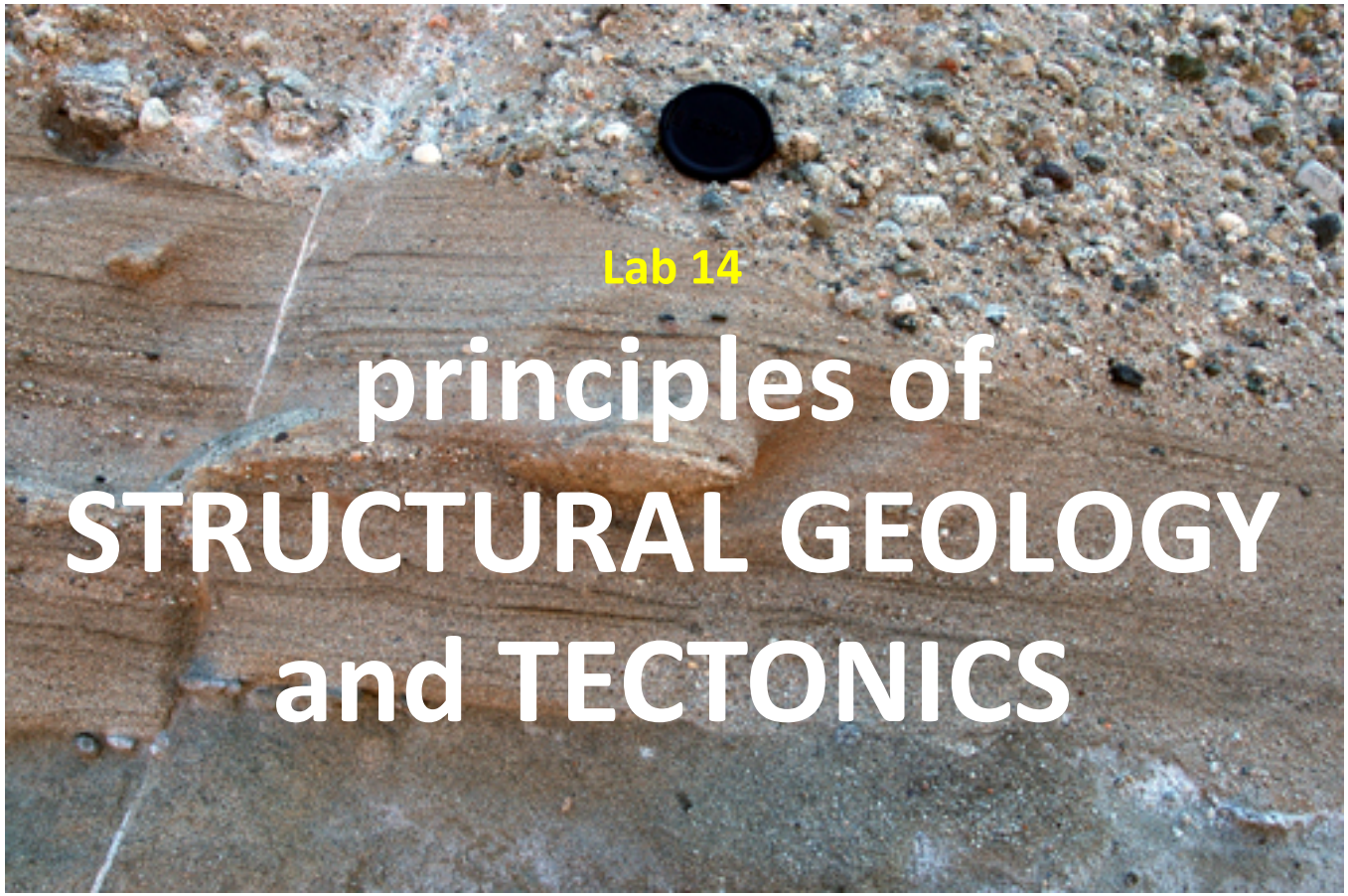


Lab 14

principles of STRUCTURAL GEOLOGY and TECTONICS

Alessandro Grippo, Ph.D

Structural Geology and Tectonics

- Branches of geology that deal with the reconstruction of movements that have occurred over time in Earth's Lithosphere

- from Latin (struere) and Greek (tektos) = to build

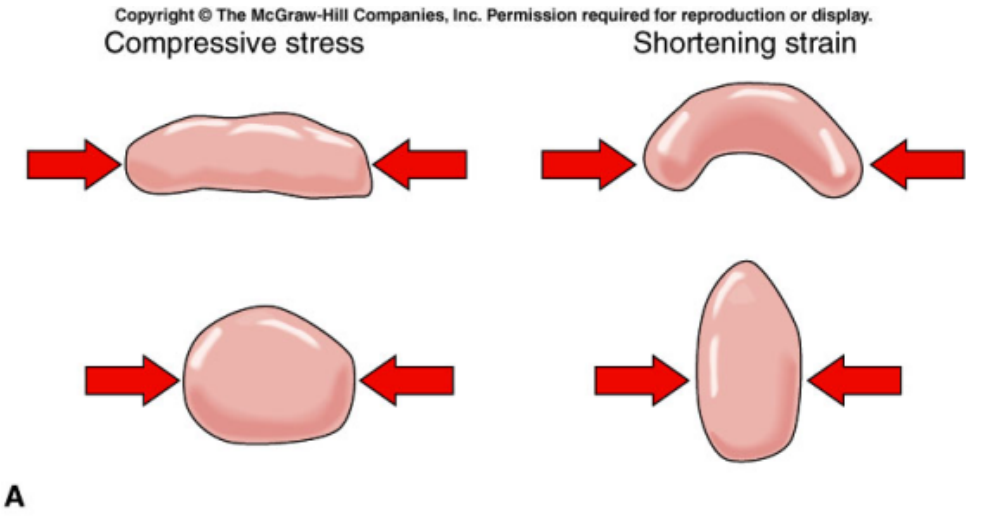
- movements include
  - simple motion
  - bending
  - breaking

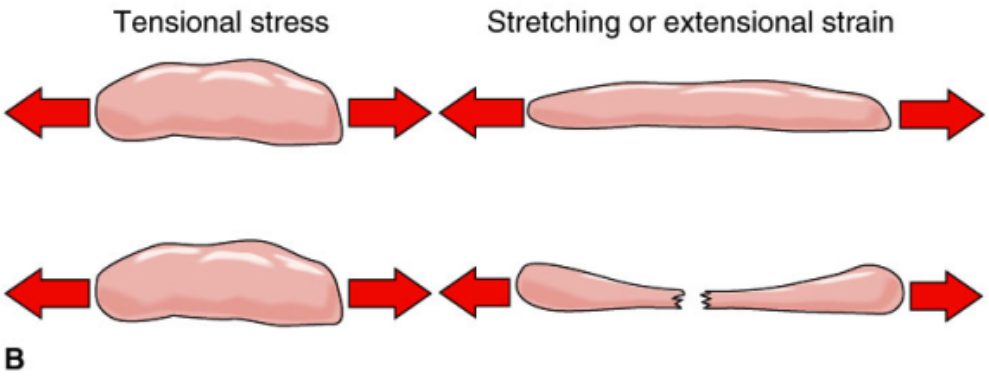
Structural Geology and Tectonics

- If we know
  - under what conditions motion occurs
  - how deformations are originated

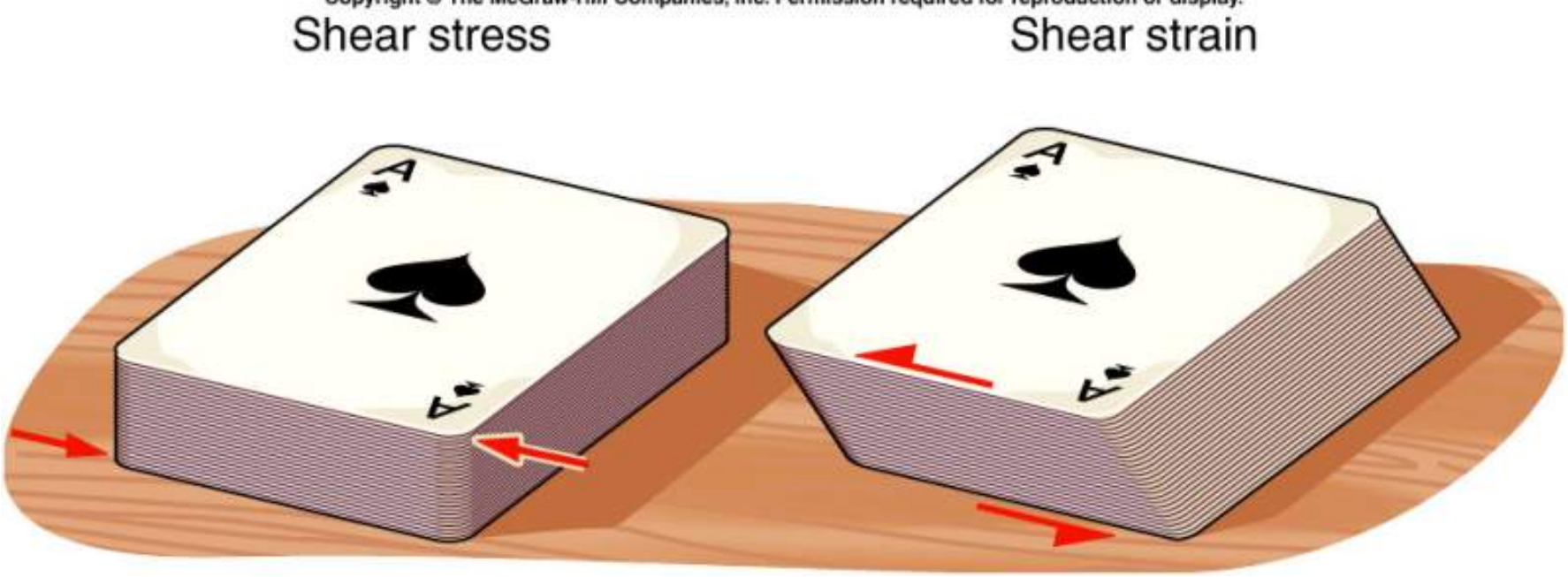
- Then we
  - get information for reconstructing Earth's History
    - big scale: plate motion (Tectonics)
    - medium-size scale: mountain building (Tectonics)
    - small scale: local deformation, as caused for instance by earthquakes (Structural Geology)
    - micro- and submicroscopic scale: deformation in rocks and minerals (Structural Geology)

