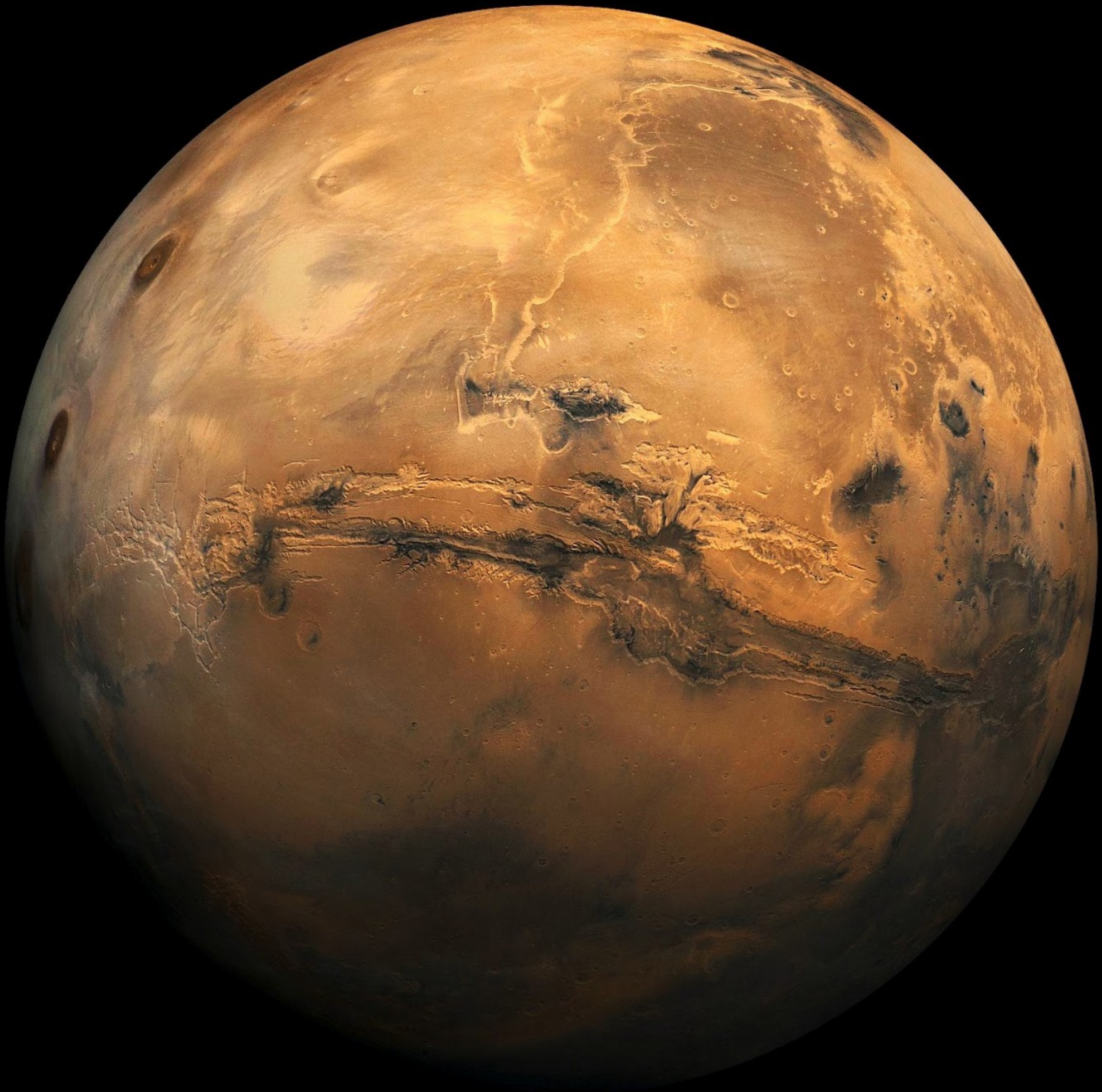
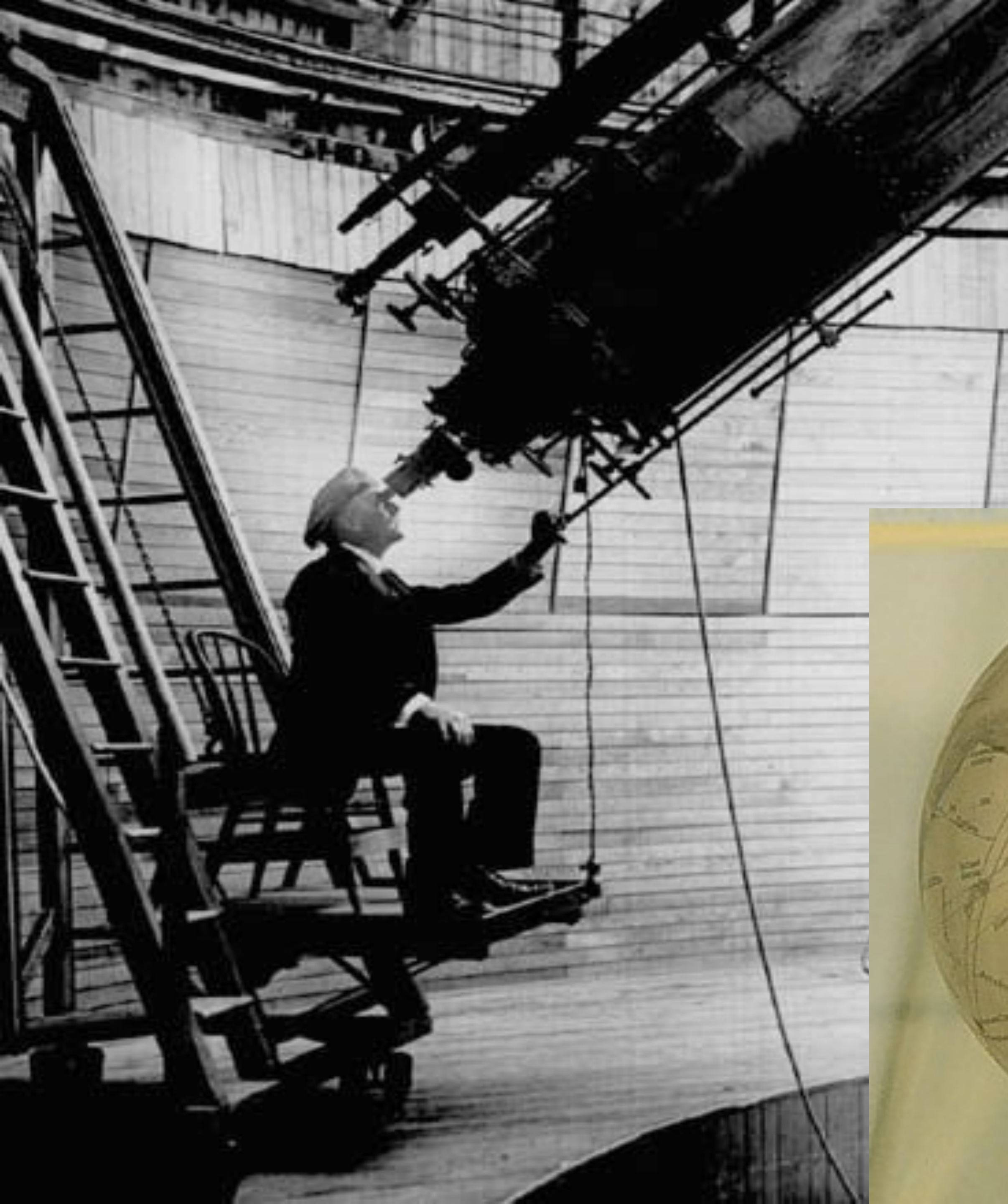
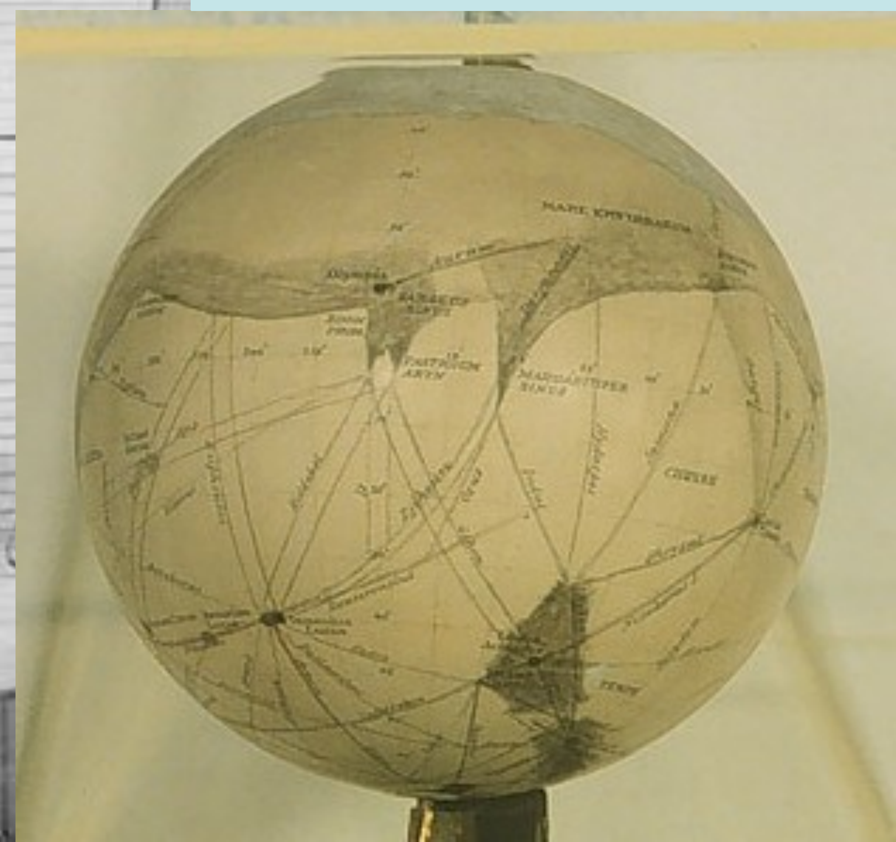


Mars Mysteries

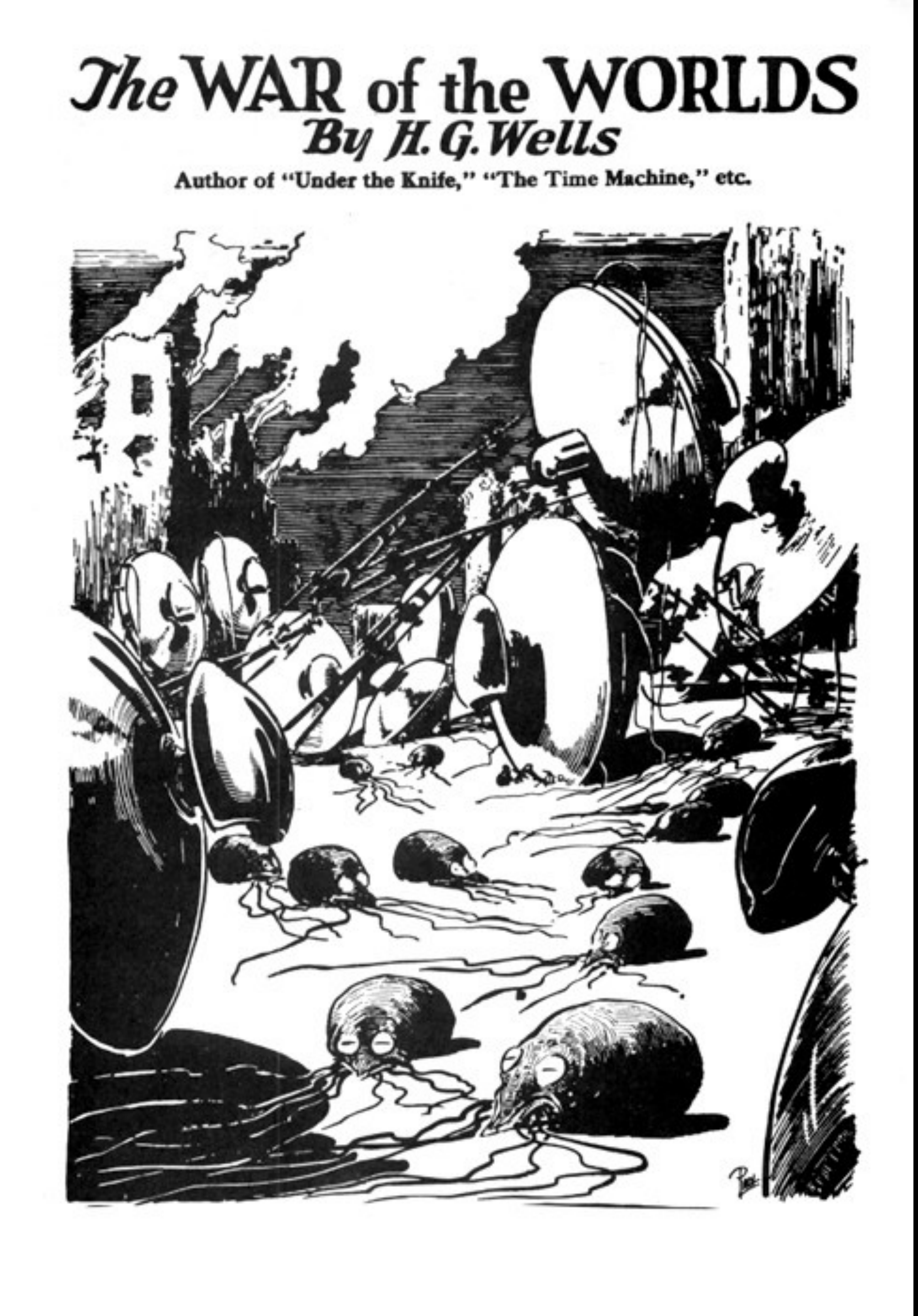
Donna M. Jurdy
Earth & Planetary Sciences
Northwestern University



