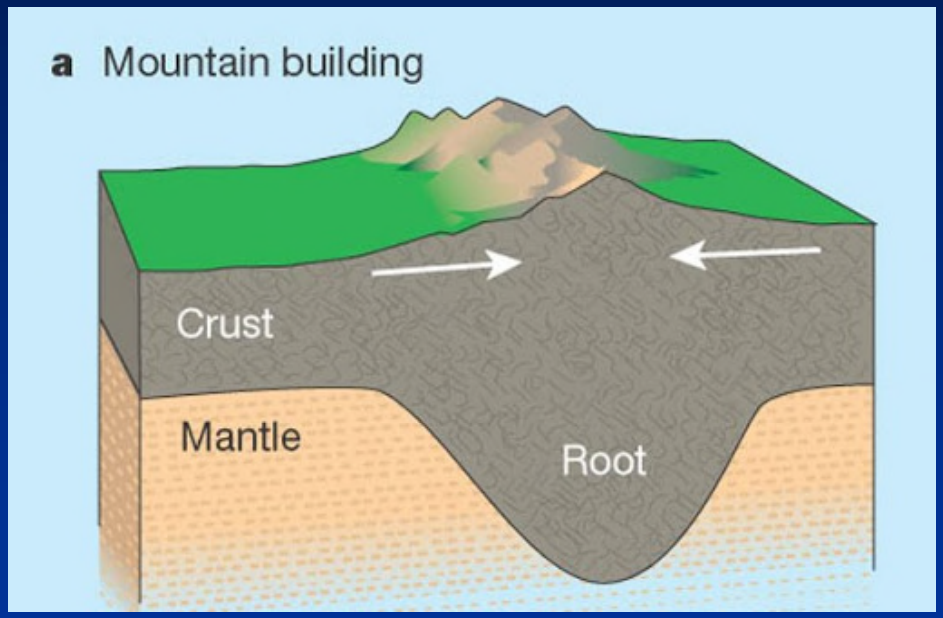
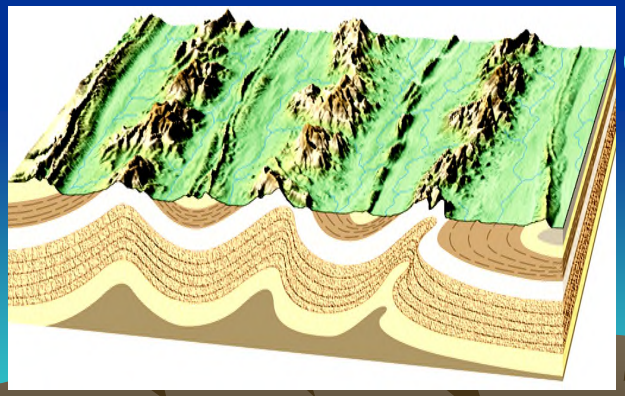
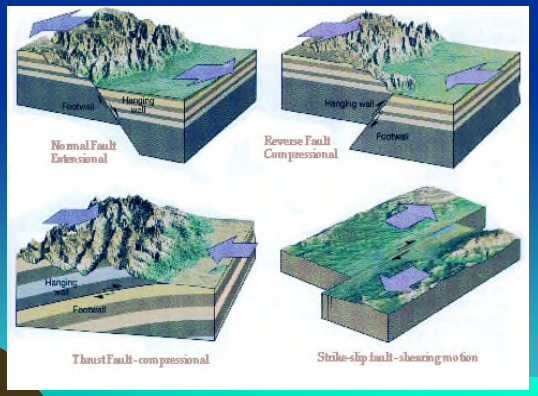
Crustal Deformation and Mountain Building



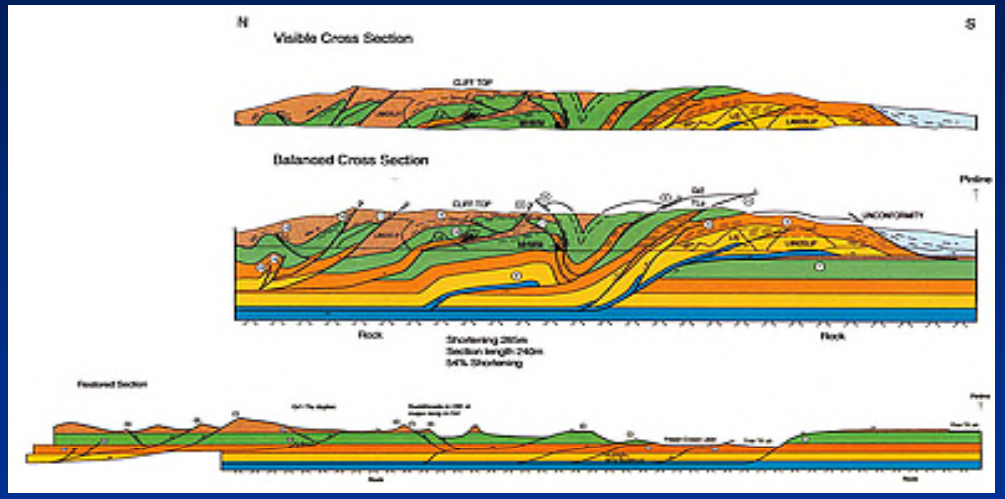


Geology 100 Lecture

Ray Rector: Instructor

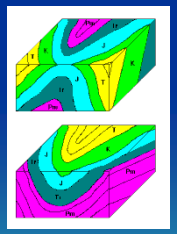


Crustal Deformation Resources

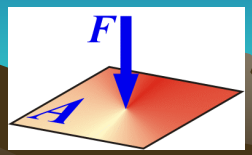


Internet Links

1) Fundamentals of Structural Geology



2) Visualizing Bed Attitude



General Geologic Terms of Structure

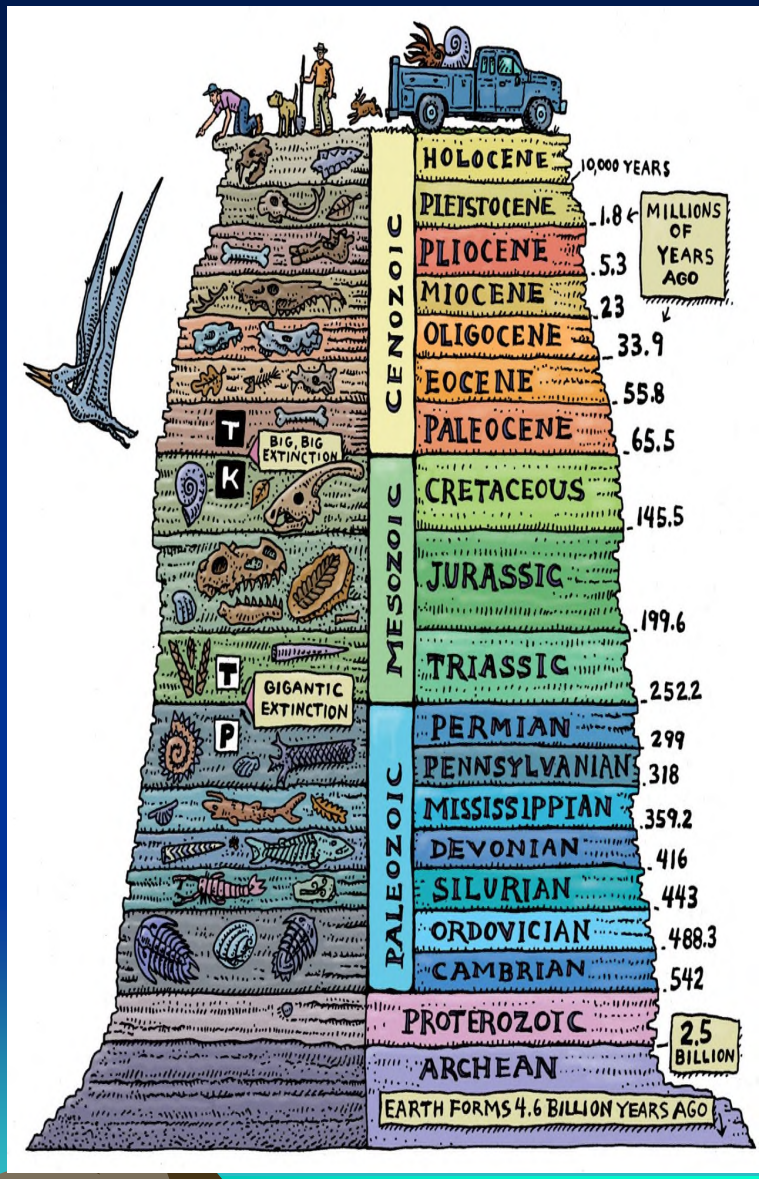
Outcrop: Exposure of bedrock at earths surface

Formation: mappable body of rock with definite age, lithology, and external boundaries (contacts)

Contact: Boundary between adjacent rock bodies or structural elements

Rock Formations and Geologic Time

1) All geologic rock formations have a specific assigned age
2) All geologic rock formations have a specific range of lithology
3) Rock formations are listed in a temporally-ordered sequence in the "explanation" of a geologic map
4) Each rock formations has an assigned geologic period
5) Geologic period assignments of formations are further divided into lower (older), middle, and upper (younger)

