



# Mars Exploration: Was there ever life?

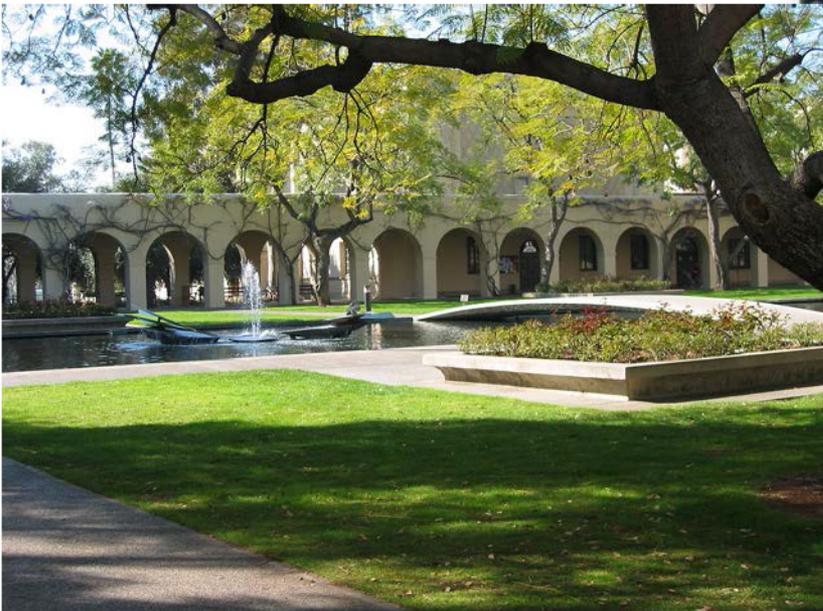
Dr. Jakob van Zyl, Associate Director

Jet Propulsion Laboratory • California Institute of Technology

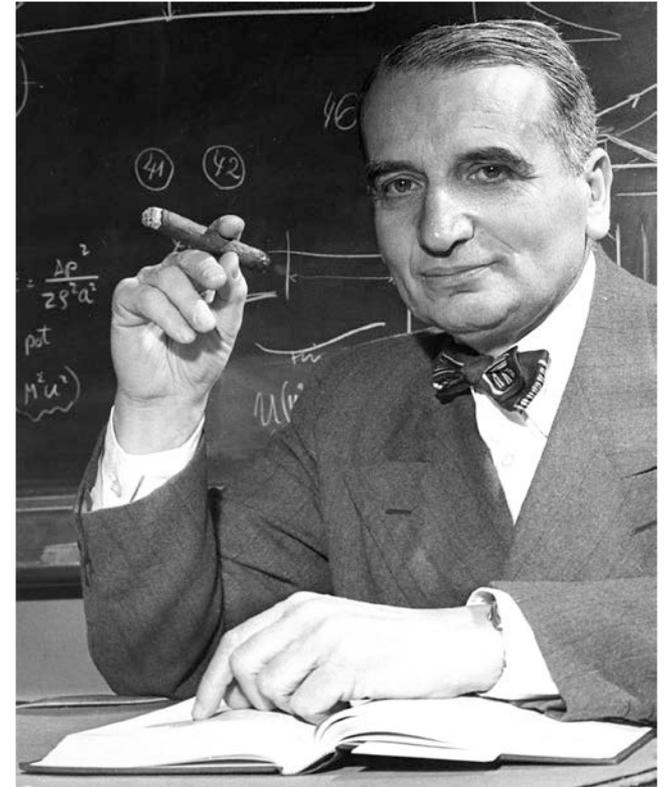


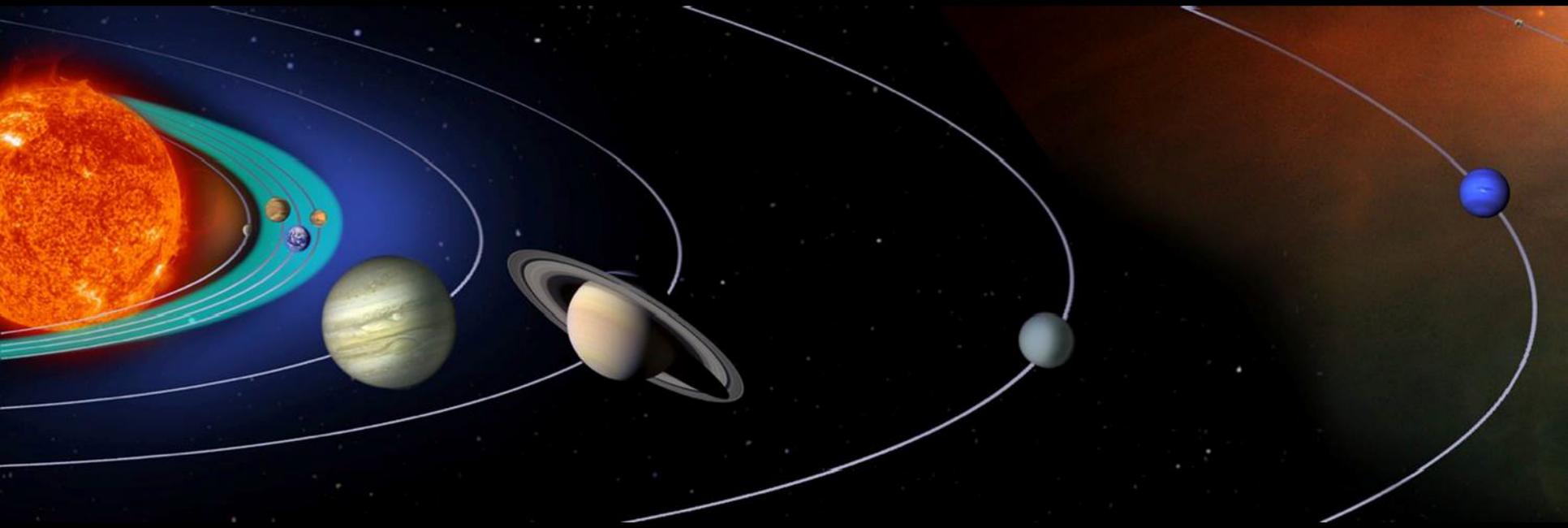
# JPL is part of NASA and Caltech

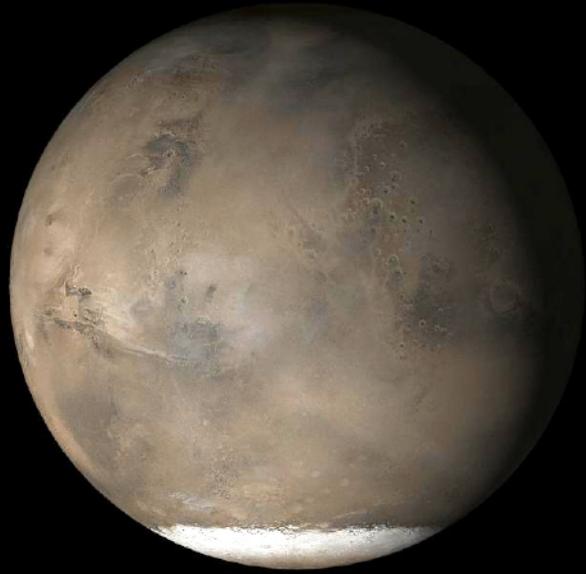
- Federally-Funded (NASA-owned) Research and Development Center (FFRDC)
- University Operated (Caltech)
- \$1.5B Business Base
- 5,000 Employees



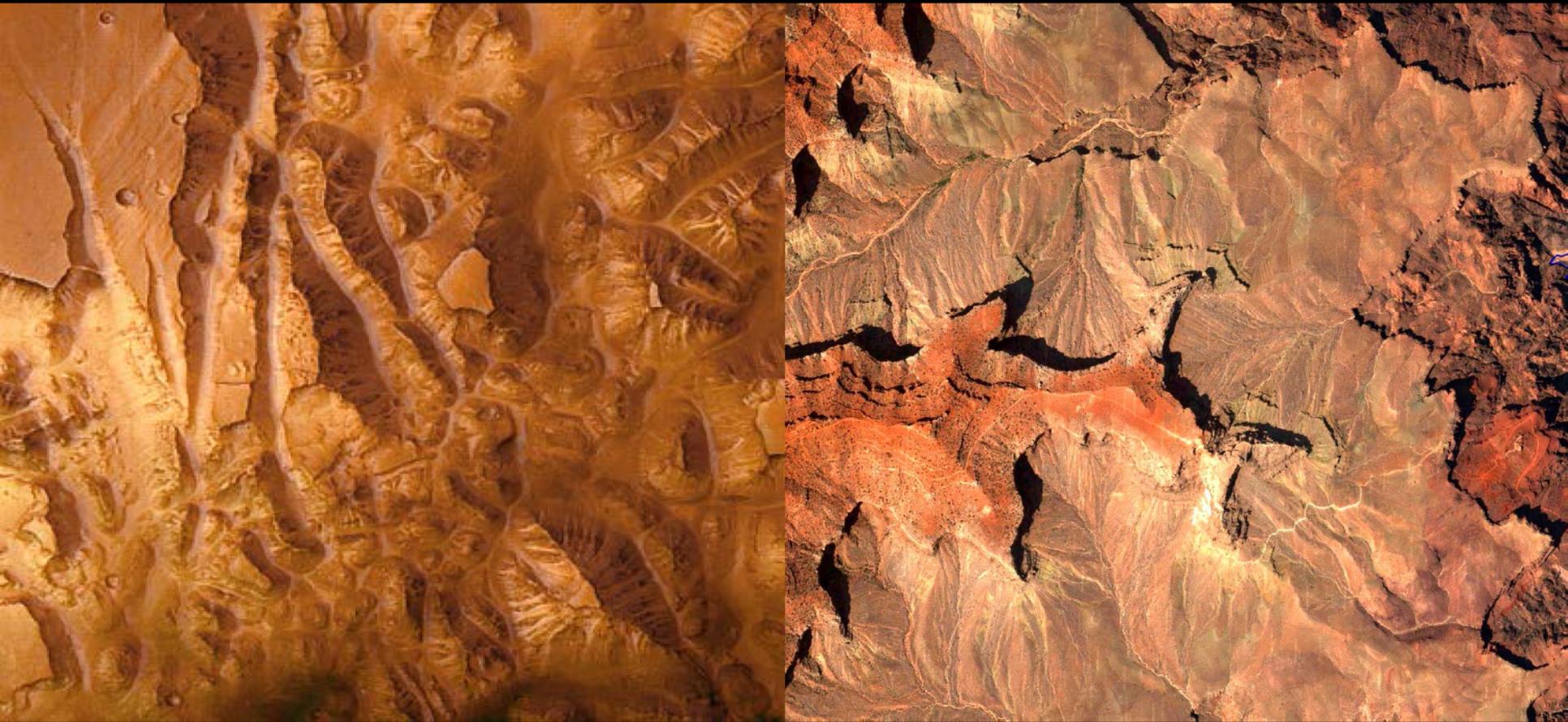
# Relentless Drive, Visionary Leadership