Compression and Tension





Shear



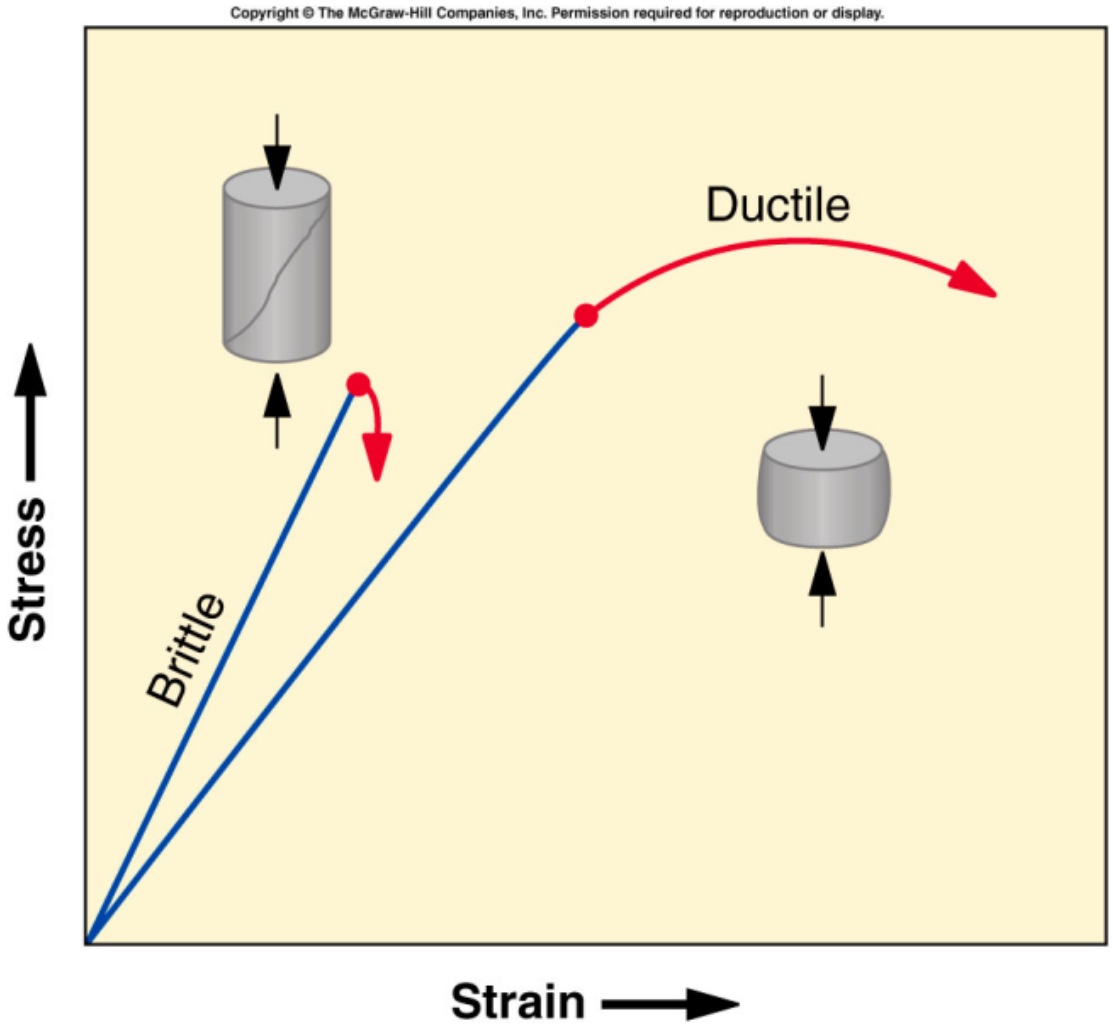
How do we study Lithosphere's deformation?

- Qualitative and quantitative analysis
  - continuum mechanics
  - laboratory deformation testing
  - mathematical models
  - study of geophysical data
    - seismic, gravity, magnetic
  - satellite images, airborne and spaceborne data
  - petrology and geochemistry
  - sedimentology, stratigraphy, paleontology

Lithospheric deformations originate Structures

- A force (stress) causes a deformation (strain)
  - elastic deformation
  - brittle deformation
    - joints
    - faults
  - ductile deformation
    - folds

Elastic, Brittle, and Ductile Deformation



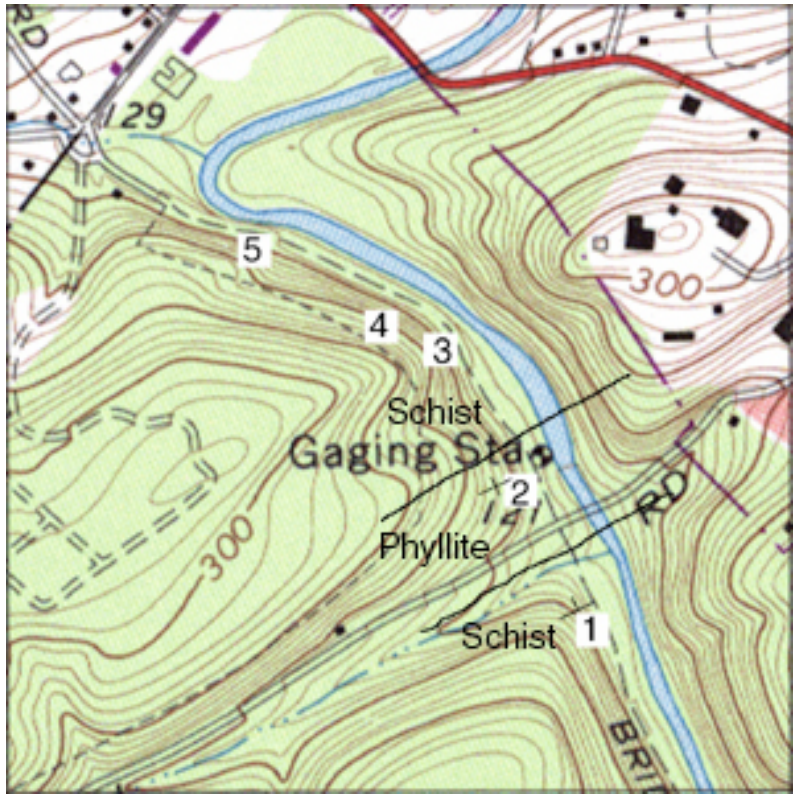
Attitudes: strike and dip

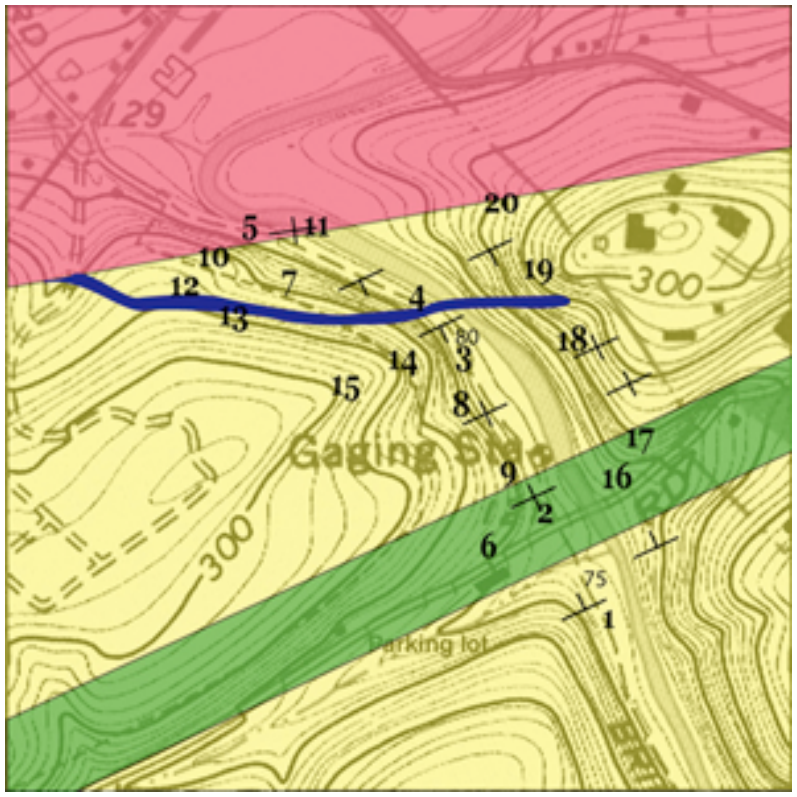
- In order to understand how tectonic deformation occurs we need to understand the orientation of structures in space

