Mechanisms of overpressure

Techtonic compaction

- Occurs in areas where large-scale tectonic stress changes occur over geolocgically short periods of time.

Hydrocarbon column heights

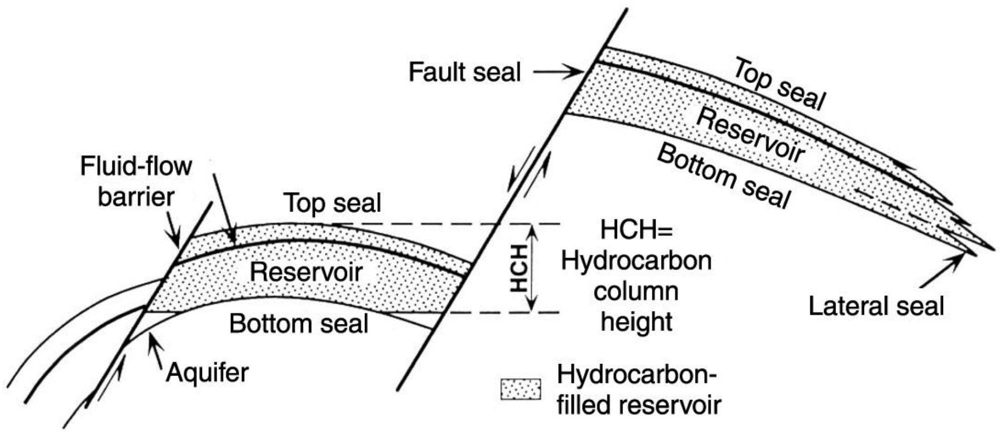
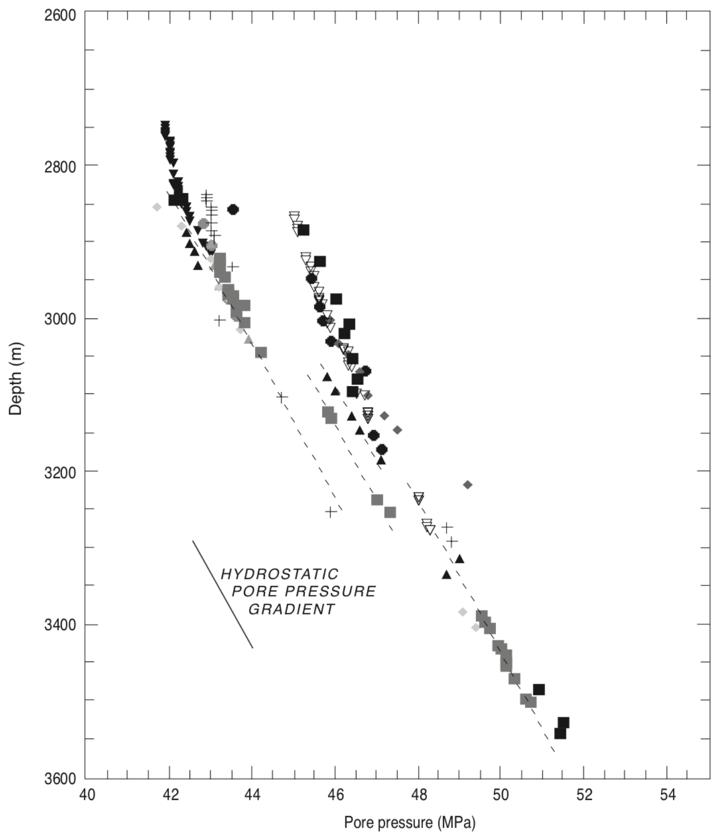


