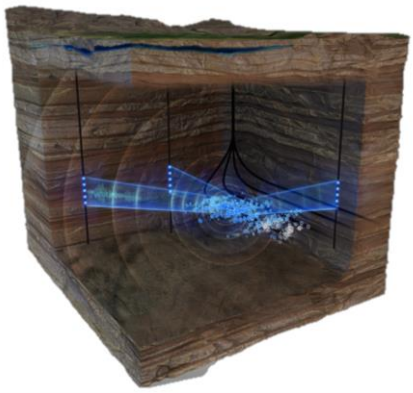
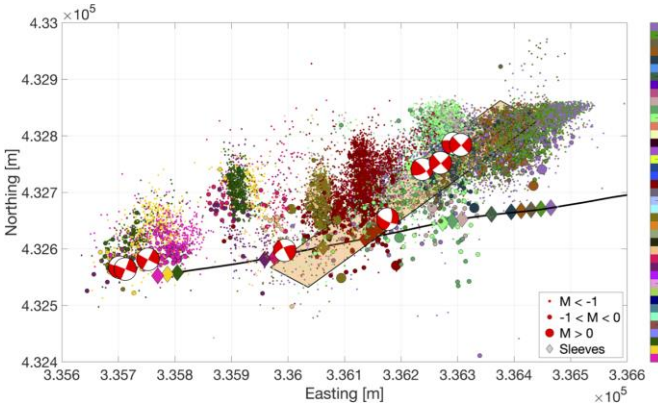
PROJECT TITLE: **Monitoring Injection-Induced Earthquakes in the UK**
DTP Research Theme(s): Dynamic Earth
Lead Institution: University of Bristol
Lead Supervisor: Dr. James Verdon, School of Earth Sciences, University of Bristol
Co-Supervisor: Dr. Max Werner, School of Earth Sciences, University of Bristol
Co-Supervisor: Brian Baptie, British Geological Survey, Edinburgh
Co-Supervisor: Richard Luckett, British Geological Survey, Edinburgh
Project Enquiries: James.Verdon@bristol.ac.uk
Project keywords: Induced seismicity; earthquakes; hydraulic fracturing



Schematic depiction showing how downhole geophone arrays can be used to detect microseismic events caused by human activities in the subsurface



Map of microseismic events detected during hydraulic fracturing at the Preston New Road site, Lancashire. The interaction between hydraulic fractures and a pre-existing fault (orange patch) can be seen.

Project Background

Understanding and managing injection-induced seismicity (IIS) – earthquakes caused by human activities in the subsurface – is a key challenge for a range of industrial activities, including: carbon capture and storage; geothermal energy; natural gas storage, hydraulic fracturing for shale gas; and disposal of oilfield waste fluids. Many of the aforementioned technologies are increasing in scale, and are being developed in new regions and countries. However, recent high-profile IIS incidents are changing levels of risk perception among both societies and regulators. Given these developments, there is a clear need to advance our scientific understanding of the causes of induced seismicity, the risks it poses, and potential mitigation methods. Furthermore, observation of induced seismicity could be used to investigate the mechanics of fault rupturing behaviour more generally.

Project Aims and Methods

The aim of this project is to investigate induced earthquakes using observational seismological methods. The student will analyse microseismic data recorded during hydraulic fracturing at the Preston New Road PNR-1 well in Lancashire, UK: a prominent example of induced seismicity caused by hydraulic fracturing. Recorded seismograms (over 40,000 individual microseismic events were detected, see Clarke et al., 2019) will be analysed to refine the existing preliminary event locations, and to characterise the source parameters of the events (rupture dimensions, stress drop, source mechanisms, etc.).

Statistical analysis of event populations will be used to relate the seismicity to operational and geological factors, as determined from reflection seismic surveys and well logs available for the site. Such analysis will also enable comparisons between this dataset and other prominent cases of induced seismicity. These investigations will serve to provide answers to important questions, including:

- What geological and geomechanical factors influence the occurrence and intensity of induced seismicity?
- Is it possible to make proactive forecasts of induced seismic hazard during operations?
- What steps can be taken to prevent or mitigate induced seismicity?

From a purely scientific perspective, cases of induced seismicity provide a "natural laboratory" whereby known stimuli produce fault reactivation in a setting that is relatively well characterised. Therefore, observations of induced seismicity can be used to enhance our understanding of fault rupturing mechanics more generally.

Candidate Requirements

This project requires a student with an undergraduate degree in geophysics, geology, physics, engineering, or a related discipline. Some experience in earthquake detection/location/analysis methods would be beneficial but not essential. Some programming experience is also desirable.

CASE or Collaborative Partner

This project will be conducted in collaboration with the British Geological Survey. The BGS operates the UK's national seismic monitoring network, as well as densified networks of seismometers around the Preston New Road site. As well as data recorded by this network, they will also provide expertise in seismological analysis. The student will be based at the University of Bristol, but will make visits to the BGS in Edinburgh to collaborate with the co-supervisors.

Training

Training will be provided in earthquake seismology, with a focus on detection, location and analysis of microseismic data. This will include an understanding of the underlying theory, and its application via codes and analysis packages that are standard in the field. The student will also gain an understanding of the both the operational and regulatory issues surrounding subsurface injection and induced seismicity.

References / Background reading list

Lee K-K., W.L. Ellsworth, D. Giardini, J. Townend, S. Ge, T. Shimamoto, I-W. Yeo, T-S. Kang, J. Rhie, D-H. Sheen, C. Chang, J-U. Woo, C. Langenbruch, 2019. Managing injection-induced seismic risks: Science 364, 730-732.

Clarke H., J.P. Verdon, T. Kettlety, A.F. Baird, J-M. Kendall, 2019. Real time imaging, forecasting, and management of human-induced seismicity at Preston New Road, Lancashire, England. Seismological Research Letters 90, 1902-1915.

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The application deadline is 1600 hours GMT Monday 6 January 2020 and interviews will take place between 10 and 21 February 2020

General Enquiries:

Bristol NERC GW4+ DTP Administrator
Email: bristol-nercgw4plusdtp-admin@bristol.ac.uk