Simulating Hydraulic Fracturing and Contaminant Transport with MATLAB® and COMSOL Multiphysics® Software

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Introduction: Hydraulic fracturing is a technique used to extract oil and gas in shale rock. Proppant is pumped into the well to keep the fissures open, which allows the gas and oil to flow. Although casings are inserted into the well to prevent the fracturing fluid or oil or gas from entering the water supply, formed cracks can permit the fracturing fluids and gas cause contamination.

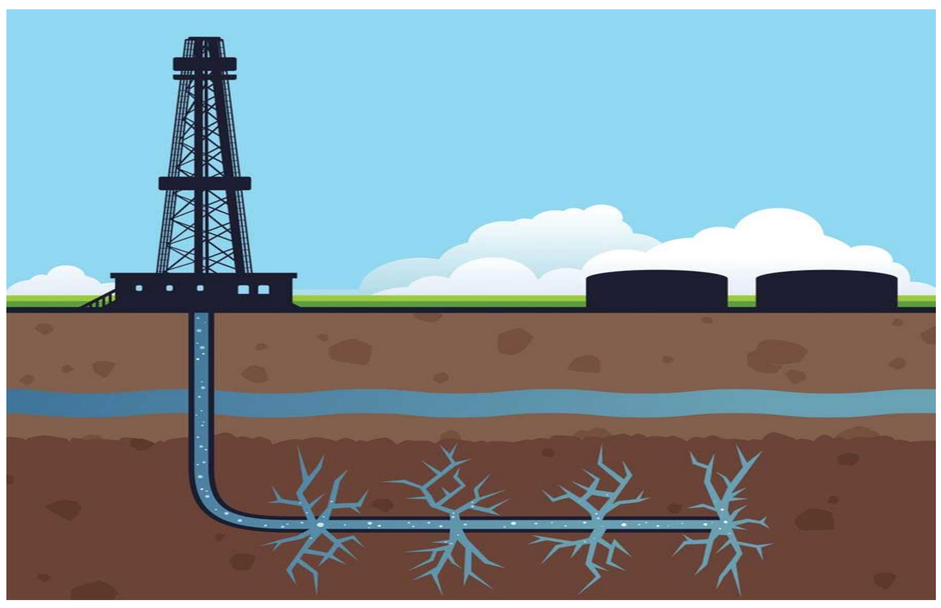

Figure 1. Hydraulic fracturing

Computational Method: Livelink for MATLAB is used to trace the fracture propagation and examine the extend of contamination associated with the fracking process. The Darcy equation is used to calculate the impose pressure:

$$S\frac{\partial P}{\partial t} - \nabla\left(\frac{k}{\mu}\nabla P\right) = Q$$

The governing equation for multi dimensional, time dependent transport of contamination within unsaturated media can be written in vector form as[1]:

$$R_d\frac{\partial C}{\partial t} + V\cdot\nabla C = \nabla\cdot(D\cdot\nabla C) + S$$

