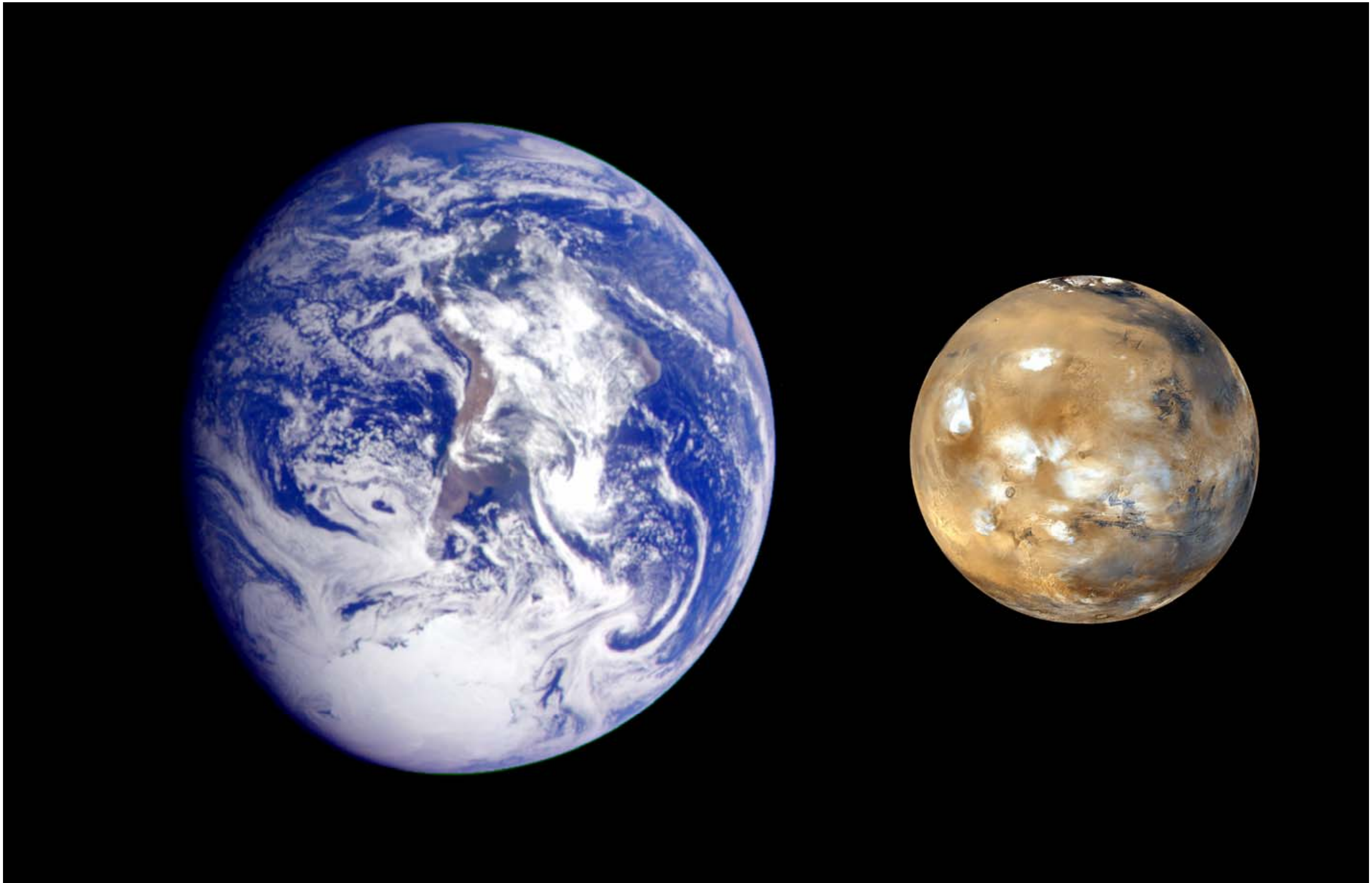
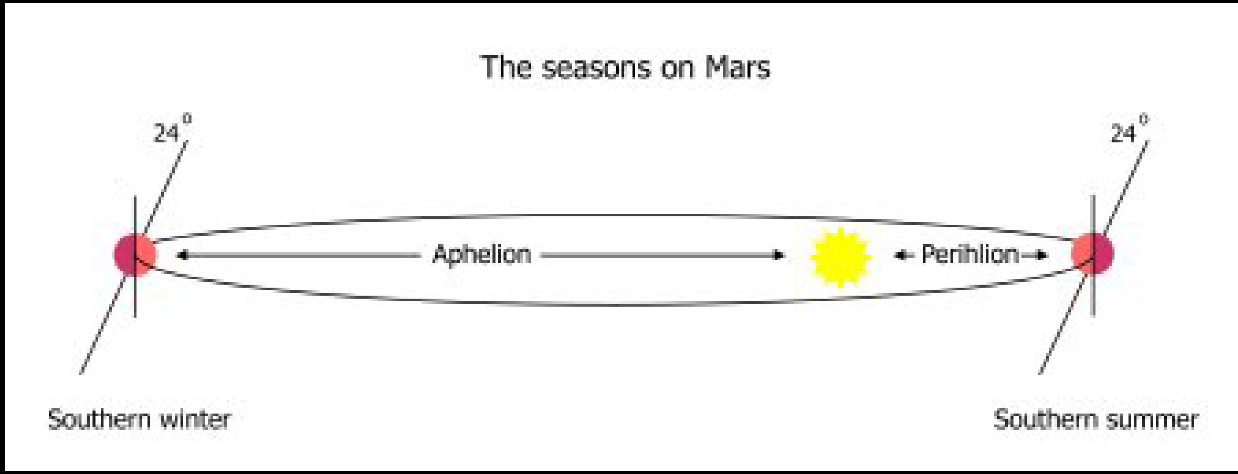


Planetary Comparison

	MARS	EARTH
Mean radius:	3390 km	6371 km
Semi-major axis:	1.523 AU	1 AU
Obliquity:	25.19° (NOW!)	23.45°
Length of day:	24 h, 37 m	24 h
Orbital period:	686 Earth days	365.2 days
Surface gravity:	3.7 m/s^2	9.78 m/s^2
Atmosphere:	95.3 % CO_2	78 % N_2
	2.7 % N_2	20.9 % 0_2
Surface Pressure:	5.6 mbar	1014 mbar

Ratio of total surface area on Mars to that on Earth (land): 0.976



Season	Earth	Mars
Spring	93	171
Summer	94	199
Fall	89	171
Winter	89	146

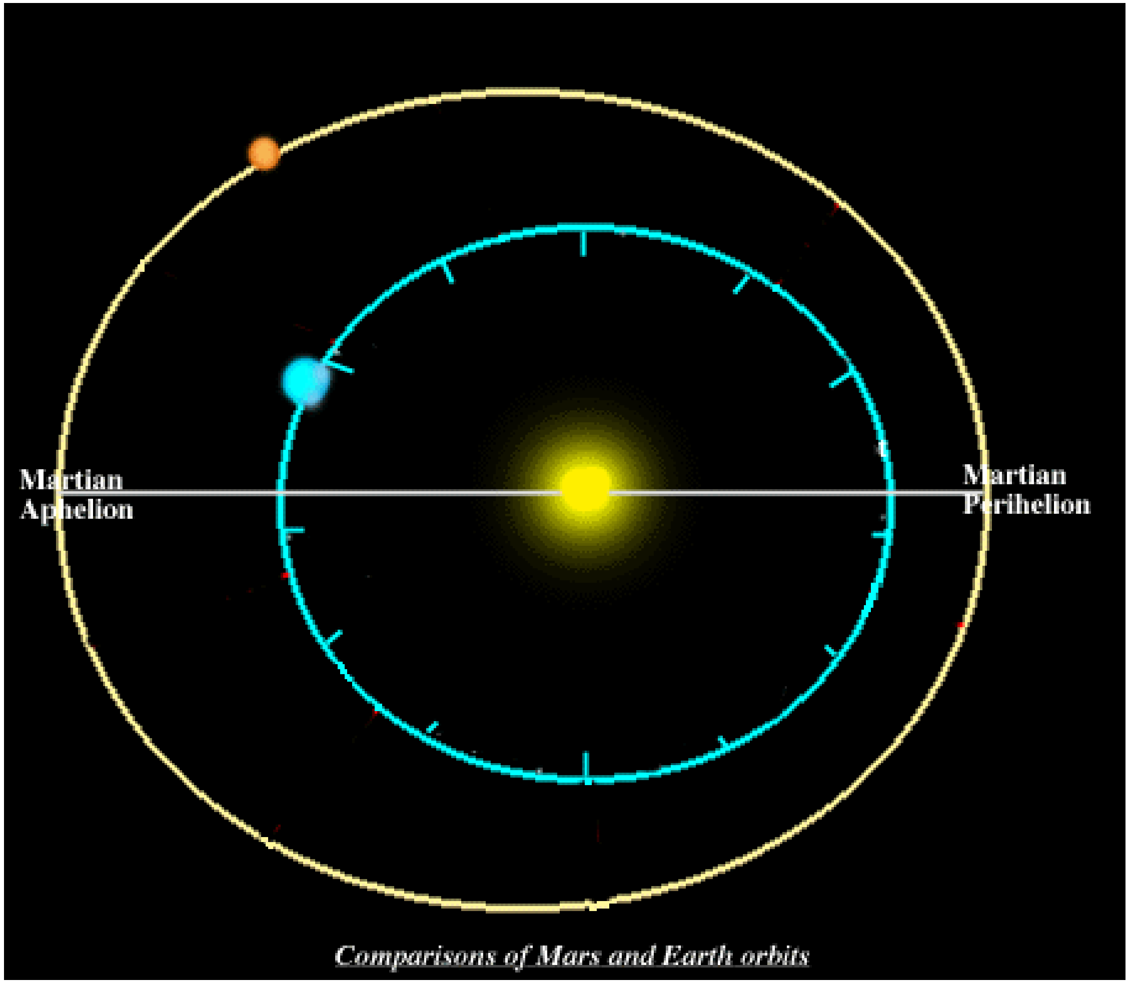
Northern Hemisphere has a short and more “mild” winter while summer is long and cool

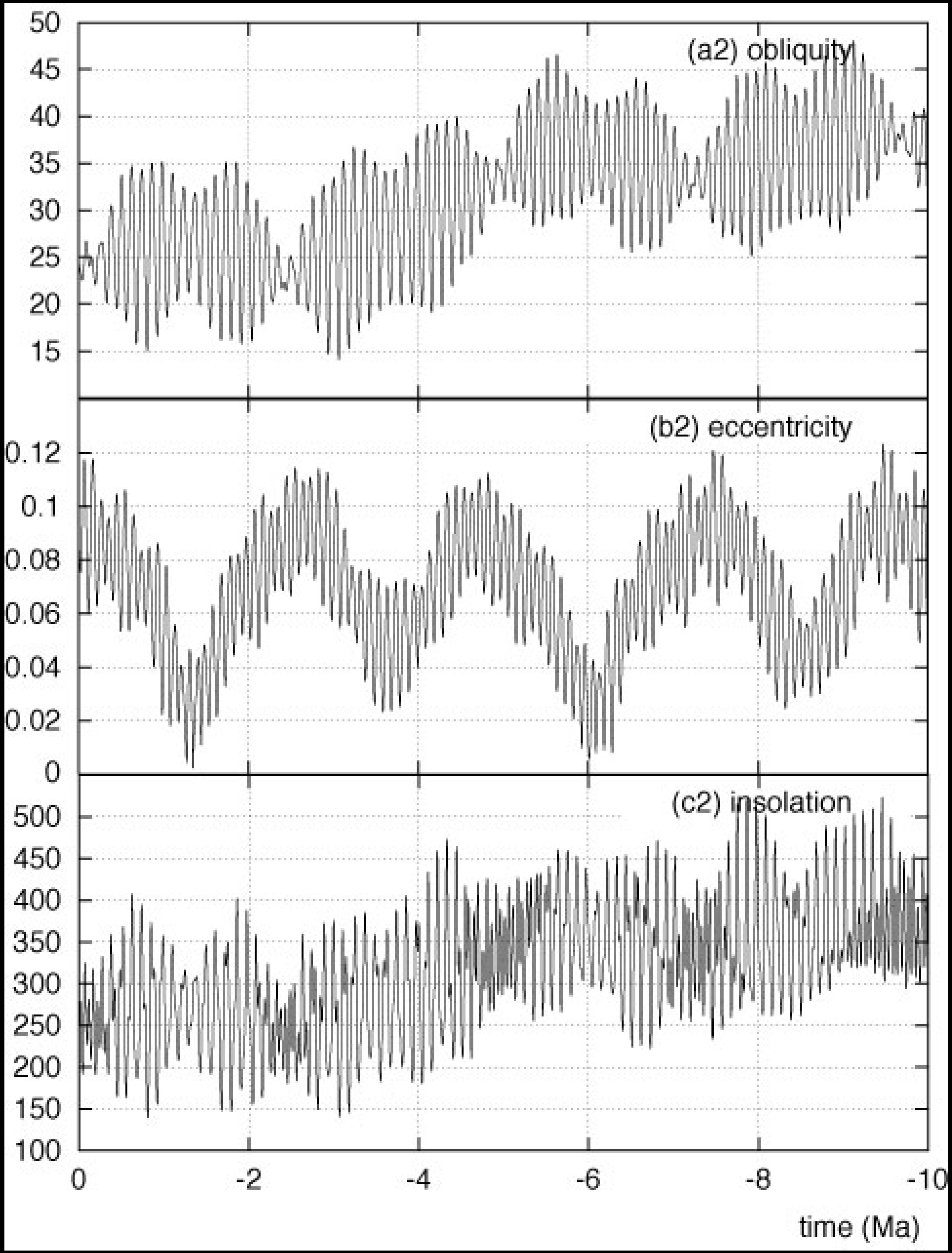
Southern Hemisphere has a short and hot summer while the winter is long and cold

Martian Orbital Parameters

Obliquity cycle = 120,000 yr
Precession cycle = 51,000 yr
Eccentricity = 0.093

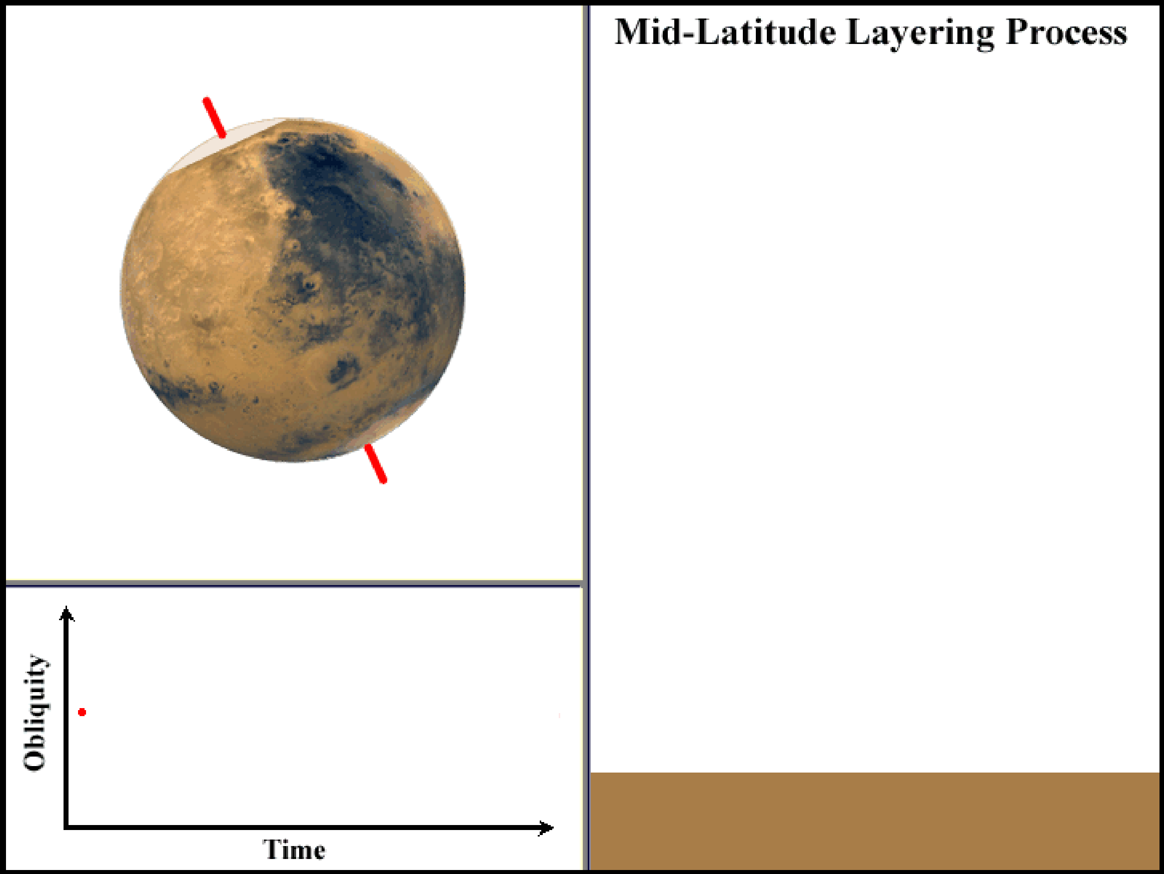
vs. Earth
Obliquity = 41,000 yr
Precession = 26,000 yr
Eccentricity = 0.017





Reproduced in
Laskar, et al. 2002

Effects of Obliquity Changes



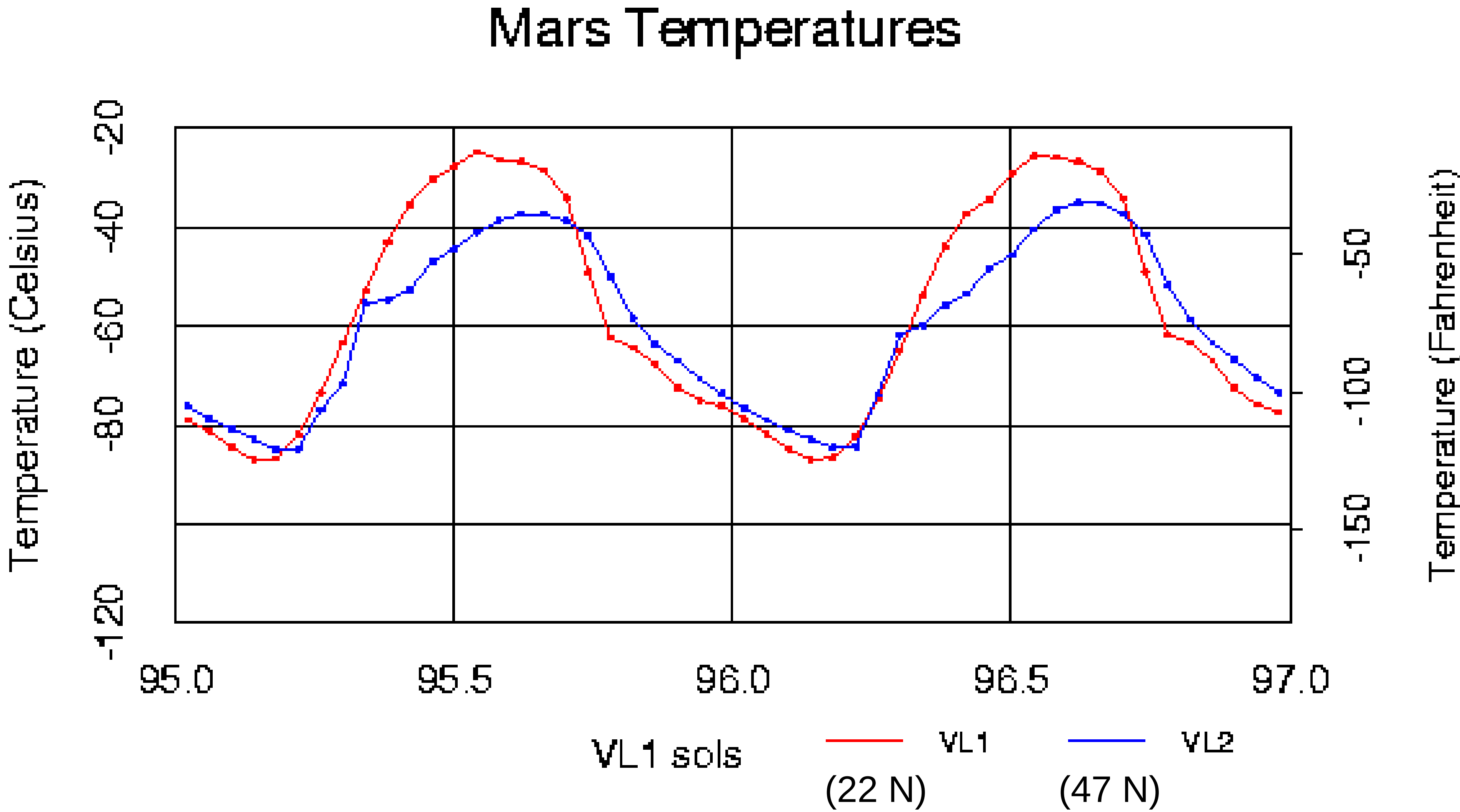
movie credit:
M. Mischna

LOW OBLIQUITY

-More sun at equator
-CO_2 condenses/sublimates at poles

HIGH OBLIQUITY

-More sun at poles
-Atm Pressure increases and
dust rises



Daily temperature range at the Viking lander site was about 60 C

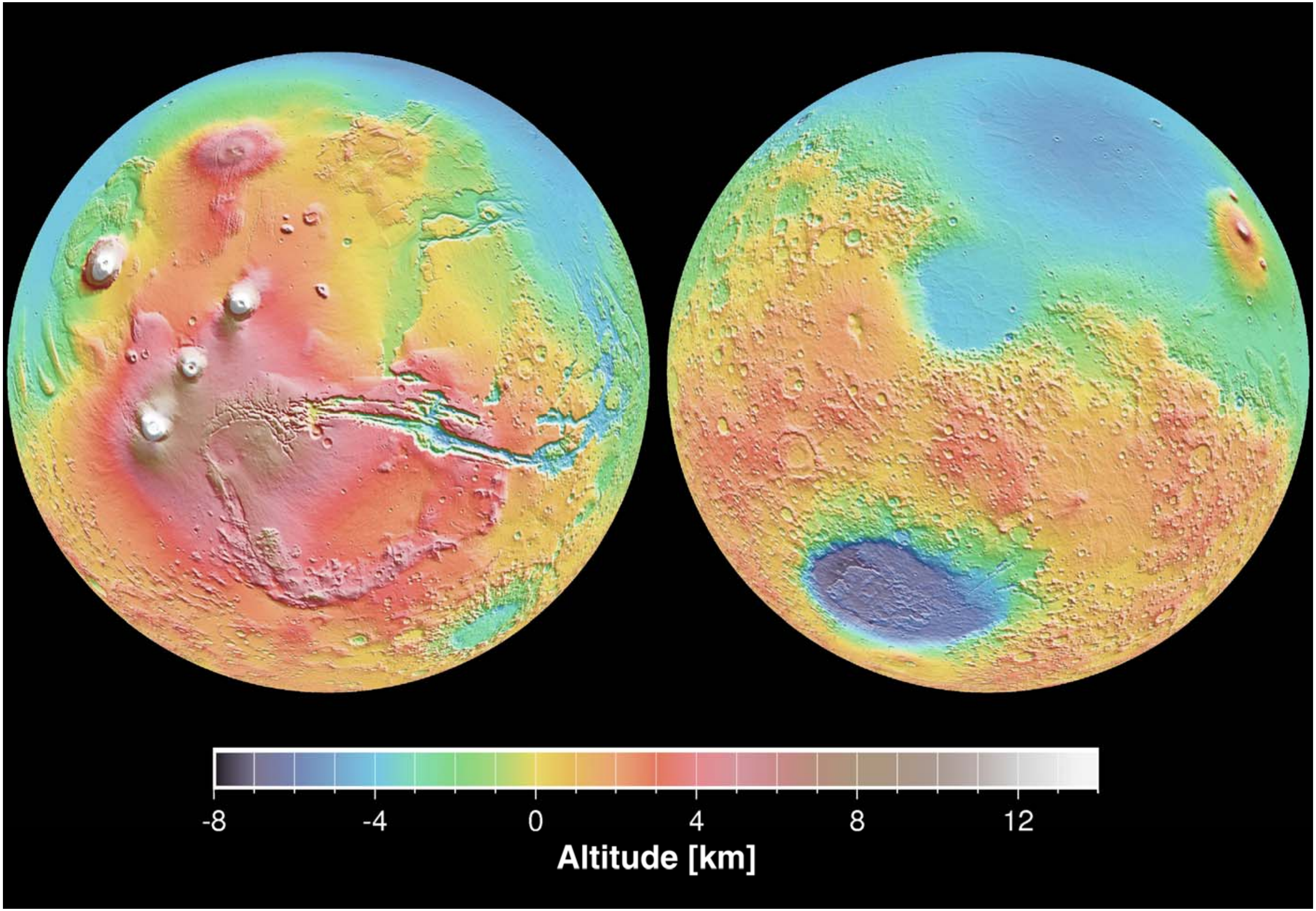
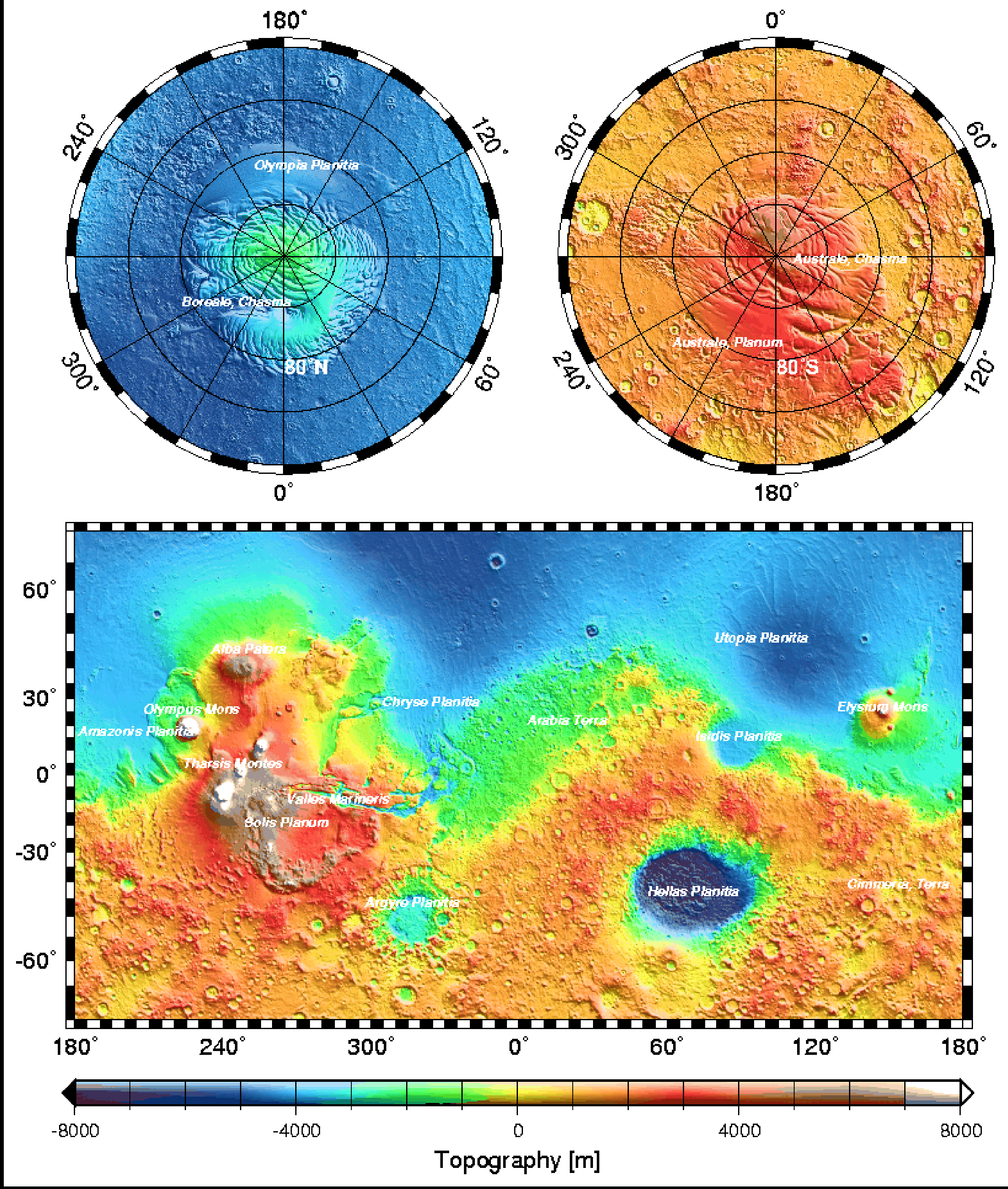


