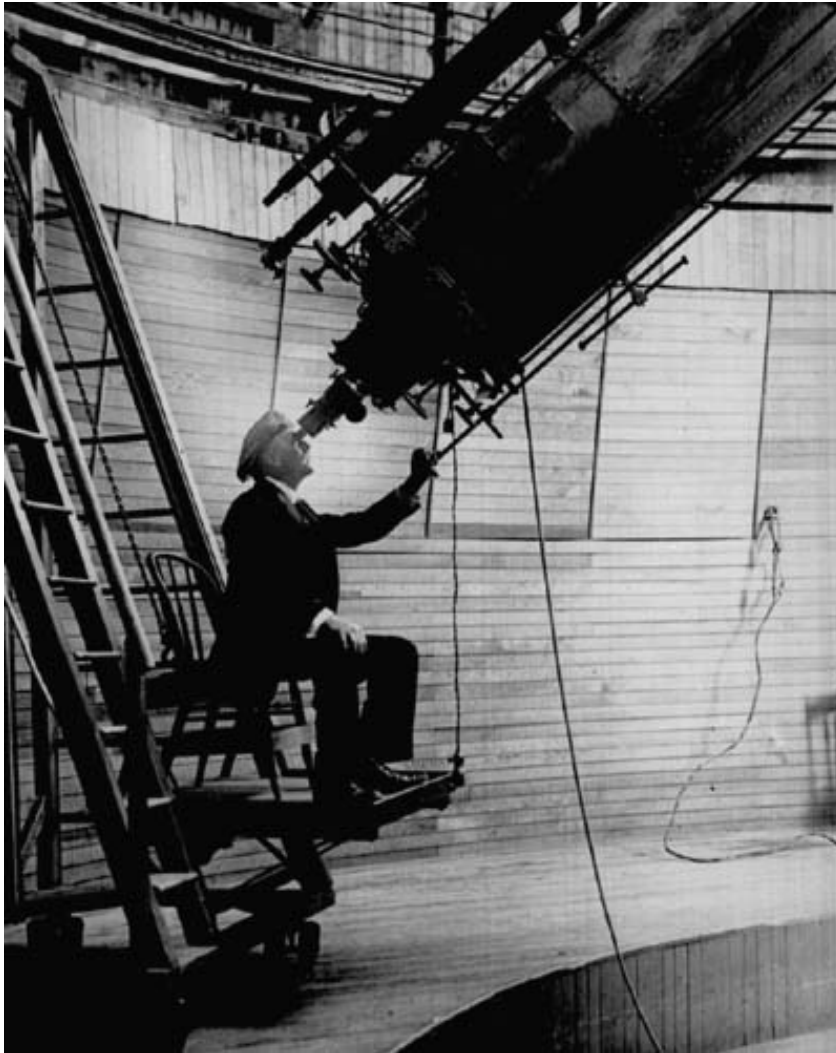


Exploration of Mars



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

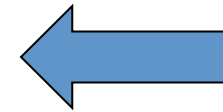
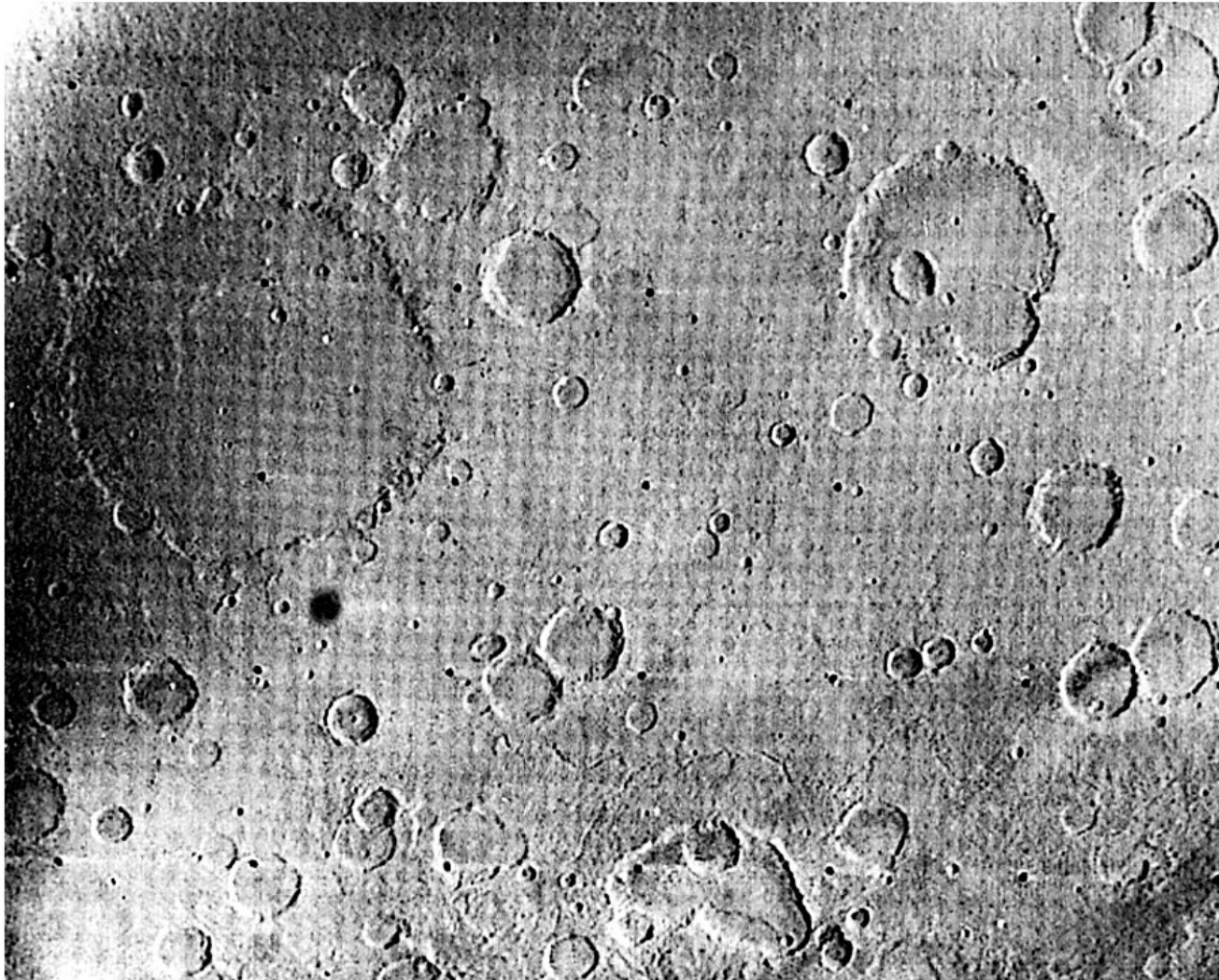


The exploration of Mars by spacecraft

- 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)

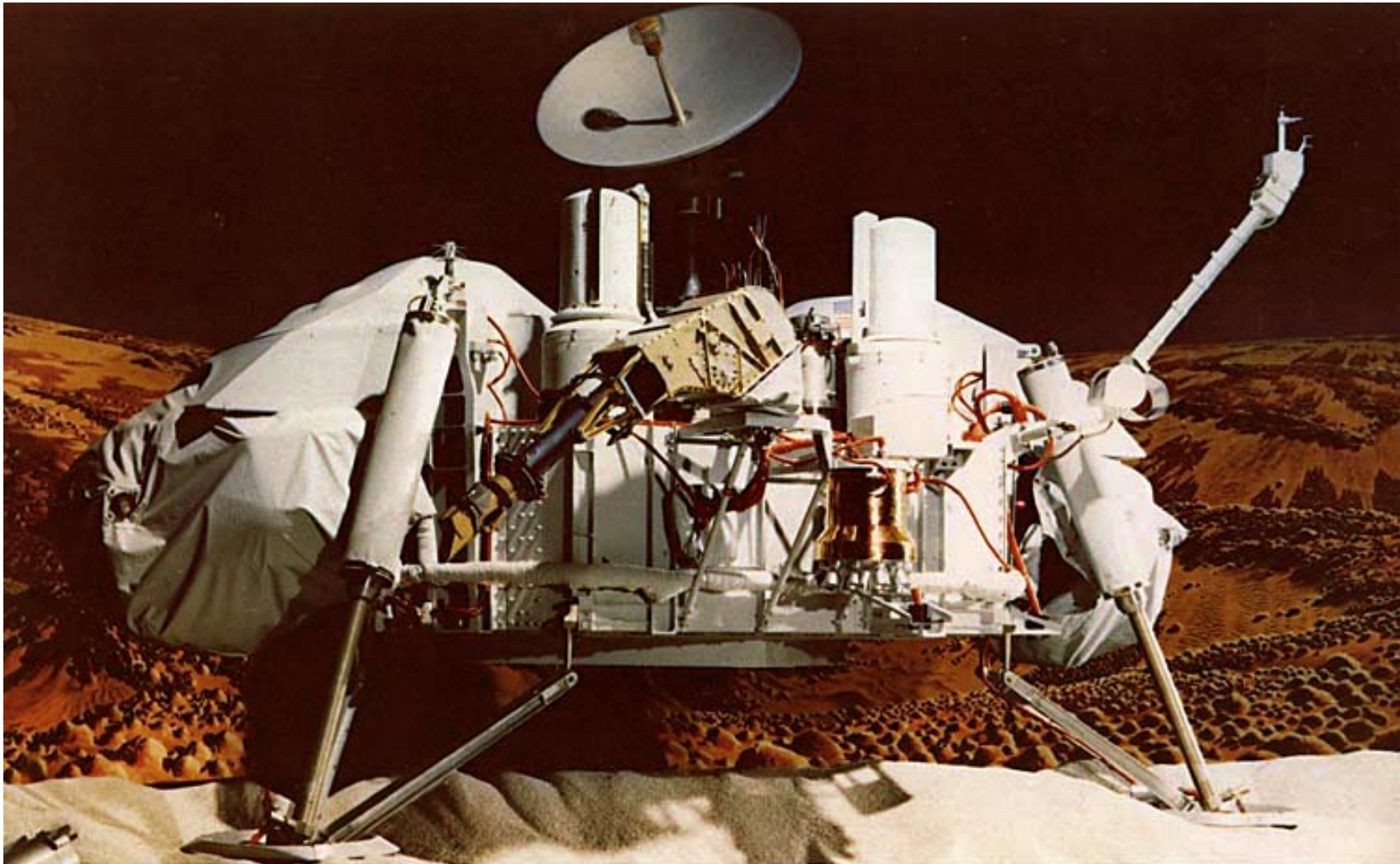
Mariner 4, our first close view of the surface of Mars

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What does this mean?

