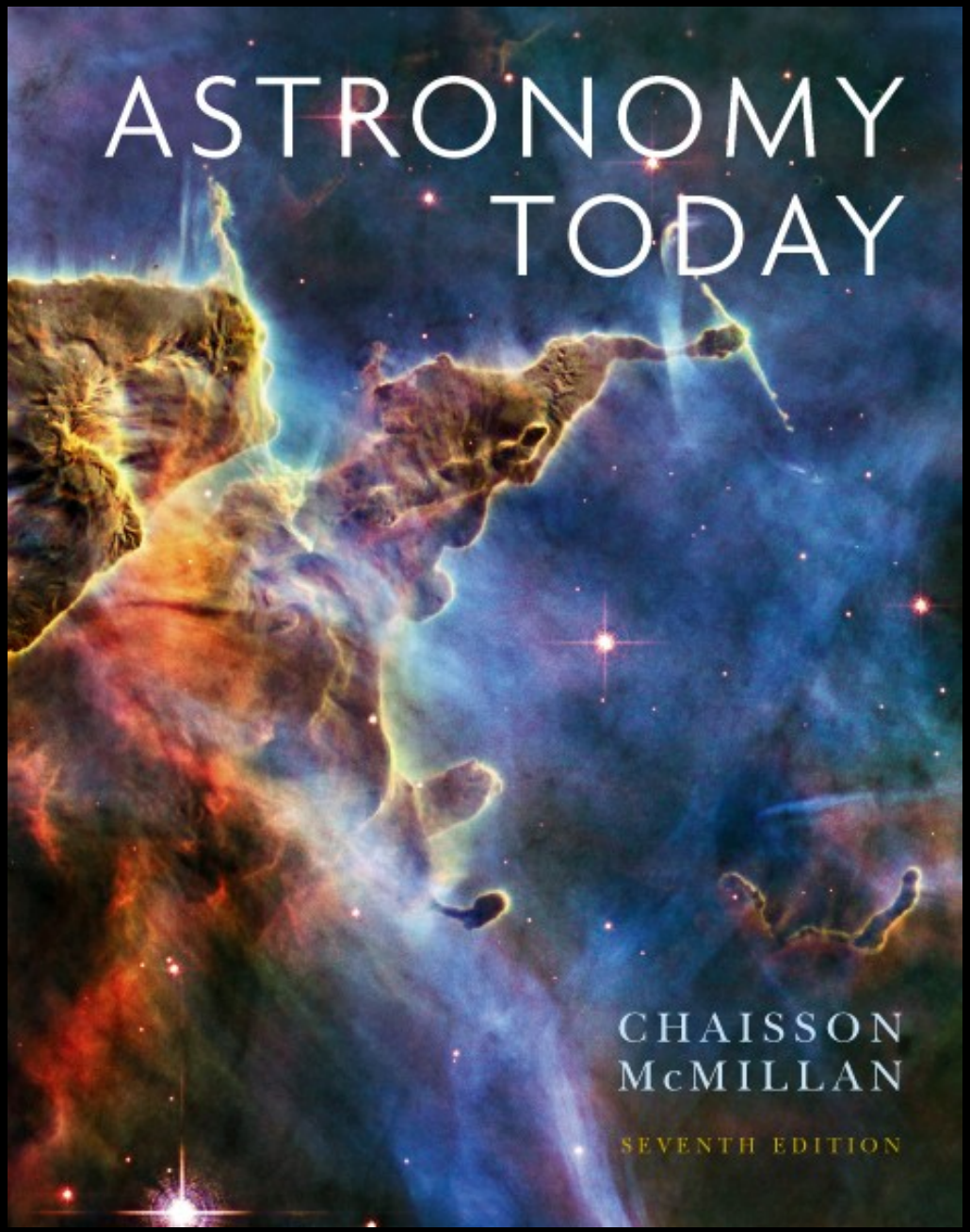


Lecture Outlines

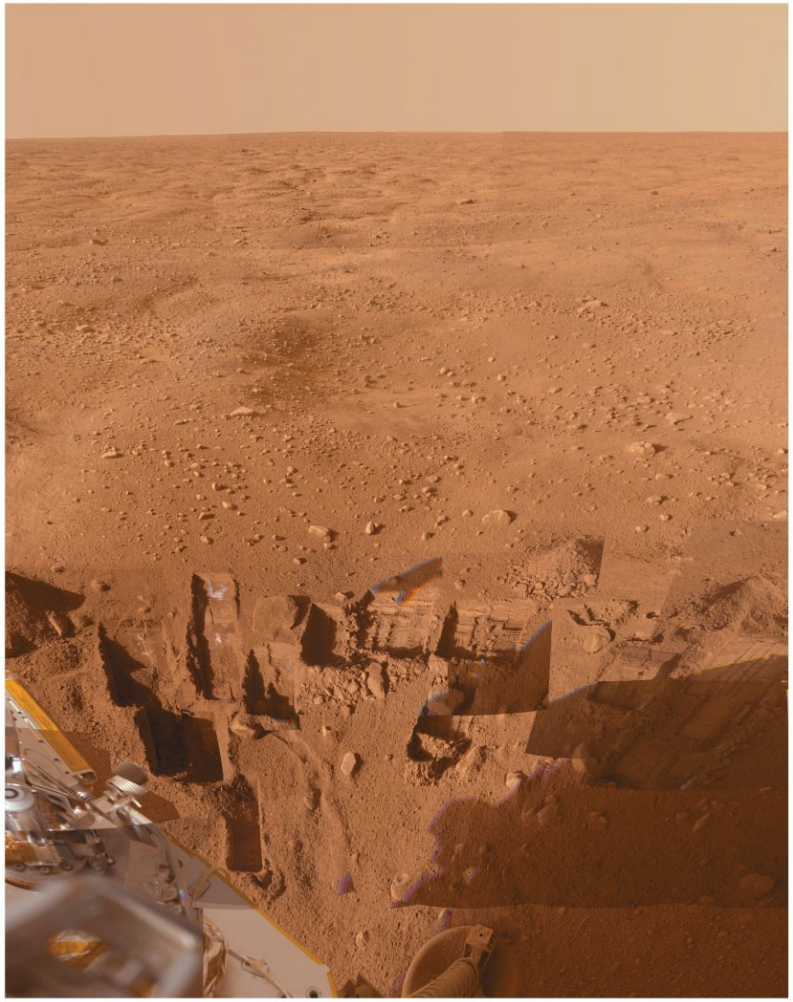
Chapter 10

Astronomy Today

7th Edition

Chaisson/McMillan

Chapter 10
Mars



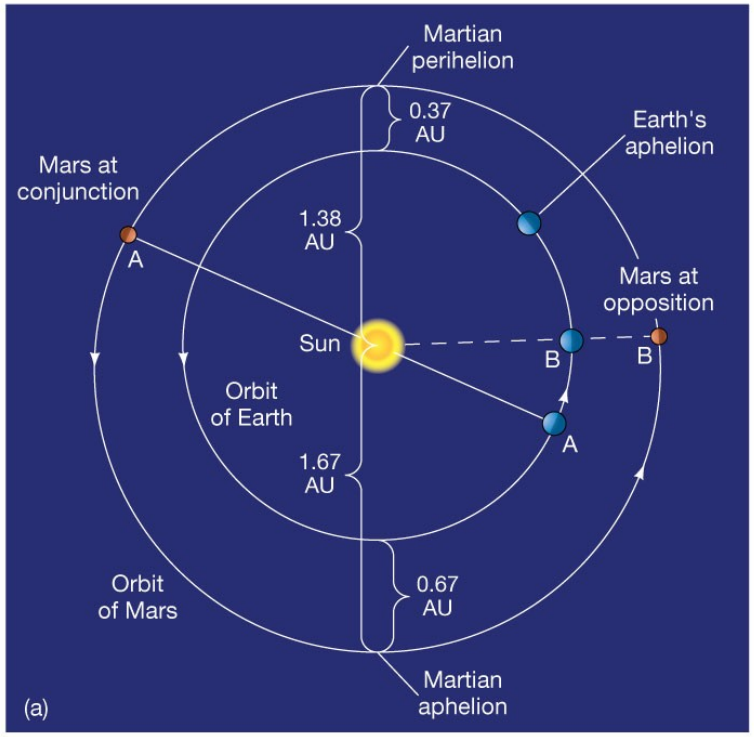
Phoenix scoops surface at Mars' arctic region.

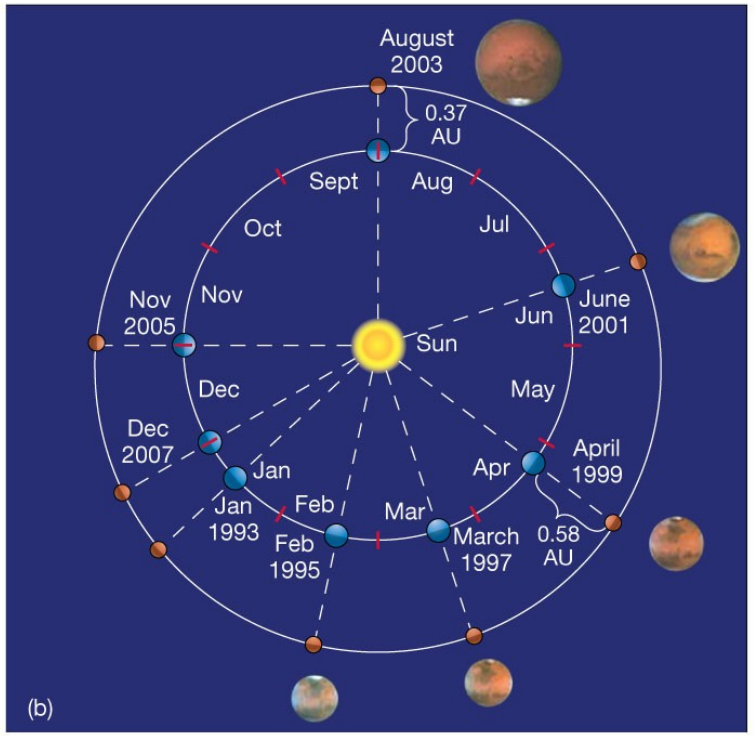
Units of Chapter 10

10.1 Orbital Properties

Mars' orbit is fairly eccentric which affects amount of sunlight reaching it. This leads to:

Seasonal asymmetries
Polar ice cap asymmetries
Differences between oppositions (covered later)





