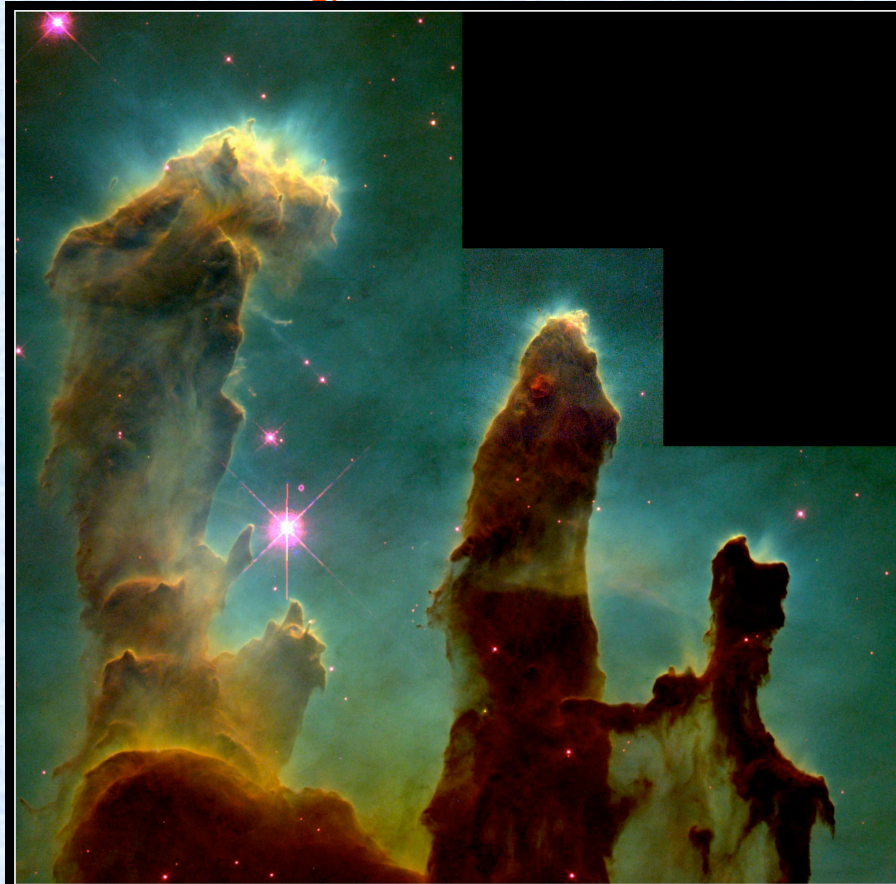


Astronomy 1 – Winter 2011



Gaseous Pillars in M16 • Eagle Nebula
Hubble Space Telescope • WFPC2

PRC95-44a • ST ScI OPO • November 2, 1995 • J. Hester and P. Scowen (AZ State Univ.), NASA

Lecture 14; February 7 2011

Previously on Astro-1

- **Global Warming**
 - Is Earth getting warmer?
 - Are humans causing it?
 - What are the consequences?
 - What can we do to stop it?

Stargazing Events

- Santa Barbara Museum of Natural History
 - Feb 12, this Saturday. 7PM
 - March 12. 7PM
 - Ticket is \$2
 - 2% credit if you sign your name at the museum
- Broida Hall
 - March 7/8
 - 2% credit, first come first served basis, register with TA. Instructions to be given later (-2% if you register and don't show up!)
- **YOU CAN ONLY GET CREDIT FOR ONE EVENT**

Today on Astro-1

- **Mercury, Venus, Mars (and Earth)**
 - **Size and composition**
 - **Crusts and cores**
 - **Volcanism and internal activity**

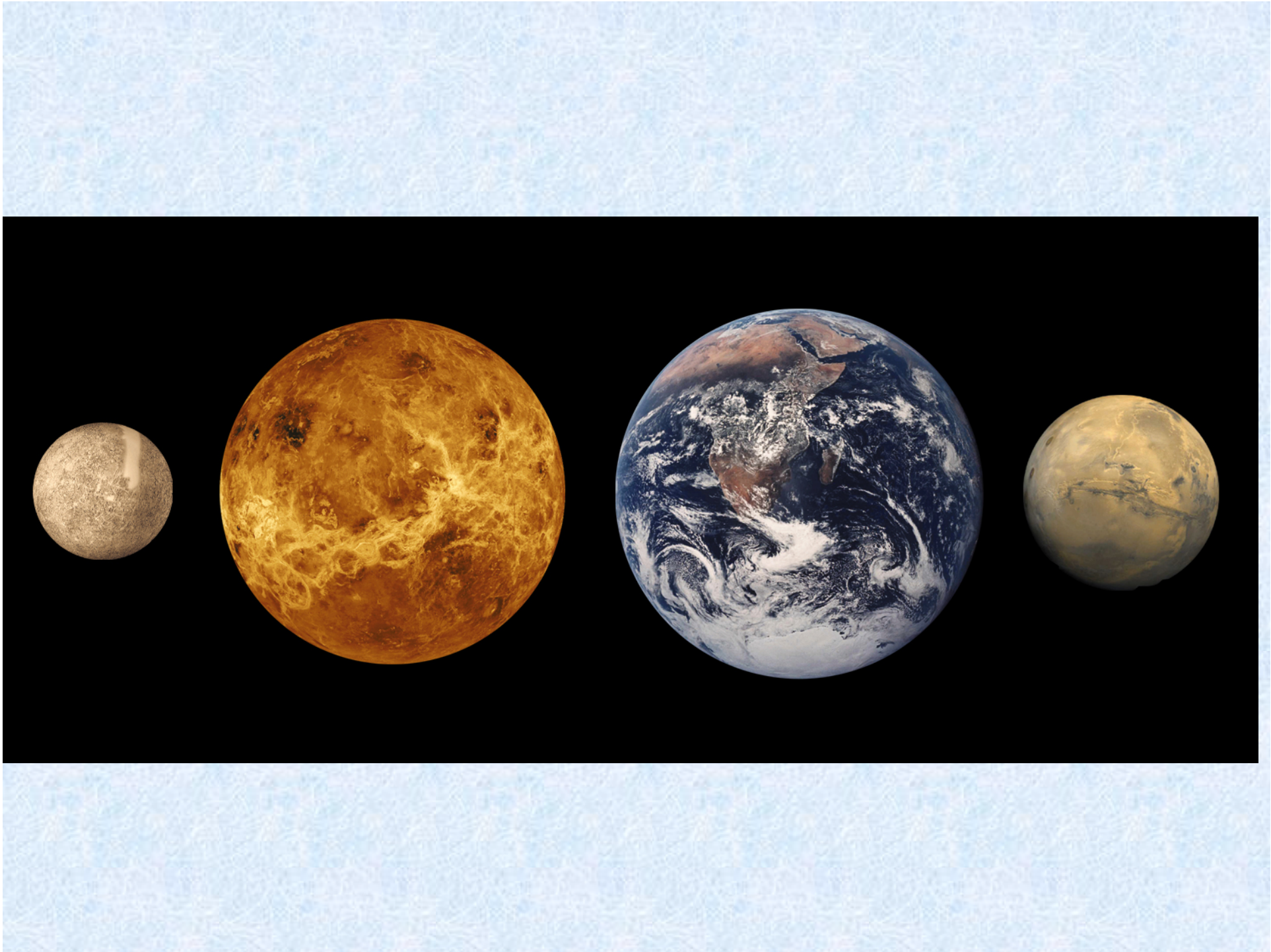
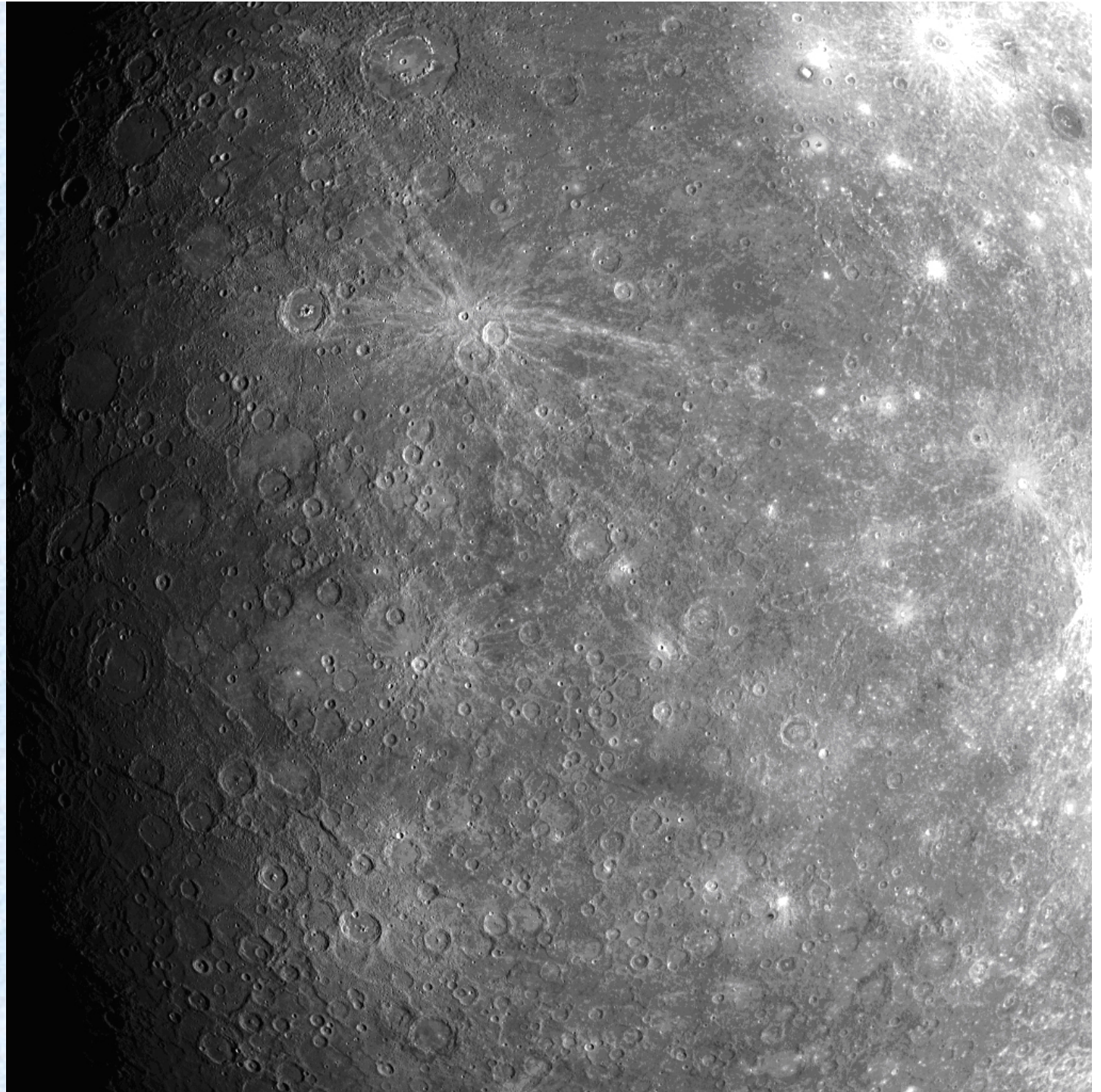




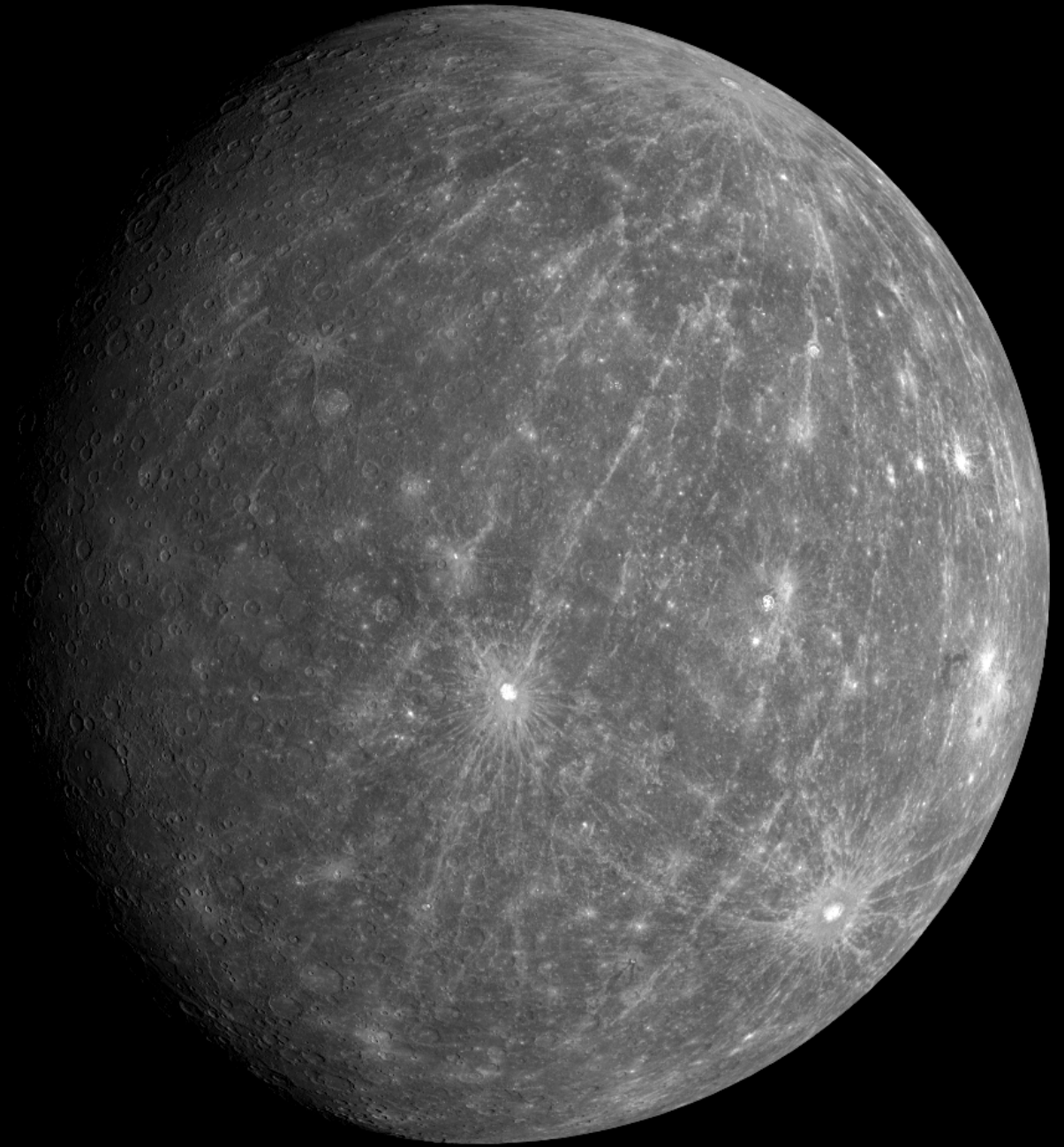
Figure 11-8
Universe, Eighth Edition
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**MESSENGER's
Journey to
Mercury**

New images
of never-
before-seen
regions of
Mercury from
Messenger
spacecraft
released in
2009



Messenger 2nd
flyby.



Mercury Orbit Insertion

Coming up soon!! March 18 2011

Mantle

Earth

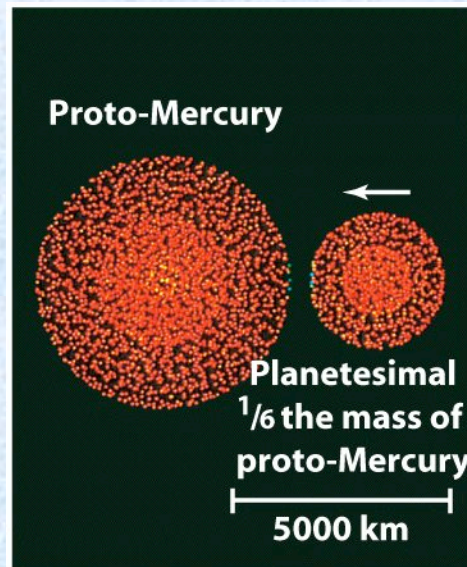
Earth's iron core is 55% of the diameter of the entire planet, or 17% of its volume...

