

Reading for next week: Chap. 8, Sect. 8.3-8.4; Chap. 10, Sect. 10.3, Chap. 11

Homework 6: due tomorrow/Monday in recitation

Homework 7: available soon, due next Friday/Monday

Last time: Impact rates, absolute ages, and our Moon

- Relative Ages via Crater Density

more craters, worn-down craters = older surface

- Calibrating crater density ages - radioisotope dating

- Planetary Surfaces - the Moon

- Highlands (old) & Maria (young)
- impact history of the inner solar system
- the Moon's surface history

- Mercury: craters, scarps



Touching a piece of the Moon  
Air & Space Museum, Washington, DC

Today: Venus & Mars

- Venus: impact craters, volcanism, tectonics?
- Mars: craters, volcanism, erosion, tectonics
  - Hemisphere dichotomy, weathering, impacts
  - Tharsis Bulge features, volcanos and tectonics
  - evidence of liquid water in the past and present

## Venus

- **The Basics:**

- **Mass** = 0.82 x Earth
- **Diameter** = 0.95 x Earth
- **Surface Gravity** = 0.91 x Earth
- **Atmosphere**: 92 x denser than Earth's
- view from Earth: surface obscured by clouds

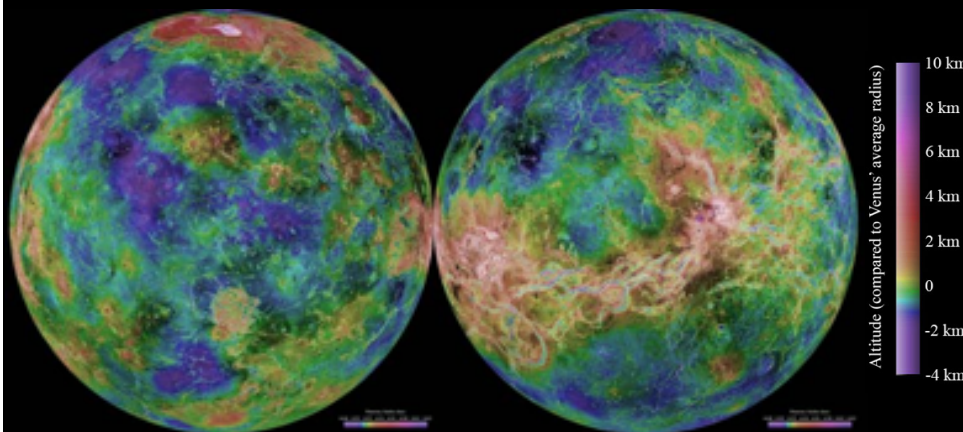


- **visits:**

- flyby by Mariner 10 (1974)
- landers: Venera 13, 14 (1982)
- orbiter: Magellan (1990) - radar mapping
- Venus Express (2006 - )

