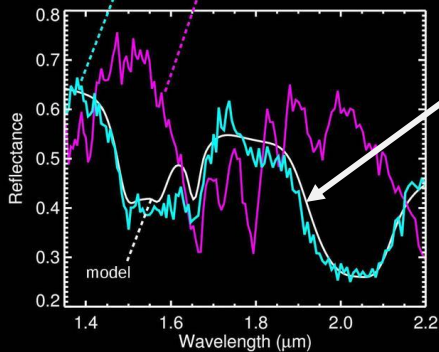
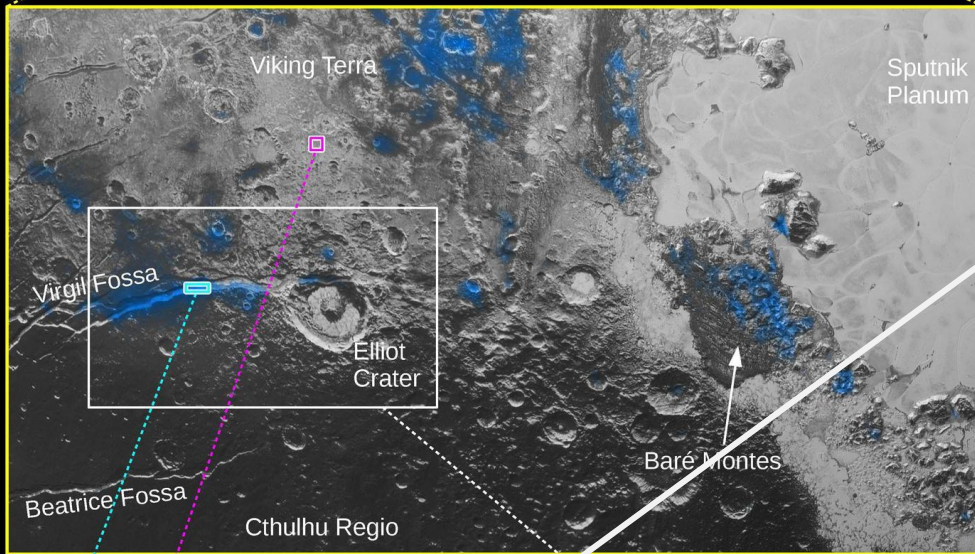
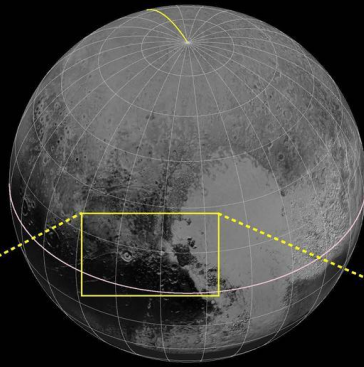
Sputnik Planum Shoreline



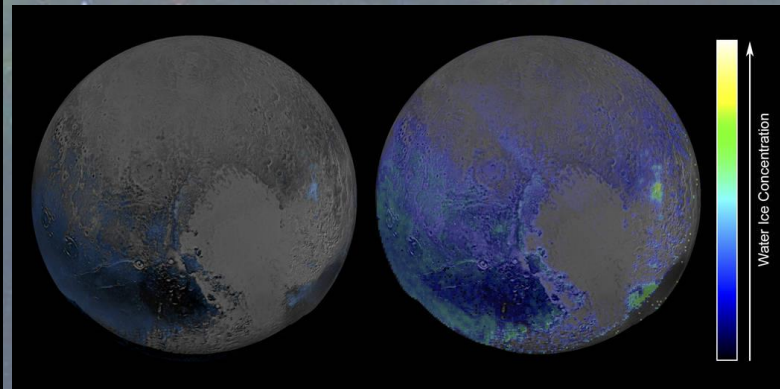
Mountainous region on
nitrogen convective cell
shoreline

