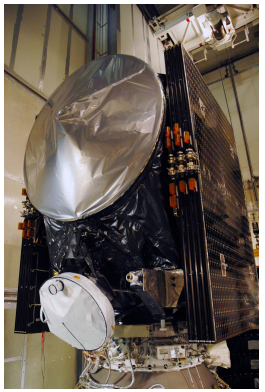
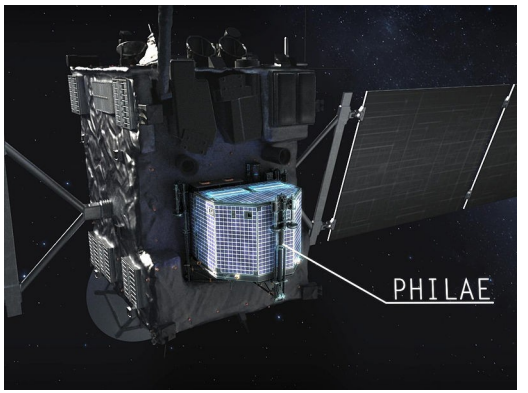
New Planetary Science from Dawn, Rosetta, and New Horizons





We have many active probes exploring deep space now.

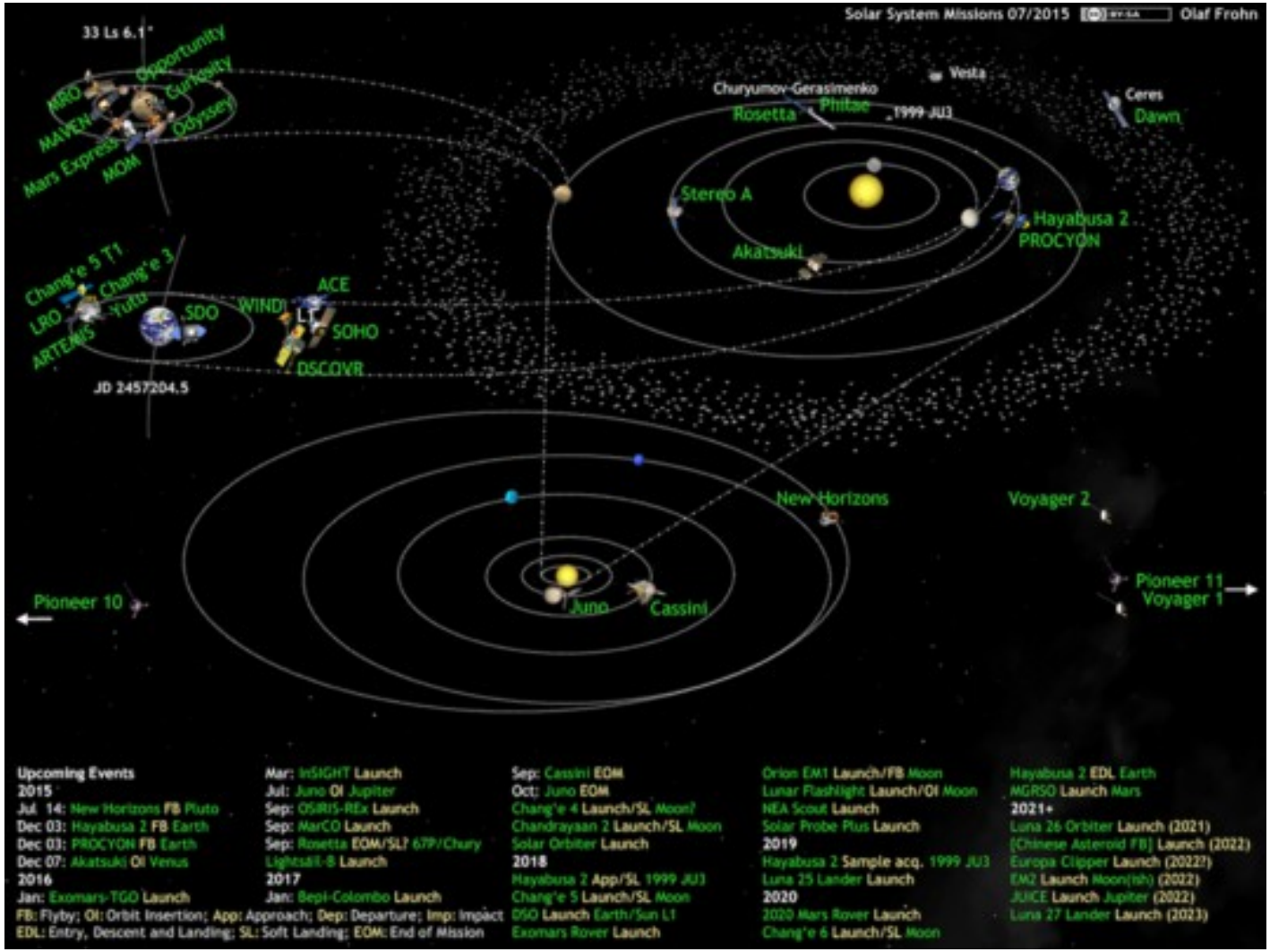


Image: The Planetary Society

Three of them are giving us great new science from minor planets.

- Dawn
  - NASA mission
  - Asteroid Vesta and asteroid and dwarf planet Ceres
  - First asteroid orbiter
  - First to orbit two different deep space targets
- Rosetta
  - European Space Agency mission
  - Comet 67P/Churyumov–Gerasimenko
  - First comet orbiter and landing
  - Hopes the be the first to make two landings on a comet
- New Horizons
  - NASA mission
  - Dwarf planet Pluto and other Kuiper belt objects beyond
  - First mission to Pluto

But first, a surprise guest appearance by

Messenger

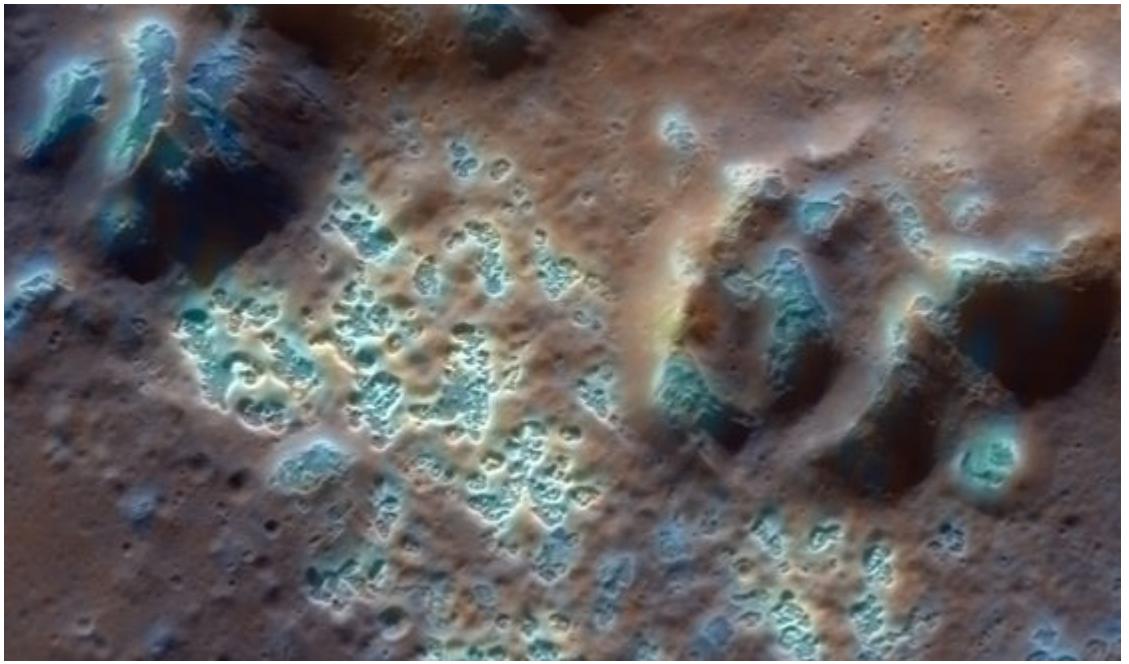
- Launched August 2004 by NASA.
- March 2011 arrived at Mercury.
- April 2015 crashed into Mercury.

Photo: NASA

Significant Science by Messenger at Mercury

- Crashed into the planet April 30 2015.
- For earlier mission highlights, see RAC program by Brenda Conway October 2011.
- Last few orbits were as low as possible.
- Highest resolution photos ever of the surface.
- Unexpected discovery that Mercury's magnetic field grows and shrinks in response to the Sun's level of activity.

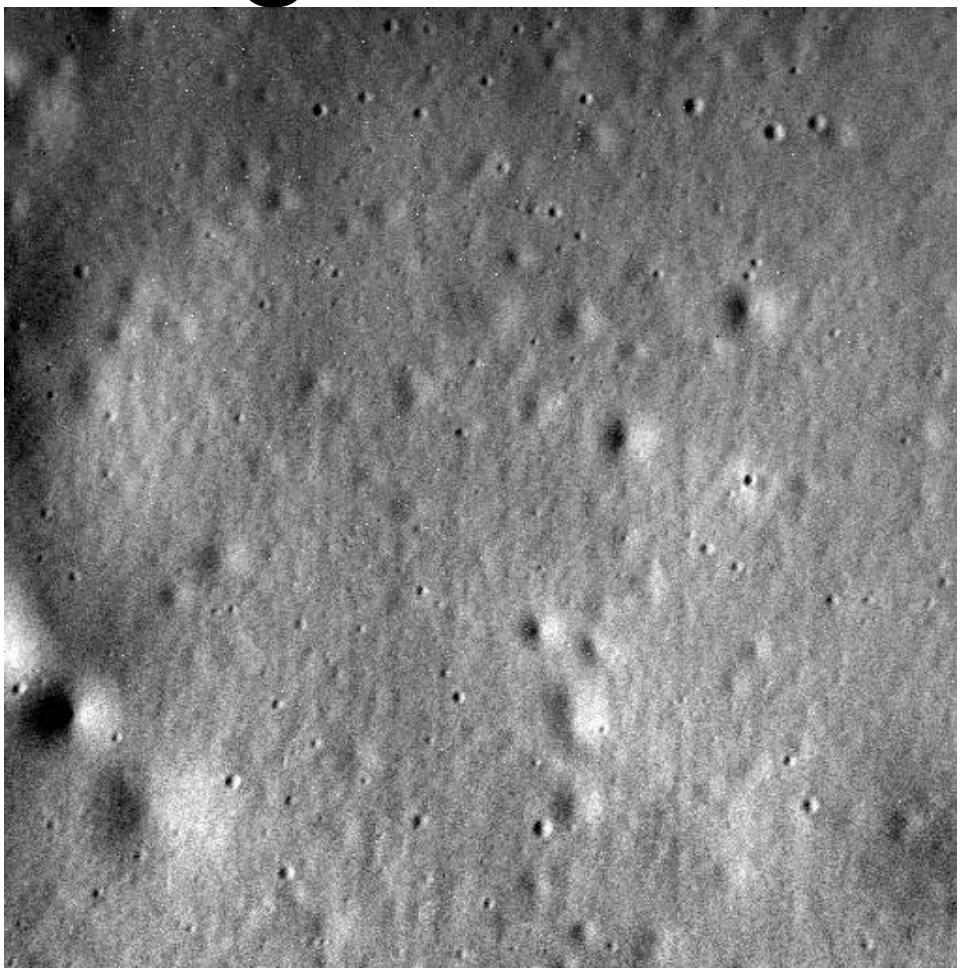
Significant Science by Messenger at Mercury



- Discovered unexpected hollows on the surface.
- Younger than impact craters around them (some are in or on craters - the surface collapsed some time after the impact).
- Mercury was believed to be geologically inactive.
- First evidence there are dynamic processes on the surface of Mercury today.

Photo: NASA

Significant Science by Messenger at Mercury



•The last image sent by Messenger before its crash.

Photo: NASA

Dawn

- Launched September 2007.
- February 2009 Mars flyby and gravity assist.
- July 2011 arrived at Vesta.
- September 2012 left Vesta for Ceres.
- March 2015 arrived at Ceres.
- Ion engine makes it the first craft able to enter and leave orbit around multiple targets.