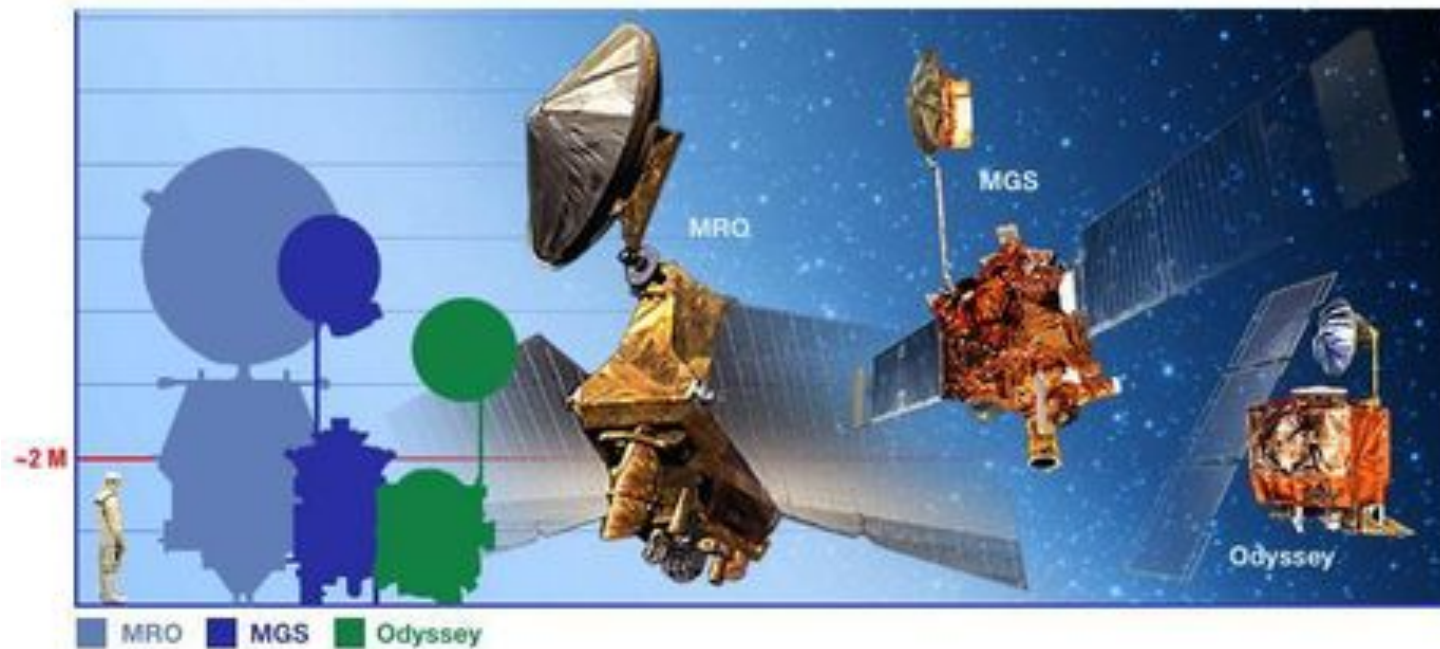
The “new era” in Mars studies began in the 1970s: the Viking spacecraft



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

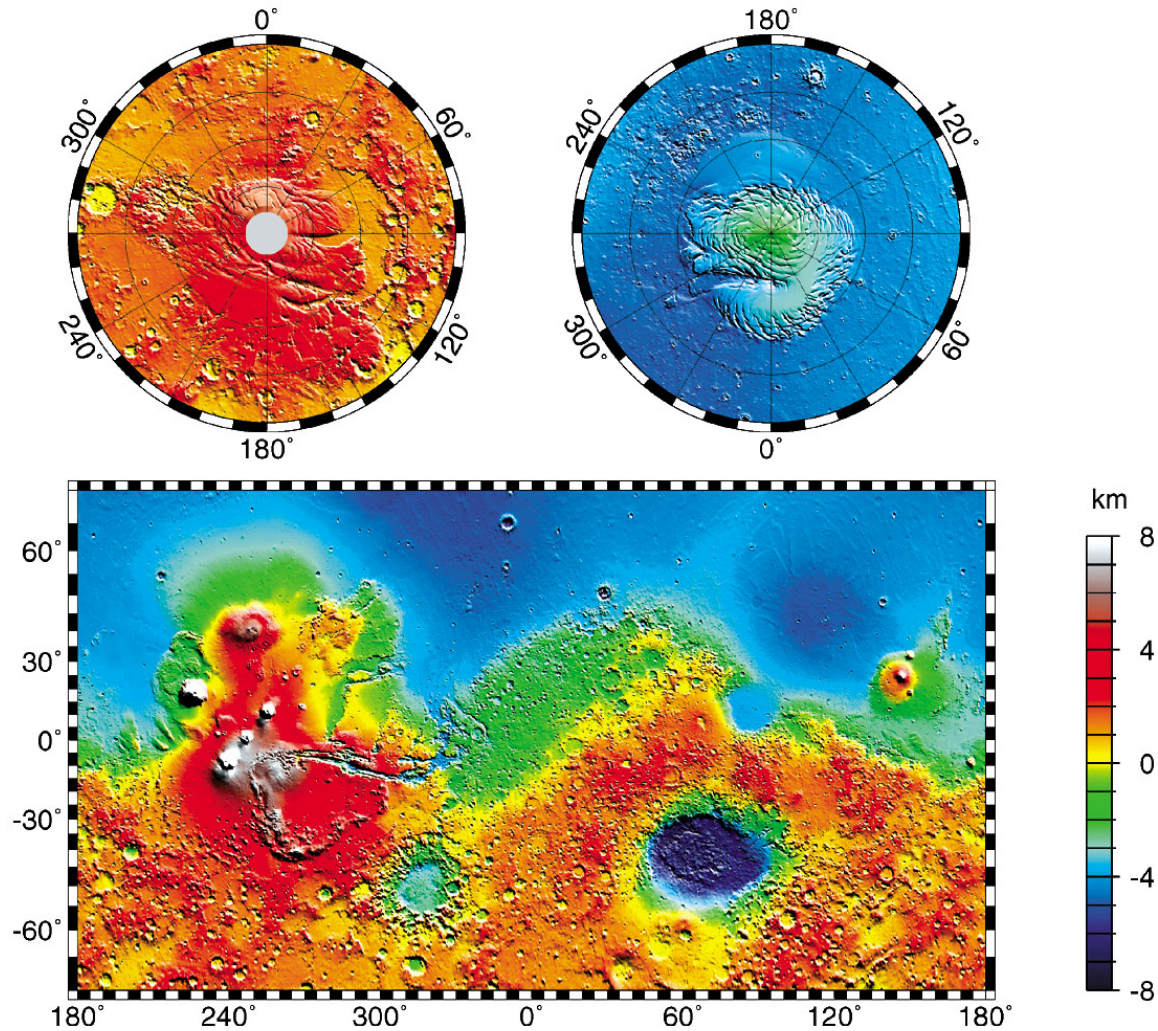


A summary of what we have learned from orbiting spacecraft, 1971-present

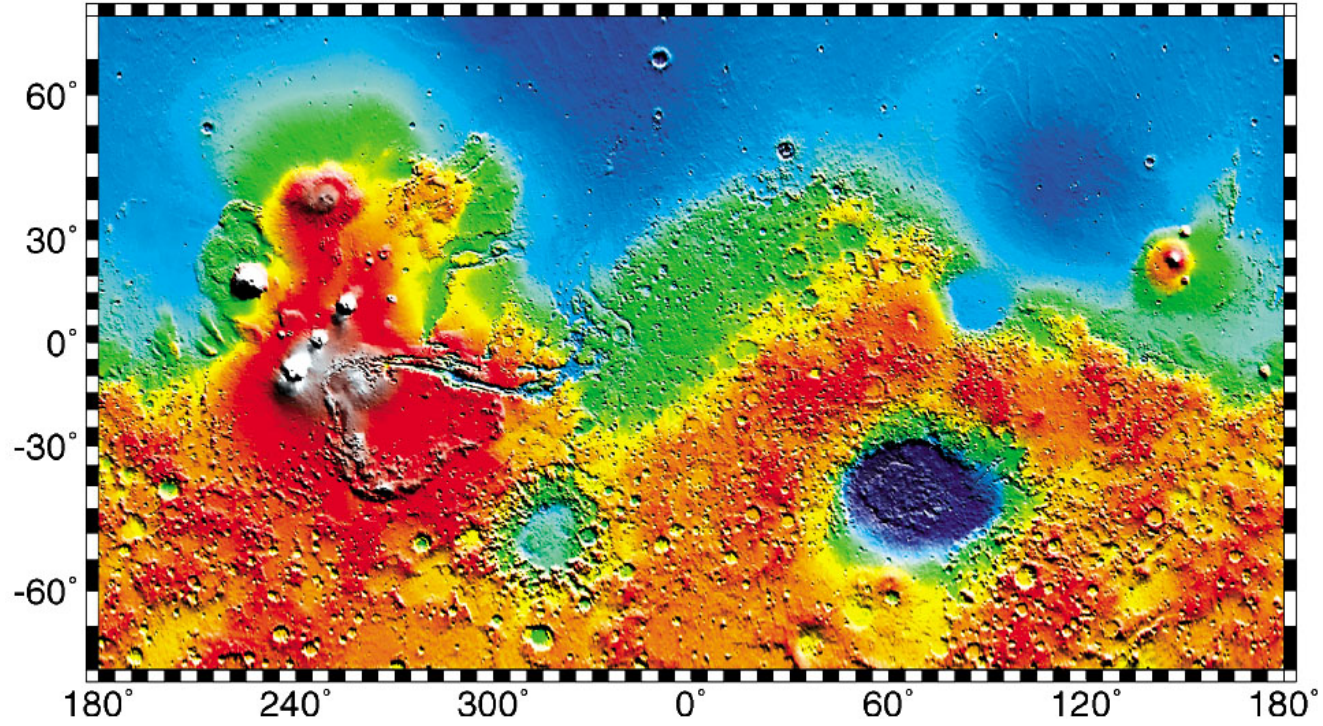
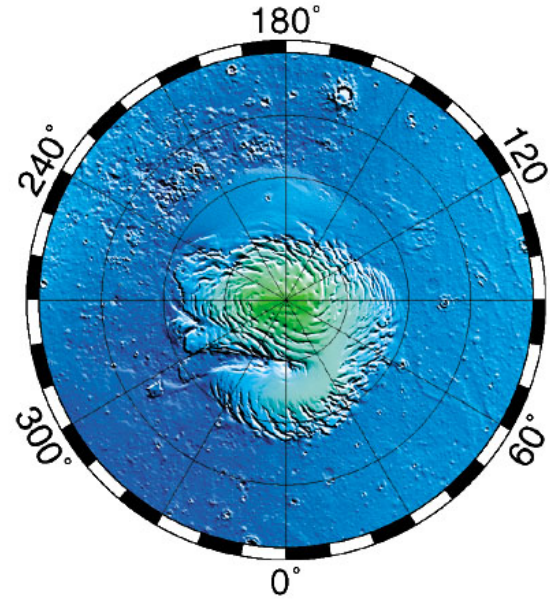
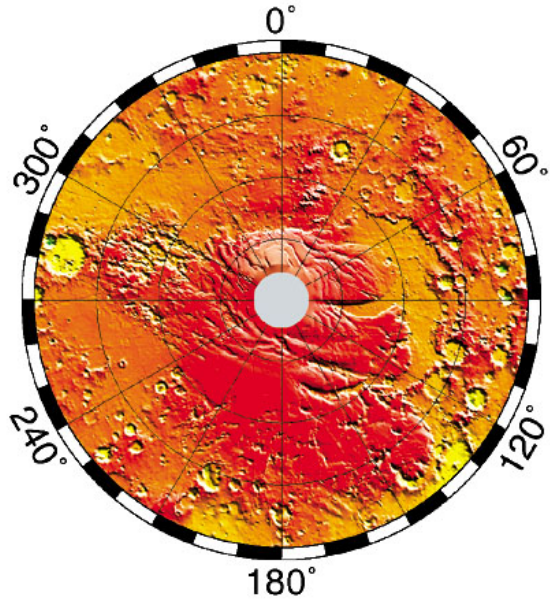


