# GeoNetZero Centre for Doctoral Training (CDT): Geoscience and its Role in the Low Carbon Energy Transition

(2022 start)

**Project Title**:
Permian Zechstein Facies across the Central North Sea: Reservoir and Subsurface Storage Potential.


**Host institution: University of Aberdeen**

**Supervisor 1: Dr. Rachel E. Brackenridge**

**Supervisor 2: Dr. Joyce Neilson**


**Project description (250 words max.):**

**Rationale:** The Permian Zechstein has both hydrocarbon prospectivity and subsurface storage potential and could provide continued energy security in the UK aiding the move to netzero. Despite this, the properties of the Zechstein facies, and their distribution remain poorly understood in offshore areas of the Central North Sea. This is despite planned hydrocarbon exploration wells, and the development of offshore windfarms in the region.

**Project Aim:** To assess the distribution and character of Zechstein seismic and sedimentary facies in and around the margins of the Mid North Sea High Platform (MNSH) and Forth Approaches Basin (FAB), and their potential for hydrocarbon reservoirs and Hydrogen ($H_2$) storage in solution-mined salt caverns.

**Objectives:** (1) Z1, Z2 and Z3 carbonate facies distribution mapping on the MNSH Platform using reassessment of petrophysical data and legacy/modern seismic data; (2) Use petrophysical analysis and core logging/sampling to characterize platform, slope, basinal facies and reservoir potential (N2G, porosity; permeability); (3) Map the distribution of Halite, and impurities within Zechstein Aller and Liene Halites across the MNSH Platform and FAB using legacy wells with seismic facies mapping. (4) Assess the geological feasibility of $H_2$ storage in the FAB.

**Outcomes:** Provide a case study for risking integrated energy systems encompassing the analysis of both reservoir and non-reservoir facies for multiple uses. Learnings could aid subsurface de-risking in other regions in the South Permian Basin (e.g. offshore the Teeside hub) ensuring continued energy security for the UK in a netzero basin, and provide learnings for other salt basins around the World.

**Stated link to the overarching theme of the CDT i.e. The Role of Geoscience in the Energy Transition and the challenge to meet the net zero emission targets (NOTE: In order to qualify for NEO Energy CDT funding, there must be an explicit link to the Energy Transition with a clear application to the UK's Continental Shelf (UKCS). For projects supported by 100% matched funding from your University, links to the broader Energy Transition remit are sufficient):**

This project directly links to the themes: (1) 'Extending the life of mature basins to address the energy transition'; and (2) 'The role of geoscience in the energy transition'.

Proposals must be fit on 4 sides of A4 page and be completed in Calibri 12pt font. Submission of the proposals will be co-ordinated by your University so please check your local submission deadline. Each university must submit its final project listing to the CDT hub at Heriot-Watt on or before 4pm on Friday 3rd September 2021 for onward distribution to the CDT Awards Committee for their review.

**(1) 'Extending the life of mature basins to address the energy transition'.** There has been a recent increase in exploration interest of the Z2 Hauptdolomit Play in the North Sea, with the recent high-profile Ossian-Darach discovery, and a number of 3D seismic surveys currently being acquired or recently shot. However, existing well data targeting this play is sparse, and the reservoir distribution and quality remains a key exploration risk (alongside hydrocarbon charge). The development of the Hauptdolomit Play provides an opportunity to ensure continuing domestic hydrocarbon supply to the UK. Strict guidance from the regulatory body (OGA UK) on the sustainability of the UK oil and gas industry and the requirement to support netzero 2025 could see the North Sea become a type example and world leader in integrated energy systems in a netzero basin. The Zechstein play fits well within this remit.

**(2) 'The role of geoscience in the energy transition'.** Hydrogen ($H_2$) will be critical for the UK's transition to net zero, providing a versatile low-carbon replacement of fossil fuels for power, heat and transport. It can be generated from methane and combined with CCUS (blue hydrogen) or during temporary gluts of renewable energy generation, to be used at a later time when demand requires (green hydrogen). Solution-mined salt caverns provide a cost effective, high-capacity solution to store $H_2$ at the scale required for a UK-wide hydrogen economy. A recent review of salt cavern storage capacity of the UK identified no suitable onshore salt storage sites in Scotland. This region is seeing numerous ambitious renewable energy developments which would benefit from local $H_2$ storage. One such project of note is the Seagreen development – the largest offshore wind farm in Scotland, which is currently under construction in the Forth Approaches salt basin. One nearby $H_2$ storage opportunity may lie in porous rocks within the Midland Valley, however this remains untested. The underlying offshore salt accumulations could provide a safer long-term solution. This project, therefore, provides an opportunity to assess the geological feasibility of the Zechstein as an intermittent subsurface storage facility, and supports the netzero 2050 mandate.

