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Innovation and Creativity

Teoretisk Grunnlag for Hydraulisk Splitting

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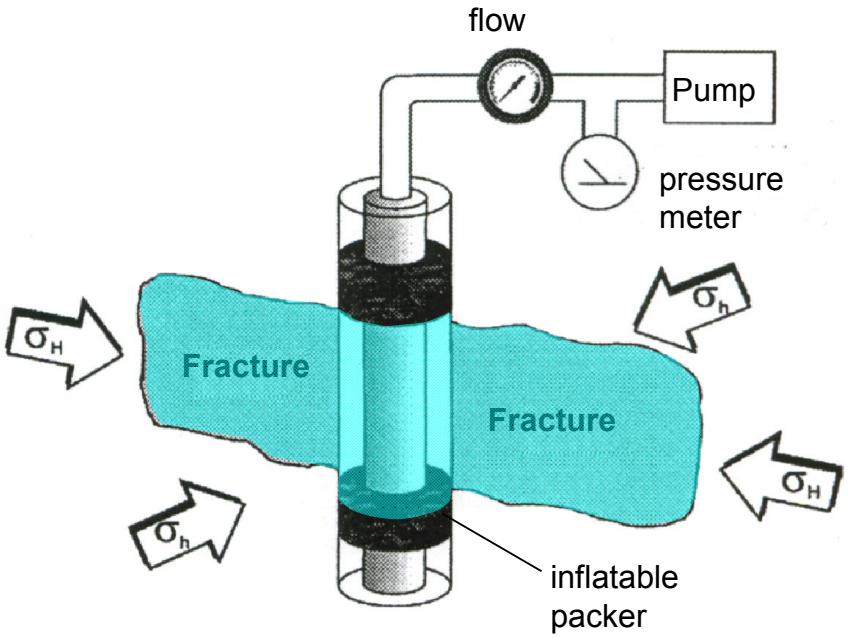
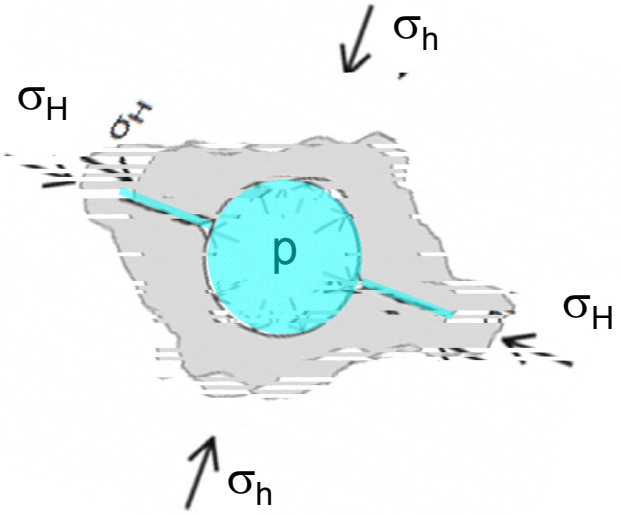
Prinsippet





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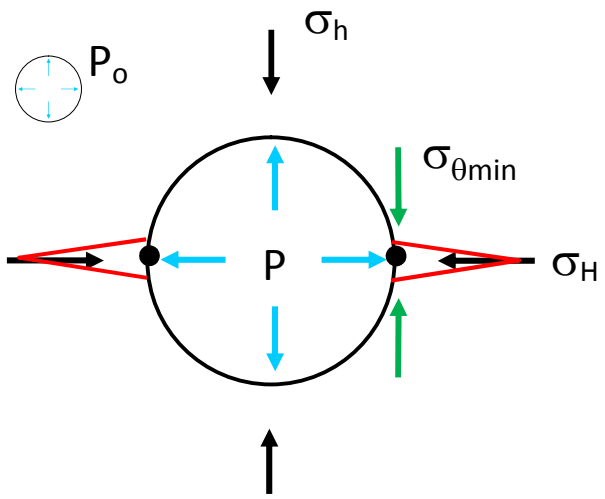
Antagelser

