



- Last Homework before Exam (HW#4) is due Friday at 11:50am.
- Nighttime observing has 8 more nights. Check the webpage.
- 1<sup>st</sup> exam is October 10<sup>th</sup>, less than 2 weeks away!

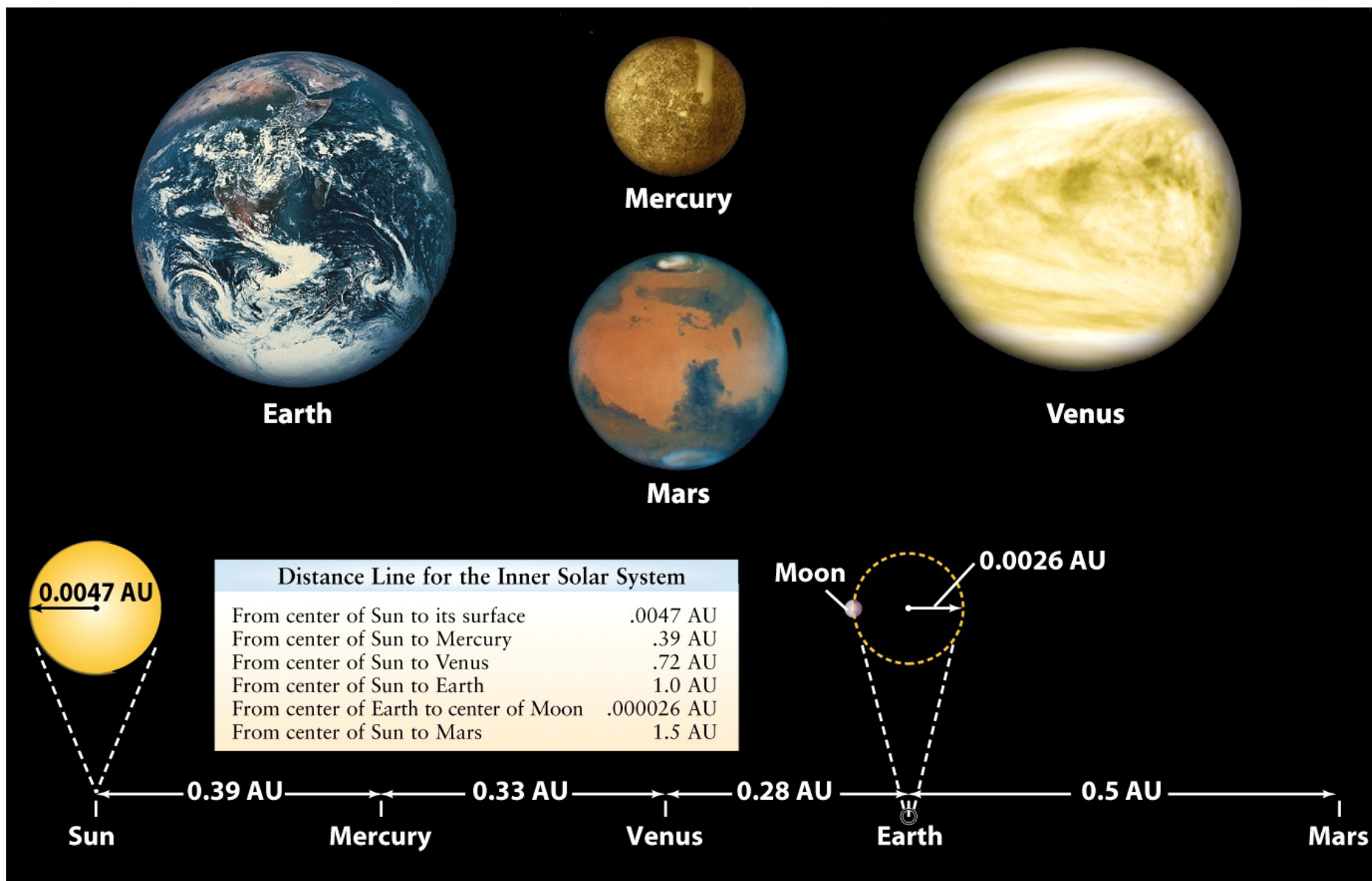
# Outline



- Mercury
  - Shortest year
  - Tenuous atmosphere
- Venus
  - Hottest Planet and longest day
  - Greenhouse Effect
- Mars
  - Weather
  - Water
  - Life?



# The Terrestrial Planets



# Earth – Mercury – Moon comparison



Mercury has  
shortest year in  
Solar System

Radius	0.382 Earth
Surface gravity	0.377 Earth
Mass	0.055 Earth
Distance from Sun	0.387 AU
Eccentricity	0.206
Tilt	0°
Albedo	0.12
Year	88 Earth days
Solar day	176 Earth days

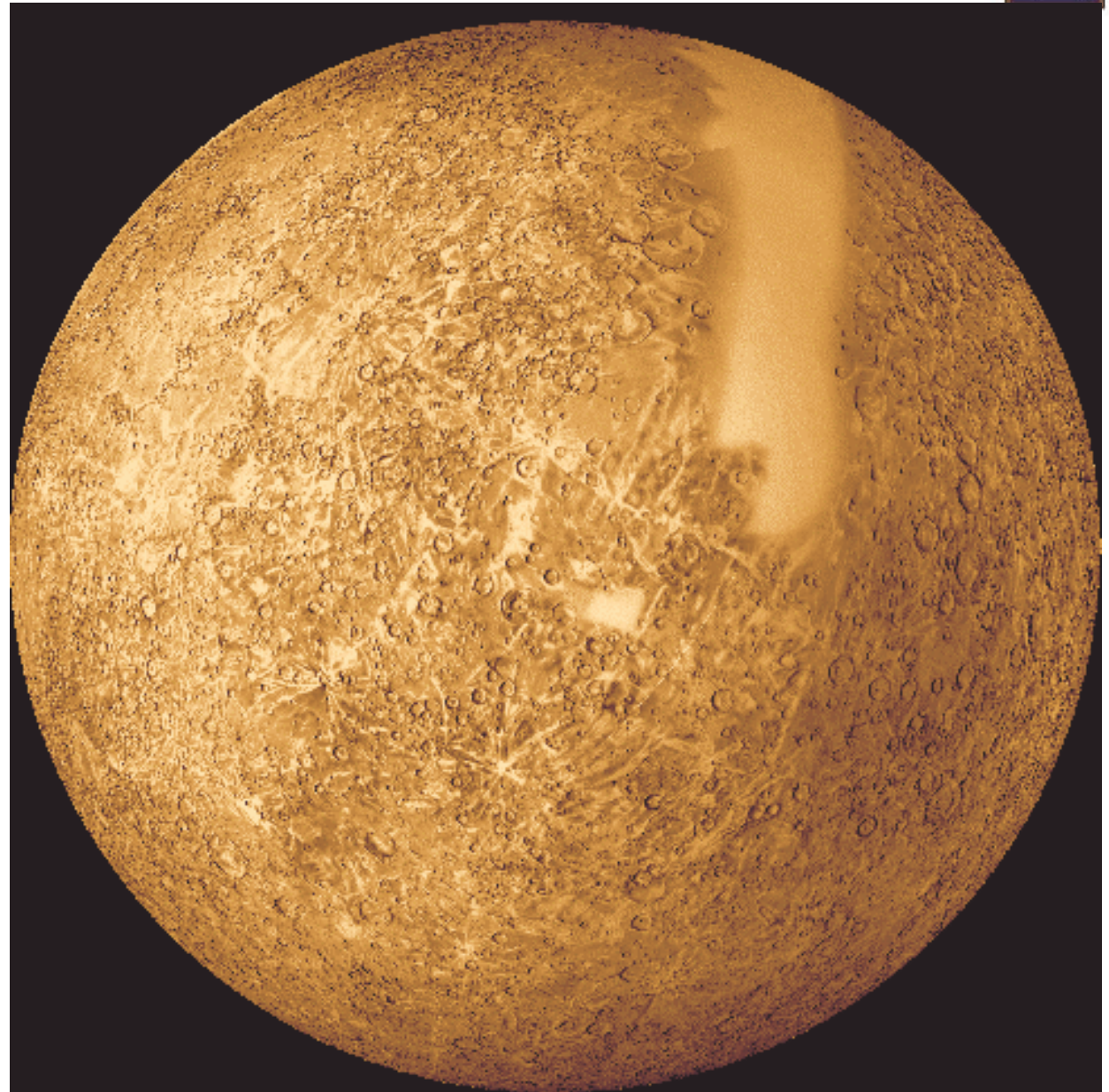
# Mercury Compared to Moons



# Terrestrial Planets: Mercury



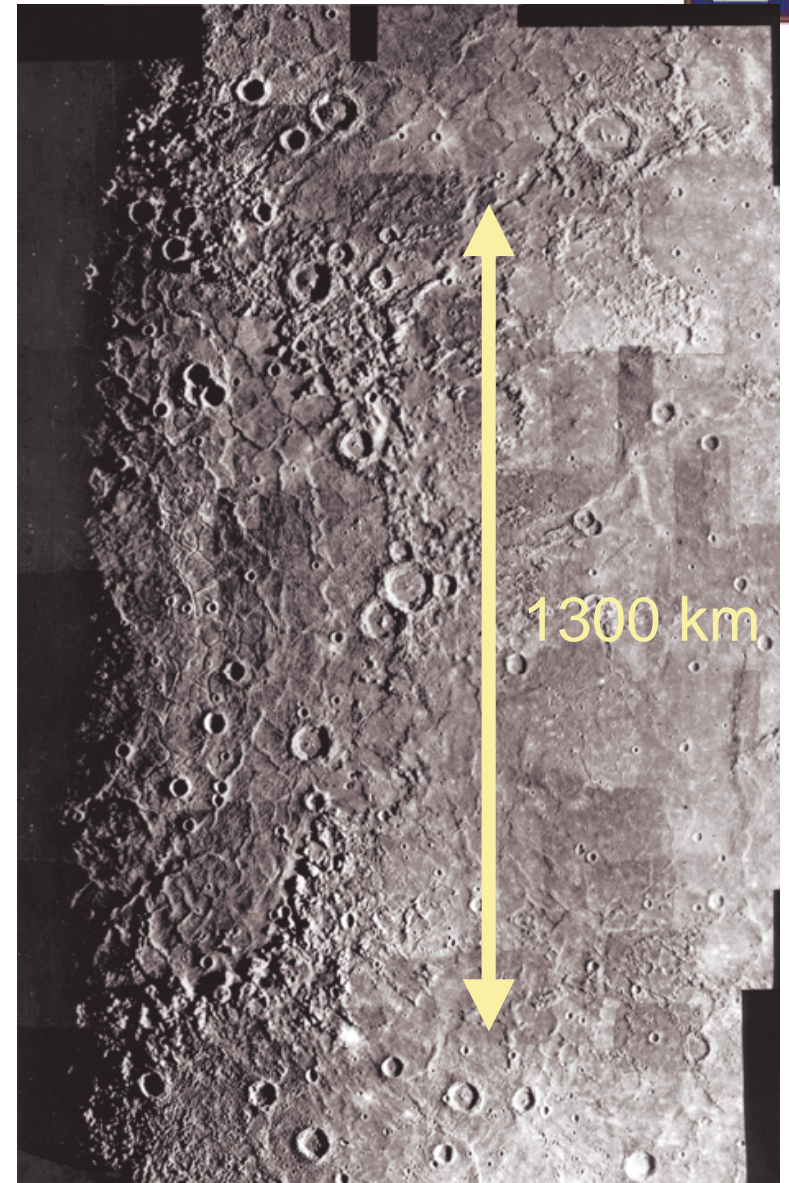
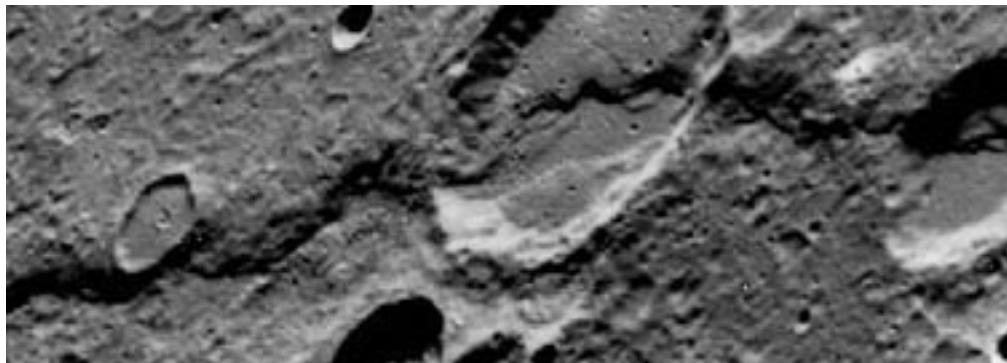
- Visited in 1974/75 by Mariner 10—only 40% of surface mapped
- Like surface of Moon, but more heavily cratered
- Most iron rich planet

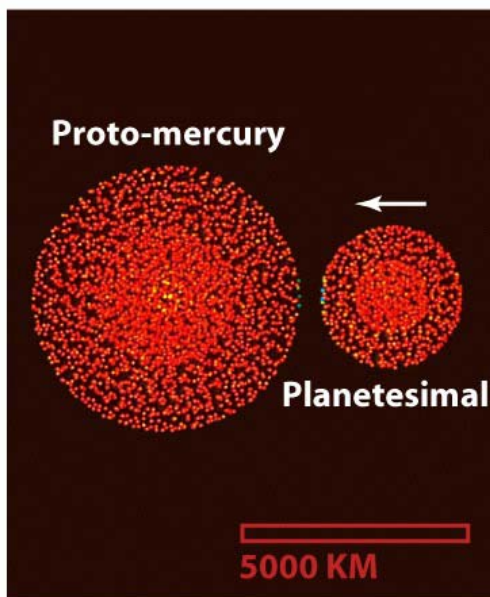


# Mercury

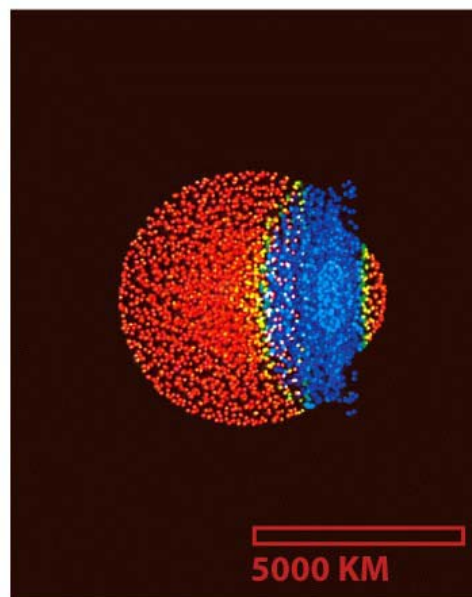


- Huge lava-filled basin (Caloris Basin)
- Mile-high cliffs (Discovery Scarp)
- Early shrinkage of crust → no geological activity at present
- Interior is solid to a significant depth
- Density comparable to Earth's, but weak magnetic field
  - Iron core, few silicates in crust
  - Cataclysmic impact early in history?

