A Low-Cost Technique for In-Situ Stresses and Geomechanical Properties Measurement Based on Leak-Off Tests and Caliper Logs

Knowledge of state of in-situ stress and geomechanical properties is essential to understand the potential wellbore instability and induced fracturing in the injection zone and confining zone as a result of CO₂ injection in a carbon storage site. Traditional in-situ measurement of stress field is at high cost and traditional laboratory measurement of geomechanical properties is affected by the disturbed core samples. In this project, the University of Wyoming, University of Stavanger, in partnership with Baker Hughes Inc. carried out the investigation of a method that can keep the measurement “in-situ” while in the meantime reducing the cost and enhancing the accuracy by developing an in-situ technique for state of in-situ stress and geomechanical properties measurement at low cost and with enhanced accuracy and by demonstrating the feasibility of such a technique for in-situ stress measurement by comparing with different field data from oil fields.

Section of image log of MIP 3H pilot hole showing induced fractures in the Middlesex Formation
Accomplishments:
In-situ stress has traditionally been estimated through expensive and uncertain borehole pressure measurement. The project developed a new inexpensive method to estimate in-situ stress through borehole deformation measurement, which is routinely obtained in caliper logs. Field demonstrations showed excellent accuracy of the method.

Research conducted for the project impacted the classic method of in-situ stress determination by hydraulic fracturing test. Their breakout simulation demonstrated that the difference between the breakdown pressure of a circular borehole and a borehole with breakouts could be as large as 82 percent. Therefore, the factor of borehole breakout measurements must be considered when doing typical hydraulic fracturing test and interpretation for in-situ stress determination.

NETL Collaboration:
Multiple teleconferences, discussions, and site visits were conducted in acquisition of field data and the arrangement of the laboratory tests in collaboration with Mark Mckoy, Bob McLendon, Dustin Crandall, Robert Vagnetti, and Igor Haljasmaa of NETL, and Maneesh Sharma, Timothy Carr, and Samuel Taylor of West Virginia University. Results from analyzing the data found that the core of rock at depth 7538.5 feet is available and geomechanical properties of the shale sample at this depth are important for the geomechanical modeling. The suggestion was made to NETL on possible rock mechanics testing. Then laboratory core sample preparation made a breakthrough. NETL was working with the team and got two-thirds slabbed sections of the core from the Marcellus Shale Energy and Environmental laboratory available around the depth 7538.5 ft. NETL performed the rock mechanics tests and determined the Dynamics Young’s modulus to be approximately 40GPa.

Benefits:
The results of this research lower the cost of field characterization of geomechanical properties with improved accuracy. It is critical to successful carbon storage in saline aquifers or oil/gas reservoirs. Obtaining accurate geomechanical information and state of stress related to carbon storage sites is beneficial to understand the potential for geomechanical deformation to the injection zone, confining zone, and wellbore because of CO\textsubscript{2} injection. The impact of such deformation may include induced seismicity, opening and closing of faults and fractures, and damage to wellbore materials. The research reduces the costs of many CCS projects in the United States and the world in terms of early stage of characterization of in-situ stresses and geomechanical properties. This contributes to a bright future for CCS in detecting subsurface geomechanical changes, tracking fluid movements, and can lead to better injection management practices.

Relevant Publications:


