GY111 Introductory Geology

Lecture 10: Deformation of the Earth's Crust

Stress & Strain

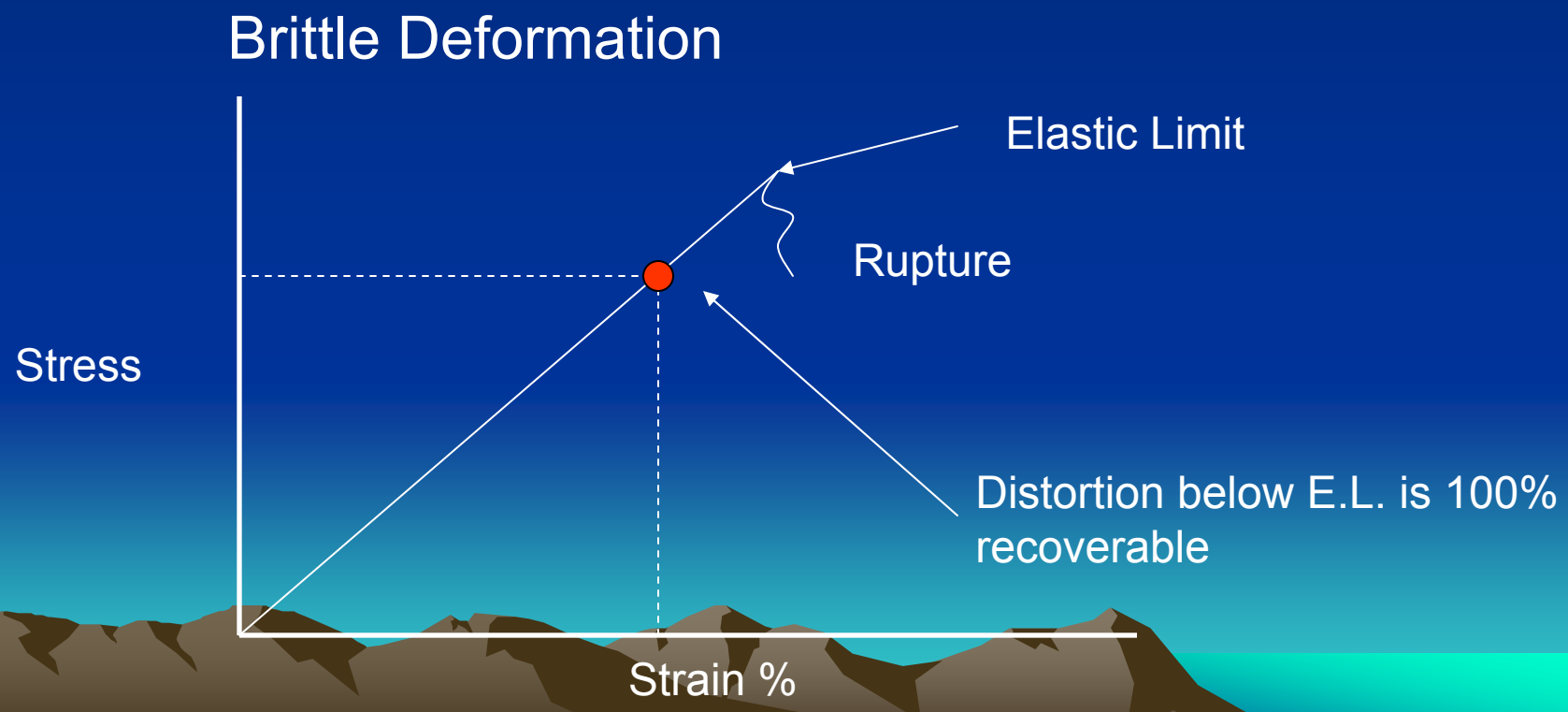
- Stress: a force applied to an area
  - Example: tire pressure in psi
- Strain: a change in original shape or volume (produced by stress)
- Elastic strain: analogous to a steel spring or rubber band
- Plastic strain: analogous to deforming mud or putty