Image Credit: MOLA Science Team

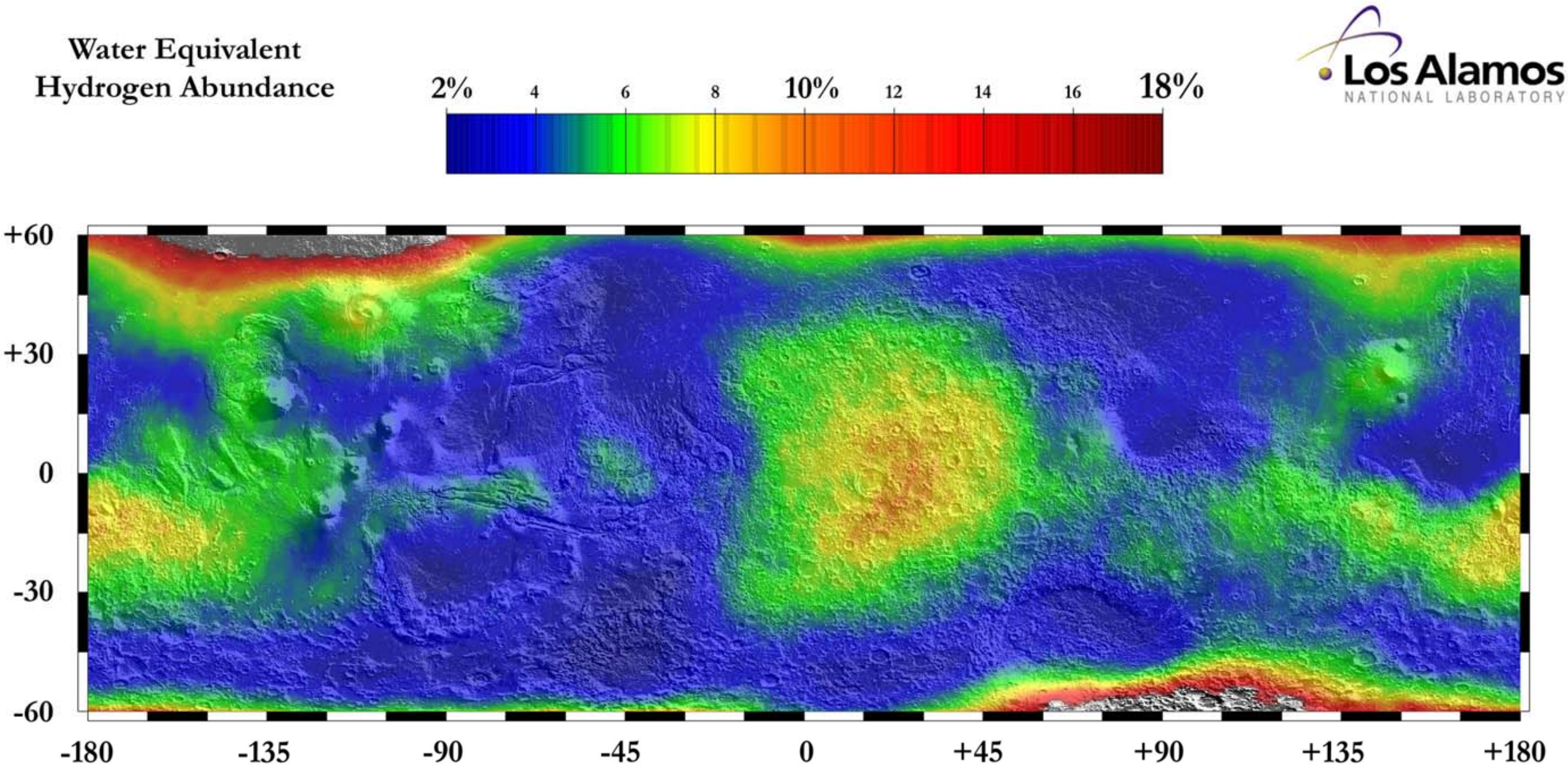
North



South

Southern Highlands about 6 km higher than Northern Lowlands

Image Credit: MOLA Science Team



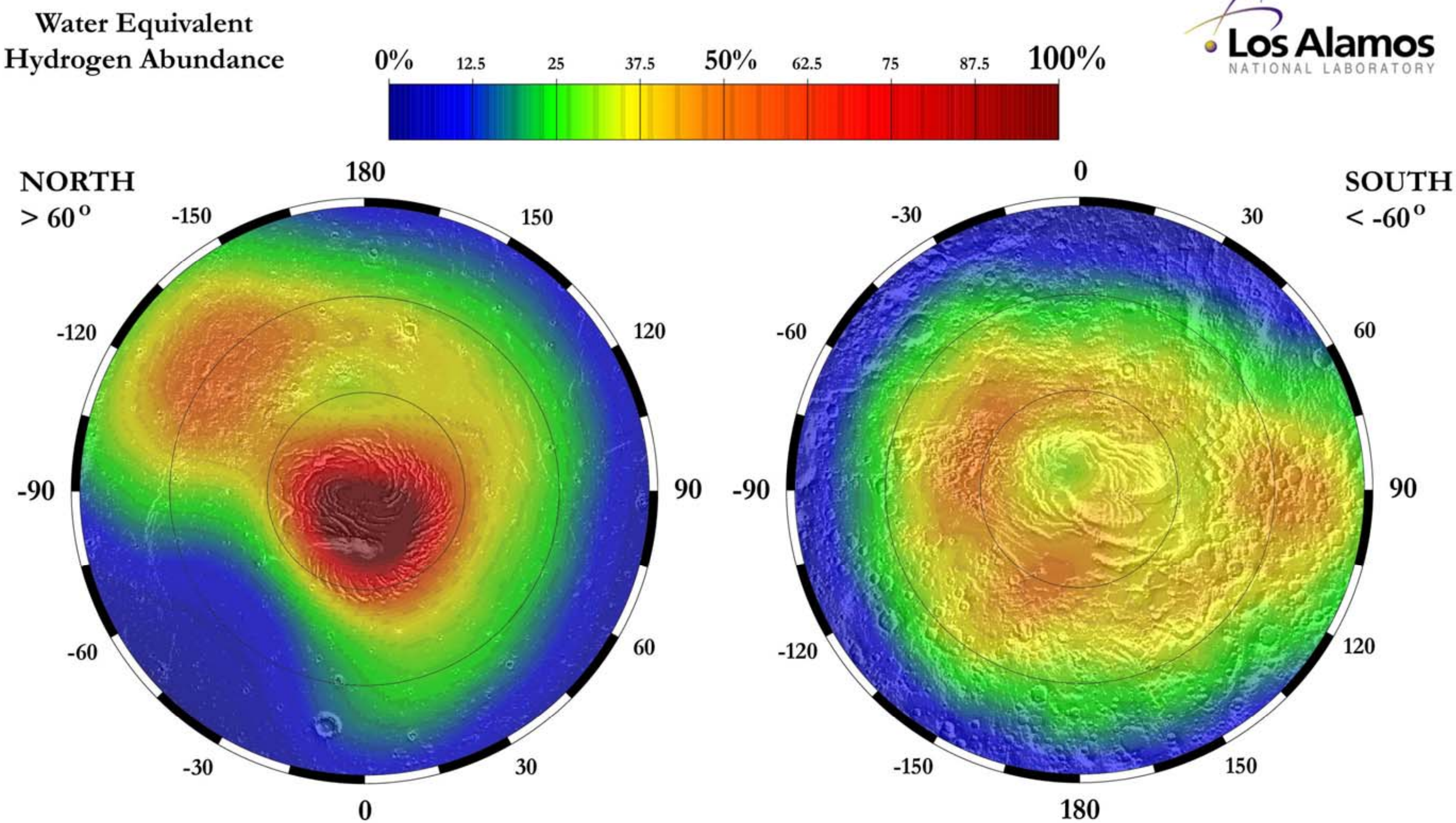
Distribution of Water on Mars: Overlay of water equivalent hydrogen abundances and a shaded relief map derived from MOLA topography. Mass percents of water were determined from epithermal neutron counting rates using the Neutron Spectrometer aboard Mars Odyssey between Feb. 2002 and Apr. 2003.

Reference: Feldman W. C., T. H. Prettyman, S. Maurice, J. J. Plaut, D. L. Bish, D. T. Vaniman, M. T. Mellon, A. E. Metzger, S. W. Squyres, S. Karunatillake, W. V. Boynton, R. C. Elphic, H. O. Funsten, D. J. Lawrence, and R. L. Tokar, The global distribution of near-surface hydrogen on Mars, *JGR-planets*, submitted July 2003.

These data were generated by the Planetary Science Team at Los Alamos: B. Barraclough, D. Bish, D. Delapp, R. Elphic, W. Feldman, H. Funsten, O. Gasnault*, D. Lawrence, S. Maurice*, G. McKinney, K. Moore, T. Prettyman, R. Tokar, D. Vaniman, and R. Wiens. * Also at Observatoire Midi-Pyrenees, France

The neutron spectrometer aboard Mars Odyssey, a component of the Gamma-ray Spectrometer suite of instruments, was designed and built by the Los Alamos National Laboratory and is operated by the University of Arizona in Tucson. The Mars Odyssey mission is managed by the Jet Propulsion Laboratory.

Gamma-Ray Spectrometer (GRS) Data



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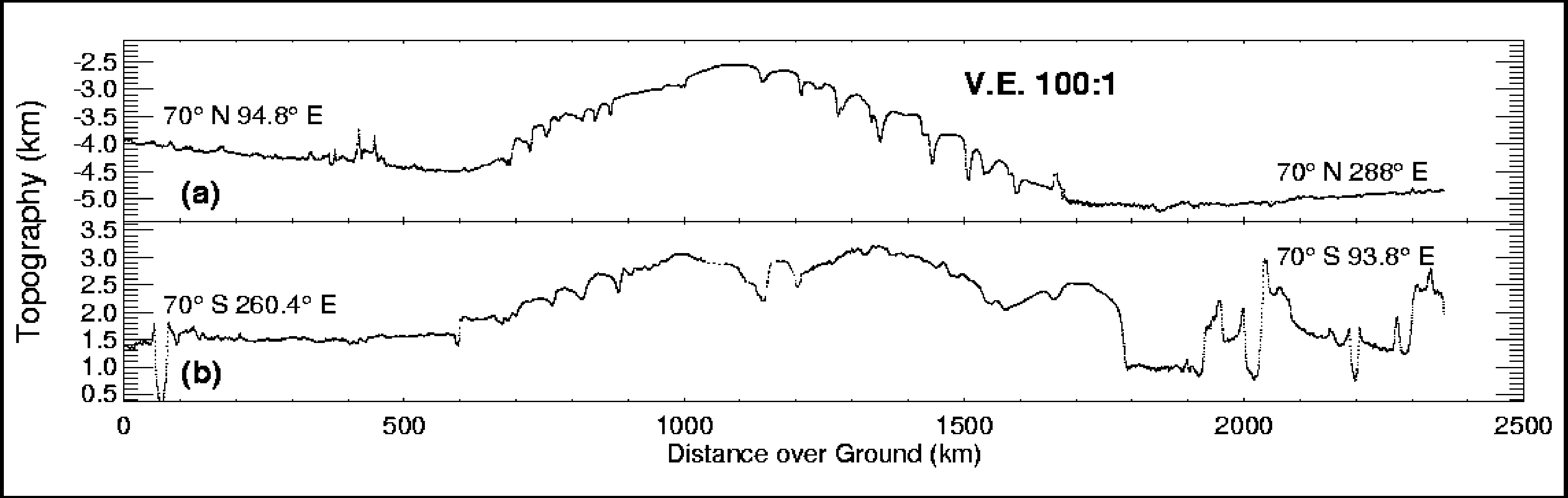
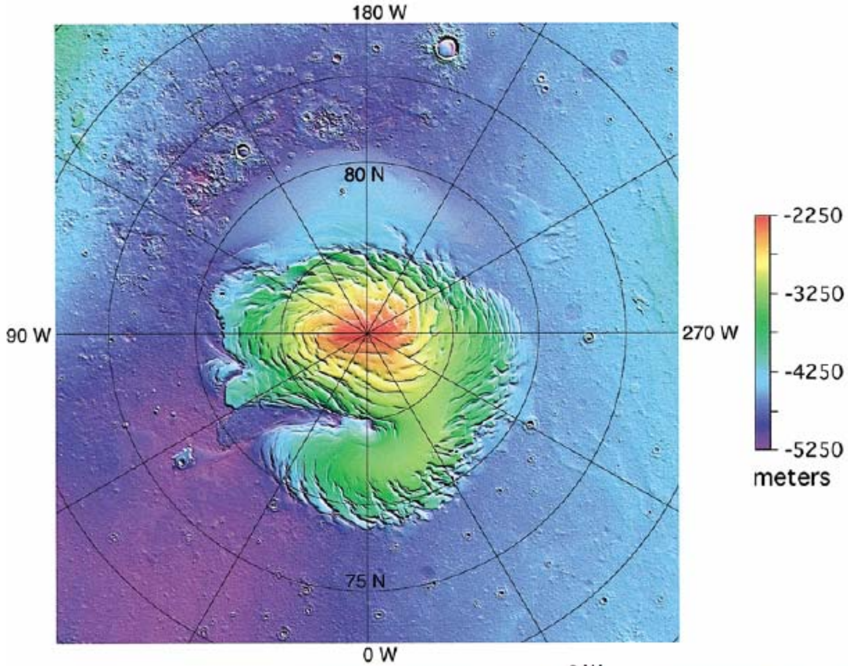
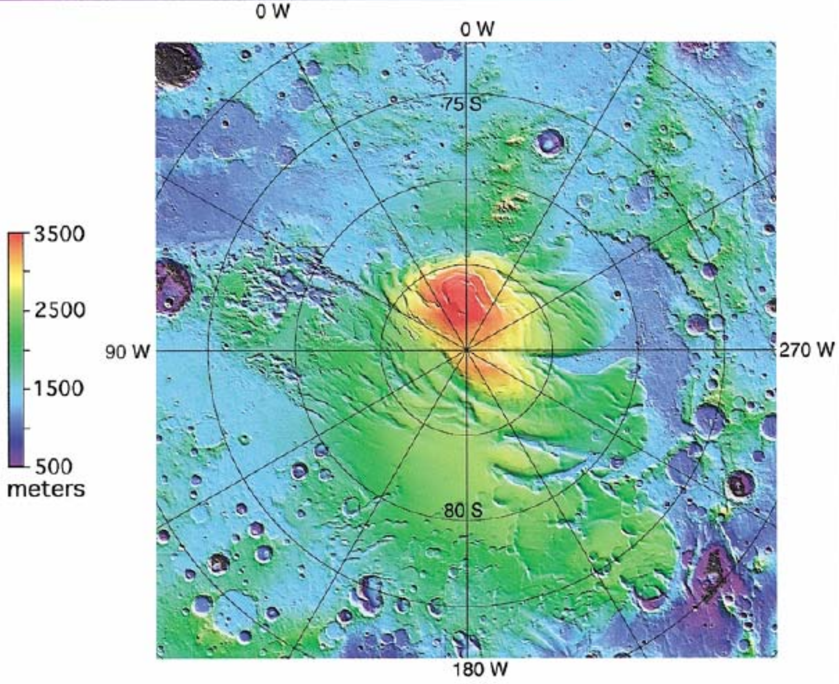
Martian Polar Regions

	NORTH	SOUTH
Residual Cap:		
Composition	H_2O ice	CO_2 ice
Diameter	1100 km	400 km
Area of PLD:	1.0 x 10^6 km^2	1.5 x 10^6 km^2
Age Estimate:	~0.1 Ma	30-100 Ma







Fishbaugh and Head (2001)

1. Basal Deposits -- meters to hundreds of meters

North: basal unit and surrounding polar sand erg (10-50 m high)
South: “Dorsa Argenta” formation

bottom

top

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bottom

2. Polar Layered Deposits (polar ice caps) -- kilometers

Layers of ice/dust (possibly CO_2 clathrate)
Troughs, scarps, chasmae

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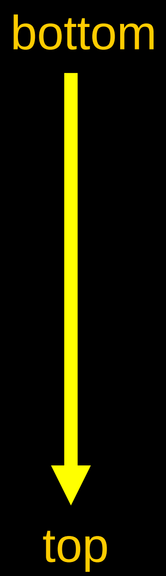

2. Polar Layered Deposits (polar ice caps) -- kilometers

Layers of ice/dust (possibly CO_2 clathrate)
Troughs, scarps, chasmae

3. Residual Ices – meters to ten meters

North: water ice; over much of the cap, ~ m thick
South: CO_2 ice – known from T_{sub} = 148 K; over small area, ~ 10 m thick

1. Basal Deposits -- meters to hundreds of meters

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bottom

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   Layers of ice/dust (possibly CO2 clathrate)
   Troughs, scarps, chasmae

top

3. Residual Ices – meters to ten meters

   North: water ice; over much of the cap, ~ m thick
   South: CO2 ice – known from T_{sub} = 148 K; over small area, ~ 10 m thick

4. Seasonal Ice – centimeters to meters

   CO_2 ice – slab ice deposits (Cryptic terrain)

What is the composition, structure, and chronology expressed in the stratigraphy of the PLD?

