PRF# 58769-DNI9
Project Title: Constitutive modeling of friction and flow properties of faults during multiphase flow-induced seismicity
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I used PRF funding to conduct research in experimental and computational modeling of coupled fluid flow and rock deformation in fractured and faulted rocks. I feel fortunate and happy in reporting the following two journal papers coming out of these projects:

1. A. Bubshait and B. Jha, Coupled poromechanics-damage mechanics modeling of fracturing during injection in brittle rocks, Int J Numerical Methods in Engineering, doi: 10.1002/nme.6208, 2019
2. G. L. Manjunath, B. Jha, Geomechanical characterization of Gondwana shale across nano-micro-meso scales, Int J. Rock Mechanics and Mining Sciences, doi: 10.1016/j.ijrmms.2019.04.003, 2019

A third paper, S. Meguerdijian and B. Jha, Leakage dynamics of faults: Effect of induced seismicity and multiphase flow, is under review at International Journal of Greenhouse Gas Control. Another graduate student, X. Zhao, and I are hoping to present "Effect of poroplasticity on geomechanical stability of a faulted reservoir under production" at the American Geophysical Union Fall Meeting in December 2019. We are waiting on the notification of abstract review from the AGU session committee.

One of the figures from Paper 3 above is shown in Fig. 1. This shows a model of multiphase flow-induced seismicity, as discussed in my PRF proposal.

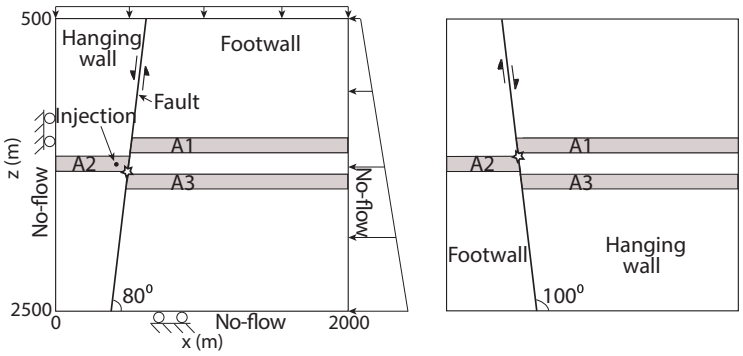

Fig. 1. The left-hand side figure shows a physical model of gas injection and leakage in a faulted reservoir. Two fault models, 80 deg-dip model (left) and 100 deg-dip model (right), are shown such that the same injection location (A2 aquifer) falls in the hanging wall block and footwall block of the two models, respectively. The arrows on the top and right boundaries of the left figure indicate overburden and tectonic compressions, respectively. The stresses increase linearly with depth under lithostatic gradient. The hypocenter locations of injection-induced seismicity, shown with the star symbols, are located on the aquifer boundary where injection-induced shear is aligned with the tectonic shear.

Benefit to my career

PRF is the most prestigious and significant funding award that I have received in the last three years. It has showcased my research in a positive light in my home department and the engineering school I am a part of. I received recognition for receiving this fund during my mid-tenure review, which further emphasizes the importance of PRF in my career. I have been using, and will continue to use, the funding to support two graduate students and purchase materials and supplies for the experimental work in my PRF proposal. I will use the results from this work for my NSF CAREER proposal that I will submit next year.
In August 2019, I visited University of North Dakota's Petroleum Engineering department and gave an invited seminar based on the work done with PRF's support (Journal Papers 1 and 2 below). This helps my career because it increases the visibility of my research in the relevant community.

Benefit to the scientific community

Modeling of coupled poromechanical processes is at the forefront of geophysics and petroleum engineering research due to its role in addressing injection-induced seismicity problems, understanding mechanical stability of faults, and hydraulic stimulation of rocks. Papers 1 and 2 in the list above are published in mainstream computational mechanics journals, which are read by researchers affiliated with US National Congress on Computational Mechanics (USNCCM), Engineering Mechanics Institute of American Society of Civil Engineers (ASCE), and Society of Industrial and Applied Mathematics (SIAM) Geoscience. The experimental and numerical results presented in these two papers benefit these communities by addressing the questions associated with quantification of flow-induced stress and failure of faults and fractures.

Benefit to the students

My PhD student and postdoc (first authors in the paper list above) worked on their respective research projects, which were made possible by PRF. The list of papers above is a testimony to their success. One of the students, A. Bubshait, is planning to submit his PhD thesis within a month. The postdoc, Manjunath, benefited from his publication by securing a postdoc fellowship at MIT Civil and Environmental Engineering. Other two students, S. Meguerdijian and X. Zhao, are hoping to publish journal papers next year based on their PRF-funded research, which will count towards their graduation.