Aquifer Properties 1

Aquifer Properties

- What is the importance of identifying aquifer properties?
  - Planning & management of groundwater resources
    - Quantitative evaluation
    - Reliable interpretations
    - Descriptive understanding
    - Comprehensive idea about temporal variability of groundwater system.

Aquifer Properties

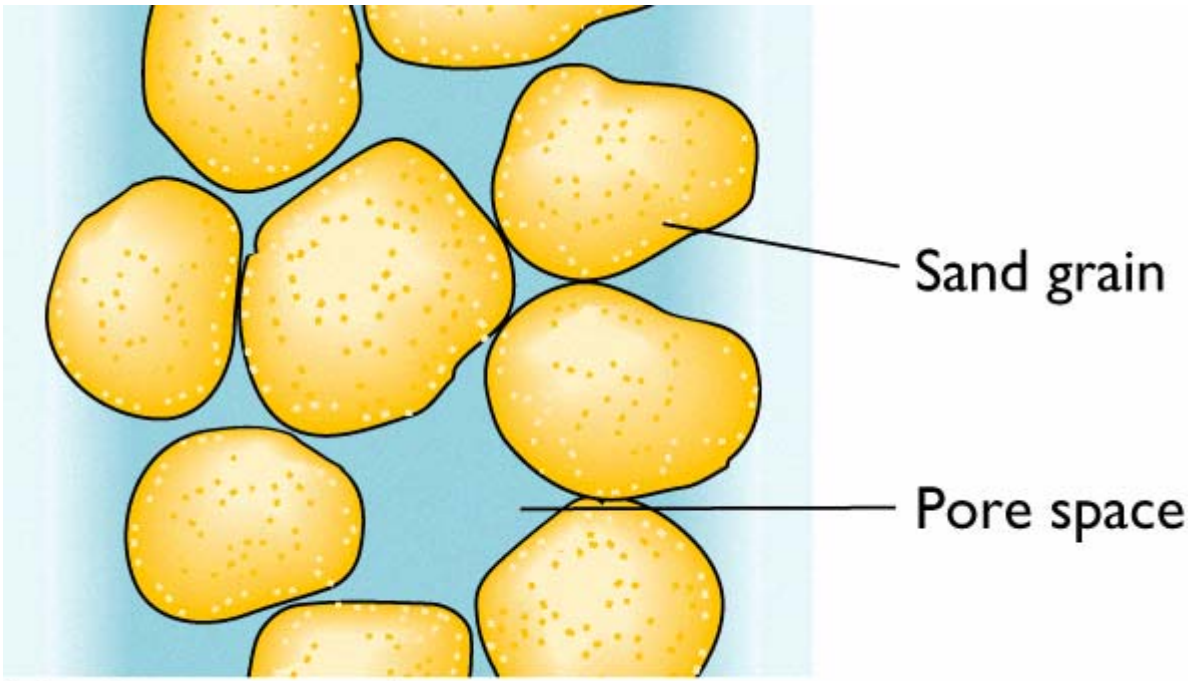
- Important aquifer properties
  - Storage properties

    Storage: is the ability of an aquifer to store water
    - Porosity
    - Specific yield
    - Storativity
  - Transmission properties
    - Hydraulic conductivity
    - Transmissivity

