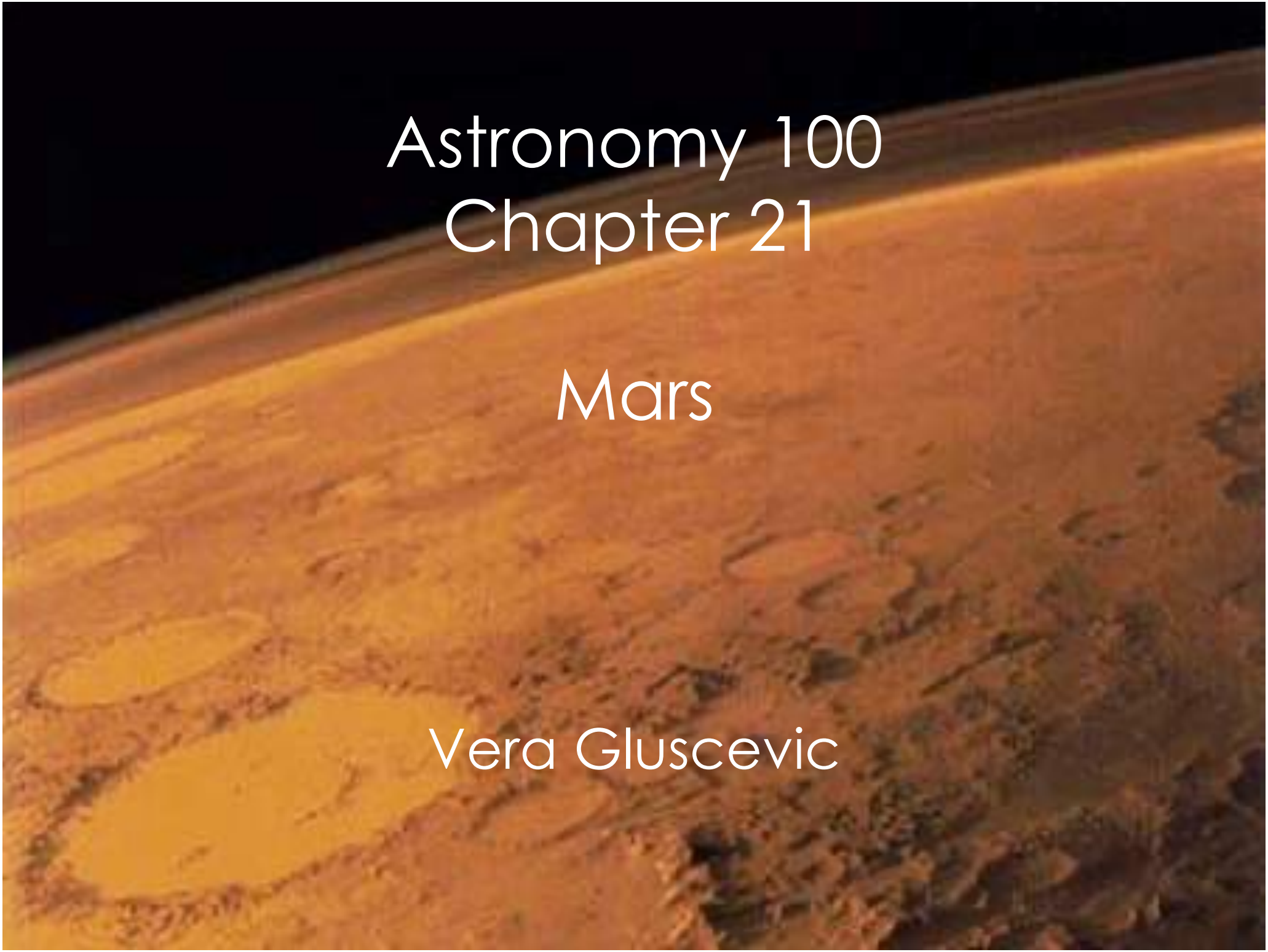
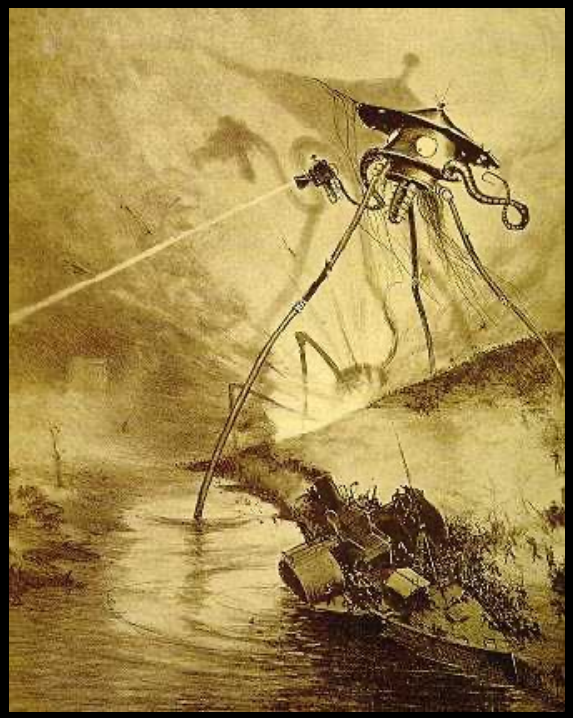


Astronomy 100
Chapter 21

Mars

Vera Gluscevic

Martians in Science Fiction



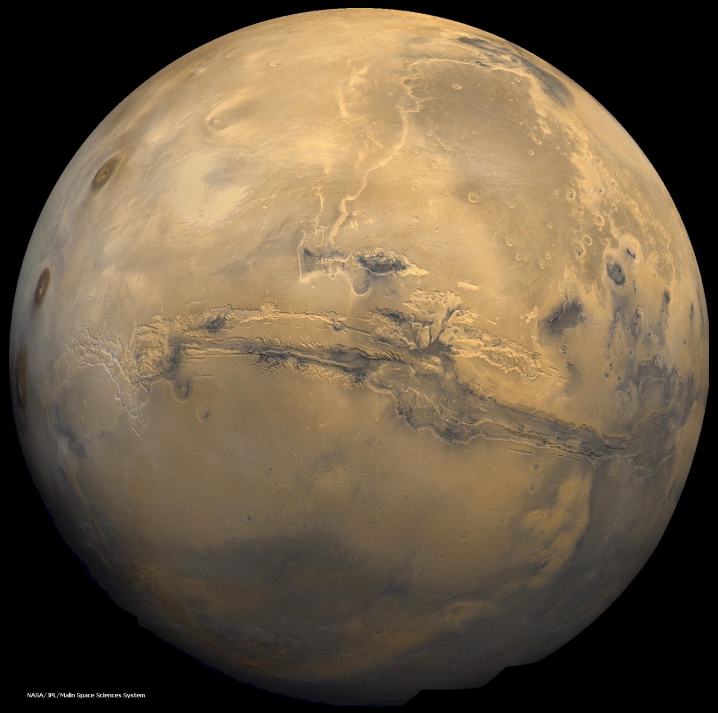
Mars, the planet

Mars: The Big Picture

- Average distance from Sun: 1.52 AU (228 million km)
- Orbital period: 1.88 Years
- Orbital eccentricity: 0.09
- Red color due to iron oxide in its soil.

Mars: The Big Picture

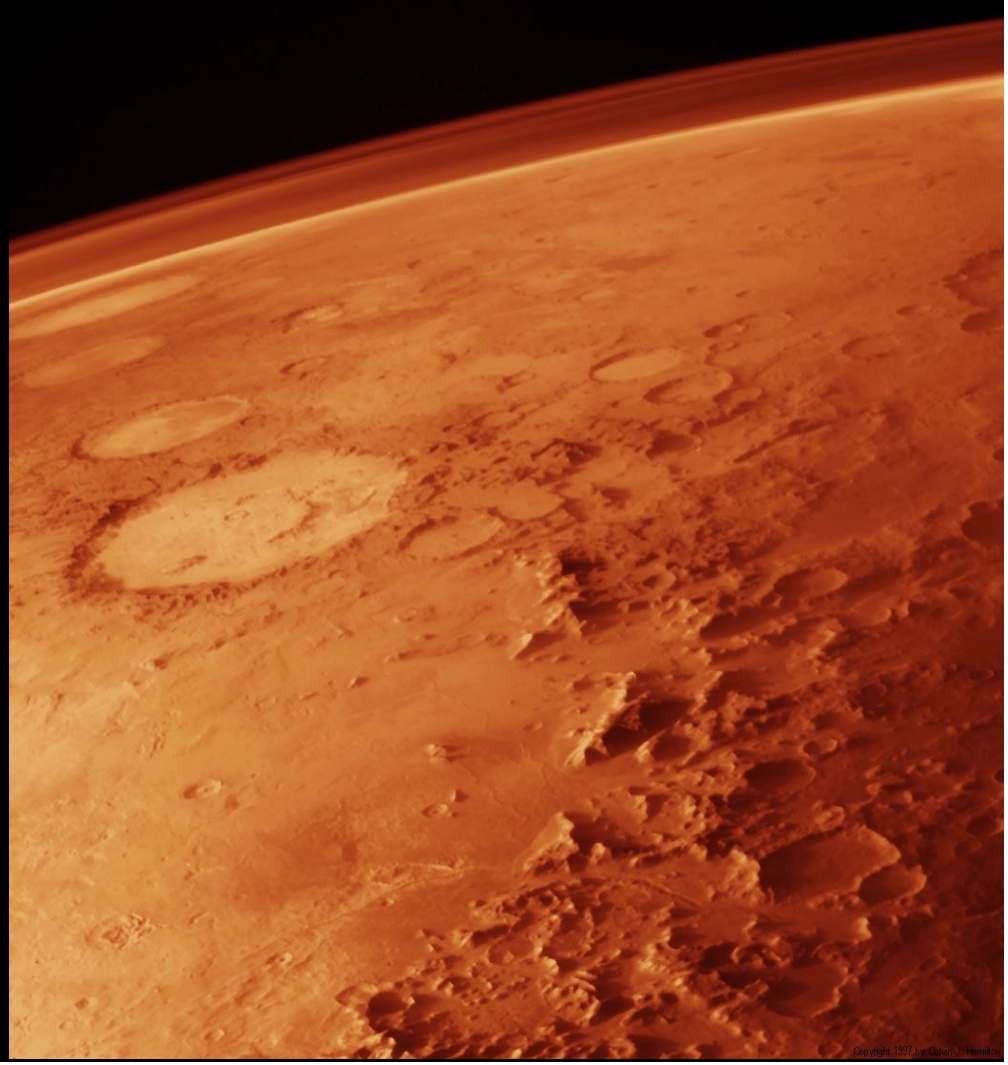
- 10.7% of Earth's mass, ½ Earth's radius (3,397km)
- Surface Gravity: 38% of Earth's surface gravity
- Rotation period: 24 hours 37 minutes
- Axial tilt: 25.19°



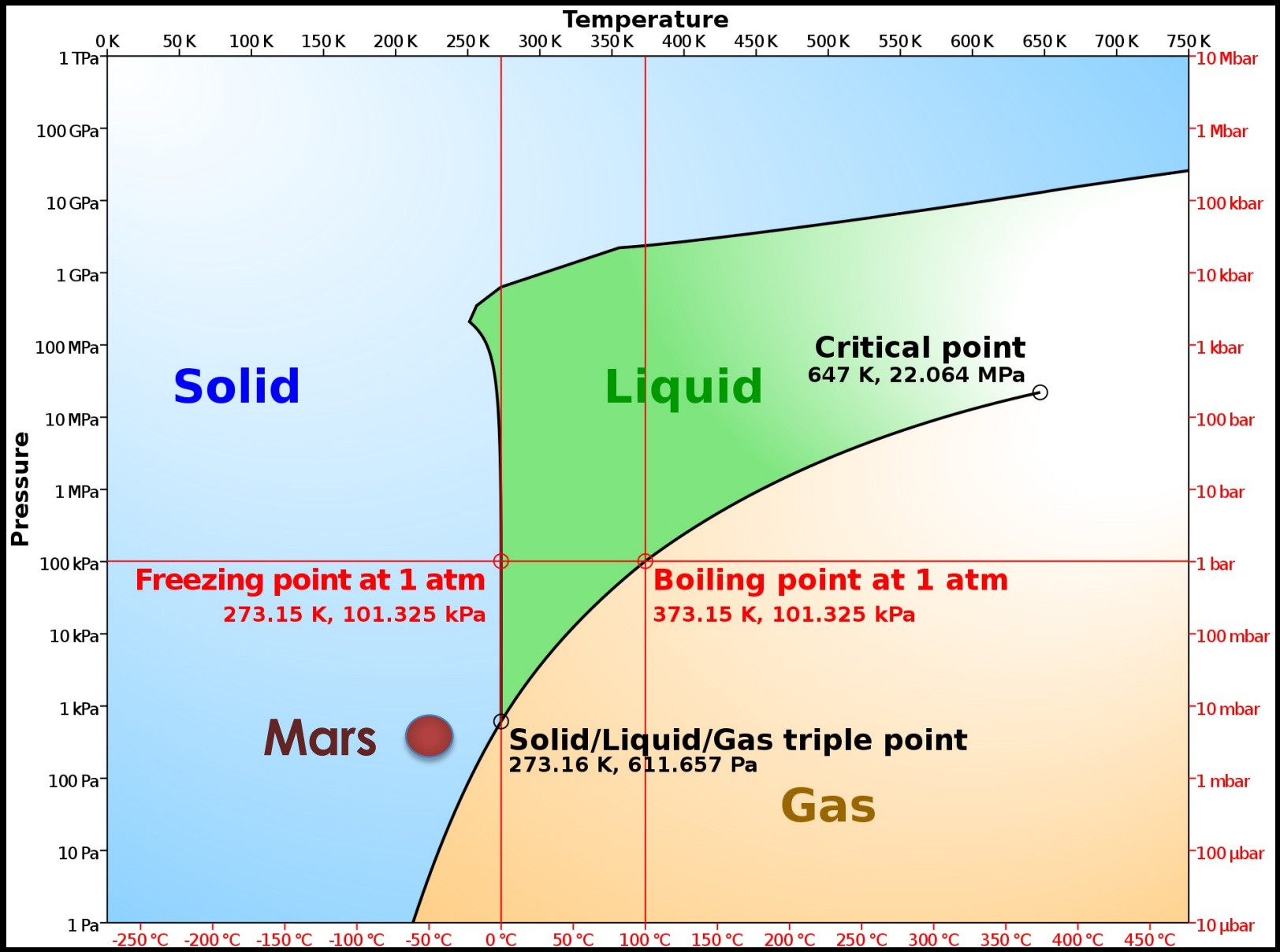
NASA/JPL/Malin Space Sciences System

Martian atmosphere

- Atmosphere: 95% CO_2, 2.7% N_2, 1.6% Ar
- Average surface temperature: –50°C (–58 °F)
- Average surface pressure is 0.007 of the Earth's
- Low pressure means that water cannot remain liquid and evaporates away.

