

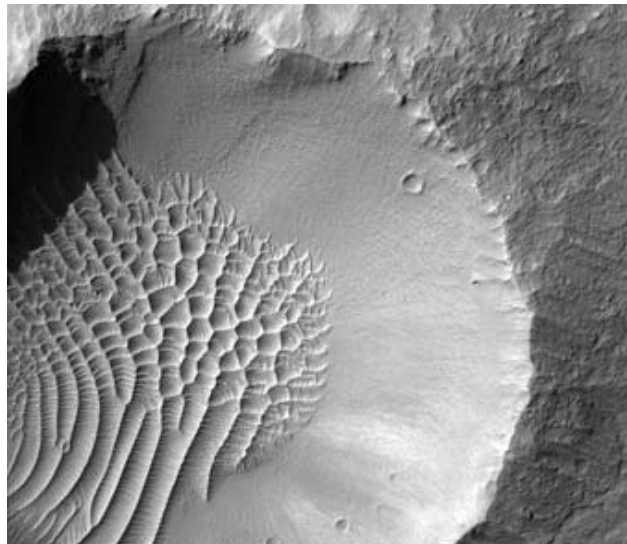
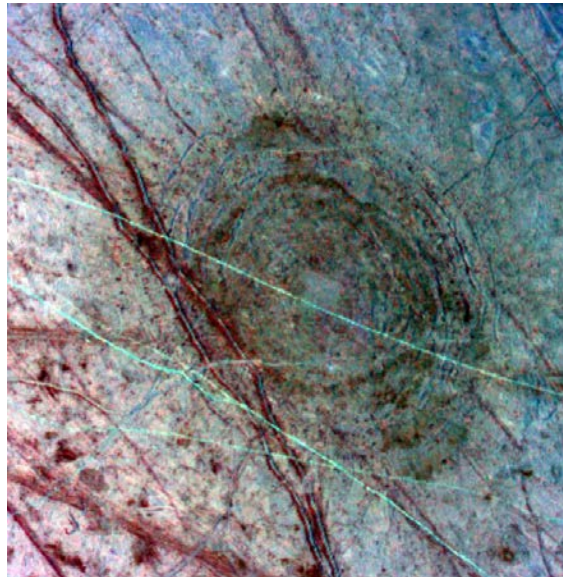
Planetary Surface Processes

Cratering
Gravity
Tectonics
Volcanism
Winds

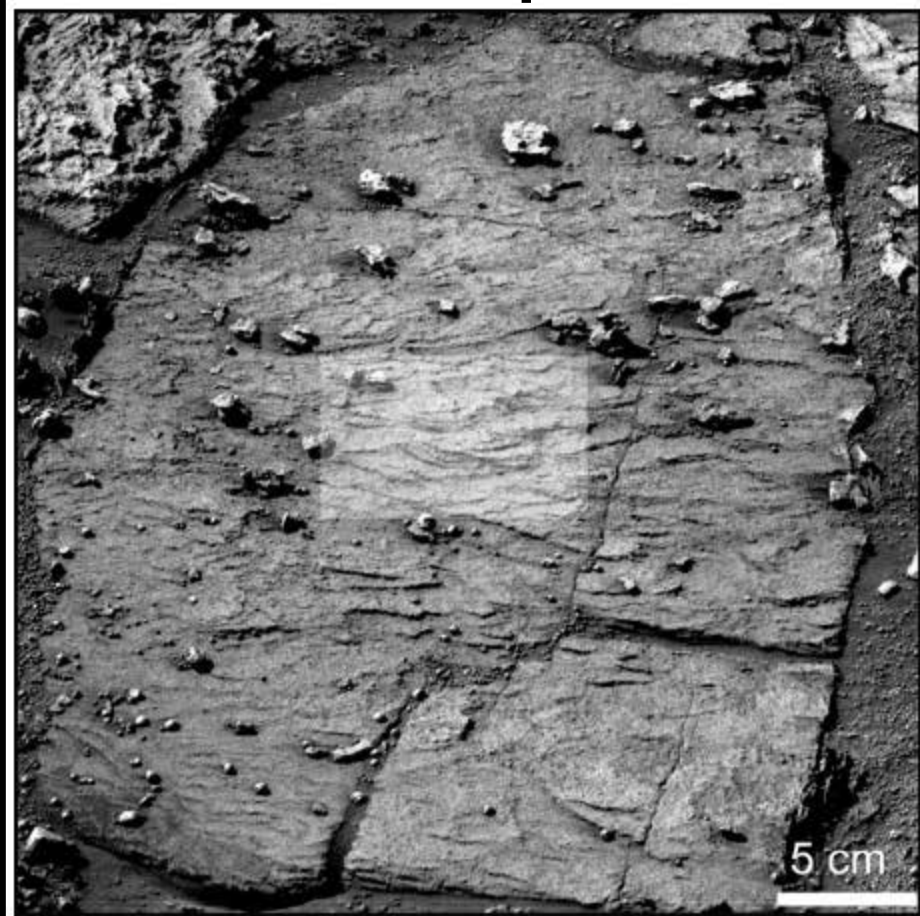
Fluvial

Glacial

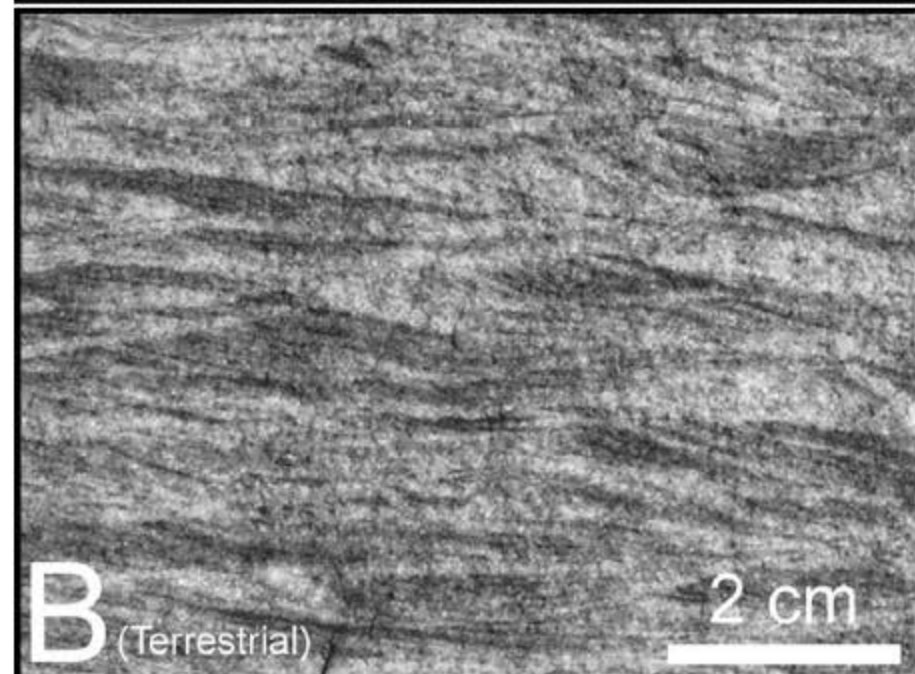
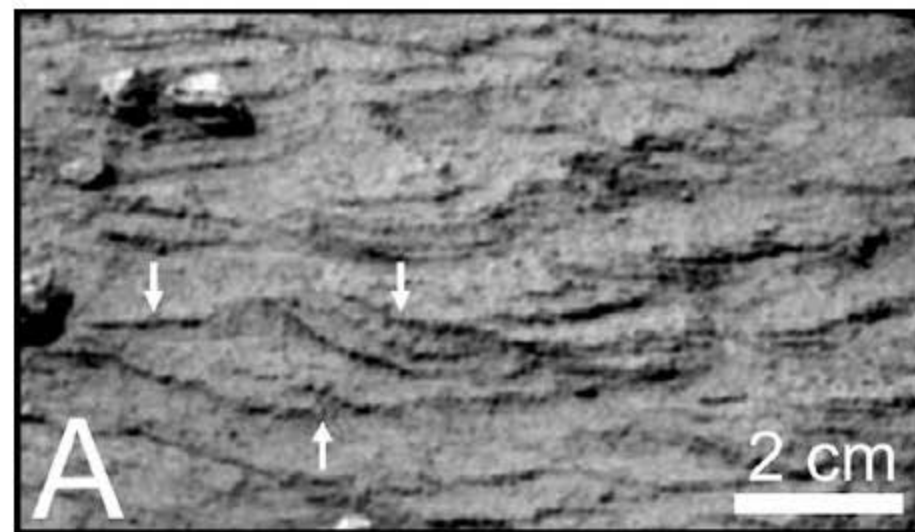
Chemical
weathering