10.2 Physical Properties

Radius: 3394 km

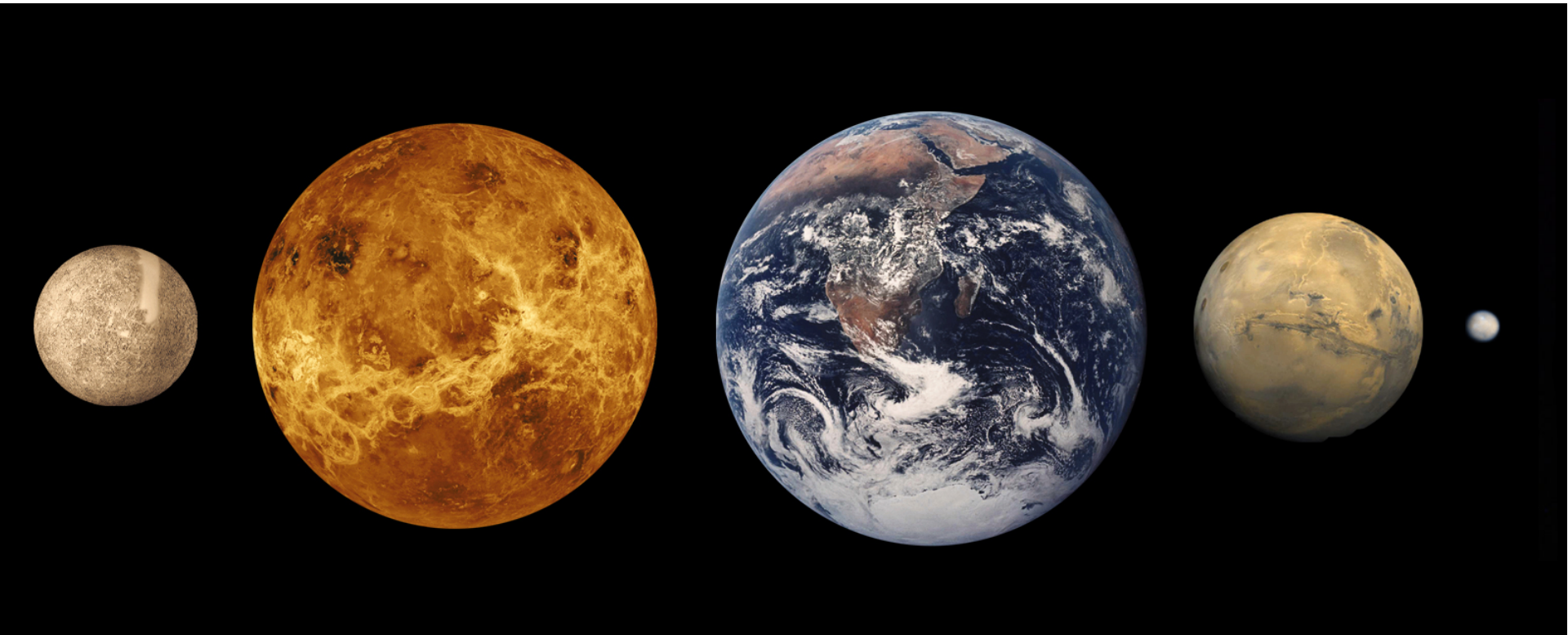
Moons: Deimos, Phobos

Mass: 6.4 x 10^{23} kg

Density: 3900 kg/m^3

Length of day: 24.6 hours

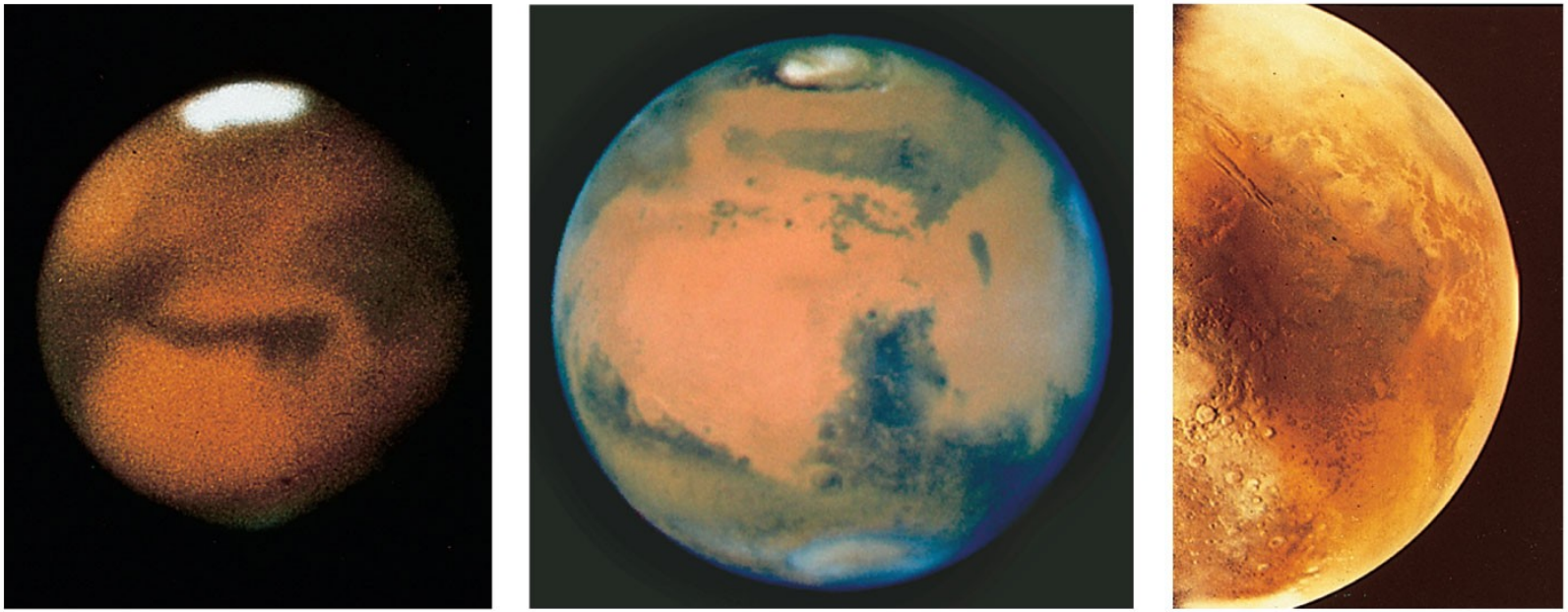
Axial tilt: 25.2 º to its orbit



10.3 Long-Distance Observations of Mars

From Earth, can see polar ice caps that grow and shrink with the seasons

Much better pictures from Mars missions, close-up

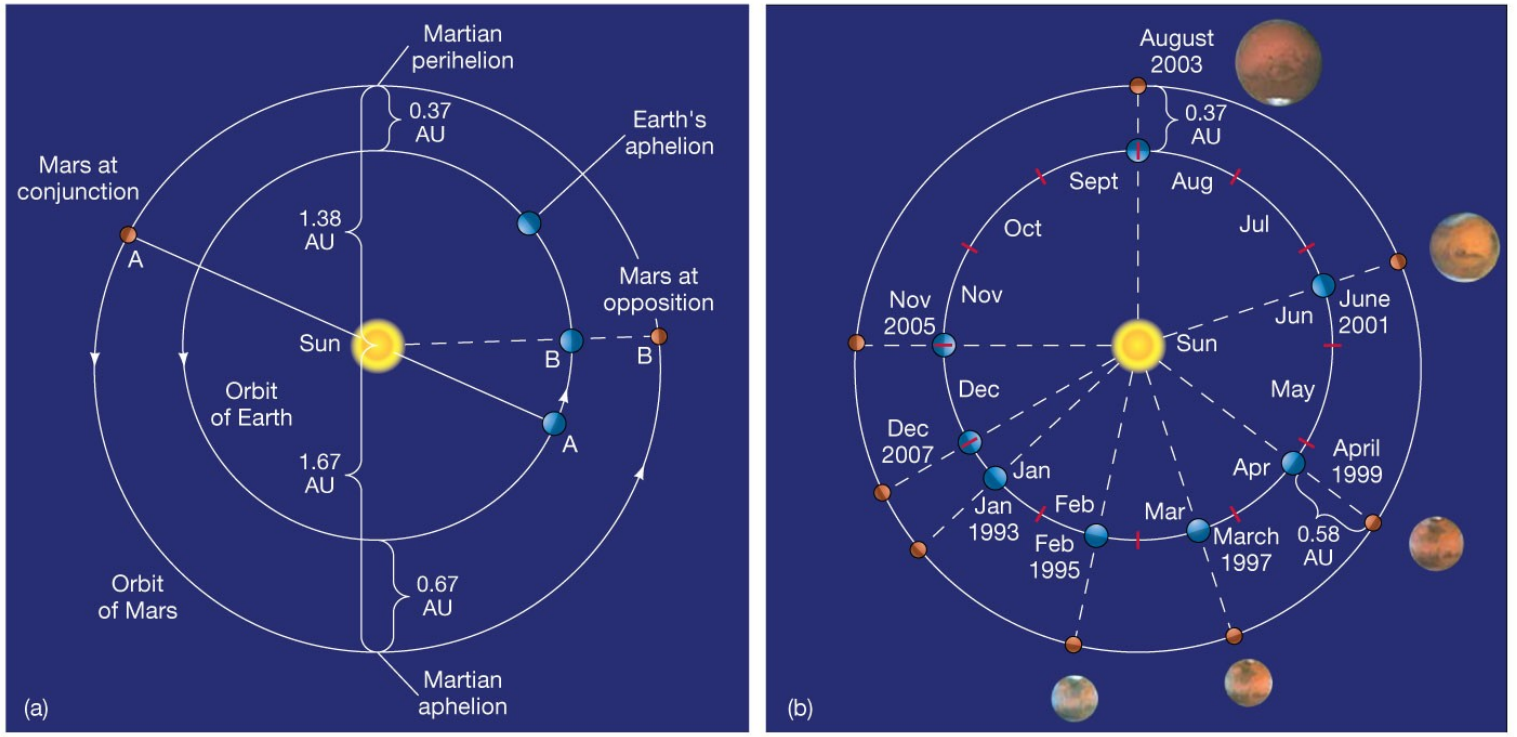


10.3 Long-Distance Observations of Mars

Best (closest) views happen during opposition.

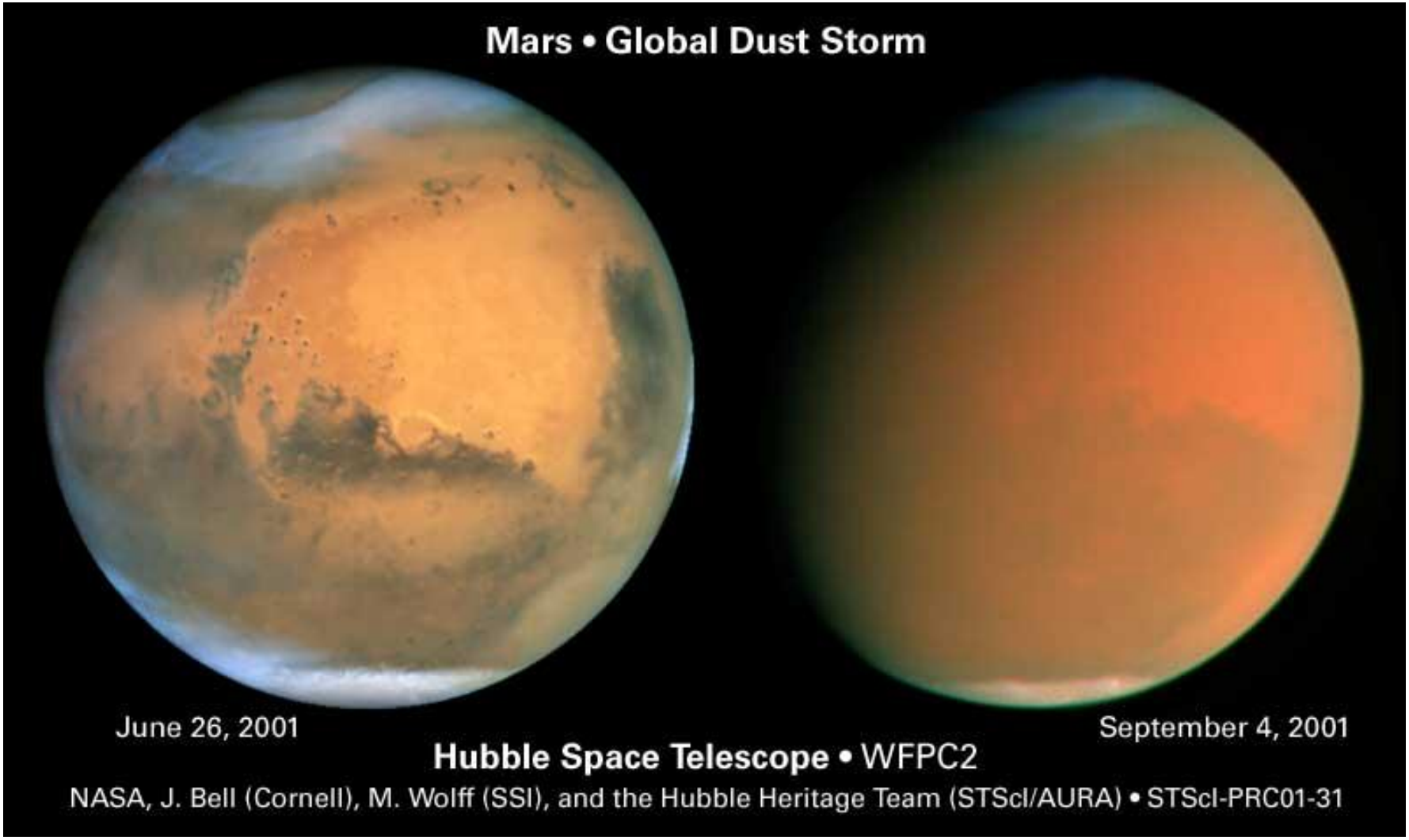
Oppositions happen every ~ 2.1 years (780 days)

Best oppositions during Martian perihelion, Earth aphel.



10.3 Long-Distance Observations of Mars

- Changing polar ice caps are frozen carbon dioxide; water ice is permanently frozen
- Shifting dust cover makes surface change tones/colors
- Frequent dust storms, with high winds

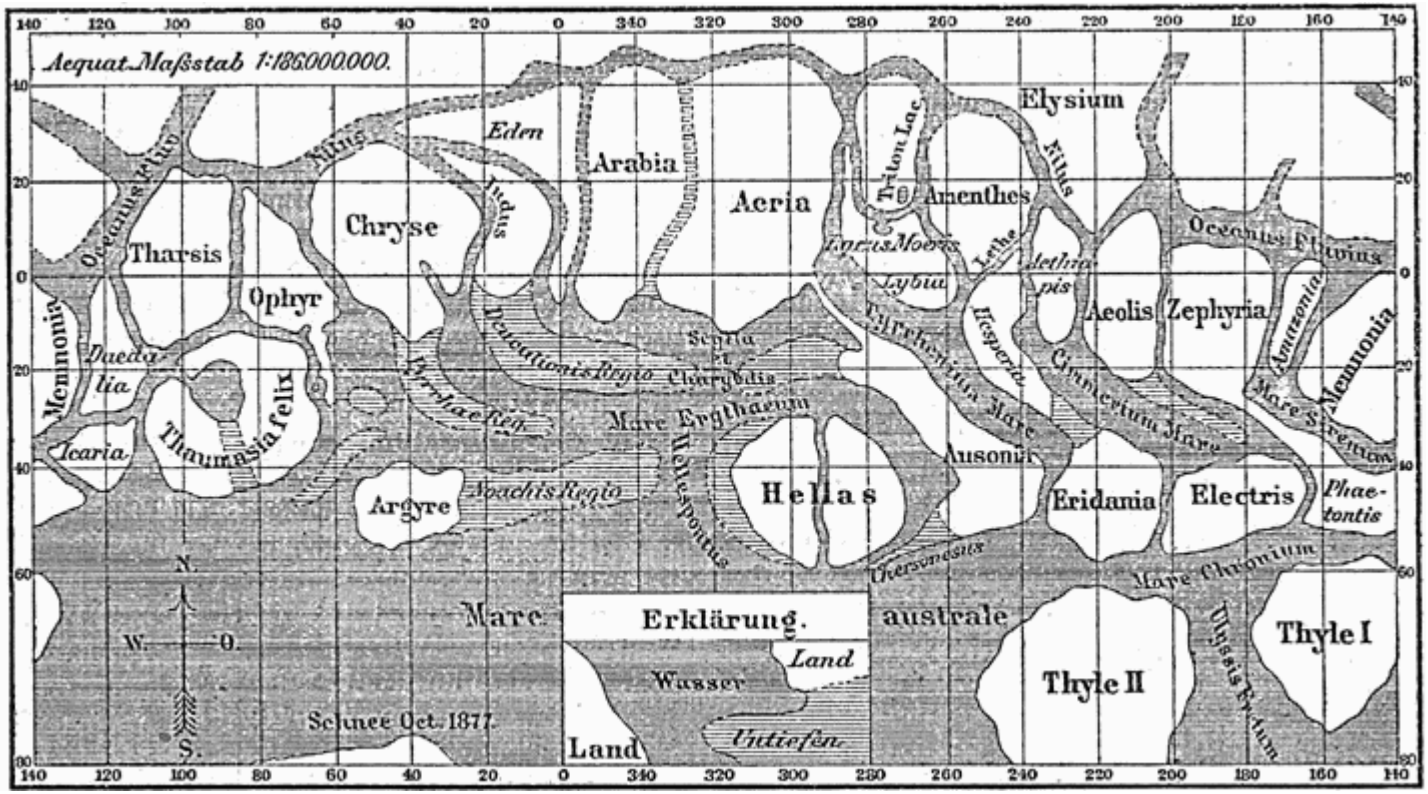


10.3 Long-Distance Observations of Mars

The Mars Reconnaissance Orbiter spotted a gigantic Martian "dust devil" roughly 20 kilometers (12 miles) high, churning through the Amazonis Planitia region of northern Mars on Mar 12, 2012.

