Long Term Risk of Potable Aquifer Contamination via Fracking Fluids

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Need for Research

Due to pressing public concerns, there is an critical need for a quantitative assessment of the risk that fracking fluids will reach and contaminate potable aquifers.

Concept

Risk assessment, as used herein, is defined as the quantification of the product of the probability of event and its consequence. Thus the risk of fracking fluid contamination of a potable aquifer is the product of the probability of contaminant occurrence in a potable aquifer times its concentration.

Calculation of Risk

- The concentration field generated by a realization gives a value of concentration at each node in the model
- The highest concentration observed among the nodal values located in the potable aquifer is recorded.
- A bar graph is created with the concentrations (defined as intervals) along the abscissa and the frequency on the ordinate.
- The process is repeated for a second realization and the highest value is added to the bar graph.
- The process is repeated for all realizations.
- A horizontal line is drawn at the concentration determined to be the acceptable limit from a public health or political perspective.
- The number of realizations that are above this line is recorded.
- The ratio of the number of realizations above the line to the total number of realizations is the calculated risk of fracking fluids impacting the modeling potable aquifer.

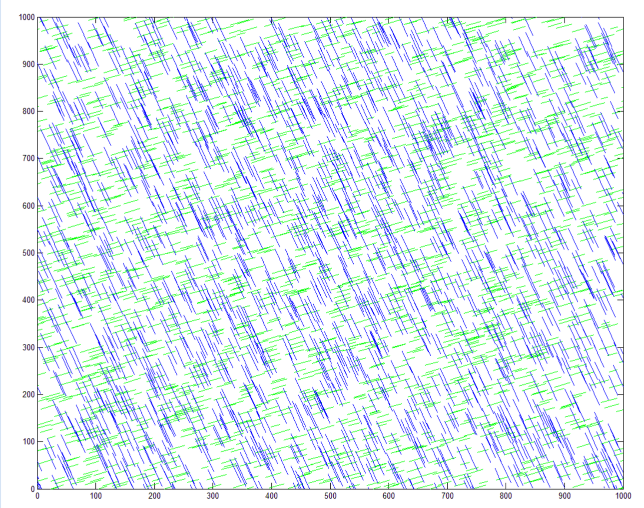


Figure 2: Randomly generated fracture distribution based on observed field data of natural fracture angles and lengths along the eastings-z plane for the Marcellus shale.

Field Information

Field data to develop near and far field fractures was obtained to develop statistically probable physical models. The data set on induced fractures, obtained from Richard Davies[1], will be used to develop hydraulic properties of shale immediately around the well. Data on natural fractures, obtained from Terry Engelder[2], will be used to model discrete fractures within shale and rock layers.

