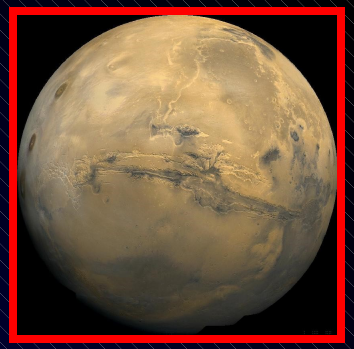
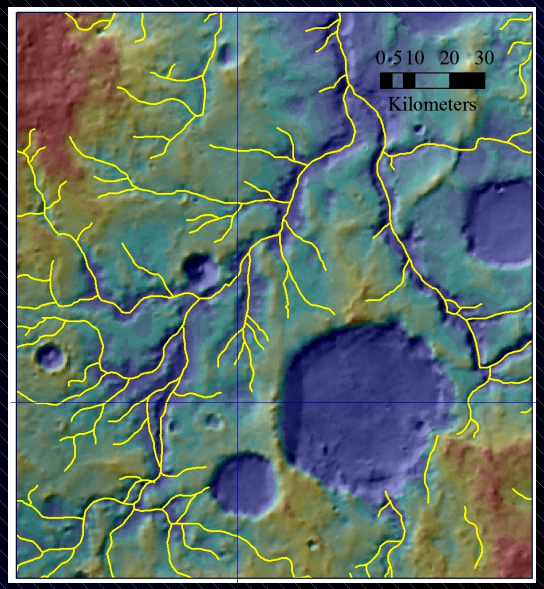
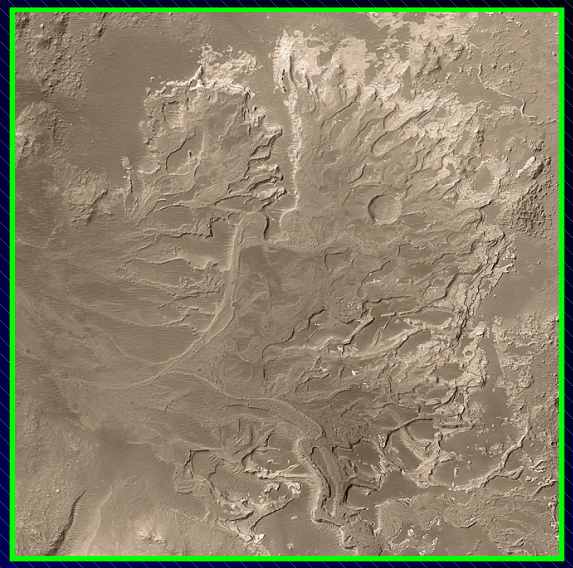
The Latest from Mars: Recent Results and the Next Decade of Exploration







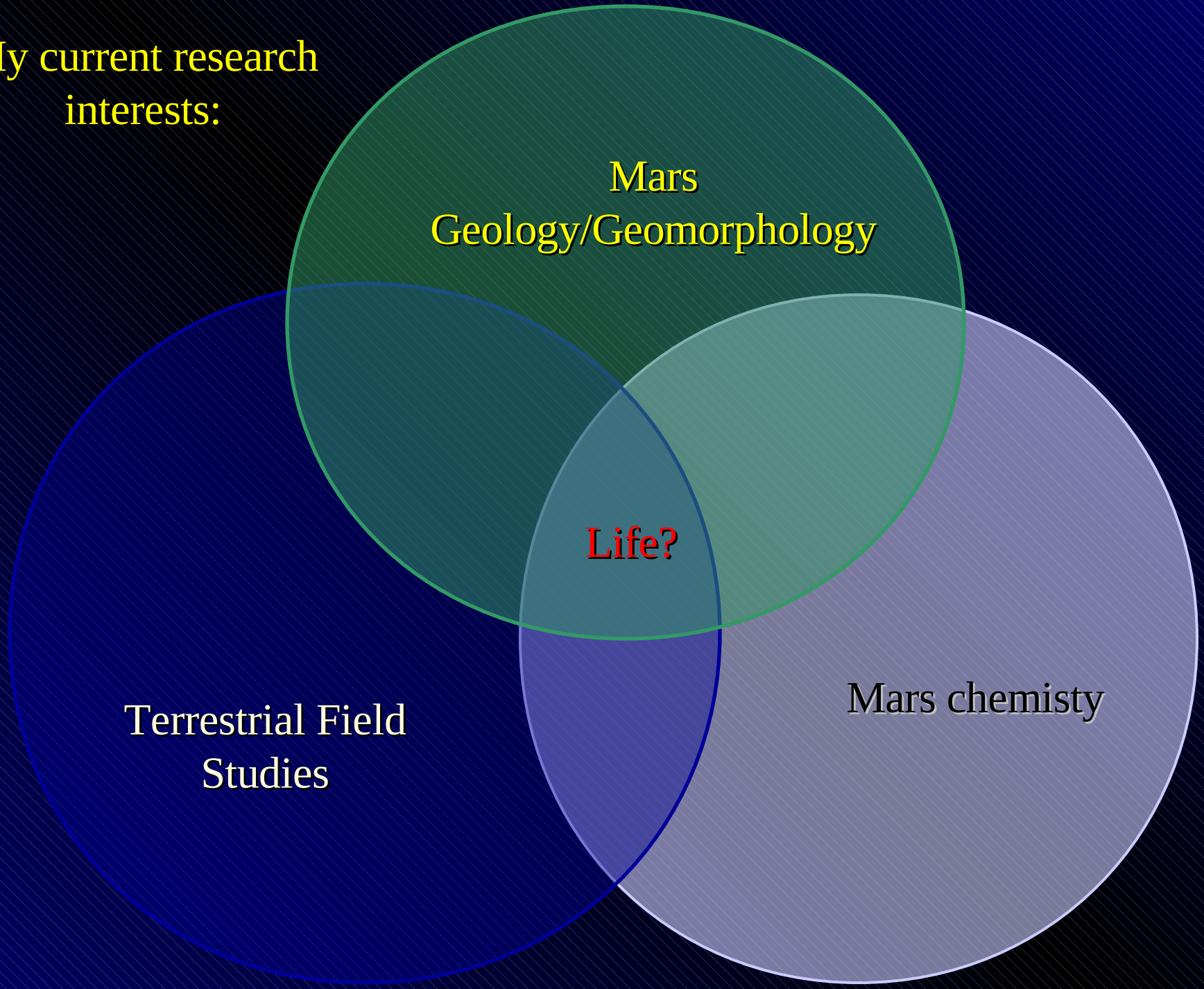
Brian M. Hynek

Laboratory for Atmospheric and Space Physics &
Department of Geological Sciences, University of Colorado

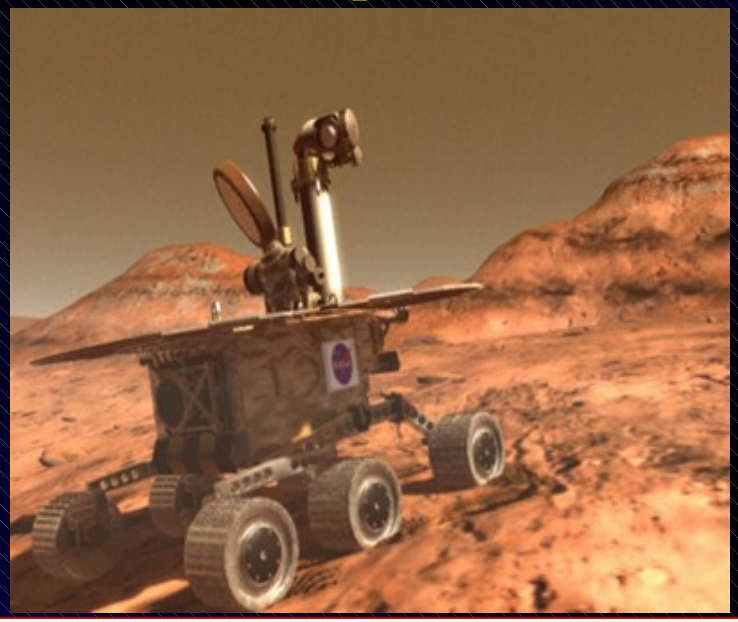
Mars

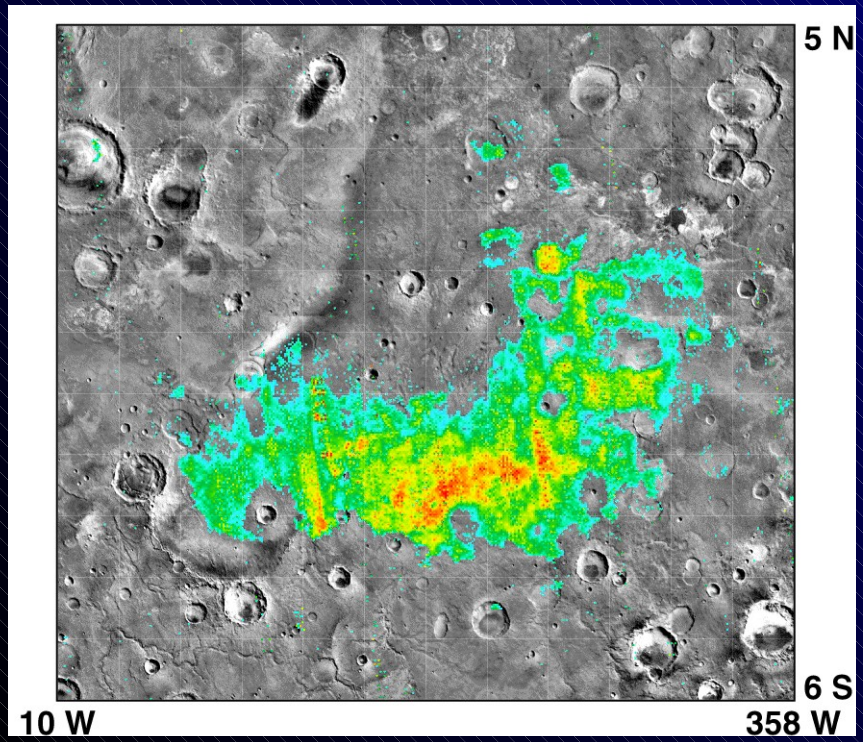
- ½ diameter of Earth
- 1½ times farther from sun
- Thin CO_2 atmosphere
- Average temp = -70°F
- Geologically complex
- Polar ice caps
- Lots of near-surface ice
- Evidence of ancient (and recent) surface water
- 2 tiny asteroid-like moons

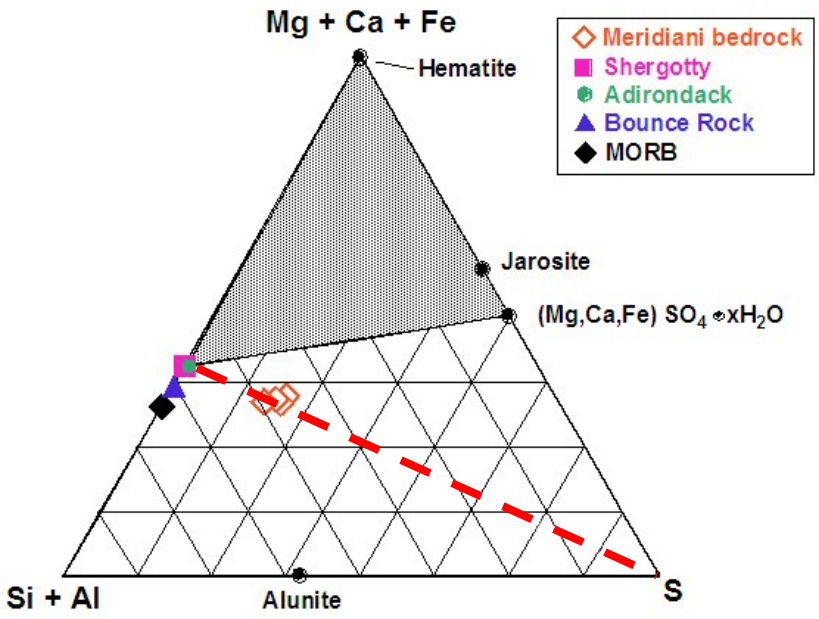
My current research interests:



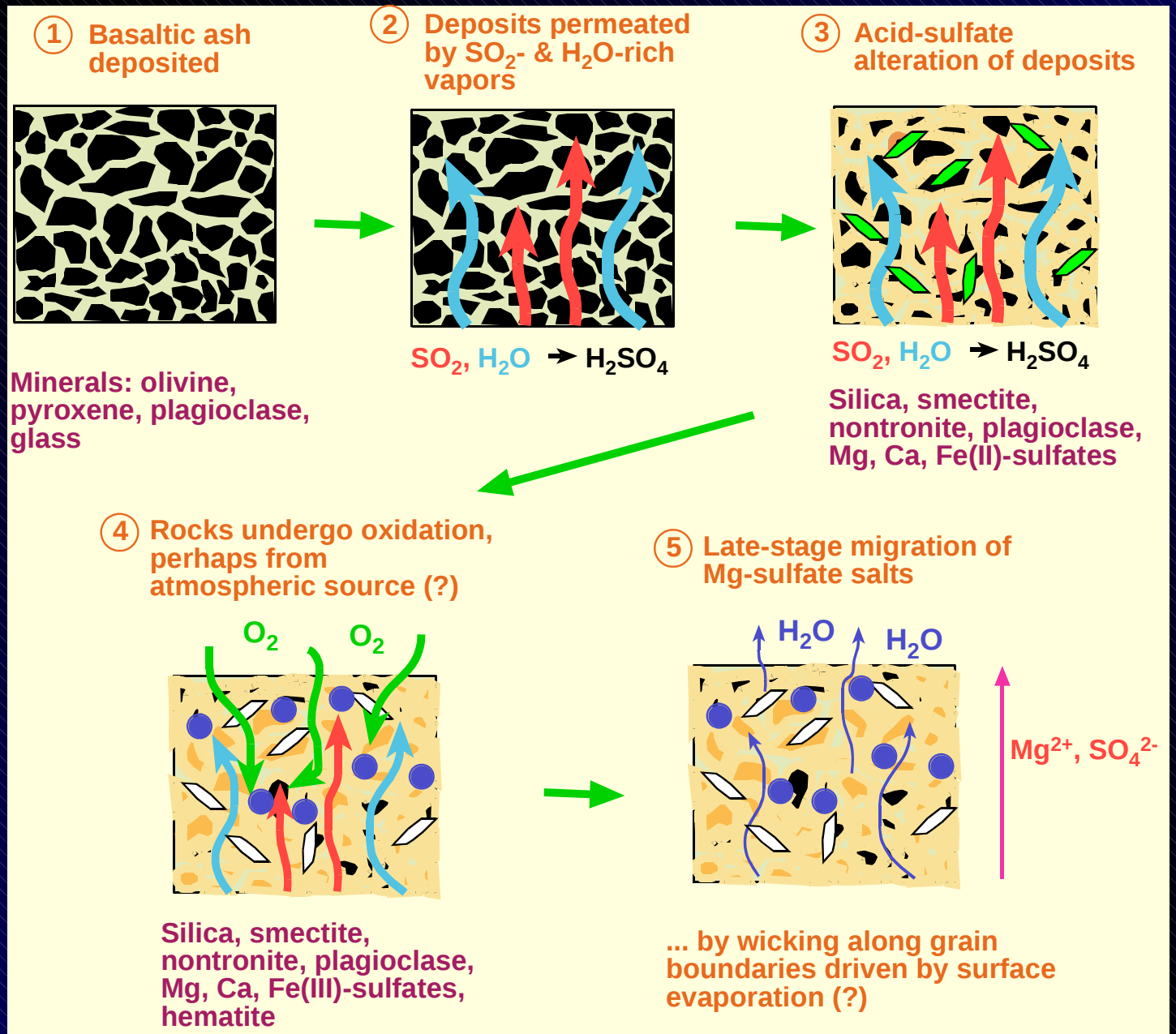
2003 Mars Exploration Rovers







Chemical Weathering Model (McCollom and Hynek, *Nature*, 2005)



Mars Analog: Cerro Negro, Nicaragua

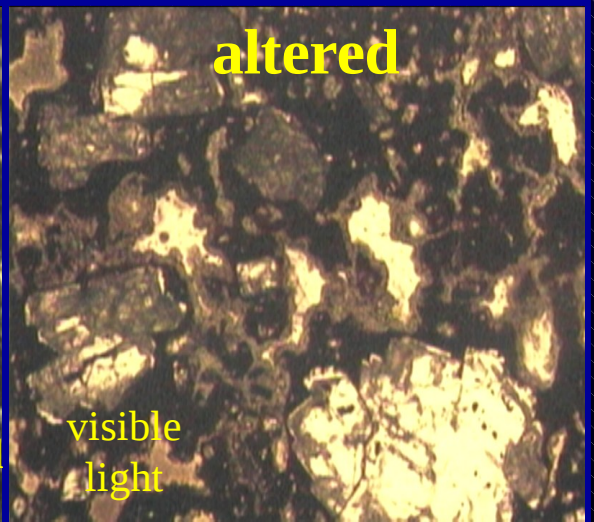
	Typical Cerro Negro alteration products Hynek et al., 2007	Some altered minerals identified and inferred at the MER sites e.g., Squyres and Knoll, 2005; Arvidson et al., 2006; Morris et al., 2006	Typical Theoretical Modeling Results McCollom and Hynek, 2005
SULFATES	Anhydrite ($CaSO_4$) Gypsum ($CaSO_4$ $2H_2O$) Natroalunite ($NaAl_3(OH)_6(SO_4)_2(OH)$)	Ca-, Fe-, Mg-sulfates Jarosite ($FeAl_3(OH)_6(SO_4)_2(OH)$) Fe3D3 (possibly Schwertmannite)	Anhydrite (137 g) Mg-sulfates (270 g) Alunite (107 g)
IRON OXIDES	Bernalite ($Fe_{3+}(OH)_3$)	Hematite (Fe_2O_3) Goethite (α-FeOOH)	
SiO2	Quartz Opal	Amorphous silica (possibly opal)	Quartz (68 g)
PHYLLO-SILICATES	Muscovite Smectites	Silicates Aluminosilicates	Muscovite (74 g) Smectites (593 g)

$$4SO_2 + 4H_2O = 3H_2SO_4 + H_2S$$

$$H_2S + 2O_2 = H_2SO_4$$

energy for life:

$$\Delta G = \Delta G_o + RT \ln Q$$



Today's Focus:

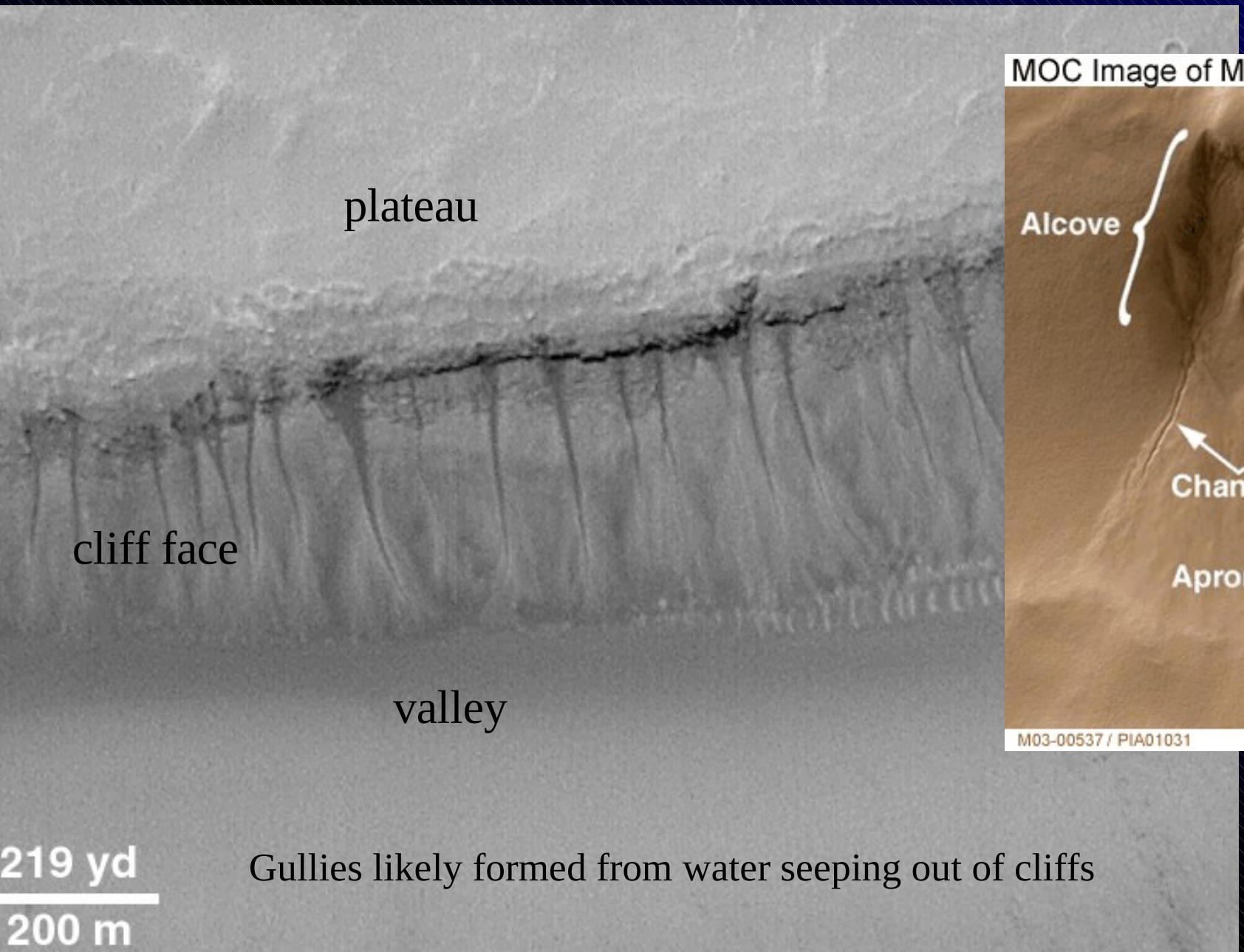
- The climate history of Mars as inferred from the geologic record.

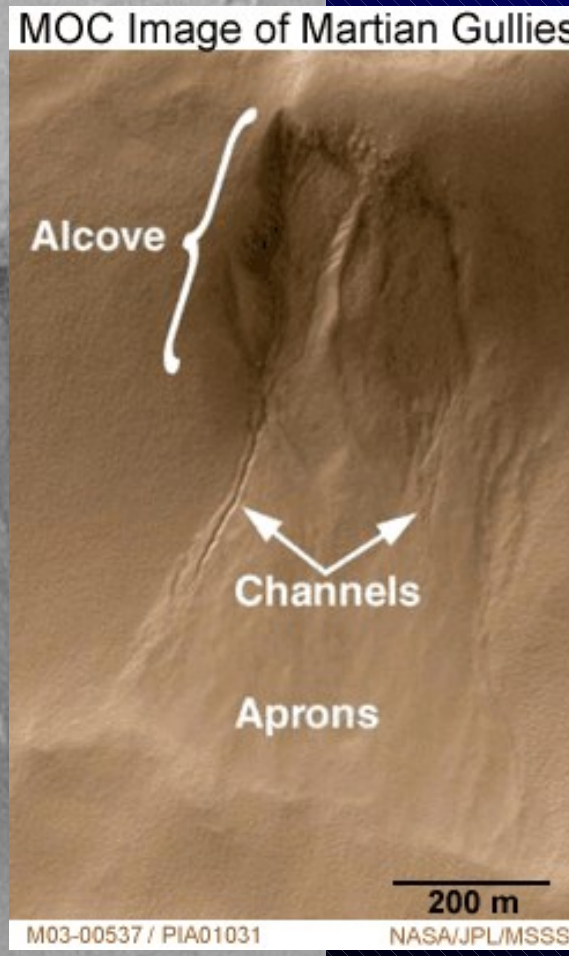
- NASA's next decade of Mars exploration.

Which of these statement is true?

1. Mars presently has glaciers.
2. Mars has permafrost under 1/3 of its surface.
3. We currently are operating 5 spacecraft at Mars
4. Water has flowed across Mars’ surface in the last year.

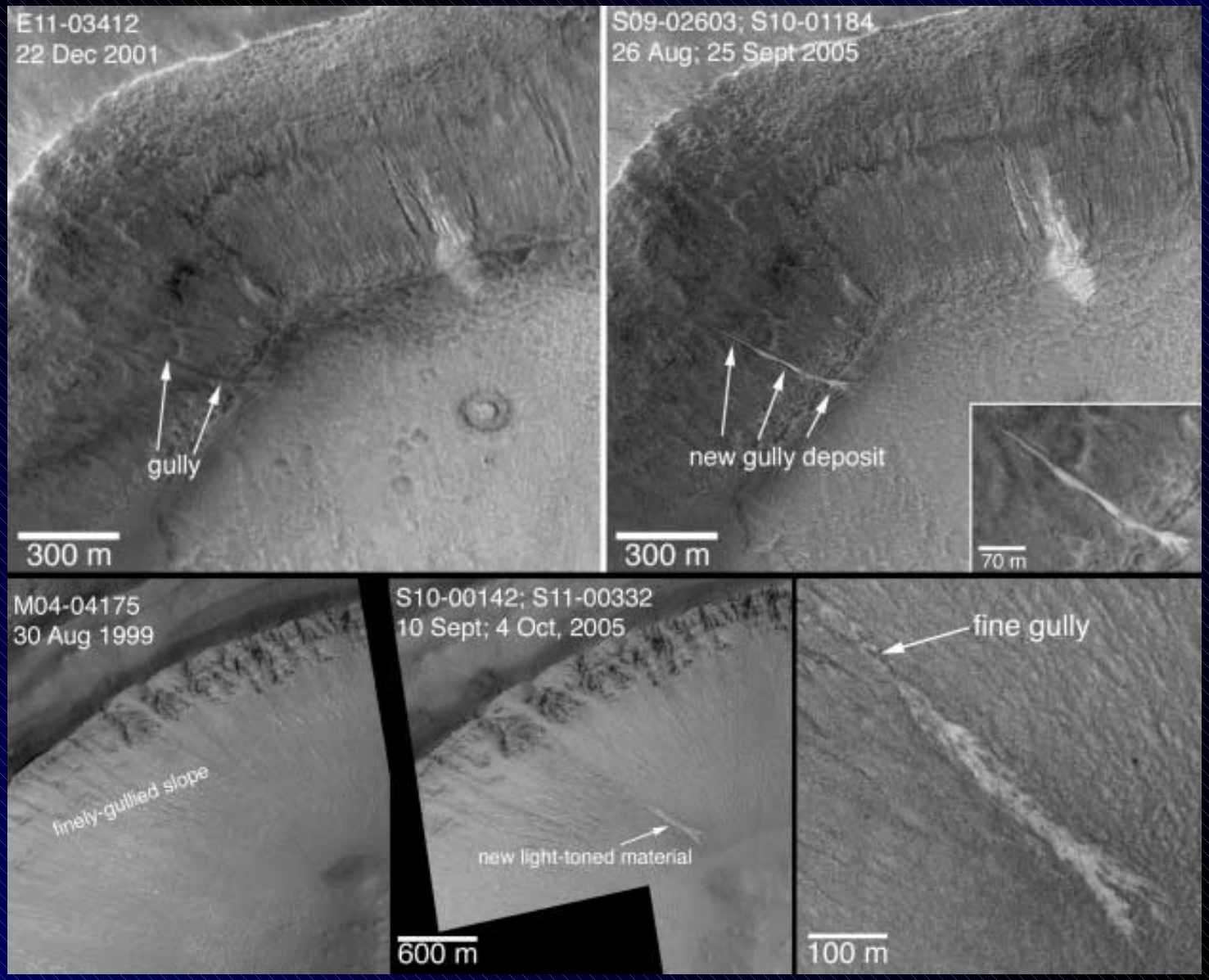
Recent small-scale water on Mars - martian springs





