

## ESC 1022

### Lecture 2: Composition and Morphology of Continental Crust

#### The Continental Crust

- What is it?
- What size is it?
- What shape is it?
- What is it made of?
- What age is it?

#### Surface Features of the Earth's Crust

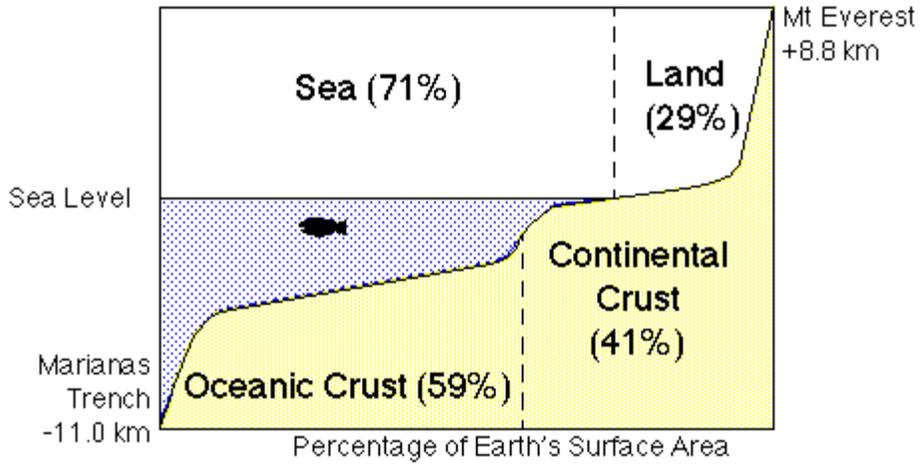
1. Two types of crust: high areas (continental crust) and low areas (oceanic crust).
2. The boundary between them does not follow the coastlines (much of the continental crust is below sea level).
3. The oceanic crust is mainly flat, but also has linear or curved ridges and trenches.
4. The continental crust is mainly flat, but also has linear or curved mountain ranges and rift zones.
5. Mountains on the continents are wider than similar features in the oceans.
6. Mountains are often at the edges of continents, but also occur in the centre of continents.
7. Mountain ranges vary in elevation, some are high and wide, others low and narrow.

#### Surface Elevation

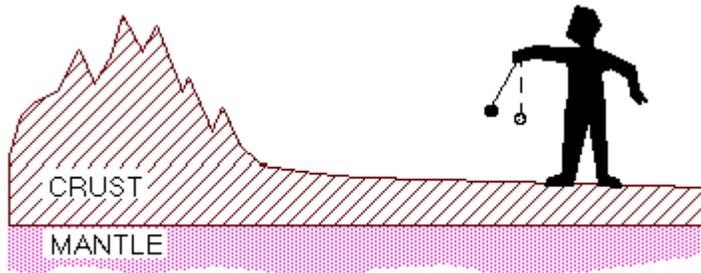
Not every piece of continental crust is above sea level.  
 31% of all continental crust is covered by ocean.

Continental Block	Area ( $10^6 \text{ km}^2$ )	% below sea level
Eurasia	62.2	26
North America	39.8	31
Africa	35.7	15
South America	24.0	19
Antarctica	19.0	78
Australia	14.2	35
India	4.6	15
Arabia	4.6	11
New Zealand	4.0	90

Central America	1.3	53
Rockall	0.5	100
Seychelles	0.4	100
Agulhas	0.1	100
Jan Mayen	0.1	99
<b>Total</b>	210.5	31