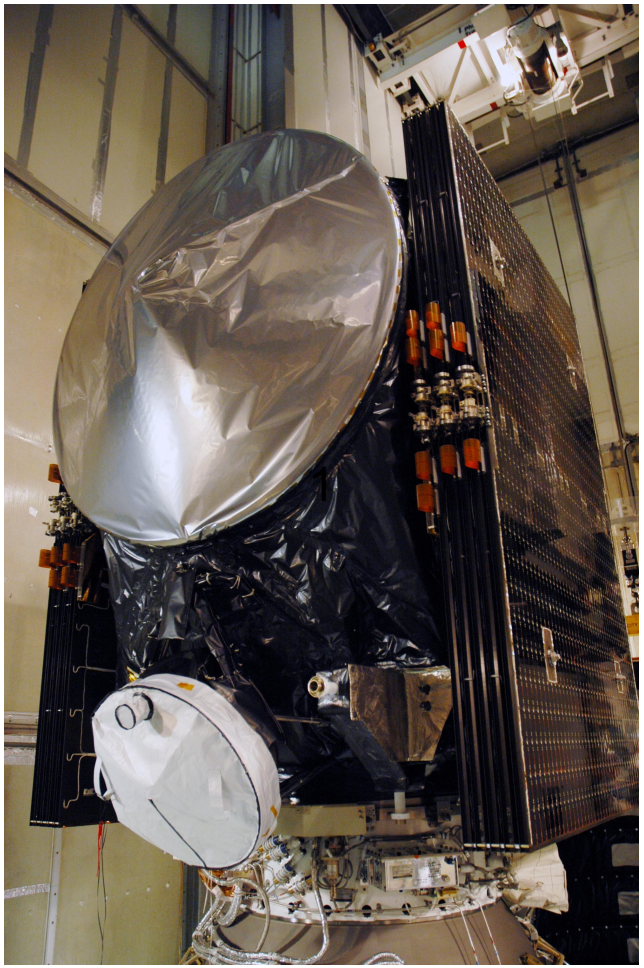
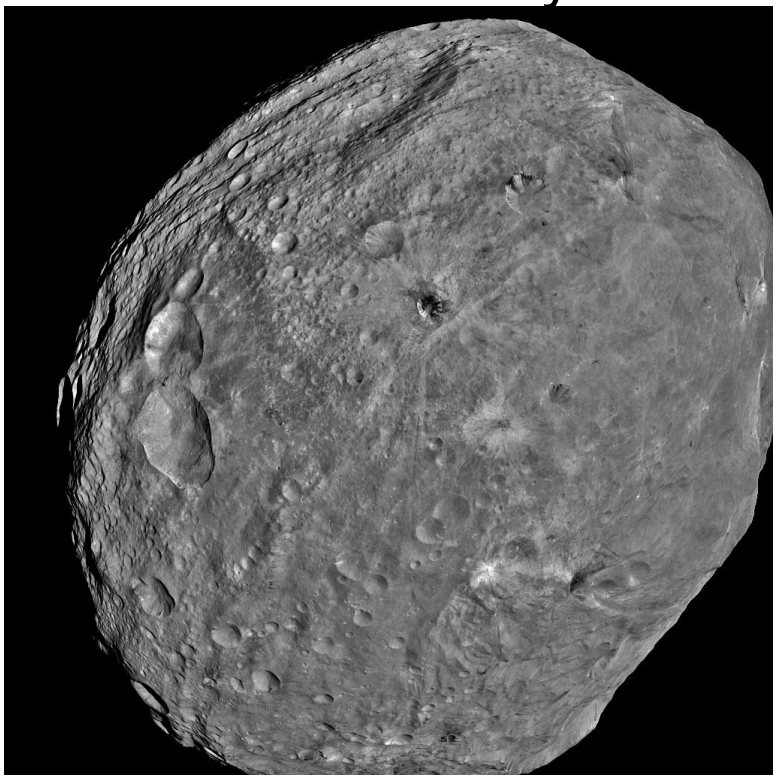


Photo: NASA

Vesta and Ceres

- Older
- Smaller
  - 10% of mass of asteroid belt.
  - Not enough gravity to pull the asteroid truly round.



- Younger
- Larger
  - 33% of mass of asteroid belt.

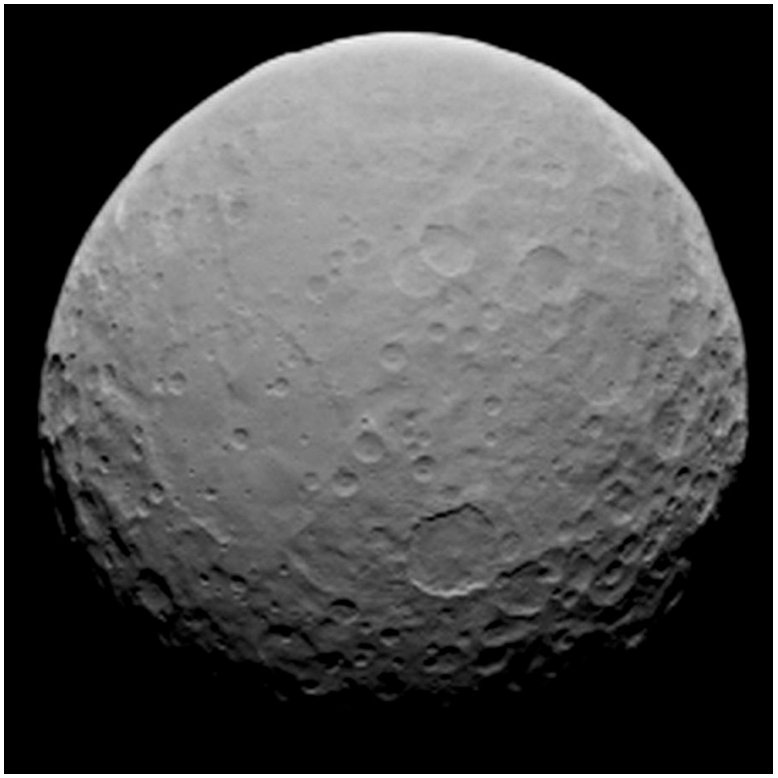
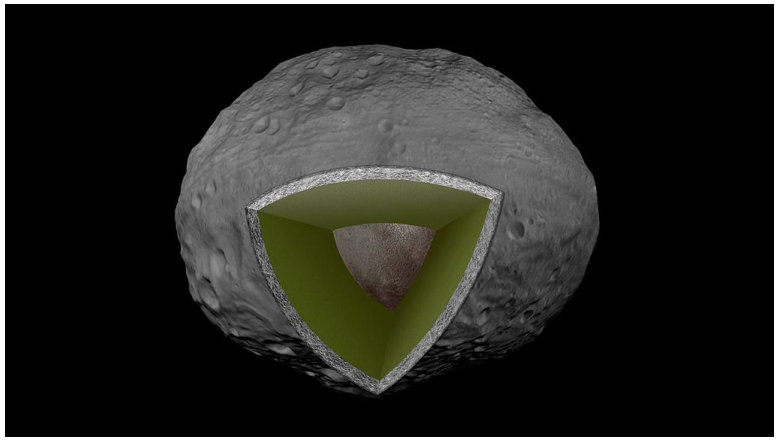


Photo: NASA

Vesta and Ceres

- Heated, melted, differentiated.
- Metal core.
- Rocky crust.
- Lava flows.
- Water is gone.
- Similar to large moons.
- Last large protoplanet not accreted into a rocky planet.



- Still in original primitive state.
- Uniform rocky body.
- Ice layer accumulated on surface.
- Dust accumulated on the ice.
- Similar to Kuiper belt objects.
- Not considered a protoplanet because it never differentiated.

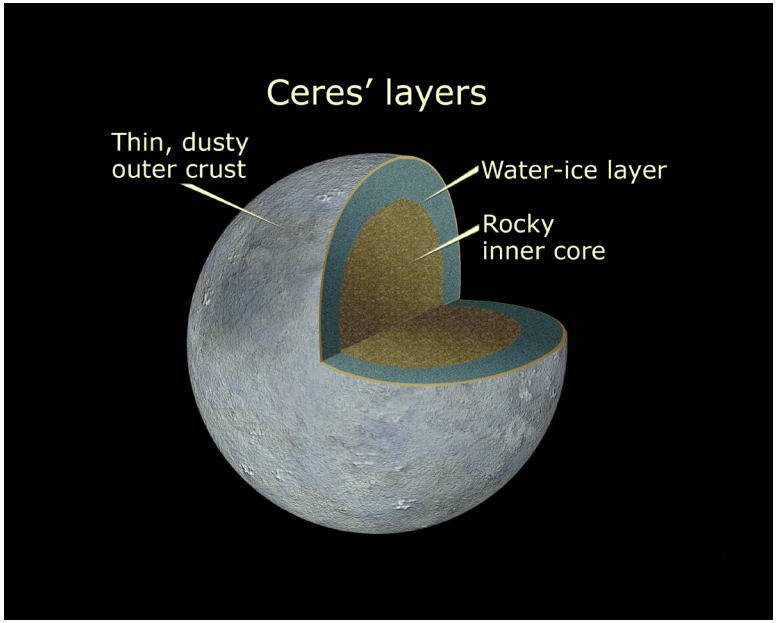


Image: Wikimedia

Vesta and Ceres

Attributes in common

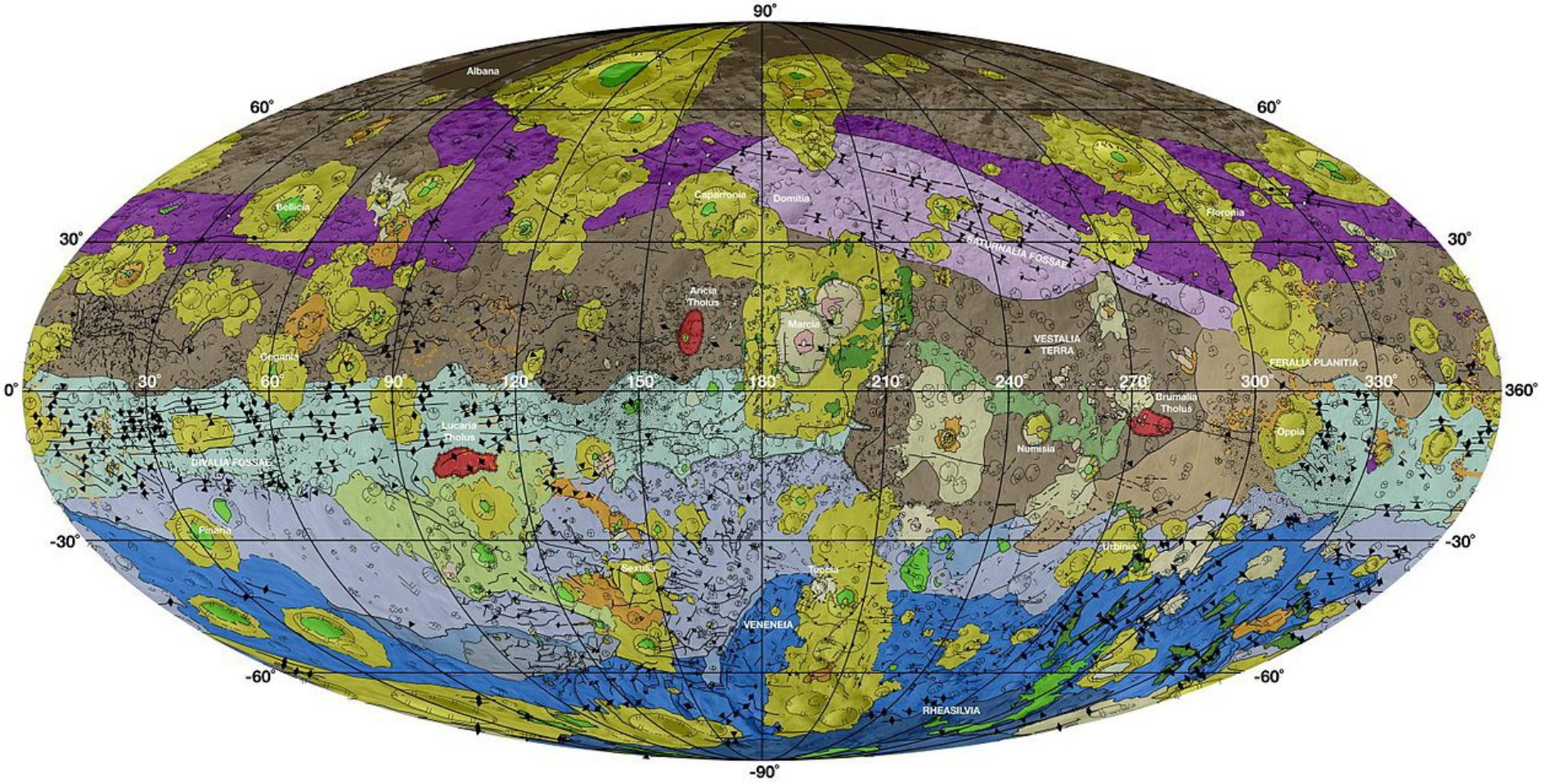
- Both are pieces of our Sun's original accretion disk.
- Both had accretion into larger planets interrupted by formation of Jupiter.

Chosen as targets because they have similar origins but very different evolution.

Significant Science by Dawn at Vesta

- Closest, best pictures.
- Evidence of impacts by other asteroids.
- Unexpected evidence of ancient flowing water.
- Unexpected mountain at south pole.