Water Ice Detection on Pluto

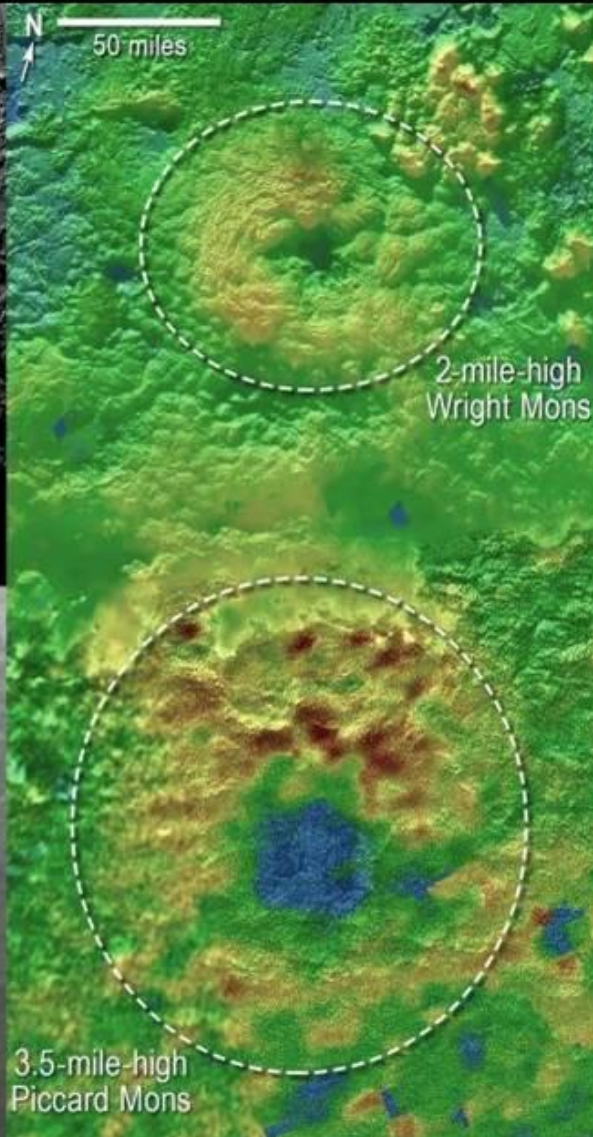
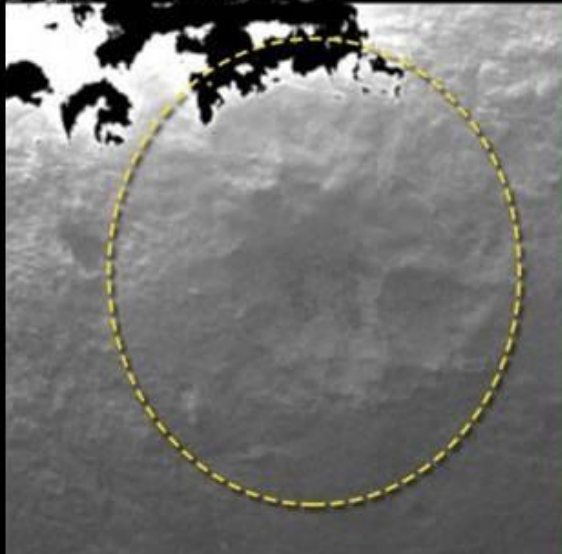
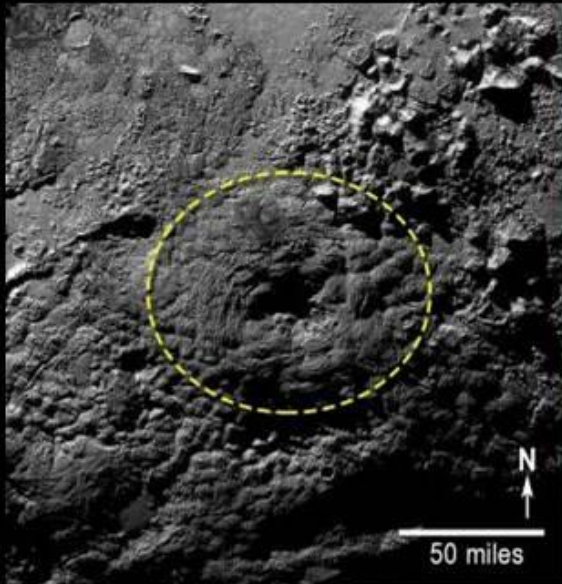
Blue shaded areas match signature of model simulation for reflectance spectra



