Astronomy 210

Section 1– MWF 1500-1550

134 Astronomy Building

This Class (Lecture 22):

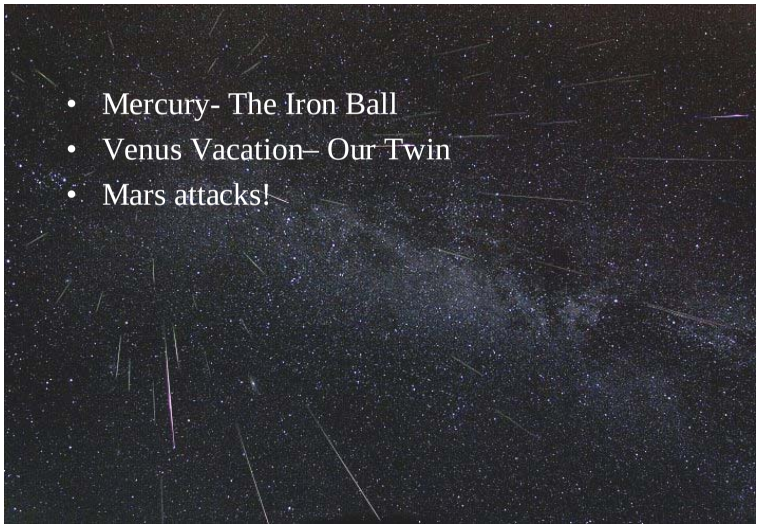
Terrestrial Planets

Night Observations!

Next Class:

Giant Planets

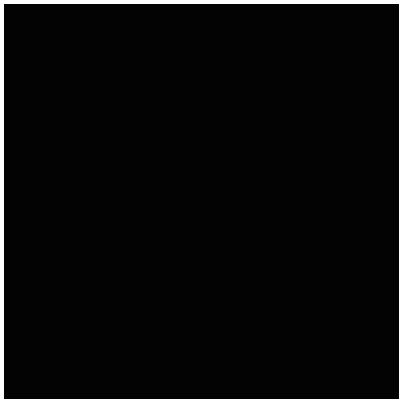
Outline

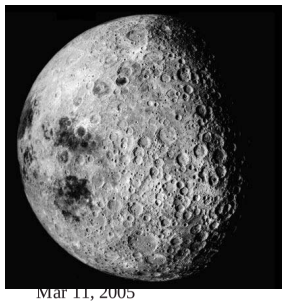


- Mercury- The Iron Ball
- Venus Vacation– Our Twin
- Mars attacks!

Lunation

- Image of a complete lunar cycle.
- See more than half the surface (59%)– libration.
- Mostly due to the elliptical orbit.

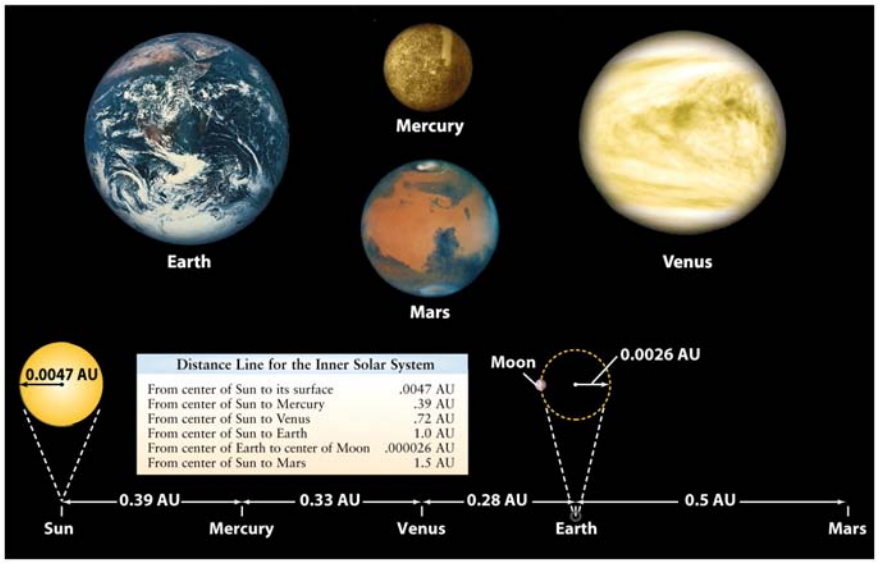




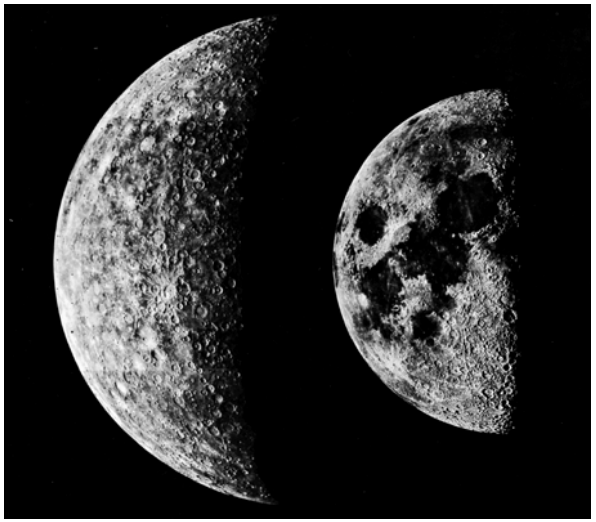
The far side of the Moon.

http://antwrp.gsfc.nasa.gov/apod/ap991108.html
http://antwrp.gsfc.nasa.gov/apod/ap981008.html

The Terrestrial Planets



Different sides of the Moon?



http://www.whfreeman.com/discovering/DTU/EXMOD36/F3609.HTM

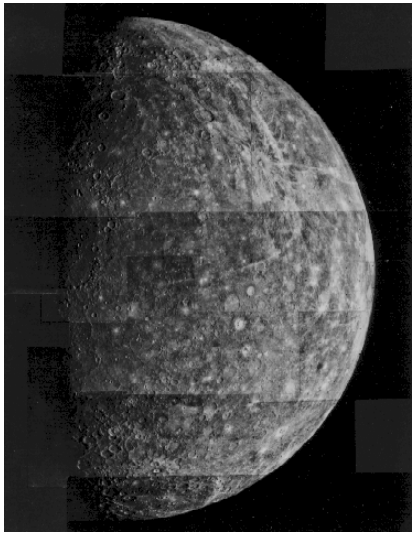
Earth - Mercury - Moon Comparison

Mercury has the shortest year in Solar System

Radius	0.38 Earth
Surface gravity	0.38 Earth
Mass	0.055 Earth
Distance from Sun	0.39 AU
Orbit Eccentricity	0.21
Tilt	0°
Year	88 Earth days
Rotational Period	59 Earth days
Solar day	176 Earth days

