



NERC Centre for Doctoral Training in Oil & Gas (2017 start)

Project Title: A fully coupled XFEM model for hydraulic fracturing in multi-phase porous media
Host institution: University of Exeter
Supervisor 1: Prof. Akbar Javadi
Supervisor 2: Prof. John Coggan
Additional Supervisor (s): Dr Tim Harper (Director of Geosphere Ltd)

Project description: Gas produced from shale has revolutionised the oil and gas industry in the US and is a potential resource in many countries including the UK. Production is dependent on hydraulic fracture stimulation. In shales, which are extremely low permeability, fracture stimulation depends on the presence of a natural fracture network (open or filled) having a large surface area available for connection to the well. Shale gas has the potential to revolutionise the energy supply and have a significant impact on the economic development and energy security and diversity in the UK and throughout the world. This is contingent on increasing the efficiency by improving the current understanding of the processes involved. Shale gas development has met with considerable resistance (e.g. currently banned in France) for environmental reasons. The main concerns relating to the stimulation process are: (i) The intensity of surface disturbance by fracturing operations (site preparation etc); (ii) Fracturing water usage, storage and disposal of large volumes of flow back fluid; (iii) The potential for induced seismicity; (iv) The potential for leakage of fracturing fluids to surface aquifers.

Although hydraulic fracturing has been used for several years, a thorough understanding of fracking processes is still lacking. To increase efficiency and meet political, environmental and public concerns it is essential to improve our understanding of the geomechanical processes which occur during fracture stimulation which is the focus of this proposal.

In this study, we will build on our extensive experience in modelling of fracture propagation in porous media to develop a fully coupled hydro-mechanical model for hydro-fracturing of porous media with existing discontinuities. Two fluids will be considered: one representing the fracturing fluid and the other the host fluid. Flow through fracture will be defined based on lubrication assumption, while flow through the matrix will be expressed as Darcy flow. The fracture discontinuity in the mechanical model will be captured using eXtended Finite Element Method (XFEM) while the fracture propagation criterion will be defined through cohesive fracture model. The developed model will provide a valuable tool that can be used for (i) evaluating the hydraulic fracturing process and fracture propagation, (ii) predicting induced seismicity, and (iii) assessing potential leakage from the system and fate of contaminants in subsurface environment. Using this novel approach further understanding of the processes involved and their impacts can be achieved.

CDT Research theme(s): - Effective Production of Unconventional Hydrocarbons
- Environmental Impact and Regulation

Research context: This project falls within NERC's research areas: "Driving UK innovation, economic growth and societal wellbeing"; "Addressing the challenges and opportunities of managing the environment"; "Developing science that helps us find and extract energy and minerals ever more safely and efficiently"; "Investing in world-class research and skills"; "Training highly skilled people"; and "Enhancing national capability".

We already have 4 PhD students working on different aspects of modelling of hydraulic fracturing and the NERC student will be part of, and work closely with, the existing team.

Research costs: £20k over four years (£5k/annum): Travel costs to central Training Academy activities. Work station - high powered computer. Participation at conferences & Software licenses.

Career routes: The student undertaking this project will have unique research and practical skills to work in the oil and gas industry or continue academic research in this field.