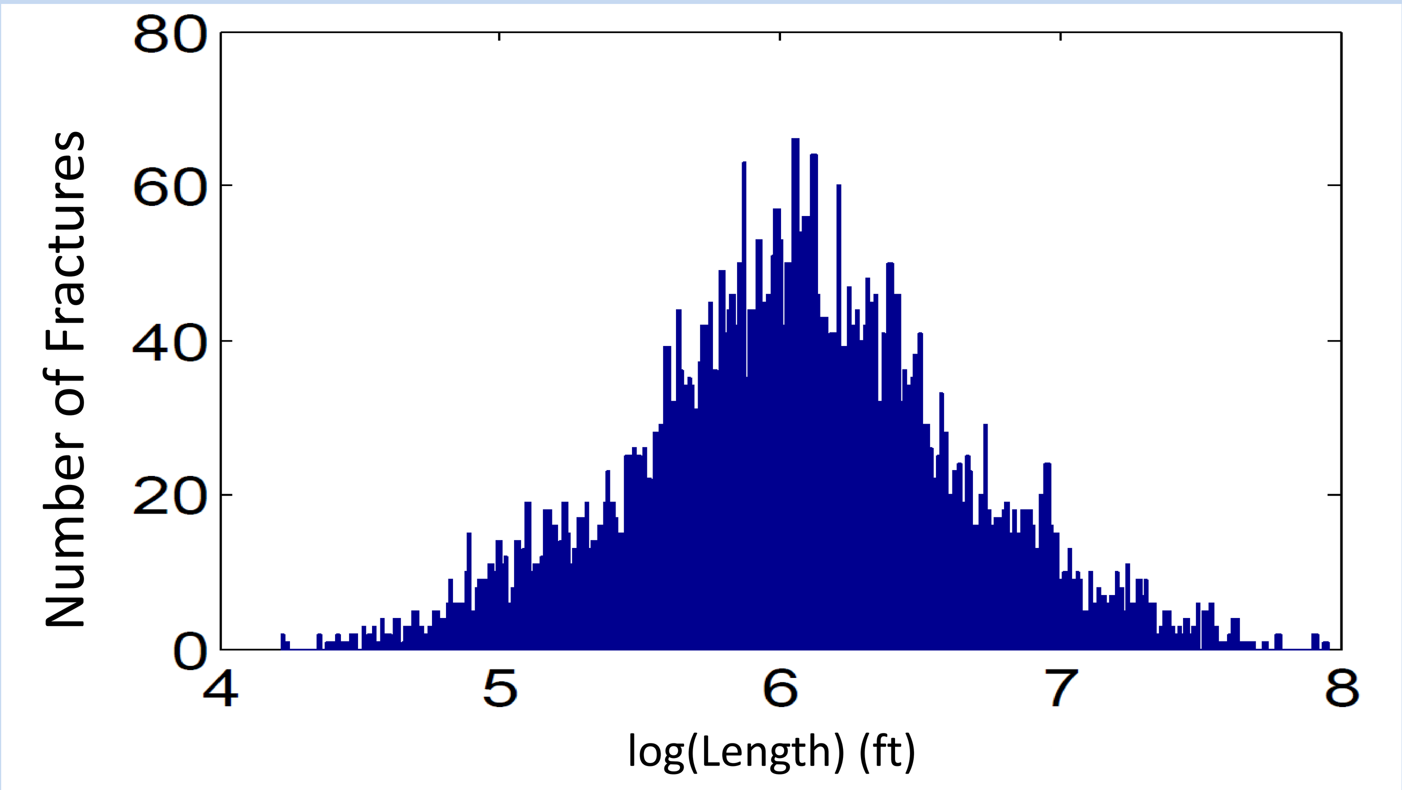
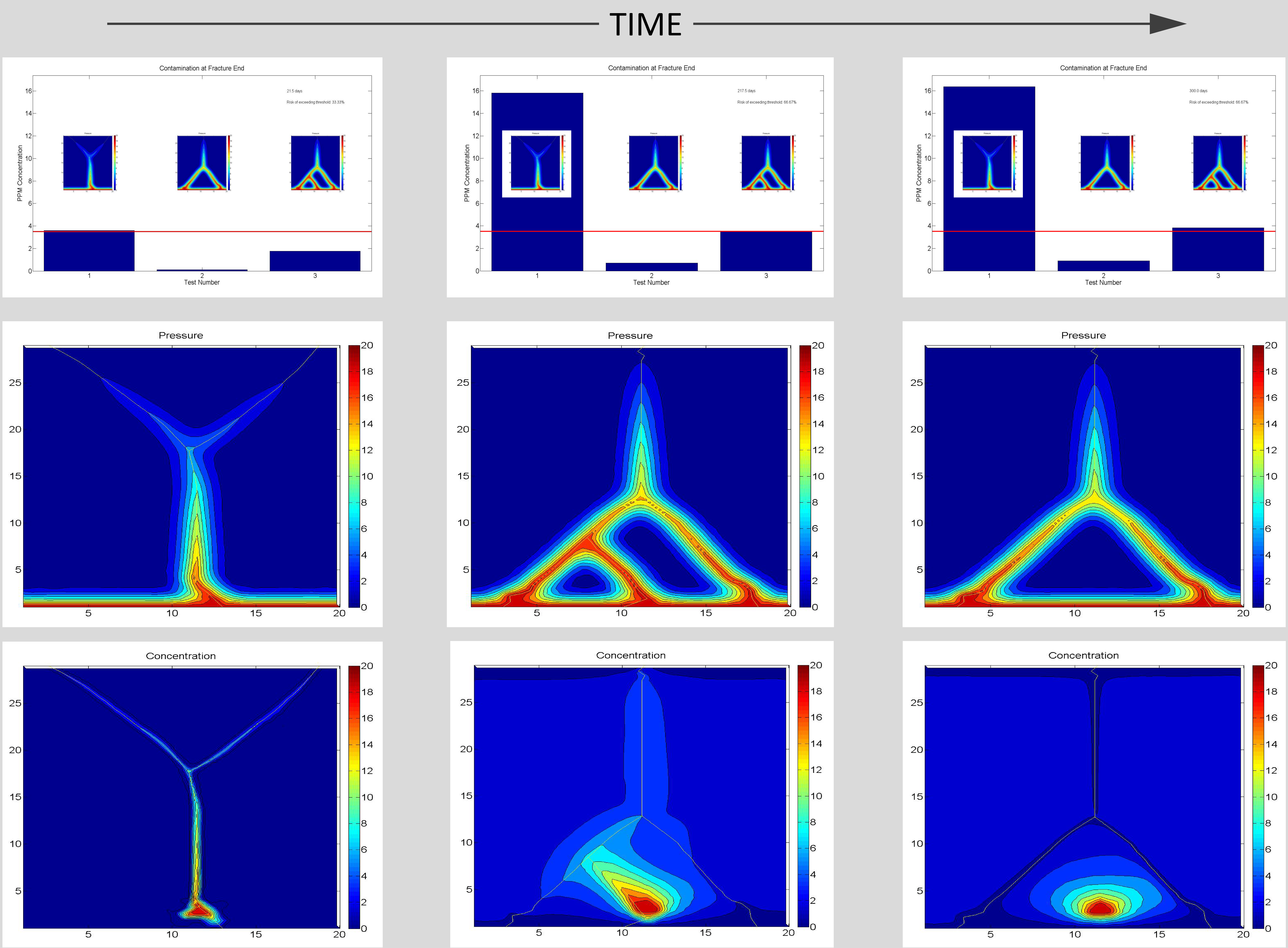


Figure 1: Statistical distribution of 5,000 fractures observed in Barnet, Eagle Ford, Marcellus, Niobrara, and Woodford shales.



(a) Test 1 exceeds the threshold at t = 21.5 days.

(b) Test 3 exceeds the threshold at t = 217.5 days.

(c) Test 2 does not exceed the threshold during the test duration.

Figure 3: Pressure and Concentration at the time when concentration exceeds the threshold at the top boundary.

Technical Approach

Simulation

- Fracking fluid flow and transport is primarily through fractures, and secondarily through the surrounding intact source rock.
- Equations describing fracking fluid flow and transport have physically-based coefficients that are known with uncertainty.
- The statistics of the uncertain physically-based coefficients can be determined for a specific site from field information.
- The resulting stochastic equations are used to produce realizations (samples) from the random fields.
- Each realization is used to do a simulation of the physical system (fracked and natural media) and obtain a concentration field.
- The combination of the concentration fields provides the statistics of the concentration in the system.

Model

A two dimensional triangular finite element model with discrete one dimensional fracture elements was developed to model flow and transport through discrete fractures as a stepping stone to a more robust three dimensional model with finite element volumes representing the rock and soil matrix while a planar element represents discrete fractures. The benefit of including lower dimensional elements for fractures is that no additional computational effort is required to solve the flow and transport equations than is needed for the continuum model.

Results and Conclusions

The generation of preliminary realizations for random fields for the near-field and far-field fractures has been achieved. Flow and transport for selected test problems has also been realized, while the problems do not represent any real-world situations, they do demonstrate the feasibility of the proposed method.

The assessment of the risk of potable aquifer contamination by fracking fluids over very long time frames can be determined using stochastic models wherein the hydraulic conductivity of both near-field and far-field fractures can be represented as random fields.

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1. R. J. Davies, S. A. Mathias, J. Moss, S. Hustoft, and L. Newport, "Hydraulic fractures: How far can they go?," *Marine and Petroleum Geology*, vol. 37, pp. 1-6, 2012.
2. T. Engelder, G. G. Lash, and R. S. Uzcategui, "Joint sets that enhance production from middle and upper devonian gas shales of the appalachian basin," *American Association of Petroleum Geologists Bulletin*, vol. 93, no. 7, pp. 857-889, 2009.