Evaluating the State of Stress Beyond the Borehole

Award Numbers: FWP-FE-451-14-FY15; FWP-FE-617-15-FY15

Prime Performer:
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Project Duration:
10/01/2014 – 08/30/2016

Performer Location:
Los Alamos, New Mexico

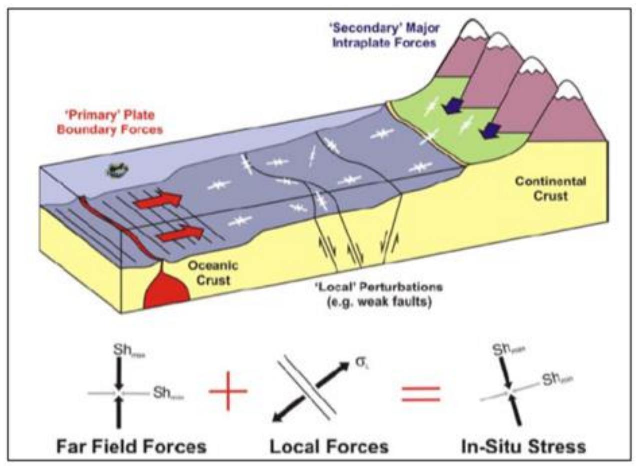
Program:
Carbon Transport & Storage

Project Summary:

This project demonstrated the utility of a unique method for determining the bulk stress state in the reservoir. The primary objective of this research was to develop a method to evaluate the reservoir state of stress using geophysical data coupled with computational analysis. The methodology is based on a novel advanced multi-physics tomographic (AMT) approach for determining the state of stress, thereby facilitating the ability to monitor and control subsurface geomechanical processes. The following approach was utilized in this research:

1. Development of the AMT algorithm for deriving state-of-stress from integrated density and seismic velocity models and demonstrate feasibility by applying the AMT approach to synthetic data sets.
2. Demonstrate the feasibility of the AMT method relative to producing sufficient accuracy and resolution for data sets representing realistic field resolutions.
3. Evaluation of a novel method for determining whether a fault is near its critical state of stress.
4. Production of next-generation regional- to basin-scale maps of the background state of stress.
5. Development of a method to use discrete fracture networks for modeling the effective permeability at the reservoir scale.

Figure 1: Schematic of the background state of stress.



Project Outcomes:

Work under this project successfully developed an approach to extract the stress tensor at reservoir-to-basin scales and a passive monitoring approach to determine if a fault is near critical stress. The project successfully developed and applied the AMT approach to a demonstration site in Oklahoma as well as successfully developed a method to evaluate the excitation of critically stressed faults by Earth tides through the use of very low-magnitude events arising from variations in tidal forces and triggering seismic waves. In addition, the project constructed the next-generation maps of the background state of stress in North America and successfully developed a method to use discrete fracture networks for modeling the effective permeability at reservoir scale.

Work from this project has led to development of a methodology to measure the state of stress at the reservoir scale, determine the means to identify and locate critically stressed faults, and quantify when faults and fractures are in a critical state. The work has also refined and improved maps of the background (regional) state of stress and developed a comprehensive method for mapping discrete fracture networks from microseismic data and the methodology for modeling the stress-permeability relationship (expansion of LANL's *dfnWorks*). The project team is now in the position to develop a field-deployable, real-time monitoring system for the analysis and prediction of the stress field in the subsurface.