Module 14

Crustal Deformation

CRUSTAL DEFORMATION

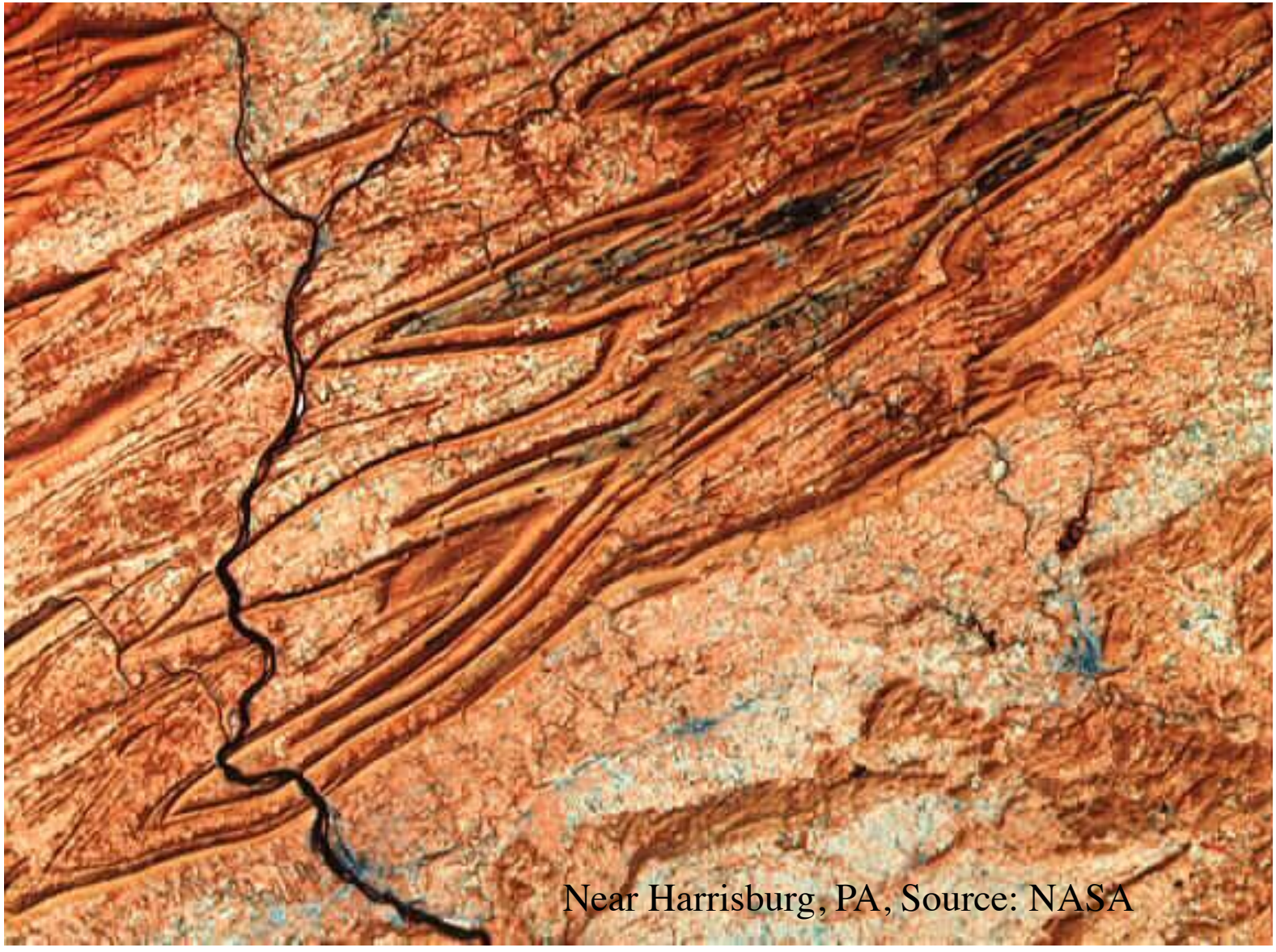
Although ordinary people might think that the crust of the Earth is permanent and fixed, a great deal of evidence, both direct and indirect, indicates that the crust is in continuous motion and that it has moved on vast scale throughout all of geologic time.

How do we know that the Earth's crust has been and continuous to be deformed?

- **Direct evidence: earthquake, …**
- **Indirect evidence: folds, joints, faults, …**

Folds

Folded Appalachians, near Harrisburg, PA - USA



Near Harrisburg, PA, Source: NASA

Folds

Types of Folds:

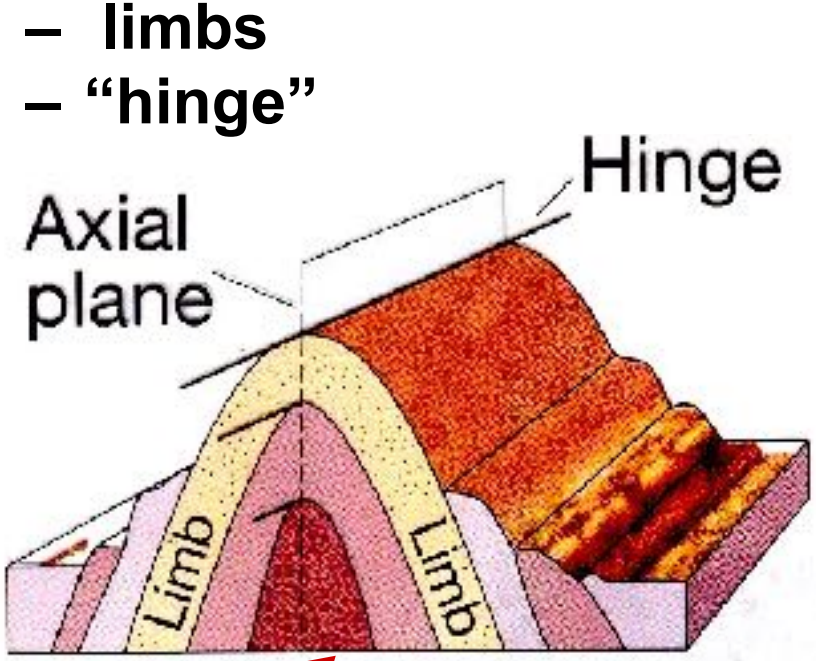
- Anticline = Arch
- Syncline = through
- Monocline = stair step
- Dome
- Basin