Quantitative Properties

Storage properties

Pore spaces

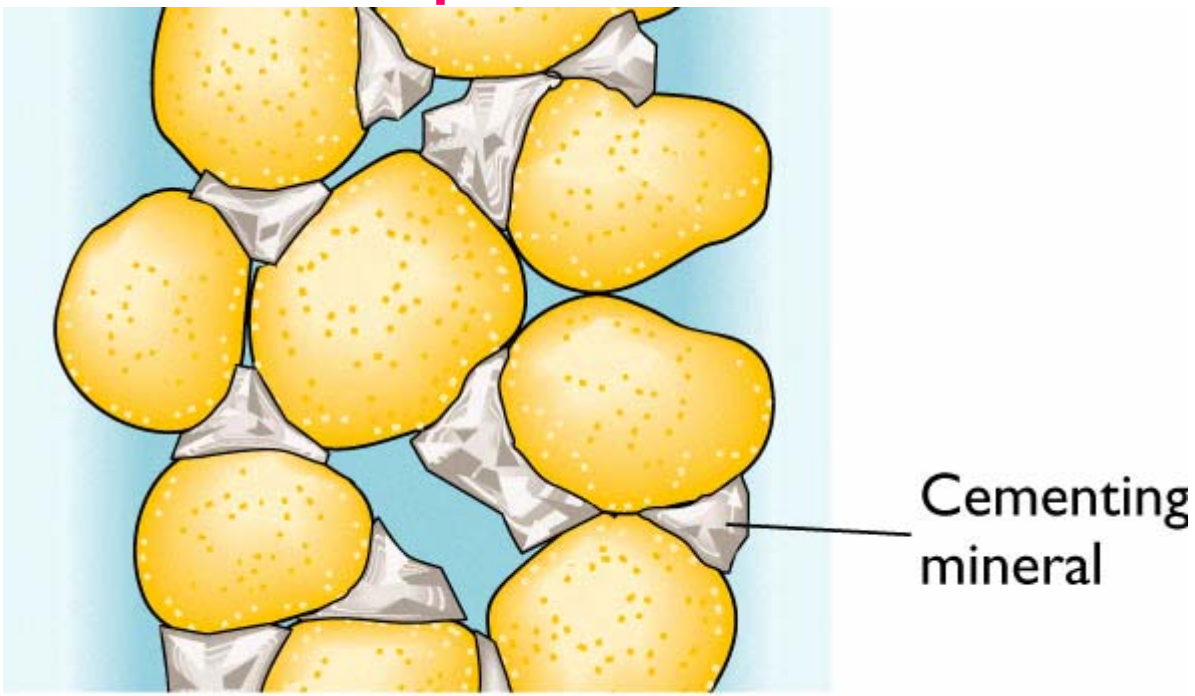


(a) Porous sandstone

Quantitative Properties

Storage properties

Pore spaces

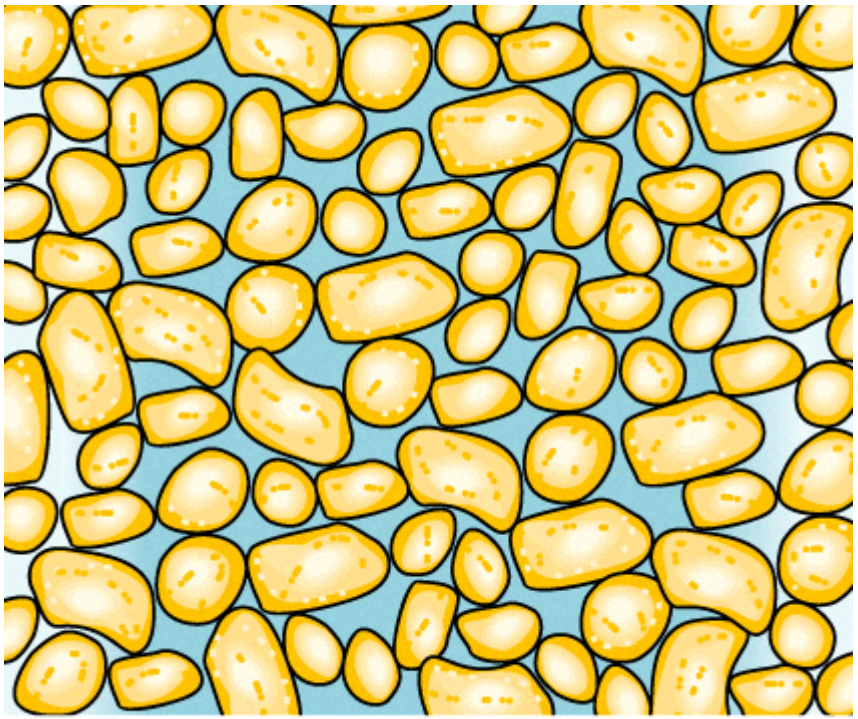


(b) Cemented sandstone

Quantitative Properties

Storage properties

Pore spaces

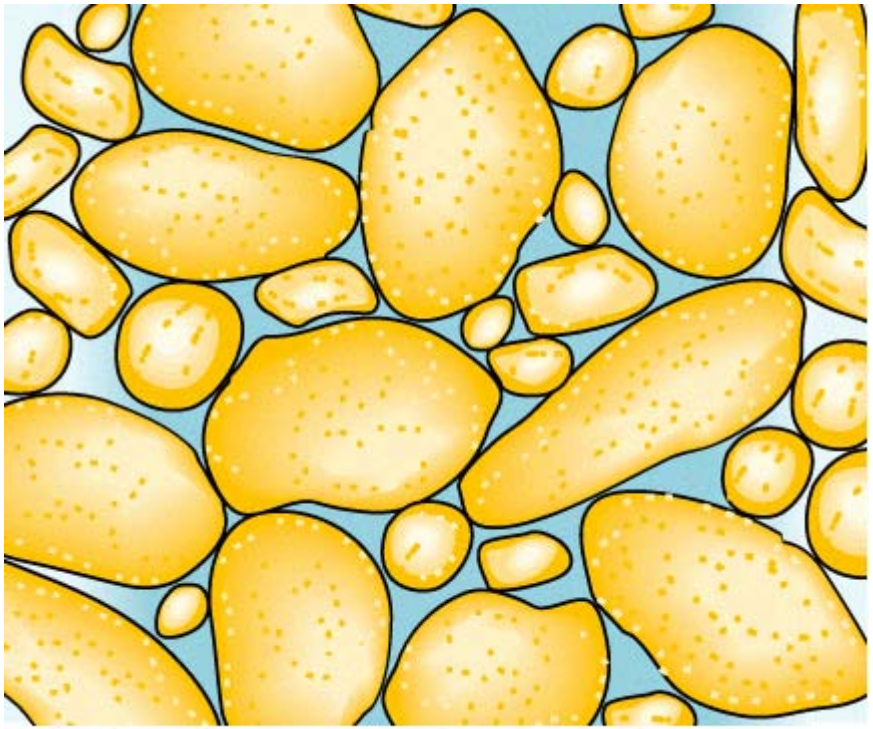


(c) Fine-grained sandstone

Quantitative Properties

Storage properties

Pore spaces

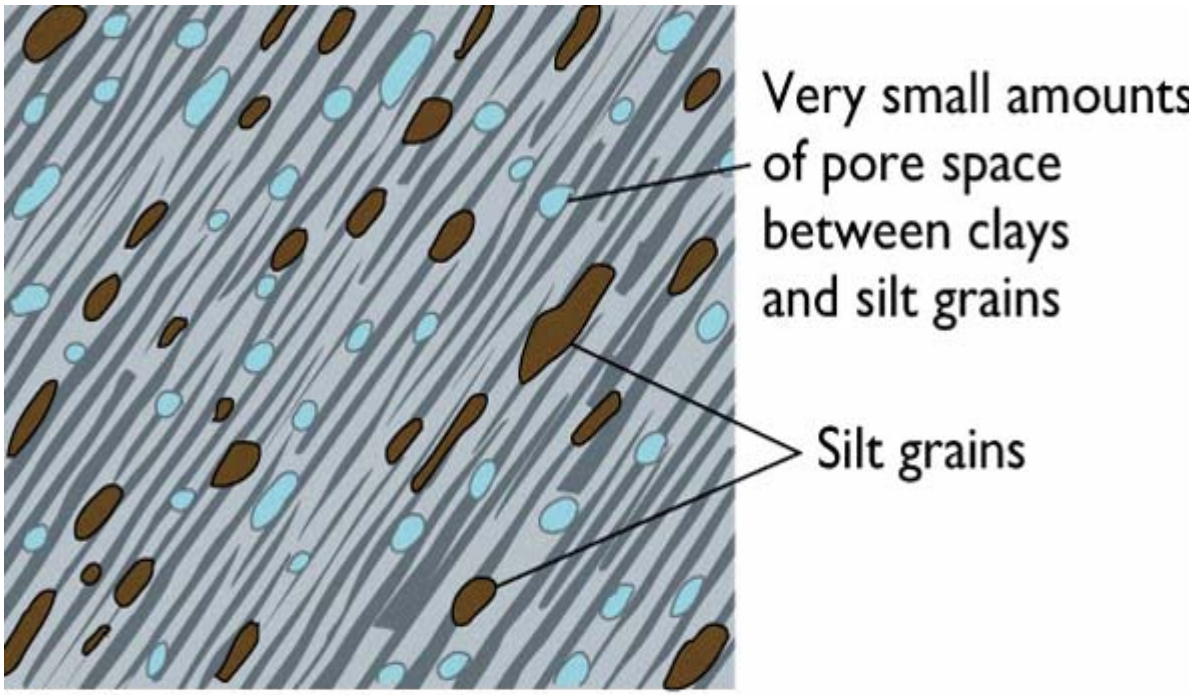


(d) Sandstone with irregular shapes

Quantitative Properties

Storage properties