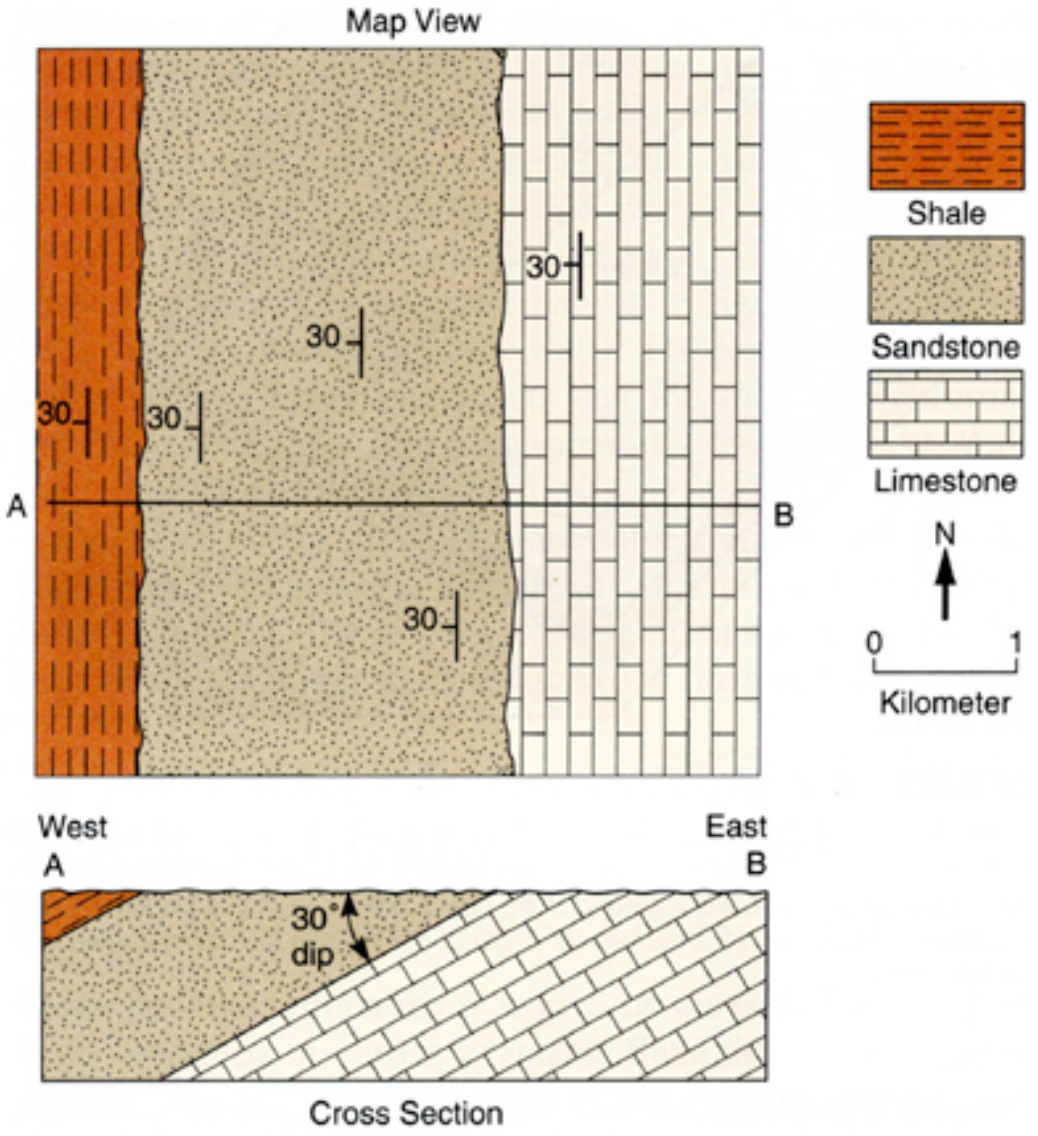
- This system is based on the **strike** and the **dip** of a surface (its attitude)

- Mostly used for geologic mapping, strike and dip are useful in understanding structures

Topographic Map vs. Geologic Map

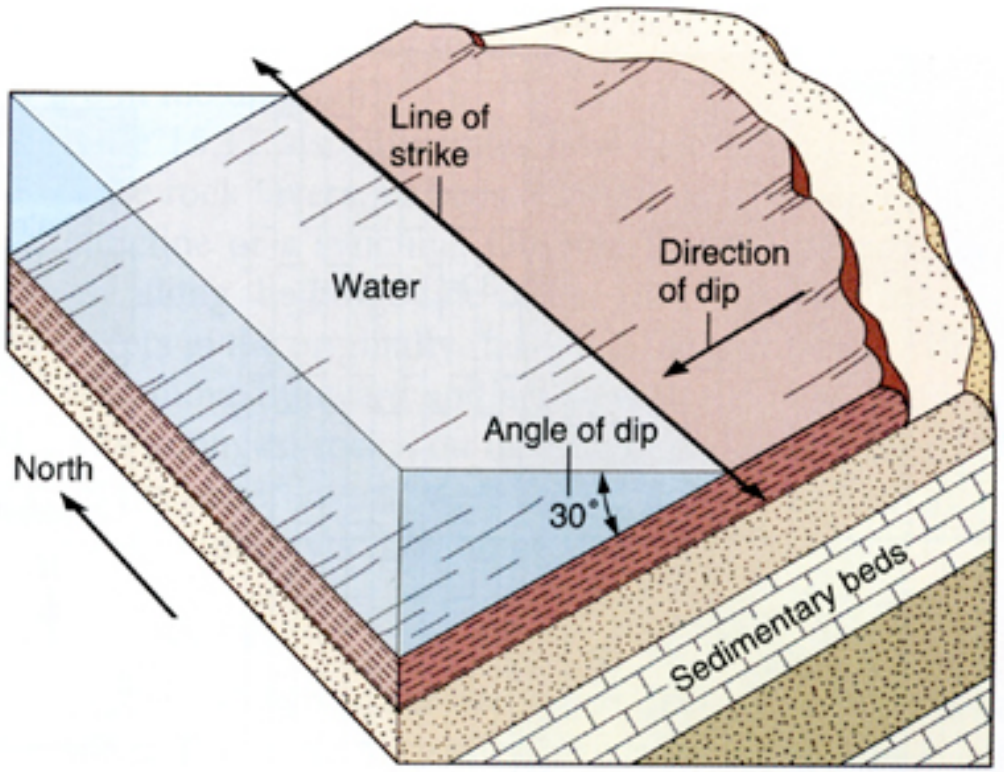





Map View
30
30
30
30
30
A
B
Shale
Sandstone
Limestone
N
0
1
Kilometer
West
East
A
B
30°
dip
Cross Section

- The **STRIKE** is a line that comes from the intersection of an inclined plane (a tilted layer, for instance) with an imaginary horizontal surface

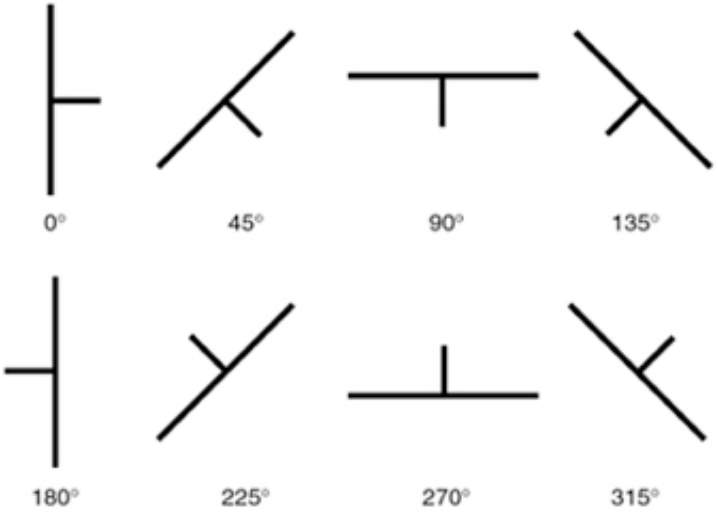
- Its direction can be measured in the field with a compass

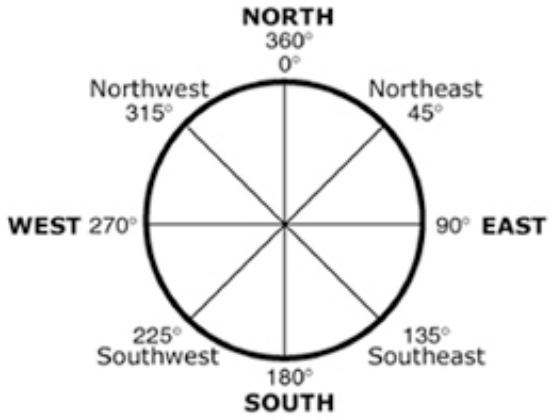

Line of
strike
Water
Direction
of dip
Angle of dip
30°
North
Sedimentary beds

- The DIP is is simply the angle of maximum inclination of our surface (layer)
- The dip is always at 90° from the strike
- The dip points in the direction of the tilt

Strike and Dip symbols

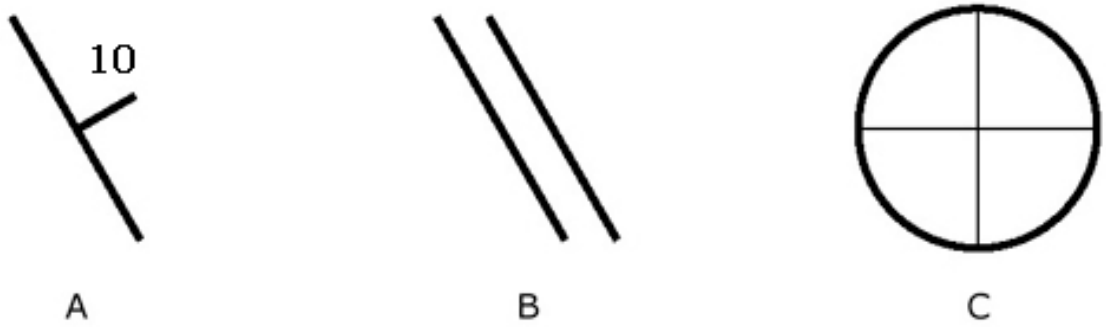
- Attitude is represented by a T-shaped symbol
  - the long arm of the T represents the strike
  - the short arm of the T represents the dip
  - a number is associated with the symbol, indicating the angle of dip





