

ASTRONOMY TODAY

CHAISSON
McMILLAN

SEVENTH EDITION

Lecture Outlines

Chapter 10

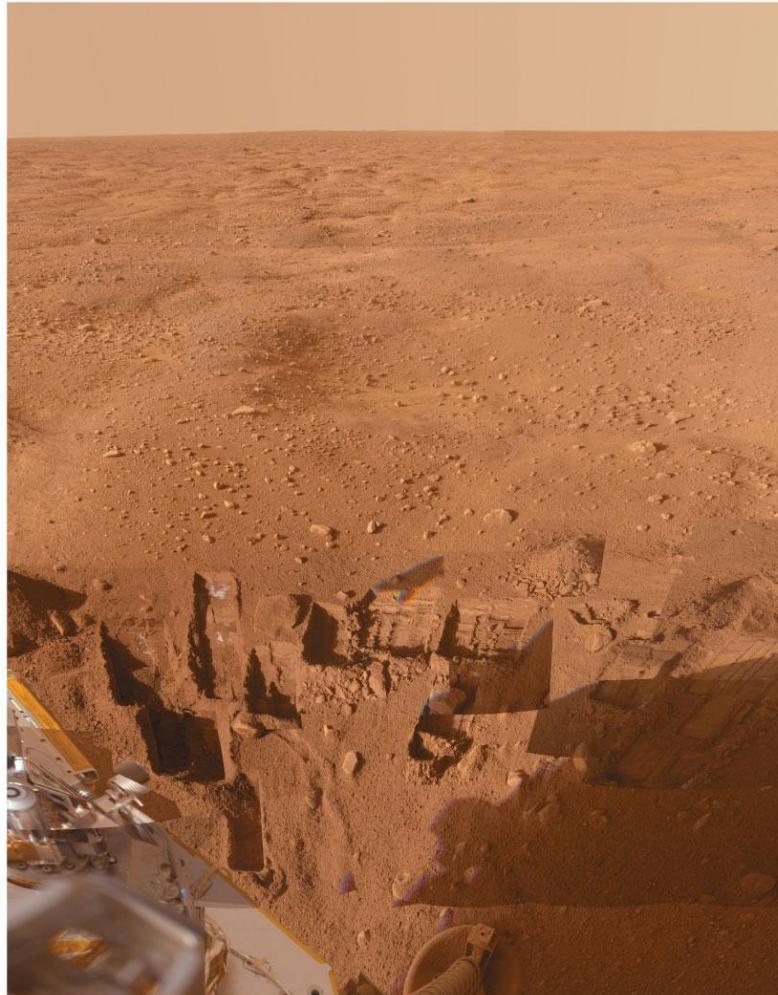
Astronomy Today

7th Edition

Chaisson/McMillan

Chapter 10

Mars



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Units of Chapter 10

10.1 Orbital Properties

10.2 Physical Properties

10.3 Long-Distance Observations of Mars

10.4 The Martian Surface

10.5 Water on Mars

Life on Mars?

10.6 The Martian Atmosphere

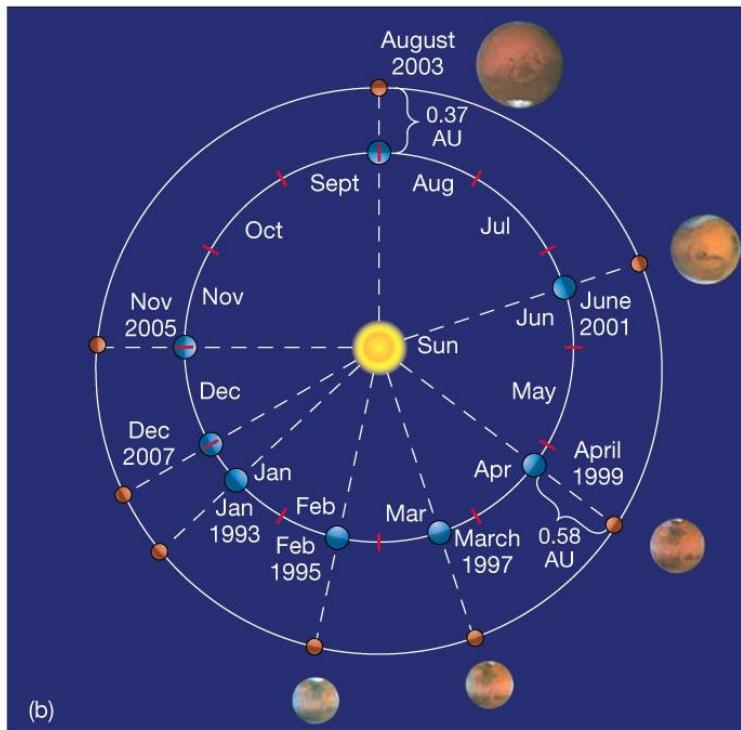
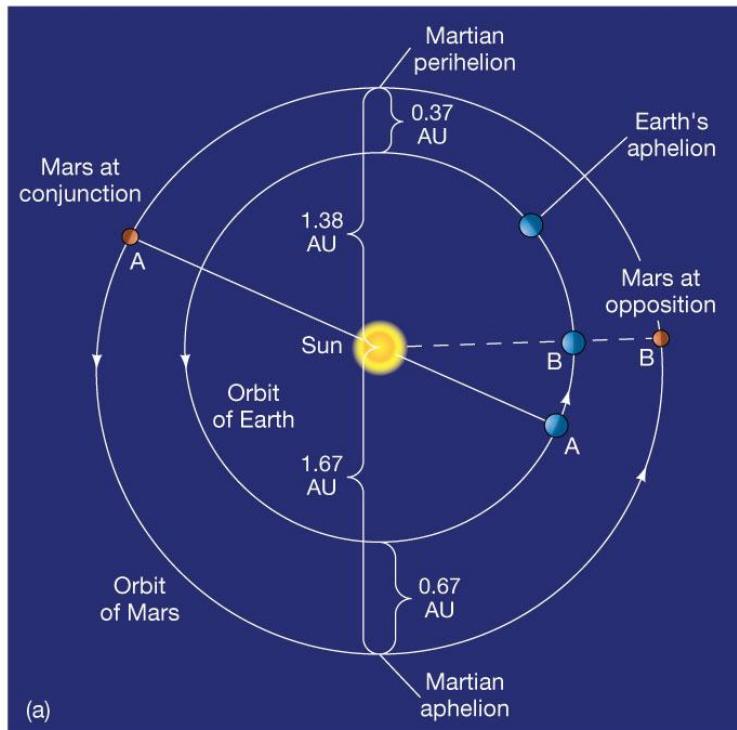
10.7 Martian Internal Structure

10.8 The Moons of Mars

10.1 Orbital Properties

Mars's orbit is fairly eccentric which affects amount of sunlight reaching it

When viewed from Earth, Mars can be located either in the general direction of the Sun (conjunction) or away from it (opposition).



10.2 Physical Properties

Radius: 3394 km

Moons: Deimos, Phobos

Mass: 6.4×10^{23} kg

Density: 3900 kg/m³

Length of day: 24.6 hours

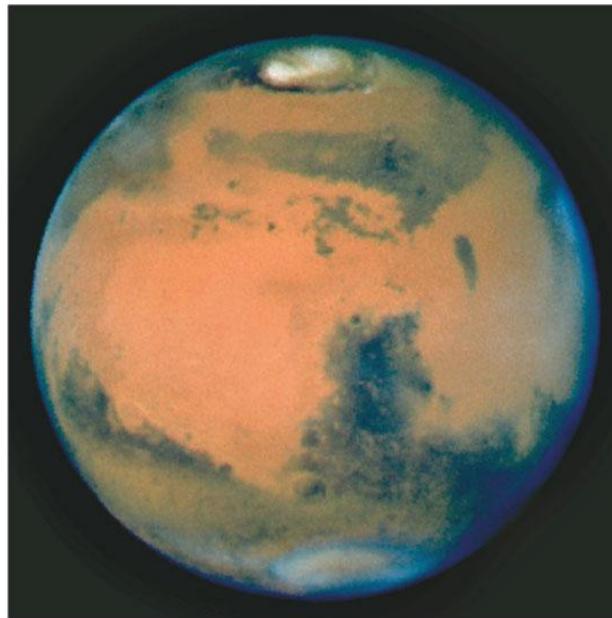
10.3 Long-Distance Observations of Mars

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

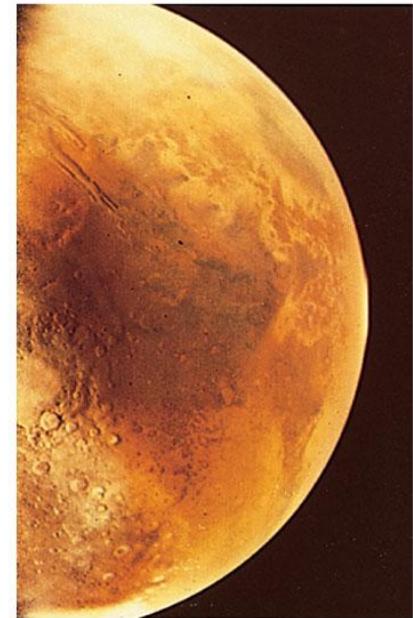
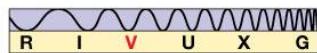
Much better pictures from Mars missions, close-up