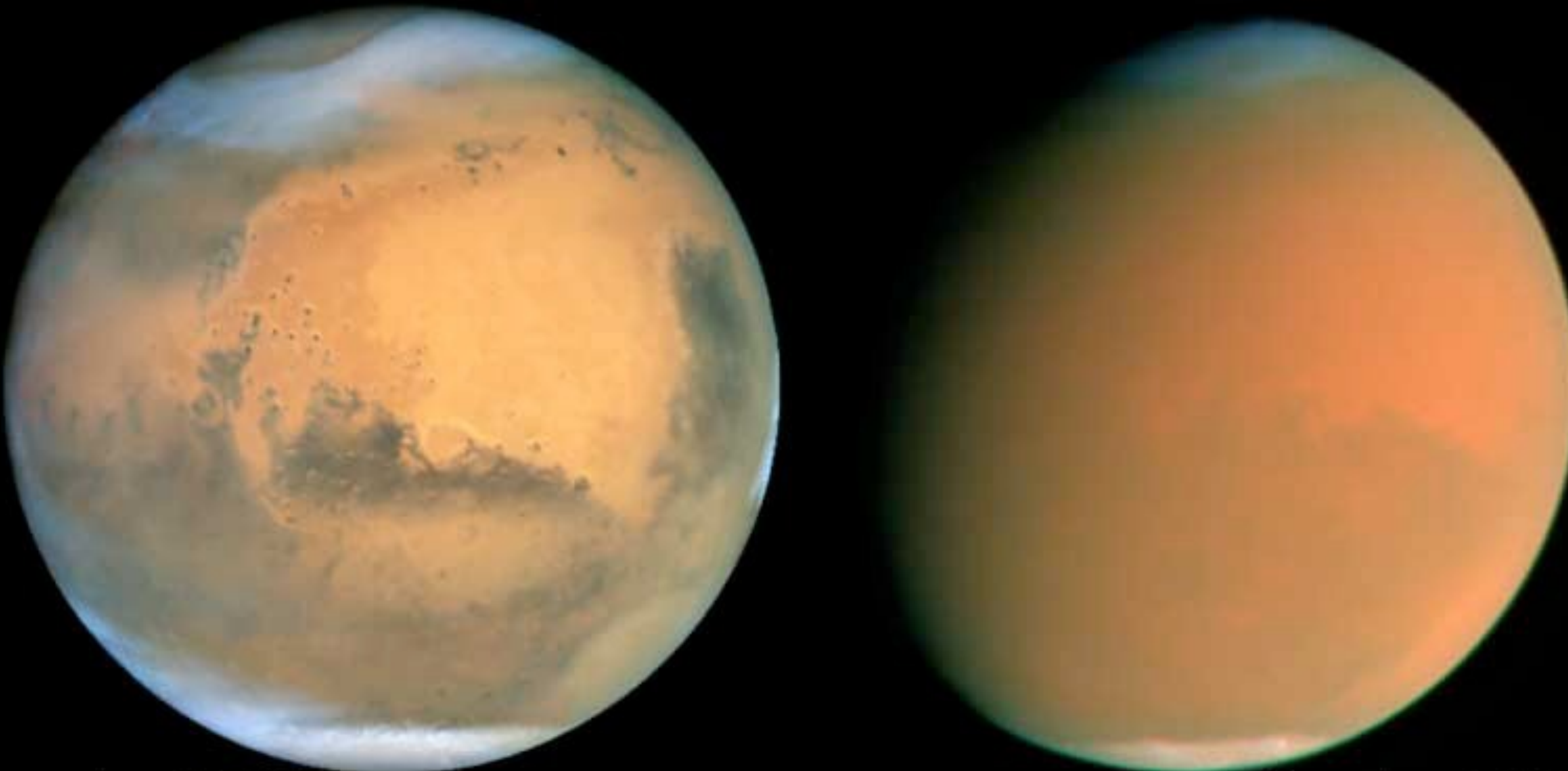
PERCIVAL LOWELL AT THE
24 INCH REFRACTOR,
FLAGSTAFF, ARIZONA
OBSERVING MARS DURING
FAVORABLE OPPOSTION
(PERIHELIC OPPOSTION)
OF 1894
BELOW IS A GLOBE
CONSTRUCTED FROM HIS
DRAWINGS



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



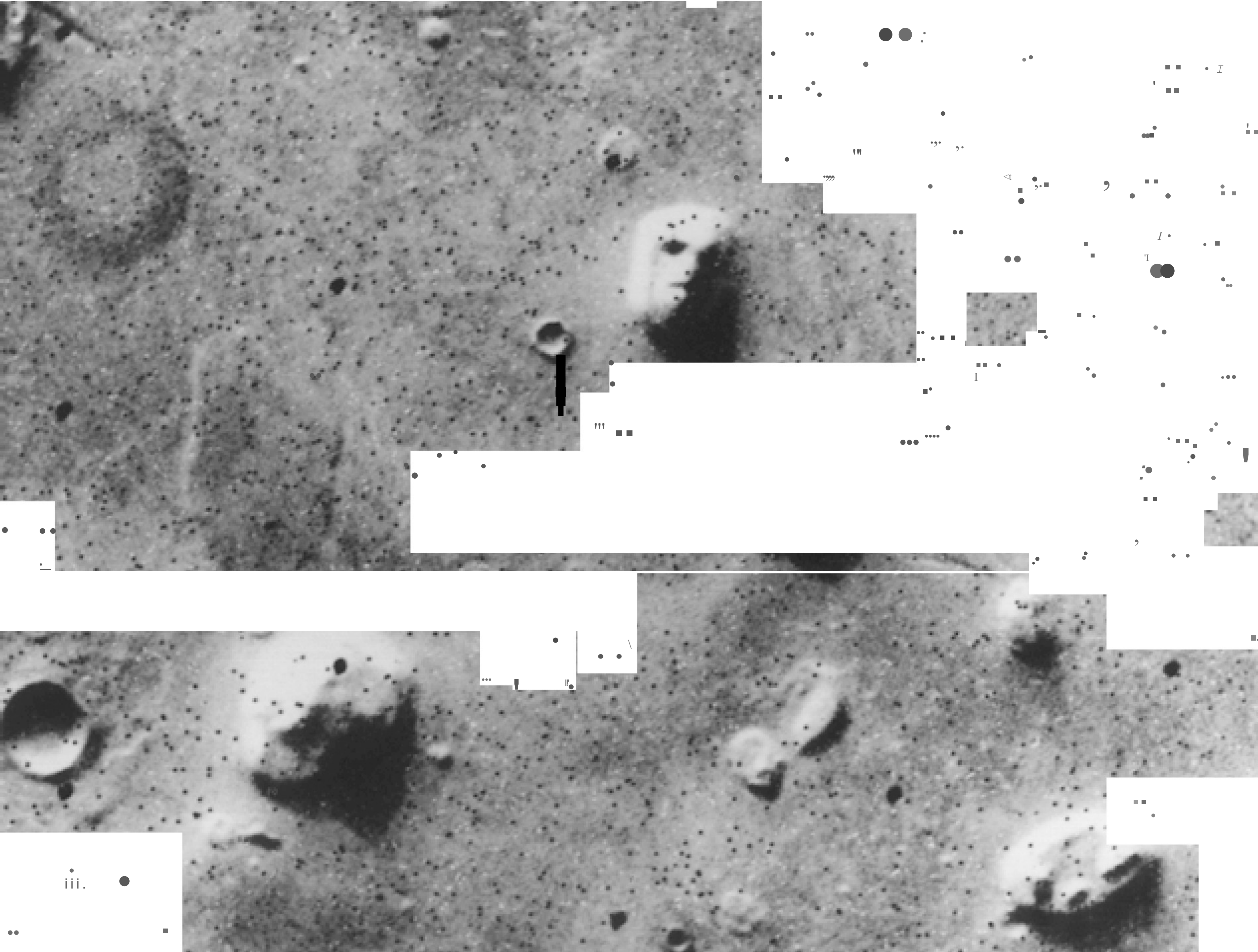
Mars • Global Dust Storm



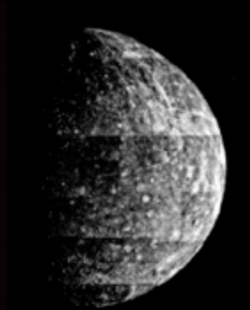
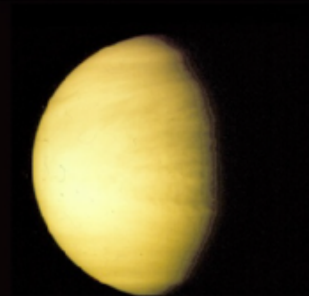
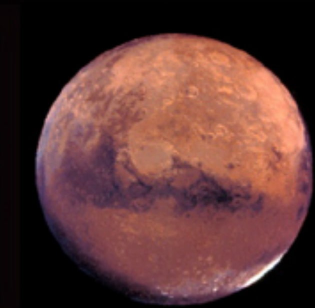
June 26, 2001 September 4, 2001

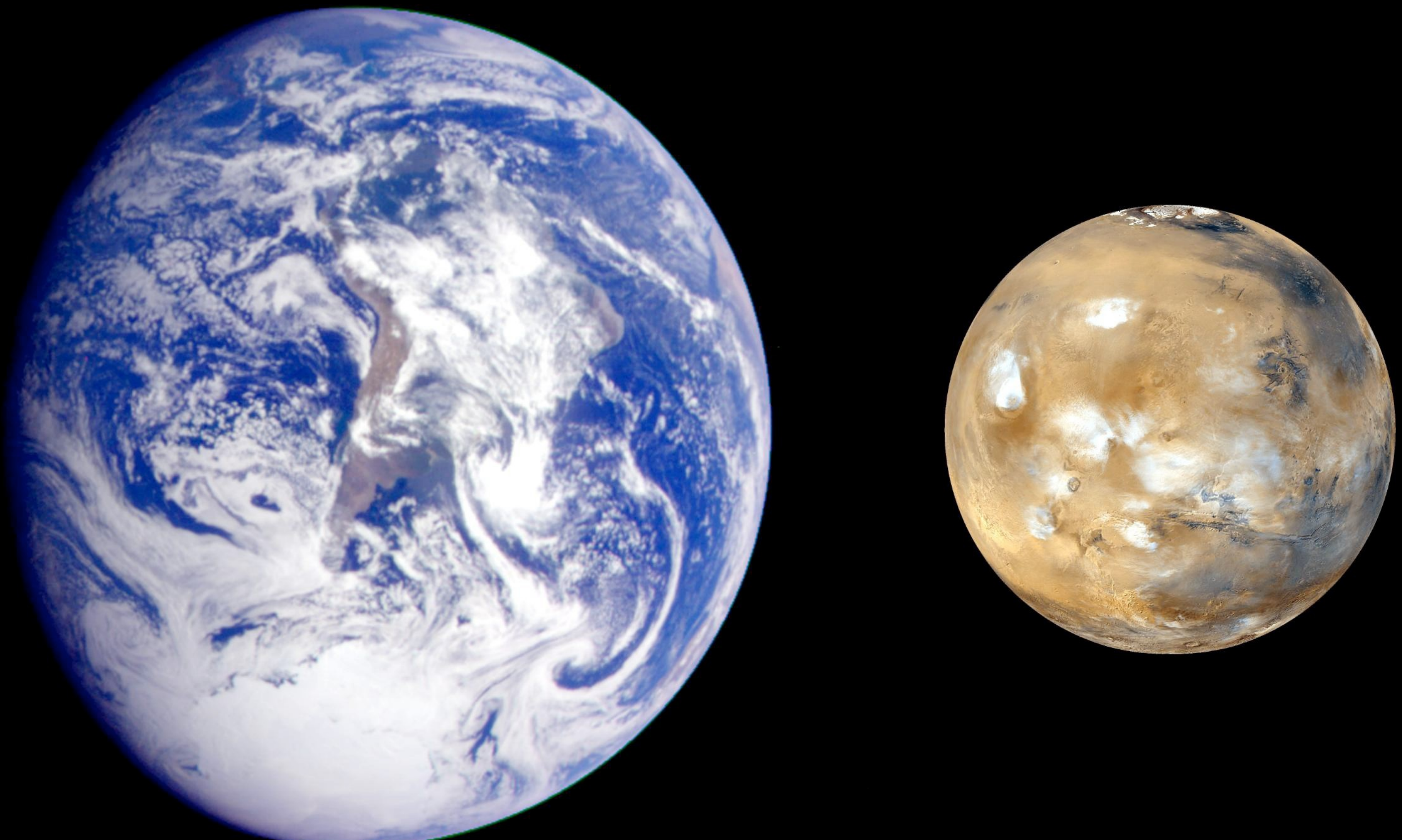
Hubble Space Telescope • WFPC2

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

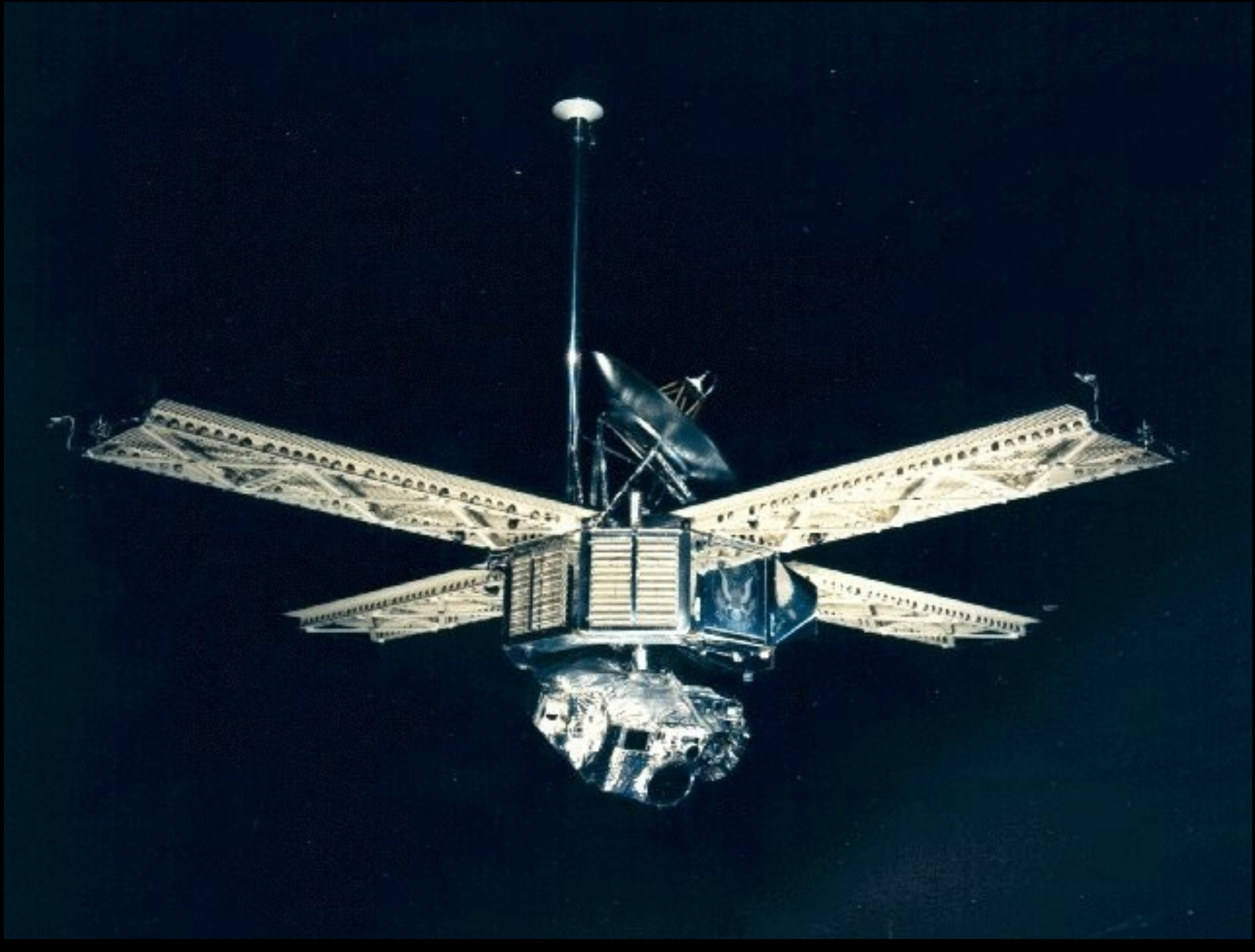


When is a face not a face?

