



## ESC 1022

### Lecture 3: Continental Birth and Evolution through Geologic Time

#### Continental Birth and Evolution through Geologic Time

##### The Continental Crust

- Where does it form today?
- How does it form?
- What happens to it afterwards?
- Does it grow with time?
- Was it different in the past?
- The role of "Plate Tectonics"

##### Plate Tectonics and Continental Crust

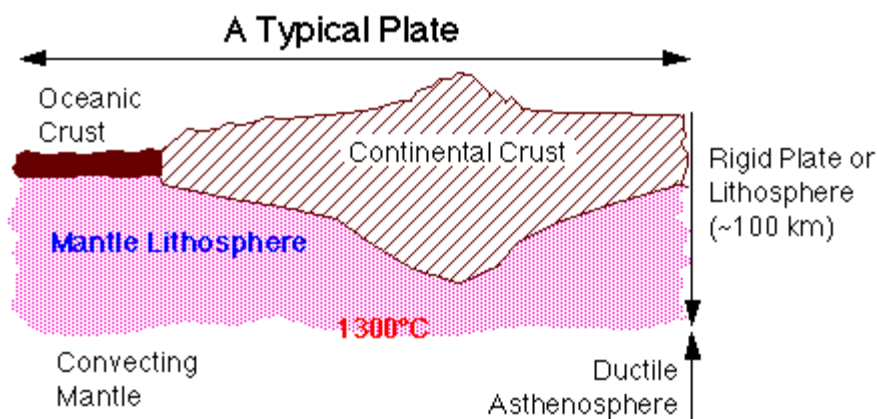
Most geological activity occurs near plate boundaries...

Including:

1. The formation of new continental crust.
2. The reworking (deformation, metamorphism) of old continental crust.

##### What is a plate?

A (mobile) segment of the Earth's crust.

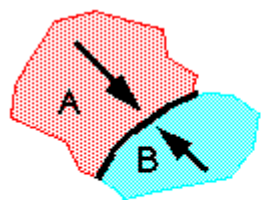


- 1.
2. Plates include all of the crust, and also the uppermost (cold and rigid) part of the

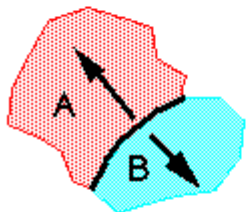
mantle.

Two (or more) plates meet at plate boundaries...

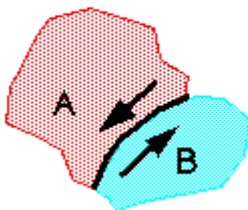
**Three types of plate boundary**



1. Convergent Boundary  
(plates moving together)



2. Divergent Boundary  
(plates moving apart)



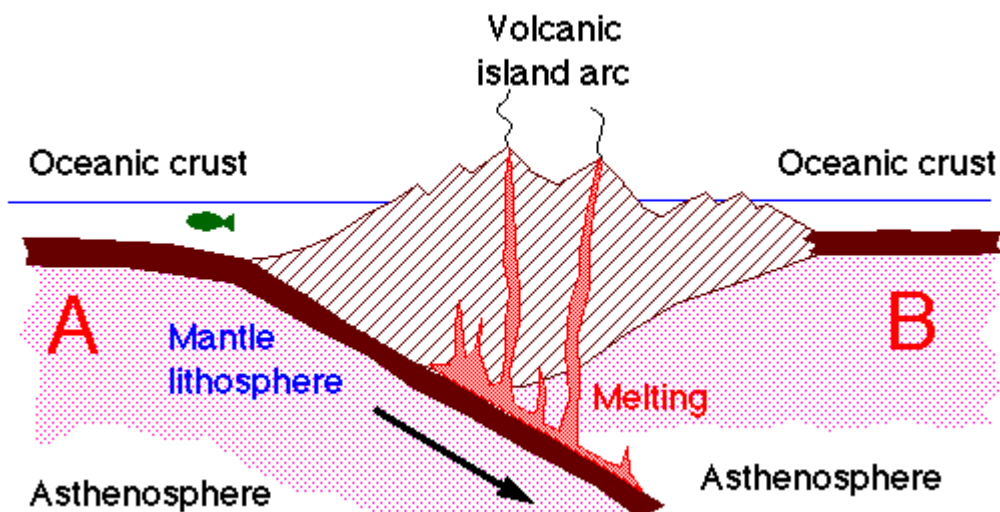
3. Transform Boundary  
(plates moving past one another)

**Convergent Plate Boundaries**

There are three types of convergent boundary where plates meet:

1. ocean-ocean
2. ocean-continent
3. continent-continent

**Ocean-Ocean Convergence**



1. Plate A subducts below Plate B.

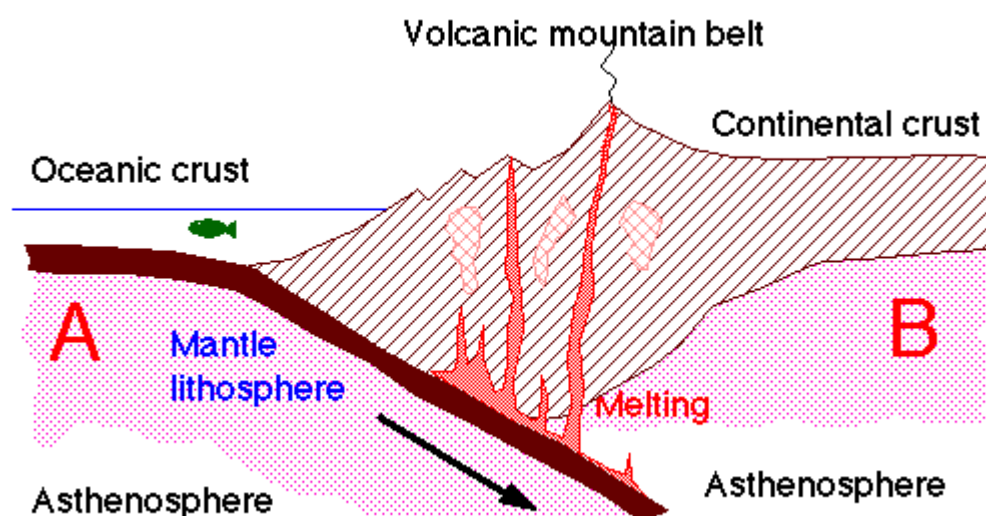
2. Plate A heats up as it descends.
3. Water is driven from the crust of Plate A into the overlying mantle of Plate B.
4. This water causes the overlying mantle to melt.
5. Magma rises up to form a volcanic arc.

Volcanic arcs represent juvenile continental crust - eg. the Tongan Islands.

NOTE:

1. Mantle beneath mid-ocean ridges is dry and produces mafic ocean crust when it melts.
2. Mantle above subduction zones is wet because of the water released from the subducting slab, and produces felsic continental crust when it melts.

### Ocean-Continent Convergence



Similar to Ocean-Ocean convergence...

Water is released from the subducting plate...

Overlying mantle melts...

Magmas rise to form new felsic crust...

