

# **Astronomy 405**

## **Solar System and ISM**

### **Lecture 9**

### **Mars**

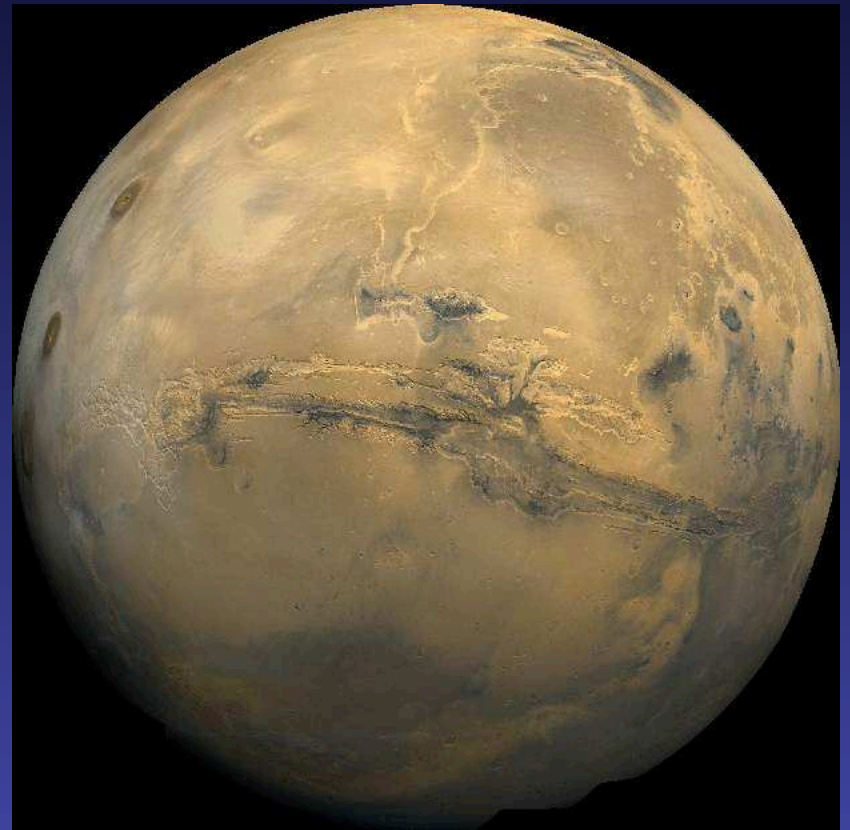
**February 4, 2013**

# Mars

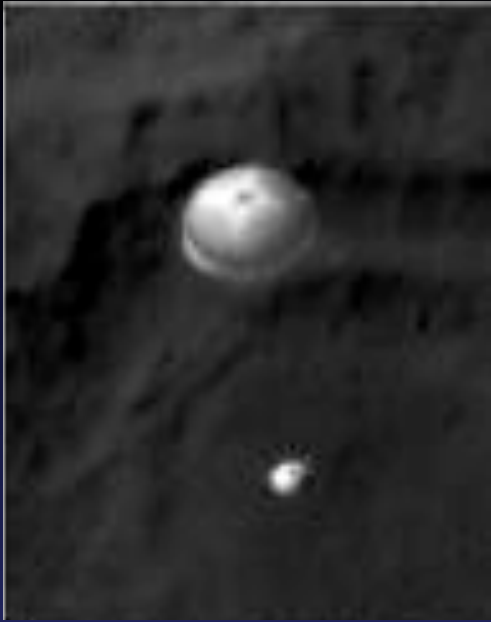
Mariner; Viking Orbiter; Mars Global Surveyor; Mars Odyssey;  
Mars express Orbiter; Mars Reconnaissance Orbiter;  
Mars Pathfinder - Spirit and Opportunity Rovers



Hubble Space Telescope



Viking Orbiter (1976)



Mars Reconnaissance Orbiter  
imaged Mars Rover Curiosity









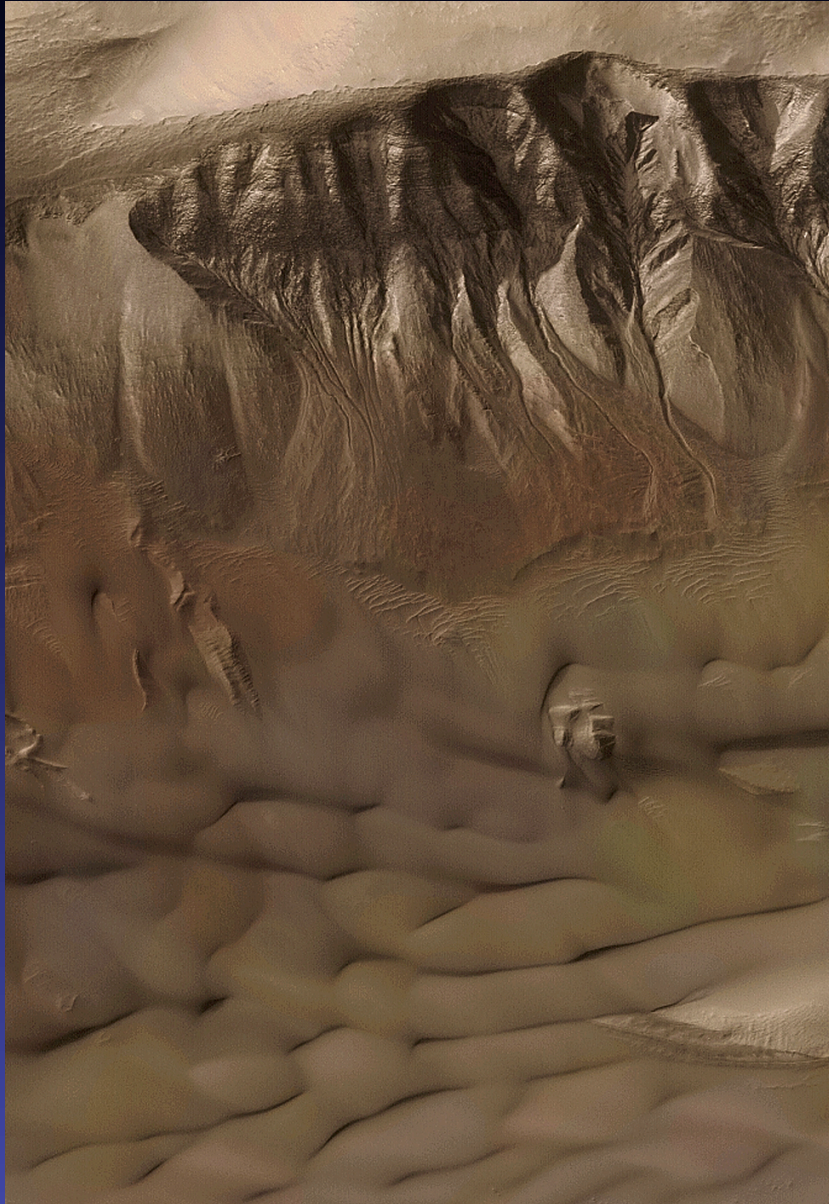
# Mars

Images show a dry, dusty world.

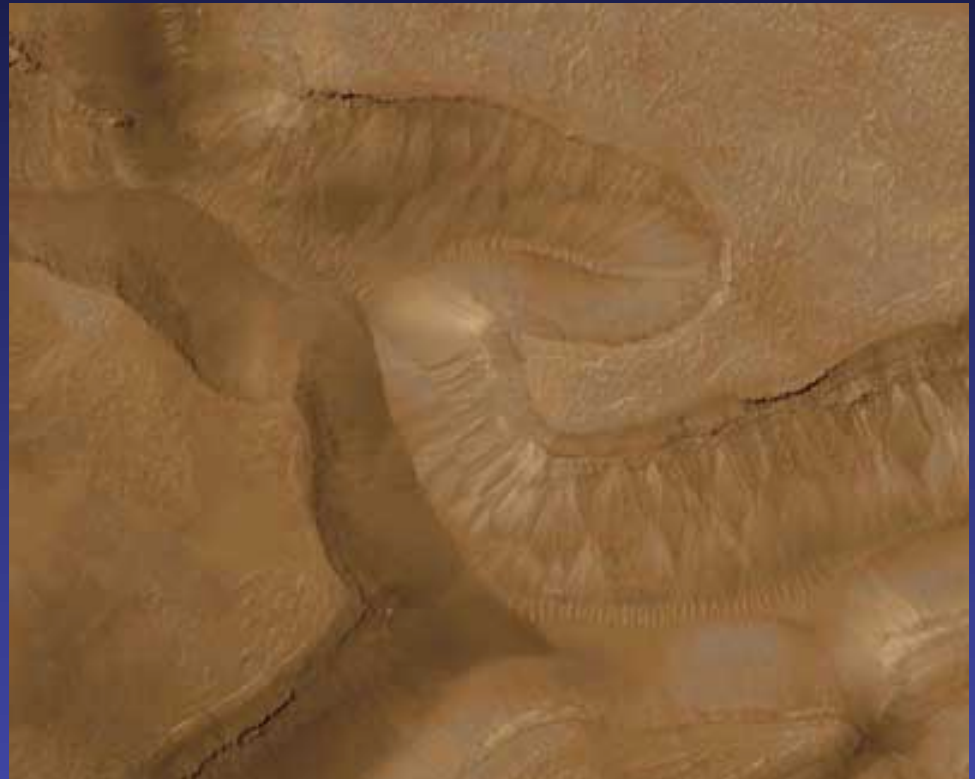




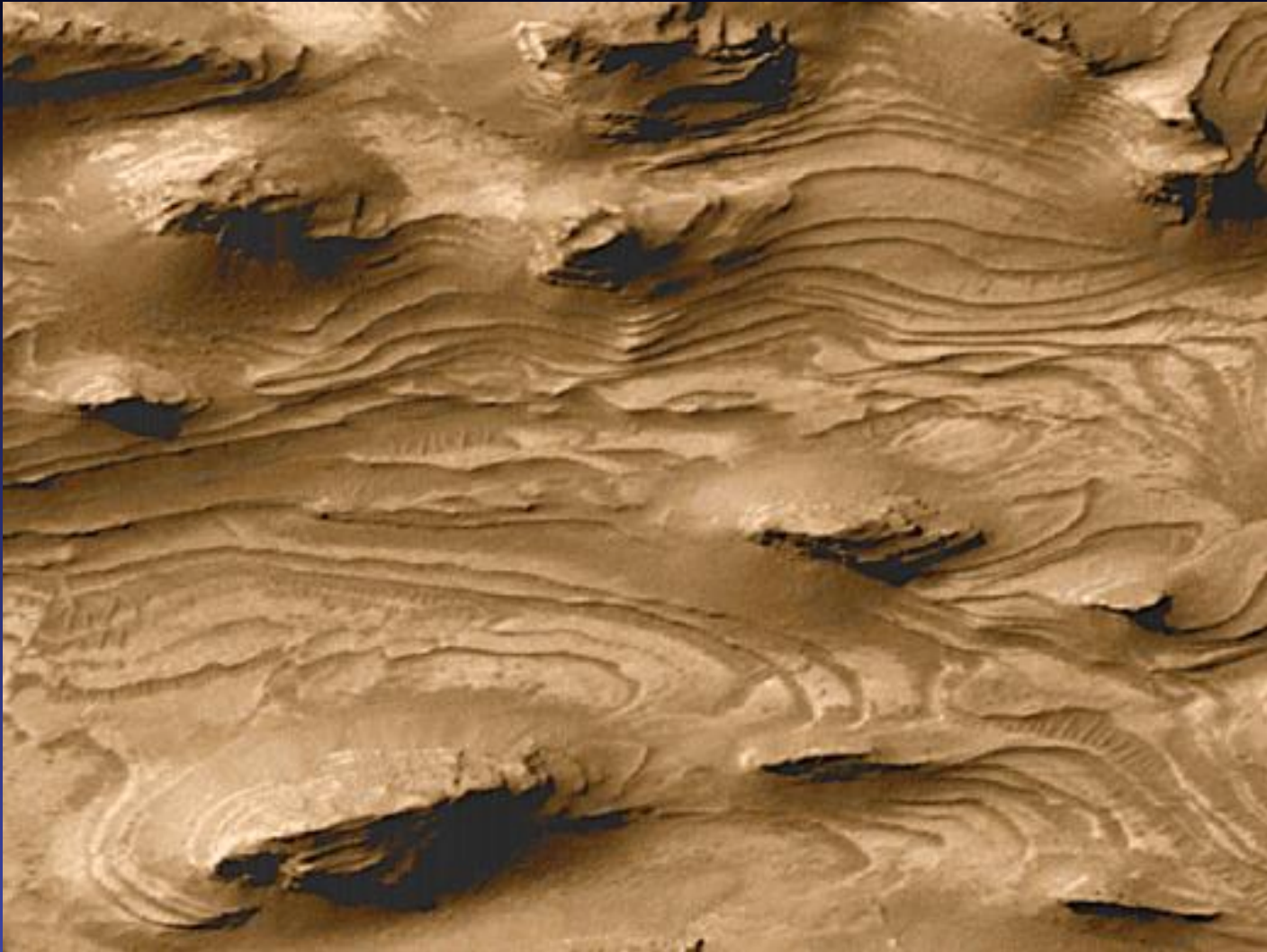
# Water on Mars



There are signs indicating that water flowed on the Surface in the past.

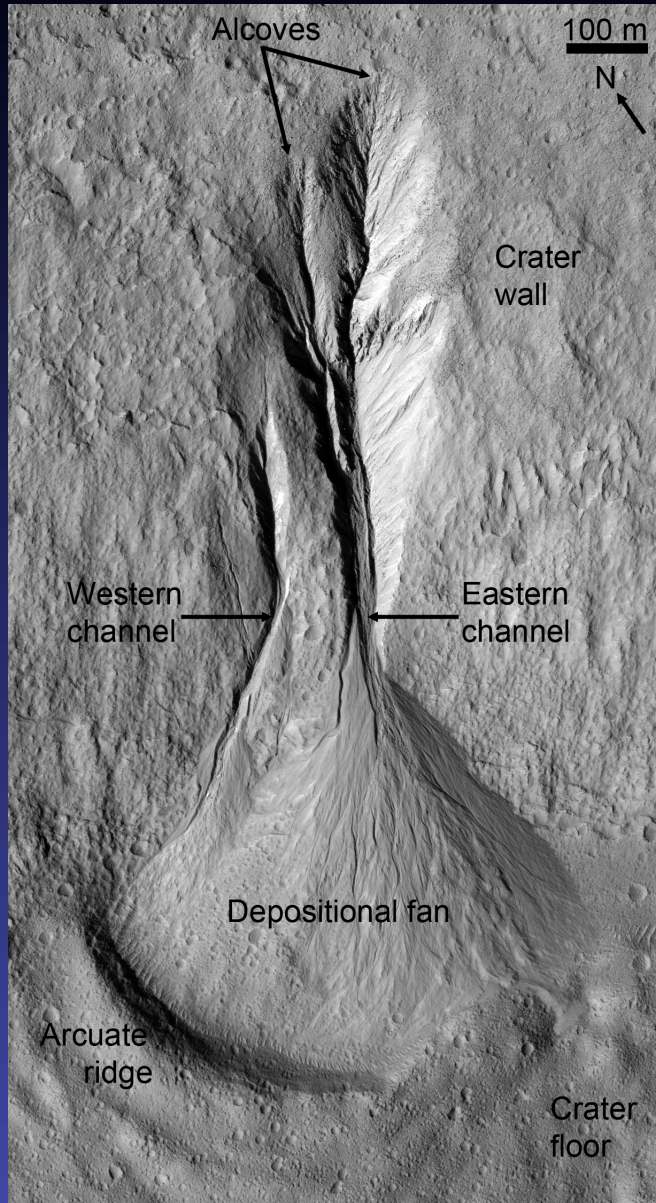


# Water on Mars



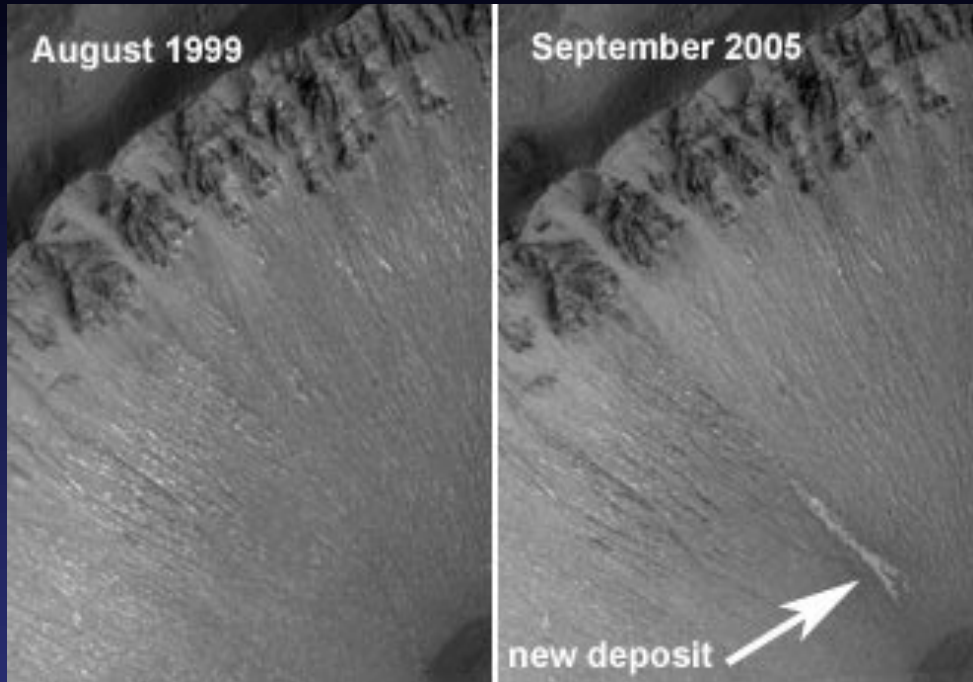


# Water on Mars



Rim of an Impact Crater in Sirenum Terra

# Water on Mars



Mars Global Surveyor  
images of a gully in a  
crater in the Centauri  
Montes Region





# Water on Mars





# Water on Mars

Present-day surface temperature variations between  $-140^{\circ}\text{C}$  and  $20^{\circ}\text{C}$ .

