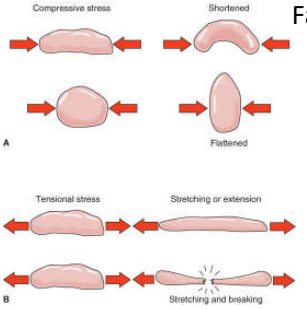
Chapter Outlines

NOTE: This is intended to help students 'organize' their understanding of each topic. It is <u>not</u> a comprehensive study guide for quizzes or midterms, i.e. <u>study your text!</u>

Mountain Building

Geologic structures are usually the result of the powerful tectonic forces that occur within Earth. These forces very very slowly fold and break rocks, form deep faults, and build mountains. Repeated applications of force—the folding of already folded rocks or the faulting and offsetting of already faulted rocks—can create a very complex geologic picture that is difficult to interpret. Most of these forces are related to plate tectonic activity. Some of the natural resources we depend on, such as metallic ores and petroleum, often form along or near geologic structures. **Mountains** result from the application of tectonic forces to rocks, usually sedimentary or volcanic rocks. These may be changed to metamorphic rocks as mountain-building progresses. **Mountain-building** on continents is associated with intense deformation, folding, and faulting, usually along convergent plate boundaries. An **orogeny**, or **orogenesis**, is the overall process by which a mountain system is built.

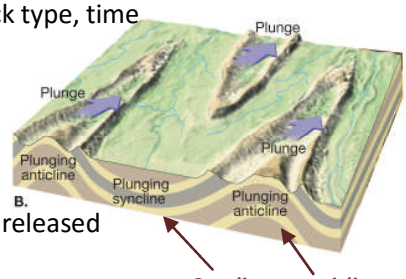
I. **Deformation** - a general term that refers to all changes in the original form and/or size of a rock body.
Factors that influence the strength of a rock: T°, confining pressure, rock type, time



Stresses, and the resultant strains

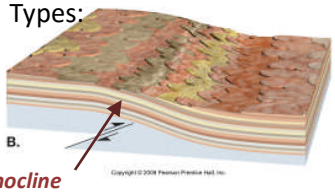
A. **Stress**
   1. **Tensional stress** – pulling apart
   2. **Compressive stress** – pushing together
   3. **Shear stress** – sliding past *(offset compression)*

B. **Strain** – the result of stress *(behavior of rock when stressed)*
   1. **Elastic strain** - material returns to original shape when stress is released
   2. **Brittle strain** - material will brake instead of deforming
   3. **Plastic strain** - material will retain its new shape when the stress is released

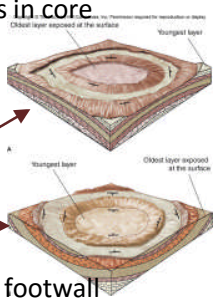


Syncline, *anticline*

II. **Folds** – usually the result of compressional forces that shorten and thicken the crust. Types:
   A. **Anticline**—upfolded, or arched, rock layers
   B. **Syncline**—downfolded rock layers
   C. **Monocline** – large step-like fold in an otherwise horizontal sedimentary strata
   D. Where surface evidence of folds 'die out' they are said to be **plunging**
   E. Other types of folds
      1. **Dome**: circular, or slightly elongated, upwarped displacement of rocks, oldest rocks in core
      2. **Basin**: circular, or slightly elongated, downwarped displacement of rocks, youngest rocks in core



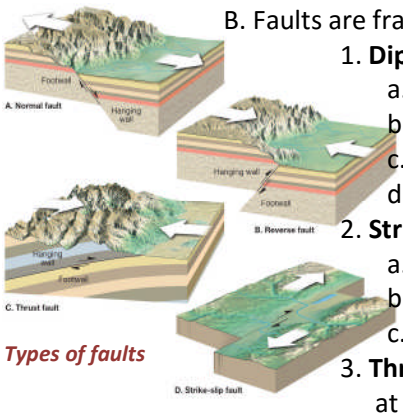
Monocline



Dome

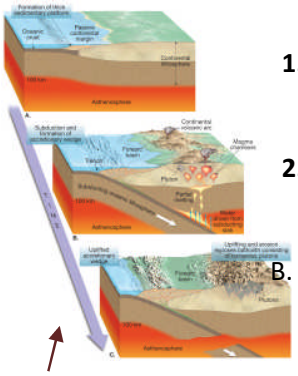
Basin

III. **Faults**
   A. **Joints** are fractures in rock that have had no horizontal or vertical displacement
   B. Faults are fractures in rocks along which appreciable displacement has taken place. Types:
      1. **Dip-slip fault** – movement is along the inclination *(dip)* of fault plane
         a. **Hanging wall**—the rock above the fault surface
         b. **Footwall**—the rock below the fault surface
         c. **Normal fault** – the hanging wall has 'slid' downward relative to the footwall
         d. **Reverse fault** – the hanging wall has moved 'pushed' upward relative to the footwall
      2. **Strike-slip fault** – dominant displacement is horizontal and parallel to the trend, or strike
         a. **Right lateral** – the block on the opposite side moves to your right
         b. **Left-lateral** - the block on the opposite side moves to your left
         c. The San Andreas Fault is a transform fault, and also a very deep strike-slip fault
      3. **Thrust fault** – a reverse dip-slip fault in which the hanging wall has overridden the footwall at a very shallow angle, often over a great distance