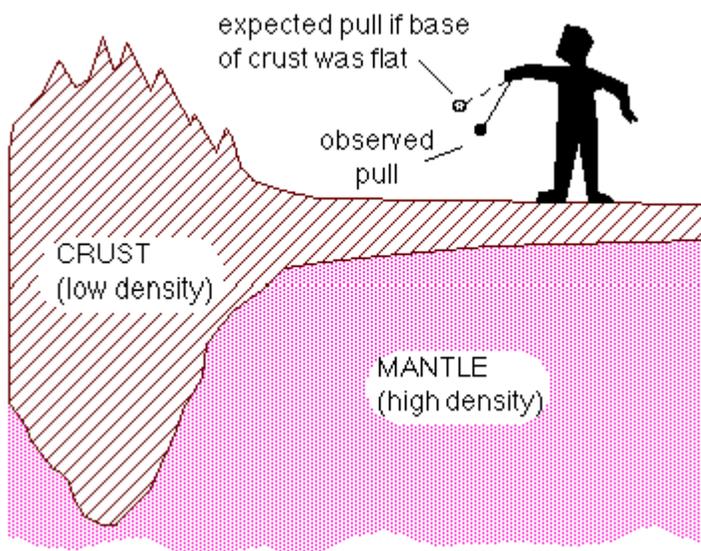


### The Base of the Crust



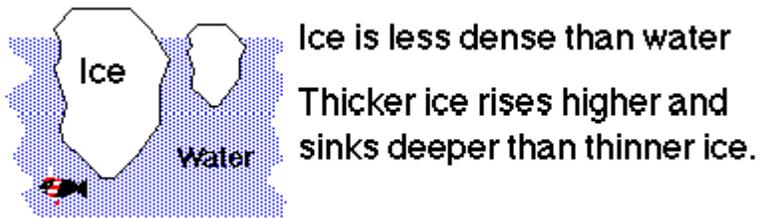
Mountains have a lot of mass and a gravitational pull

But not as much pull as they should if the base of the crust was flat...



Mountain ranges have less mass than expected because they have a deep root of low-density crust that displaces DENSE mantle.

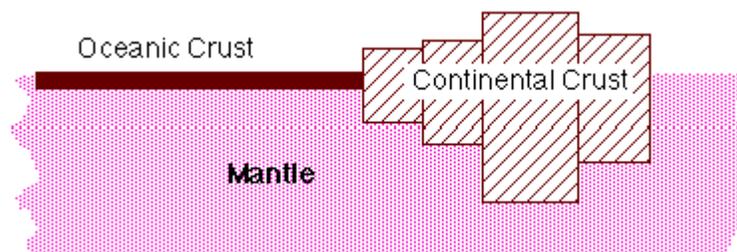
Why do high mountains have deep roots?



### Principle of ISOSTASY

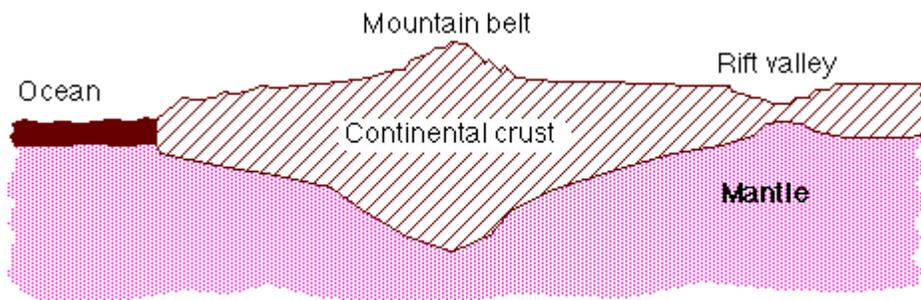
Over long time scales the upper mantle behaves like a fluid and the crust floats on top of it.

Treat the crust as floating blocks of different thickness.



- Thick crust has a higher elevation and a deeper root than thin crust.
- Denser crust (oceanic) floats at a lower level than less dense crust (continental).

More realistically:



1. Continental crust is 10-70 km thick.
2. Average thickness = 35-40 km.

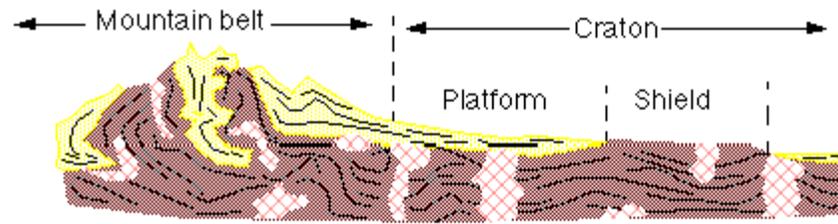
Topography at the base of the continental crust is much more dramatic than at the Earth's surface...

Each extra km of mountain at the surface must be balanced by an extra 6 km of root.

### Surface Geology

**Cratons - (a) Shields, (b) Stable platforms**

**Mountain belts**



Average chemical composition? "Granitic" or "felsic".

Common minerals:

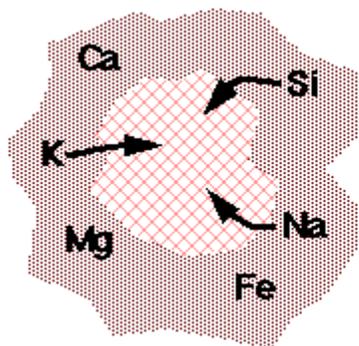
- quartz
- plagioclase feldspar
- alkali feldspar (K-feldspar)

Rich in silicon (Si), potassium (K) and sodium (Na).