Gullies likely formed from water seeping out of cliffs

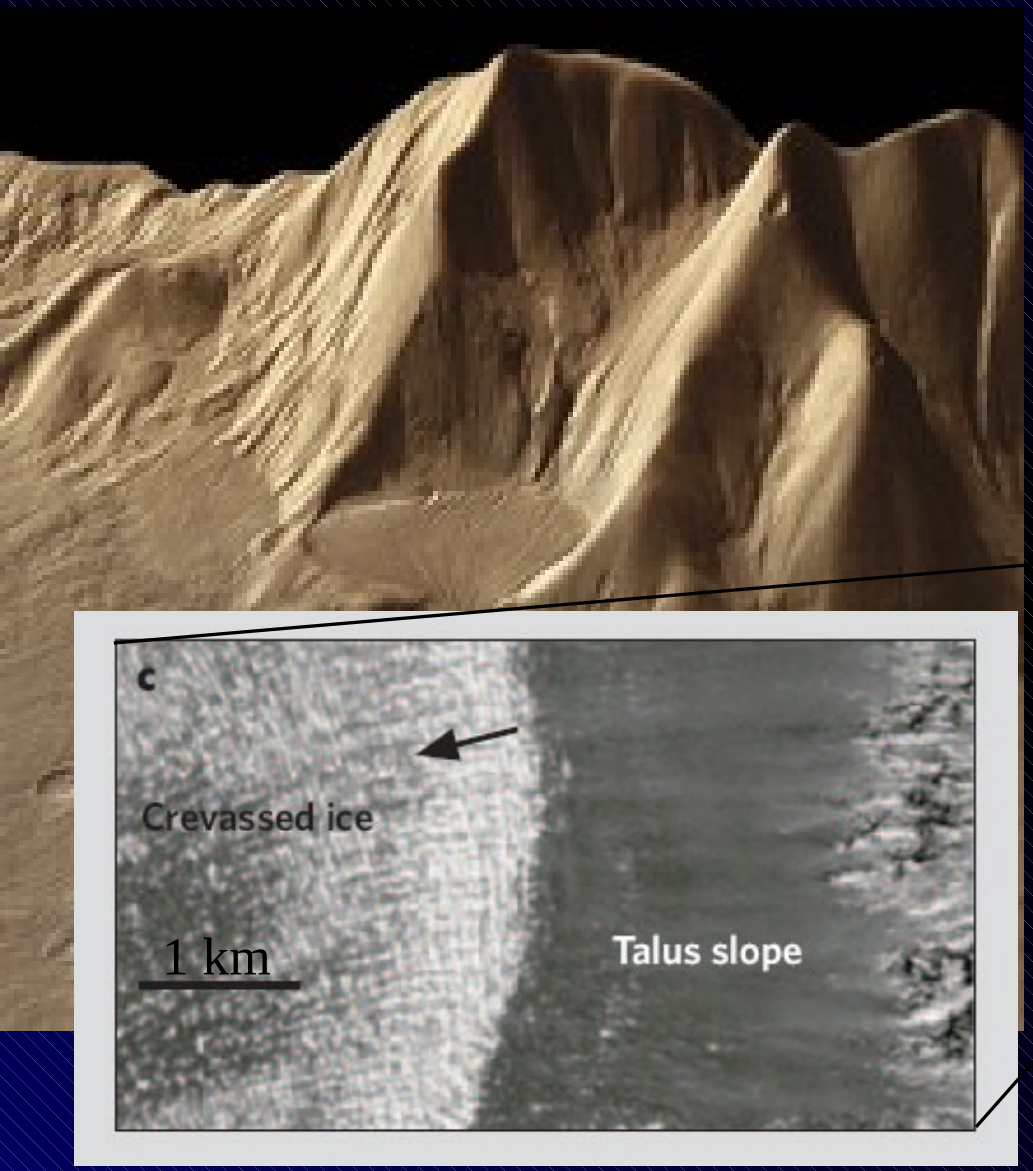
Gullies are forming on Mars today!

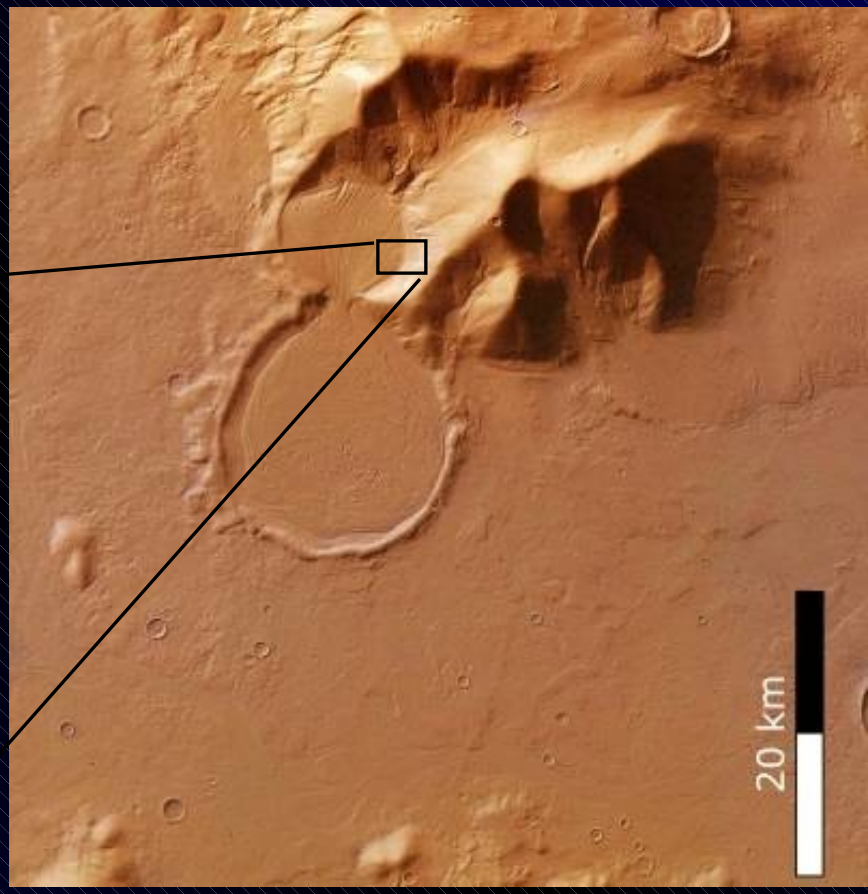


Hard to reconcile with models.

Malin et al., 2006

Evidence for current glaciation

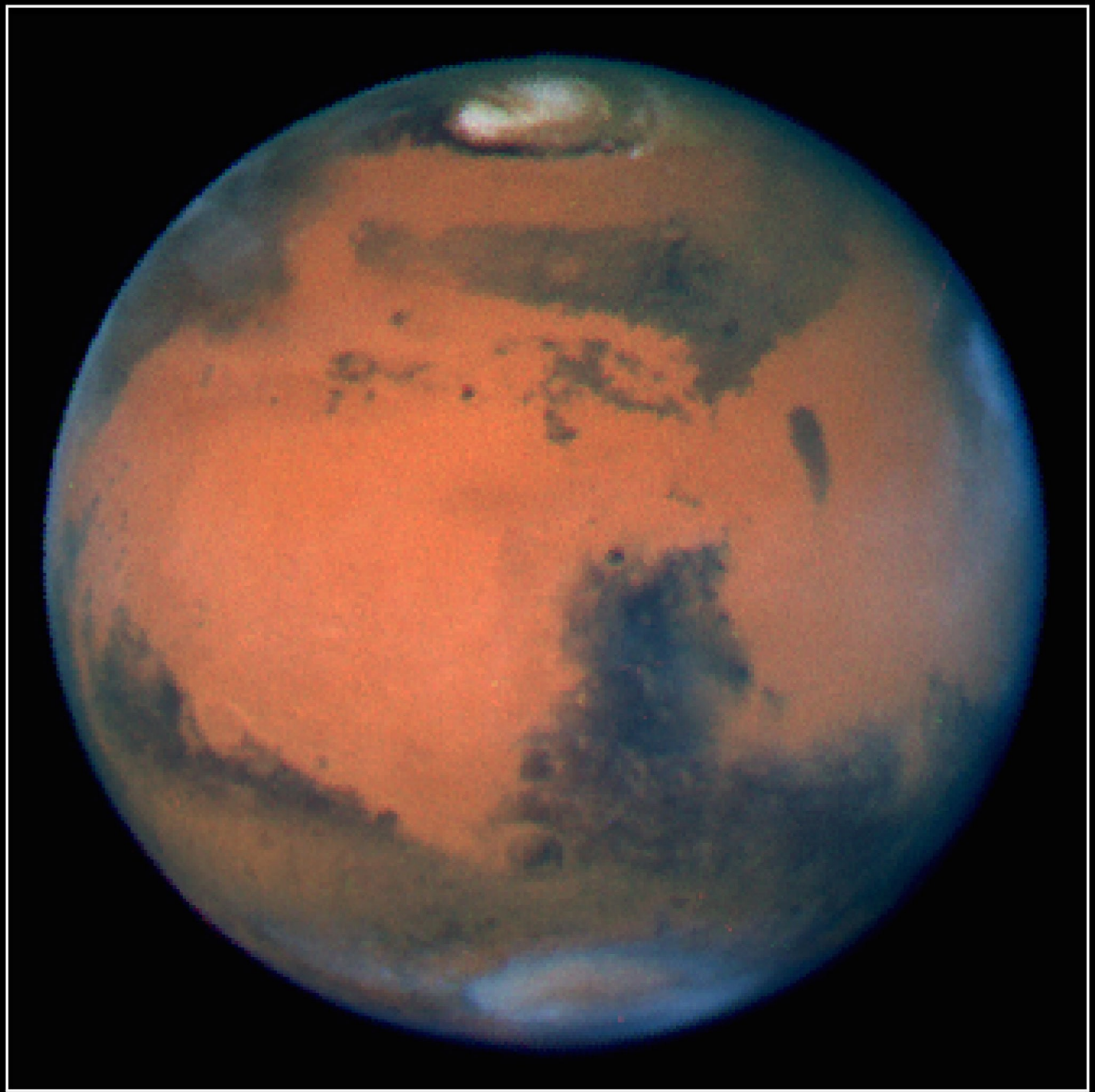




ESA's Mars Express Mission

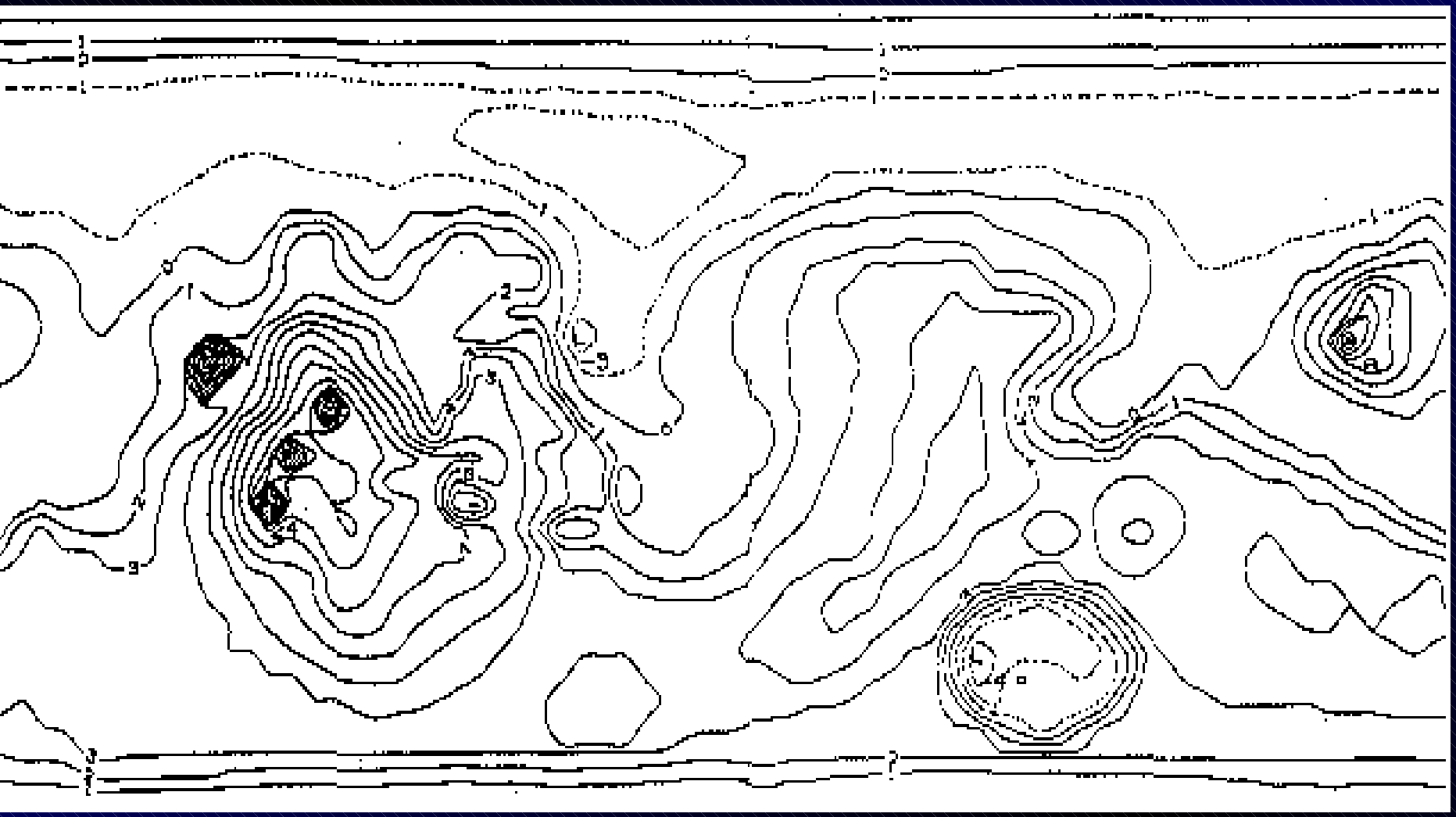
Mars Missions (2nd Golden Age)

- There are currently six spacecraft operating at Mars.
- Mars Global Surveyor – 1997-2007
  - Global imaging, topography, and chemical composition of the surface.
- Mars Odyssey – arrived 2001
  - Discovered huge regions of ground ice and “takes the temperature of Mars”
- Mars Express (ESA) – arrived 2004
  - High-resolution stereo imaging (~20 m), subsurface radar
  - Released a lander (Beagle II), which failed.
- 2 Mars Exploration Rovers – arrived Jan 2004 (ongoing)
  - Chemical/mineralogical spectrometers, imagery.
- Mars Reconnaissance Orbiter – arrived 2006
  - Contains the highest resolution cameras and spectrometers.
- Phoenix – arrived Memorial Day, 2008
  - Sent to study ice-rich soils near the north pole.

