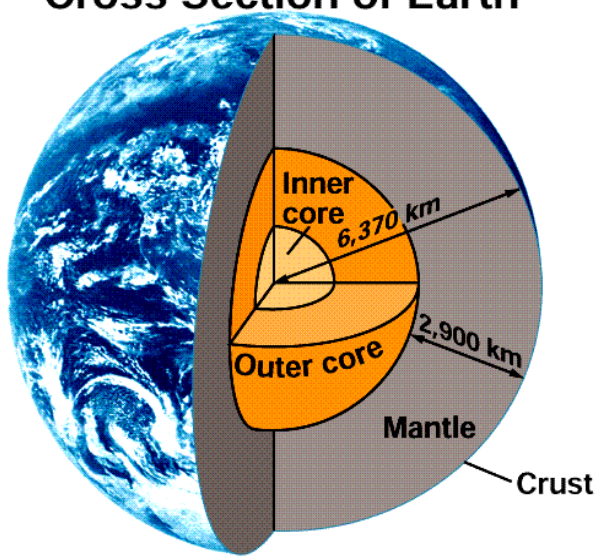
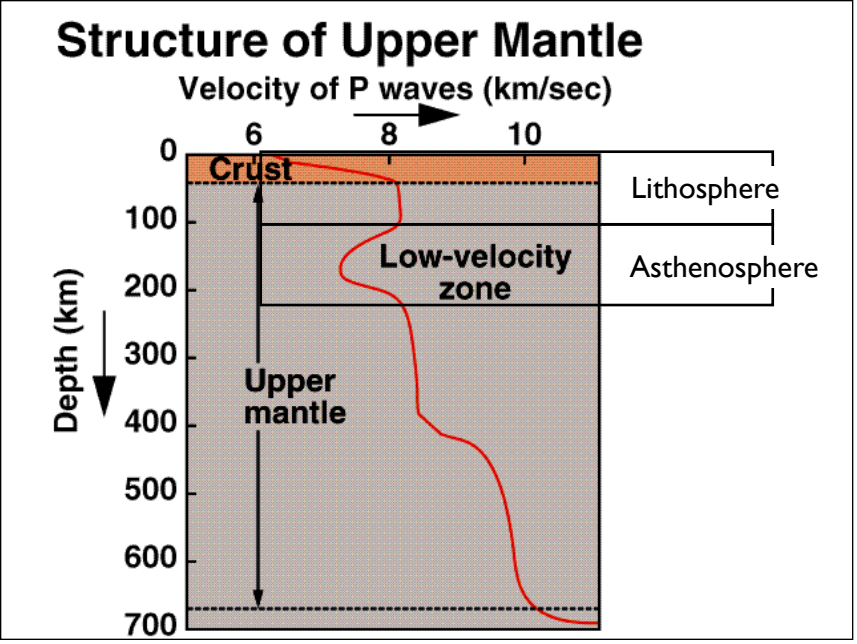
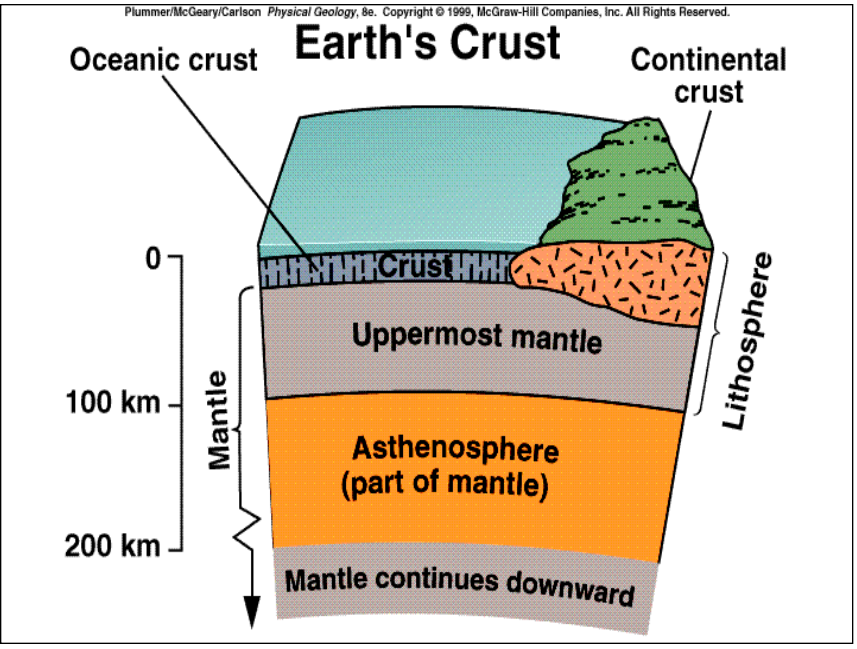
Isostasy and the dynamics of the Earth's crust