(a)



(b)



(c)

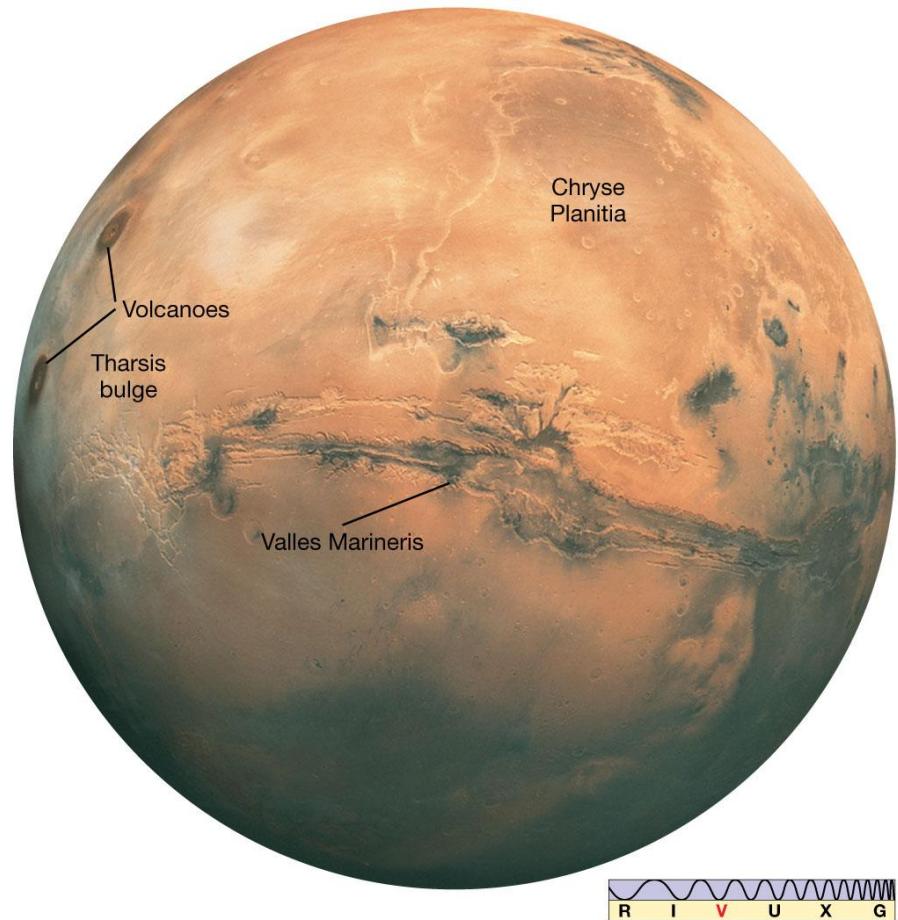
10.3 Long-Distance Observations of Mars

- Changing polar ice caps are frozen carbon dioxide; water ice is permanently frozen
- Shifting dust cover makes surface look like it is changing
- Frequent dust storms, with high winds

10.4 The Martian Surface

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

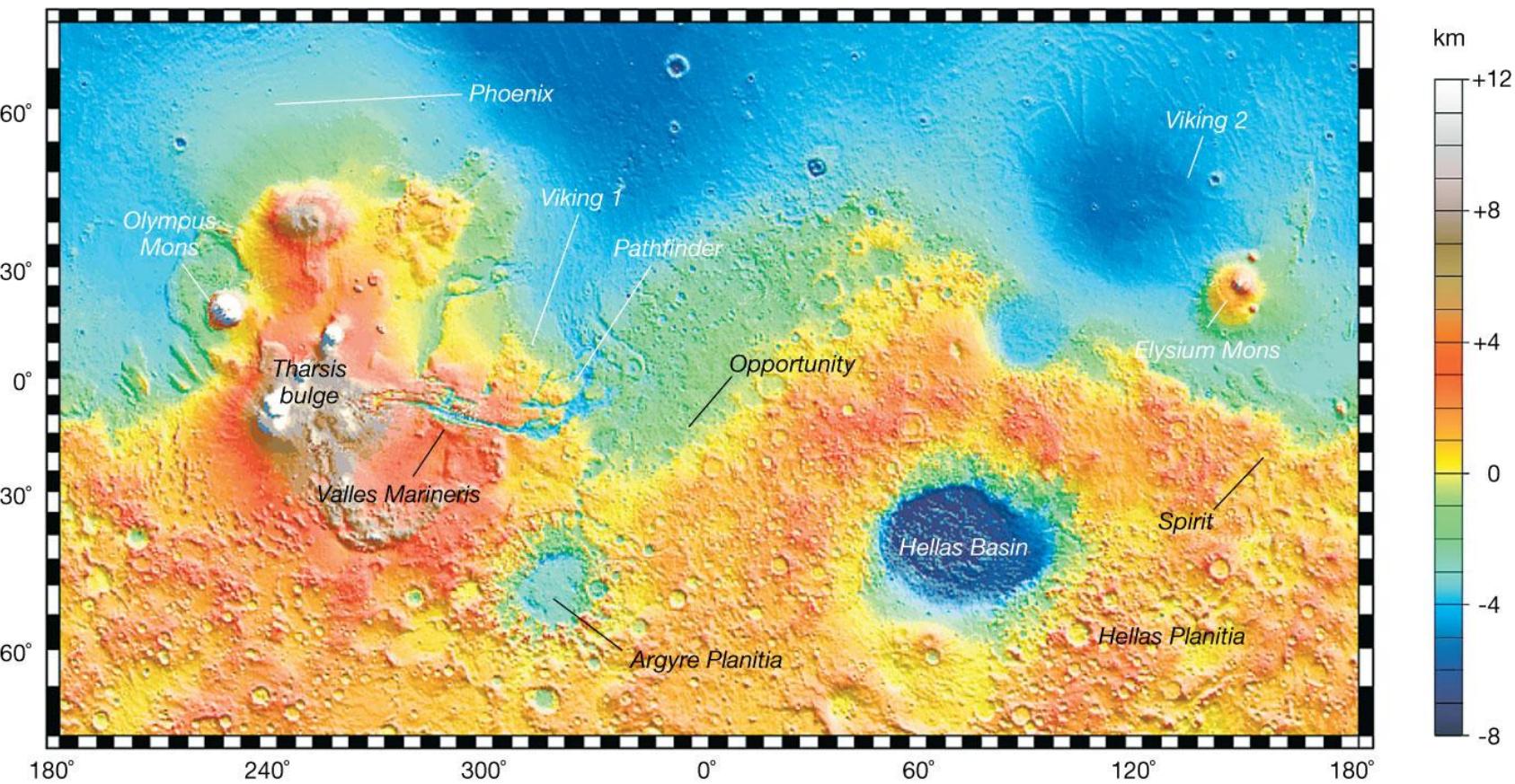
Minimal cratering; youngest surface on Mars



