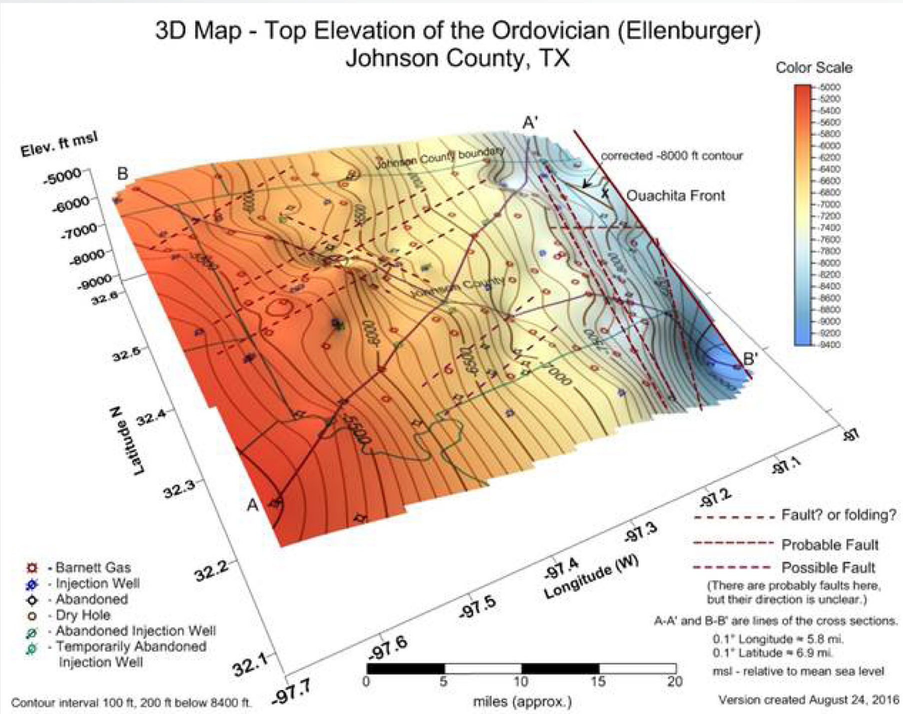
GEOMECHANICAL IMPACTS OF SHALE GAS ACTIVITIES



BACKGROUND

The technique of hydraulic fracturing, in which large volumes of fluid are injected at high pressures into low-permeability shale, can improve hydraulic connectivity and enable production of gas. In the past decade, hydraulic fracturing has dramatically increased the domestic production of natural gas due to widespread application in formations nationwide. This rapid increase in hydraulic fracturing activities has also created concern regarding the safety of hydraulic fracturing and related activities. Induced seismic events from subsurface injections and the contamination of underground sources of drinking water are two topics of concern being investigated at the National Energy Technology Laboratory (NETL).

NETL

NATIONAL ENERGY TECHNOLOGY LABORATORY

When human activity changes the stress field in the subsurface, earthquakes can occur. Researchers refer to this as induced seismicity, and while most induced seismic events are small earthquakes, some can cause property damage or be a public nuisance. While hydraulic fracturing does involve injection of large volumes of fracturing fluids at high pressures, the duration of these injections are short enough that stress changes remain close to the stimulated wells. Very few cases of seismic activity directly related to hydraulic fracturing operations have been felt at the surface.

Following a hydraulic fracturing well stimulation, the fracturing fluids are produced from the injection well to enable gas flow through the manufactured fracture network. This produced fracturing fluid is contaminated, both from contact with the subsurface formations and with the additives that were used prior to initial injection, and must be cleaned or disposed of safely. Deep wastewater disposal wells have been used for this purpose for many decades, but the recent expansion of hydraulic fracturing fluid injection volumes appears to be triggering induced seismic events in several locations. Seismic activity has dramatically increased in locations nationwide and appears to be correlated to the injection of large volumes of produced fracturing fluid that has been disposed of in deep waste water injection wells. Understanding what conditions influence this behavior and how the induced seismicity risk associated with wastewater injection can be managed are important topics of research.

GEOMECHANICAL IMPACTS OF SHALE GAS ACTIVITIES

The vertical extent of hydraulically induced fractures, and their ability to produce conduits into underground sources of drinking water (USDW), remain a topic of debate. Recent simulation studies have suggested that hydraulic fractures may extend outside of the target shales, but that the vertical extent of these fractures is not large enough to reach USDW from deep shale deposits. Microseismic studies of the Marcellus and other shales have also shown that vertical fractures do sometimes extend outside of the shales, but have not detected any microseismic events within hundreds or thousands of feet of USDW. Thus, the main area of interest is not to determine if hydraulic fractures will directly reach USDW, but if they will extend to permeable overlying formations. These formations could connect other conduits, such as abandoned wellbores not completed to surface, to USDW, and thereby create pathways for gas migration.

GOALS AND OBJECTIVES

GOAL – A science-based assessment of fluid migration and induced seismicity associated with unconventional oil and gas development through modeling-based approaches.

OBJECTIVE 1 – Develop detailed subsurface descriptions of locations where both seismic activity and wastewater injection volumes have increased.

OBJECTIVE 2 – Construct and explore scenarios with models to simulate geomechanical changes in the subsurface due to high volumes of wastewater injection at these sites.

OBJECTIVE 3 – Modify in-house code NFFLOW to model multiphase flow in fractures and examine flow characteristics from hydraulically fractured deep shale. Determine what scenarios could result in the contamination of USDW from deep shale hydraulic fracturing.

PROJECT DESCRIPTION

Our goal is to produce a science-based assessment for propagation of stress fields from wastewater injection wells and potential conduits for fluid migration from deep shale hydraulically fractured reservoirs to underground sources of drinking water (USDW).

Researchers at NETL are gathering data from literature sources to develop subsurface geologic maps of locations surrounding recent increases in seismic activity believed to be associated with wastewater injections. This data is being used to populate geomechanical and flow models that will be used to simulate the changes in the subsurface stress field due to injection. These models will be used to examine the changes in the subsurface that are caused by high rates of volume injection, providing insight into how induced seismic events occur in a variety of locations.

Building on previous work examining propagation of hydraulically induced fractures to define likely maximum vertical extents of induced fractures, researchers will conduct flow studies on the potential migration of fluids from the Marcellus shale to USDW. The in-house code NFFLOW will be utilized to evaluate the potential fluid migration from the Marcellus shale to shallow reservoirs containing drinking water. Multiphase flow through natural fractures, induced fractures, and multiple permeable geologic layers will provide information on what the subsurface requirements would be to permit fluid migration to USDW.

BENEFITS

This study will facilitate the production of validated and tested models of fracture growth and stress evolution at specific sites, and use those models to predict behavior at a range of sites.

ACCOMPLISHMENTS

2D heterogeneous model of hydraulic fracturing in shales was developed to study the vertical growth of fractures in the Marcellus shale.

A 3D Marcellus-specific layered model for hydraulic fracturing for simulating hydraulic fracturing was developed. Modifications were made to this model to account for the presence of existing fractures in the overburden. Simulations have been made to predict fracture growth under different injection rates and for varying subsurface parameters.

This research was published in the journal article: Myshakin, E.; Siriwardane, H.; Hulcher, C.; Lindner, E.; Sams, N.; King, S.; McKoy. M. Numerical Simulations of Vertical Growth of Hydraulic Fractures and Brine Migration in Geological Formations above the Marcellus Shale. *Journal of Natural Gas Science and Engineering* 2015, 27, 531-544.

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