What are mass and energy budgets? What processes dominate on longer timescales?

What is the dynamical history?

Are there places where life is/was present?

Are the caps really as young as they look?
Was there ever a steady-state system?
Water cycling between the poles and mid-latitudes?

Martian North Pole

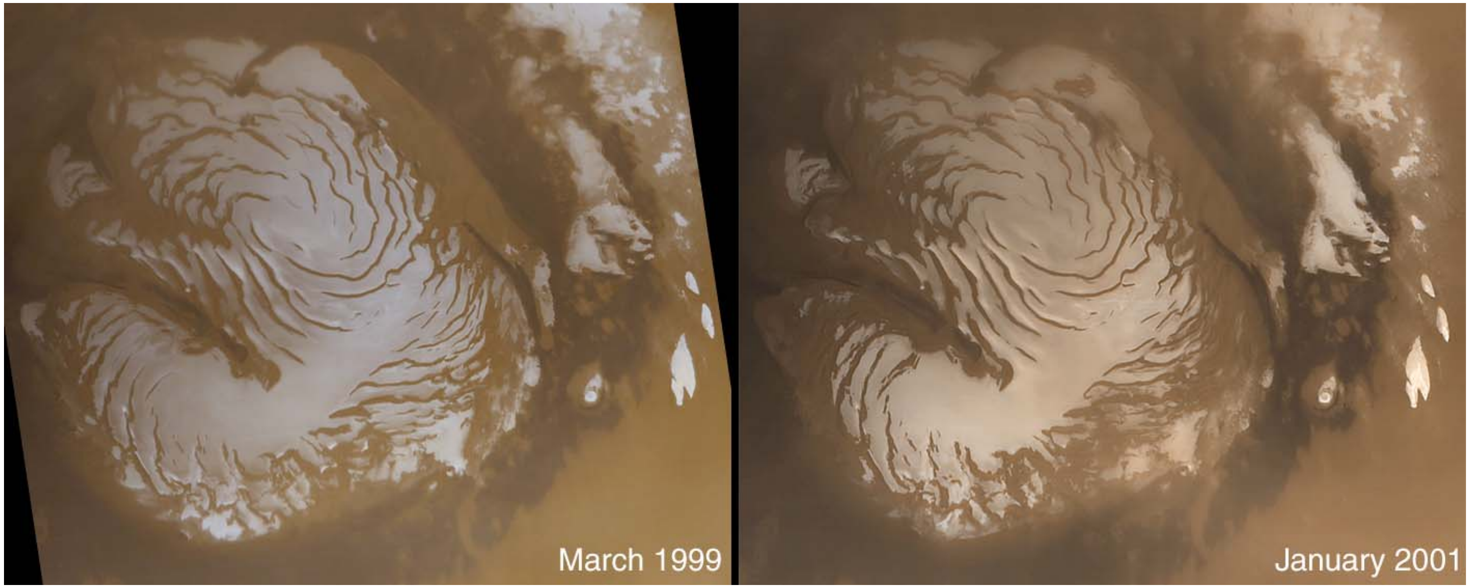


Image Credit: NASA/JPL//MSSS

- Views of residual Cap, one Martian year apart
- Dark surrounding material is sand dunes (polar erg)
- Changes in residual cap extent from changes in the heat budget
- Changes in coloration or brightness suggest that dust has been deposited

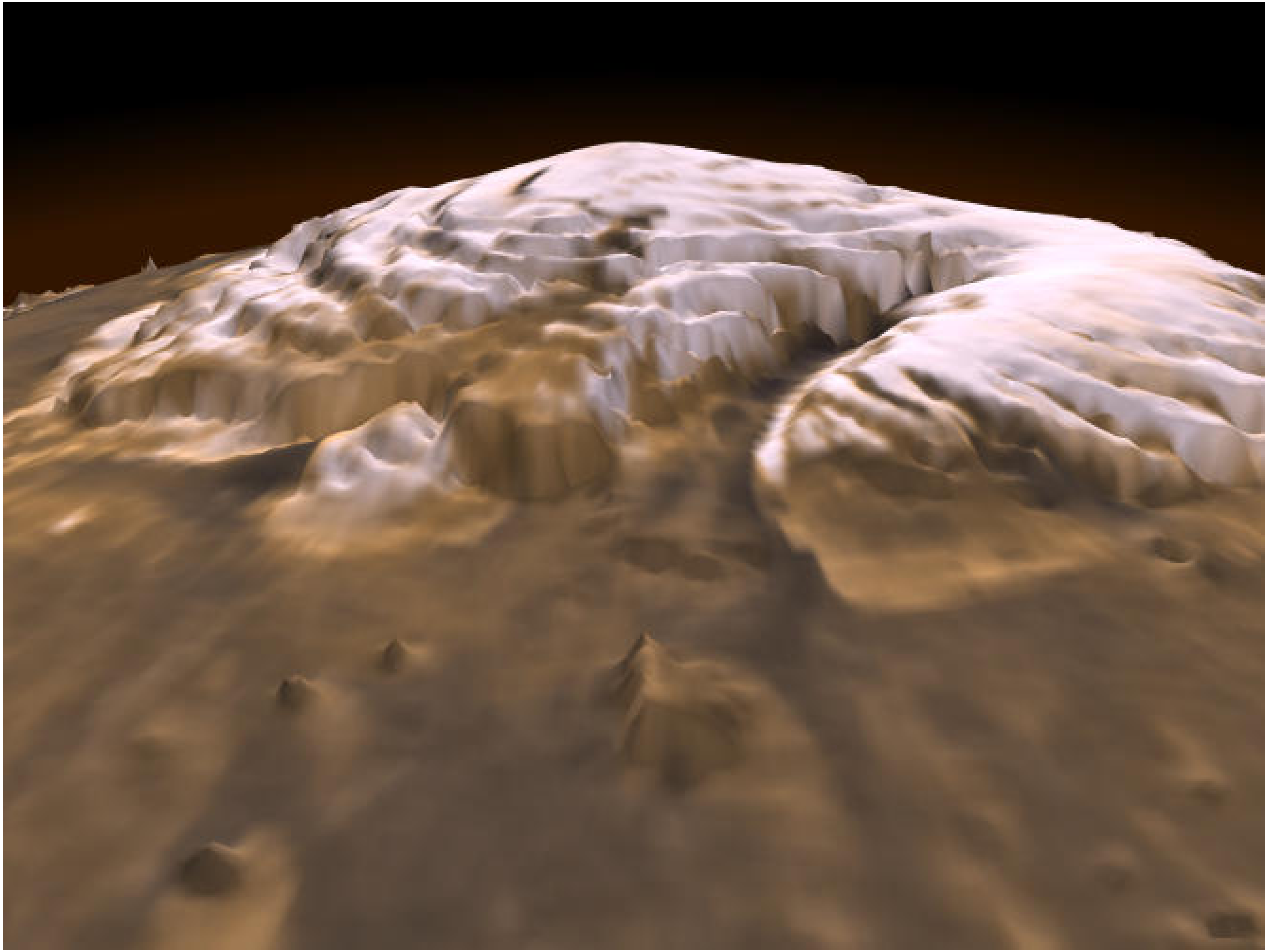
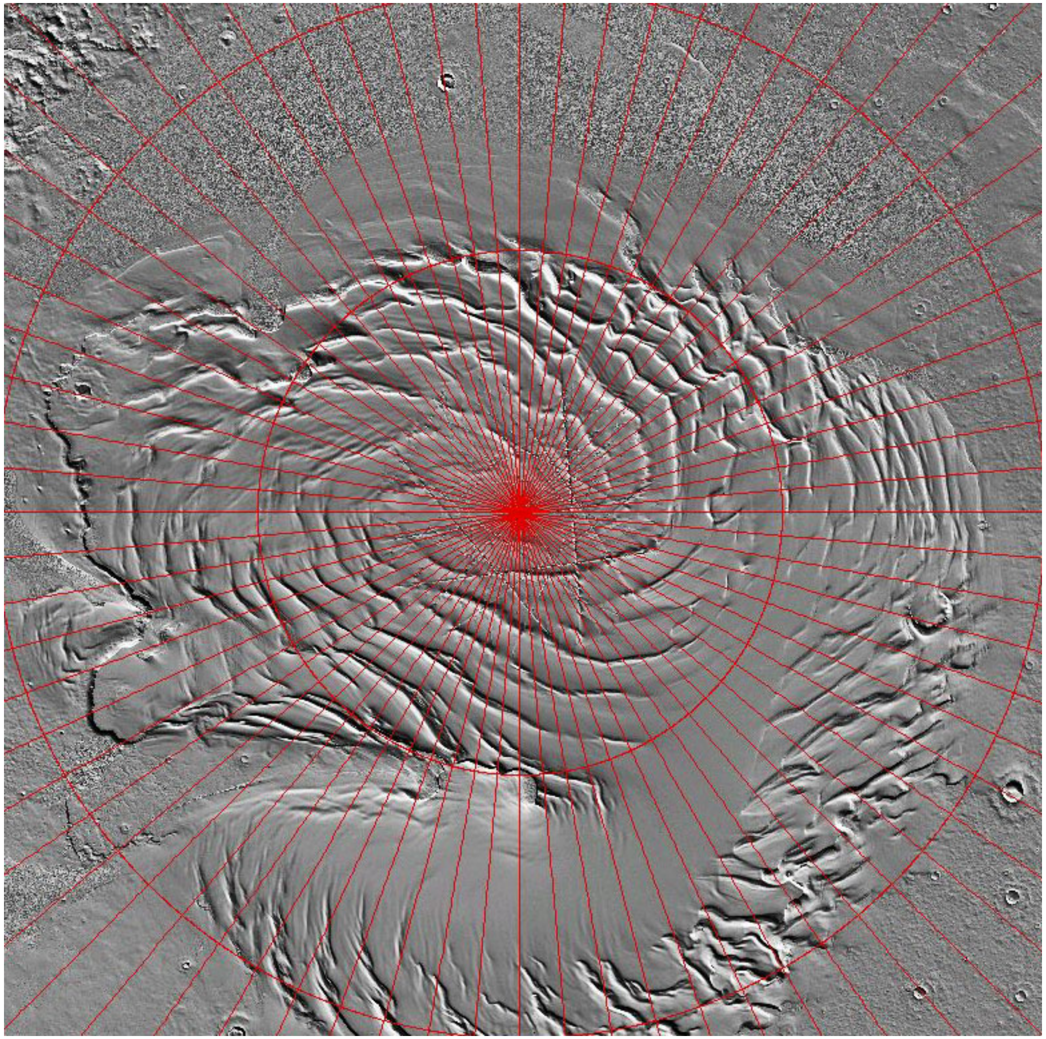


