- Types of faults and earthquakes
- How the type of earthquake is known from seismograms
- Types of plate boundaries and the earthquakes they produce

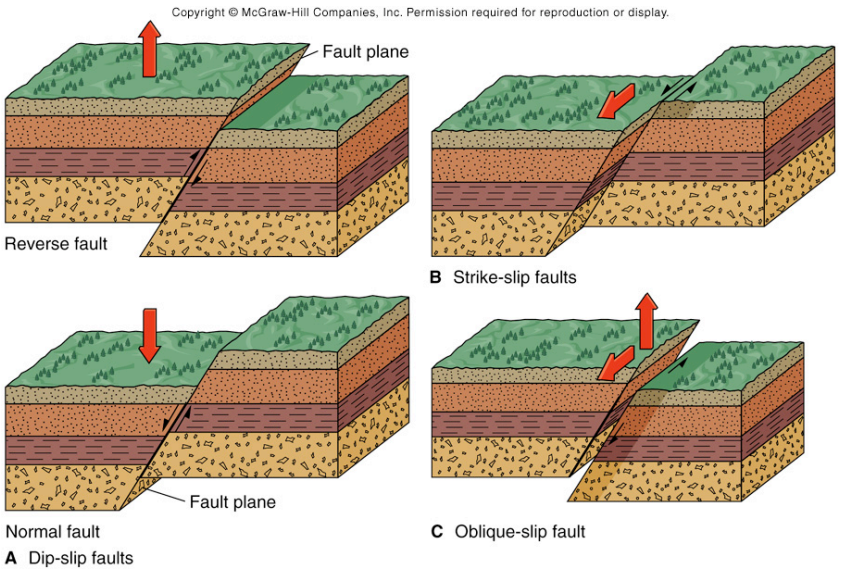
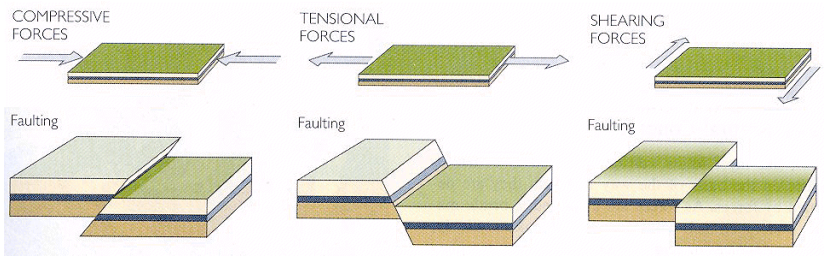