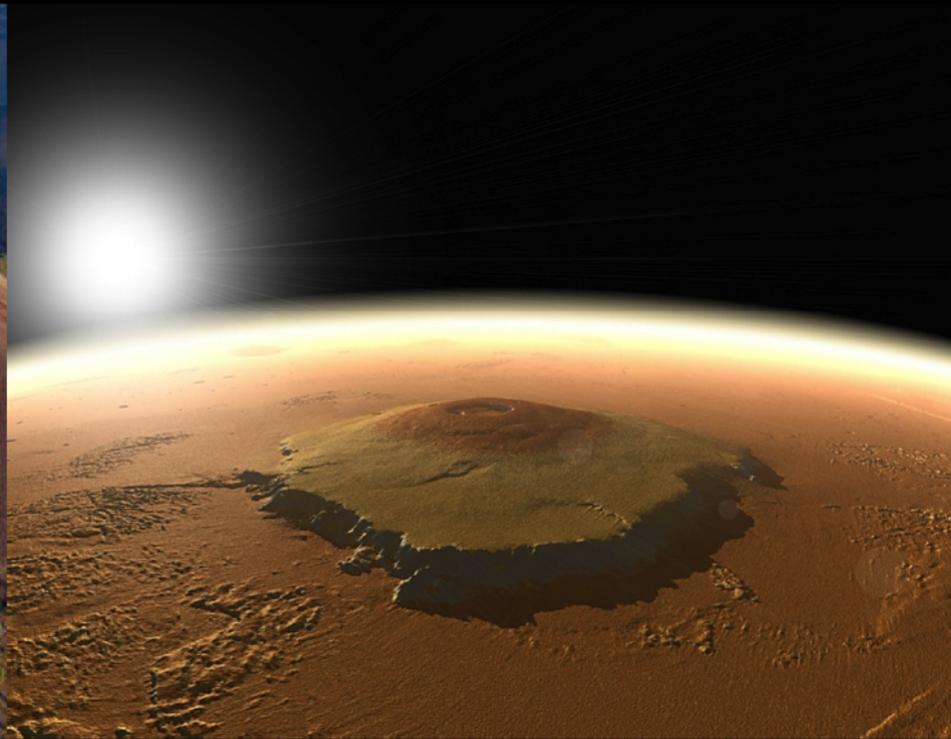




Earth and Mars share several features



Grand Canyons



Great Volcanoes



Geology

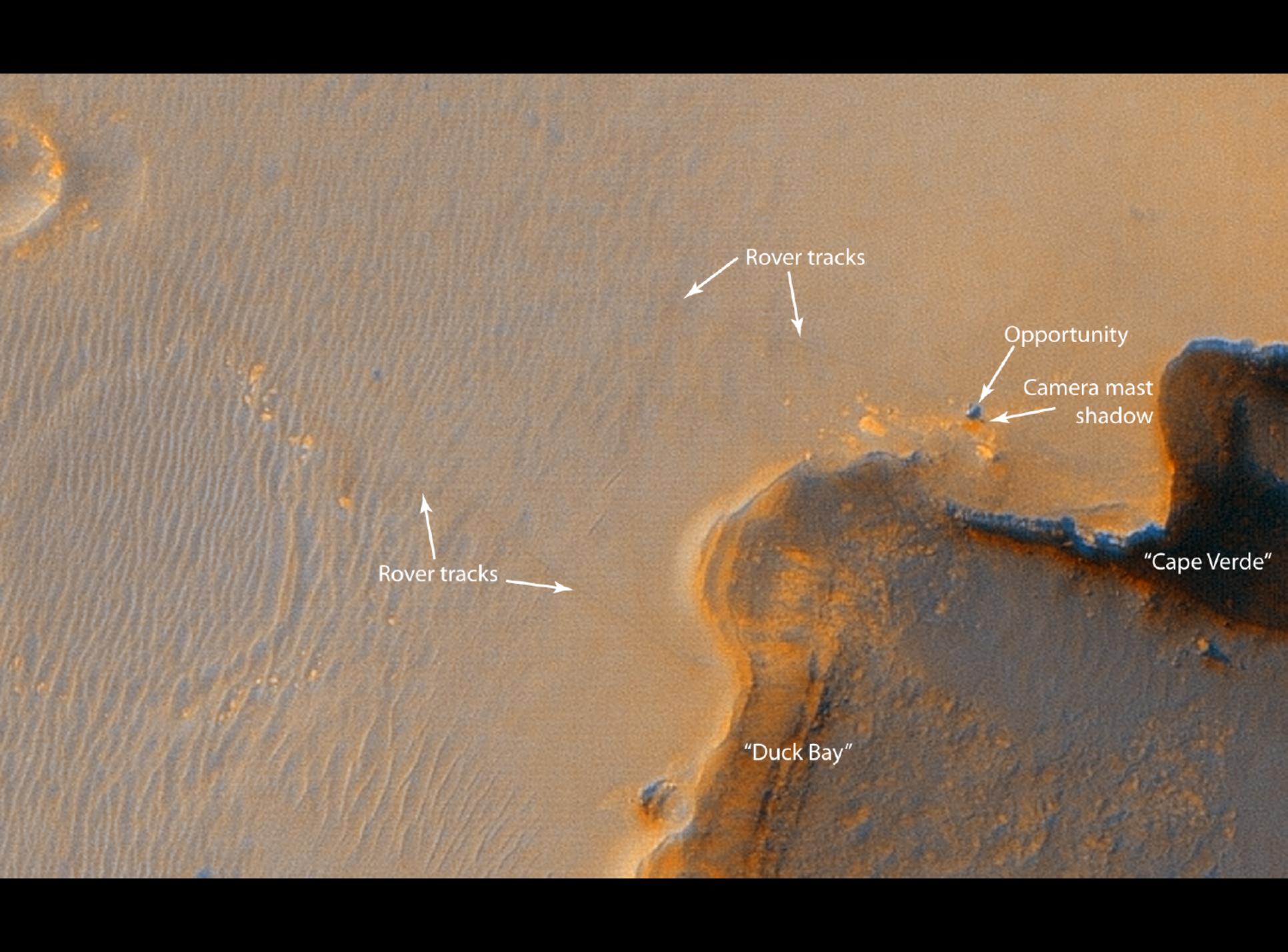


Three Generations of Rovers



Driving test in the lab  
*Spirit*





Rover tracks

Opportunity

Camera mast shadow

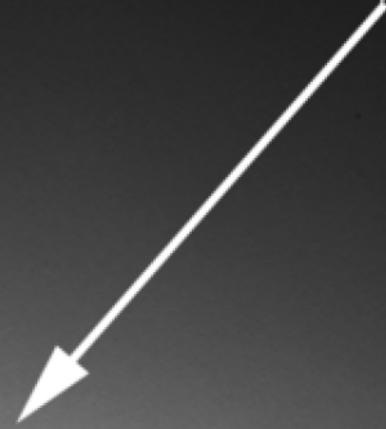
"Cape Verde"

"Duck Bay"