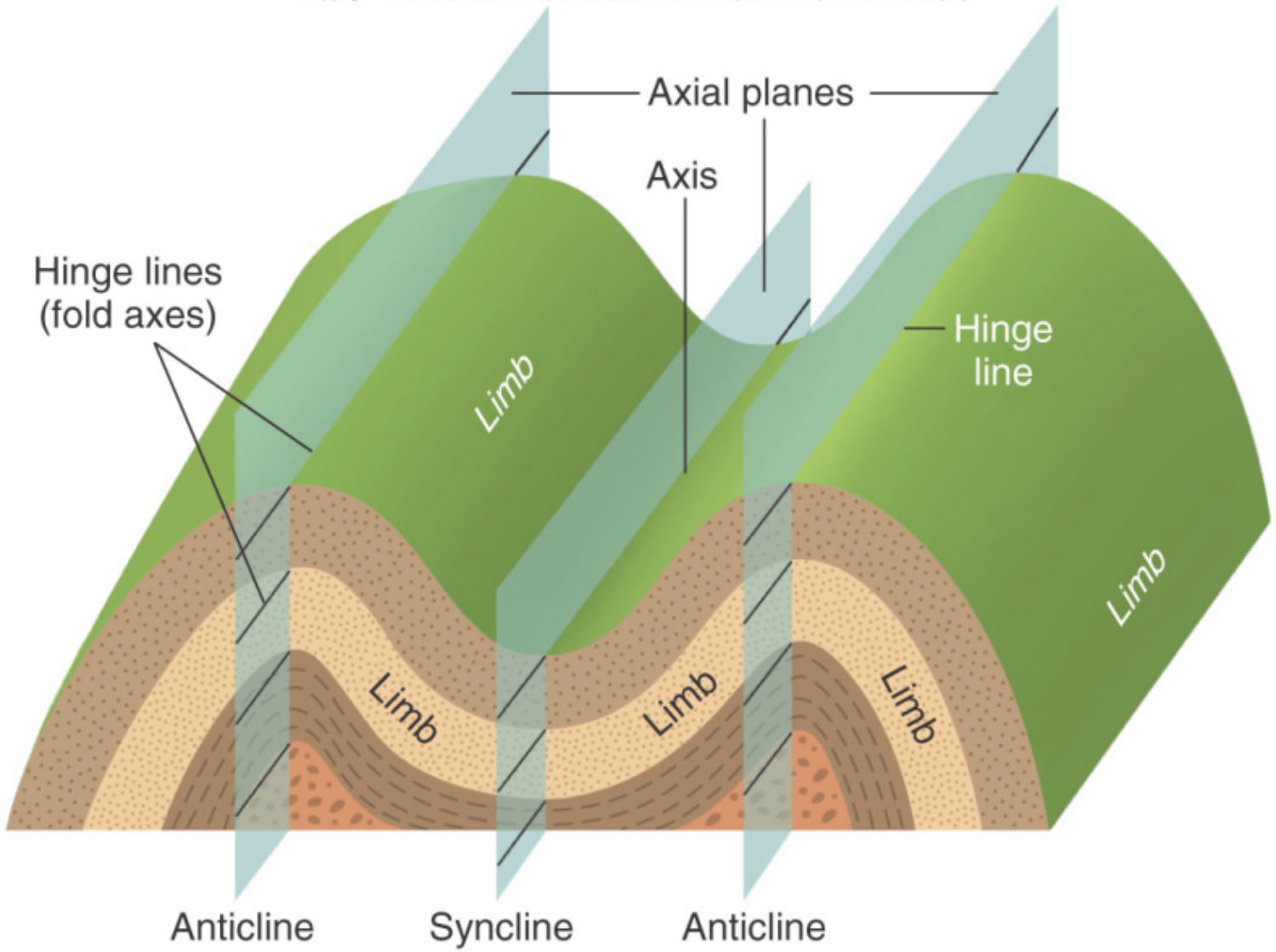
Vertical layers: dip is 90°

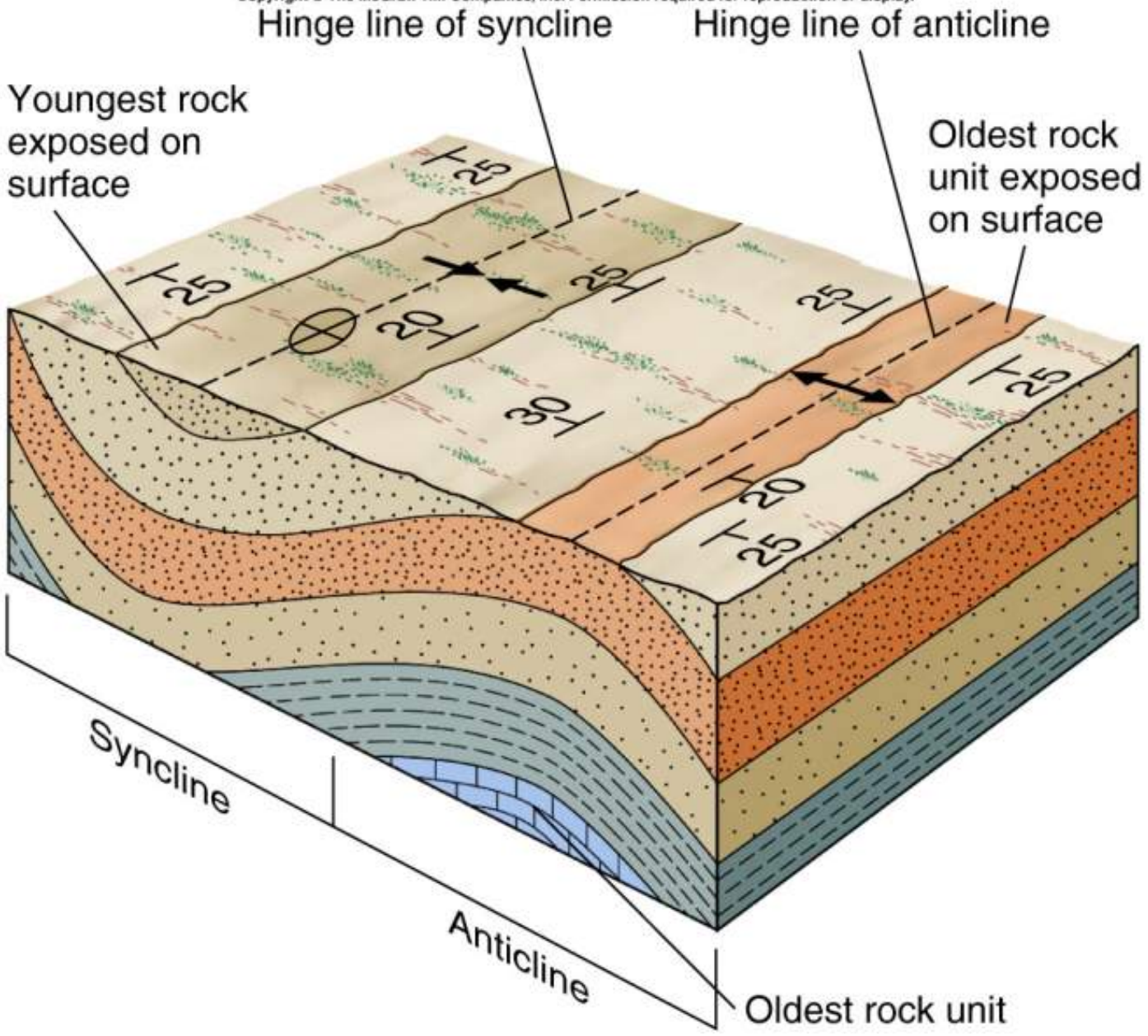
Duluth, Minnesota

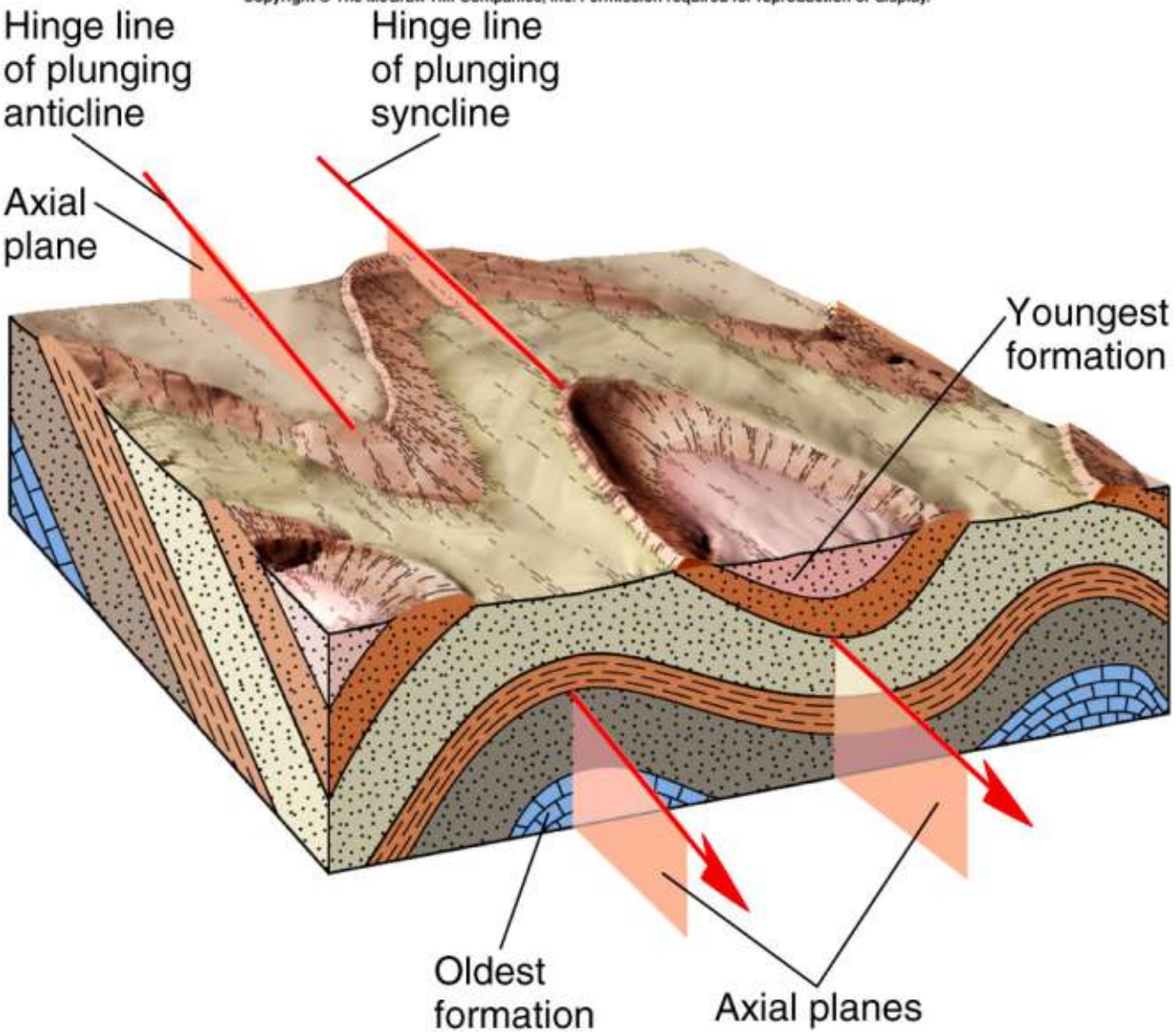


- A: the “normal” symbol for strike and dip: a layer tilted by 10° towards ENE
- B: vertical layers
- C: horizontal layers

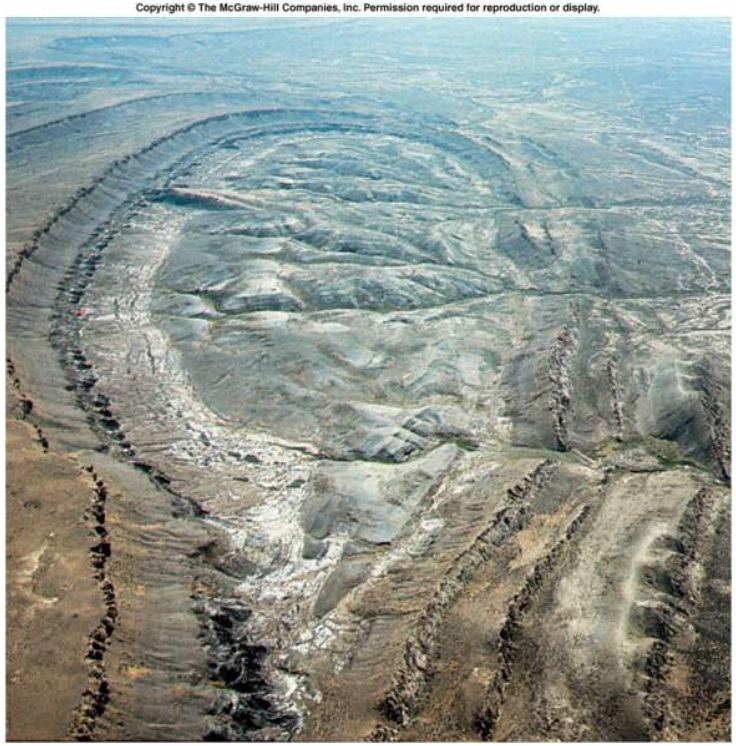
FOLDS

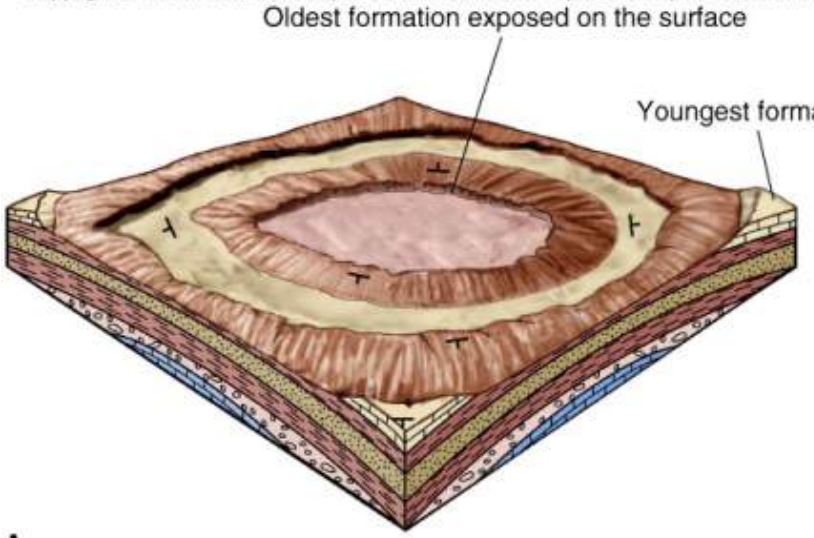




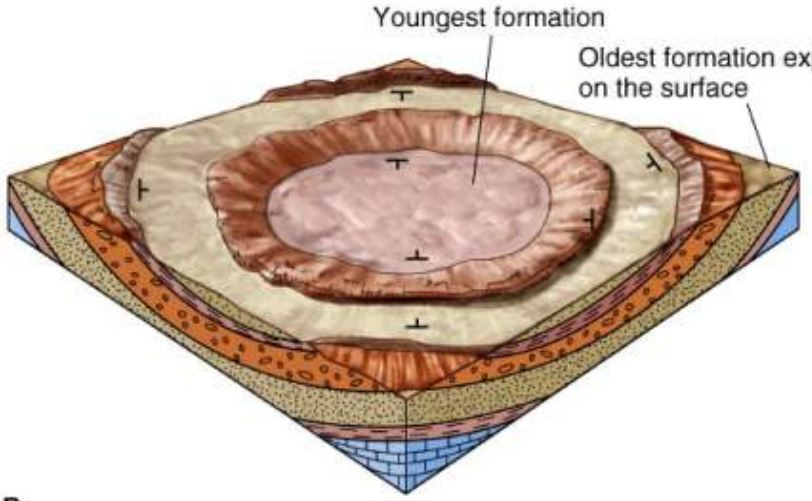


Domes and Basins



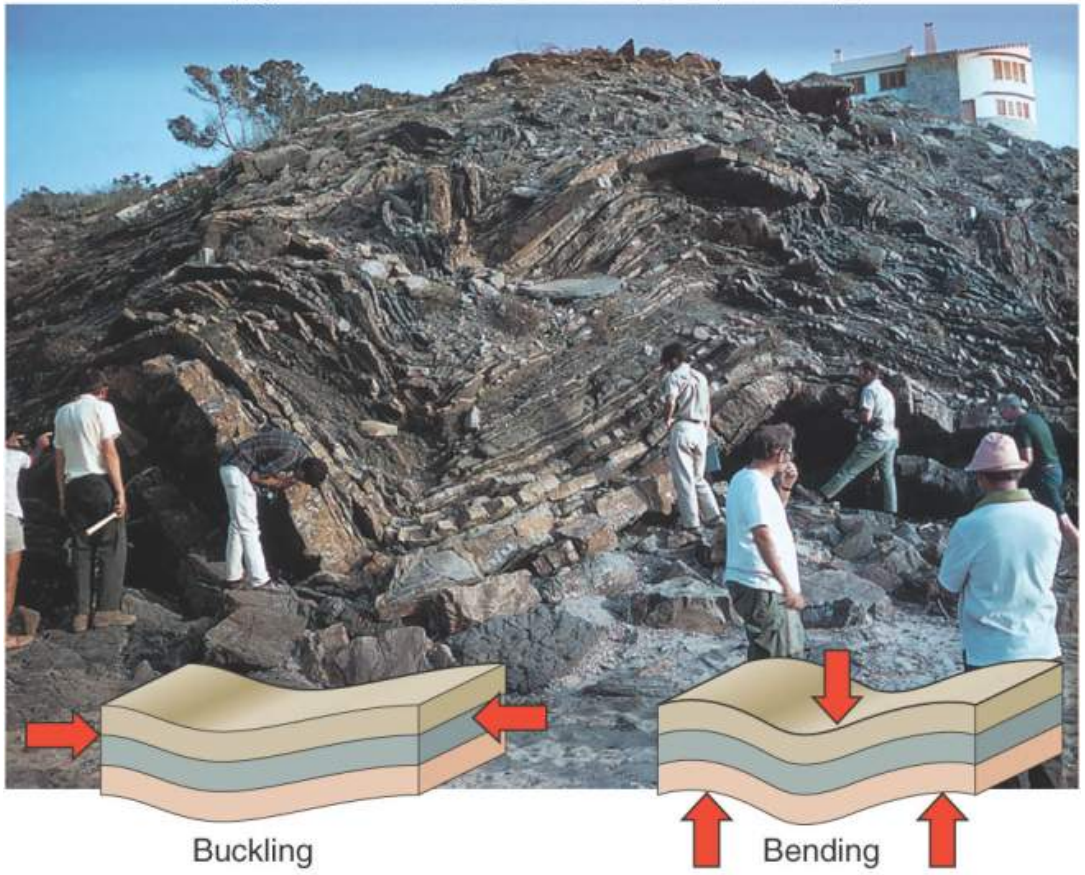


A



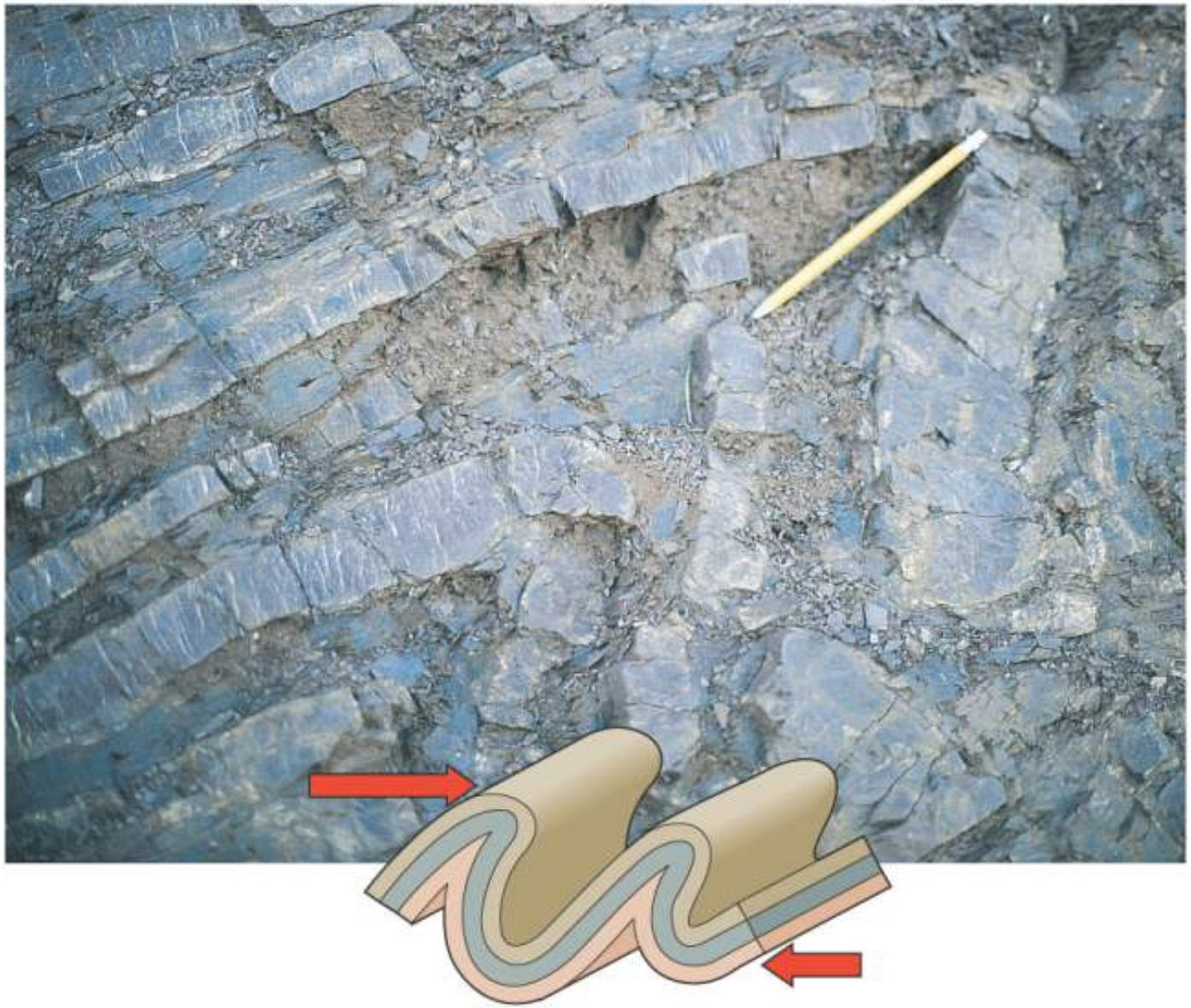
B

A Strata before folding

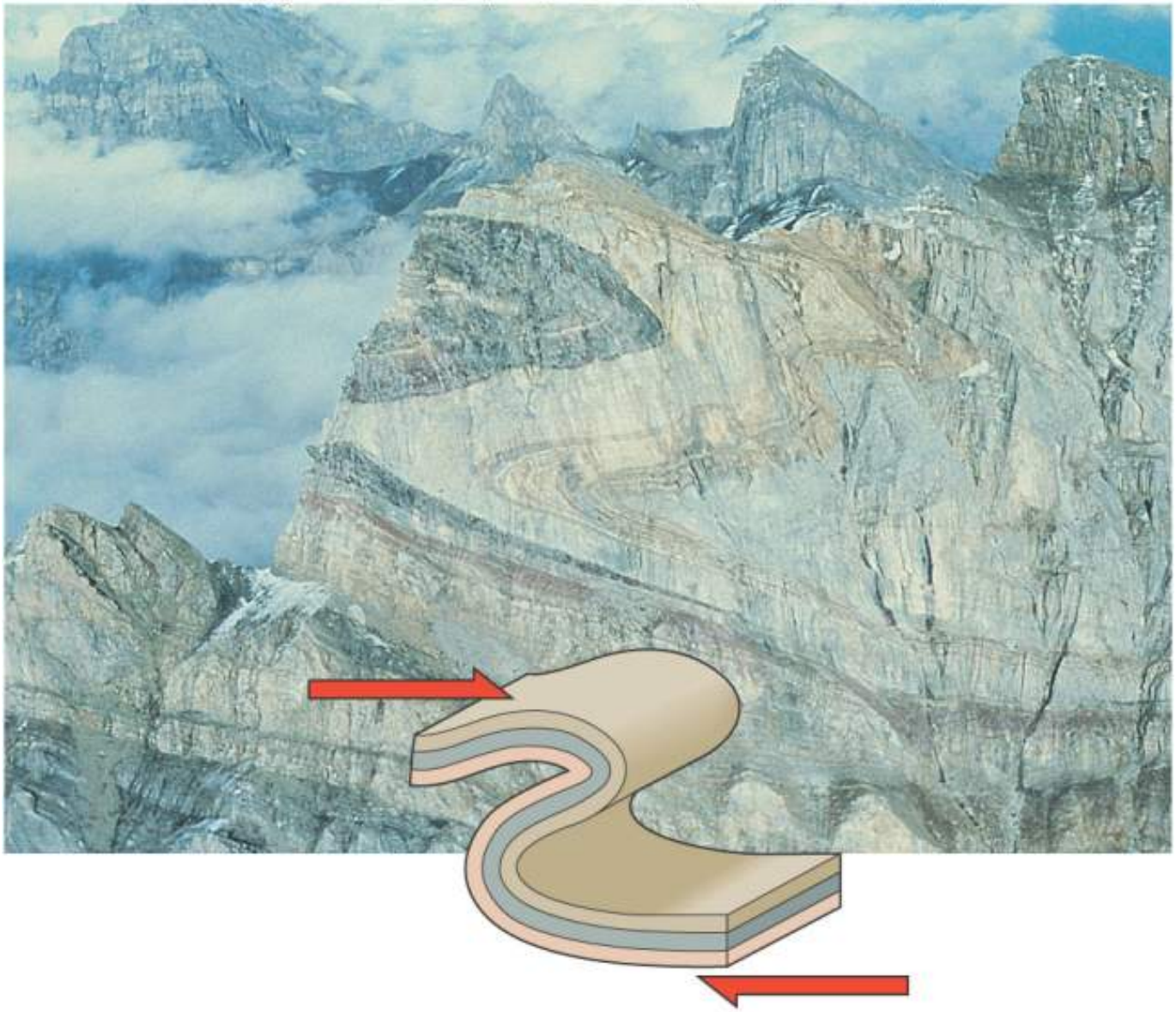


B Open folds—the two diagrams show alternate ways that stresses may have been distributed to have caused the folding.