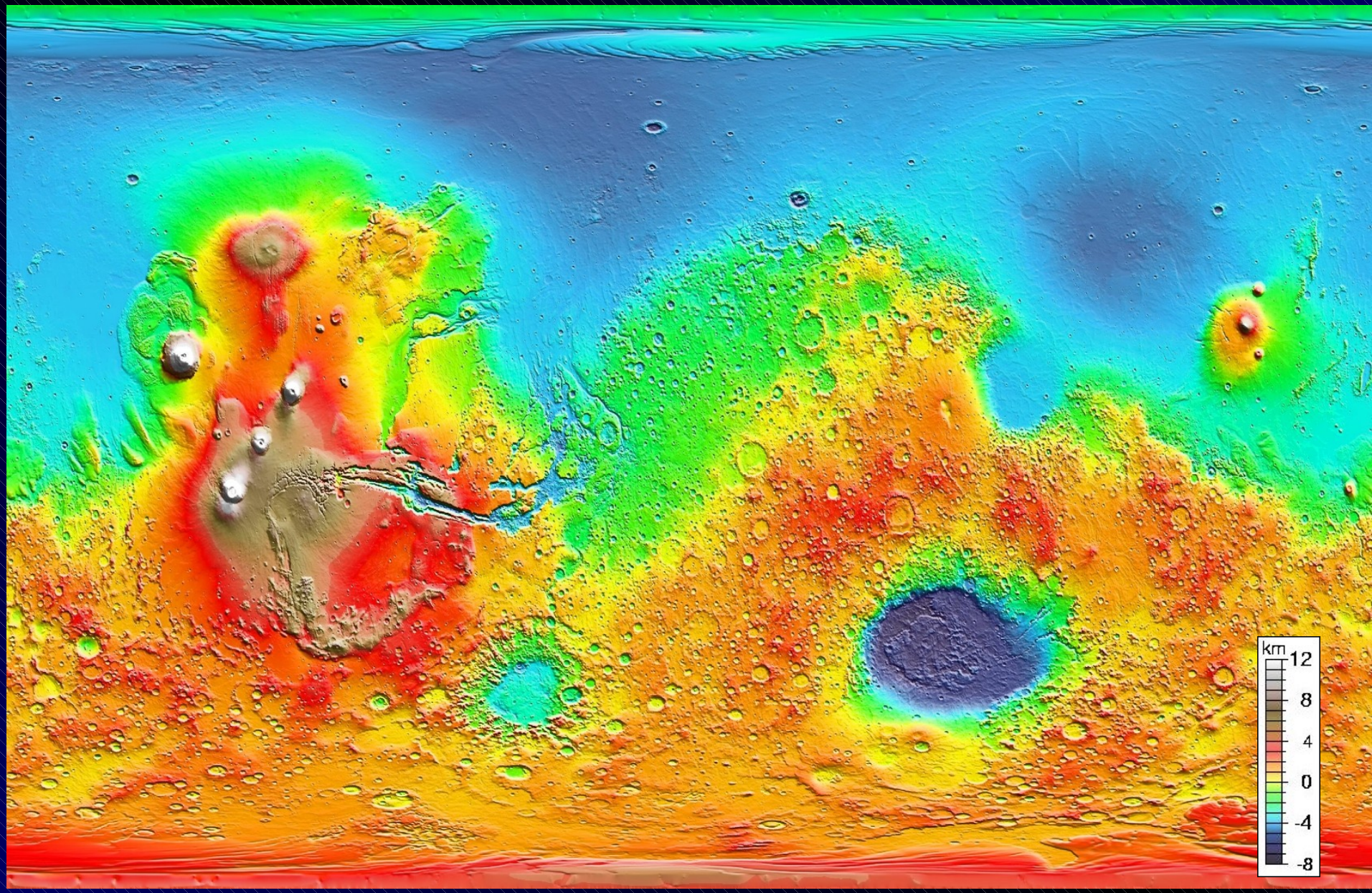


Hubble View of Mars

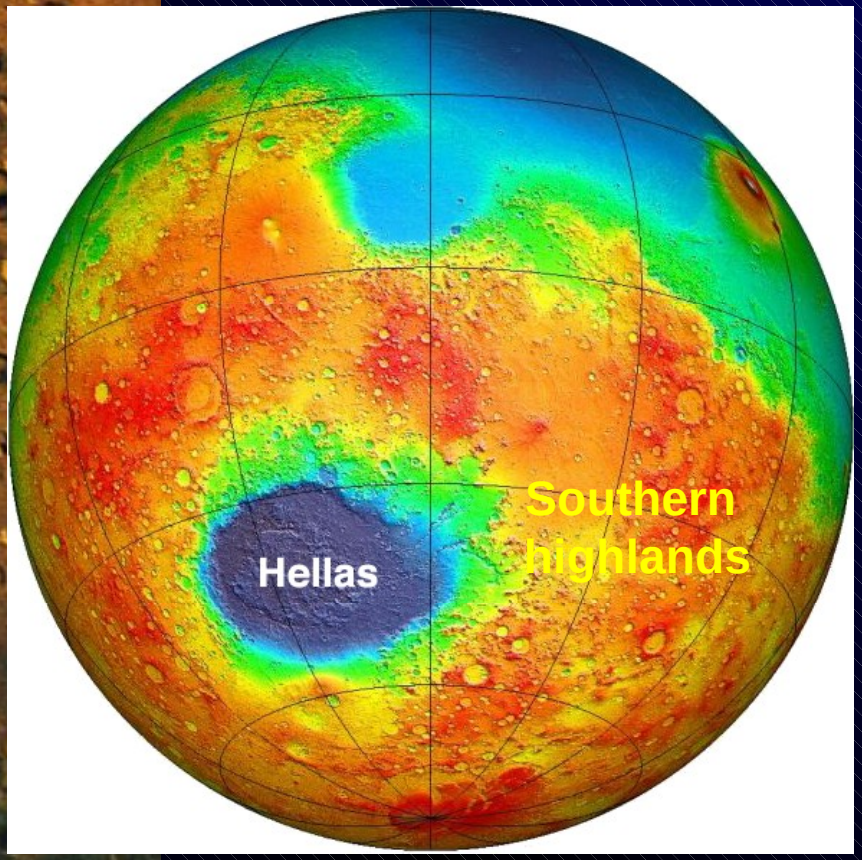
Pre-MGS Global Topography



MGS Topography

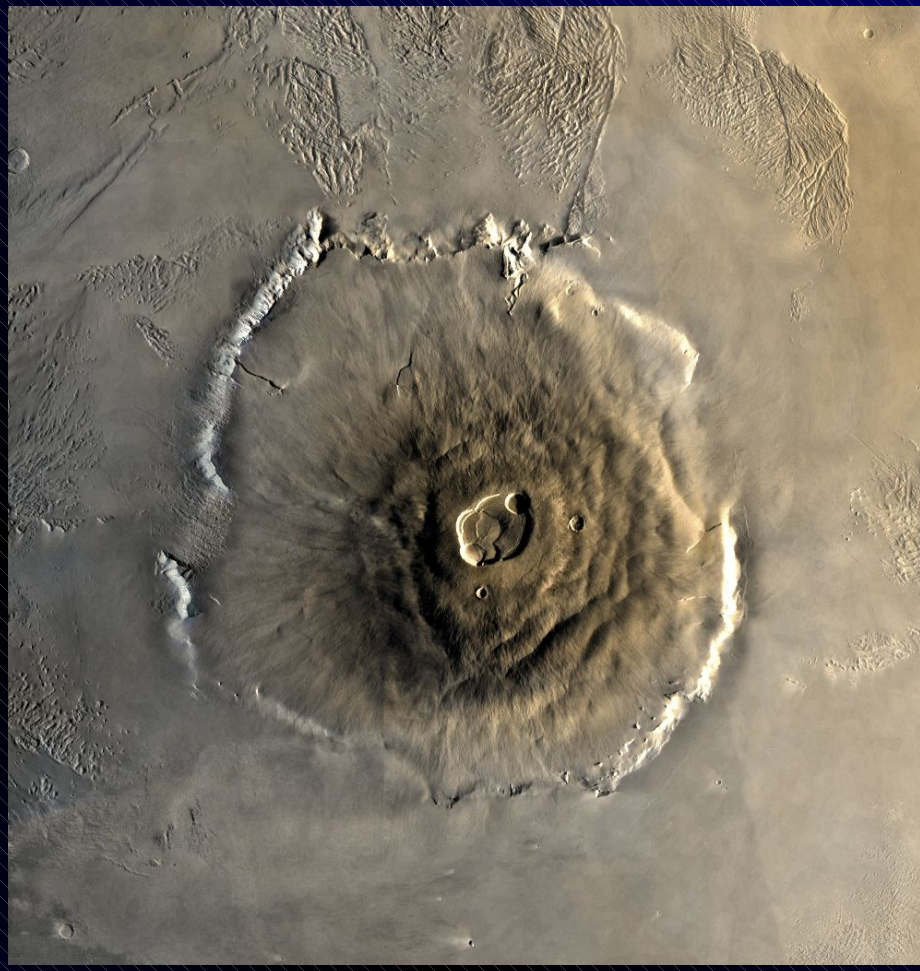


Impact Craters on Mars



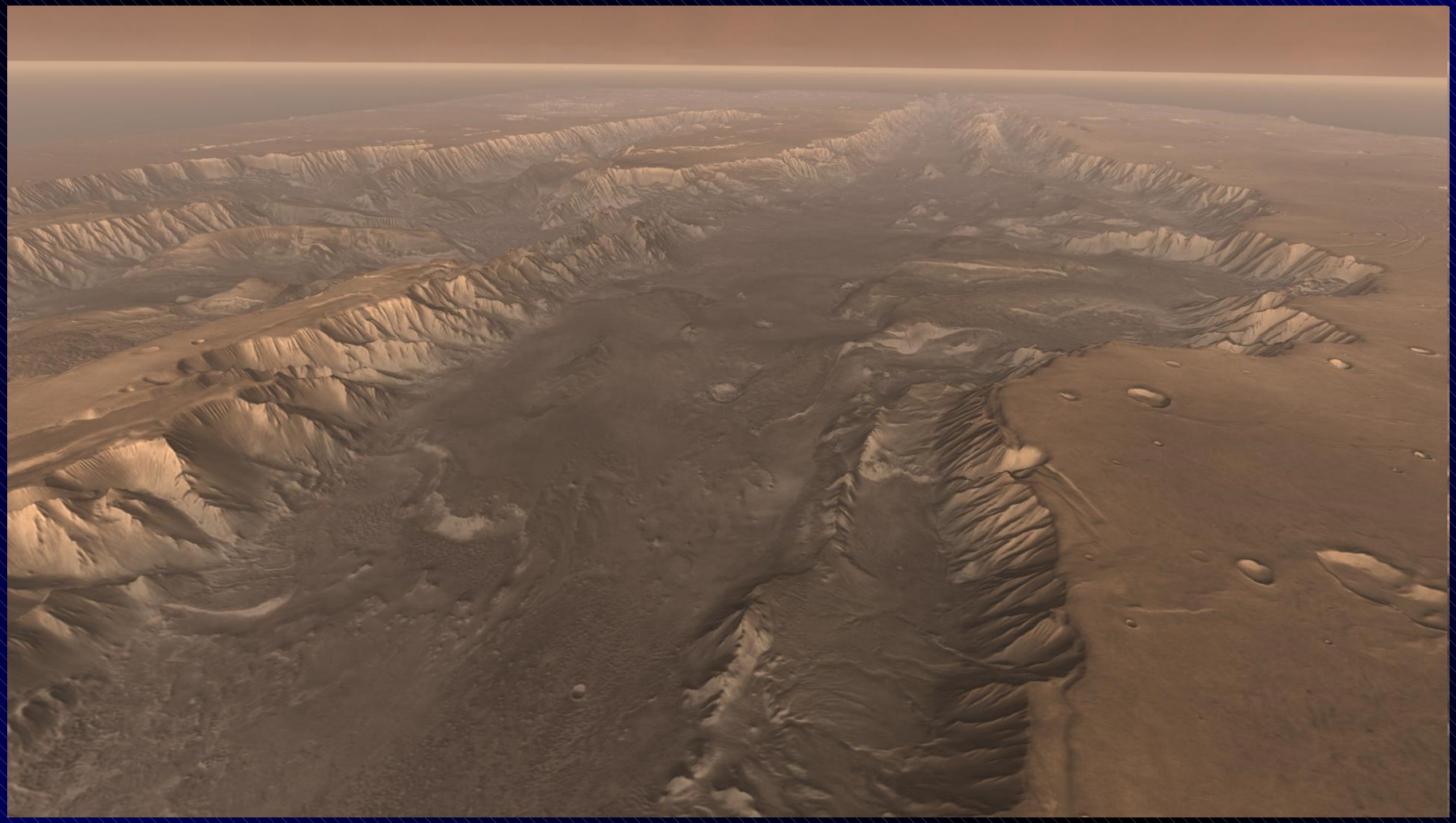
Volcanism on Mars

- *Olympus Mons*
  - A **shield volcano**.
  - Located on the Tharsis bulge.



Larger than Colorado!!