Fig. 11.21

Forces that cause different types of faults



‘reverse’ or ‘thrust’ fault

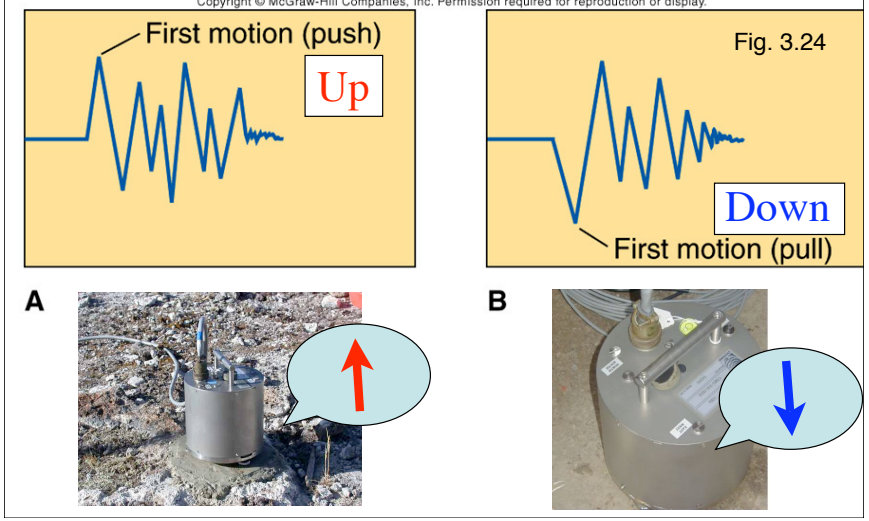
‘normal’ fault

‘strike-slip’ or ‘transform’ fault

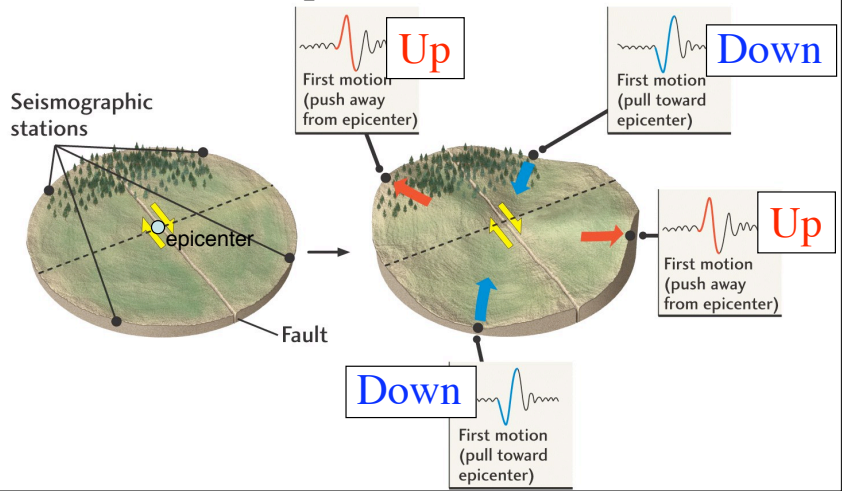
FIRST MOTION STUDIES OF EARTHQUAKES

Plummer Ch. 3 pp 92-94

First motion is read from seismograms -- either up or down (for vertical motion)



First motion is *always either* up, pointing away from the earthquake *or* down, pointing toward the earthquake



First motion is *always either* up, pointing away from the earthquake *or* down, pointing toward the earthquake

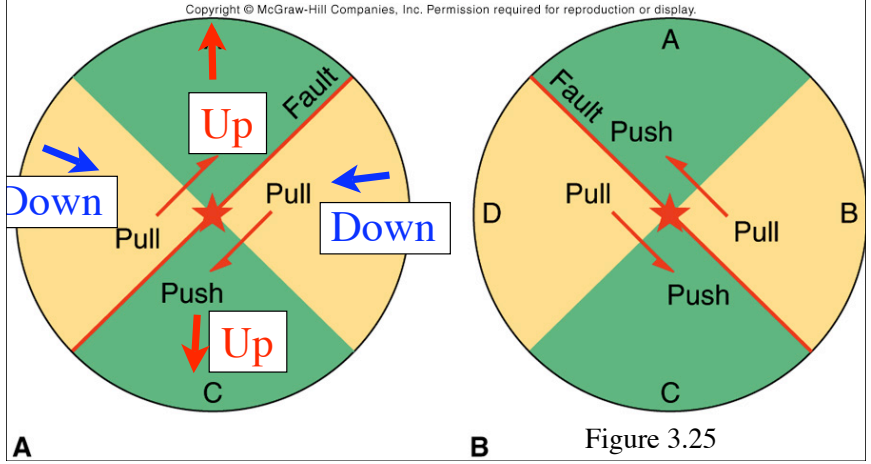
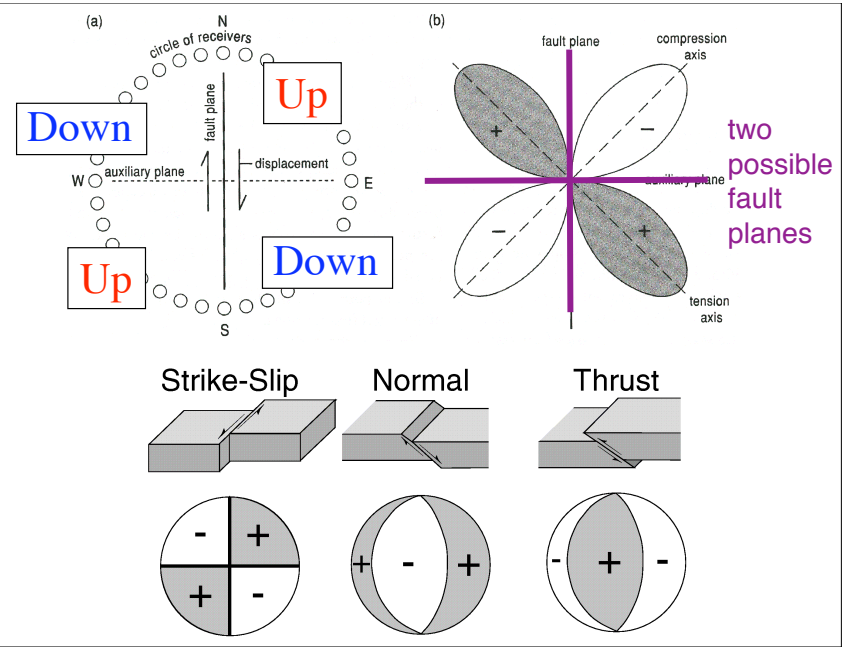
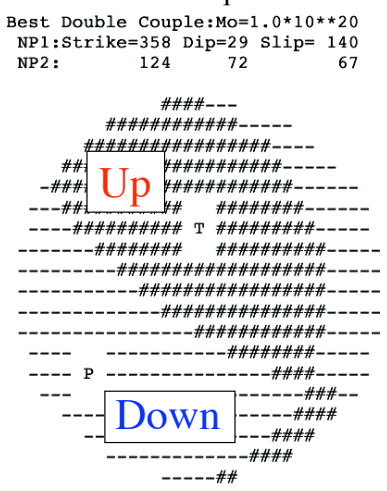


Figure 3.25



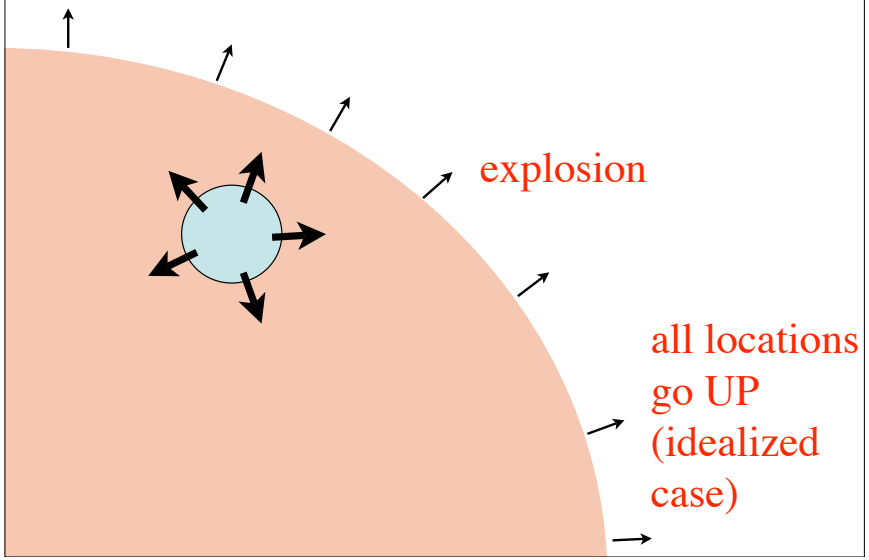
Pakistan earthquake



NNW-SSE Fault Plane with steep dip to N
or with shallower dip to the S

USGS

Underground Bomb Tests



FIRST MOTION STUDIES: MAIN POINTS

- Sign (up,down) of P-wave arrival at seismometer depends on fault orientation
- first motion data from many seismometers tell us two possibilities for its orientation (and type of earthquake)
- fault plane ambiguity is resolved through other information

