An express journey to Mars

Angelo Pio Rossi
European Space Agency

Why to Mars?

- Mars is the only terrestrial planet with strong similarities with early Earth
- It's a fascinating planet
  - Evidences of past liquid water
  - Current presence of large reservoirs of water in form of ice
  - Looking for signs of past (or present) microbial life
  - Exploration started on the '60s and going on today

Mars in the Solar System

esa SCIENCE

Mars facts

Distances:

1.52 AU from Sun

(or 227,940,000 km)

58,400,000 km to Earth

Dimensions:

Diameter: 6794 km

Mass: 6.41x1023 kg

Surface: 144x106 km2

Escape: 5.02 km.s–1

Temperatures:

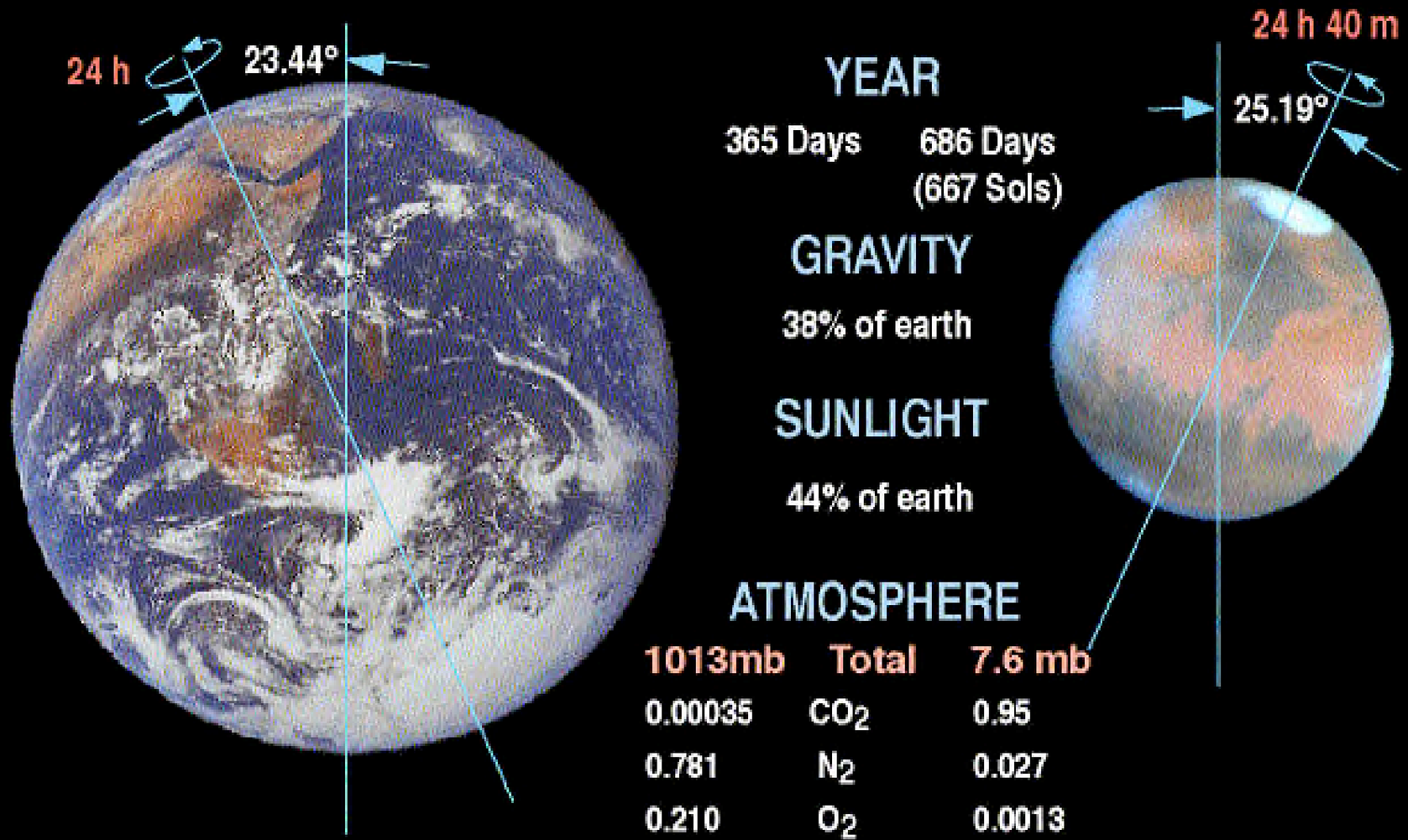
Min: –133°C (winter pole)

Max: +27°C (summer noon)

Average: –55°C (218K)

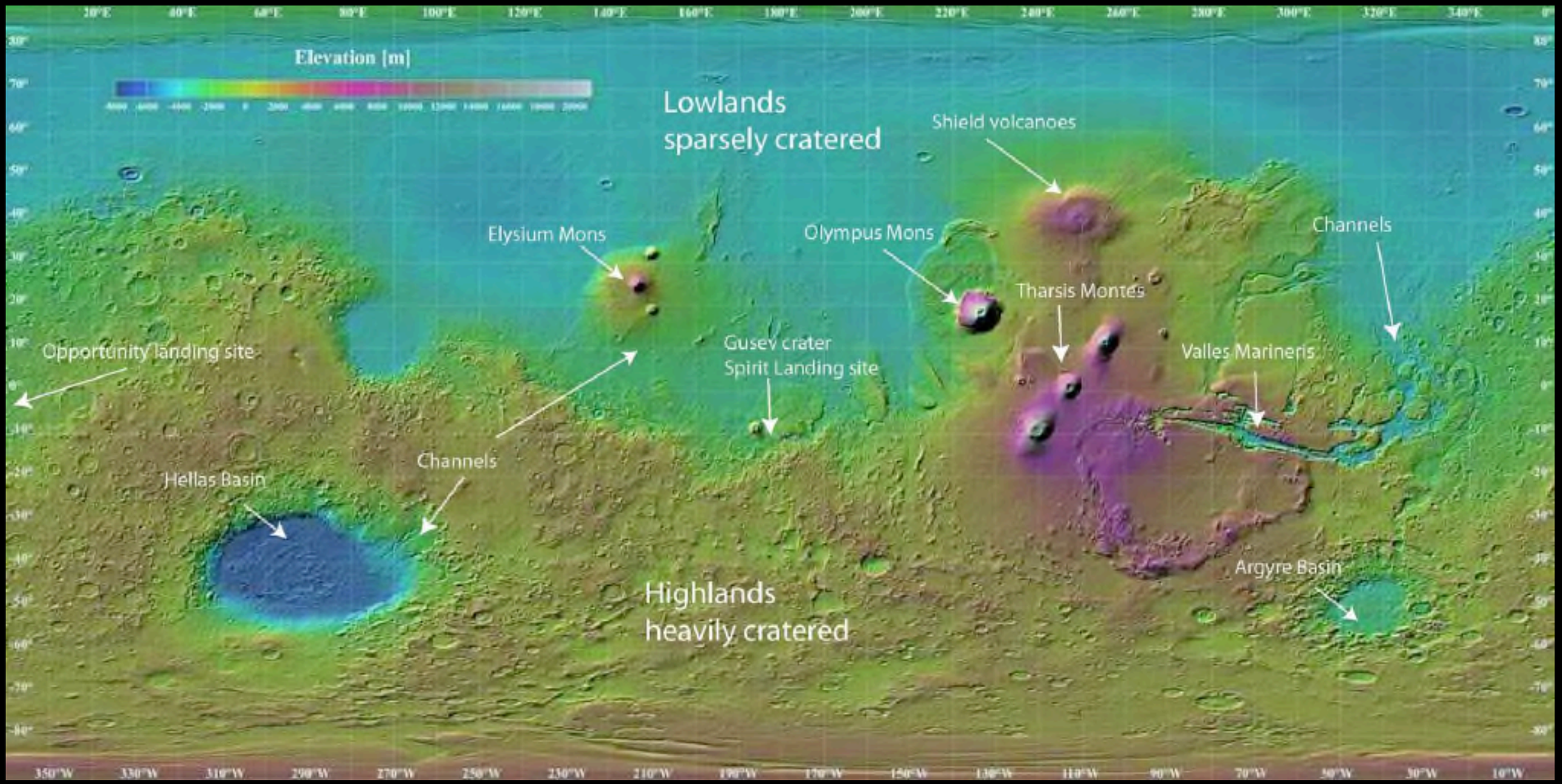
Albedo: 0.16 (darker)

Speed of sound: 235 m.s–1



esa SCIENCE

How Mars looks like

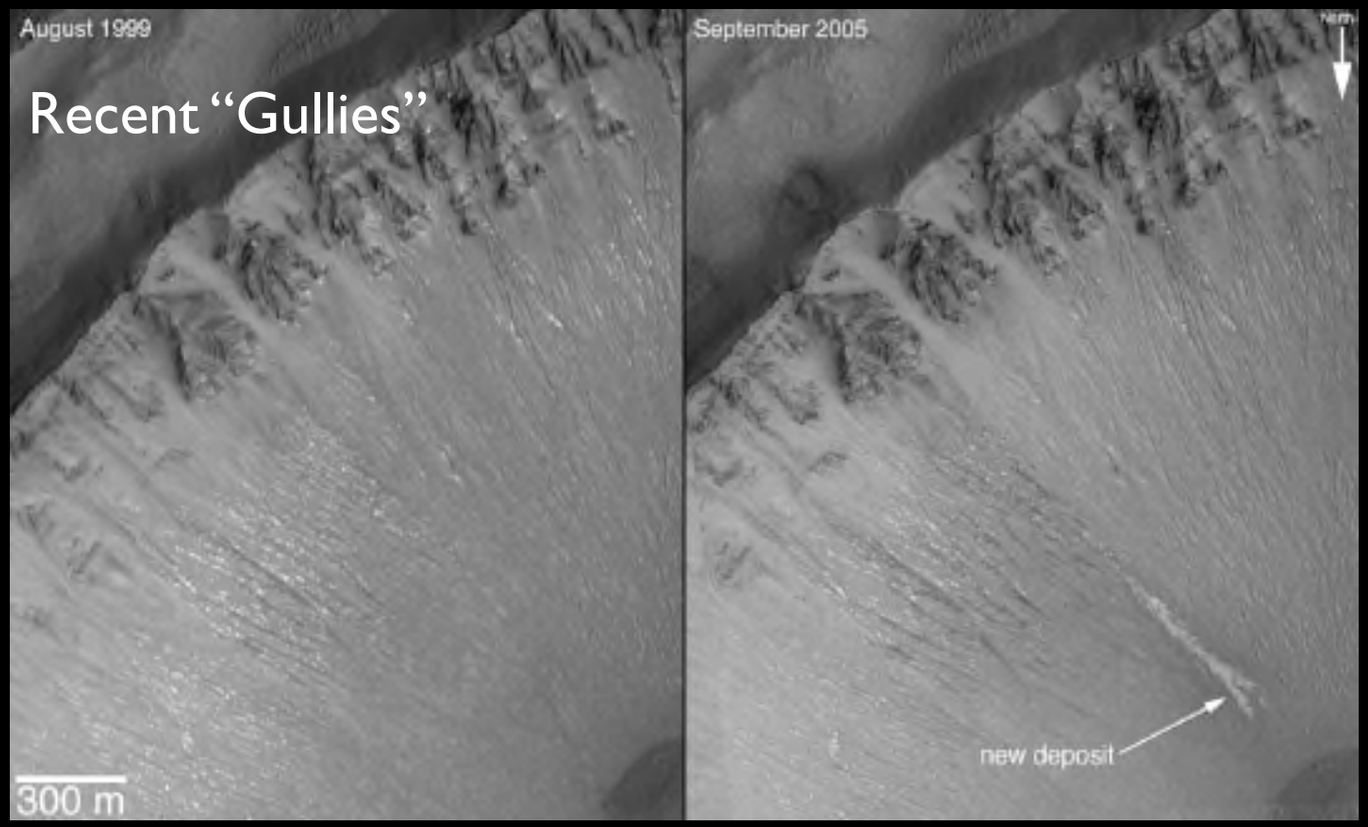


esa SCIENCE

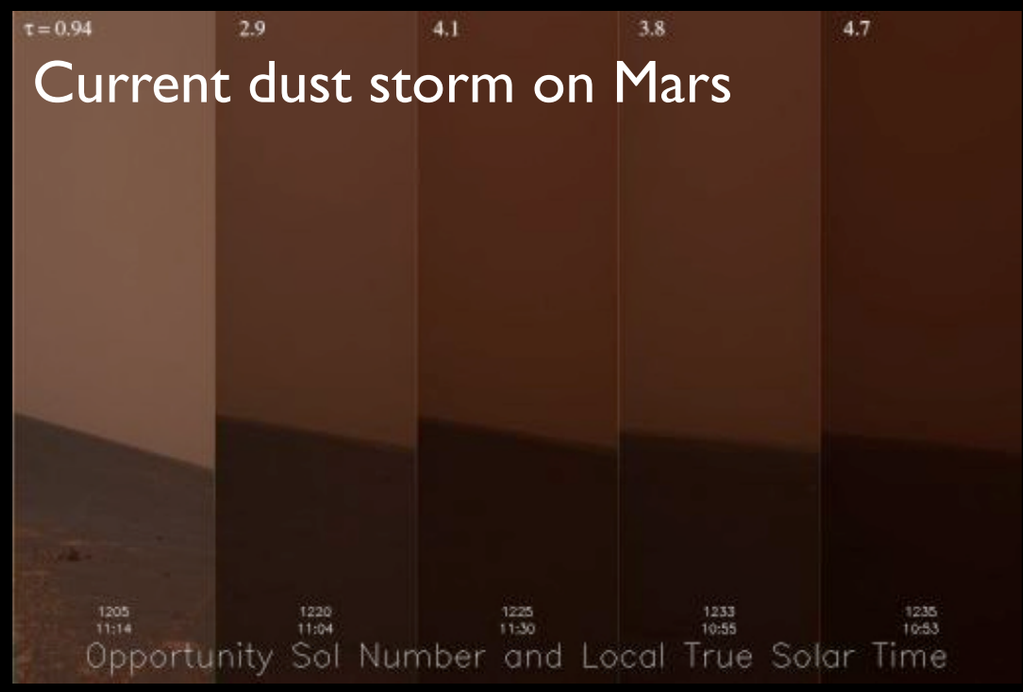
Mysteries of Mars

Mars covered by a global dust storm in 1973

Entrance of a cave on Mars
(NASA / JPL / U.Arizona)



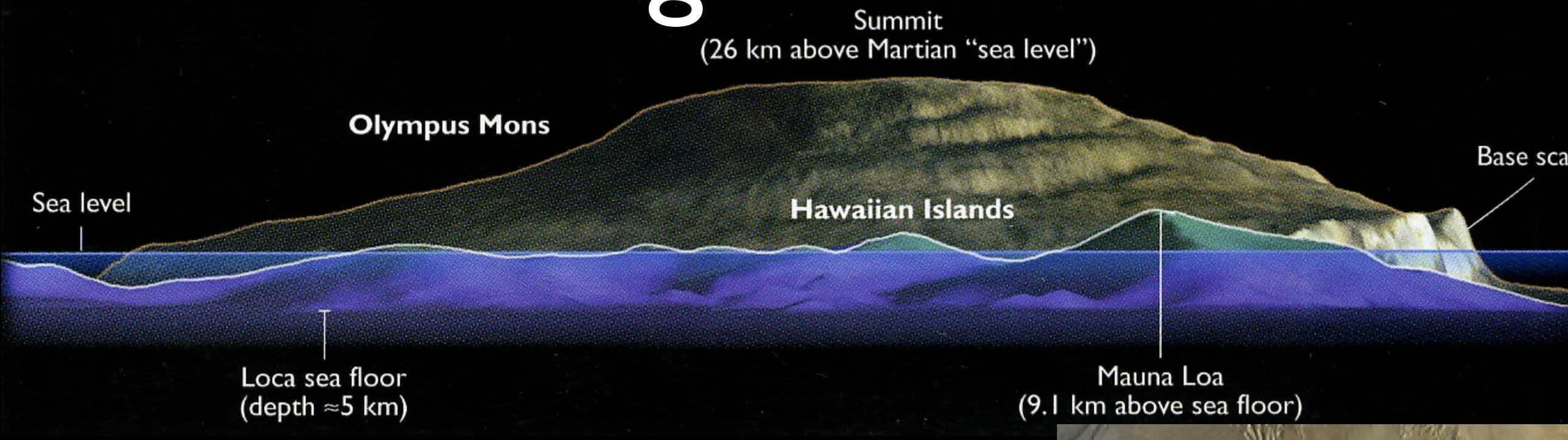
Recent "Gullies"



Current dust storm on Mars

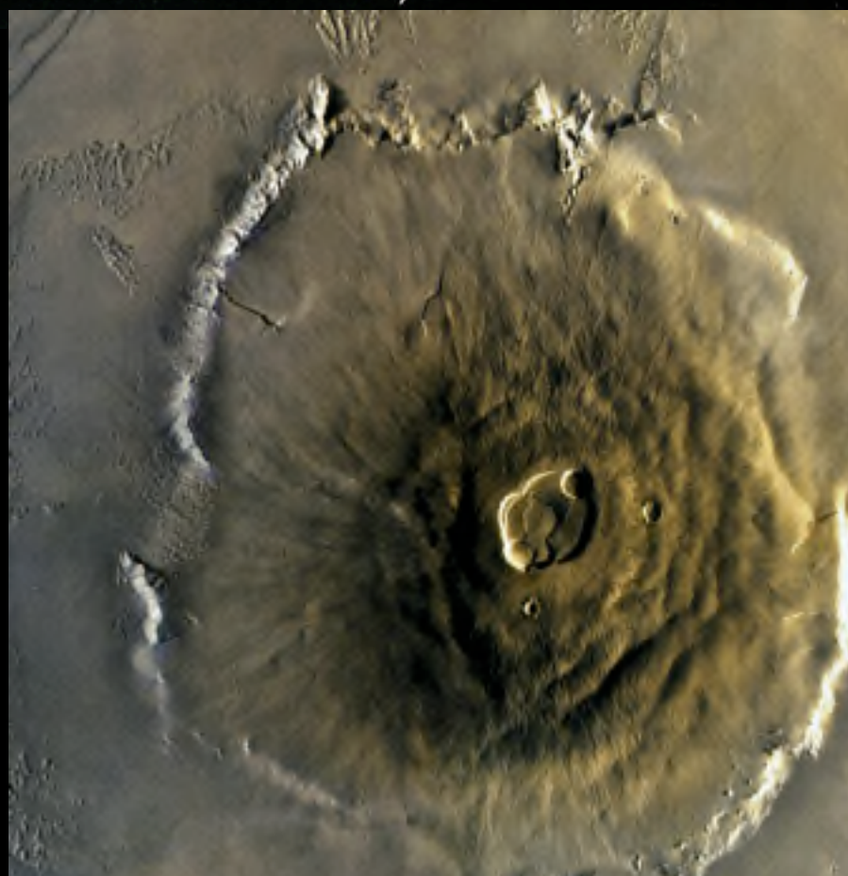
esa SCIENCE

The largest volcano



Mons Olympus is the largest volcano
in the Solar System. Its height is more than 3 times
mount Everest.