Spacecraft finding #1 - the north-south asymmetry

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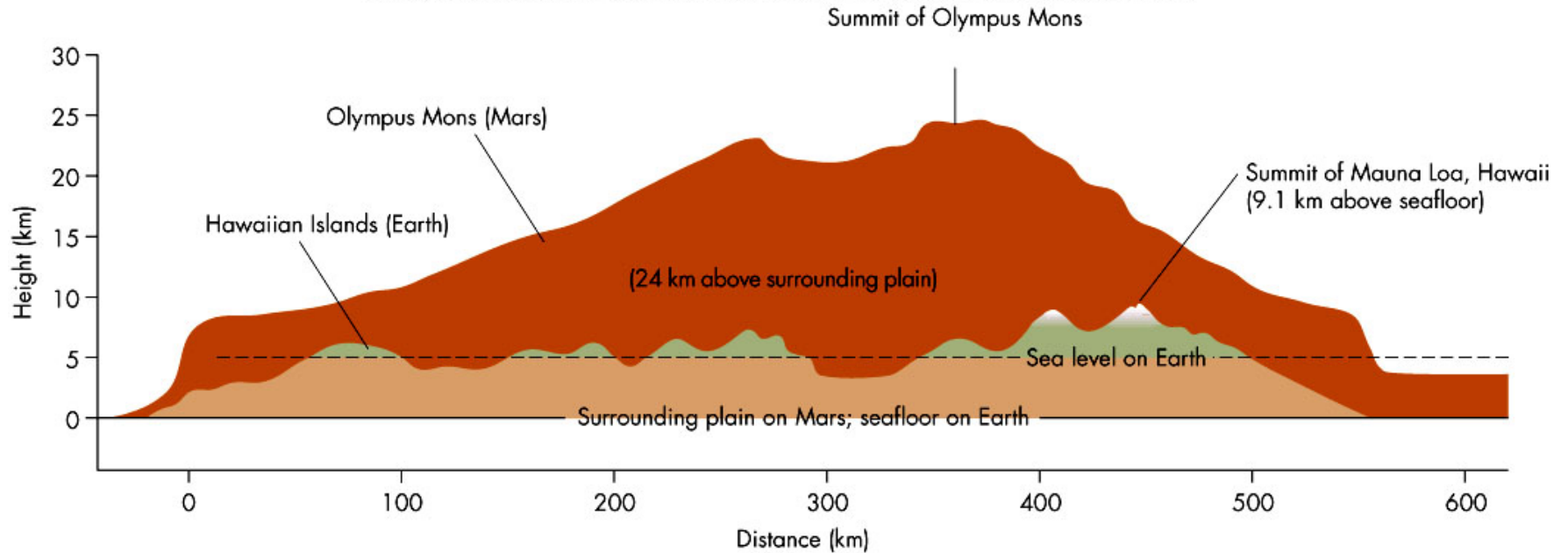


Finding #2: The
volcanos of
Mars: Olympus
Mons



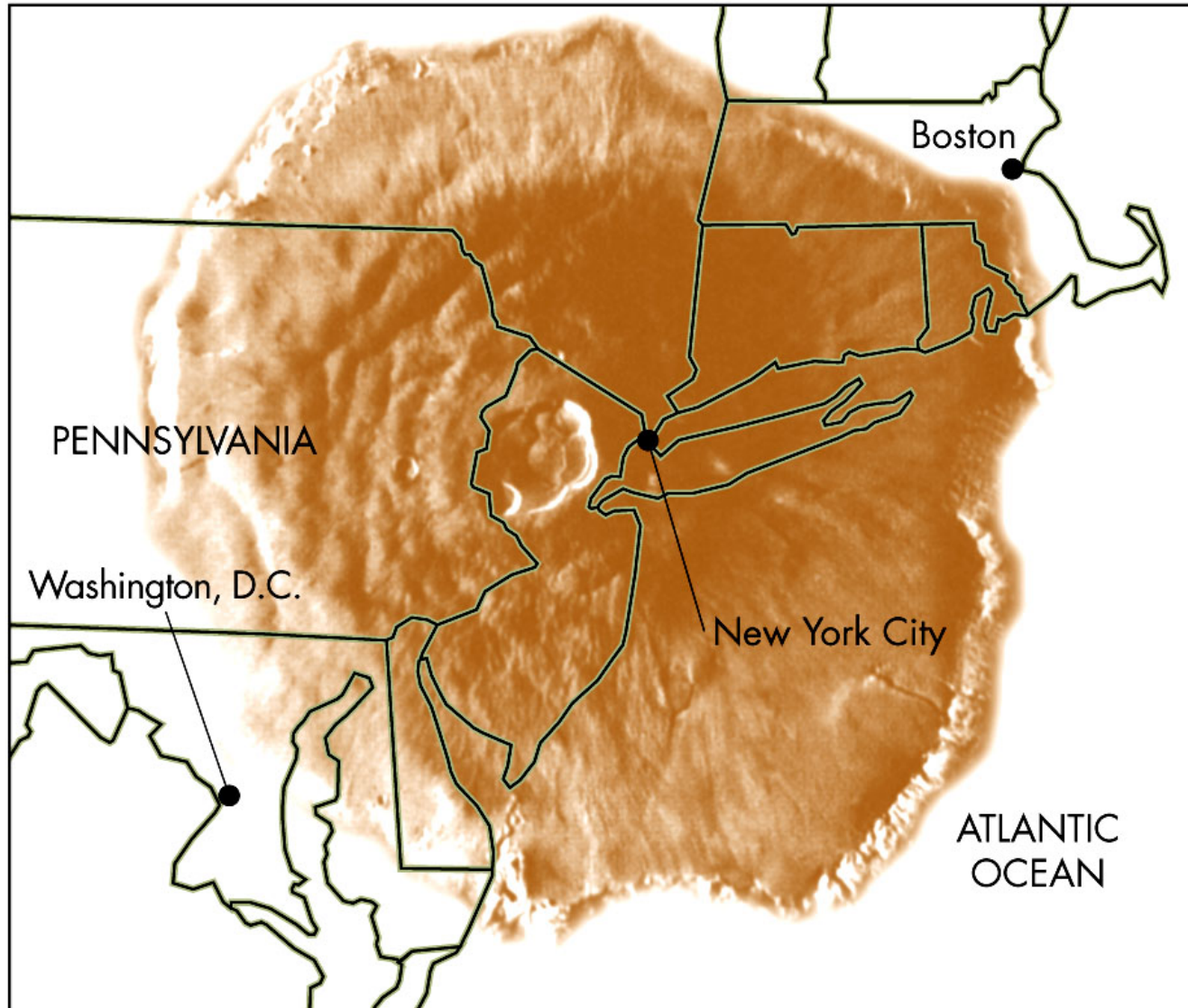
The size of Olympus Mons

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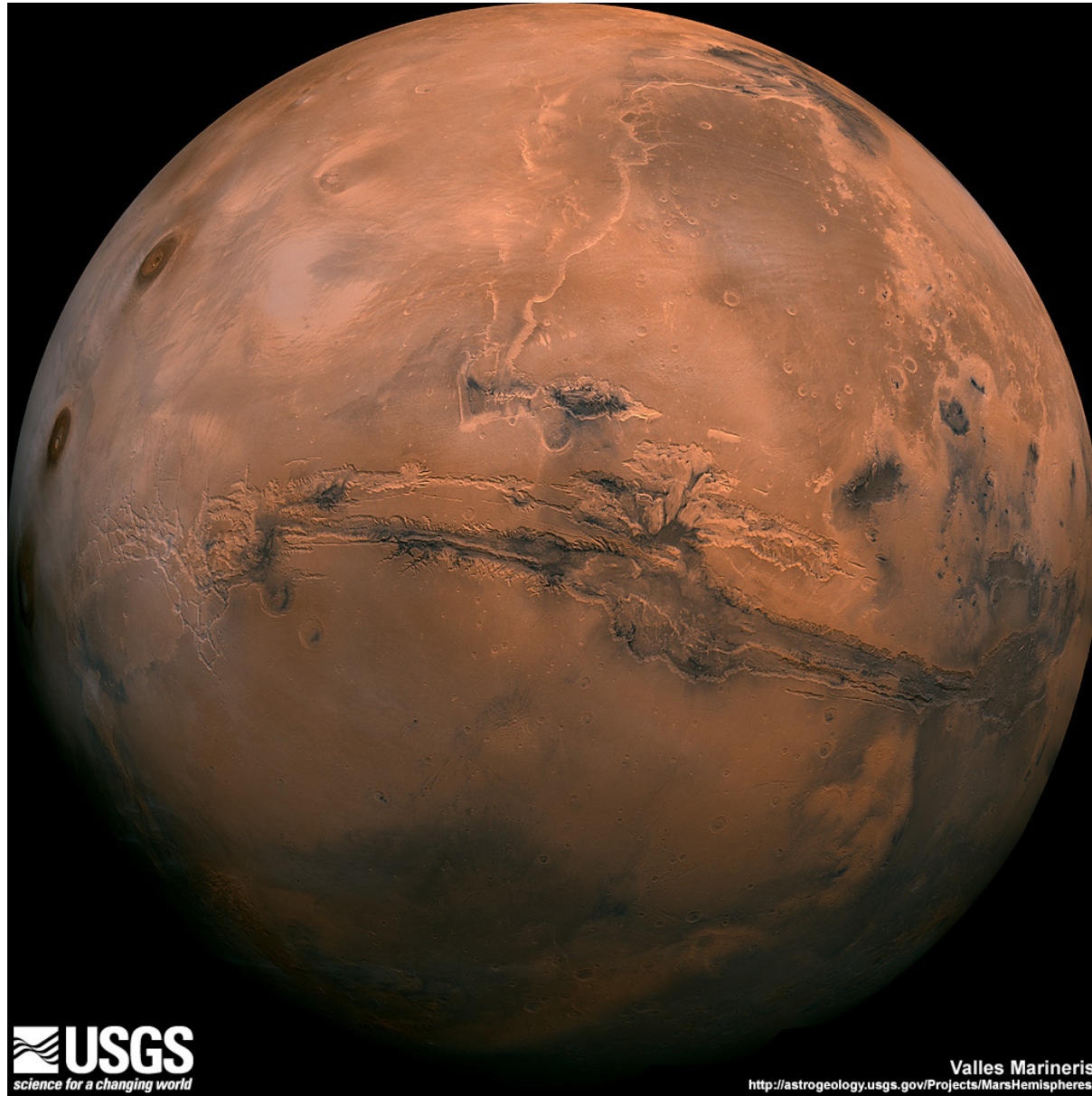