Rover tracks



**You are here**

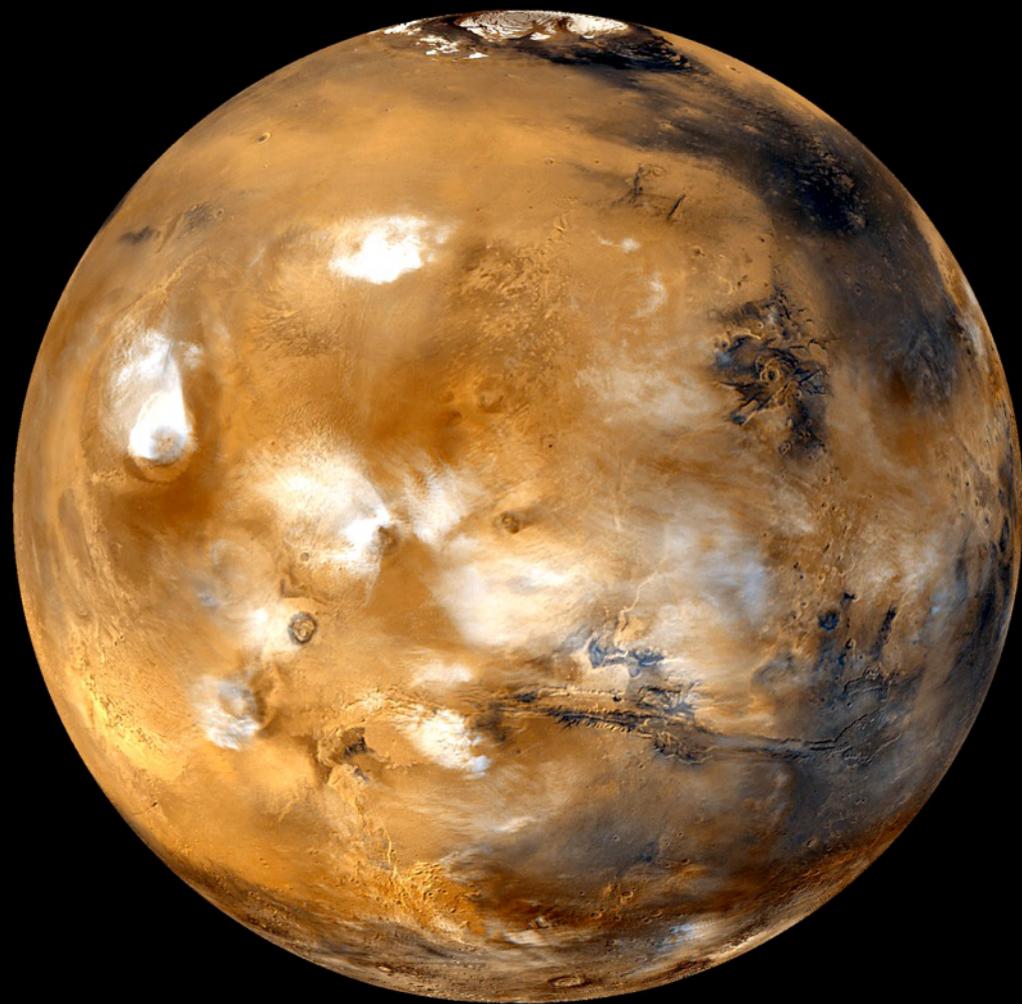




0000

# Hematite on Mars







Lewis & Clark  
40,000 YEARS



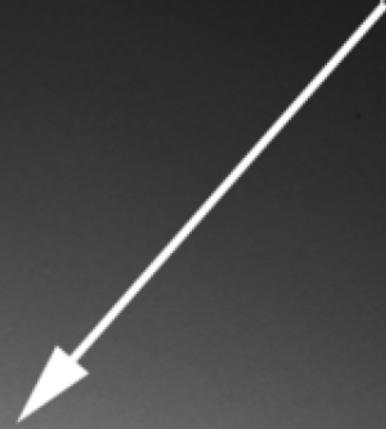
Columbus  
10,000 YEARS



JPL Director's Z  
175 YEARS

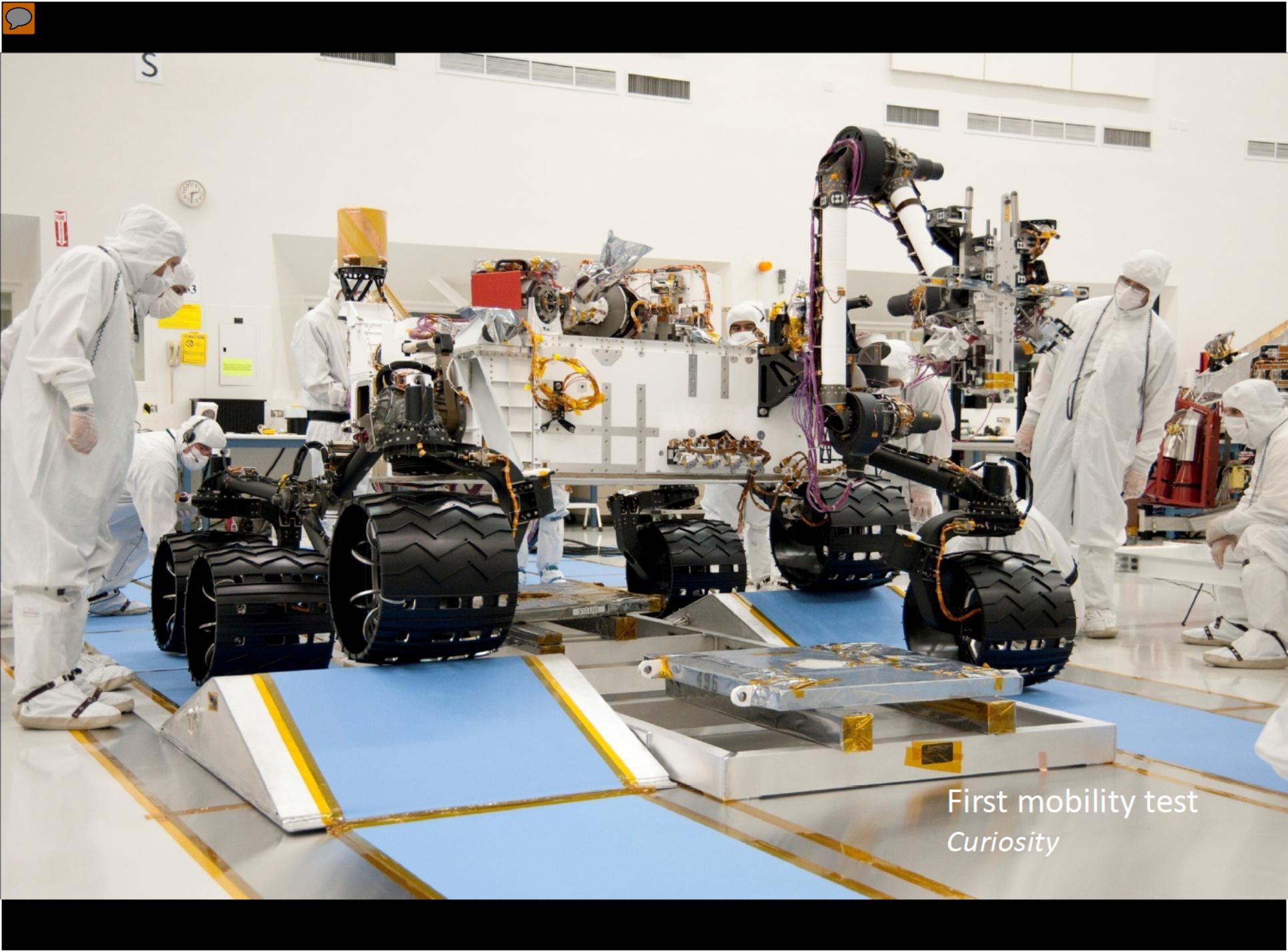


**You are here**





0000



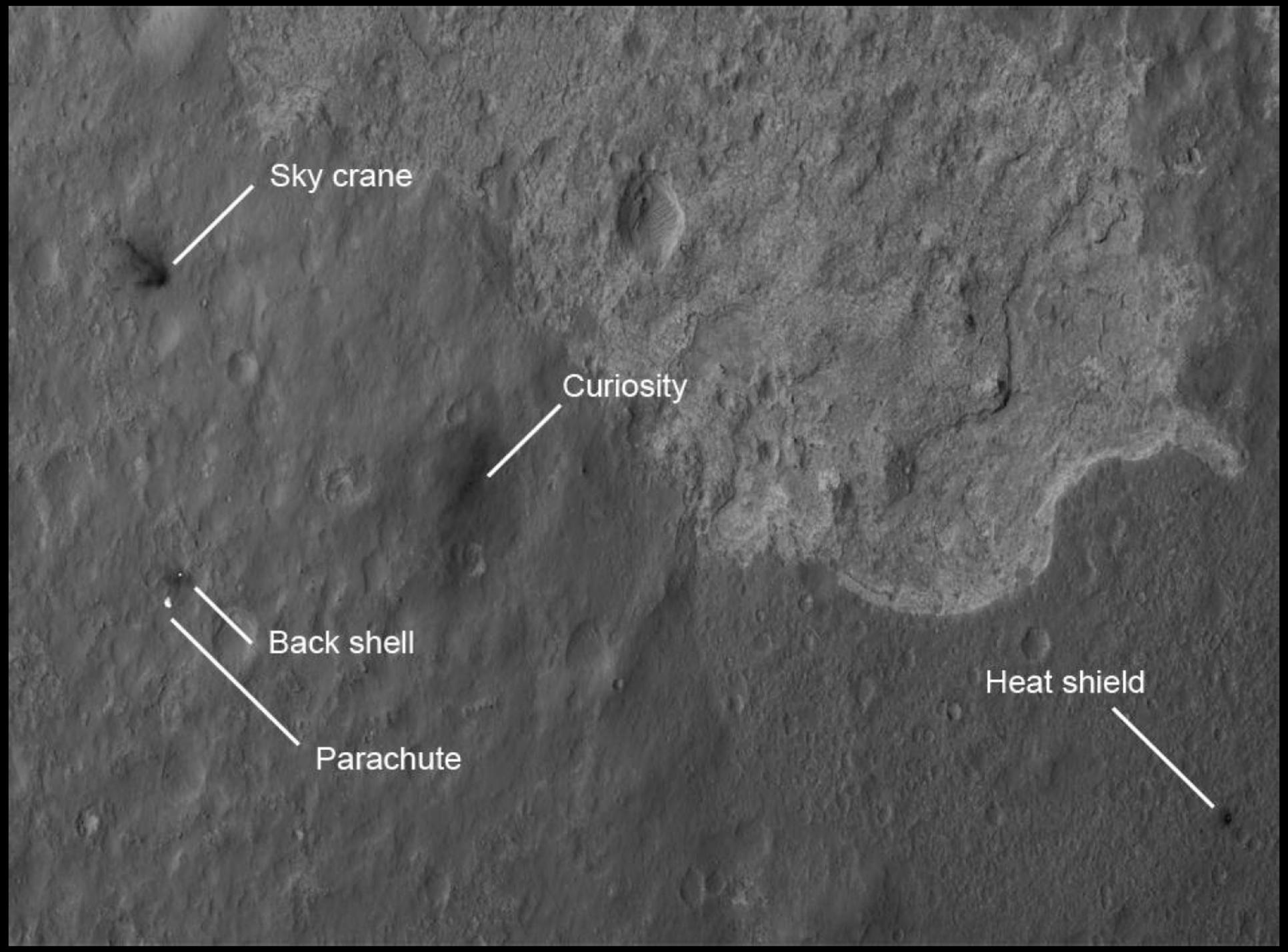