Mantle

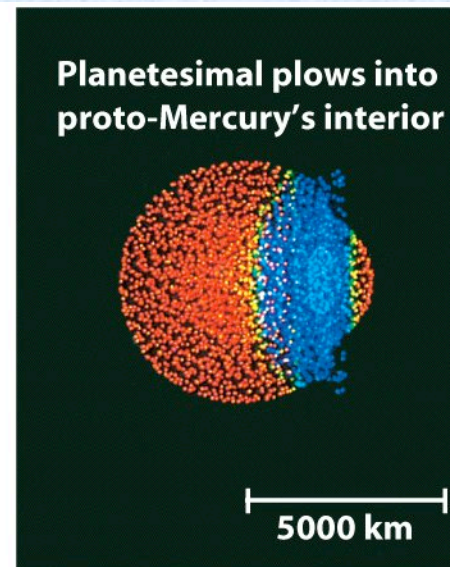
Mercury

...whereas Mercury's iron core is about 75% of the planet's diameter, or 42% of its volume.

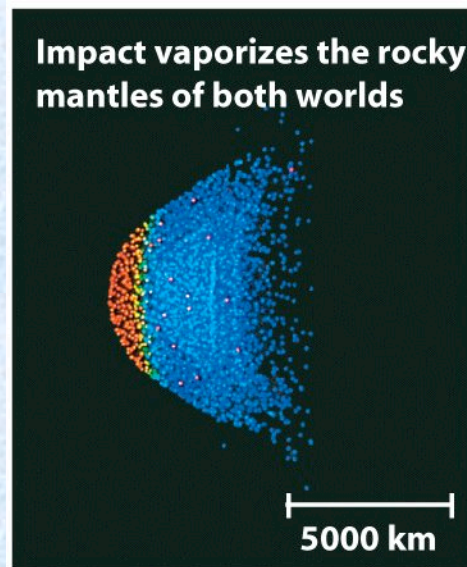
Figure 11-12
Universe, Eighth Edition
© 2008 W. H. Freeman and Company



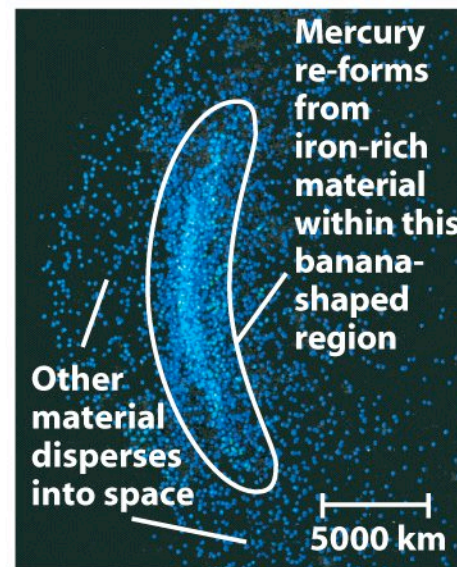
Just before contact



3 minutes after contact



6 minutes after contact



30 minutes after contact

Figure 11-13

Universe, Eighth Edition

© 2008 W. H. Freeman and Company

Main features of Mercury

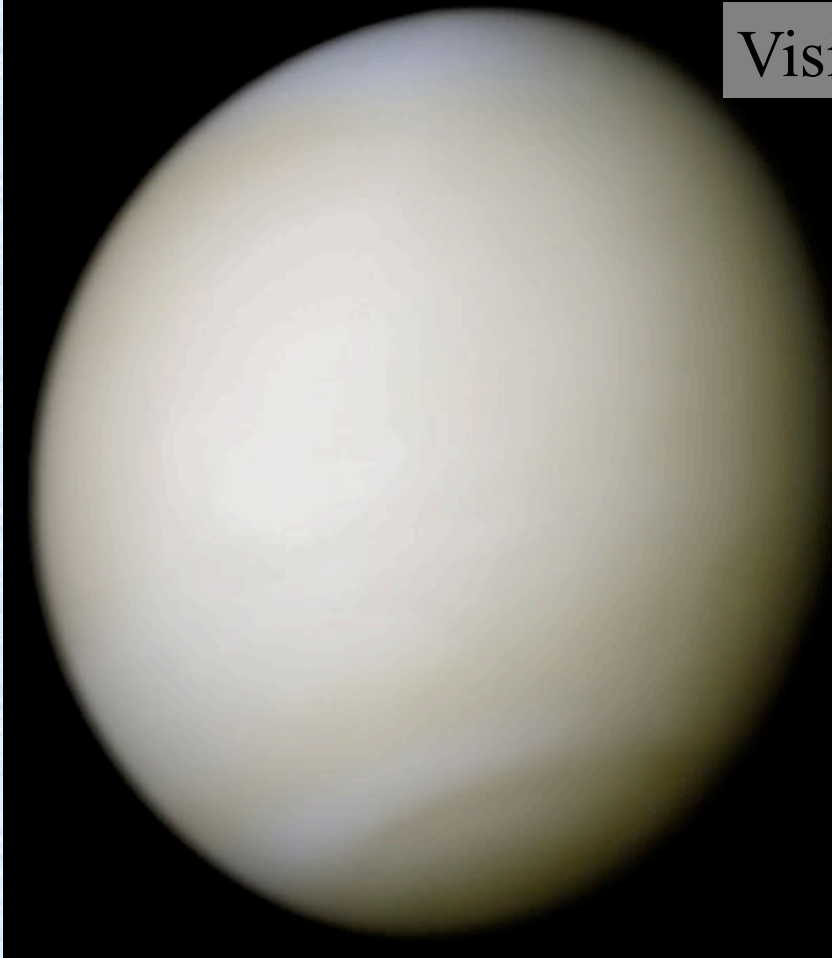
- **Too small and hot to have atmosphere**
- **Orbit is eccentric, in 2/3 resonance with rotation on its axis**
 - **Sun rises mostly in the East but occasionally in the West!**
- **Days (almost 3 Earth-month long) are very hot (700K at equator), Nights very cold (100K)**
- **Small molten iron core**
- **Weak magnetic field**
- **No volcanism**

Question 14.1 (iclickers!)

- There is no evidence of plate tectonics on Mercury. The most likely explanation is
 - A) The planet cooled too slowly and the mantle remained too soft
 - B) The planet cooled too rapidly and the mantle became too rigid
 - C) Mercury has no iron core like Earth
 - D) Plate tectonics can only occur on a body with continents separated by oceans

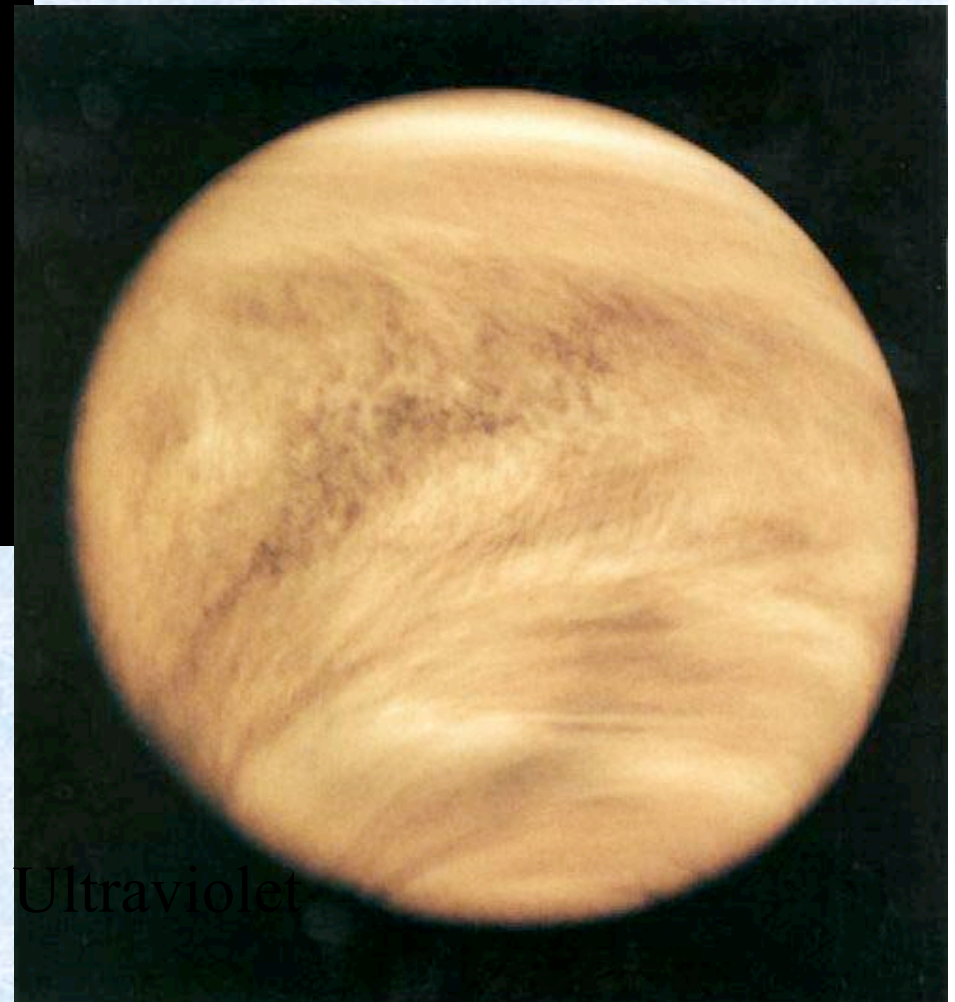
Visible light

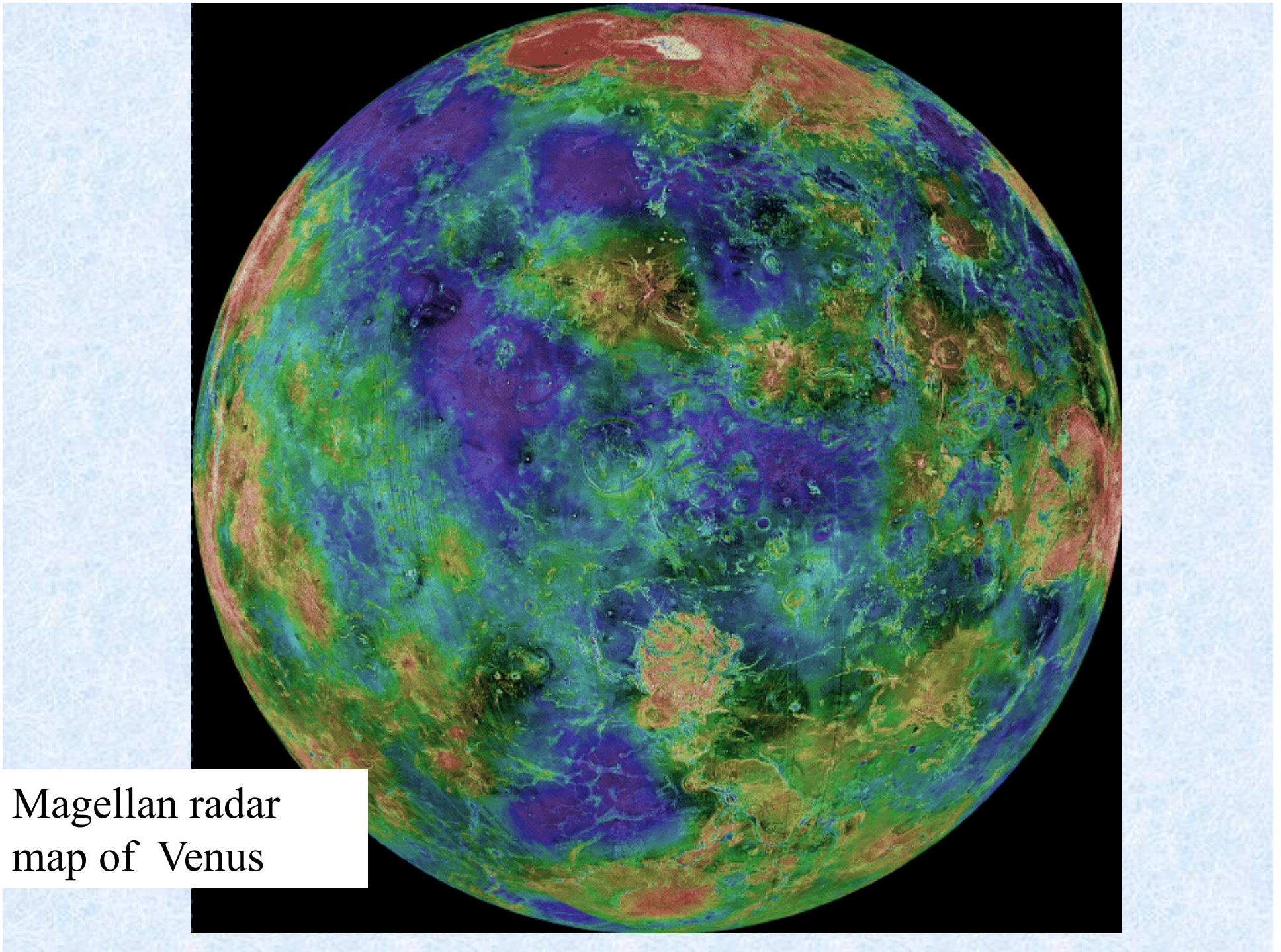
Venus



Venus is covered by a thick CO₂ atmosphere and has sulfur dioxide (battery acid) clouds.

Ultraviolet





Magellan radar
map of Venus

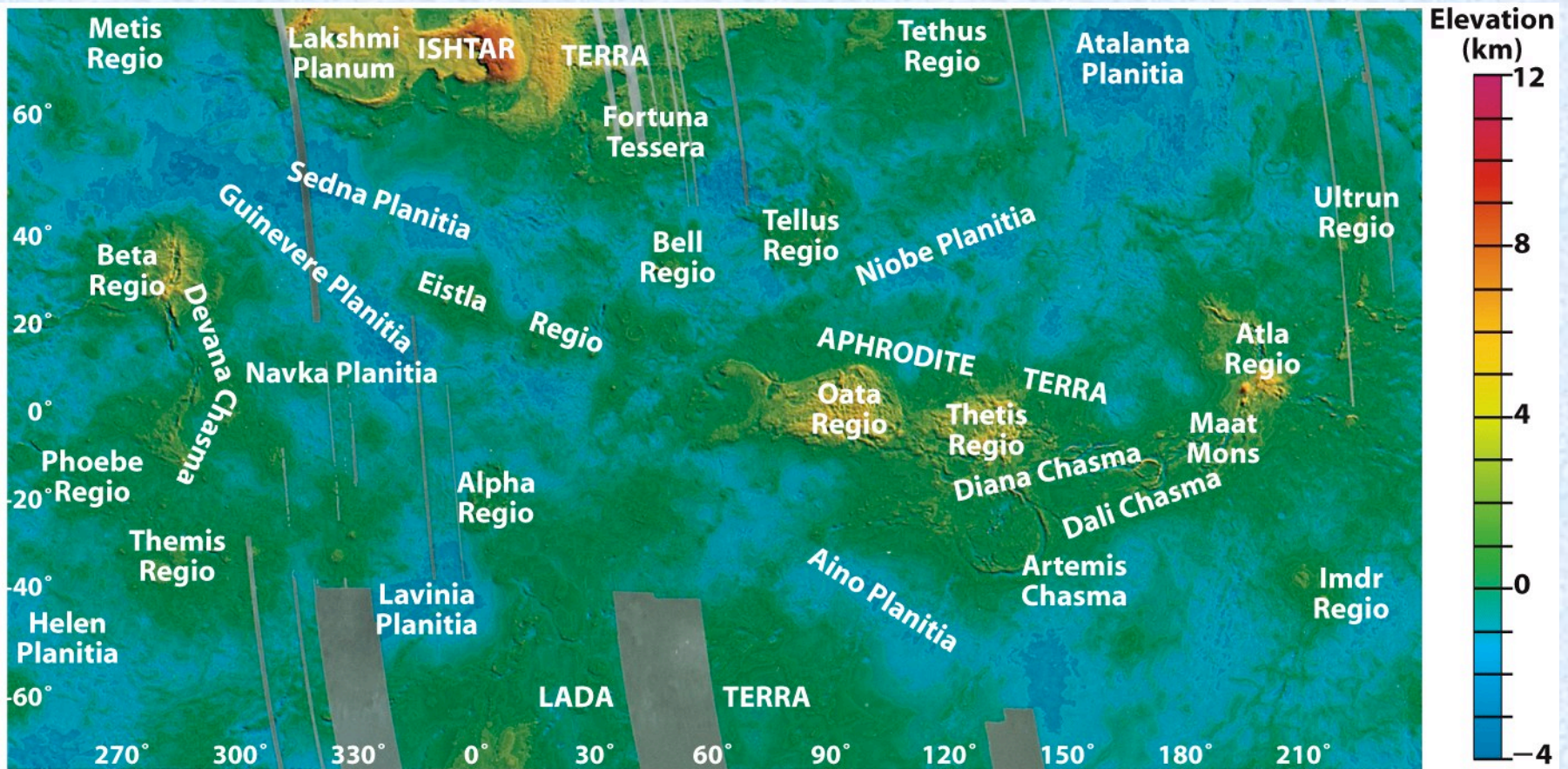


Figure 11-19
Universe, Eighth Edition
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Radar altimeter measurements of Venus. Color indicates elevations -- the blue areas are *not* oceans! Gray areas were not mapped by *Magellan*. Flat plains of volcanic origin cover most of the planet's surface, with only a few continentlike highlands.