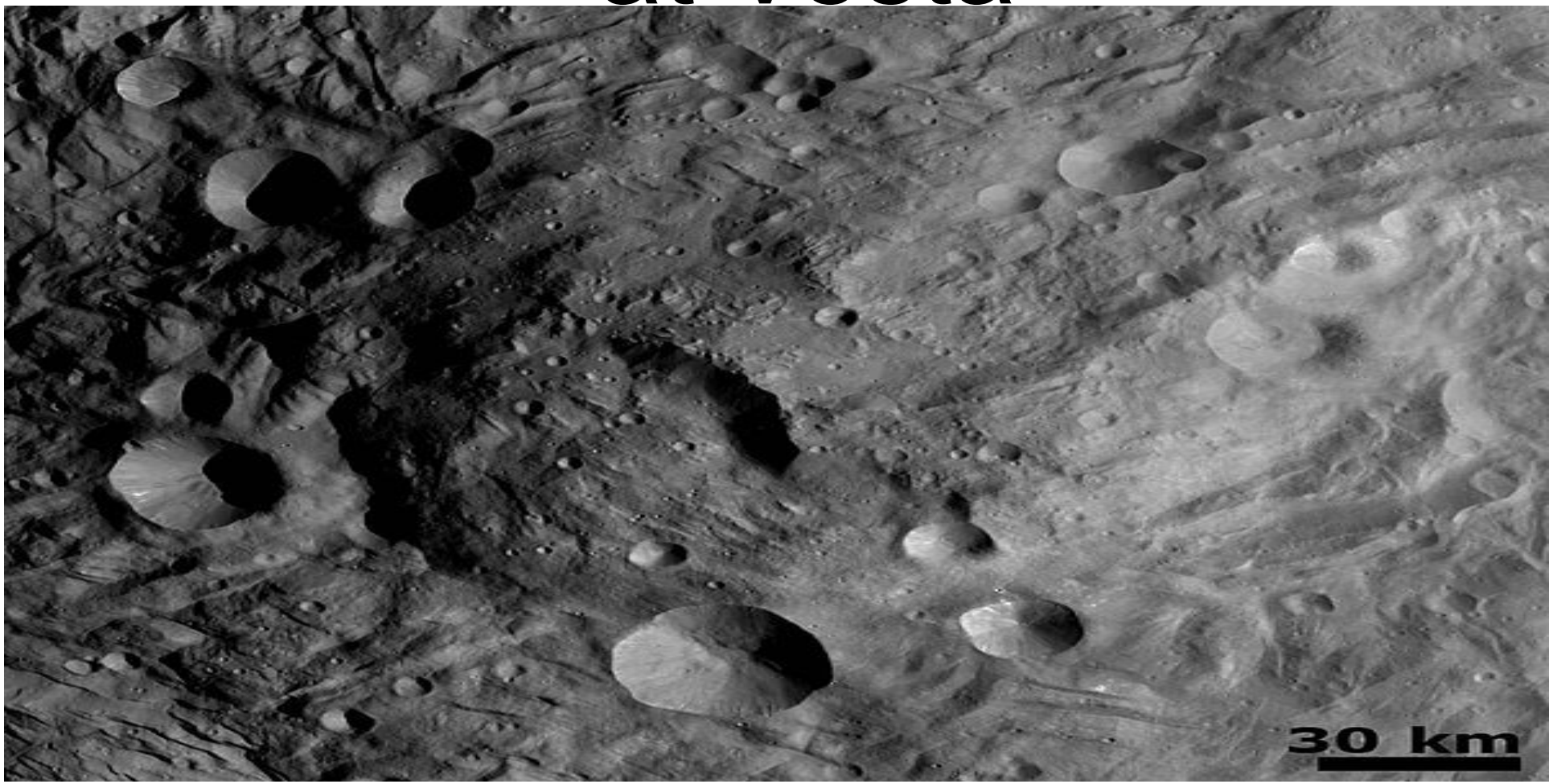
Significant Science by Dawn at Vesta



- Geological map of entire asteroid.
- Colors are features caused by different specific impacts.
- Points are height measurements.

Image: NASA

Significant Science by Dawn at Vesta



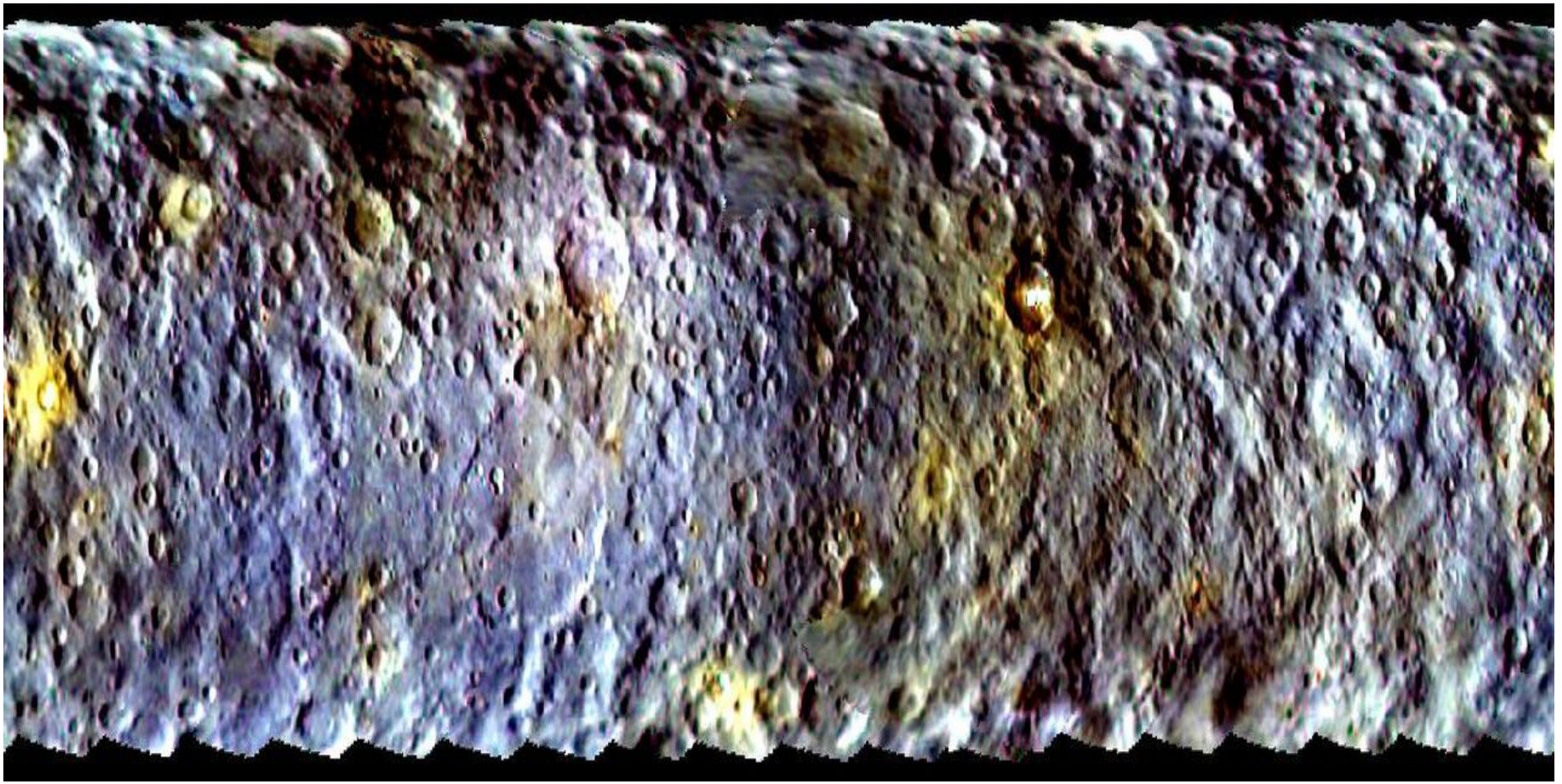
- Not completely round – features such as south pole mound.
- Huge impact basins – source of meteorites found on Earth.

Photo: NASA

Significant Science by Dawn at Ceres

- Dawn is taking pictures and sensor measurements in 4 different orbits. The 4th and lowest will be its permanent orbit.
- Planned to spend July 2015 moving from 4400 km orbit to 1450 km orbit, where it will spend a month, then spend 2 months moving to final 375 km orbit.
- June 30 2015 Dawn began to change orbit, but reported a problem. NASA is still analyzing what happened and replanning the mission schedule.

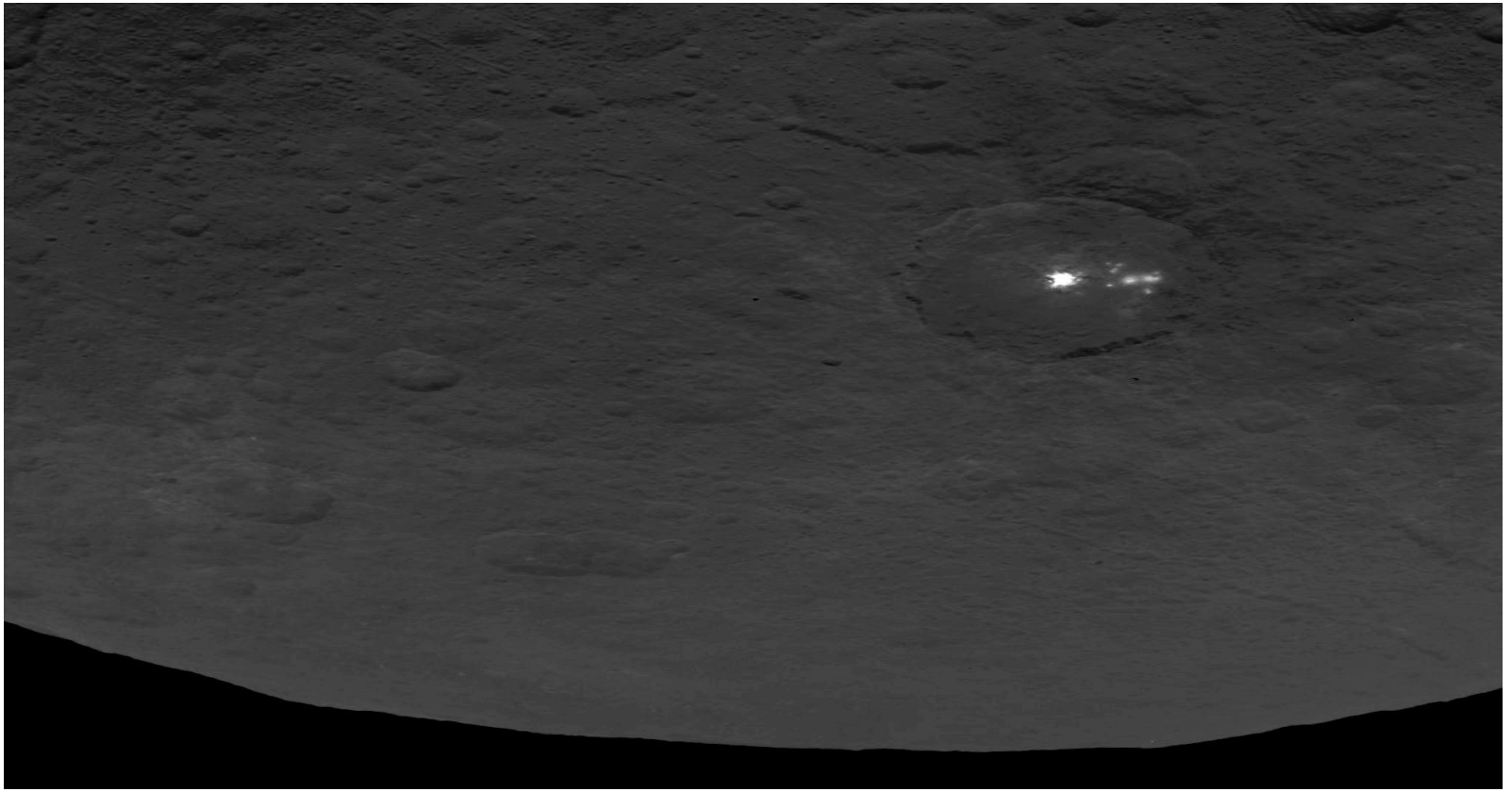
Significant Science by Dawn at Ceres



- Photographic map of entire asteroid.
- False color to emphasize different colors seen.

Photo: NASA

Significant Science by Dawn at Ceres



- Unexpected bright spot in crater.
- Closer approach revealed it to be multiple spots.
- Leading hypothesis so far is reflective ice.

Photo: NASA

Rosetta

- Launched March 2004.
- March 2005 flyby of Earth and gravity assist.
- February 2007 low (250 km) flyby of Mars and gravity assist.
- November 2007 flyby of Earth and gravity assist.
- Mistaken for an asteroid and given name minor planet 2007 VN_{84}.
- September 2008 flyby of asteroid 2867 Šteins.
- November 2009 flyby of Earth and gravity assist.
- July 2010 flyby of asteroid 21 Lutetia.
- September 2014 enters orbit around comet 67P/Churyumov–Gerasimenko.
- November 12 2014 Philae lands on the comet.
  - But bounces into a shadow by a cliff face, canted at an angle.
- June 13 2015 Philae wakes up and begins communication.