The extent of Olympus Mons

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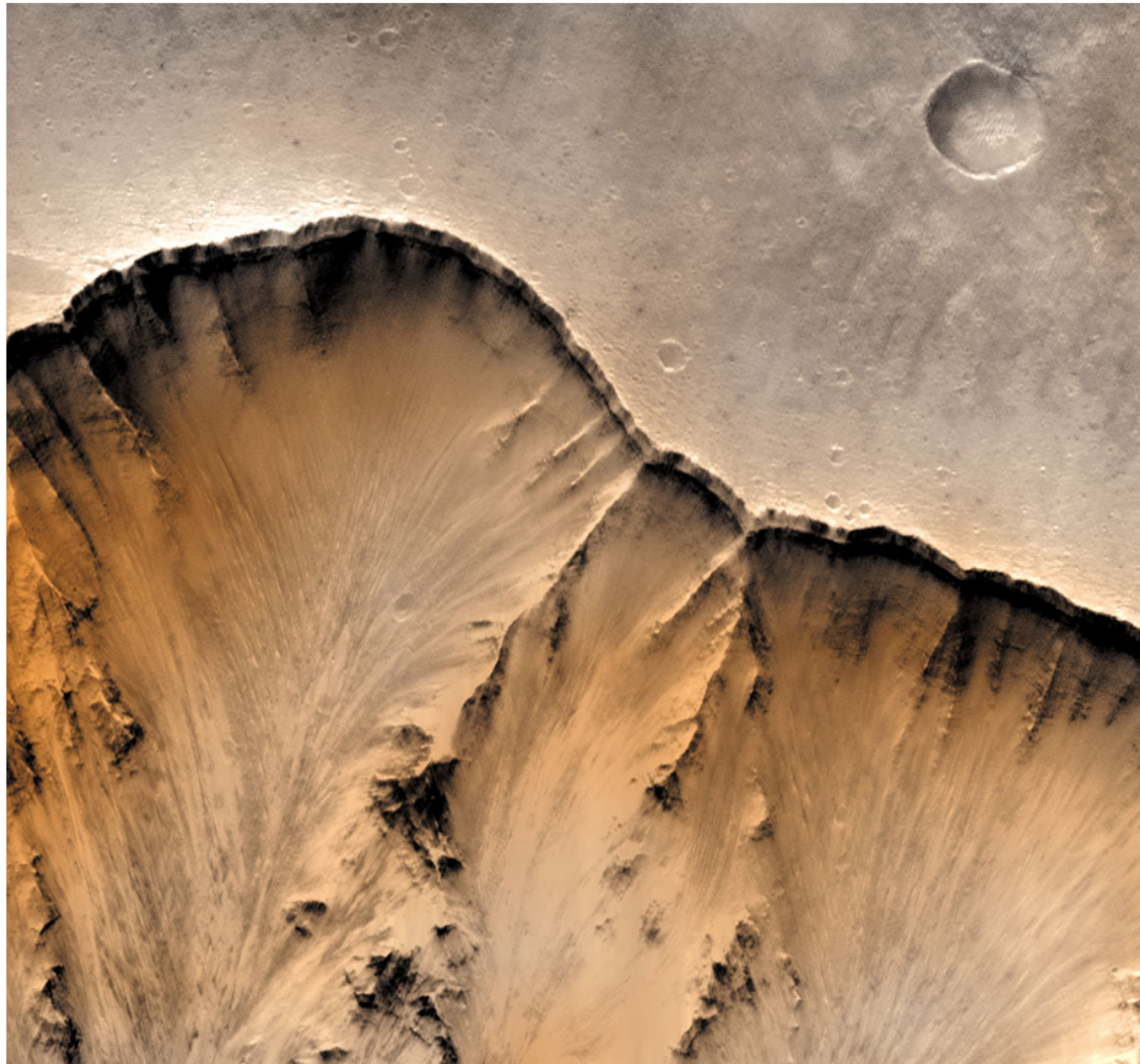


Valles Marineris...Grand Canyon of Mars

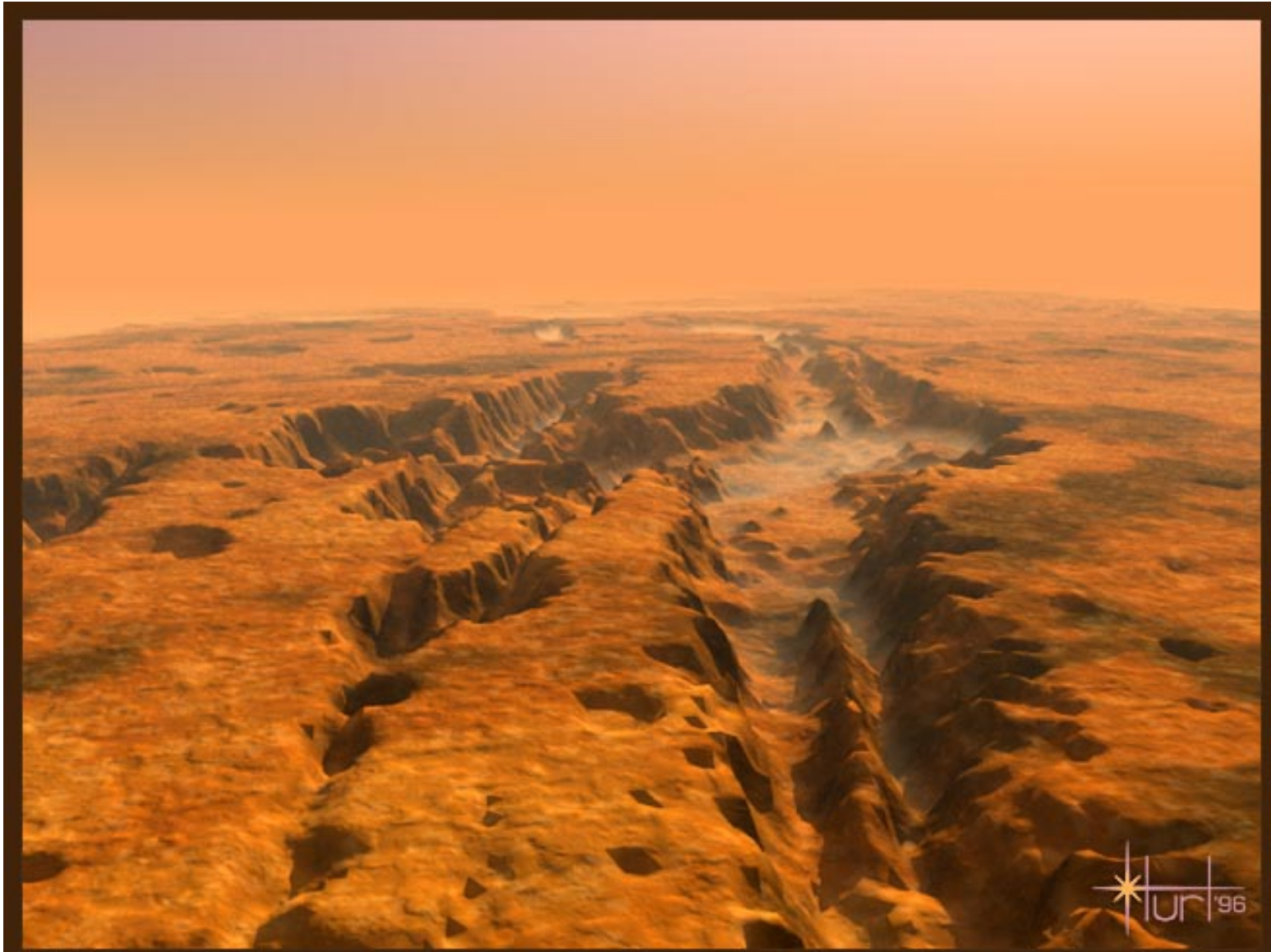


Valles Marineris

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Valles Marineris...the view of a future astronaut

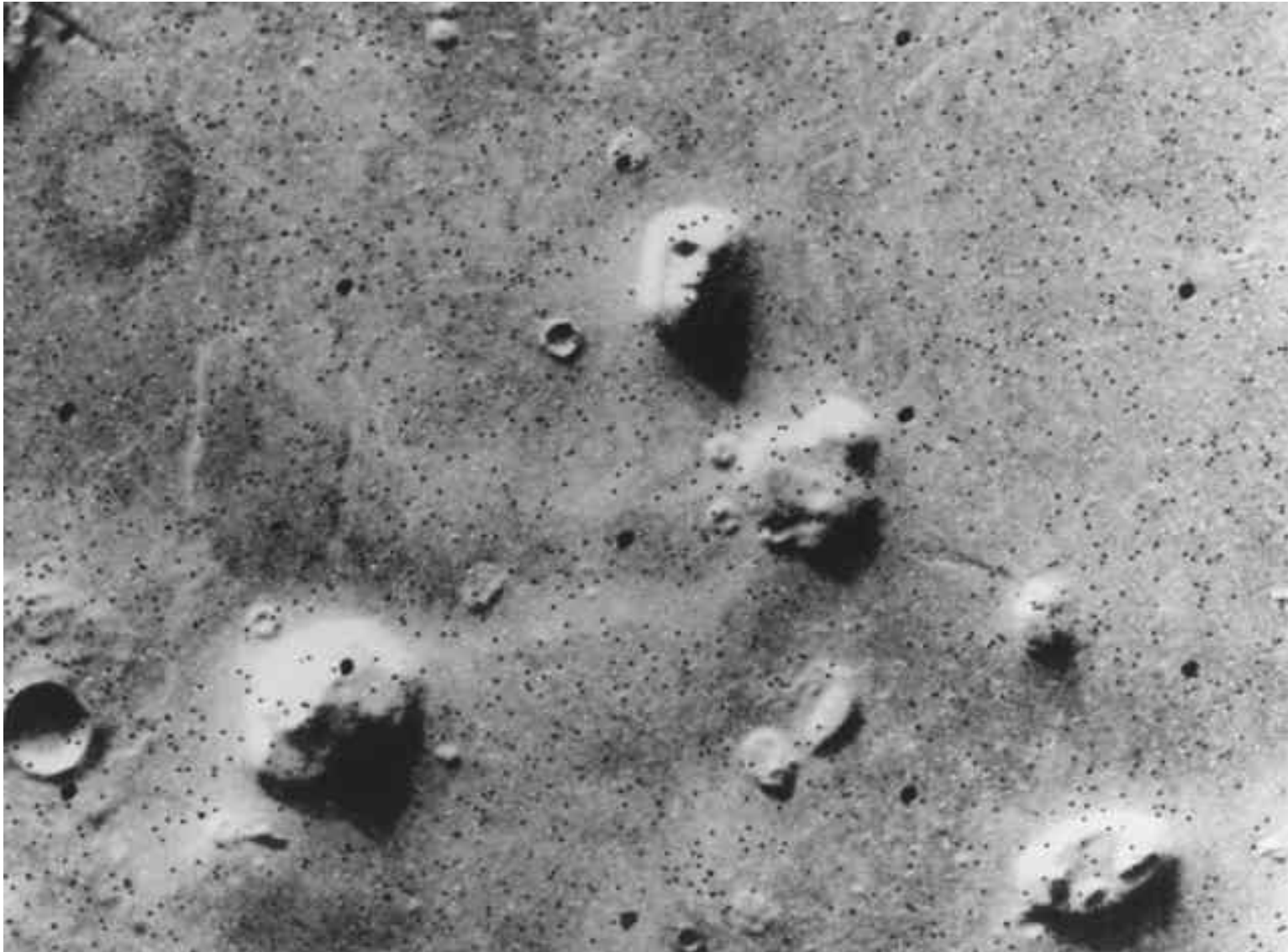


'Valles Marineris'