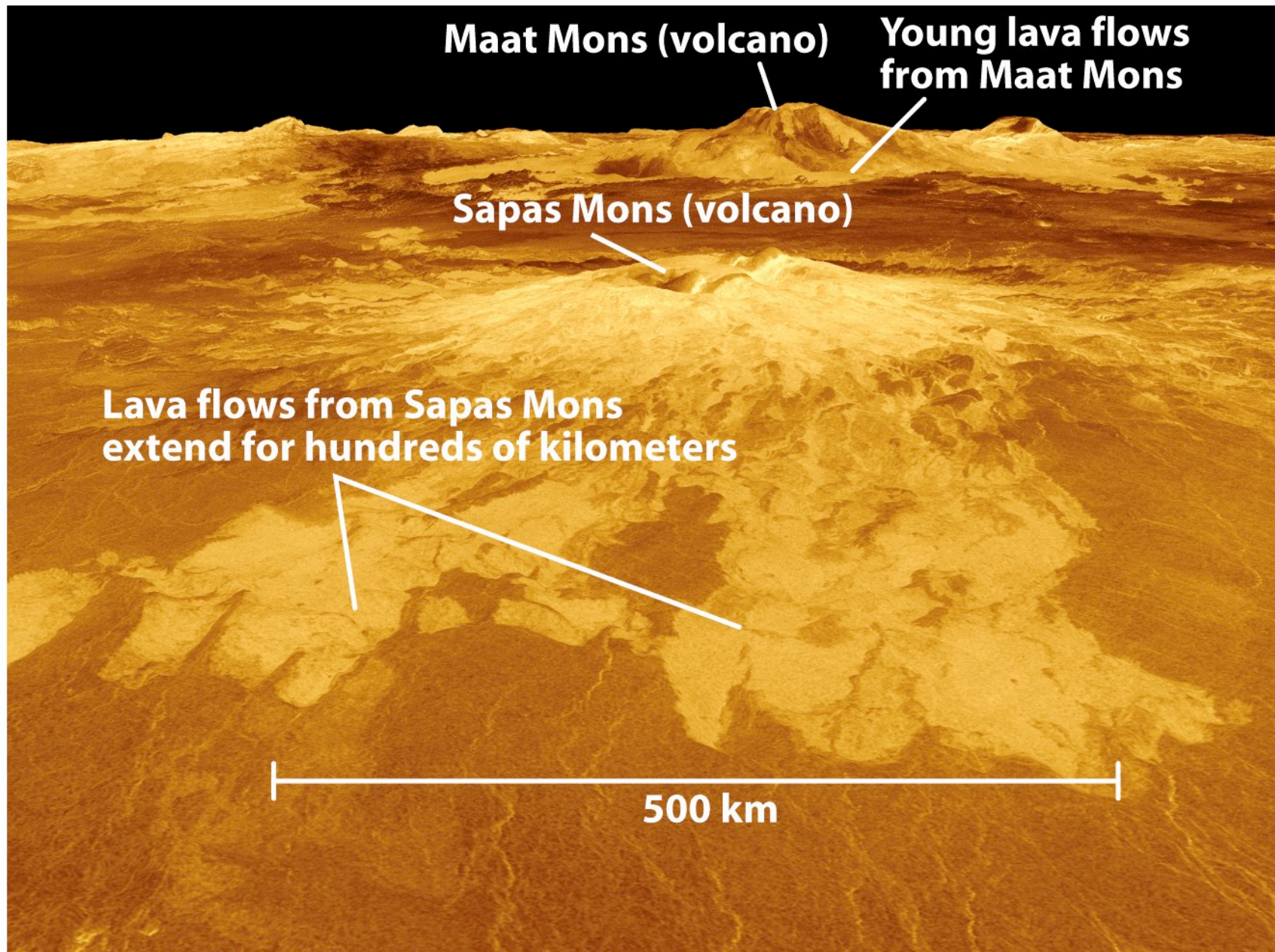


Figure 11-24a
Universe, Eighth Edition
© 2008 W. H. Freeman and Company

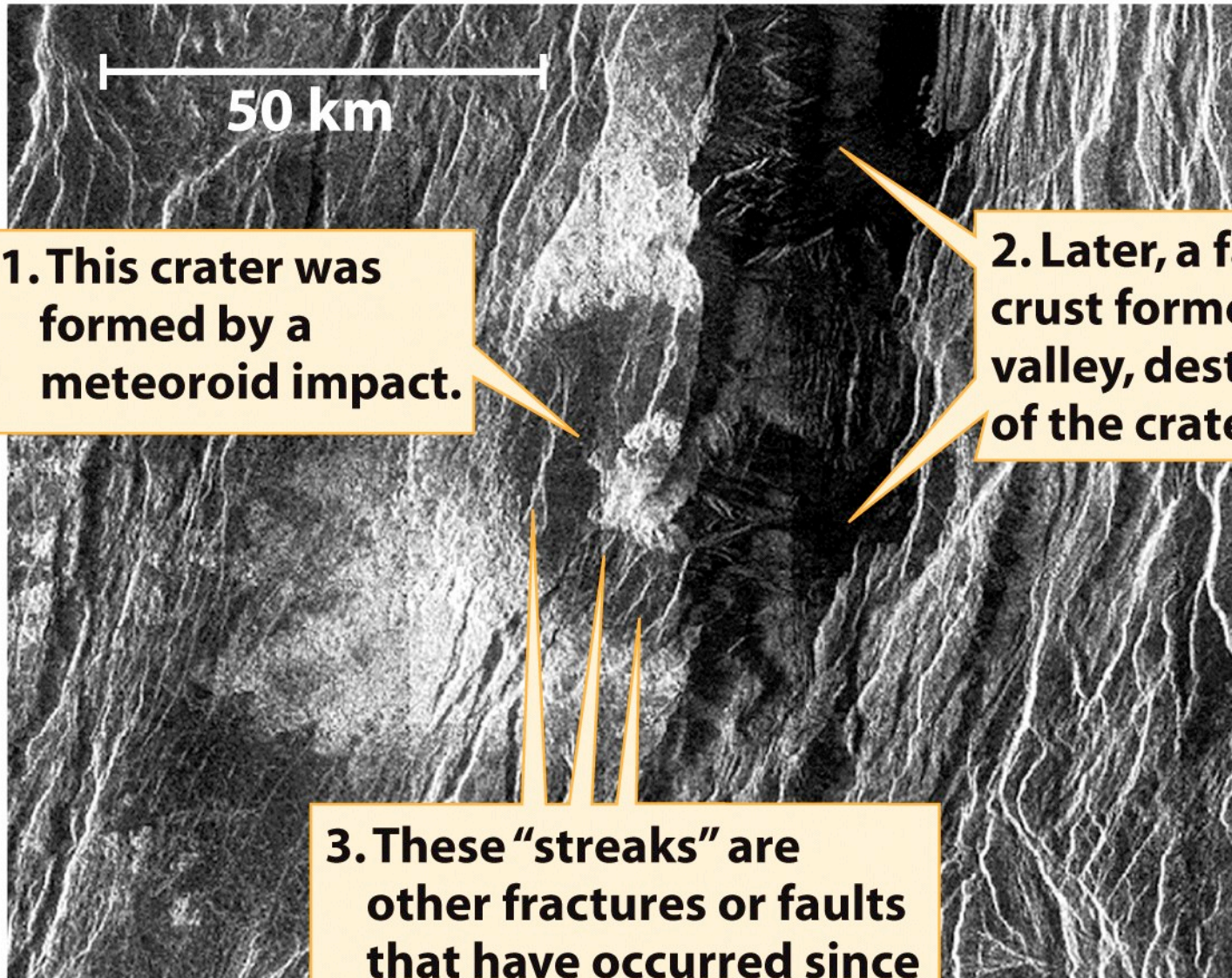


Figure 11-21
Universe, Eighth Edition
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1. Hot matter from the mantle rises,...

2. ...causing plates to form and diverge.

3. Where plates converge, a cooled plate is dragged under the neighboring plate,...

4. ...sinks, warms, and rises again.

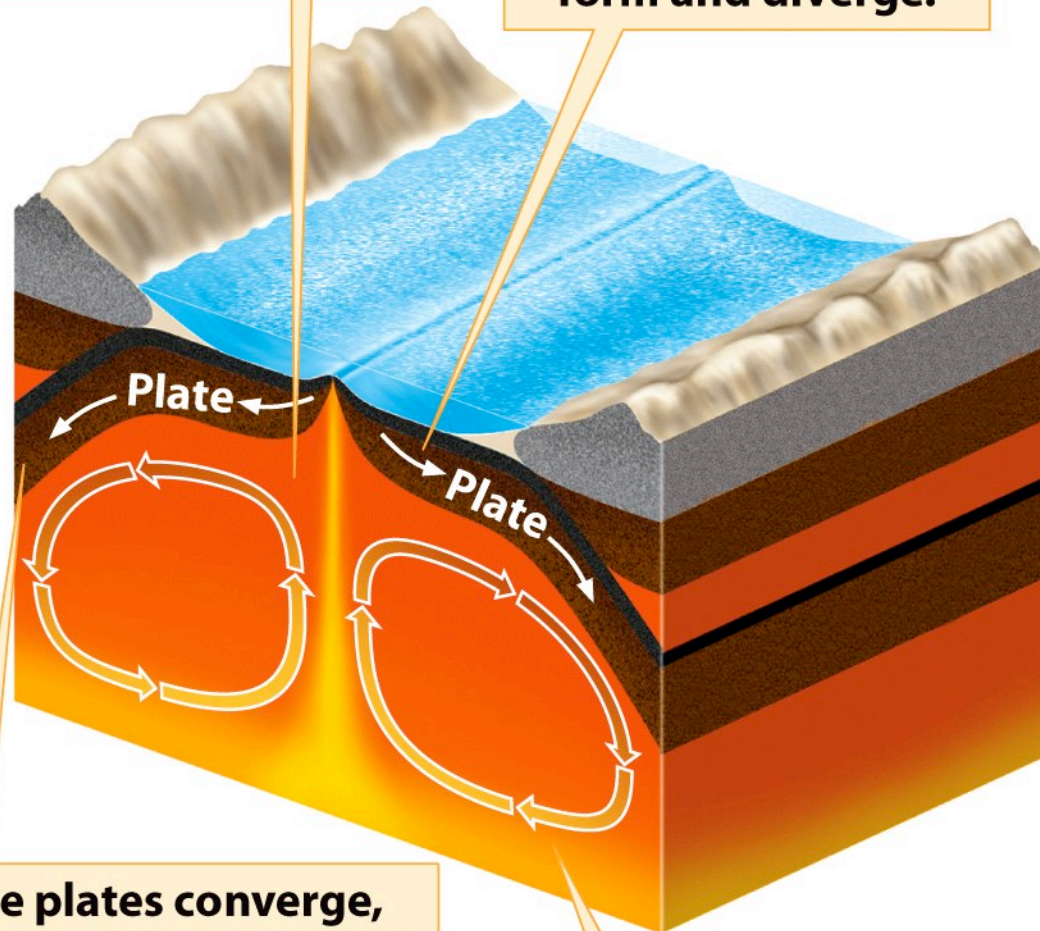
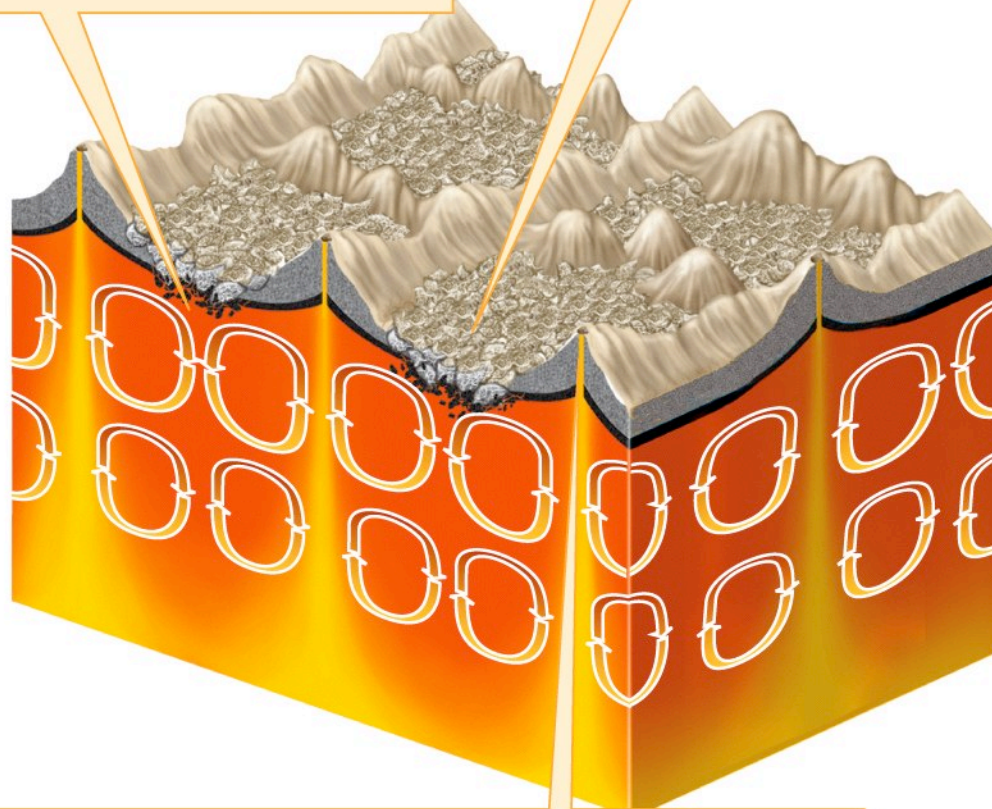


Figure 11-22 part 1
Universe, Eighth Edition
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5. On Venus, in contrast, convection currents are more vigorous. They prevent thick crust from forming, and push and stretch the thin crust that does form.

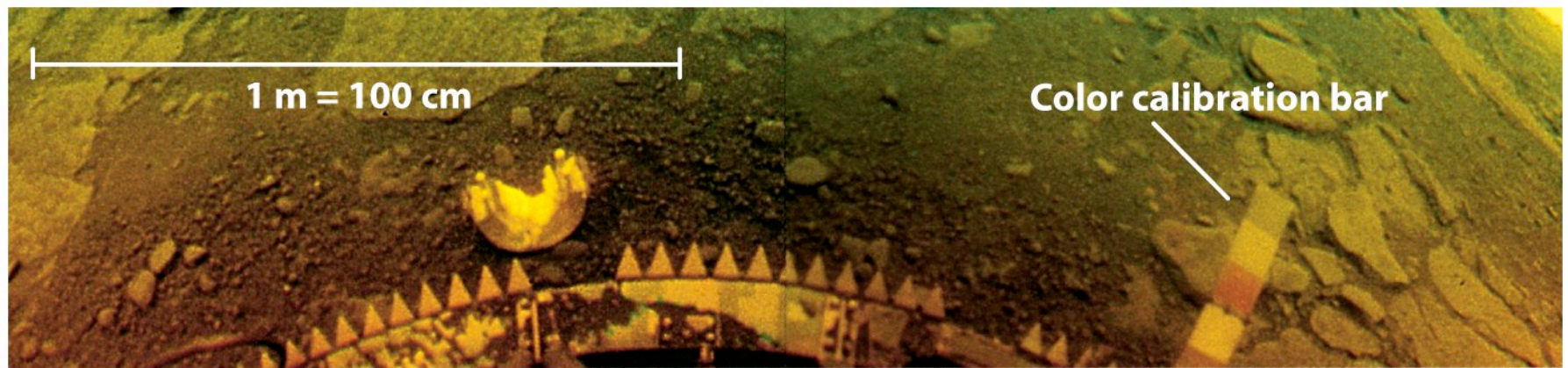
6. The surface crust breaks up into flakes or crumples like a rug.



