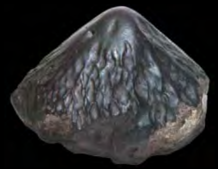
Small bodies: Lecture 5

Asteroids
and meteorites

Asteroid Gaspra,
11 x 12 x 19 km



Meteorite Karakol
Ordinary chondrite
6 x 6 cm

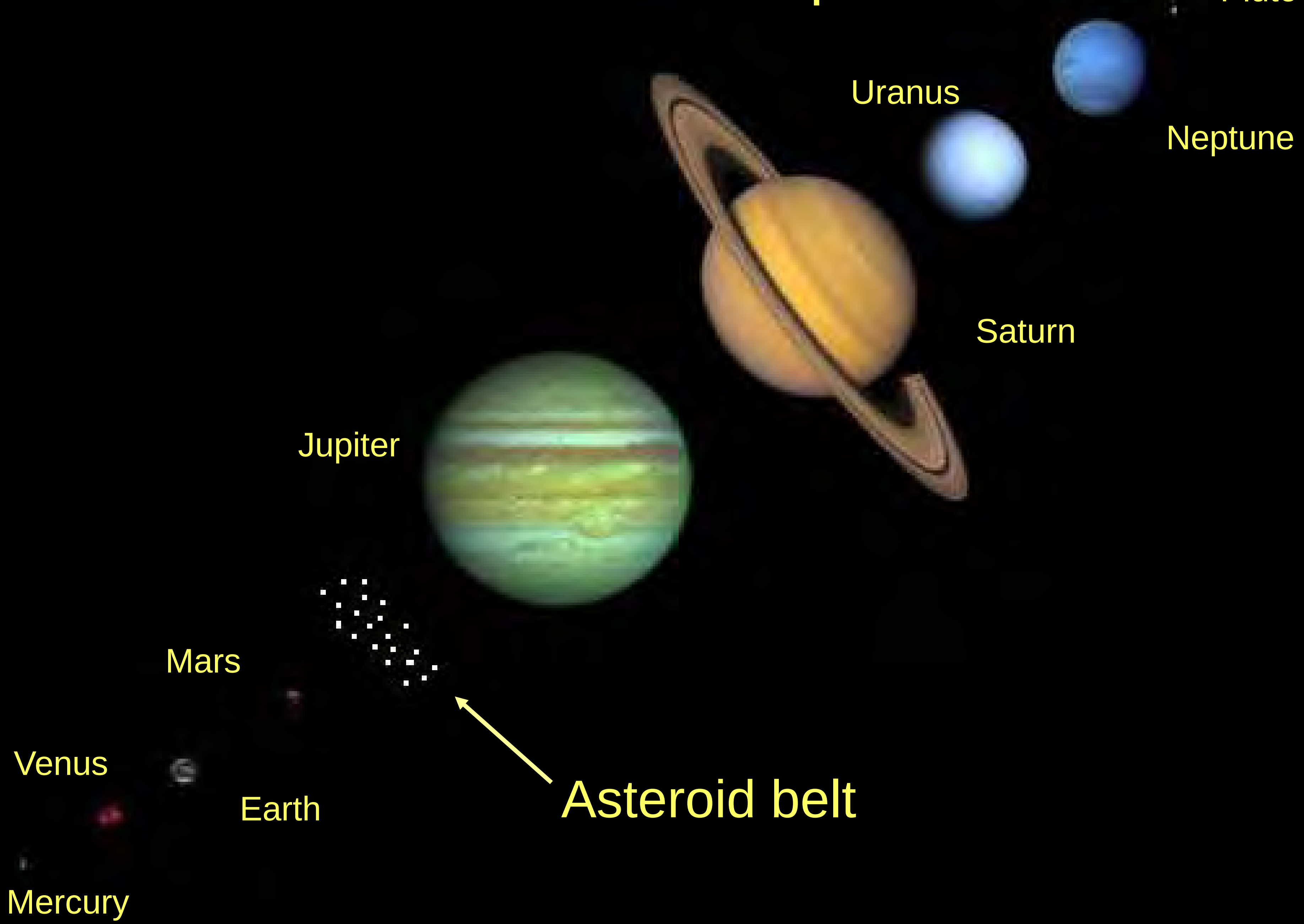
Comets

Comet Halley,
7 x 8 x 16 km

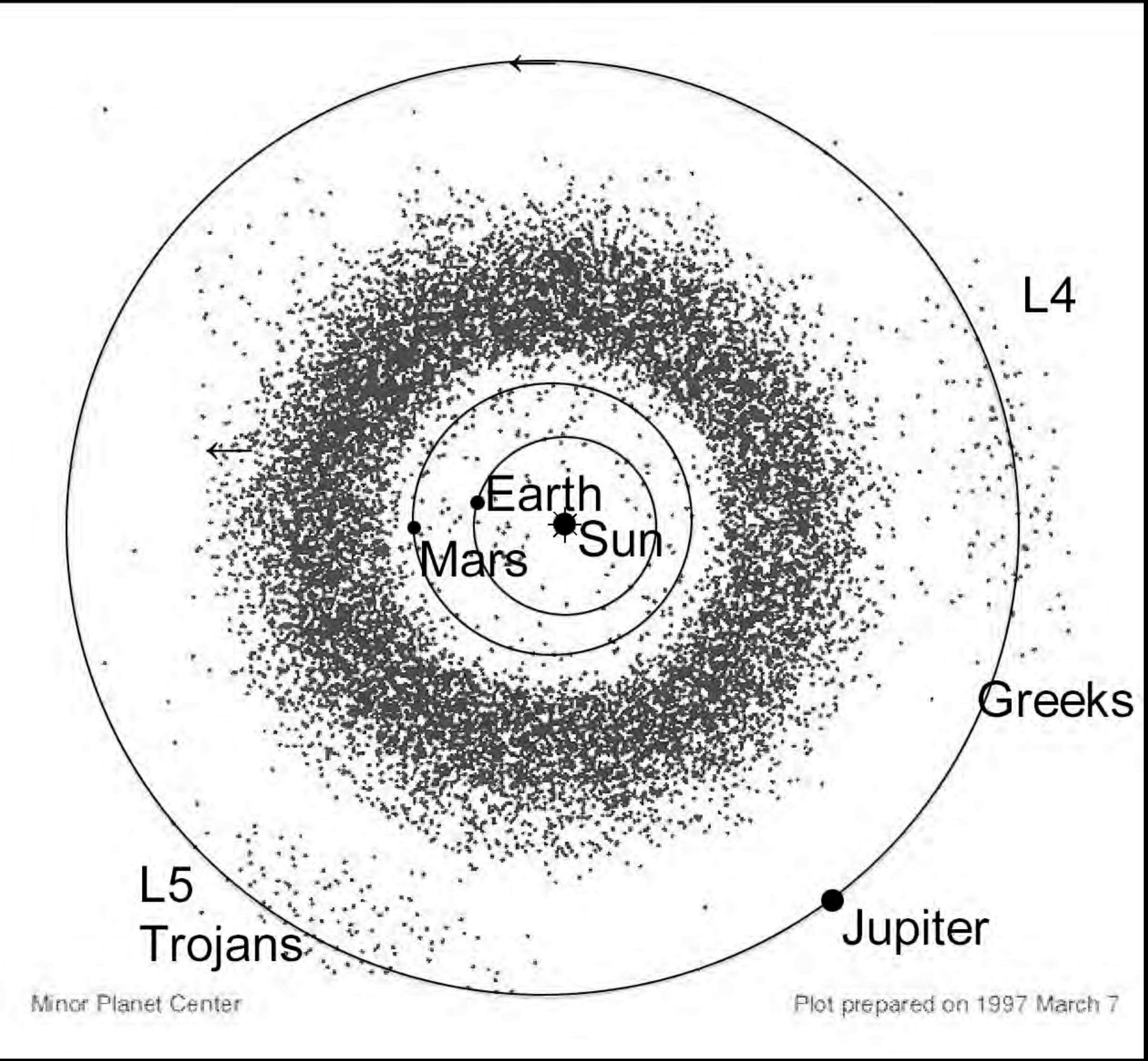
Small satellites
of planets

Phobos – satellite of Mars
18 x 22 x 26 km

Asteroid belt and 9 planets



Asteroids = small planets, orbit around the Sun



Asteroid belt,
2.2 – 3.2 a.u.
from the Sun,
Orbital period
3 – 7 years.

Trojans – on the orbit
of Jupiter 60º arc
ahead and behind,
orbital period
12 years.

Near-Earth asteroids
– approach orbit of
Earth or cross it.
- dangerous because of
possible collisions with Earth

Most of asteroids are in the asteroid belt.

Asteroids, cont.

Number of bodies with D > 1 km in the asteroid belt is estimated to be 1.1 to1.9 million. As of November 2014, 11,600 near-Earth asteroids are known.

Total mass of asteroids ~ 5% M Moon

Largest asteroids:		albedo		
Ceres	D = 1020 km,	5 %	-	Dwarf planet
Vesta	550 km	23 %		
Pallas	538 km	8 %		
Hygiea	450 km	4 %		

Number of asteroids larger than 100 km = 237

Major spectral types of asteroids and suggested meteorite analogs:

Type	E	Albedo	>23 %	Enstatite chondrite
	S		7-23 %	Ordinary chondrite
	M		7-20 %	Iron, Iron-stone.
	V		3 - 8 %	Eucrite / basalt
	C		2-7 %	Carbonaceous chondrite

Asteroid Gaspra, type S

9 x 11 x 18 km

Orbit semiaxis 2.2 au
Aphelion 2.6 au
Perihelion1.8 au
Density 2.7 g/cm^3 (estimate)
g = 2 mm/s^2
V escape = 6 m/s
Rotation period 4.63 h

The body shape - angular, «fragmental». Weak color variations

Снимок Galileo

Surface features:
Craters - impact,
Furrows - fractures in asteroid body.

Crater estimated surface age = 20 - 300 million years.

Time of collisional destruction at 2.2 au = 200 my – 1 by.

Veverka et al., 1994

Asteroid Ida, type S

15 x 24 x 54 km

Orbit semiaxis 2.9 au
Aphelion 3 au
Perihelion 2.7 au
Density 2.6 g/cm^3
g = 11 mm/s^2
V escape = 19 m/s
Rotation period 7 h

The body shape
- angular,
«fragmental».
Weak color
variations

Images Galileo

Surface features:
Craters – impact.

Dactyl
Satellite of Ida
1.2x1.4x1.6 km

Crater estimated surface age > 1 by.

Asteroid Mathilde, type C

46 x 48 x 66 km

Orbit semiaxis 2.65 au
Aphelion 1.9 au
Perihelion1.3 au
Density 1.3 g/cm^3
=> high porosity (50%)
g = 2.5 mm/s^2
V escape = 16 m/s
Rotation period 17.4 days

The body shape - angular, «fragmental».

Surface features:
Craters – impact.

Numerous large craters.

Why not destroyed by
These large impacts?

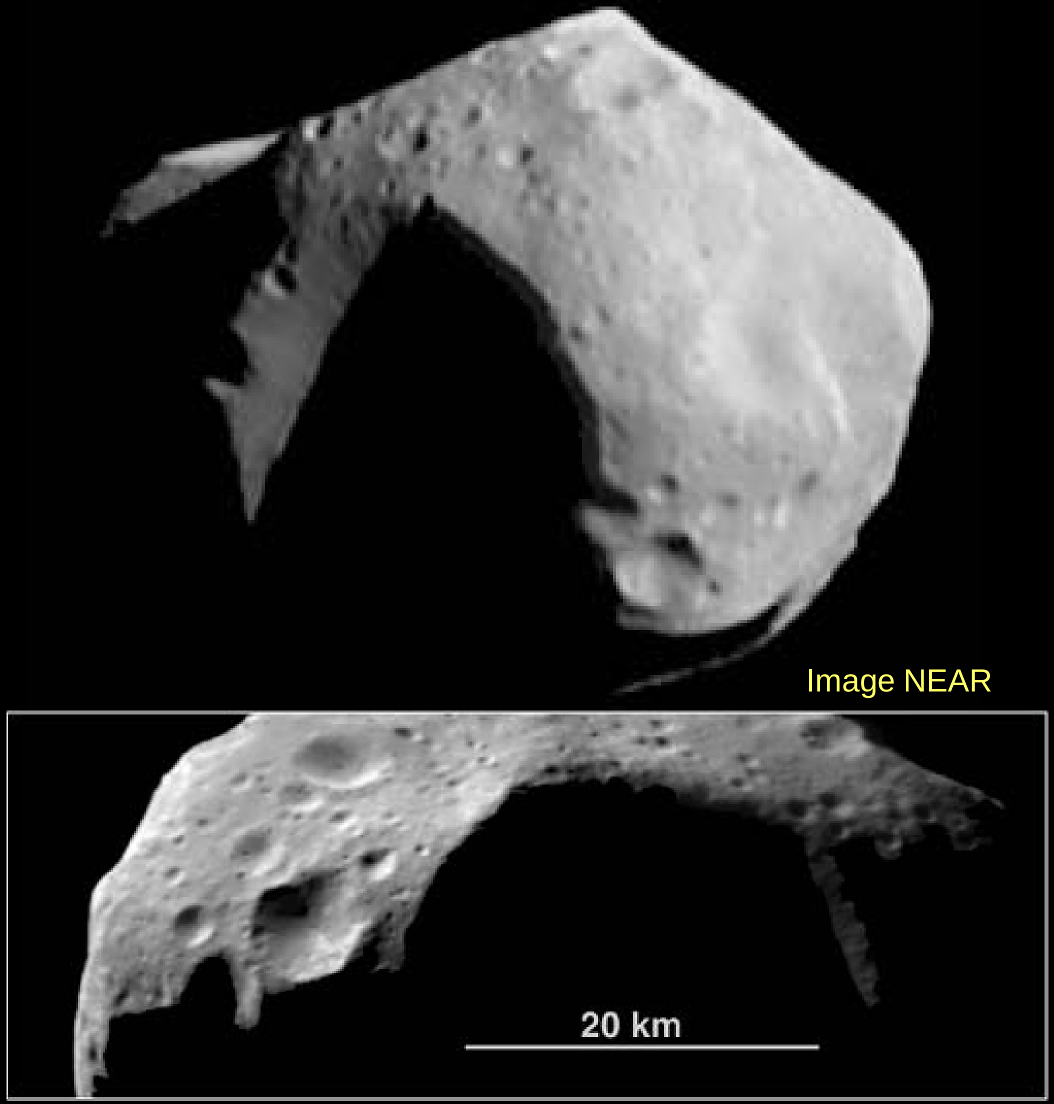


Image NEAR

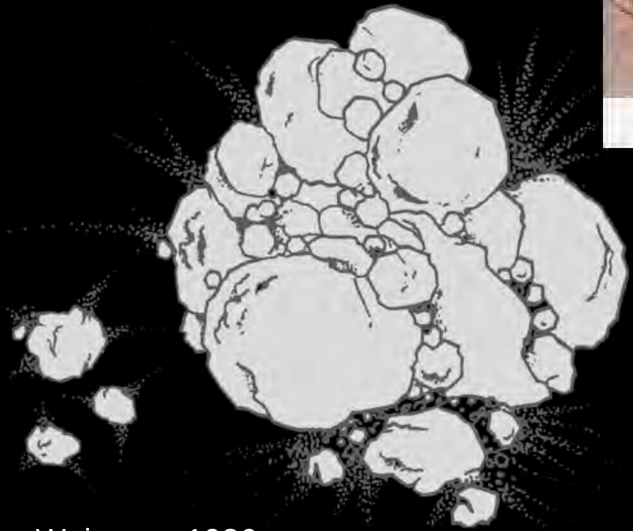
Crater estimated surface age ~ 4 by.

Time of collisional destruction ~4 by. *Wikipedia*

High porosity of Mathilde is, probably, microporosity, but not the «rubble-pile» case .

http://www.popularmechanics.com/science/military/2002/10/tiny_nukes/print.phtml

In the «rubble-pile» case the crater rims would not be co continuous, and the crater shape would not be so close to ideal.



Weisman, 1986

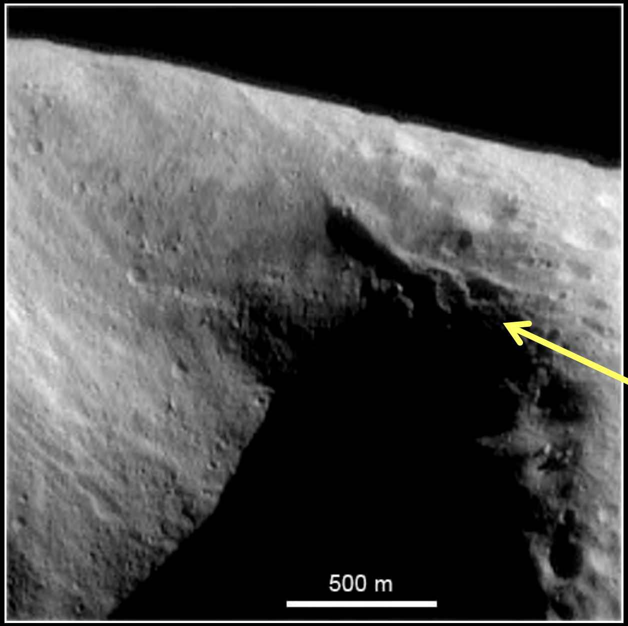
Asteroid Eros, type S

13 x 13 x 33 km

Orbit semiaxis 1.46 au
Aphelion 1.78 au
Perihelion 1.13 au
Density 2.4 g/cm^3
g = 6 mm/s^2
V escape = 10 m/s
Rotation period 5.27 h

Images NEAR

The body shape
- irregular,
«rounded».
Weak color
variations

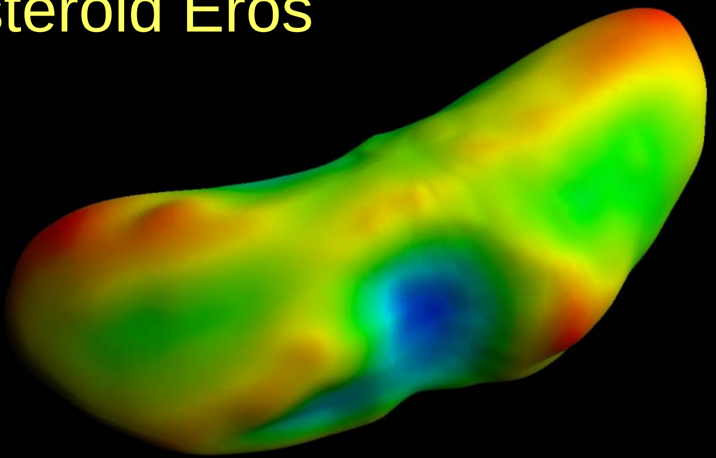


Surface features:
Craters - impact,
Furrows - fractures
in asteroid body.
Ridge of unknown
origin.

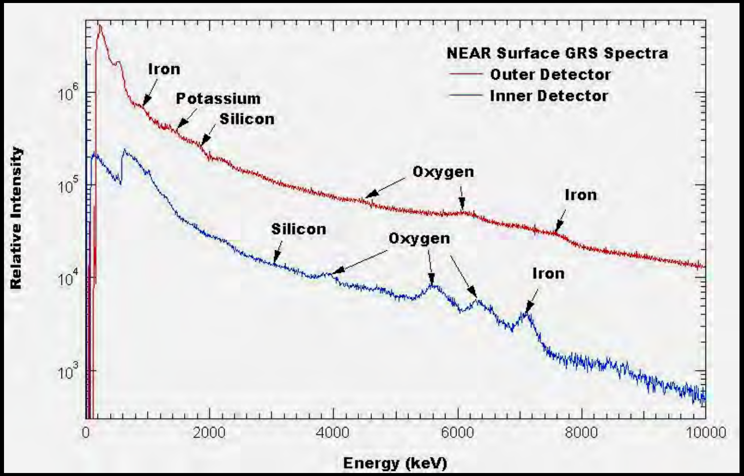
Richardson et al., 2004

Crater estimated surface age = 400 +/- 200 my.

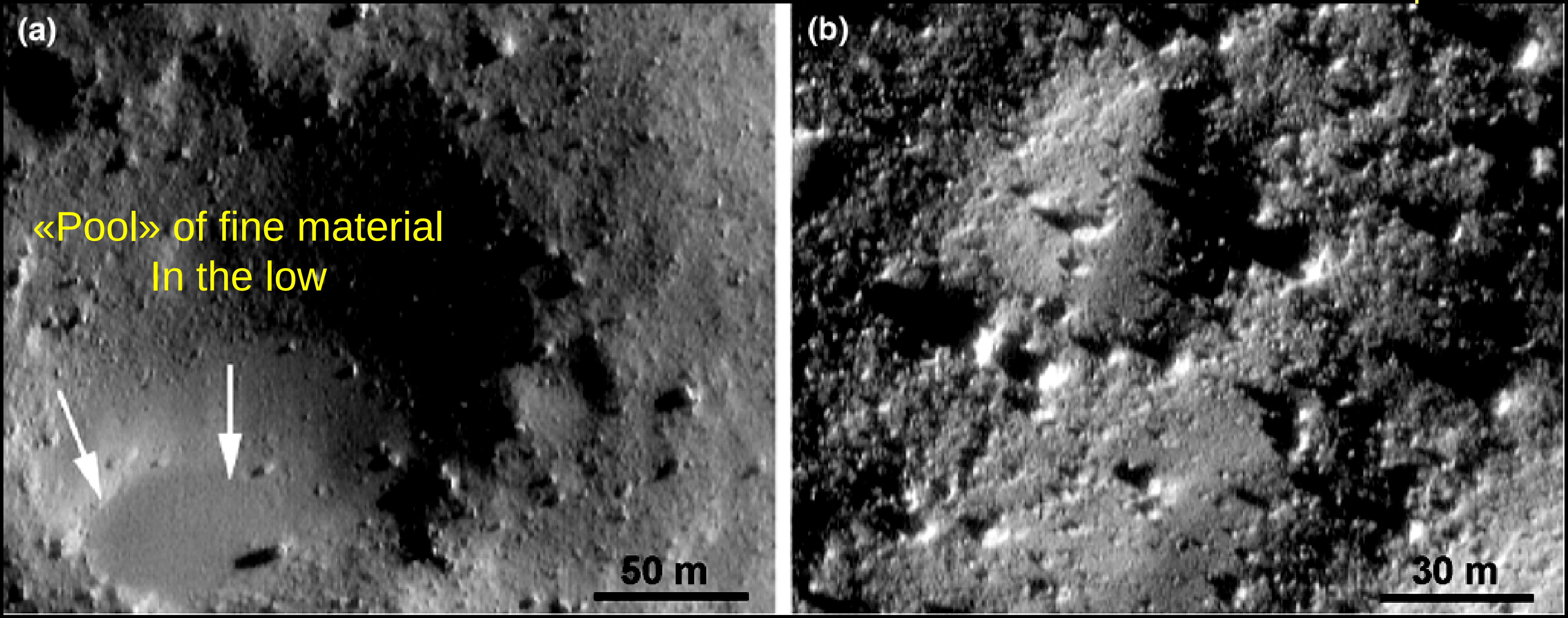
Asteroid Eros



Topography above the mass center



Gamma spectra of Eros: ordinary chondrite with deficit of sulphur



«Pool» of fine material
In the low

Surface features on Eros. Regolith is seen NEAR-Shoemaker images

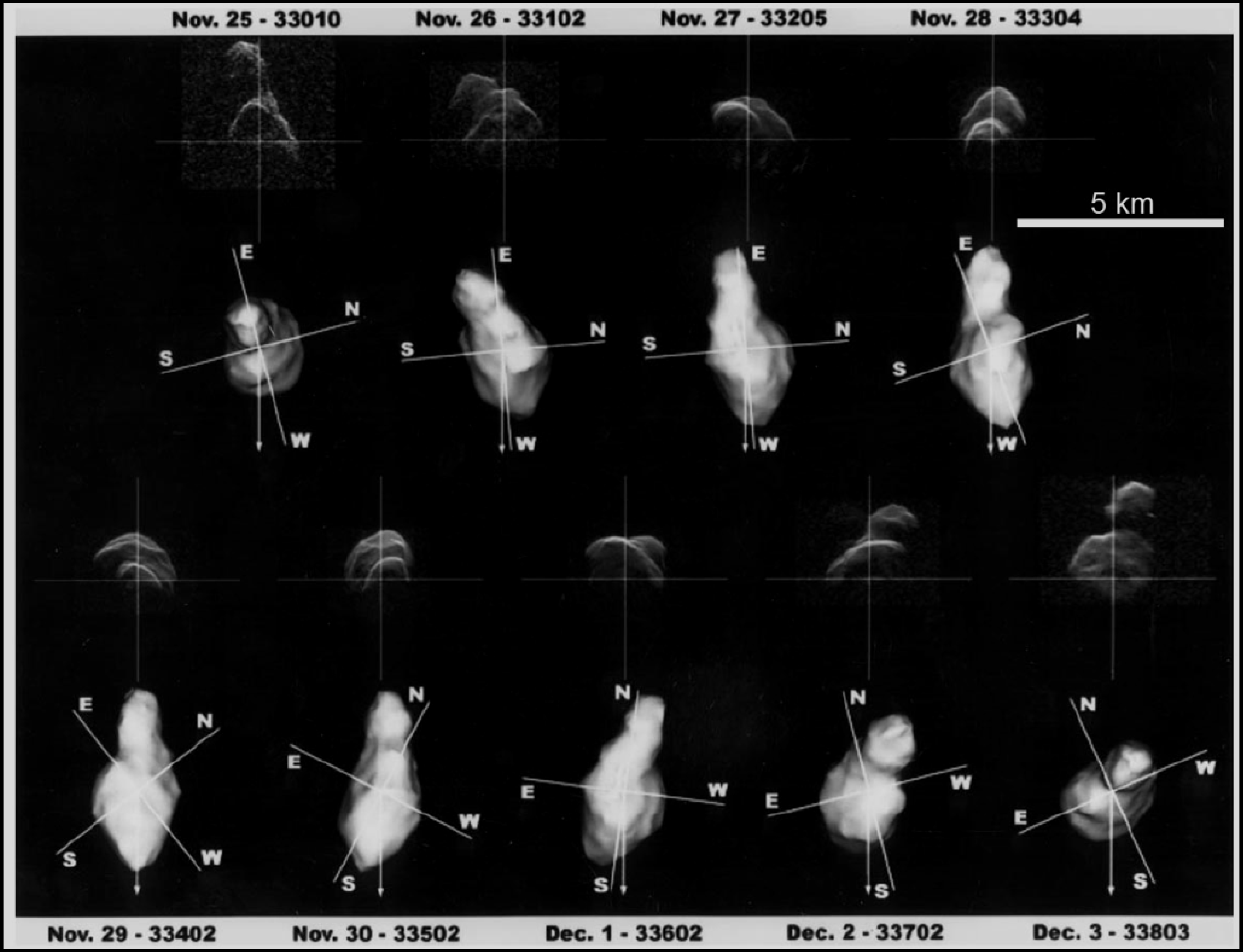
Cheng, Asteroids III, 2003, 351-366

Asteroid Toutatis

1.9 x 2.4 x 4.6 km

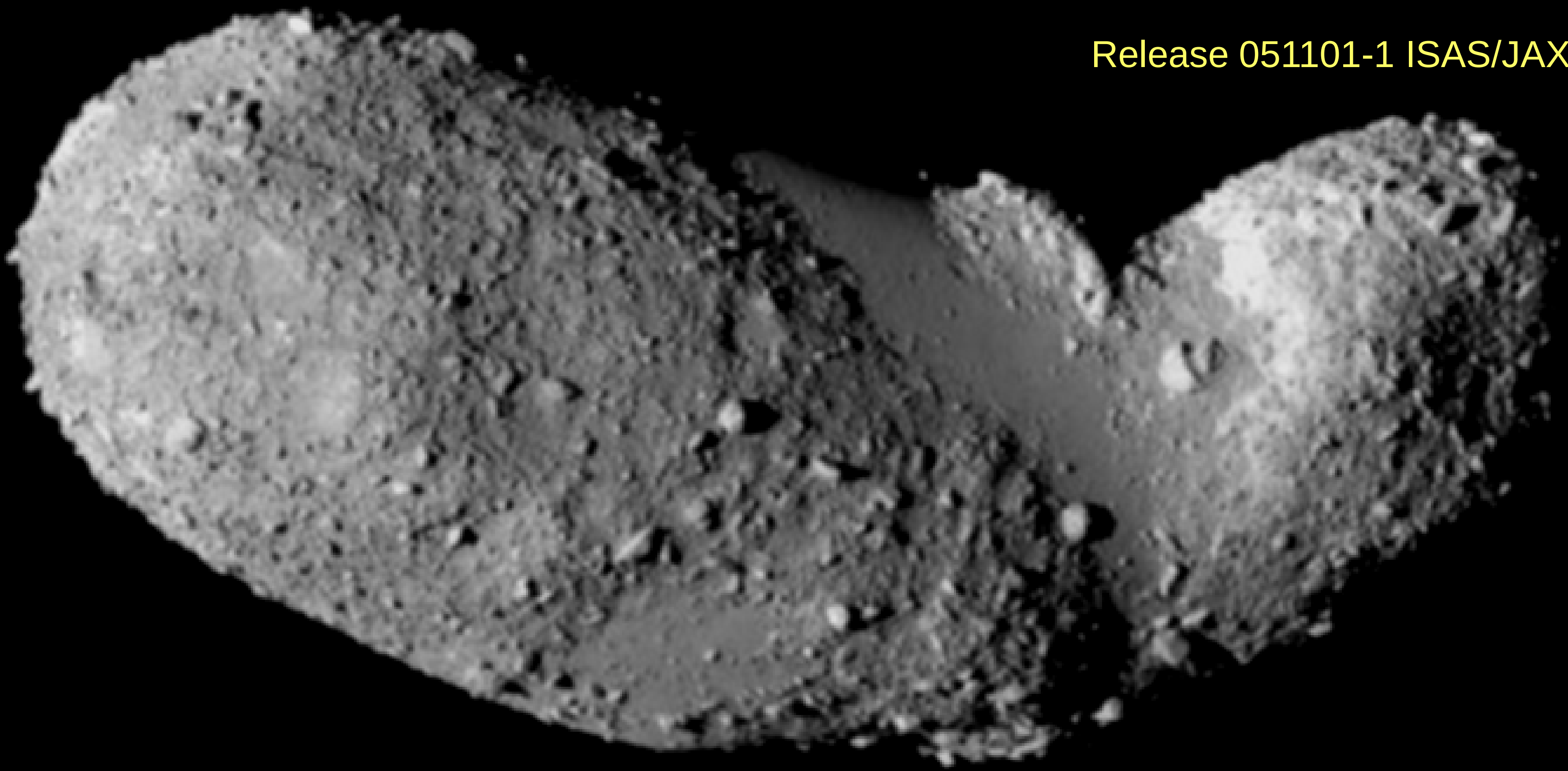
Radar images
And models of body shape

Ostro et al., 1999



Recently flew by Earth at the distance 0.01 au (4 distances to the Moon)

Near-Earth asteroid Itokawa,
550 x 300 x 200 m,
Hayabusa mission, Japan


Release 051101-1 ISAS/JAXA

Consists of two large lobes – kind of rubble pile.
Fine material in gravitational lows. Almost no craters – why?
Mini-samples are brought by Hayabusa – ordinary chondrite.