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10.4 The Martian Surface

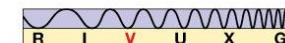
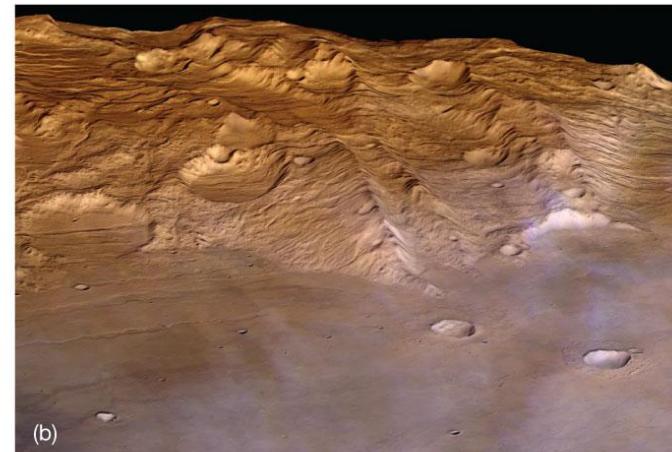
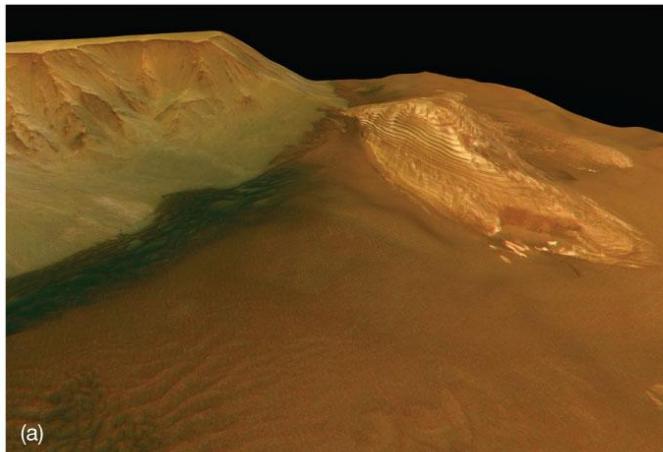
This map shows the main surface features of Mars. There is no evidence for plate tectonics.



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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
- Assumption is that northern surface is younger than southern
- Means that northern hemisphere must have been lowered in elevation and then flooded with lava

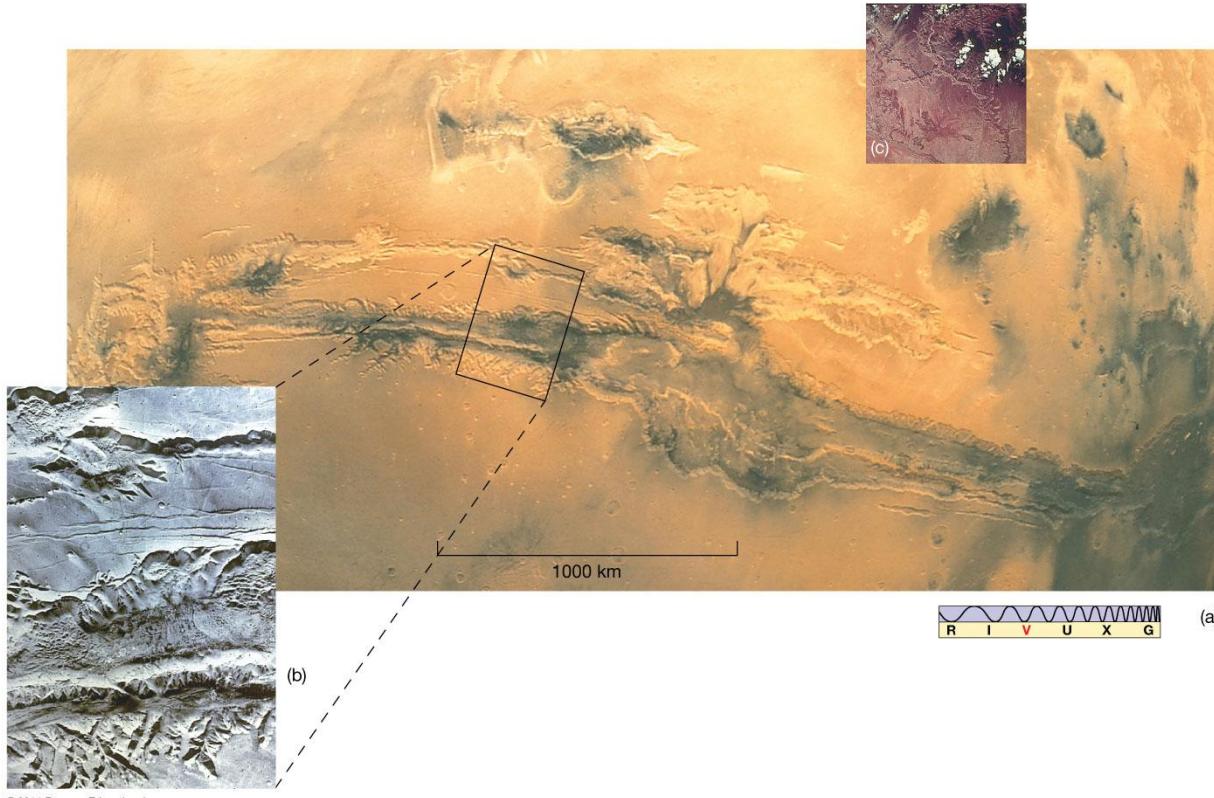


10.4 The Martian Surface

Valles Marineris: Huge canyon, created by crustal forces

- 4000 km long
- Maximum 120 km wide, 7 km deep

Top right: Grand Canyon on same scale

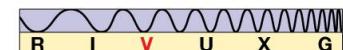
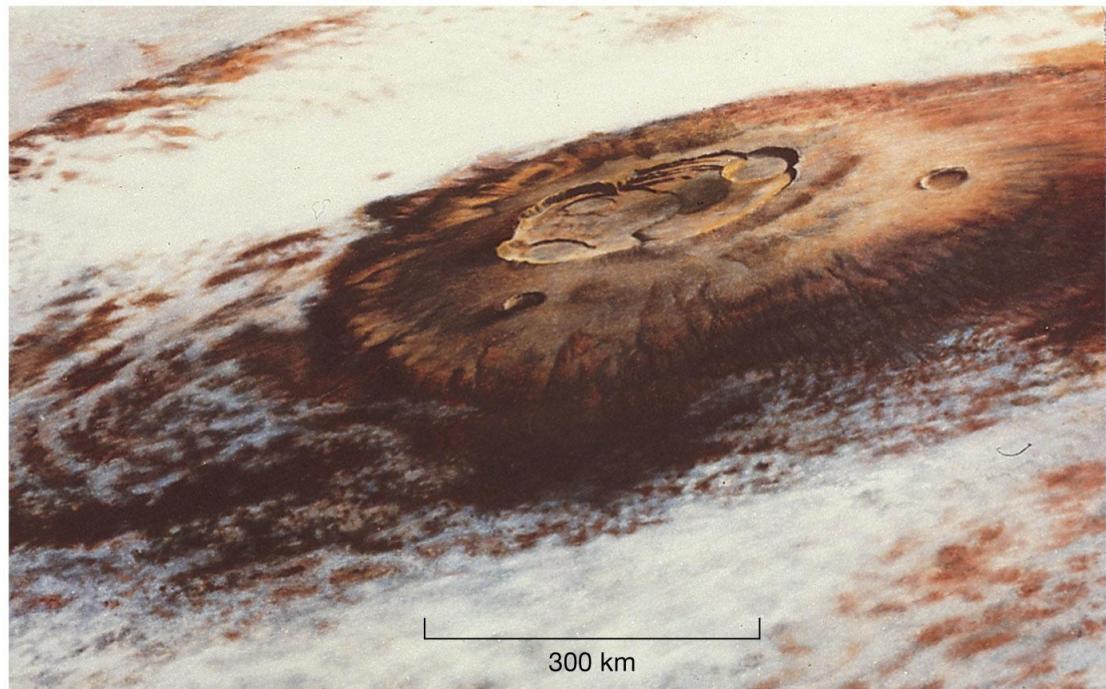


10.4 The Martian Surface

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



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10.5 Water on Mars

Was there running water on Mars?