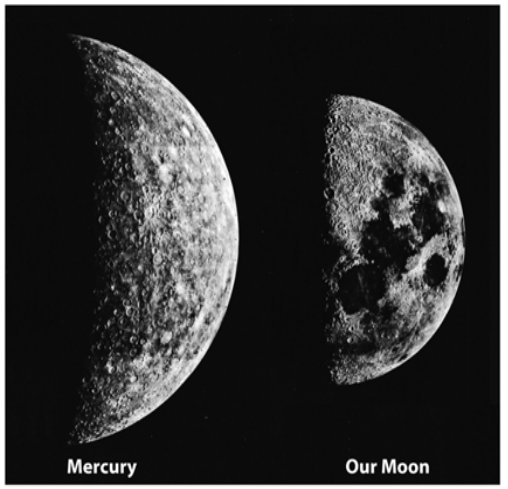
Mercury Revealed

- Visited in 1974/75 by Mariner 10 – only 40% of surface mapped



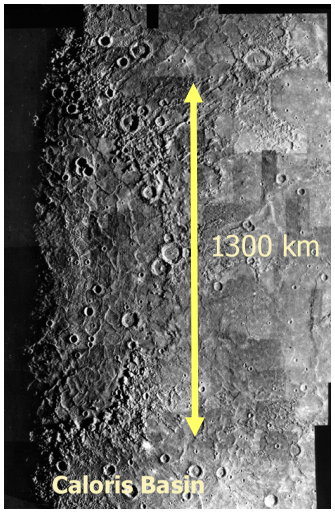
Mercury's Surface

- Mercury's surface is similar to the Moon's
- Heavily cratered
- No volcanoes
- No air, water
- But there are differences…



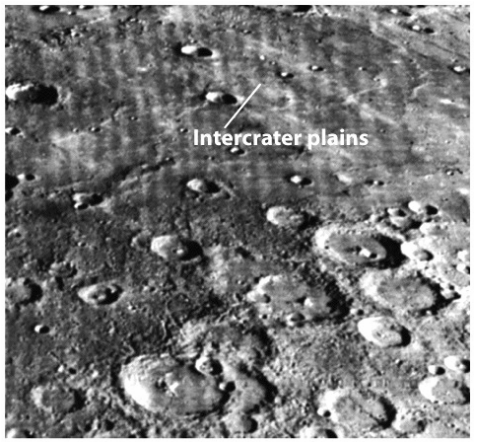
Massive Crater

- Largest known crater is the Caloris Basin
  - 1300 km across
- Punctured the crust
  - Created rings of mountains
  - Lava-filled
- Mariner 10 only saw half of it



Lava Plains

- Mercury has large, low-lying lava-plains with fewer craters
- Formed near the end of the heavy bombardment
- More craters than the Moon's maria, so they must be older



Scarps

- Mercury's surface is "cracked" man
  - Huge cliffs called *scarps*
  - Kilometers high!
  - Formed when the planet cooled and its core shrank

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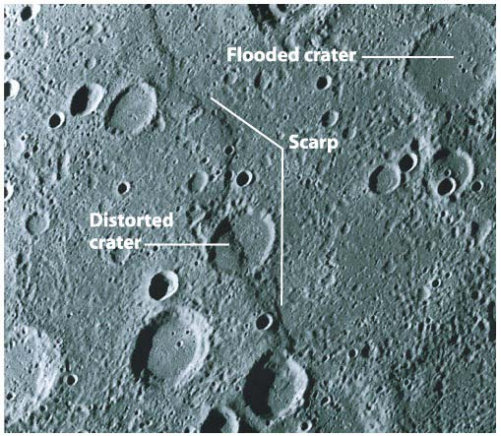
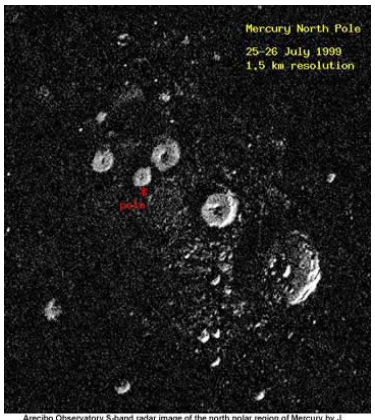


Atmosphere?

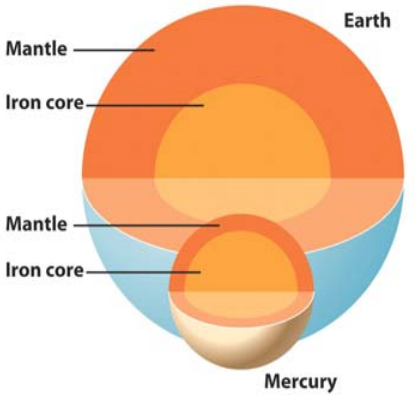
- Tenuous atmosphere quickly escapes
  - Sodium, Potassium, Oxygen, Helium
- Some evidence for possible water ice in polar crater shadows
- Lack of thick atmosphere and long solar days produce huge day/night temperature difference
  - 700K (430 C) to 90 K (-183 C)



Arecibo Observatory S-band radar image of the north polar region of Mercury by J. Harmon, P. Perrillat, 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.

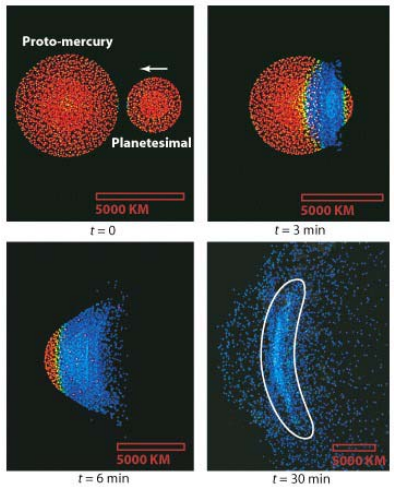
The "Ironball"

- Mercury's density almost equal to Earth's
- Indicates a large iron core
  - About 75% of its radius!
  - Relatively, largest core of the planets
- Core is part-molten
  - But, Mercury spins slowly
  - Weak magnetic field
- No recent geological activity



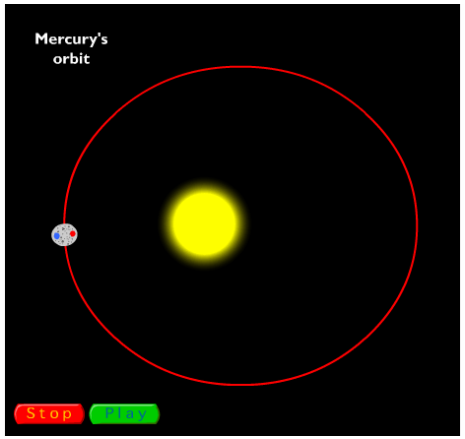
What Happened to Mercury?

- Why is Mercury's iron core so big?
- We think it was an impact
- Proto-Mercury collided with another body
- Lighter material (rock) was ejected



Mercury's Orbit

- Mercury is *tidally locked* to the Sun, as the Moon is to the Earth
- But not co-rotating
- Mercury rotates 3 times every 2 orbits
  - Orbit too eccentric for 1 rotation per orbit
- This makes a solar day equal to 2 Mercurian years!



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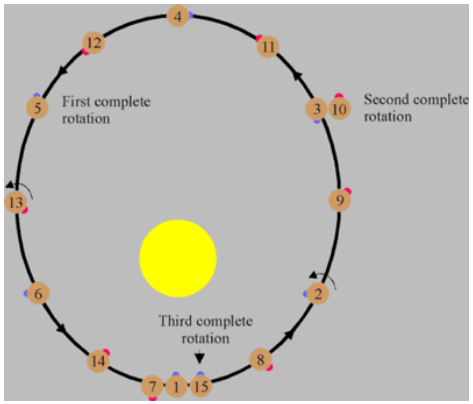
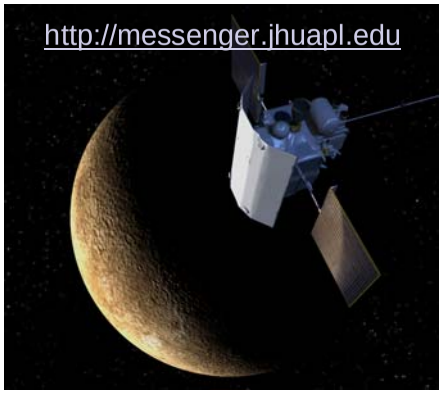


Return to Mercury: MESSENGER

- Launched August 3rd
- Scientific Questions:
  1. Why is Mercury so dense?
  2. What is the geologic history of Mercury?
  3. What is the structure of Mercury's core?
  4. What is the nature of Mercury's magnetic field?
  5. What are the unusual materials at Mercury's poles?
  6. What volatiles are important at Mercury?



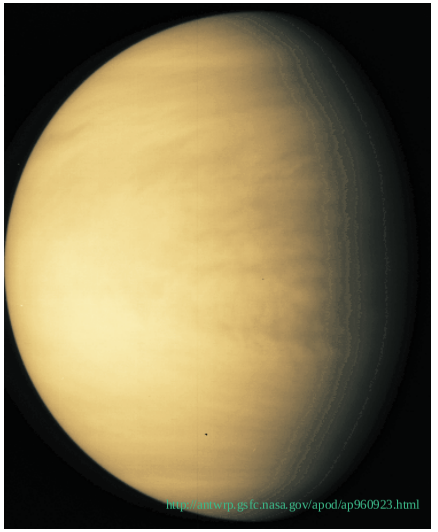
Earth - Venus Comparison

Venus is the closest in size to Earth, but the two planets are strikingly different…

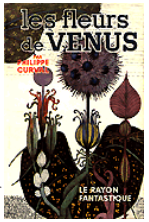
Radius	0.95 Earth
Surface gravity	0.90 Earth
Mass	0.81 Earth
Distance from Sun	0.72 AU
Orbit Eccentricity	0.01
Tilt	177°
Year	225 Earth days
Rotation Period	243 Earth days
Solar day	117 Earth days

Our "Twin"

- Nearly the same size and mass as Earth
- Always covered in thick clouds
- Very little was known until first space missions in the 1960s
- morning star or the evening star. 3rd brightest object in the sky. Often mistaken for UFO.



What We Used to Think



Venus must be hotter, as it is closer the Sun, but the cloud cover must reflect back a large amount of the heat.

In 1918, a Swedish chemist and Nobel laureate concluded:

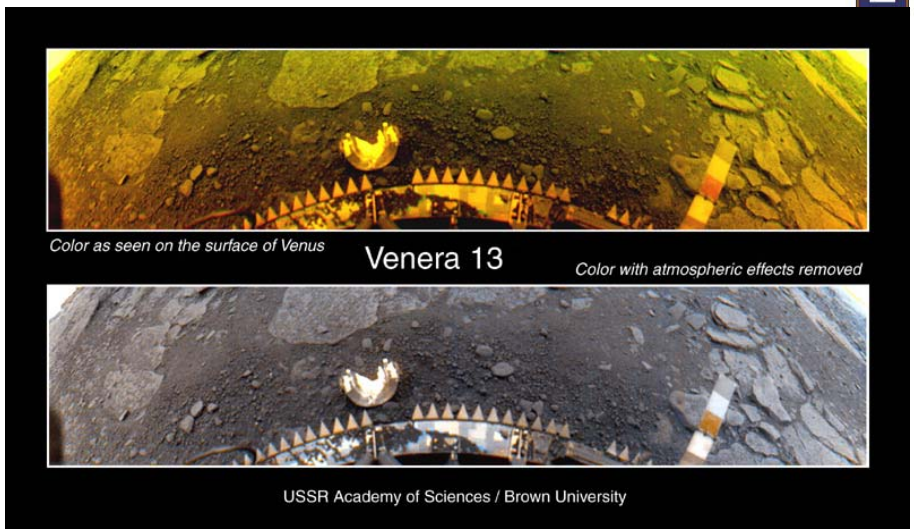
- Everything on Venus is dripping wet.
- Most of the surface is no doubt covered with swamps.
- The constantly uniform climatic conditions result in an entire absence of adaptation to changing exterior conditions.
- Only low forms of life are therefore represented, mostly no doubt, belonging to the vegetable kingdom; and the organisms are nearly of the same kind all over the planet.

http://www.daviddarling.info/encyclopedia/V/Venuslife.html

Turns Out that Venus is Hell

- The surface is hot enough to melt lead
- There is a runaway greenhouse effect
- High pressure, like 1km under ocean
- There is almost no water
- There is sulfuric acid rain
- Not a place to visit for Spring Break.

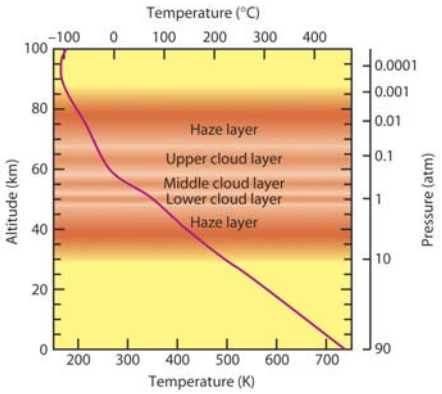
Soviet Satellites on Venus



Mostly Basalts-like rocks, indicative of volcanoes

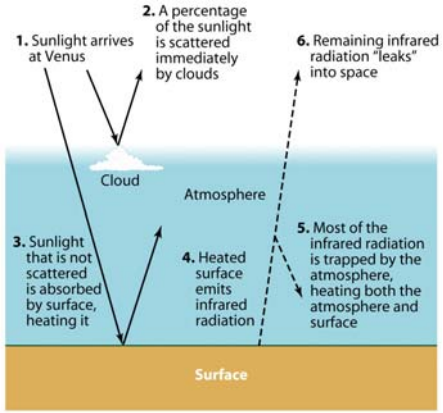
The Venusian Atmosphere

- Planet completely covered by clouds
  - Sulfuric acid, not water vapor
- Atmosphere mostly carbon dioxide, 96% and nitrogen, 4%
  - 90 times more air pressure than Earth
- Extremely hot!
  - Surface temp - 750K
  - Hotter than Mercury!



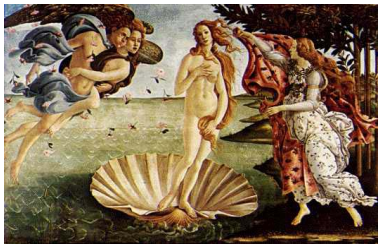
Runaway Greenhouse

- On Earth, greenhouse gasses insulate us
  - Keep Earth 35 K warmer than it would be otherwise
- On Venus, massive amounts of CO_2 keep it incredibly hot
  - Almost 300 K warmer!
  - The hottest planet in the Solar System



Why So Different?

- Earth and Venus have similar amounts of carbon, nitrogen, and oxygen
- Earth's carbon is locked up
  - Dissolved into the oceans
  - Locked into rocks and life



- Venus' carbon is in its atmosphere
  - Too close to the Sun for liquid water
  - No oceans to trap the carbon dioxide
  - No life to process the carbon into sedimentary rocks

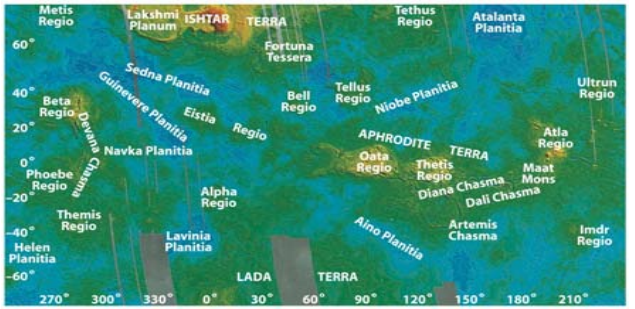
http://www.edgechaos.com/MECA/WALLART/VR89/venus.jpeg

The Venusian Surface Revealed

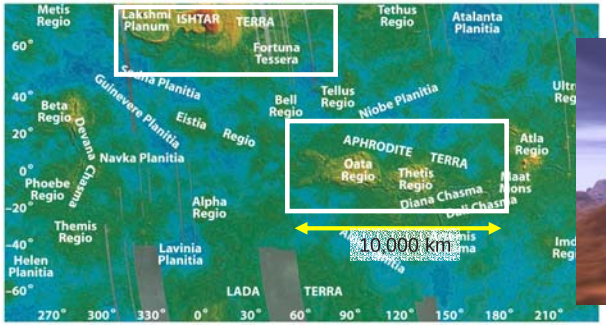
- We can't see Venus' surface in visible light, clouds block the view
- Magellan's Radar showed the surface
- Most of surface is smooth lava flows
- Many large volcanoes
- Probable ongoing volcanism