C Isoclinal ("hairpin") folds



D Overturned folds



E Recumbent folds

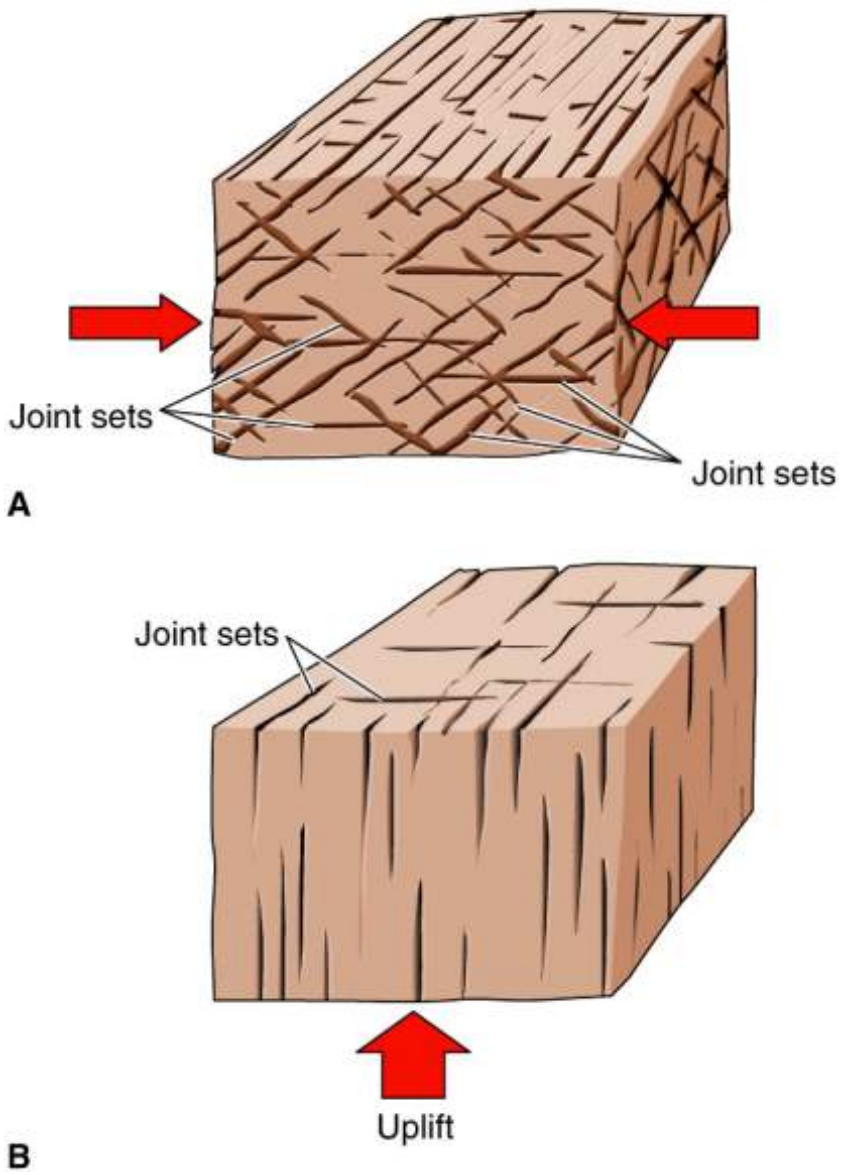
FRACTURES, or JOINTS

- Fractures are surfaces along which rocks or minerals have broken

- Fractures generate two free surfaces where none existed before

- Systematic Joints
  - planar, parallel to each other, regularly spaced

Joint Sets



- Other kinds of joints

Exfoliation Joints

Half Dome, Yosemite National Park, California

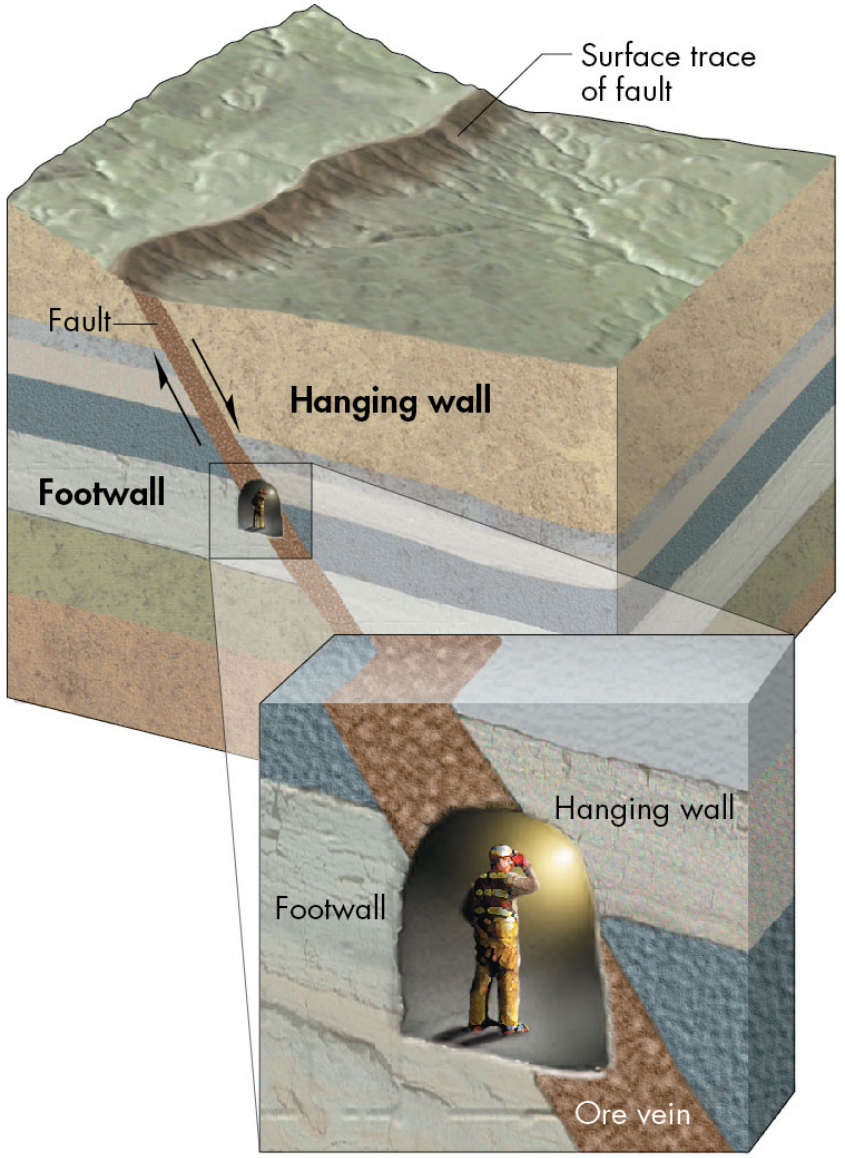
Columnar Joints

Devil's Tower National Park, Wyoming

FAULTS

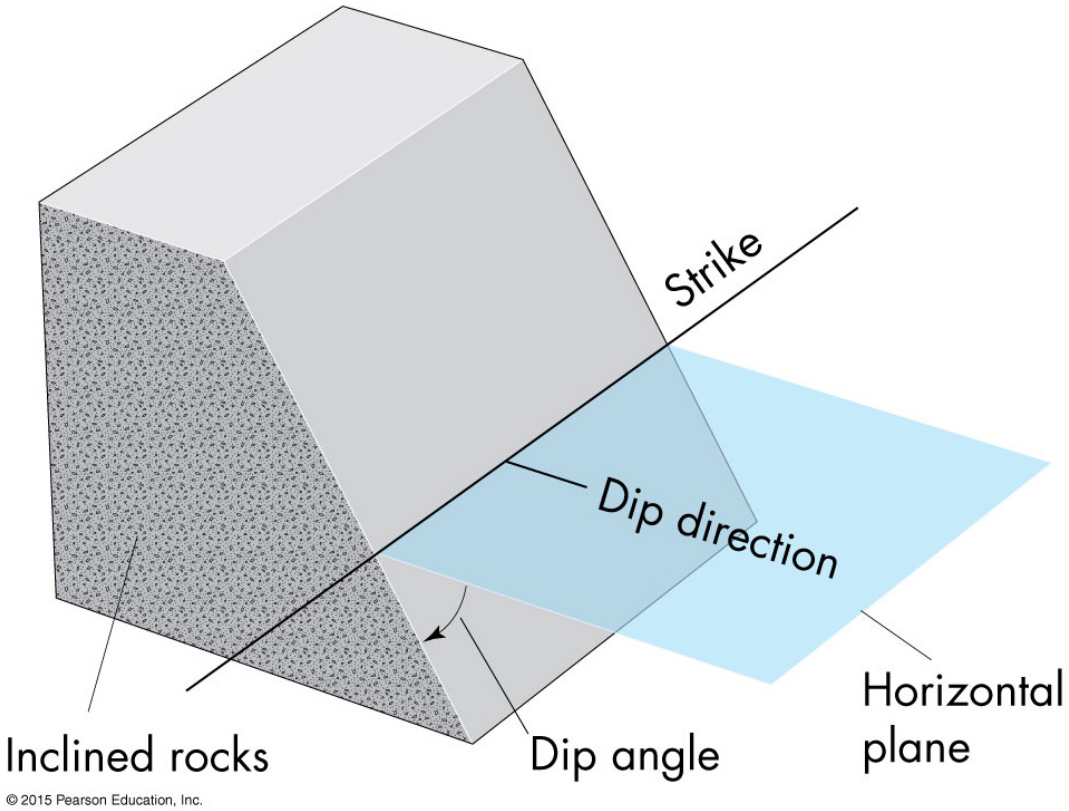
- Faults: fractures along which motion occurs

- Centuries-old mining terminology used
