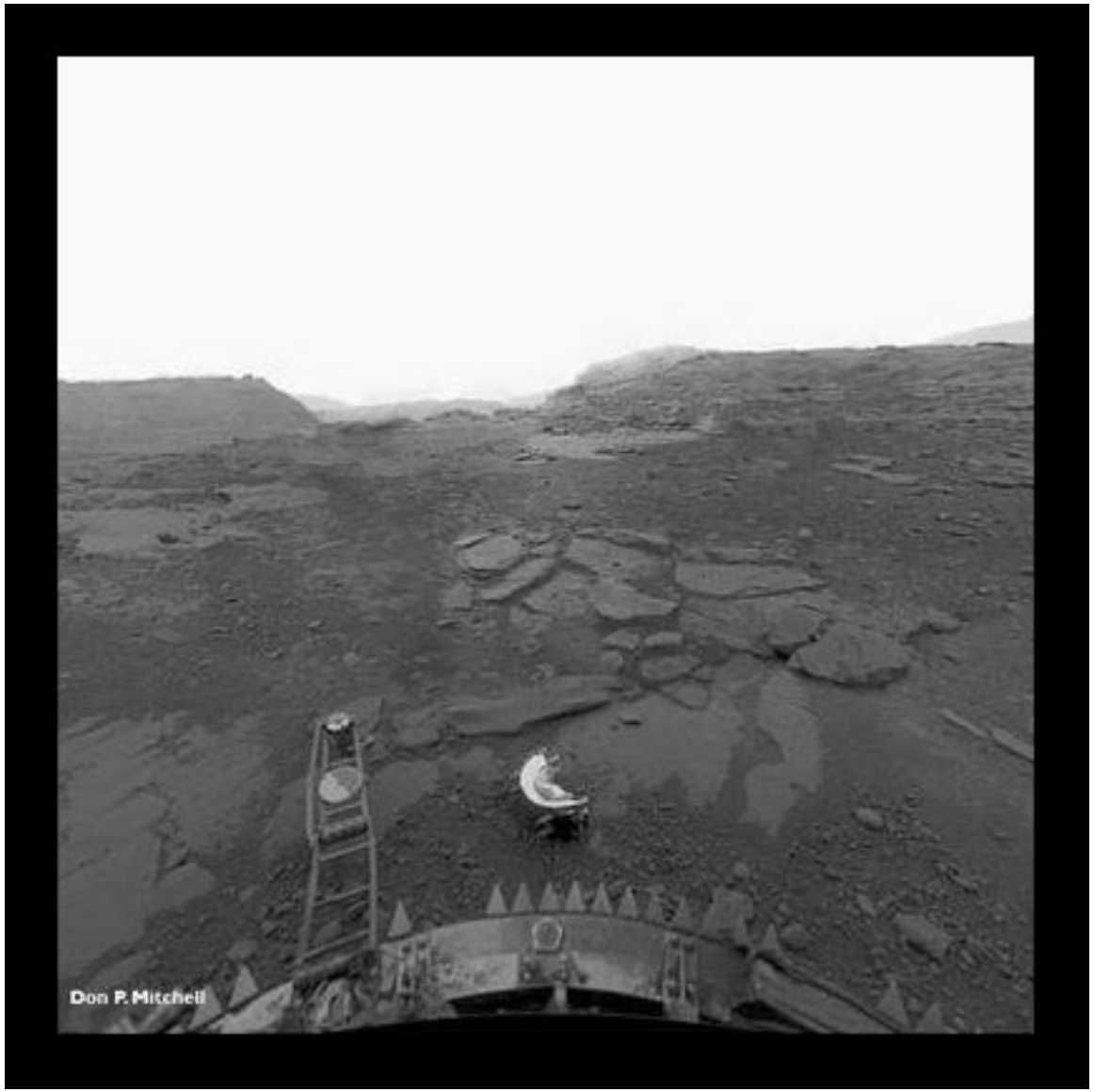
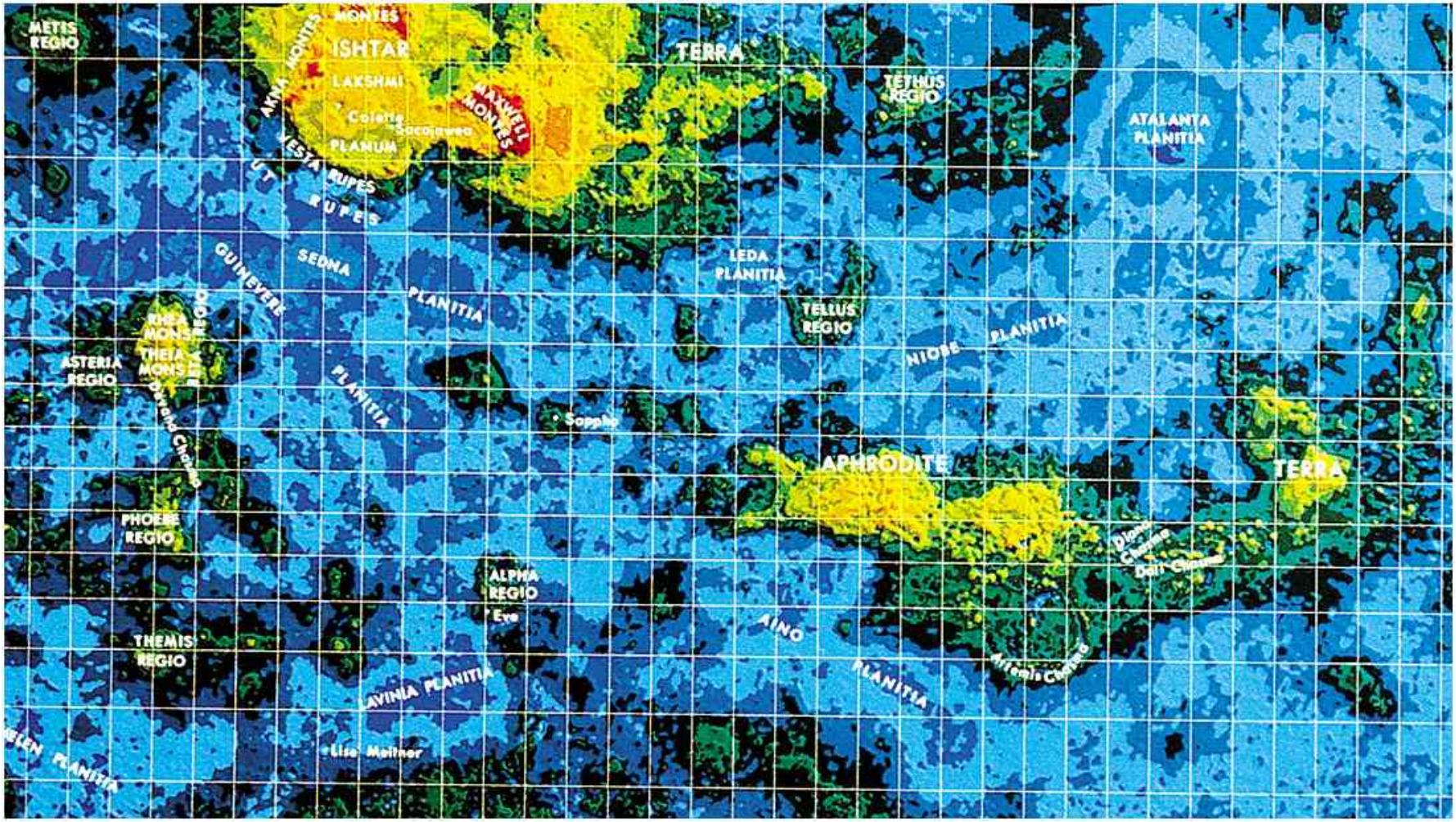
The atmosphere of Venus



Another way to look at things: a topographical map of Venus



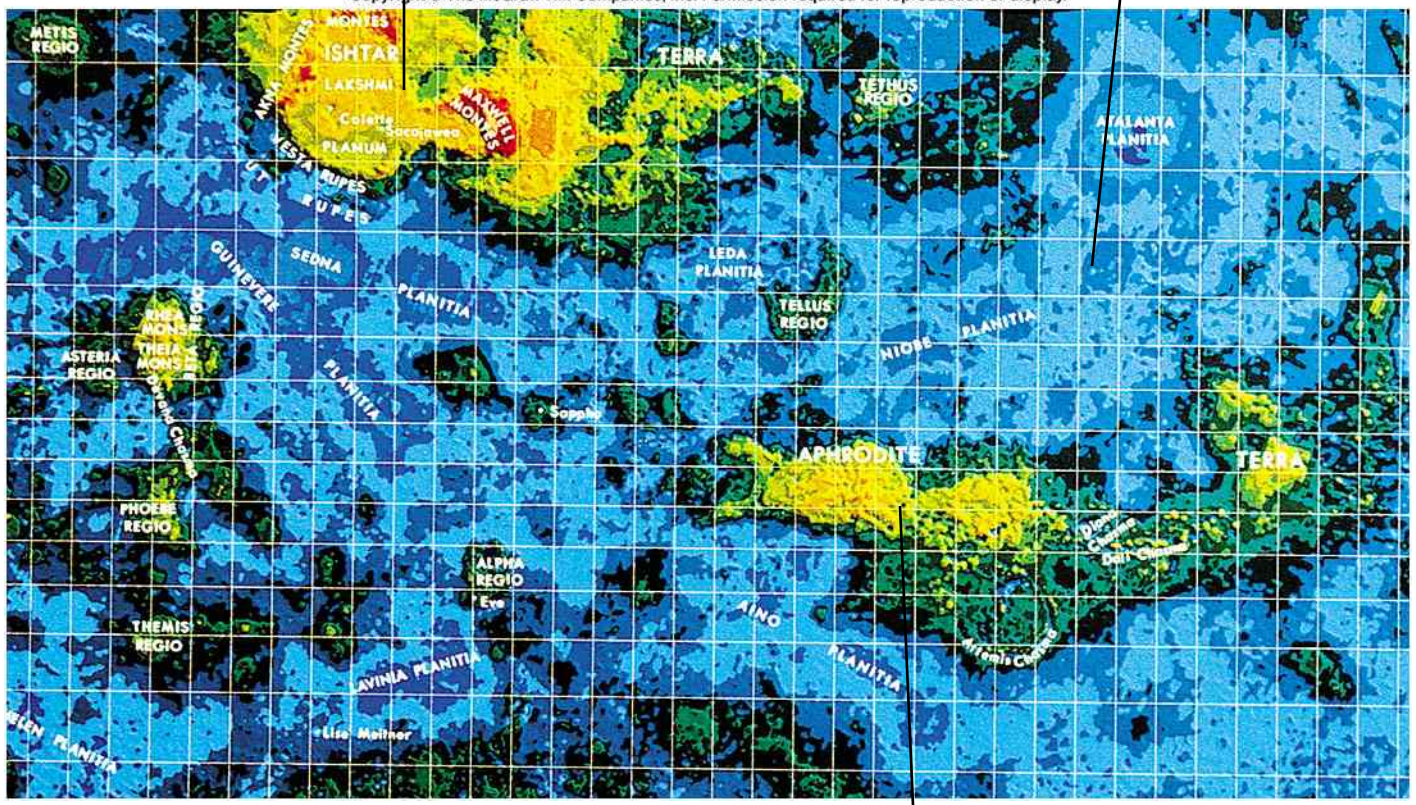
What have we learned from our exploration of the surface of Venus?

- Some similarities: low flat areas that resemble ocean floors on Earth
- Two higher areas of thicker crust that resemble the continental portions of the crust on Earth. These are called Ishtar and Aphrodite, and are about the size of Australia
- Strangely, no sign of tectonic plate boundaries (absence of continental drift on Venus?)

The Continents of Venus

Ishtar Terra

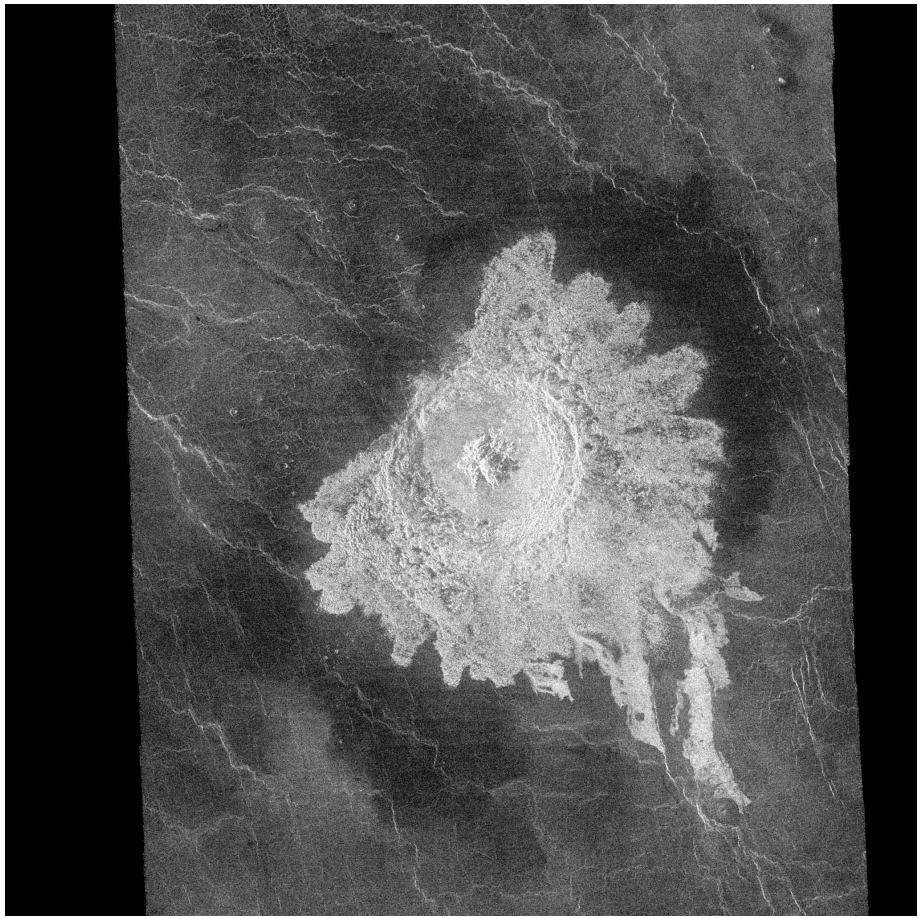
"ocean" bottoms?