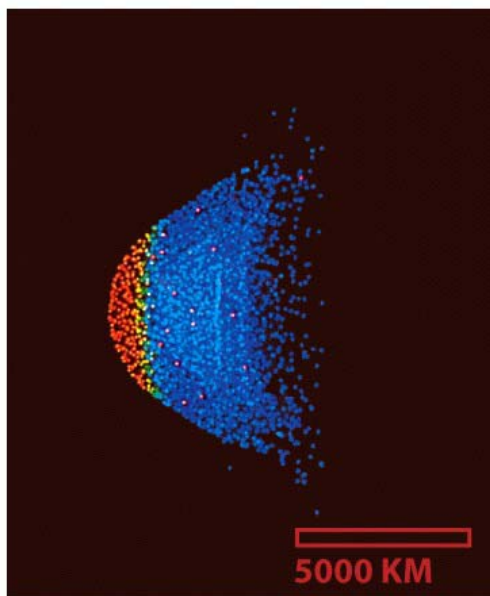




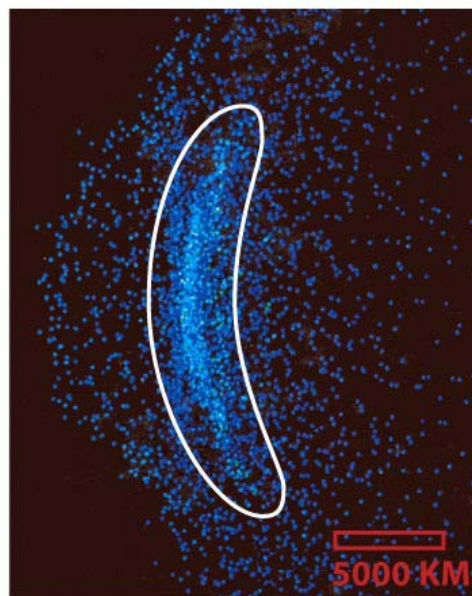
$t = 0$



$t = 3 \text{ min}$



$t = 6 \text{ min}$



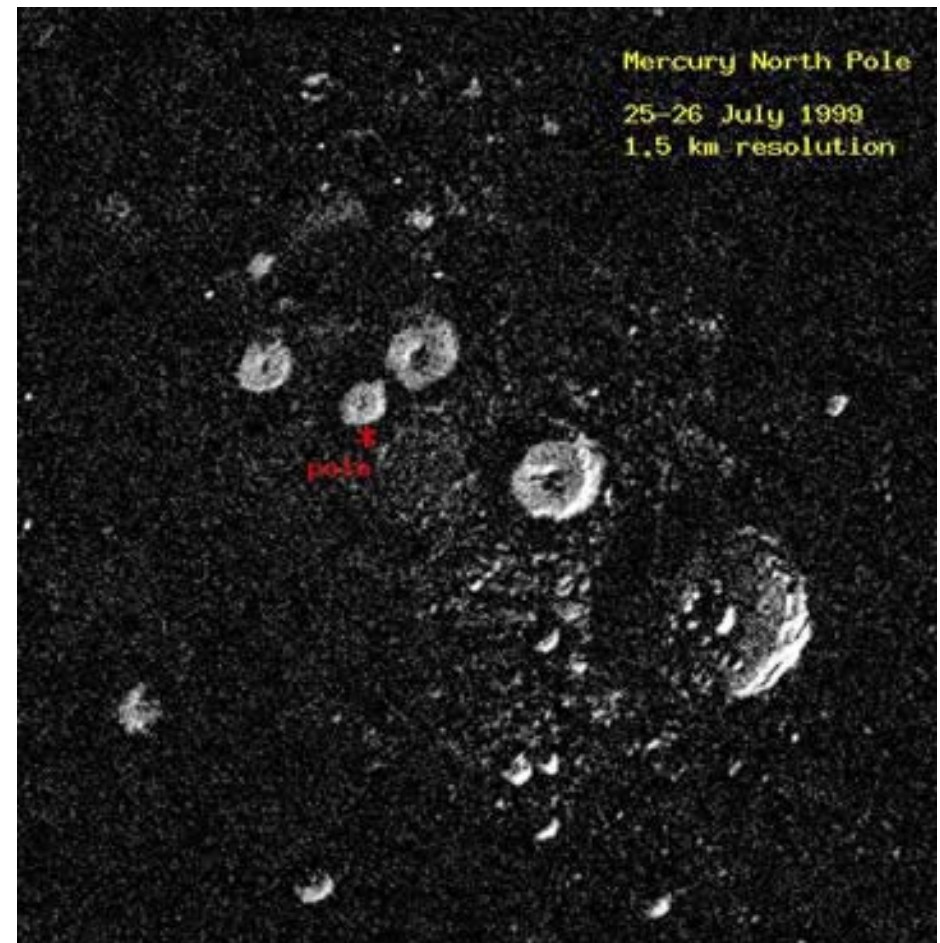
$t = 30 \text{ min}$



# Volatile compounds on Mercury

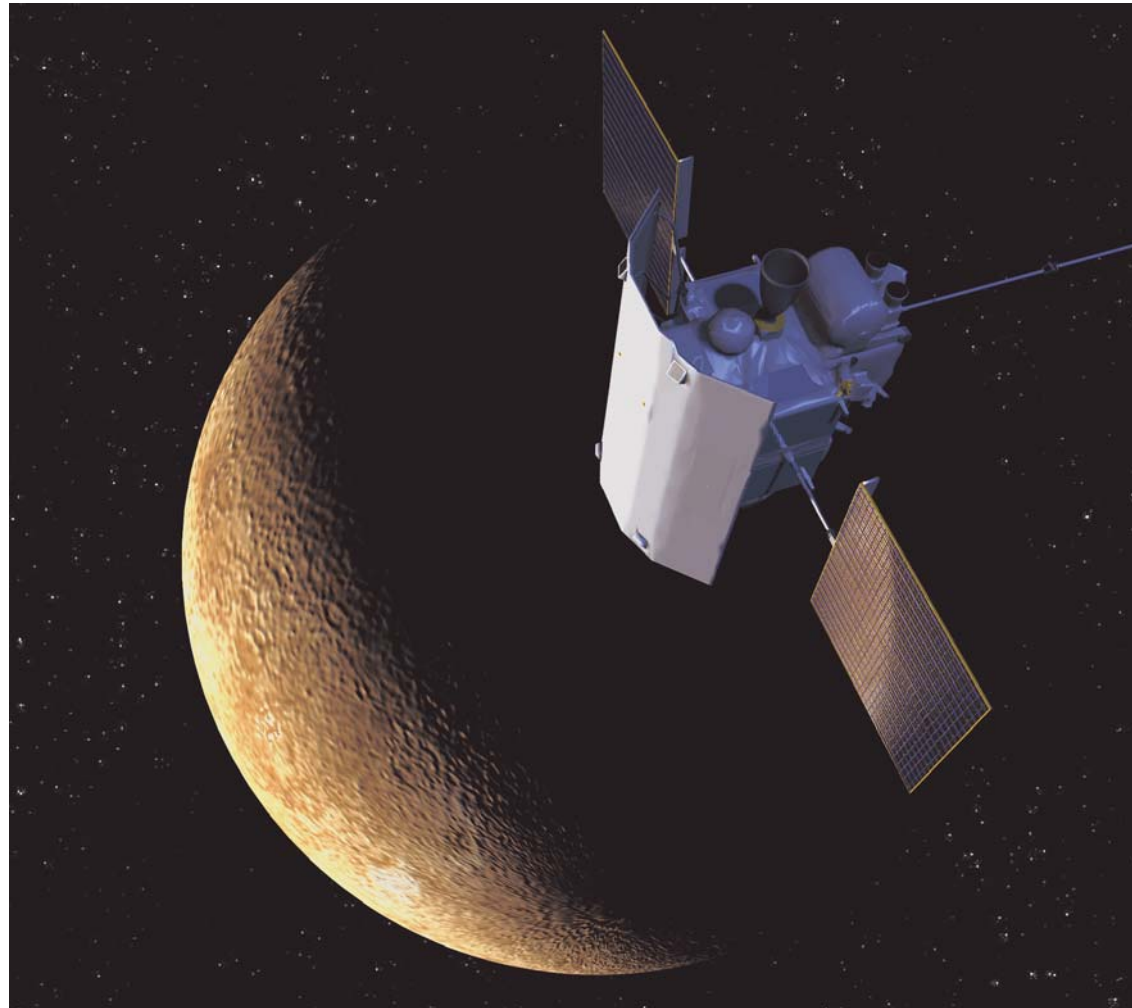


- Rotation period comparable to year
- No tilt in spin axis
  - A long time from noon to noon
  - Huge day/night temperature difference (467 C vs. -183 C)
- Tenuous atmosphere from constant pounding by solar wind (quickly escapes)
  - Oxygen, Sodium, Helium
- Some evidence for water ice in crater shadows



Arecibo Observatory S-band radar image of the north polar region of Mercury by J. Harmon, P. Perrilat, and M. Slade. The resolution is 1.5 kilometers (about 1 mile) and the image measures 450 kilometers on a side. The bright features are thought to be ice deposits on permanently shadowed crater floors.

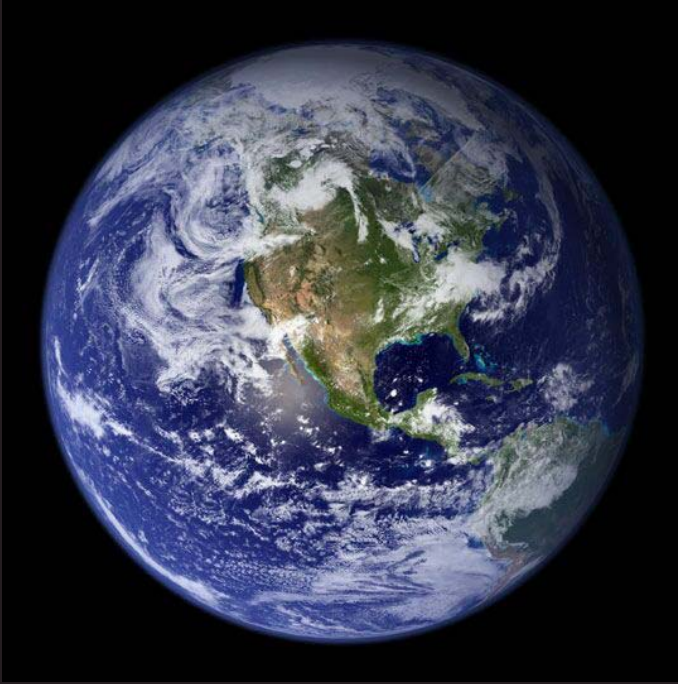
# Return to Mercury: MESSENGER



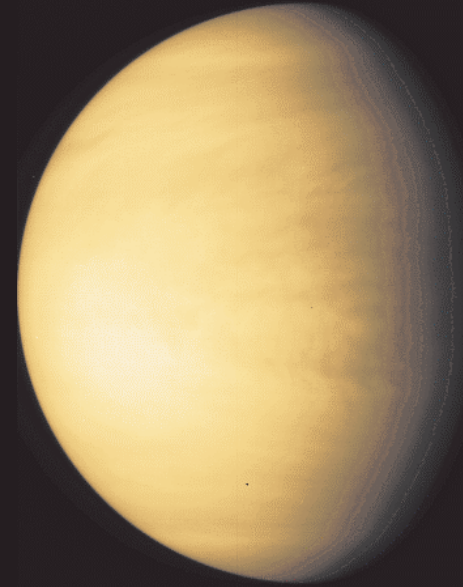
Scheduled launch: 2004

<http://messenger.jhuapl.edu>

# Earth – Venus comparison



Venus is the hottest planet, the closest in size to Earth, the closest in distance to Earth, and the planet with the longest day.