  - **Footwall**
    - Block below the fault plane
    - Miner would stand here
  - **Hanging wall**
    - Block above the fault plane
    - Hang a lantern here



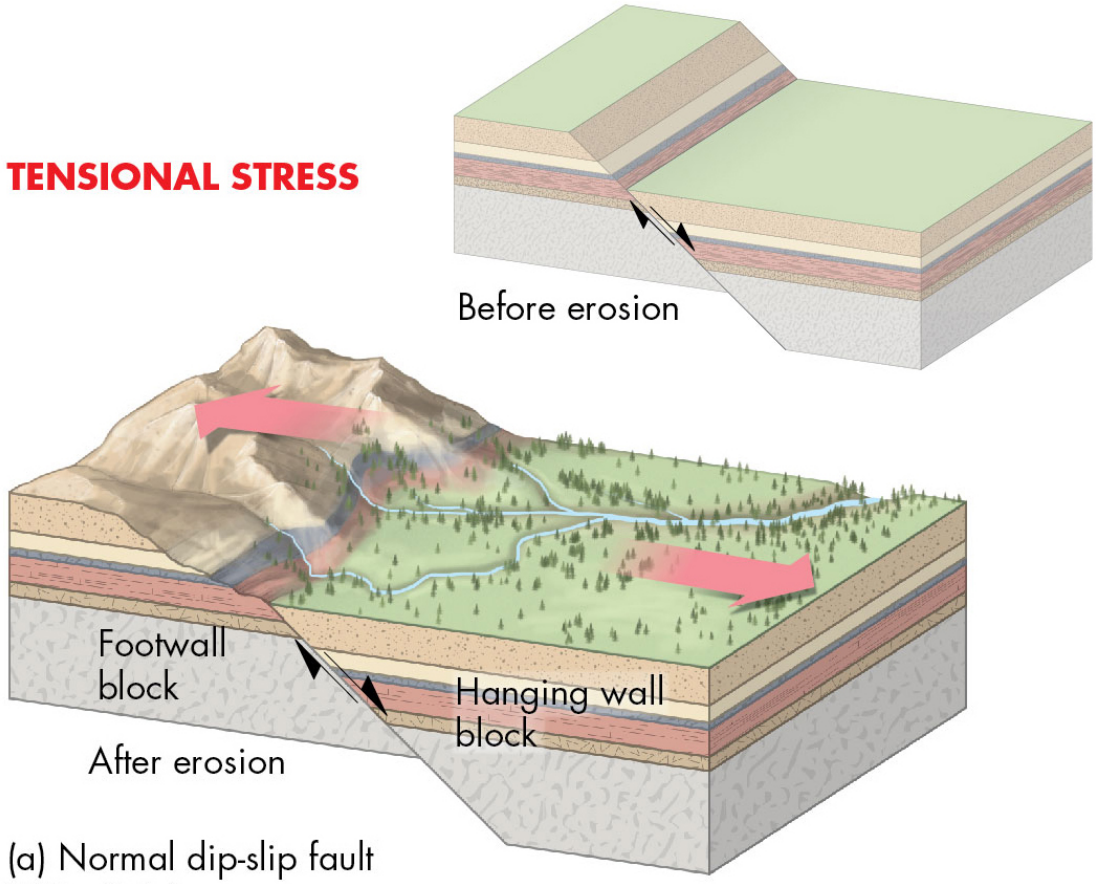
Fault types

- Fault types
  - Distinguished by direction of rock displacement
    - Normal dip-slip
    - Reverse dip-slip
    - Strike-slip

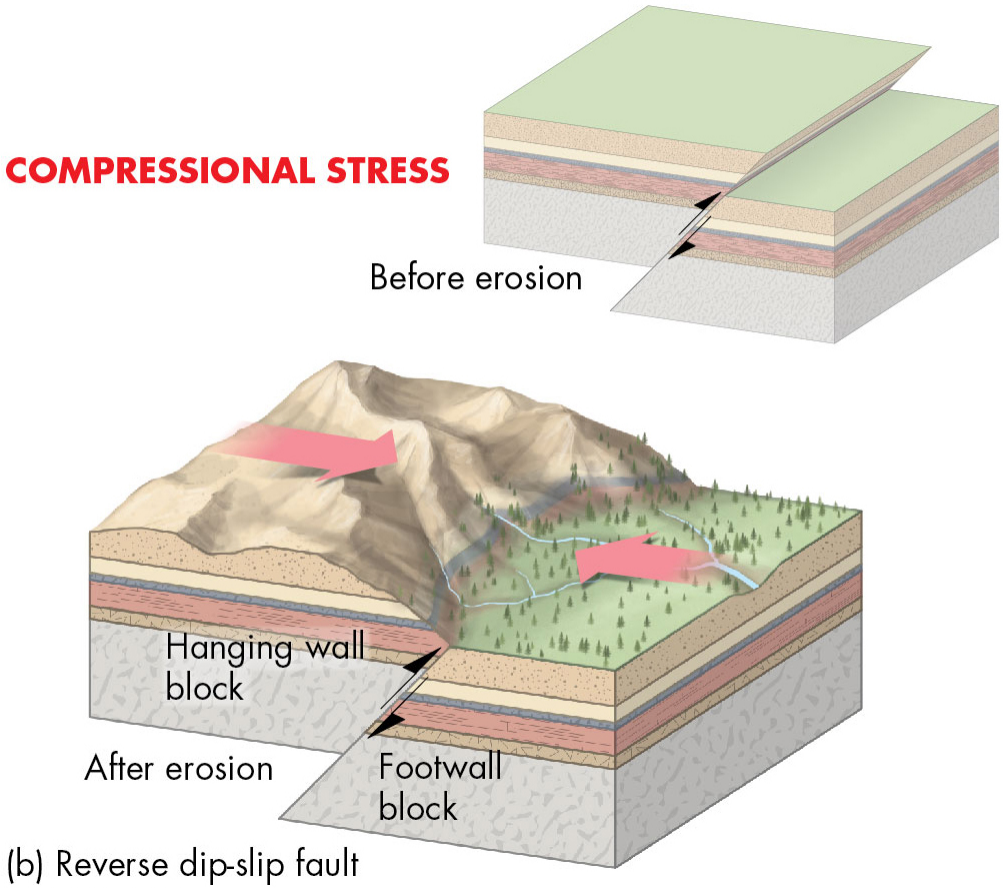


- Dip-slip faults”
  - Vertical motion
  - Normal Faults
    - the hanging wall moves downward with respect to the footwall (caused by extension)
  - Reverse Fault
    - the hanging wall moves upward with respect to the footwall (caused by compression)