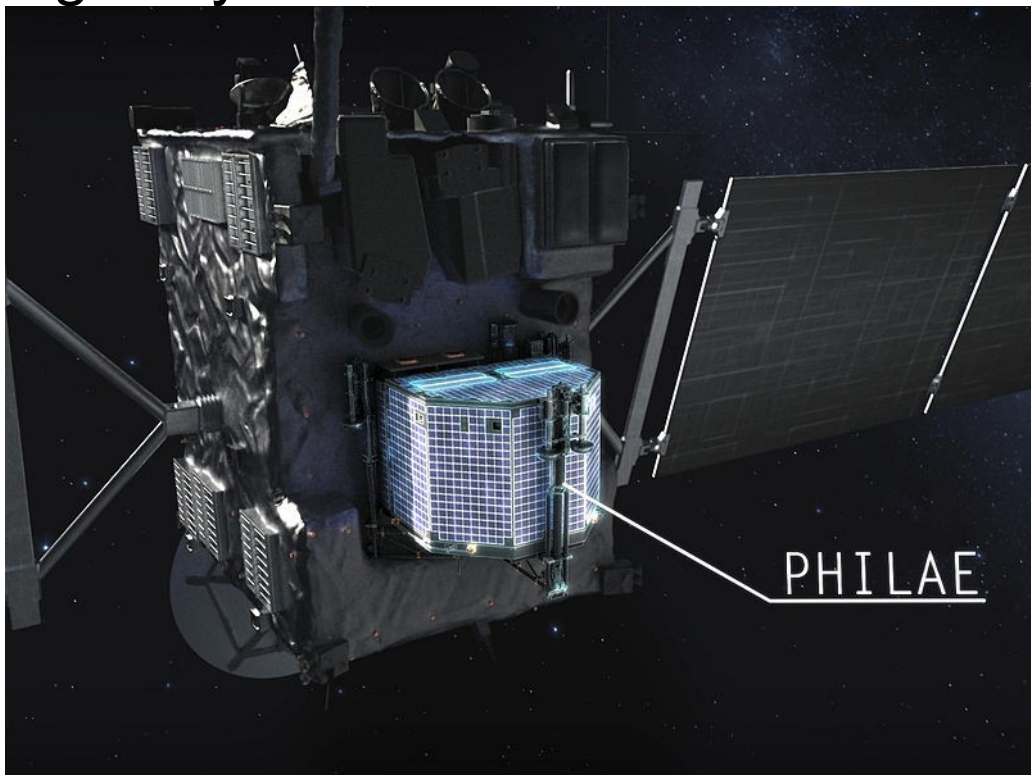


Photo: ESA

Philae

- November 12 2014 Philae lands on comet 67P.
- Its anchors failed to enter the crust.
- Interesting, because it means the crust is harder than expected.
- Bounced at least twice, then settled at an angle, in shadow.
- Performed its initial experiments till its battery ran down, then went to sleep.

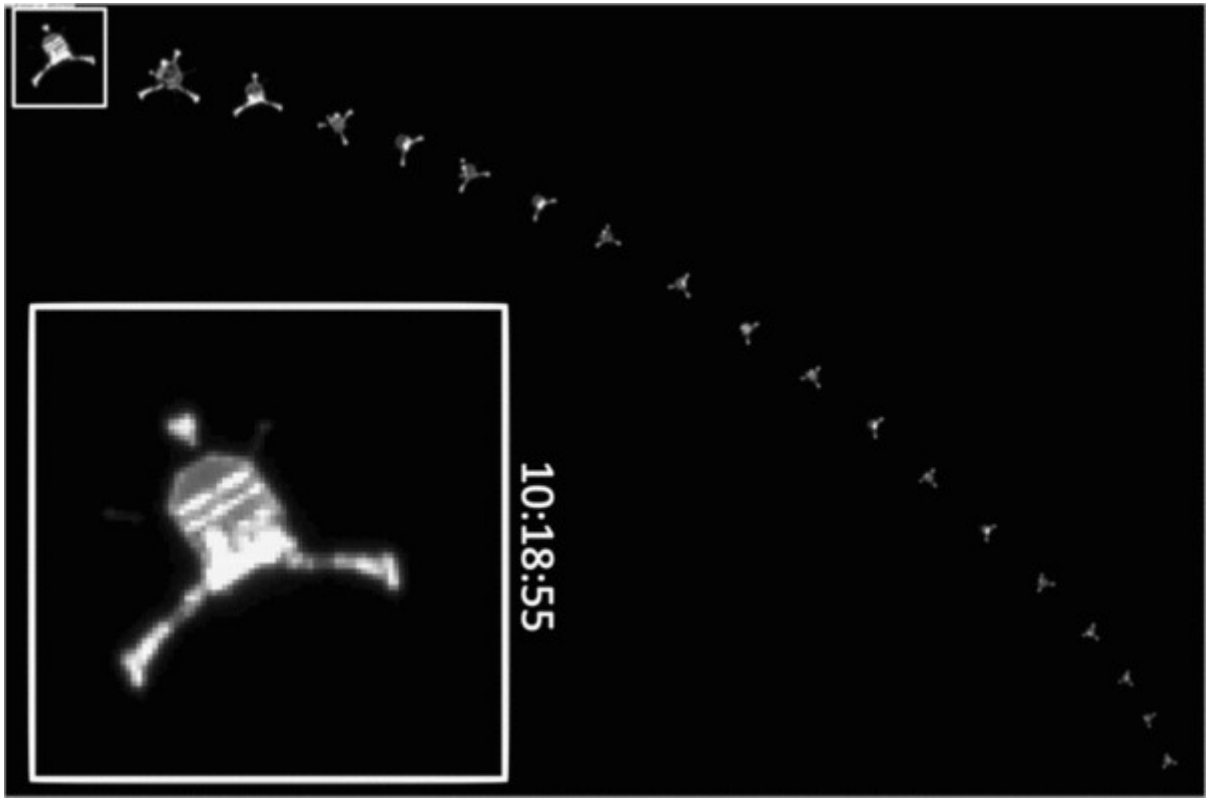


Photo: ESA

Philae

- Not Dead Yet

- June 13 2015 Philae woke up.
- July 9 2015 Philae transmitted results of a new experiment.
- Communications still intermittent.

Photo: ESA

Philae

- Where exactly on the comet is Philae?
- July 2015: This bright spot is the leading candidate for Philae.

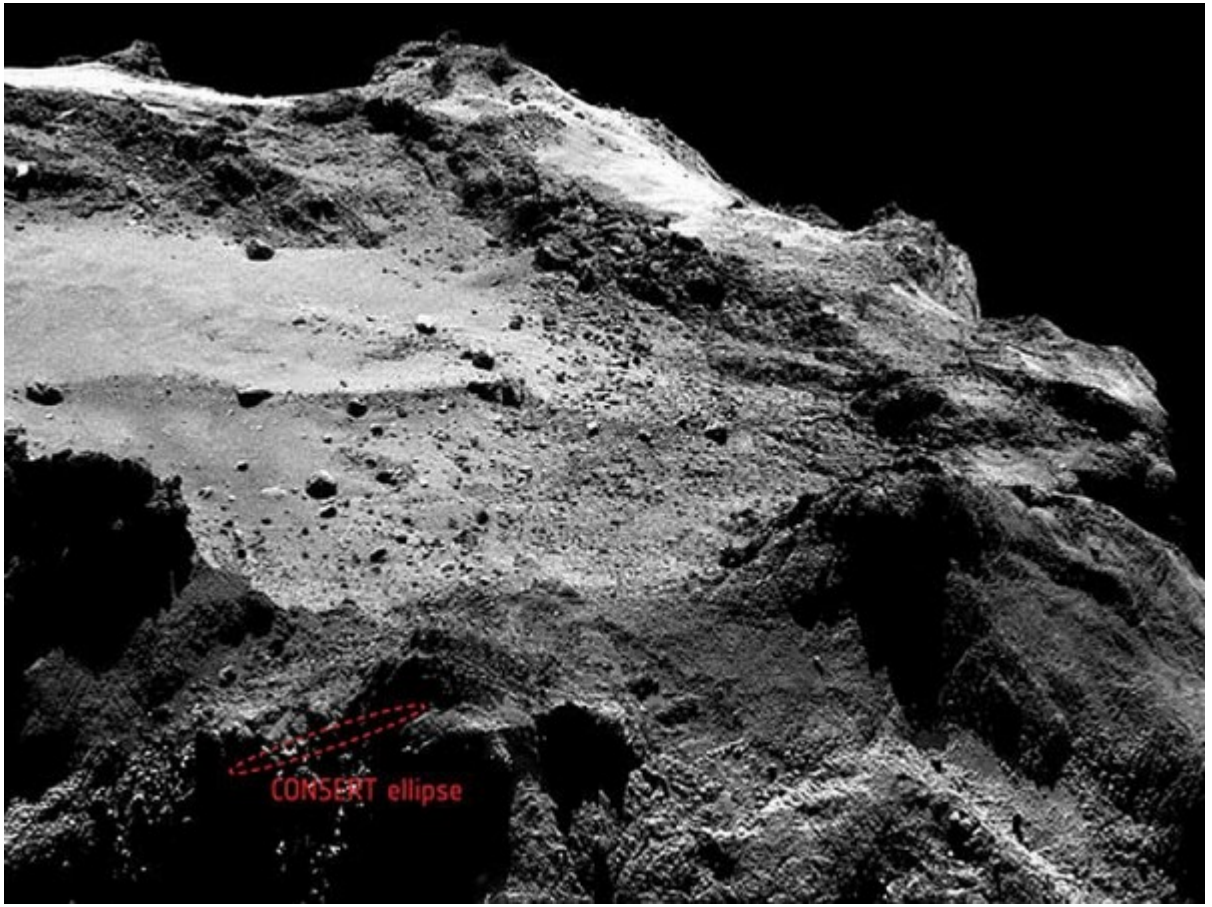


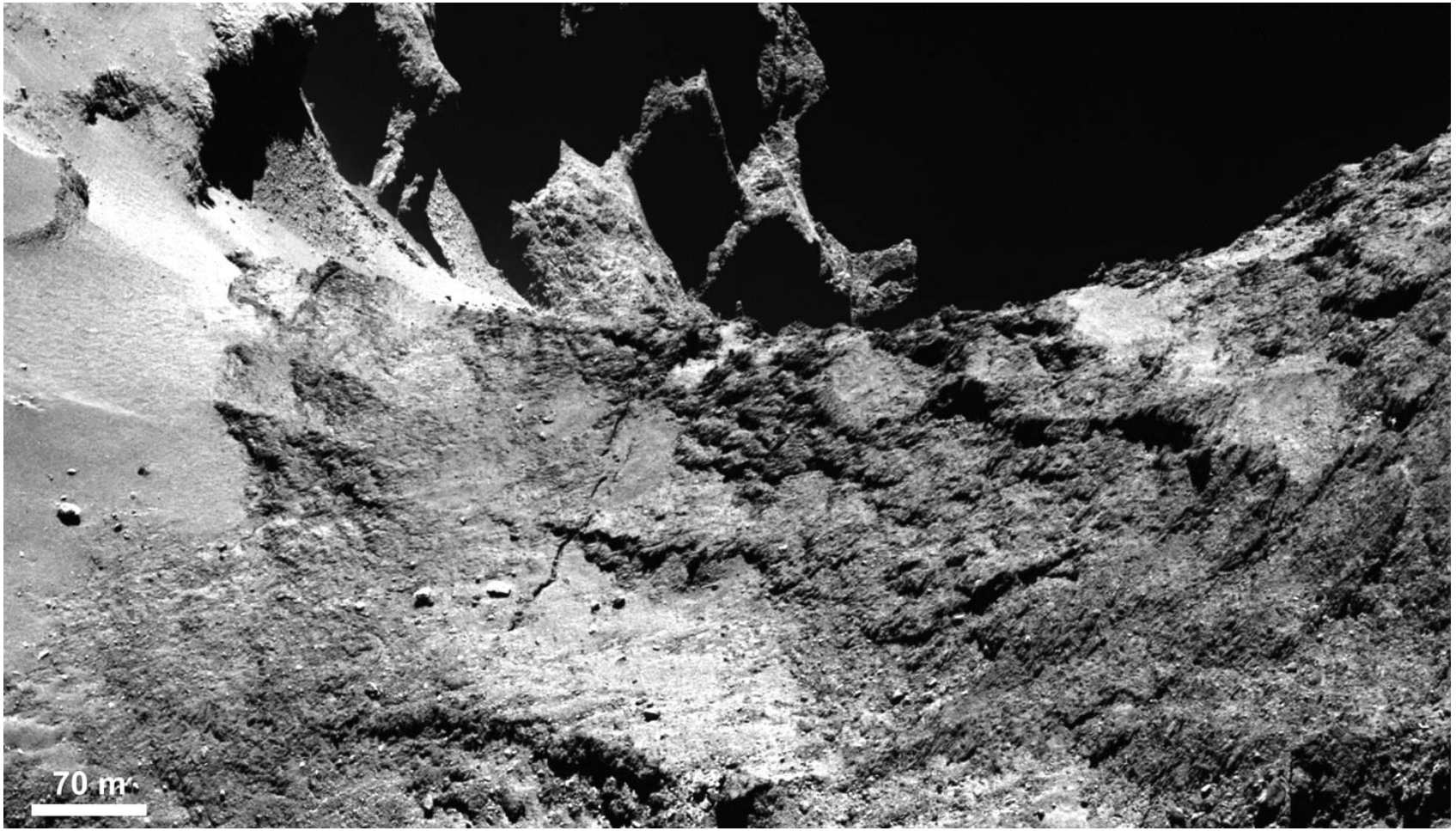
Photo: ESA

Significant Science by Rosetta at 67P

- Mapping a comet of a very odd shape.
- Leading hypothesis so far is that two smaller objects collided and stuck together.