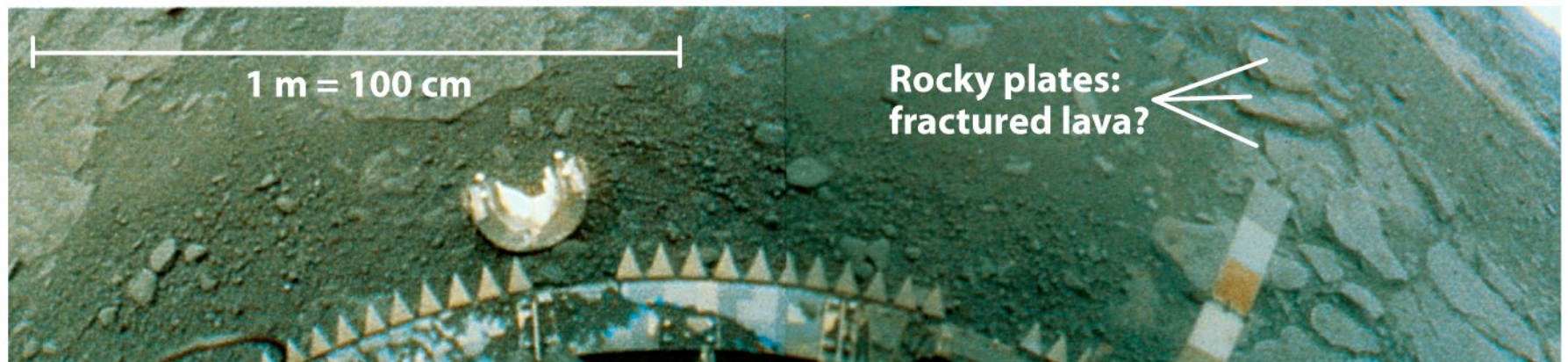
7. As the mantle moves around, blobs of hot lava bubble up to form large landmasses, mountains, and volcanic deposits.

Figure 11-22 part 2
Universe, Eighth Edition

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(a) Image from *Venera 13*



(b) Color-corrected image

Figure 11-26

Universe, Eighth Edition

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The lander survived for 127 minutes in an environment with a temperature of $457\text{ }^{\circ}\text{C}$ ($855\text{ }^{\circ}\text{F}$) and a pressure of 89 Earth atmospheres.

Main features of Venus

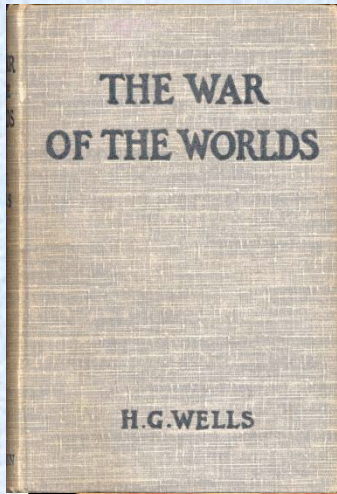
- **Almost as big as Earth**
- **Ultradense atmosphere (~90 atmosphere pressure) dominated by CO₂**
- **Huge greenhouse effect (+400K)**
- **Retrograde motion (probably from Sun's gravity + winds)**
 - **Sun rises in the West!**
- **Days are VERY long, and temperature is uniform because of atmosphere (730K)**
- **Mostly molten**
- **No magnetic field (no rotation)**
- **Volcanism and flake tectonics**

Question 14.2 (iclickers!)

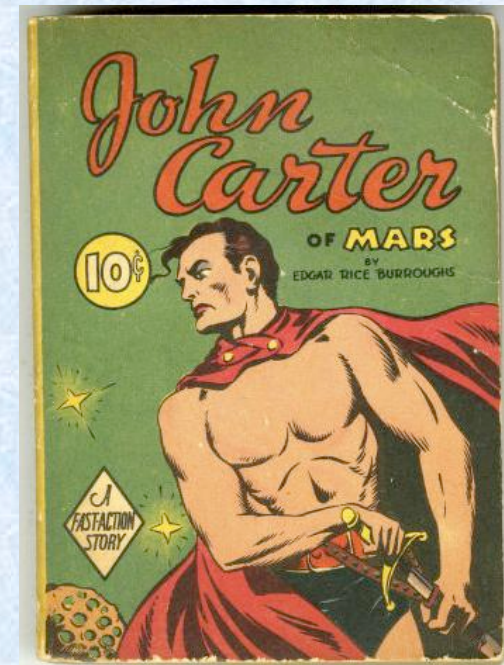
• Venus has a higher surface temperature than Mercury.

Which of the following is an explanation for this fact?

- A) Venus is closer to the Sun than Mercury is
- B) Venus has a dense atmosphere of carbon dioxide
- C) Venus is still contracting gravitationally and thus gives out more radiation than it receives.
- D) Venus has a higher albedo than Mercury



Schiaparelli's
imaginary "canals"



Mars



Figure 11-16
Universe, Eighth Edition
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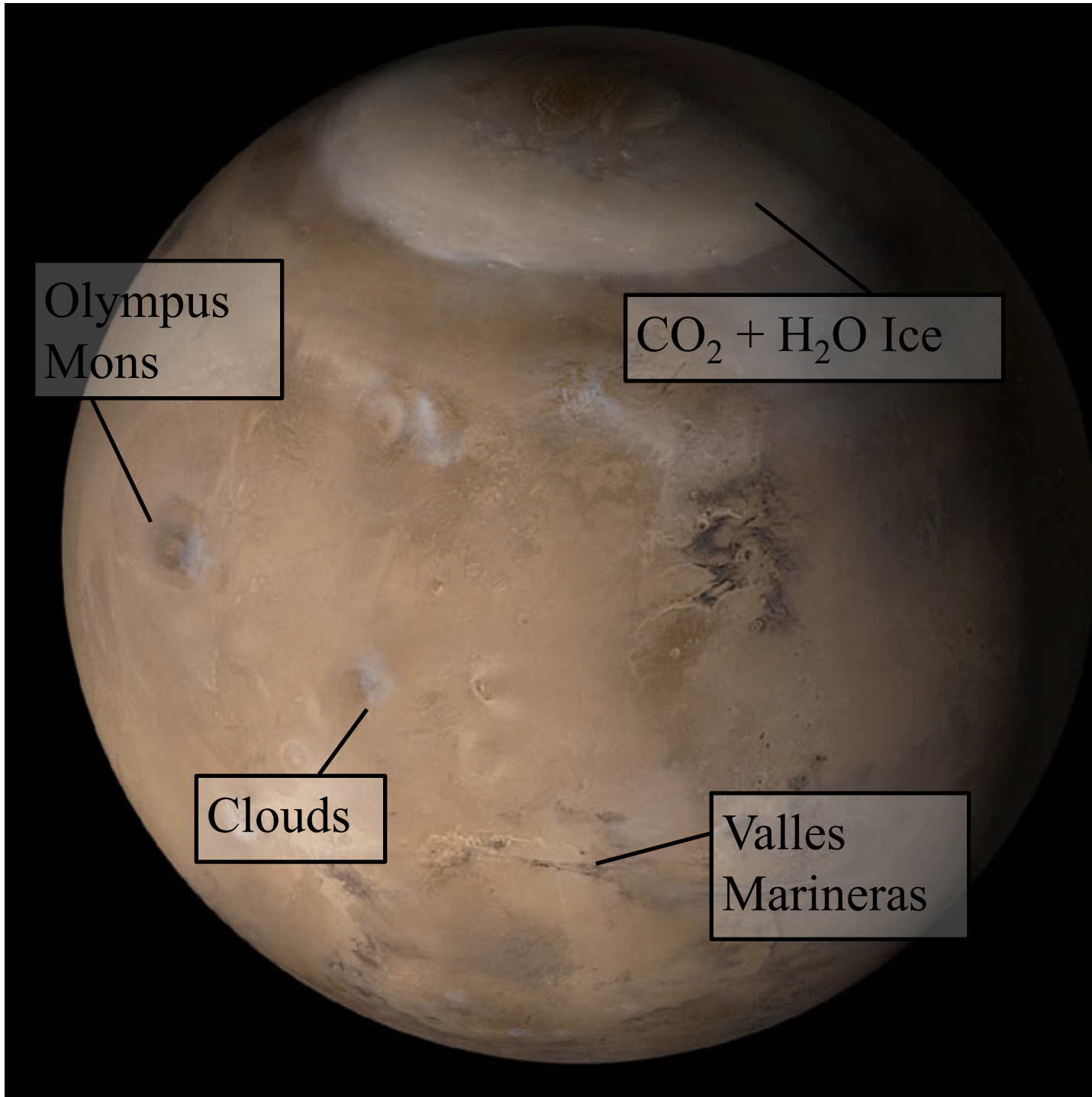
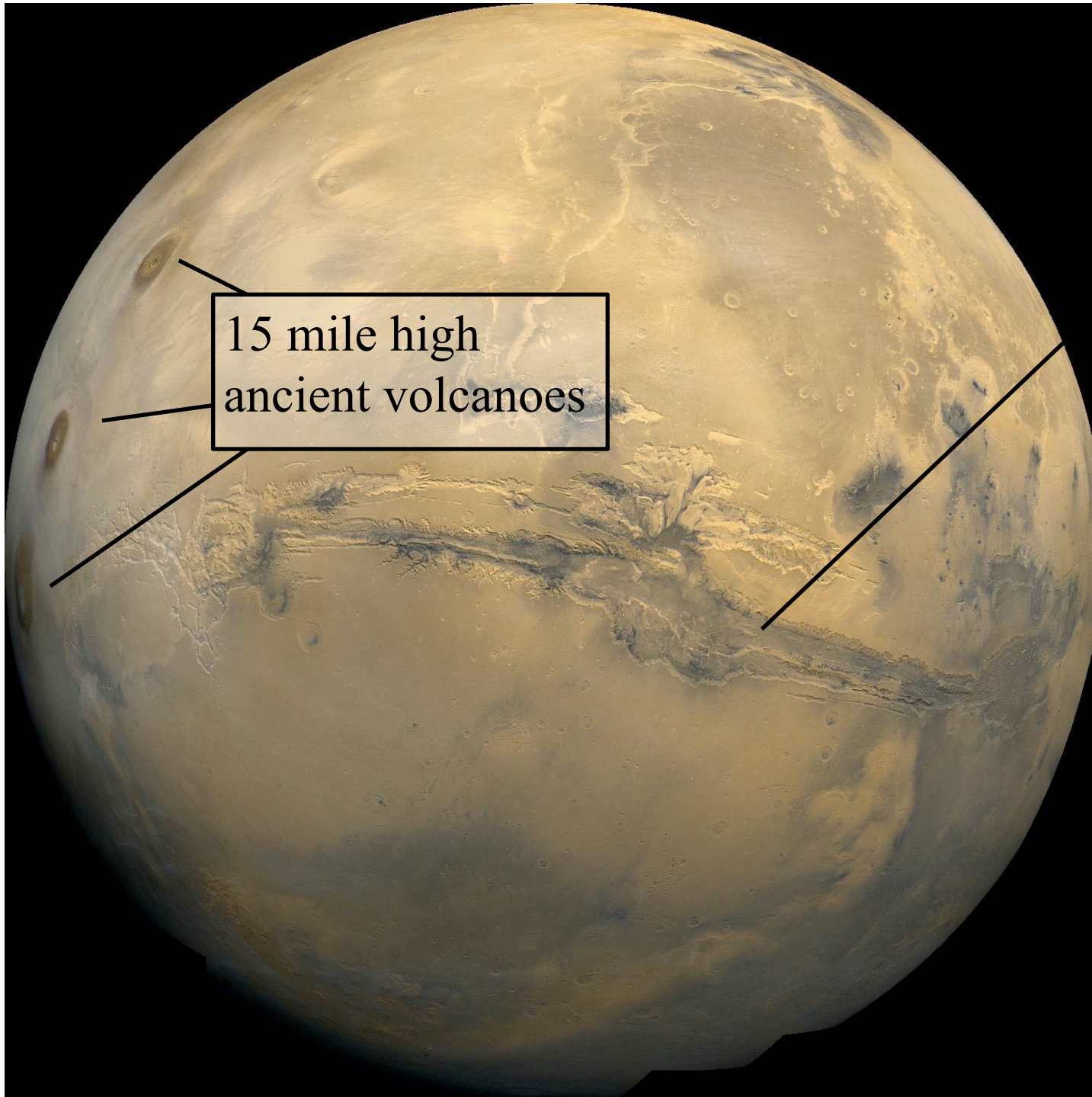


Image from
Mars Global
Surveyor in
May 2002,
spring in the
northern
hemisphere

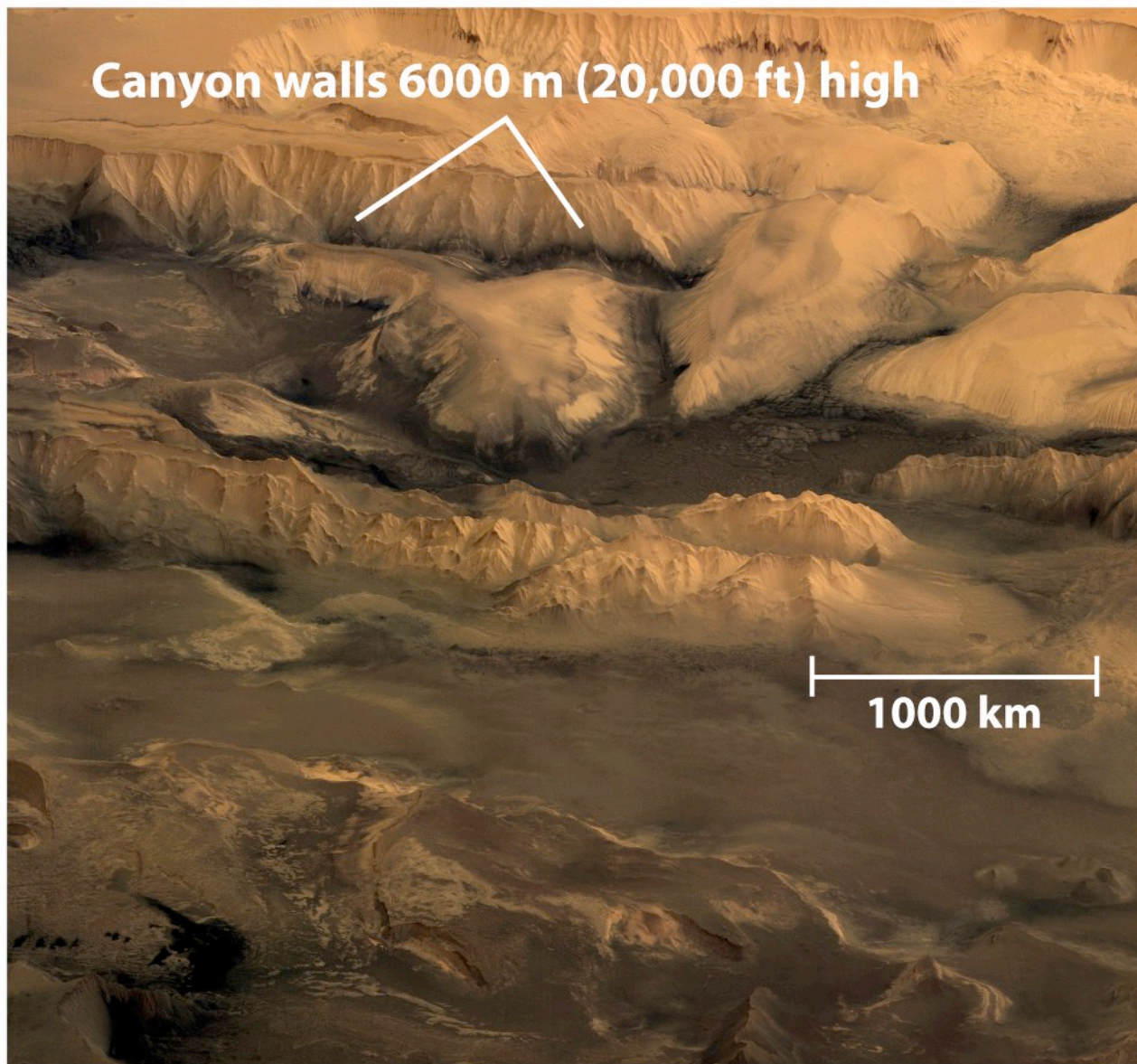
Mars



Viking Orbiter
image of Mars

Valles

Marineris, the
largest chasm
in the solar
system, 1,860
miles from
west to east, up
to 5 miles deep
(5x the Grand
Canyon)