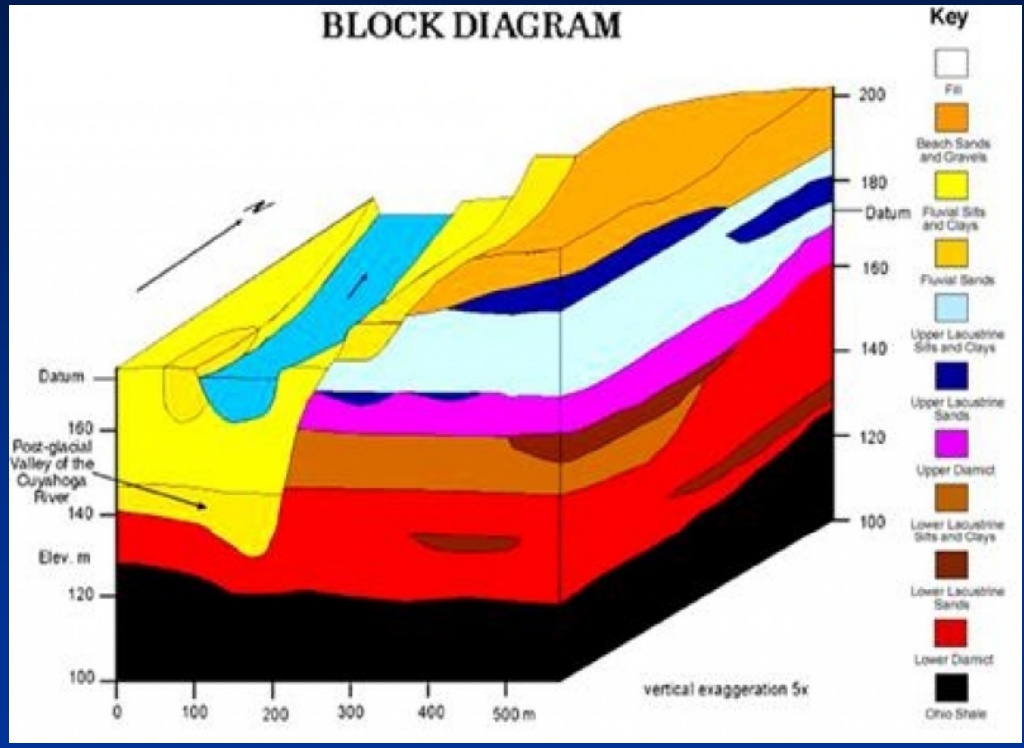


Rock Formations and Block Diagrams

1) Geologic block diagrams combine a geologic map (top) with two cross-sections (sides) to create a three-dimensional block model of the crust.

2) Most block models are oriented in a particular way in respect to cardinal directions.

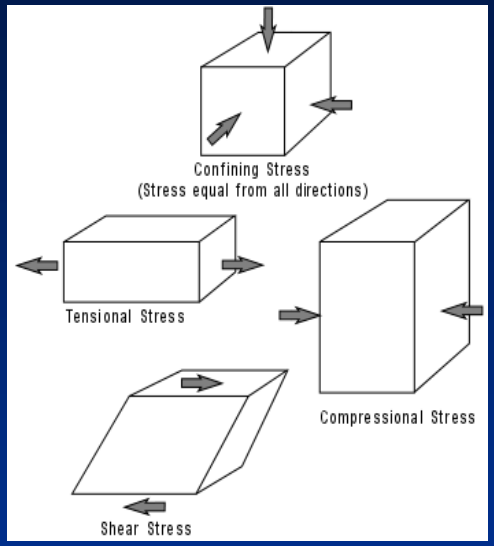
3) Block diagrams can be very helpful in analyzing various types of geologic structures, like stratigraphy, intrusions, folds and faults.

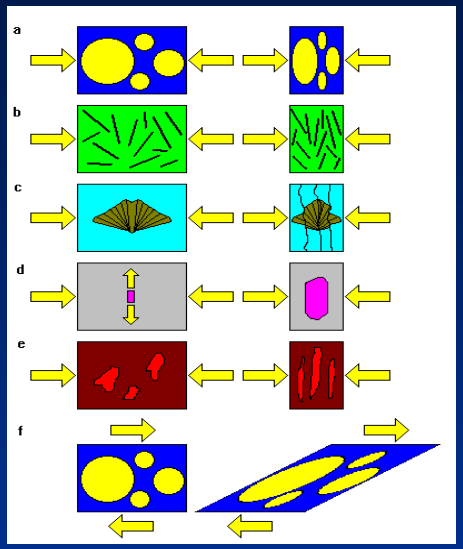


Origin and Nature of Rock Deformation

A. Stress Leads to Strain

- ✓ Stress is an applied force over an area
- ✓ Strain is the deformation of a solid body



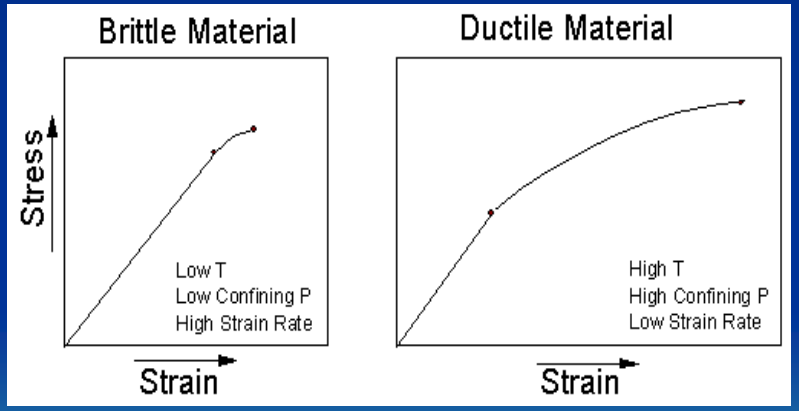


B. Different Types of Stress

- ✓ Tensional = pulling apart forces
- ✓ Compressional = pushing together forces
- ✓ Shear = grinding past each other force

C. Different Types of Strain

- ✓ Brittle = breaking into pieces
- ✓ Ductile = changing shape without breaking
- ✓ Elastic = deformed body returns to normal shape after stress released
- ✓ Plastic = deformed body remains deformed after stress released



Rocks strain in a predictable fashion, according to the amount and duration of strain under a given set of temperature-pressure conditions

Resultant Rock Strain from Specific Stresses

A. Undeformed Strata

- ✓ Original Horizontal layering

B. Compressional Stresses

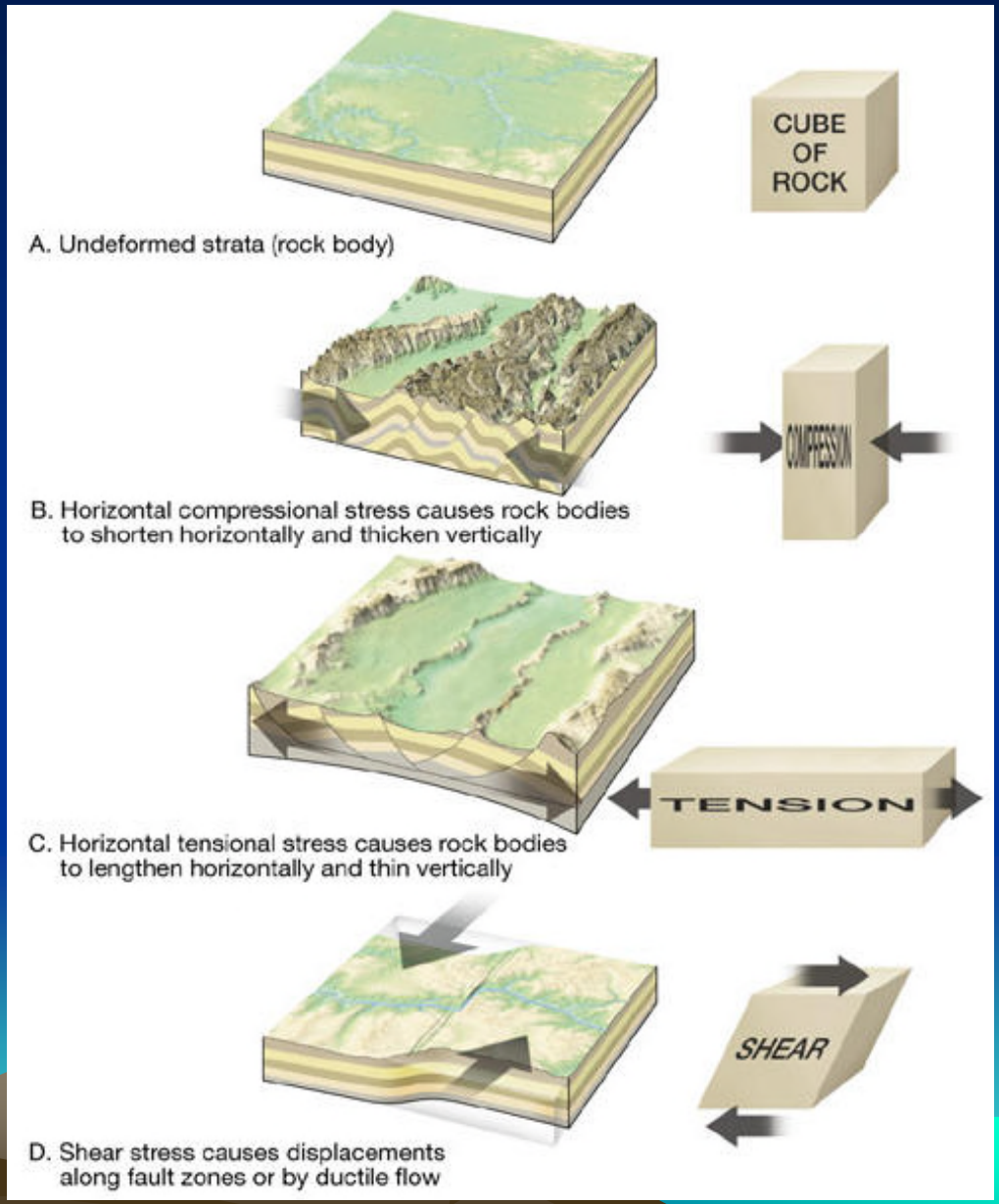
- ✓ Shorten horizontally
- ✓ Thicken vertically
- ✓ Folding and Reverse Faulting