Isostasy: the condition of equilibrium, comparable to floating, of the units of the lithosphere on the asthenosphere.

Cross Section of Earth




Structure of Upper Mantle
Velocity of P waves (km/sec)
6
8
10
0
100
200
300
400
500
600
700
Depth (km)
Crust
Low-velocity zone
Upper mantle
Lithosphere
Asthenosphere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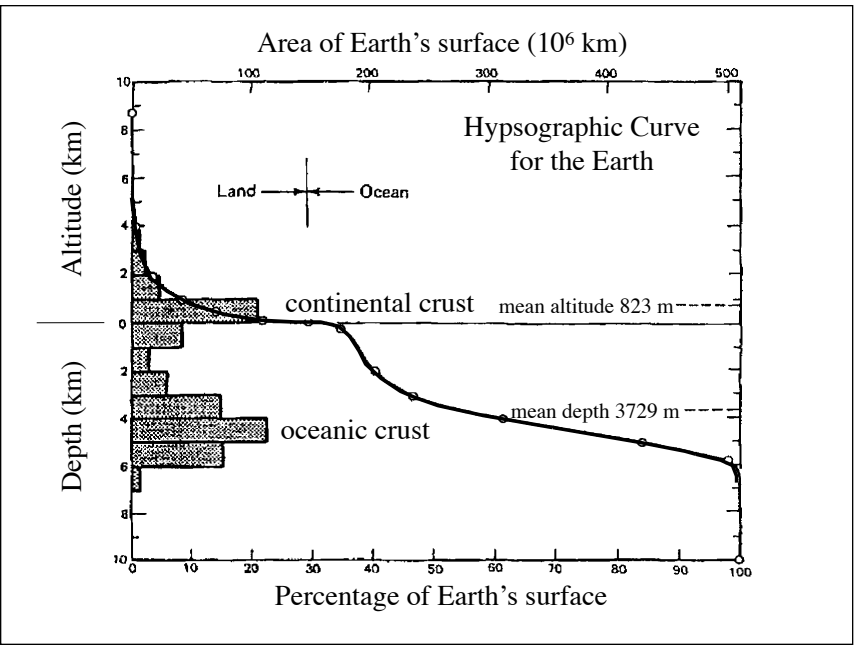
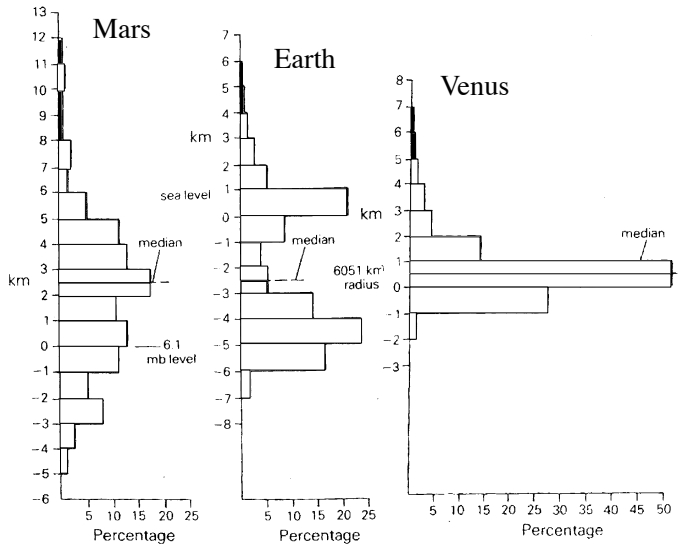
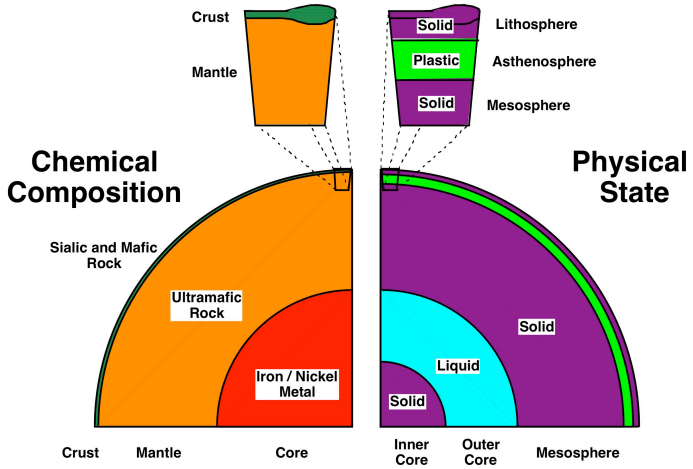
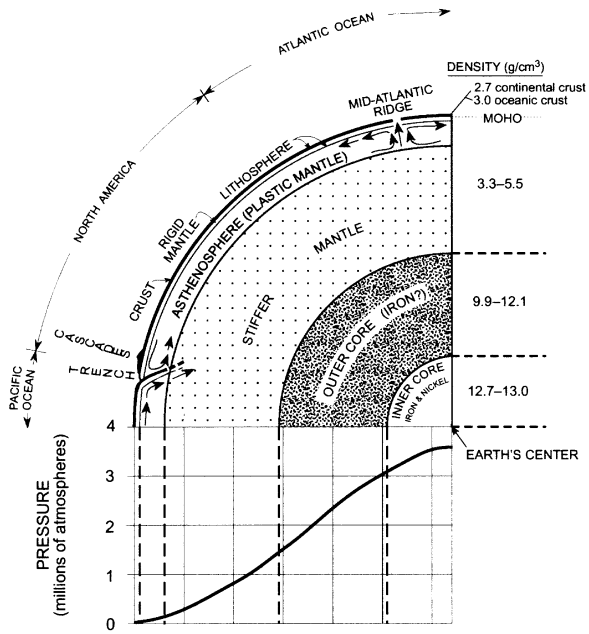
Earth's Crust
Oceanic crust
Continental crust
0
100 km
200 km
Crust
Uppermost mantle
Asthenosphere (part of mantle)
Mantle continues downward
Mantle
Lithosphere