- Materialet:
  - lineært elastisk,
  - isotropisk,
  - homogent
- Insitu spenningsforhold:
  - ikke-hydrostatisk spenningstilstand
  - en av de tre hovedspenningene er parallell med borehullet

Teorier



σ_t = Strekkfasthet
P_o = Poretrykket
P = Vanntrykket i borehullet
P_c = Splittingstrykket

Minste tangentialspenning:

Uten vanntrykket i borehullet:

$$\sigma_{\theta\min} = 3\sigma_h - \sigma_H + P_o$$

Med vanntrykket:

$$\sigma_{\theta\min} = 3\sigma_h - \sigma_H + P_o - P$$

Strekkbrudd :

$$\sigma_{\theta\min} = 3\sigma_h - \sigma_H + P_o - P_c = -\sigma_t$$

$$P_c = \sigma_t + 3\sigma_h - \sigma_H + P_o$$

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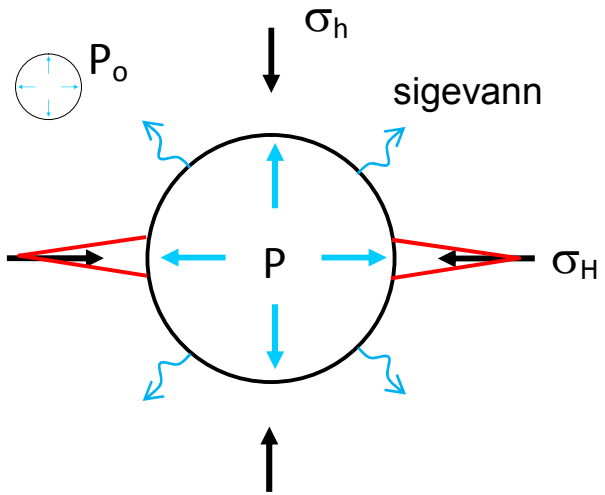

I permeabelt berg:

$$P_c = \frac{\sigma_t + 3\sigma_h - \sigma_H + 2\eta P_o}{2(1-\eta)}$$

$$\eta = \frac{\alpha(1-2\nu)}{2(1-\nu)}, \quad \text{poreelastisk koeffisient}$$

$$\alpha = 1 - K/K_s, \quad \text{Biot koeffisient}$$

ν = Poissons tall
K = Bulkmodul av berg (korn + porer + sprekker)
K_s = Bulkmodul av mineralkorn

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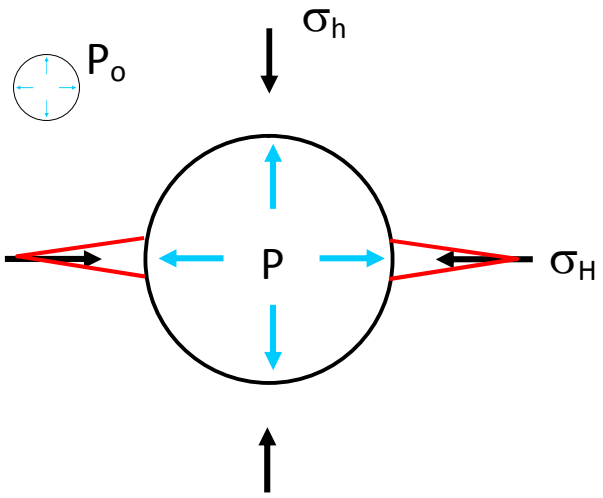
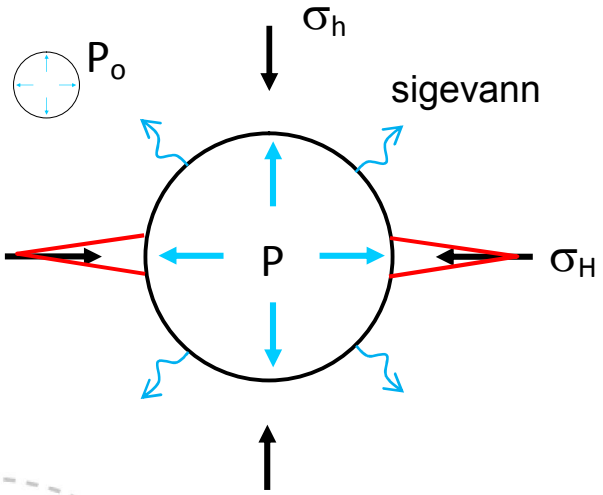
Beregningslingninger