Asteroid Lutetia

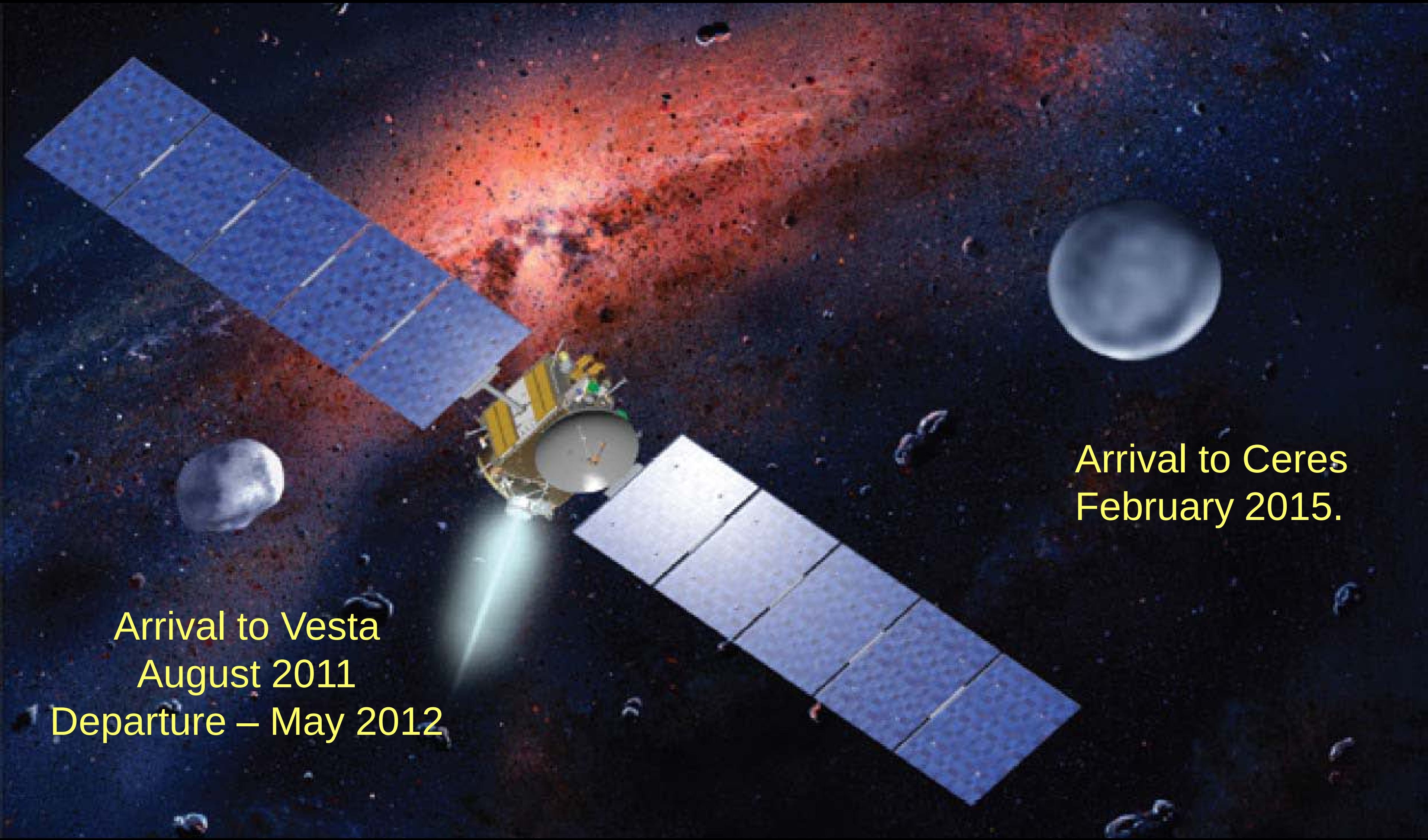
132 × 101 × 76 km

Image of Rosetta, ESA

2010

http://en.wikipedia.org/wiki/21_Lutetia

NASA mission Dawn



Arrival to Ceres
February 2015.

Arrival to Vesta
August 2011
Departure – May 2012

Xenon
ion
engine

Gamma and neutron spectrometer
Mapping spectrometer – visual and IR
Frame TV camera

Transition to planet

Asteroid Vesta

458 x 560 x 578 km

Dawn, NASA

Dwarf planet Ceres

D pol.. = 910 km
D eq.. = 974 km

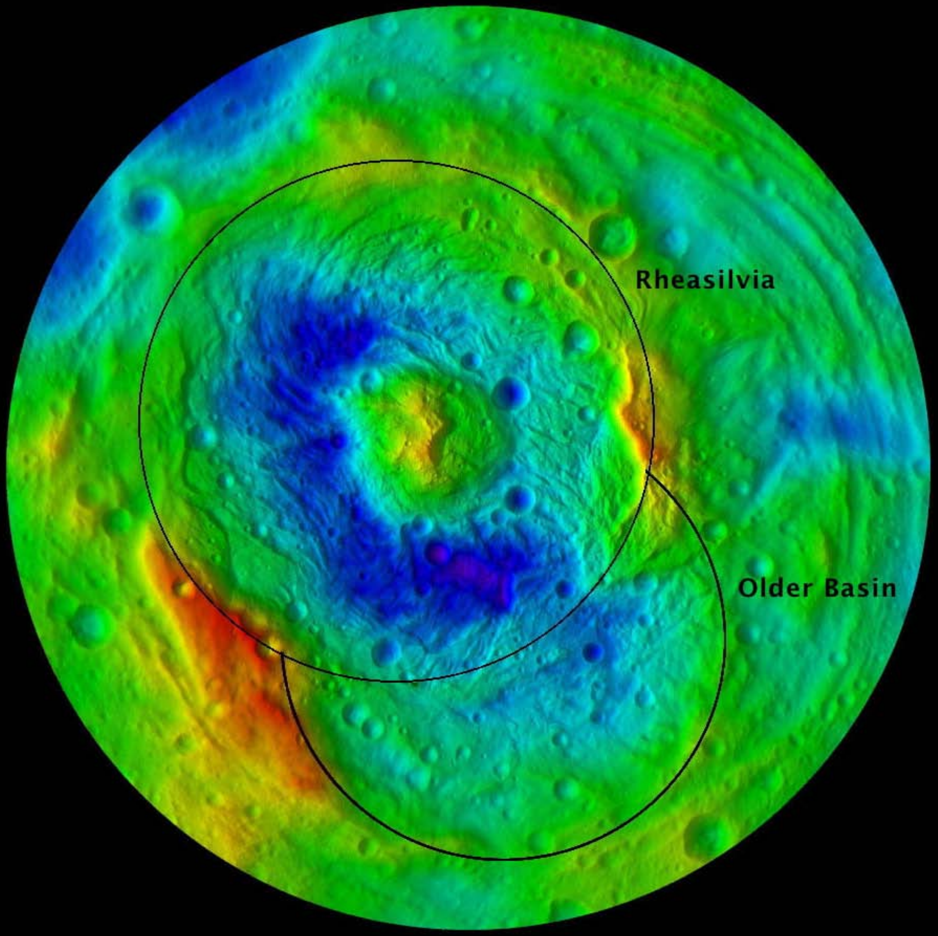
Dawn, NASA

Orbit semiaxis 2.36 au, $\rho = 3.4$ g/cm^3 g = 22 см/с^2, V escape = 350 m/s Rot. period 5.33 h Albedo 0.42, Spectral type V Source of achondrites?	Orbit semiaxis 2.77 au, $\rho = 2.14$ g/cm^3 g = 27 см/с^2, V escape = 510 m/s Rot. period 9 h Albedo 0.09, Spectral type c Source of carbonaceous chondrites?

Asteroid Vesta:

Heavily cratered, Composition achondritic

Image taken by Dawn and digital terrain model
of the south pole area

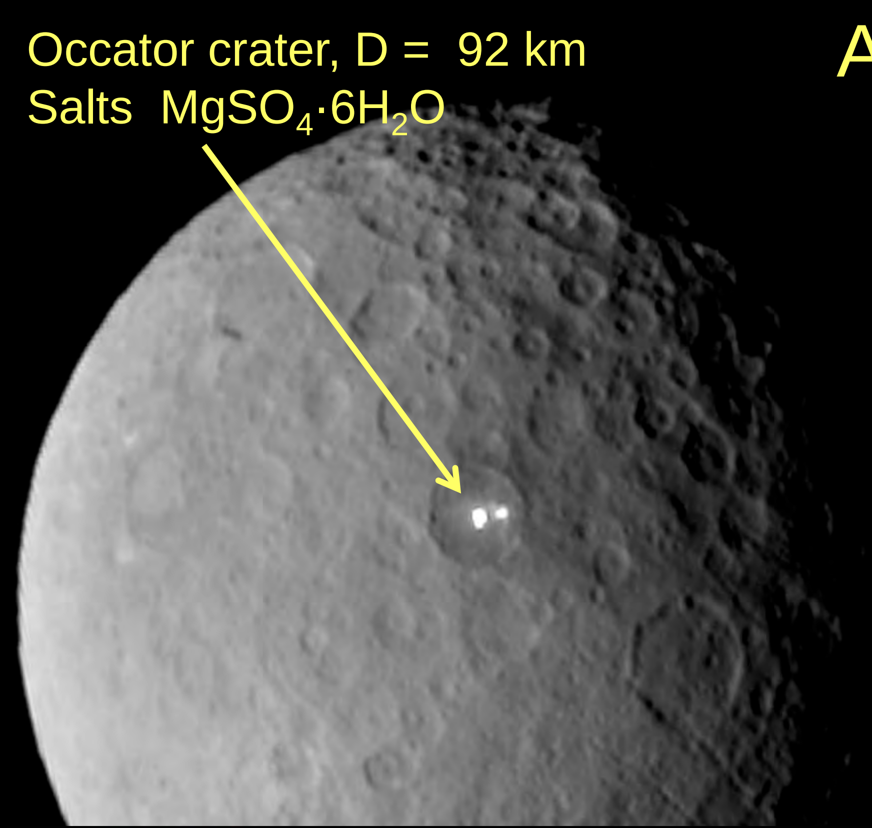


Colorized shaded-relief map showing identification of older 375-kilometer-wide impact basin beneath more recent Rheasilvia impact structure

Asteroid (dwarf planet) Ceres

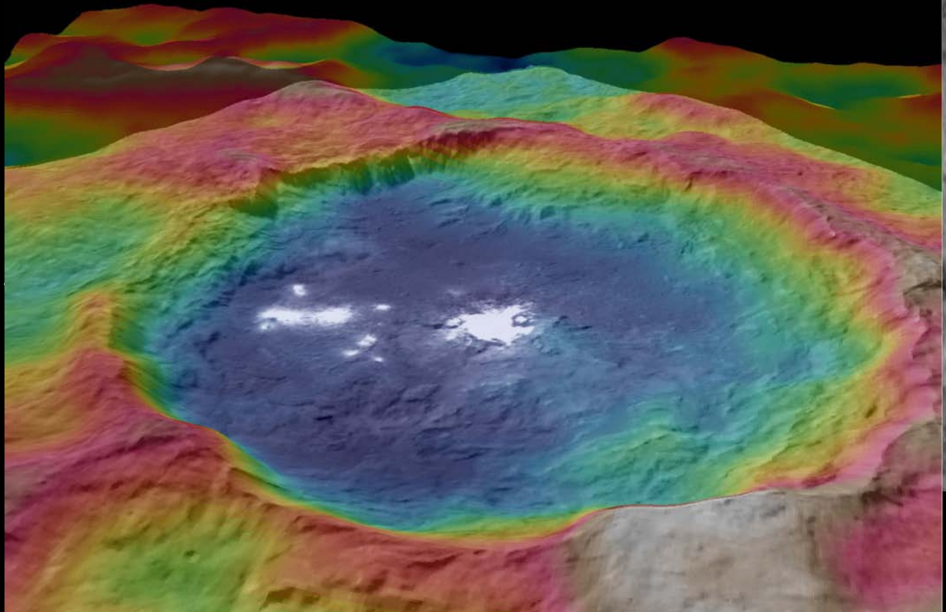
Heavily cratered

Composition carbonaceous chondrite



Occator crater, D = 92 km

Salts $MgSO_4 \cdot 6H_2O$



Ahuna Mons, 6 km high, 15 km wide
origin unknown

Meteorites - Stones falling from the sky

During the passage through the atmosphere the surface layer Is melted and blown out (ablated).

Because way through atmosphere is short in time, the meteorite interior is not heated

Ordinary chondrite Karakol. Melted crust is seen as well as traces of ablation.

During the passage through atmosphere hot surface of meteorite and products of its vaporization are light radiating – bolide.

Photographing way of bolide, one can calculate a trajectory of meteorite before it entered the Earth’s atmosphere.

The calculations show that meteorites come from the asteroid belt

A piece of iron meteorite Canyon Diablo whose impact formed crater Meteor. Meteorite collection of RAN.

http://www.solarviews.com/raw/earth/meteor.jpg

Impact crater Meteor (D = 1.2 km), Arizona.

Iron meteorite Needles. One can see Widmanstetten structure - evidence of very slow cooling in The interior of rather large body.

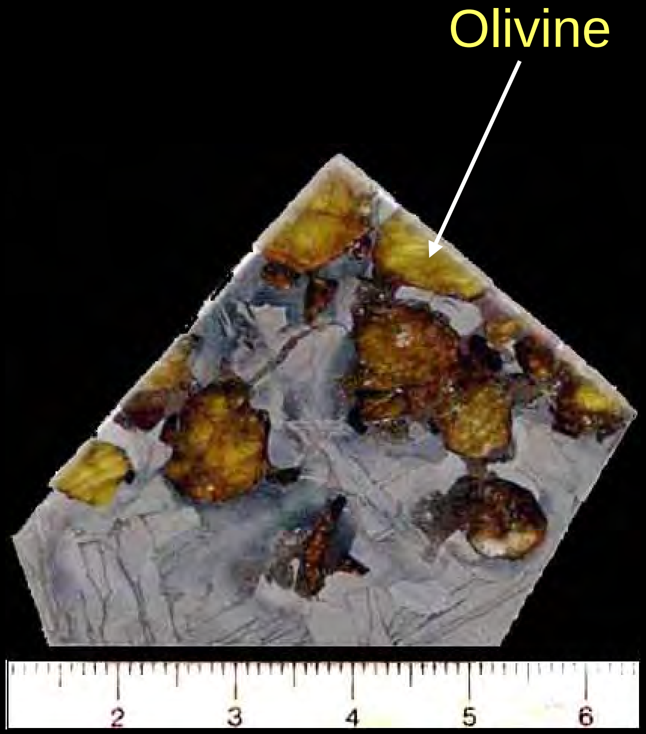
Meteorite collection of RAN

Iron meteorites – fragments of asteroids of M type, which are fragments of iron cores of large asteroids

Iron-stony meteorites

Pallasovo zhelezo, Russia

Meteorite collection of RAN



Marjalahti, Russia

Also are fragments of iron cores of large asteroids

Stony meteorites: Ordinary chondrite

Chondrite, Allan Hills, Antarctica

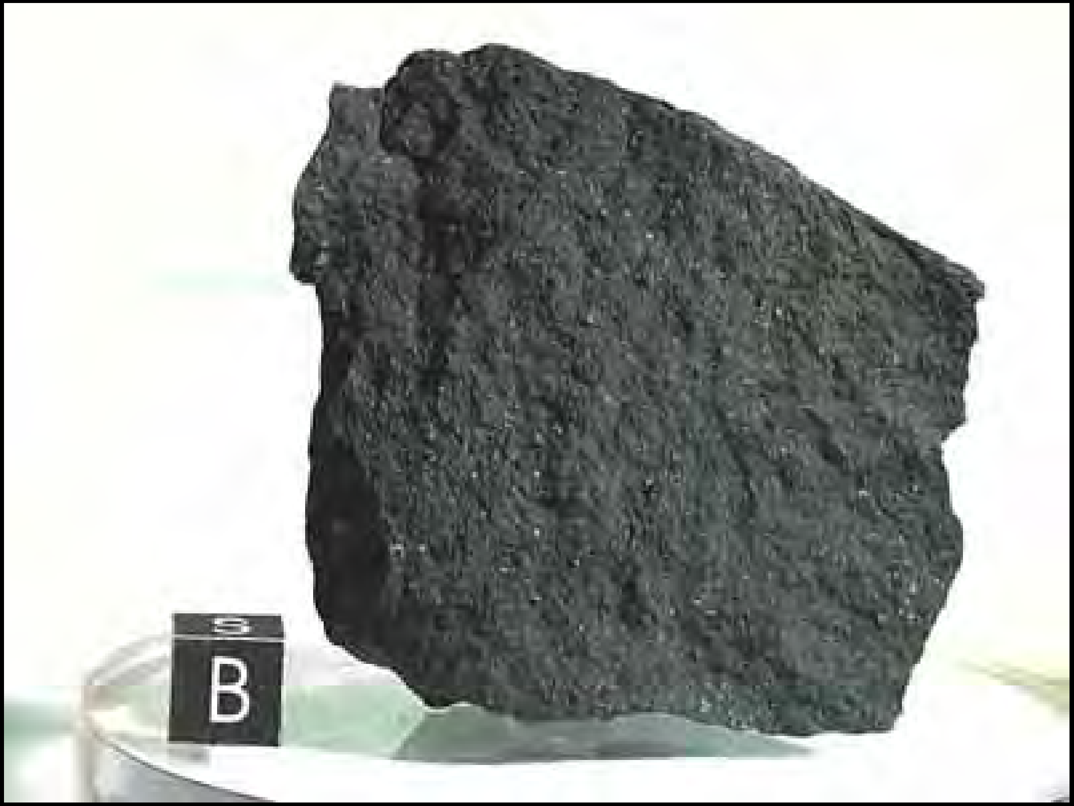
http://www.solarviews.com/eng/meteor.htm#views

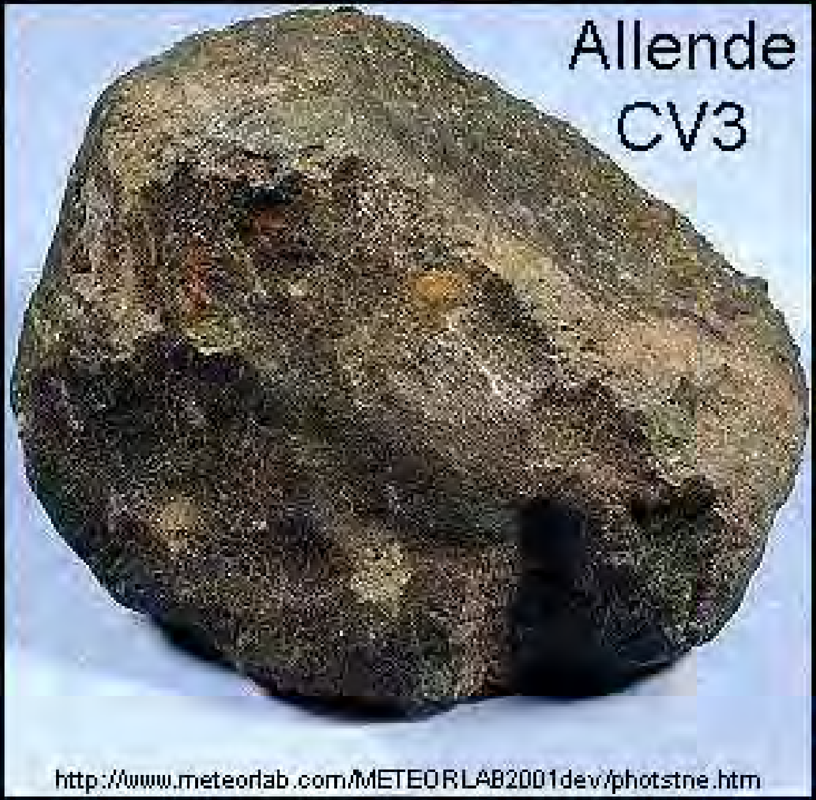
Chondrites – ordinary and carbonaceous, - formed in protoplanetary nebula ~4.5 b.y. ago. In composition close to ultramafic rocks of Earth.

Carbonaceous chondrite Efremovka. One can see chondrules - solidified drops of melt formed in protoplanetary nebula.

Meteorite collection of RAN.

Stony meteorites: Carbonaceous chondrites





http://www.meteorlab.com/METEORLAB2001dev/photstne.htm

Mighei CM

Allende CV3

Meteorite collection of RAN.

Achondrites – magmatic rocks from asteroids: Ultramafic, basalts. Age ~ 4.5 b.y. Why some asteroids melted? Radioactive Al ^{26}? Impacts?

Achondrite - Eucrite Chervonyi Kut – a piece of basalt from some asteroid, maybe from Vesta. Meteorite collection of RAN.

Stony meteorites: Achondrites

Eucrite

Stony meteorites: Achondrites - SNC meteortes

Age 0.2 to 4.5 b.y.

Anomalous oxygen isotopy

Trapped Martian atmosphere gases

=> Rocks from Mars

Shergotty

Antarctic shergottite

Martian basalts

Stony meteorites: Achondrites
SNC meteortes – Rocks from Mars

http://www.meteorlab.com/METEORLAB2001dev/photstne.htm

Nakhla pyroxene (augite)
cumulate

Chassigni olivine
(cumulate)

Stony meteorites: Achondtrites
Lunar meteorites – Rocks from the Moon

Dhofar-302
Lunar meteorite

Dhofar-029
Lunar meteorite,
Melted anorthosite

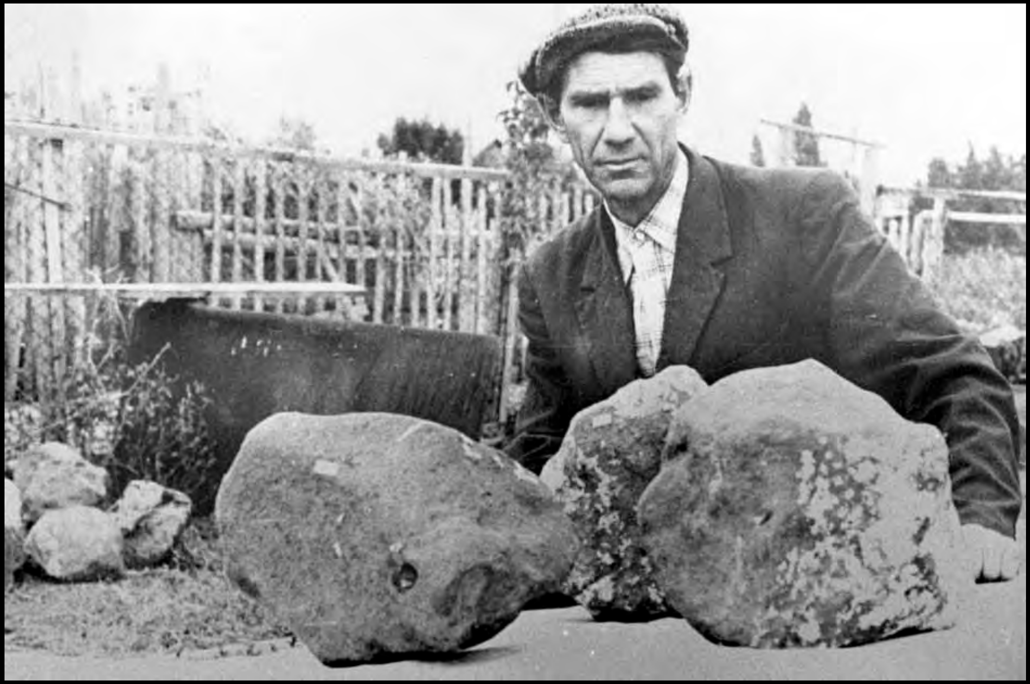
How collections of meteorites are made:

Observed falls

Meteorite Sterlitamak, fall,
May 17, 1990

Фото М.И. Петаева

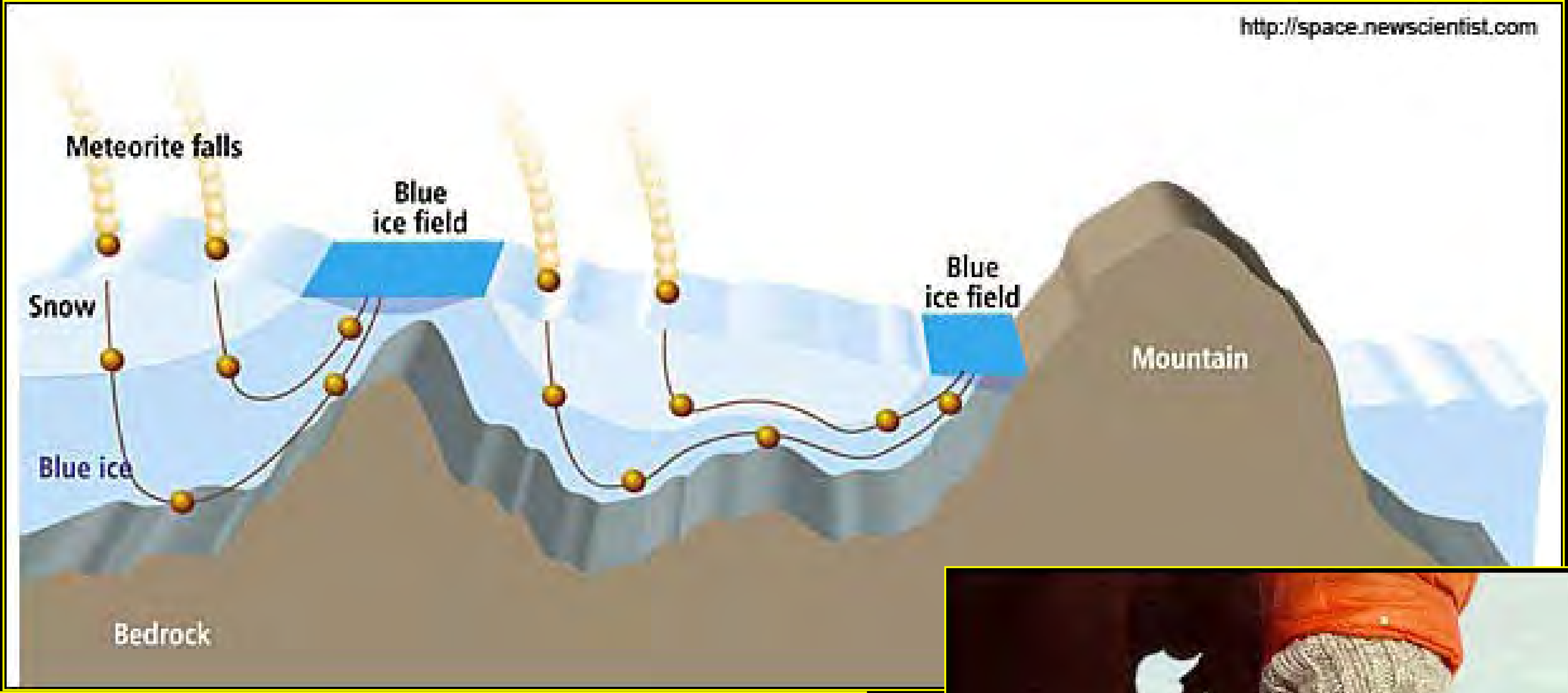
Meteorite Tsarev, Volgograd region, Russia
Finding of the unobserved falls, ordinary chondrite



Boris Nikiforov, the finder, 1979

<= Tsarev in museum of RAN

Antarctic meteorites



http://space.newscientist.com

http://space.newscientist.com

http://www-curator.jsc.nasa.gov

Collecting meteorites in deserts

Meteorite Dhofar 943, Ordinary chondtrite, Oman

http://geo.web.ru/db/meteorites/

Comets

Nucleus – dirty ice, diameter is usually several km.