First mobility test  
*Curiosity*



MSL in TVAC Chamber







Sky crane

Curiosity

Back shell

Parachute

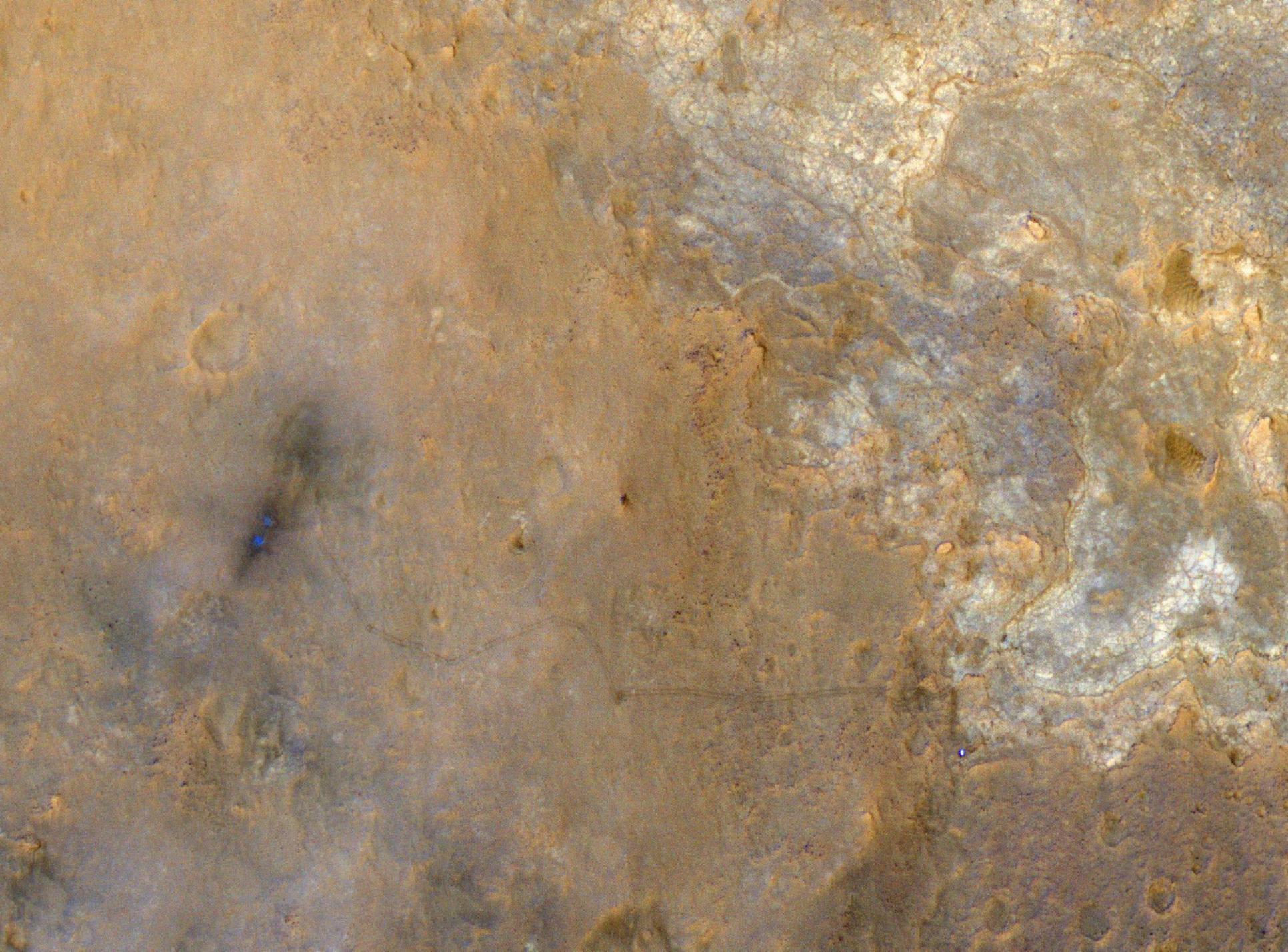
Heat shield



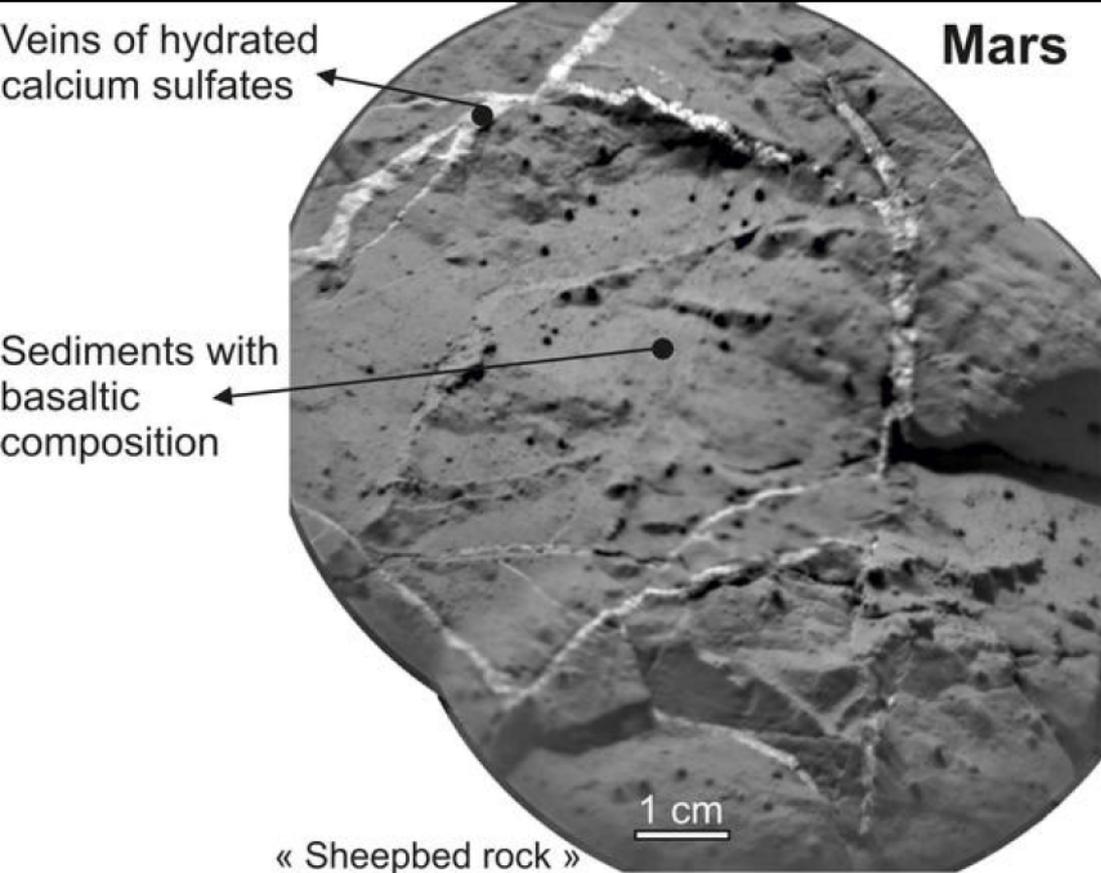
1 cm

10 cm







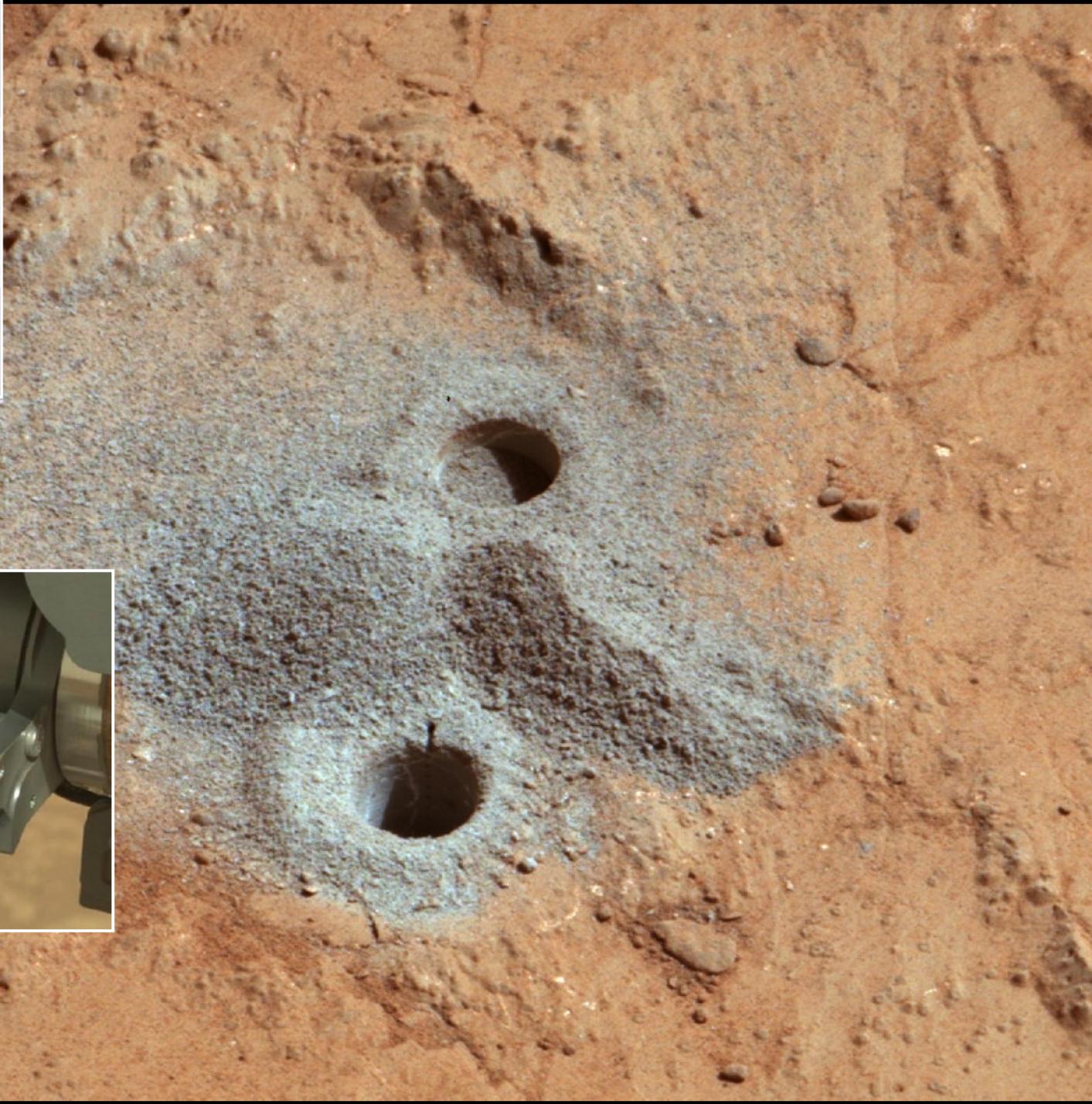


Mars

Earth



**“Sheepbed” rocks contain 1 to 5-mm fractures filled with