Enhanced color view from MVIC



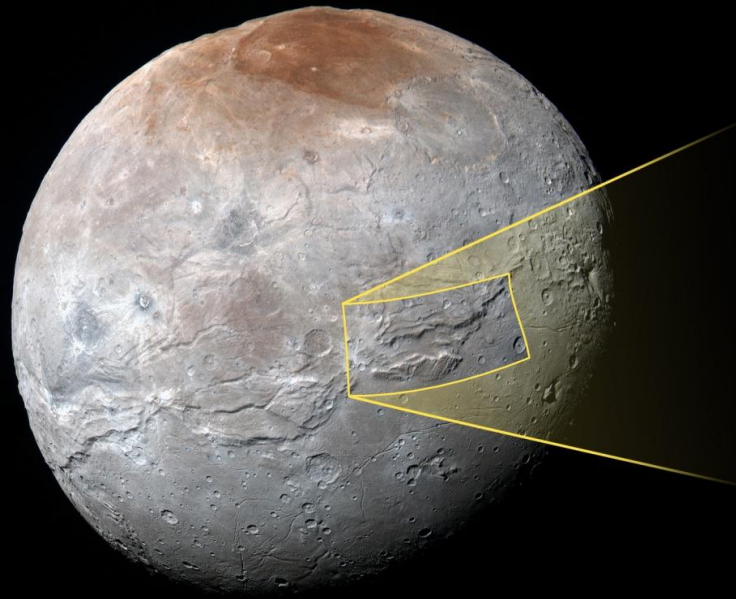
Volcanoes South of Sputnik Planum



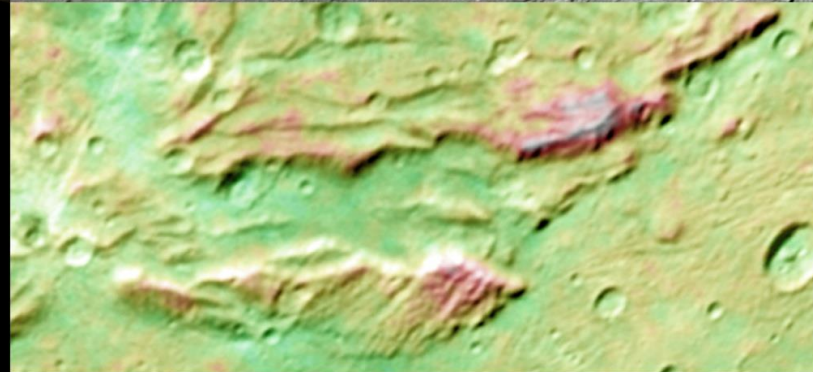
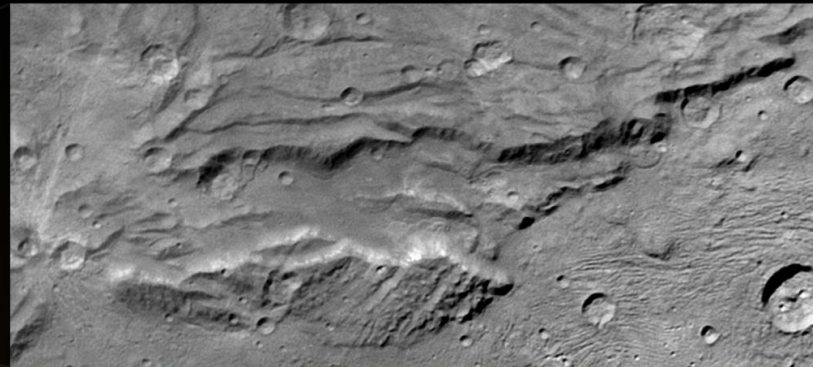
Mountains a few miles high with summit depressions; might be volcanoes



Charon



Serenity Chasma



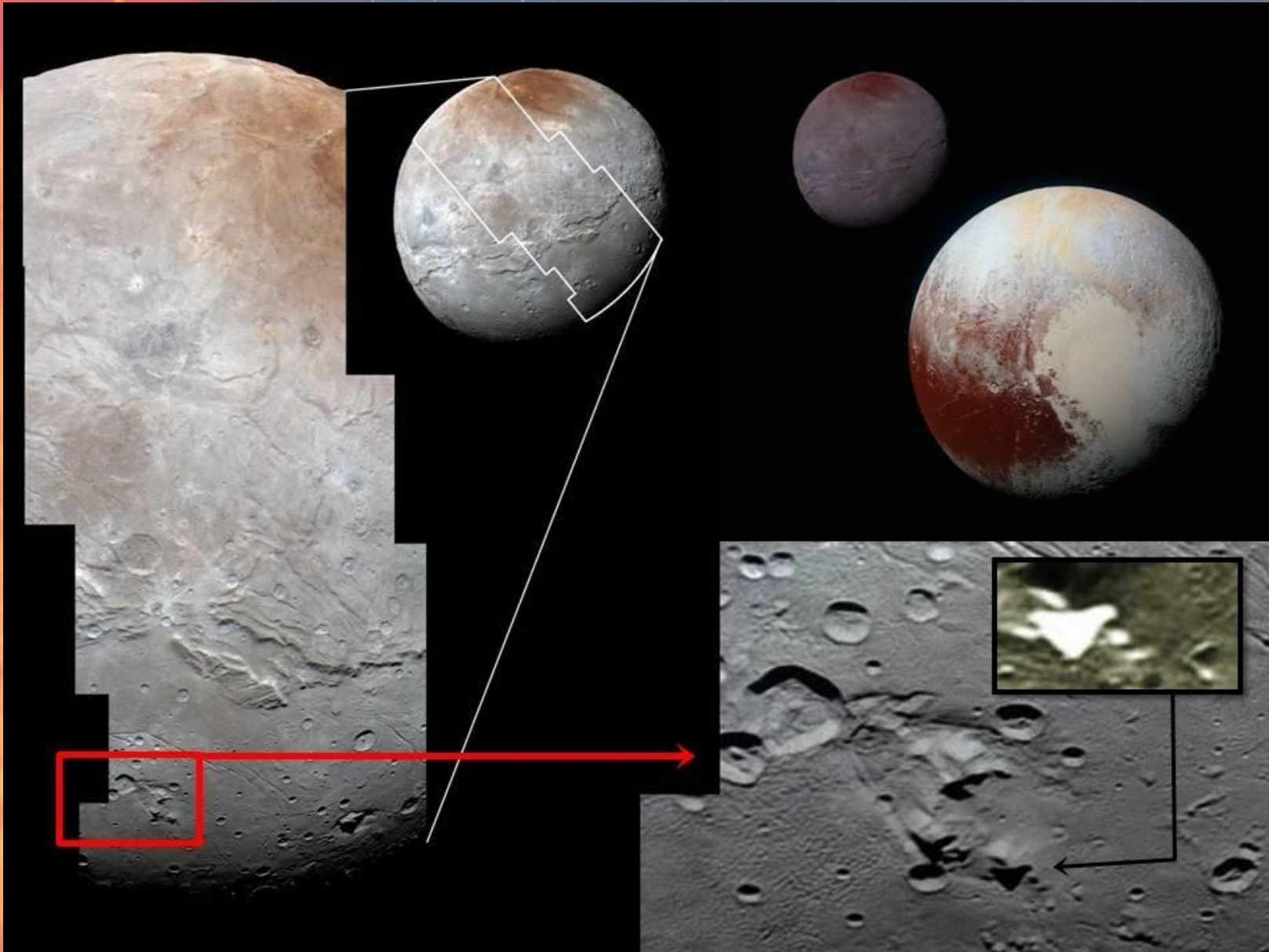
Grand Canyon on Charon: 1000mi long
More than 7 times as deep as Grand
Canyon on Earth

image resolution: 1290 ft per pixel

- Outer layer of Charon is primarily water ice with low levels of ammonia absorption over a large portion of its surface
- With presence of ammonia, water can exist in a liquid state as low as 176K (-143F)
- Fractured surface might hint at a subsurface ocean that has long since frozen
- Smooth regions suggest cryovolcanic activity