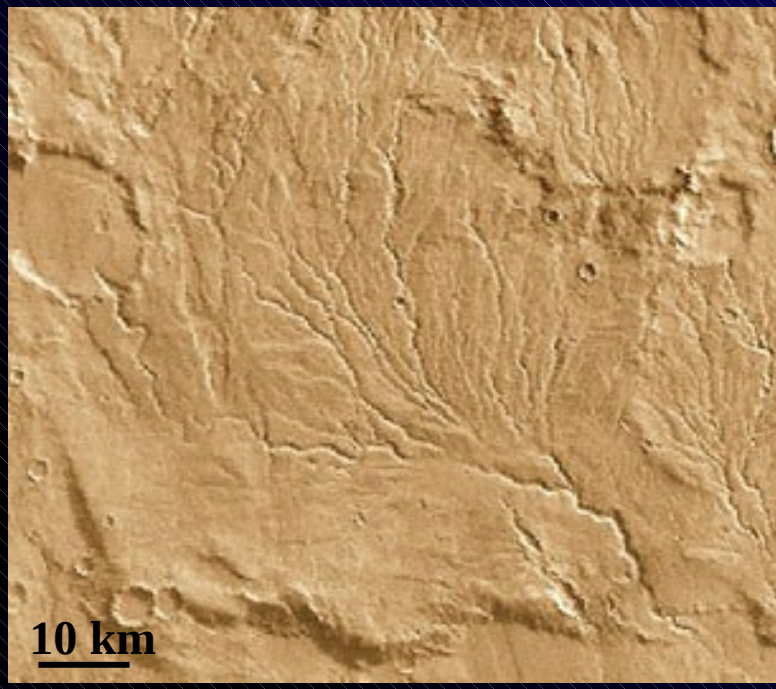
Valles Marineris: The grandest canyon



Would stretch from one end of the U.S. to the other!

Evidence for Past Water on Mars

- Current thin, cold atmosphere prohibits liquid water from being stable on the surface.
- However, there is ample evidence for past water:
  - Ancient river channels (valley networks)
  - Large flood deposits (at least 100X greater than any flood on Earth)
  - Some (arguable) evidence for oceans in the past.
  - Recently active springs on Mars.



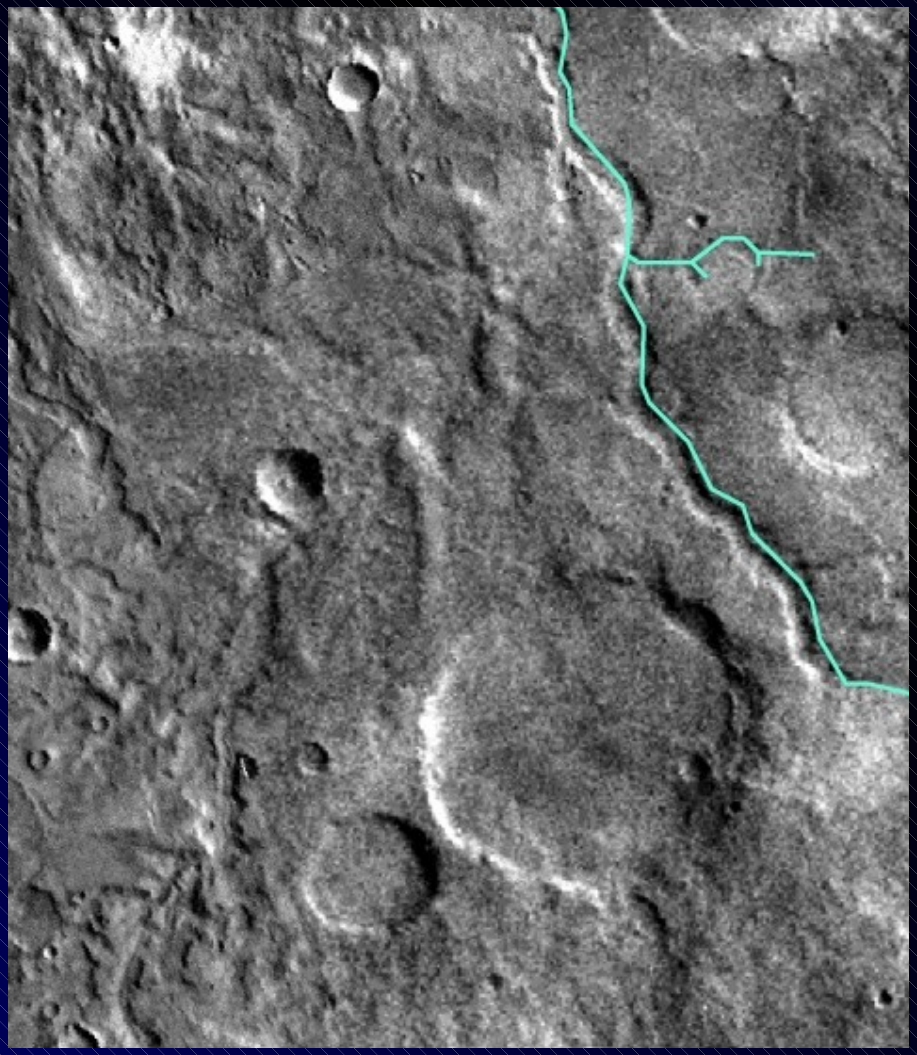
river valley

Martian Valley Networks

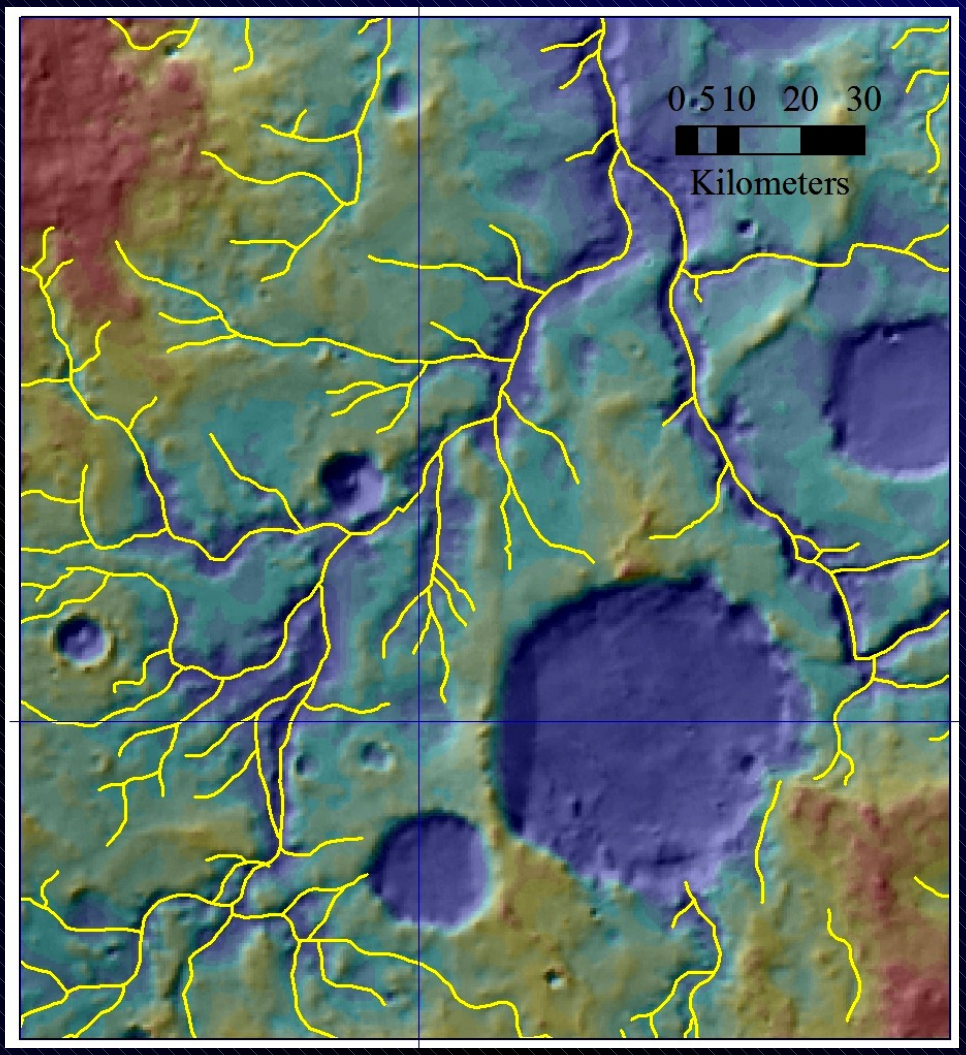
- The networks occur over much of the southern highlands and are generally thought to be ancient features (~84% are >3.7 Ga).

- They remain the best evidence for widespread liquid water at the Martian surface; however, the role of groundwater vs. surface runoff has long been debated.

