The History of Water on Mars: Implications for Future Exploration

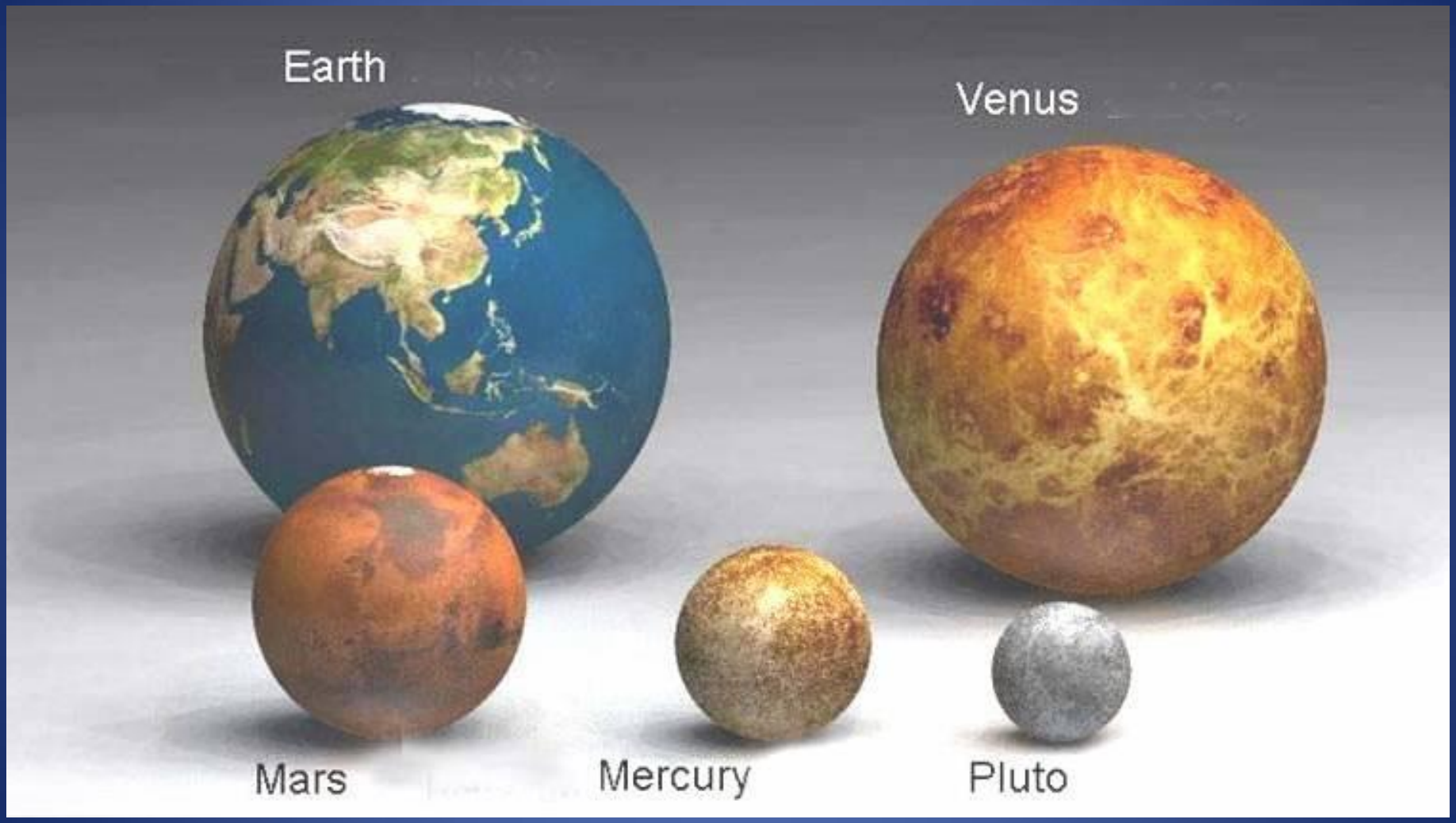
Patricia Craig, Ph.D.

Lunar and Planetary Institute

Houston, TX

Let’s compare…

1 AU	Distance from Sun	1.5 AU
12,754 km	Diameter	6,779 km
365 days	Year	687 sols
24 hrs	Day	24 hrs, 40 min
1 g	Gravity	0.38 g
1000 mbar	Atmosphere	7 mbar
61°F (16°C)	Temperature	-67°F (-55°C)


Earth
Venus
Mars
Mercury
Pluto

Mars Exploration Strategy:

Prepare for Human Exploration

Mars Exploration Strategy:

W A T E R

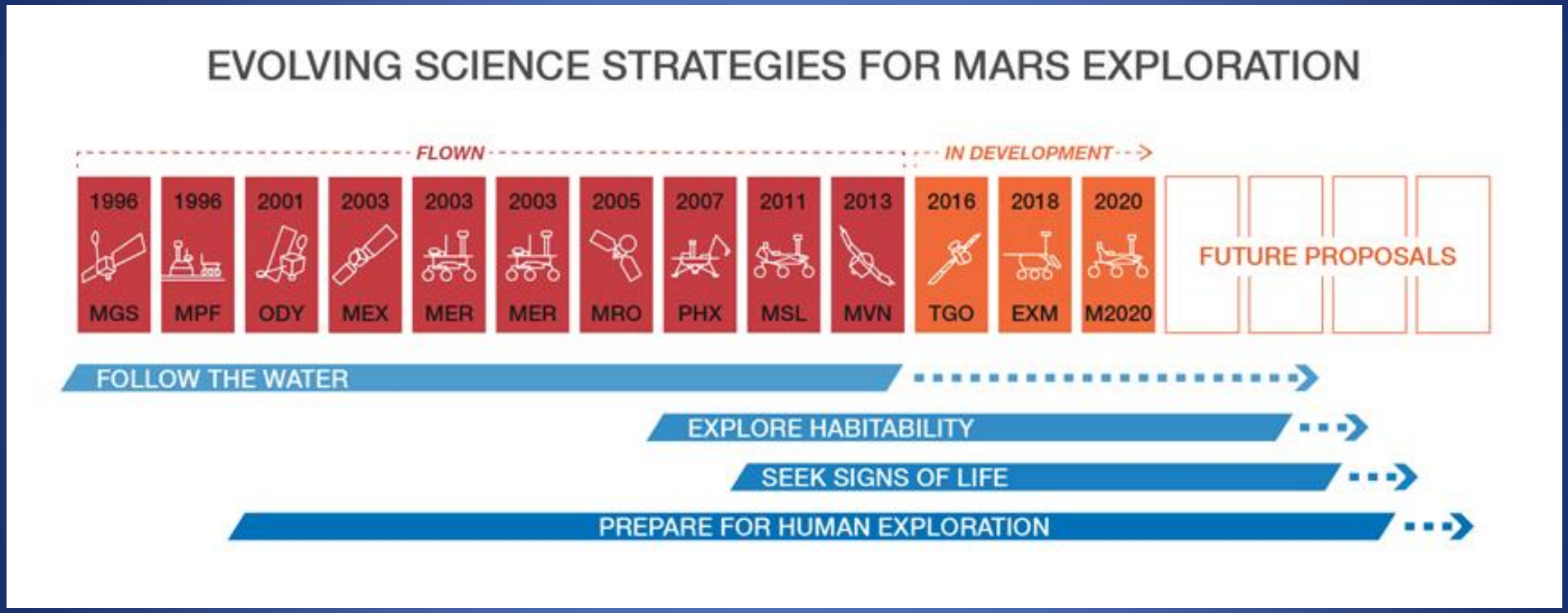
Determine if Life Ever Arose on Mars

Characterize the Climate

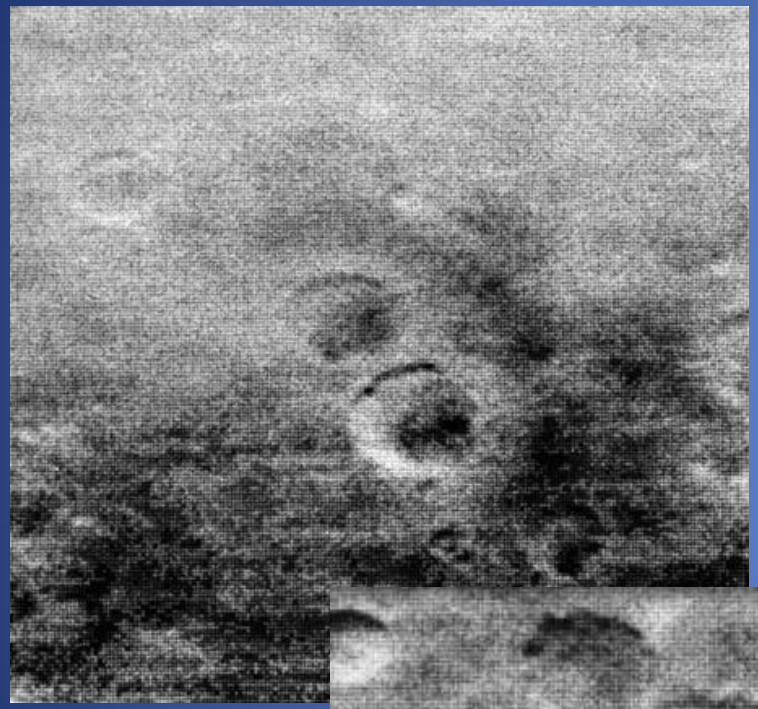
Characterize the Geology

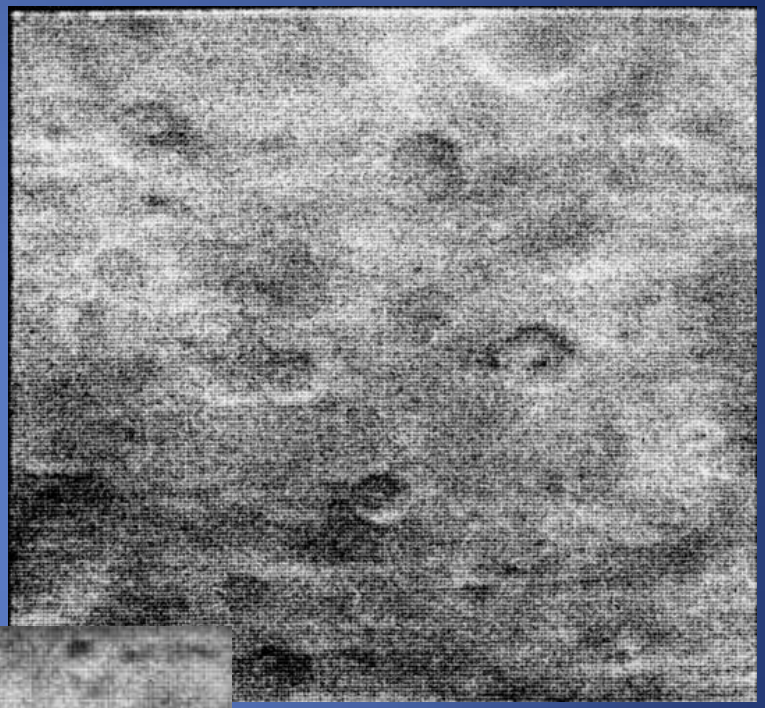
Prepare for Human Exploration

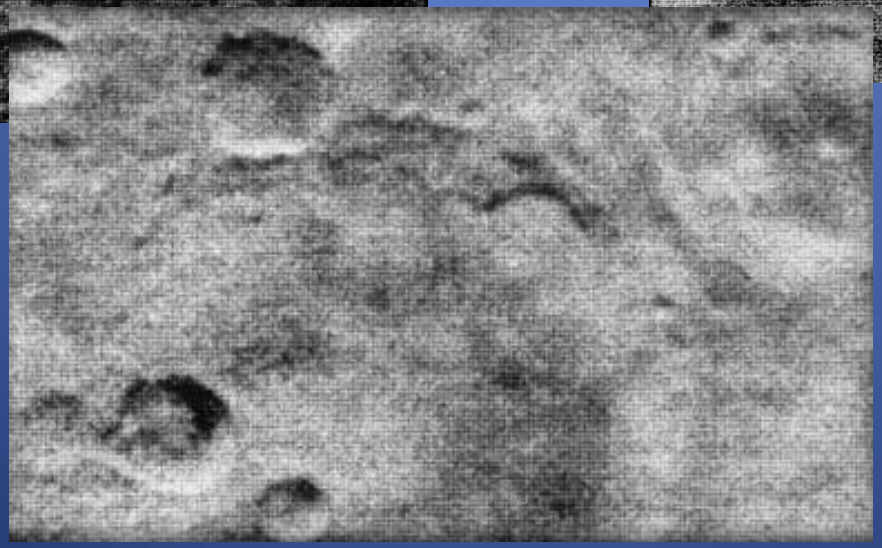
Follow the Water

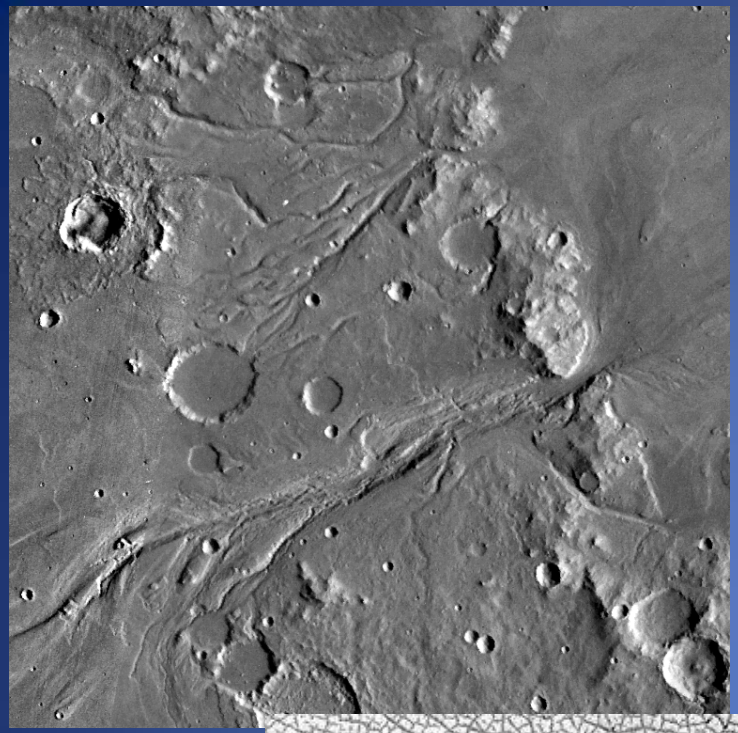


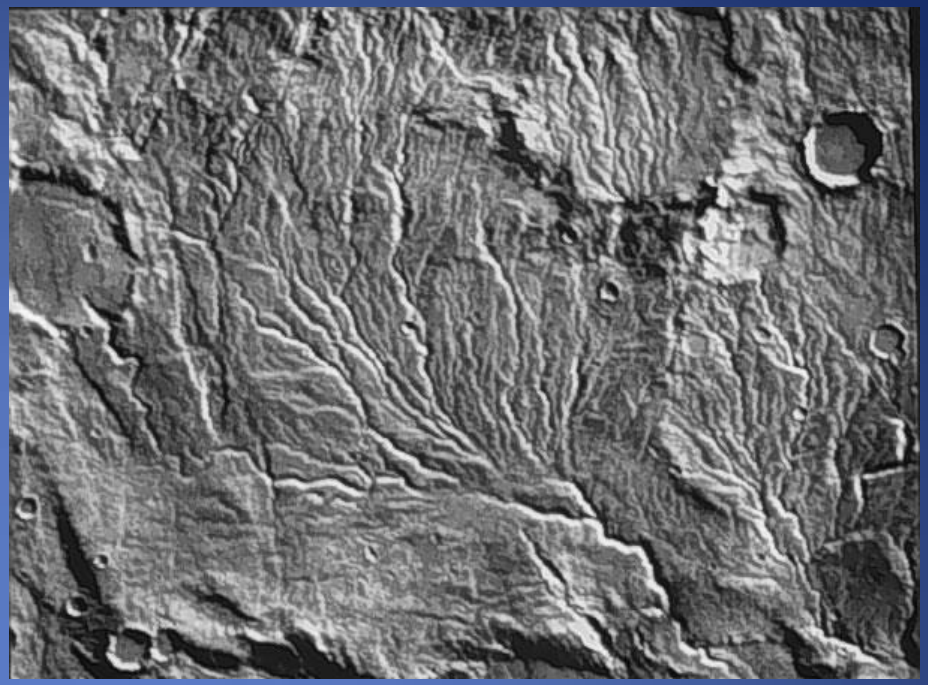
Mariner 4 – First Mars Flyby

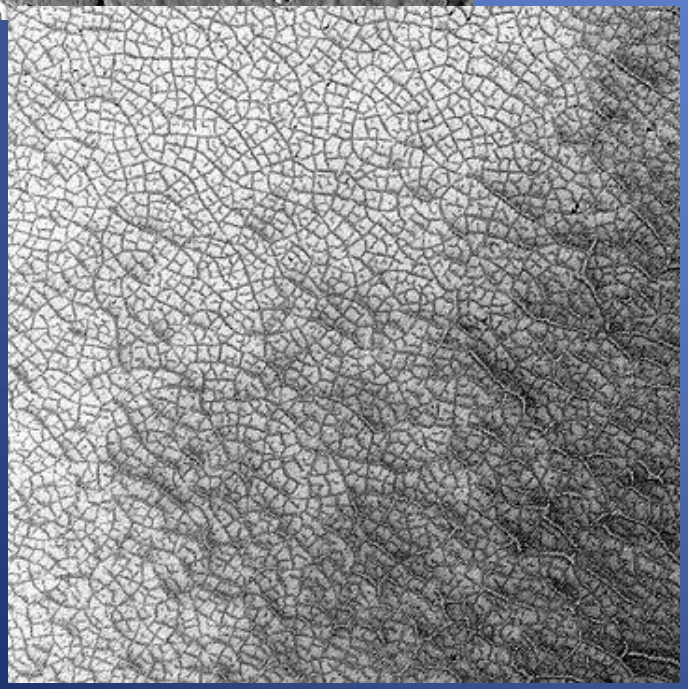


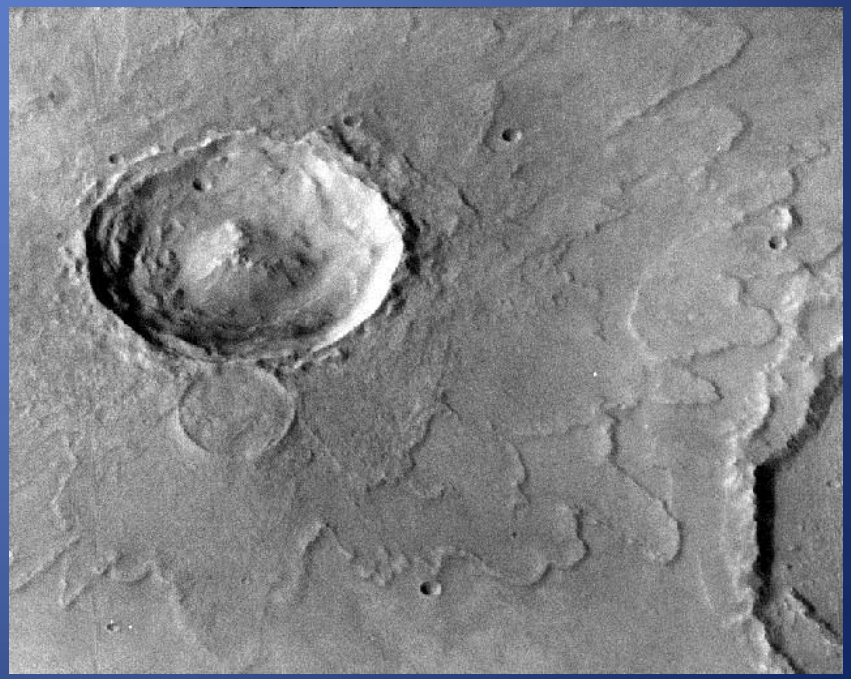




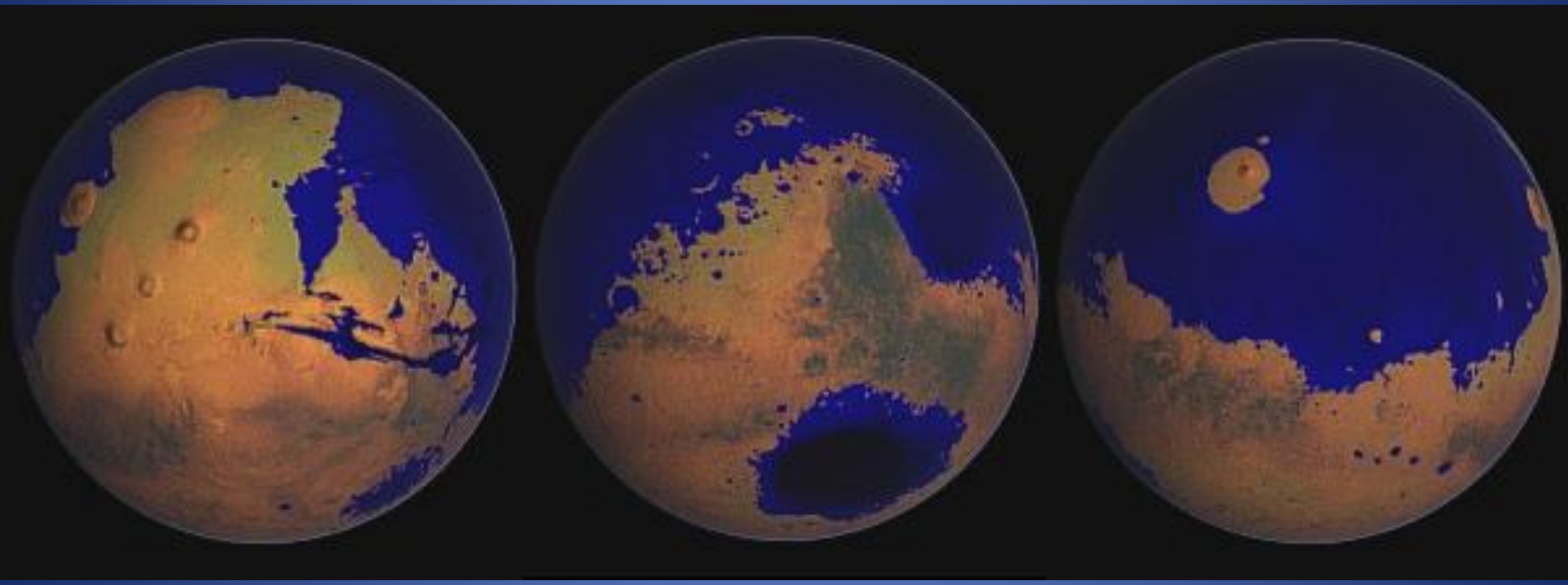




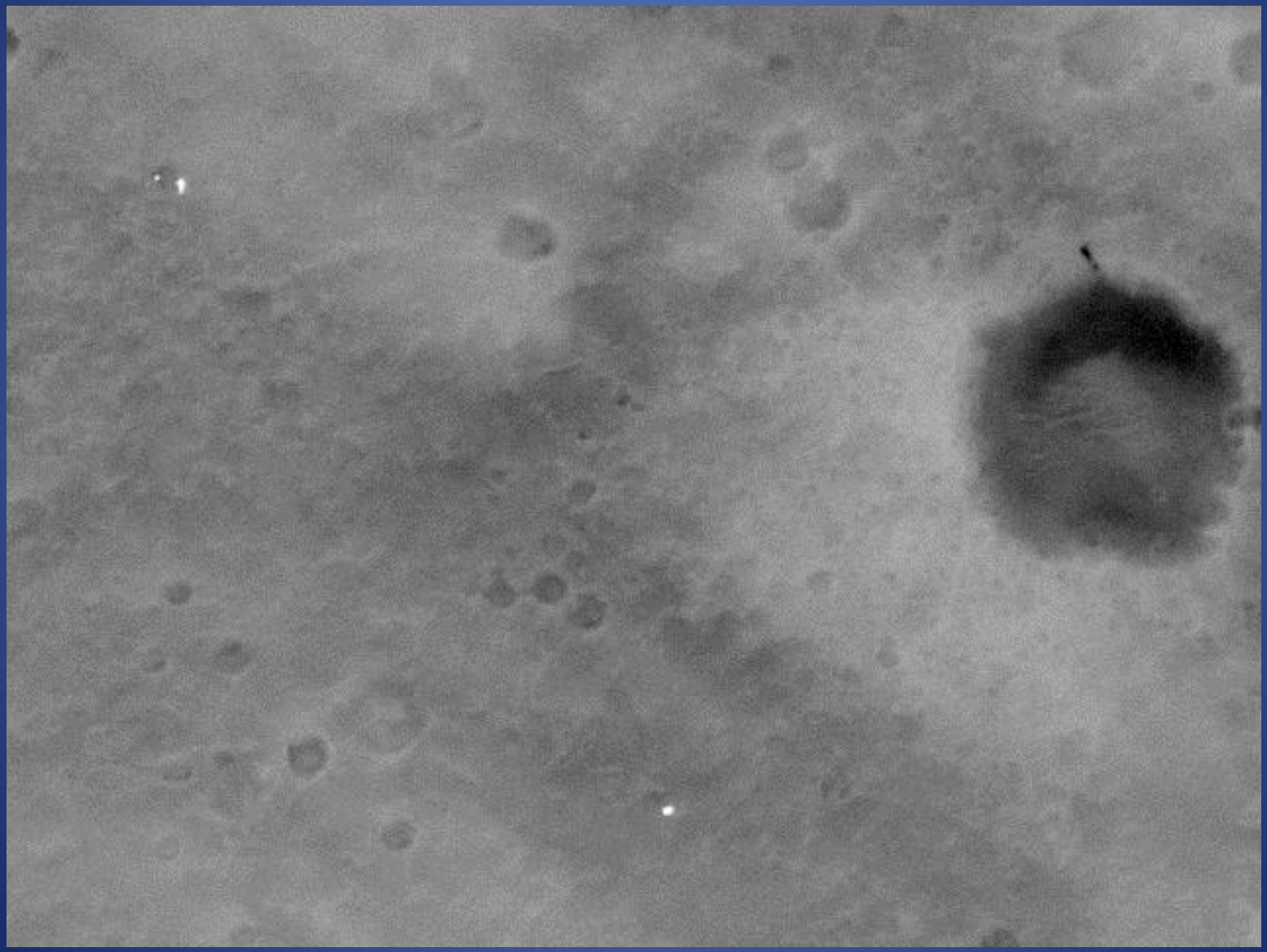




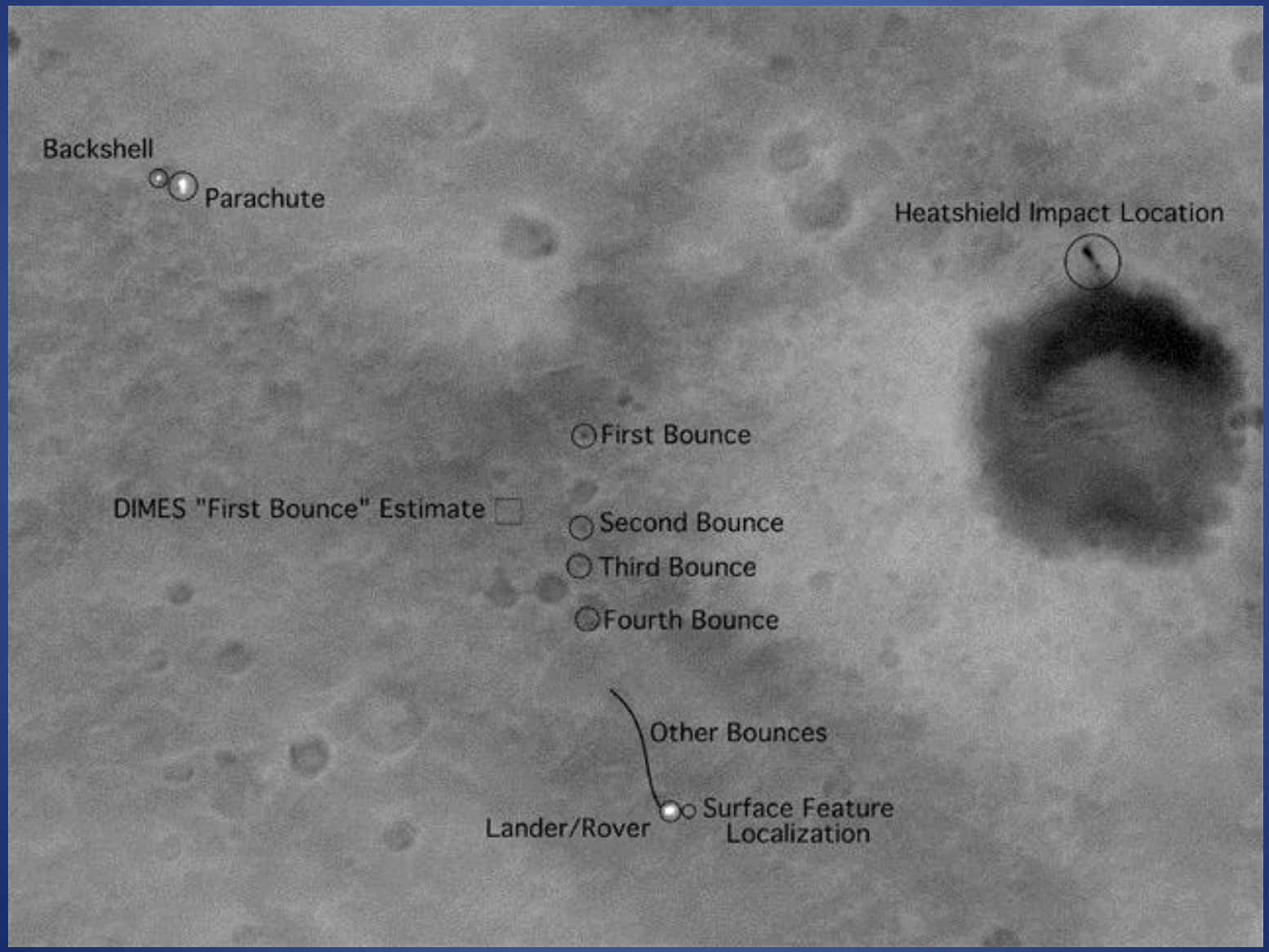
Did Mars once have an ocean?



MER - Spirit

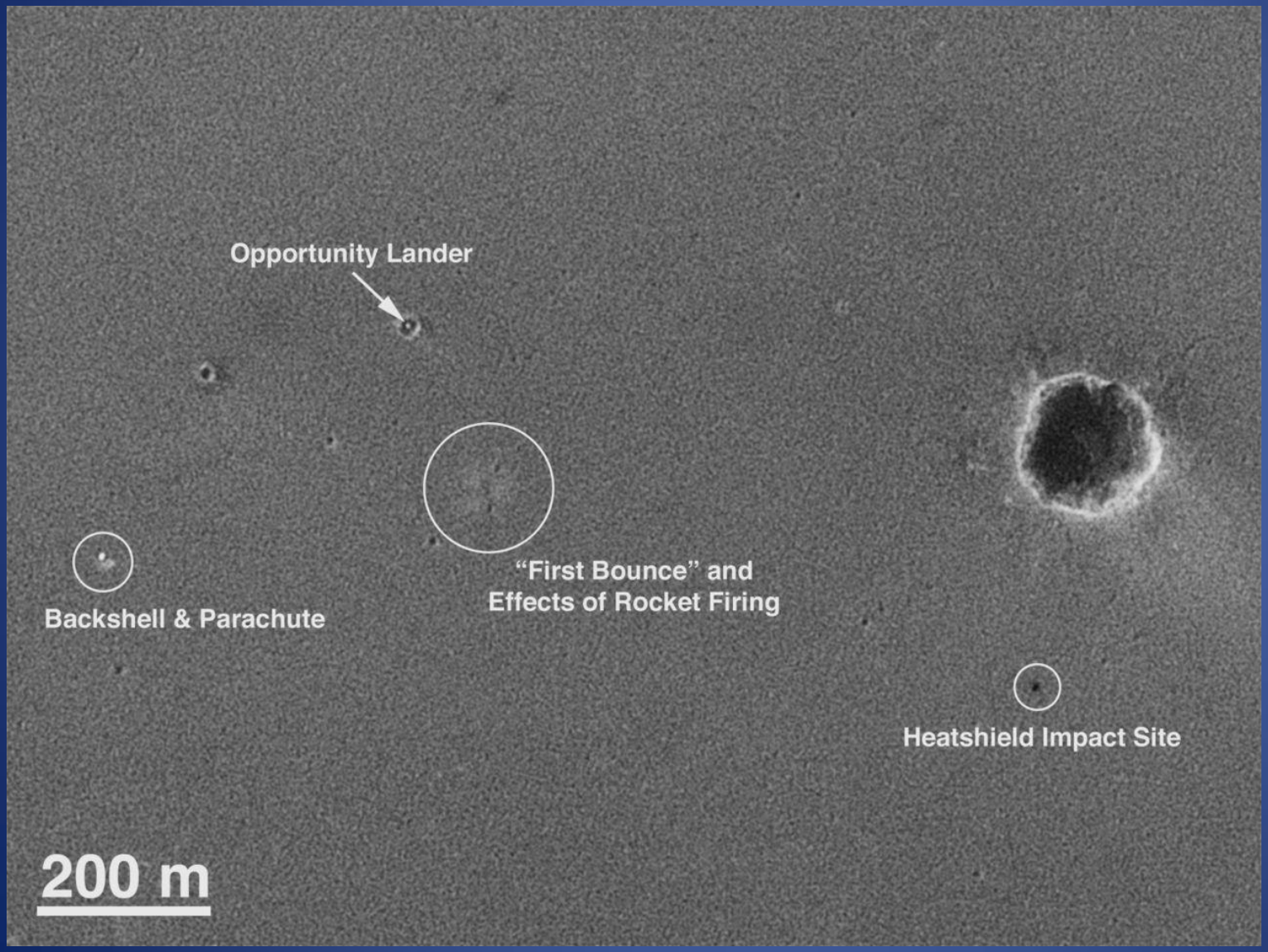


MER - Spirit


Backshell
Parachute
Heatshield Impact Location
First Bounce
DIMES "First Bounce" Estimate
Second Bounce
Third Bounce
Fourth Bounce
Other Bounces
Lander/Rover
Surface Feature
Localization