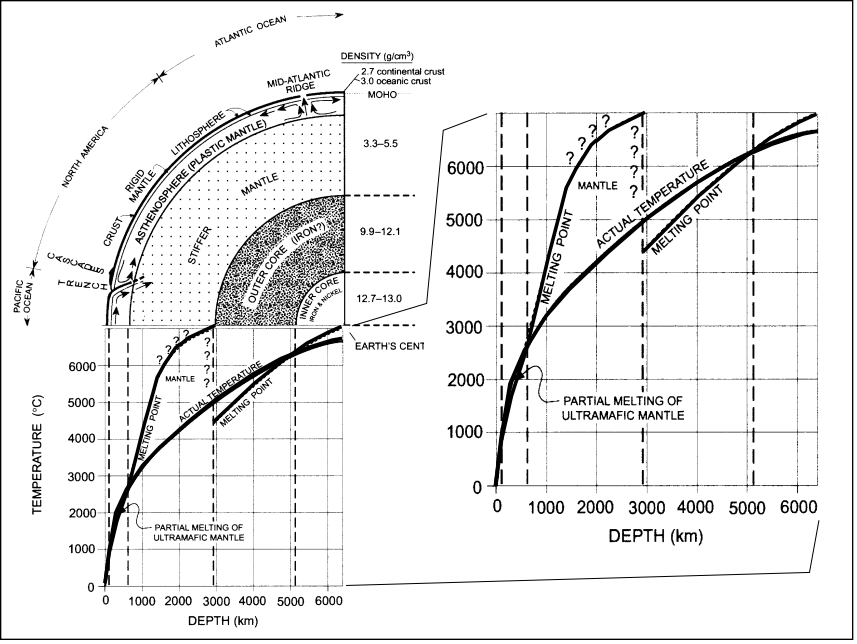

Area of Earth's surface (10⁶ km)
100
200
300
400
500
10
8
6
4
2
0
2
4
6
8
10
Altitude (km)
Depth (km)
Hypsographic Curve for the Earth
Land
Ocean
continental crust
mean altitude 823 m
mean depth 3729 m
oceanic crust
0
10
20
30
40
50
60
70
80
90
100
Percentage of Earth's surface