C. Tensional Stresses

- ✓ Lengthen horizontally
- ✓ Thin vertically
- ✓ Tilting and Normal Faulting

D. Shear Stresses

- ✓ Lateral displacement
- ✓ Strike-slip Faulting



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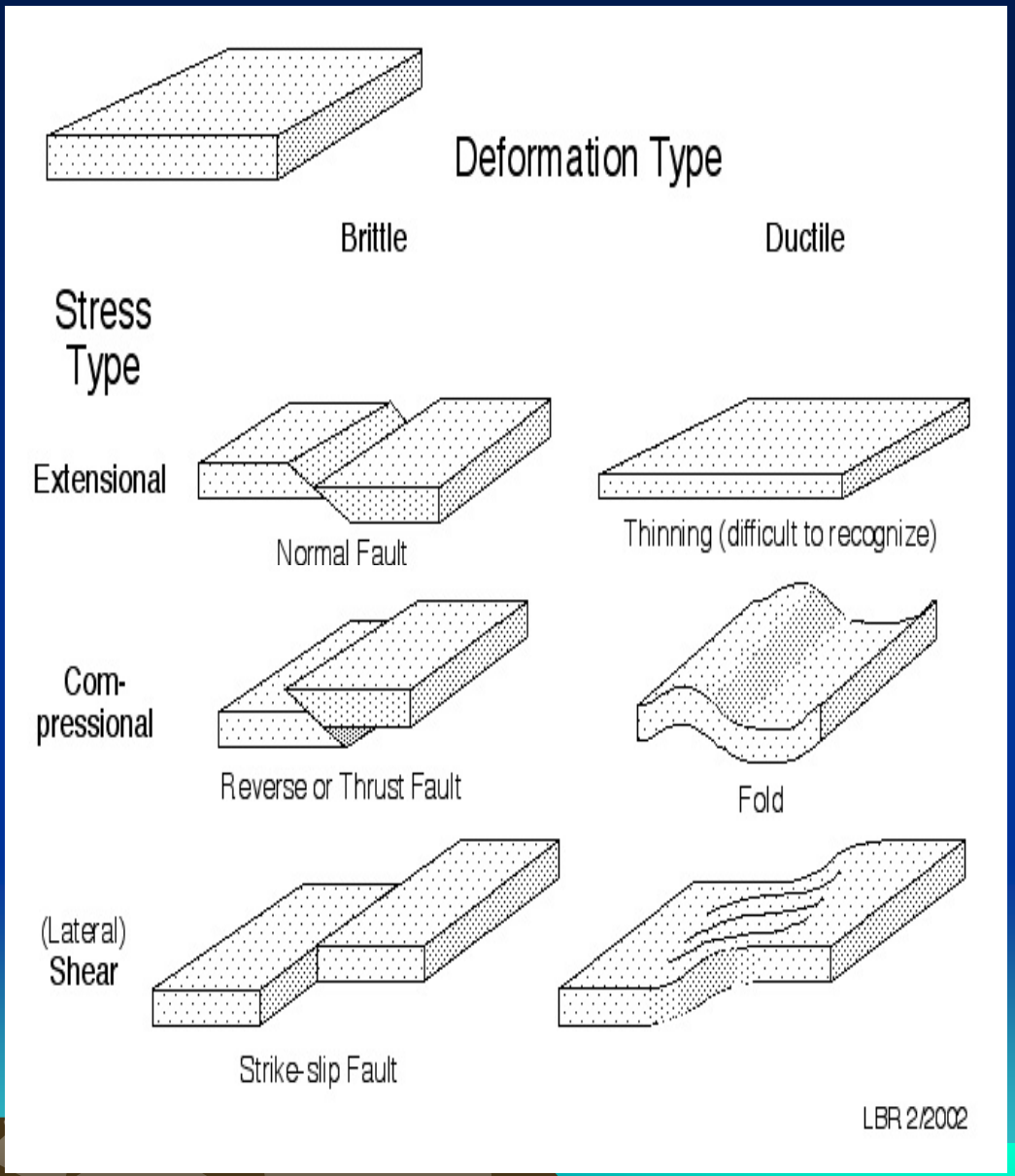
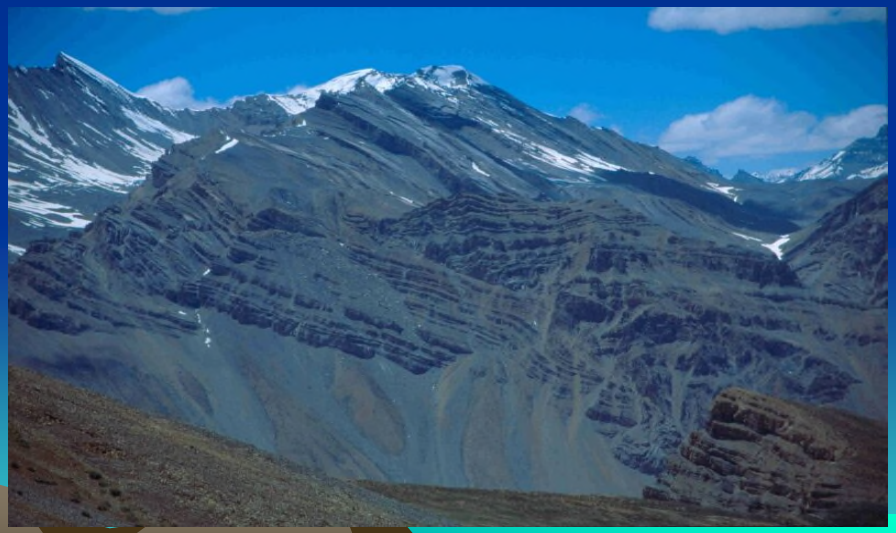


Geologic Structures

Rock Layering

Tilted Rock Layers

Folded Rock Layers



Faulted Rock Layers

The Basic Rules of Structure

1) Strike of beds is always parallel to the direction of the contacts.
2) Rock layers dip towards the youngest exposed rock layers.
3) Oldest rocks exposed in the center of eroded anticlines and domes.
4) Youngest rocks exposed in the center of eroded synclines and basins.
5) Horizontal folds form parallel sets of belt-like outcrop patterns.
6) Plunging anticlines form “V” of "U" shaped, belt-like outcrop patterns.
    - Anticline fold plunges toward *closed* end of “V” or “U” pattern.
7) Plunging synclines form ”V” of “U" shaped, belt-like outcrop patterns.
    - Syncline fold plunges toward *open* end of “U” pattern.
8) Steeper the dip of the layer, the more narrow the width of its outcrop.
9) Hanging wall is towards the fault dip direction; foot opposite to fault dip direction
10) Hanging wall *moves up* relative to foot wall in reverse and thrust faults.
11) Hanging wall *moves down* relative to foot wall in normal faults.
12) Slickenside grooves oriented horizontal in fault scarp indicate strike-slip offset.
13) Slickenside grooves oriented vertical in fault scarp indicate dip-slip offset.

Spatial Orientation of Layers

Strike and Dip

1) The spatial orientation, or ***attitude*** of a planar rock layer or structural feature can be measured and recorded in the field.

2) Two spatial aspects are needed:

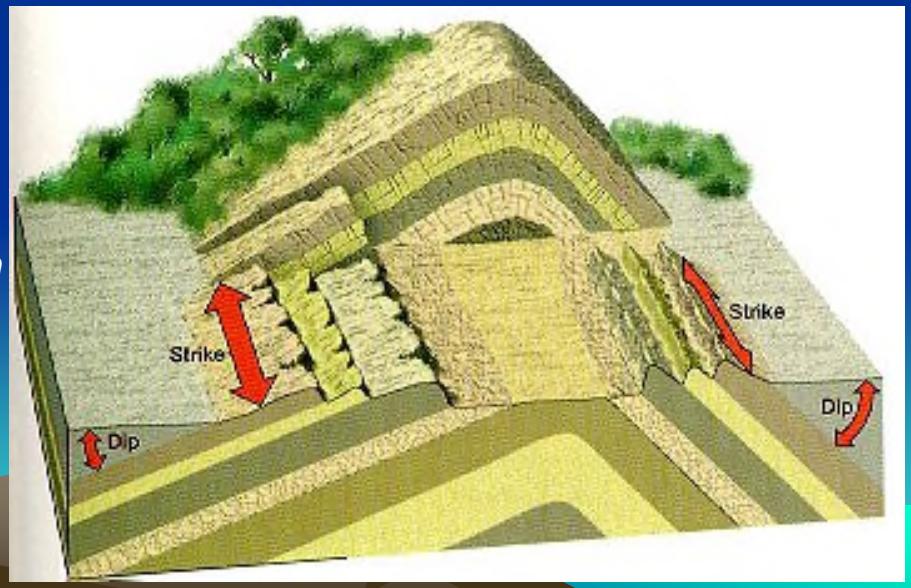
- ✓ **Strike** = horizontal component
- ✓ **Dip** = angle below the horizontal

3) The **Strike** is the line, or *trend* that represents the intersection of the planar feature with the horizontal.

4) **Strike** is measured with a compass.

5) **Dip** is the downward angle, or *inclination* of the feature from horizontal at a right angle to the strike.

6) **Dip** is measured with a clinometer.