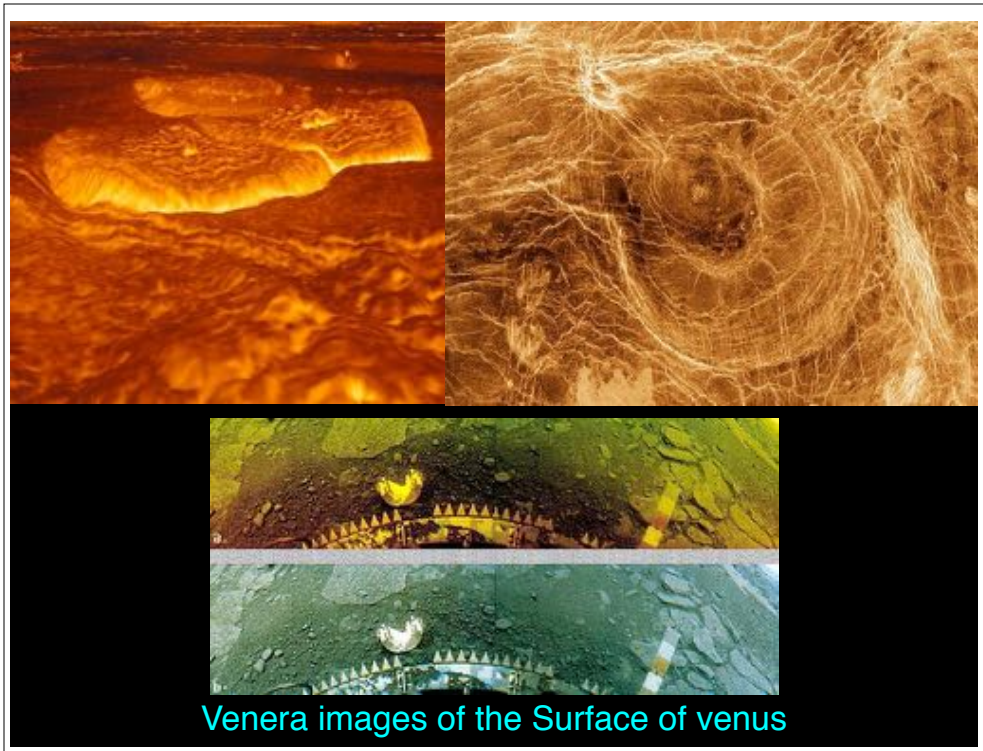
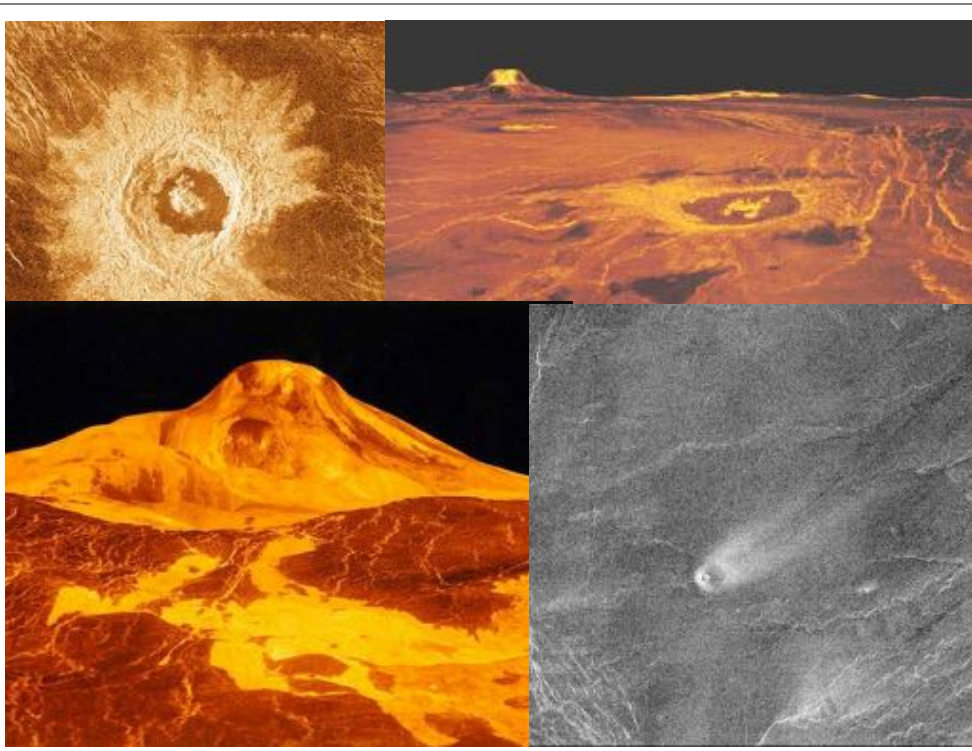


## Radar map of Venus



## The Venusian Surface

- a few (mostly large) **impact craters**
- recent and continued **volcanic activity**:
  - shield volcanoes
  - flooded plains and craters
  - relatively young surface (a few hundred million yr or so)
- **Minimal erosion or weathering**
- **Unusual tectonic activity**
  - **coronae**: collapsed magma domes
  - **arachnoids**: circular regions connected by "web" fractures
  - crustal distortions - tectonics, but *not* plate tectonics
- surface composition: basalt (where landers were...)



Venera images of the Surface of venus

# Mars

## The Basics:

- Mass = 0.11 x Earth
- Diameter = 0.53 x Earth
- Surface Gravity = 0.39 x Earth
- Atmosphere: 0.007 x density of Earth's
- Earth view: - the "Red Planet"
  - seasonal polar caps, vague surface markings