It had been active for billions of years,
up to recent times, perhaps 5 Million years ago

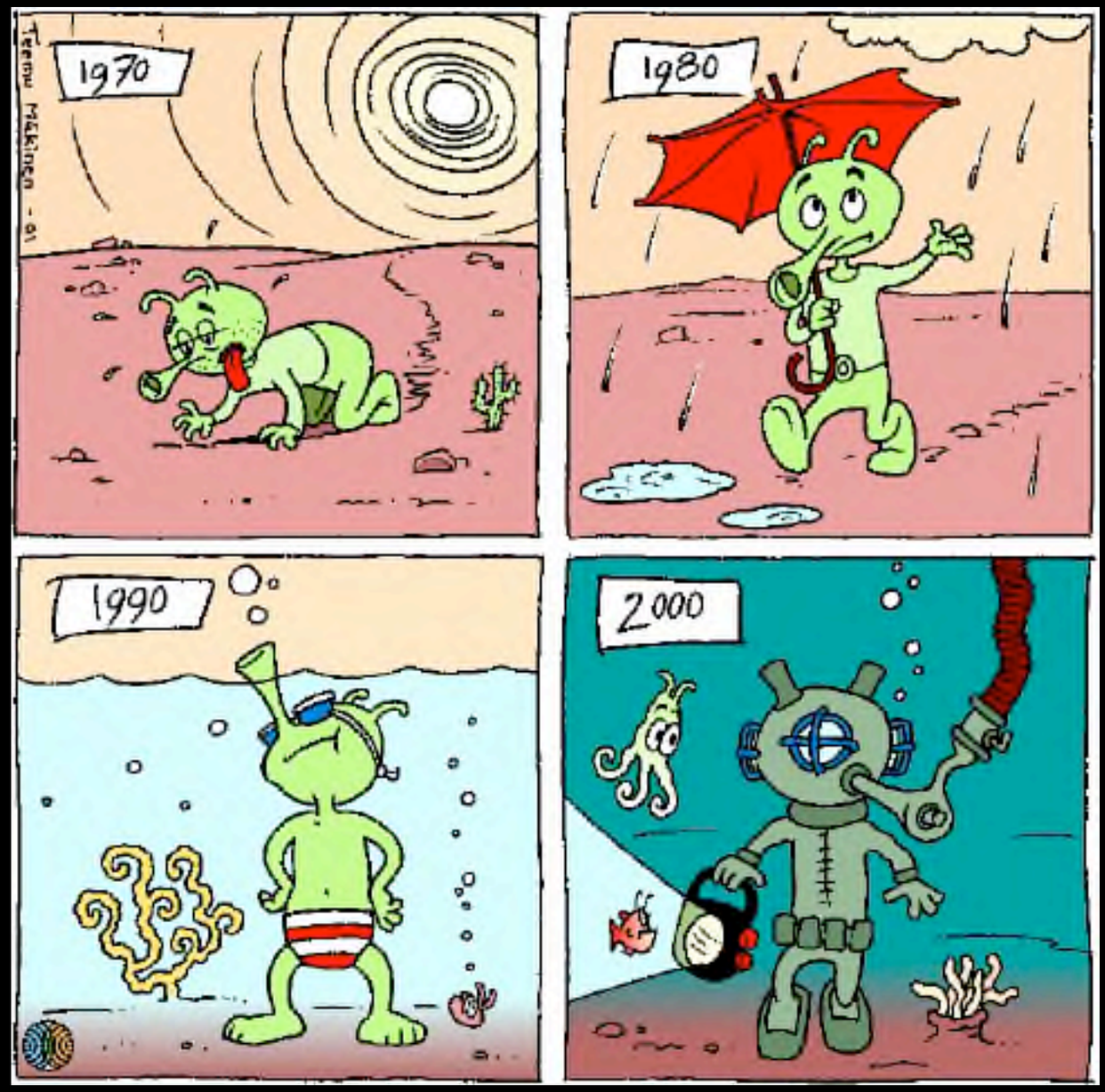


esa SCIENCE

Where is the water?

Estimates (in the Planetary Science community) of how much water there has ever been on the planet Mars:

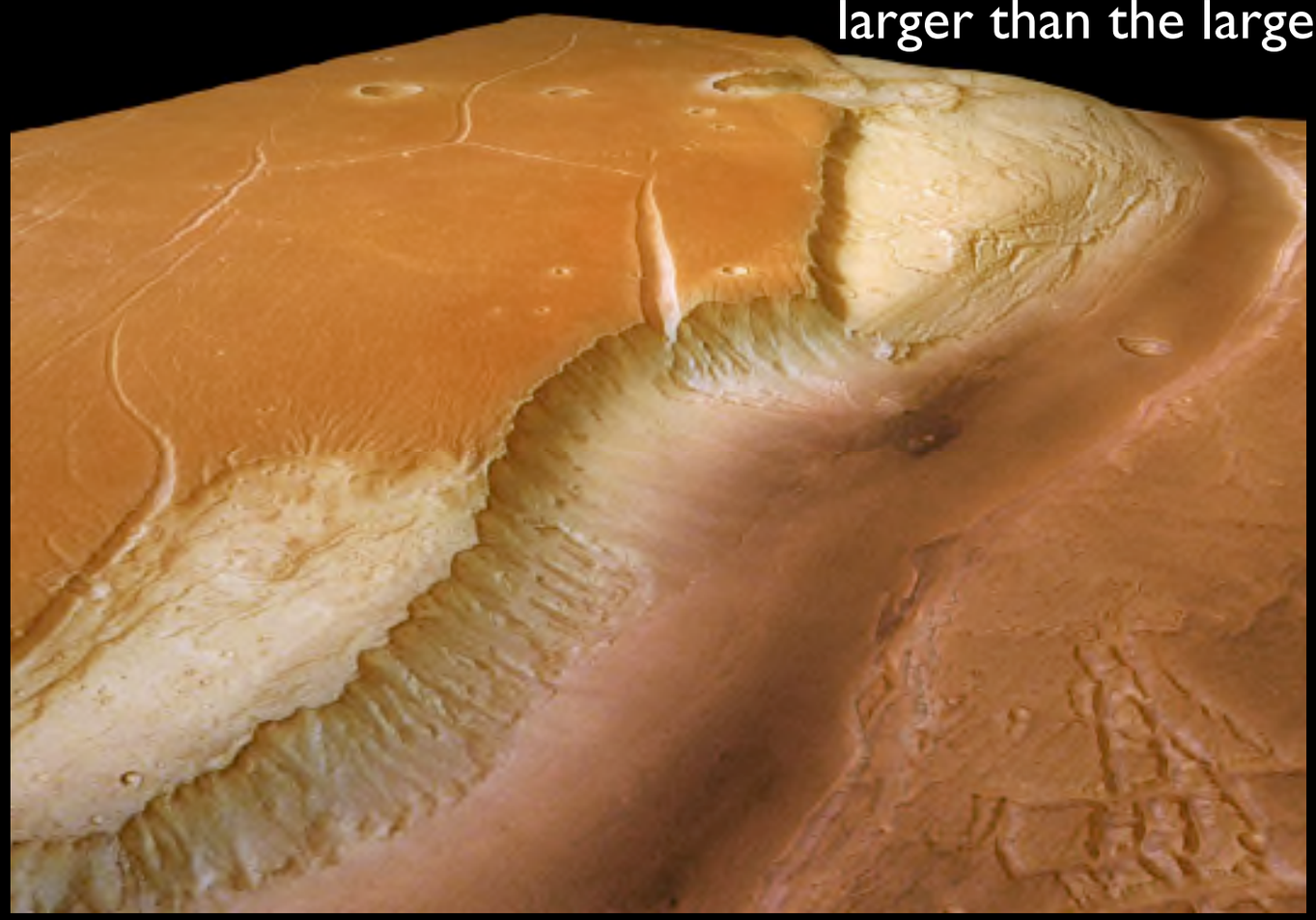
- 1970's: after Mariner-9
- 1980's: after Viking
- 1990's: after Pathfinder
- 2000's: after MGS

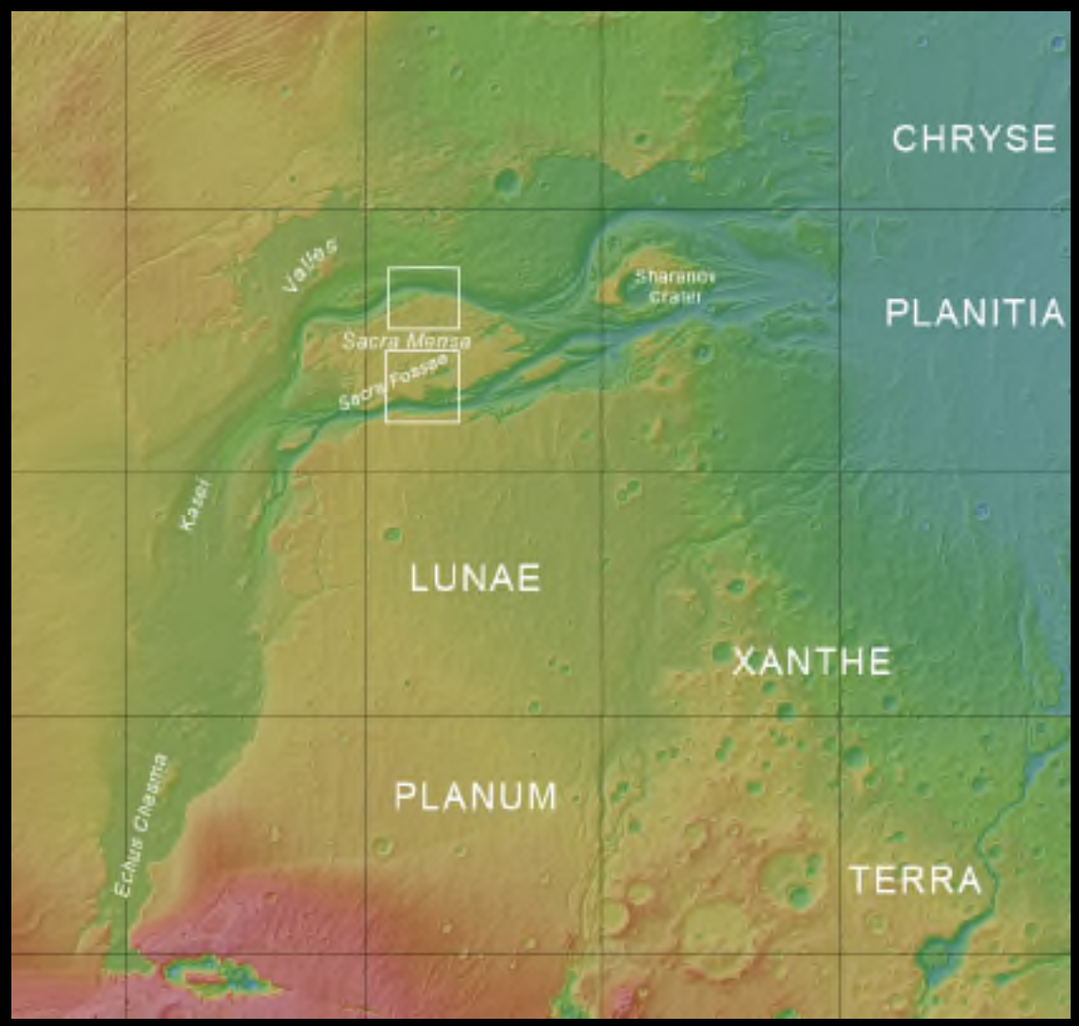


esa SCIENCE

Past signs of water on Mars

Huge channels, catastrophic floods, thousands of times larger than the largest on Earth





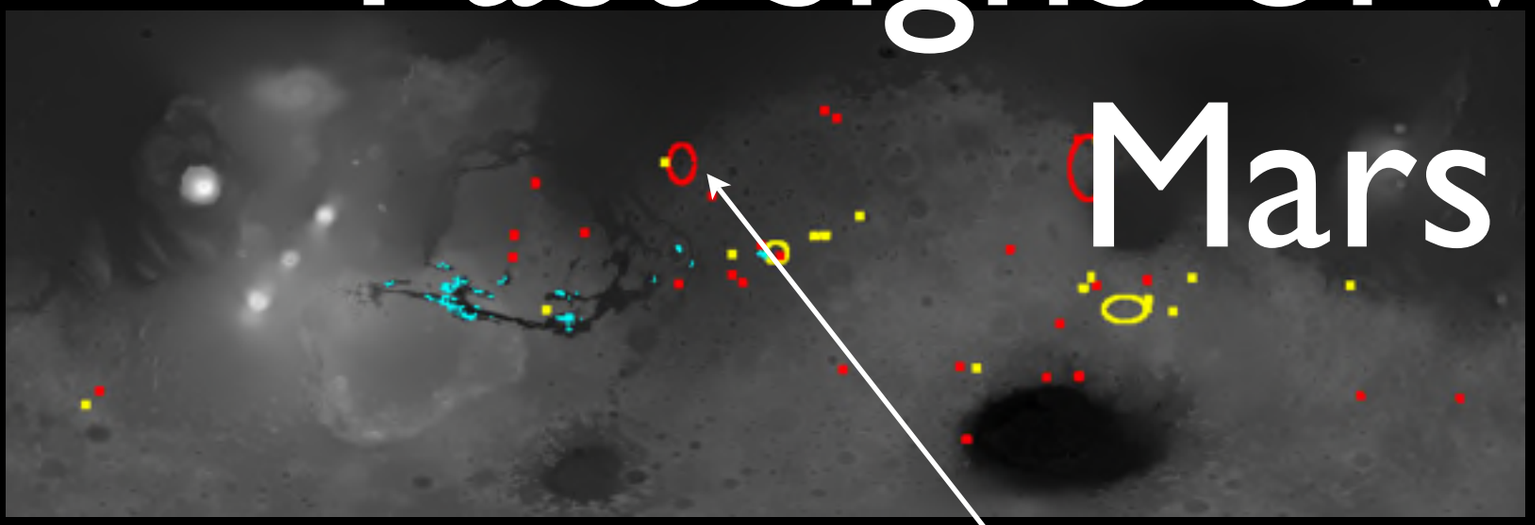
esa SCIENCE

Past signs of water on Mars

Evidence of warmer climate earlier on Mars?

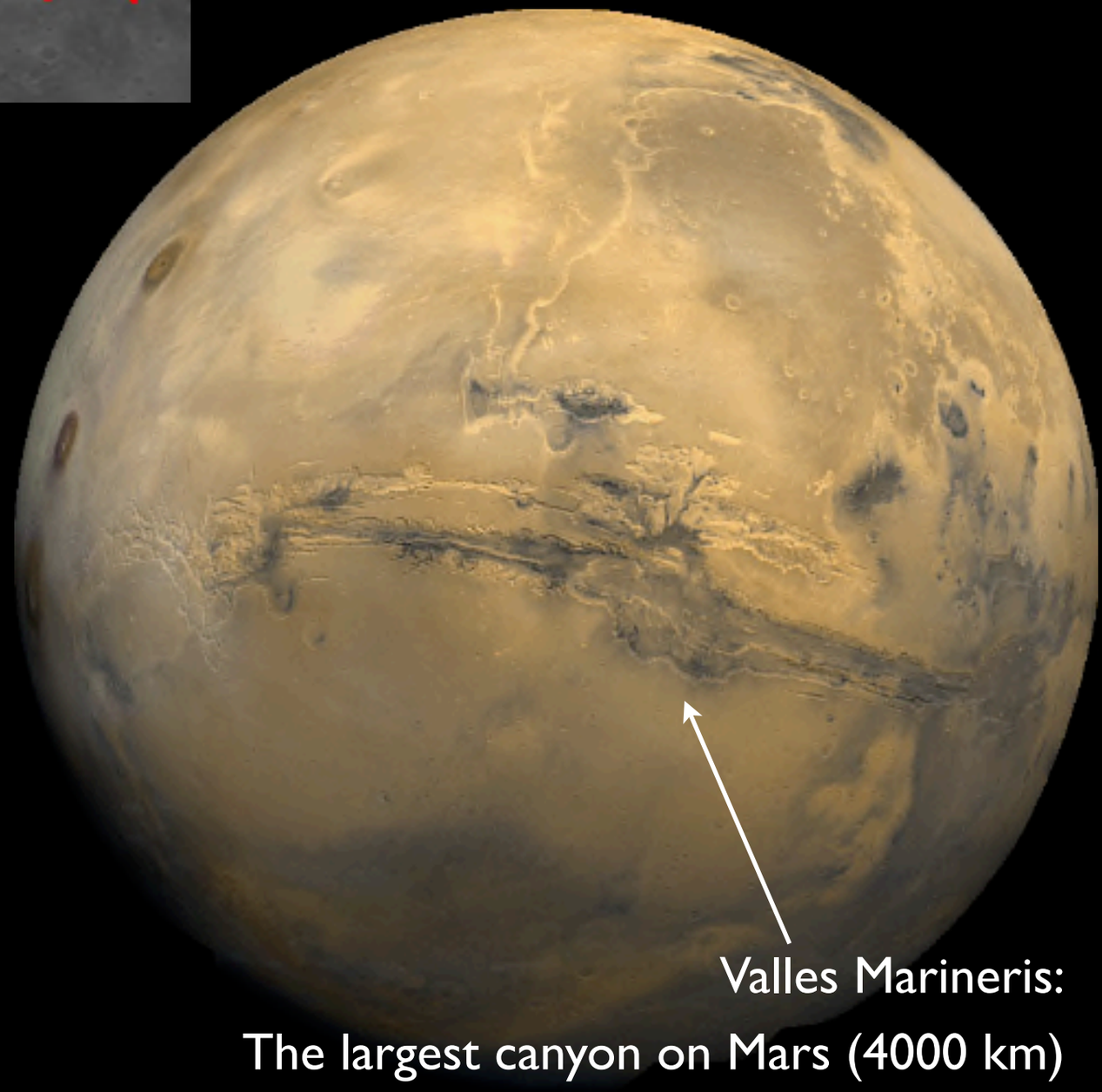
esa SCIENCE

Past signs of water on Mars



Areas showing water alteration in minerals (results from Mars Express OMEGA)