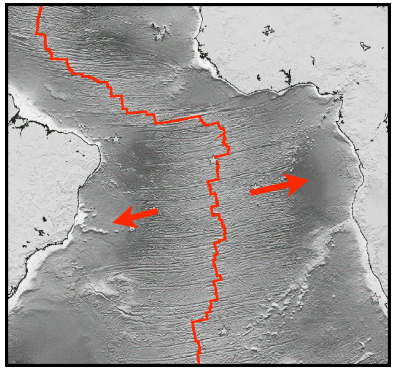
EARTHQUAKES AND PLATE TECTONICS

Plummer Ch. 3 pp 94-99

Divergent boundaries

(“rift valley” on continent
“spreading center” or “mid-ocean ridge” in ocean lithosphere)

- Where plates move away from each other
- Shallow earthquakes, normal faulting
- Small to moderate earthquakes
- Examples:
  mid Atlantic Ridge (ocean)
  East African Rift (continent)



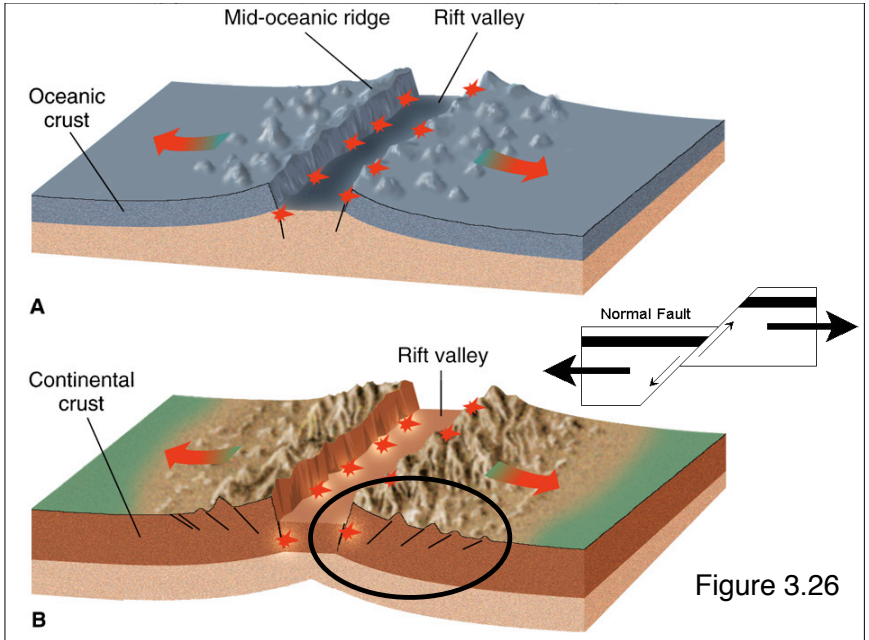
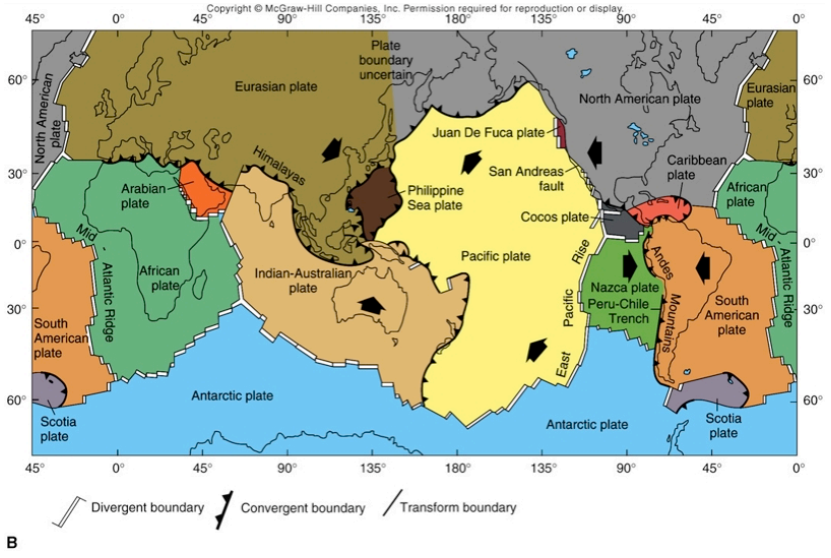


