

# Venus and Mars

Chapter 10

# Viewing Venus and Mars

- Venus is often the brightest object in the night sky. Like Mercury it must be close to the Sun so it is only visible 3 hours after sunset or before sunrise. Even a small telescope can reveal that it goes through phases as seen by Galileo.
- Mars can be identified by its reddish color. No features can be seen with a small telescope though people thought they could see canals, this turned out to just be wishful thinking.

# Our Neighbor Planets

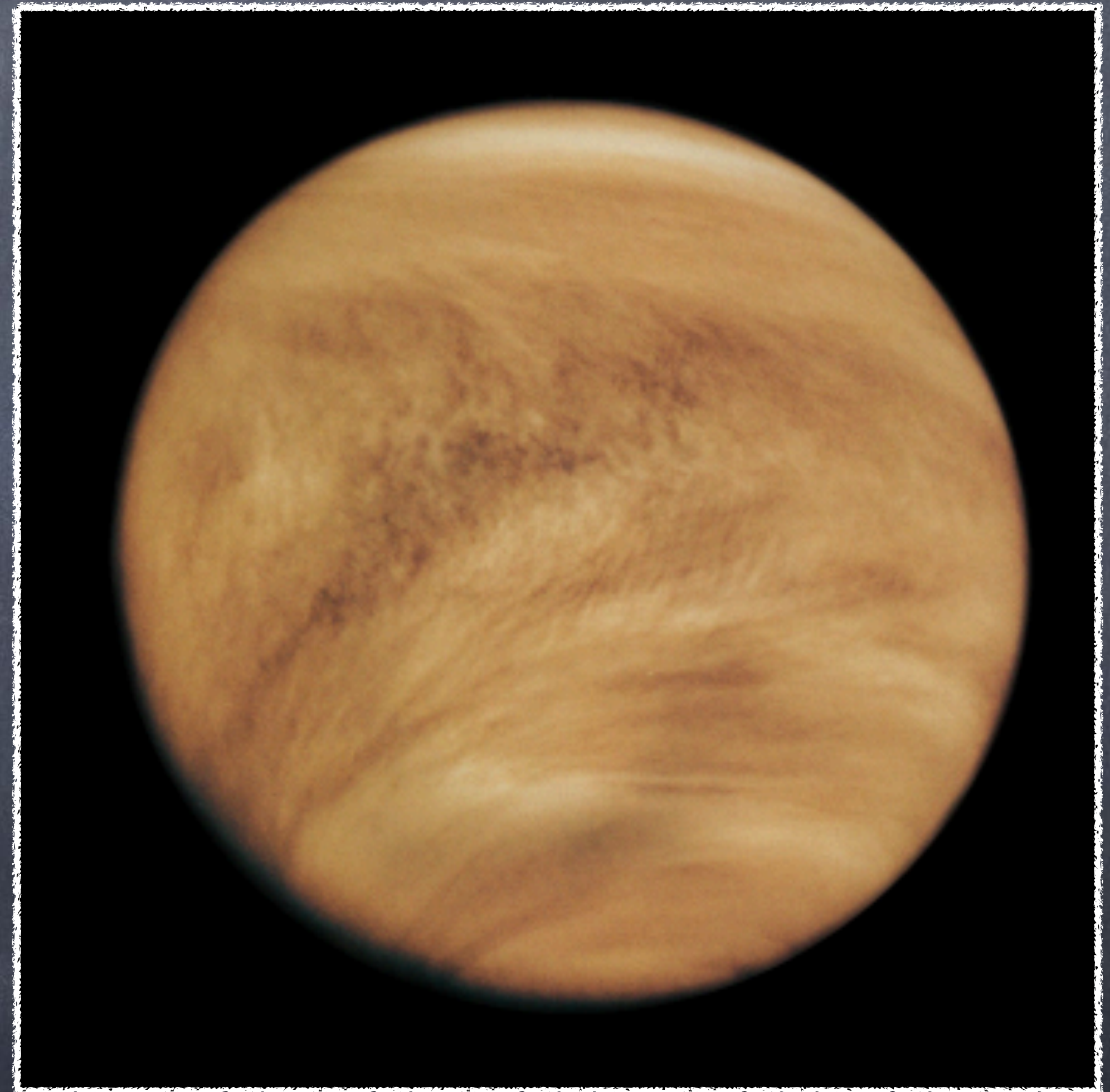
- Venus and Mars are the closest planets to Earth both in physical proximity and in their physical properties. Mars orbits at 1.5AU from the Sun so only 0.5AU from the Earth at closest approach while Venus is at 0.7AU from the Sun, so only 0.3AU at closest to Earth.
- Venus is 82% the mass of the Earth and just a little smaller at 6000km in radius. It's density is close to Earth's  $5.3 \text{ g/cm}^3$  as is its surface gravity 91% that of Earth's. Venus is accurately described as Earth's sister planet.

# Our Neighbor Planets

- Mars is actually substantially smaller than Earth and Venus, only 11% of Earth's mass and about half the size. Its density is  $3.9\text{g/cm}^3$  while its surface gravity is only 38% that of Earth's.
- While Mars is thus closer to Mercury in some ways, its mass is enough to keep an atmosphere and to have had geological activity so in that way it is more like Earth and Venus.
- Mars's low density implies it has a small metal core and no magnetic field is observed so it is likely to have little if any liquid metal in the core.

# Venus

- Venus's most notable feature is that it is covered in clouds. This is what makes it so bright as the clouds reflect 70% of the sunlight that fall on it.
- To see Venus's surface requires the use of radar that can penetrate the cloud layers.