Pore spaces

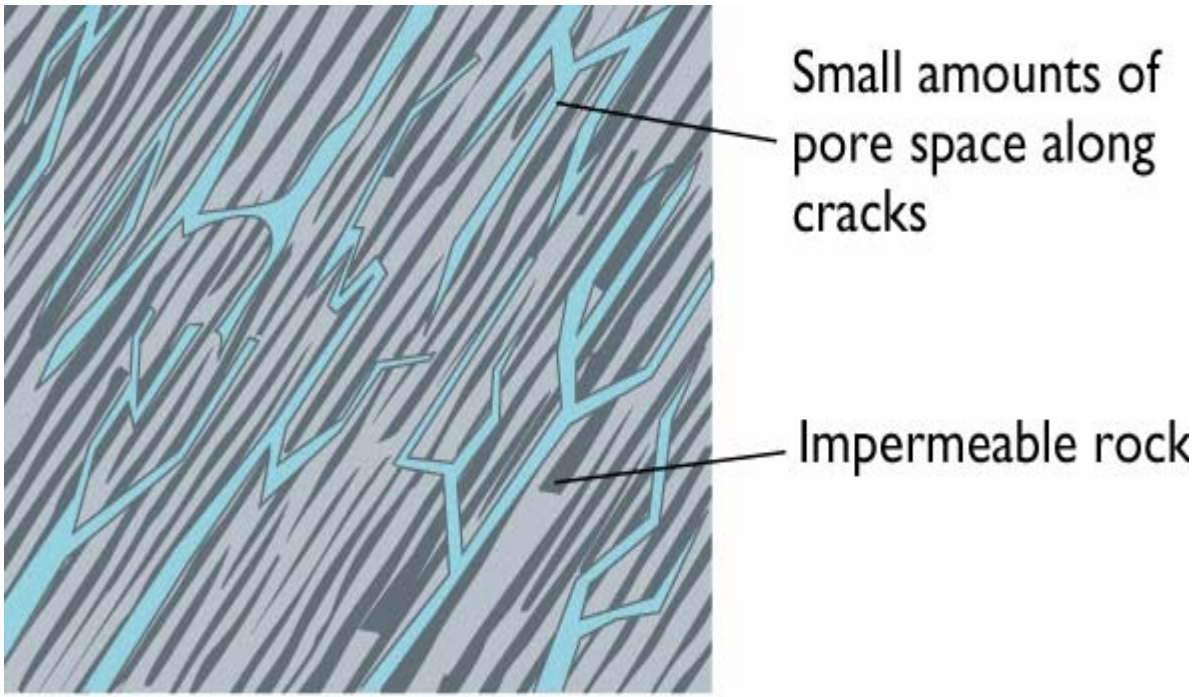


(e) Unfractured shale

Quantitative Properties

Storage properties

Pore spaces



(f) Fractured shale

Quantitative Properties

Storage properties

Porosity and effective porosity

Ratio between volume of voids to the total volume of rock

$$n = \frac{V_v}{V_T}$$

$$n_e = \frac{V_f}{V_T}$$

Quantitative Properties

Storage properties

Porosity and effective porosity

- Importance of porosity in planning and management
- Porosity and grain size & shape
- Porosity and depth
- Types of porosity:
  - Primary
  - Secondary

Quantitative Properties

Transmission properties

Hydraulic Conductivity and Permeability

- Hydraulic conductivity: is the ability of a rock or sediment to transmit water.
- Permeability: represents the ease by which a fluid passes through a porous medium.
- Both terms could be used interchangeably

Quantitative Properties

Transmission properties

Hydraulic Conductivity and Permeability

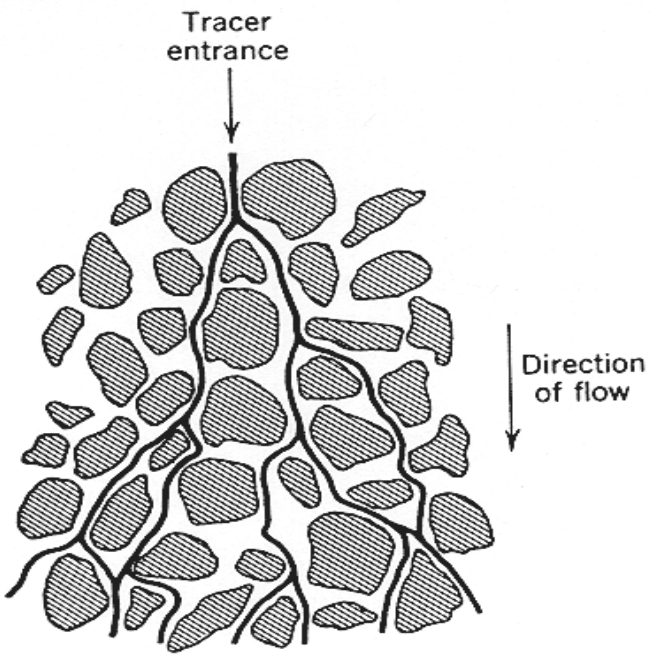


Fig. 3.21 Lateral dispersion of a tracer originating from a point source in a porous medium.