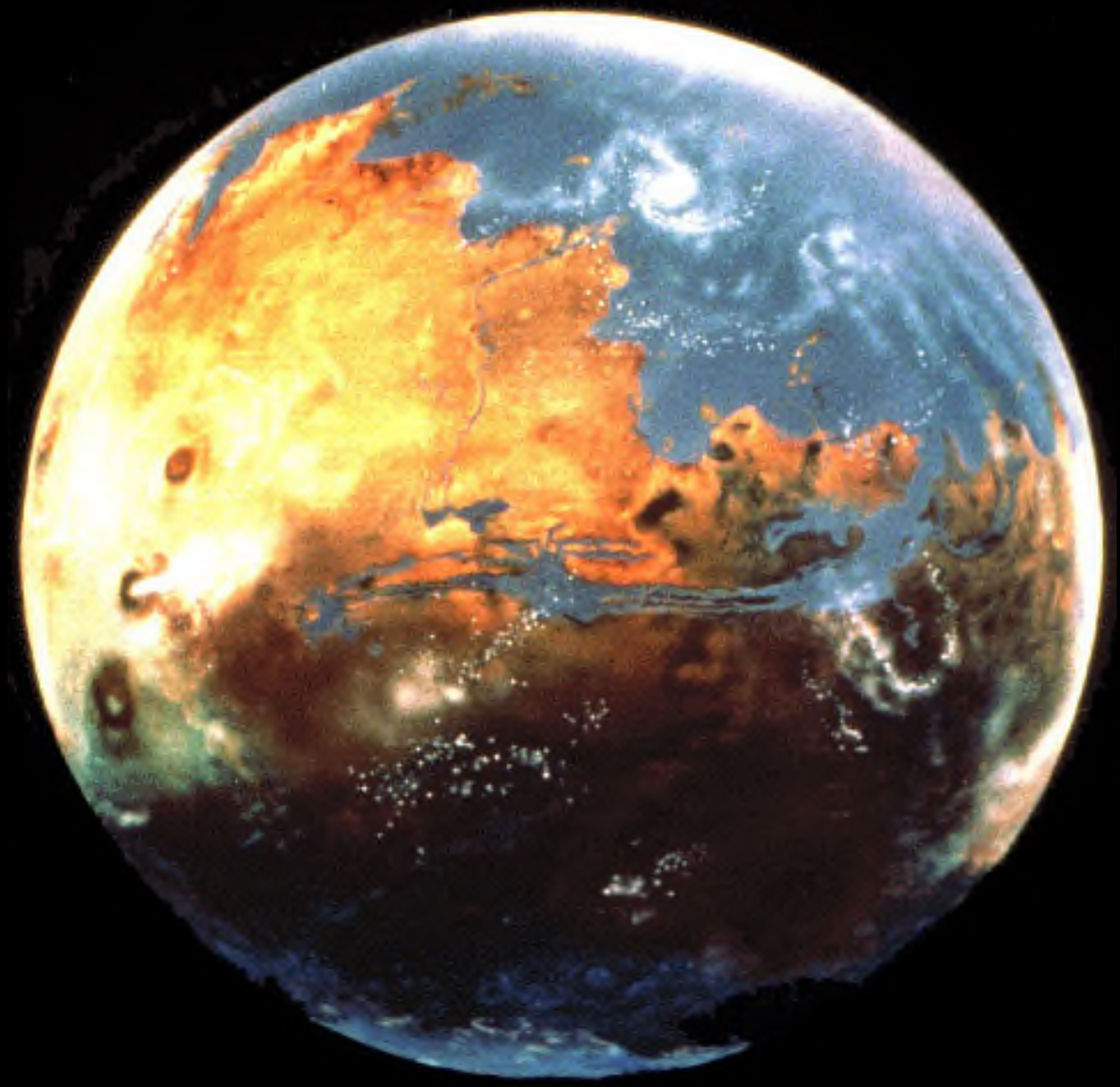
MEX HRSC image of Marwth Vallis, where OMEGA discovered hydrated minerals



Valles Marineris:
The largest canyon on Mars (4000 km)

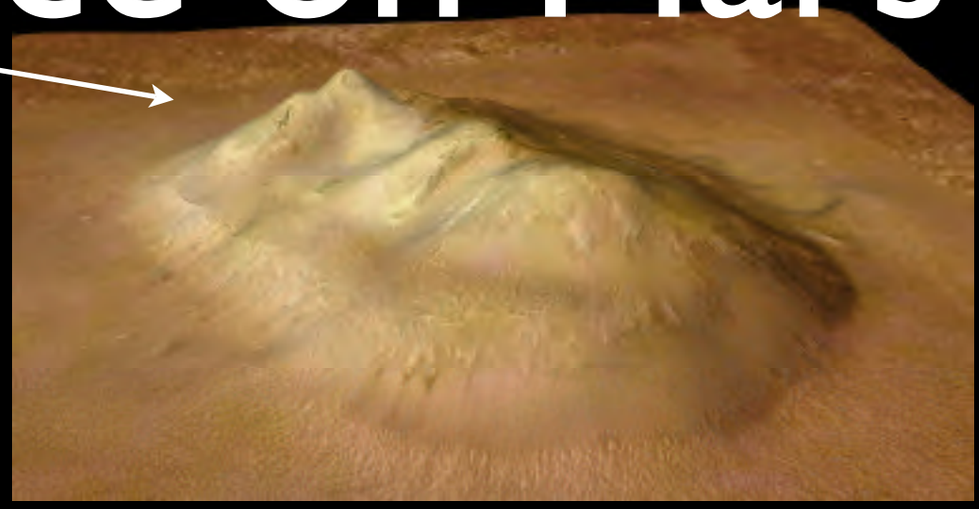
esa SCIENCE

Past wet Mars?



esa SCIENCE

Recent ice on Mars



esa SCIENCE

History of Exploration

Near wheel-shaped space station 1,000 miles from the earth, built especially for assembly of the Mars expedition, weightless workers put together

Can We Get to MARS?

By Dr. WERNHER von BRAUN with CORNELIUS RYAN

Chief, Guided Missile Development Division, Redstone Arsenal, Huntsville, Alabama

Man's trail-blazing journey to Mars will be a breath-taking experience—with problems to match

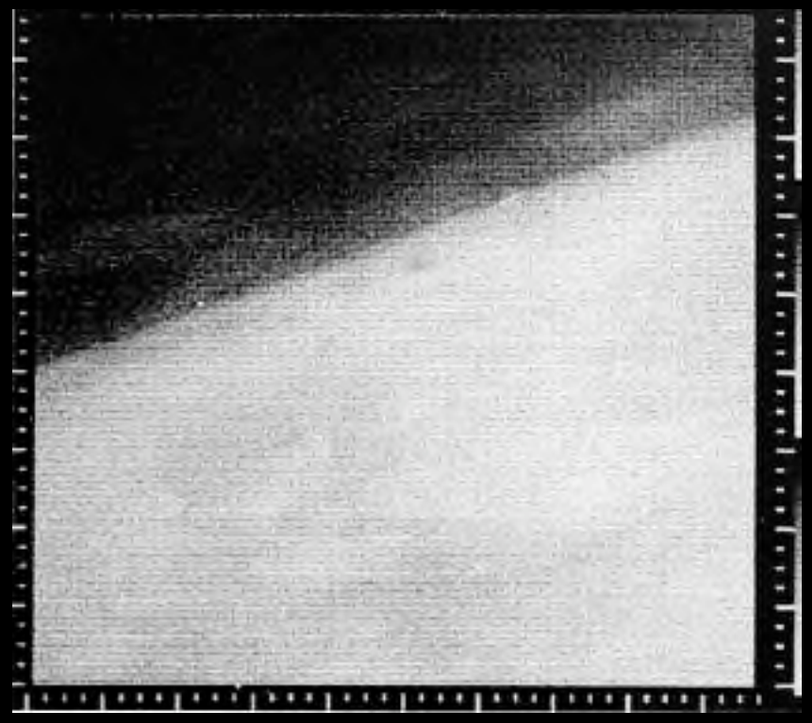
22 Collier's for April 30, 1954

We did not go this way....

…but with robots

esa SCIENCE

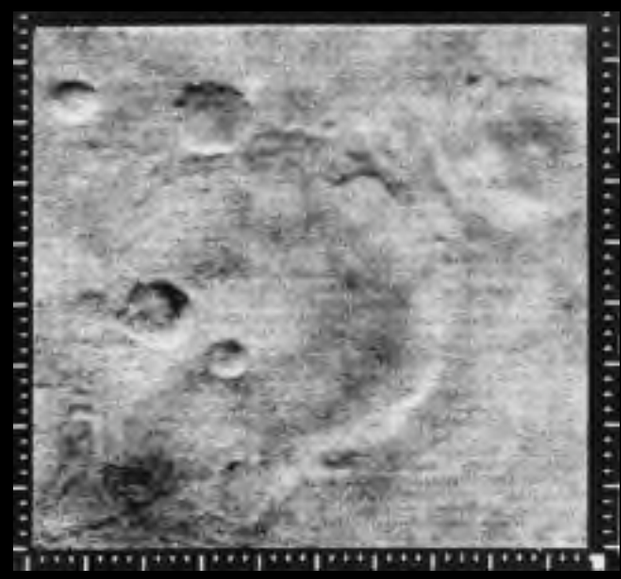
1964: American succeed at Mars



Mariner 4

- First launch fails - Mariner 3
- Second launch succeeds Nov 28,1964
- Successful flyby on July 15, 1965
- Craters, not canals!

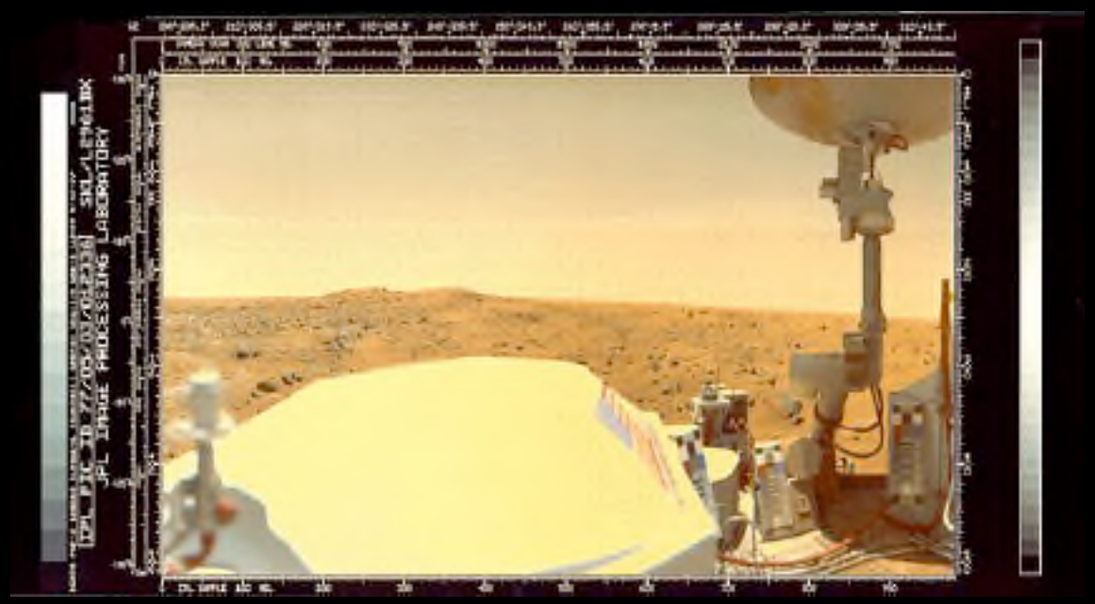
The famous picture No.11



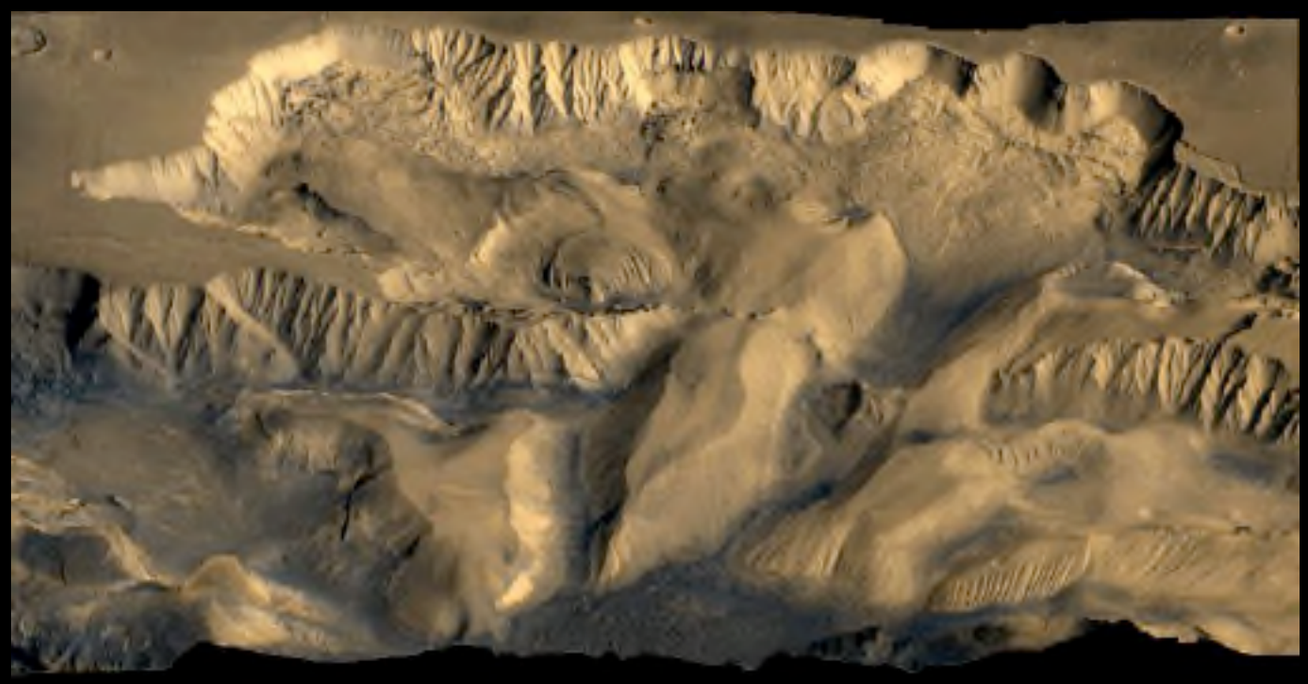
First s/c image of Mars

esa SCIENCE

1975: the American Viking Lander



- Two orbiters & landers at Mars
- Spectacular images from orbit
- and from the surface
- First successful landers, but
- unsuccessful (?) search for life
- Interest in Mars wanes after Viking



esa SCIENCE

ESA Solar System Missions

2013 - BEPI COLOMBO — Mercury

2005 - VENUS EXPRESS — Atmosphere & Surface

2004 - ROSETTA — Comet Orbiter & Lander

2003 - SMART-1 — Moon & Technology

2003 - MARS EXPRESS — Planetology & Exobiology

1997 - CASSINI-HUYGENS — Titan Probe

1986 - GIOTTO — Halley's Comet Fly-by

esa SCIENCE

Mars Espress

Results & Highlights

esa SCIENCE

Soyuz rocket

- Overview
  - First launched in 1963
  - Used more than 1600 times (98%)
  - Manned and unmanned versions
  - Built in Samara, Russia
  - Assembled in Baikonur
- 3+1 Stages
  - S1: 4 boosters around central core
  - S2: cylindrical core
  - S3: payload adapter and fairing
  - S4: Fregat (tested) for use with MEX
- Characteristics
  - Lift-off weight: 304 tons (prop. 279 t)
  - Total height: 43.5 m
  - Figures include MEX mass (~1200 kg)

esa SCIENCE

Launch

- Overview
  - Soyuz launch number 1677
  - Fregat stage use: 5th time
  - Roll-out: 4 days before launch
  - Tanks fill-up: 4 h before launch
- Time
  - Monday, 02 June 2003
  - 23:45:26 local (Kazakhstan)
  - Moscow time (-2h); CEST (-4h)
  - Fair weather, some wind
- Characteristics
  - MEX mass load: 1223 kg
  - Window up to 14/06 for mass load
  - Two launch slots (02-03/06)
  - All systems nominal (green)