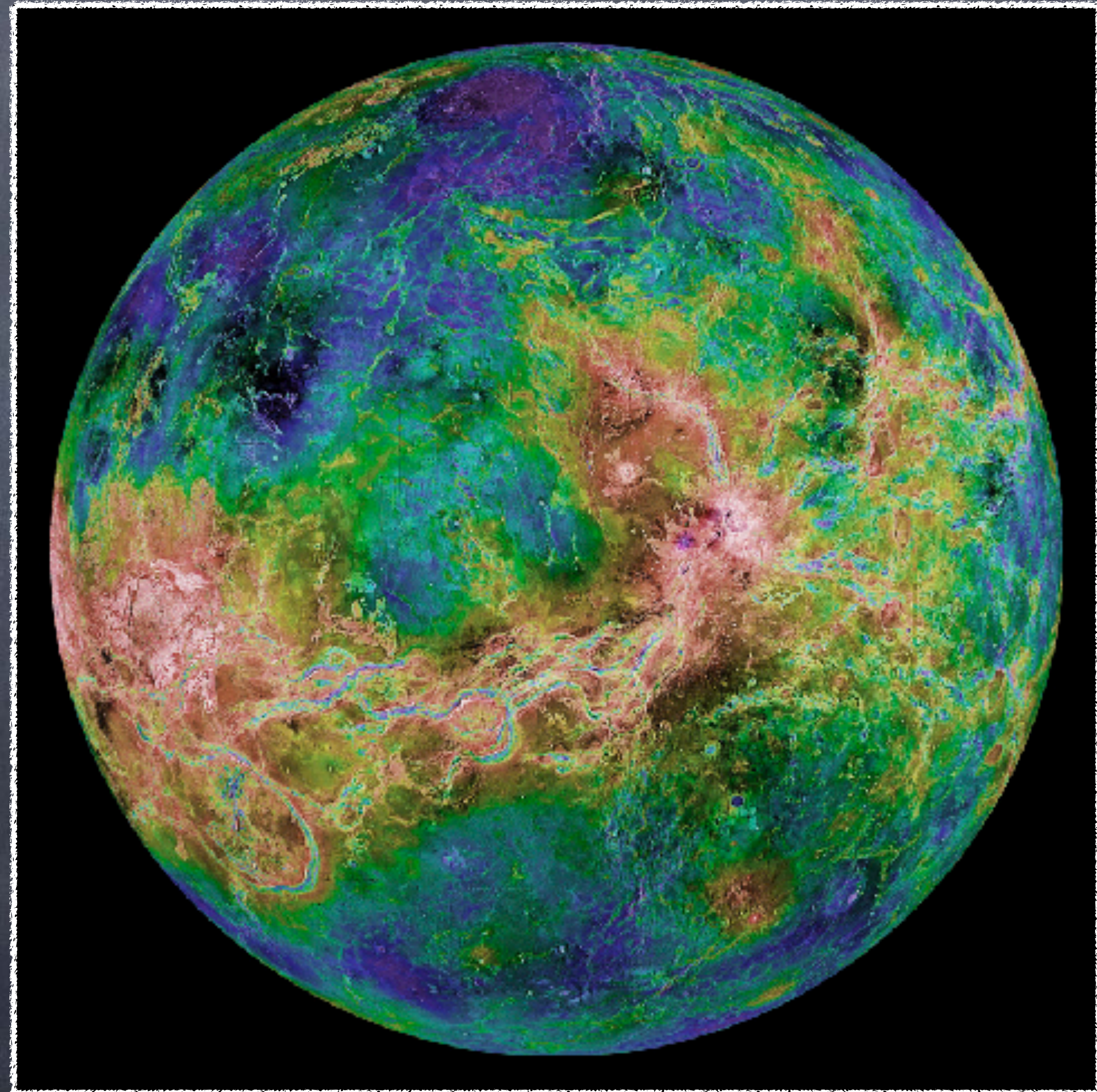


# Venus's Orbit

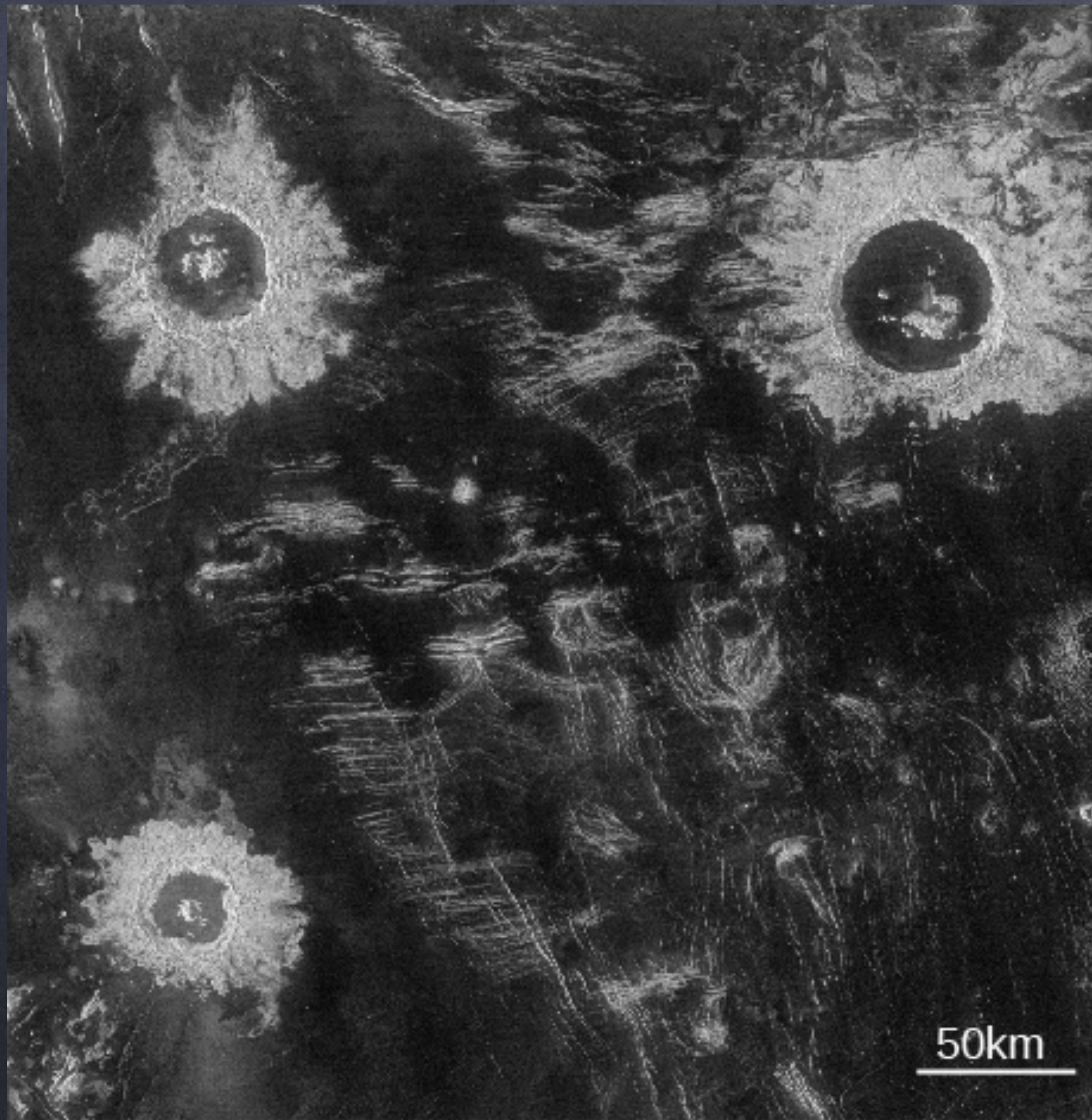
- Venus takes 225 Earthdays to orbit the Sun but 243 Earth days to make single rotation on its axis. A Venusian day is longer than a Venusian year.
- Furthermore Venus rotates the wrong way. The Sun, if you could see it, rises in the West and sets in the East.
- The explanation for this is the same for all planets weirdnesses, Venus was hit by some large object during its formation that got it to spin very slowly the wrong way.

# Venus in Radar

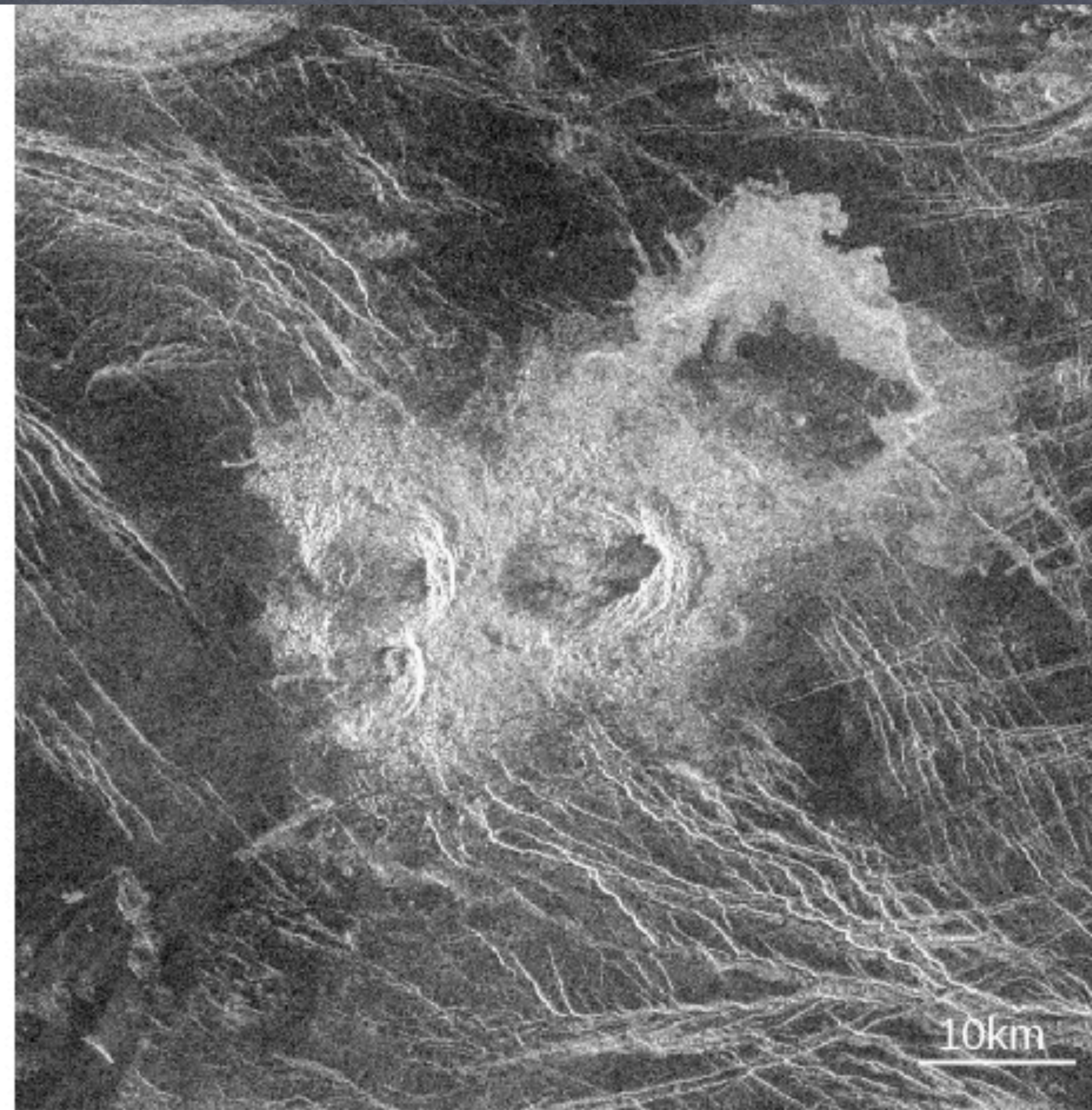
- Looking at Venus's surface with radar reveals a planet that looks much like Earth.
- Giant lava plains cover 3/4 of Venus's surface, much like the oceanic crust on Earth.
- The other 1/4 is covered by two highland continents called Aphrodite and Ishtar.
- Despite looking like Earth's surface we do not believe Venus has plate tectonics.



# Craters on Venus



(a)



(b)



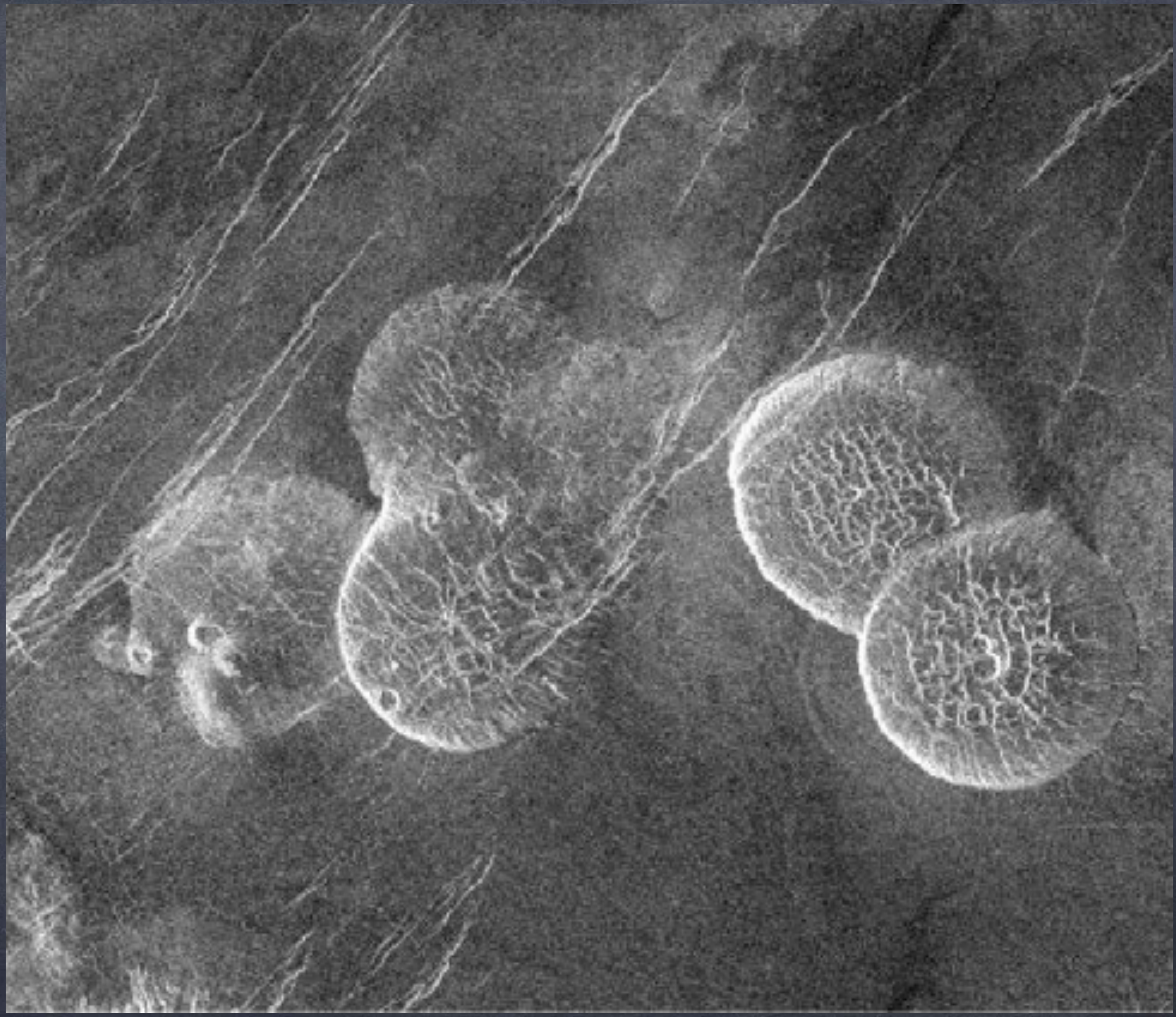
# Craters on Venus

- Venus is not covered by craters indicating that its surface is fairly young with an age between 300 and 600 million years. This would make it older than Earth's oceans but younger than Earth's continents.
- You might worry that crater aging doesn't work on Venus because of the thick atmosphere. This keeps small meteors from hitting the surface, but not the really big ones. There are very few craters less than 10km in diameter on Venus, but 30km diameter craters and larger are made by meteors that make it through the thick atmosphere.