calcium sulfate minerals that precipitated from fluids at low to moderate temperatures**



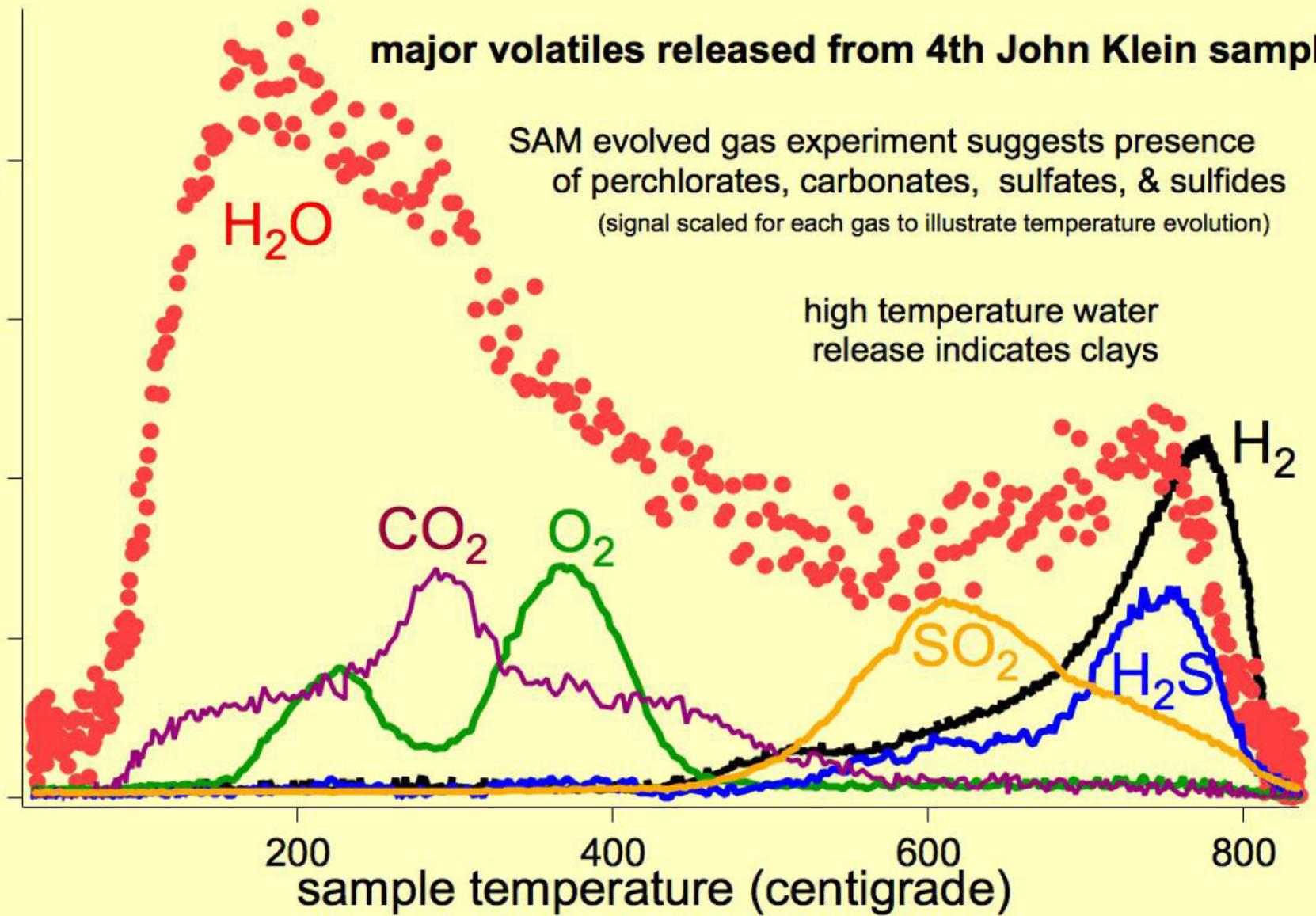


# major volatiles released from 4th John Klein sample

SAM evolved gas experiment suggests presence of perchlorates, carbonates, sulfates, & sulfides  
(signal scaled for each gas to illustrate temperature evolution)