Aphrodite Terra

What about craters? We have learned from the the Moon, the Earth, and Mercury that the presence (or absence) of craters is an important clue to the geological history of a planet.

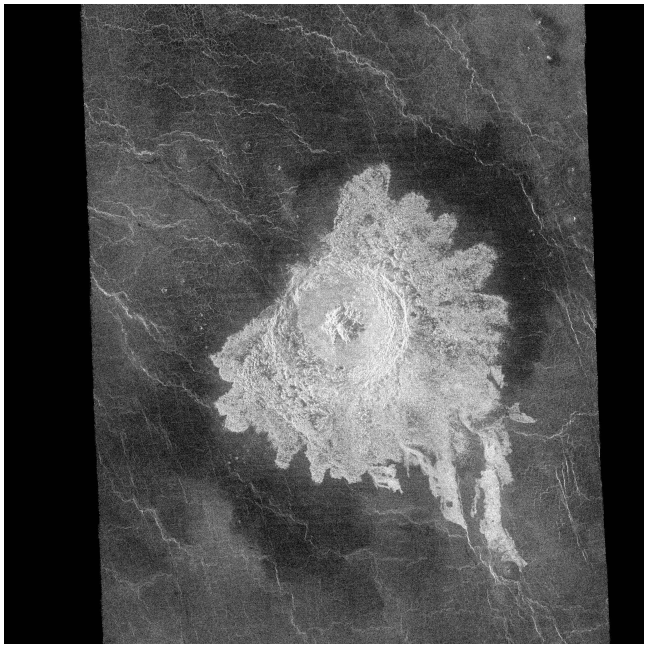
Craters are present on Venus (all discovered by Magellan radar)



But *relatively* few in number. Consistent with an "exposure time" of about 500 million years rather than 3-4 billion years

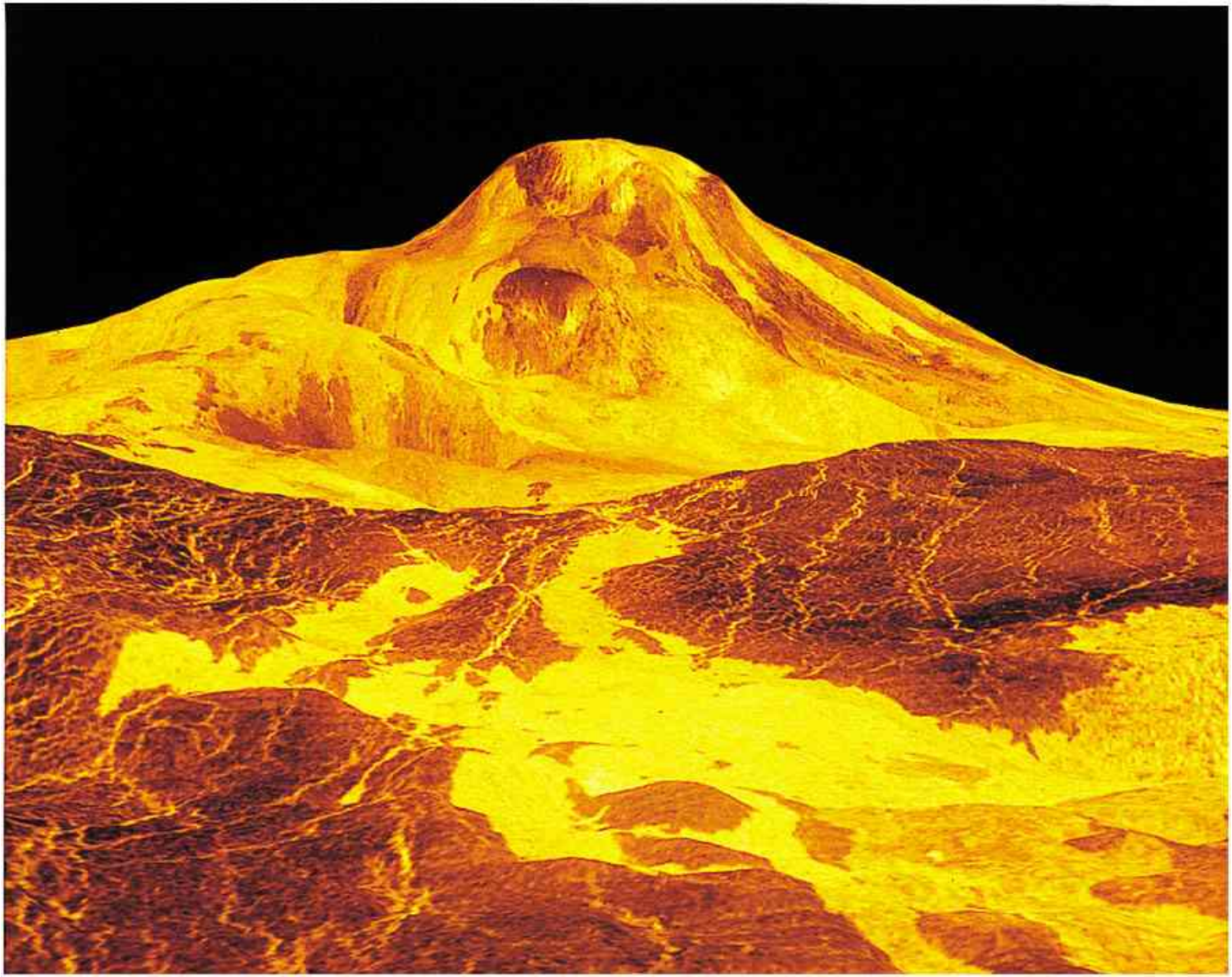
500 million year old “surface exposure” of Venus may point to an enormous, planet-wide eruption of lava at that time. Quote from book: “to erase all preexisting impact craters, even large ones, the surface of Venus must have been covered with lava to a depth of several kilometers”

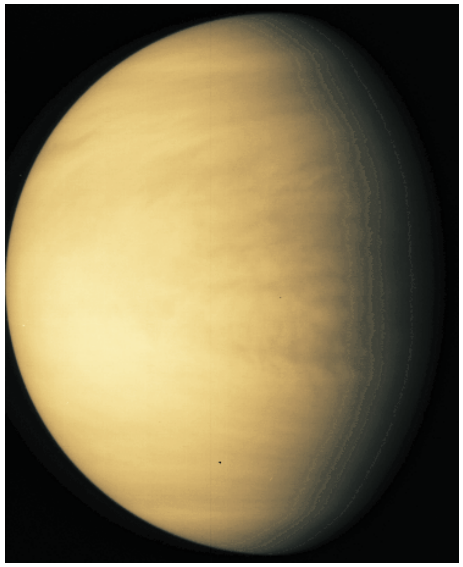
An event which *may* be similar is the lava eruptions which occurred at the end of the Permian Age on Earth (250 Myr ago). The end of the Permian was the largest mass extinction event in Earth’s history



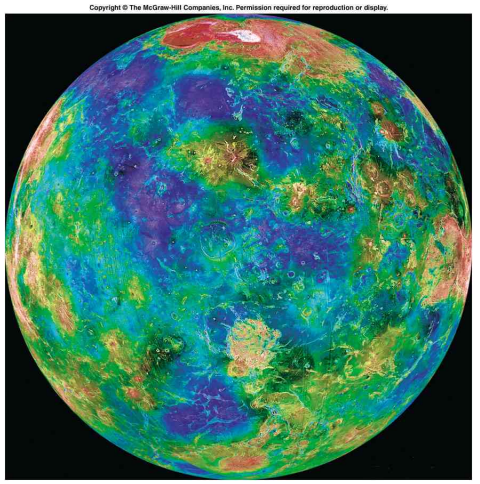
A similar event (flood basalt) occurred on Earth at the time of the Cretaceous-Tertiary extinctions

A hint of the volcanism of Venus: The shield volcanoes of Venus

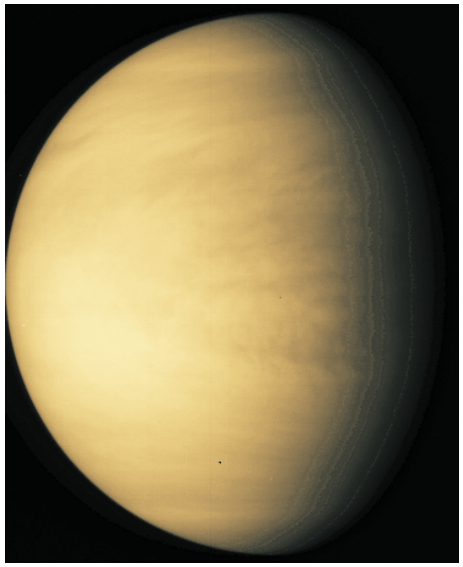




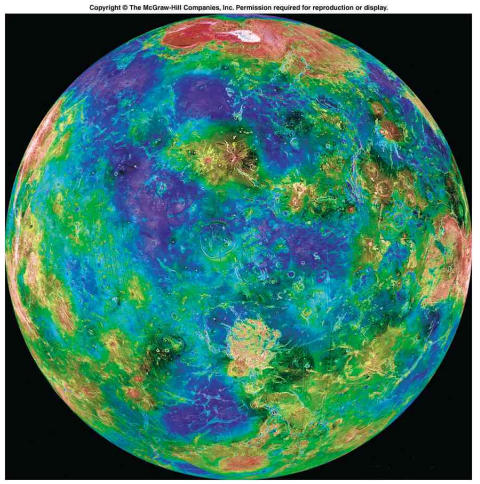
Remaining questions about Venus



- Why is the surface temperature so high?
- Did Venus ever have oceans like the Earth?
- If it did have them, where did they go?
- These questions may be related…tune in next time



The atmosphere of Venus



The books raises the point, "One intriguing question is why the atmospheres of Venus and Earth are so different from each other". It is generally accepted that this difference is due to the presence of large amounts of liquid water, in the form of oceans, on the surface of the Earth. Carbon dioxide is dissolved in the oceans, and undergoes the following chemical reactions.

$$CO_2 + H_2O \Leftrightarrow H^+ + HCO_3^- \quad (1)$$

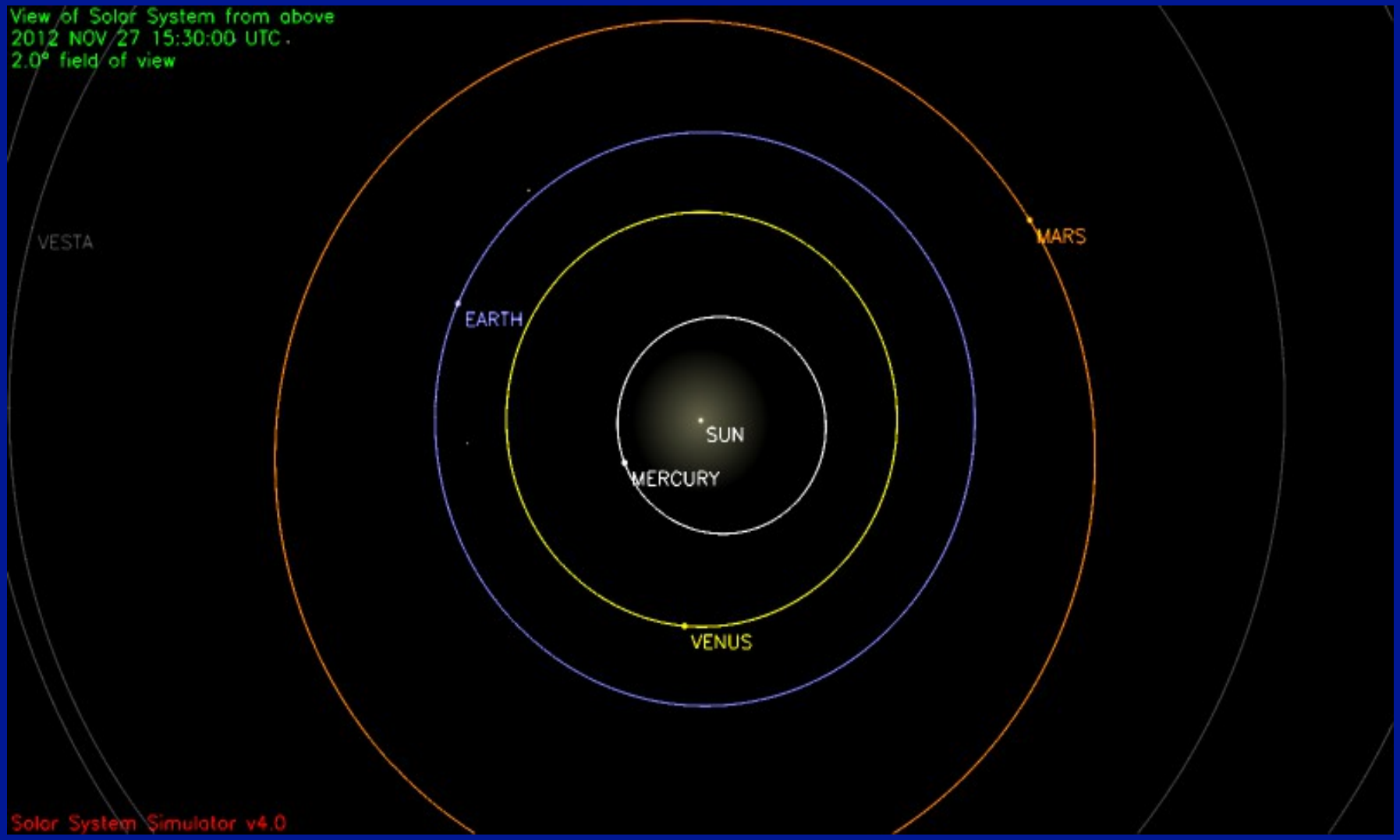
$$Ca^{2+} + 2HCO_3^- \Leftrightarrow CO_2 + H_2O + CaCO_3 \quad (2)$$

The end product of this is calcium carbonate, which is limestone. Essentially, this reaction takes 2 molecules of CO2 dissolved in the water and "permanently buries" one of them in limestone.

There are estimates that the amount of CO2 which is locked up in limestone, dolomite, and other minerals, on the surface of the Earth, is equivalent to the amount of CO2 in the atmosphere of Venus.

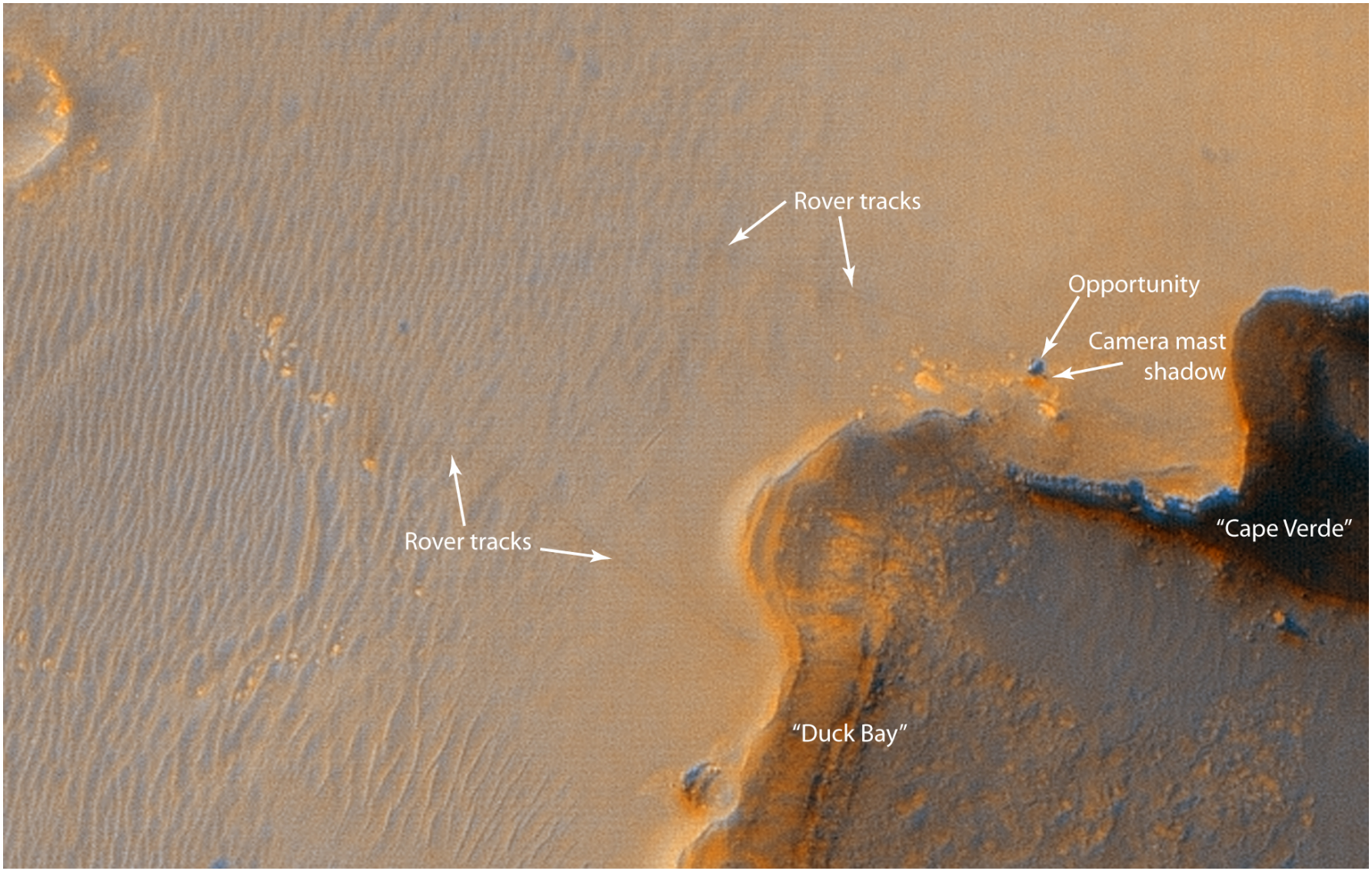
Exploration of Mars

Why is Mars of such great interest, and what do we know about it?

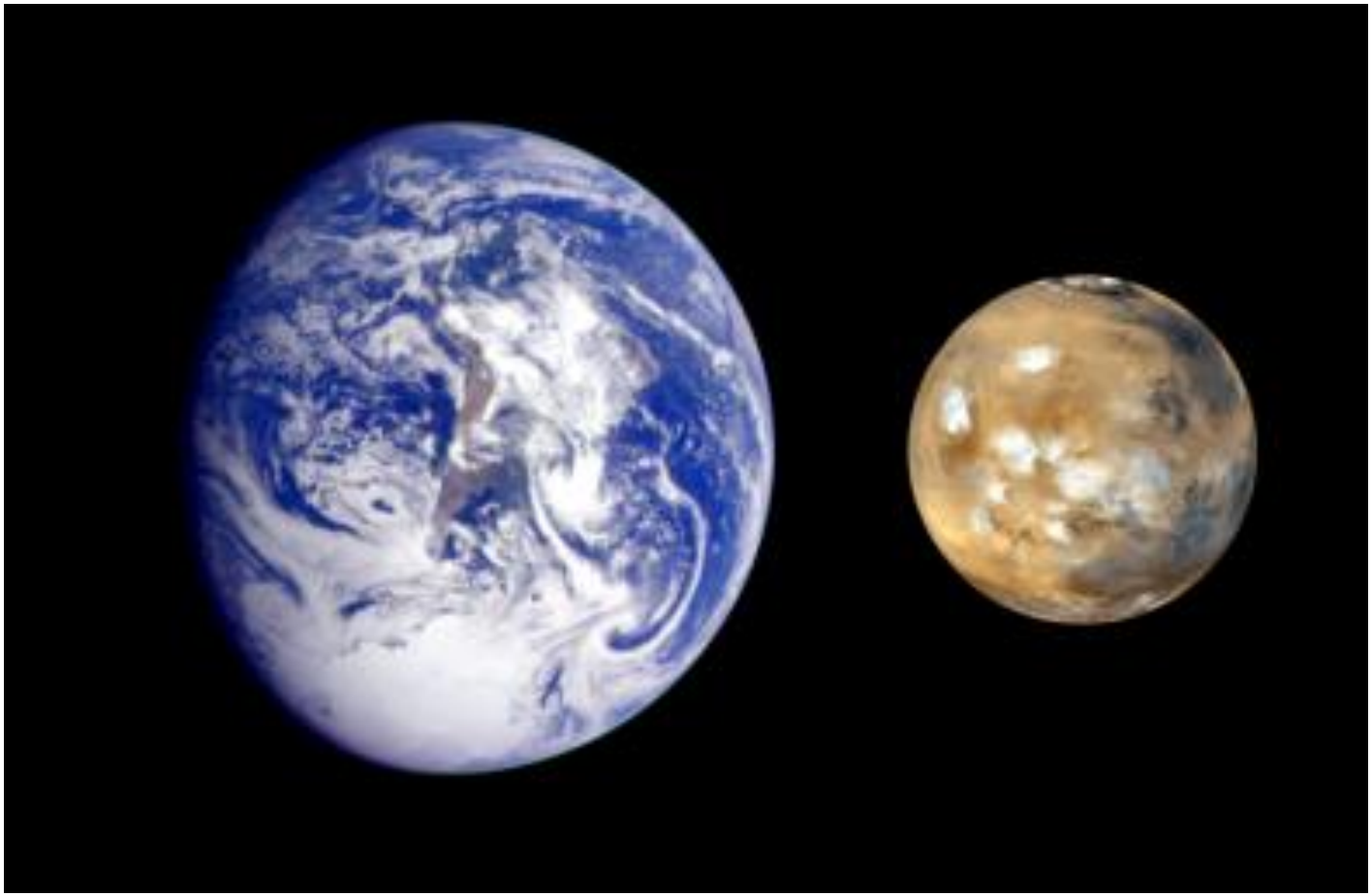


First the orbit; a=1.523 au, period =1.88 years

The study of Mars today

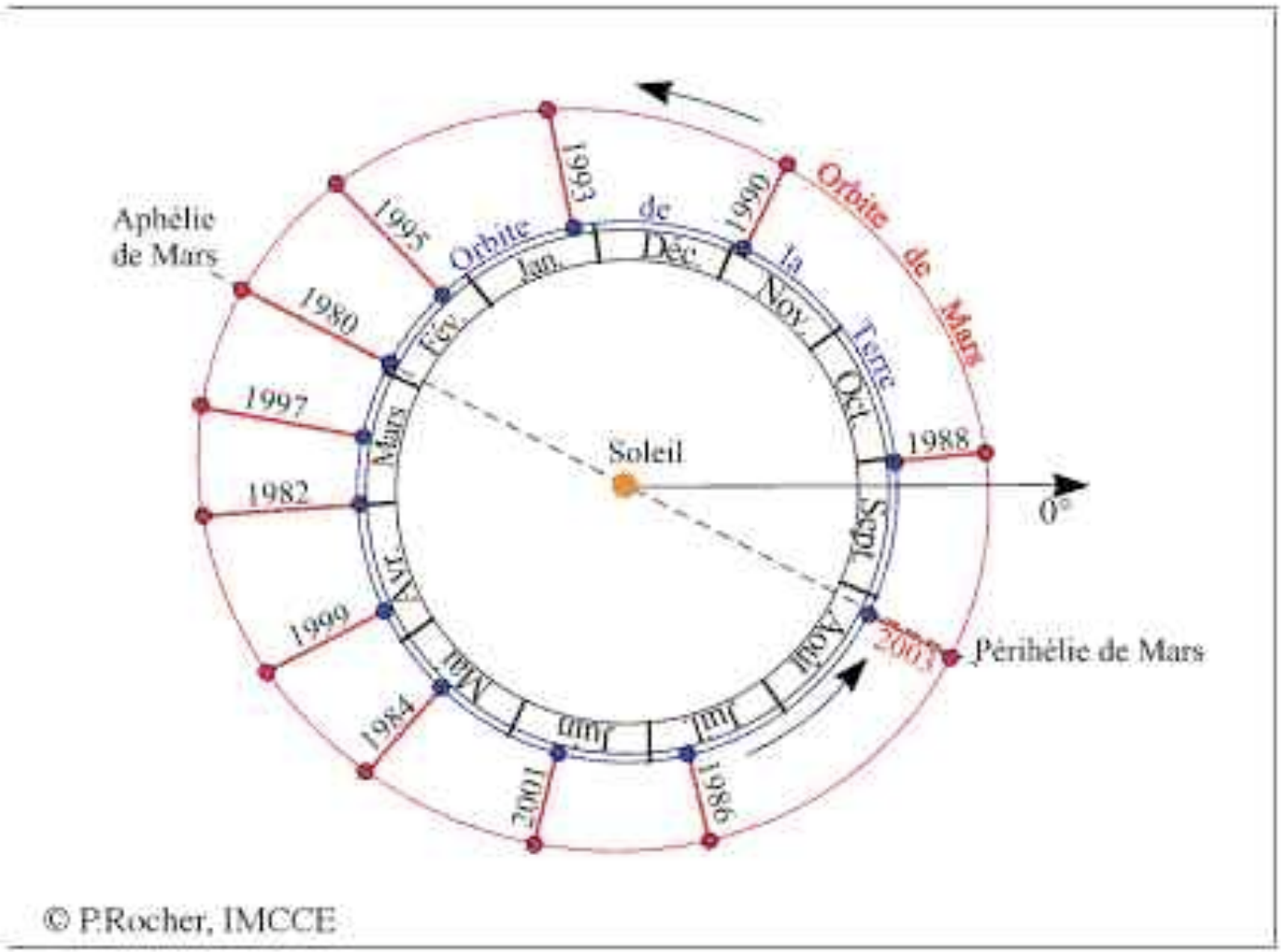


Physical characteristics of Mars

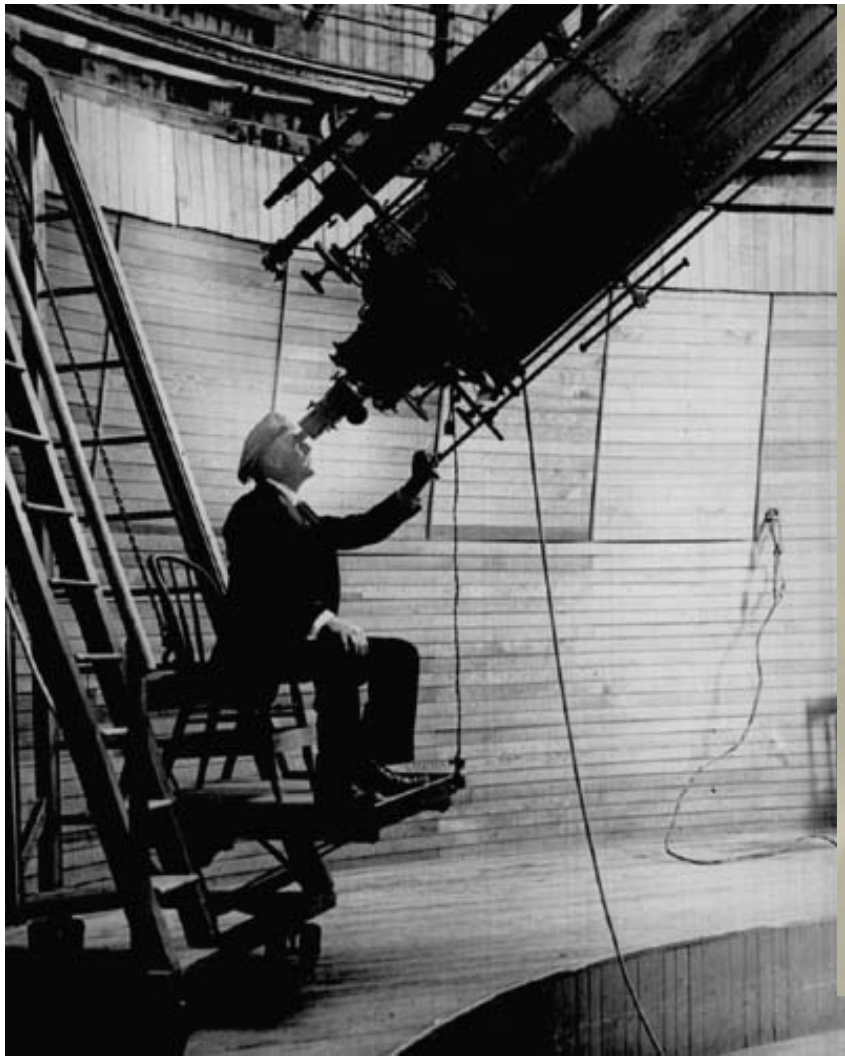


Radius 53% that of Earth (3397 km), mass is 11 percent that of Earth

The varying distance of Mars at opposition



Percival Lowell and the Canals of Mars



Earth-like attributes of Mars (leave out smaller size of planet)

- Polar caps at north and south poles, that change with the seasons
- Rotation period of 24.6 hours
- Obliquity of the ecliptic = 25 degrees
- In time of Lowell, apparent coming and going of features on Mars, perhaps indicating seasonal changes in vegetation

By the 1960s it was known that Lowell's view of an Earth-like Mars with higher life forms could not be right; the atmosphere on the surface of Mars is about 0.7 % the sea-level pressure on Earth. Water cannot exist in liquid form under those conditions.

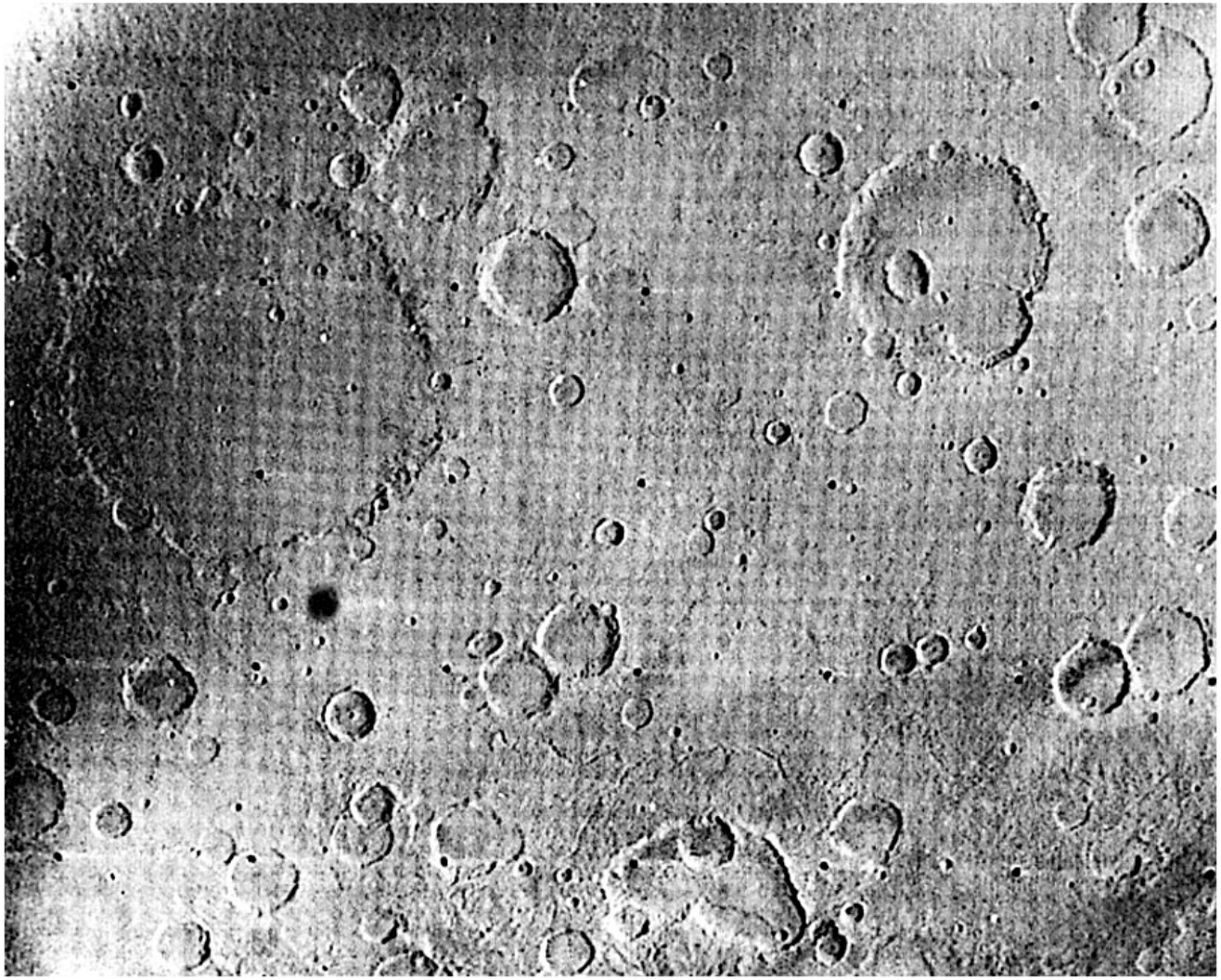
The average surface temperature on Mars is also about 60 degrees Centigrade below freezing (210K rather than 293K in this room).

Robotic Exploration of Mars

The exploration of Mars by spacecraft

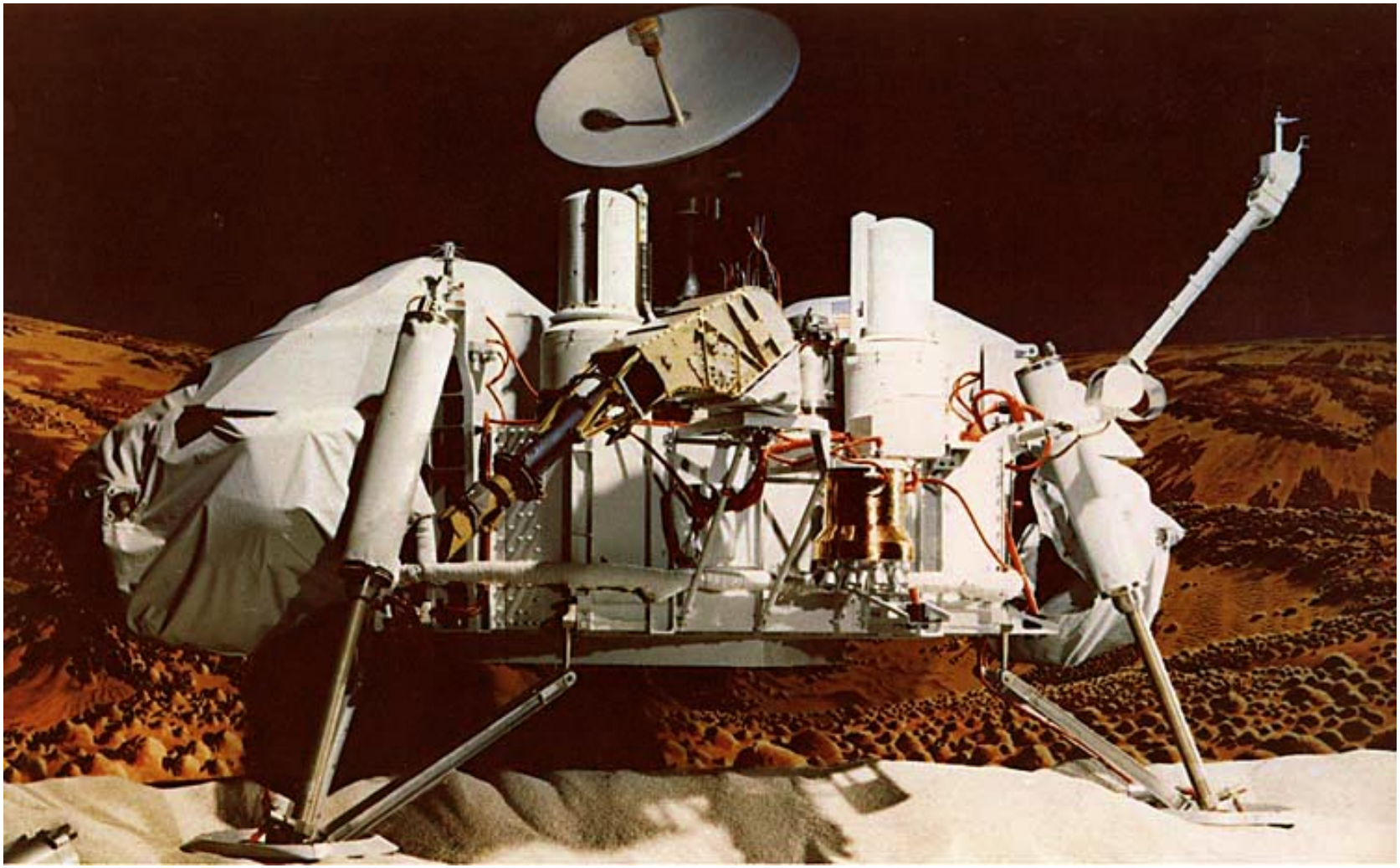
- Began in 1960
- 38 missions attempted
- 19 successful
- First with results was US Mariner 4 in 1965
- Mariner 4 gave us our first close-up view of Mars
- Several other major ones since then (Mariner 9 in 1971, Viking 1 and 2 in 1976, MER in 2004- present, and *Curiosity,* the Mars Science Laboratory

Mariner 4, our first close view of the surface of Mars

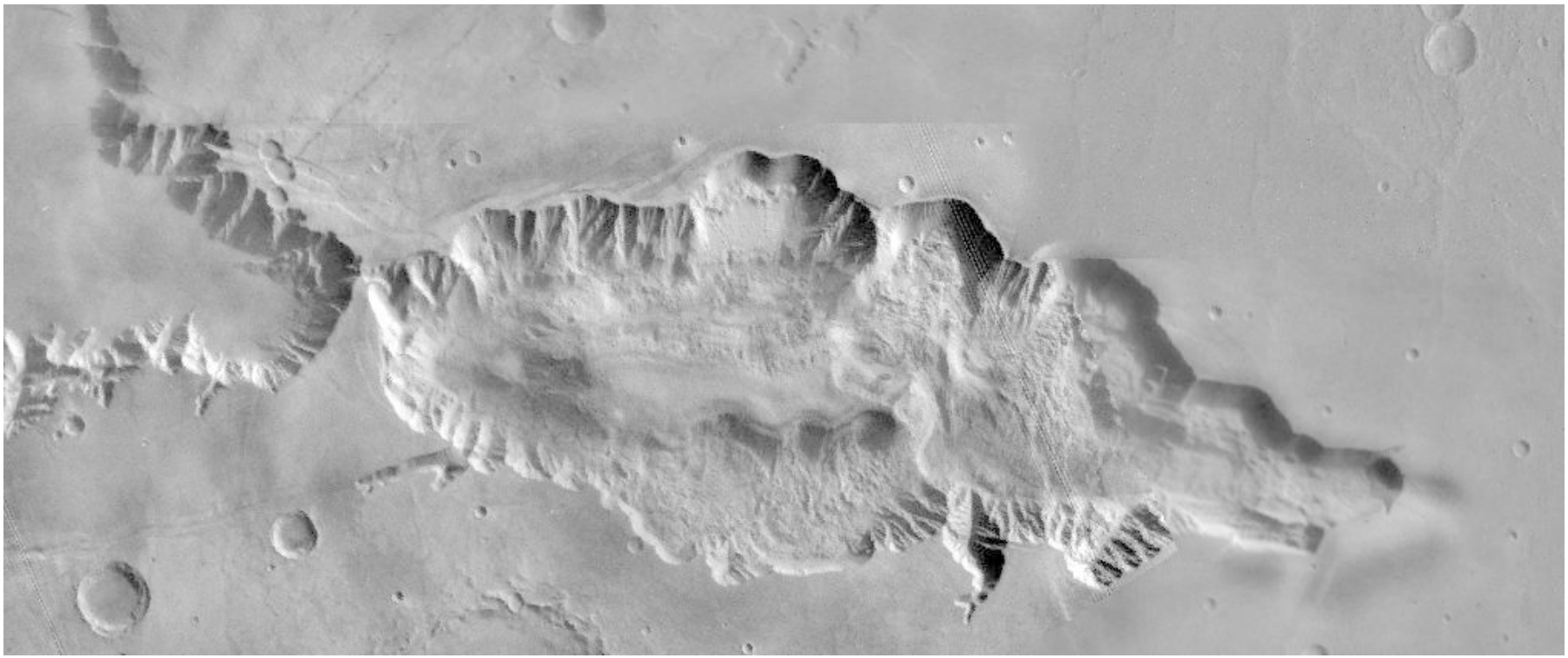


What does this mean?