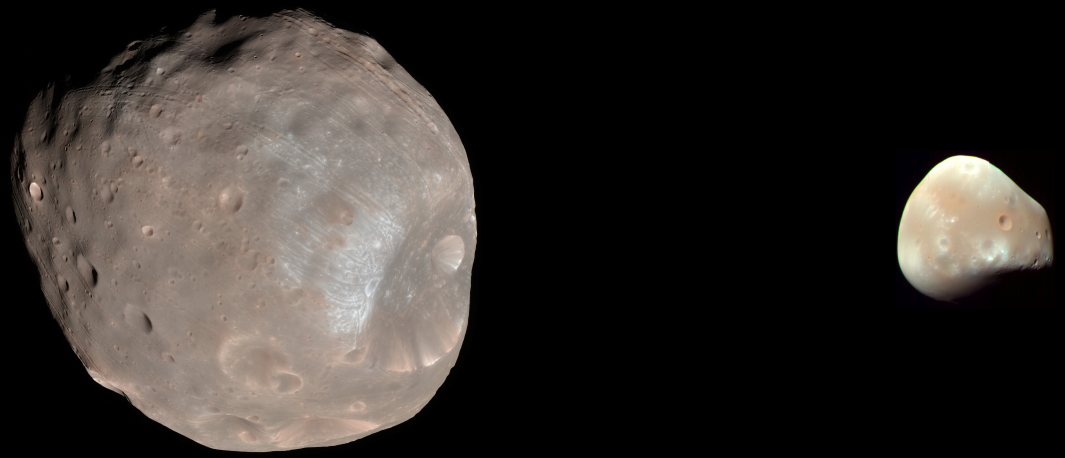


Phase diagram of water



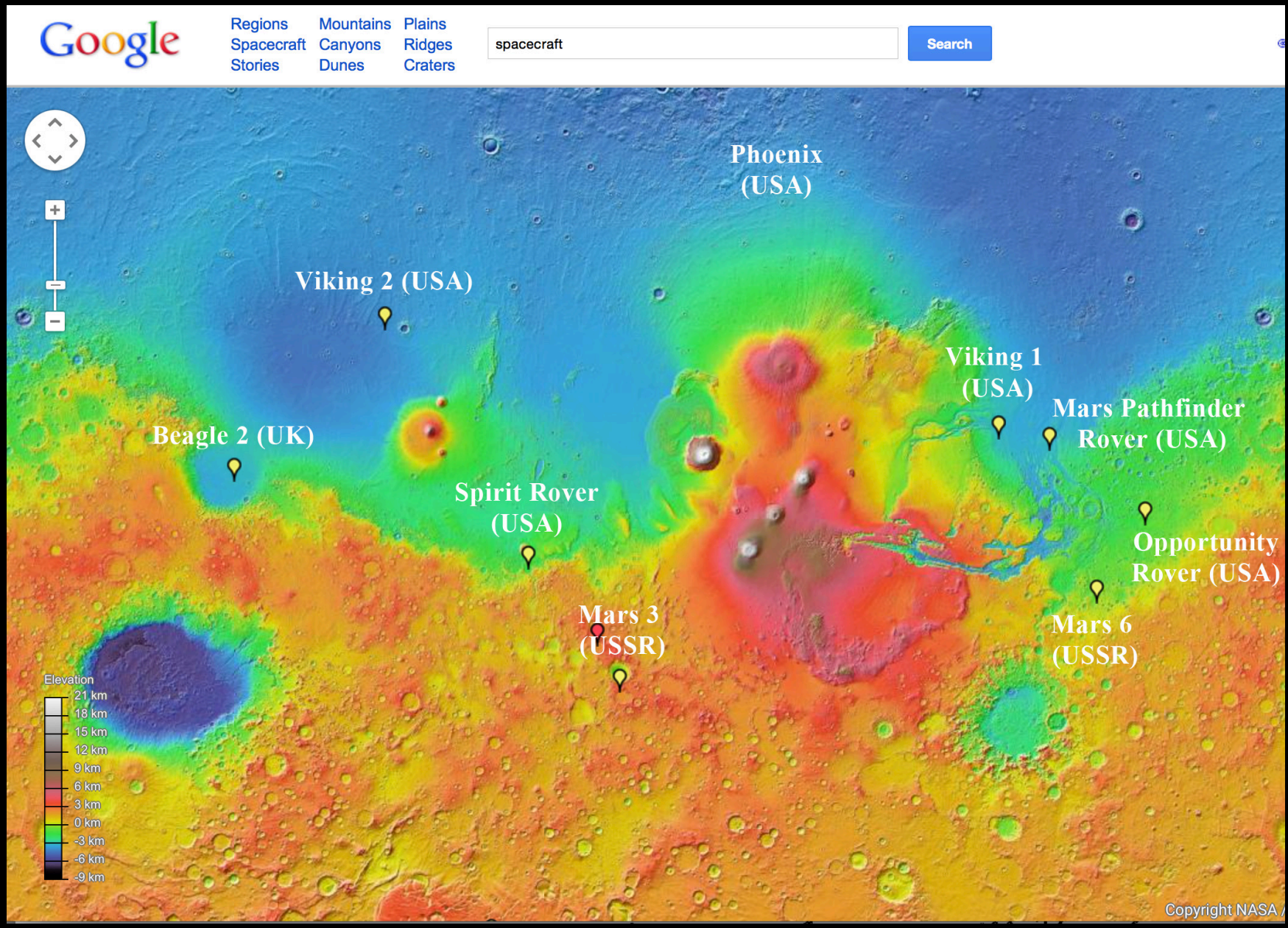
The moons of Mars

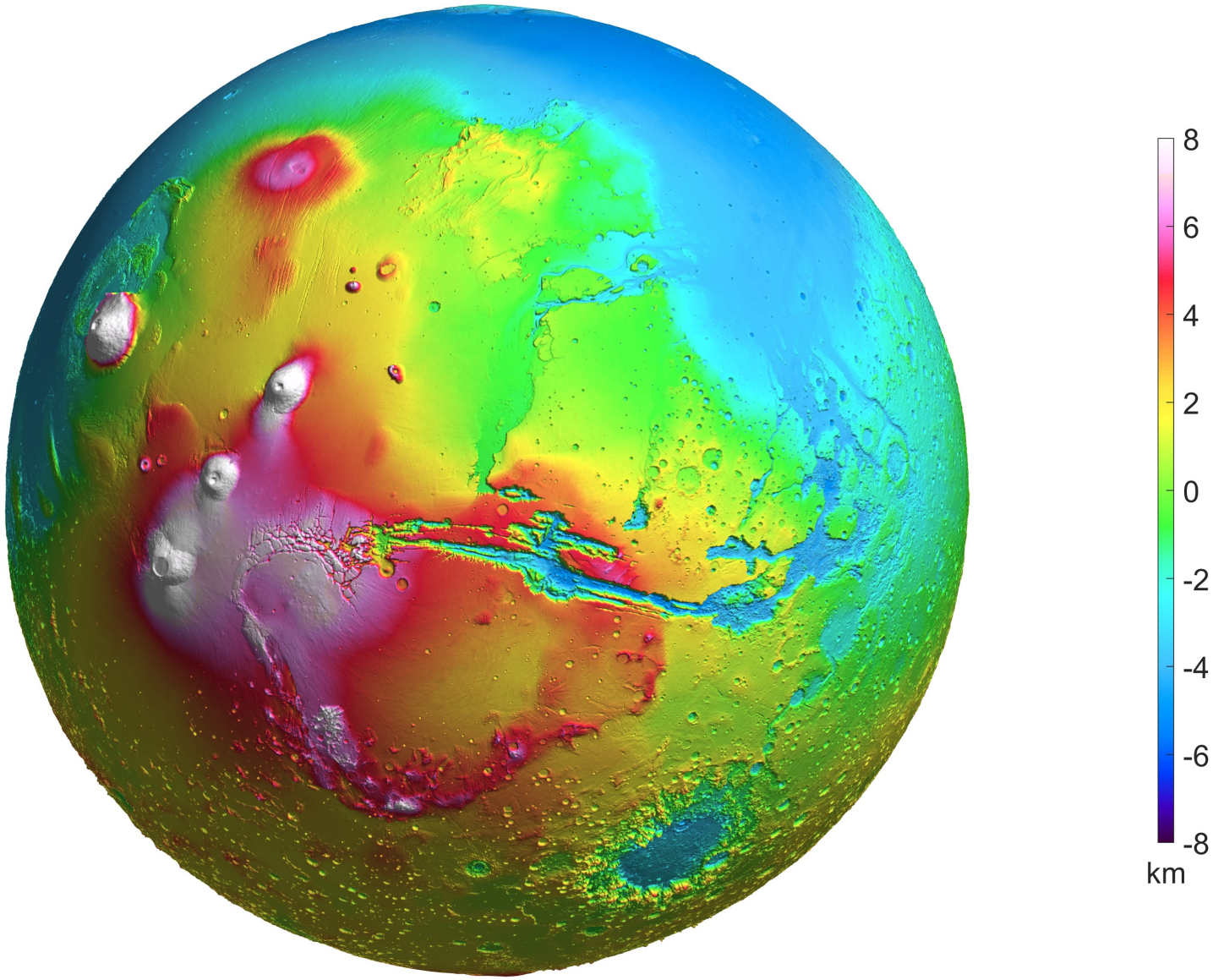
- **Phobos** is an irregularly shaped moon 27 x 22 x 18 km in size, orbiting at an altitude of less than 6000 km from Mars.
- Phobos' low density is fueling speculation that it's either 30% hollow, or contains lots of water ice.
- **Deimos** is in a 30-hour orbit around Mars and is only ~6 km in radius.



Martian “planetology”

Our View of Mars Today
Courtesy of Mars Orbiter Laser Altimeter (MOLA) on Mars Global Surveyor



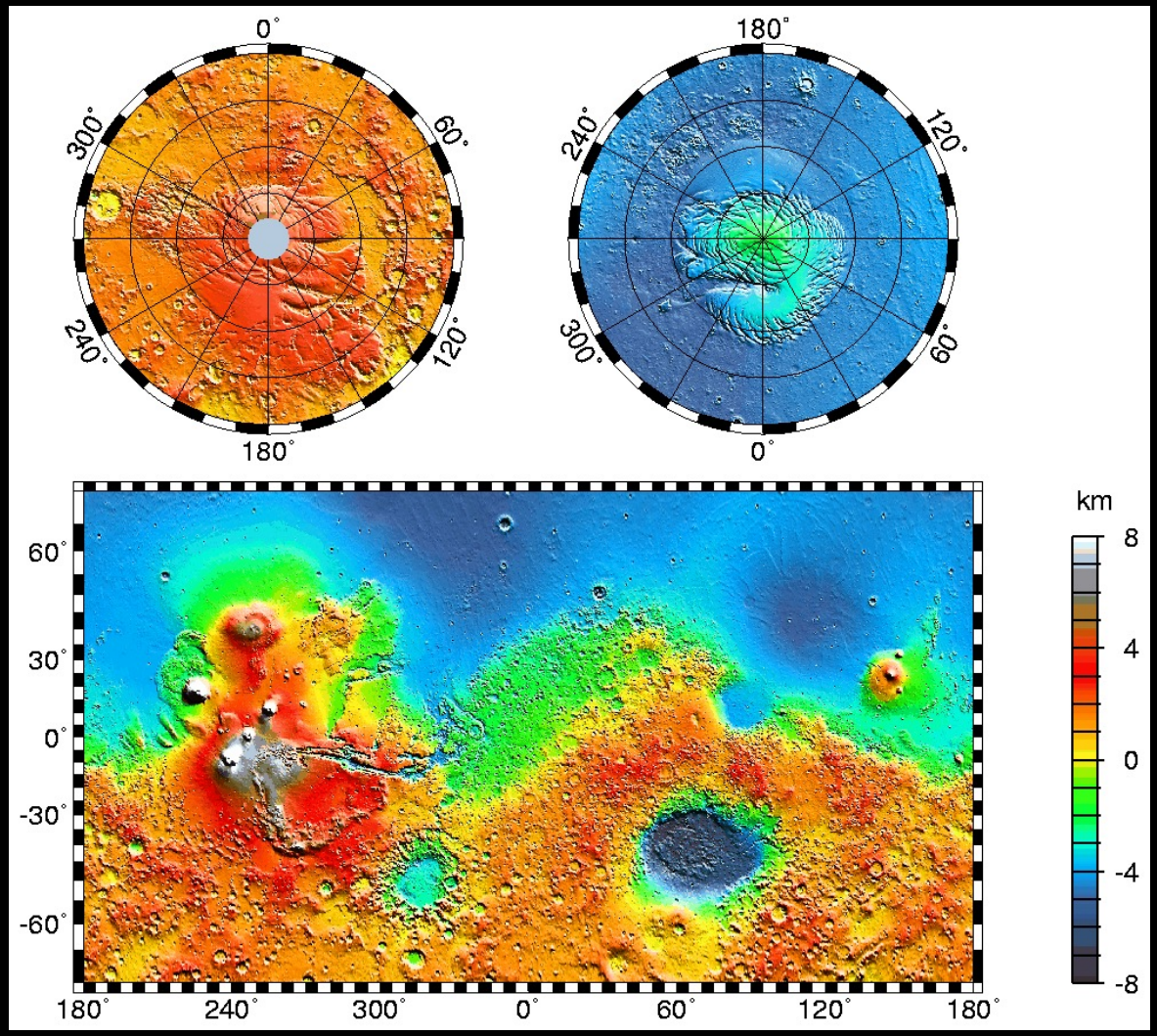


Mars topography (MOLA_16)