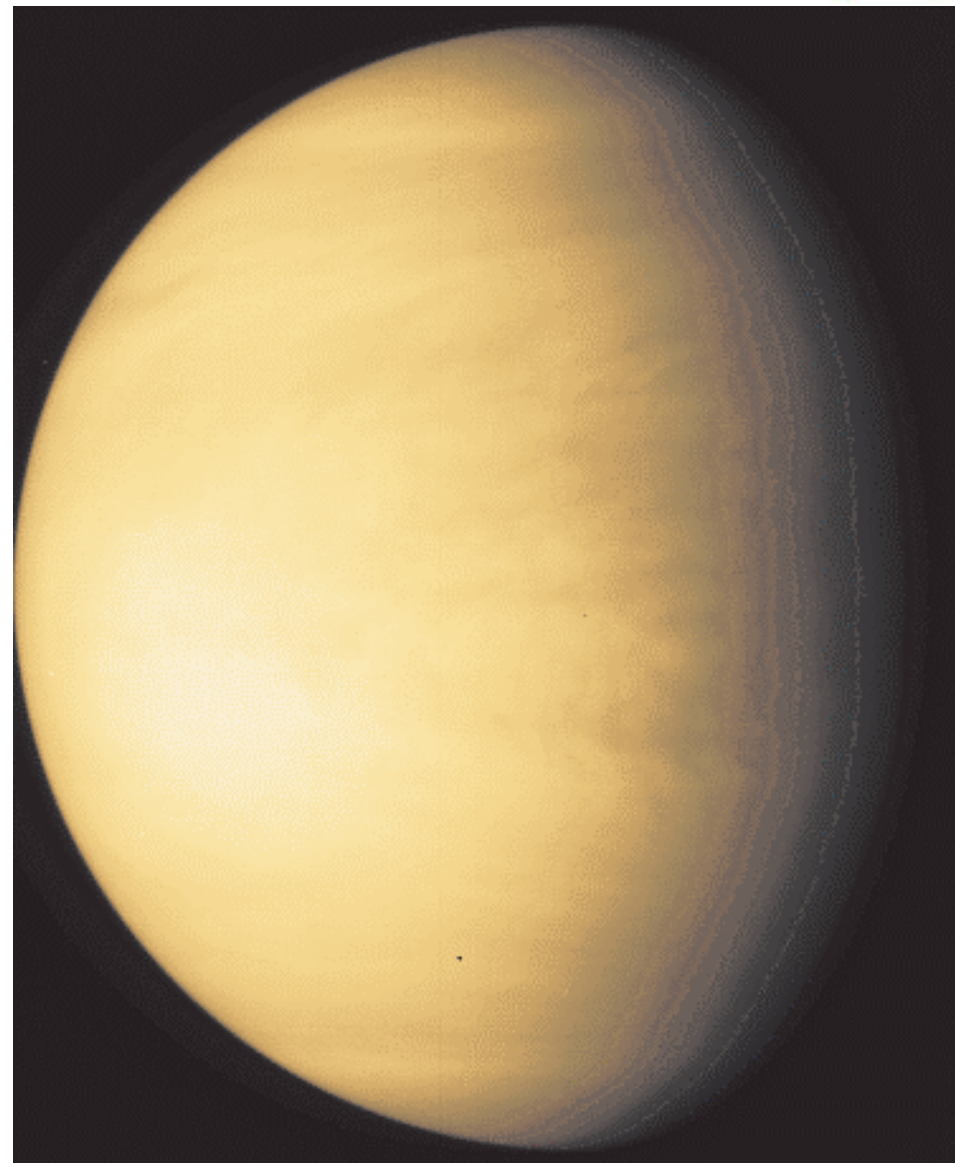


Radius	0.949 Earth
Surface gravity	0.905 Earth
Mass	0.815 Earth
Distance from Sun	0.723 AU
Albedo	0.65
Eccentricity	0.01
Tilt	177°
Year	224.7 Earth days
Solar day	116.8 Earth days



# Inner Planets: Venus

- Always covered in thick clouds that make it the hottest planet in the Solar System.
- Often called the morning star or the evening star. 3<sup>rd</sup> brightest object in the sky. Often mistaken for UFO.
- Phases helped establish heliocentric model
- Retrograde rotation – Sun rises in west
- No moons, no magnetic field
- Pressure on surface is 90 times that on Earth– like 1 km under the sea

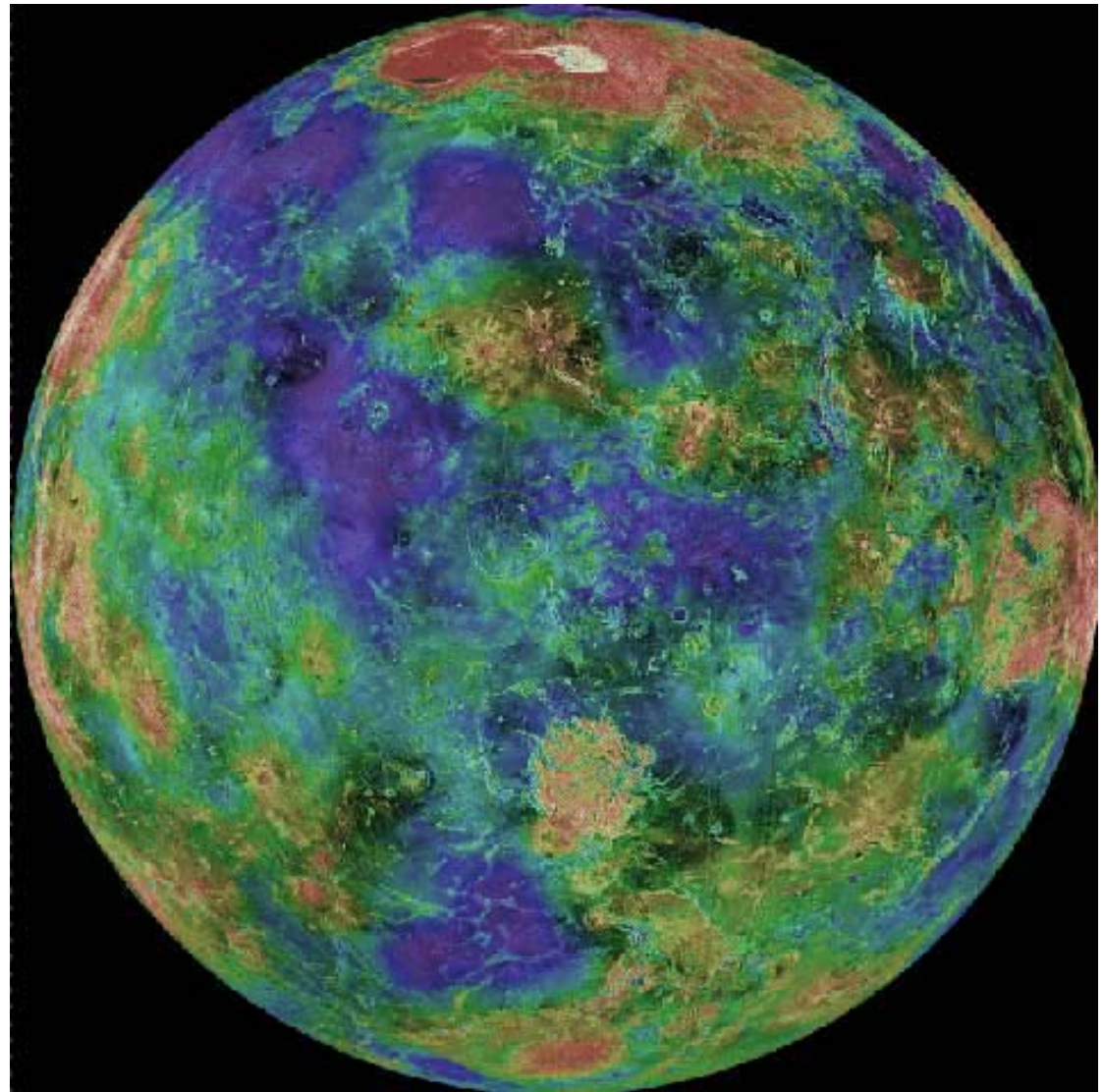


<http://antwrp.gsfc.nasa.gov/apod/ap960923.html>

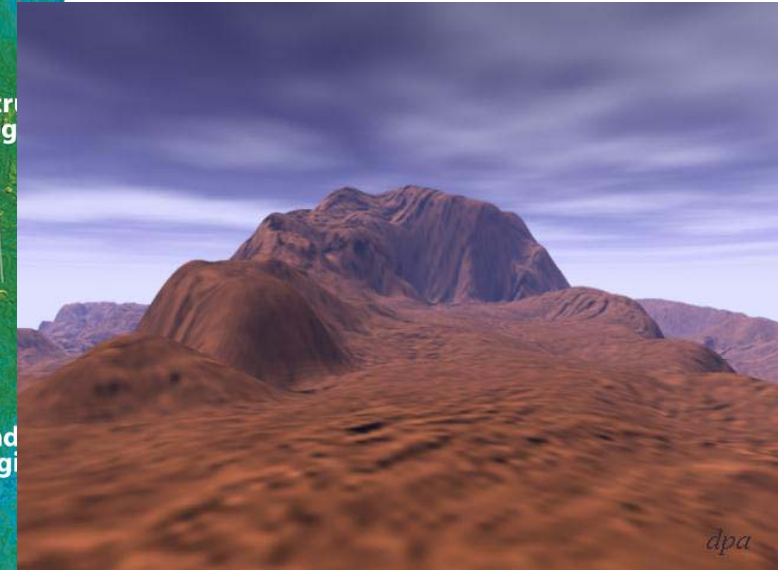
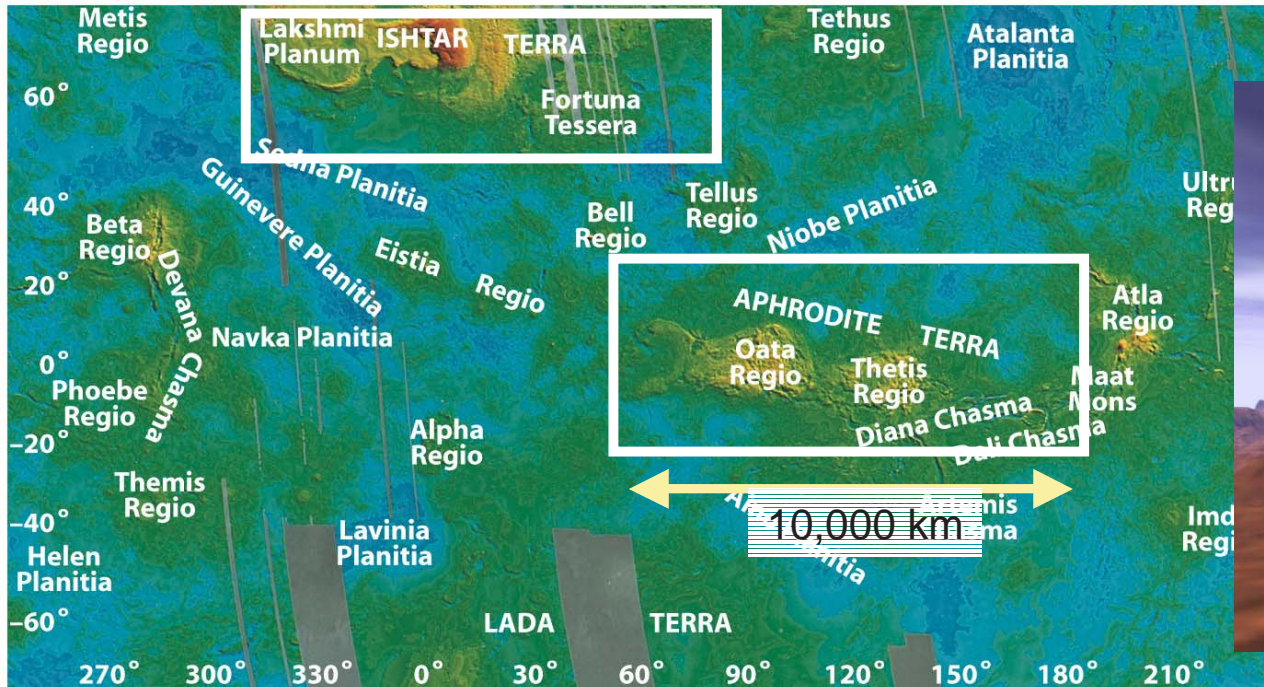


# Surface

- Blue is lowest and Red is highest— there is no water
- Most of surface is smooth lava flows
- Many ( $> 1,000$ ) large volcanoes
- Possible ongoing volcanism
- Slow wind erosion of impact craters
- Craters are clustered



# Venus: surface features



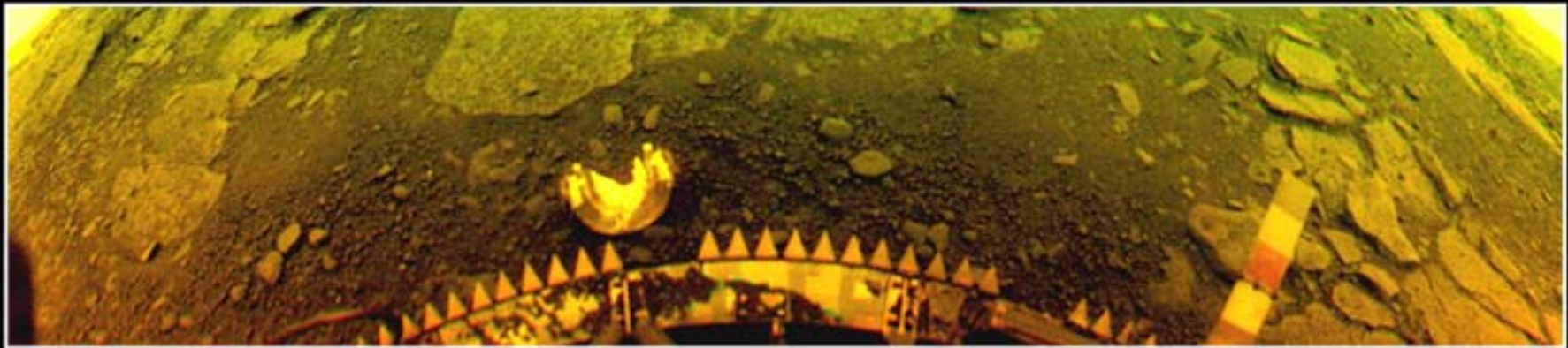
Maxwell Montes  
(Highest mountain range in the solar system  
11km high– Everest is 8km)

