PETRIVA

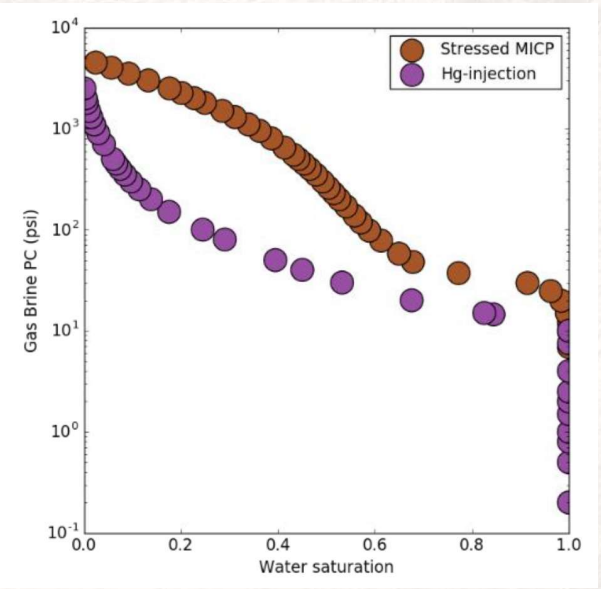
UNIVERSITY OF LEEDS

Fault rock property database: an up-date for the energy transition

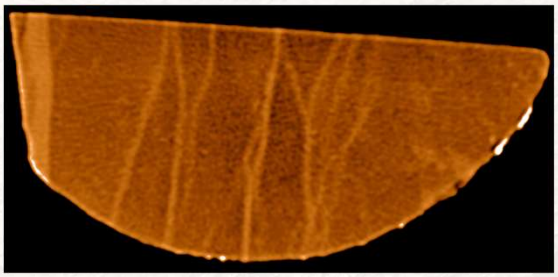
Fault rock properties for the energy transition

A joint industry project focused on:

- Upgrading current corporate fault rock databases by undertaking thorough QC to ensure that any poor quality data are either removed entirely from the database or flagged so that they can easily be filtered out by the user.
- Collecting new data on the flow properties of fault rocks by measuring the absolute permeability (using realistic brine compositions) and Hg-injection pressures of fault rocks under reservoir stress conditions to assess the accuracy of data currently used in industry.
    - These experiments may lead to the development of corrections factors so that legacy databases can continue to be used with some confidence.
- Measuring relative permeabilities in the CO2-brine system, which will be ideally suited for modelling CO2 injection into faulted storage sites.



Comparison of MICP curves obtained from the same sample using the traditional high pressure MICP method (purple) and the stressed MICP porosimeter (brown).



CT scan of a core sample used to assess the fault zone structure and orientation to drill core plugs for flow analysis.

Proposed work packages

Bespoke database of existing data thoroughly QC'd fault rock properties, customised for each sponsor.
New measurements of fault rock properties from outcrop and new subsurface samples to include

- **General core analysis** microstructural analysis; single phase fault permeability; unconfined MICP analysis.
- **Special core analysis** CO2 relative permeability of fault rocks; Stressed MICP analysis; Numerical modelling

Deliverables include: project website, PETMiner data visualization software and databases, company specific as well as overall project reports, sponsors meetings, company specific meetings and training.

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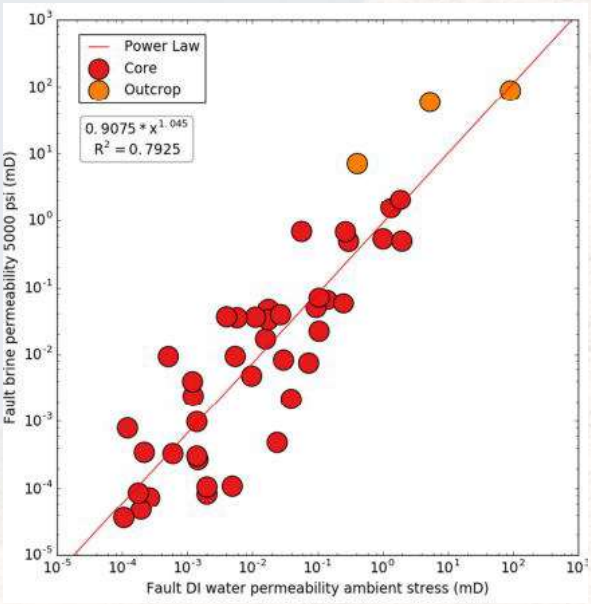
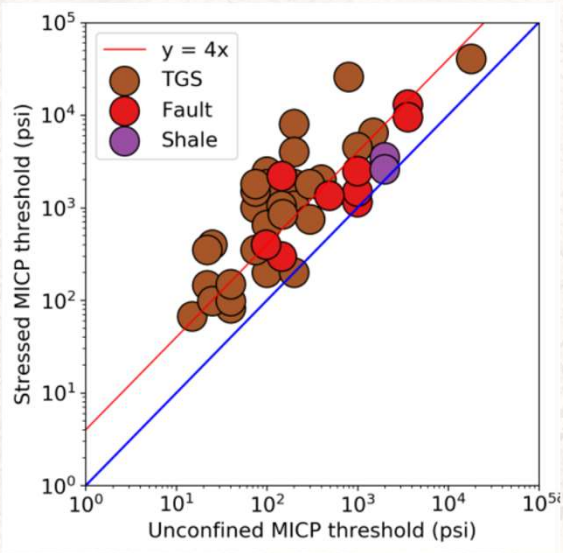


Plot of fault permeability measured using distilled water at ambient stress vs brine permeability at 5000 psi confining pressure. Data quality has been compromised by conducting measurements at low stress and using distilled water.



Comparison of threshold pressures estimated using stressed MICP compared to those estimated from traditional high pressure MICP analysis.

Introduction: learning from the past

Over the past 30 years, a significant amount of data has been collected on the single-phase permeability and mercury injection threshold pressure of fault rocks (e.g. Fisher and Knipe, 1999, 2002; Sperrevik et al., 2002; Tückmantel et al., 2010). A smaller number of studies have also measured the relative permeability of fault rocks (e.g. Al-Basafi et al., 2005; Al-Hinai et al. 2008; Tückmantel et al., 2011, 2012). There are, however, several problems with these data particularly if used to assess the impact of faults on fluid flow in CO2 storage sites; in particular:-

- Much of the permeability data available was measured at low confining pressures using distilled water instead of a formation compatible brine.
- Mercury injection measurements were generally on samples without a confining pressure and it is well known that such measurements are stress sensitive (e.g. Guise et al., 2018). In addition, the threshold pressure used to estimate membrane sealing capacity was not directly measured but instead estimated from the shape of the injection pressure vs. mercury saturation curve.
- There are very few relative permeability measurements have been made on fault rocks and none have been made using dense phase CO2.

The accuracy of many fault rock property data is potentially insufficient for use in CCS, hydrogen storage and geothermal applications without further QC and the addition of new data.

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Proposed work packages

Database up-grade: By upgrading existing fault rock property databases owned by sponsors and collecting new fault rock property data, we aim to close the data gap and provide accurate fault rock property data that is relevant to the energy transition. The data will be incorporated into the PETMiner data visualization and mining software copies of which will be provided to sponsors

Microstructural analysis: All samples will be photographed at low, medium and high resolution using backscattered electron microscopy.

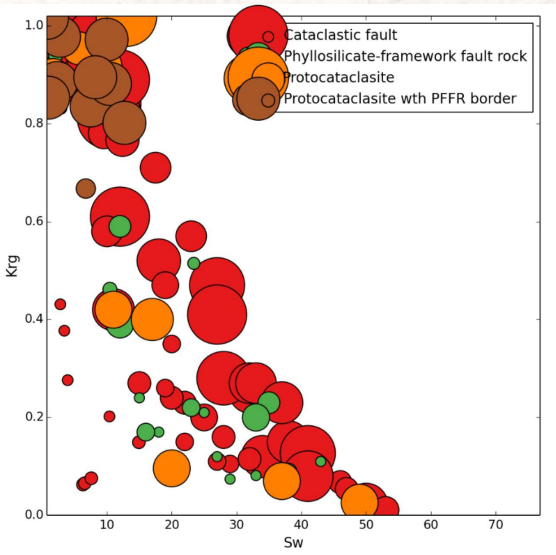
Single phase fault permeability: Application of best-practise measurement of gas and brine permeability at in situ stress conditions, with brine permeability measured using formation compatible brines. Development of workflows to correct previously corrected data to in situ conditions where possible.

Unconfined MICP analysis: We will conduct traditional unconfined MICP measurements on all samples. We are hoping to improve correlations between stressed and unstressed MICP results to provided added value to the large amount of unstressed MICP data that has previously been collected by industry.

CO2-brine relative permeability of fault rocks: Brine-CO2 relative permeability measurements will be conducted on a wide range of fault rocks from outcrop including poorly lithified cataclastic faults that are likely to be quite common in shallow saline aquifers.

Stressed MICP analysis: We will use our unique stressed MICP porosimeter to conduct this analysis on selection of samples submitted to the project. By comparing these results with those made using the traditional unconfined system we hope to develop empirical relationships to correct vintage MICP data.

Numerical modelling: Fault rock samples are intrinsically heterogeneous so data from multiphase flow experiments will need to be inverted to obtain relative permeability data; this will be undertaken in conjunction with Three Cliffs Geomechanics.



Gas relative permeability measurements conducted on a range of fault rocks during the FAULTPROP JIP conducted at the University of Leeds.

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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 **Wolfson multiphase flow laboratory** has compiled a large database of the single and multiphase flow properties of faults.
- **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.
- Numerical models for multiphase flow through fault rock samples will be developed with the help of **Three Cliffs Geomechanics (www.parageo.co.uk)**, who are leaders in the development of advanced finite element modelling software dedicated to geoscience applications.
- The project outputs will be made available via a dedicated webpage and via bespoke software PETMiner - https://www.petriva.co.uk/en/software-new/.

Project costs

Sponsors may join one of both of the subprojects and sponsors may join one or both

Subproject 1 will cost £30,000 for the first year and £10,000 for the following 2 years (i.e. £50,000 total). £10,000 per year is to cover the PETMiner license, support and development. The extra £20,000 fee in the first year is to cover the cost of building and QC'ing the sponsors fault rock data.

Subproject 2 will cost £50,000 per year for three years (i.e. £150,000 total) but sponsors of subproject 1 will receive a discount of £10,000 per year as they will already paying for the PETMiner licence, support and development.

The project will begin in January 2023 and last for three years. It should be noted that results will be delivered throughout the project.

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