Basics of Mountain Building and Structural Geology

I. INTRODUCTION

A. Mountains: topographically elevated portions of the earth that rise thousands to 10's of thousands of feet above surrounding low lands.
   1. Single / isolated mountains
   2. chains of mountains
   3. volcanic vs. structural mountains
   4. Youthful vs. Old-age Mountains

B. Orogenesis: refers collectively to the tectonic processes that result in the elevation of land areas to form mountains.
   1. Volcanic Mountain Building
   2. Tectonic Collision (e.g. India / Asia)
   3. Crustal Uplift - elevating the Earth's crust (relative to sea level)

II. ROCK DEFORMATION- process of rocks becoming physically deformed as they are subjected to stress

A. Plastic vs. elastic vs. brittle deformation of rocks:

rocks may respond to stress in the form of folding like paper (plastic deformation) or fracturing into blocks (brittle deformation) or may deform elastically (i.e. given volume of rock will return to its original size and shape after stress is removed)

1. brittle deformation of rocks is rather easy to recognize, analogous to hitting concrete with sledge hammer. Conditions of stress result in fracturing or rupturing of rocks.

2. elastic: stress is applied slowly under constant pressure, rocks return to original size and shape after stress is removed.

3. plastic deformation: a set of conditions must be met before rocks will deform plastically
   a. relative heat, constant pressure, and time

B. "Attitude" of Rock Layers
   1. Attitude of rock layers = angle of tilt of planar beds of rock
      a. Flat Lying Rock Layers
      b. Tilted Rock Layers

   2. Strike of Rock Layer
      a. A line connecting points of equal elevation on a bed rock rock
         (1) measured by the compass direction of the line

3. Dip of Rock Layer
    a. Angle of tilt of rock layer
        (1) Flat-lying rock layer: dip angle= 0
        (2) Vertical rock layer: dip angle= 90

    b. Measured perpendicular to strike
        (1) The compass direction water would flow down the plane of the rock layer

III. FOLDING OF ROCKS OR ROCK STRATA (LAYERS OF ROCKS)

A. Under components of horizontal stress: flat-lying layers of sedimentary/volcanic rocks may become bent into a series of folds (analogous to pushing and folding sheet of paper).
    1. folding process results in shortening and thickening the crust

B. Fold Types
    1. Anticlines-upfolded forms, wave crests
        a. results in older rocks becoming enclosed within younger strata

    2. synclines-downfolded forms, wave troughs
        a. results in younger rocks becoming enclosed within older strata.

    3. Fold Geometry
        a. symmetrical folds - both limbs of the fold dipping at same angle away from fold axis
        b. asymmetrical folds - both limbs of the fold not dipping at same angle away from fold axis

    4. Domes- more or less circular equivalent of anticline, oldest rocks exposed in center of dome

    5. Basin- more or less circular equivalent of syncline, youngest rocks exposed in center of dome

IV. FAULTING AND RELATED STRUCTURES
A. Faults - fractures withing the earth's crust along which movement or offset of crustal blocks has occurred.

    1. Dip-slip faults- movement is vertical down the plane of the fault, movement along the inclination or dip of fault plane hence "dip-slip".

        a. Normal Faults-faults in which crustal block above the fault plane (hanging wall) move down relative to crustal block below the fault plane (foot wall)

        b. Reverse Faults- faults in which crustal block above the fault plane (hanging wall) moves up relative to crustal block below the fault plane (foot wall).

c. Thrust Fault- reverse fault with very low angle, or very gently inclined (<30^{o}) fault plane.

2. Strike-slip faults- movement along fault is horizontal along the fault (similar to notion of transform faults in plate tectonics), i.e. offset is parallel to the trend or strike of the fault plane.

a. Strike - the trend or compass direction of the line formed between the intersection of a horizontal plane with any inclined plane.

3. Oblique-slip faults- faults which have both vertical and horizontal components of movement.

B. Stress Regimes and Style of Faulting

1. Reverse/Thrust Faults- often associated with compression or squeezing of crustal blocks, rupture results when stress>strength of rocks.
a. E.g. in association with convergent tectonic zones.