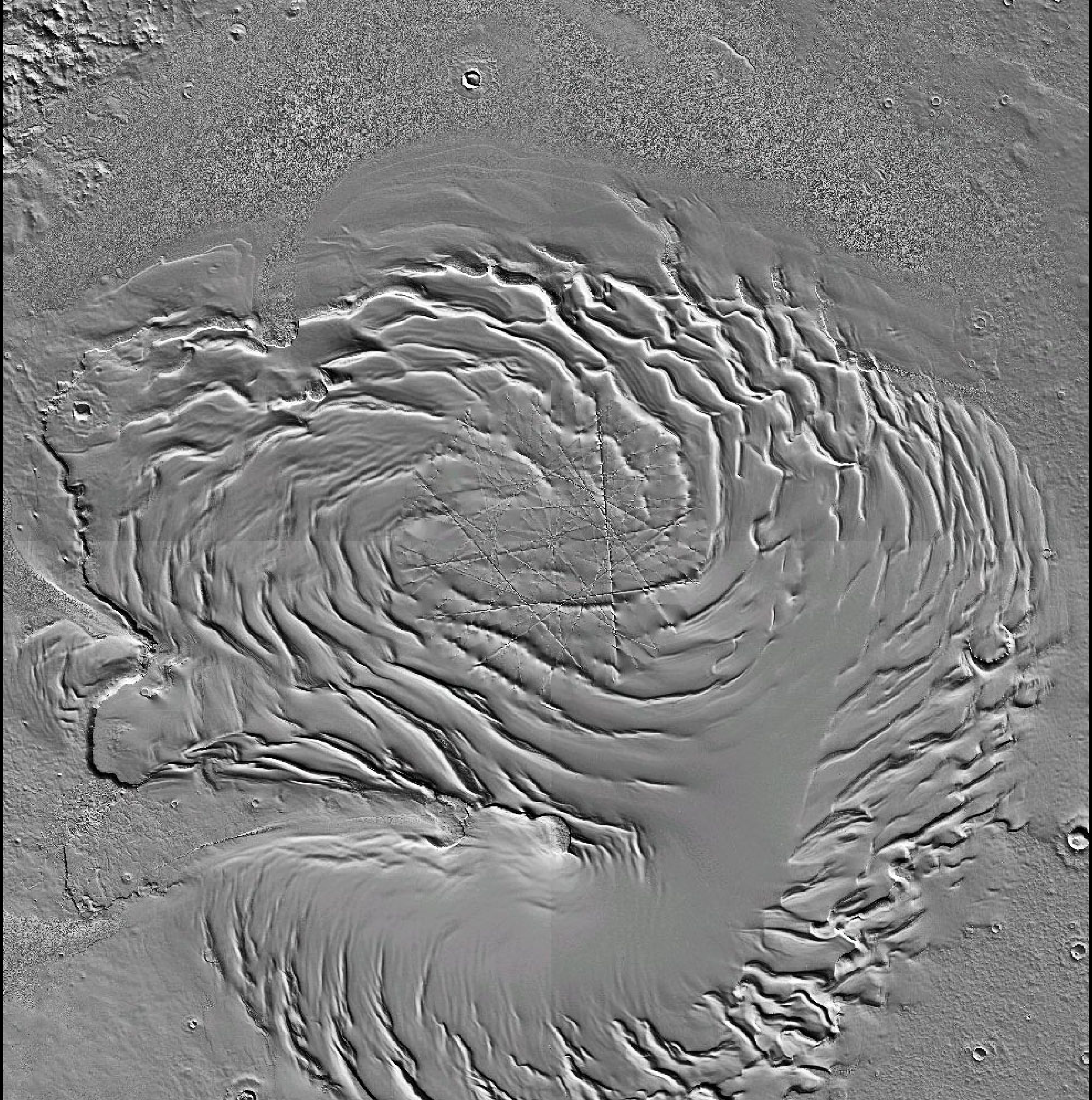
Image: MOLA Science Team

North Polar MOLA Shaded Relief Map

- Furthest extent ~80° N latitude

- Almost entirely considered residual cap



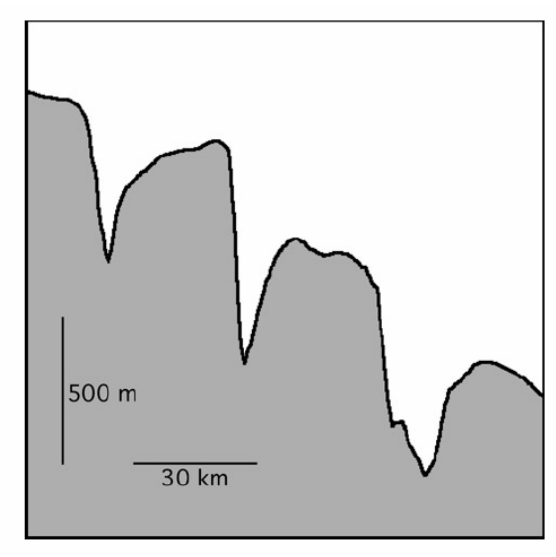


Troughs

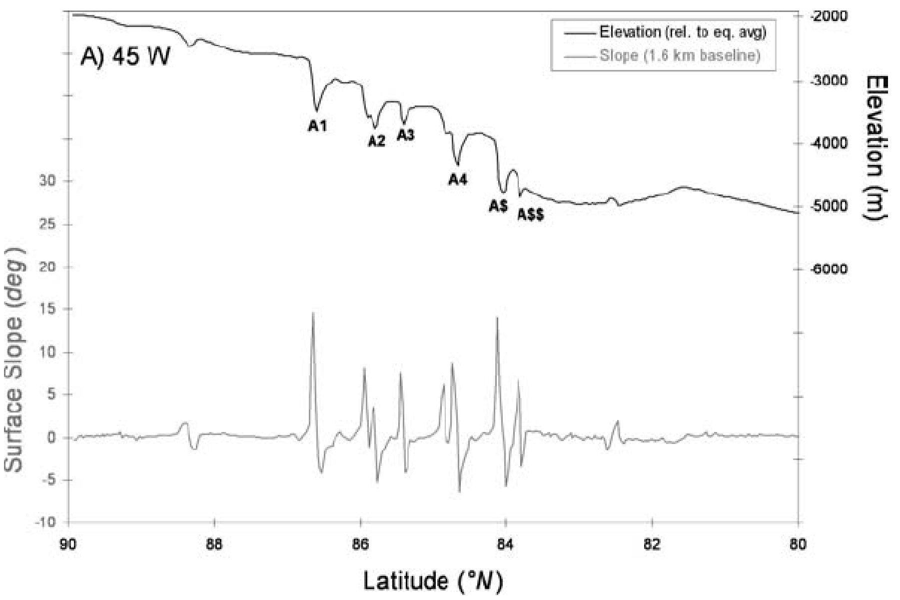
Curvilinear structures, swirl outward counter-clockwise from the pole

Enhanced steepness with increased latitude not due to latitudinal variations in sublimation

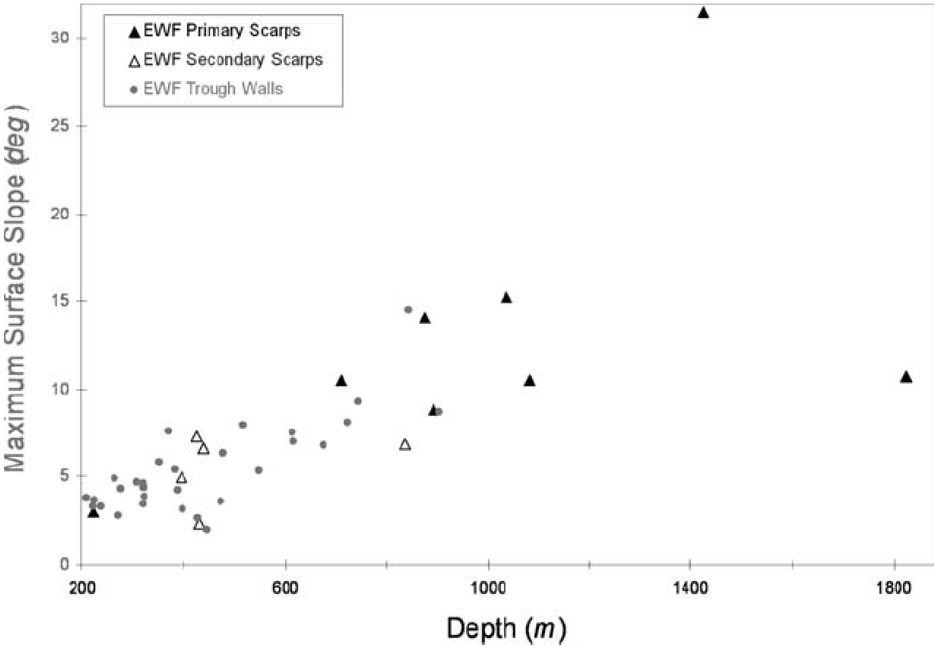
Equator facing slopes steeper than Pole facing slopes



Fishbaugh and Head (2002)



Pathare and Paige (2005)

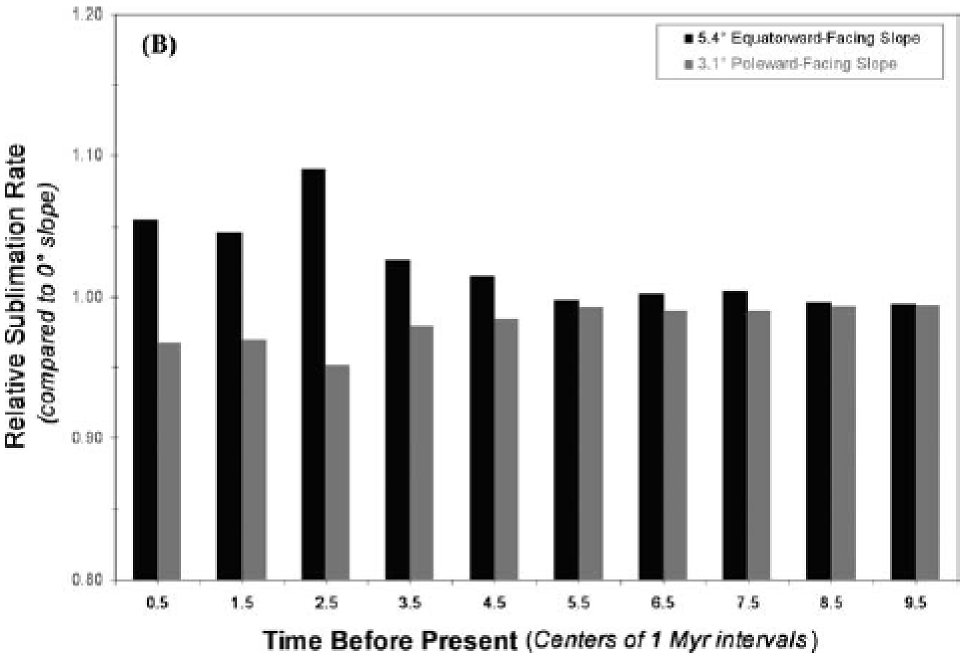


Pathare and Paige (2005)

Depth correlates with surface slope
(hard to explain by sublimation or eolian erosion)

Little long-term sublimation advantage for EWF slopes vs. PWF slopes

Most sublimation at high Obliquity (5-10 Ma)



North Polar Layered Deposits

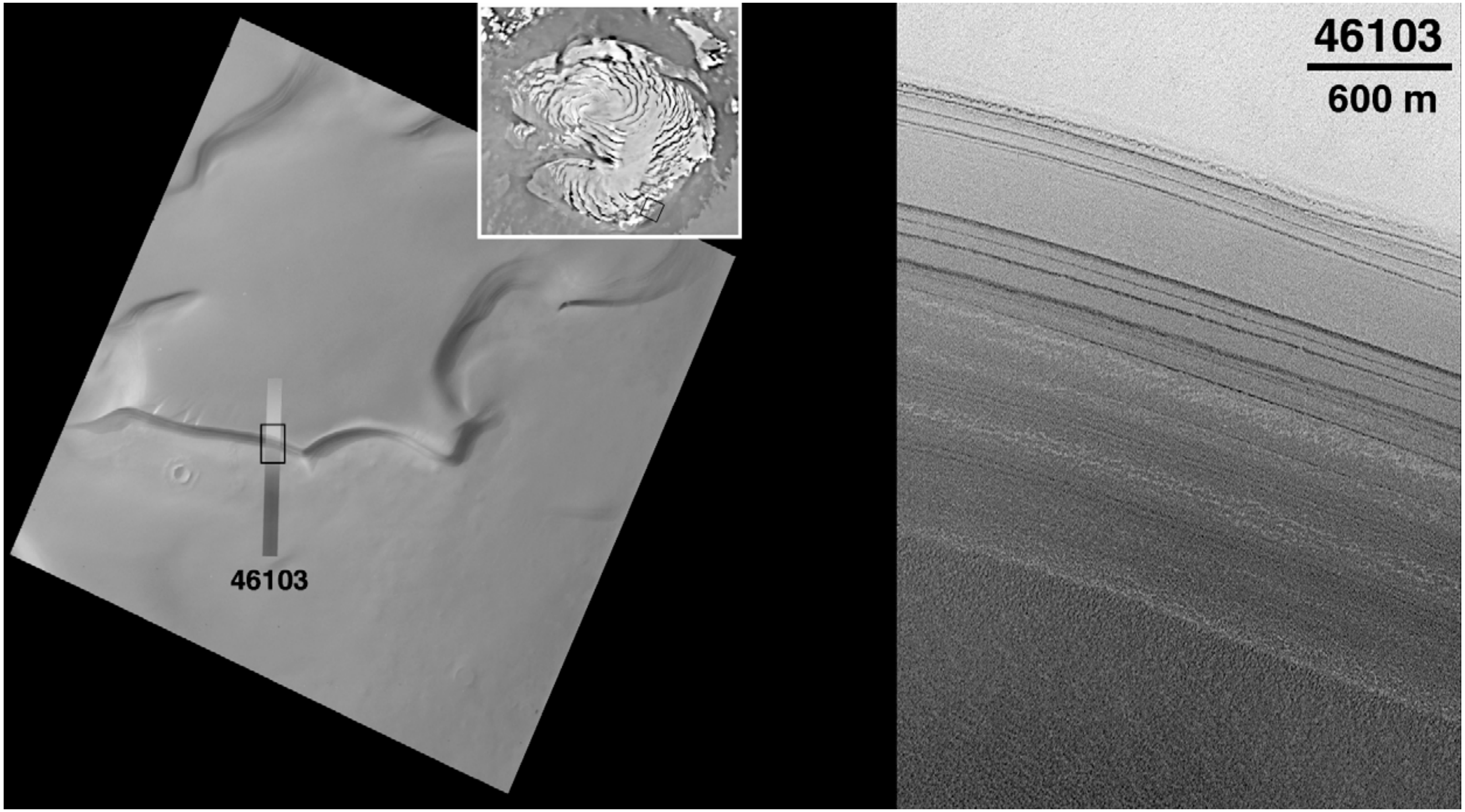
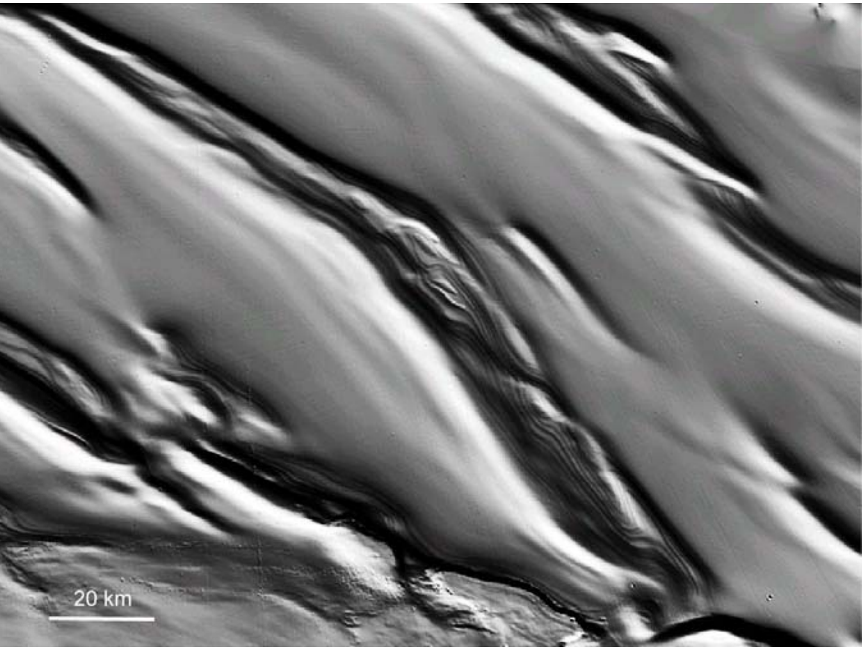


Image Credit: NASA/JPL/MSSS

-Extremely regular, linear layered structure

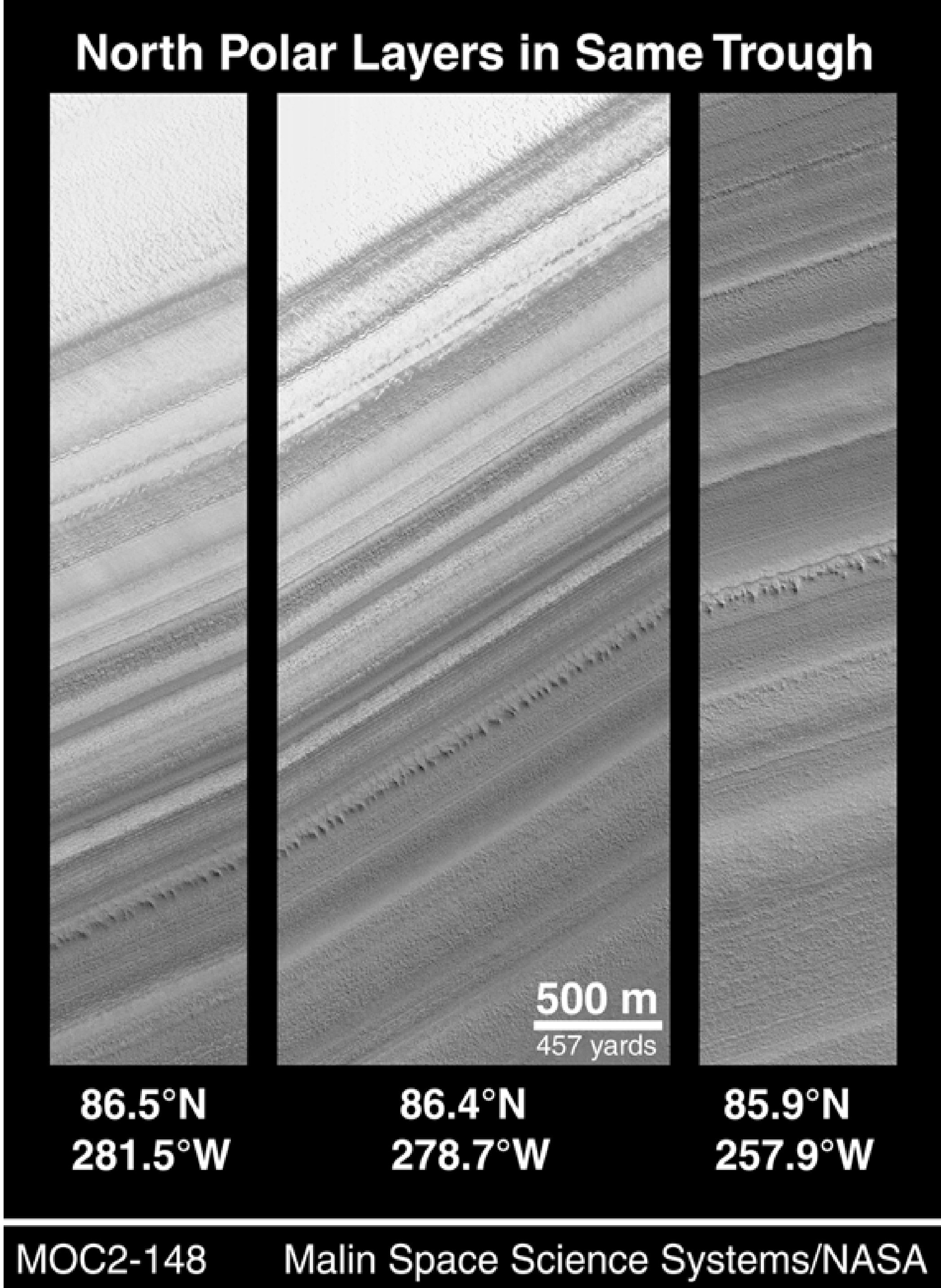
-Composition: undetermined ratio of dust, ice, void space

