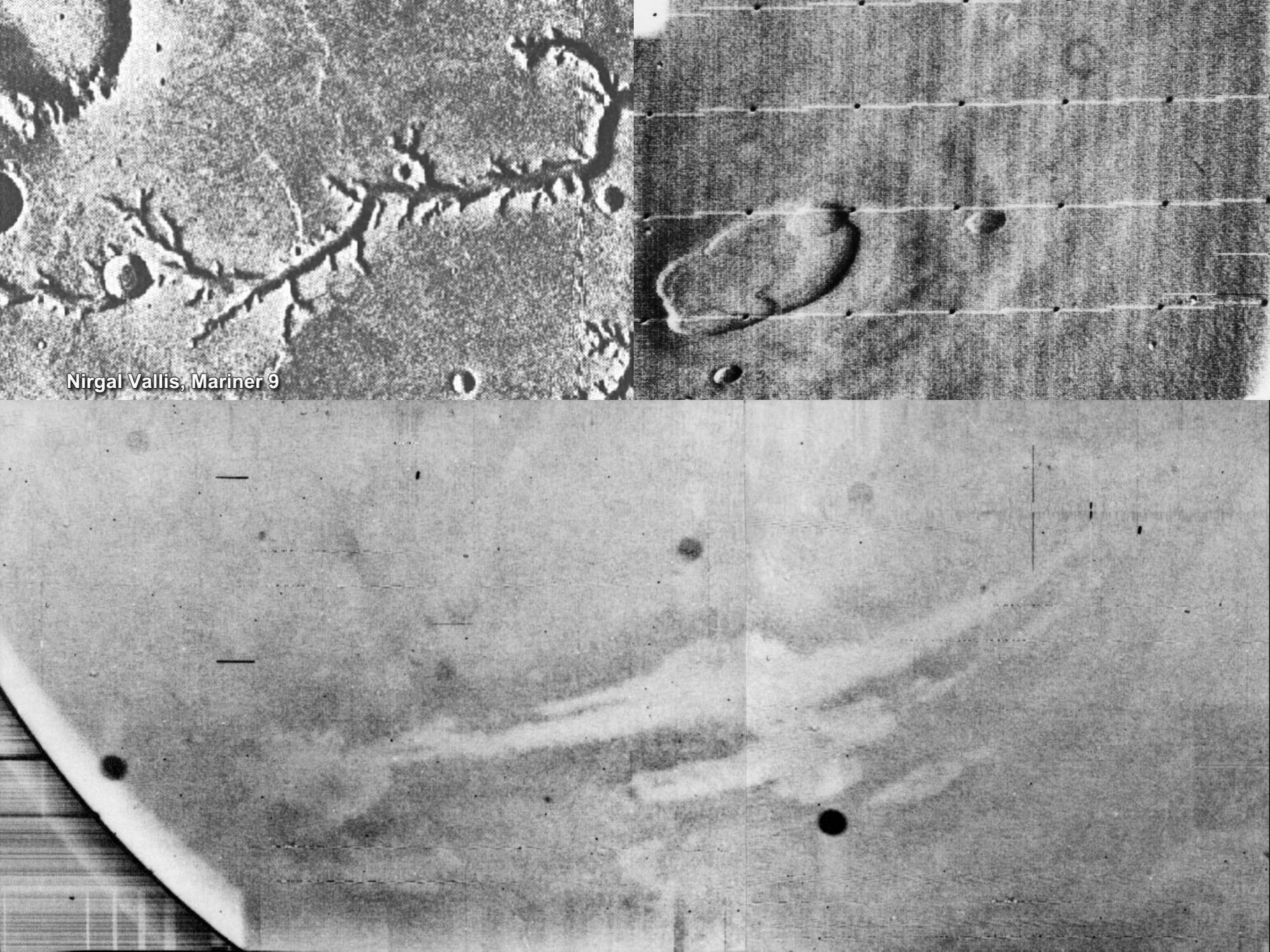
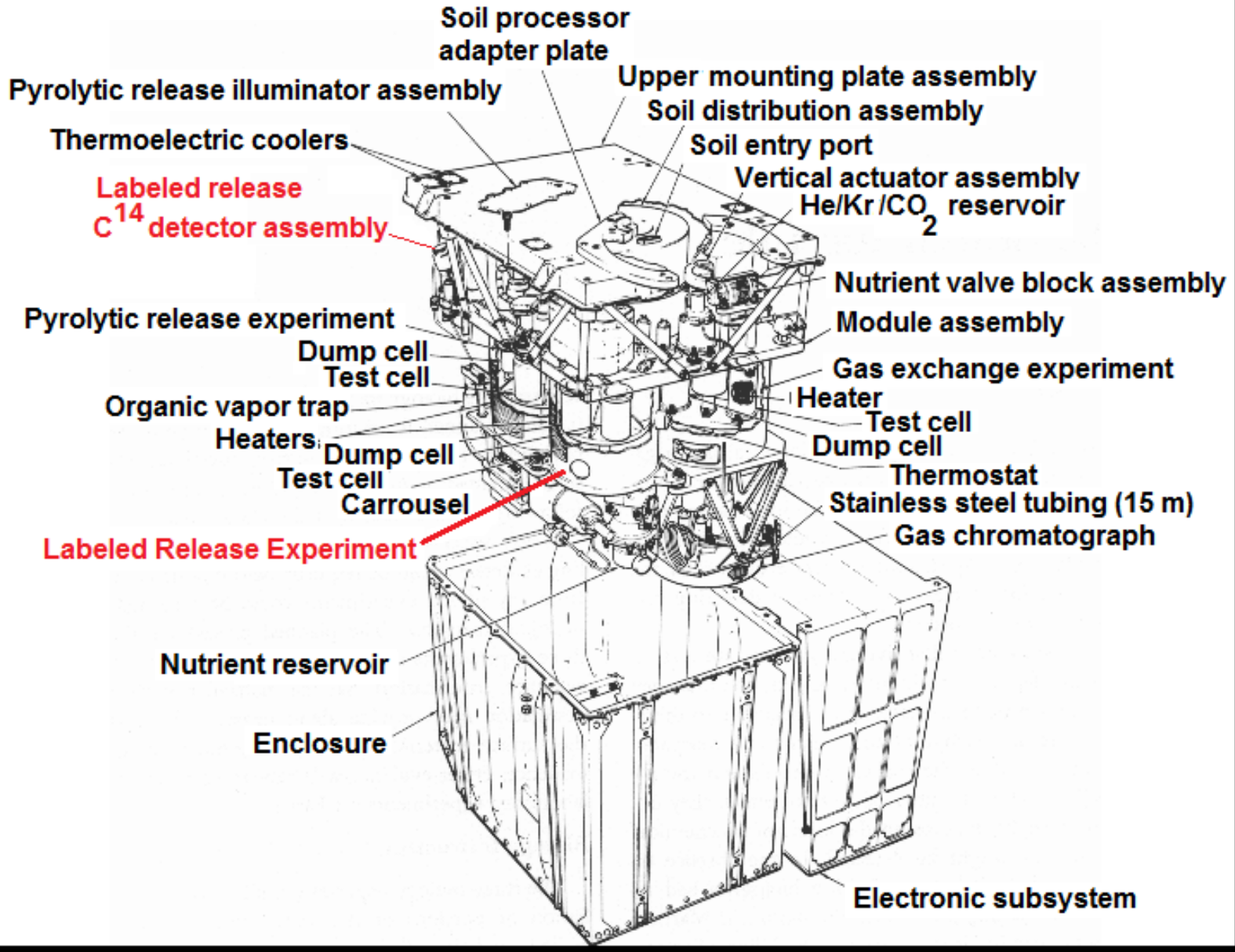
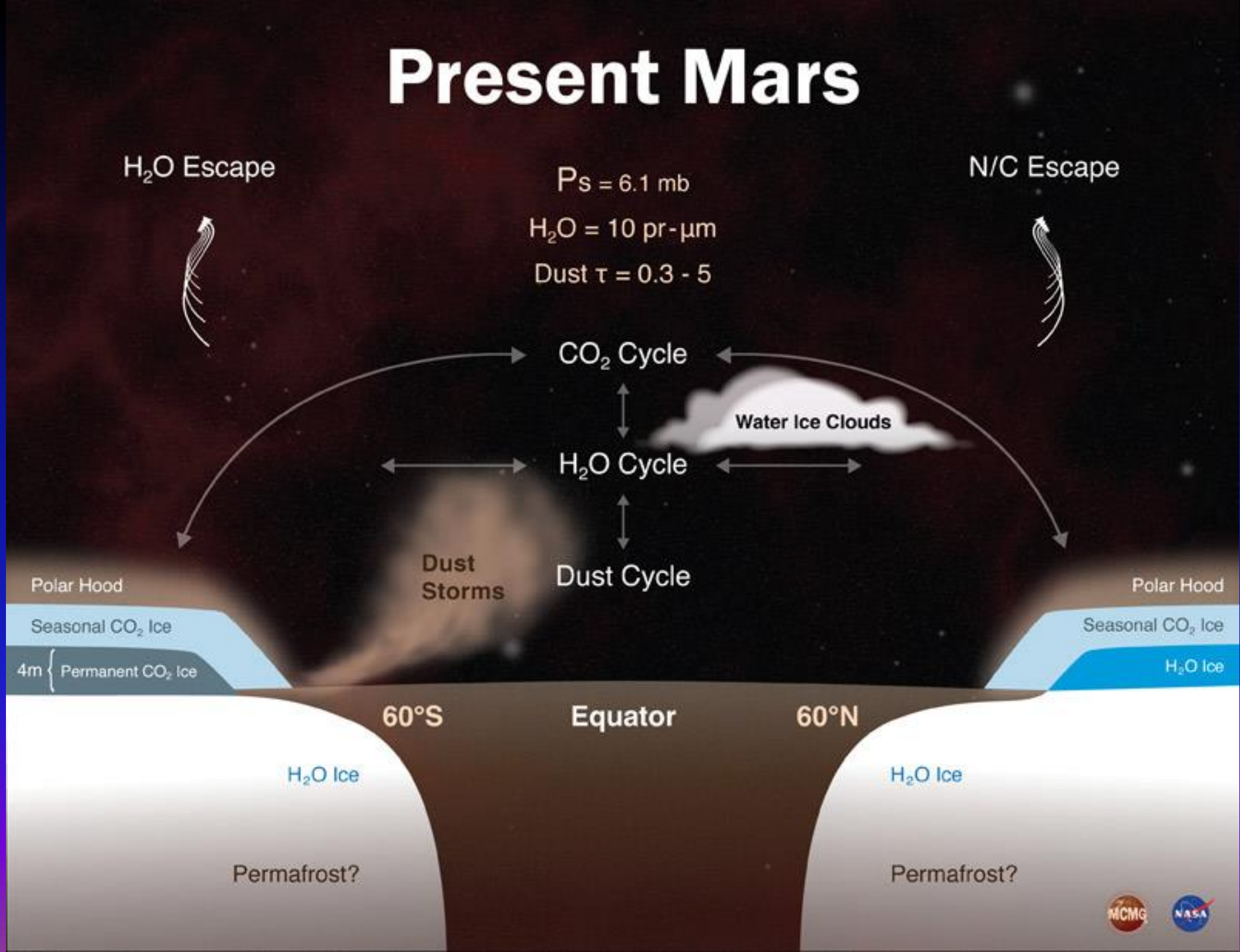
Radar evidence of subglacial liquid water on Mars

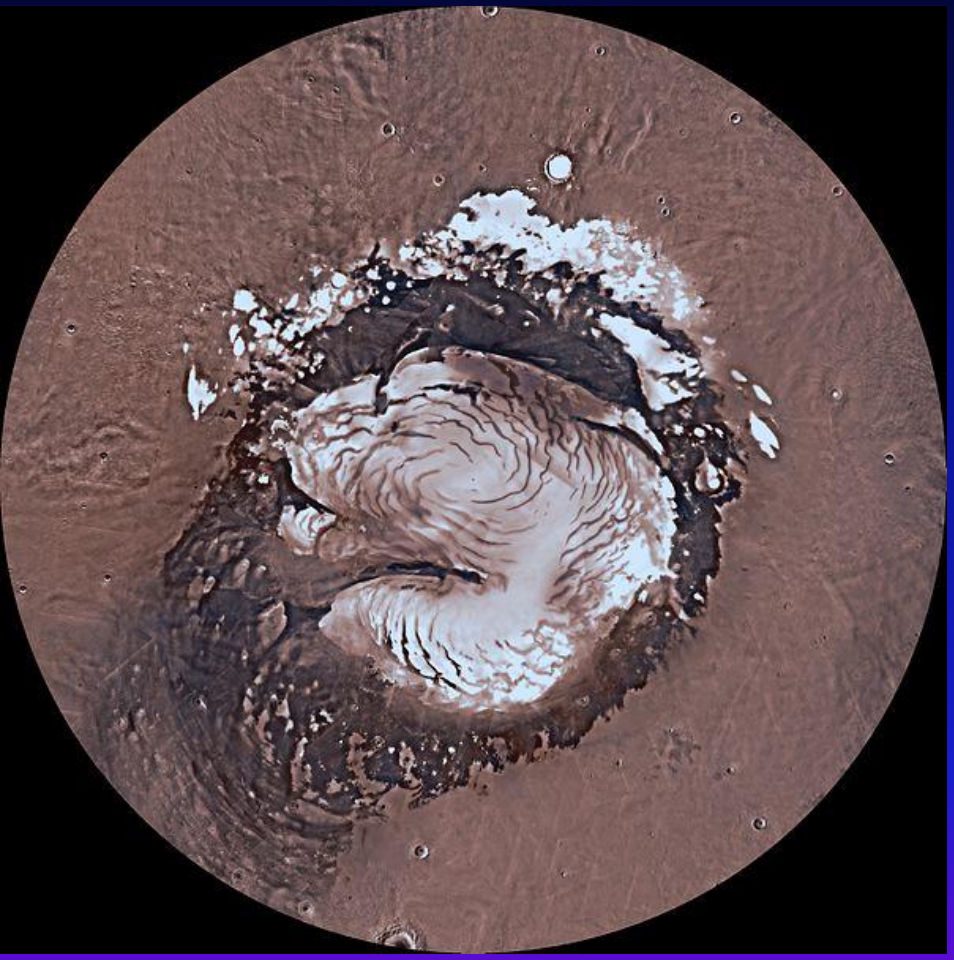
R. Orosei, S. E. Lauro, E. Pettinelli, A. Cicchetti, M. Coradini, B. Cosciotti, F. Di Paolo, E. Flamini, E. Mattei, M. Pajola, F. Soldovieri, M. Cartacci, F. Cassenti, A. Frigeri, S. Giuppi, R. Martufi, A. Masdea, G. Mitri, C. Nenna, R. Noschese, M. Restano, R. Seu

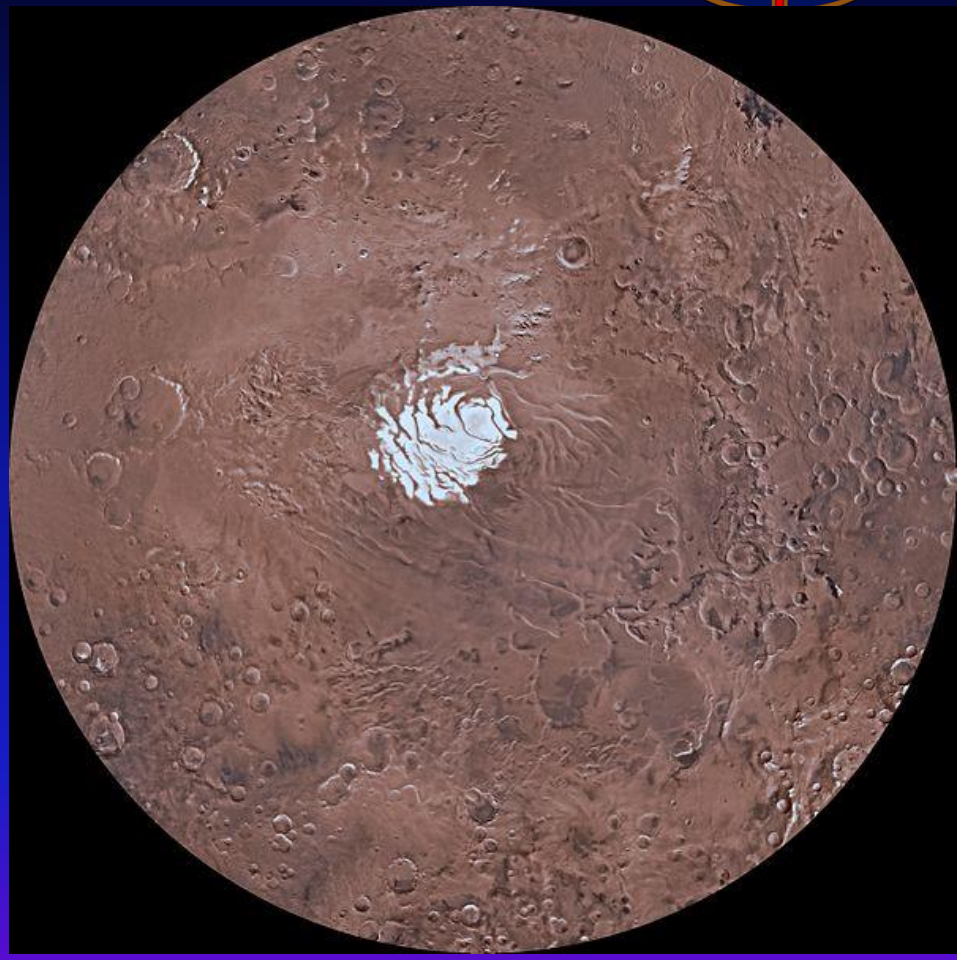

Nirgal Vallis, Mariner 9

SCHEMATIC OF THE VIKING LANDER BIOLOGICAL EXPERIMENT SYSTEM

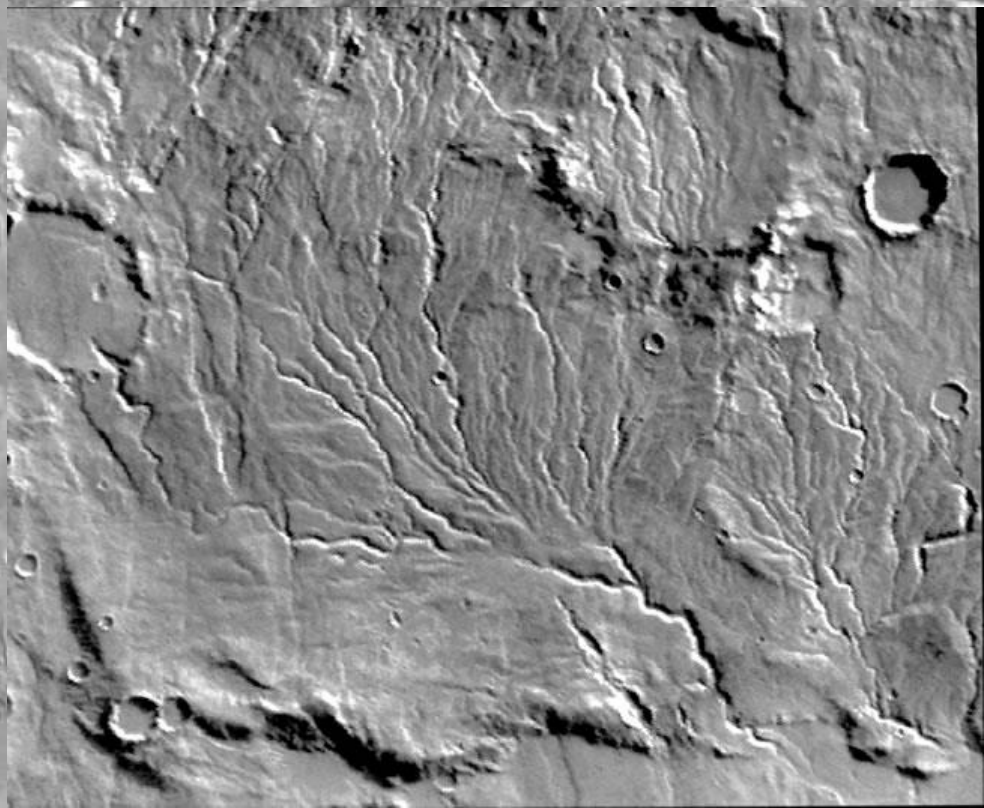



Present Mars
H2O Escape
N/C Escape
Ps = 6.1 mb
H2O = 10 pr-μm
Dust τ = 0.3 - 5
CO2 Cycle
Water Ice Clouds
H2O Cycle
Dust Storms
Dust Cycle
Polar Hood
Seasonal CO2 Ice
4m
Permanent CO2 Ice
Polar Hood
Seasonal CO2 Ice
H2O Ice
60°S
Equator
60°N
H2O Ice
H2O Ice
Permafrost?
Permafrost?
MCMG
NASA



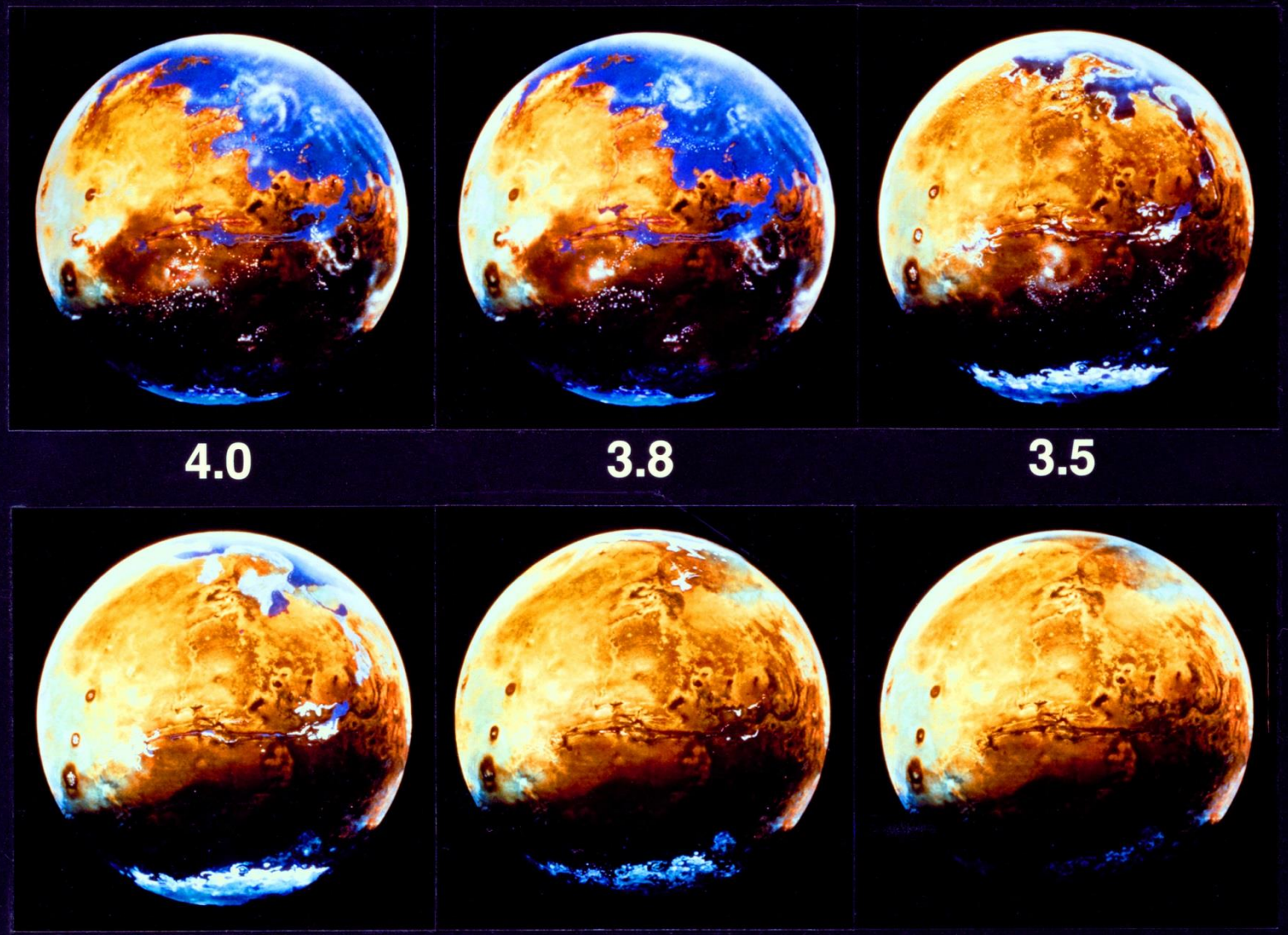



100 km
streamlined features
direction of flow
Hydaspis Chaos



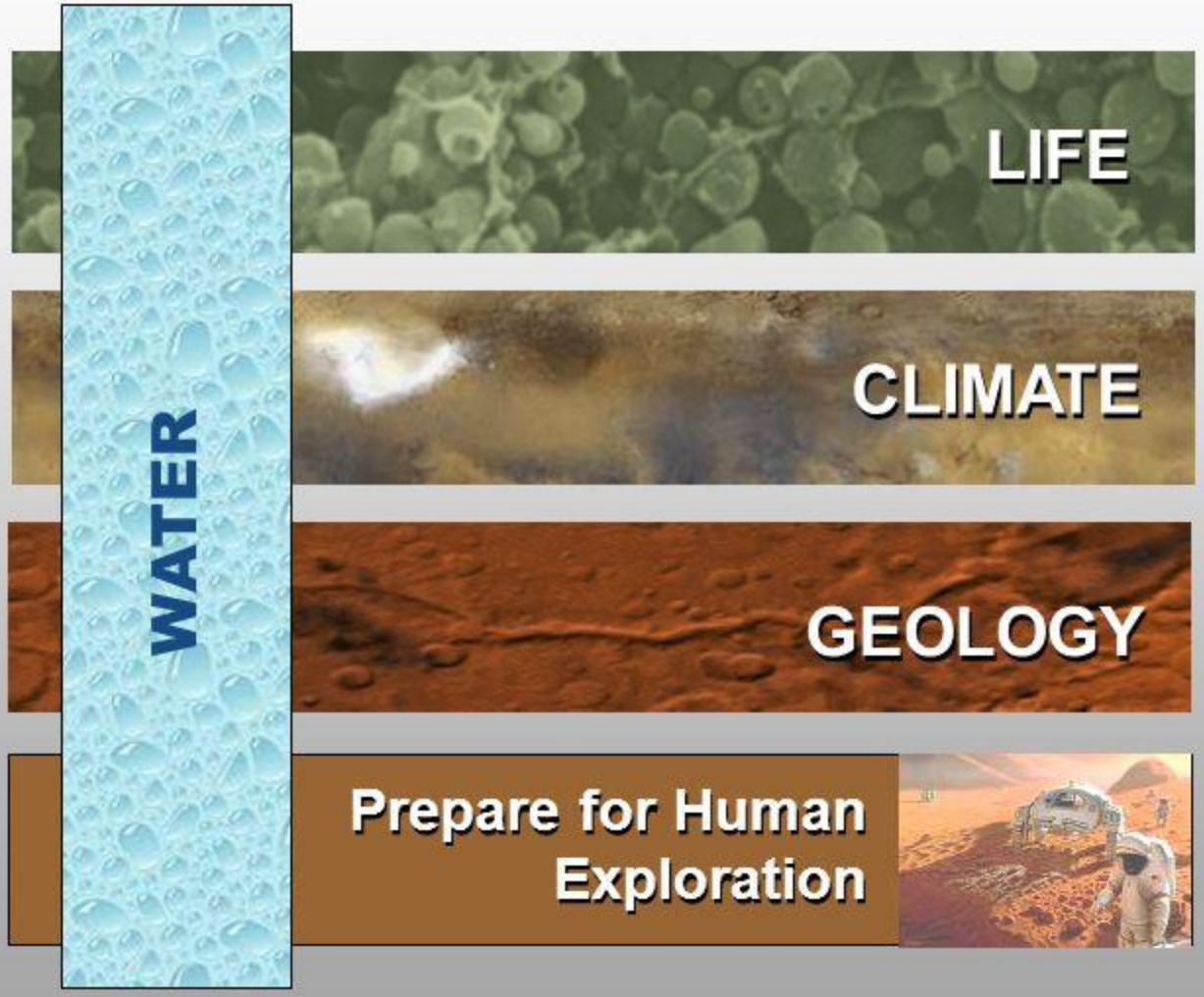
HISTORY OF WATER ON MARS

b.y.a.