Ref: Todd, Groundwater hydrology, 1980, Fig. 3.21

The concept of hydraulic head and Darcy's experiment

$$h = z + h_P$$

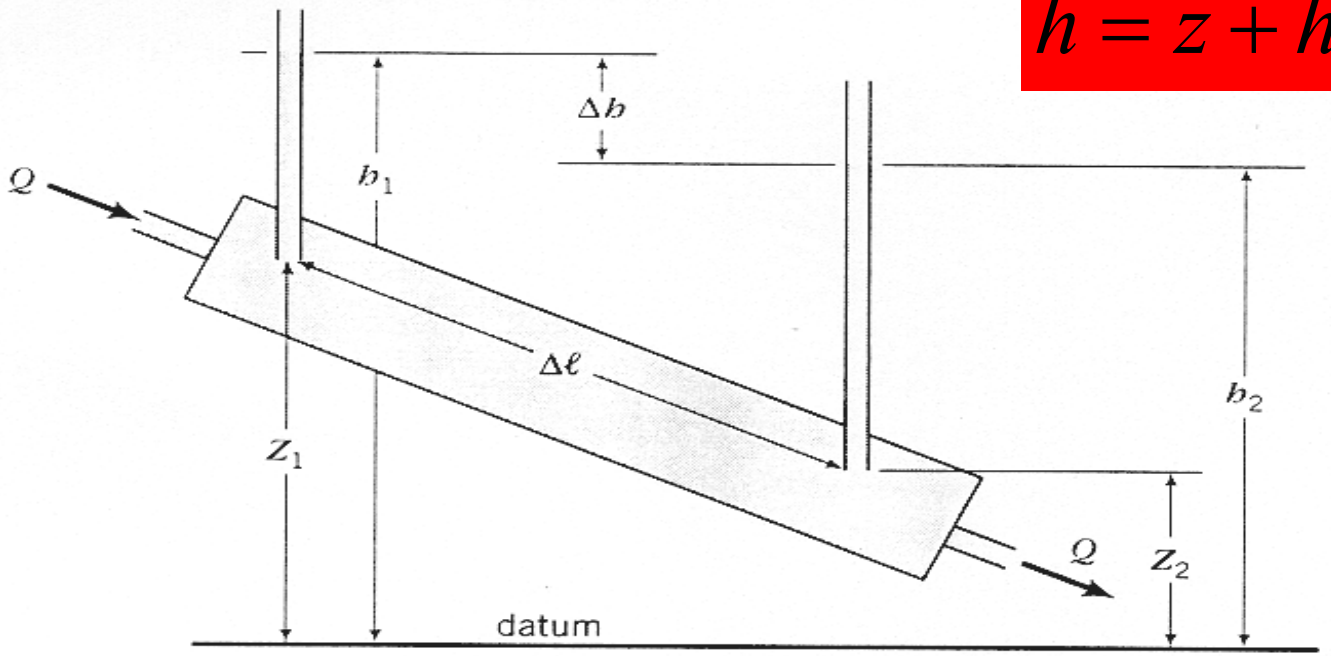
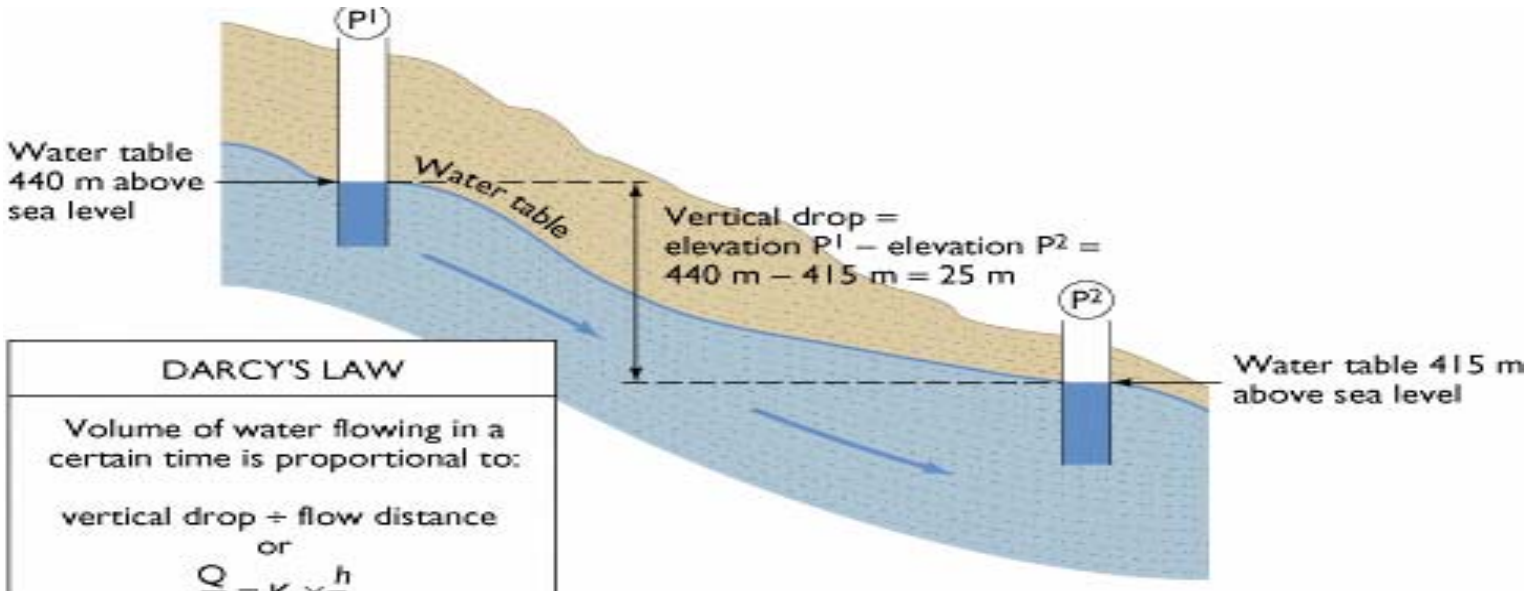


