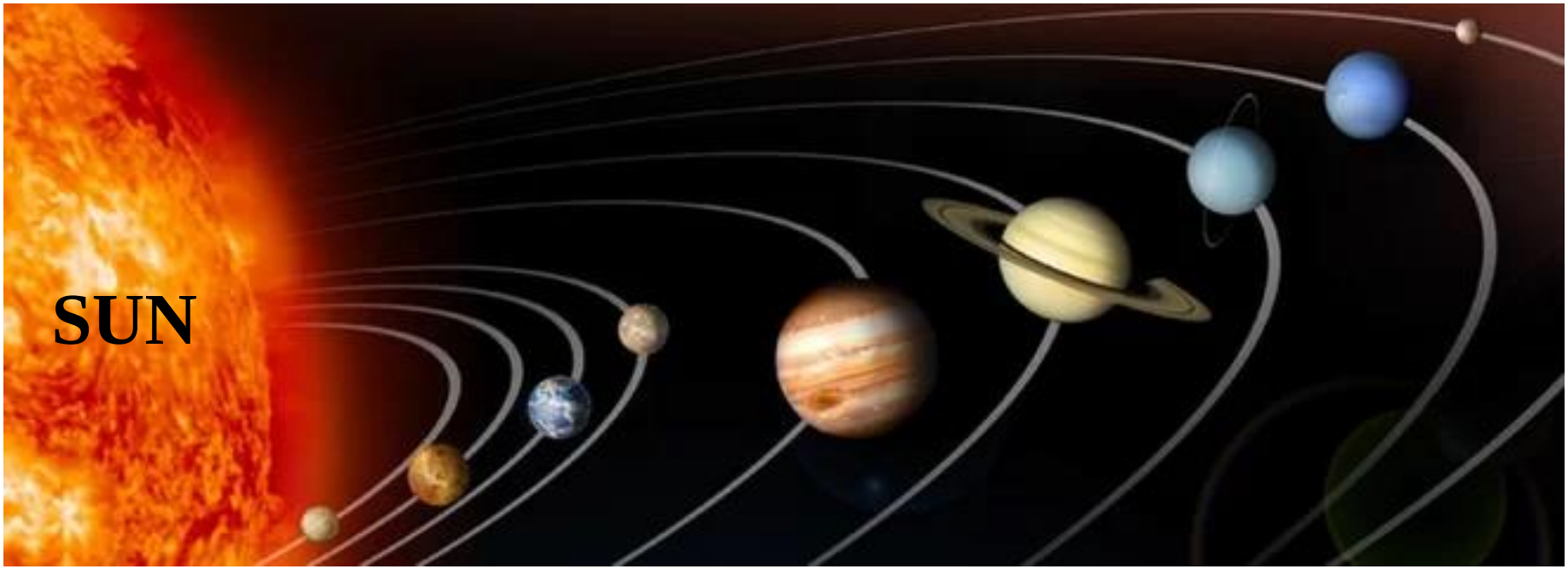
Lesson 08

Part 1

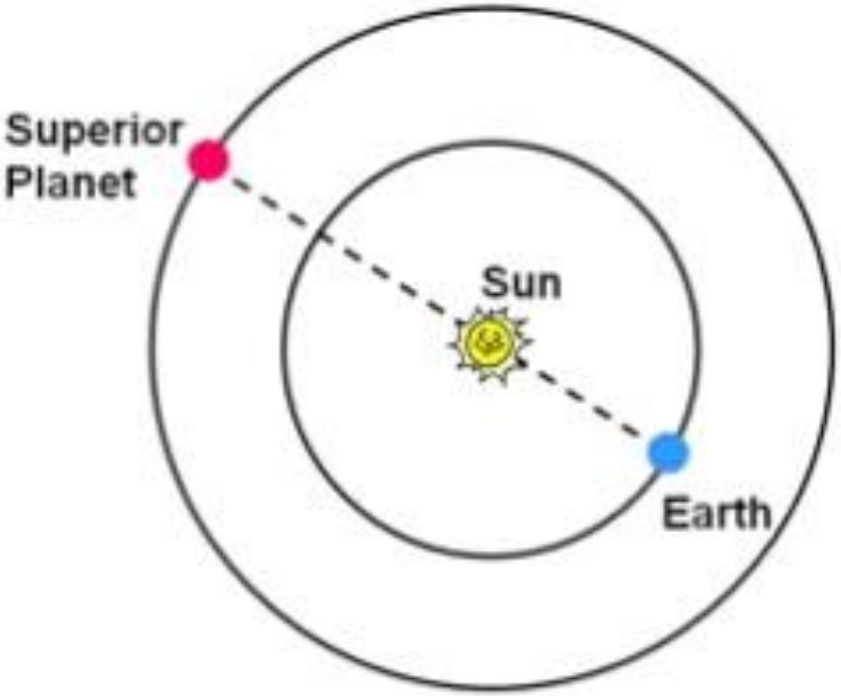
Mars

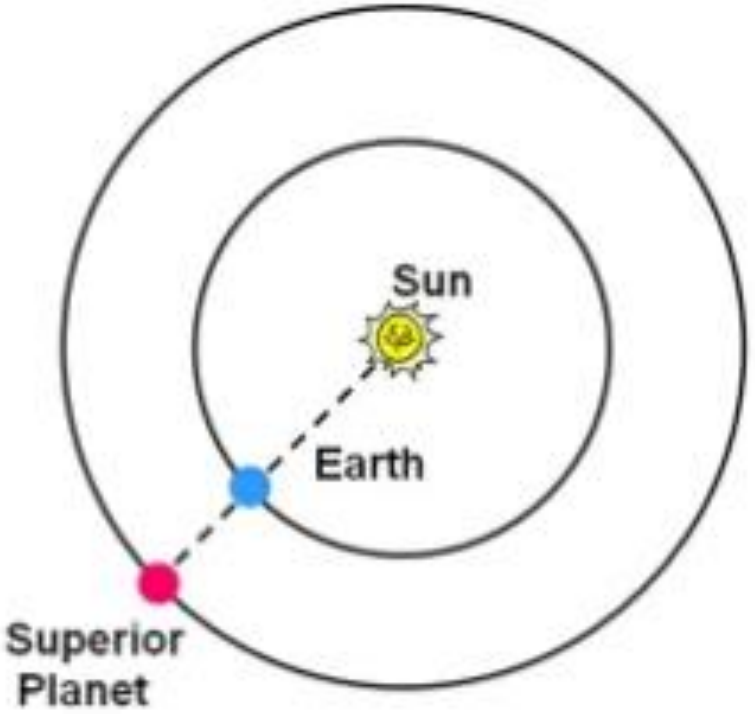
4 **Terrestrial planets**
(small inner planets)

4 **Jovian planets**
(large outer planets)



Additional bodies in the solar system: Moons, comets, asteroids, dwarf planets, and dust.



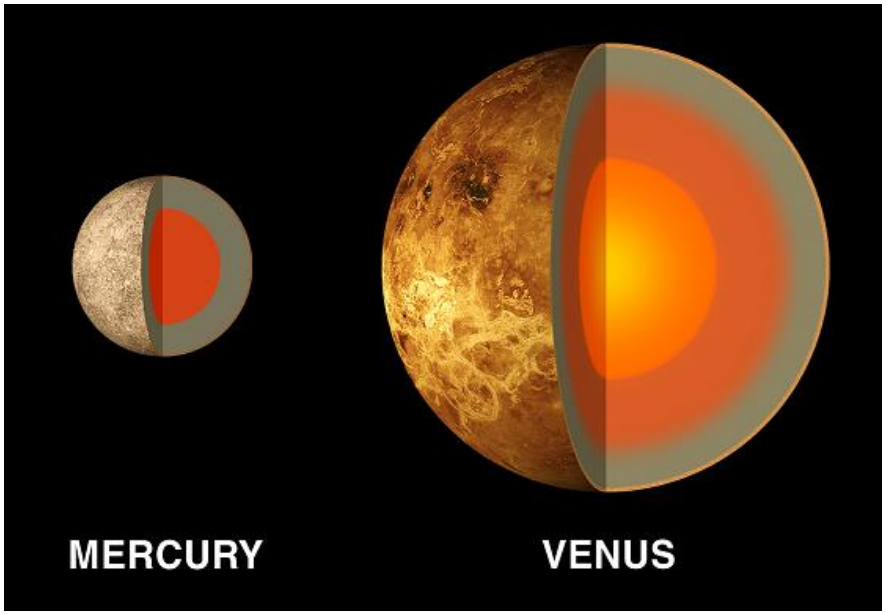


Mercury and Venus are **inferior planets**. **Inferior planets** have orbits that are closer to the Sun than Earth's orbit. The other planets and Pluto are **superior planets**. **Superior planets** have orbits that are farther from the Sun than Earth's orbit.

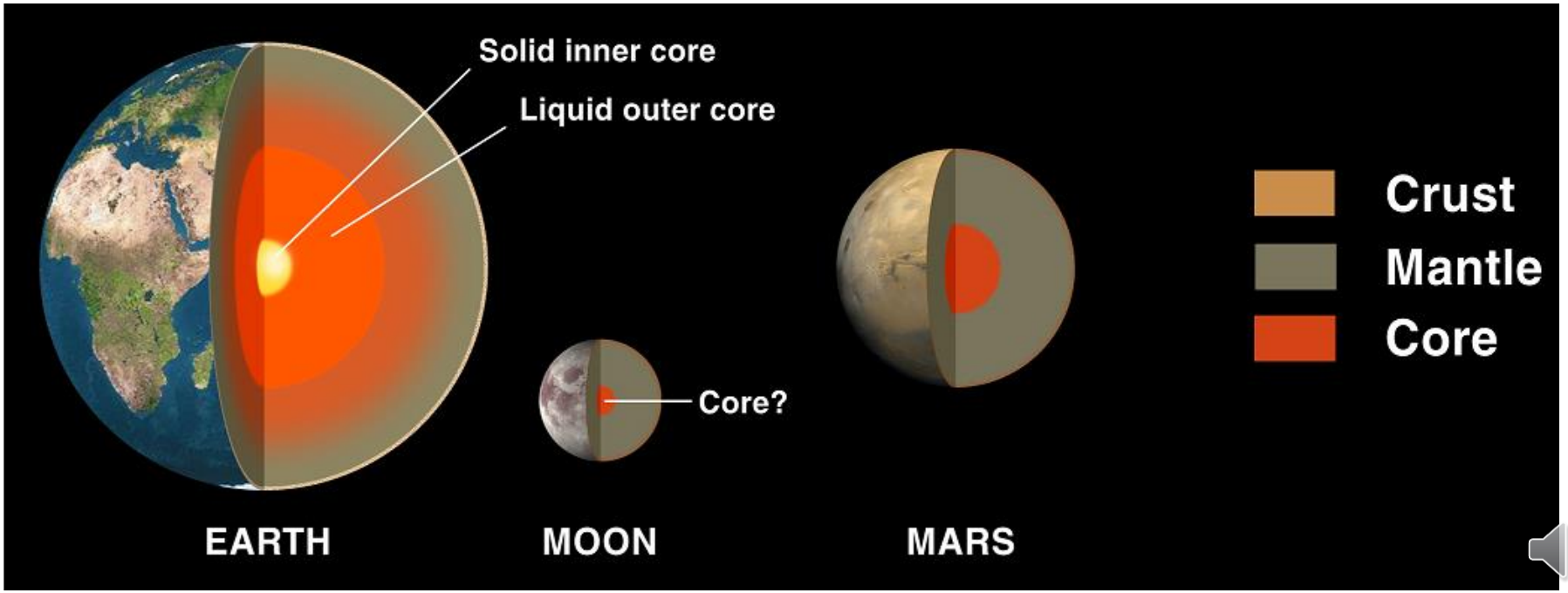
Terrestrial Planets: "Earth-like"

Mercury, Venus, Earth & Mars

- Small in size.
- Inner solar system. Orbit closest to the Sun.
- Made of rock and metal.



