Analysis of seismic monitoring for CO2 storage in depleted offshore reservoirs

Supervisory team
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Project description

CO2 underground storage is an acknowledged way of offsetting the global emissions of greenhouse gases. It is a safe, mature technology and is ready for broad implementation. Re-use of depleted oil or gas reservoirs from a single field or clusters of fields will contribute significantly to this effort, due to the relatively lower investment and risk than aquifer injection. The assessment of areal monitoring techniques such as 4D seismic, forms a key component in preparing the groundwork MMV plan for such projects. 4D seismic surveys in the offshore environment create value due to their relatively low cost and comprehensively proven track record when monitoring North Sea geology. It is also likely that many fields selected will already have an established historical 4D seismic programme. These surveys provide areal information with which to image plume development, the evolution of pressure build up within the reservoir, and contribute to leakage and caprock integrity evaluation.

Two of the main challenges in using seismic surveys are: (1) the CO2 in the pore space of reservoir rocks is difficult to quantify from the seismic anomalies; (2) the pressure sensitivity of the rocks after years of production is somewhat uncertain. Detailed technical assessment of the capability of the seismic to monitor a given site is therefore of critical importance. In response to the growing demand, North Sea energy companies are currently carrying out feasibility studies to evaluate the complex signatures that arise from gas injection into a previously producing reservoir. These studies include an understanding of the fluid saturants, the likely interaction between fluid types and trapping mechanisms and also the effects of pressure elevation in the already depleted reservoir. Much of this understanding can be addressed by re-purposing the technology elements of 4D Quantitative Interpretation (4D QI). This PhD project investigates the transfer of key 4D QI knowledge as input into an
extensive feasibility analysis based on 4D seismic, rock and fluid physics and fluid flow modelling focussed on several North Sea field. These case studies will use field data from existing oil and gas fields donated by sponsors to calibrate the behaviour, in combination with geological, geophysical and reservoir engineering information from existing companies working on CO\textsubscript{2} projects to formulate an understanding of the performance of a 4D seismic monitoring.

**Socio-economic impact of project**

CO\textsubscript{2} underground storage is an acknowledged way of offsetting the global emissions of greenhouse gases. It is a safe, mature technology and is ready for broad implementation. Depleted oil and gas reservoirs have a massive CO\textsubscript{2} storage capacity of 32 GT worldwide. They are well characterized with significant infrastructure in place, with a relatively lower investment and risk than aquifer injection. Re-use of depleted oil or gas reservoirs from a single field or clusters of fields will therefore contribute significantly to offsetting our carbon footprint. Many North Sea fields are ideally suited for this re-purposing both in terms of their legal and economic framework.

**Planned project workflow**

1) Preliminary review: This will be directed initially to the available literature that address injection into existing depleted reservoirs, although the wider literature on CO\textsubscript{2} storage per se should also be considered. Studies will also address the 4D QI tools and 4D seismic analysis developed over the years. This will help bring into focus the perspective of the project, and the areas requiring research development.

2) Data setup: Collection of data relevant to the project from donating companies, including setting up of meetings to discuss objectives and challenges with energy companies.

3) Modelling and inversion: Establish the main tools in 4D QI to model, invert and interpret datasets. This will include simulation runs, sim2seis modelling, log analysis, calibration of the petroelastic model, use of pressure and saturation inversion tools. Depending on the field, geomechanical modelling may also be required.

4) Analysis: Thorough analysis of the performance of this monitoring capability. Interpretation of the findings in the context of the wider objectives for the North Sea.
Main project deliverables

- Review of current state of science
- Results of analysing field data with 4DQI tools from ETLP
- Generalisation of findings to wider context of other North Sea fields

Project location

The project will be based on the Edinburgh campus of Heriot-Watt University. The successful candidate will become a PhD student in the Institute of GeoEnergy Engineering, and will be allied to the Edinburgh Time-Lapse Project, a successful group specialising in 4D seismic data analysis with over twenty one years of experience of working in this subject. The student will benefit from the library of information and software developed by this group.

Data access

Data from an existing field in the UKCS will be made available through several energy companies that are actively preparing MMV documentation for CO₂ injection into their fields. These companies belong to the ETLP sponsorship group (see detailed list at etlp.hw.ac.uk). The data will include geological description, petrophysical logs, production data, simulation model and 3D seismic. Time-lapse seismic will be modelled using these existing data as part of this study and more may become available towards the end of the study period. The earlier part of the project will also utilise data from several companies with fields in which large volumes of 4D seismic surveys have been shot. These data will be made available for study by the PhD student via the Edinburgh Time-Lapse Project. Finally, this project will have access to a public dataset from CO₂ injection into a saline aquifer for references purposes.

Likely graduate career routes

As companies move up the energy transition, many personnel are re-skilling their O&G subsurface geoscientists to meet the needs of CO₂ storage. This need has already been identified in academia and within professional societies such as the EAGE, in the education and training resources for membership. A PhD student with already in-built knowledge of this area will be in much demand within most energy companies in the North Sea sector. Interaction with the companies during the course of the PhD will also help create job opportunities with the industry itself.

Further information

For further information please contact Colin MacBeth (c.macbeth@hw.ac.uk)