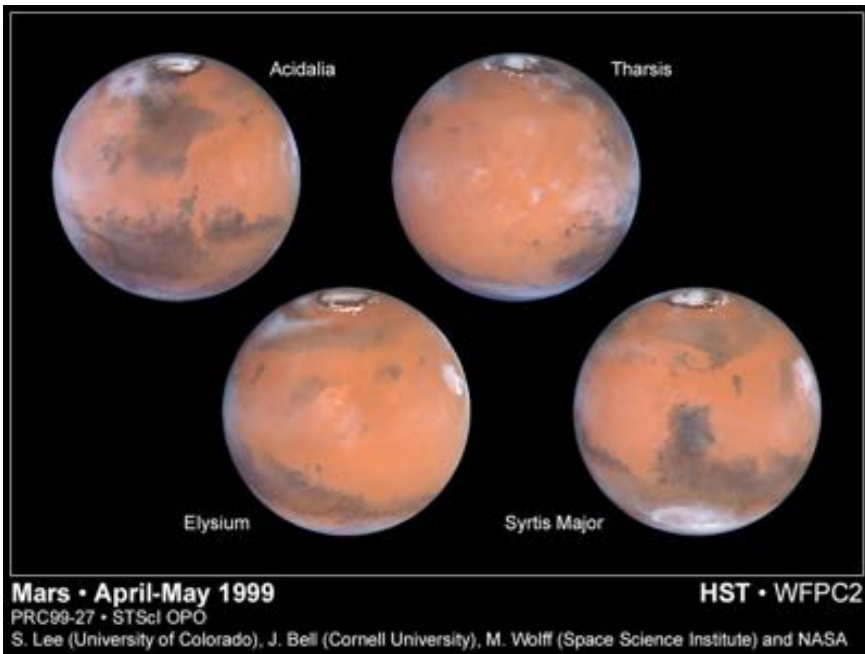


## visits:

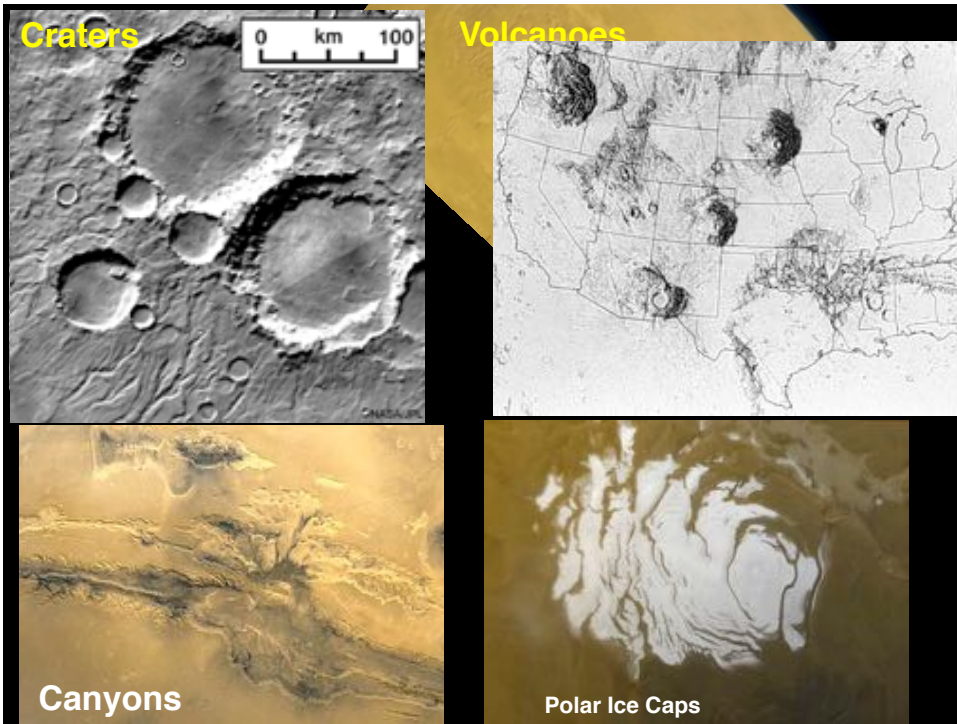
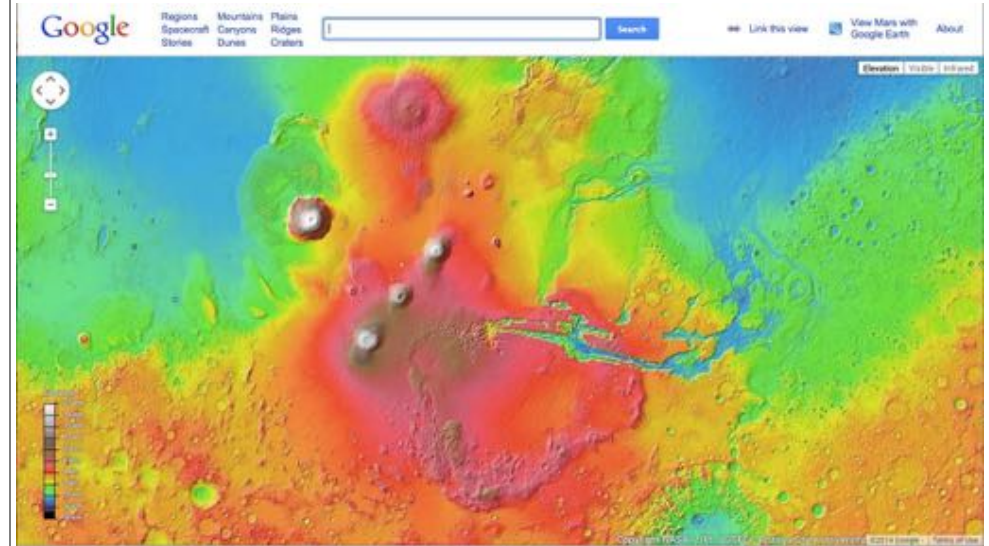
- orbiters:
  - Mariner 9 (1971)
  - Viking (76-79)
  - Global Surveyor (97-06 ), Odyssey (01- ), Express (03 -), MRO (06 -), Maven (14-)
- landers:
  - Viking (1976)
  - Pathfinder (1997)
  - Exploration Rovers (2004-14)
  - Curiosity (2013-)







