ESS 411/511 Geophysical Continuum Mechanics Class #14

Highlights from Class #13 – Maleen Kidiwela
Today's highlights on Monday – ______________

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

For Monday class – Please read

- 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

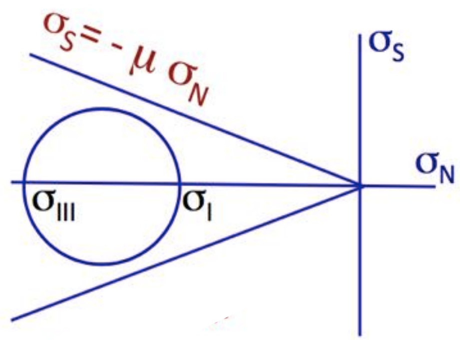
Broad Outline for the Quarter

- 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

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

Failure of materials

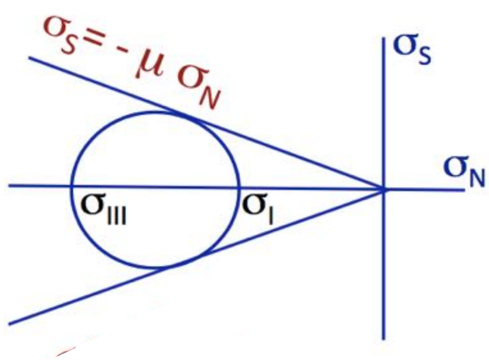
Faults can slip when shear stress σ_S is large enough to overcome frictional resistance. Frictional resistance to failure can be modeled as increasing proportional to the normal traction σ_N.
In stress space, if a stress state σ_N and σ_S exists that intersects or touches the frictional line, then the plane represented at that point can fail.



In the diagrams, all principal stresses are negative.

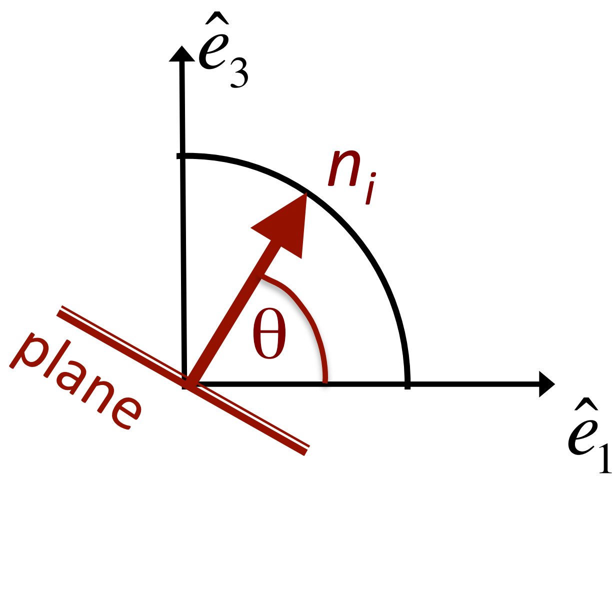
- Are they compressive or extensile?
- In the first diagram, do any stress states exist outside the circle shown?
- Can any faults fail in this stress field?

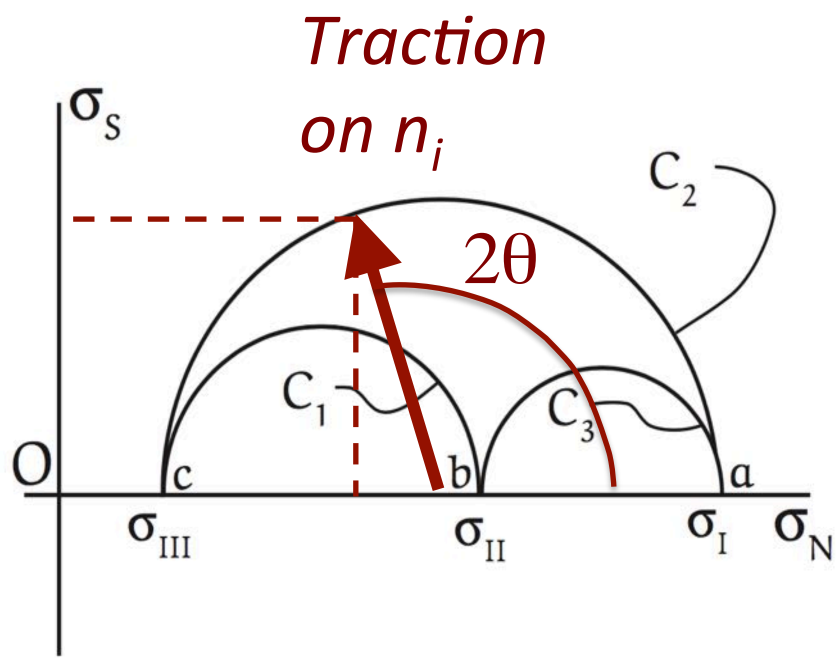
In the second diagram (below):



- What has changed in the stress field?
- Can any faults fail in this new stress field?
- If yes, how many different faults can fail?
- How could you identify the orientation(s) from the Mohr's circle?

Mohr's circle in 2-D view





Cartesian Space *vs* Stress Space

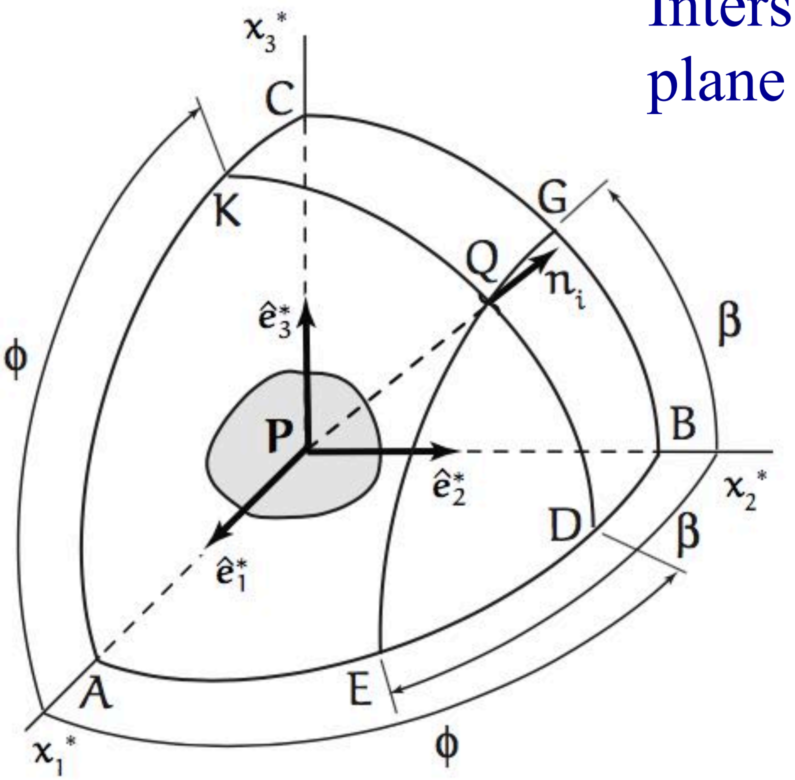
$\hat{e}_i^*$ are principal directions defining principal planes at **P**.

Small circles in Cartesian space (e.g. EQG) map onto circles (e.g. eqg) concentric with primary Mohr's circles (e.g. akc).

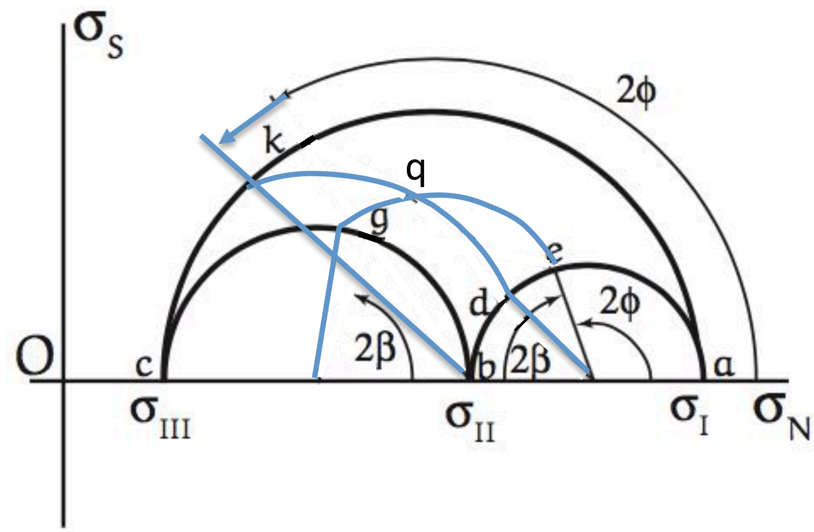
Similarly, KQD maps onto kqd.