2. Normal Faults- associated with "pulling apart" or tensional forces exerted on crustal blocks.
a. E.g. in association with rift zones or spreading centers in plate tectonics.

b. Grabens- crustal block bounded by two inward-dipping normal faults, crustal block downdrops to form a graben.

c. Horst- relatively uplifted crustal block flanked by two adjacent grabens.

C. Joints-in contrast to faults- fractures along which no appreciable movement has taken place.

1. joints serve as a by-product, or structural features that accommodate stress during tensional and shear stresses associated with crustal movements.

V. MOUNTAIN TYPES

A. Folded Mountains (aka "complex mountains")

1. Mountain relief a result of erosion and dissection of portions of the earth's crust that has been folded and thickened.

2. Fold belts are also commonly associated with faulting, metamorphism, and igneous intrusion; although folding is the most conspicuous deformation style.

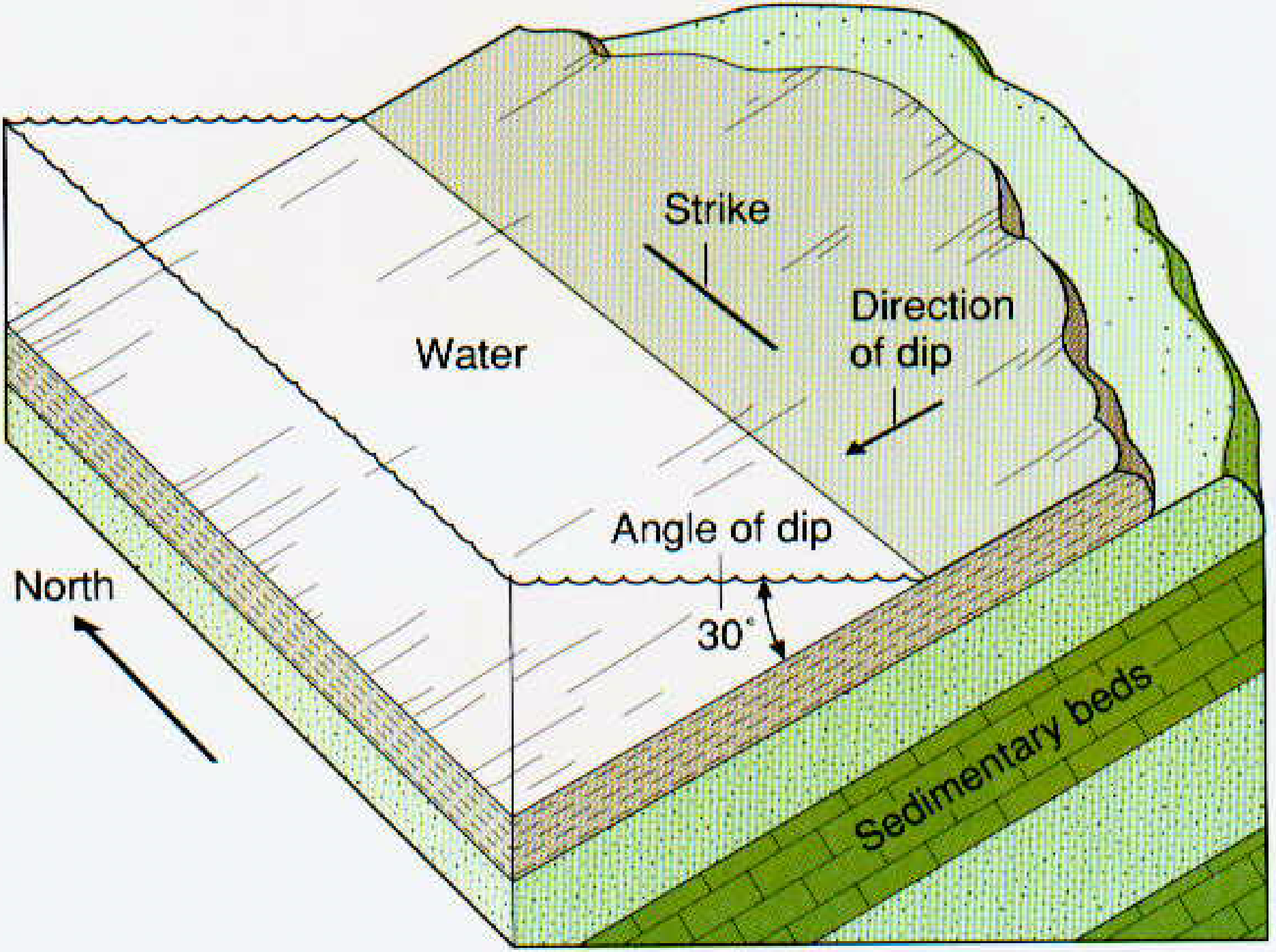
a. E.g. Alps, Himalaya's, Appalachian Mountains