# Volcanos on Venus

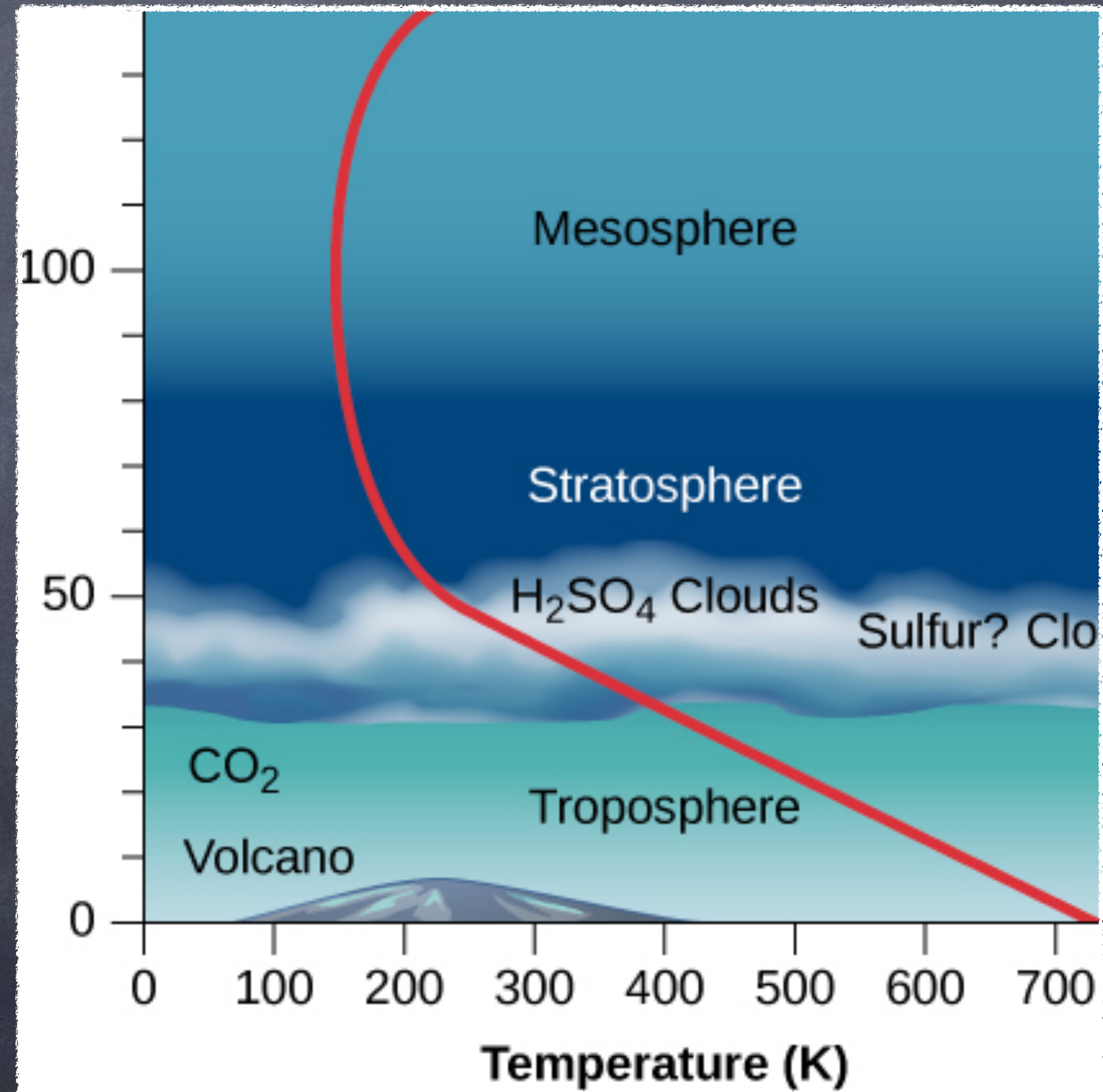
- Venus has lots of volcanos, the largest, Sif Mons, is 3km high and 500km across, similar to the big island of Hawaii.
- Most volcanos are like those on Earth, but some are different. Venus has pancake dome volcanos that are believed to be the result of eruptions of very sticky lava that makes a circular shape instead.
- Venus has evidence of other geological activity like rift valleys, cliffs and ridges.

pancake-dome  
volcanoes



# Venus's Atmosphere

- Venus's atmosphere is 90 times the mass of Earth's atmosphere. Which means surface pressure is 90 times greater.
- Venus's thick atmosphere is mostly composed of CO<sub>2</sub> (96%) with some nitrogen (3.5%). This is very similar to Mars, but 10,000 times more massive.
- The troposphere is very high, 50km as opposed to 10km on Earth. There are clouds, but they are sulfuric acid not water vapor. There is almost no water on Venus.



# Venus's Surface Temperature

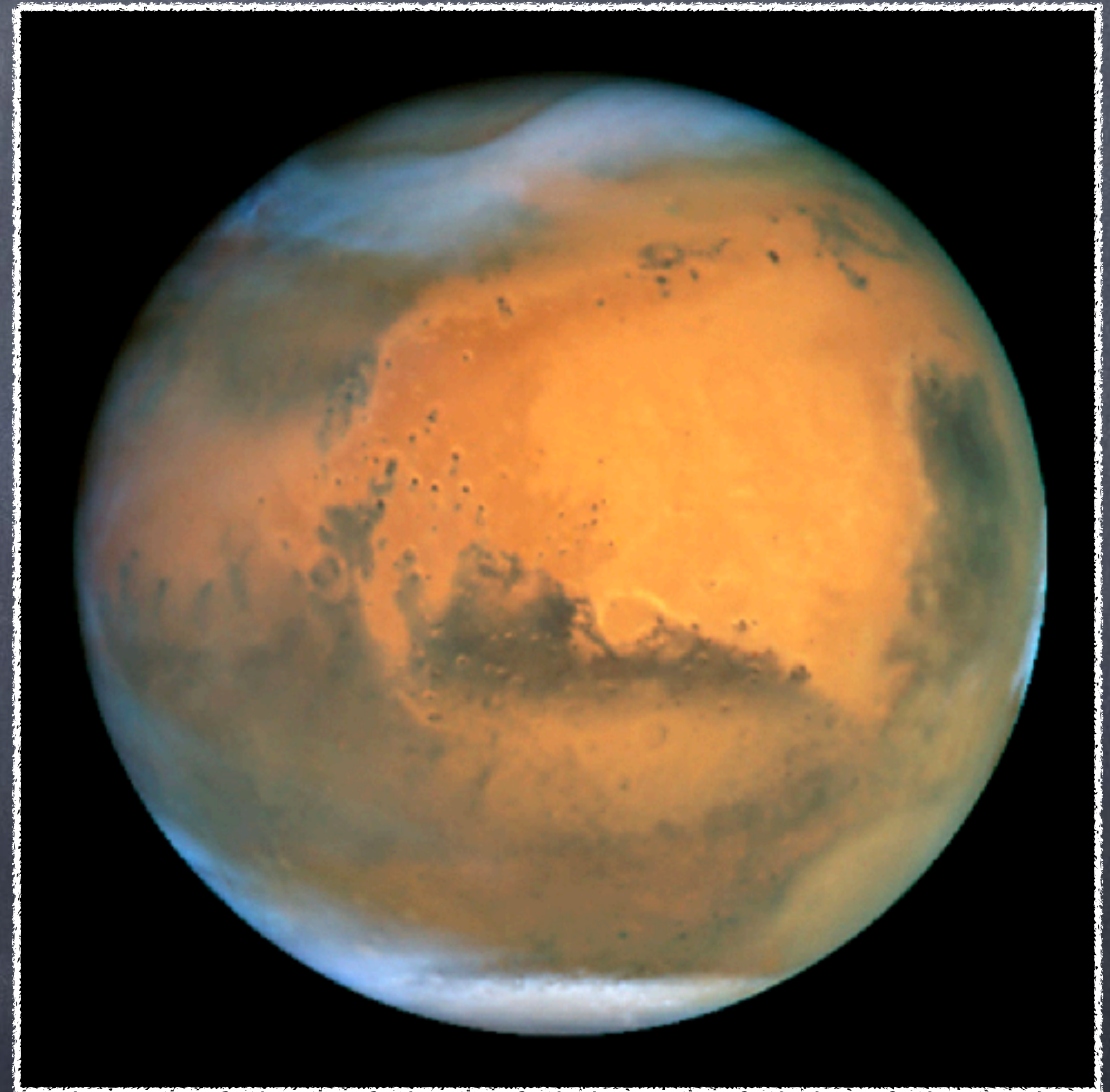
- That thick atmosphere creates a very effective greenhouse on Venus, heating the surface to 700K. Since little sunlight reaches the surface there is little difference in temperature between the equator and the poles or between night and day.
- The greenhouse works the same as on Earth, but because there is a million times more carbon dioxide it is that much more effective.
- We do not think Venus was always this way. Instead, Venus has suffered from a runaway greenhouse effect.