Intersection at q shows σ_N and σ_s on plane defined by normal vector n_i at Q.

(I have attempted to (sort of) correct the stress-plane figure below. ☺)

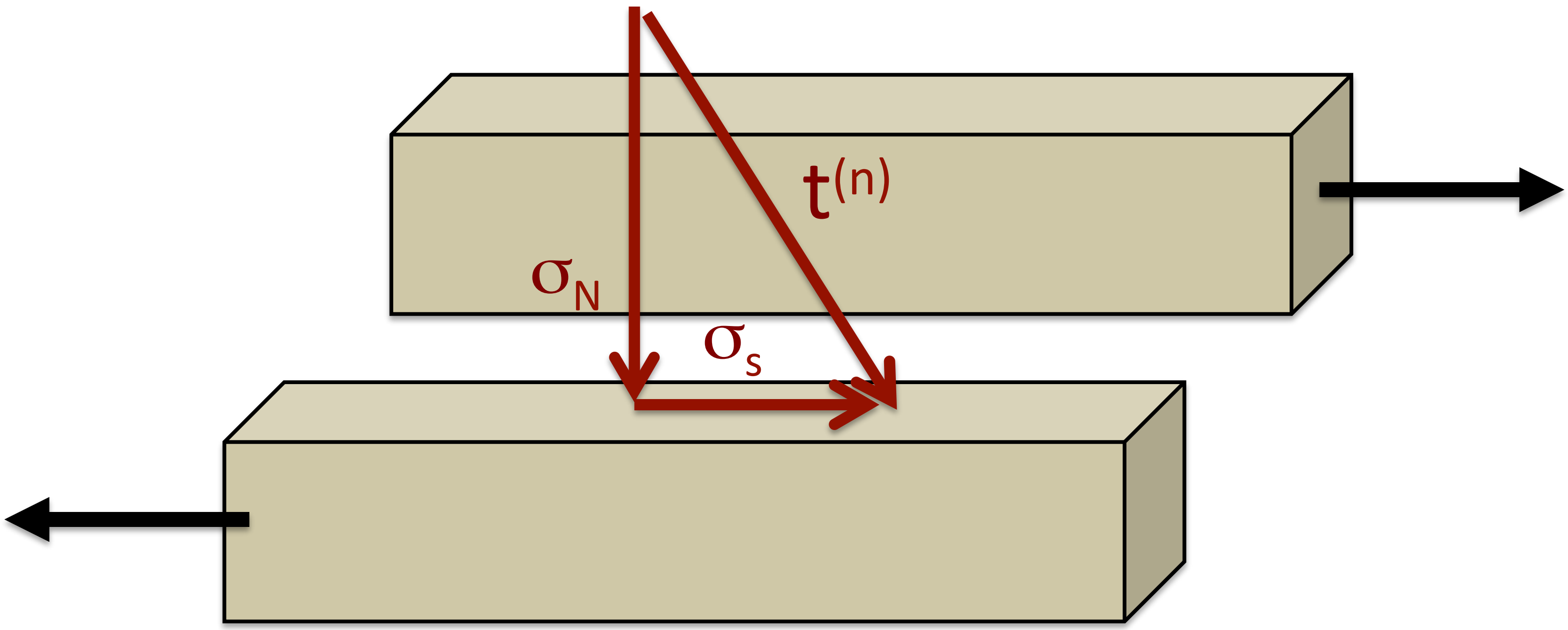


(a) Reference angles φ and β for intersection point Q on surface of body octant.