Terrestrial Planets have a thin rocky crust, a thicker denser mantle made of rock, and an iron & nickel core. The thicknesses and depths of their mantles and cores vary.

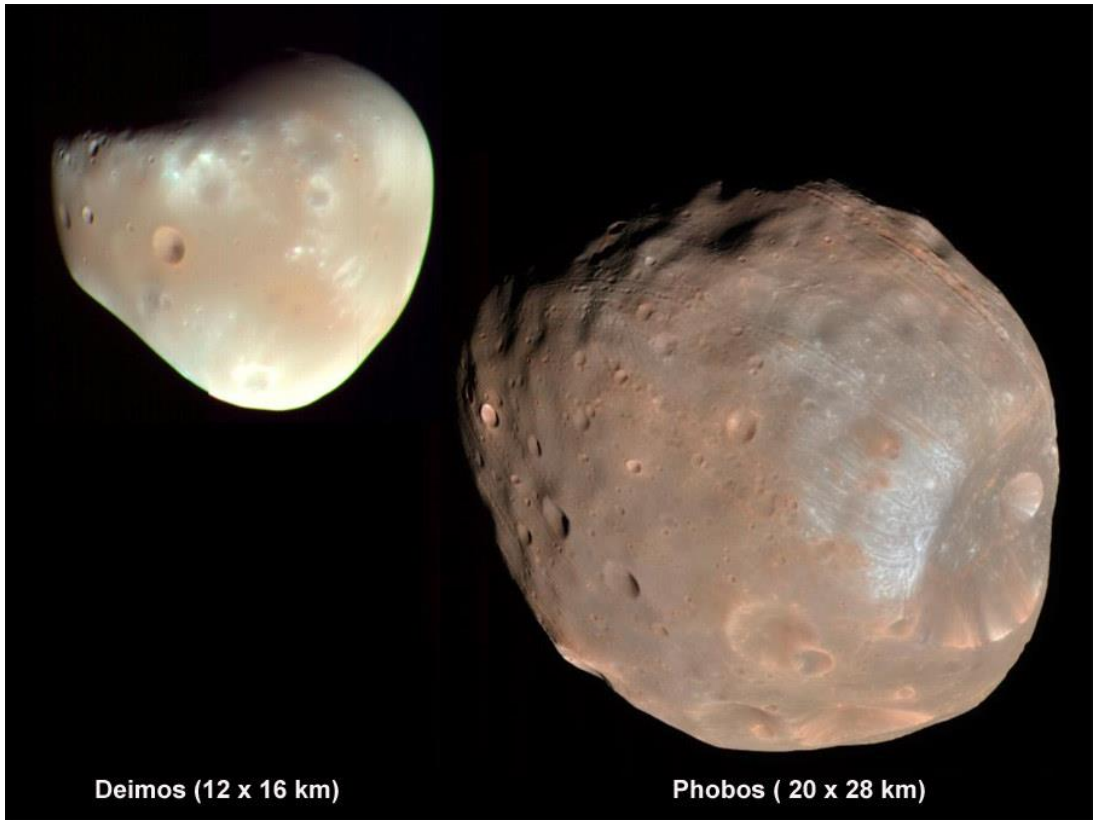


	Atmosphere Composition	Atmosphere Pressure (Atmo)	Avg. Surface Temperature
Mercury	None	None	430ºC Day -180º Night
Venus	96% CO_2 4%N_2 H_2SO_4 clouds	90	460ºC
Earth	78% N_2 21% O_2 H_2O clouds	1.0	15-20ºC
Mars	95% CO_2 3% N_2 H_2O, CO_2 clouds	0.007	-70ºC

MARS

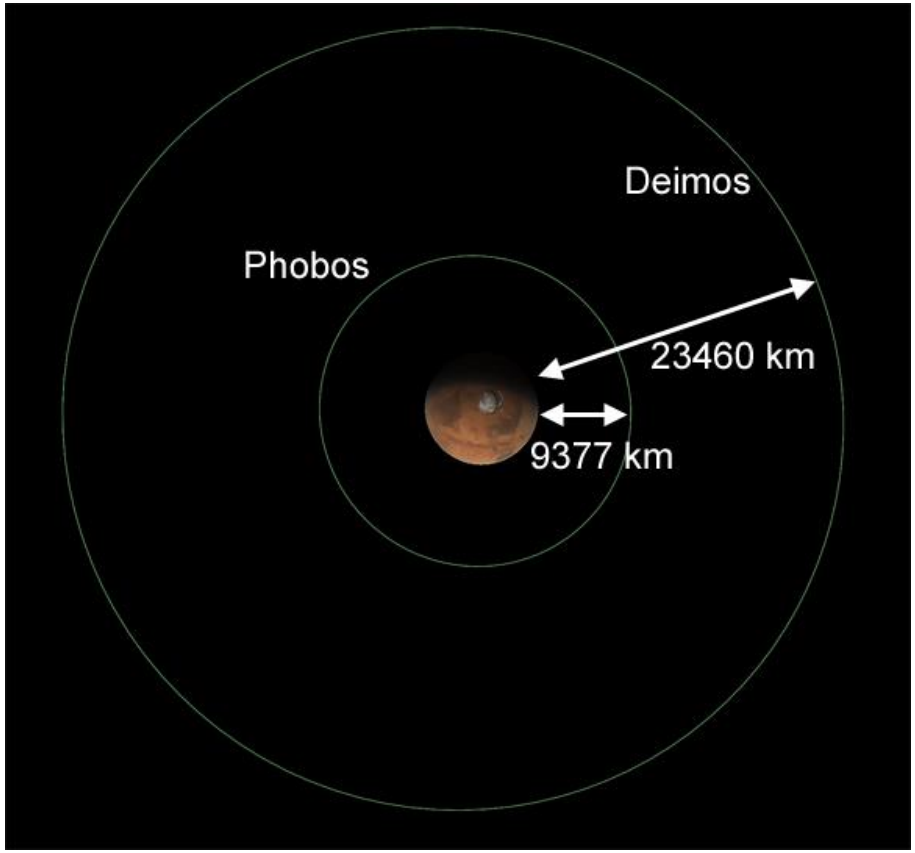
- Fourth planet from the Sun.
- Equatorial diameter = 6790 km
- Planetary mass = 6.42×10^{23} kg
- Bulk density = 3.95 g/cm^3
- Mean orbital radius = 2.28×10^8 km (1.52 AU)
- Orbital period = 687 days (1.88 yrs)
- Rotational period = 1.03 Earth days
- Tilt on its axis of rotation = 25º from upright
- Two moons: Phobos and Deimos
- Atmosphere (% mass): 95% CO_2(g), 3.5% N_2, 1.5% Ar
- Atmosphere ~ 0.007
- Surface temperatures: ~5ºC day and -123ºC night

- Mercury has zero moons
- Venus has zero moons
- Earth has one large moon: Luna
- Mars has two tiny moons: Phobos and Deimos



Martian satellites: ***Phobos*** (Fear) is the larger and ***Deimos*** (Panic) is the smaller.

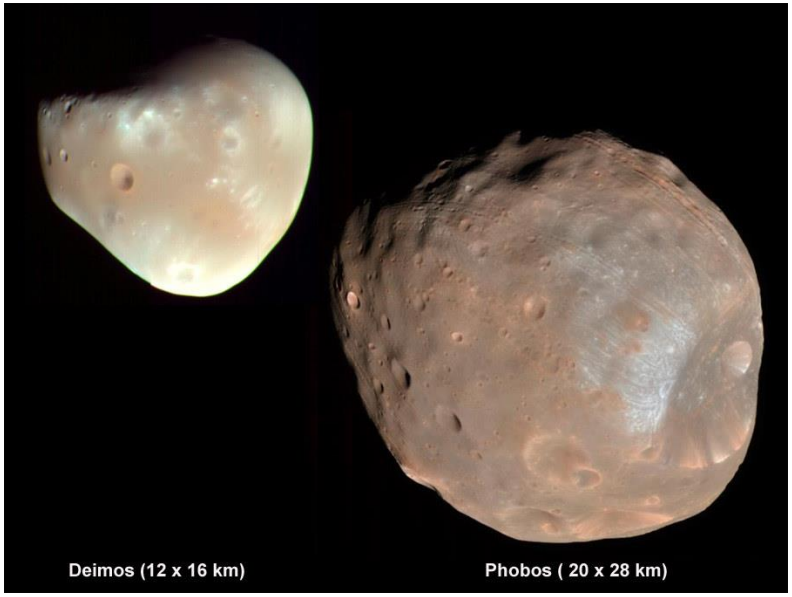
The moons were discovered in 1877 by Asaph Hall.



Phobos and Deimos orbit Mars much closer than the Moon orbits Earth.

They orbit Mars in almost circular orbits.

- Phobos orbits 9400 km away, with an orbit period of 7.6 hours.
- Deimos orbits 23,500 km away with an orbit period of 30 hours.

