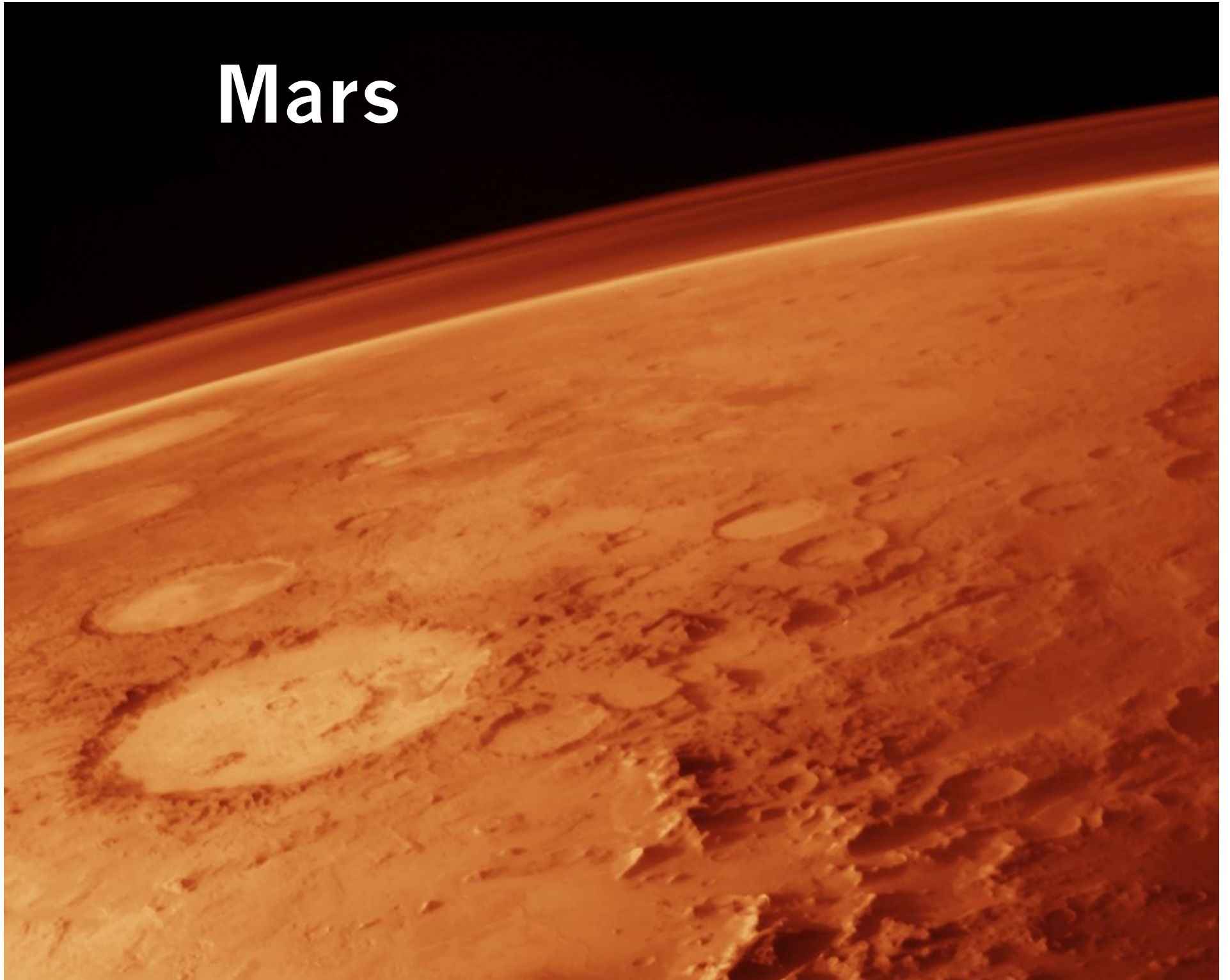


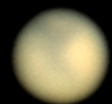
# Mars



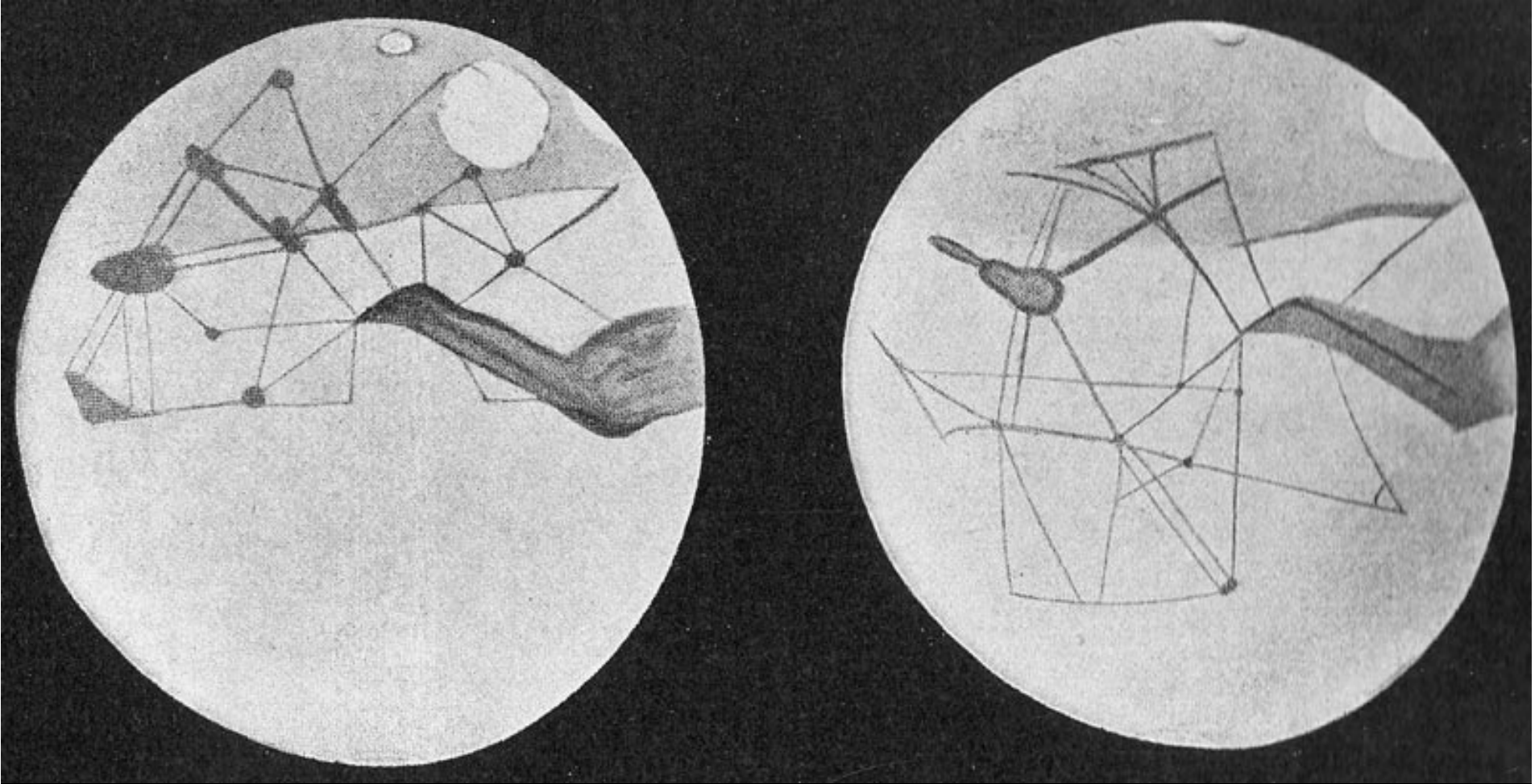
# Big Questions

- What have we learned by studying Mars?
- How does studying Mars relate to the Search for Life in the Universe?





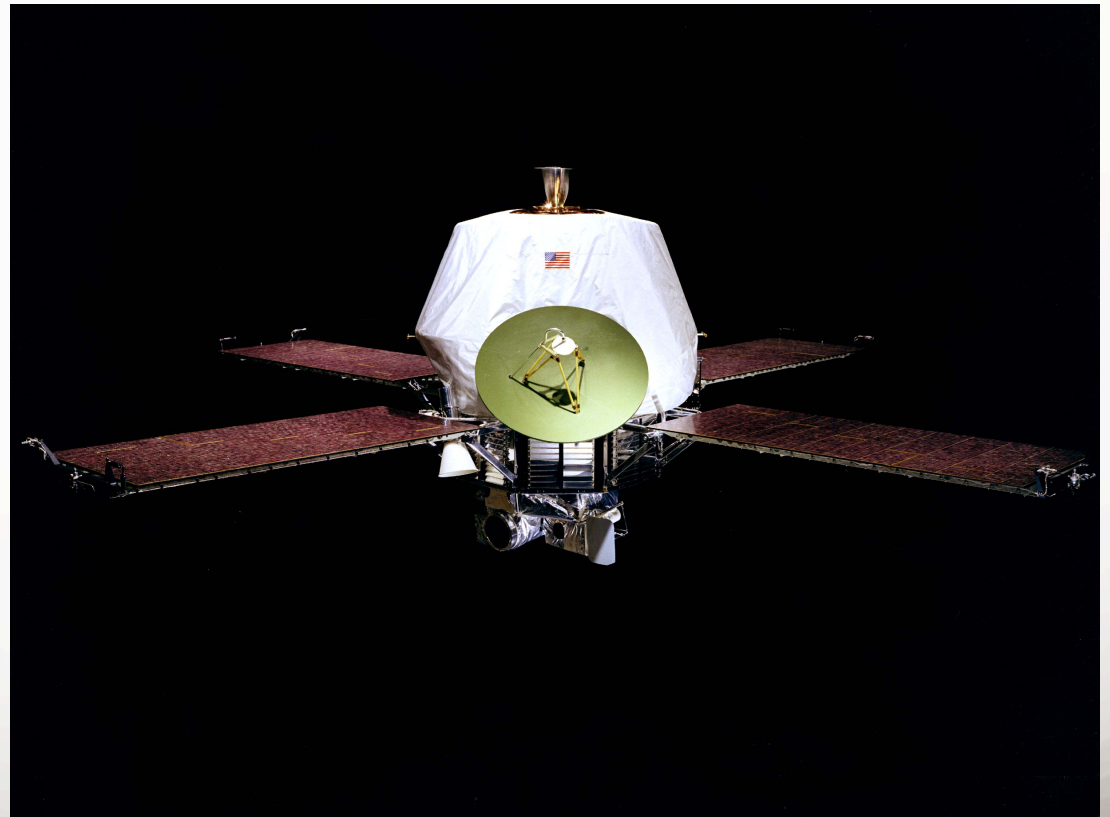
## Early Observations of Mars



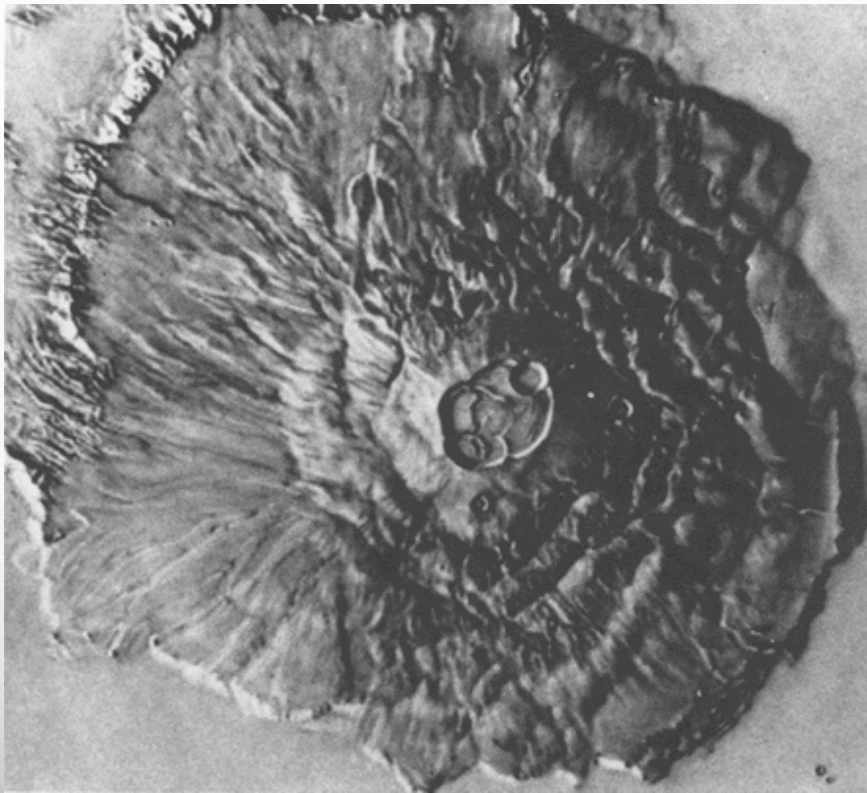
Late 1800s, early 1900s – multiple scientists see “canals” or “channels” on Mars