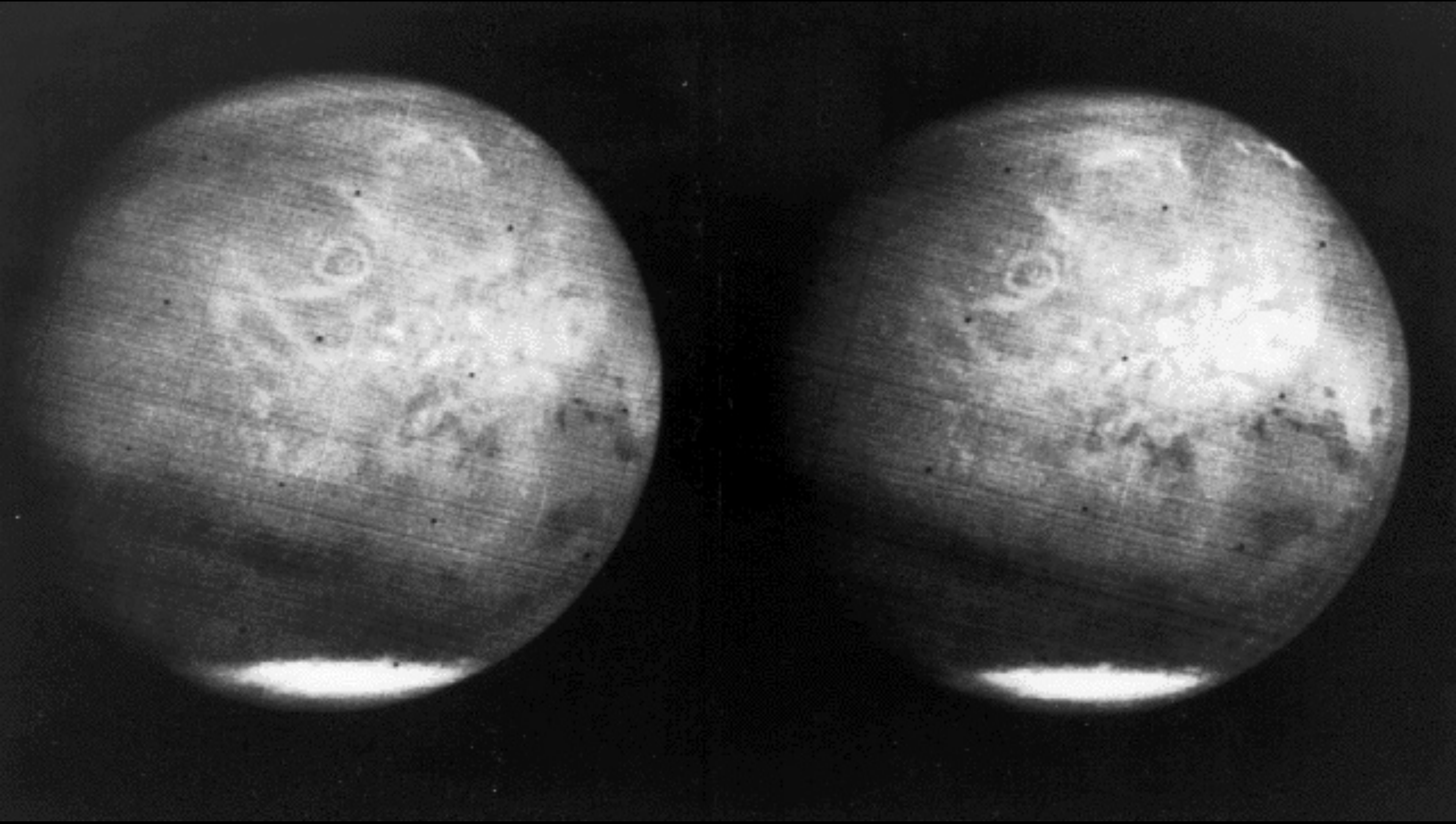
	Mercury	Venus	Earth	Moon	Mars
					
Radius (km)	2439	6052	6378	1738	3398
Mass (kg)	3.30×10^{23}	4.87×10^{24}	5.98×10^{24}	7.35×10^{22}	6.42×10^{23}
Density (kg/m^3)	5420	5250	5520	3340	3940
Distance from the Sun (A.U)	0.387	0.723	1.000	---	1.524
Mean Surface Pressure (bars)	---	92	1	---	0.006
Mean Surface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



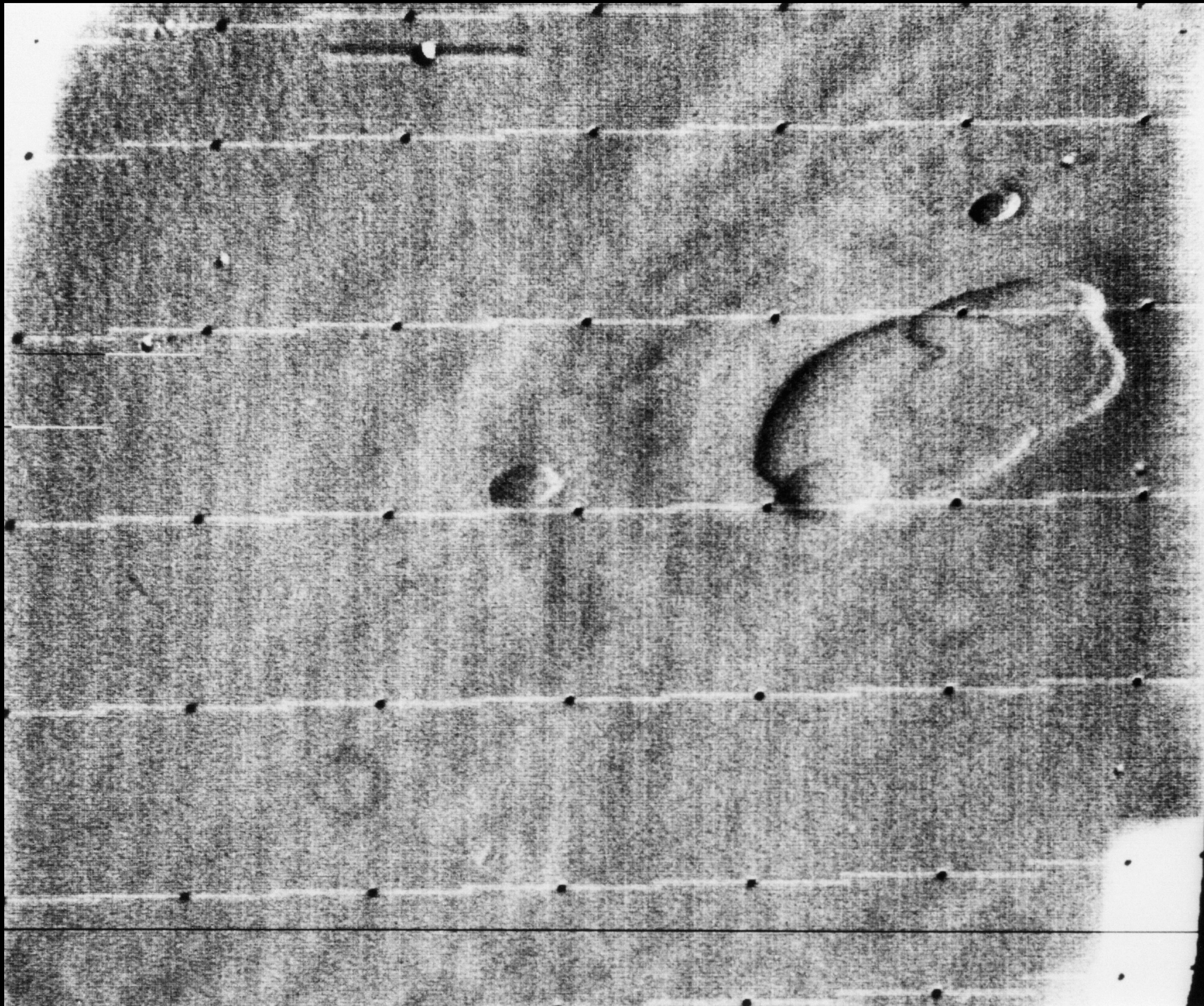
Mariner 7 (1969)



Mariner 7 Approach to Mars

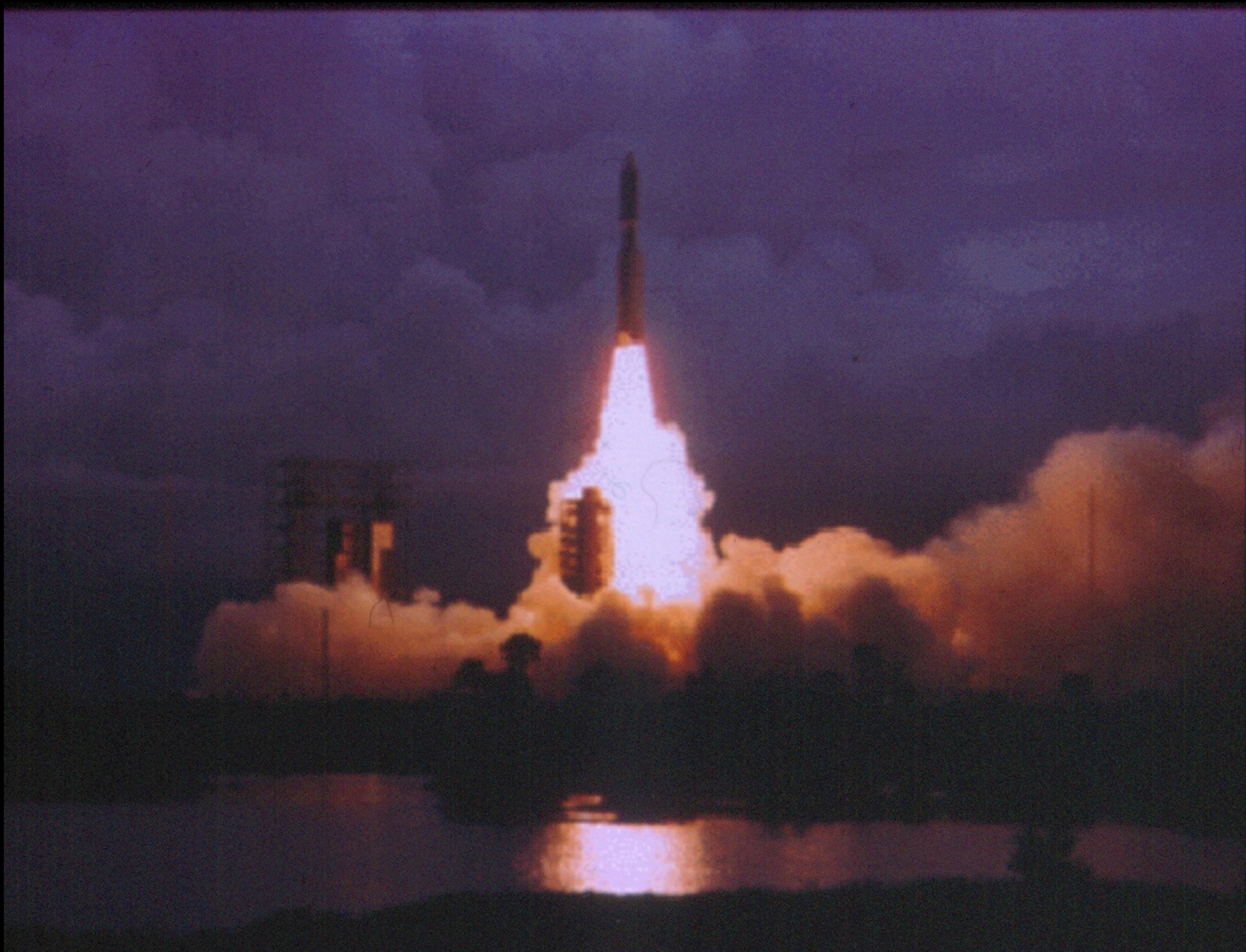


Olympus Mons, as seen from Mariner 9 (1971)