Coma – dust particles in rarefied gas around core, diameter ~ 100,000 – 1 million km, appear at 3 a.u. from the Sun.

Tail – dust particles and ions, blown by pressure of light and solar wind to direction opposite of the Sun, extension- 10-100 million km.

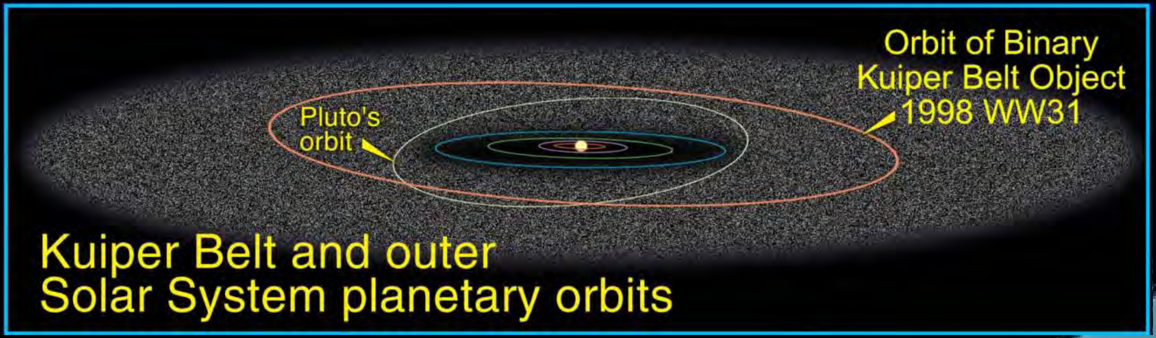
Dust tail – yellow – Dust particles, illuminated by the Sun.

Ionic tail – blue – ions of (CO^+), fluorescing due to illumination by the Sun.

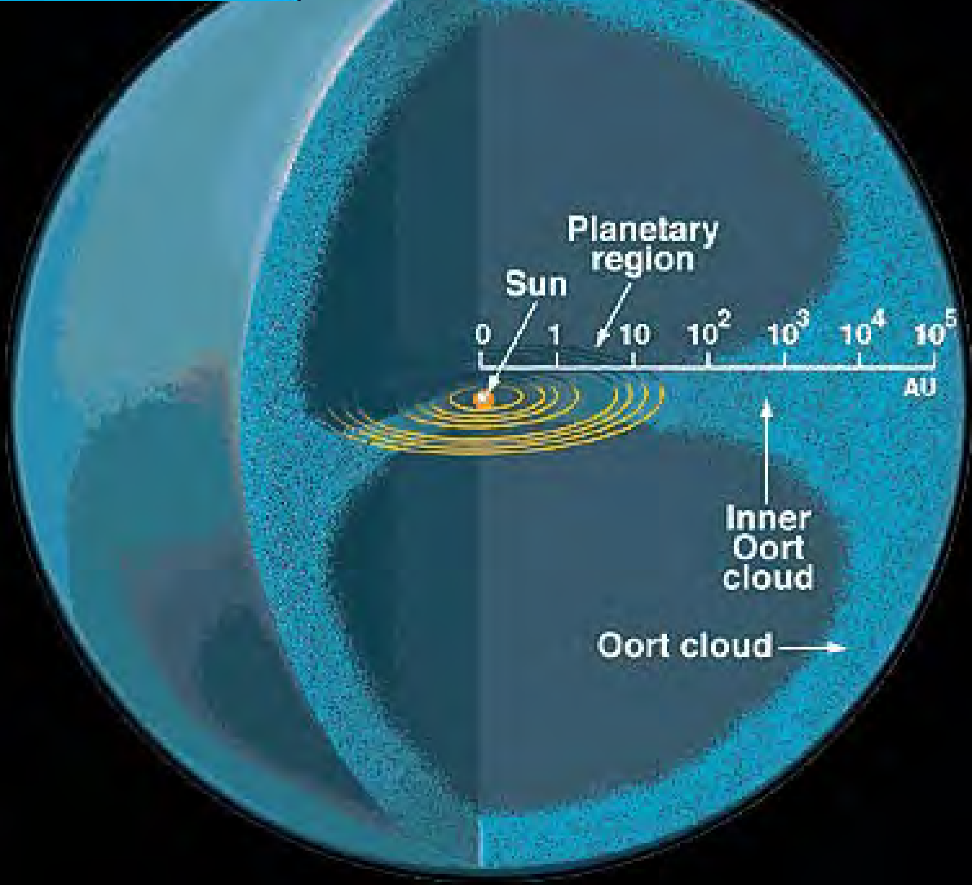
Period rotation around Sun:
> 200 years – long period comets
< 200 years – short period comets


Comet Hale-Bopp, 1997, Mar. 7, 19h55m (UT) Courtesy of National Astronomical Observatory of Japa

Comets come from Kuiper belt and Oort cloud

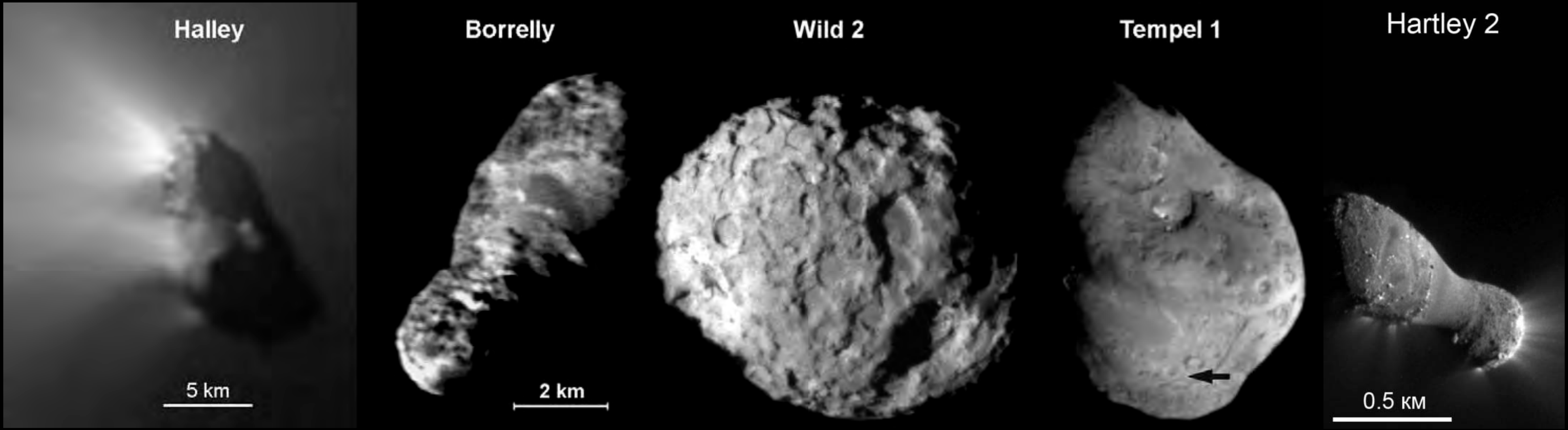


Kuiper belt– disk at 35-50 a.u. from the Sun – source of short period comets.



Oort cloud– spherical envelop at 50,000-200,000 a.u. from the Sun - source of long period comets.

Comet nuclei seen at close distance



Comet	Halley	Borelli	Wild 2	Tempel 1	Hartley 2
Obs. year.	1986	2001	2004	2005	2010
Perihel.	0.587	1.358	1.58	1.5	1.05 a.e.
Aphelion	35.35	5.86	5.20	4.72	5.87 a.e.
Orbital period	71.6	6.86	6.4	5.5	6.5 лет
Size	16 x 8 x 8	8 x 3	5.5 x 4 x 3.3	6 x 6	1.2-1.6 км
Albedo	0.05	0.03	0.03	0.04	0.03
Bulk dens.	550±250	490+340/-200	?	350 ± 250 кг/м^3	?

Nucleus of comet Halley, 7 x 8 x 16 km

Mission Giotto, Keller et al., 1990

Nucleus - mixture of ices and dust
~ 50 : 50

Gases escaping from the nucleus

H_2O	80 %
CO	10 %
CO_2	3.5 %
$(H_2CO)_n$	a few %

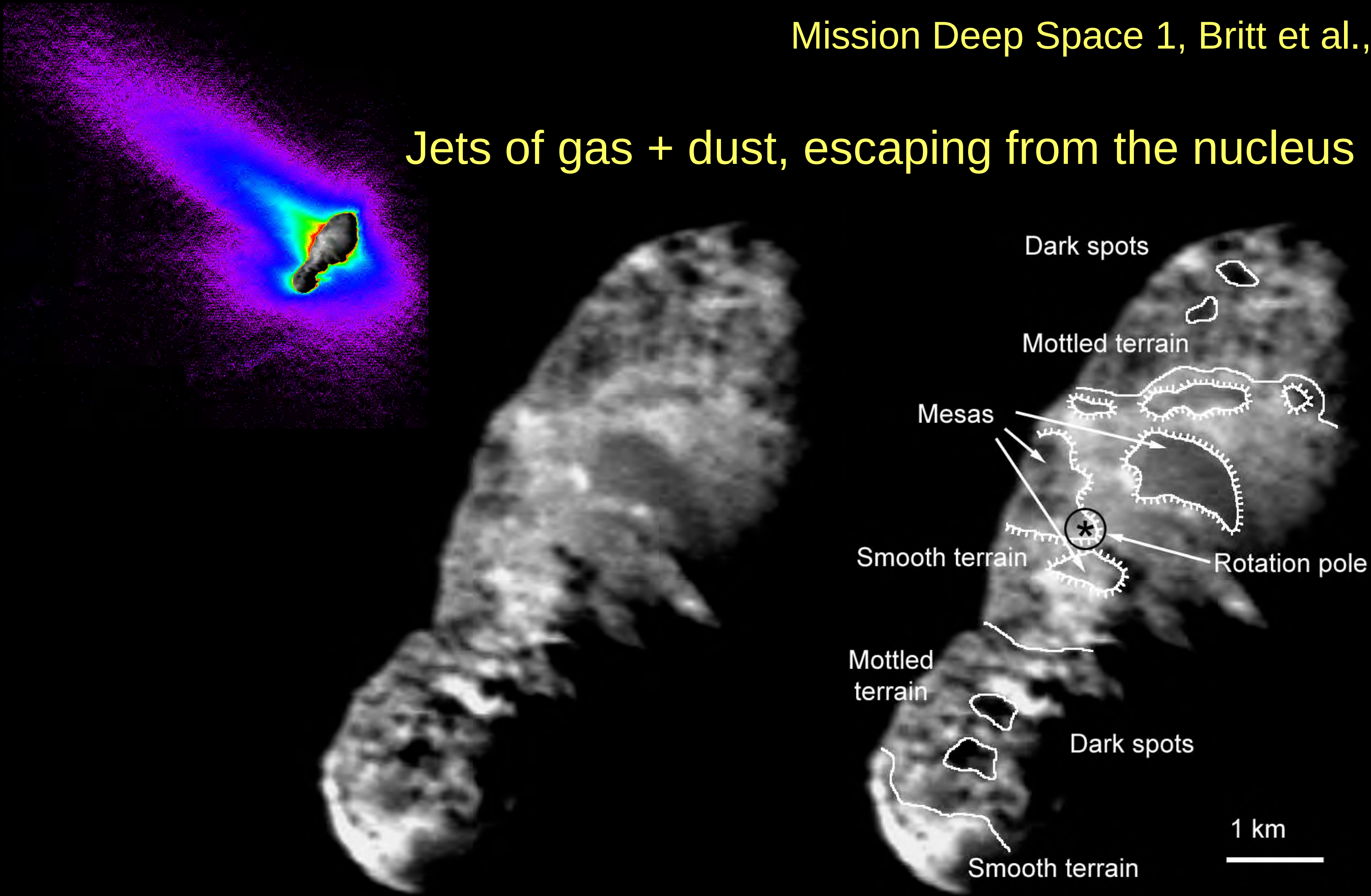
Ices of comet nuclei – model:

H_2O	0.85	H_2CO	0.02	H_2S+HCN+
CO	0.04	CH_3OH	0.02	NH_3+CH_4+
CO_2	0.03	N_2	0.01	CS_2+CH_2+… 0.03

Dust = carbonaceous material + silicates
(mostly, serpentine-chlorite??)

Borrelly comet nucleus, 3 x 8 km

Mission Deep Space 1, Britt et al., 2004



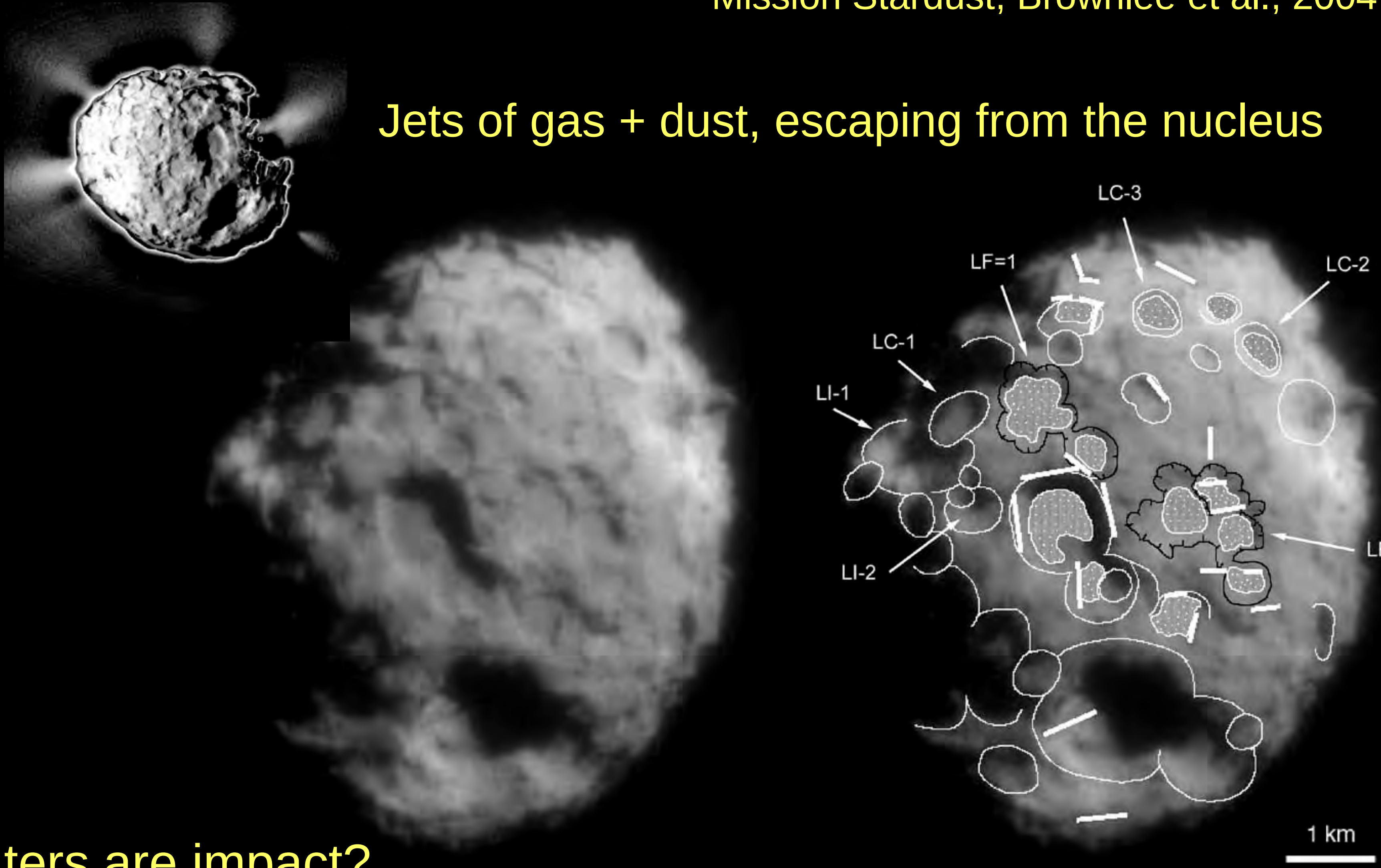
Jets of gas + dust, escaping from the nucleus

How mesas did form?

Slope retreat (with collapse) due to sublimation of ice?

Wild-2 comet nucleus, 3.3 x 5.5 km

Mission Stardust, Brownlee et al., 2004



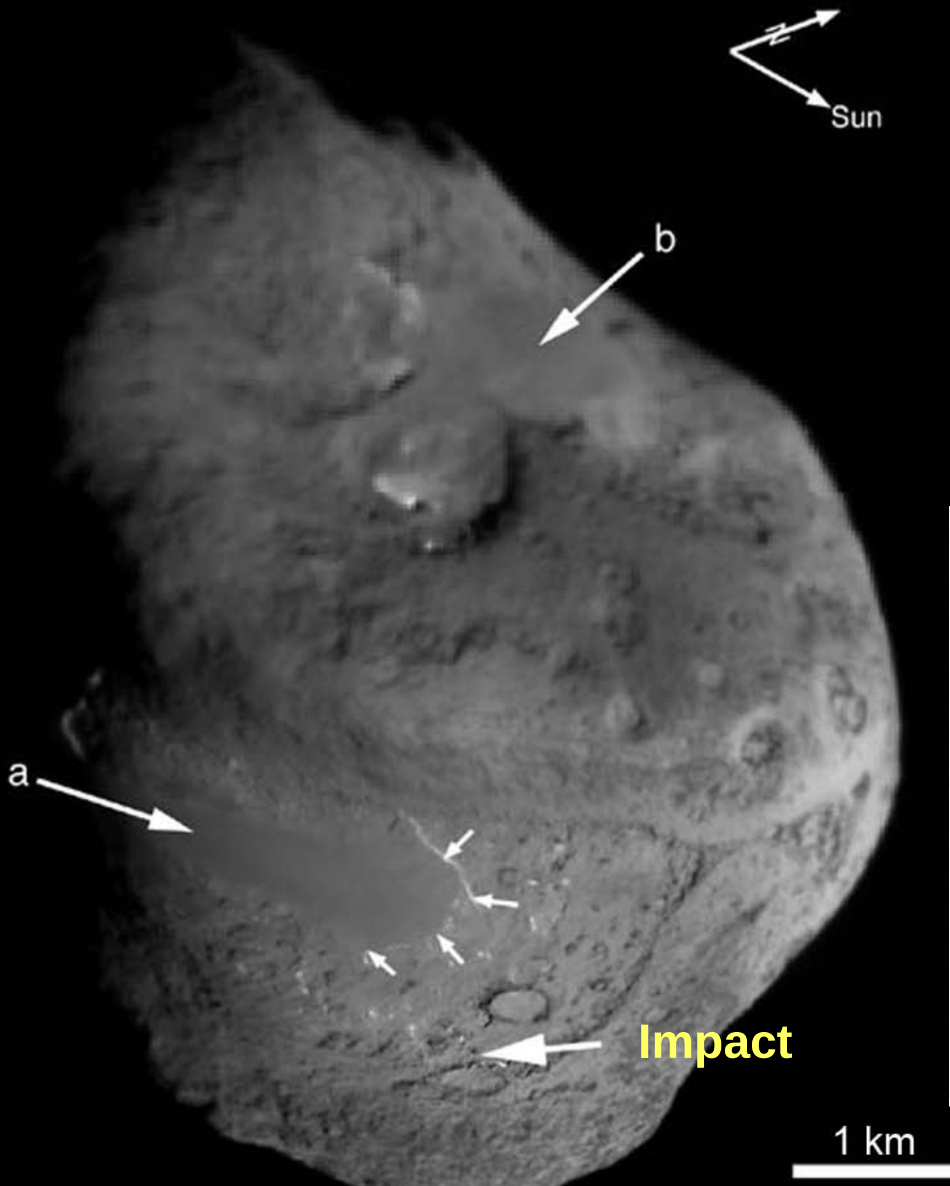
Jets of gas + dust, escaping from the nucleus

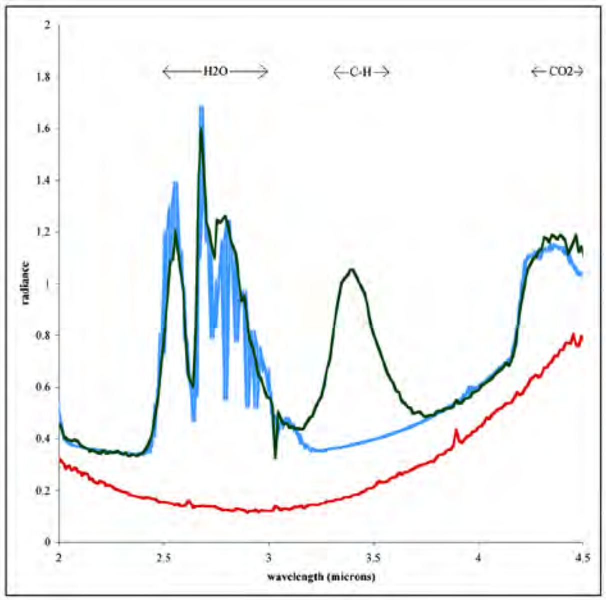
Craters are impact?

How crater flat floors did form?

Slope retreat (with collapse) due to sublimation of ice?

Nucleus of comet Tempel 1, 6 x 6 km



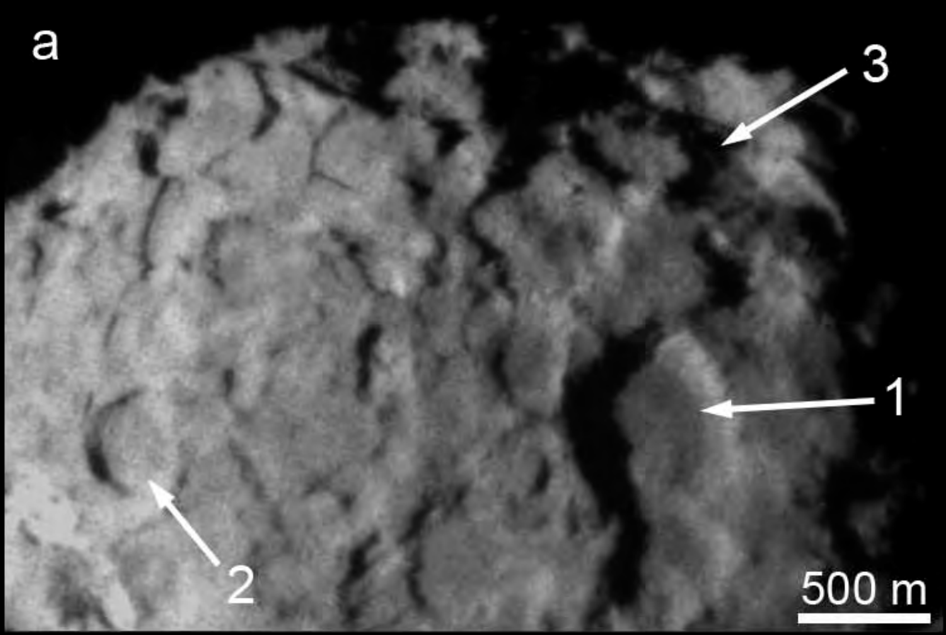


Spectrum
before impact
after impact
model

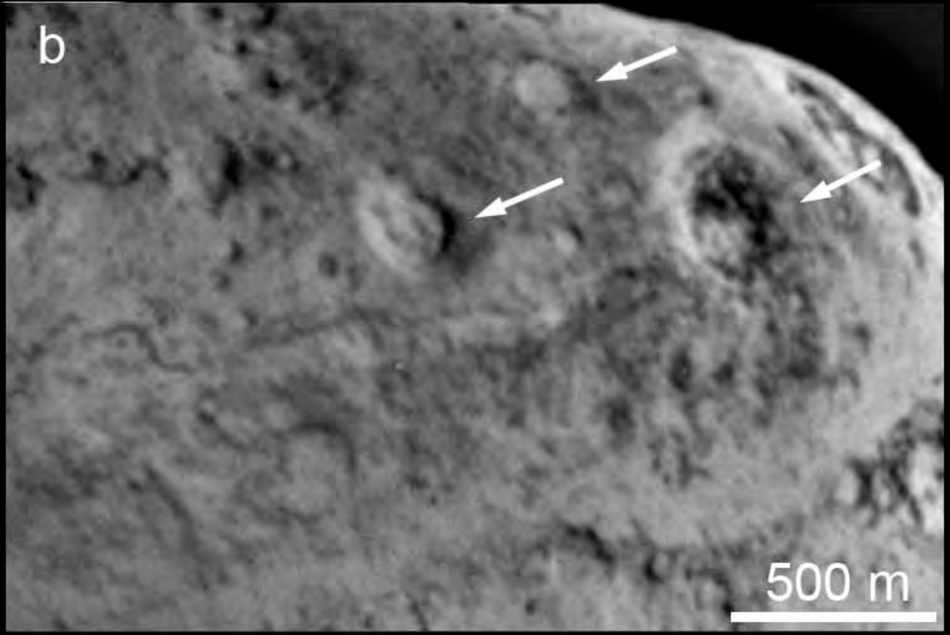
Impactor (copper) kinetic energy ~ 4.8 т TNT