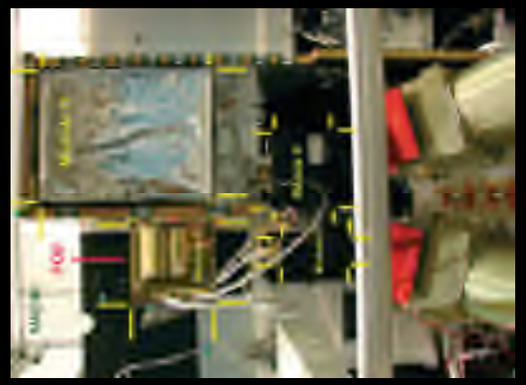
esa SCIENCE

Experiments on Board

HRSC
P.I. G. Neukum
GERMANY

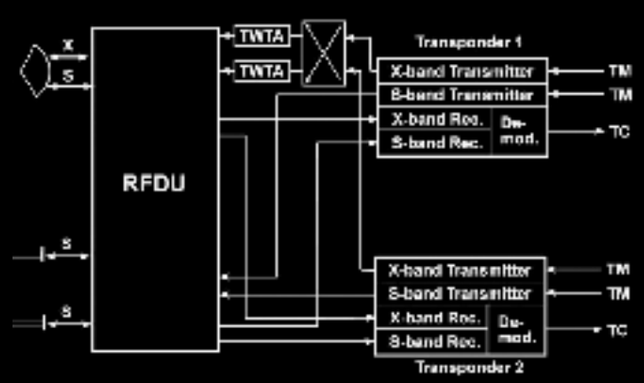
OMEGA
P.I. J.P. Bibring
FRANCE

SPICAM
P.I. G. J. L. Bertaux
FRANCE



PFS
P.I. V. Formisano
ITALY

ASPERA
P.I. S. Barabash
SWEDEN

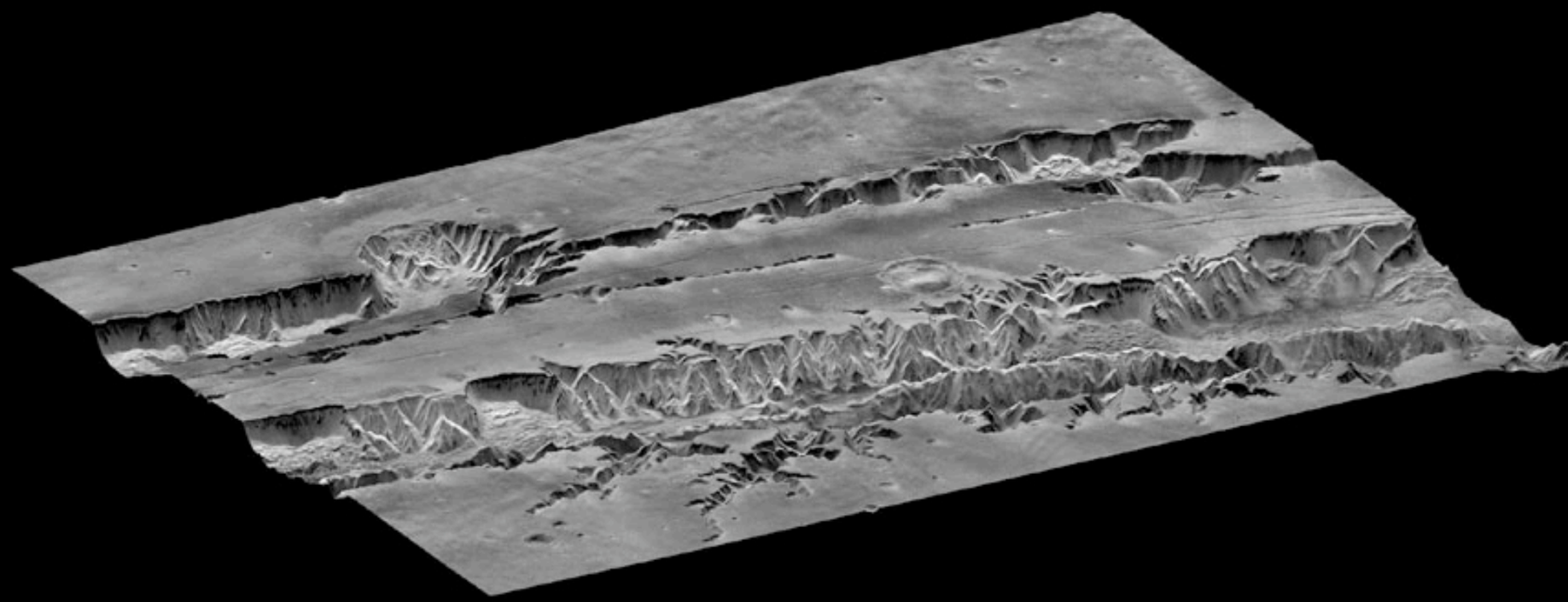


MaRS
P.I. M. Paetzold
GERMANY

MARSIS
P.I. G. Picardi
ITALY

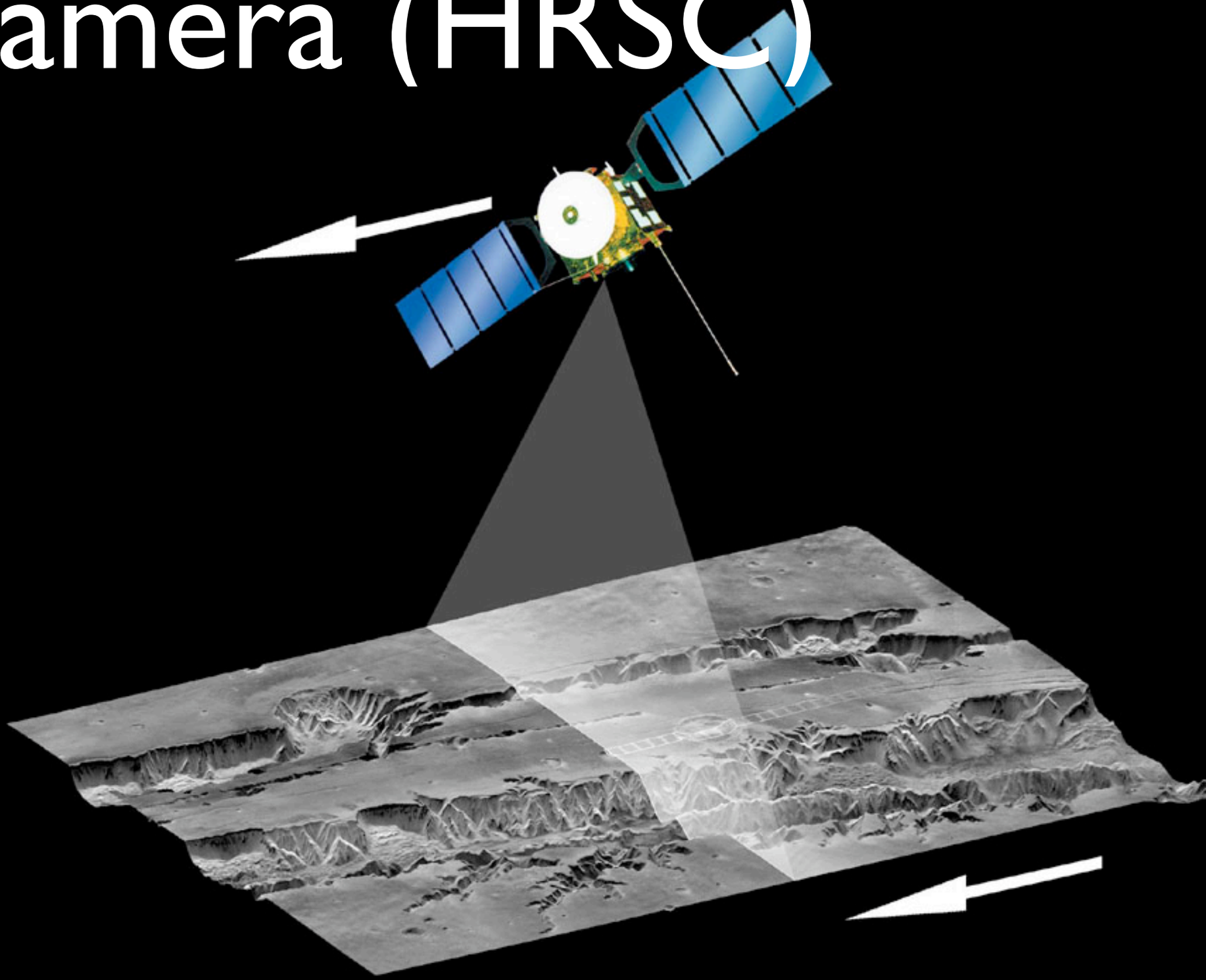
esa SCIENCE

High Resolution Stereo Camera (HRSC)



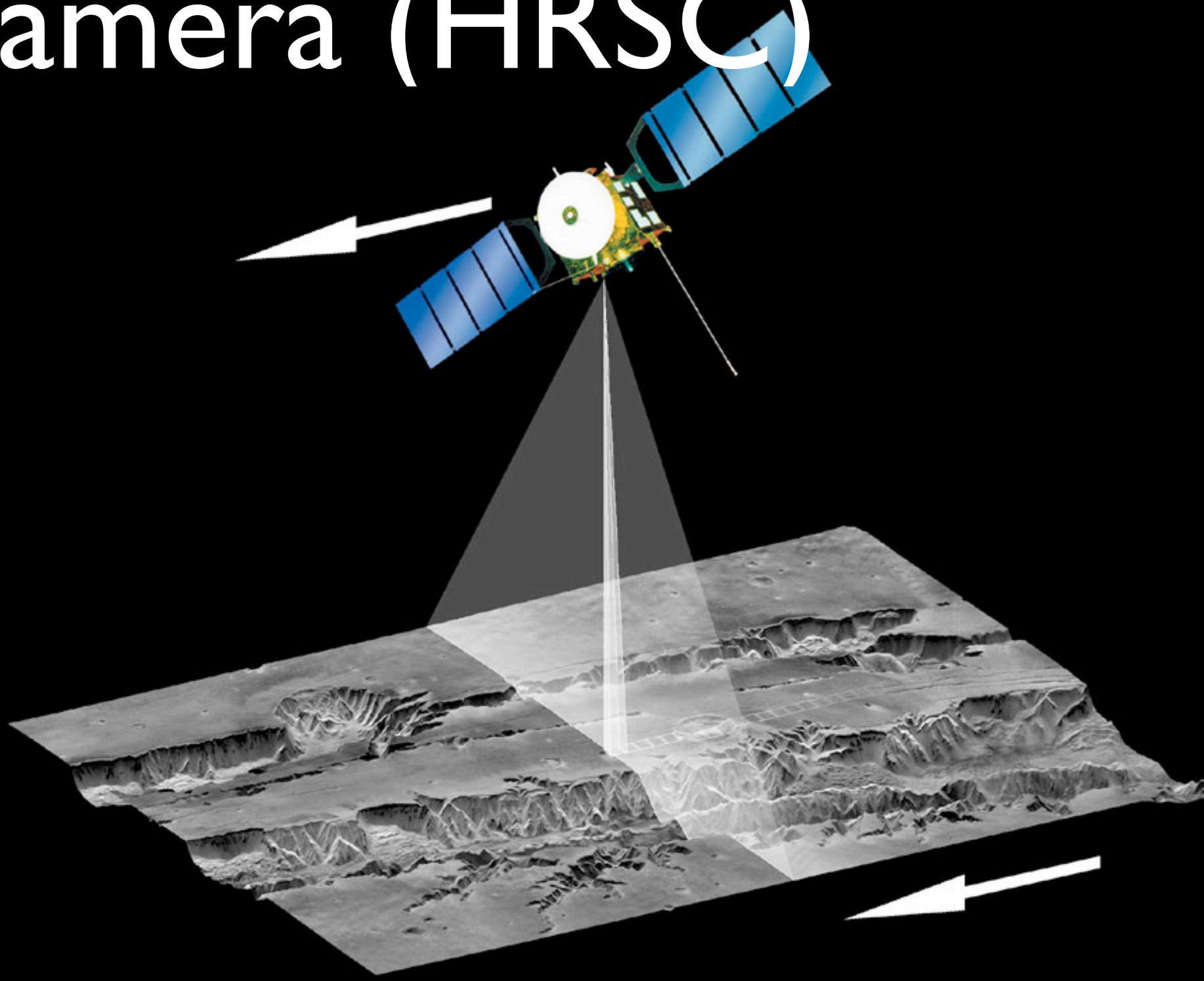
esa SCIENCE

High Resolution Stereo Camera (HRSC)



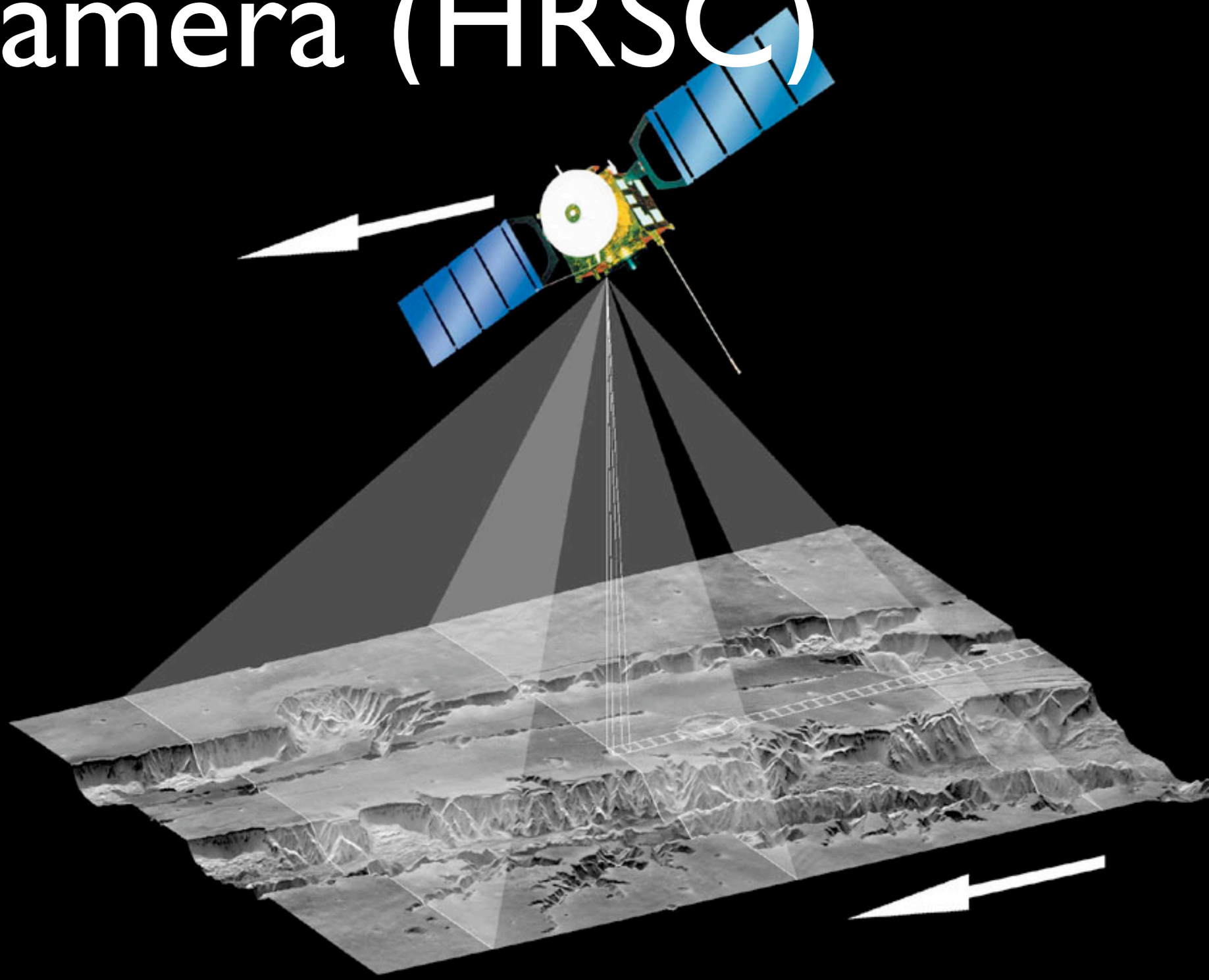
esa SCIENCE

High Resolution Stereo Camera (HRSC)



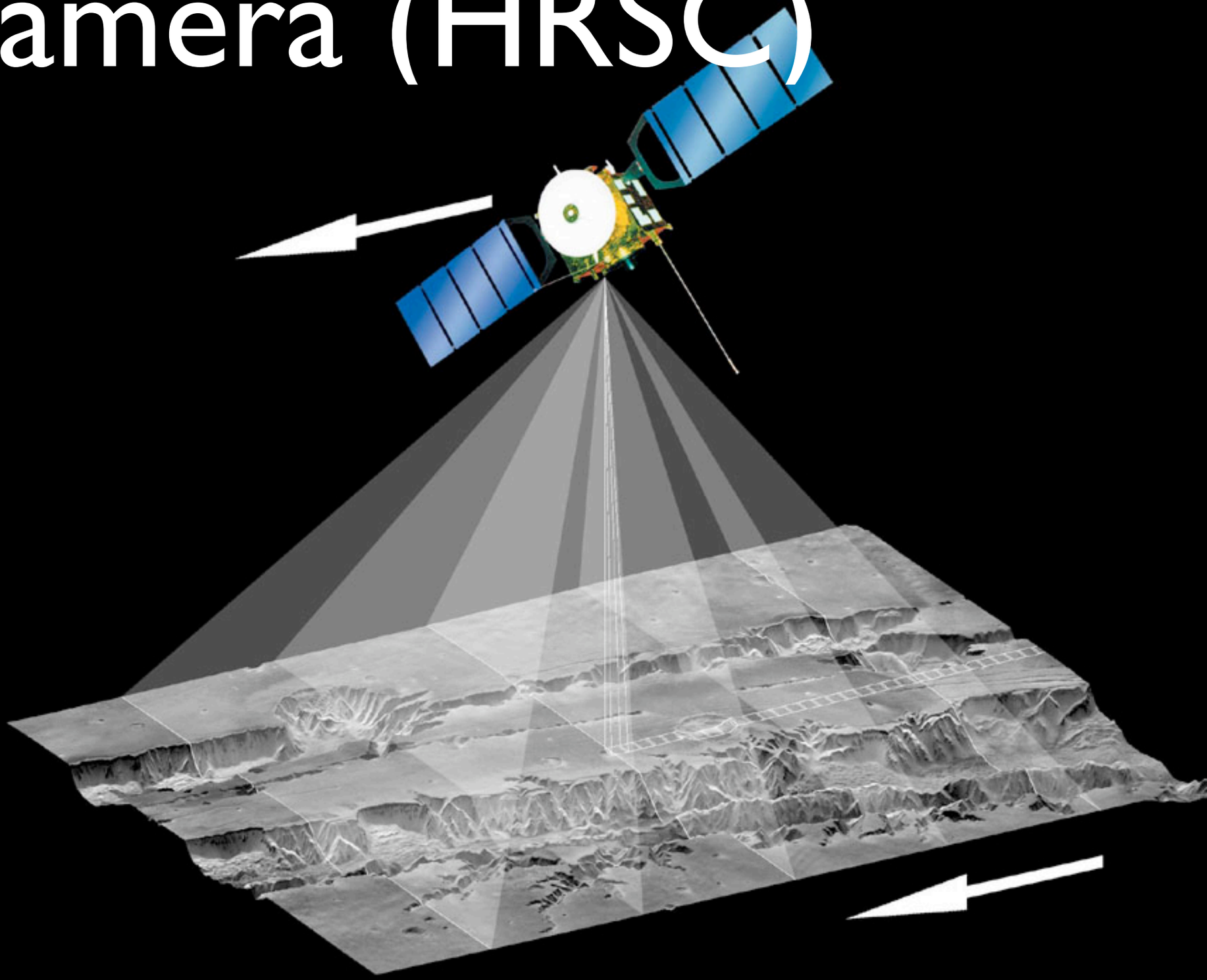
esa SCIENCE

High Resolution Stereo Camera (HRSC)



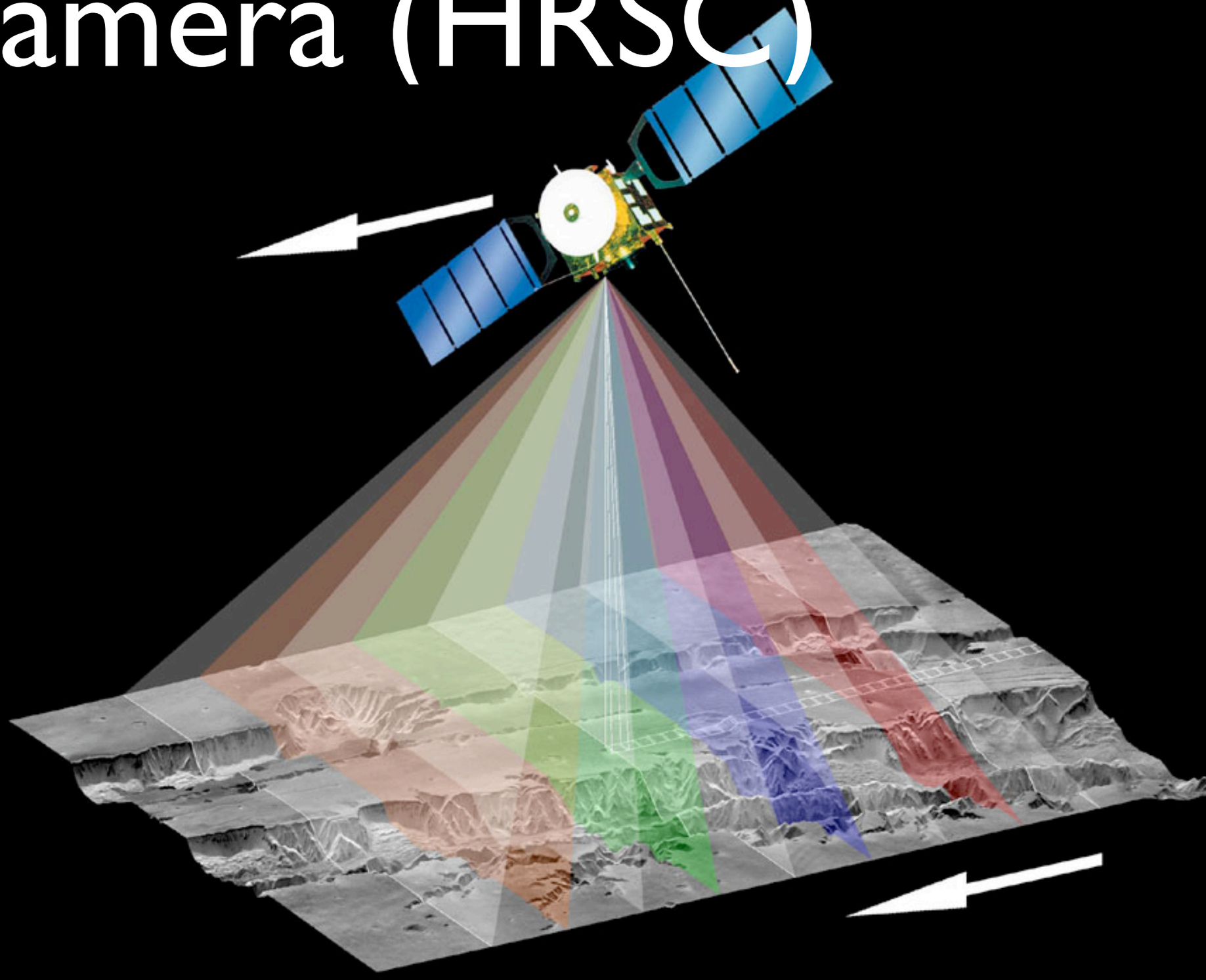
esa SCIENCE

High Resolution Stereo Camera (HRSC)



esa SCIENCE

High Resolution Stereo Camera (HRSC)