Comparison of Viking and MGS data

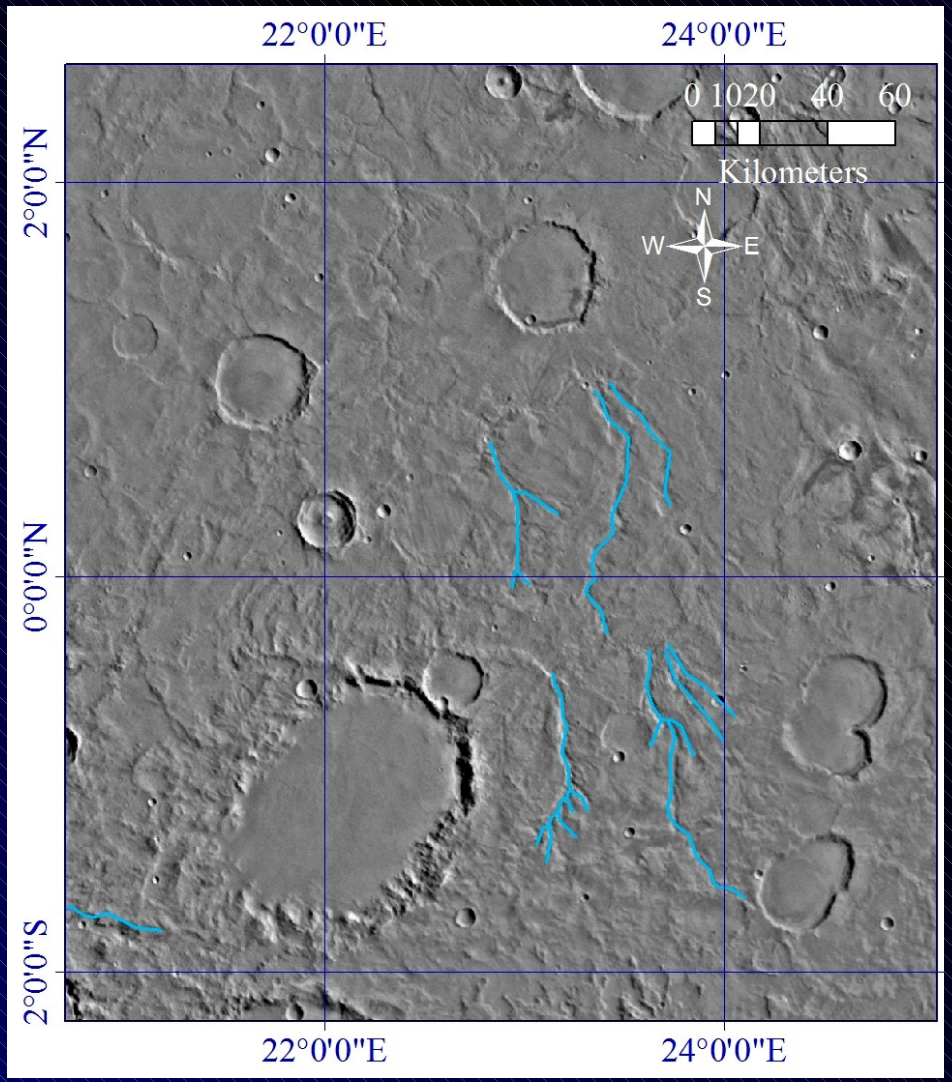


Viking MDIM and Carr VN

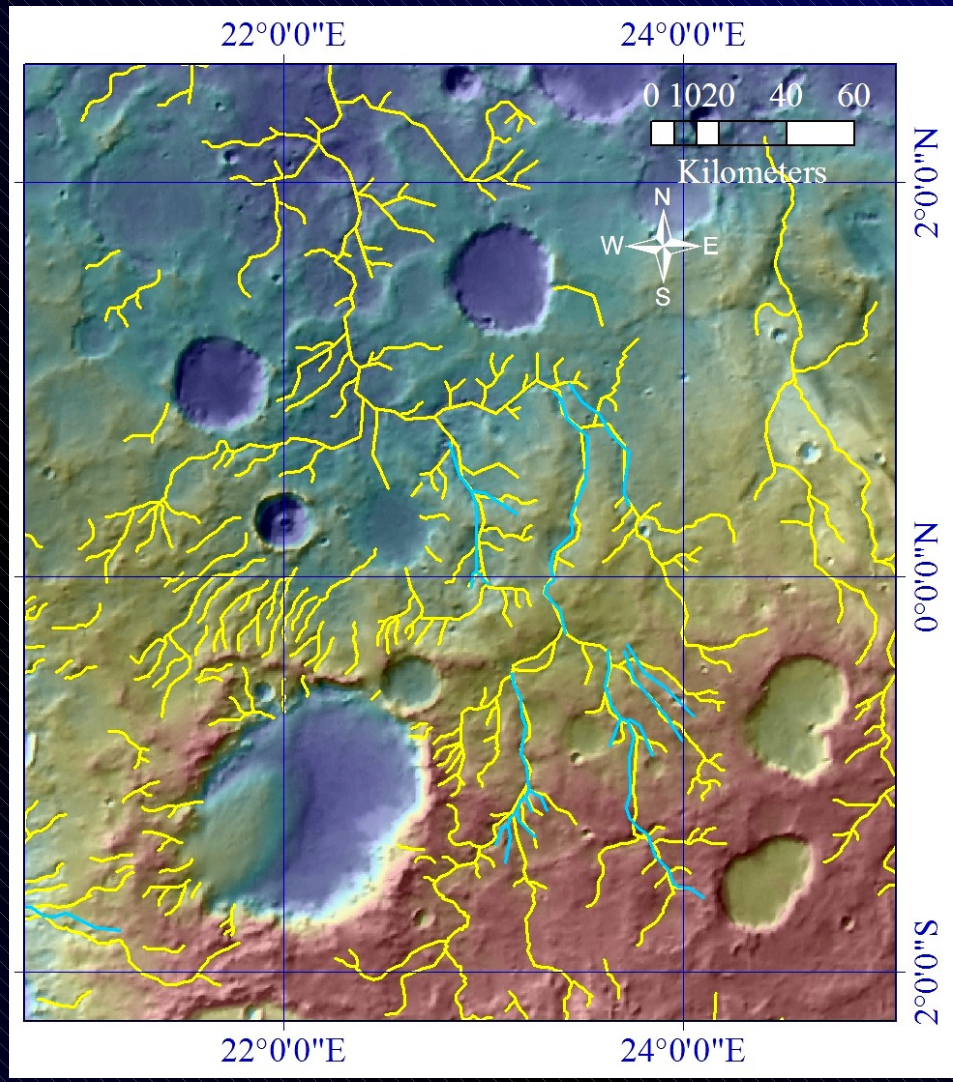


MGS data and newly recognized VN

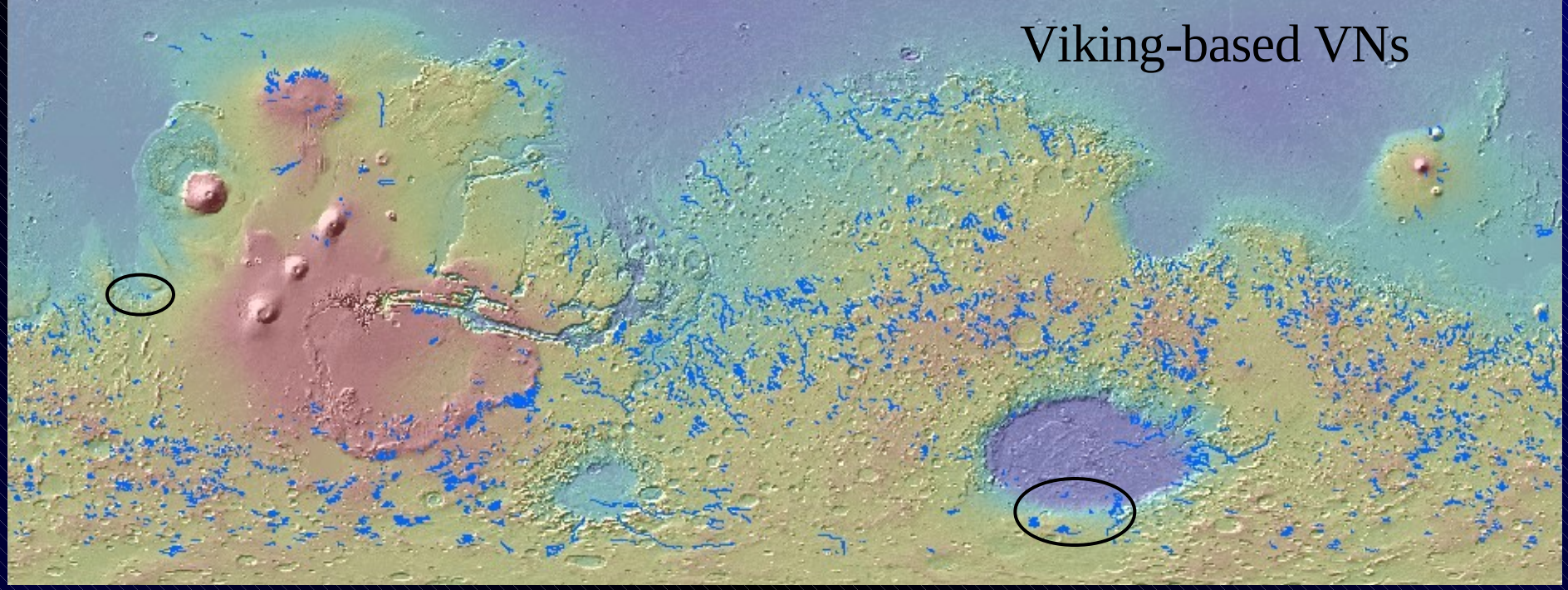
Previously mapped unconnected valleys (blue) are now recognized as an integrated drainage system (yellow).