Image Source

Hydrocarbon column heights



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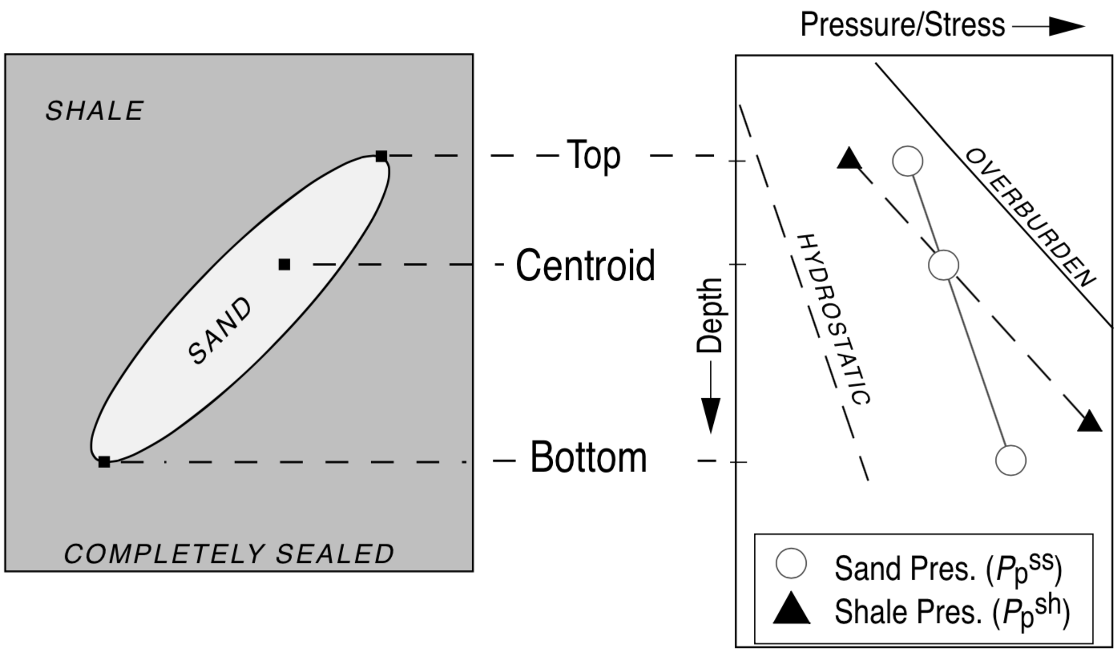
The University of Texas at Austin

Centroid effects



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Other mechanisms

Aquathermal pressurization

- Temperature increases due to radioactive decay and upward heat flow from mantle

Hydrocarbon generation

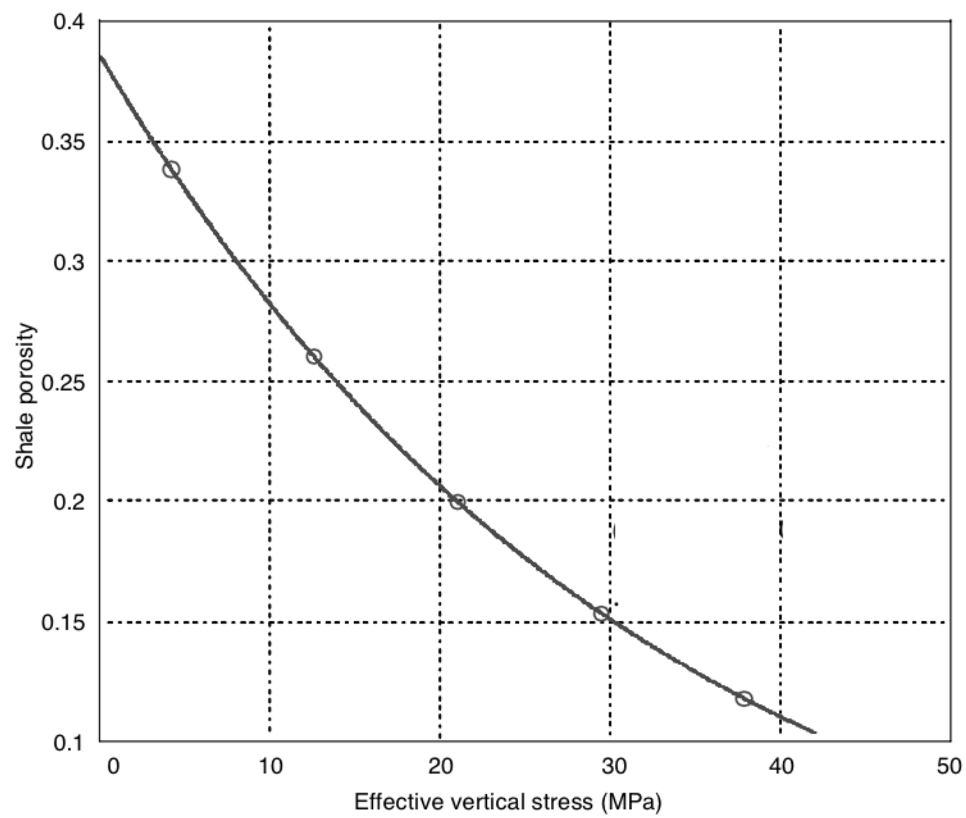
- From thermal maturation of kerogen

Direct measurement of pore pressure

- Via wireline samplers that isolate formation pressure from annular pressure in a small area at the wellbore wall.
- Mud weight