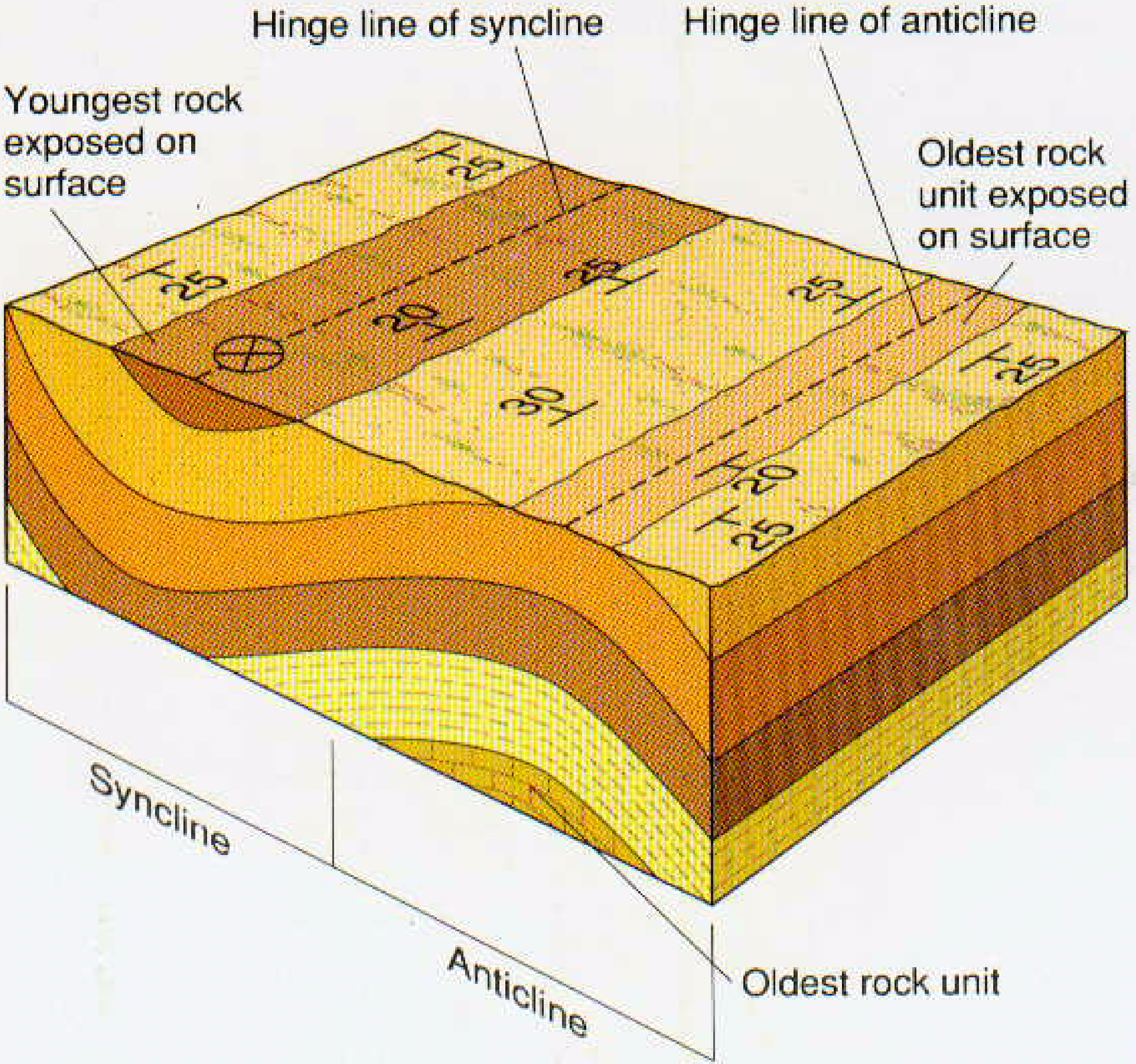
B. Fault-Block Mountains

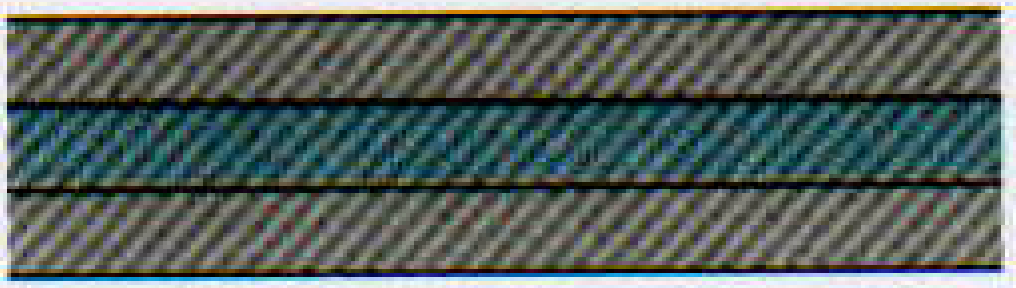
1. Associated with erosion and dissection of portions of the earth's crust that has been displaced and tilted along high-angle