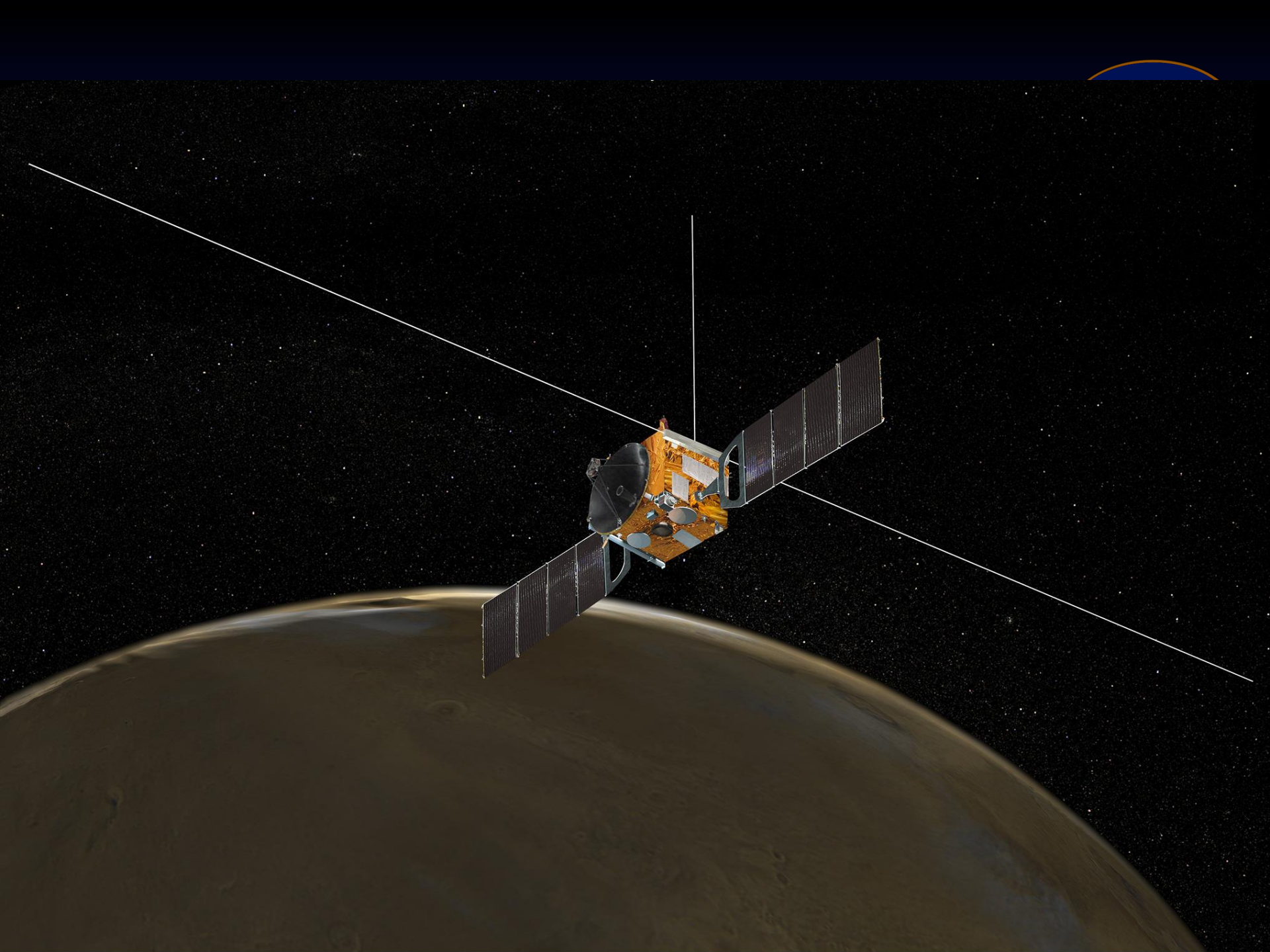
NASA's Strategy for Mars Exploration

"Follow the Water"



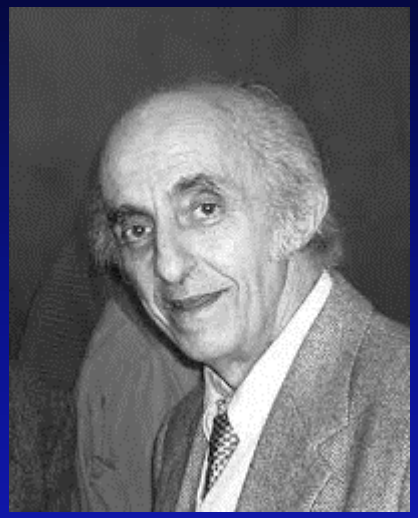
Mars Express

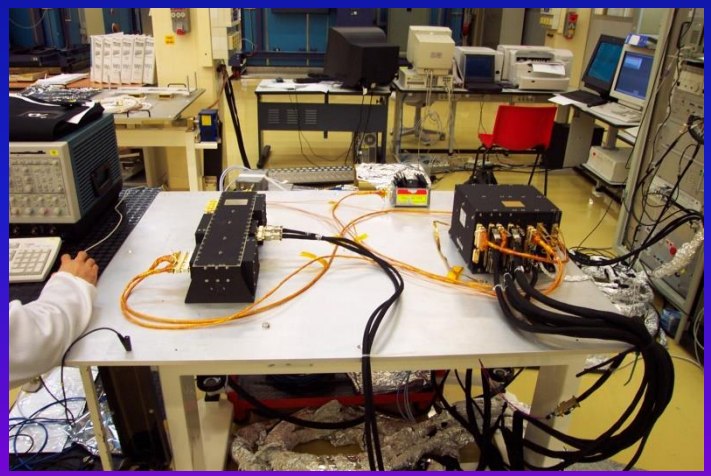
- On December 1996, during the IMEWG meeting held in Cocoa Beach, ESA announced the intention to realize a class F mission.
- ASI proposed to include a new instrument in the payload, a radar sounder to analyze the structure of the Martian subsurface and search water reservoirs in the depths: MARSIS.
- Mars Express was launched on June 2, 2003, MARSIS started to operate on July, 5 2005.



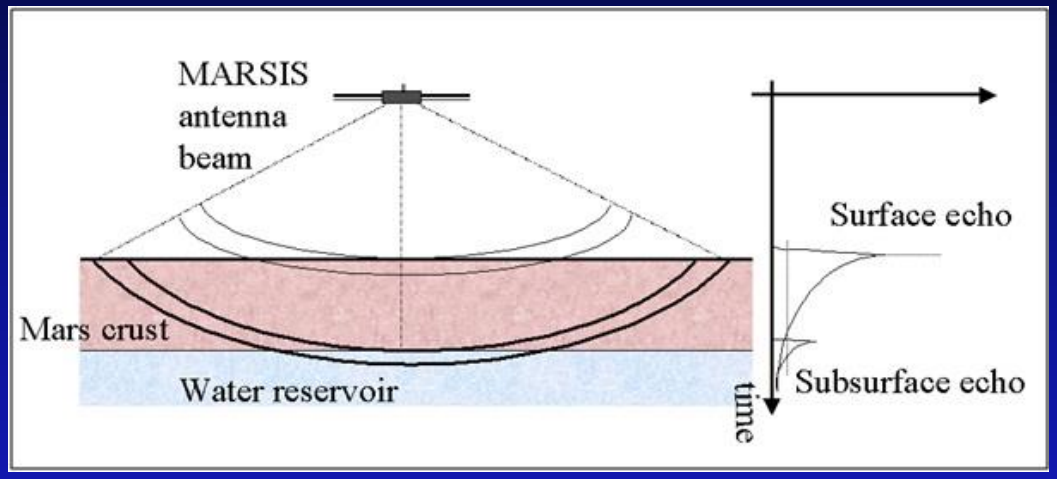
MARSIS

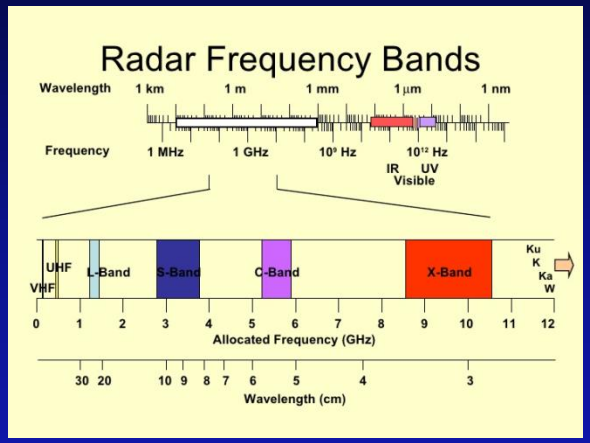
- MARSIS was conceived by Prof. Giovanni Picardi and realized under ASI management by Thales Alenia Space Italy with the contribution of Jet Propulsion Laboratory (antennas) and University Of Iowa (RF receiver).
- Picardi was the first PI, with J.Plaut co-PI and R. Seu as Deputy-PI.
- ASI is still managing the science contract in Italy.



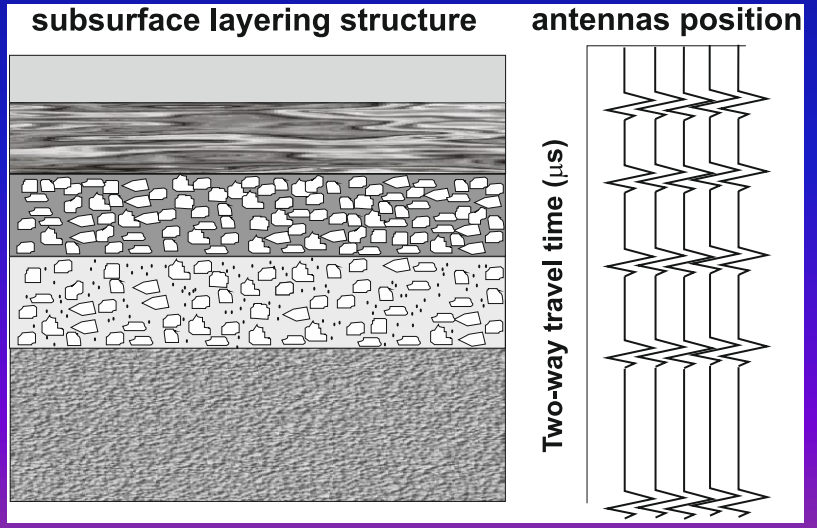


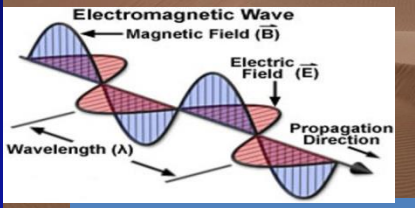
How MARSIS works

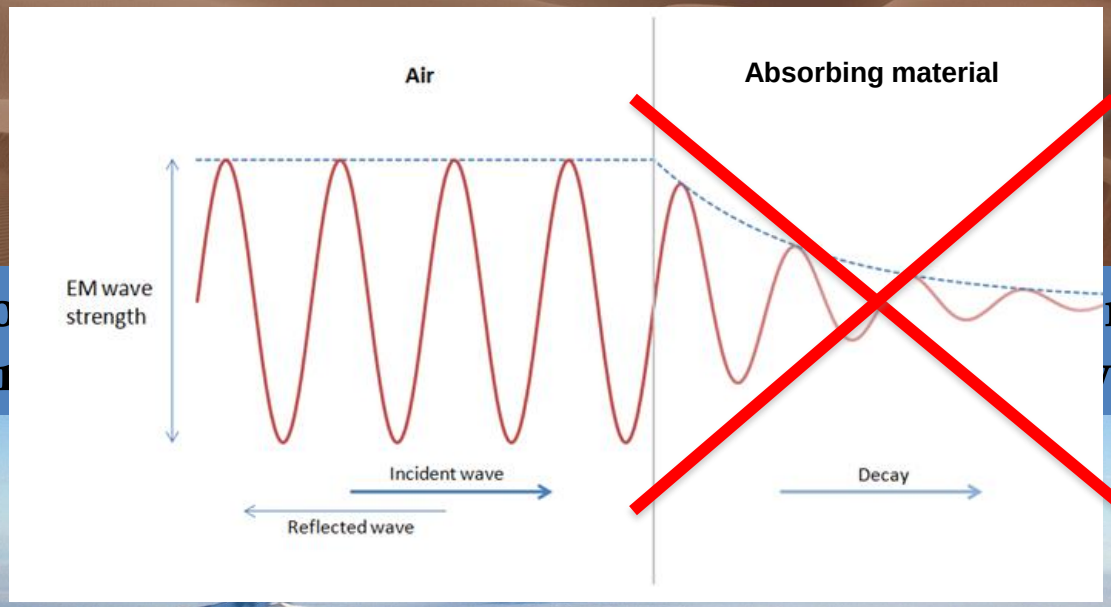




interfaces between layers having different electrical properties



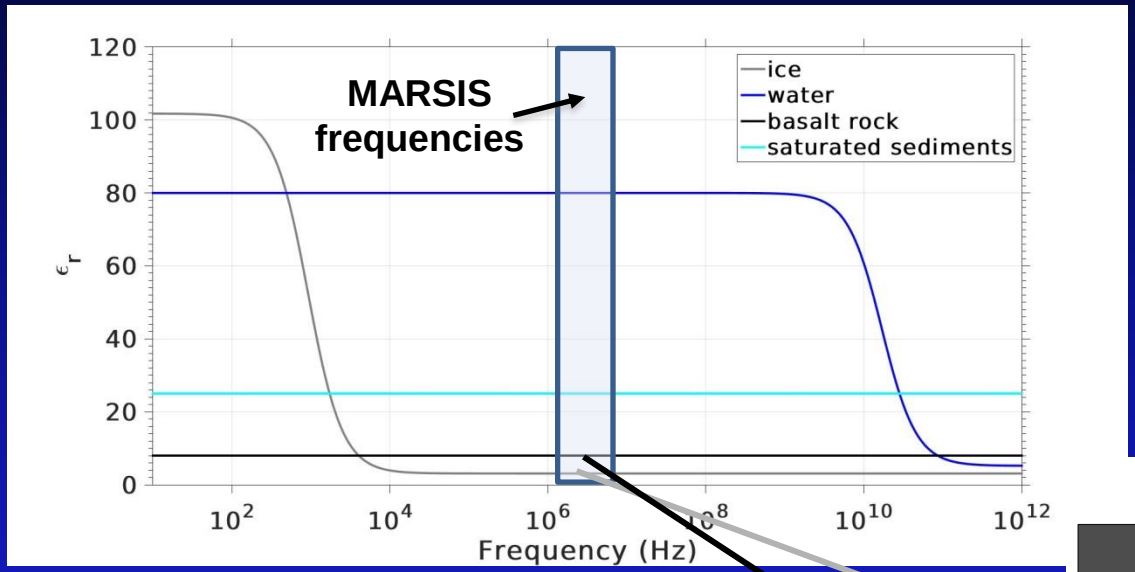




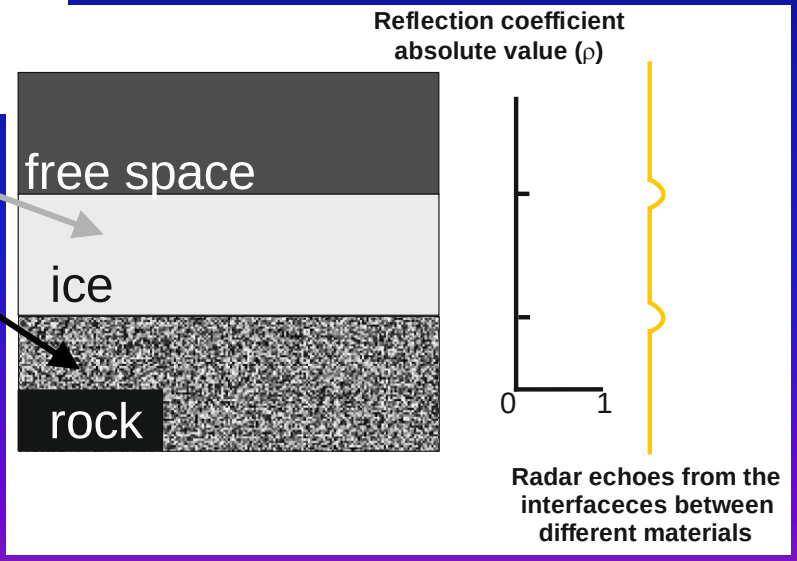
Dry and/or co ments for deep radio wave pr .