Runoff channels
resemble those on
Earth

Left: Mars

Right: Louisiana

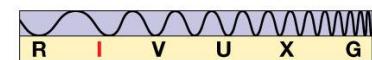


(a)

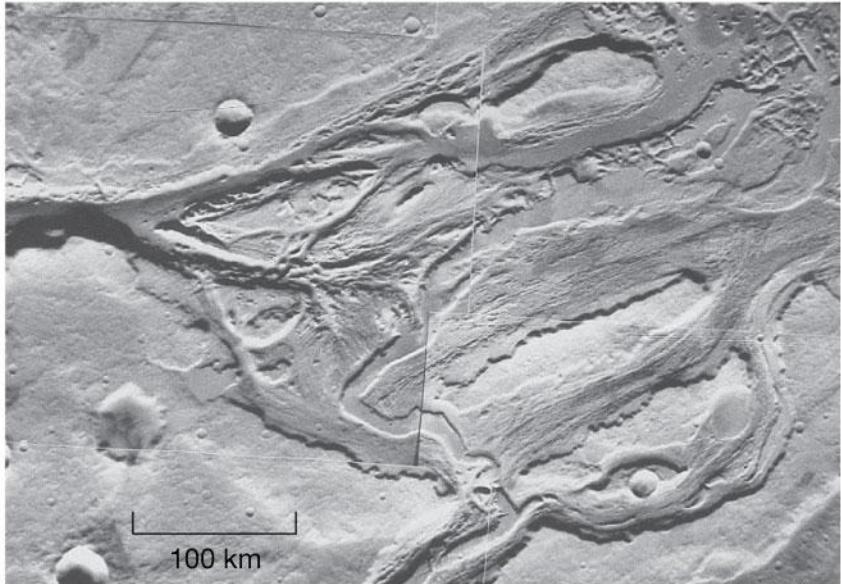
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(b)



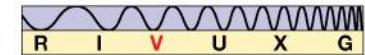
10.5 Water on Mars



(a)



(b)

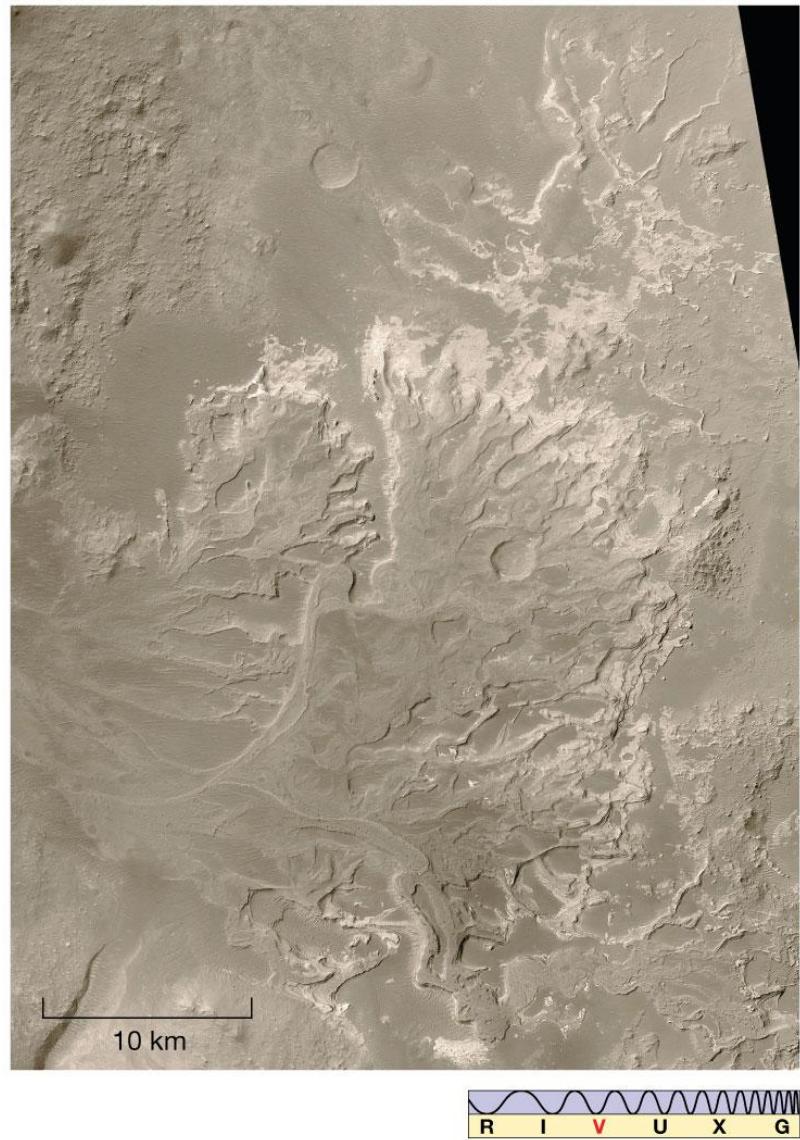


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Current thinking: Open water (rivers, lakes) once existed on Mars

10.5 Water on Mars

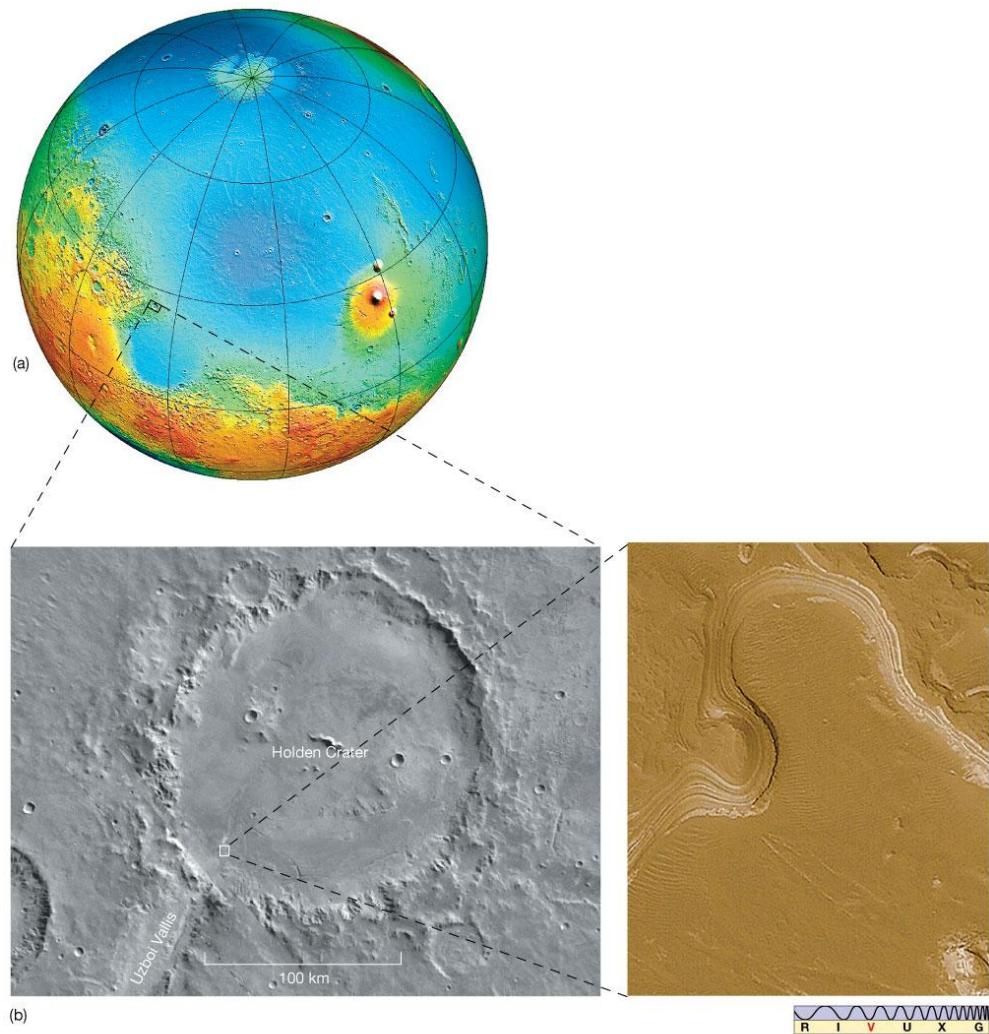
This may be an ancient
Martian river delta (or it
may not)