# Mariner Missions

- 1962 – 1973
- 10 spacecrafts to study Mercury, Venus, and Mars
- Flybys and orbiters
- Got close up images of surface
- Learned a lot about the surface and atmosphere of Mars



# Mariner 9 images Martian Surface



# Properties of Mars



# Mars compared to Earth

Earth diameter: ~12,000 km

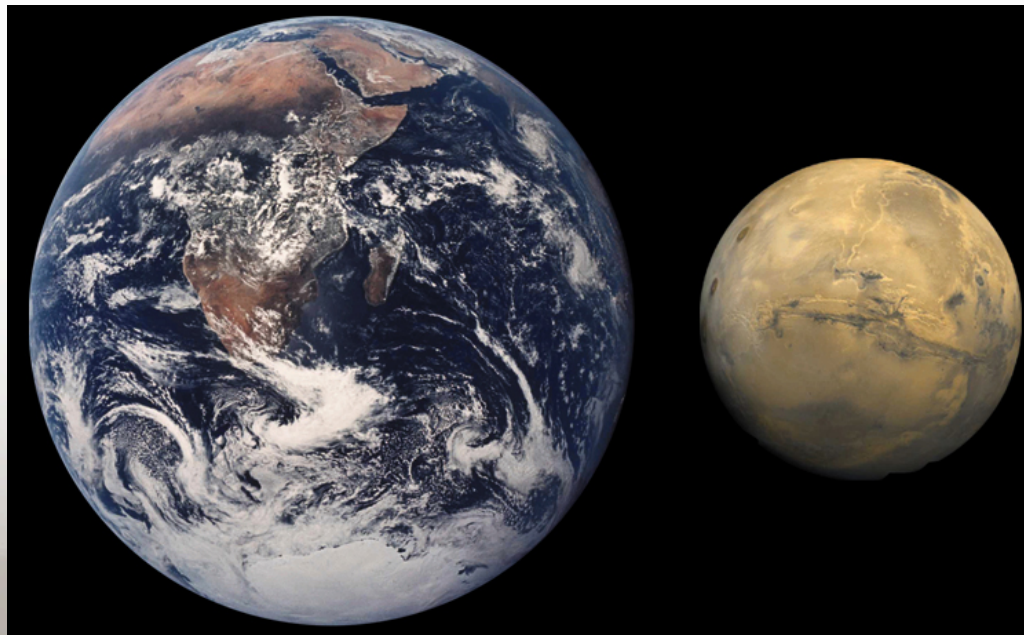
Mars diameter: ~6000 km

Average Earth Temp: 56.93° F

Average Mars Temp: -67.3° F

Air pressure on Earth: 100,000 Pa

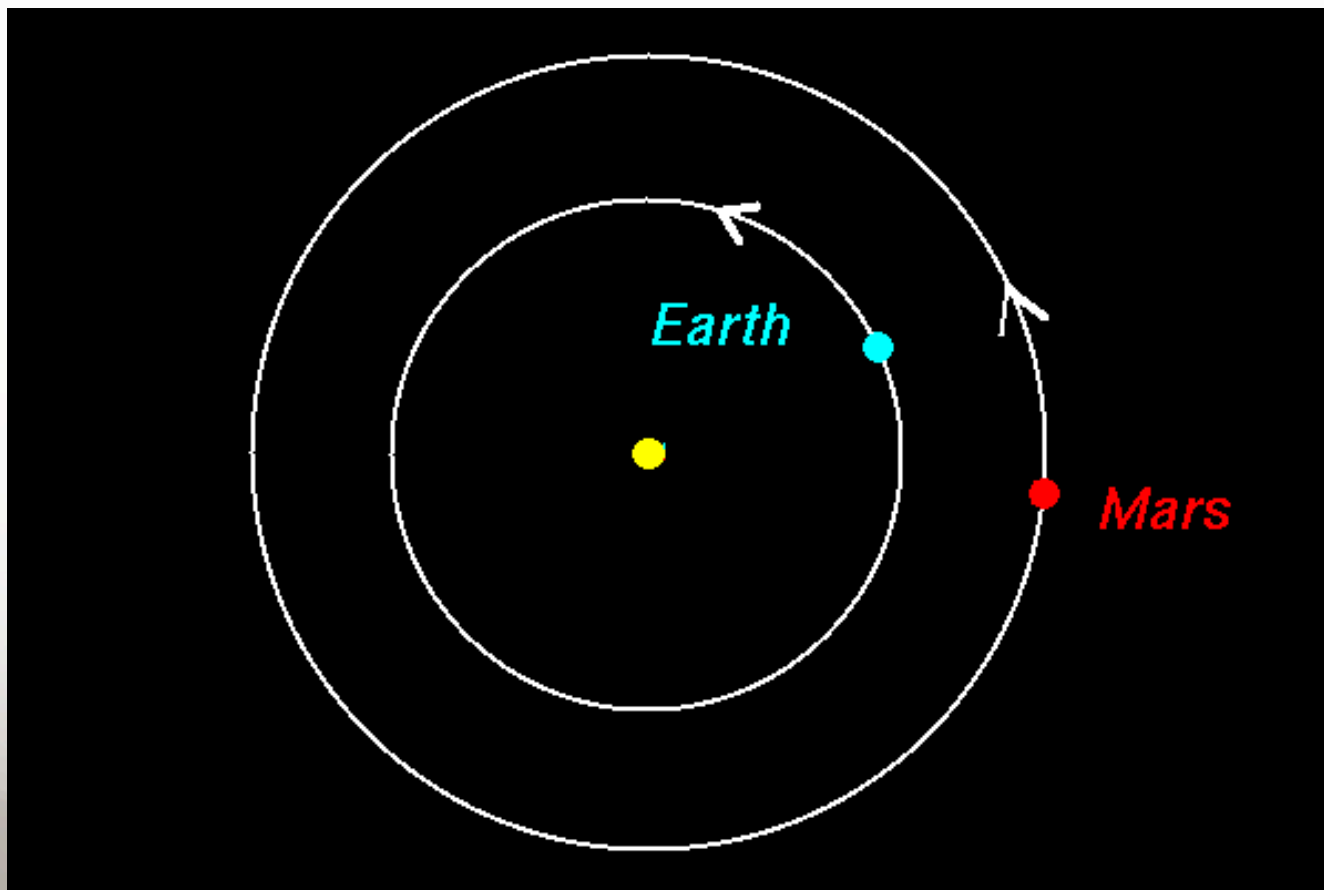
Air pressure on Mars: 600 Pa



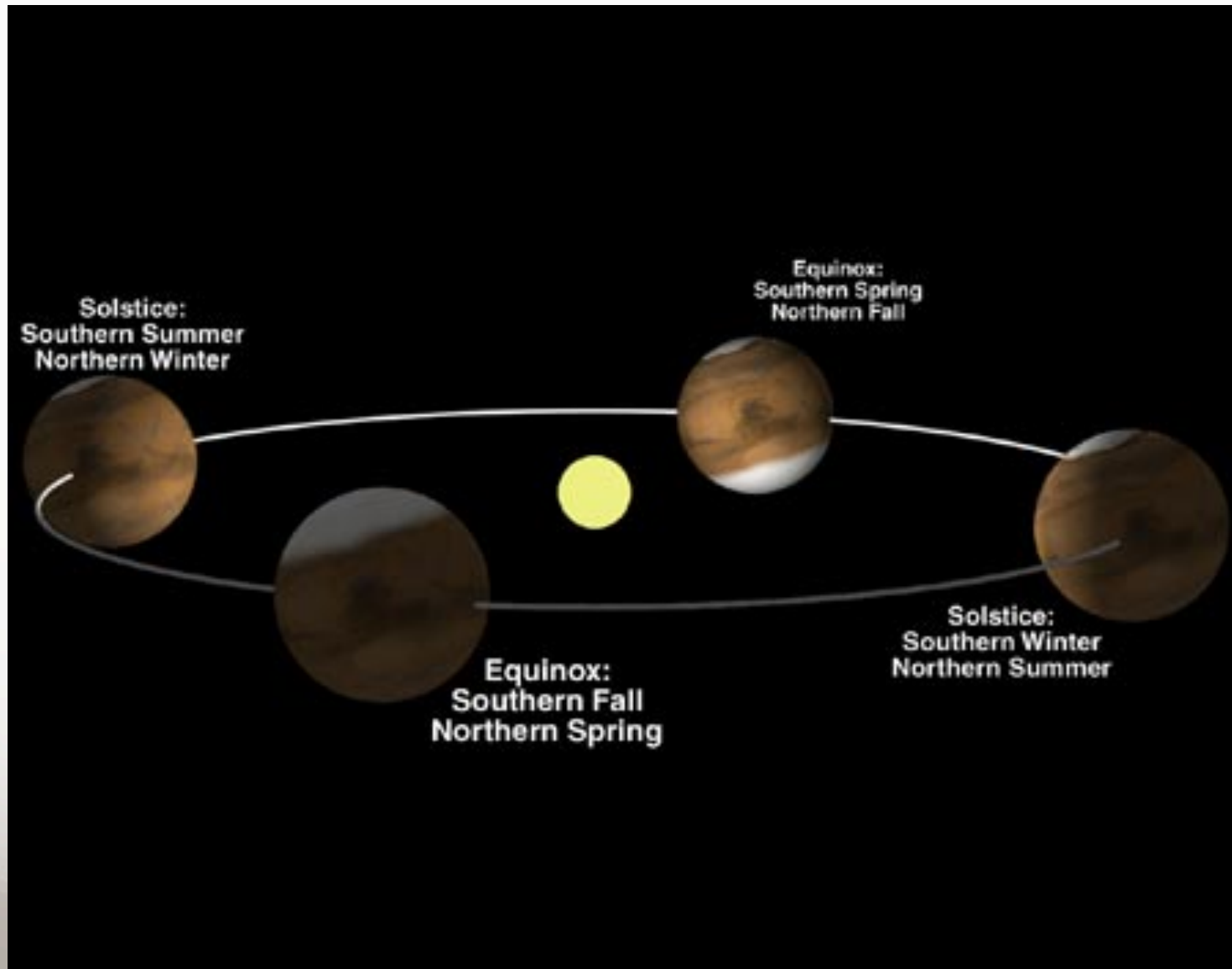
# Mars in the Solar System

One day on Mars = 24 Earth hours 37 min

One year on Mars = 686.6 Earth days



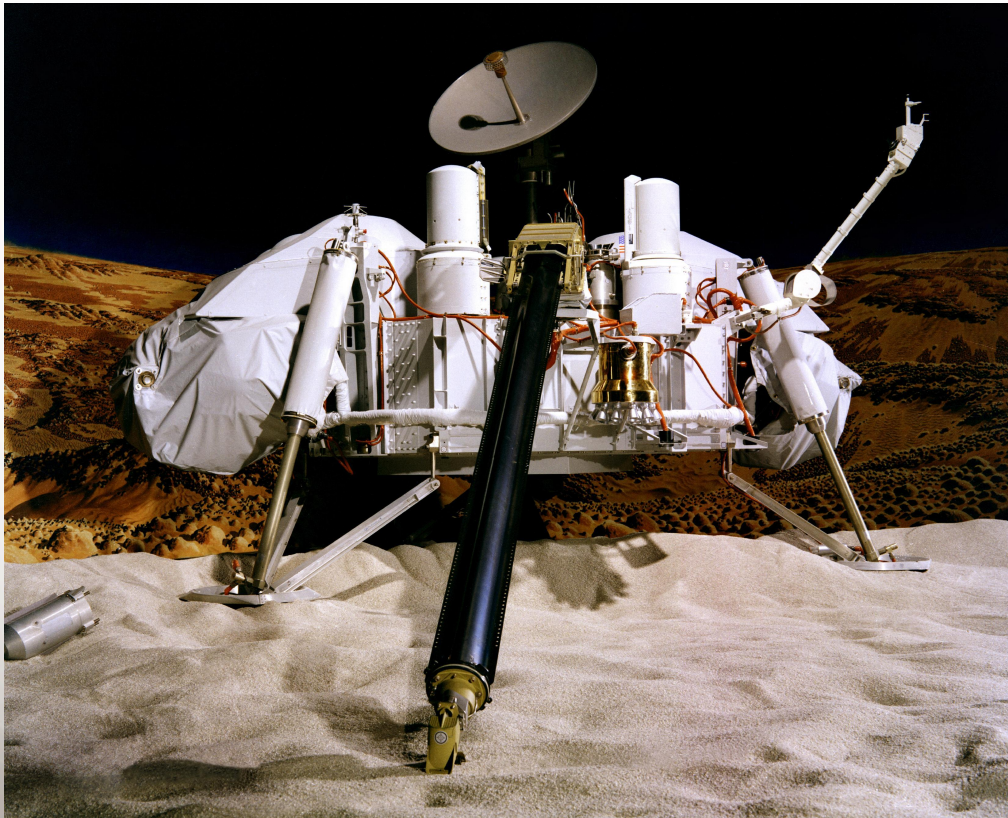
# Seasons on Mars



# What does this mean for Life

- Based on what you just heard, why are we interested in the red planet?

# Searching for Life with the Viking Missions

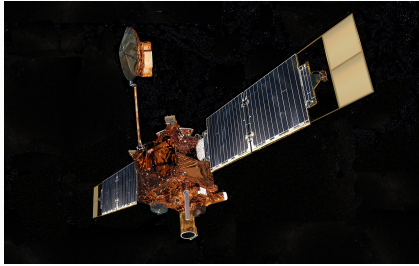


- Launched 1975
- 2 orbiters and 2 landers
- Landers performed biological experiments to look for micro-organisms

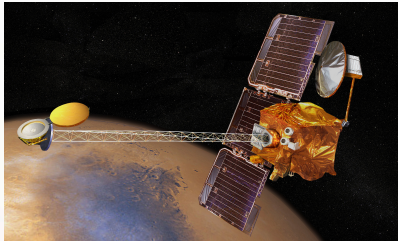
# Findings from Viking Missions

- No evidence of micro-organisms found
- Martian soil = iron rich clay
- Very little seismic activity detected
- Polar regions have both Water and CO<sub>2</sub> caps
  - Yearly pressure changes of 30% due to sublimation of CO<sub>2</sub> from North Pole
- Evidence of dry river beds