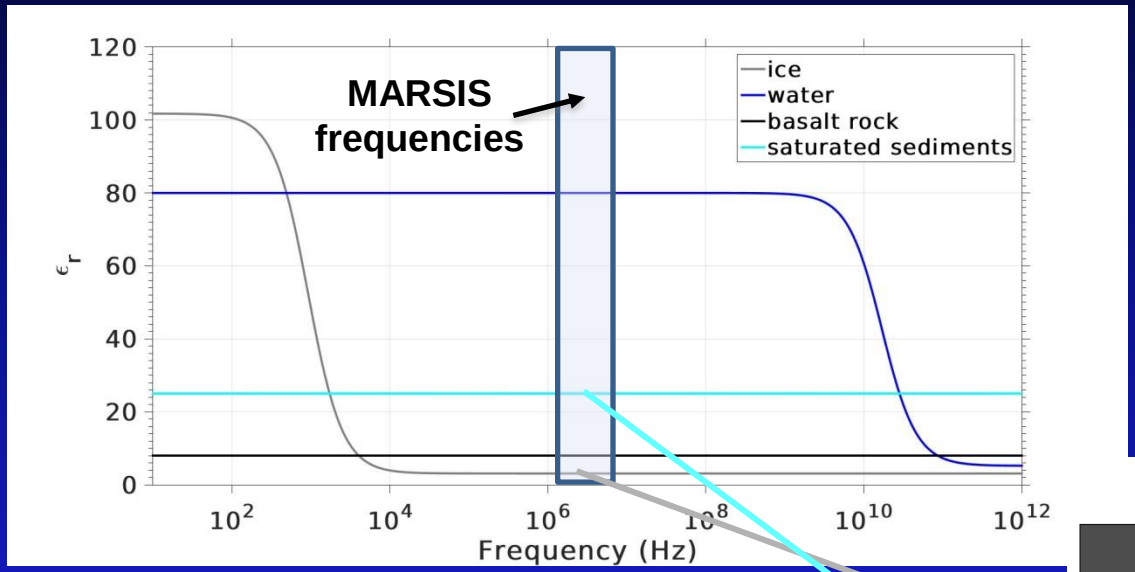
Mars subsurface meets this requirement in many areas

Water ice is particularly suitable for radar sounder investigations because it is transparent to radio waves, especially if cold and pure.



The capability to detect liquid water under the ice depends on the dielectric contrast between materials





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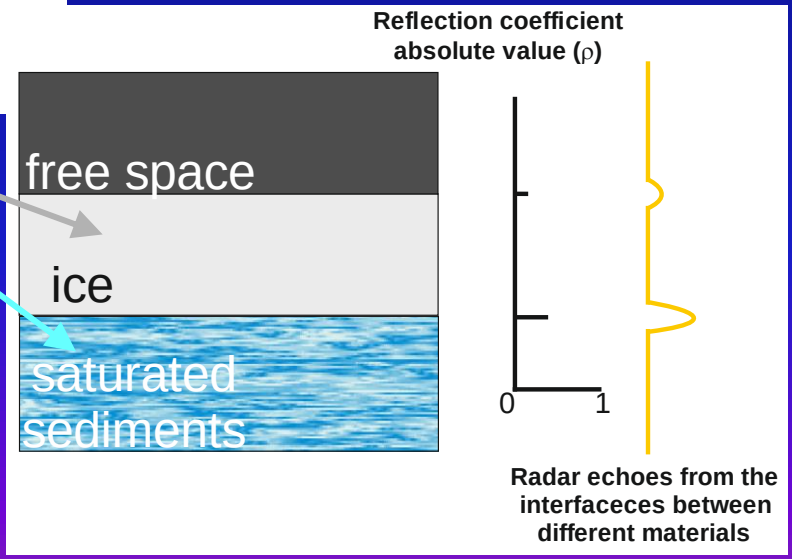

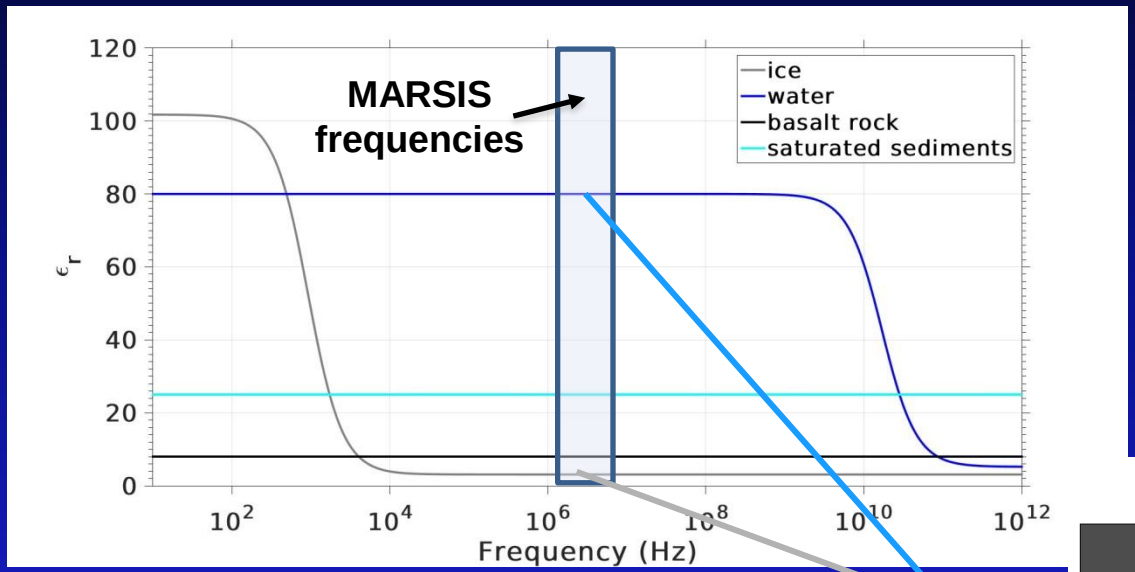

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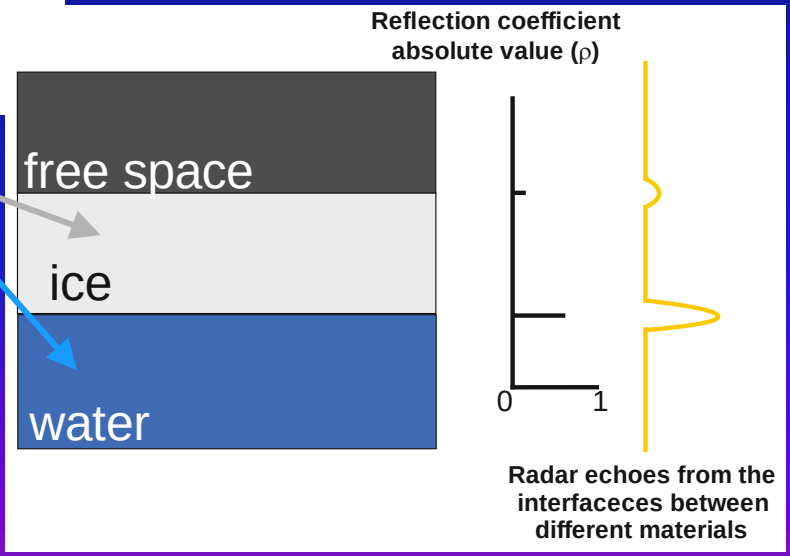
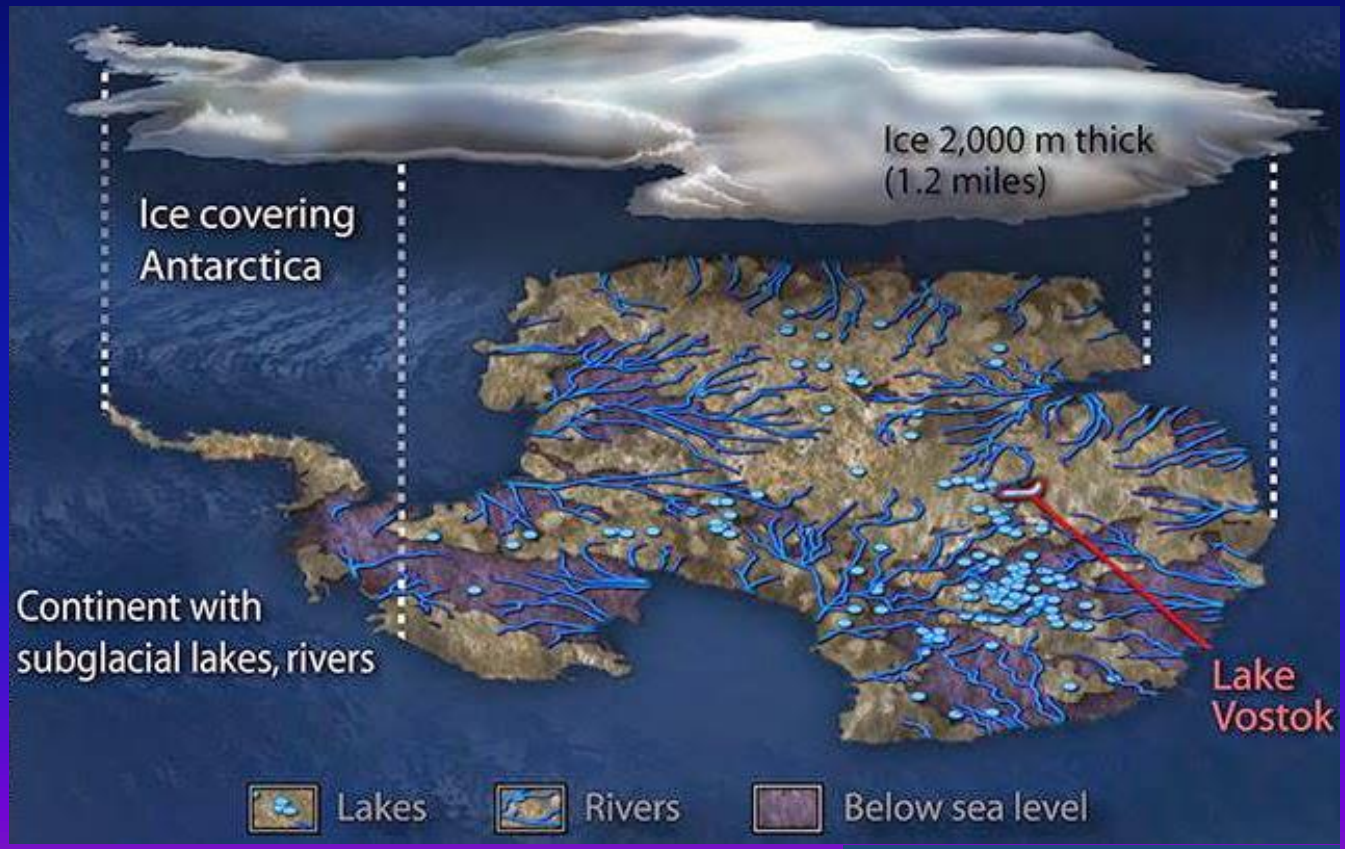
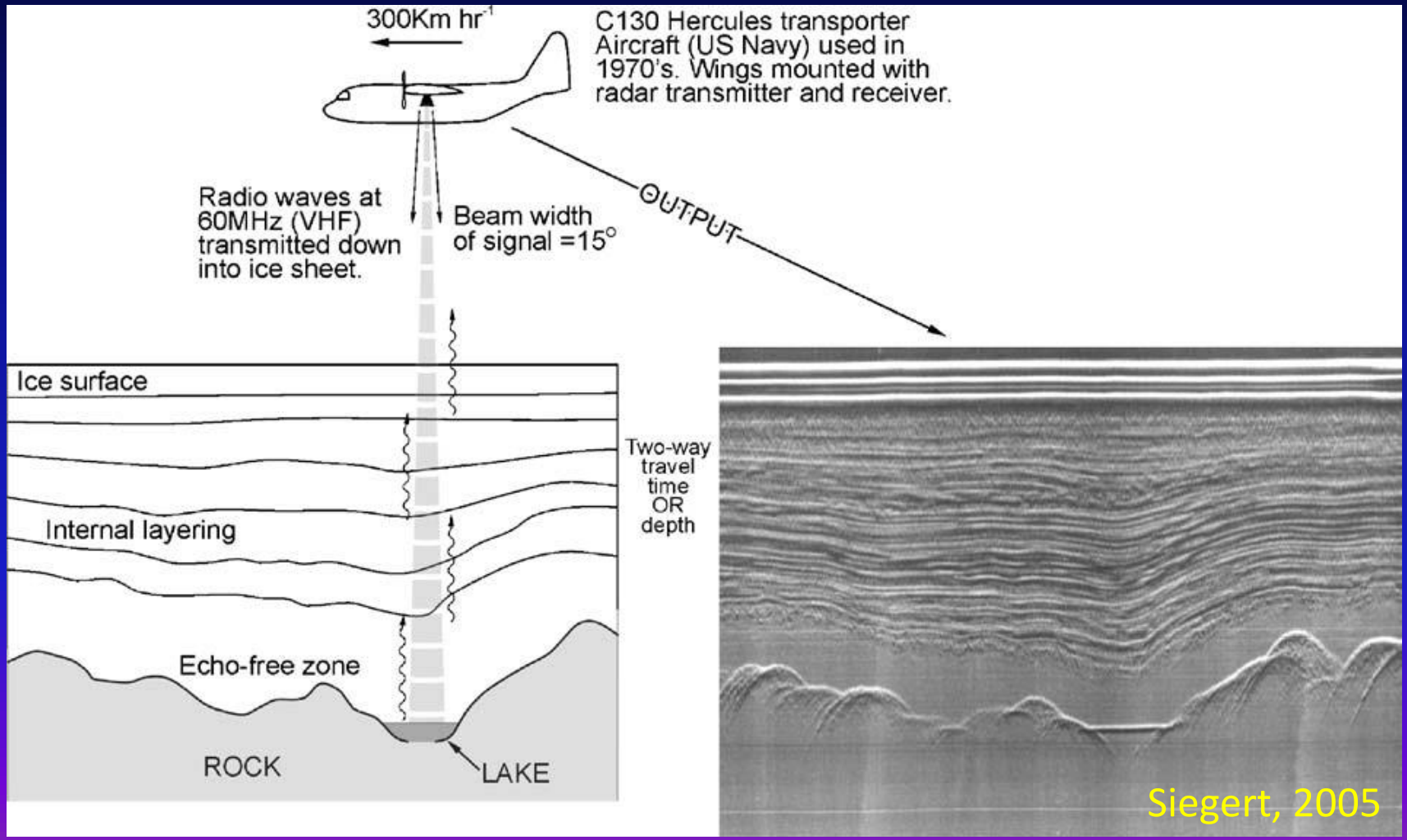