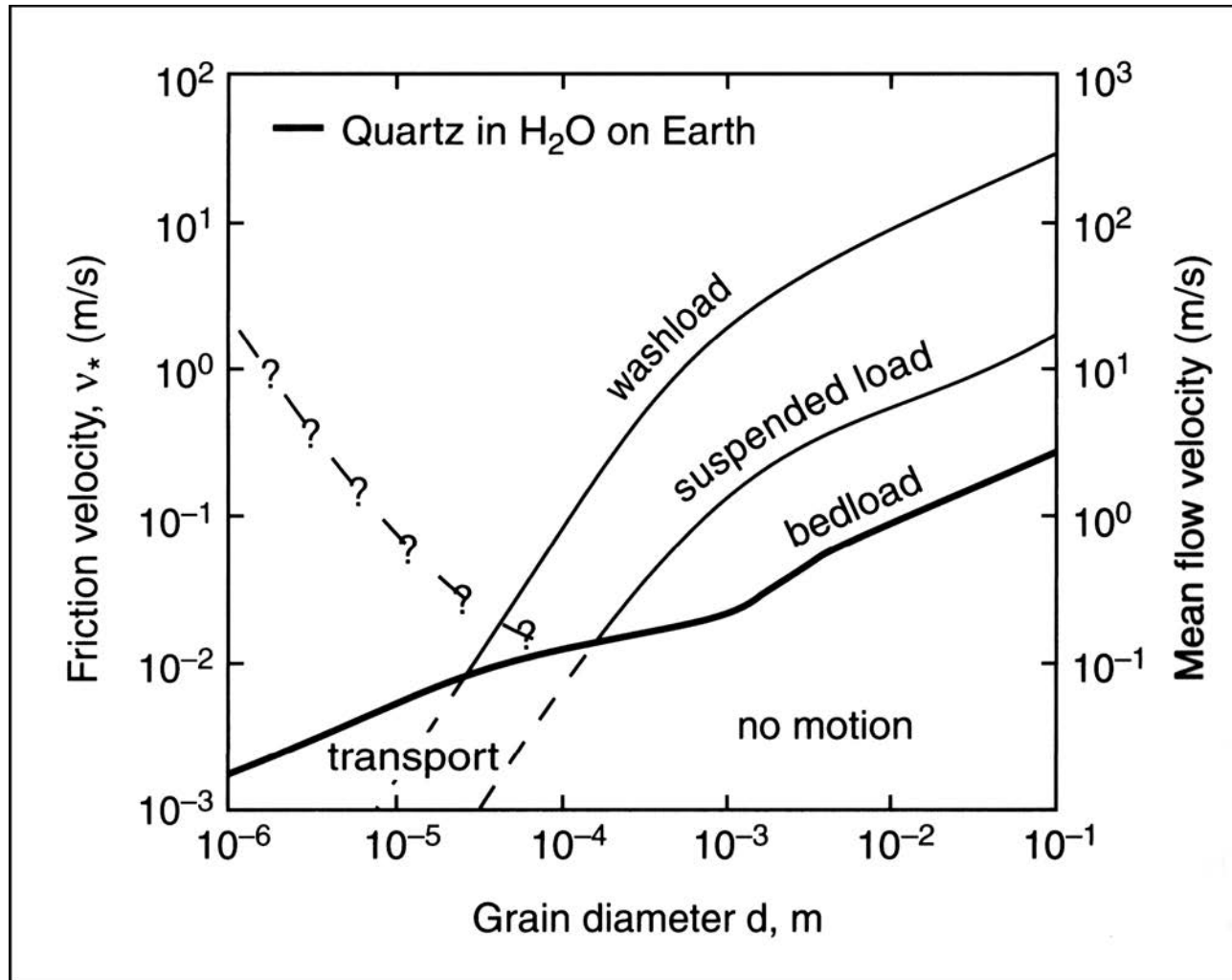
Shallow ponds at Meridiani Planum



Grotzinger et al. (2006)

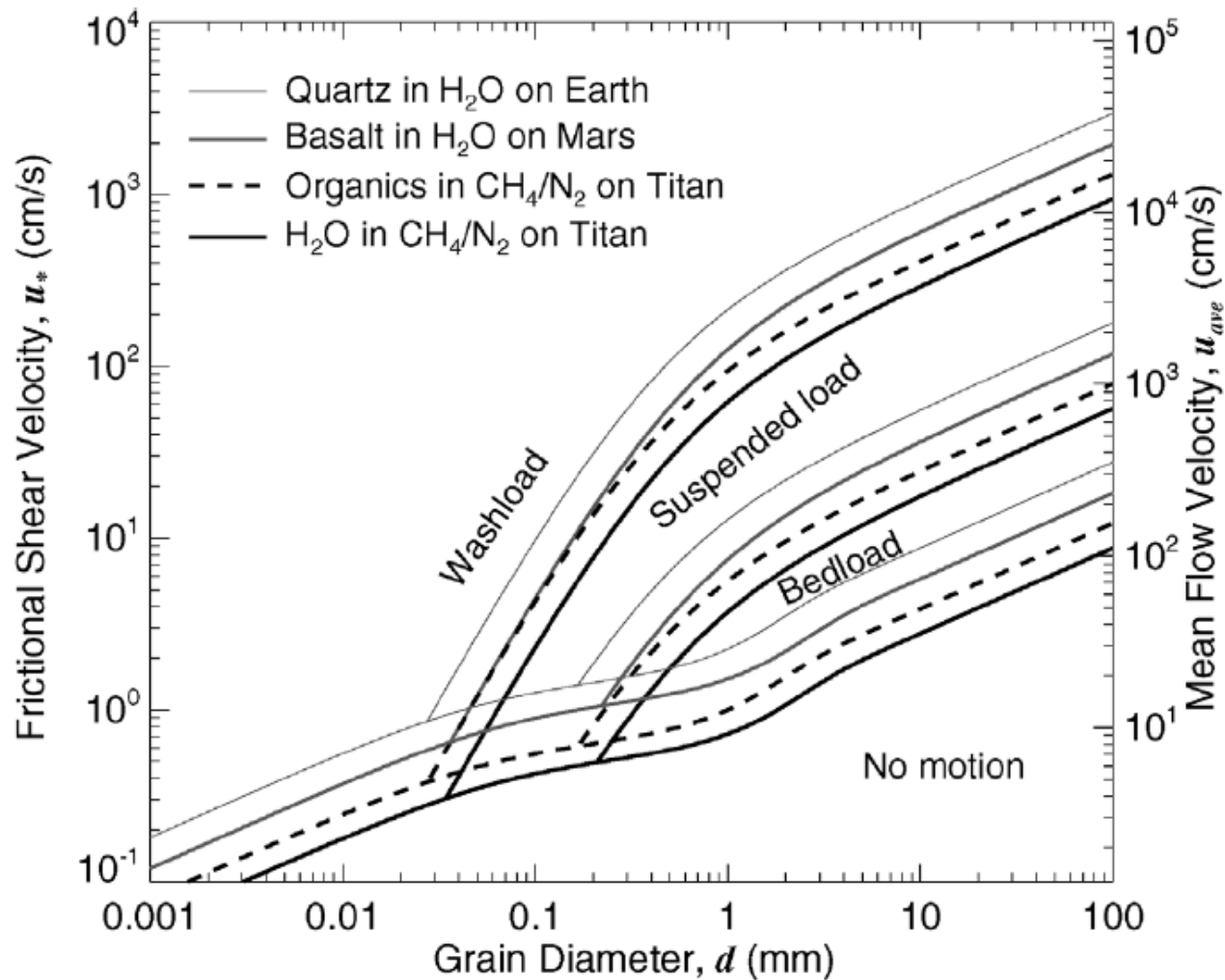


Fluvial sediment transport



Melosh (2011)

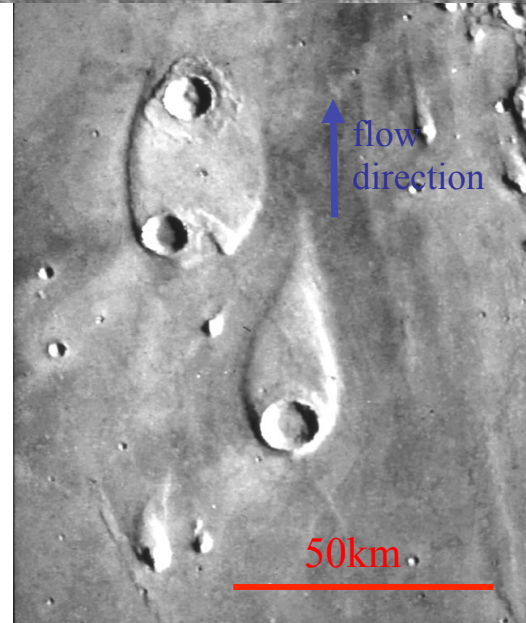
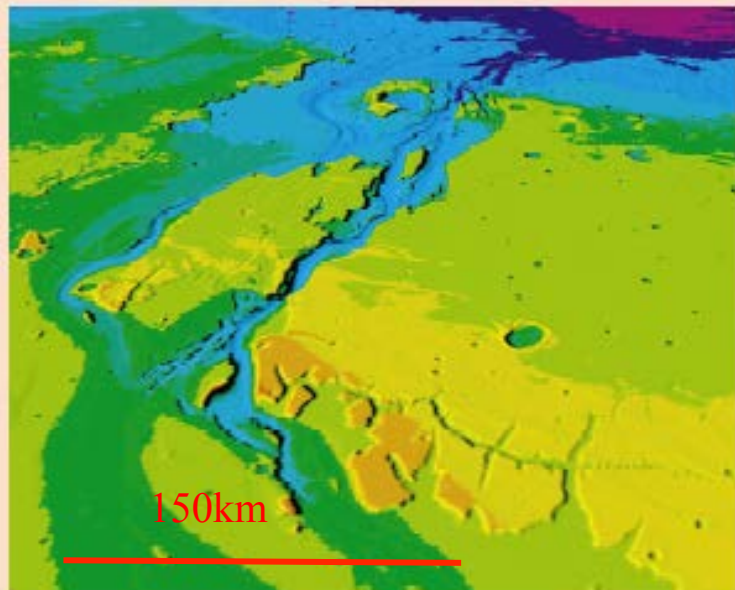
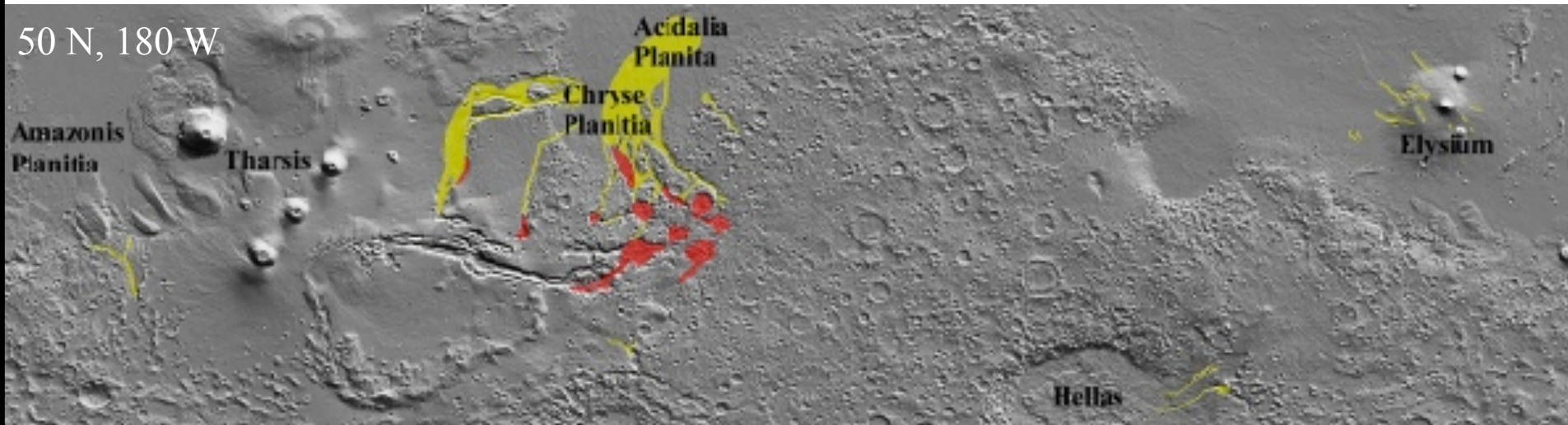
Fluvial sediment transport