- Exposed primarily in troughs



North Polar shaded relief showing exposed layers in troughs on a large scale

-MOC images resolve small scale layering features in individual troughs



North Polar "Cottage Cheese" Terrain

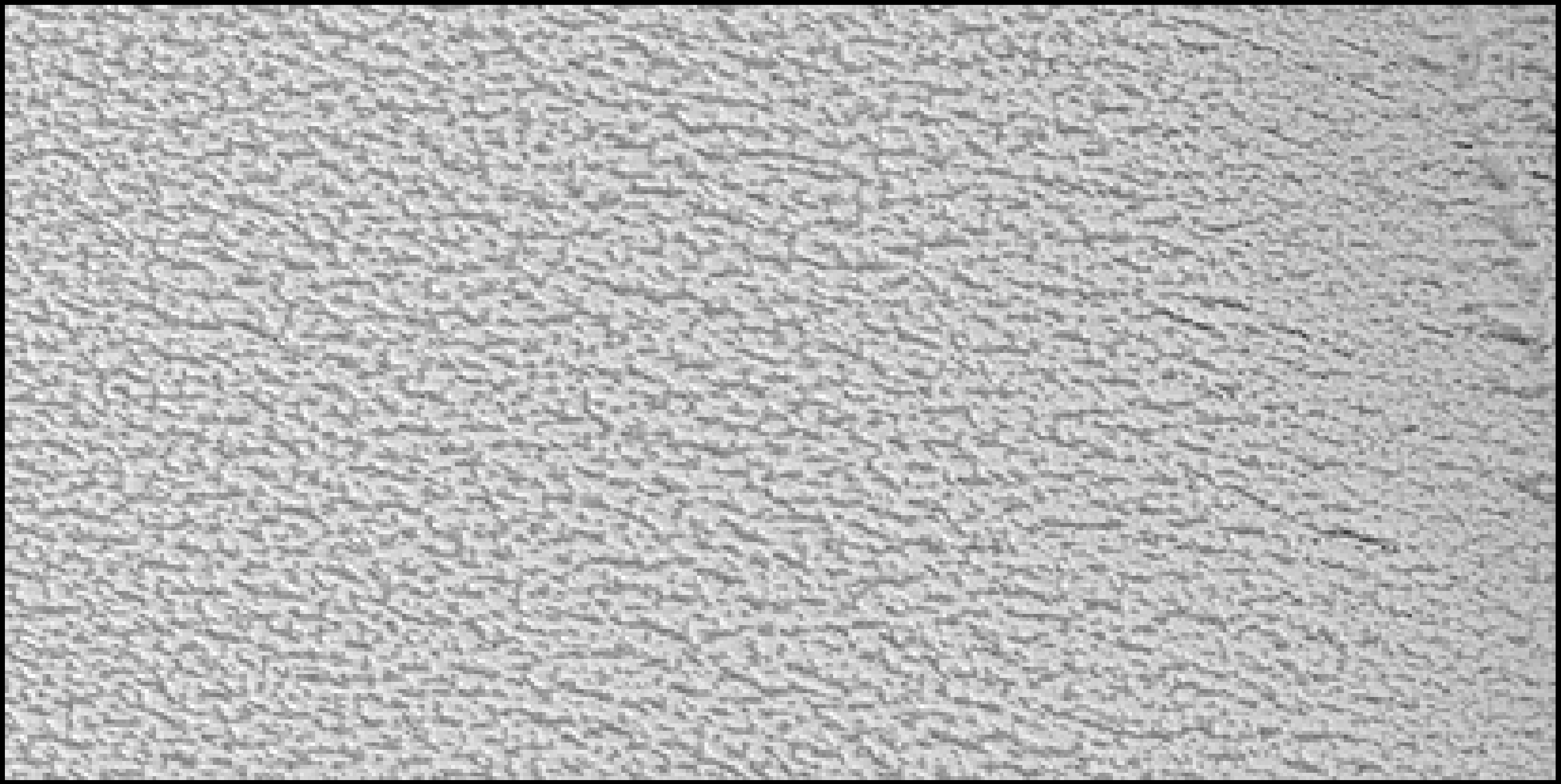
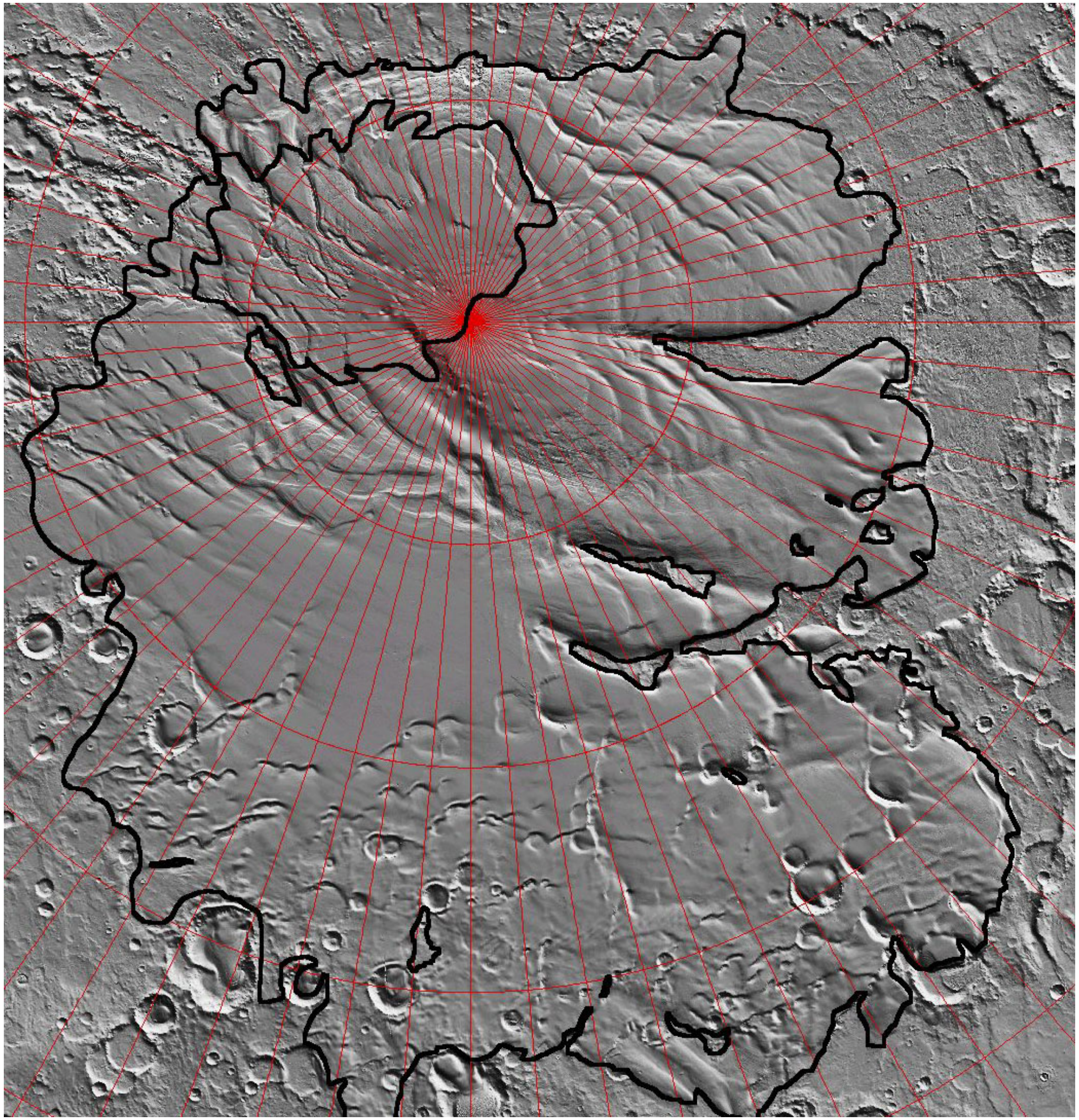


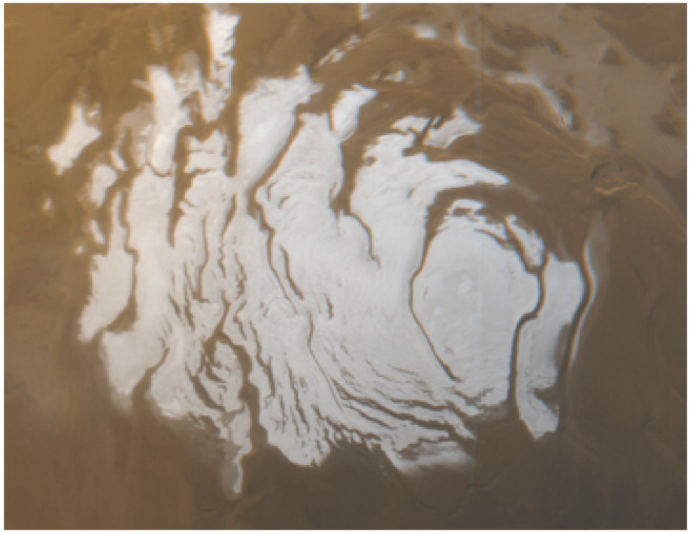
Image Credits: NASA/JPL/MSSS

Pitted, erosional features on the meter-scale

Martian South Pole



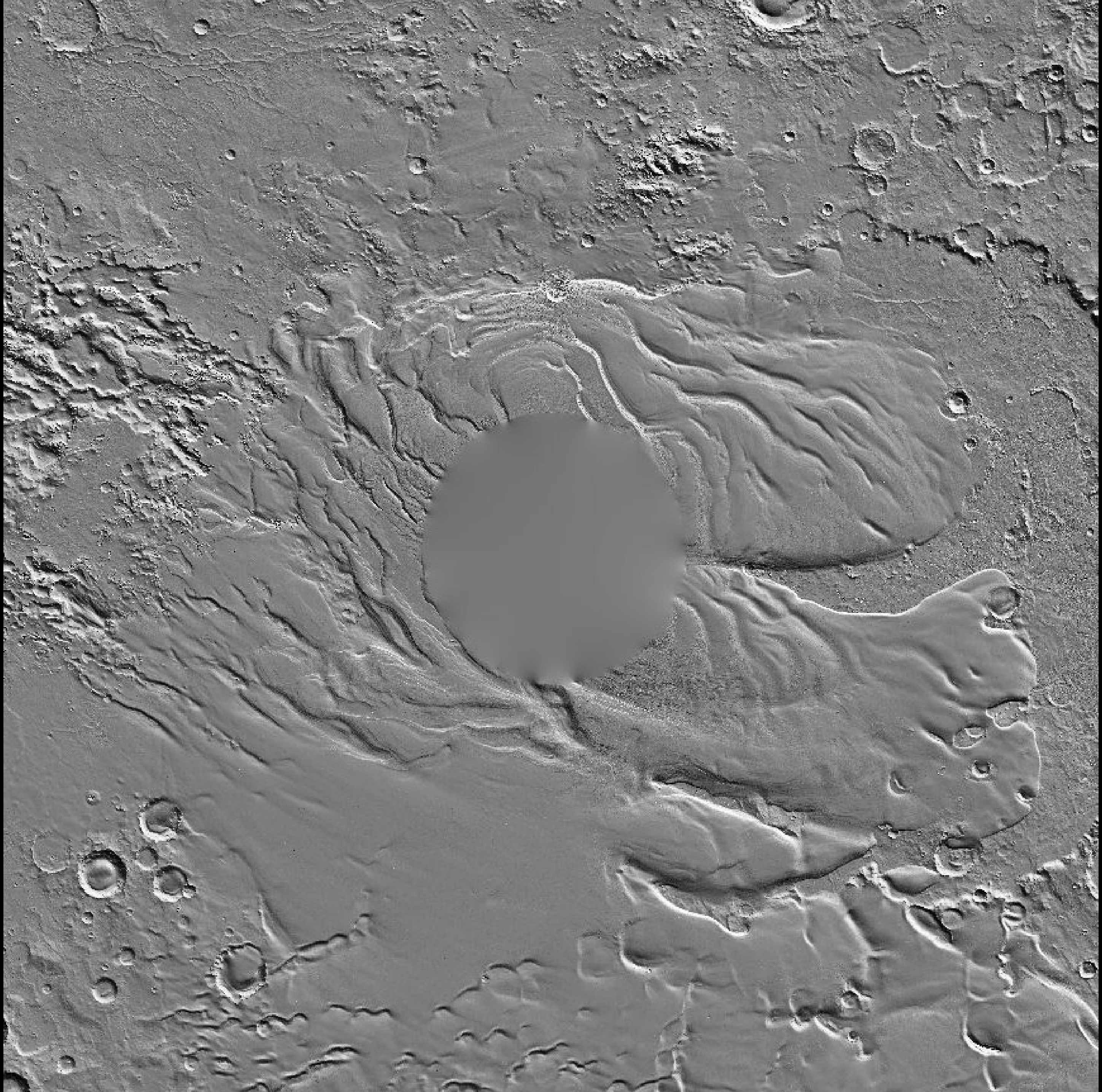
SPLD shaded relief map



Martian South Polar Cap (Image: NASA/JPL/MSSS)

