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Reservoir quality of Triassic saline aquifers and the sealing capacity of their caprocks, North Sea region and East Irish Sea: tools to identify potential CO_2 storage sites.

TriStore

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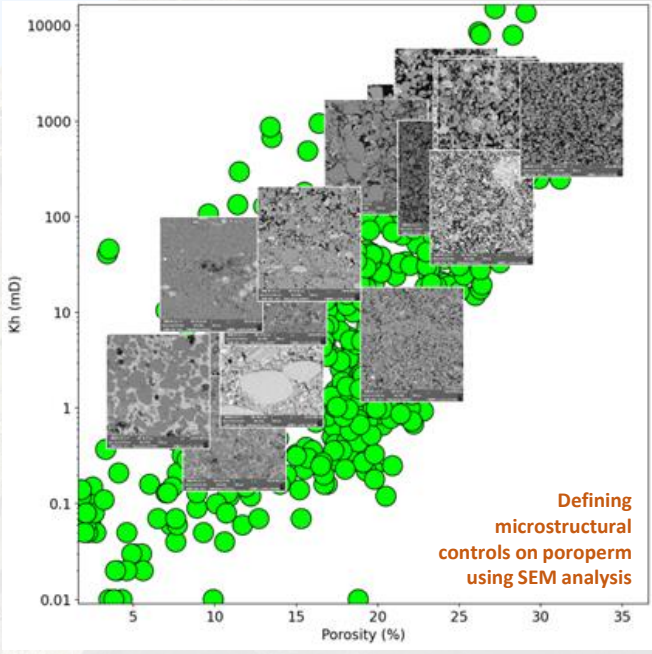
A joint industry project focused on building a large relational database for the characterization of reservoir quality and top seal capacity of Triassic saline aquifers for CO_2 storage in the UK continental shelf and North Sea region. The database serves as a tool to deliver the following:

Determine key factors that control injection and storage and map these properties across the aquifer.

Mapping of the aquifer and top seal based on an integration of wire-line logs, cuttings and core to enable high-grading of specific areas which present a lower risk for CO_2 storage targets.

Develop an adapted play fairway analysis used in traditional oil and gas industry, reworked for CCS storage.



TriStore proposed work programs

- Database of the microstructural and petrophysical properties of Triassic sandstones.
- Sedimentological database of lithologies and architectural elements that comprise Triassic sandstone successions.
- Cuttings analysis to determine poroperm transforms and integration with wire-line log data.
- Fault rock properties e.g. absolute permeability at subsurface stress conditions, their mercury injection threshold pressures and their relative permeability to dense phase CO2.
- Caprock properties e.g. determine capillary pressure and self sealing characteristics.

Image: Triassic Helsby Sandstone Formation, type section at Helsby Hill, Cheshire, UK.

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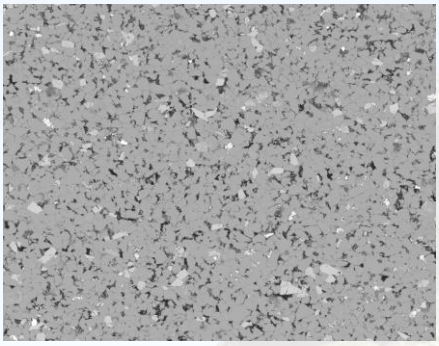
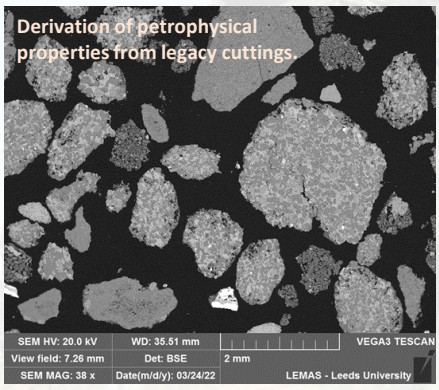
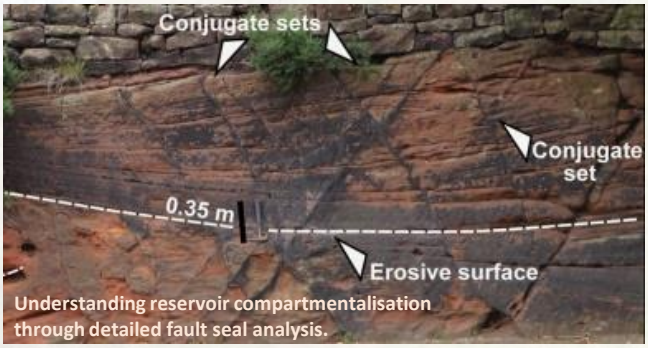
Below: High-resolution panorama of a sandstone sample created by combining >1000 BSE images; the image is of a 1 cm² area of the sample and has a total of ~1 billion pixels.







Reservoirs

United Kingdom Triassic successions chiefly comprise the Bacton and Haisborough groups of the southern North Sea region, and the Sherwood Sandstone, Mercia Mudstone and Penarth groups of the East Irish Sea Basin and onshore regions. North Sea equivalent formations also include the Skagerrak and Lunde formations. These lithostratigraphic units record sedimentation in a range of channelized and non-channelized fluvial, overbank, aeolian, lacustrine, shoreline, sabkha, and marginal to shallow-marine palaeo-environmental settings. At times, these related sub-environments developed coevally, resulting in the accumulation and preservation of a highly varied sedimentary architecture.

Thus, Triassic successions exhibit considerable lithological heterogeneity at both local (10^0-10^1 m) and regional scales (10^2-10^4 m) scales, resulting in highly variable poroperm distributions, and therefore complicated fluid-flow properties. Moreover, some lithological elements are prone to complex patterns of fracturing and diagenesis, and compartmentalization is an issue due to the presence of low-permeability fault rocks. Outcrop studies of Triassic sandstones from onshore UK demonstrate that they commonly contain faults dominated by cataclastic fault rocks.