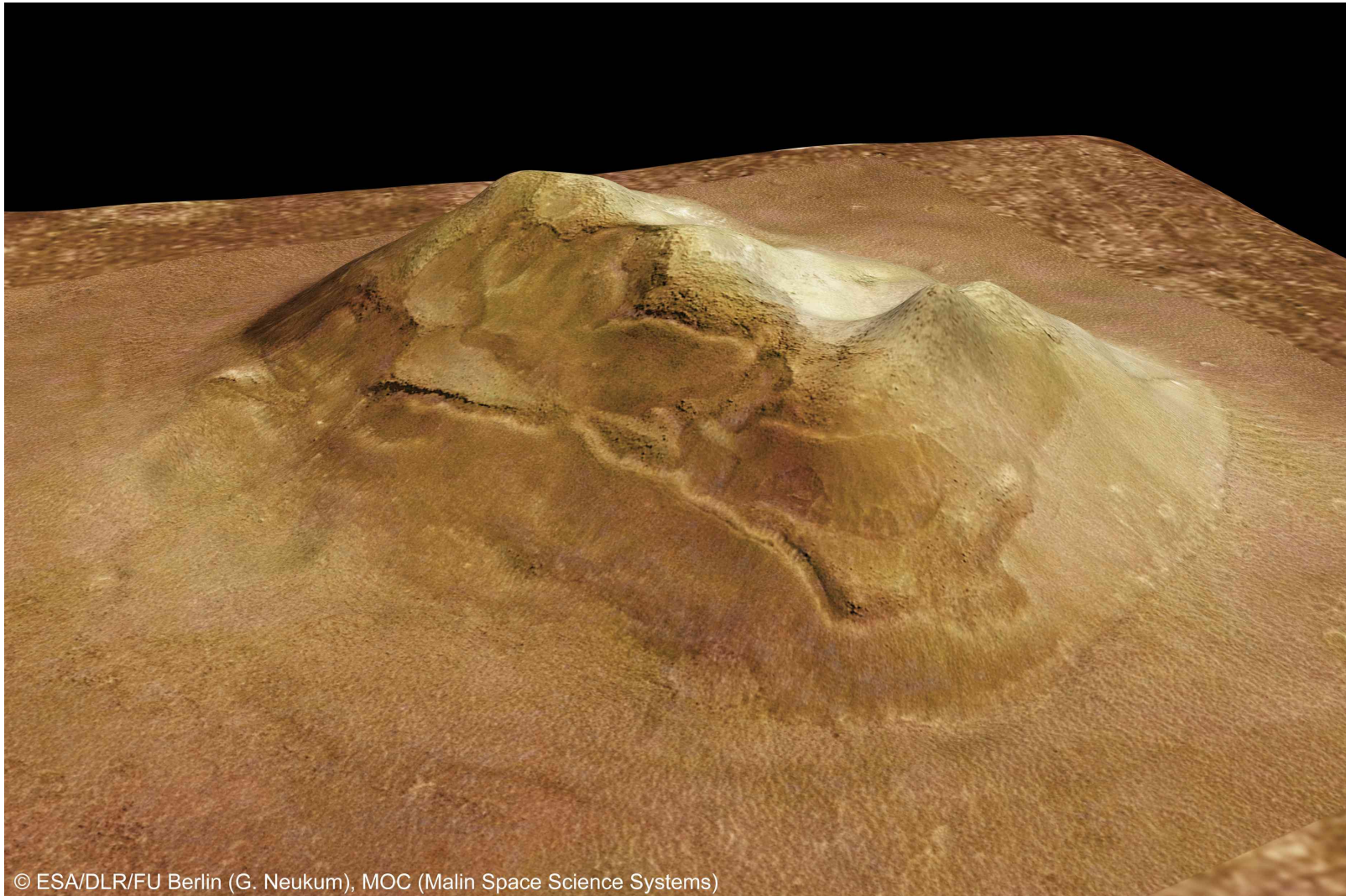
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More mysteries on Mars?



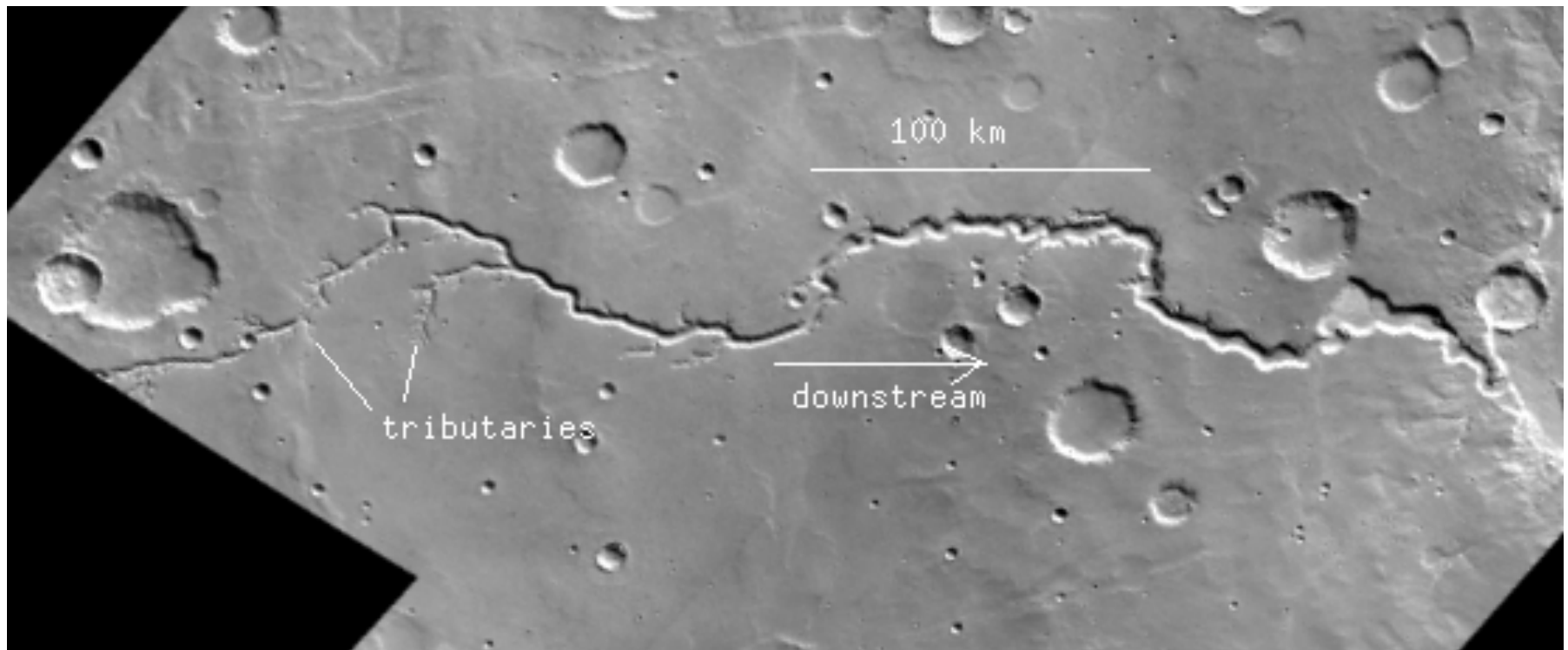
A better look at “The Face”



© ESA/DLR/FU Berlin (G. Neukum), MOC (Malin Space Science Systems)

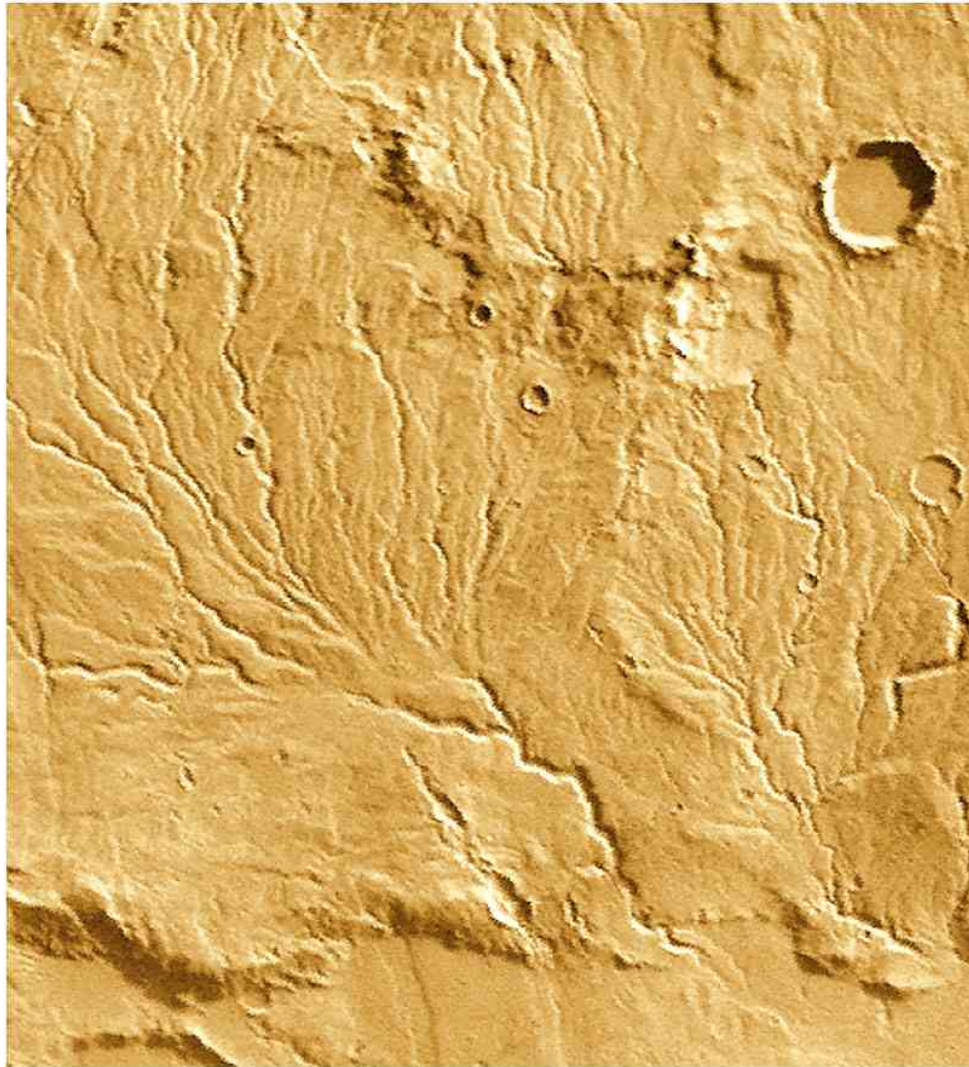
The most important finding of orbital studies of Mars: apparent water channels

