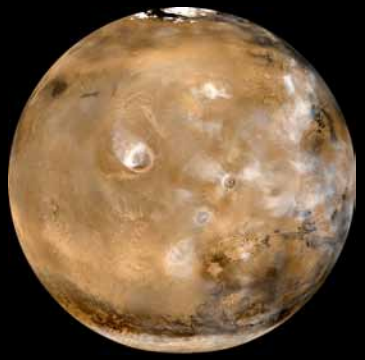
Preservation of Evidence of Ancient Environments and Life on Mars



Mars today

Early Mars ?

Dave Des Marais
NASA Ames Research Center

Key factors affecting biosignature preservation & abundance on Earth

Paleo-productivity

Transport and burial

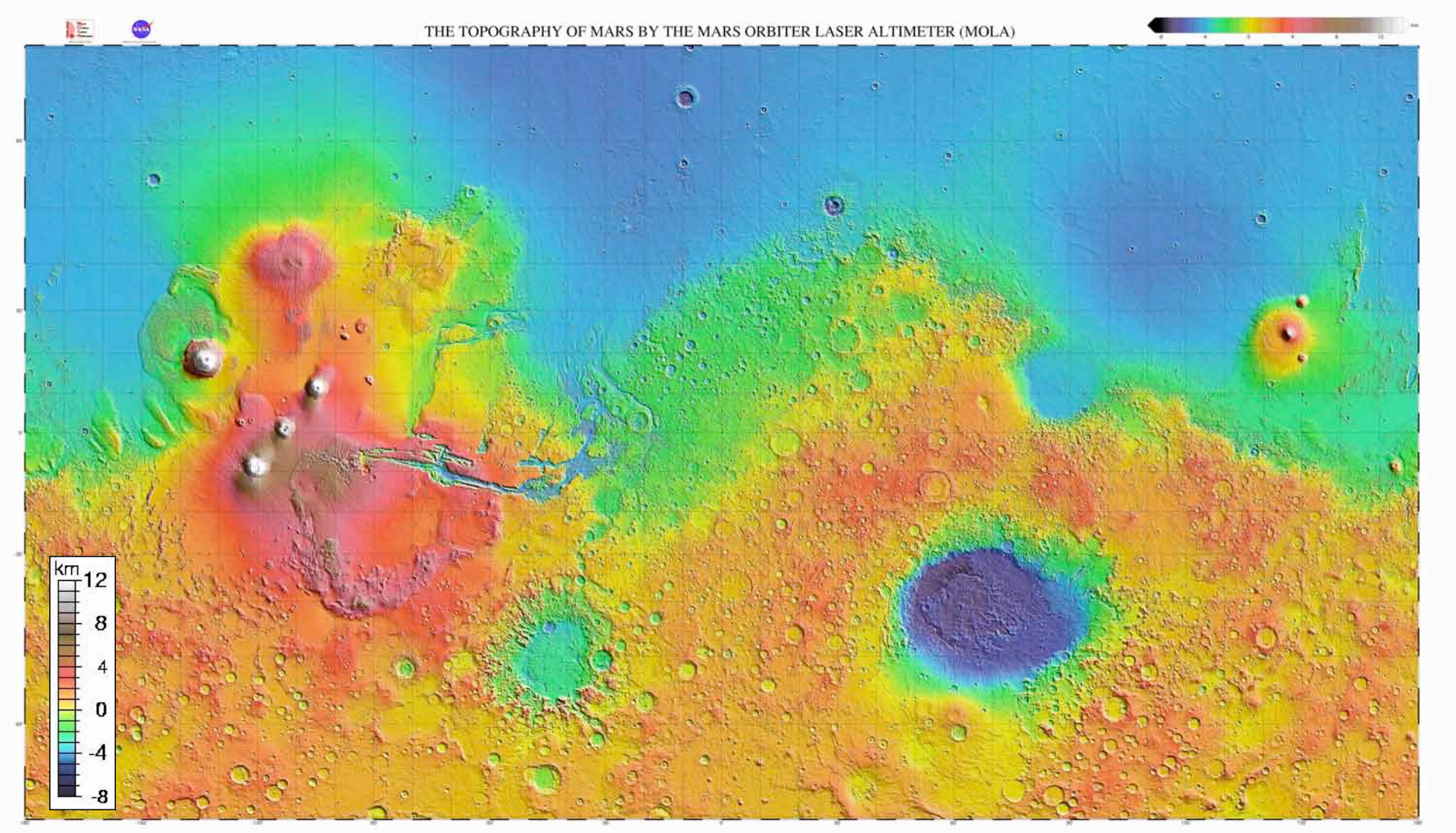
Sedimentary redox conditions

Mineralogy

Lithification

Subsequent alteration / destruction

Mars Global Surveyor MOLA Topography



Martian attributes relevant to perservation

Noachian: Active tectonics, magnetic field, near-surface water was relatively abundant and persistent
(also a northern lowlands large water body?)

Lower elevations and deeper subsurface environments enchance persistence of aqueous conditions
(thus favor habitable environments, sediment lithification)

Phyllosilicate deposits in reducing environments enhance organic abundances and preservation

Implications for relative preservation potential of the four “finalist” MSL sites