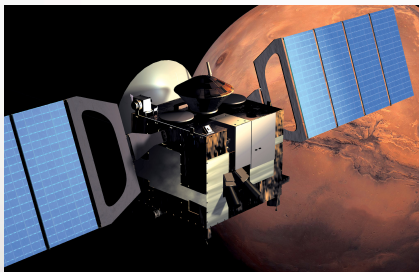
# Successful Orbiters



- Mars Global Surveyor – 1992



- Mars Odyssey – 2001

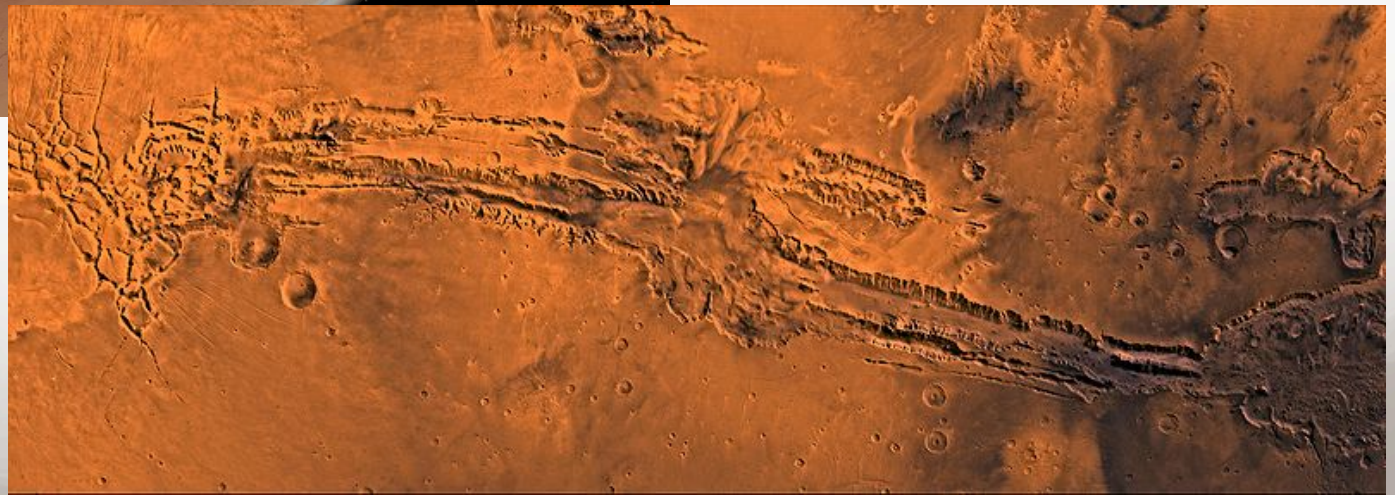


- Mars Express – 2003

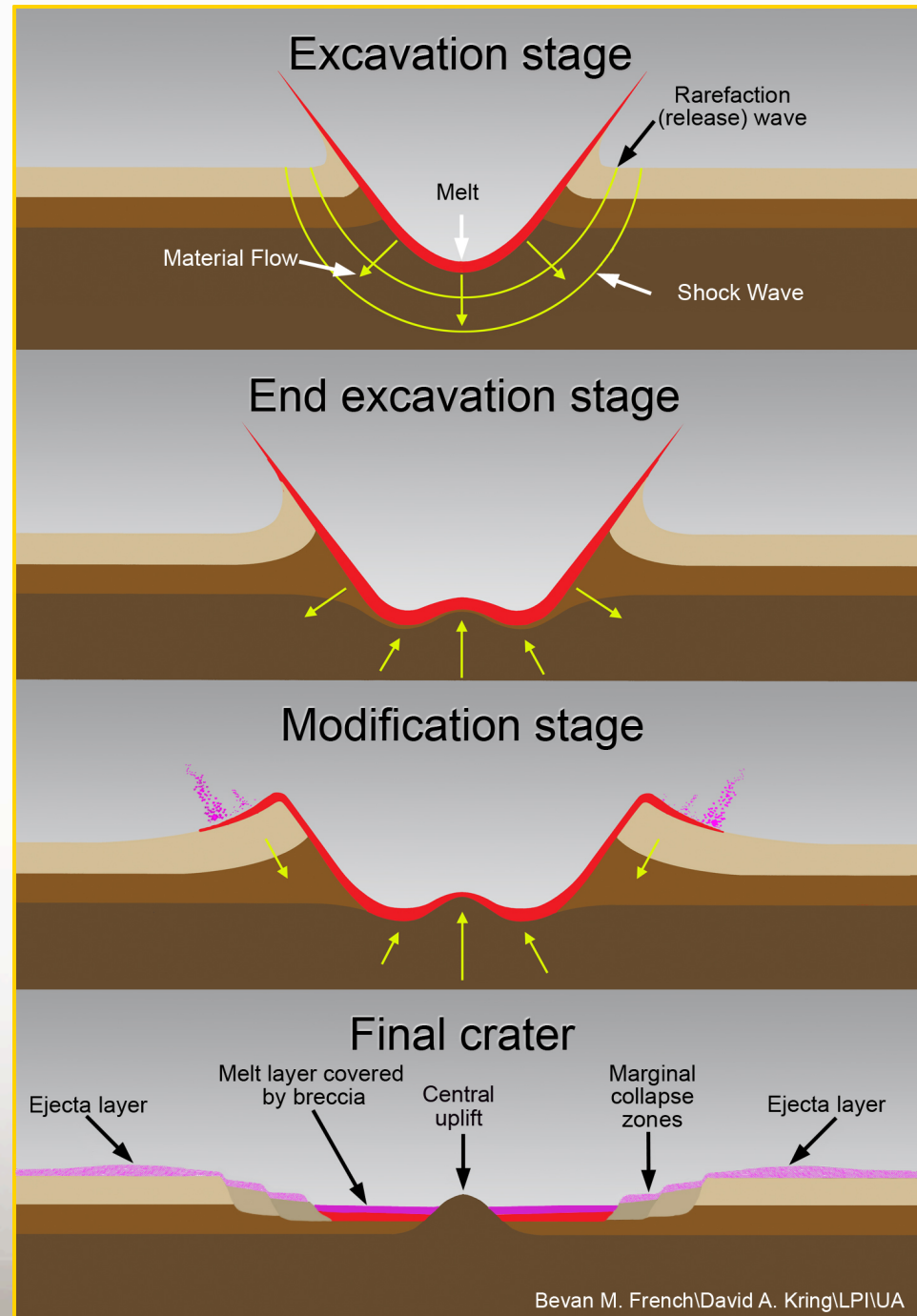


- Mars Reconnaissance Orbiter - 2005

# Geology on Mars

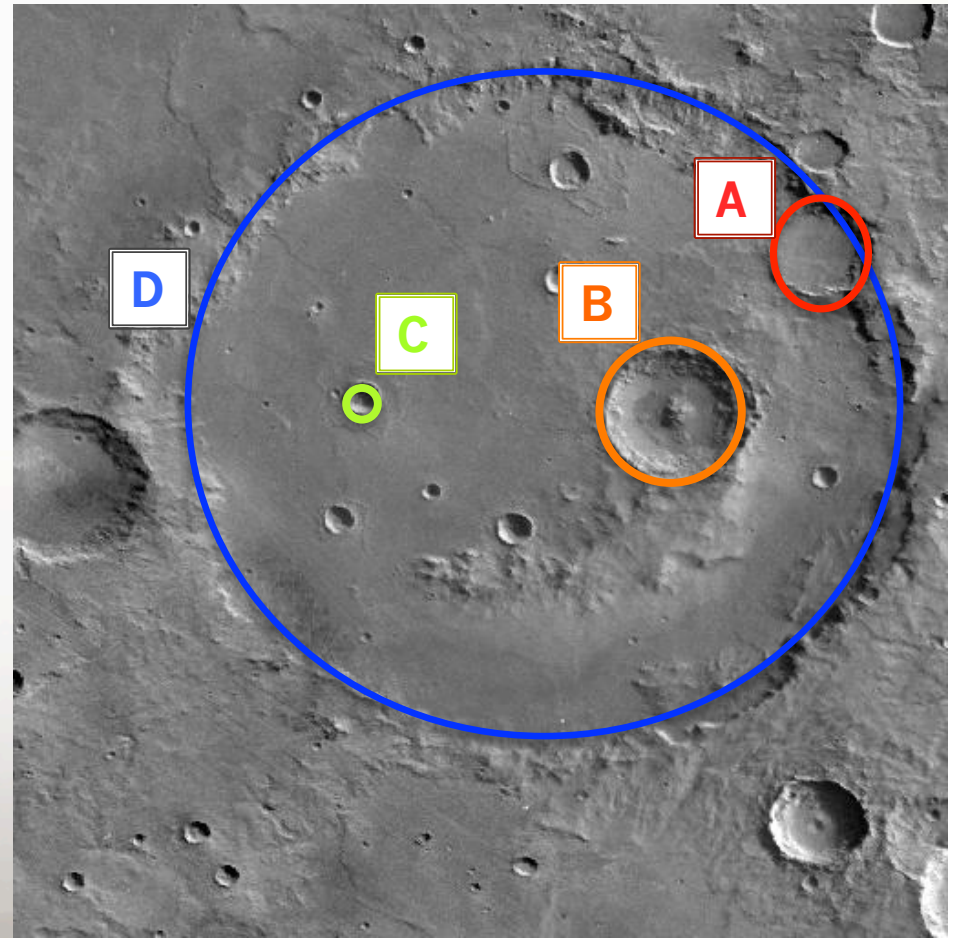
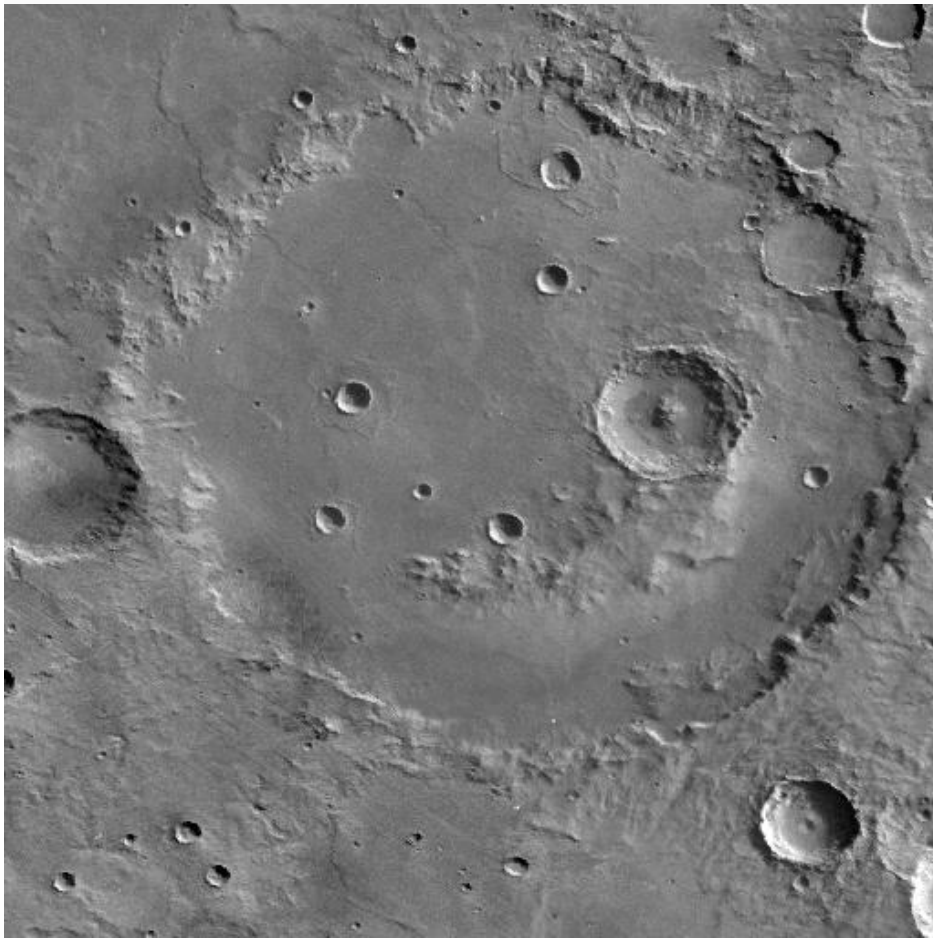


# Craters on Mars

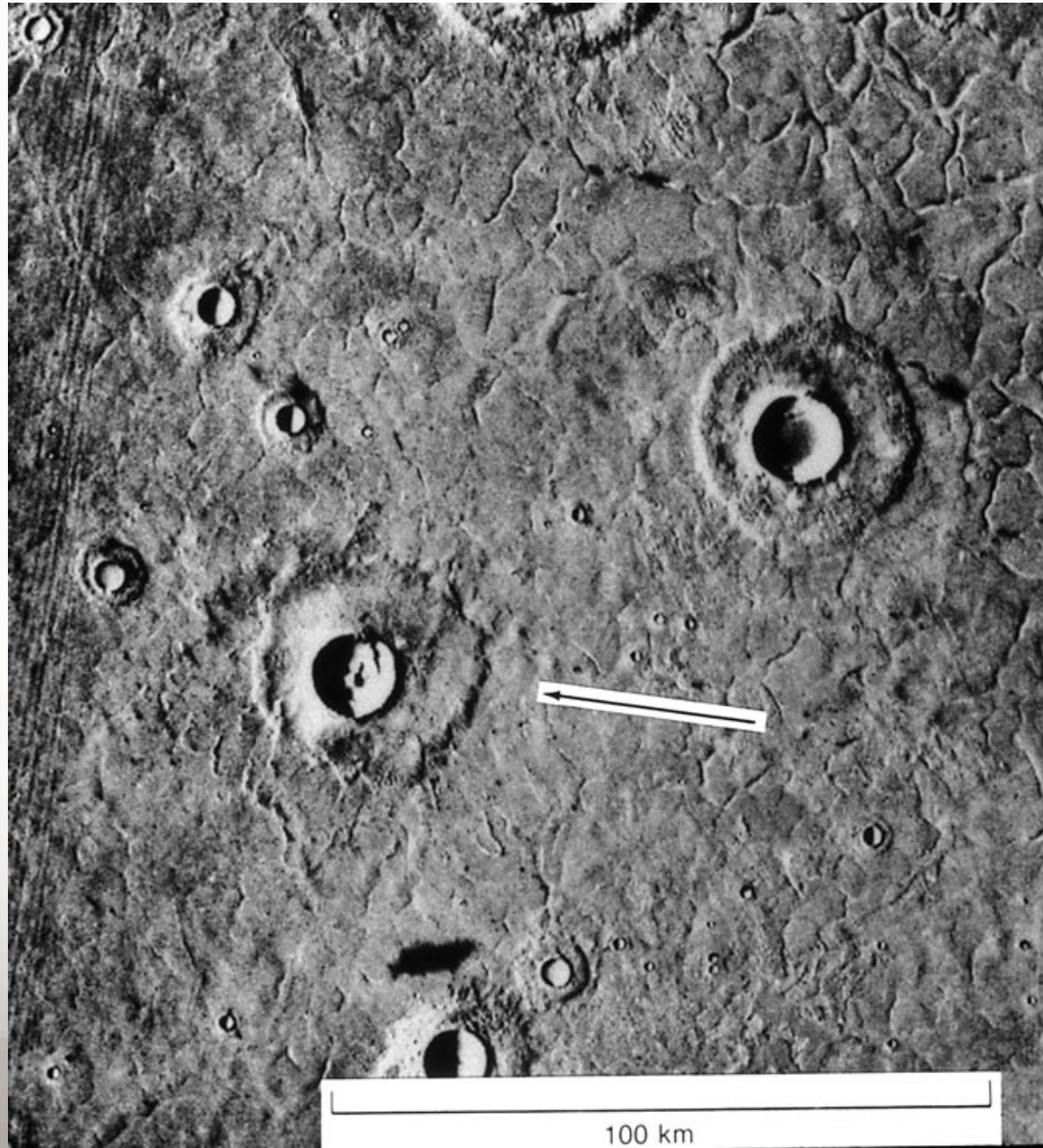


# Clicker Question

- Which colored crater is the oldest?



