

Reading for next week: Chap. 9, Sect. 9.4-9.5, Chap. 10, Sect. 10.1-10.2, 10.4-10.5

Homework 5: Due in recitation Friday/Monday Oct. 11, 14

Homework 6: Available on website, due Friday/Monday, Oct. 18, 21

Public Lecture (extra LC credit) : Tuesday, Oct. 15, 8:15pm - MU Great Hall:

Dr. Chris Lintott: "How to Find a Planet Without Leaving Your Couch"

Last time: Planet interiors and surfaces

- **Planetary interiors:** hot and stratified
- **Processes affecting planetary surfaces**
 - Impact cratering
 - Volcanism and melting
 - Weathering, erosion

Today: Planet surface processes, cont'd., ages

- (plate) tectonics
- **Relative Ages via Crater Density**
 - more craters, worn-down craters = older surface

Dust devils on Mars



More Mars Weathering: Wind Streaks



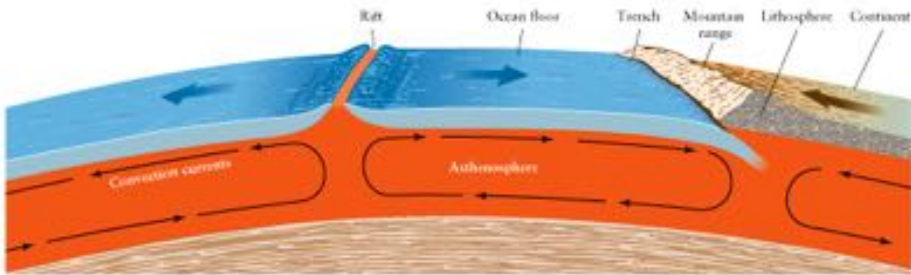
Tectonic Changes

Mercury, Venus, Earth, Mars

- **Definition:** large-scale changes as a planet's crust responds to stress
- **Earthquakes:**
 - sliding and cracking of crust
- **Mountain Building:**
 - buckling and folding of crust
- **Subduction:**
 - forcing down of crust into interior

Plate Tectonics on the Earth

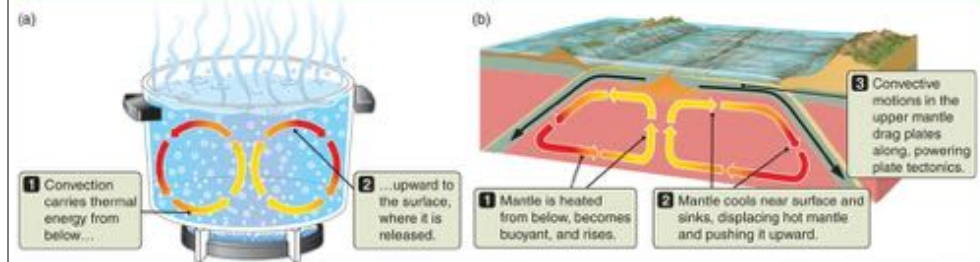
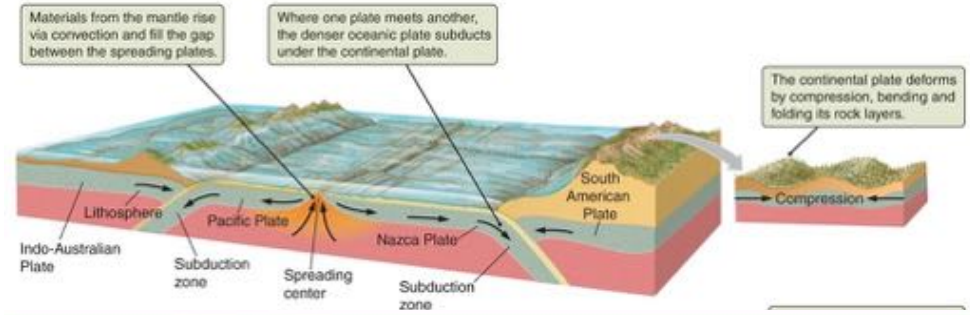
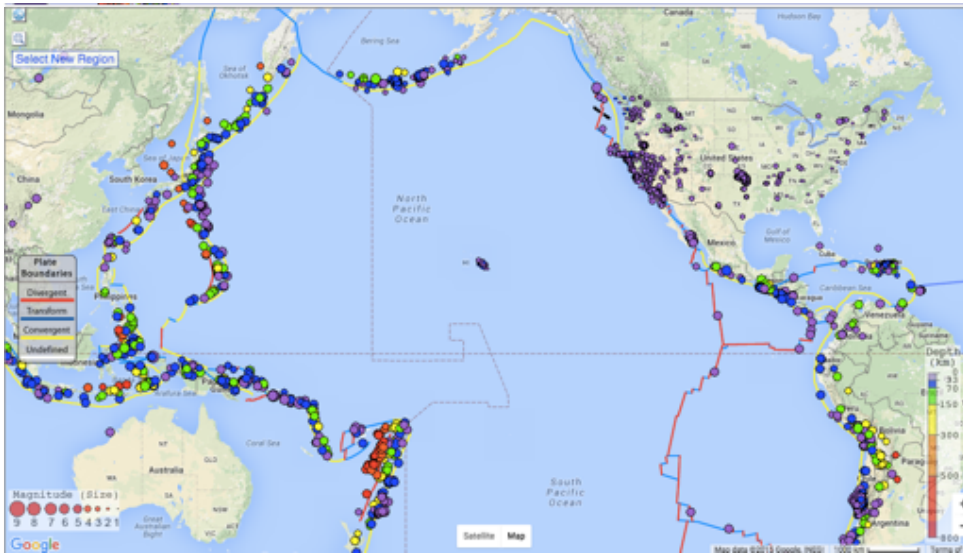
- partially molten **asthenosphere** (upper mantle)
- crustal plates “float” atop asthenosphere
- **subduction zones**: where plates overlap
- **faults**: where plates slide past