Figure 3.26



Transform boundaries

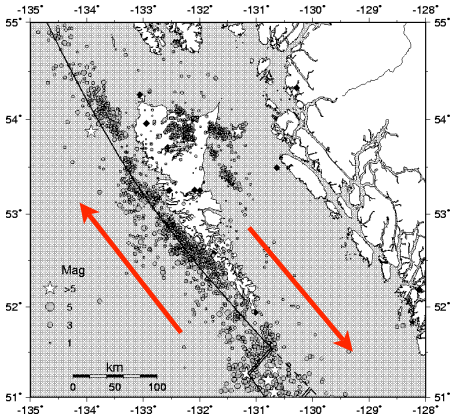
- Plates move horizontally **past** each other
- **Strike-slip parallel** to **boundary**
- **Oceanic** (majority)**:**
  - **Small to moderate shallow** earthquakes
- **Continental:**
  - Shallow-to-mid **focal depth** (<100km)
  - **Broad distribution:** low-to-high **intensity**

- **e.g. Queen Charlotte, San Andreas, and North Anatolian Faults**

Continental transform plate boundaries

San Andreas Fault

Queen Charlotte Fault



Box 3.4

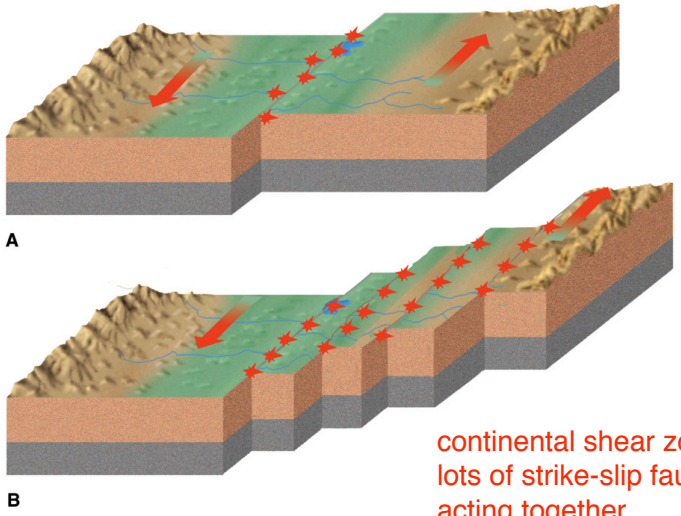
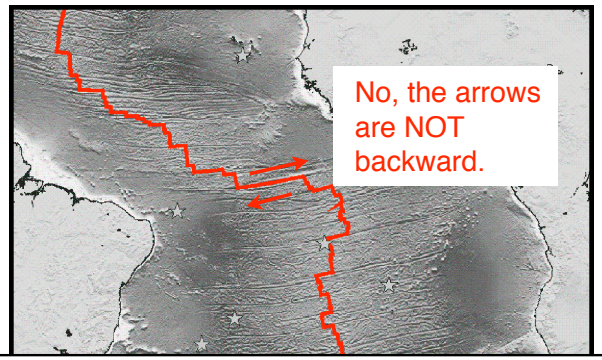


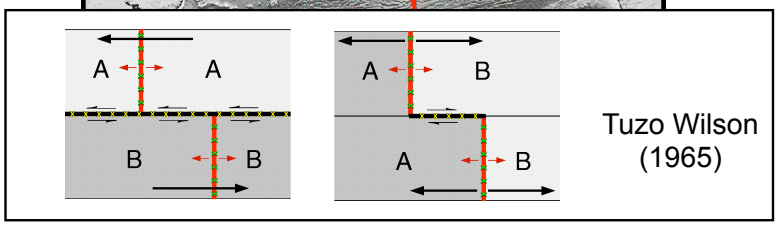
Figure 3.27

continental shear zone: lots of strike-slip faults acting together

Oceanic transform faults



No, the arrows are NOT backward.