End

Preservation of Evidence about Ancient Mars

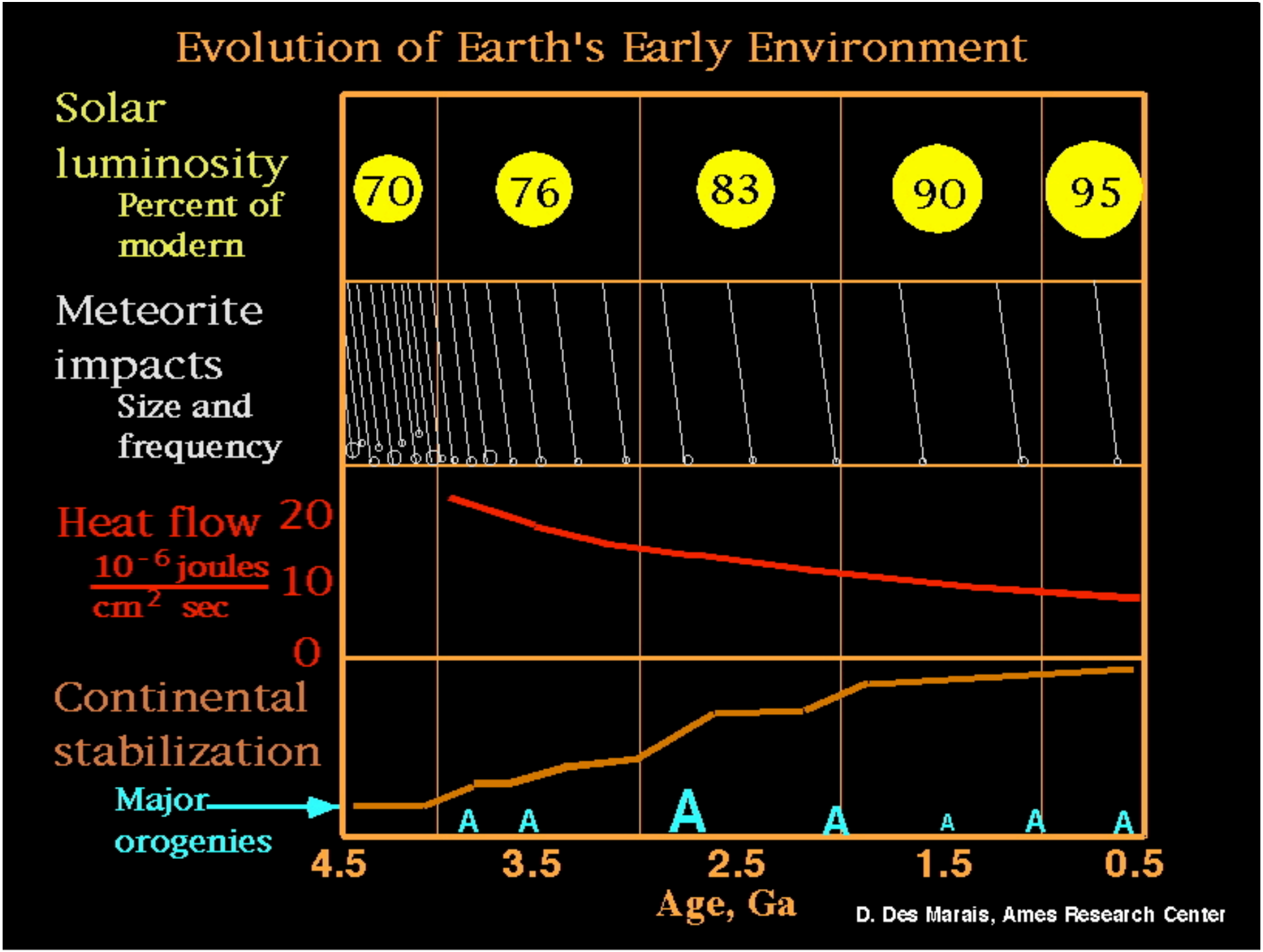
Noachian-Hesperian environments and processes

Persistence of ancient aqueous environments

Noachian deposits in aqueous environments

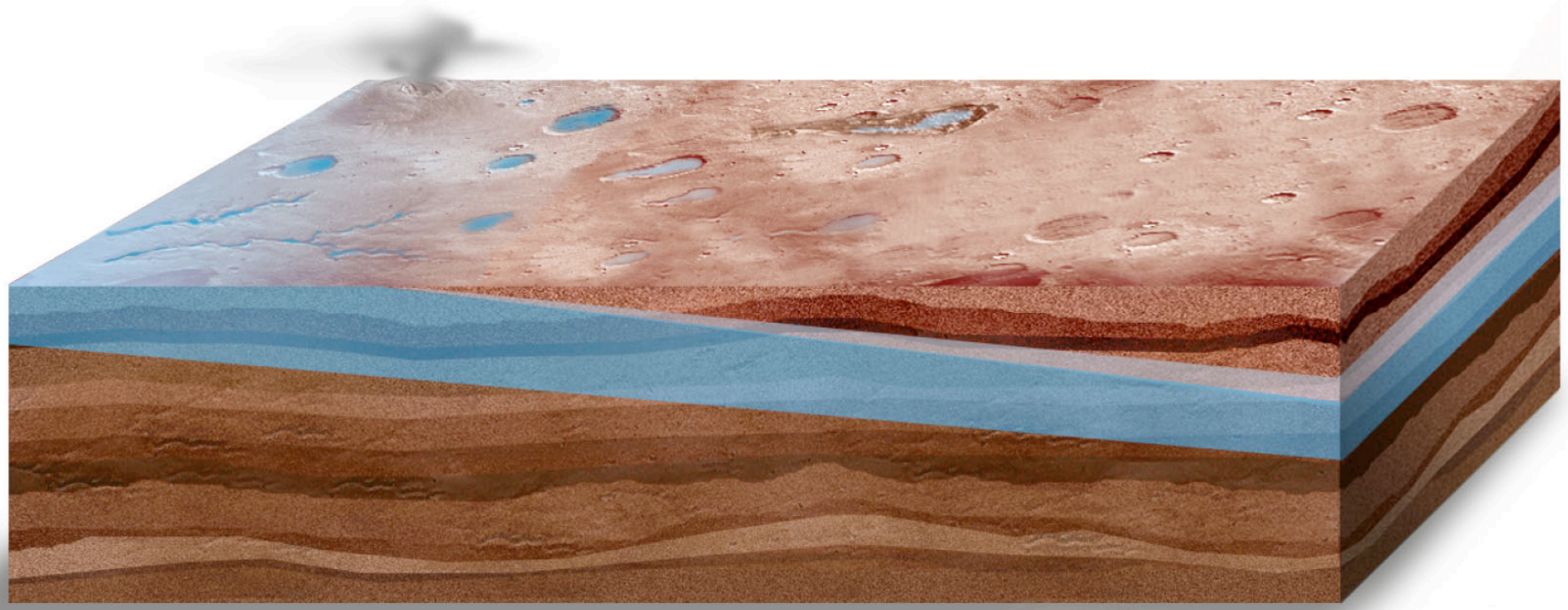
Phyllosilicate-rich deposits and organic matter contents

Preservation potential of the four “finalist” MSL sites


Evolution of Earth's Early Environment
Solar luminosity
Percent of modern
70
76
83
90
95
Meteorite impacts
Size and frequency
Heat flow
$\frac{10^{-6}\,\text{joules}}{\text{cm}^2\ \text{sec}}$
20
10
0
Continental stabilization
Major orogenies
A
A
A
A
A
A
A
4.5
3.5
2.5
1.5
0.5
Age, Ga
D. Des Marais, Ames Research Center

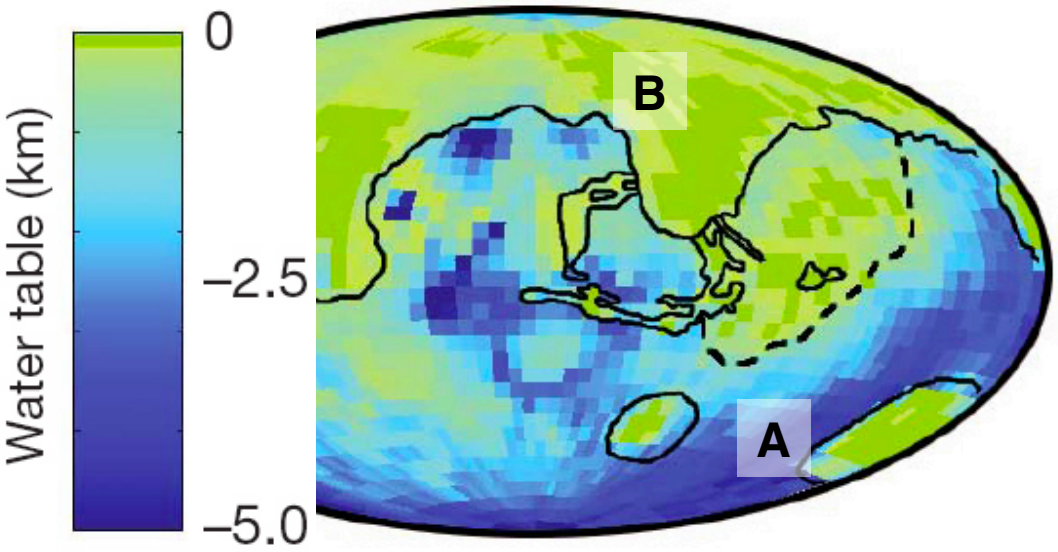
Conditions That Could Sustain Life on Mars: Changes Over the Eons