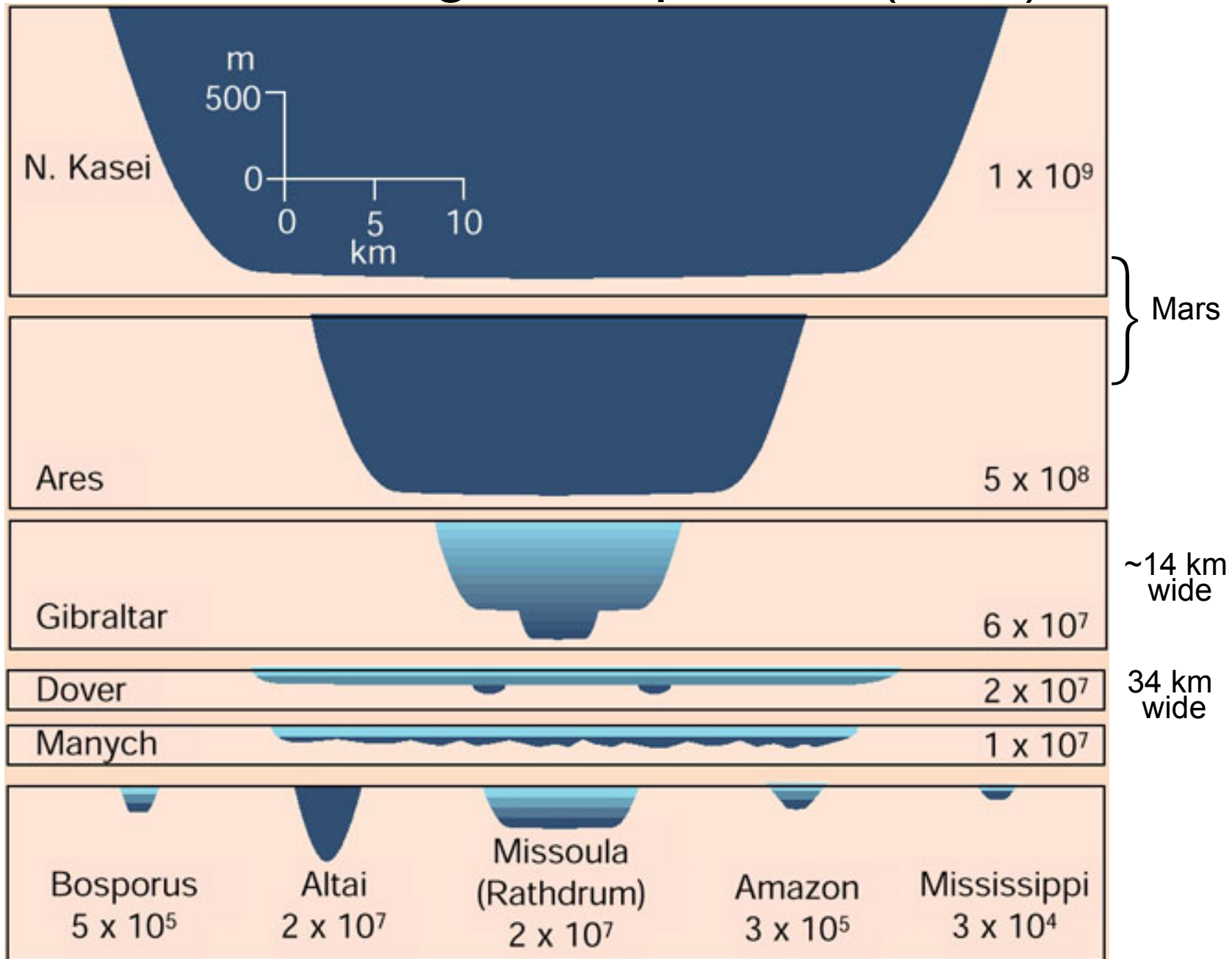
Burr et al. (2006)

Map of Mars Outflow Channels

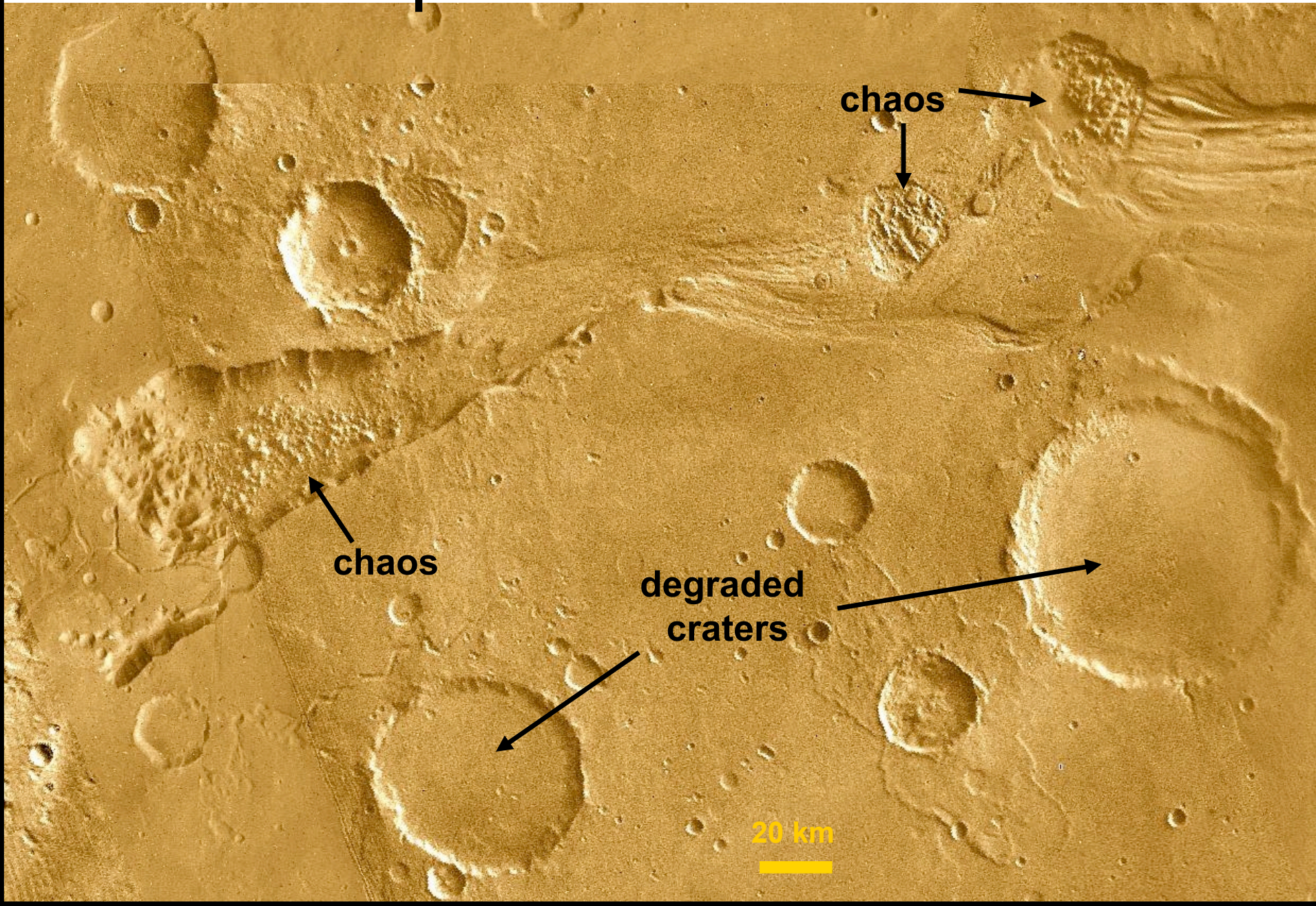
Concentrated east of Tharsis in topographic trough



Flood Discharge Comparison (m^3/s)

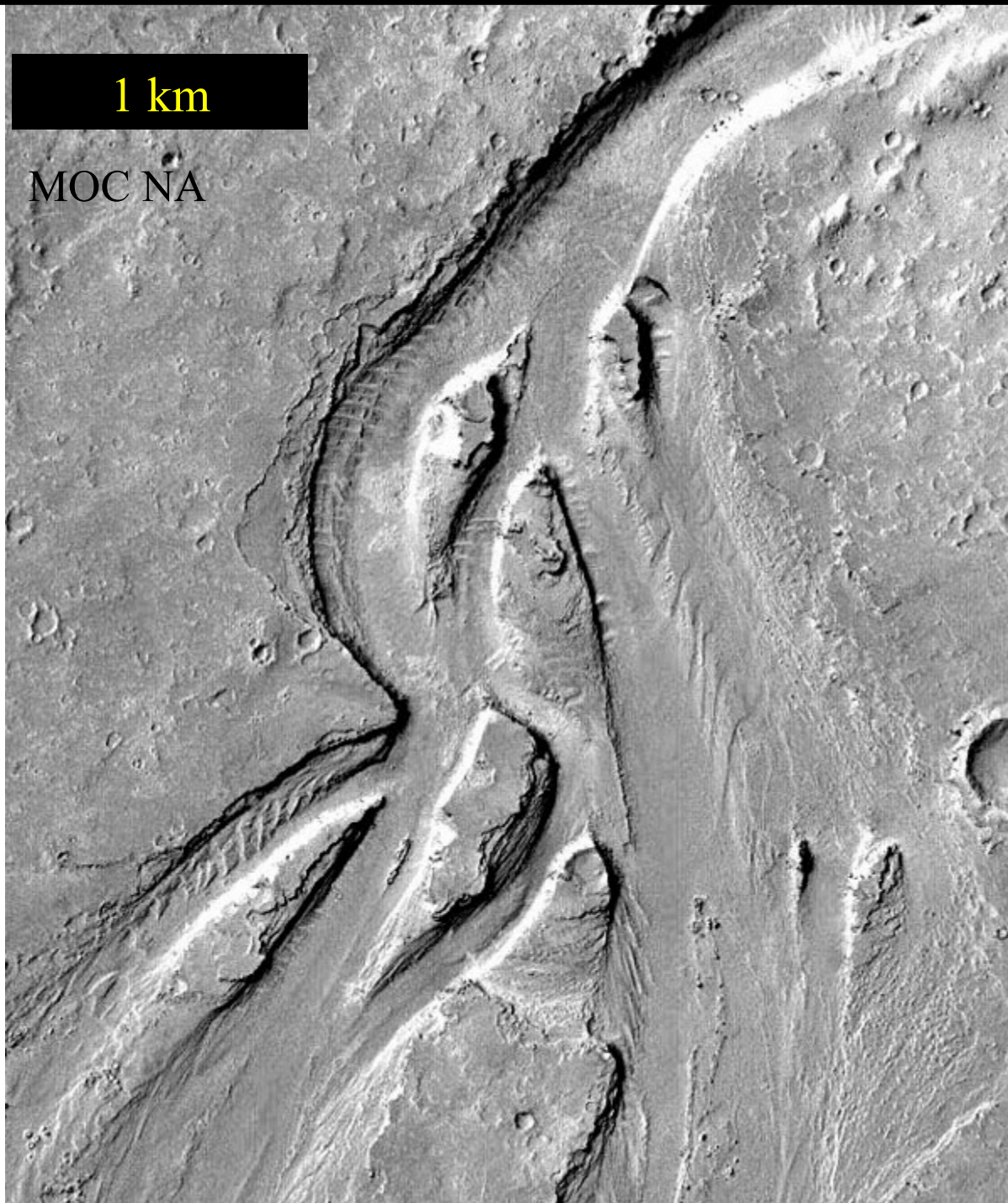


Catastrophic Outflow Channels



1 km

MOC NA



Mars/Earth Flood Comparison

Similarities

- Morphological Features
 - terraces, streamlined hills, bars, inner channel cataracts, scour marks, longitudinal grooves, megaripples, low sinuosity
- Duration (?)
- Multiple Events