<http://www.solarviews.com/raw/venus/vidven2.mpg>

<http://www.geology.smu.edu/~dpa-www/venus/mpeg/max.mpg>



# Images from the Surface of Venus (Soviet Venera probes)



*Color as seen on the surface of Venus*

Venera 13

*Color with atmospheric effects removed*



USSR Academy of Sciences / Brown University

# Greenhouse Effect



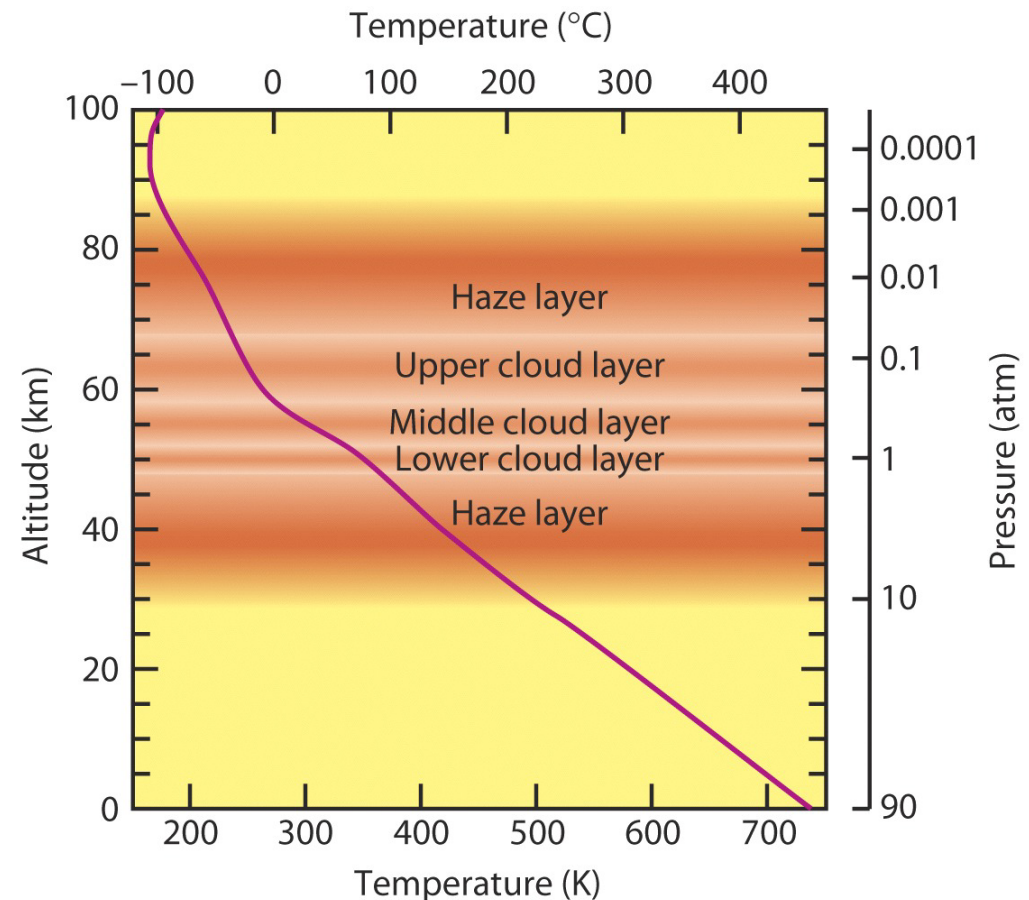
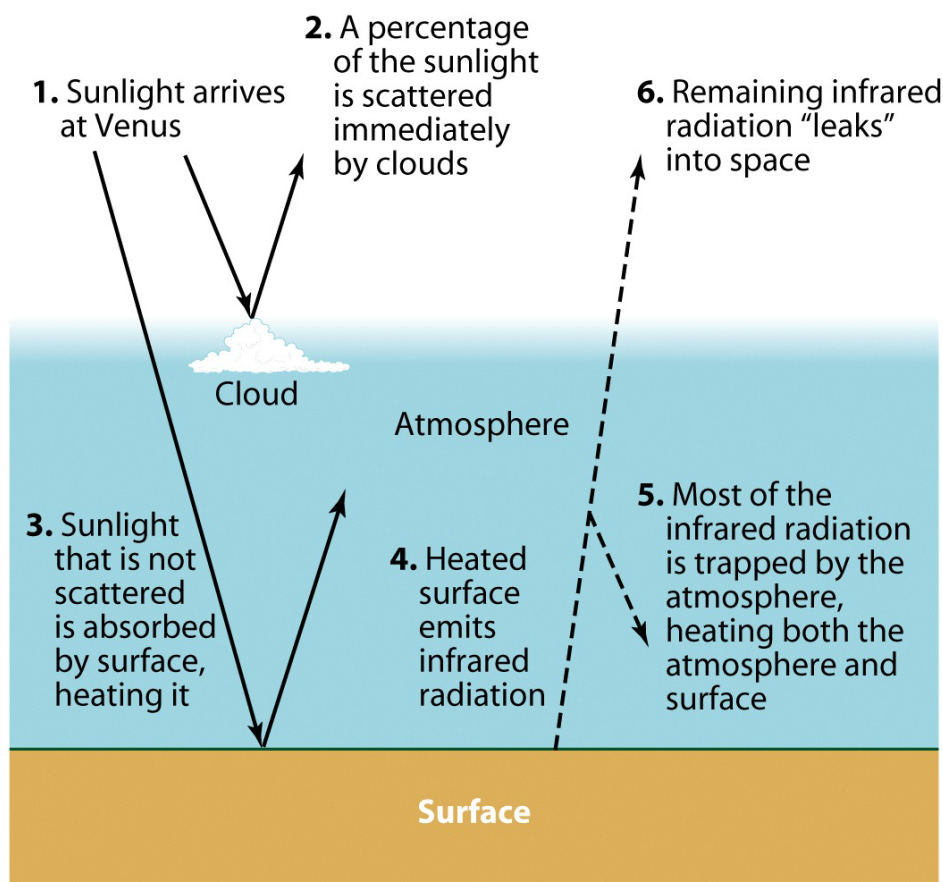
You get into your car in the summer, and it's much hotter inside the car as compared to outside the car. Why?



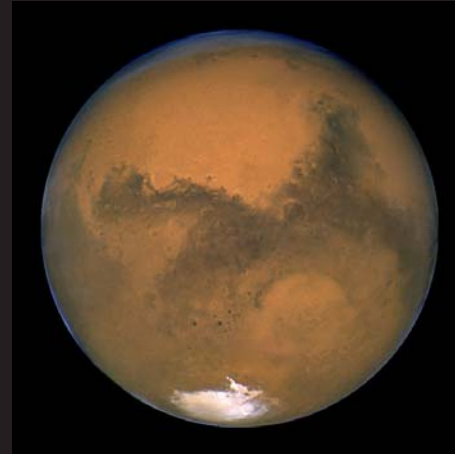
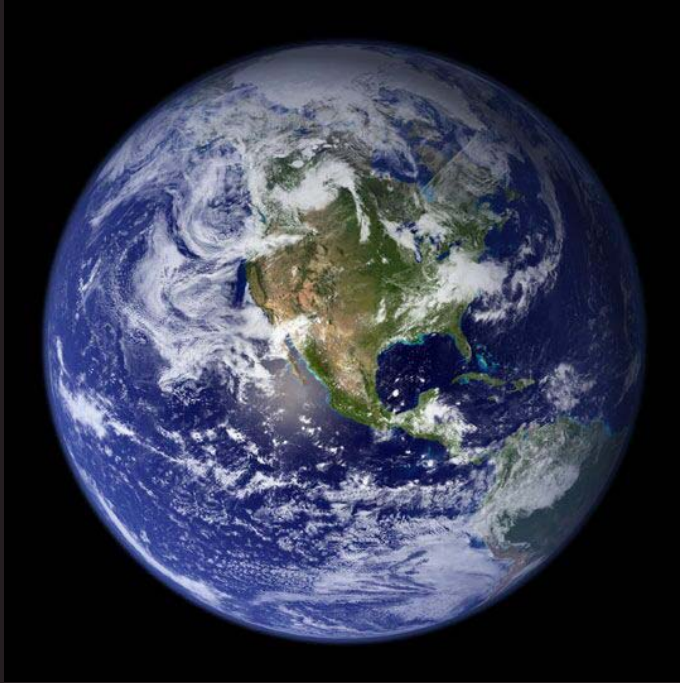


# The Venusian Atmosphere

- Surface completely covered by clouds
- Atmosphere mostly carbon dioxide and nitrogen
- Sulfuric acid clouds
- Runaway greenhouse effect – surface temperature  $> 700$  K



## Earth – Mars comparison



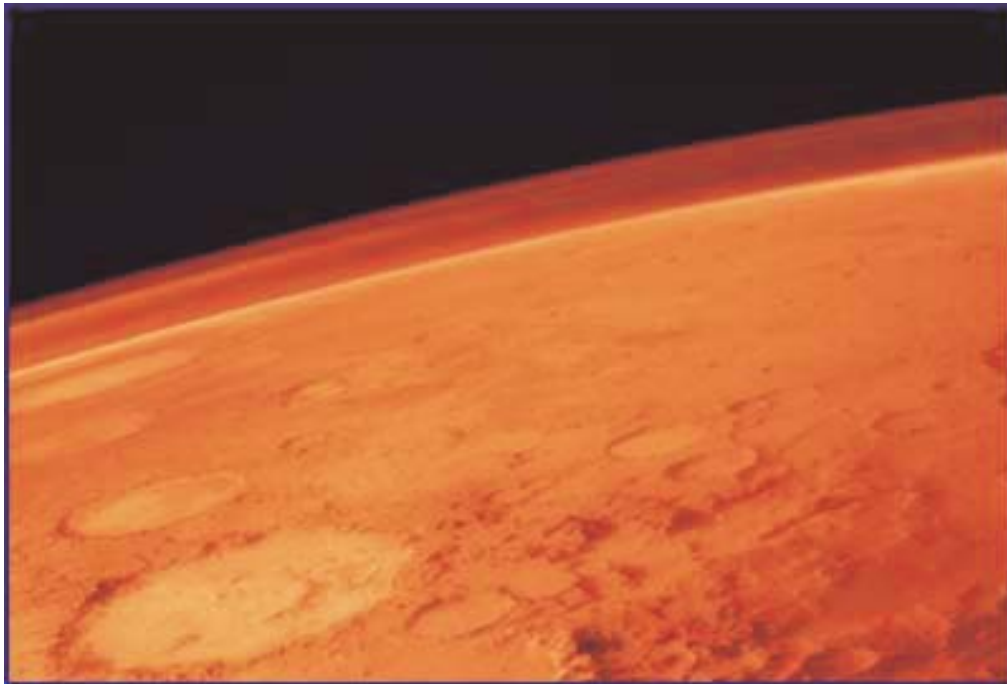
Mars has the Solar System's largest Volcano, Olympus Mons – 27 km tall.

Radius	0.532 Earth
Surface gravity	0.378 Earth
Mass	0.107 Earth
Distance from Sun	1.52 AU
Albedo	0.15
Eccentricity	0.006
Tilt	25°
Year	687 Earth days
Solar day	24 hours 39 minutes

# The Martian Atmosphere

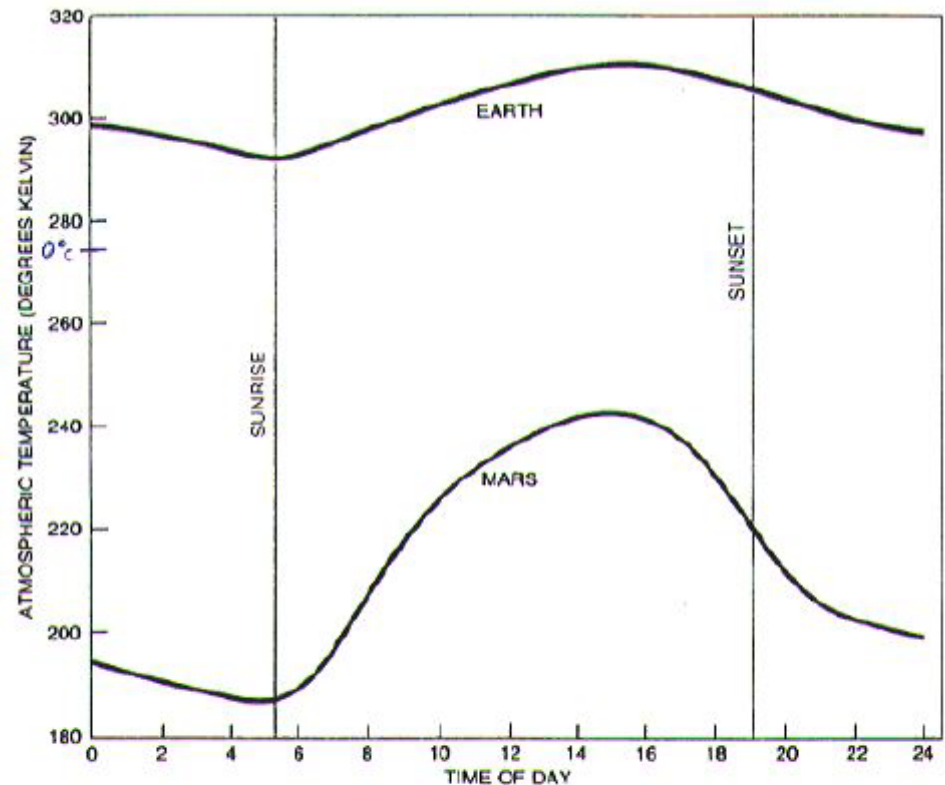


- 95% carbon dioxide
- Atmospheric pressure 0.6% of Earth's
  - like 40 km altitude on Earth
- Large daily swings in surface temperature
- Not protected by a global magnetosphere like Earth's