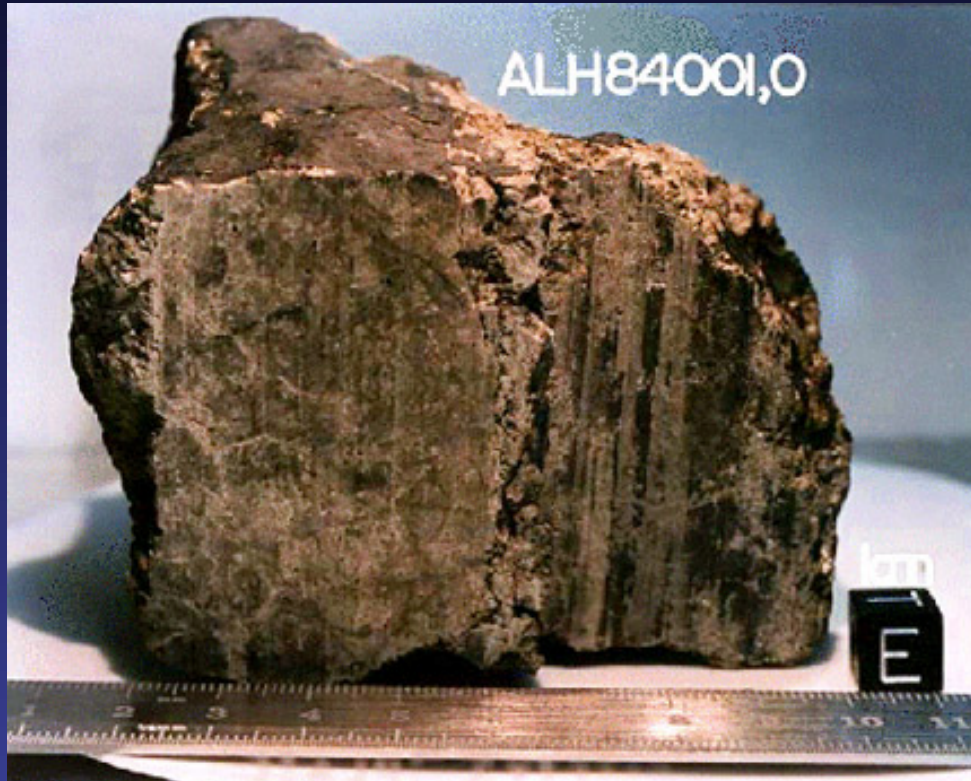
Pressure  $\sim 0.006\text{ atm}$

The low pressure makes it impossible for liquid water to exist on the surface.

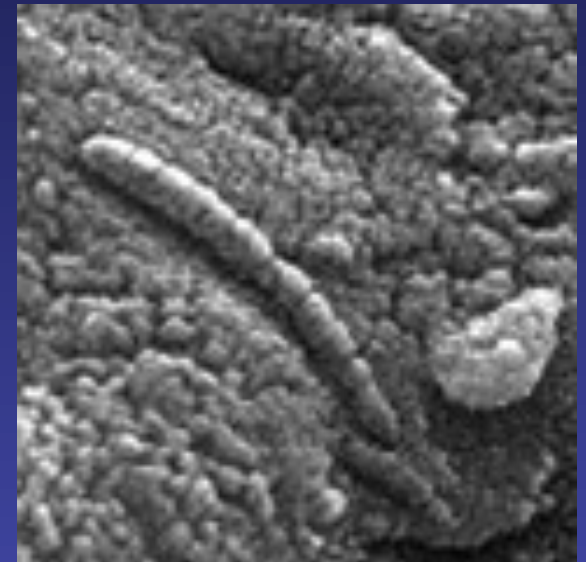
The liquid water that was present on Mars is now either trapped in a layer of permafrost or frozen in its polar caps.

# Life on Mars ?

Robotic landers have not found any evidence of life on Mars.  
A Martian meteorite found in Alan Hills, Antarctica in 1984

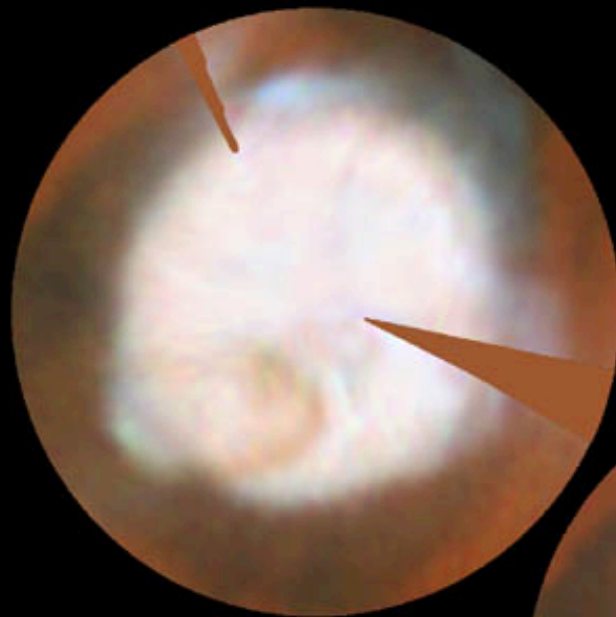


Formed 4.5 Gyr ago,  
ejected 16 Myr ago  
by a collision, struck  
Earth 13 kyr ago.