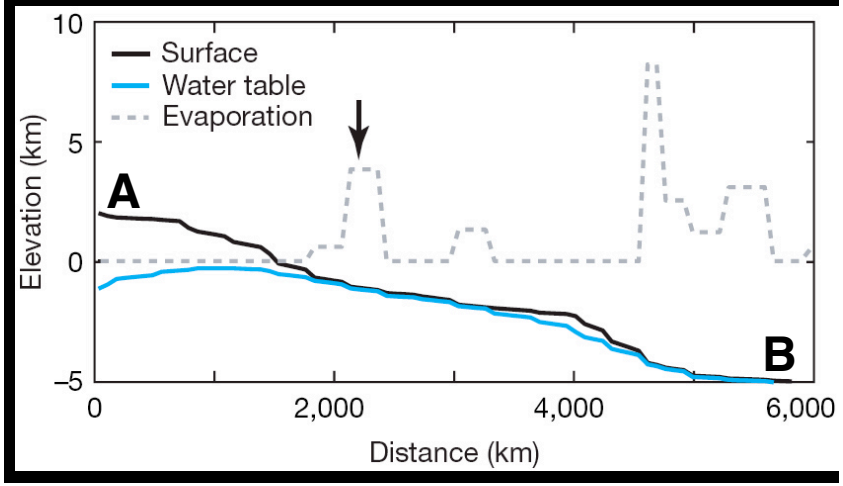
Importance of Age

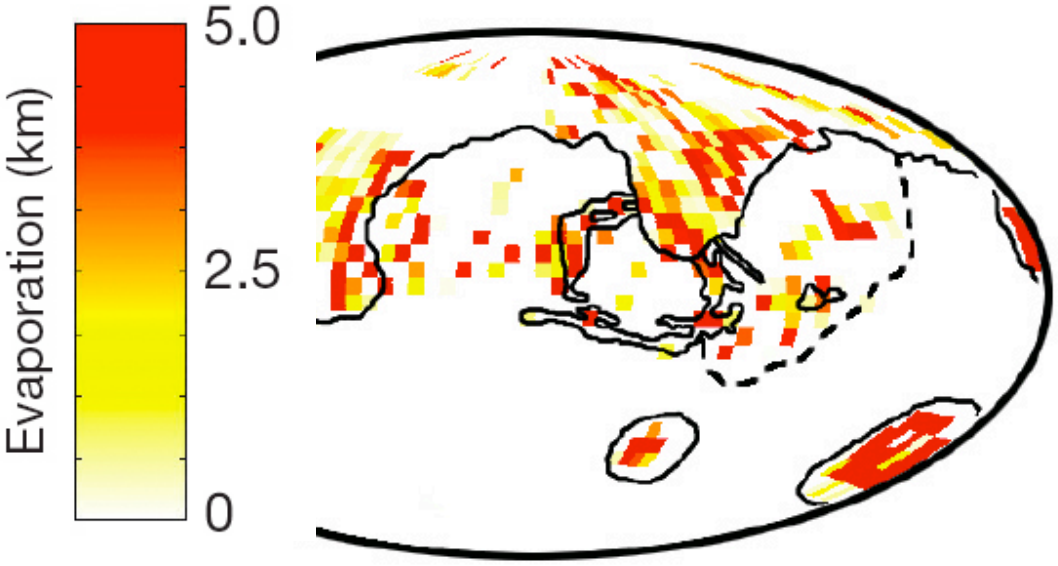


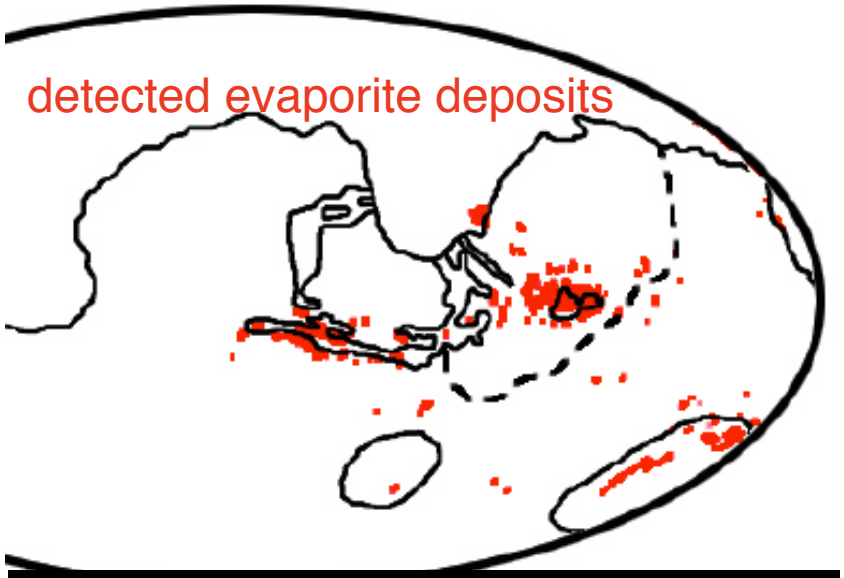
Meridiani Planum and the Global Hydrology of Mars *