## Ejecta from craters



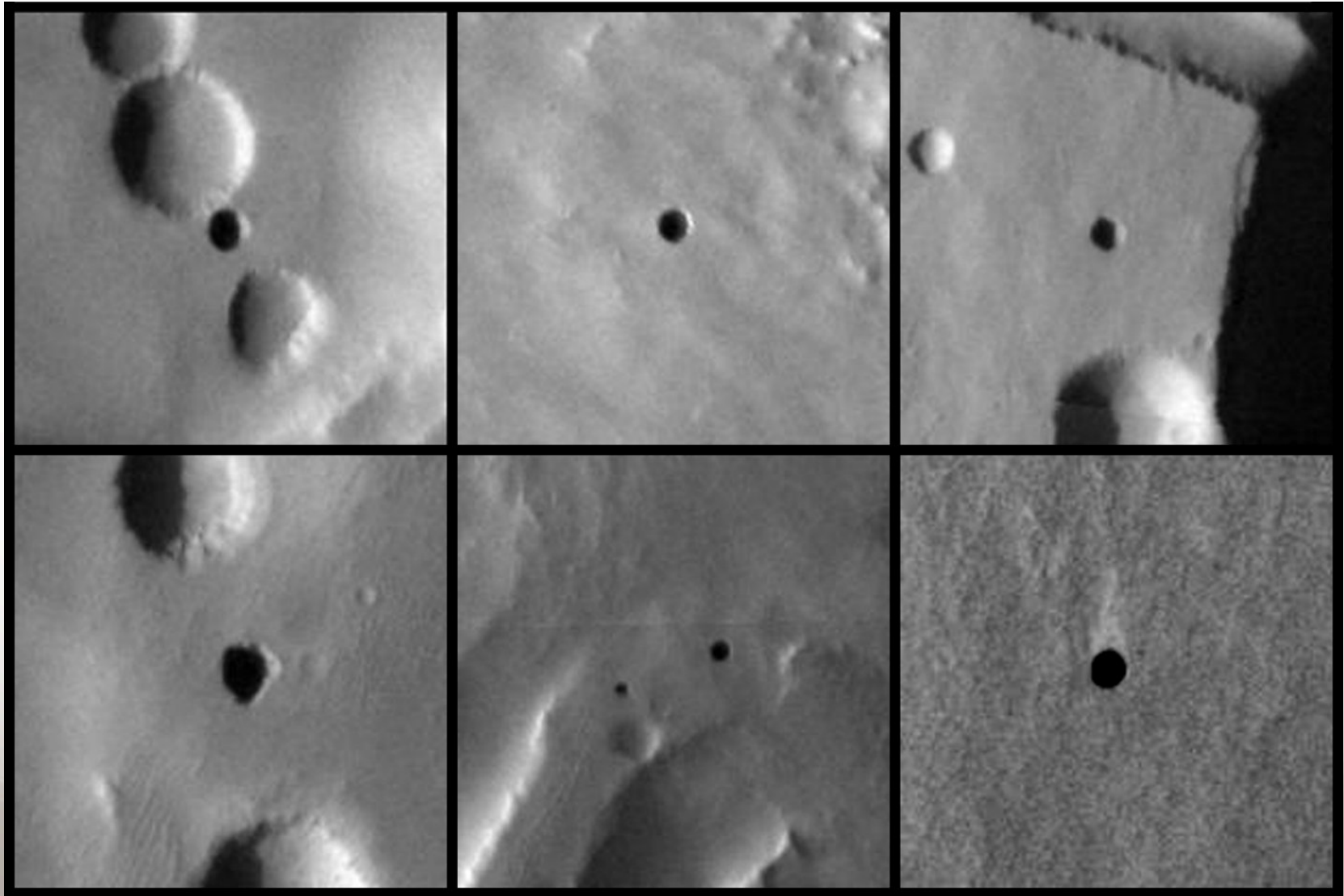
## Flows through cratered areas



# Caves on Mars



# Caves on Mars

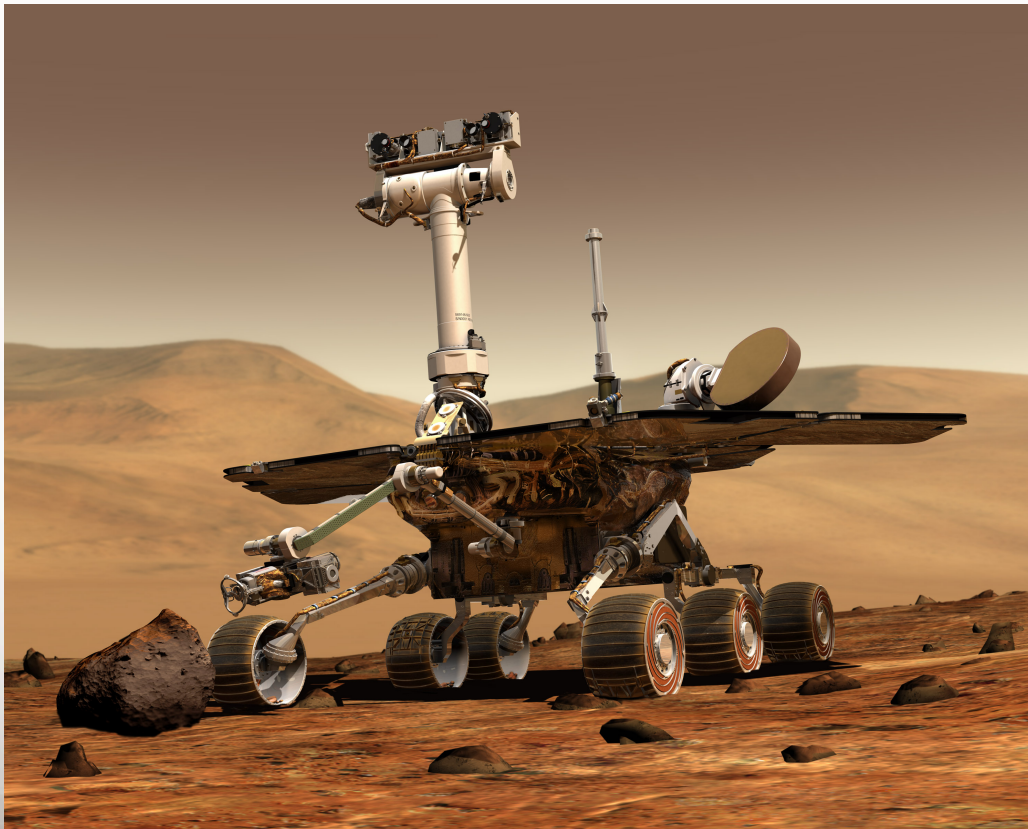


# Pathfinder



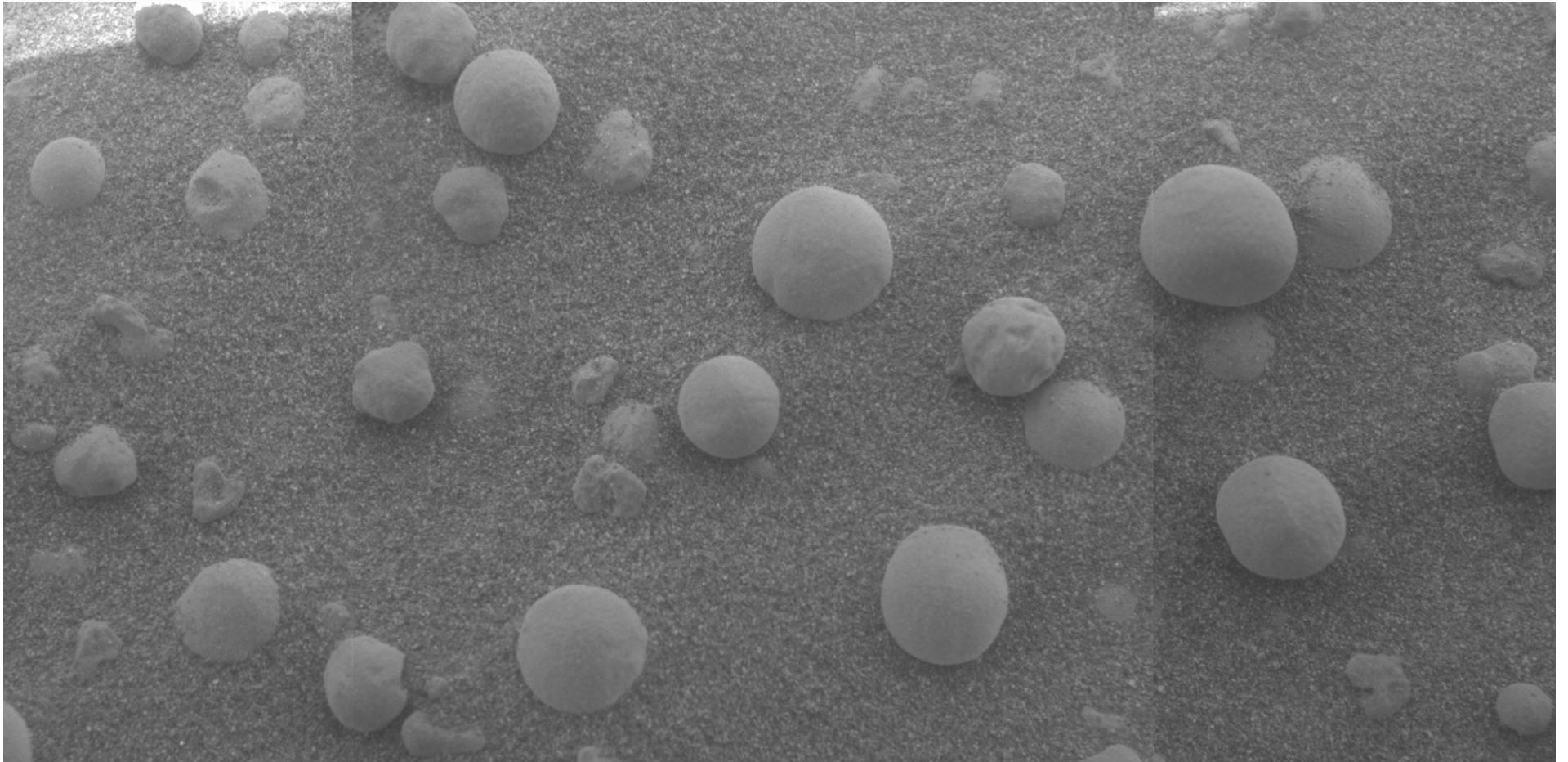
- Lander
- Launched 1996
- Mostly a technology mission
- Determined soil composition
- Observed dust devils on Mars
- Determined that Mars had metallic core