normal faults (in associatin ith tensional stresses)

a. E.g. Basin and Range Province of Nevada, Utah, Eastern CA, SE Oregon, AZ

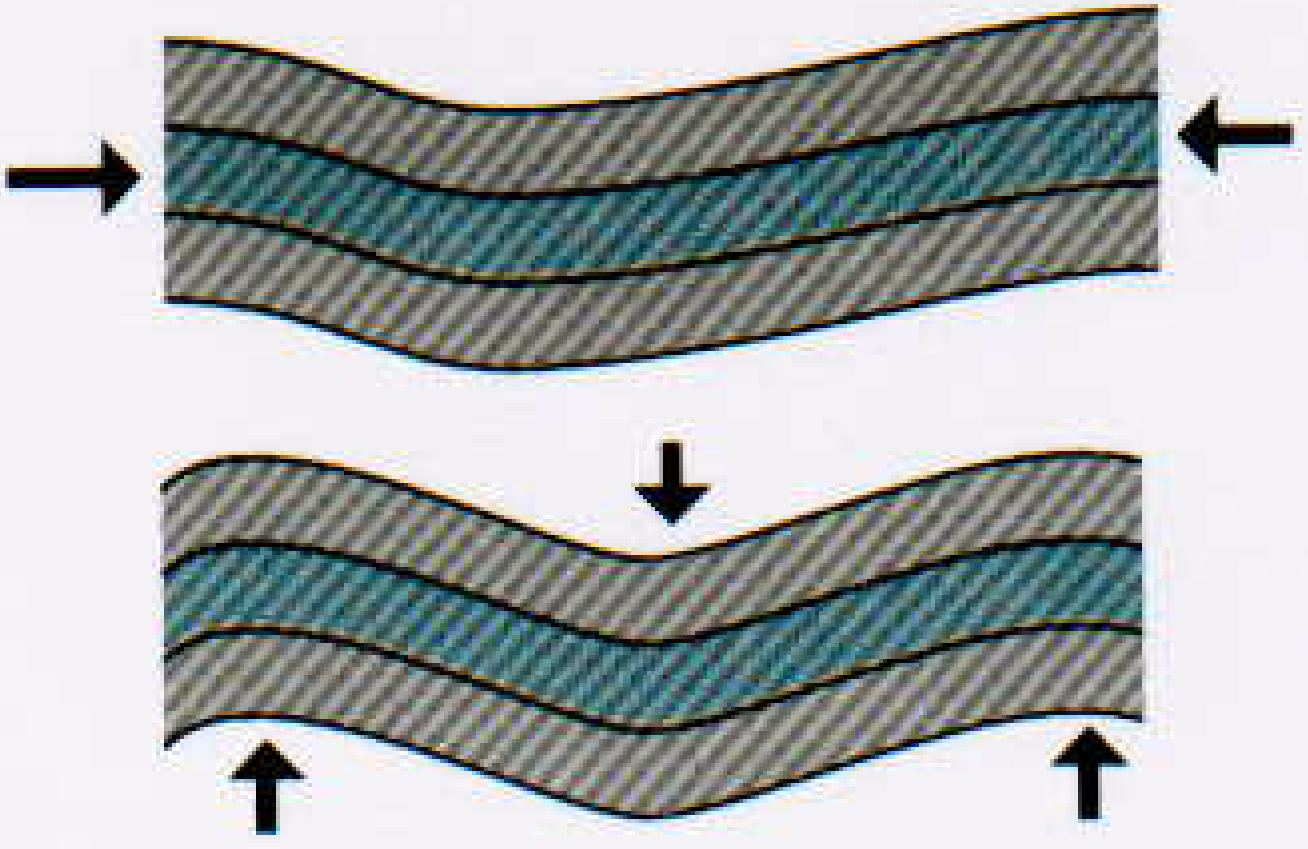
C. Volcanic Mountains - mountains built from lava flows