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10.5 Water on Mars

Much of northern hemisphere may have been ocean



10.5 Water on Mars

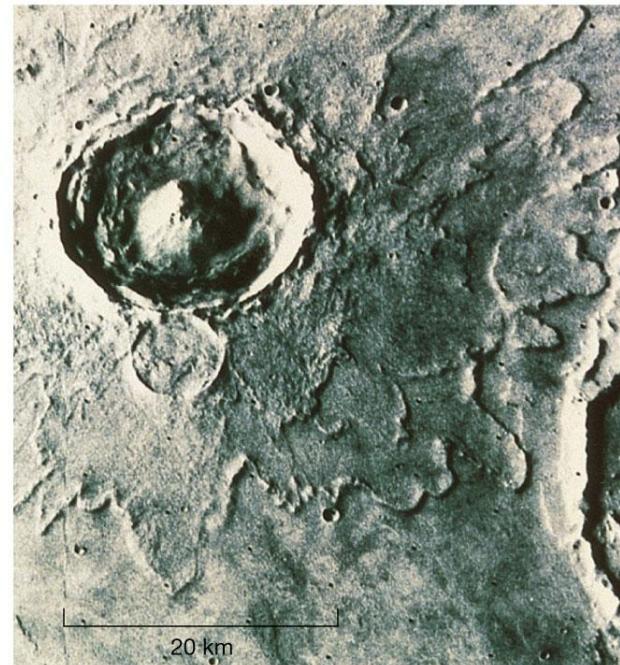
Impact craters less than 5 km across have mostly been eroded away

Analysis of craters allows estimation of age of surface

Crater on right was made when surface was liquid



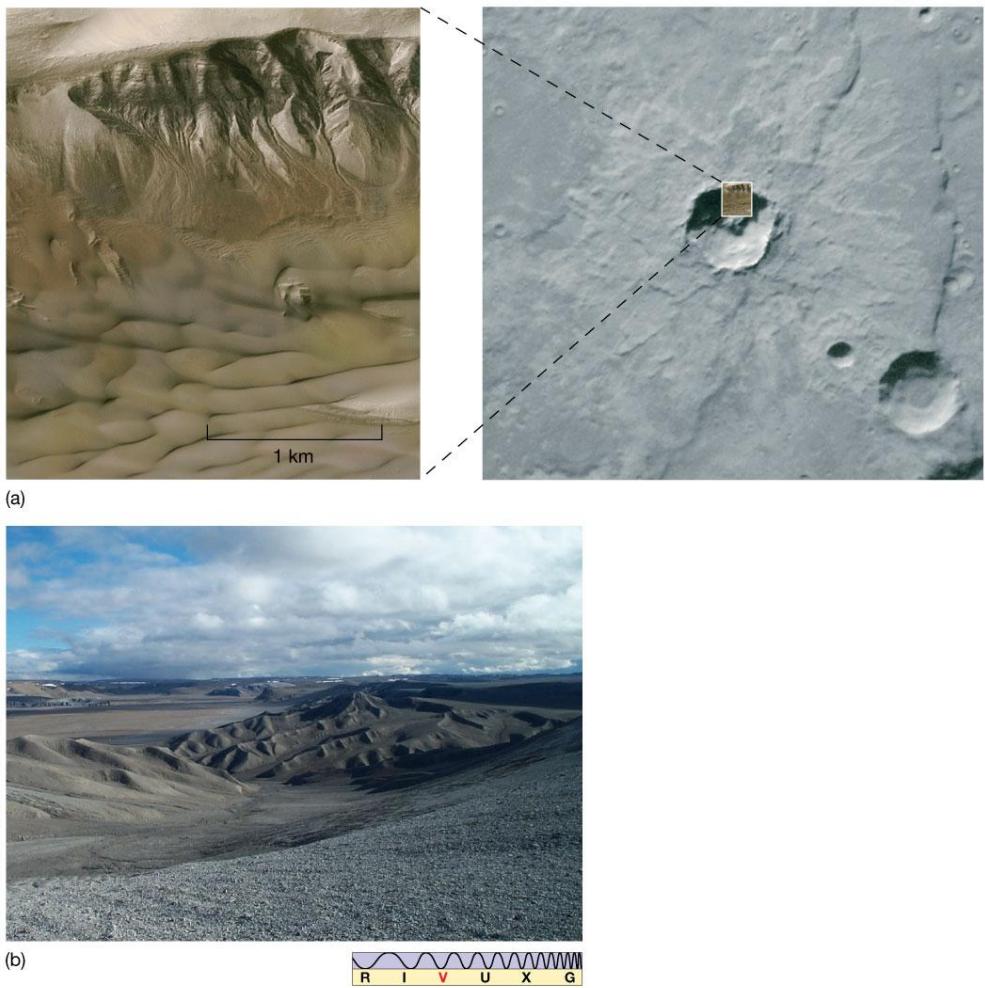
(a)



(b)

10.5 Water on Mars

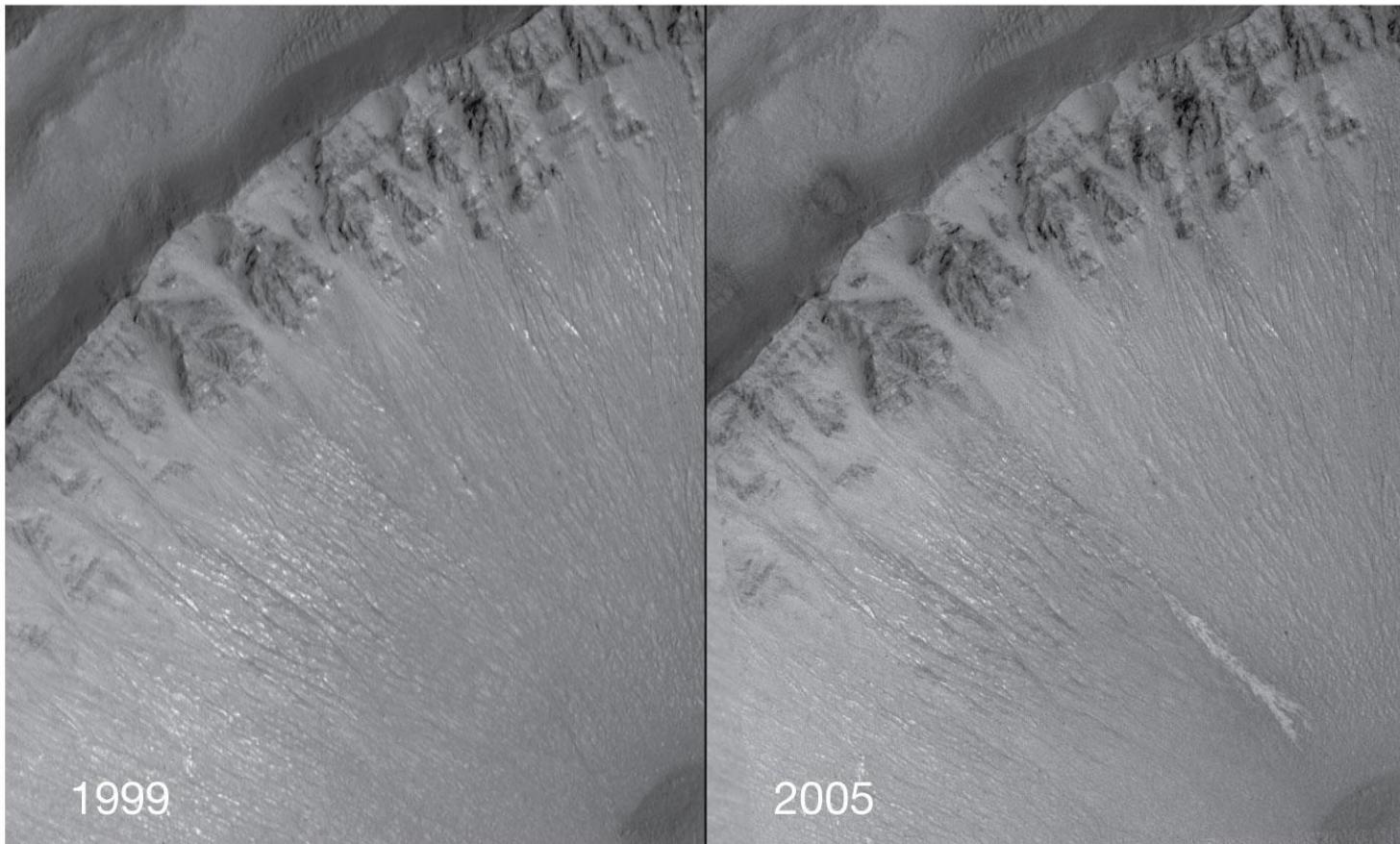
Recently, gullies have been seen that seem to indicate the presence of liquid water; interpretation is still in doubt



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10.5 Water on Mars

More intriguing, this pair of images appears to show that gully formation is ongoing



