12.005 Lecture Notes 9

Stress Rotation, after Zoback et al, 1987

The principal stress directions are observed to rotate in the vicinity of the San Andreas fault (SAF). In the far-field (e.g., Nevada), the maximum compressive stress is oriented at an angle to the fault trace $\beta \sim 55°$. But in the near field, this angle, now called α, is close to 85°. (Note that this is the same as the angle between the least compressive stress and the normal to the fault plane, the angle conventionally used in Mohr circle analysis.)

Assume that in the far-field stress has σ_I = -68 MPa, σ_{II} (assumed vertical and lithostatic) = -136 MPa, and σ_{III} = -204 MPa. (What style of faulting would this cause?)

Assume that the fault has strength C_0, so that σ_{12} becomes smaller approaching the fault. (How could this happen, given Newton's second law?).

Also assume that the normal stress across the fault maintains its far-field value (σ_{22} in the coordinate system fixed to the fault, as shown in the diagram). Assume that σ_c remains the same. (Does this agree with the style of faulting and the folding near the SAF?)

Then, from a Mohr's circle construction, it is straightforward to obtain a relation between α and β.

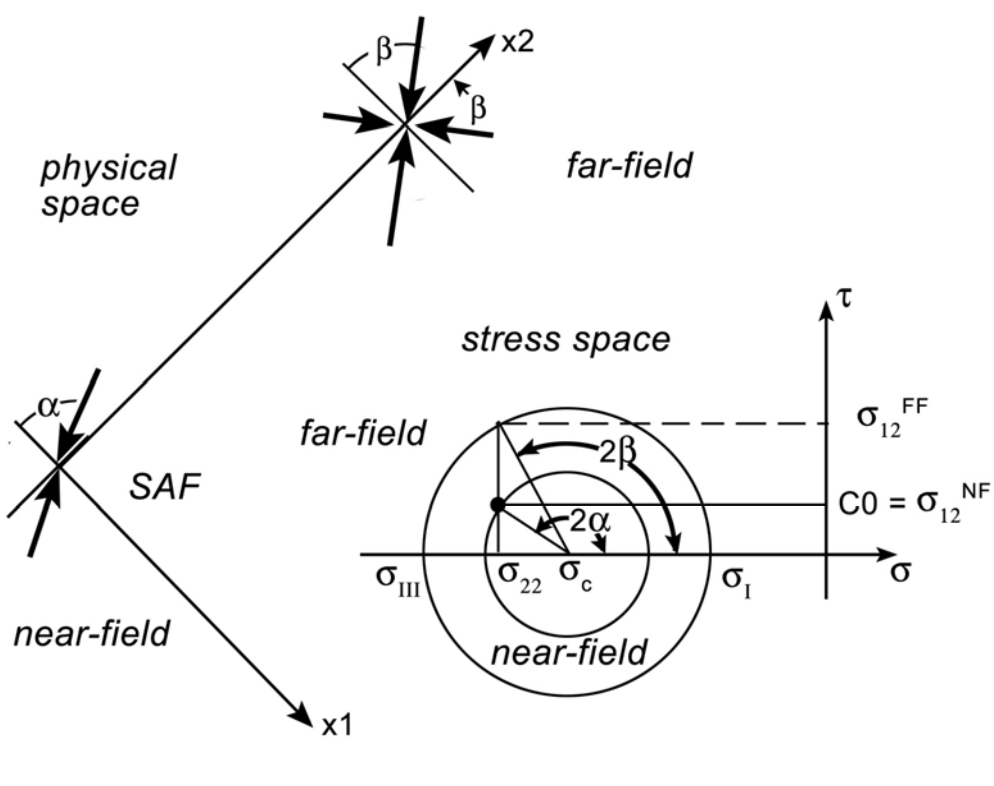

Figure 9.1

Figure by MIT OCW.

Possible cause of "weak" faults

- Preexisting fracture

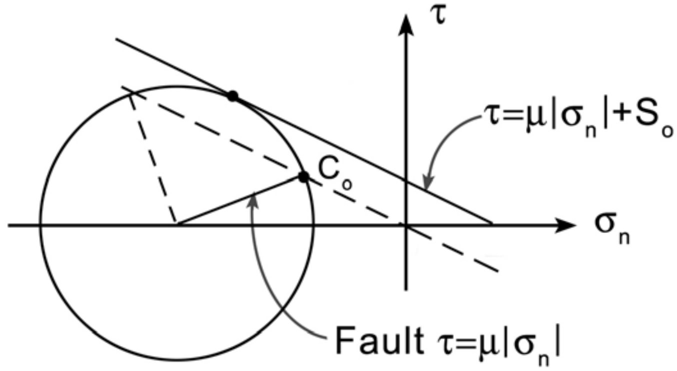

Figure 9.2

Figure by MIT OCW.

- Clay $\Rightarrow$ low μ

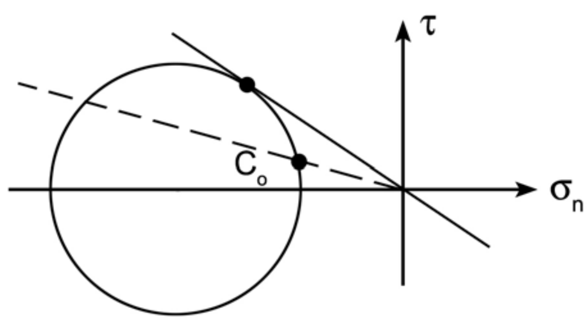

Figure 9.3

Figure by MIT OCW.

Pore fluid pressure model of fault weakening

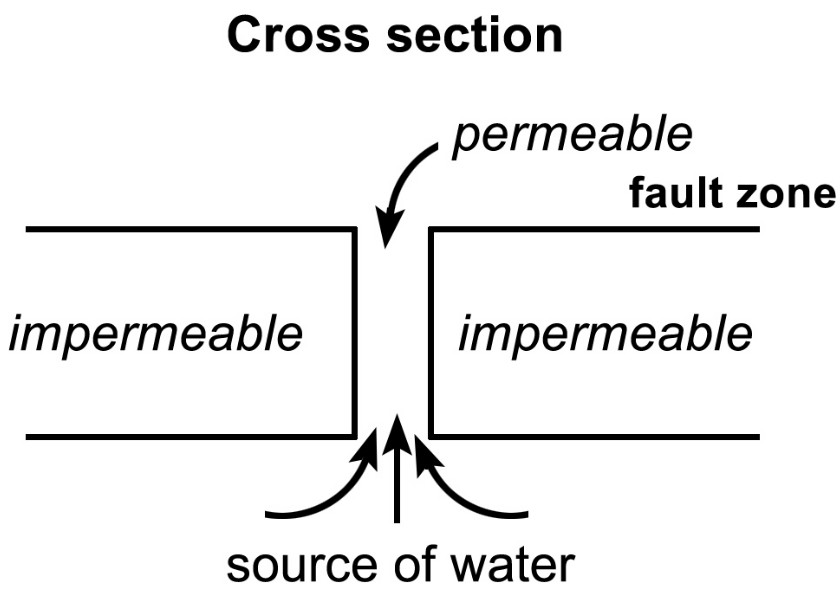

Figure 9.4

Figure by MIT OCW.

Fault zone highly permeable

Darcy flow $\approx$ heat flow
Permeability $\approx$ conductivity
$p \approx T$□