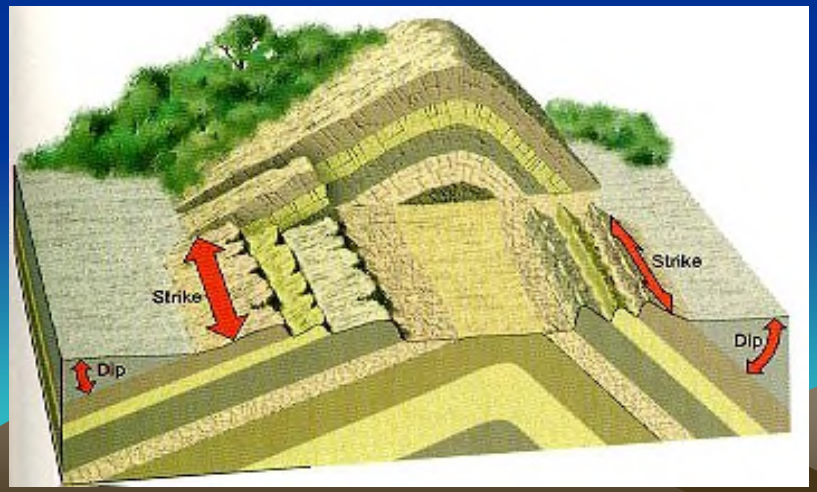


Using a Compass/Inclinometer to Determine Spatial Orientation of Layers

Strike and Dip

Measuring Strike Azimuth

Measuring Dip Angle



Strike Azimuth and Dip Angle

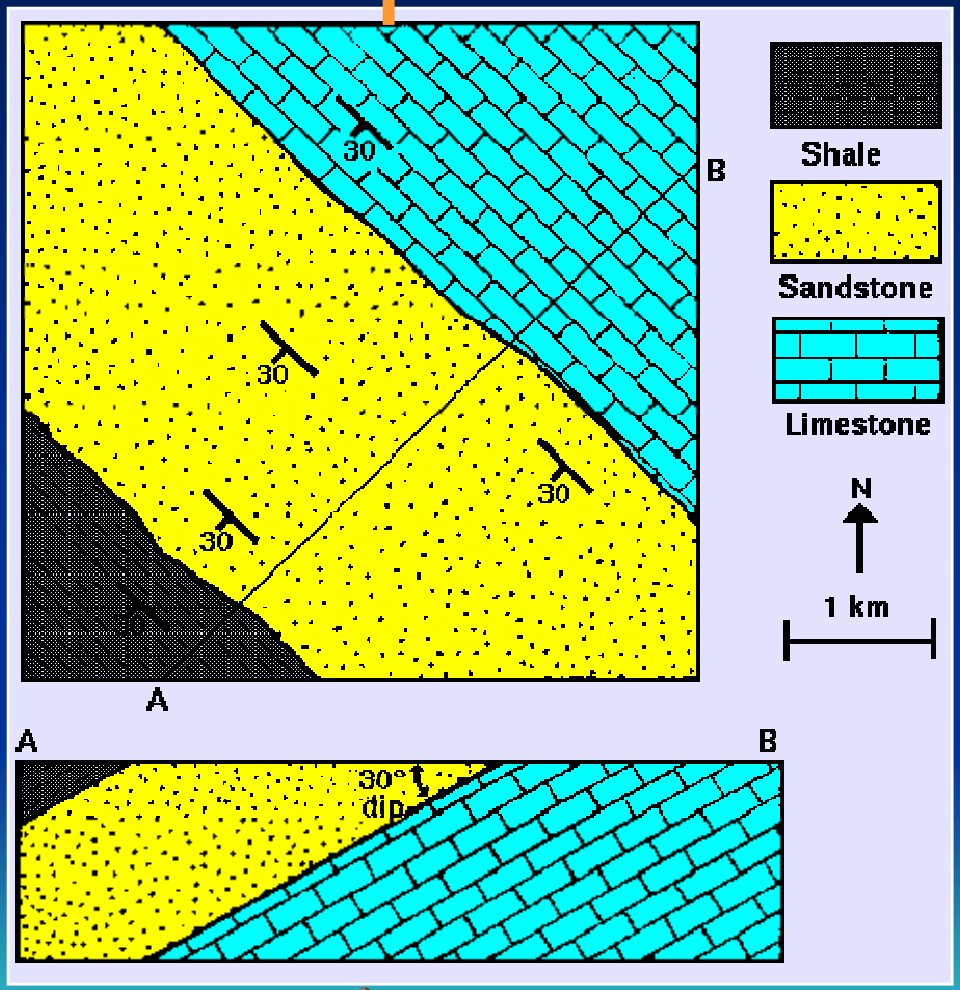
Completed Strike and Dip Measurement

Spatial Orientation of Layers

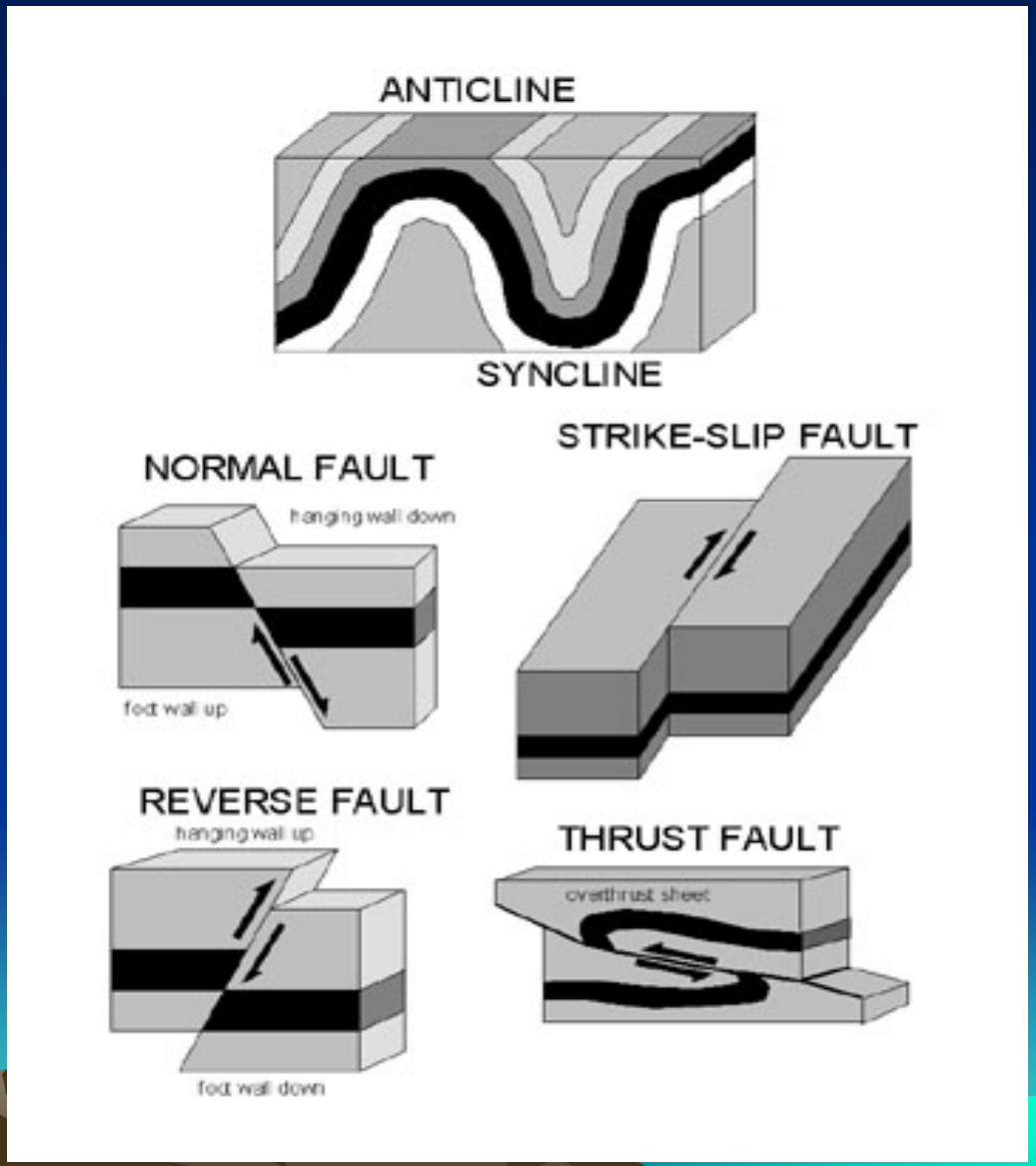
Strike and Dip

The **Strike** and **Dip** of a planar rock layer or feature is symbolized on a geology map by a

- ✓ The long bar is the strike trend
- ✓ The short bar points to the down dip direction with dip angle