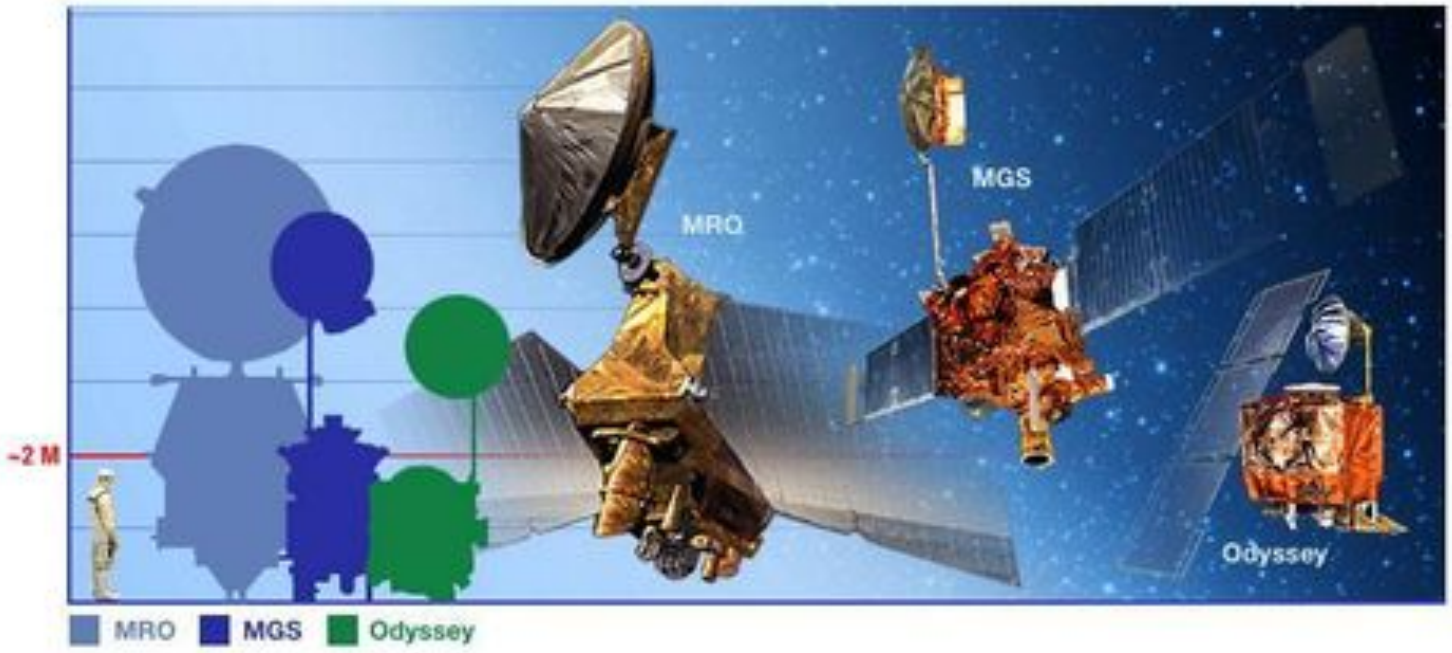
The “new era” in Mars studies began in the 1970s: the Viking spacecraft



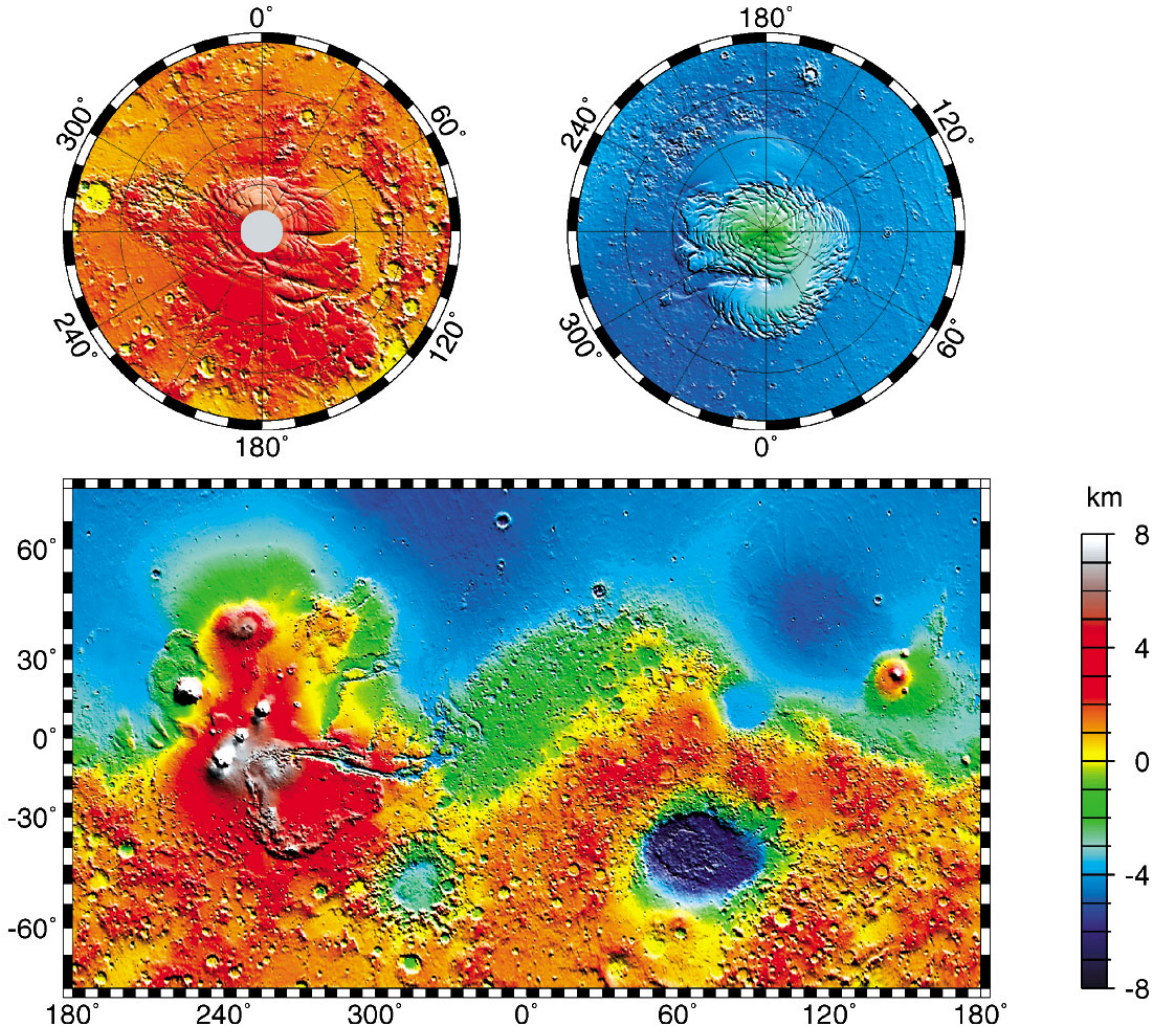
Orbiting spacecraft revealed more varied terrain, e.g. Hebes Chasma

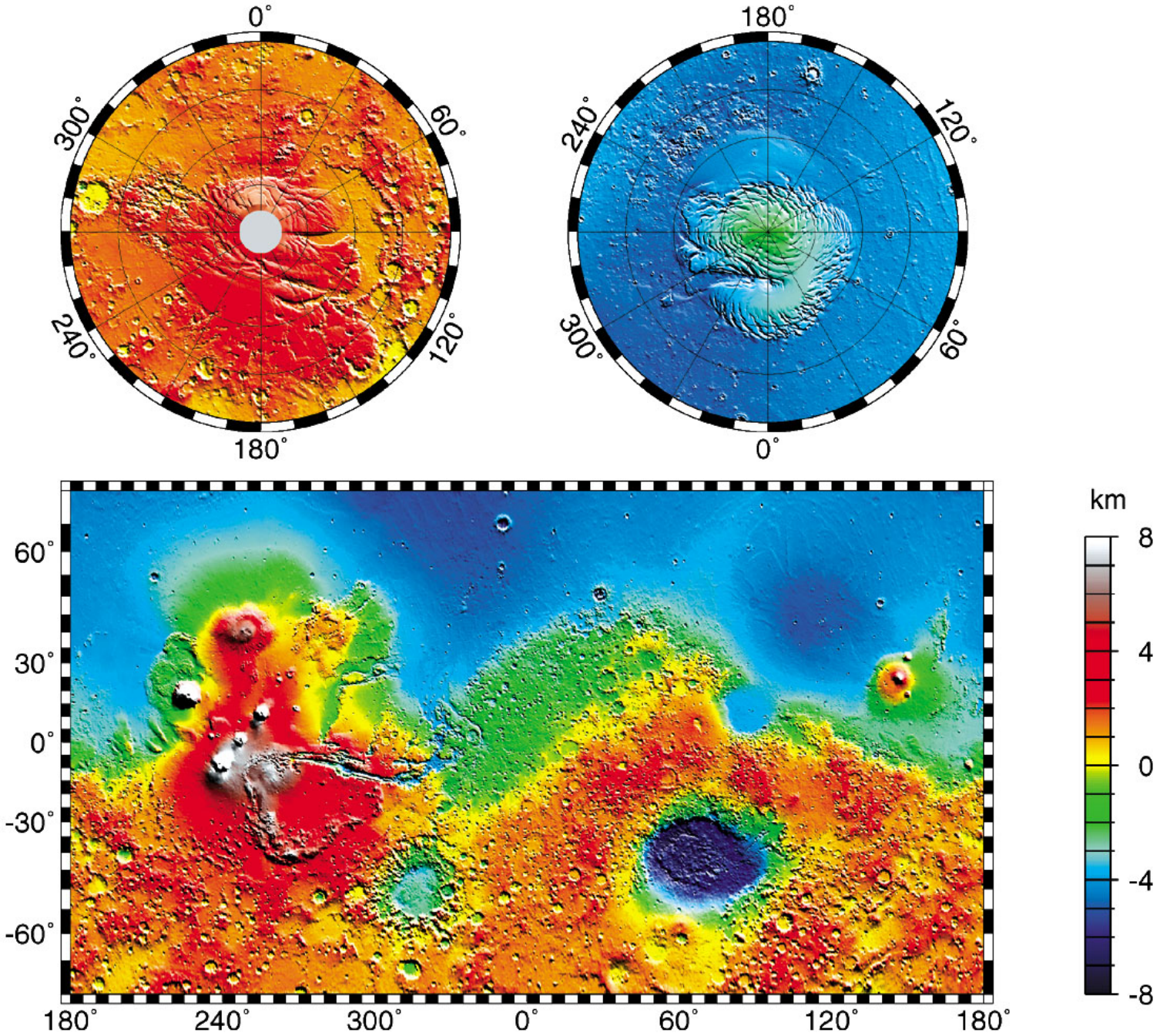


A summary of what we have learned from orbiting spacecraft, 1971-present



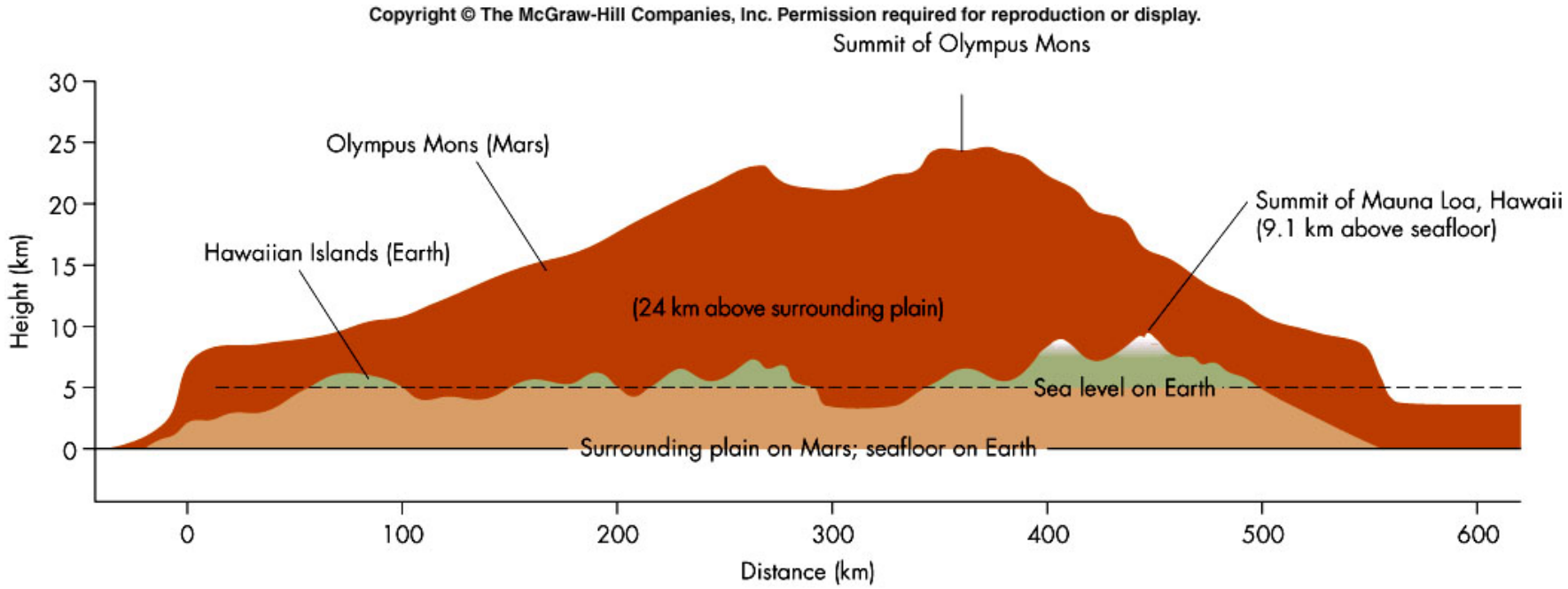
Spacecraft finding #1 - the north-south asymmetry