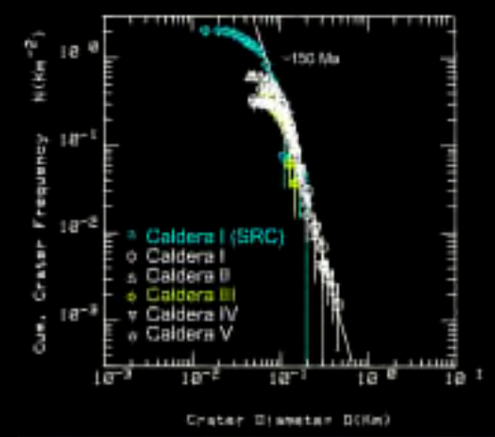


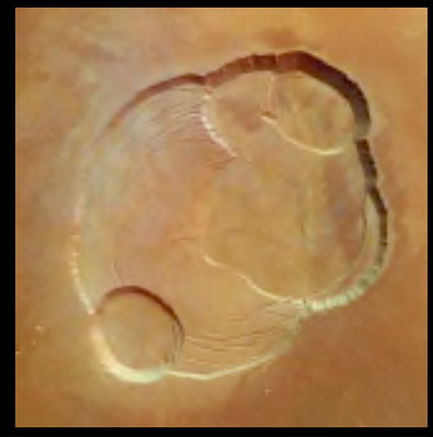
esa SCIENCE

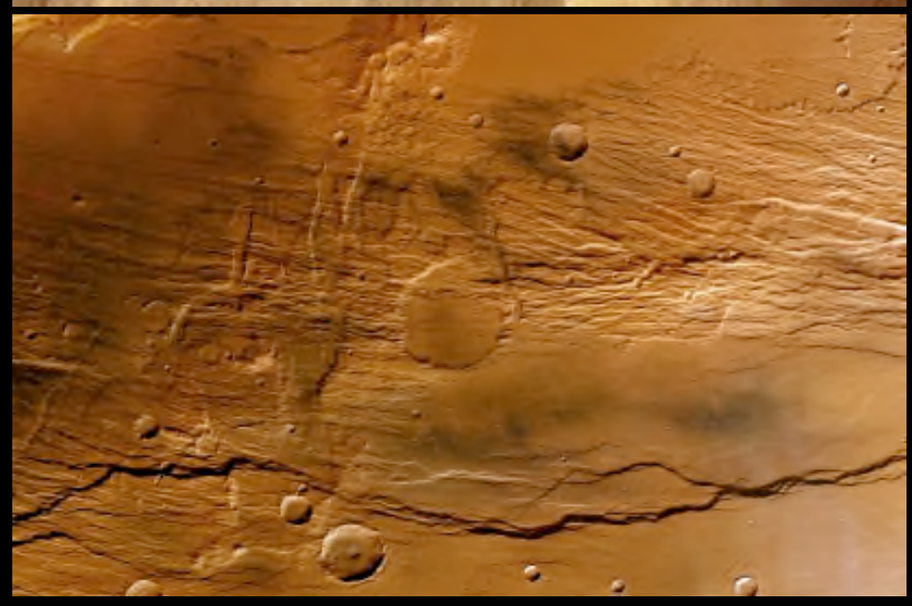
HRSC Results

HRSC

- Much more recent geological ages than previously estimated (one order of magnitude) for volcanic processes and glacial processes, which means that the planet is basically "active" today.
- Confirmation of glacial processes in current equatorial regions. Glacial, not fluvial activity, in combination with volcanic activity, seems to have dominated the evolution of the surface of Mars.
- No evidence of a large ocean in the Northern lowlands from HRSC data, as hypothesized in previous investigations.
- Climate change (cold/wet colder/dry) occurred early in Martian history.