Photo: ESA

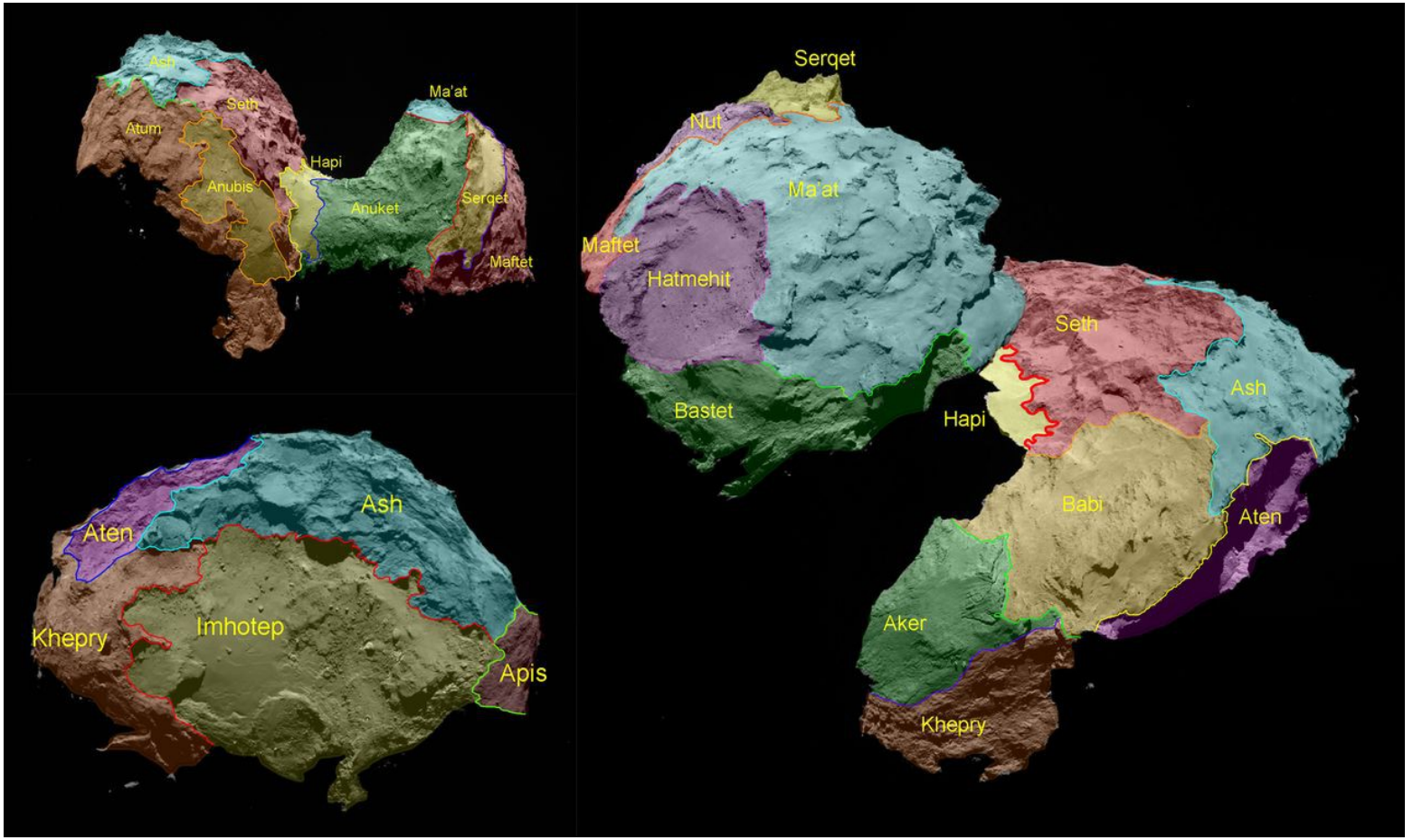
Significant Science by Rosetta at 67P



- This crack between the two lobes suggests they are only weakly connected.
- They may break apart as the Sun warms the comet.

Photo: ESA

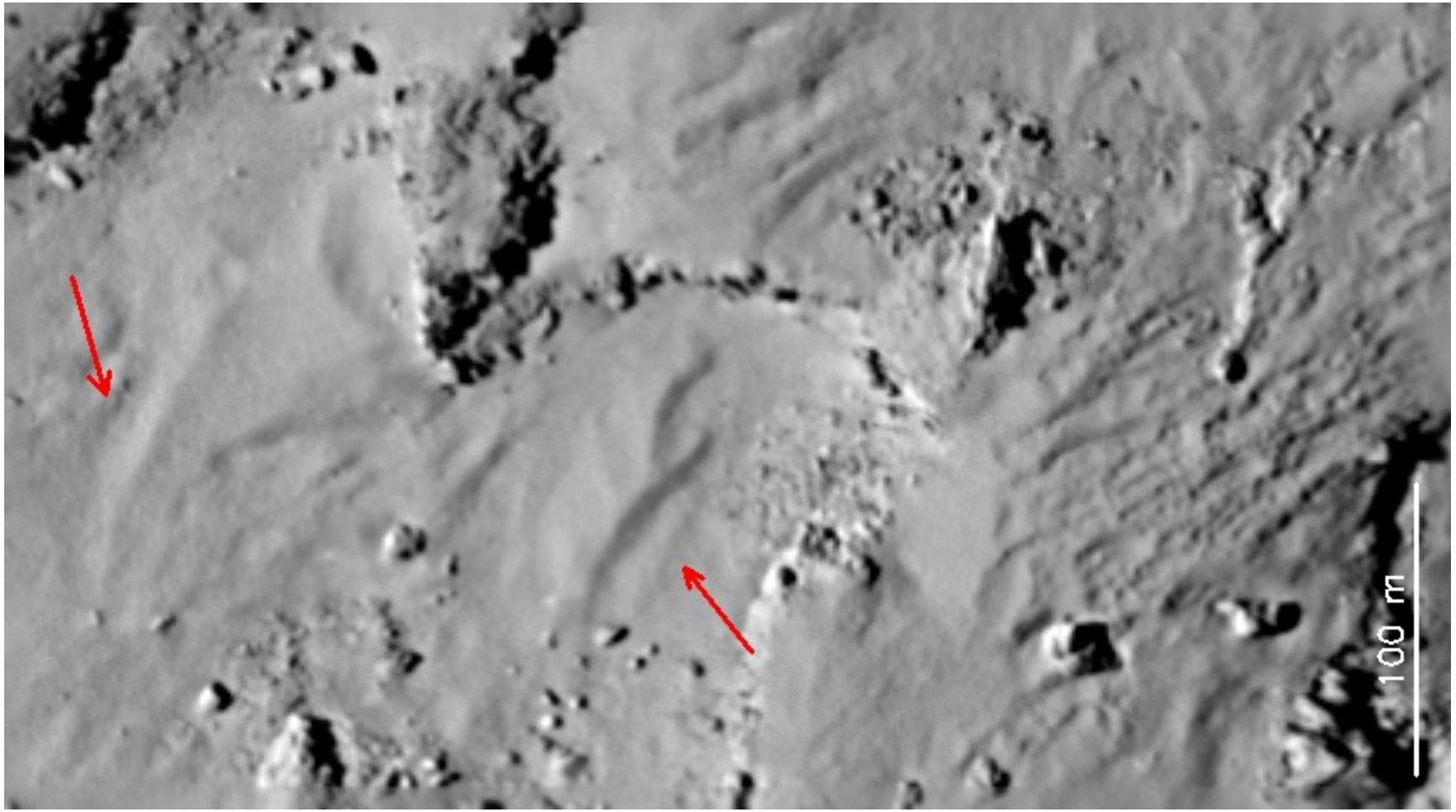
Significant Science by Rosetta at 67P



- Colors are named regions.
- Rosetta and Philae are the two Egyptian monuments whose inscriptions permitted learning ancient Egyptian languages. Features are names from Egyptian history and mythology.

Photo: ESA

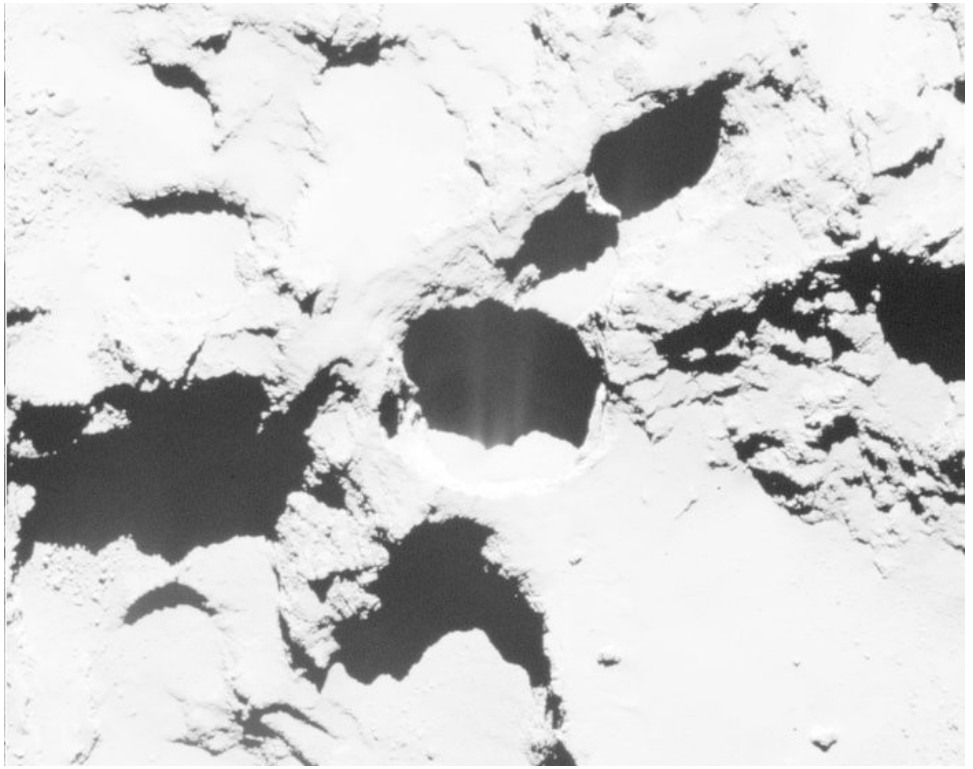
Significant Science by Rosetta at 67P



- These dunes suggested the surface is mostly soft piles of loose material.
- However, Philae landed on hard ice, causing it to bounce.