10.3 Long-Distance Observations of Mars - Seeing things.

- Schiapparelli (1877) saw “canali” on Mars – channels
- Percival Lowell (c. 1910) sees “canals” on Mars



10.3 Long-Distance Observations of Mars - Seeing things.

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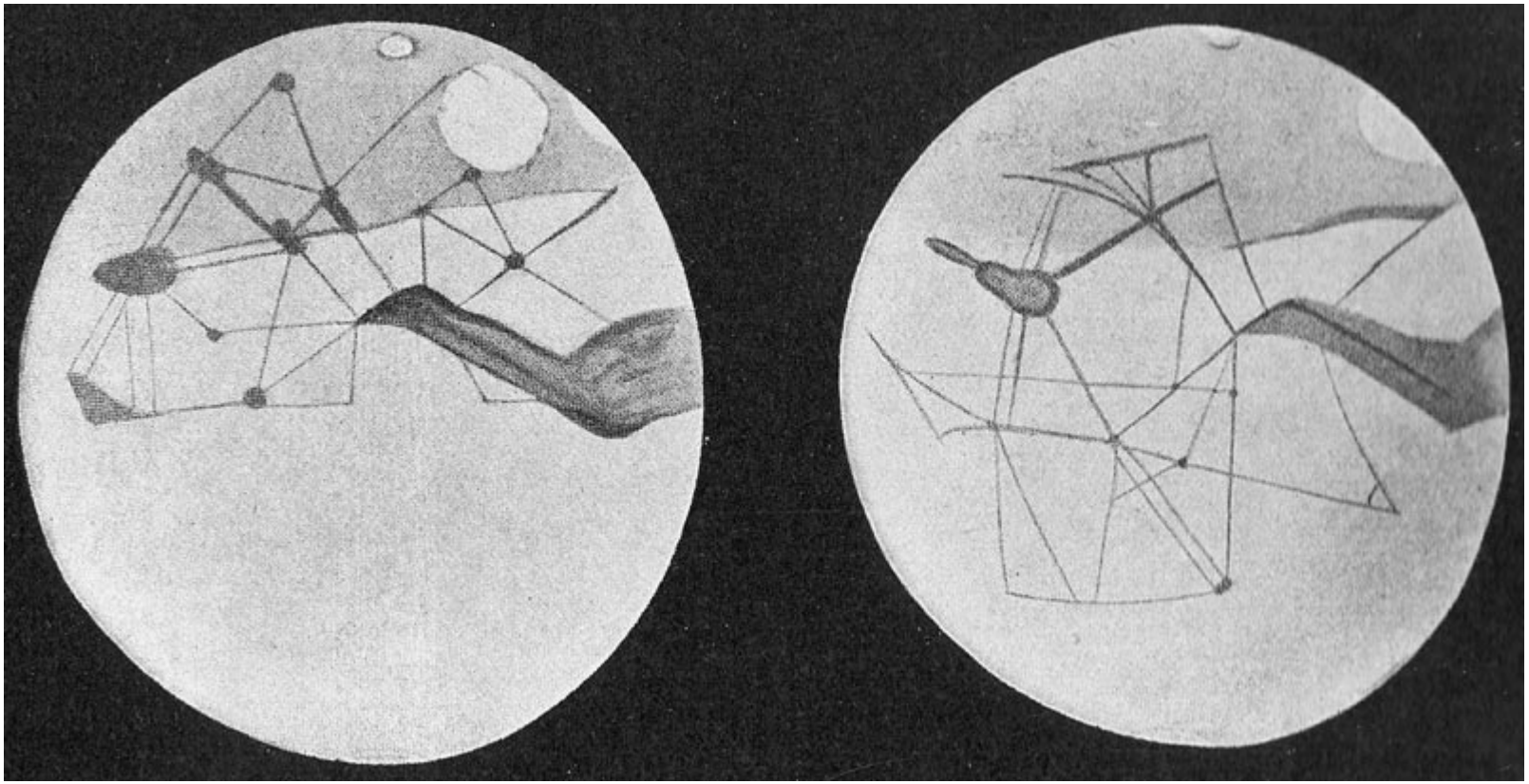
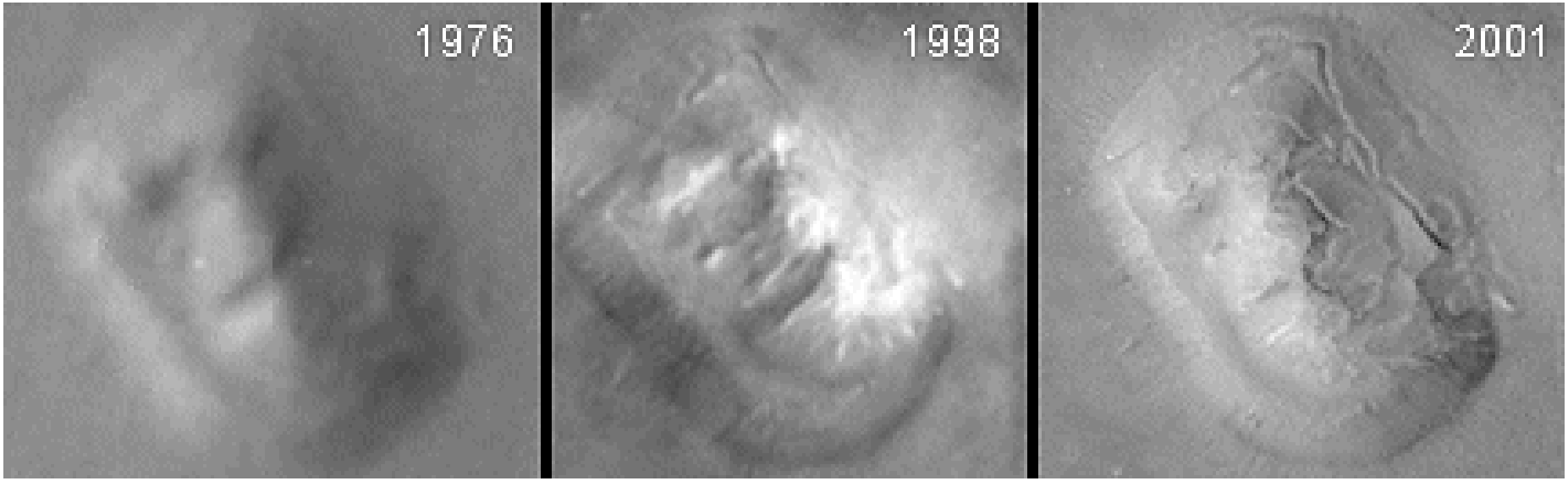


10.3 Long-Distance Observations of Mars - Seeing things: the Face on Mars.

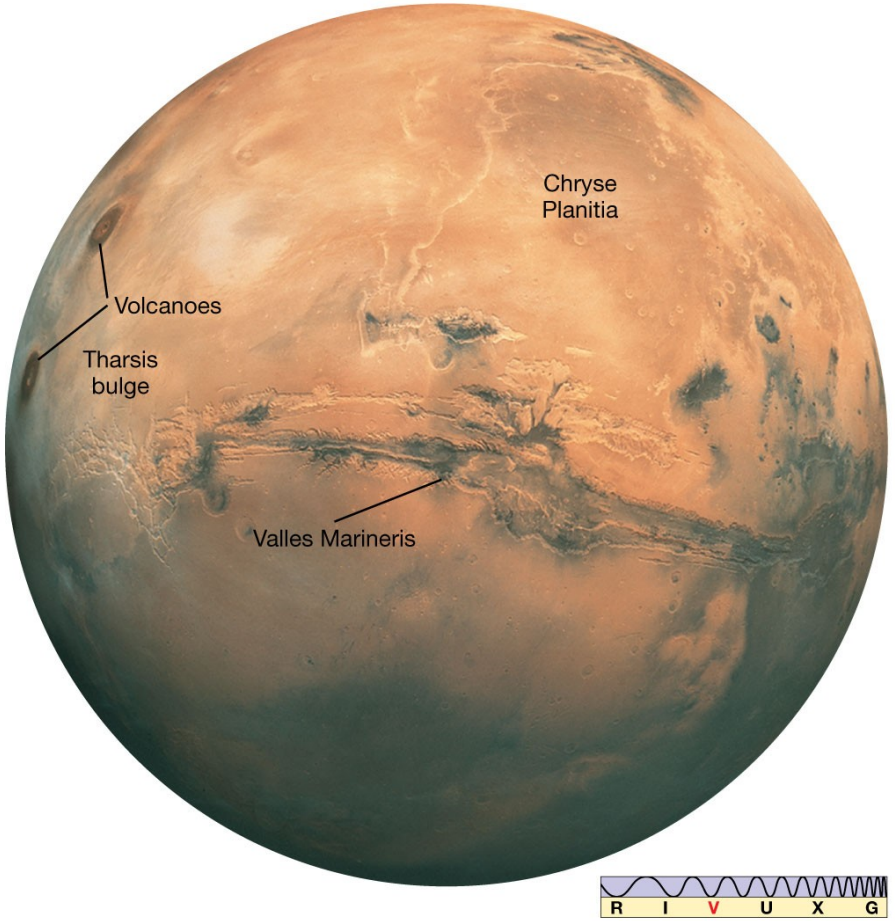
- "Face on Mars" first noticed by NASA from Viking data (1976).
- One of many mesas in "Cydonia" region.
- *Pareidolia*: misperception from vague stimulus.



10.4 The Martian Surface

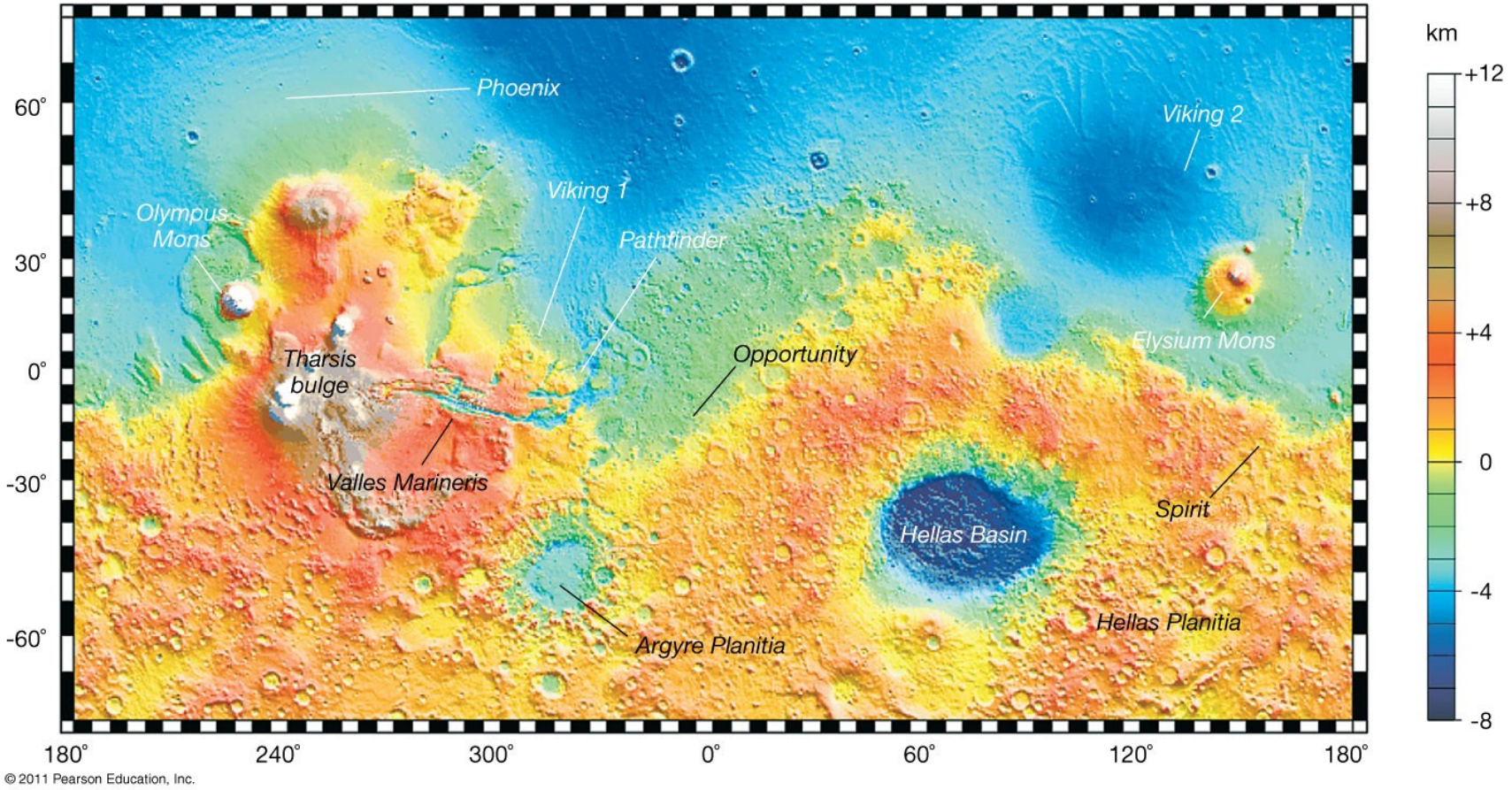
Major feature: Tharsis bulge, size of North America and 10 km above surroundings

Minimal cratering; youngest surface on Mars



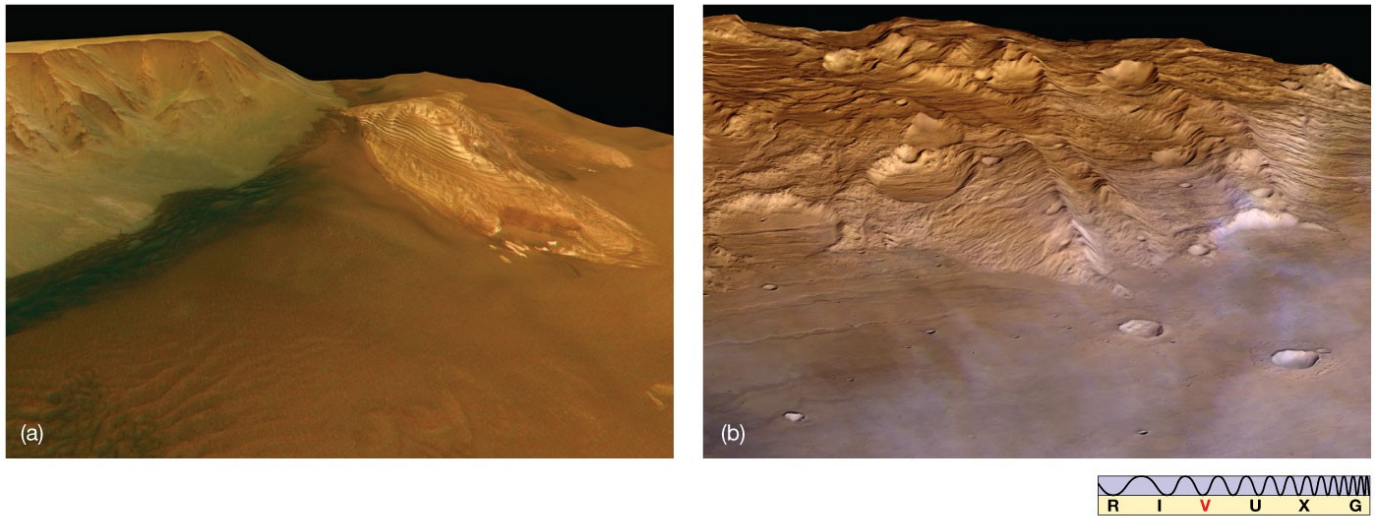
10.4 The Martian Surface

This map shows the main surface features of Mars. There is no evidence for plate tectonics.