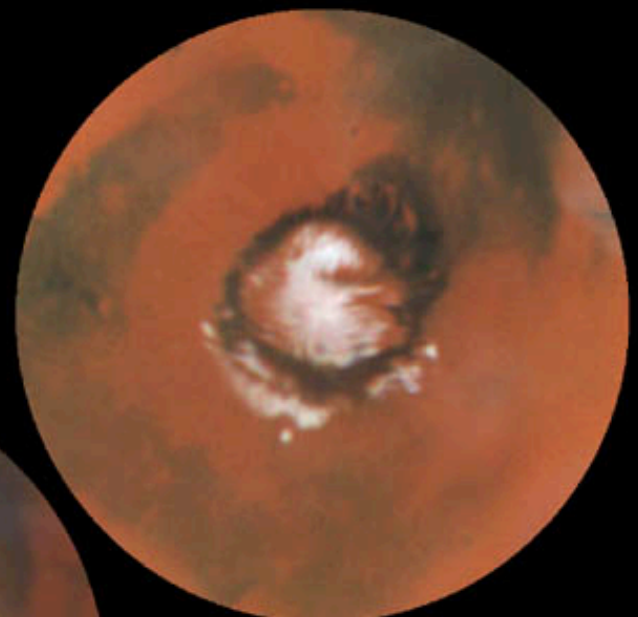
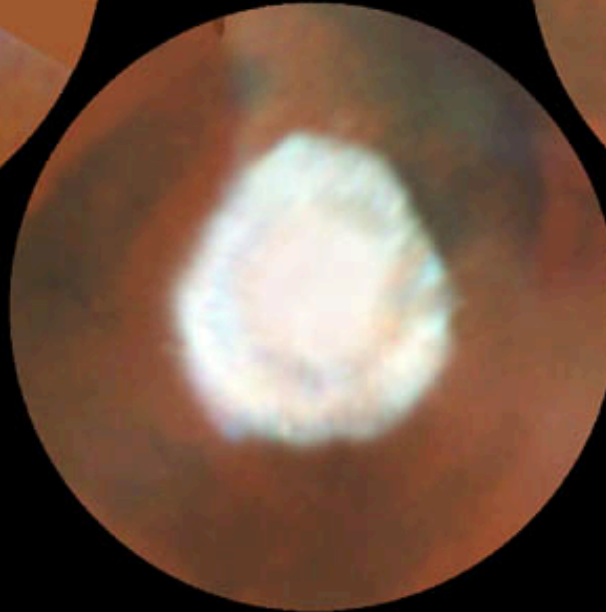
Carbonate grains, in fractures, 200  $\mu\text{m}$   
in size. Nanofossils? Formed by  
inorganic mechanisms? Contamination from Earth?