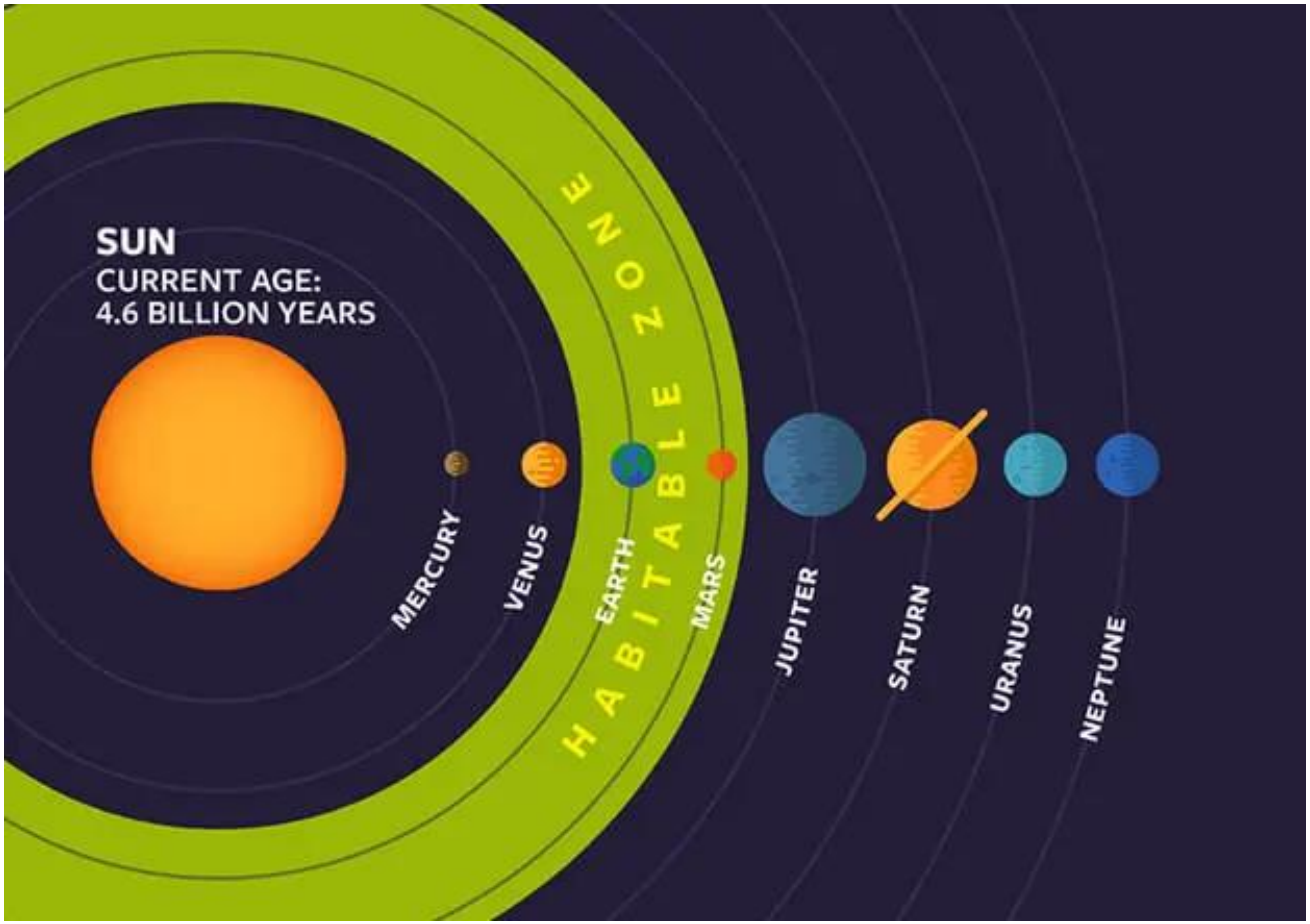


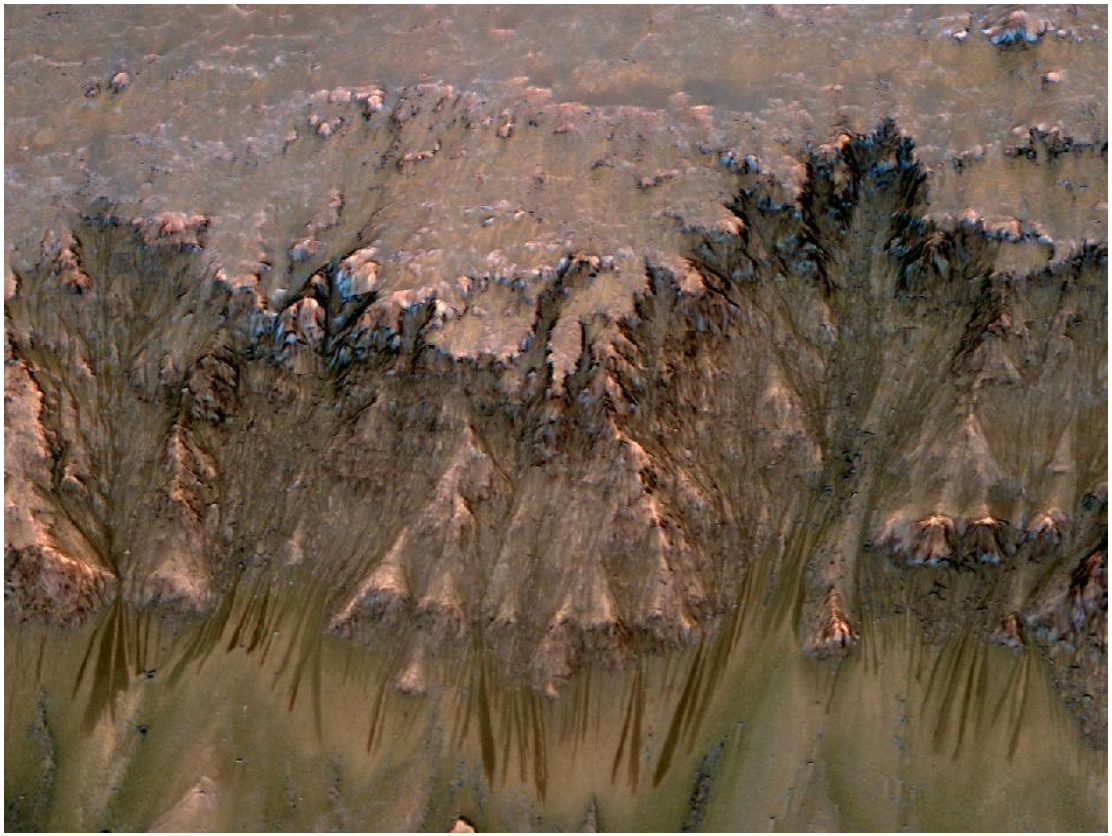
Phobos is spiraling inward in its orbit. In the distant future, Phobos will crash into Mars's surface.

Mars's moons were thought to be captured asteroids from the asteroid belt. Asteroids were perturbed by Mars's gravity or Jupiter's gravity, drifted too close to Mars and were caught in Mars's gravity field.

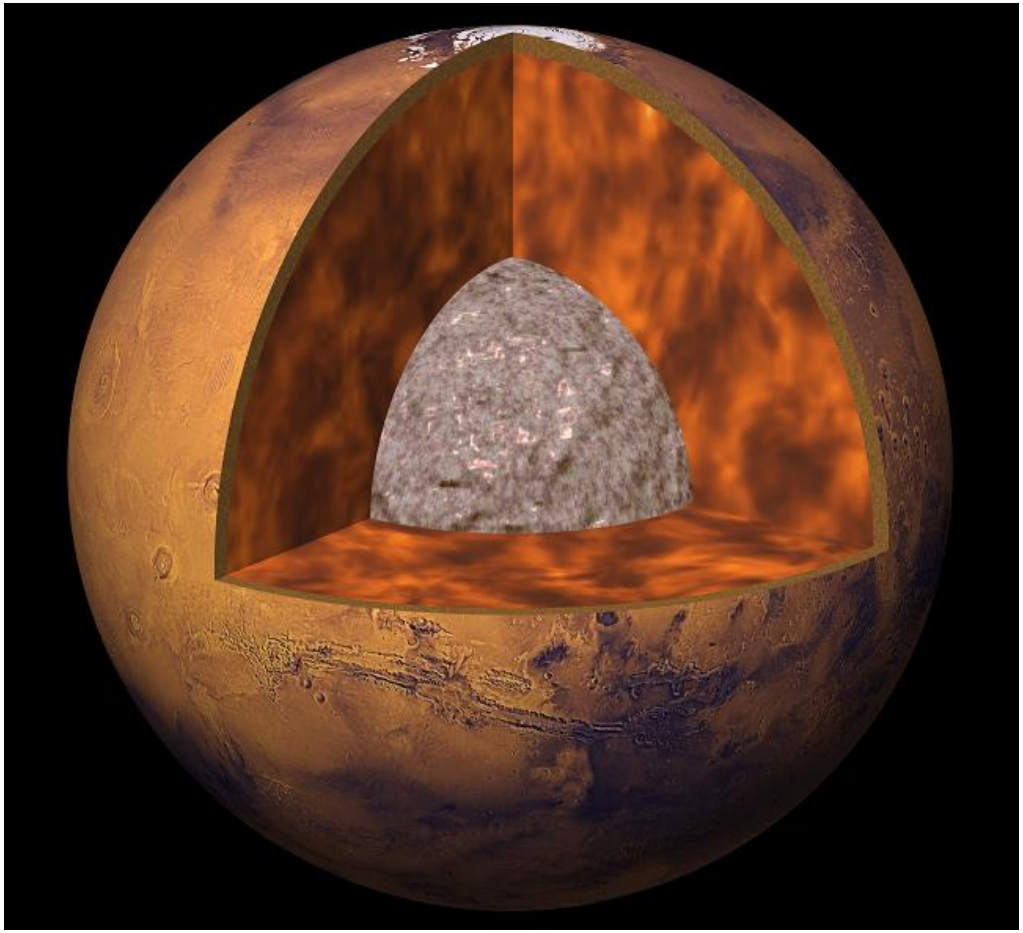
The newest and stronger explanation for the origin of Mars's moons is that both may be left over chunks of a larger moon that disintegrated or was smashed by a collision.

Mars's orbit lies at the very outer edge of the Habitable Zone in our solar system. Conditions, however, are not suitable now for Mars to support liquid water on its surface.





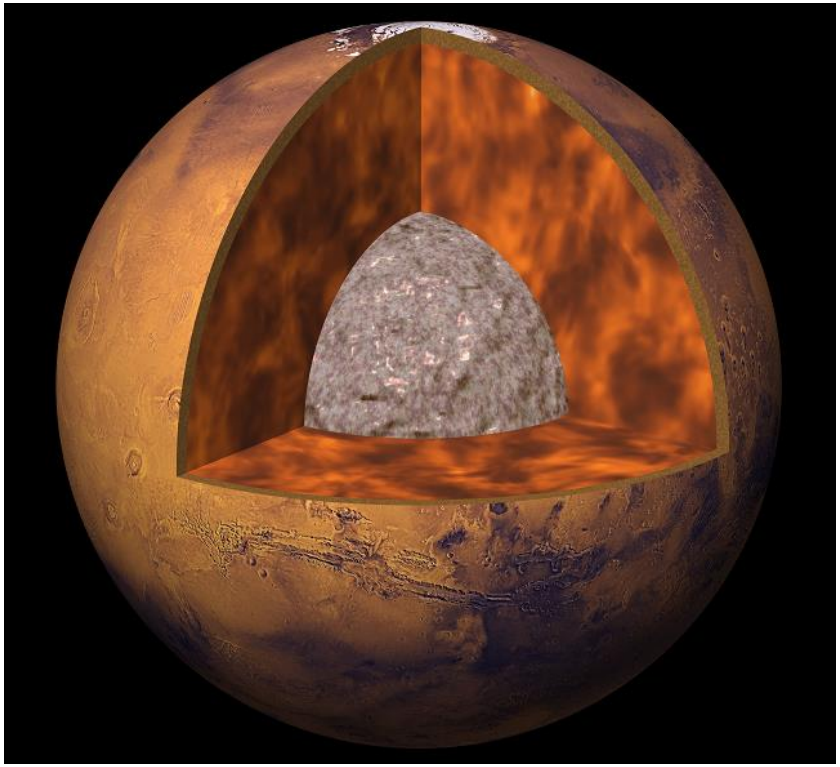
In 2015, evidence of liquid water flowing beneath the soils' surfaces. Mars orbiting satellites used non-visible light to measure water in the soils. Additionally, photographs were taken of the loose sides of canyons and craters that were sliding like they were wet mud.



Mars's planetary mass is ~ 11% of Earth's mass.

Mars's density is only 3.9 g/cm^3 compared to Earth's 5.57 g/cm^3.

