ESS 411/511 Geophysical Continuum Mechanics Class #15

Highlights from Class #14 – (Andrew Gregovich)
Today's highlights on Wednesday – Andrew Gregovich

Our text doesn't cover our next topics very thoroughly, so we will use a few other sources, which are posted on the class web site under READING & NOTES. https://courses.washington.edu/ess511/NOTES/notes.shtml

- Stein and Wysession 5.7.2
- Stein and Wysession 5.7.3/4
- Raymond notes on failure

Also see slides about upcoming topics

- Failure and Mohr's circles – slides

Your short CR/NC Pre-class prep writing assignment (1 point) in Canvas

- It will be due in Canvas at the start of class.
- I will send another message when it is posted in Canvas.

ESS 411/511 Geophysical Continuum Mechanics

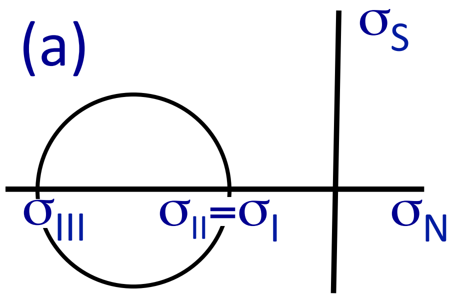
Broad Outline for the Quarter

- Continuum mechanics in 1-D
- 1-D models with springs, dashpots, sliding blocks
- Attenuation
- Mathematical tools – vectors, tensors, coordinate changes
- Stress – principal values, Mohr's circles for 3-D stress
- Coulomb failure, pore pressure, crustal strength
- Measuring stress in the Earth
- Strain – Finite strain; infinitesimal strains
- Moments – lithosphere bending; Earthquake moment magnitude
- Conservation laws
- Constitutive relations for elastic and viscous materials
- Elastic waves; kinematic waves

Warm-up questions – (break-out)

Explain what's going on in each case.

(a)



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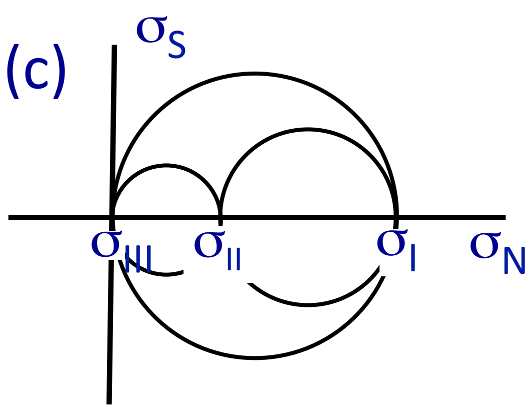

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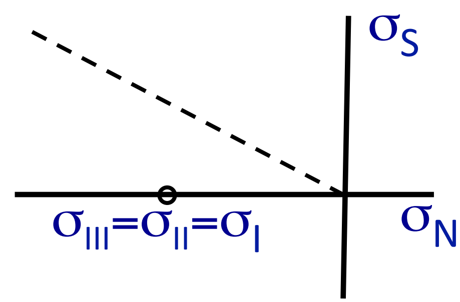

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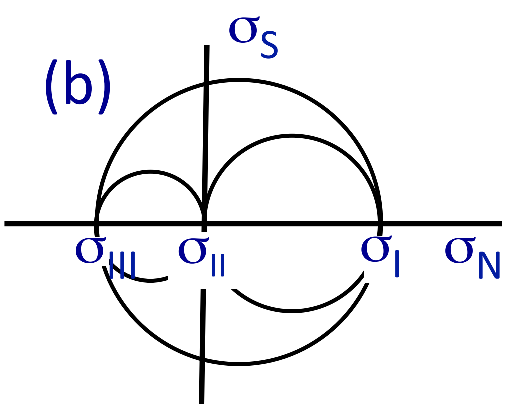