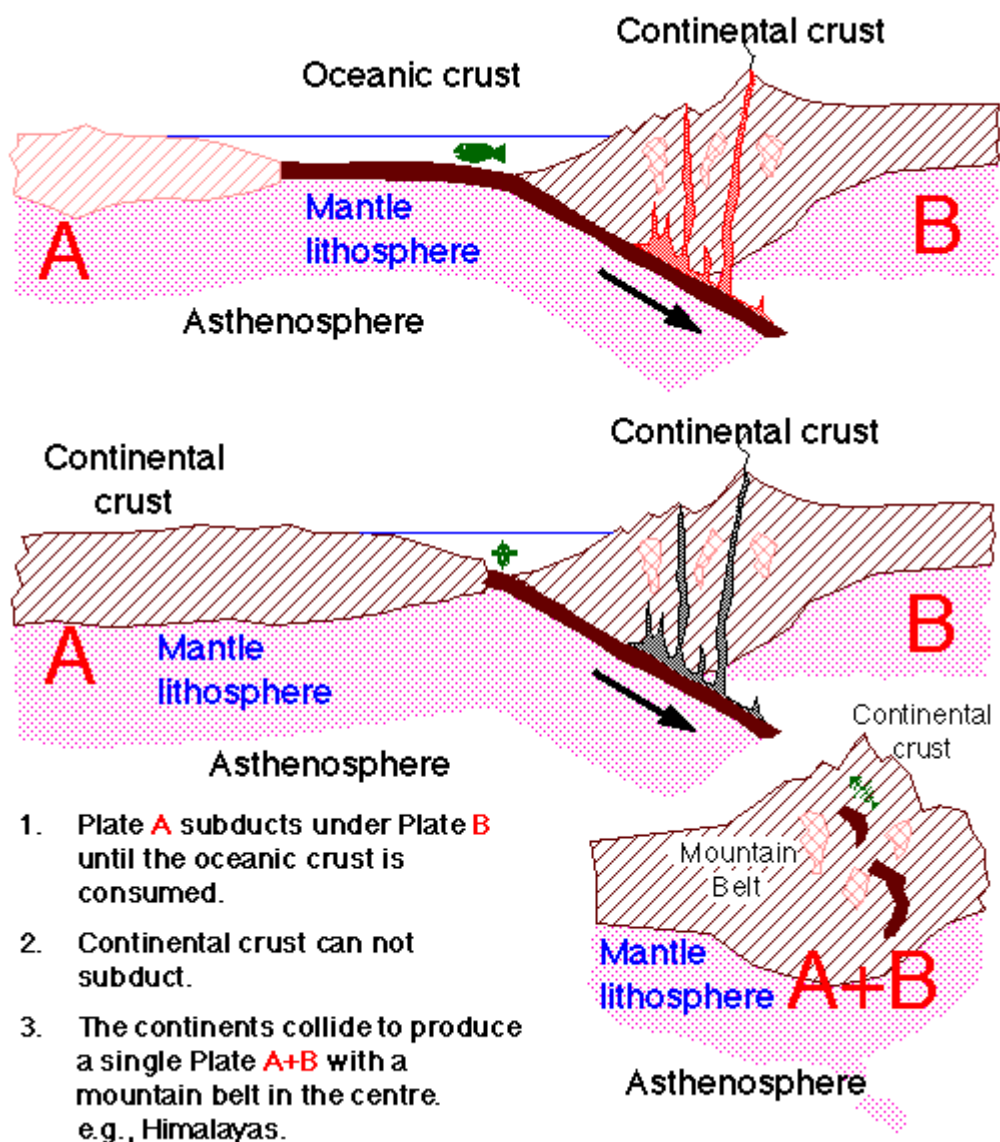
But note...

1. The Oceanic plate ALWAYS subducts below the continental plate.  
Why? Because of the density difference.
2. New felsic crust is added to the continental margin (i.e., the continent grows).
3. A mountain belt is formed at the continental margin.

eg. The Andes of South America.

### Continent-Continent Convergence

What happens if a subducting slab of oceanic crust is attached to a piece of continental crust?

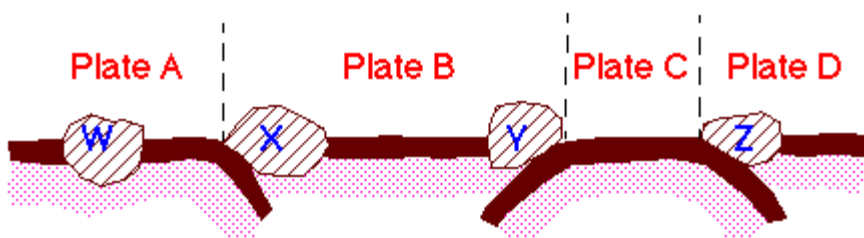


1. Plate A subducts under Plate B until the oceanic crust is consumed.
2. Continental crust can not subduct.
3. The continents collide to produce a single Plate A+B with a mountain belt in the centre. e.g., Himalayas.