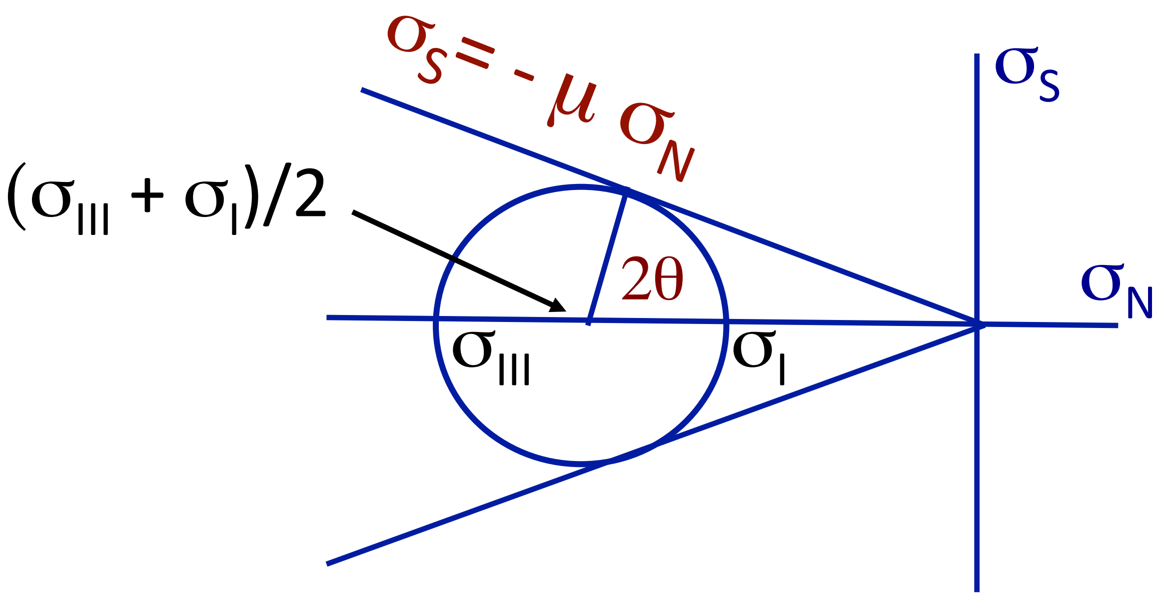
(b) Mohr's stress semicircle for octant of Fig. 3.15(a).

Sliding friction



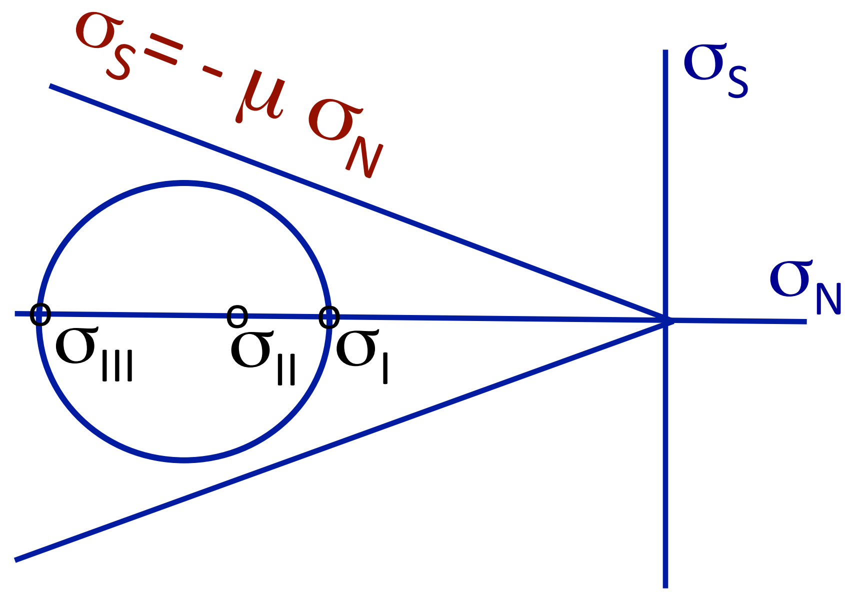
$\sigma_S = -\mu\,\sigma_N$ μ is ***coefficient of friction*** for sliding on a pre-existing break