The Martian Dichotomy

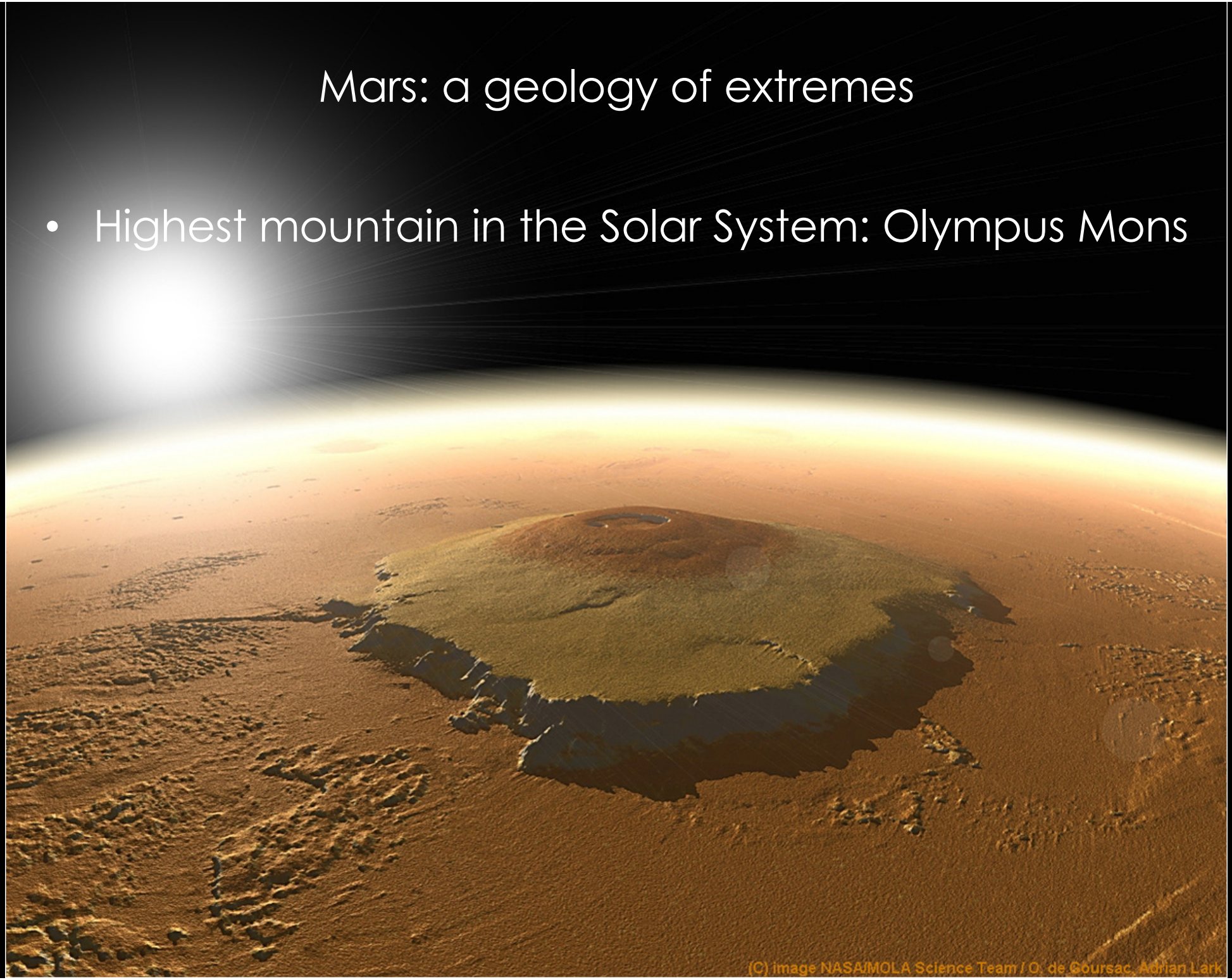
Compare the northern and southern hemispheres:

- Southern hemisphere 1 – 3 km higher altitude than northern hemisphere.
- Northern crust much thinner than southern crust.



Mars: a geology of extremes

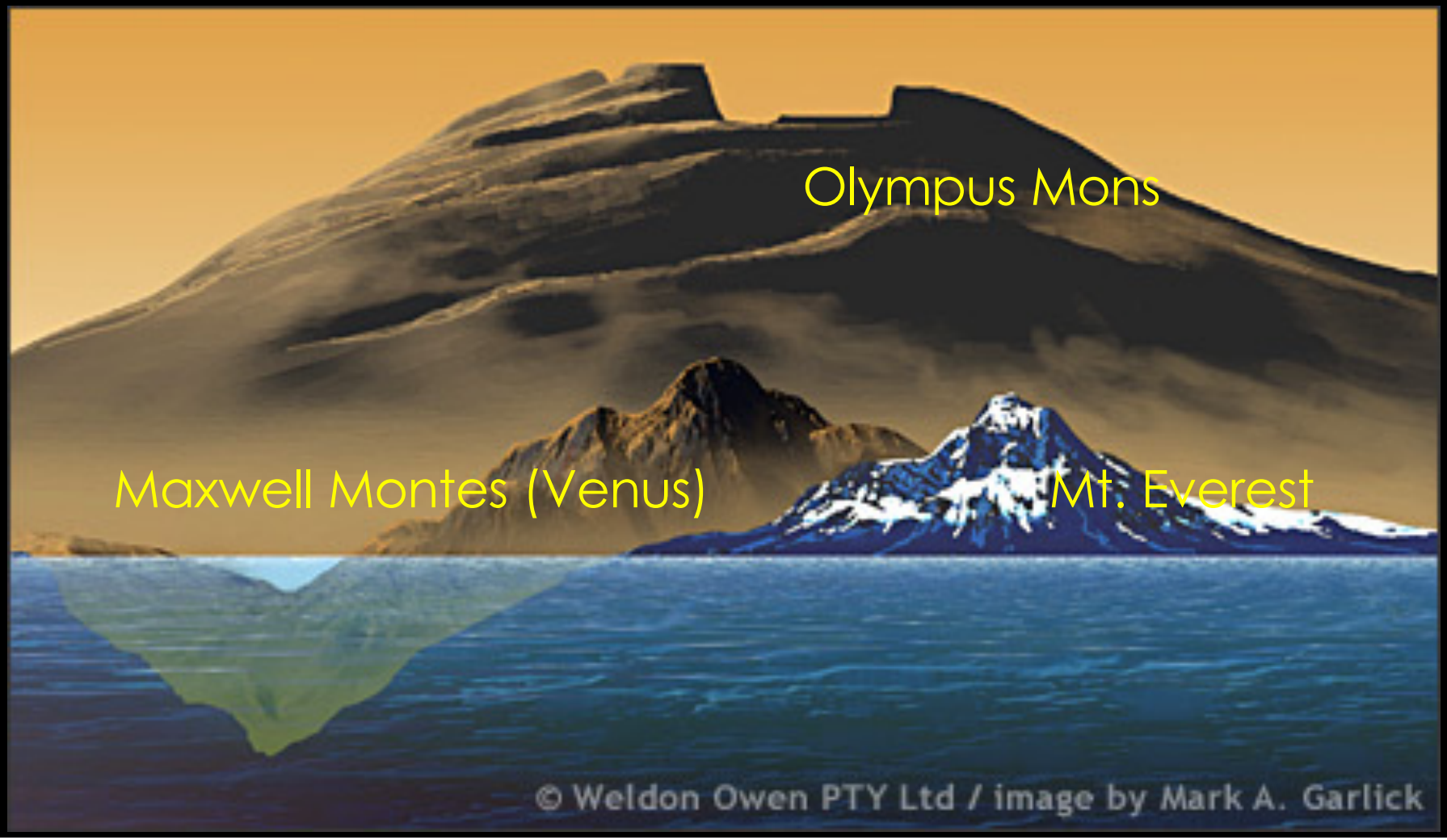
- Highest mountain in the Solar System: Olympus Mons



Olympus Mons vs. France

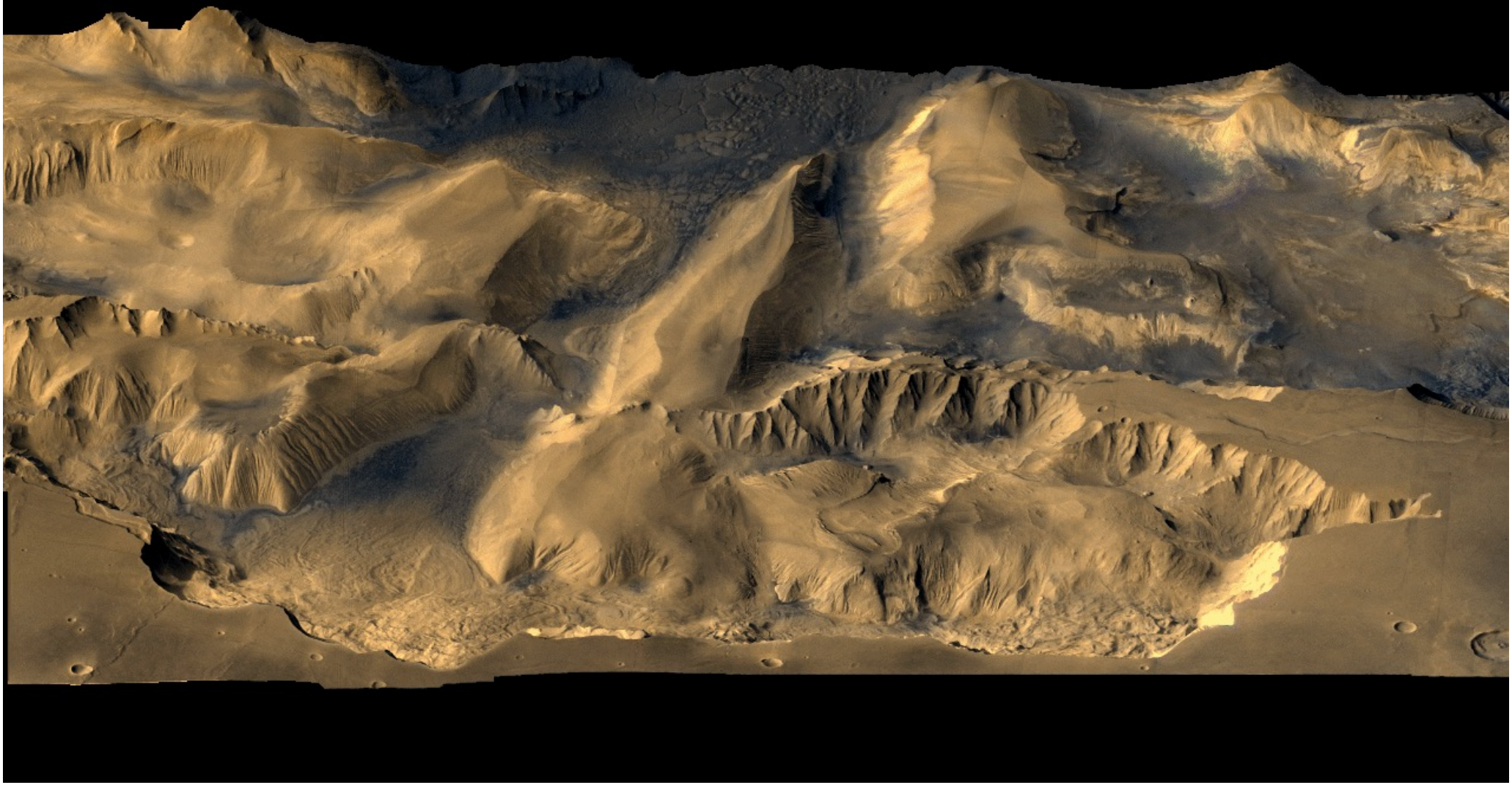
Mars: a geology of extremes

- Comparison of Solar System mountains



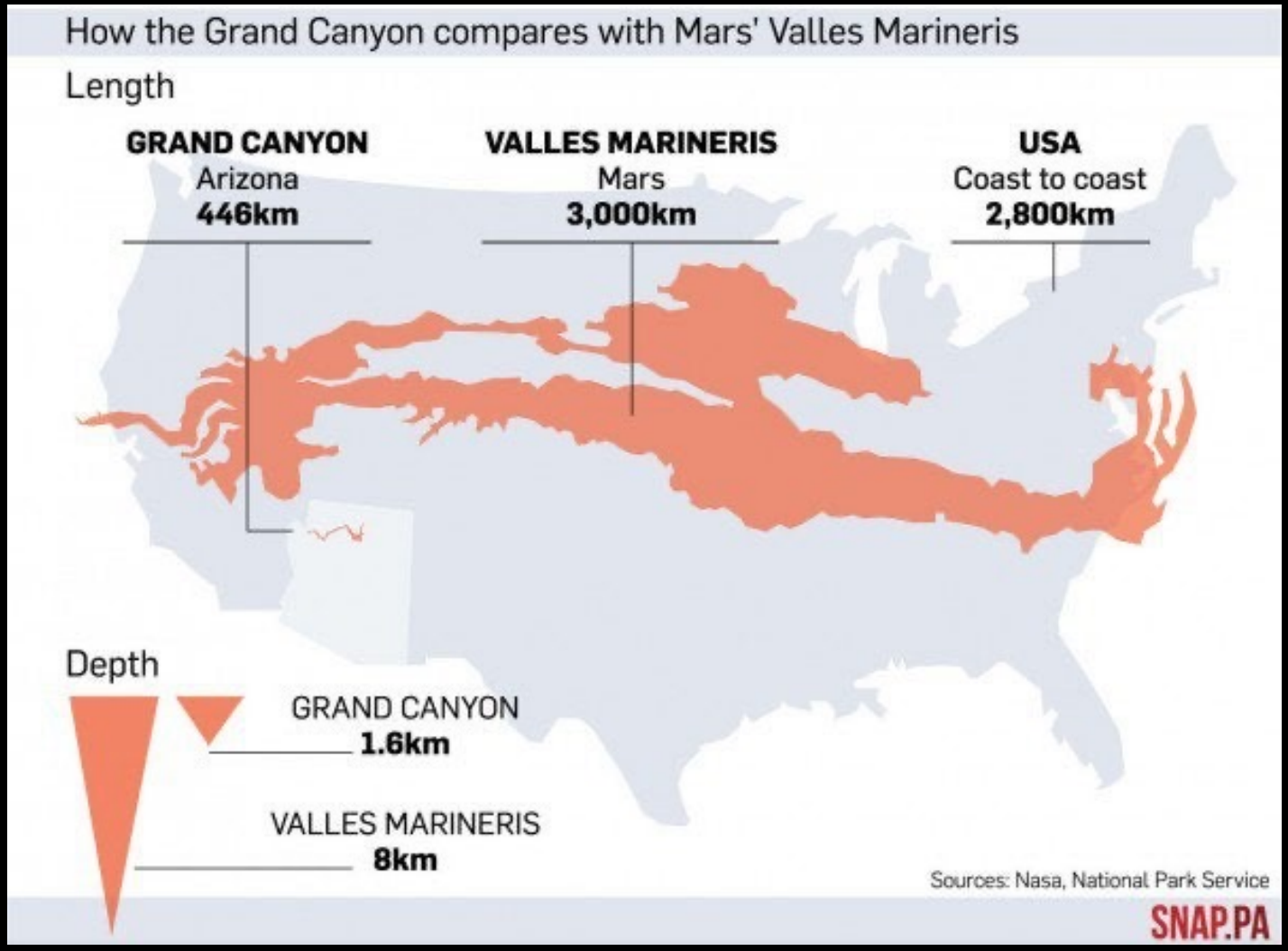
Mars: a geology of extremes

- Deepest canyon in the Solar System: Valles Marineris



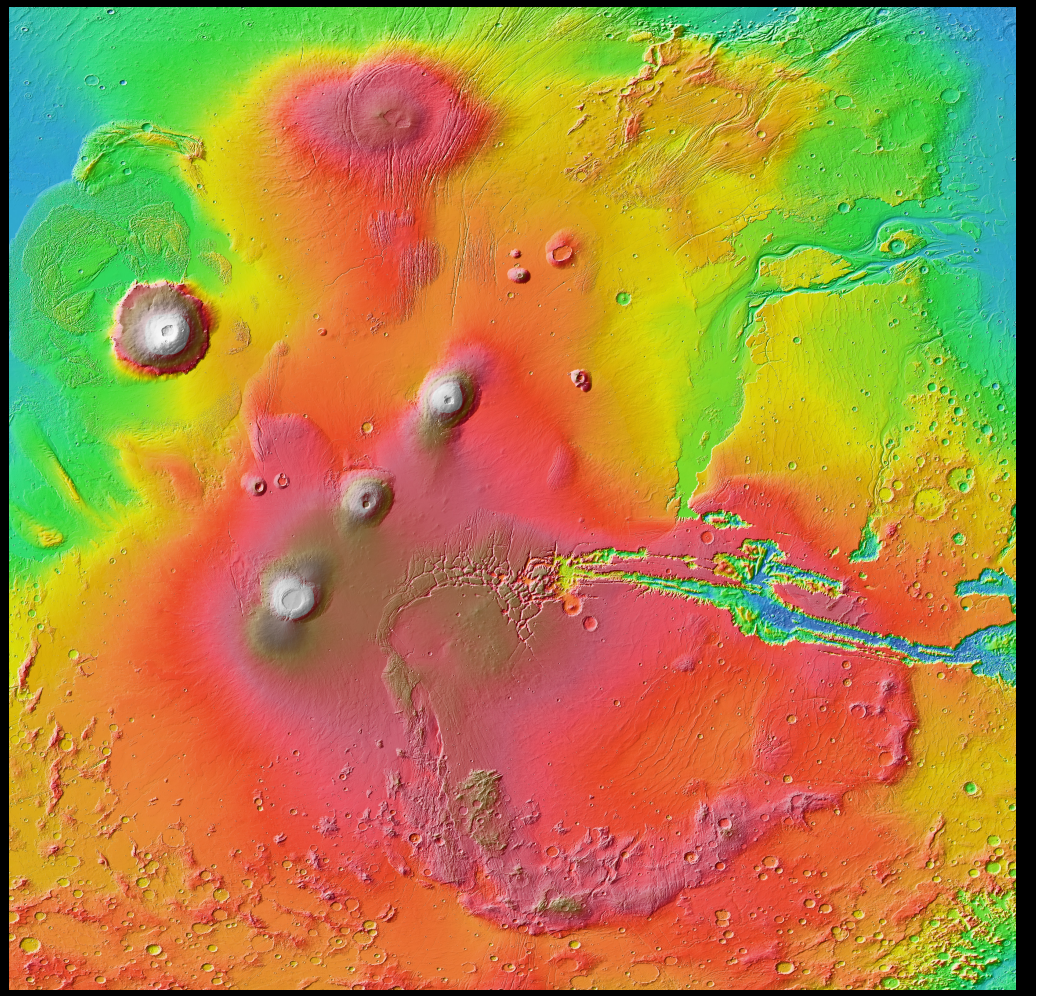
Mars: a geology of extremes

- Comparison of Grand Canyon and Valles Marineris



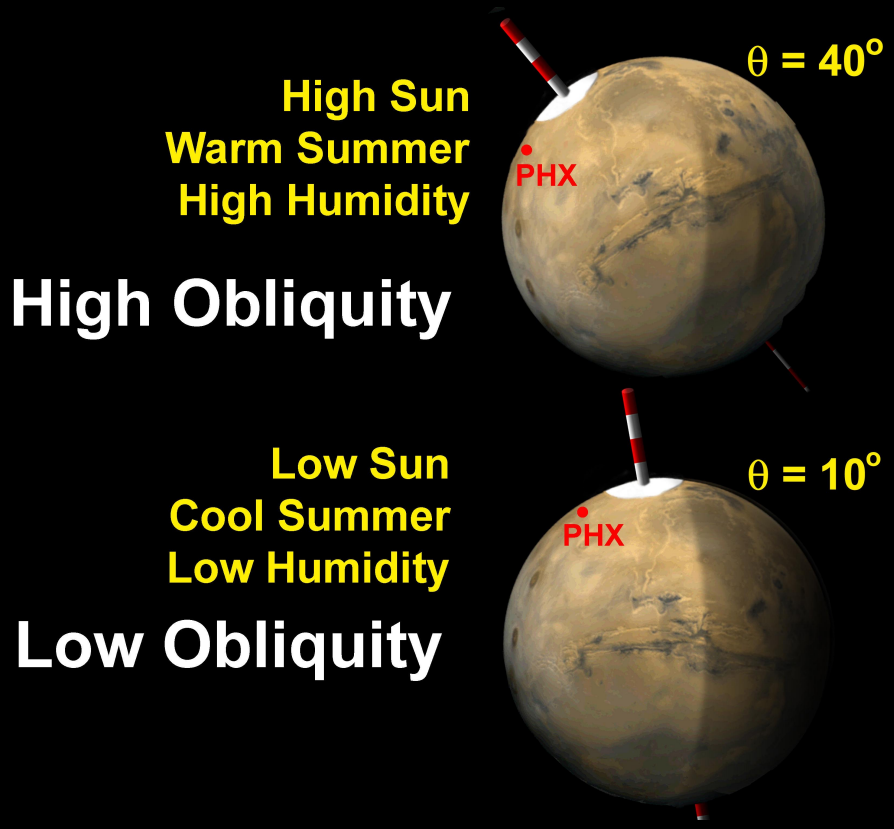
Mars: a geology of extremes

The **Tharsis region:**
sometimes more than 7 km (not counting volcanoes) above the rest of the surface of Mars, has a mass comparable to the dwarf planet Ceres! Almost opposite from **Hellas** crater.



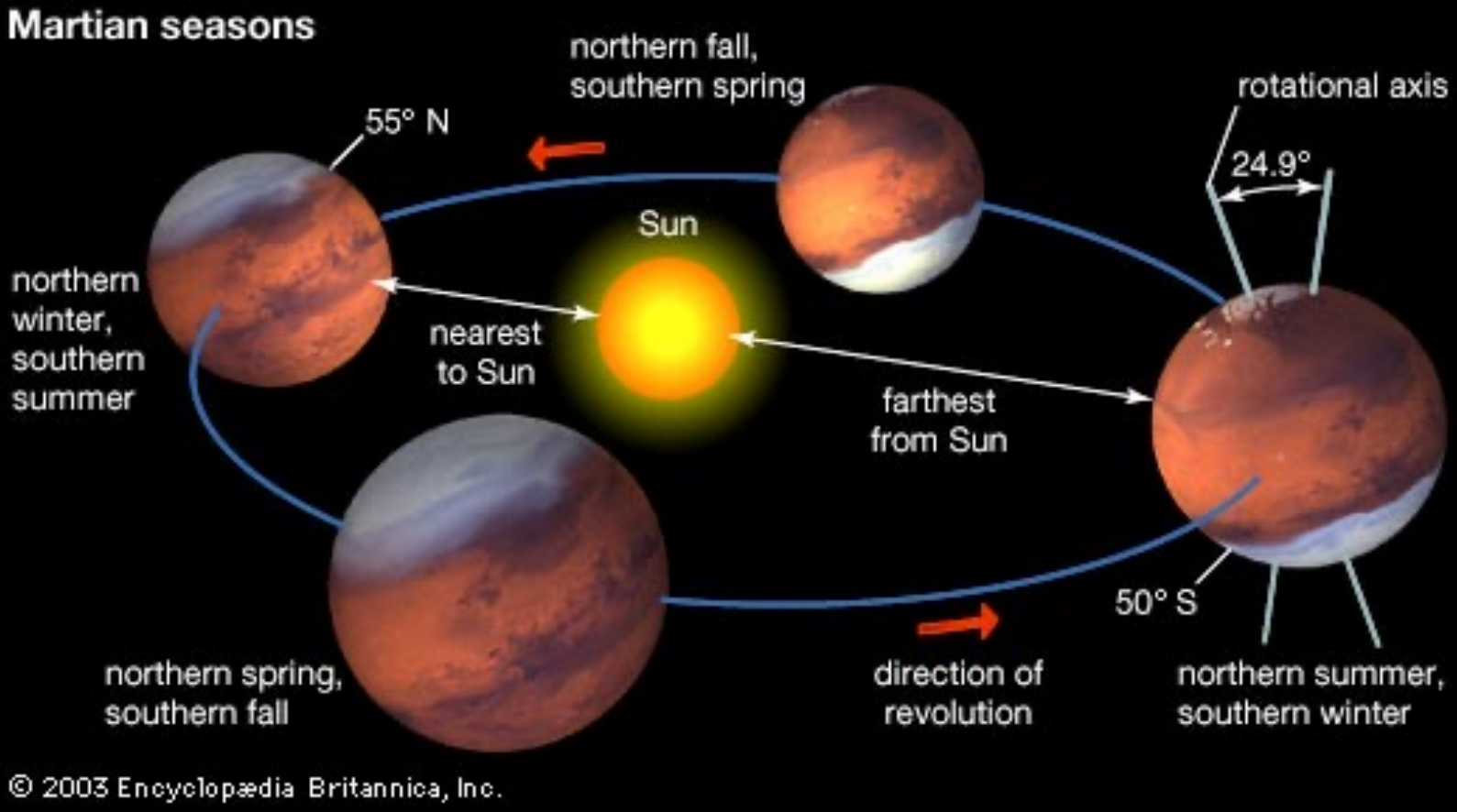
Martian obliquity

The **obliquity** (axis tilt) changes over time (100,000 – 1 million years), because Mars has no large moons to stabilize it, and is close to Jupiter and its gravitational influence.



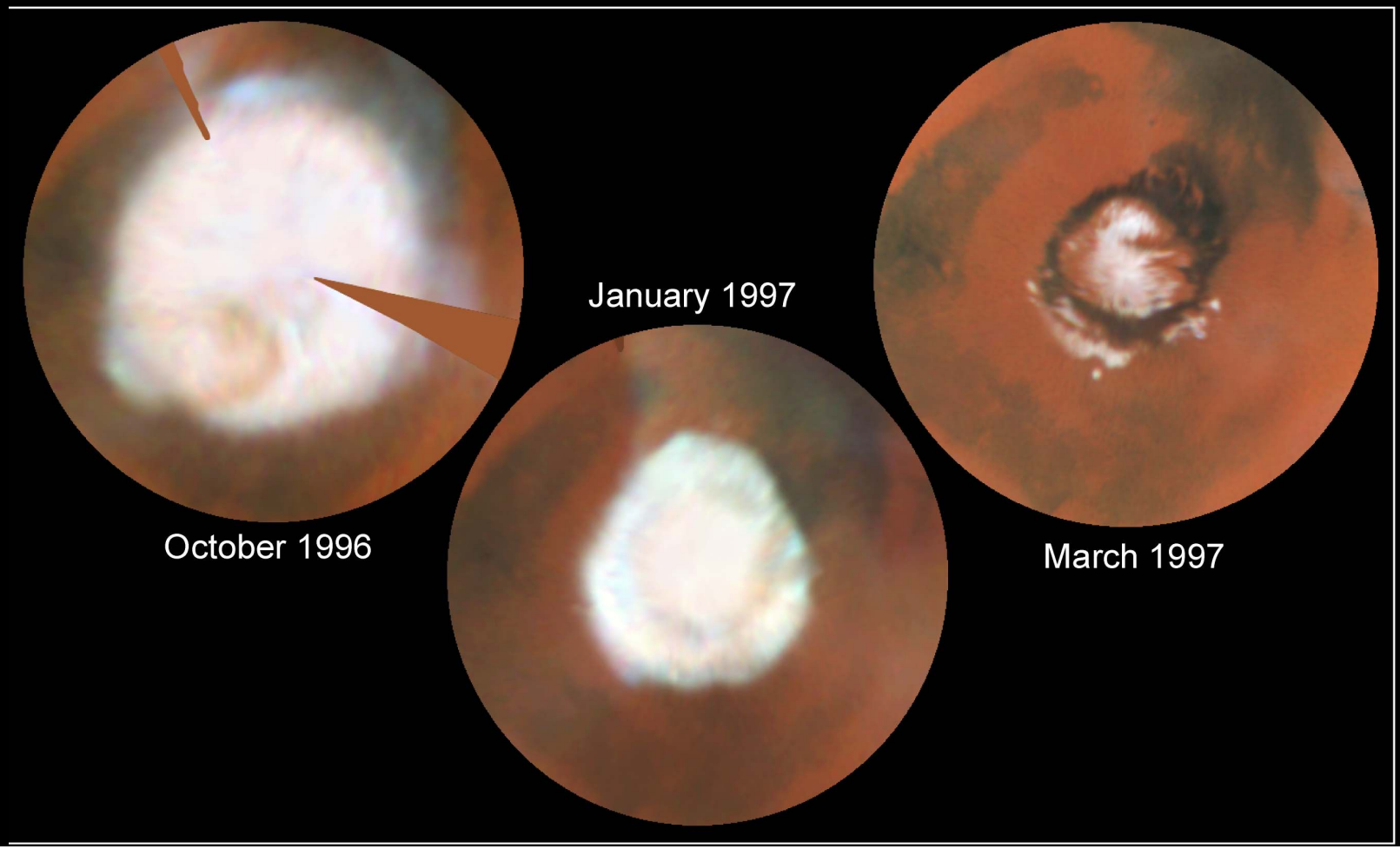
Martian orbital eccentricity

Mars has second largest eccentricity of all the planets.



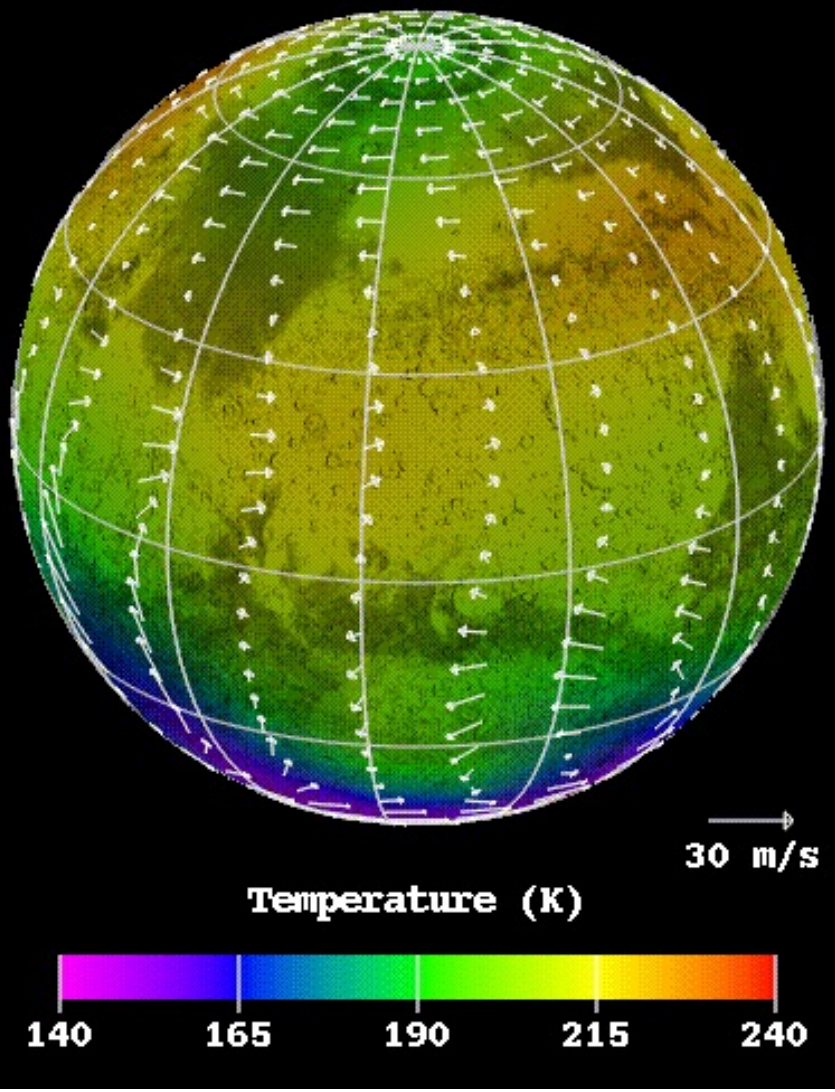
Martian Weather

- During Martian summer, CO2 polar cap nearly disappears. What's left over is water ice.

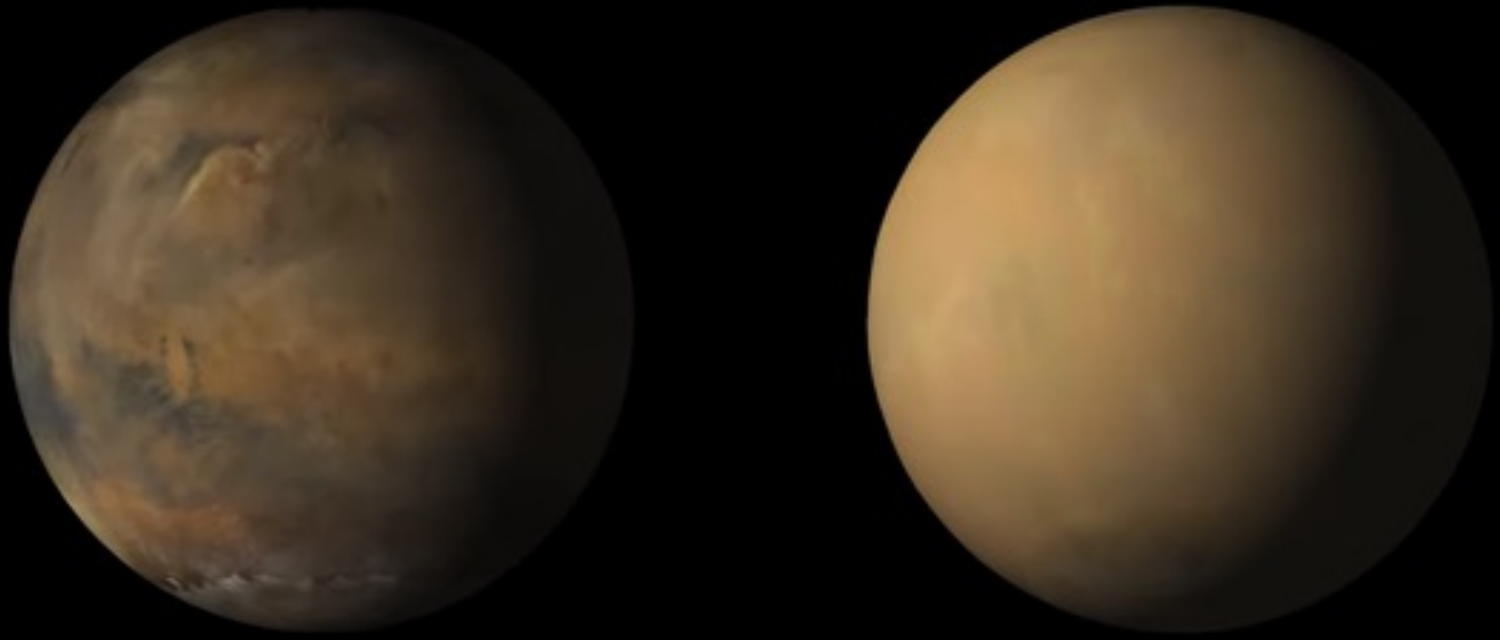


Martian wind patterns

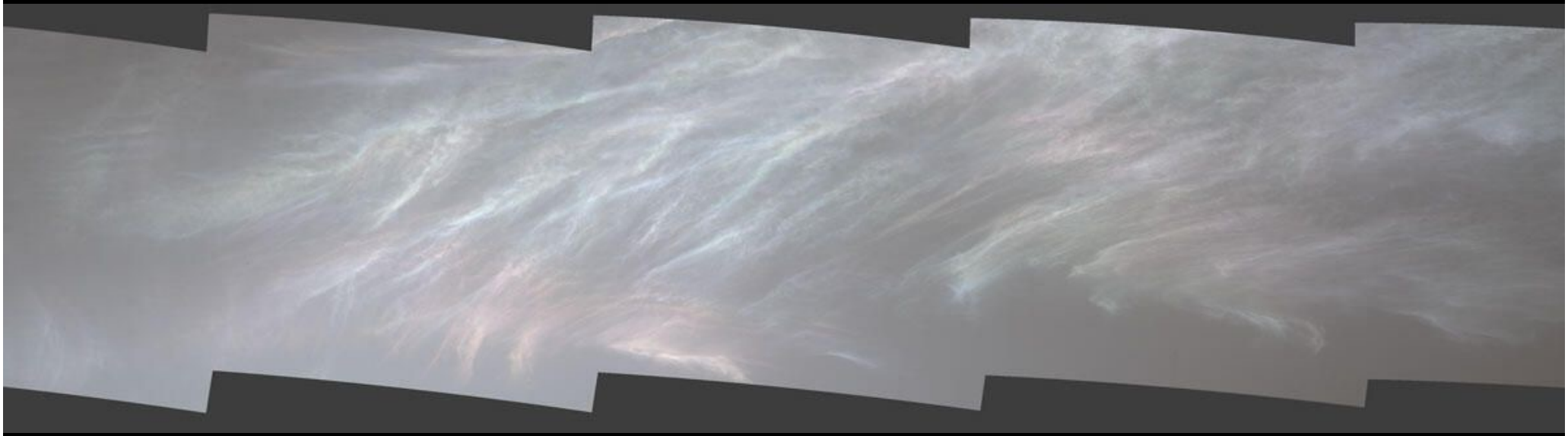
- CO_2 in winter hemisphere freezes, decreasing atmospheric pressure.
- CO_2 sublimation increases pressure in summer hemisphere.
- Winds from summer to winter hemisphere.



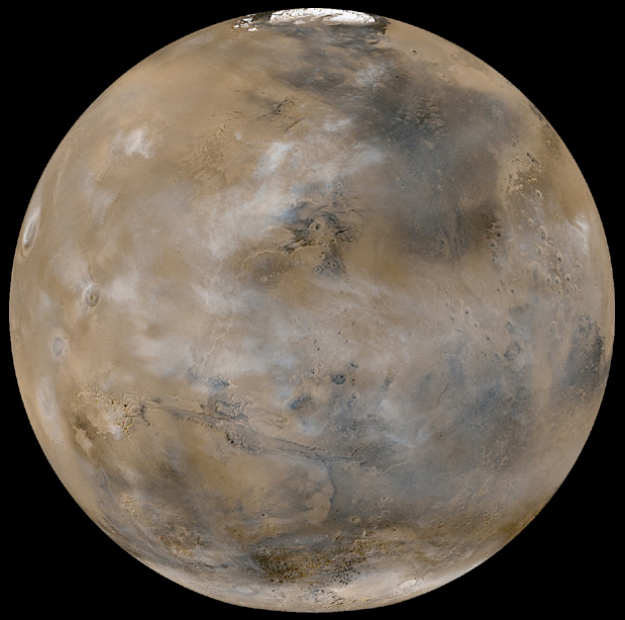
2018 Martian Dust Storm



Wispy ice clouds



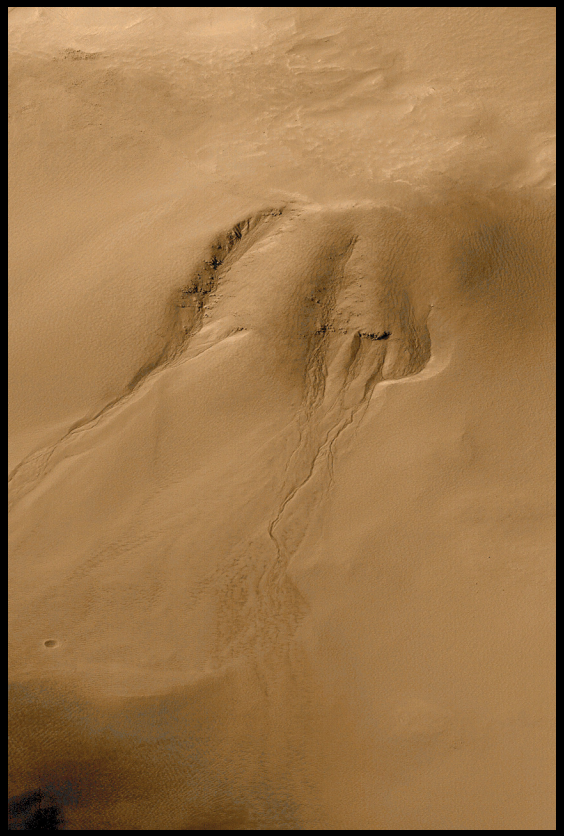
Clouds on Mars are comprised of water ice and sometimes CO_2 ice.

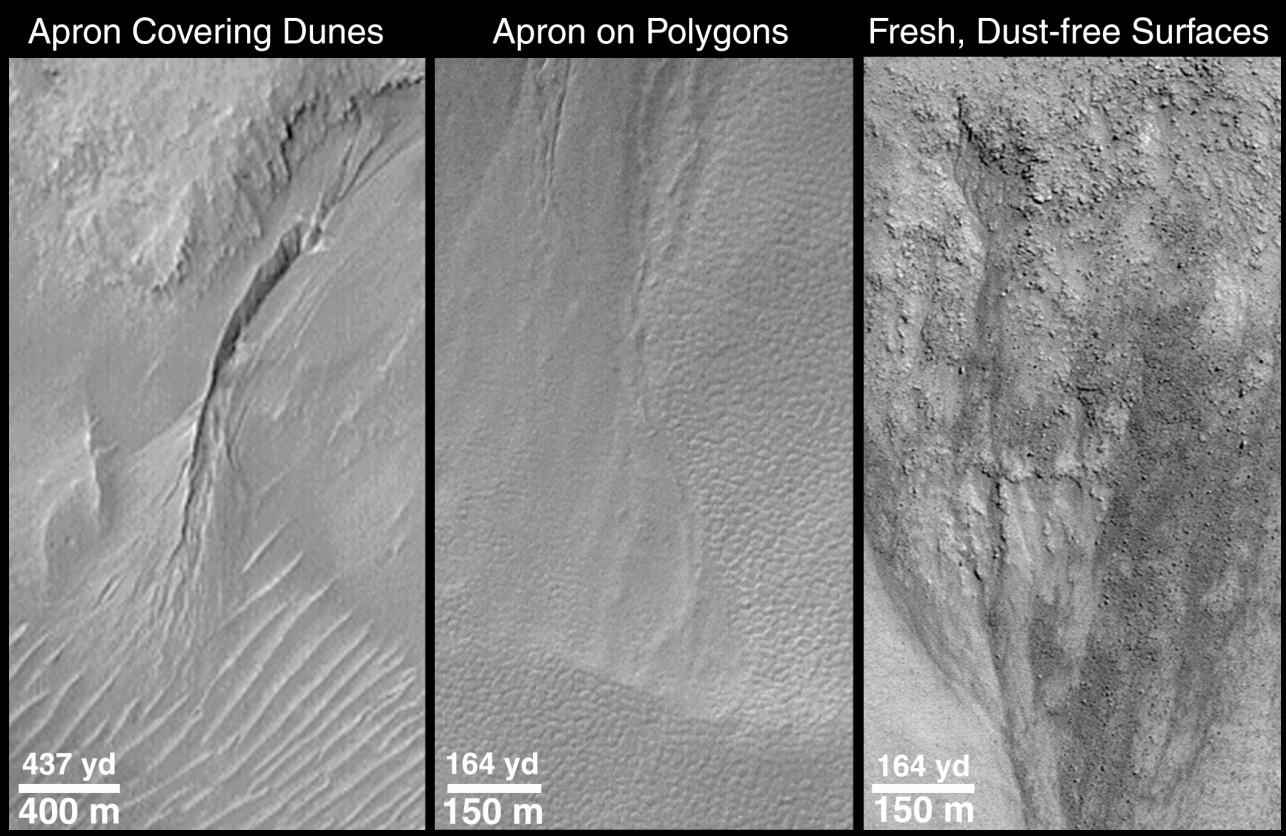


Water on Mars?

Liquid water on Mars?

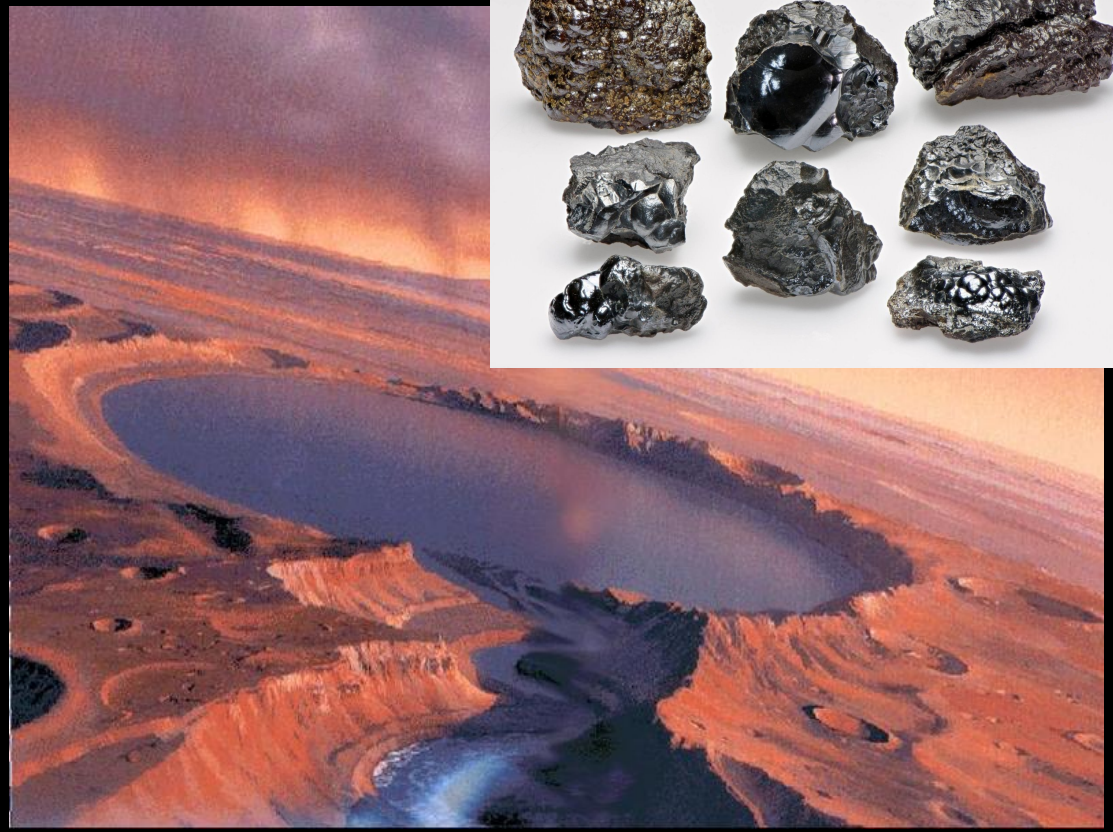
- Multiple locations where channels and gullies have formed from the flow of liquid water.
- Question is, when did these flows occur?

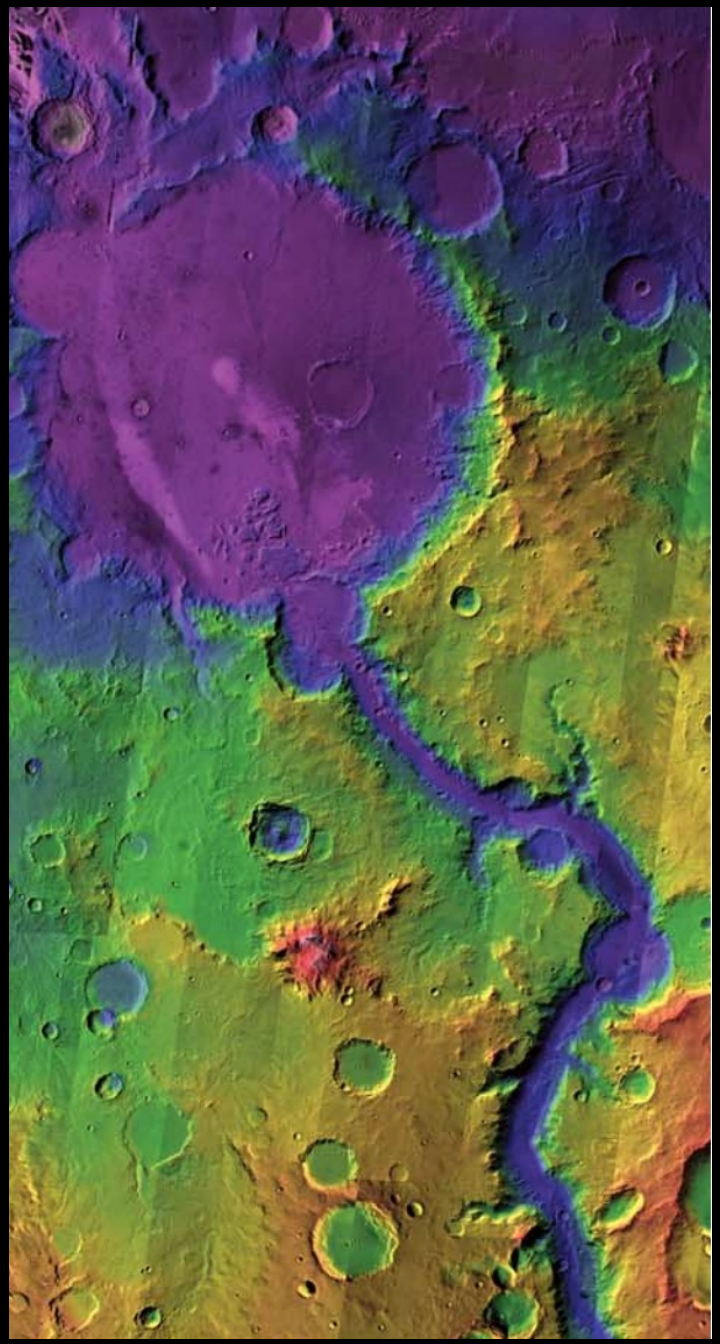




Liquid water on Mars?

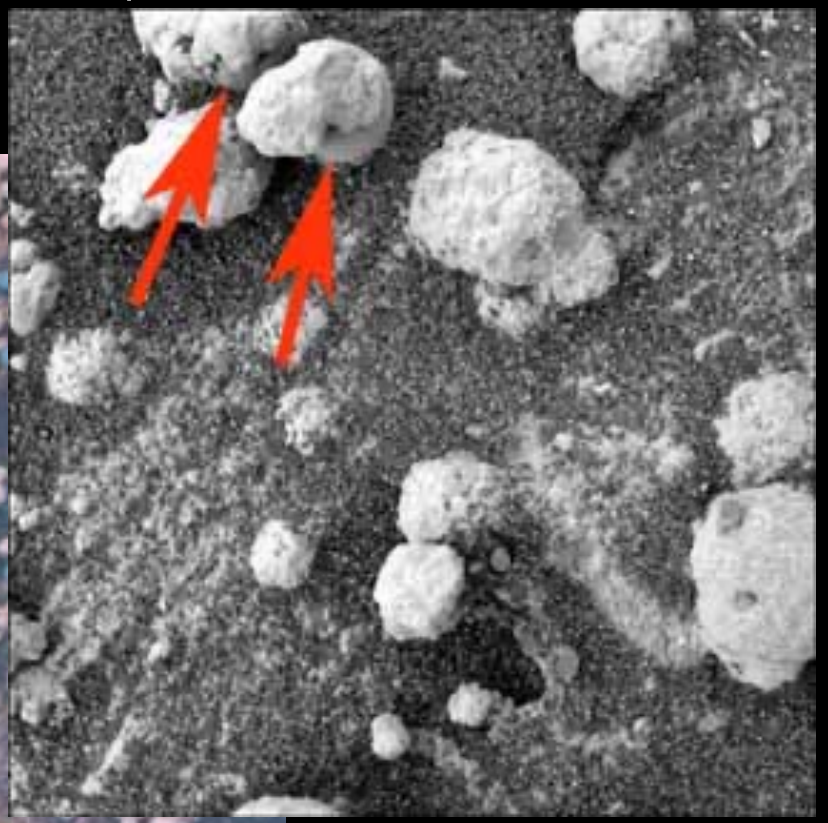
Gusev Crater (Spirit Rover landing site) rocks contain iron-rich **hematite**, which forms in water…

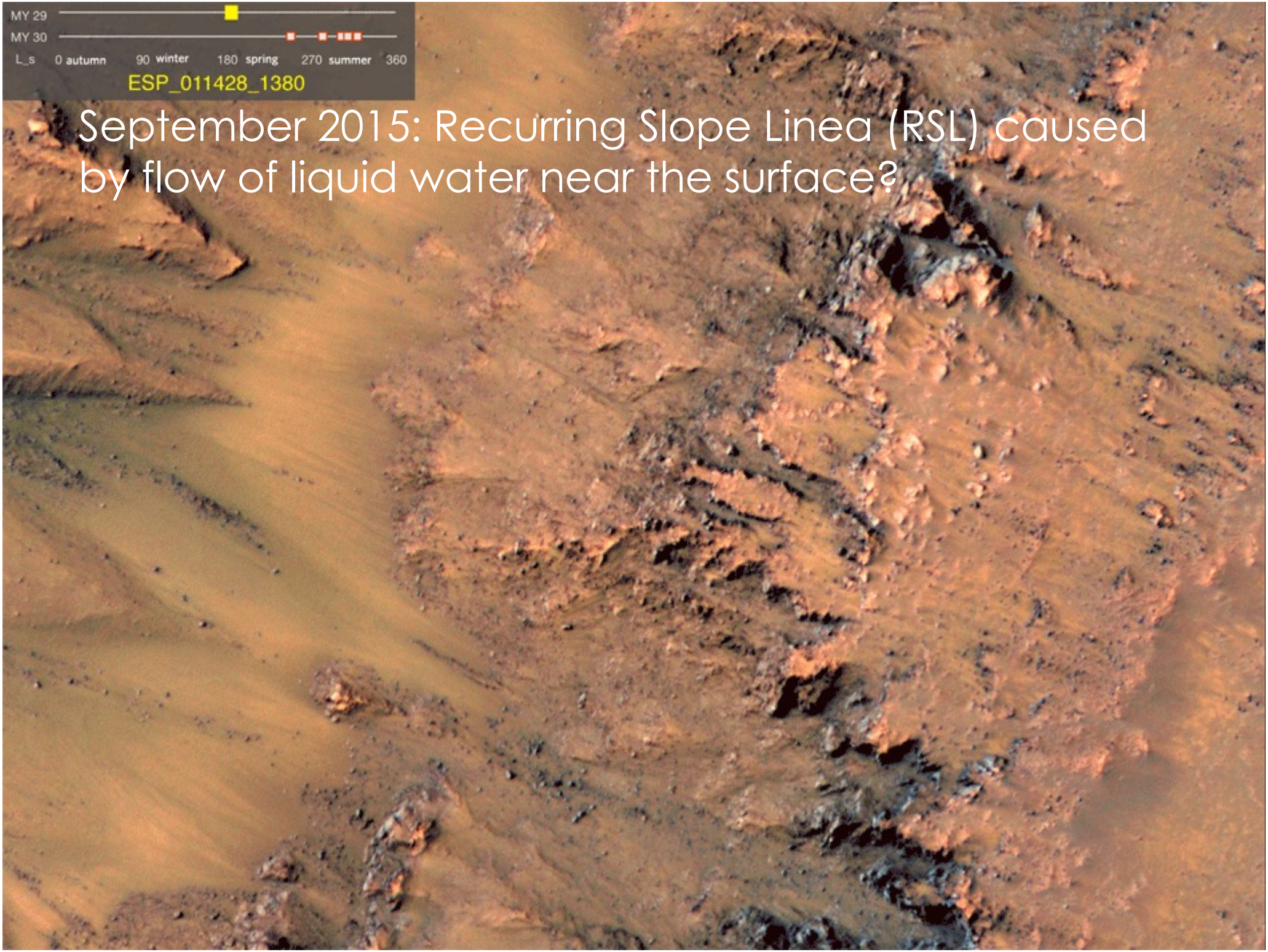




Liquid water on Mars?