Folds and Faults



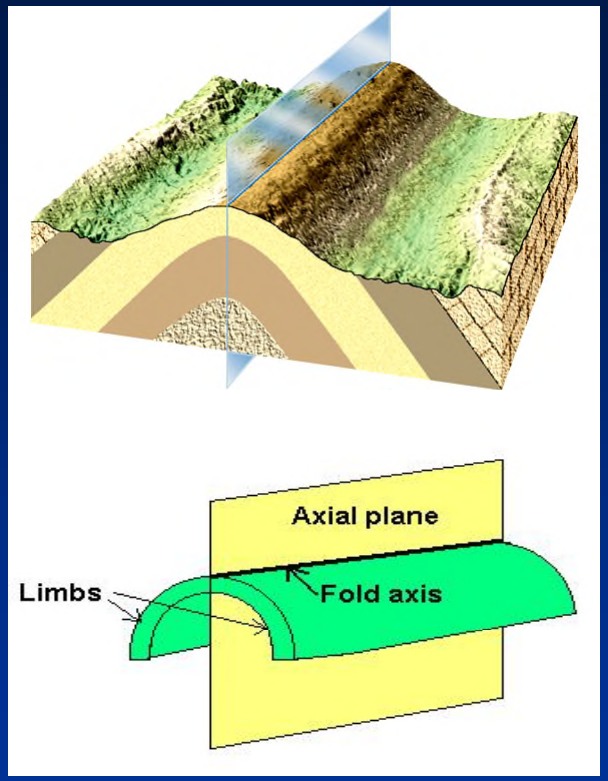
General Geologic Terms of Folds

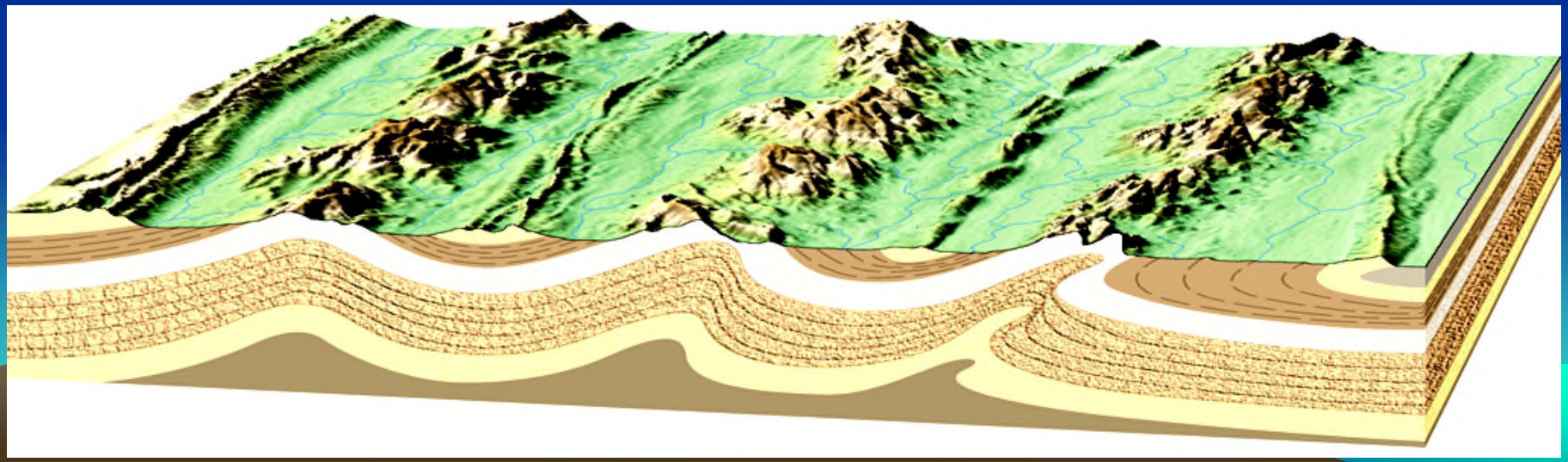
Folds: Buckled layers of rock formed by compressive stresses

Anticline: Upwards-buckled fold with oldest rock at center and outward-dipping limbs

Syncline: Downwards-buckled fold with oldest rock at center and outward-dipping limbs

Fold Basics





Fold Basics

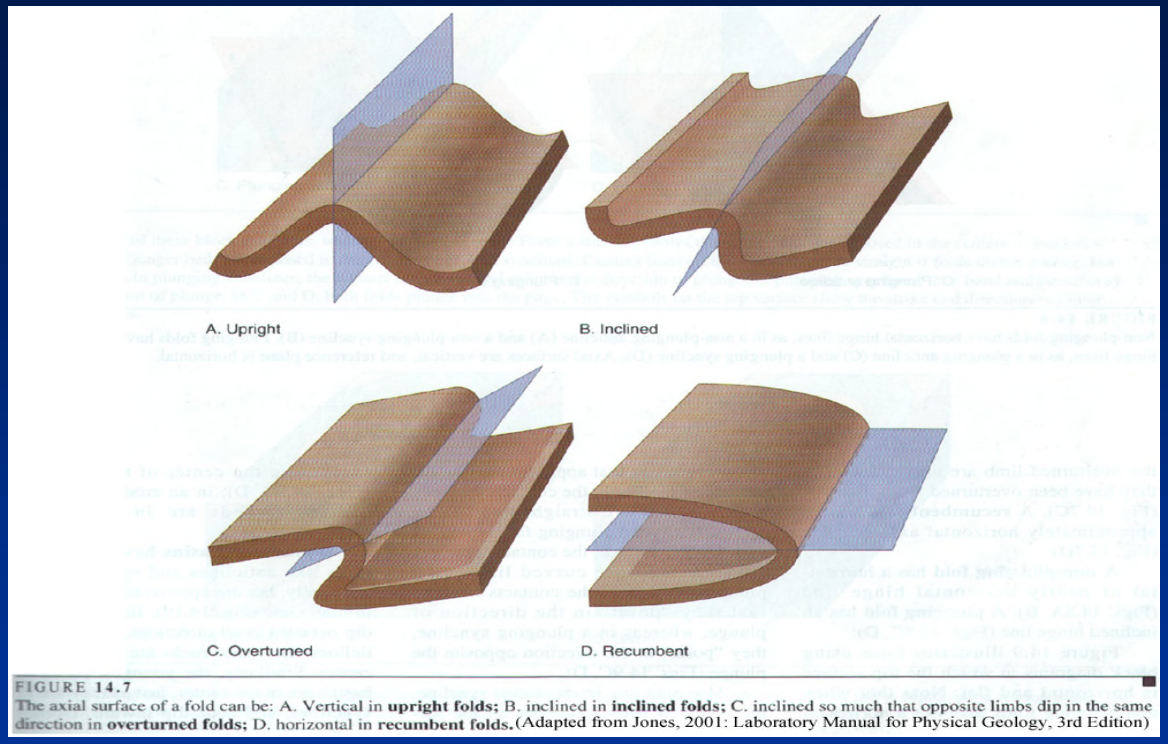
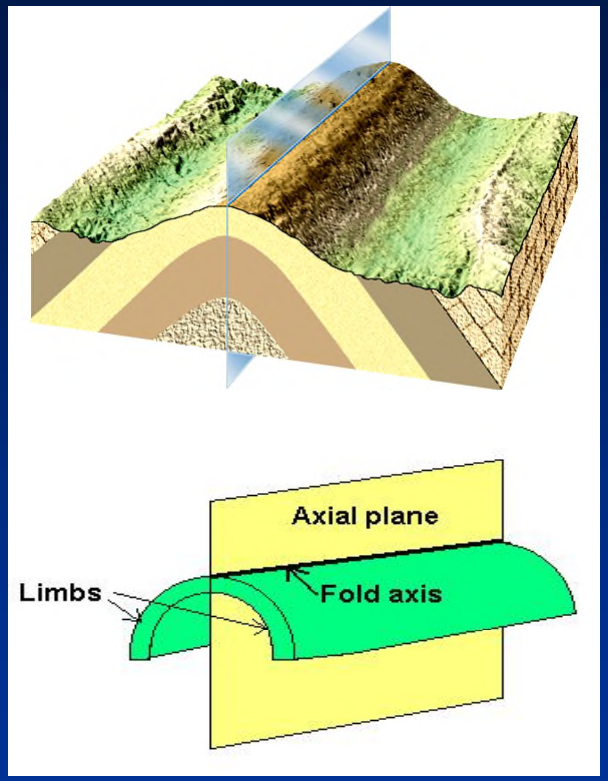
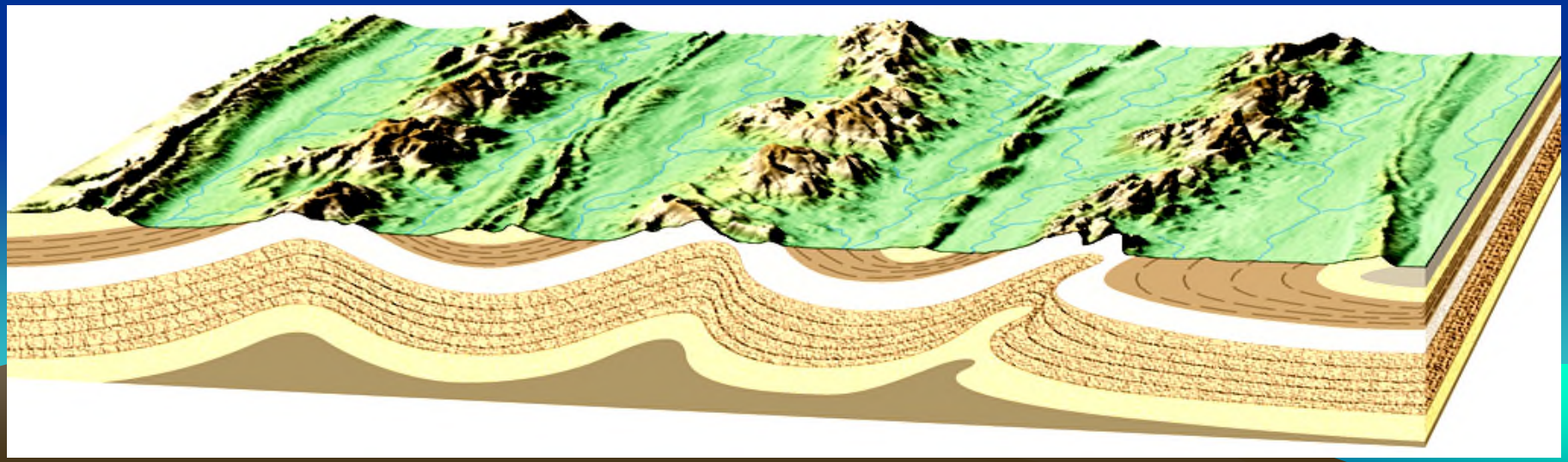
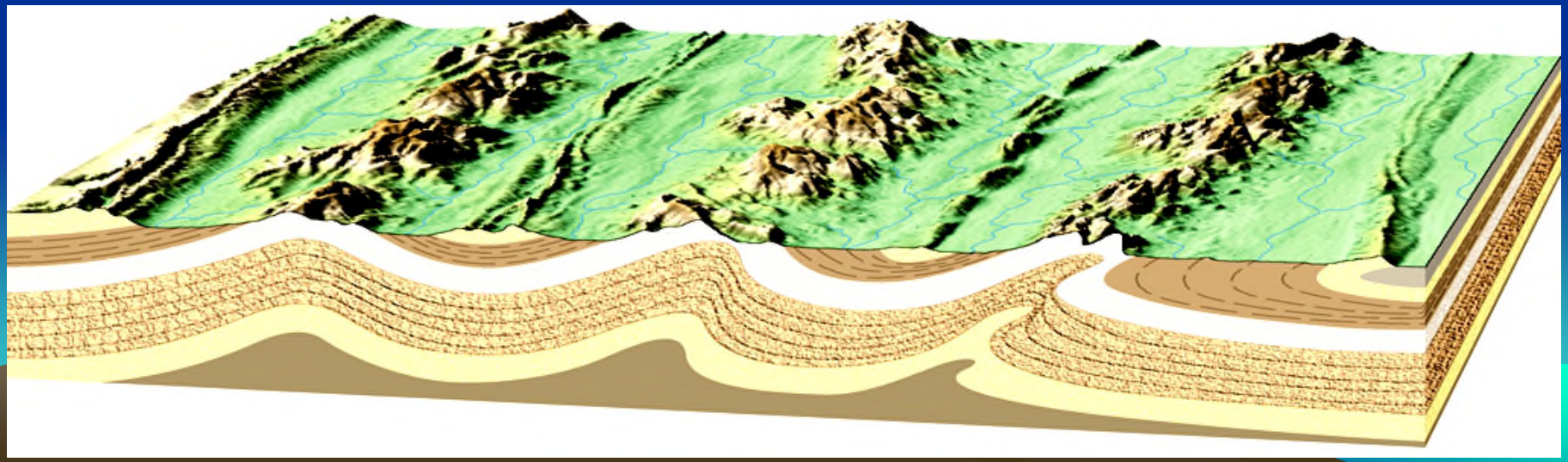


FIGURE 14.7
The axial surface of a fold can be: A. Vertical in **upright folds;** B. inclined in **inclined folds;** C. inclined so much that opposite limbs dip in the same direction in **overturned folds;** D. horizontal in **recumbent folds.** (Adapted from Jones, 2001: Laboratory Manual for Physical Geology, 3rd Edition)





Fold Basics



Rules of Folds

Anticlines

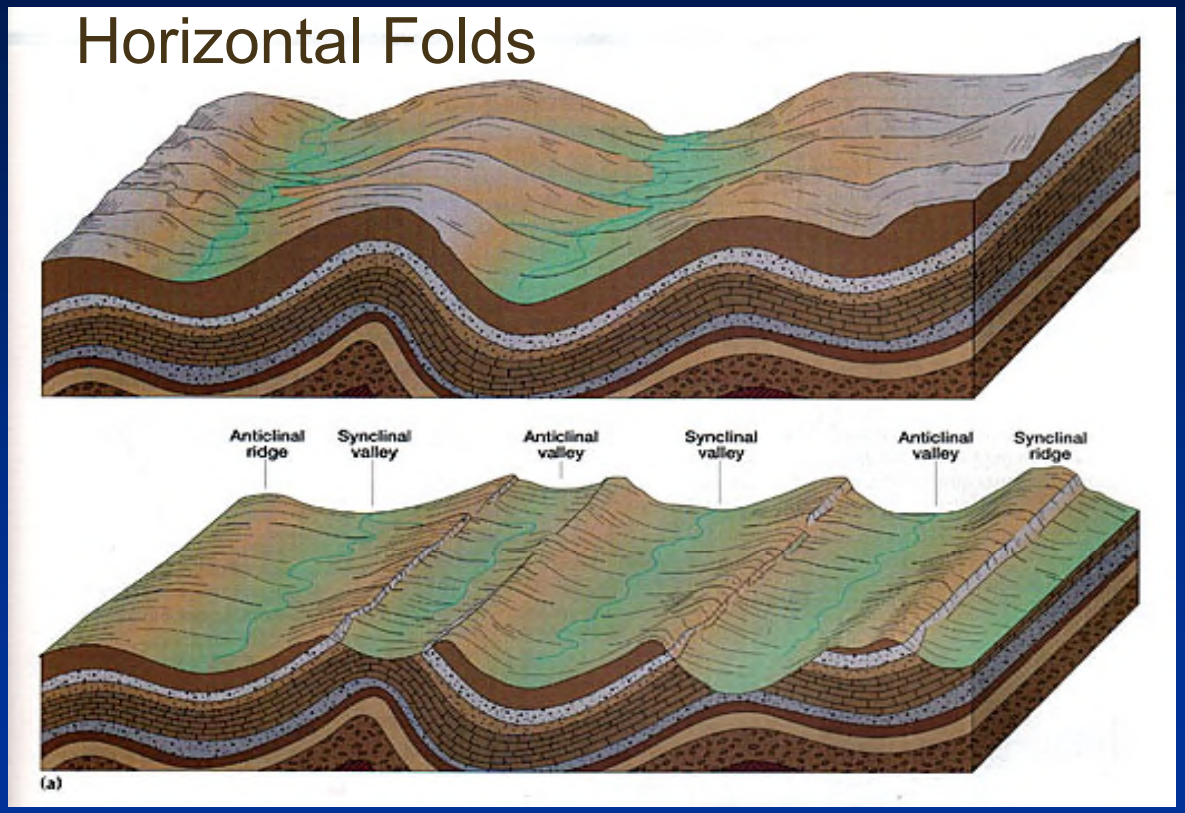
1) Oldest unit in center
2) Limbs dip outward

Synclines

1) Youngest unit in center
2) Limbs dip inward

Horizontal Folds

1) Strikes of opposing fold limbs are all parallel
2) Folds form parallel striped pattern on geology map

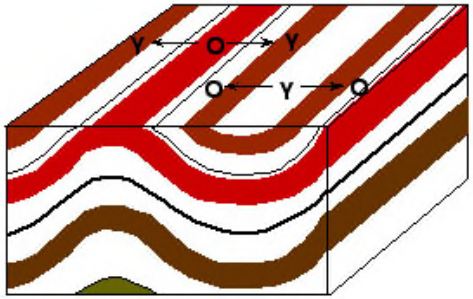


Plunging Folds

1) Strikes of opposing fold limbs are not parallel
2) Folds form V-shaped pattern on geology map
3) Anticlines plunge toward closed end of “V”-shaped bedding pattern
4) Synclines plunge toward open end of “V”-shaped bedding pattern

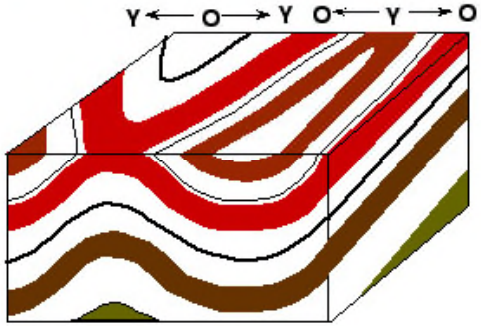
Plunging Folds

Plunging Folds

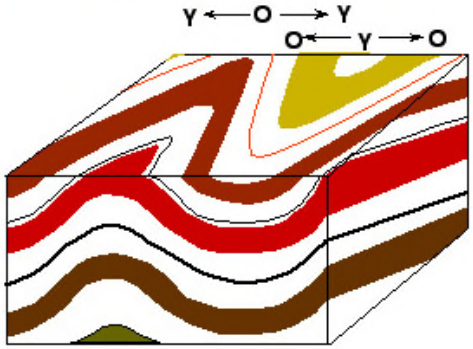


Anticline and Syncline in 3-dimensional view

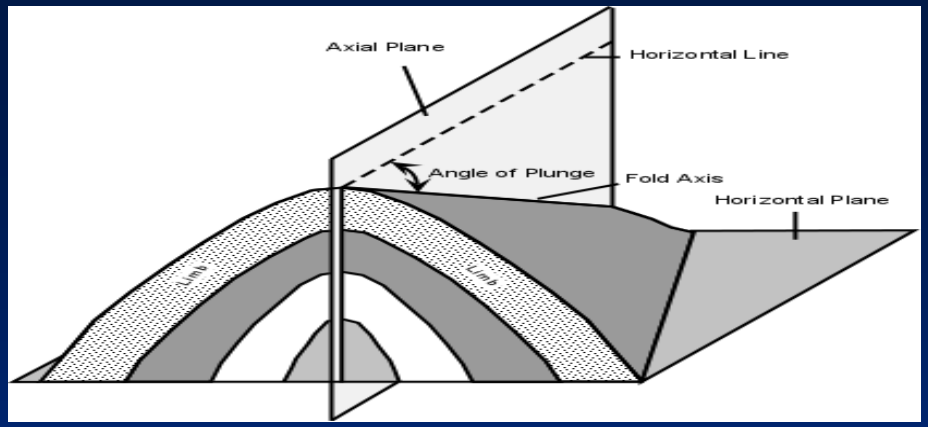
Oldest beds are in centers of anticlines; youngest beds are in centers of synclines.