- Normal (dip-slip) Fault
  - Hanging wall moves down relative to footwall



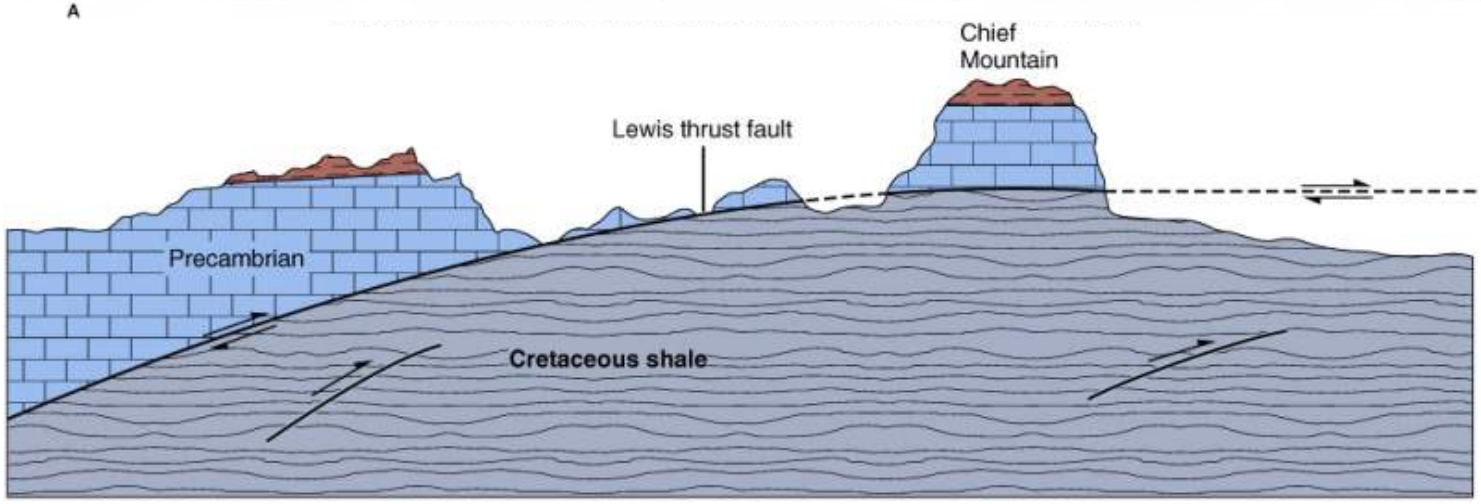
- Reverse (dip-slip) Fault
  - Hanging wall moves up relative to footwall



(b) Reverse dip-slip fault

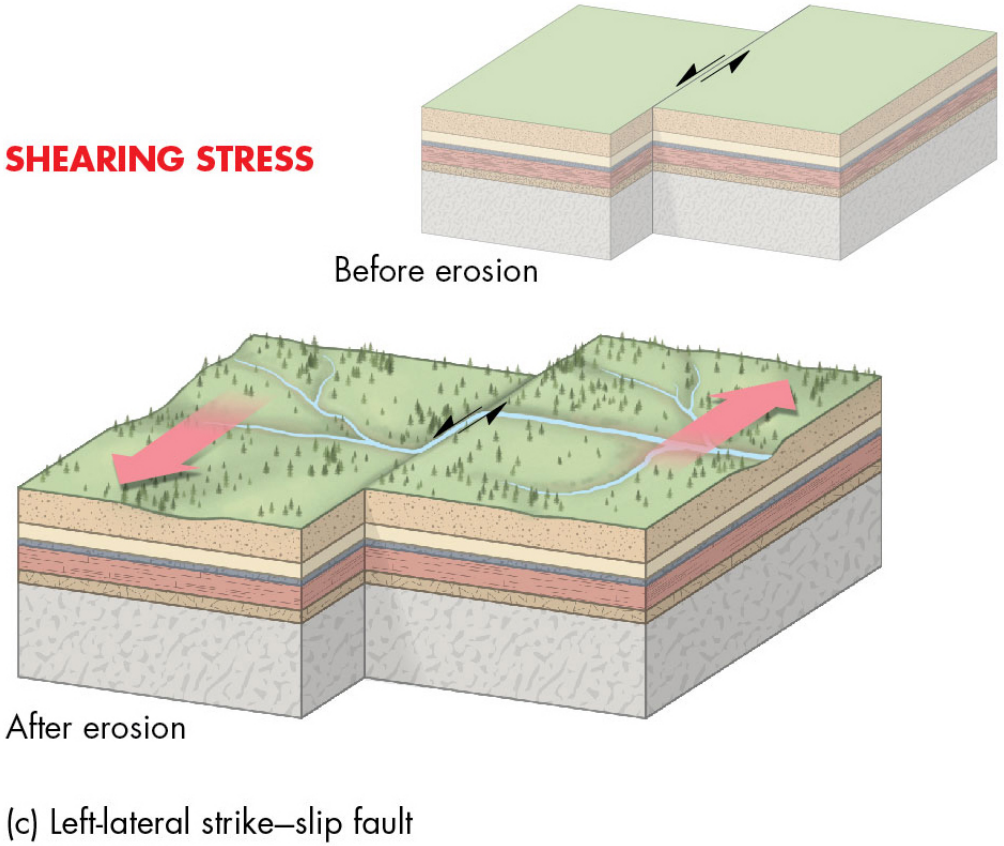
Thrust Faults

A



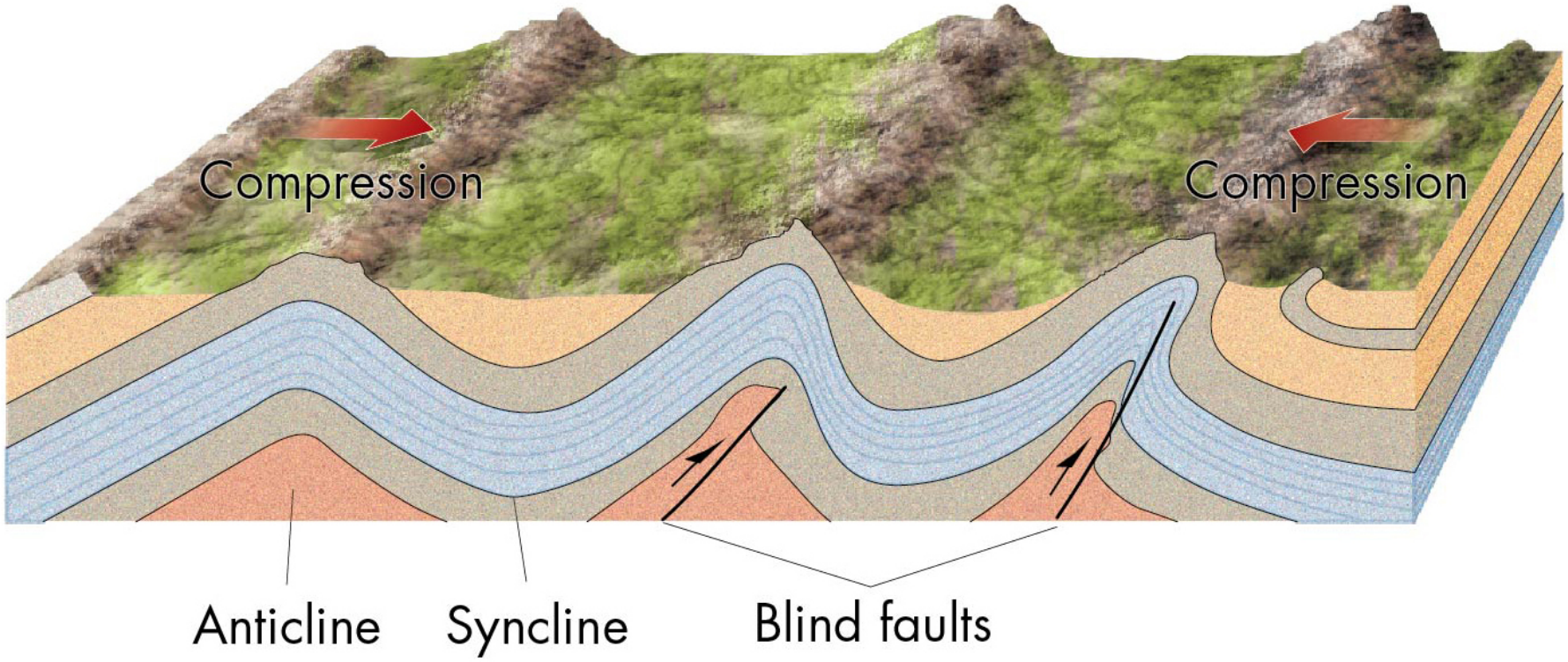
B

- Transform (Strike-slip) Fault
  - Crust moves in horizontal direction



(c) Left-lateral strike–slip fault

- Some active faults do not extend to the surface
  - Blind Faults



Structural Geology and Tectonics

the end