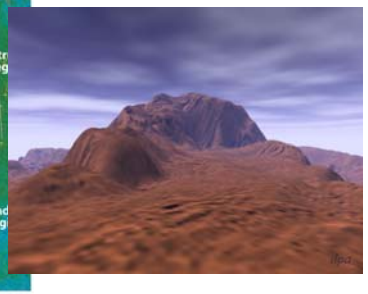
The Venusian Surface

- Venus' surface marked by highlands, plains, and lowlands
- All landforms are volcanic
- Dry & desolate
- No plates, unlike Earth



The Venusian Surface





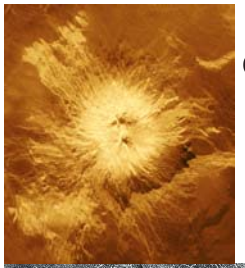
Maxwell Montes (65N 5E)
(Highest mountain range in the solar system
11km high– Everest is 8km)

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

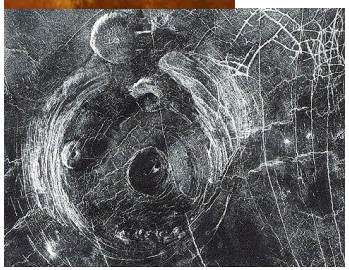
http://www.geology.smu.edu/~dpa-www/venus/mpeg/max.mpg

Venusian Volcanoes

- Many shield volcanoes (like Hawaii)
- Also, *circular coronae* - "pancake volcanoes"

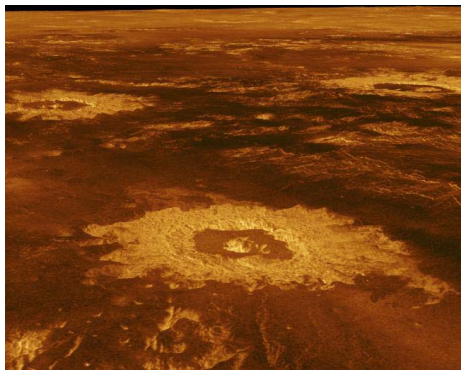


Sapas Mons
(2.5 km high)



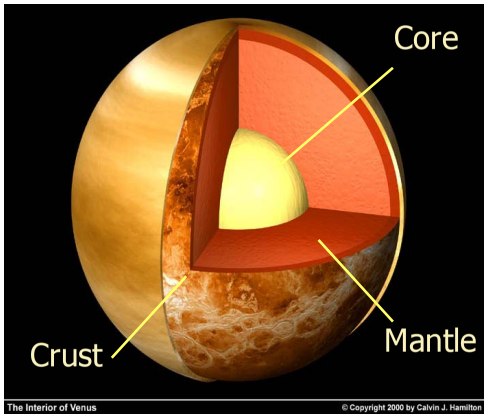
Impacts on Venus

- Venus has about 1,000 craters, often clustered
- No trace of heavy bombardment
- Cratering rate indicates Venus' surface about 500 million yrs old
- Why?
  - Possibility: Extreme temperatures soften rock, making the surface subject to catastrophic volcanic upheaval



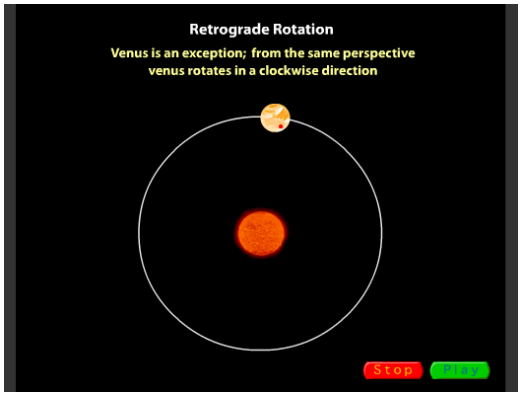
Venus' Interior

- Venus' size and density are roughly equal to Earth's
  - Indicates iron core of similar size
- No magnetic field
  - Very slow rotation - 243 Earth days



Venus' Peculiar Motion

- Doppler radar shows Venus spins backwards!
  - Very slowly, once every 243 days
  - Longer than its year
  - About 2 solar days per year
  - Axis almost vertical to the ecliptic
  - Why? Probably a large impact



What Happened to Venus?