Figure 3.1 Laboratory apparatus to demonstrate Darcy's law.

How to observe hydraulic head?

Piezometer and Observation wells



DARCY'S LAW

Volume of water flowing in a certain time is proportional to:

vertical drop ÷ flow distance

or

$$\frac{Q}{A} = K \times \frac{h}{\ell}$$

- Q: Volume of water flowing in a given time
- A: Cross-sectional area through which water flows
- K: Hydraulic conductivity (a measure of permeability)
- h: Vertical drop between two points
- ℓ: Distance the flow travels

How did Darcy figure out the law?

$$Q = AK \frac{\Delta h}{\Delta l}$$

$$q = -\frac{Q}{A}$$

$$v = -\frac{Q}{n_e A}$$

Quantitative Properties

Transmission properties

Hydraulic Conductivity and Permeability

$$K = \frac{Q}{A\left(dh/dl\right)}$$

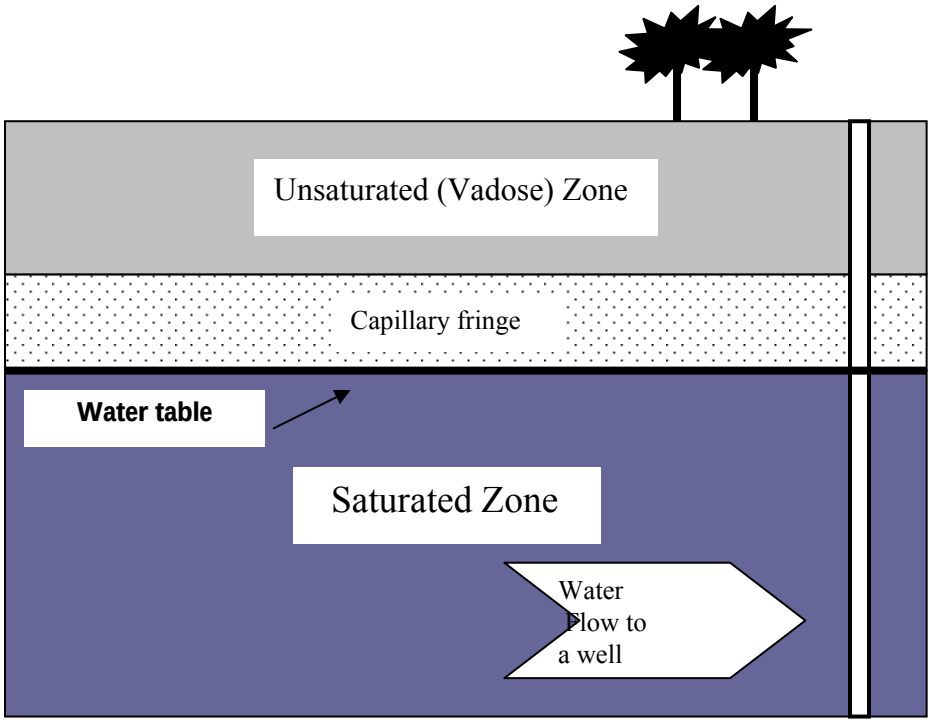
$$K = k\left(\frac{\rho g}{\mu}\right)$$

How to calculate K? Refer to Darcy's experiment

Force potential and hydraulic head

How does groundwater move in an aquifer?