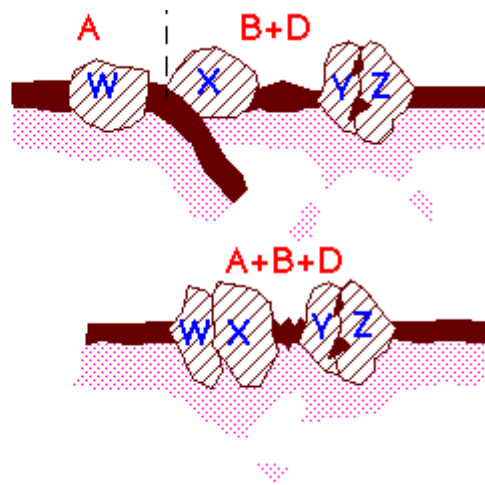
**Processes at Convergent Margins**

1. New continental crust forms above subduction zones. i.e. at ocean-ocean and ocean-continent convergent margins, where oceanic crust is subducted beneath another plate.
2. No new crust is formed at continent-continent convergent margins because there is no subduction.

This process is called ACCRETION. Large continents are formed by collision of smaller continental fragments at continental margins.



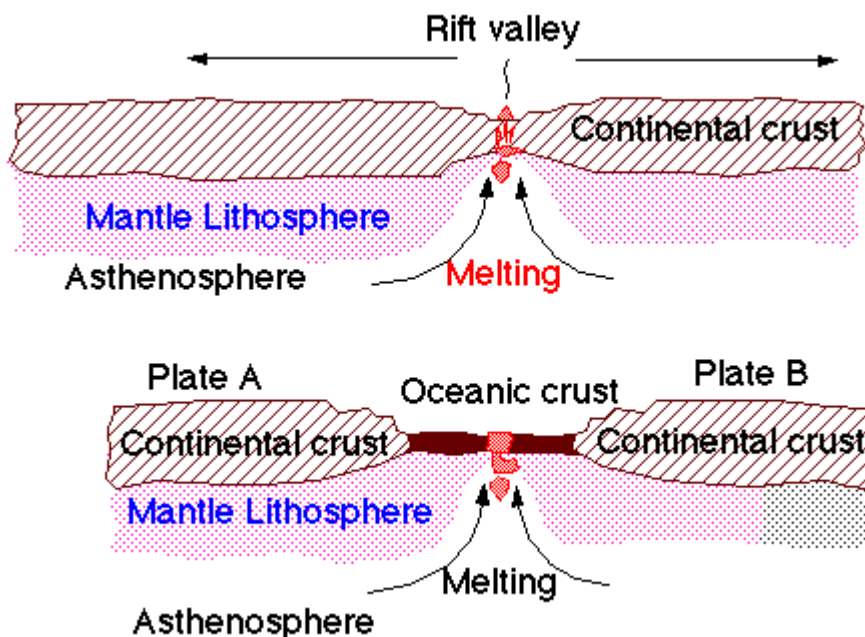
1. Four plates (A B C D) and four continental fragments (W X Y Z).
2. Plate C disappears and Y and Z collide to form a single plate B+D.
3. W collides with X to form a single plate A+B+D.



### Rifting

Accretion at convergent margins means that continents get bigger with time...

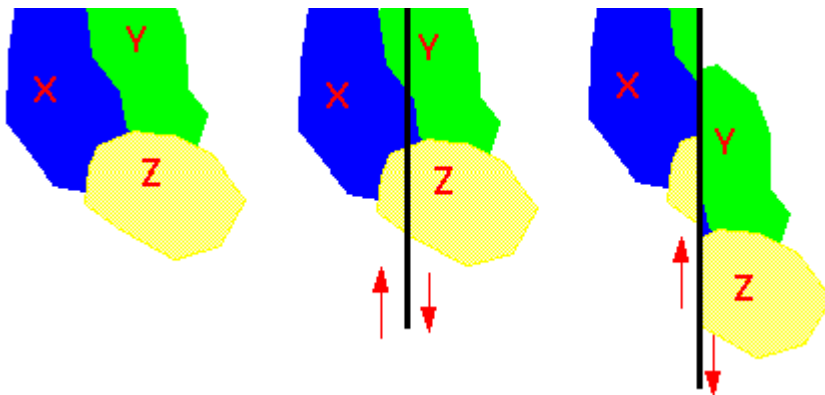
But continents also break up...