- It really should have been more like Earth, but probably a run-away greenhouse effect.
- Probably was cooler in past with a young dimmer Sun.
- CO_2 was dissolved in oceans/rocks.
- As heated up, H_2O evaporated releasing CO_2
  - From brighter Sun or change in axis
- Eventually all water evaporated.
- And as H_2O is lighter than CO_2, it went to upper atmosphere
- There and H escapes
- So irreversible procedure!

Earth – Mars Comparison

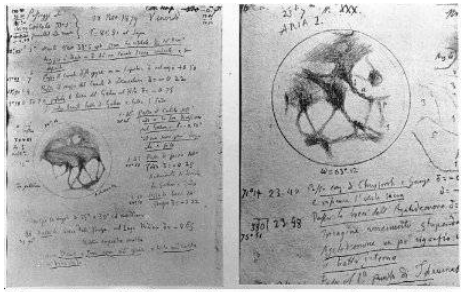
Mars has the Solar System's largest Volcano, Olympus Mons – 26 km tall

Radius	0.53 Earth
Surface gravity	0.38 Earth
Mass	0.11 Earth
Distance from Sun	1.5 AU
Eccentricity	0.09
Tilt	25°
Year	687 Earth days
Solar day	24 hours 39 minutes

What we used to think.

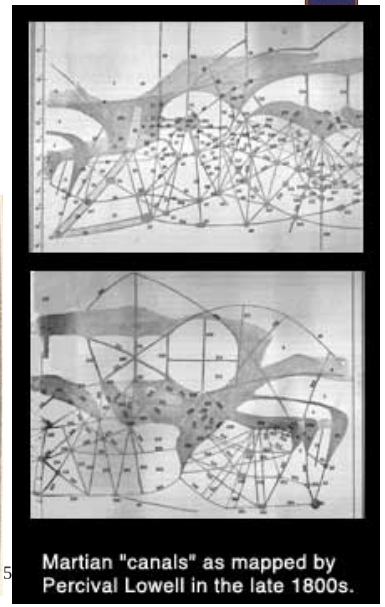
- Was thought to be similar to the Earth in many ways.
- Life was argued to exist on Mars by many astronomers.
- The astronomer Schiaparelli announced that he saw regular linear markings on the surface, which he named *canali*.
- Technically, in Italian means channels, but it was mistranslated to canals.


Giovanni Virginio Schiaparelli


Pages from Schiaparelli's observing notebook, 1879

Percival Lowell's Canals

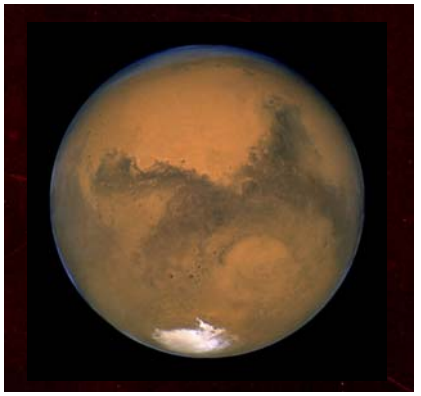
- Evidence for intelligent life?
- Mapped the civilization.
- Influenced culture.



Martian "canals" as mapped by Percival Lowell in the late 1800s.

The "Canals" of Mars

- Mars' color suggested a desert world
- "Canals" thought to irrigate the desert with water from ice caps
- No doubt Martians would want to conquer Earth for its abundant resources
- Spawned many sci-fi stories



Of course, modern telescopes show no canals on Mars