Når vann er ikke penetrerende:

$$P_c = \sigma_t + 3\sigma_h - \sigma_H + P_o \qquad (1)$$



Når vann er penetrerende:

$$P_c = \frac{\sigma_t + 3\sigma_h - \sigma_H + 2\eta P_o}{2(1-\eta)} \qquad (2)$$

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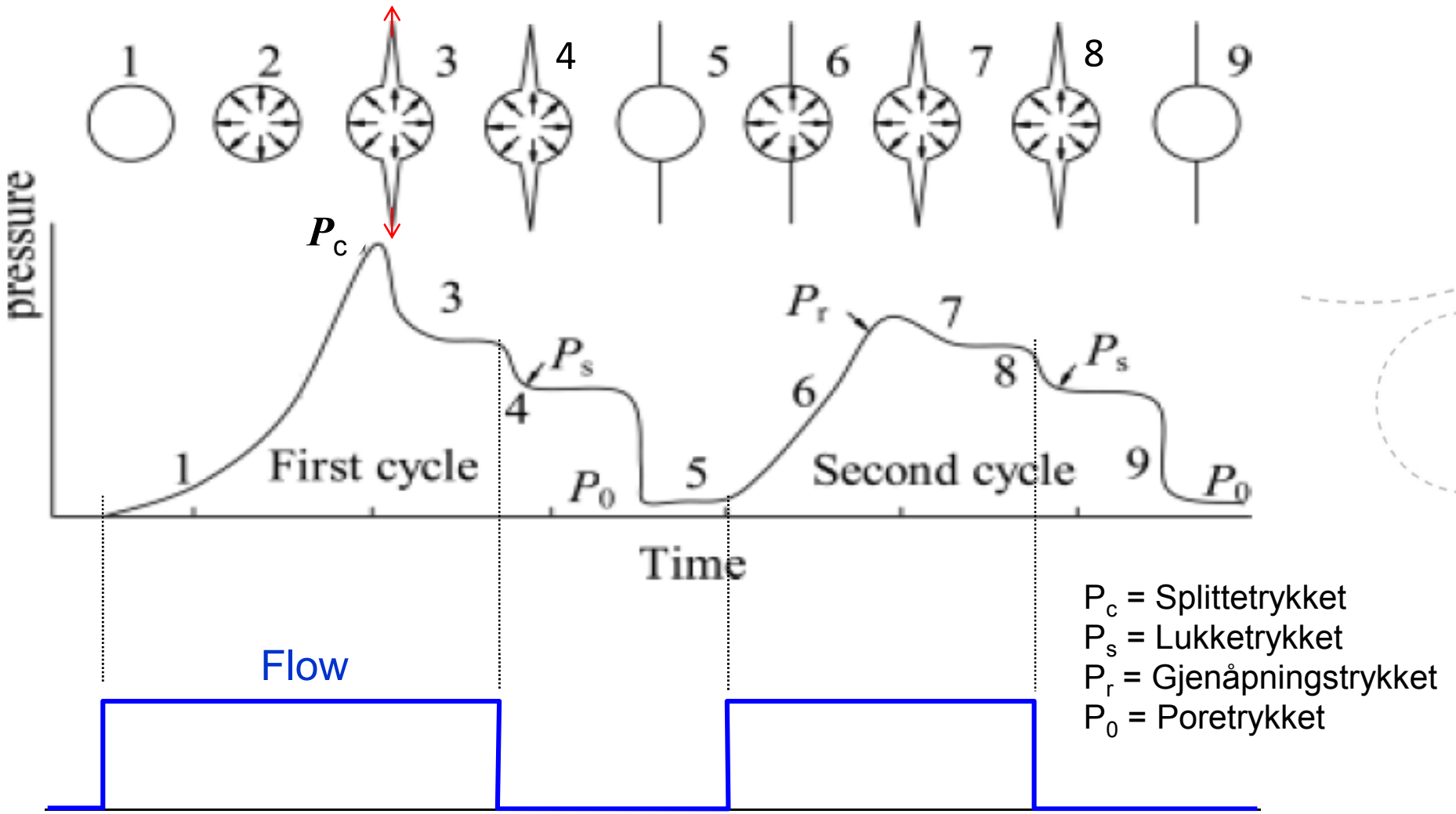
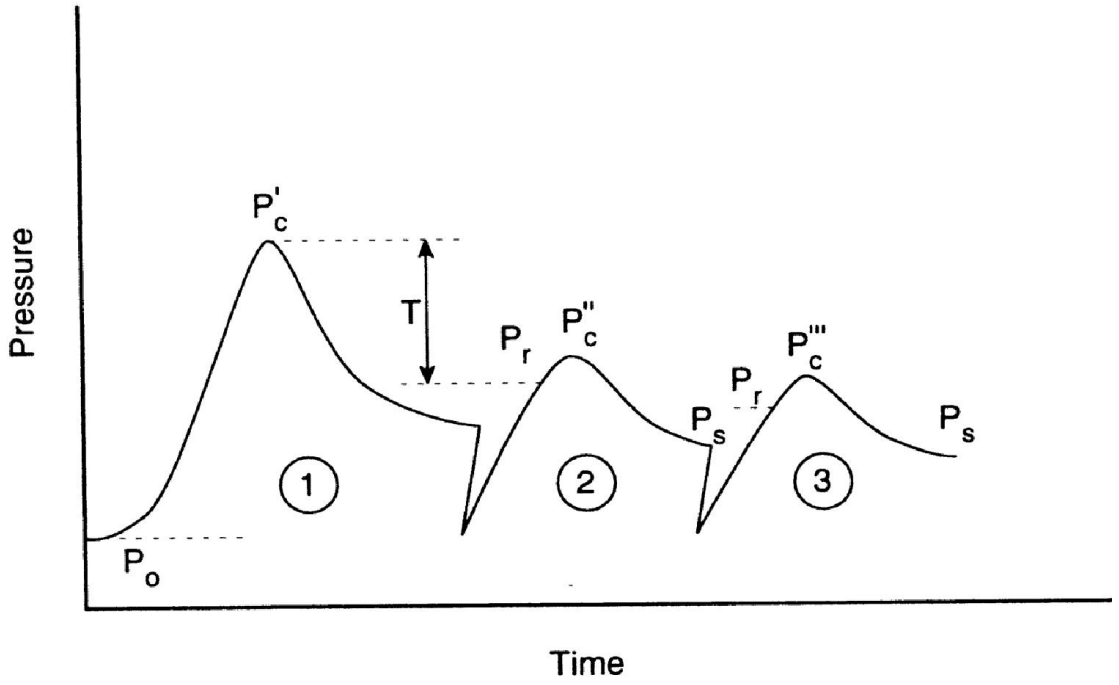