Types of Stress

- Lithostatic Stress: stress due to the burial and overlying overburden of rock
- Lithostatic stress can only cause a change in volume referred to as dilation
- Directed stress: stress is unequal in different directions
- Directed stress is generated by plate tectonic motion and will cause a change in shape referred to as distortion

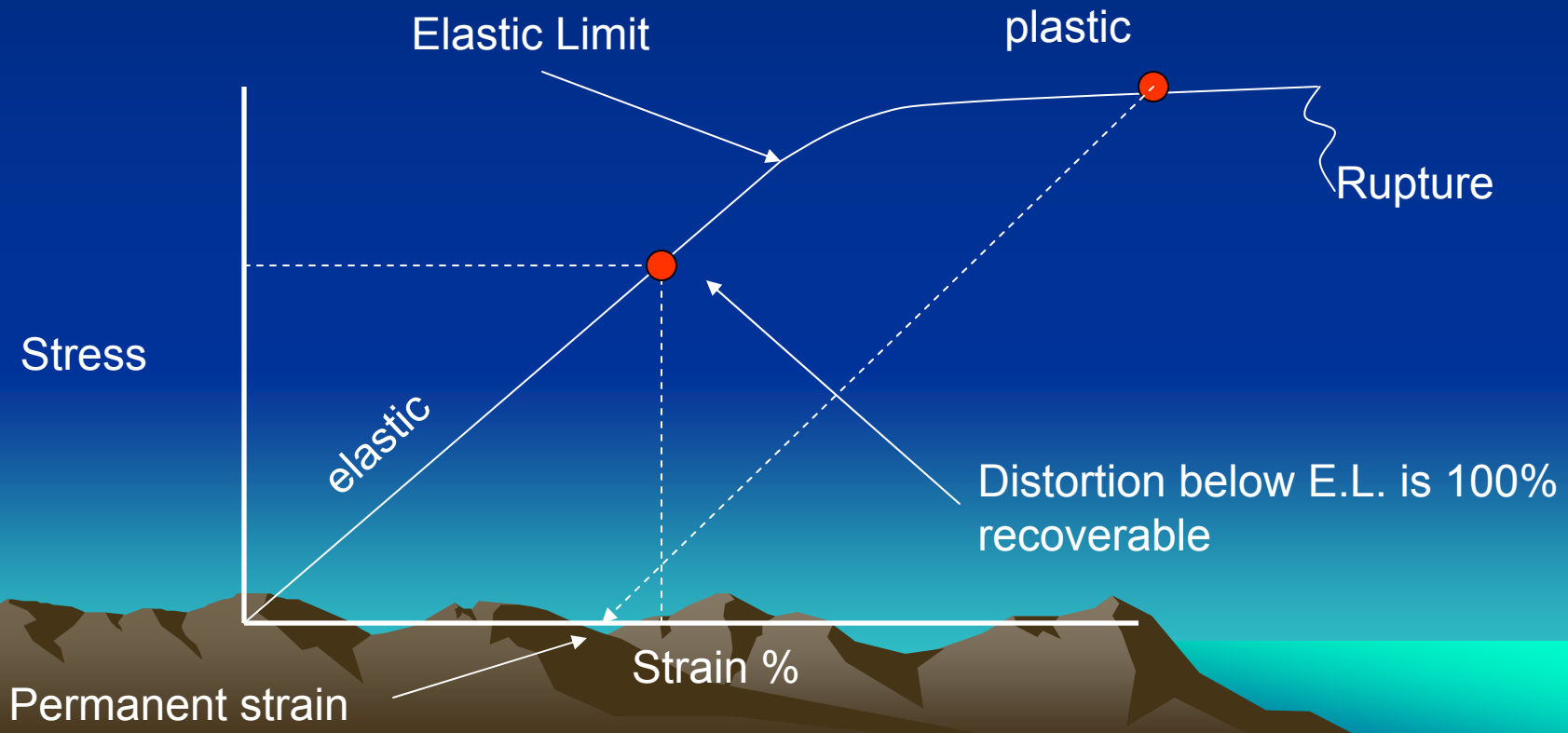
Stress vs. Strain Diagrams

- Illustrate the mechanical behavior of rock materials
- Brittle: rocks near the surface of the Earth behave as brittle materials- their behavior is mainly elastic