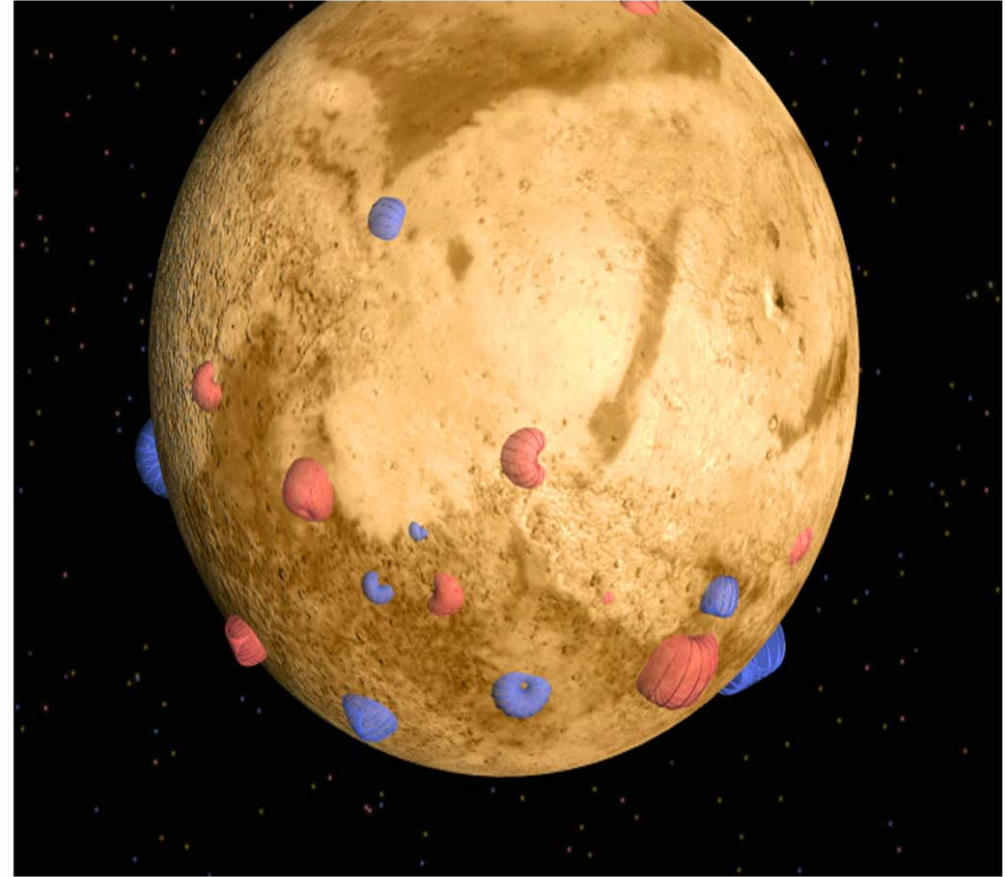
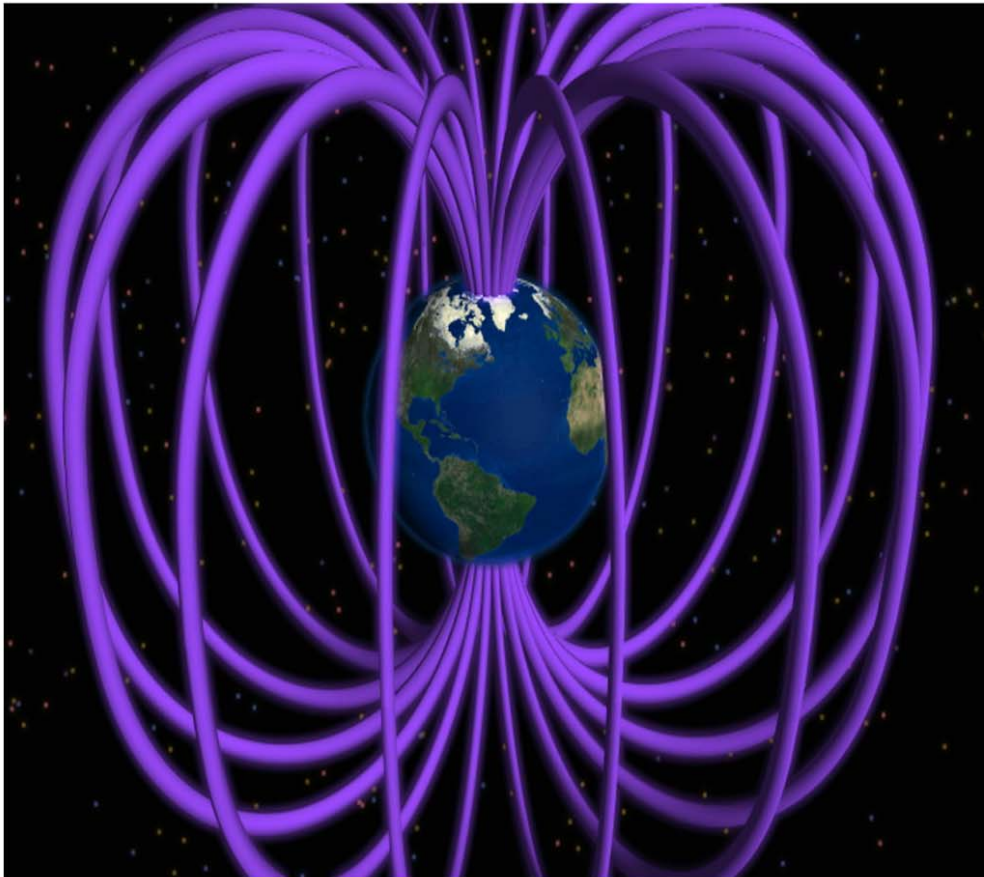
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Astronomy 1



**DAILY VARIATIONS IN ATMOSPHERIC TEMPERATURE** at the *Viking 1* landing site (*color*) are qualitatively similar to those at China Lake, Calif., a desert site (*black*). In both cases the temperature touches a minimum around sunrise and reaches a peak about 10 hours later. The daily range, however, is about three times greater on Mars than it is on the earth. At Viking site range is 55 degrees, from about 187 to 242 degrees Kelvin (−86 to −31 degrees Celsius). At China Lake range is 18 degrees, from 292 to 310 degrees K. (19 to 37 degrees C).

# Magnetic Field



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<http://www.solarviews.com/cap/mgs/field.htm>

# The Surface of Mars

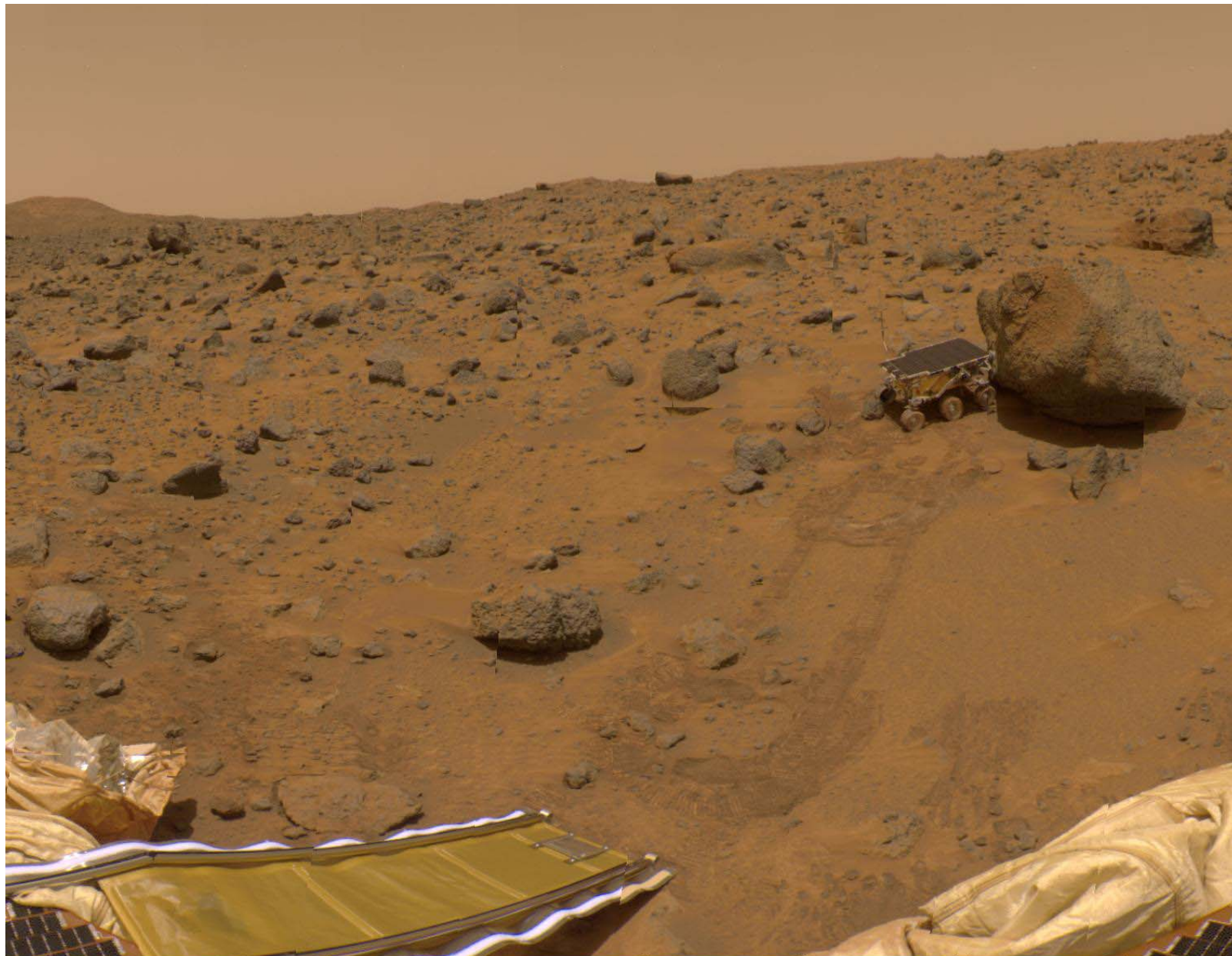


- Mars is a desert!
- Iron oxide in soil gives reddish cast



View of “Twin Peaks” from Mars Pathfinder

# The Surface of Mars

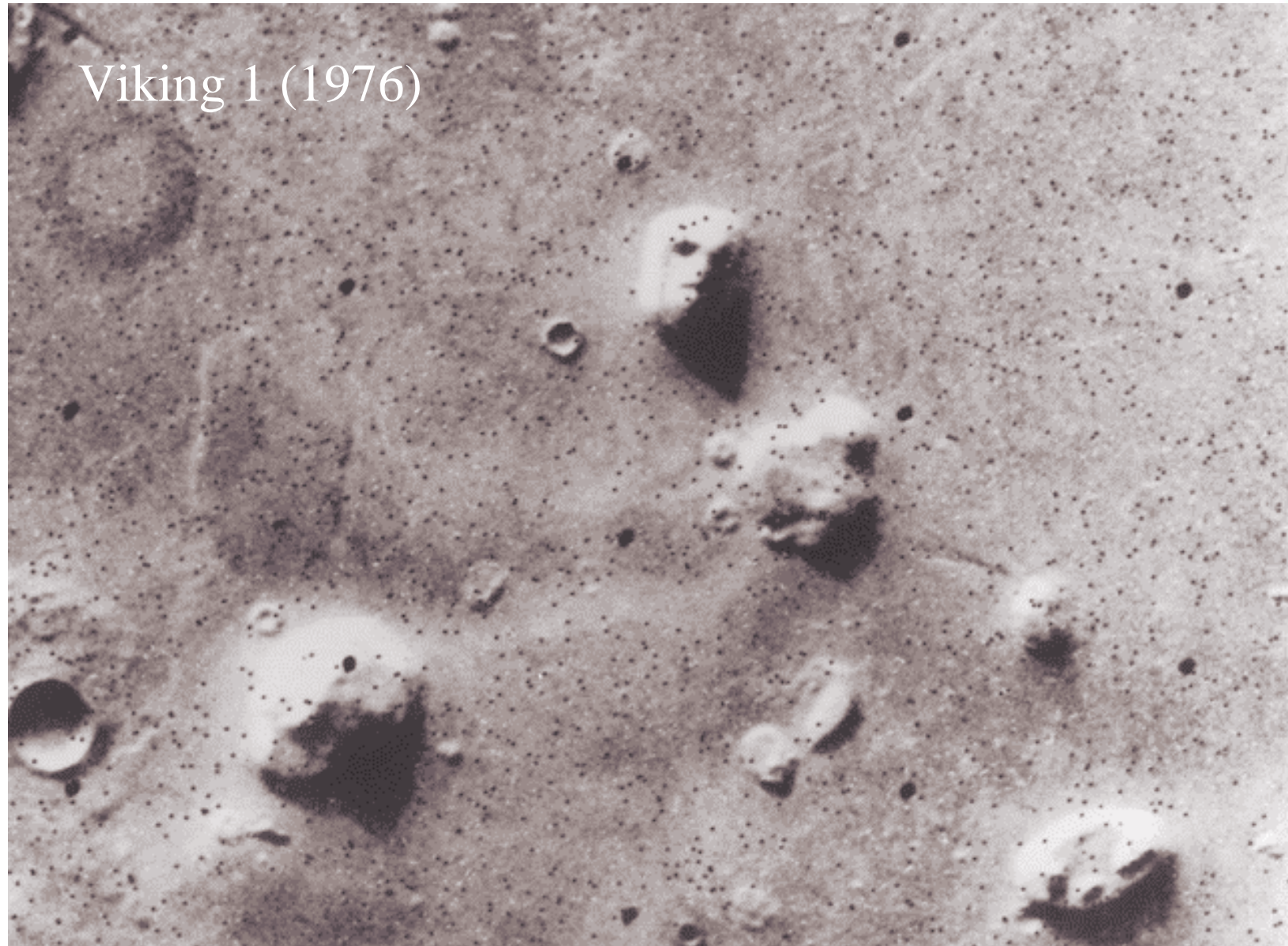


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[http://mpfwww.jpl.nasa.gov/MPF/ops/81696\\_full.jpg](http://mpfwww.jpl.nasa.gov/MPF/ops/81696_full.jpg)