Mission Deep Impact, A’Hearn et al., 2006

Craters



Wild 2

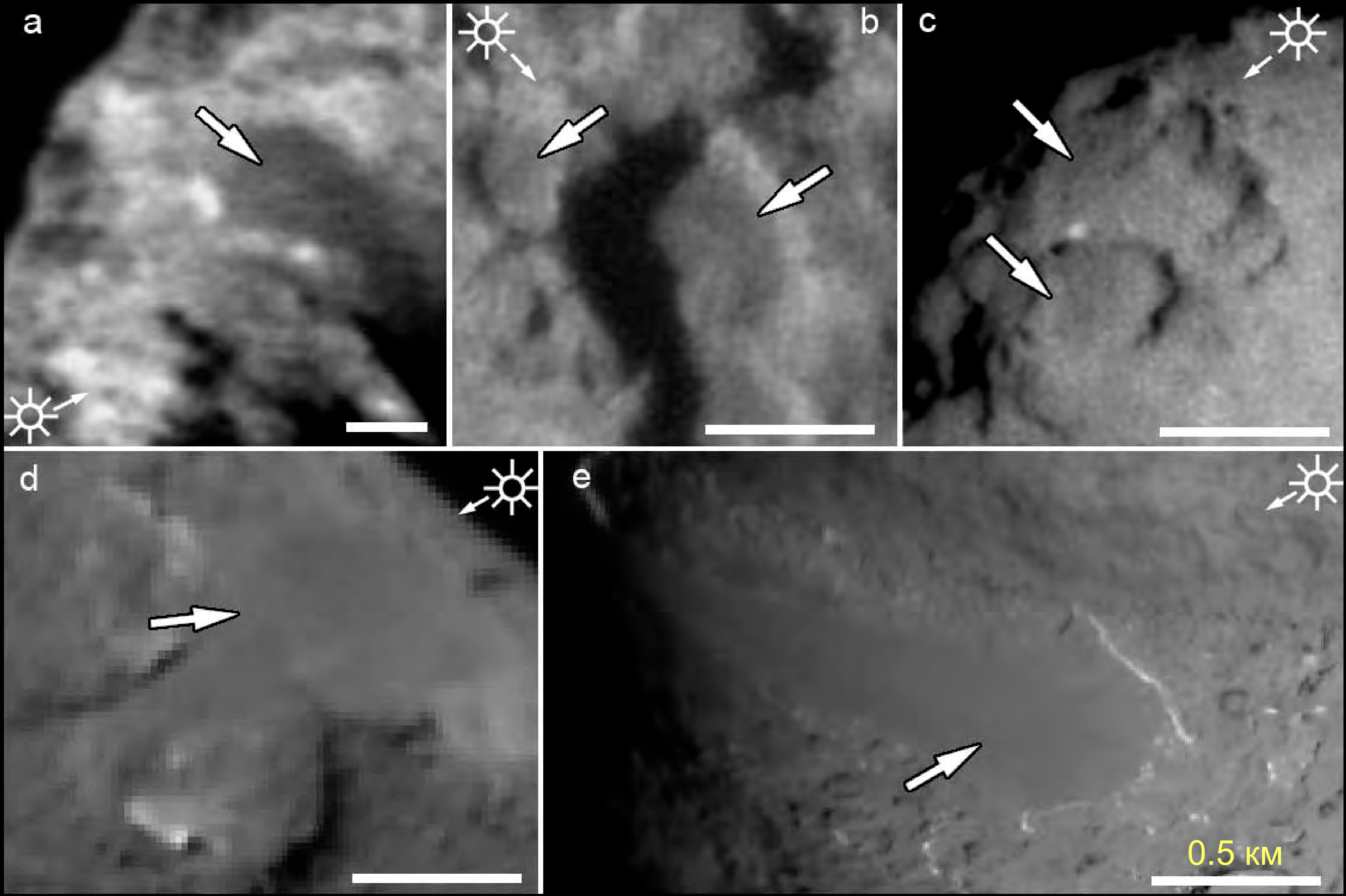


Tempel 1

Tempel 1

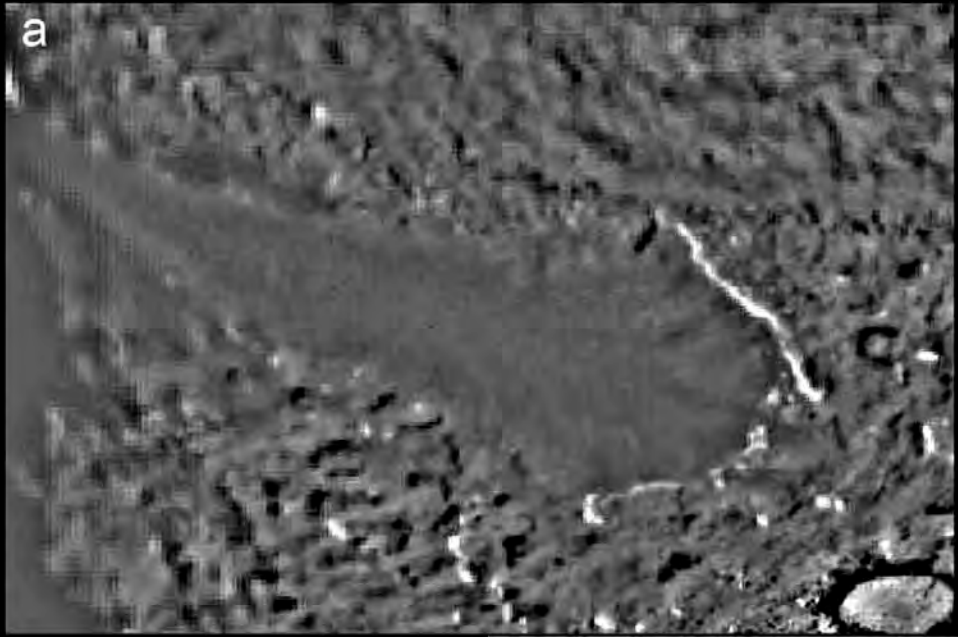
Basilevsky & Keller, 2006

Planation on the surface of comet nuclei



Basilevsky & Keller, 2006

Flow on Tempel 1 and potential terrestrial analogs

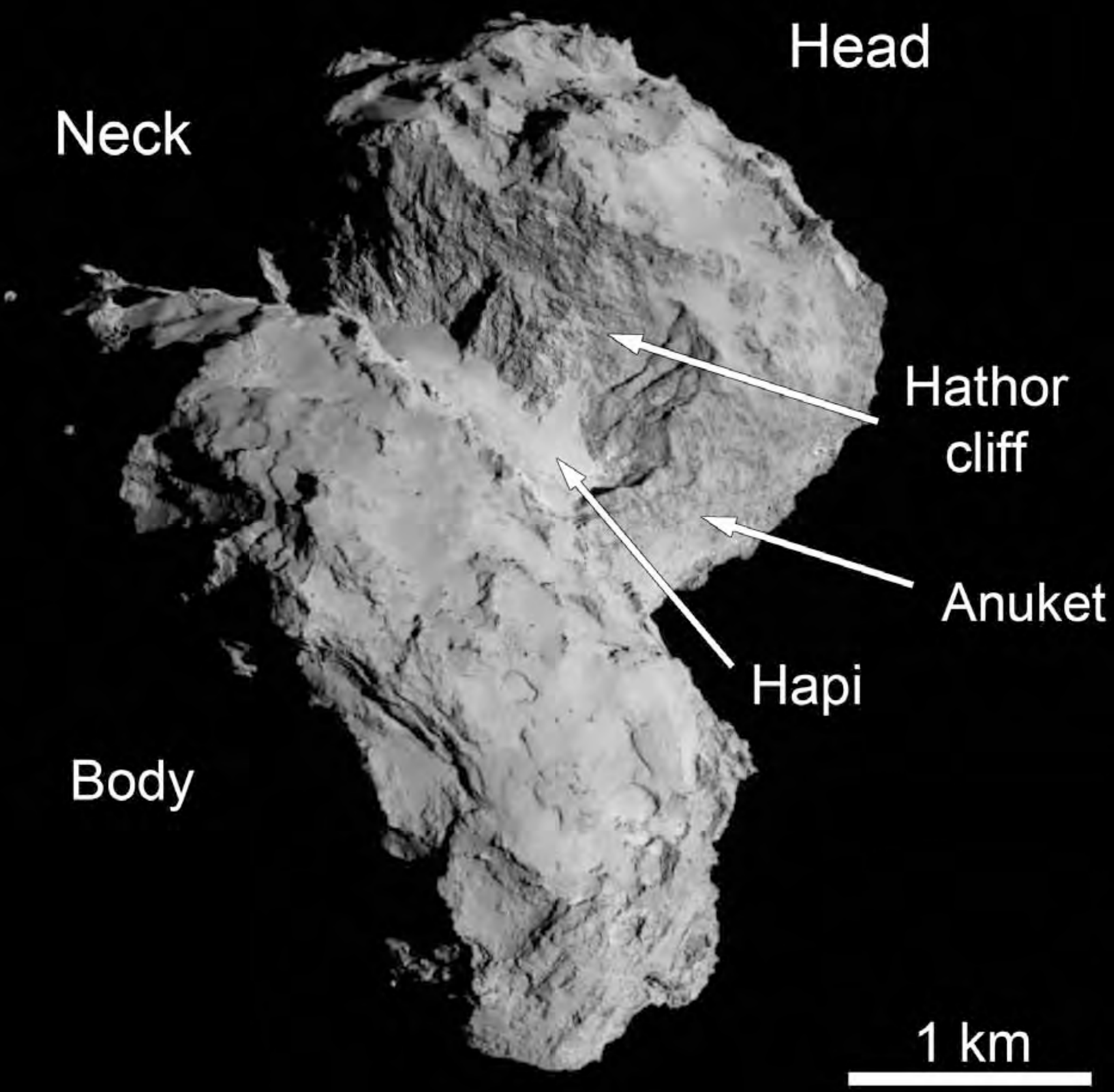


Basilevsky & Keller, 2006

Snow avalanches, Colorado

Pyroclastic flow, St. Helens

Comet 67P Churyumov-Gerasimenko



Short-period (6 years and 7 months).

In aphelion extends the Jupiter orbit (5.7 au).
In perihelion – betw. orbits of Earth and Mars (1.24 a.e.).

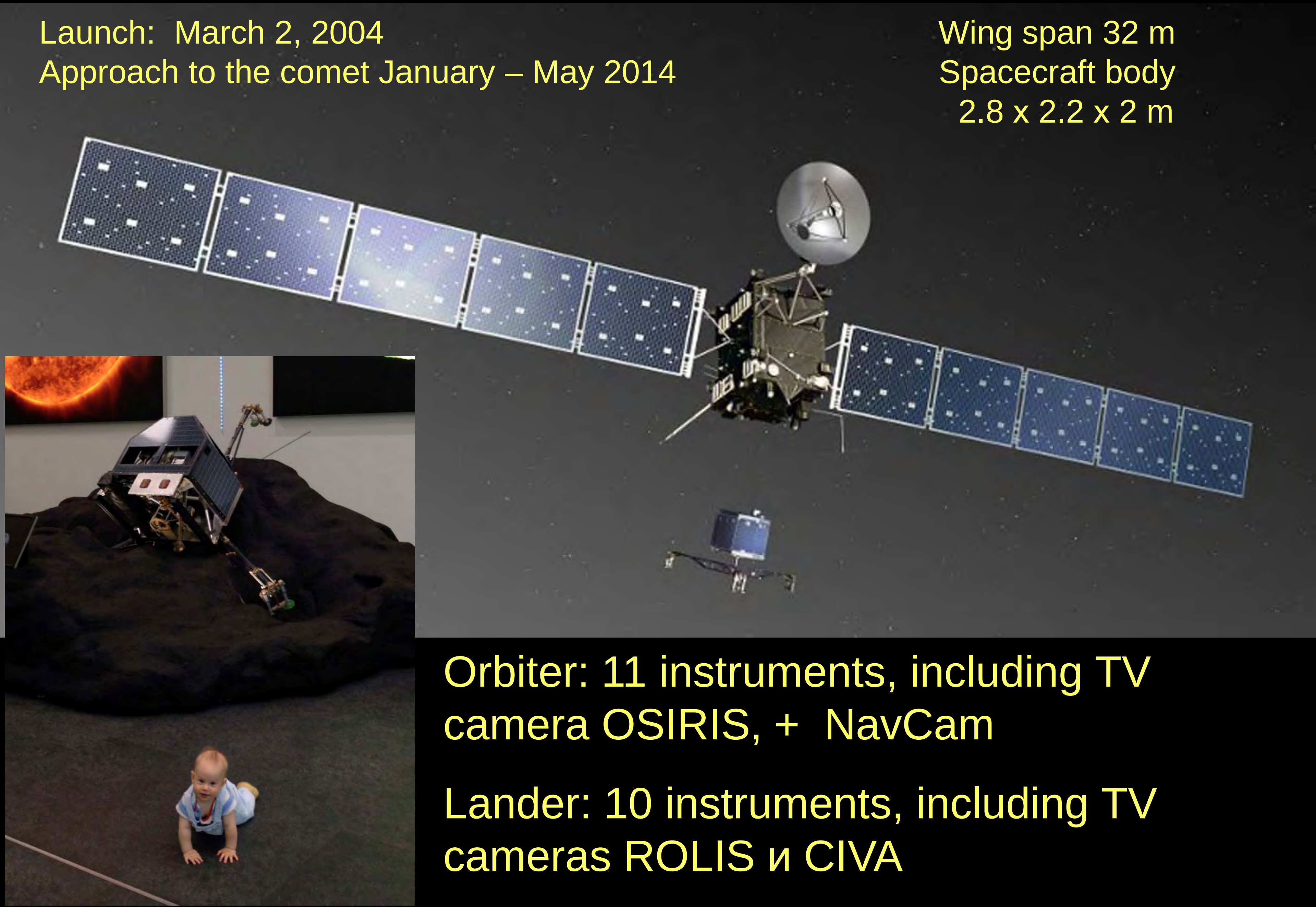
Discovered in 1969 K.I. Churyumov and S.I. Gerasimenko.

Two lobes:
Body 4.1 x 3.3 x 1.8 km and
Head 2.6 x 2.3 x 1.8 km.

ρ = 470 ± 45 кг/м^3,
P = 70-80%.

Sierks et al., 2015

Rosetta mission: Orbital module + Phlae lander

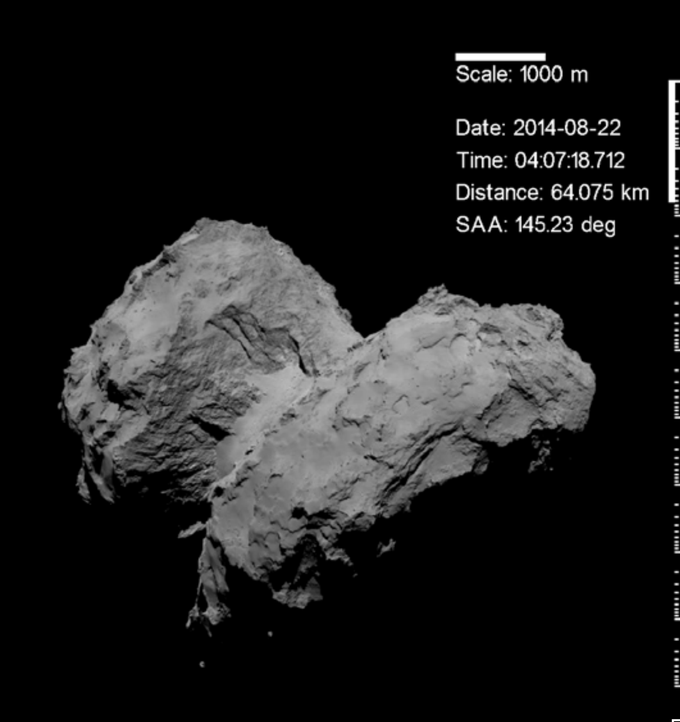


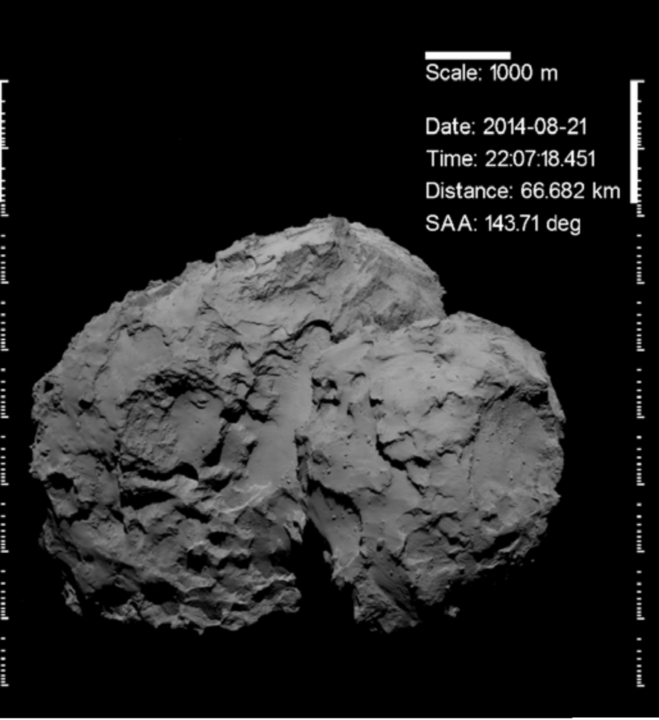
Launch: March 2, 2004
Approach to the comet January – May 2014

Wing span 32 m
Spacecraft body
2.8 x 2.2 x 2 m

Orbiter: 11 instruments, including TV camera OSIRIS, + NavCam

Lander: 10 instruments, including TV cameras ROLIS и CIVA


Scale: 1000 m
Date: 2014-08-22
Time: 04:07:18.712
Distance: 64.075 km
SAA: 145.23 deg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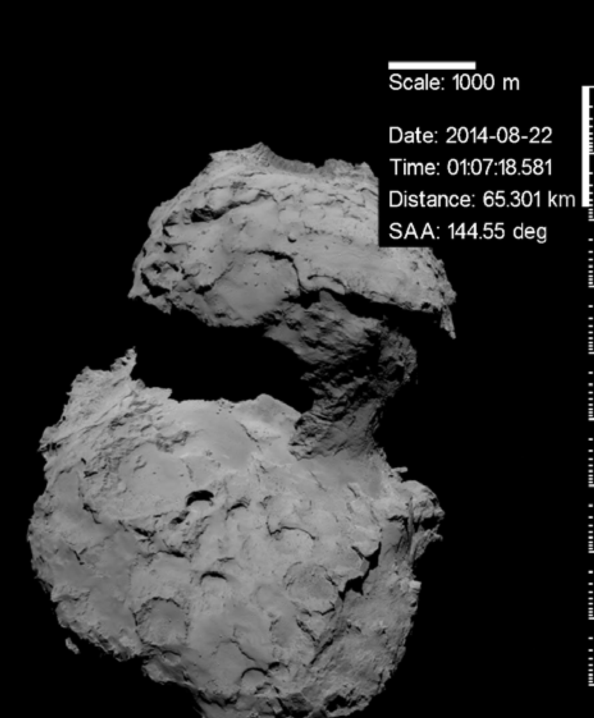
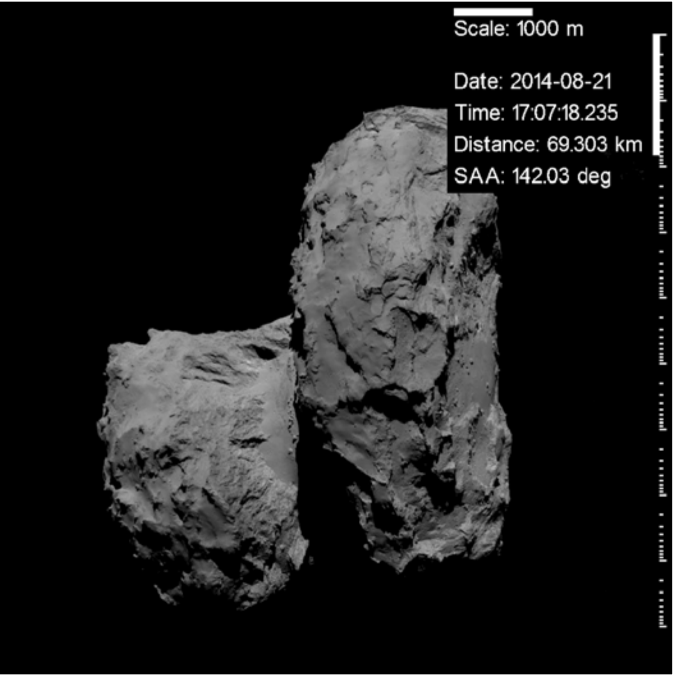
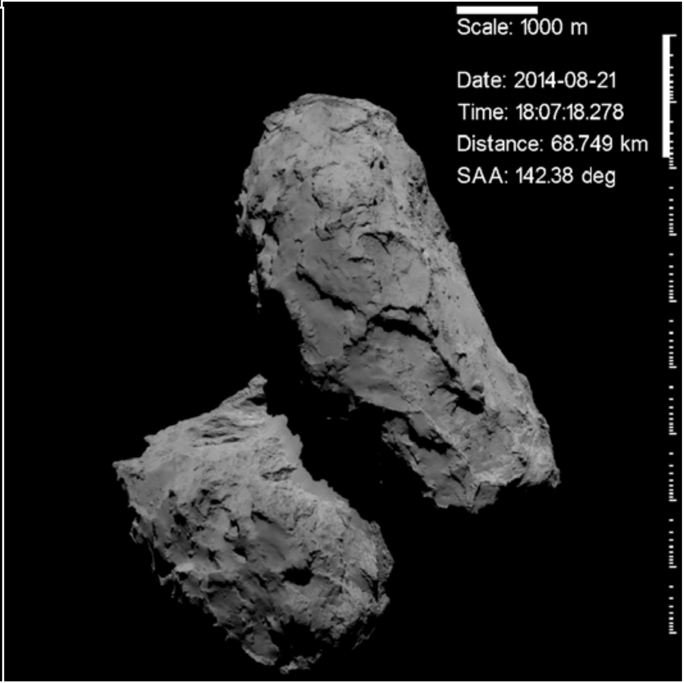
Time: 22:07:18.451
Distance: 66.682 km
SAA: 143.71 deg

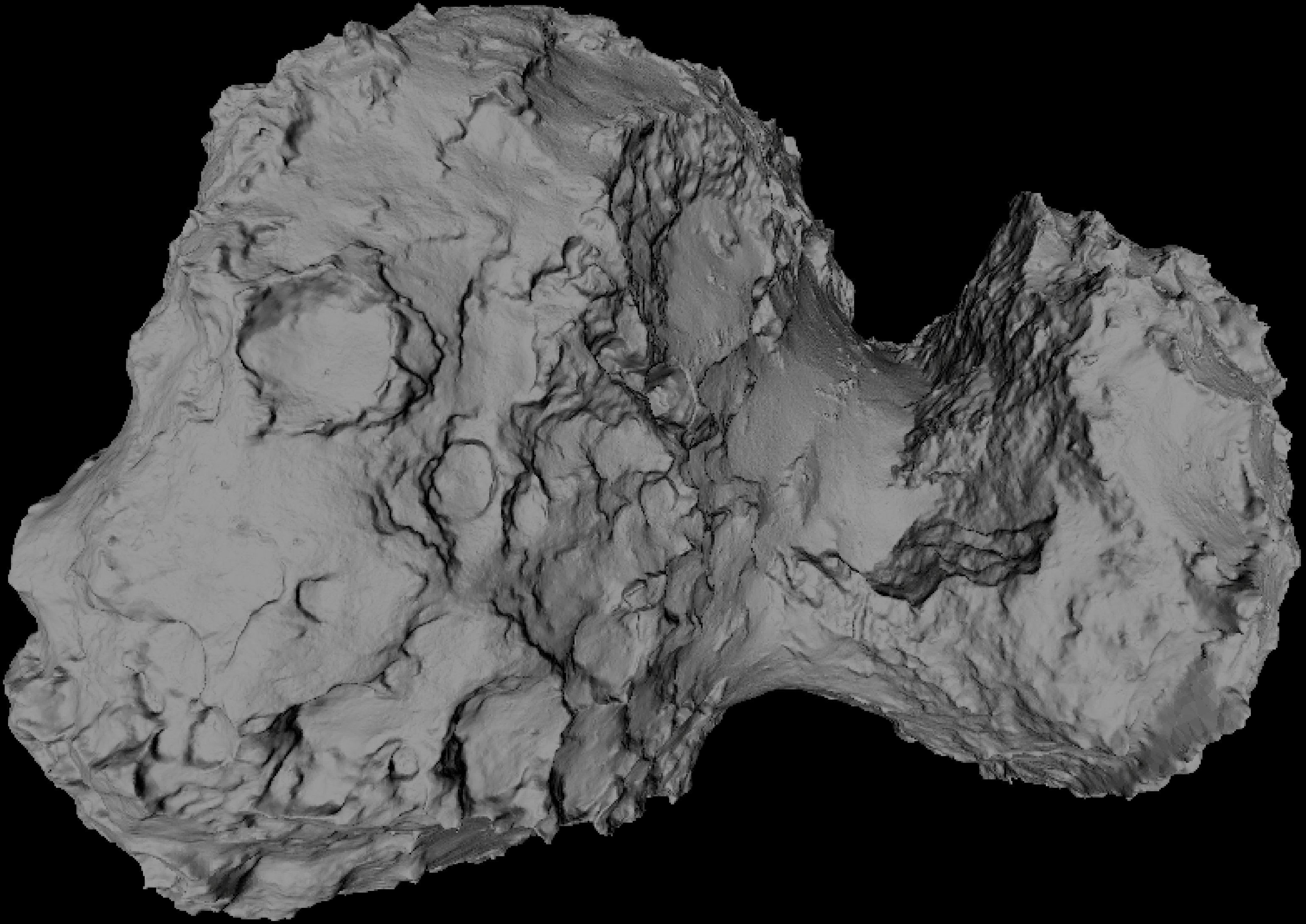

Scale: 1000 m
Date: 2014-08-22
Time: 01:07:18.581
Distance: 65.301 km
SAA: 144.55 deg


Scale: 1000 m
Date: 2014-08-21
Time: 17:07:18.235
Distance: 69.303 km
SAA: 142.03 deg


Scale: 1000 m
Date: 2014-08-21
Time: 18:07:18.278
Distance: 68.749 km
SAA: 142.38 deg

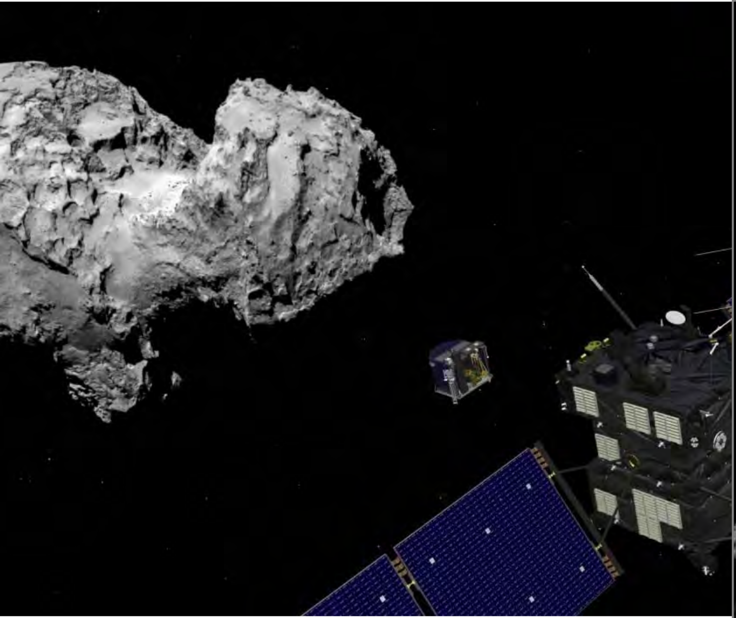

Scale: 1000 m
Date: 2014-08-21
Time: 20:07:18.365
Distance: 67.684 km
SAA: 143.07 deg

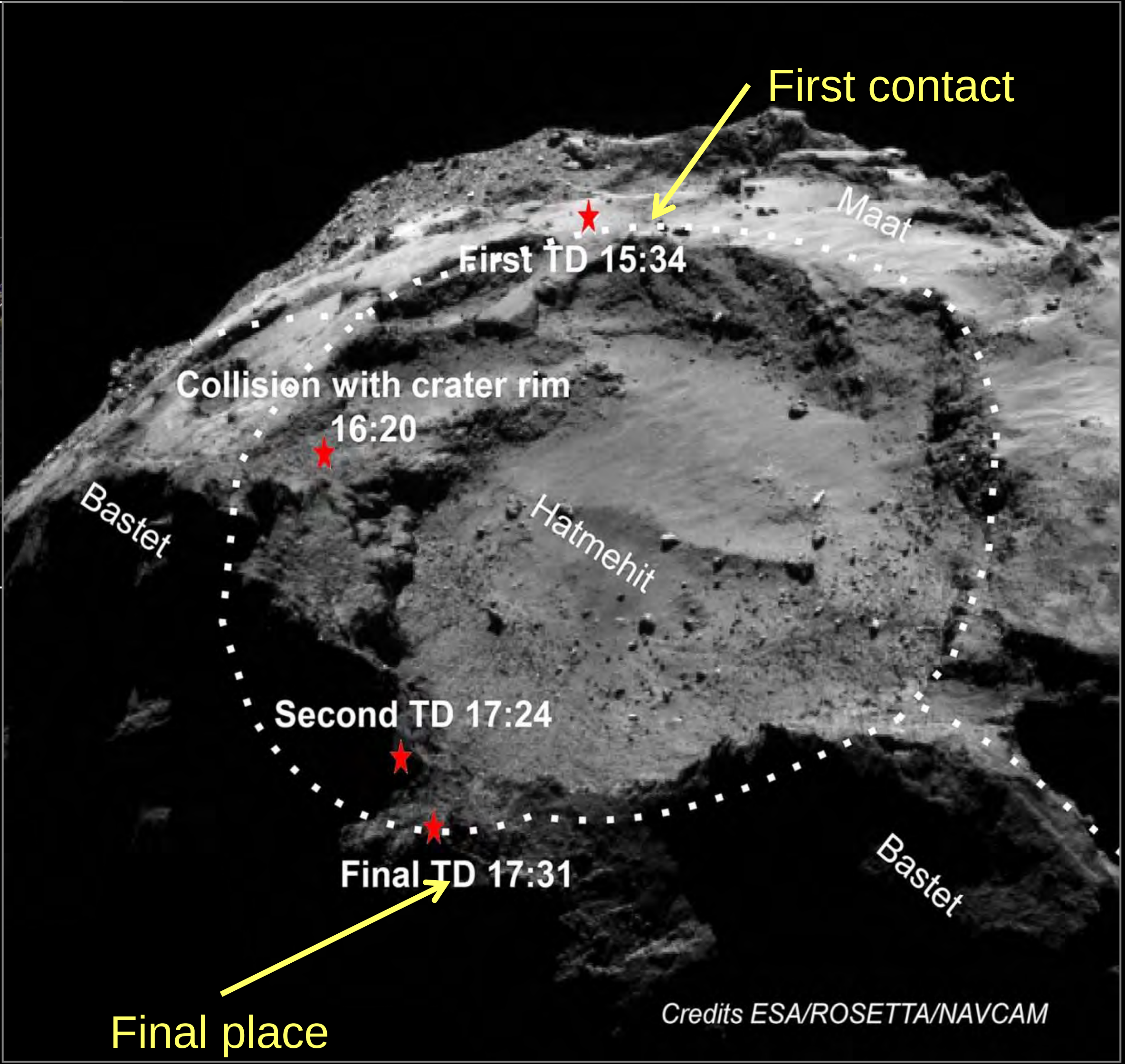
The comet DTM SHAP4s (Preusker et al., 2015)



Spatial resolution 2 м, vertical accuracy – decimeters.

