The Stress Equations

Thankfully, once the magnitudes and orientations of the principal stresses at a point are known, we can readily calculate the normal stress ($\sigma_n$) and shear stress ($\tau$) for planes of any orientation using the fundamental stress equations derived in standard engineering and structural geological texts (e.g., Ramsay, 1967; Jaeger and Cook, 1976; Means, 1976).

\[
\sigma_n = \frac{\sigma_1 + \sigma_3}{2} + \frac{\sigma_1 - \sigma_3}{2} \cos 2\theta
\]

\[
\tau = \sigma_s = \frac{\sigma_1 - \sigma_3}{2} \sin 2\theta
\]
θ is measured positive counterclockwise from σ₁ to the normal to the surface of interest.
Christian Otto Mohr (October 8, 1835 – October 2, 1918) was a German civil engineer. In 1882, he famously developed the graphical method for analysing stress known as Mohr's circle and used it to propose an early theory of strength based on shear stress.

Faults, stress, and tractions

Mohr Circle
Graphical construction that lets us visualize the relationship between the principal stresses and tractions on a boundary (like a fault).

Θ measured positive counter clockwise from \( \sigma_1 \) direction to normal of plane of interest
20 measure positive counter clockwise from \( \sigma_n \) direction on Mohr circle
Using both the Mohr circle and the fundamental stress equations, determine the normal and shear tractions on the two planes. For Mohr circle, use 1 cm = 10 MPa.

\[ \sigma_1 = 120 \text{ MPa} \]

\[ \sigma_3 = 40 \text{ MPa} \]
Mohr Circle

10 mm = 10 MPa

Faults, stress, and tractions

- Davis and Reynolds
Fig. 1. Stress regimes in the lithosphere as indicated by laboratory experiments. Each rectangle represents a stress regime encountered during laboratory experiments. The box represents the cross section of a cylindrical sample during a uniaxial compression experiment. The stress regimes are: (a) ductile flow, (b) shear fracture, (c) crack propagation, (d) frictional slip. The stress regimes are identified by bold letters.