Ductile Deformation

- Ductile deformation requires a significant component of plastic mechanical behavior



Mechanical Behavior of Rocks

- Near-surface rocks that are under low T-P conditions behave as brittle material:
  - Fault fracture (slippage)
  - Joint fracture (no slippage)
- Deep rocks under elevated T-P conditions behave as ductile material:
  - Folding

Examples of Deformation Experiments

- Lab equipment can reproduce all geological conditions except geologic time

Undeformed

Low T-P (brittle)

High T-P (ductile)

Mapping Geological Structures

- Orientation
  - Planar: strike and dip
  - Linear: plunge and bearing
- Azimuth: compass direction along the horizontal map surface
  - 0-90: northeast quadrant
  - 90-180: southeast quadrant
  - 180-270: southwest quadrant
  - 270-360: northwest quadrant
- Strike is always read from a northern quadrant therefore it must always be 0-90 or 270-360
- Dip: maximum angle of inclination in a geological plane (bedding, fault, joint fracture, etc.). The azimuth direction of the dip is always perpendicular to the strike

Examples of Planar Structures

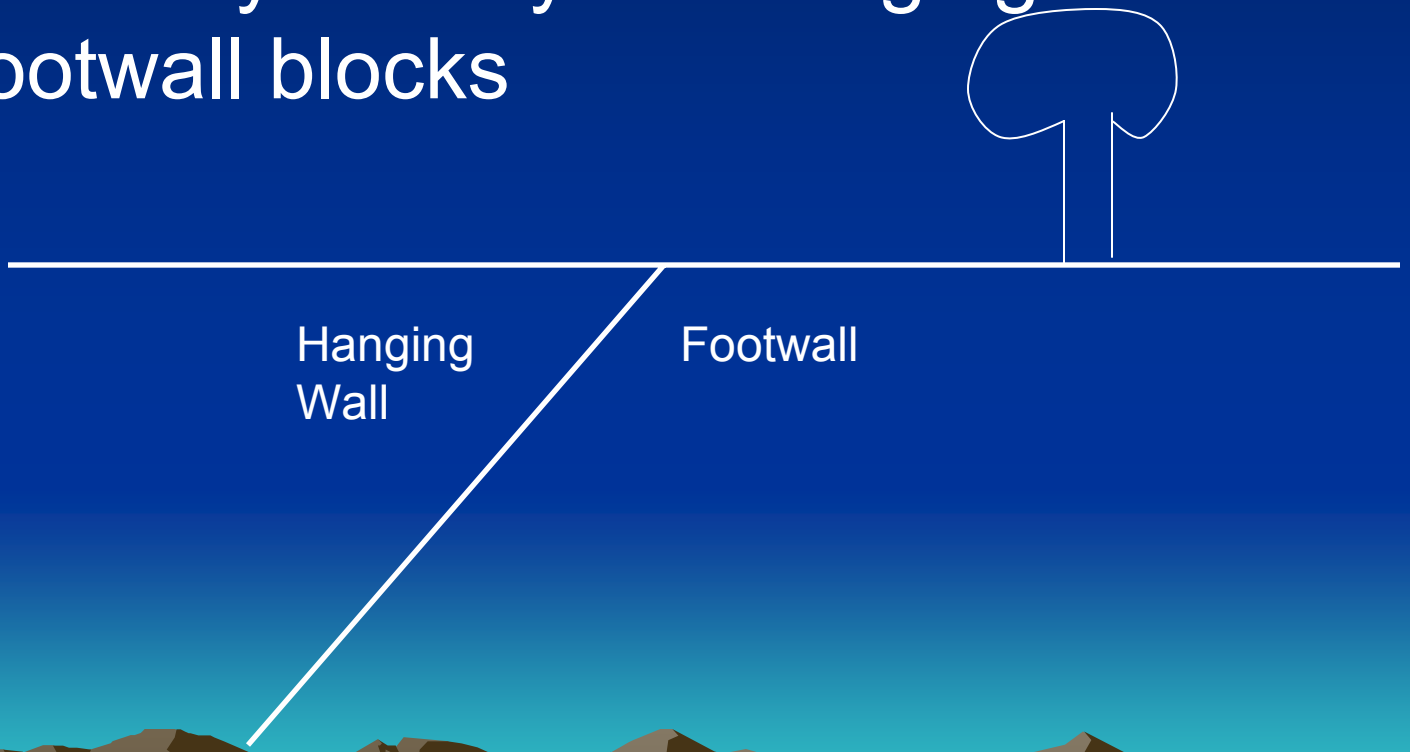
- All would be measured with a strike and dip

