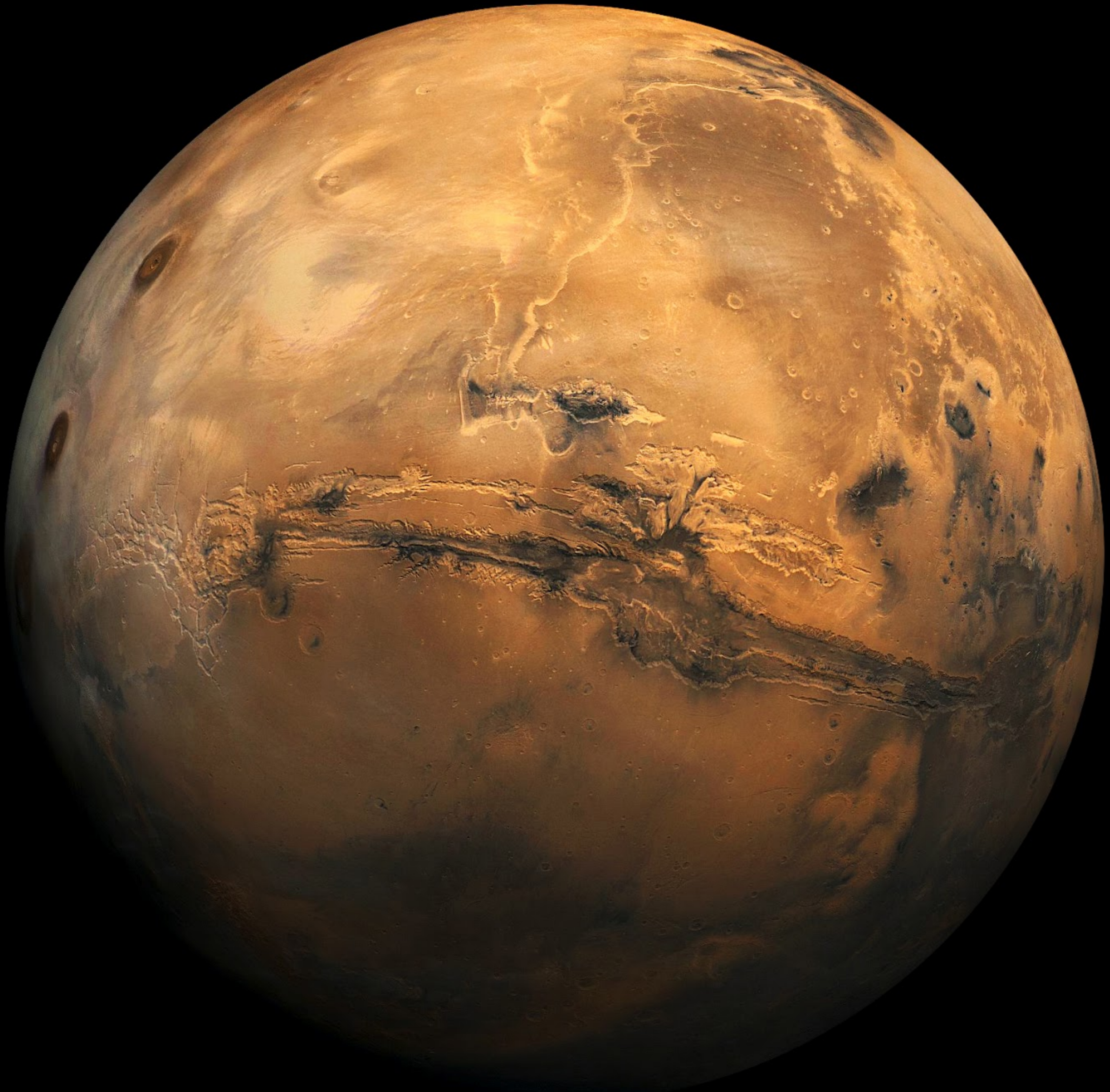
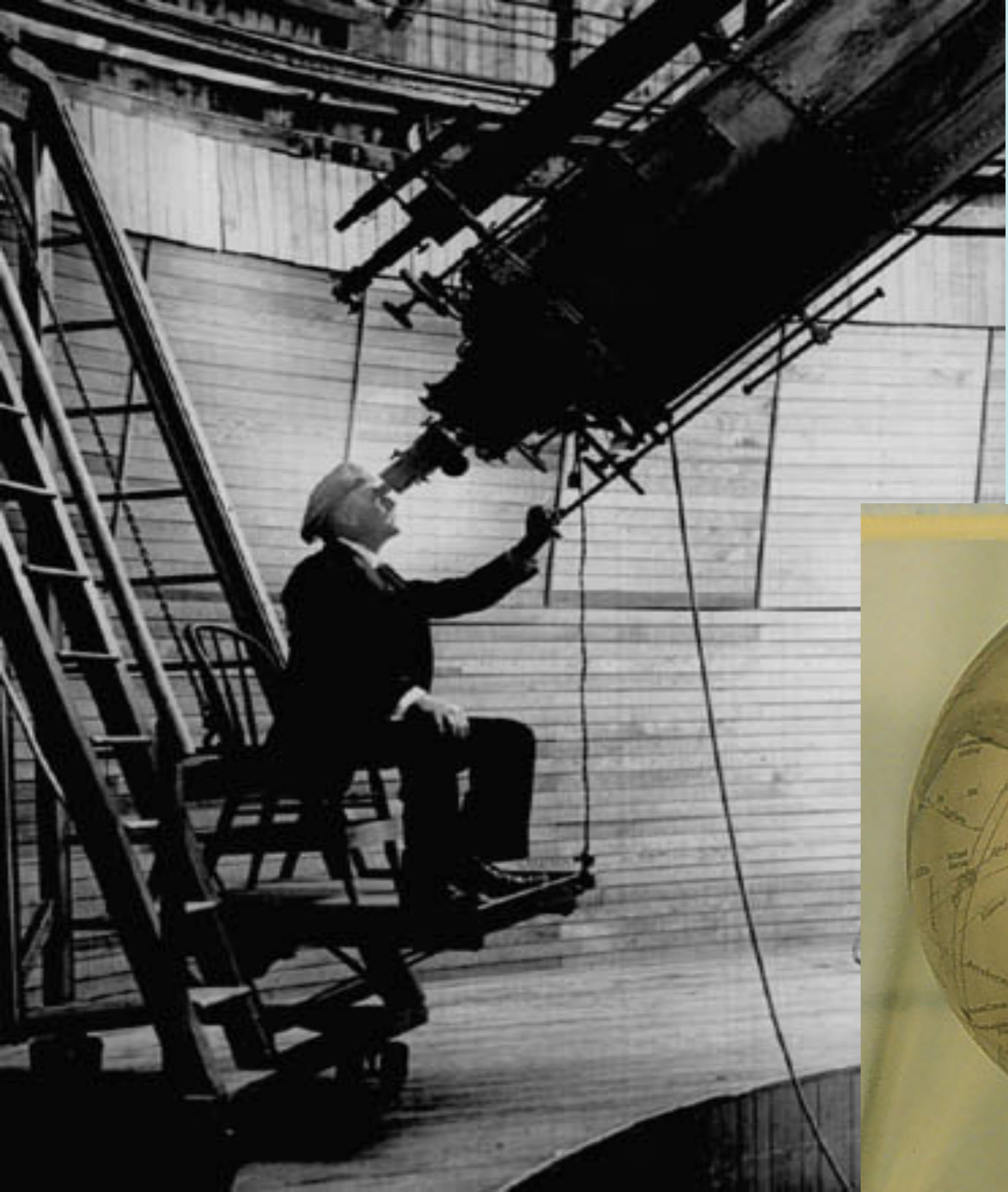
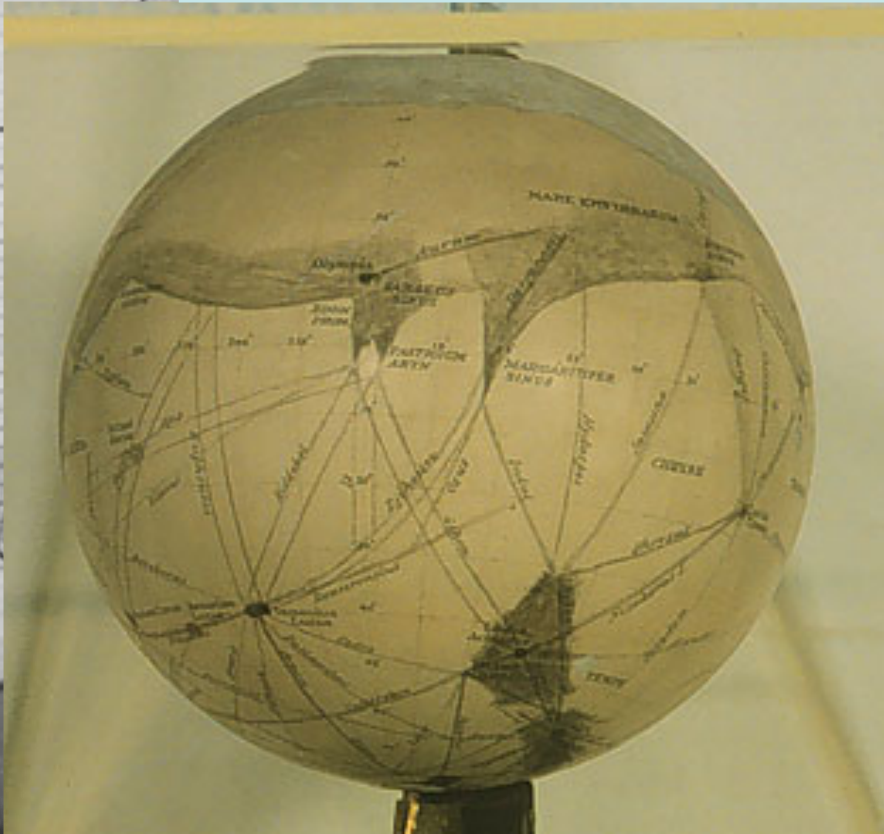


Mars' Mysteries

Donna M. Jurdy
Earth & Planetary Sciences
Northwestern University



PERCIVAL LOWELL AT THE 24 INCH REFRACTOR, FLAGSTAFF, ARIZONA OBSERVING MARS DURING FAVORABLE OPPOSTION (PERIHELIC OPPOSTION) OF 1894
BELOW IS A GLOBE CONSTRUCTED FROM HIS DRAWINGS



H.G. Wells
The War of
the Worlds
(1898)

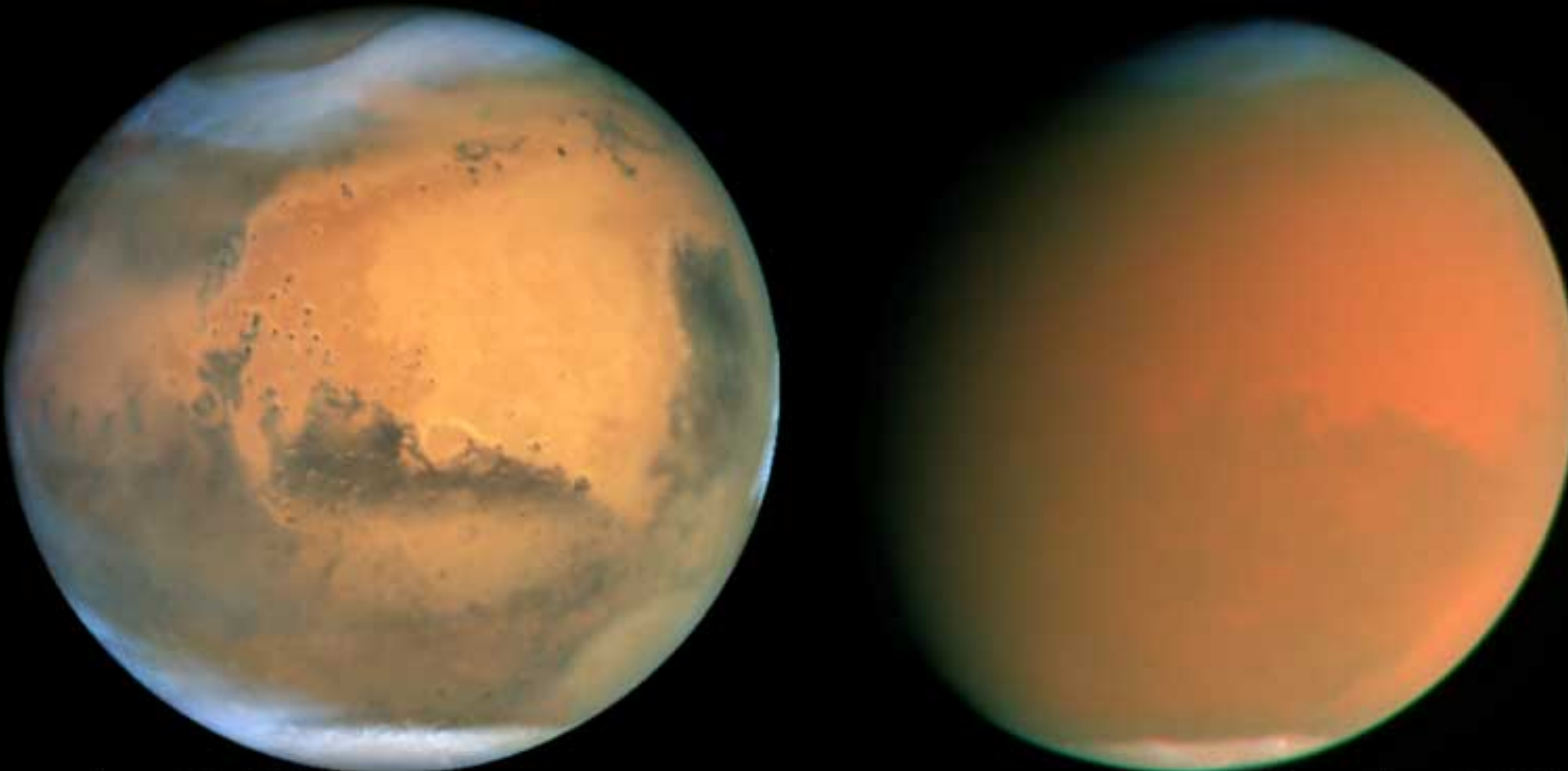
The WAR of the WORLDS

By H. G. Wells

Author of "Under the Knife," "The Time Machine," etc.

Photograph
Of Mars
Taken with
A 5 Inch
Refracting
Telescope
June 2003,
2 Months
Before
Opposition

Mars • Global Dust Storm

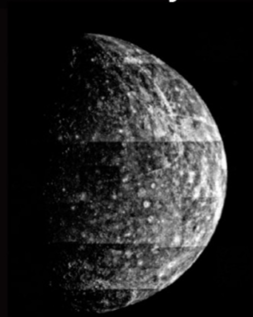
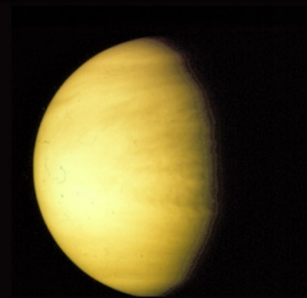


June 26, 2001 September 4, 2001

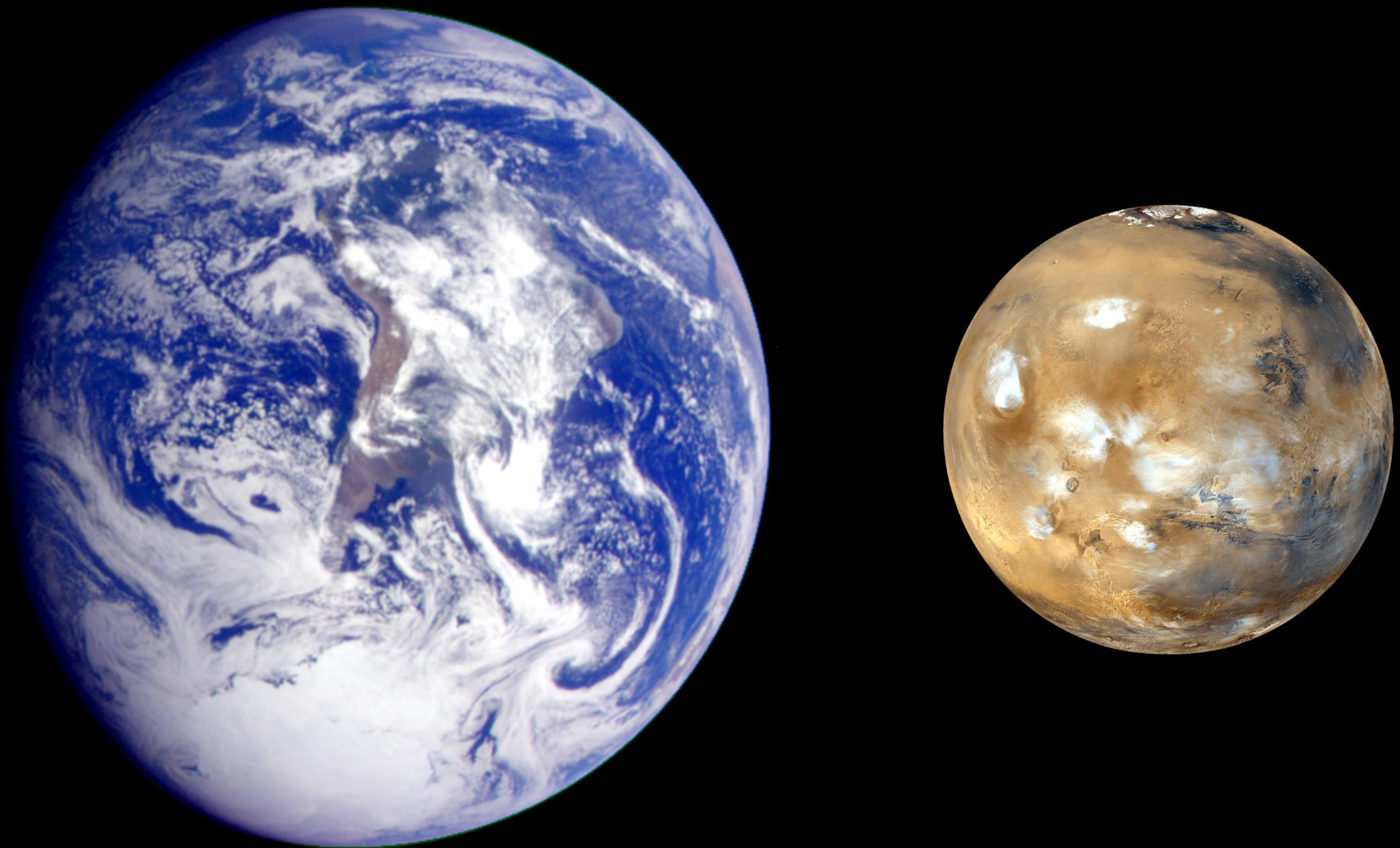
Hubble Space Telescope • WFPC2

NASA, J. Bell (Cornell), M. Wolff (SSI), and the Hubble Heritage Team (STScI/AURA) • STScI-PRC01-31

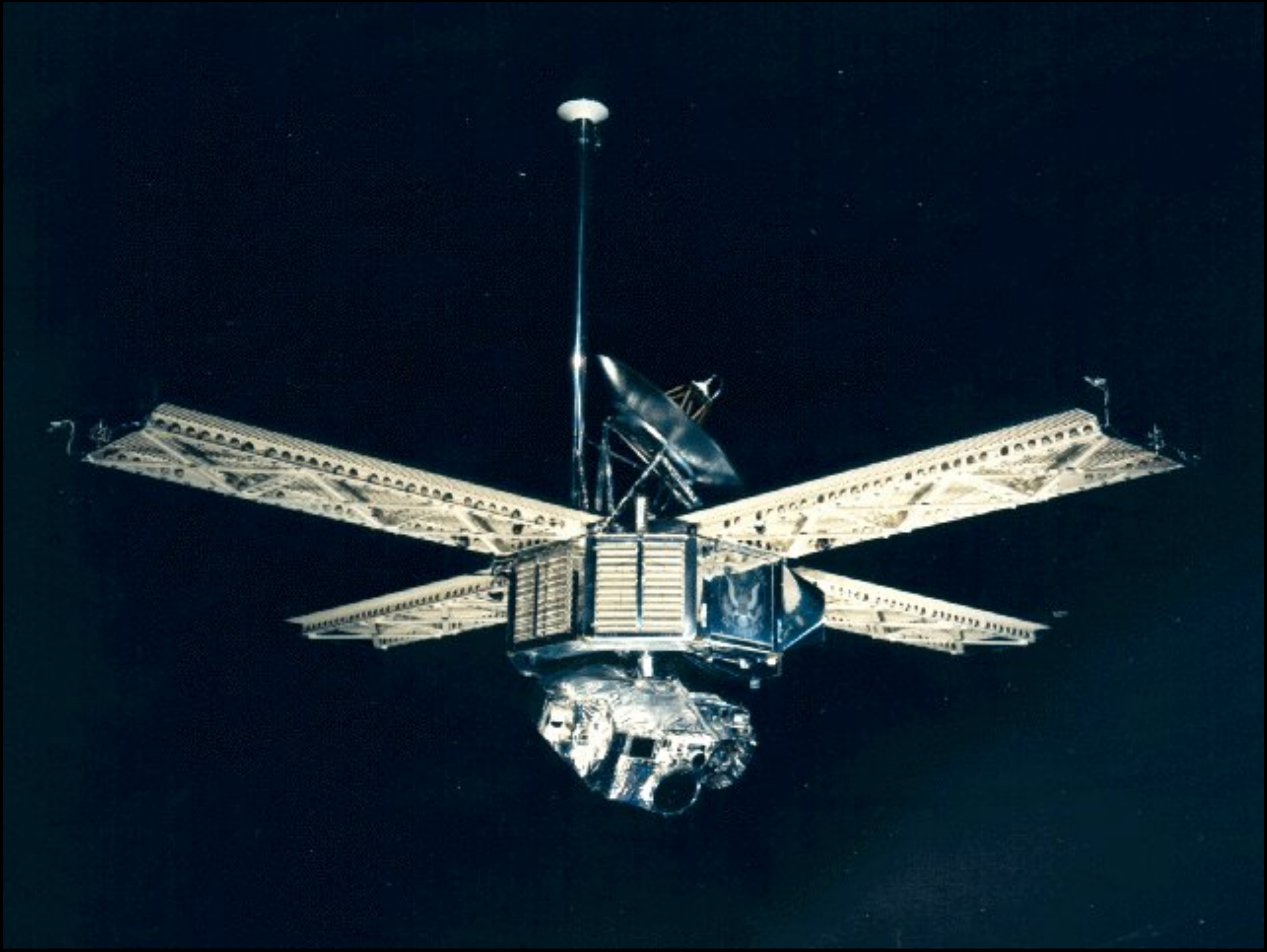
When is a face not a face?