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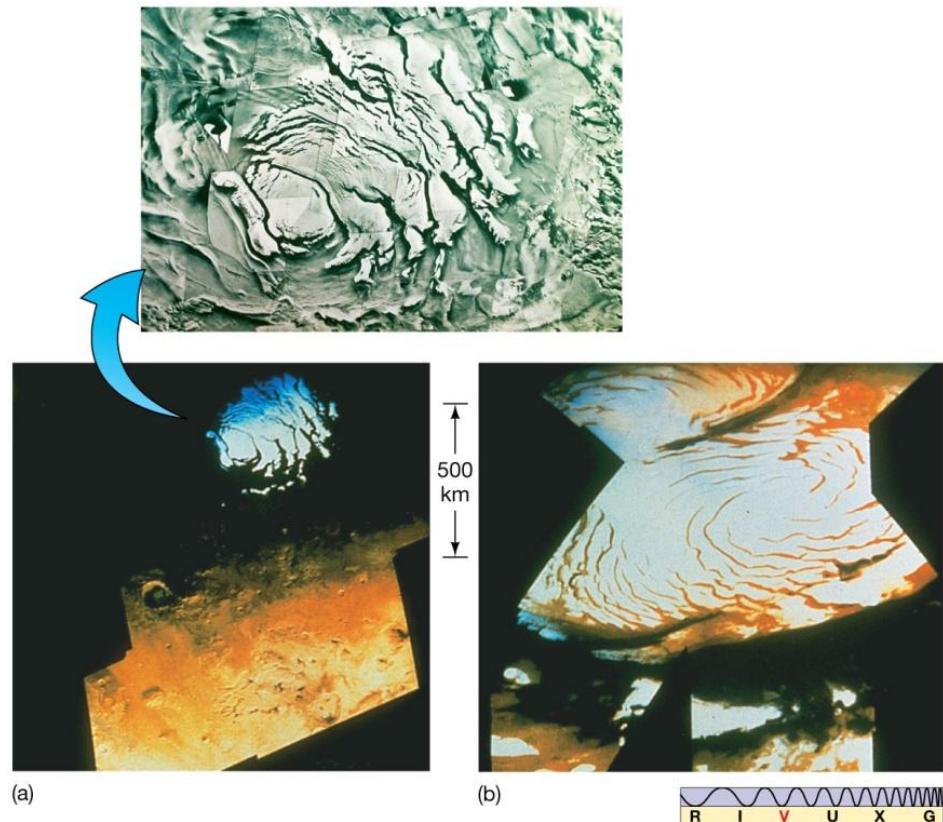
10.5 Water on Mars

Some water may now be permafrost under polar ice caps

Left: Southern polar cap, mostly carbon dioxide

Right: Northern polar cap, mostly water

Both images taken during local summer

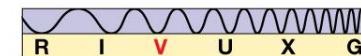


10.5 Water on Mars

Viking landers both landed in low-latitude northern plains

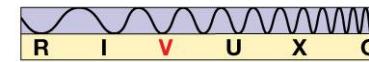
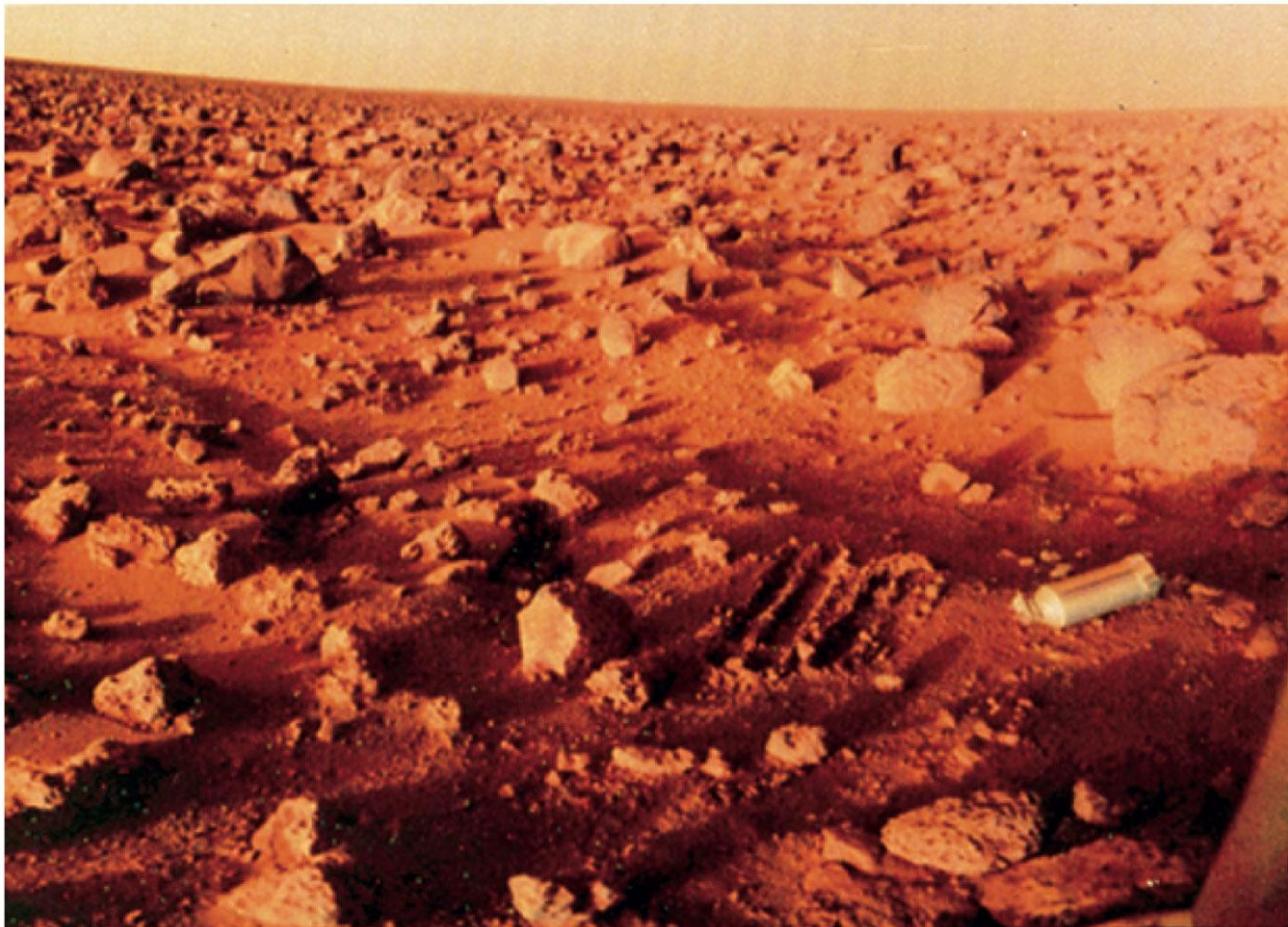
Rocky surface, red due to iron content

Viking 1



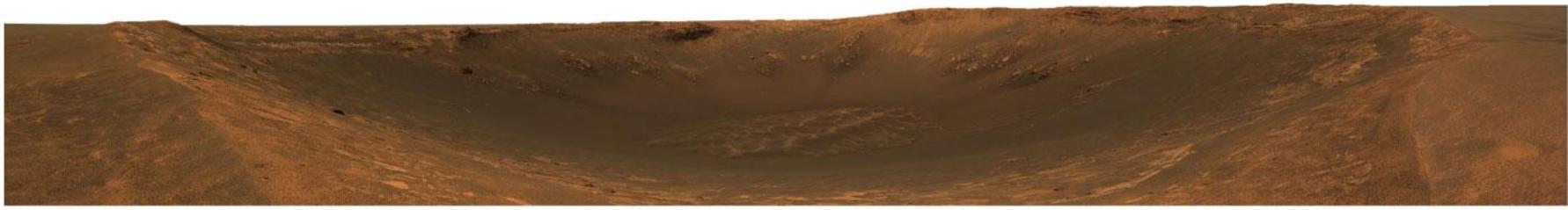
10.5 Water on Mars

Viking 2



10.5 Water on Mars

The landing site for *Opportunity* was chosen to maximize the chances of finding water, or evidence for water



(a)



(b)

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Discovery 10-1: Life on Mars?

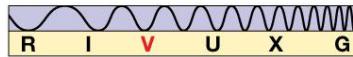
Viking landers looked for evidence of living organisms;
did not find anything conclusive



(Before)



(After)



Discovery 10-1: Life on Mars?