Fault Classification

- Classified by the nature of the slippage of one fault block past another block
  - Dip Slip: slippage is parallel to dip of fault
    - Normal: hanging wall down motion
    - Reverse: hanging wall up motion
      - A special case of reverse where the fault dips < 45 degrees
  - Strike Slip: slippage is parallel to strike of fault
    - Right lateral: a right-hand turn must be followed to find offset features
    - Left lateral: a left-hand turn must be followed to find offset features
  - Oblique Slip: has combined strike-slip and dip-slip motion

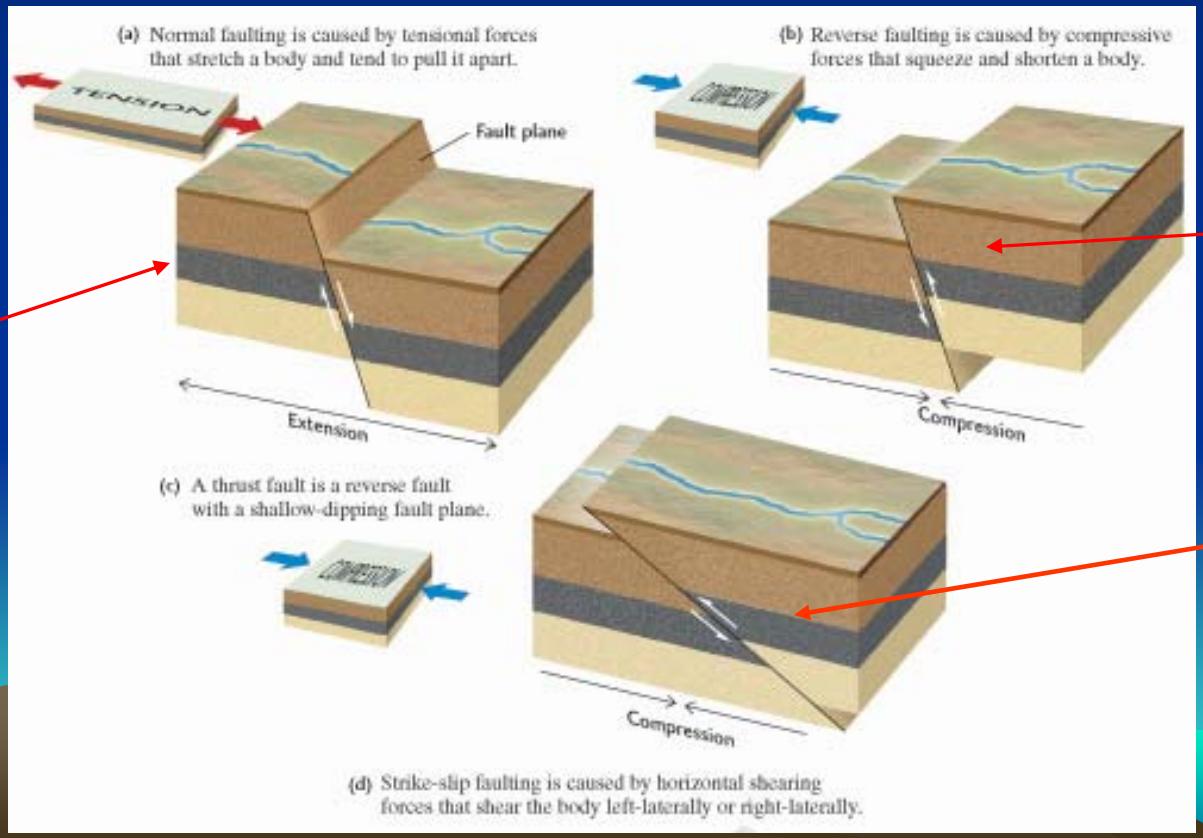
Hanging Wall and Foot Wall

- To classify a dip-slip fault you must correctly identify the hanging wall and footwall blocks



Dip-Slip Fault Motion Examples

- Note that normal faults accommodate tensional stress, whereas reverse faults accommodate compressional stress