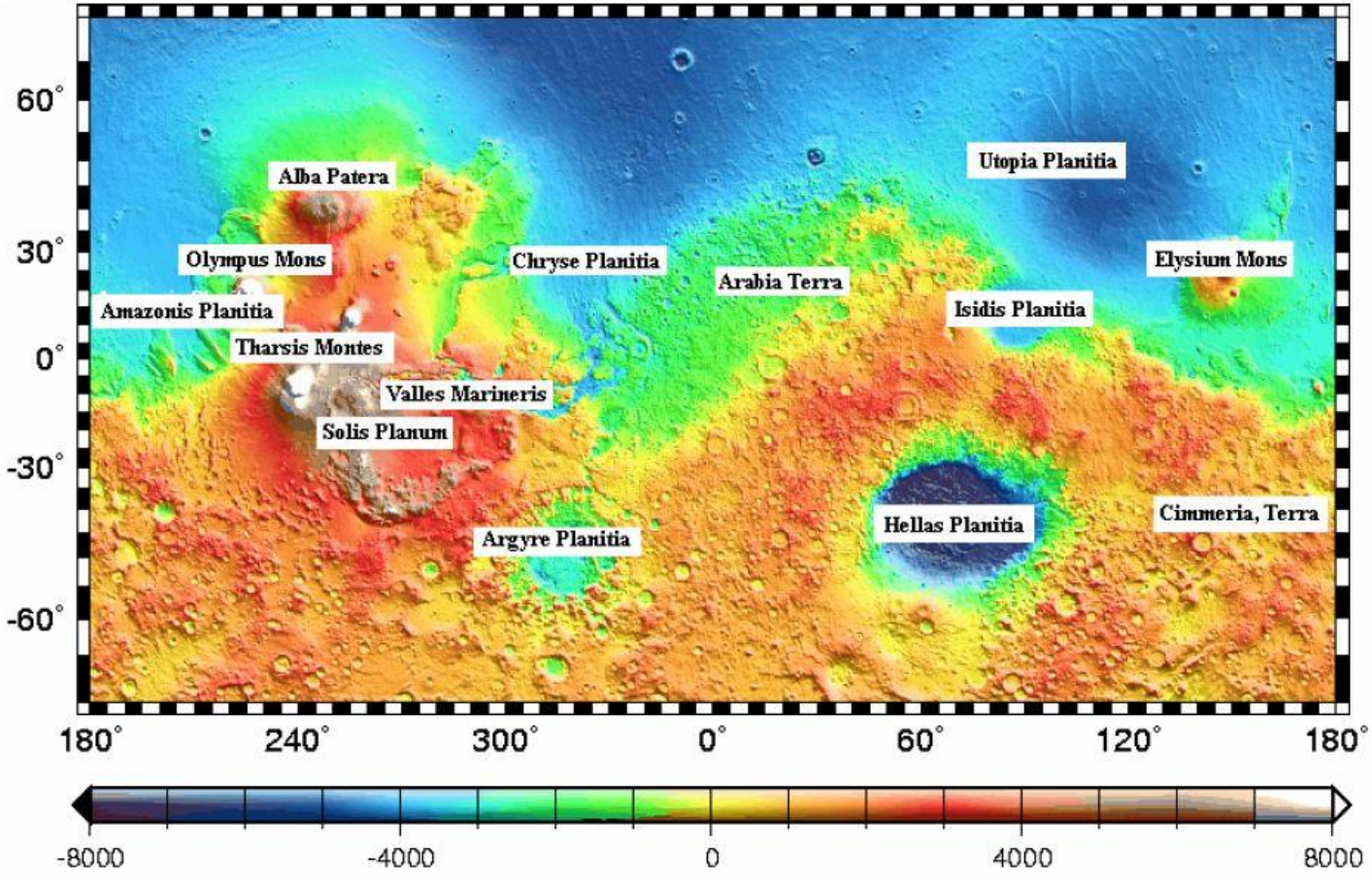
Mars has a very weak magnetic field

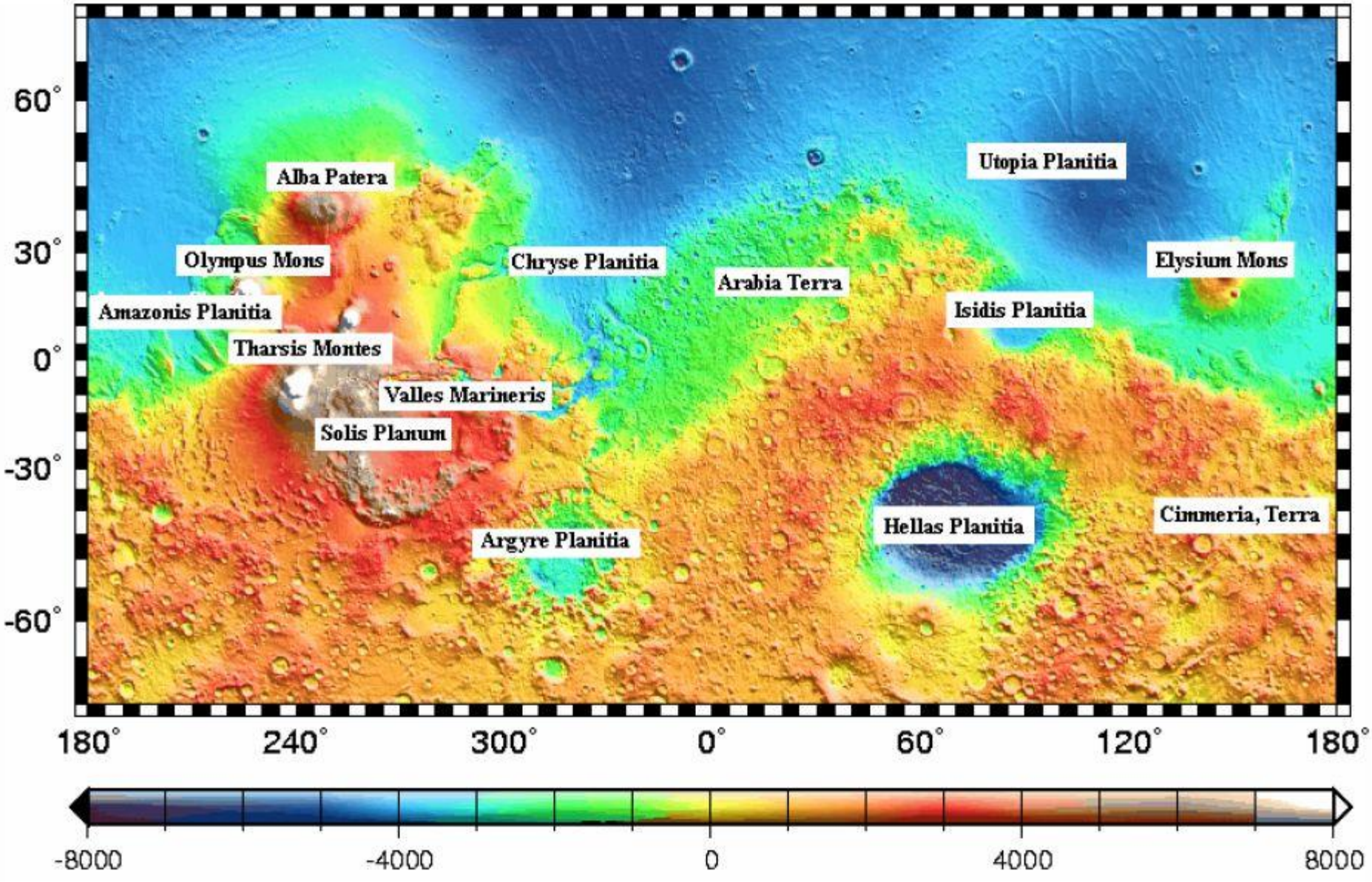


Mars's interior cooled off within the first 1-2 billion years after Mars's formation. Smaller size planets cool faster because there is less mass of rock covering the hot inner and outer cores.

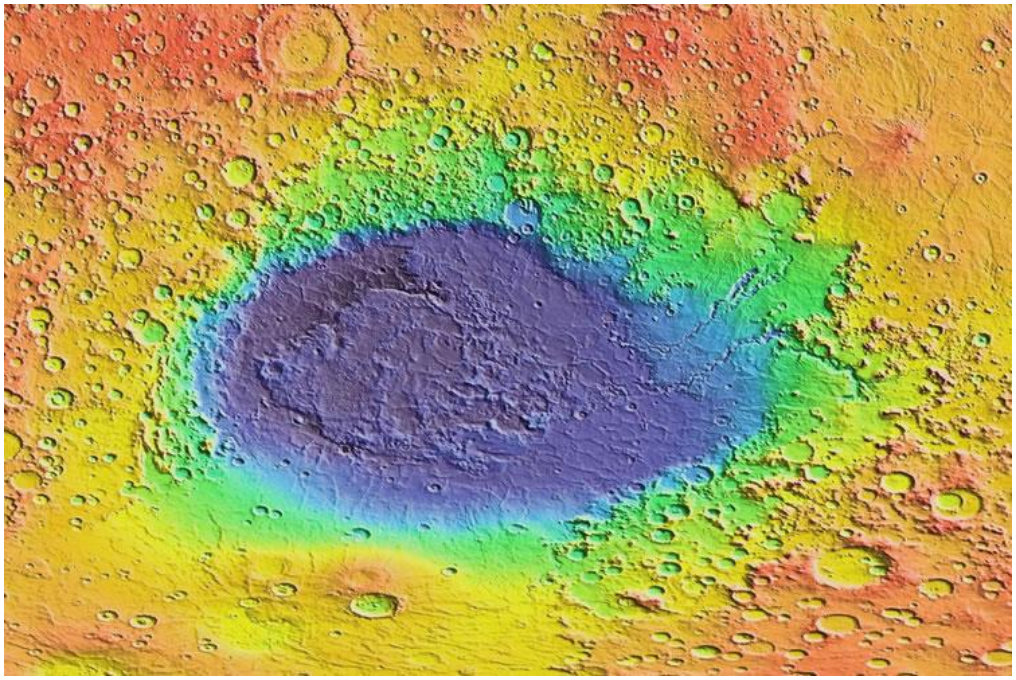
- Mars is tectonically and volcanically dead. The volcanic remnants are billions of years old.
- Recent thermal measurements suggest a small amount of molten "outer core" material.

Martian geography is highly variable like Earth's and Venus's geography. There are highlands, mountain ranges, and heavily cratered plateaus (continents) and smoother lowland basins (like former ocean basins)



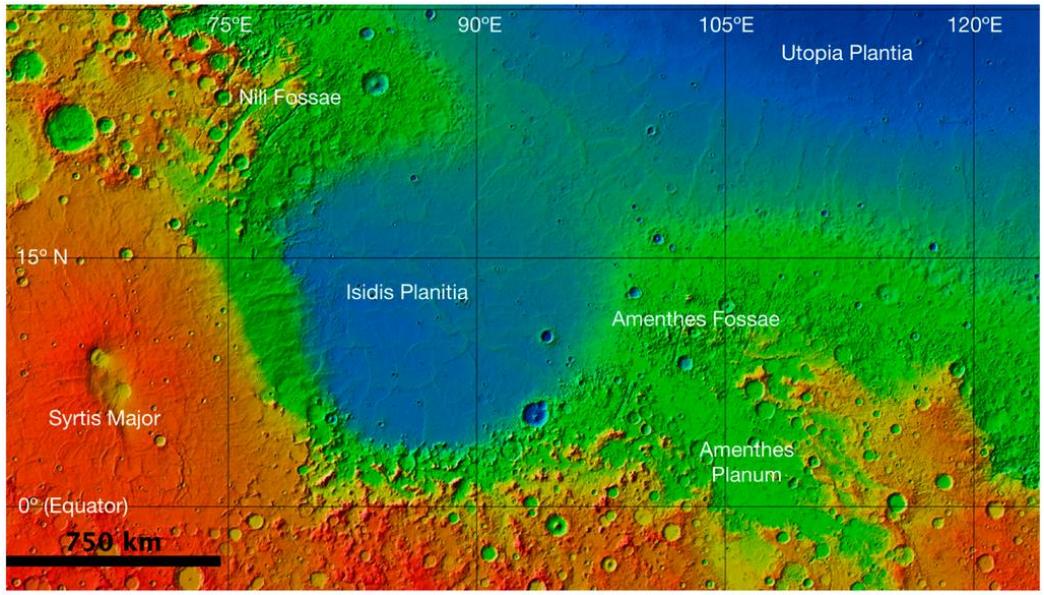

Alba Patera
Utopia Planitia
Olympus Mons
Chryse Planitia
Elysium Mons
Arabia Terra
Amazonis Planitia
Isidis Planitia
Tharsis Montes
Valles Marineris
Solis Planum
Hellas Planitia
Cimmeria, Terra
Argyre Planitia
60°
30°
0°
-30°
-60°
180°
240°
300°
0°
60°
120°
180°
-8000
-4000
0
4000
8000

- **Planitia**: Deep and flat bottomed basins with relatively few craters (“past ocean basins”?)
- **Planum**: Plains on the highlands.
- **Terrae**: Densely cratered higher elevation regions and mountains (“continents”?)
- **Montes (Mons)**: Volcanic mountain ranges and peaks
- Very large Impact craters and impact basins (Utopia, Hellas, Isidis)
- **Borealis Province**: The extensive lowland basins that cover the northern Hemisphere



Hellas Planitia

2,300 km diameter impact crater formed 3.8-4.0 BY ago.