10.4 The Martian Surface

- Northern hemisphere (left) is rolling volcanic terrain
- Southern hemisphere (right) is heavily cratered highlands; average altitude 5 km above northern
- Conclusion is that northern surface is younger than southern
- The northern hemisphere appears to be lower in elevation and has been flooded with lava

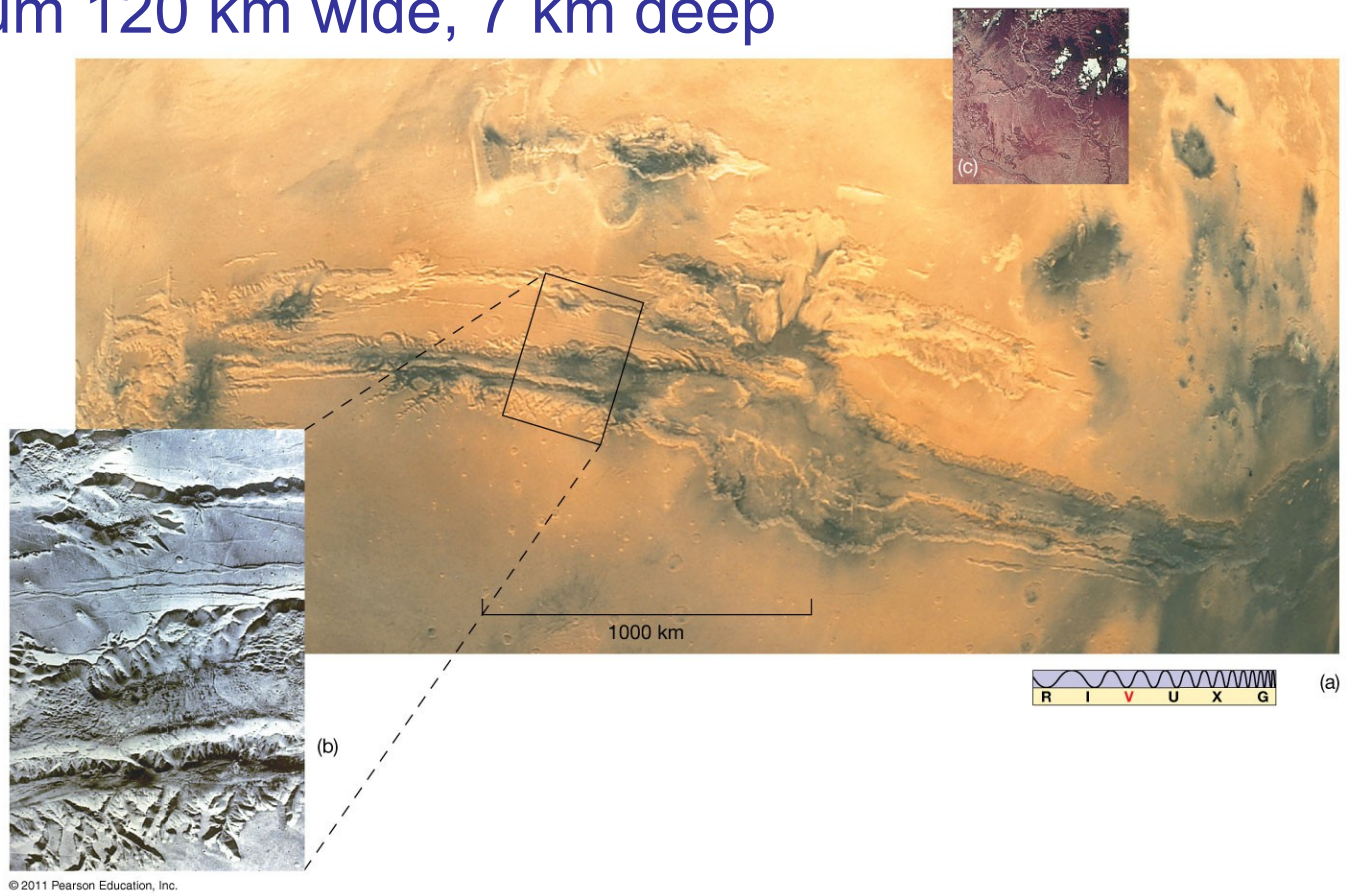


10.4 The Martian Surface

Valles Marineris: Huge canyon, created by crustal forces

- 4000 km long (2500 mi)
- Maximum 120 km wide, 7 km deep

Top right: Grand Canyon on same scale

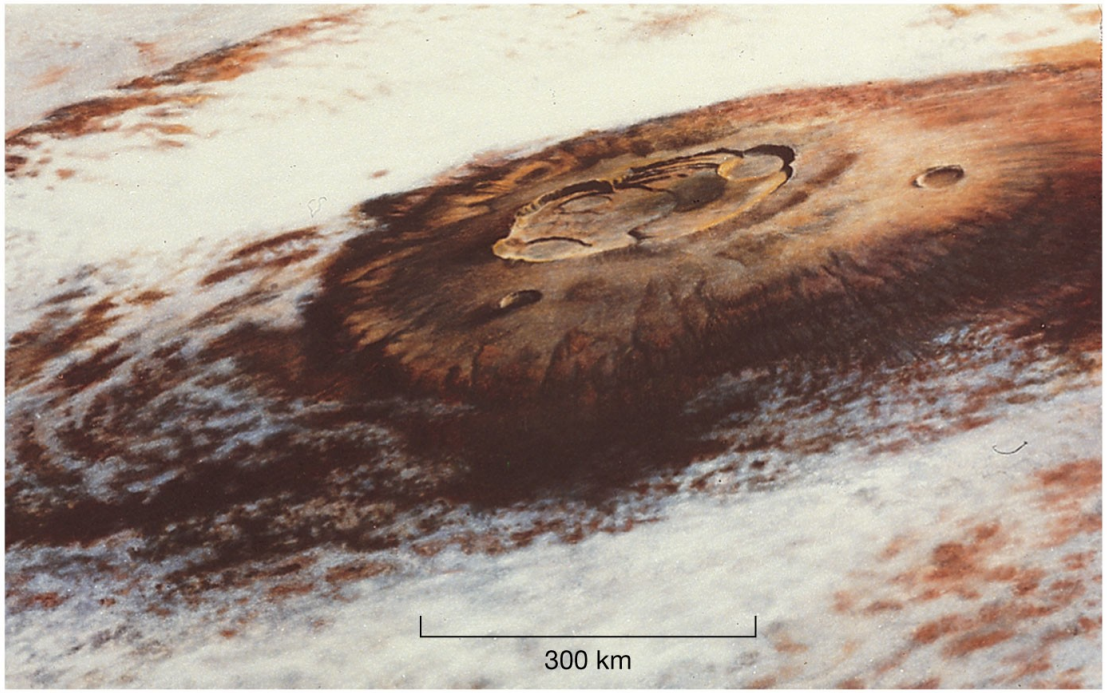


10.4 The Martian Surface

Mars has largest volcano in solar system: Olympus Mons

- 700 km diameter at base
- 25 km high
- Caldera is 80 km in diameter

Three other Martian volcanoes are only slightly smaller



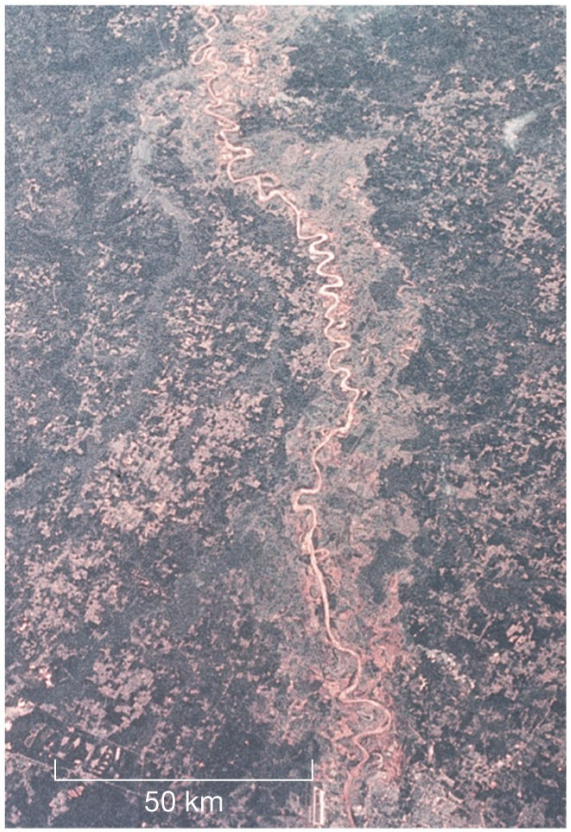
10.5 Water on Mars

Was there running water on Mars?

Two main flow features seen:

1. runoff channels
2. outflow channels

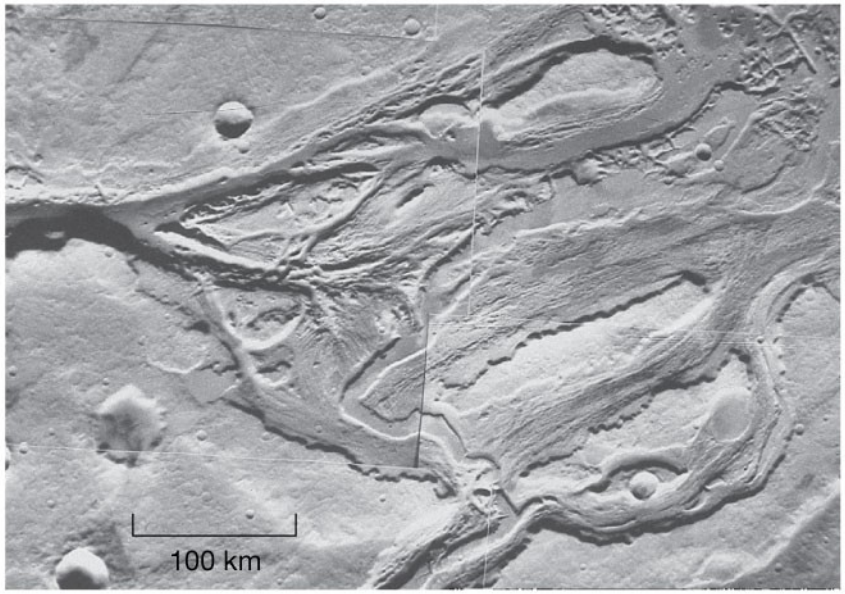
These runoff channels resemble those on Earth



Mars highlands

Louisiana

10.5 Water on Mars



(a)

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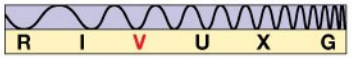
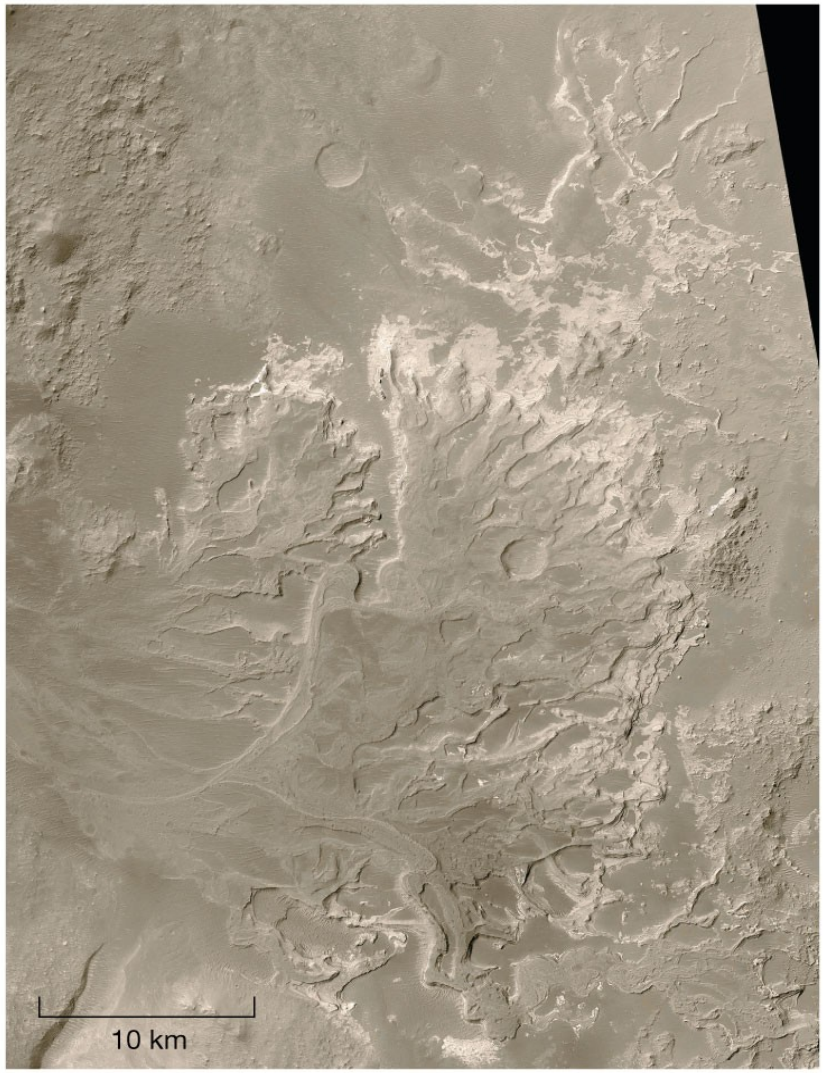


These outflow channels were probably formed by large volumes of water flowing out of a lake or ocean.
Thus: open water (rivers, lakes) once existed on Mars.

10.5 Water on Mars

This appears to be an old Martian river delta.



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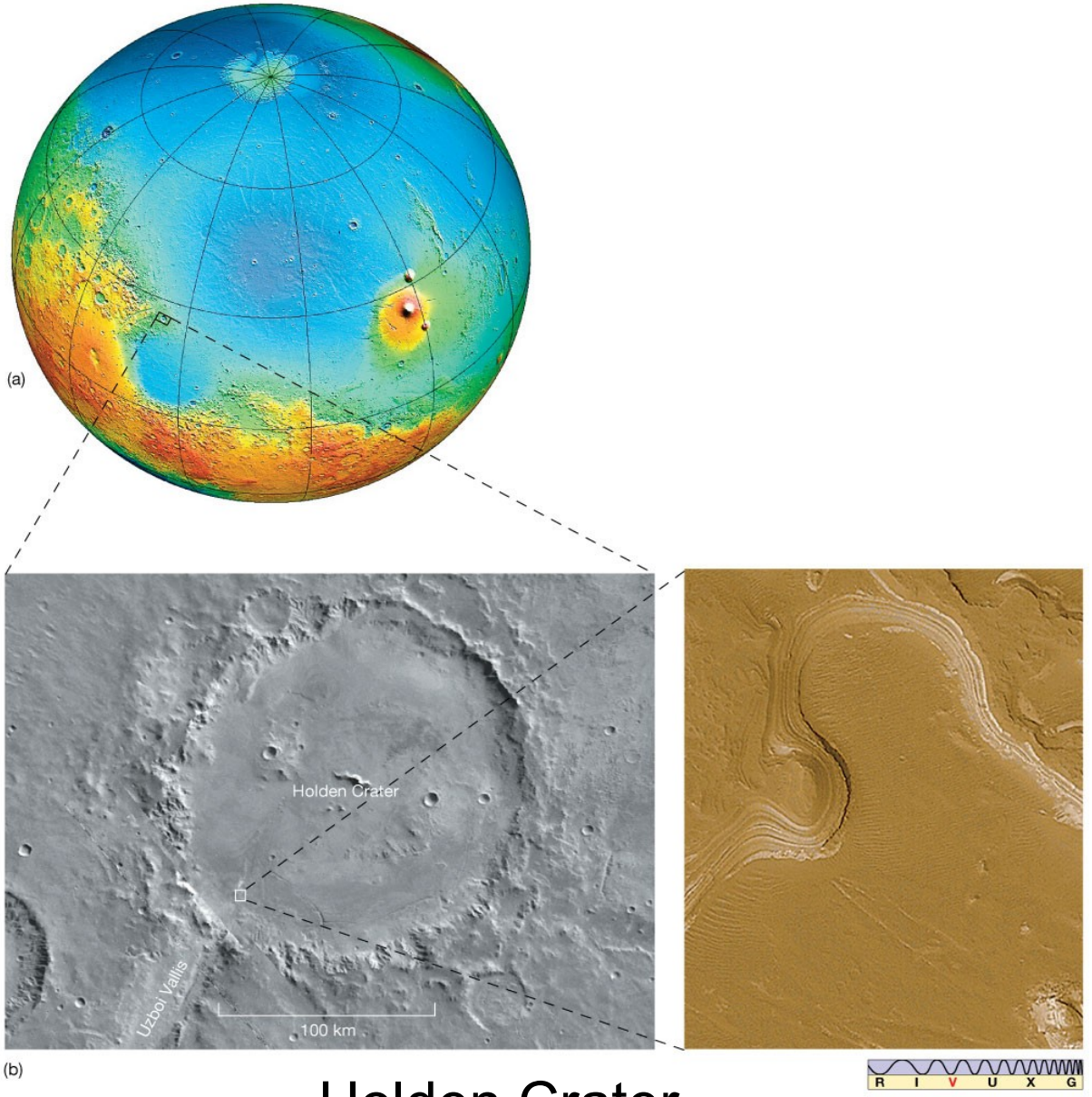
10.5 Water on Mars

Much of northern hemisphere may have been ocean.