This perspective image from the *Mars Express* spacecraft shows what you would see from a point high above the central part of Valles Marineris

The central region of Valles Marineris

Figure 11-23b
Universe, Eighth Edition
© 2008 W. H. Freeman and Company

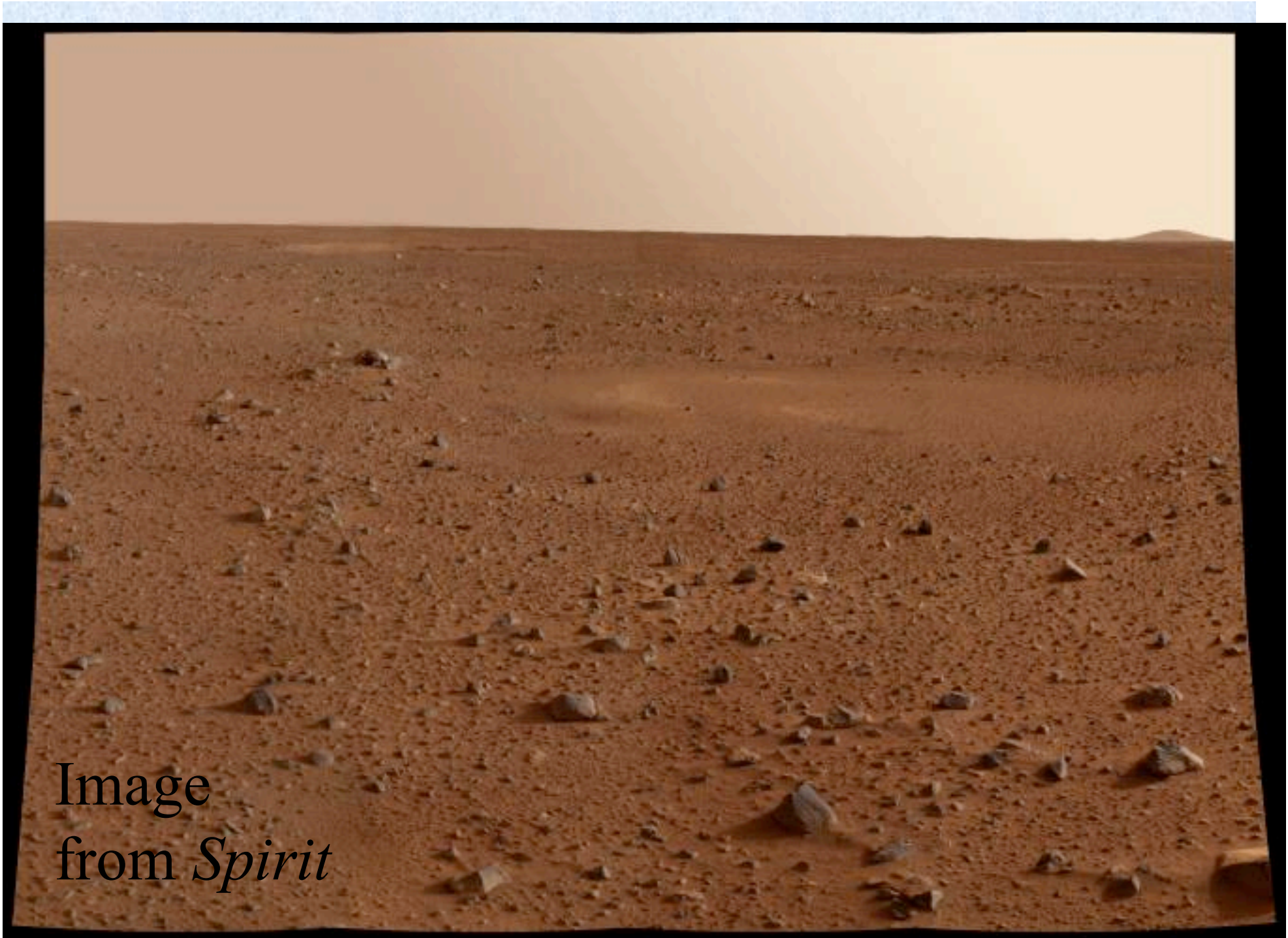
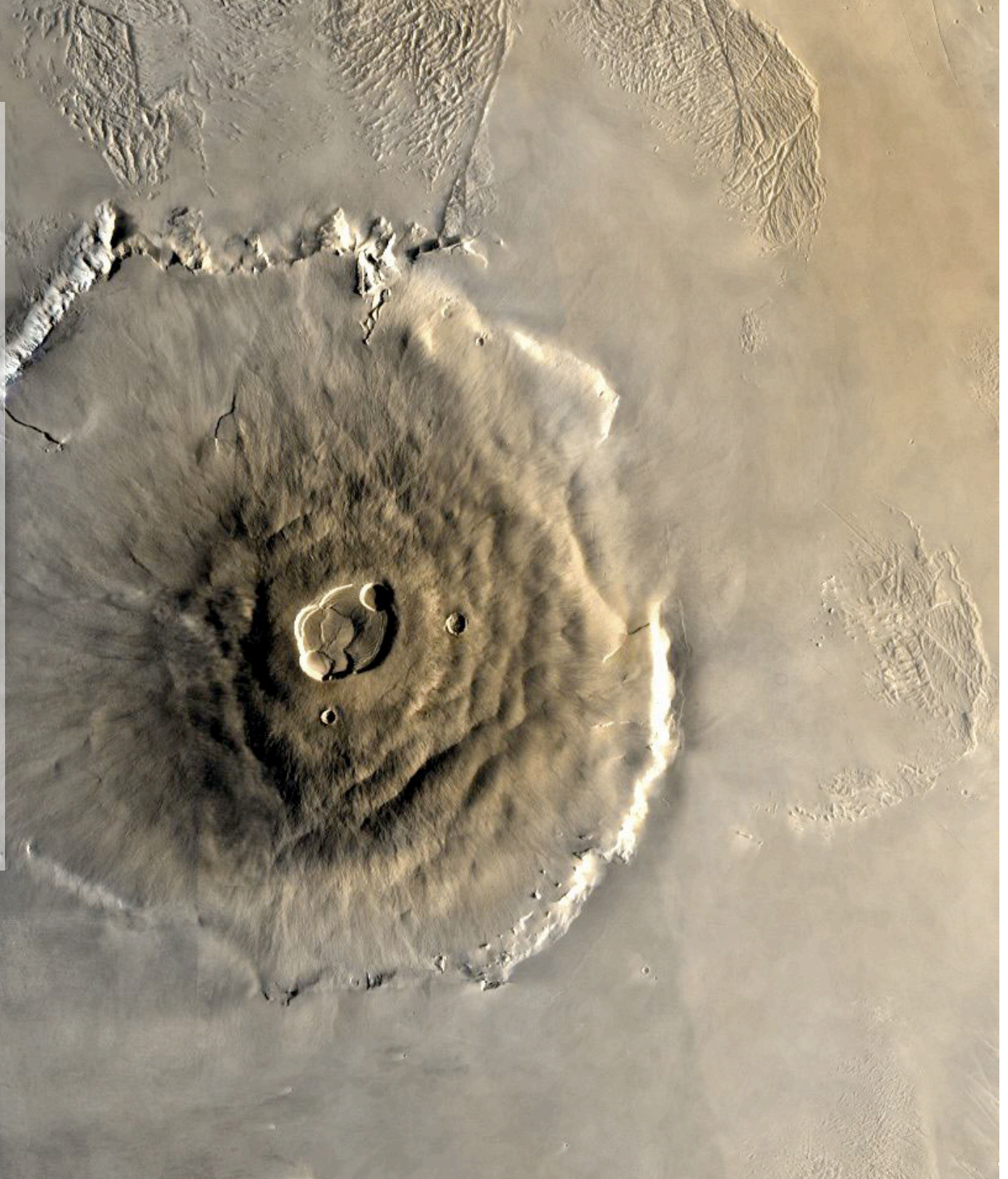


Image
from *Spirit*

Viking Orbiter
image of
Olympus
Mons

Largest known
volcano in the
Solar System.
2.5 times the
height of Mt.
Everest, 340
miles in
diameter



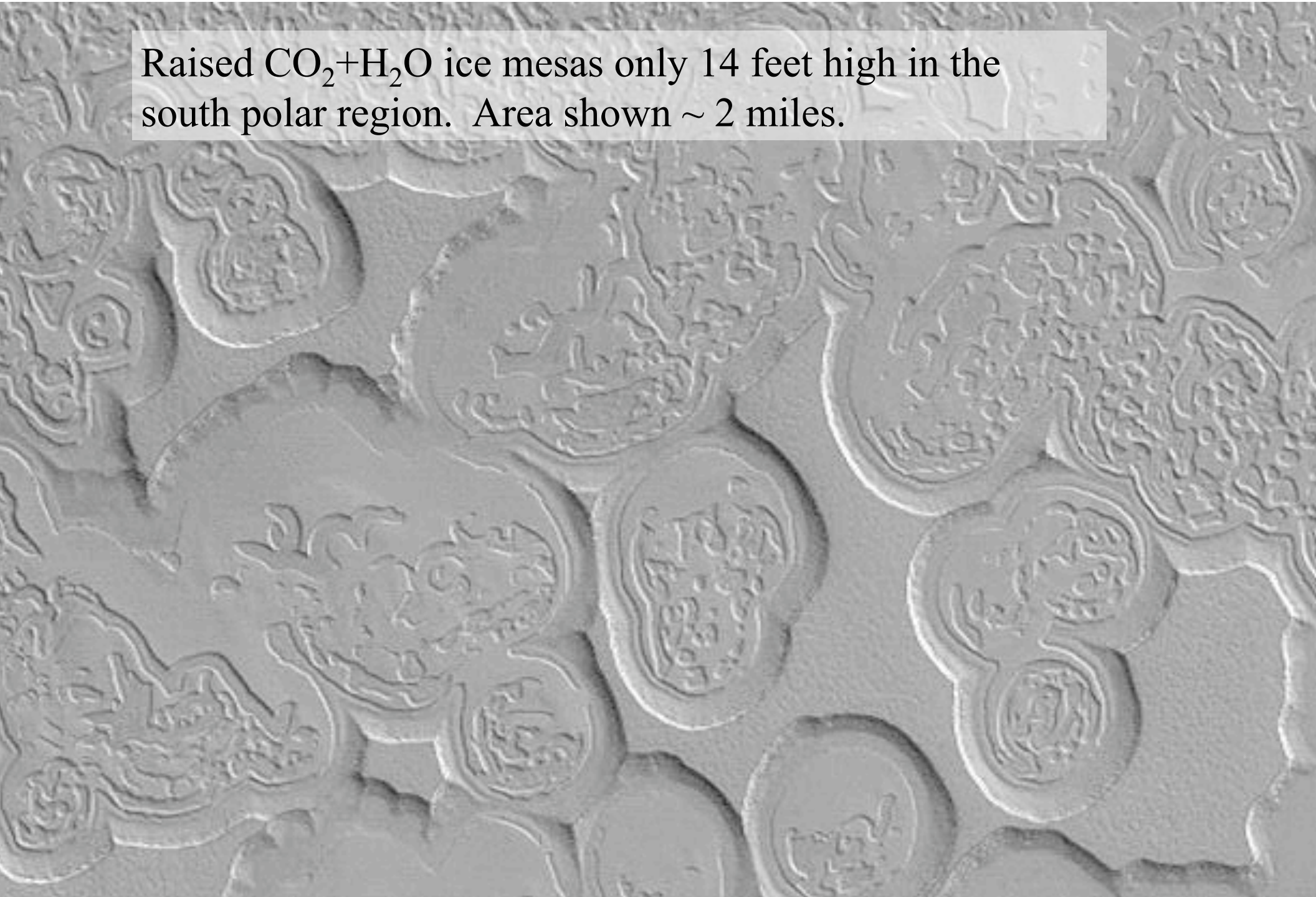


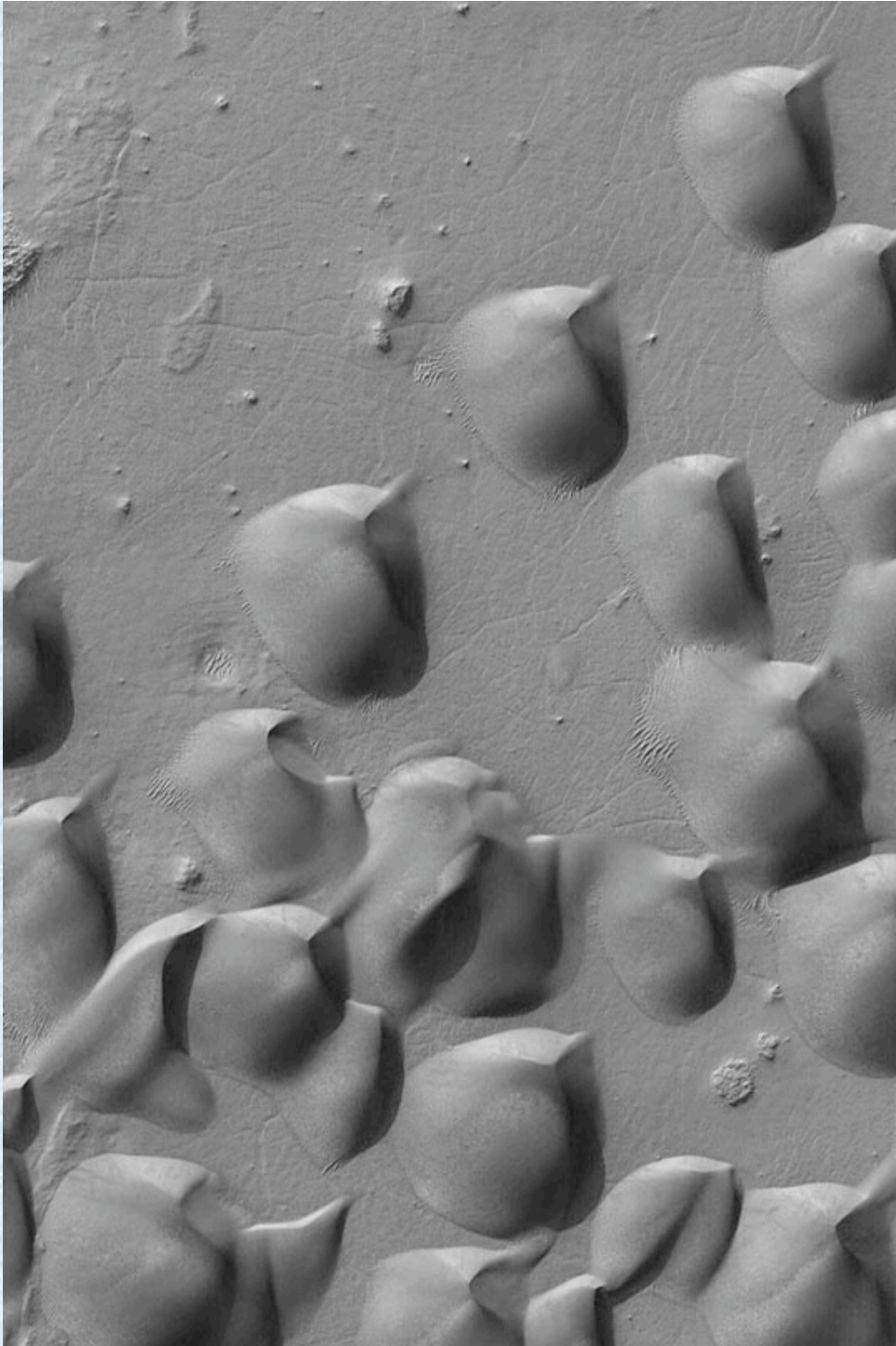
Clouds over Apollinaris Patera

Three miles high, its
summit is about 50
miles across.