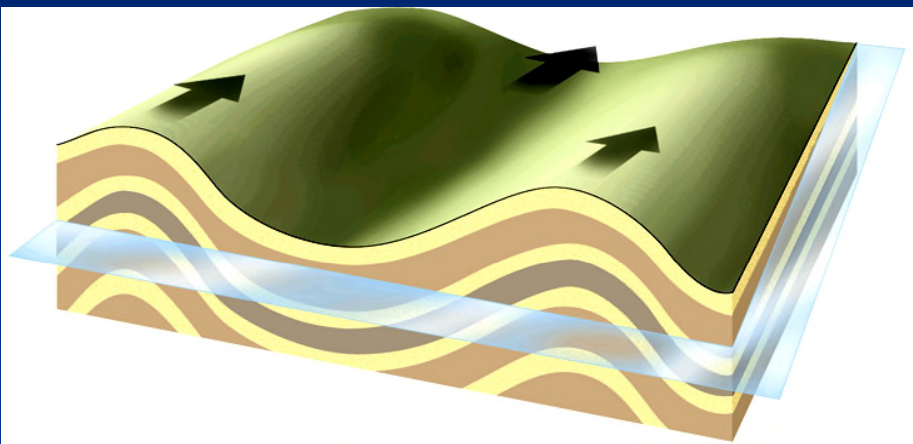


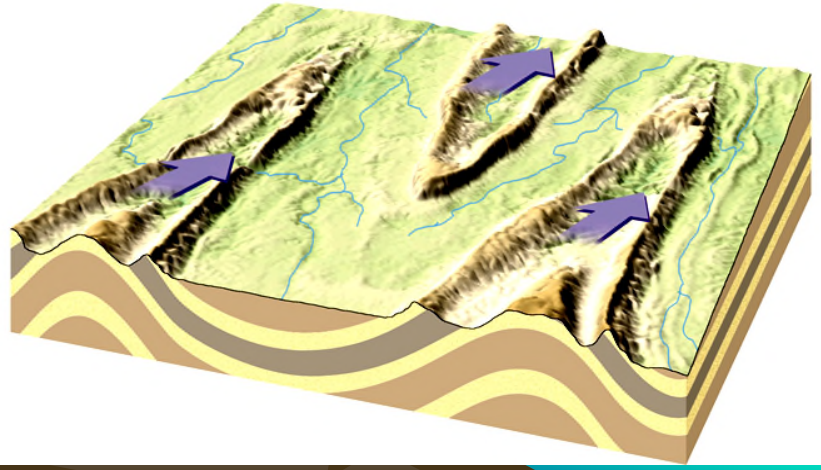
Anticline and Syncline plunging toward viewer



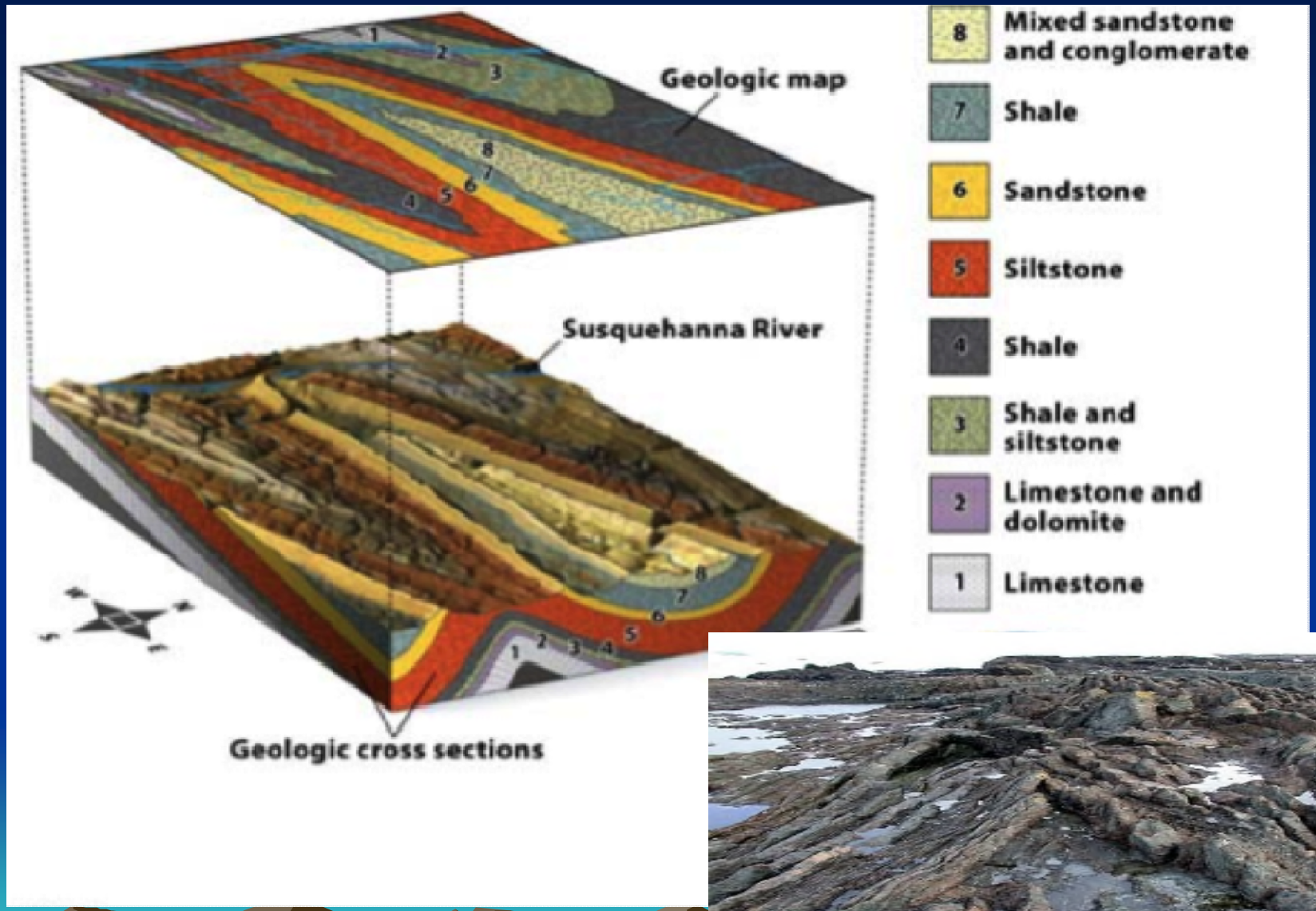
Anticline and Syncline plunging away from viewer