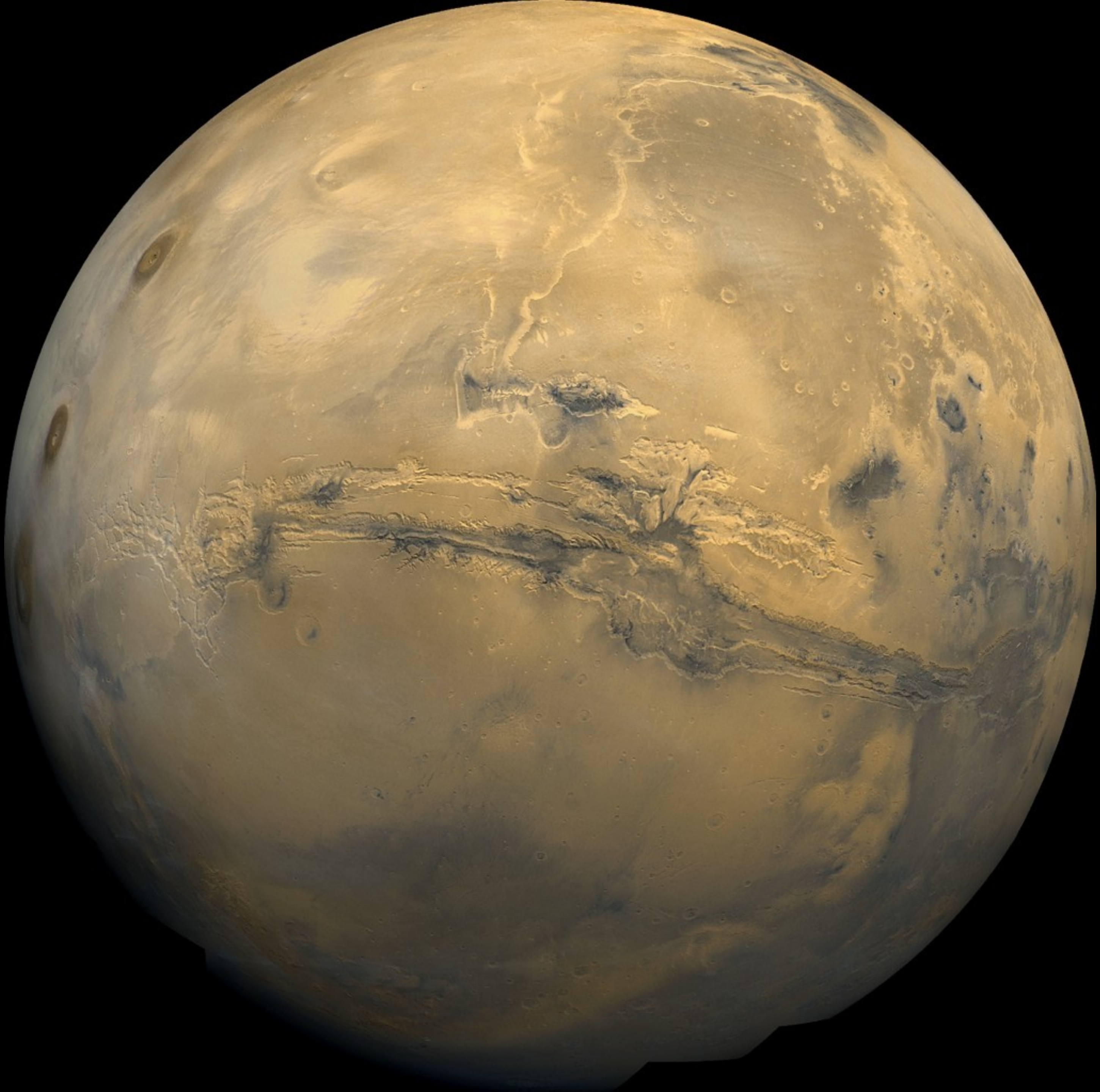
Olympus Mons Caldera

Viking 2 Liftoff, Sept 5,1975

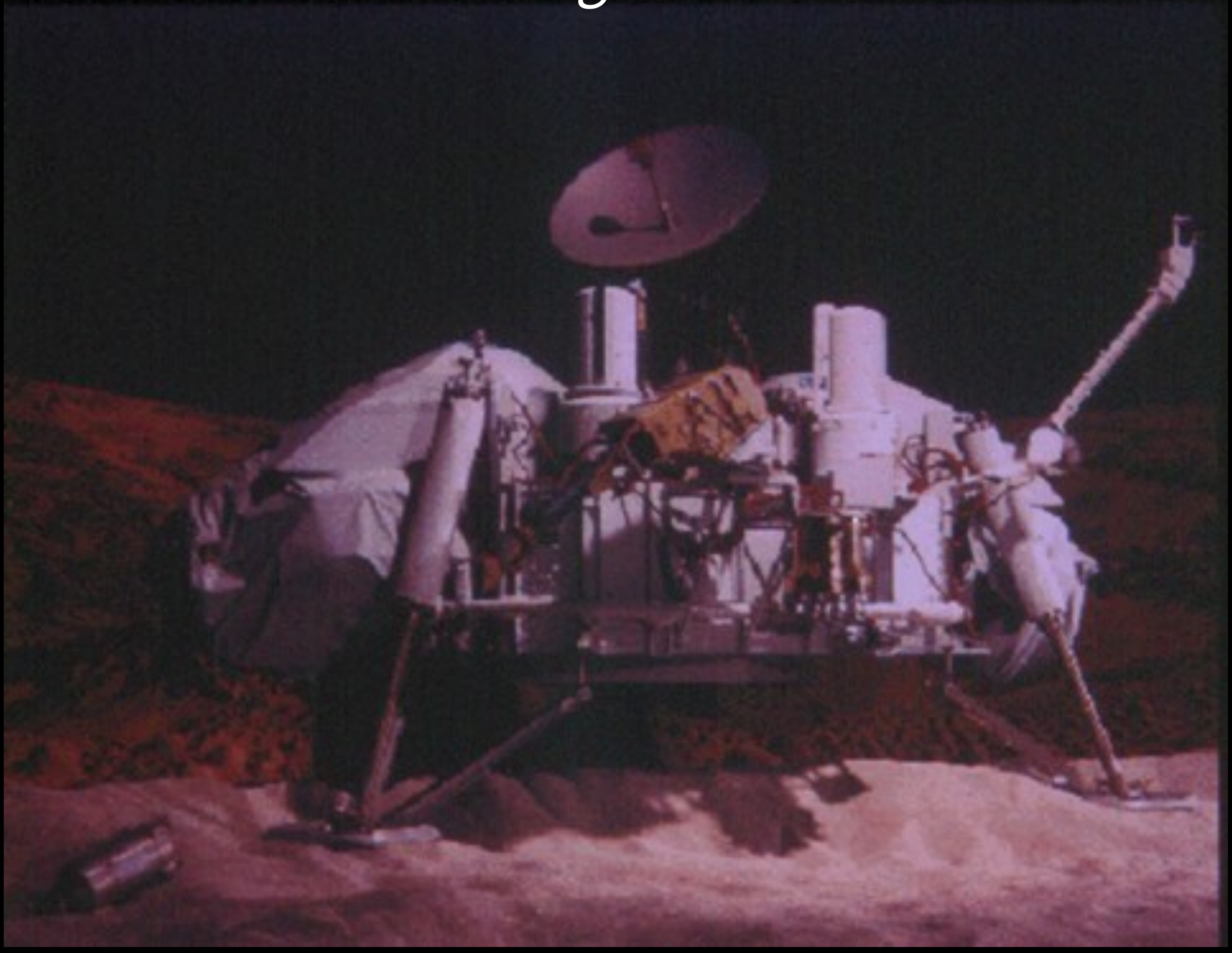


COMPOSITE IMAGE OF MARS TAKEN FROM SMALL TELESCOPES ONBOARD THE 2 VIKING ORBITERS

Mid 1970’S



Viking Lander

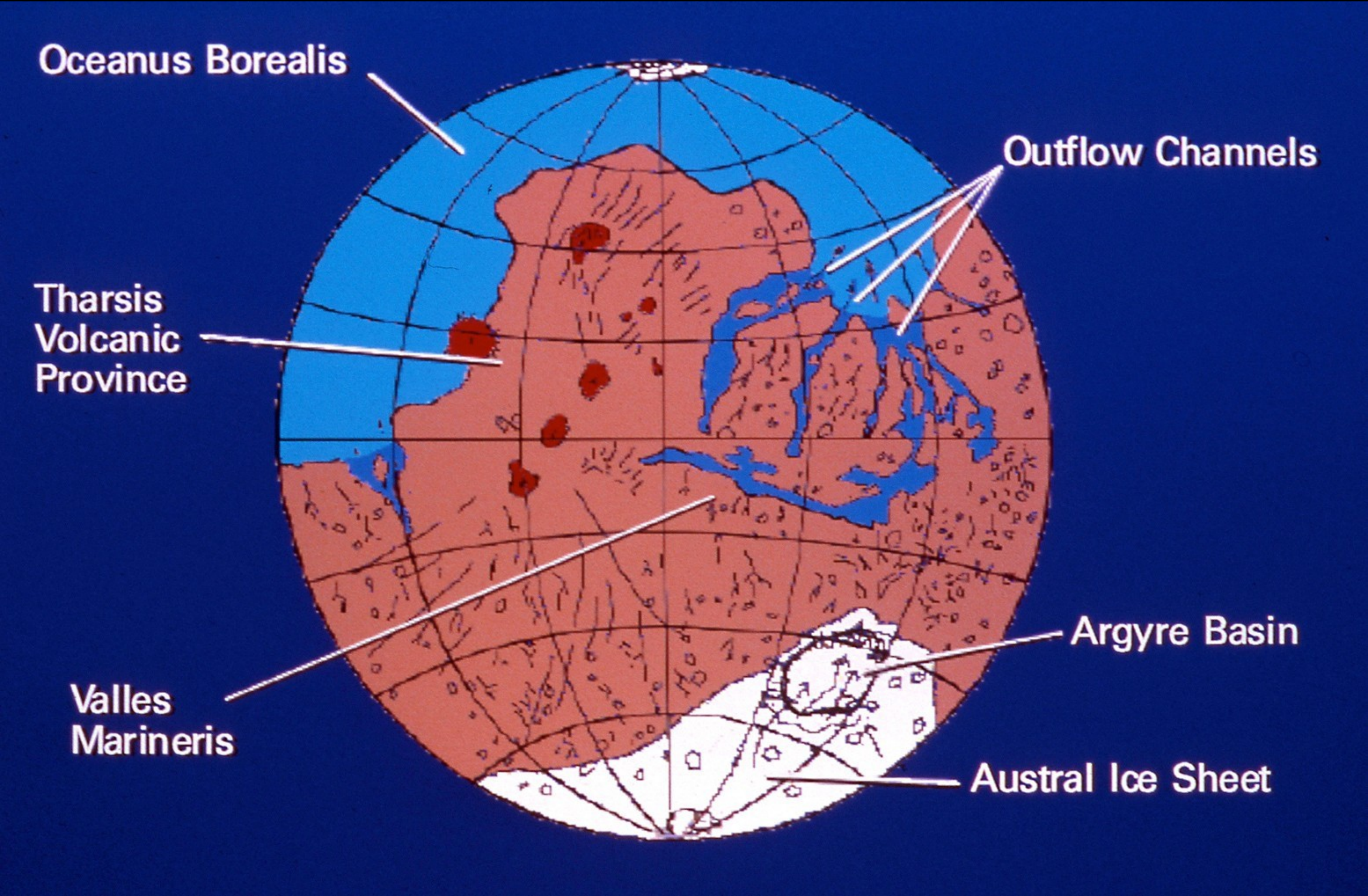


Viking 2 Landing Site (Sept, 1976)

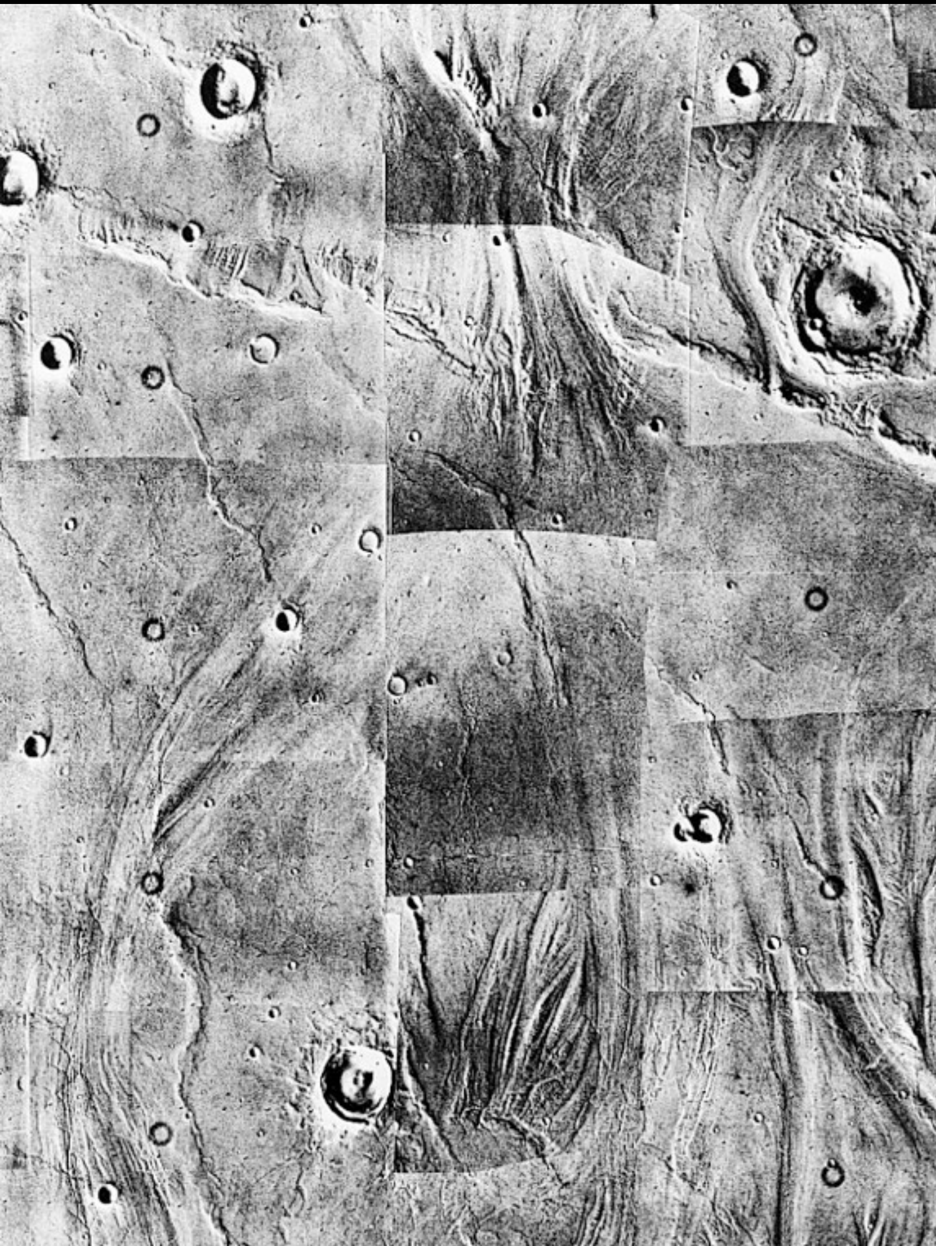

ALH84001,0
N
1 cm

Evidence for (really old, really tiny) Martians?

Mars Schematic

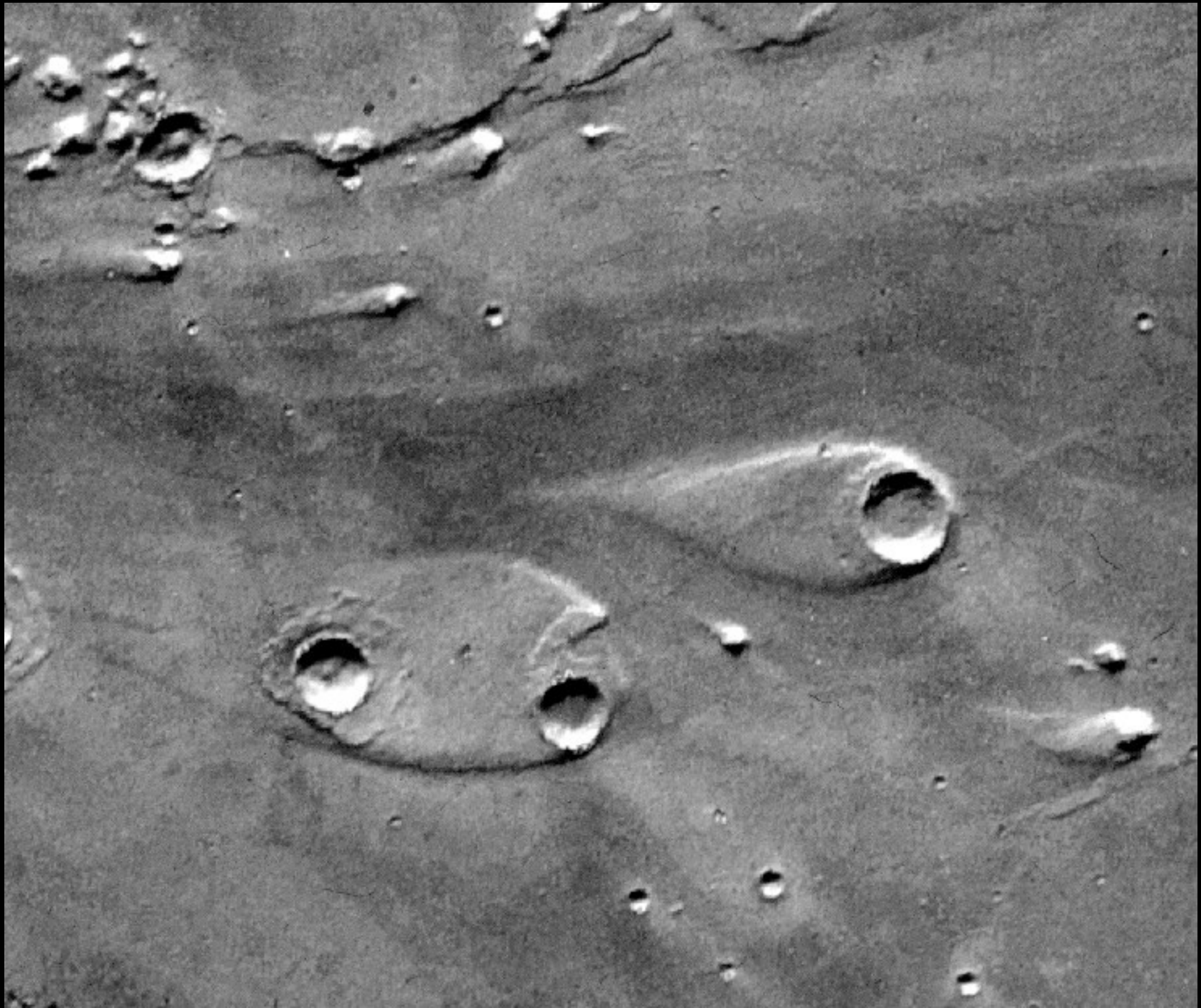


Water on Mars



- 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.