Frictional sliding



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

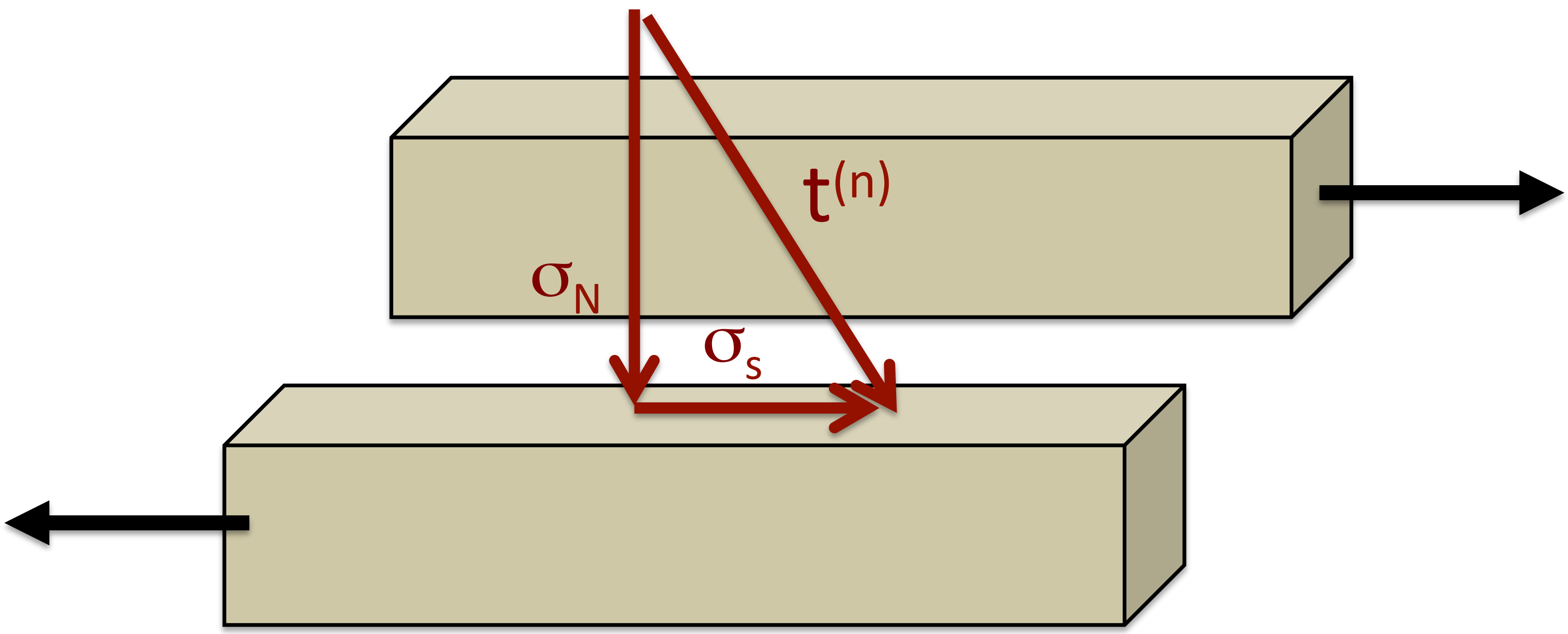
Differential stress σ_{III} - σ_I



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?

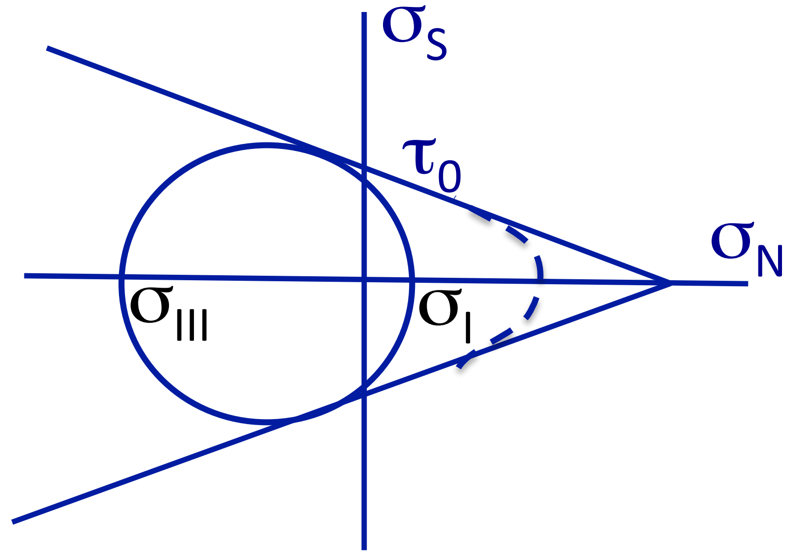
Mohr-Coulomb Fracture



$\sigma_S = \tau_0 - n\ \sigma_N$ n is ***coefficient of internal friction for*** fracture on a new fault surface

τ_0 is cohesion of the material

Mohr-Coulomb Fracture



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