# Runaway Greenhouse

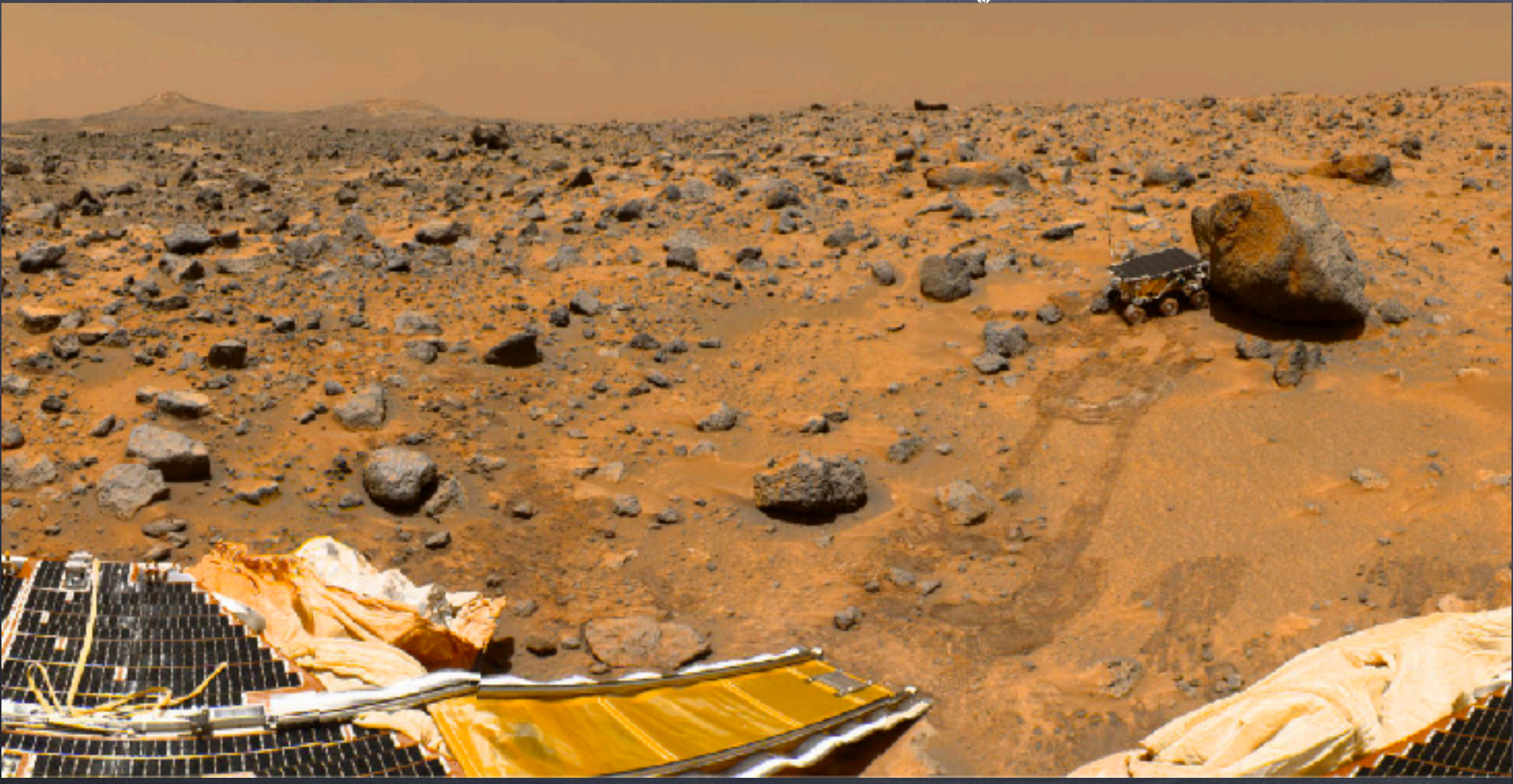
- Venus was probably originally only a bit hotter than Earth. This extra heat though begins to evaporate the oceans, which puts  $\text{CO}_2$  and water vapor into the air making the greenhouse effect stronger.
- This evaporates more water, which makes it hotter, evaporating more water, until the entire oceans evaporate and add their  $\text{CO}_2$  to the atmosphere. If this happened on Earth it would increase the mass of the atmosphere by 70 times, making it close to mass of Venus's atmosphere.

# MARS

- Mars takes almost 2 Earth years to go around the Sun and its day is 24.6 hours, almost the same as Earth.
- It has a tilt of  $25^\circ$  also close to Earth's.
- The surface of Mars is not that different then some places on Earth, cold dry places like the Atacama desert in Chile.

