Proposal form for a DTP project

Project Title:  
Seismicity induced through CO2 storage

Proposed by:  

Contact details for Oxford Supervisor:  
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Contact details for CASE Supervisor (if relevant):  
TBC

Please indicate stream and whether CASE

- [ ] CASE  
- [ ] non-CASE

- [ ] Biodiversity, Ecology and Evolutionary Processes  
- [ ] Dynamic Earth, Surface Processes and Natural Hazards  
- [ ] The Physical Climate System

Please highlight up to three of the following keywords that apply to this project from either or both categories (stream and cross-stream)

**Stream Keywords**

<table>
<thead>
<tr>
<th>BEEP</th>
<th>DESPNH</th>
<th>PCS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conservation &amp; Ecosystem Services</td>
<td>Deep Earth, Geodynamics and Geochemistry</td>
<td>Atmosphere</td>
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<tr>
<td>Macronutrient Cycling</td>
<td>Experimental Petrology</td>
<td>Oceans &amp; Freshwater</td>
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<td>Biotic Interactions</td>
<td>Volcanology and magmatism</td>
<td>Cryosphere</td>
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<td>Macroeocology &amp; Biogeography</td>
<td>Earth Surface Processes</td>
<td>Climate Modelling</td>
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<td>Origins of Life</td>
<td>Critical Natural Resources</td>
<td>Clouds &amp; Aerosols</td>
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<td>Biodiversity Assessment</td>
<td>Seismology and Active Tectonics</td>
<td>Climates of the Past</td>
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<td>Macro- and Micro-evolution</td>
<td>Geomorphology &amp; Landscape Dynamics</td>
<td>Geophysical Fluid Dynamics</td>
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<td>Global Change</td>
<td>Chronology</td>
<td>Predictability of Weather and Climate</td>
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<tr>
<td>Organisms</td>
<td>Materials Characterisation</td>
<td>Global Biogeochemical Cycles</td>
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**Cross-Stream Themes**

| Artificial Intelligence & Machine Learning | Citizen Science | Transforming Waste |
| Engineering Solutions to environmental challenges | Data Science | Geoengineering |
| Novel sensors | Clean Energy | Decarbonising the economy |
| Greening Chemistry | Water Security | Policy & Practice |
Brief introduction of the project including: (boxes will expand to fit text)

<table>
<thead>
<tr>
<th>Background</th>
<th>Project to join Oxford seismology group investigating microseismicity in a range of settings. Particular focus of this project is induced seismicity associated with CO2 injection. The Department has diverse interests in CO2 storage and has founding members in the newly launched Oxford Net Zero initiative (<a href="http://www.netzeroclimate.org">www.netzeroclimate.org</a>).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Key Research Question</td>
<td>What factors control induced seismicity resulting from CO2 injection into sub-surface geologic reservoirs?</td>
</tr>
<tr>
<td>Aims of the project</td>
<td>Establish methods for real-time monitoring of seismicity at CO2 storage sites</td>
</tr>
<tr>
<td>Methods to be used</td>
<td>Novel sensors such as using fibre optic cables as distributed optic sensors (DAS); machine learning methods; seismic array analysis</td>
</tr>
<tr>
<td>Any specialised skills the student will need to carry out the project</td>
<td>Programming/coding skills; interest in working with team on larger project; background in geophysics or physics desirable</td>
</tr>
</tbody>
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Extended description of the project

The storage of CO₂ in geologic reservoirs is a key component in plans for a net zero carbon economy. In a recent budget, the UK government pledged over £800 million for two Carbon Capture Usage and Storage (CCUS) clusters situated in northeast England. CO₂ will be piped off-shore and injected into a deep saline aquifer. World-wide, projects of this kind are set to ramp up dramatically in scale and numbers in the next decade.

The injection or extraction of fluids changes the stress state of reservoirs, promoting failure in the rock. Monitoring the associated seismicity leads provides useful insights into fracture development and fluid migration. Occasionally such activities can lead to fault reactivation and felt seismicity, which is of concern to regulators and the general public. Furthermore, this induced seismicity can provide an early warning of top seal failure and reservoir leakage. It is therefore imperative that good seismic monitoring practices are used to detect and mitigate unwanted seismic effects. This project aims to develop near real time methods for monitoring seismicity using seismic arrays. It also aims to better understand conditions that lead to fault reactivation and felt seismicity.

The nascent CCUS industry can learn a lot from other subsurface injection industries such as hydraulic fracture stimulation in geothermal and shale gas settings. We can therefore use extensive datasets from these other technologies to develop monitoring strategies. This project will investigate the use of sparse seismic arrays in detecting seismicity. It will also explore the use of fibre optic cables as distributed acoustic sensors (DAS). Final, the use of transfer learning in convolutional neural networks will be explored in an effort to use waveform picks from one reservoir setting in a different setting.
The project will be involved in the analysis of microseismic data from CO2 storage demonstration sites. Furthermore, data from a planned seismic array to monitor North Sea seismicity in proposed sites of CO2 injections will be analysed using a range of array methods.

We are looking for a talented young researcher with interests in seismology and its role in subsurface injection as part of CCUS. You will have opportunities to interact with other researchers, industry and regulators through existing research programmes that Oxford is involved with, such as the DigiMon project (digimon.norceprosjekt.no). Furthermore, the project will benefit from interactions with a diverse range of researchers involved with the newly formed Oxford Net Zero network. You will ideally have a background in geophysics or physics, with some programming and coding skills and an interest in basin-scale geology. The proposed project provides a natural stepping-stone to careers in industry, NGOs, regulatory bodies and academia.

Suggested reading:
