12.001 Leture Notes Rock deformation
O.Jagoutz

Rocks are deformed due to directional forces acting on them. These are essentially the results of plate tectonic (and we will discuss the driving forces for that later in the course).

Definition of stress: $\sigma = F/A$

2 types of stresses: uniform and differential. Uniform relates to pressure, which we think about in metamorphism.

3 types of differential stresses (draw a picture for each):

1. Compression results in shortening
2. Extension results in pulling apart
3. Shearing pushes two sides apart

Explain the sigma 1,2,3 notation for major, minor and intermediate stresses.

Changes in a body's dimensions are measured in strain:

Definition of strain: $\varepsilon = (L_1-L_0)/L_0$
Definition of shear strain: $\gamma = \tan \alpha$ (opposite/adjacent)

Stresses can result in two types of deformation: recoverable (elastic) and permanent (ductile, brittle)

Brittle deformation:

Related to breaking of rocks: minerals break apart mainly along pre-existing weak zones such as microfractures. Make an experiment of two students breaking chalk along extension and compression. Ask for an explanation as to why chalk is so much weaker in tension than in compression. Explain that this is true for rocks, too.

Ductile deformation:

Show the folded rock from Clark and ask how students think it is possible to deform a rock without breaking it.

Explain the main mechanisms of ductile deformation:

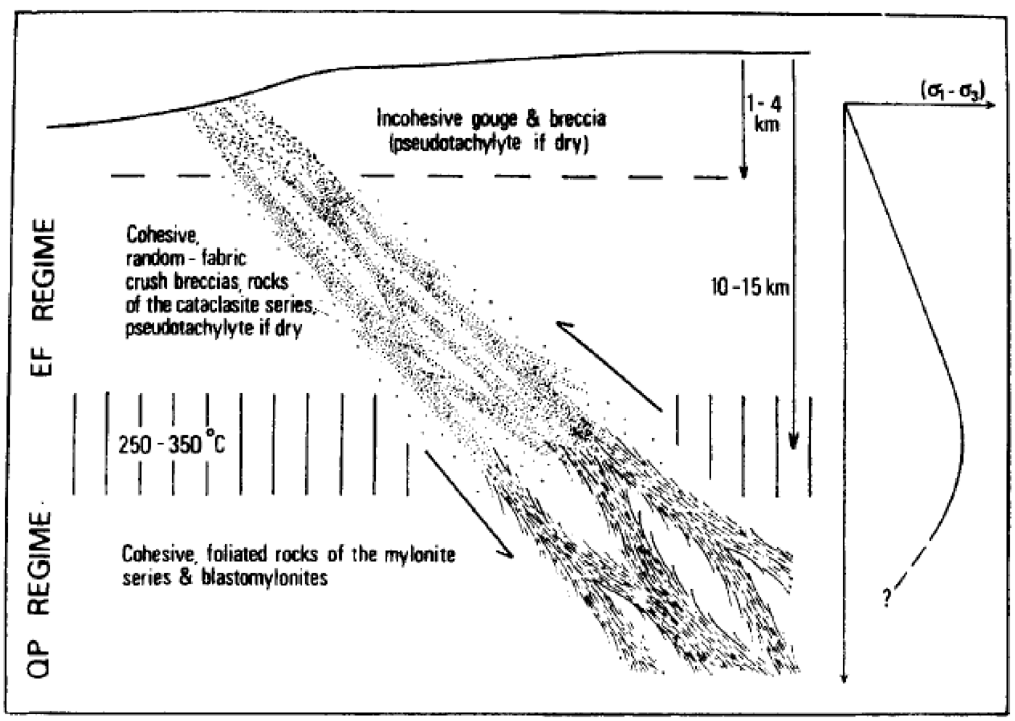
Diffusion creep.
Explain intracrystalline diffusion and grain boundary diffusion with or without fluid.

Dislocation creep.
Explain the glide of dislocation, due to the fact that we need to only break one bond at a time, the stress needed is much smaller than normal.