Given source of water
High permeability $\Rightarrow$ high p

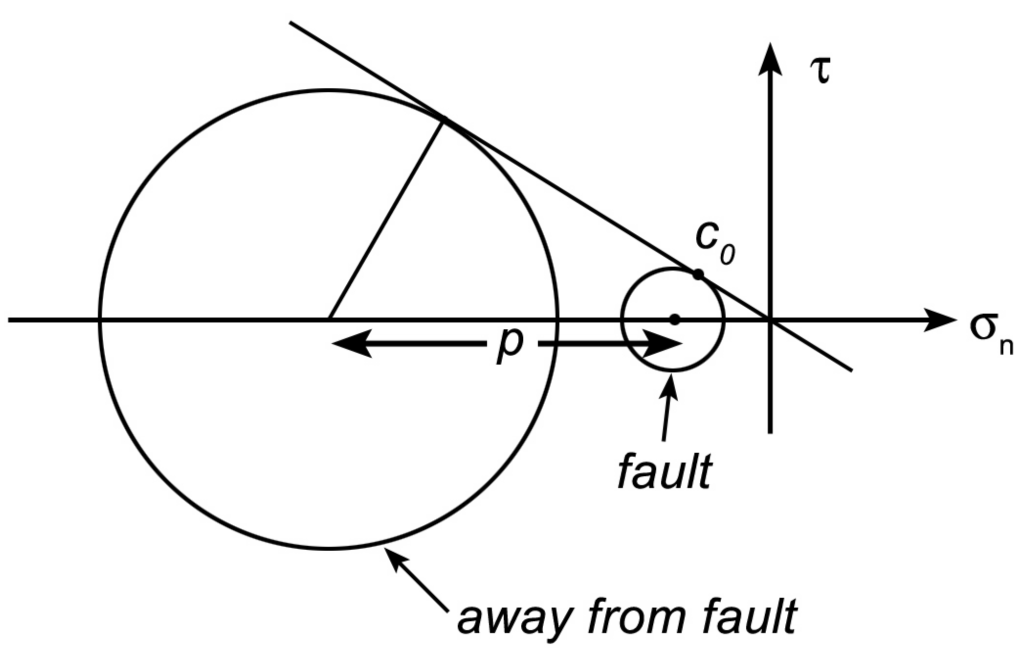

Figure 9.5

Figure by MIT OCW.

Question:

- What are implication for stress direction in fault zone?
- Is low $\Delta\sigma$ in fault zone consistent with large $\Delta\sigma$ outside?

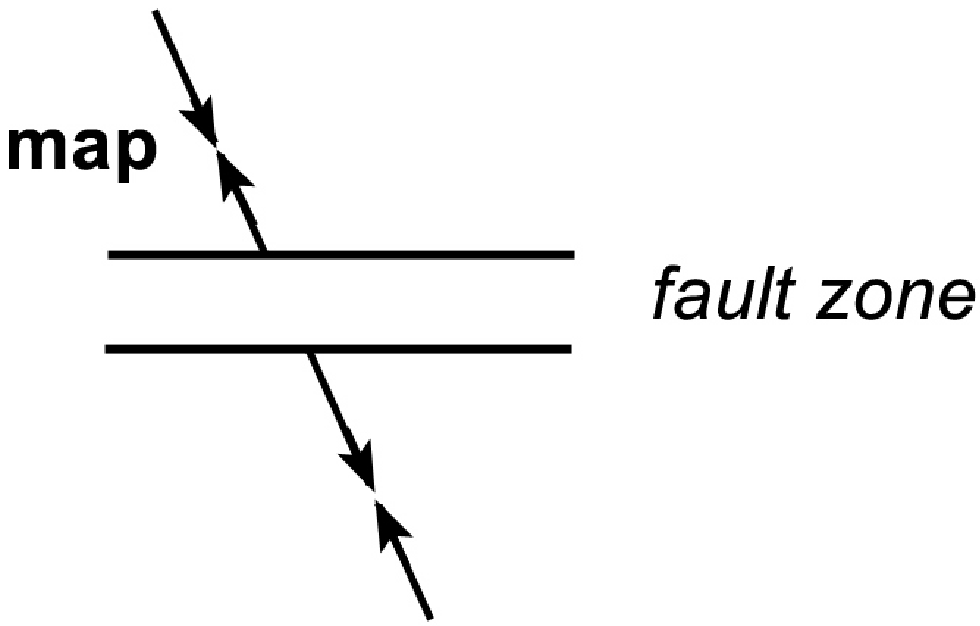

Figure 9.6

Figure by MIT OCW.