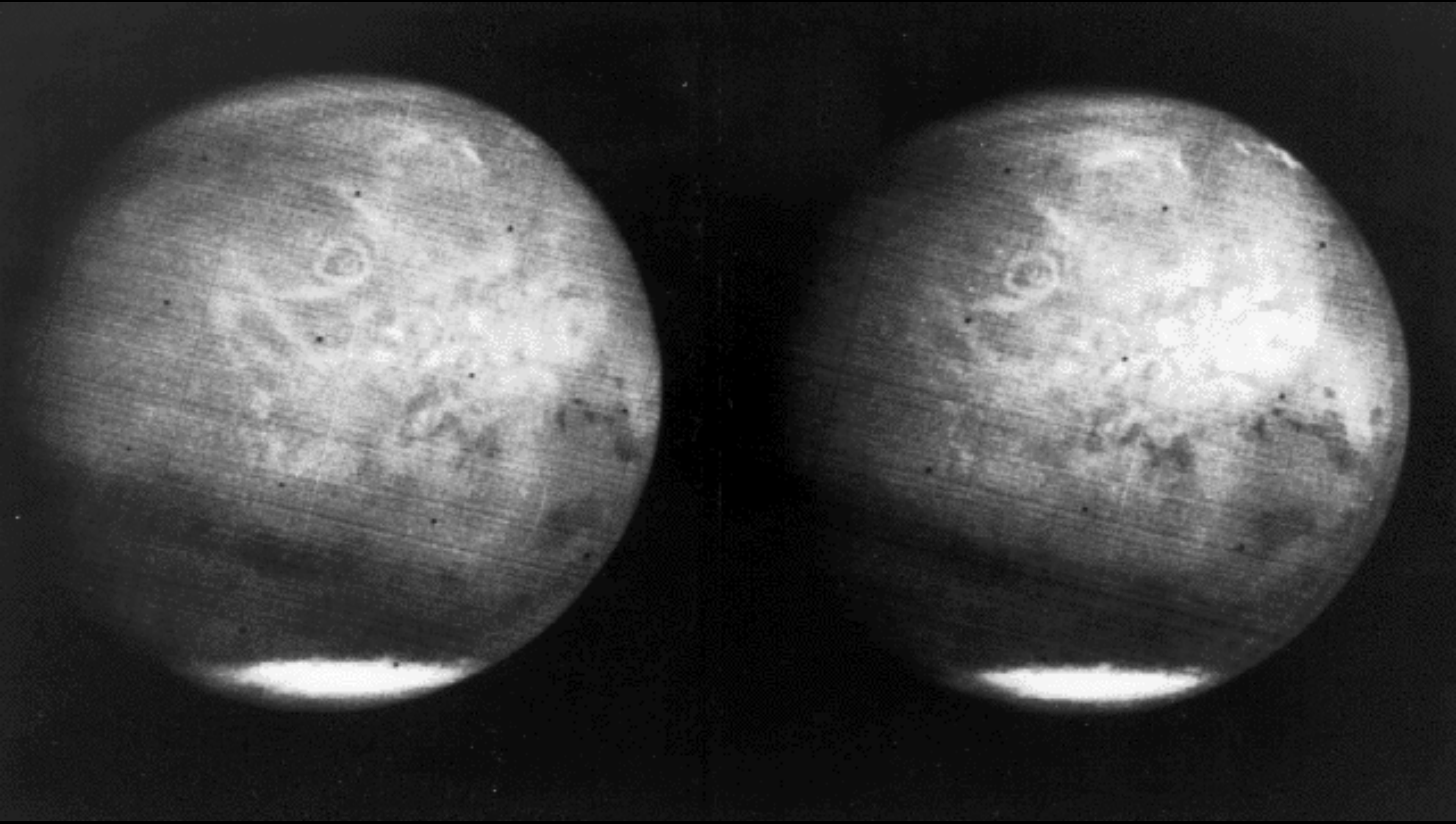

	Mercury	Venus	Earth	Moon	Mars
Radius (km)	2439	6052	6378	1738	3398
Mass (kg)	3.30×10^{23}	4.87×10^{24}	5.98×10^{24}	7.35×10^{22}	6.42×10^{23}
Density (kg/m^3)	5420	5250	5520	3340	3940
Distance from the Sun (A.U)	0.387	0.723	1.000	---	1.524
Mean Surface Pressure (bars)	---	92	1	---	0.006
Mean Surface Temp (K)	452	726	281	250	230
Atmosphere	---	CO_2	N_2, O_2	---	CO_2



Mariner 7 (1969)



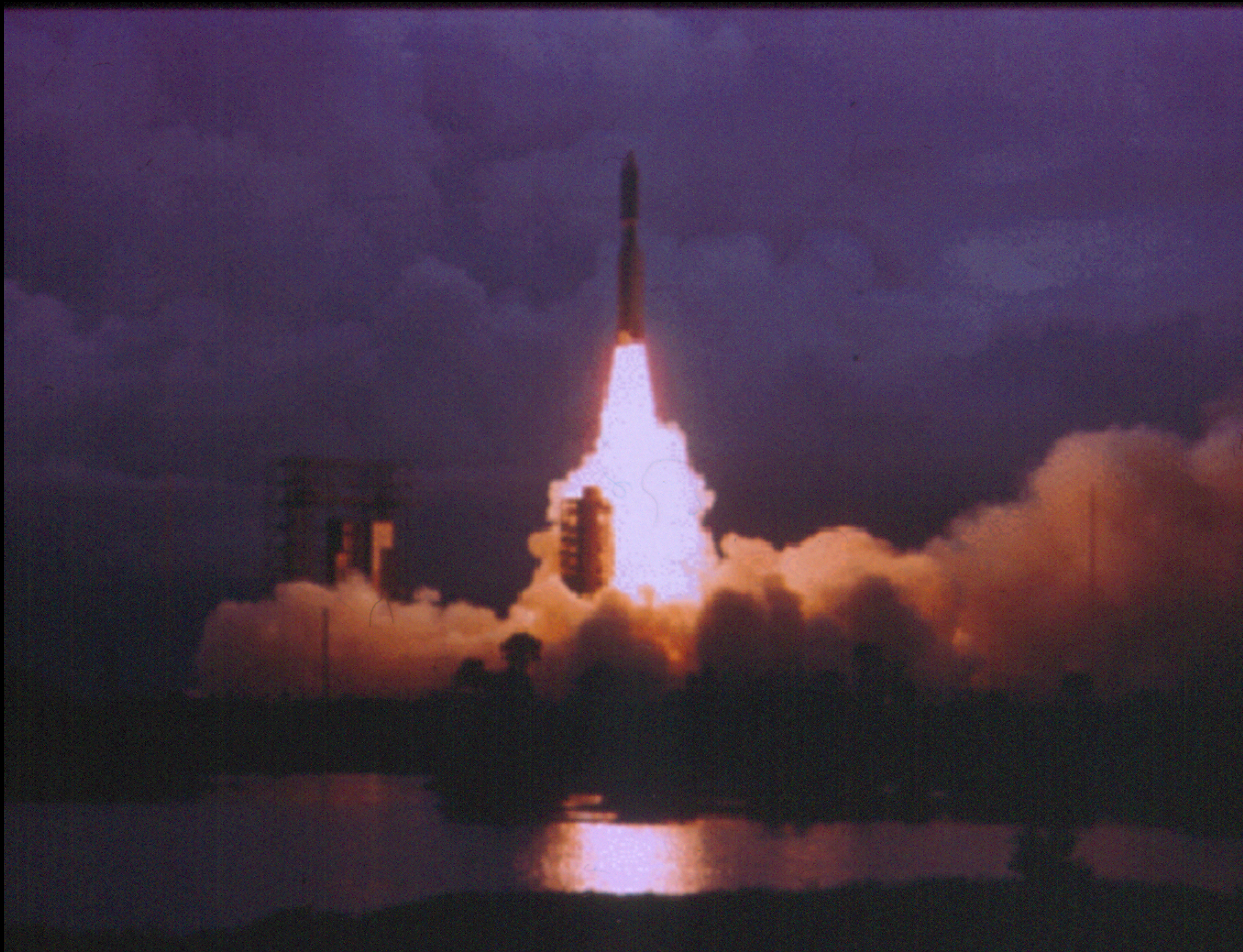
Mariner 7 Approach to Mars



Olympus Mons, as seen from Mariner 9 (1971)

