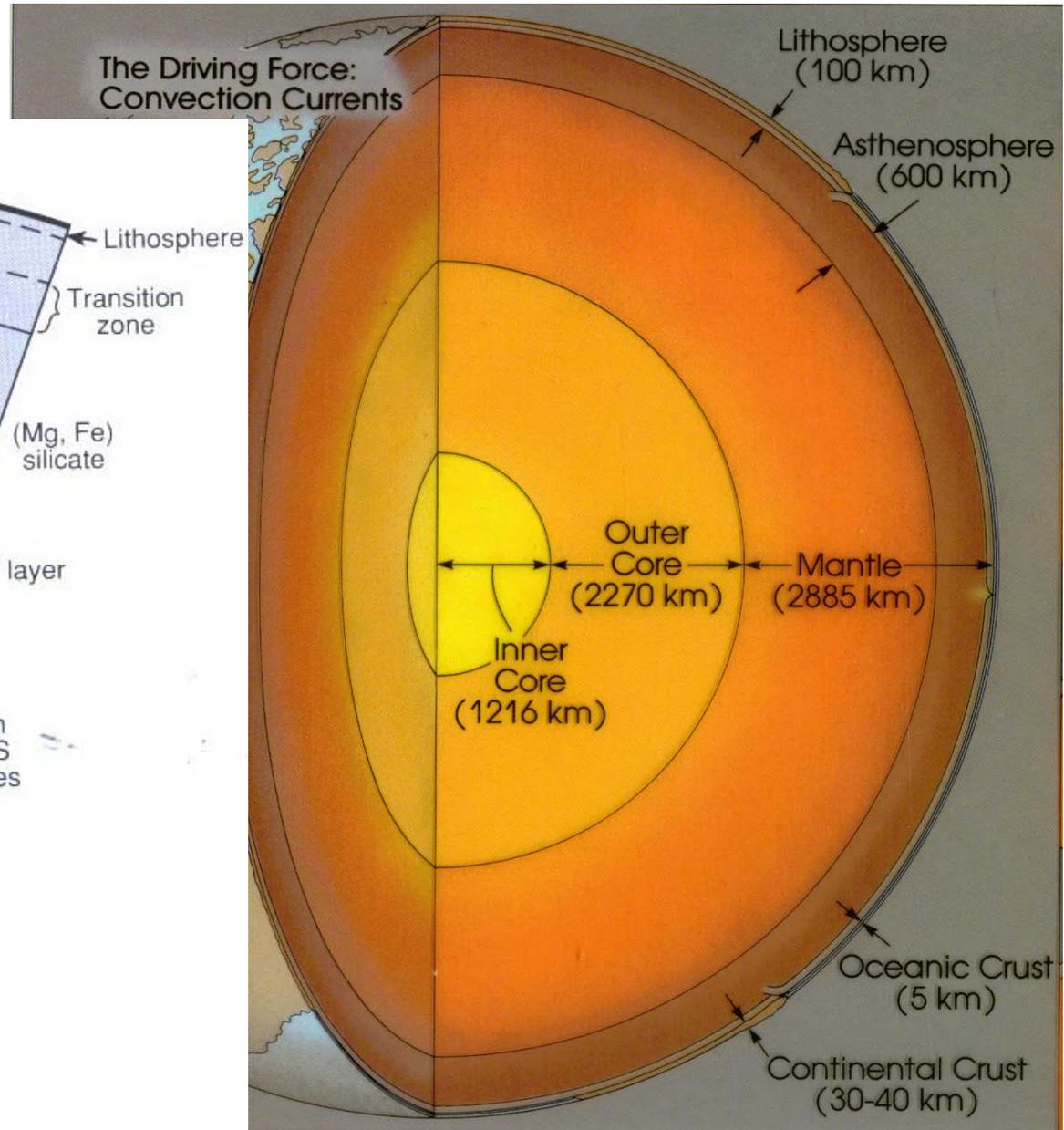
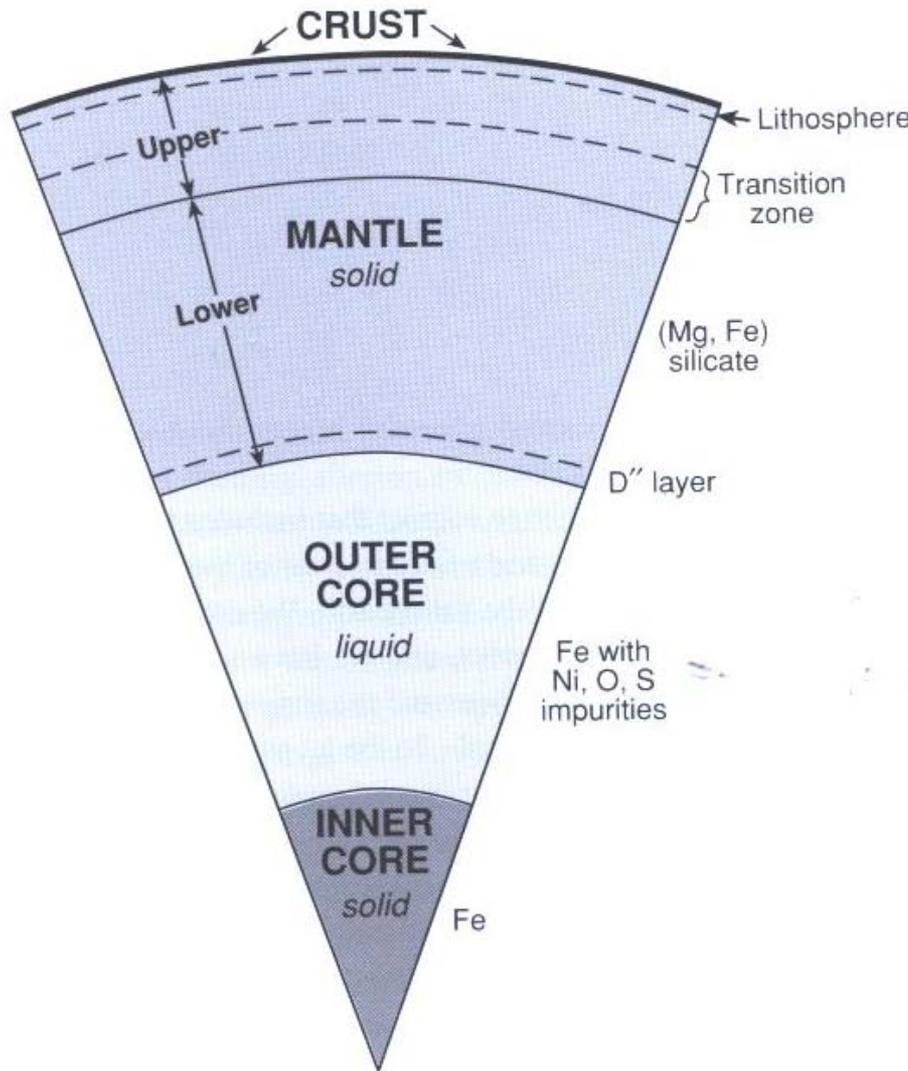
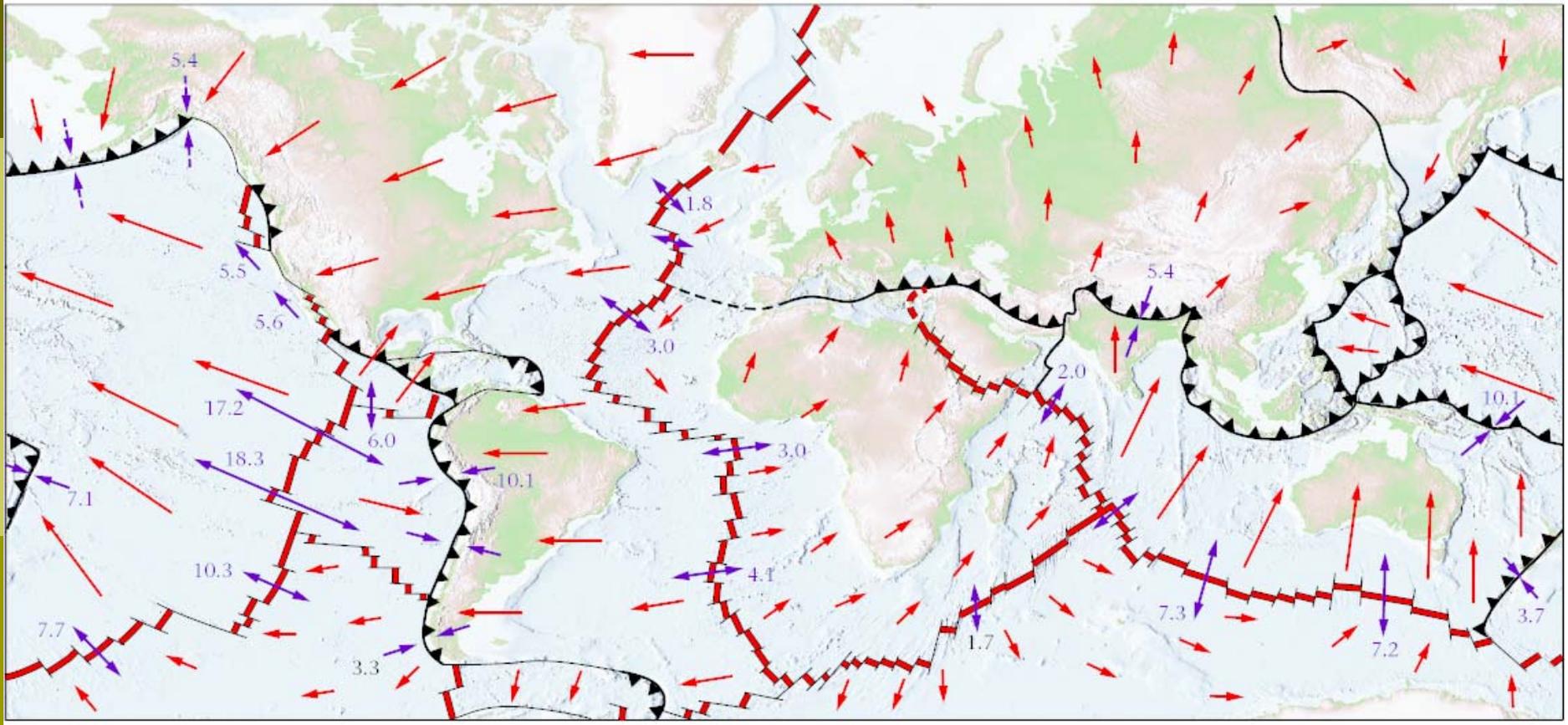


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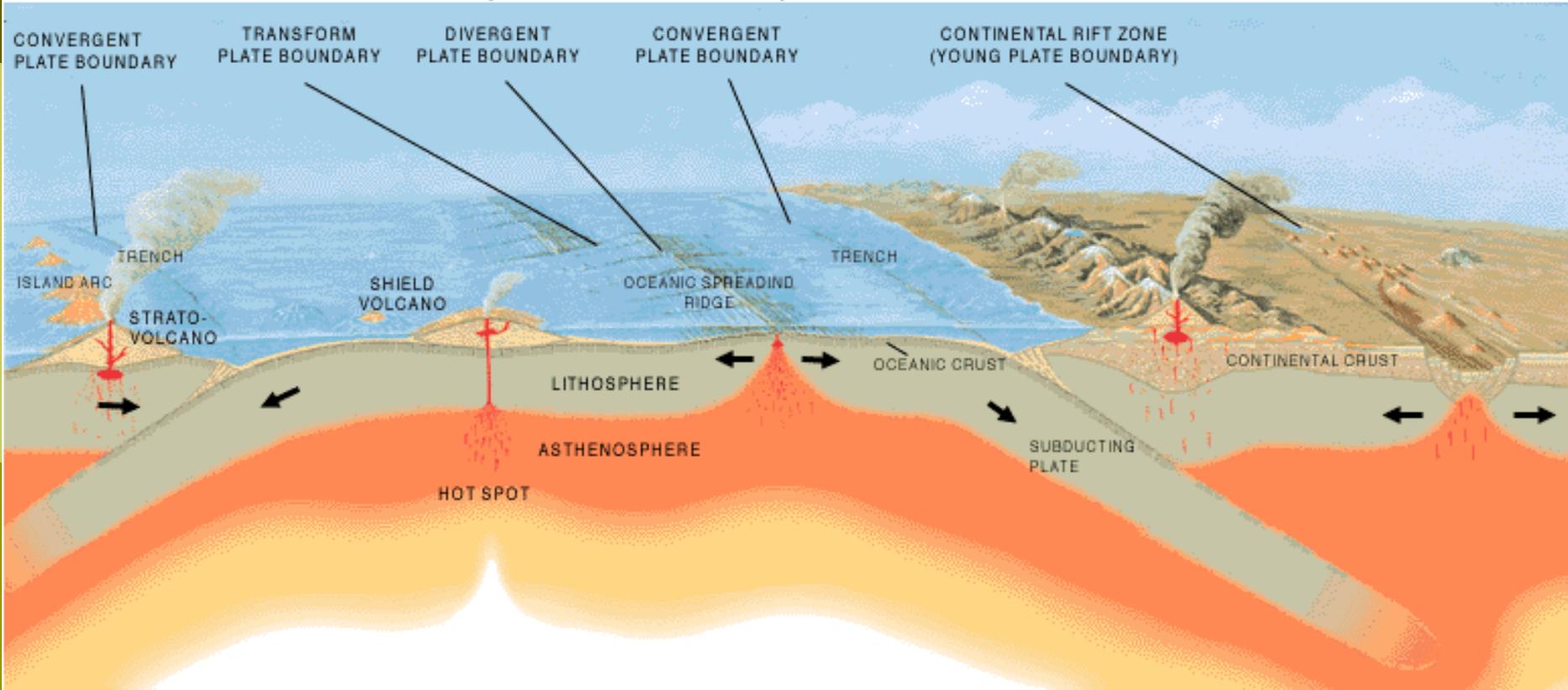
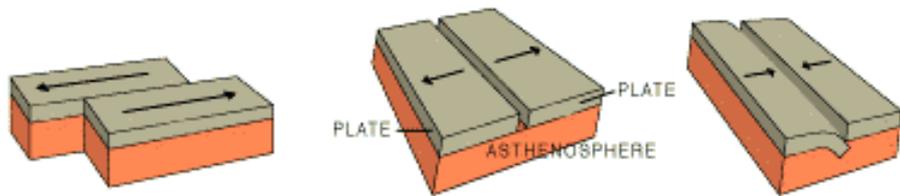
# The Plate Tectonics and Seismicity

# The Earth's Layers

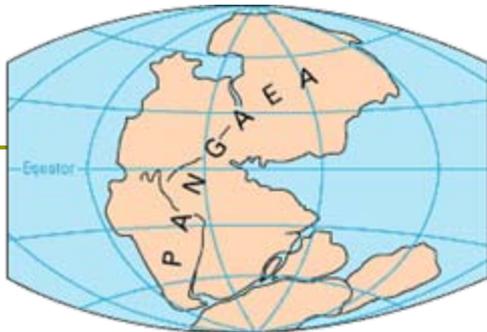




Convergent boundary    
  Ridge    
  Transform    
  Absolute plate motions    
  Relative plate motions (5.5 cm per year)



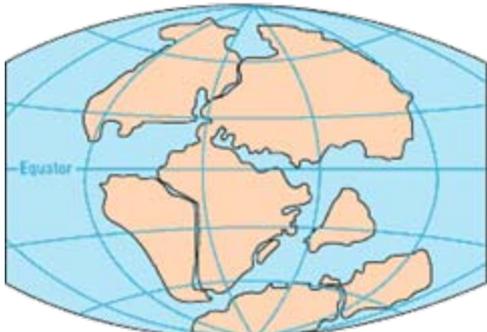
A cross section illustrating the main types of plate boundaries. Illustration by Jose F. Vigil from *This Dynamic Planet* -- a wall map produced jointly by the U.S. Geological Survey, the Smithsonian Institution, and the U.S. Naval Research Laboratory