the San Andreas fault



Earth's continental plates - Pacific region

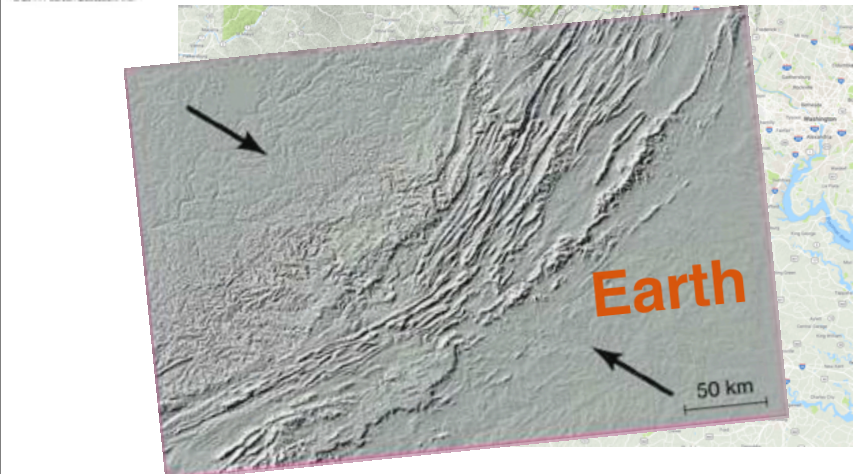


Mid-Atlantic Ridge



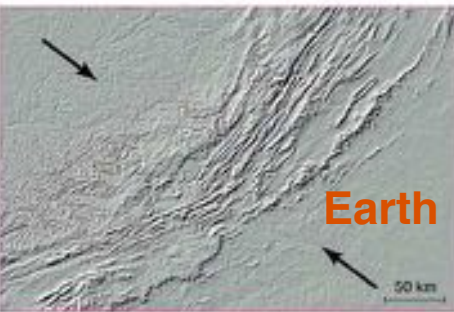
Appalachian Mountains in eastern United States