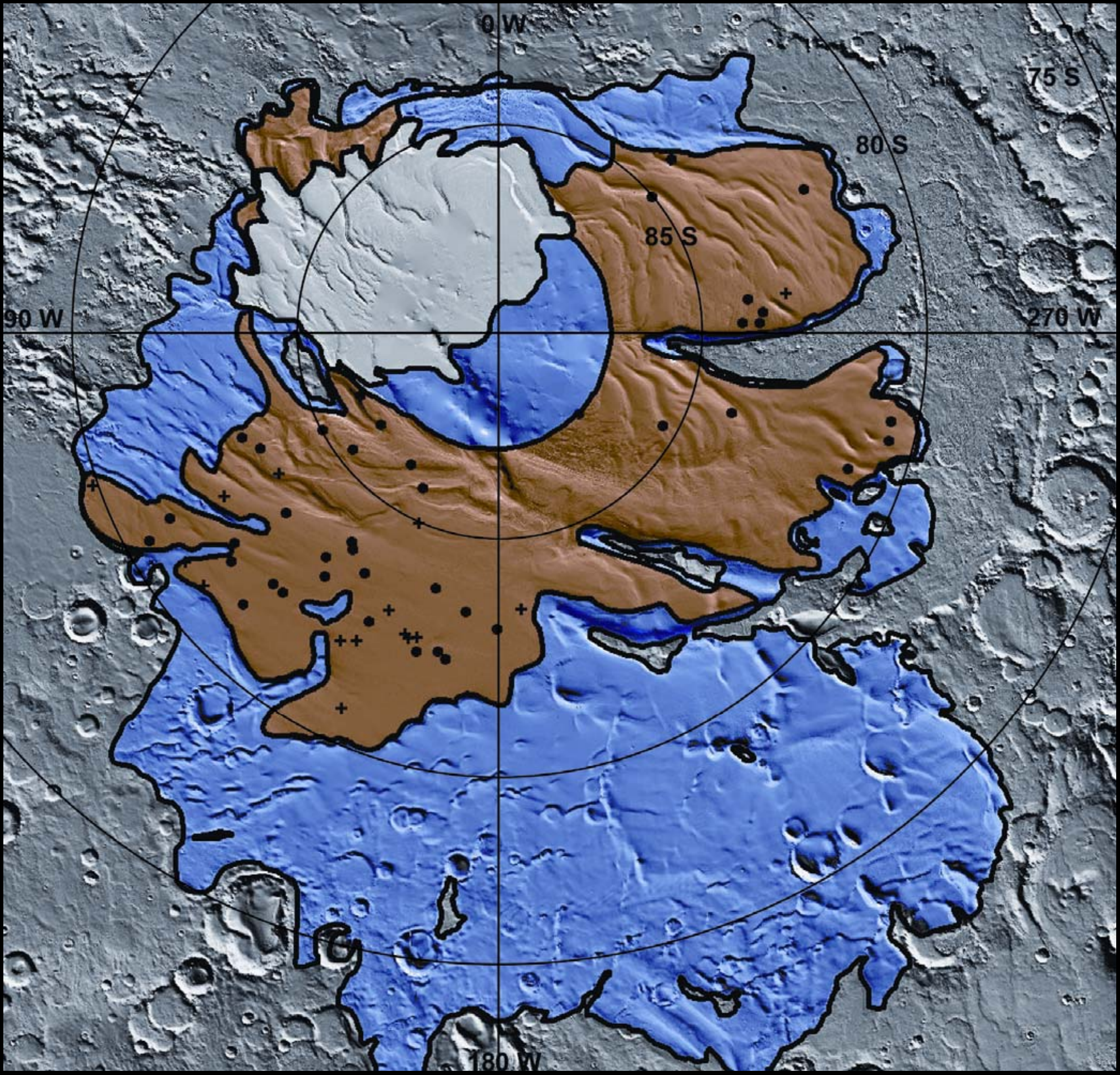
- SPLD to furthest extent ~72° S latitude

- Almost entirely considered layered deposits, not residual cap



Distribution of > 800 m craters at the south pole

→Viscous relaxation



North and South Residual Cap Comparison

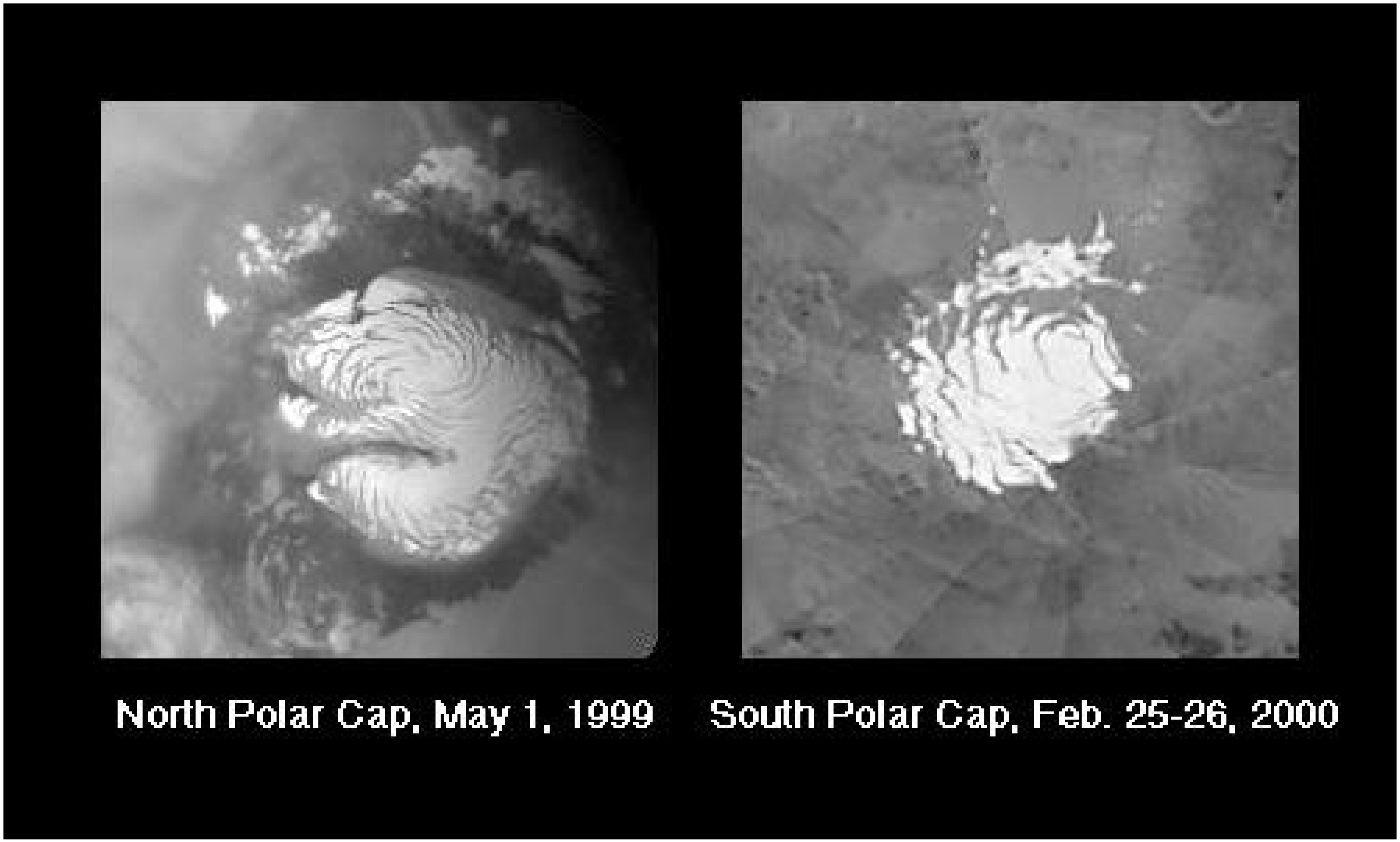
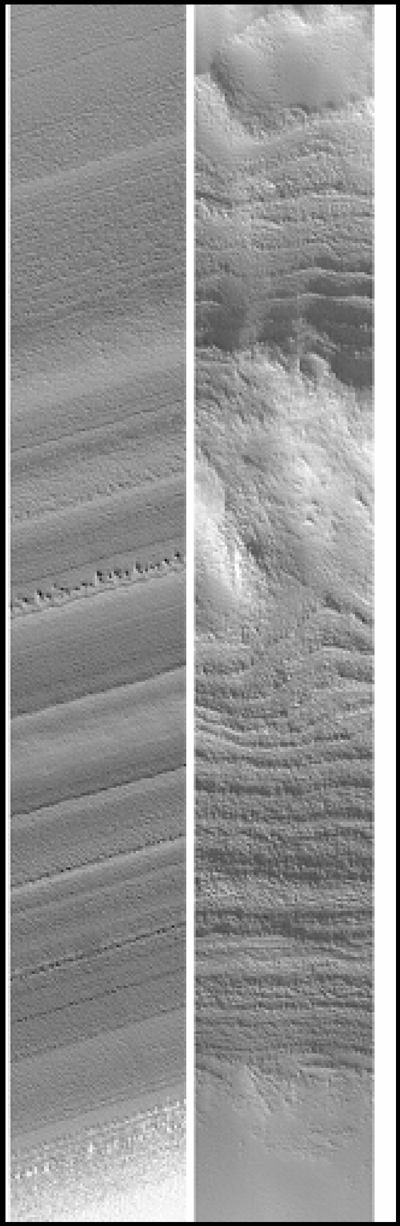
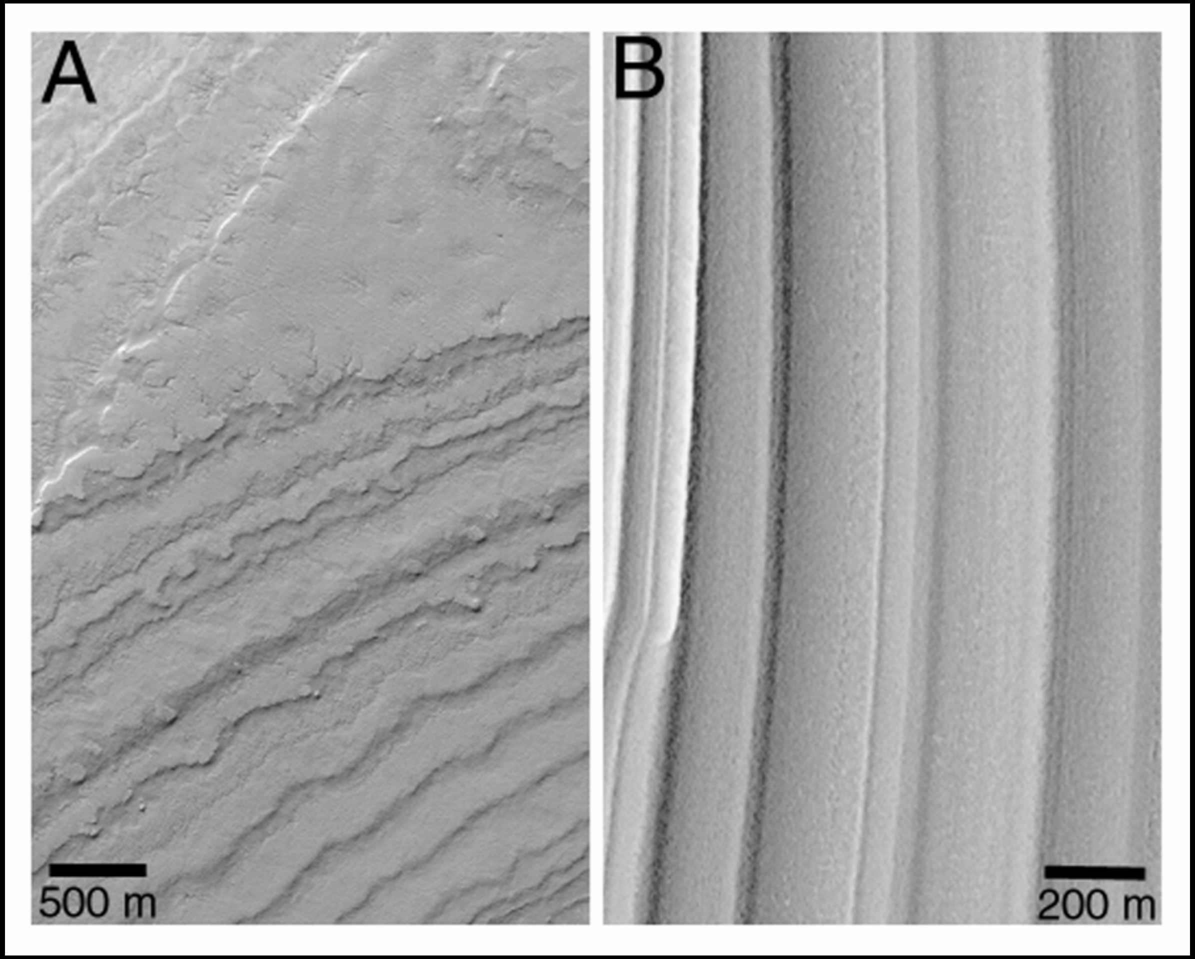