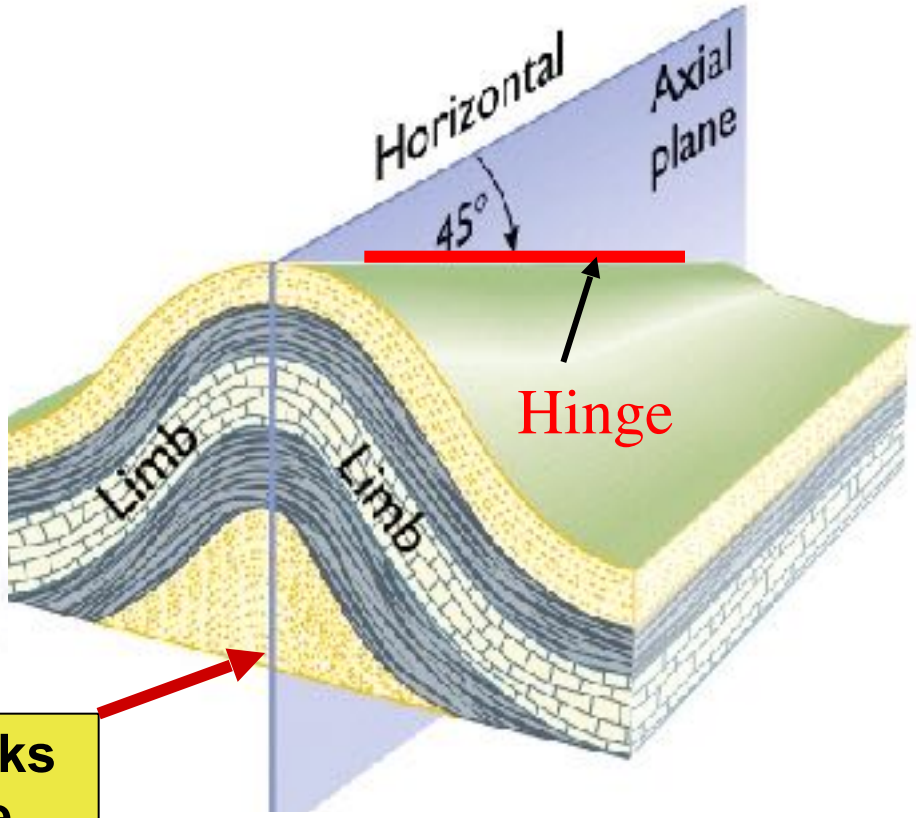
Chevron Fold, Laurel Mt., CA

Folds

Parts of a fold:

- **axial plane**
- **limbs**
- **"hinge"**



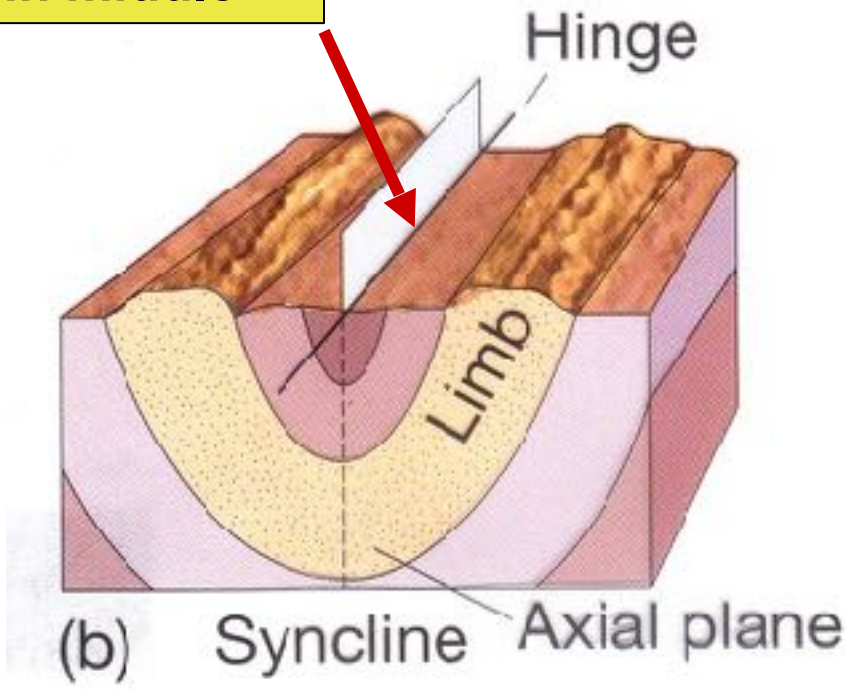


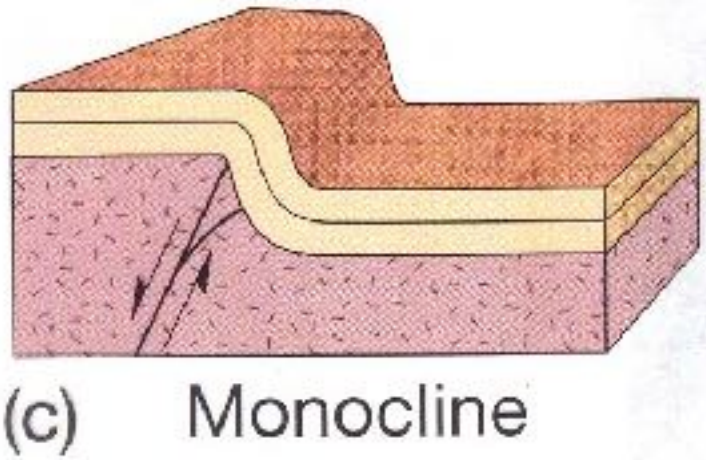
Oldest rocks in middle

Anticline

Folds

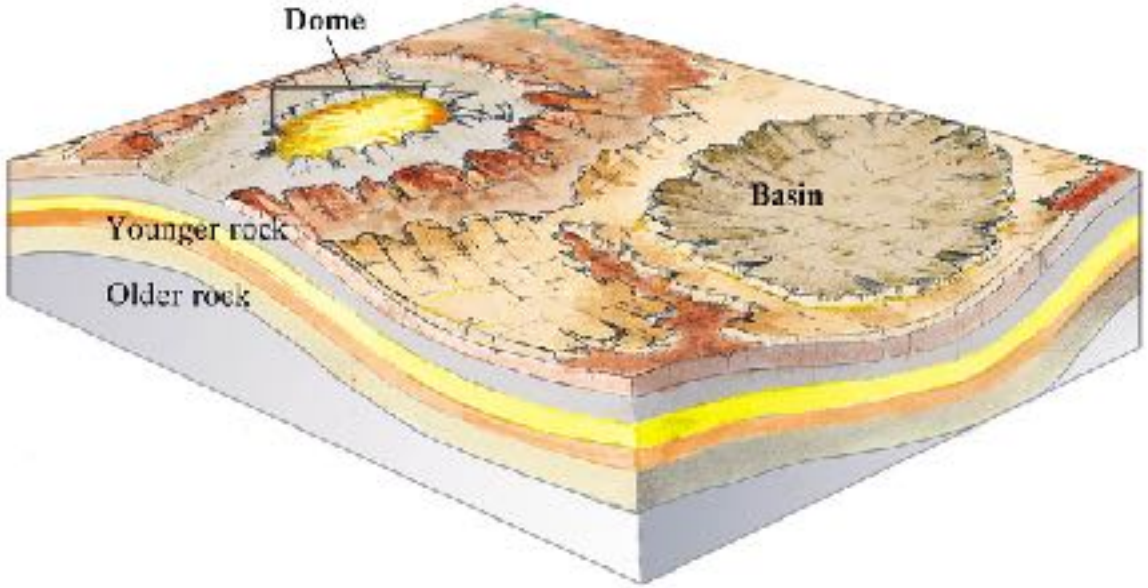
Youngest rocks in middle



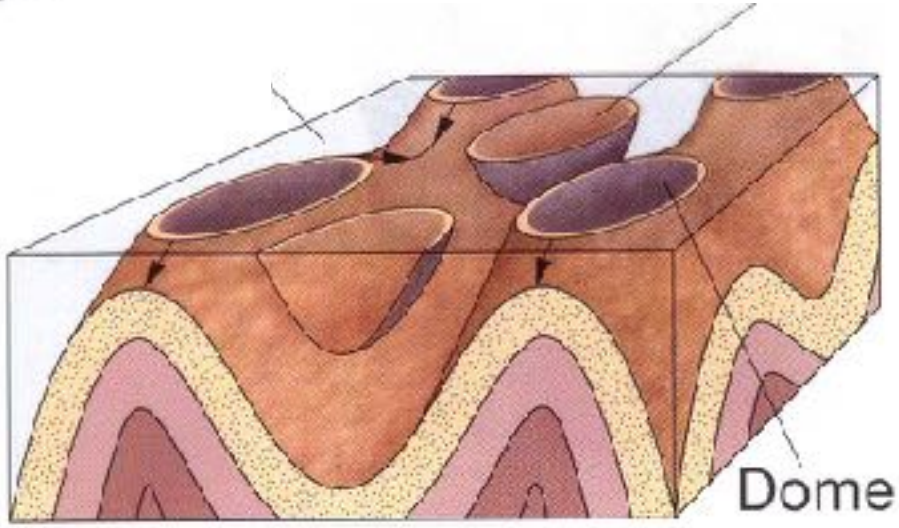


Syncline and Monocline

Folds



Think of an Egg Carton!



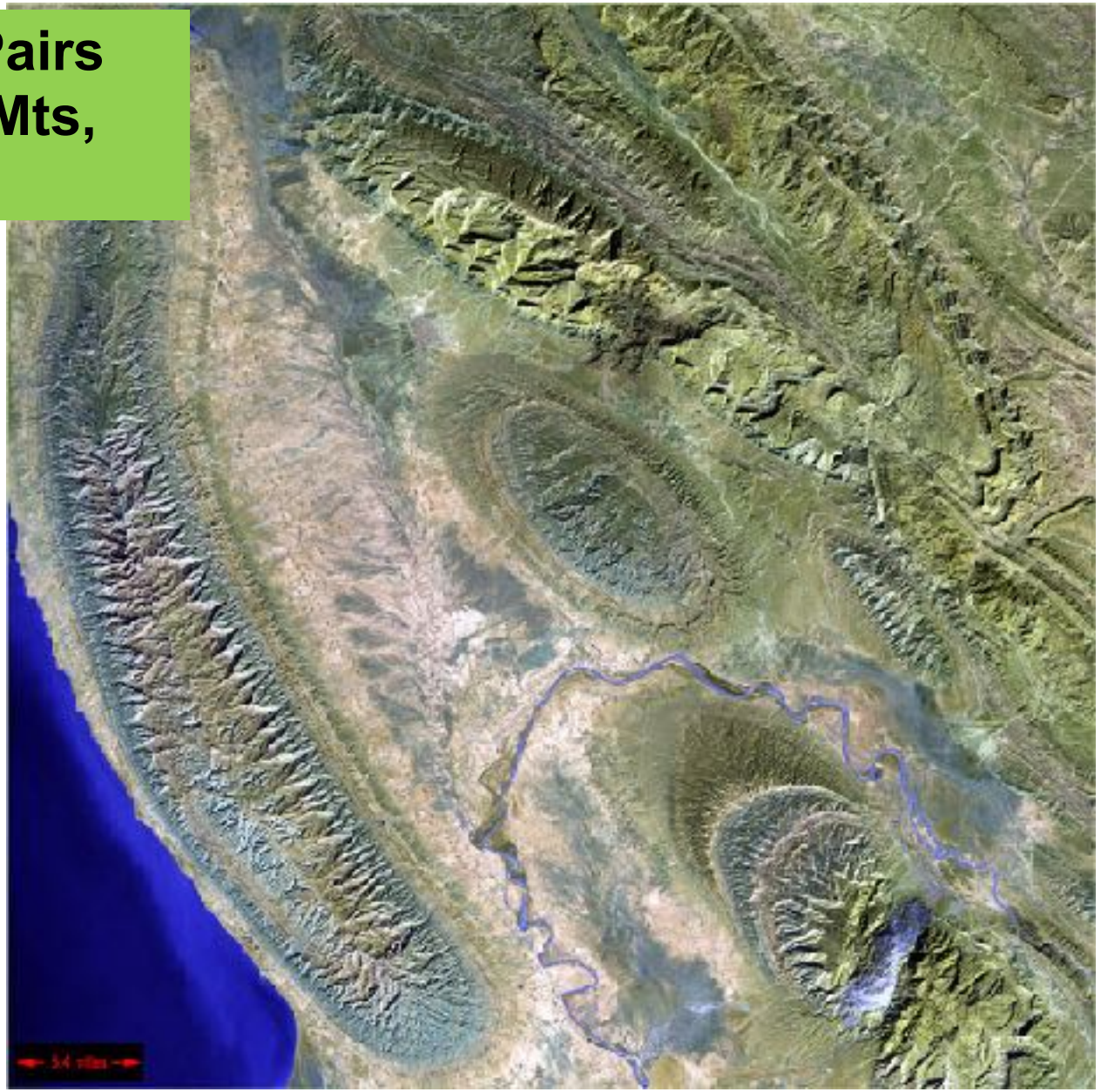
Domes and Basins

Folds

Virgin Anticline,
Southern Utah

Folds

Syncline-Anticline Pairs + Domes at Zagros Mts, Iran



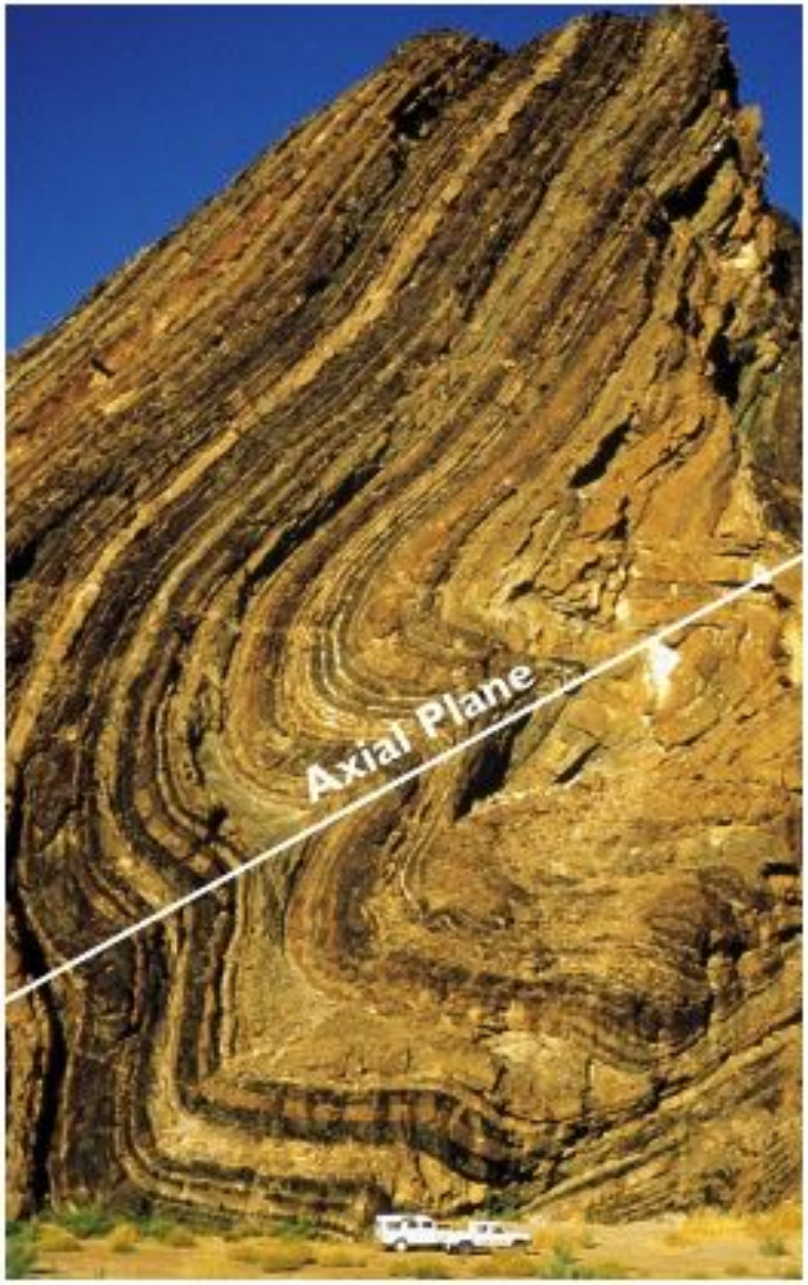
NASA “Earth as Art” web page

Folds

Grenville Dome: Sinclair, WY

Folds

Syncline, Israel



Folds

Which deformation and stresses cause theses structures ?

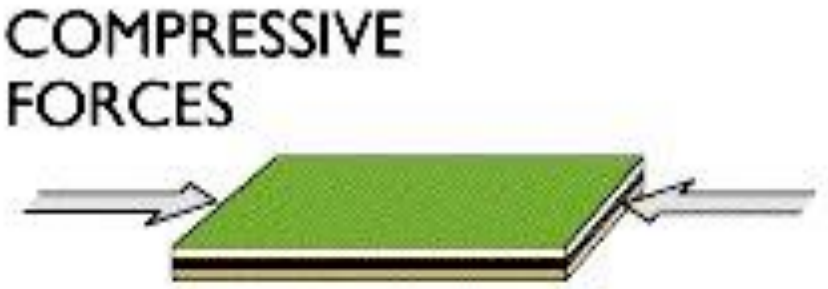
Folding of Shale-Sandstone sequence, Kings Canyon, California