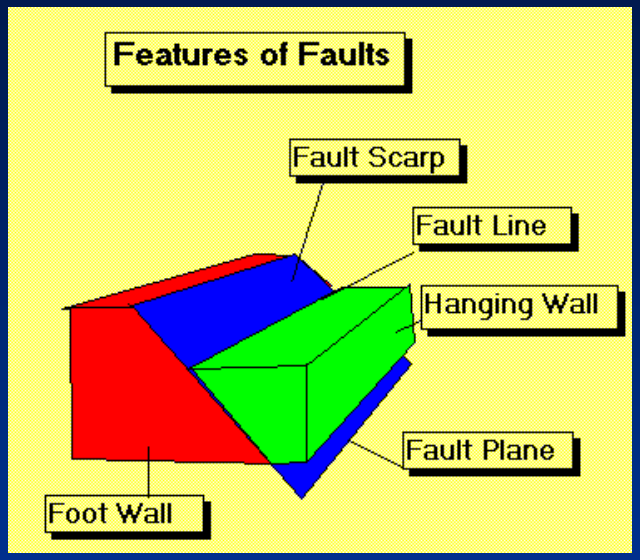


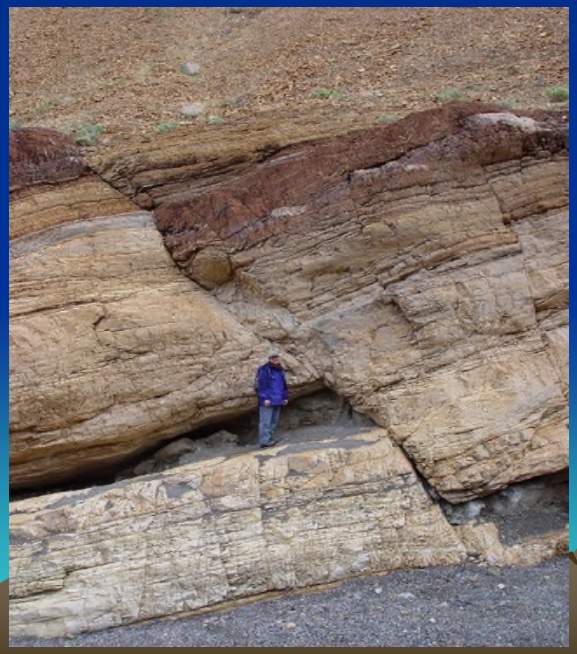


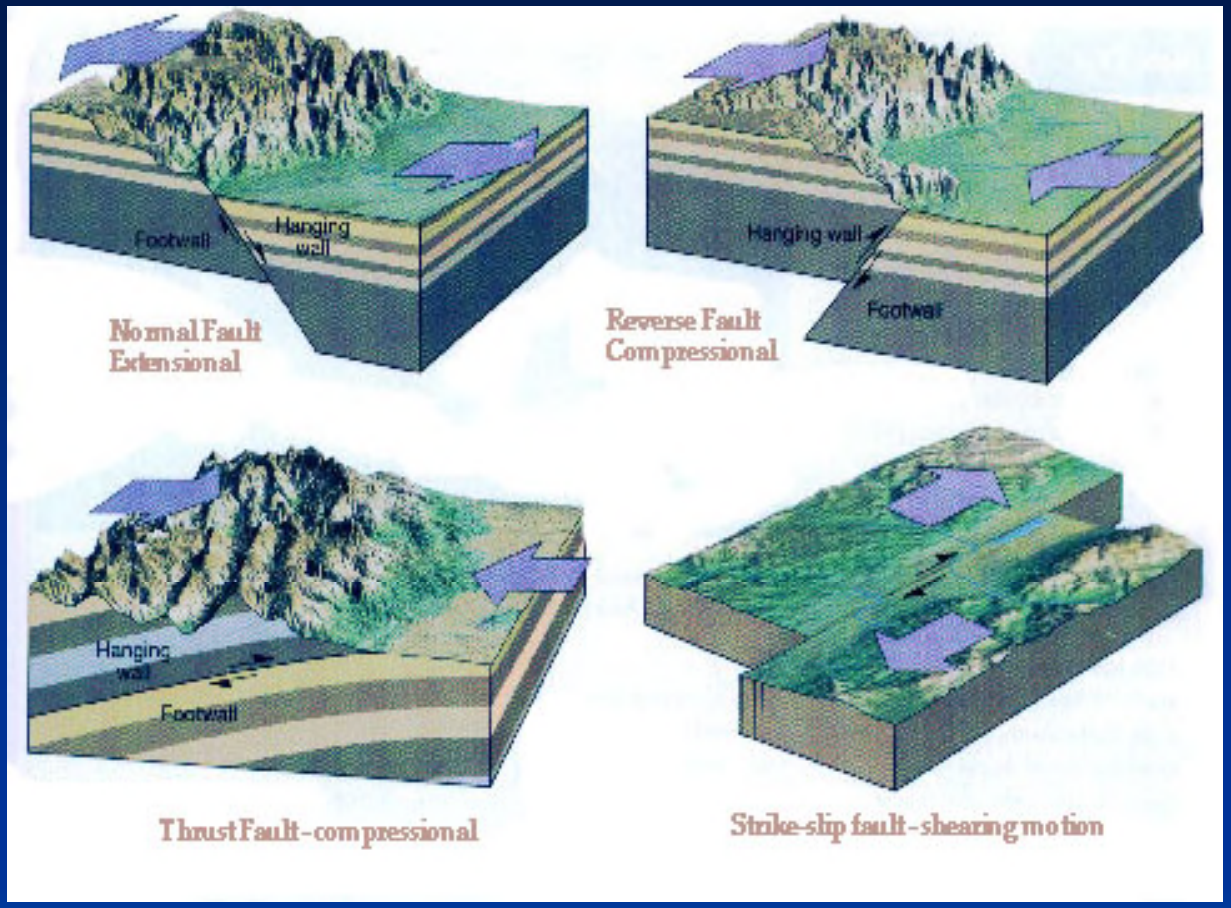
Plunging Folds



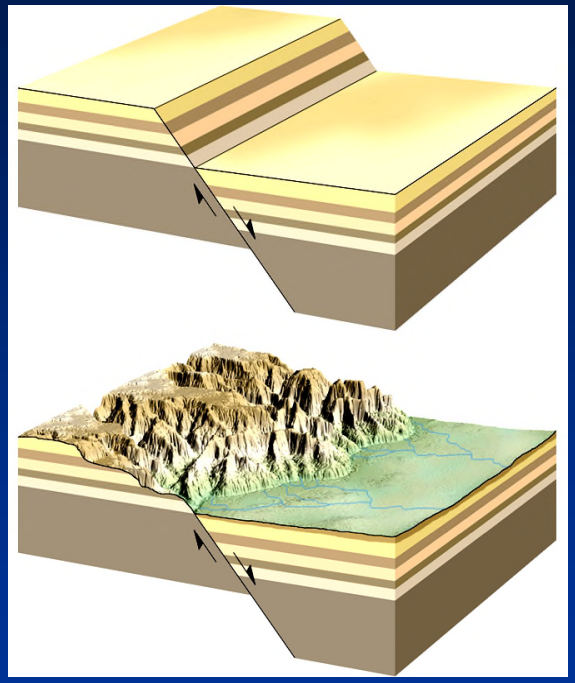
Fault Terminology



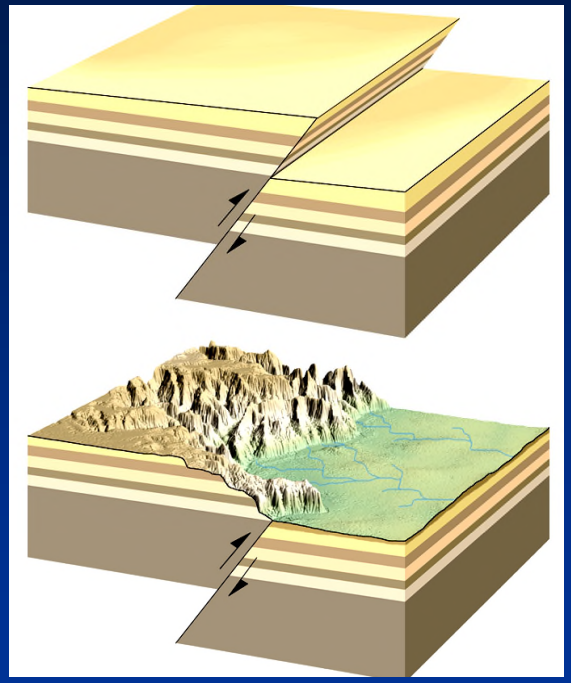




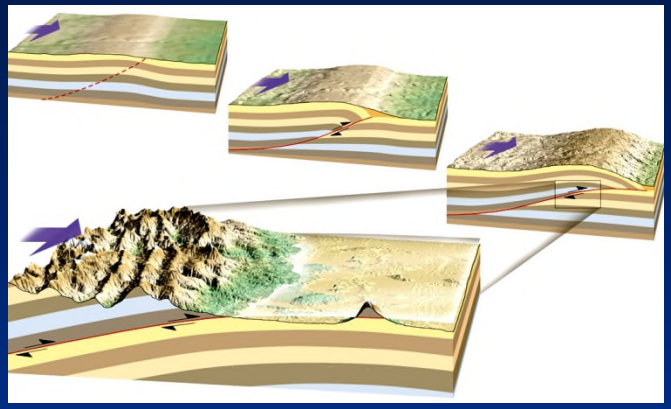
Types of Faults



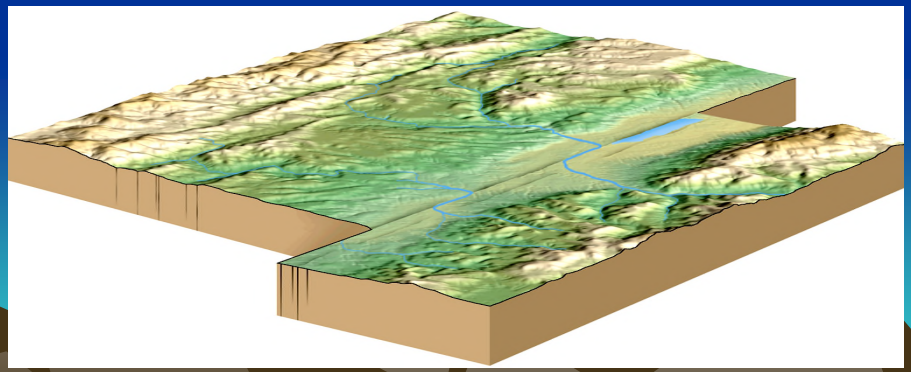
Normal Fault



Reverse Fault

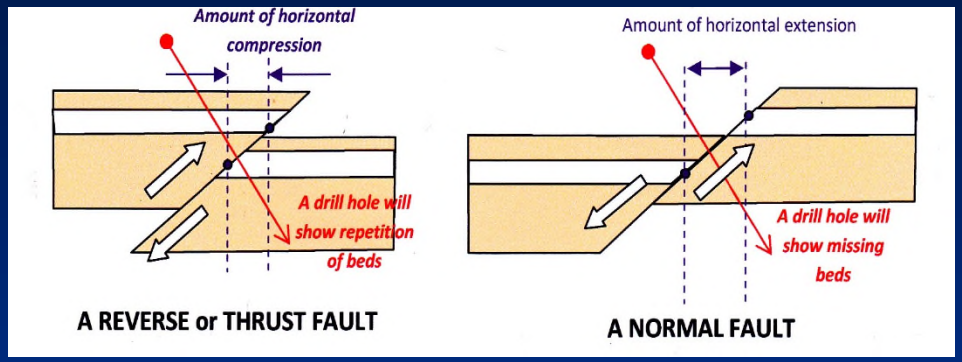


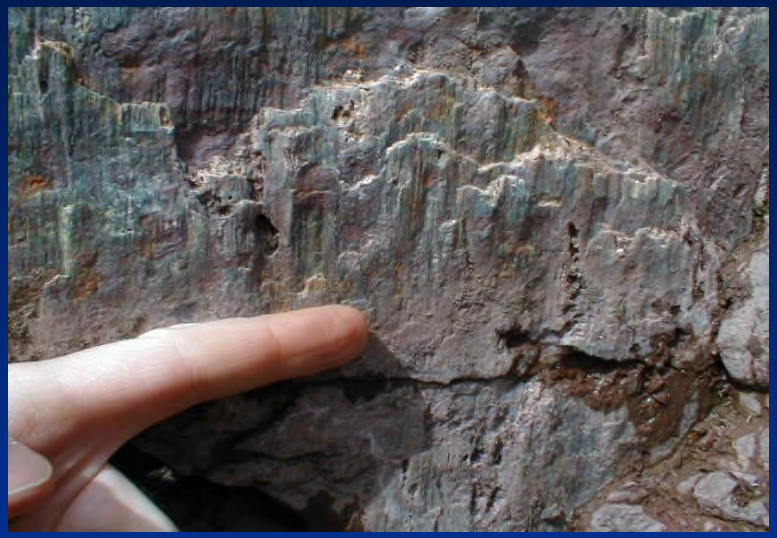
Thrust Fault



Strike-Slip Fault

Fault Offset and Slickensides





Dip-slip oriented slickensides

Normal-sense, dip-slip offset

Reverse-sense, dip-slip offset