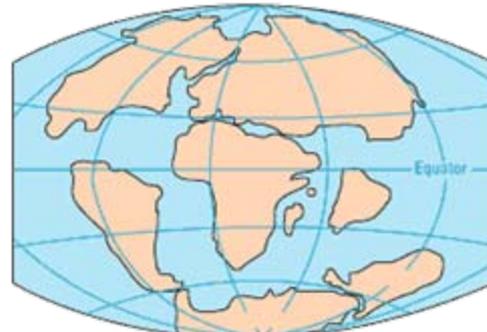
PERMIAN  
225 million years ago



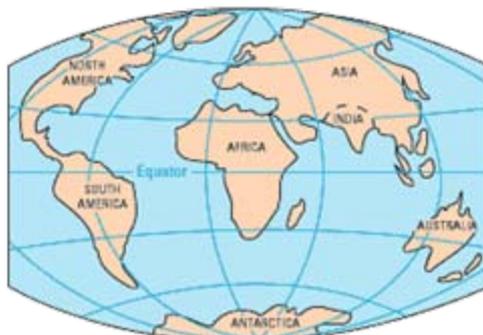
TRIASSIC  
200 million years ago



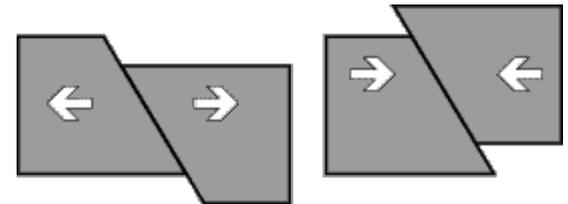
JURASSIC  
135 million years ago



CRETACEOUS  
65 million years ago

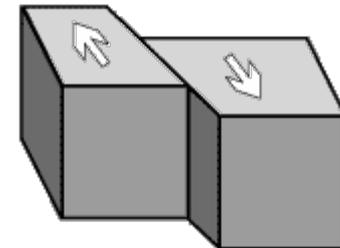


PRESENT DAY



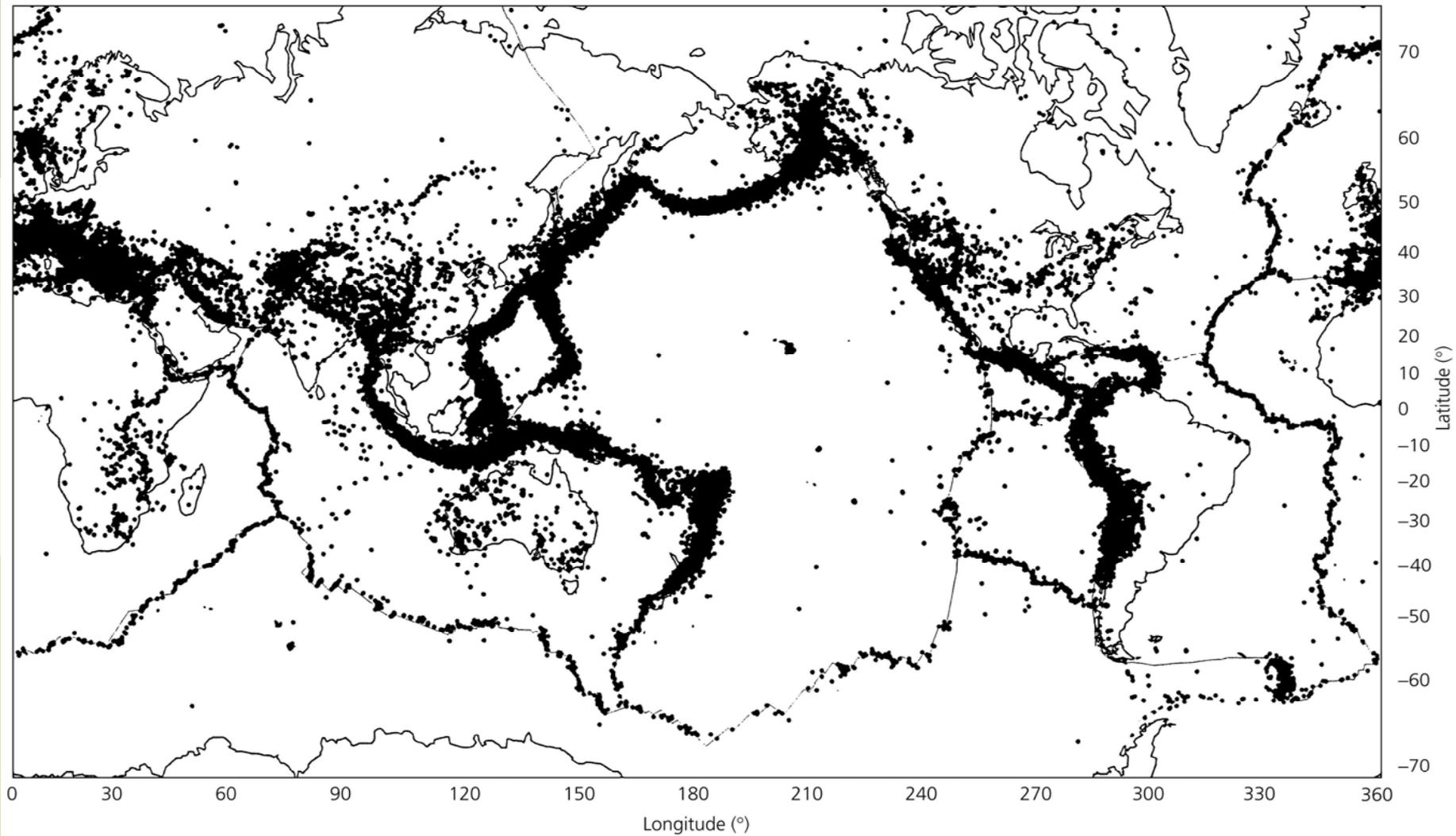
*Extensional*

*Compressional*



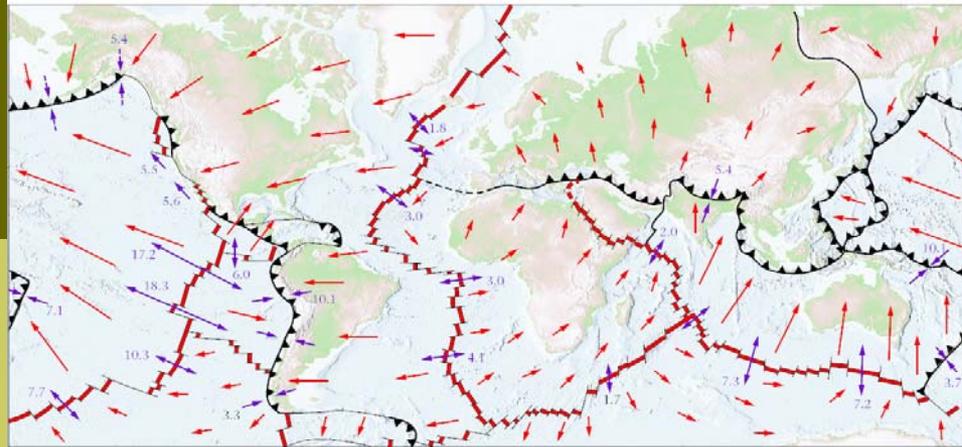
*Transform*

**Figure 1.2-1: Global seismicity, 1963-1995.**

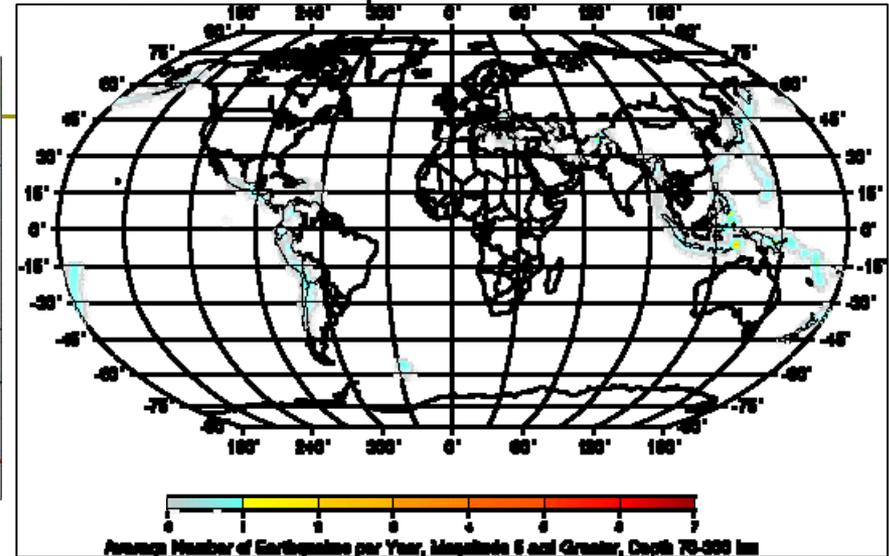




### 70 - 300 km deep

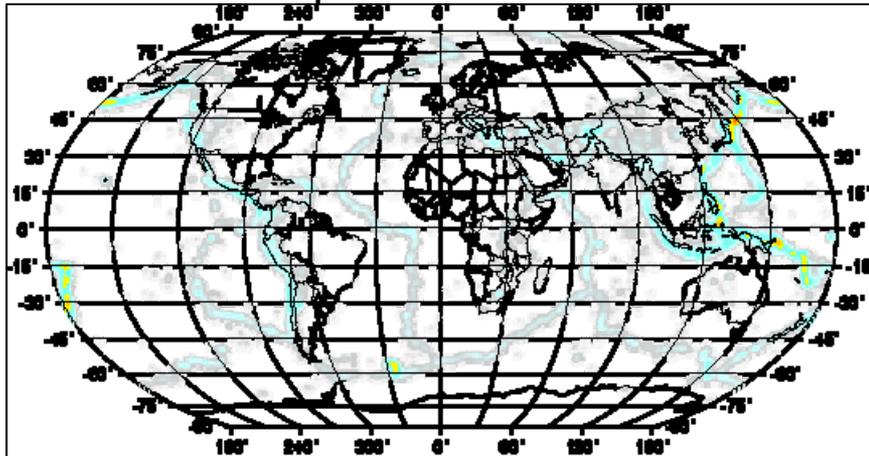


▲▲▲ Convergent boundary    - - - Ridge    — Transform    → Absolute plate motions    ← Relative plate motions (5.5 cm per year)



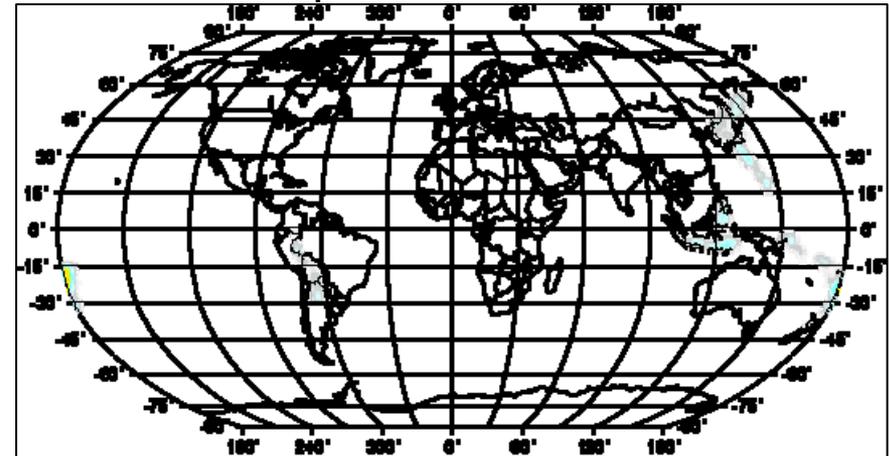
Average Number of Earthquakes per Year, Magnitude 5 and Greater, Depth 70-300 km

### 0 - 70 km deep



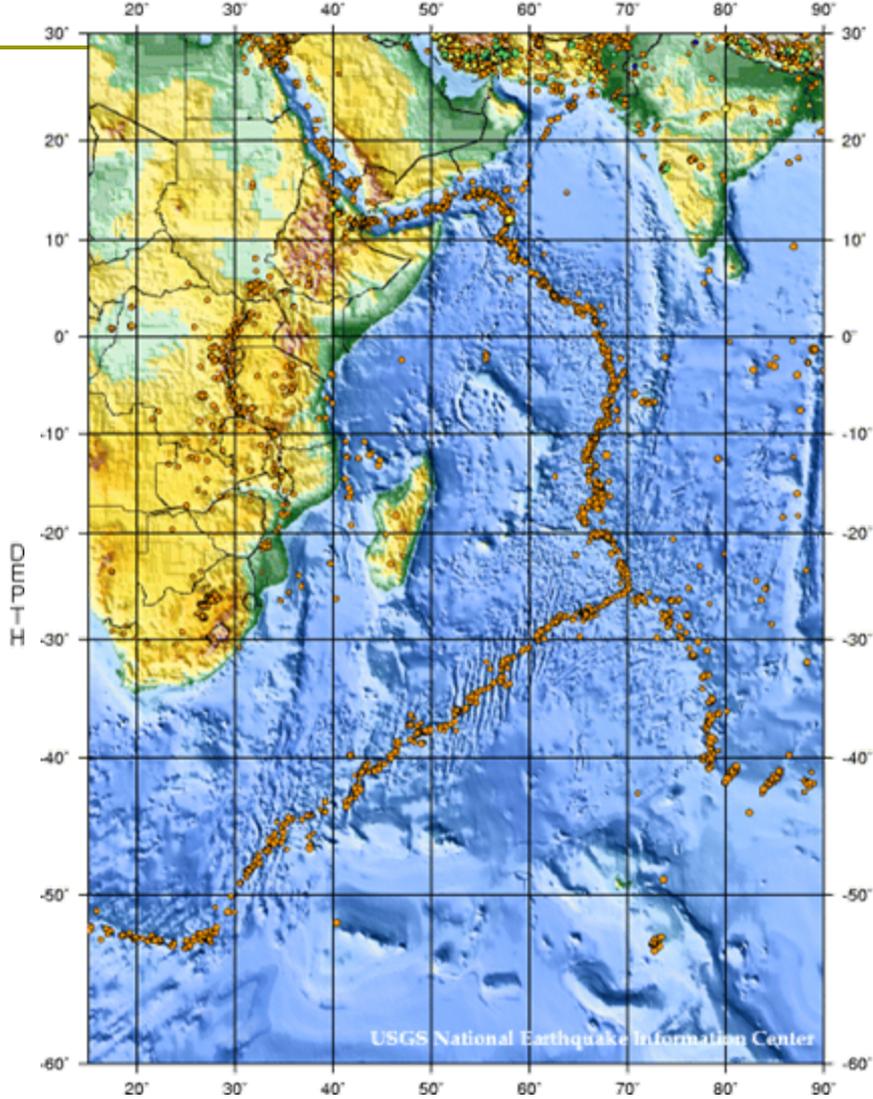
Average Number of Earthquakes Per Year, Magnitude 5 and Greater, Depth 0-70 km

### 300 + km deep

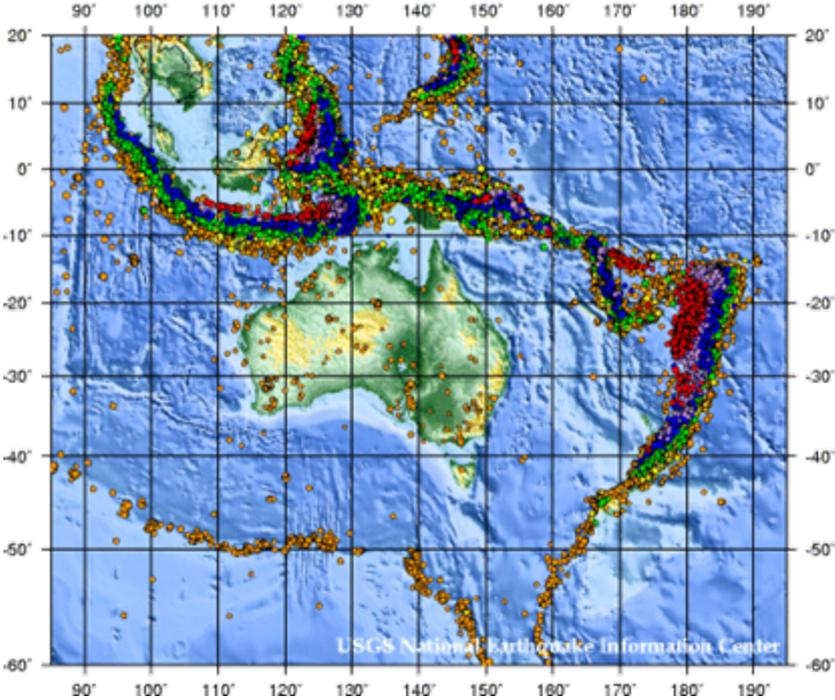


Average Number of Earthquakes per Year, Magnitude 5 and Greater, Depth 300 km and greater

