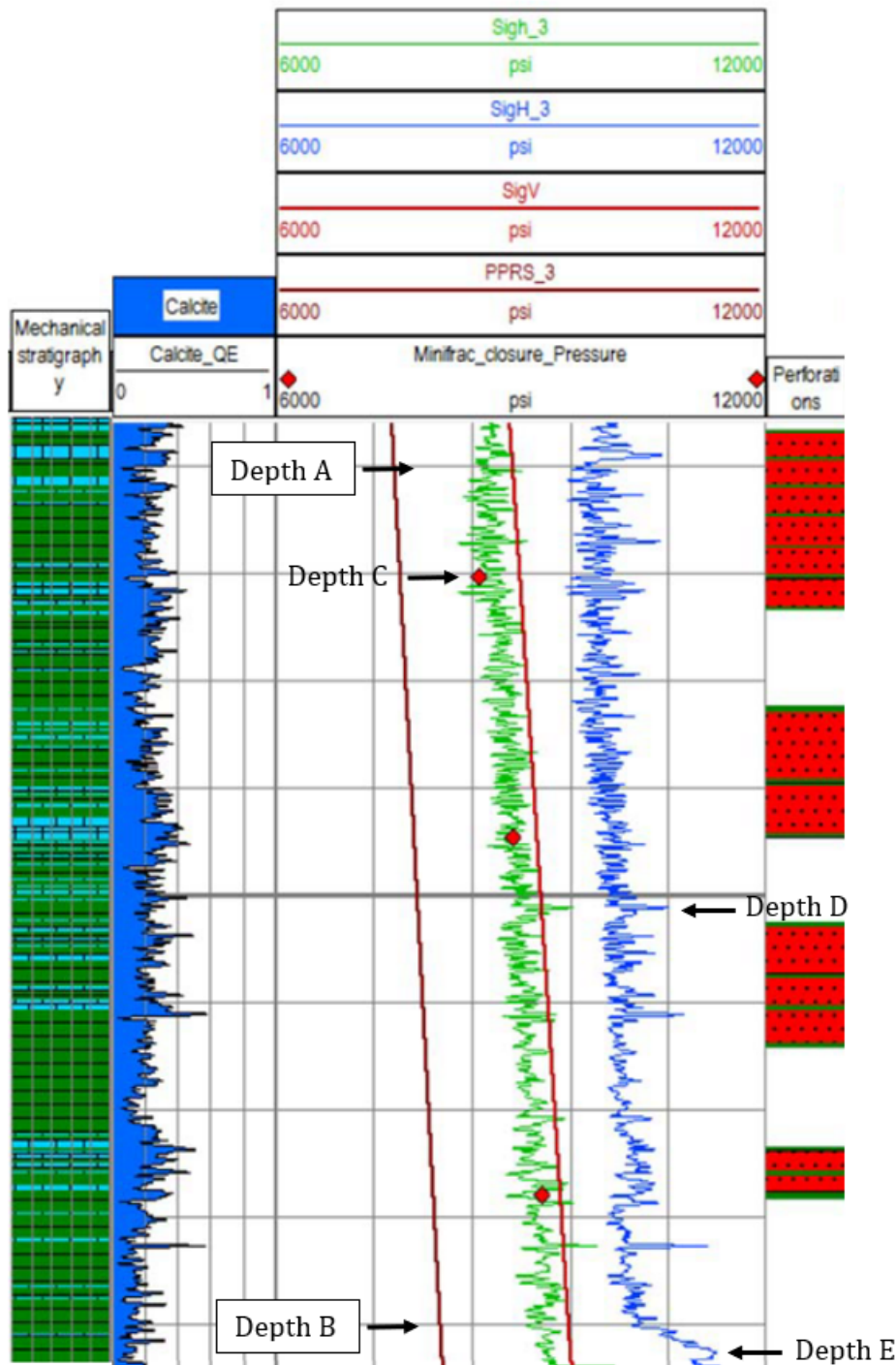


Pravda

—  
—

Pravda









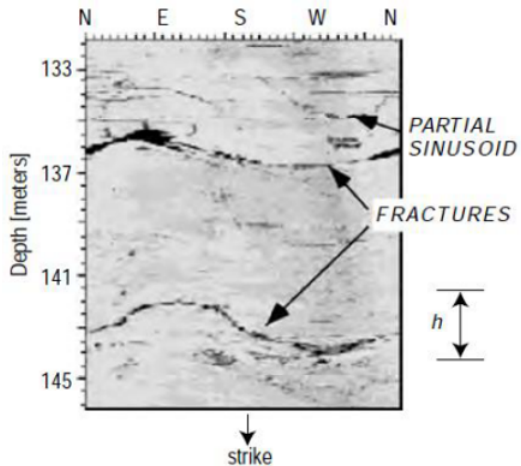




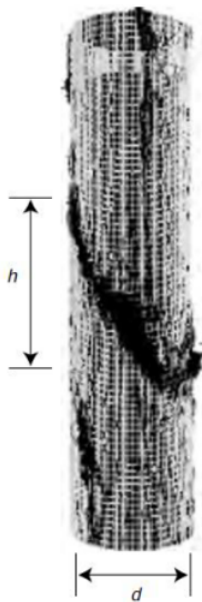




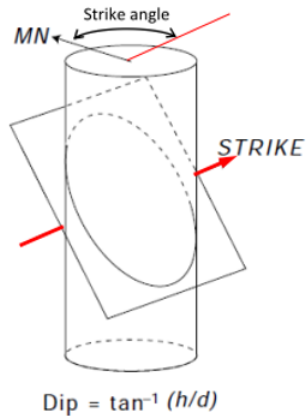