Image from 1999
Mars Global
Surveyor

Raised $\text{CO}_2 + \text{H}_2\text{O}$ ice mesas only 14 feet high in the south polar region. Area shown ~ 2 miles.



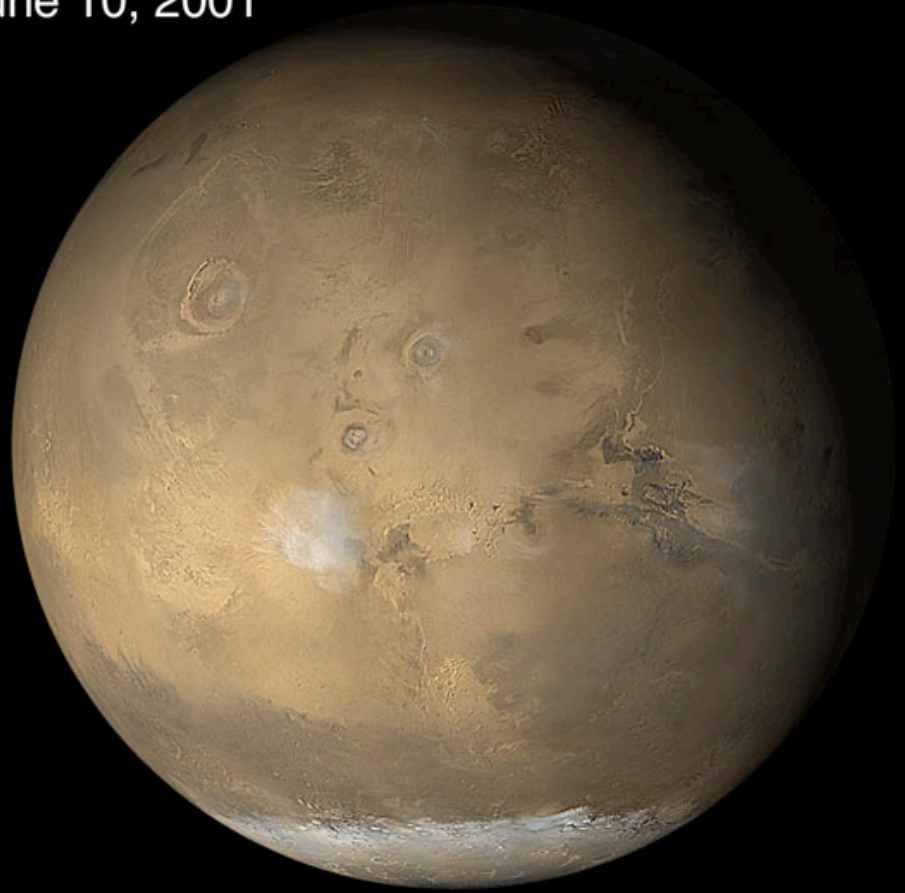


Sand dunes.

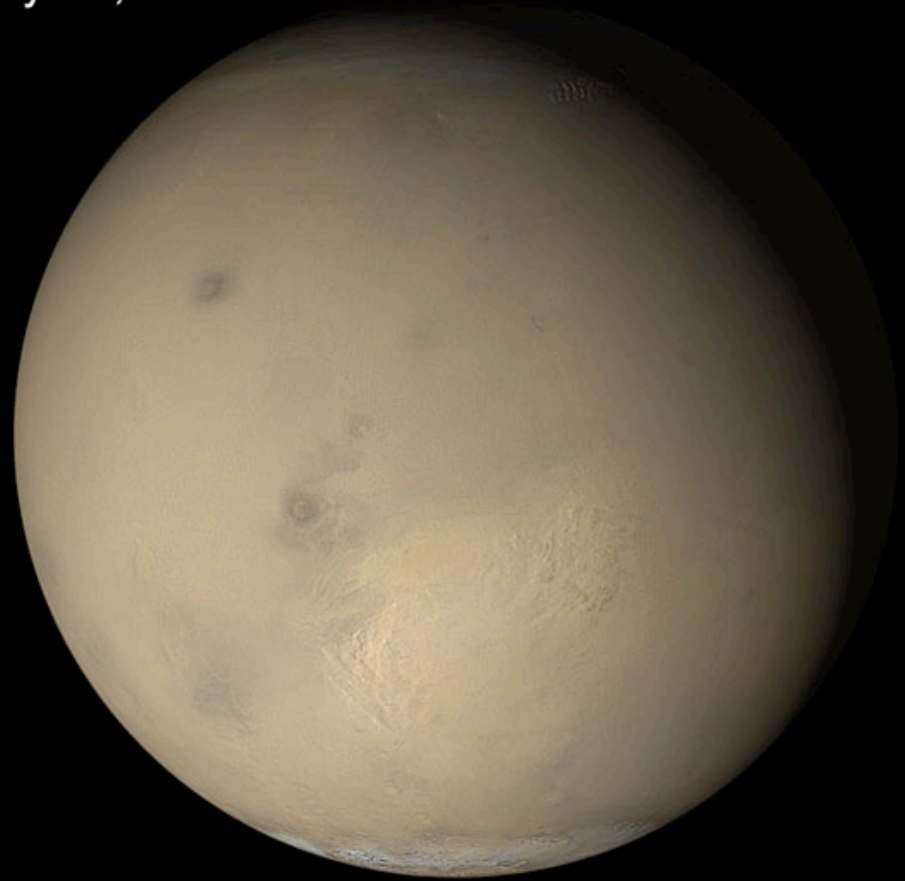
Image scale ~2
miles

From Mars Global
Surveyor

June 10, 2001



July 31, 2001





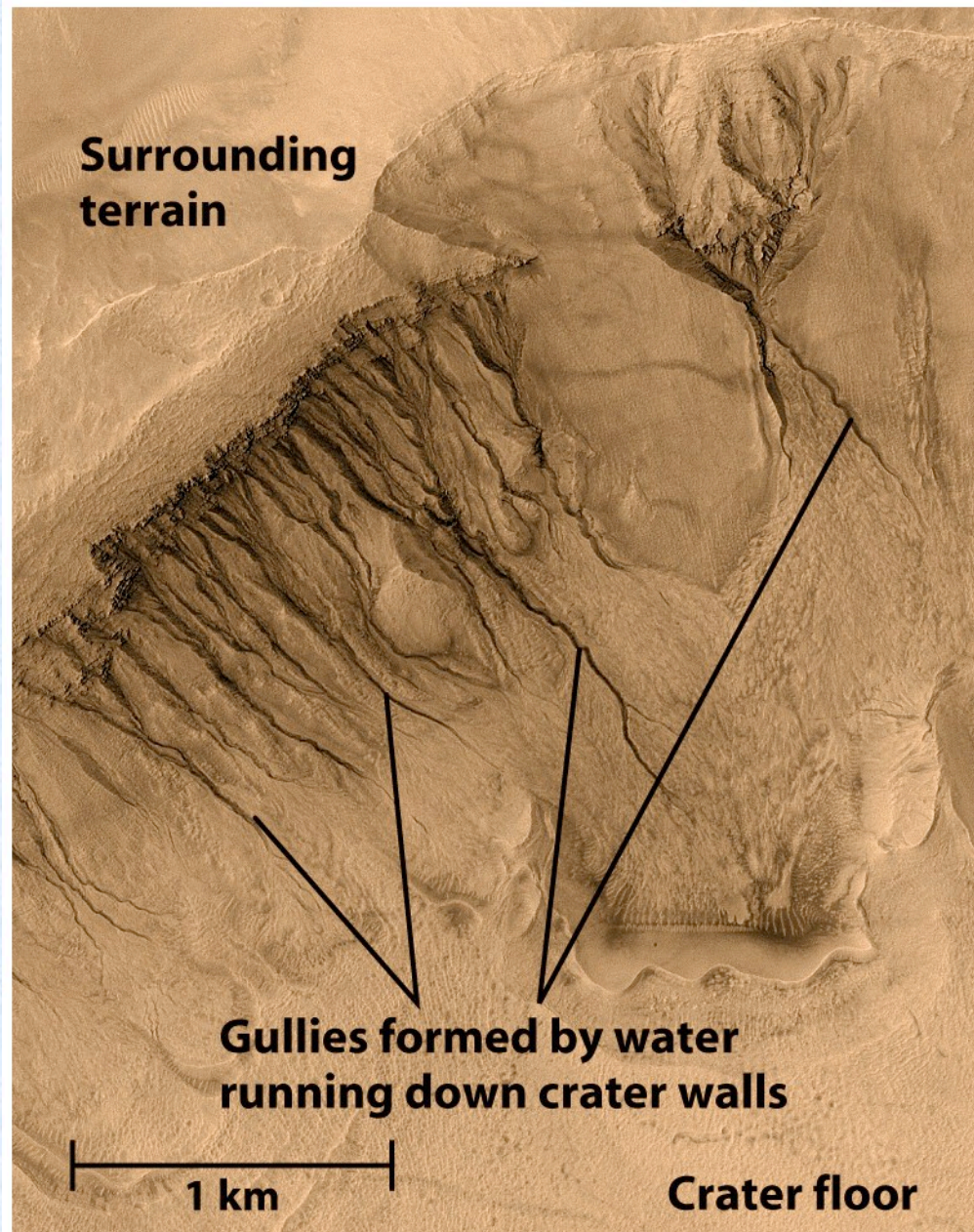
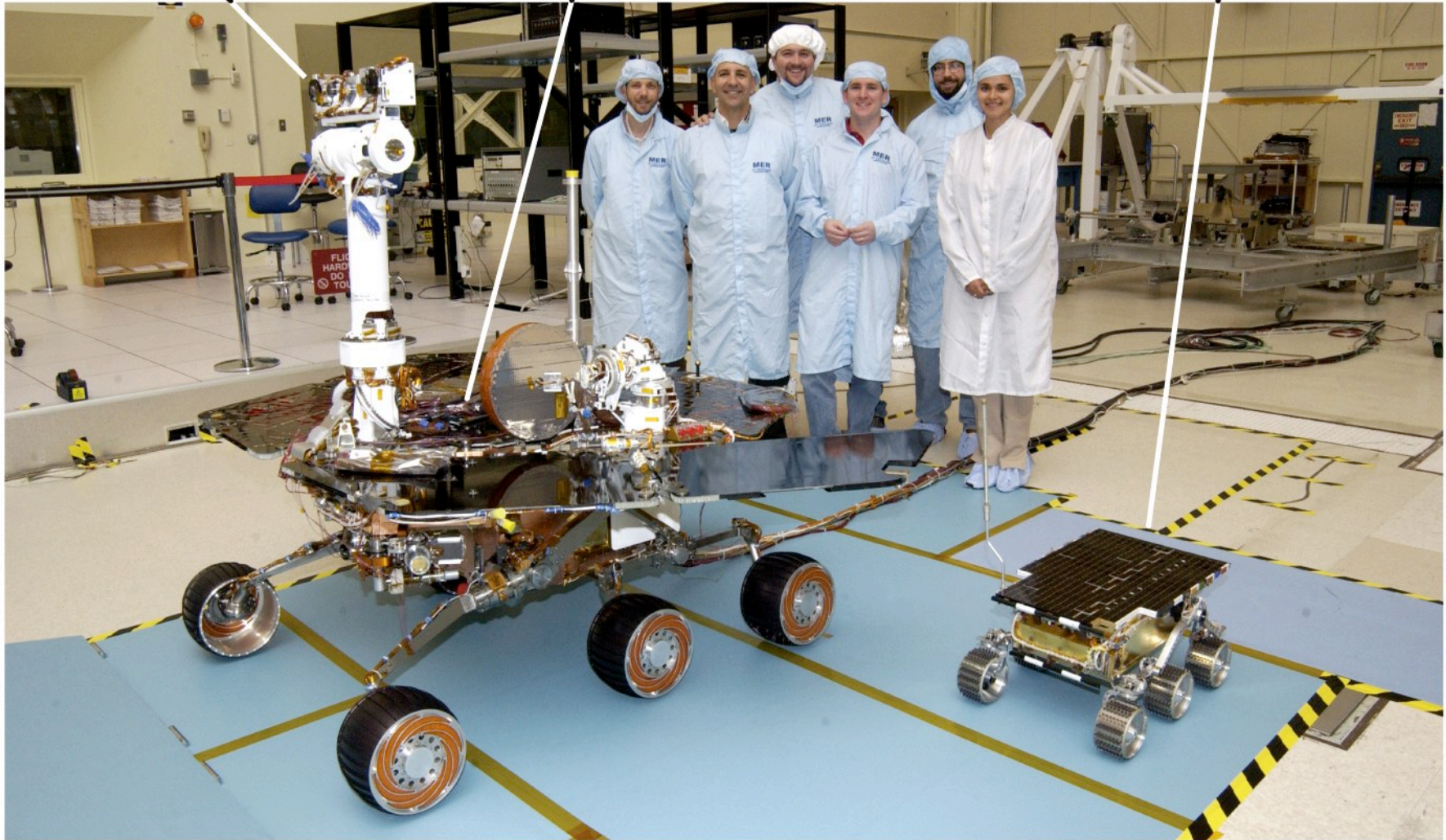


Figure 11-40
Universe, Eighth Edition
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Cameras