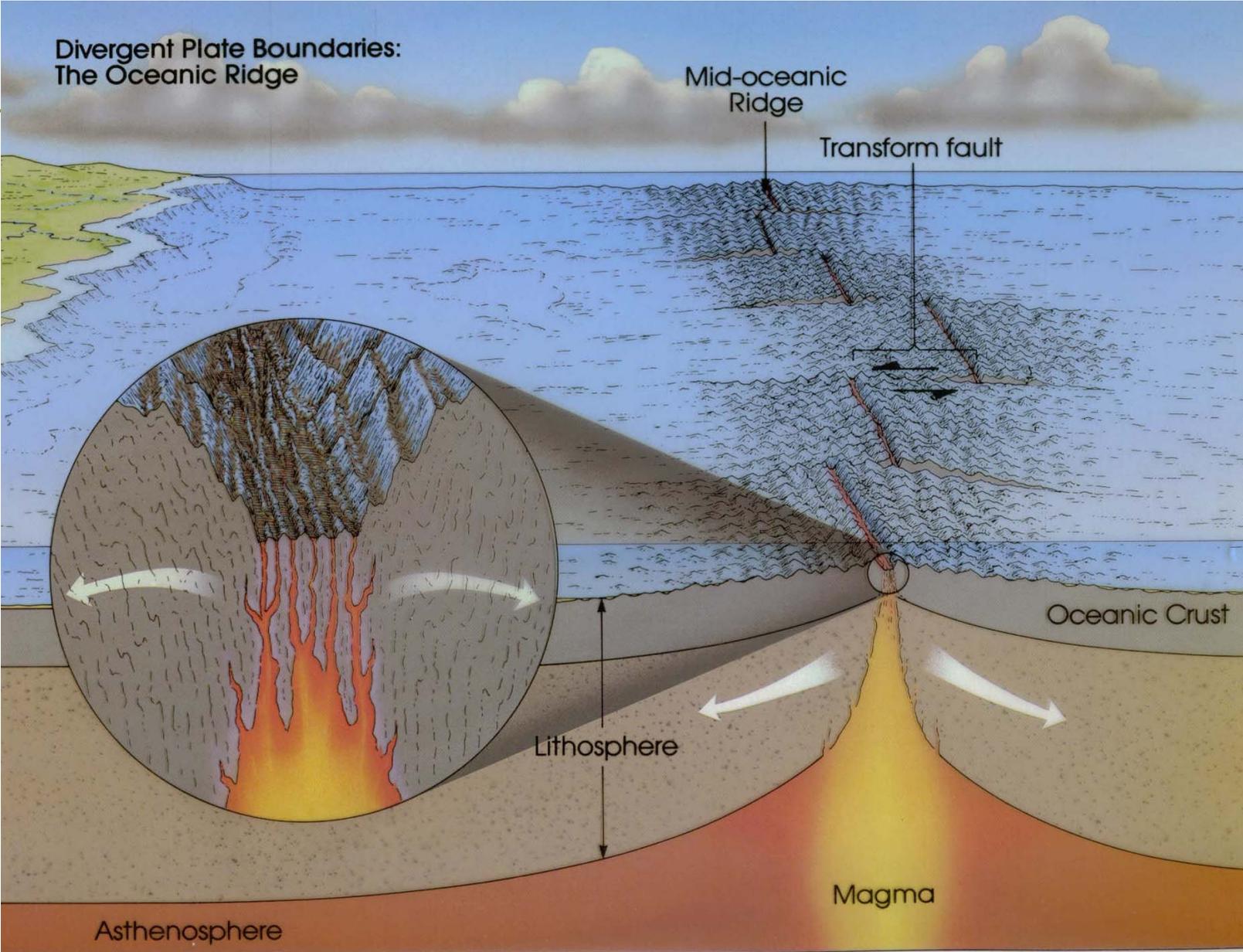
Seismicity of the Indian Ocean: 1990 - 2000

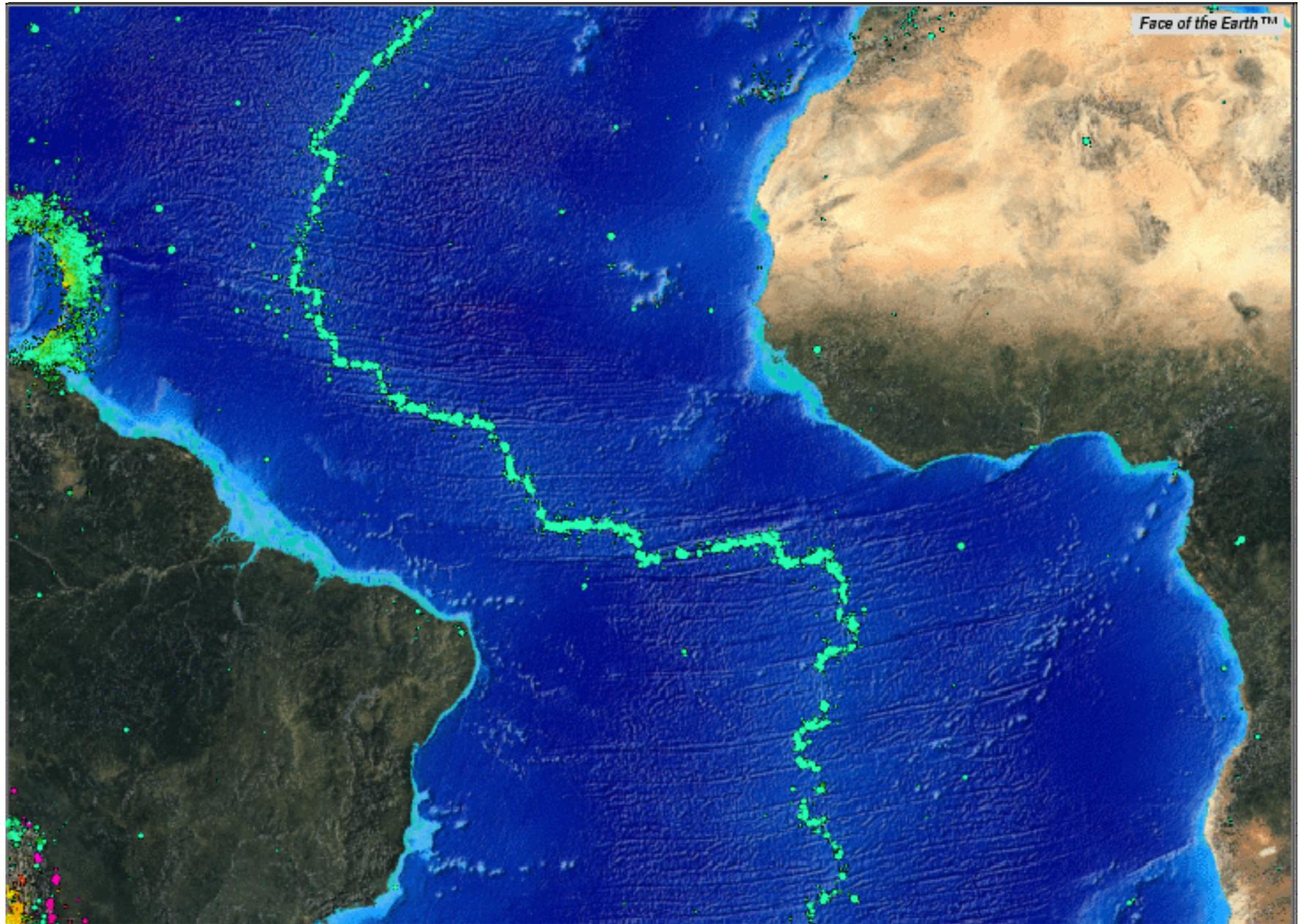


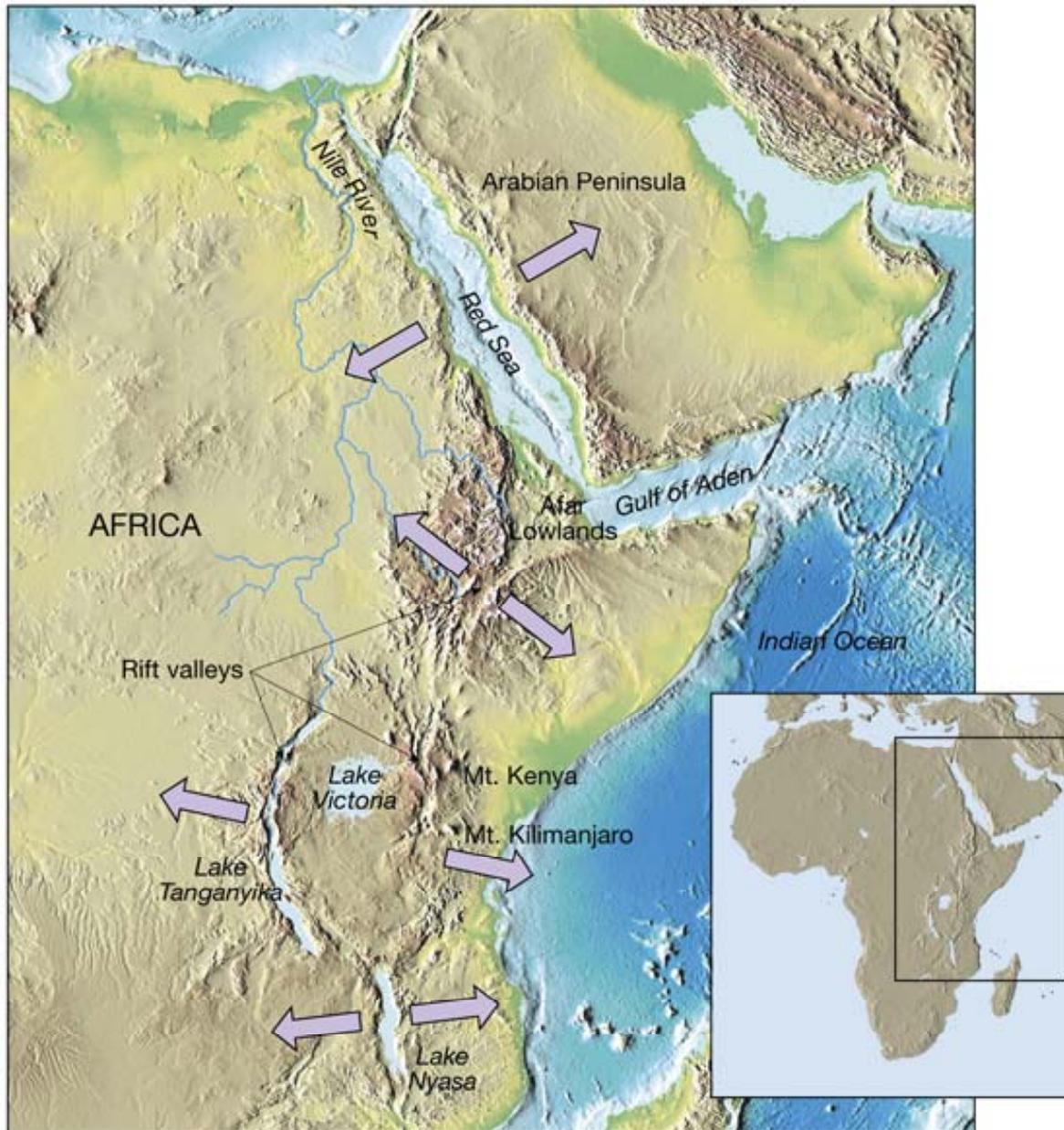
Seismicity of Australia, Indonesia and New Zealand: 1990 - 2000



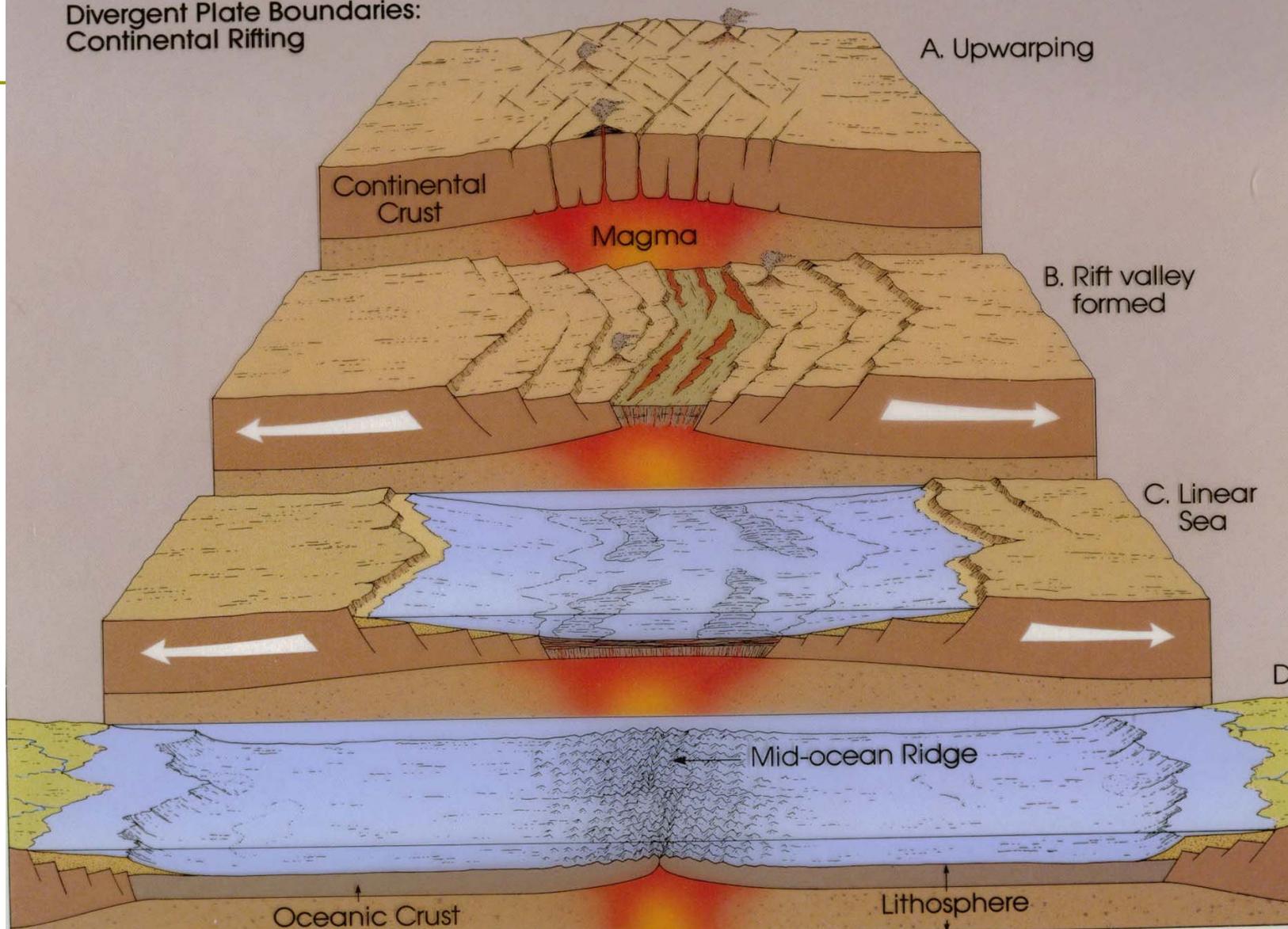
Divergent Plate Boundaries:  
The Oceanic Ridge