## Un-wrapped image (ultrasonic)



## 3D-representation



## Interpretation



(Zoback 2013, RM, Ch 5.3)

SPRING









BO



100

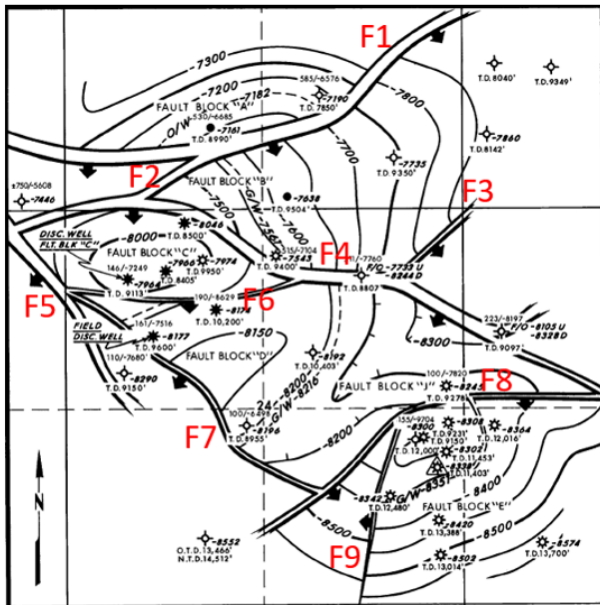




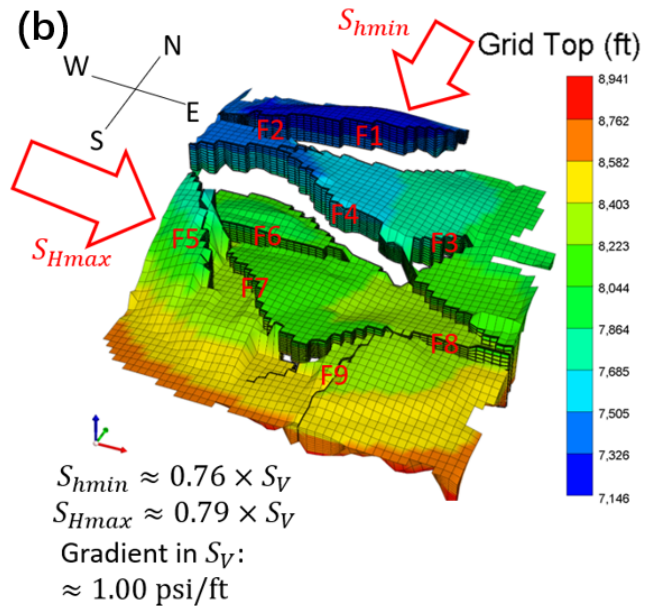




(a)



(b)



SPRING











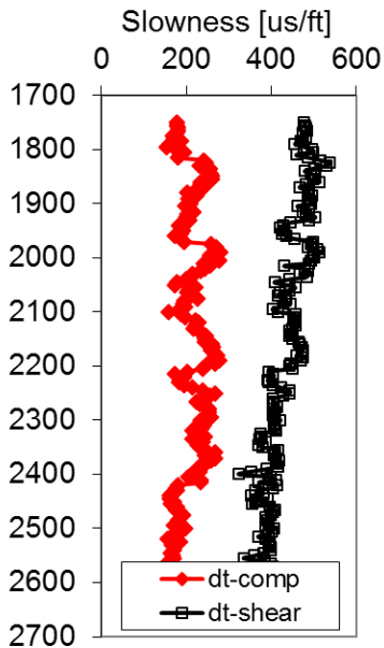
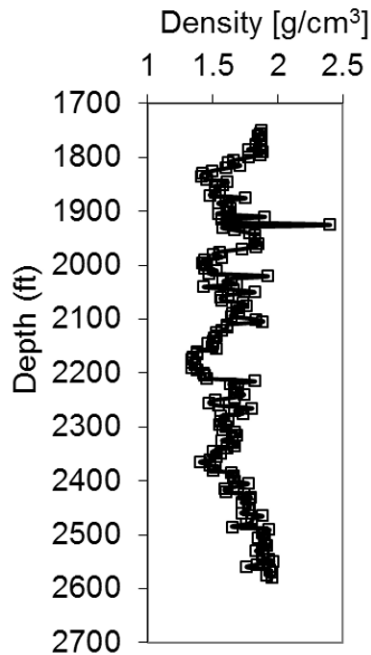


ESL and ESOL

Exercise 1-2







$$\begin{bmatrix} \varepsilon_{11} \\ \varepsilon_{22} \\ \varepsilon_{33} \\ 2\varepsilon_{23} \\ 2\varepsilon_{13} \\ 2\varepsilon_{12} \end{bmatrix} = \begin{bmatrix} +\frac{1}{E_h} & -\frac{\nu_h}{E_h} & -\frac{\nu_v}{E_v} & 0 & 0 & 0 \\ -\frac{\nu_h}{E_h} & +\frac{1}{E_h} & -\frac{\nu_v}{E_v} & 0 & 0 & 0 \\ -\frac{\nu_v}{E_v} & -\frac{\nu_v}{E_v} & +\frac{1}{E_v} & 0 & 0 & 0 \\ 0 & 0 & 0 & \frac{1}{G_v} & 0 & 0 \\ 0 & 0 & 0 & 0 & \frac{1}{G_v} & 0 \\ 0 & 0 & 0 & 0 & 0 & \frac{1}{G_h} \end{bmatrix} \begin{bmatrix} \sigma_{11} \\ \sigma_{22} \\ \sigma_{33} \\ \sigma_{23} \\ \sigma_{13} \\ \sigma_{12} \end{bmatrix}$$

$$G_h = \frac{E_h}{2(1 + \nu_h)}$$





$$E_h = \frac{(C_{11} - C_{12}) [C_{33}(C_{11} + C_{12}) - 2 C_{13}^2]}{C_{11} C_{33} C_{13}^2}$$