Differences

- Origination
 - Earth → glacial breakout
 - Mars → subsurface breakout
- Scale
- Discharge

Martian Gullies

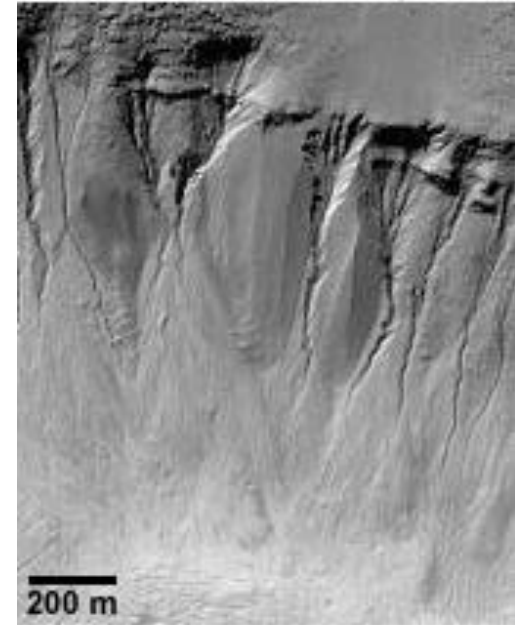
- A very unexpected discovery (Malin & Edgett, *Science* 283, 2330-2335, 2000)
- Found predominantly at high latitudes ($>30^\circ$), on pole-facing slopes
- Inferred to be young < 10 MA – cover young features like dunes and polygons
- Snowmelt? Melting of ground ice?
Groundwater aquifers?!?
Or not related to water at all?

Gullies in the northern wall of a crater at 39.1°S , 166.1°W
Subframe of MOC image E11-04033



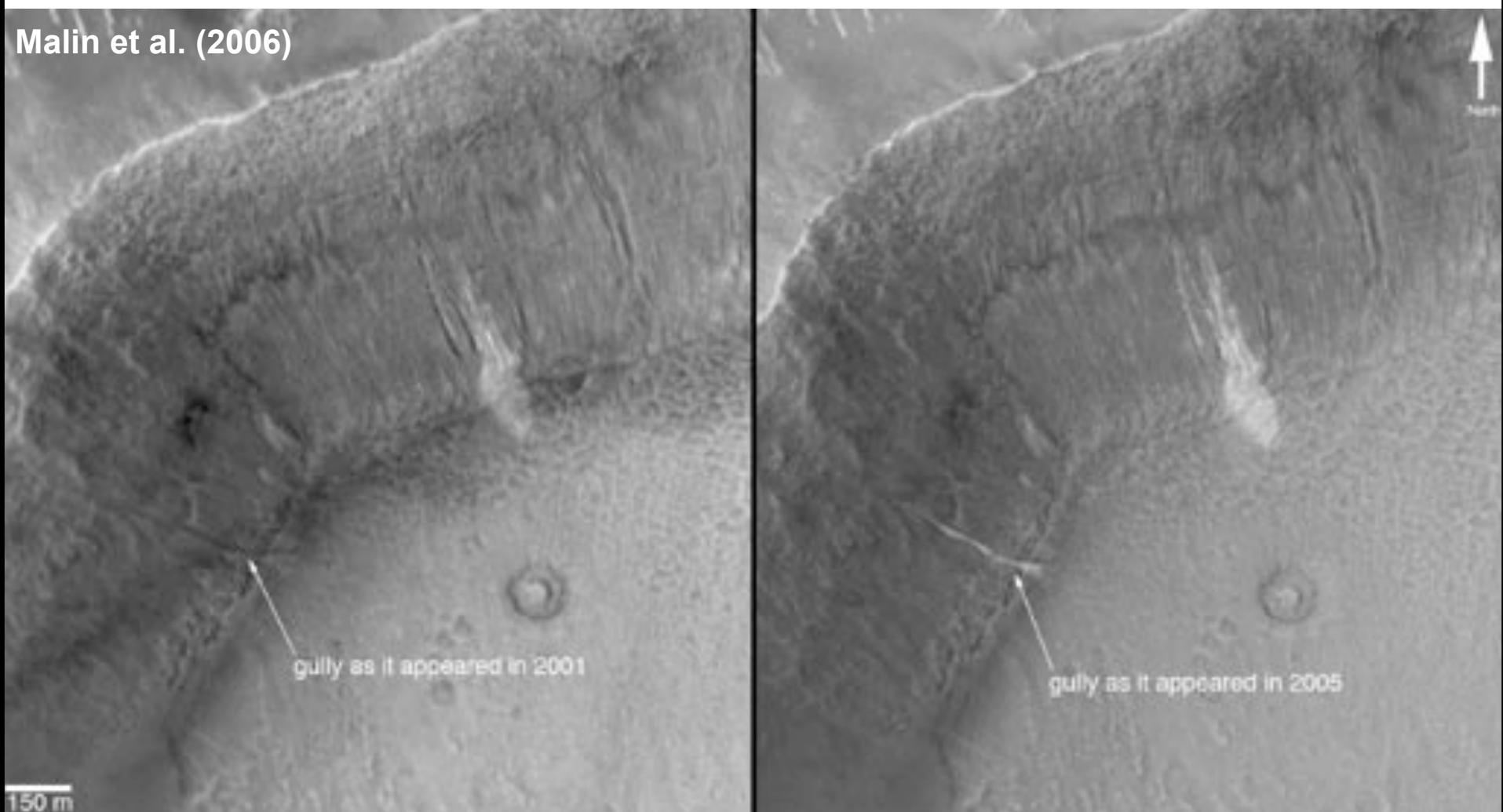
NASA/JPL/Malin Space Science Systems

Gullies in crater near 39°S , 200°W



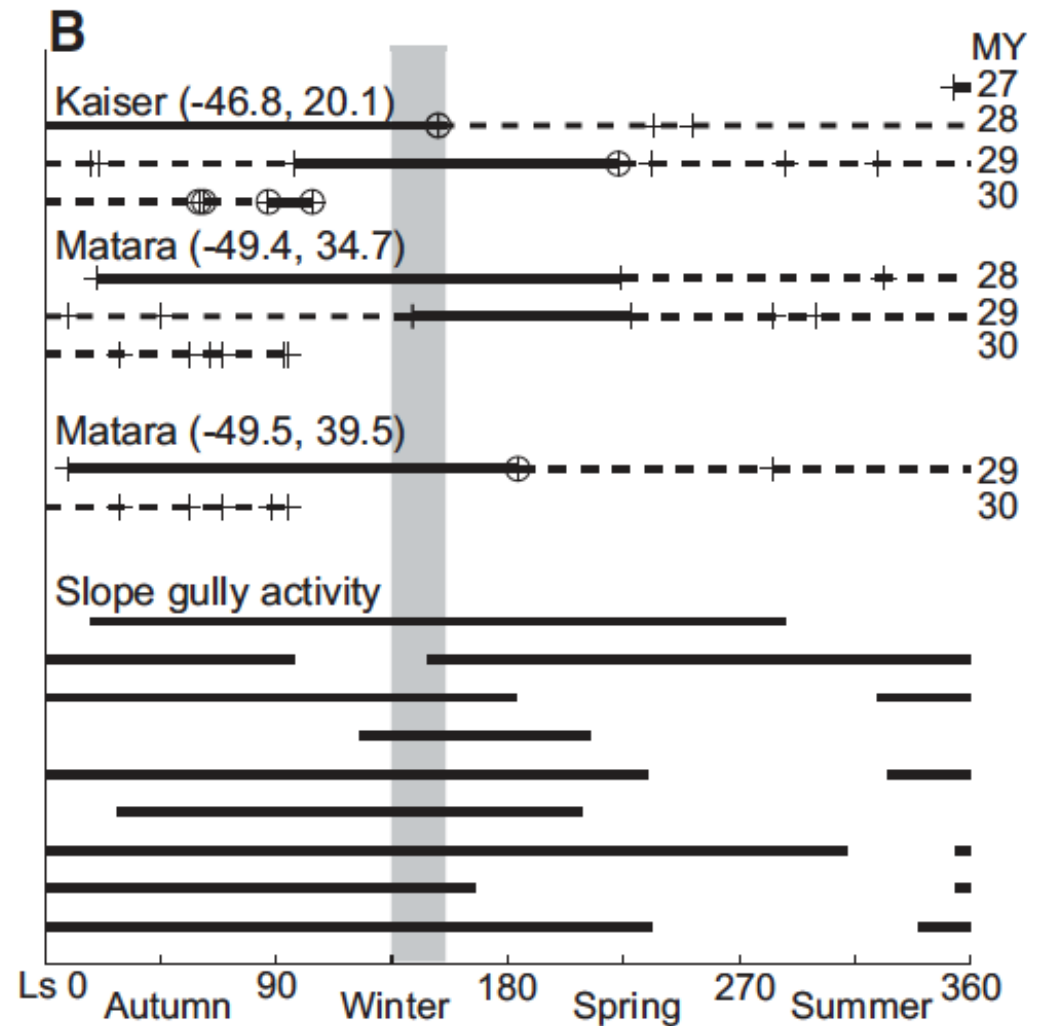
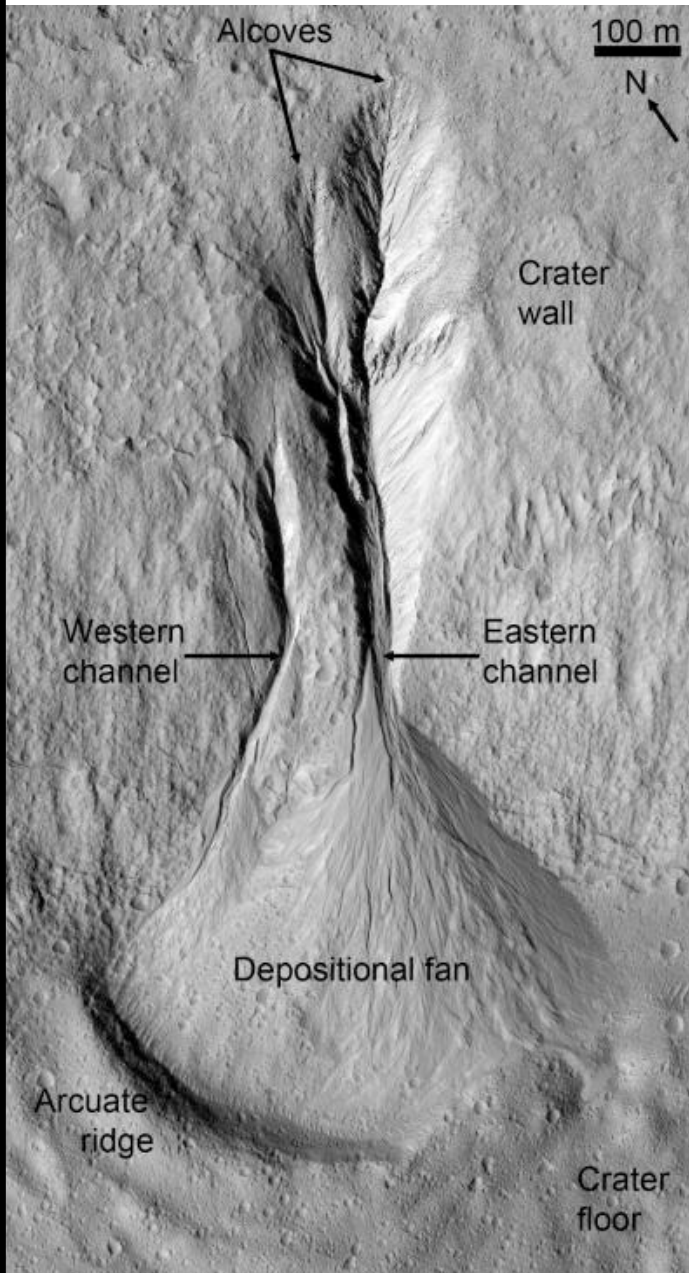
MOC2-388/PIA04570 NASA/JPL/MSSS

Gullies are active today!

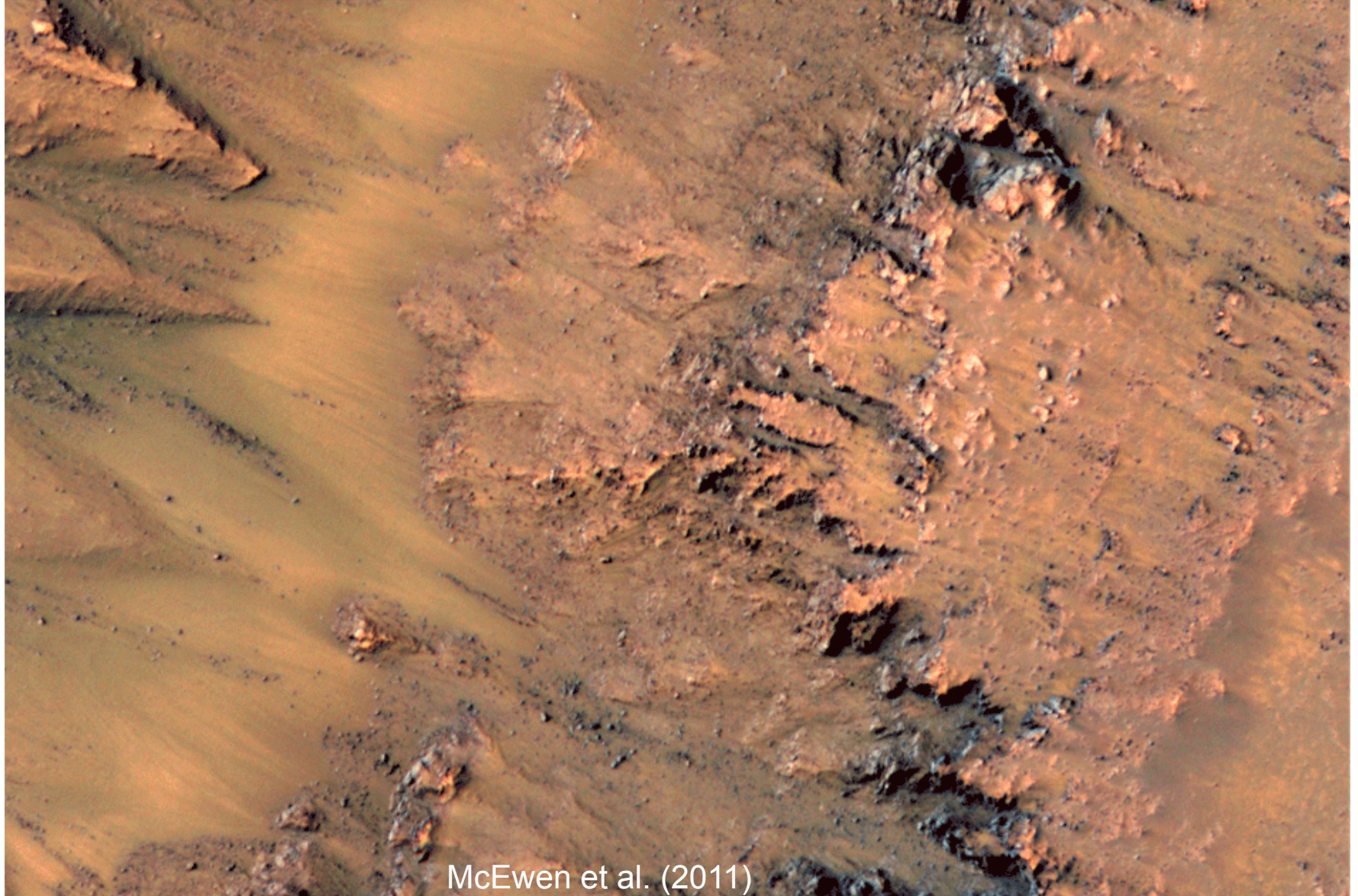


Gullies look like water-carved features...

...but they're active in the winter time!
➔ related to CO₂ frost?



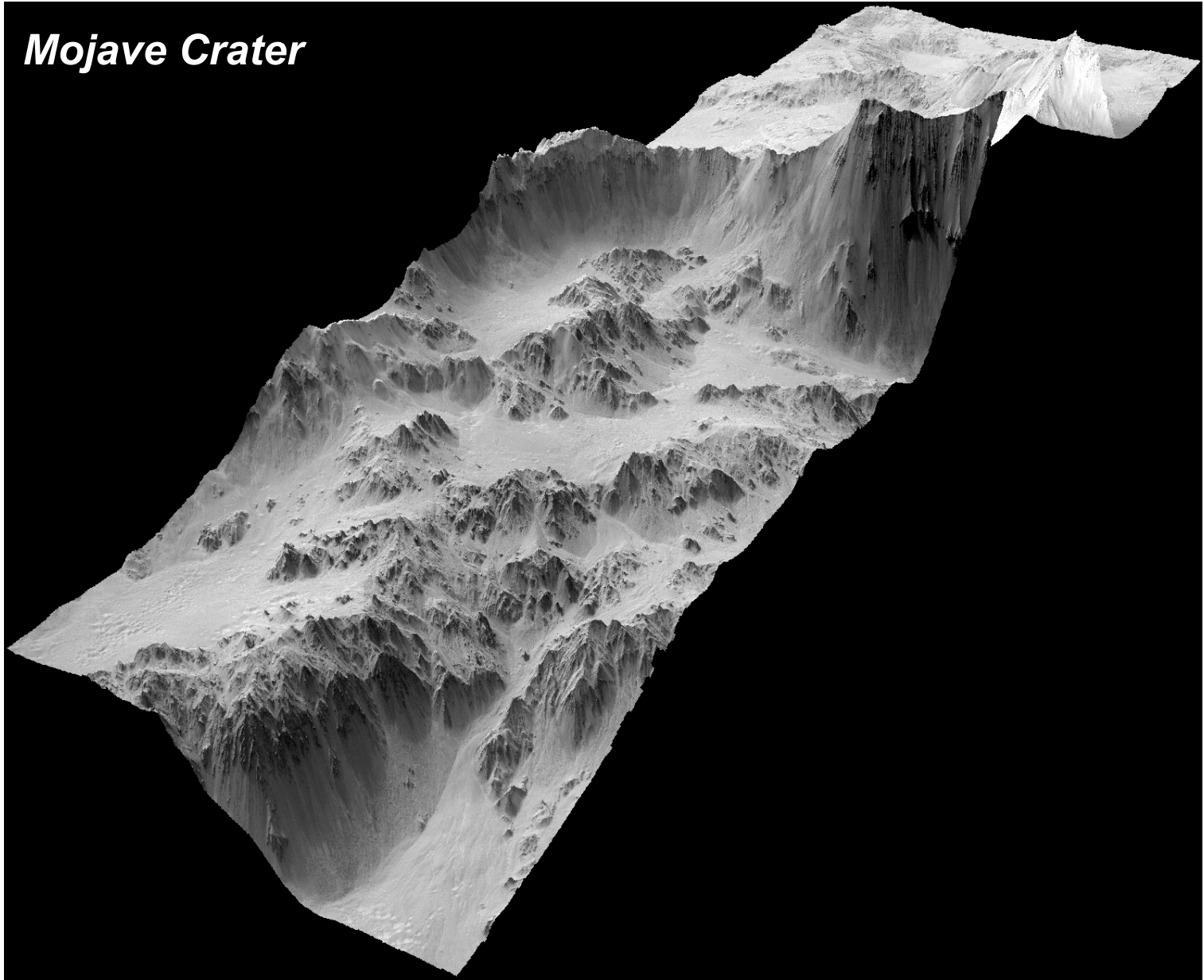
Recurring slope lineae: active in summer



McEwen et al. (2011)

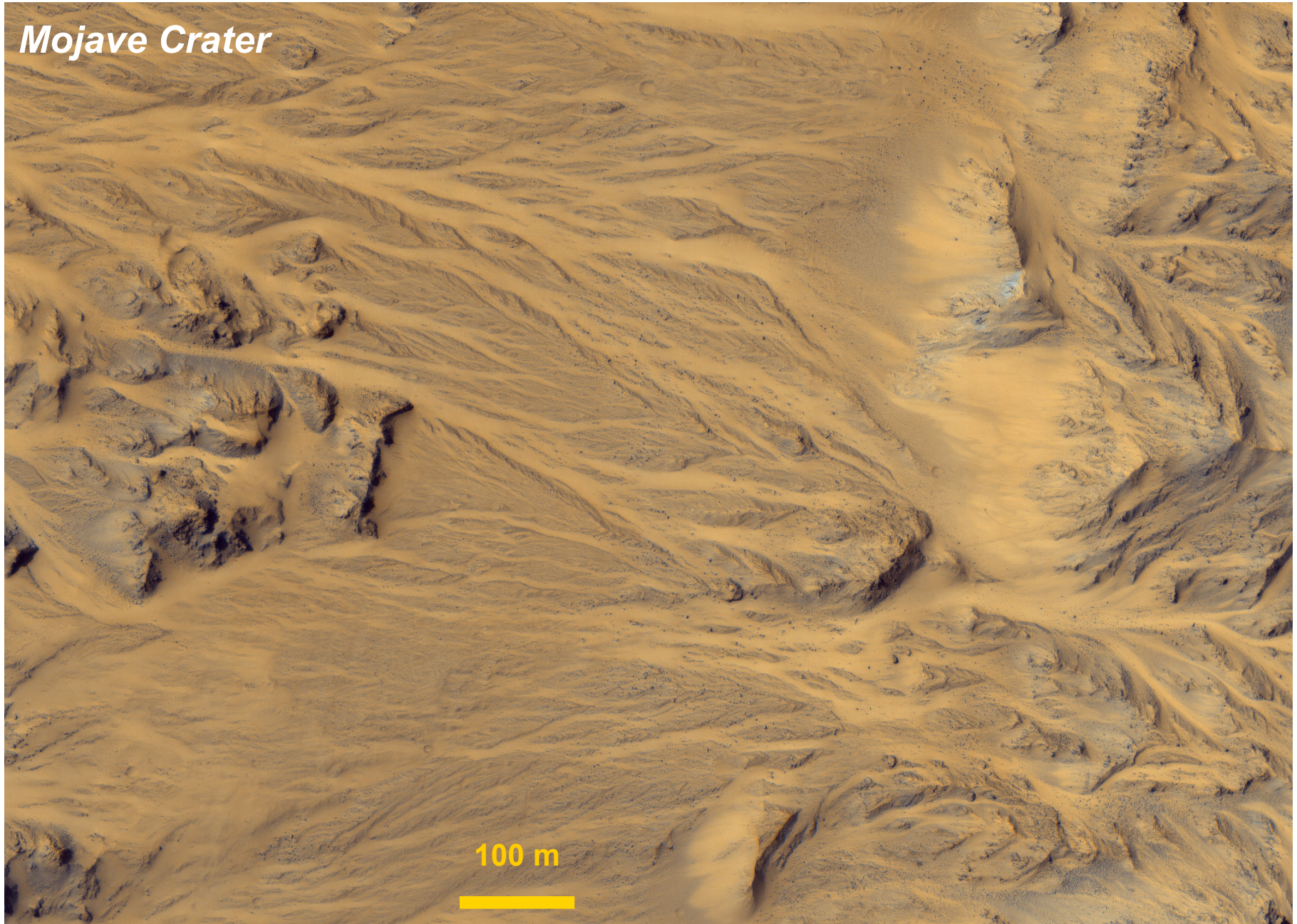
“Recent” fluvial activity driven by impact melting?

Mojave Crater



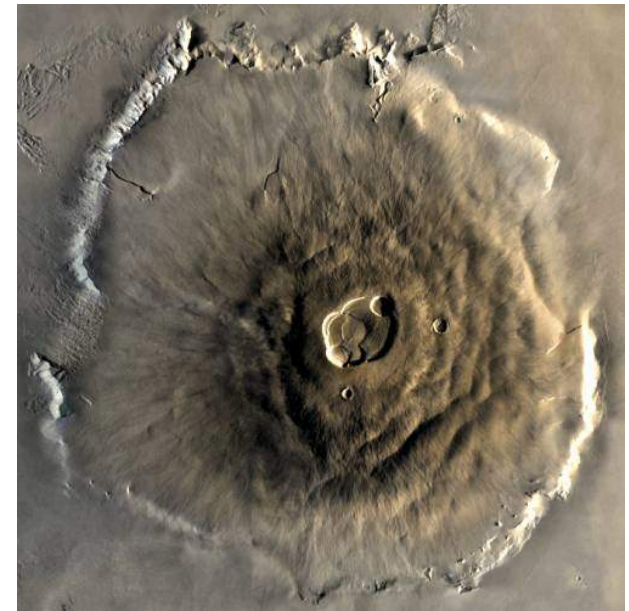
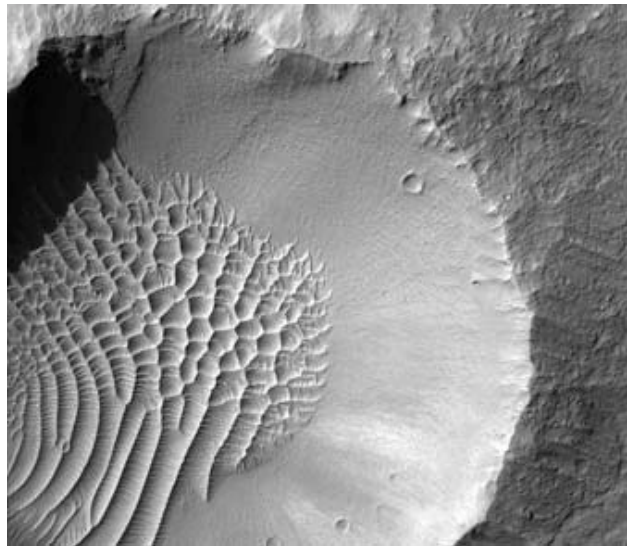
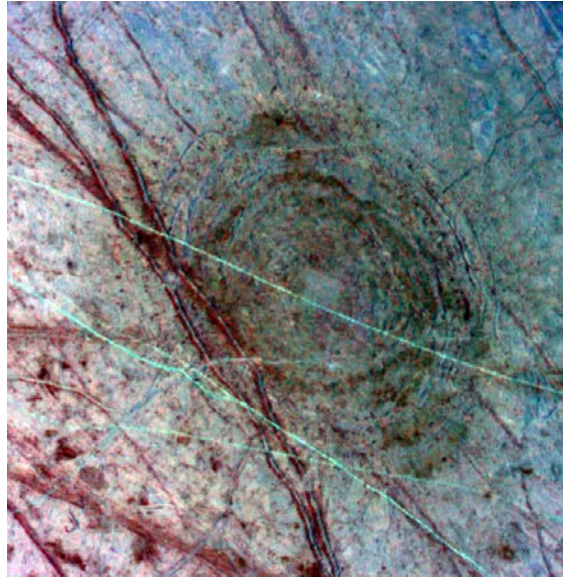
“Recent” fluvial activity driven by impact melting?

Mojave Crater



Planetary Surface Processes

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Gravity
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Chemical
weathering



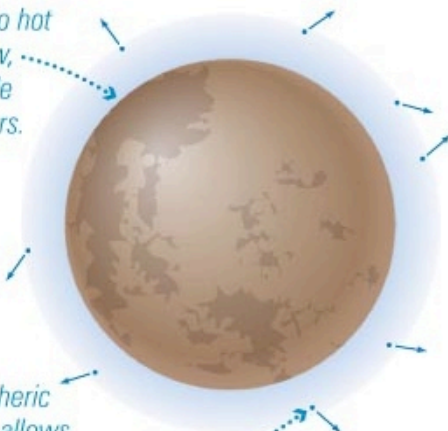
Mars is the outermost terrestrial planet.

The Role of Distance from the Sun

Planets Close to the Sun

Surface is too hot for rain, snow, or ice, so little erosion occurs.

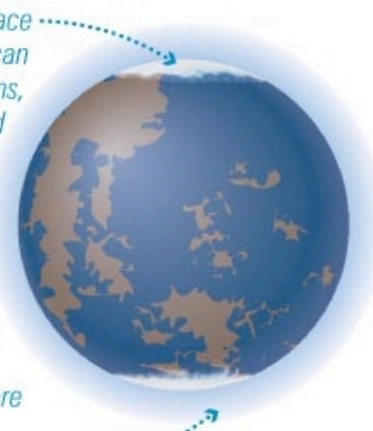
High atmospheric temperature allows gas to escape more easily.



Planets at Intermediate Distances from the Sun

Moderate surface temperatures can allow for oceans, rain, snow, and ice, leading to substantial erosion.

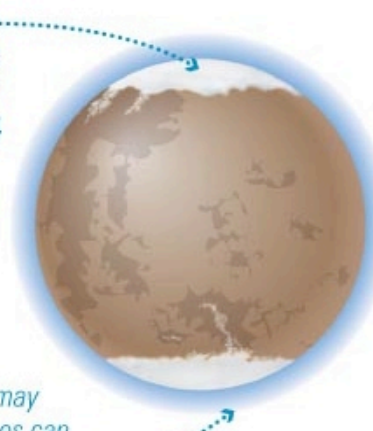
Gravity can more easily hold atmospheric gases.



Planets Far from the Sun

Low surface temperatures can allow for ice and snow, but no rain or oceans, limiting erosion.