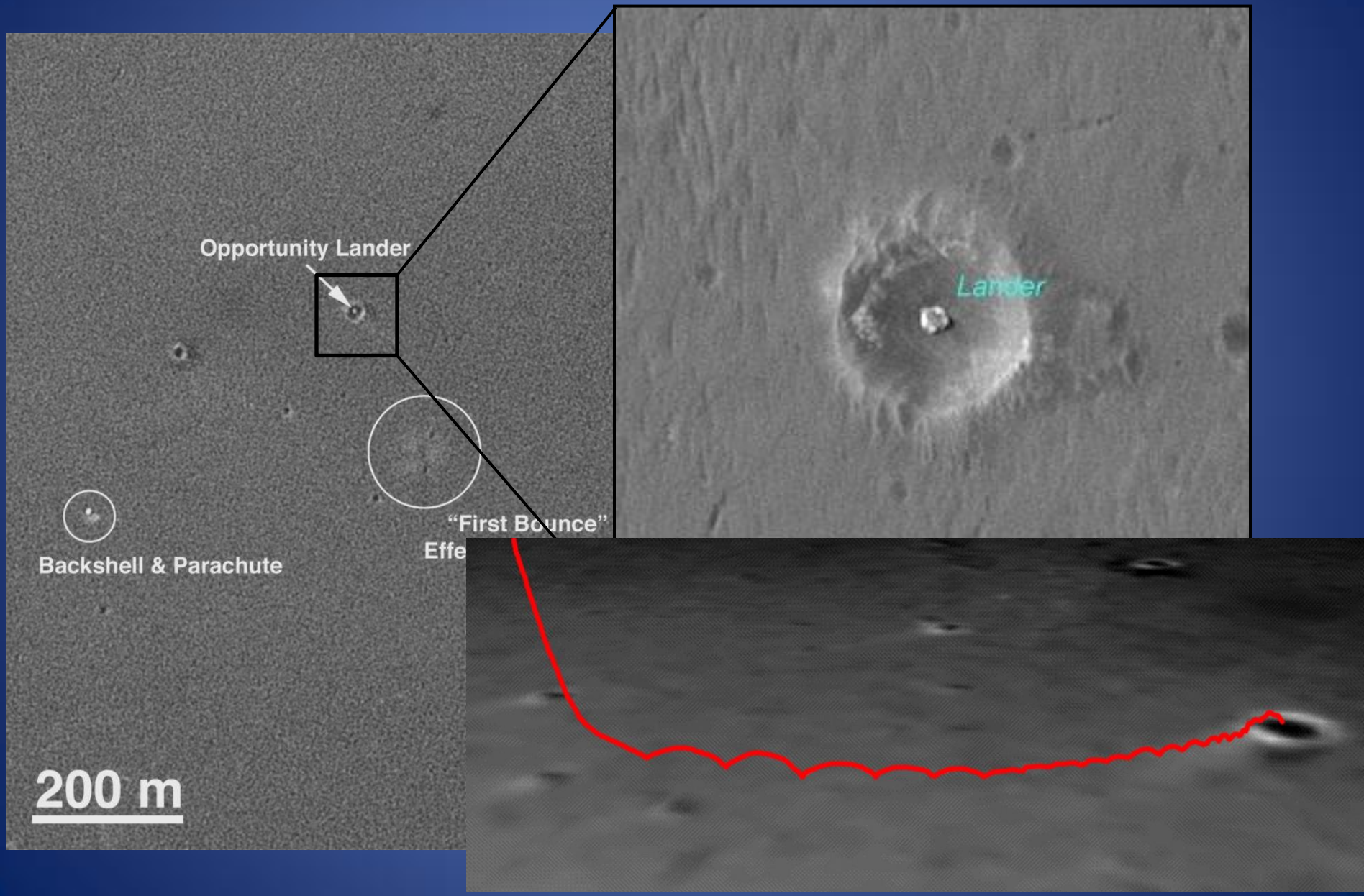
Celebrating Spirit on Mars

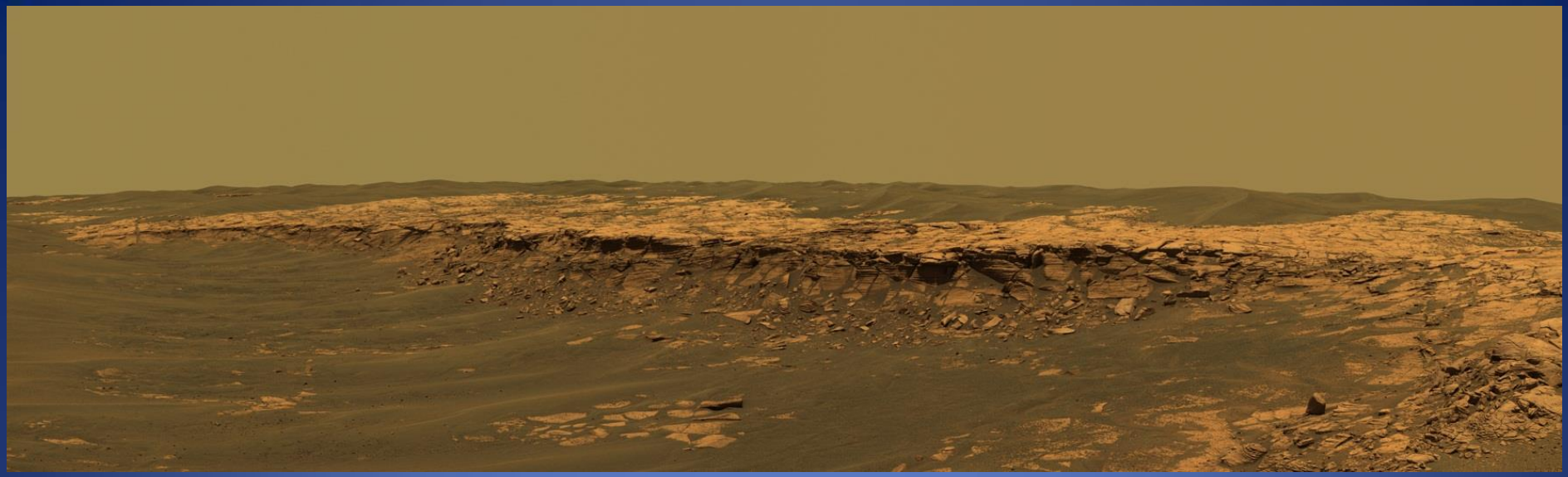
MER – Opportunity

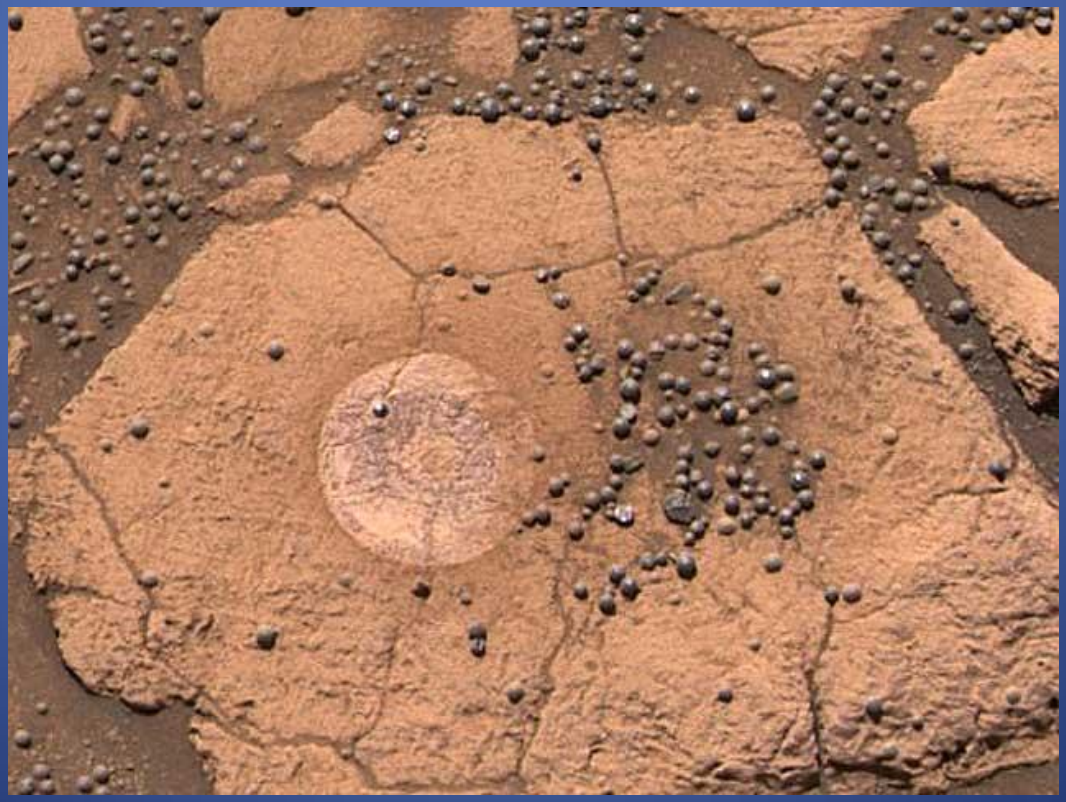


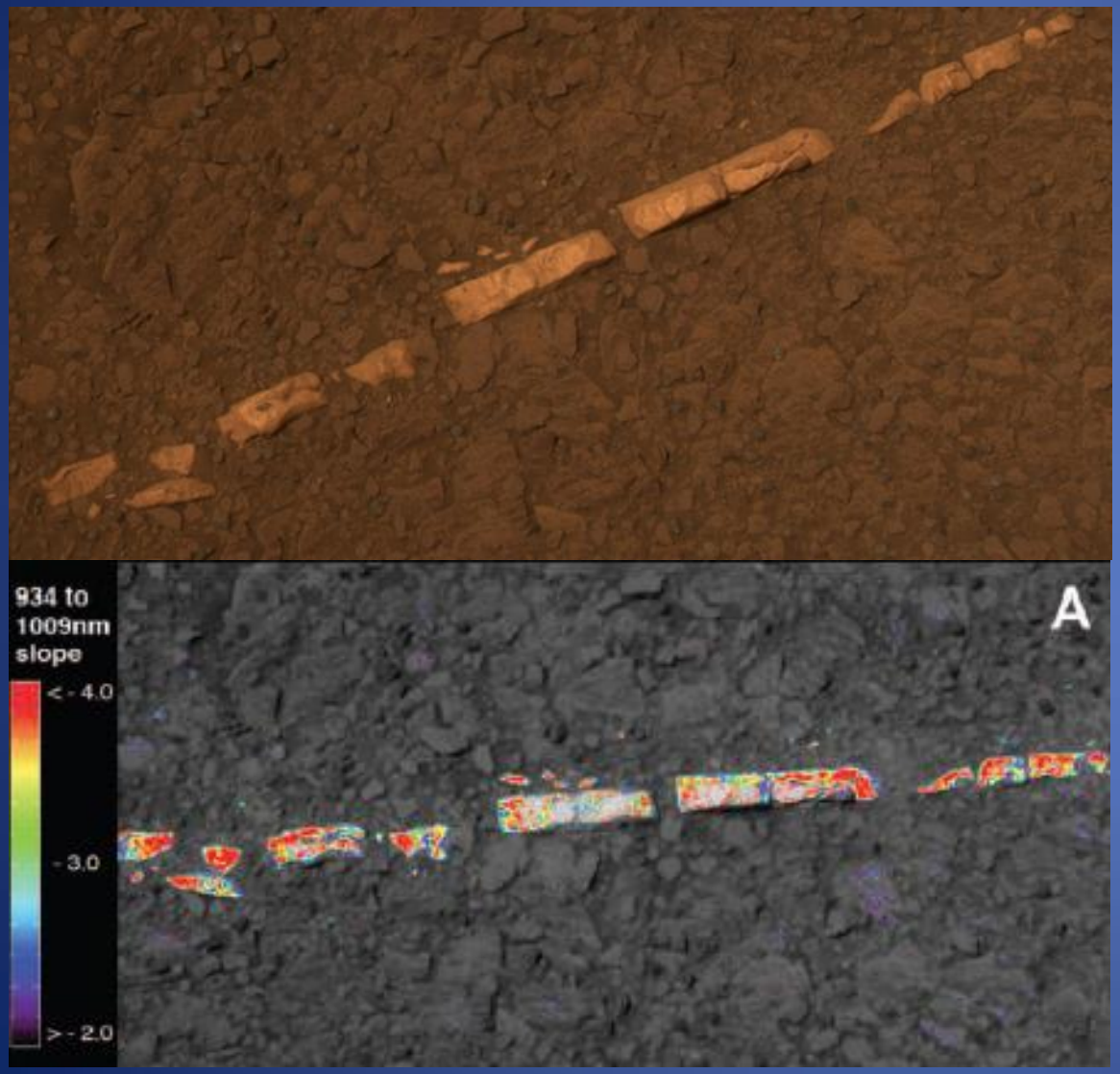
MER – Opportunity

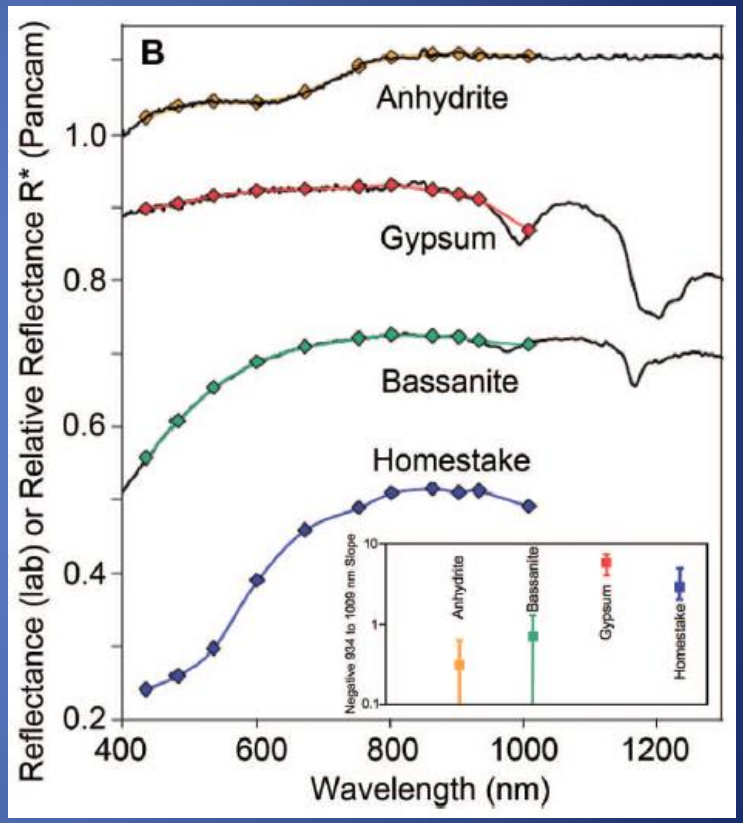
MER – Opportunity





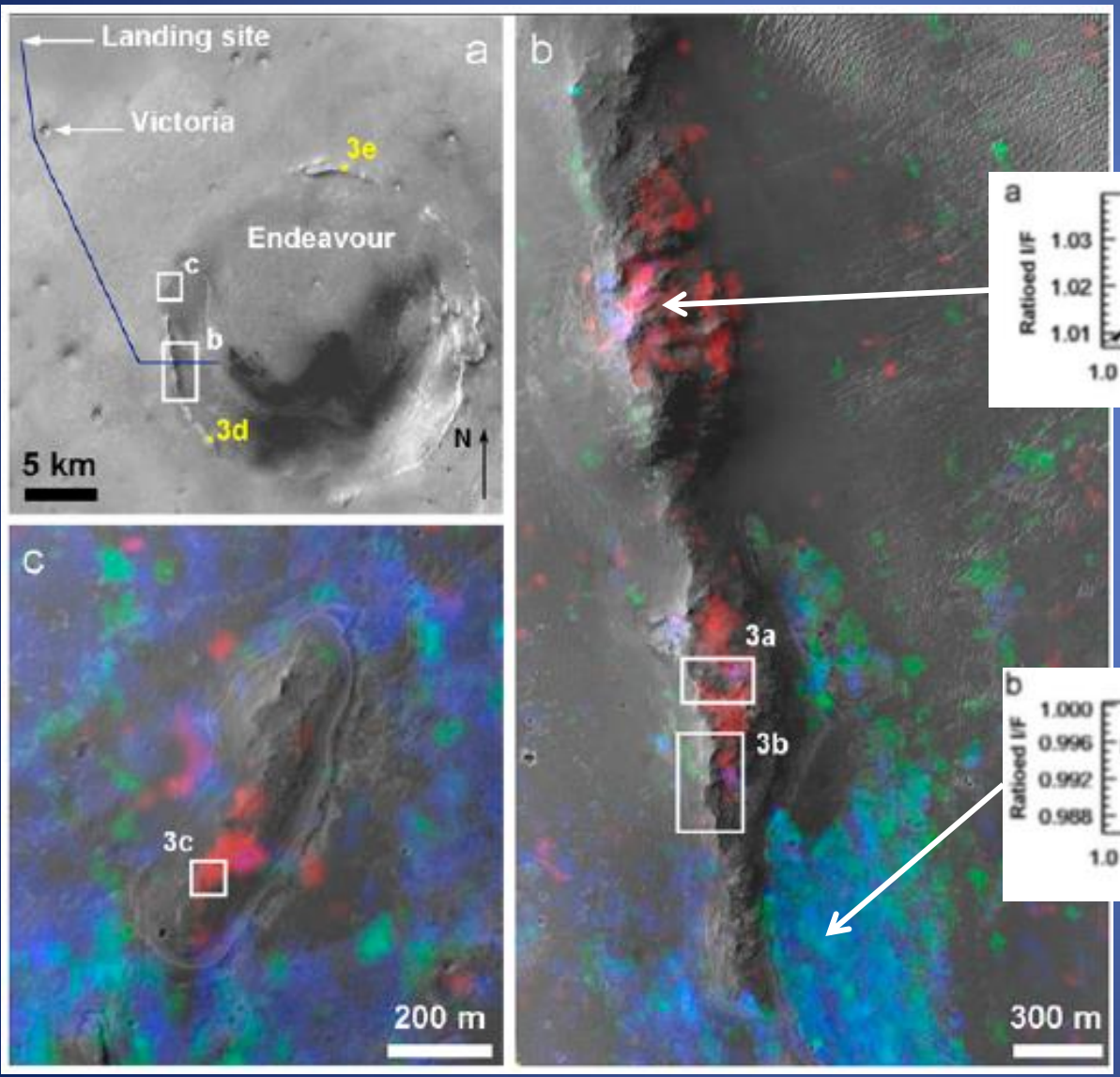




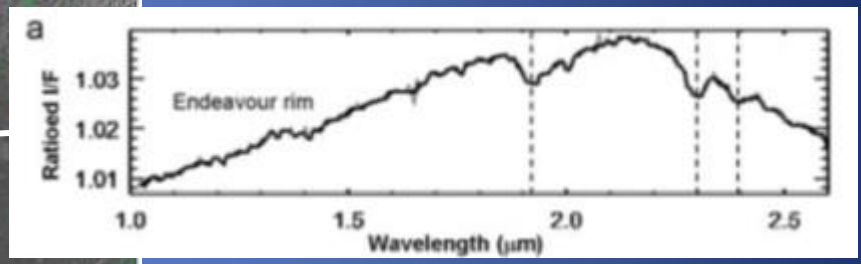


Squyers et al., 2012

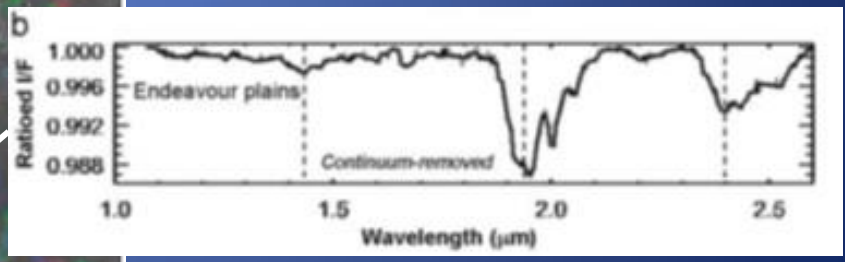
Opportunity at Endeavour Crater



Fe/Mg-phyllosilicates

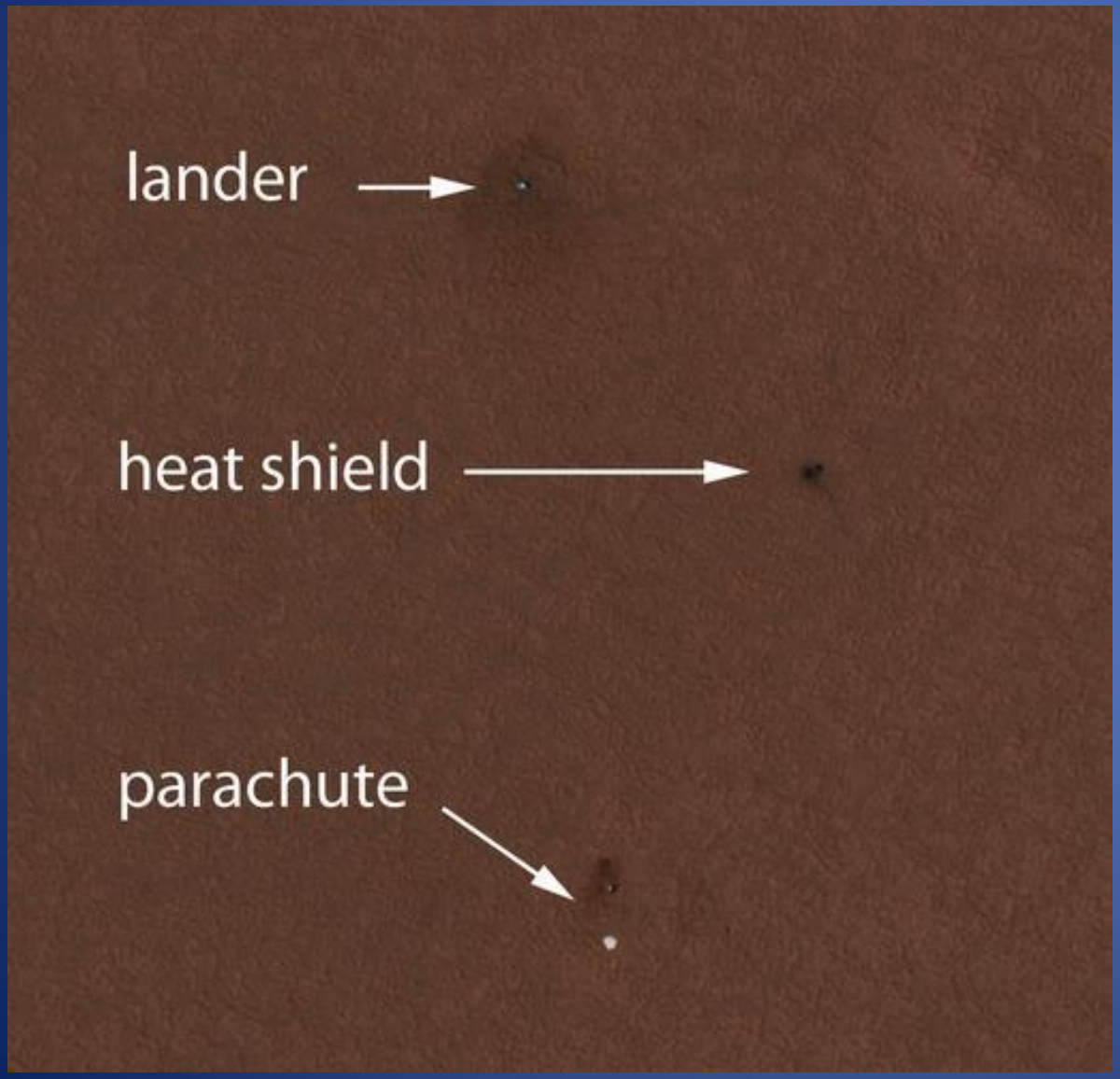