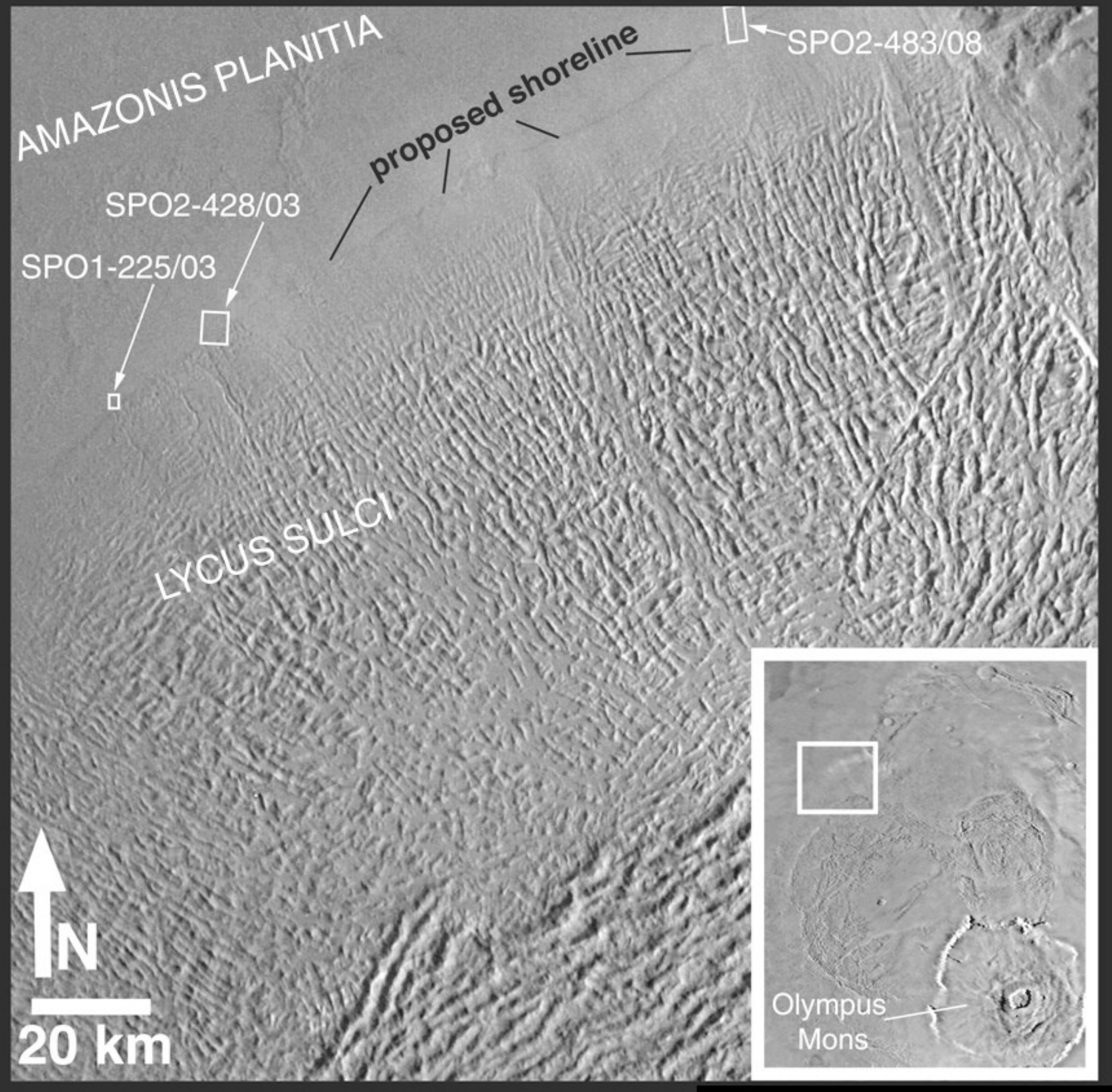
Channel Islands



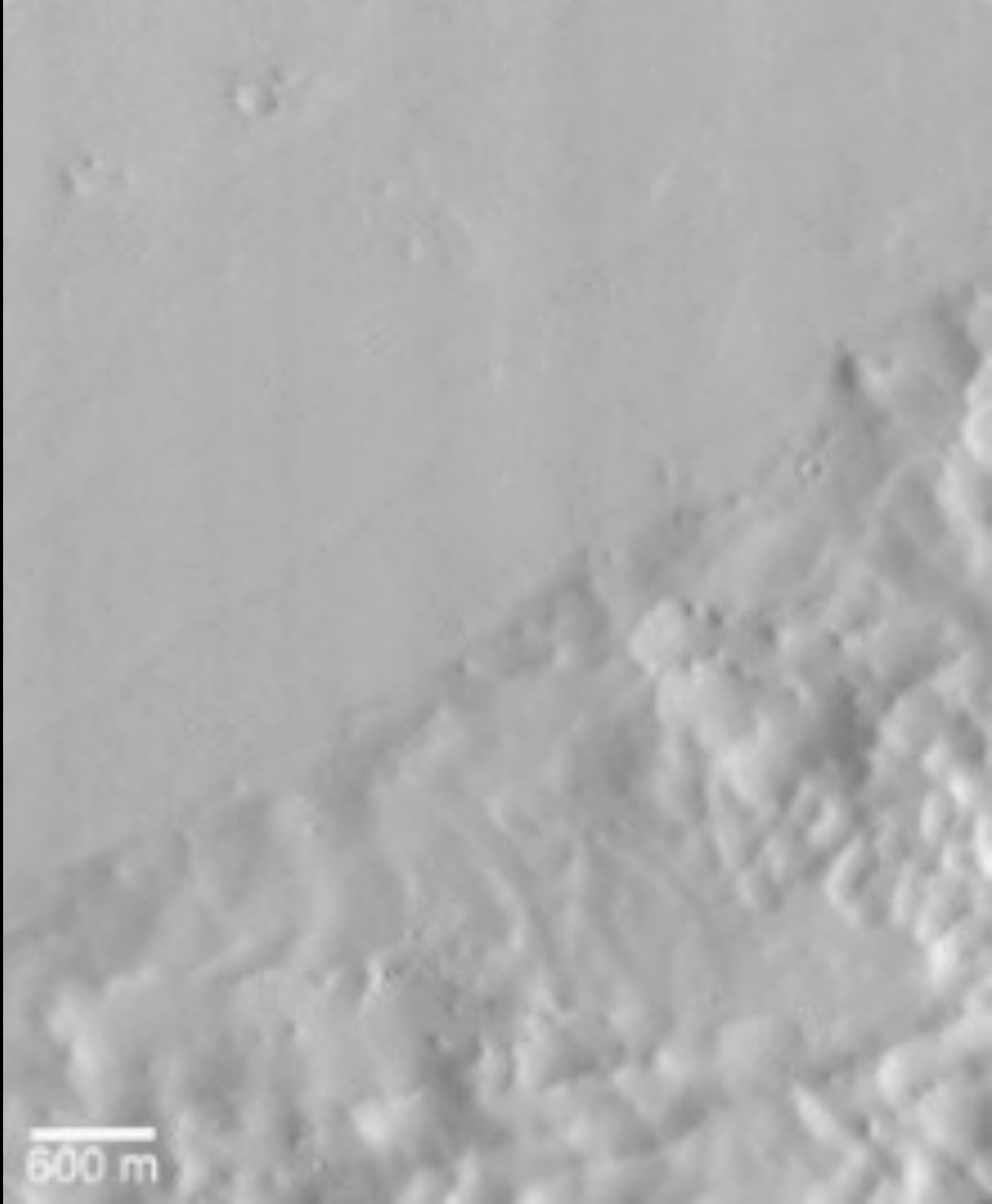
Erosion, Lobate Ejecta

River Channels

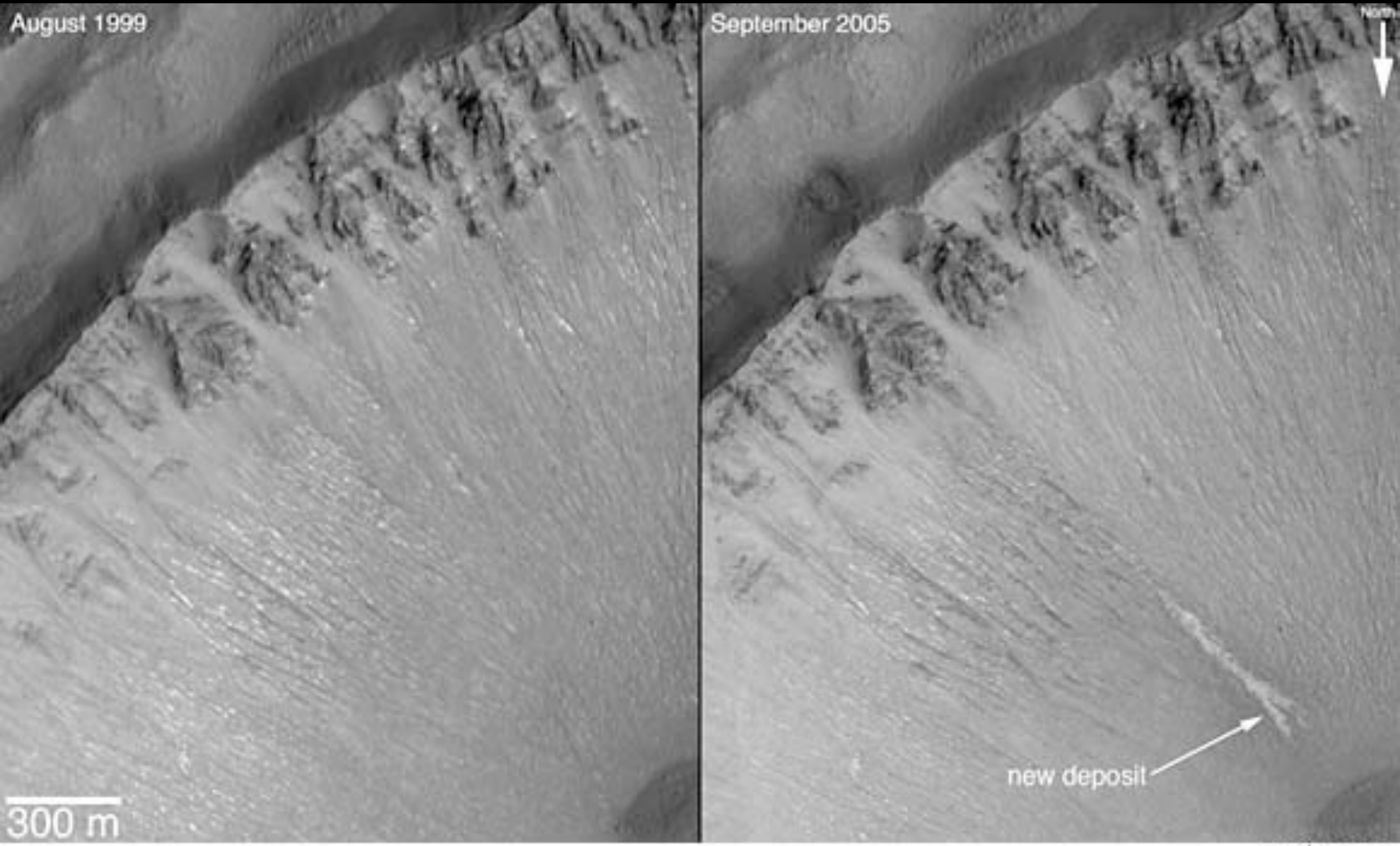
Ancient Martian Shoreline?



Shoreline? – Up Close and Personal



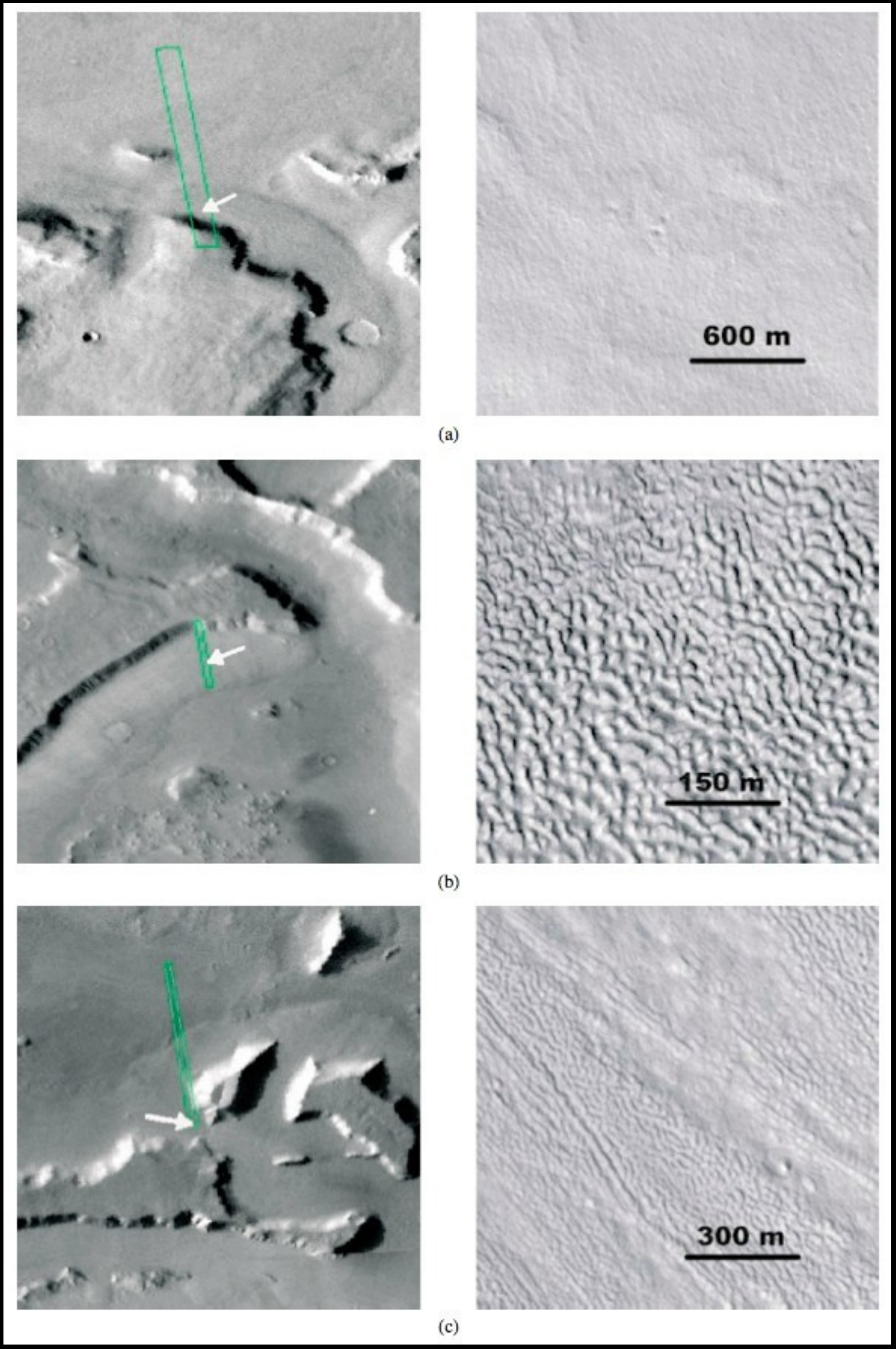
New Groundwater Flow?



AP / NASA

Debris Aprons

MOC wide angle MOC narrow angle



(a) (b) (c)

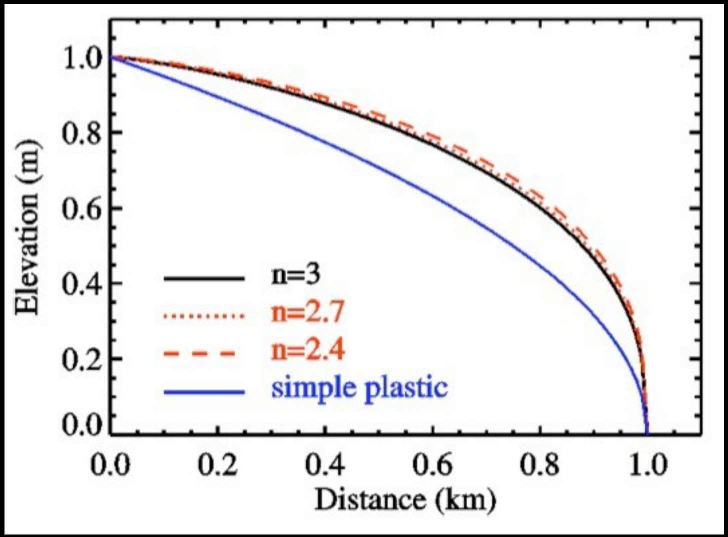
(a) Smooth surface texture may represent original apron surface

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

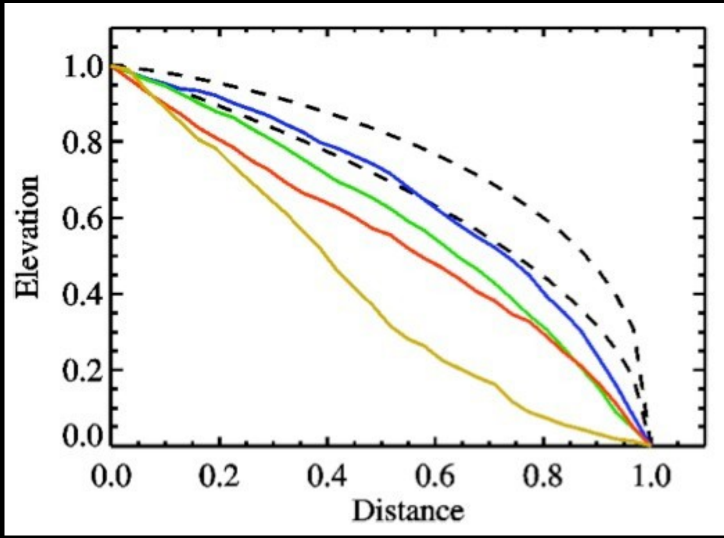
(c) Ridged texture

Li, Robinson, Jurdy (2005)

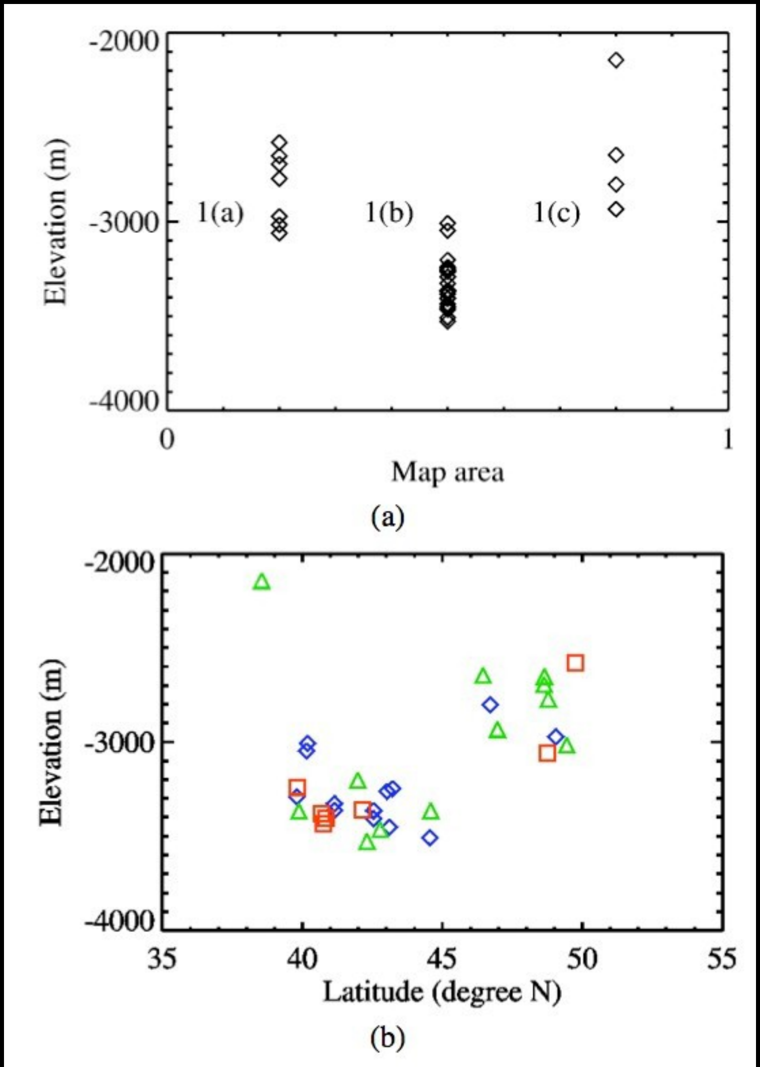
Debris Aprons



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



Li, Robinson, Jurdy (2005)

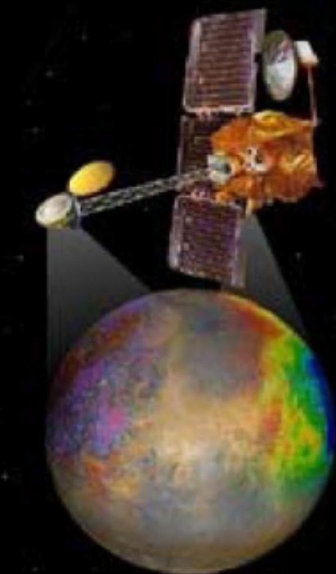


Above: Relationships between apron type and (a) elevation and (b) latitude (type I blue diamond shape, type II green triangle, type III red square).

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

Mars Global Surveyor (MGS)

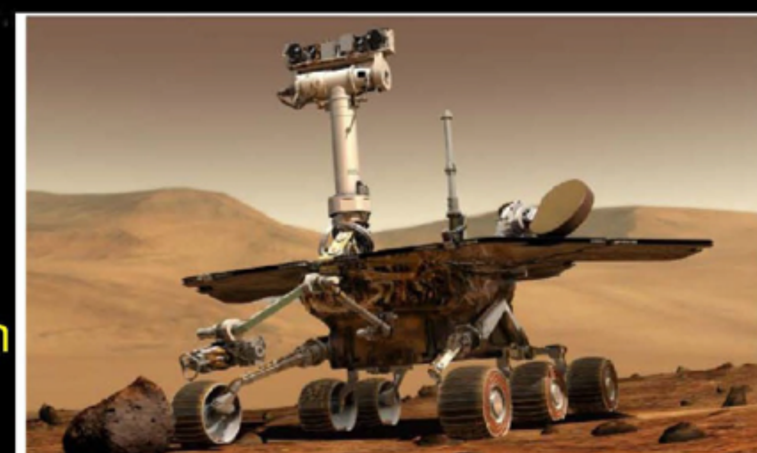
Mars Odyssey



Mars Reconnaissance Orbiter

Mars Express

Mars Exploration Rovers (MERs)

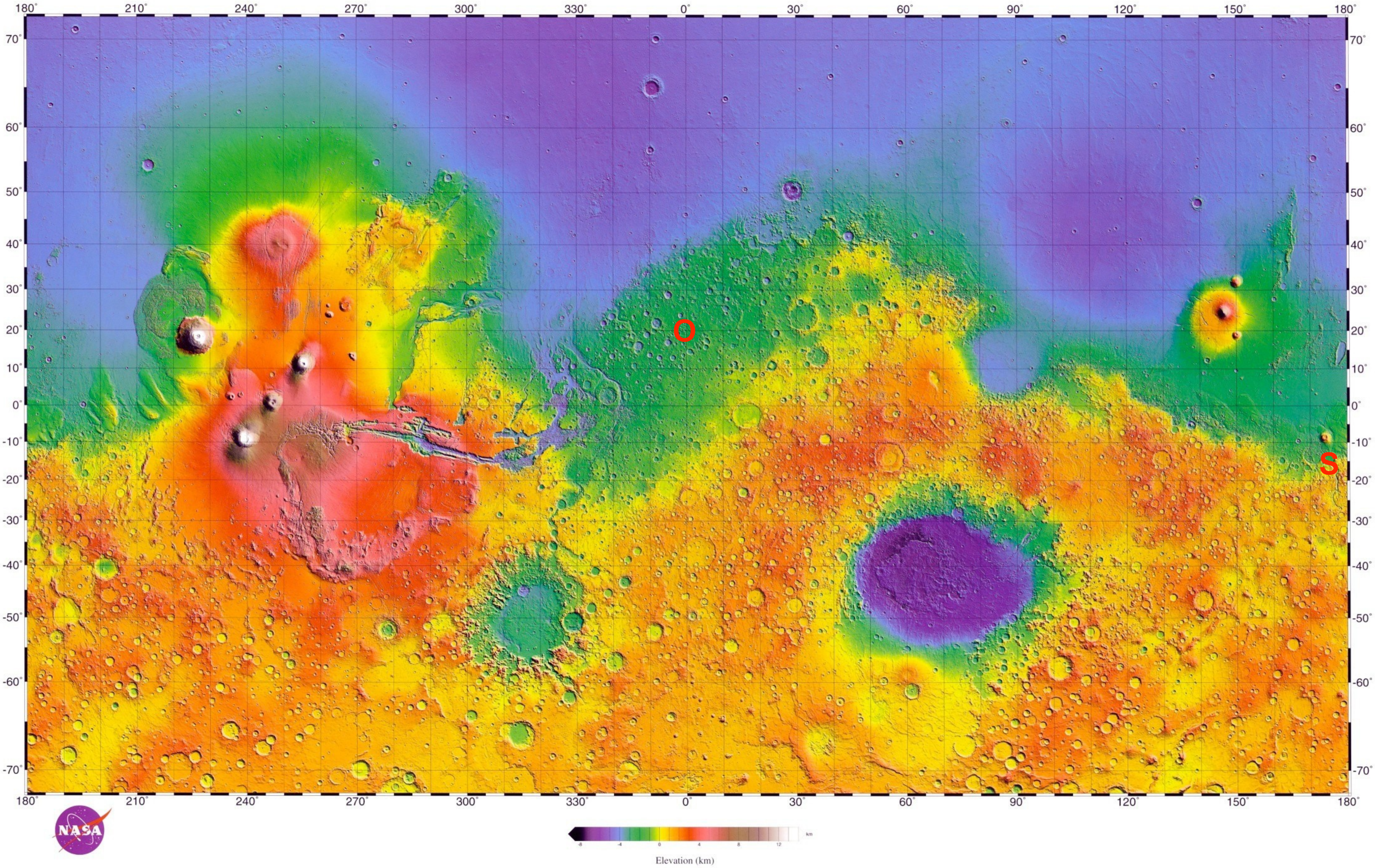


Artist's simulation of a Mars Exploration Rover at work on Mars.

Mars Global Surveyor Liftoff

November 7, 1996

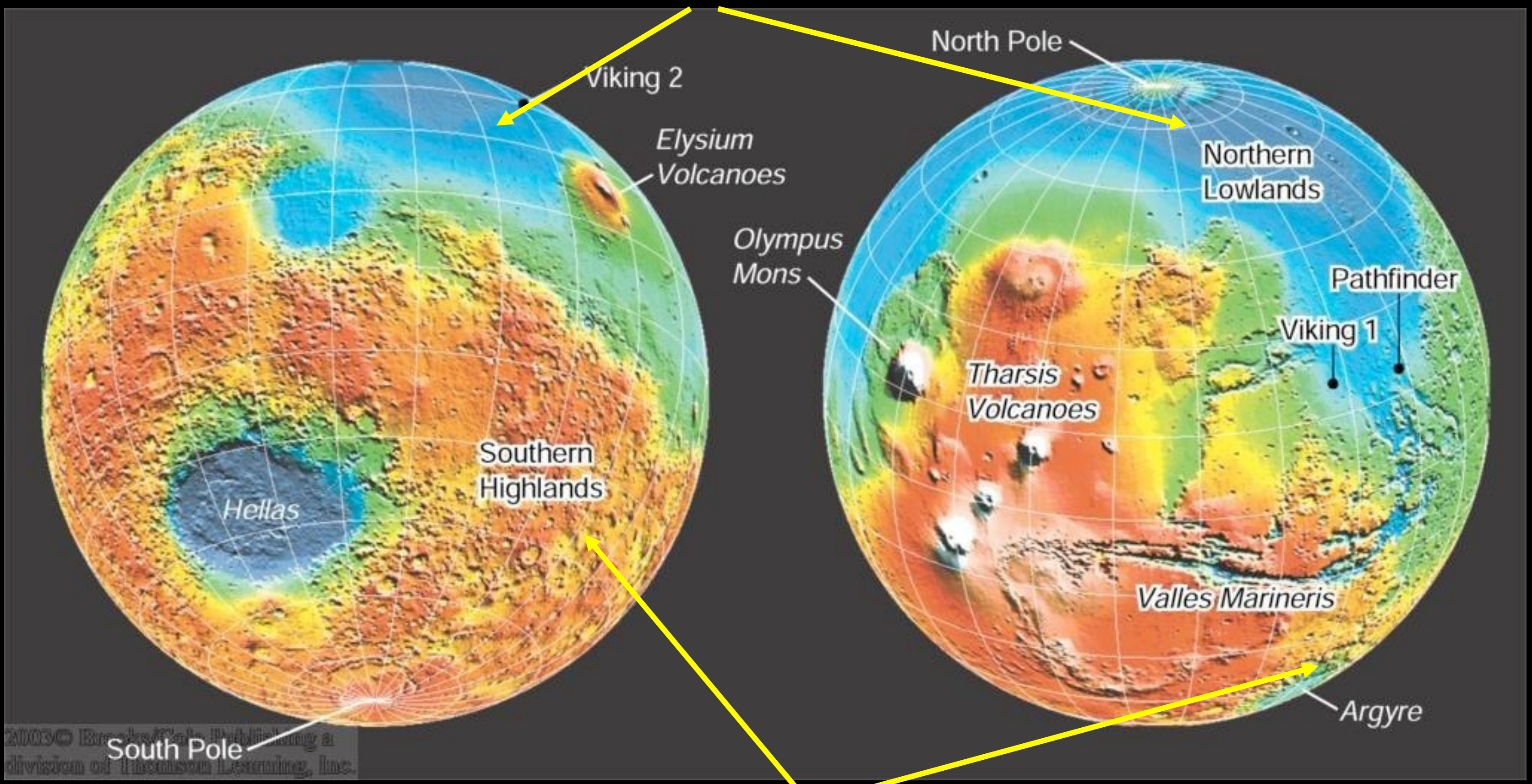
The Topography of Mars



The Geology of Mars

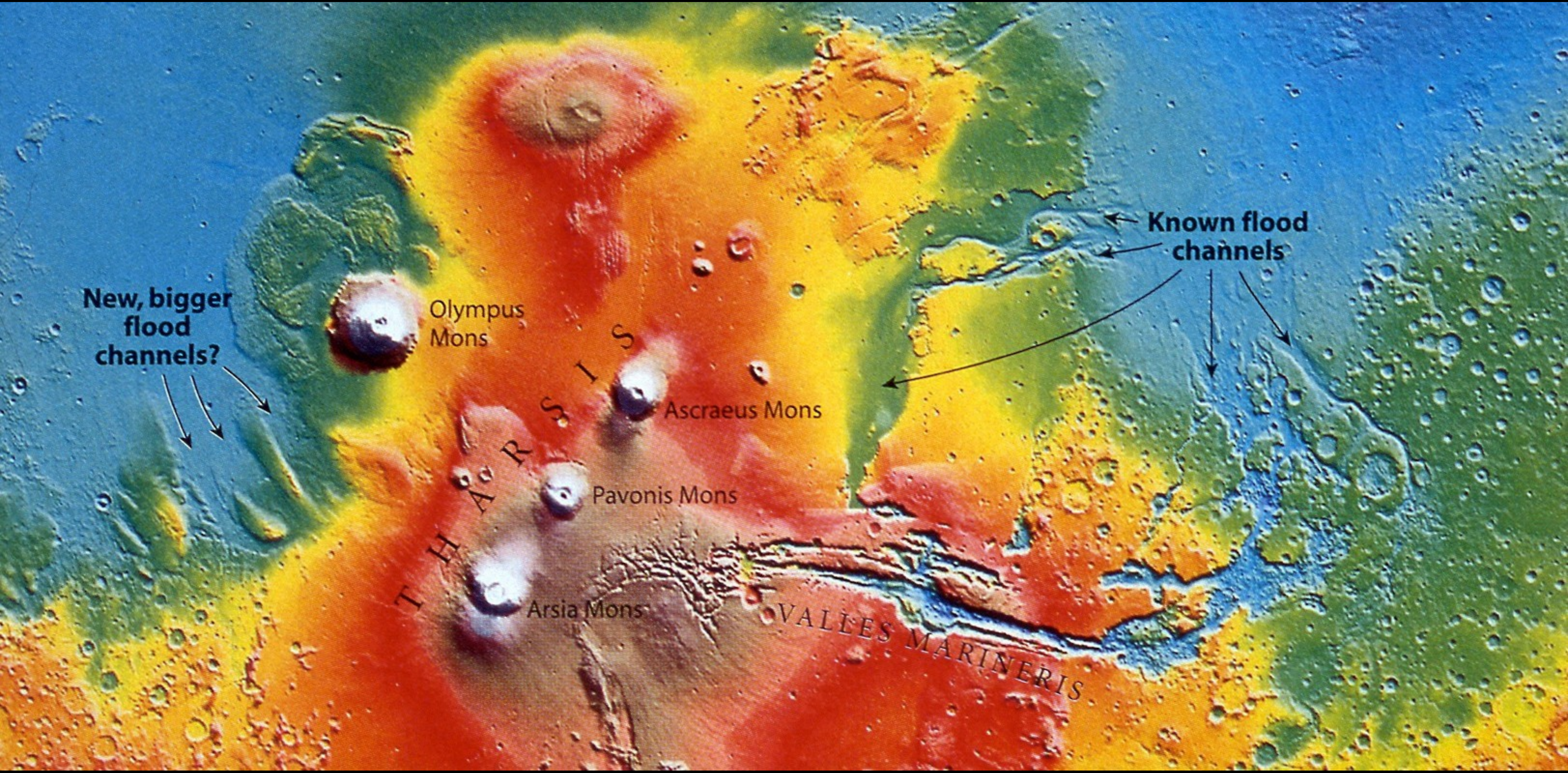
Northern Lowlands: Free of craters; probably re-surfaced a few billion years ago.

