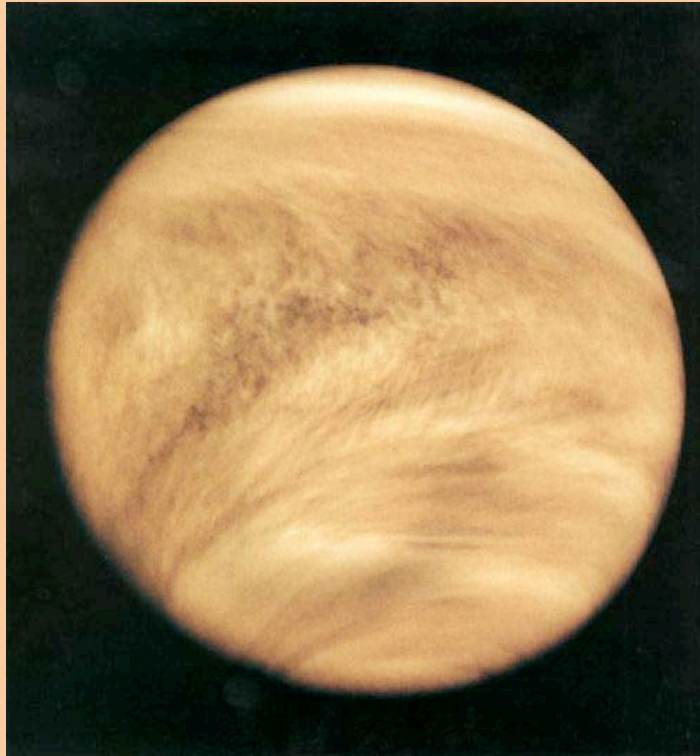


# Venus



# Venus

- Similar to Earth in
  - size (95% diameter of Earth)
  - density (95% of Earth)
  - mass (82% of Earth's mass)
  - Has an atmosphere!

Thick cloud layer obscures surface. Before era of satellites, it was believed that Venus was a swampy, warm planet that harbored life.

# Mariner Missions

- Mariner 2 (1962) was first successful mission to Venus (there were 4 before this that failed for various reasons)
- Orbited the planet. Found that:
- Venus is Hot (~500 deg C or 900 deg F)
- Venus has little or no magnetic field
- No water in atmosphere (97% CO<sub>2</sub>)
- Mariner 5 detected atmospheric pressure 90x that of Earth's.

# Venera Missions

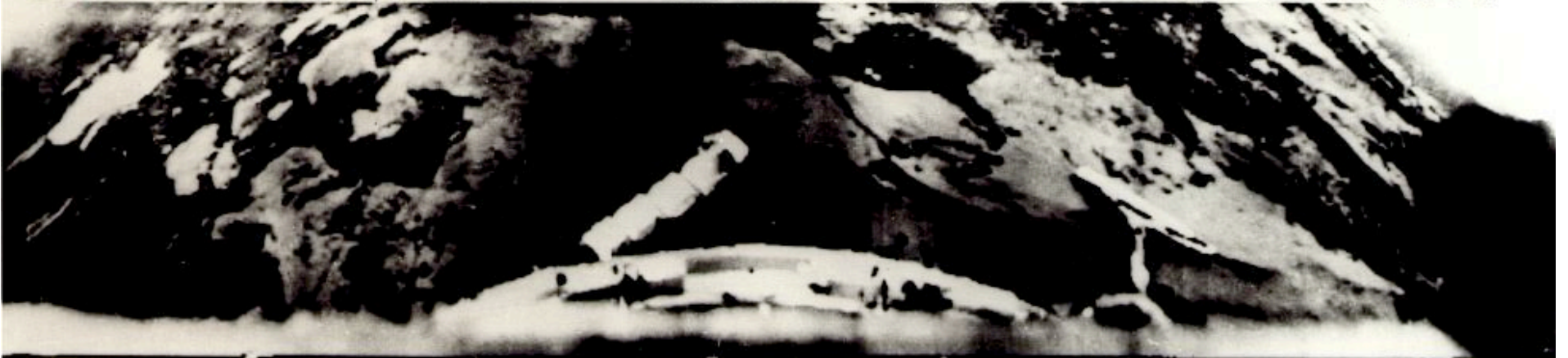
- Venera 7 was the first satellite to land on Venus and “lived” for 23 minutes before pressure, heat and sulfuric acid droplets killed it.
- Venera 8 measured light levels. Light enough for pictures.
- **Venera 9** took the very first optical images of the surface. Bunch of rocks, on a lava bed. Didn’t last long either.
- Venera 10-14 took more images, lifetime around ~2 hours



# Venera 9 Images



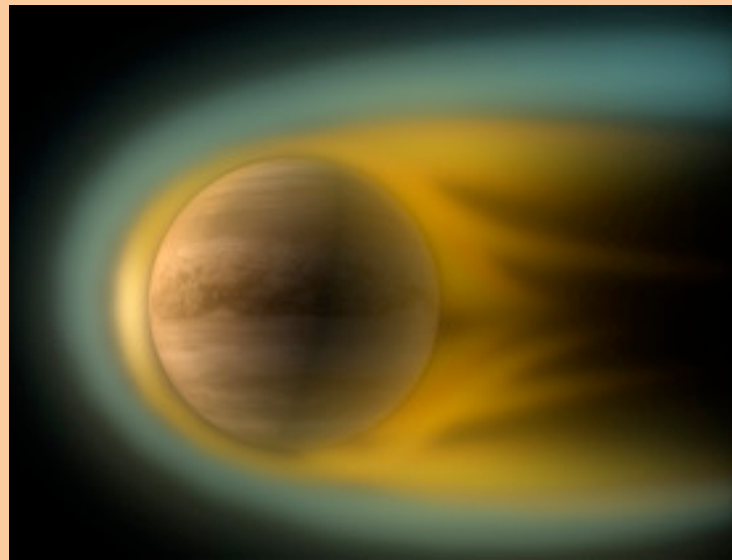
ВЕНЕРА-9 22.10.1975 ОБРАБОТКА ИППИ АН СССР 28.2.1976



ВЕНЕРА-10 25.10.1975 ОБРАБОТКА ИППИ АН СССР 28.2.1976

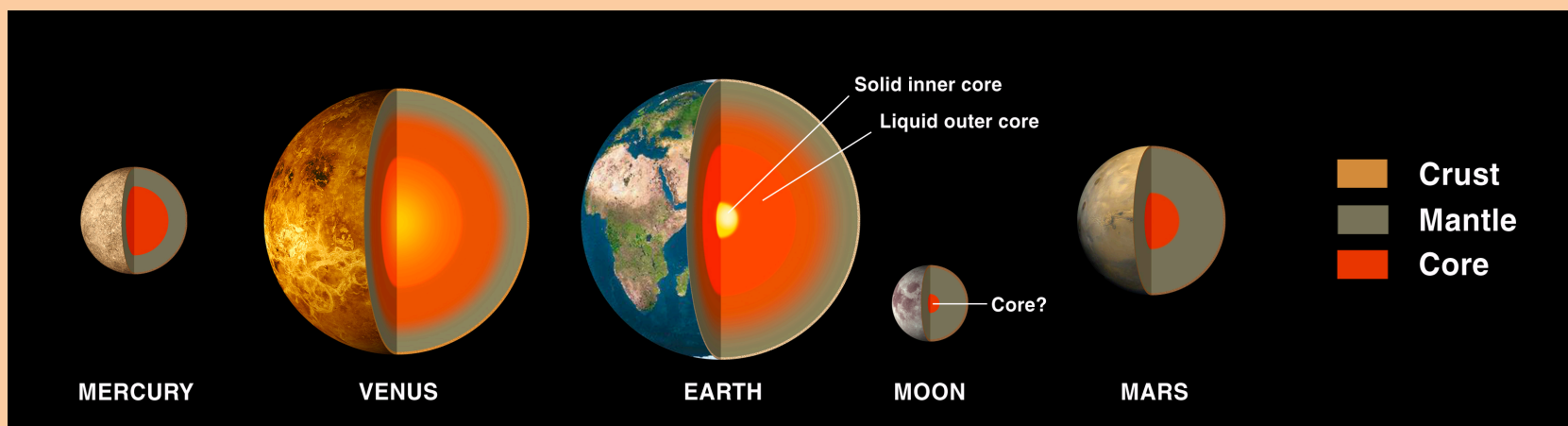
# Other Venus Facts

- Venus rotates very slowly (243 Earth days). A Venusian day is longer than a Venusian year (225 Earth days).
- Rotation is retrograde, sun rises in west and sets in east.
- Slow rotation –caused by frictional drag of atmosphere.
- Small induced magnetic field from interaction of solar wind and ionosphere.



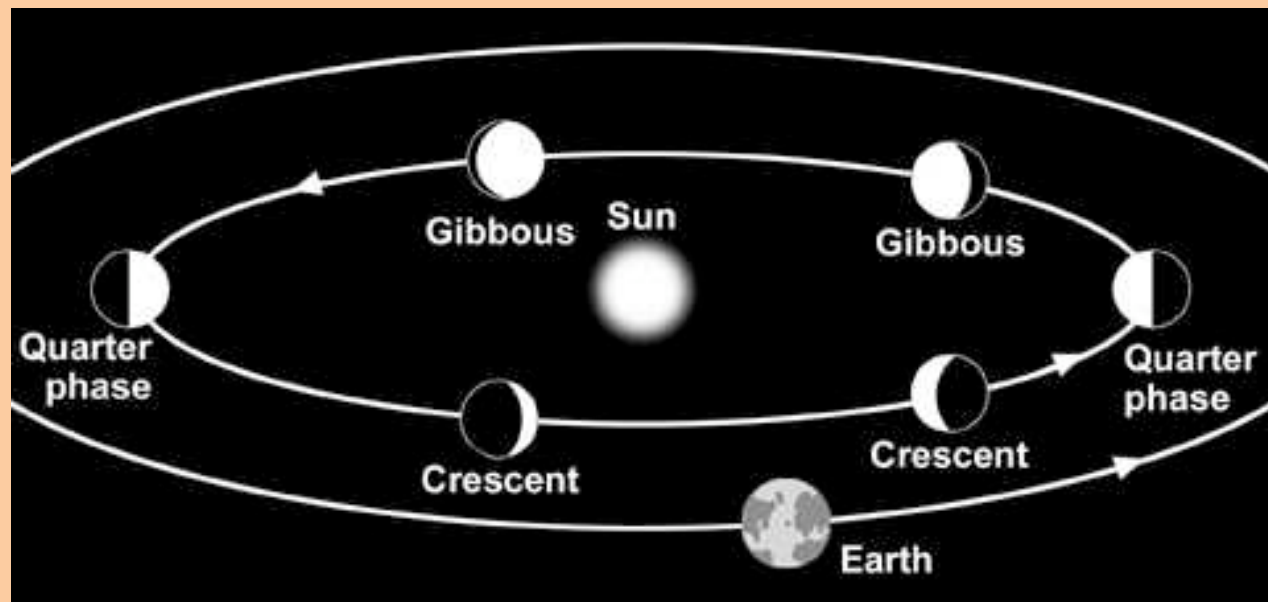
# More Venus Facts

- Since density and size of Venus are similar to Earth, then core should be similar to Earth's core. Magnetosphere should be similar as well.
- But small Venus' intrinsic magnetic field is a fraction of Earth's ( $\sim 1/100000$ ). Weird. Possibly due to solid core, no molten outer core to create dynamo and induce magnetic field.



# Even More Venus Facts

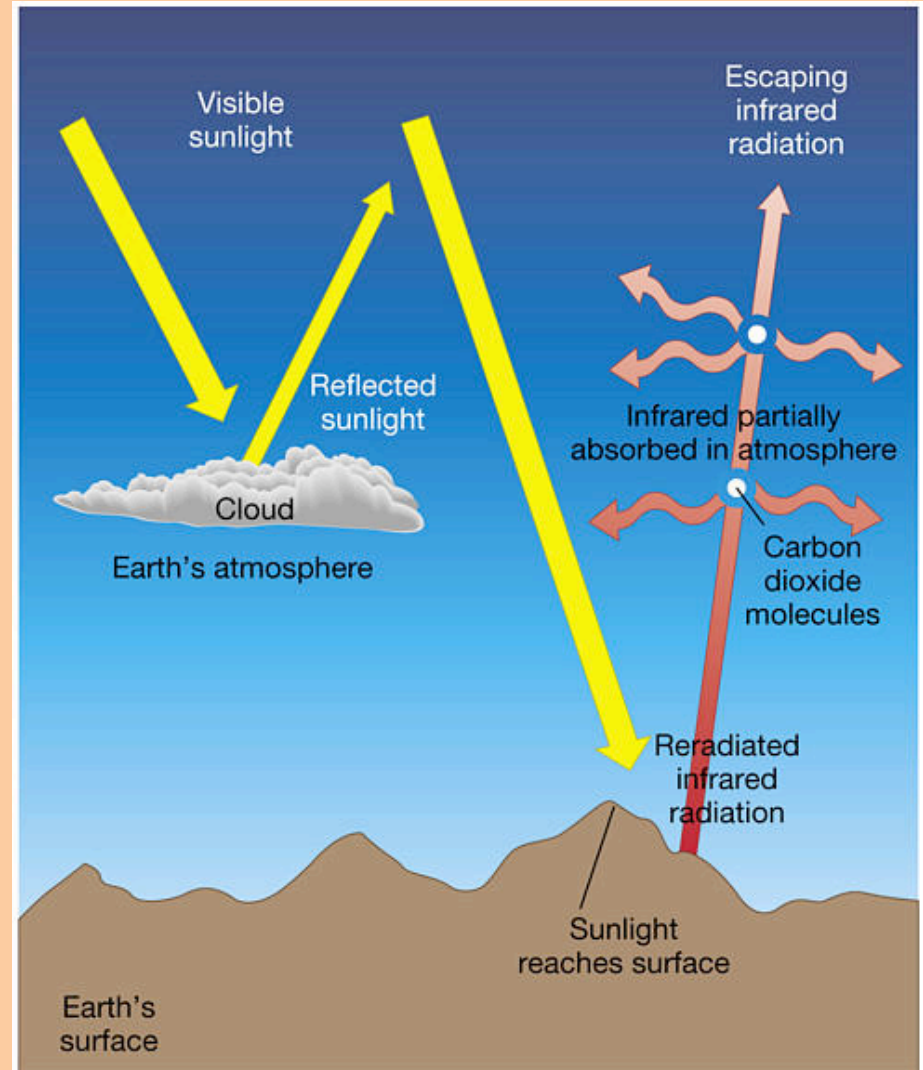
- From the perspective of the Earth, Venus has phases like our moon. This is because Venus is located inside the orbit of the Earth. And unlike Mars, Jupiter and other planets outside Earth's orbit, we don't always see the sunlit side
- Clouds are composed of sulfuric acid ( $\text{H}_2\text{SO}_4$ , really nasty corrosive stuff) which start at 50km above the surface. Below this altitude, the atmosphere appears clear.





# Greenhouse Effect

- $\text{CO}_2$  and  $\text{H}_2\text{O}$  are greenhouse gases – transparent to optical light but absorb a lot of infrared light (heat).
- Sun emits light primarily in visible part of spectrum. This gets absorbed or reflected by planet.
- The planet emits light itself – in infrared. Carbon dioxide and water vapor absorb infrared and are “transparent” to visible light.
- Dumping more  $\text{CO}_2$  and  $\text{H}_2\text{O}$  vapor into atmosphere increases the amount of greenhouse gases thereby increasing the temperature.



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# Runaway Greenhouse Effect

- Temperature of surface reaches boiling point (100 C or 212 F) of water. Water evaporates from oceans, dumping H<sub>2</sub>O into atmosphere -> increasing temp -> accelerating the evaporation-> dumps more water into sky -> increases temp and so on....
- Note that Venus temperature is way beyond the boiling point of water, so yeah, Venus atmosphere is the product of runaway greenhouse effect.
- Water molecules rise to top of atmosphere are broken apart, and blasted away by solar wind.

# Needed more data...

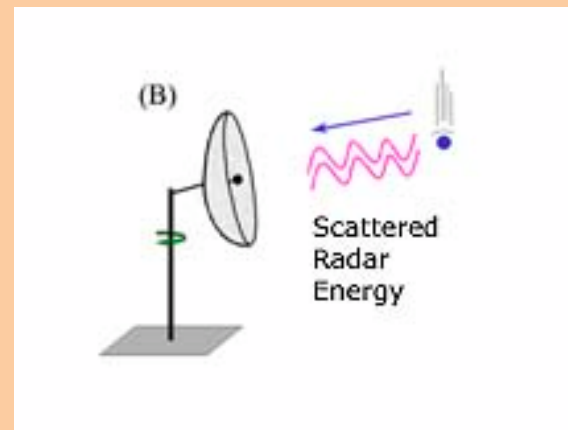
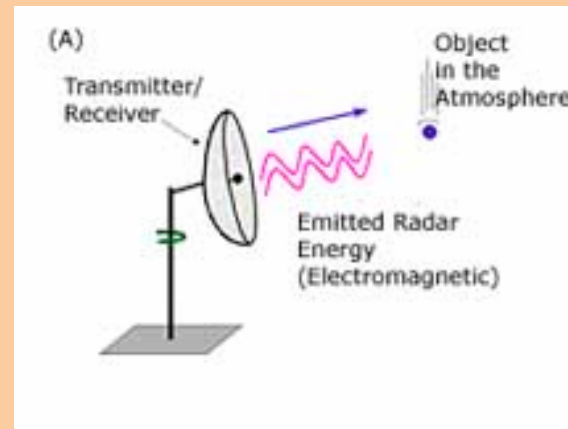
- Problem – how do you explore the surface of Venus when
  - a. each landing probe thrown at it transmits for ~1hour...Not enough time!
  - b. orbiters can't see through heavy clouds
- Solution! **Radar mapping**
- Pioneer Venus Probes (1978) were the first to do this.
- Magellan Mission (1990-1994) highly successful at high resolution imaging.....but how does radar work?

# Radar simplified

- Radar stands for RAdio Detection And Ranging.
- A source emits a pulse of radio waves. These waves bounce off a “target” (planet surface).
- The waves bounce in all directions, however, some come back in the direction of the source.
- Conveniently, attached to this source is a detector and receiver that measures the time it takes for the wave to travel the distance.
- In math terms:

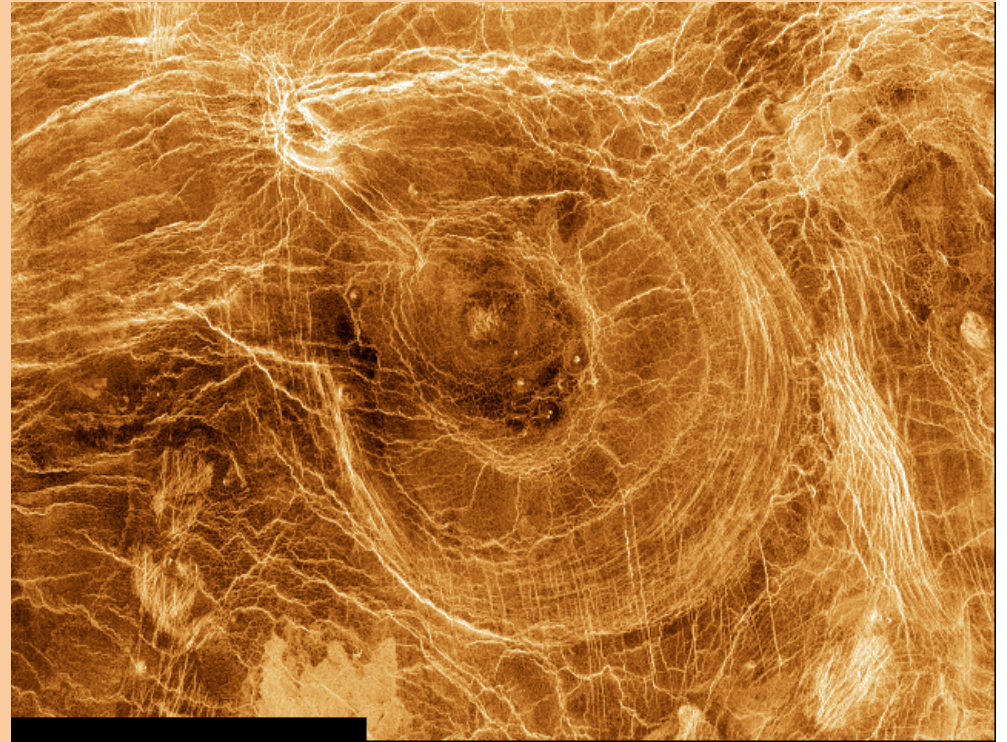
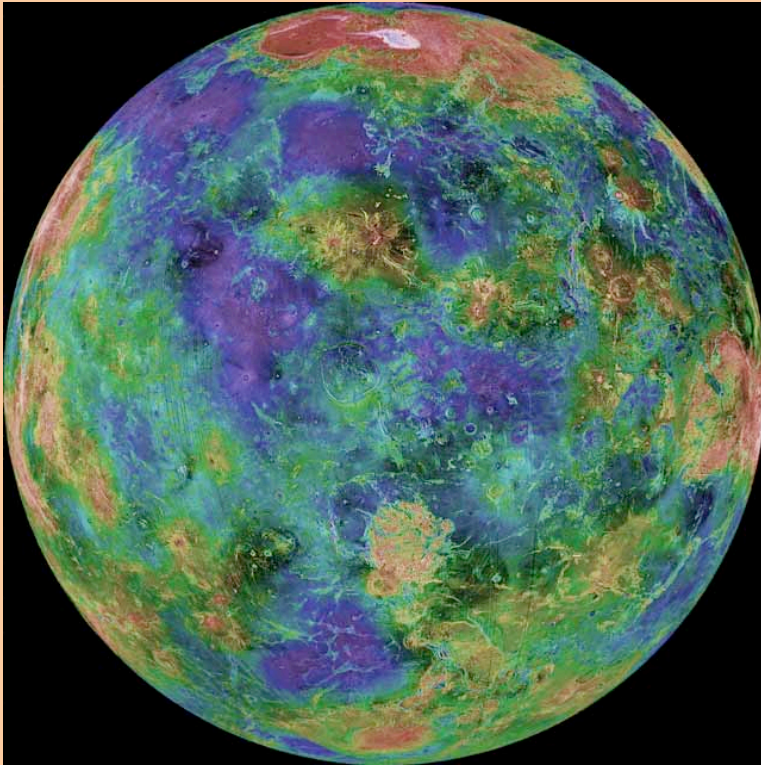
**Distance=time x speed of pulse/2.**

- The speed of the pulse is speed of light (300,000km/s)
- the factor 2 is needed to account for the wave traveling to and away from target.



# Magellan Results

- Amazing Hi res radar maps:

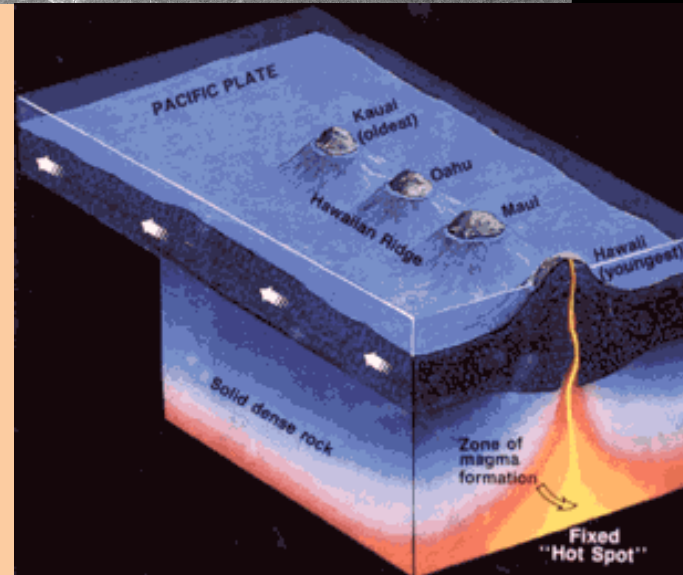


# Magellan Results

- Found:
  - No indication of oceans (at least in last 500 million years). No erosion.
  - Tectonic activity is non existent
    - randomly distributed volcanoes (not on plate boundaries)
    - fault lines exist, but not similar to ridges/rifts on Earth
    - No subduction zones
  - Millions of volcanoes, but no apparent ongoing lava flow. Volcanoes maybe active but presently there is no solid evidence.
  - Surface is relatively young 300-500Myrs

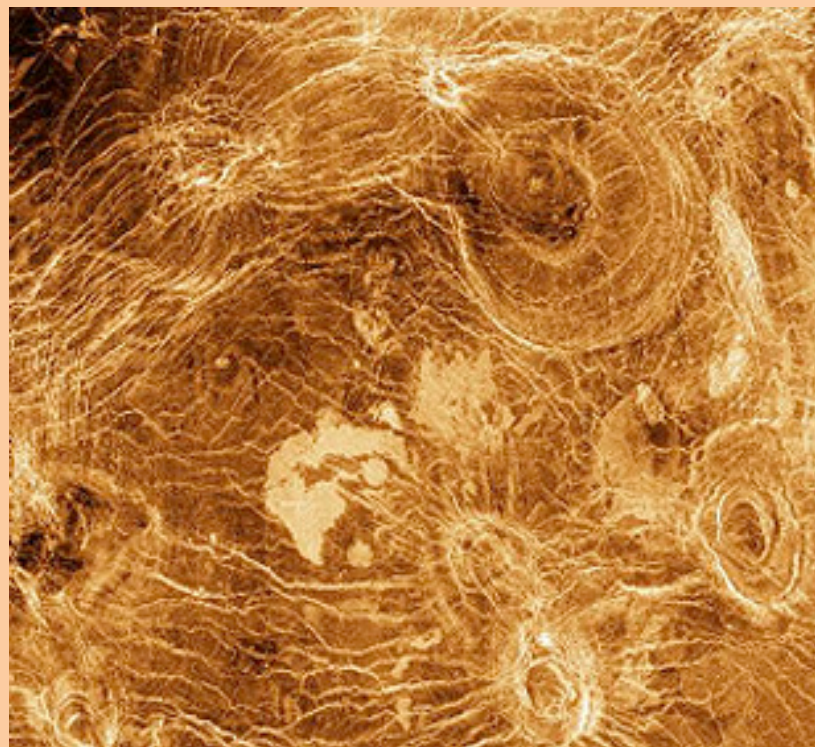
# Magellan Results

- Chains of Volcanoes – like Hawaiian Island “hotspot” formation.
  - But this is part of several randomly spread volcanic formations.