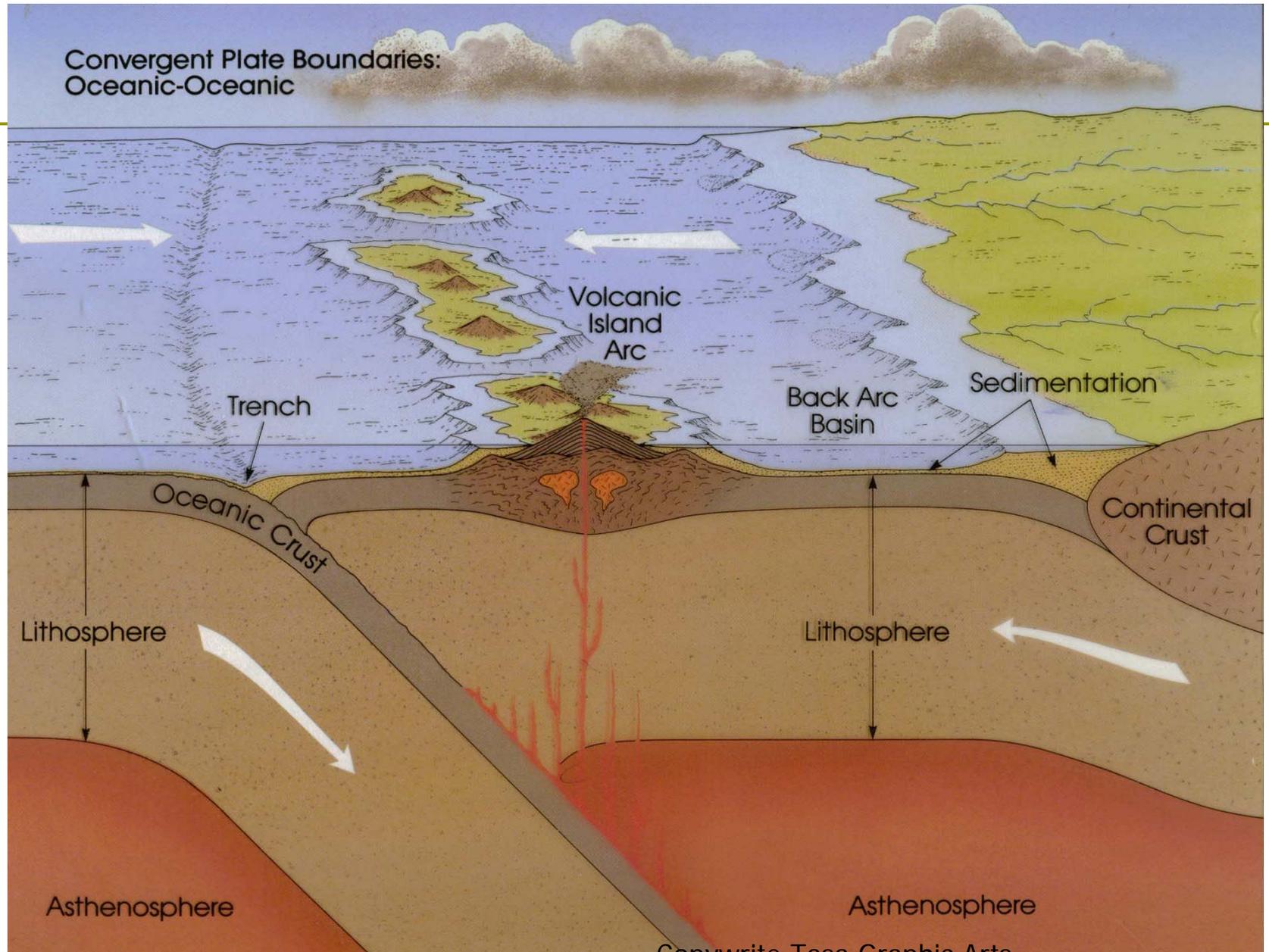




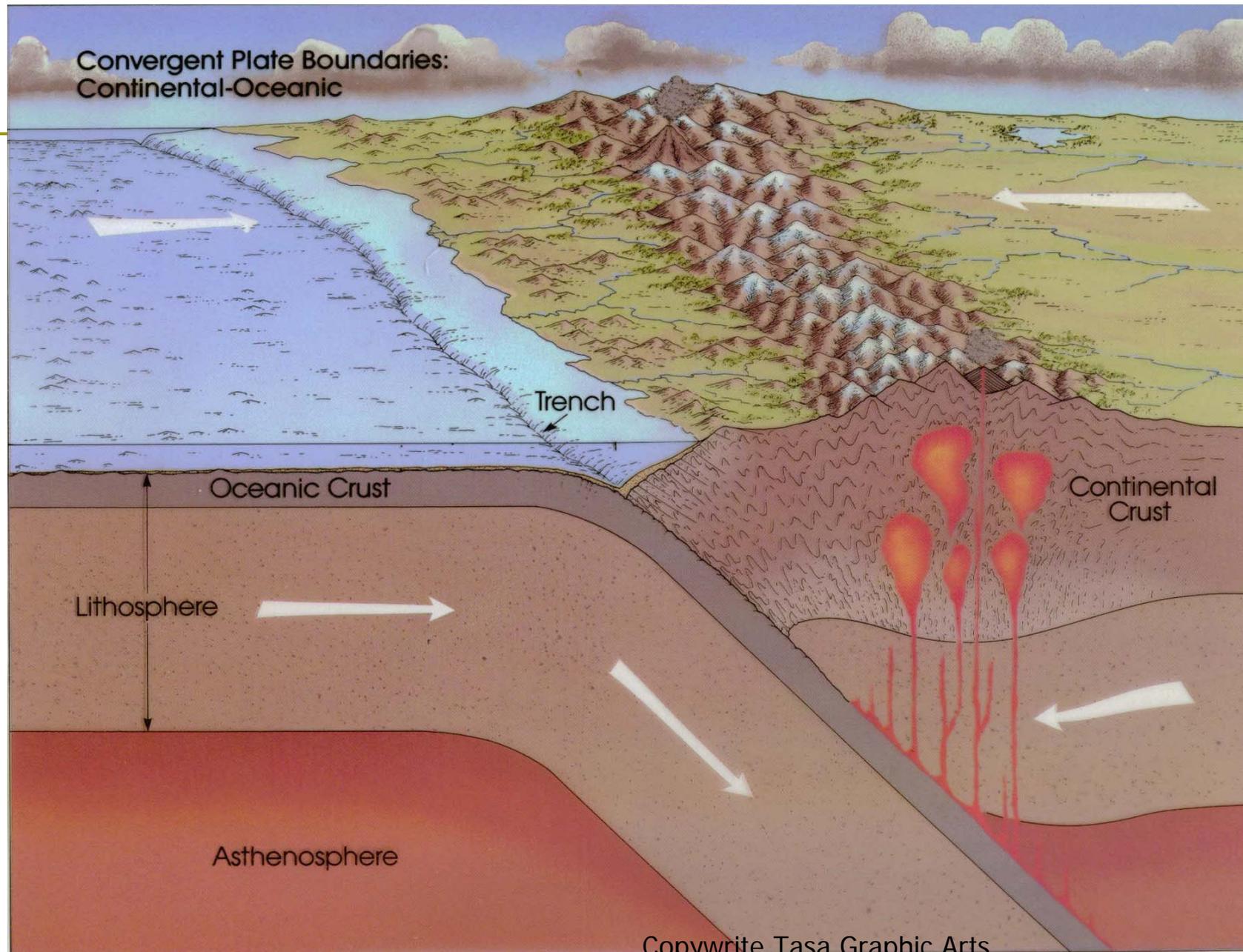
Divergent Plate Boundaries:  
Continental Rifting

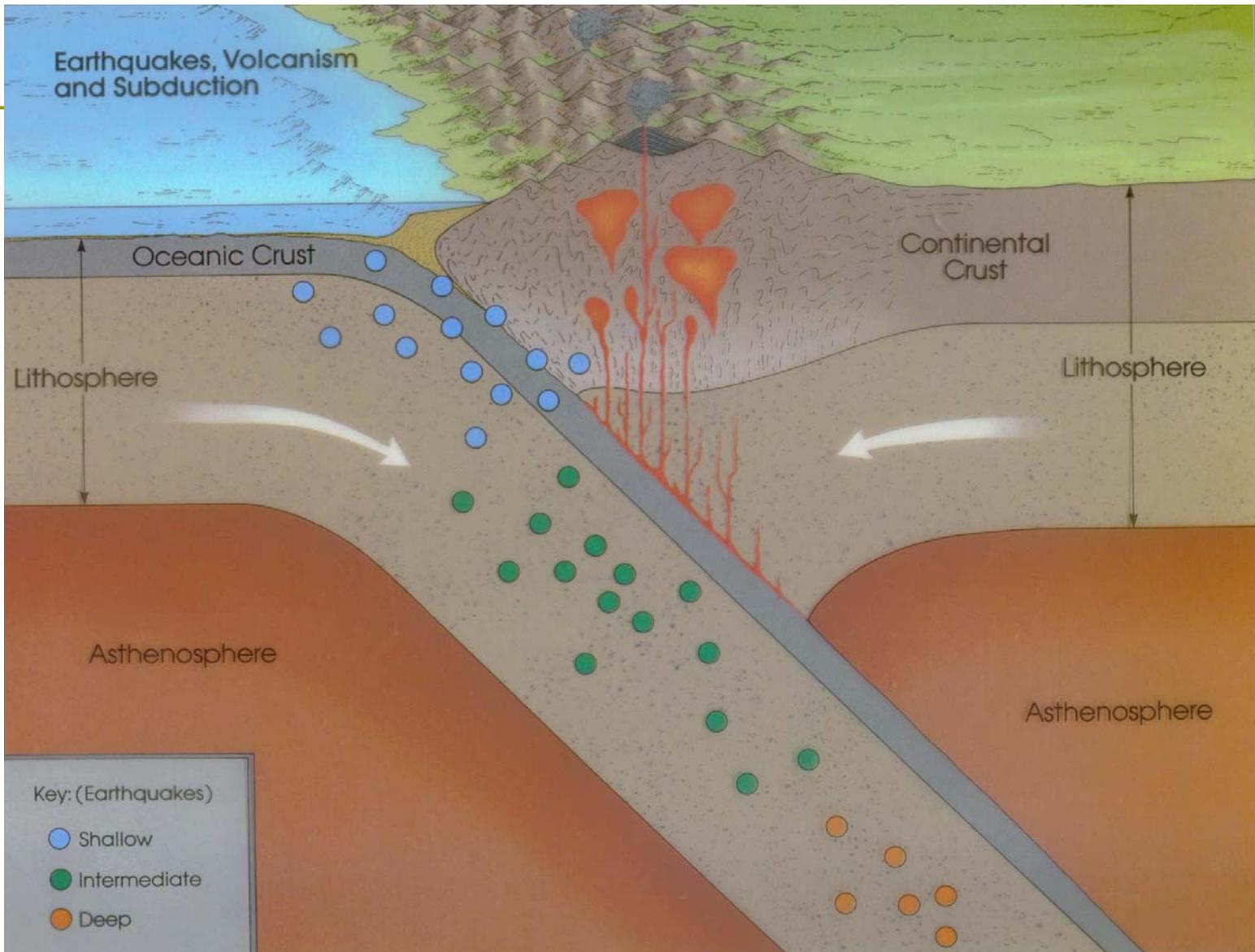


Convergent Plate Boundaries:  
Oceanic-Oceanic



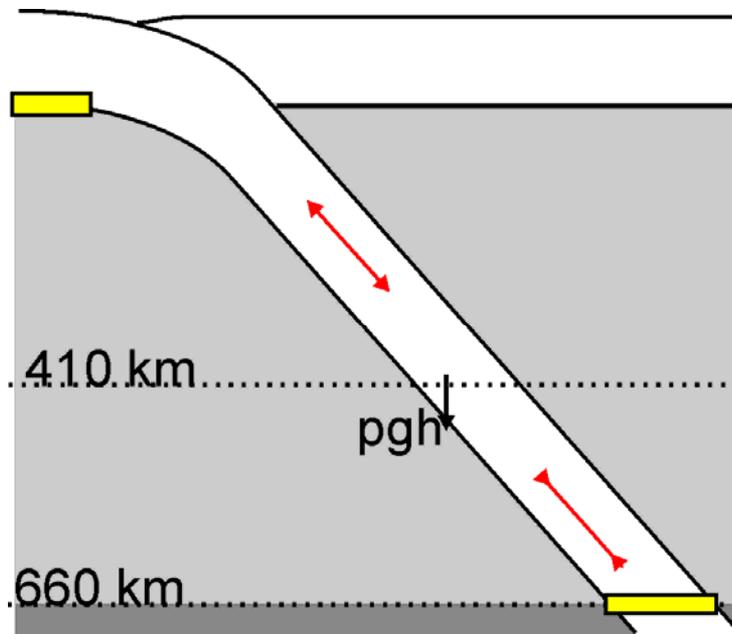
# Convergent Plate Boundaries: Continental-Oceanic



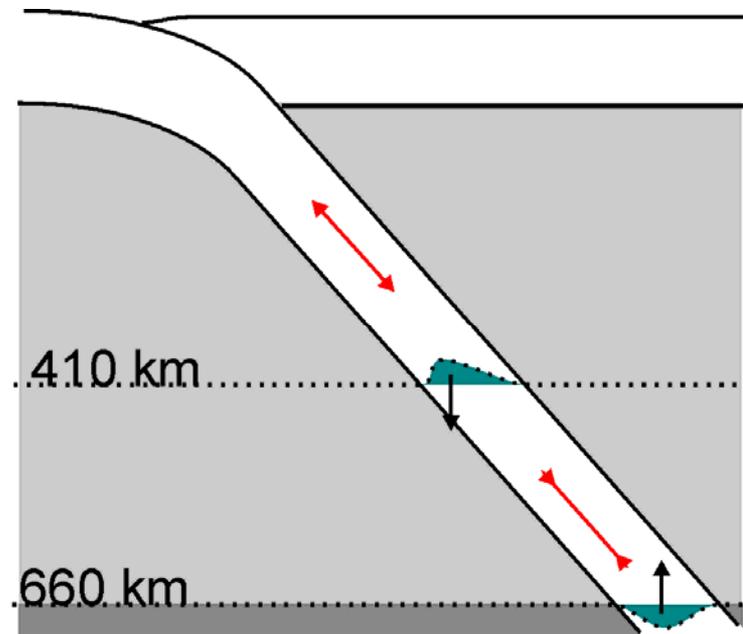


# Causes of intermediate and deep earthquakes

Body forces, with increased resistance caused by lower mantle density increase

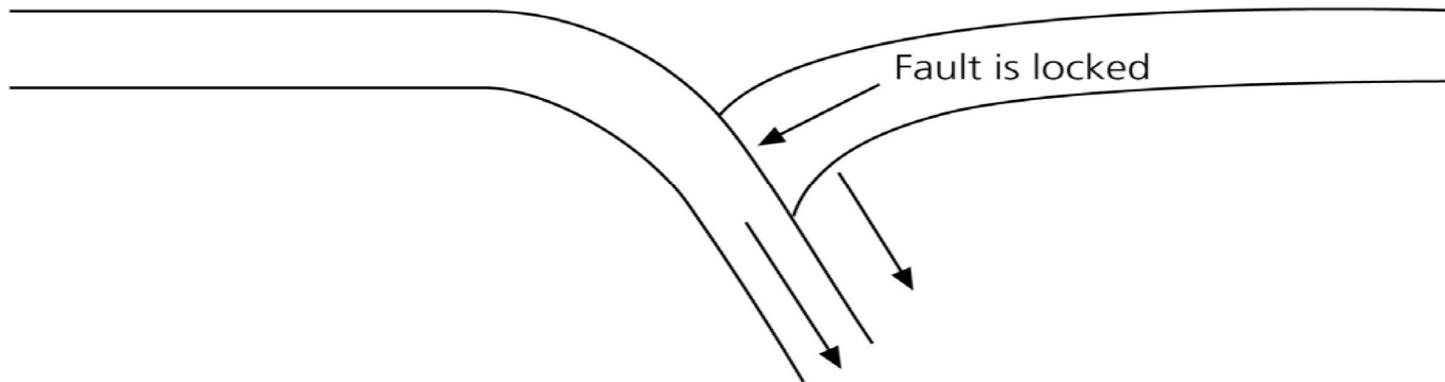


variation in negative buoyancy caused by altered depth of phase transitions

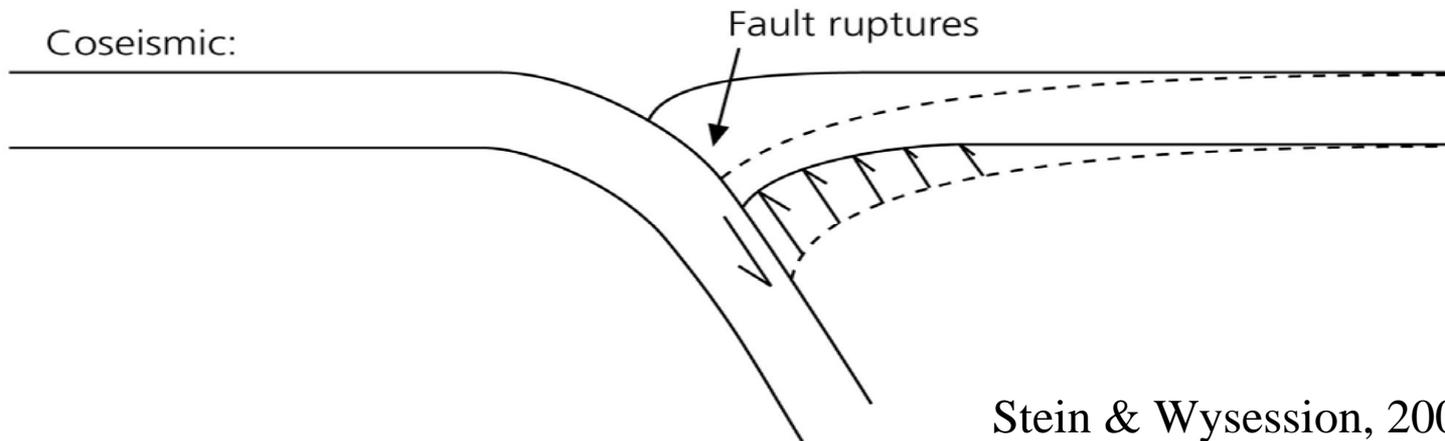


# Cause of shallow thrust earthquakes

Interseismic:

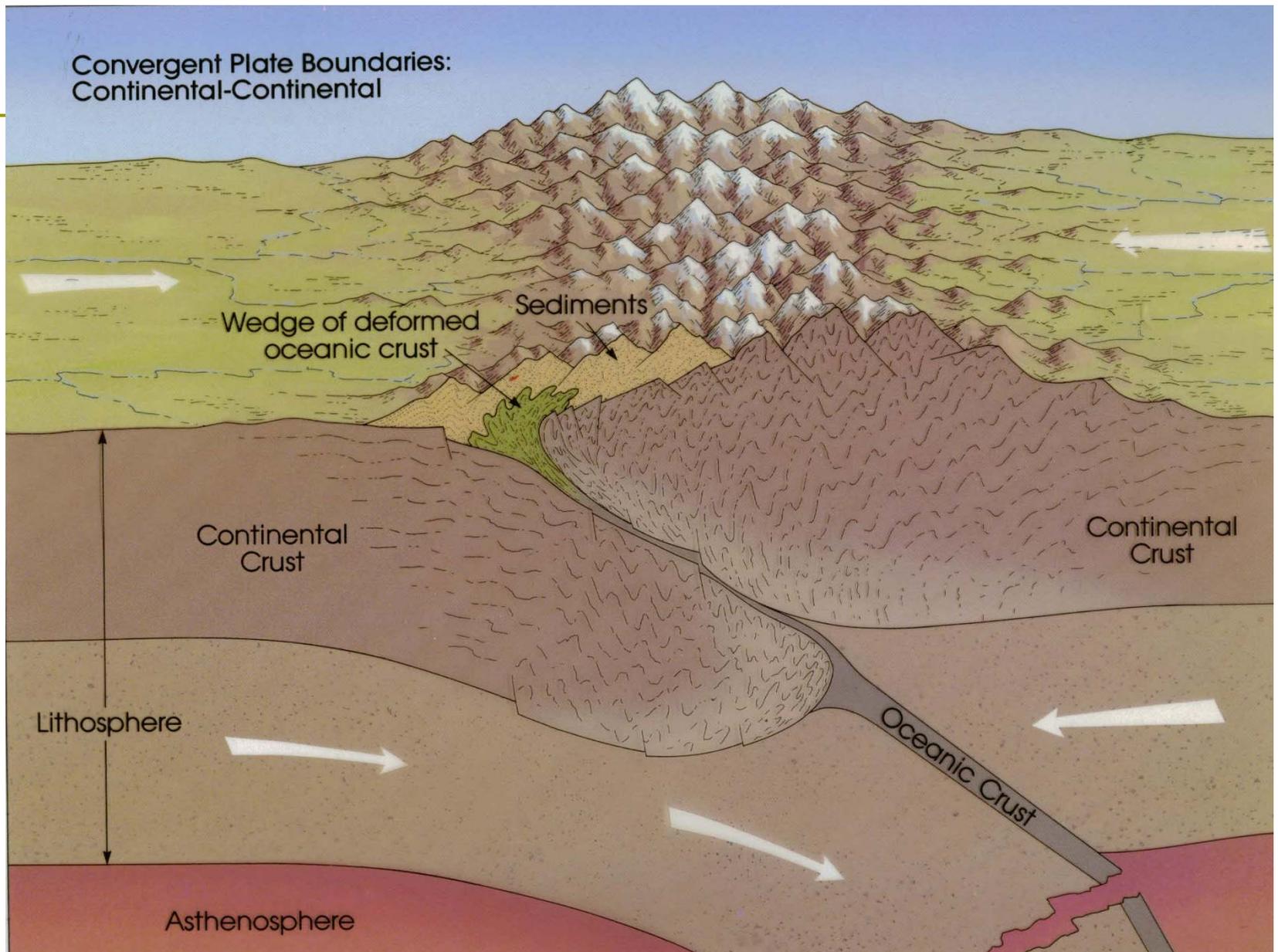


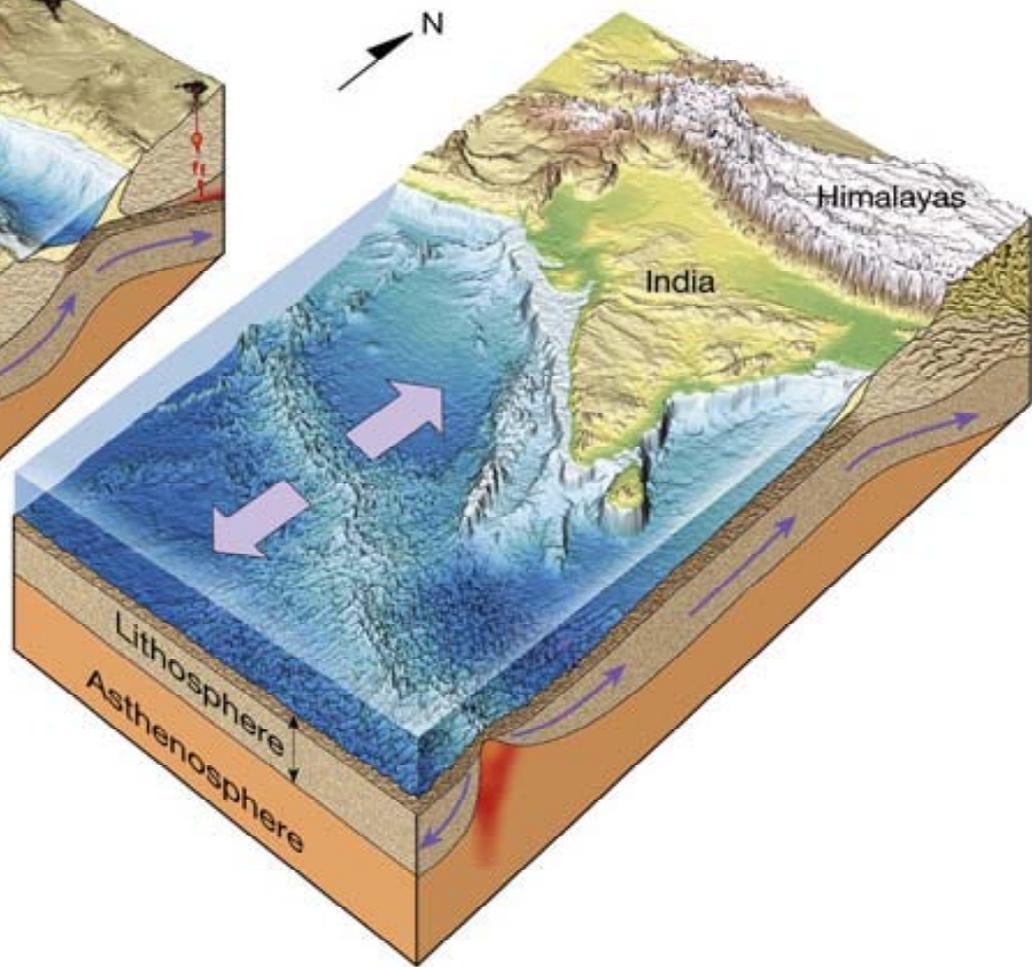
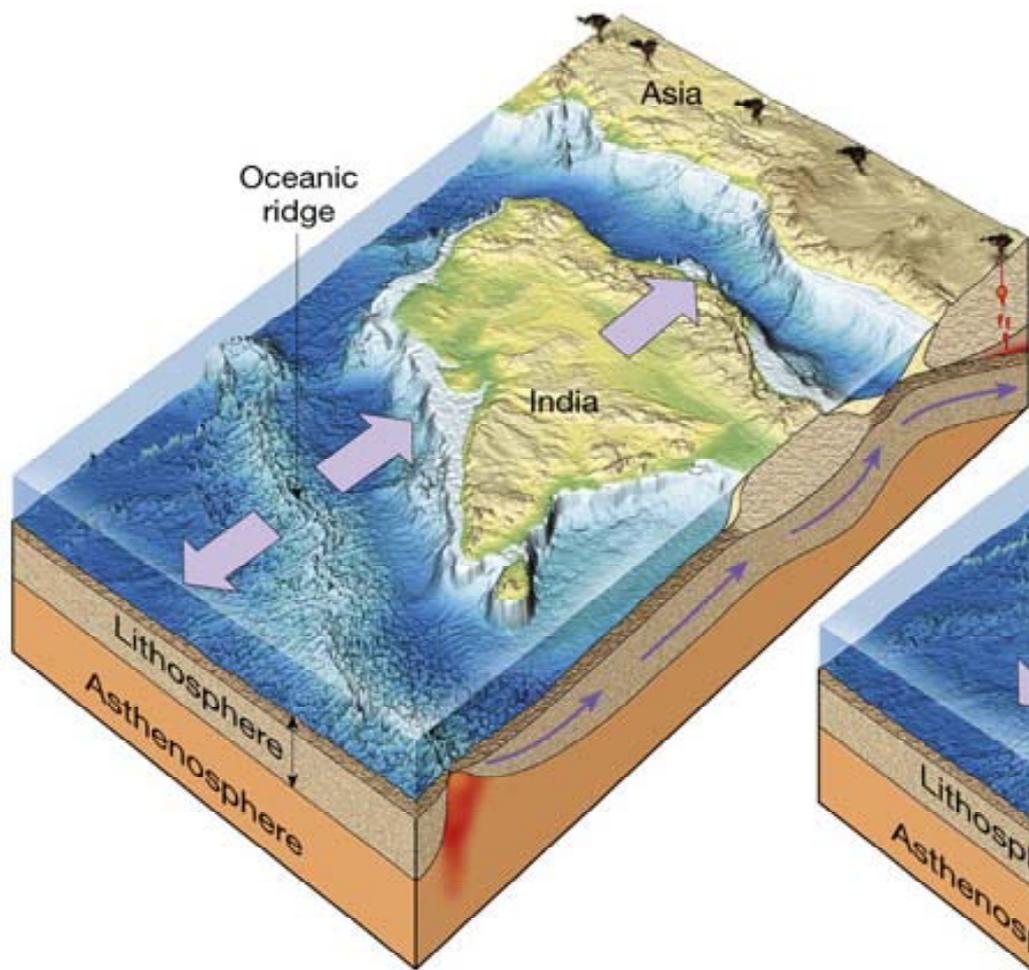
Coseismic:



Stein & Wysession, 2003

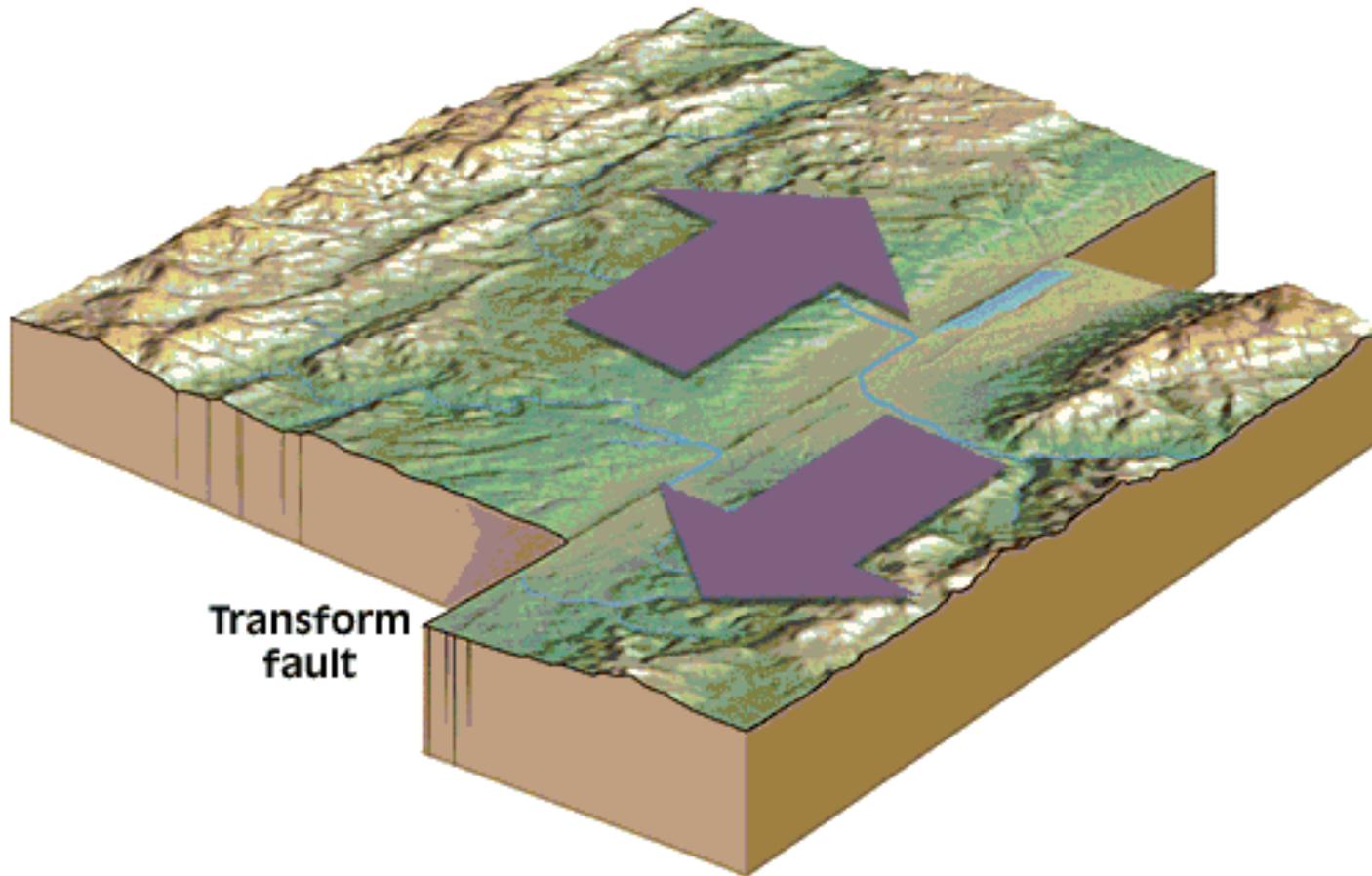
# Convergent Plate Boundaries: Continental-Continental

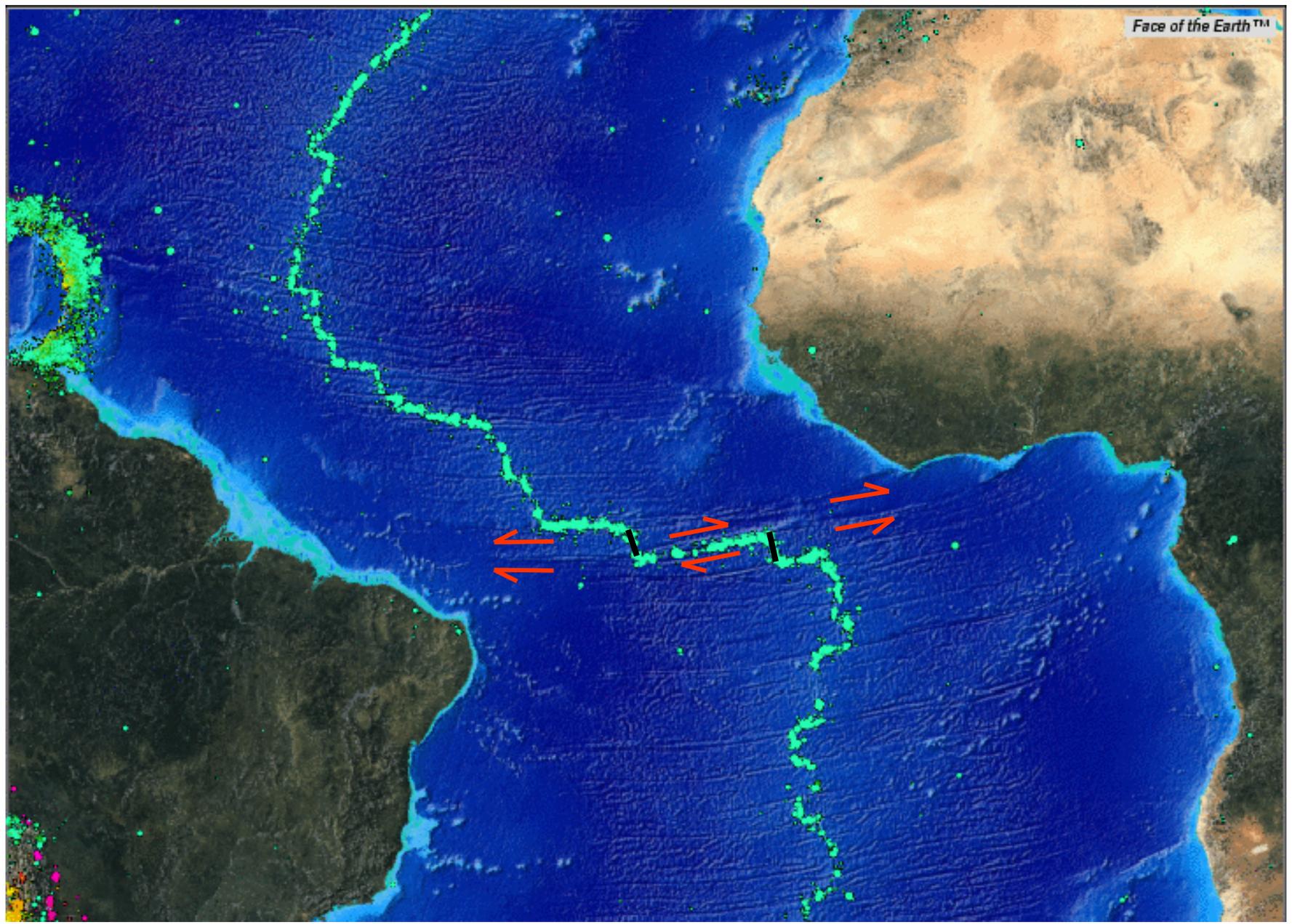




# Transform boundaries

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# *The San Andreas Fault System is a Major Transform Fault*