Image: NASA/JPL/MSSS

North vs. South Layer Comparison



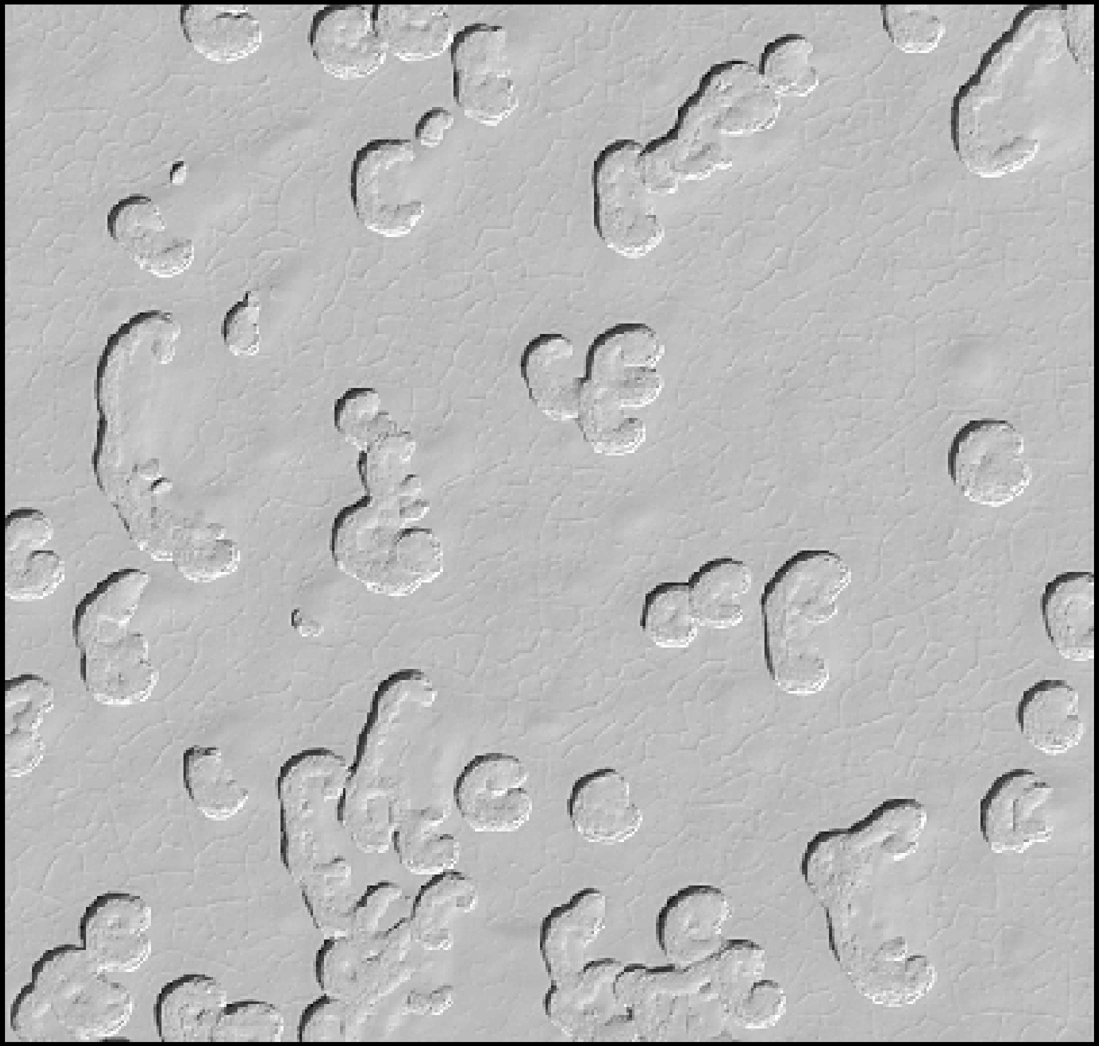
North South



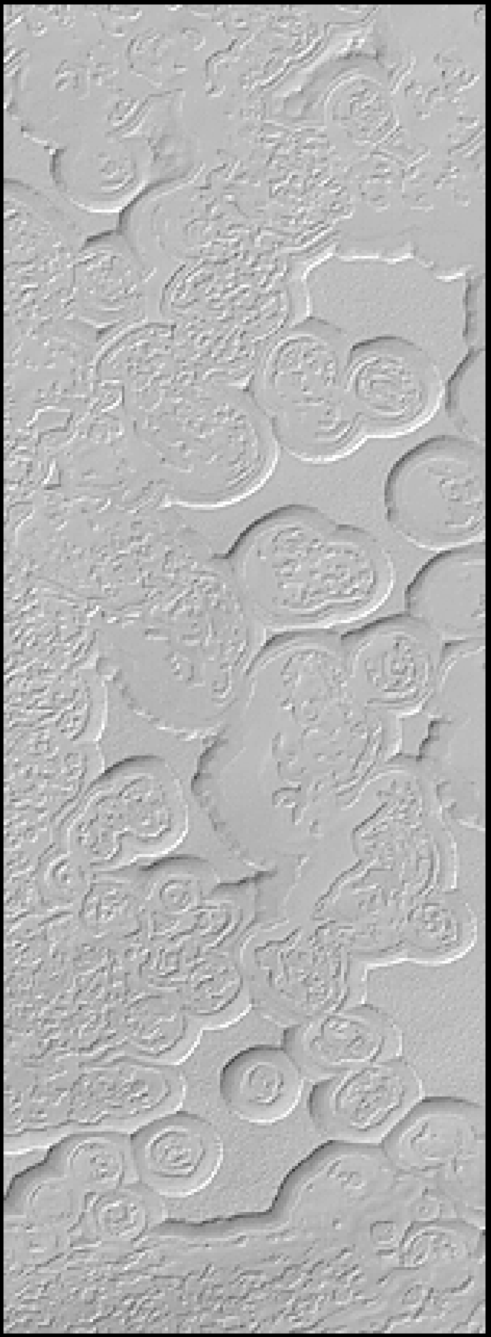
South North

Images: *Malin and Edgett*, JGR 2001

South Polar "Swiss Cheese" Terrain



Images: NASA/JPL/MSSS



Surface Mass Balance

Fisher (1993, 2000): “accublation”

- accumulation on poleward facing slopes of troughs
- ablation of equatorward facing slopes of troughs
- trough migration towards the pole

Alternating zones of accumulation and ablation and flow shape cap

→ Not necessarily sublimation advantage
→ accumulation may be very small

Accumulation of water ice at highest latitudes where troughs are absent with retreat of seasonal ice

“vacuuming effect” (Houben et al., 1997; Bass and Paige, 2000)

Deformation: Ice Flow and Viscous Relaxation

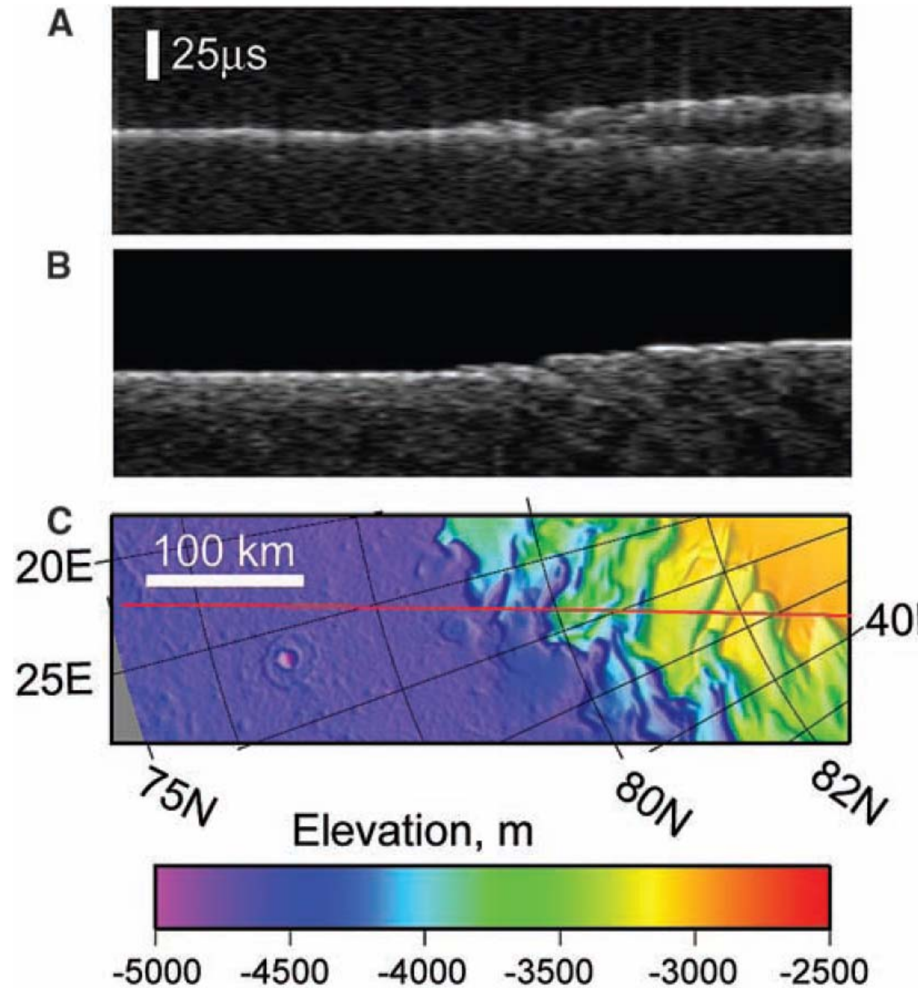
Ice caps are largely ice (>98 %)

Apparently little isostatic deflection in the North (with first look)

TODAY: mass balance > flow

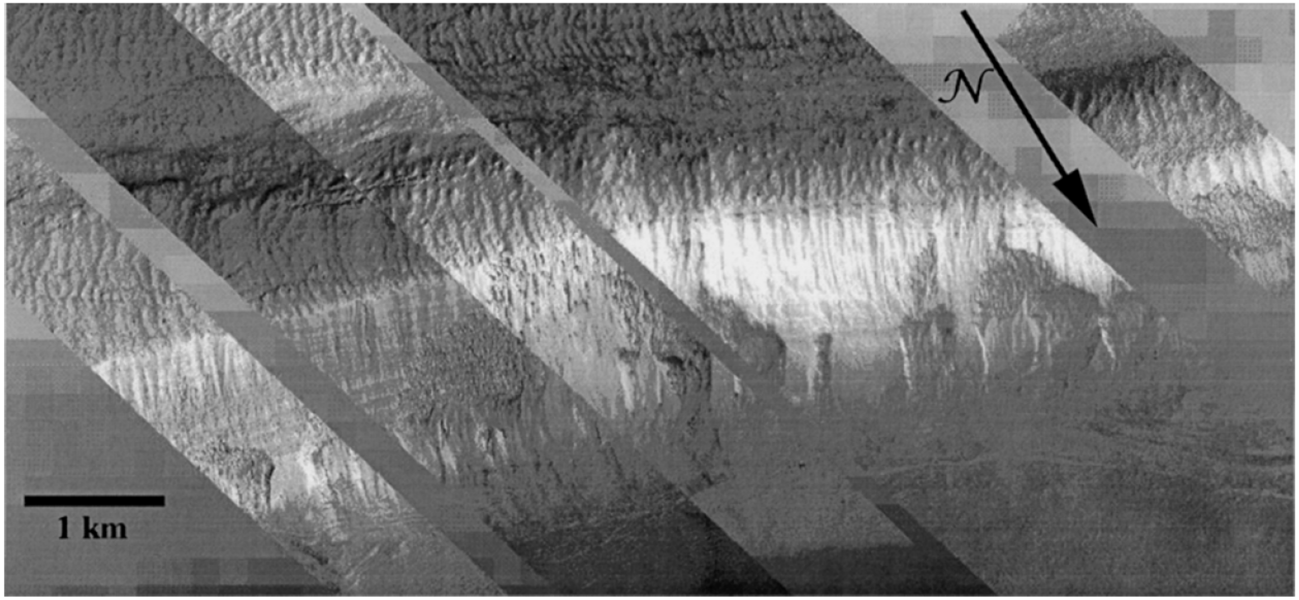
PAST: likely flow > mass balance
Topography preserves this evidence

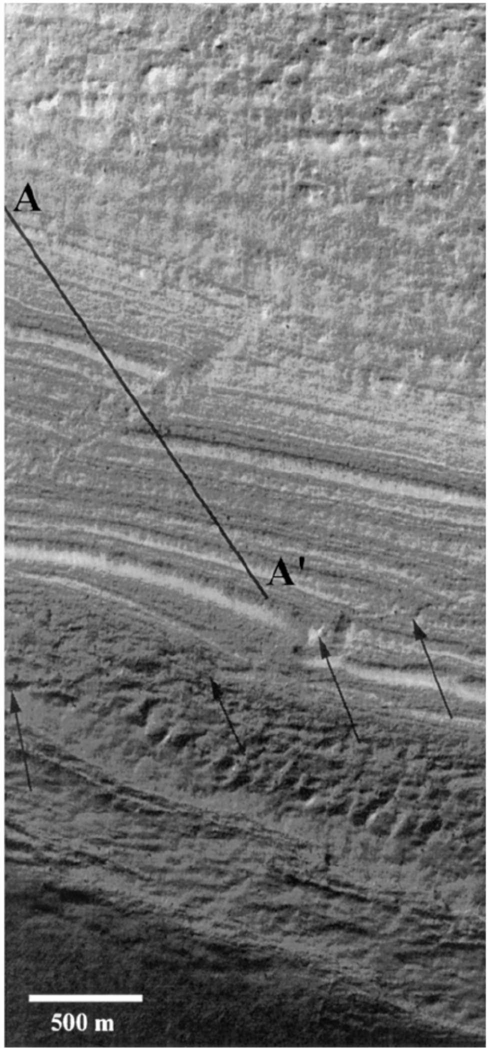
Viscous relaxation is also important for large-scale modification



(Picardi et al., 2005)

Deformation: Brittle Fracture and Mass Wasting



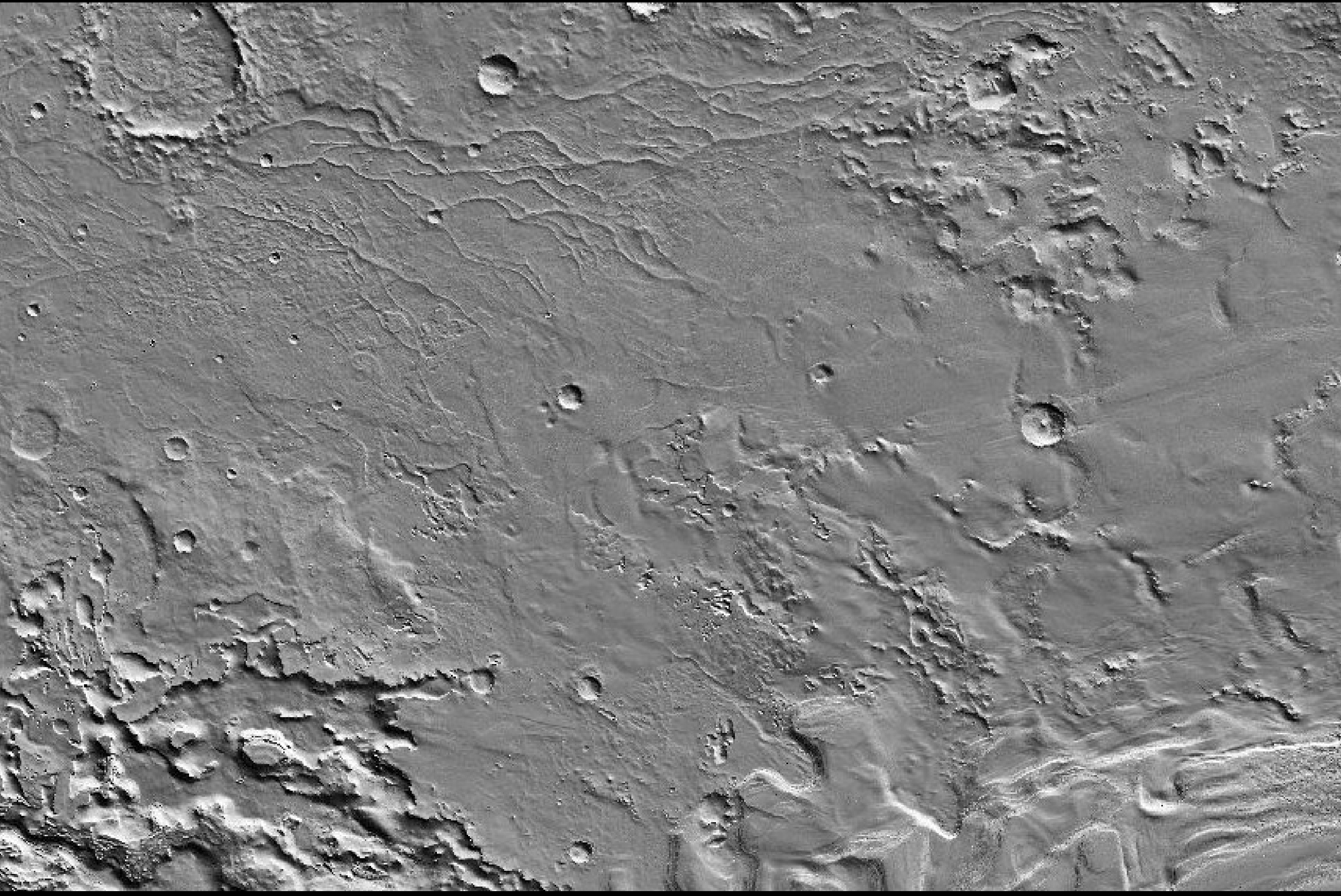


Murray et al. (2001)

Basal Melting

Clifford (1987, 2000):

- Depends on surface temperature, areothermal heat flux, and thermal conductivity of deposits
- Today need ~6.5-13 km thick cap
- Eskers?
- Chasma formation by jökulhlaup?



What is the composition, structure, and chronology expressed in the stratigraphy of the PLD?

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Are they really that young?
Was there ever a steady-state system?
Water cycling between the poles and mid-latitudes?
? ? ? ? ?