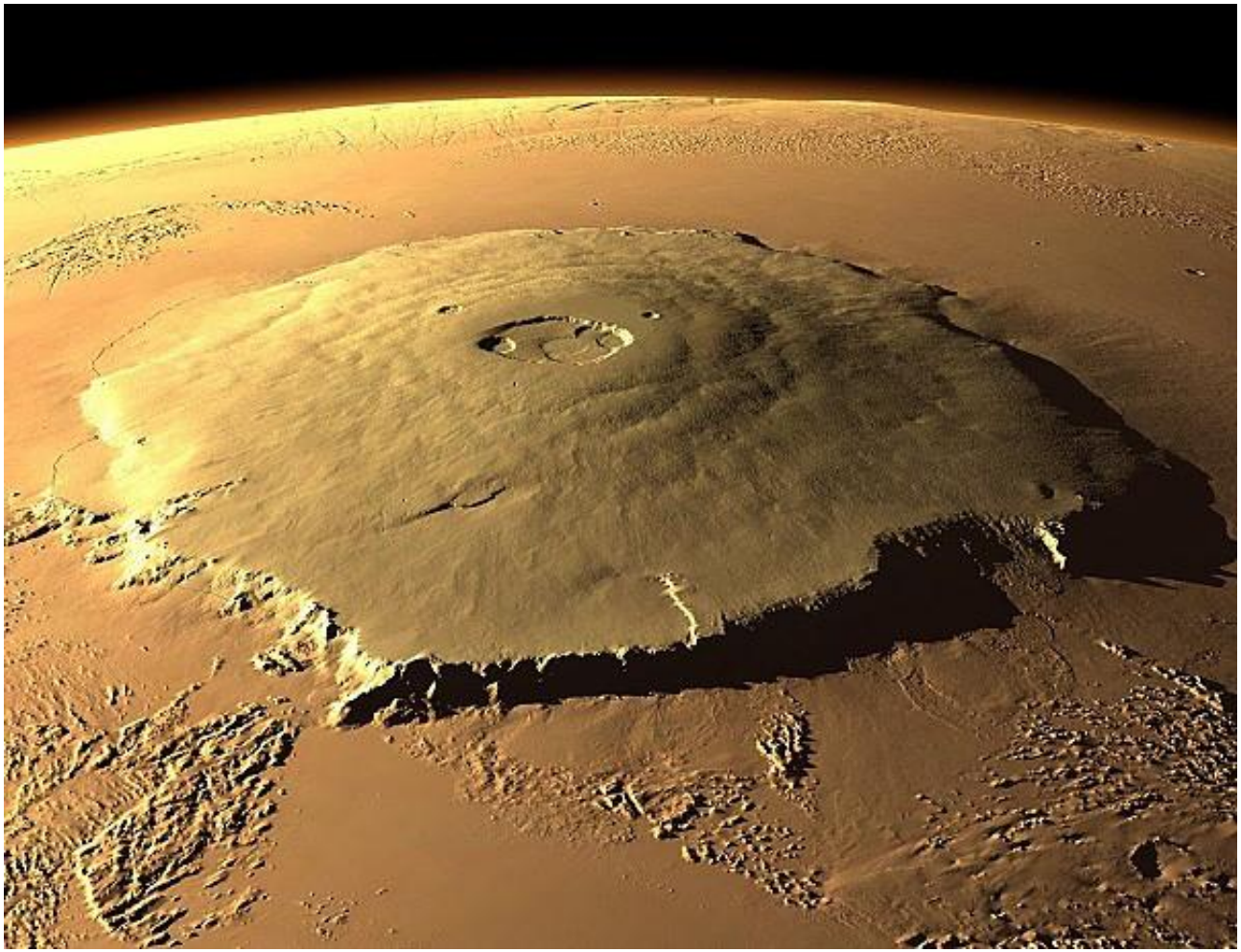


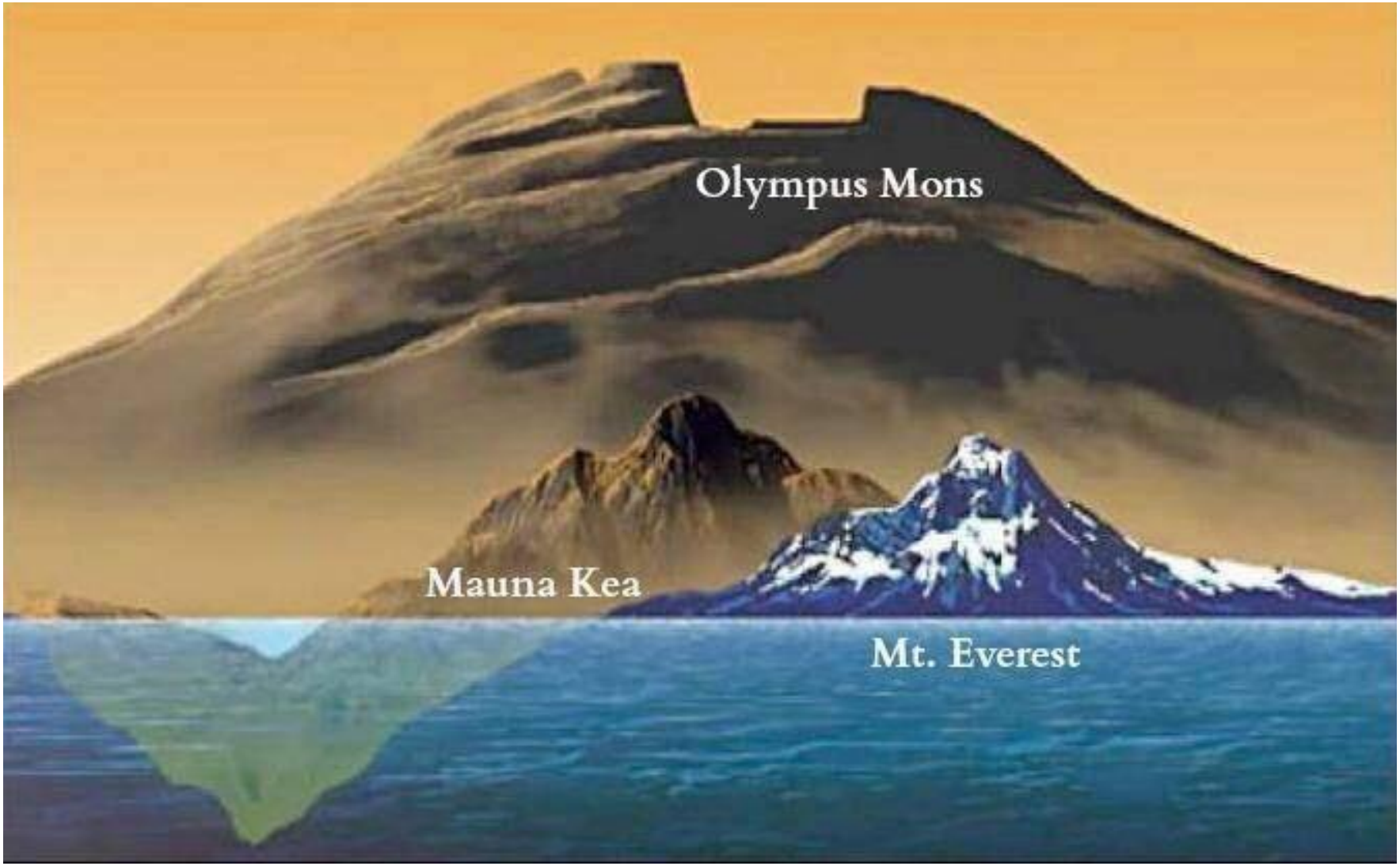
Utopia Planitia

Largest impact basin 3,000 km diameter.

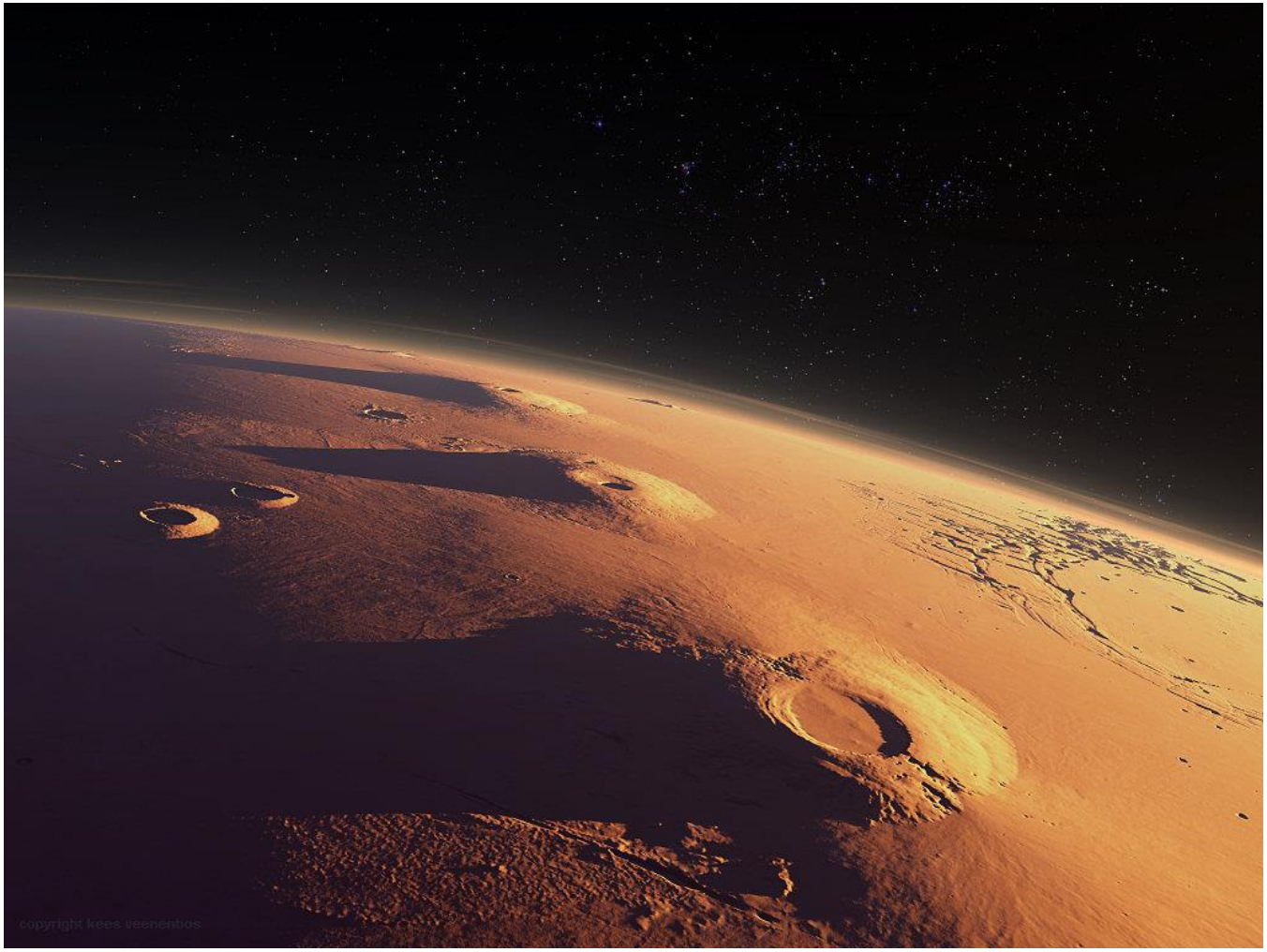
Olympus Mons

Olympus Mons is the tallest planetary mountain in the solar system. It is an extinct shield volcano that is 22 km in elevation and 600 km in diameter.