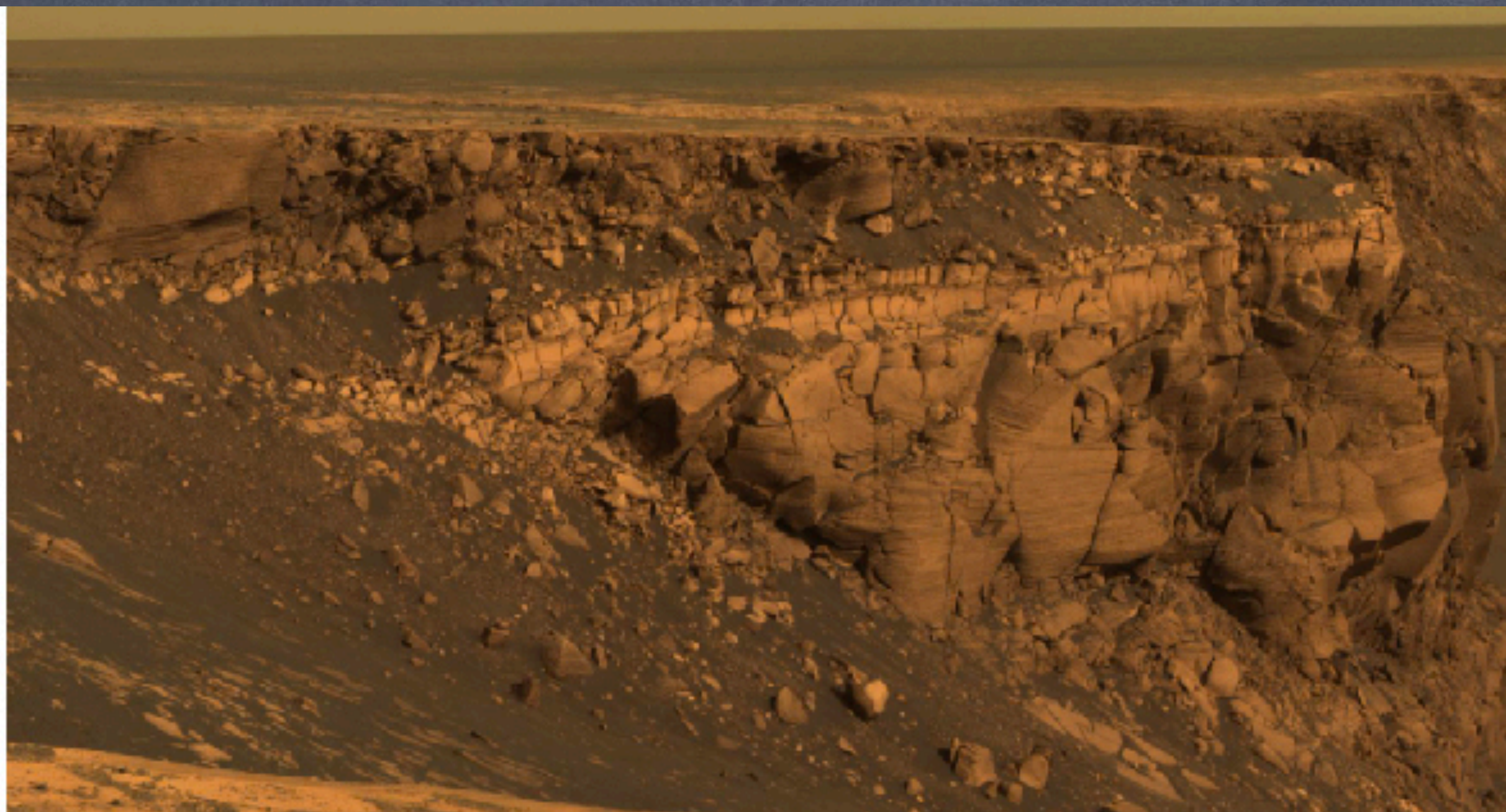


# Mars, Pathfinder Lander and Sojourner Rover



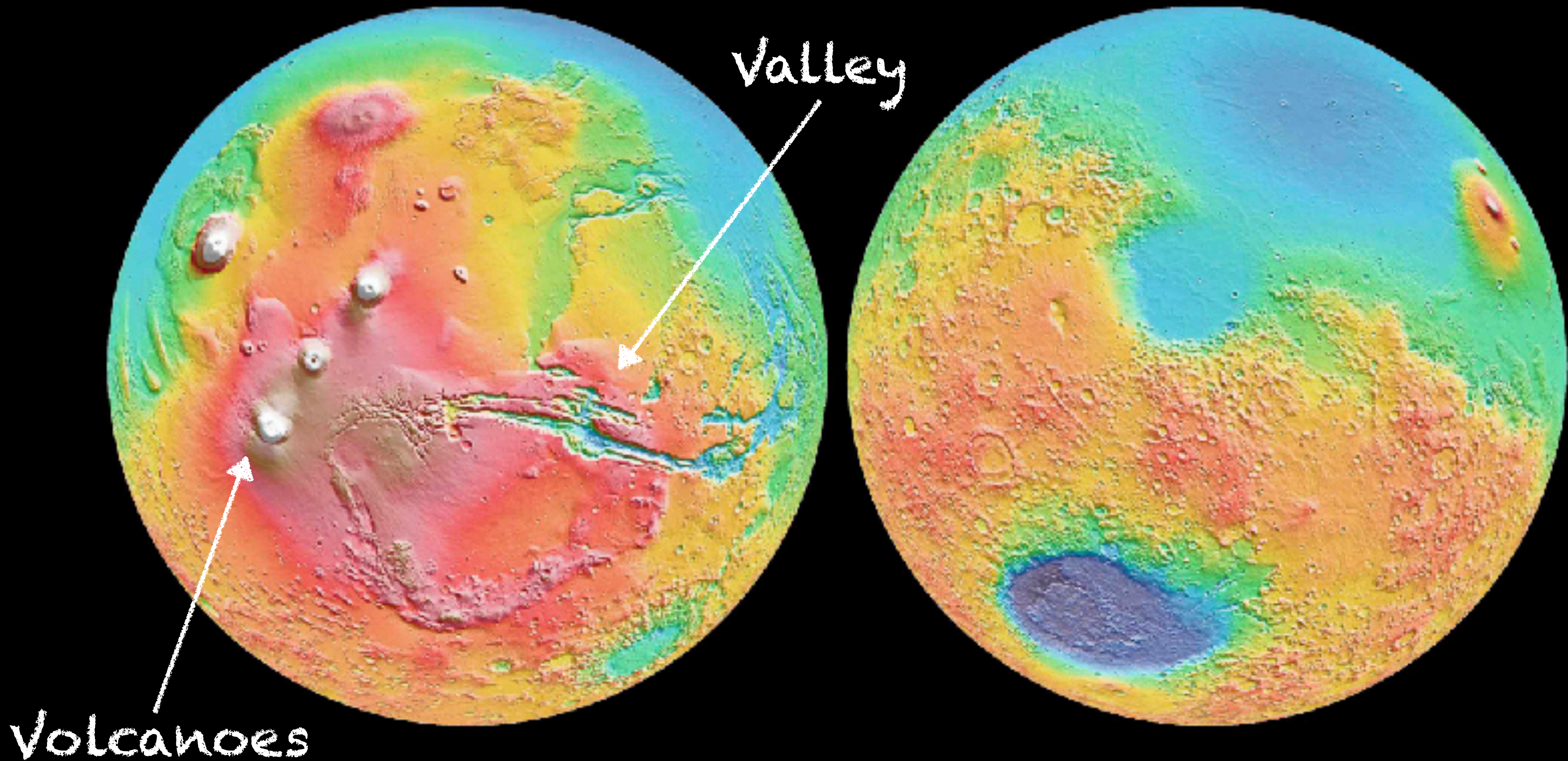


A crater and cliffs on Mars, don't look that different than Earth.



# Mars's Surface

- Mars's surface is similar to Venus, Earth and Luna in that it has continent like highlands that rise above younger flatter lowlands.
- Mars has rift valleys and volcanos, evidence that at one point it was geological active. Most have many craters on them suggesting they were formed many billion of years ago.
- There is some evidence for more recent geological activity around Olympus Mons.