Normal

Reverse

Thrust

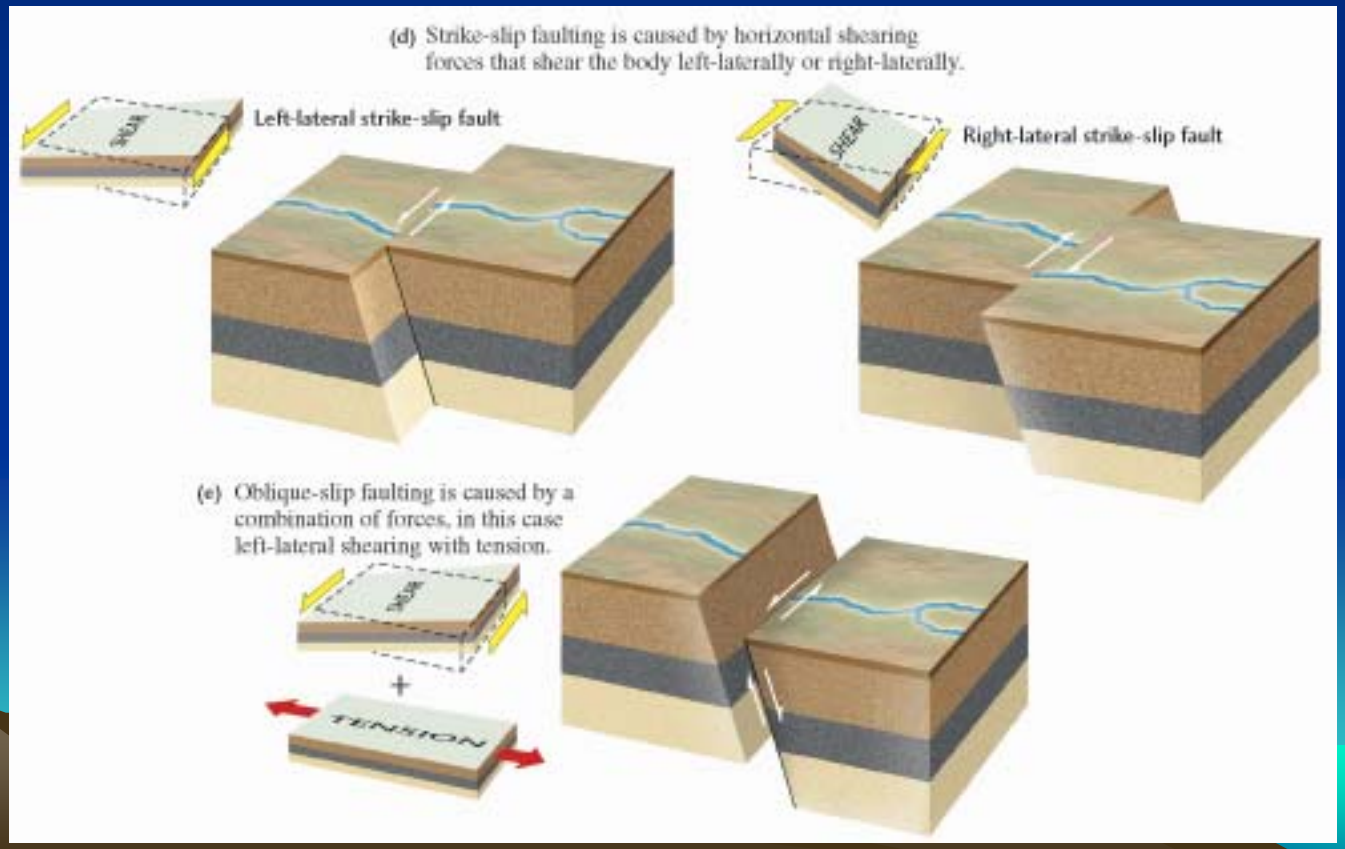
Fault Offsets

- Some fault offsets are easy to recognize

Fault Scarp

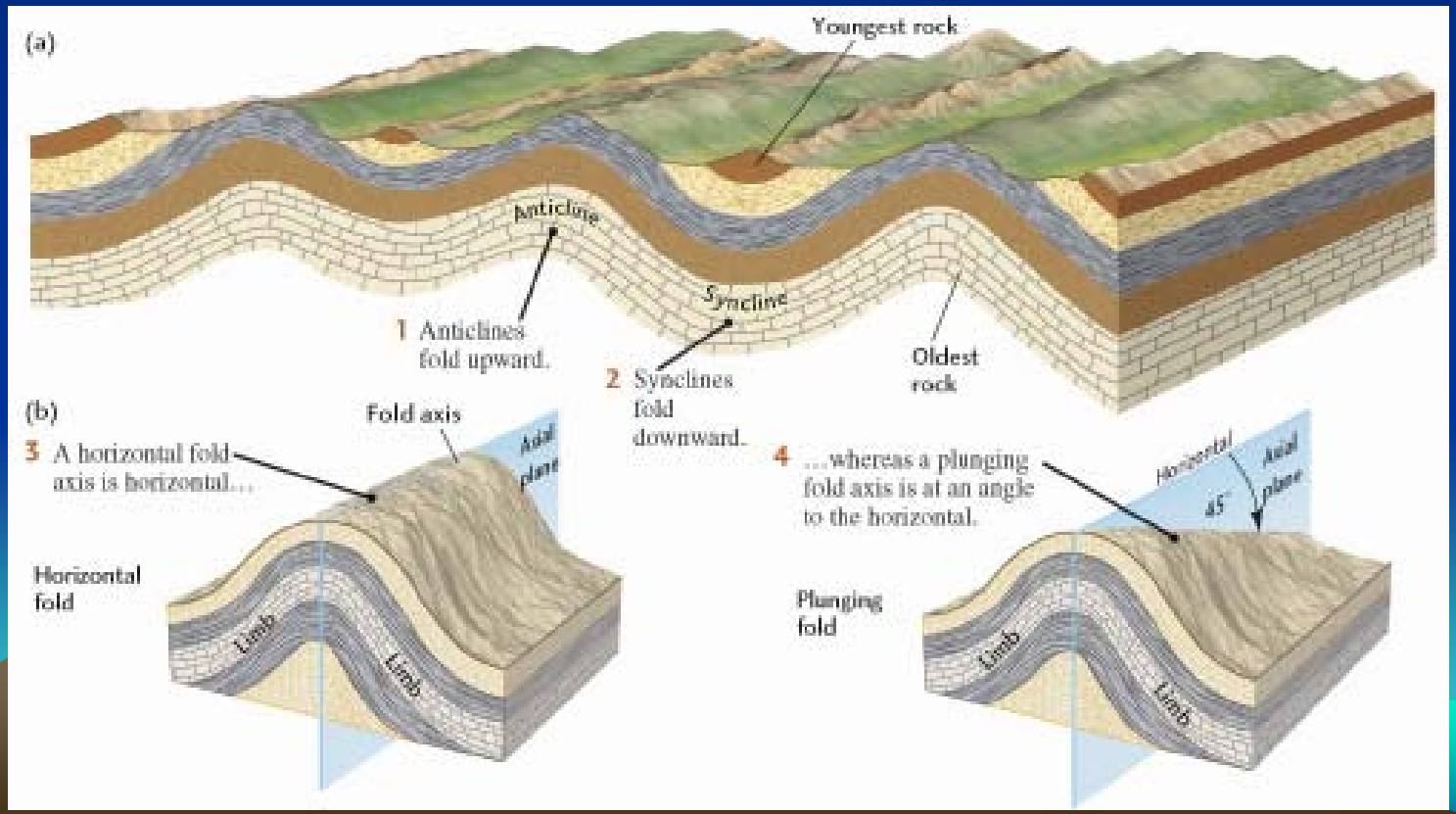
Strike-Slip Fault Motion Examples