P_c = Splittetrykket
P_s = Lukketrykket
P_r = Gjenåpningstrykket
P_0 = Poretrykket

Strekkfashet:

$$\sigma_t = P_c' - P_r$$

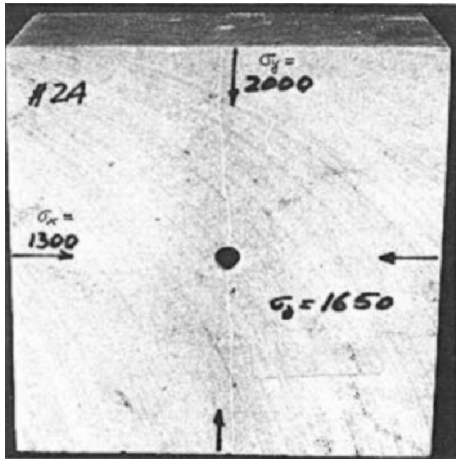


Gjenåpningstrykket P_r er det punkt hvor en plutselig nedgang i trykkøkning med tiden

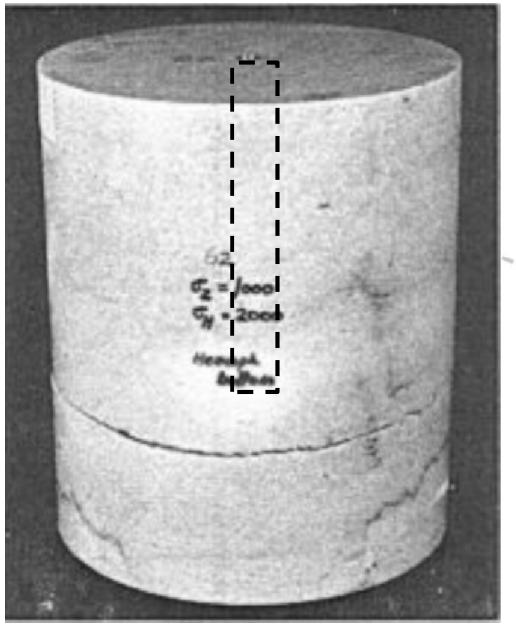
Bruddtyper (i et vertikalt borehull)

- Sprekken er vertikal, $\sigma_h = \sigma_3$
- Sprekken er horisontal, $\sigma_v = \sigma_3 << \sigma_h$
- Sprekken initiert vertikalt men utvider sig horisontalt, $\sigma_v = \sigma_3$

Tennesse marmor

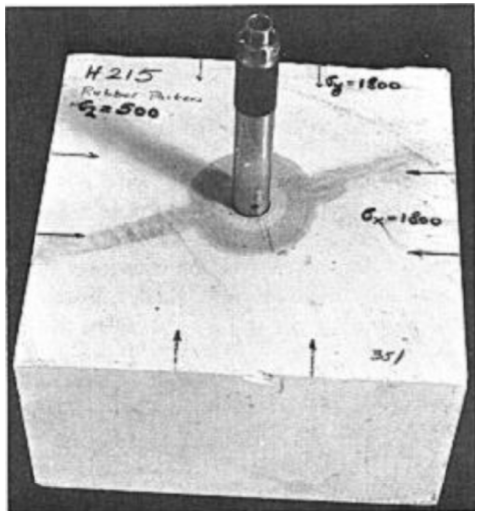


Vertikalsprekk, $\sigma_x < \sigma_z < \sigma_y$



Horisontalsprekk

$\sigma_z < \sigma_x = \sigma_y$



Vertikalsprekk, $\sigma_z < \sigma_x = \sigma_y$

(Haimson & Fairhurst 1969)

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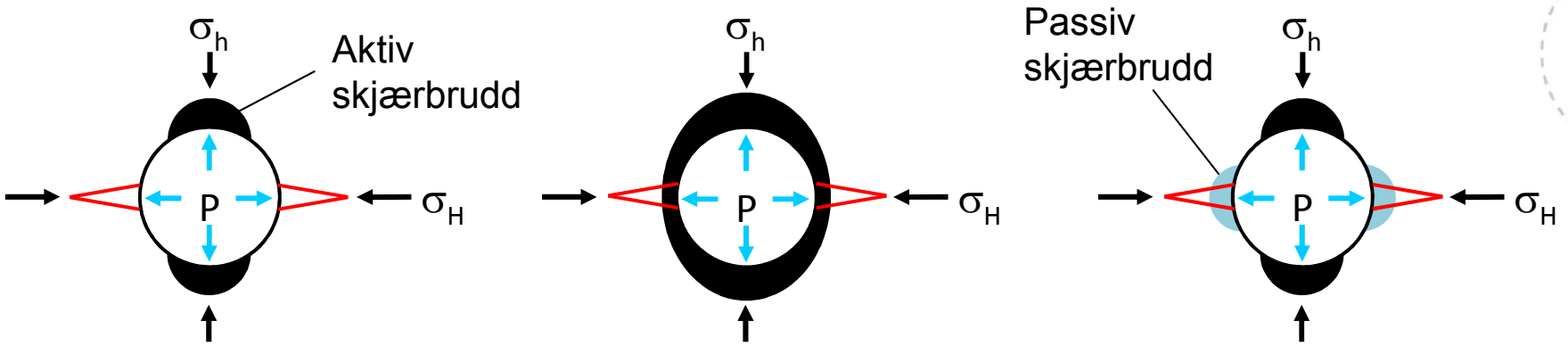
Splittingtrykket i svakt berg