# Mars Exploration Rovers

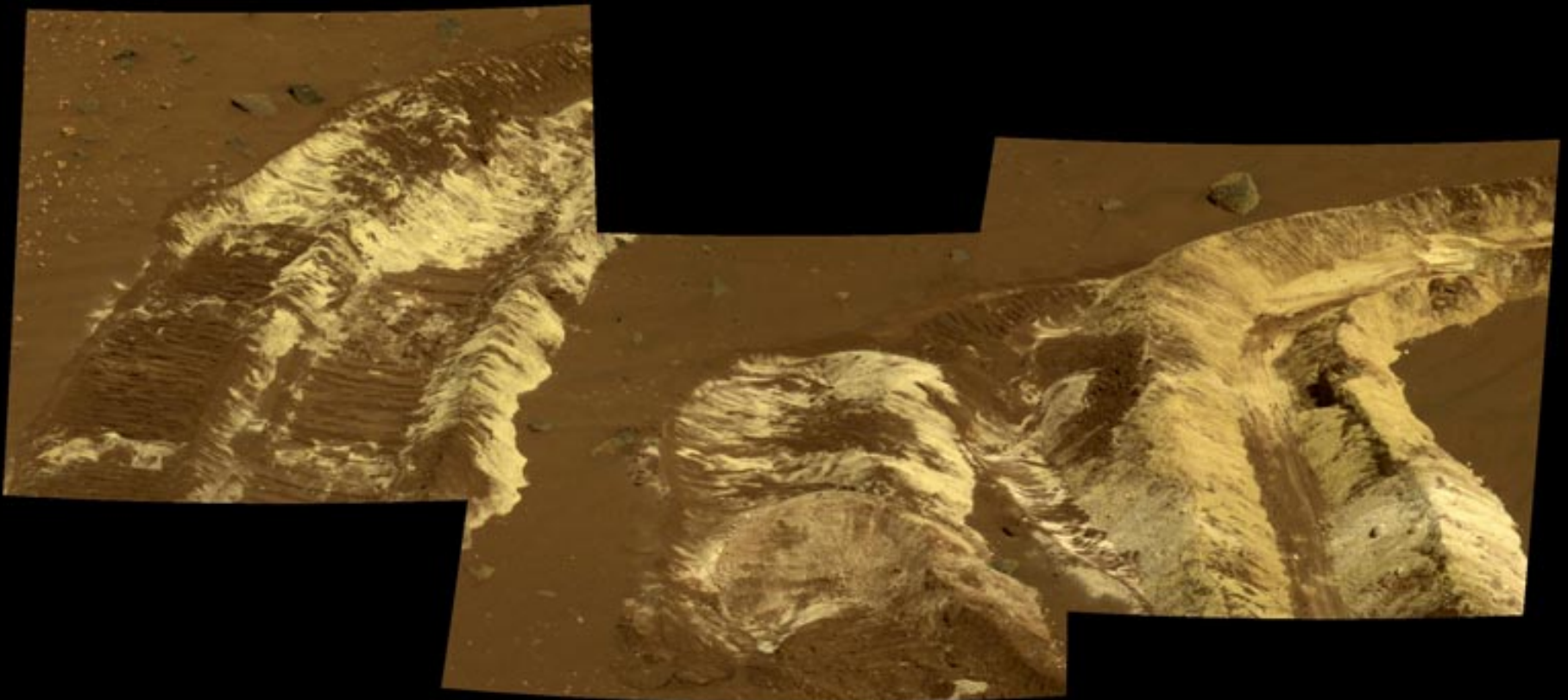


- 2 land rovers
- Launched 2003
- Follow the water

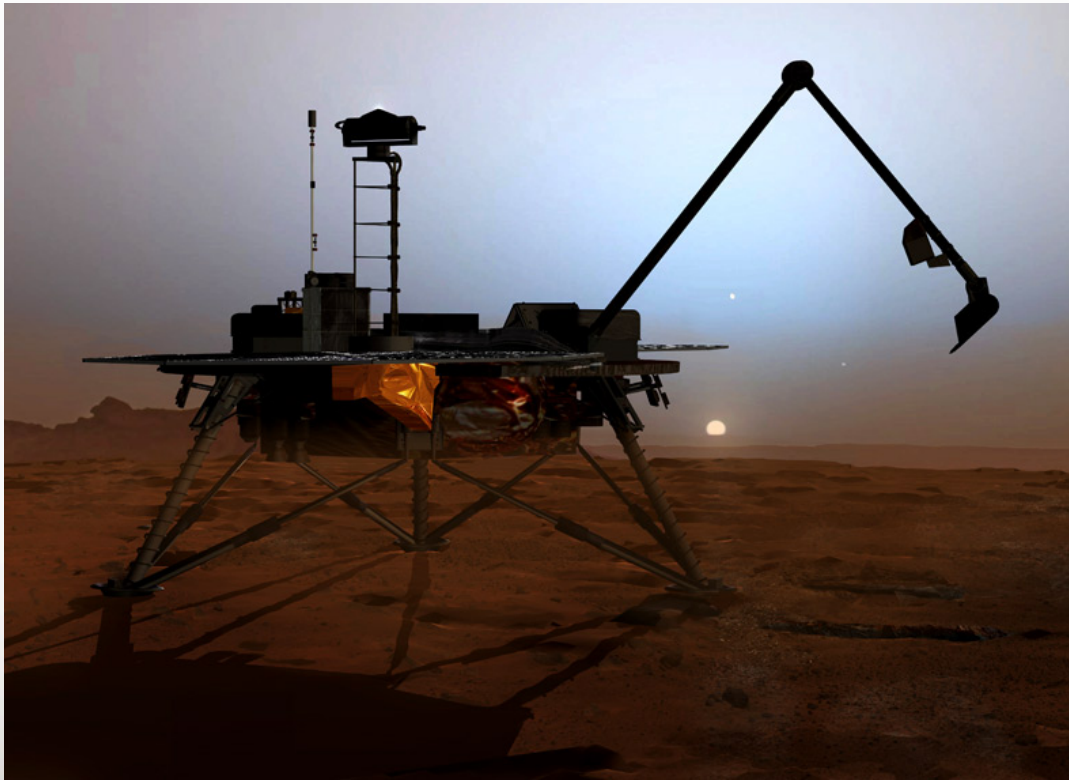
# Evidence of Water on Mars



# Evidence of Water on Mars

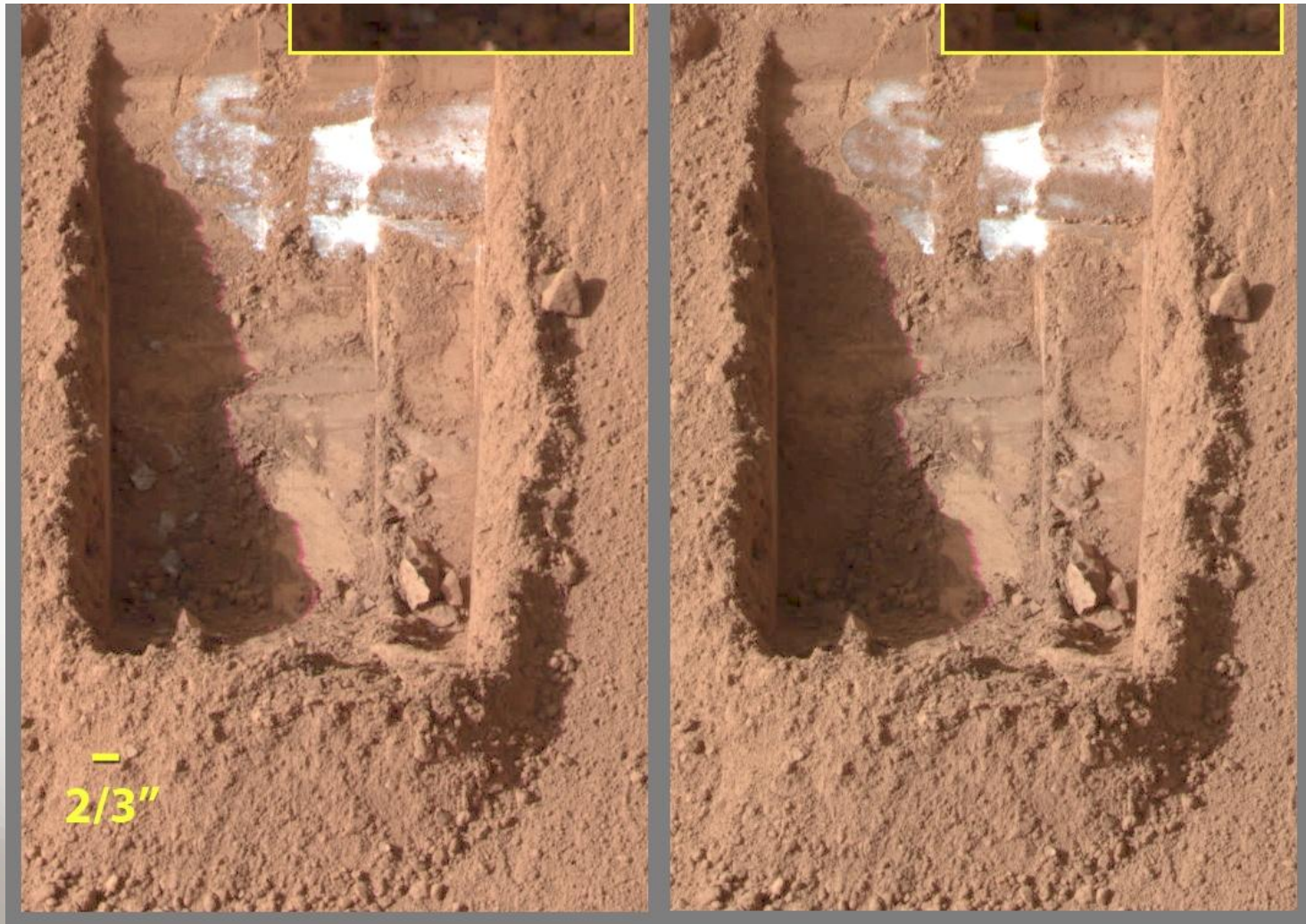


# Phoenix

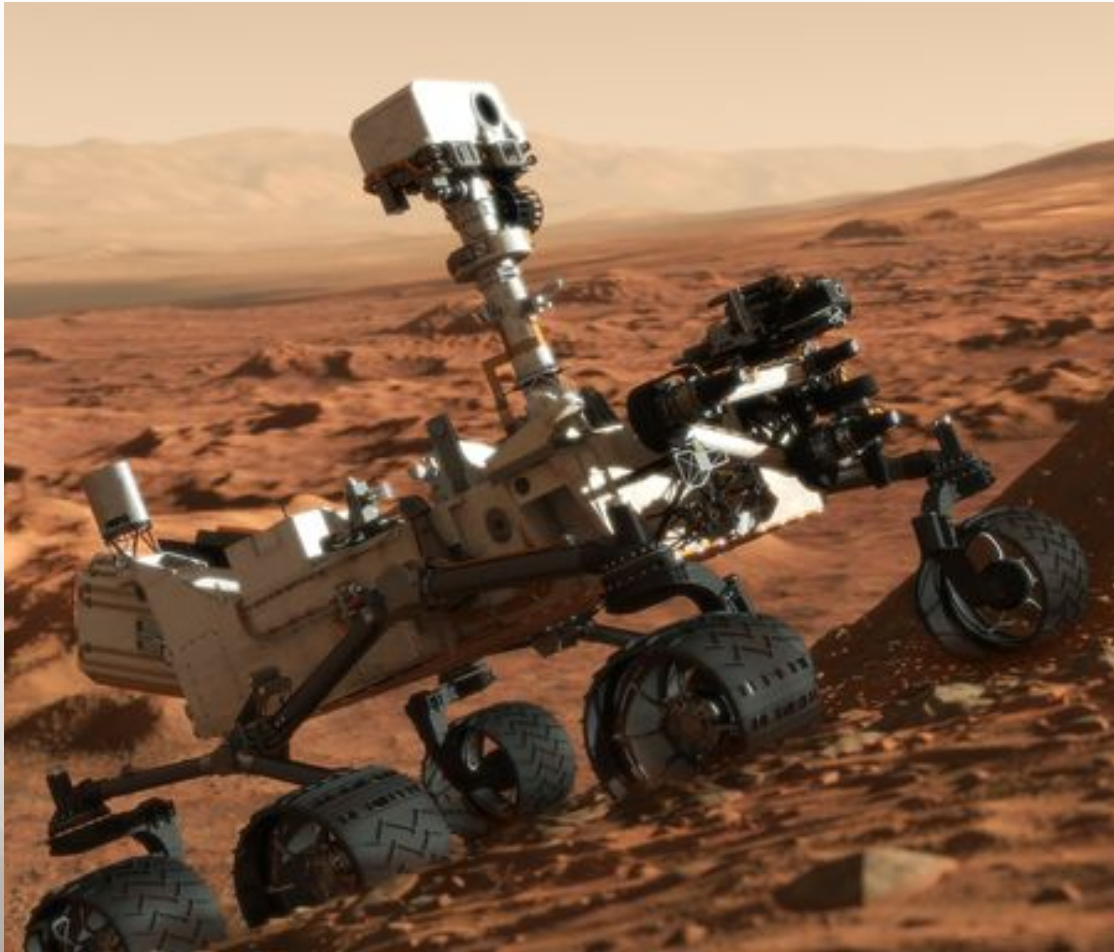


- Lander
- Launched 2008
- Goal was to “Follow the Water”