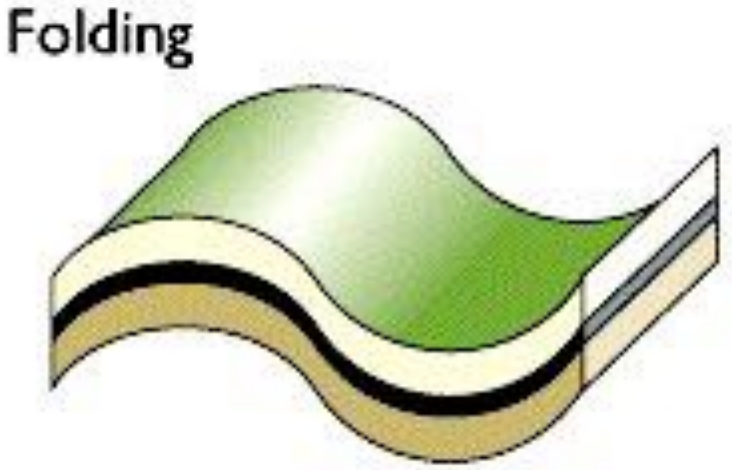
Folds

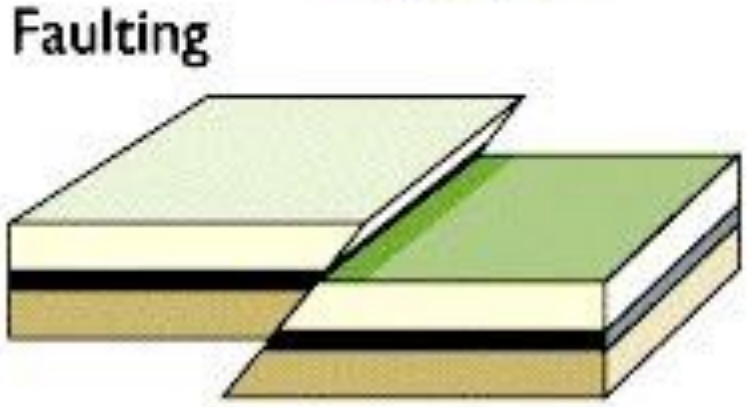
Compressive Forces…

Folds axis are perpendicular to the main direction of compression

Folds and Thrust have the same origin

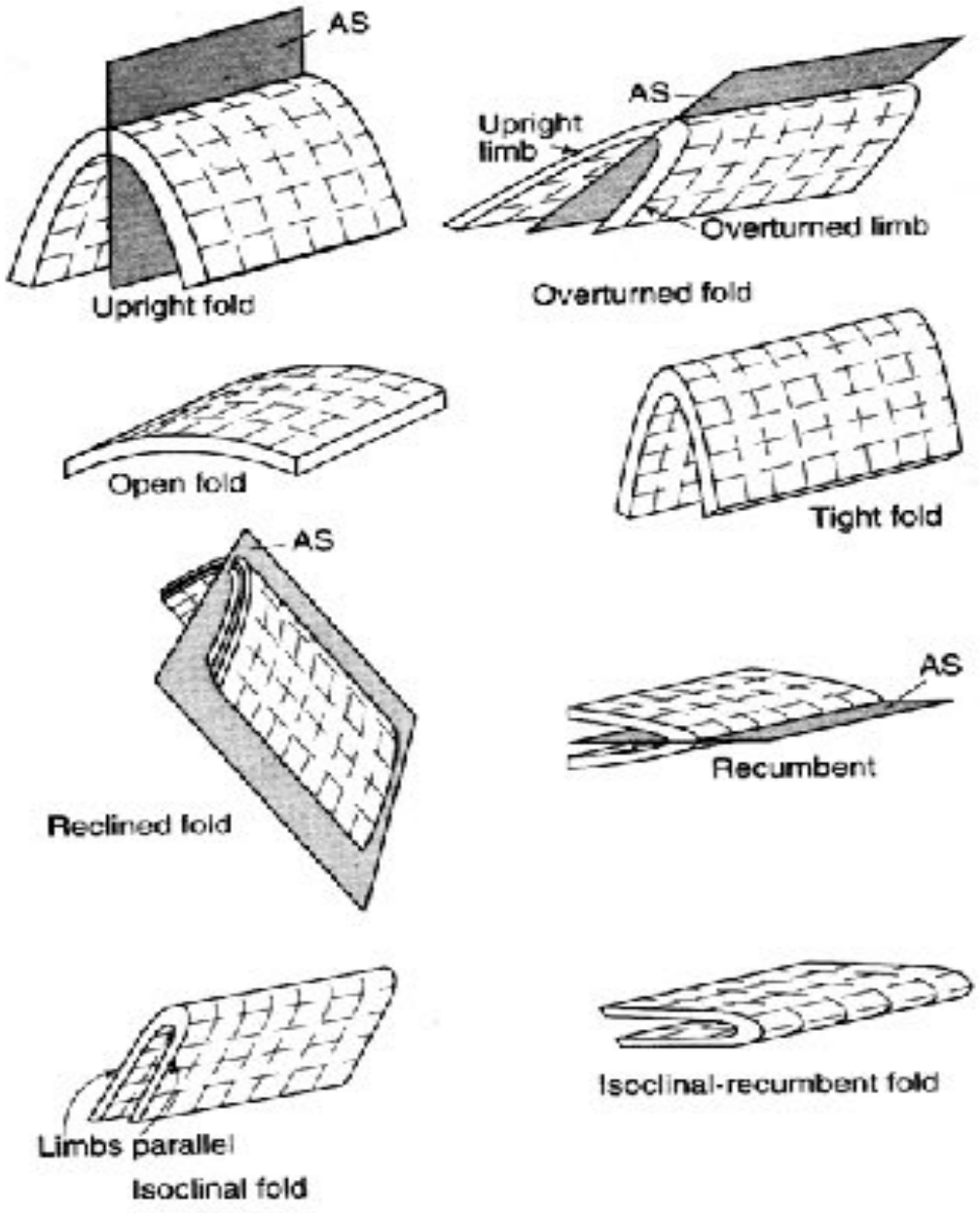




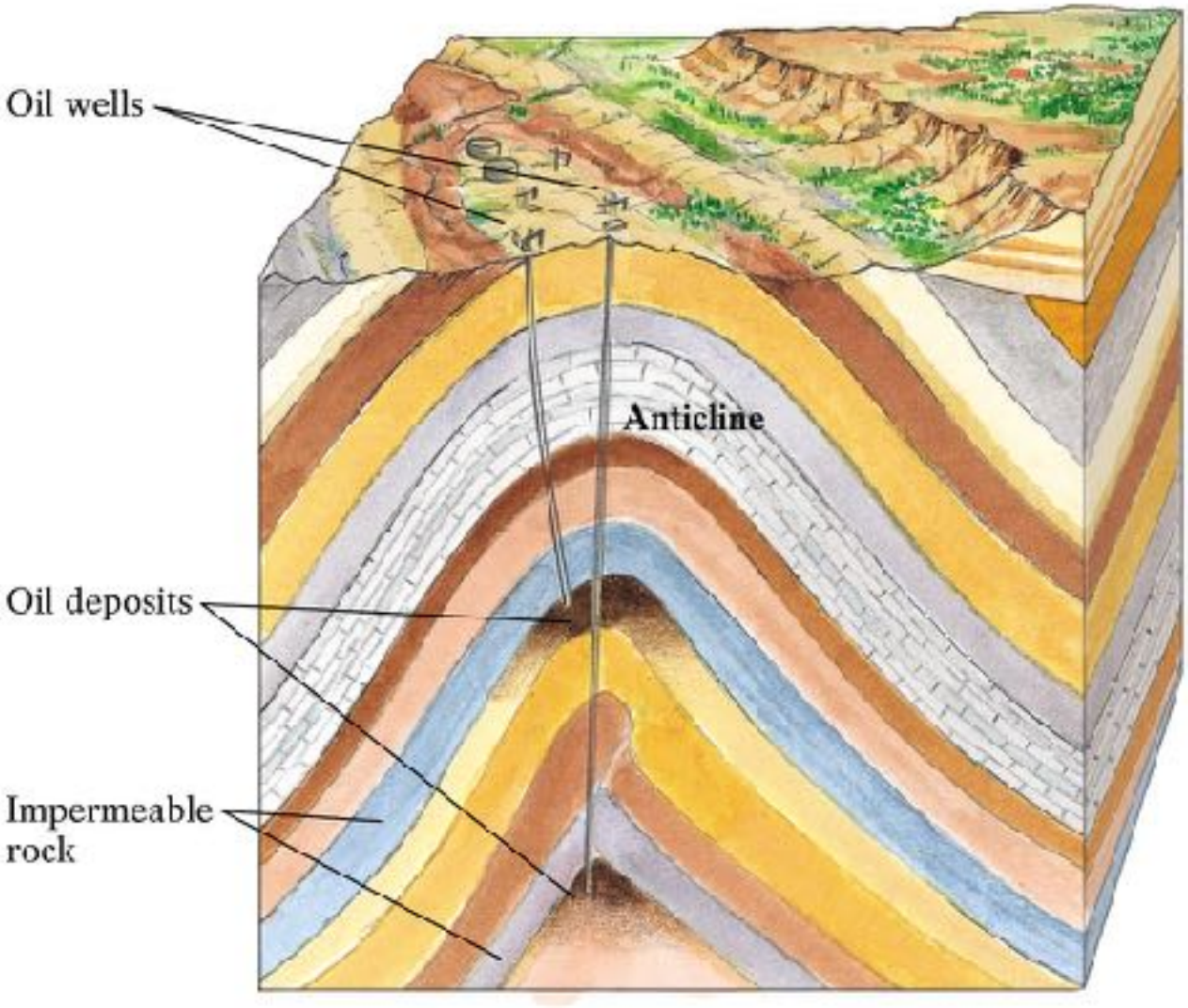


Folds

Folds Classification



Oil and Gas Concentrate in Domes



Chernicoff and Whitney

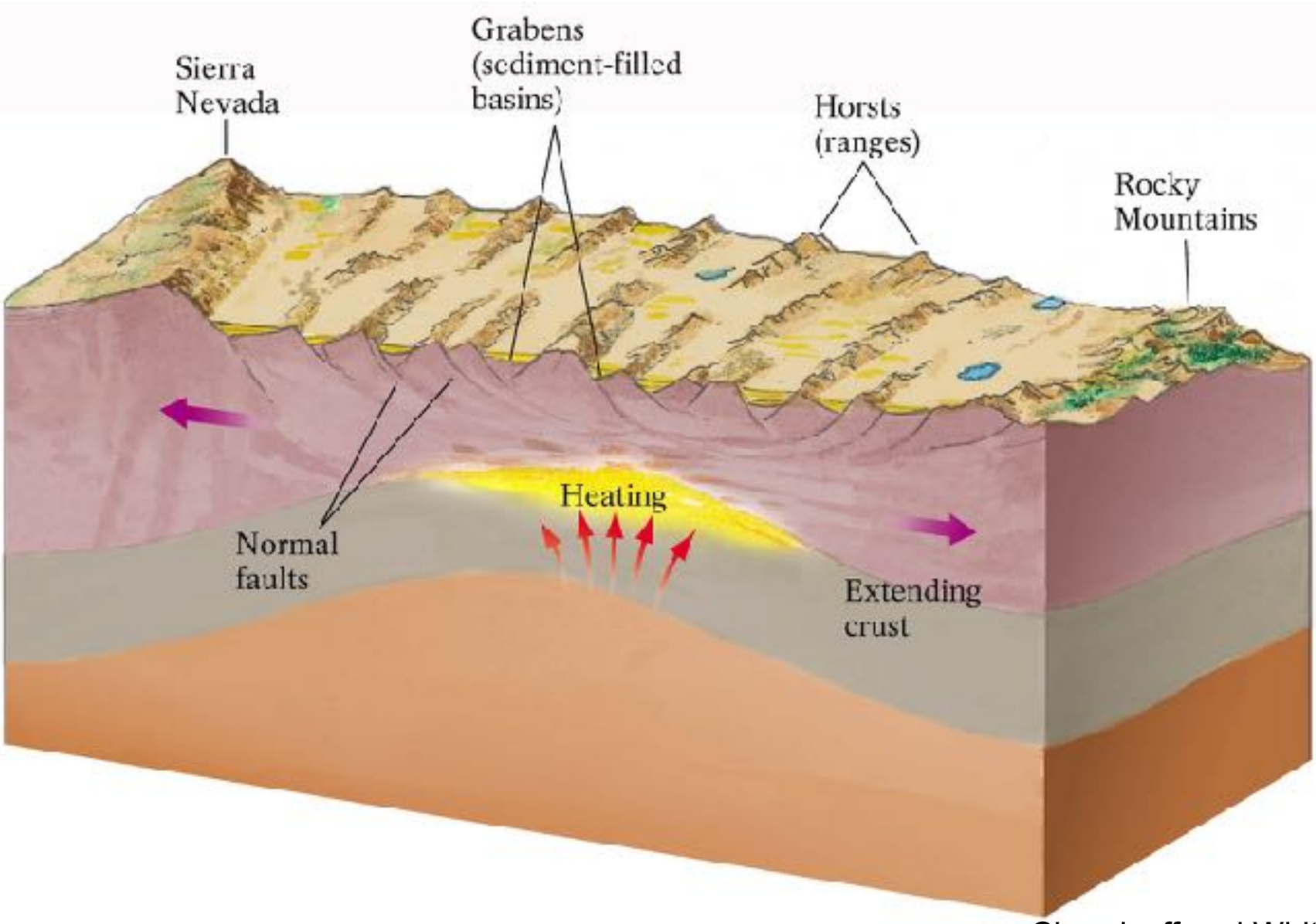
Folds and Faults

Folds and thrust are both responsible for the orogens

R.W.H. Butler

Fold-thrust complex developed in Upper Jurassic limestones in the Haut Giffre area of the Subalpine thrust belt (Morcles nappe in France)