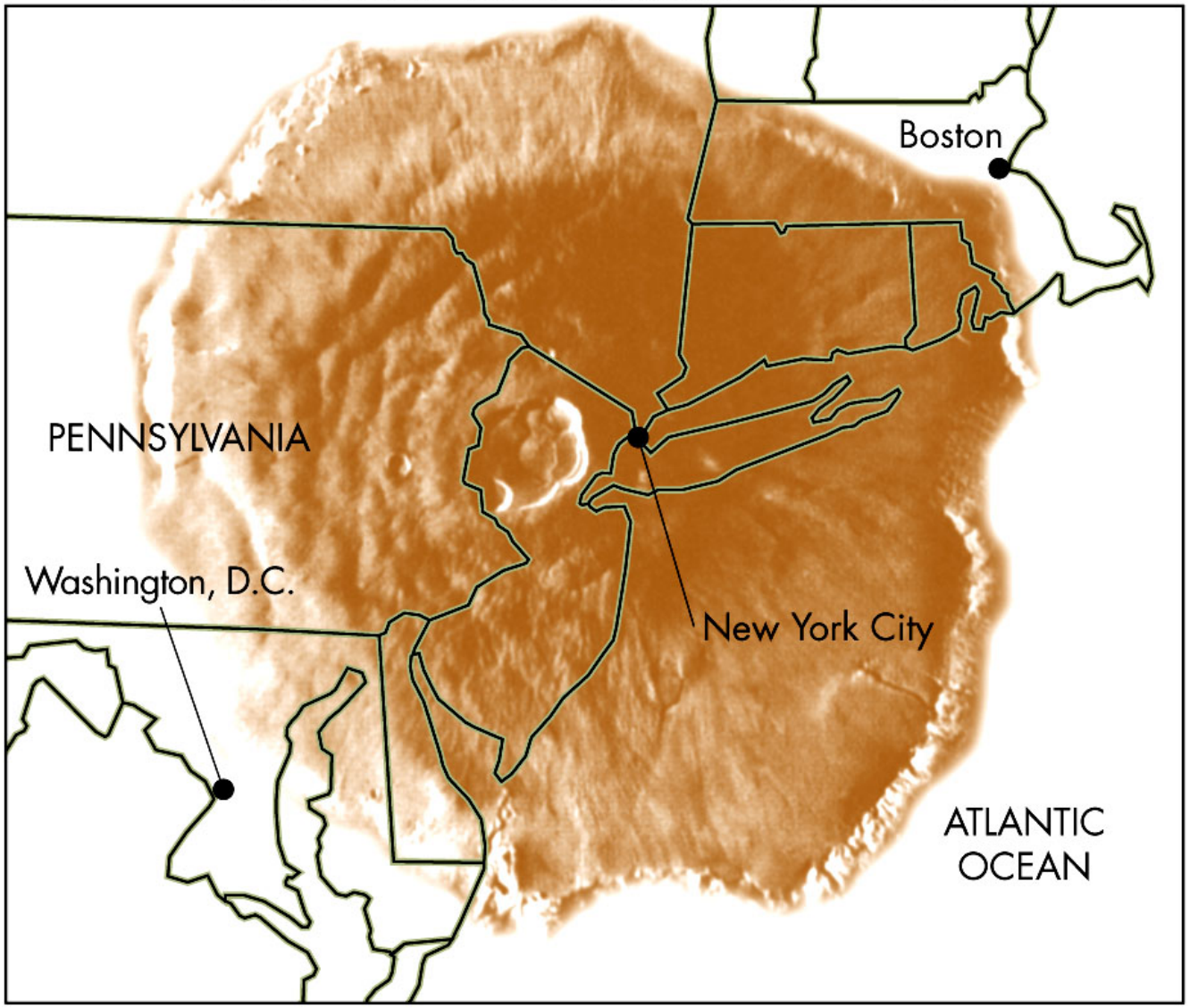


Finding #2: The volcanos of Mars: Olympus Mons

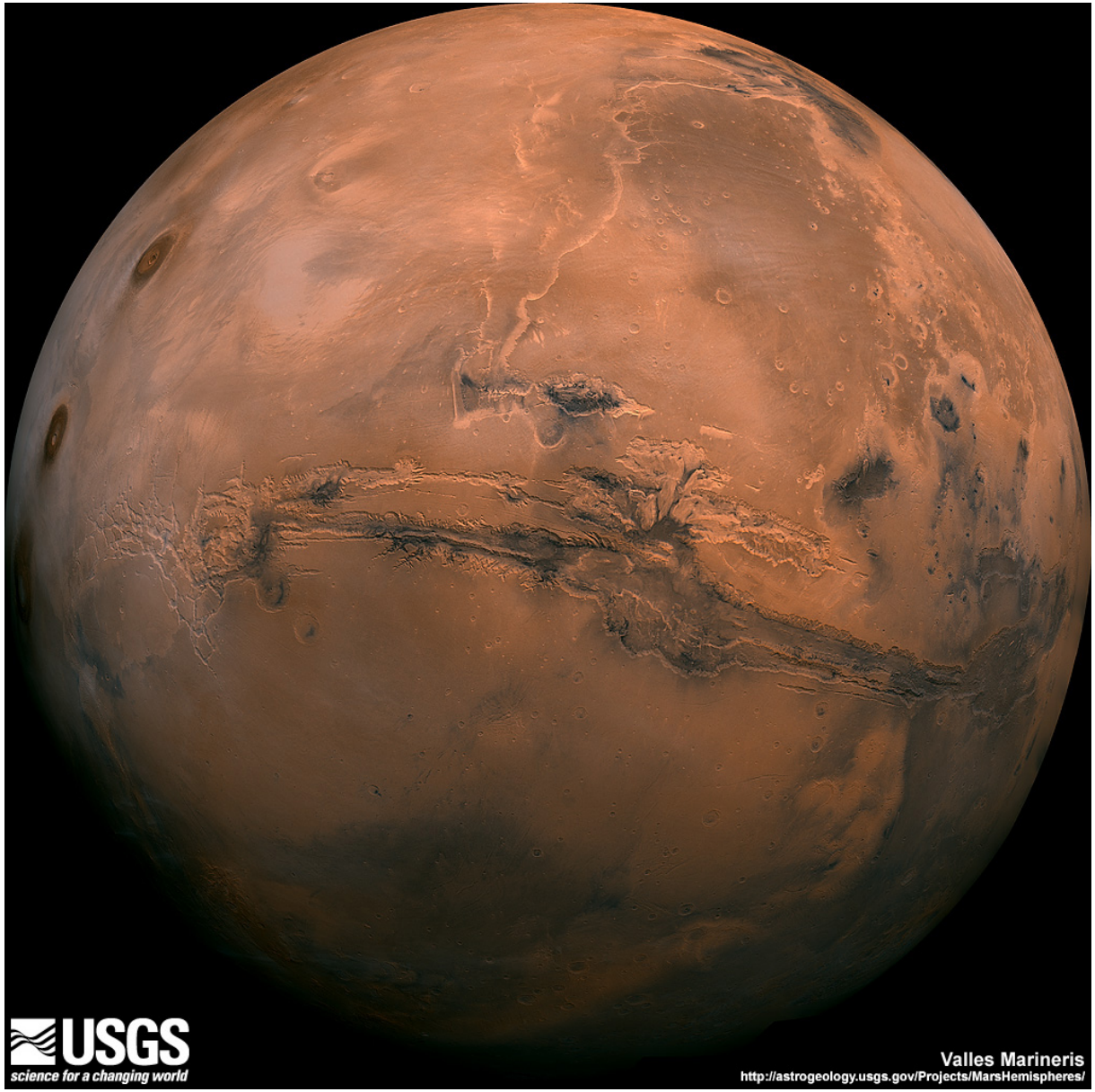
The size of Olympus Mons



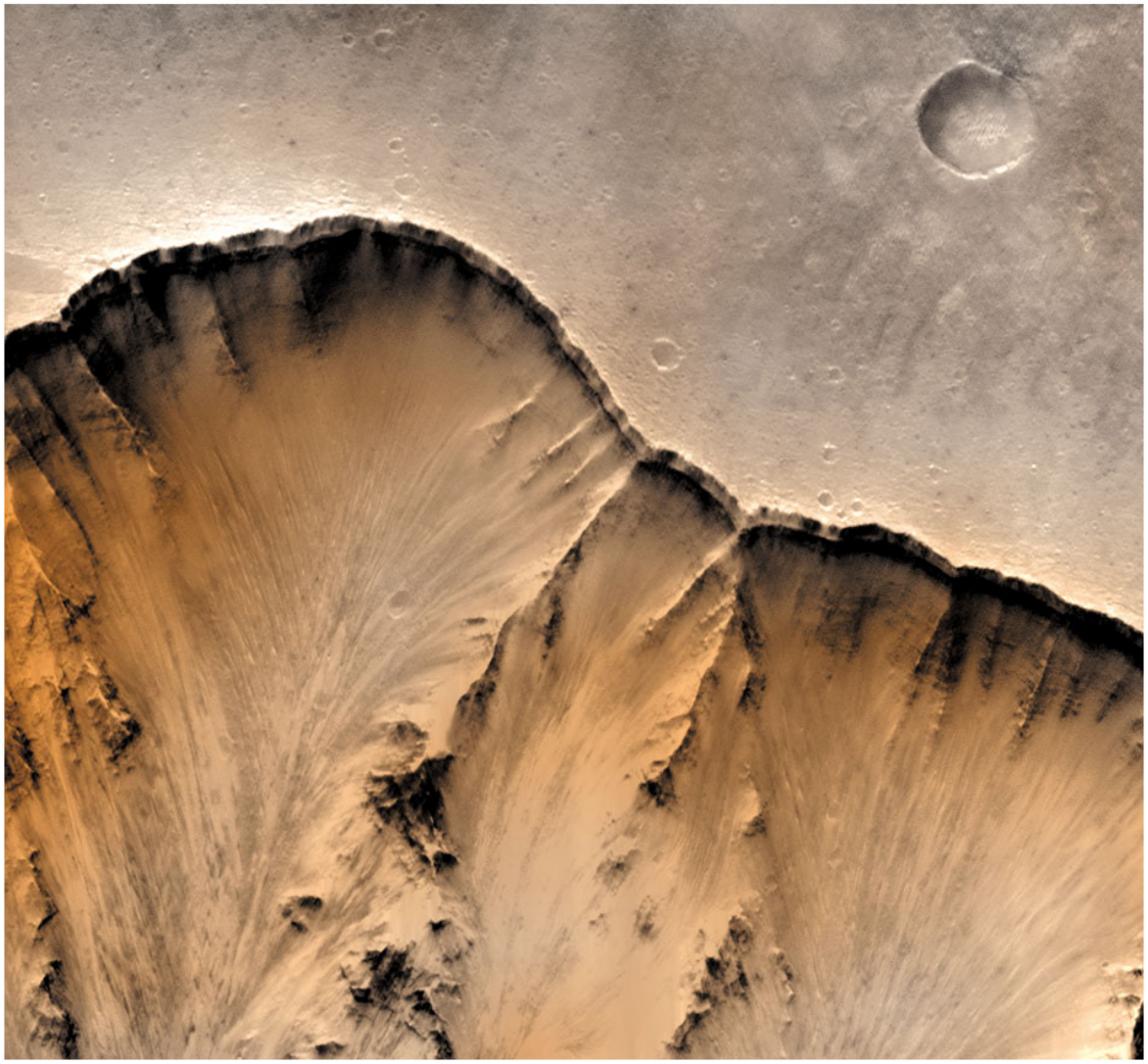
The extent of Olympus Mons



Valles Marineris…Grand Canyon of Mars

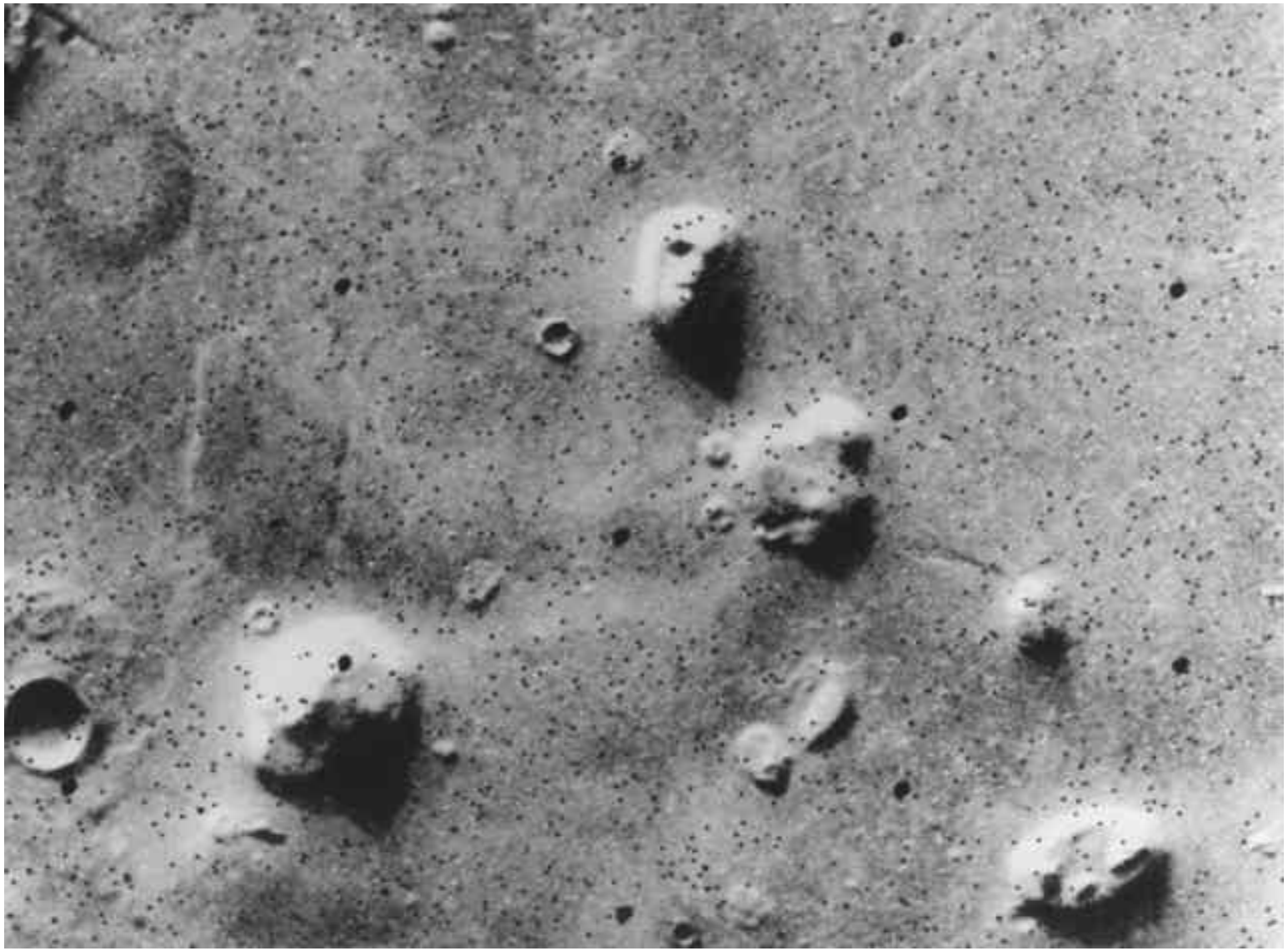


Valles Marineris