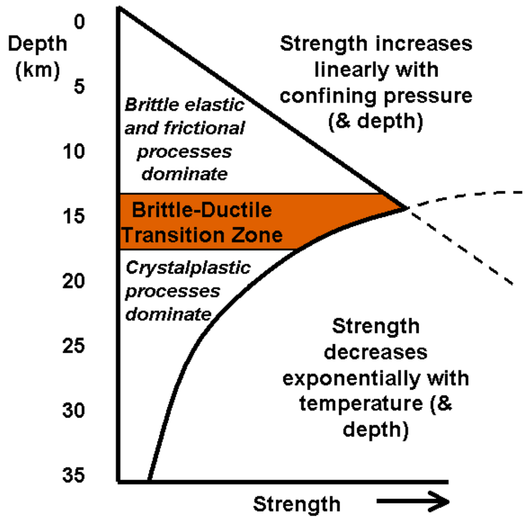
The important implication of dislocation creep is that the orientation of the mineral changes. Make a drawing of the crystallographic axis in the two examples of diffusion creep and dislocation creep. Anisotropic minerals have different seismic properties in different directions, and with preferred glide planes we can preferentially align minerals in rocks. If this alignment becomes prominent we can produce seismic anisotropy as the seismic waves travel faster in one direction than in the other. And we can measure the anisotropy in one direction and so infer something about the direction of flow in the mantle.

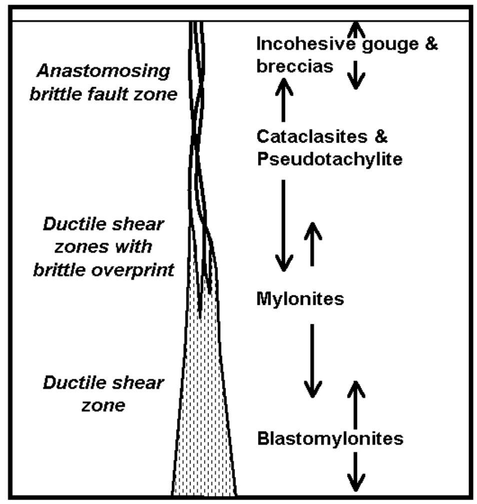
Introduce the principal rock structures: folds and faults
Macroscopic rock structures:

Faults

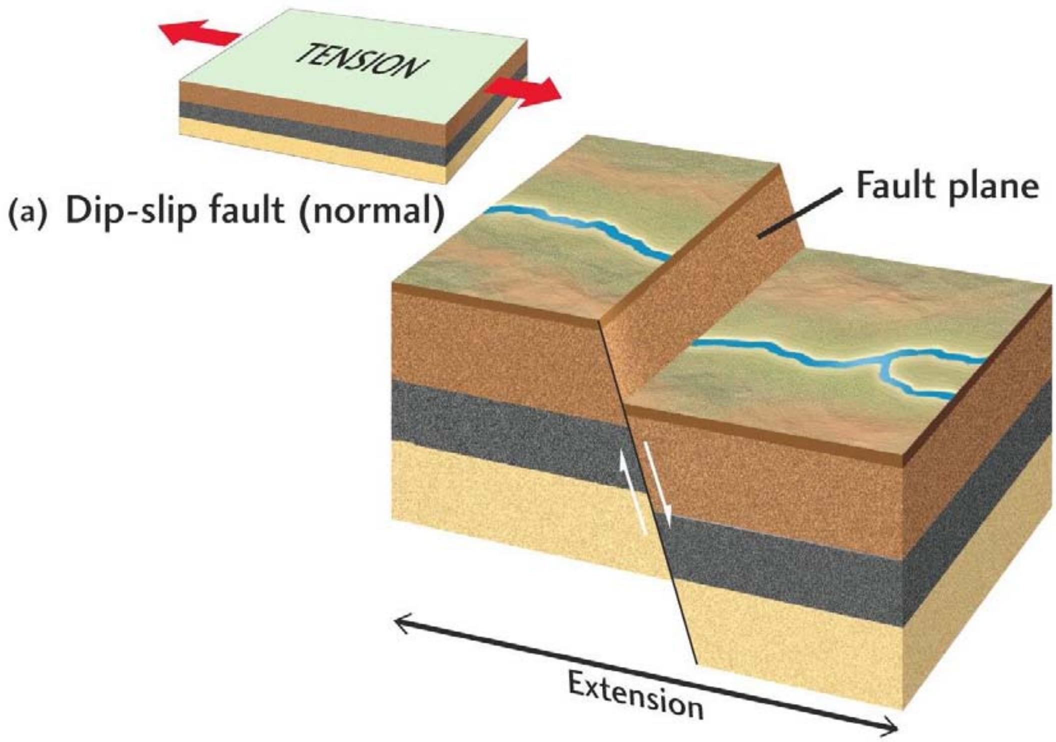


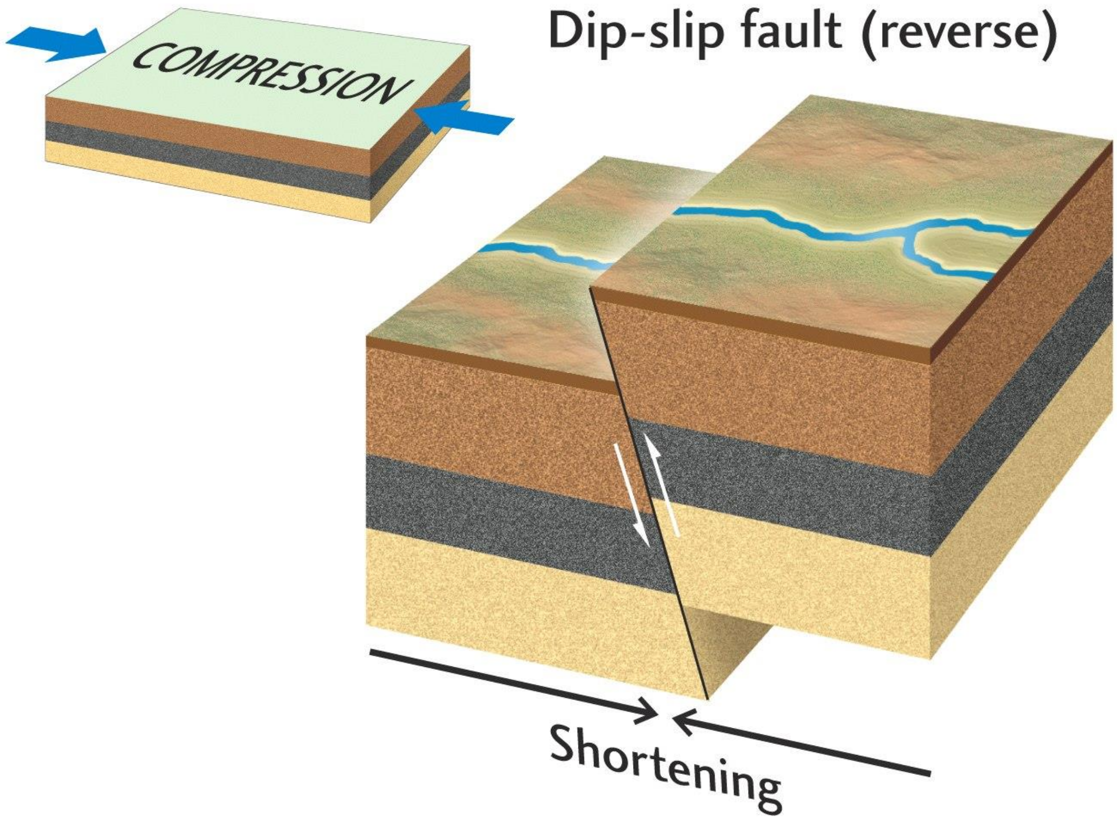
Sibson, 1977

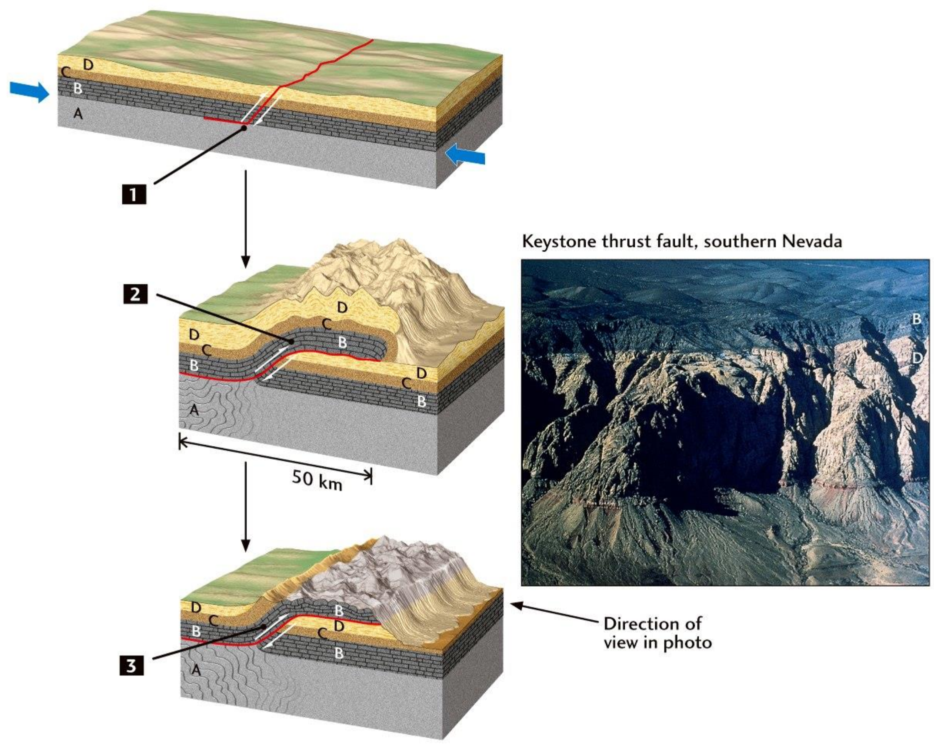




Explain the brittle ductile transition

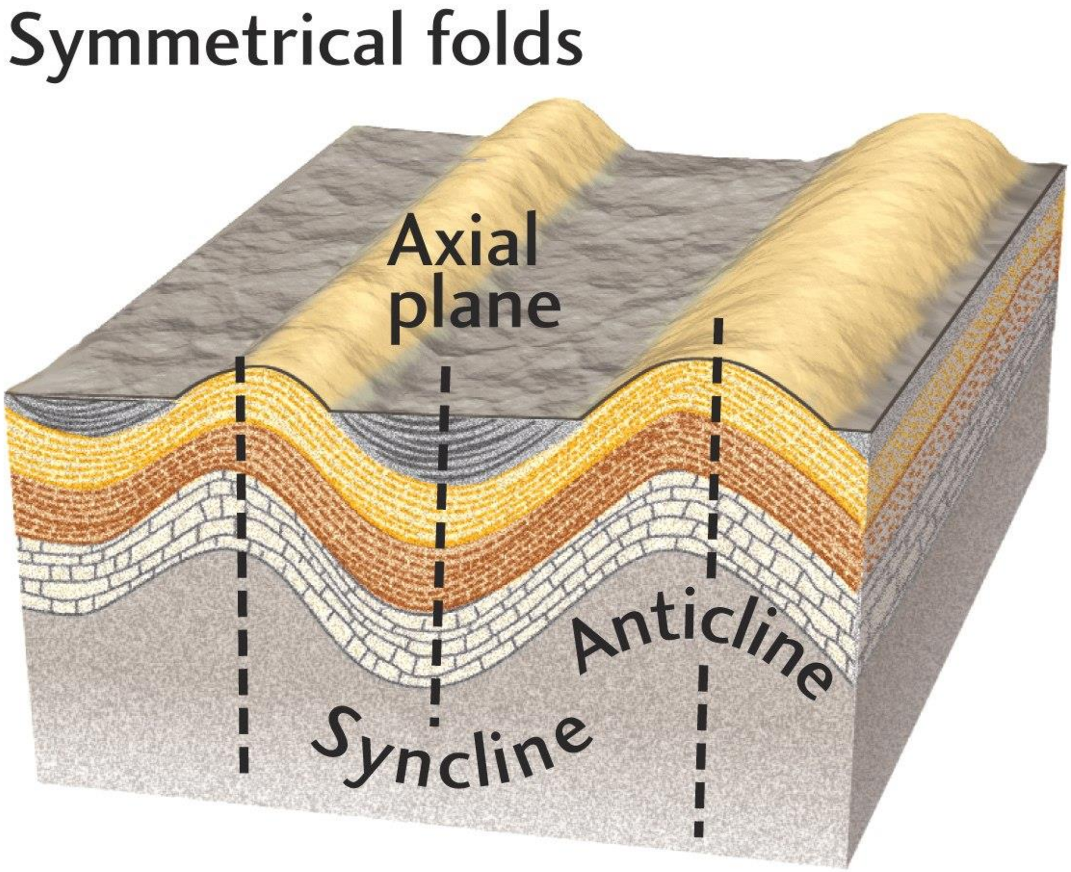



COMPRESSION
Dip-slip fault (reverse)
Shortening


D
C
B
A
1
2
3
50 km
Keystone thrust fault, southern Nevada
Direction of view in photo

Folds:

Anticline: oldest rocks in the center
Syncline: youngest rocks in the center.



Explain fold axis and fold axial plane, often parallel to foliation (show picture)

Explain the difficulty that we have in inferring 3D structures from 2D observations. Topography is trivial compared to the magnitude of rock structures.