Radar echo sounding (RES) has detected most subglacial lakes in Antarctica

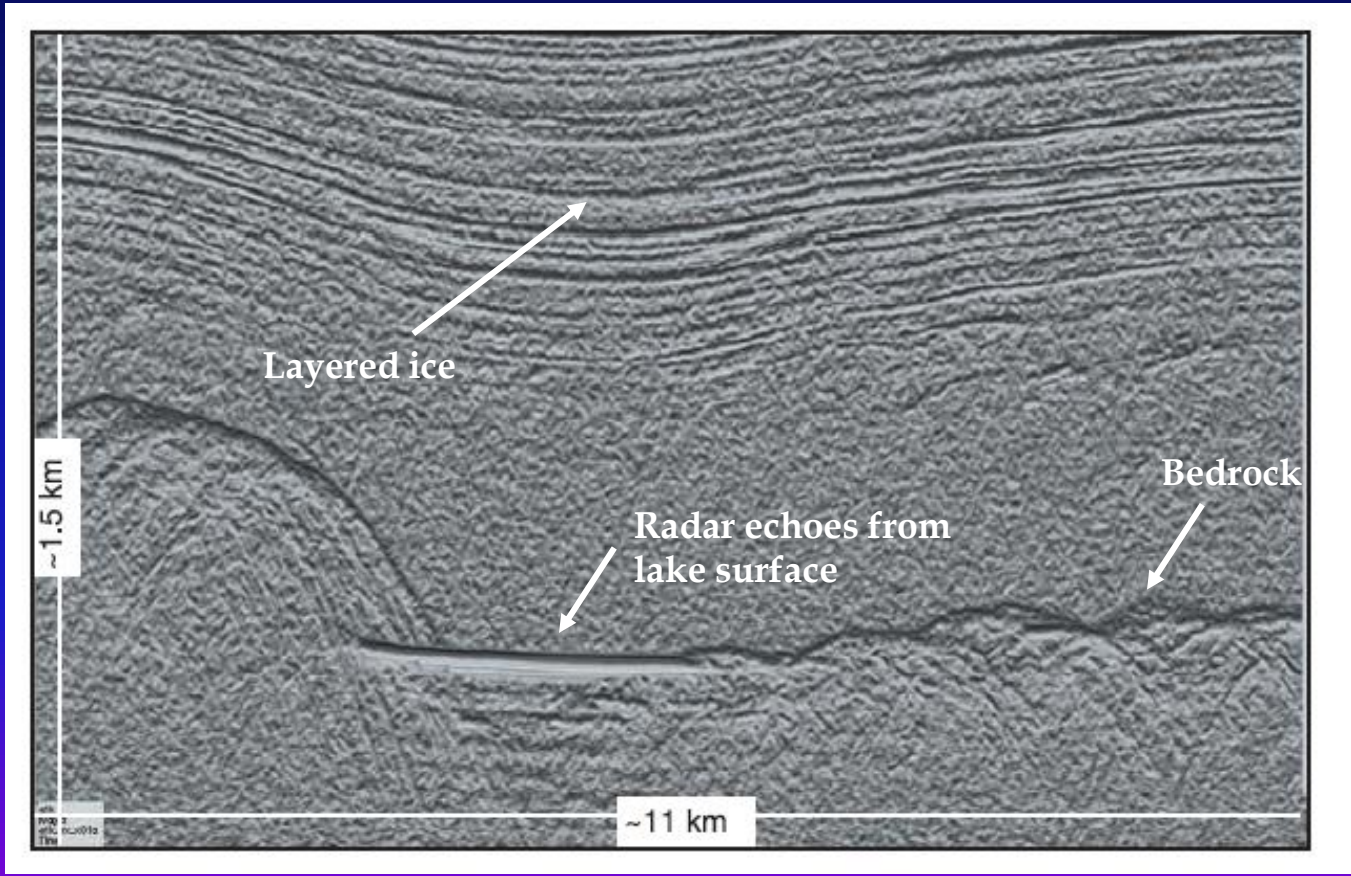


Credits: NSF/Zina Deretsky

Lakes beneath the ice

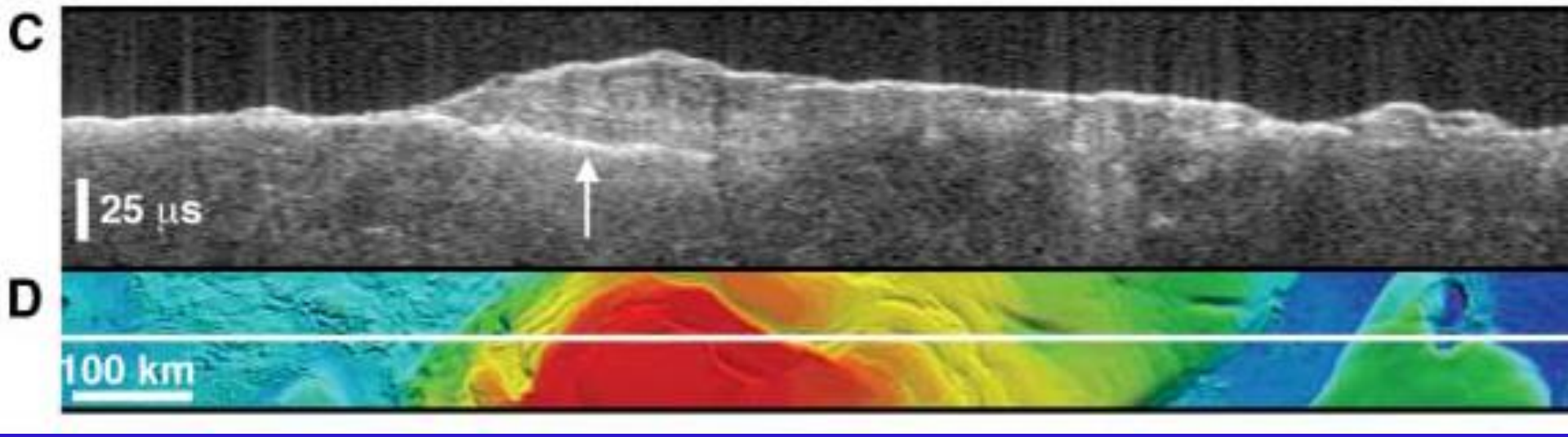


Detection of lakes



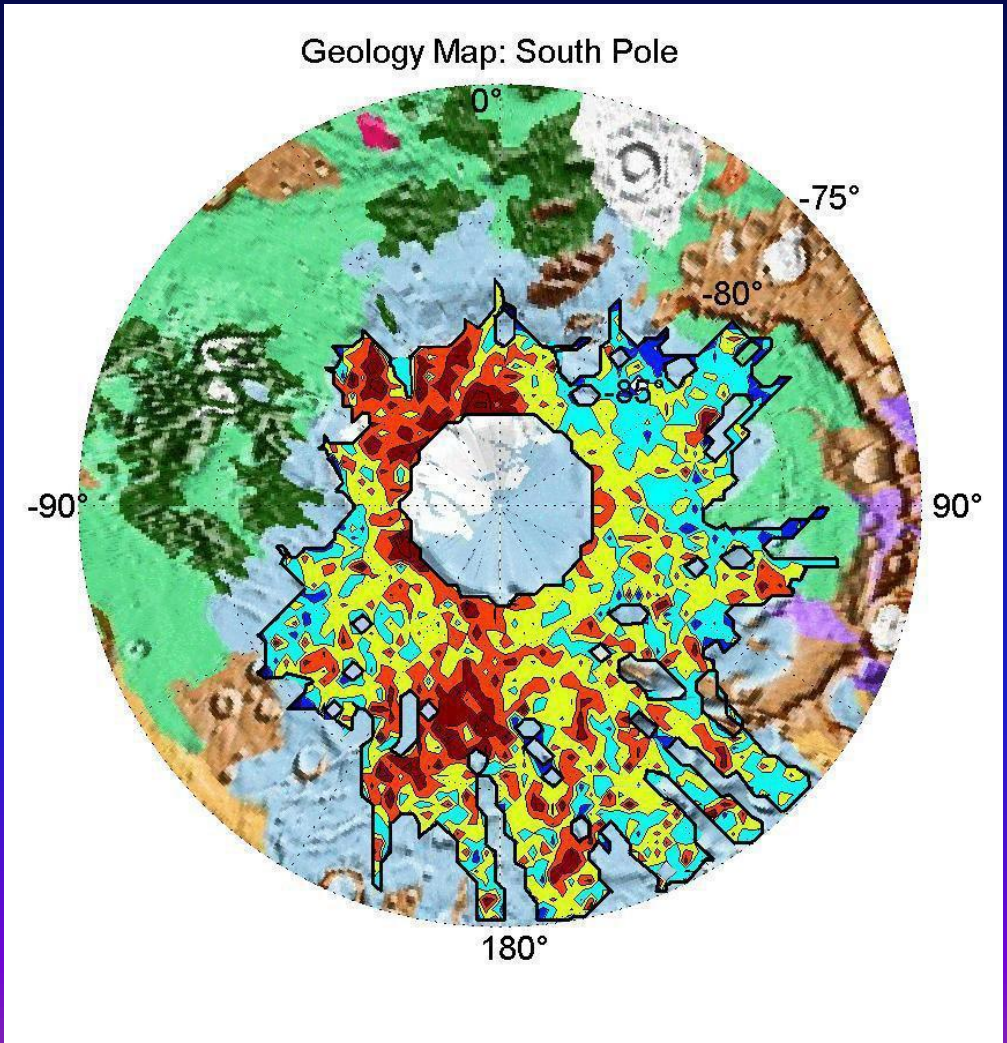
Carter et al., 2007

MARSIS over the SPLD



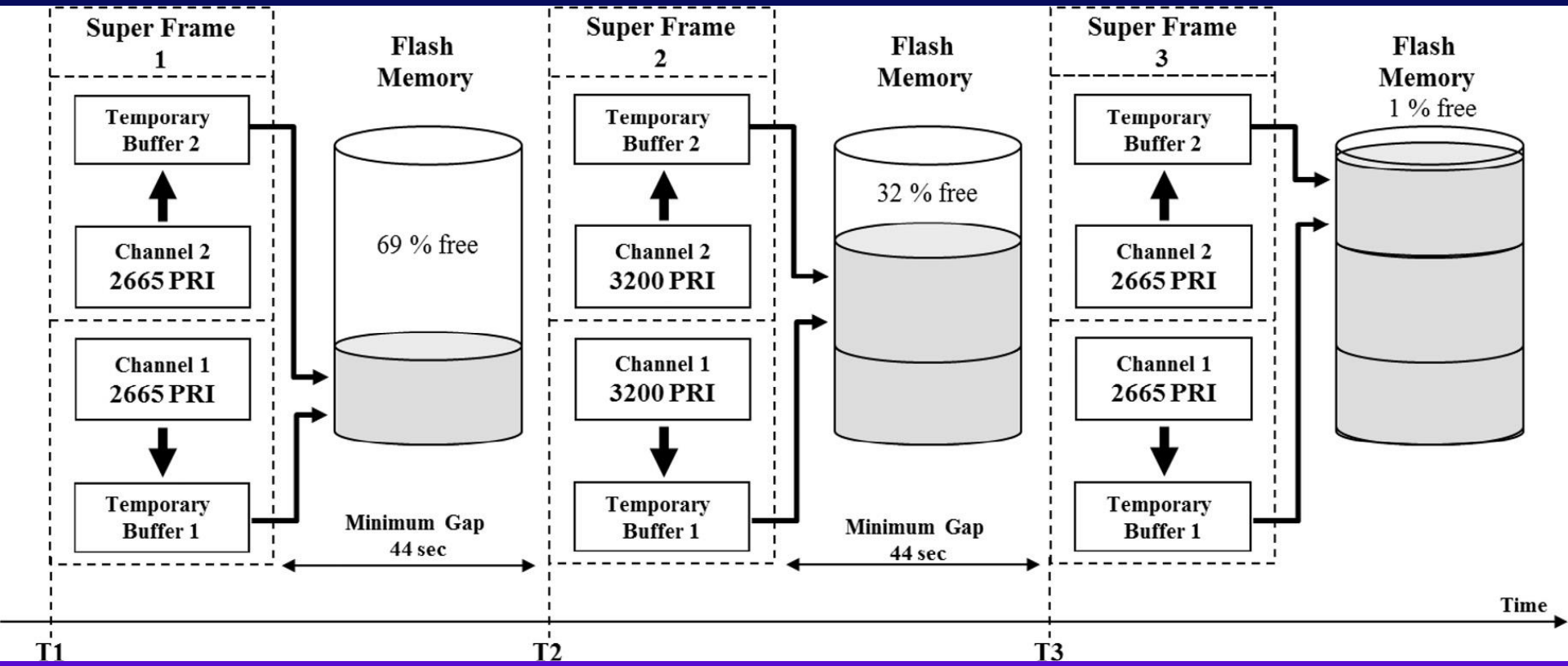