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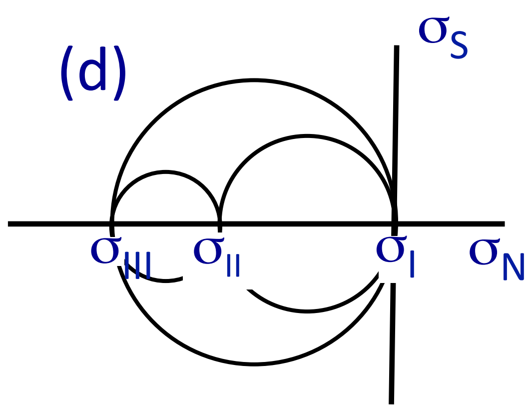


(f)

$p = -\sigma_{ii}/3$

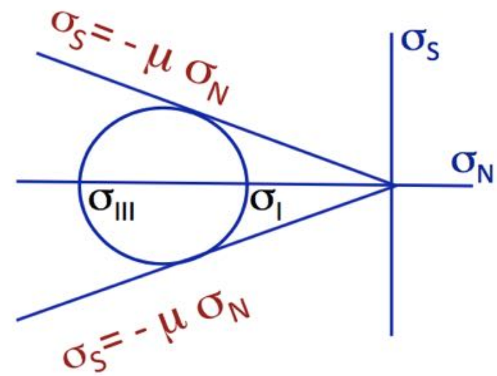
- What is p?
- Why the minus sign?

Class-prep questions for today (break-out rooms)

Failure of materials

Last class, we looked at frictional sliding on pre-existing fractures or faults with a coefficient of friction μ.

- What physical characteristics of a surface cause friction?



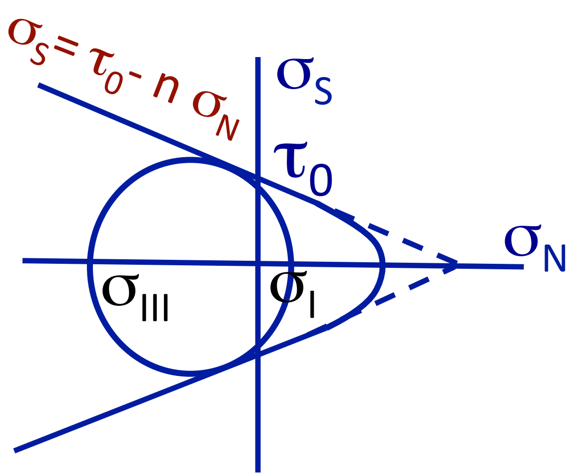
Now we are going to actually break new rocks.

Mohr–Coulomb failure

$$\sigma_S = \tau_0 - n\,\sigma_N$$

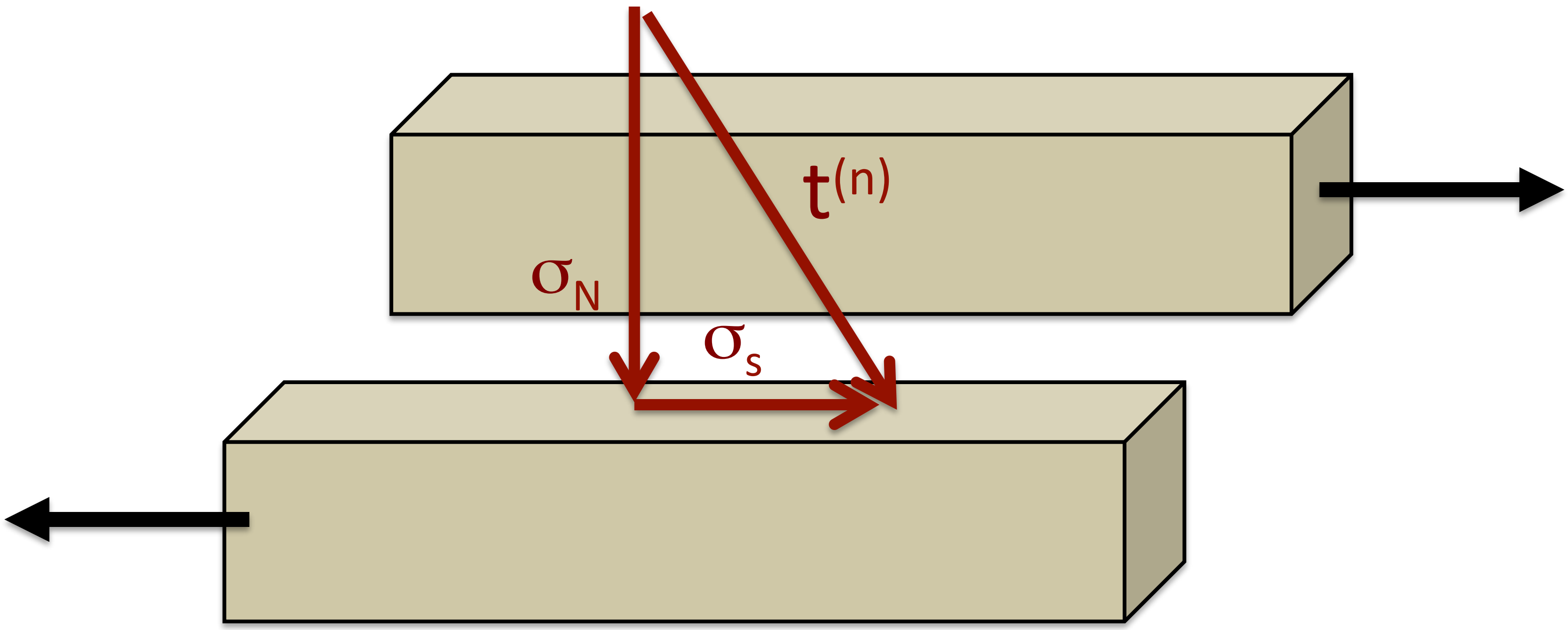
n = ***coefficient of internal friction*** for fracture on a new fault surface

τ_0 = cohesion of the material



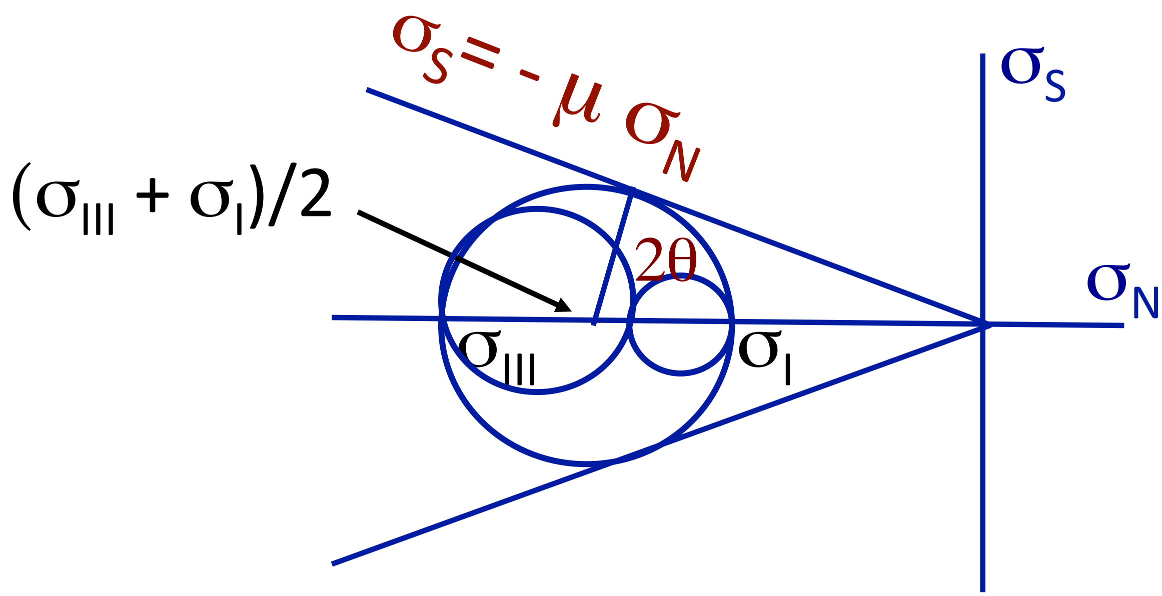
- Explain what you think n and τ_0 might mean in terms of micro-scale processes at the micro-crack, crystalline, or lattice scales.
- Why do you think the failure envelope is rounded off at the right? Think about the sign of σ_N and the processes that might contribute to internal friction.

Sliding friction



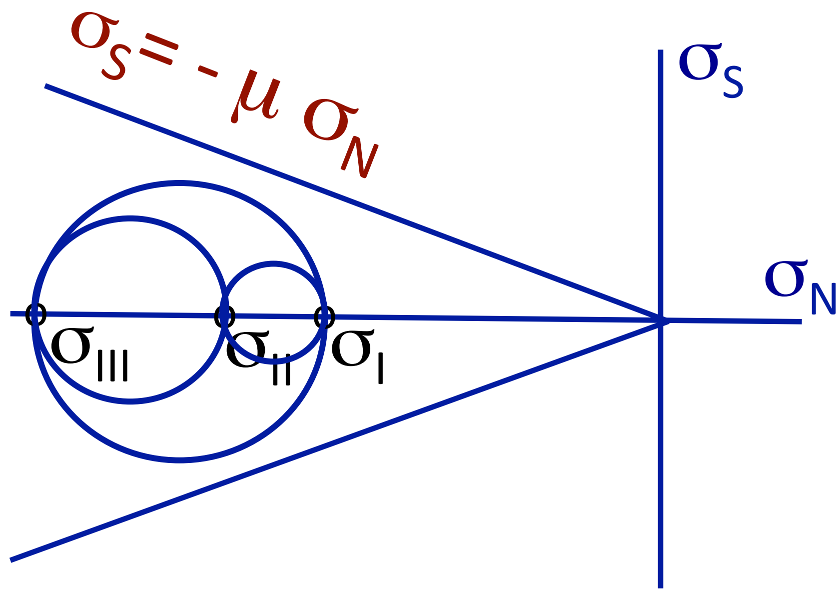
$\sigma_S = -\mu\, \sigma_N$ μ is ***coefficient of friction*** for sliding on a pre-existing break

Frictional sliding



$\sigma_S = -\mu\, \sigma_N$ μ is ***coefficient of friction*** for sliding on a pre-existing break