Ceraunius Valleys on Mars



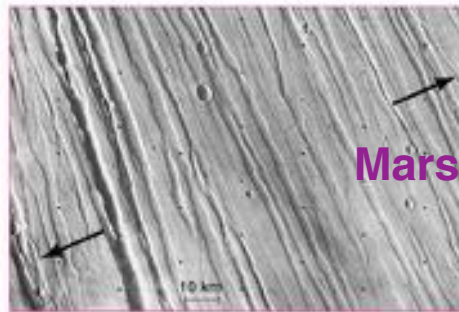
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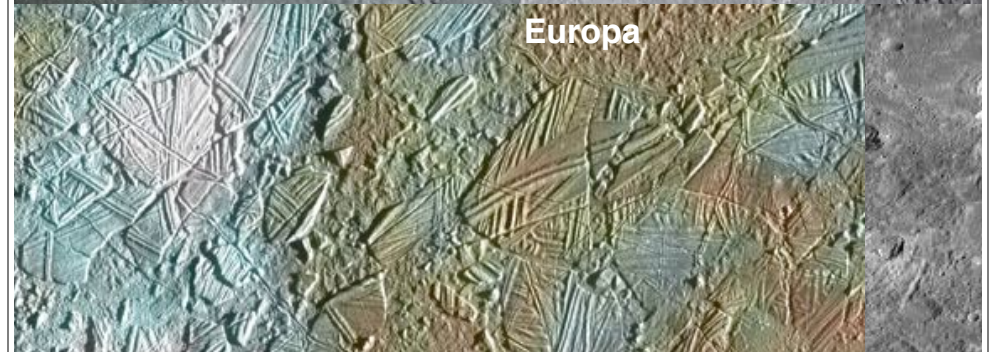
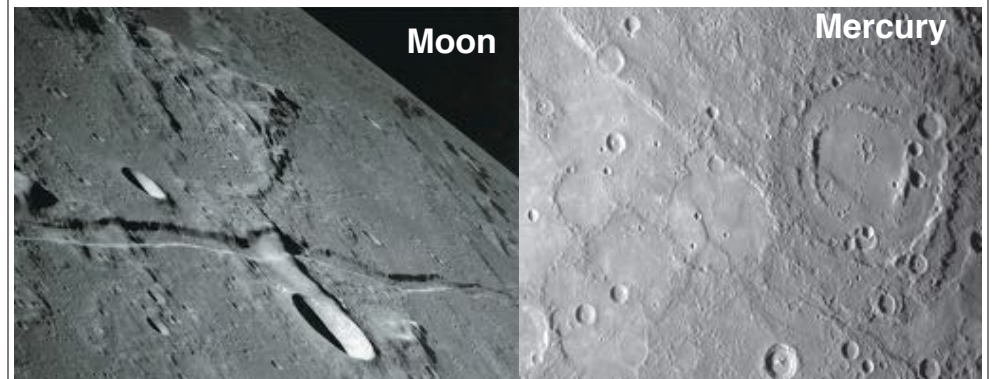
Appalachian Mountains in eastern United States

Internal stresses can cause compression in crust, which can make mountains.

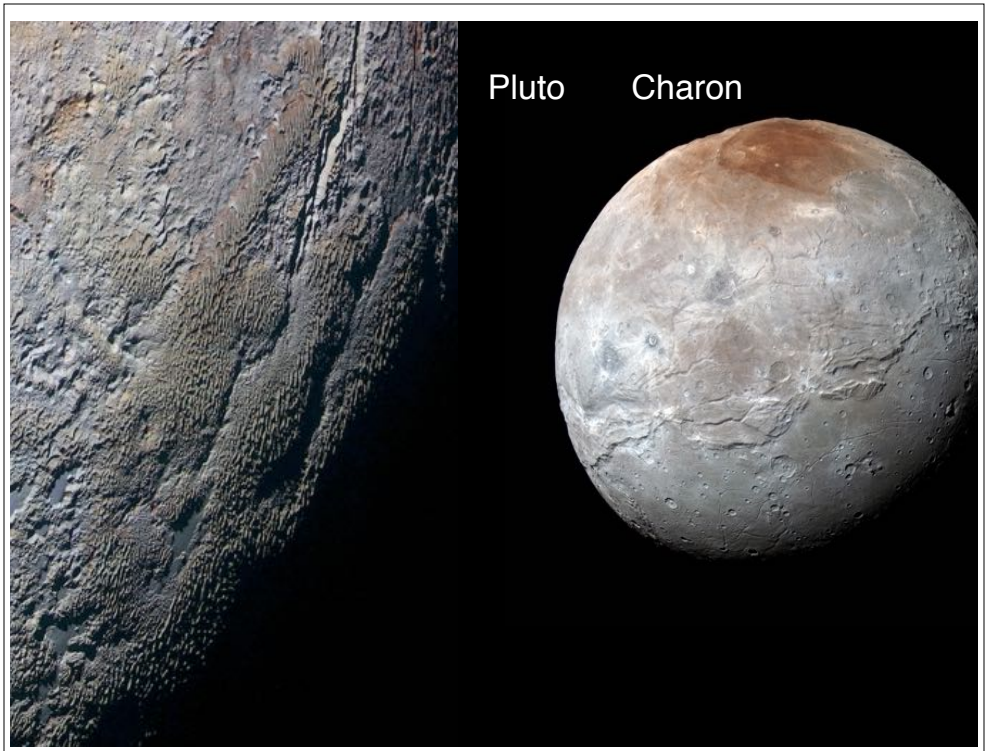
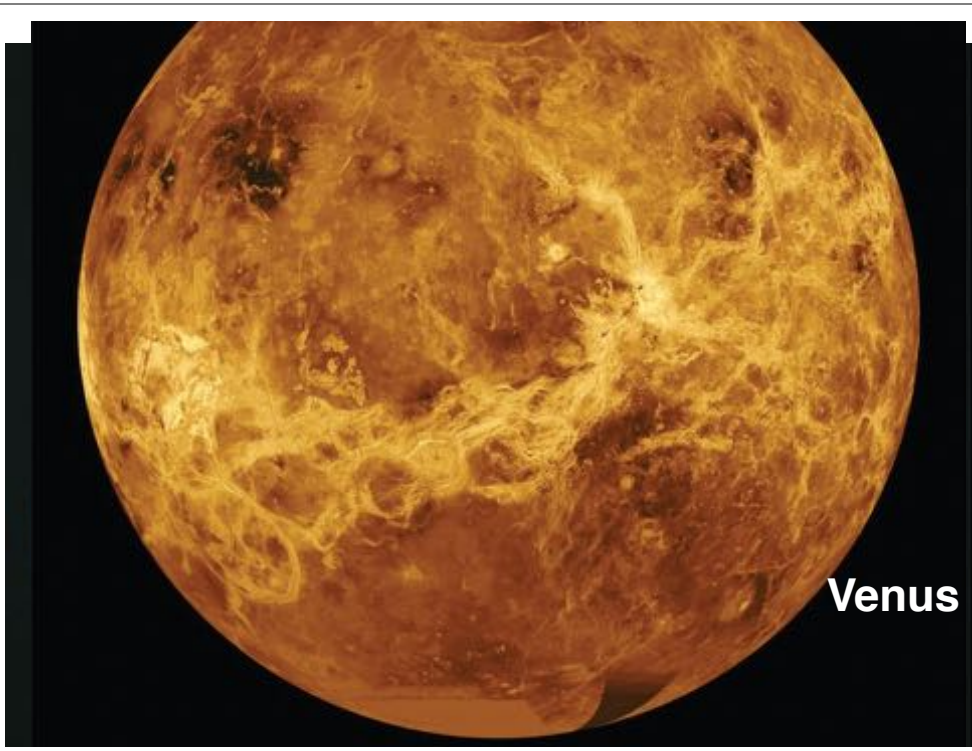


Ceraunius Valleys on Mars

Internal stresses can pull the crust apart. This extension can make cracks and valleys.



Europa



Contrasting the planets

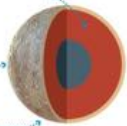
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• Size matters

Interior cools rapidly.

...so that tectonic and volcanic activity ceases after a billion years or so. Many ancient craters therefore remain.