high temperature water release indicates clays

mass spectrometer signal

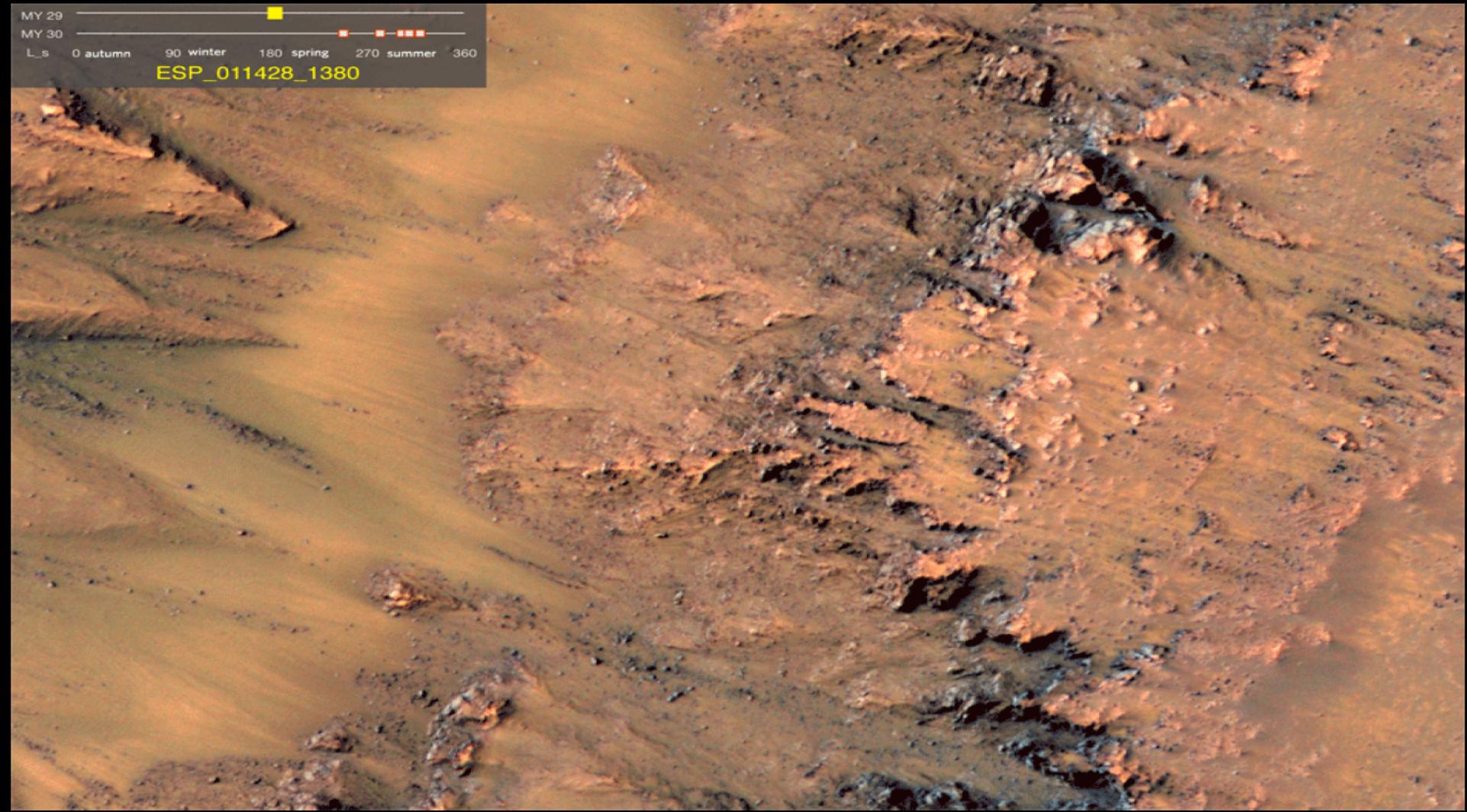


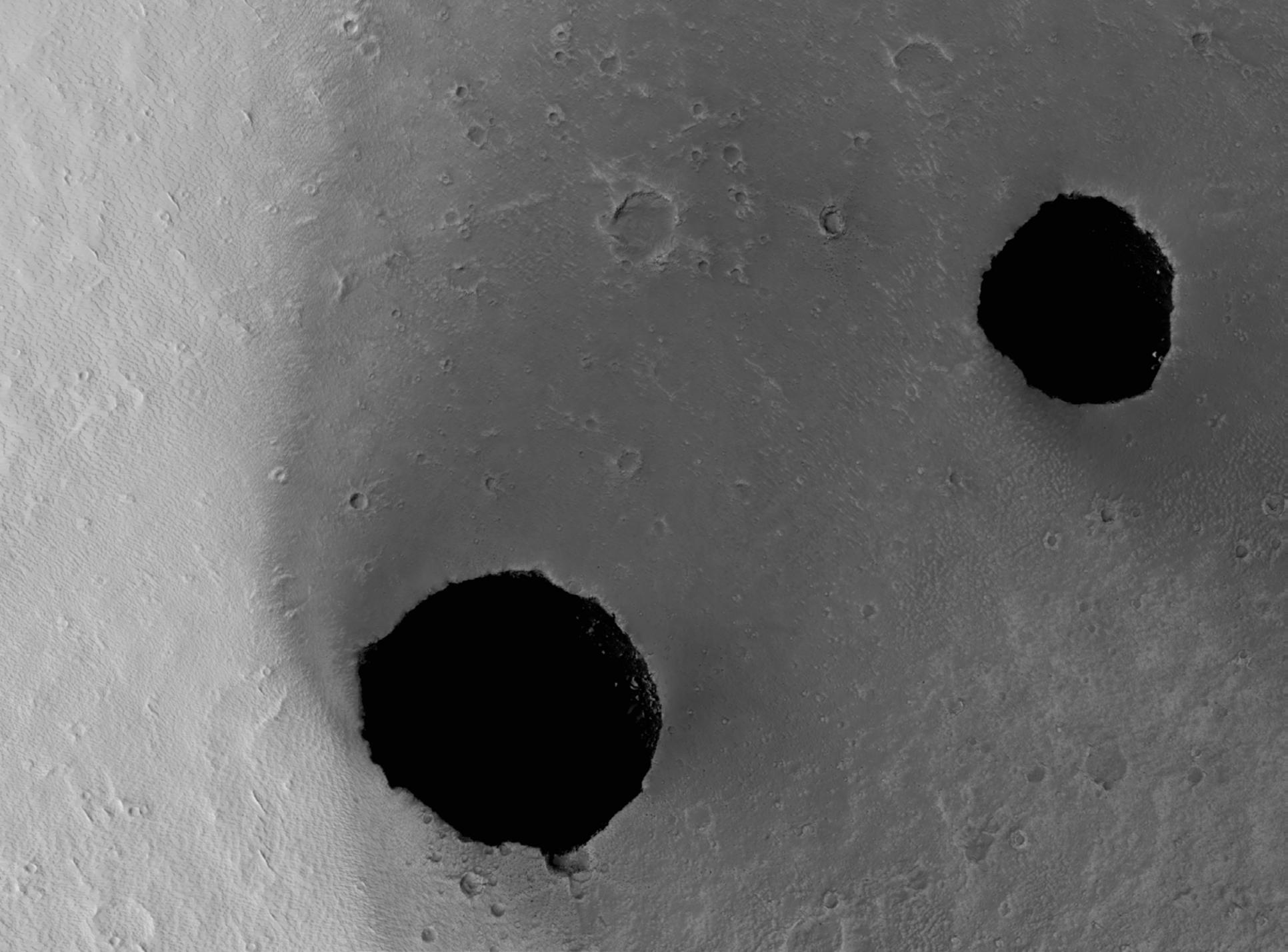


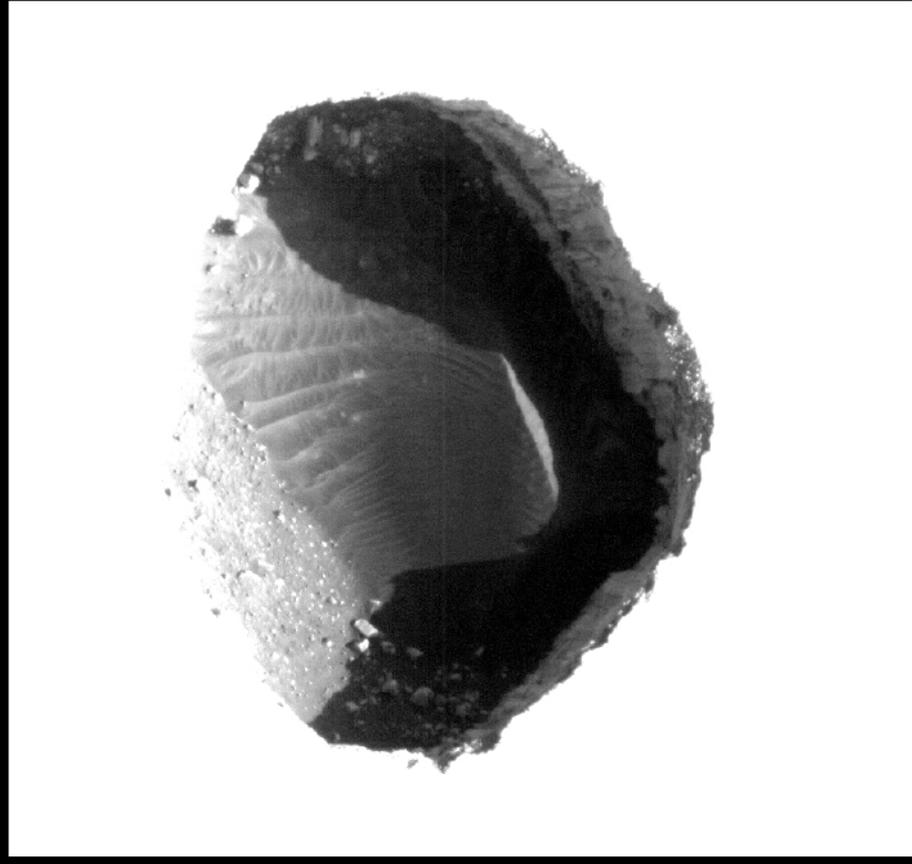
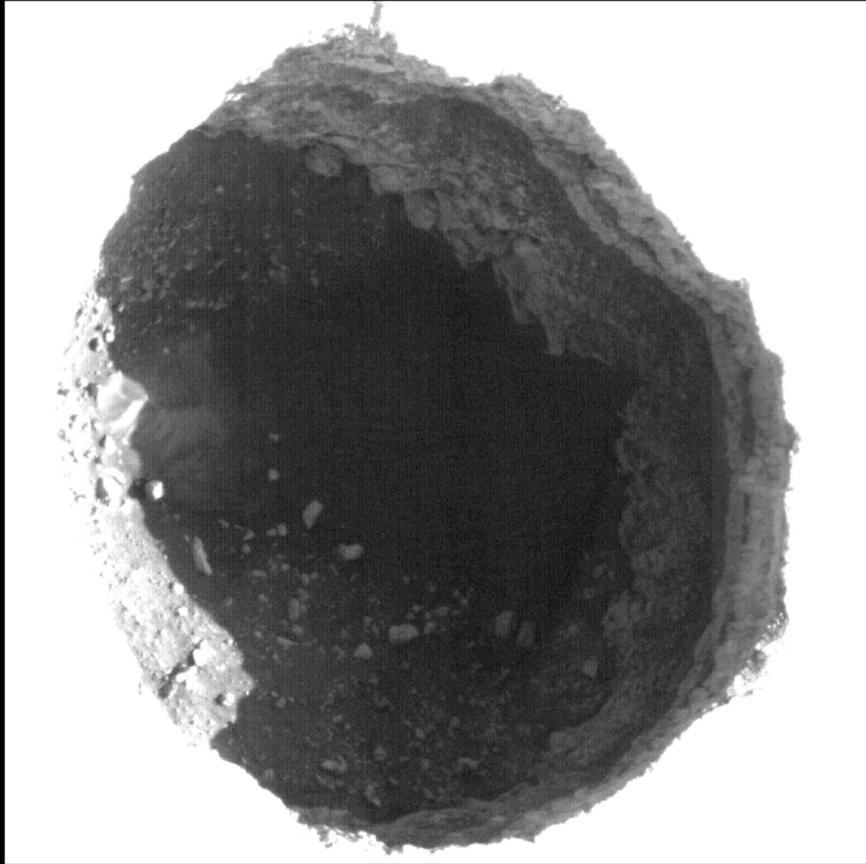
Earth and Mars share several features