# South East Asia

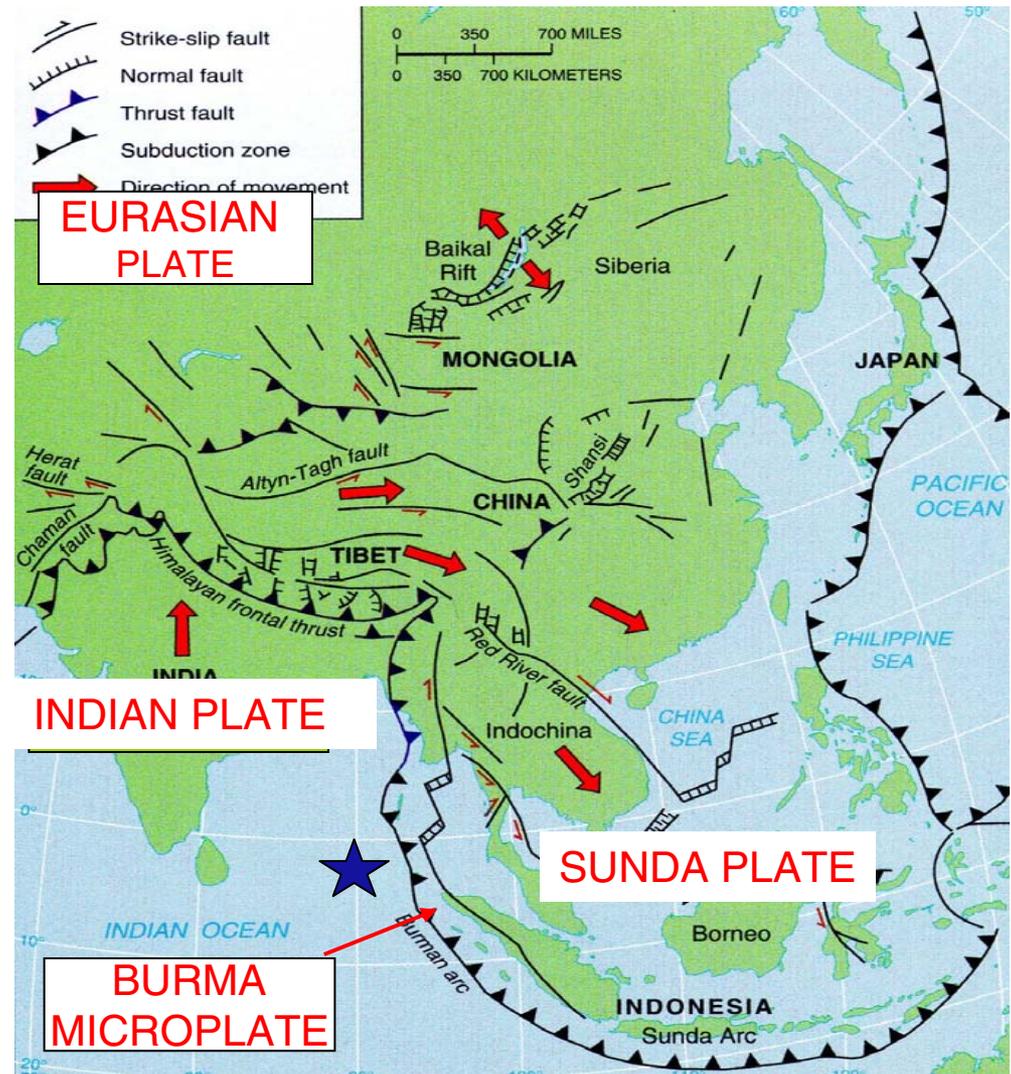
## COMPLEX PLATE BOUNDARY ZONE

Northward motion of  
India deforms the  
region

Eastward motion in  
China & SE Asia

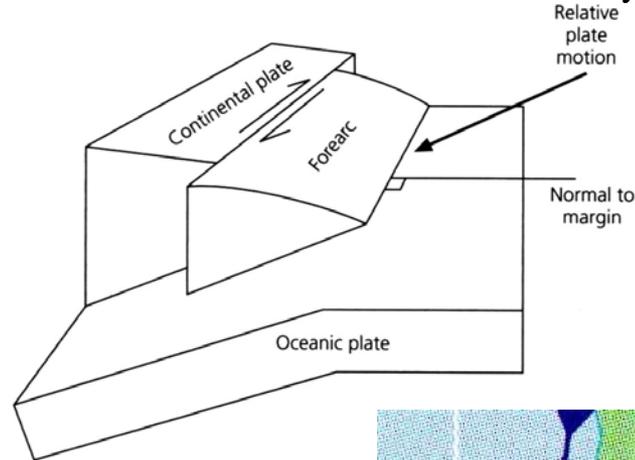
Many small plates  
(microplates) and  
blocks

India subducts beneath  
Burma microplate



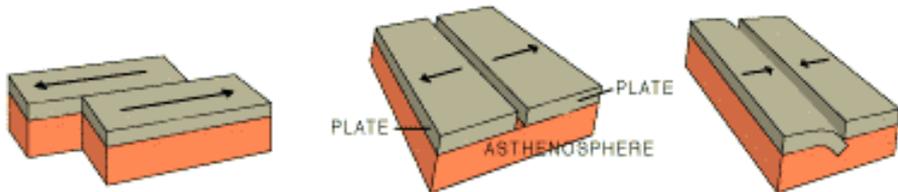
Molnar & Tapponnier,

Stein & Wysession 2003

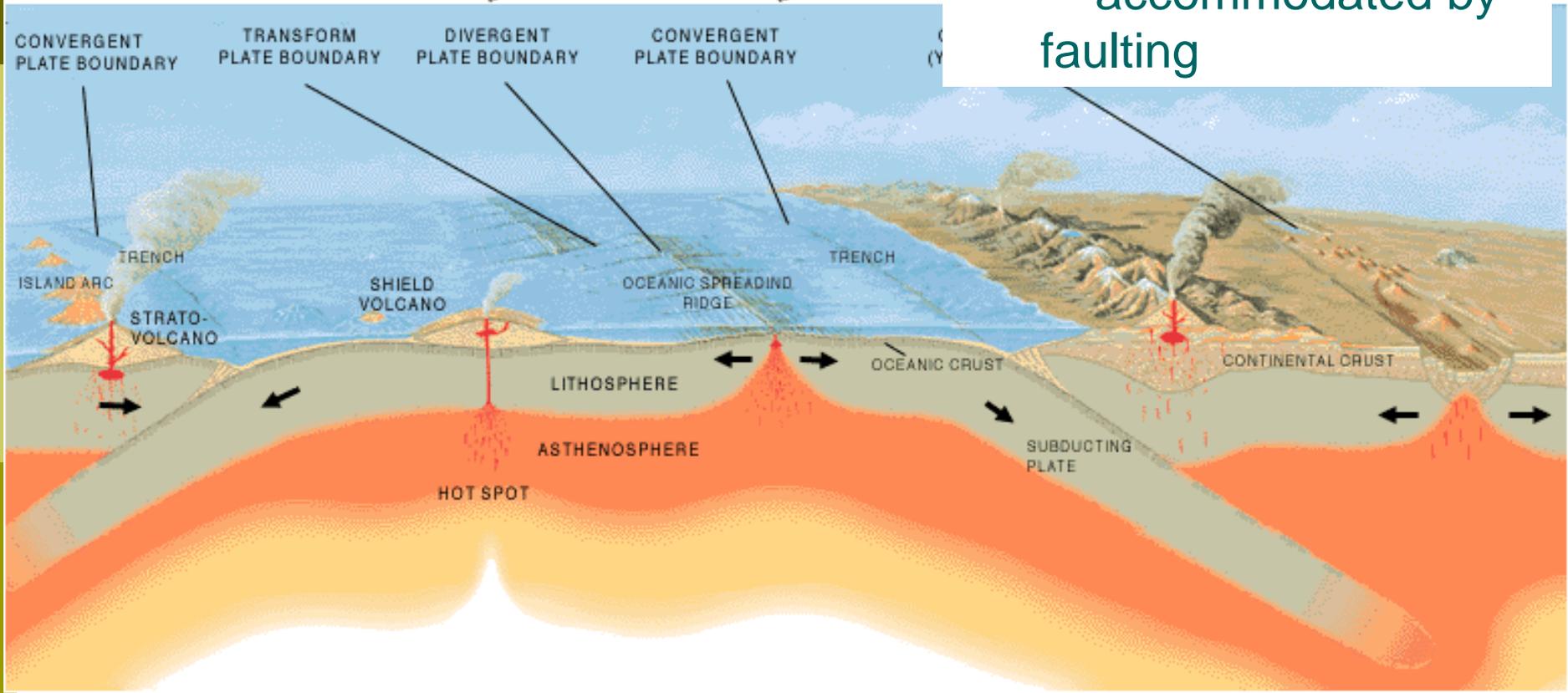


Partitioning of strain between thrust motion at the trench and strike-slip motion on the Sumatra fault

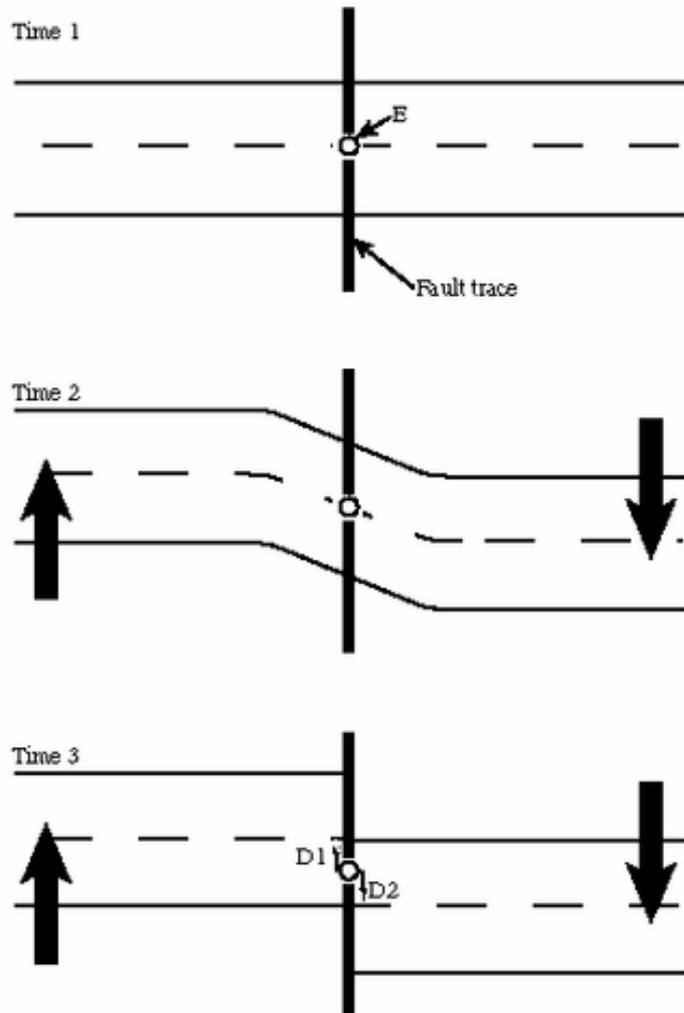




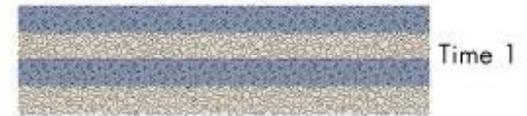
Regions of compression,  
tension and shearing  
stresses  
– accommodated by  
faulting



# The relationship between faults and earthquakes – Elastic Rebound Theory



No strain and  
no displacement



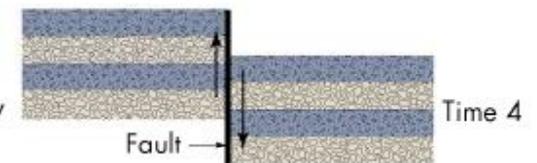
Elastic strain  
begins (rocks  
begin to bend)



Elastic strain  
accumulates  
(rocks bend)

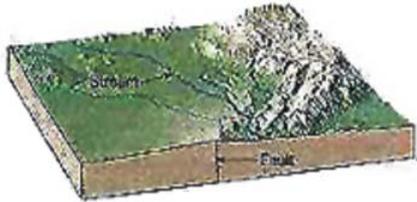


Rupture (earthquake)  
occurs and rocks  
rebound. Elastic strain  
(bending) is replaced by  
horizontal displacement  
known as fault slip.



Rock units that  
cross the fault

Fault showing  
direction of displacement,  
in this case, right-lateral strike-slip



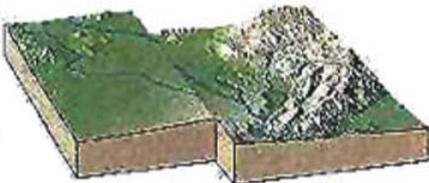
A. Original Position



B. Build up of Strain



C. Rupture



D. Strain Released



A. Original Position



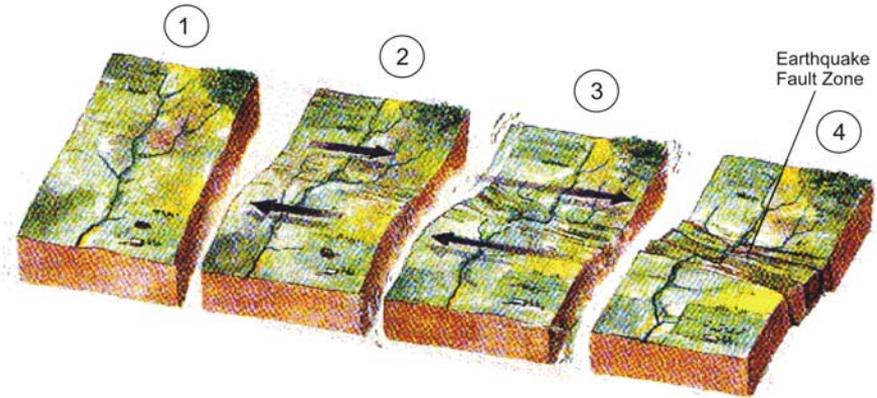
B. Build up of Strain



C. Rupture

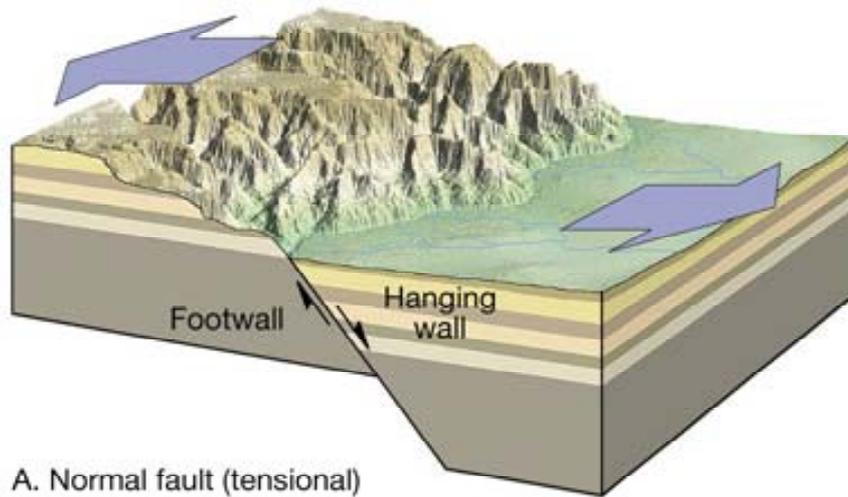


D. Strain Released

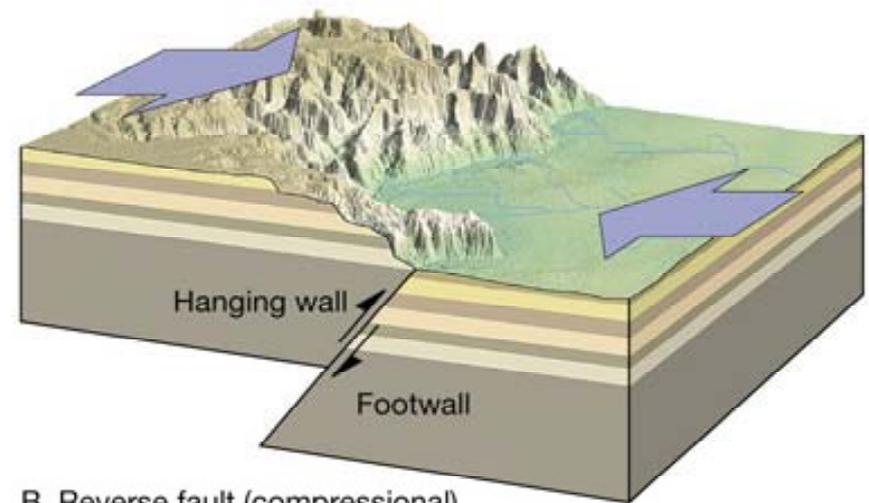


1. *Crustal rocks at rest*
2. *Deformation; dilatancy and development of cracks*
3. *Instant rupture (earthquake)*
4. *Sudden drop in stress after earthquake*