Poly-hydrated
Fe/Mg-sulfates

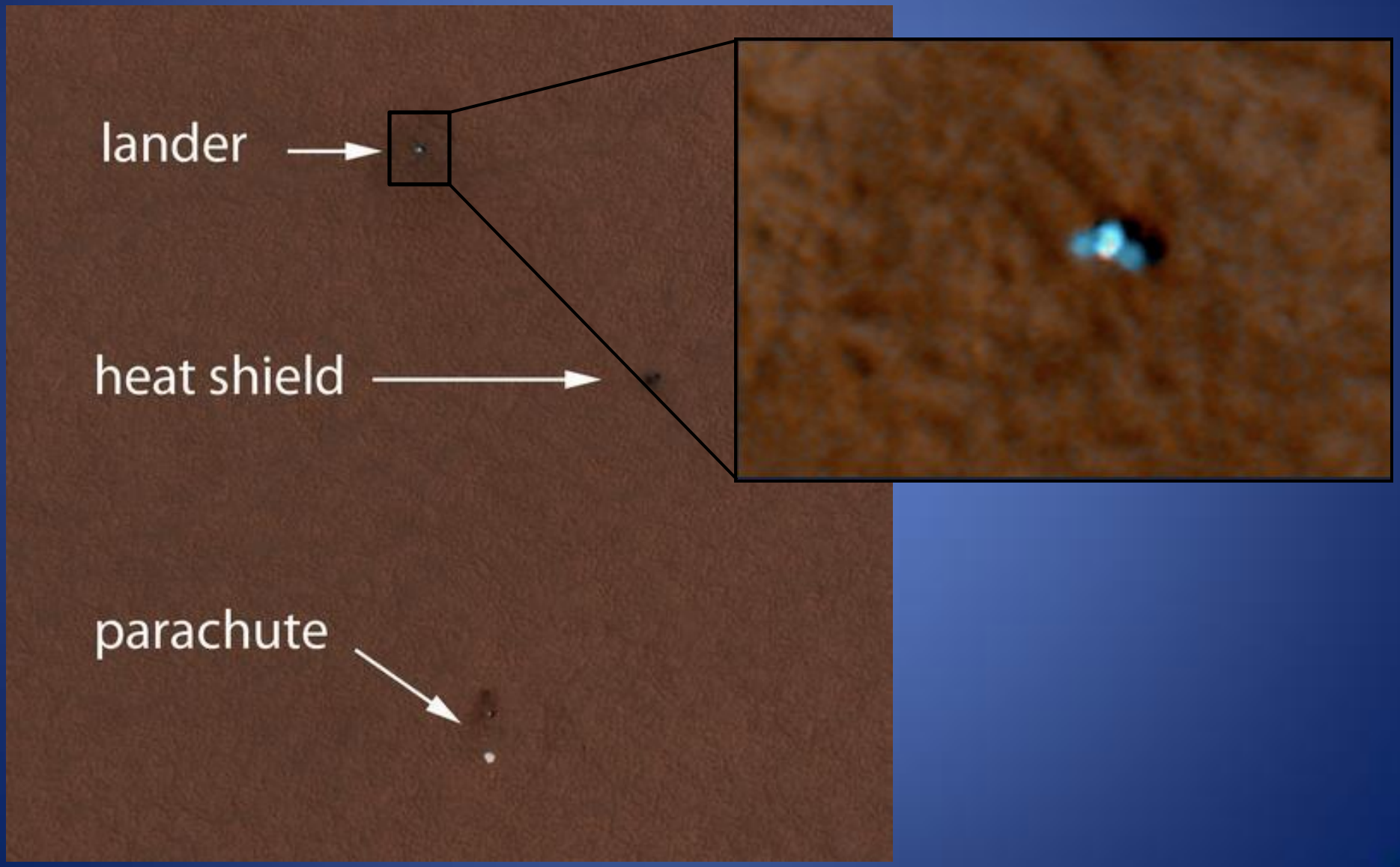


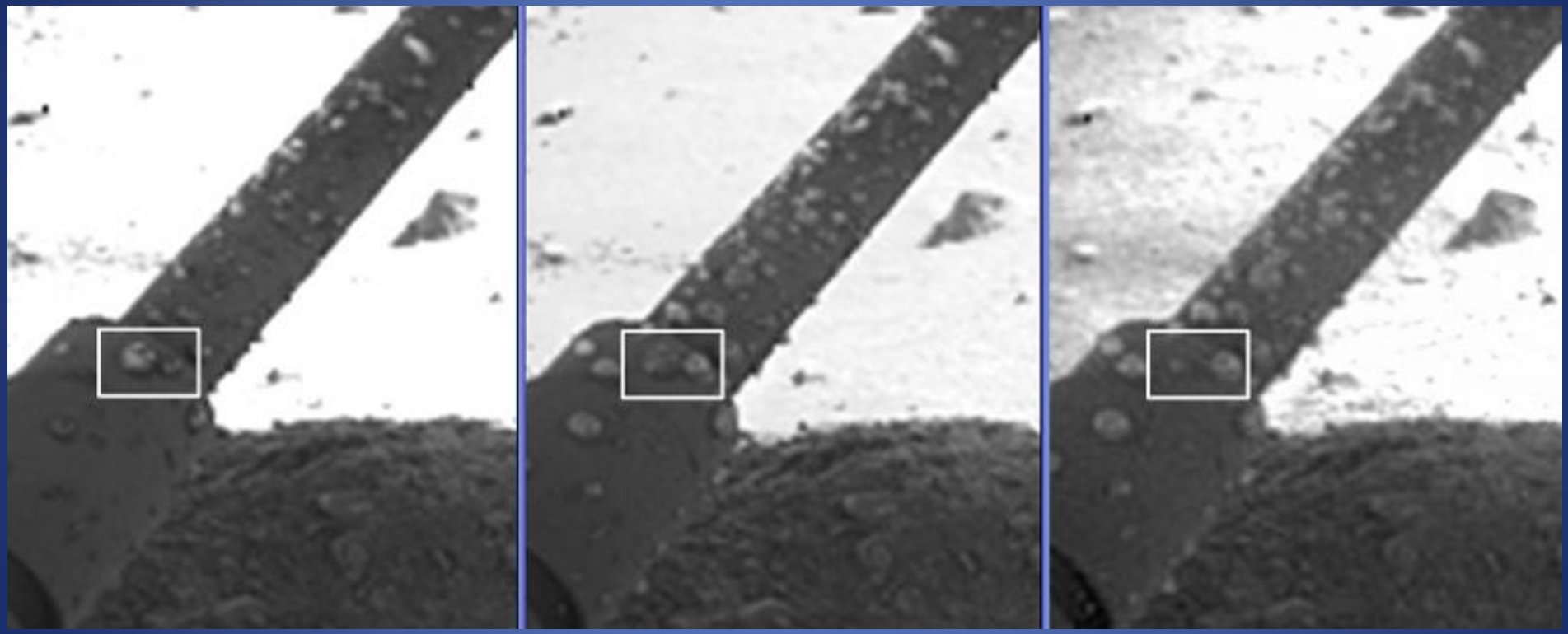
Wray et al., 2009

Phoenix Lander



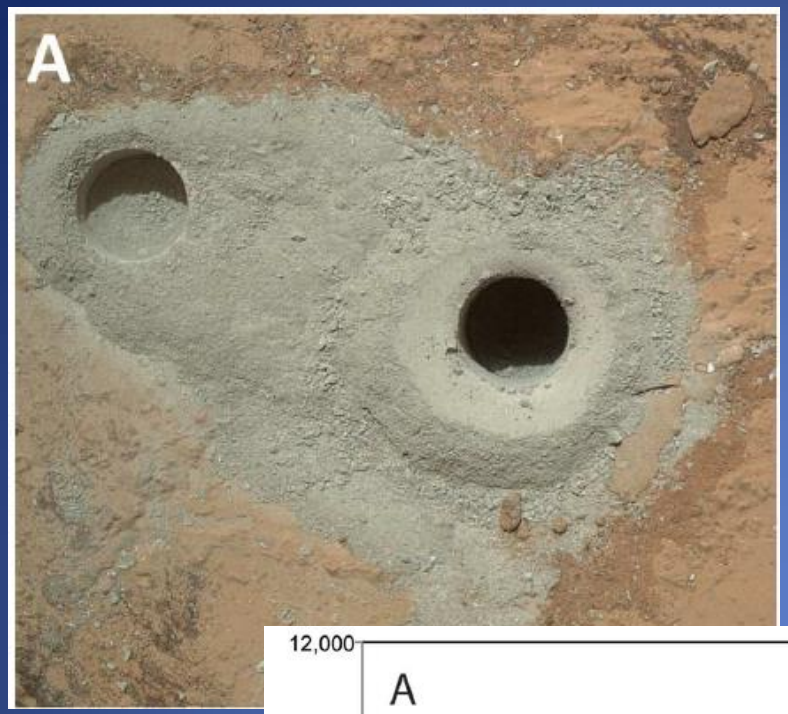
Phoenix Lander

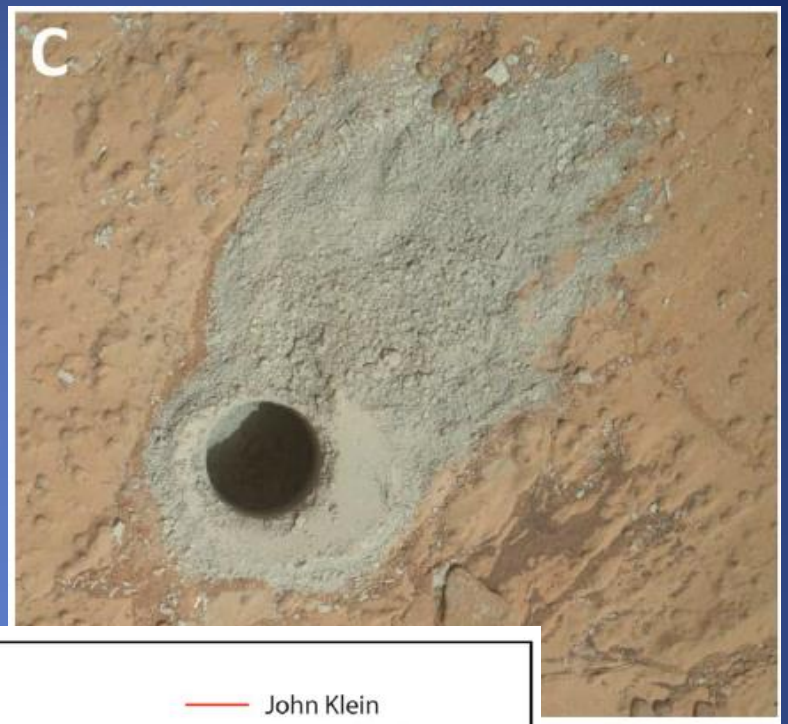


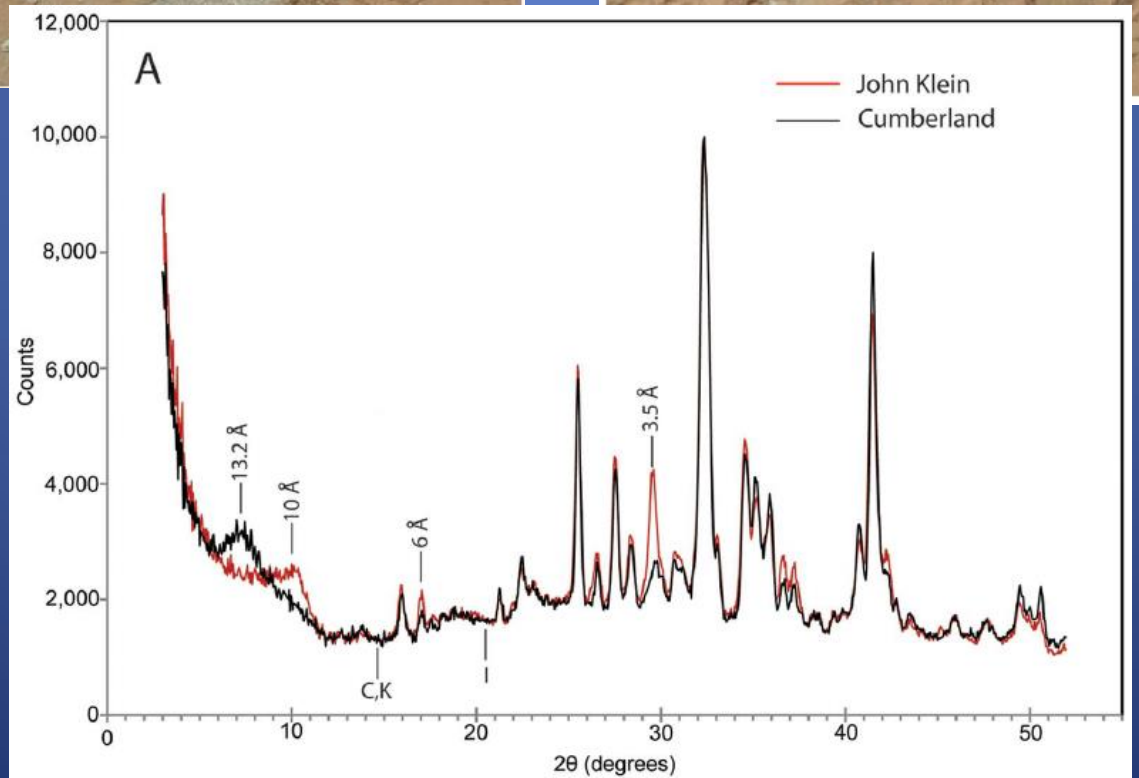


MSL - *Curiosity*

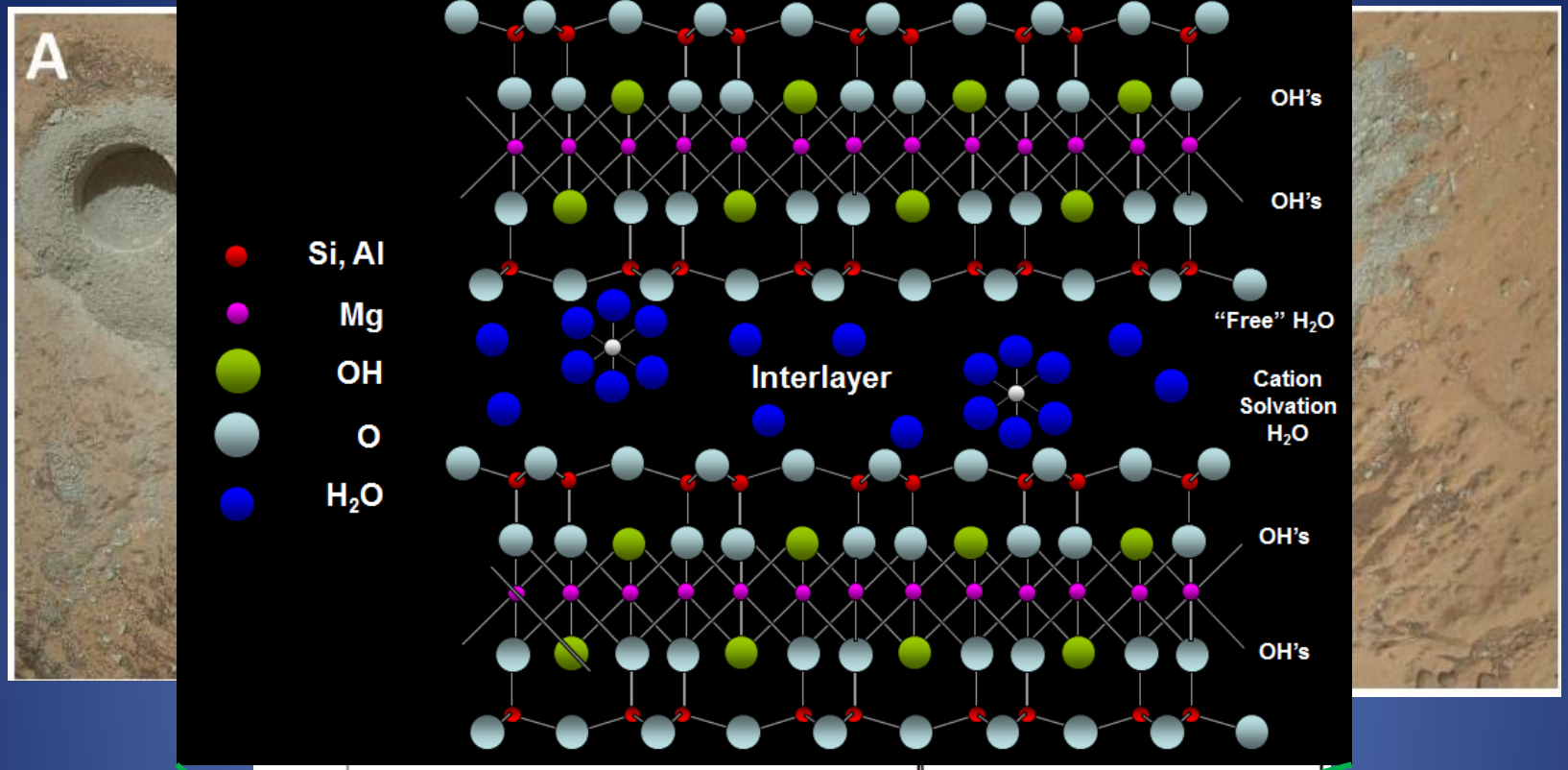
Curiosity selfie, sol 85

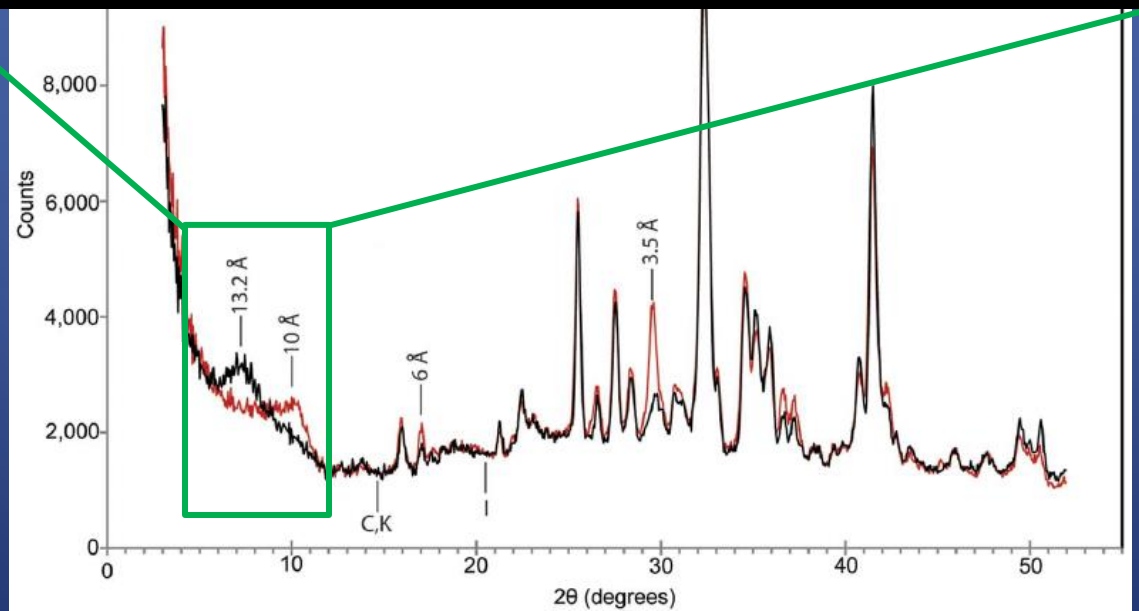




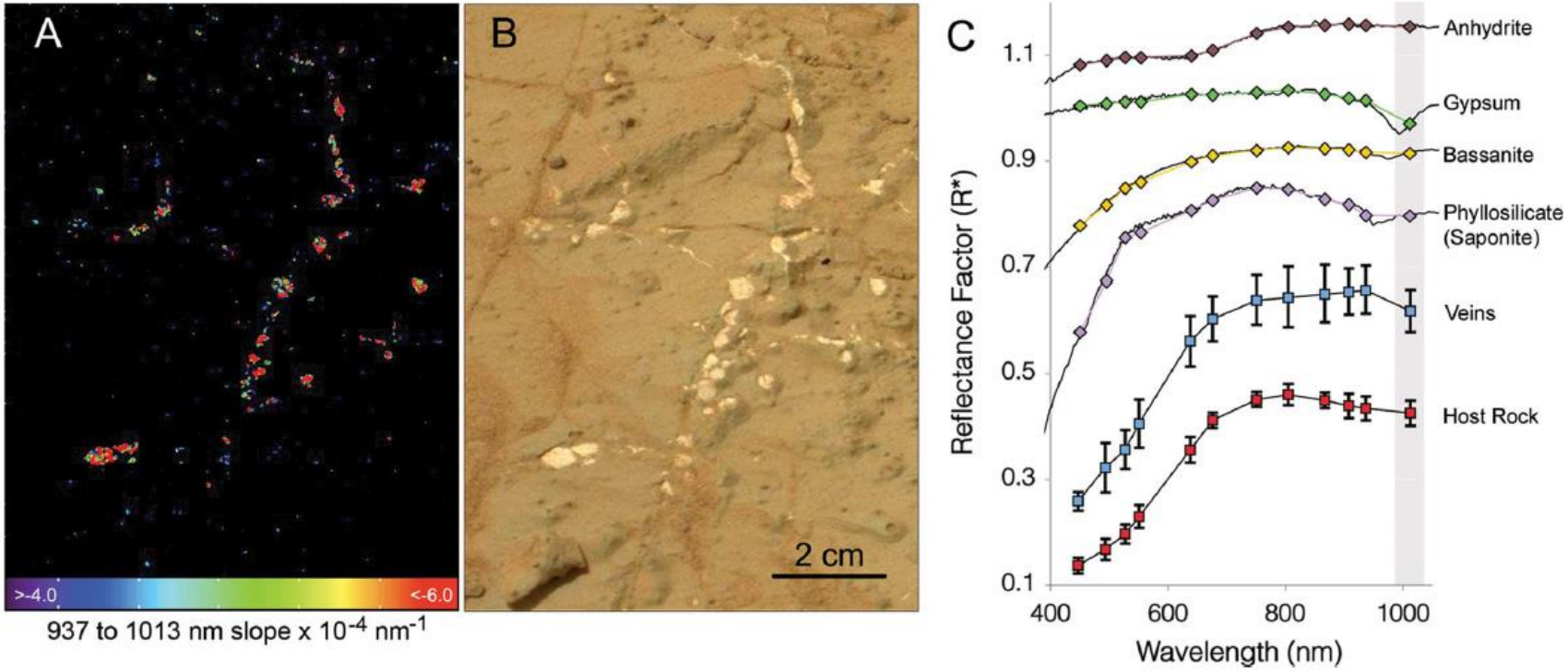


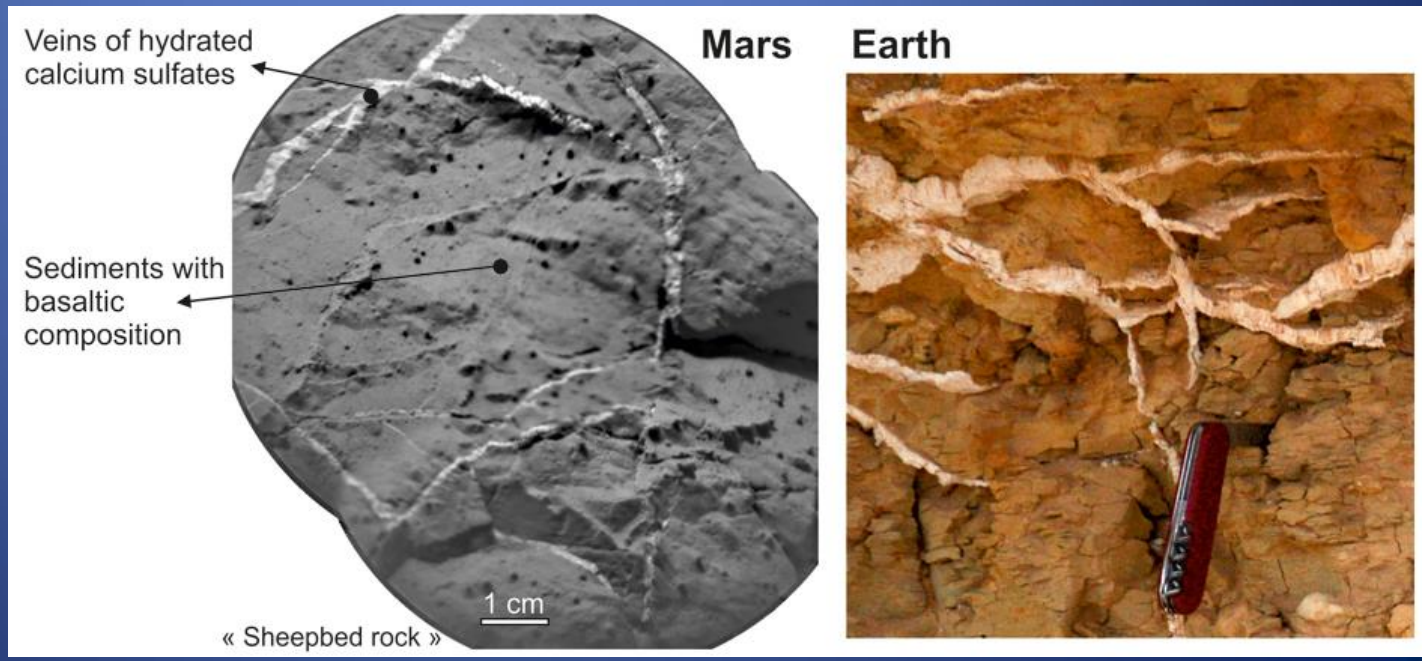
Vaniman et al., 2014