- Movement is parallel to strike of fault therefore offset is seen in a map view



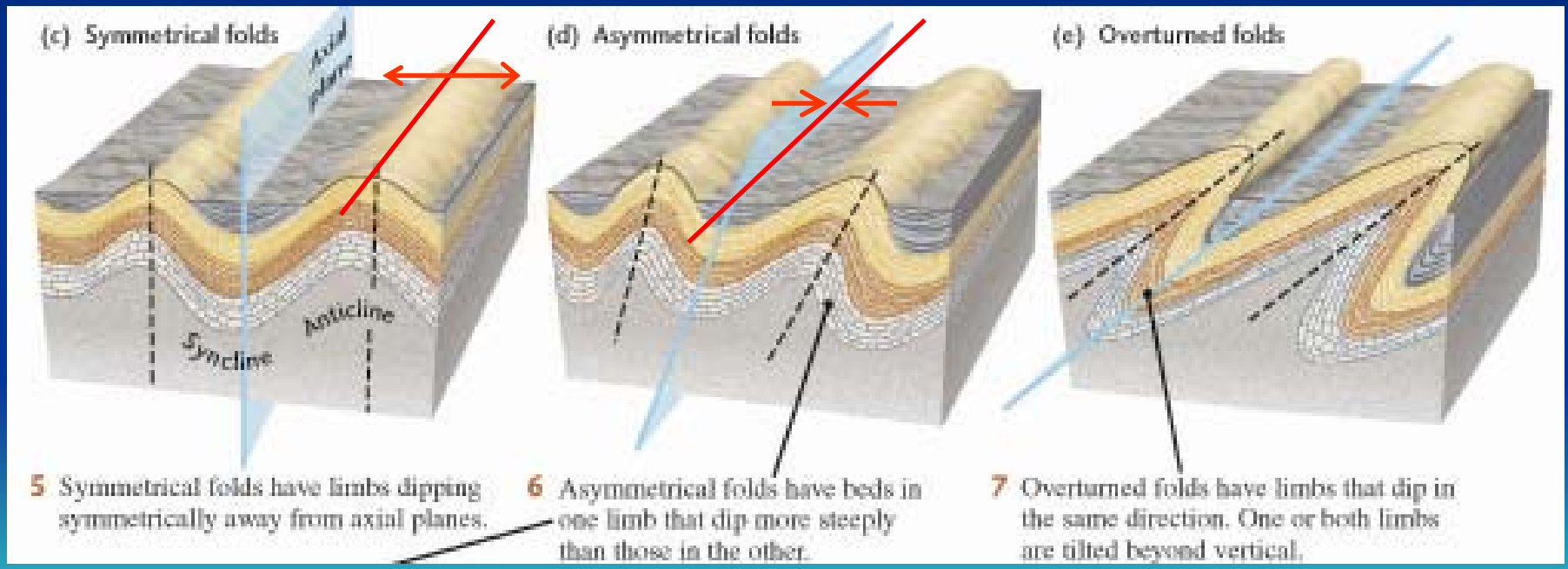
Fold Geometry

- Anticline: concave down (arch)
- Syncline: concave up (trough)



Fold Symmetry

- Based on dip of axial plane



Plunging Fold

- Anticline: plunge of axis is in direction of arrow formed by beds on the map
- Syncline: plunge of axis is opposed to the arrow formed by beds on the map