Contours from the slow recession of shoreline outline much of the highland / lowland boundary.



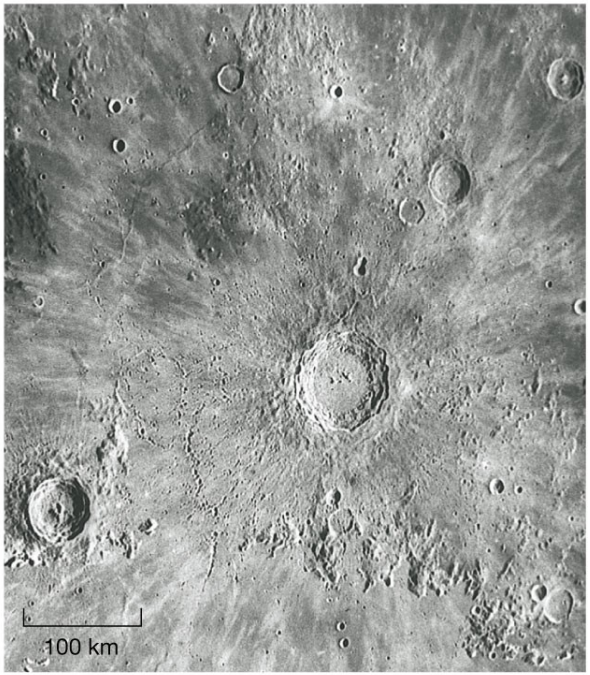
Holden Crater

10.5 Water on Mars

Impact craters less than 5 km across have mostly been eroded away.

Crater on left is Copernicus on the Moon - dry ejecta.

Crater Yuty on right is a “splosh” crater on Mars – fluidized ejecta from liquid water or permafrost



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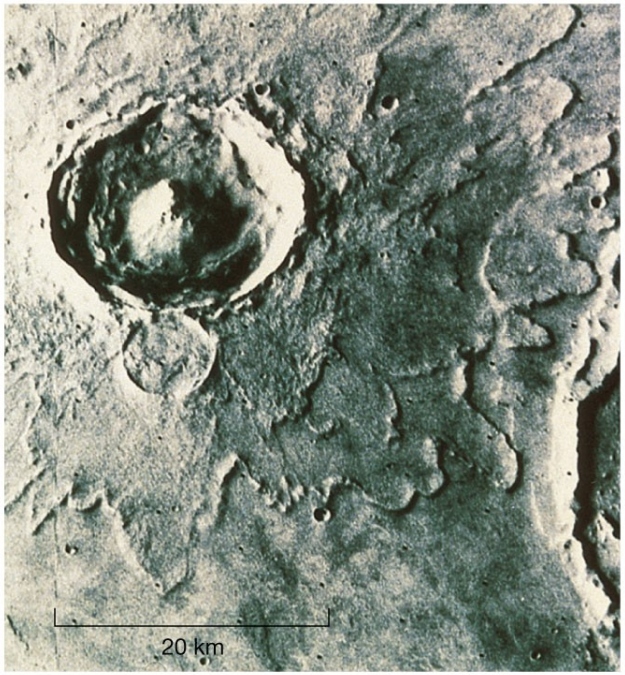

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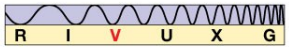
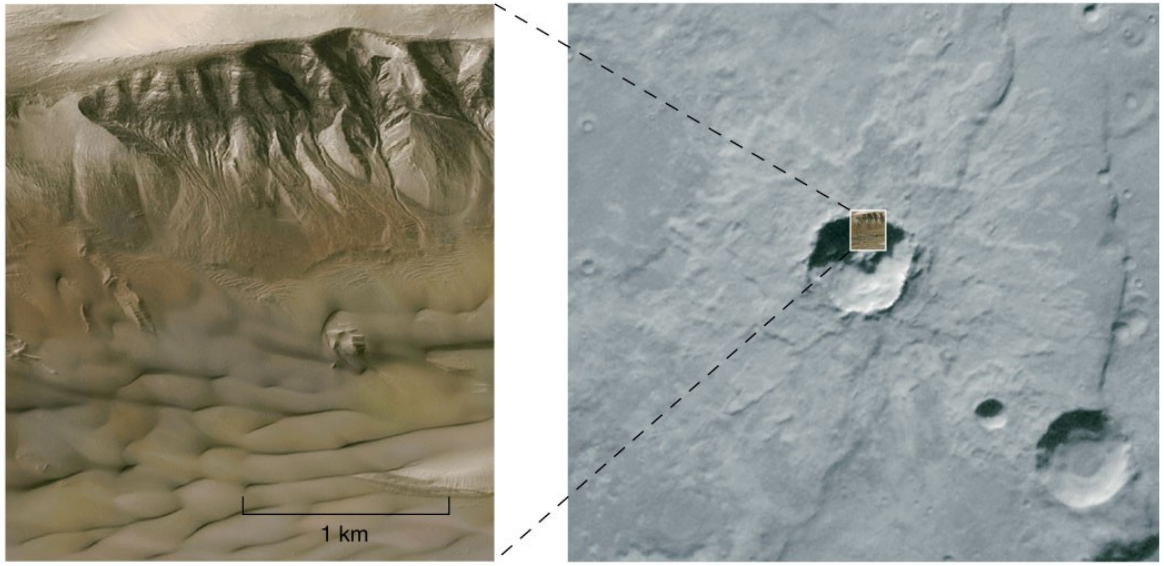


10.5 Water on Mars- Recent?



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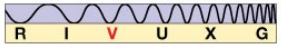
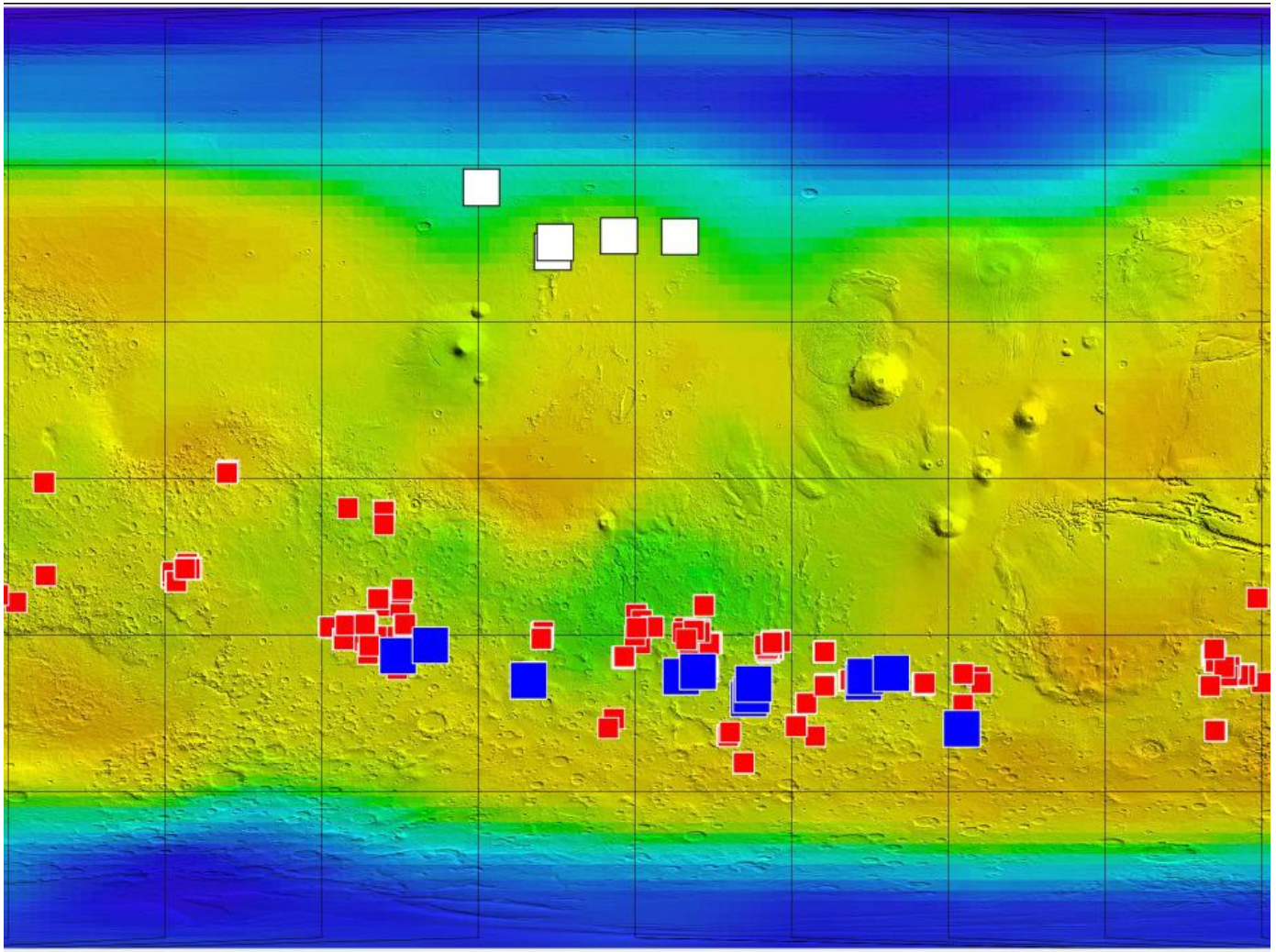


Gullies on the side of a (splosh?) crater.
Similar to Haughton impact crater in the Arctic – underground ice melted and flowed after being exposed.

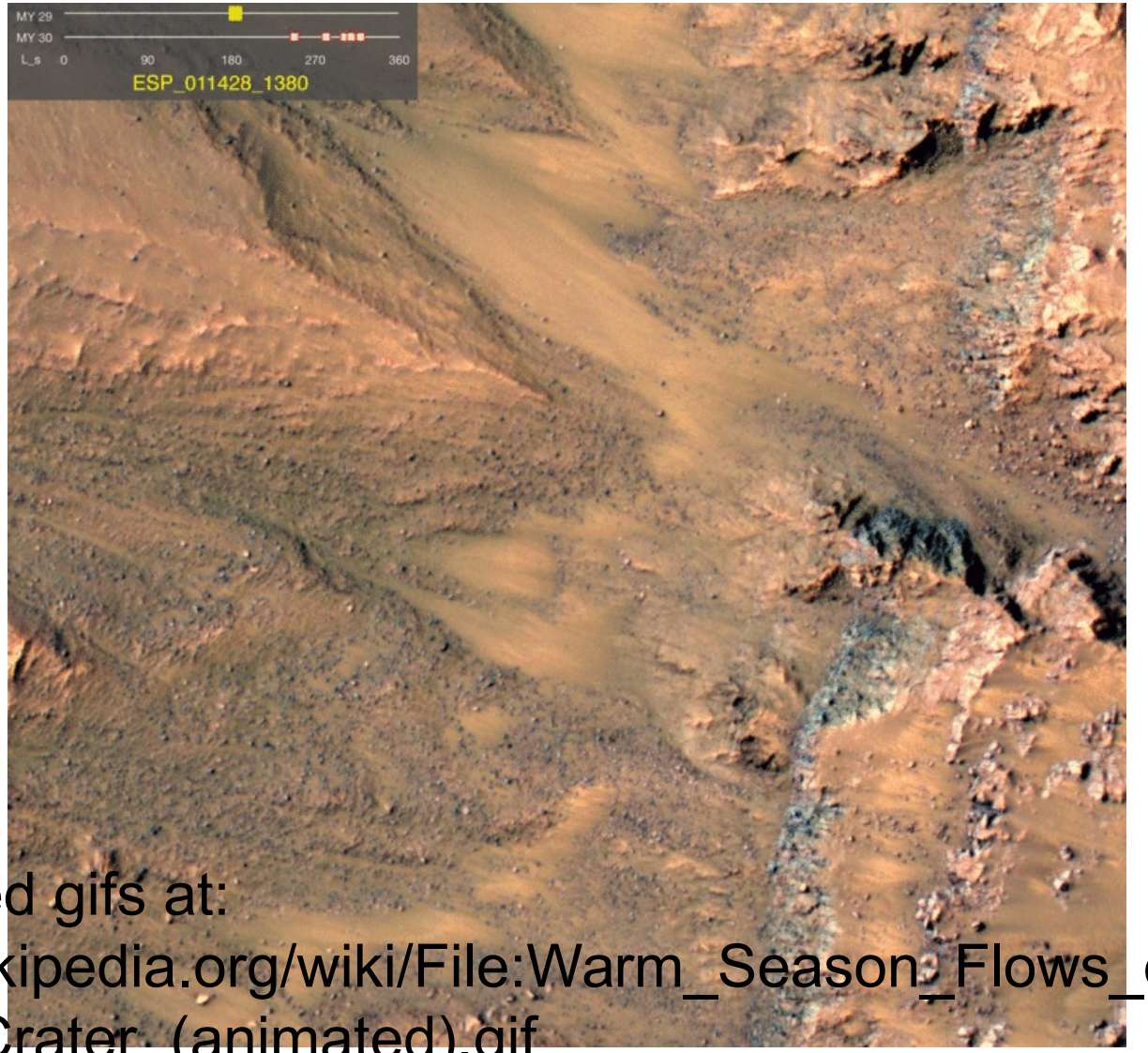
10.5 Water on Mars- Recent?



Blue = possible “brine flow” regions. Red=salt flow, White=ice flow.