Photo: ESA

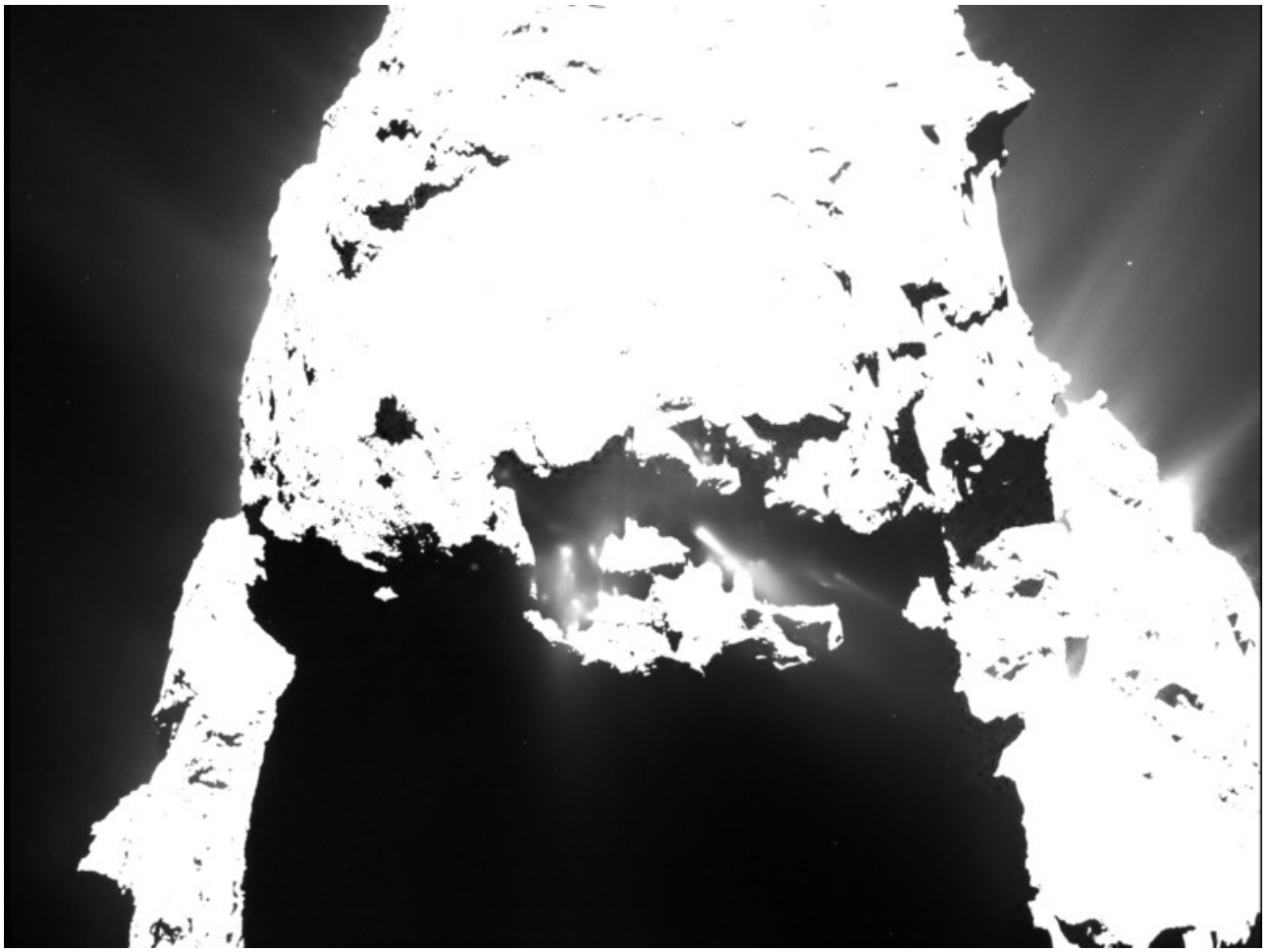
Significant Science by Rosetta at 67P



- As the comet approached the sun, jets of gas developed at specific locations on the comet.
- Scientists previously thought the sun's warmth sublimated gas and dust evenly all over a comet's surface.
- This gas and dust is becoming the comet's coma.

Photo: ESA

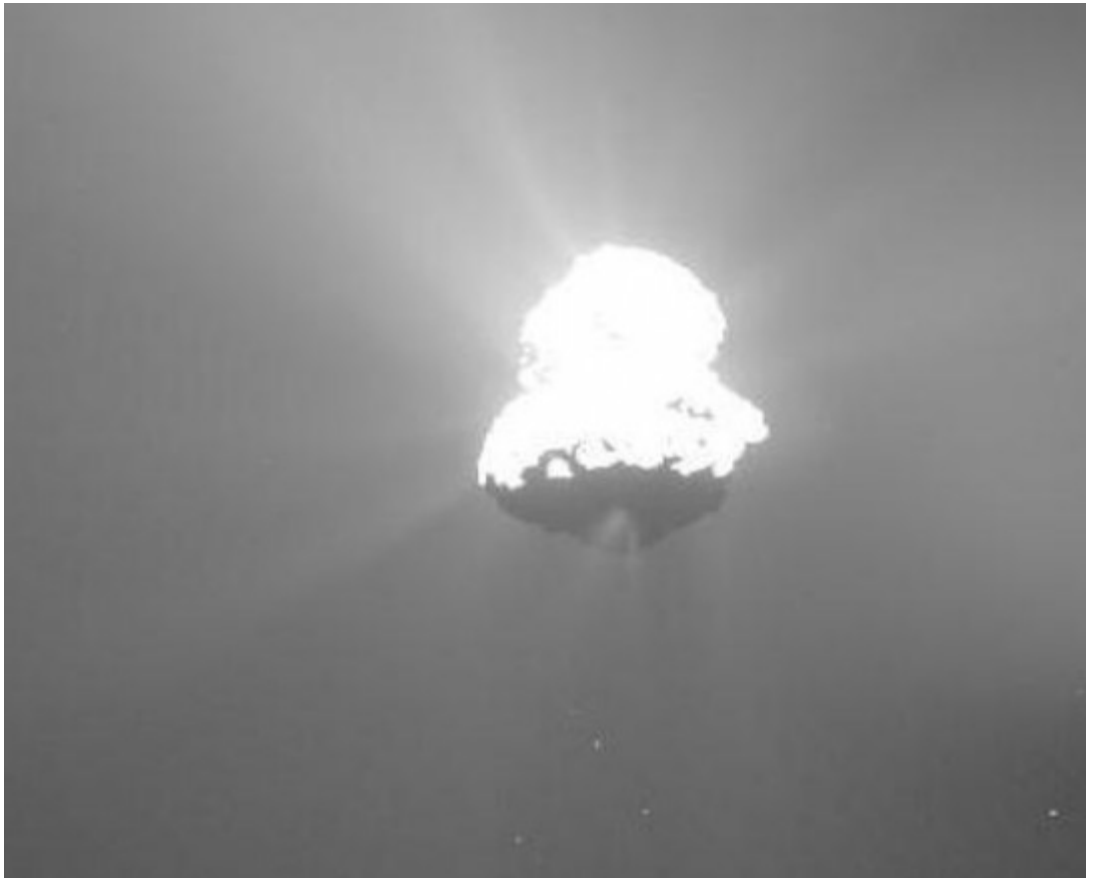
Significant Science by Rosetta at 67P



- In June, the comet was close enough to the sun that it continued to produce jets of gas even where the sun had set.

Photo: ESA

Significant Science by Rosetta at 67P



- In July, Rosetta saw this sudden outburst of dust from the comet.

Photo: ESA

Significant Science by Rosetta at 67P

- The water cycle on comet 67P is not what we thought.
- Sun constantly sublimates ice to water vapor.
- Most water molecules break apart into hydrogen and oxygen.
- It was thought that absorbtion of energy from solar photons drove this cycle.
- Rosetta spectroscopy of water vapor shows UV emission characteristic of electron absorbtion rather than photon absorbtion.
- This suggests that solar energy initially ionizes water molecules, and those free electrons then drive further splitting of water molecules much more than solar energy does.

Significant Science by Rosetta at 67P

Is there life on comet 67P?

- In July, two astronomers published the suggestion that 67P contains life.
- The comet's surface has large amounts of organic compounds.
- This was expected. It has long been theorized that these chemicals formed in deep space and were delivered to the young Earth by comets.
- The new suggestion is that the Sun is constantly evaporating the comet surface, yet new organic compounds are constantly being formed. This could only be the result of biological metabolism.
- Note that these are the same astronomers who believe they have found fossils of life in photos taken on Mars.
- Every other scientist agrees the data do not support a conclusion of life on 67P (unfortunately).

Rosetta's Future

- If Philae can generate enough electricity and communicate reliably, it will be commanded to drill into the surface and measure the chemical composition of the comet.
- After completing its science mission, probably late 2016, ESA plans to attempt to land Rosetta itself on the surface of the comet.

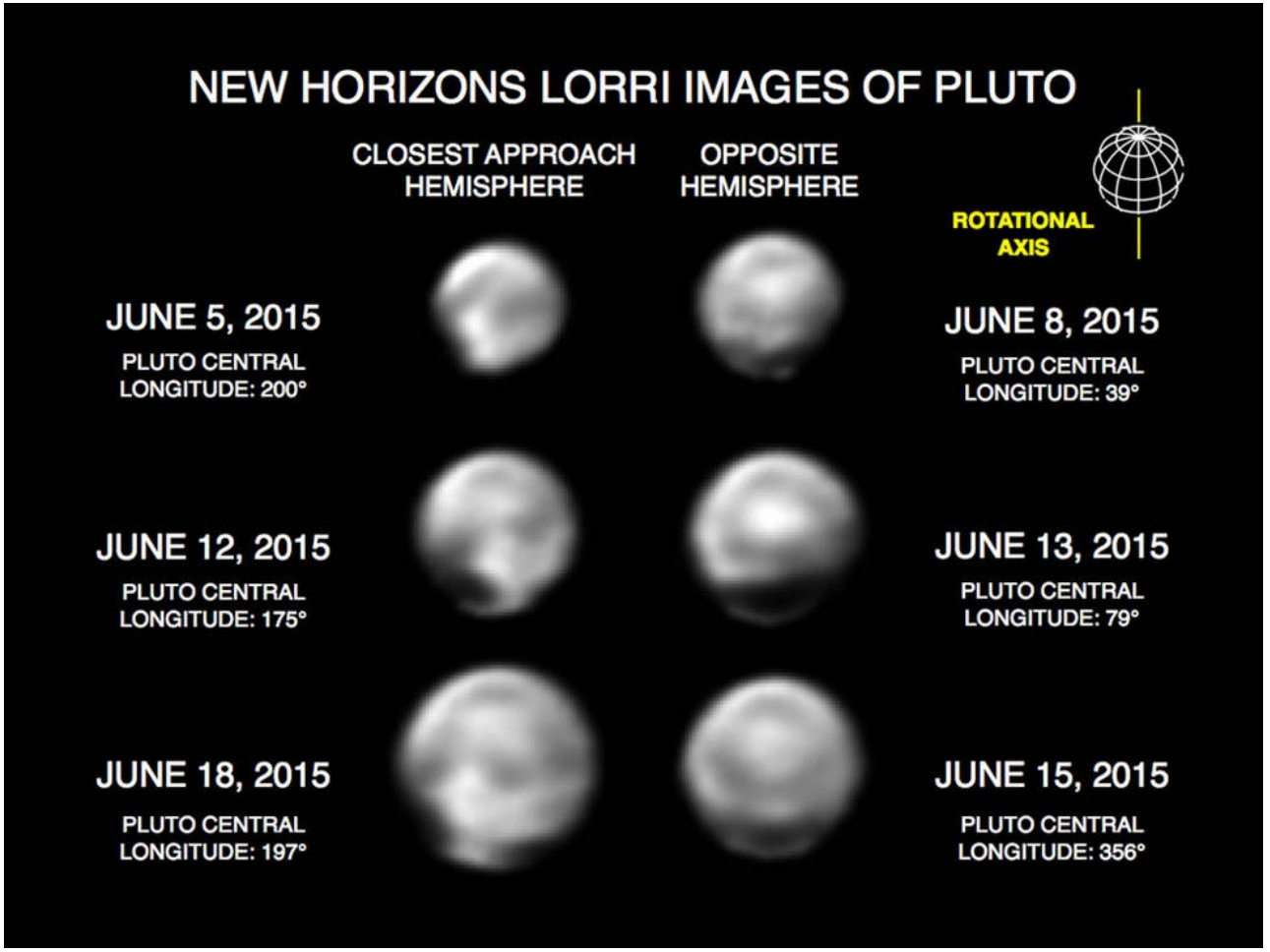
New Horizons

- Launched January 2006.
- Fastest launch speed of any spacecraft.
- Current final speed second only to Voyager 1.
- February 2007 flyby of Jupiter and gravity assist.
- Planned high speed flyby of Pluto July 14 2015.
- Photos and sensor data during flyby.

- NASA used Ice Hunters program to solicit public suggestions for more targets after passing Pluto.
- The actual next target was found in a survey by Hubble Space Telescope.

Photo: NASA

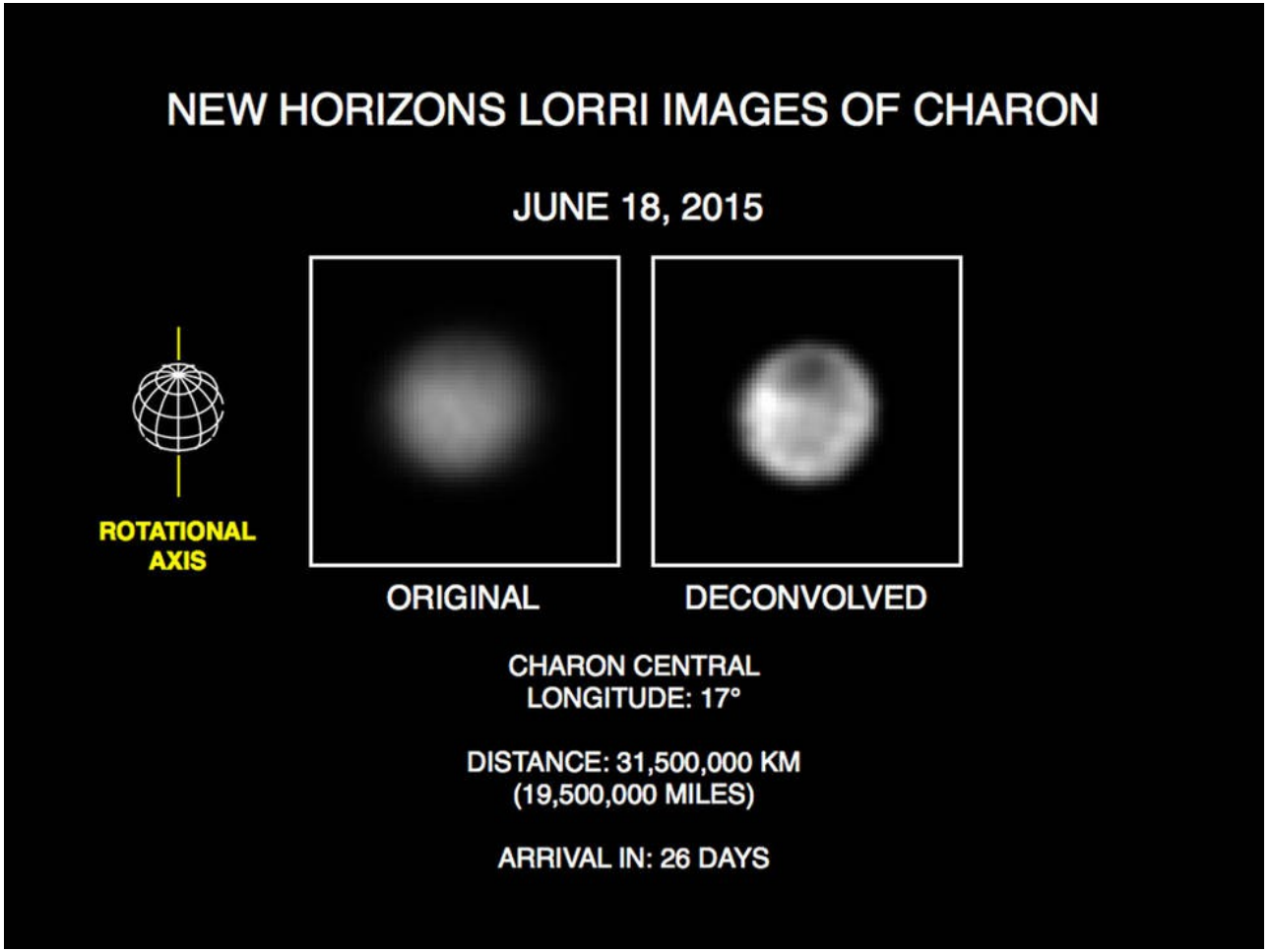
Significant Science by New Horizons at Pluto



- In June, New Horizons took the closest, highest resolution images ever of Pluto.