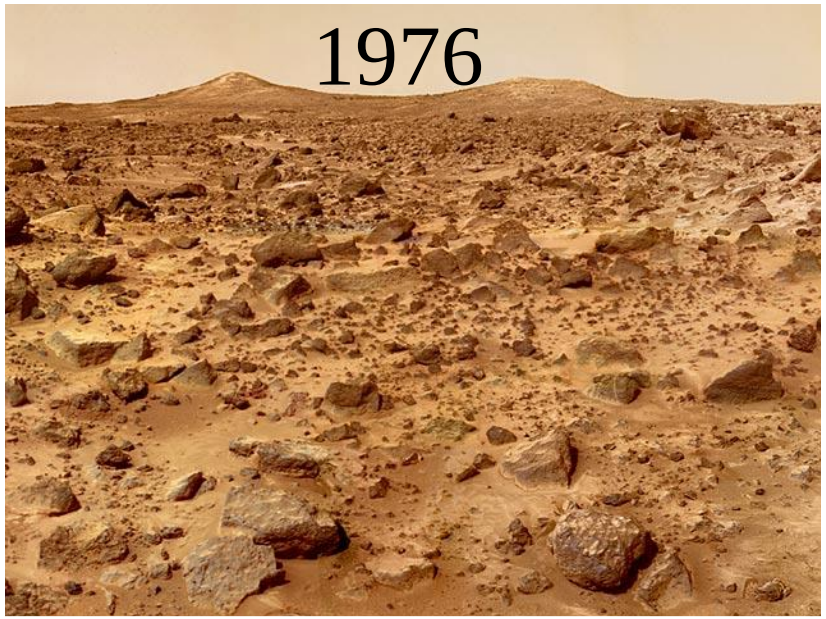


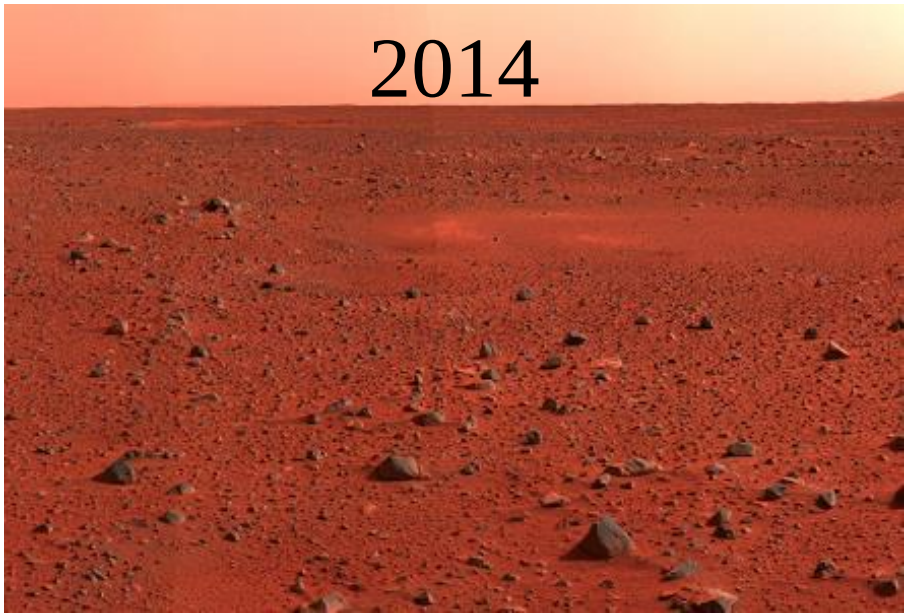
Comparison of Olympus Mons to Mt. Everest (tallest terrestrial mountain) and Mauna Kea (largest volcano)



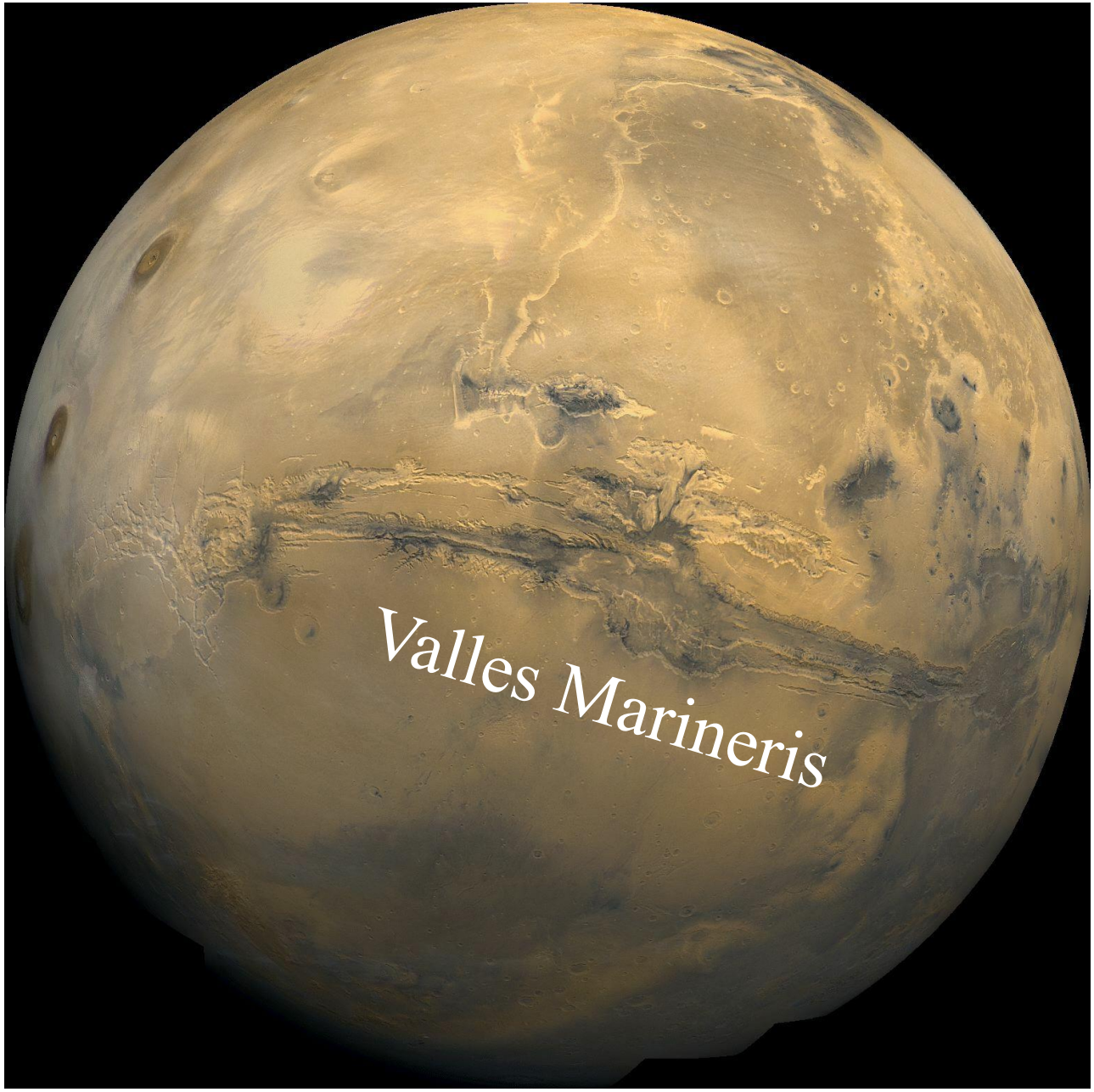
Tharsis Montes *is a m*ountain range near the Martian equator. They are a cluster of extinct, high elevation shield volcanoes

Mars has a desert-like surface covered in reddish-orange dust and soil. "The Red Planet"



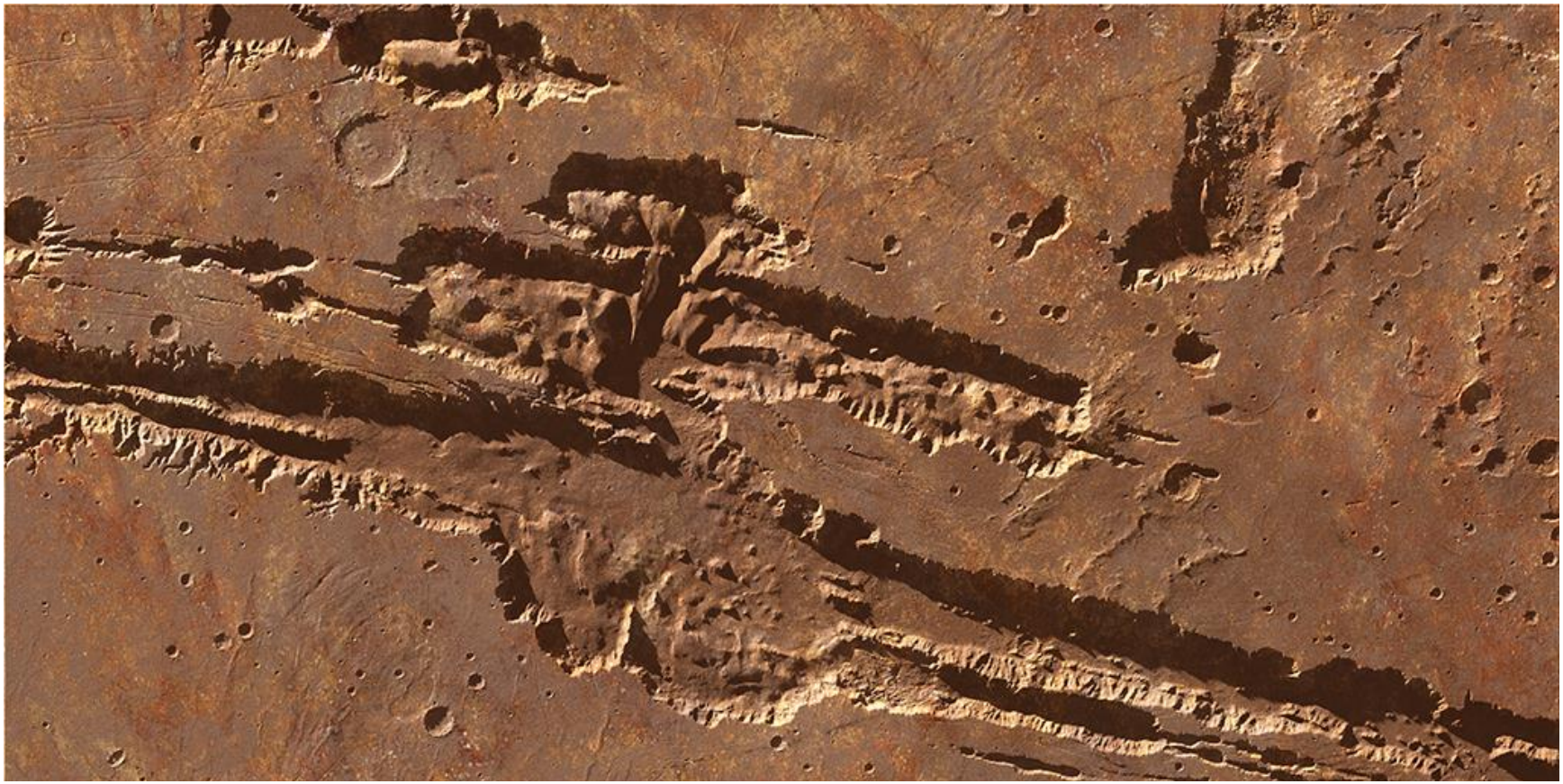


- The Martian soil have been oxidized to form ***iron oxide*** compounds (rust).
- Possible evidence that Martian atmosphere once contained oxygen and widespread presence of liquid water on surface.


Valles Marineris

Valles Marineris is a huge network of deep and wide canyons in the Martian crust. Valles Marineris is 4000 km long, 200 km wide at its widest location, and some locations are 7 km deep.