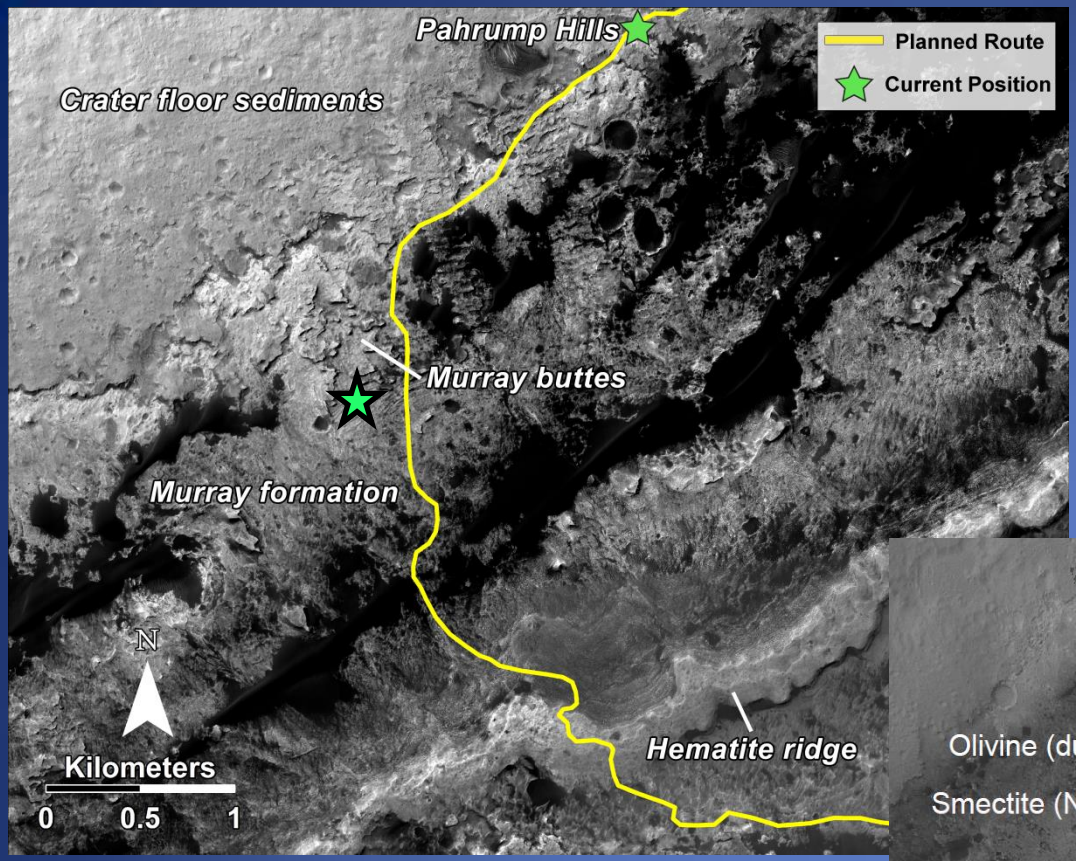


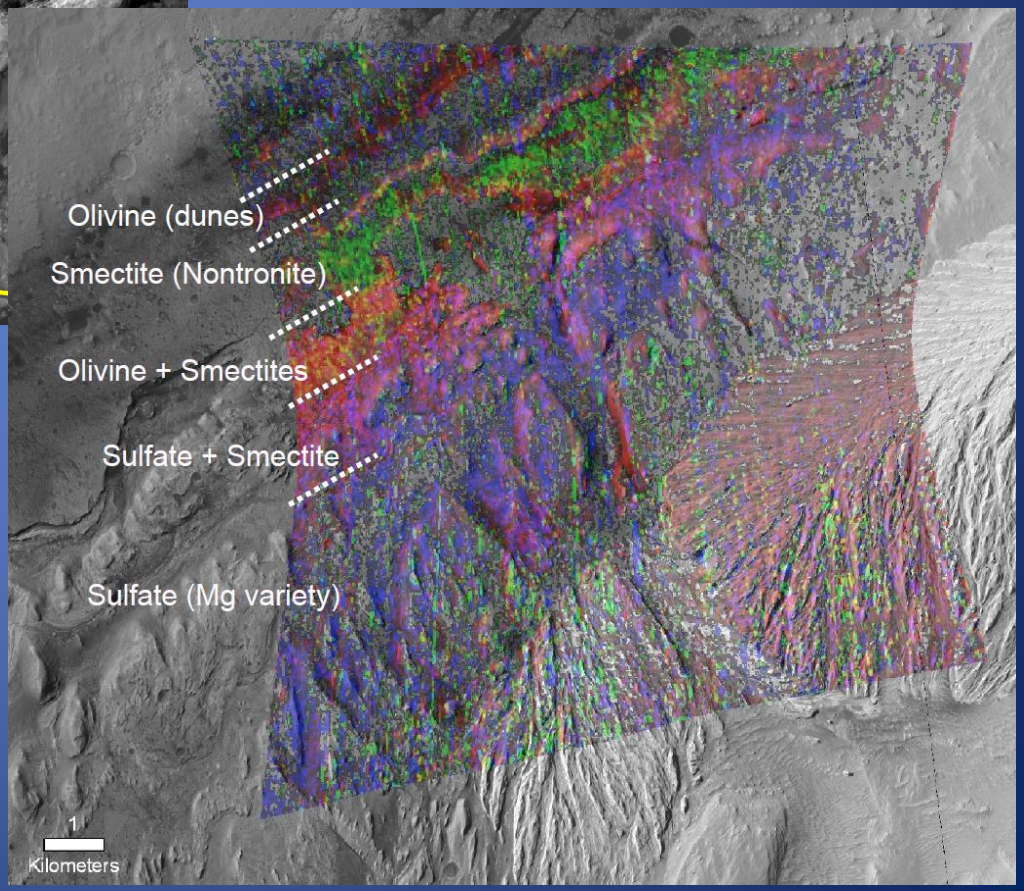
Vaniman et al., 2014



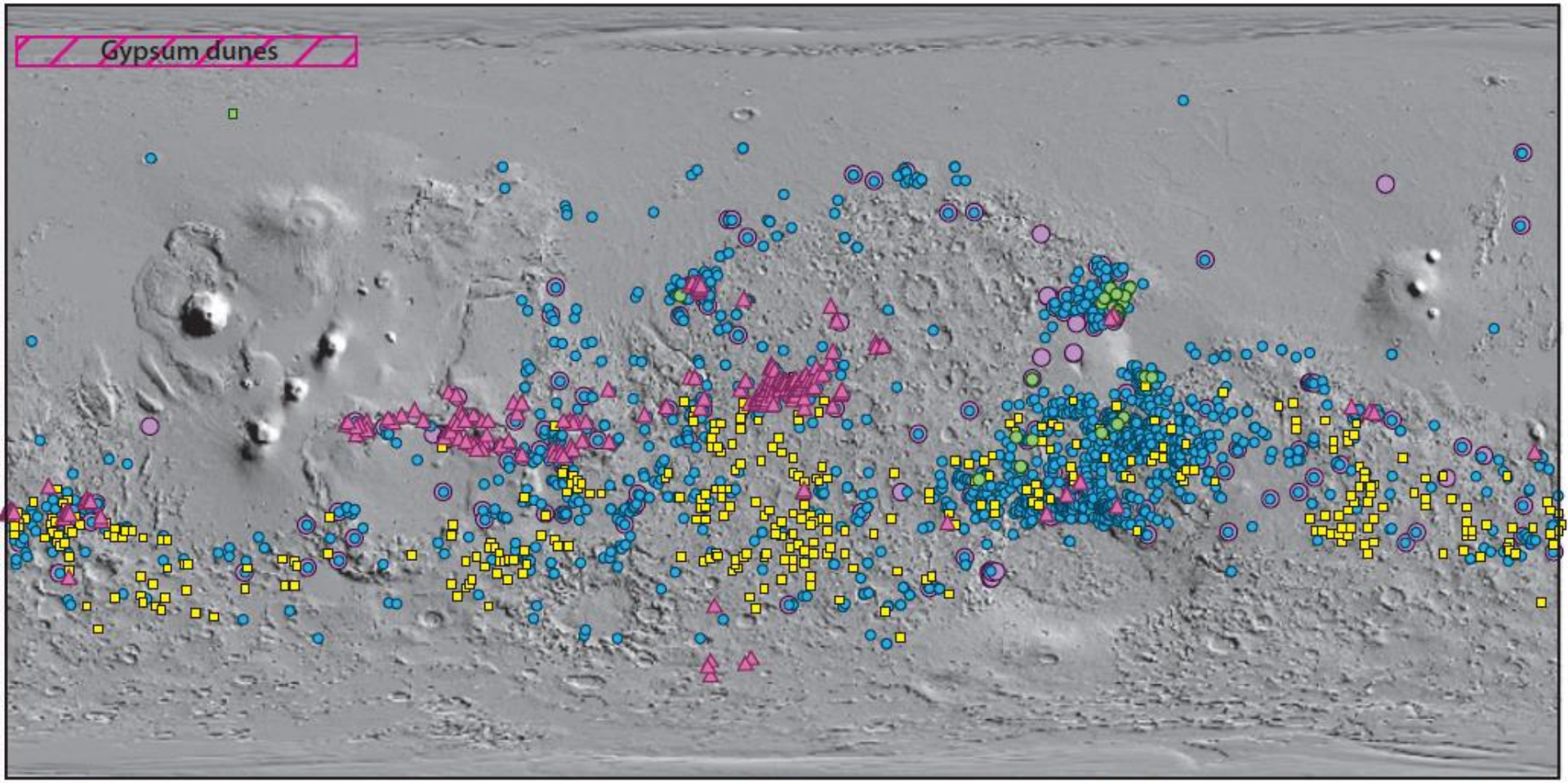


Vaniman et al., 2014





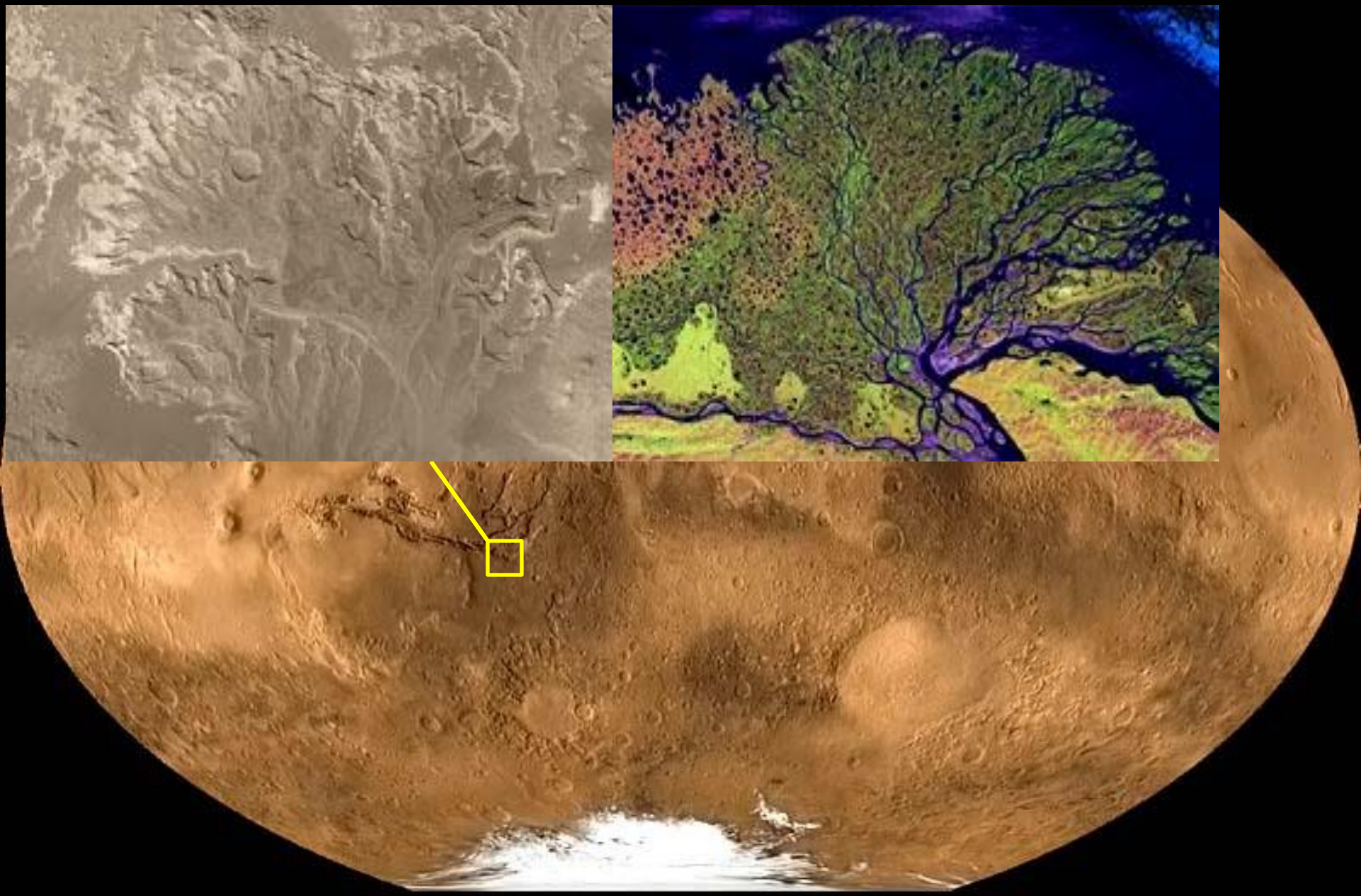
Milliken, 2011



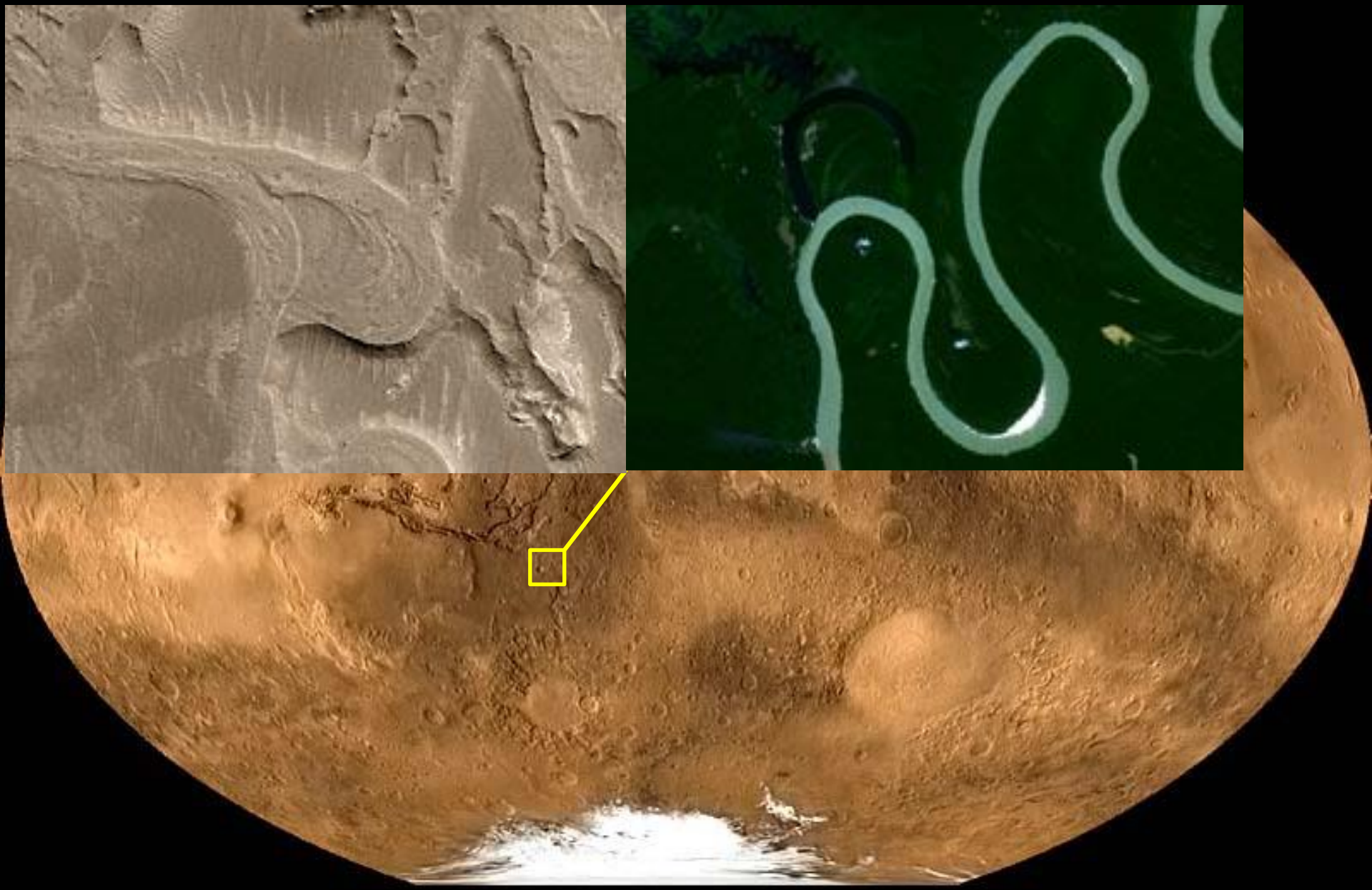
Phyllosilicates Silica Chlorides Carbonates Sulfates

Ehlmann and Edwards, 2014

Evidence of water on a global scale



http://phoenix.lpl.arizona.edu/mars161.php



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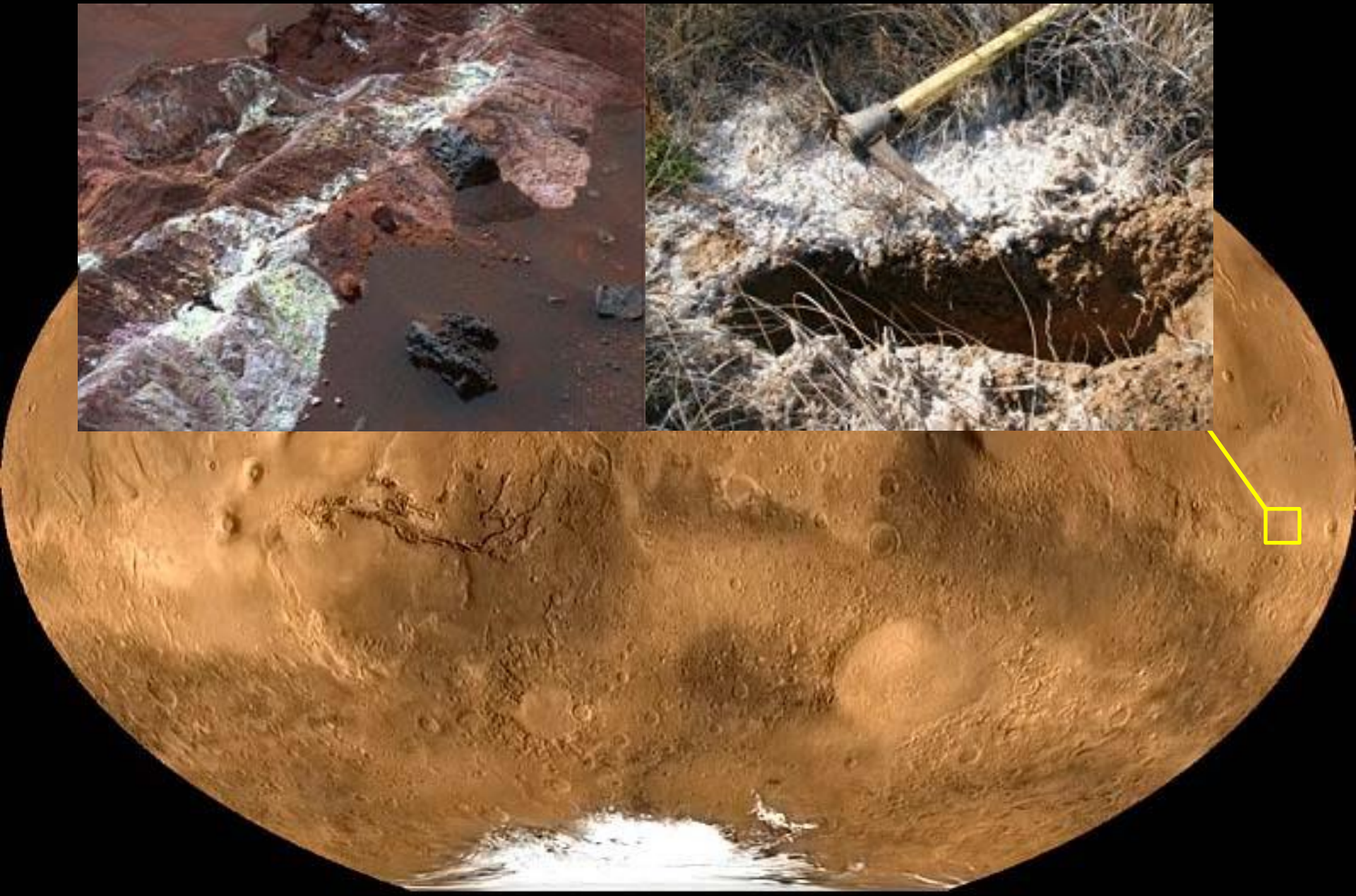