A startling discovery...the new canals of Mars

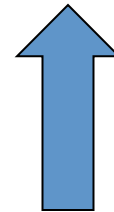


Two types of channels: Valley networks

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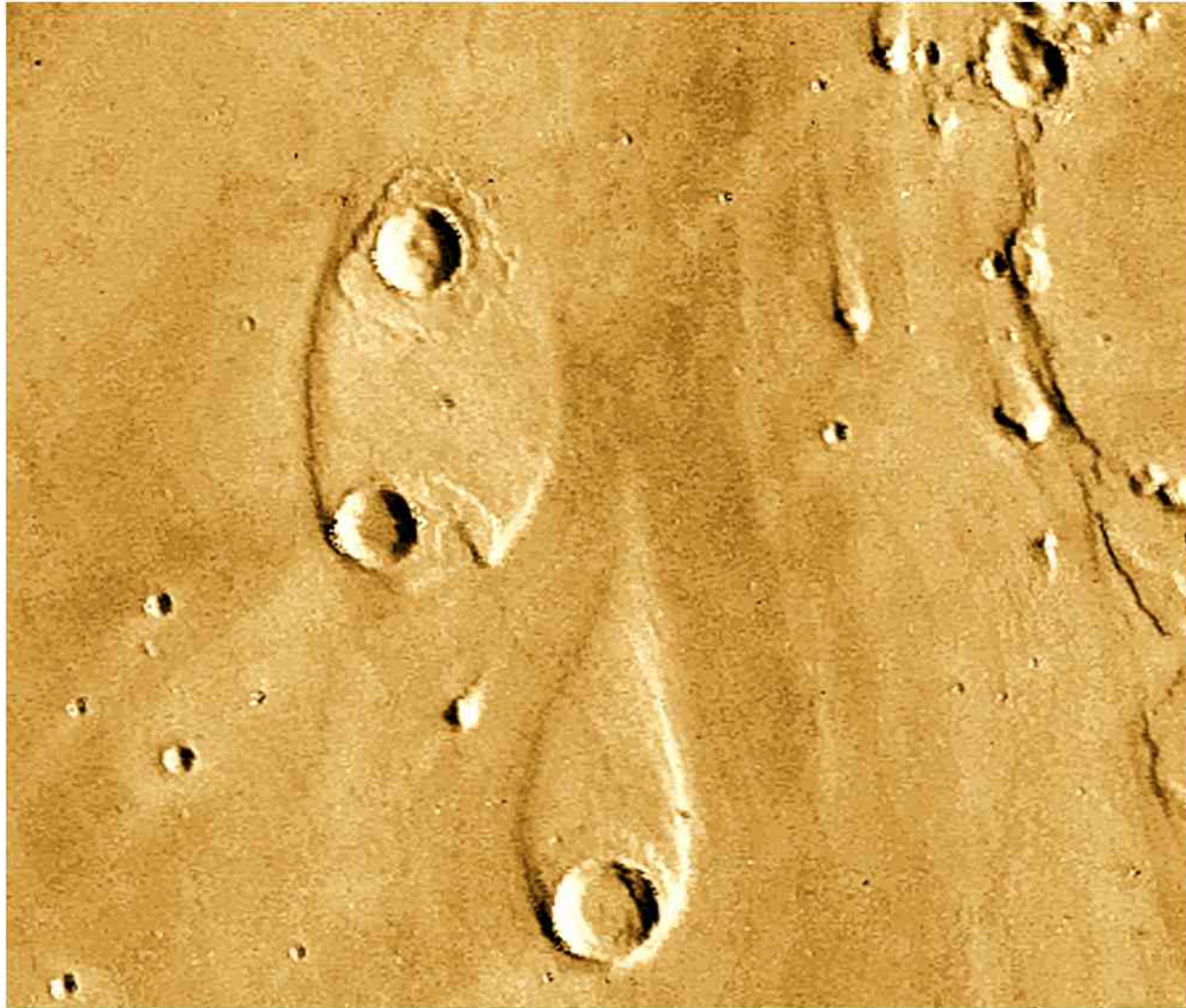


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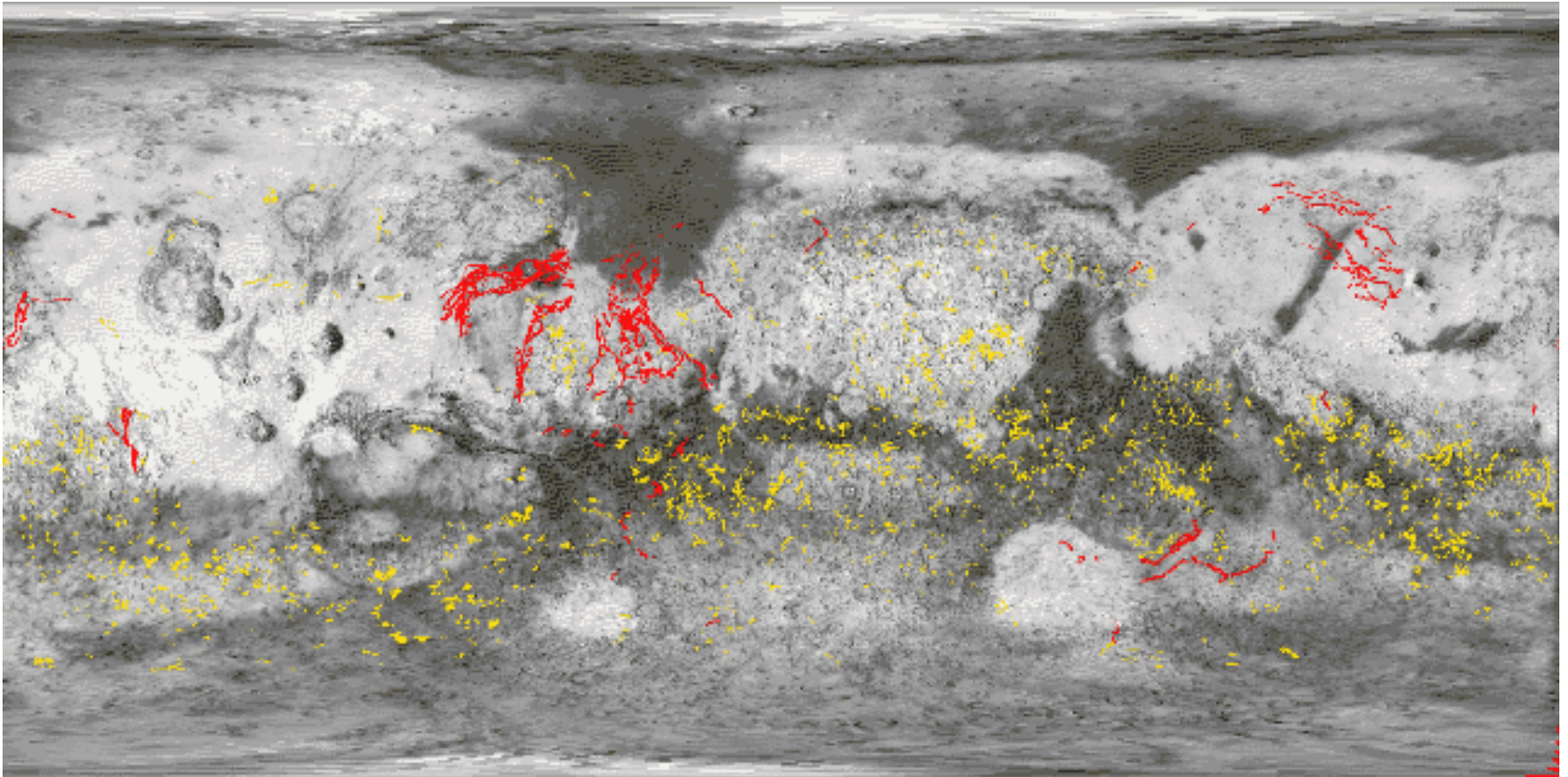


Second type: outflow channels

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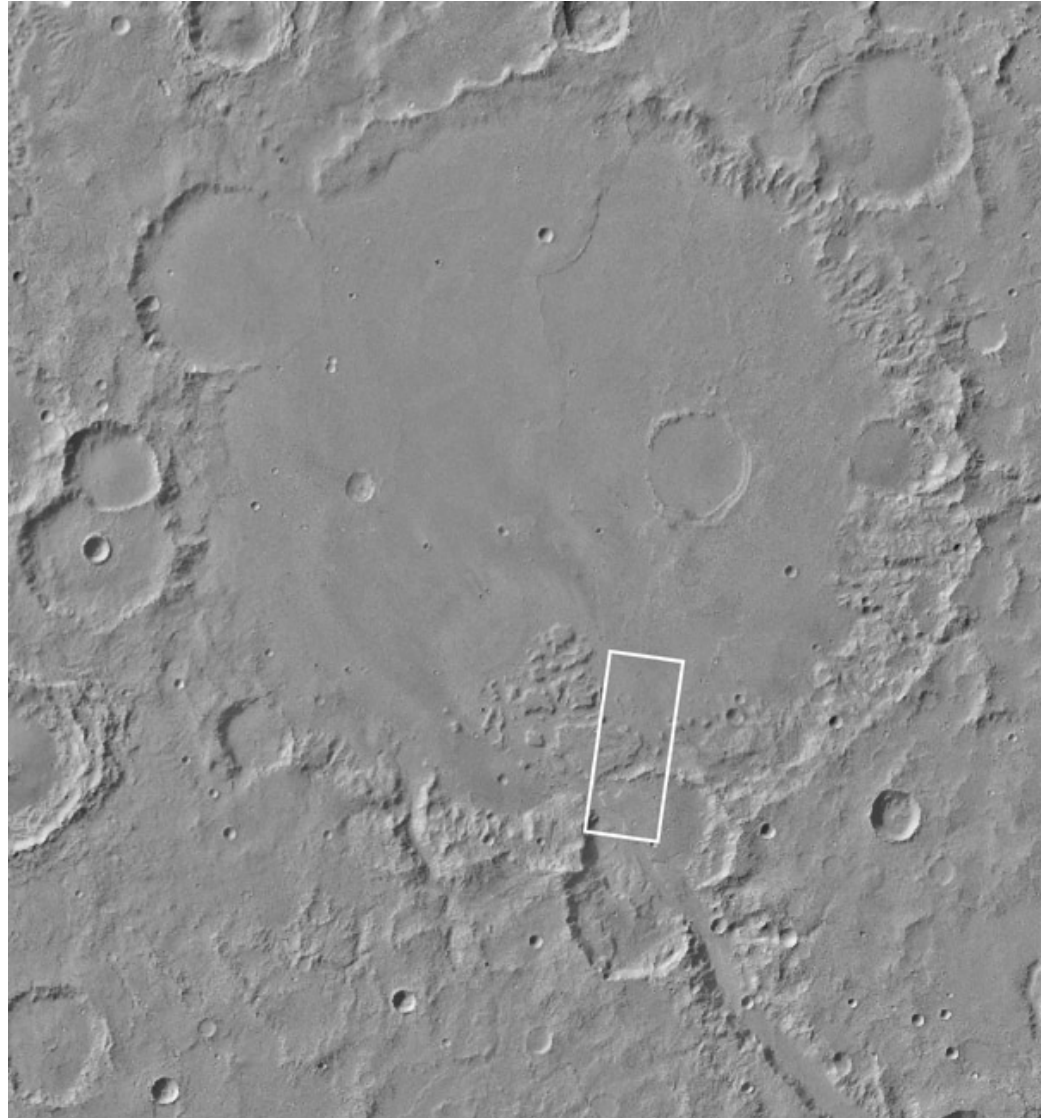


Where are water channels formed?