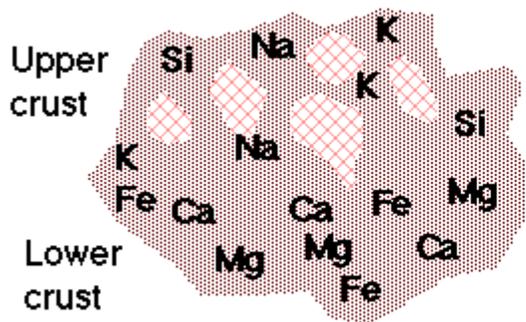
But geophysical evidence (seismic velocity) indicates that lower crust is denser than upper crust.

Lower continental crust is more "mafic".  
Richer in magnesium, iron, calcium.

**Why does composition change with depth?**



Melting produces granite magma which scavenges Si, K and Na



Granites rise into upper crust as they are less dense

What is the average composition of continental crust?

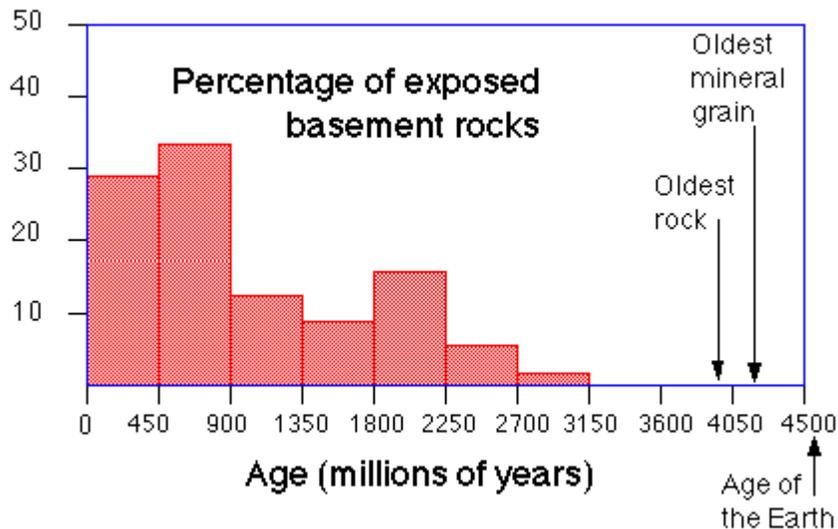
	Continental Crust	Oceanic Crust
SiO <sub>2</sub>	57.3	49.5
Al <sub>2</sub> O <sub>3</sub>	15.9	16.0
FeO	9.1	10.5
MgO	5.3	7.7

CaO	7.4	11.3
Na <sub>2</sub> O	3.1	2.8
K <sub>2</sub> O	1.1	0.2

- Continental crust is more "felsic" (has more silicates) than oceanic crust.
- Continental crust is less dense than oceanic crust.
- Continental crust is weaker than oceanic crust.

### Age of the Continental Crust?

Compare the ages of exposed continental basement rocks (ignoring platform sediments).



This graph under-estimates the amount of old crust:

- Older rocks are likely to occur deeper in the crust.
- Ages can be reset by later thermal events.

But it is clear that:

The continental crust has a long and complex history . . .  
Unlike oceanic crust which is only 0-210 million years old.

### To summarise:

Continental Crust	Oceanic Crust
1/3 of Earth surface	2/3 of Earth surface
Higher elevation (126 m above sea level)	Lower elevation (3.7 km below sea level)
Thicker (15-70 km) (average = 35-40 km)	Thinner (6 km thick)
Wider mountain belts	Narrower mountain belts
Felsic composition "granitic rocks" quartz, plagioclase, alkali-feldspar (rich in Si, K, Na)	Mafic composition "Basaltic rocks" pyroxene, plagioclase (rich in Mg, Fe, Ca)

Less dense (2800 kg/m <sup>3</sup> )	More dense (3000 kg/m <sup>3</sup> )
Easier to deform (viscosity = 10 <sup>23</sup> Pa.s)	Harder to deform (Viscosity = 10 <sup>24</sup> Pa.s)
Older (0-4000 million years)	Younger (0-210 million years)

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