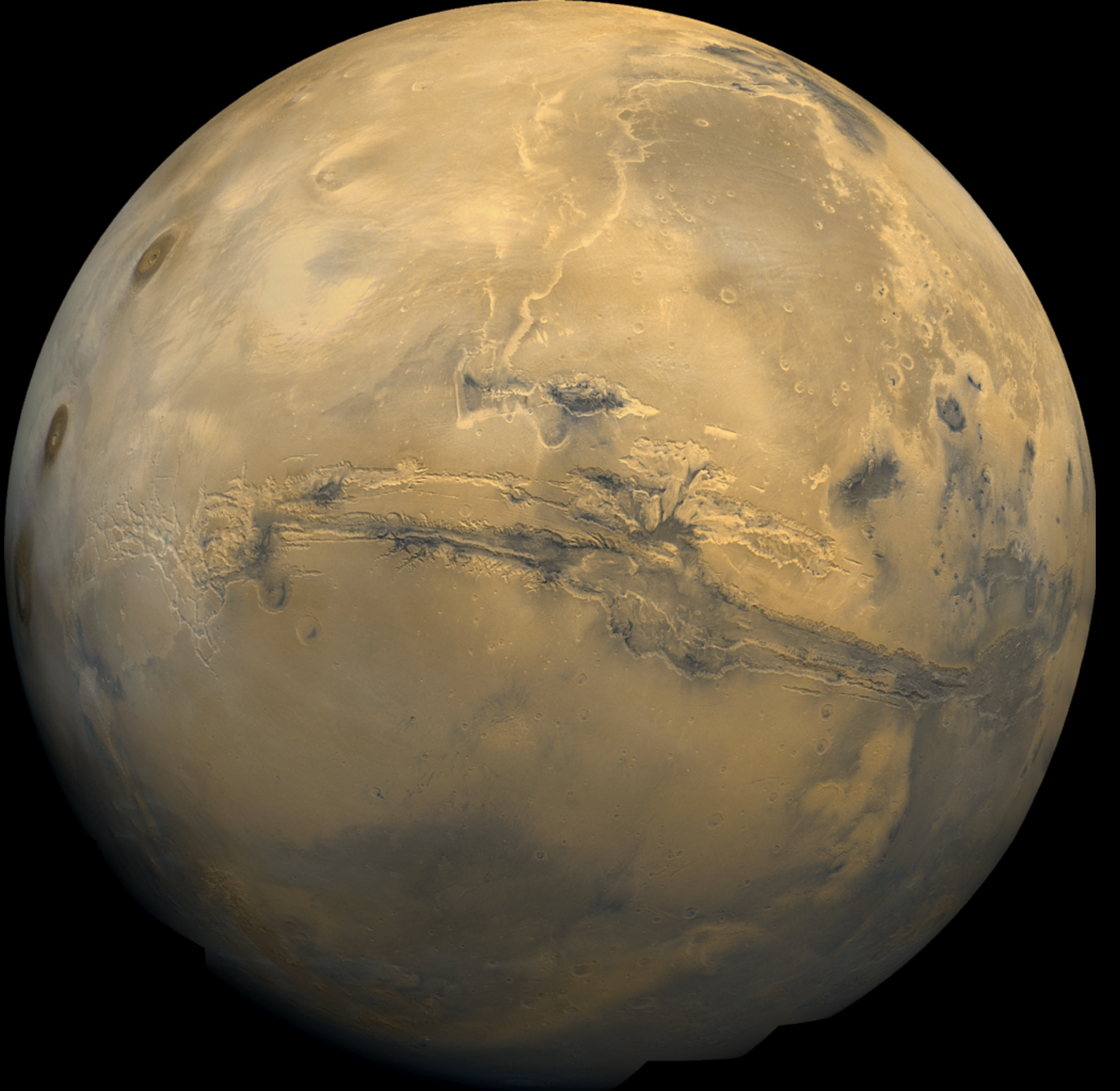
Olympus Mons Caldera

Viking 2 Liftoff, Sept 5, 1975

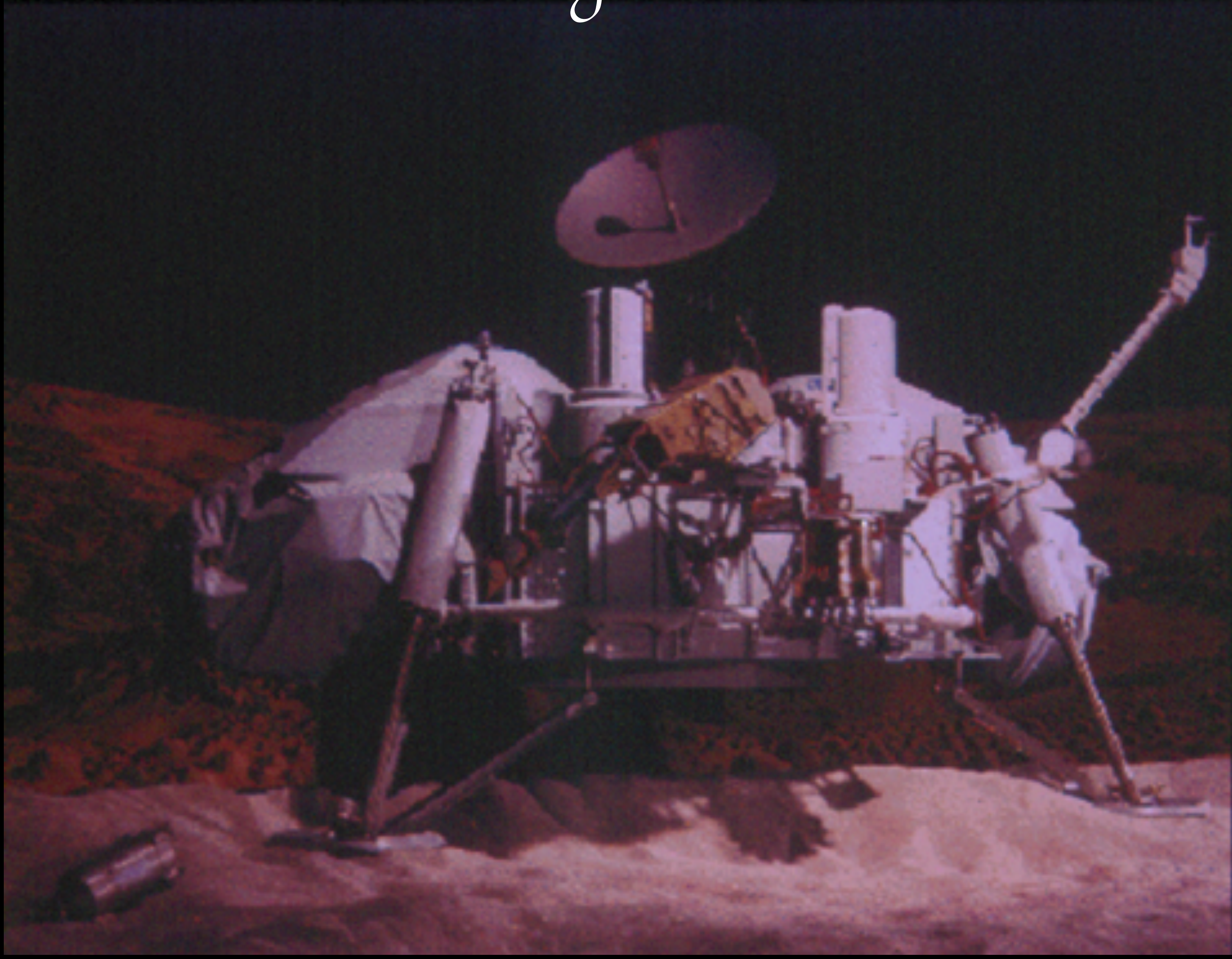


COMPOSITE IMAGE OF MARS TAKEN FROM SMALL TELESCOPES ONBOARD THE 2 VIKING ORBITERS

Mid 1970'S



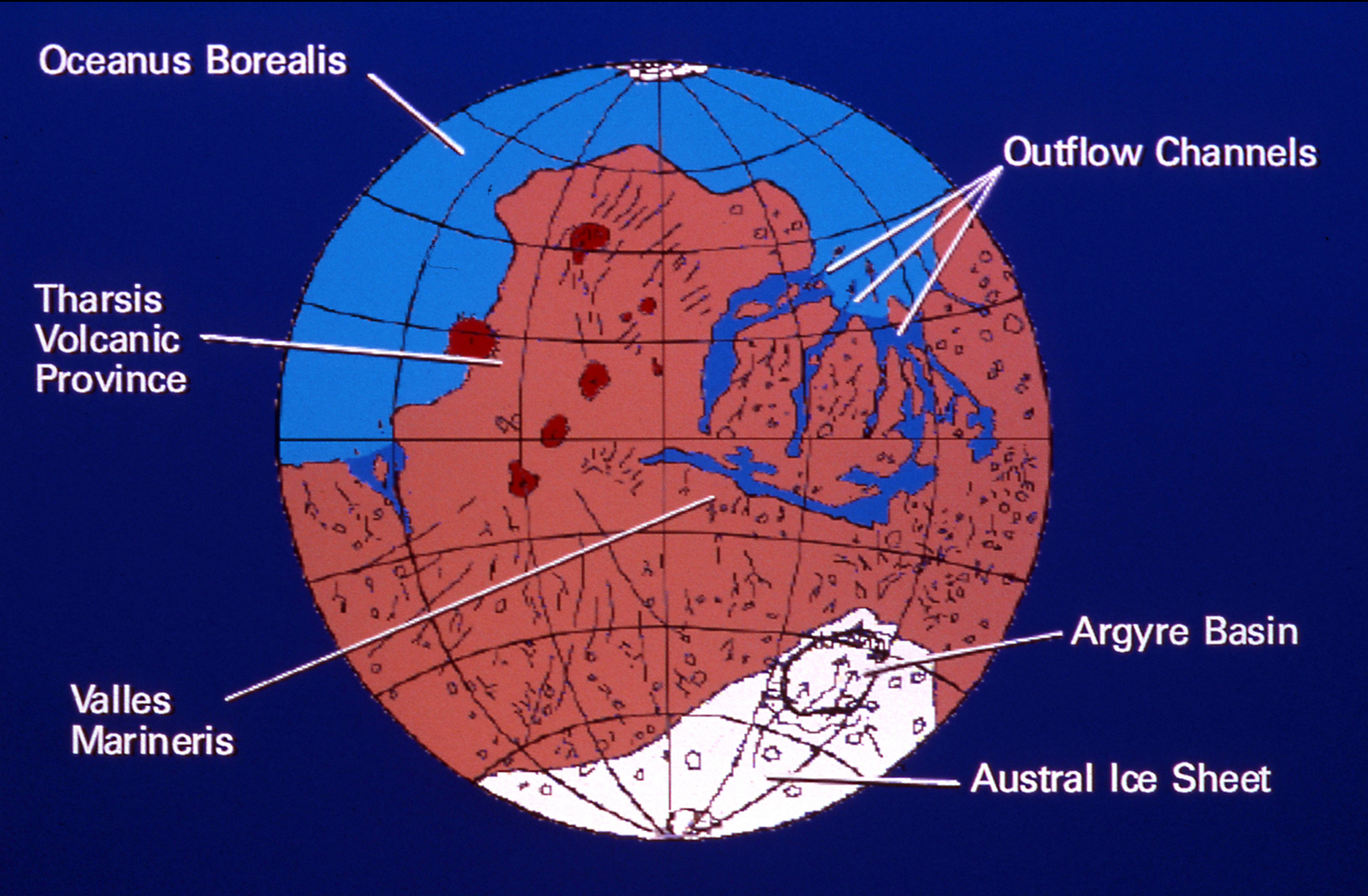
Viking Lander



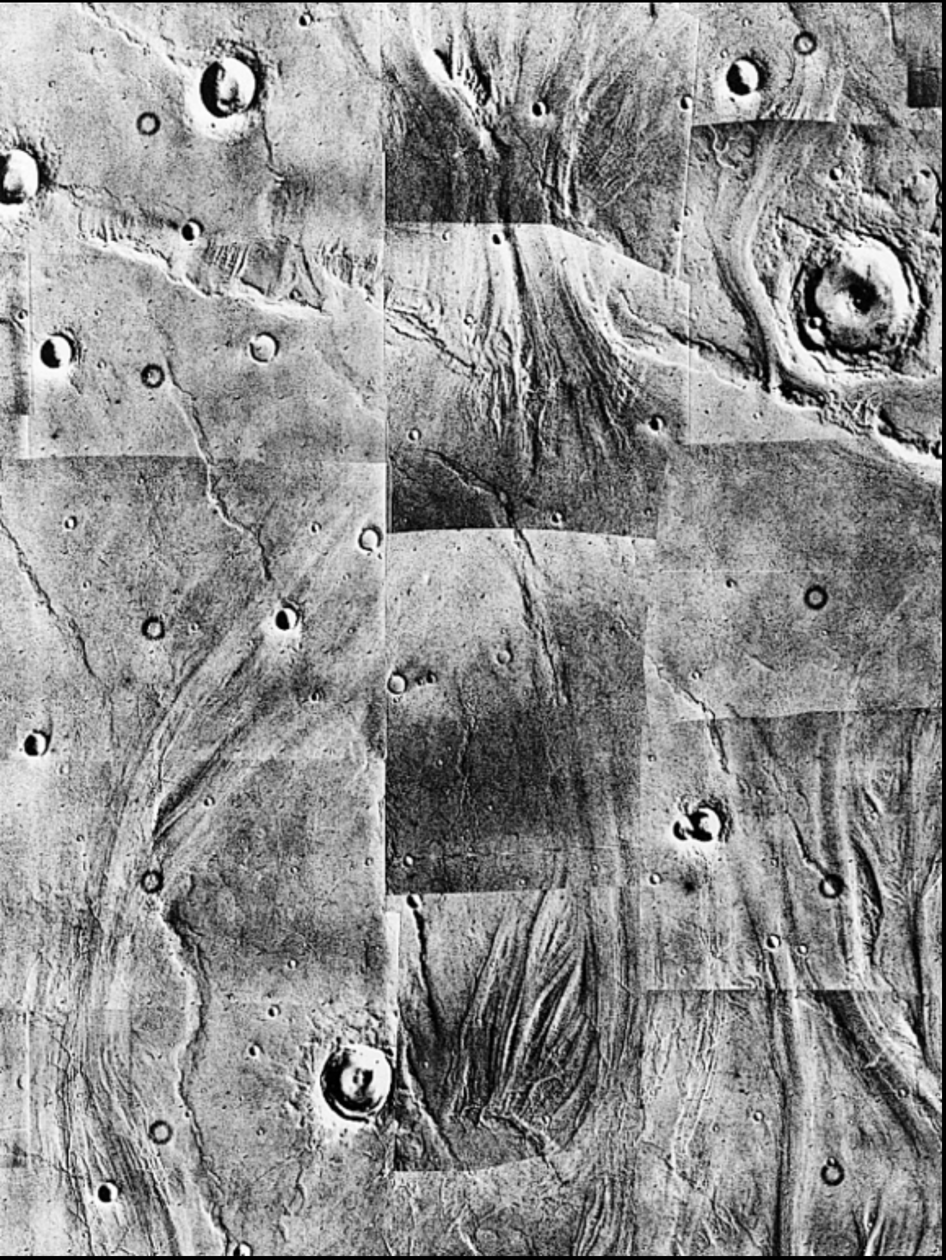
Viking 2 Landing Site (Sept, 1976)

Evidence for (really old, really tiny) Martians?

Mars Schematic



Water on Mars



❖Ancient Mars had flowing water on its surface.

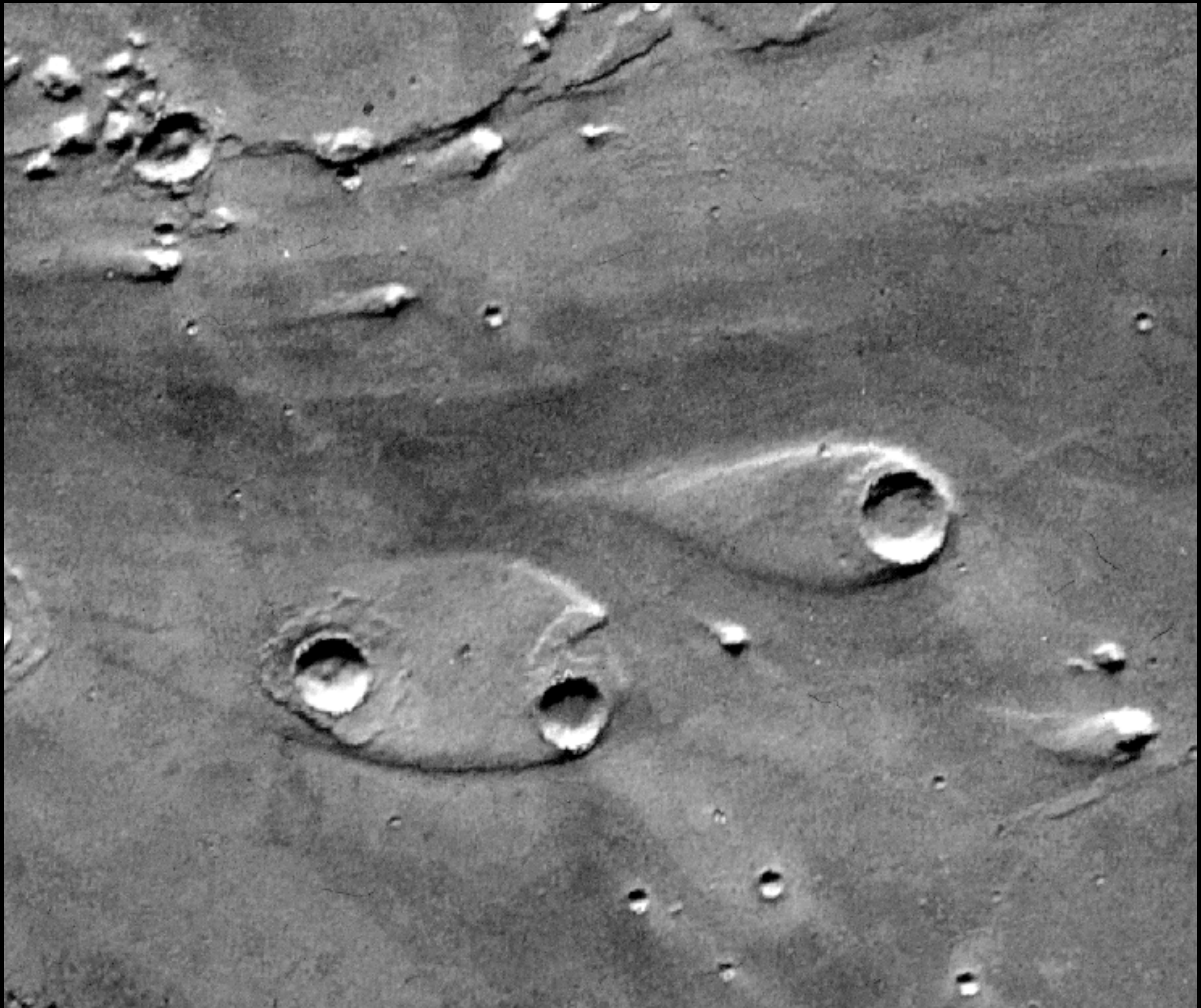
❖These images clearly show the results of what appears to have been flowing water.

❖The Viking landers actually recorded frost forming, then evaporating.

❖There does not seem to be any liquid water on Mars today.

❖It is possible that there may be surface water in shallow lakes under ice.

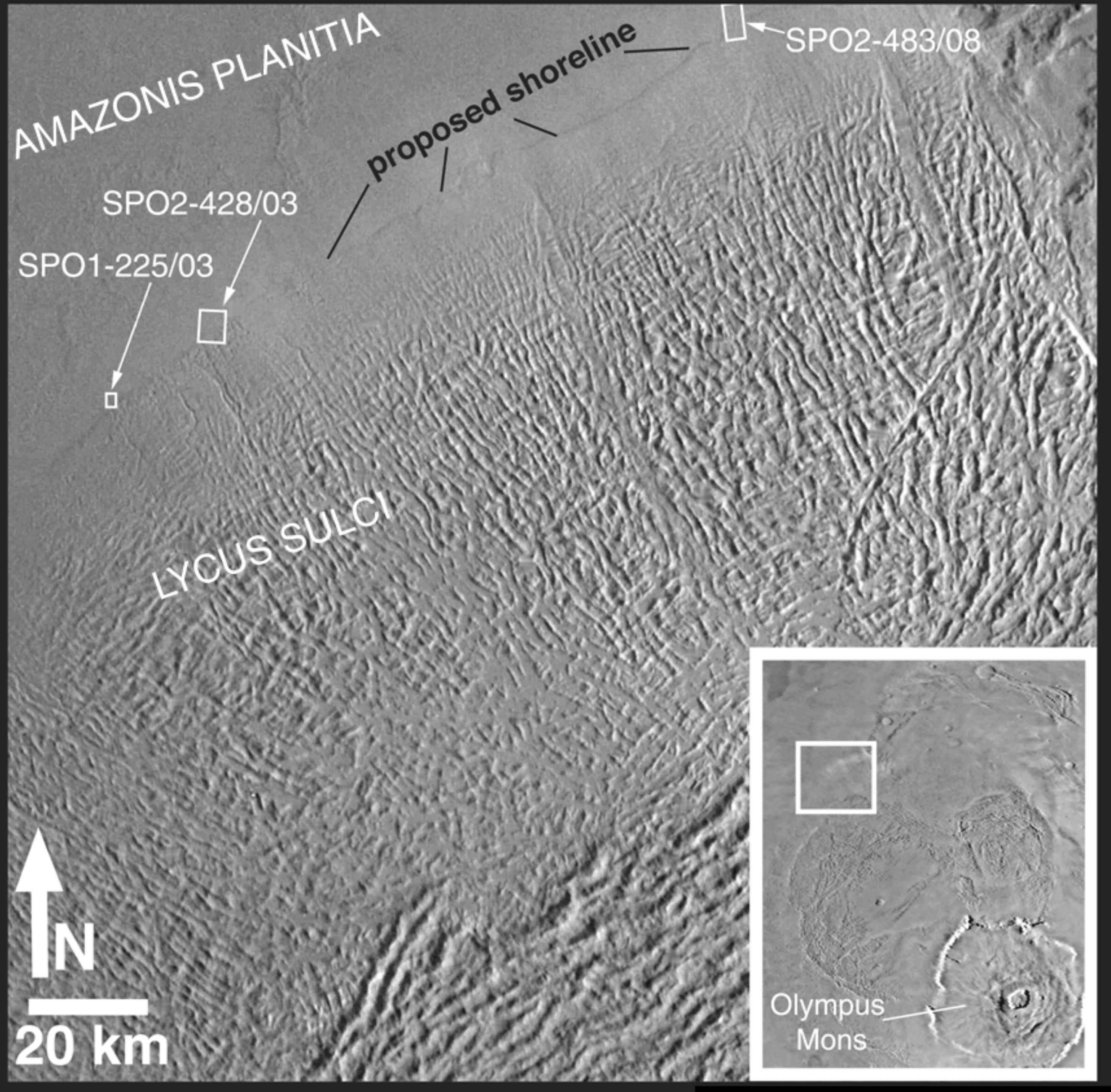
Channel Islands



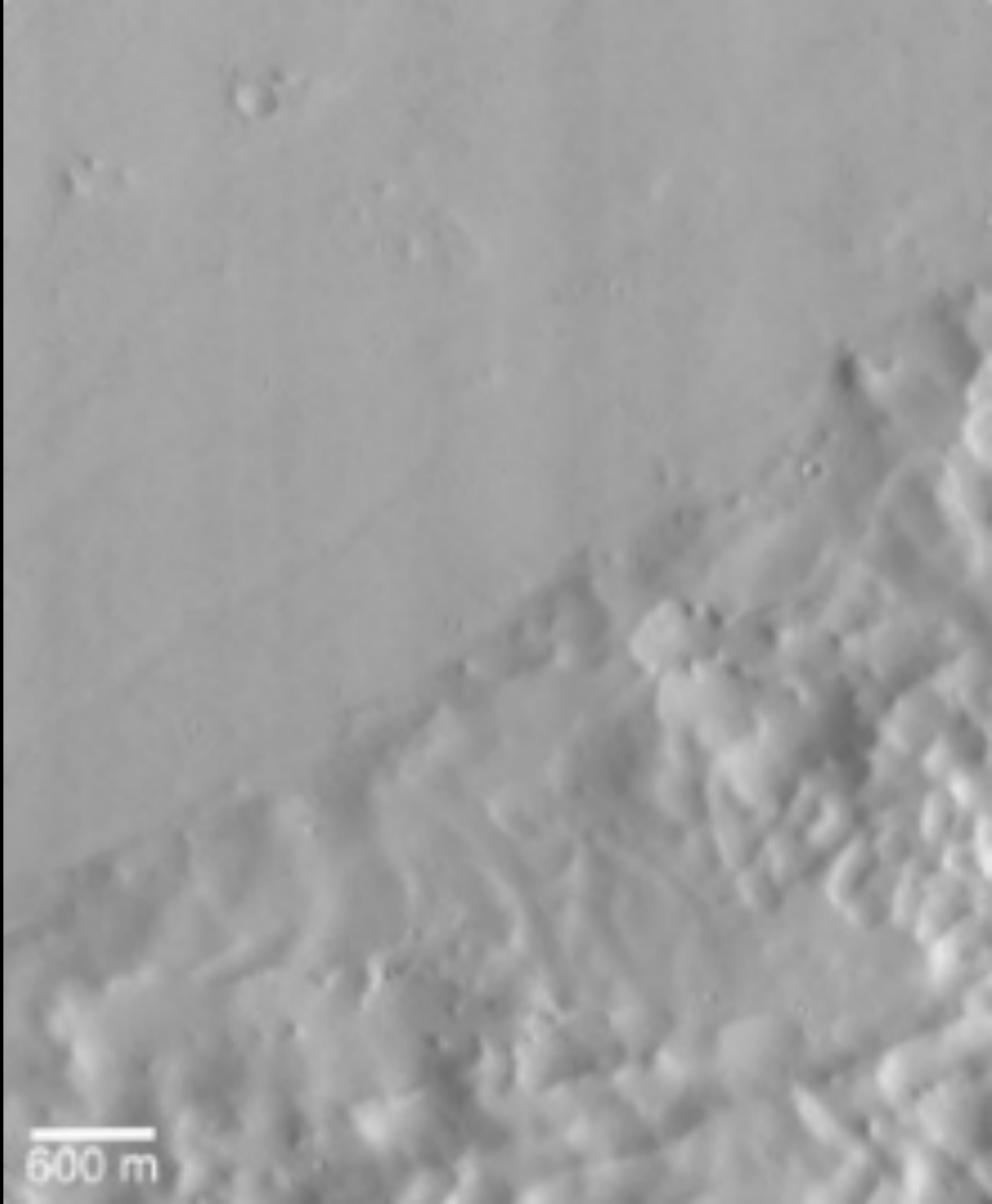
Erosion, Lobate Ejecta

River Channels

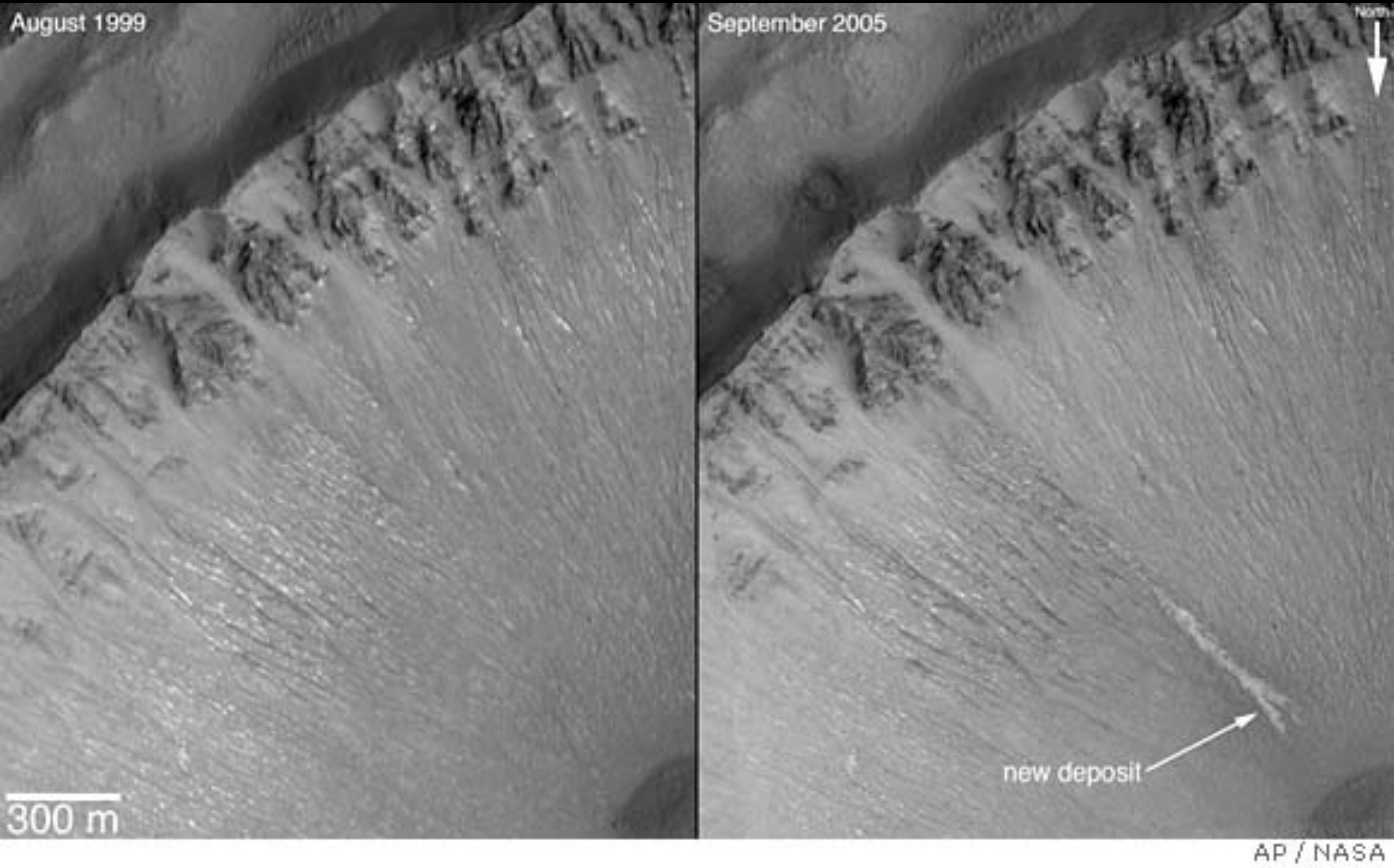
Ancient Martian Shoreline?