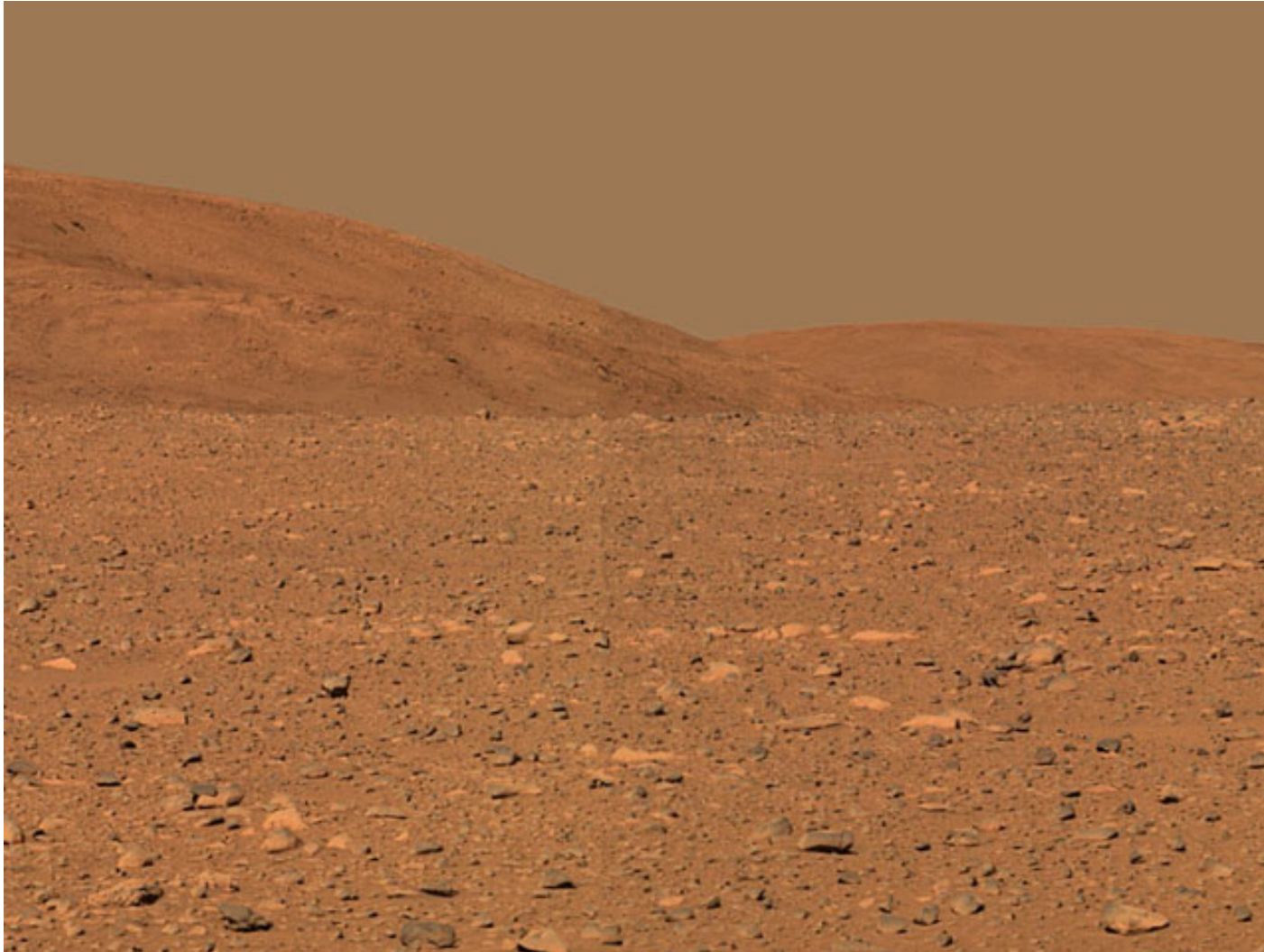


Does anyone see any patterns?

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?



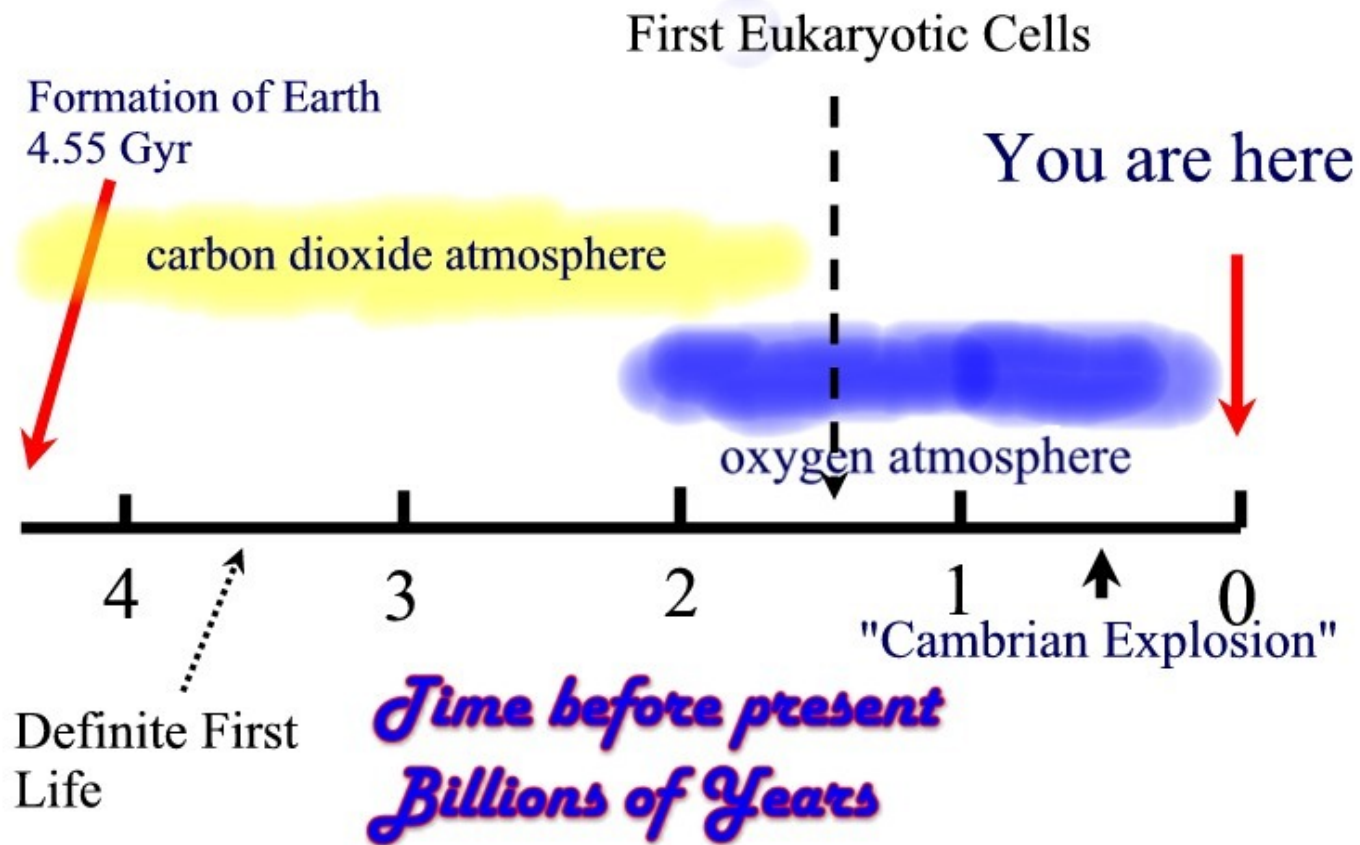
Mars and water

- Liquid water cannot be present on the surface of Mars at the present time
- Nonetheless, pictures from orbit show water channels going through ancient landscapes on Mars (2 types of channels)
- Perhaps the climate of Mars 3-4 billion years ago was conducive to the presence of bodies of standing water

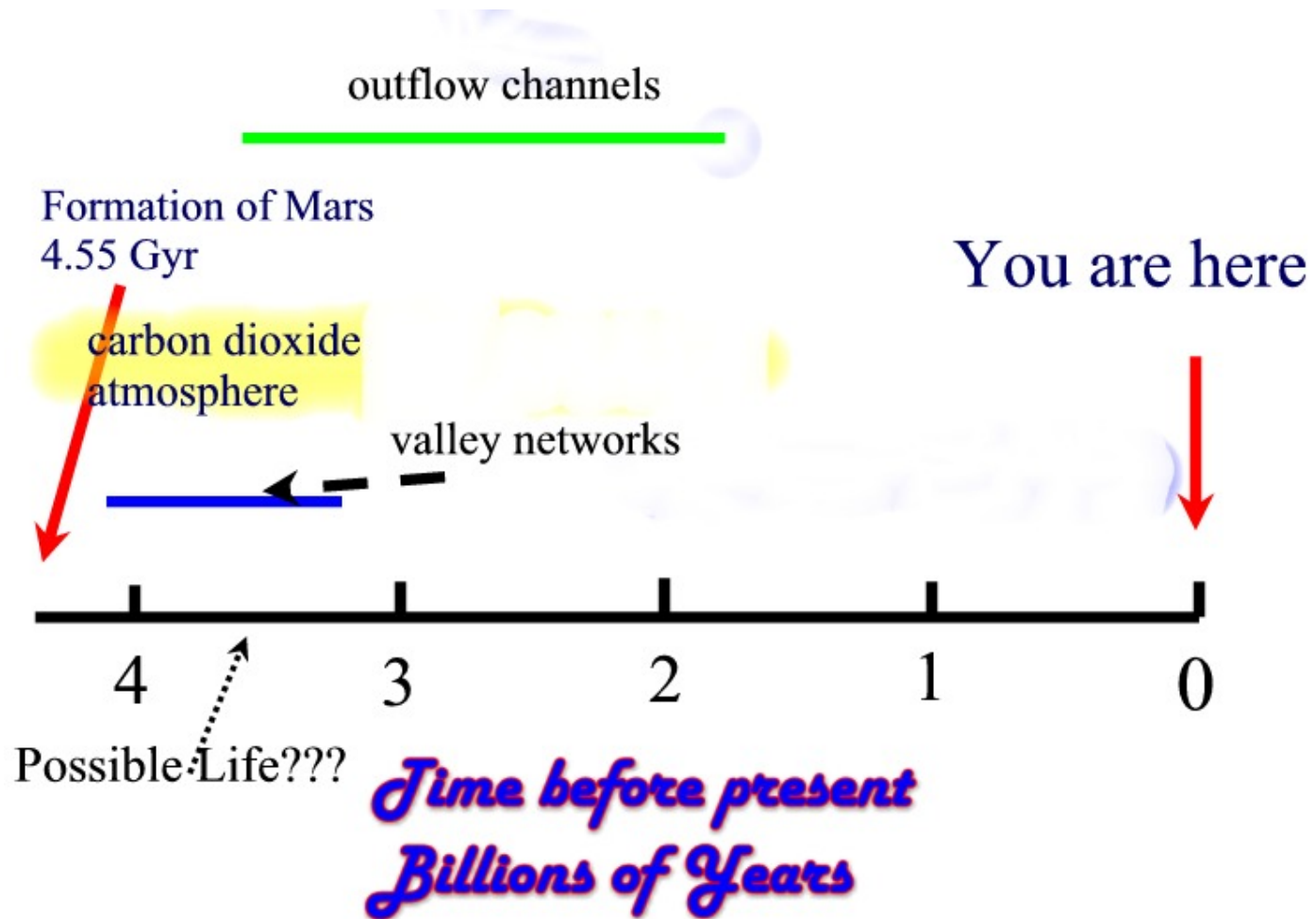


To see what people have in mind, let's compare the (relatively) well-known geological history of Earth with a speculative history of Mars

A sketchy history of the planet Earth



An even sketchier history of the planet Mars



To determine if there were stable bodies of water on ancient Mars requires geological measurements, studies of minerals in Martian rocks

Some minerals (hematite) form in presence of standing water. Others, (olivine) are destroyed by water.



The Mars Exploration Rovers (MER) are mobile, geological laboratories sent to see if Martian rocks are lava flows (e.g. basalts) or minerals formed in the presence of water.