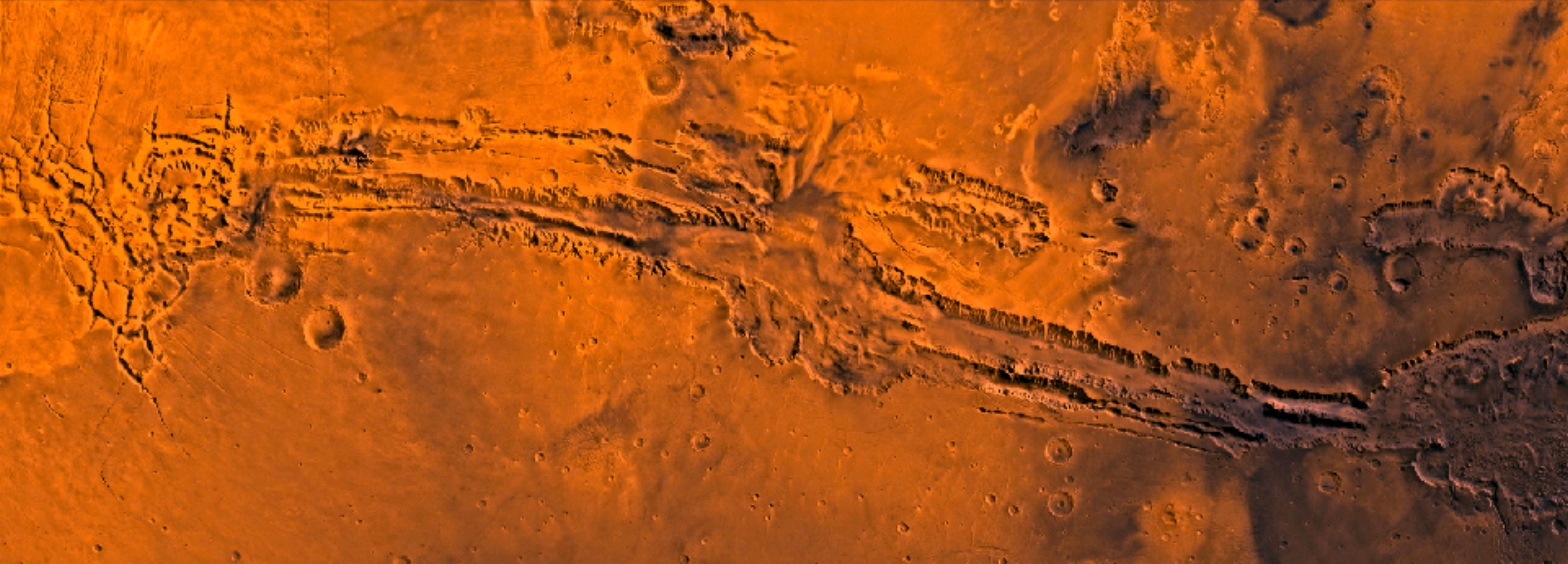


Altitude [km]

# Shield Volcanoes

- Olympus Mons, the largest volcano in the Solar System.
- The base is over 500km across and the height is 20km, 2.5 times Mt. Everest. The caldera is 65km across.
- This volcano is 100 times the size of the big island of Hawaii.





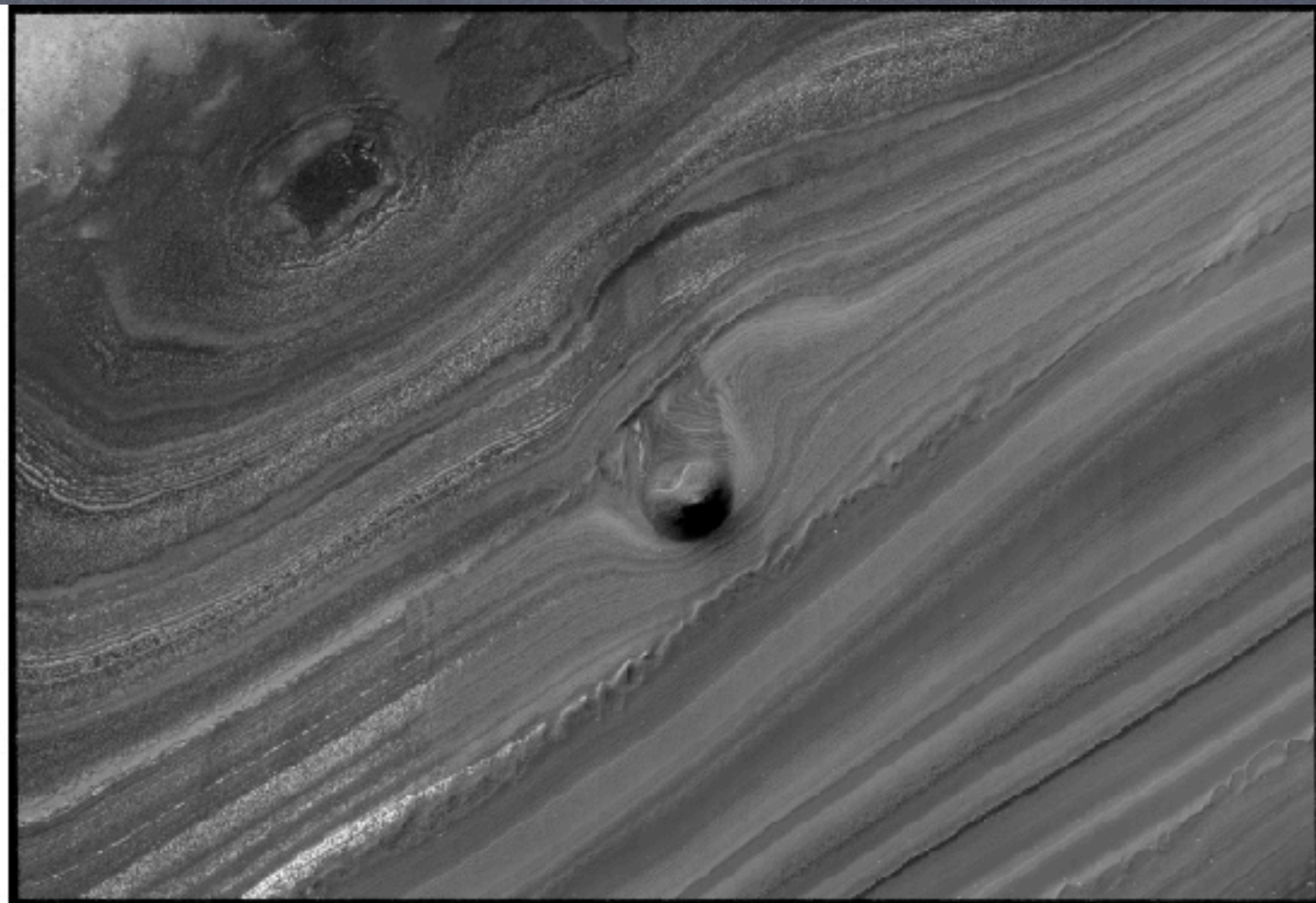
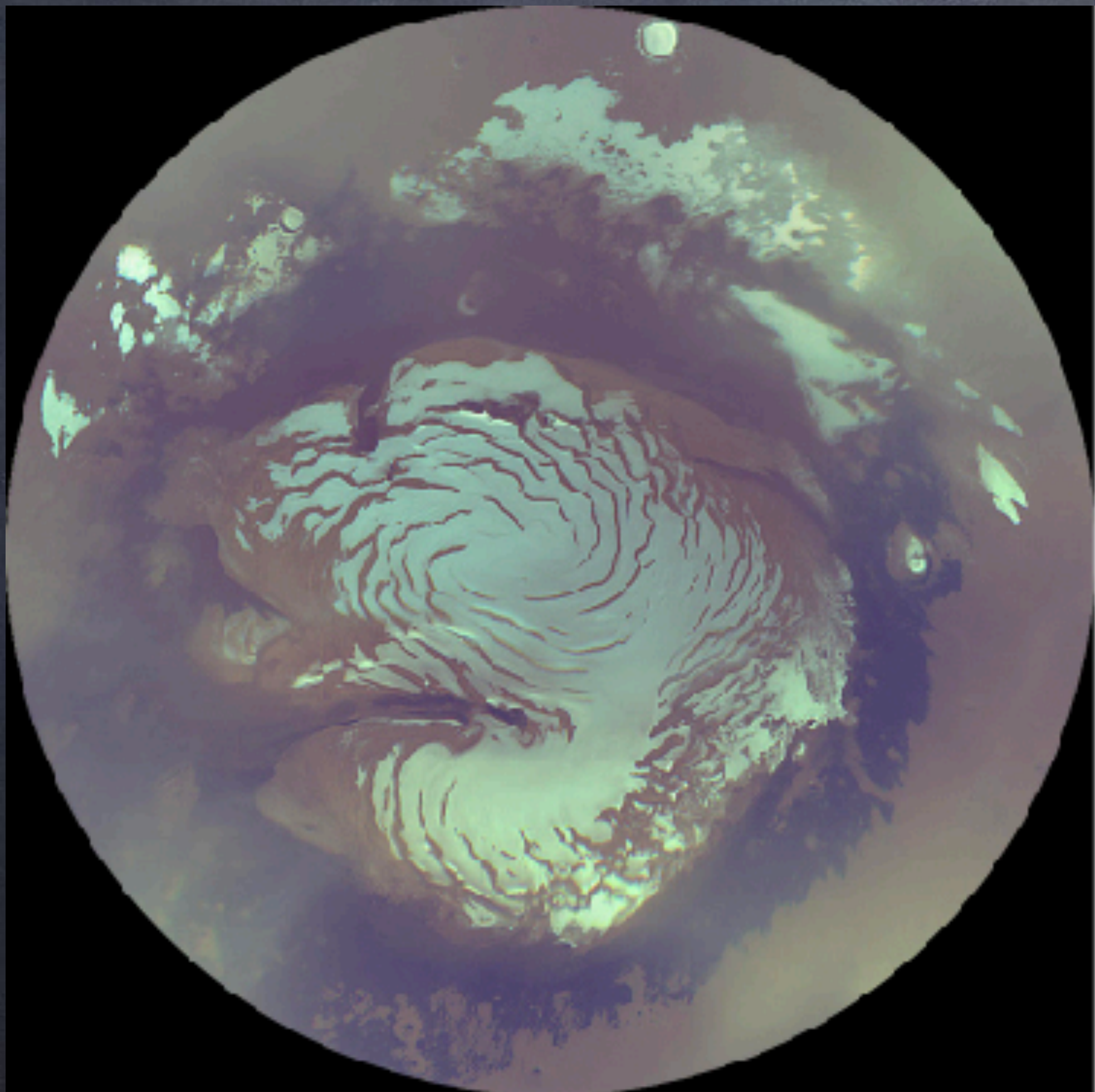
## Valles Marineris

