Bayesian inference in hydraulic fracturing models

Hasini Garikapati[*,†], Clemens V. Verhoosel[*], E. Harald van Brummelen[*], Sergio Zlotnik[†] and Pedro Díez[†]

[*] Eindhoven University of Technology
PO Box 513, 5600 MB, Eindhoven, The Netherlands
email: h.garikapati@tue.nl, c.v.verhoosel@tue.nl,
e.h.v.brummelen@tue.nl

[†] Universitat Politècnica de Catalunya
Jordi Girona 1-3, E-08034, Barcelona, Spain
email: sergio.zlotnik@upc.edu, pedro.diez@upc.edu

ABSTRACT

The hydraulic fracturing process has raised environmental concerns over the years. The commonly used models for this process are still rudimentary, as hydraulic fracturing is a challenging process to simulate by virtue of the fact that it involves the coupling of various submodels: a solid model which describes the deformation of the rock induced by the fluid; a fluid flow model within the fracture, including a model for the representation of fluid leak off to the rock formation; a fracture propagation model. Besides, hydraulic fracturing processes are surrounded by uncertainty, as available data on e.g. rock formations is typically minimal. In this contribution we combine Bayesian inference techniques with existing models for hydraulic fracturing, specifically the commonly used Perkins-Kern-Nordgren (PKN) model [1, 2]. The focus in this work is on sampling-based techniques, particularly the Markov Chain Monte Carlo (MCMC) method.

This talk discusses how Bayesian inference can be used to solve hydraulic fracturing problems in an inverse setting [3]. First, the PKN hydraulic fracturing model is taken to solve a forward problem with prior soil properties modeled by random fields [4]. Next, we combine the forward problem results with the observables using the Bayesian framework to deduce information about the uncertain parameters. The reservoir pressure, which is a function of time, is considered as the observable based on which we infer uncertain parameters such as rock properties. This technique is further extended to multiple uncertain parameters such as the height of the fracture, the leak-off rate, etc. Our study addresses the handling of observations with time trends and effects of sub-sampling in the MCMC setting. Moreover, based on synthetic data, we illustrate how the Bayesian framework can be combined with hydraulic fracturing models to assist in the prediction of well stimulation processes.

REFERENCES

[1] Perkins, T., Kern, L., Widths of hydraulic fractures., J. Pet. Tech. Trans. AIME **222**, 937949, 1961.

[2] Nordgren, R., Propagation of vertical hydraulic fractures. J. Pet. Tech, **253**, 306314, 1972.

[3] Albert Tarantola. 2004. *Inverse Problem Theory and Methods for Model Parameter Estimation*. Soc. for Industrial and Applied Math., Philadelphia, PA, USA.

[4] Sampling-based stochastic analysis of the PKN model for hydraulic fracturing Garikapati, H., Verhoosel, C. V., van Brummelen, E. H., Zlotnik, S. & Díez, P., 2018, In : Computational Geosciences. 25 p.