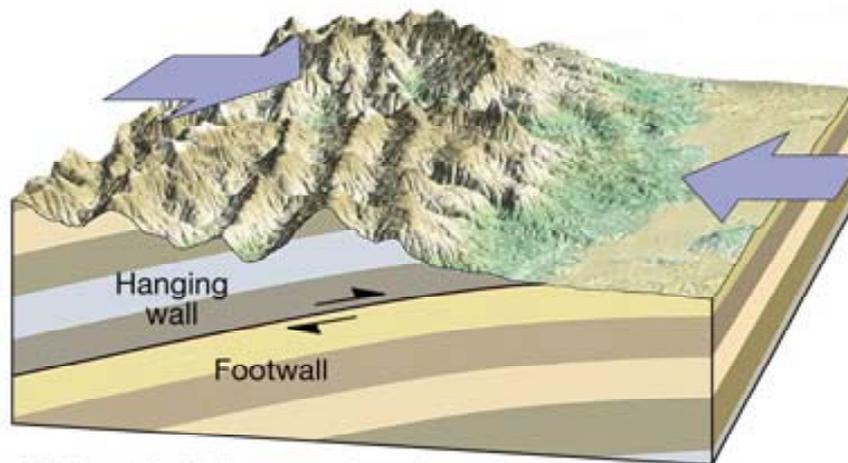
# Classification of faults



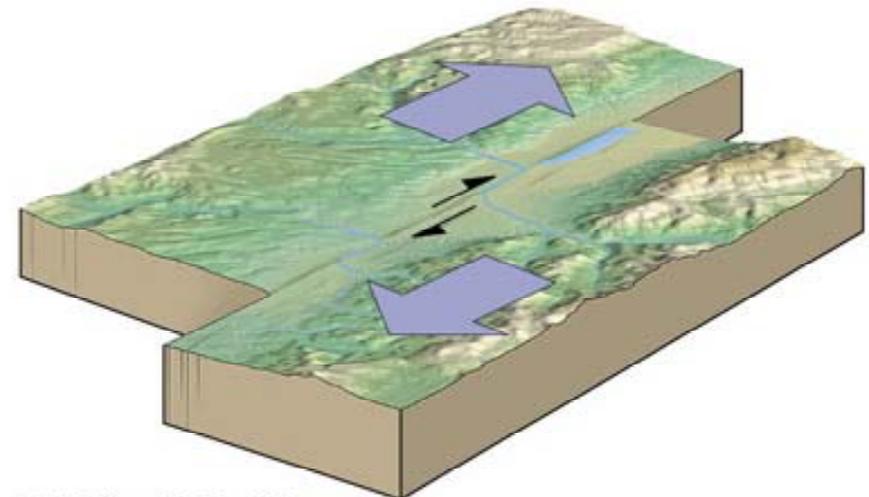
A. Normal fault (tensional)



B. Reverse fault (compressional)

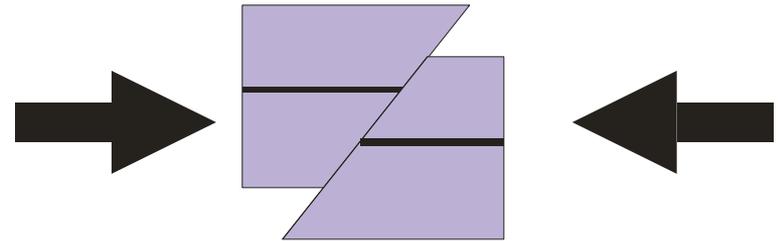
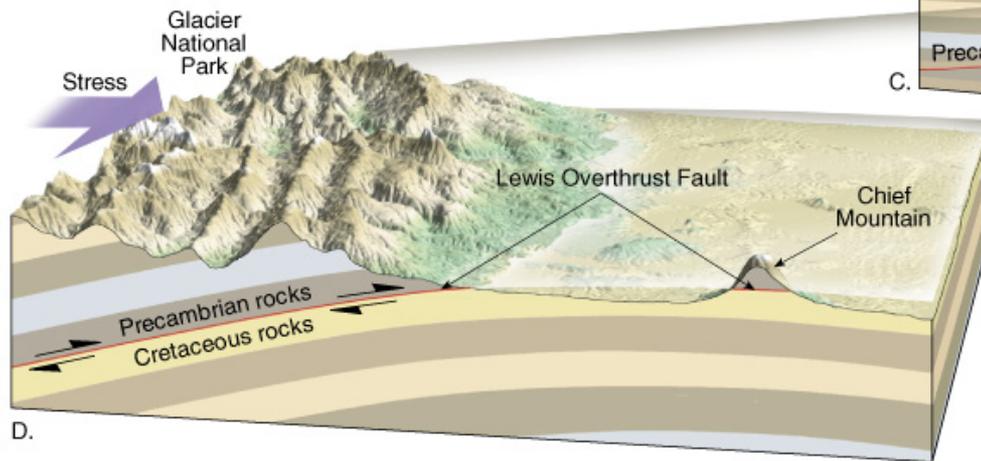
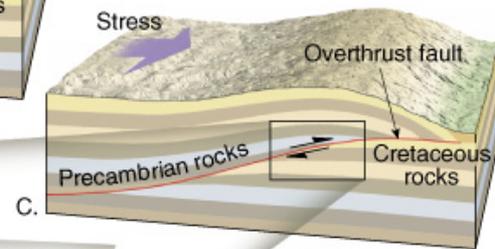
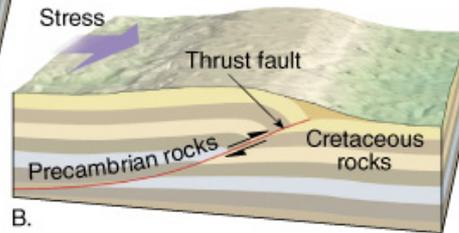
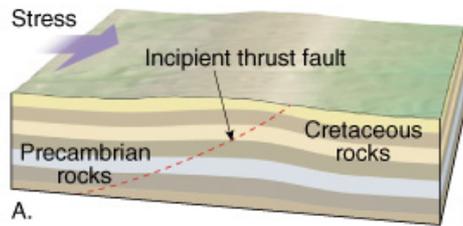
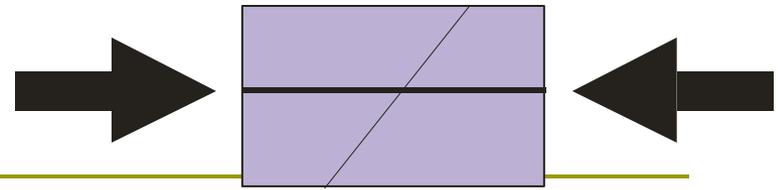


C. Thrust fault (compressional)



D. Strike-slip fault (shear)

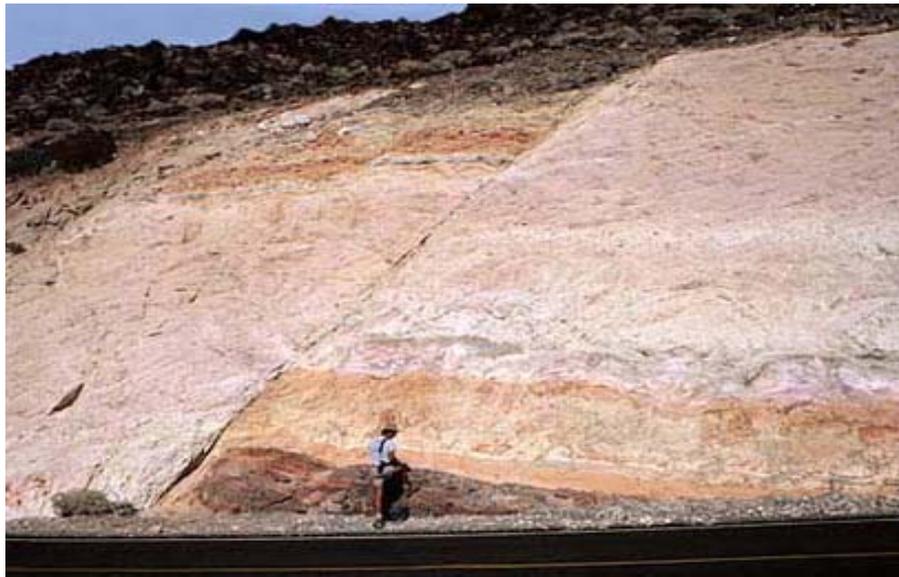
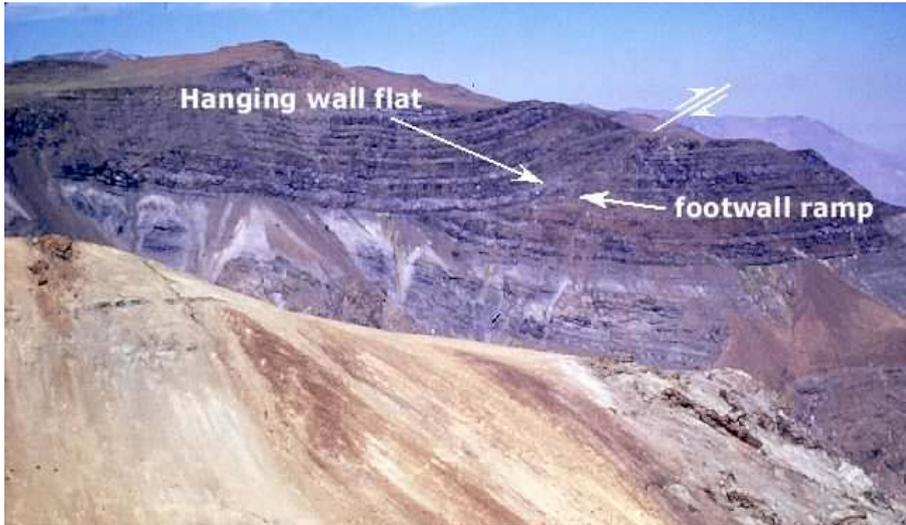
# Reverse faulting





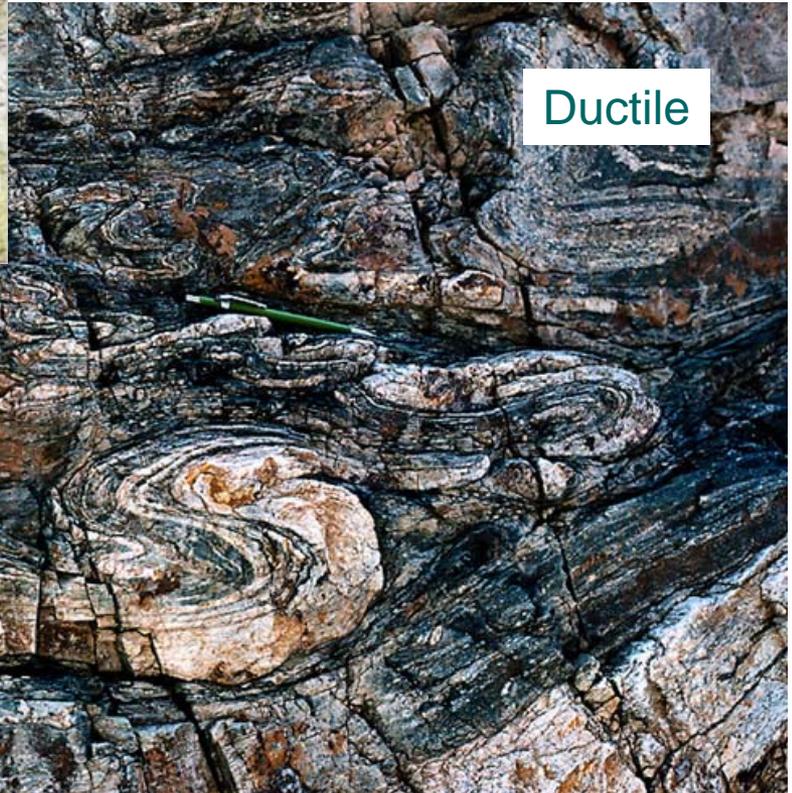
## Faults occur at many scales

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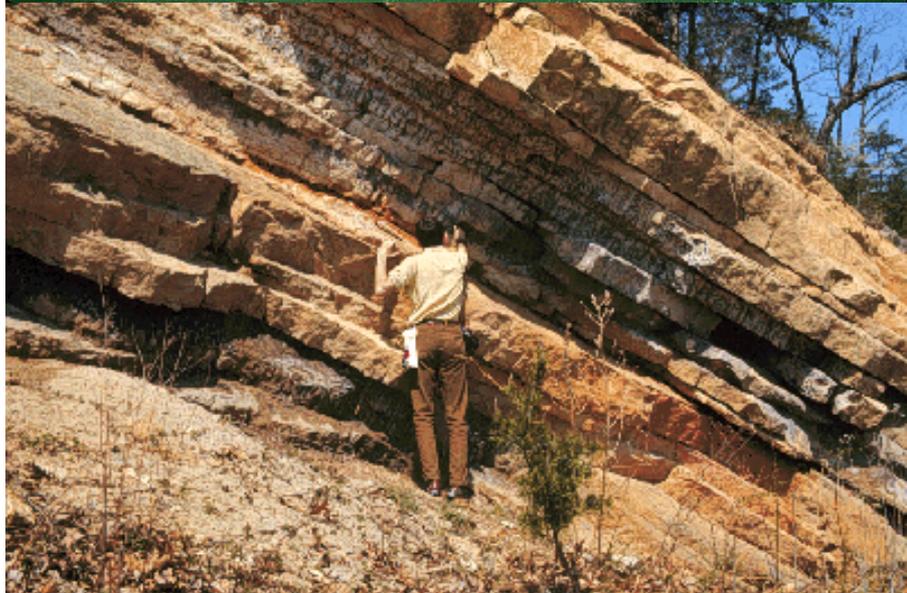




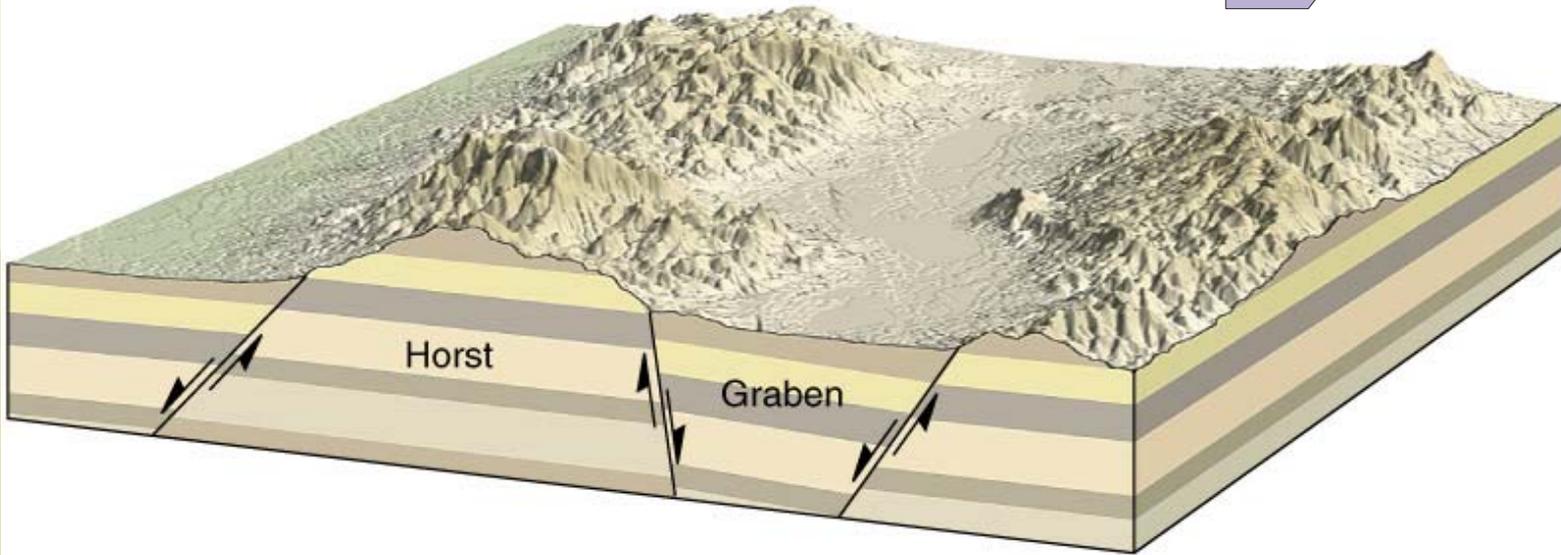
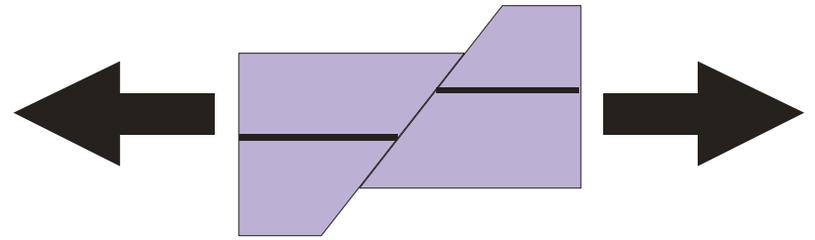
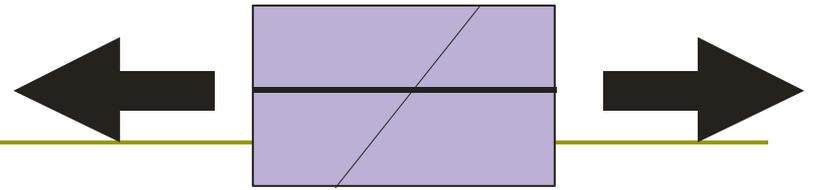
Brittle