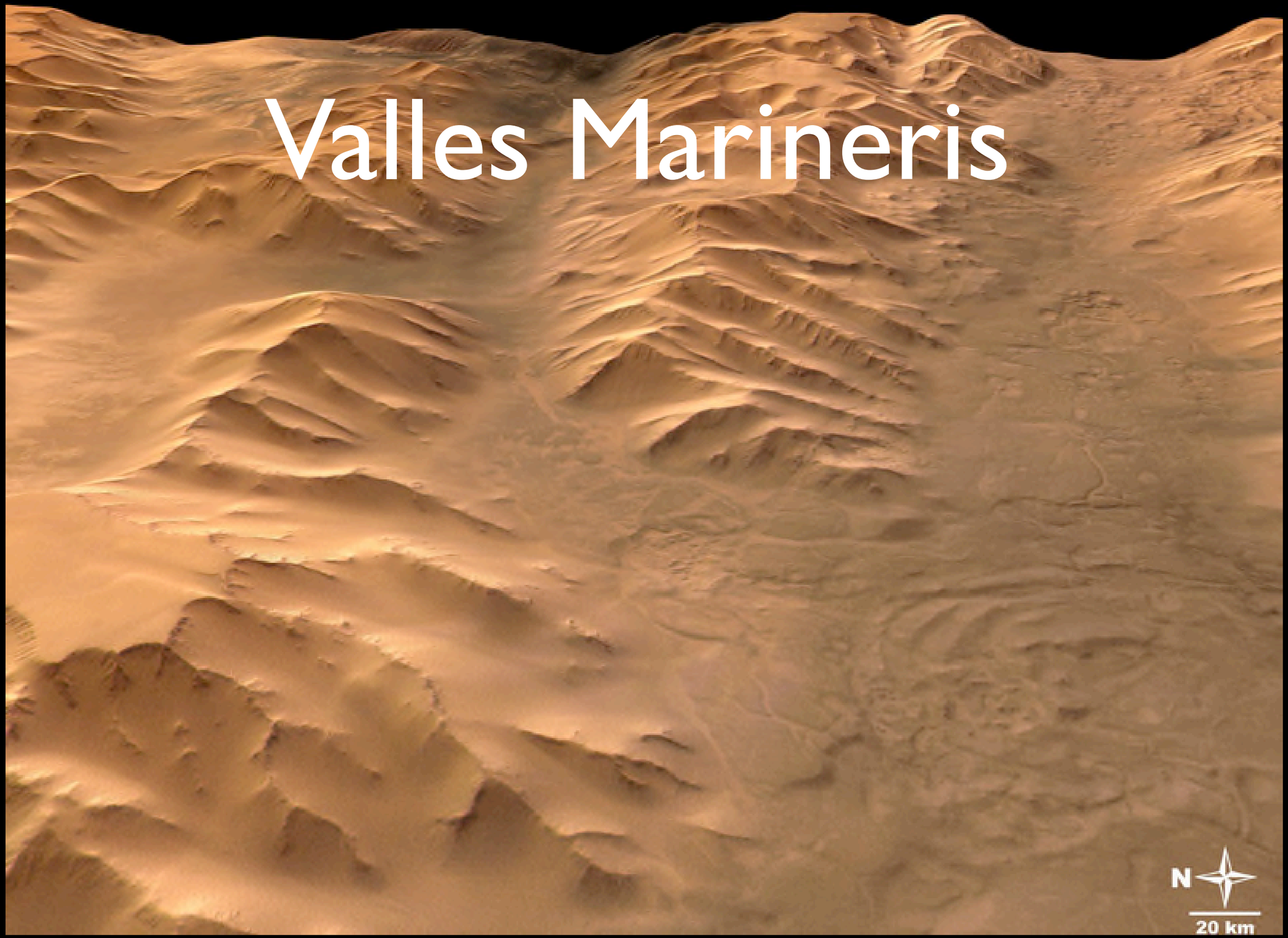






esa SCIENCE

Valles Marineris

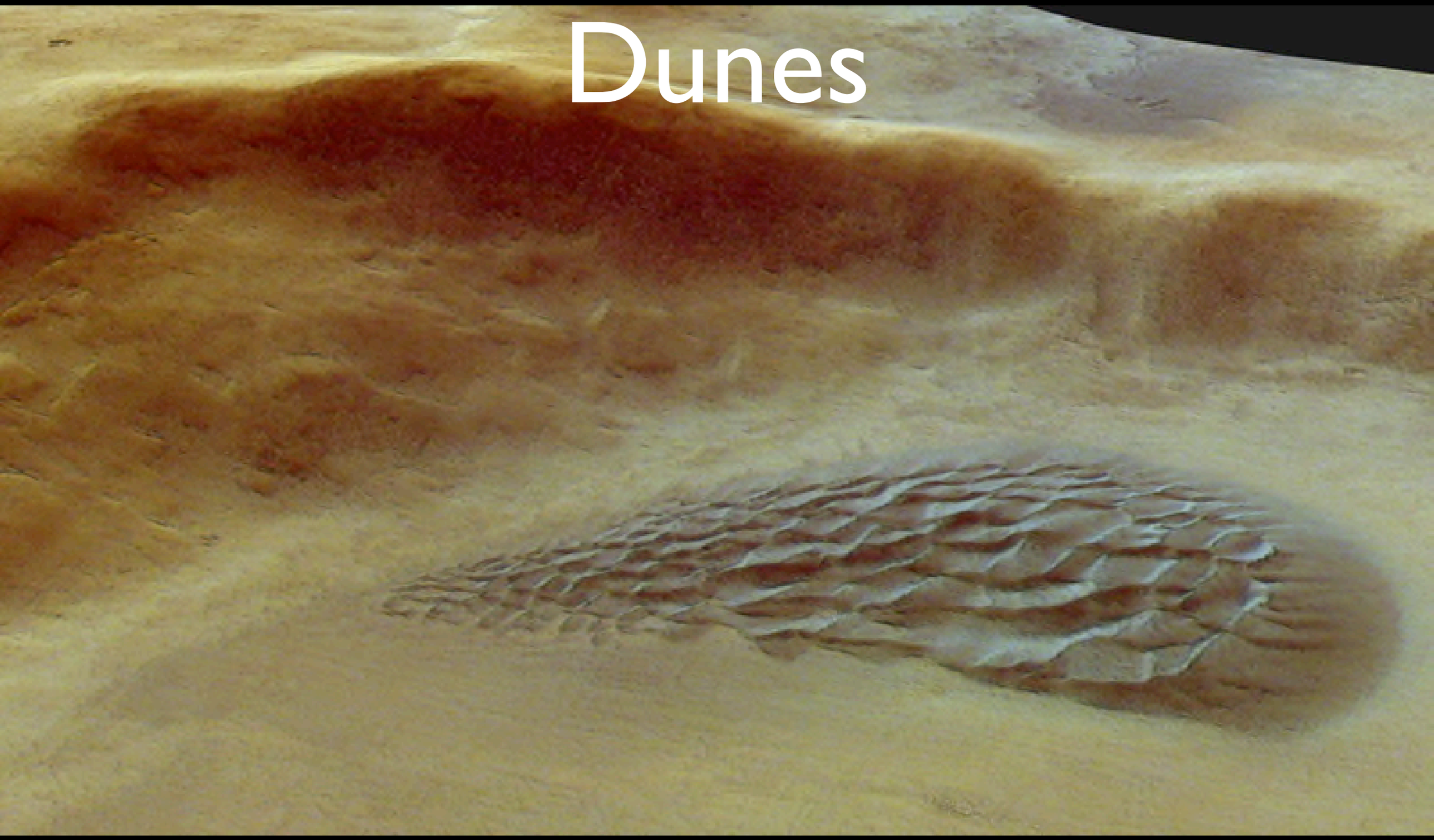


esa SCIENCE

Polar deposits

esa SCIENCE

Dunes

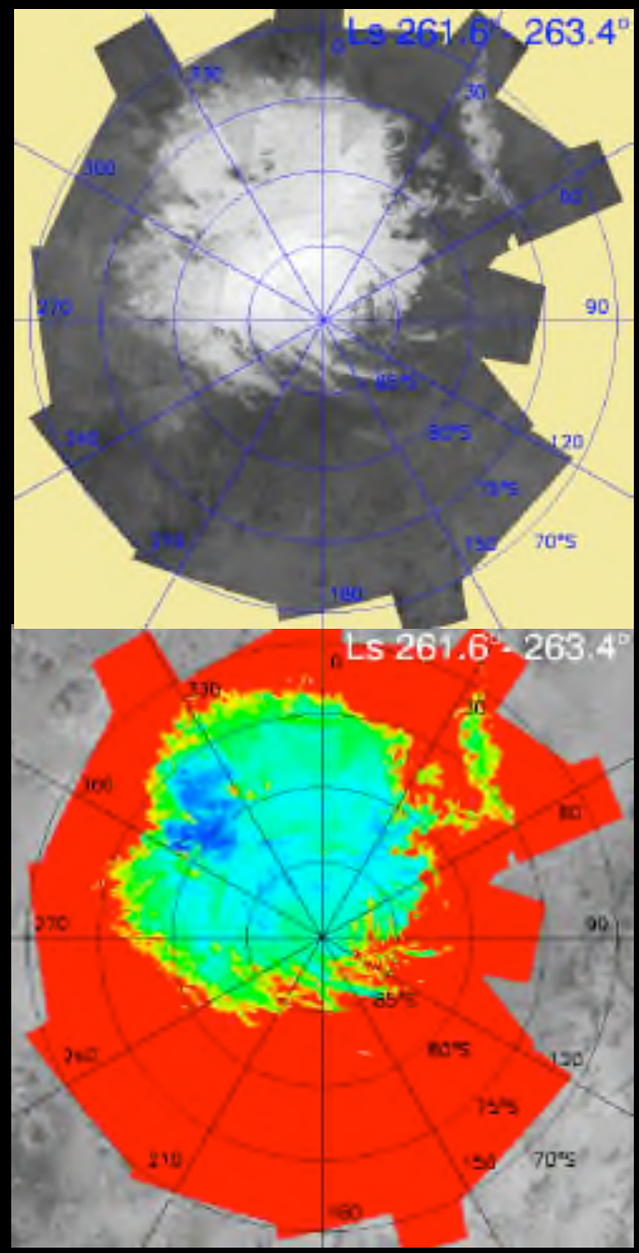


esa SCIENCE

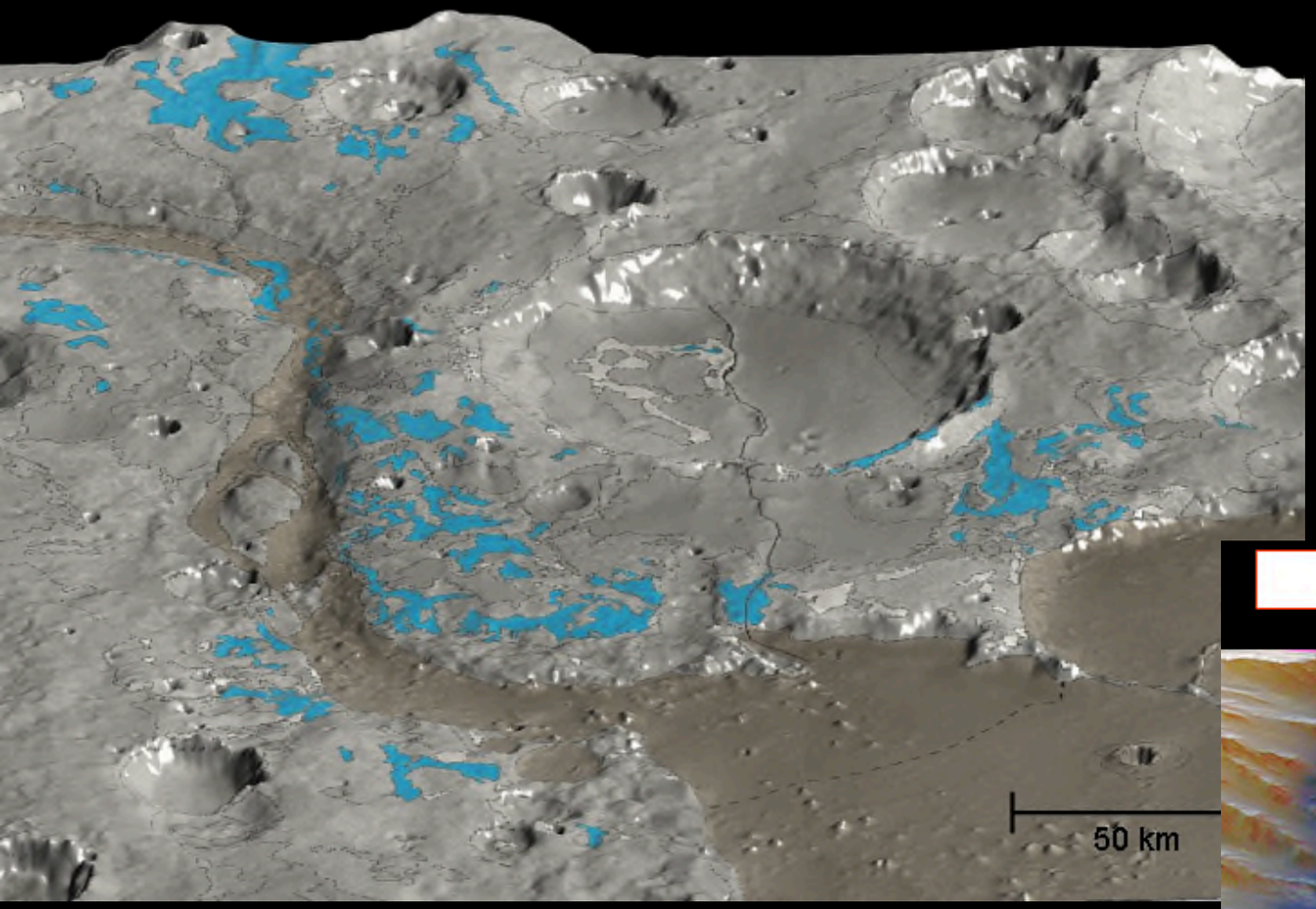
OMEGA results

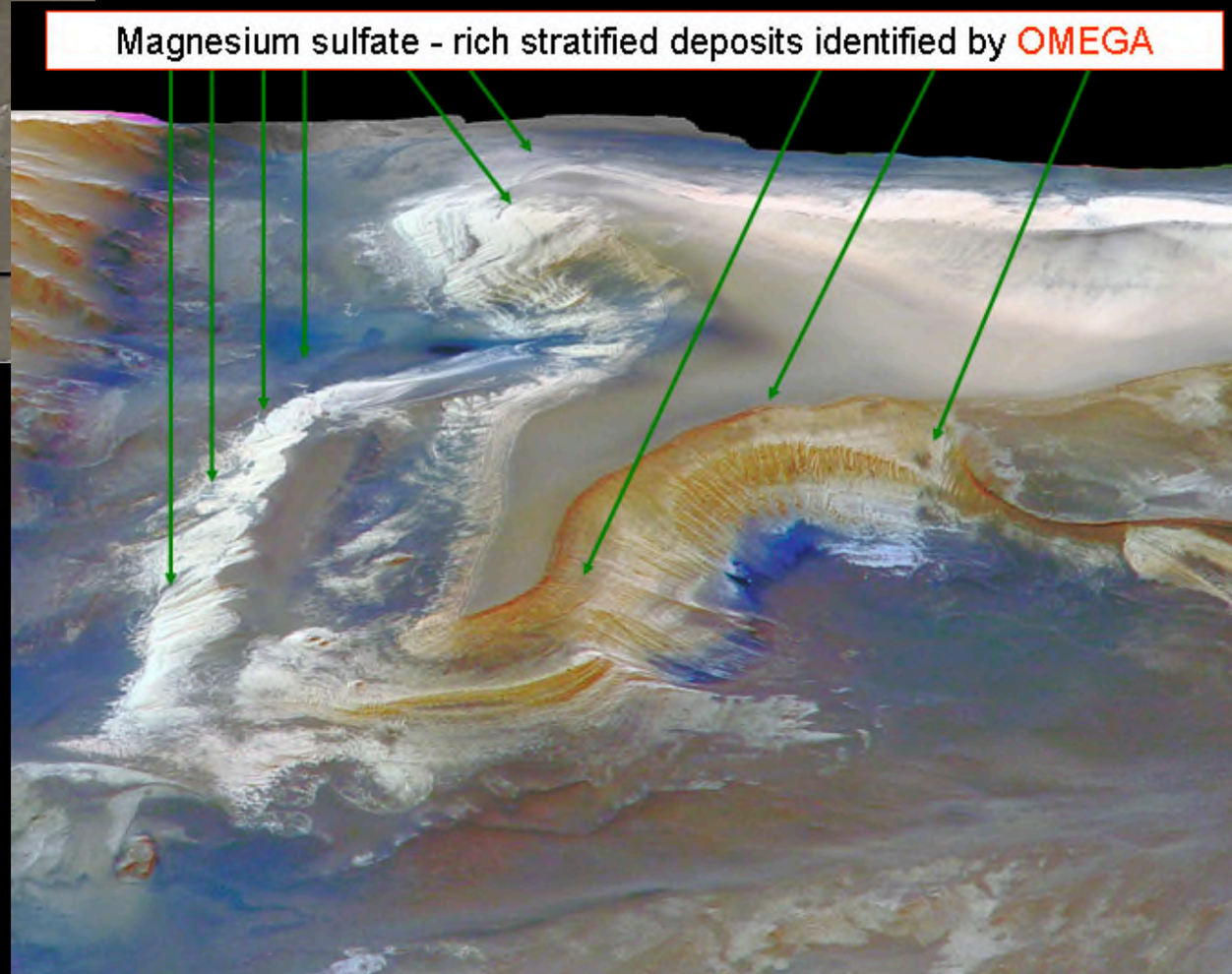
OMEGA

- Various types of ice (H_2O and CO_2), either mixed or distinct, mapped in polar regions.
- Lack of aqueous alteration of mafic minerals (olivine) in Northern plains suggests that large bodies of water, such as lakes or seas, have not existed for long periods on the Martian surface.
- Hydrated minerals (clays in Noachian, sulfates later) indicate alteration in varying amounts of water and climate regimes.
- Most of the Northern plains (volcanic origin) do not exhibit mafic minerals.
- At present, CO_2 is dominantly stored in the atmosphere, as no carbonates have been found.



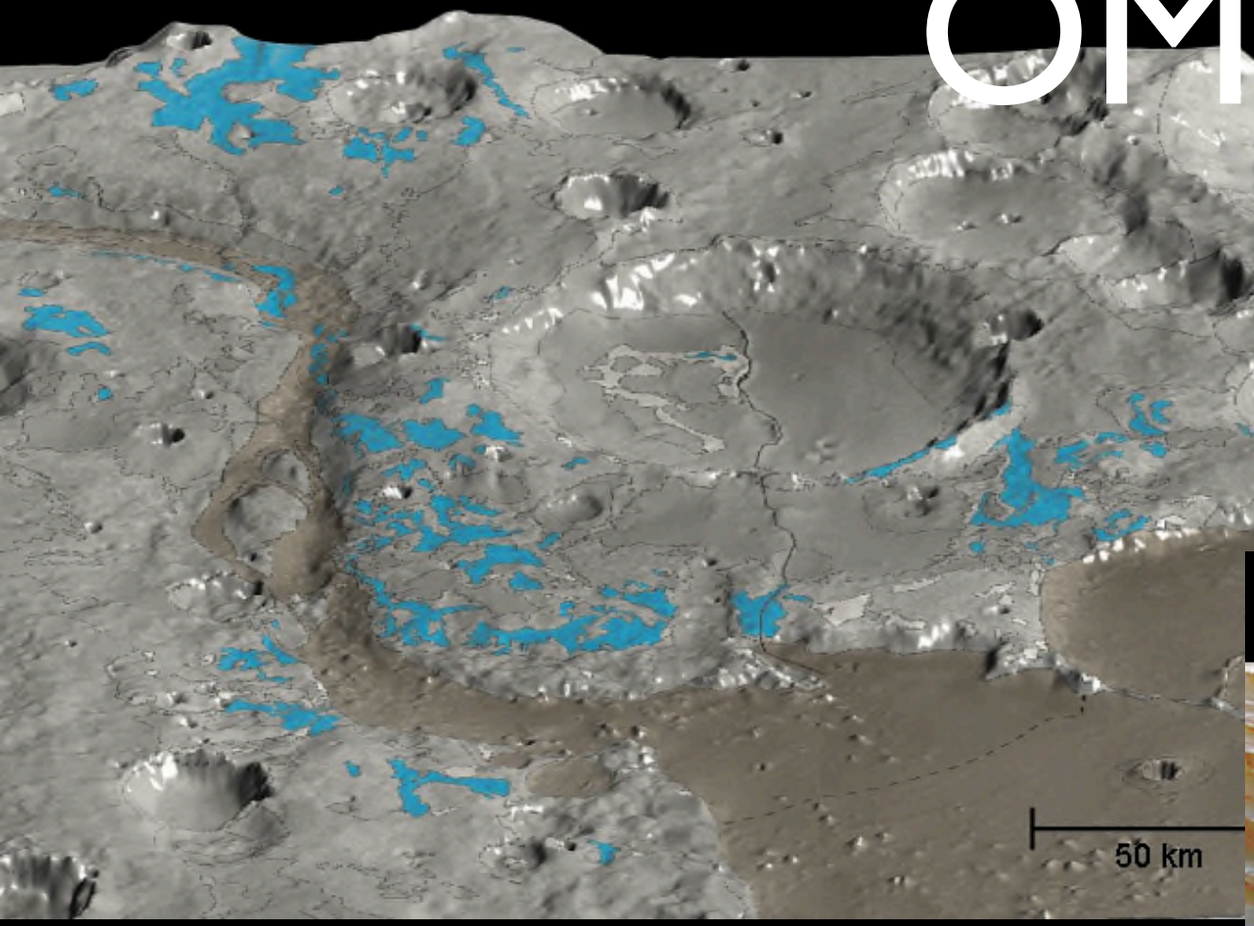
Minerals revealed on the surface (OMEGA)

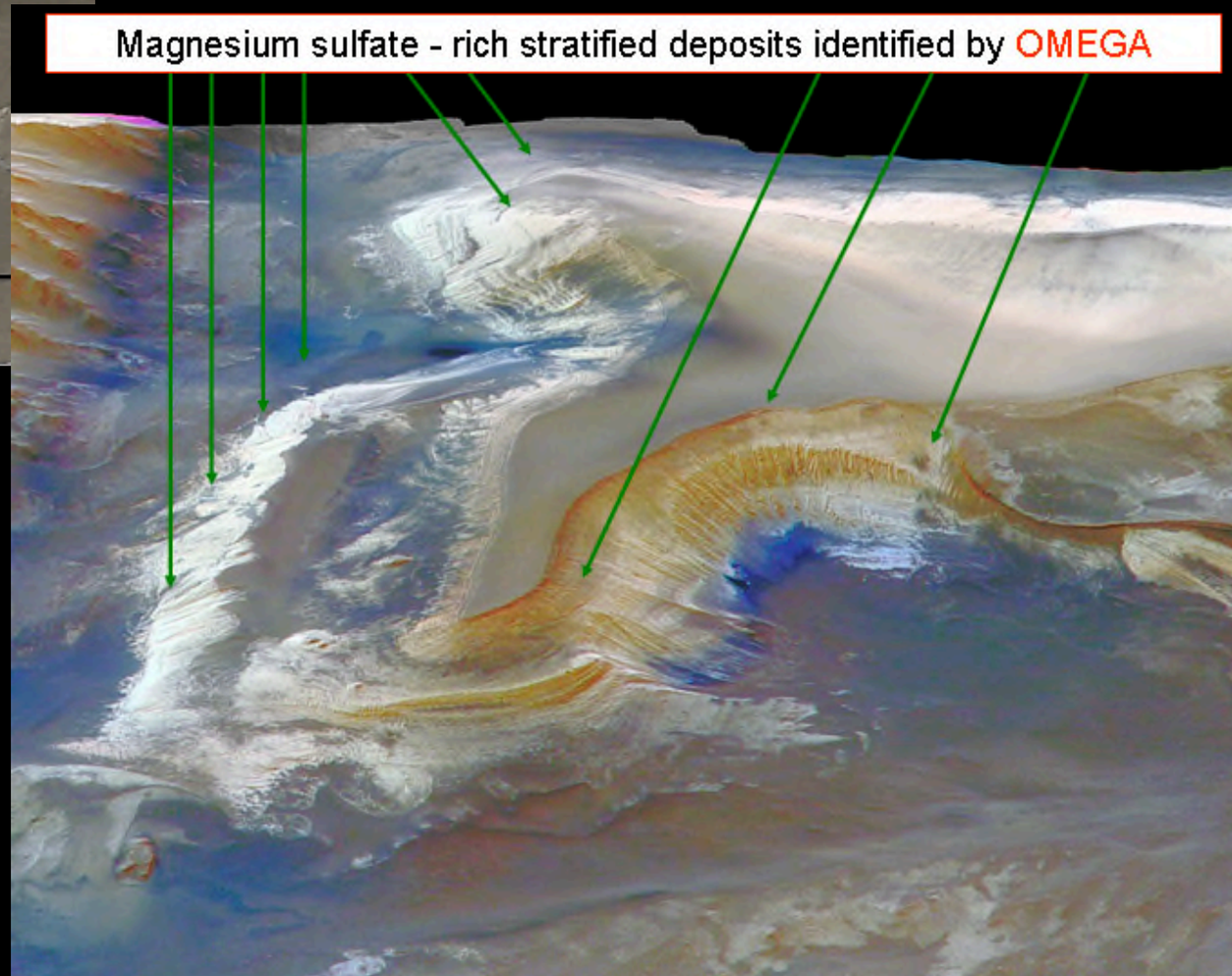




esa SCIENCE

Minerals Revealed by OMEGA

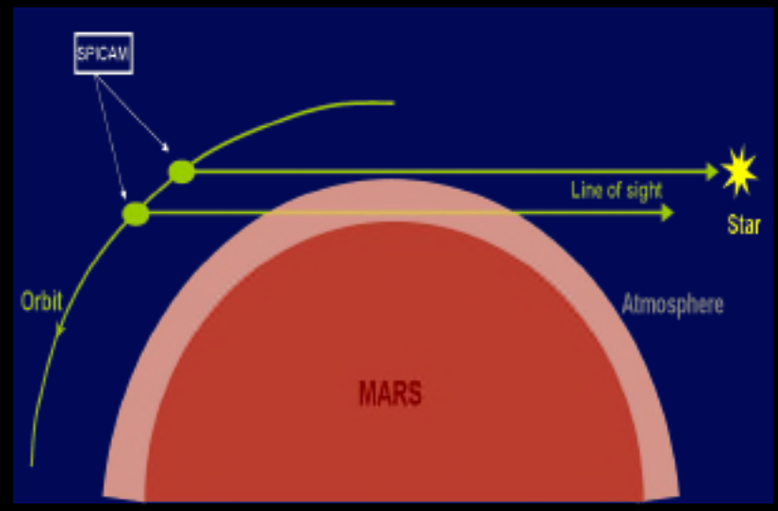


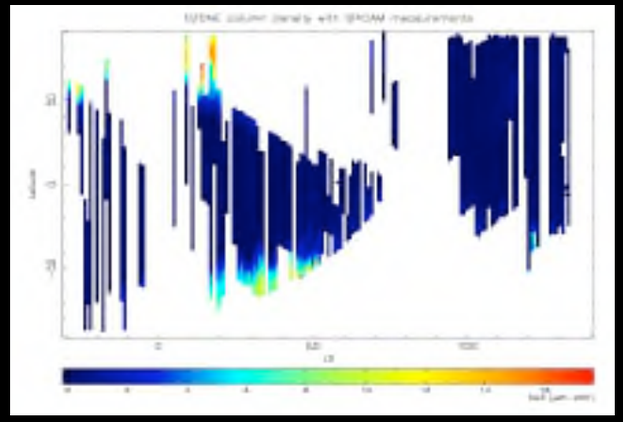


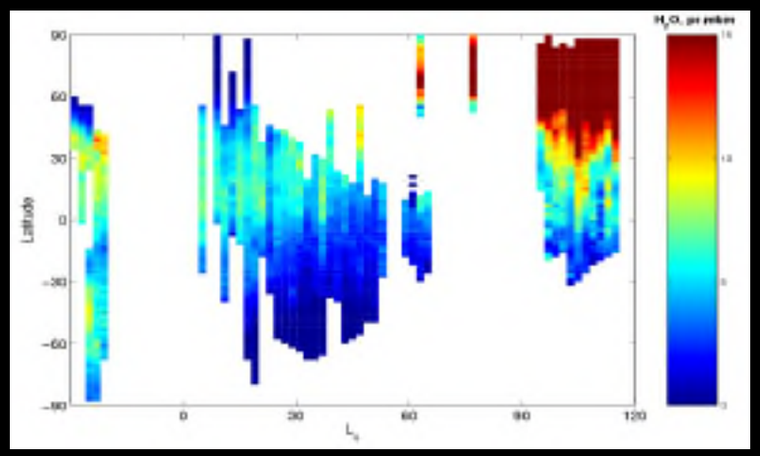
esa SCIENCE

SPICAM results

- **SPICAM**
  - Complete atmospheric profiles between 10 and 100 km altitude through limb observations, which for the first time include both density and temperature.
  - Discovery of nightglow in upper atmosphere; implications for atmospheric transport.
  - Discovery of auroras in the Martian atmosphere (paleomagnetic areas).
  - First simultaneous measurements of H_2O and O_3.
  - Ozone vertical profiles: model predictions not always confirmed.
  - Dust altitude profiles: discovery of small particles population (r< 0.15 μm).
  - UV signature on Phobos: organic materials ?

