GLY 5828, Assignment 4:

1. Solve the Poiseuille equation for water at 25C flowing in a 3 mm wide fracture a) driven by gravity when the fracture is vertical and b) driven by a pressure gradient of 0.98 kg m^{-2} s^{-2} when the fracture is horizontal. Ignore entry length effects. You can find the viscosity of water in the Handbook of Chemistry and Physics. Plot the velocity profiles.

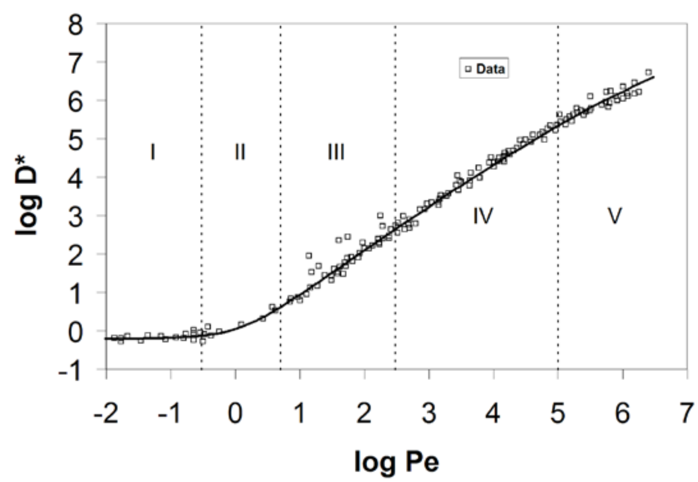
$$u(x) = \frac{G}{2\mu}(a^2 - x^2)$$

2. Compute the Reynolds number for each case in Problem 1. What is the significance of these particular numbers for the flow?

3. Compute the expected dispersion coefficient for toluene using Taylor's formula for each case in Problem 1 assuming laminar flow. u is the mean velocity and $W = 2a$.

$$D = D_m + {u^2 W^2}/{210 D_m}$$

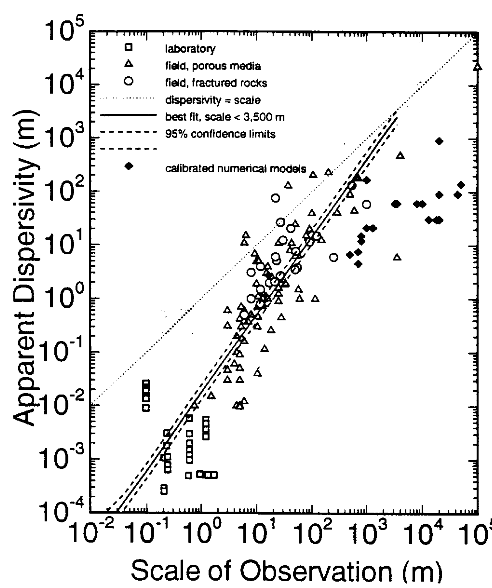
4. We wish to estimate dispersion of toluene in an aquifer composed of uniform particles of diameter 3 mm. Ignore any retardation. The flow Q through a 1-inch diameter area is known to be 6.84 g water/6 minutes. Stating appropriate assumptions, compute the mean pore water velocity in m s^{-1}.



Then compute the Peclet number Pe (= ul/Dm). Using the attached graph (Fried and Combarnous, 1971), find D^* (=Dd/Dm). Compute Dd (= D^* Dm).

5. Repeat Problem 4 for 0.03 mm particles. What is the relative importance of diffusion and hydrodynamic dispersion in Problems 4 and 5?

6. Consider a 35 cm long column. Give a third estimate of the dispersion coefficient based on the scaling relations (Neuman, 1995) shown on the attached graph. What are the relative magnitudes of the dispersion coefficients computed from Taylor's formula (Problem 3), the grain size (Problem 4), and the scale of the transport problem?



7. The problem in the aquifers of interest is the arrival of toluene at a well field from a leaking gas tank 1000 m away. Give an estimate of the dispersion coefficient based on the scaling relations (Neuman, 1995) shown on the attached graph.

References

Fried J. J., and M. A. Combarnous. 1971. Dispersion in porous media. Adv. Hydrosci. Vol. 7: 169

Neuman, S. P. (1995), On Advective Transport in Fractal Permeability and velocity Fields, Water Resour. Res., 31(6), 1455–1460, doi:10.1029/95WR00426