Lack of volcanism means little outgassing, and low gravity allows gas to escape more easily; no atmosphere means no erosion.

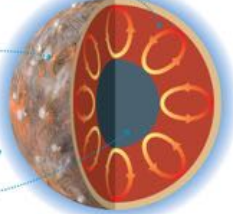


Warm interior causes mantle convection.

...leading to ongoing tectonic and volcanic activity; most ancient craters have been erased.

Outgassing produces an atmosphere and strong gravity holds it, so that erosion is possible.

Core may be molten, producing a magnetic field if rotation is fast enough.

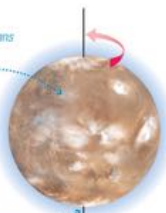


• Rotation matters

Slow Rotation

Less wind and weather means less erosion, even with a substantial atmosphere.

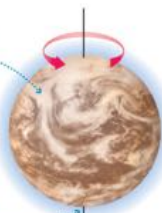
Slow rotation means weak magnetic field, even with a molten core.



Rapid Rotation

More wind and weather means more erosion.

Rapid rotation is necessary for a global magnetic field.



Ranger 9 Mission to the Moon
March 24, 1965



Ages: when did the surface solidify after being molten?

Relative Ages from cratering density

Moon, Mercury, Mars, Venus, outer moons

crater density:

number of craters per unit area on a surface

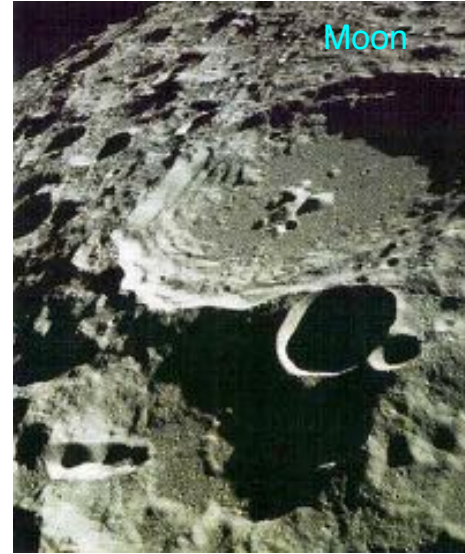
Younger Surfaces:

- low crater density
- fresher looking craters

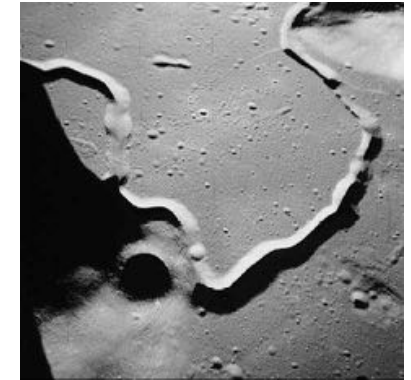
Older Surfaces:

- more time to collect impacts
- higher crater density
- older, degraded craters
- saturation - new ones cover old

Crater density gives relative ages across a body calibrated for the Moon only via lunar sample dating



An "old" surface on the lunar farside (4.0 billion yrs)



A "new" surface: Hadley Rille (3.2 billion yrs)

Absolute Ages from Radiometric Dating

unstable isotopes

- an unstable isotope is a form of an element with too many, or too few neutrons.
- example: ^{12}C (6p, 6n) is 'normal' while ^{14}C (6p, 8n) has two extra neutrons, and is *unstable*

radioactive decay

- i.e. neutron changes to a proton+electron
- occurs at random, but with well defined average rate
- **half life** = time for 1/2 of the unstable isotopes to decay
 - intrinsic property of atomic nuclei
 - unchanged over time
 - specific for a given decay channel

example: $^{40}\text{K} \rightarrow ^{40}\text{Ar}$; half life = 1.25×10^9 yr

Element	Start	1 half-life	2 half-lives	3 half-lives	4 half-lives
		1.25 Gyr	2.5 Gyr	3.75 Gyr	5.0 Gyr
Potassium 40	1000	500	250	125	62
Argon 40	0	500	750	875	938
Ratio K/Ar	--	1	0.33	0.14	0.067

