Oil and Gas CDT

NERC DOCTORAL TRAINING

Thermal stimulation of shale for improved hydrocarbon recovery

University of Aberdeen, School of Engineering

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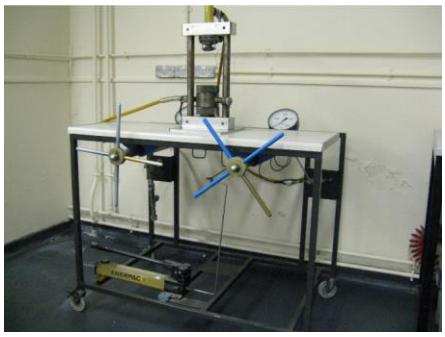
Key Words	**fluid mechanics, porous media flow, multiphase flow, adsorption, swelling, geomechanics**

Overview

This project aims to (a) identify the fundamental processes that govern fluid transport through shale, (b) understand the interactions between hydraulic, mechanical, and thermal characteristics of shale, and (c) to develop predictive models for fluid transport in terms of readily measurable parameters. The student will use a combination of customised laboratory equipment, theoretical analysis, and numerical simulation.



Background: Following the success of unconventional hydrocarbon production in the United States, there is an increasing interest in shale gas production in the UK. Particular attention is being paid to resource evaluation as well as the environmental impact of exploitation of shale gas through hydraulic fracturing (fracking).

Unlike conventional gas reservoirs, the primary storage mechanism for gas in shale is adsorption on the pore surface within the organic matrix. Surface chemistry research suggests that gas adsorption or desorption in chemically active materials, such as coal and shale, induces stresses proportional to the volume adsorbed or desorbed. As the permeability of fractured reservoirs depends on the local state of stress, any change would impact its permeability. These two hypotheses seem to be plausible, but they have not been rigorously tested. Key questions remain:

- Is the primary transport mechanism in shale matrices Fickian diffusion?
- How can we relate adsorption-induced stresses to anisotropy arising from mineral composition of the shale matrix?
- What parameters control the structural deformation of shale? Is it mineral composition, distribution of existing fractures or pore pressure?
- How do shale respond to applied temperature gradients? What is the minimum thermal energy required for the generation and propagation of fractures?

The last question is of particular interest as thermal response of shale could be exploited to create fractures through well stimulation in order to increase the production of gas from shale and, if successful, can be an alternative to fracking.

This project aims to investigate these questions through a detailed laboratory program to generate high quality data that will then be used to calibrate predictive models.

Methodology

Laboratory experiments will be performed in the High Temperature High Pressure Laboratory in the School of Engineering.

The student will first measure adsorption isotherms of gas and water on finely graded shale samples to establish the effect of shale organic content on its gas storage capacity. In second set of experiment, the student will measure the matrix swelling strains on shale samples and correlate it with the adsorption data. Simultaneous measurements of shale matrix swelling and permeability will be carried out under triaxial stress state using a custom built apparatus (photo 1).

Multistage triaxial tests will be carried out on shale samples using a 50t INSTRON test frame at UoA (photo 2) and a 200t ESH testing machine at Imperial College to measure elastic modulus and failure envelope of shale. Experiments will be repeated with samples subjected to thermal stresses for specific period of time, and are expected to illustrate the effect of thermal energy on elastic properties and mechanical strength of shale.

Finally, the student will use all the data to develop a predictive model for shale permeability. The experimental data generated will also be used in reservoir simulations using geological models of representative shale plays.

Timeline

Year 1: Measurement of adsorption and swelling isotherms for gas and water on shale. Develop theoretical model to relate adsorption and swelling.
Years 2-3: Simultaneous measurement of swelling strain and permeability of shale to gas and water. Present at the Gordon Research Conference on Flow and Transport in Porous Media and the American Geophysical Union Fall Meeting.
Year 4: Measurement of relative permeability to gas and water. Development of geological model to assess the effect of proposed well stimulation. Present at the SPE Unconventional Resource Conference.

Training & Skills

The successful candidate will join the Environmental & Industrial Fluid Mechanics Group, a vibrant group of academics, postdoctoral researchers, and PhD students within the School of Engineering. Members of the Group use different combinations of laboratory experiments, field measurements, numerical simulations, and theoretical analysis to study physical processes associated with a wide range of applications, including geological CO_2 storage, wind turbines, fishing, and coastal erosion. The Petroleum Engineering Laboratory, launched in June 2013, is the latest addition to the Group's outstanding facilities.

The University continues to enhance its portfolio of experimental facilities, having been awarded funds of £950k under the framework of the Oil & Gas Academy of Scotland to further invest in equipment for oil and gas training.

The student will also interact with members of the Minerals, Energy and Environmental Engineering Research Group at Imperial College London.

Further Information

Applicants should have at least an upper second class honours degree (or equivalent) in a relevant engineering, applied mathematics, or physics discipline. *Some background in earth sciences is required to participate in the core training programme of the CDT.* Expertise in fluid mechanics, laboratory experience, and knowledge of MATLAB will be an advantage. Good written and spoken communication skills are essential.

Details on the application procedure are available at www.abdn.ac.uk/geosciences/departments/geology/proposed-phd-projects-107.php. The closing date for the application is 31 January 2015.

Enquiries are welcome and can be directed to Dr. Syed (a.syed@abdn.ac.uk).