PROJECT TITLE: Imaging reservoirs using passive seismic data
DTP Research Theme(s): Solid Earth

Lead Institution: University of Bristol
Main Supervisor: Dr. James Verdon, School of Earth Sciences, University of Bristol
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Image Caption: Map of microseismic data recorded during hydraulic fracturing of a shale gas reservoir. Data is recorded on multiple downhole geophone arrays. Over 100,000 microseismic events have been detected and located.

Image Caption: Raypaths from a selection of microseismic sources and receivers in a reservoir. Good ray-path distributions allow the geophysical properties of the reservoir to be imaged using joint inversion and migration-based methods.

Project Background
The use of hydraulic stimulation (or fracking) to improve production from oil and gas reservoirs is becoming increasingly widespread. The technique is also used for geothermal energy, and in extracting potable water from subsurface aquifers. Effective and safe hydraulic stimulation requires the ability to track the growth of fractures through the reservoir. To this end, geophones can be deployed in the reservoir to image the microseismic events – small “pops” and “cracks” produced as the rock deforms.

The purpose of this project is to develop the scientific understanding that may lead to a significant change in how microseismic data is utilised. Whereas currently, the primary application is to simply locate microseismic events, our aim is to use migration-based and joint tomographic inversion methods to not only locate microseismic events but also to illuminate the geophysical properties and structures of the reservoir in which the events occur.

Project Aims and Methods
Microseismic events are typically located using a fixed velocity model, using only the observed P- and S-wave arrival times. However, the growth of fractures during stimulation is expected to affect seismic velocities. By developing combined tomographic and event location methods (where both the changing velocity model and event locations are jointly inverted) we aim to image these velocity changes. This has two benefits: (1) event locations will be constrained more accurately, and (2) changes in velocity can be used to further illuminate the positions of fractures and the stimulated volume.
Furthermore, a wealth of information is contained in the waveforms of recorded microseismic events. As well as direct arrivals, scattered arrivals from pre-existing structures in the reservoir, such as faults, pre-existing fractures or sedimentary features, will also occur. Presently, such features are rarely investigated. By developing migration-based algorithms, the scattered energy can be used to identify and locate these structures. The project will develop these joint inversion and seismic migration algorithms, and apply them to both synthetic and real microseismic datasets. In particular, the student will have access to high quality, multi-well downhole microseismic datasets recorded during hydraulic fracturing of shale gas reservoirs (see examples in the attached figures).

**Candidate**
This project requires a student with a background in physics, geophysics or a related subject. Previous experience in locating and analysing local or regional earthquake data will be beneficial. Programming experience is desirable, as are good communication skills, and an analytical mind-set.

**Case Award Description**
CASE Support will be provided by the Schlumberger Gould Research Centre. SGR is a major R&D facility for one of the world’s largest oilfield services companies. The SGR Geophysics Department has been instrumental in conducting research into modelling and inversion algorithms to link seismic data to rock properties, and the use of passive seismic techniques to image hydraulic fracturing operations.

**Training**
The student will receive training in microseismic monitoring methods, and seismic data analysis, with specific focus on migration and seismic tomography. Where necessary, training in appropriate computational languages, and in the use of High Performance Computing, will be provided. The student will acquire a diverse range of geophysical skills that will prepare them for a career either in academia or in the geophysics industry. The student will also be expected to undertake an internship at SGR, gaining direct, first-hand industrial experience.

**References / Reading List**


**Links**
School webpage: [http://www.bristol.ac.uk/earthsciences/courses/postgraduate/](http://www.bristol.ac.uk/earthsciences/courses/postgraduate/)

NERC GW4+ DTP Website: [http://nercgw4plus.ac.uk/](http://nercgw4plus.ac.uk/)

Bristol NERC GW4+ DTP Prospectus: [http://www.bristol.ac.uk/study/postgraduate/2017/doctoral/phd-great-western-four-dtp/](http://www.bristol.ac.uk/study/postgraduate/2017/doctoral/phd-great-western-four-dtp/)

**Application deadline:** 23.59 GMT, Sunday 7 January 2018

How to apply to the University of Bristol: [http://www.bristol.ac.uk/study/postgraduate/apply/](http://www.bristol.ac.uk/study/postgraduate/apply/)

**General Enquiries:**
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