**Details of mapping/fieldwork locations/data to be used by the project and confirmation of access to key data being secured (please attach map as an appendix if relevant)**:

The project will be predominantly workstation based, however there will be some fieldwork and core logging opportunities.

**Well Data:** Petrophysical well data and complimentary well reports are available open access form the national data repository (NDR). Following initial assessment of suitable wells of interest and core availability, core logging will be completed at the BGS core repository in Keyworth. Core sample and analysis (thin sections, porosity and permeability analysis) will be completed on an >100 core sticks available through the Zechstein at well 44/15- 1, in-house in the University of Aberdeen.

**Seismic Data:** Regional 2D seismic surveys are available via the National Data Repository (NDR). A case study on the seismic stratigraphy of the Mid North Sea High Platform will be conducted on a smaller data-set provided by TGS and Horizon Energy. This TGS-shot data set has been approved to be used in-house at the University of Aberdeen under the terms of a Confidentiality Agreement.

**Fieldwork:** In addition to the seismic and well analysis, there is an option for fieldwork to be completed on equivalent facies in the NE England, or undertake analysis of previously collected virtual outcrops in this region. This is not a requirement of the project, but will provide the PhD candidate an opportunity to develop additional skills, and possibly substitute core samples with field samples and integrate onshore and offshore paleogeographic reconstructions.

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**Outline of planned work schedule for the 4-year research period**:

**Year 1:** Initial regional 2D seismic mapping across the study area. Well Data QC and initial petrophysical facies and property analysis and databasing. A sub-set of key wells of interest will be identified, which demonstrate: (a) good quality wireline data through the Zechstein section; (b) available core or cuttings data; and (c) good coverage of a variety of Zechstein depositional environments (carbonate margin, slope and basin- dominated deposition).

**Year 2:** Core logging trip to Keyworth for sedimentology training and initial logging of key wells. Core logging and sampling of core 44/15-1 inhouse and additional cores where appropriate. Thin section and mercury injection analysis to determine facies, fabrics, depositional environment, porosity and permeability. Results integrated with petrophysical data. This work will feed into a thesis chapter characterising the sedimentary and petrophysical properties of the Zechstein facies (carbonate platform, margin, slope, basin shales and salts).

**Year 3:** Seismic stratigraphy of the Mid North Sea High margin. Integrating well results with 3D seismic interpretation with the aim of understanding the controls on facies distribution. Results will feed into a thesis chapter on the seismic stratigraphy of the Mid North Sea High margin.

**Year 4:** Implications of the data analysis will be outlined with respect to reservoir distribution and potential of the Zechstein dolomites, and the suitability of the Zechstein halite for subsurface storage. Results will be summarised in two chapters on these topics.

**Any Additional Research Costs (NOTE**: **Each CDT studentship includes an individual Research Training and Support Grant (RTSG) budget of £20k for the full 4-year study period)**

We do not expect additional costs above the £20k research, training and support grant.

**Supervisory arrangements and involvement of external partners (NOTE: Please indicate the area(s) of expertise covered by each supervisor. External collaboration is encouraged, but if proposed partner is not currently providing support to the CDT, please outline the extent of the partner's involvement with the project.)**

**Dr. Rachel E. Brackenridge:** Primary supervisor, Dr. Brackenridge, has extensive experience in the structural and stratigraphic evolution if the study area (see Brackenridge et al. 2020). Recent research has provided the foundation for this proposal. She will primarily support the petrophysical and seismic interpretation, along with the impact case studies.

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**Dr. Joyce Neilson:** Secondary supervisor, Dr. Neilson, is a world-leading carbonate sedimentologist with industry experience. She will support the sedimentary analysis and both data- and model-driven palaeogeography mapping over the study area.

**Prof. John Underhill:** Secondary supervisor Prof. John Underhill brings a wealth of knowledge on the seismic stratigraphy of the Zechstein in the SNS, and the North Sea Geology. He will support with knowledge share and support the seismic interpretation workflow.

**External Partner:** Horizon Energy. Horizon are actively exploring the Permian Hauptdolomit Play in the region and have considerable knowledge of the data and challenges of this play. They are keen to share newly acquired seismic and well data, as well as knowledge, to support the PhD candidate.

**Likely graduate career routes**:

This PhD proposal integrates subsurface seismic, petrophysical and sedimentary skills. There is a strong focus on integrated energy systems in a netzero basin. As such, upon completion of the PhD, the candidate would be well suited to fill a wide range of position as a subsurface scientist within the energy industry. The PhD candidate will be encouraged to develop a wide range of academic skills (through paper publication, conference presentations, applications for small grants, student demonstrating etc.) in order to prepare them for a career in further research.