# Polar Caps of Mars



October 1996

January 1997



March 1997

**Mars**  
**North Polar Cap**

HST • WFPC2

PRC97-15b • ST ScI OPO • May 20, 1997

P. James (Univ. Toledo), T. Clancy (Space Science Inst.), S. Lee (Univ. Colorado) and NASA

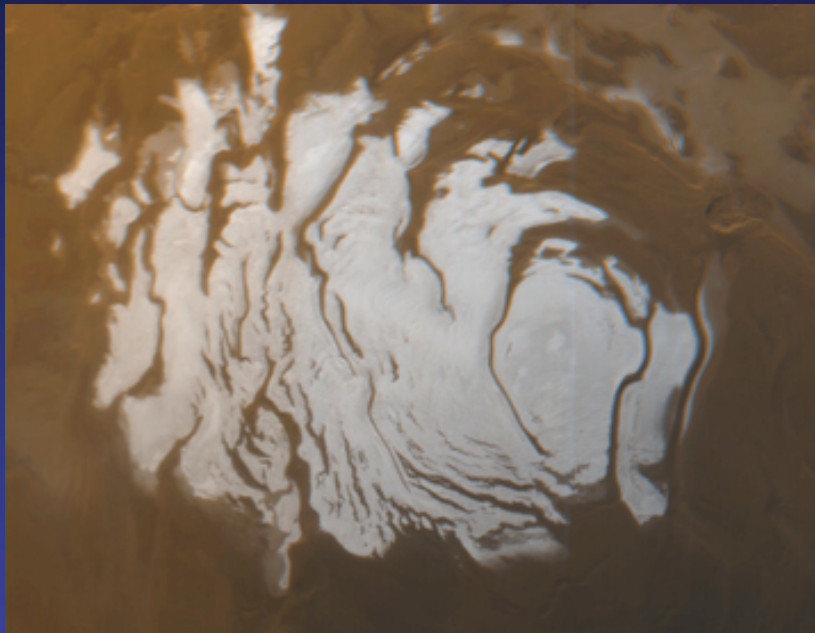


# Polar Caps of Mars

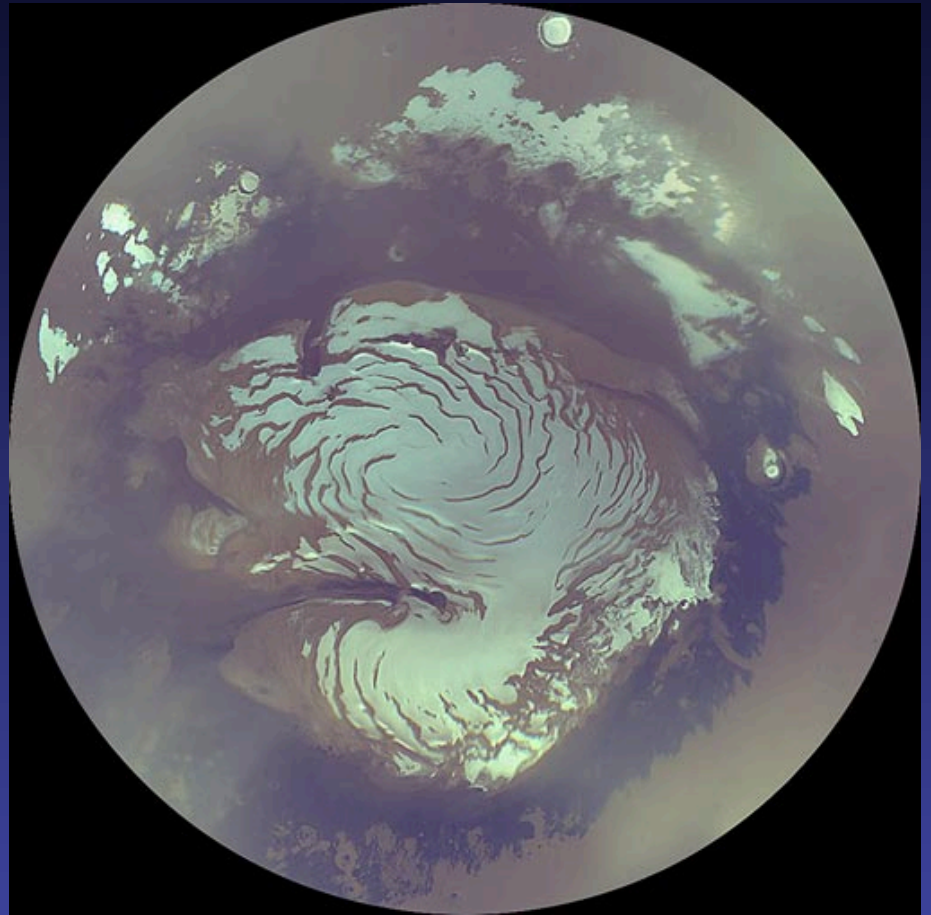
The polar caps are mostly dry ice.

Dry ice sublimate during summer and freezes back in winter.

The residual cap in the summer is composed of water ice.



South Polar Cap taken by  
Mars Global Surveyor



North Polar Cap taken by NASA's  
Mars Reconnaissance Orbiter

# Polar Caps of Mars

Mars' s axis tilt =  $25^\circ$ .

Orbital period = 1.88 yr.

$e = 0.0935$  (Earth 0.0167)

Perihelion  $a (1 - e)$

Aphelion  $a (1 + e)$

Seasons on Earh is caused by the rotation axis tilt.

Seasons on Mars is affected by BOTH the rotation axis tilt and the different distances at perihelion and aphelion.

Southern winter is at aphelion

=> Colder and lasting longer => larger cap in winter.

# Rotation Axis of Mars

Numerical simulations of long-term stability of planetary motions indicate that Mars' s spin axis fluctuates wildly between  $0^\circ$  and  $60^\circ$  over timescales of a few Myr.

Polar caps could completely melt at high tilt angles.

The similarity of the current tilt to that of Earth is only coincidental.

The variations of axis tilt develop only if general relativity is taken into account.

Earth' s spin axis is stable because of the strong tidal Interaction with the large Moon.

Stable climate => Makes life easier!!!!



# Thin Atmosphere of Mars

Mars' s atmosphere: 95% CO<sub>2</sub>, 2.7% N<sub>2</sub> (by number)

Similar to Venus, but no greenhouse effect, due to thin atmosphere. 90 atm on Venus, 0.006 on Mars.

Water was present in the past.

The atmosphere might have a lot of water and rainfalls.

Water in the atmosphere and surface absorbed CO<sub>2</sub> , locking it in carbonate rocks, and reducing the greenhouse effect.

Temperature dropped, water froze. Permafrost.

CO<sub>2</sub> can freeze out in the winter and sublime in the Summer, causing seasonal changes of the atmospheric pressure.

# Dust Storms on Mars

Dry world. Dusty. Dust storms.

Dust storms provide heating of the atmosphere.