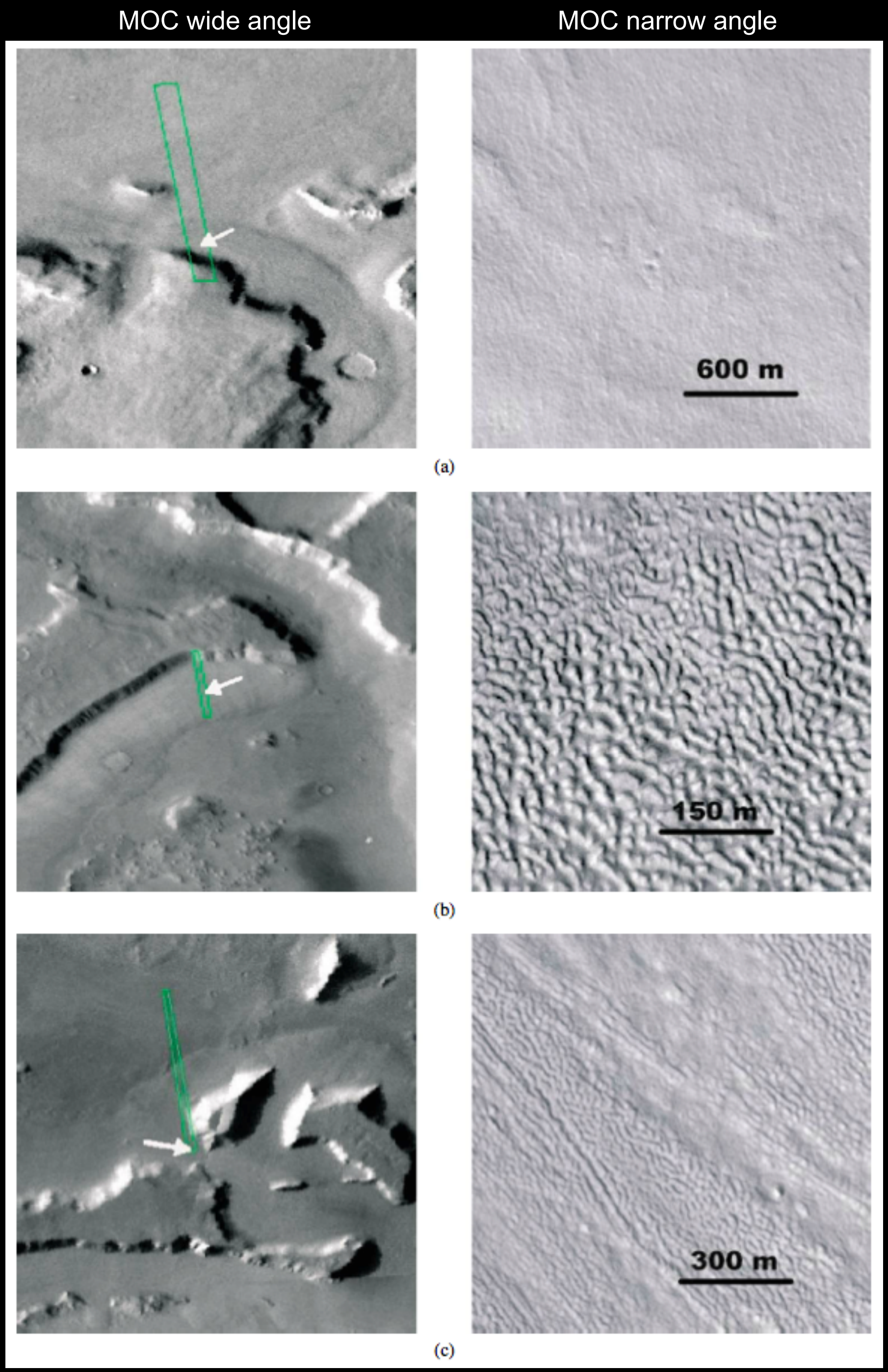
Shoreline? – Up Close and Personal



New Groundwater Flow?



Debris Aprons



(a) Smooth surface texture may represent original apron surface

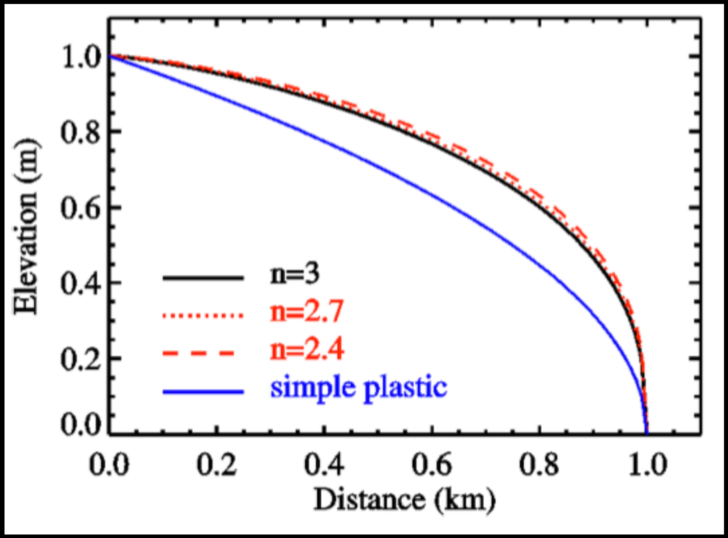
(b) Pitted surface texture may develop through ice sublimation induced collapse

(c) Ridged texture

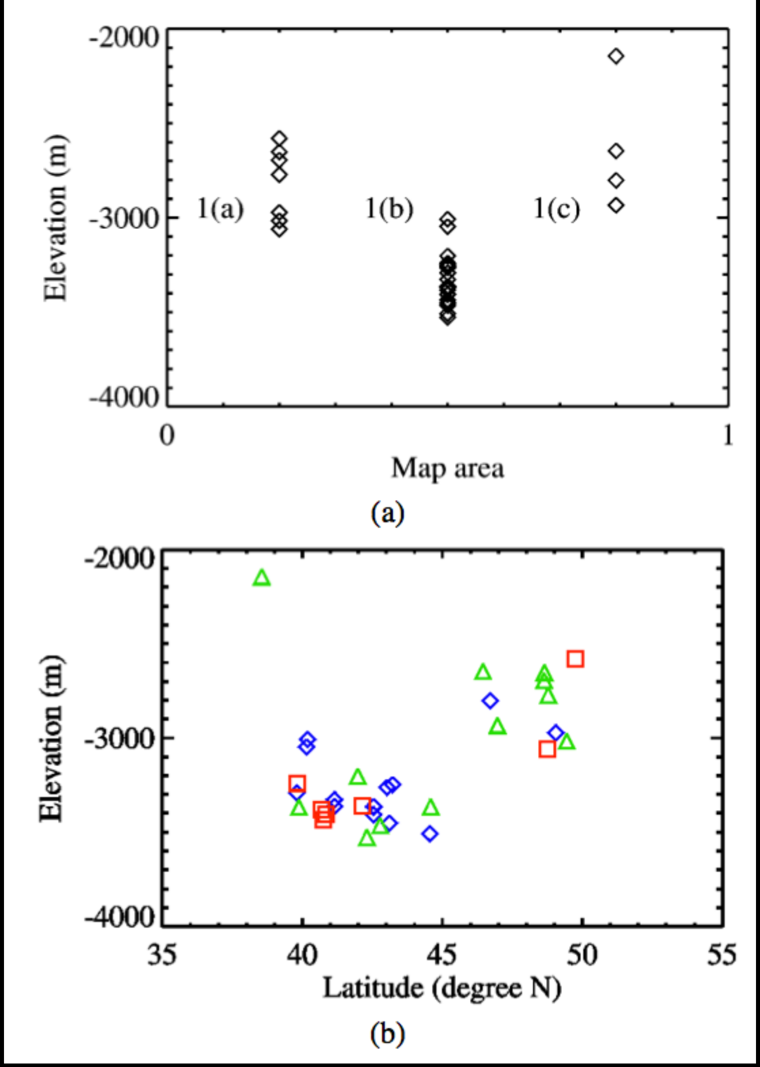
Li, Robinson, Jurdy (2005)

Debris Aprons

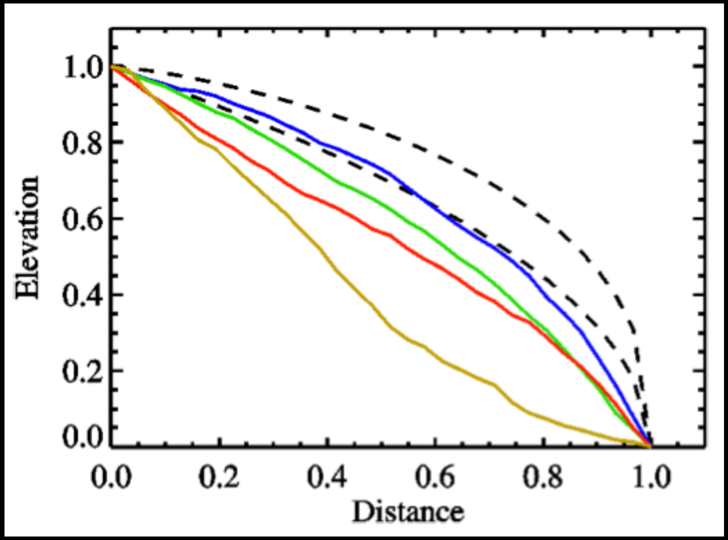
Li, Robinson, Jurdy (2005)



Above: Longitudinal profile predicted by viscous power law model when *n* varies within the range of 2.4 to 3.



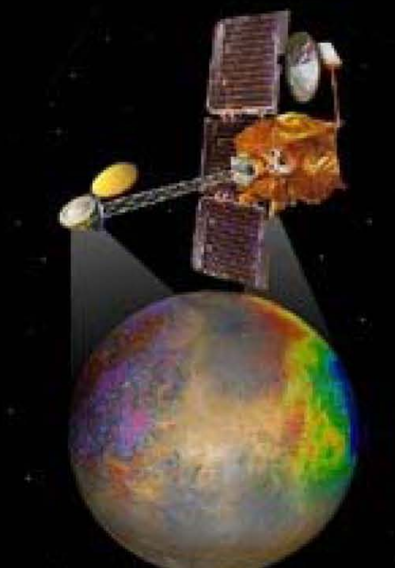
Above: Relationships between apron type and (a) elevation and (b) latitude (type I blue diamond shape, type II green triangle, type III red square).



Left: Composite profiles of three types of lobate debris aprons and Valles Marineris landslide, normalized to unit length and thickness.

Mars Global Surveyor (MGS)

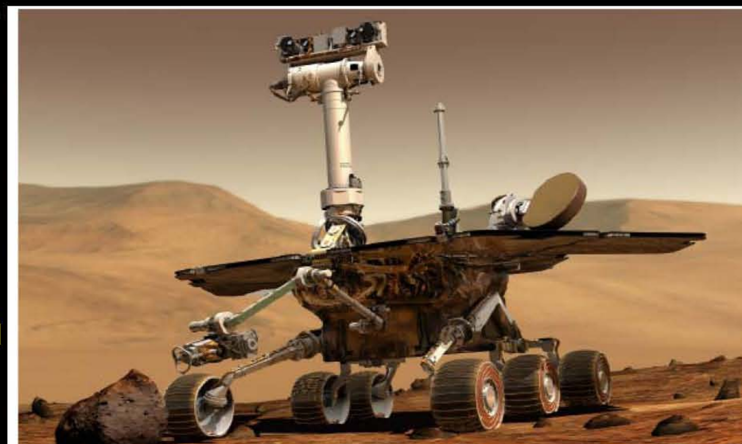
Mars Odyssey



Mars Reconnaissance Orbiter

Mars Express

Mars Exploration Rovers (MERs)

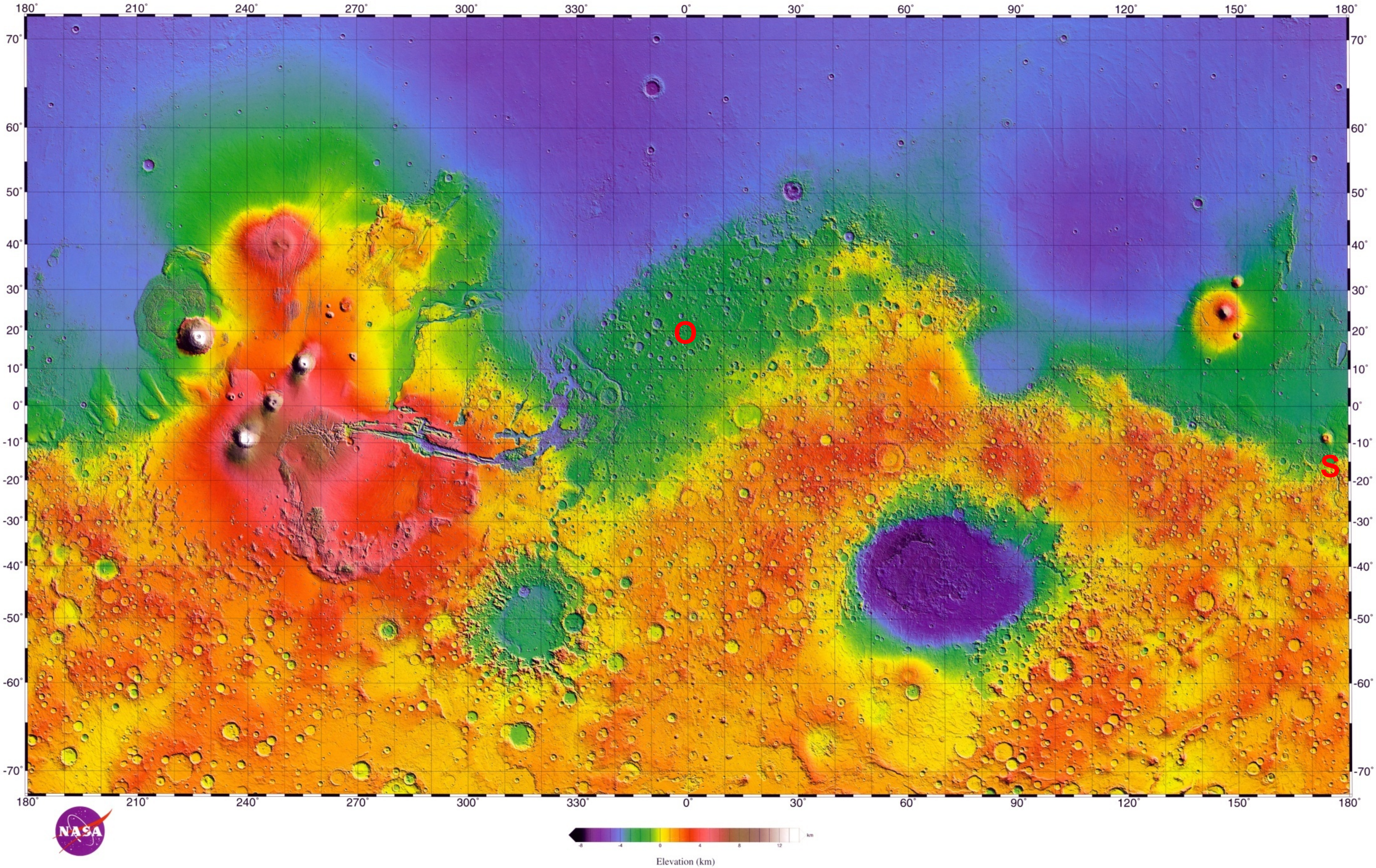


Artist's simulation of a Mars Exploration Rover at work on Mars.

Mars Global Surveyor Liftoff

November 7, 1996

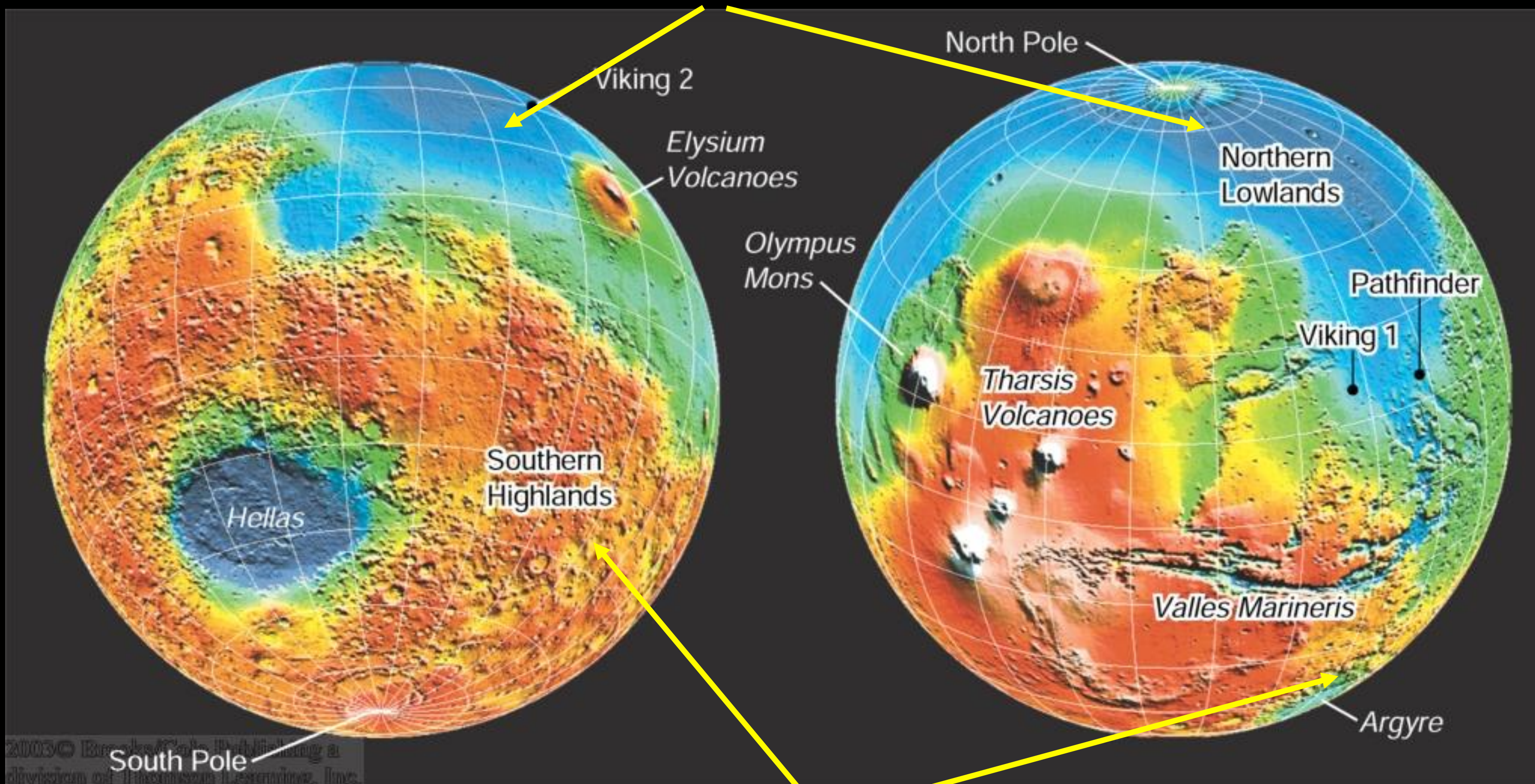
The Topography of Mars



The Geology of Mars

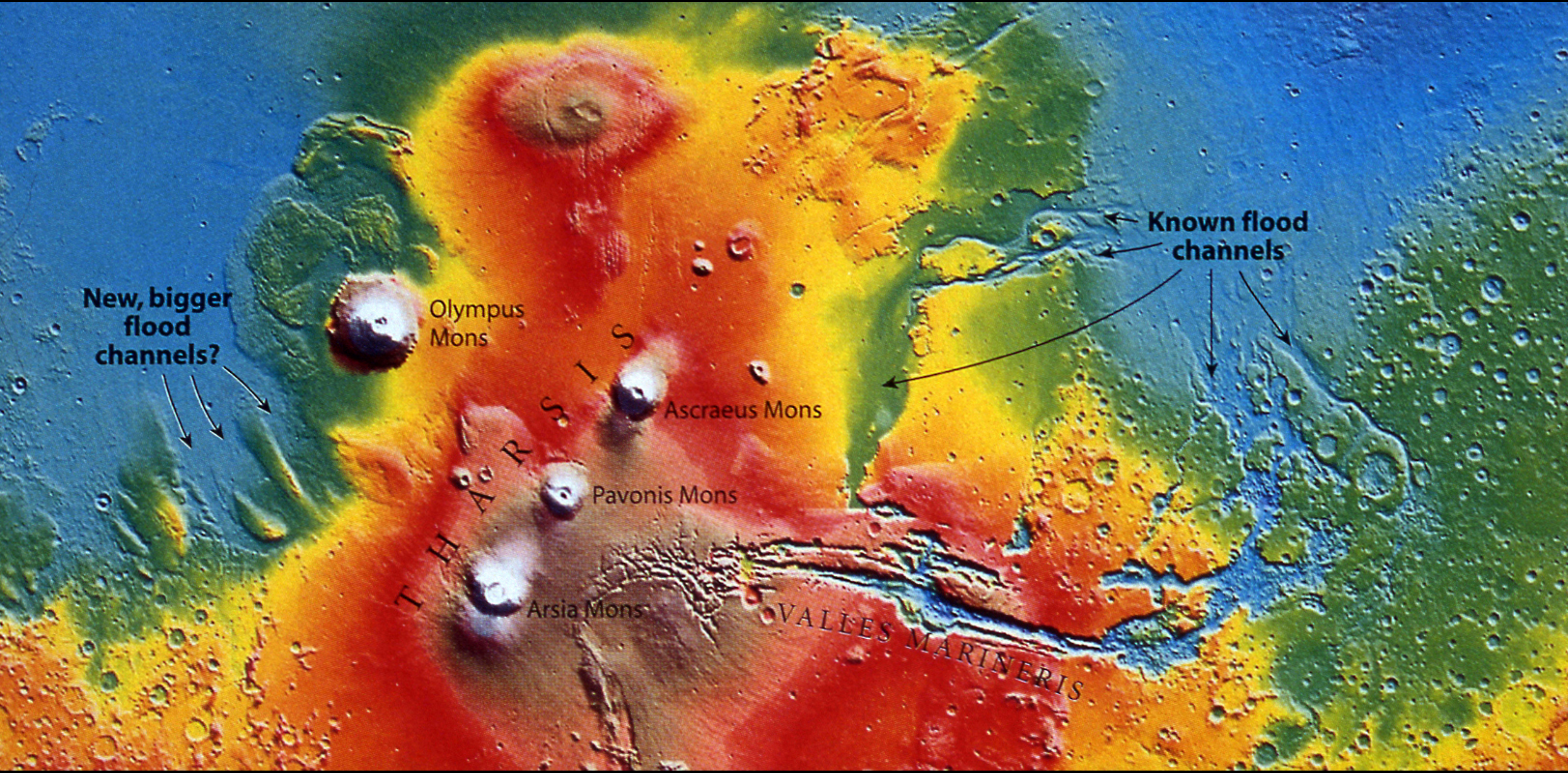
Northern Lowlands: Free of craters; probably re-surfaced a few billion years ago.