1. The continent stretches and thins (extends) to form a rift valley at the surface, and hot asthenosphere rises from below (mantle upwelling) causing volcanism.
2. The continent ruptures and new oceanic crust is formed at an ocean ridge separating two new plates (i.e. a new divergent boundary).
3. Not sure if crustal extension causes mantle upwelling, or the other way around...

### Transform margins

Continental crust is also split and rearranged along transform margins, sometimes called DISPERSION.



An example is the San Andreas Fault..

So the evolution of continental crust is COMPLEX..

It forms above subduction zones, it grows by accretion at convergent margins, and is split and rearranges at rifts and transforms...

This occurs in time cycles.

**Supercontinents**

Continents break up into smaller fragments which then accrete and grow to form SUPERCONTINENTS, which then break up again. This is known as the "Wilson" cycle.

Wilson cycles take anywhere up to 300 million years to complete.

The Earth is about 4,600 million years old.

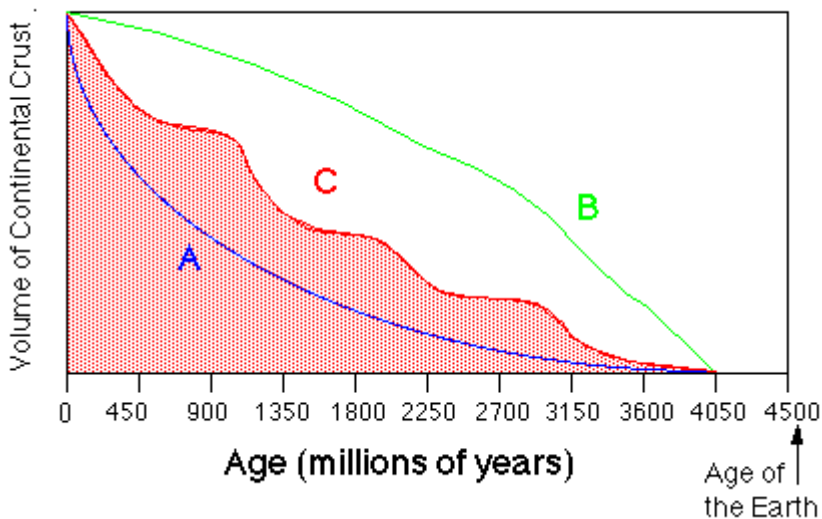
How many cycles may there have been?

NOTE:

Continental crust is NEVER (or almost never) destroyed, as it is not dense enough to subduct.

The volume of continental crust has increased with time.

**Continental Evolution**



Model A: Continental crust forms more rapidly now than it did in the past.

Model B: Continental crust forms more slowly now than it did in the past.

Or the most popular current view:

Model C: Growth rate is now similar to that in the past.

### **The Big Question**

Have the processes of crustal formation, accretion and rifting been the same throughout geological history?

Certainly evidence for plate tectonics back to at least 2500 million years ago...

But records of older times are difficult to interpret, and processes are likely to have been different early on, because the Earth was hotter...

### **Summary:**

1. New continental crust forms at ocean-ocean or ocean-continent convergent margins, where oceanic crust is being subducted.
2. Fragments of continental crust are welded together by collision at continent-continent convergent margins (ACCRETION).
3. Continents split and rearrange at divergent and transform plate boundaries (DISPERSION).
- 4.
5. Continental crust is never destroyed.
6. The volume of continental crust has increased throughout geological time.
7. The processes involved in continental evolution have been similar for much of geological time, but there were probably differences when the first crust formed.
8. Subduction at ocean-continent convergent plate boundaries produces mountains at the continental margin.
9. Continental collision and welding at continent-continent convergent plate boundaries produces mountains in the middle of continents.

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