Mars Exploration Rover

Mars Pathfinder rover



Two generations of rovers

Figure 11-34b

Universe, Eighth Edition

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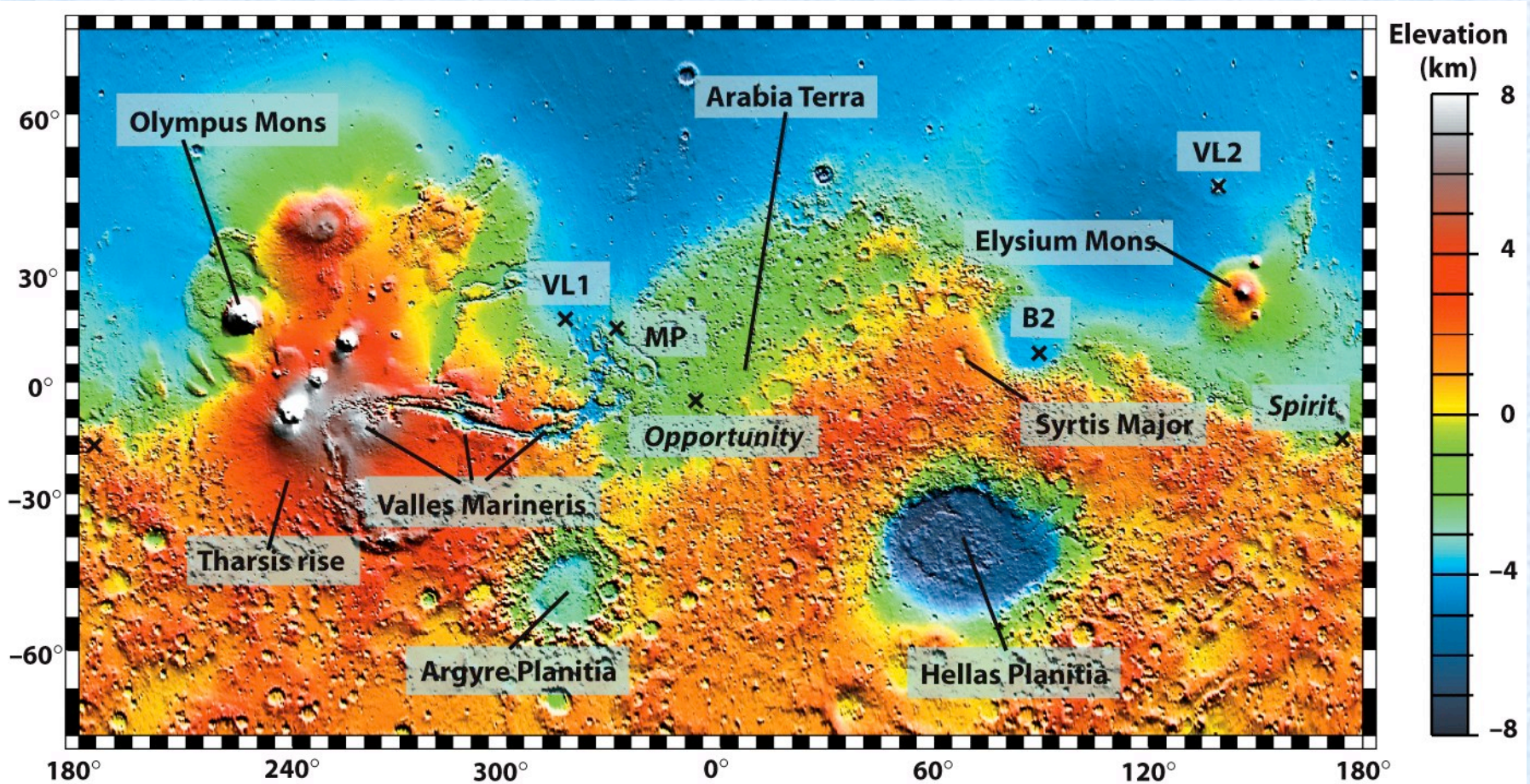
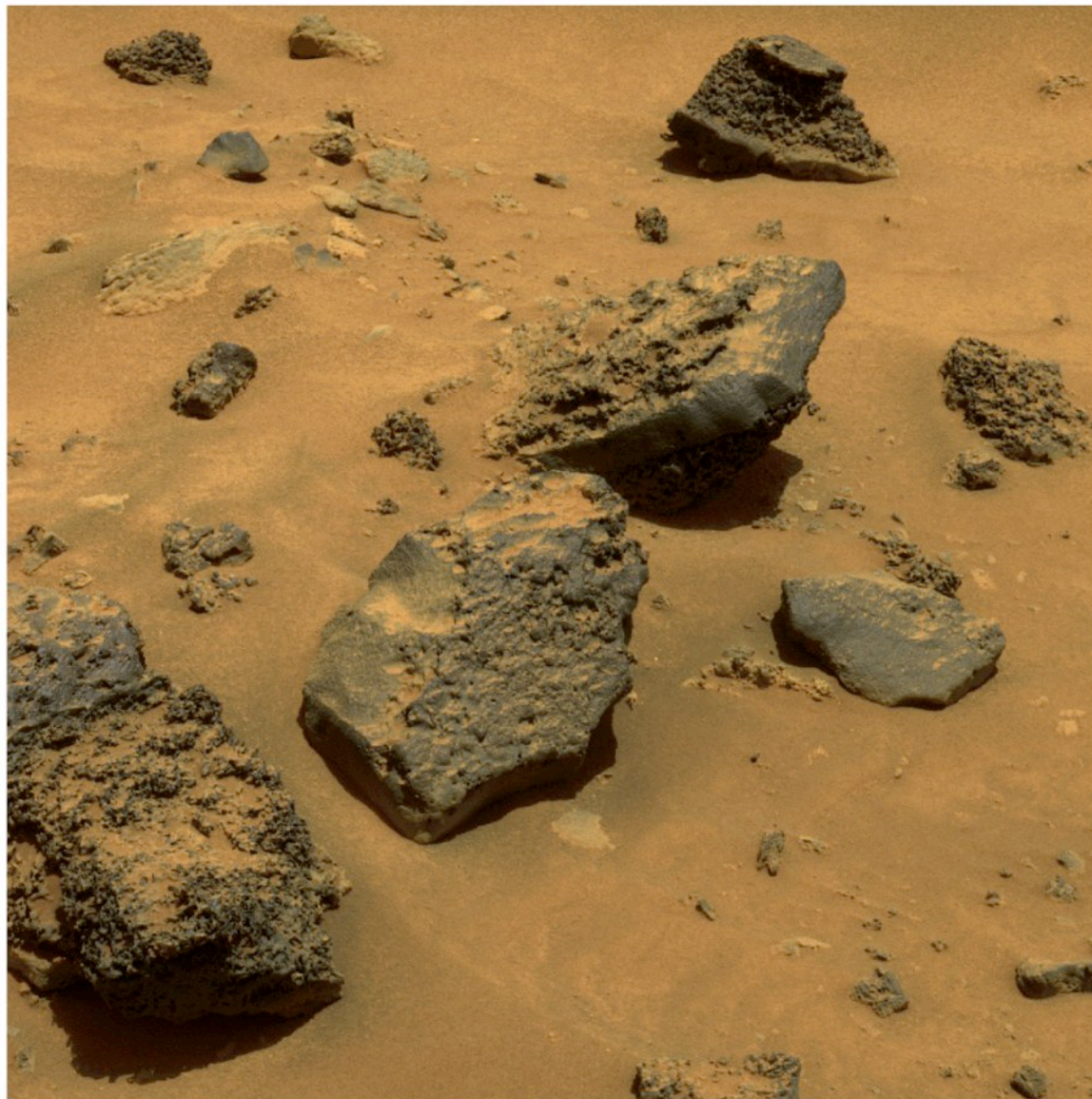


Figure 11-20
Universe, Eighth Edition
 © 2008 W. H. Freeman and Company

Most of the southern hemisphere lies several kilometers above the northern hemisphere: Mars has southern highlands and northern lowlands.



Dry Mars At the *Spirit* landing site dusty volcanic rocks dominate.

Volcanic rocks

Figure 11-37a

Universe, Eighth Edition

© 2008 W. H. Freeman and Company



Sulfur salts

Figure 11-37b
Universe, Eighth Edition
© 2008 W. H. Freeman and Company

Spirit site: According to *Universe, 9th edition* these light-colored sulfur salts contain minerals that break apart upon contact with liquid water. Hence, this area must have been dry for billions of years.

But other theories say they could have formed in the presence of hot water.

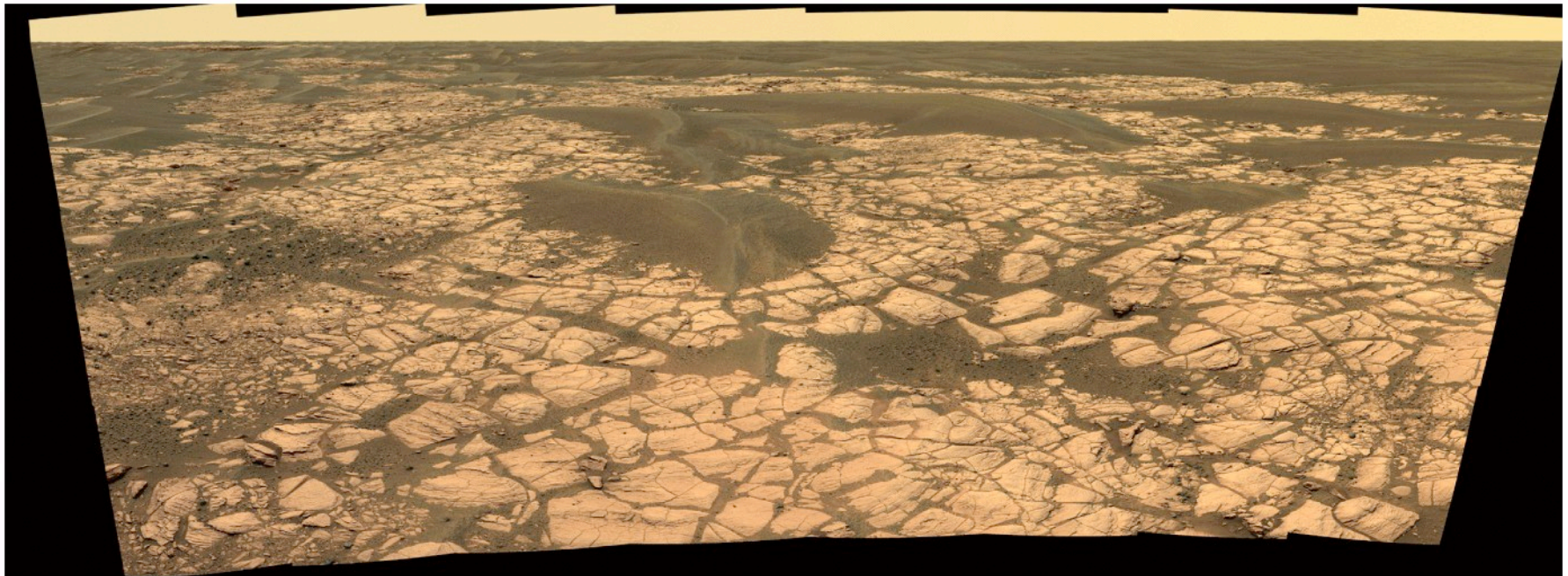


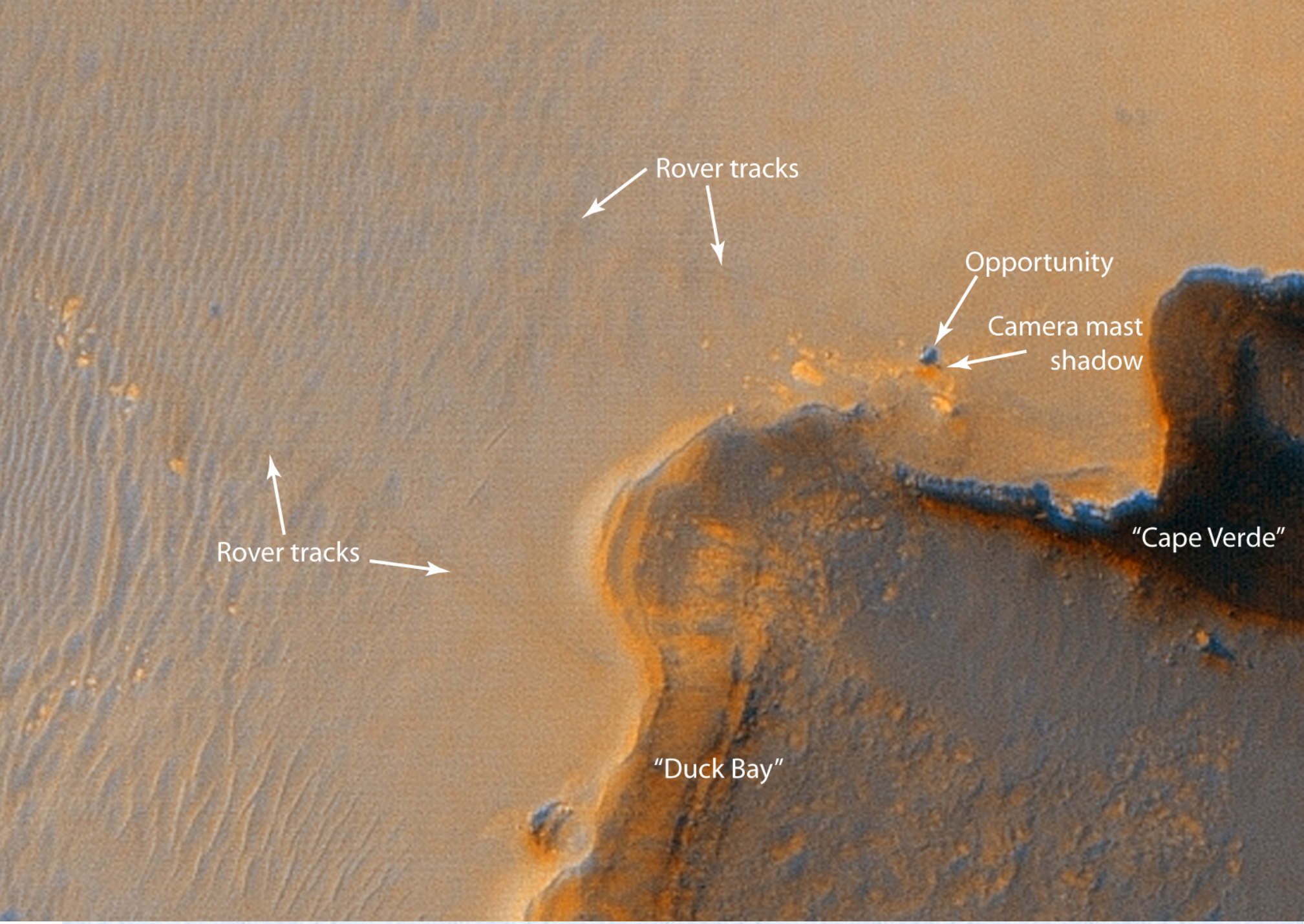
Figure 11-38

Universe, Eighth Edition

© 2008 W. H. Freeman and Company

Sedimentary rocks are formed when minerals collect in standing water. Hence, the site where *Opportunity* found this extensive outcrop of light-colored sedimentary rocks must have been under water for an extended period. This panoramic view spans about 120 degrees from side to side.





Rover tracks

Opportunity

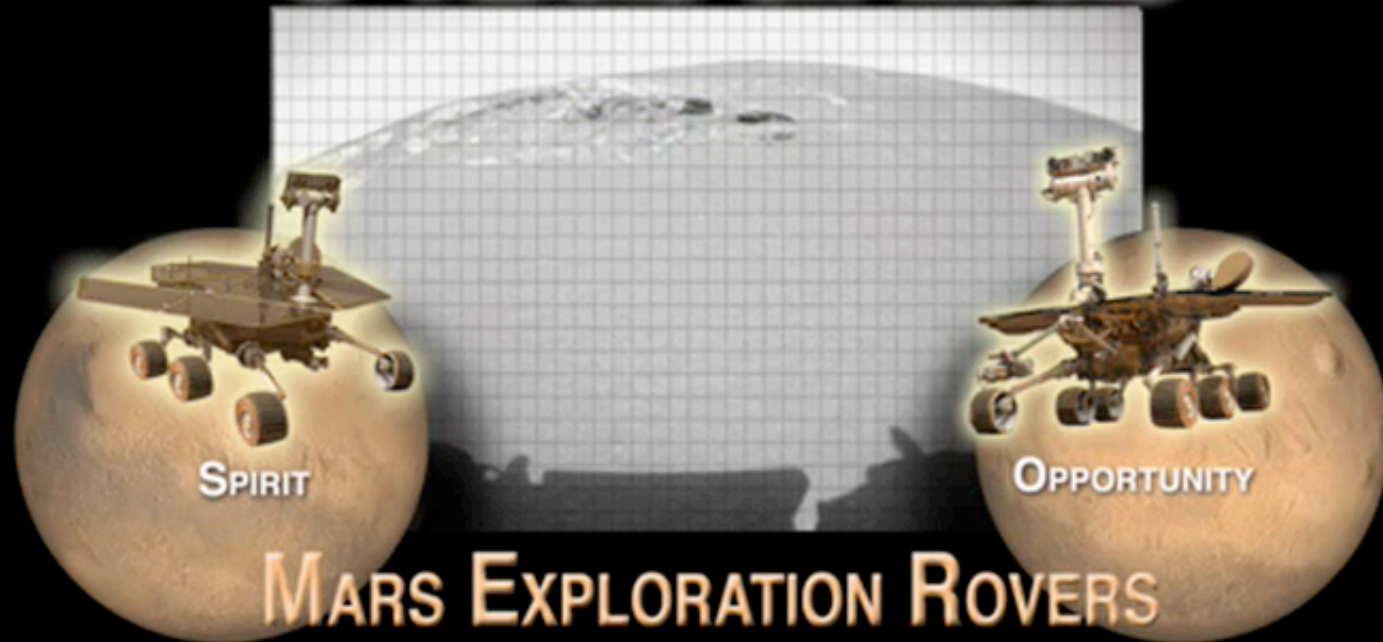
Camera mast shadow

"Cape Verde"

"Duck Bay"