Strike
Direction of dip
Water
Angle of dip
North
30°
Sedimentary beds

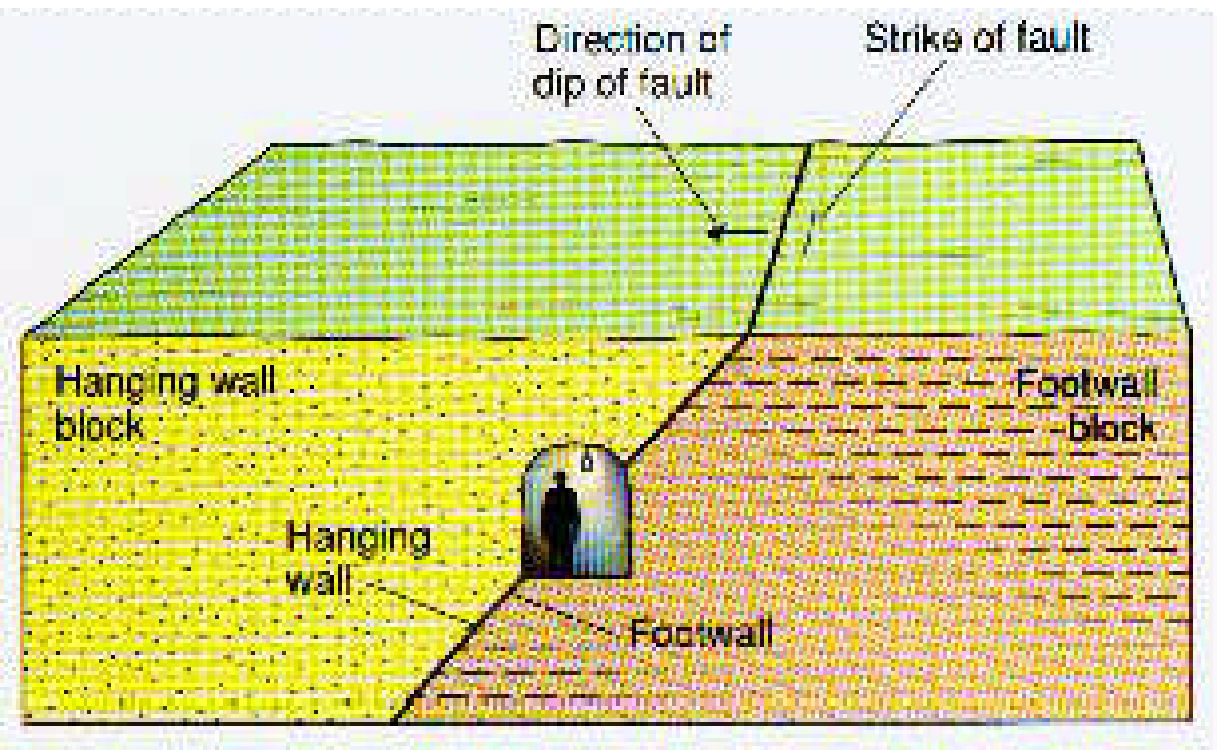

Hinge line of syncline
Hinge line of anticline
Youngest rock exposed on surface
Oldest rock unit exposed on surface
Syncline
Anticline
Oldest rock unit

