I. Heterogeneity

A. *Homogeneous* if conductivity is independent of position

B. *Heterogeneous* if conductivity is dependent on position

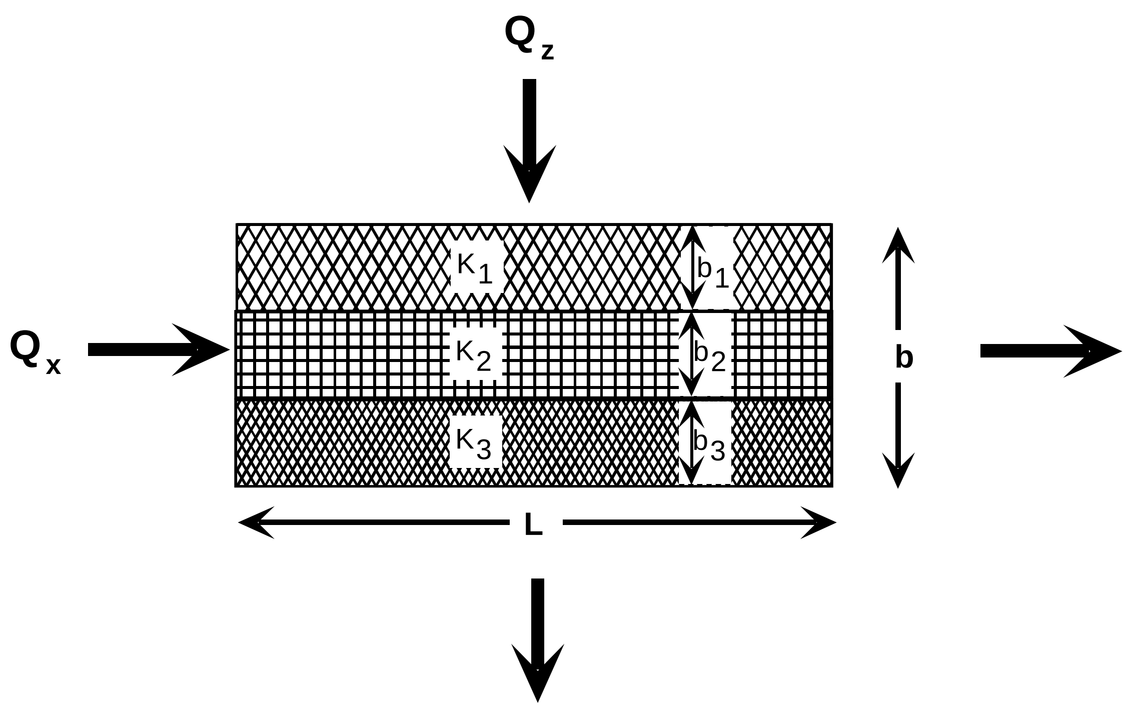
C. Freeze and Cherry (p. 30) discuss *trending heterogeneity* that occurs laterally in delta and alluvial fan deposits and vertically in soils

D. The directions in space corresponding to the maximum and minimum values of conductivity are termed the *principal directions on anisotropy*

E. Commonly layered horizontal rock are *transversely isotropic*, $K_x = K_y \neq K_z$

F. On a large scale, a heterogeneous layered system may be treated as anisotropy

1. consider horizontal flow in a vertically layered rock sequence



2. Total discharge in the *x* direction through the entire sequence is

$$Q_x = bq_x = bK_x\frac{\Delta h}{L} \qquad (1)$$

where *b* is the total thickness of the sequence and K_x is the effective horizontal conductivity.

3. Q_x is also equal to the sum of the discharges from each of *n* strata or

$$Q_x = \frac{\Delta h}{L} \sum_{i=1}^{n} b_i K_{xi} \tag{2}$$

so

$$bK_x \frac{\Delta h}{L} = \frac{\Delta h}{L} \sum_{i=1}^{n} b_i K_{xi} \tag{3}$$

$$K_x = \frac{1}{b} \sum_{i=1}^{n} b_i K_{xi} \tag{4}$$

4. Similary, flow in the horizontal direction in a horizontally stratified sequence may be treated as a homogeneous, anisotropic material.

$$q_z = q_1 = q_2 = ... = q_n \tag{5}$$

$$q_z = \frac{K_1 \Delta h_1}{b_1} +. \frac{K_2 \Delta h_2}{b_2} ...+ \frac{K_n \Delta h_n}{b_n} \tag{6}$$

But

$$q_z = K_z \frac{\Delta h}{b} \tag{7}$$

so

$$K_z = \frac{q_z b}{\Delta h} = \frac{q_z b}{\Delta h_1 + \Delta h_2 + ... + \Delta h_n} \tag{8}$$

therefore

$$K_z = \frac{q_z b}{\frac{q_1 b_1}{K_1} + \frac{q_2 b_2}{K_2} + ... + \frac{q_n b_n}{K_n}} \tag{9}$$

or

$$K_z = \frac{b}{\sum_{i=1}^{n} \frac{b_i}{K_i}} \quad (10)$$