Charon: Alien Base Conspiracy Theories

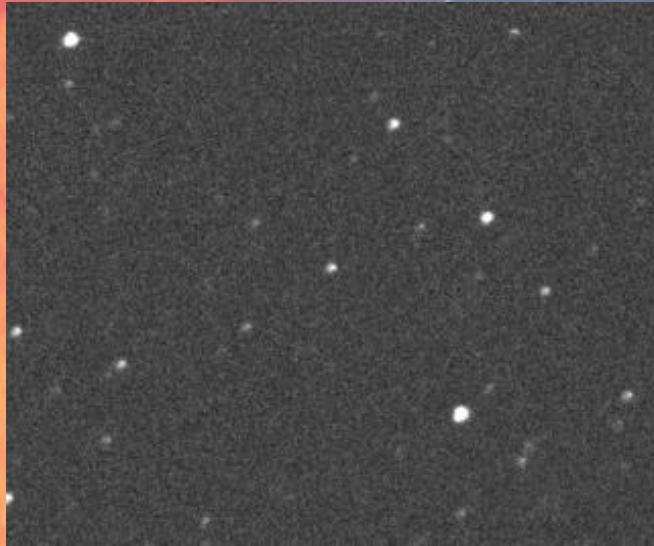
© Terry P. Riopka 2018



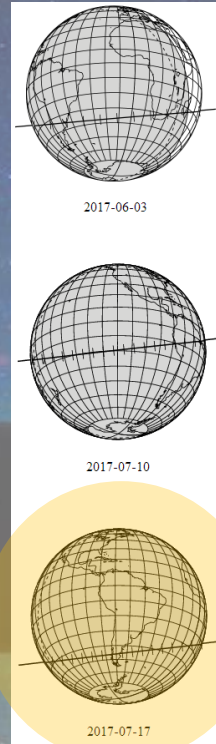
Shuttle
and
buildings

Flyby of Kuiper Belt Object: January 1, 2019

- HST located 5 candidate KBOs in 2014, out of which 1 was selected



Occultation observed on July 16, 2017 in Argentina



5 of 24 portable telescopes caught the shadow

- Object believed to consist of two lobes, 20km and 18km
- 1 billion mi further than Pluto



OR

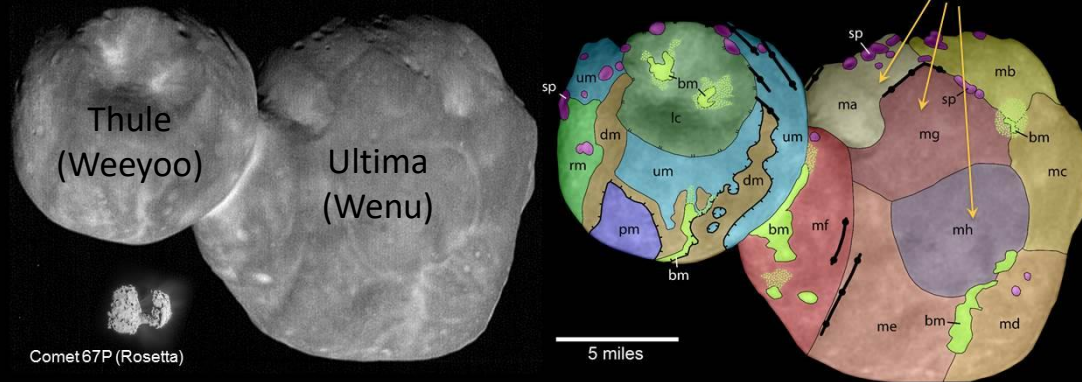


?

Flyby: January 1, 2019

Arrokoth

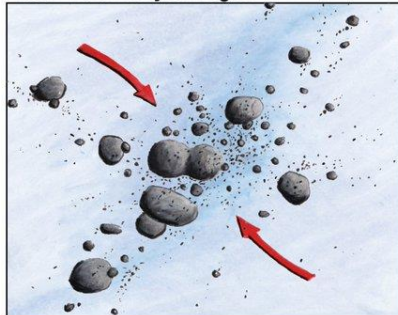
Ultima Thule's Complex Geology



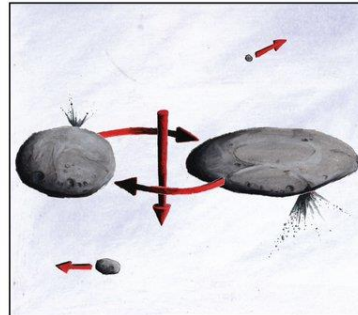
- passed Arrokoth at 2198 mi, 9 mi/s
- no detectable atmosphere
- orbits Sun once every 298 years

The Formation of 2014 MU69

About 4.5 billion years ago...