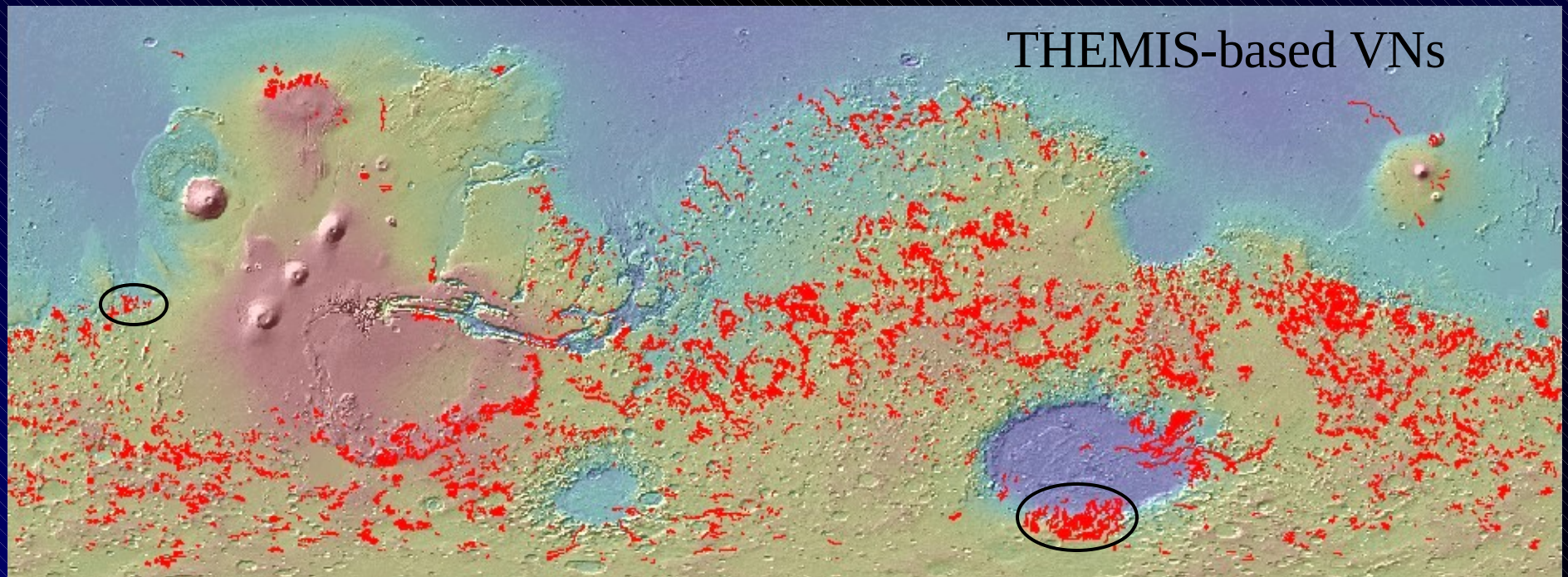


Carr VN on Viking base

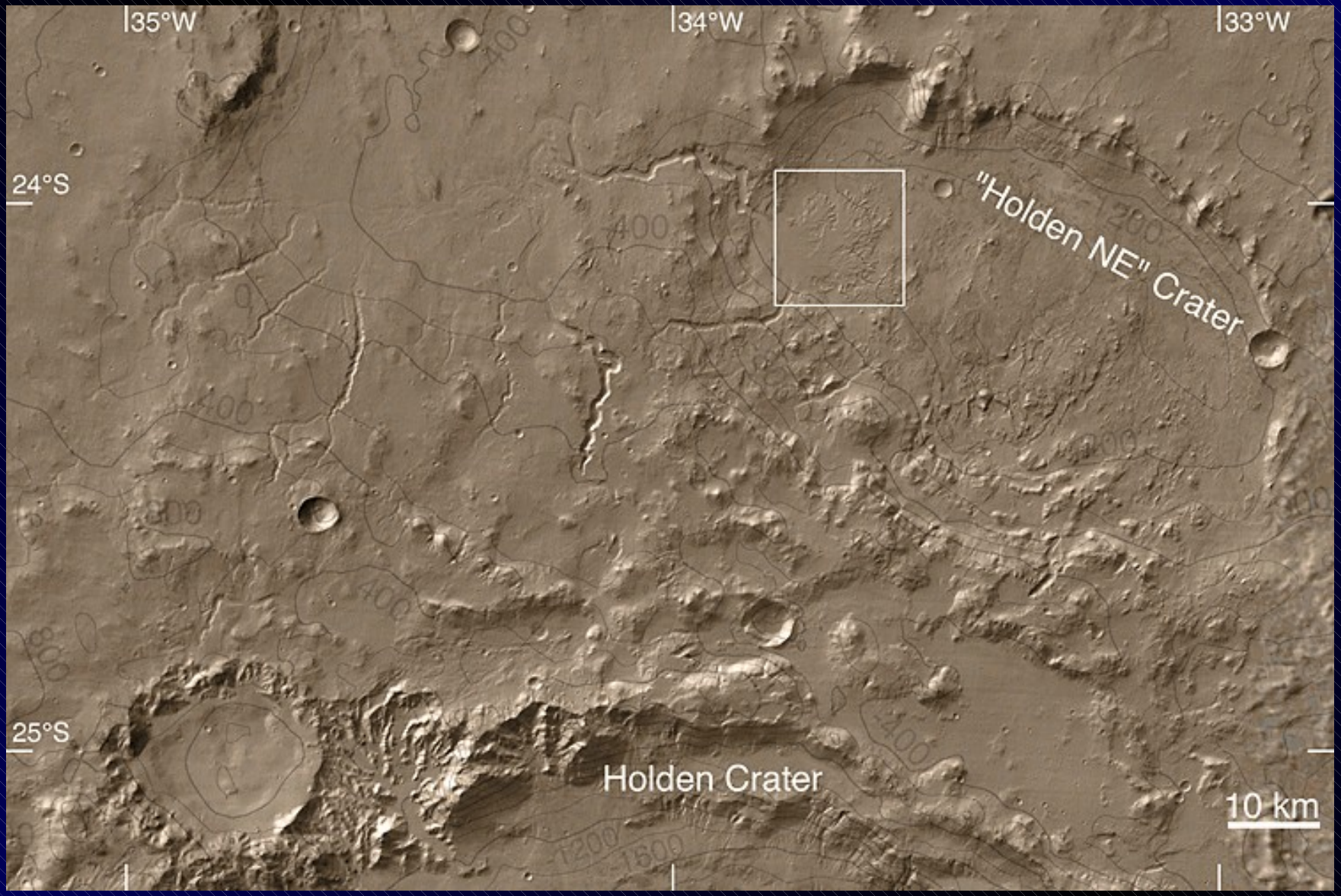


Newly recognized VN from MGS

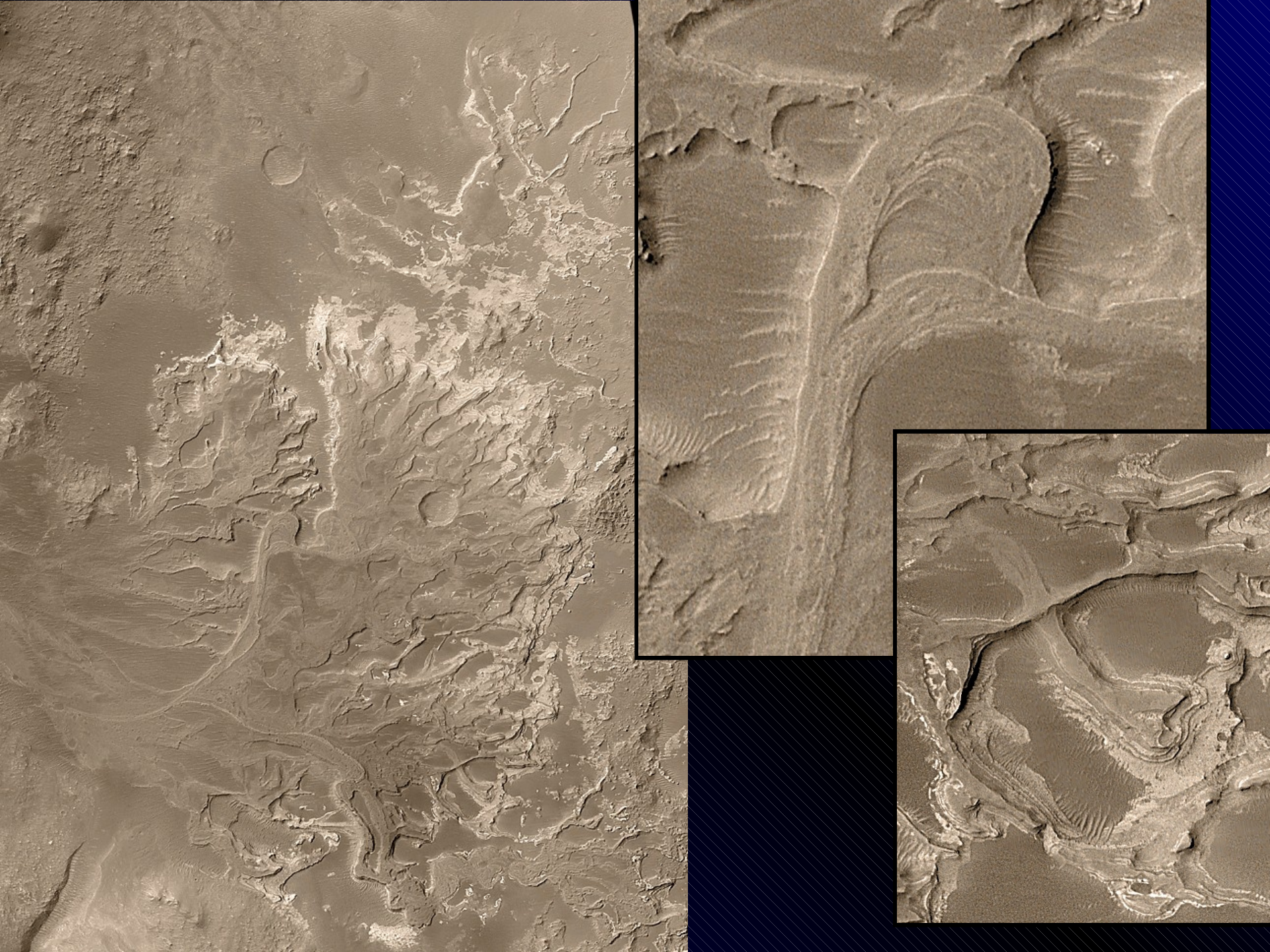

Viking-based VNs

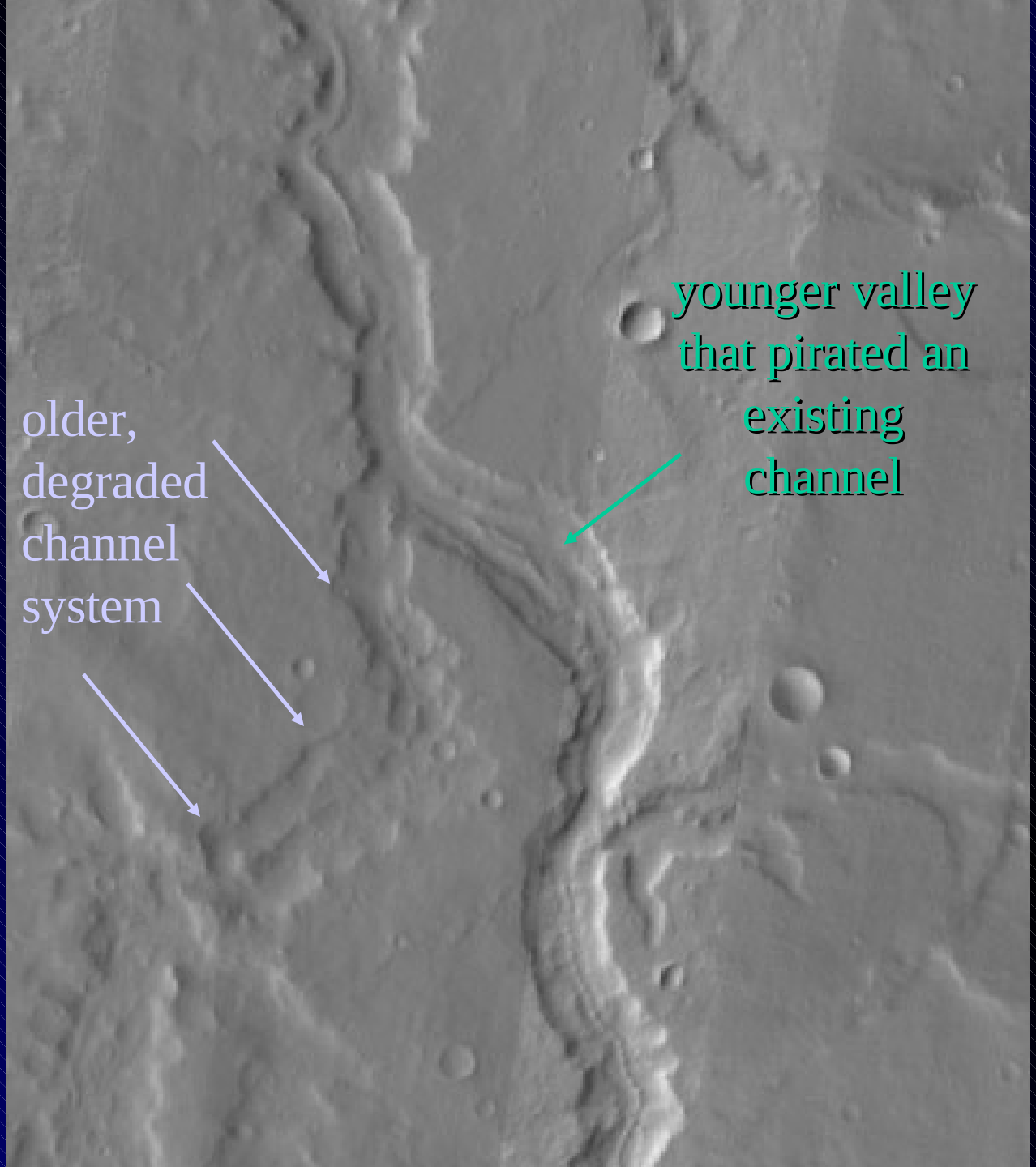

THEMIS-based VNs

Deltas on Mars!



Probably required sustained flow for >10,000 years.

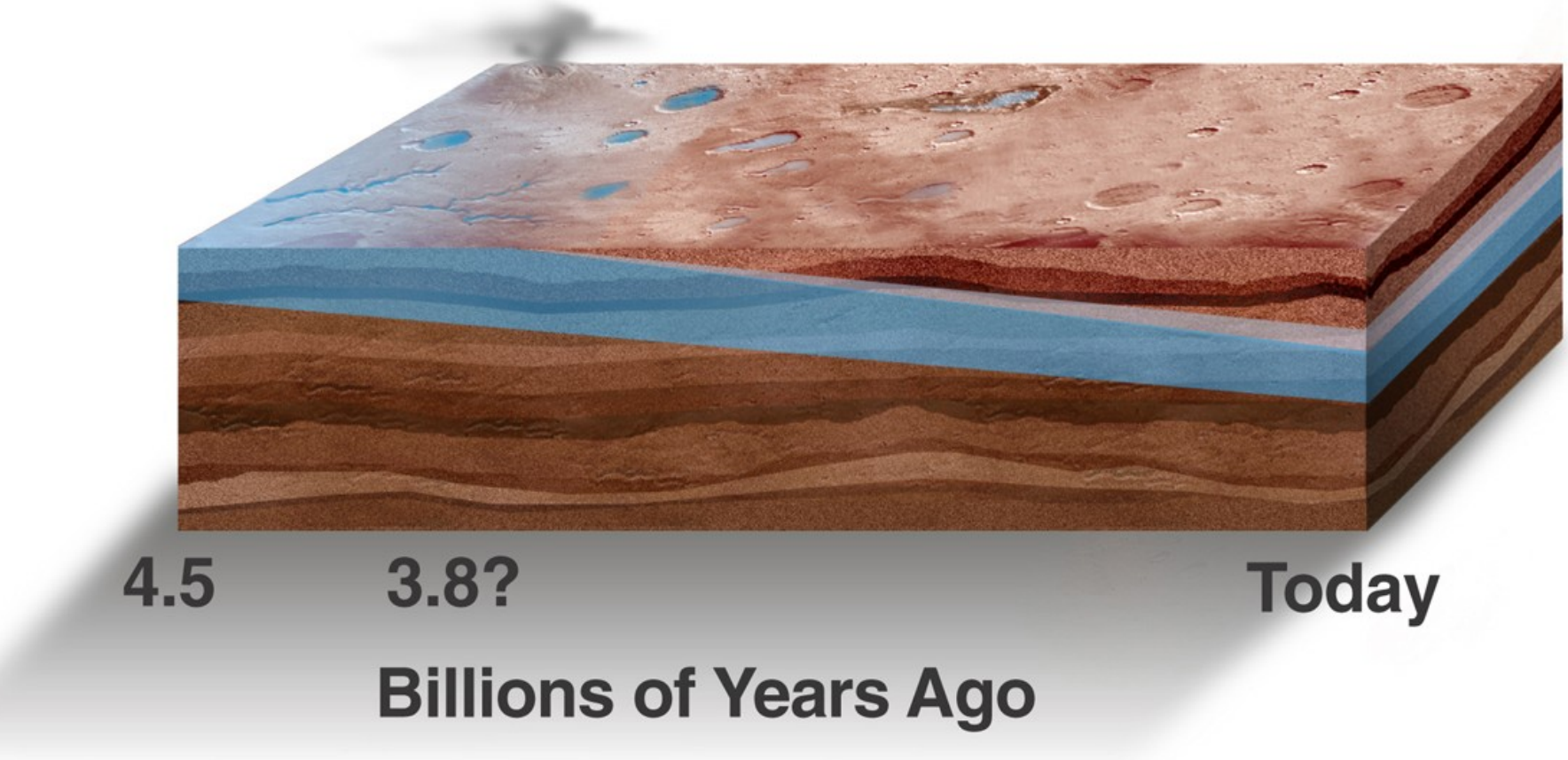




Evidence of episodic surface runoff.

(means it rained multiple times)

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



So what are we doing now?

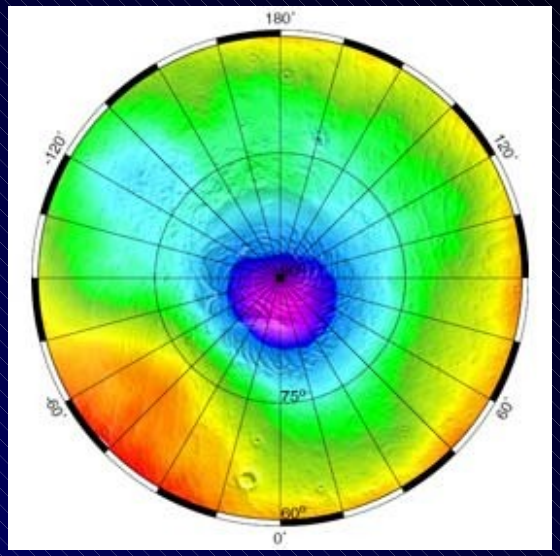
Phoenix Lander

Launched 8/07, landed 4/25/08, died Nov. 2008

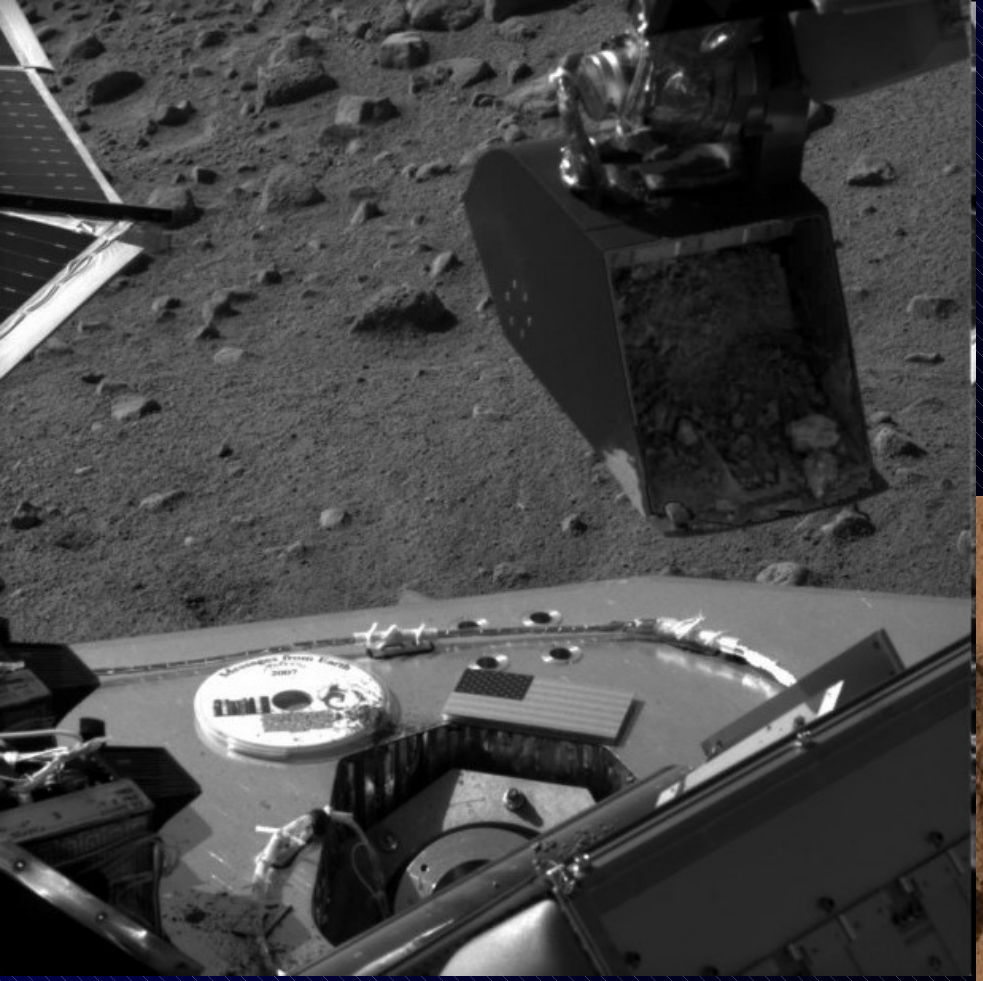
(1) Can the Martian arctic support life?

(2) What is the history of water at the landing site?

(3) How is the Martian climate affected by polar dynamics?



ground ice near N pole



2011 Mars Science Laboratory

- *GOAL: Explore and quantitatively assess a local region on Mars' surface as a potential habitat for life, past or present.*

- Launch in 2011, land 2012
- Planned to last 3 years, drive at least 20 km
- A sophisticated geological, chemical and astrobiological field rover
- Onboard instruments include stereo cameras, a hand lens, XRD/XRF, mass spectrometer for isotopic analysis, laser-induced breakdown spectroscopy, and more!

A very capable field geologist!

And not tiny!