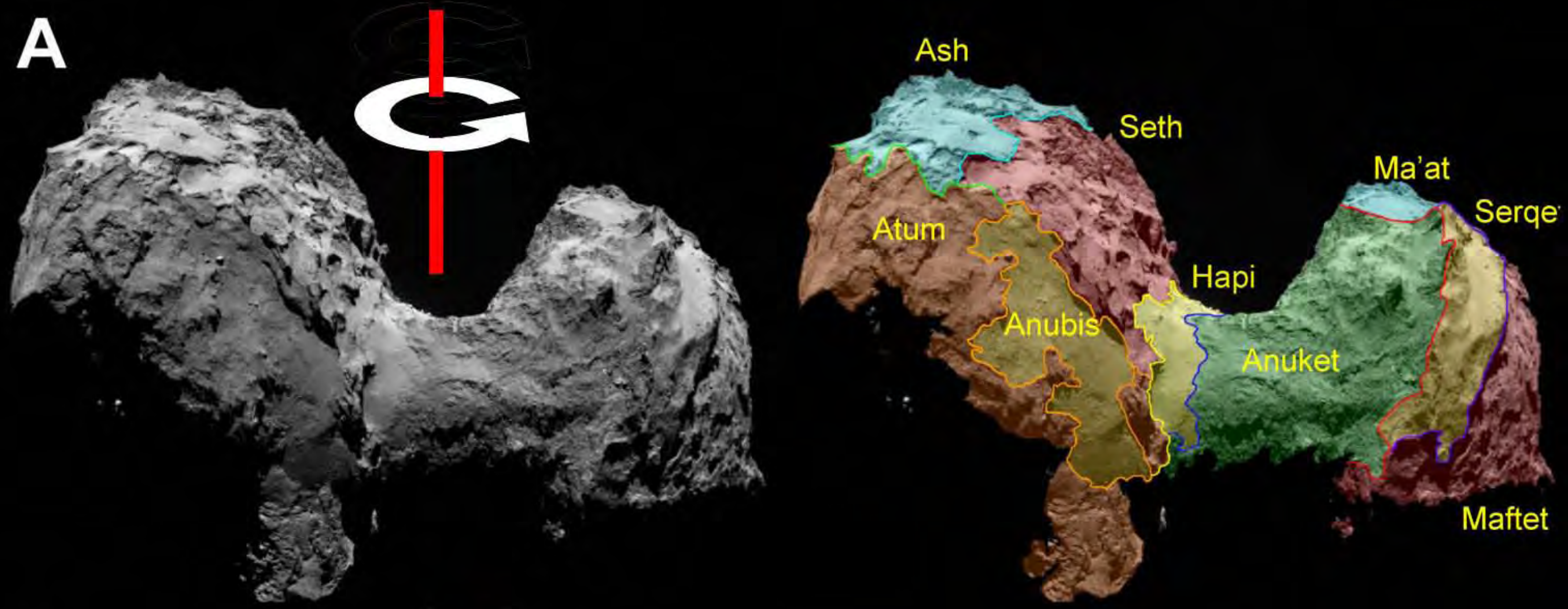
Landing of Philae on the surface of nucleus of comet 67P

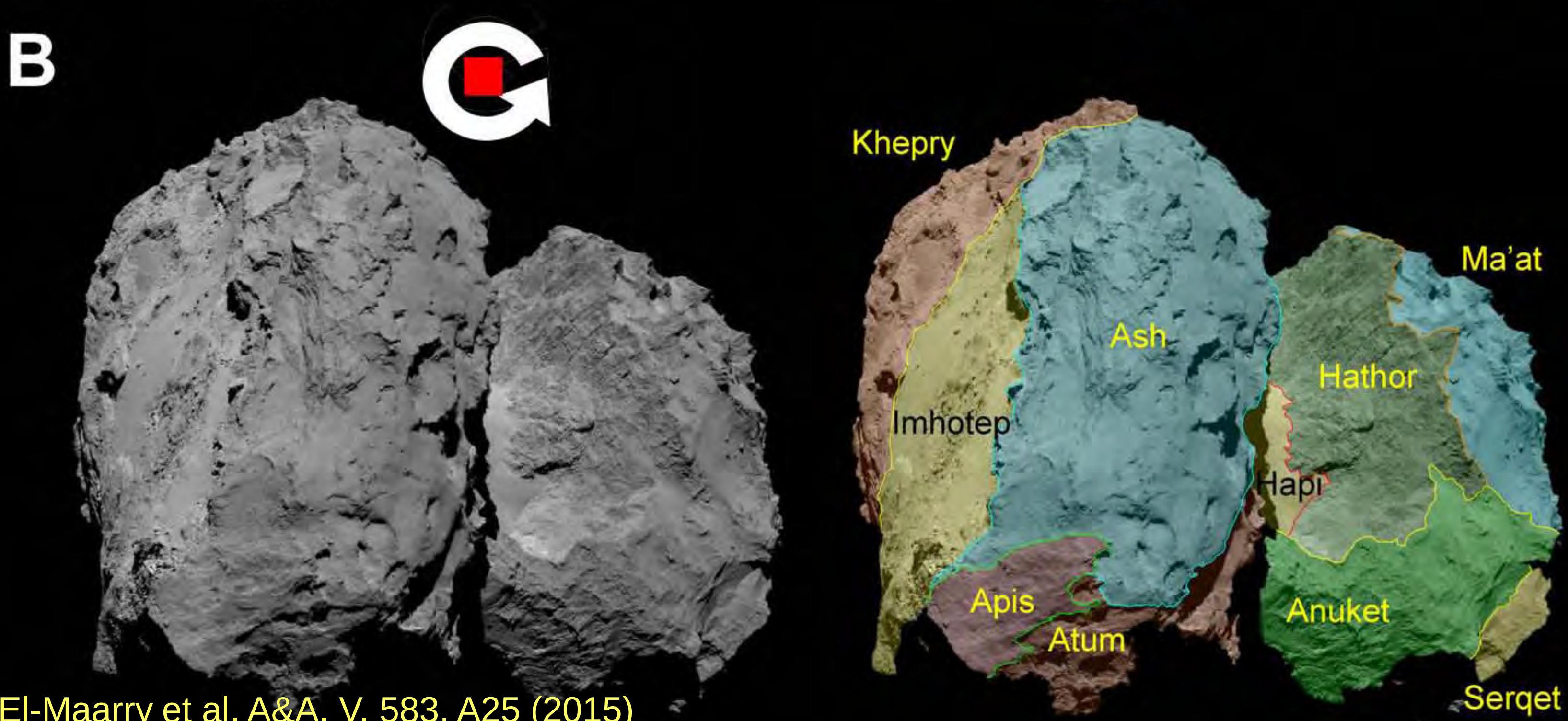




Credits ESA/ROSETTA/NAVCAM

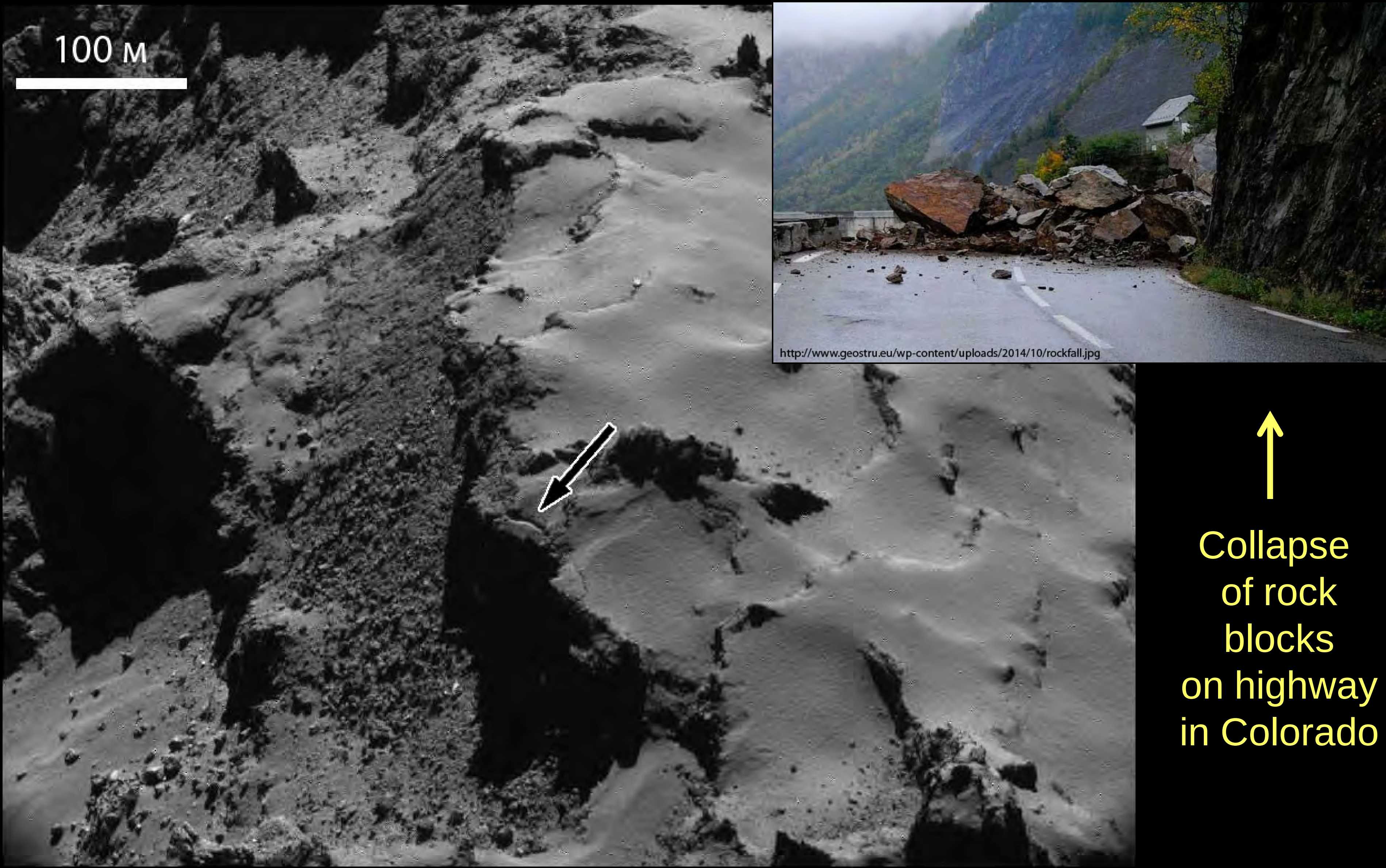
On landing did not work harpoons and the press-down gas engine. So the lander jumped up and after two more contactslanded in ~1.5 km from the target place.





El-Maarry et al. A&A. V. 583, A25 (2015)

Collapse of blocks of consolidated nucleus material from steep scarp in Ash region. Arrow – fracture of separation.



http://www.geostru.eu/wp-content/uploads/2014/10/rockfall.jpg

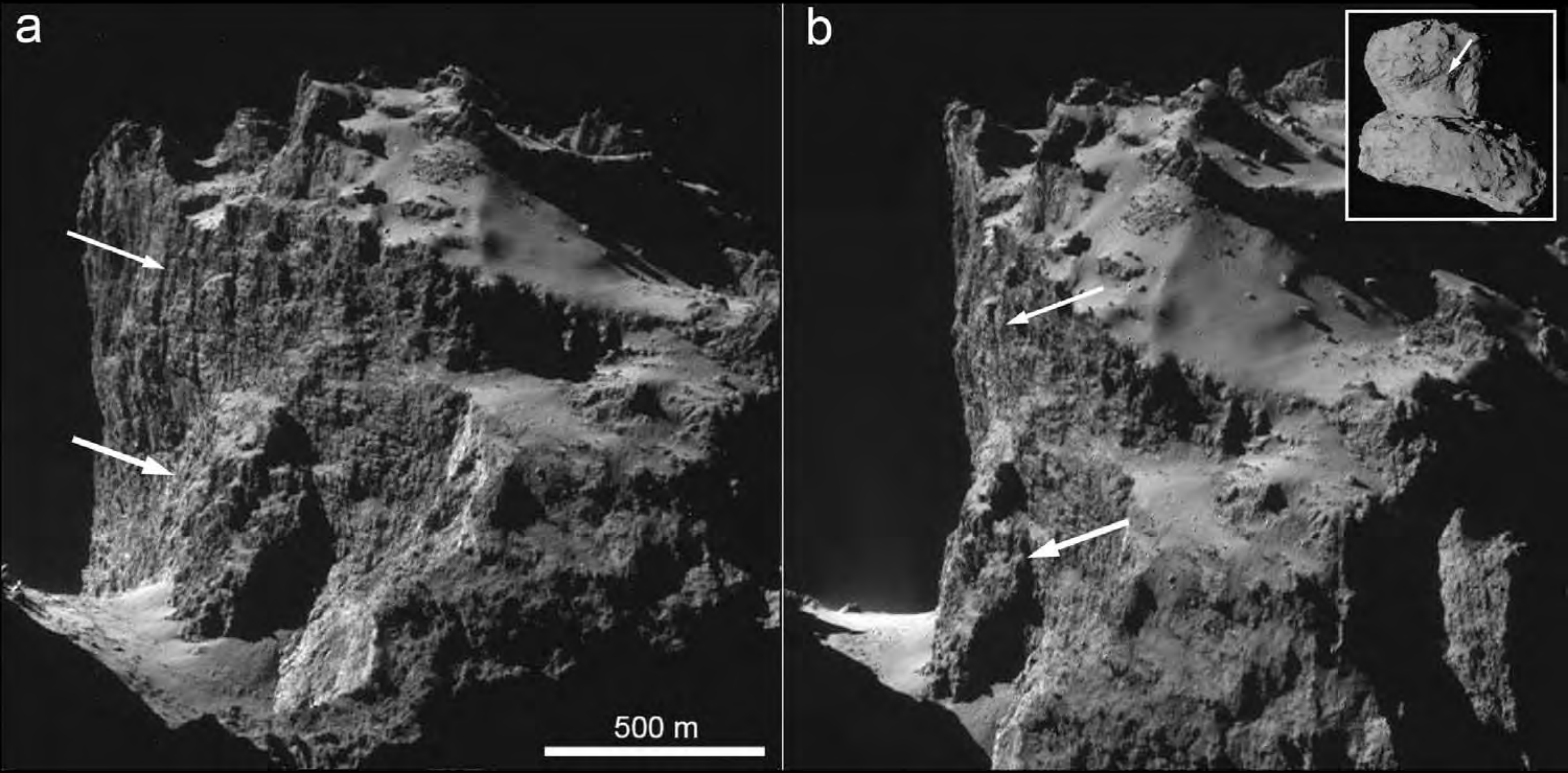
↑

Collapse
of rock
blocks
on highway
in Colorado

NavCam image 20141028T020855

Landslide body (thick arrow) in the lower part of the Hathor cliff.

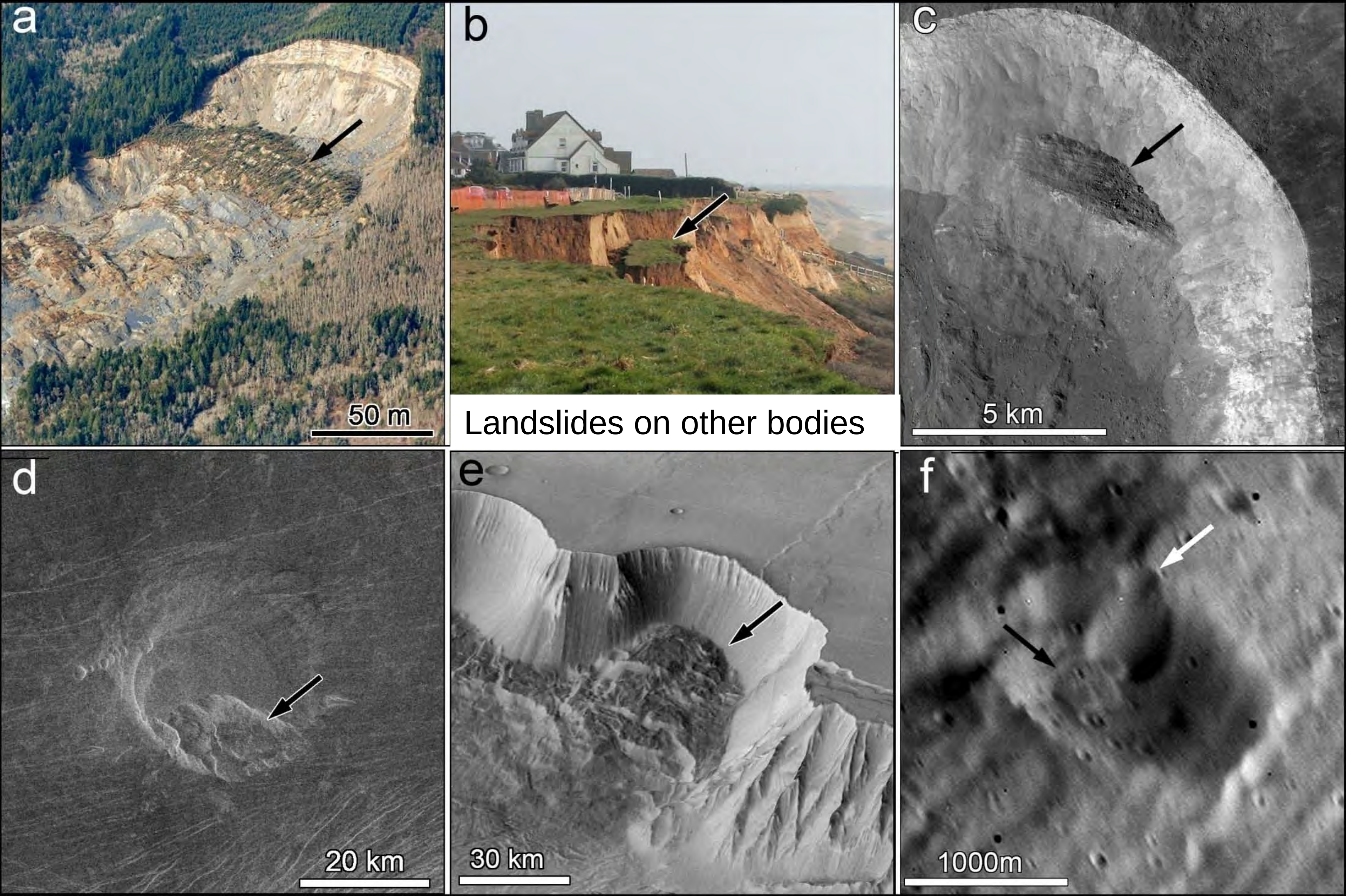
Fine arrow shows dowmslope lineaments.



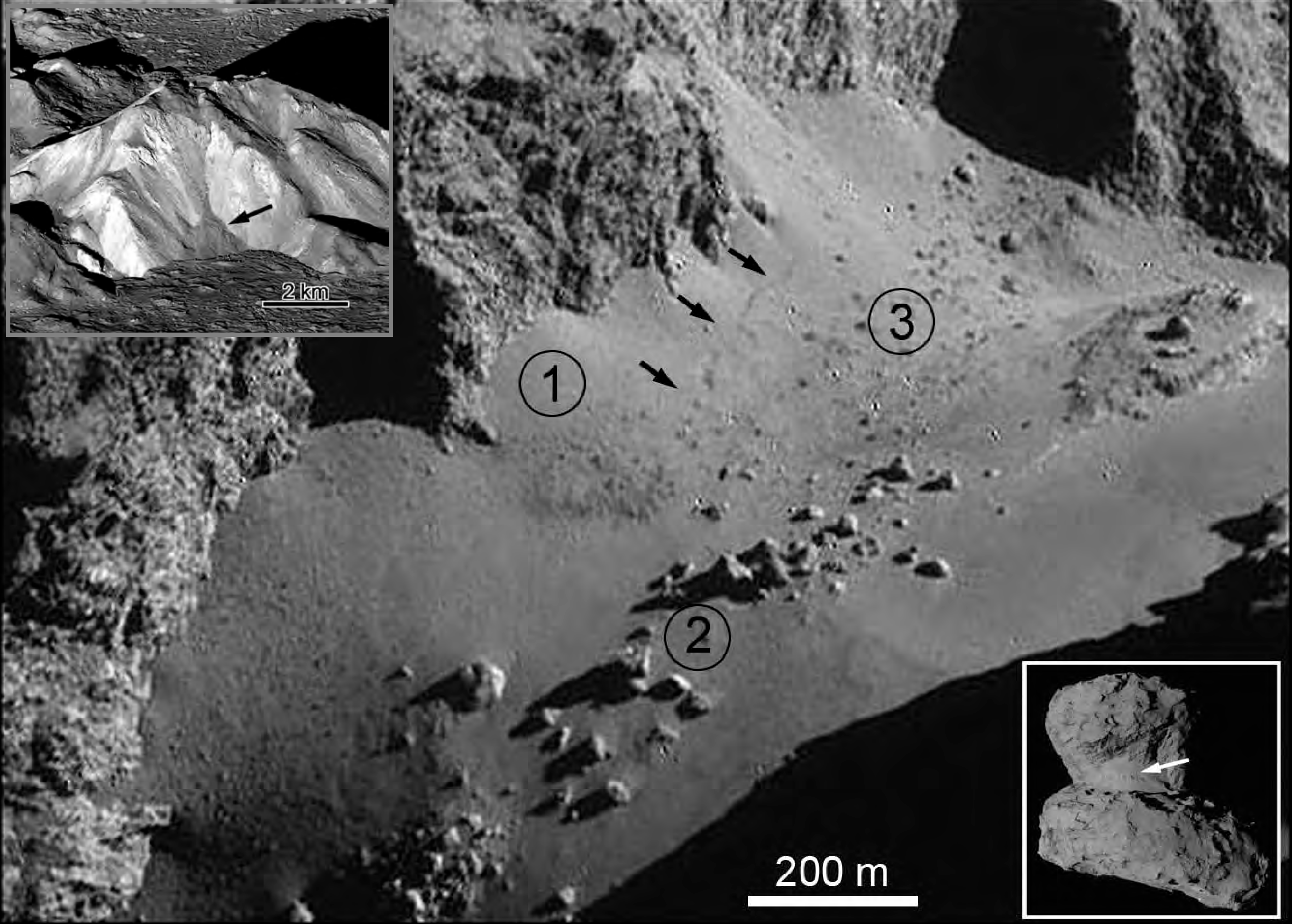
Parts of NavCam images 20141106T202256 и 20141107T081255, rotated clockwise by 24º и 48º, respectively.

Landslides on other bodies

Oso, Washington, USA Barton-on-Sea, Great Britain Луна, кратер Giordano Bruno

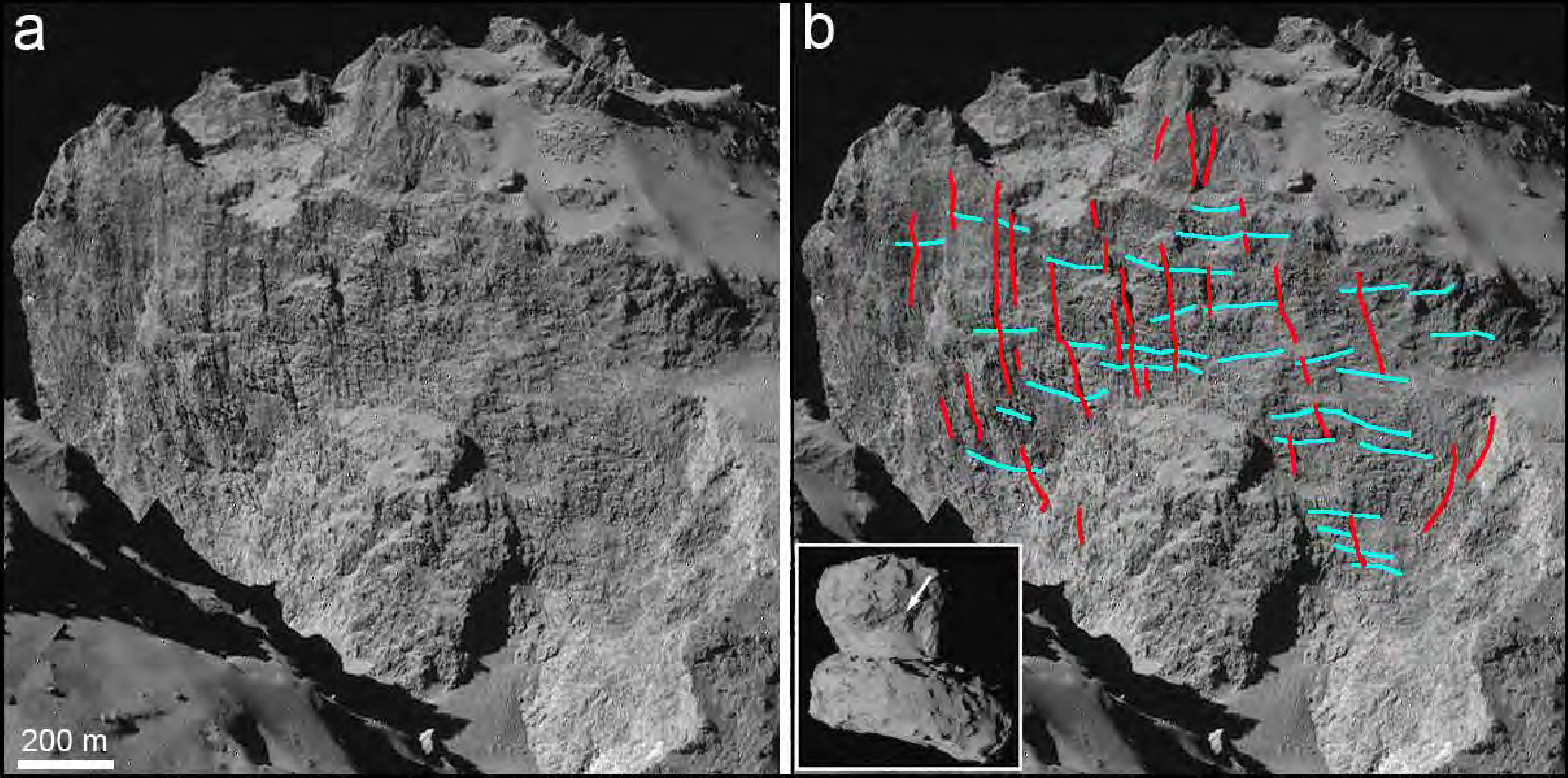


Andesite dome, Venus Canyon Ophyr, Mars Landslide in crater, Phobos



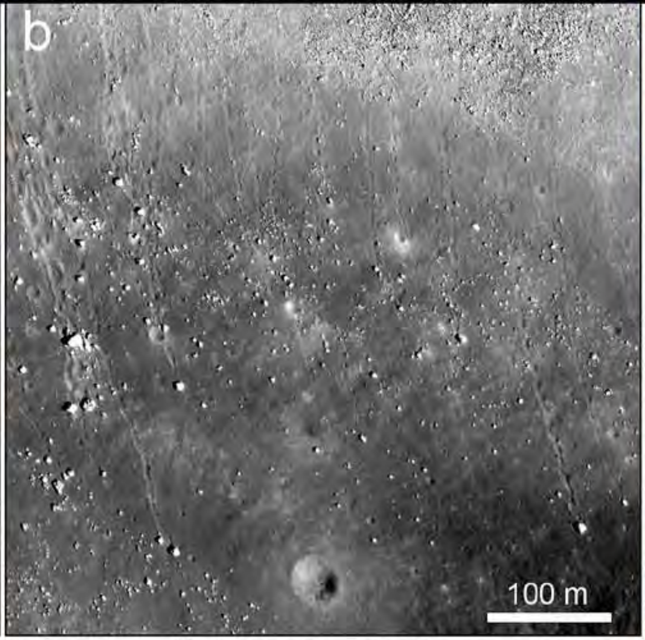
Fine loose (?) material(1), blocks of consolidated material (2) and semiburied blocks (3) in Hapi are at the foot of Hathor cliff.

Lineaments, oriented downslope (red) and subhorizontal (turquoise) on the Hathor cliff.