- Scraped surface of Mars to study ice underneath
- Detected calcium carbonate – an indication that there may have been water on the surface in the past

# Phoenix Mission

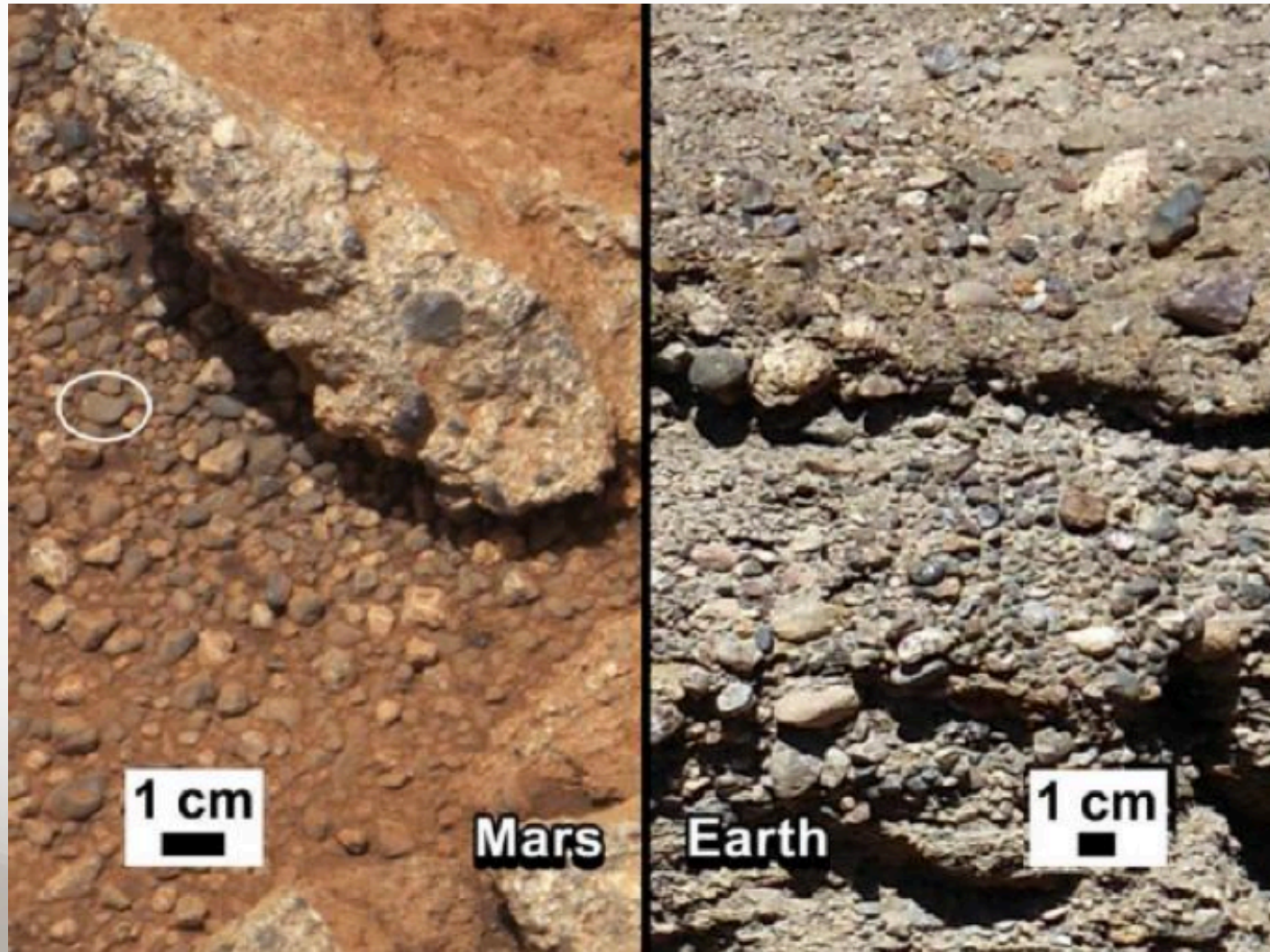


# Mars Science Lab (MSL)



- “Curiosity”
- Landed August 2012
- Sky crane
- Found evidence of dry river beds Mars
- Found that Martian soil is ~2% water by weight