(http://science.nasa.gov/science-news/science-at-nasa/2011/04aug_marsflows/)

10.5 Water on Mars- Recent?



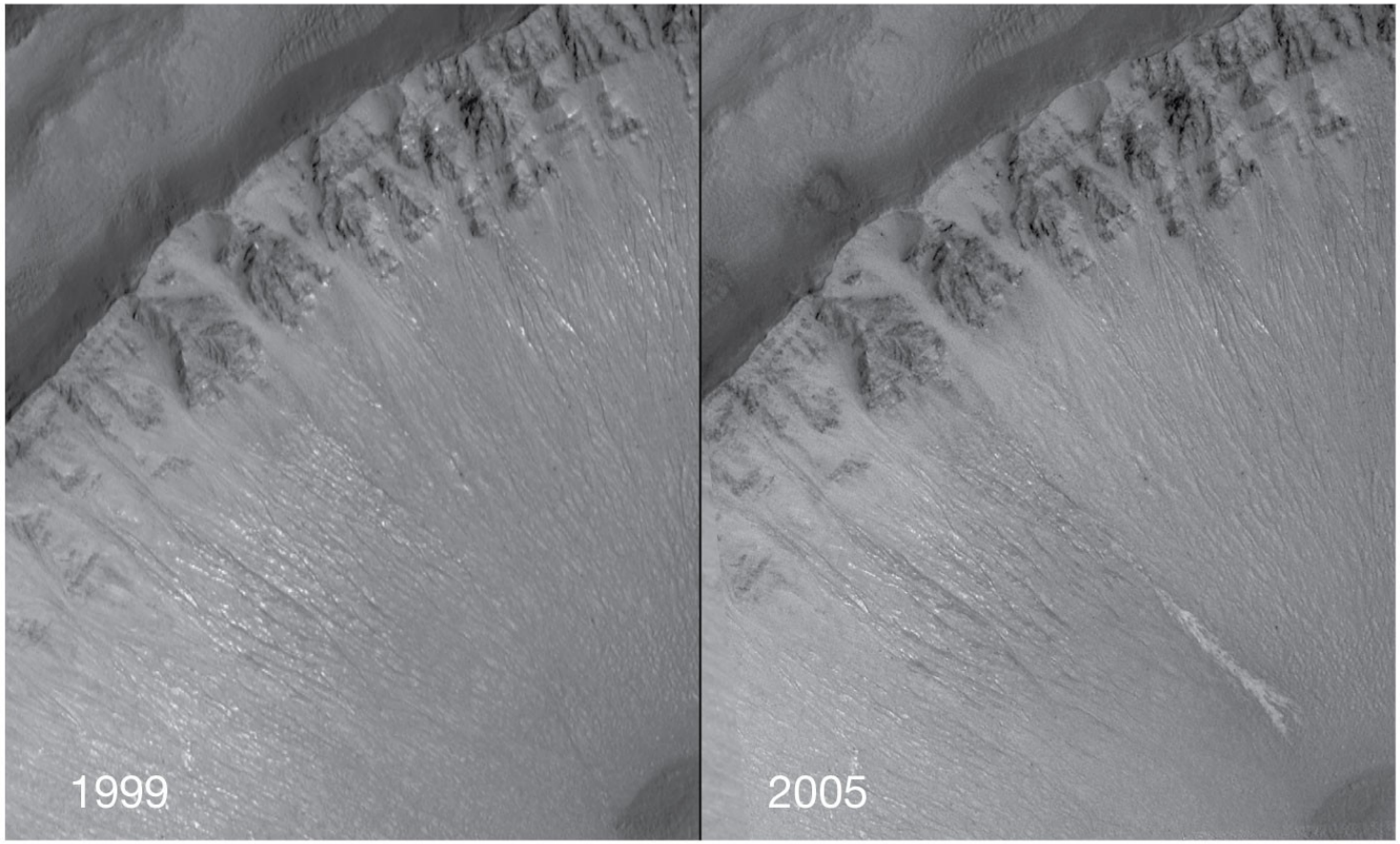
See animated gifs at:
https://en.wikipedia.org/wiki/File:Warm_Season_Flows_on_Slope_n_Newton_Crater_(animated).gif

Recurrent Slop Linaea (RSL) or Brine Flows.

(By NASAUnleaded by Surajt88 at en.wikipedia - by SreeBot, Public Domain.)

10.5 Water on Mars-Recent?

This very recent change could be from water flow, but ... such brightenings are also possible from rock/sand slides.



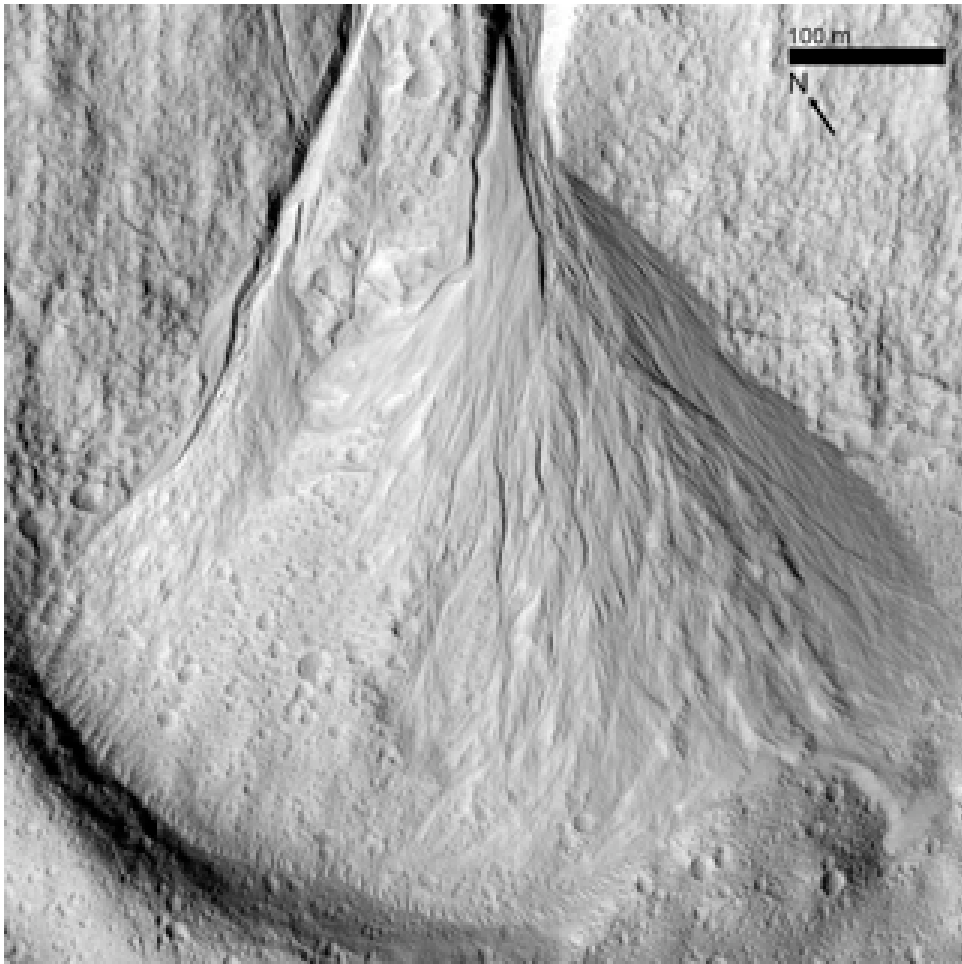
10.5 Water on Mars-Recent?

This river delta has secondary craters (shot off of a nearby, big crater). The age of the big crater is only 1.25 million years old. First the delta formed by an early flow, then the big crater formed, then more flow happened on top of that.

So this water flow may be < 1 million years old.

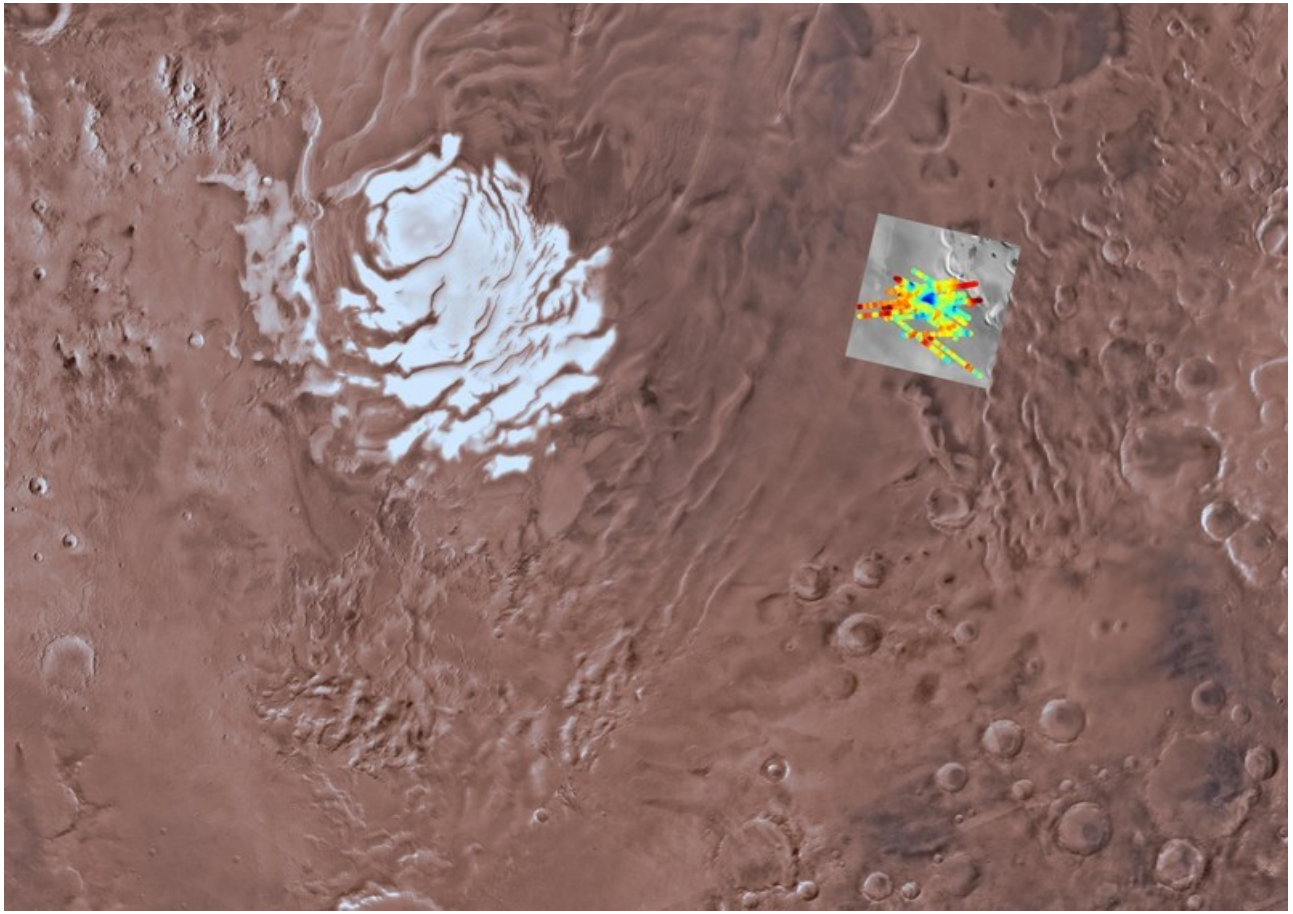
Image: NASA/JPL/UNIVERSITY OF ARIZONA

Alluvial fan on Earth



10.5 Water on Mars-Recent?

Sub-surface brine "lakes" discovered!



- 1st in 2018, 3 more in 2020
- All near S. Polar Cap
- Ground-penetrating radar using Mars Express (ESA)
- 1.5 km deep

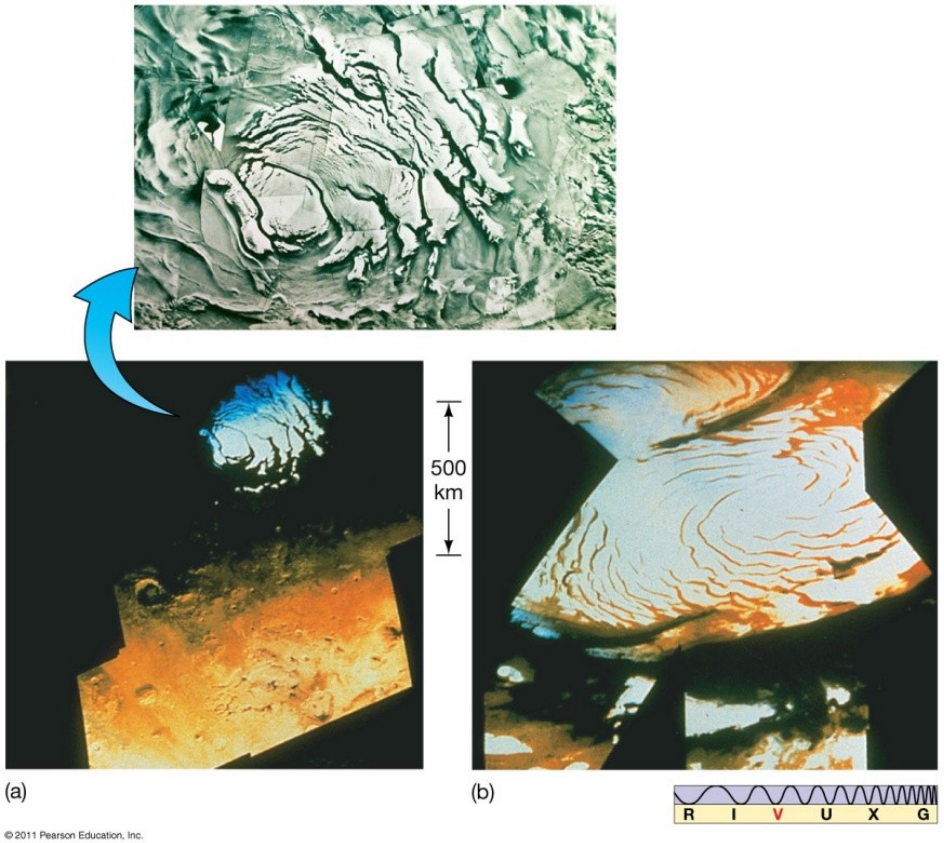
Radar tracks on Mars's Planum Australe show the location of a potential buried lake (in blue). Credit: USGS Astrogeology Science Center, Arizona State University, INAF

10.5 Water on Mars

Water in solid form exists in *residual polar caps* and *permafrost* especially above 50° latitude (N and S).

Residual polar caps:
Left: Southern polar cap, mostly carbon dioxide
Right: Northern polar cap, mostly water ice

(All images taken during local summer.)