Possibly once filled with water.

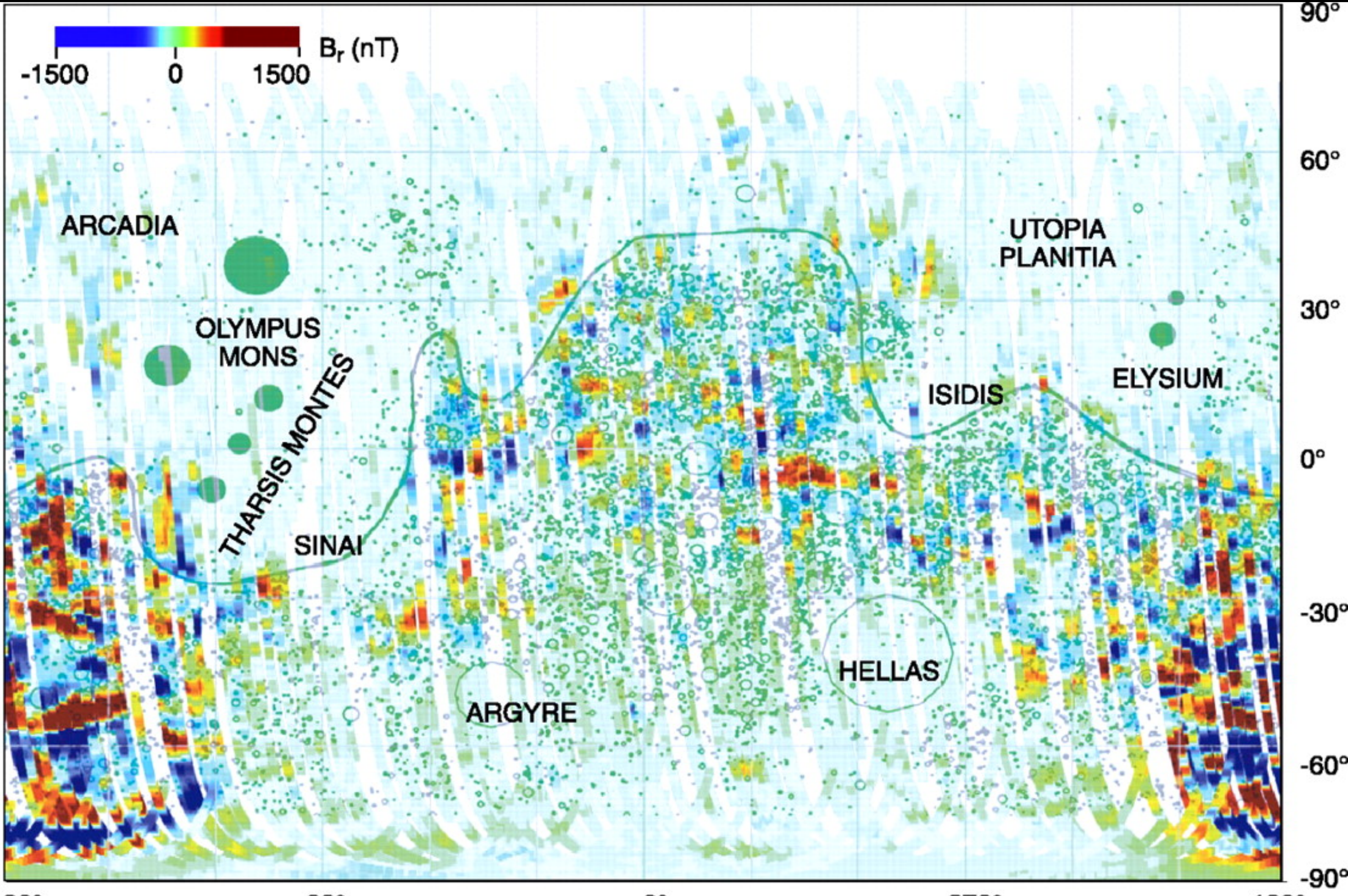


Southern Highlands: Heavily cratered; probably 2 – 3 billion years old.

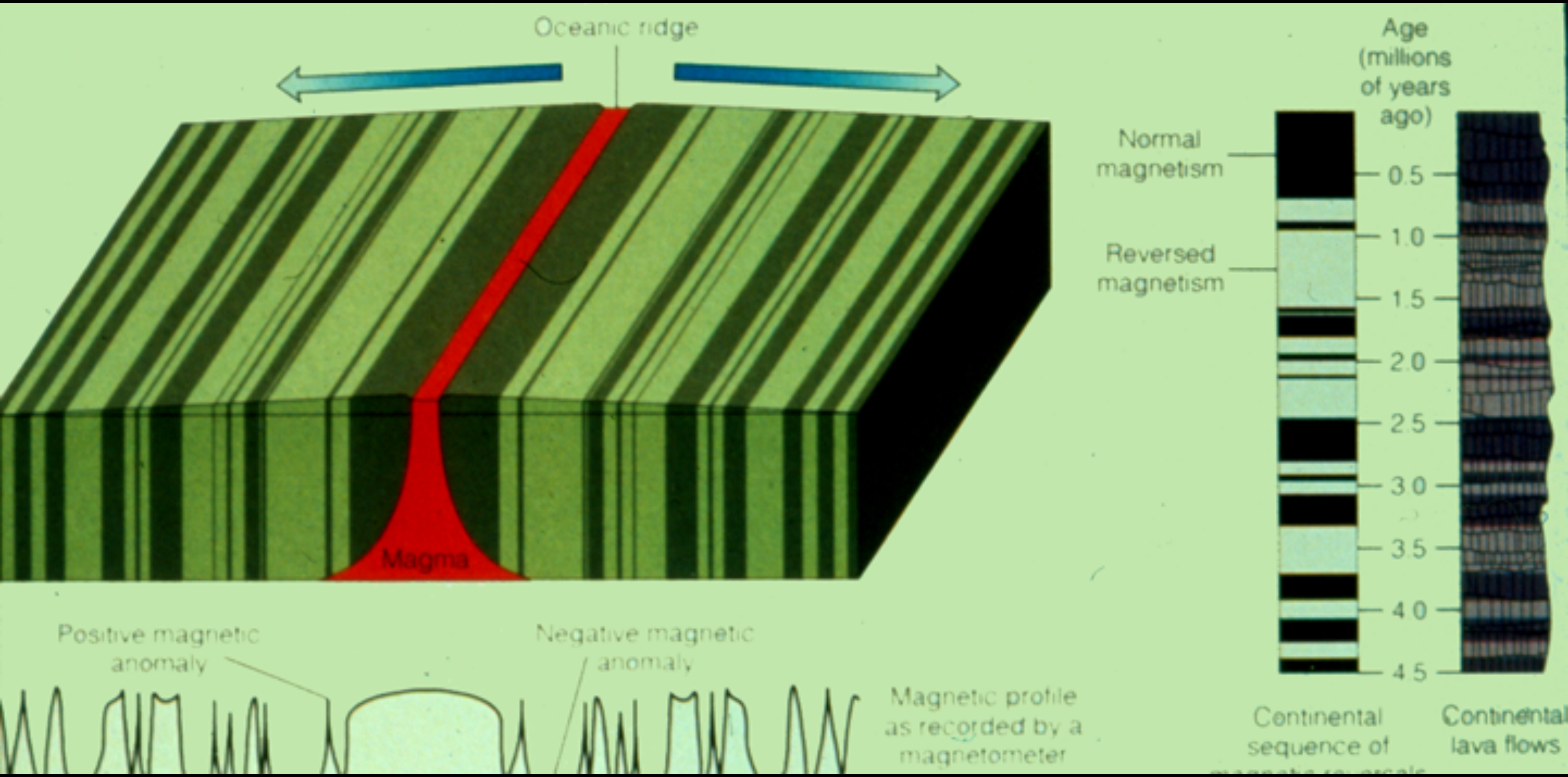
Tharsis Region Topography



Martian Magnetics



Generation of Magnetic Lineations

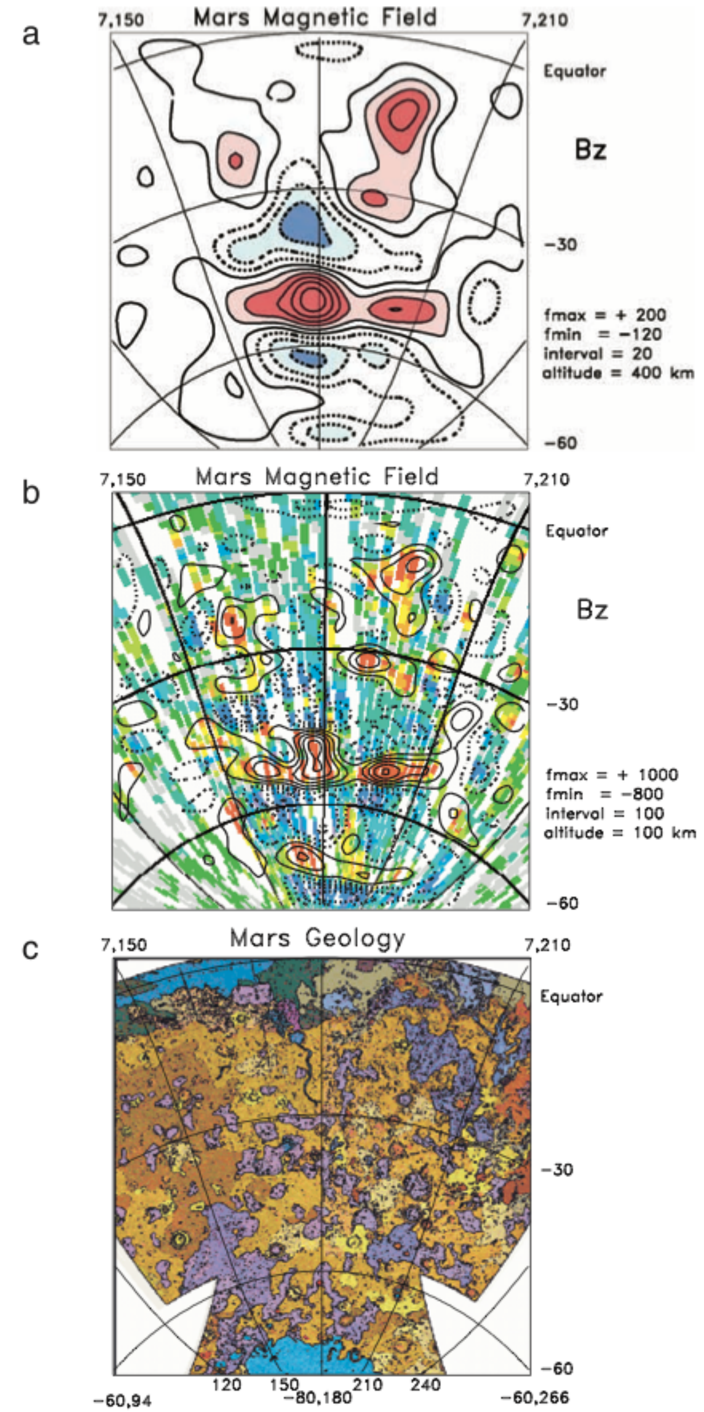


Magnetization of Mars

Figure:
(a) The vertical component of the magnetic field B_z as measured at 400 km.

(b) The vertical component of the magnetic field B_z extrapolated downward from 400 to 100 km using a Fourier transform. The result agrees very well with aerobraking data obtained at 100 km (shown in color) and fills in data gaps. Aerobraking data: red, strongly positive; blue, strongly negative.

(c) Geology of Mars' highland terrain.



Jurdy and Stefanick (2004)

Magnetization of Mars

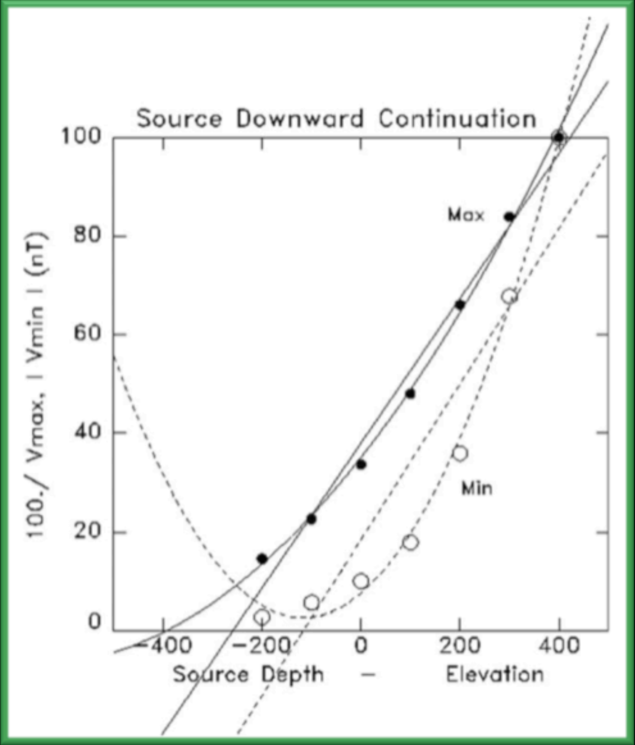


Figure: Reciprocals of maximums and minimums of sources in model shown as a function of altitude and depth of extrapolation. Linear and parabolic fits are made for maximums of the positives (solid circles) and for minimums of the negatives (open circles).

Jurdy and Stefanick (2009)

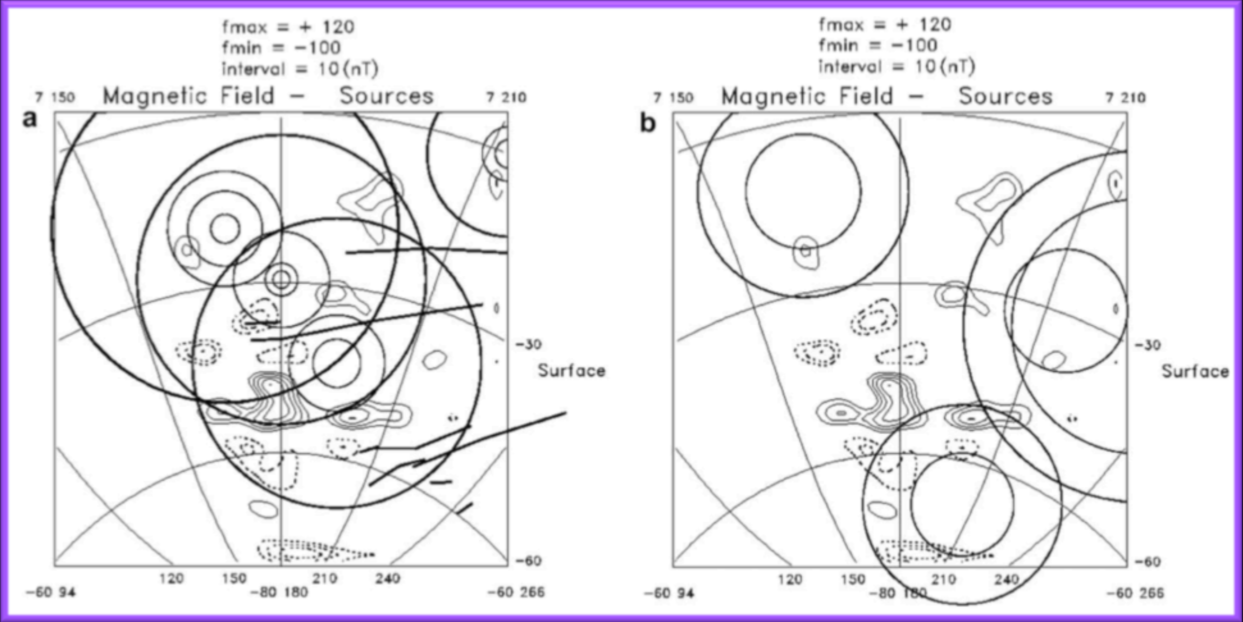
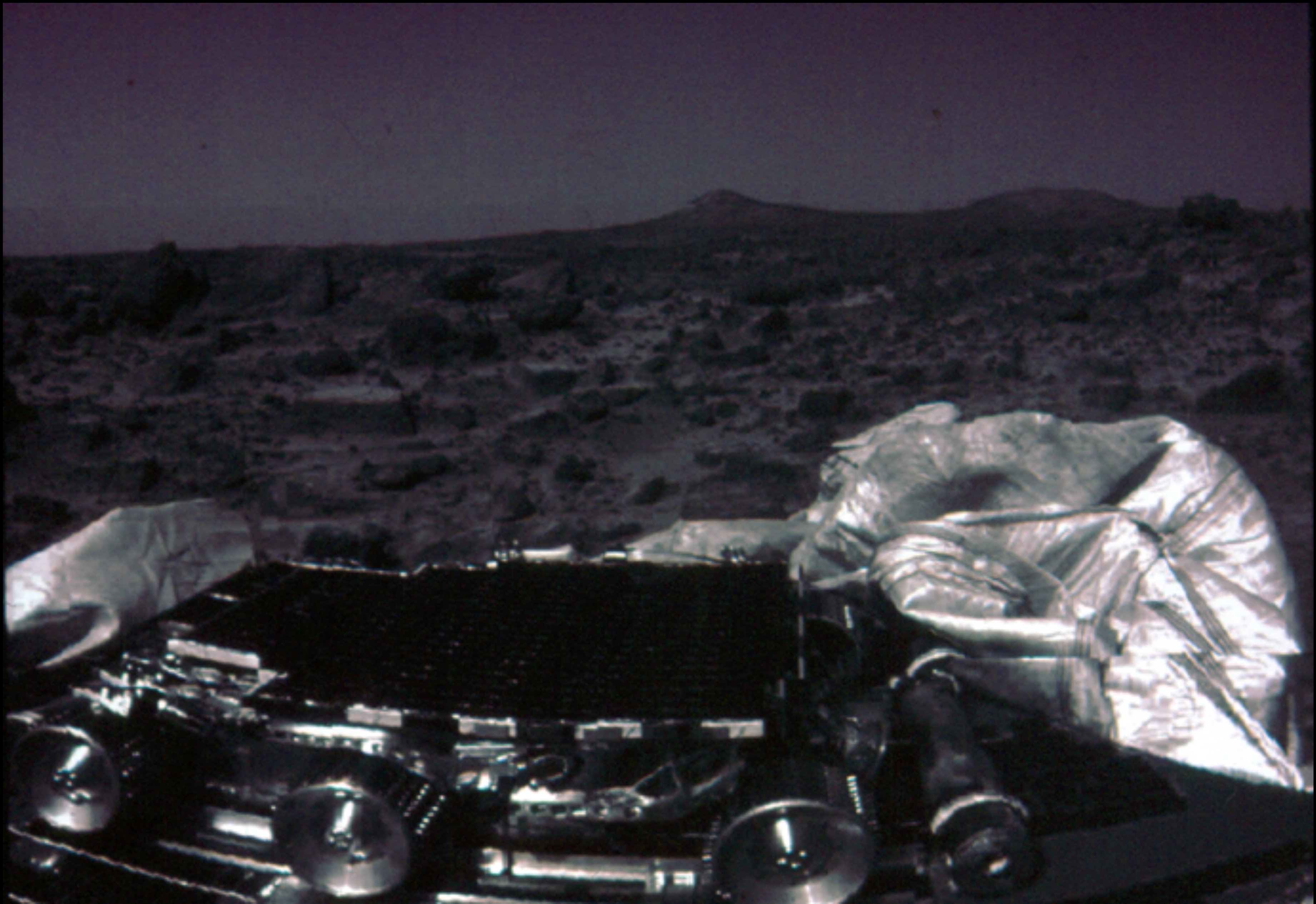