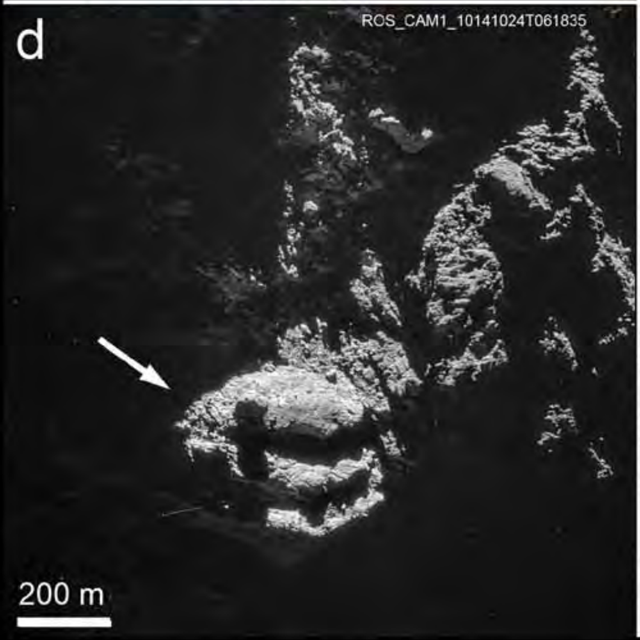


Oso, Washington, USA

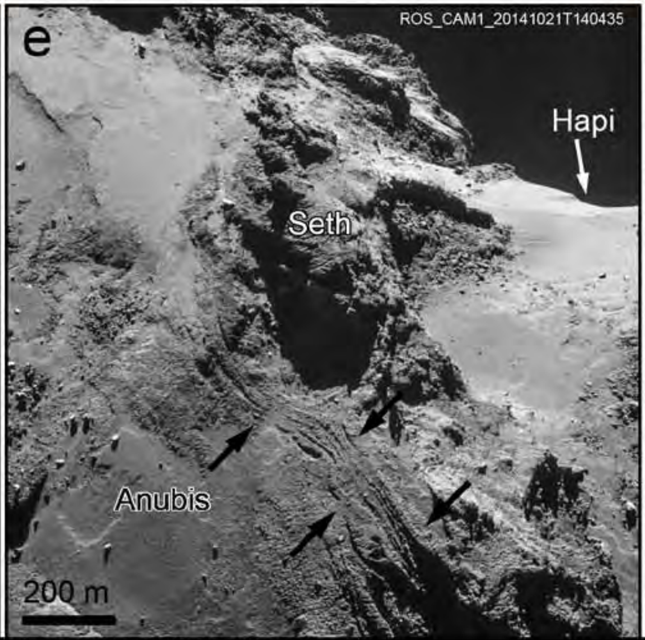
Slope in Oceanus Procellarum



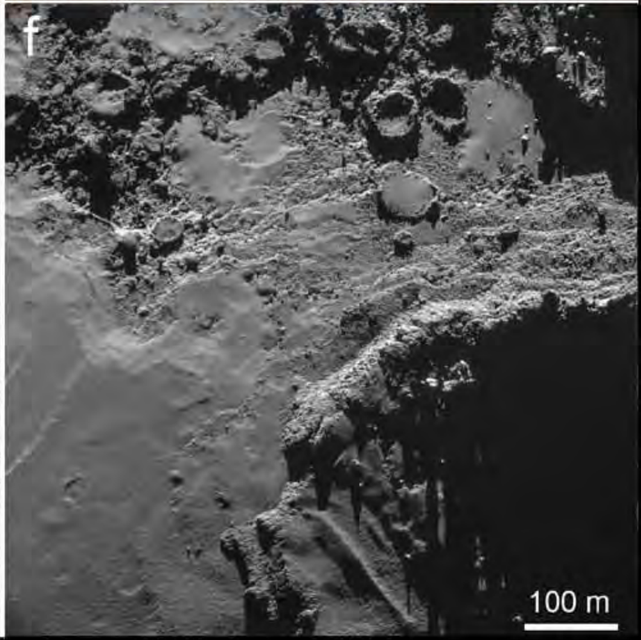
Wingate Sandstone, Co.



Layers in Atum region, 67P

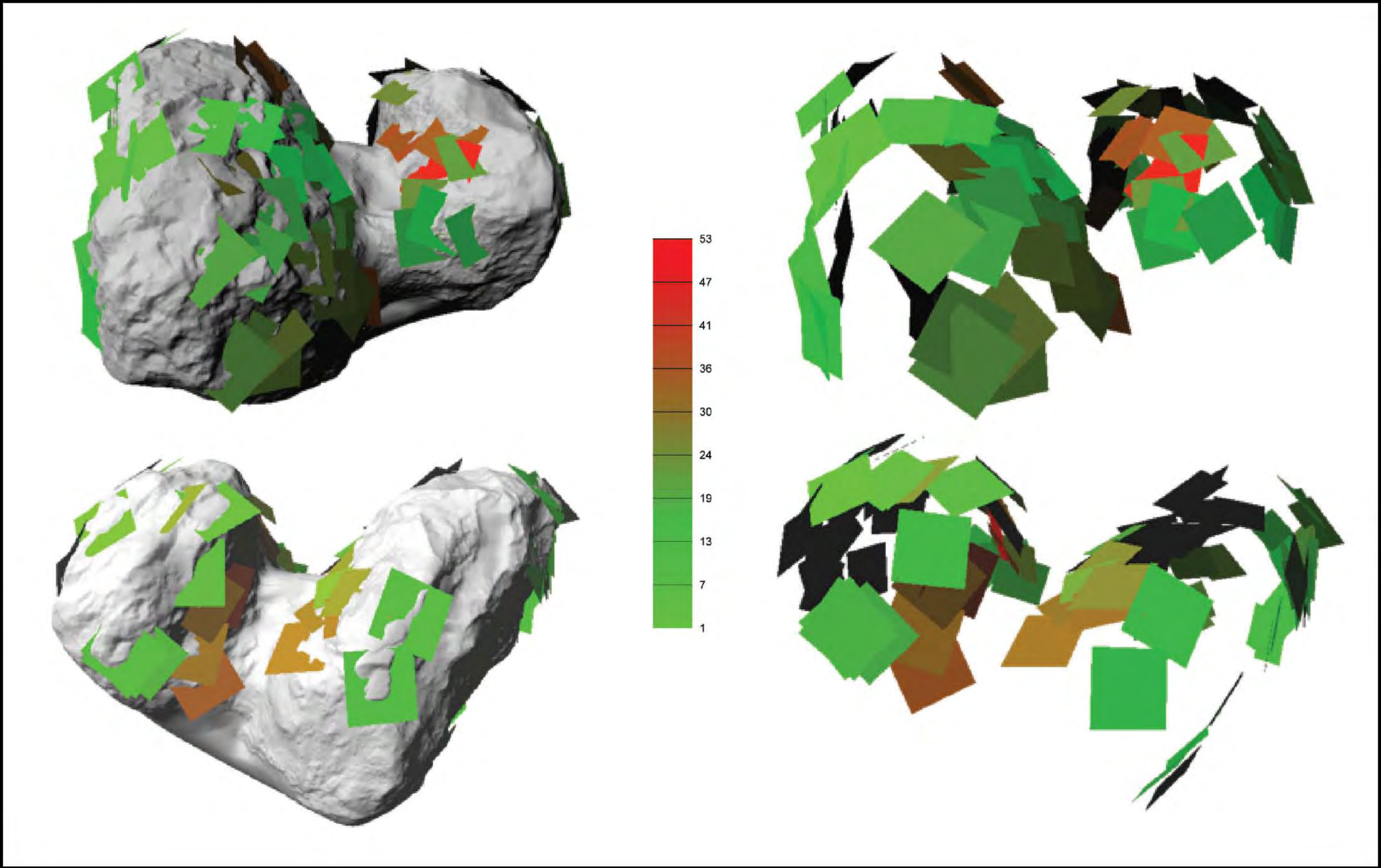


Layers in Seth region, 67P



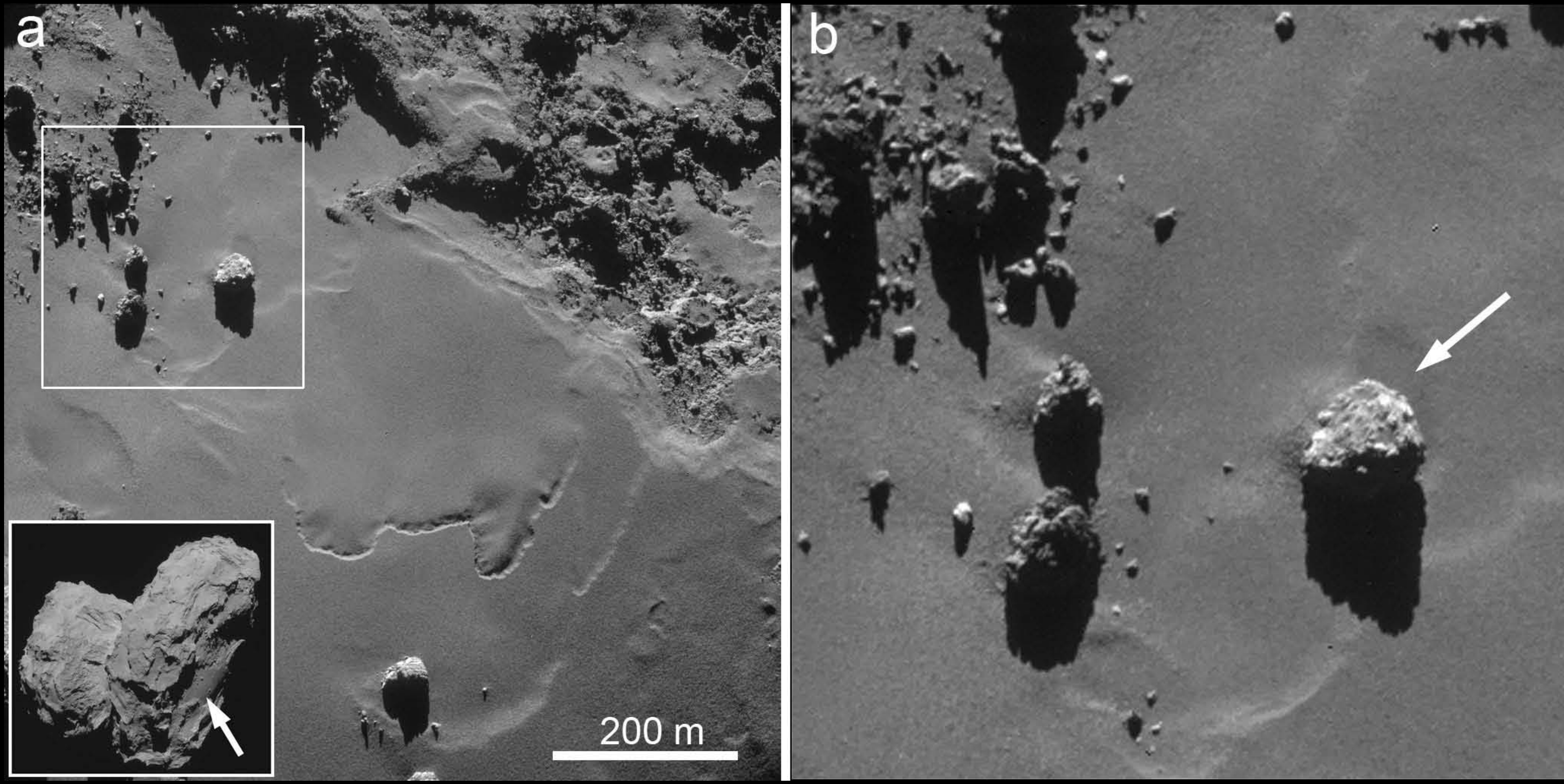
Layers in Imhotep region, 67P

Two lobes of the nucleus – result of jointing of two separately formed bodies?



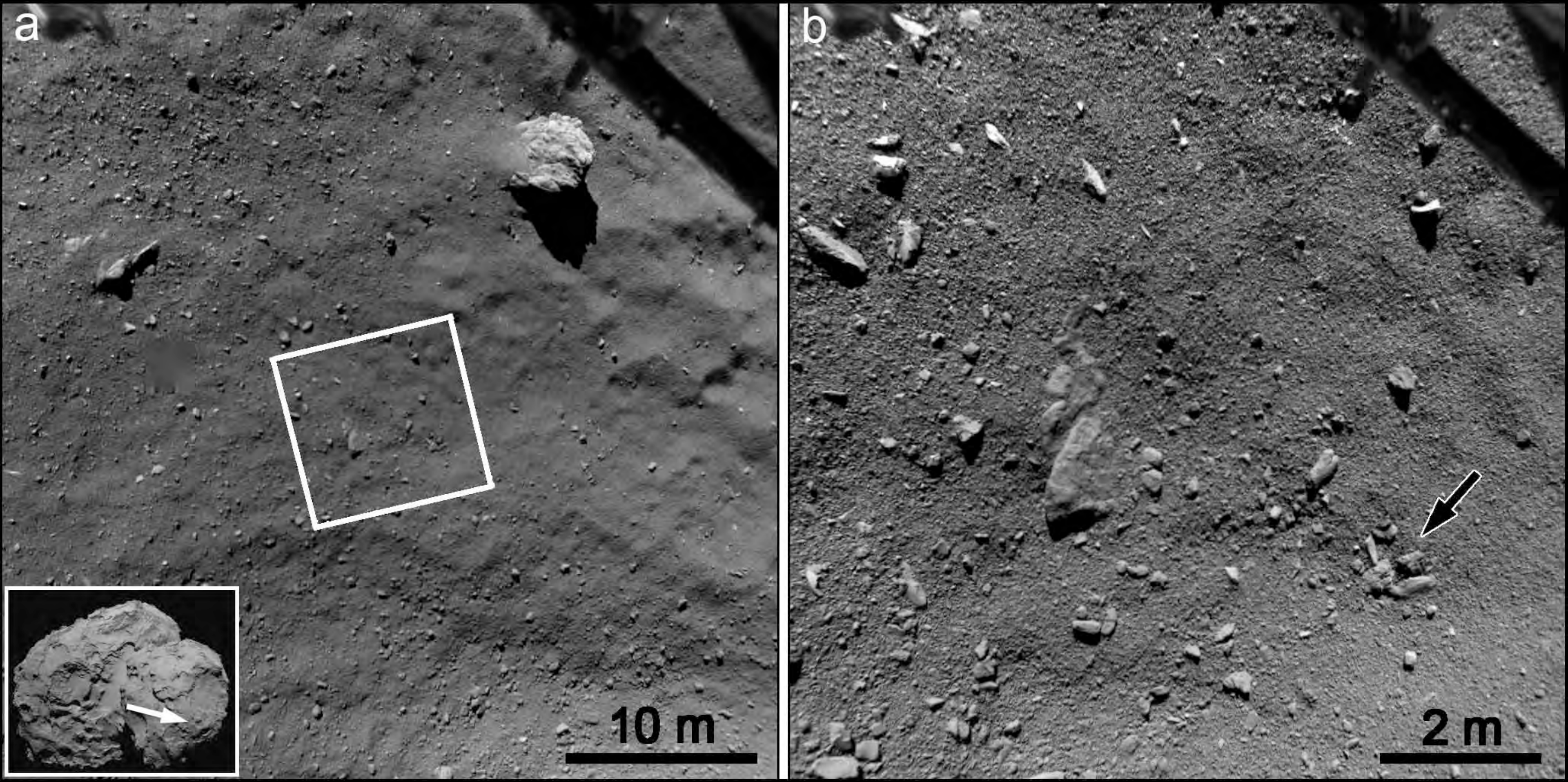
Massironi et al., Nature, 2025, doi:10.1038/nature15511

Blocks with inhomogeneities (inclusions?) of 3-5 m across in Imhotep region.

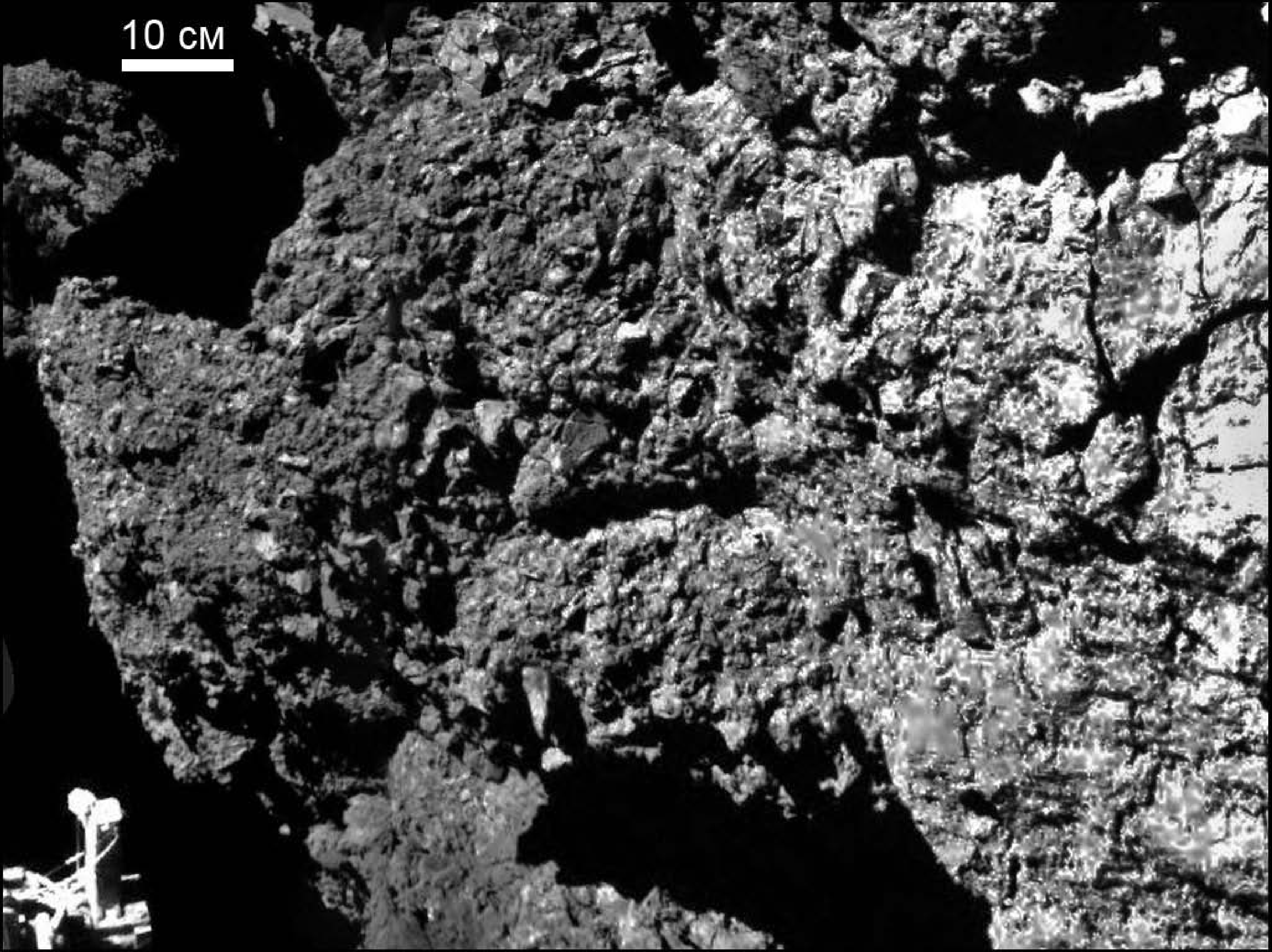


Arrow shows to block Cheops ~50 m across
NavCam image 20141023T182255

Surface of the nucleus in the place of the first contact of Philae, Agilkia area, ROLIS images.



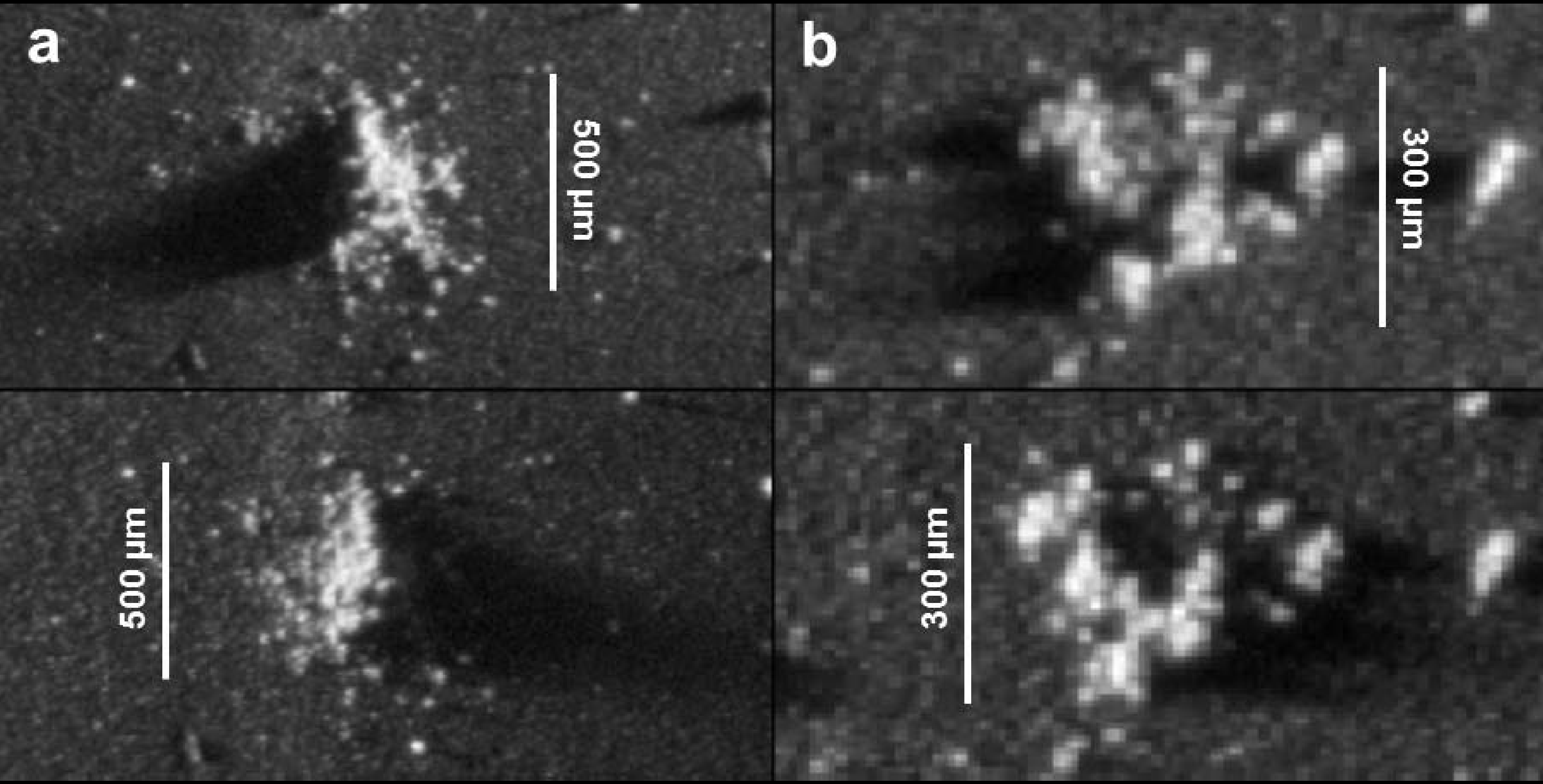
a) Image, taken from the height 38.6 m, white quadrangle shows outlines of image b, taken on the height of 9 м bb). The 5-meter block of consolidated material shows «grainy» character with 0.3-1 m grains. Grains of centimeter(s) size are seen on the surface.



Agglomerate of grains of mm-cm size in the place of final landing of Philae

Bibring et al., Science, 349, 2015

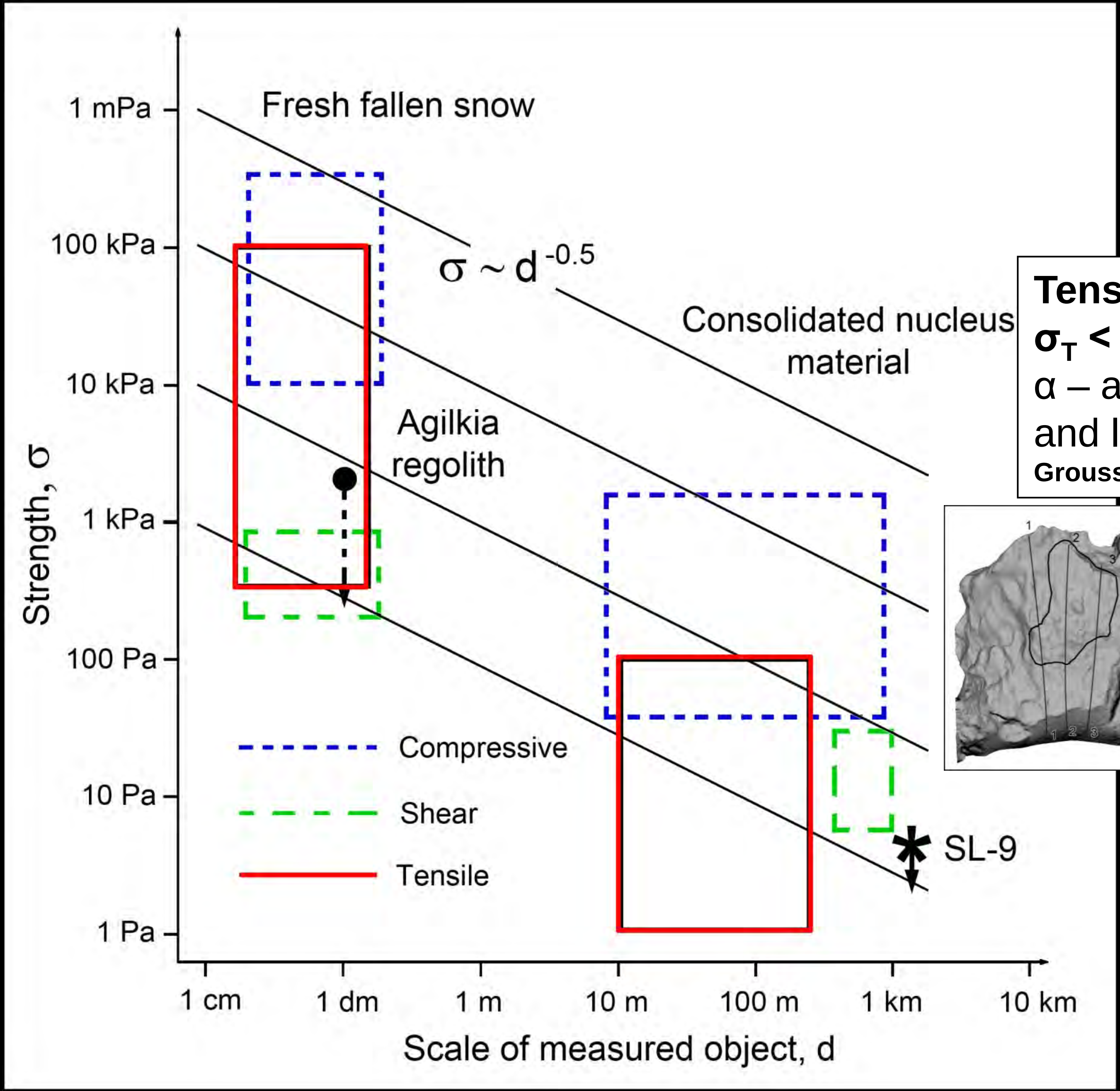
Particles caught in 67P coma by the COSIMA instrument at the 10-20 km distance from the nucleus surface.

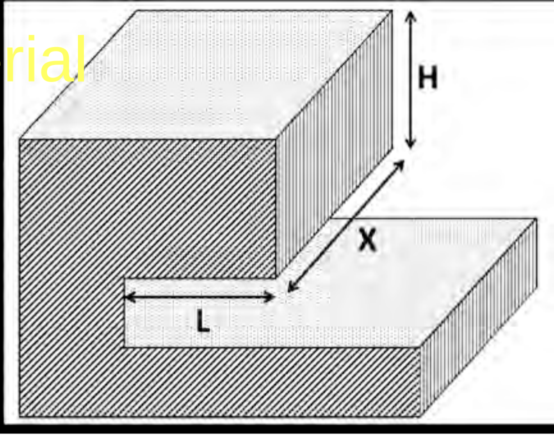


It is seen that particles of hundreds microns across are composed of particles of tens microns across.

Schultz et al., Nature. 2015, doi:10.1038/nature14159.

