

RHEOLOGY AND DEFORMATION

Stress & Strains

- **stress** - a force producing or tending to produce deformation in a body; stress is measured as (F/A) the force divided by the area over which the force is applied, and defined in such units as dynes per square centimeter, or pounds per square feet, etc.
- **Strain** - refers to the deformation resulting from the stress, i.e. to the change in the dimensions or shape of the body relative to the original dimensions or shape.
- **Bulk Modulus**: is a measure of the "incompressibility" of a material. The more incompressible a material is, the smaller will be the value $(V-v)$, and hence the greater the value of the BULK MODULUS.

$$\frac{\text{Stress}}{\text{Strain}} = \frac{\text{hydrostatic pressure}}{(V-v)/V} = \text{BULK MODULUS}$$

- **Shear Modulus**: is a measure of the "rigidity" of a material. The more rigid a material is, the smaller will be the value "tan q", and thus the larger the value of the shear modulus.

$$\frac{\text{Stress}}{\text{Strain}} = \frac{\text{Force (tangential)}}{\tan A} = \text{SHEAR MODULUS}$$

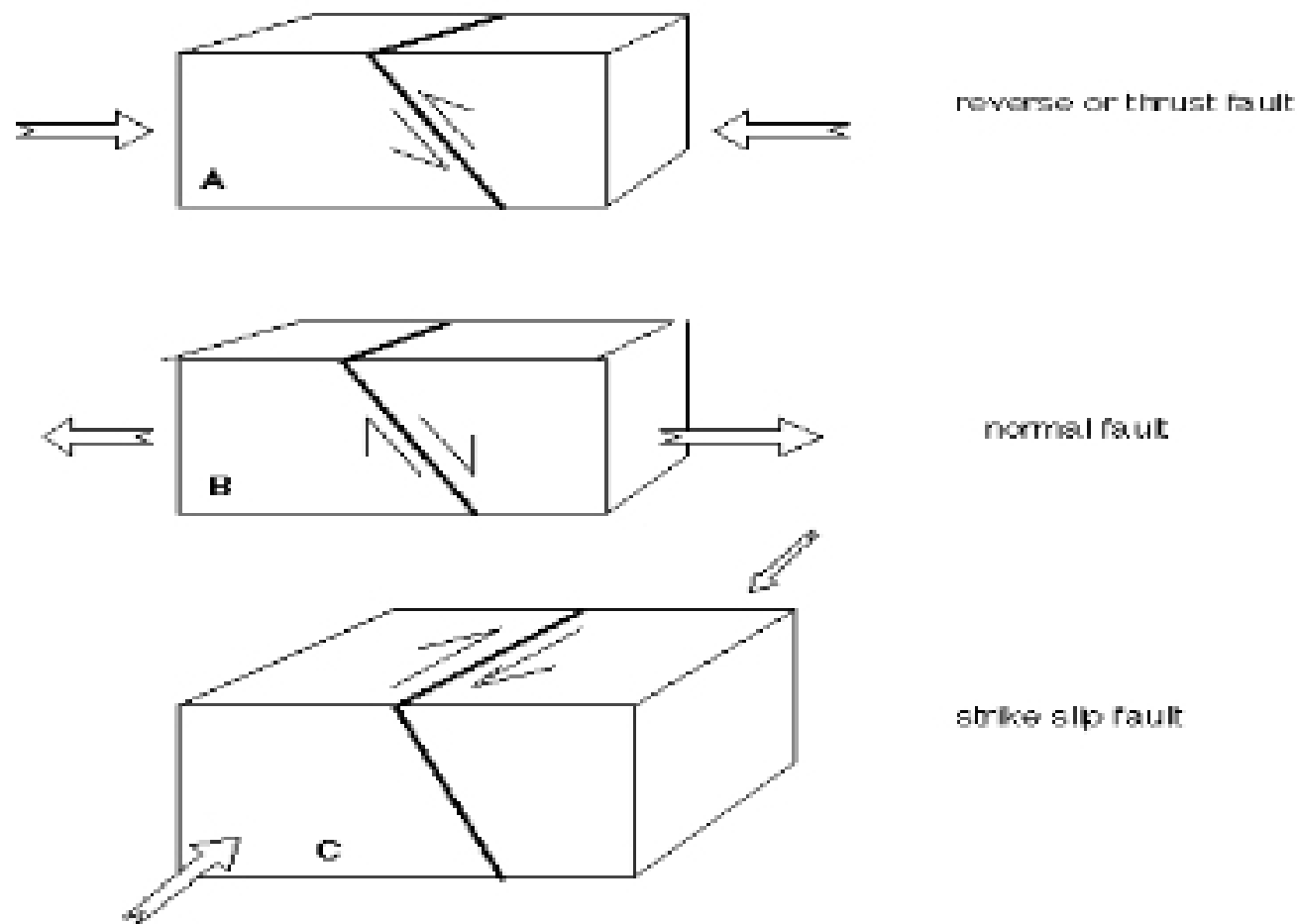
- Whether solids are brittle or ductile depends on their temperature and the strain rate.
 - they can be brittle at low temperatures and ductile at higher temperatures
 - they can be brittle under high strain rates and ductile under low strain rates

Faults

During deformation, rocks can be folded and faulted. The type of folds and faults and their orientations provide information about the orientation of the ancient stress fields.