# The Surface of Mars

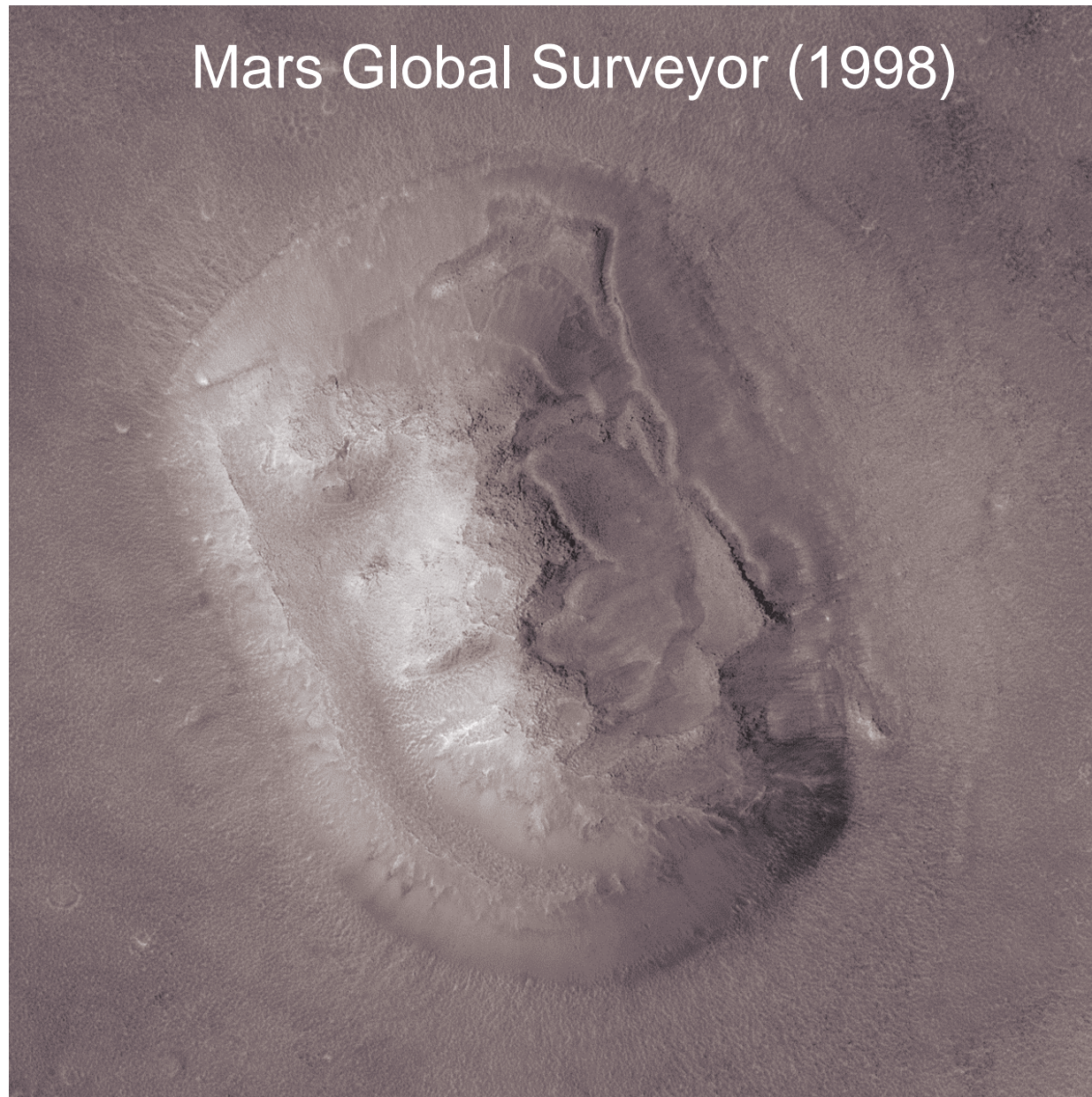


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<http://antwrp.gsfc.nasa.gov/apod/ap980406.html>

# The Surface of Mars



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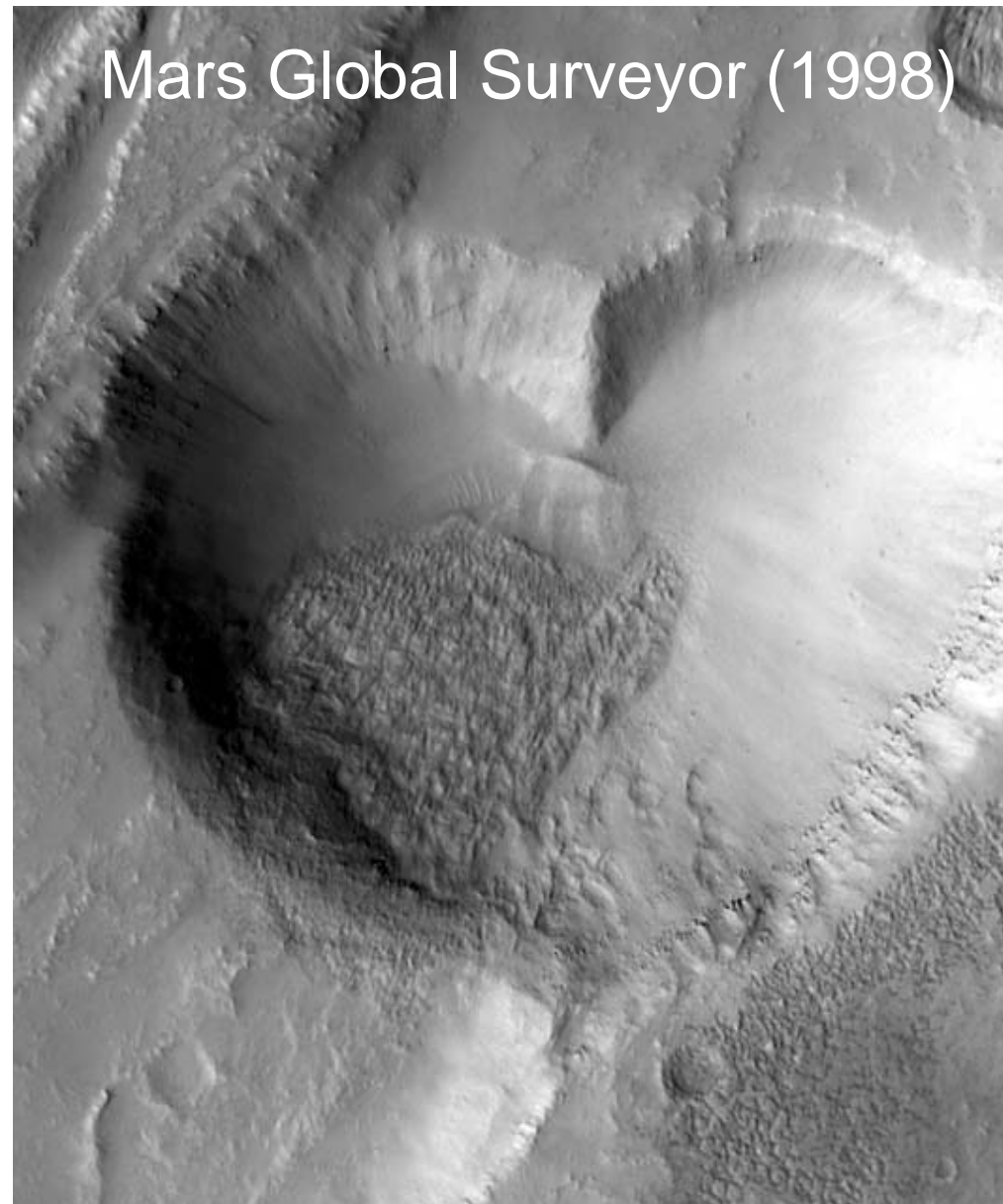
<http://antwrp.gsfc.nasa.gov/apod/ap010528.html>



# The Surface of Mars



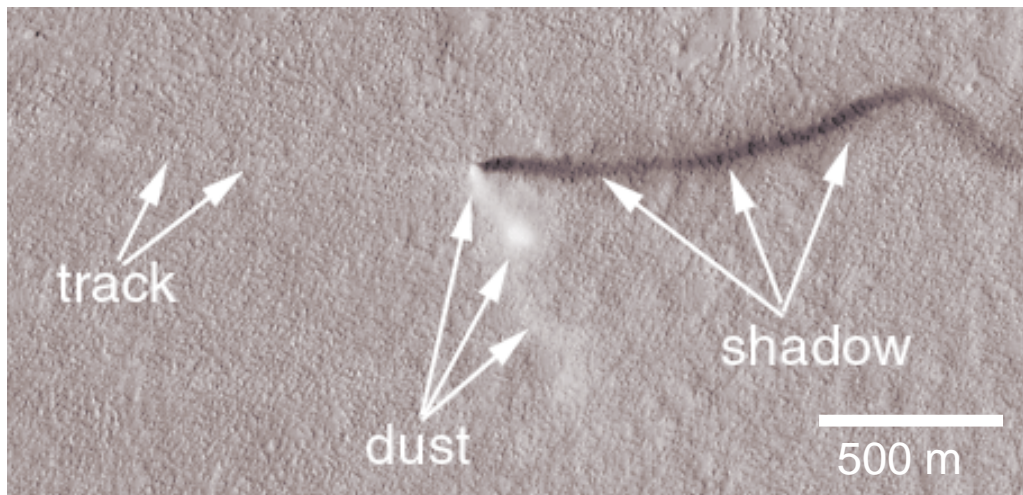
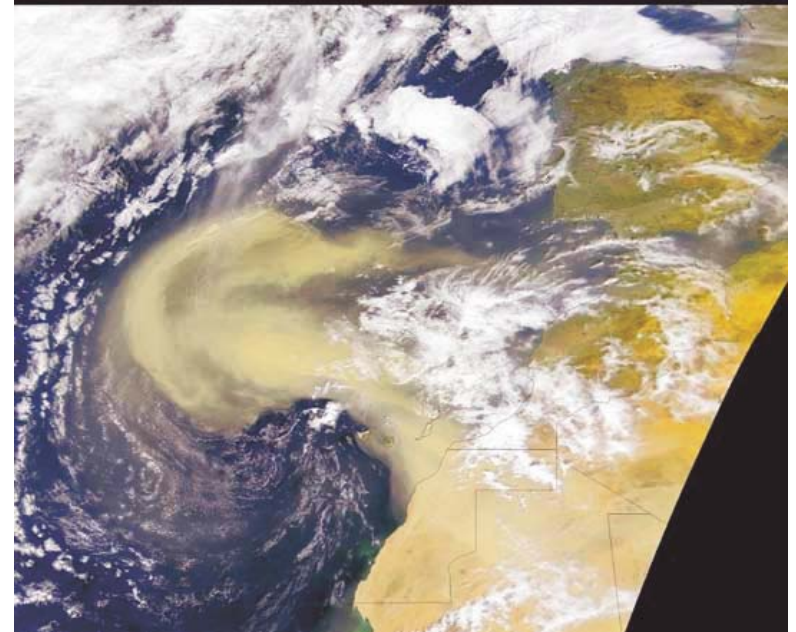
# The Surface of Mars



# Dust Storms and Dust Devils on Mars



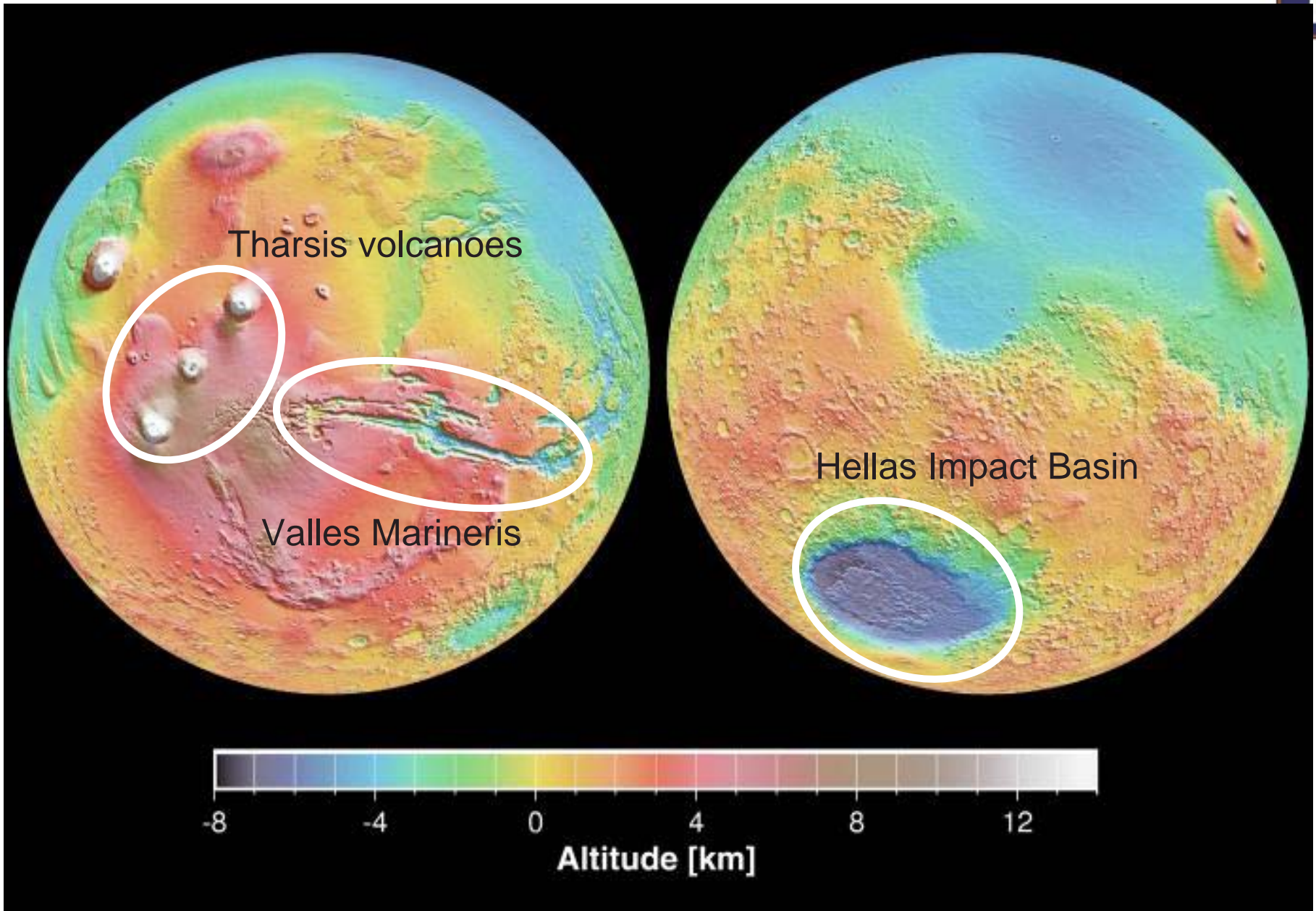
Dust devil on Earth (D. Catling)



Dust devil seen by Mars Global Surveyor

Dust storms: Mars vs. Earth

# The Surface of Mars



# Olympus Mons



- The largest mountain in the Solar System rising 24 km (78,000 ft.).