Tuzo Wilson (1965)

Convergent boundary

- Plates move **towards** each other
- Lead to **subduction zones or collisions**
  - Oceanic-oceanic
  - Oceanic-continental
  - Continental-continental

Convergent boundary oceanic-oceanic or oceanic-continental: subduction

- Locations of earthquakes:
  - **interface** between **descending slab** and **overriding lithosphere (< 50 km depth)**
  - within **overriding lithosphere (<15-20 km depth)**
  - within **descending slab** (tension or mineral phase changes) to 670 km depth : WADATI-BENIOFF
  - thrust (compression) and normal (tension)

- e.g. O-O Japan, Fiji
- e.g. O-C Cascadia, South America, Alaska

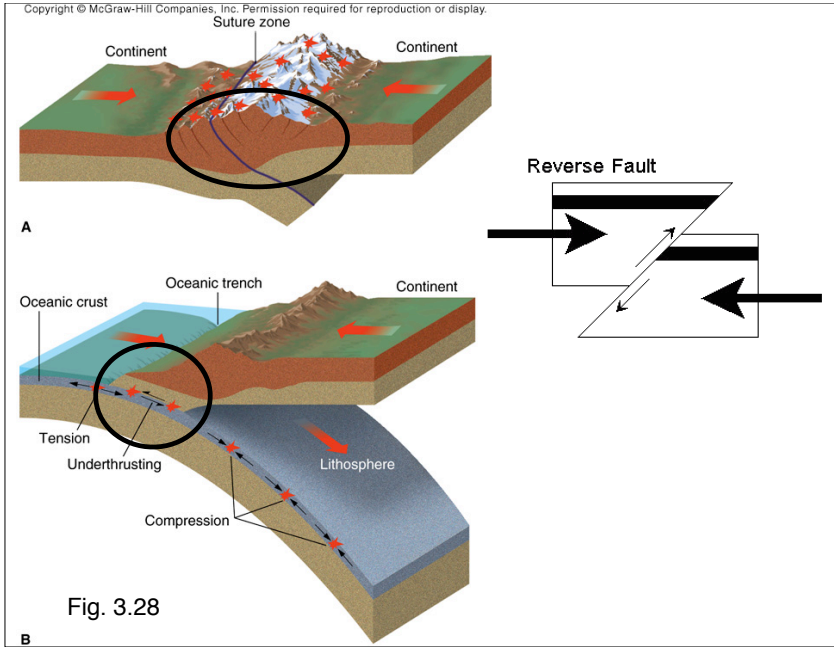
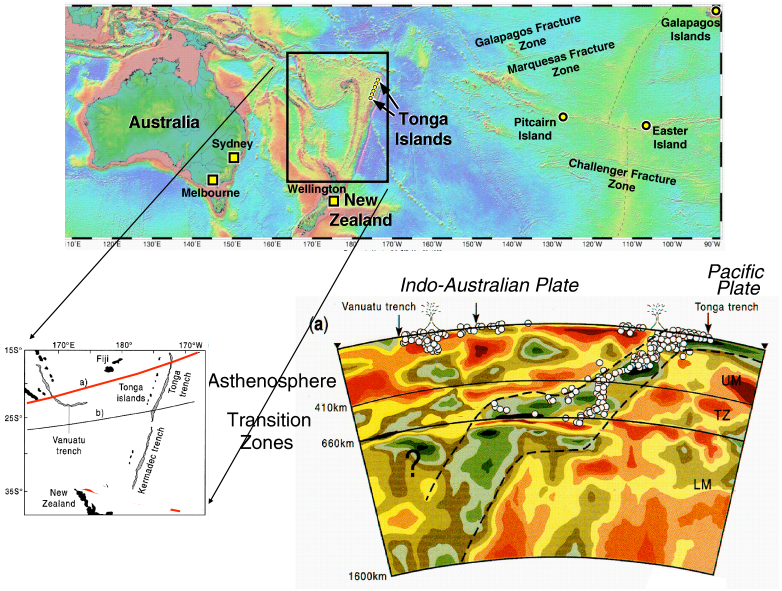
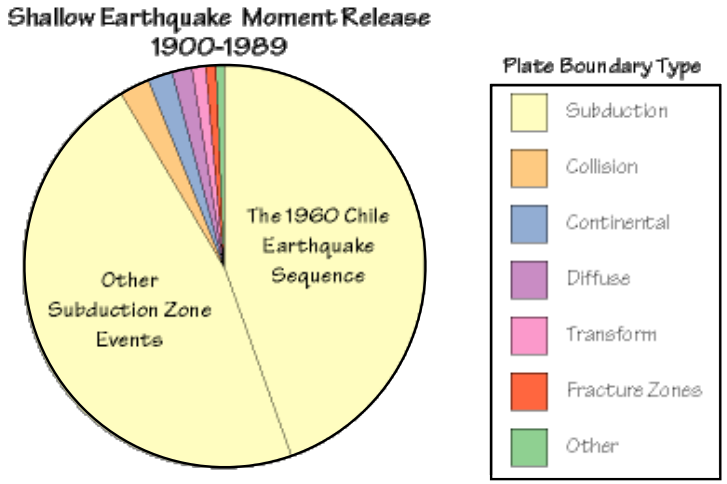