Estimation of strength of the 67P nucleus material





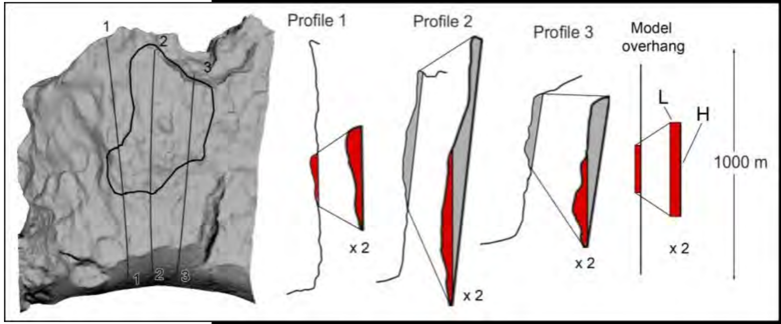
Tension strength:

$\sigma_T < 3\rho g \cos\alpha\ L^2/H$,

α – angle between the overhan

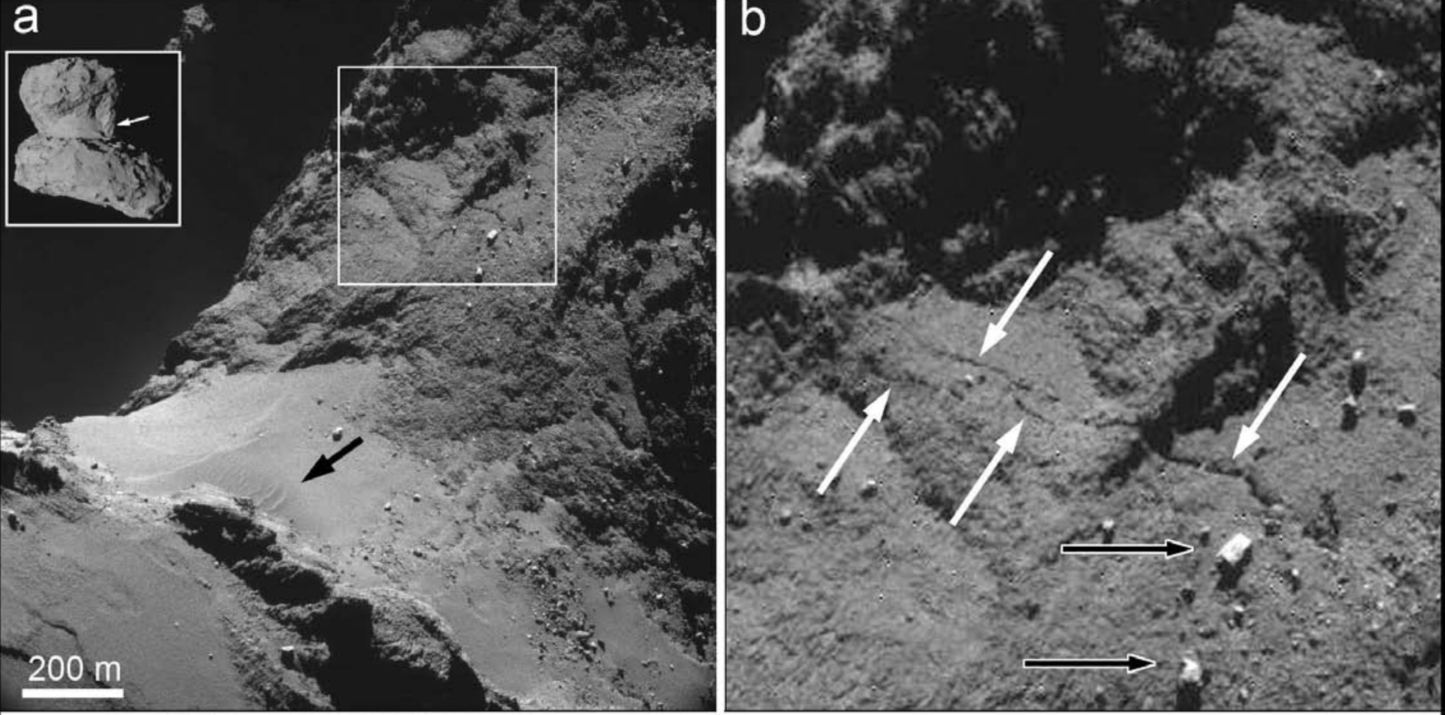
and local vertical

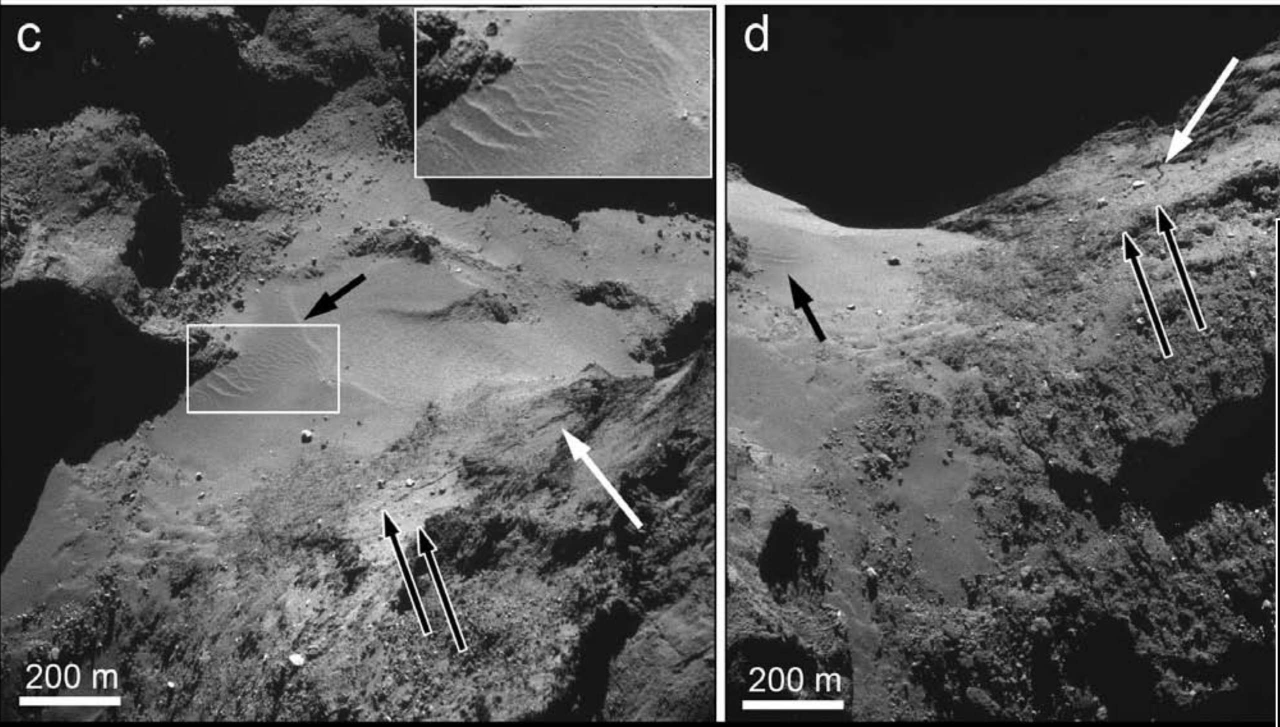
Groussin et al., A & A, 583, A32 (2015),



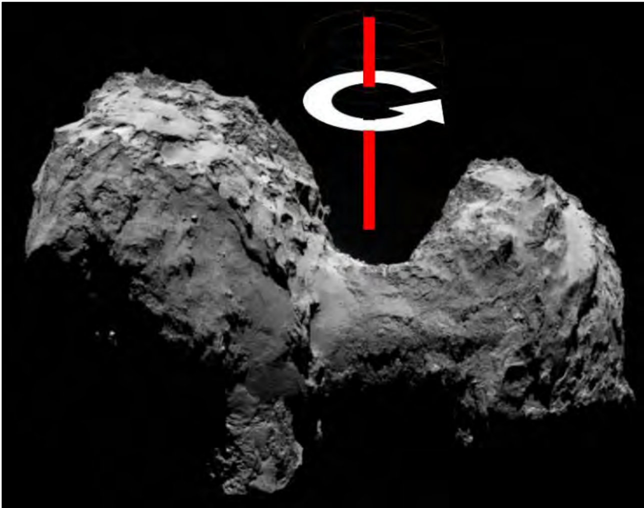
Also were estimated strengths for shear and compression.

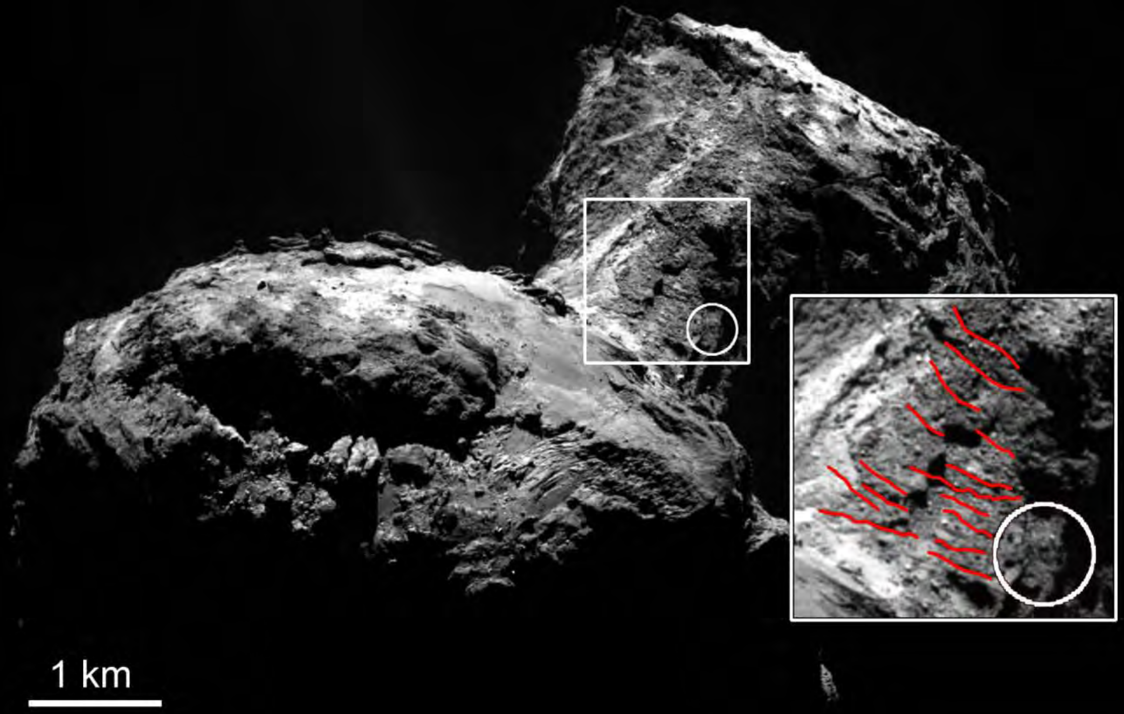
Influence of the facto of scale



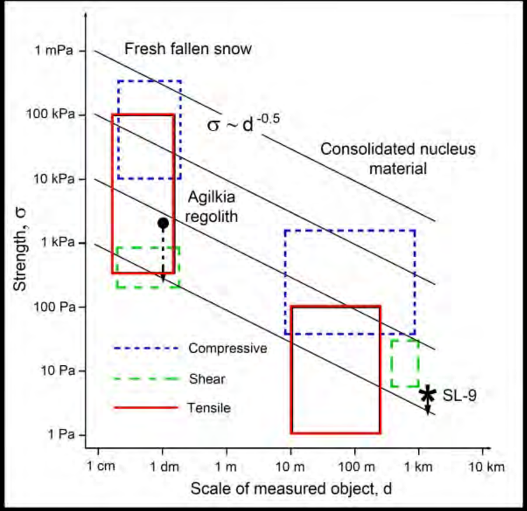


Tension fractures and structures like eolian ripples in Anuket area. Lower right is a scheme of rotation of nucleus around Its axis.

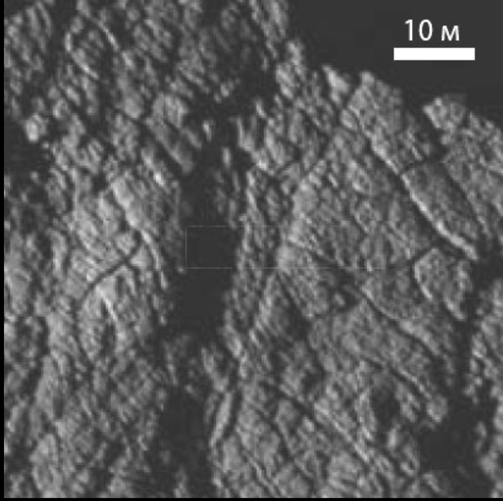


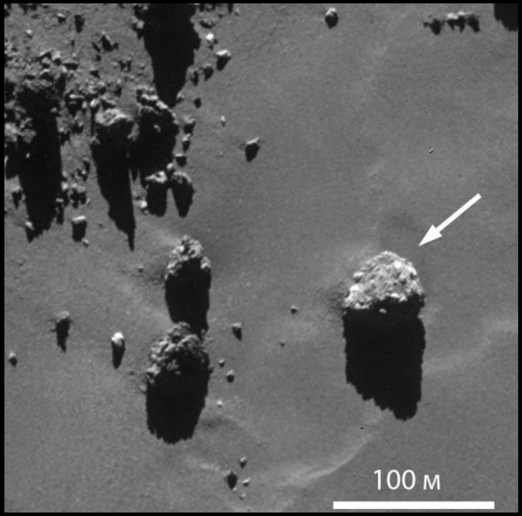


Short but powerful
outburst
Of gas and dust
on July 29 2015
in Anuket area
and the outburst
place
determined by the
Osiris team.

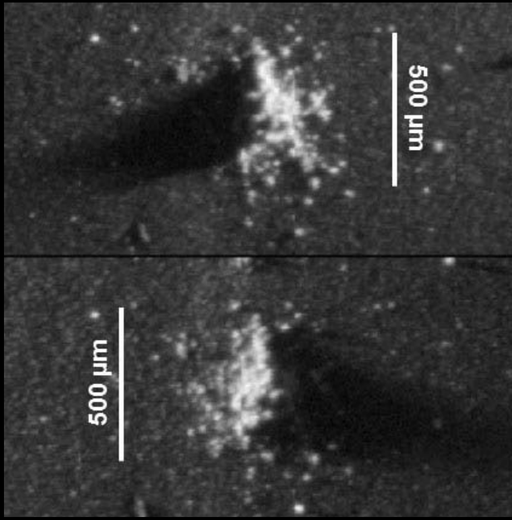


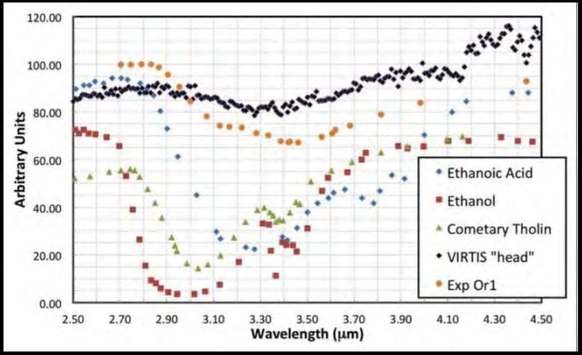
Taking into account the scale effect one can conclude that consolidated material of 67P comet has strength close to hat of fresh snow at -10C





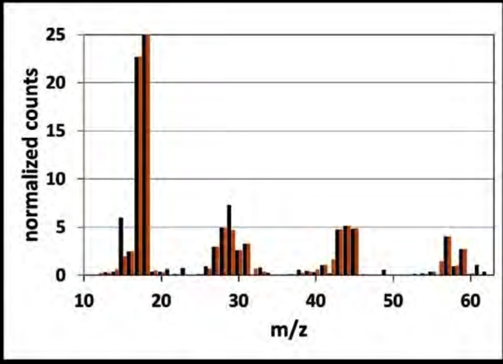
It is grainy with observed “grains” from tens of meters to tens of microns





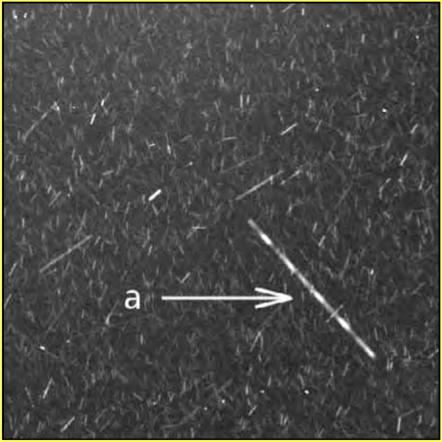
The surface is covered by black porous material containing organics

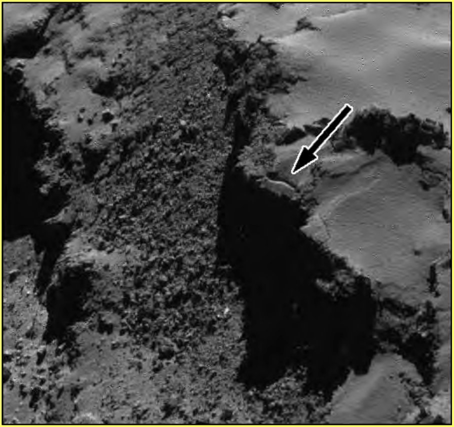
.



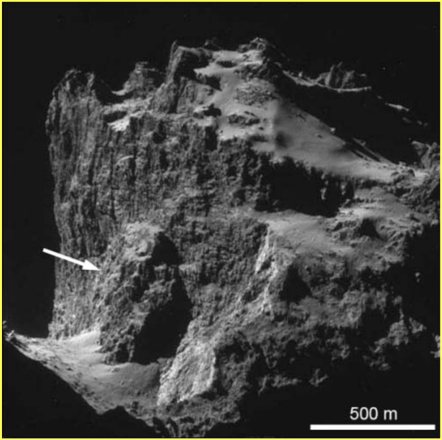
Material transportation:

From below up:
by gas of sublimation





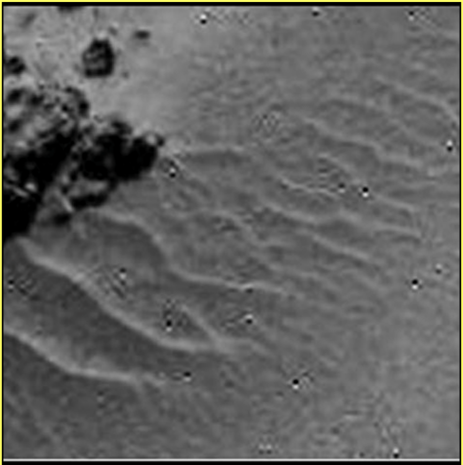
Down:
by gravity force



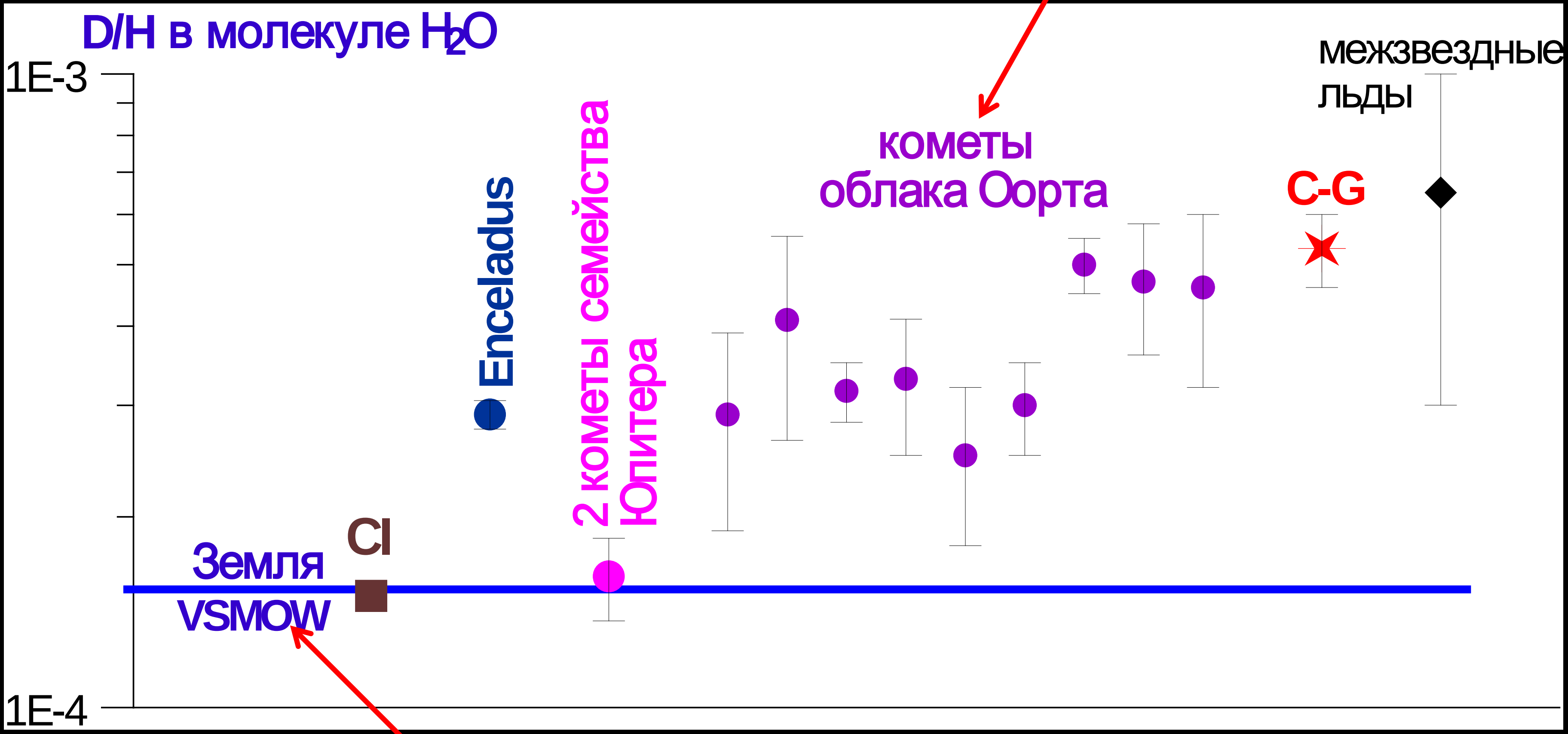
Horizontally:

by inertia, acquired at
the movement down

By action of gas jets?

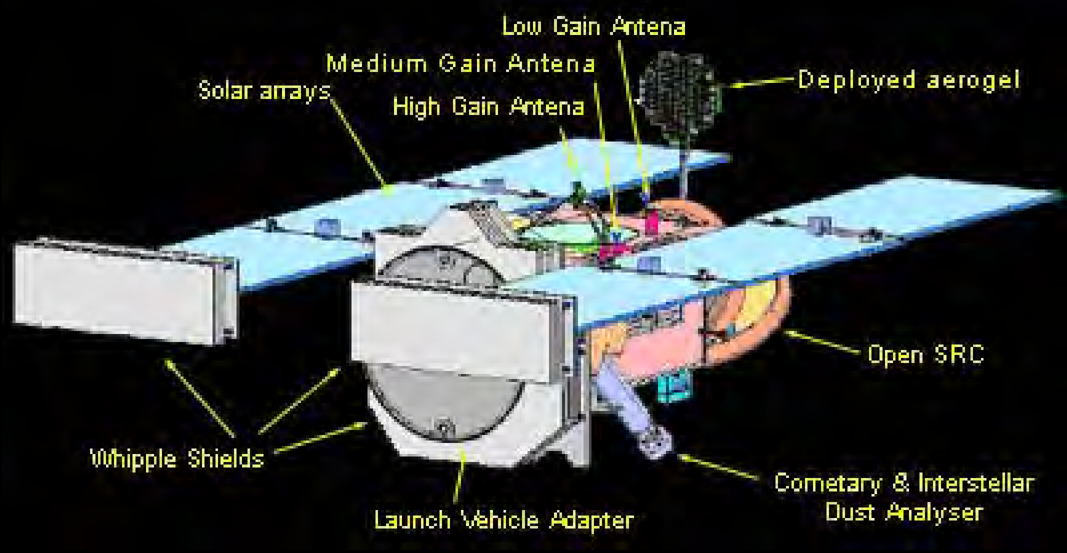


D/H = $(5.3 \pm 0.7) \times 10^{-4}$, that coincides with D/H in molecule H_2O of the Oort cloud.