# Evidence of Water on Mars

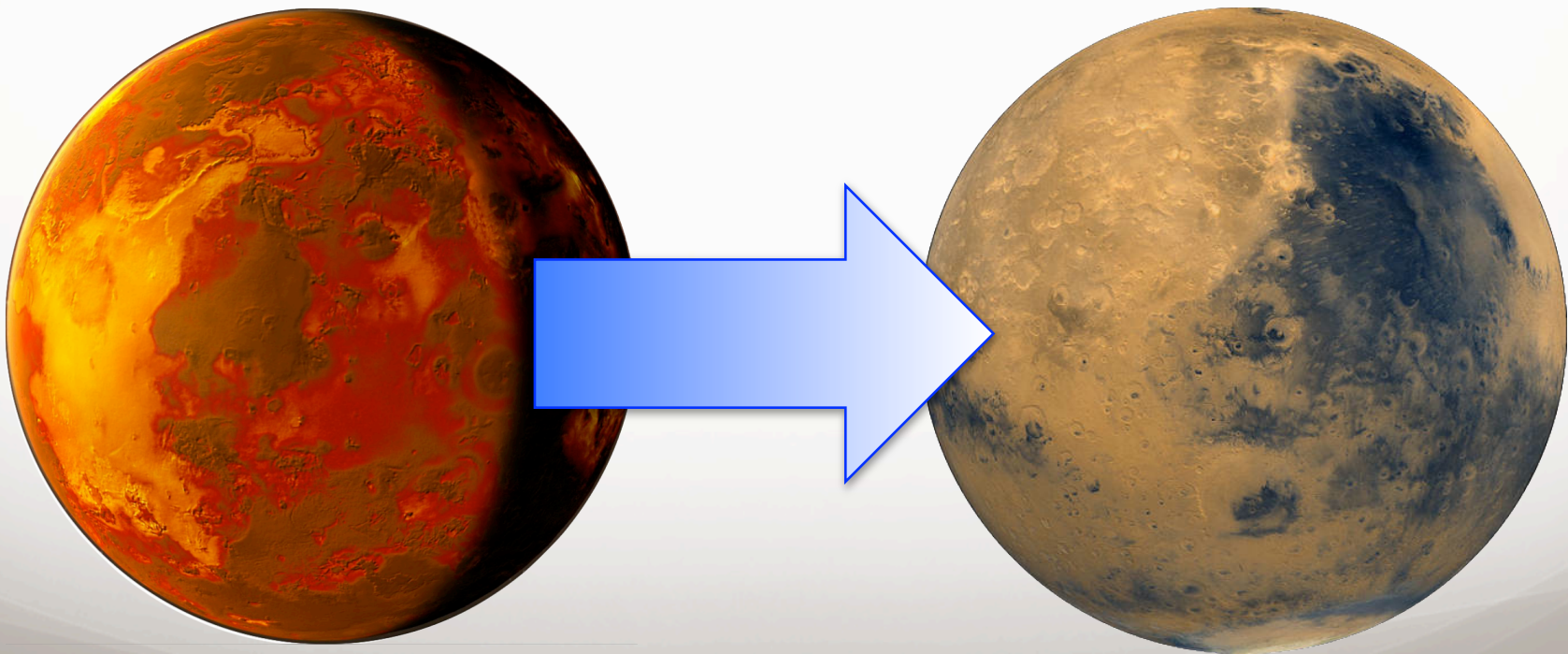


# Changes on Mars

- We have evidence that Mars used to have geologic activity and water
- What happened to Mars that changed it?
- Mars lost its atmosphere

# How did Mars lose its atmosphere

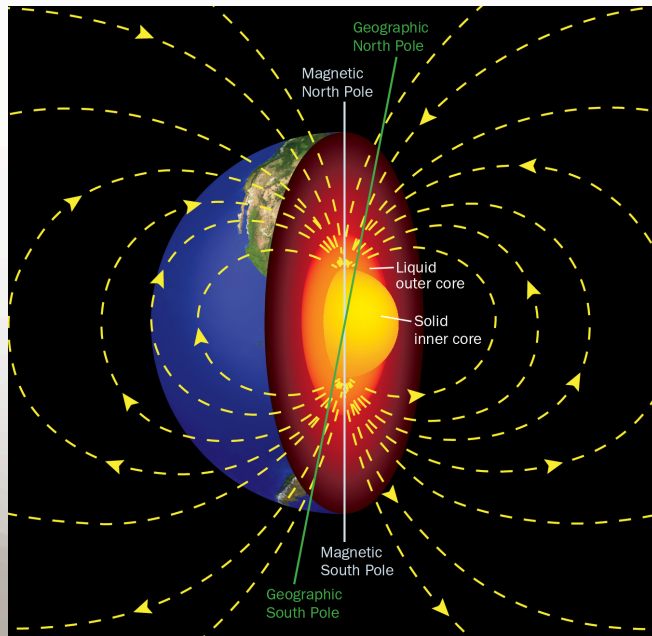
## 1. Mars cooled off



# How did Mars lose its atmosphere

## 1. Mars cooled off

- No more magnetic field
- Geologic activity stops

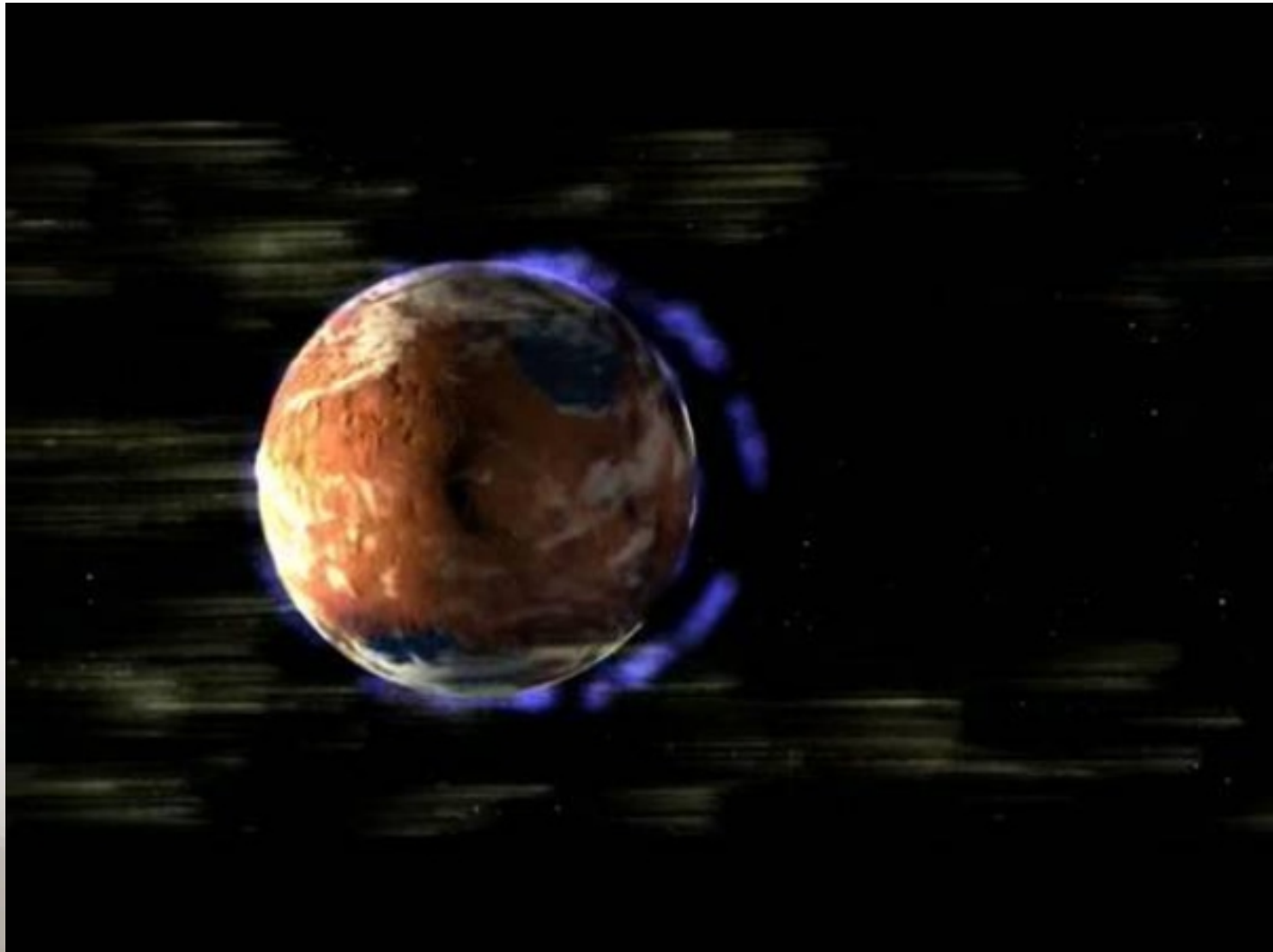


# How did Mars lose its atmosphere

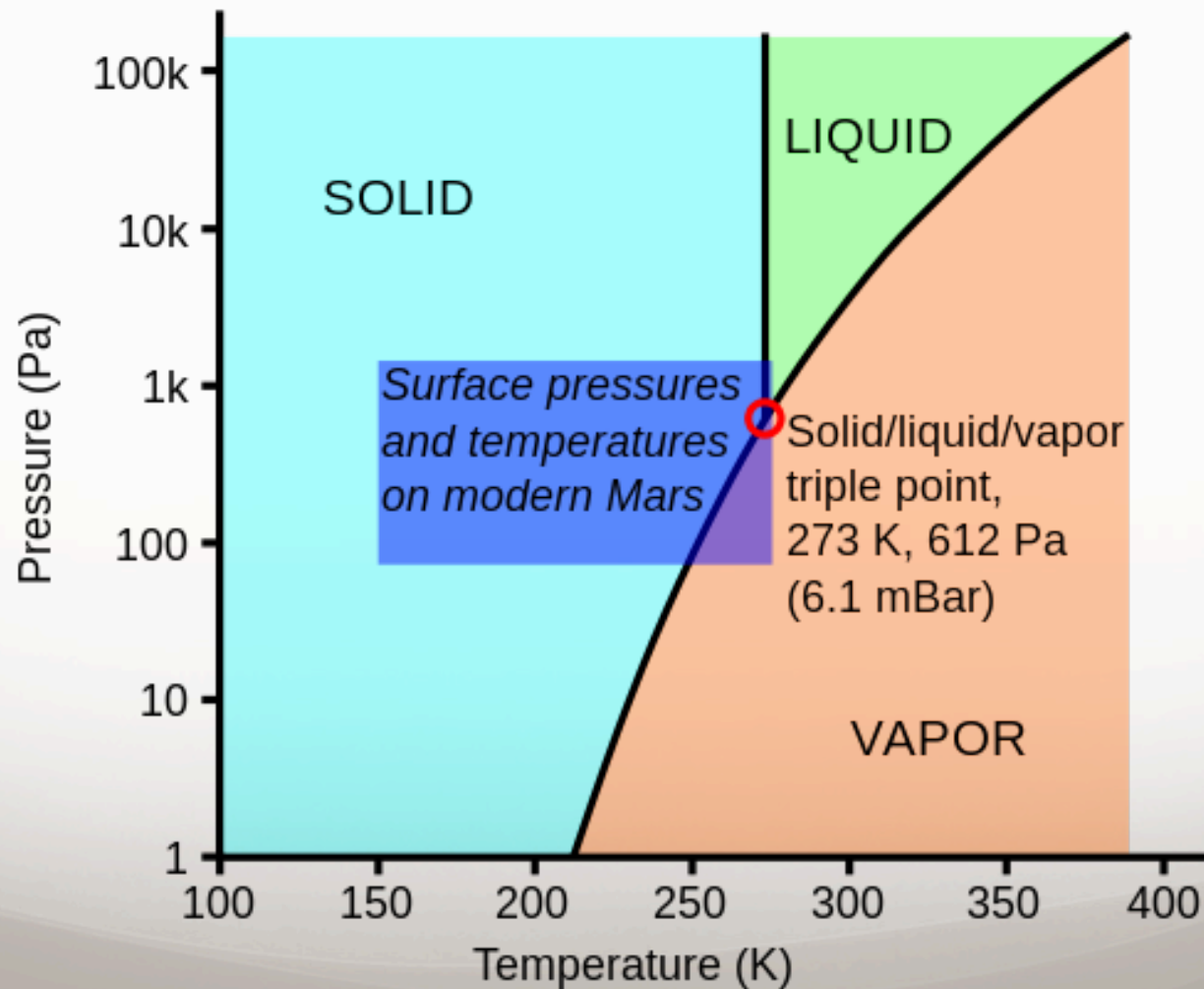
1. Mars cooled off
  - No more magnetic field
  - Geologic activity stops
2. Mars' low gravity doesn't hold onto atmosphere well