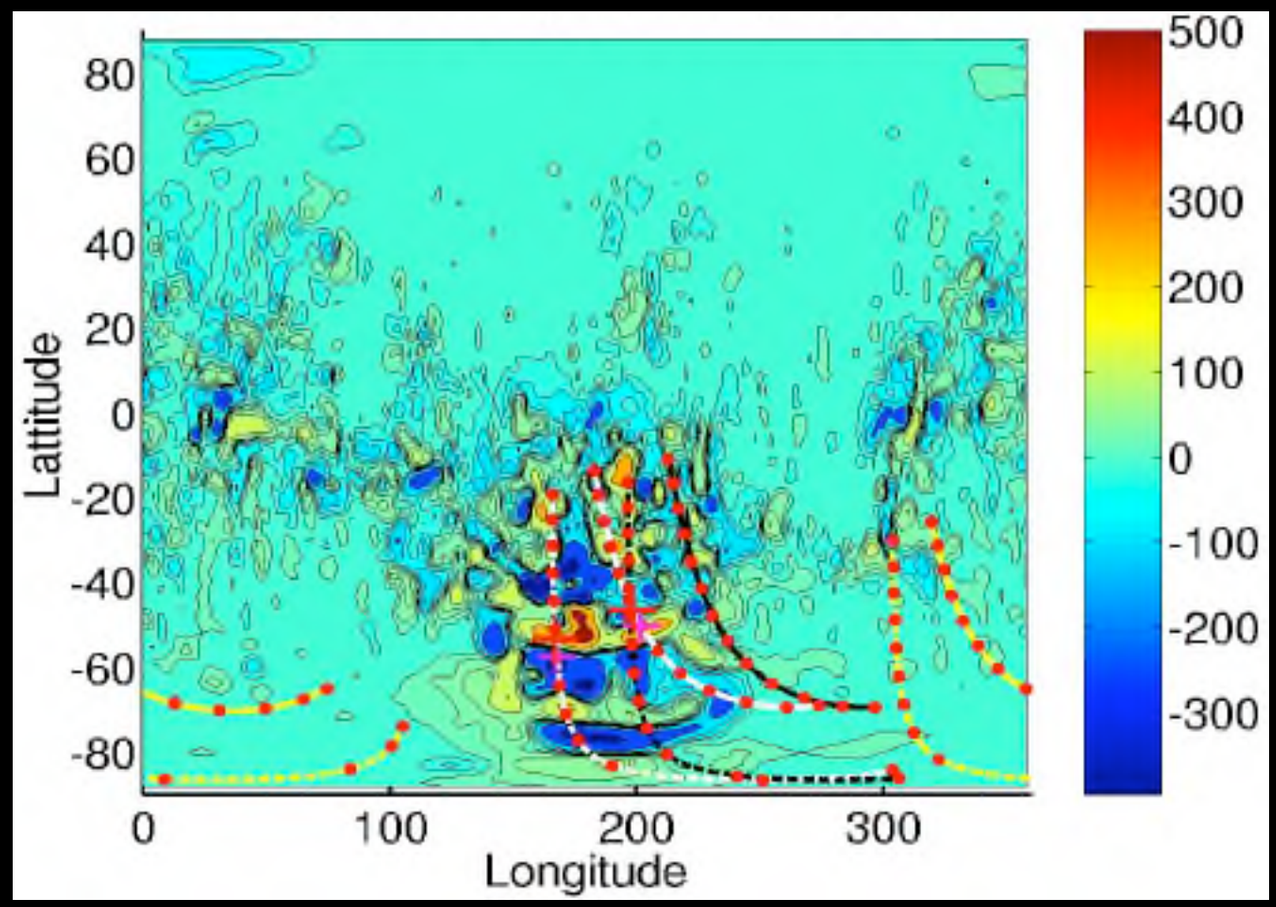






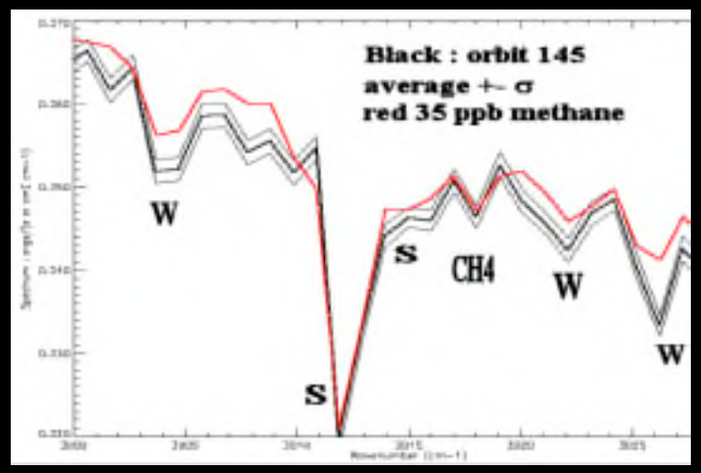
esa SCIENCE

Auroras on Mars discovered by SPICAM

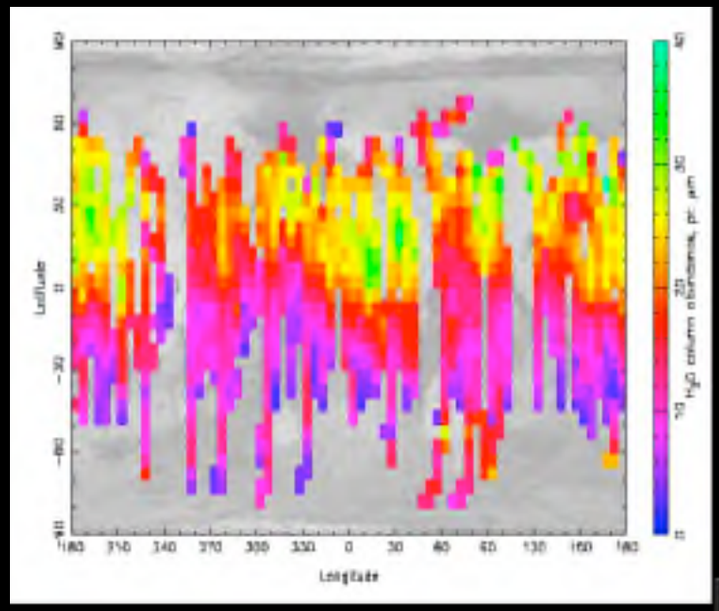


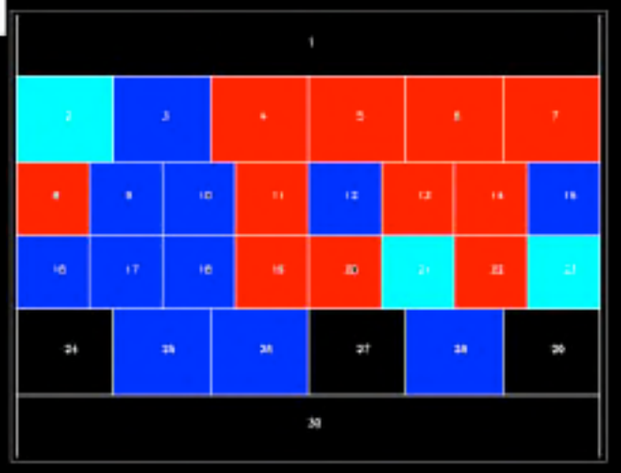
esa SCIENCE

PFS results



- **PFS**
  - Presence of methane in the atmosphere (concurrent with ground observations), which together with the formaldehyde (oxidation product of methane) also found would indicate that Mars either bears volcanic activity or biological processes today.
  - Clear correlation between water vapour in the boundary layer and methane concentrations observed from orbit, further illustrating the volcanism vs. life debate.
  - The correlation between water vapour, methane and possible underground acquifers (Mars Odyssey) points to a common underground source for water and methane.





esa SCIENCE

ASPERA results

- **ASPERA**

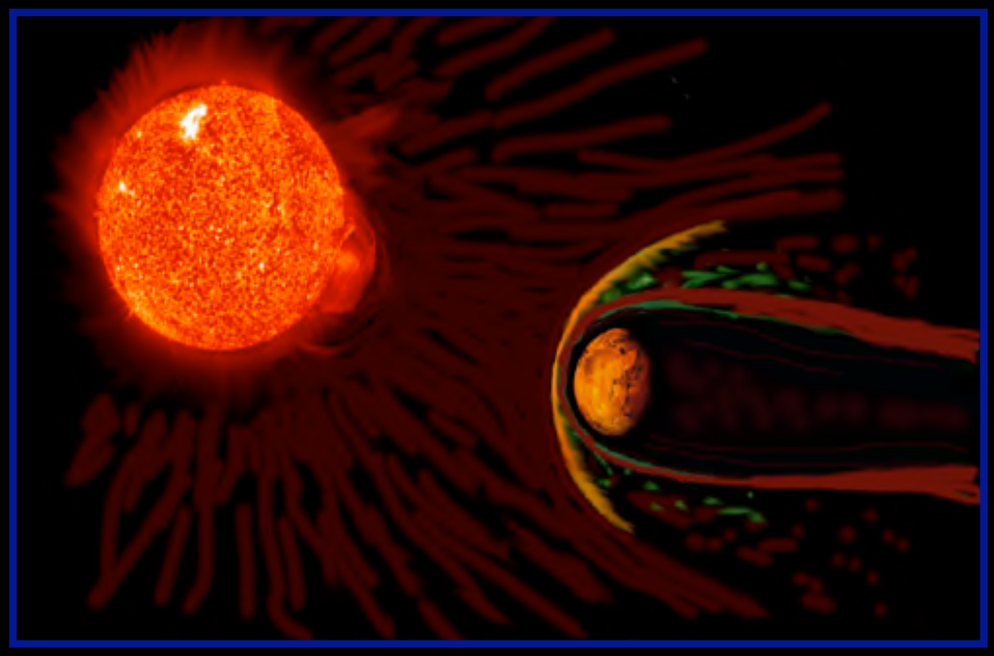
  Characterisation of the planetary wind composition (atomic & molecular O^+) away from the solar wind.

  Solar wind scavenging of the atmosphere down to 270 km altitude, representing a major mechanism in neutral atmospheric degassing and past climate change.

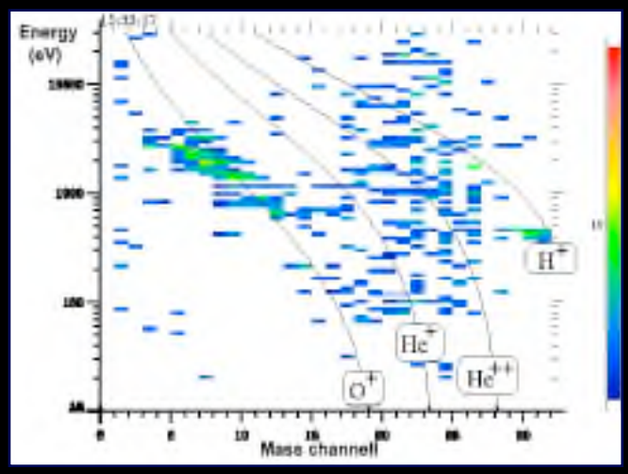
  Planetary heavy ions accelerated up to very high energies.

  For the first time, ”radiation” of fast atoms is observed at Mars.

  CO_2 also escapes from Mars. H_2O ?



Planetary wind (O^+)



esa SCIENCE

MaRS results

- **MaRS**

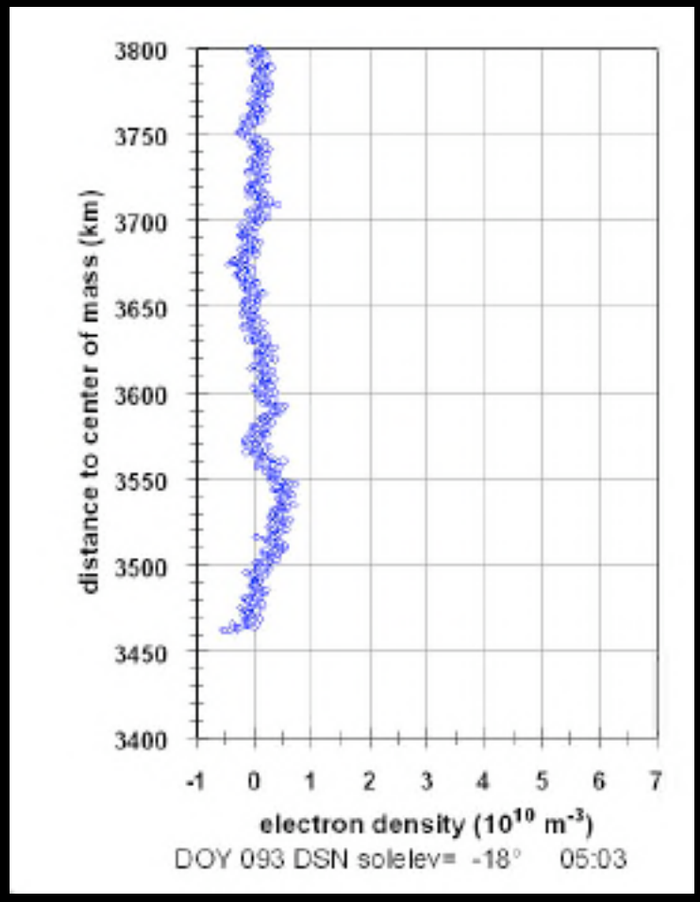
  Build-up of the ionosphere shortly before dawn.

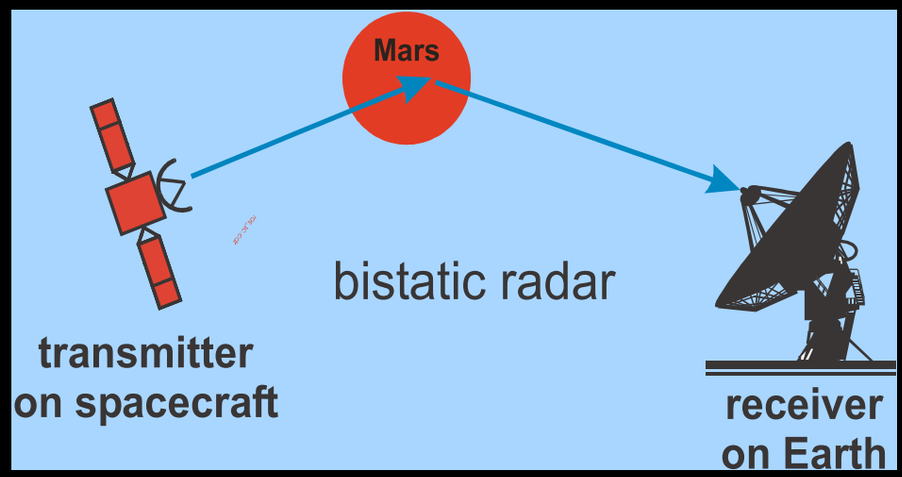
  First successful bi-static radar experiment by pointing of the high-gain antenna towards Mars to infer surface roughness and other soil properties in regions of geological interest.

  Stable two layer structure of dayside ionosphere; sporadic third layer due to meteor interaction with ionosphere.

  Very cold atmosphere over the first few kilometres (-143°C to -130°C).

  CO_2 snow fall at high Southern latitudes.



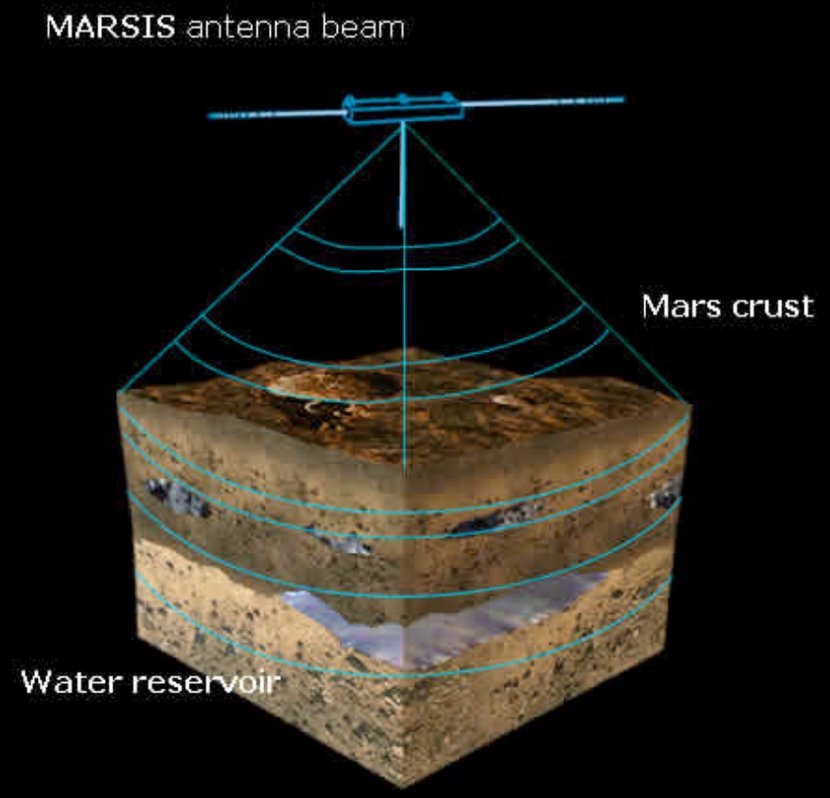


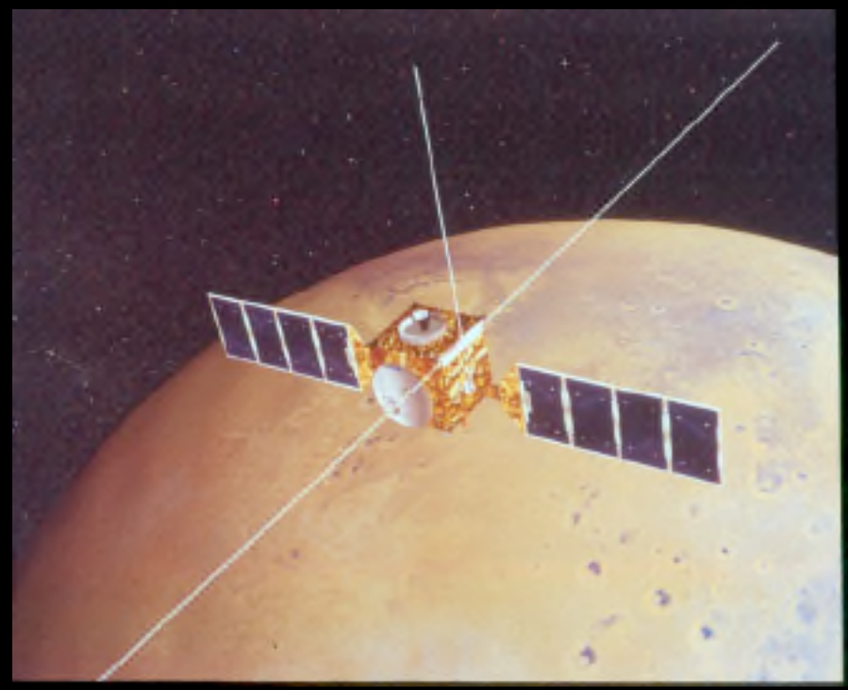
esa SCIENCE

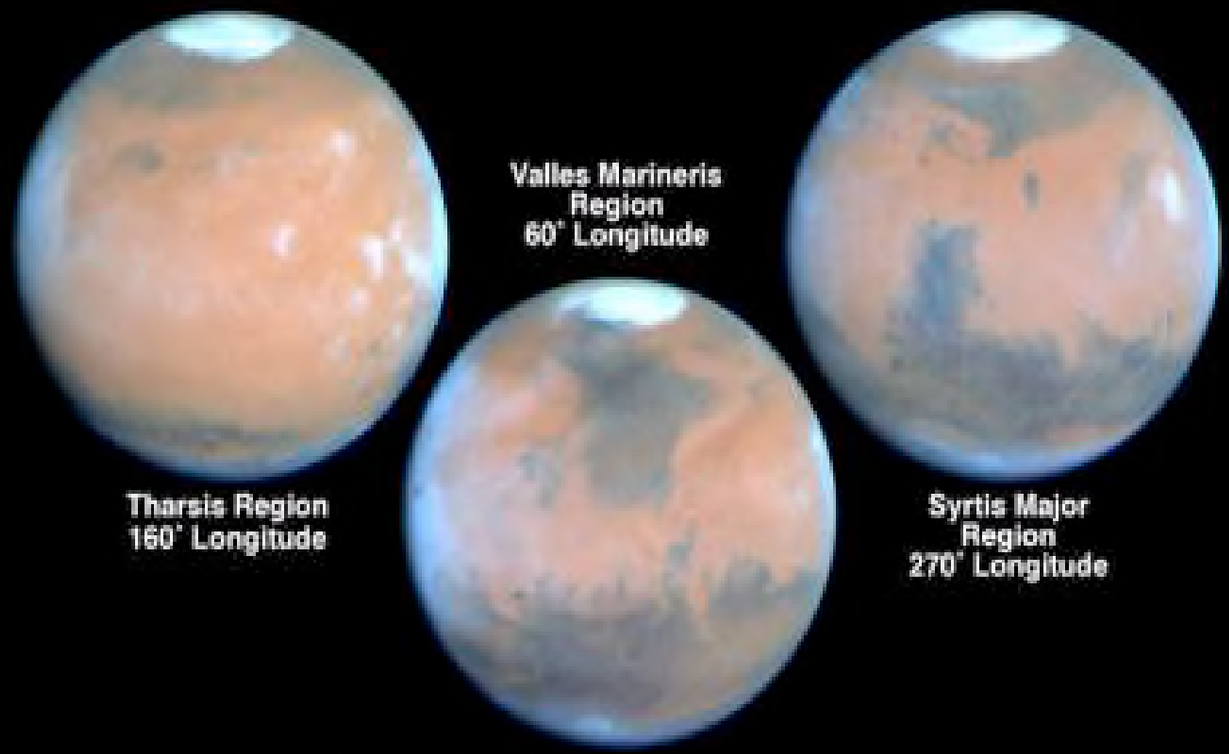
MARSIS radar

MARSIS

- Mapping the subsurface structure with micro waves.
- Current/past inventory of water.
- Study water transport, storage
- Evolution: geology, climate, life ?
- Surface roughness, topography.
- Ionospheric sounding: e^- density to H_2O and CO_2 cycles