# Google Mars



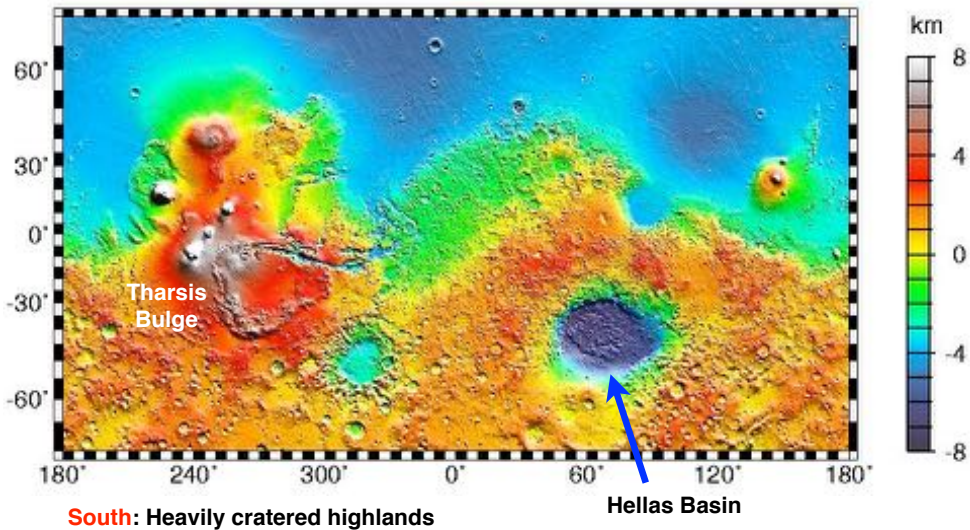
## The Martian Surface

- **Southern Hemisphere**
  - impact craters: highland-like terrain
  - oldest surfaces (4+ Gyr), some “maria” (3.8 Gyr)
  - wind features - dunes, streaks
- **Northern Hemisphere**
  - more recent surfaces, volcanic activity
  - Tharsis crustal bulge: 500 million years old
  - huge shield volcanoes of Tharsis
  - faults from crustal stretching
  - Valles Marineris – a tectonic Tharsis feature
- **Polar Caps**
  - North: water ice + CO<sub>2</sub>
  - South: CO<sub>2</sub> ice

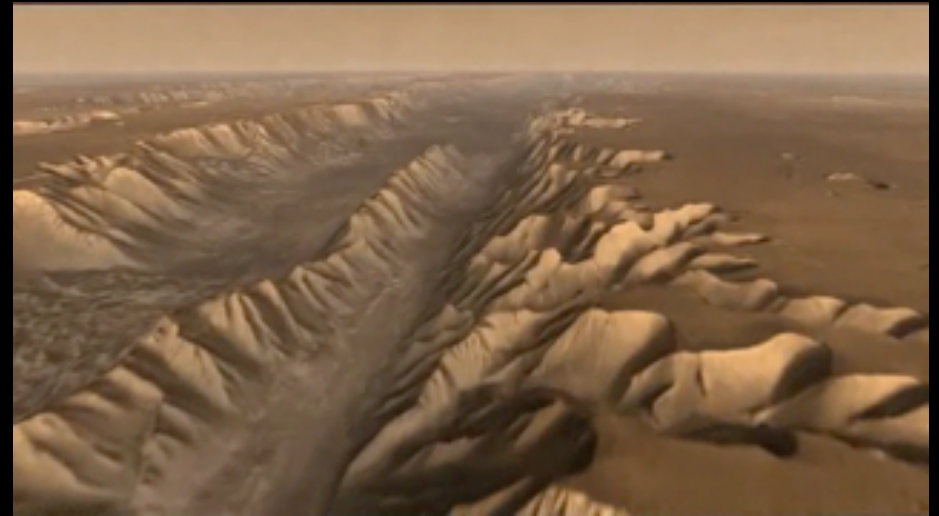


# Topographic Map

**North:** Lightly cratered, low elevation

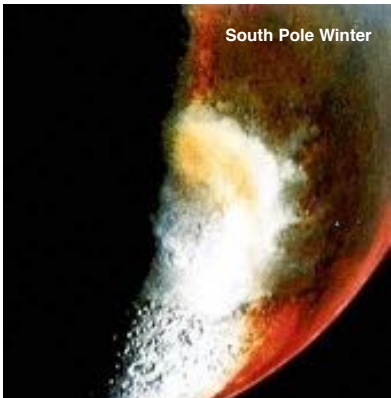


# A visit to Valles Marineris

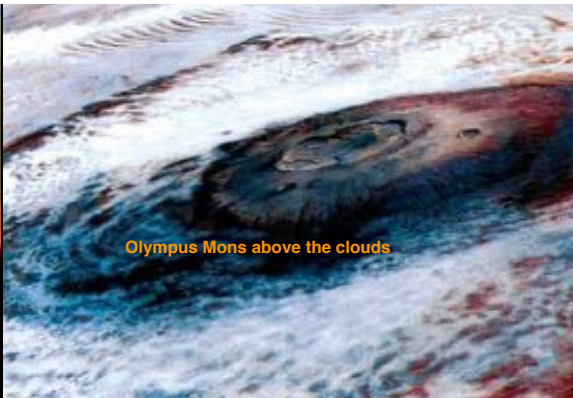


Mars Odyssey Team - [http://themis.asu.edu/valles\\_video](http://themis.asu.edu/valles_video)

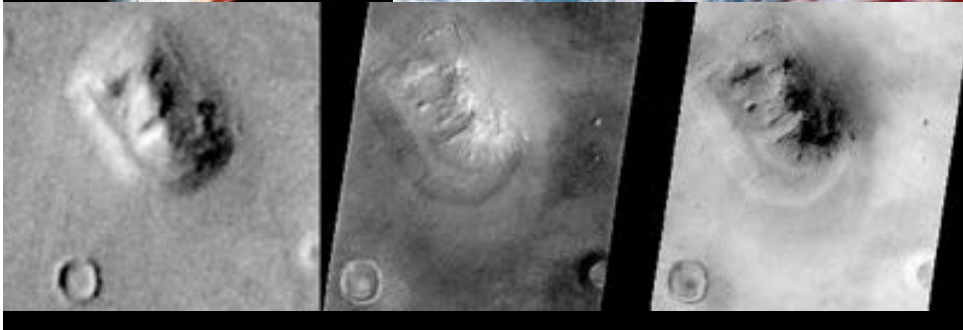
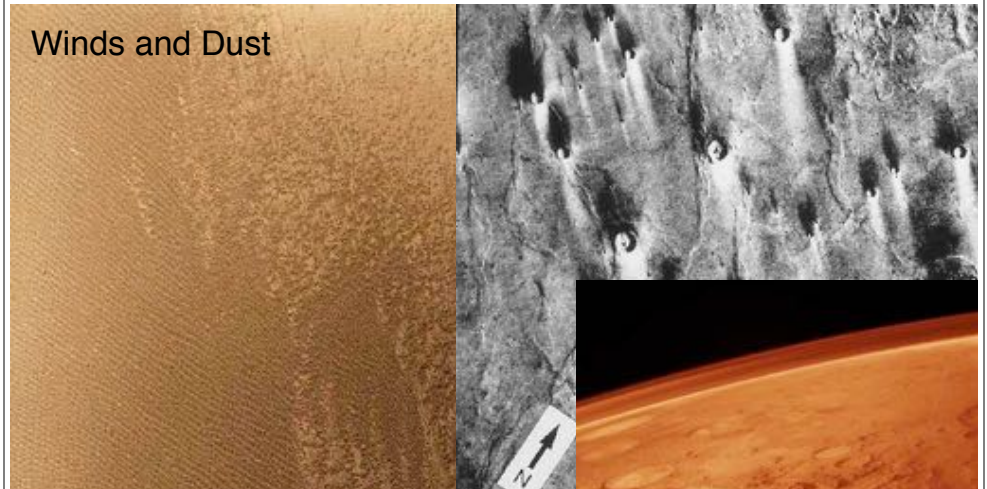
South Pole Winter



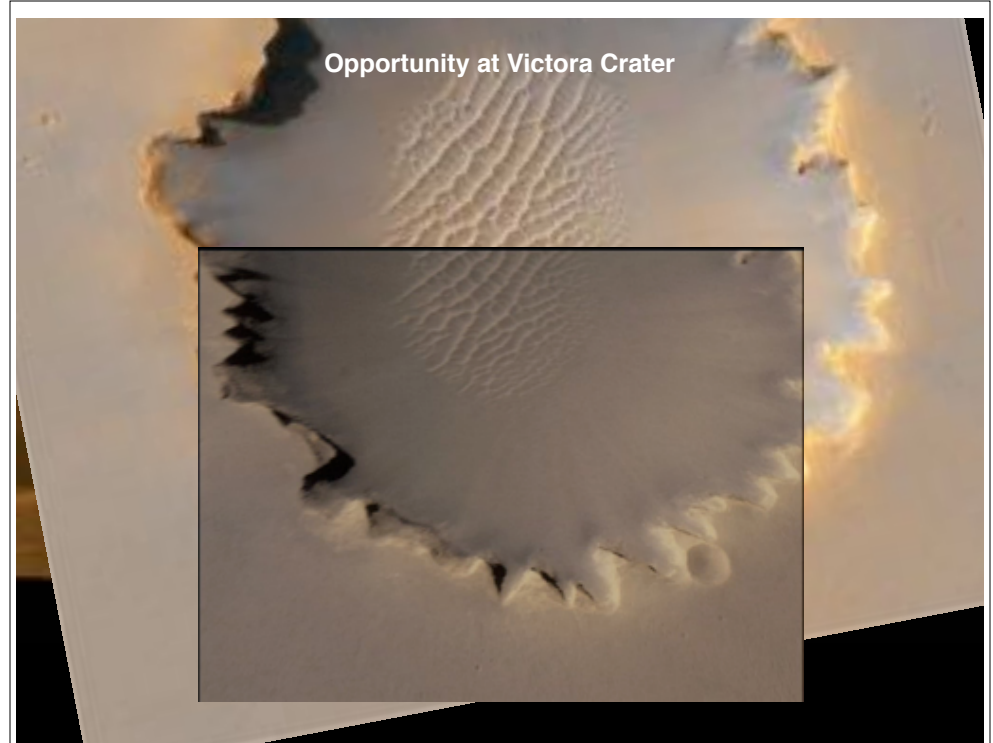
Olympus Mons above the clouds



Winds and Dust

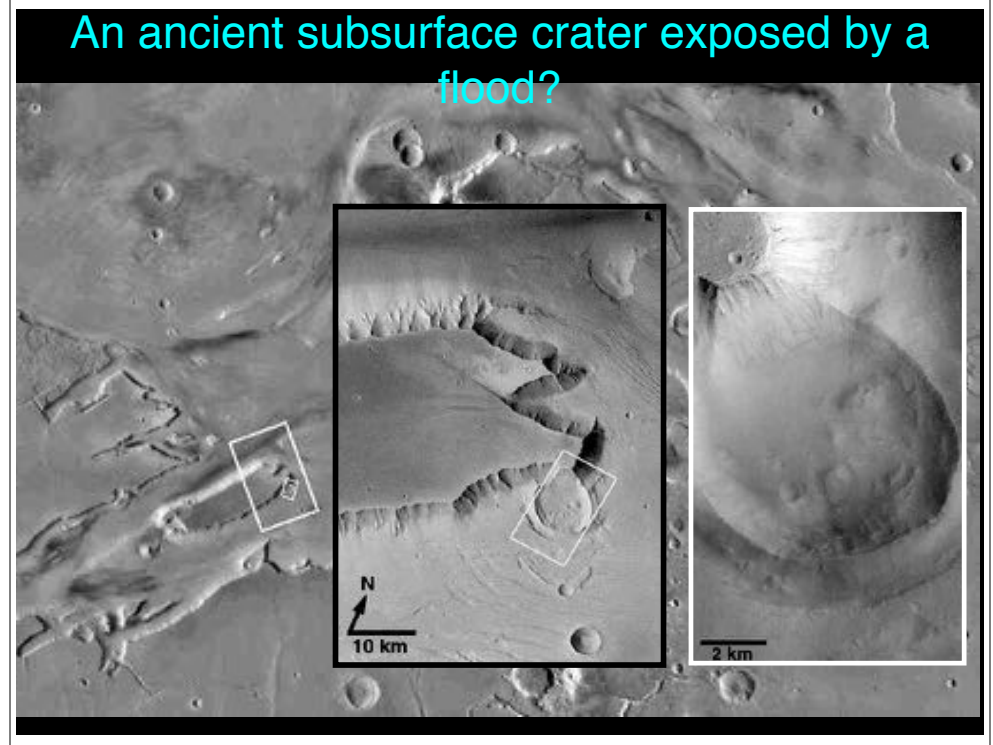
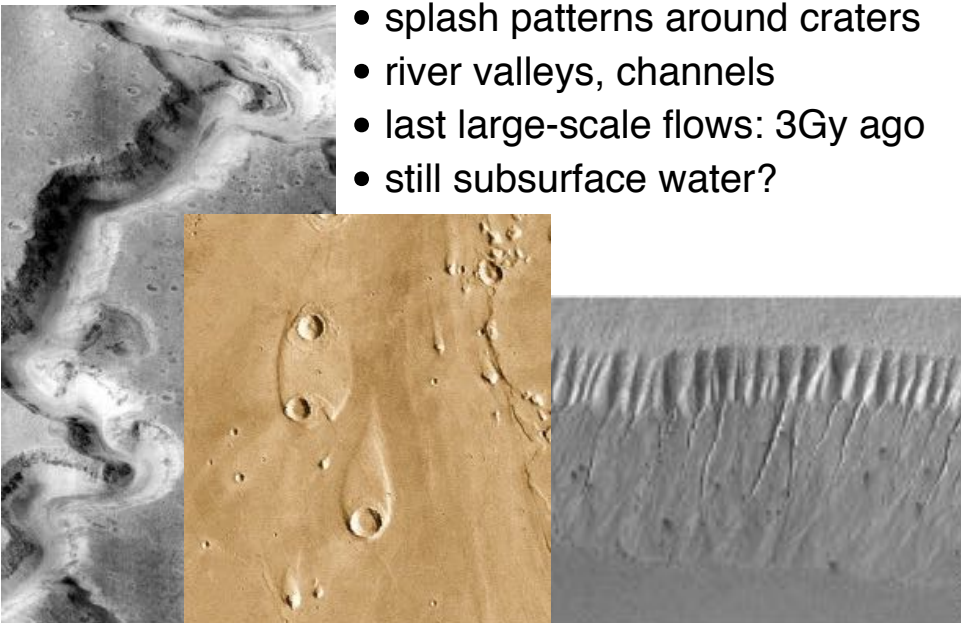






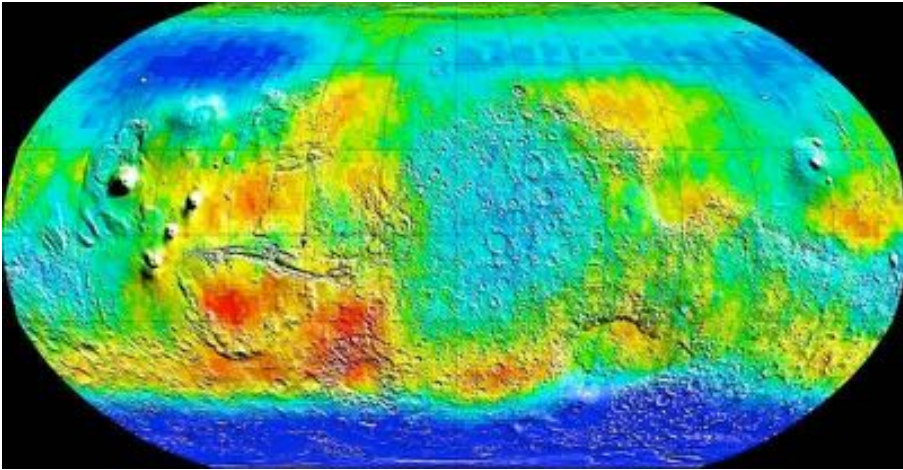
# Water on Mars?