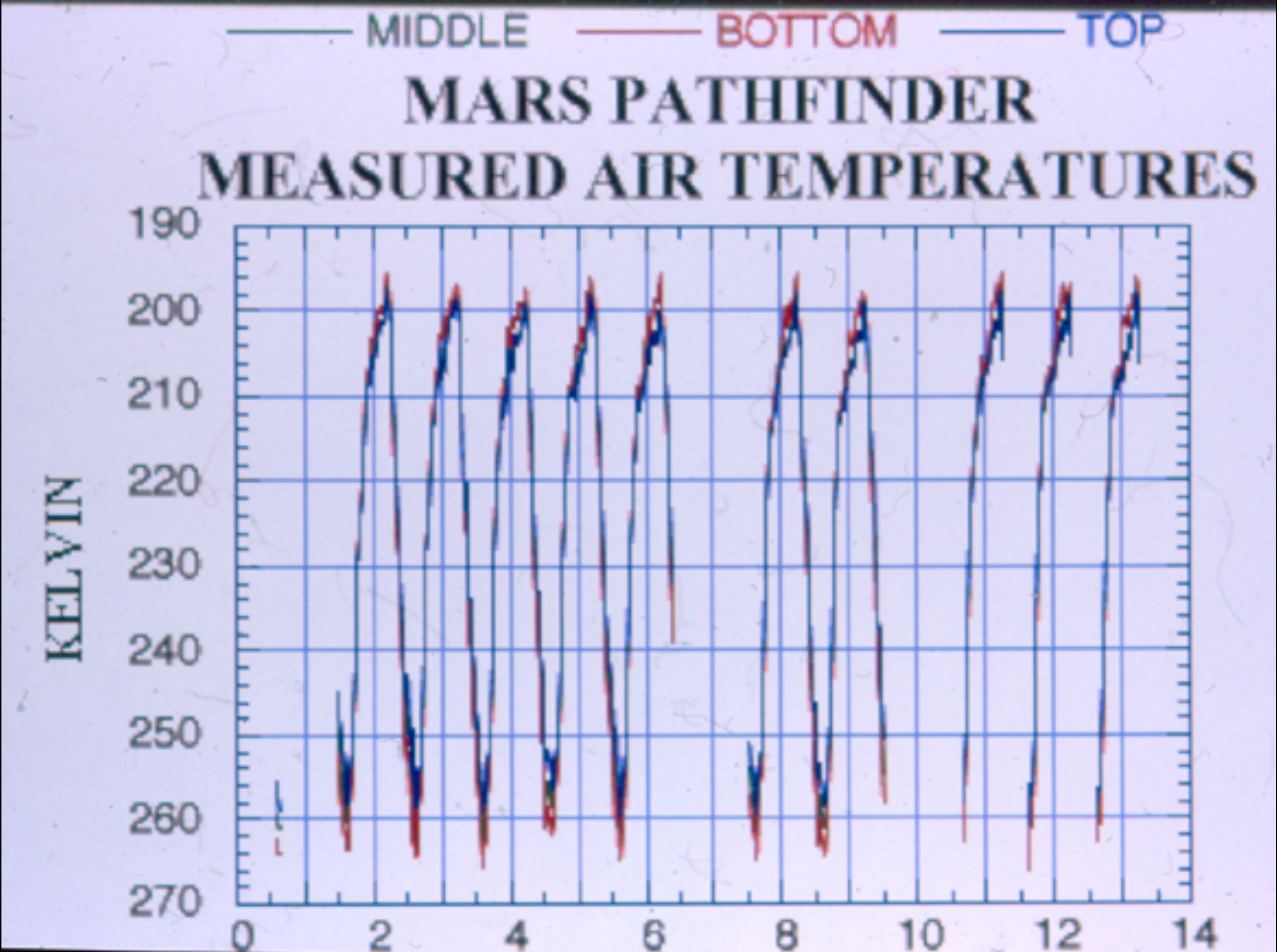
Figure: (a) Sources for magnetic field vertical component at Mars' surface. (b) Craters based on MOLA topography.

Jurdy and Stefanick (2009)

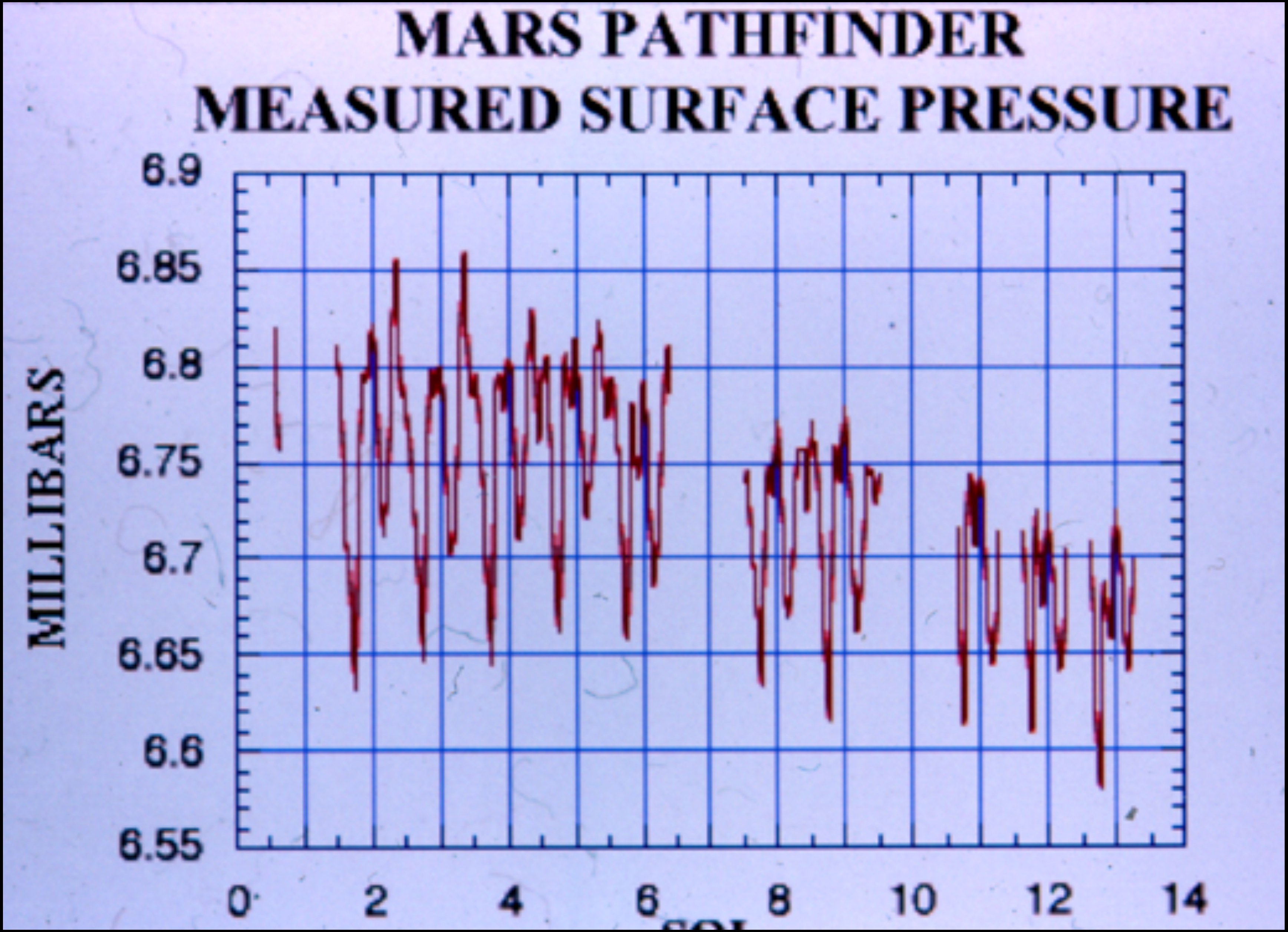
Pathfinder Landing Site (July 4, 1977)

Pathfinder/Sojourner



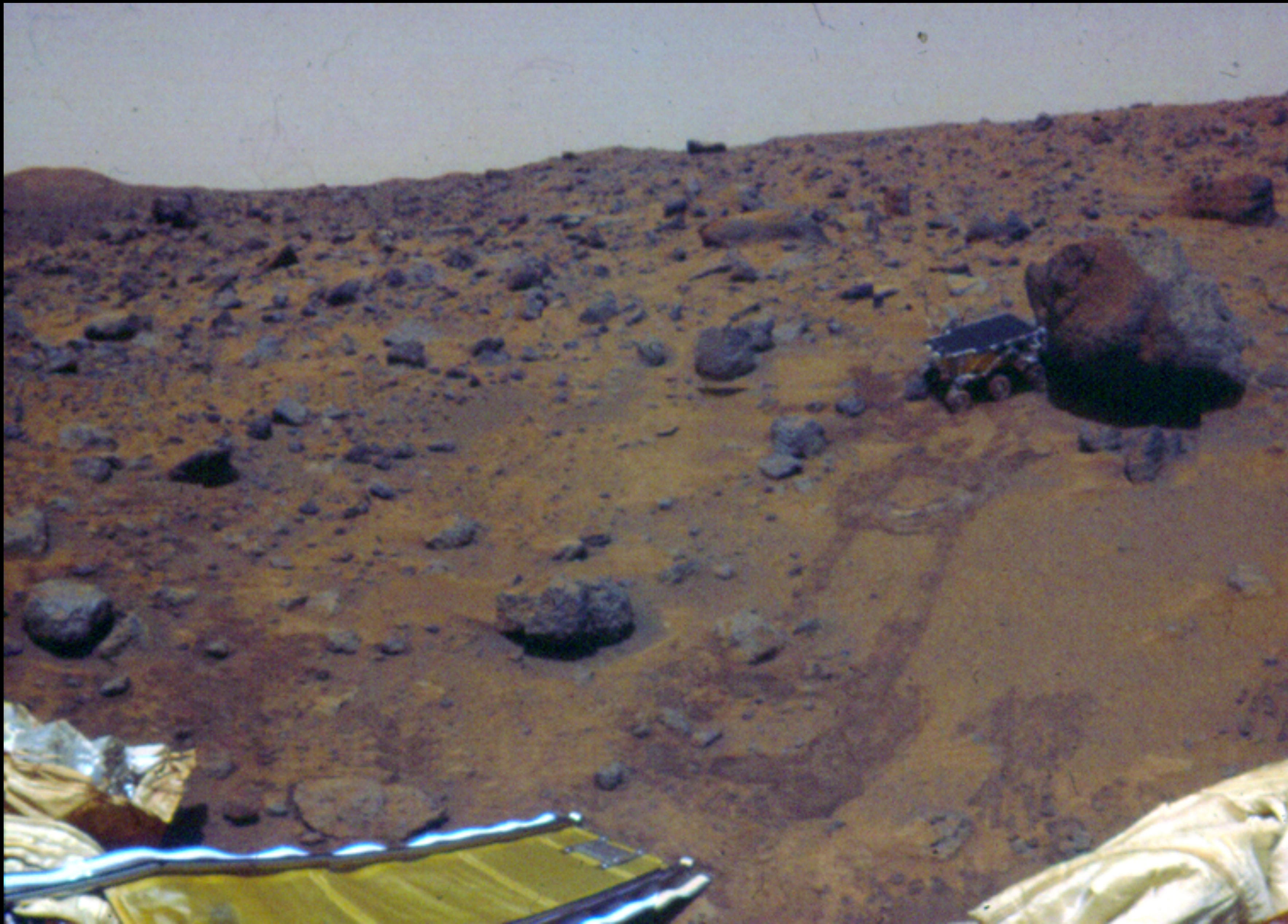


MIDDLE
BOTTOM
TOP
MARS PATHFINDER
MEASURED AIR TEMPERATURES
KELVIN
190
200
210
220
230
240
250
260
270
0
2
4
6
8
10
12
14