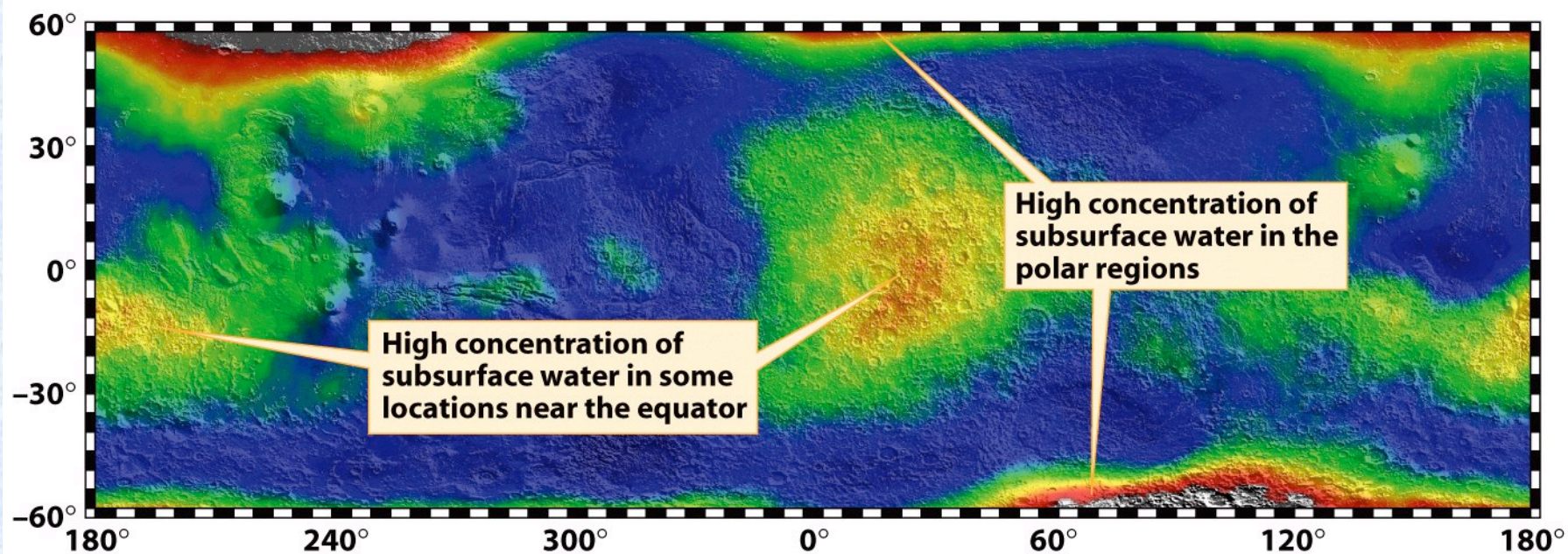
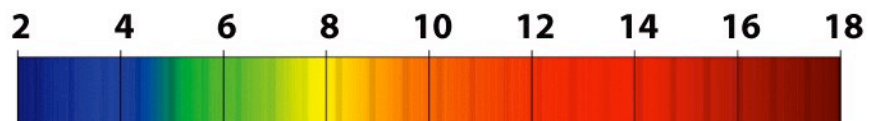
Rover tracks

5 YEARS ON MARS



MARS EXPLORATION ROVERS

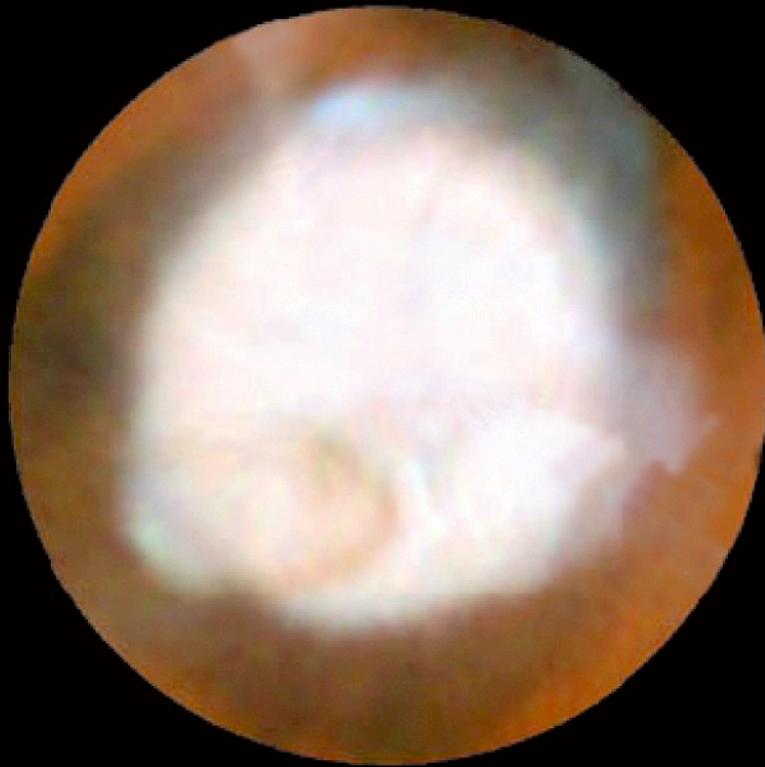
Percent abundance of water (by mass)



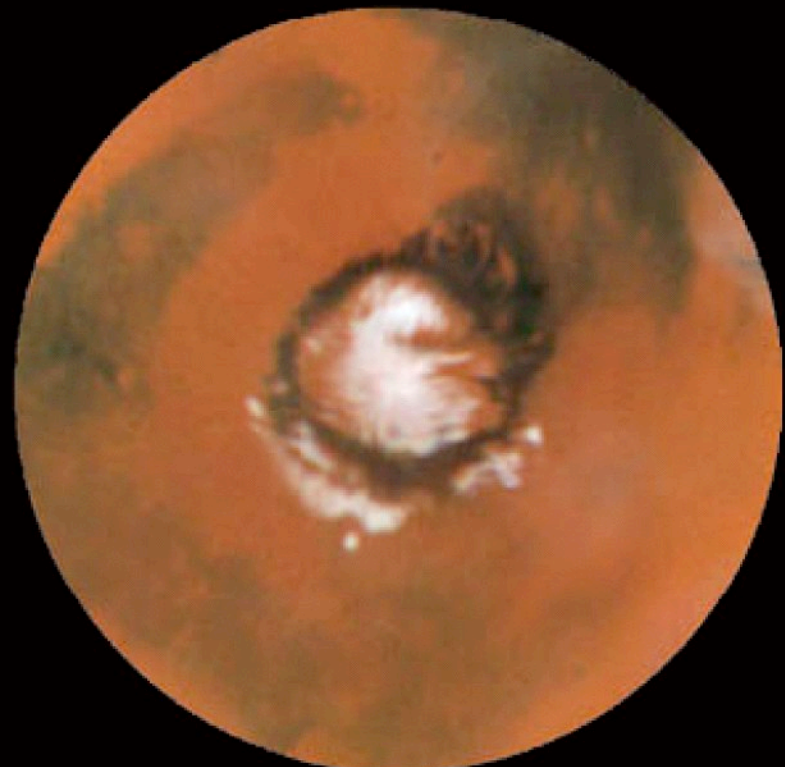
High concentration of subsurface water in some locations near the equator

High concentration of subsurface water in the polar regions

Figure 11-39
Universe, Eighth Edition
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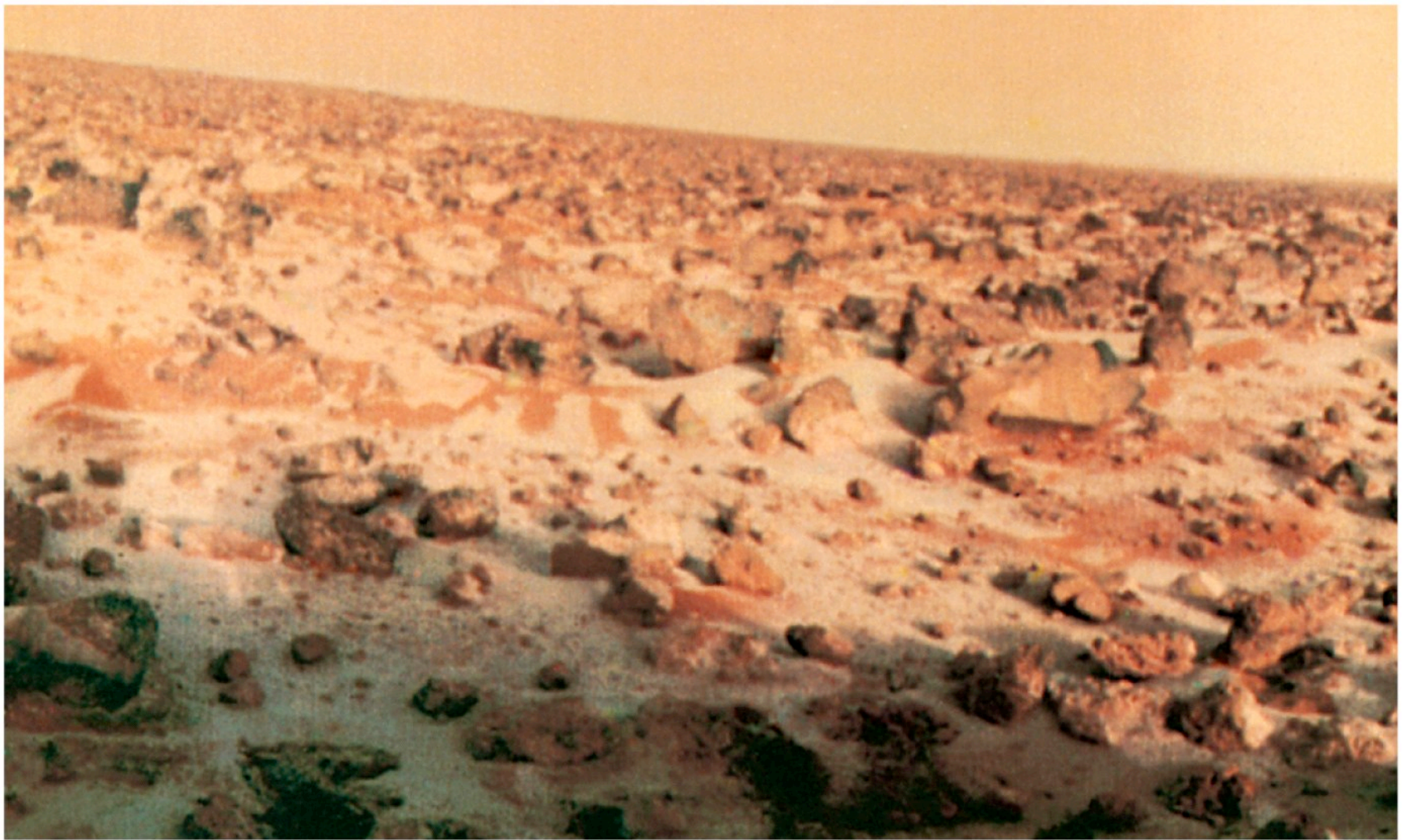
**October 1996
(Winter)**



**March 1997
(Summer)**

Figure 11-30
Universe, Eighth Edition
© 2008 W. H. Freeman and Company

Carbon dioxide freezes out of the atmosphere



A wintertime view from *Viking Lander 2*

Figure 11-31b

Universe, Eighth Edition

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Main features of Mars

- **Smaller than Earth**
- **Thin atmosphere (~0.006 atmosphere pressure) dominated by CO₂**
- **Orbit similar to Earth**
- **Two moons!**
- **Days are more or less as on Earth and temperature is cold (250K)**
- **Mostly solid**
- **Huge volcanos, mostly extinct and no tectonics**

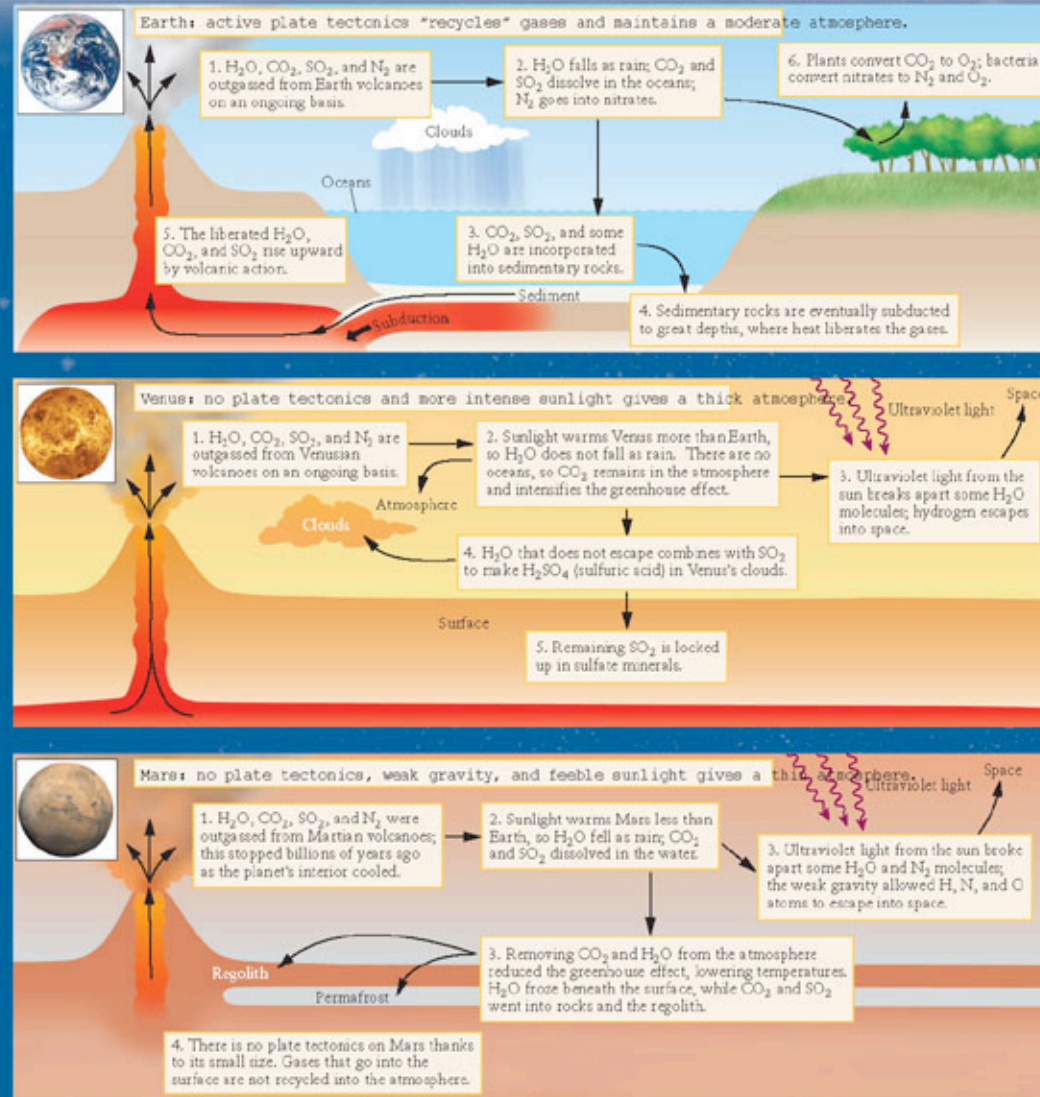
Question 14.3 (iclickers!)

- Mars has a crust which is everywhere thicker than Earth's crust. What is the primary reason for this?
 - A) Mars, being smaller, cooled more rapidly
 - B) Mars is cooler because it is farther from the Sun
 - C) Mars rotates too slowly to allow the crust to remain fluid
 - D) Mars rotates too rapidly to allow the crust to remain fluid

COSMIC CONNECTIONS

Earth, Venus, and Mars formed with similar original atmospheres. However, these atmospheres changed dramatically over time due to factors such as planetary size and distance from the Sun.

Evolution of Terrestrial Atmospheres



Summary

	Venus	Mars
Elevation	Mostly flat with few mountains and highlands	Highlands and Mountains
Atmosphere	Thick	Thin
Volcanism	Yes	Yes?
Temperature	Hot	Cold
Tectonics	Flakes	None

The End

See you on wednesday!