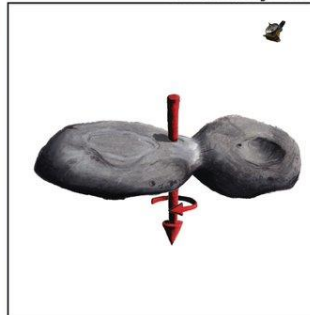


A rotating cloud of small, icy bodies starts to coalesce in the outer solar system.



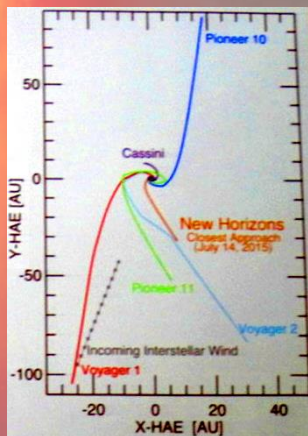
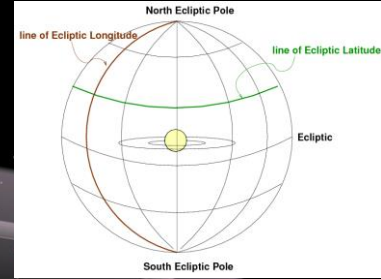
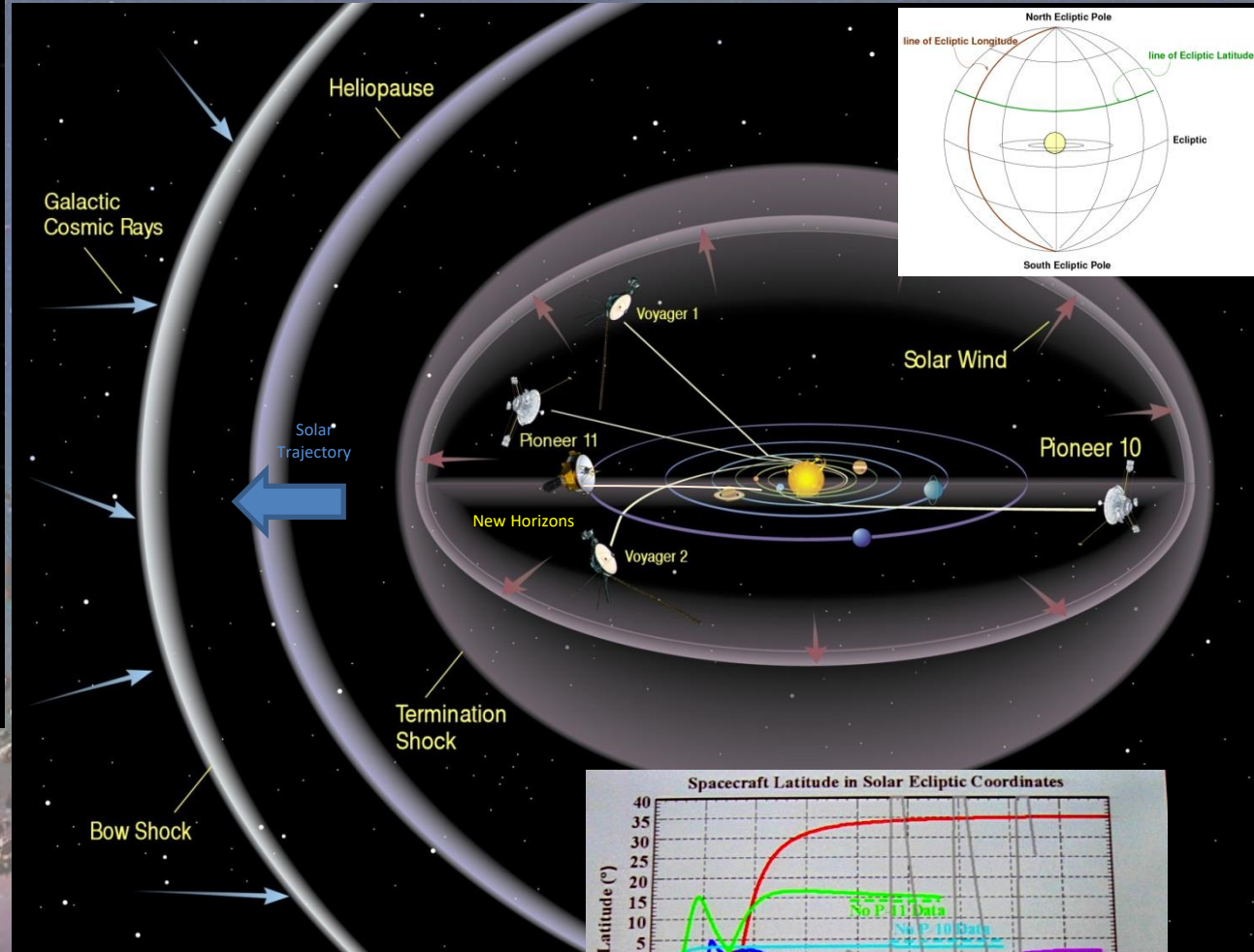
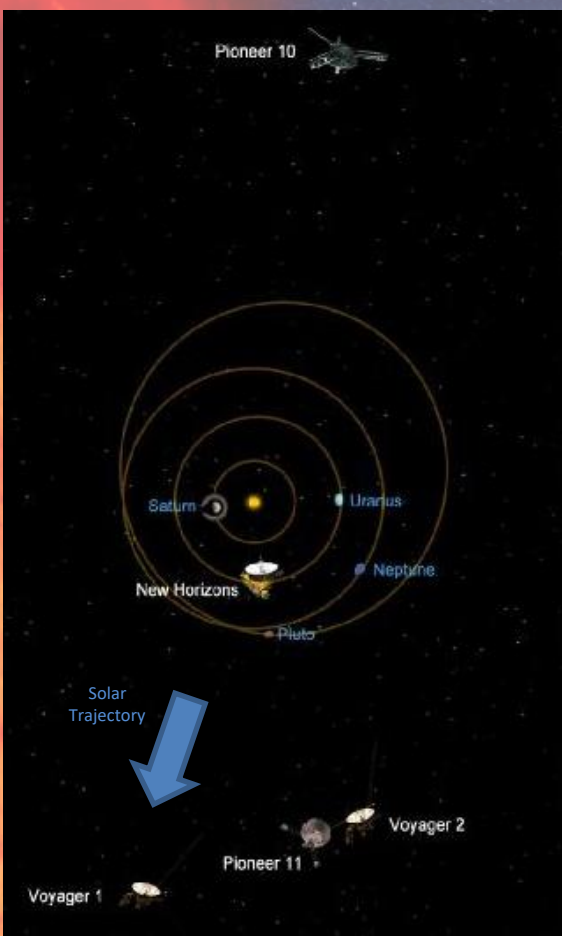
Eventually two larger bodies remain.

...1 January 2019.

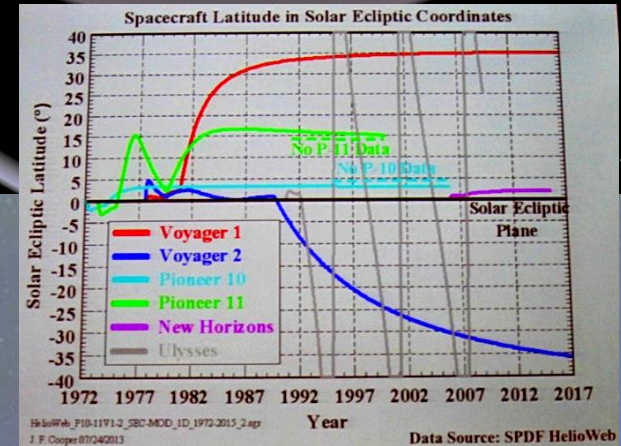


The two bodies slowly spiral closer until they touch, forming the bi-lobed object we see today.

New Horizons: End of Mission



- will extend operations until it exits the Kuiper belt, expected to occur 2028/2029



Probes to the Outer Solar System

End

Thank you!