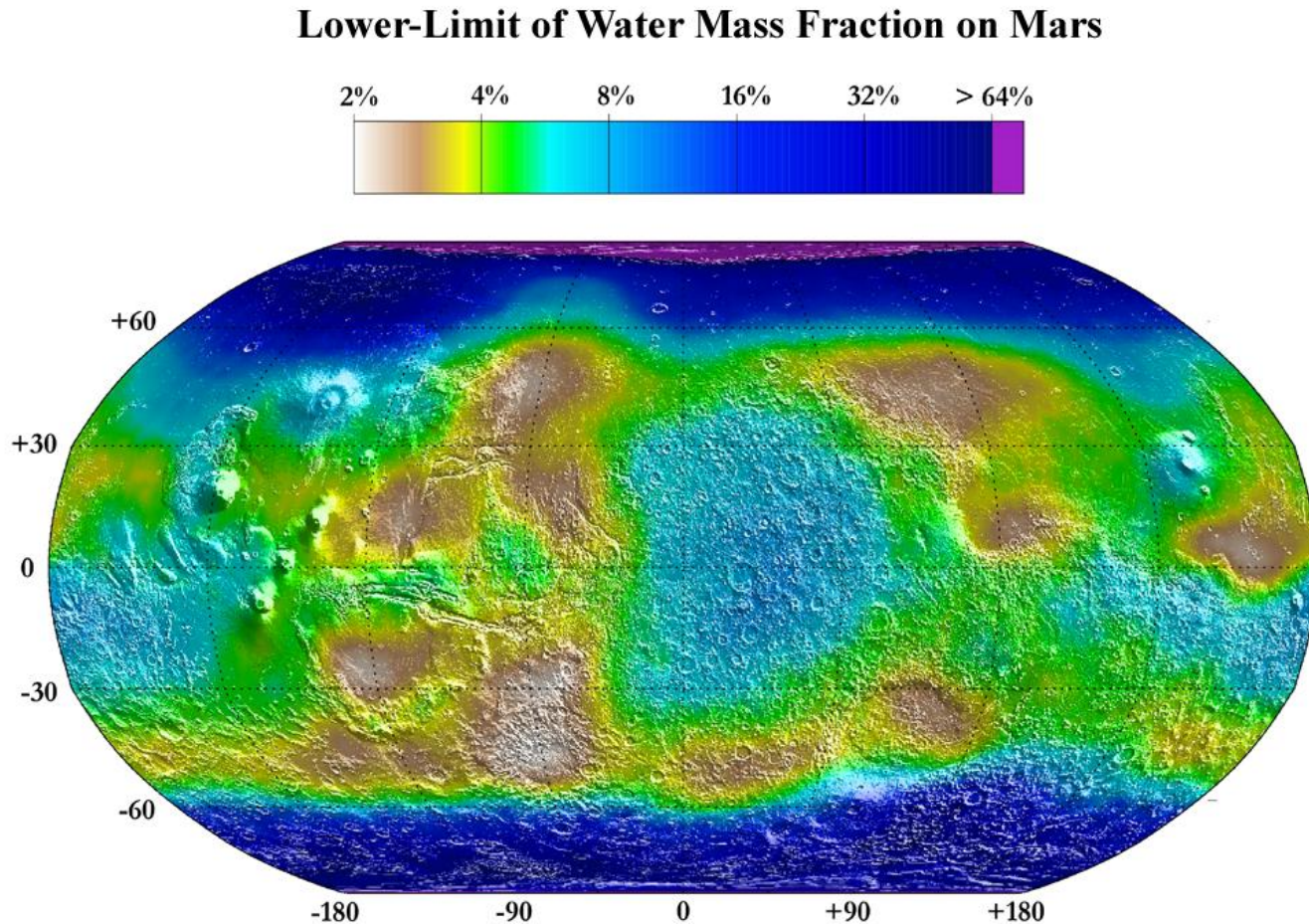
Atmosphere may exist, but gases can more easily condense to make surface ice.



Where is Mars's water now?

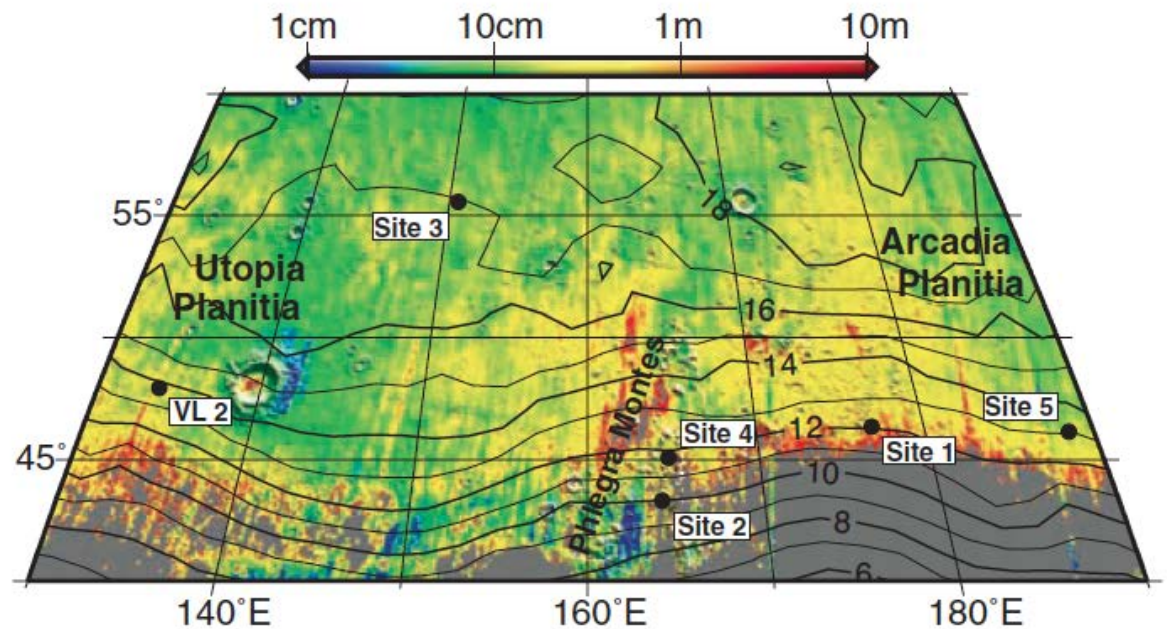
- Lost to space
- In atmosphere
- Trapped in
 - Polar caps (at surface)
 - Ground ice
 - Mineral structures in rocks

Ground Ice (and hydrated minerals): Evidence from Neutron Spectroscopy



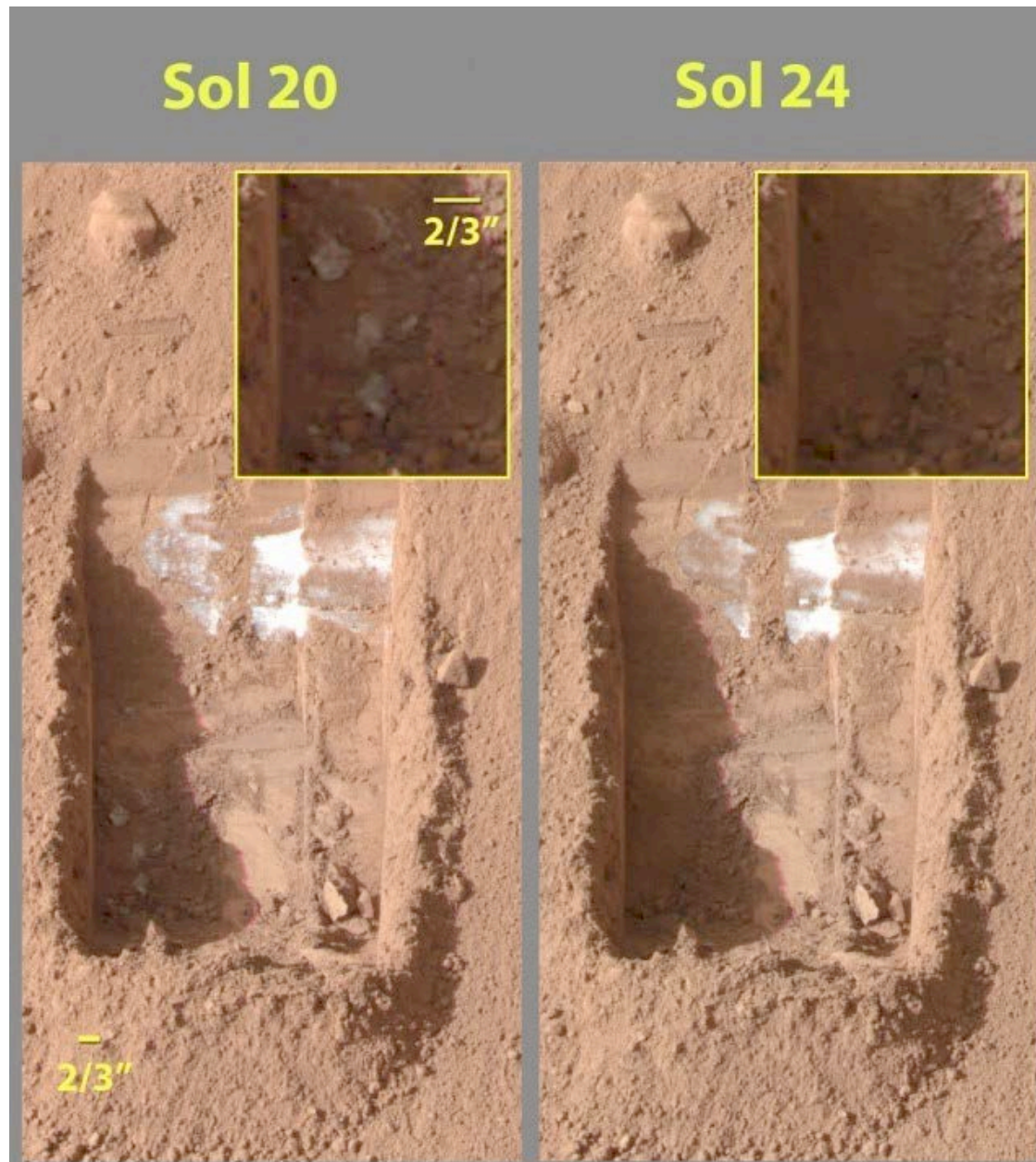
Data from Mars Odyssey Gamma Ray Spectrometer, see for example Feldman et al. 2002

