Homework 9

Applied Process Simulation

1. Determine the mean residence time (first moment), the variance (second moment) and standard deviation of the residence time, the skewness (third moment) of the residence time, and the effective volume determined from a step tracer test for the configurations listed below.

Be sure to view the videos describe moment analyses, and showing how to set up these simulations.

1a.

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| 1D flow pattern through a 2D porous region. The inflow and outflow areas extend over the entire side of the model and are shown in red. Flow is assumed steady. Step rate test requires initial concentration C=0 mol/m3.  D=1E-8 m2/s. fluid is water. K=1E-13m2, porosity = 0.1. Use flow from Darcy in Transport. | q=0.01 m/s  C=1 mol/m3  *P*=0 |
| Geometry and boundary conditions. Overall region 2m wide, 1m high. Non-labeled boundaries are no flow and no mass flux. |

1b

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| 2D flow pattern through a 2D porous region. The inflow and outflow areas are restricted to 0.1 of the side of the model and are shown in red. Flow is assumed steady. Step rate test requires initial concentration C=0 mol/m3.  D=1E-8 m2/s. fluid is water. K=1E-13m2, porosity = 0.1. Use flow from Darcy in Transport. | q=0.01 m/s  C=1 mol/m3  *P*=0 |
| Geometry and boundary conditions. Non-labeled boundaries are no flow and no mass flux. Length of inflow and outflow regions is 0.1m |

1c.

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| 2D flow pattern through a 2D porous region with baffles. The inflow and outflow areas are shown in red. Flow is assumed steady. Step rate test requires initial concentration C=0 mol/m3.  D=1E-8 m2/s. fluid is water. K=1E-13m2, porosity = 0.1. Use flow from Darcy in Transport. | *P*=0    q=0.01 m/s  C=1 mol/m3 |
| Geometry and boundary conditions. Non-labeled boundaries are no flow and no mass flux. Length of inflow and outflow regions is 0.1m  The two subdomains within the modeled area are impermeable. |

Do the simulations and briefly describe them. Summarize the residence times and other calculations in a table.

2. Simulate a pulse tracer test in a fracture with a porous matrix. Use the same configuration as described in the [Matrix Diffusion example](https://clemson.instructure.com/courses/179/pages/17-matrix-diffusion" \o "17.  Matrix Diffusion) problem—notice that this problem has been updated.

Use a moment analysis to characterize the outflow concentration. This test resembles a pulse tracer test, so the moment analysis will need to be slightly modified compared to Part 1. The details are explained here.

How does the mean residence time (first moment of the outflow concentration) change when the porosity of the matrix changes?  Porosity of crystalline rock, like the rock underlying Clemson is approximately 0.01, whereas the porosity of clay is approximately 0.5.  Use these two values to bound the max and min porosities for the matrix.

Describe the objectives, methods and results for this analysis. It is fine if you cite your previous analysis of the matrix diffusion problem for the set up of the analysis, and you can cite your description of the moment analysis from part 1 of this homework.—there is no need to repeat those descriptions here.