Photo: NASA

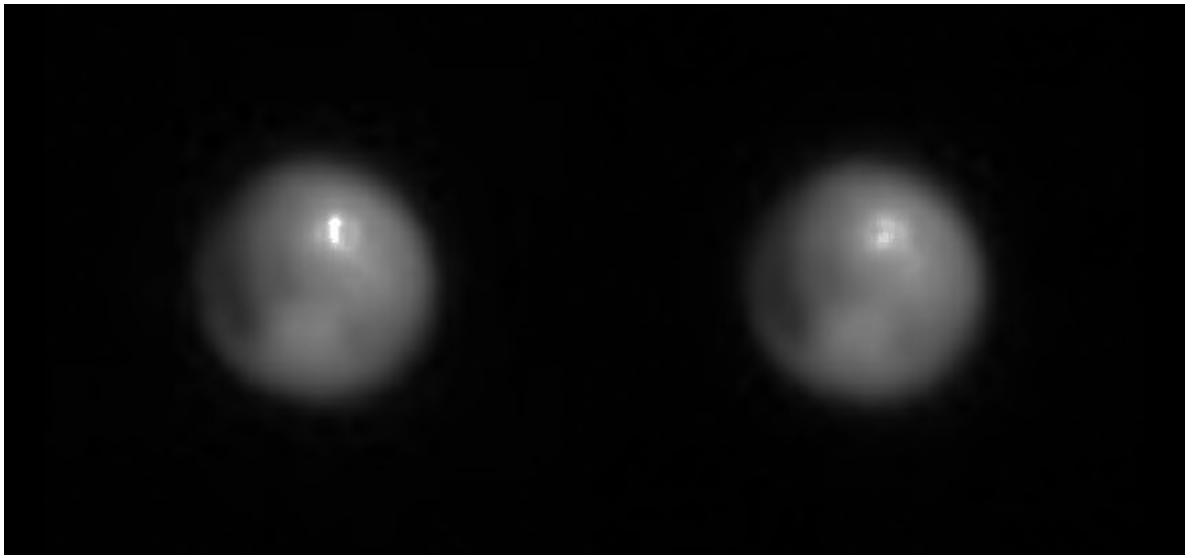
Significant Science by New Horizons at Pluto



- In June, New Horizons took the closest, highest resolution images ever of Charon.
- Charon is unexpectedly brighter than Pluto, and has a dark spot at its north pole.

Photo: NASA

Significant Science by New Horizons at Pluto



- Something is changing on Pluto. This bright spot at the North Pole is twinkling.
- These two photos were taken 30 minutes apart.

Photo: NASA

Significant Science by New Horizons at Pluto

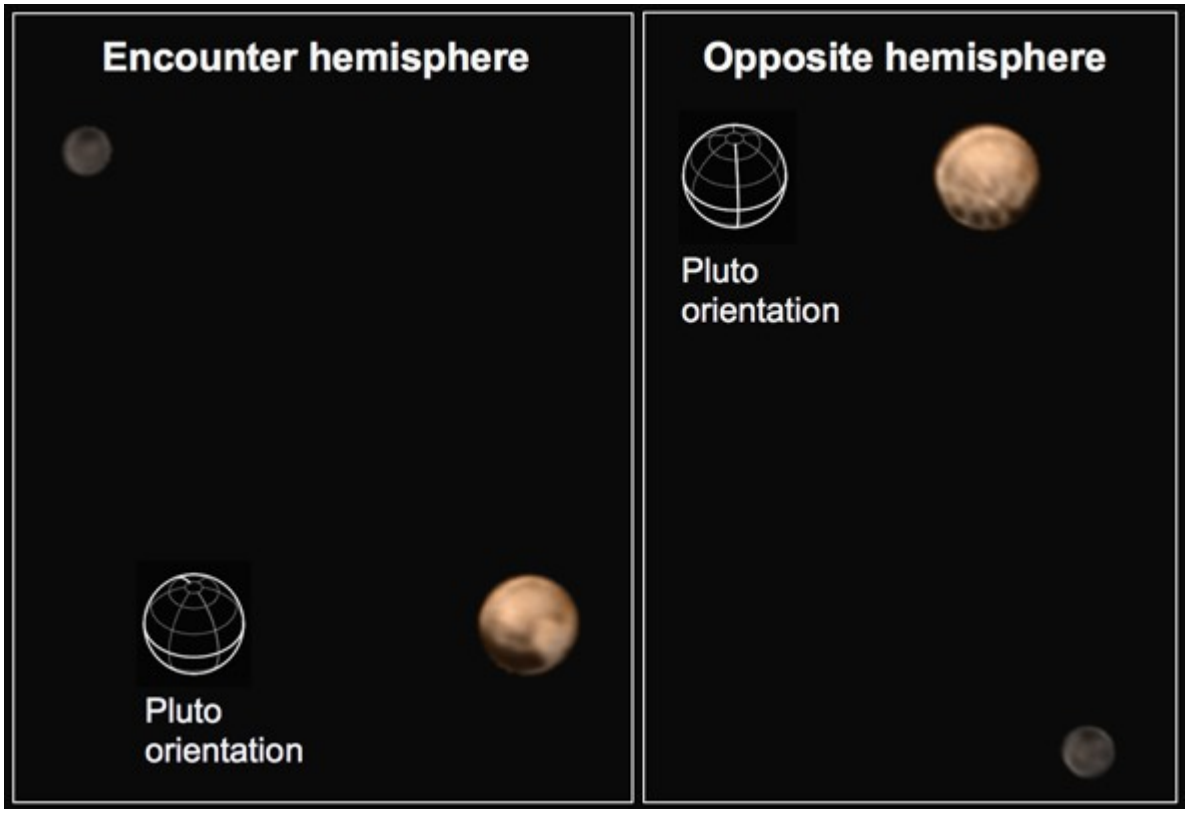
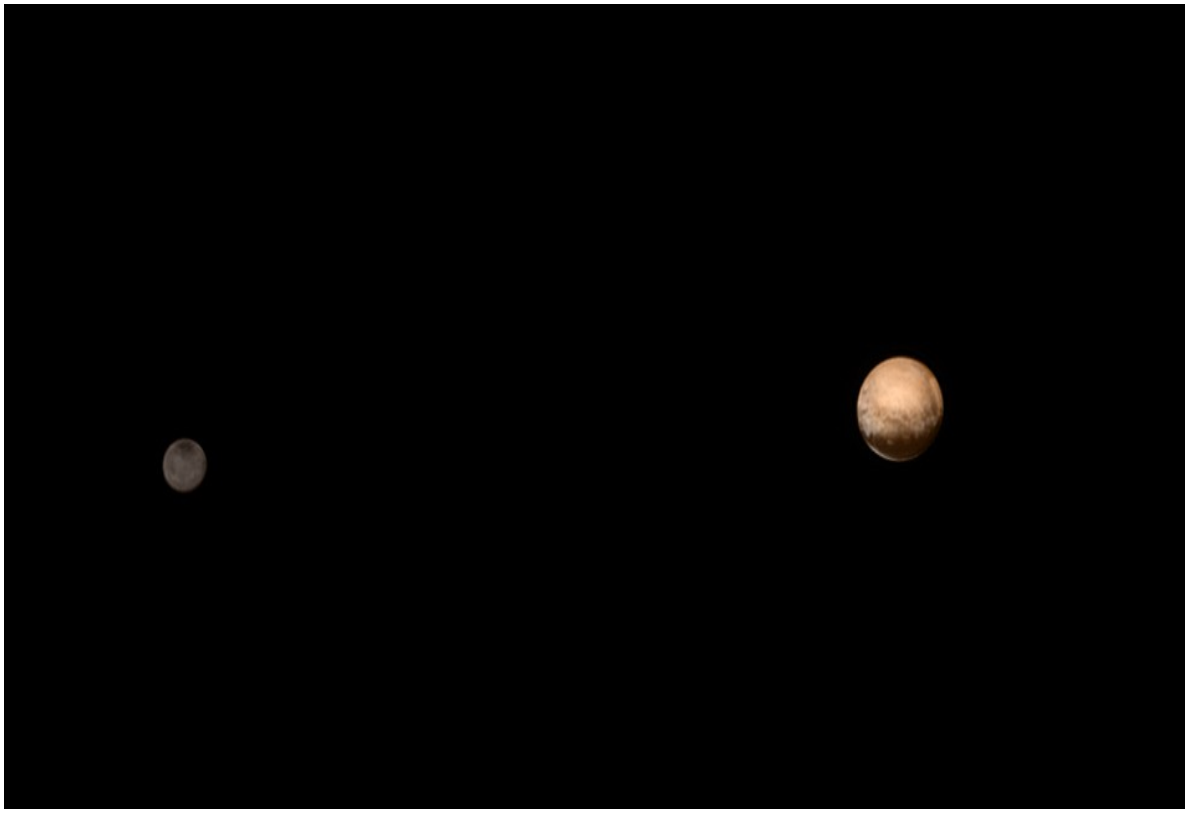


Photo: NASA

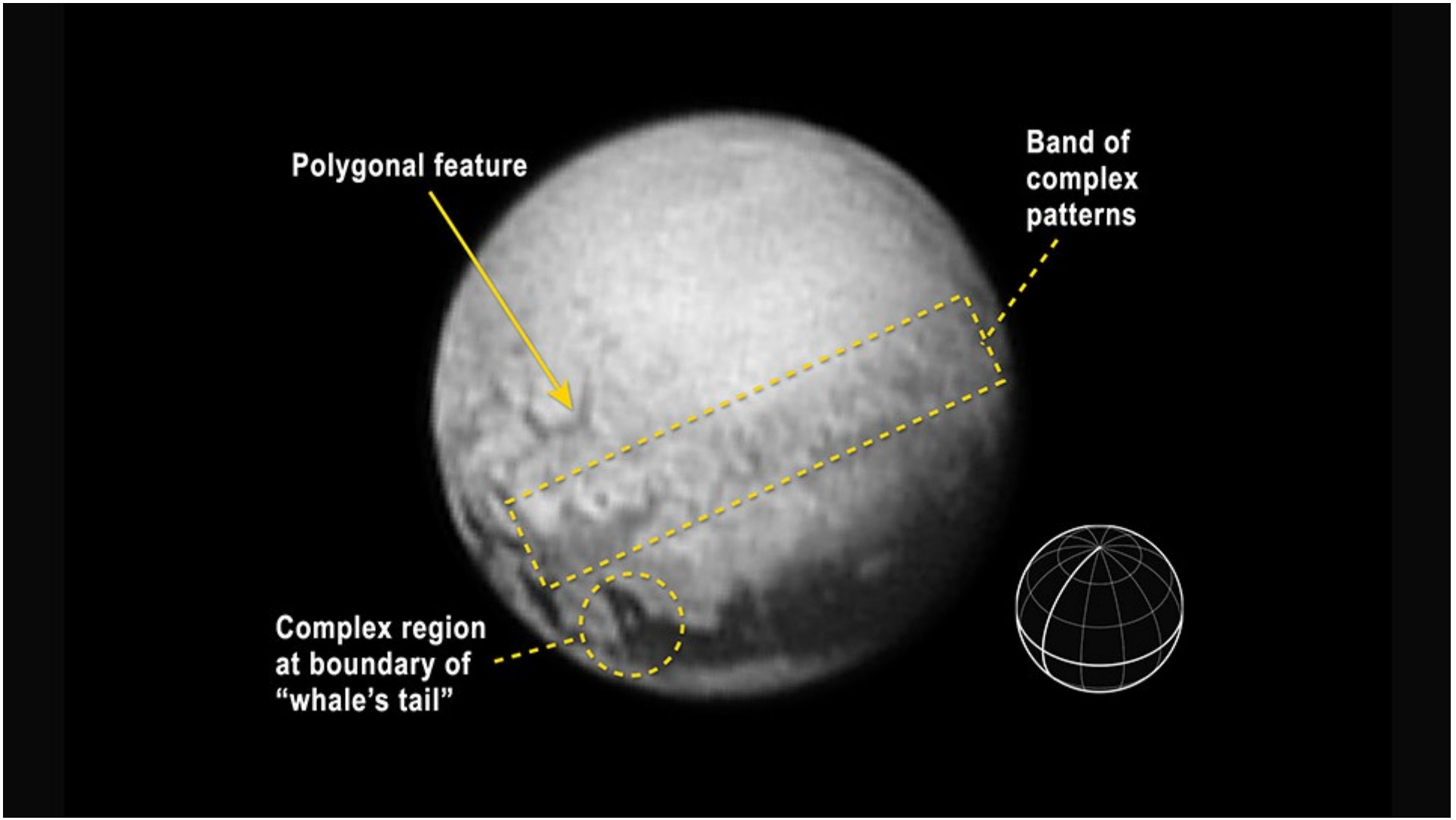
- New Horizons on June 27 began returning color photos.
- In the right-hand photo Pluto has an unexplained set of parallel straight lines.
- Pluto and Charon are remarkably different colors and reflectivity.
- Until 1990 the two were thought to have similar composition. Studies of eclipses showed Pluto is more rocky, Charon more icy.