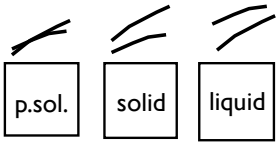


Earth's Interior

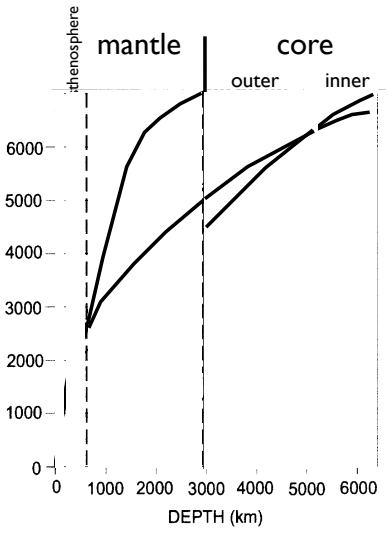




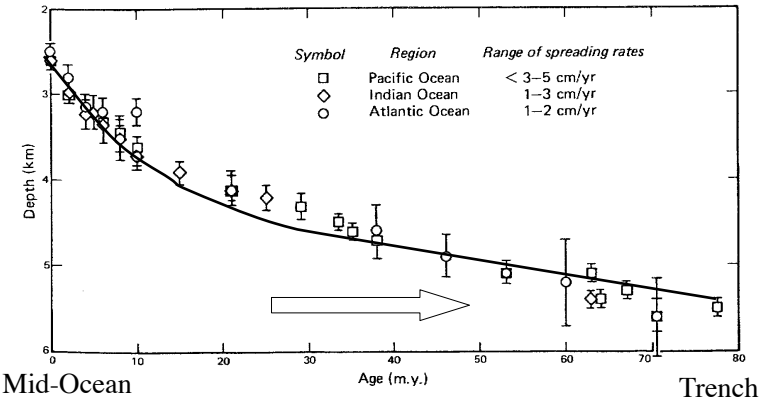
The physical state (solid / partially solid / liquid) of the different layers of the Earth depends on which is higher - the melting temperature or the actual temperature.



A = M A < M A > M



Graph of Age vs. Depth of Ocean Floor



Mid-Ocean Ridge

Trench

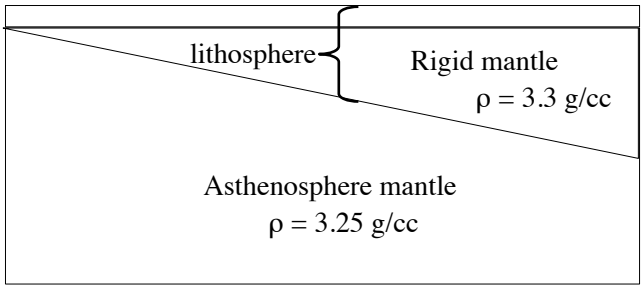
Why might the ocean floor sink as it gets older?

Mid-ocean ridge

time →

Trench

Oceanic crust $\rho = 3.0$ g/cc



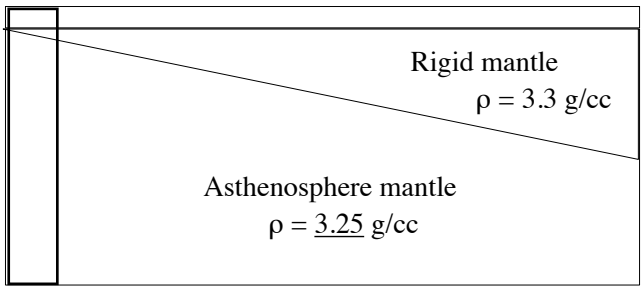
$\rho_{lithosphere} = \rho_{crust} \times \%thickness_{crust} + \rho_{mantle} \times \%thickness_{mantle}$

Mid-ocean ridge

time →

Trench

Oceanic crust $\rho = 3.0$ g/cc



age = 0 my

$\rho_{lithosphere} = 3.0$ g/cc x **1.0** + 3.3 g/cc x **0** = 3.0

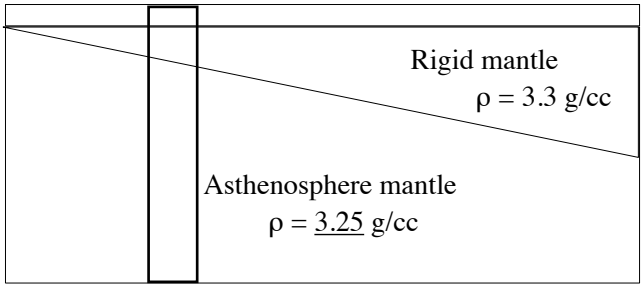
$\rho_{lithosphere} << \rho_{asthenosphere}$

Mid-ocean ridge

time →

Trench

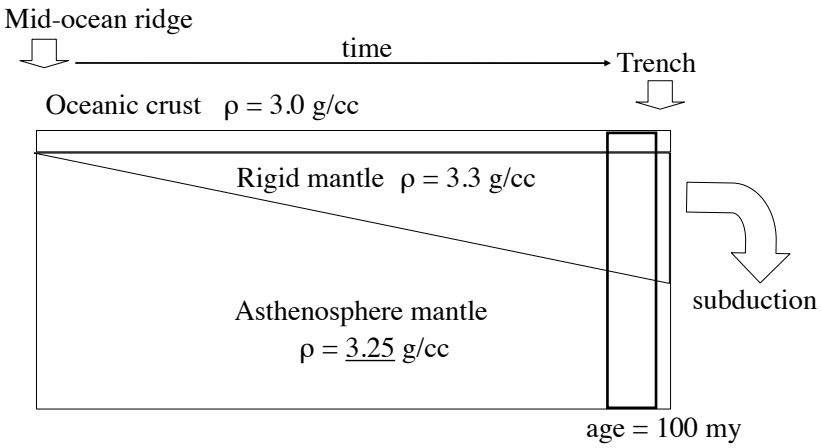
Oceanic crust $\rho = 3.0$ g/cc



age = 10 my

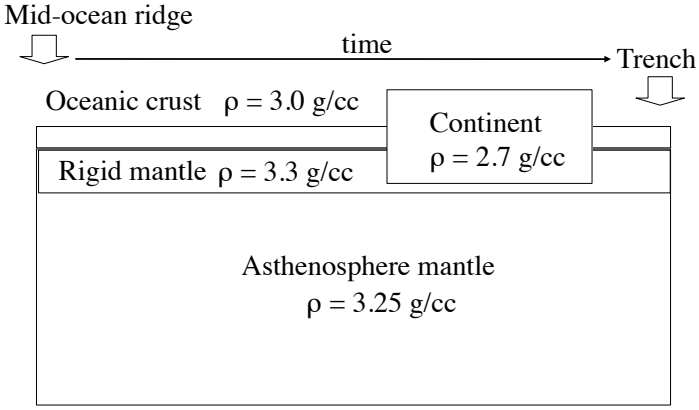
$\rho_{lithosphere} = 3.0$ g/cc x **.4** + 3.3 g/cc x **.6** = 3.18

$\rho_{lithosphere} < \rho_{asthenosphere}$



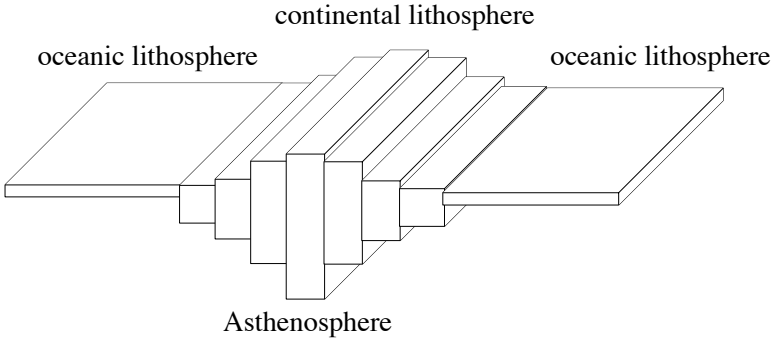
$\rho_{lithosphere}$ = 3.0 g/cc x **.06** + 3.3 g/cc x **.94** = 3.28

$\rho_{lithosphere} > \rho_{asthenosphere}$



Can continents be subducted into the mantle?

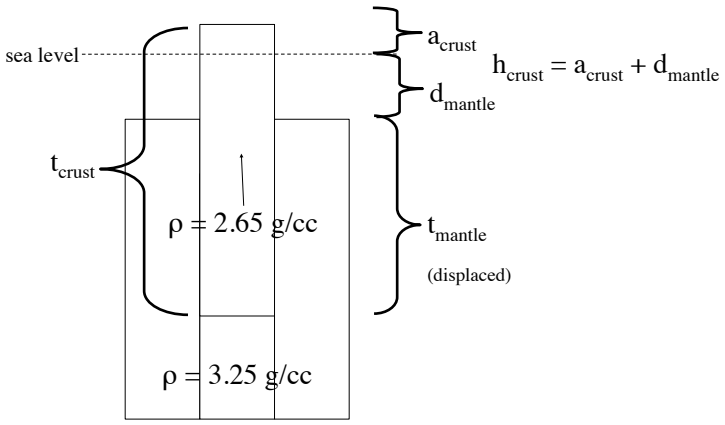
Isostasy - equilibrium position of lithosphere "floating" on asthenosphere.



Other ways to change the isostatic equilibrium of the crust

- Heating / cooling of the lithosphere
  - Changes the density of the crust = buoyancy
  - Caused by passage of plates over mantle hot spots
- Heating / cooling of the mantle
  - Rising plumes of hot mantle displace the lithosphere upward
  - Sinking slabs of cold mantle pull the lithosphere downward

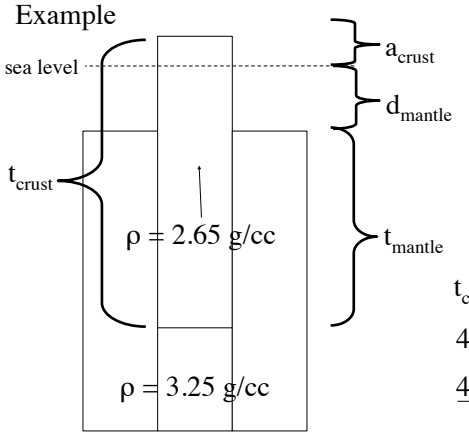
Continental Crust



Archimedes' principle:

$t_{crust} \times \rho_{crust} = t_{mantle} \times \rho_{mantle}$

Example



How much mantle will be displaced by 45 km of crust?

$t_{crust} \times \rho_{crust} = t_{mantle} \times \rho_{mantle}$

$45 \times 2.65 = t_{mantle} \times 3.25$

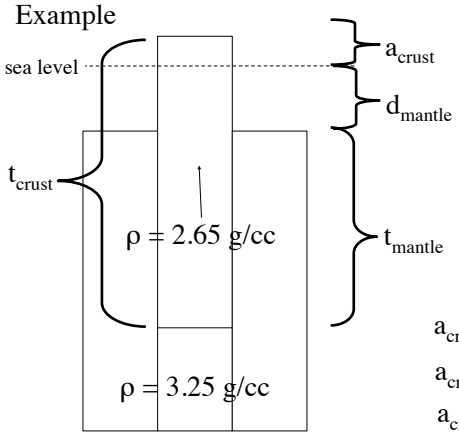
$$\frac{45 \times 2.65}{3.25} = t_{mantle}$$

$36.7 = t_{mantle}$

Archimedes' principle:

$t_{crust} \times \rho_{crust} = t_{mantle} \times \rho_{mantle}$

Example



36.7 km = t_{mantle}

45 km = t_{crust}

If d_{mantle} = 8.0 km

How high above sea level will the crust be?

$a_{crust} = t_{crust} - (d_{mantle} + t_{mantle})$

$a_{crust} = 45 - (8 + 36.7)$

$a_{crust} = .3$ km

Archimedes' principle:

$t_{crust} \times \rho_{crust} = t_{mantle} \times \rho_{mantle}$