$$E_v = C_{33} - \frac{2 C_{13}^2}{C_{11} + C_{12}}$$

$$v_h = \frac{C_{13}}{C_{11} + C_{12}}$$

$$\nu_v = \frac{C_{12}C_{33} - C_{13}^2}{C_{11}C_{33} + C_{13}^2}$$



$$G_h = C_{66} = \frac{C_{11} - C_{12}}{2}$$

$$\begin{bmatrix} \sigma_{11} \\ \sigma_{22} \\ \sigma_{33} \\ \sigma_{23} \\ \sigma_{13} \\ \sigma_{12} \end{bmatrix} = \begin{bmatrix} C_{11} & C_{12} & C_{13} & 0 & 0 & 0 \\ C_{12} & C_{11} & C_{13} & 0 & 0 & 0 \\ C_{13} & C_{13} & C_{33} & 0 & 0 & 0 \\ 0 & 0 & 0 & C_{44} & 0 & 0 \\ 0 & 0 & 0 & 0 & C_{44} & 0 \\ 0 & 0 & 0 & 0 & 0 & C_{66} \end{bmatrix} \begin{bmatrix} \varepsilon_{11} \\ \varepsilon_{22} \\ \varepsilon_{33} \\ 2\varepsilon_{23} \\ 2\varepsilon_{13} \\ 2\varepsilon_{12} \end{bmatrix}$$



$$C_{11} = \frac{1}{(1 - \nu_h) E_v - 2 \nu_v^2 E_h} \left( \frac{E_h E_v - \nu_v^2 E_h^2}{1 + \nu_h} \right)$$

$$C_{33} = \frac{1}{(1 - \nu_h)E_v - 2\nu_v^2 E_h} (E_v^2 - \nu_h E_v^2)$$

$$C_{12} = \left[ \frac{1}{(1 - \nu_h) E_v - 2 \nu_v^2 E_h} \right] \left( \frac{\nu_v^2 E_h^2 + \nu_h E_h E_v}{1 + \nu_h} \right)$$

$$C_{13} = \left[ \frac{1}{(1 - v_h) E_v - 2 v_v^2 E_h} \right] (v_v E_h E_v)$$

$$C_{66} = \frac{C_{11} - C_{12}}{2} = G_h = \frac{E_h}{2(1 + \nu_h)}$$































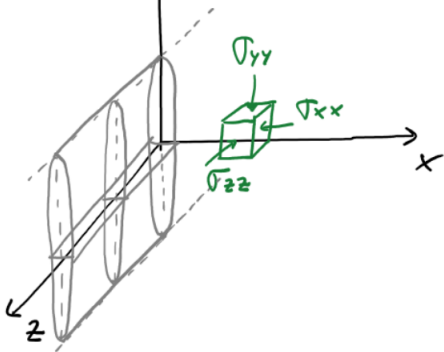




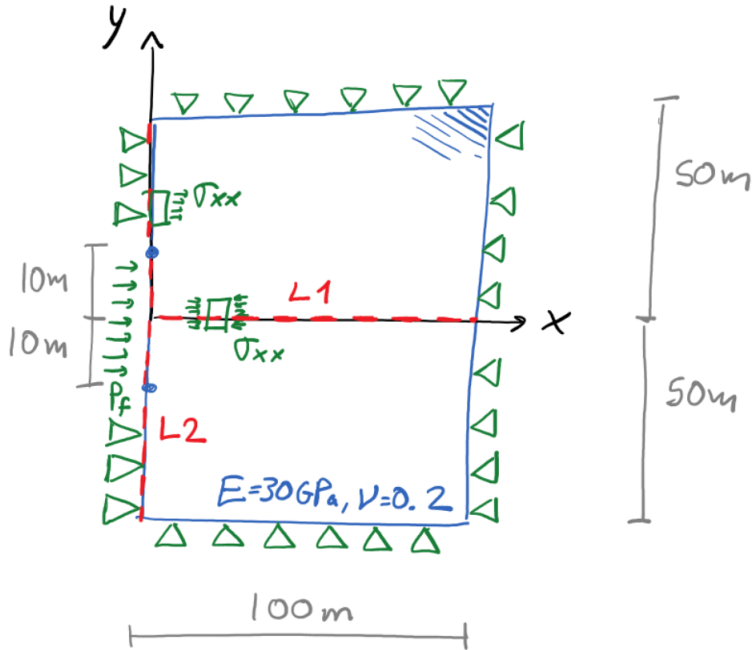




Fracture length in  $z$   
 $\gg$  fracture length in  $y$   
 $\Rightarrow$  Plane strain in  $(x, y)$