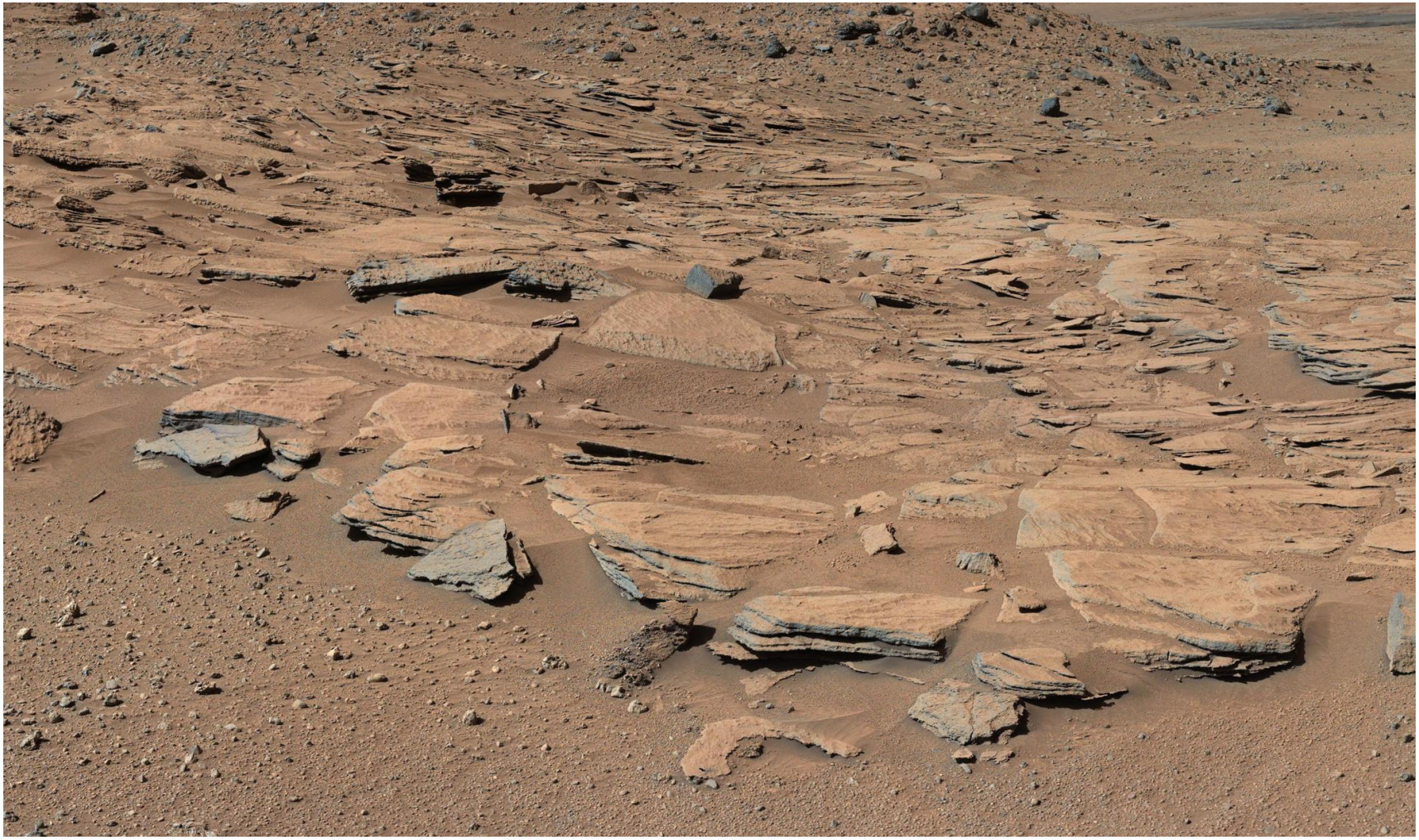
Valles Marineris is through to have formed as the crust buckled and cracked as Mars's interior cooled. A cooling planet will slightly shrink in diameter and volume. The crust cracked and rifted by the cooling.



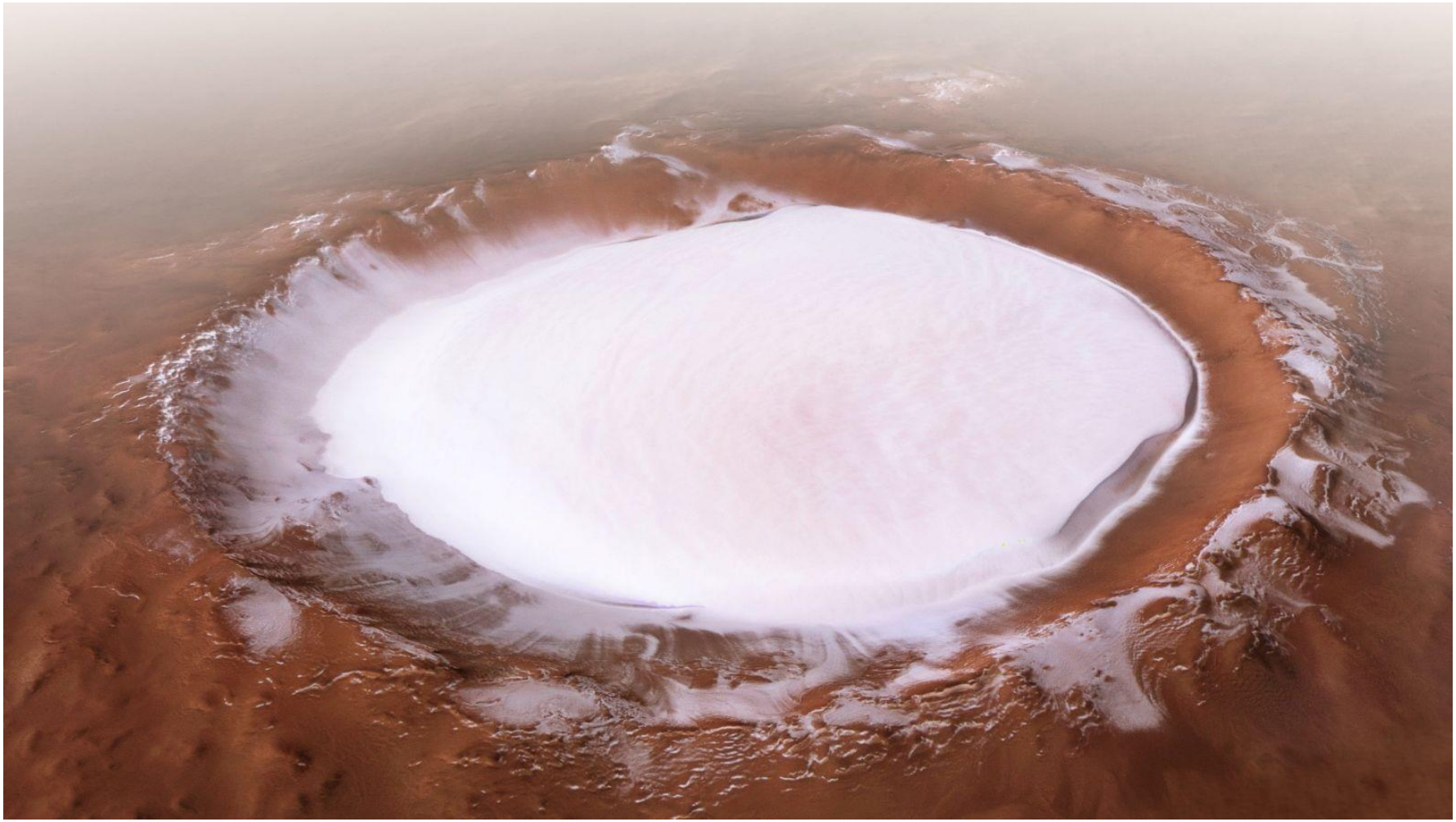
Mars 2021: A dry, lifeless landscape with mountains and weathered rocks.

Mars 2021: **Perseverance rover** taking high resolution photos of the Mars landscape. The rocks appeared to be weathered and eroded possibly by past liquid water with water washed mud and sand in between.

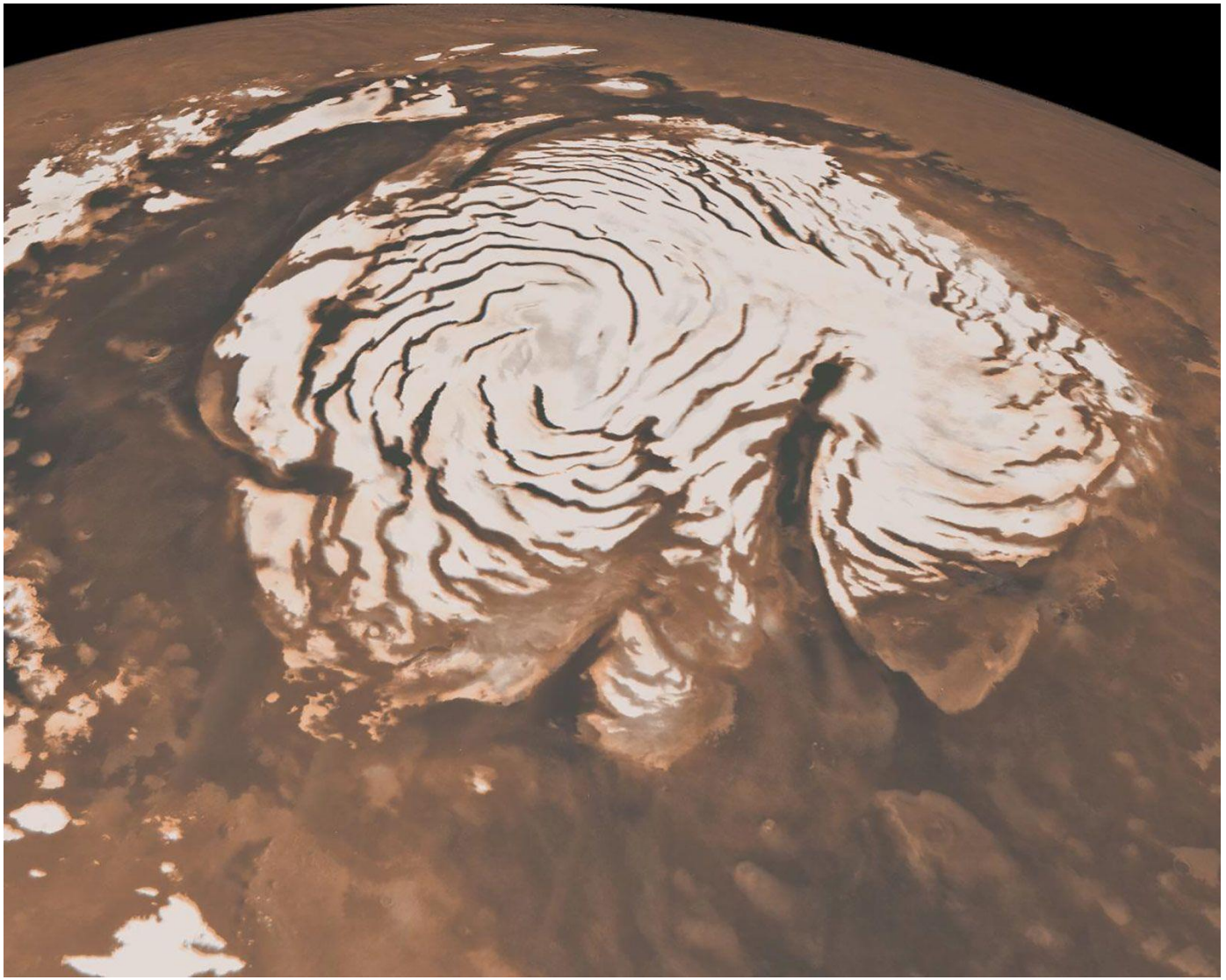
Mars 2018: **Horizontal layers of weathered sandstone.** Sedimentary rocks harden from layers of sediments lain horizontally in deep ocean basins.