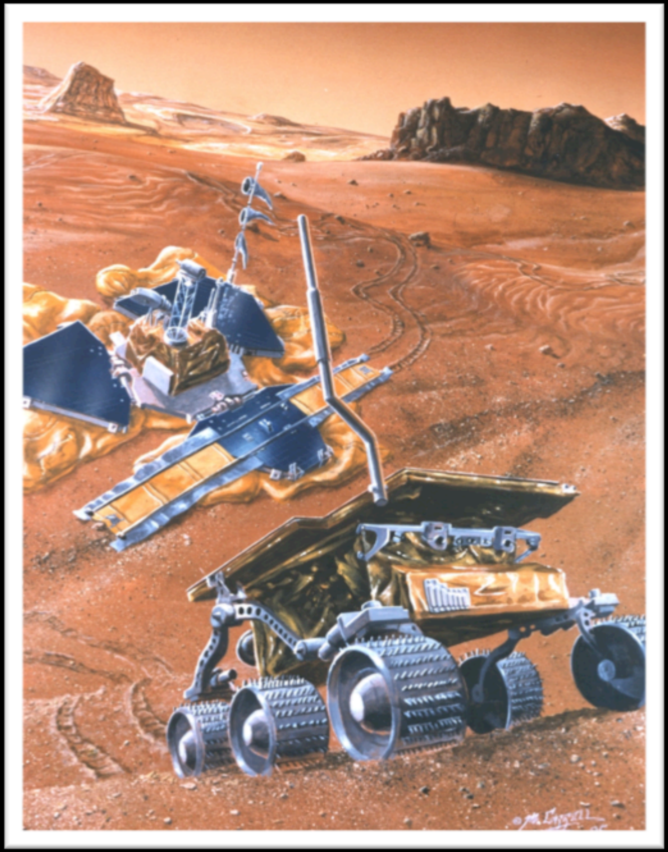

MARS PATHFINDER
MEASURED SURFACE PRESSURE
MILLIBARS
6.9
6.85
6.8
6.75
6.7
6.65
6.6
6.55
0
2
4
6
8
10
12
14

Sojourner

Sojourner at Yogi

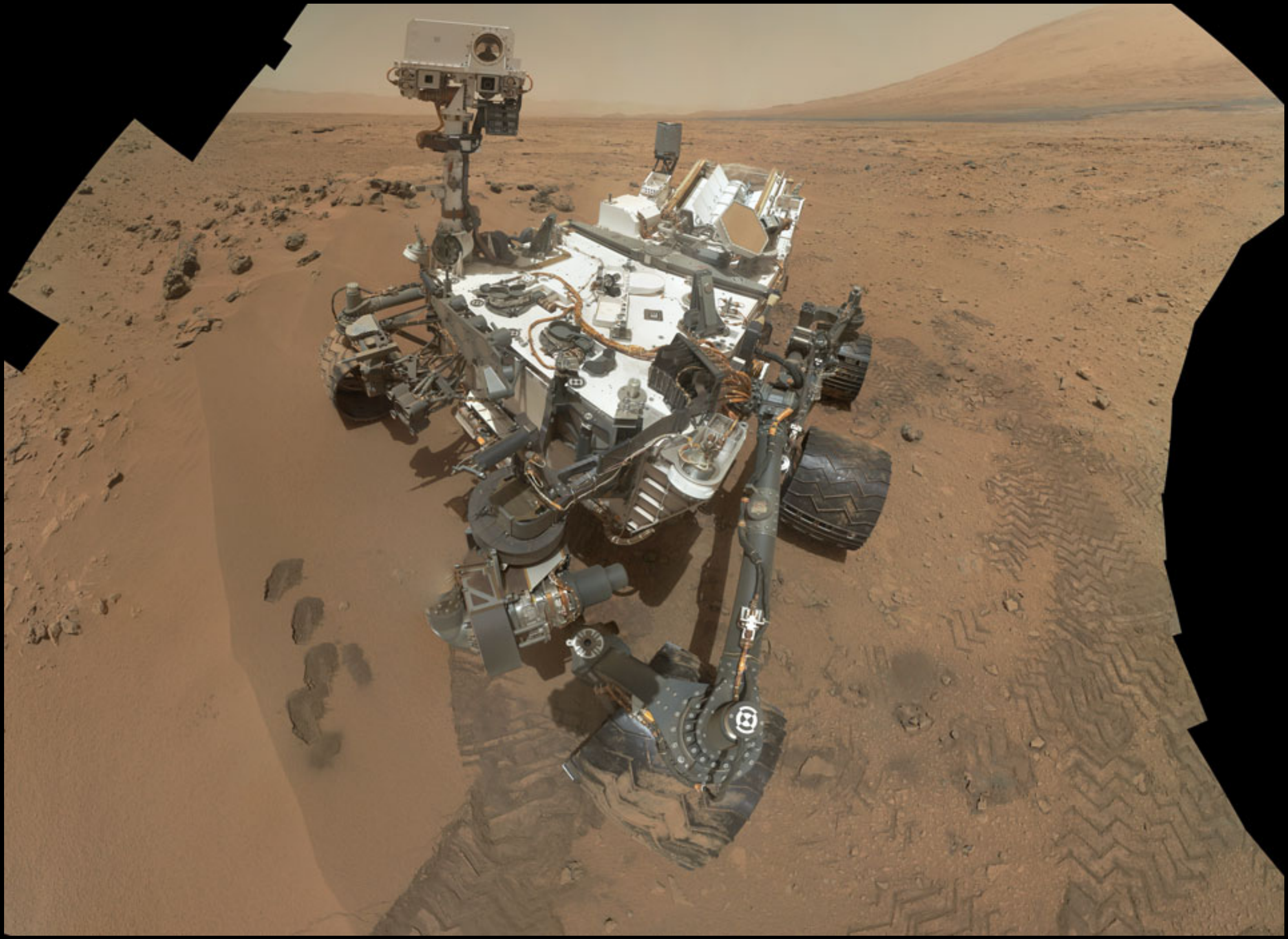


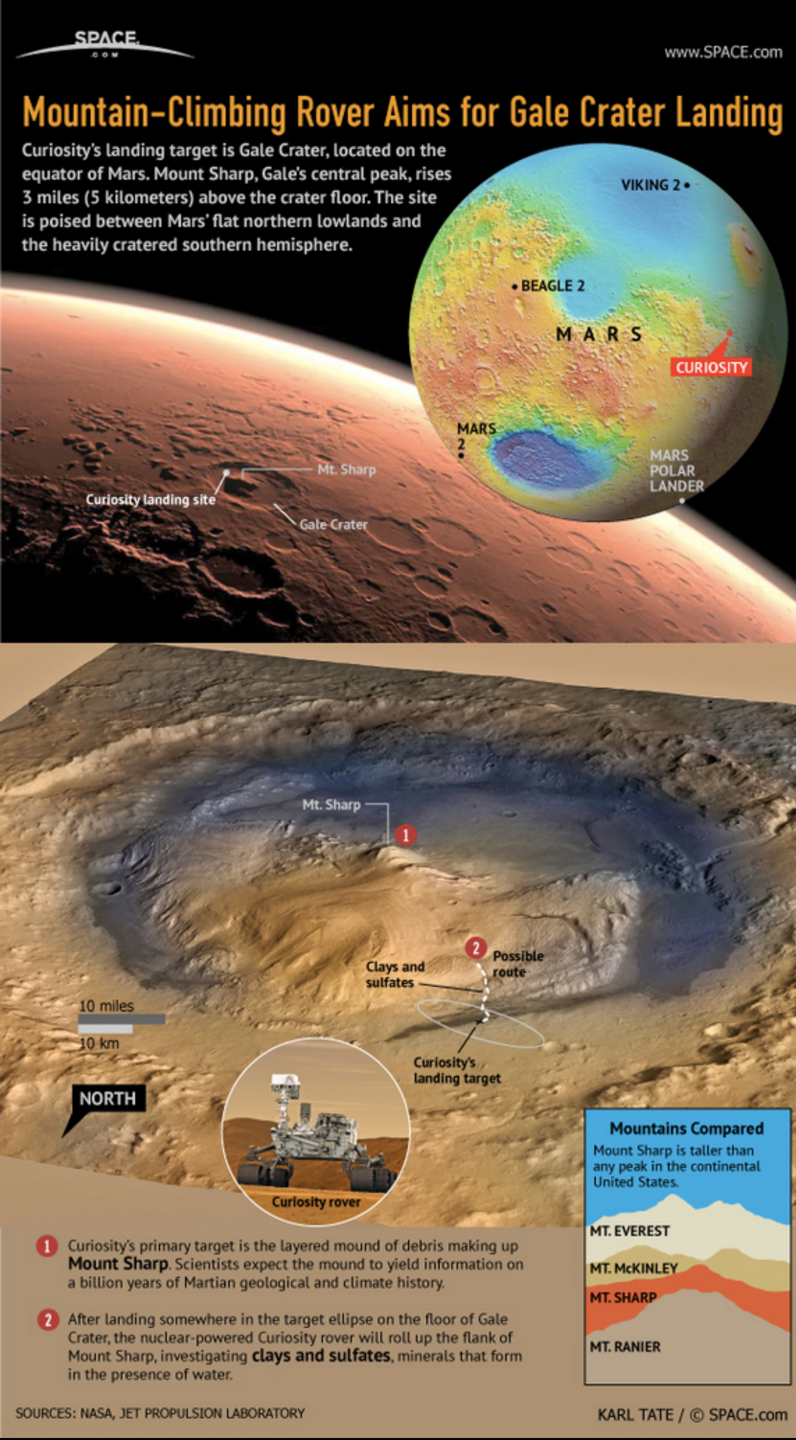
Pathfinder results



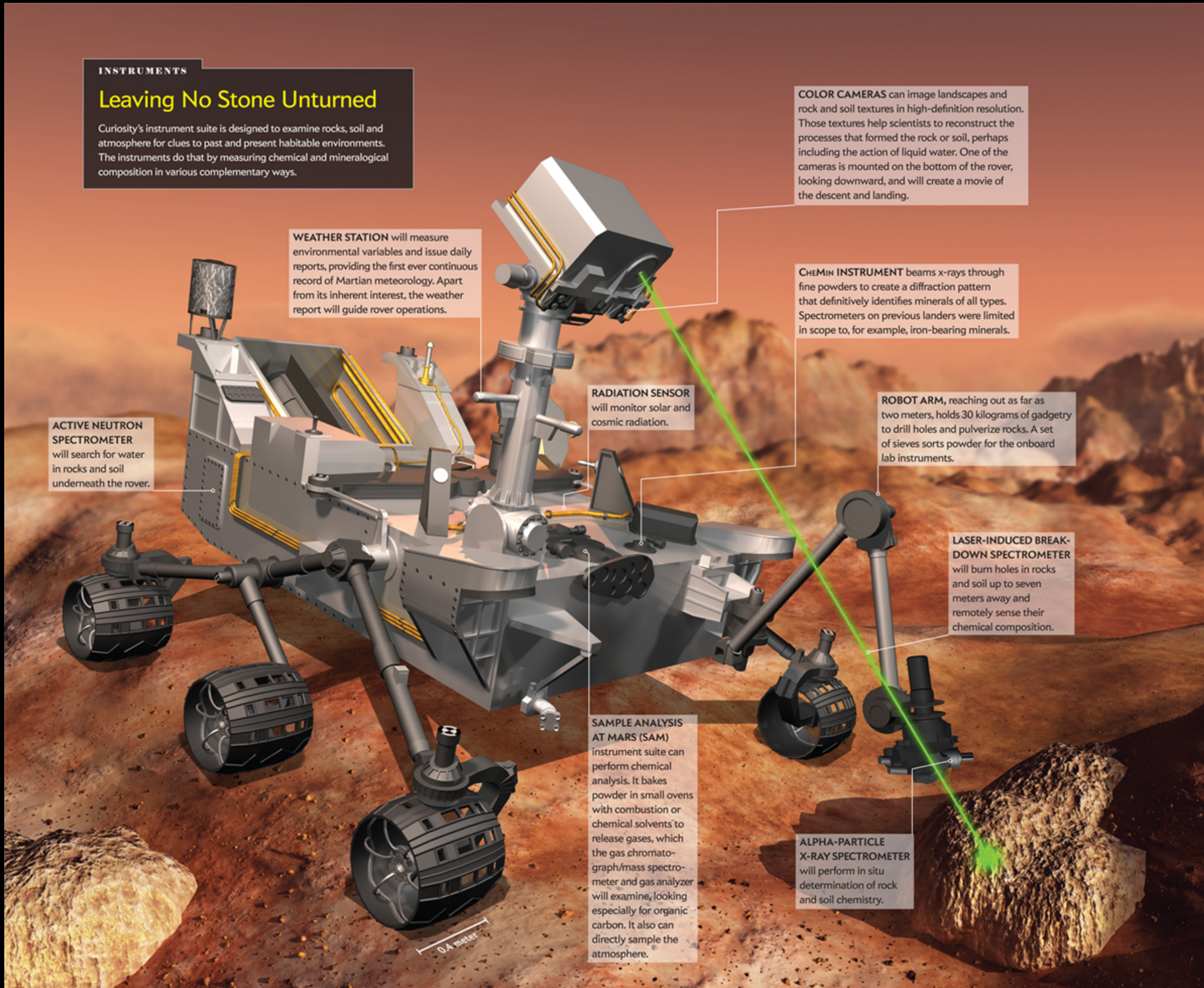
- Most rocks analyzed are basalt
- One is slightly more rich in silica
  - Could indicate tectonic activity?
  - Or could be a weathering effect

Curiosity

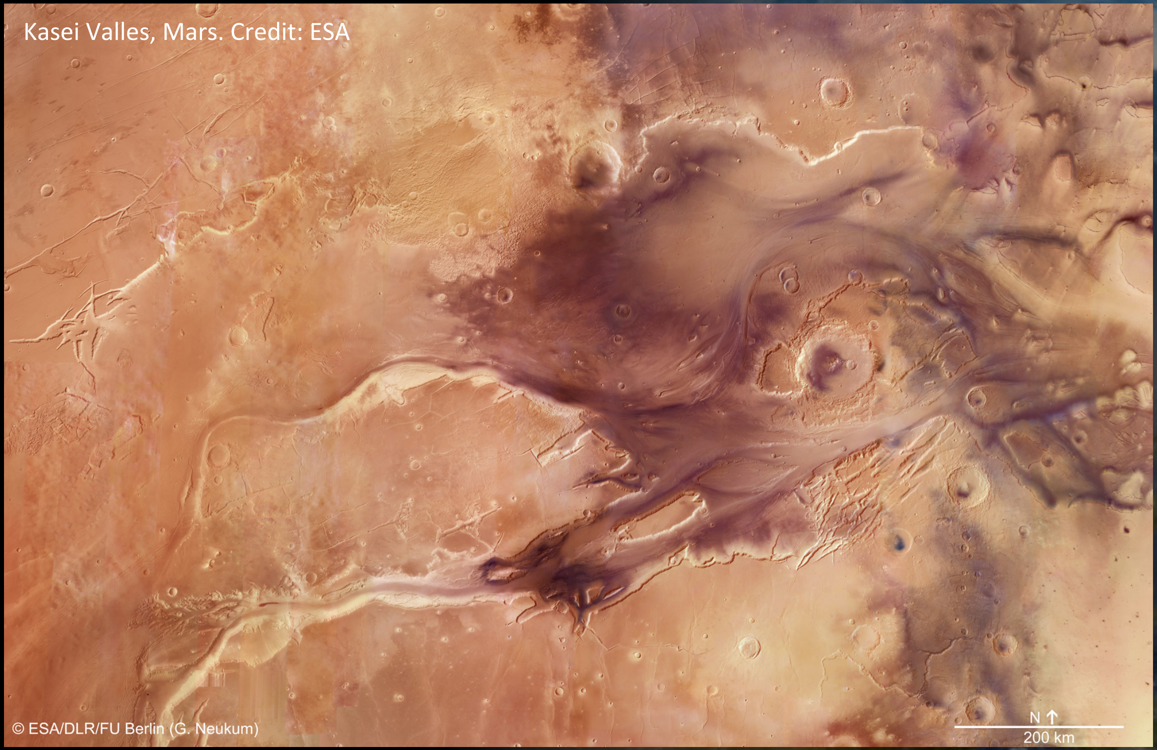




Curiosity Landing Site

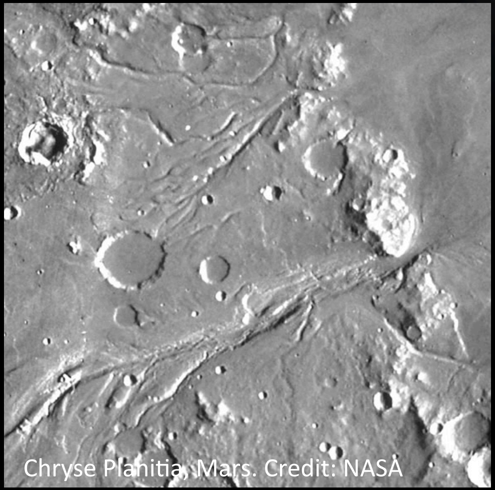

INSTRUMENTS
Leaving No Stone Unturned
Curiosity's instrument suite is designed to examine rocks, soil and atmosphere for clues to past and present habitable environments. The instruments do that by measuring chemical and mineralogical composition in various complementary ways.
COLOR CAMERAS can image landscapes and rock and soil textures in high-definition resolution. Those textures help scientists to reconstruct the processes that formed the rock or soil, perhaps including the action of liquid water. One of the cameras is mounted on the bottom of the rover, looking downward, and will create a movie of the descent and landing.
WEATHER STATION will measure environmental variables and issue daily reports, providing the first ever continuous record of Martian meteorology. Apart from its inherent interest, the weather report will guide rover operations.
CheMin INSTRUMENT beams x-rays through fine powders to create a diffraction pattern that definitively identifies minerals of all types. Spectrometers on previous landers were limited in scope to, for example, iron-bearing minerals.
RADIATION SENSOR will monitor solar and cosmic radiation.
ROBOT ARM, reaching out as far as two meters, holds 30 kilograms of gadgetry to drill holes and pulverize rocks. A set of sieves sorts powder for the onboard lab instruments.
ACTIVE NEUTRON SPECTROMETER will search for water in rocks and soil underneath the rover.
LASER-INDUCED BREAK-DOWN SPECTROMETER will burn holes in rocks and soil up to seven meters away and remotely sense their chemical composition.
SAMPLE ANALYSIS AT MARS (SAM) instrument suite can perform chemical analysis. It bakes powder in small ovens with combustion or chemical solvents to release gases, which the gas chromatograph/mass spectrometer and gas analyzer will examine, looking especially for organic carbon. It also can directly sample the atmosphere.
ALPHA-PARTICLE X-RAY SPECTROMETER will perform in situ determination of rock and soil chemistry.
0.4 meter

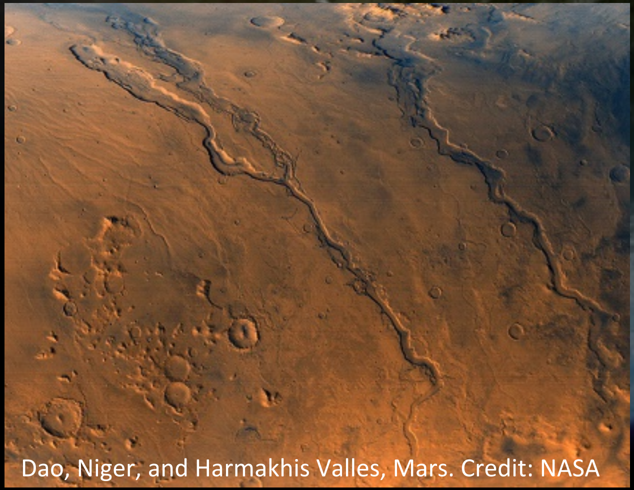
Flooding on Mars



Kasei Valles, Mars. Credit: ESA


Channel southwest of Cerberus Fossae, Mars.
Credit: NASA/JPL/MSSS

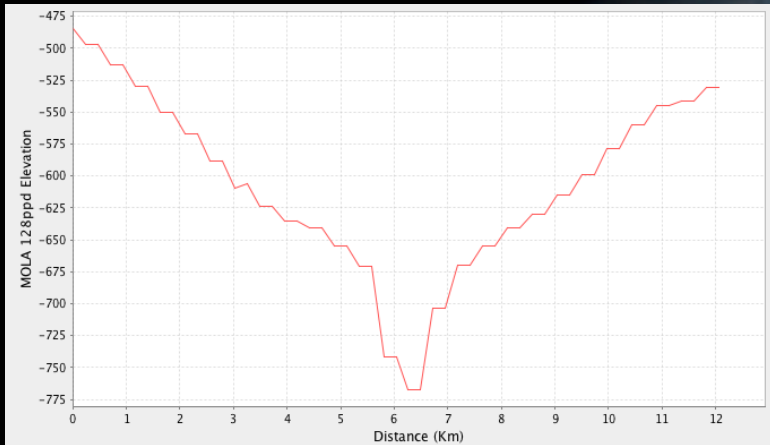

Chryse Planitia, Mars. Credit: NASA


Dao, Niger, and Harmakhis Valles, Mars. Credit: NASA

Mariner 9 and Viking orbiter were the first missions to observe Mars' gigantic flood channels.

Mars' largest flood channels are enormous in size, with widths up to several tens of kilometers, lengths of hundreds of kilometers, and depths of over a thousand meters.

Eberswalde Crater



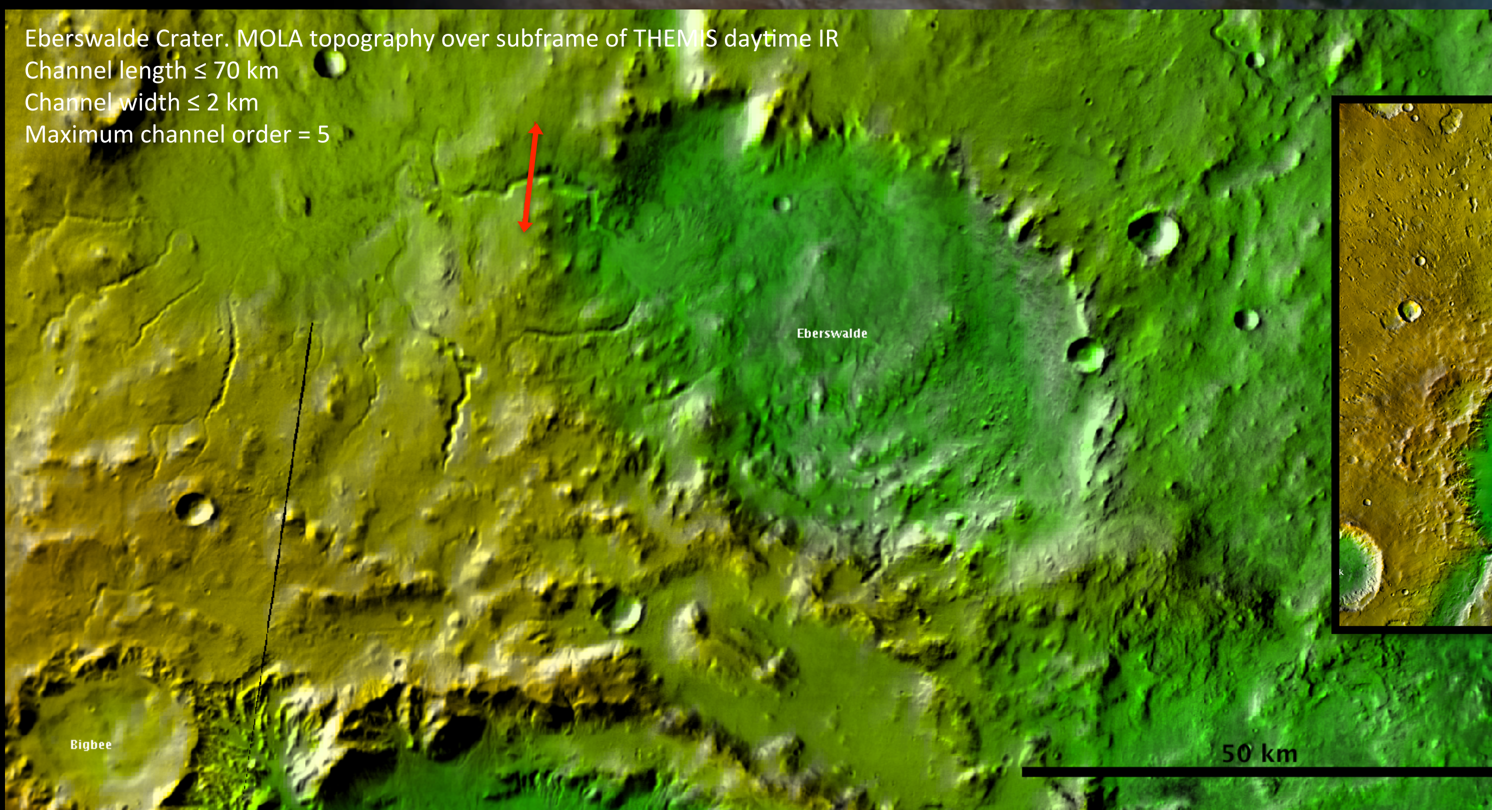
Located at 24.3°S, 33.5°W

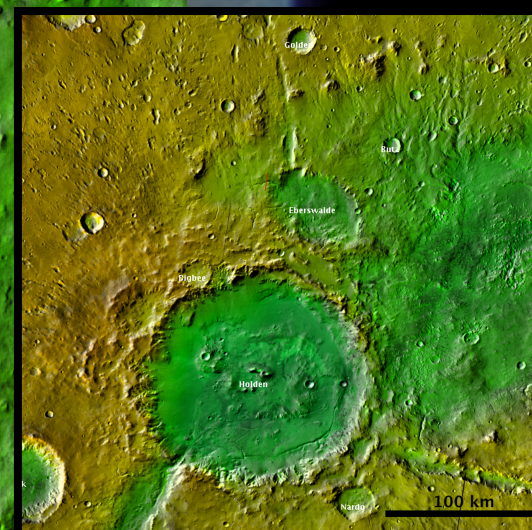
Located 50 km north of the 150 km diameter crater Holden

Evidence of an ancient network of multi-order tributaries that feed a fan deposit in the northwest margin of the crater. This fan is usually interpreted as a delta formed in a standing body of water over a period of a few years to > 100,000 years.

Stratigraphic relationship between Holden crater ejecta and Eberswalde's fluvial valleys and depositional fans shows that Holden formed before fluvial activity in Eberswalde.

Suggested that the Holden impact event triggered flooding by local heating of pre-existing ground ice possibly in combination with climatic triggers.