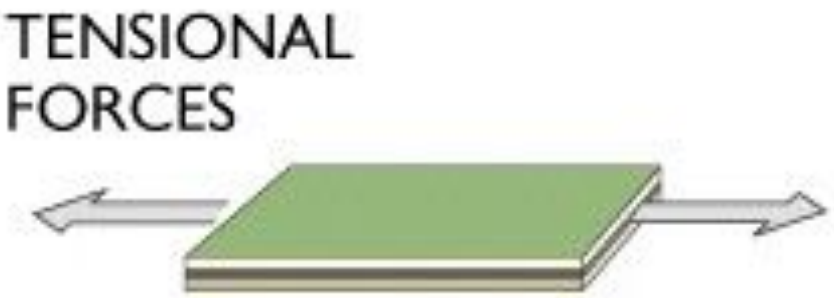
Continental Extension



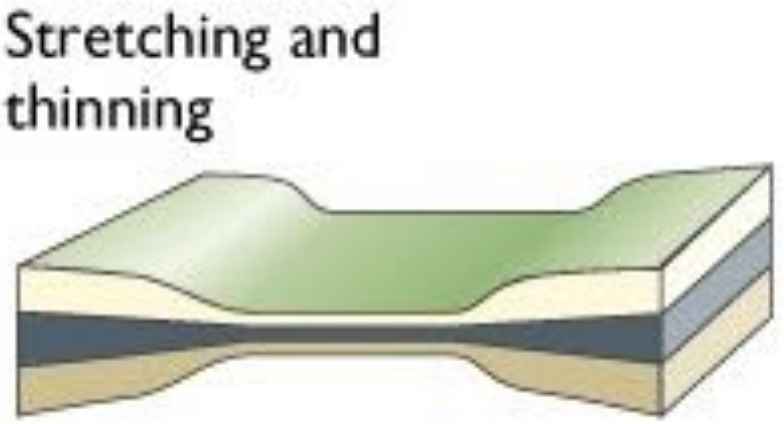
Chernicoff and Whitney

Extension

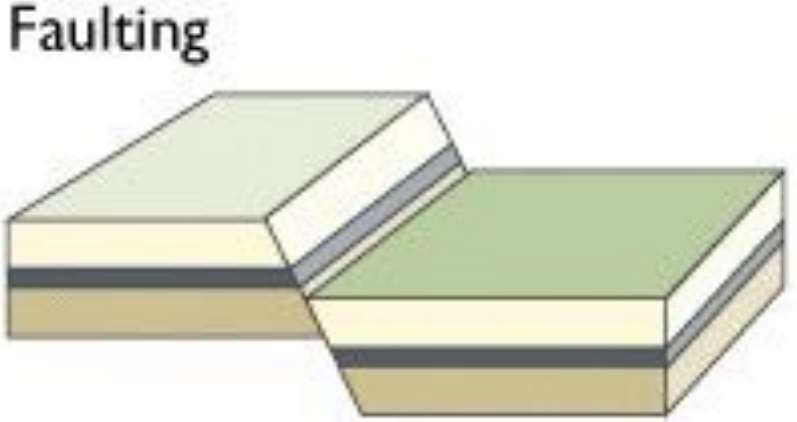
Extension



Ductile → Crust Thins



Brittle → Faulting

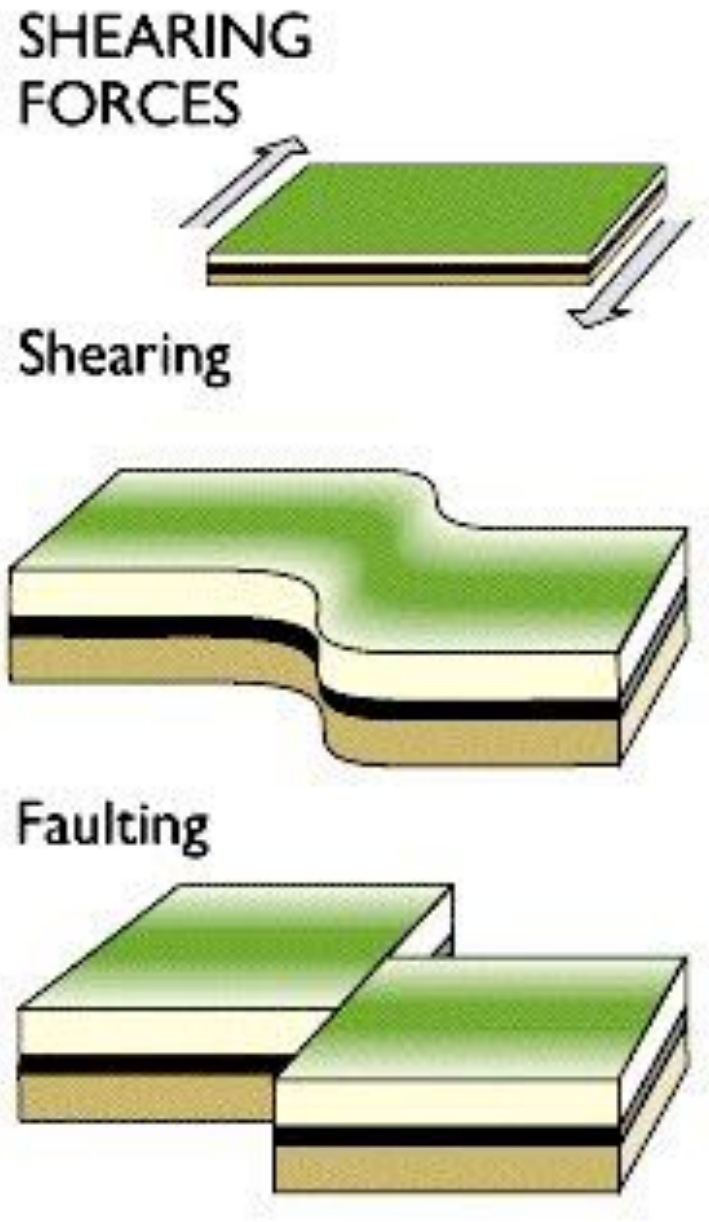


Shearing (coupling)

Shearing Forces

Lateral slip creates faults

Common at transform



Faults

Faults

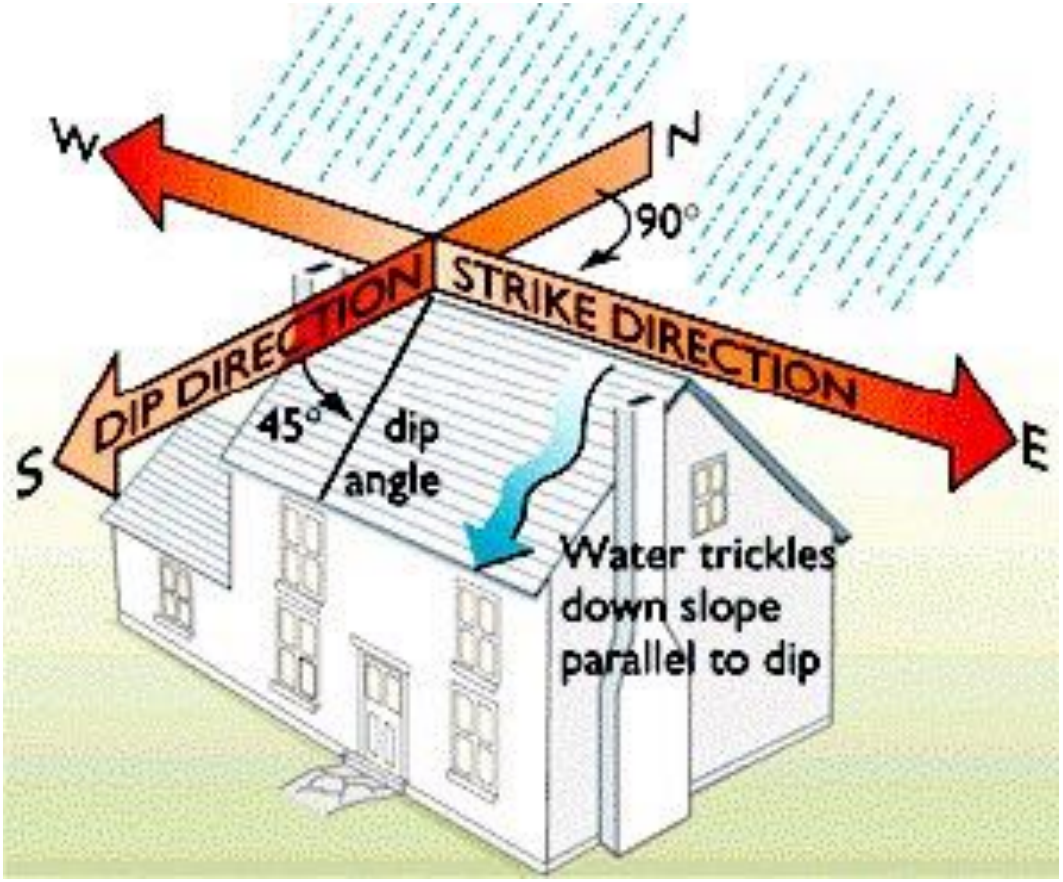
- result from brittle deformation
- rocks offset across fault
- Sides referred to as "hanging wall" and "footwall"

-- 3 types of fault

Faults

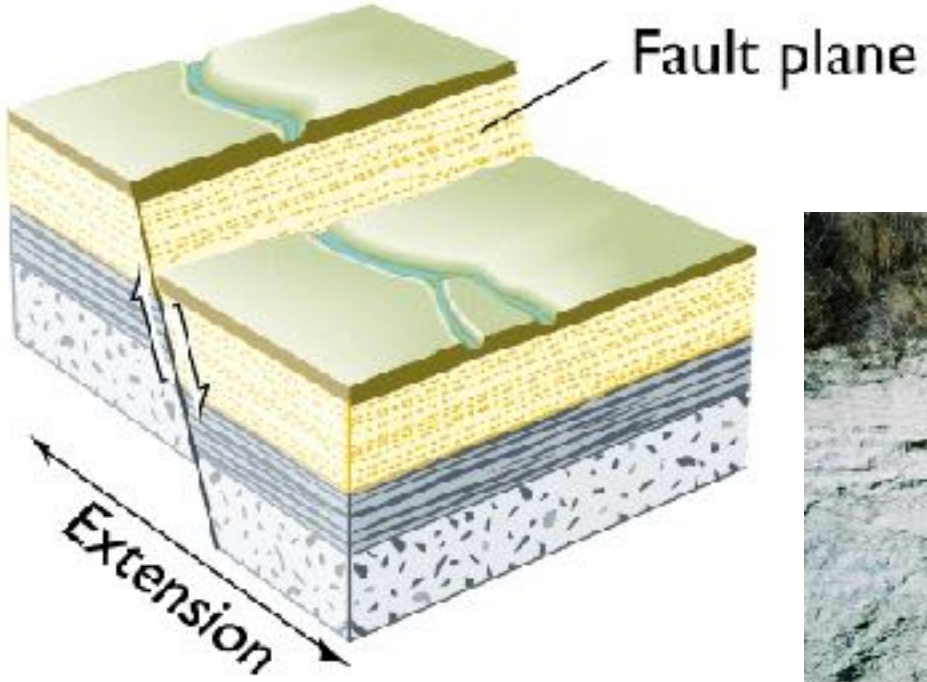
Strike & Dip

- ❑ **Describe fault orientation**
- ❑ **Direction of slip determines kind of fault: “dip-slip” or “strike-slip”**