- Hematite "blueberries" and "popcorn" give us clues to the presence of surface water.
- Presence of sedimentary rocks is another clue.
- Finally, geological features that look like river flows and deltas flowing into a crater lake all point that liquid water once existed on Mars.

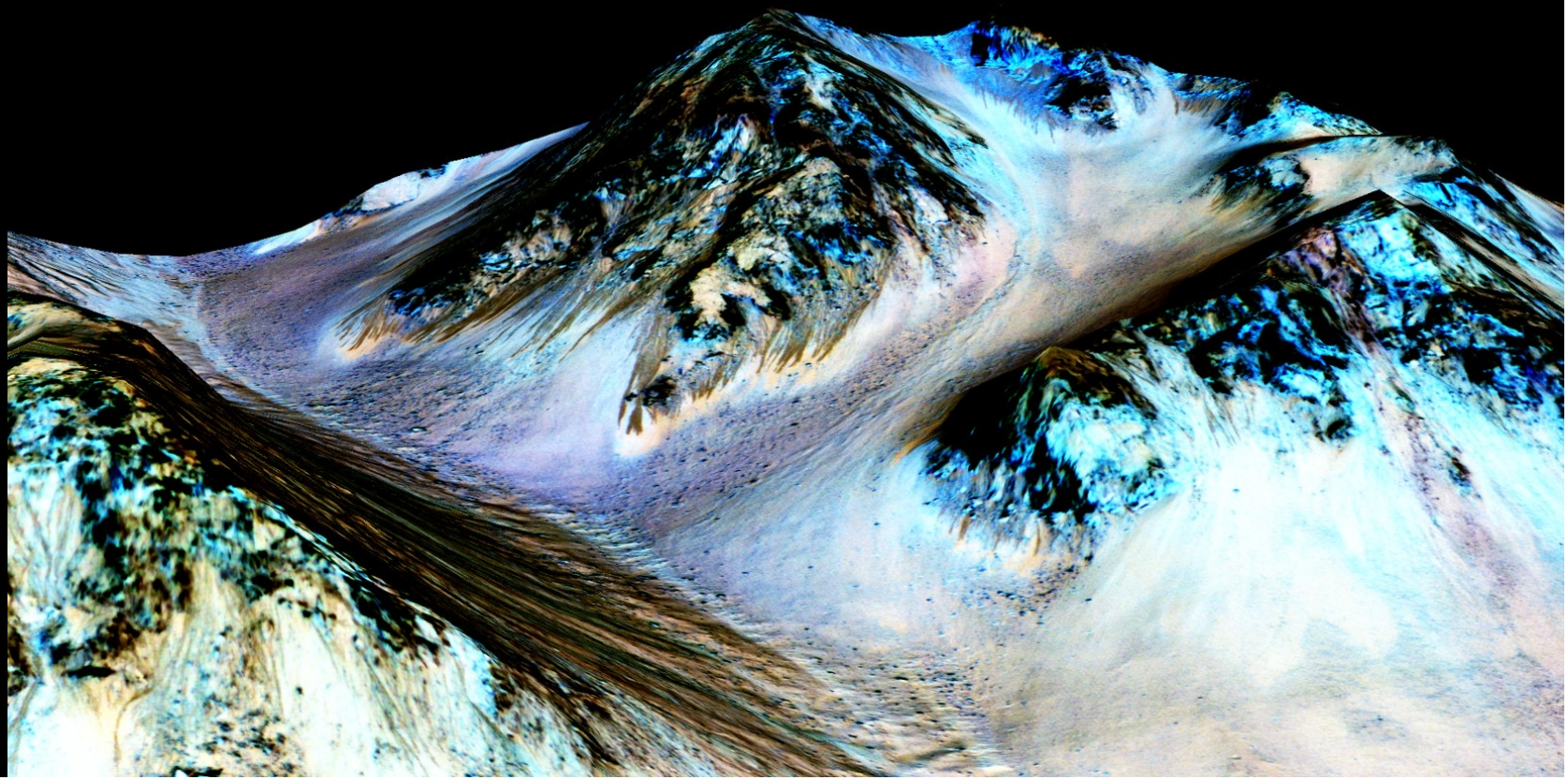




September 2015: Recurring Slope Linea (RSL) caused by flow of liquid water near the surface?

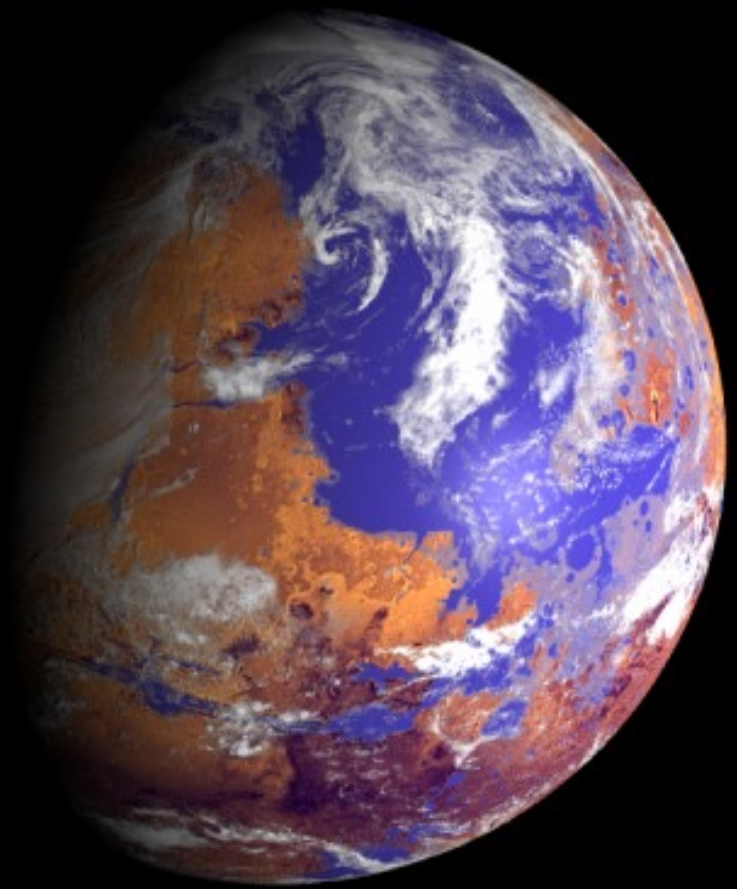
The Recurrent Slope Linea

- Dark streaks show hydrated salt (**perchlorate**) deposits that form when briny water flows through the landscape.
- Perchlorates can keep water from freezing when it's as cold as –70° C.



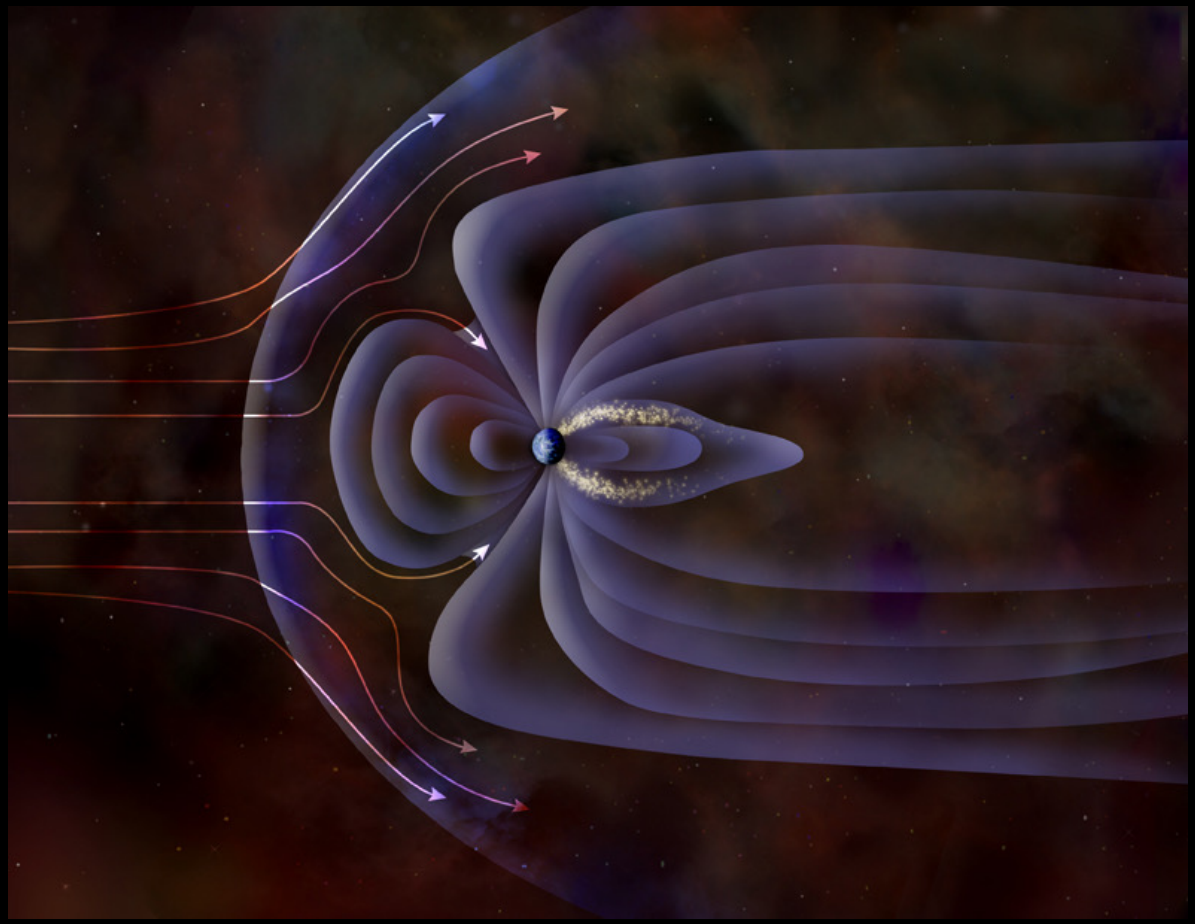
What happened?

3 billion years ago, Mars may have been a planet covered with vast oceans…



What happened to Martian oceans?

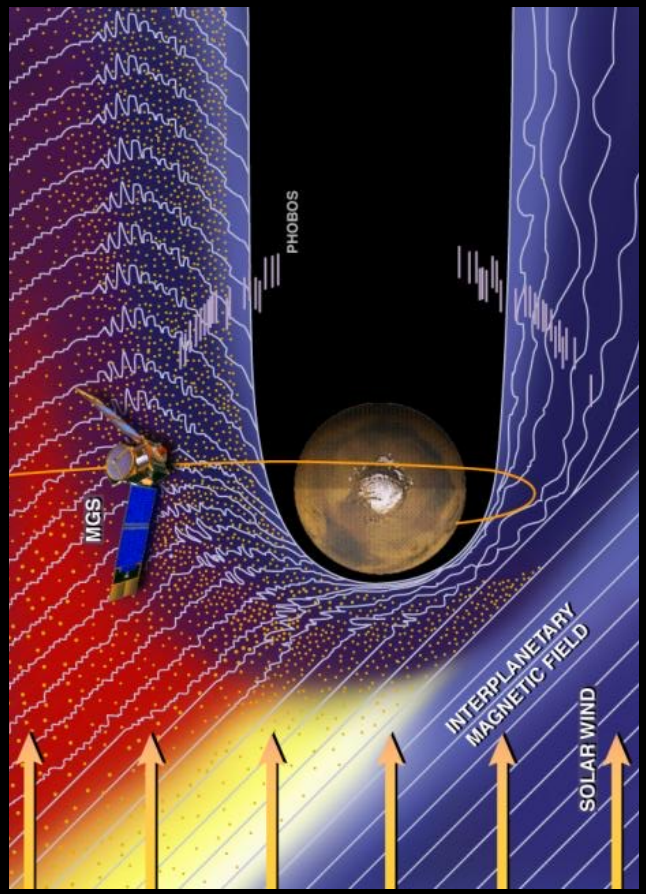
Compare Mars with Earth: Earth has a robust magnetic field that protects the atmosphere from the solar wind.



What happened to Martian oceans?

Lack of a global magnetic field results in the direct access of the solar wind to the Martian atmosphere:

1. Ocean water evaporates…
2. Solar wind breaks water molecules, H_2O, or H–O–H, into H and O–H. O–H is also broken up into H and O.
3. Hydrogen escapes from Mars.
4. Oxygen is absorbed by Martian rocks.
5. Now, atmospheric pressure is too low for liquid water to exist on the surface of Mars.

