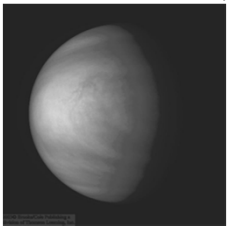
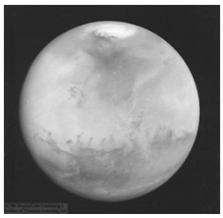
Chapter 13
Venus and Mars

Venus and Mars

Two most similar planets to Earth:

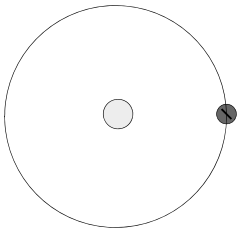




- Similar in size and mass
- Same part of the solar system
- Atmosphere
- Similar interior structure

The Rotation of Venus

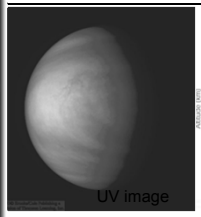
- Almost all planets rotate counterclockwise, i.e. in the same sense as orbital motion.
- Exceptions: Venus, Uranus and dwarf planet Pluto
- Venus rotates clockwise, with period slightly longer than orbital period.

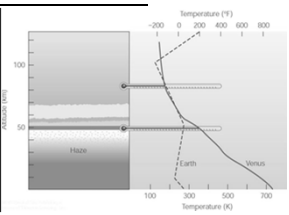


Possible reasons:

- Off-center collision with massive protoplanet
- Tidal forces of the sun on molten core and atmosphere

The Atmosphere of Venus





Extremely inhospitable:

96% carbon dioxide (CO_2), 3.5% nitrogen (N_2), water (H_2O), hydrochloric acid (HCl), hydrofluoric acid (HF)

4 thick cloud layers (→ surface invisible to us from Earth).

Very stable circulation patterns with high-speed winds (up to 240 km/h)

Very efficient "greenhouse"!

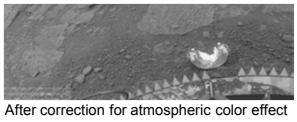
Extremely high surface temperature (up to 880 ºF)

The Surface of Venus

Early radar images already revealed mountains, plains, craters.

More details from orbiting and landing spacecraft:

Colors modified by clouds in atmosphere of Venus

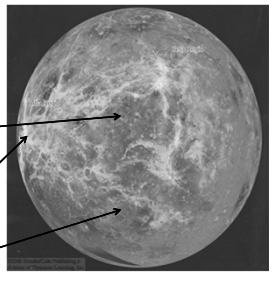


After correction for atmospheric color effect

Radar Map of Venus's Surface

Surface features shown in artificial colors

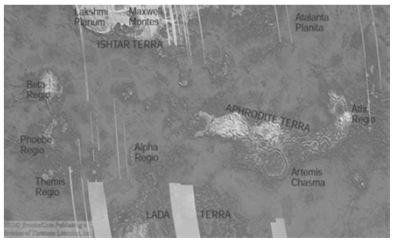
- Scattered impact craters
- Volcanic regions
- Smooth lava flows



Lava Flows

Young, uneven lava flows (shown: Lava flow near Flagstaff, AZ) show up as bright regions on radar maps.

Surface Features on Venus



Smooth lowlands

Highland regions:

Maxwell Montes is ~ 50 % higher than Mt. Everest!

Craters on Venus

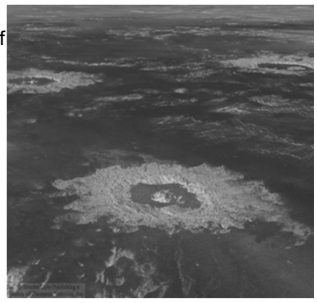
Nearly 1000 impact craters on surface of Venus:

→ Surface not very old.

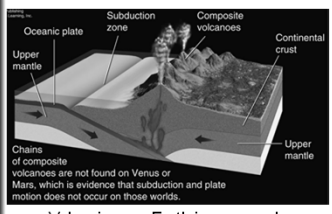
No water on the surface; thick, dense atmosphere

→ No erosion

→ Craters appear sharp and fresh



Volcanism on Earth



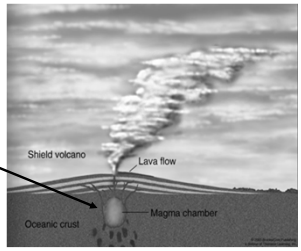
Volcanism on Earth is commonly found along subduction zones (e.g., Rocky Mountains).

This type of volcanism is not found on Venus or Mars.

Shield Volcanoes

Found above hot spots:

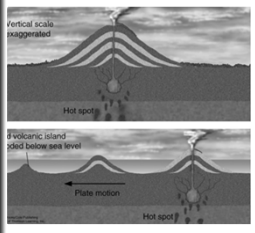
Fluid magma chamber, from which lava erupts repeatedly through surface layers above.



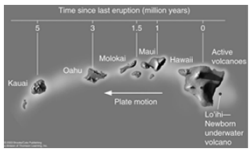
All volcanoes on Venus and Mars are shield volcanoes.

Shield Volcanoes (2)

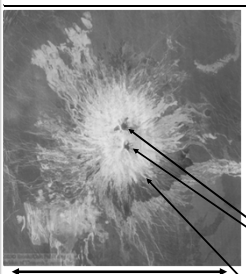
On Earth, Tectonic plates moving over hot spots producing shield volcanoes → Chains of volcanoes



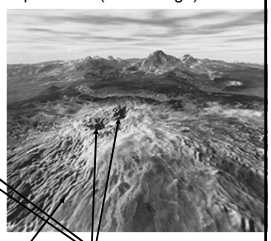
Example: The Hawaiian Islands



Volcanism on Venus



Sapas Mons (radar image)

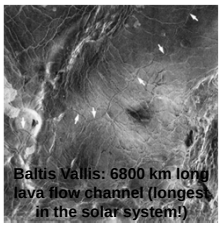


~ 400 km (250 miles)

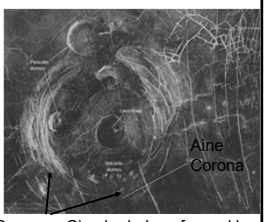
2 lava-filled calderas

Lava flows

Volcanic Features on Venus

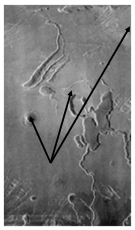


Baltis Vallis: 6800 km long lava flow channel (longest in the solar system!)

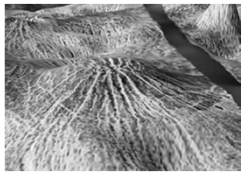


Coronae: Circular bulges formed by volcanic activity

Volcanic Features on Venus

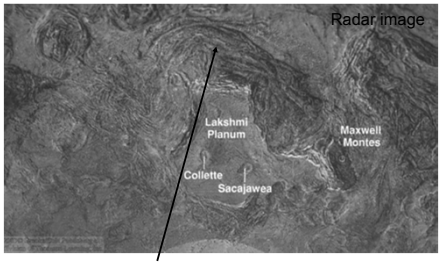


Some lava flows collapsed after molten lava drained away



Pancake Domes: Associated with volcanic activity forming coronae

Lakshmi Planum and Maxwell Mountains



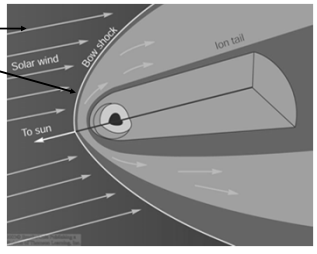
Wrinkled mountain formations indicate compression and wrinkling, though there is no evidence of plate tectonics on Venus.

A History of Venus

Complicated history; still poorly understood.

Very similar to Earth in mass, size, composition, density, but no magnetic field → Core solid? Not rotating?

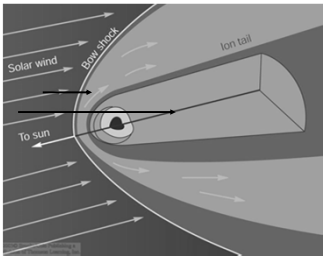
→ Solar wind interacts directly with the atmosphere, forming a bow shock and a long ion tail.



CO_2 produced during outgassing remained in atmosphere (on Earth: dissolved in water).

A History of Venus

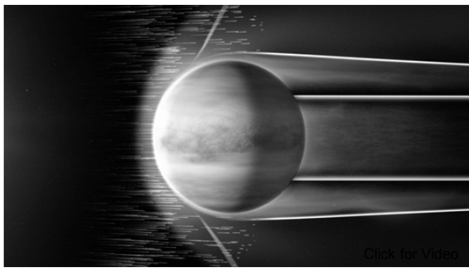
Any water present on the surface rapidly evaporated → feedback through enhancement of greenhouse effect



Heat transport from core mainly through magma flows close to the surface (→ coronae, pancake domes, etc.)

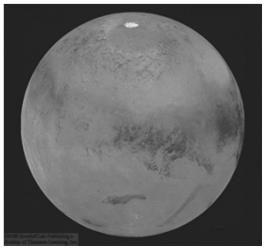
A History of Venus

Venus has a different interaction with the Sun than Earth:



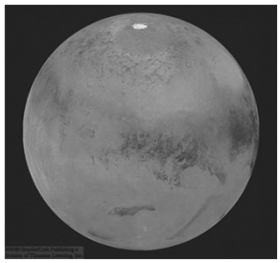
Mars

- Diameter ≈ ½ Earth's diameter
- Axis tilted against orbital plane by 25°, similar to Earth's inclination (23.5°)
- Very thin atmosphere, mostly CO_2
- Rotation period = 24 h, 40 min.



Mars (2)

- Seasons similar to Earth → Growth and shrinking of polar ice cap
- Crust not broken into tectonic plates
- Volcanic activity (including highest volcano in the solar system)



Tales of Canals and Life on Mars

Early observers (Schiaparelli, Lowell) believed to see canals on Mars

This, together with growth/shrinking of polar cap, sparked imagination and sci-fi tales of life on Mars.

We know today: "canals" were optical illusion; do not exist!

No evidence of life on Mars - yet.

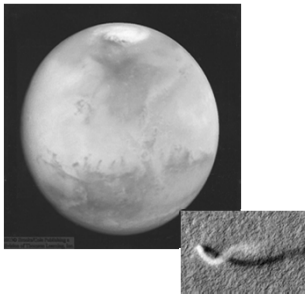
The Atmosphere of Mars

Very thin: Only 1% of pressure on Earth's surface

95% CO_2

Even thin Martian atmosphere evident through haze and clouds covering the planet

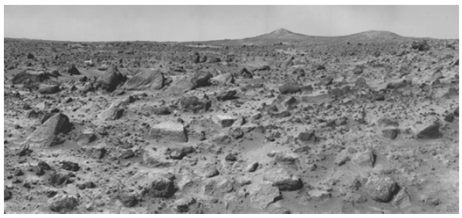
Occasionally: Strong dust storms that can enshroud the entire planet.



The Atmosphere of Mars (2)

Most of the oxygen bound in oxides in rocks

→ Reddish color of the surface

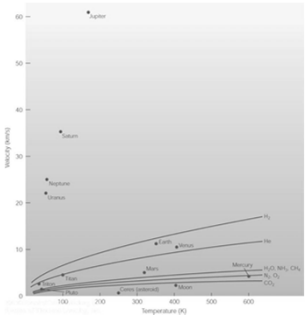


History of Mars's Atmosphere

Atmosphere probably initially produced through outgassing.

Loss of gasses from a planet's atmosphere:

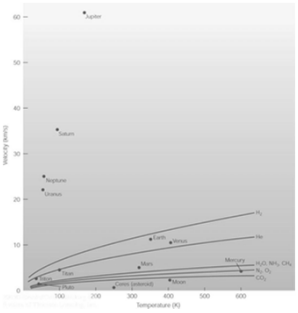
Compare typical velocity of gas molecules to escape velocity



History of Mars's Atmosphere

Gas molecule velocity greater than escape velocity → gasses escape into space.

Mars has lost all lighter gasses; retained only heavier gasses (CO_2).



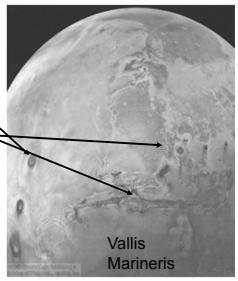
The Geology of Mars

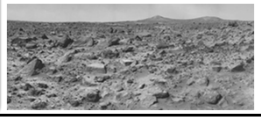
Giant volcanoes

Valleys

Impact craters

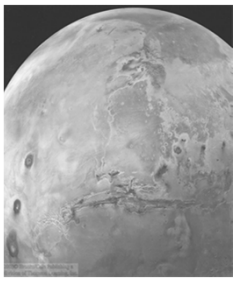
Reddish deserts of broken rock, probably smashed by meteorite impacts.





The Geology of Mars

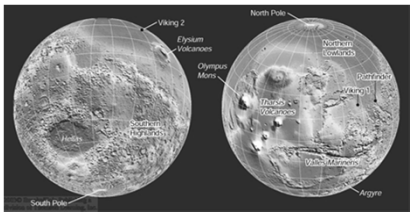
Reddish deserts of broken rock, probably smashed by meteorite impacts.



The Geology of Mars (2)

Northern Lowlands: Free of craters; probably re-surfaced a few billion years ago.

Possibly once filled with water.



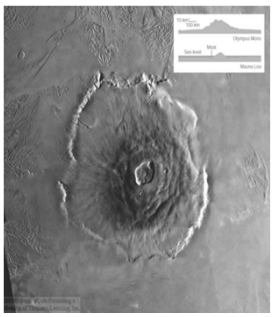
Southern Highlands: Heavily cratered; probably 2 – 3 billion years old.

Volcanism on Mars

Volcanoes on Mars are shield volcanoes.

Olympus Mons:

Highest and largest volcano in the solar system.



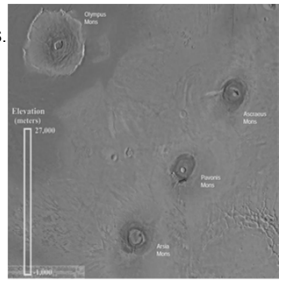
Volcanism on Mars (2)

Tharsis rise (volcanic bulge):

Nearly as large as the U.S.

Rises ~ 10 km above mean radius of Mars.

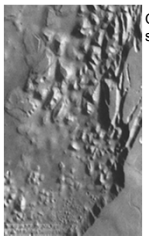
Rising magma has repeatedly broken through crust to form volcanoes.



Hidden Water on Mars

No liquid water on the surface: Would evaporate due to low pressure.

But evidence for liquid water in the past:



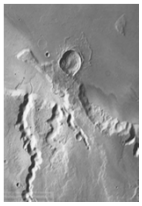
Outflow channels from sudden, massive floods

Collapsed structures after withdrawal of sub-surface water

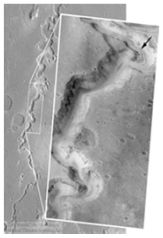
Hidden Water on Mars

But evidence for liquid water in the past:

Splash craters and valleys resembling meandering river beds

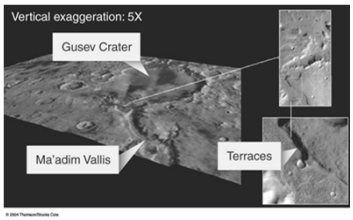


Gullies, possibly from debris flows



Central channel in a valley suggests long-term flowing water

Hidden Water on Mars (2)

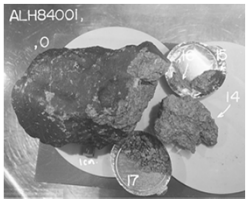


Gusev Crater and Ma'adim Vallis:

Giant lakes might have drained repeatedly through the Ma'adim Vallis into the crater.

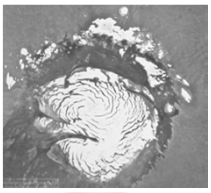
Evidence for Water on Mars

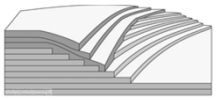
Large impacts may have ejected rocks into space.