Differential stress $\sigma_{III} - \sigma_{I}$

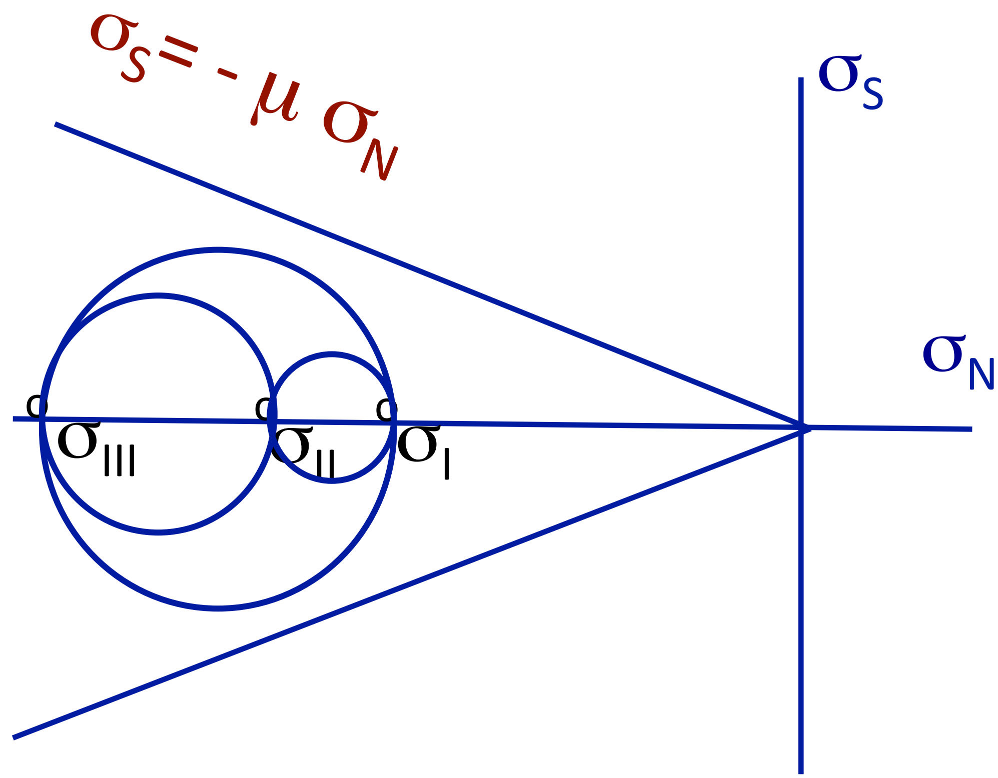


But, if $\sigma_{III} = \sigma_{I}$, all 3 principal stresses are equal

- What do the 3 Mohr's circle look like?
- Describe this state of stress inside the body.
- Is frictional failure possible, if differential stress is zero?

Differential stress

$\sigma_{III} - \sigma_{I}$



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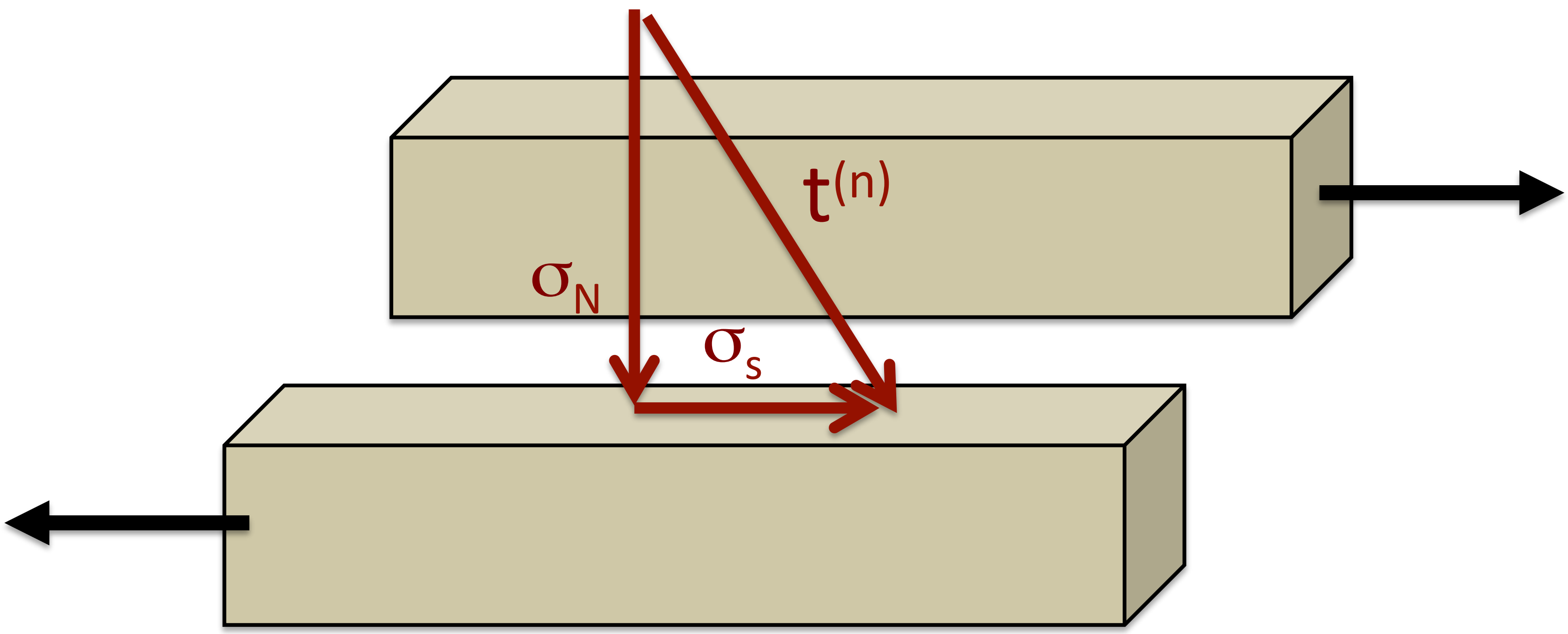
Mohr-Coulomb Fracture