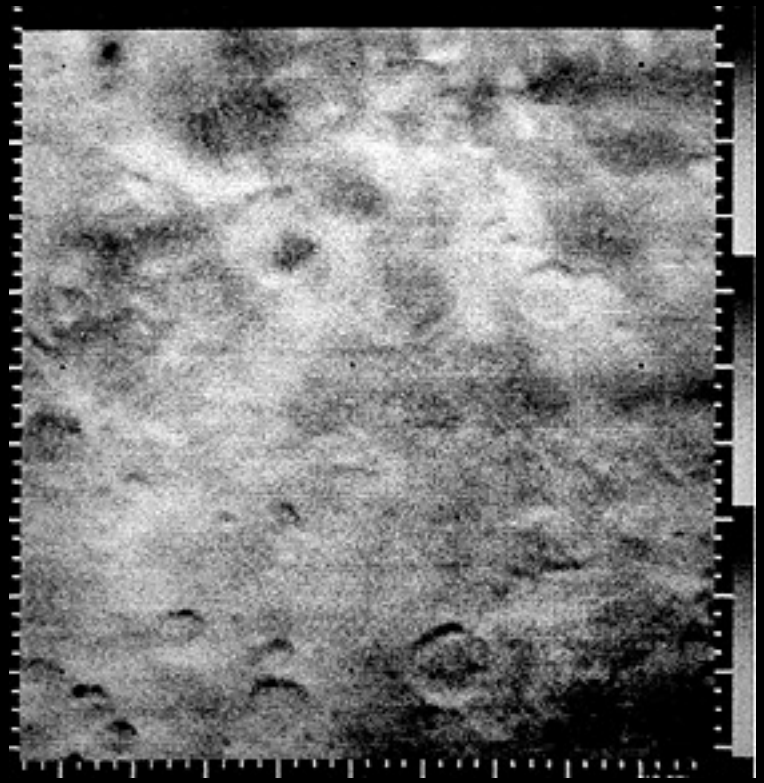


Findings of MAVEN

Mars missions

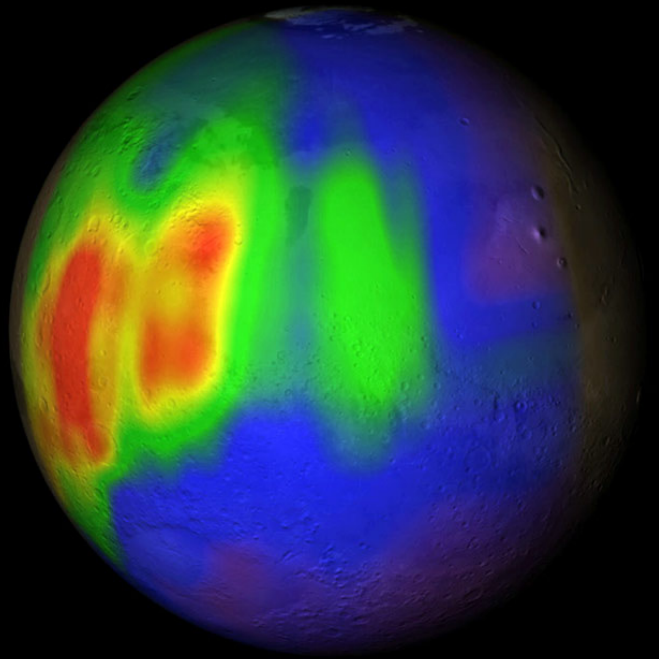
The first flyby

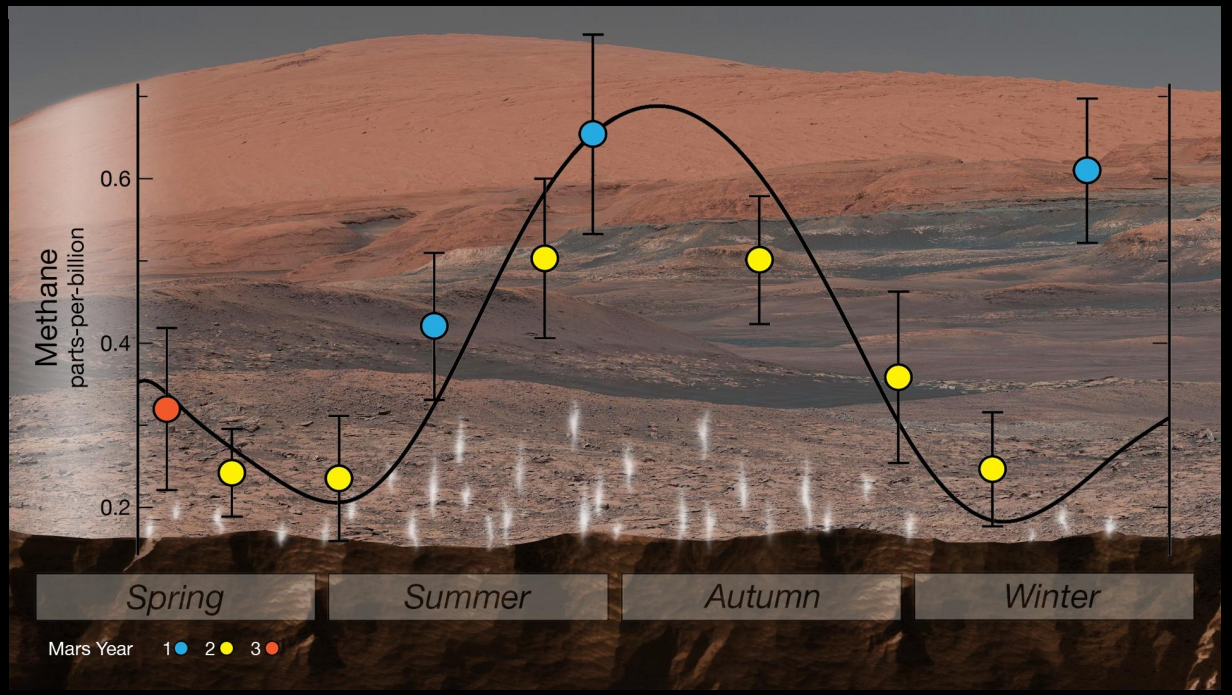
Mariner 4 flyby in 1965 established that Mars was a canal-less, rocky planet with a thin atmosphere.



Martian methane

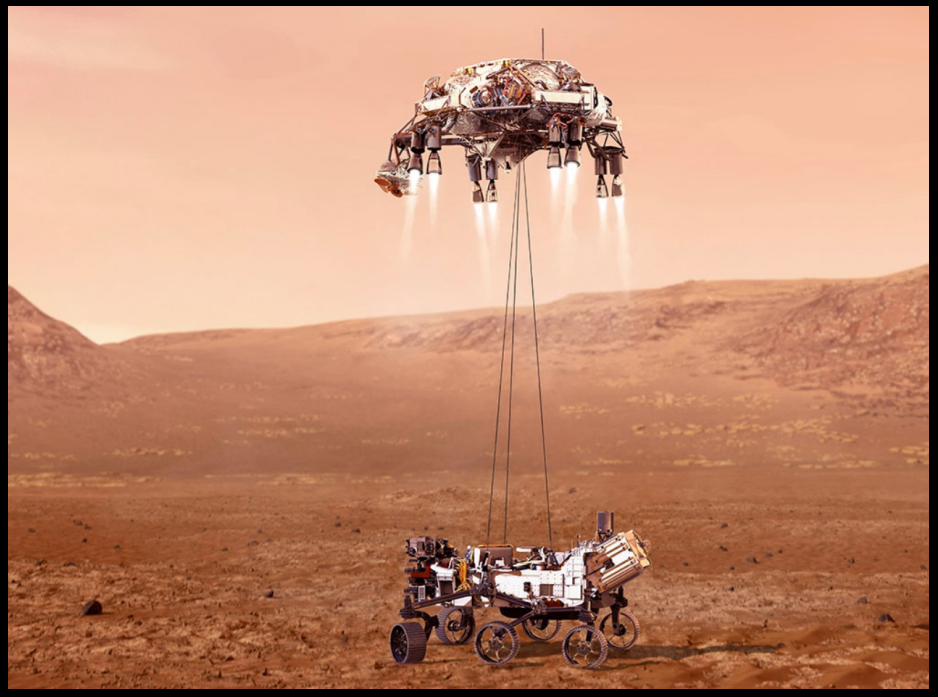
- ESA's Mars Express mission discovered methane in Martian atmosphere in 2004.
- Finding confirmed by Curiosity rover; it found seasonal changes in methane: higher in the summer months.
- Souce of methane could be 1) microbial life, or 2) heating up ofmineral olivine in presence of water. Both are possible.

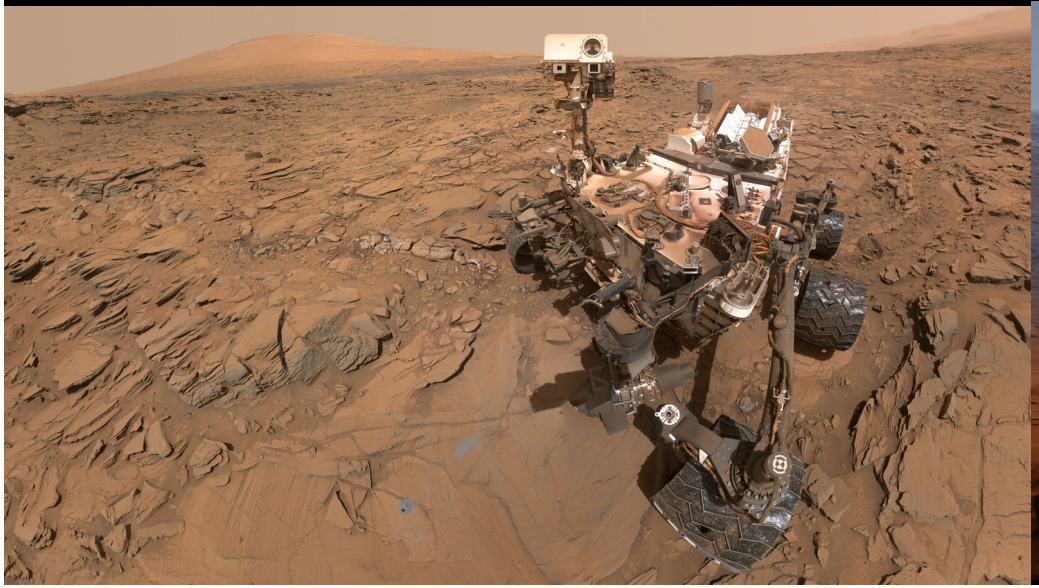


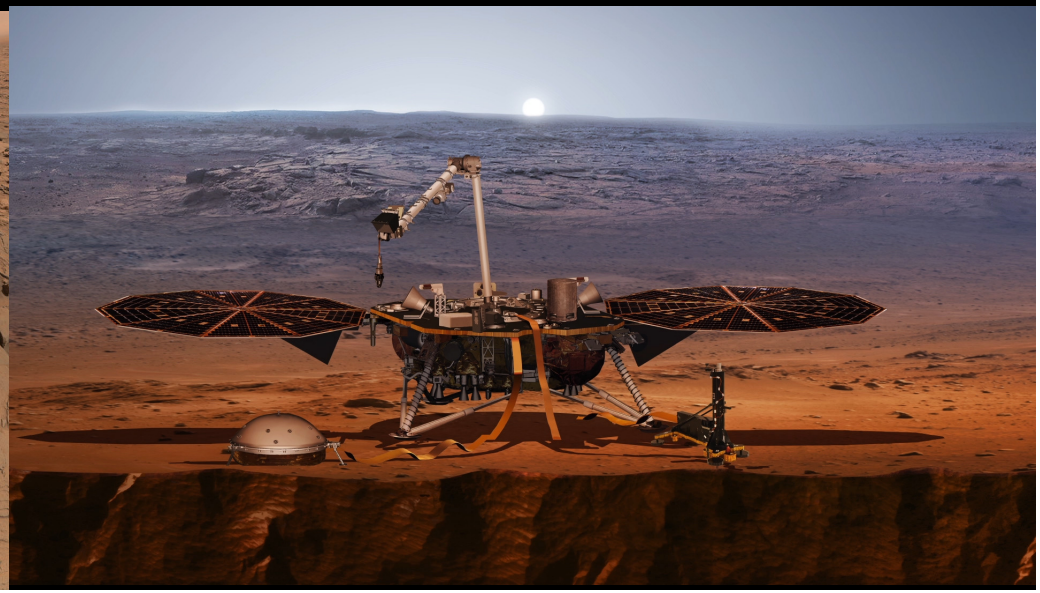


Current Operational Missions: Landers / Rovers

- ✓ **Mars Science Lab**, Curiosity Rover (left bottom).
- ✓ Mars **InSight** (Interior Exploration using Seismic Investigations, Geodesy and Heat Transport; right bottom)
- ✓ **Mars Perseverance Rover** (2021, right top)







Mars Perseverance Rover (Feb. 2021)

Mars Perseverance Rover, 2021.

A key objective of Perseverance's mission on Mars is **astrobiology**, including the search for signs of ancient microbial life.

Mars Perseverance Rover, 2021.

Sedimentary layers in the “delta” of the Jezero crater?

What did we learn in Chapter 21?

- Mars is the most visited solar system body, with 6 orbiters and 3 rovers currently operational.
- Percival Lowell's canals were shown not to exist when spacecraft visited Mars.
- Martian Dichotomy: northern and southern hemispheres of Mars are very different in geologic age and in surface features.
- Olympus Mons and Tharsis volcanoes largest in our solar system.

What did we learn in Chapter 21?

- Seasons on Mars affected both by axial tilt and distance from Sun.
- Evidence of liquid water on Mars in gullies, hematite blueberries, subsurface glaciers, potassium concentrations at the mouths of river channels, and recurring slope linea.
- Martian oceans thought to have evaporated when Mars lost its global magnetic field about 3 billion years ago.
- The four experiments on the Viking landers were inconclusive regarding the existence of life on Mars.
- Mars contains all the necessary ingredients for life, but is currently inhospitable because its atmosphere does not block out UV radiation and cosmic rays, and the soil is too rich in salts and other minerals.

What did we learn in Chapter 21?

- Venus has been mapped from orbit using radar.
- Venus suffered a runaway greenhouse effect due to its proximity to the Sun and slow rotation.
- Earth and Venus have about the same amount of CO_2, but on Earth, most of this CO_2 is locked in carbonate rocks or dissolved in the oceans. On Venus, the CO_2 is all in the atmosphere.
- Spacecraft landing on the surface of Venus have a very short lifetime due to high pressure, extreme heat, and caustic atmosphere.
- Volcanic activity occurred on Venus until at least 100 – 200 million years ago, and may be occurring now!