- Svakt berg er karakterisert av lav fasthet
- Skjærbrudd kan forekommer like etter hullboring og under trykking



Skjærbrudd endrer spenningsfordelingen rundt hullet
så at ligningene (1) og (2) ikke er gyldig

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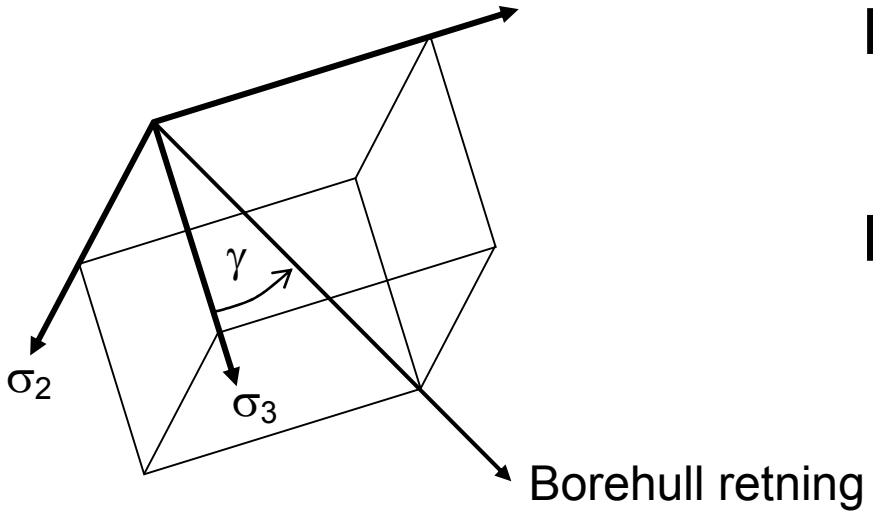
Borehull ikke i retning av hovedsspenningene

$$P_c = \sigma_t + 3\sigma_h - \sigma_H \cos^2\gamma - \sigma_v \sin^2\gamma + P_o$$



Fire ukjente: σ_1, σ_2, σ_3, γ

Hvem har prøvd metoden?

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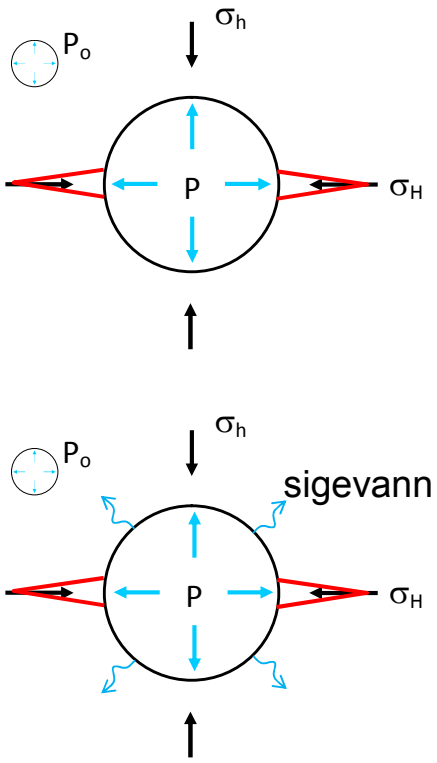
Oppsummering

- Antagelser
  - Materialet er lineært elastisk, isotropisk og homogent
  - $\sigma_H > \sigma_h$ og σ_v parallell med borehullet
- Beregningslingninger:

$$P_c = \sigma_t + 3\sigma_h - \sigma_H + P_o \qquad (1)$$

$$P_c = \frac{\sigma_t + 3\sigma_h - \sigma_H + 2\eta P_o}{2(1-\eta)} \qquad (2)$$



Referanser

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- Haimson, B. and Fairhurst, C. 1969. In-situ stress determination at great depth by means of hydraulic fracturing. 11th US Symp. Rock Mech., Chapter 28, 559-584.
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