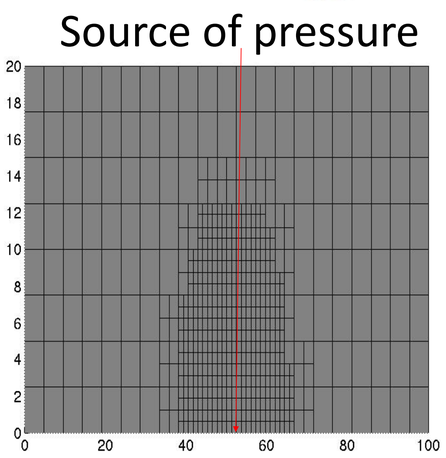

Figure 2. Mesh Refinement

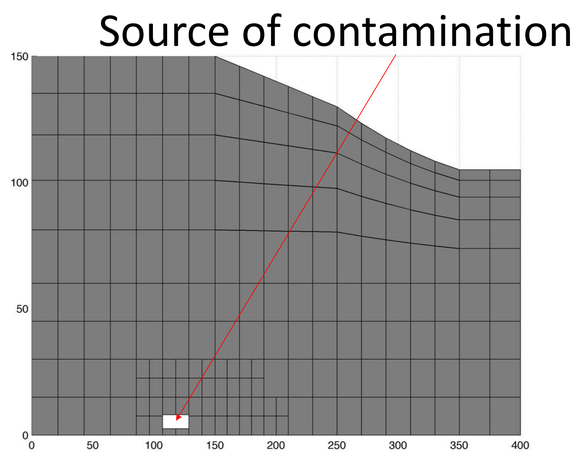

Figure 3. Groundwater contamination simulation

Result: The simulation domain for the hydraulic fracking is 100m × 2000m. The mesh is started with 20 × 800 elements. Using mixed mode intensity[2] to capture the fracture produces more realistic results than using single parameter linear elastic fracture mechanics[3][4].

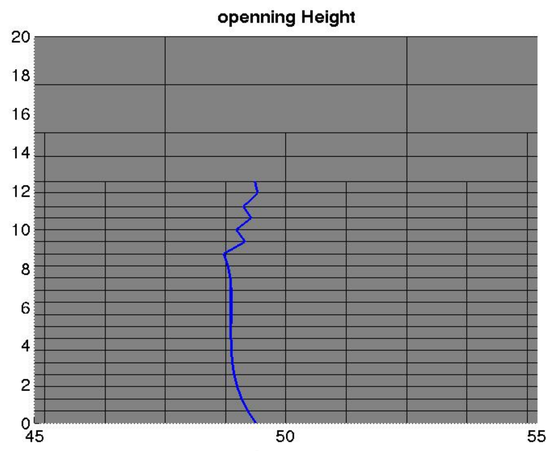

Figure 4. Crack propagation

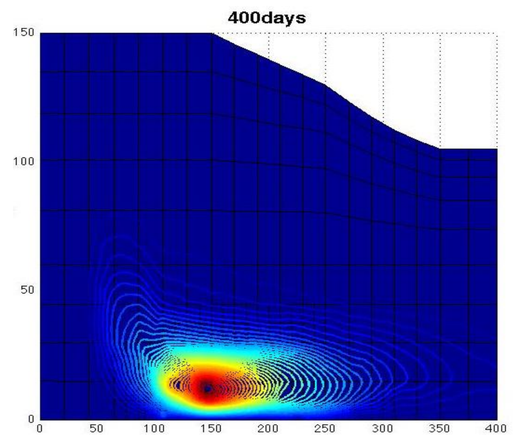

Figure 5. Contamination transport after 400 days

Variable	Value	Units
Permeability	10^3	md
Pororosity	0.35	-
Injection Rate	2.5×10^{-4}	m^3/s
Viscosity	1.23×10^{-3}	Pas
Compressibility	10^{-8}	Pa^{-1}

Table 1. Variable values

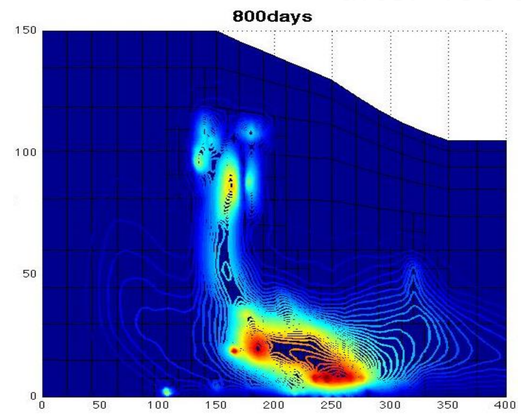

Figure 6. Contamination transport after 800 days

Conclusions: Contaminant transport is combined with hydraulic fracturing in an effort to more fully understand the contamination associated with fracking technology. Initial results using COMSOL indicate that if pumping continues for an appreciable length of time, there is the potential for aquifers to become contaminated.

References:

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3. COMSOL Multiphysics Model Gallery, Single Edge Crack, Model ID: 988
4. V. Vikram , N. Jain, T. N. Singh, Three dimensional modelling of propagation of hydraulic fractures in shale at different injection pressures, Sustain. Environ. Res., 25(4), 217-225 (2015)

Excerpt from the Proceedings of the 2016 COMSOL Conference in Boston