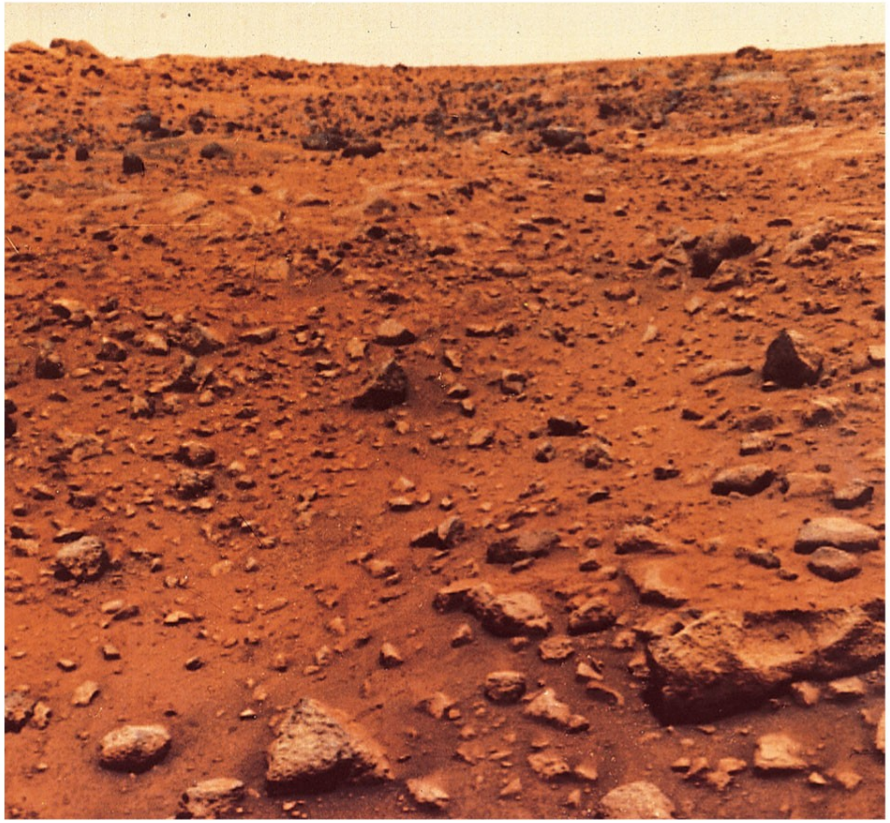


10.5 Water on Mars - close-up

Viking landers both landed in low-latitude northern plains

Rocky surface, red due to iron content

Viking 1

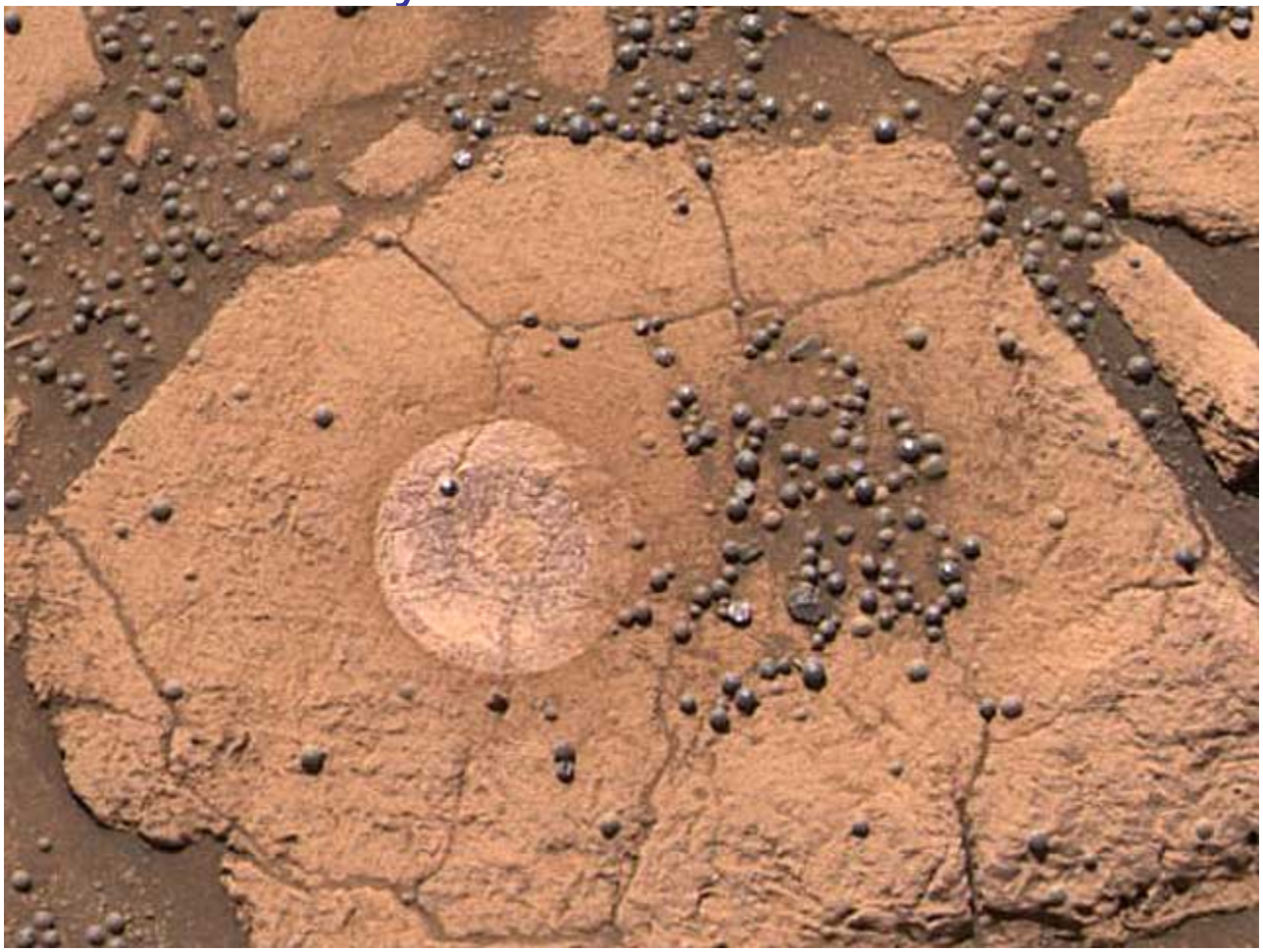


10.5 Water on Mars-close-up

Spirit and Opportunity Rovers found white silica in their tracks that was probably concentrated by liquid water.

10.5 Water on Mars - close-up

Opportunity also found "blueberries". These are a form of the mineral hematite that can only form in aqueous environments - "a bath of dirty water".



Water on Mars - summary

Surface features suggesting the presence of water: runoff channels, outflow channels, gullies, shorelines, river deltas.

Evidence for *recent* water activity: secondary crater field partly wiped out by delta, brightening gullies, dark brine flow patterns (RSL) changing with the season.

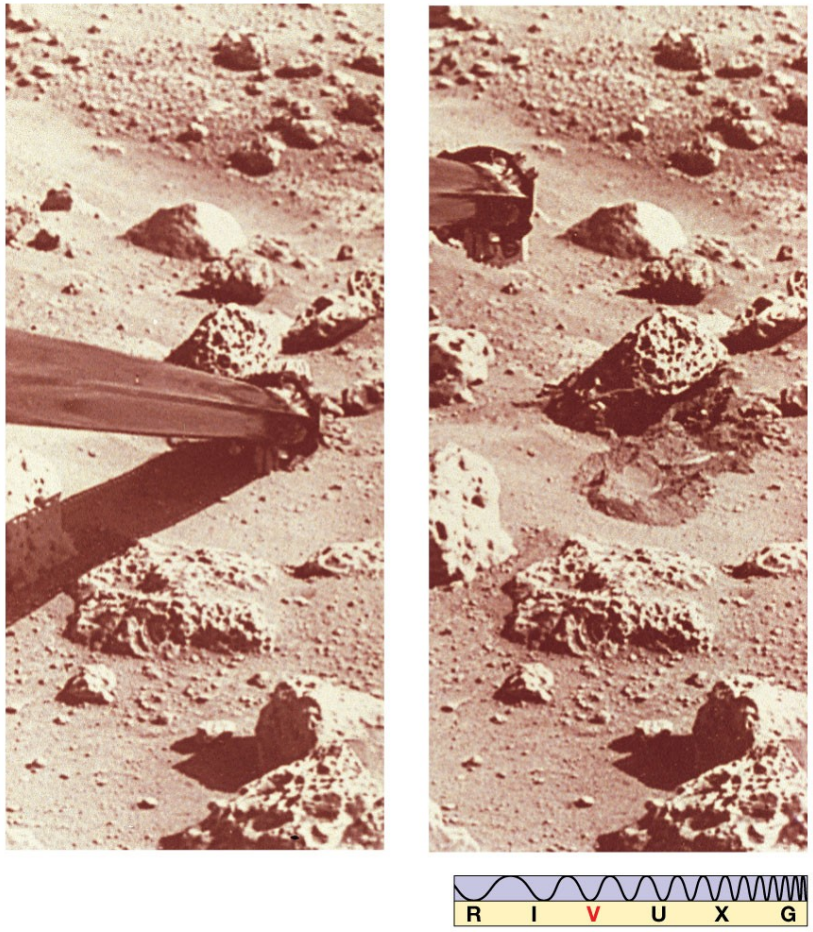
Features seen by Rovers close-up include the "blueberries" and silica soil. These are a form of the mineral hematite that can take this form in aqueous environments - "a bath of dirty water".

Atmosphere contains clouds and fog.

Permafrost (frozen) water makes up up to 50% of soil by weight above ~50° lat (from neutron albedo studies of Mars Odyssey).

Discovery 10-1: Life on Mars?

Viking landers looked for evidence of living organisms; did not find anything conclusive



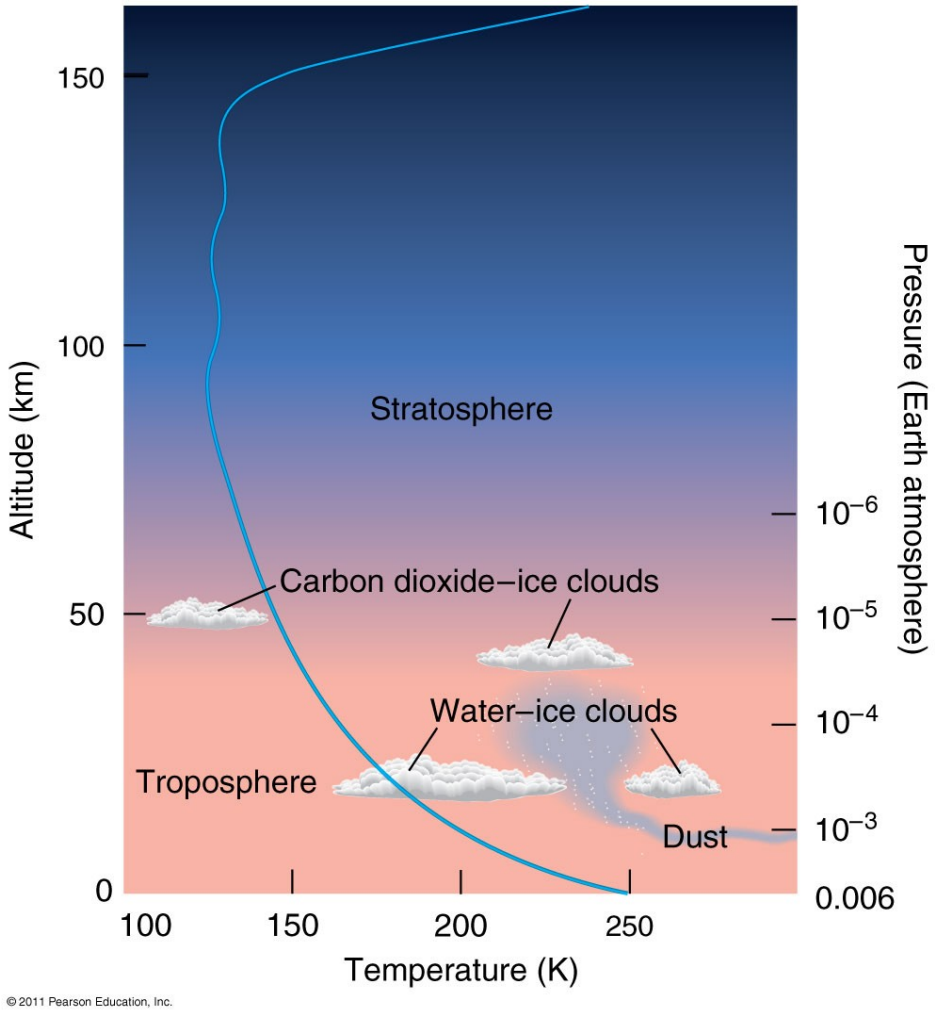
Discovery 10-1: Life on Mars?

Two Martian meteorites found in Antarctica show possible signs of microbial life, but evidence is disputed

10.6 The Martian Atmosphere

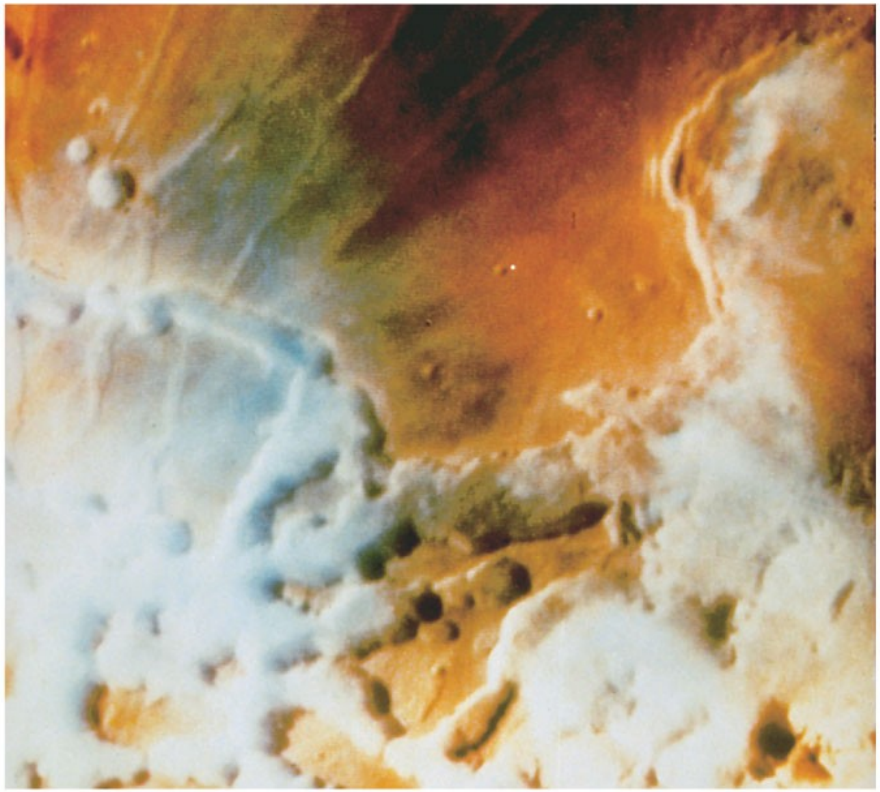
Martian atmosphere is mostly carbon dioxide, and very thin

Too thin to retain much heat; temperature drops sharply at night



10.6 The Martian Atmosphere

Fog can form in low-lying areas, as sunlight strikes.