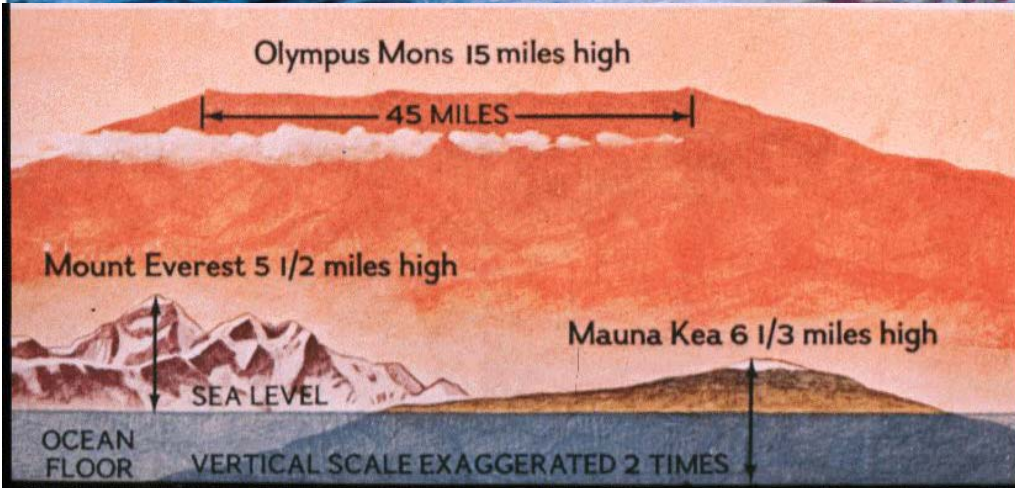
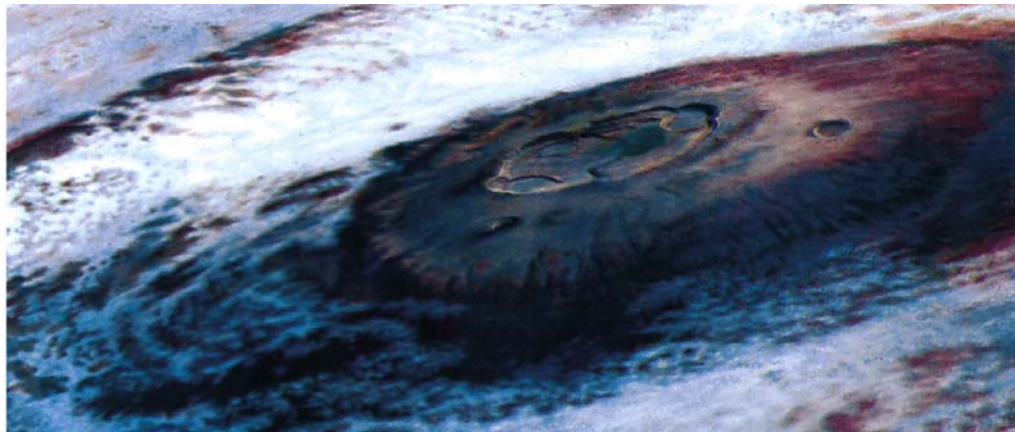
- Its base is more than 500 km in diameter and is rimmed by a cliff 6 km (20,000 ft) high (right).
- Erupted 200 years ago.



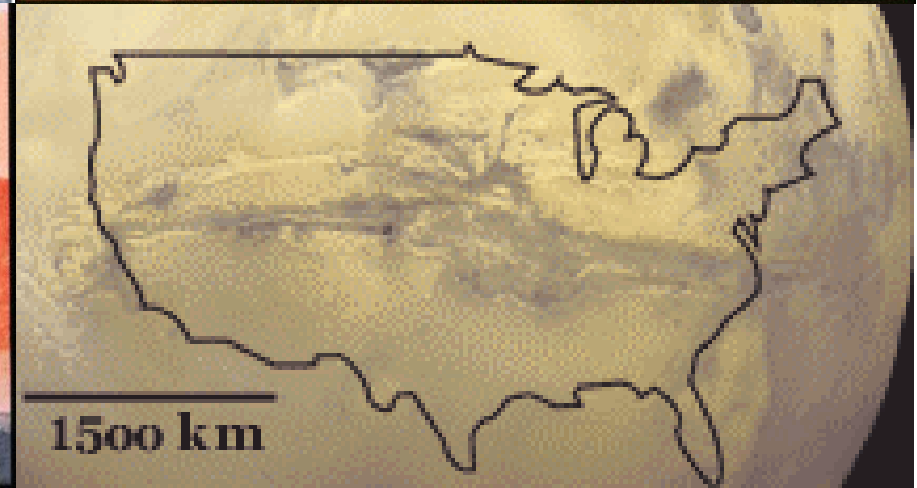
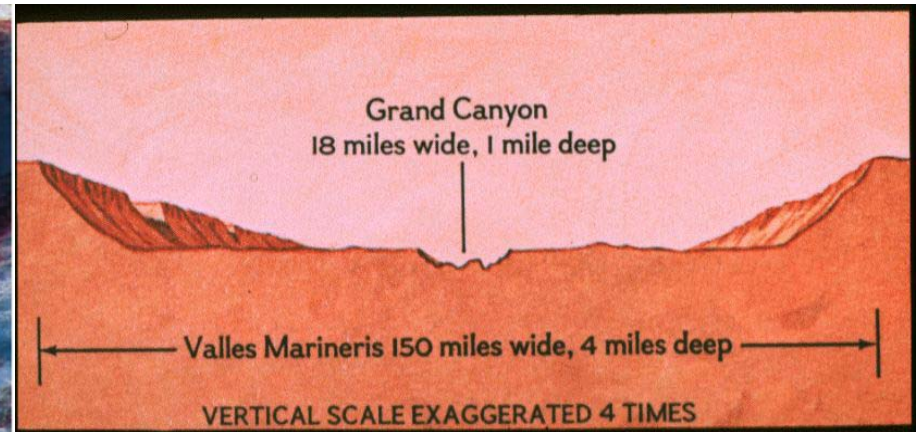
# Volcanoes and chasms



## Olympus Mons



## Valles Marineris

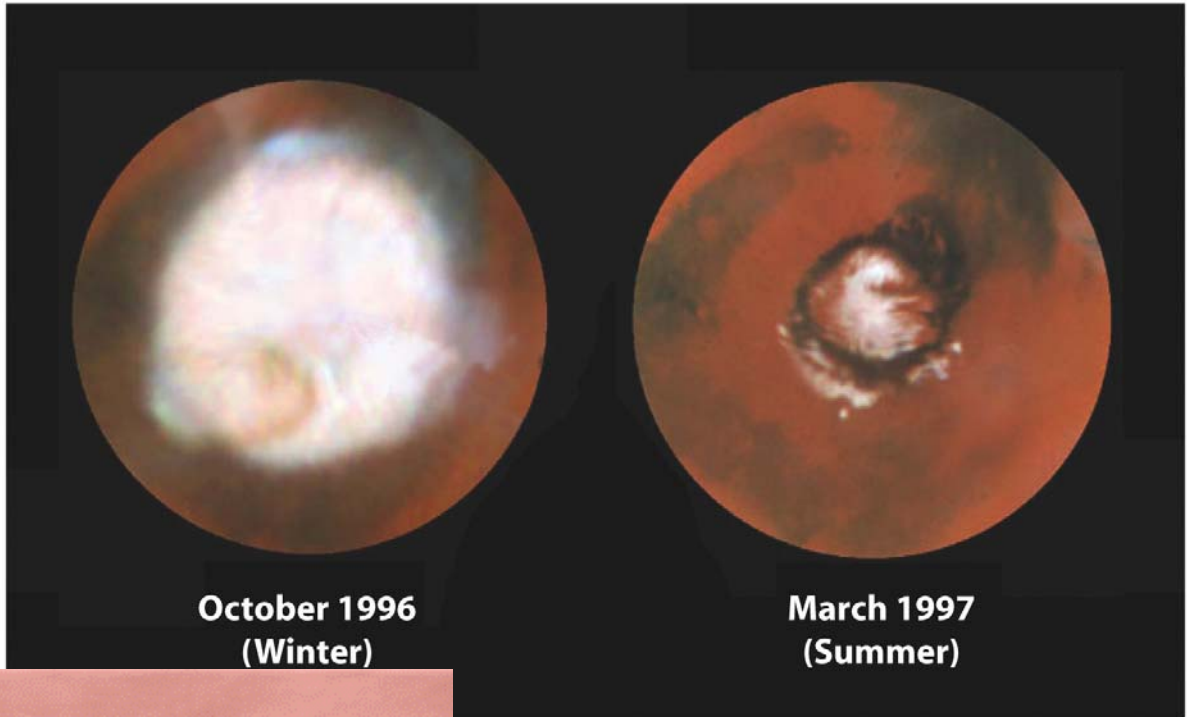


# Water on Mars



- North and south polar caps
- Frost
- Clouds (ice crystals)

<http://www.solarviews.com/eng/marsclld.htm>



October 1996  
(Winter)

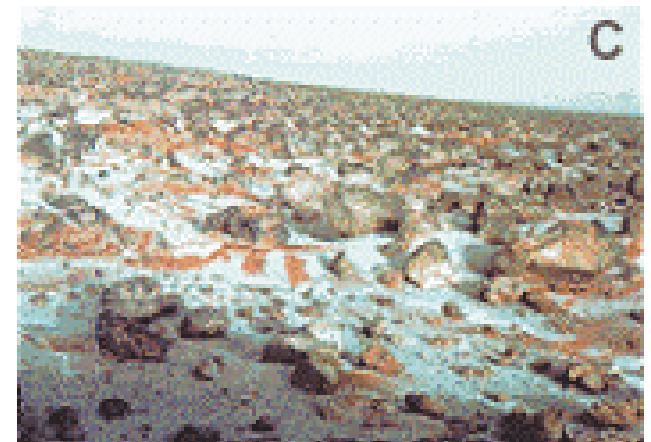
March 1997  
(Summer)



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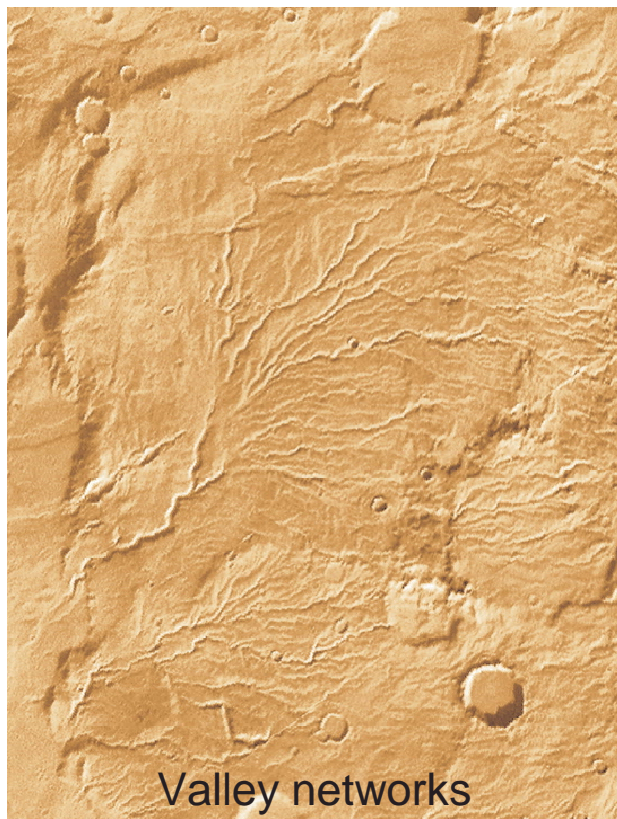


NASA Spacelink



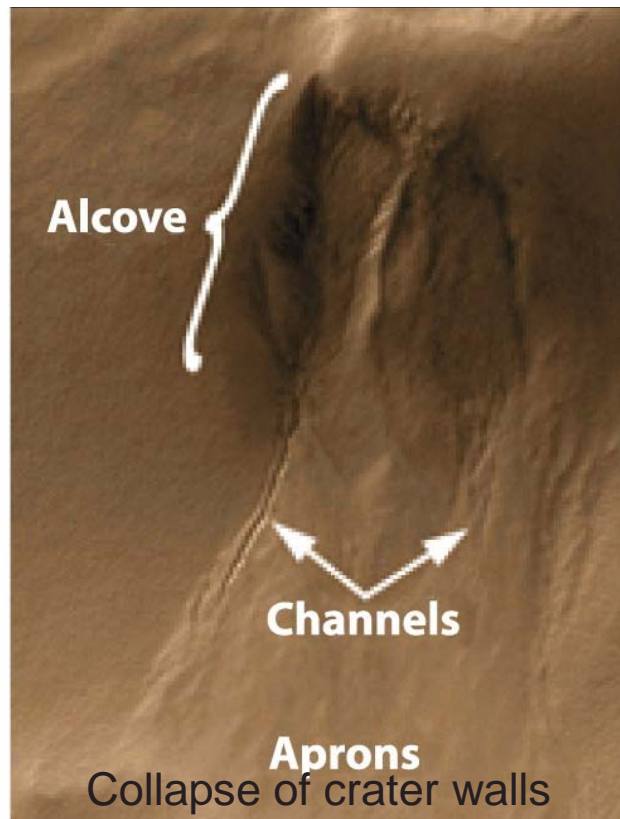
# Liquid water on Mars?