Possibly once filled with water.

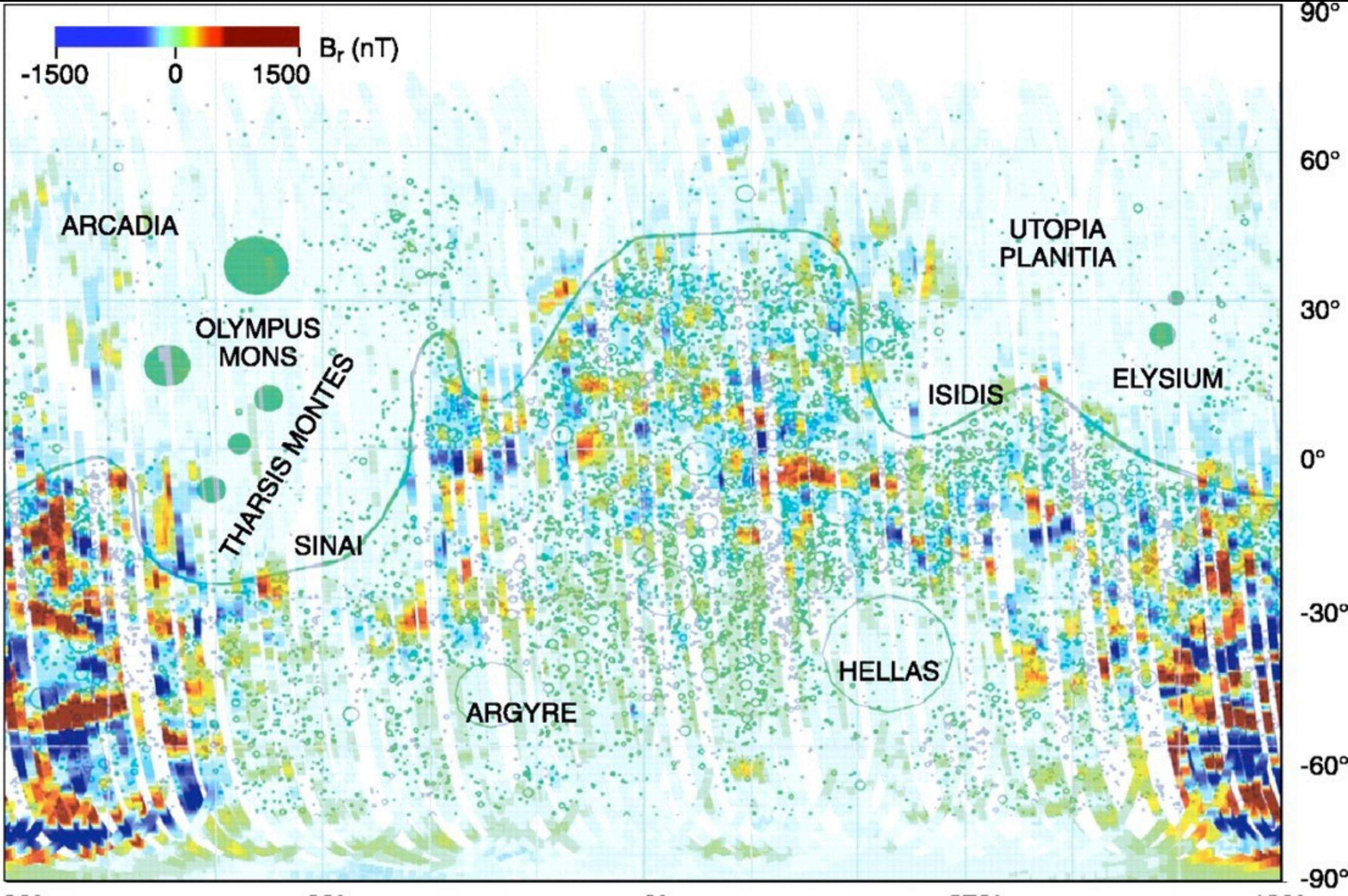


Southern Highlands: Heavily cratered; probably 2 – 3 billion years old.

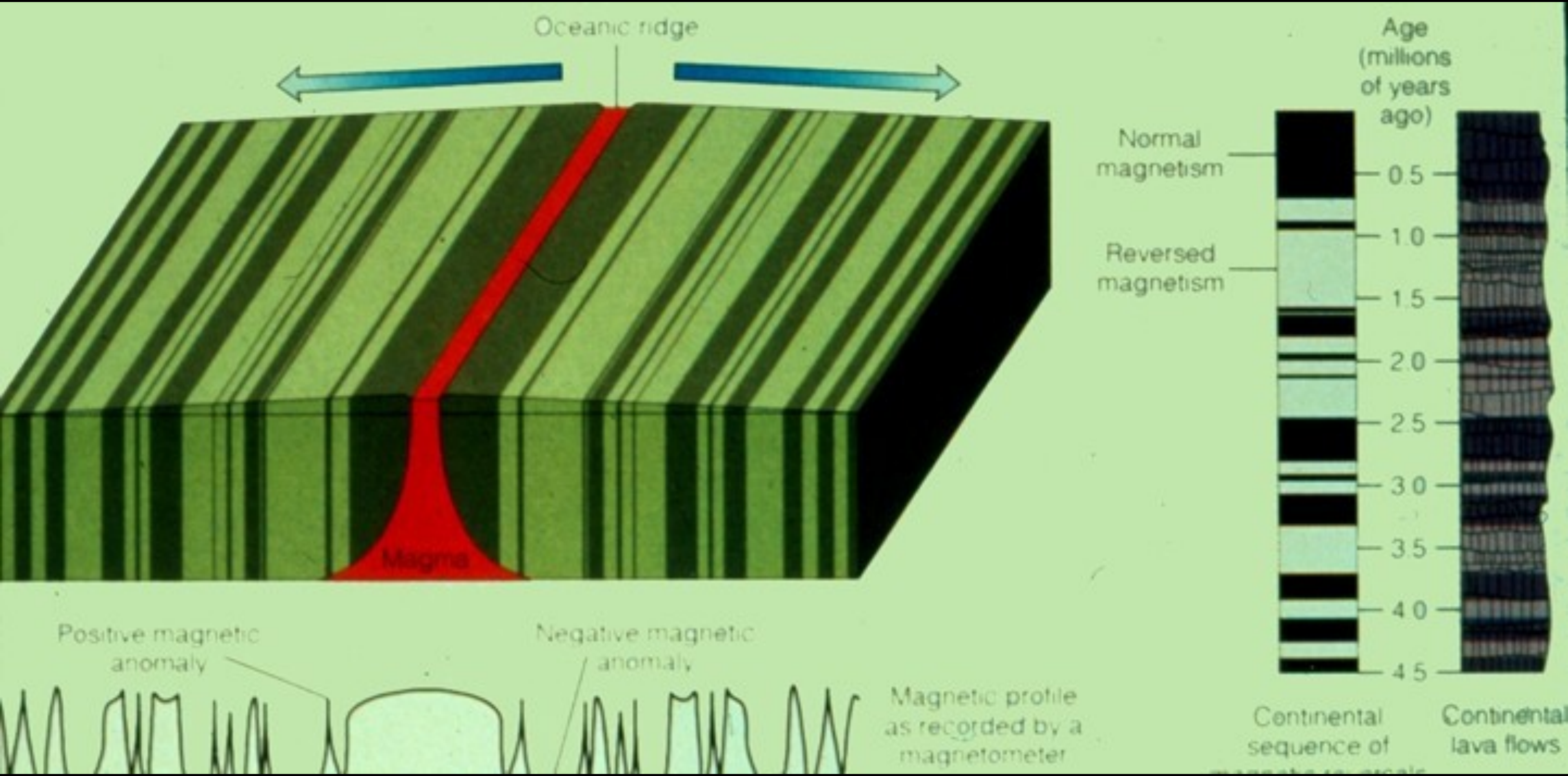
Tharsis Region Topography



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)

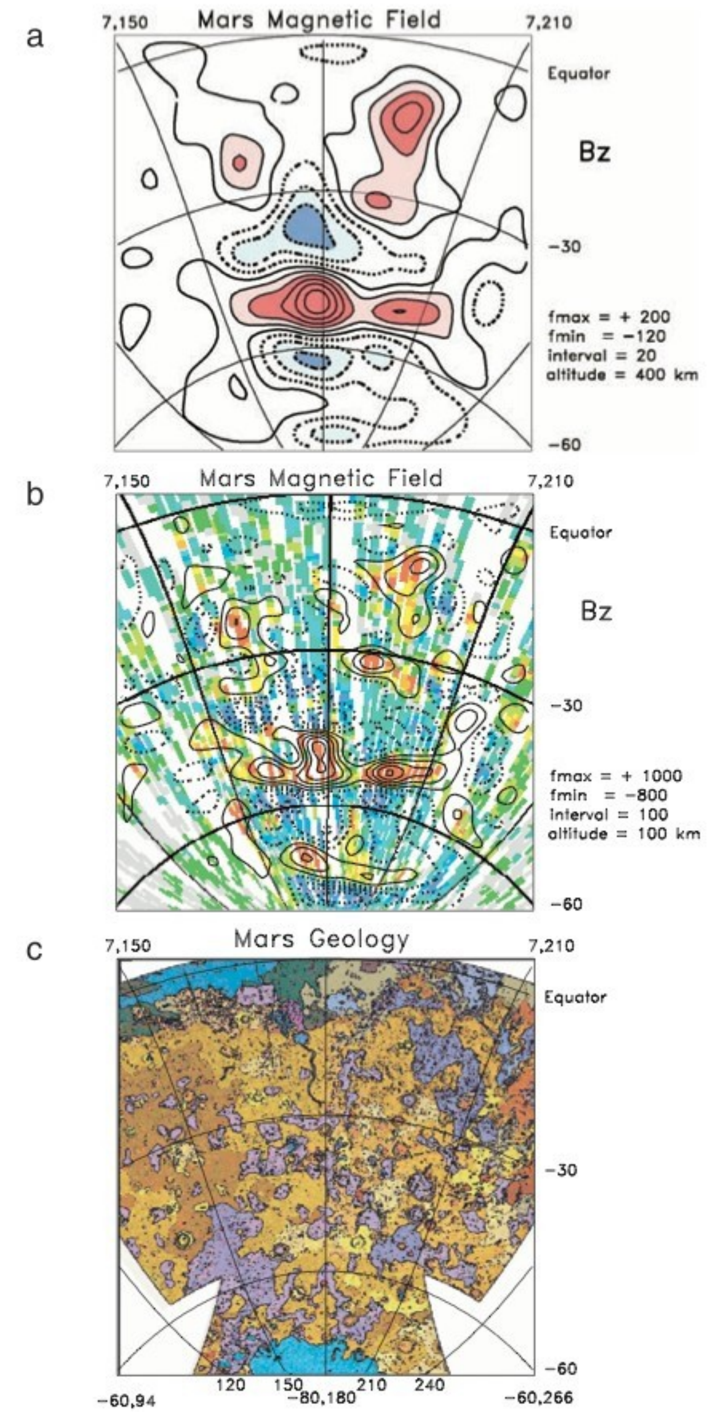


Table 1. Possible magnetic minerals of the Martian crust, their Curie temperatures [46], and the depth at which their Curie temperature is reached for multiple estimates of Martian heat flux ~3.7 - 4.5 Ga. Magnetic minerals are considered end members if part of a series (e.g., magnetite-titanomagnetite). The magnetized depth is calculated using $(Tc - Ts)k/F$, where k is thermal conductivity (3 W/(m·K)), Tc is Curie temperature (K), Ts is surface temperature (assumed to be 230 K [33]), and F is heat flux (W/m^2).

Likely Magnetic Minerals	Curie Temp (K)	Magnetized depth 1a (km)	Magnetized depth 2b (km)	Magnetized depth 3c (km)	Magnetized depth 4d (km)	Magnetized depth 5e (km)	Magnetized depth 6f (km)	Magnetized depth 7g (km)
titanomagnetite	123	-	-	-	-	-	-	-
magnetite	853	6.2	18.7 - 934.5	27.9 - 35.3	28.3	58.4 - 109.9	37.4 - 93.5	32.8 - 50.5
titanohematite	73	-	-	-	-	-	-	-
hematite	953	7.2	21.7 - 1084.5	32.4 - 40.9	32.9	67.8 - 127.6	43.4 - 108.5	38.1 - 58.6
pyrrhotite	598	3.7	11 - 552	16.5 - 20.8	16.7	34.5 - 64.9	22.1 - 55.2	19.4 - 29.8

a Using a 4.5 Ga heat flux of 300 mW/m^2 [42]. b Using a 4 Ga heat flux range of ~2 - 100 mW/m^2 [41]. c Using a 4 Ga heat flux range of 53 - 67 mW/m^2 [29]. d Using a 4 Ga heat flux of 66 mW/m^2 [22]. e Using a 4.0 - 3.7 Ga global mean heat flux range of 17 - 32 mW/m^2 [45], with the true value likely closer to the lower heat flux bound. f Using a >3.7 Ga heat flux range of 20 - 50+ mW/m^2 [44]. g Using an "early" Mars heat flux range of 37 - 57 mW/m^2 for Terra Cimmeria, Arabia Terra, and Noachis Terra [28].