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

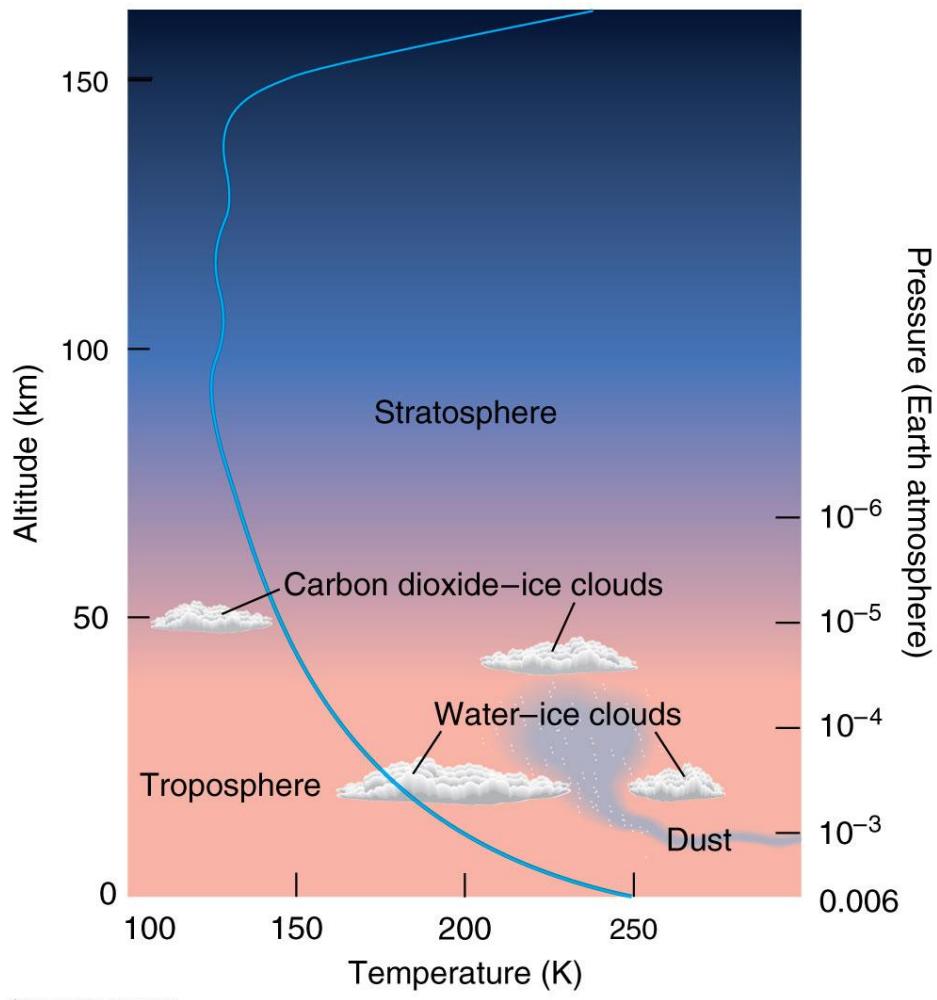


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10.6 The Martian Atmosphere

Martian atmosphere is mostly carbon dioxide, and very thin

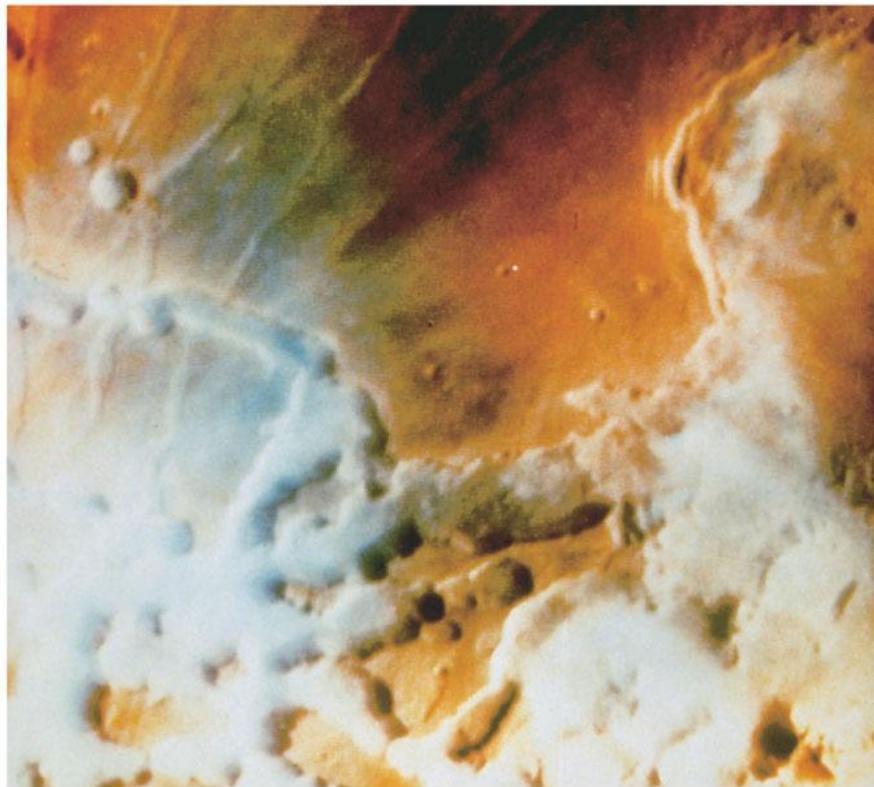
Too thin to retain much heat; temperature drops sharply at night



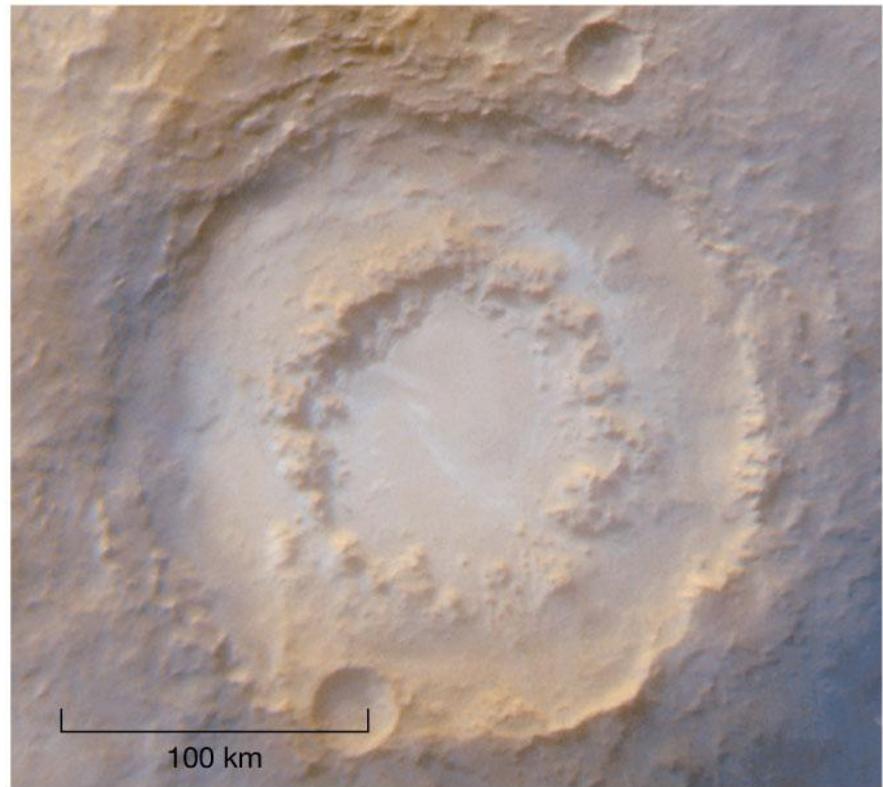
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10.6 The Martian Atmosphere

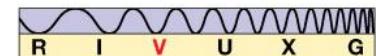
Fog can form in low-lying areas, as sunlight strikes



(a)