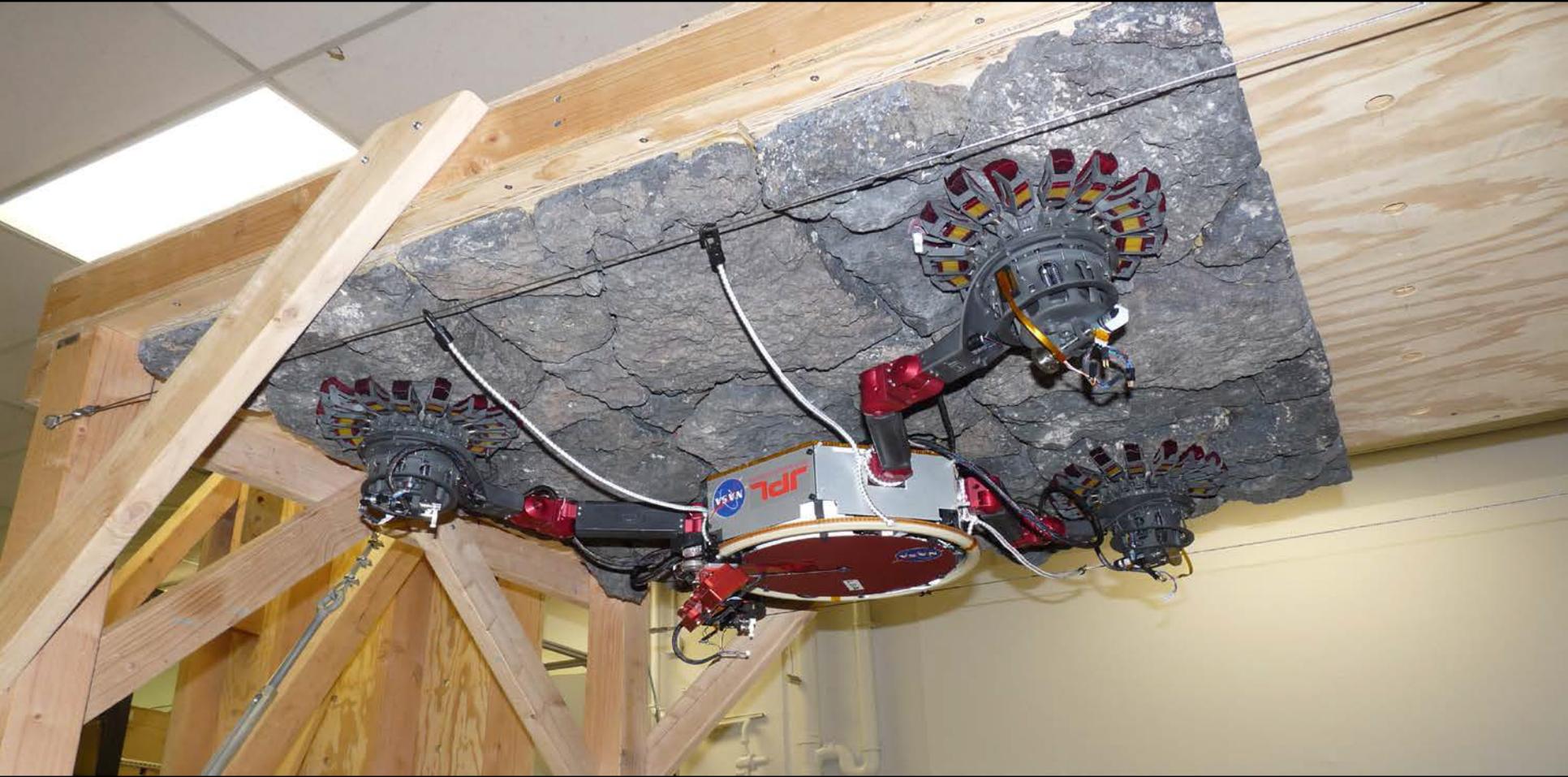
MY 29  
MY 30  
L\_s 0 autumn 90 winter 180 spring 270 summer 360

ESP\_011428\_1380





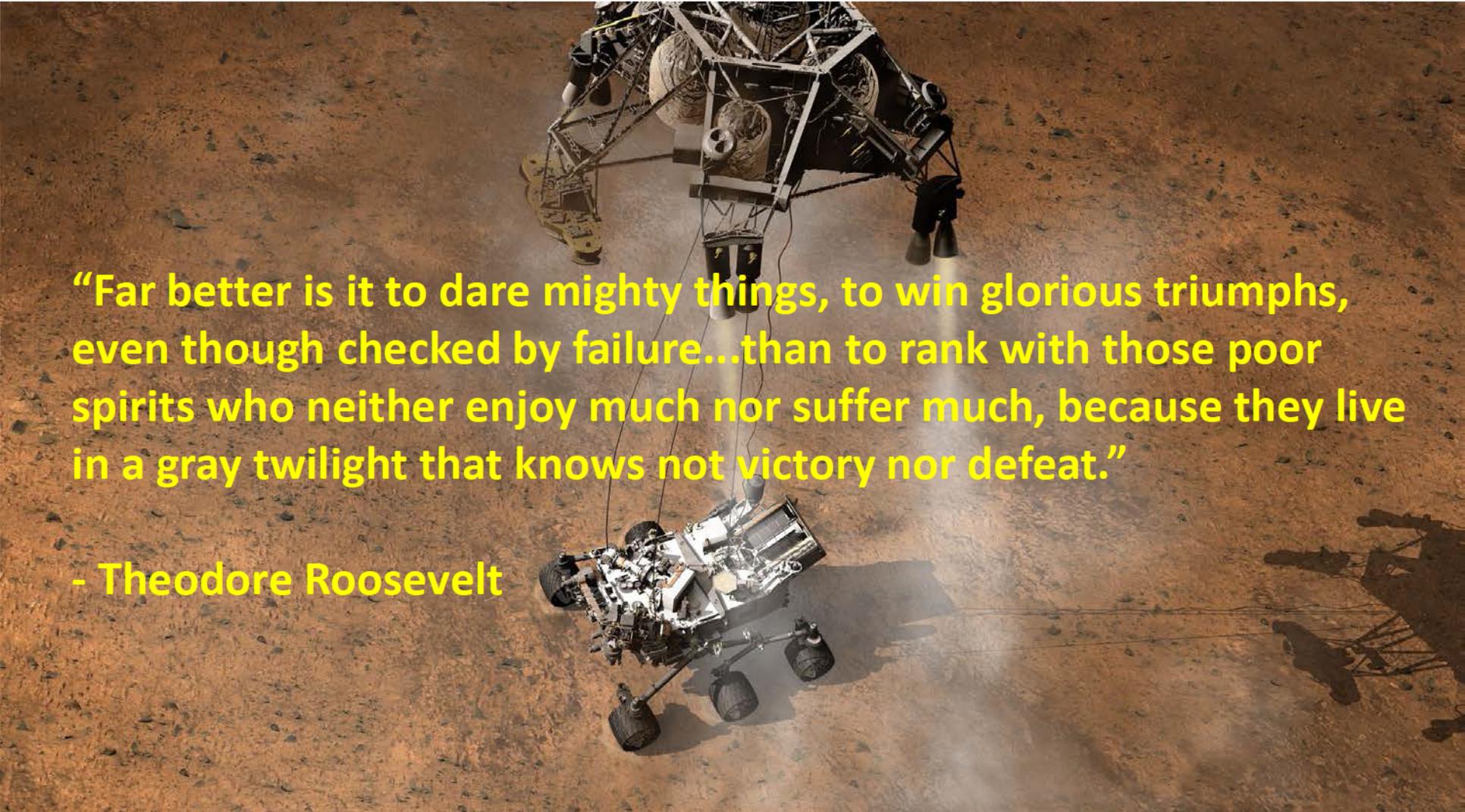






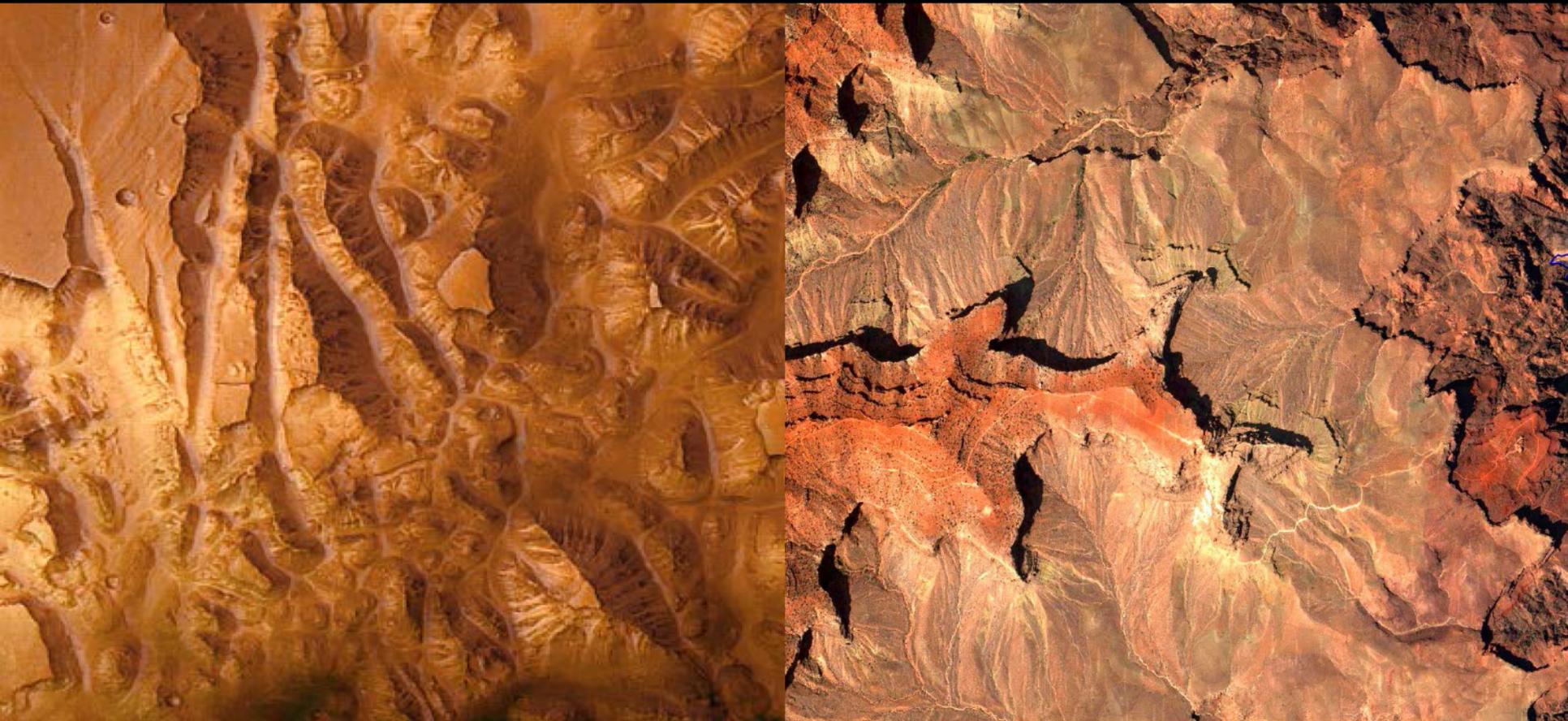
National Aeronautics and  
Space Administration  
Jet Propulsion Laboratory  
California Institute of  
Technology

