Poroelasticity

Poroelasticity Assumptions

1. There is an interconnected pore system uniformly saturated with fluid.
2. The total volume of the pore system is small compared to the volume of the rock.
3. The pore pressure, the total stress acting on the rock externally, and the stresses acting on the grains are statistically defined.

Effective stress

Terzaghi definition

$$\boldsymbol{\sigma} = \mathbf{S} - P_p \mathbf{I}$$

"Exact" effective stress

$$\boldsymbol{\sigma} = \mathbf{S} - \alpha P_p \mathbf{I}$$

α is called Biot's coefficient

Biot's coefficeint

$$\alpha = 1 - \frac{K_T}{K_S}$$

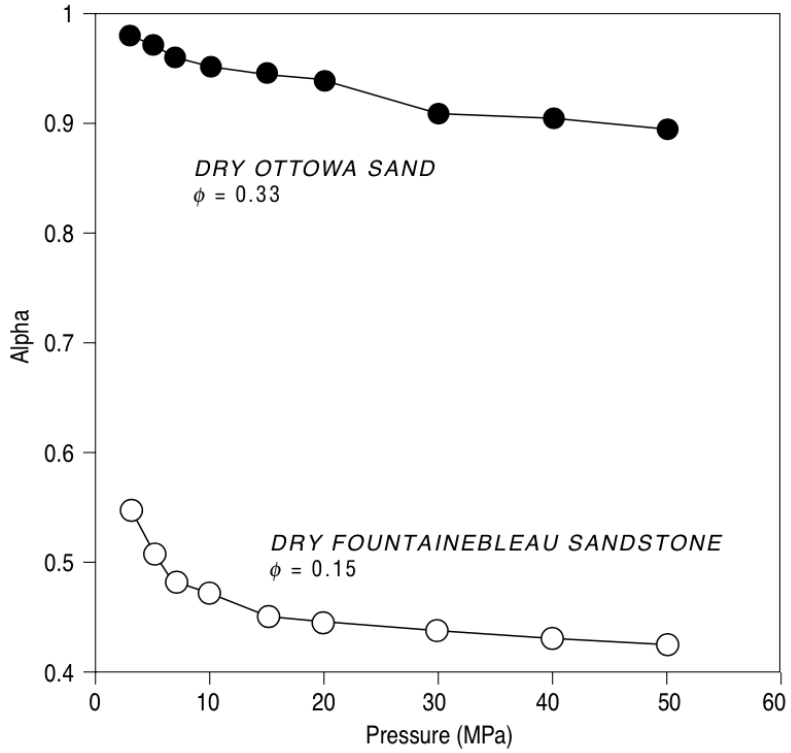
For sand

$$K_S >> K_T \qquad \alpha \approx 1$$

For rocks

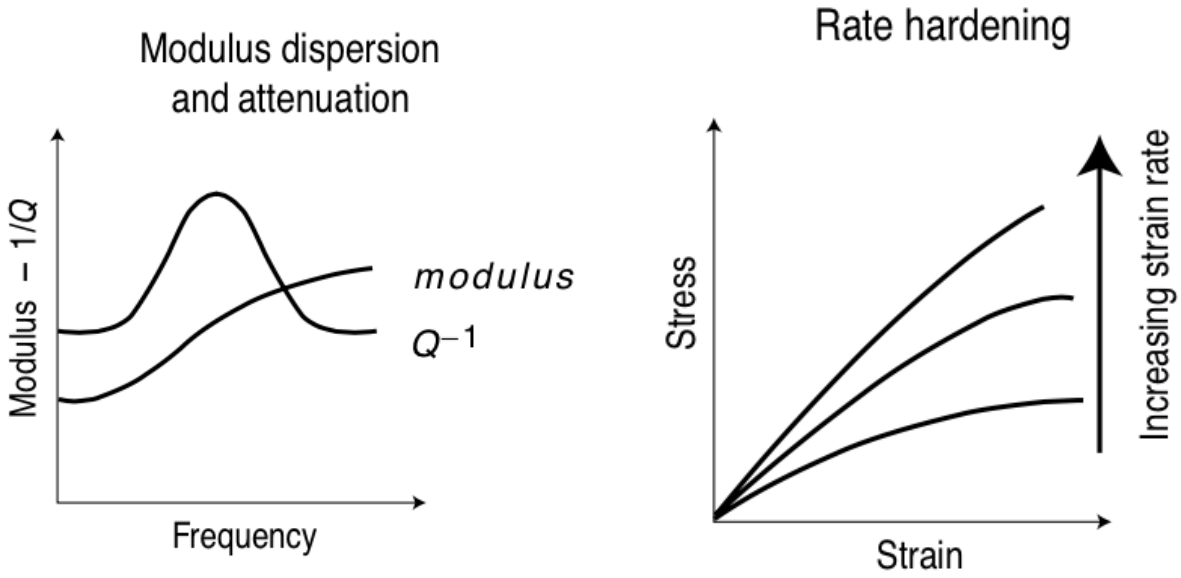
$$\alpha \approx \frac{2}{3}$$

Biot's coefficient (cont.)



 Zoback, *Reservoir Geomechanics* (Fig. 3.5c, pp. 69)

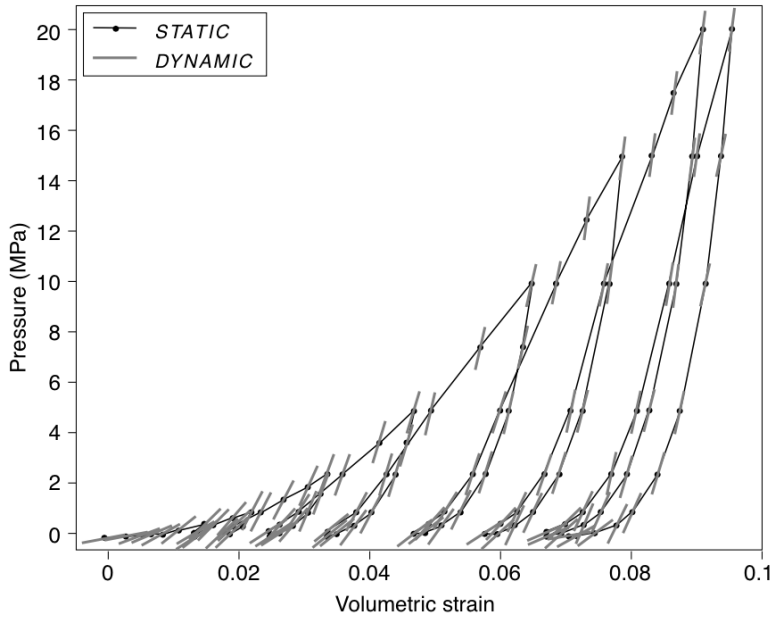
Poroelasticity = viscoelasticty



 Zoback, *Reservoir Geomechanics* (Fig. 3.10c,d, pp. 75)

Frequency dependence (load frame - ultrasonic)

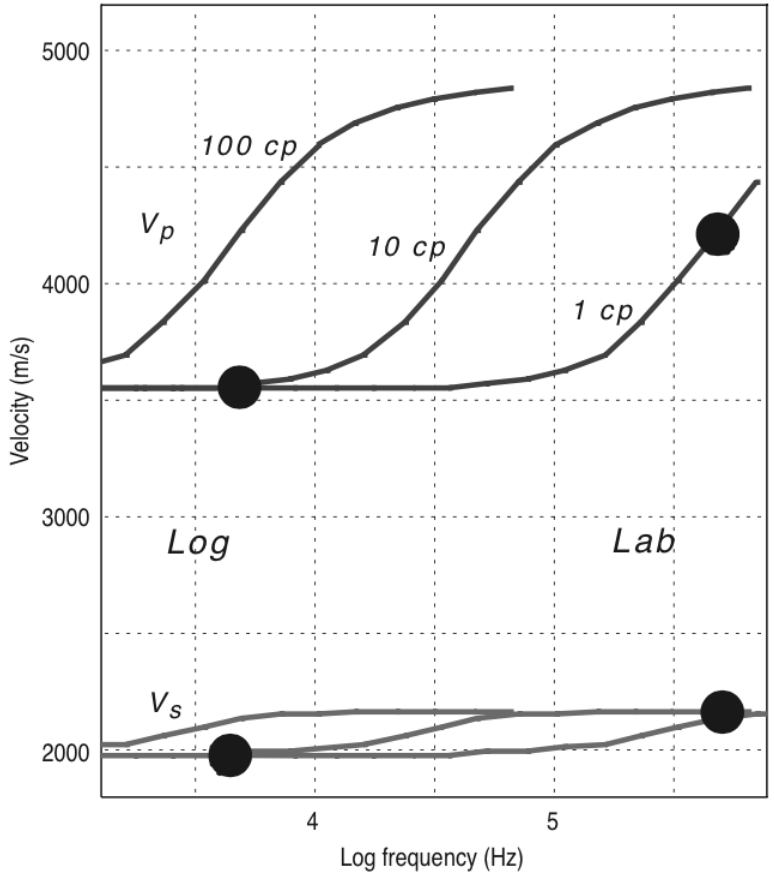
Elastic moduli measured from sonic logs will be frequency dependent in poroelastic rocks.



 Zoback, *Reservoir Geomechanics* (Fig. 3.7a, pp. 71)

Frequency dependence (sonic - ultrasonic)

Elastic moduli measured from sonic logs will be frequency dependent in poroelastic rocks.

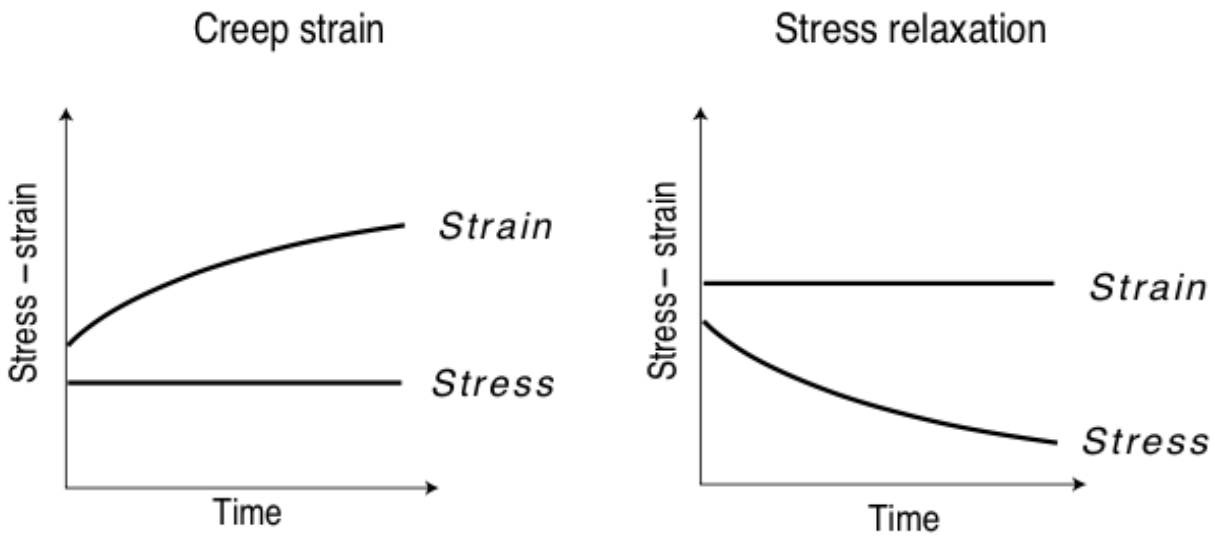


SQRT Theory

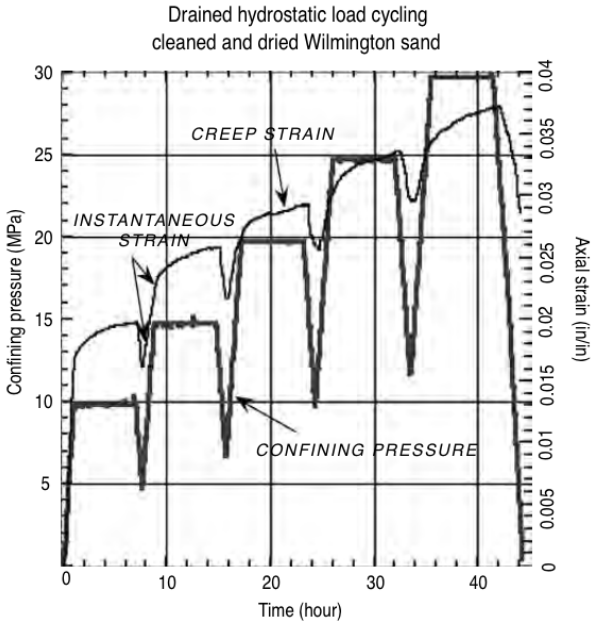
Transistion from *drained* to *undrained* behavior

- Drained limit
  - Slow loading on very permeable media
- Undrained limit
  - Fast loading on impermeable media

Other viscous effects



Creep



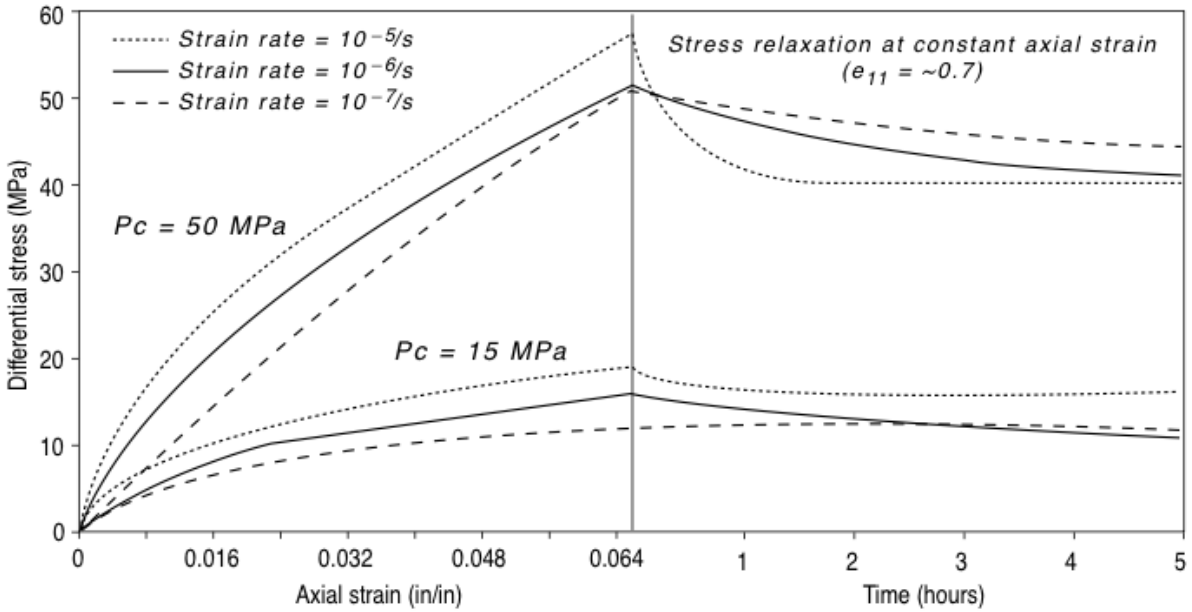
 Zoback, *Reservoir Geomechanics* (Fig. 3.8, pp. 73a)

Constitutive model for creep

Power law

$$\varepsilon(t) = \varepsilon_0 + ct^n$$

Stress relaxation



Thermoporoelasticity

$$\boldsymbol{\sigma} = \mathbf{S} - \alpha P_p \mathbf{I} - K\alpha_T \Delta T \mathbf{I}$$

α_T is coefficient of thermal expansion/(contraction)