Faults are fractures in the earth along which there has been displacement of one side relative to the other side.

- **Reverse or thrust faults**: arrow give direction of primary compressional stress. A reverse fault is called a thrust fault if the dip of the fault plane is small.
- **Normal fault**: arrows give direction of primary tensional stress. This fault motion is caused by tensional forces and results in extension.
- **Strike slip fault**: arrows give orientation of shear couple. In a strike-slip fault, the movement of blocks along a fault is horizontal. If the block on the far side of the fault moves to the left, the fault is called left-lateral. If the block on the far side moves to the right, the fault is called right-lateral. The fault motion of a strike-slip fault is caused by shearing forces



EARTHQUAKES

Regions of the Earth's crust and lithosphere that are subjected to sufficient stresses can undergo elastic strain. Recall it is the nature of elastic strain that it is proportional to the stress applied. This strain can continue to build up over long periods of time. If the stress are suddenly released, as they might be when rocks slip along a fault, the stored elastic strain energy is released - some of it in the form of seismic waves that are travel outward away from the point of origin or focus of the earthquake.

What is an earthquake & what causes it?

- Earthquakes happen because plates from the lithosphere collide and sub duct, the enormous amounts of pressure and heat buildup and then release, causing and Earthquake. These plates are part of the lithosphere which is 3-5 miles deep on continents and 5-10 in the ocean. 700km is BELOW that, so you are now in the upper part of the mantle, called the Asthenosphere, which is not a liquid, nor solid, but a "plastic" with characteristics like Silly Putty. An Earthquake will not happen here because there is no rock to collide in a "plastic" environment.

What are the major hazards of earthquakes?

- 1) ***The Effect of Ground Shaking:*** The first main earthquake hazard (danger) is the effect of ground shaking. Buildings can be damaged by the shaking itself or by the ground beneath them settling to a different level than it was before the earthquake

- (subsidence). Buildings can even sink into the ground if soil liquefaction occurs. Liquefaction is the mixing of sand or soil and groundwater. Buildings can also be damaged by strong surface waves making the ground heave and lurch. Any buildings in the path of these surface waves can lean or tip over from all the movement. The ground shaking may also cause landslides, mudslides, and avalanches on steeper hills or mountains, all of which can damage buildings and hurt people.
- 2) **Ground Displacement:** The second main earthquake hazard is ground displacement (ground movement) along a fault. If a structure (a building, road, etc.) is built across a fault, the ground displacement during an earthquake could seriously damage or rip apart that structure.
 - 3) **Flooding:** The third main hazard is flooding. An earthquake can rupture (break) dams or levees along a river. The water from the river or the reservoir would then flood the area, damaging buildings and maybe sweeping away or drowning people.
 - 4) **Fire:** The fourth main earthquake hazard is fire. These fires can be started by broken gas lines and power lines, or tipped over wood or coal stoves. They can be a serious problem, especially if the water lines that feed the fire hydrants are broken, too. For example, after the Great San Francisco Earthquake in 1906, the city burned for three days. Most of the city was destroyed and 250,000 people were left homeless.

What is meant by magnitude and how do the various magnitude levels compare?

- The magnitude of an earthquake refers to the amount of energy released during an earthquake. It is commonly referred to a numerical scale 2 to 10. The difference between whole numbers is approximately a factor of 30X.

Where do most earthquakes occur and how deep are the foci?

- Earthquakes are concentrated in specific regions of the Earth, and they often occur in linear belts or arcs. One belt surrounds the Pacific Ocean, including Japan, Alaska and the western coast of North, Central and South America. Another region is from southeastern Europe through the Middle East and the Himalayan Mountains. There are also earthquakes in linear zones in the oceans.
 - (i) Shallow-focus earthquakes appear to be associated with mid-ocean ridges, with mountain ranges in the interior of the continents of Europe and Asia, and with the mountains and ocean trenches that surround the Pacific Ocean.
 - (ii) Deep-focus earthquakes appear to be associated mainly with the mountains and ocean trenches that surround the Pacific Ocean (for example, near the coast of South America, or the coast of Japan)

Why do earthquakes originate in the lithosphere, but not in the asthenosphere?

- The significance difference between the lithosphere and asthenosphere is their rheological properties (the lithosphere is more rigid; the asthenosphere more ductile). The