Importance of Elevation



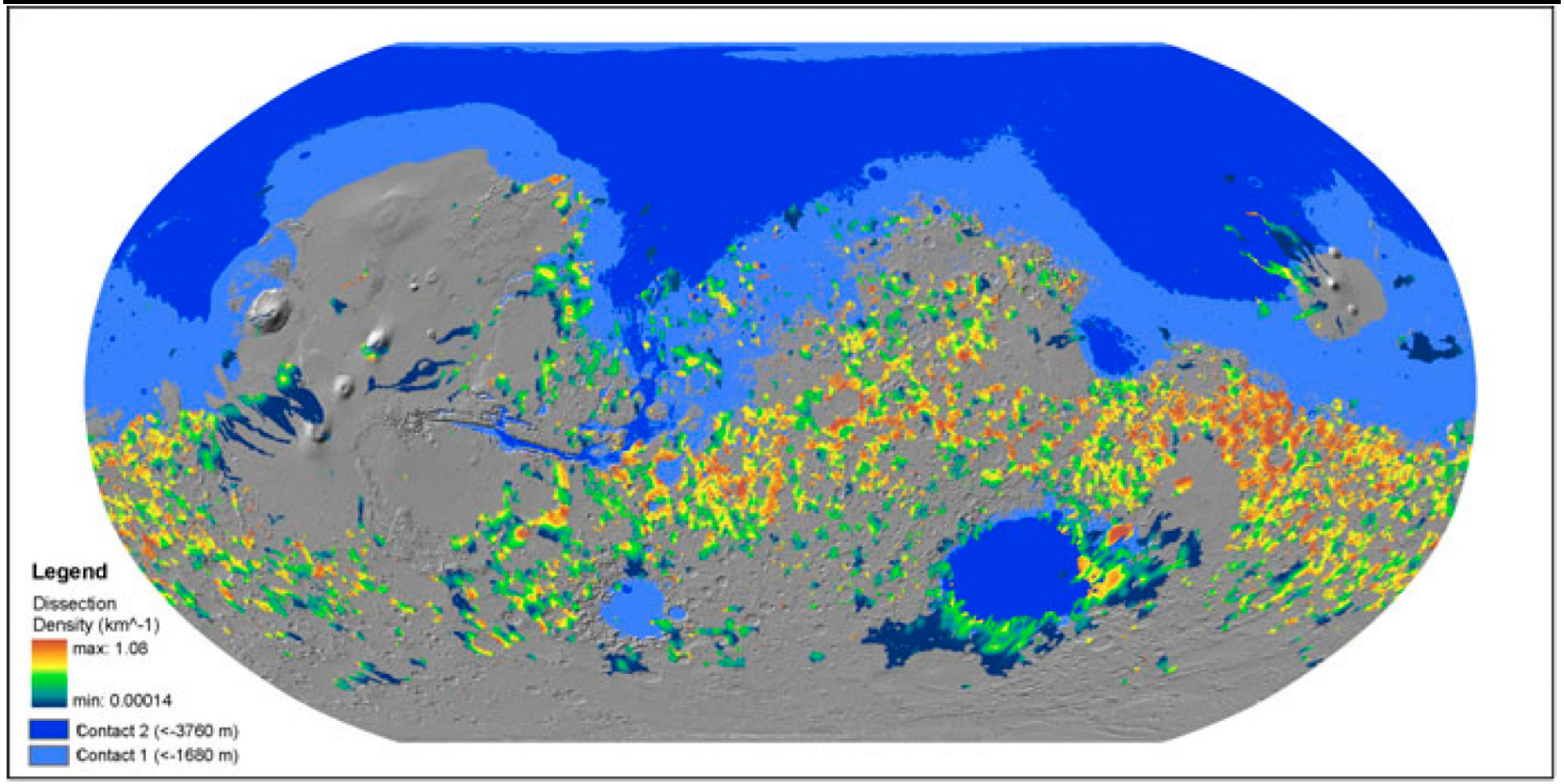






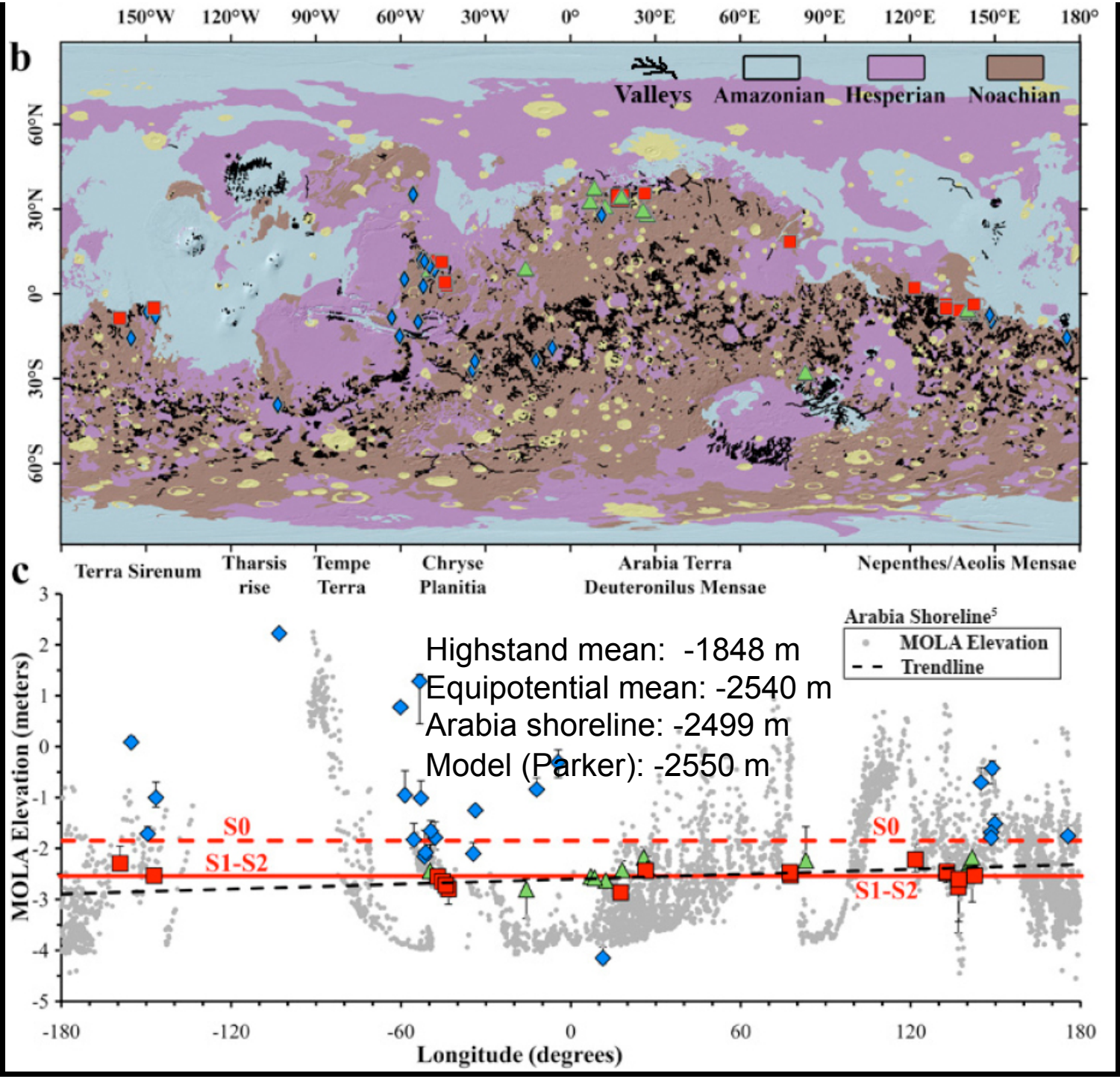
** Andrews-Hanna et al. (2007)*

Stream Systems

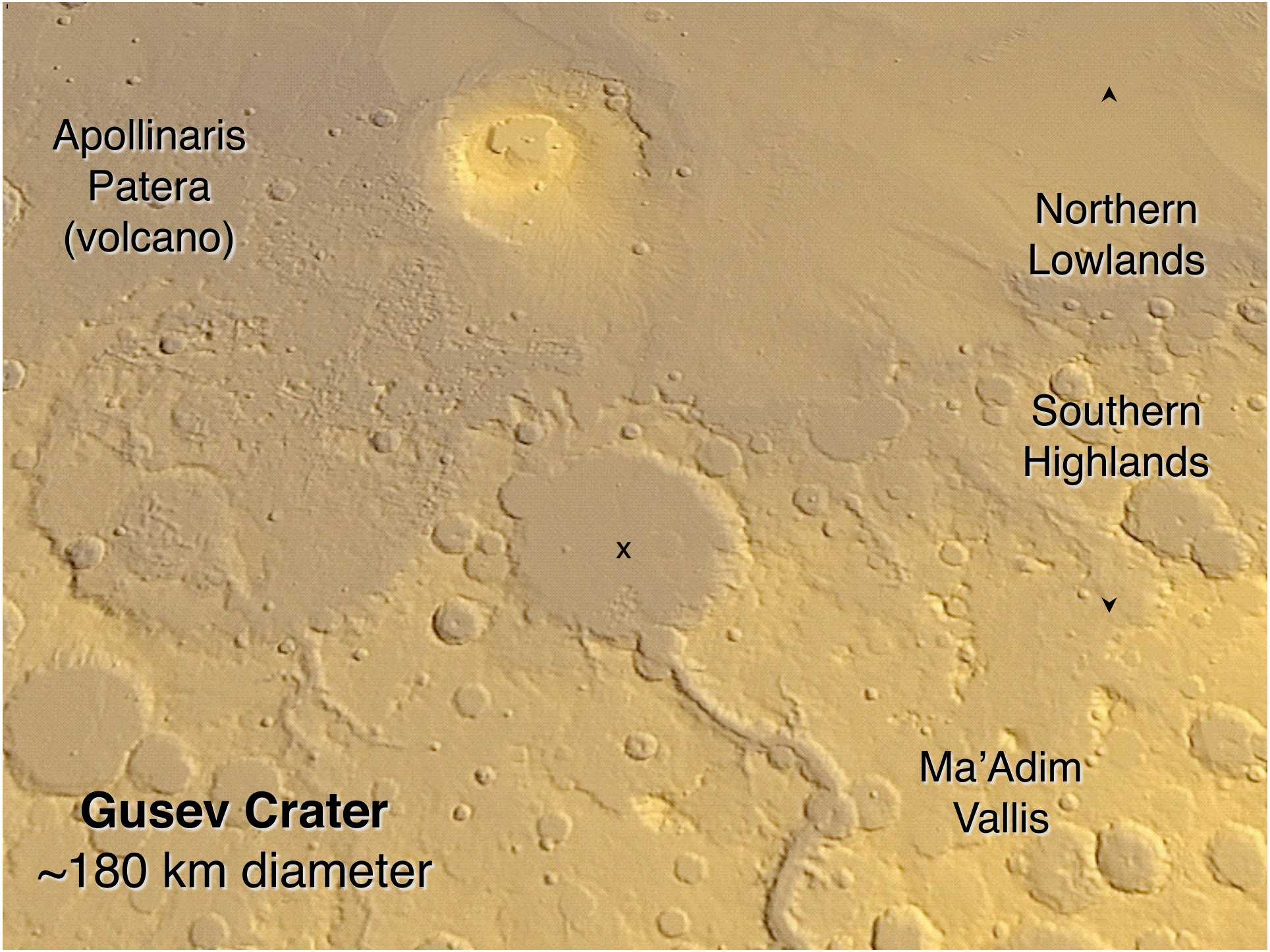


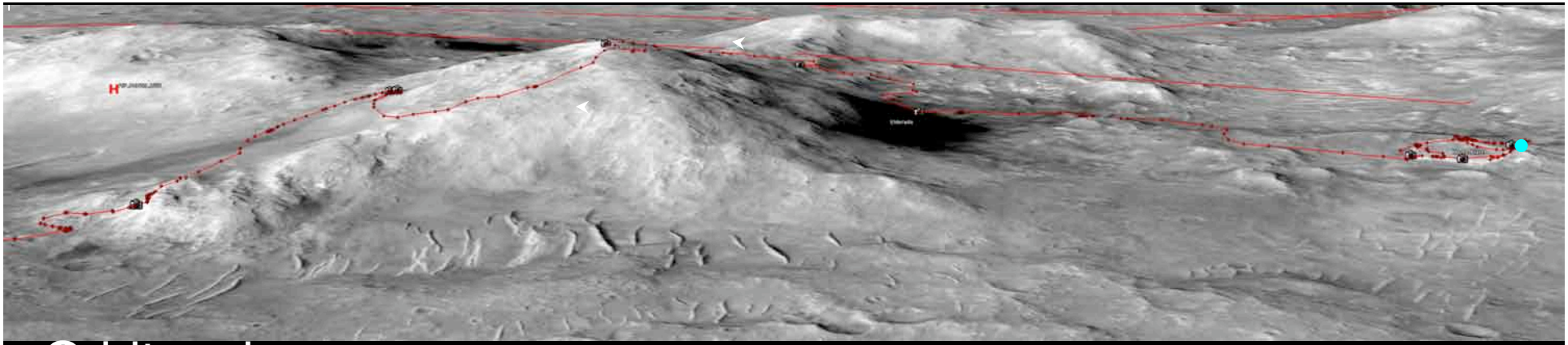
Stepinski & Luo, LPSC41, 2010

Deltas



Di Achille & Hynek, LPSC41, 2010


Apollinaris
Patera
(volcano)
Northern
Lowlands
Southern
Highlands
x
Ma'Adim
Vallis
Gusev Crater
~180 km diameter



Orbiter view

(MRO HiRISE)