Significant Science by New Horizons at Pluto



- New Horizons on July 4 experienced a software error in the timing of two processes, and put itself into safe mode for 81 minutes.
- Several days of science lost while NASA returned the probe to normal operation.
- On July 8 returned this photo of Charon and Pluto. Photo: NASA

Significant Science by New Horizons at Pluto



- July 9 New Horizons returned this photo showing geological features on Pluto.

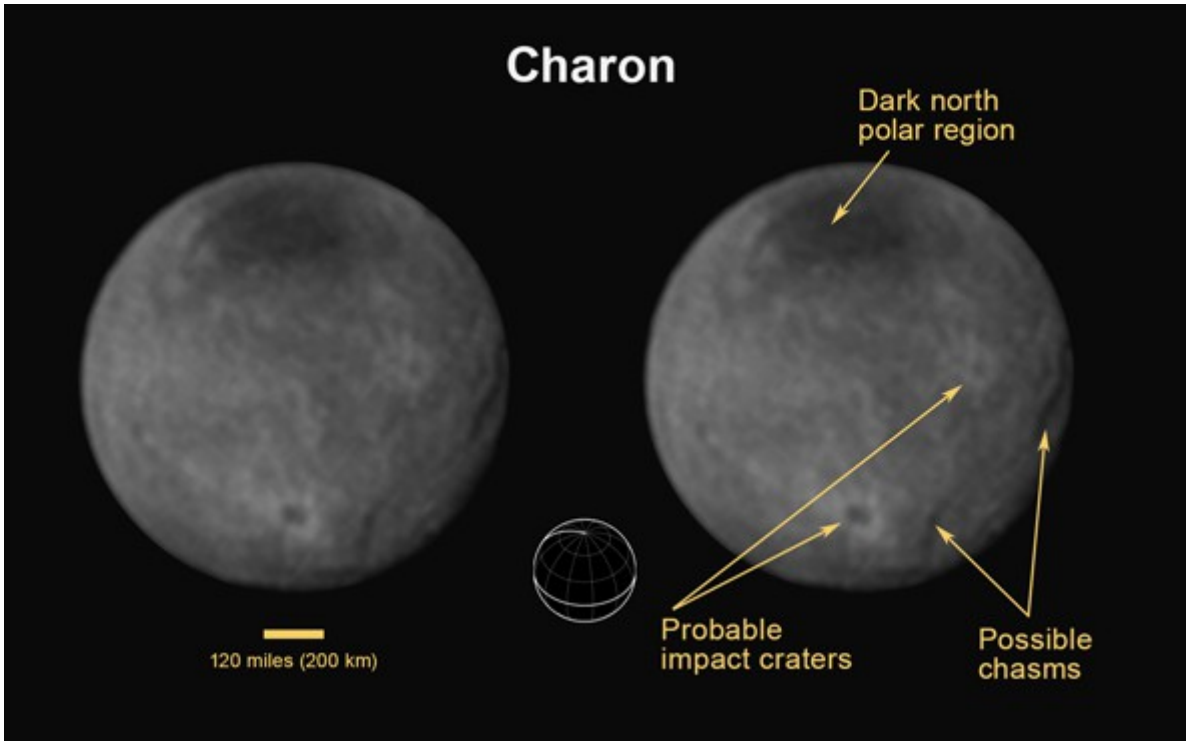
Photo: NASA

Significant Science by New Horizons at Pluto

- July 11 New Horizons returned this photo showing more details on Pluto. We now have a more accurate diameter for Pluto. It is larger than Eris, and less dense than thought, meaning less rocky and more icy.

Photo: NASA

Significant Science by New Horizons at Pluto



- July 11 New Horizons returned this photo showing more details on Charon.
- New Horizons detected traces of Pluto's atmosphere while farther away than the orbit of Charon. That means Pluto and Charon share an atmosphere.

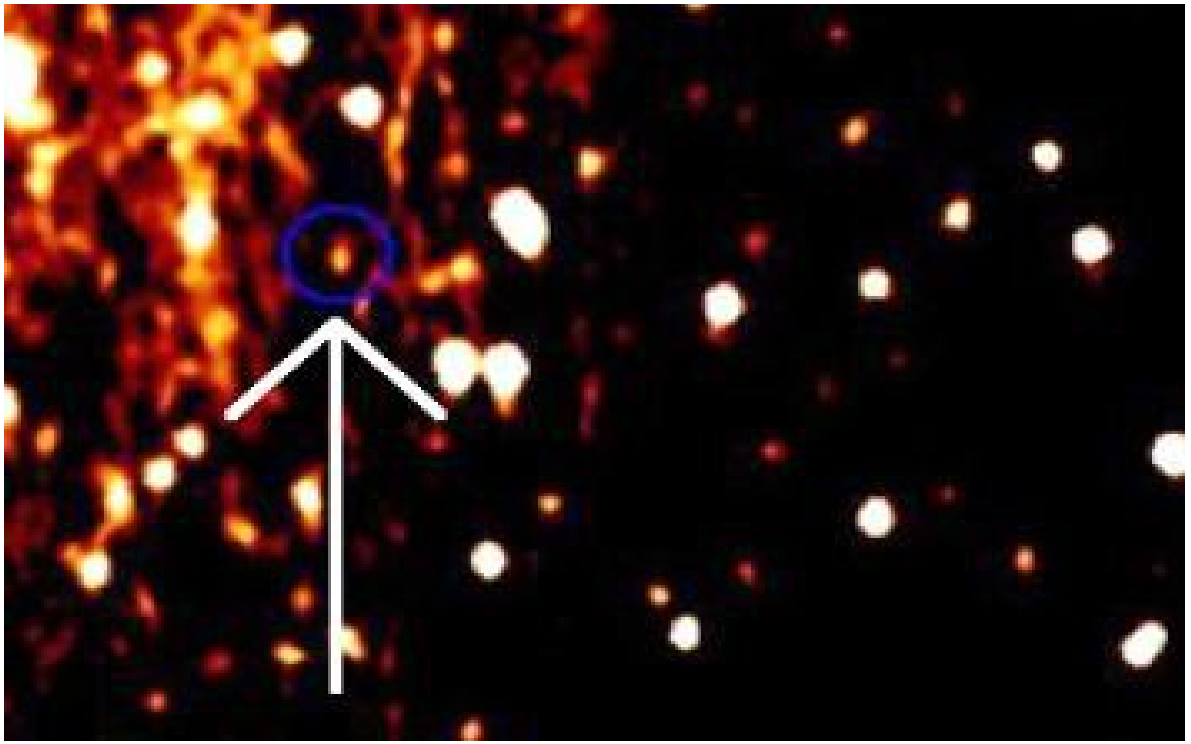
Photo: NASA

Significant Science by New Horizons at Pluto

- July 13 Just before its closest approach New Horizons returned this photo of Pluto.

Photo: NASA

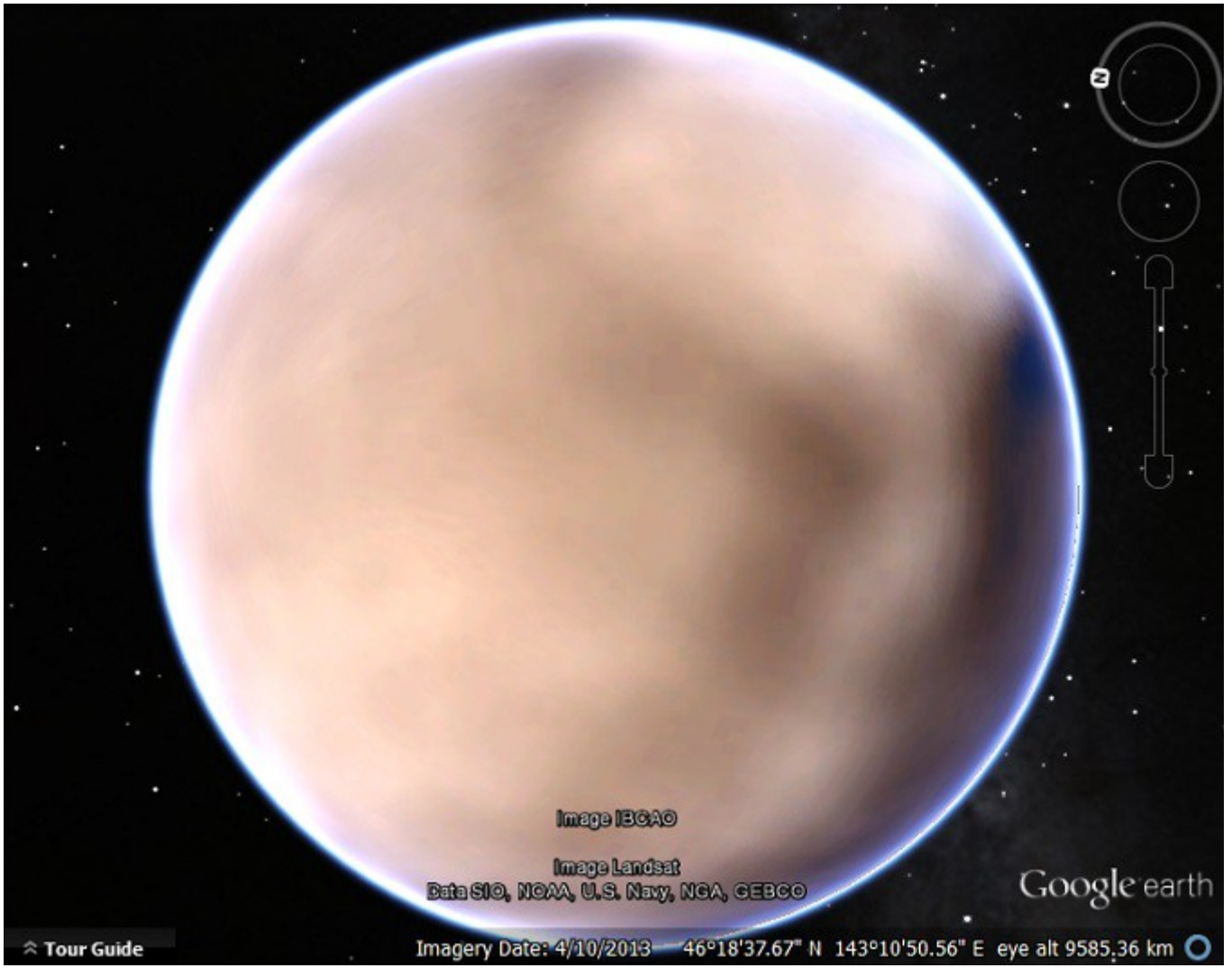
New Horizons even has Rosetta interested



•July 12 Rosetta returned this photo of Pluto

Photo: ESA

Significant Science by New Horizons at Pluto



- July 2015 Google added Pluto to Google Earth, using New Horizons images.

Image: Google

Significant Science by New Horizons at Pluto

- Since this program is scheduled to be given the day after New Horizons' closest approach, we should check the Web now for exciting new updates since I started talking.

Bibliography and References

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- Philae. https://en.wikipedia.org/wiki/Philae_%28spacecraft%29
- Pluto. https://en.wikipedia.org/wiki/Pluto
- Rosetta. http://rosetta.esa.int/
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- Vesta. https://en.wikipedia.org/wiki/4_Vesta