# Thank You for Your Time

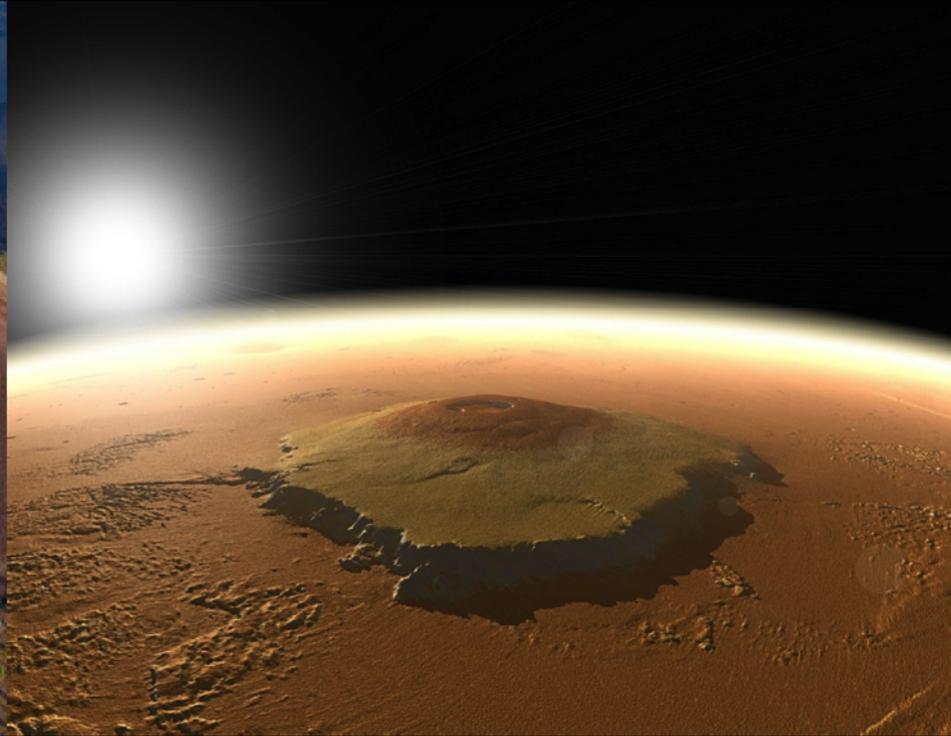
An aerial view of a Mars lander on the surface, with a rover being lowered by a crane. The lander is a large, complex structure with multiple legs and a central body. The rover is a smaller, six-wheeled vehicle with solar panels and various instruments. The ground is a reddish-brown, rocky surface.

**“Far better is it to dare mighty things, to win glorious triumphs,  
even though checked by failure...than to rank with those poor  
spirits who neither enjoy much nor suffer much, because they live  
in a gray twilight that knows not victory nor defeat.”**

**- Theodore Roosevelt**

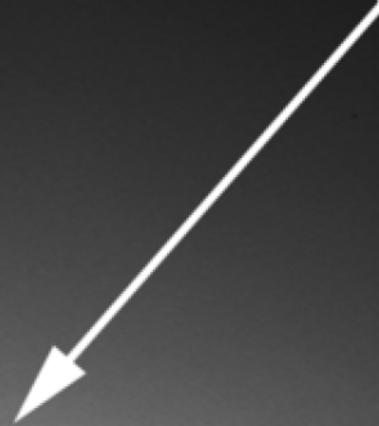


Grand Canyons



Great Volcanoes

**You are here**





0000

**You are here**





0000



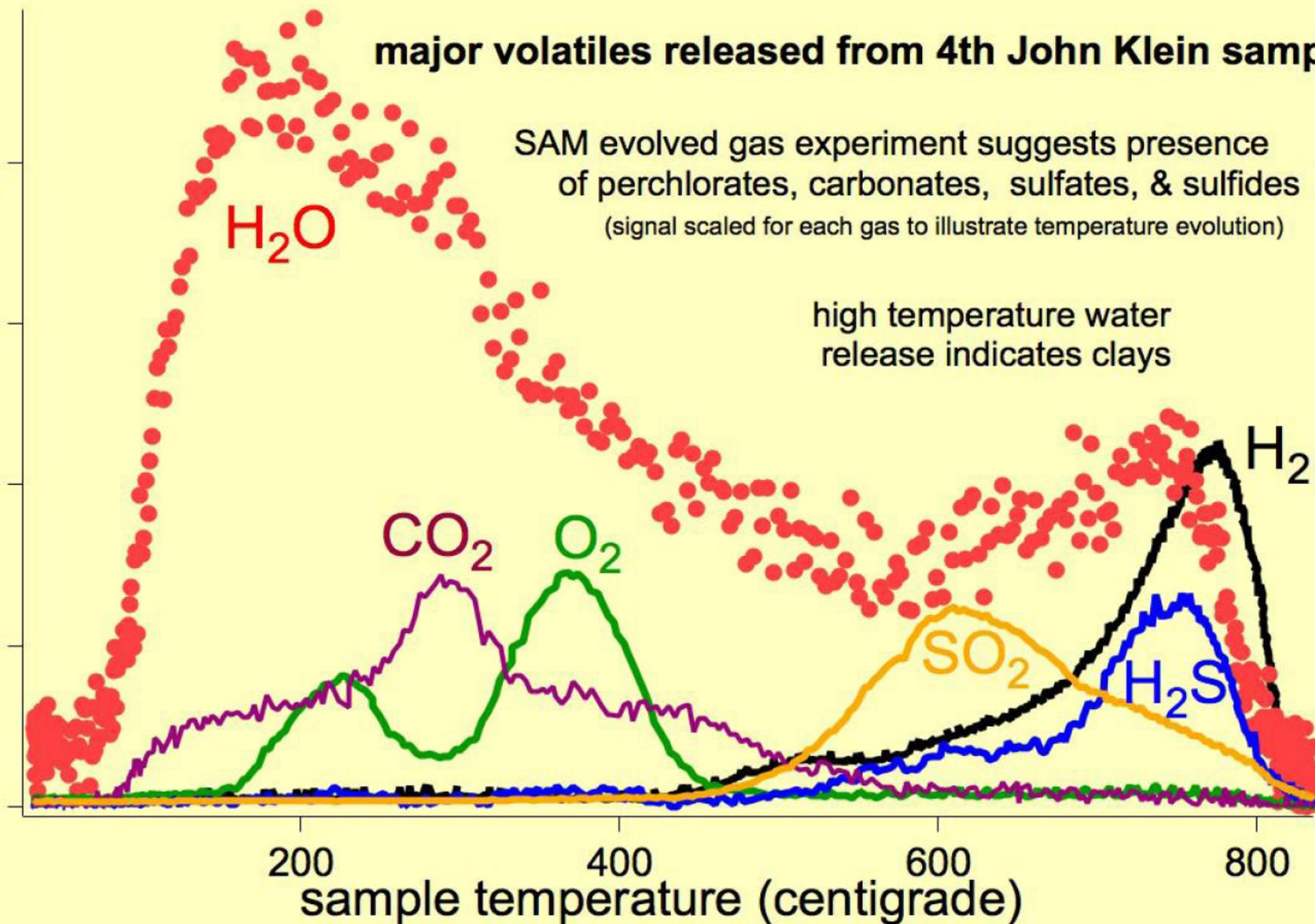
First mobility test  
*Curiosity*

# major volatiles released from 4th John Klein sample

SAM evolved gas experiment suggests presence of perchlorates, carbonates, sulfates, & sulfides  
(signal scaled for each gas to illustrate temperature evolution)

high temperature water release indicates clays

mass spectrometer signal



# **An Ancient Habitable Environment at Yellowknife Bay**

- **The regional geology and fine-grained rock suggest that the John Klein site was at the end of an ancient river system or within an intermittently wet lake bed**
- **The mineralogy indicates sustained interaction with liquid water that was not too acidic or alkaline, and low salinity. Further, conditions were not strongly oxidizing**
- **Key chemical ingredients for life are present, such as carbon, hydrogen, nitrogen, oxygen, phosphorus, and sulfur**
- **The presence of minerals in various states of oxidation would provide a source of energy for primitive organisms**