**Mars • Global Dust Storm**



June 26, 2001



September 4, 2001

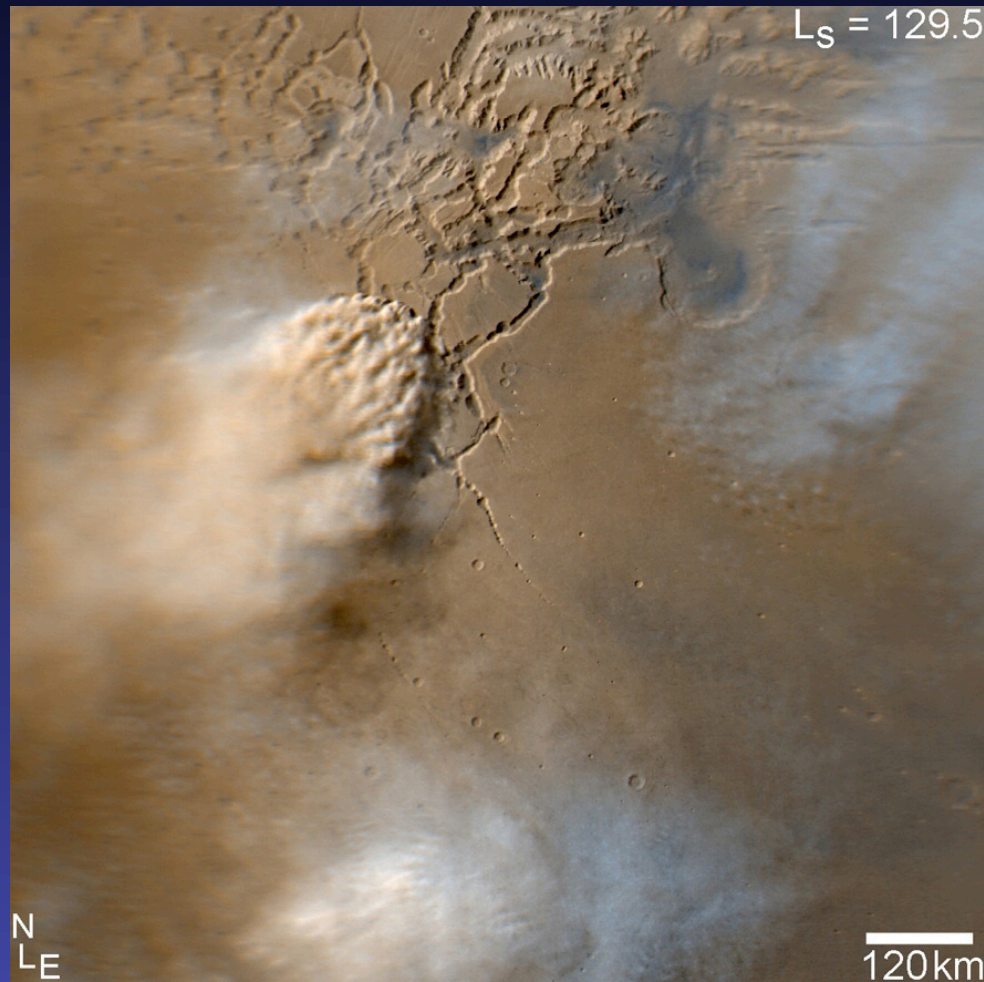
**Hubble Space Telescope • WFPC2**

NASA, J. Bell (Cornell), M. Wolff (SSI), and the Hubble Heritage Team (STScI/AURA) • STScI-PRC01-31

# Dust Storms on Mars

Dry world. Dusty. Dust storms.

Dust storms provide heating of the atmosphere.



Imaged by Mars Reconnaissance Orbiter



# Abundance of Iron

The Martian dust is reddish because of its relatively high iron abundance.

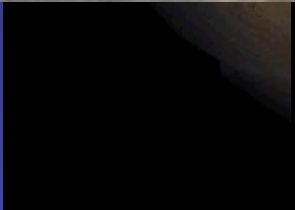
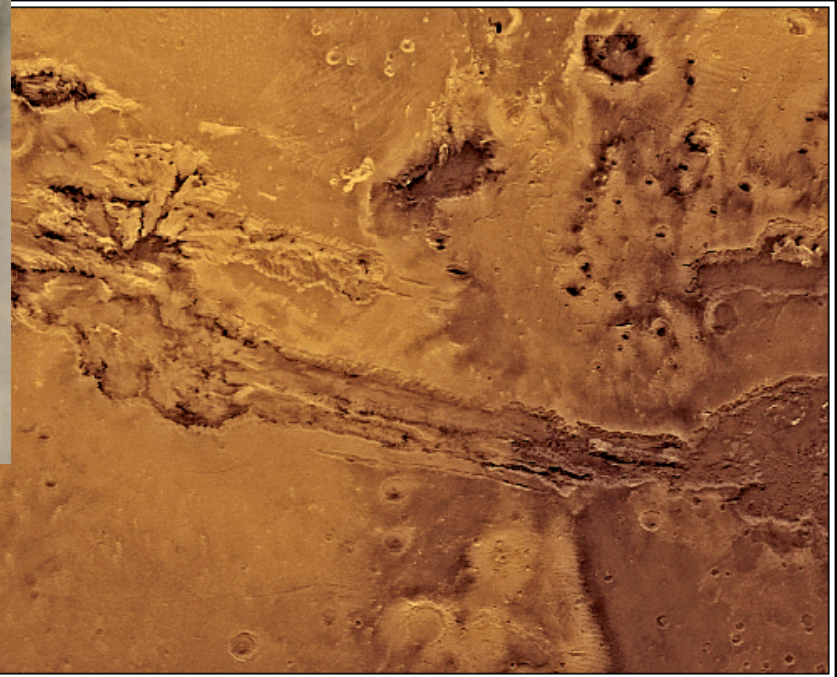
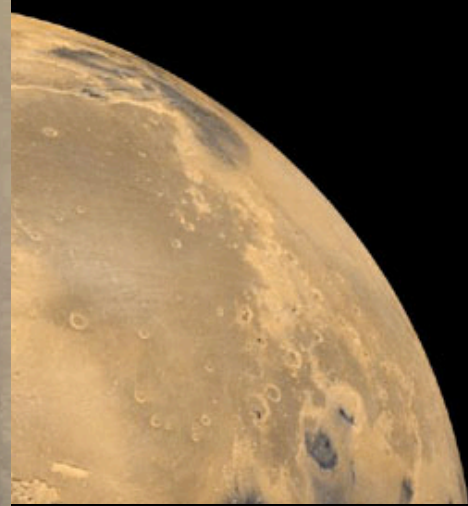
The overall iron abundance of Mars is low compared to Earth.  
Average density: Mars  $3.9 \text{ g/cm}^3$ , Earth  $5.5 \text{ g/cm}^3$ .

Mars did not go through significant gravitational separation (heavy material sinks and lighter material floats)

⇒ No or small iron core.