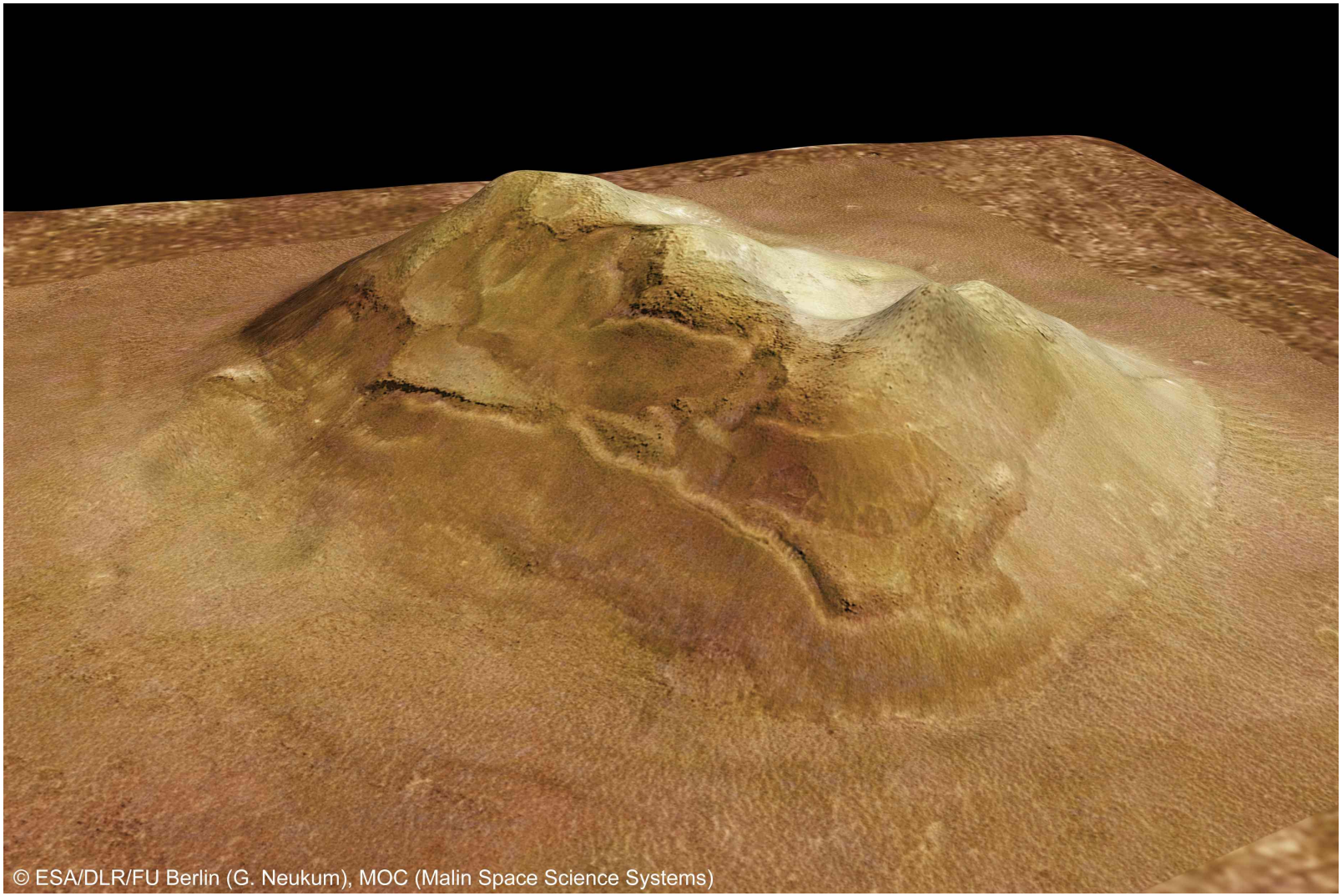


Valles Marineris…the view of a future astronaut

More mysteries on Mars?

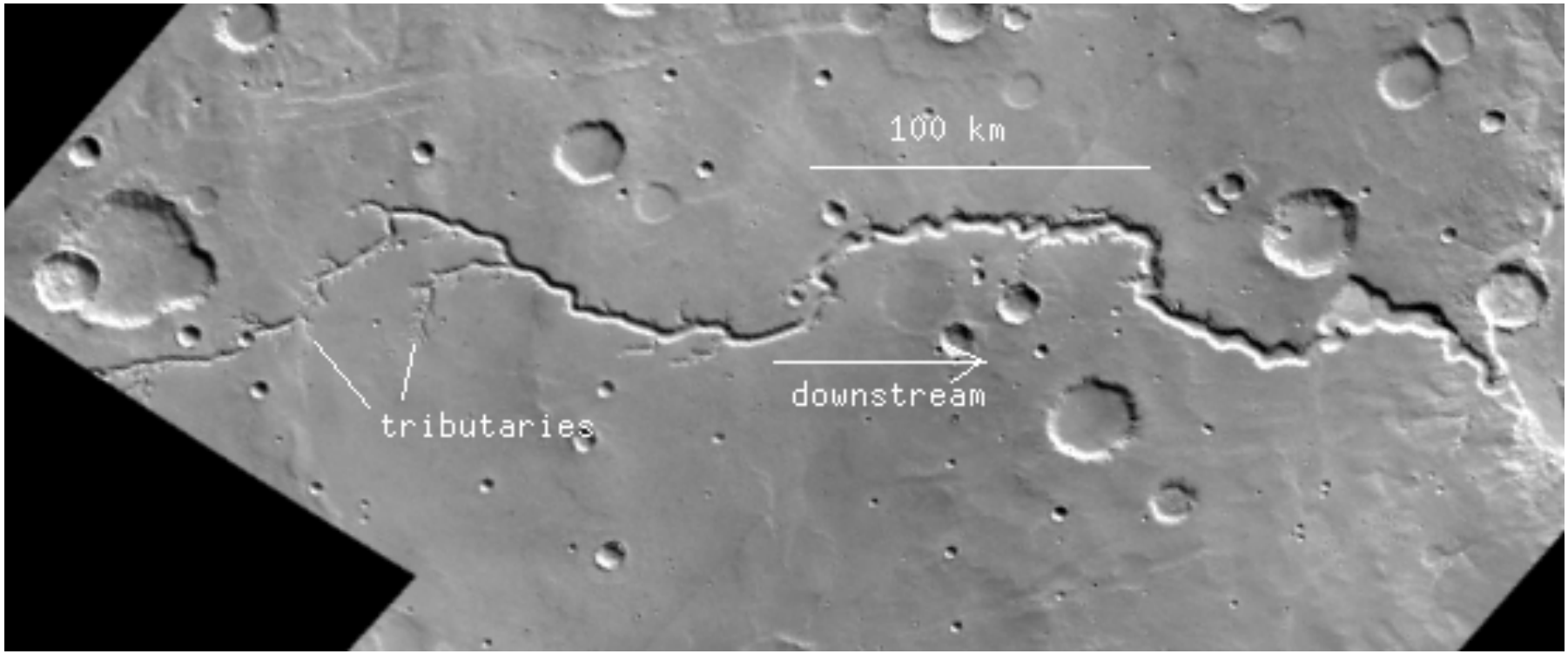


A better look at “The Face”

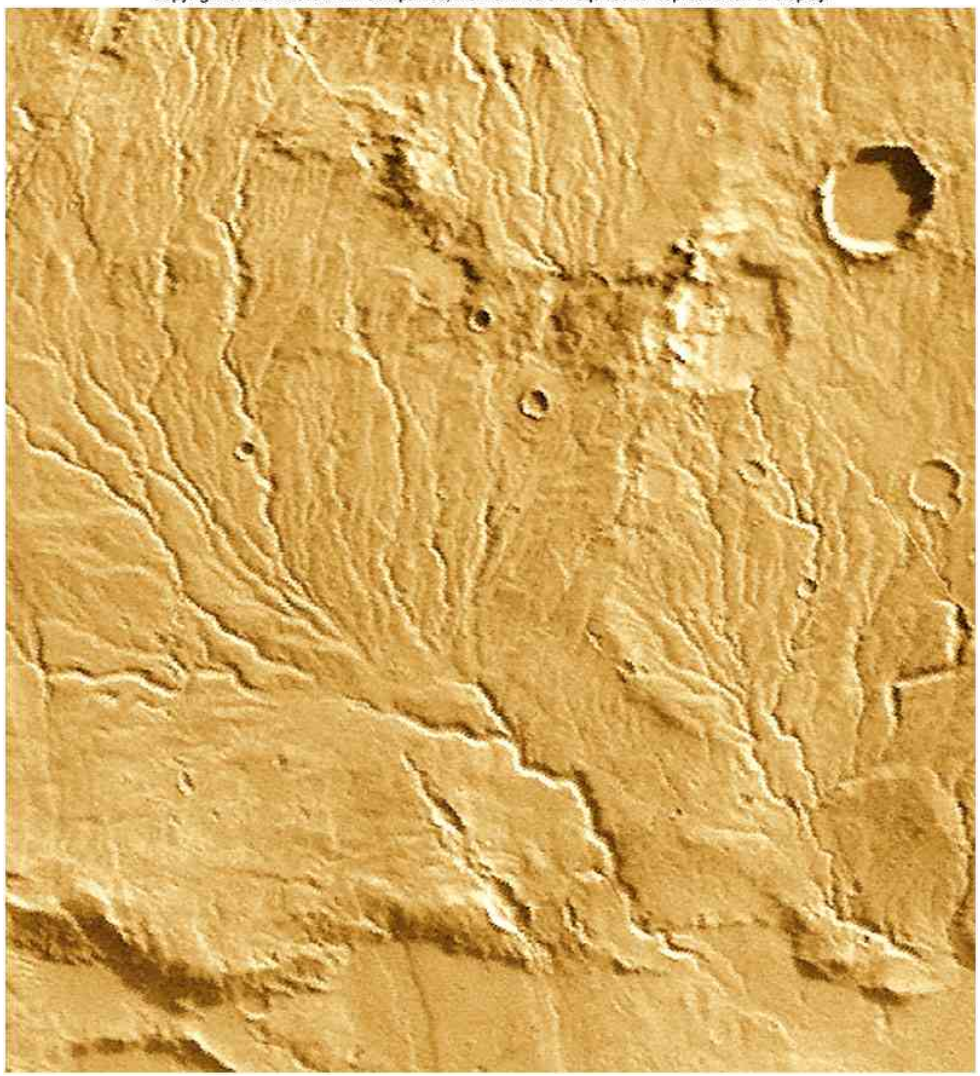


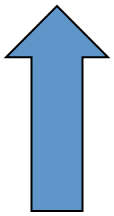
The most important finding of orbital studies of Mars: apparent water channels