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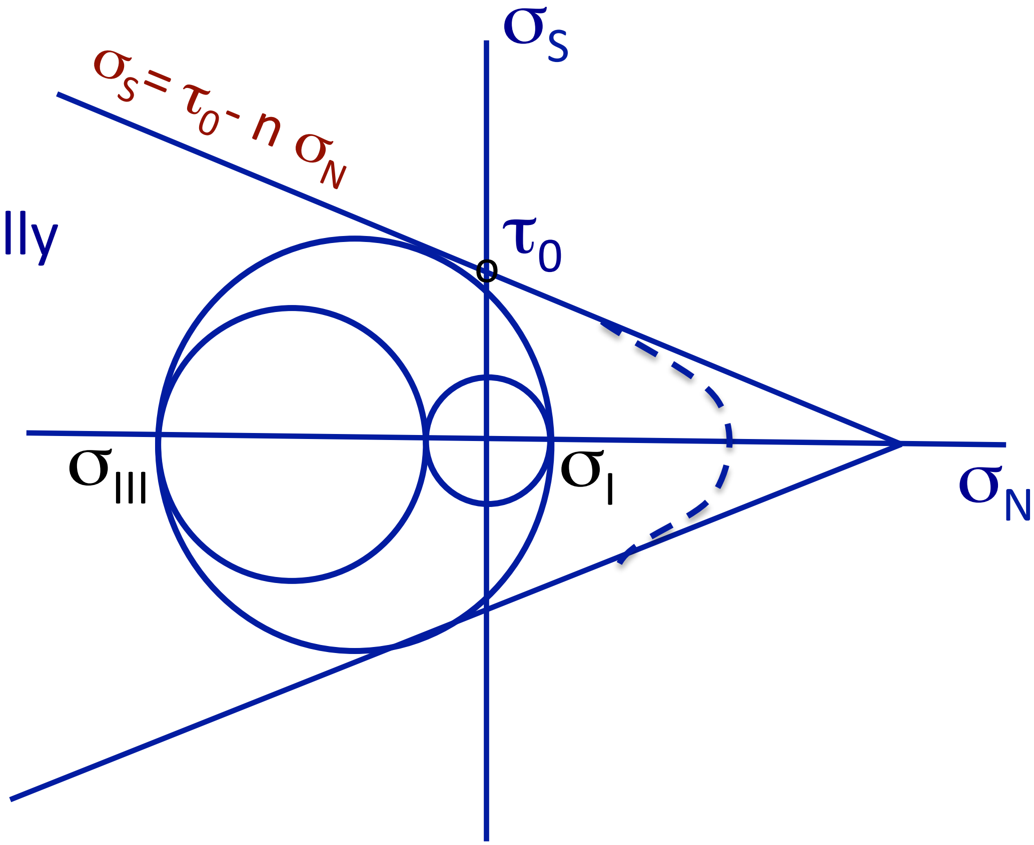
τ_0 is cohesion of the material

Mohr-Coulomb Fracture

Now we are actually breaking rock …



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τ_0 is cohesion of the material

Failure in shear

- Why is failure is not on the plane with maximum shear stress?
- Why are there 2 conjugate failure planes?