$\equiv$











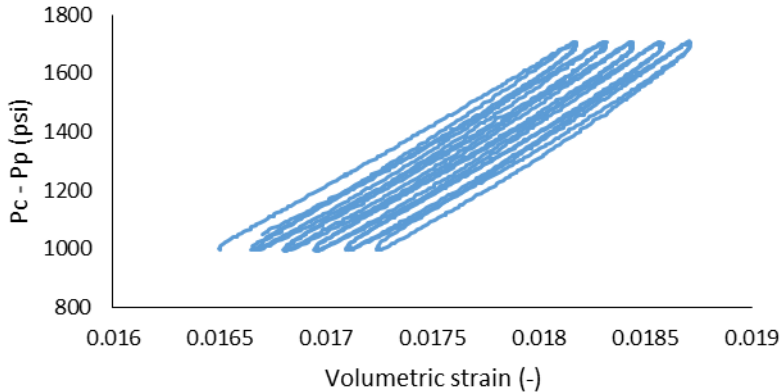














Production : 120 bbl/day  
Min. BHP : 240 psi

1000 ft

$S_v = 1200$  psi

Zero displacements  
except for vertical  
direction

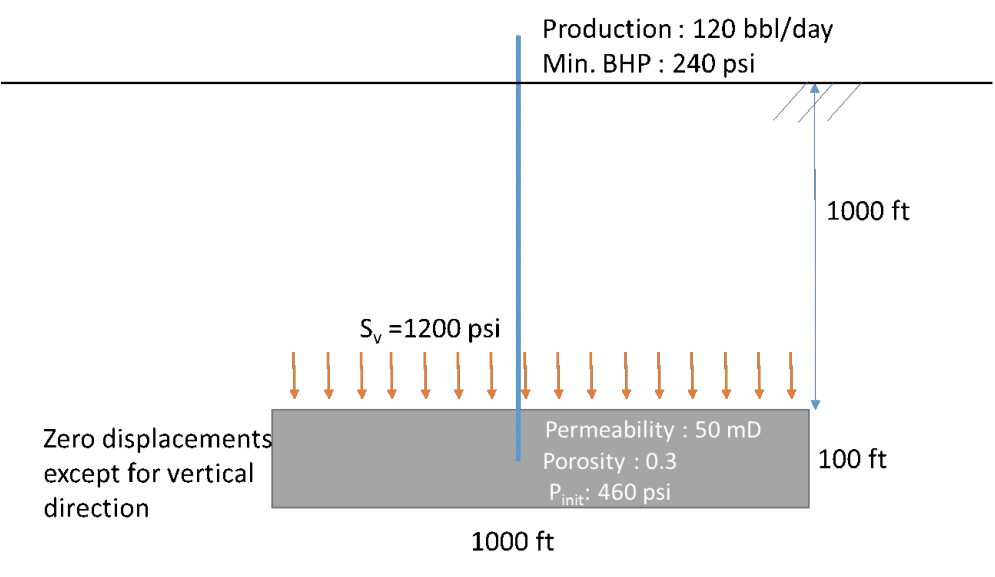
Permeability : 50 mD

Porosity : 0.3

$P_{init}$  : 460 psi

100 ft

1000 ft



$$a \frac{(1-2v)}{(1-v)}$$







THE FIRST WORLD WAR

Q1E2E+Q2E













123456789





ESP-00-0100-1000



























$$\frac{d\epsilon_p}{d\epsilon} = \frac{\kappa}{v} \frac{dp'}{dp}, \quad \frac{d\epsilon_q}{d\epsilon} = \frac{dq}{2\epsilon}$$

$$\begin{bmatrix} d\varepsilon_p^p \\ d\varepsilon_q^p \end{bmatrix} = \frac{\lambda - \kappa}{vp'(M^2 + \eta^2)} \begin{bmatrix} M^2 - \eta^2 & 2\eta \\ 2\eta & \frac{4\eta^2}{M^2 - \eta^2} \end{bmatrix} \begin{bmatrix} dp' \\ dq \end{bmatrix}$$





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ved