A startling discovery…the new canals of Mars

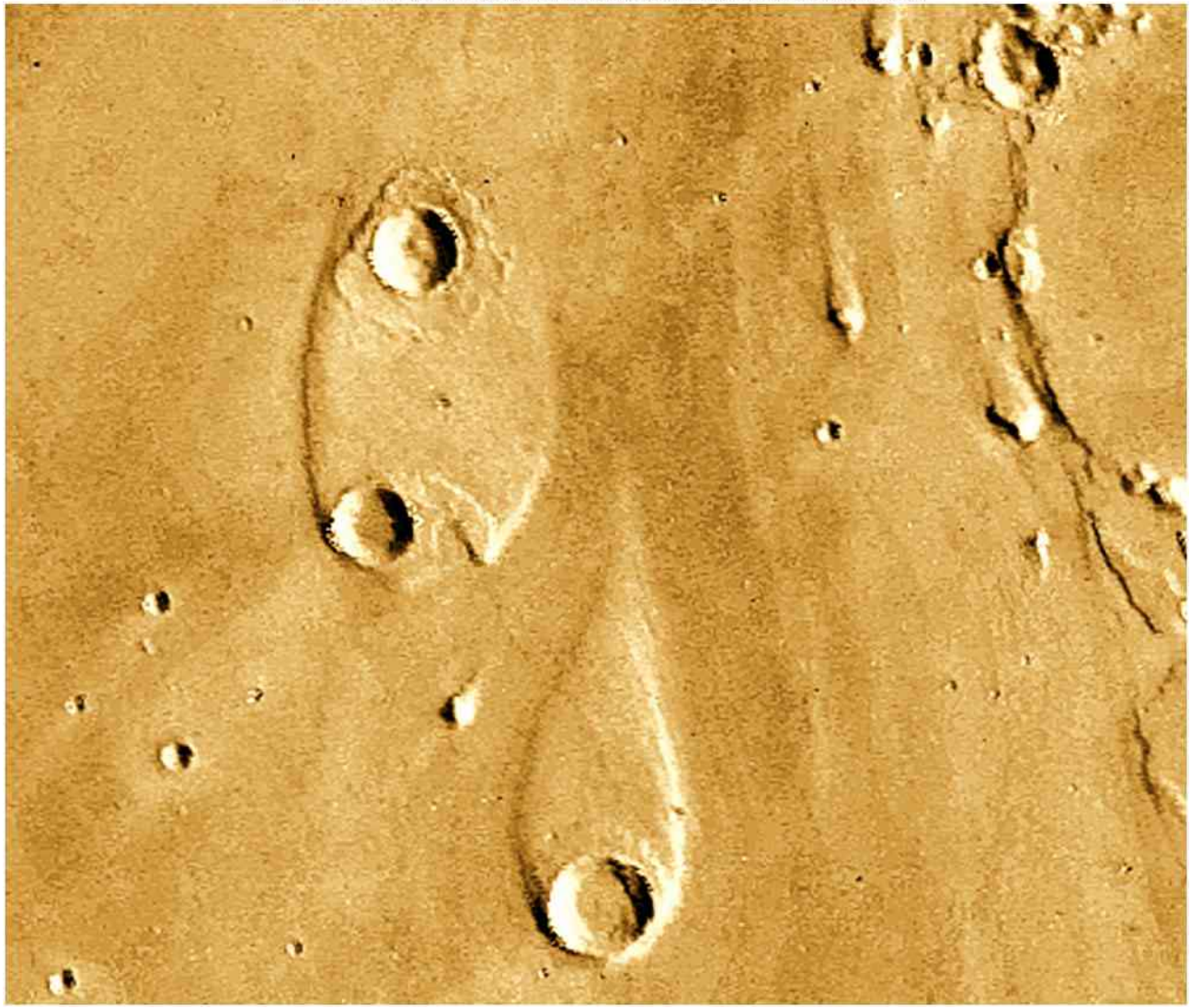


Two types of channels: Valley networks

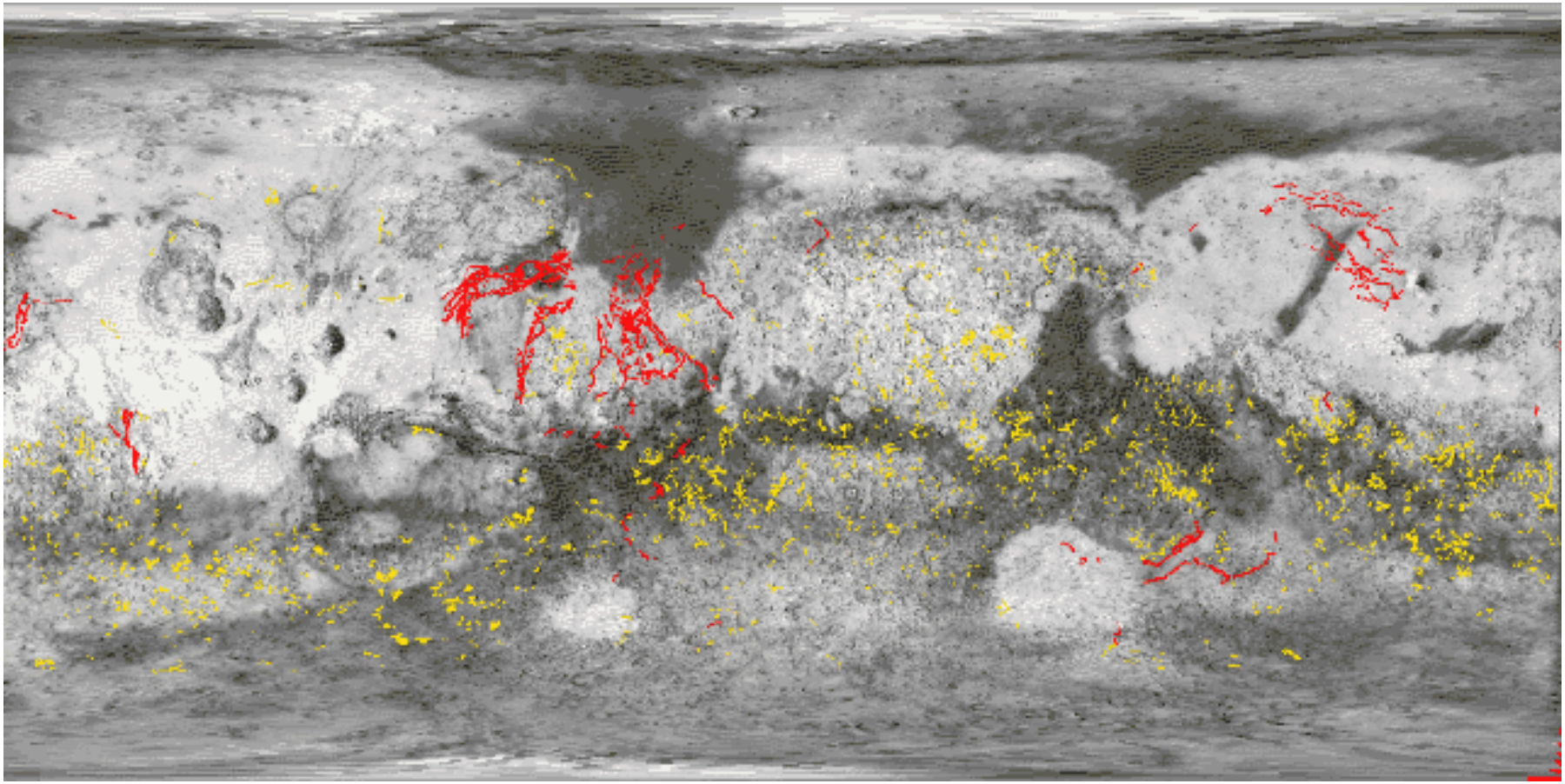




Second type: outflow channels

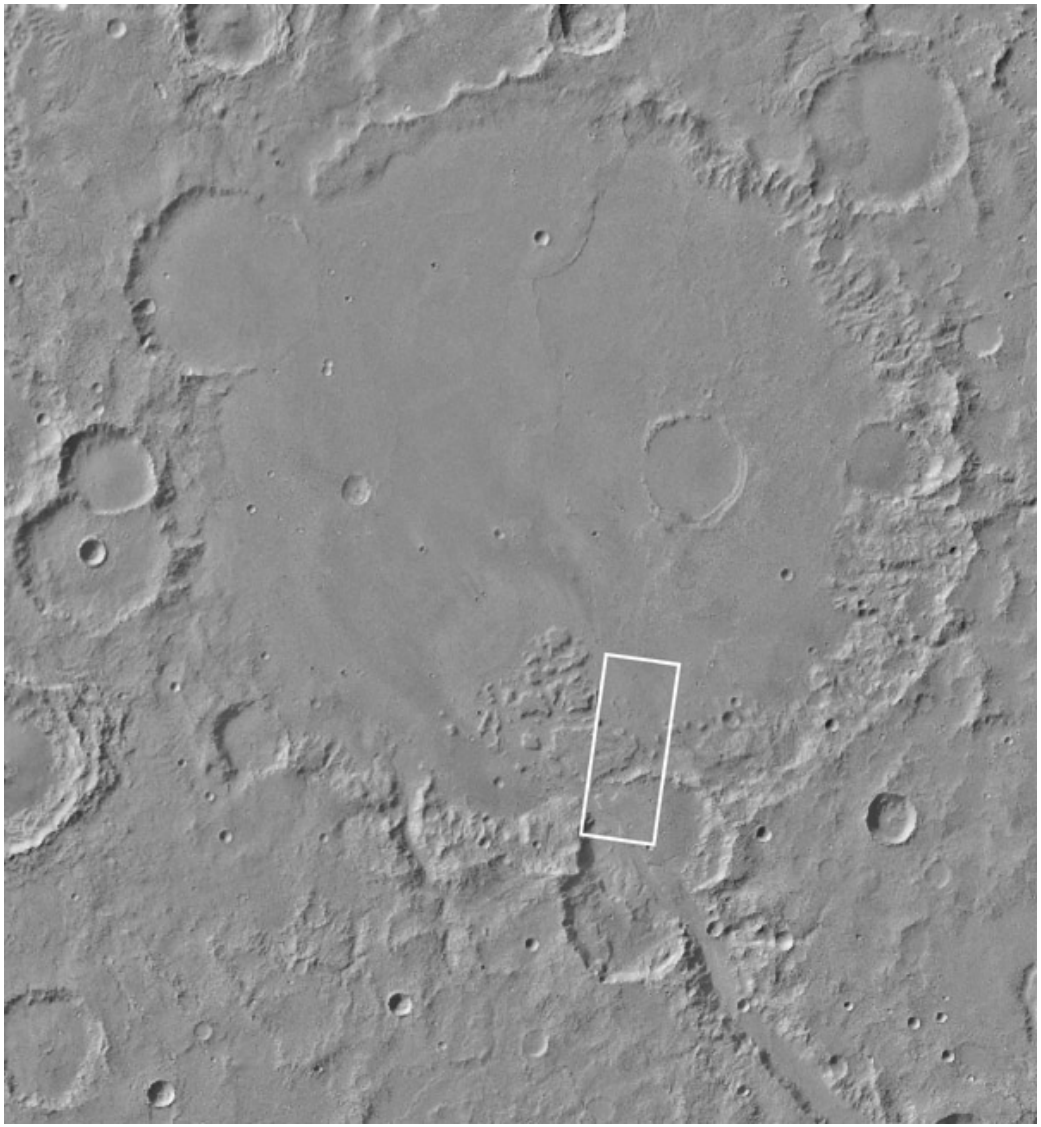


Where are water channels formed?

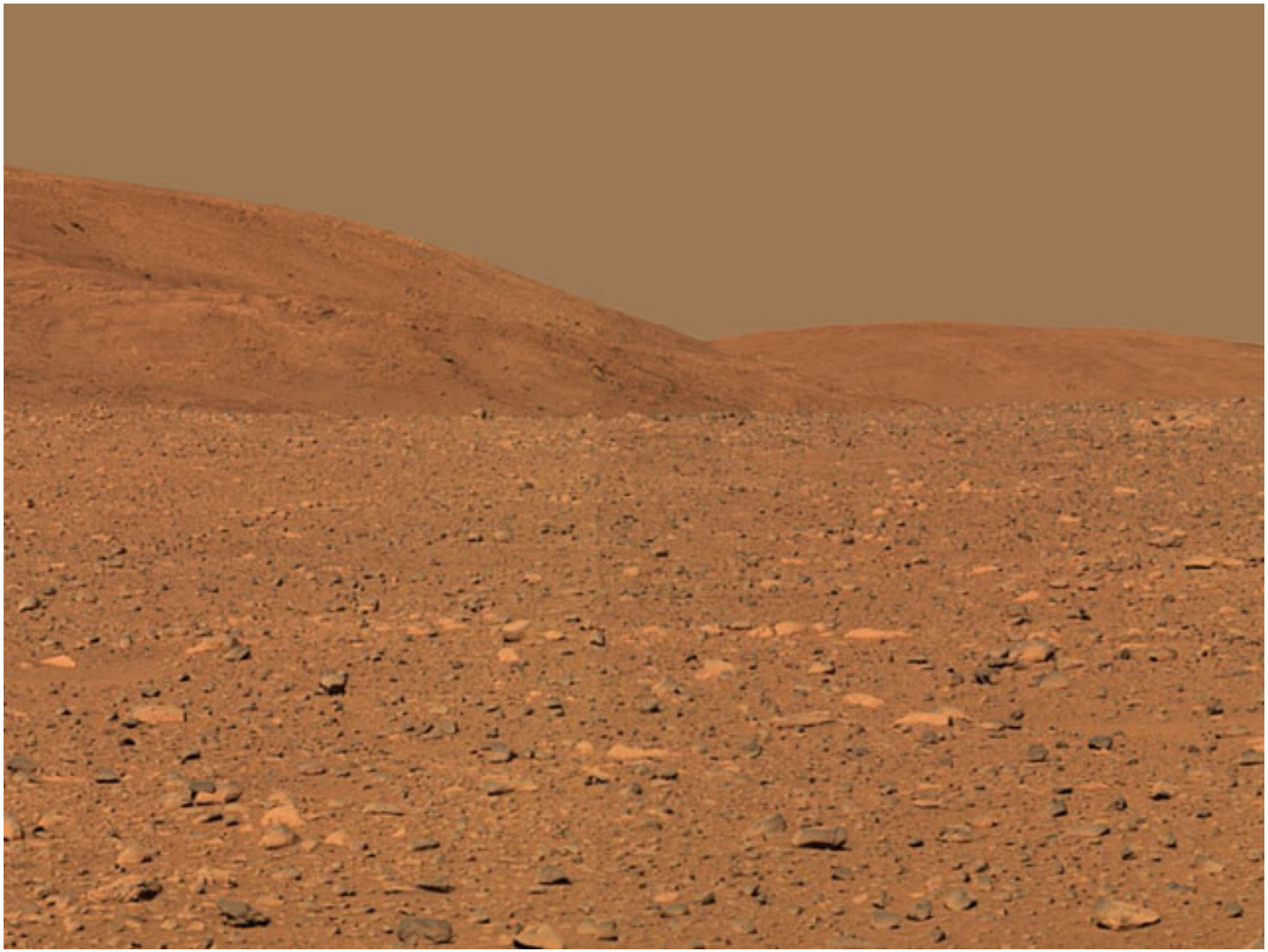


Does anyone see any patterns?

A case of particular interest: Gusev crater



Gusev Crater: the view from the surface…more next time



A question for the scholarly assembly:

- Last time, said that the surface conditions of Mars did not allow liquid water
- Now we see what are claimed to be water flow channels, like dry river beds in the southwest
- What's up?