Husband Hill and Inner Basin

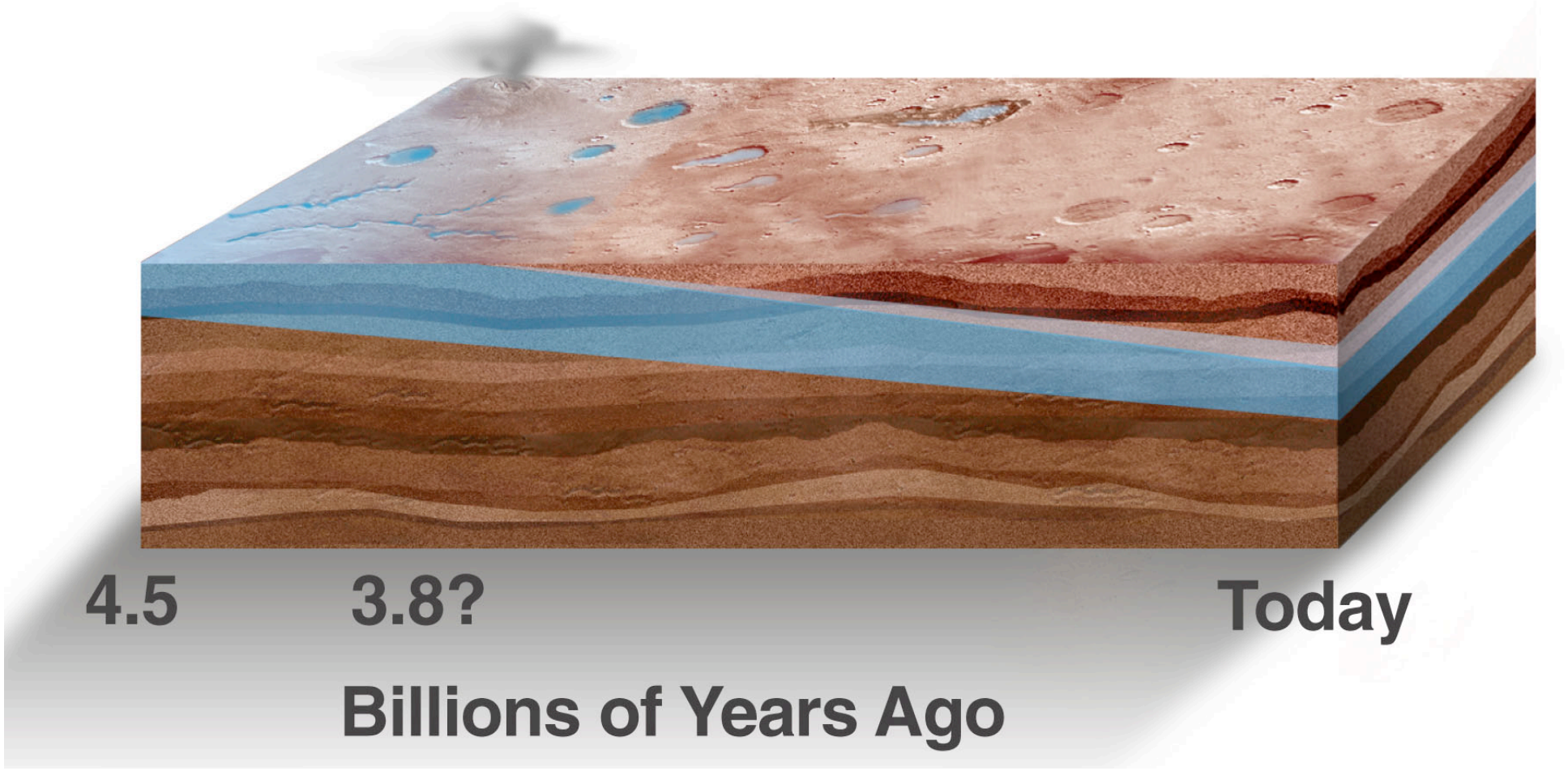
ground view

(MER Pancam)

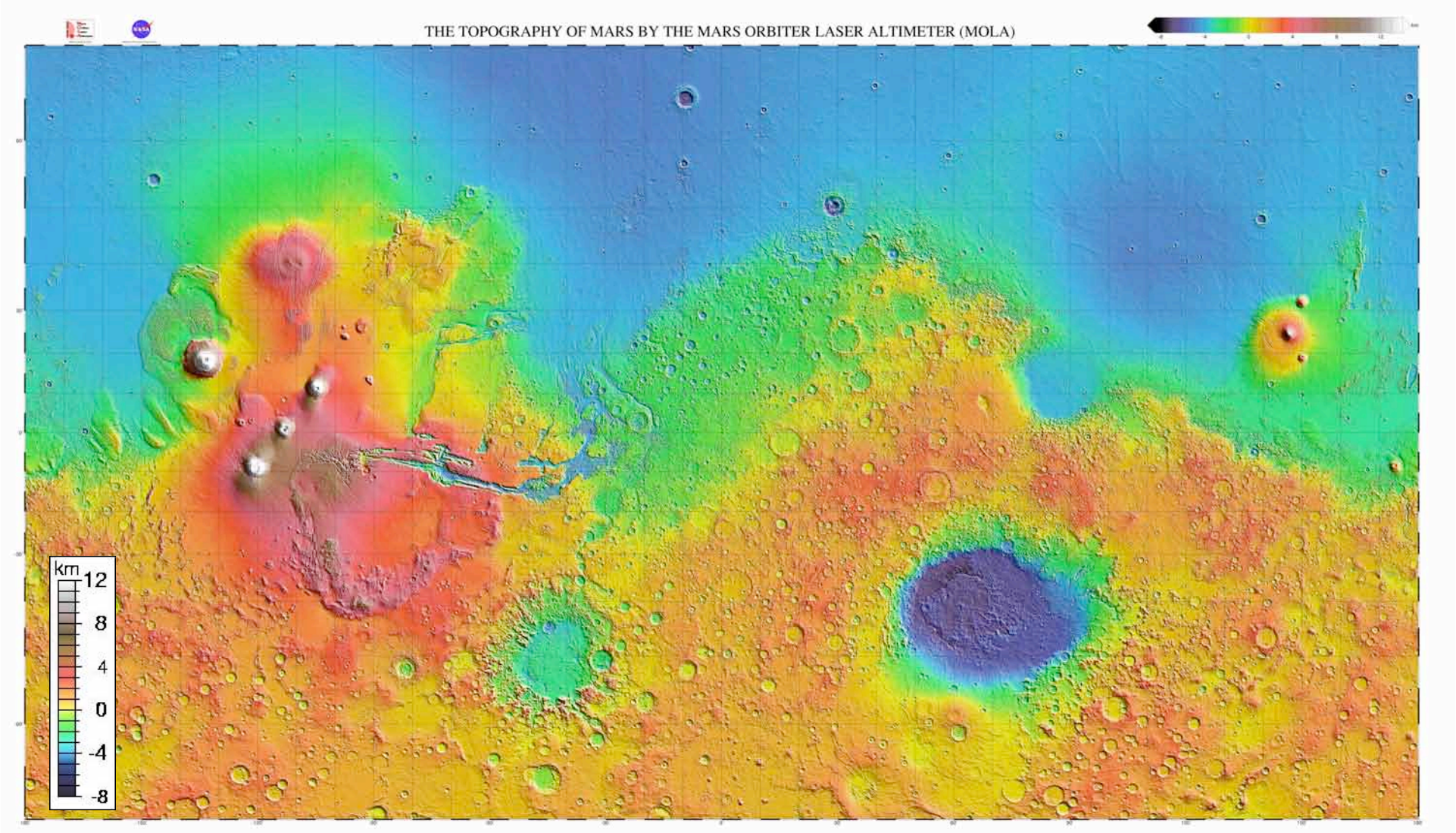
Vesicular basalts: water-rich magma
Explosive volcanism: volatile-rich
Bomb sag: bomb impacting wet sediment
Ferric sulfate-rich deposits: hydrothermal/fumarolic/acidic
Pure silica: sinter/acid leaching
Carbonate rich bedrock