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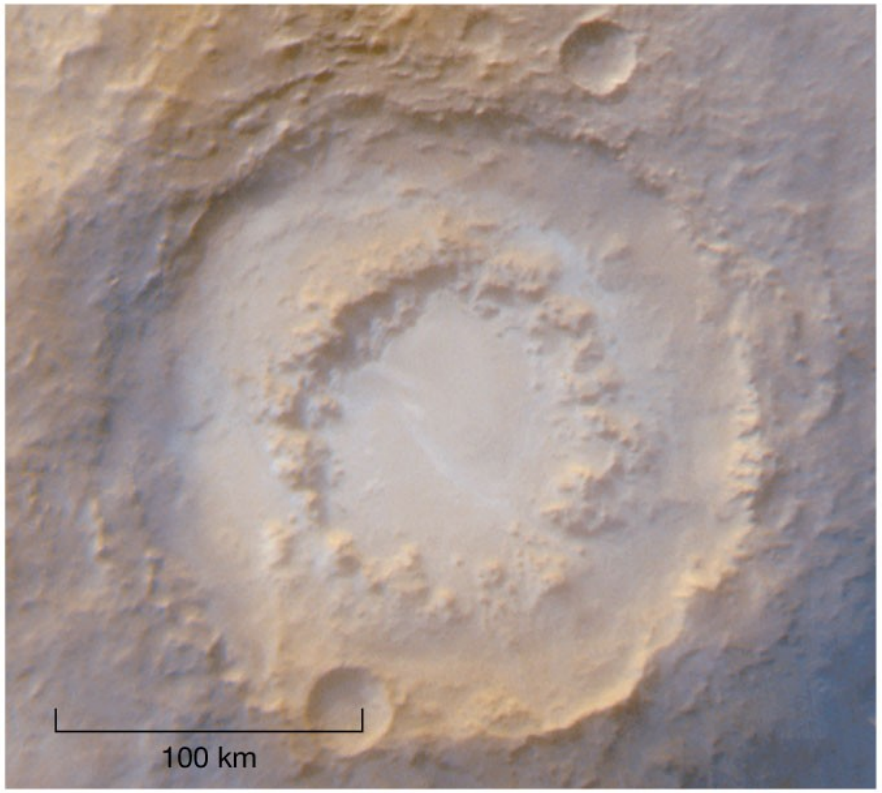

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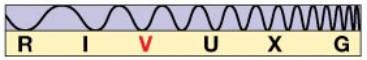
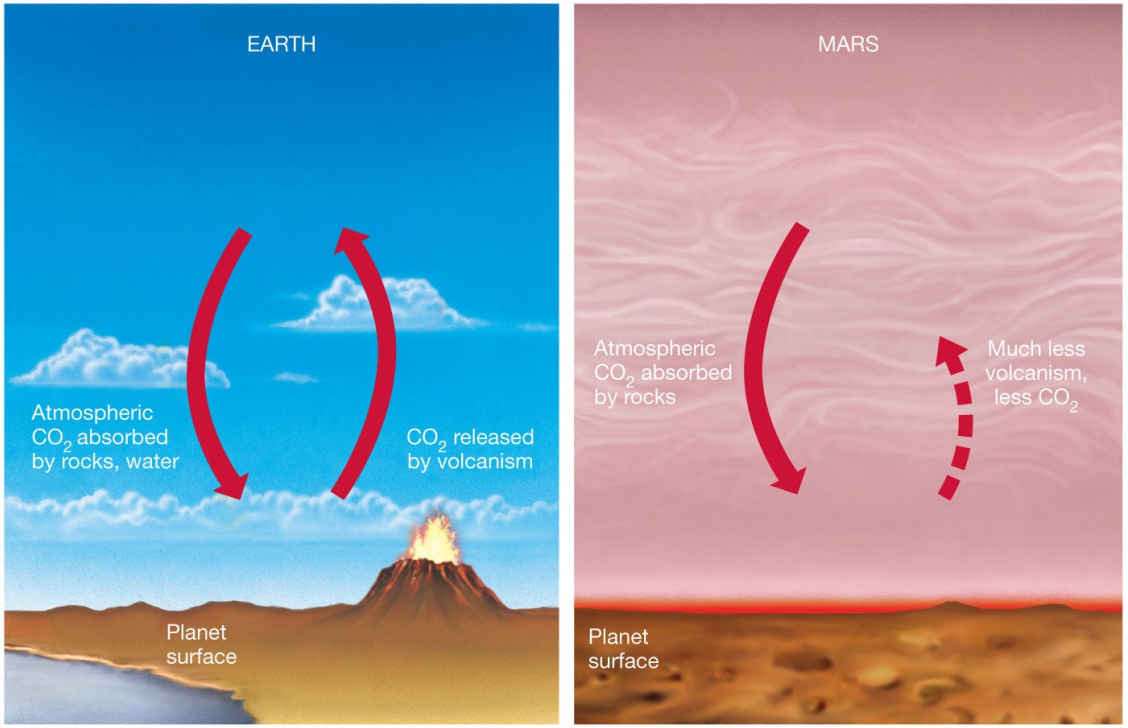


10.6 The Martian Atmosphere

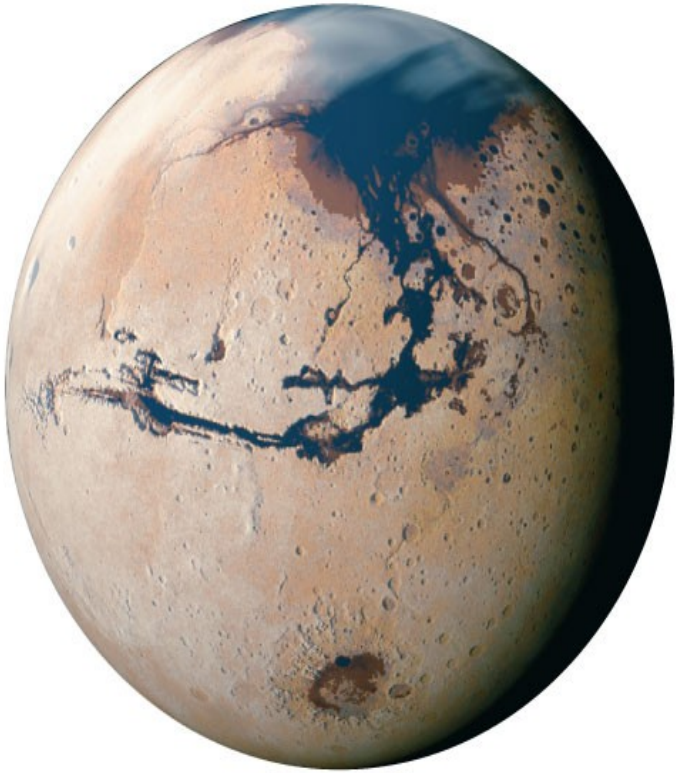
Mars may be victim of runaway greenhouse effect in the opposite sense of Venus's.

As water ice froze, Mars became more and more reflective and its atmosphere thinner and thinner, freezing more and more water and eventually carbon dioxide as well.



10.6 The Martian Atmosphere

As a result, Mars may have had a thicker atmosphere and liquid water in the past, but they are now gone



(a) Ancient Mars

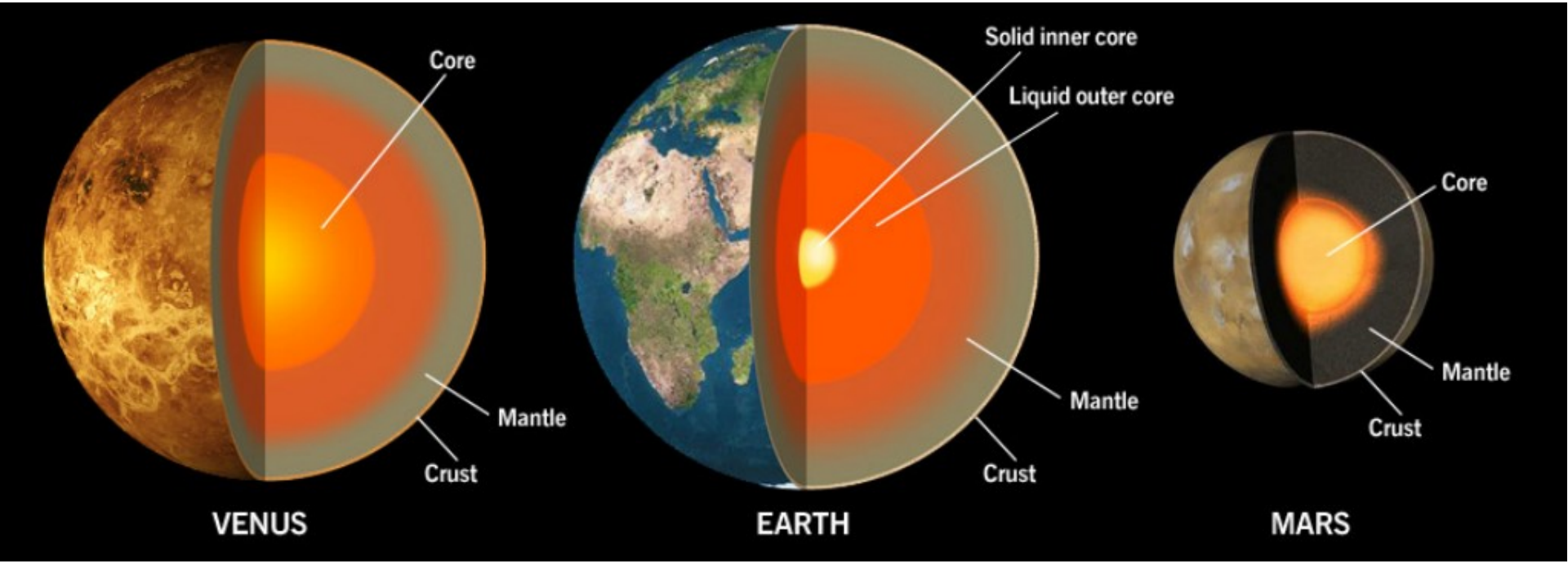
(b) Today's Mars

10.7 Martian Internal Structure

- No seismic studies have been done
- From behavior of crust, it is estimated to be 100 km thick (compare Earth's 5-30 km).
- No magnetic field, so core is probably not metallic, not liquid, or neither liquid nor metallic

10.7 Martian Internal Structure

- Less differentiation occurred compared to Earth and Venus. → more iron on surface → red.



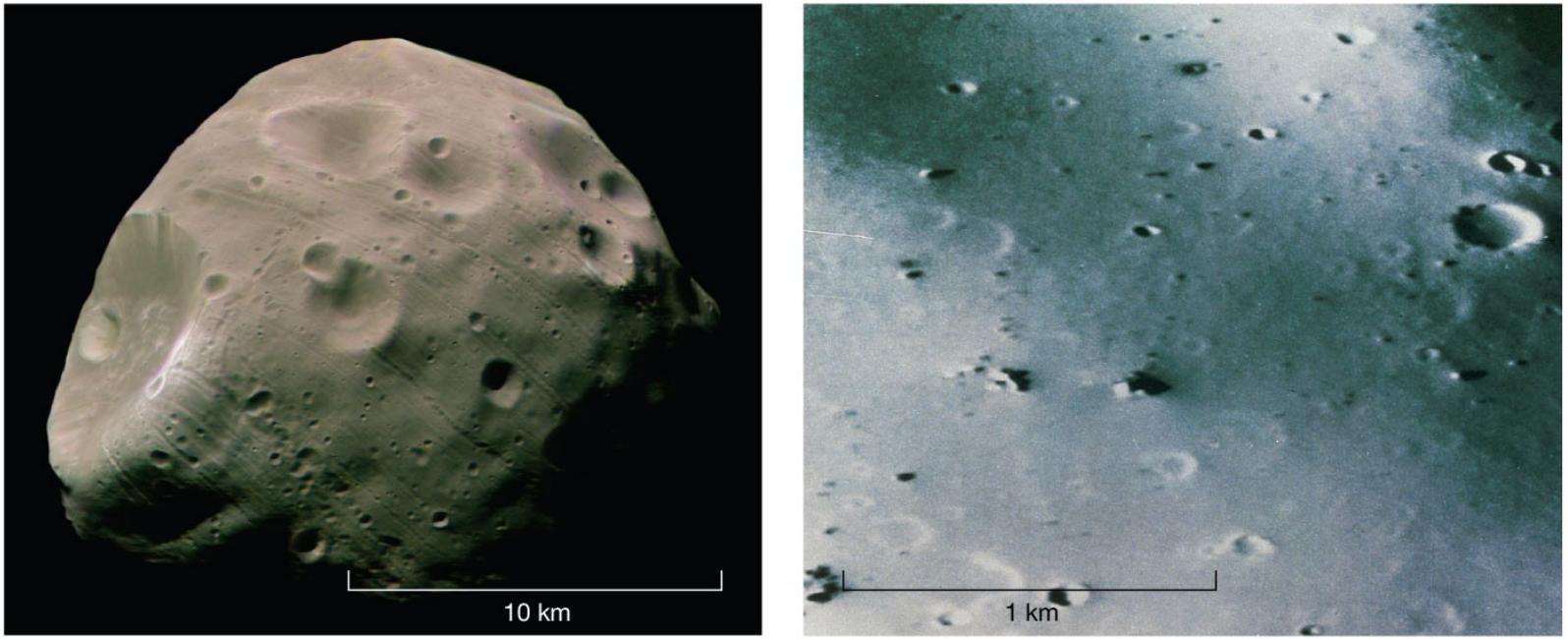
10.8 The Moons of Mars

Mars has two tiny moons:

Phobos (left, 28 km x 20 km)

Deimos (right, 16 km x 10 km)

Both possibly captured from the asteroid belt. Phobos may have accreted from impact ejecta



Summary of Chapter 10

- Mars has always held our interest as a possible site for E.T. Life, and for terraforming
- Similarities to Earth: rotation period (24.6 hrs), axis tilt about 25 degrees, surface gravity about 2/5, warmest regions about “room temperature”
- Differences from Earth:
  - Seasons more extreme (longer orbital period and more eccentric orbit)
  - Day-to-night temperature difference is more extreme (little greenhouse effect), avg temps 50 K below Earth's
- Atmosphere very thin, mostly carbon dioxide
- Crust 100 km thick, little seismic activity, volcanoes extinct.

Summary of Chapter 10 (cont.)

- Northern and southern hemispheres are very different: South is higher and heavily cratered, North is lower and relatively flat
- Major features: Tharsis bulge, Olympus Mons, Valles Marineris
- Lot's of evidence for flowing water in past – climate probably became colder (reverse runaway greenhouse effect)
- Crater ejecta provide evidence for permafrost layer under surface (easily liquidized)
- Two small moons, probably captured asteroids