Types of faults

IV. **Mountain building**
   A. **Orogenesis**—the processes that collectively produce a mountain belt



Accumulation of sediment, magma intrusion, and uplift

1. **Accumulation stage** – typically occurs in marine environment at opening ocean basins. An ocean basin opens, collects sediment from adjacent land areas, then closes, collecting sediment during the entire course *(a very long tectonic process)*
2. **Orogenic stage** – closing of an ocean basin, a subduction complex, & subsequent uplifting of mountains. The result of ocean-continent, arc-continent, or continent-continent convergence. Subsequent gravitational collapse & spreading may bring deep-seated metamorphic rock to surface

B. Mountain building that has occurred during the recent geologic past:

1. **American Cordillera**—the western margin of the Americas from Cape Horn to Alaska
2. **Alpine–Himalayan** chain
3. Mountainous terrains of the western Pacific

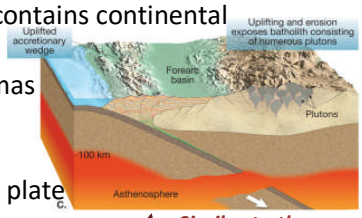
V. Subduction and mountain building

A. **Island-arc** mountain building

- Occurs where two ocean plates converge and one is subducted beneath the other

B. **Andean-type** mountain building – 'ocean–continent' convergence

1. Involves the convergence of an oceanic plate and a plate whose leading edge contains continental crust… exemplified by the Andes Mountains of South America
2. Volcanic-arc building - Subduction and partial melting generates primary magmas
3. Emplacement of plutons and development of an **accretionary wedge**

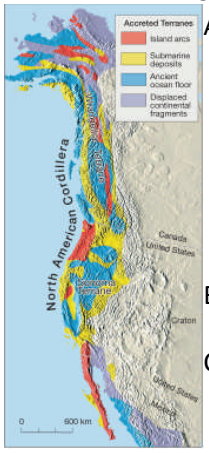


Similar to the formation of California

C. **Sierra Nevada** and **Coast Ranges** in California

1. Subduction of the Pacific Basin under the western edge of the North American plate
2. Sierra Nevada batholith is a remnant of a portion of the continental volcanic arc
3. Franciscan Formation of California's Coast Ranges constitutes the accretionary wedge

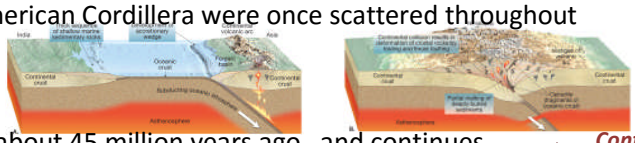
VI. Continental collisions



Map of the west coast terranes

A. **Accretion of terranes** – the addition of 'geologically distinct' continental pieces

1. Small crustal fragments collide and merge with continental margins
2. Prior to accretion some of the fragments may have been microcontinents or island arcs
3. Collision of these fragments with the continental margin deforms both blocks, adding to the zone of deformation and to the thickness of the continental margin
4. Many of the terranes found in the North American Cordillera were once scattered throughout the eastern Pacific



Continent-continent collision

B. **Himalayan Mountains**

- Youthful — collision of India with Asia began about 45 million years ago…and continues

C. **Appalachian Mountains**

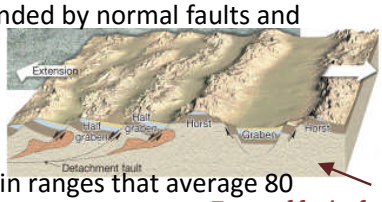
1. Formed long ago *(about 250 - 300 million years ago)* and substantially lowered by erosion
2. Resulted from a collision among North America, Europe, and northern Africa

D. **Ural Mountains** – formed long ago in a collision of Europe and Asia

VII. **Fault-block mountains** – the result of tectonic tensional forces

A. Large blocks *(mountain-size)* slip downward forming basins which are bounded by normal faults and adjacent higher blocks. These higher blocks form the ranges.

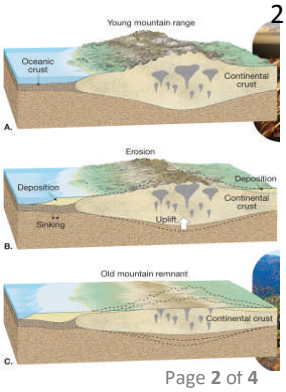
1. **Graben** – name given to the descending block forming a 'basin'.
2. **Horst** – name given to the higher block forming the adjacent 'range'.



Types of faults from 'extension'

B. **Basin and Range** province of Nevada – began 20 million years ago

1. Tilting of these faulted structures has produced nearly parallel mountain ranges that average 80 km's in length
2. High heat flow and several episodes of volcanism provide evidence that mantle upwelling caused doming of the crust and subsequent crustal extension to twice its original width



Isostatic adjustment after erosion

VIII. Buoyancy and the **principle of isostasy**

Reasons for crustal uplift

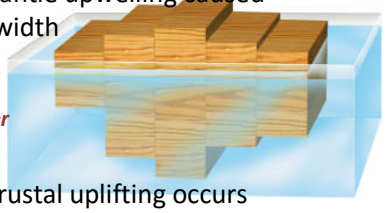
a. Mantle plumes, mountain building, etc.

b. Isostasy – the concept of a floating crust in gravitational balance.

When weight *(mass)* is removed from crust *(usually by erosion),* crustal uplifting occurs

i. Called **isostatic adjustment**

ii. Crustal buoyancy can account for considerable vertical movement of crust



Remove weight from the top and the bottom will rise higher