Conditions That Could Sustain Life on Mars: Changes Over the Eons

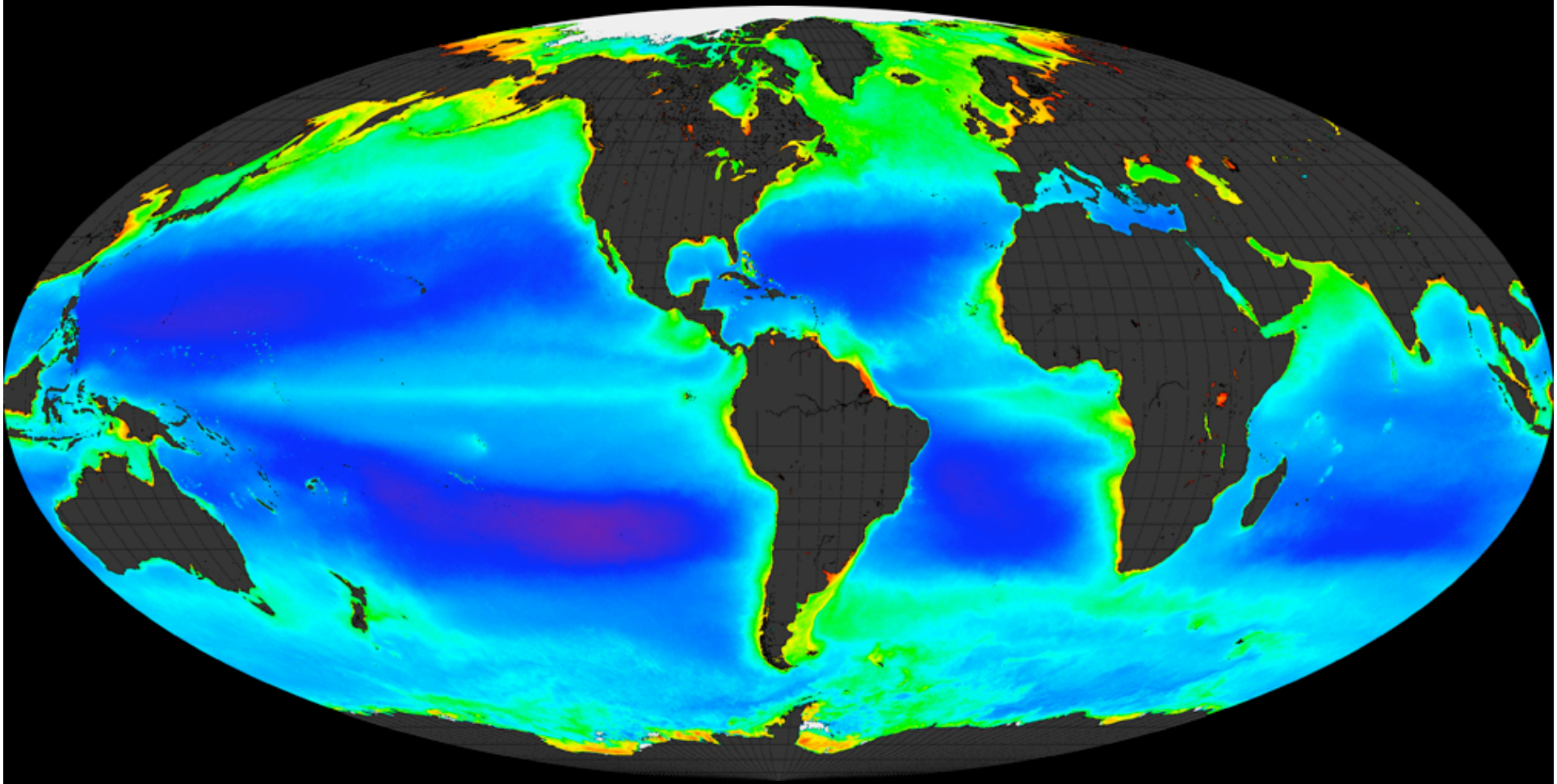
Importance of Age and Depth in Crust



Mars Global Surveyor MOLA Topography



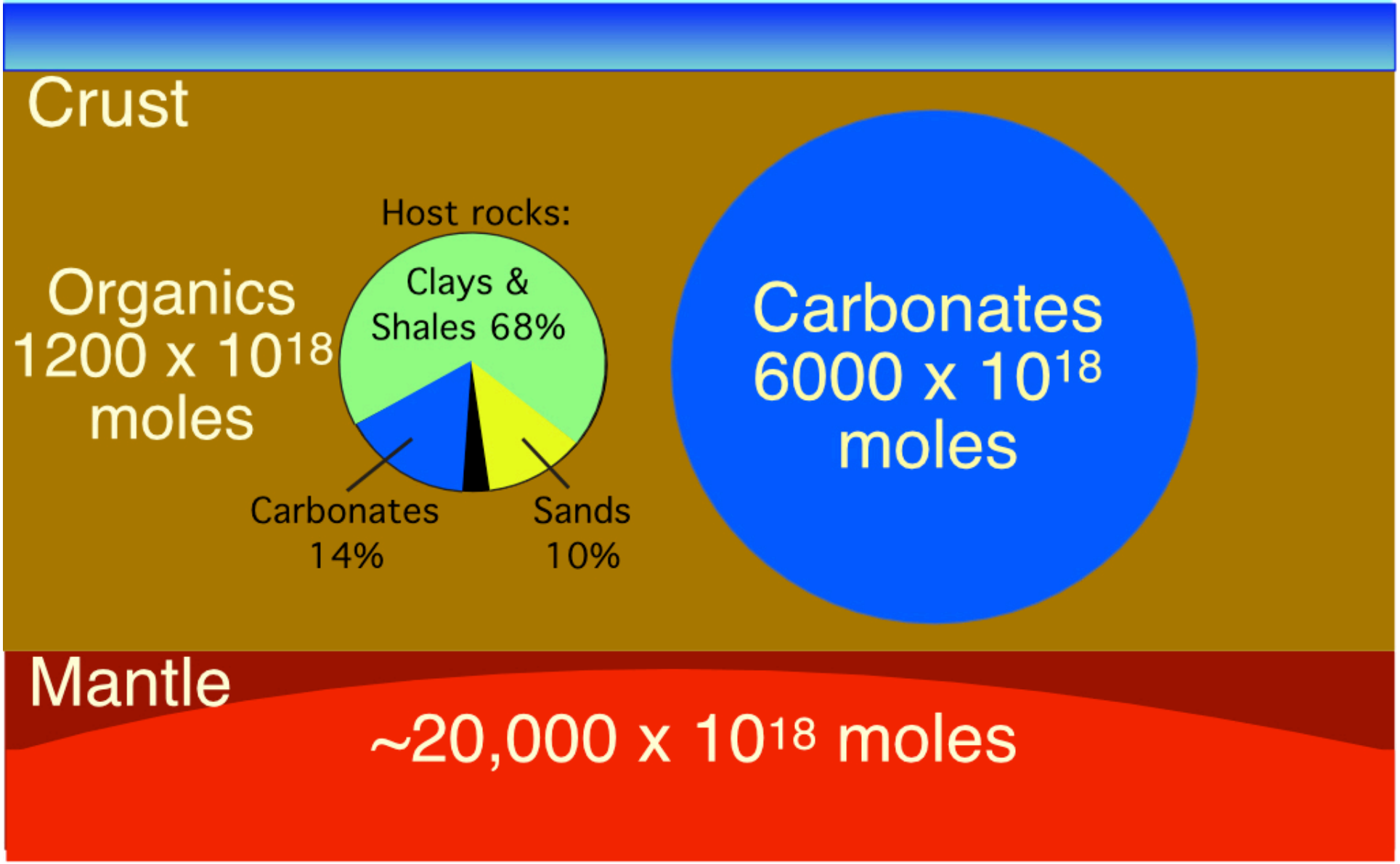
Marine Chlorophyll Abundances (Low Moderate High)