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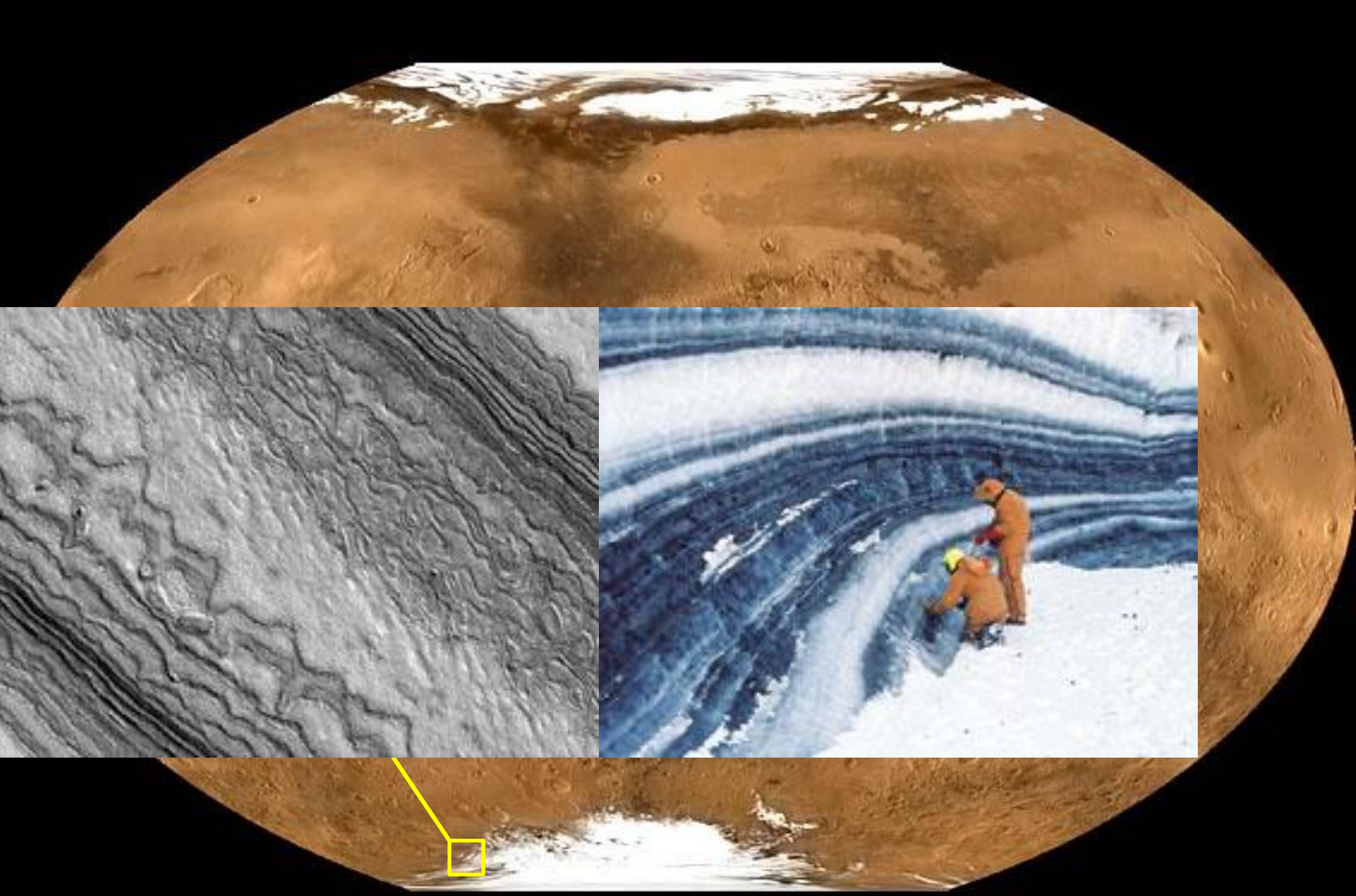

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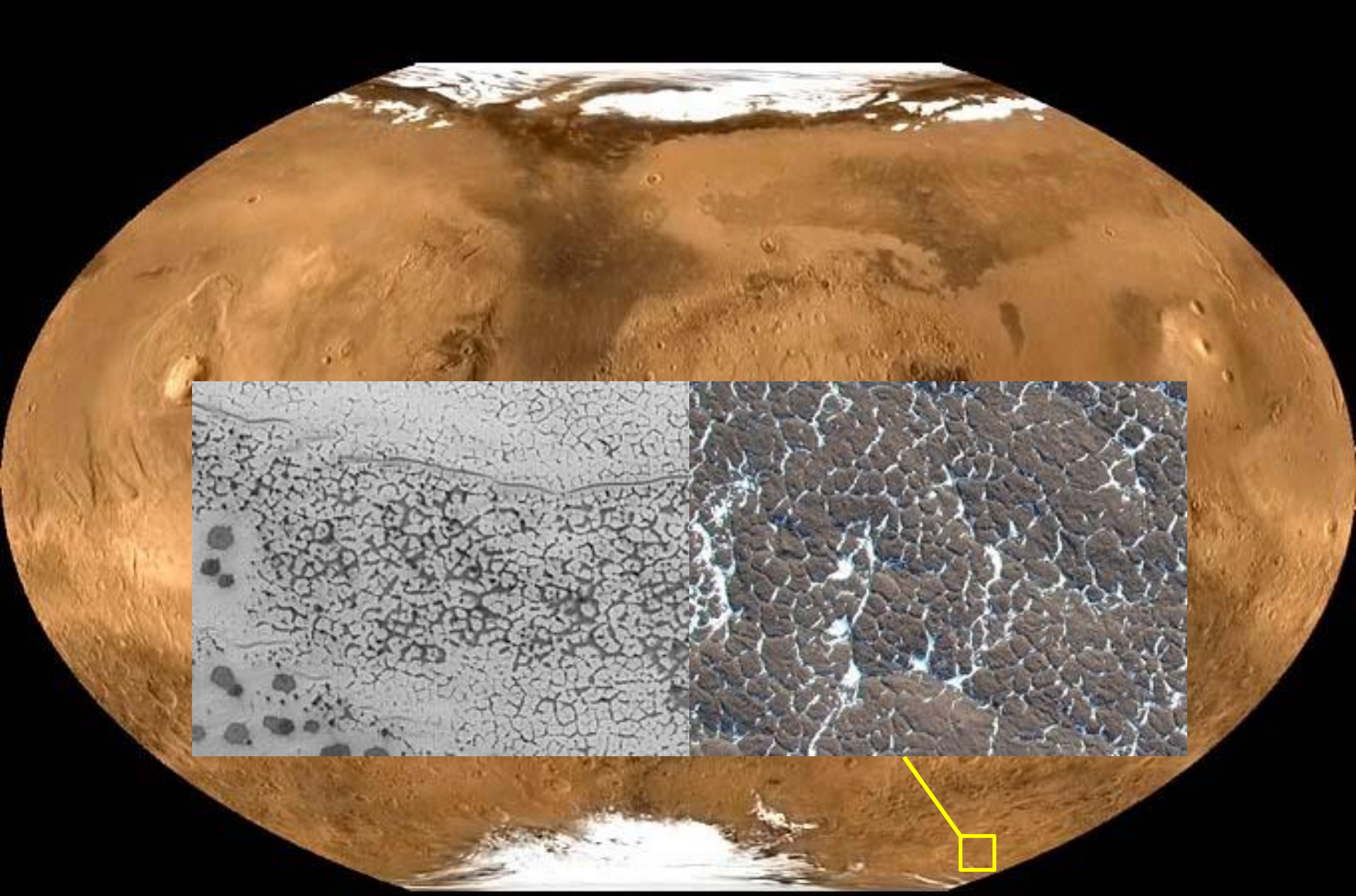

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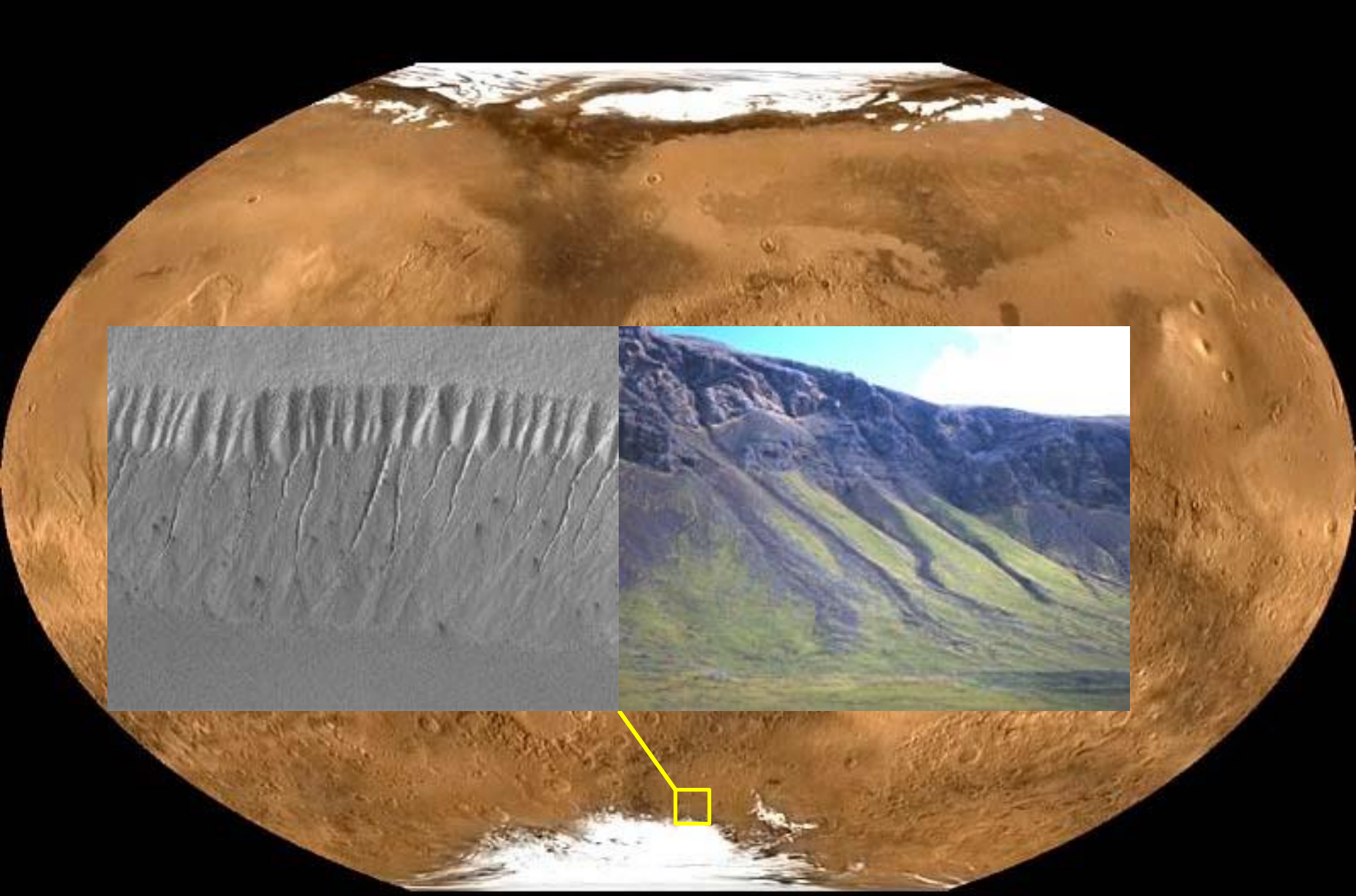

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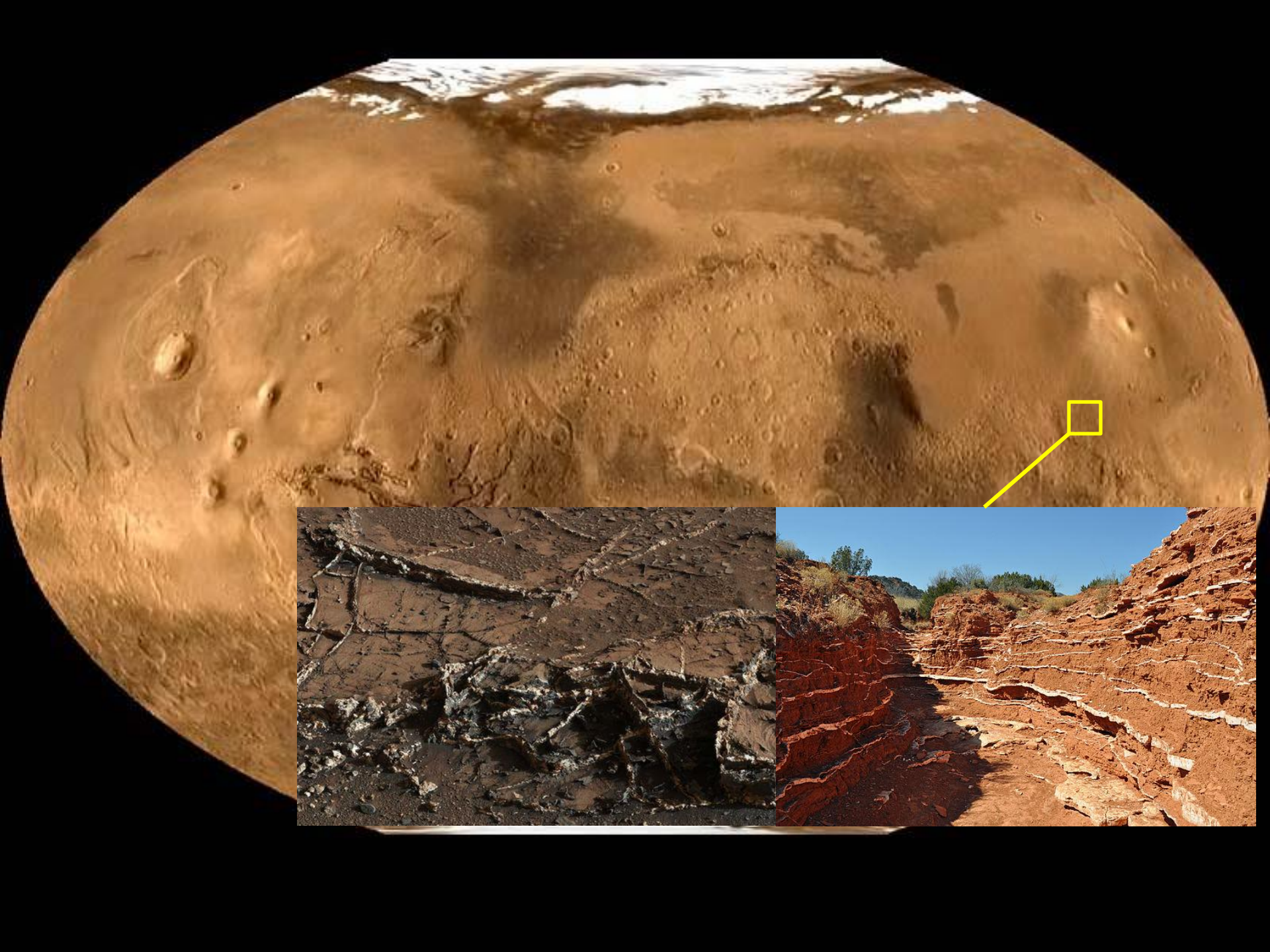
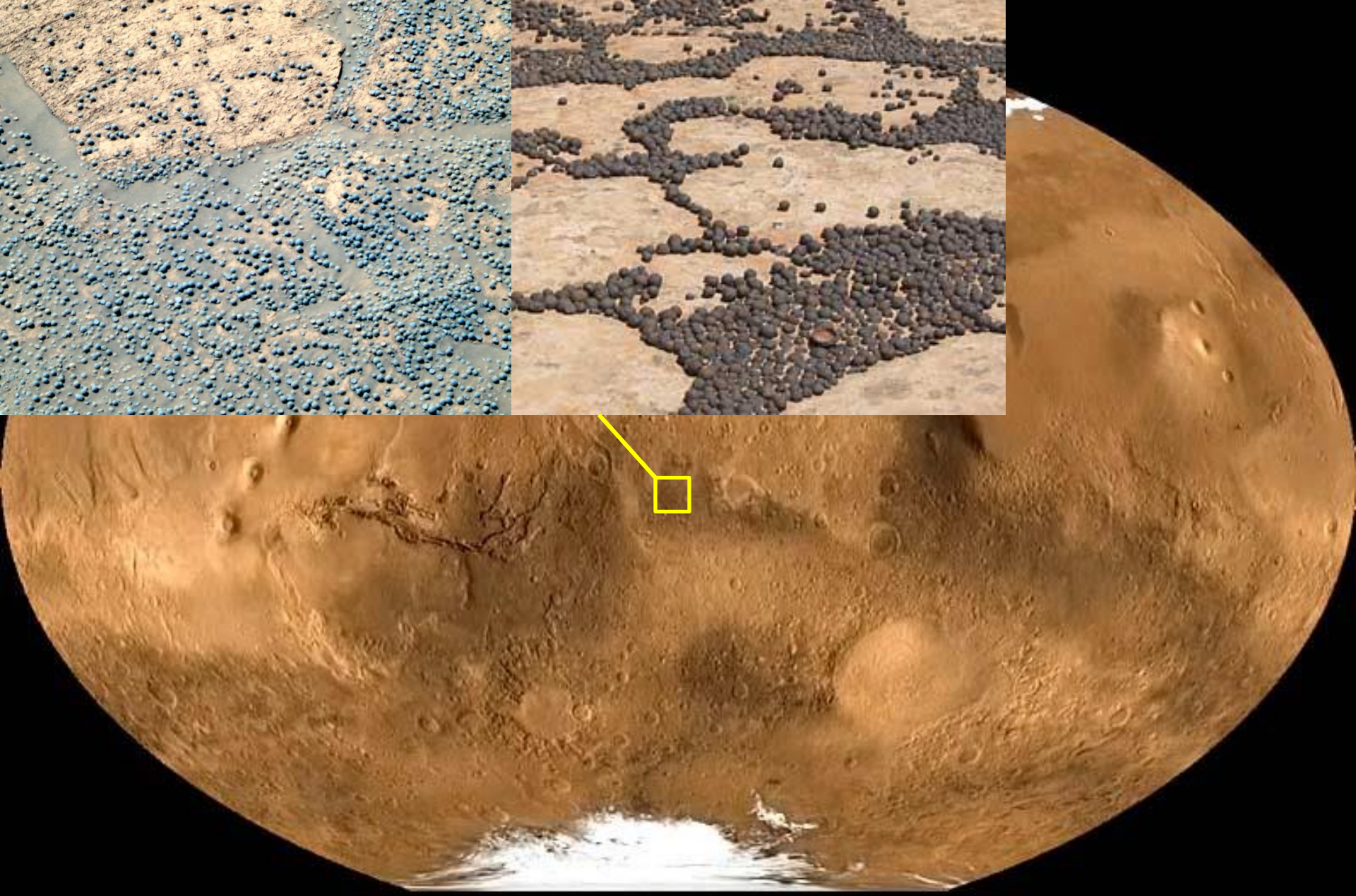
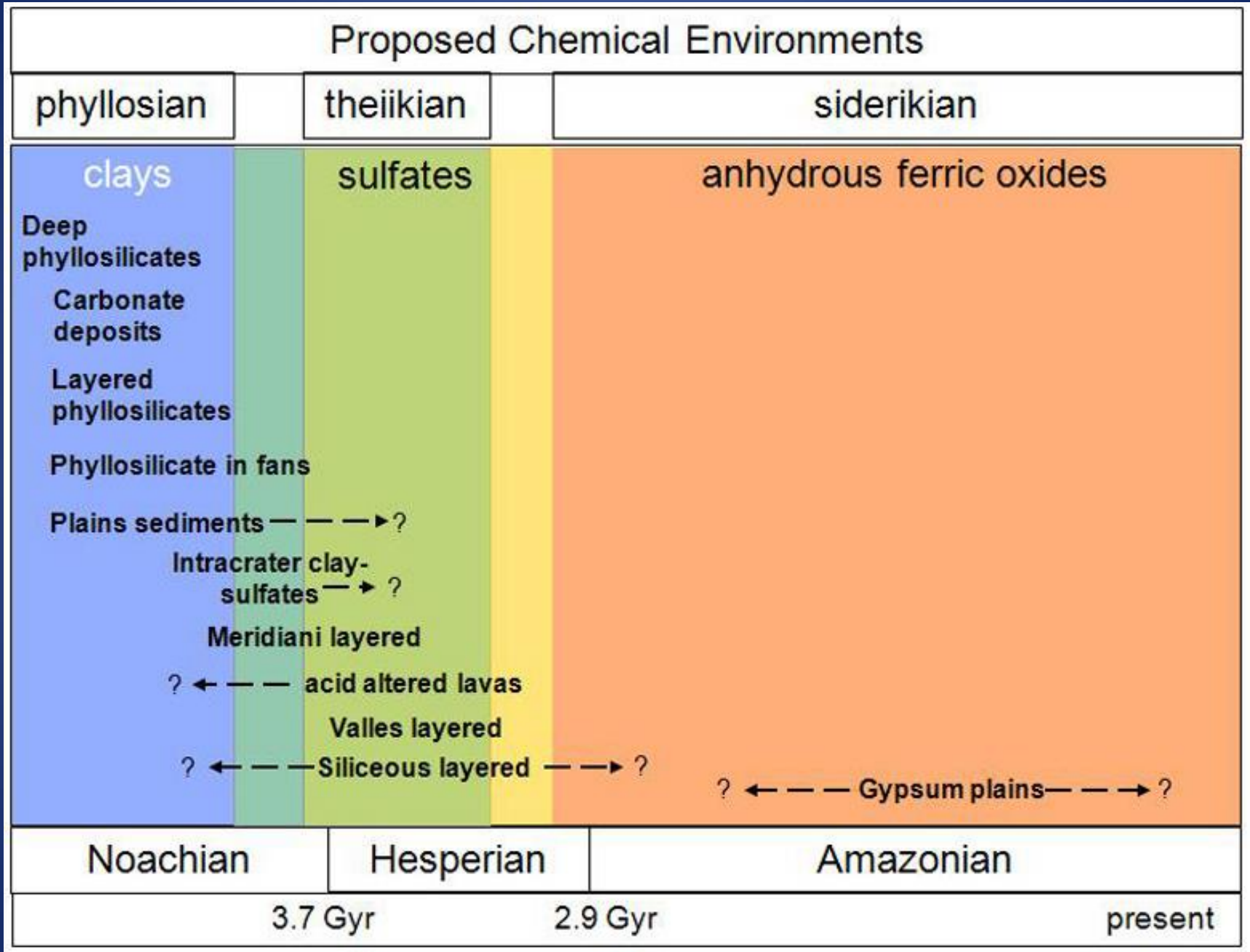
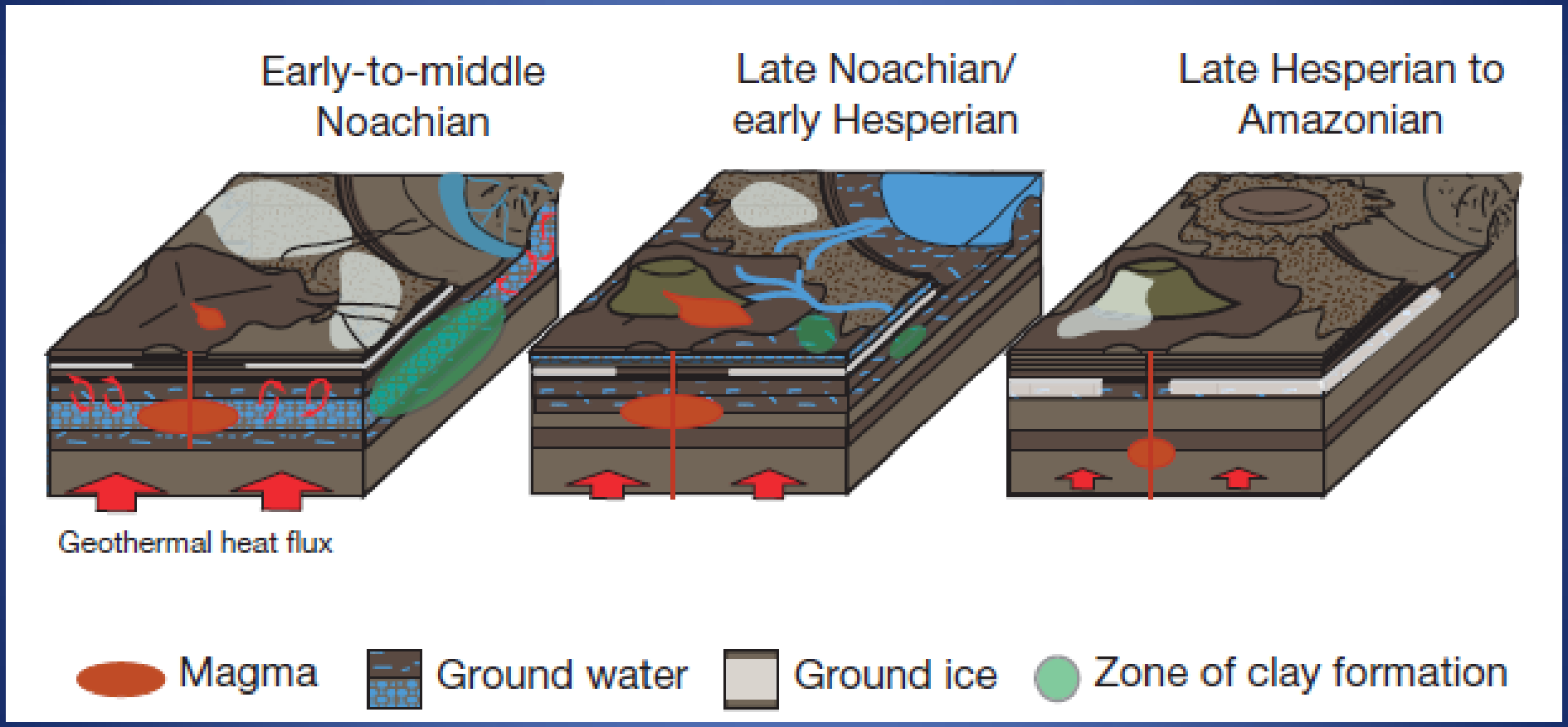
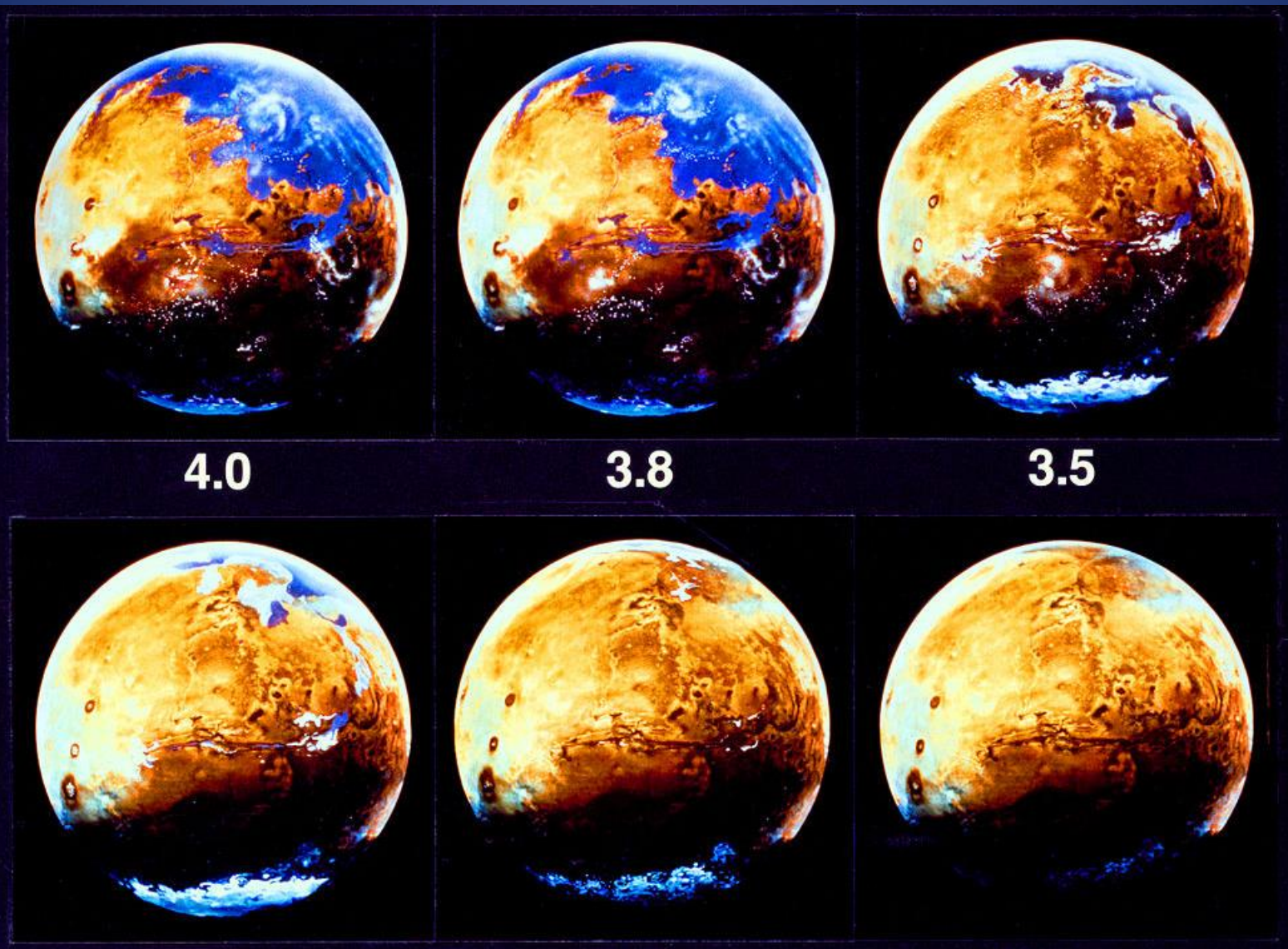





Proposed Chemical Environments
phyllosian
theiikian
siderikian
clays
sulfates
anhydrous ferric oxides
Deep phyllosilicates
Carbonate deposits
Layered phyllosilicates
Phyllosilicate in fans
Plains sediments
?
Intracrater clay-sulfates
?
Meridiani layered
?
acid altered lavas
Valles layered
?
Siliceous layered
?
?
Gypsum plains
?
Noachian
Hesperian
Amazonian
3.7 Gyr
2.9 Gyr
present

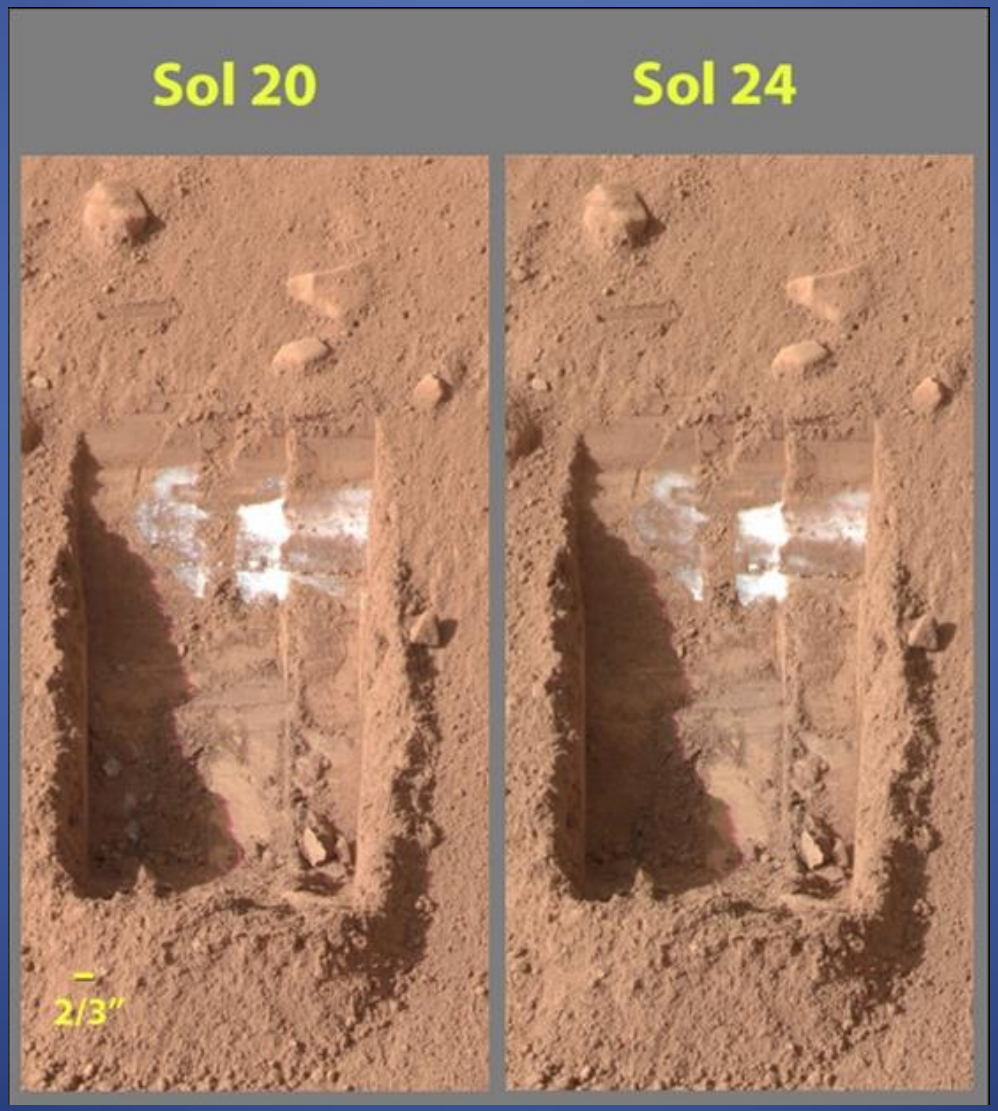


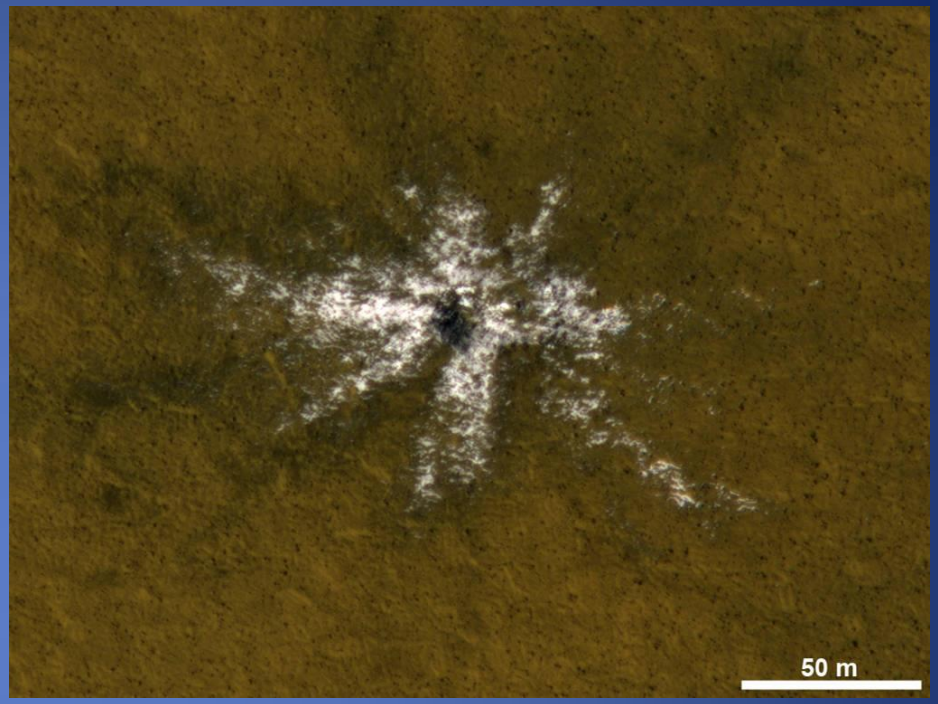
Ehlmann et al., 2011

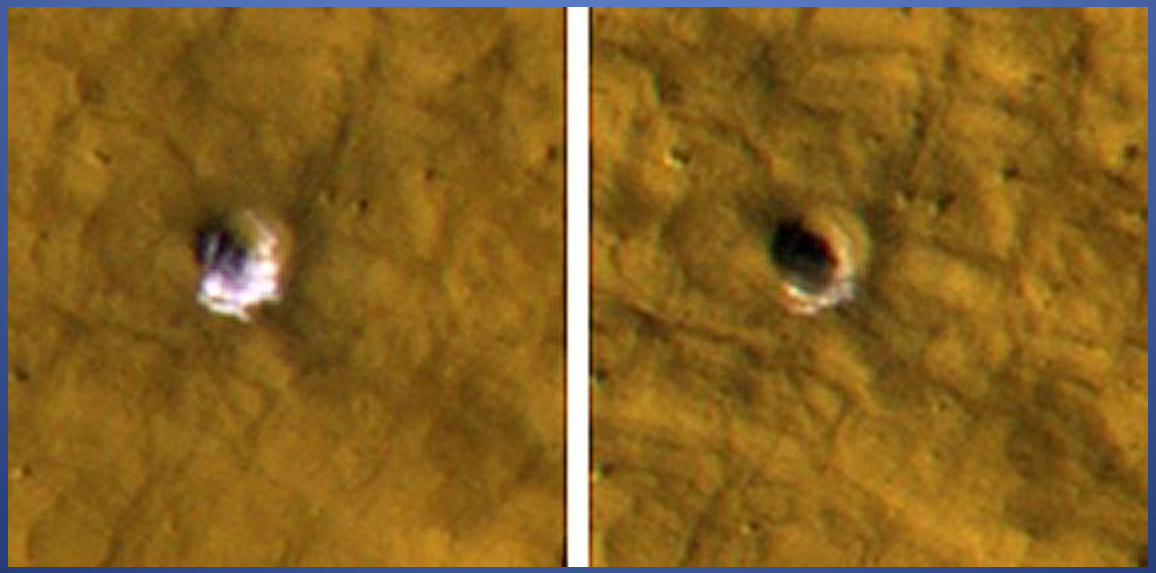

4.0
3.8
3.5
2.0
1.0
Now

Where is the water now?

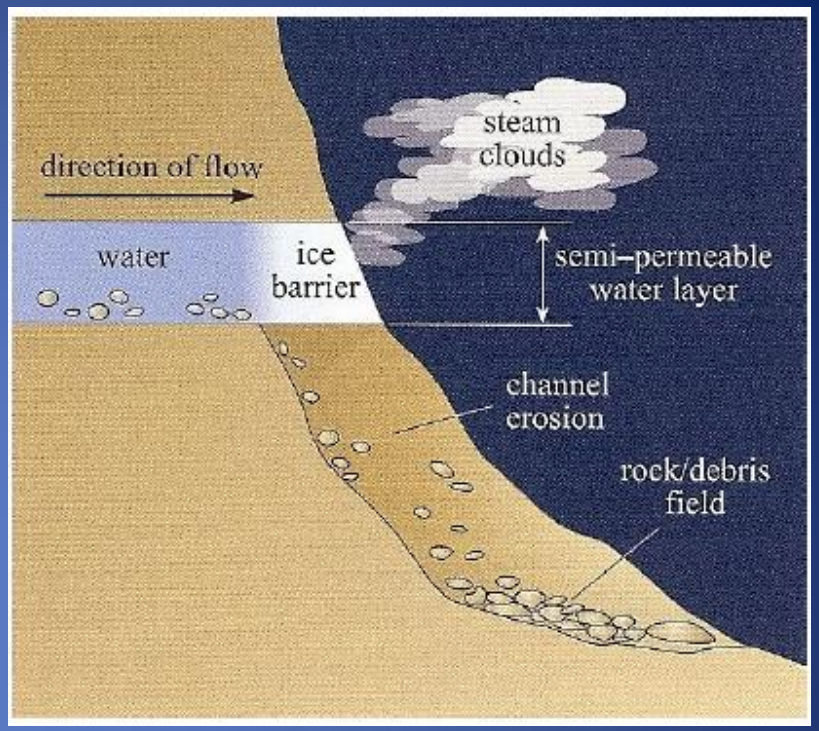
Underground!



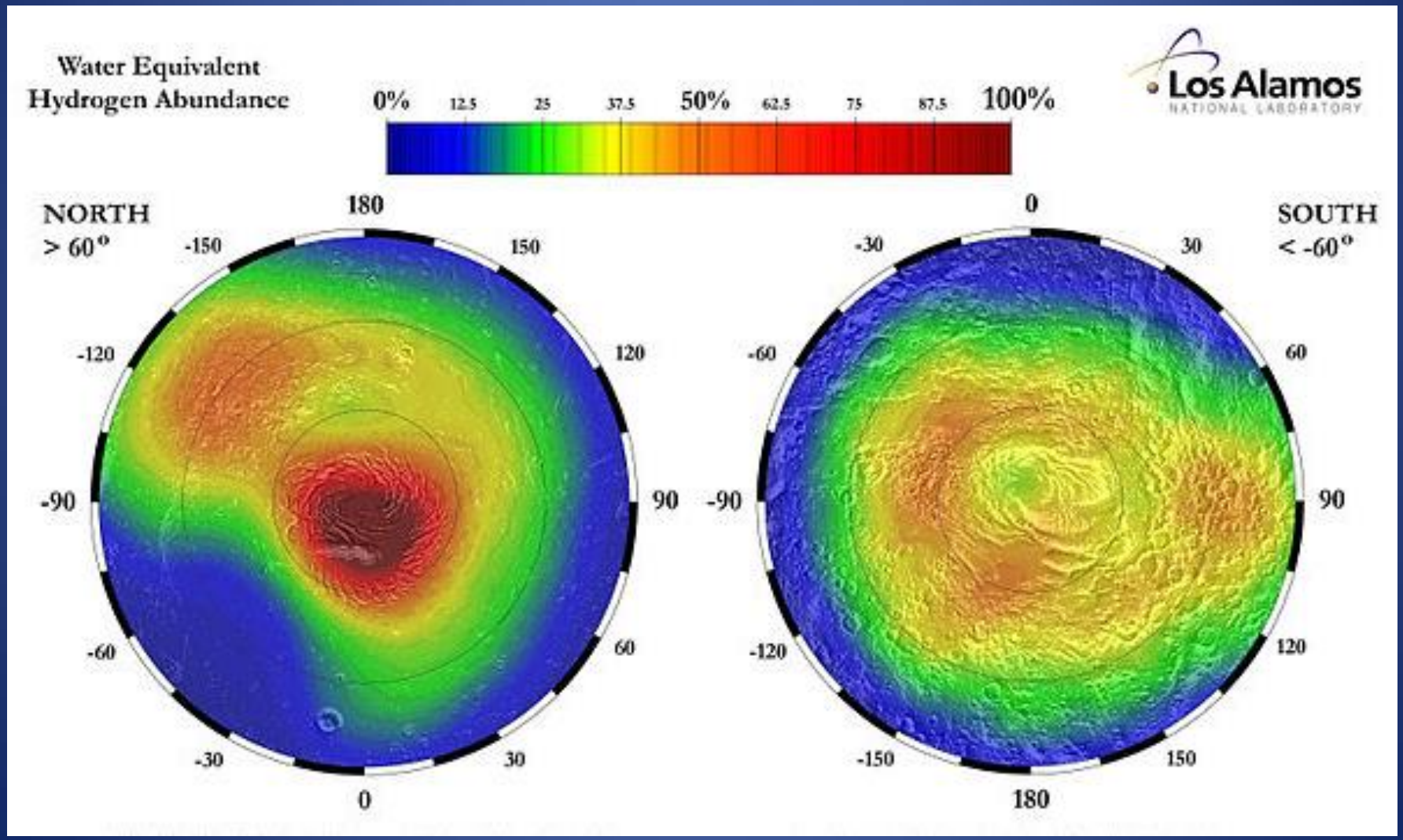

50 m

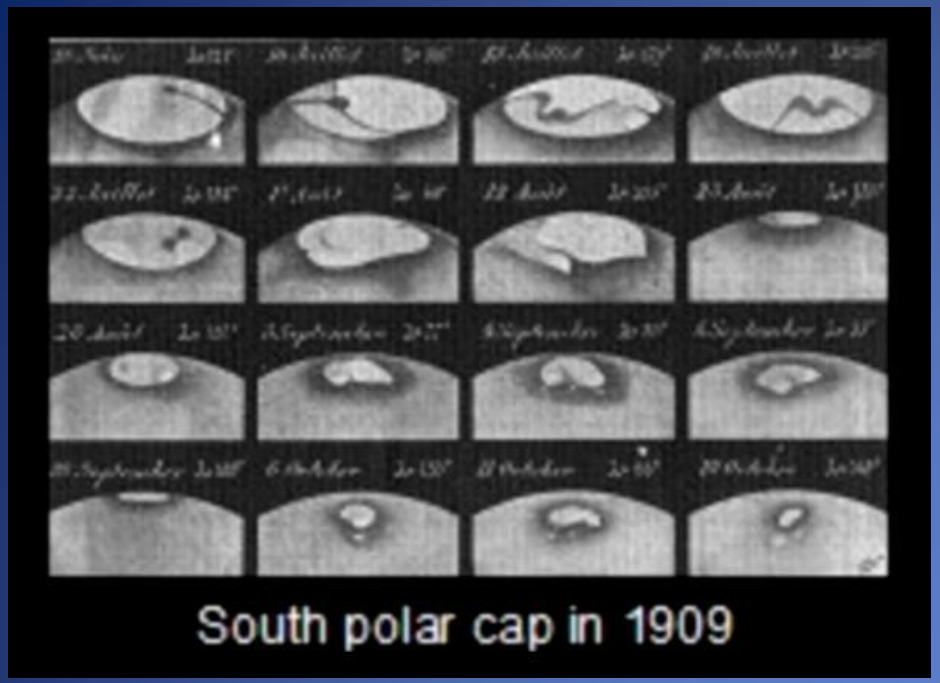


August 1999
September 2005
new deposit

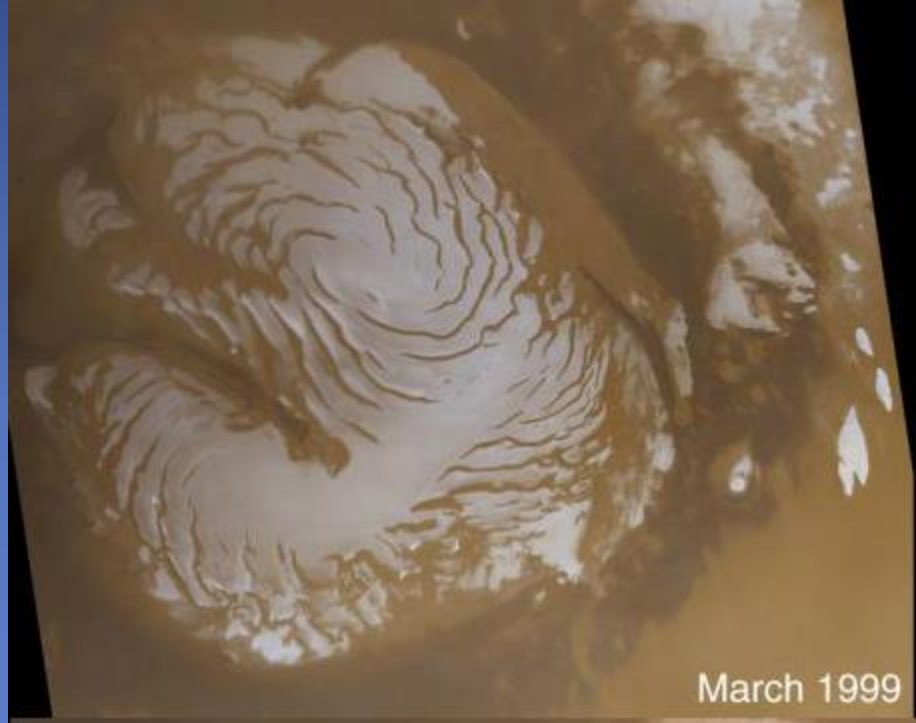

steam clouds
direction of flow
water
ice barrier
semi–permeable water layer
channel erosion
rock/debris field

In the polar ice caps

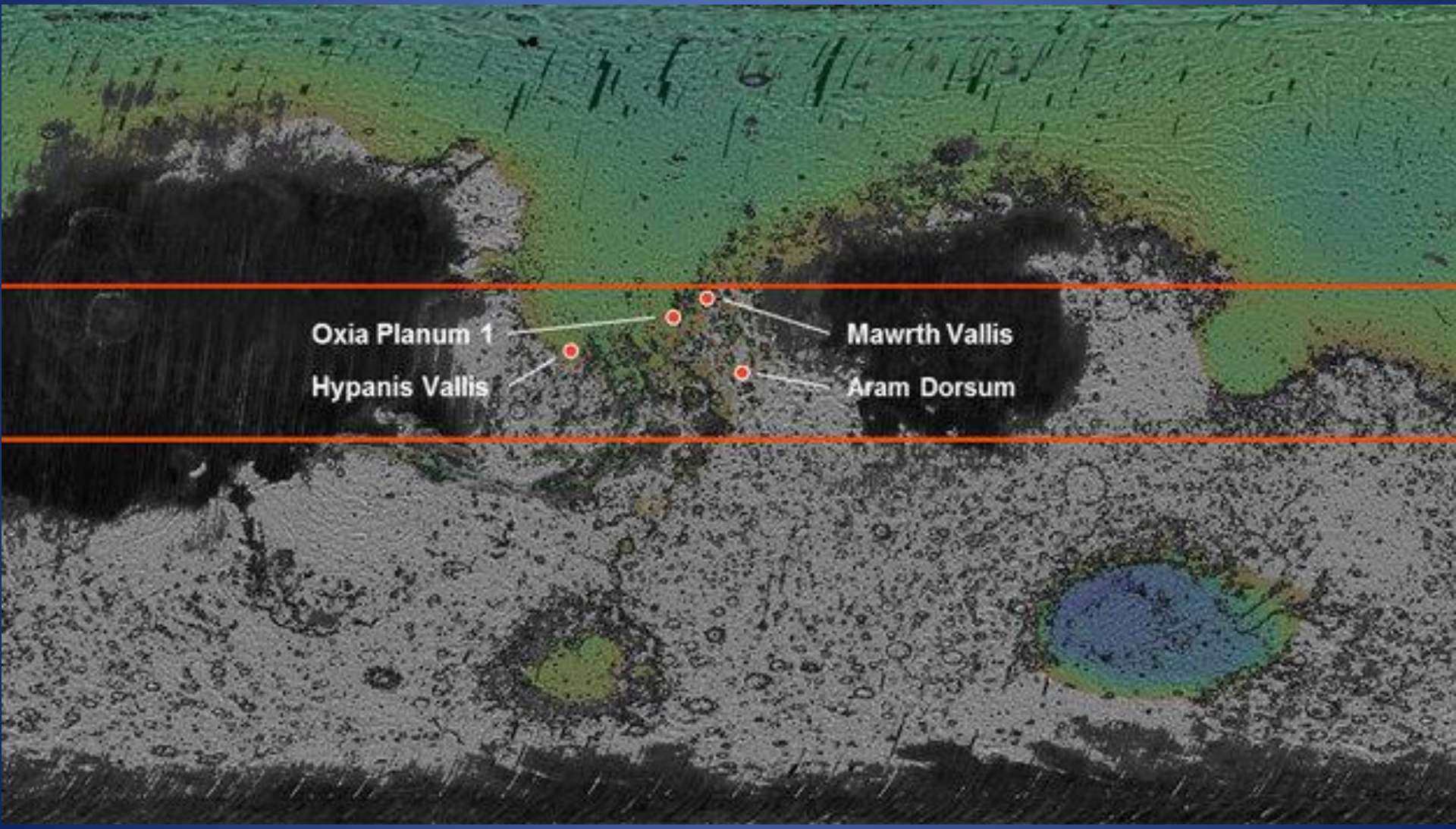




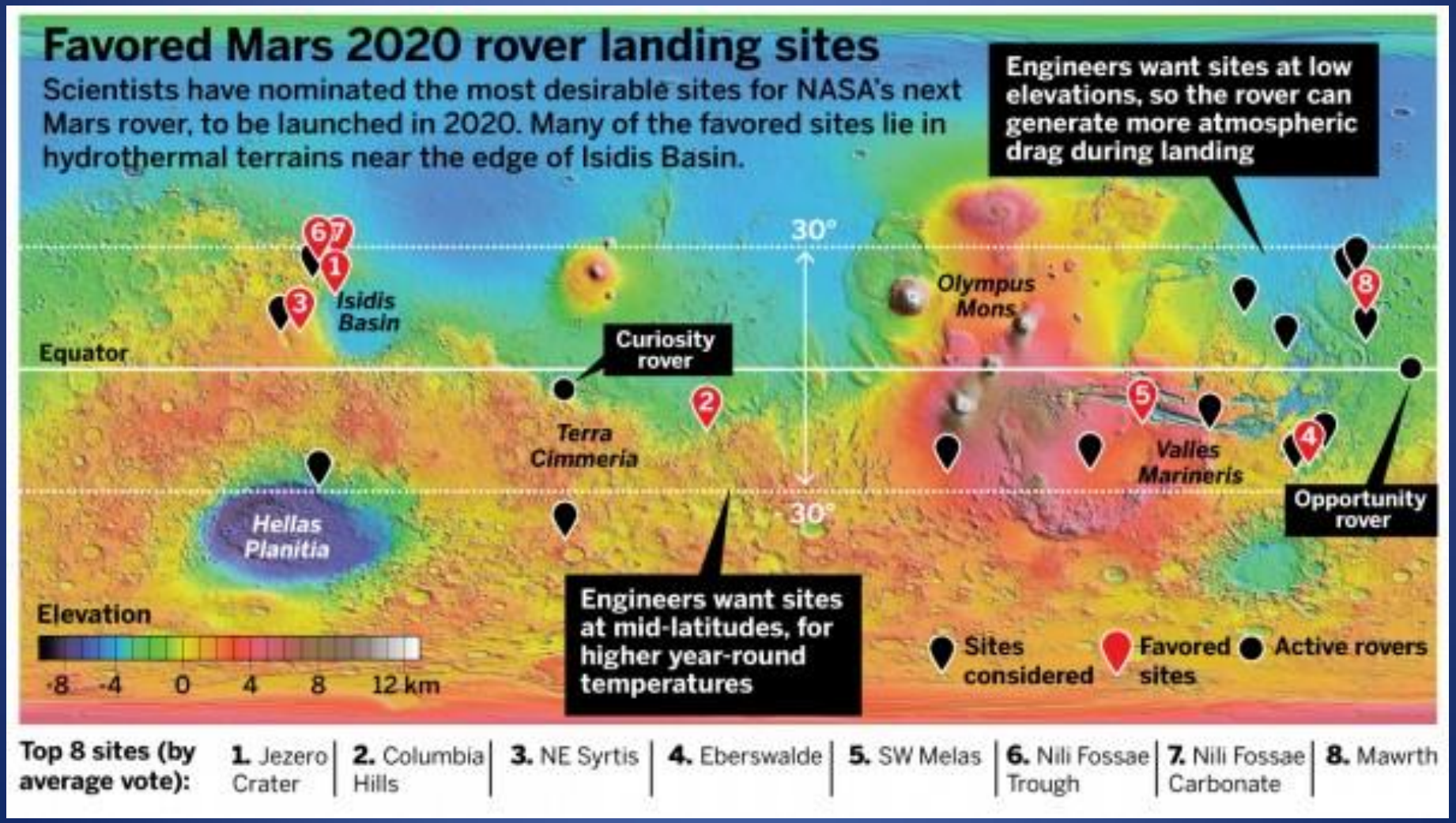
French amateur astronomer
Rene Jarry-Desloges

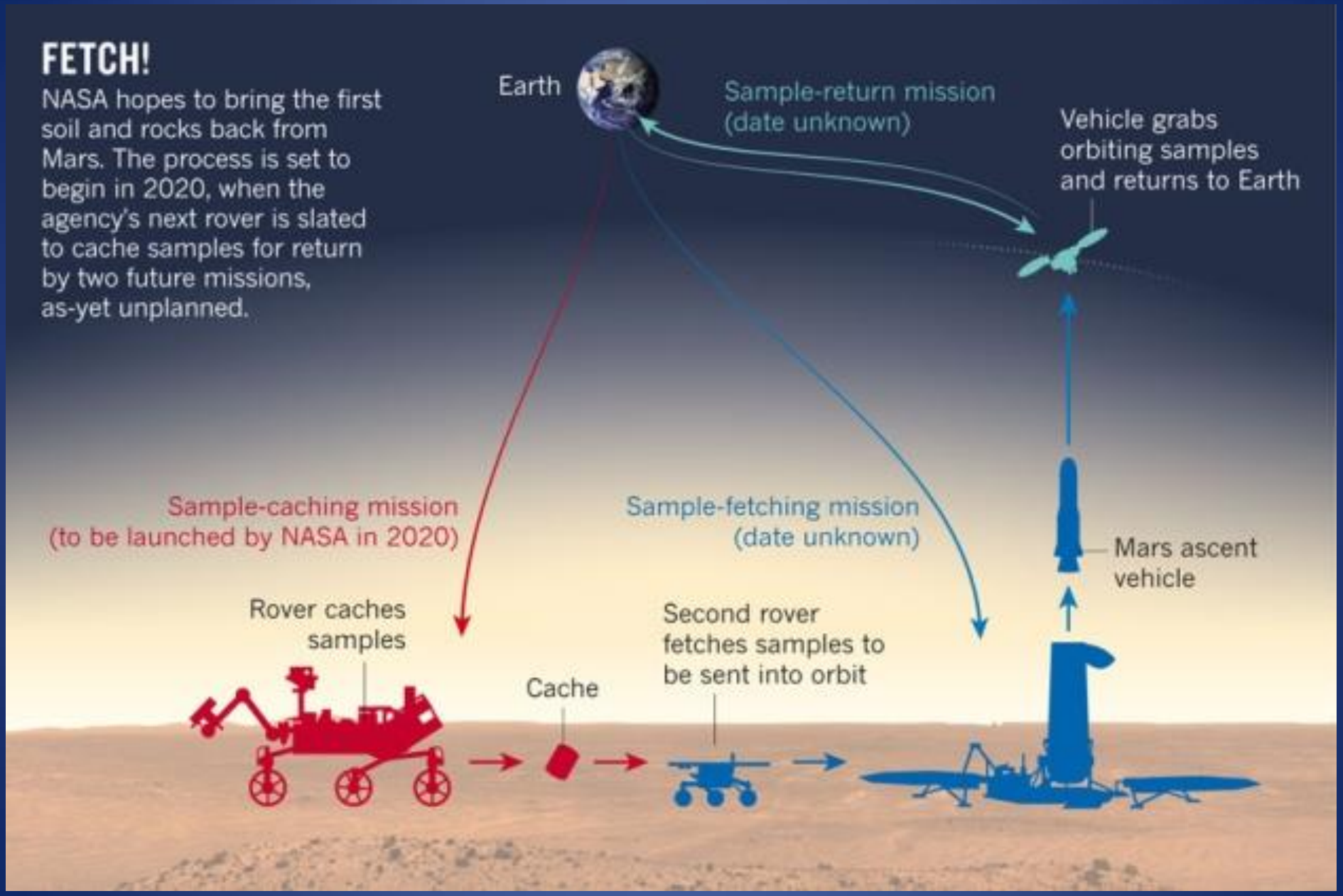


ExoMars Proposed Landing Sites



Mars 2020 Proposed Landing Sites

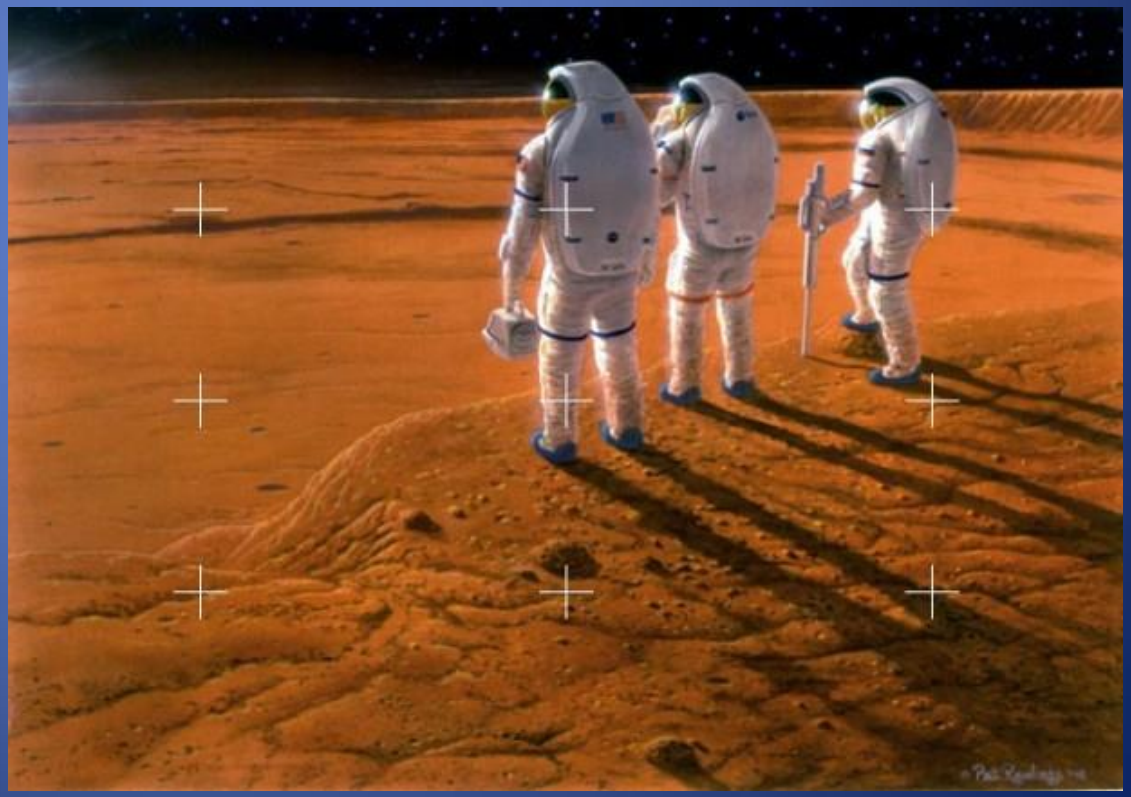



FETCH!
NASA hopes to bring the first soil and rocks back from Mars. The process is set to begin in 2020, when the agency's next rover is slated to cache samples for return by two future missions, as-yet unplanned.
Earth
Sample-return mission (date unknown)
Vehicle grabs orbiting samples and returns to Earth
Sample-caching mission (to be launched by NASA in 2020)
Sample-fetching mission (date unknown)
Mars ascent vehicle
Rover caches samples
Cache
Second rover fetches samples to be sent into orbit

Witze, 2014

Human Exploration (?)

- Length of time to get there
- Habitat
- Food and water
- Landing site
- Post-landing



Don’t tell me the sky is the limit when there are footprints on the moon.