- splash patterns around craters
- river valleys, channels
- last large-scale flows: 3Gy ago
- still subsurface water?





## Mars Odyssey map of neutron emission:



blue = hydrogen-rich compounds (water)

## Evidence of water from the surface:

Spirit, Opportunity, and Curiosity Rovers

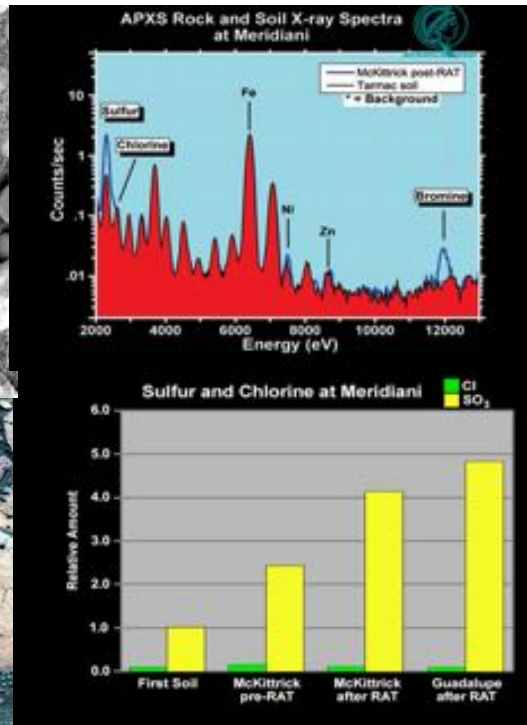
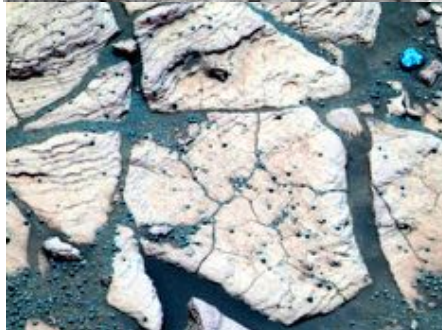
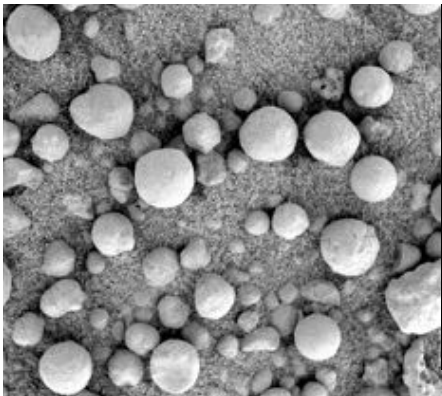


- **Chemical Evidence**

- Sulfate salts, bromine salts - evaporites
- hematite concretions (blueberries) generally form as minerals precipitate out from water

- **Mechanical Evidence**

- cross-bedding (think mud in shallow streams)
- stratification
- leeching gaps in rocks

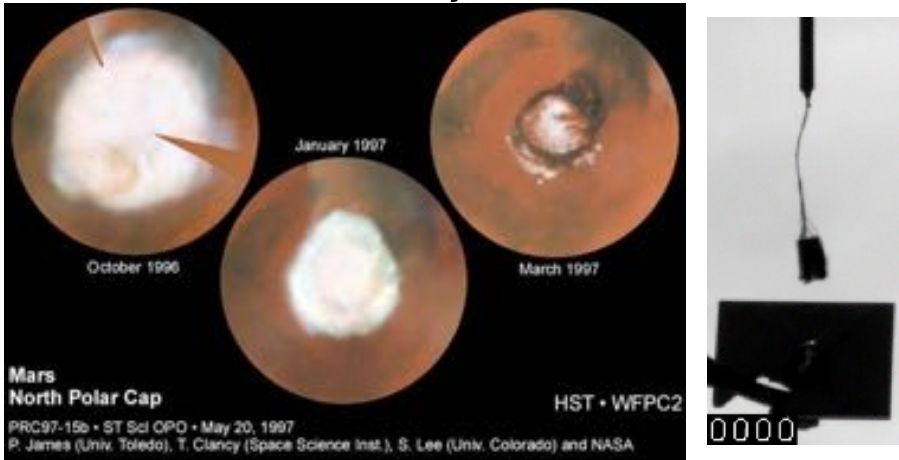


## Cross-bedding



# Where is the water today?

- ice at the polar caps
- surface permafrost?
- **YES! Curiosity Rover - 2% of soil is water**



# Mars Phoenix lander