Earth's Carbon Budget

Biosphere, Oceans and Atmosphere

- 3.7×10^{18} moles



Late Proterozoic Shale	TOC, mg/g		
Wyman	0.9	to	2.3
Chapel Is.	<0.02	to	0.45
Cijara	1.2		
Fuentes	0.8		
Klatyspyt	207		
Pusa	1.6		
Timperley	0.3		
Sheepbed	1.4	to	10
Luoquan	0.3	to	3.9
Twitya	0.1	to	2.4
Tapley Hill	2.6		
Woocalla	2.6		
River Wakefield	0.3		
Visingso	0.4	to	2.0
Little Dal	0.4	to	6.9
Sayunei	<0.02	to	0.06
Chuar	0.2	to	29.6
Red Pine	2.2		
Kuktur	7.9		

Key Factors:

Paleo-productivity

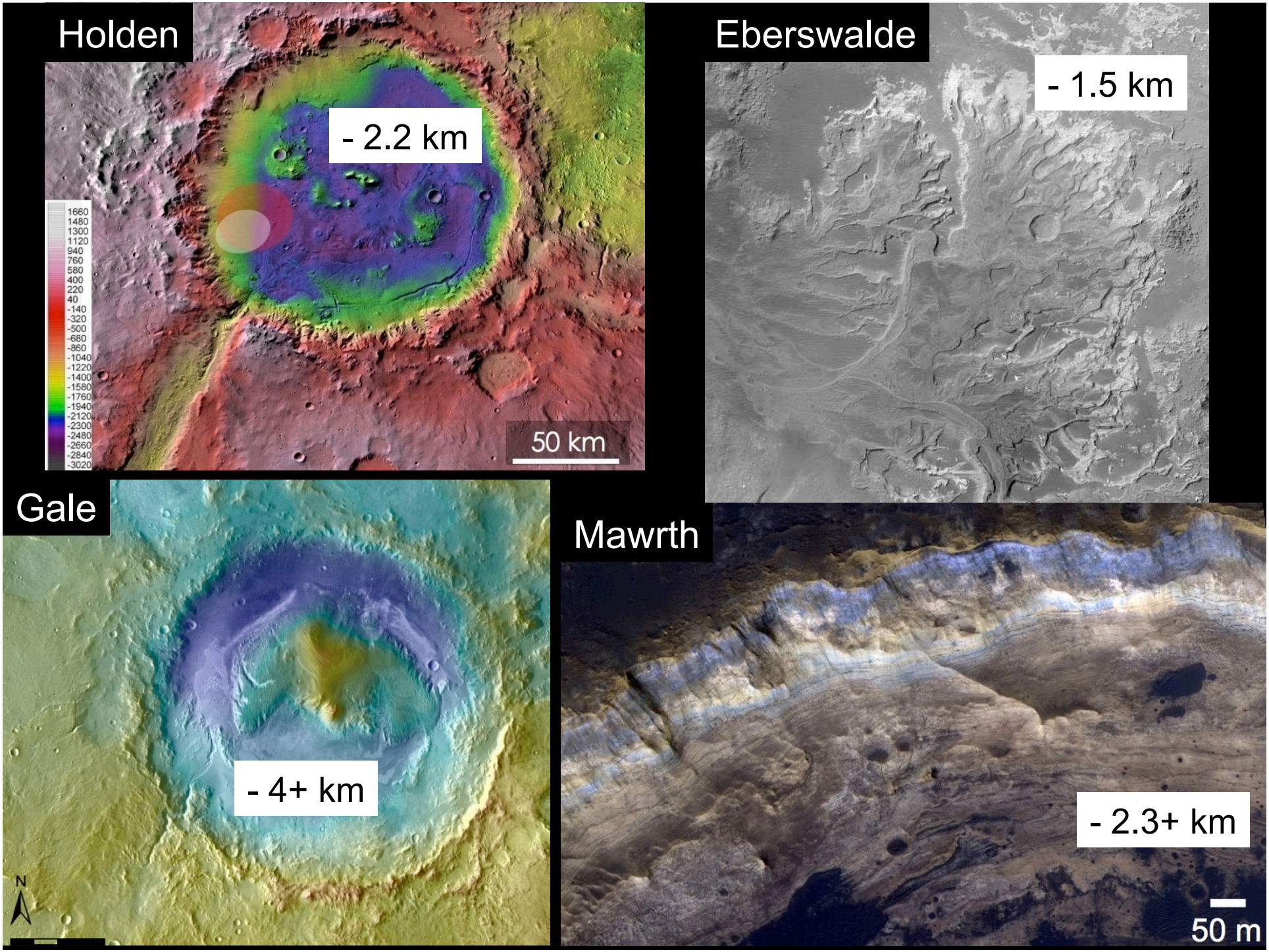
Transport & burial

Sedimentary redox

Mineralogy

Lithification

Later alteration


Holden
- 2.2 km
1660
1480
1300
1120
940
760
580
400
220
40
-140
-320
-500
-680
-860
-1040
-1220
-1400
-1580
-1760
-1940
-2120
-2300
-2480
-2660
-2840
-3020
50 km
Eberswalde
- 1.5 km
Gale
- 4+ km
N
Mawrth
- 2.3+ km
50 m

Preservation of Evidence about Ancient Mars

Noachian-Hesperian environments and processes

Persistence of ancient aqueous environments

Noachian deposits in aqueous environments

Phyllosilicate-rich deposits and organic matter contents

Preservation potential of the four “finalist” MSL sites

- Age of deposits: mid-Noachian to early Hesperian
- Water persistence: effects of elevation and geologic age
- Allochthonous vs autochthonous phyllosilicates (Kennedy work, redox state, nature of organics [e.g., plant lignin can survive transport; can microbial components?])
- Redox state of deposit
- Lithification: rate and extent