# Magellan Results

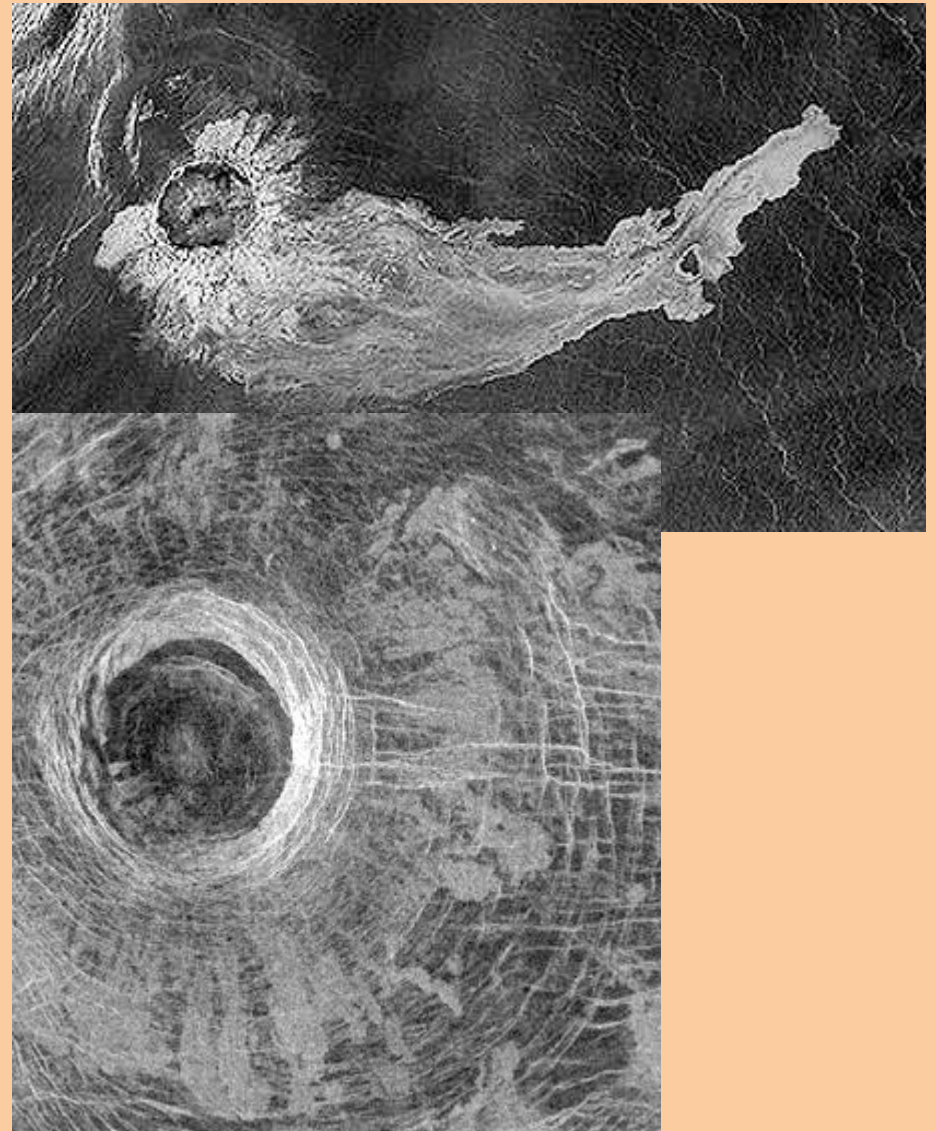
- New weird features with no analog on Earth
  - Coronae (100km -1000km) probably caused by magma lifting the surface, cools then sinks forming circular rings.
  - Arachnoids (precursor to Coronae?) Smaller versions of coronae with radial lines.





# Magellan Results

- Similar features to Earth:
  - Shield volcanoes (flat volcanoes caused by lava flow accumulation)
  - Caldera -> **How can one tell the difference between impact craters and volcanoes?**



# Impact craters vs Volcanic Craters

- Impact craters:
  - central peak
  - sharp edges
- Volcanoes
  - Bullseye ridge pattern
  - smooth crater floor
  - rounded/flattened rim
  - lava flow



Is this caused by a meteor or volcano?

# Impact craters

- No small craters, meteorites are probably destroyed in atmosphere.
- Crater clusters exist – larger meteorites break up before impact
- Also a lack of large craters indicates resurfaced area.