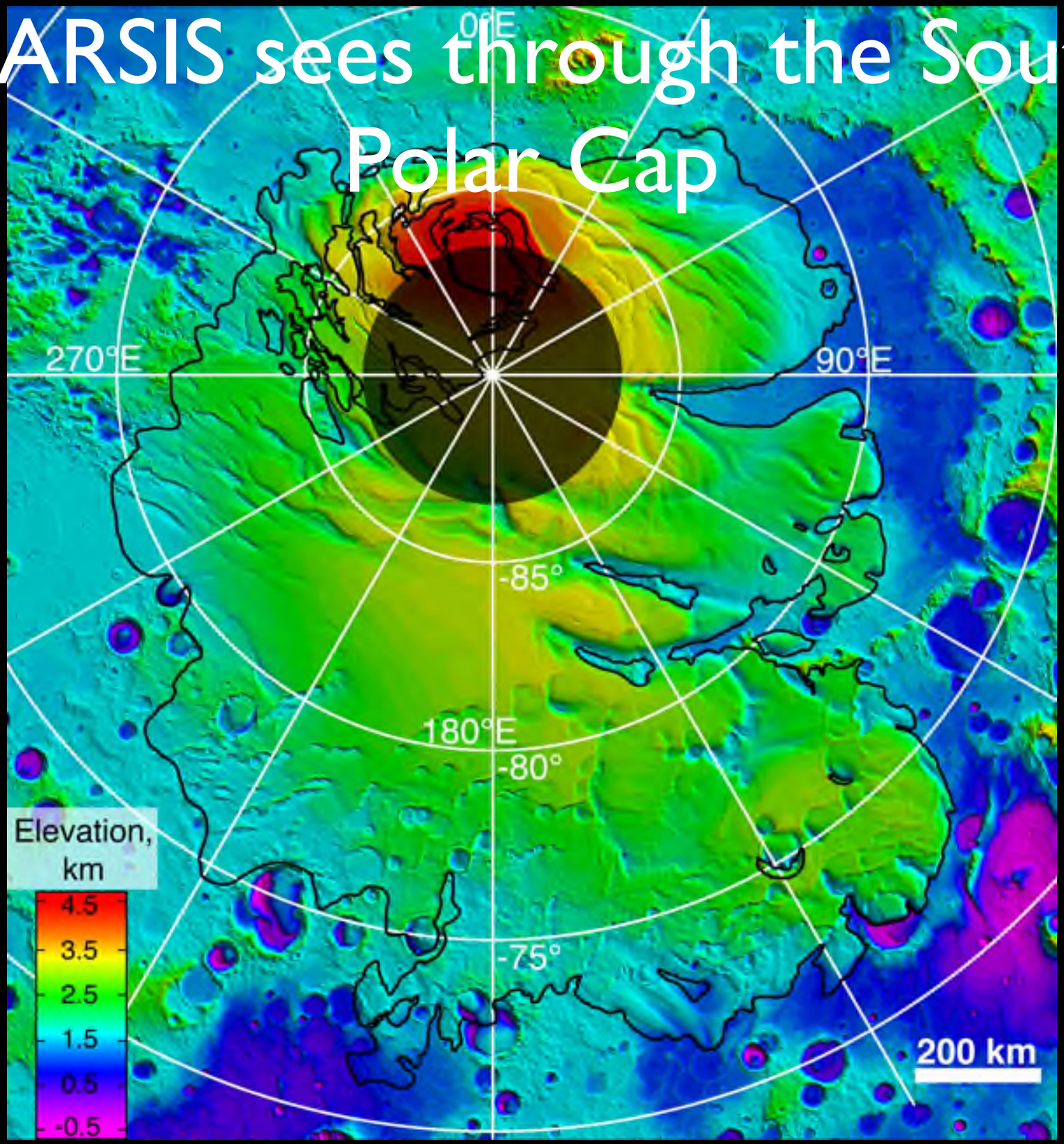






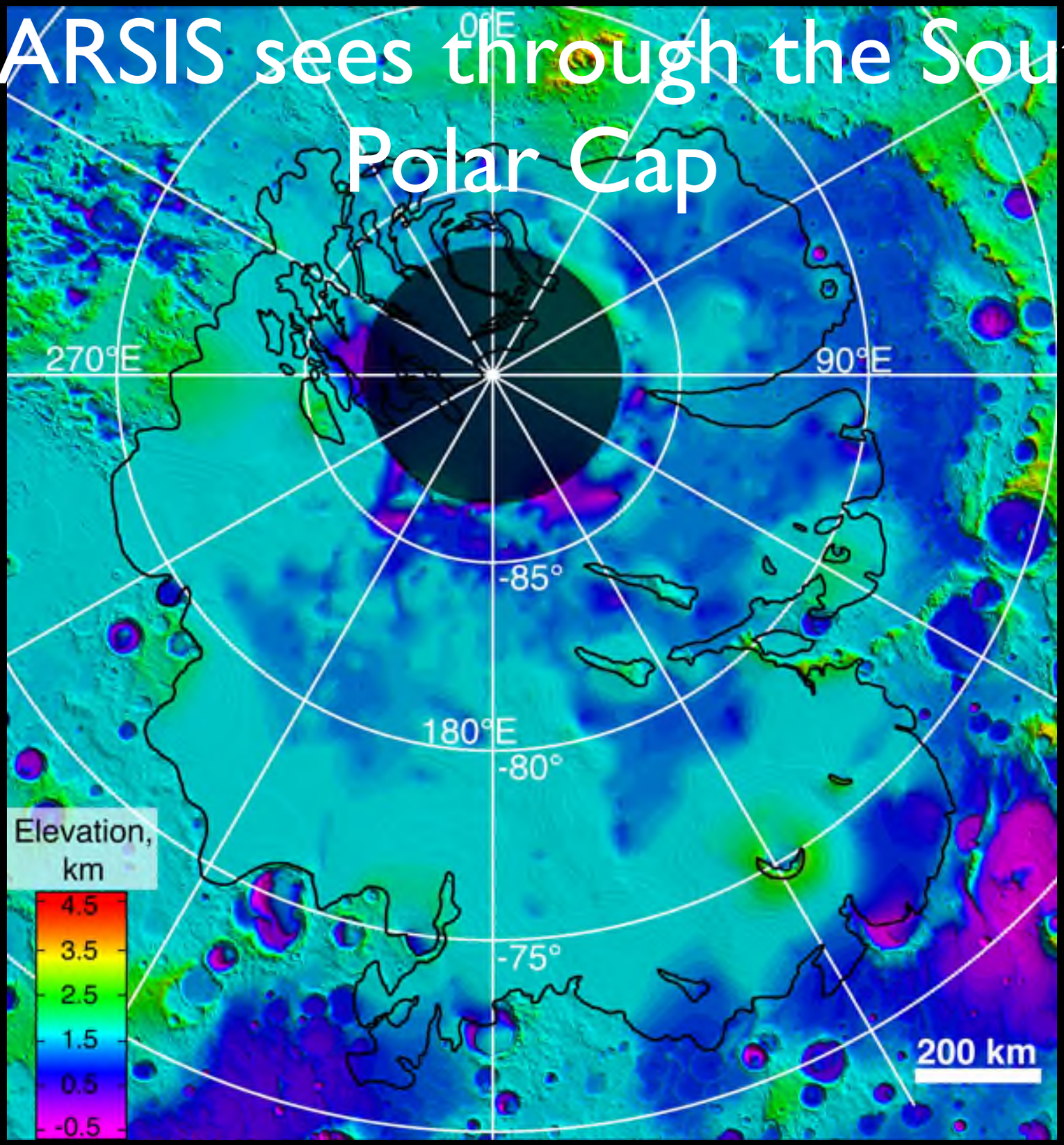
esa SCIENCE

MARSIS sees through the South Polar Cap



esa SCIENCE

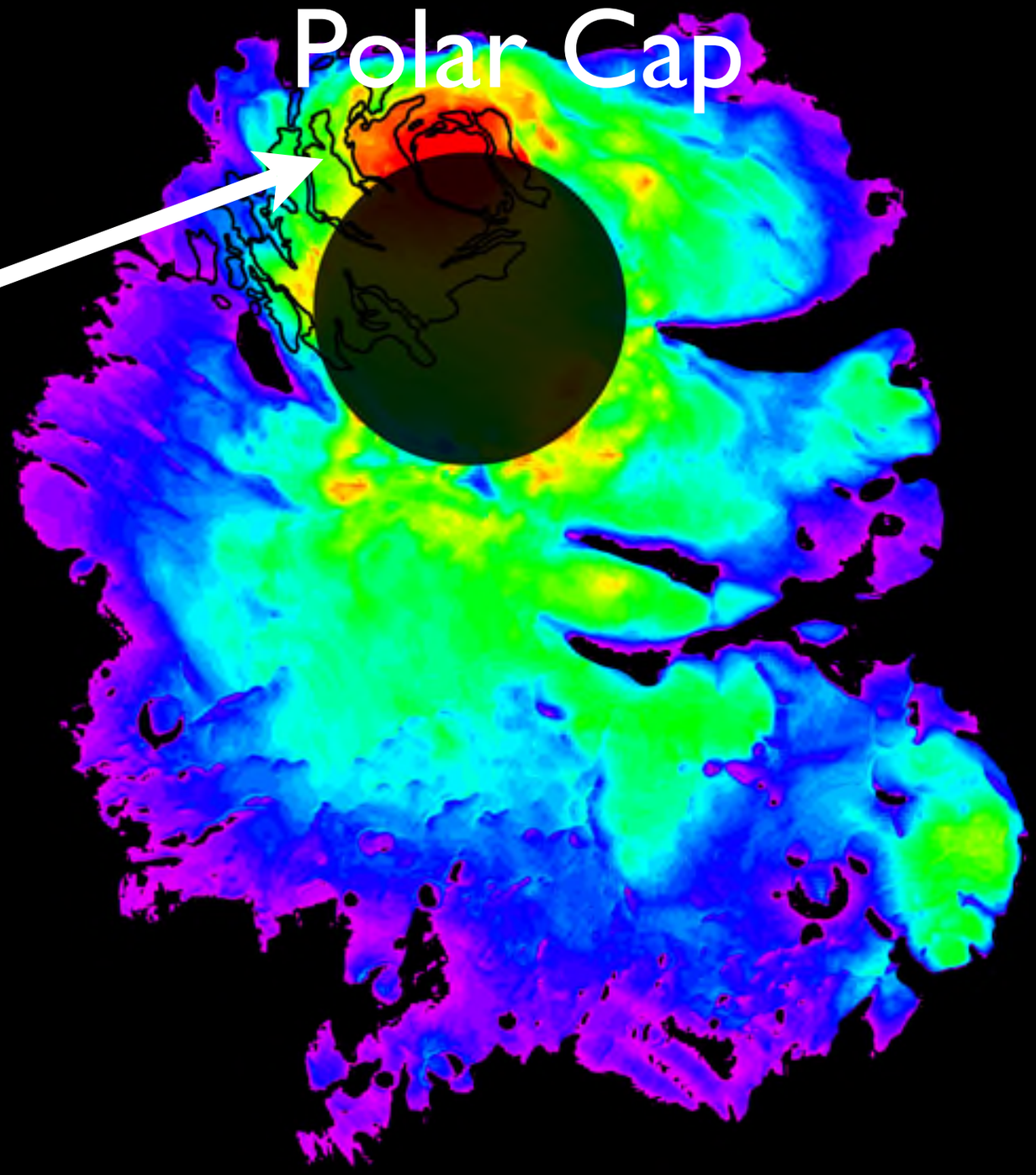
MARSIS sees through the South Polar Cap



esa SCIENCE

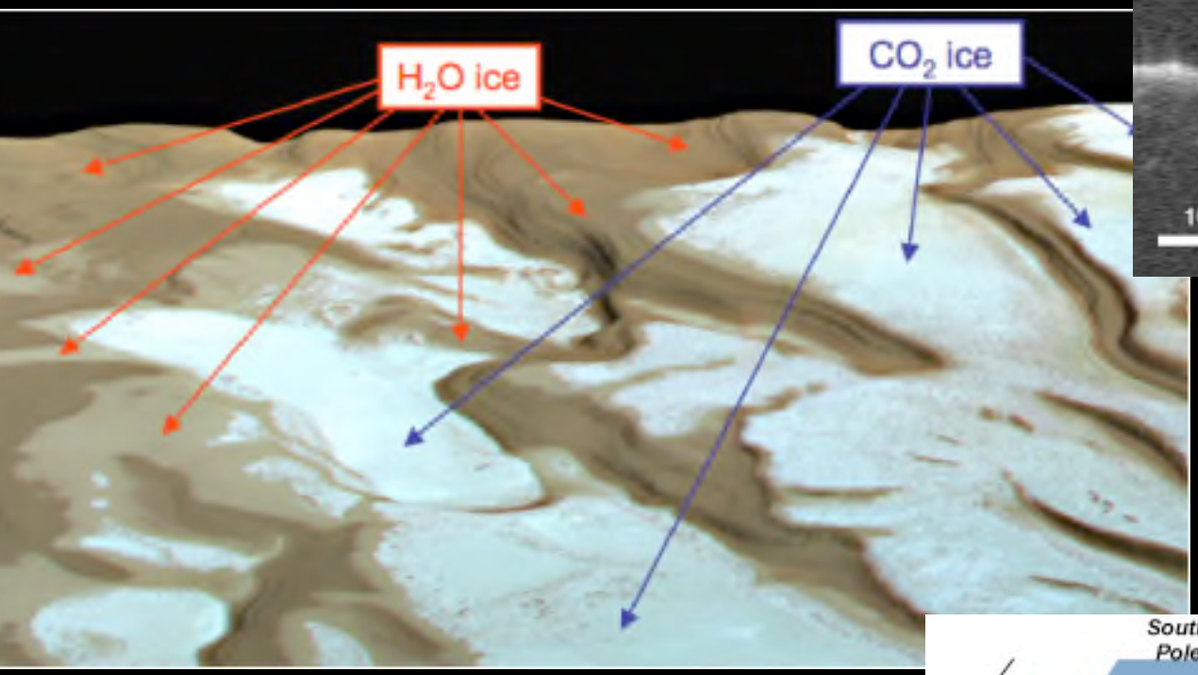
MARSIS sees through the South Polar Cap

3.7 km !

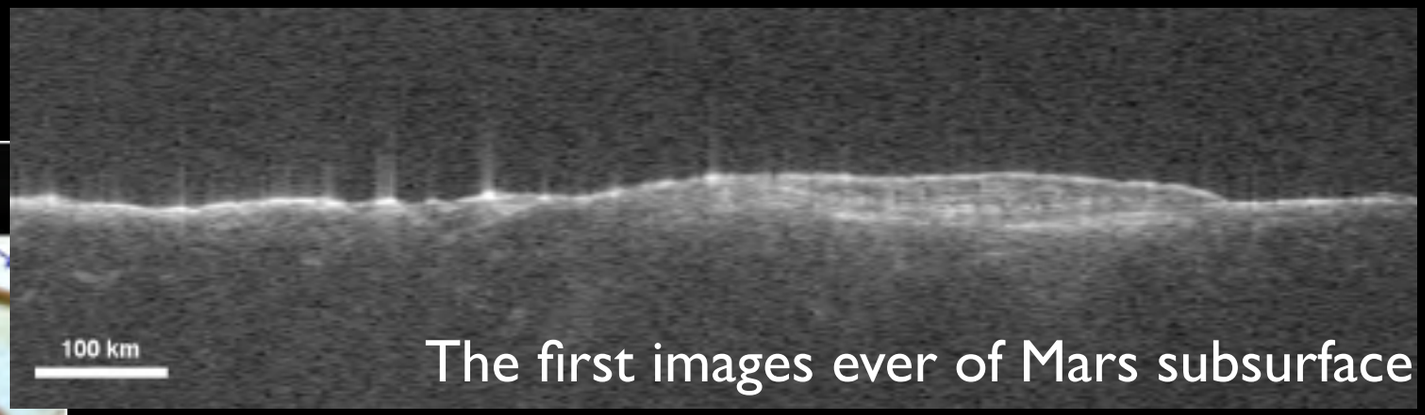


esa SCIENCE

New light on the Poles

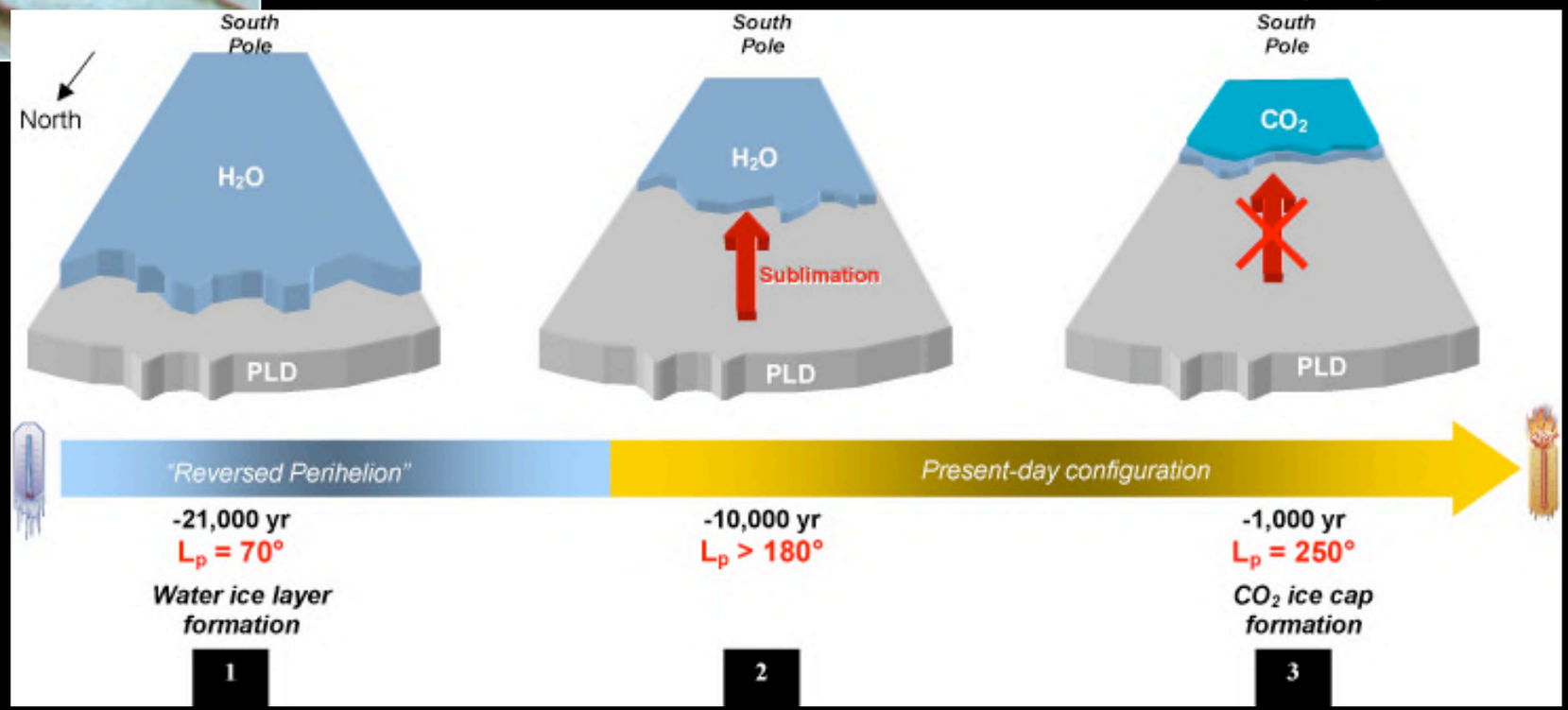


Composition of the ices
(OMEGA)



The first images ever of Mars subsurface
(MARSIS)

Polar cap dynamics



esa SCIENCE