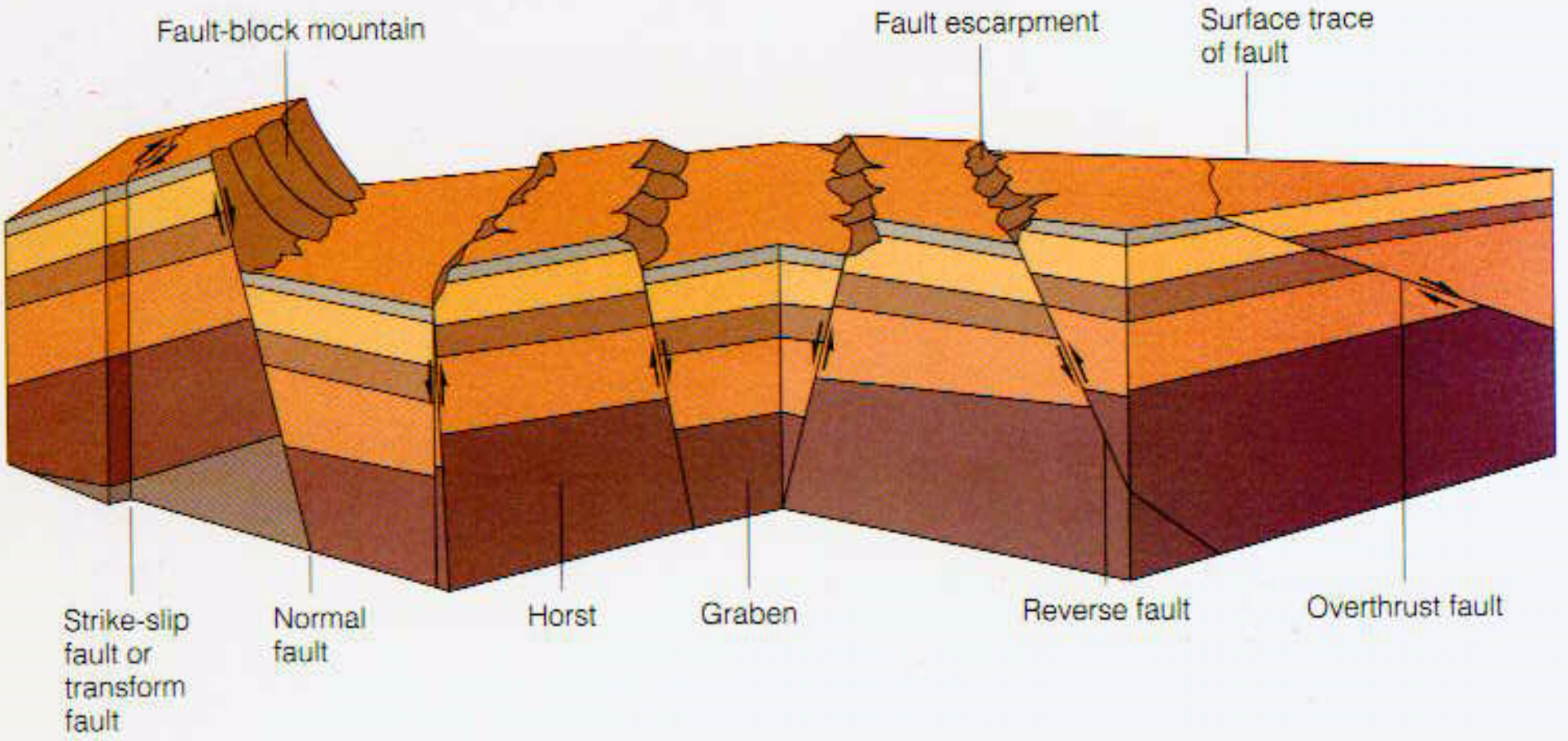


A Strata before folding



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


Direction of dip of fault
Strike of fault
Hanging wall block
Footwall block
Hanging wall
Footwall


Fault-block mountain
Fault escarpment
Surface trace of fault
Strike-slip fault or transform fault
Normal fault
Horst
Graben
Reverse fault
Overthrust fault