Estimation of pore pressure at depth

Confined compaction experiment

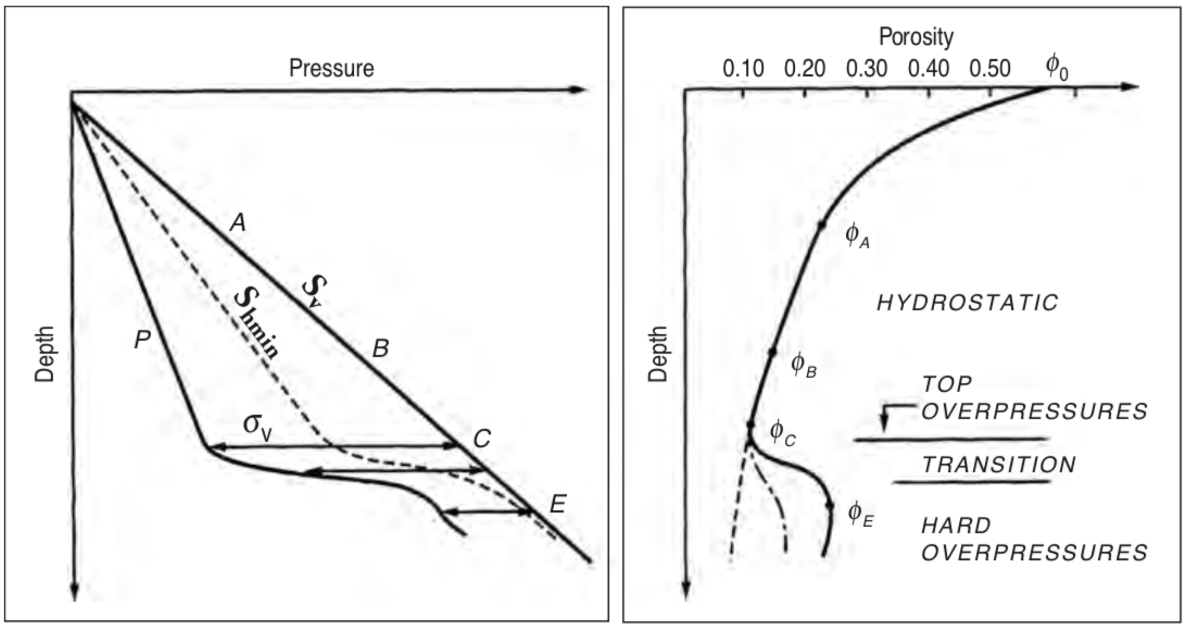


 Zoback, *Reservoir Geomechanics* (Fig. 2.13, pp. 46)

Shale compaction relation

$$\phi = \phi_0 e^{-\beta(S_v - P_p)}$$

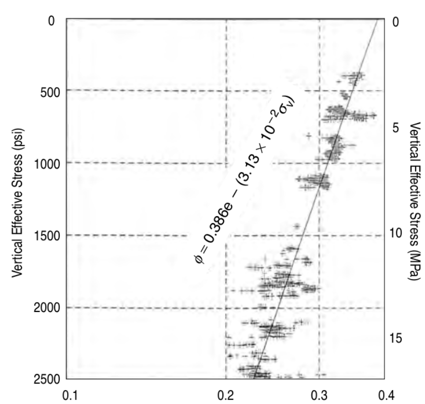
Use with caution!