- Forces acting on groundwater
  - Gravity
  - External pressure
  - Molecular attraction (Friction)
    - Viscosity
    - Stresses



Mapping Flow in Geologic Systems

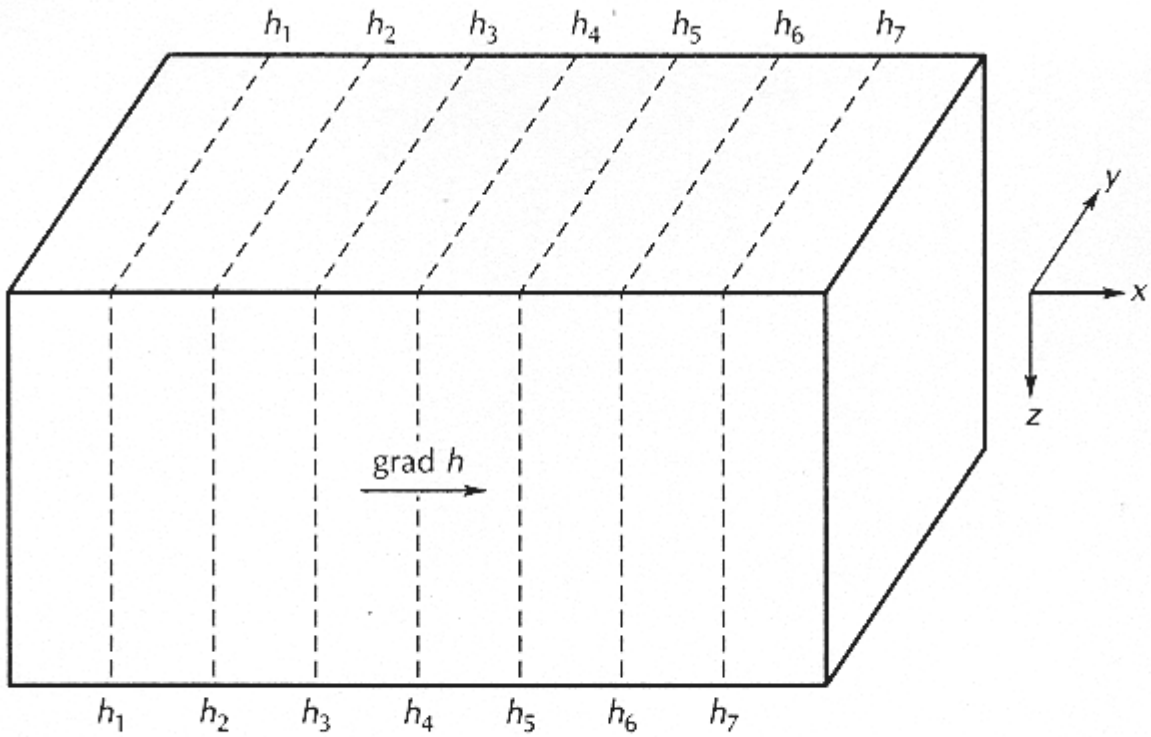
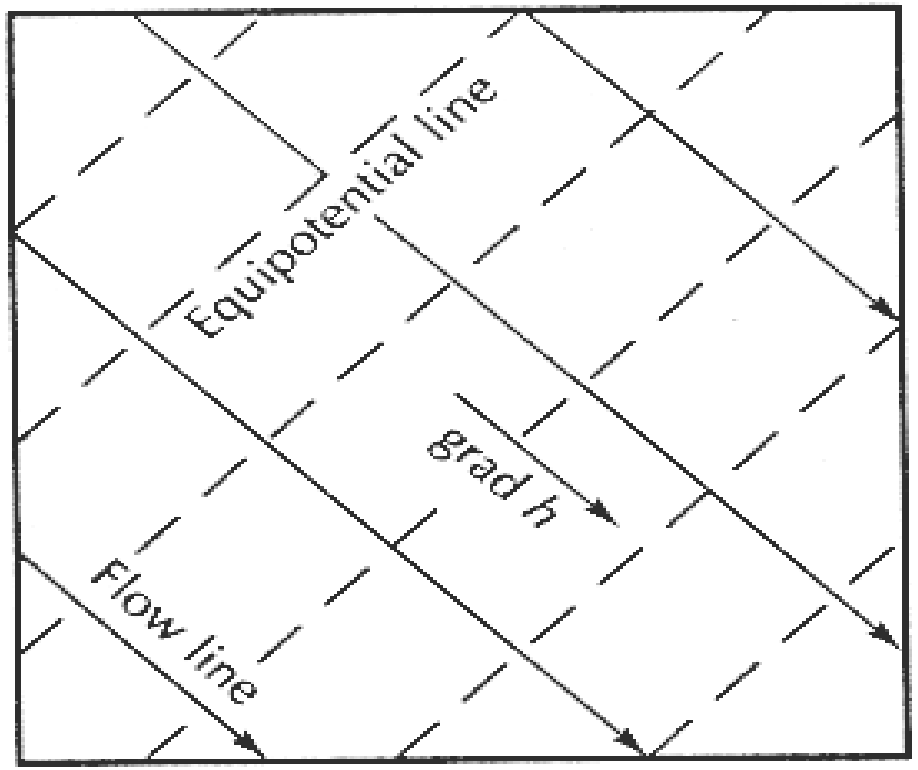


FIGURE 5.8. Equipotential lines in a three-dimensional flow field and the gradient of h.