The biggest valley in the solar system, 6000km long, 300km wide and up to 7km deep. The Earth's Grand Canyon would be as big as one of the side canyons. This is a rift valley made by geological forces.

# Mars's Atmosphere

- Mars's atmosphere, like Venus's, is almost entirely  $\text{CO}_2$ . But it is very thin, 1/100 the mass of Earth's atmosphere.
- Winds on Mars can reach high speeds, and giant dust storms occur something engulfing the entire planet.
- However, because the atmosphere is so thin these winds do not blow with the force they would have on Earth and erosion by wind occurs, but slowly on Mars.
- Mars has ice caps like Earth, but not made only of water. There is also carbon dioxide ice (dry ice).

Mars's polar ice cap, but this is a mixture of water and carbon dioxide. The carbon dioxide evaporates and (frosts?) during the year, but the water is always frozen.



# Water on Mars

- There is no evidence of liquid water on Mars today, and based on its current surface temperature that is not surprising.
- There is evidence that at times there has been liquid water on Mars.
  - There are runoff channels in the highlands that look like erosion from flowing water.
  - There are outflow channels that look like they were formed from flood waters.
  - There are gullies, small areas of water flow usually down cliff face which seem to come from some short term water flow, like underground ice that melts.





outflow  
channels

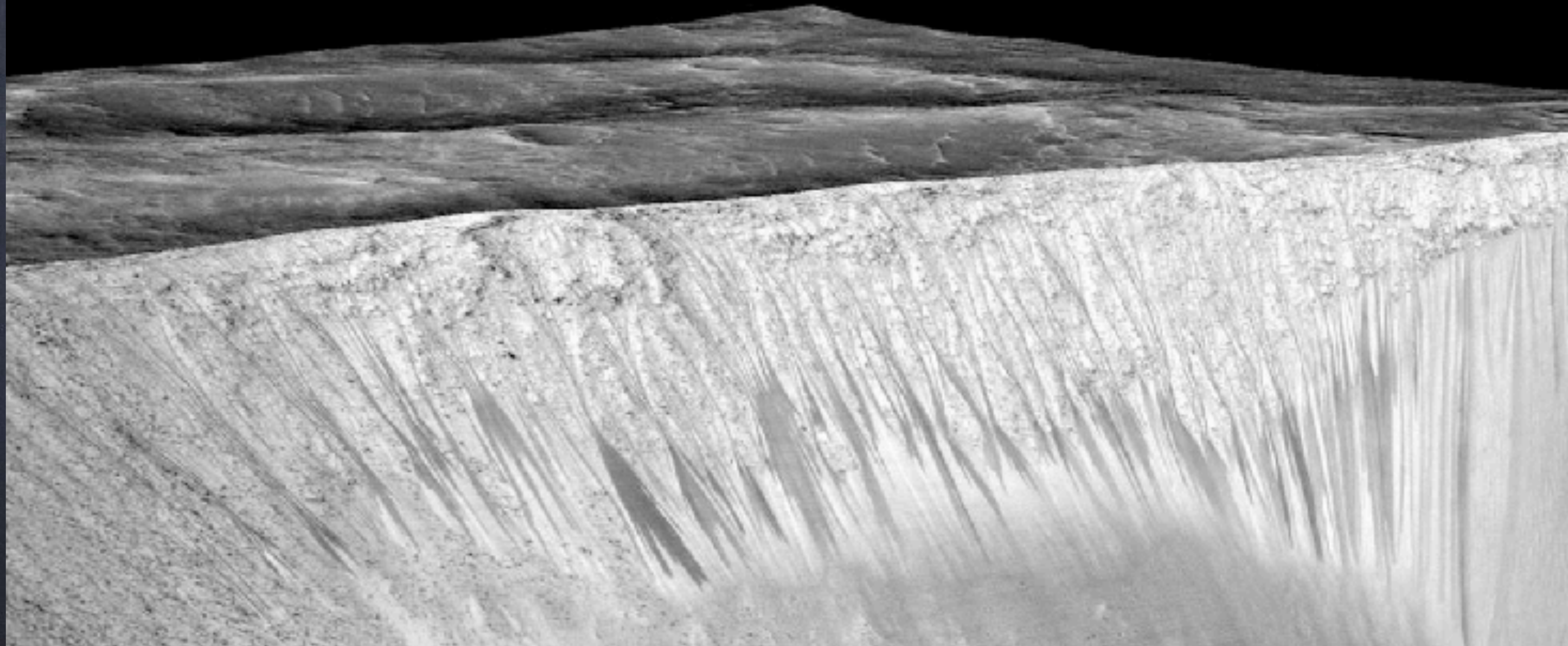
(a)



Look like a  
river bed?

(b)

gullies



# Water on Mars

- The rovers have found sedimentary rock on Mars, so we know at some point rock formed in liquid water, lakes or oceans.
- They have also found ice just below the dust, so we know there are currently glaciers or large amounts of subsurface water ice on Mars.
- There doesn't appear to be any liquid water on the surface now, which is not surprising given the temperature, but the evidence for liquid surface water in the past is overwhelming and it is likely that there is short lived liquid water even today.

# Climate Change on Mars

- The evidence for liquid surface water on Mars raises the question, what happened?
- Imagine Mars started off similar to the Earth and Venus. Mars has lower surface gravity so it has a harder time holding on to its atmosphere. As the atmosphere is lost to space the greenhouse gasses escape.
- This makes Mars colder, so the water vapor freezes out, which as a greenhouse gas makes Mars colder and then carbon dioxide can freeze out.
- Mars is a **reverse runaway greenhouse effect**. Loosing greenhouse gasses causing it to lose even more greenhouse gasses.