⇒ no global magnetic field

# Geological Activity on Mars





# Geological Activity on Mars

## Olympus Mons - largest volcano

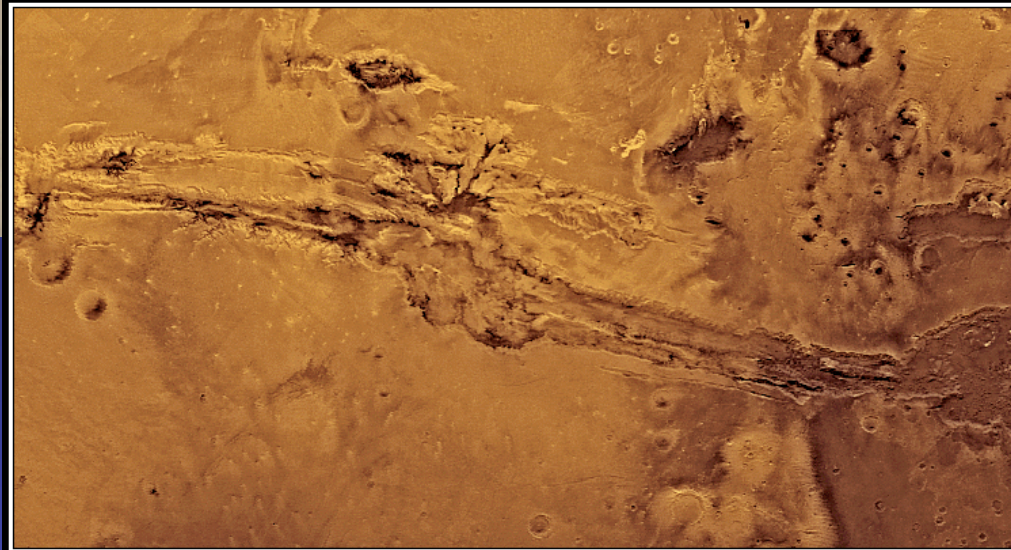
A shield volcano, 24 km high, 500 km diameter.

Hot-spot volcanism.

No tectonic motion, build at the same spot.

## Valles Marineris

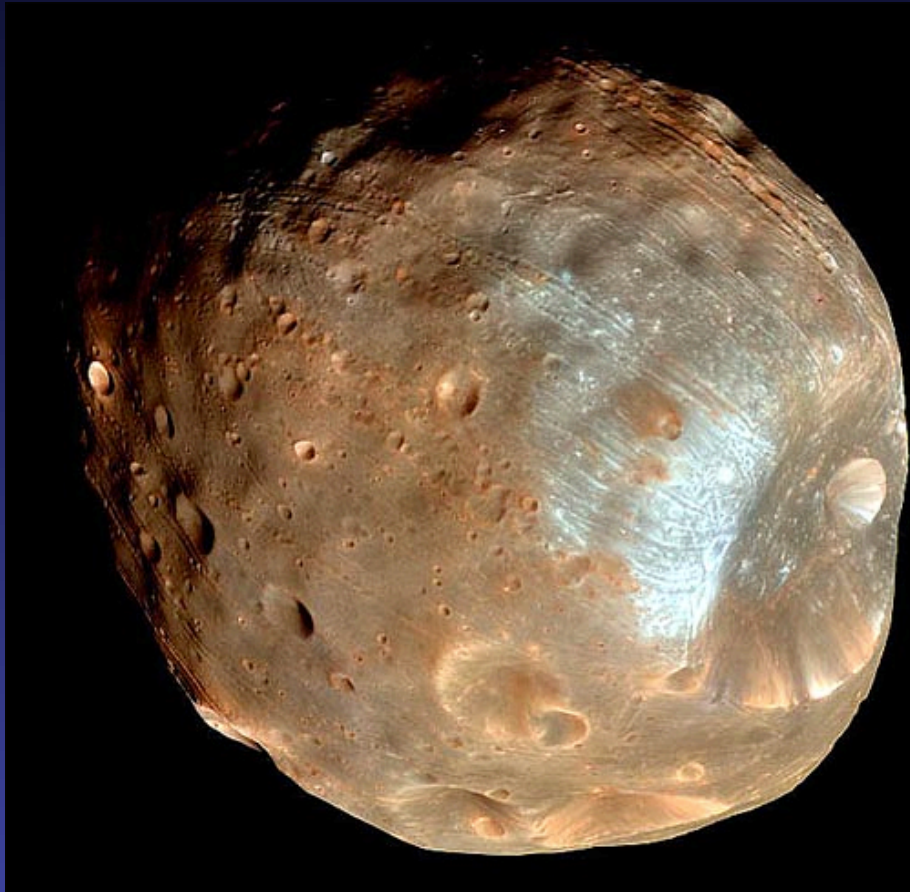
A fault (fracture of the crust) 3000 km long, 600 km wide, 8 km deep



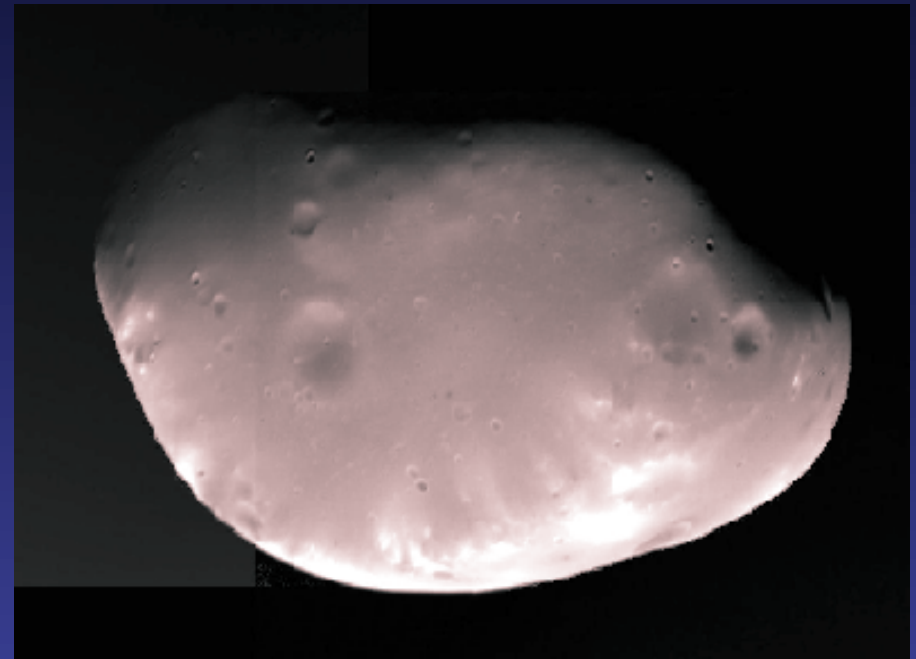


# Mars Has Two Moons

Two moons - captured asteroids.  
What are the masses of these asteroids?



Phobos (fear)



Deimos (panic)