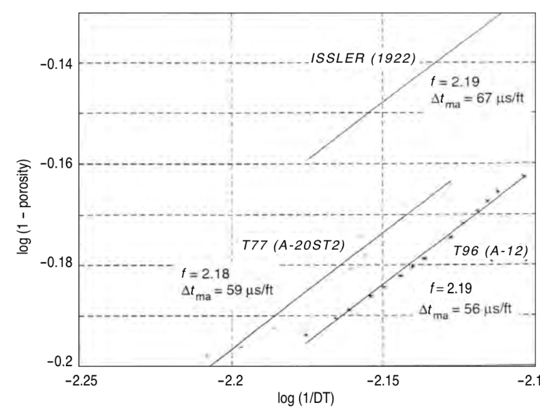
 Zoback, *Reservoir Geomechanics* (Fig. 2.14, pp. 48)

Porosity inference from P-waves

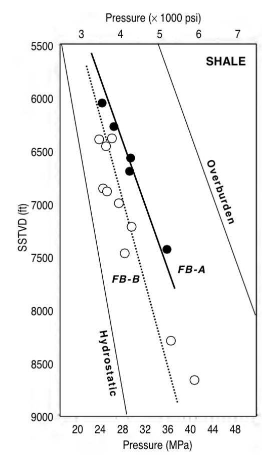
$$P_p = S_v + \left(\frac{1}{\beta}\ln\left(\frac{\phi}{\phi_0}\right)\right) \qquad \phi = 1 - \left(\frac{\Delta t_{ma}}{\Delta t}\right)^{\frac{1}{f}}$$



Compaction

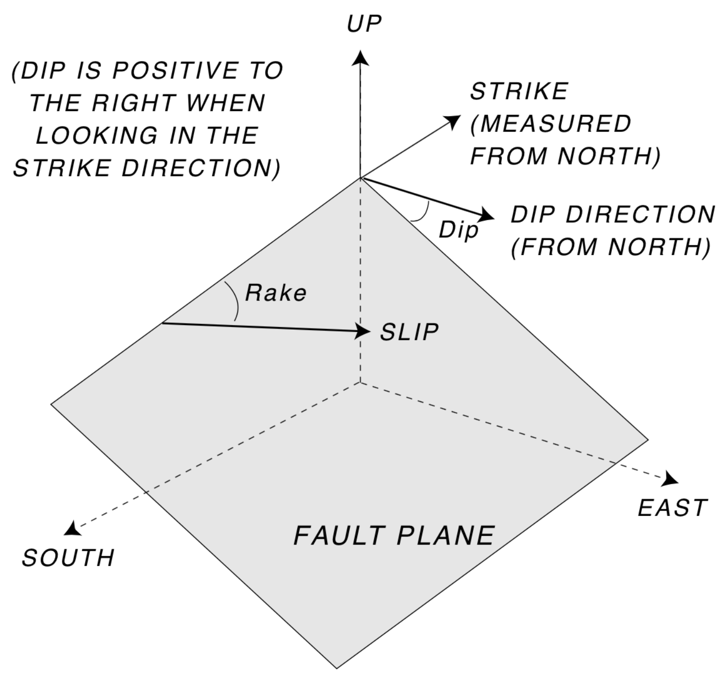


P-wave



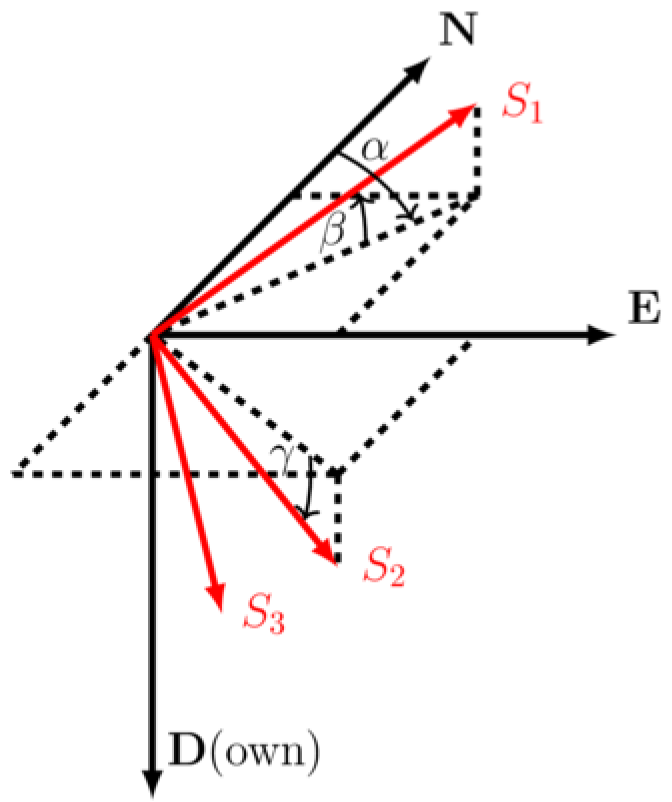
Pore pressures

Faults and fractures at depth



 Zoback, *Reservoir Geomechanics* (Fig. 5.5, pp. 150)