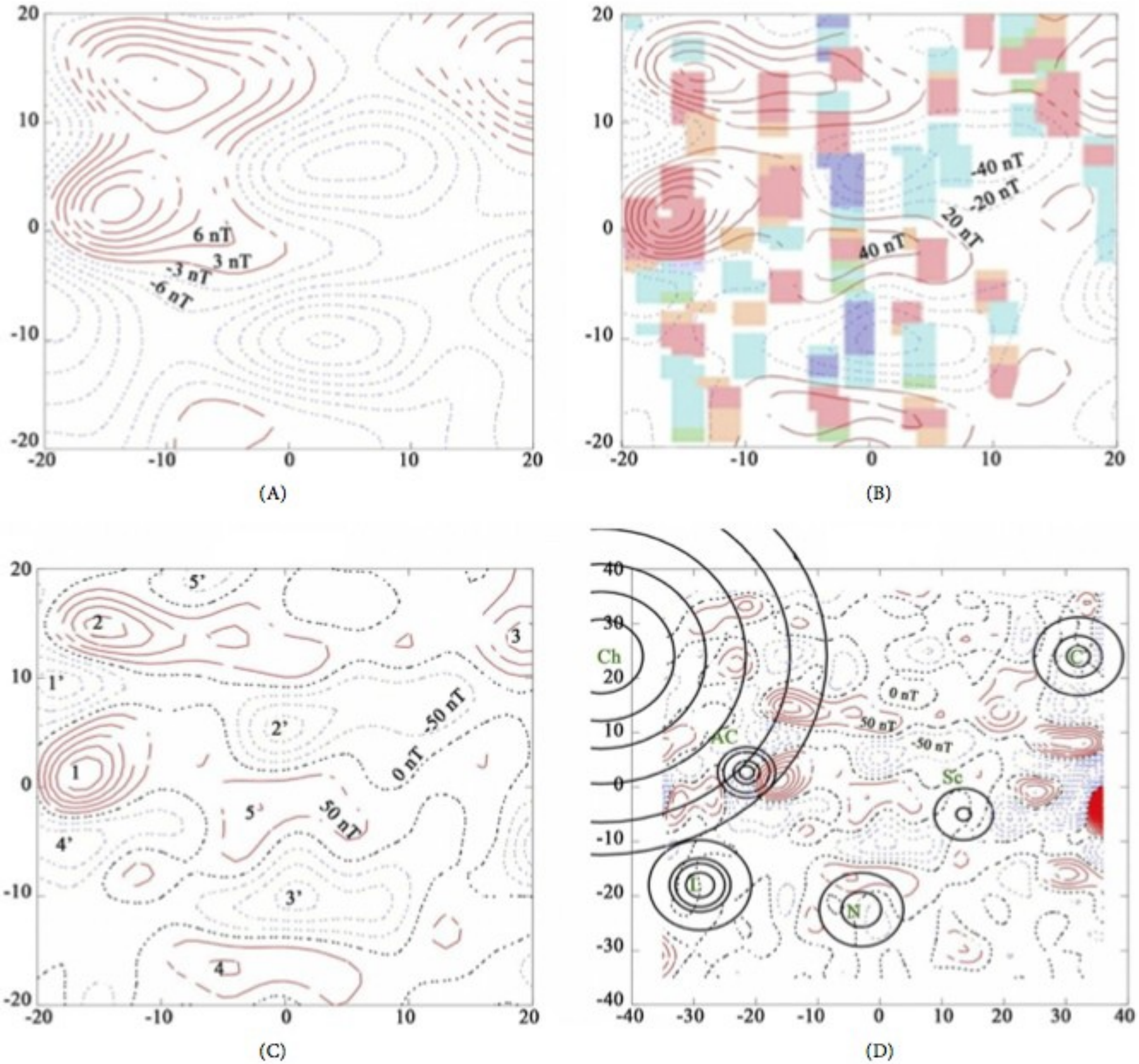


Figure 1. Magnetization in Terra Meridiani. Each base map uses MGS MAG Br data, where red contours represent positive anomalies and blue contours represent negative anomalies (black lines are 0 nT). (A) Data collected at 400 km (mapping) altitude (contour interval of 3 nT); (B) 400 km data downward continued to 110 km (contour interval of 20 nT) and correlated with aerobraking data (swaths) collected at the same altitude. In the swaths, red represents Br > 150 nT, orange is 150 > Br > 50, green represents −50 < Br < −150, light blue represents −150 < Br < −250, and dark blue represents Br < −250 nT; (C) 400 km data downward continued to the surface (contour interval is 50 nT). The numbers correspond to possible sources of magnetization; (D) Surface magnetization (contour interval is 50 nT) expanded to ~35° × 35° with regional multi-ringed basins [49] (Ch = Chryse, L = Ladon, AC = Aram Chaos, N = overlapped by Newcomb, Sc = overlapped by Schiaparelli, C = Cassini).

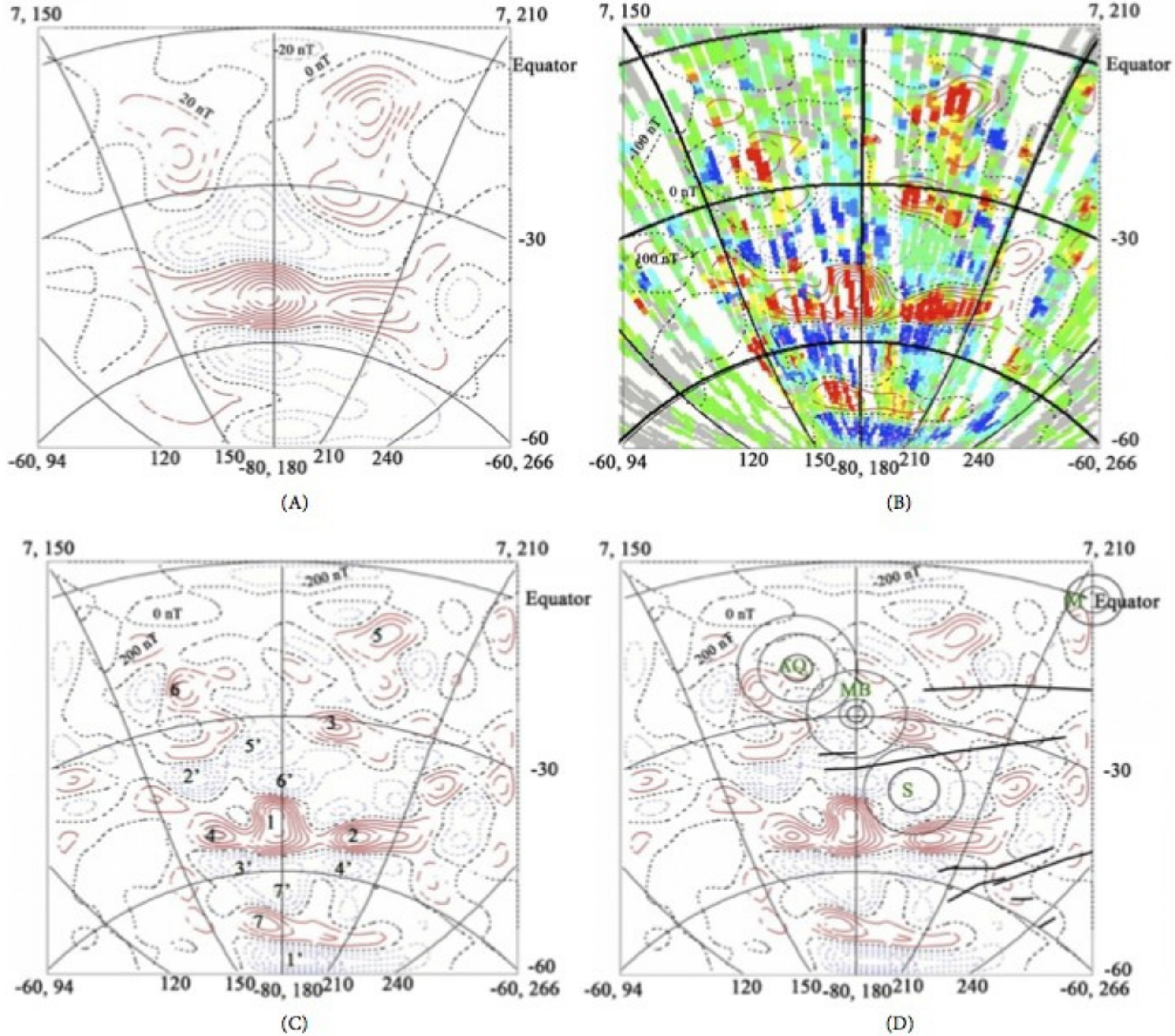


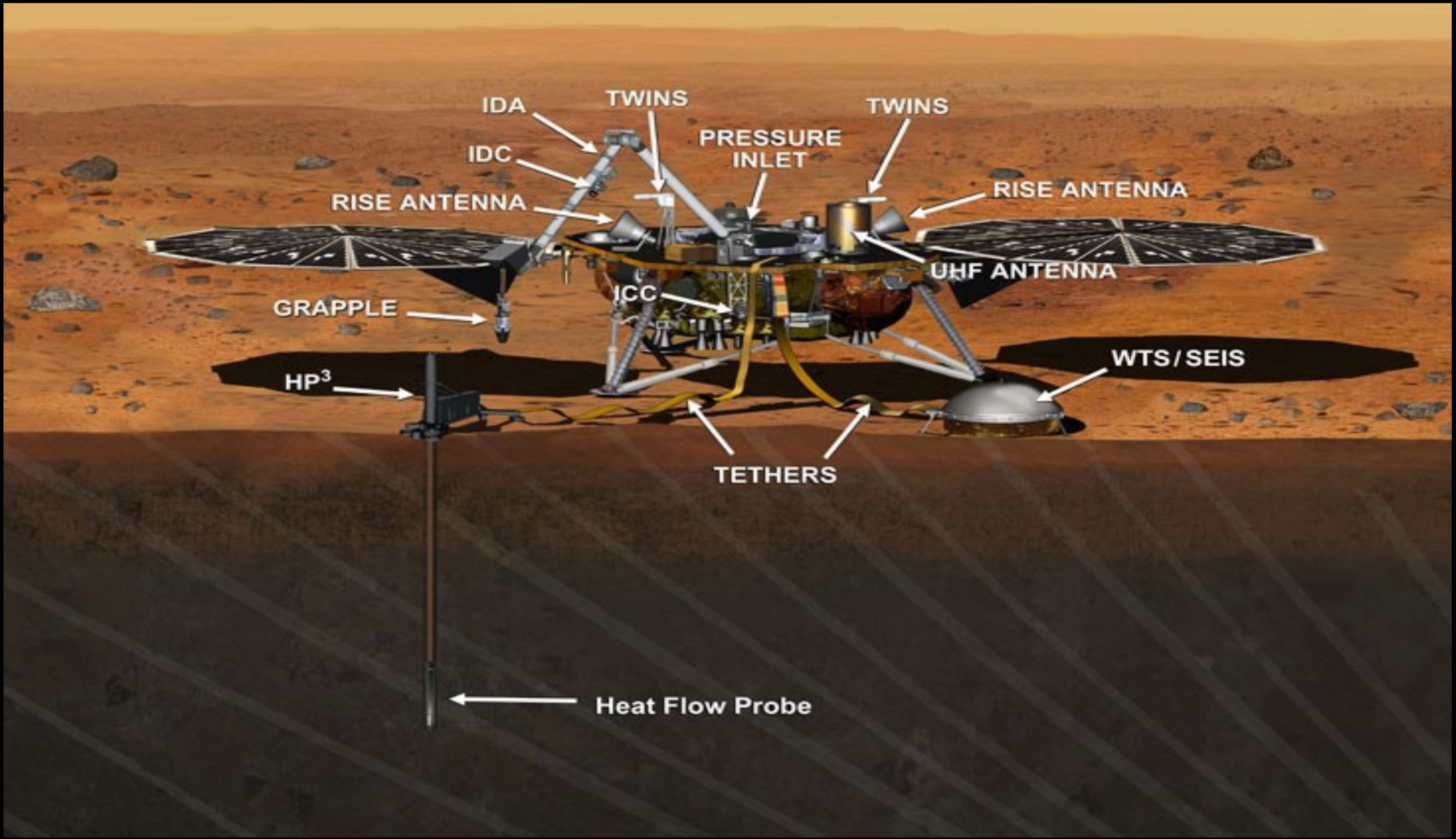
Figure 2. Magnetization in Terra Sirenum. Each base map uses MGS MAG Br data. (A) Data collected at 400 km (mapping) altitude (contour interval is 20 nT); (B) 400 km data downward continued to 100 km (contour interval is 100 nT) and correlated with aerobraking data (swaths) collected at the same altitude. Dark red represent strongly positive while dark blue represents strongly negative; (C) 400 km data downward continued to the surface (contour interval 200 nT). The numbers correspond to depth estimates; (D) Surface magnetization (contour interval 200 nT) with mapped faults [14] [15] and mapped regional multi-ringed basins [49] [50] (AQ = Al Qahira, MB = Memnonia-B, S = Sirenum, M = Mangala).

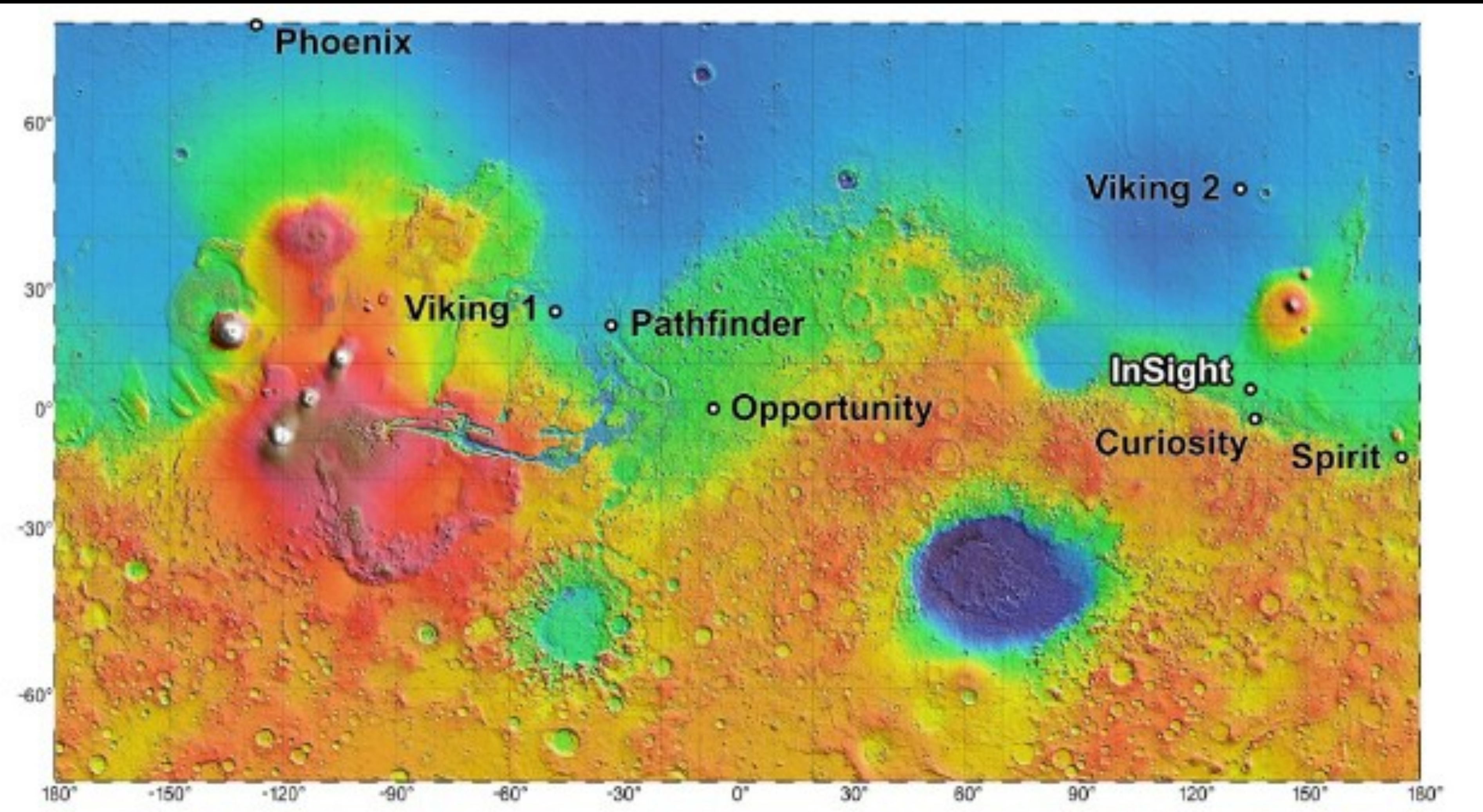
INSIGHT Mars Mission

λ**In**terior Exploration using **S**eismic **I**nvestigations, **G**eodesy and **H**eat **T**ransport.

λThe mission's objective is to study early geological evolution.

λLaunching May 5, 2018


IDA
TWINS
TWINS
PRESSURE
INLET
IDC
RISE ANTENNA
RISE ANTENNA
UHF ANTENNA
ICC
GRAPPLE
WTS / SEIS
HP3
TETHERS
Heat Flow Probe



Phoenix
Viking 2
Viking 1
Pathfinder
InSight
Opportunity
Curiosity
Spirit
60°
30°
0°
-30°
-60°
180°
-150°
-120°
-90°
-60°
-30°
0°
30°
60°
90°
120°
150°
180°

Conclusions

- *Mars had a magnetic field early in its history.*
- *Martian crust either very strongly magnetized or extending to great depth. Perhaps both.*
- *True Polar Wander may have occurred on Mars.*
- *InSight lander will include seismometer and heat flow experiment, projected launch May 5, 2018.*

Sunset on Mars (Spirit)