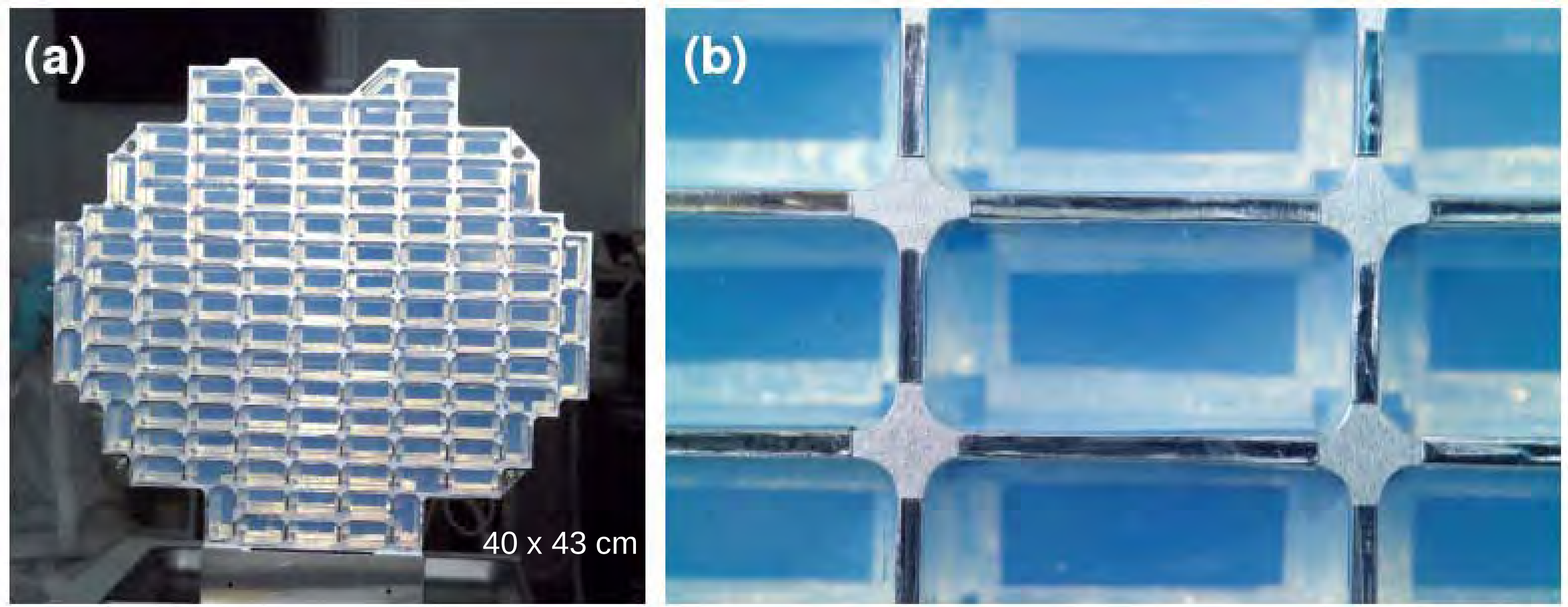


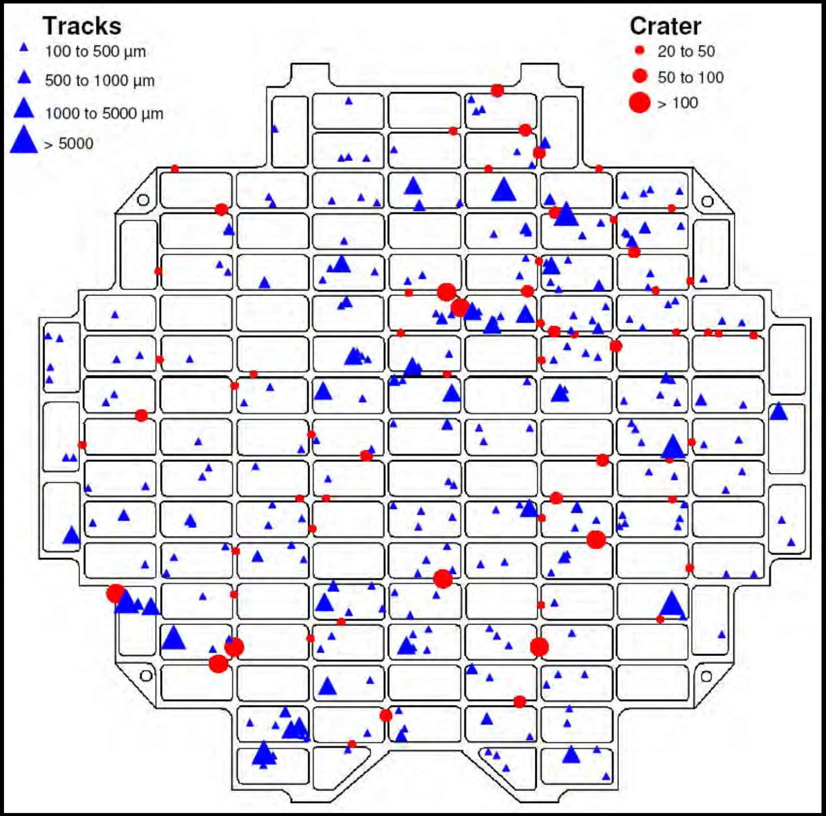
Earth oceans

Stardust mission to sample comet Wild 2 particles

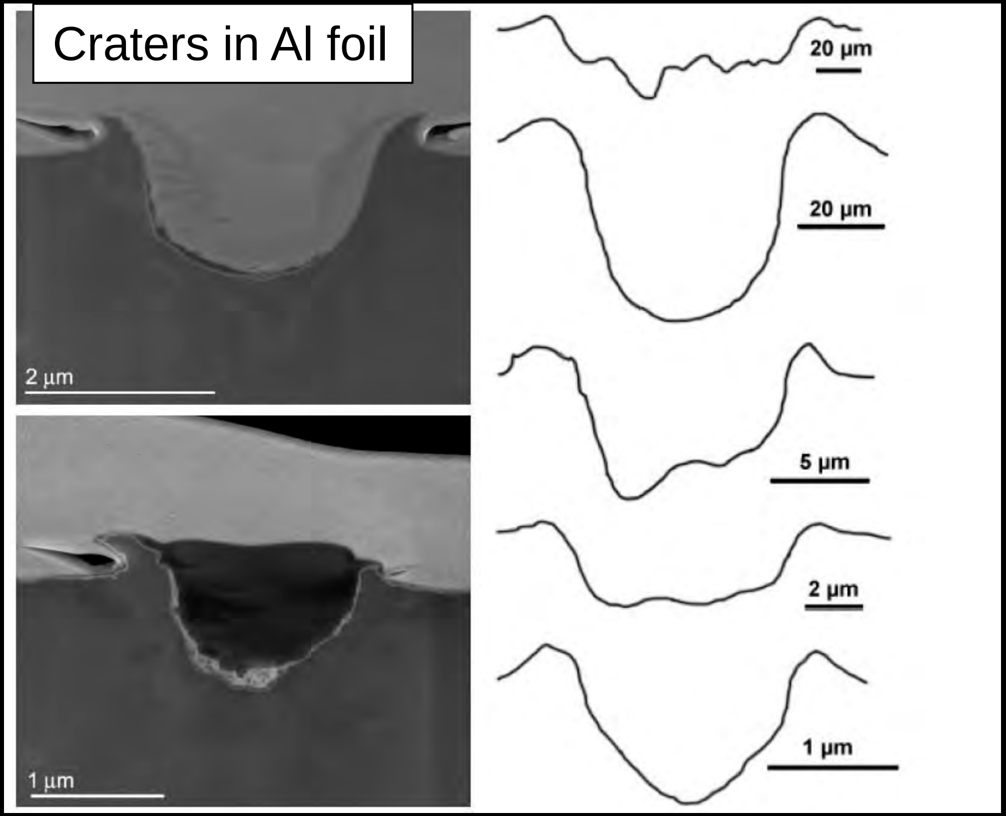


Stardust sample return, Brownlee et al., 2006

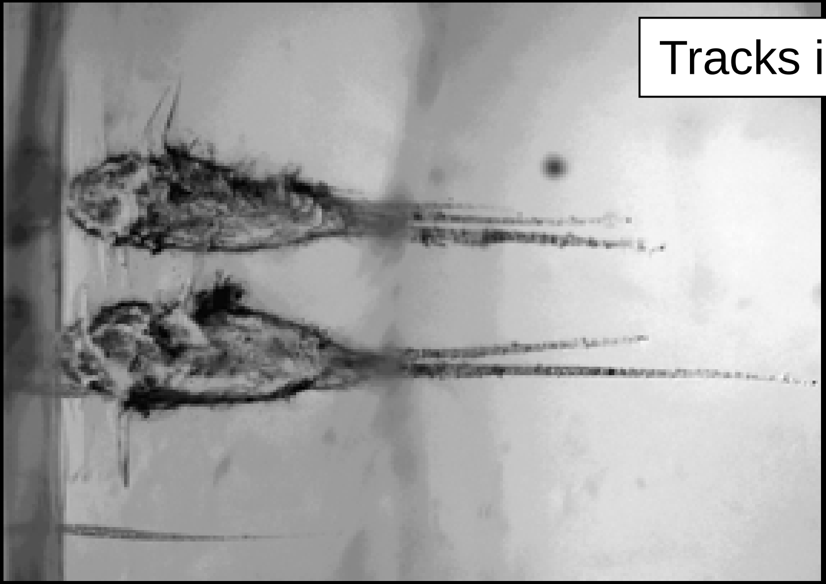


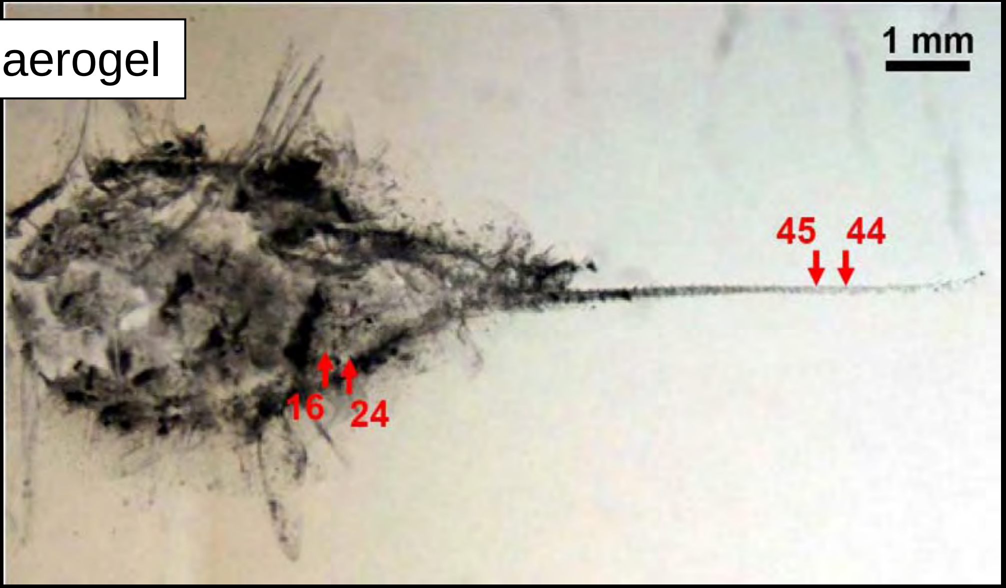


Craters in Al foil



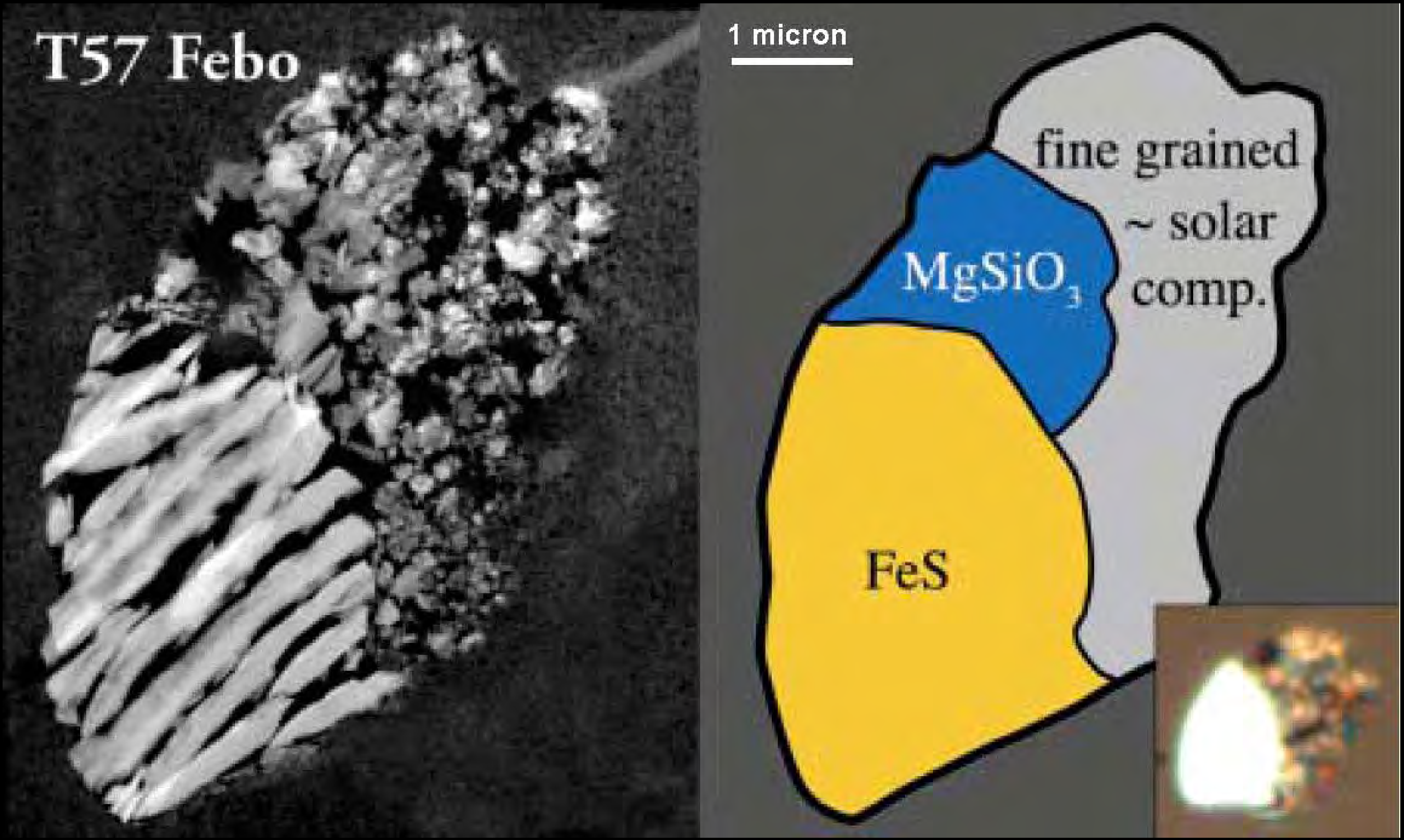
Tracks in aerogel





Brownlee et al., Science, 2006

The 8 mm terminal particle T57 (Febo)

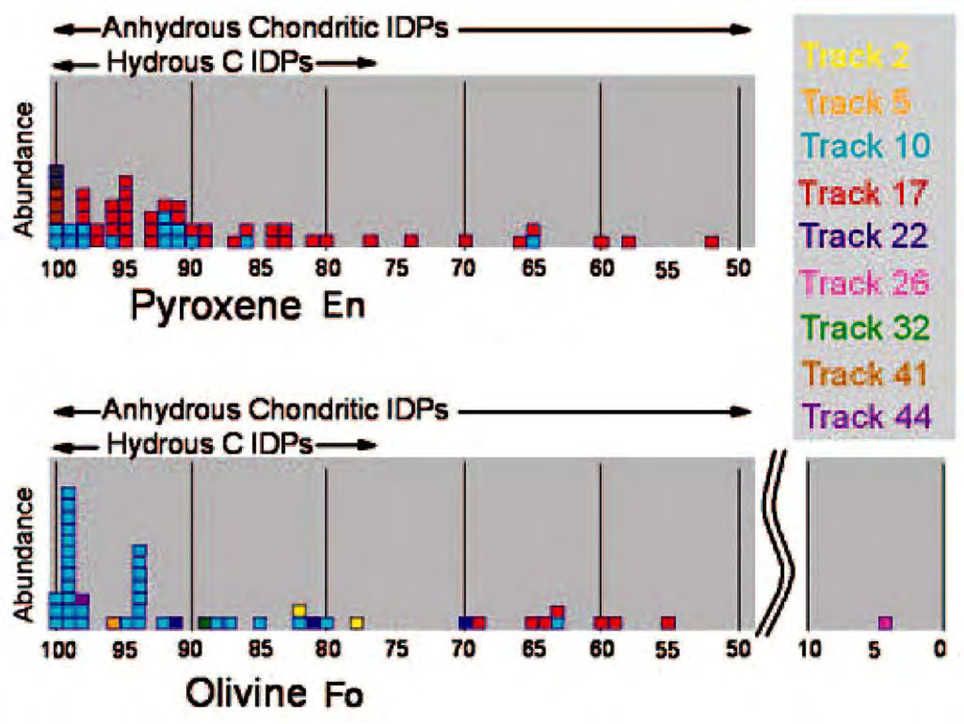


High-angular annular dark-field image

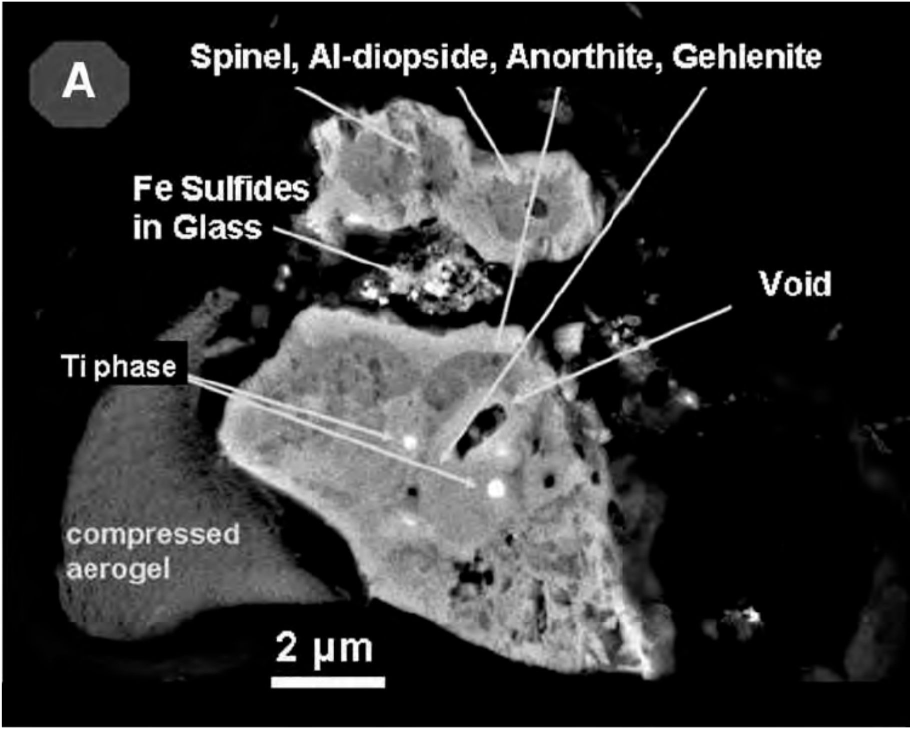
Reflected light

Grain size: Weakly constructed mixtures of nanometer-scale grains, with occasional much larger (> 1 μm) ones.

Mineralogy: Ferromagnesian silicates, Fe-Ni sulfides, and Fe-Ni metal and accessory phases. Hydrous phases are not found.



Pyroxenes and olivines



CAI particle

Zolensky et al. Science, 2006

Implication 1: The very wide range of olivine and low-Ca pyroxene compositions in comet Wild 2 requires a wide range of formation conditions, probably reflecting very different formation locations in the protoplanetary disk.

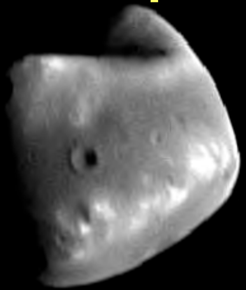
Implication 2: The restricted compositional ranges of Fe-Ni sulfides, the wide range for silicates, and the absence of hydrous phases indicate that comet Wild 2 experienced little or no aqueous alteration.

Implication 3: Less abundant Wild 2 materials include a refractory particle, whose presence appears to require radial transport in the early protoplanetary disk.

Zolensky et al. Science, 2006

Smal satellites of planets:

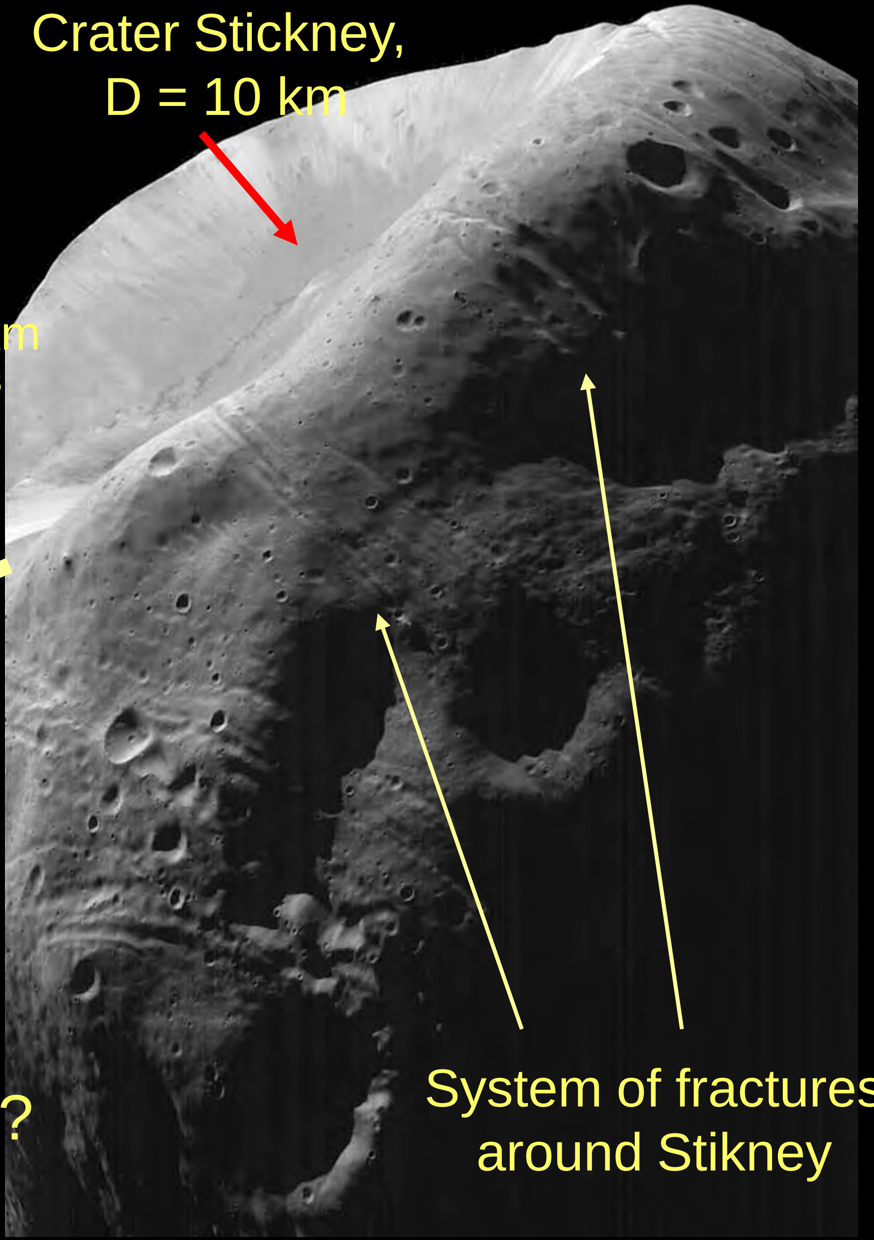
Satelites of Mars



Deimos, 10 x 12 x 16 km
A = 0.06, ρ = 1.9 g/cm^3
V escape = 6 m/s

Phobos, 18 x 22 x 26 km
A = 0.05, ρ = 1.9 g/cm^3
V убегания = 10 m/s

Meteorite Kaidun – fragmant of Phobos?



Crater Stickney,
D = 10 km

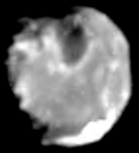
System of fractures
around Stikney

Carbonaceous chondrite Kaidun, Meteorite collectio of RAN

Small satellites of giant planets

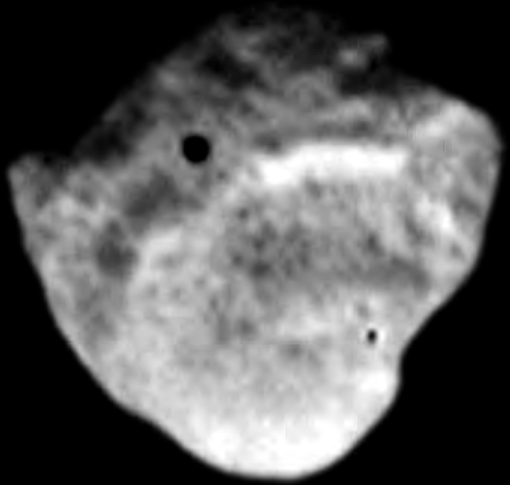
Jupiter satellites

Methis,
20 km



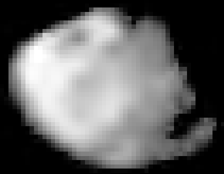
Phoebe, 50 km

Amalthea,
67 x 75 x 131 km



Hiperion, 226 x 280 x 370 km

Saturn satellites



Pandora, 60 x 90 x 110 km

Shadow of Saturn's F-ring

Epimetheus, 110 km

Neptune satelites

Larisa, 190 km

Proiteus, 400 km

Characteristics of small bodies

Shape – irregular,
maybe except the largest asteroids

Atmosphere
- Asteroids and small satellites – no atmosphere
- Comets – gas of coma on approach to the Sun

Material – primitive (chondrites, carbonaceous chondrites, ice + silicate-oxide dust)
Exception – achondrites, asteroid Vesta

Geological processes
- Impact cratering
- Collapses, landslides, creep
- Sublimation of ice of comet nuclei on approach to the Sun
- No volcanism (there was early volcanism on parent bodies of achondrites)
- No endogenic tectonism
- Faults made by impacts

Phobos Sample Return Project

L. Zelenyi

Space Research Institute

Phobos Sample Return Project

Goals of the Mission

- Phobos regolith sample return,
- Phobos in situ study and remote sensing,
- Martian environment study
- Mars monitoring

Pecularities of the mission:

- Samples return
- Mars system science:
  - Martian moon (regolith, internal structure, origin, evolution),
  - Martian environment (dust, plasma, fields),
  - Mars (surface and atmosphere global dynamics)

Elements of the spacecraft

the Earth-Mars Interplanetary flight

Approach Phobos and landing

The Mars-Earth interplanetary flight

At the Phobos surface after take off the Return Module

Lavochkin Assosiation

Phobos Sample Return Project

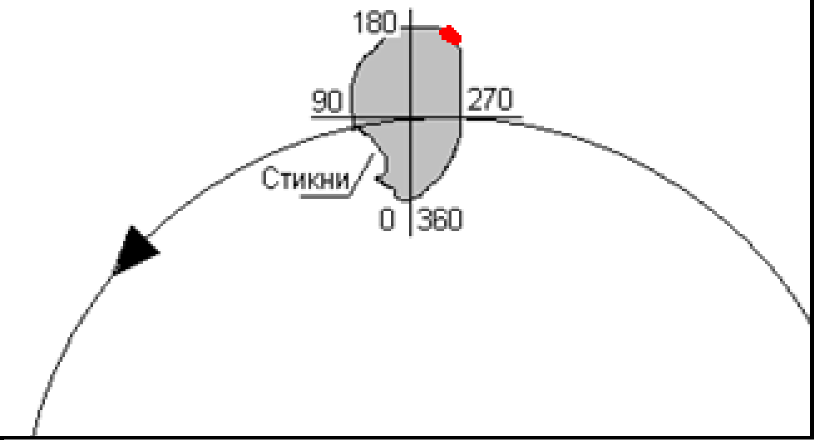
Main characteristics of the spacecraft

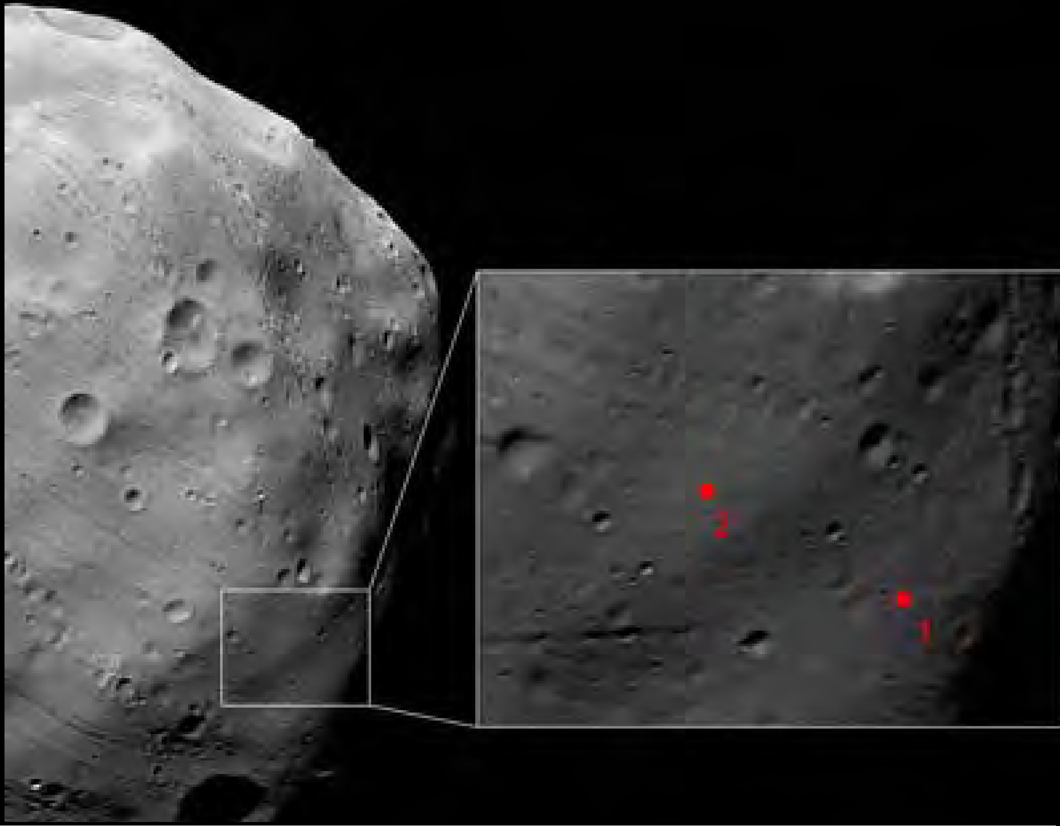
Launcher	“Zenit-2"
SC mass budget	11 990 kg
– Jet propulsion system (charged)	9 965 kg
– transfer SC (charged)	1 290 kg
– returned SC (charged)	248 kg
– landing module	11 kg
– Chinese SC+adapter	287 kg
Mass of the payload	50 kg
Mass of returned samples	0.2 kg

Lavochkin Assosiation

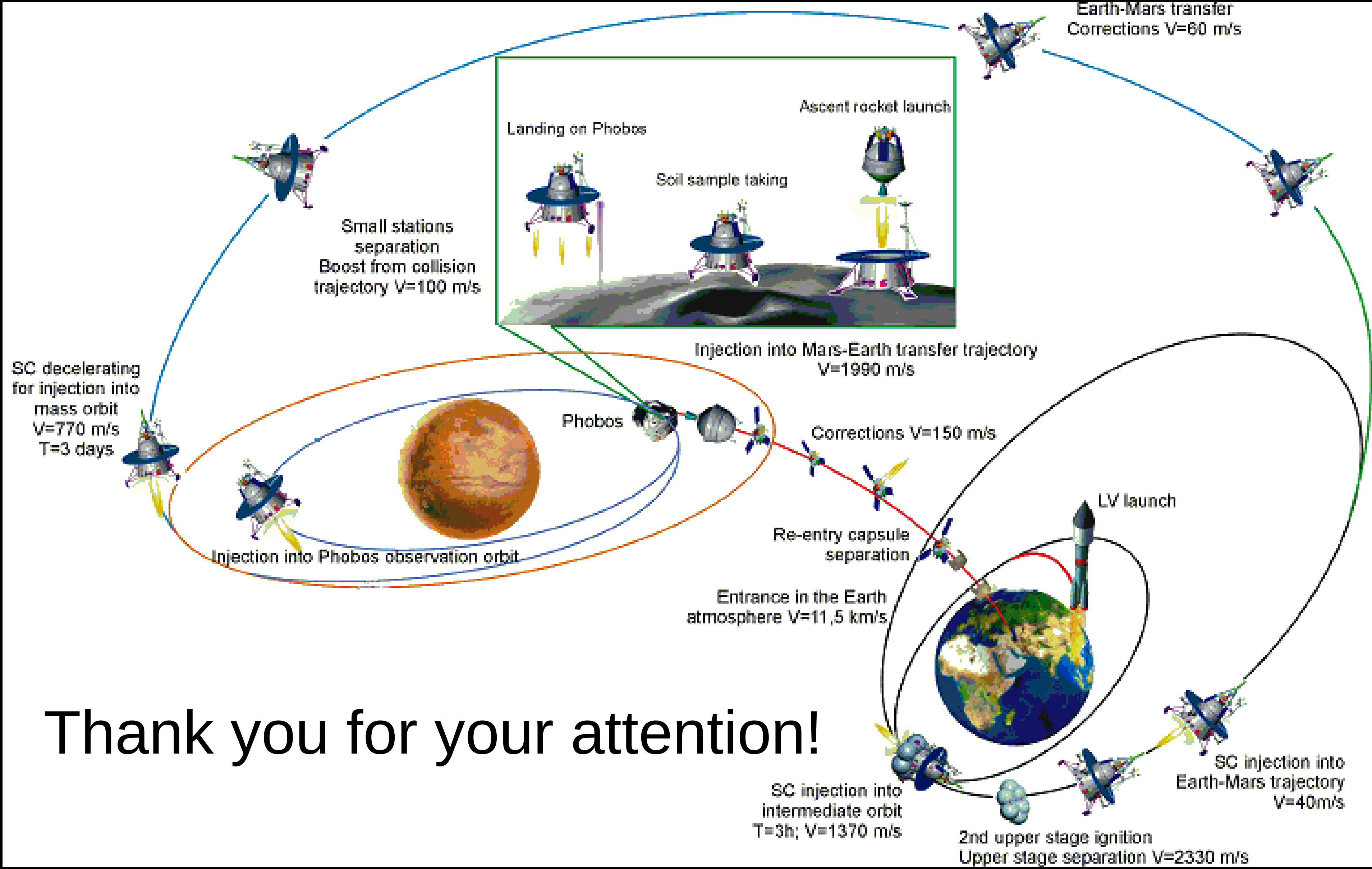
Landing site

Images taken by «Mariner 9», «Phobos2» and «MarsExpress» were used for selection of the landing site





Please wait until mid-2020’s



Thank you for your attention!