Meteorite ALH84001: Identified as ancient rock from Mars. Some minerals in this meteorite were deposited in water → Martian crust must have been richer in water than it is today.

Ice in the Polar Cap

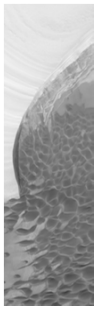




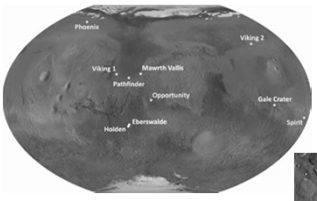
Polar cap contains mostly CO_2 ice, but also water.

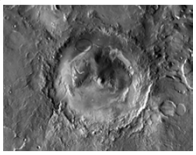
Multiple ice regions separated by valleys free of ice.

Boundaries of polar caps reveal multiple layers of dust, left behind by repeated growth and melting of polar-cap regions.



Mars Curiosity Rover

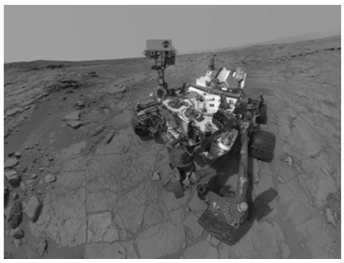




The Curiosity Rover landed at Gale Crater, a location with many layered mineral deposits suggestive of water in the past.

http://www.nasa.gov/mission_pages/msl/index.html

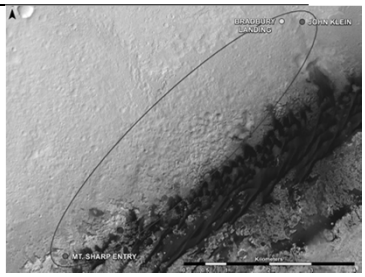
Mars Curiosity Rover (2)



The Curiosity Rover in a "self-portrait".

http://www.nasa.gov/mission_pages/msl/index.html

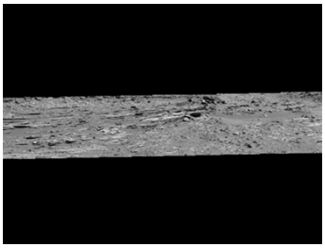
Mars Curiosity Rover (3)



Curiosity's landing site, location of most of its work so far, and its next location.

http://www.nasa.gov/mission_pages/msl/index.html

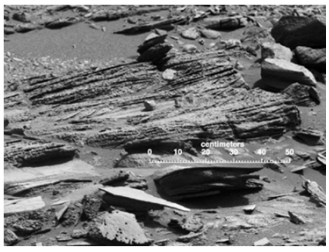
More evidence for water on Mars



Layered rocks found by Mars Curiosity rover. Layering is typical of sedimentary rocks.

http://www.nasa.gov/mission_pages/msl/index.html

More evidence for water on Mars (2)



Same outcrop shows small-scale cross-bedding typical of water current deposition.

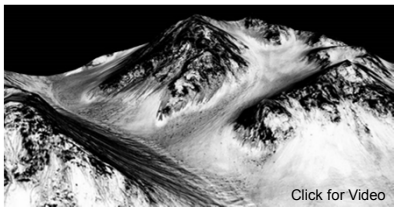
http://www.nasa.gov/mission_pages/msl/index.html

More evidence for water on Mars (3)

Rounded gravel clasts – a conglomerate – sedimentary rocks typically associated with high energy water flow.

http://www.nasa.gov/mission_pages/msl/index.html

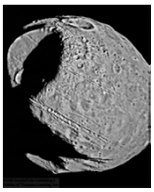
More evidence for water on Mars (4)



On September 28, 2015 NASA announced that under certain circumstances, water does now flow on Mars! This fact was confirmed by the Mars Reconnaissance Orbiter.

http://www.nasa.gov/press-release/nasa-confirms-evidence-that-liquid-water-flows-on-today-s-mars

The Moons of Mars



Very close to Mars; orbits around Mars faster than Mars's rotation.

Probably captured from outer asteroid belt.

Two small moons: Phobos and Deimos

Too small to pull themselves into spherical shape.

Typical of small, rocky bodies: Dark gray, low density.