Ice revealed by impacts

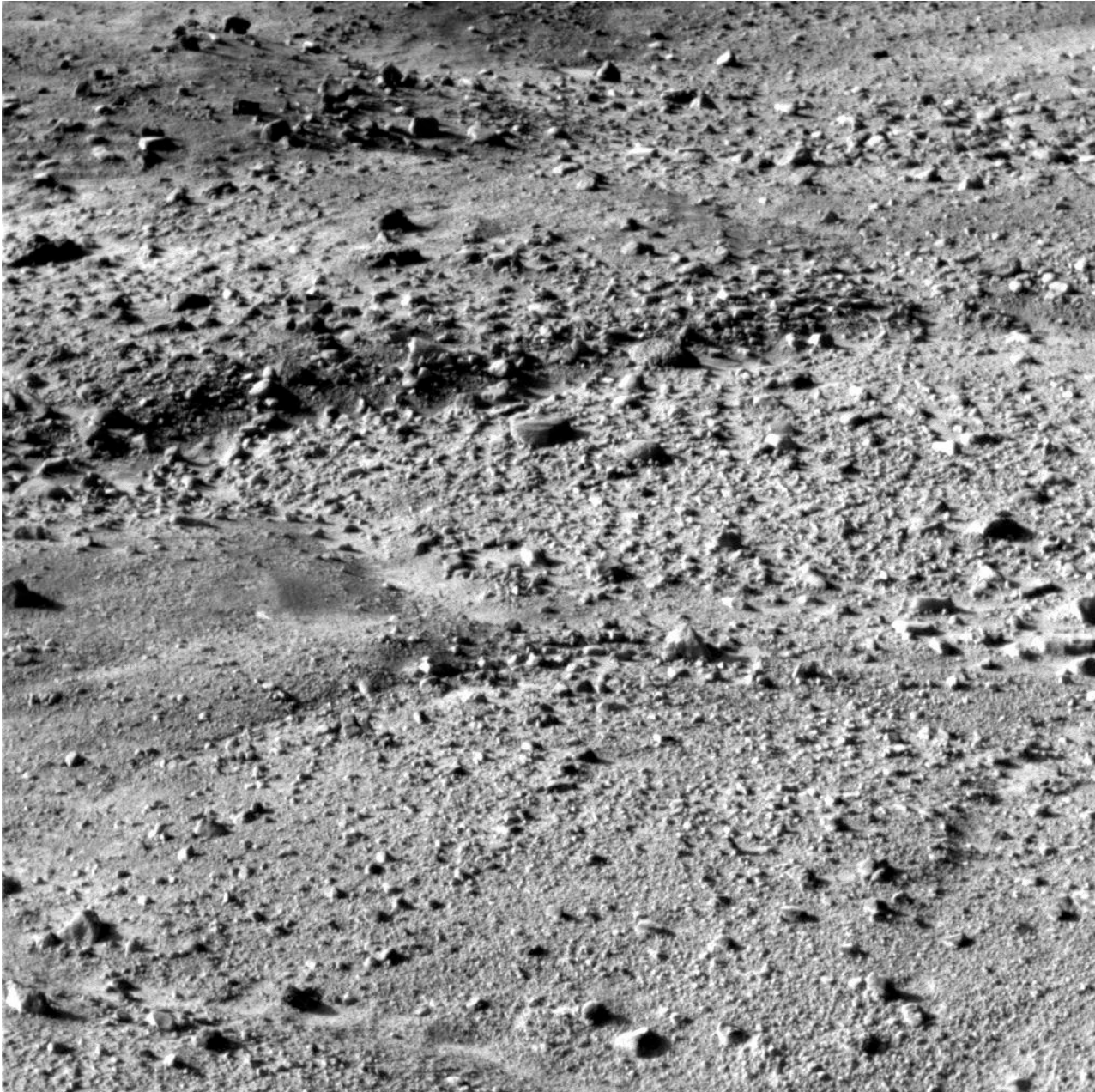


Byrne et al. (2009)

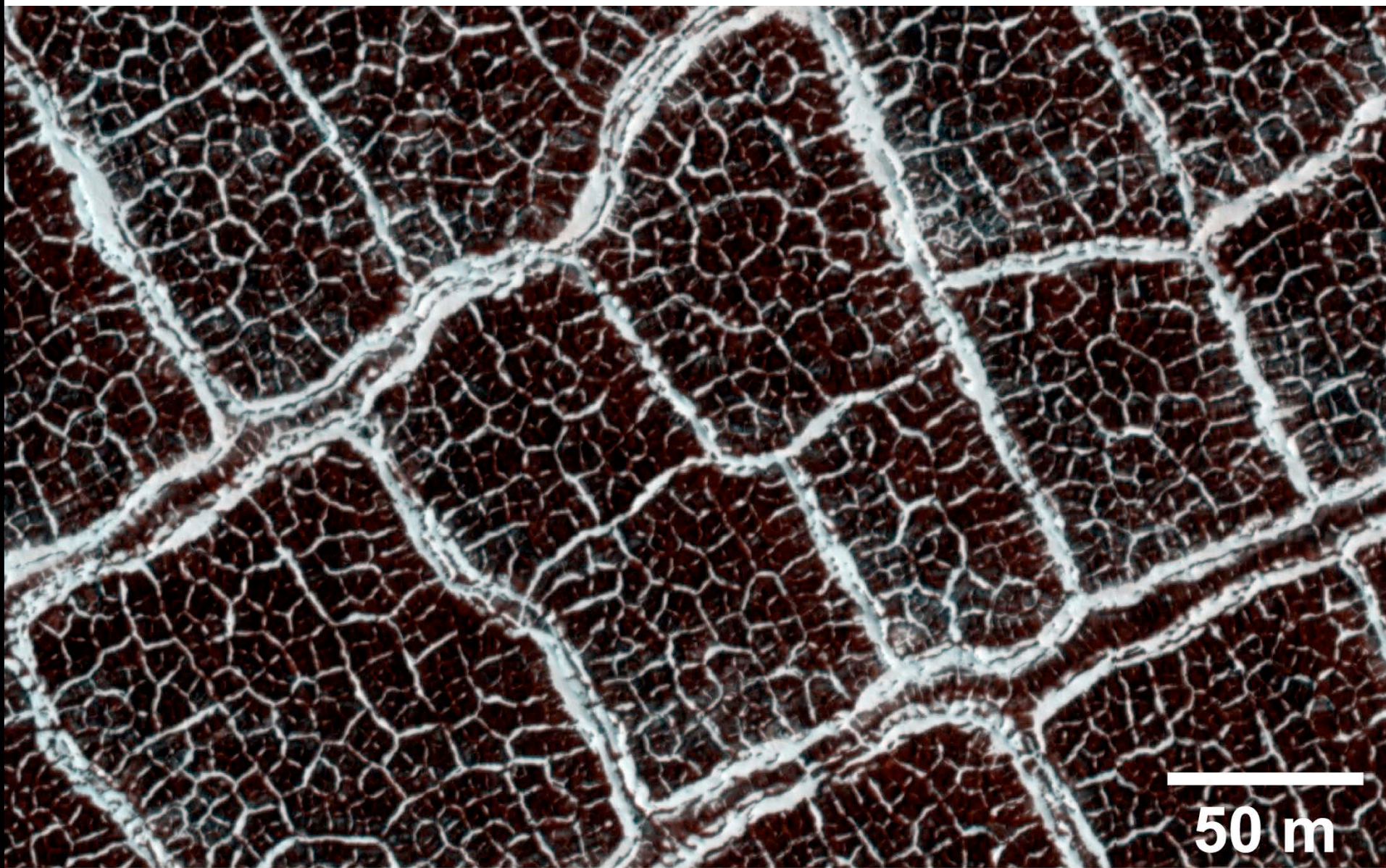
Phoenix observed ice directly



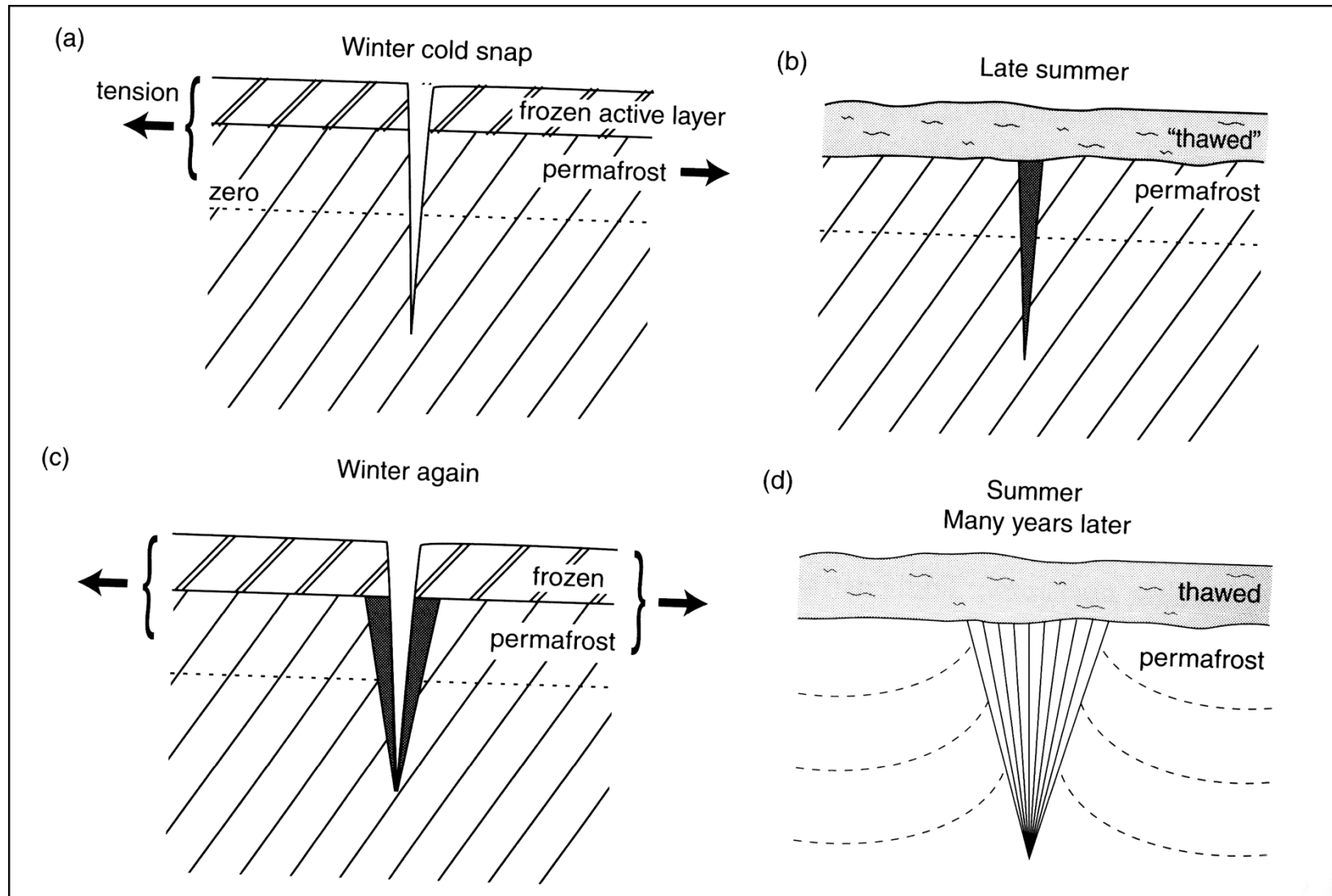
Polygonal patterned ground - Phoenix



Polygonal patterned ground - HiRISE



Contraction crack formation



Melosh (2011)