Plaut et al., 2007

Strong basal reflections outside the residual polar cap

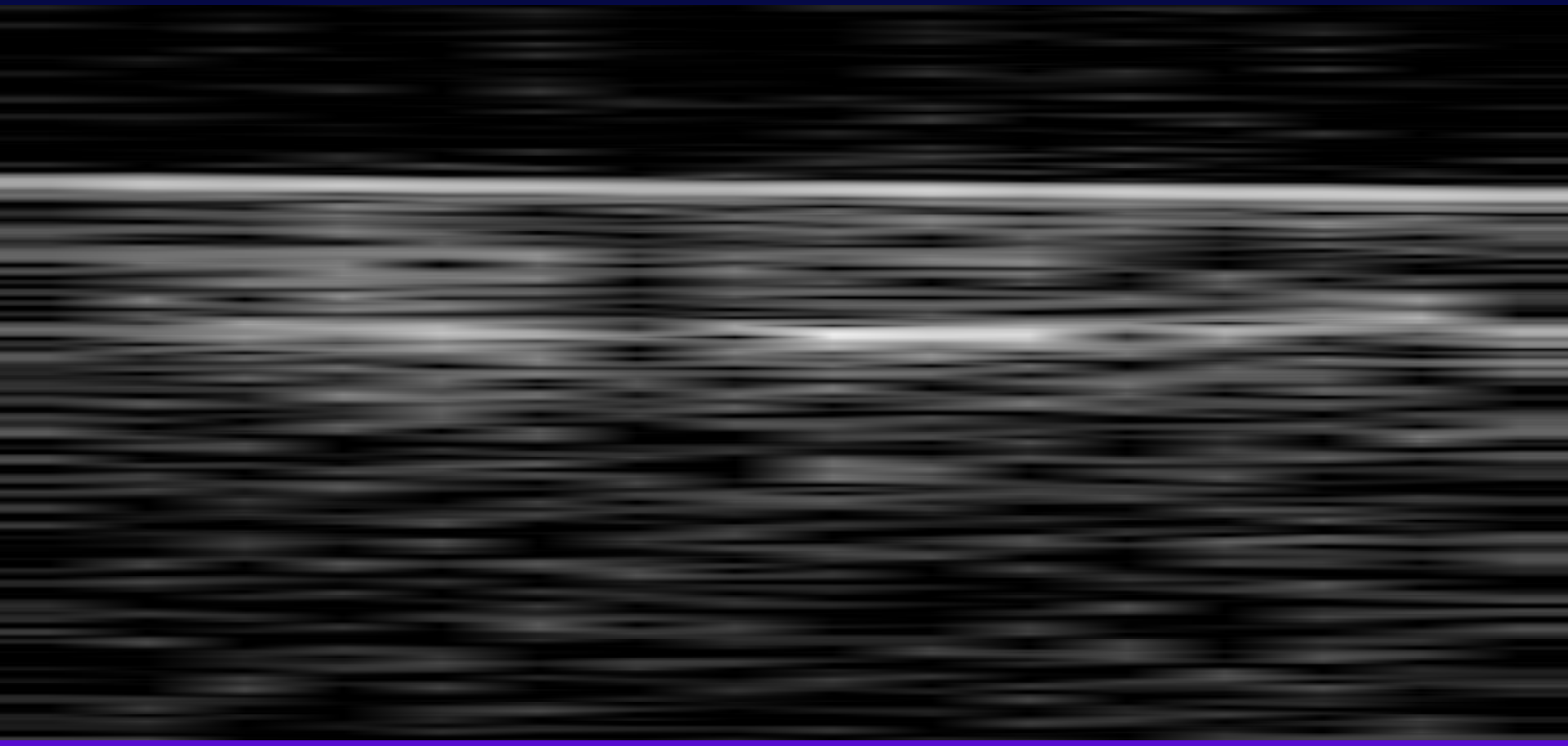


Cartacci et al., 2008

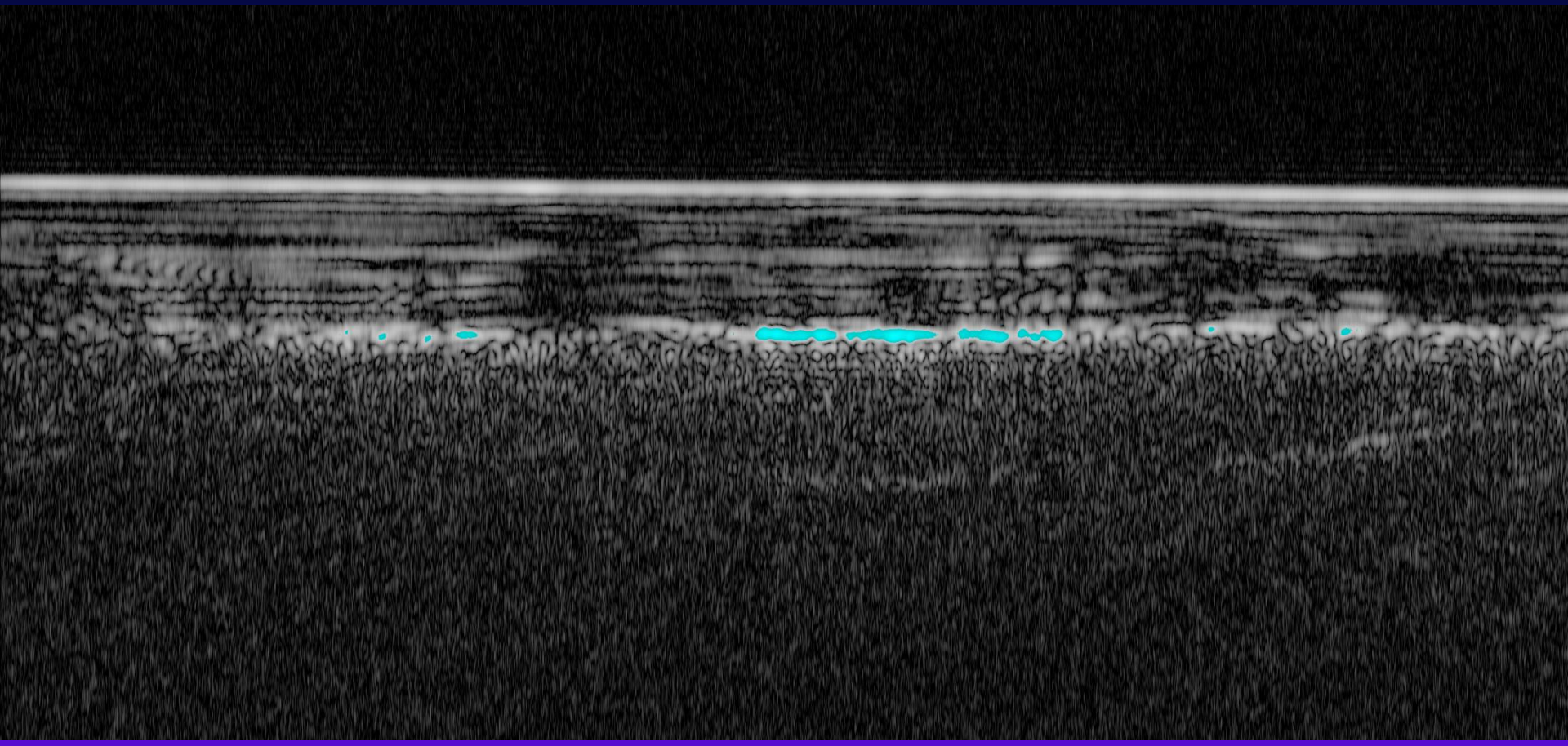
Superframes

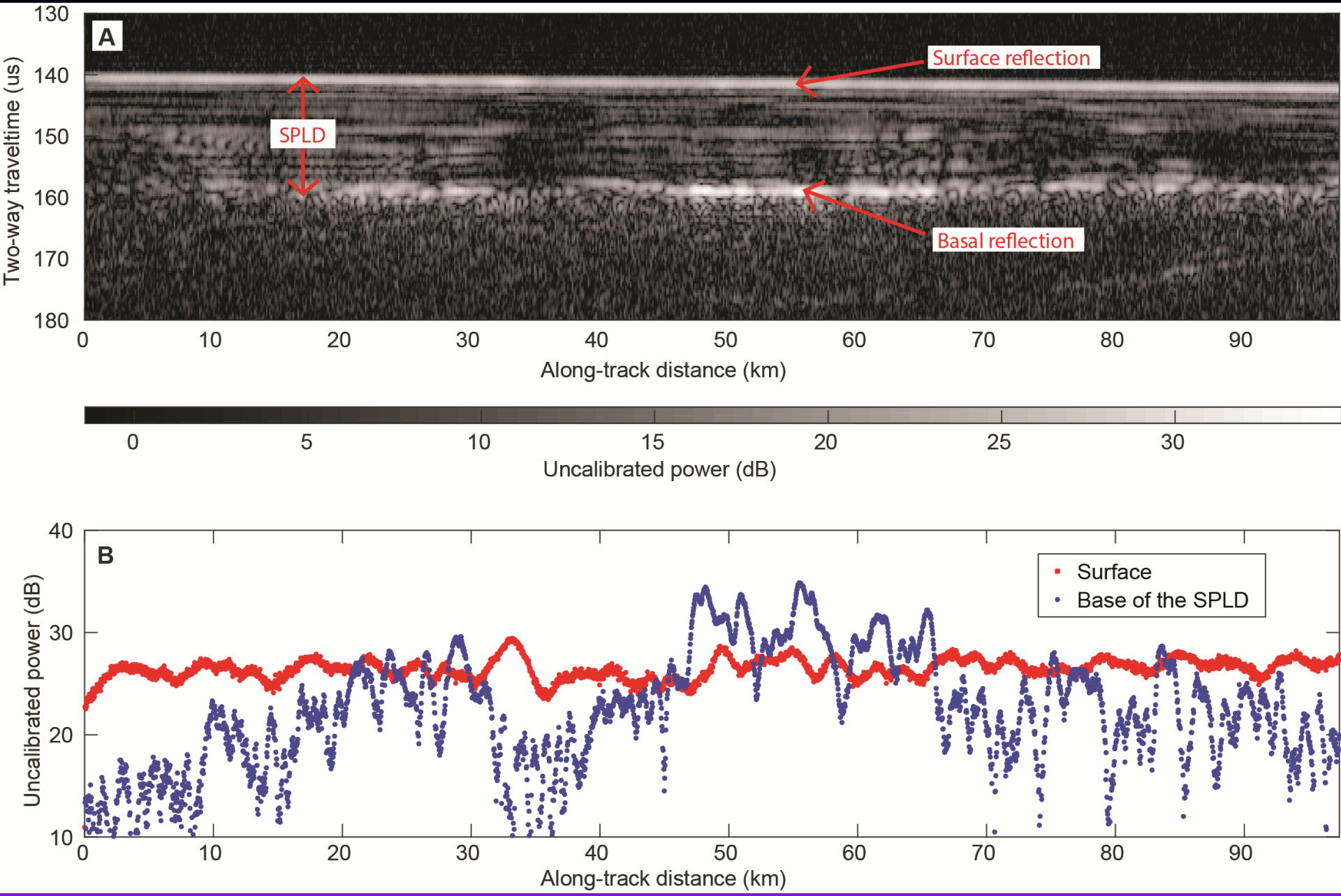


On-board processed data

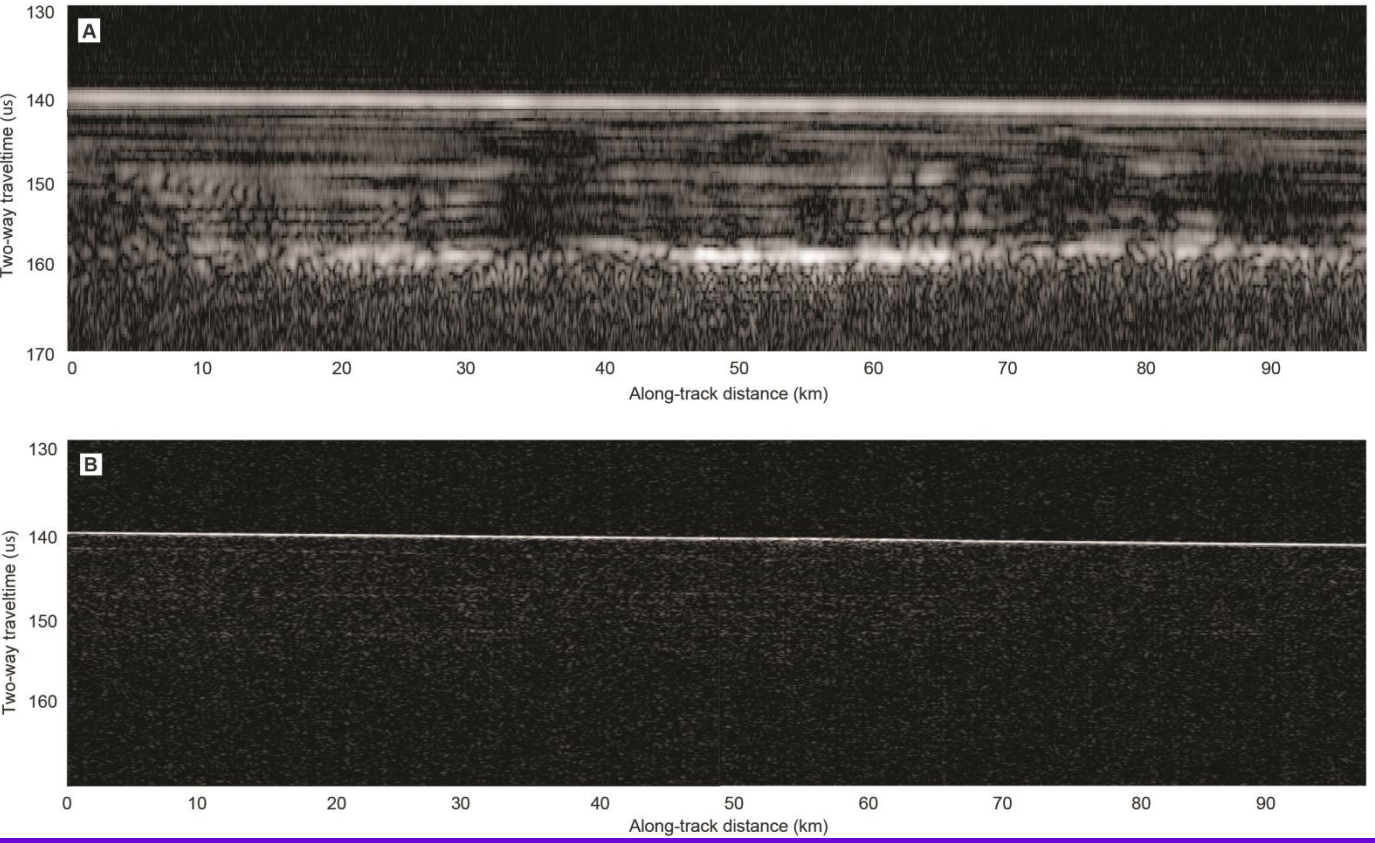


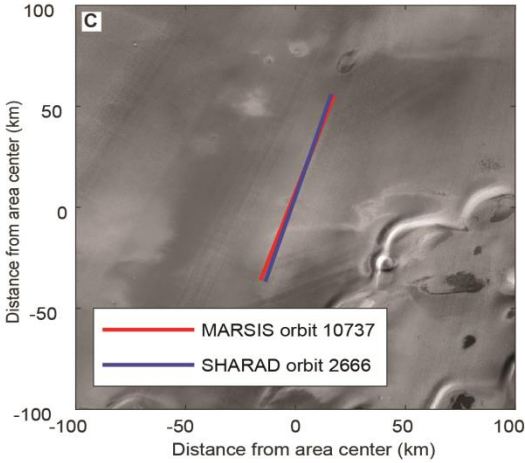
Superframe