Chernicoff and Whitney

Normal Fault

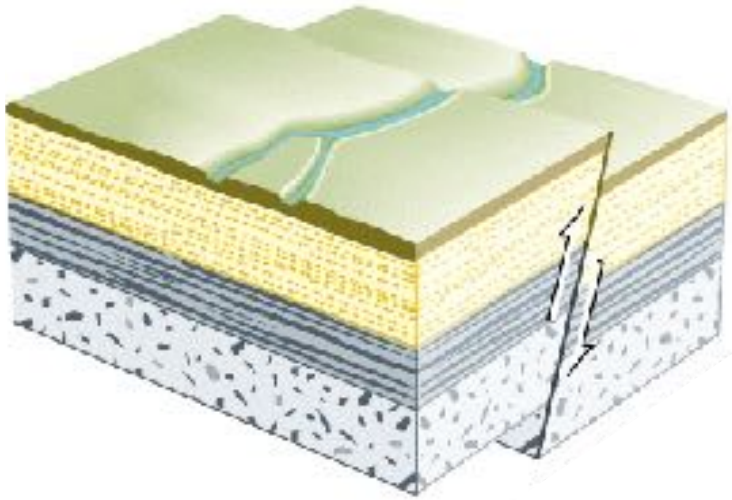


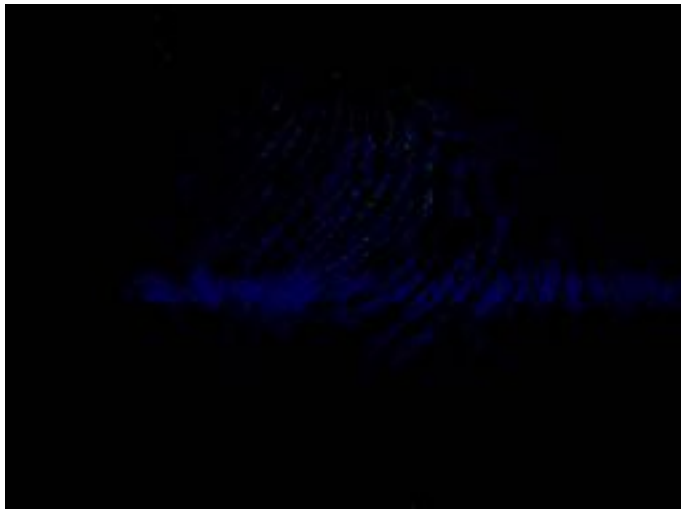
Normal Fault (Dip-Slip Fault)

Normal Fault, Lamb Canyon, CA

Faults

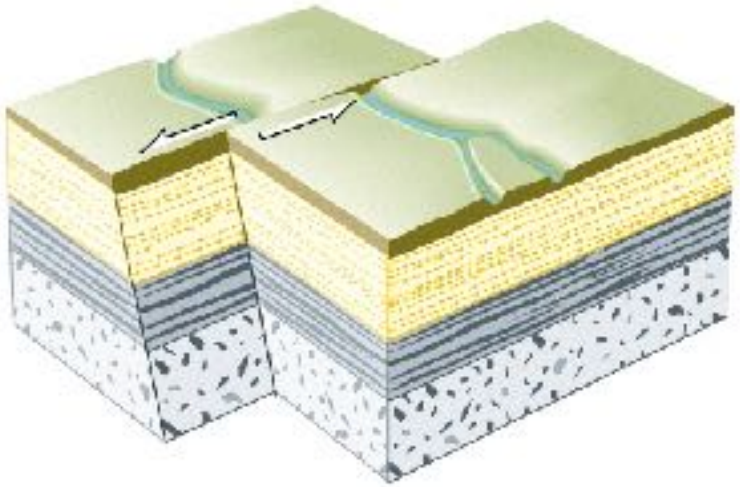
Reverse or Thrust Fault



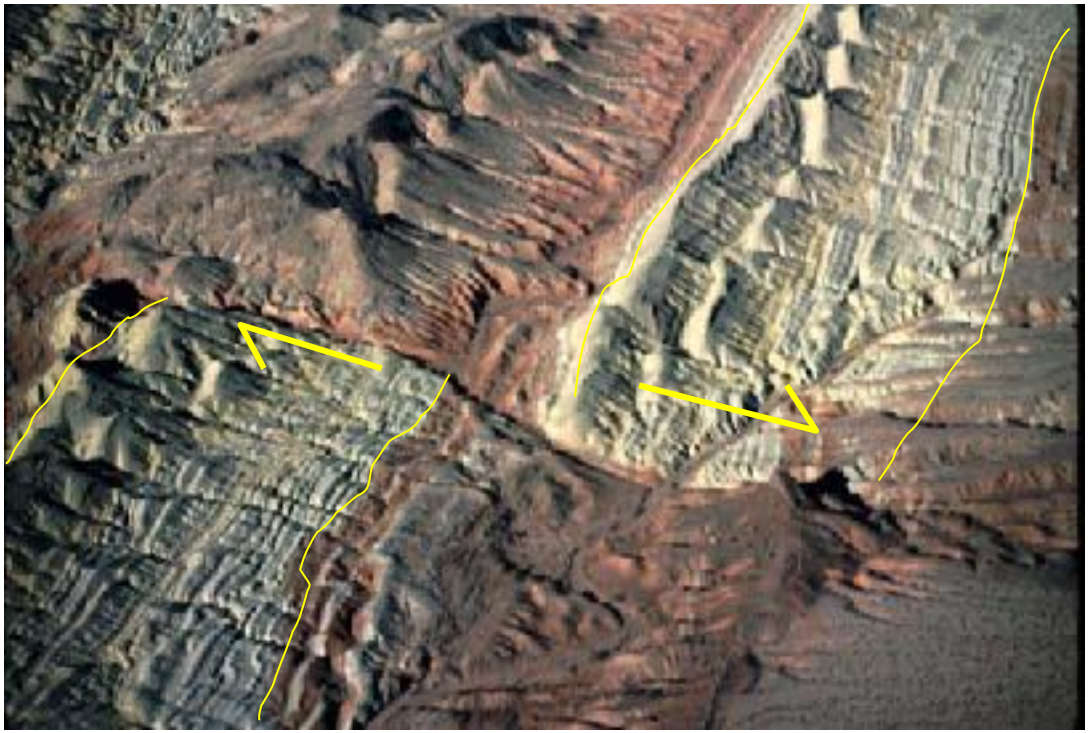


Small thrust fault, Las Vegas, NV,
Source: M. Miller, U. of Oregon

Strike-Slip Fault



Strike-Slip Fault (left-lateral)



Strike-slip fault near Las Vegas, NV,
Source: M. Miller, U. of Oregon

Faults

Strike-slip fault displacement in orchard

Folds and Faults

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Fold-thrust complex developed in Upper Jurassic limestones in the Haut Giffre area of the Subalpine thrust belt (Morcles nappe in France)

JOINTS (FRACTURES)

Joints

- Brittle “cracks” in rocks
- Form near surface
- Regular spatial distribution
- No offset

JOINTS (FRACTURES)

Preferential weathering of joints in Sandstone;

Calcite veins in joints of marble, Laurel Mt., CA