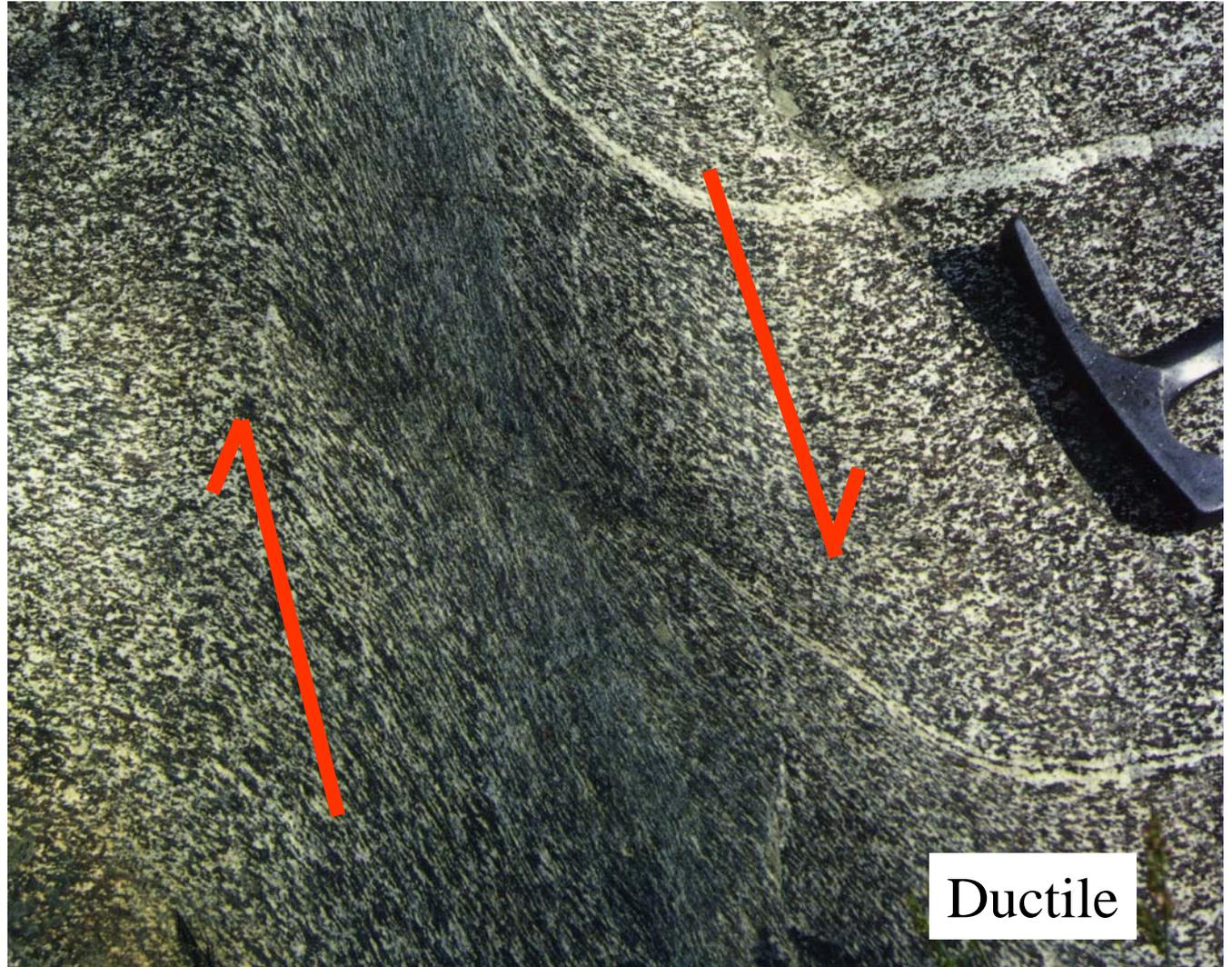
Ductile



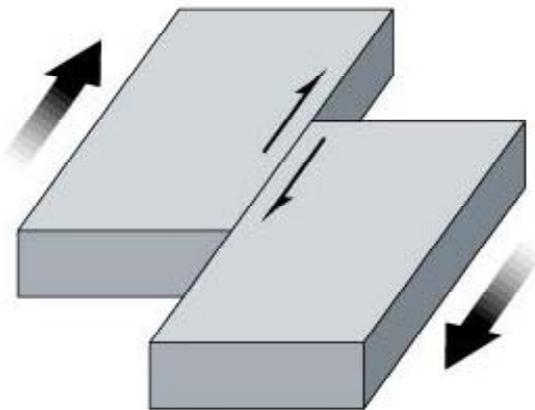
# Normal faulting







# *Strike-Slip Fault*

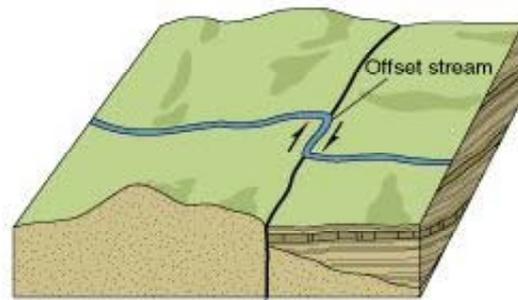


Right-lateral  
strike-slip fault  
Stress: shear

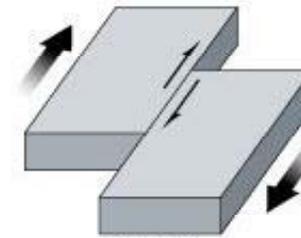
*Identifying faults - Fault Scarps*



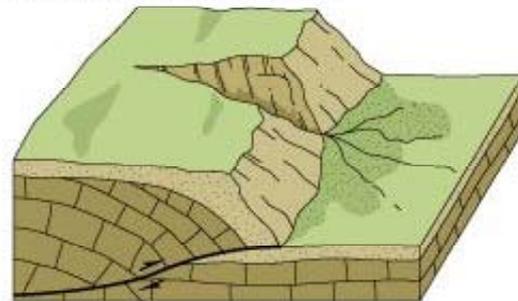
Normal and reverse faults both generate scarps



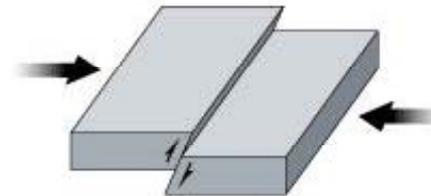
(a) Right-lateral strike-slip fault



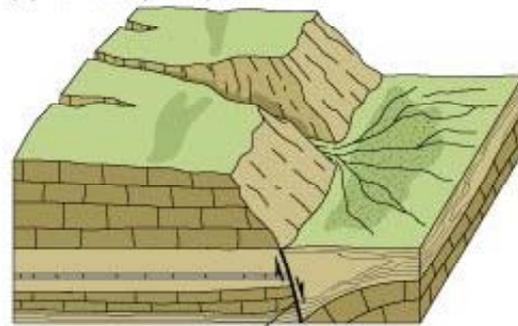
Right-lateral strike-slip fault  
Stress: shear



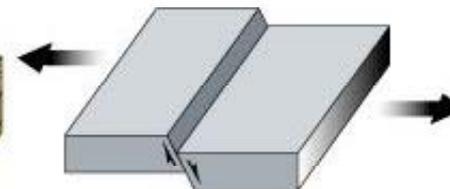
(b) Reverse (thrust) fault



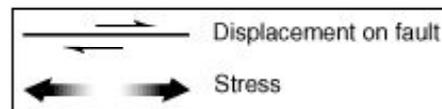
Reverse fault  
Stress: compression

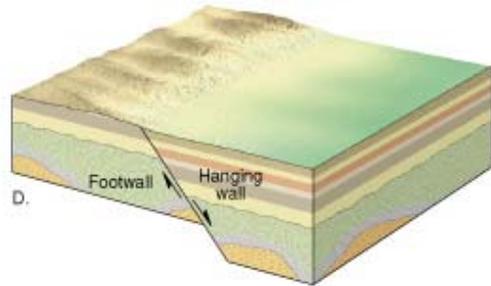
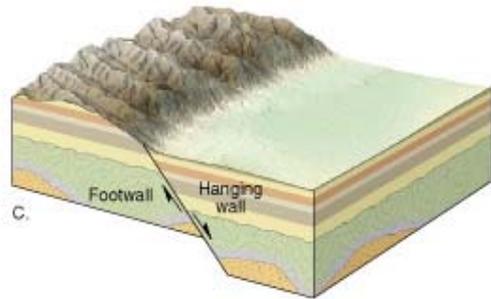
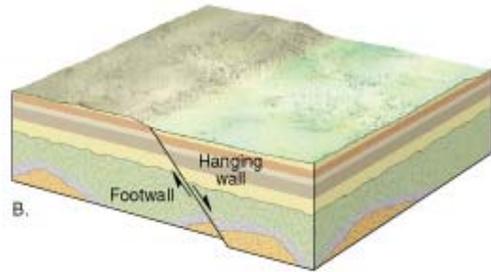
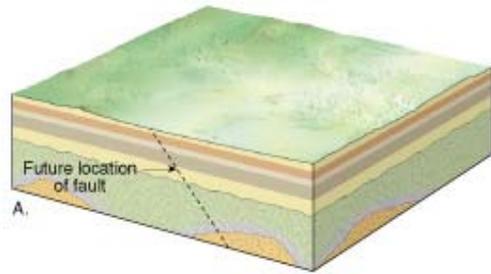


(c) Normal fault

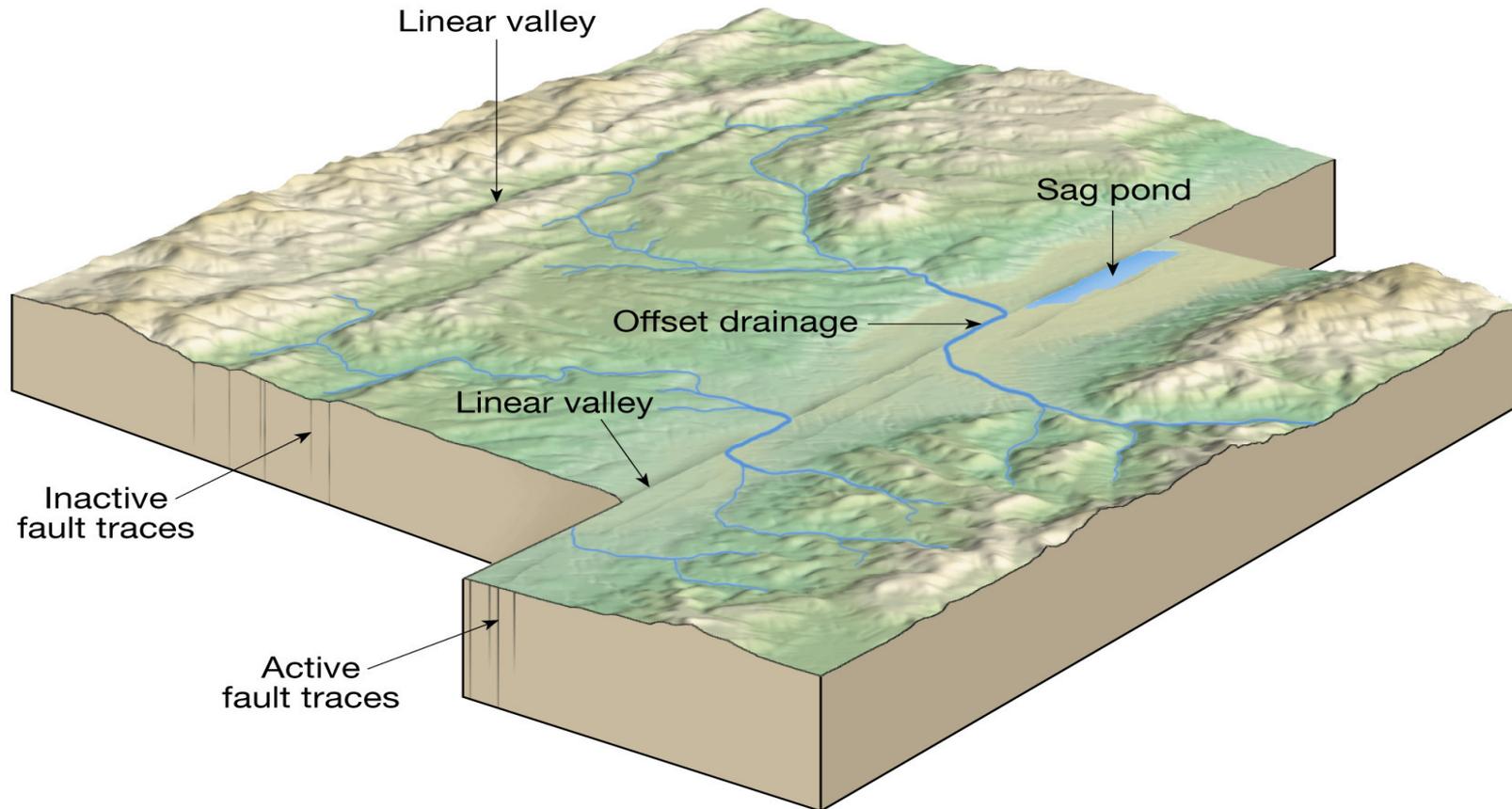


Normal fault  
Stress: tensile





## *Block Diagram showing features along a Strike-Slip Fault*



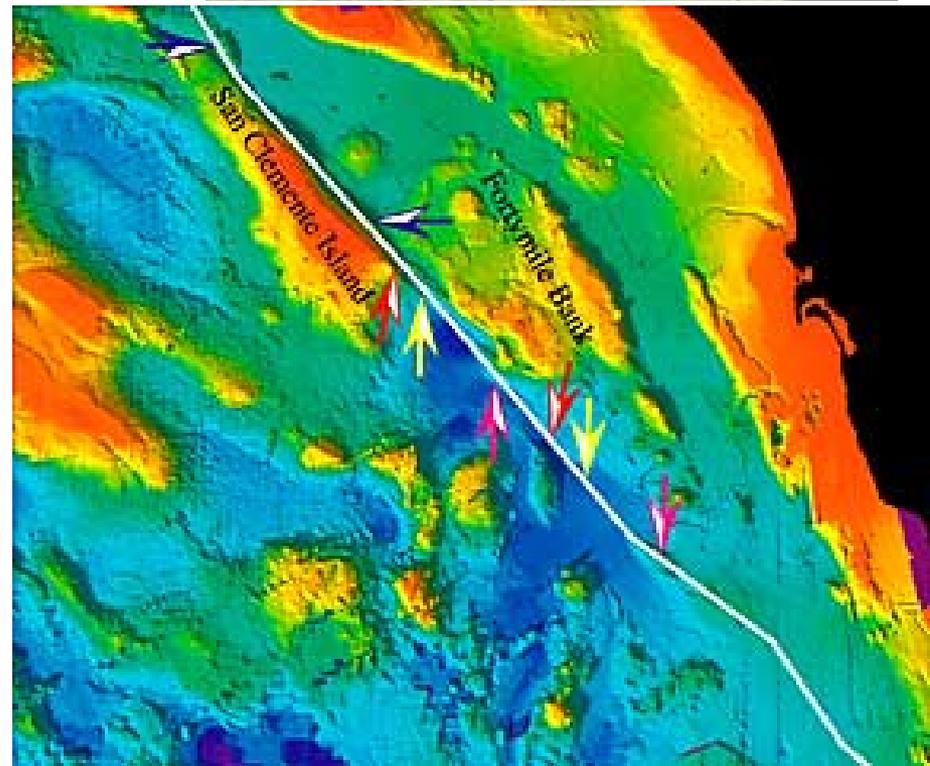
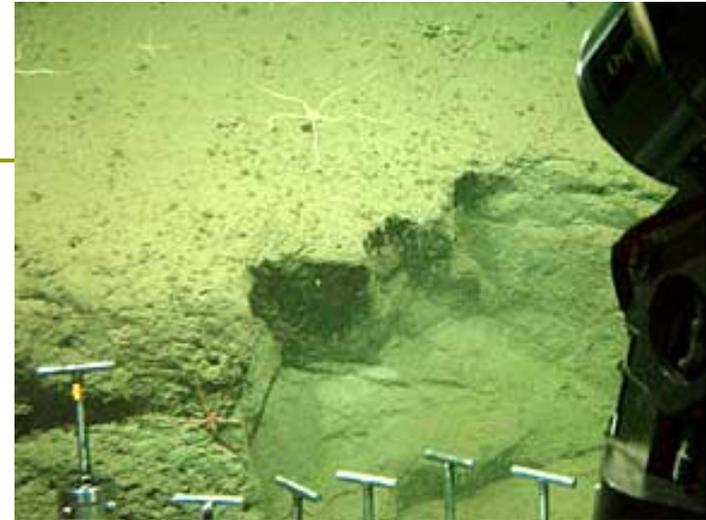


**San Andreas Fault**

Wallace Creek

Wallace Creek

## *Faults at Sea!!*



# Review

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- ❑ The Earth lithosphere is broken into numerous plates, which move independently of each other.
- ❑ This results in regions of divergence (**destructive boundaries**), convergence (**constructive boundaries**) and regions where the plates slide past one another (**transform or conservative boundaries**)
- ❑ The vast majority of earthquakes occur at **plate boundaries**. The nature of these earthquakes is related to the processes at the boundaries.
- ❑ Earthquakes occur when strain built up over many years is released rapidly as brittle failure – **Elastic Rebound Theory**.
- ❑ 3 end members of fault: **strike-slip, normal, reverse/thrust**.