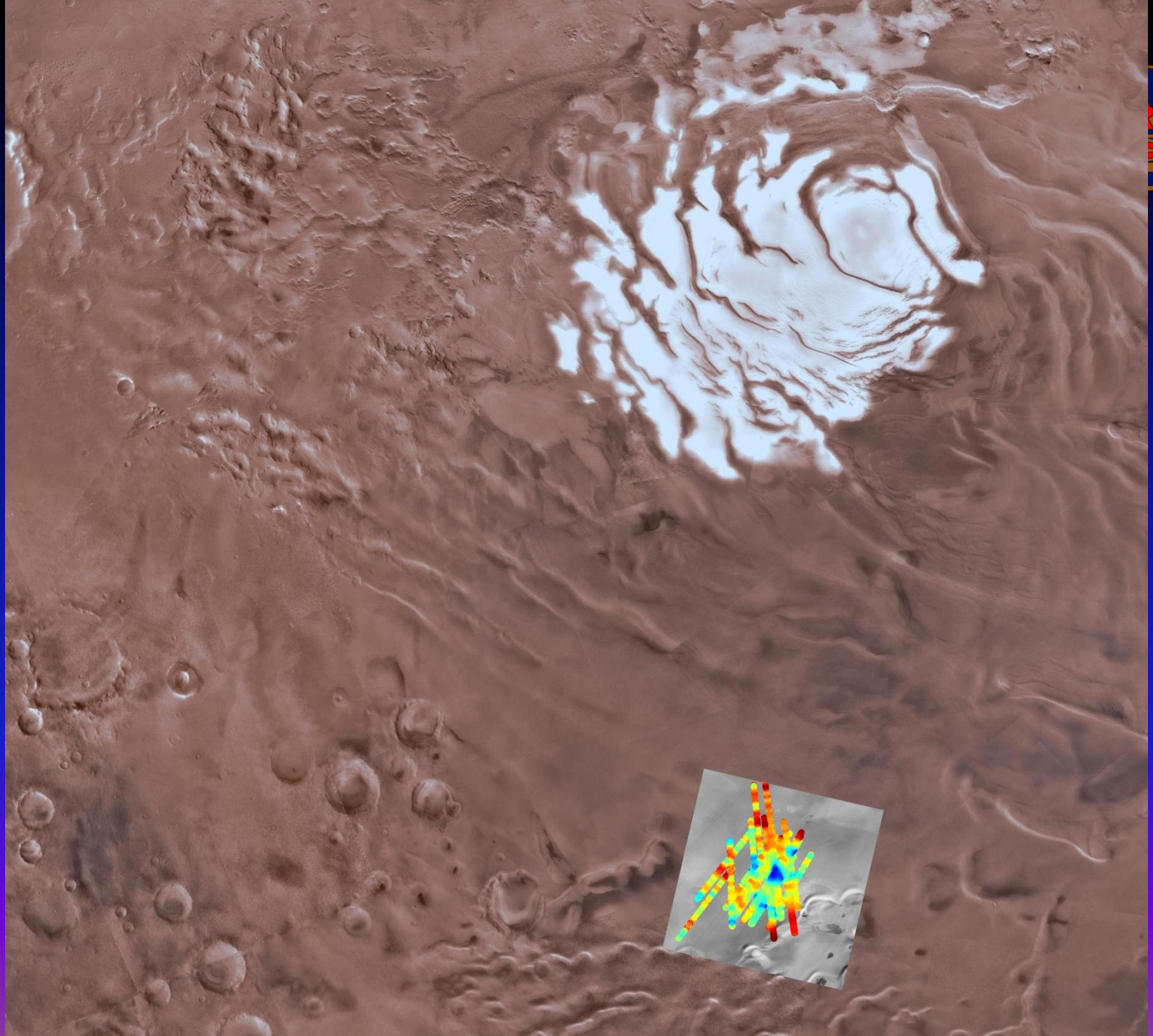


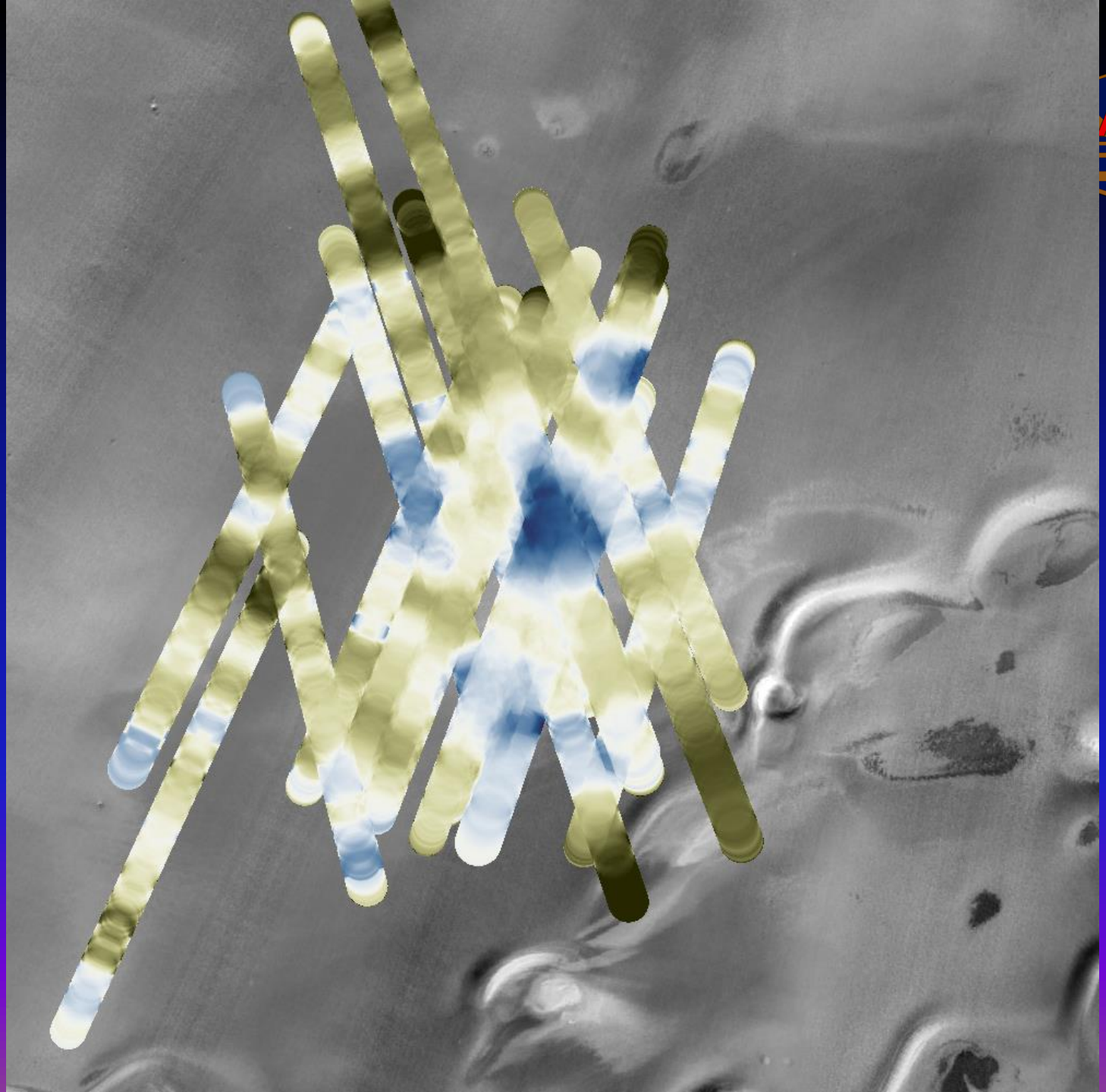

A
Surface reflection
SPLD
Basal reflection
Two-way traveltime (us)
130
140
150
160
170
180
0
10
20
30
40
50
60
70
80
90
Along-track distance (km)
0
5
10
15
20
25
30
Uncalibrated power (dB)
B
Surface
Base of the SPLD
Uncalibrated power (dB)
40
30
20
10
0
10
20
30
40
50
60
70
80
90
Along-track distance (km)