Geographical coordinate system



$$\mathbf{R}_G = \begin{bmatrix} \cos\alpha\cos\beta & \sin\alpha\cos\beta & -\sin\beta \\ \cos\alpha\sin\beta\sin\gamma - \sin\alpha\cos\gamma & \sin\alpha\sin\beta\sin\gamma + \cos\alpha\cos\gamma & \cos\beta\sin\gamma \\ \cos\alpha\sin\beta\cos\gamma + \sin\alpha\sin\gamma & \sin\alpha\sin\beta\cos\gamma - \cos\alpha\sin\gamma & \cos\beta\cos\gamma \end{bmatrix}$$

Stress in geographical coordinate system

$$\mathbf{S}_G = \mathbf{R}_G^T \mathbf{S} \mathbf{R}_G$$

Example: Strike-slip faulting

$$\mathbf{S} = \begin{bmatrix} 30 & 0 & 0 \\ 0 & 25 & 0 \\ 0 & 0 & 20 \end{bmatrix}$$

$$\alpha = 0^\circ \qquad \text{Azimuth of } S_{Hmax}$$
$$\beta = 0^\circ \qquad S_1 = S_{Hmax}$$
$$\gamma = 90^\circ \qquad S_2 = S_v$$

$$\mathbf{R}_G = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & -1 & 0 \end{bmatrix}$$

$$\mathbf{S}_G = \begin{bmatrix} 30 & 0 & 0 \\ 0 & 20 & 0 \\ 0 & 0 & 25 \end{bmatrix}$$

Example: Normal faulting

$$\mathbf{S} = \begin{bmatrix} 30 & 0 & 0 \\ 0 & 25 & 0 \\ 0 & 0 & 20 \end{bmatrix} \qquad \begin{aligned} \alpha &= 0^\circ \\ \beta &= -90^\circ \\ \gamma &= 0^\circ \end{aligned} \qquad \begin{aligned} &\text{Azimuth of } S_{hmin} \\ &S_1 = S_v \end{aligned}$$

$$\mathbf{R}_G = \begin{bmatrix} 0 & 0 & -1 \\ 0 & 1 & 0 \\ 1 & 0 & 0 \end{bmatrix}$$

$$\mathbf{S}_G = \begin{bmatrix} 20 & 0 & 0 \\ 0 & 25 & 0 \\ 0 & 0 & 30 \end{bmatrix}$$

Example: Reverse faulting

$$\mathbf{S} = \begin{bmatrix} 30 & 0 & 0 \\ 0 & 25 & 0 \\ 0 & 0 & 20 \end{bmatrix}$$

$\alpha = 90^\circ$ Azimuth of S_{Hmax}

$\beta = 0^\circ$ $S_1 = S_{Hmax}$

$\gamma = 0^\circ$ $S_2 = S_{hmin}$

$$\mathbf{R}_G = \begin{bmatrix} 0 & 1 & 0 \\ -1 & 0 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

$$\mathbf{S}_G = \begin{bmatrix} 25 & 0 & 0 \\ 0 & 30 & 0 \\ 0 & 0 & 20 \end{bmatrix}$$

Example: Strike-slip faulting

$$\mathbf{S} = \begin{bmatrix} 60 & 0 & 0 \\ 0 & 40 & 0 \\ 0 & 0 & 35 \end{bmatrix}$$

$$\alpha = 135^\circ \qquad \text{Azimuth of } S_{Hmax}$$

$$\beta = 0^\circ \qquad S_1 = S_{Hmax}$$

$$\gamma = 90^\circ \qquad S_2 = S_v$$

$$\mathbf{R}_G = \begin{bmatrix} -\frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & 0 \\ 0 & 0 & 1 \\ \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} & 0 \end{bmatrix}$$

$$\mathbf{S}_G = \begin{bmatrix} 47.5 & -12.5 & 0 \\ -12.5 & 47.5 & 0 \\ 0 & 0 & 40 \end{bmatrix}$$