Mapping Flow in Geologic Systems



A

Mapping Flow in Geologic Systems

Water table or potentiometric surfaces

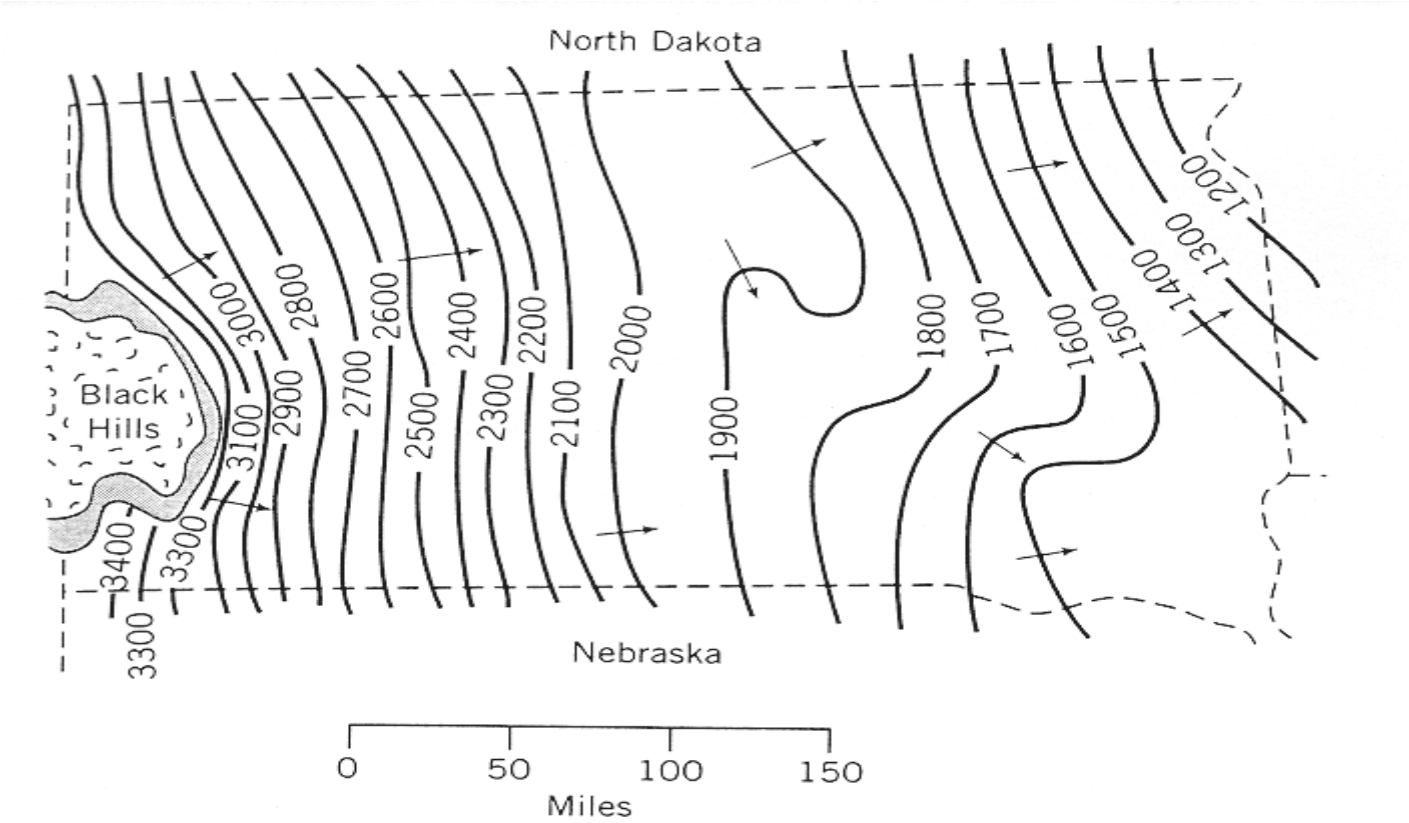


Figure 3.13 Potentiometric surface of the Dakota Sandstone, contour interval 100 ft (from Darton, 1909).

How to measure aquifer properties?

- Porosimeter
- Permeameter
- Slug tests
- Pumping tests
- Pressure transducers and water level measurements

Water level transducers &
water level measurements in the field