Monitoring and Modelling Induced Seismicity in the UK

Supervisors

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Host Institution: University of Bristol

Project description

Understanding and managing injection-induced seismicity (IIS) is a key challenge for a range of industrial activities, including: hydraulic fracturing of tight hydrocarbon formations; disposal of oilfield waste fluids; carbon capture and storage; geothermal energy; and natural gas storage.

Several of these technologies are considered key components of the UK's future energy portfolio, with the use of these technologies expected to grow substantially over the coming decade.

However, recent high-profile IIS incidents are leading to changing levels of risk perception among both societies and regulators. Furthermore, many of the aforementioned technologies are increasing in scale, and are seeing increased utilisation in new regions and countries. Given these developments, there is now a clear need to advance the scientific understanding of IIS. There is also a need to generate science-based criteria from which effective regulation for IIS can be developed.

The aim of this thesis is to improve the scientific understanding of IIS by answering the following questions:

1. What geological features might be identified prior to injection that might indicate a site carries a high risk of IIS?

2. What are the controls that determine whether a particular operation will or will not re-activate a fault?

3. What types of model are most effective in simulating induced seismicity?

4. Does induced seismicity pose a risk to safe operations beyond seismic hazard?

By answering these questions, we hope to establish what are the Best Available Technologies for monitoring IIS and mitigating risks. This will allow both regulators and industrial operators to mitigate IIS issues more effectively.

The project will include analysis of seismic data collected by the UKArray, and datasets from past examples of injection-induced seismicity from around the world. In addition to analysis of seismic data, the student will construct geomechanical models that simulate how industrial activities impact on faults.

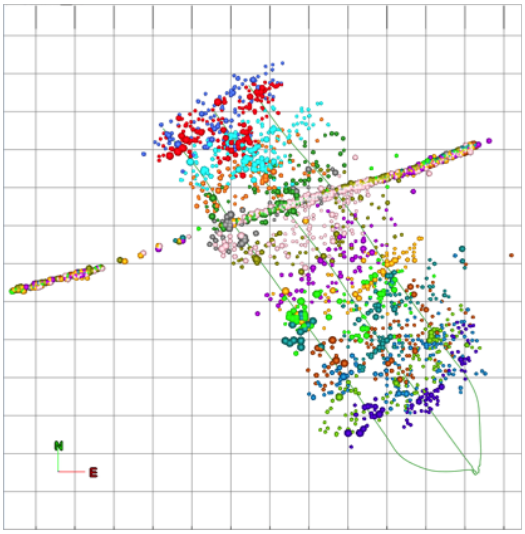
The project will benefit from both Bristol and the BGS's involvement in monitoring industrial activities both in the U.K. and around the world, including involvements in the world's largest CCS projects to date such as Weyburn (Canada), In Salah (Algeria) and Aquistore (Canada).

This project requires a motivated student with a degree in physics, geophysics or a related degree. Some programming experience is desirable, as are good communication skills. Training will be provided in earthquake seismology, seismic data analysis, statistical analysis, geomechanical modelling and seismic hazard and risk analysis. The student will thereby acquire a diverse set of skills relevant for both academia and industry.

Suggested Reading:

Ellsworth, W.L., 2013. Injection-induced earthquakes: Science 341, 1225942.

Verdon, J.P., Kendall J-M., Stork A.L., Chadwick R.A., White D.J., Bissell R.C., 2013. Comparison of geomechanical deformation induced by megatonne-scale CO2 storage at Sleipner, Weyburn, and In Salah: Proc. Nat. Acad. Sci. 30, E2672-2771.



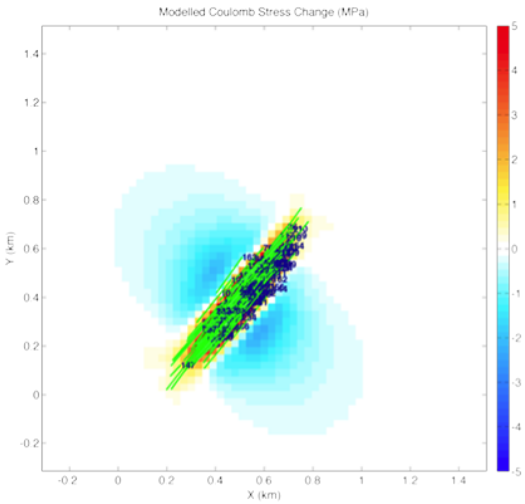


Figure 1: Microseismic events track hydraulic fractures in a shale gas formation. The events demarcate the interaction of these fractures with a larger fault system. Figure 2: Geomechanical model simulating stress changes induced by a hydraulic fracture.