6 finalist candidate landing sites

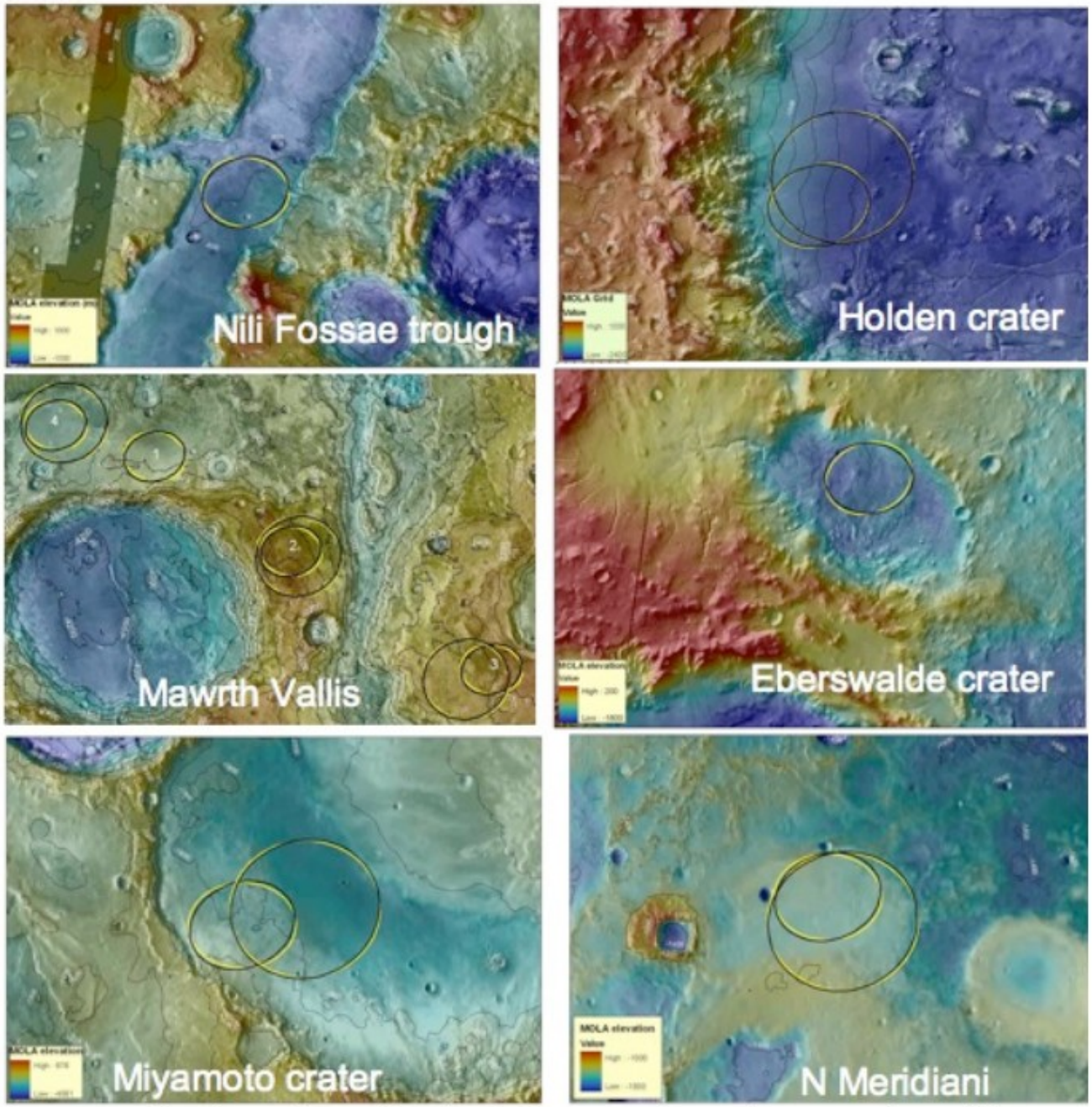
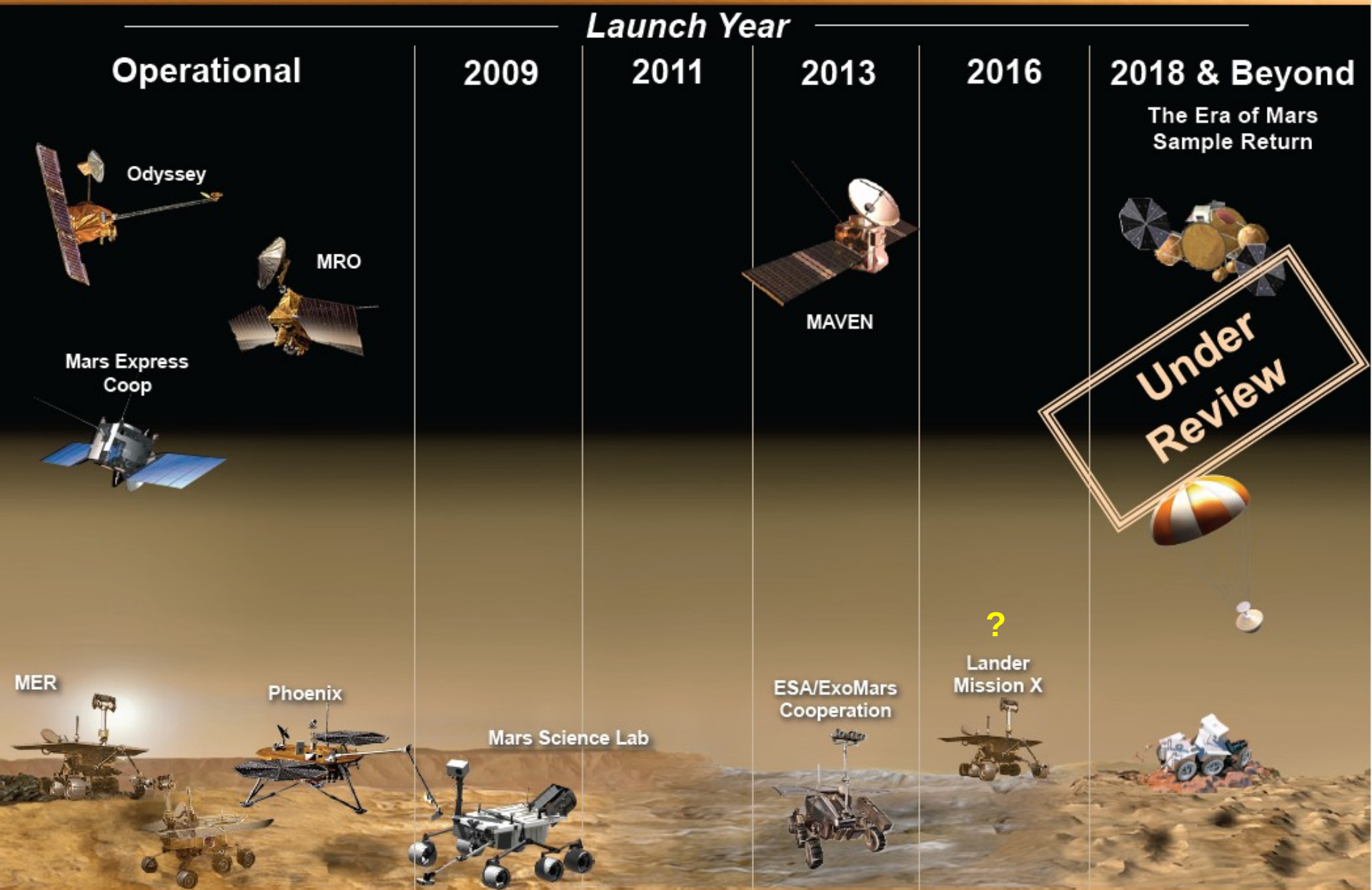
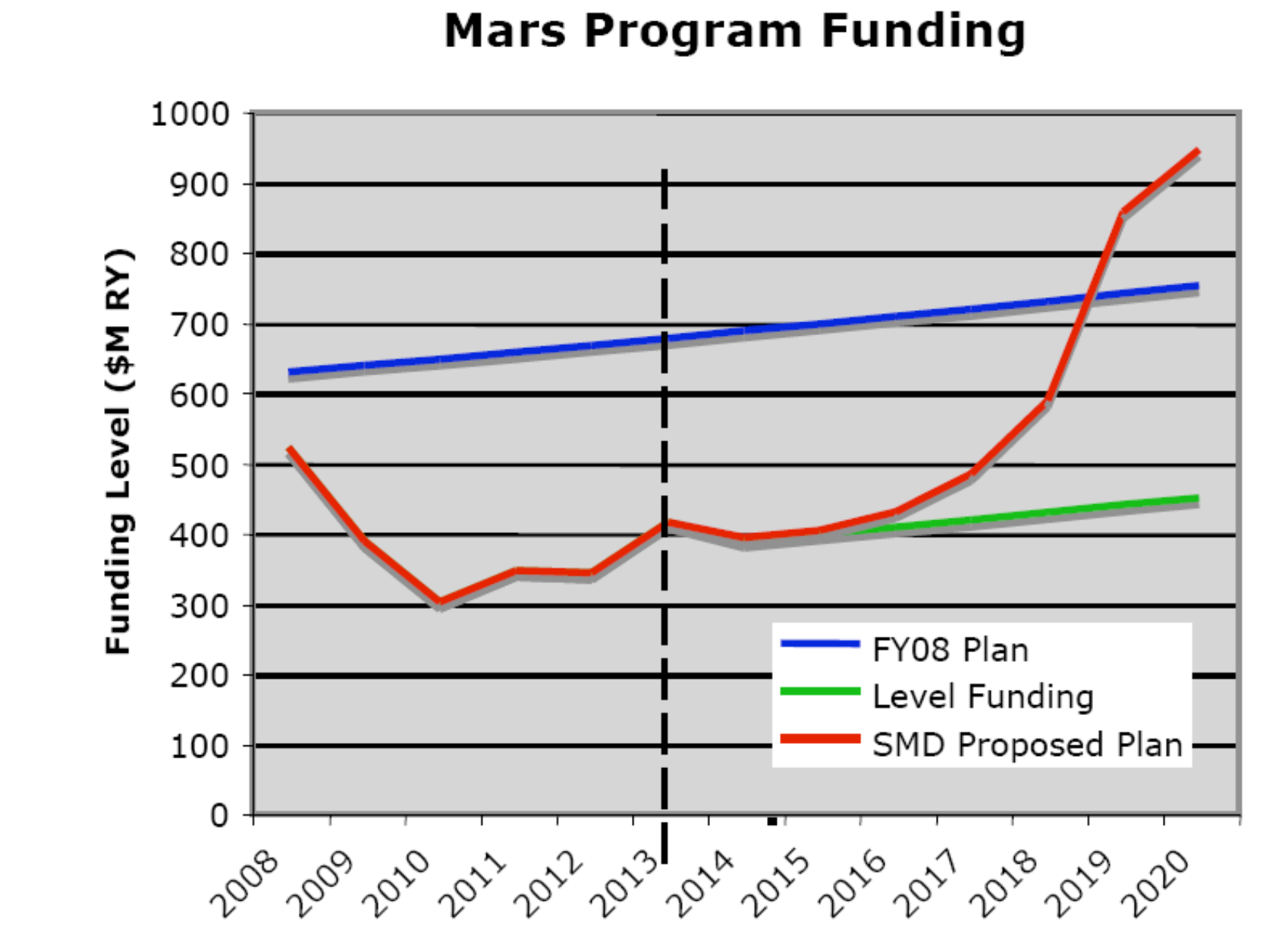


Figure 1: Landing sites under consideration for the Mars Science Laboratory. Primary ellipses are 20 km by 25 km and safe haven ellipses are 32 km by 35 km at coordinates in Table 1.

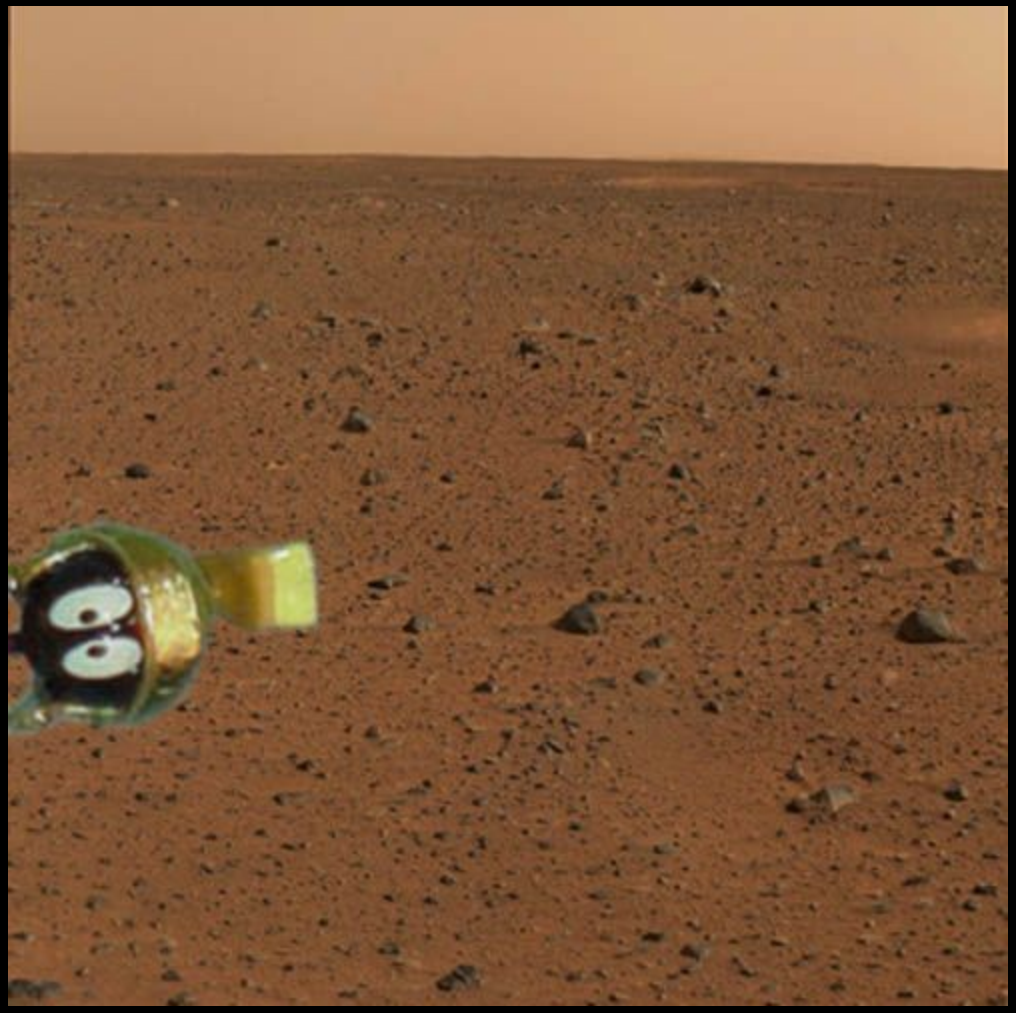
MEP Next Decade—Where to From Here?



However….


Mars Program Funding
Funding Level ($M RY)
1000
900
800
700
600
500
400
300
200
100
0
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
FY08 Plan
Level Funding
SMD Proposed Plan

We will continue our search for life beyond Earth.



Stay tuned for more fascinating discoveries!