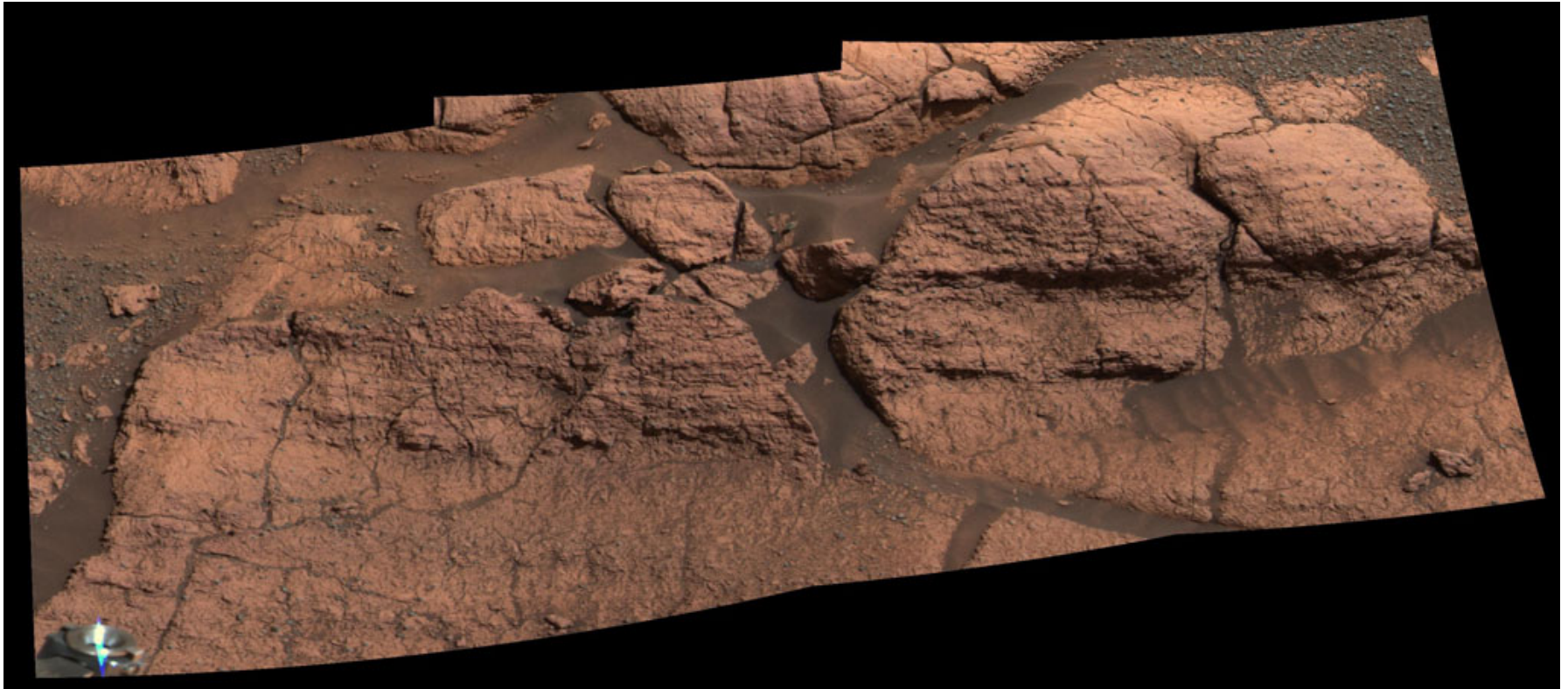
Spirit and Opportunity on the Surface of Mars



On a hill in Gusev crater



Sedimentary rocks on Mars



Opportunity finds hematite spheres...minerals that condensed from water

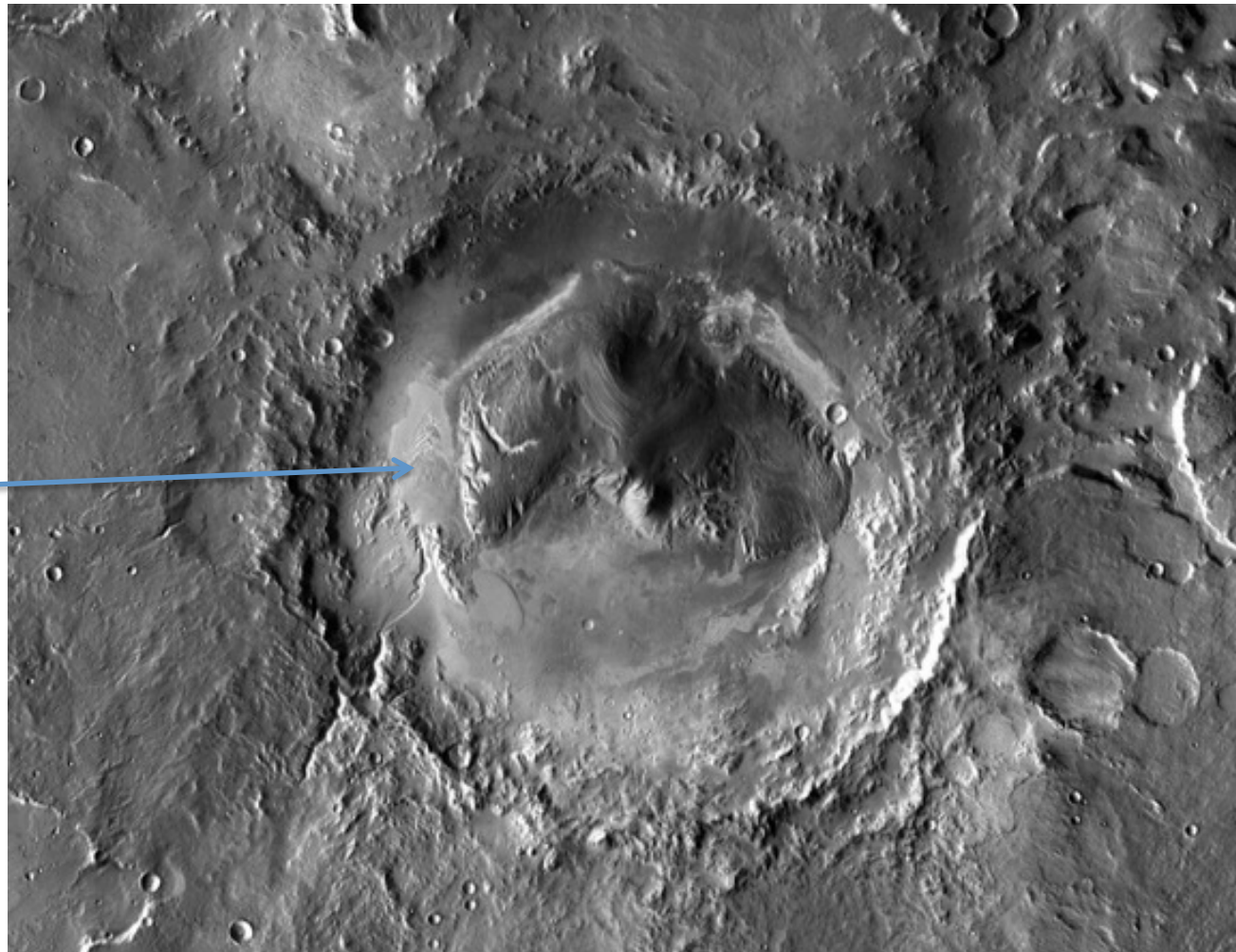


What have we learned from the MERs and “Mars Phoenix”

- It now seems clear that there were standing bodies of water for long periods of time early in Martian history
- Evidence is presence of hematite, jarosite, and other minerals that form in lakes or oceans
- Relative absence of carbonate rocks is due to alternative chemistry in acidic water
- **But**, apparently oldest rock strata do contain carbonate rocks and clay (montmorillonite)

The Mars Science Laboratory and Gale Crater

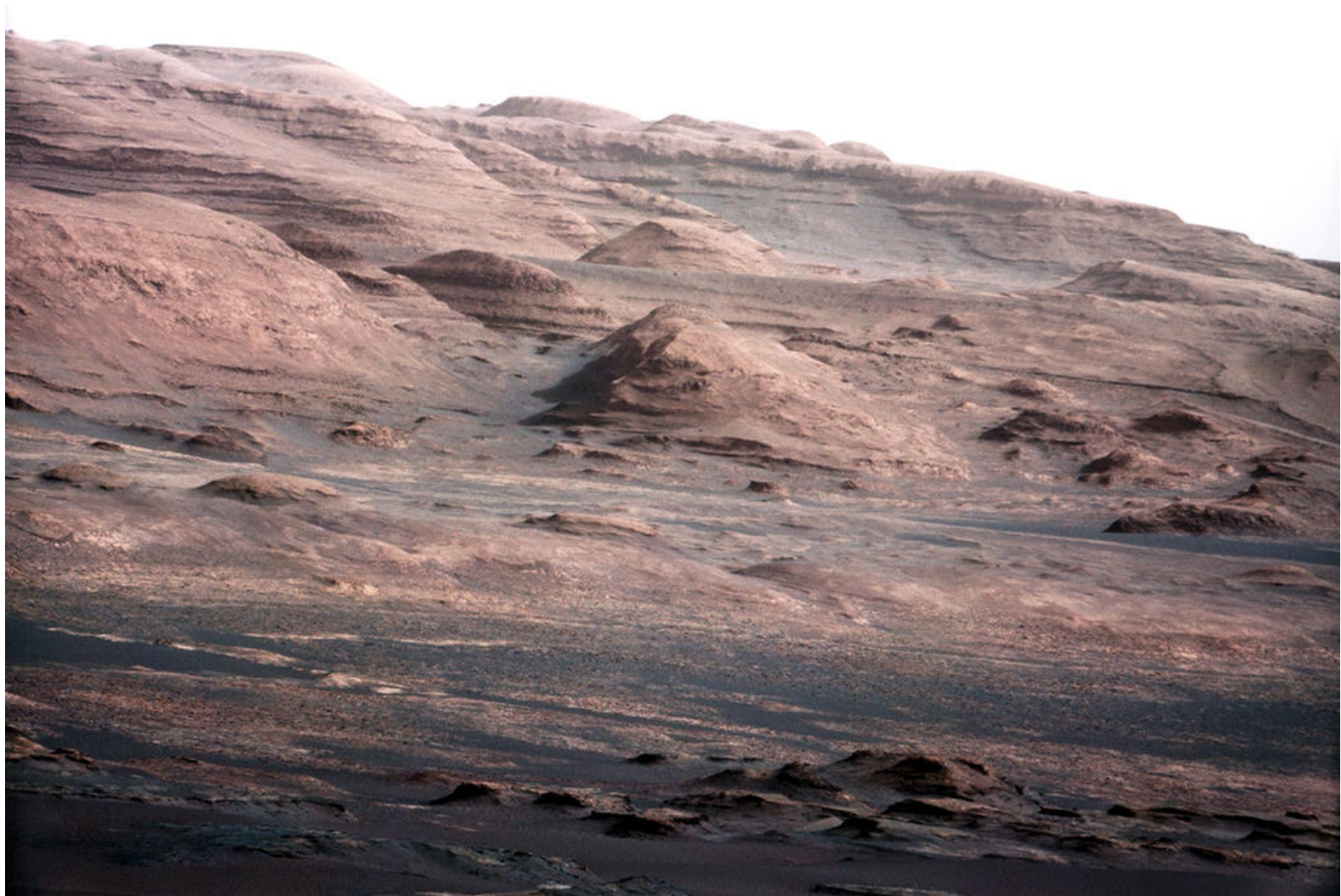
Clay
deposits at
bottom of
central
mountain



Mars Science Laboratory “Curiosity” in Gale Crater on Mars



The destination for “Curiosity”



What can we expect (and hope for) from Curiosity?

- Can it confirm existence of clays in lowest, oldest Martian strata (formed in non-saline waters)?
- Can this confirm (or reject) the possibility of a prolonged “warm, wet” period on Mars?
- Something else?
- Stay tuned

The El Dorado of future missions: Mars Sample Return