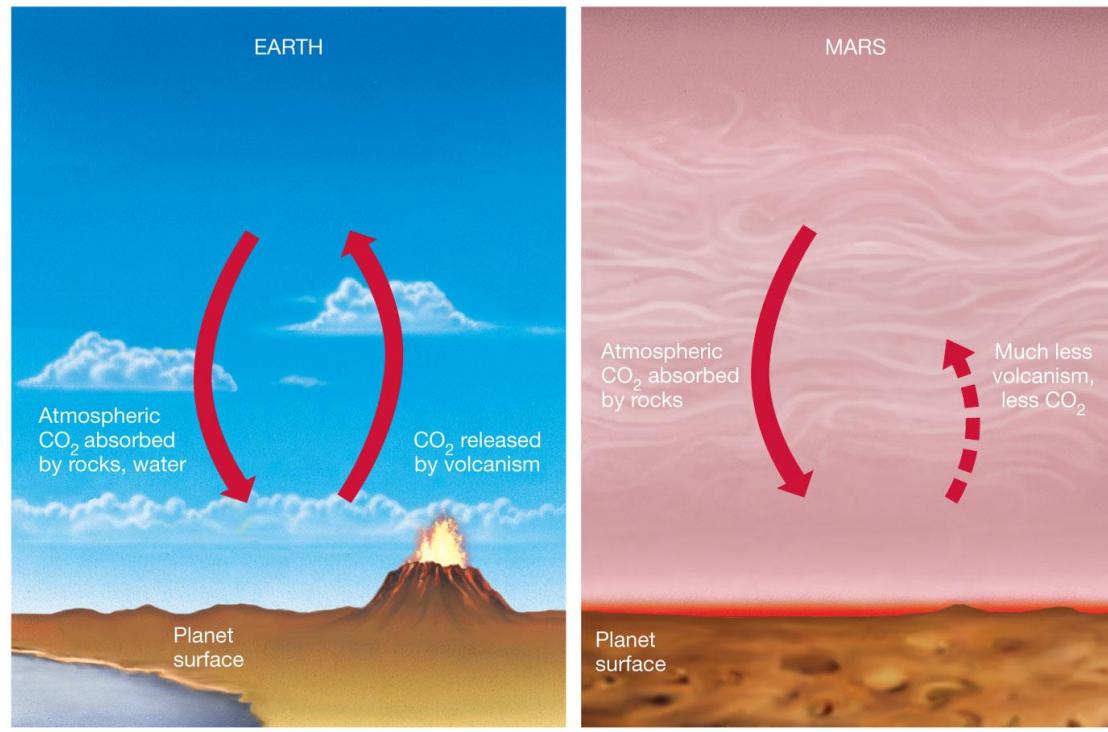
(b)



10.6 The Martian Atmosphere

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

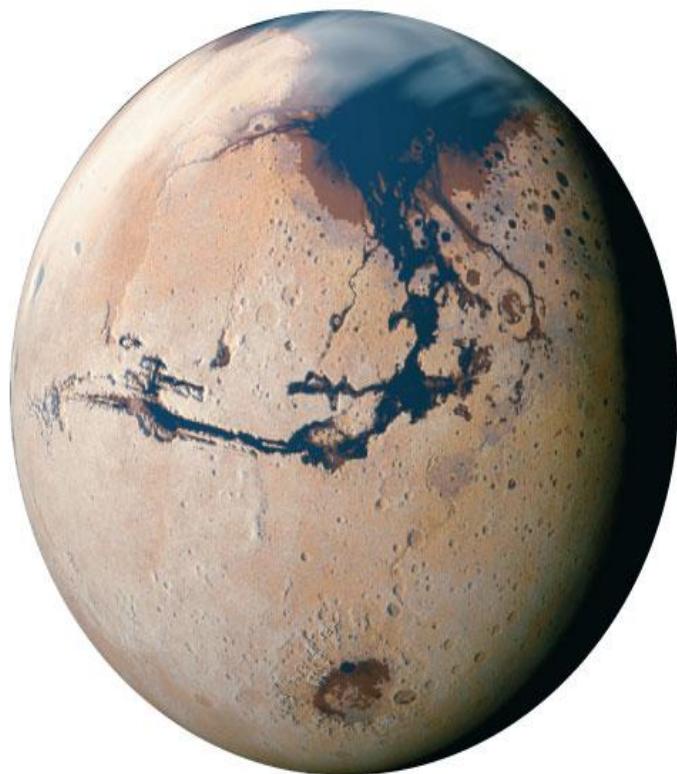
As water ice froze, Mars became more and more reflective and its atmosphere thinner and thinner, freezing more and more water and eventually carbon dioxide as well.



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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

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10.7 Martian Internal Structure

- No seismic studies have been done
- From behavior of crust, it is estimated to be 100 km thick
- No magnetic field, so core is probably not metallic, not liquid, or neither liquid nor metallic

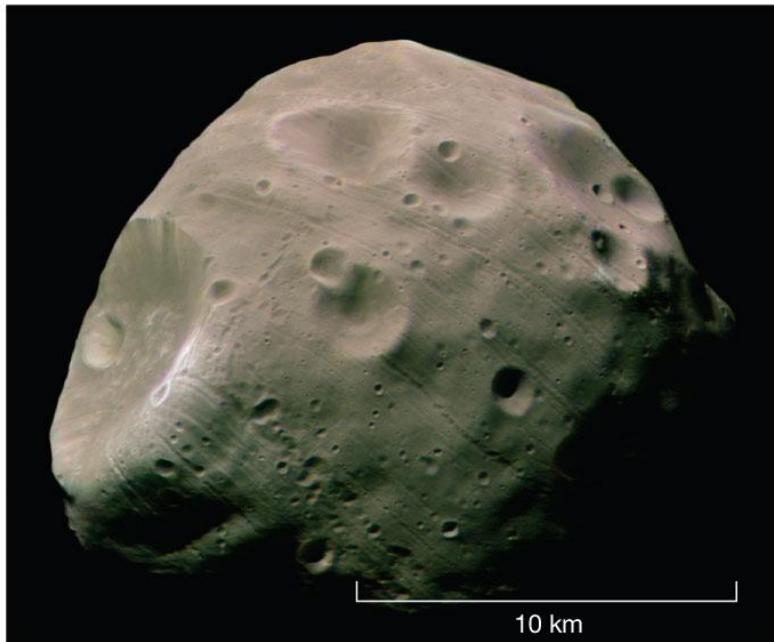
10.8 The Moons of Mars

Mars has two tiny moons:

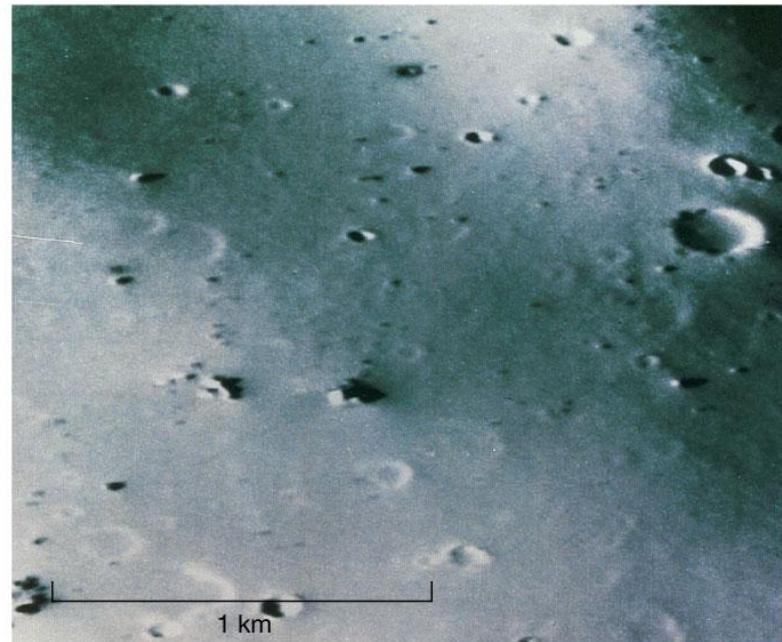
Phobos (left, 28 km x 20 km)

Deimos (right, 16 km x 10 km)

Both probably captured from the asteroid belt



(a)



(b)



Summary of Chapter 10

- Mars's orbit is more eccentric than Earth's
- Rotates in 24.6 hours; axial tilt similar to Earth's
- Atmosphere very thin, mostly carbon dioxide
- Temperature averages 50 K below Earth's, but seasons are otherwise similar
- Mars landers have yielded substantial amounts of data

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
- Crater ejecta provide evidence for permafrost layer under surface (easily liquidized)
- Two small moons, probably captured asteroids