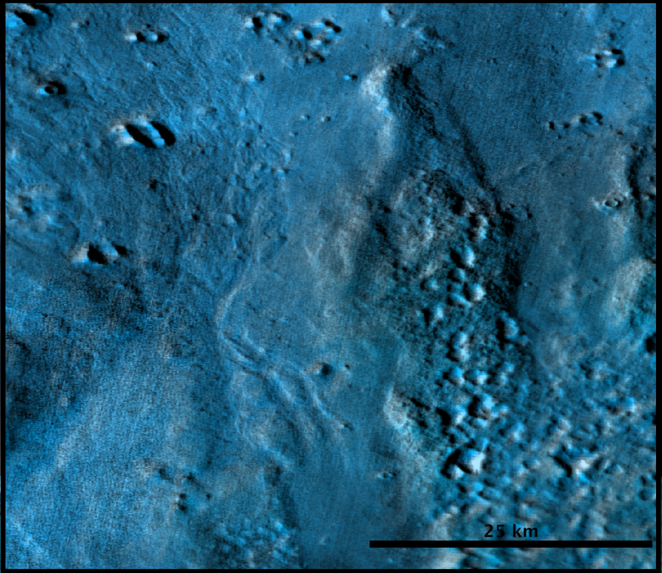


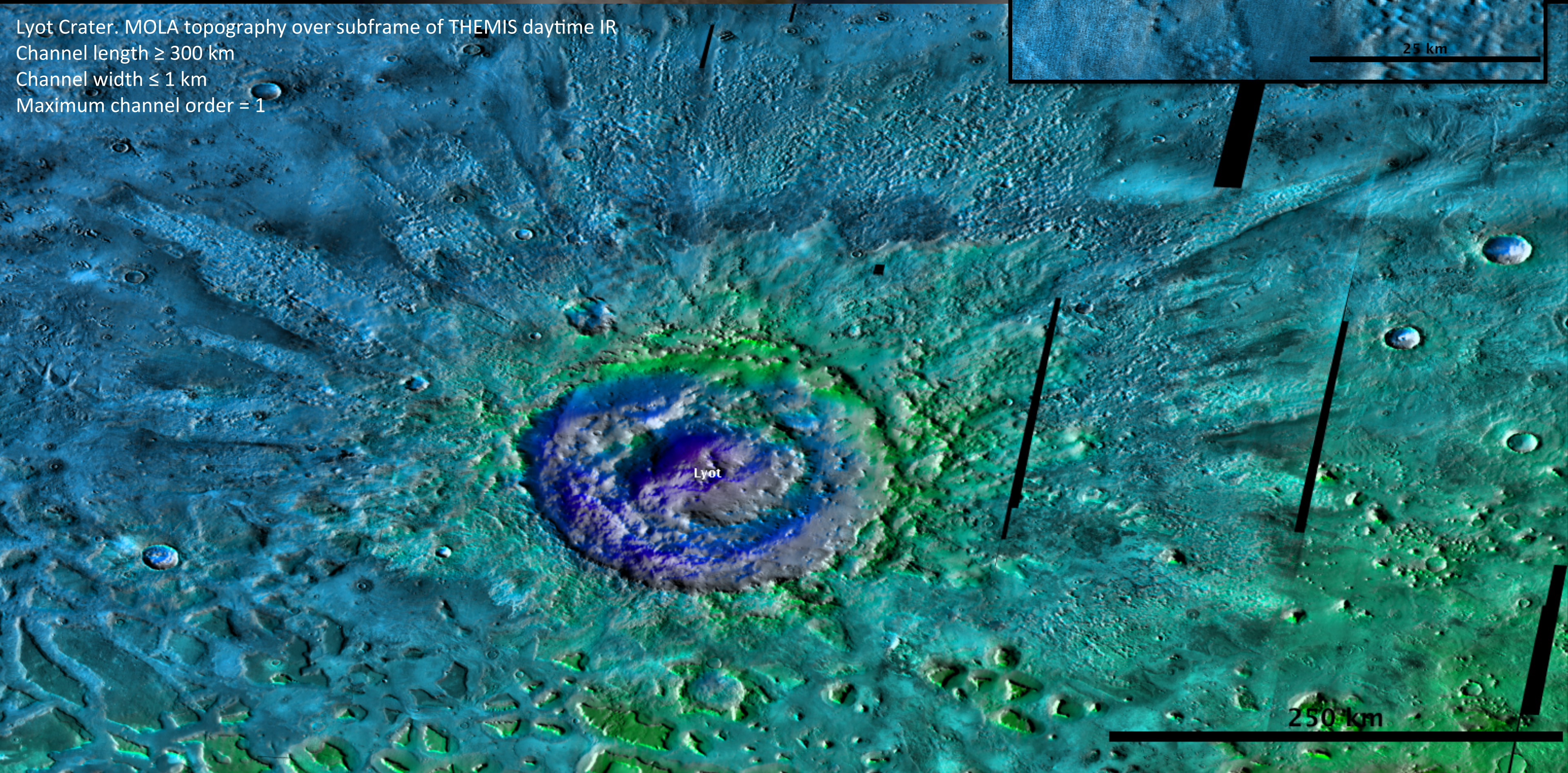
Lyot Crater

Located at 50.7°N, 29.2°E

To the north, west, and east of Lyot is an extensive channelized scabland region, including braided reaches and large areas of scour.

Channels cover about 300,000 km^2 and are attributed to carving by sediment-laden water from the target substrate and/or nearby terrain via either mobilization of shallow groundwater by seismic energy from the impact event or dewatering of the ejecta.





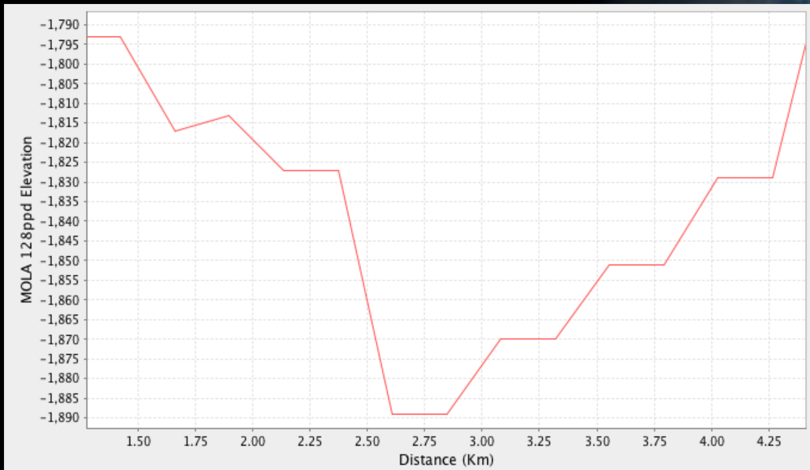
Lyot Crater. MOLA topography over subframe of THEMIS daytime IR
Channel length ≥ 300 km
Channel width ≤ 1 km
Maximum channel order = 1

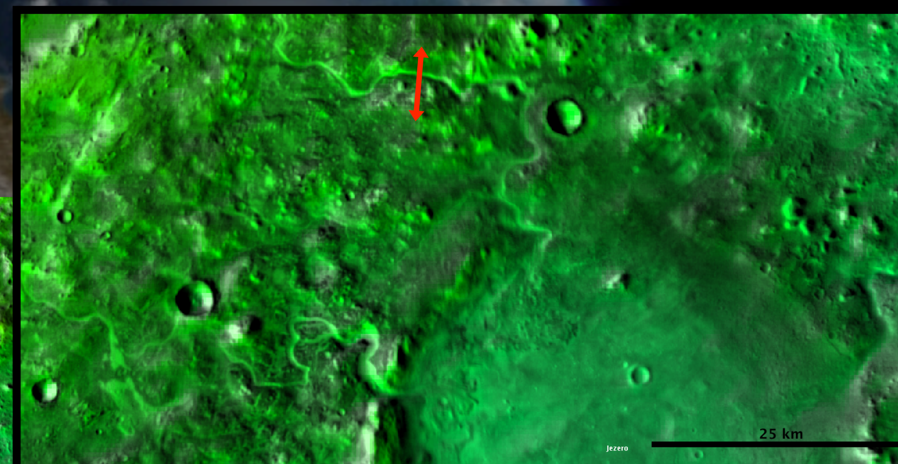
Jezero Crater

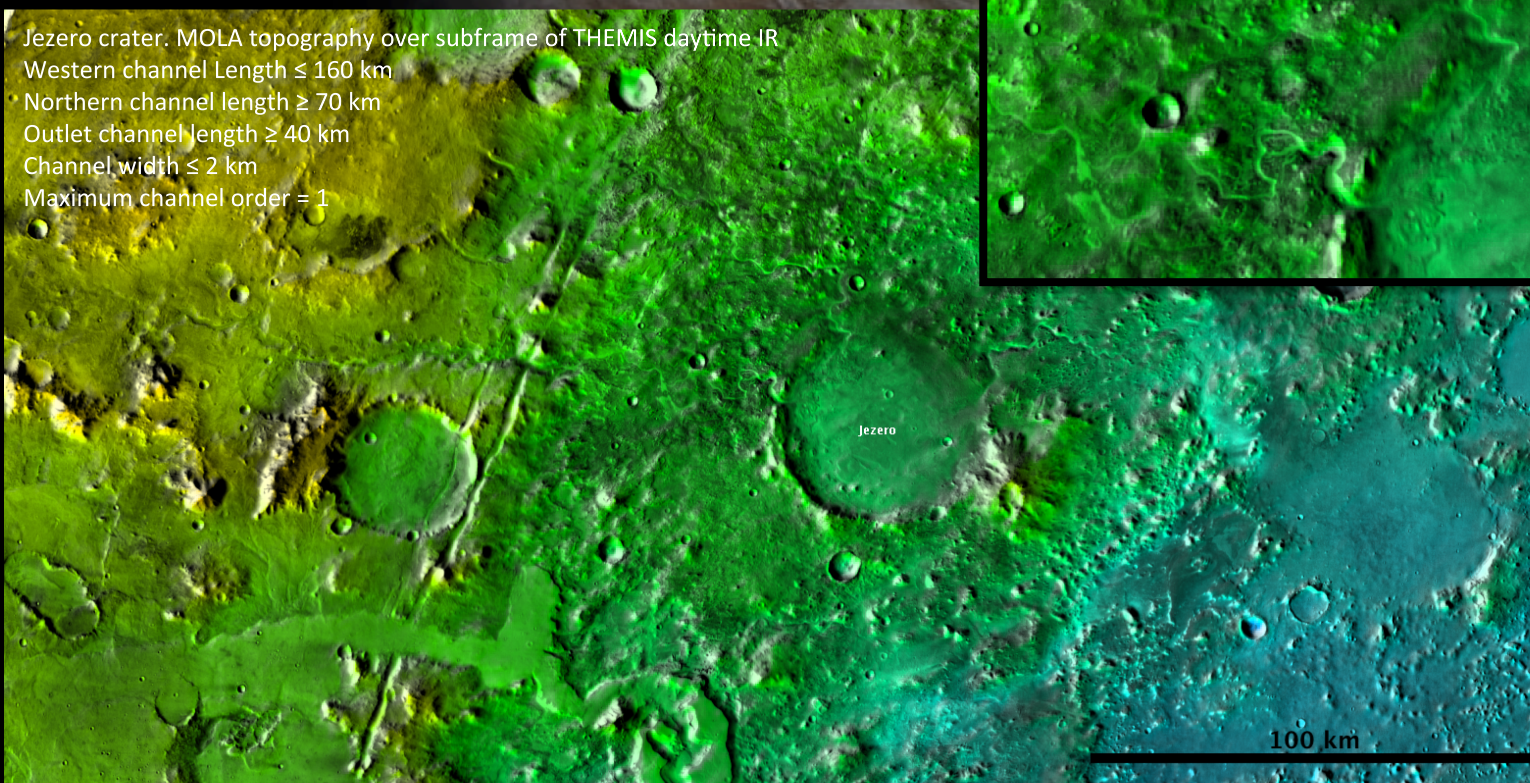
Two valleys enter the crater from the west and north, depositing sediments at their mouth.

Influx of water from these valleys filled the crater until the eastern rim was overtopped and breached. Water then flowed from an exit valley into the adjacent lowlands.

Jezero could have been filled in as little as 11 Earth years. Such a short time is only possible if there was a continuous source of supply such as impact-driven precipitation.

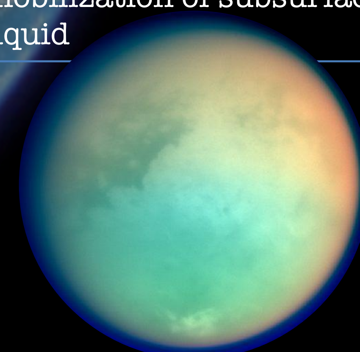




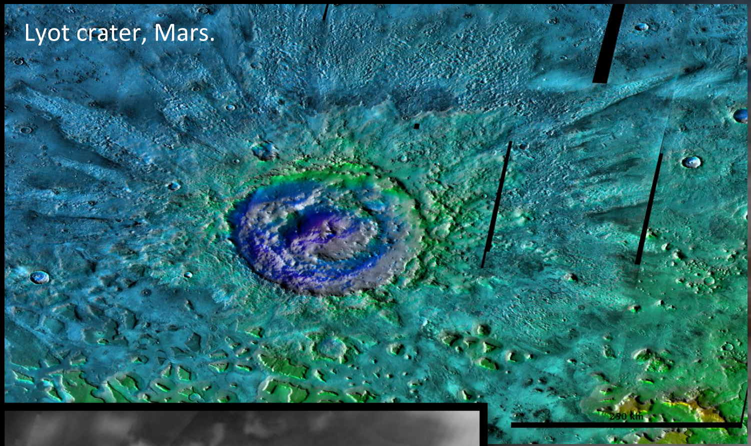


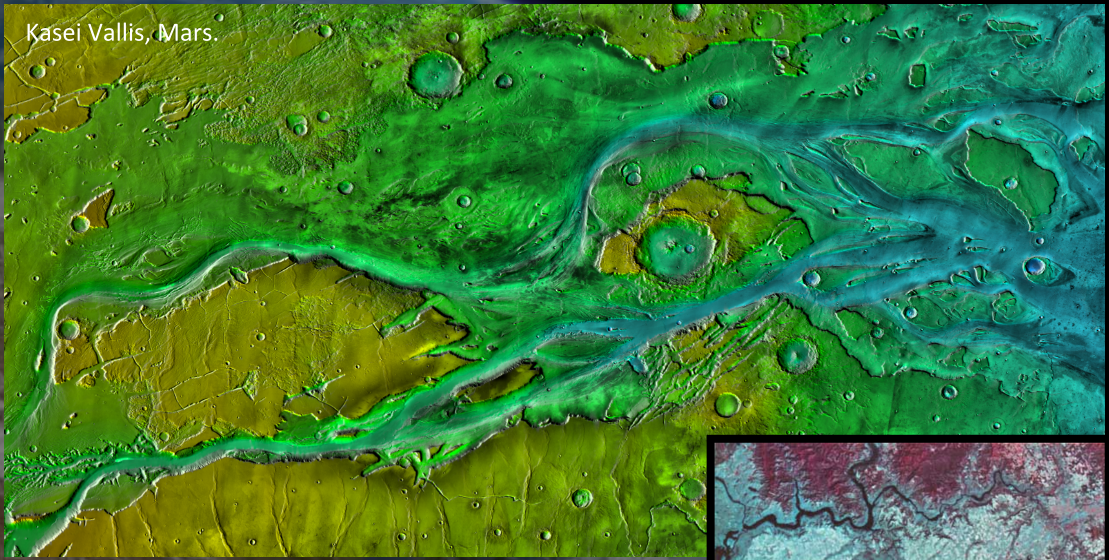
Palaeoflooding on Mars, Earth, and Titan

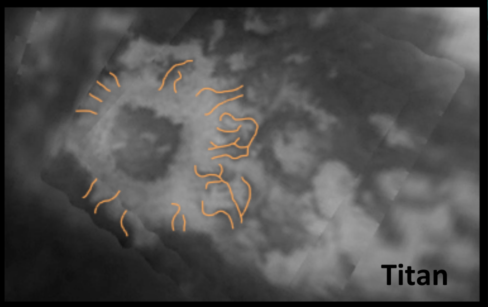
Parameter	**Mars**	**Earth**	**Titan**
Surface gravity (m/s^2)	3.71	9.81	1.35
Surface temperature (K)	210	287	94
Surface pressure (bar)	0.007	1.01	1.5
Atmospheric composition	95% CO_2, 2.7% N_2, 1.6% Ar	79% N2, 20% 02	95% N_2, 5% CH_4
Fluvial liquid, density (kg/m^3)	H_2O, 1000	H20, 1000	CH_4/N_2, 450
Liquid viscosity (Pa s)	1×10^{-3}	1×10^{-3}	2×10^{-4}
Flood-generating mechanisms	Basin overflow, precipitation, volcanism, impact-induced precipitation and groundwater release	Glaciation, volcanism, basin overflow, precipitation	Possible causes: cryovolcanism, basin overflow, precipitation, impact-induced precipitation and mobilization of subsurface liquid



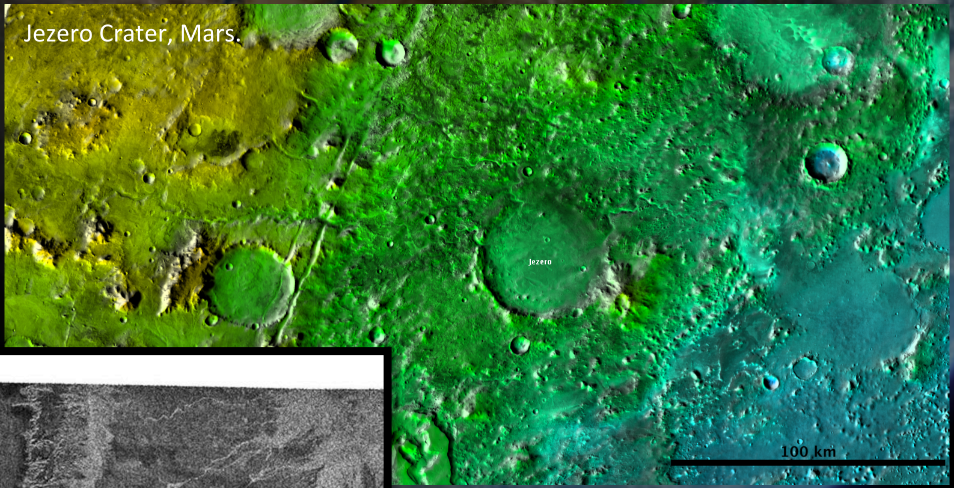
Palaeoflooding on Mars, Earth, and Titan



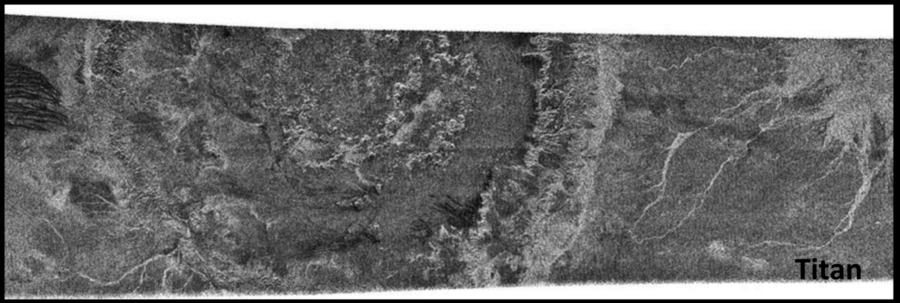




Radial network of channels surrounding Selk crater, Titan.



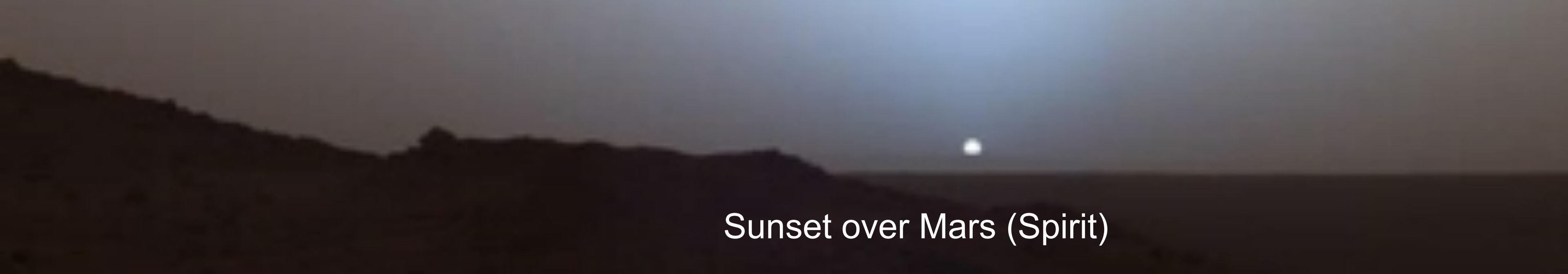
Channeled Scabland region, Earth. The dark braided pattern depicts the channelways of the Great Spokane Flood.



Channels flowing into and out of Menrva crater, Titan.

Conclusions

- Mars may have been very Earth-like when life was beginning on Earth
  - Could life have begun on Mars?
- There is still H_2O (as ice and vapor) on Mars, and may still exist (albeit briefly, perhaps) today
  - Could there be Martians living today?



Sunset over Mars (Spirit)