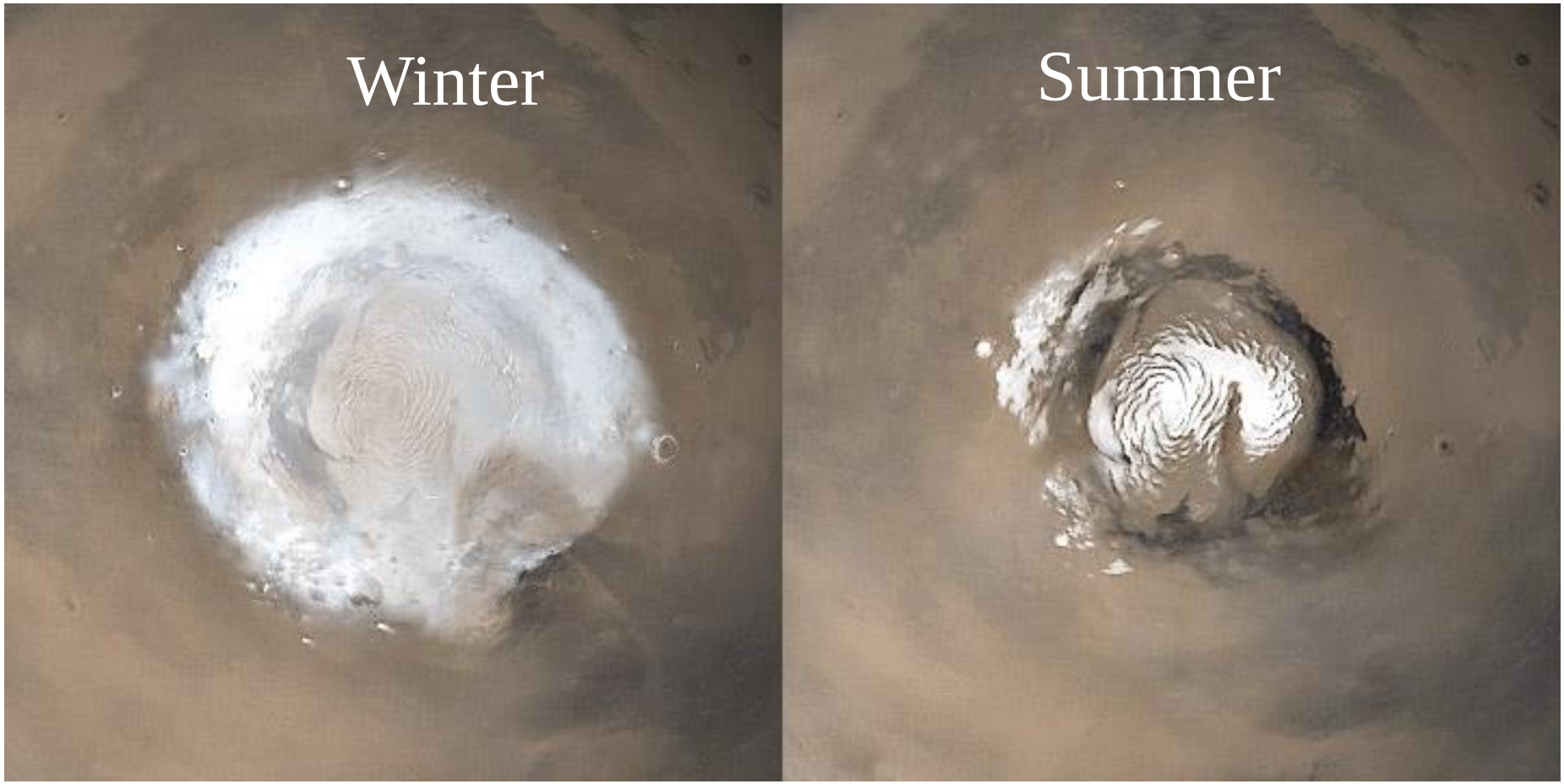


Mars 2018: **Korolev Crater** near Mars's north pole. The crate is filled with water ice and carbon dioxide ice.



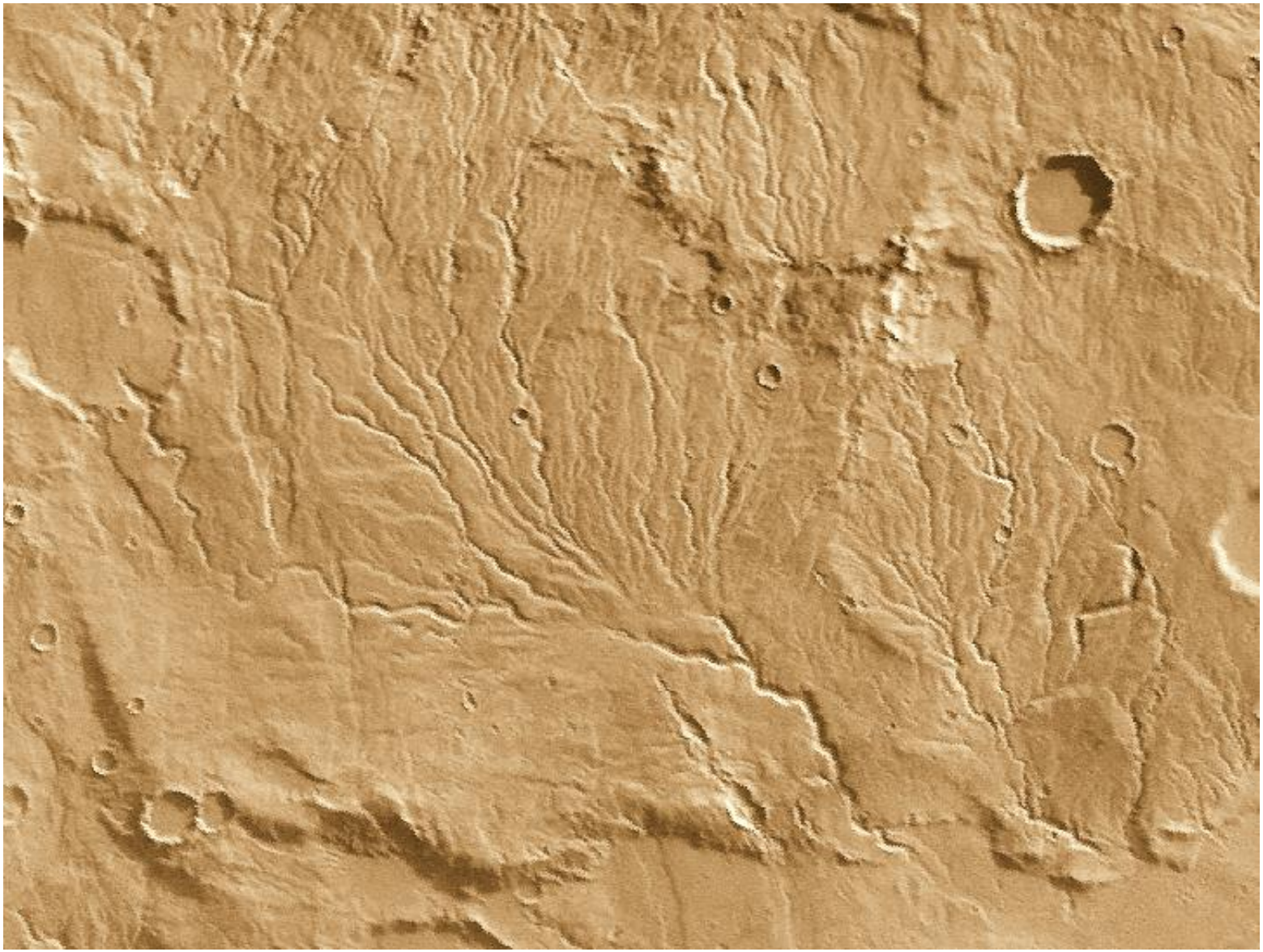
Mars 2014: High altitude view of Mars's north pole and **polar cap**.





- The polar caps are made mostly of frozen water ice covered with an 8m blanket of frozen CO_2.
- Seasonal changes in quantity due to variable sunlight and the much lower atmospheric pressure.

Dendritic drainage pattern of dried river beds on Mars.



Mars had an active atmosphere with weather and a lot of liquid water on its surface in the past. The dried river beds show evidence of headward erosion and downcutting.

Martian atmosphere is ~ 1/100 the pressure of Earth's atmosphere. The reddish sky is due to the scattering of red visible light by CO_2. In the winters, flakes of CO_2 falls as light snow and frost.

Similar in composition to the Venusian atmosphere (95% CO_2).

Little greenhouse effect

- Farther from Sun
- Thinner atmosphere
- Little retention of heat

The Martian atmosphere is 95% CO_2 by volume, which is similar to Venus's atmosphere. But the atmospheric pressure and mass is only 1% that of Earths's atmosphere.

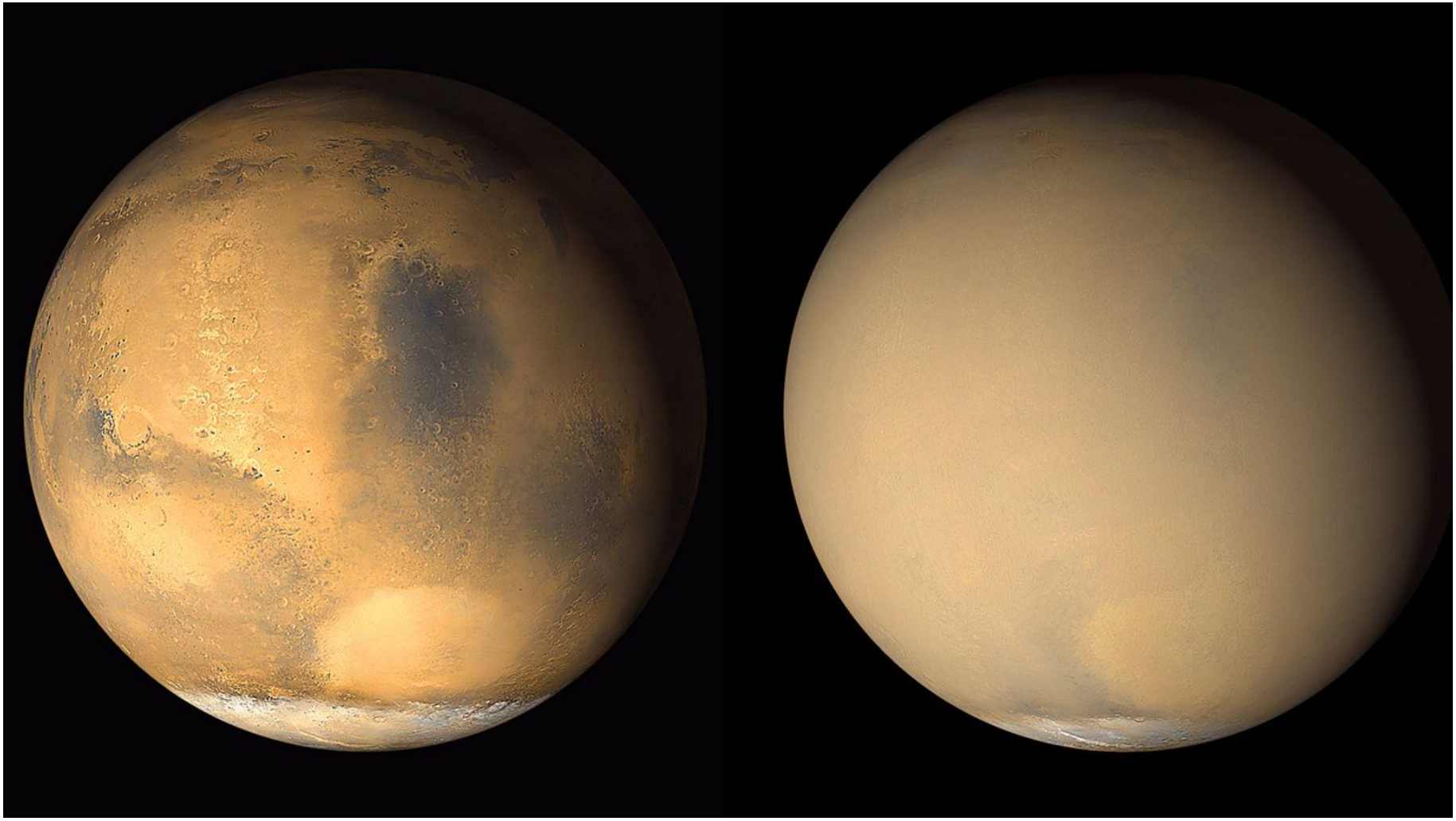
Mars is cold, with summer and winter seasons of warmer and colder temperatures. The greenhouse effect is near zero due to the very thin atmosphere.

In the past, Mars was thought to have a thicker atmosphere with oxygen and warm enough to support liquid water on its surface. Mars lost most of its atmosphere probably 1-2 billion years ago.

Mars has a much smaller mass than Earth. Smaller mass means that the planet's interior will cool faster.

- The loss of heat in the interior stopped volcanism and plate tectonics—sources of atmospheric gases.
- The loss of heat in the outer core caused the outer core to solidify—reduction in magnetic field. The solar wind can sweep away the atmosphere.

The weaker gravity field around Mars will not hold the atmospheric gases close to the surface. They will diffuse upward into space.



Mars 2001 was covered by a global sandstorm.