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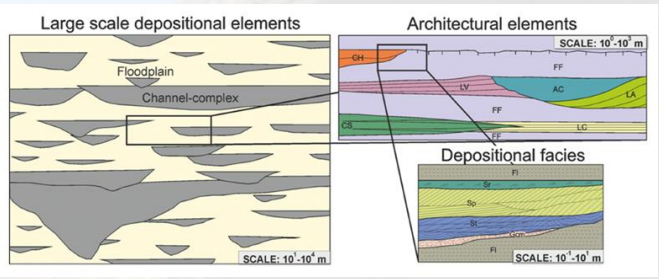
To date, no systematic and quantitative characterization of the varied lithological architecture of UK Triassic successions has been attempted at the scale of facies units, architectural elements and larger depositional elements, for the purpose of generating quantitative facies models to predict the distribution, extent and continuity of high permeability thief zones, and low-permeability barriers and baffles to flow. In addition, this project will provide a database of fault rock properties with outcrop and core data from Triassic sandstones by measuring the absolute permeability at subsurface stress conditions, their mercury injection threshold pressures and their relative permeability to dense phase CO_2.

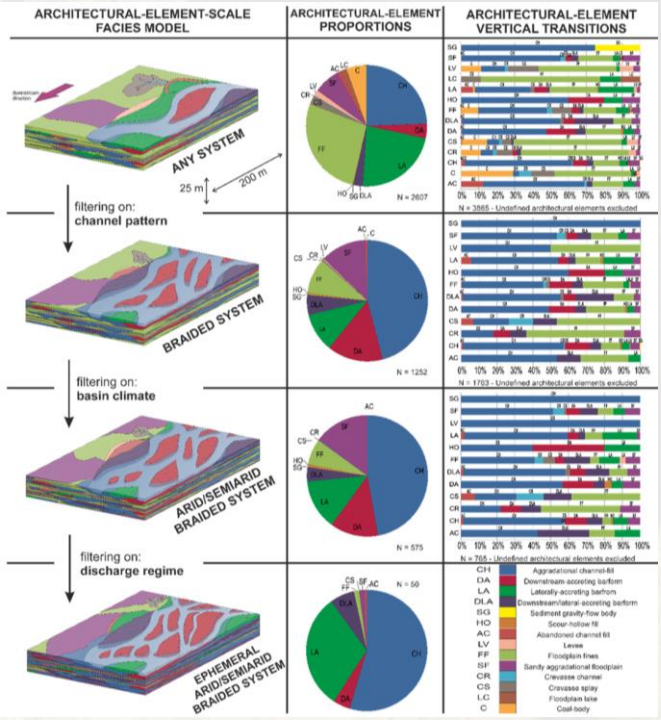
Seals

Unlike depleted oil and gas reservoirs, saline aquifers in the Triassic of the UK do not contain petroleum and therefore there is no direct evidence to suggest that caprocks can seal significant CO_2 columns. Little information is currently available on the characteristics of shale caprocks to Triassic sandstones within the UK.

This study will collect samples from both core and outcrop to determine range of column heights which the caprock can seal, in addition to collecting data to determine the self sealing potential of the caprock.



The Fluvial Architecture Knowledge Transfer System (FAKTS) is the world's largest and most sophisticated relational database on the sedimentology of fluvial systems and their preserved successions. This project will use FAKTS to characterize Triassic fluvial successions of the UK and to build bespoke facies models.



Filtering will be applied to our Triassic database to tailor a model specifically for ephemeral braided fluvial systems developed under the influence of an arid or semi-arid climate regime, as was the case in many UK Triassic fluvial basins.

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Experience and capabilities

The project team have a long track record of delivering applied research results to industrial partners and sponsors:

- Reservoir quality and petrophysics of sandstones generated during the **PETGAS Joint Industry Project** (JIP), which has been running since 2010 and has developed technology to integrate cuttings and wire-line log analyses to estimate reservoir quality when no core is available.
- The **Fluvial, Eolian & Shallow-Marine Research Group JIP** has been running since 2008 and has developed the world's largest and most sophisticated databases describing the sedimentary architecture of clastic fluvial, aeolian, lacustrine and shallow-marine successions. These databases are applied to predict multiscale lithological heterogeneity in subsurface successions, and to model connectivity of both reservoir compartments, as well as baffles and barriers to flow, especially in relation to UK Triassic successions.
- The **Wolfson multiphase flow laboratory** has compiled a large database of the single and multiphase flow properties of both faults and caprocks. It already has significant data on faults within Triassic sandstones of the UK and has unique laboratory facilities for measuring the top seal capacity of shale under reservoir stress conditions.
- **Additional facilities for analysis include:**
  - **Leeds Electron Microscopy and Spectroscopy Centre (LEMAS)** is internationally renowned as a leading research centre in microscopic and spectroscopic characterization of solid materials. LEMAS has a huge range of state-of-the-art instruments that allow imaging of samples from the atomic to the core plug scale.
  - **Sorby environmental fluid dynamics laboratory** where particle size analysis equipment will be used to determine the grain-size distribution of disaggregated cuttings and core samples. It will also make use of the **FAKTS and DASA sedimentary databases** and bespoke numerical modelling software tools developed by the research group that operates the Sorby laboratory.

The project outputs will be made available via a dedicated webpage and via bespoke software (PETMiner - https://www.petriva.co.uk/en/software-new/).

The project will cost £50,000 per sponsor per year and will last for 3 years; a minimum of four sponsors are required for the project to run.

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