Fig. 3.28



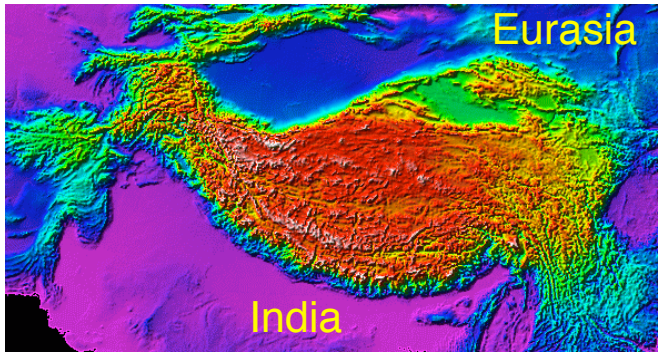
Subduction zones produce the biggest earthquakes



Convergent boundary continent-continent: collision

- thrust faults
- low to high intensity
- shallow earthquakes in crust distributed over broad zones
- e.g. India colliding with Tibet, Yakutat block colliding with Yukon/Alaska

Continent-continent collision example: the Himalayas

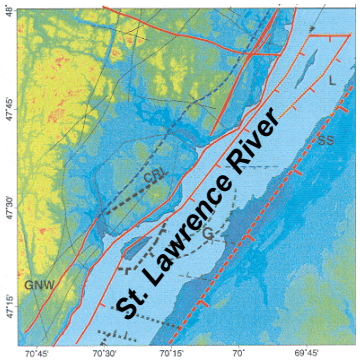


Intra-plate earthquakes: not at a plate boundary

- Uncommon, but can be of very large magnitude
- Cause?
- rupture due to gradual accumulation of strain within the plate

- ruptures tend to occur in "***weak***" zones
- ***New Madrid***, USA (1811-1812: Mw 8)
- along the trace of a ***failed mid-continent rift***

- ***Charlevoix-Kamouraska***
- Quebec (1925: Mw 6.7)
- along the St. Lawrence R. (fault controlled)
- not well understood,
- links to old impact crater



M. Lamontagne
Ph.D Thesis

EARTHQUAKE DISTRIBUTION

- most earthquakes are associated with plate boundaries
- 80% on Pacific "ring of fire"
- 10% on Alpine-Himalaya belt
- remainder are at ridges, hotspots, intraplate