- ▶ Water erosion features visible from space
- ▶ Atmospheric pressure too low for liquid water to exist
- ▶ Perhaps at some point in the past?

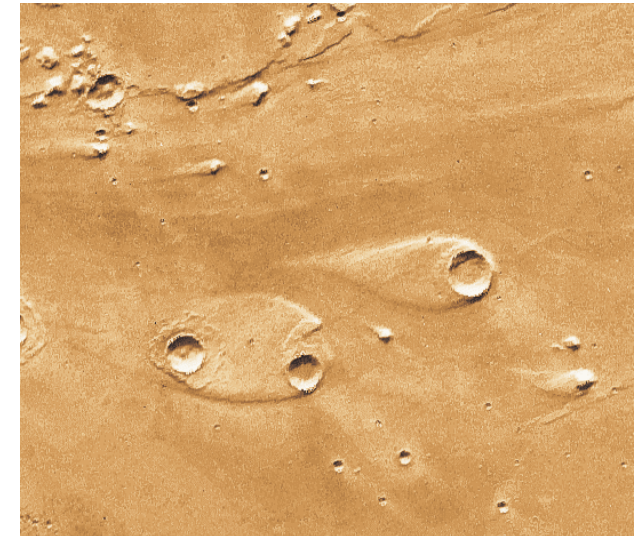


Valley networks

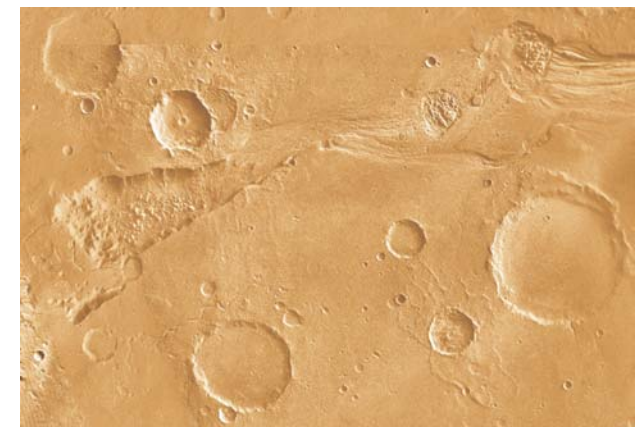
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"Islands"



Flood erosion





# Deimos

<http://www.solarviews.com/raw/mars/vdeimos3.mpg>

- About 7 x 5 km in size
- Not enough mass for gravity to make spherical

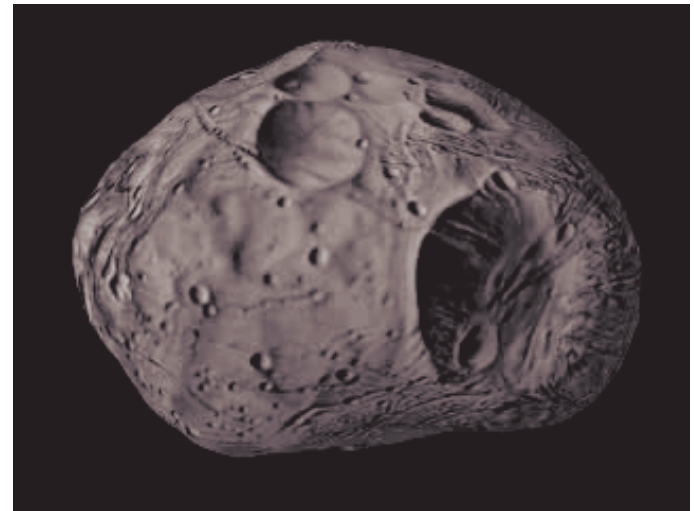


# Phobos



<http://www.solarviews.com/raw/mars/vphobos4.mpg>

- About 13 x 9 km in size
- Is slowly falling into Mars— 1 m/50 years
- More cratered



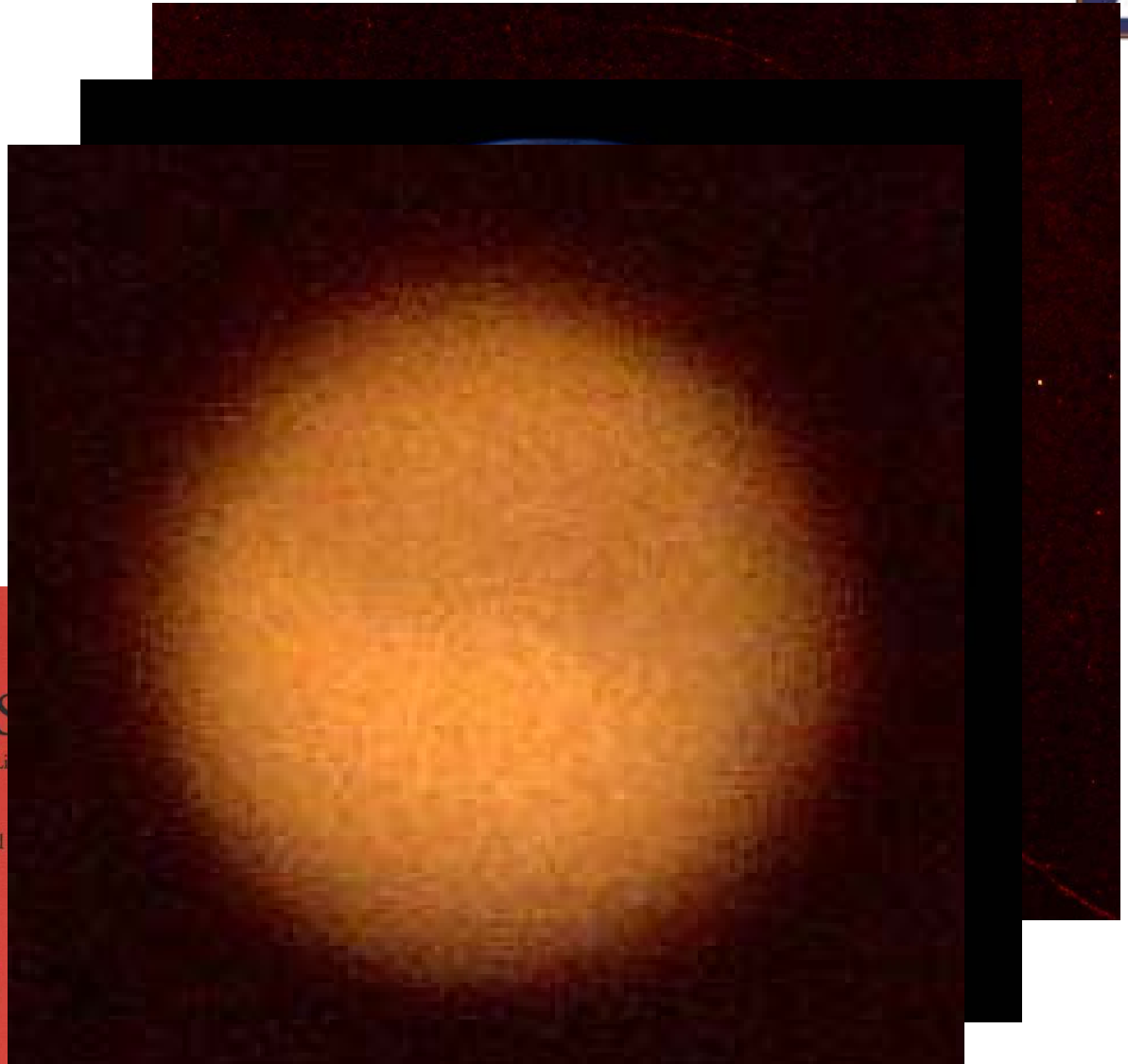
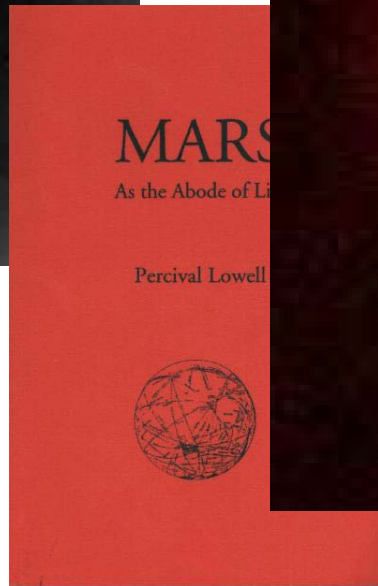
# Martian Eclipses



Eclipse from Phobos.  
These happen a few times a day whenever Phobos passes over the planet's sunlit side. The dark spots seen on three crater floors are probably small fields of dark sand dunes



# Percival Lowell and the “Canals” of Mars



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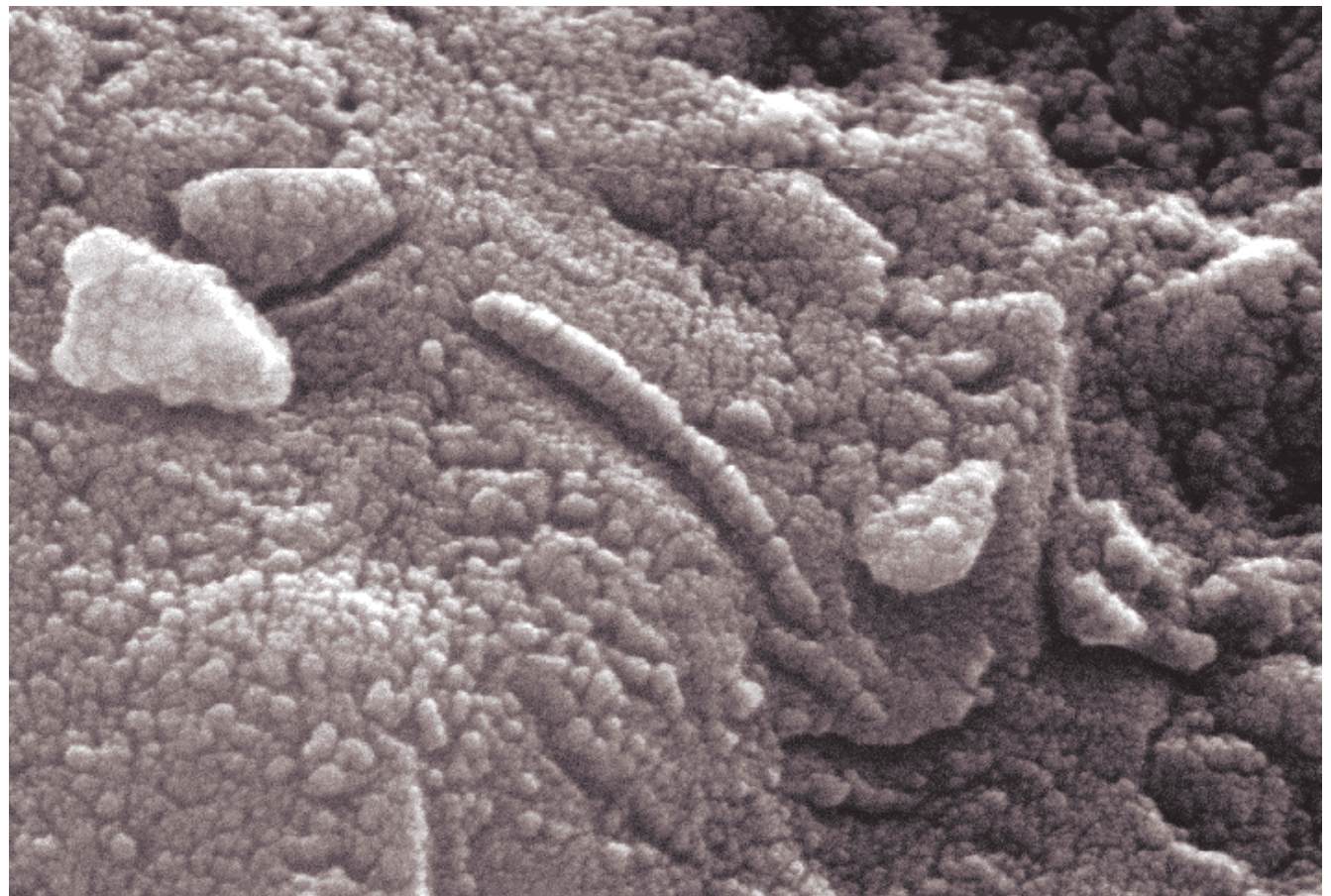
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# Life on Mars?

<http://www.solarviews.com/raw/mars/marslif1.mpg>

<http://www.solarviews.com/raw/mars/marslif4.mpg>



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<http://www.lpi.usra.edu/lpi/meteorites/Photomicrograph.gif>