MARSIS vs. SHARAD

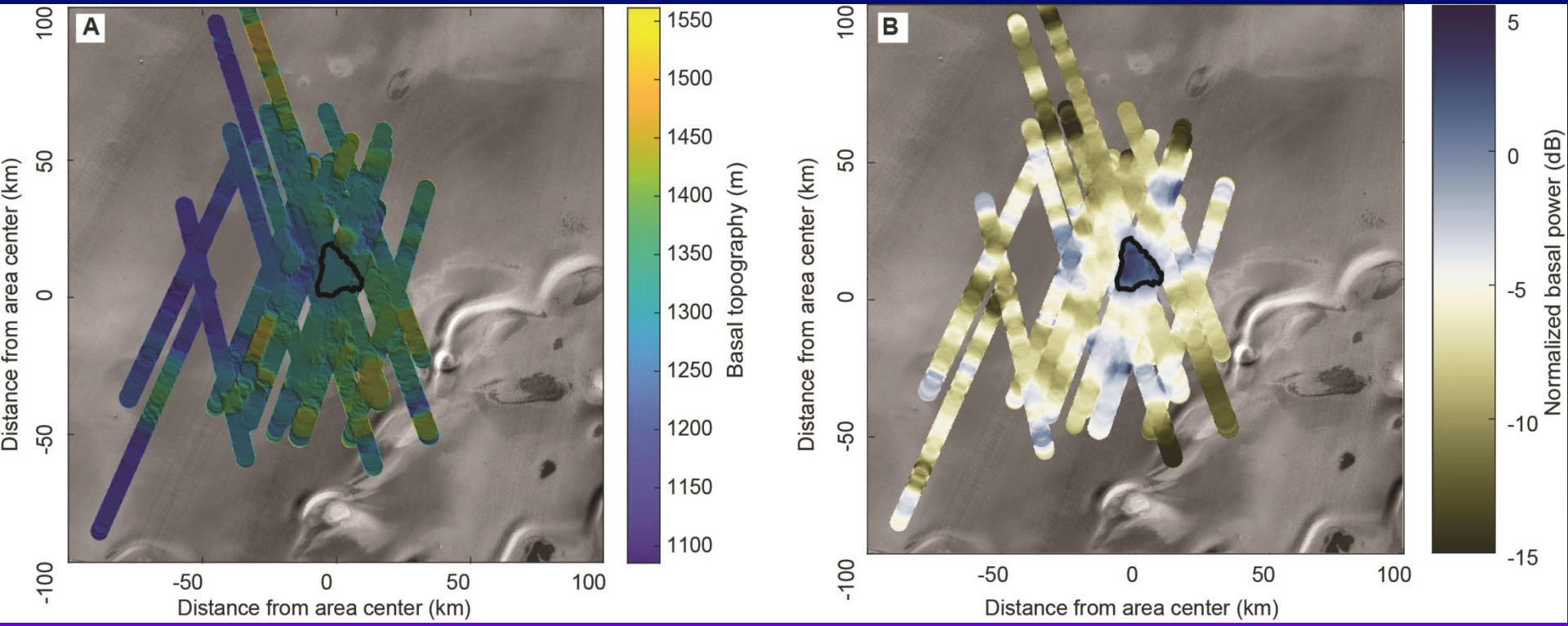






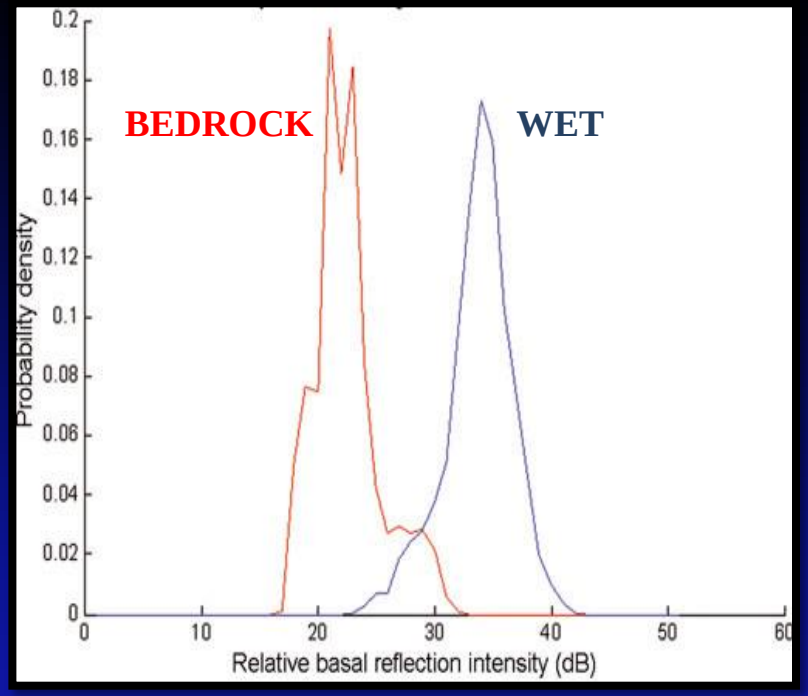


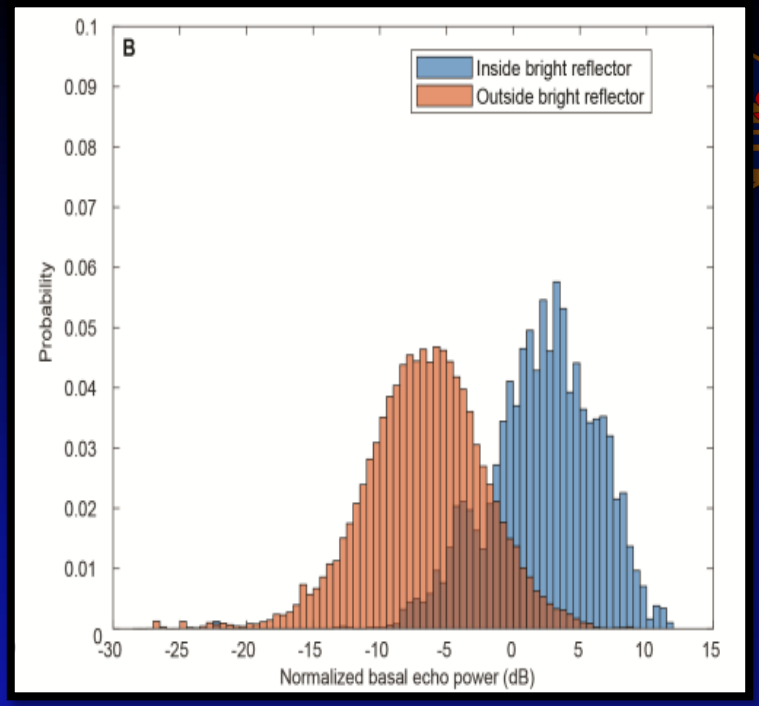
Basal topography and echo power

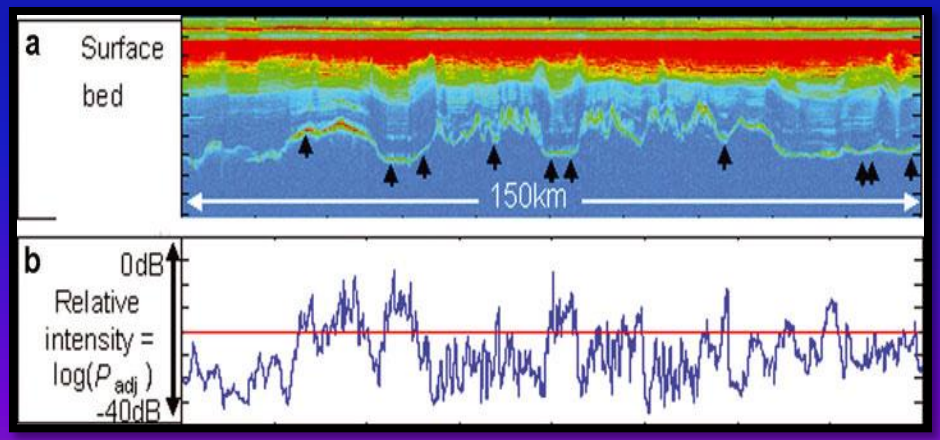


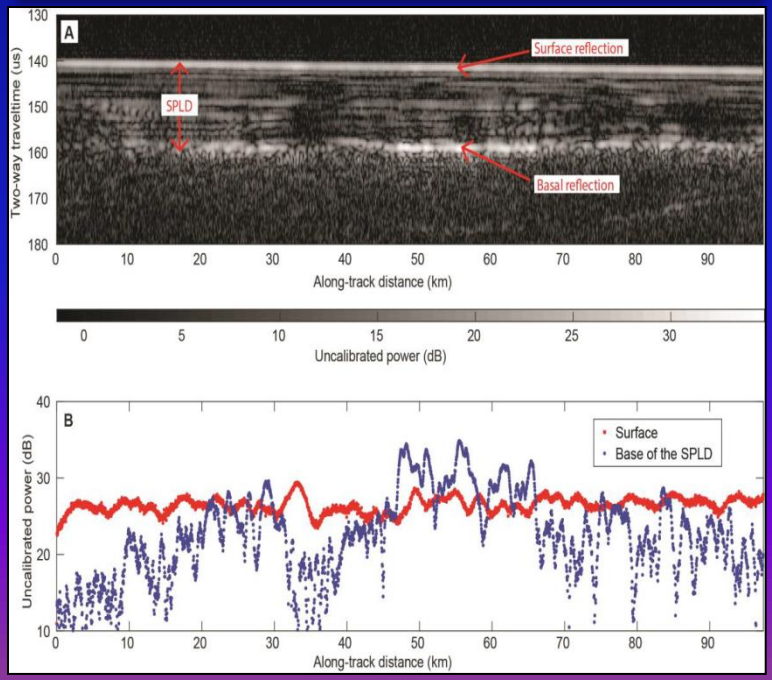
EARTH

MARS



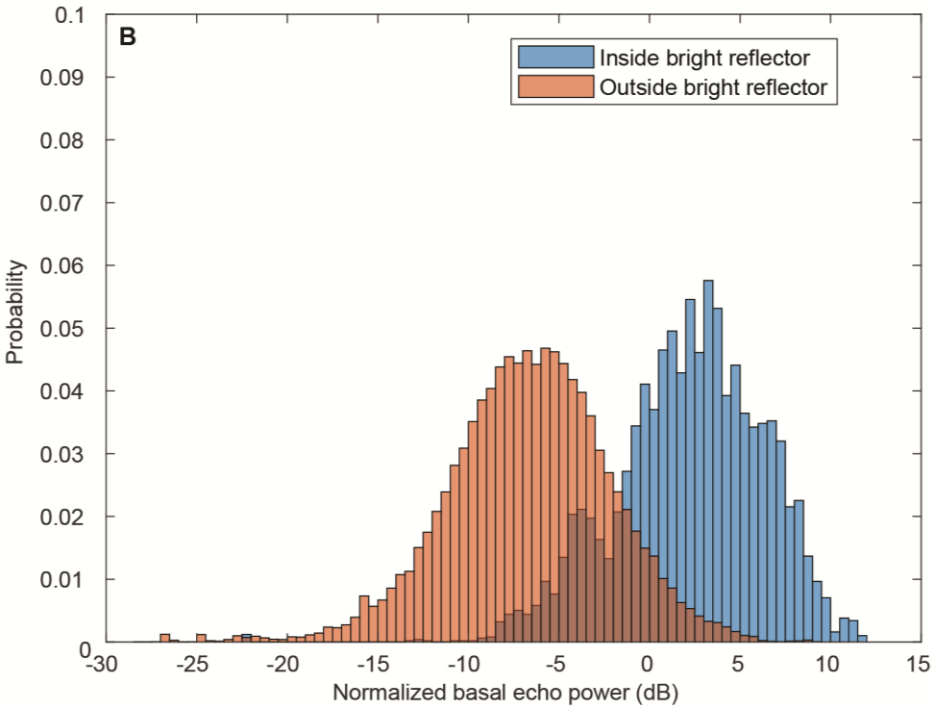


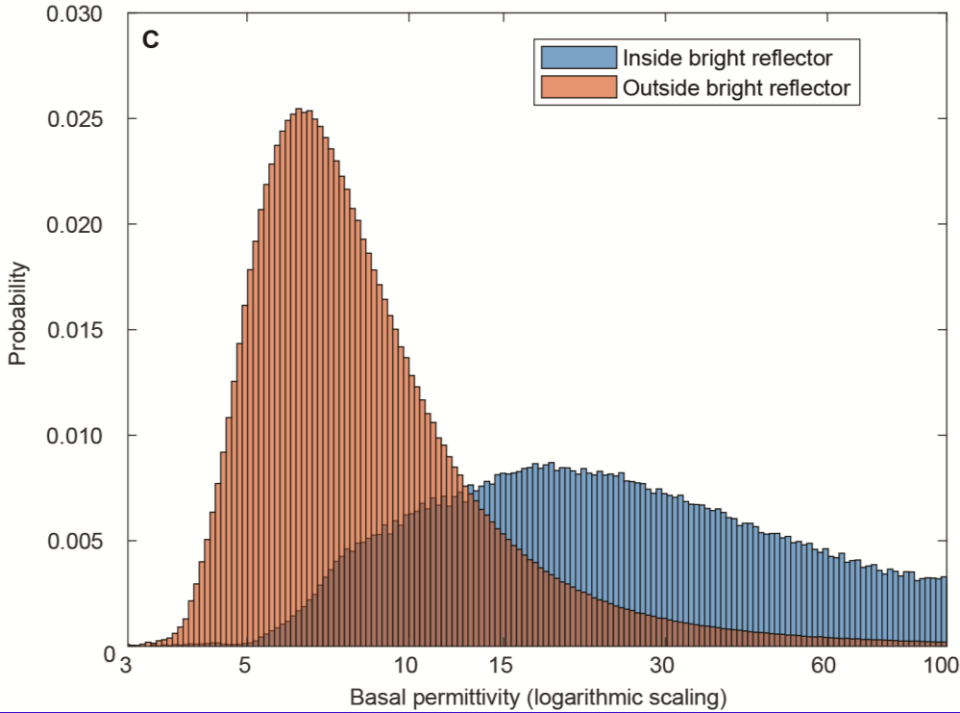




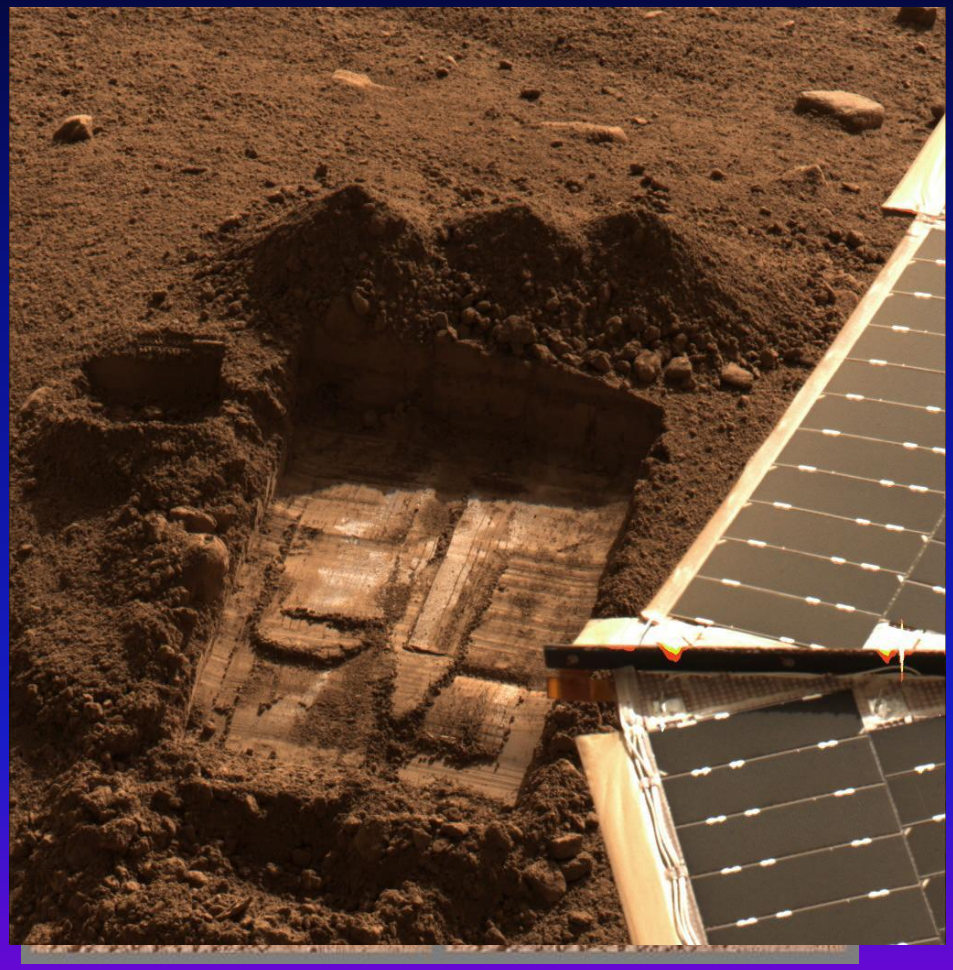
Oswald & Gogineni, 2008

Echo power and basal permittivity



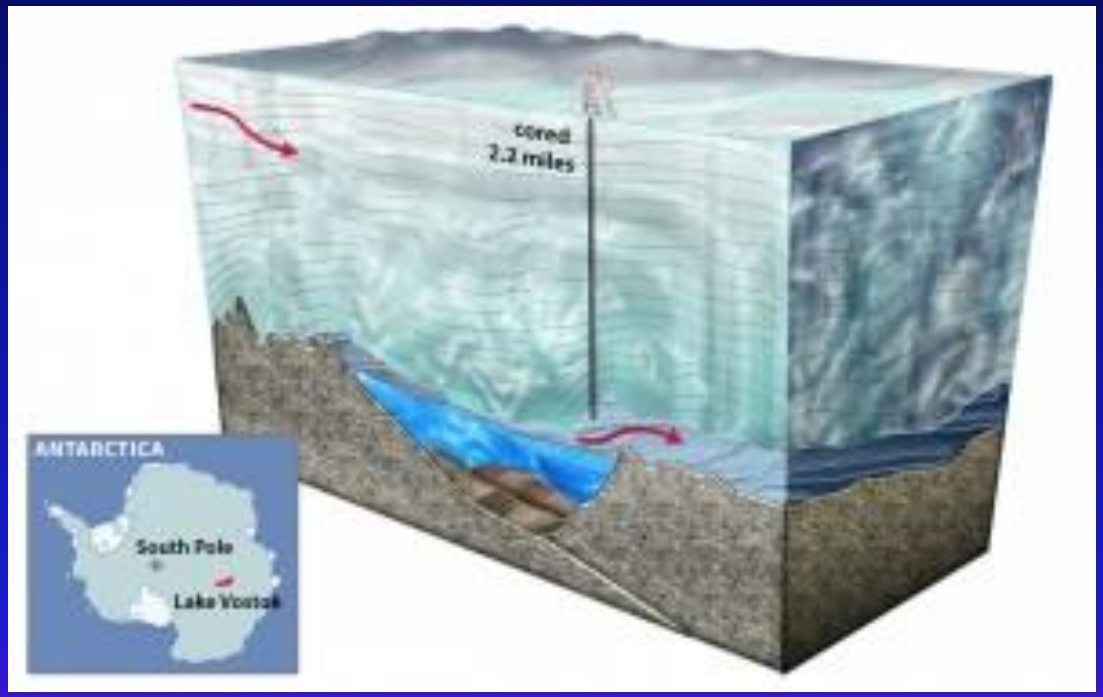


Phoenix

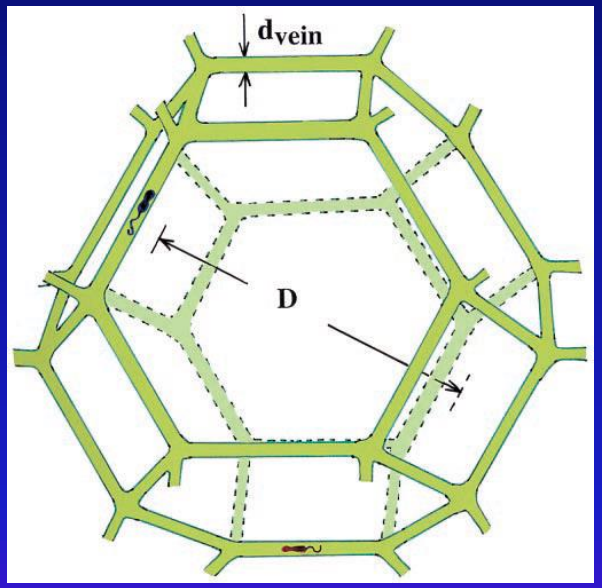


The Phoenix TECA instruments provided evidence for salts that could be present also in subsurface water

Life in the ice



Liquid veins between ice grains



In Antarctica, above lake Vostok, low metabolism bacteria have been found. They have survived in the liquid veins for over 140.000 years.

The future