The combination of low gravity and no magnetic field make Mars susceptible to Solar Wind

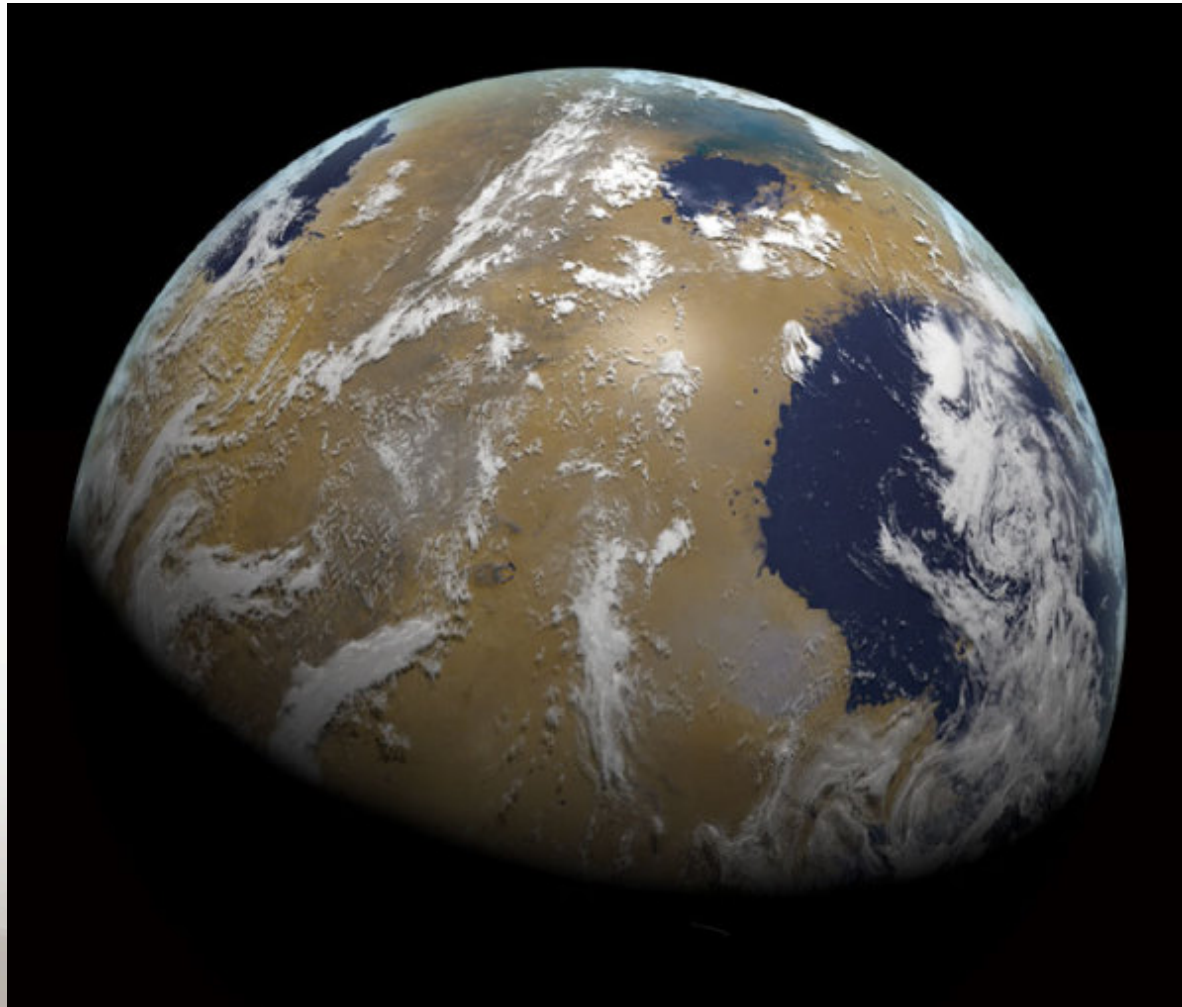
Solar wind slowly takes particles away from Martian atmosphere



# How does a weak atmosphere affect water on Mars?

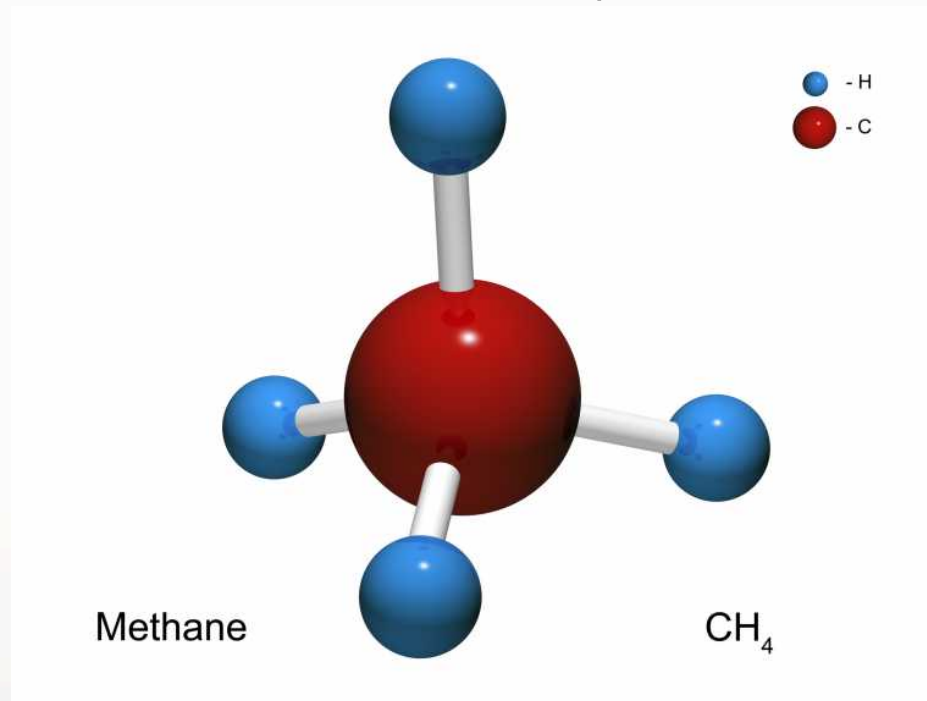


# What does Mars' climate change mean for the Search for Life?



# Methane in Martian atmosphere?

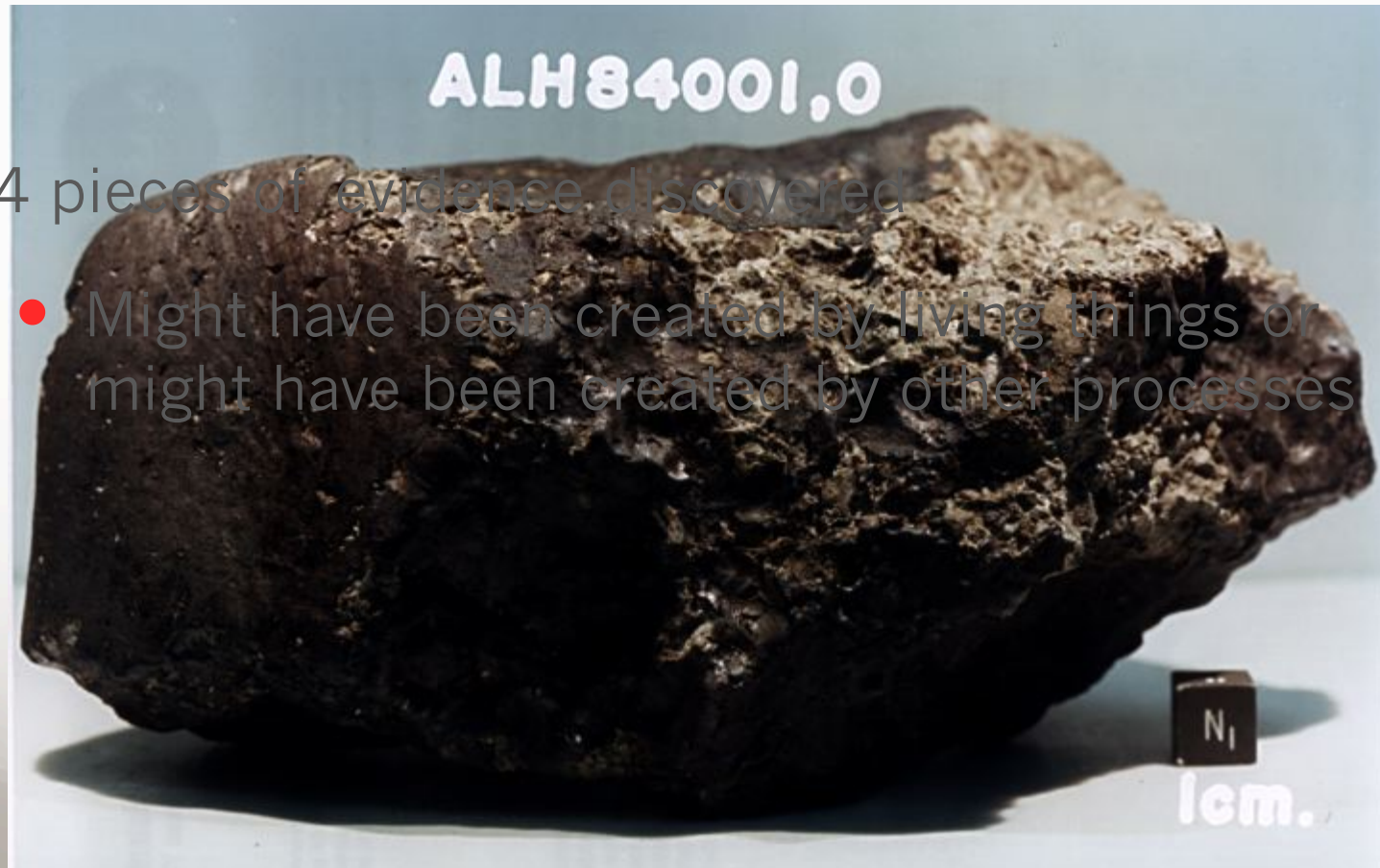
- 90% of methane in Earth's atmosphere comes from microbes



- Methane was “detected” in Martian atmosphere using ground based telescopes
- Curiosity rover did not detect ANY methane

# Evidence for Life on a Martian Meteorite?

- **ALH84001** – a Martian meteorite found in Antarctica in 1984



- 4 pieces of evidence discovered
  - Might have been created by living things or might have been created by other processes

# Evidence for Life on a Martian Meteorite?

1. Carbonate grains with layered structure
2. High concentration of hydrocarbons
3. Magnetite crystals in special formations
4. Presence of structures that look like nanobacteria



# The future of Mars

## EVOLVING SCIENCE STRATEGIES FOR MARS EXPLORATION



# Why do we want to send people to Mars?



# Takeaways

- Mars is a logical place for us to explore and look for signs of life – it's “close” and has a “similar” climate
- For nearly 50 years, Mars missions have revealed much about its climate, geology, and history
- Geological evidence indicates that Mars used to have water on its surface
  - Mars underwent major climate change when it cooled off and lost its atmosphere
- The future of Mars missions includes sending humans to the red planet and looking for signs of past life