# HIGH-PRESSURE MEASUREMENTS OF GAS-WATER RELATIVE PERMEABILITY IN COAL SEAMS USING X-RAY CT SCANNER

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## RESEARCH AIMS

This project seeks to improve relative permeability predictions of coal seams by running core flooding experiments, under reservoir conditions, using an X-ray CT scanner.

The results of this study may help develop better models of gas-water relative permeability and understand capillary heterogeneity as well as fluid distribution.

## RELATIVE PERMEABILITY IN COAL

Relative permeability is a critical parameter controlling flow in CSG reservoirs, but it is also challenging parameter to measure accurately.

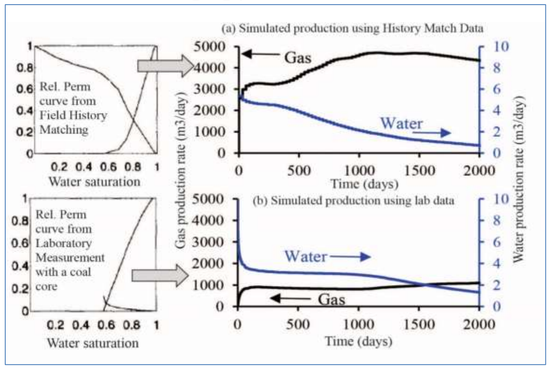


**Fig. 1:** Simulated CSG production profiles using history matching (a) and laboratory data (b), based on well DR4 GC coal from Bowen Basin reported by Meaney & Paterson (1996).

## METHODS TO MEASURE RELATIVE PERMEABILITY

The most common techniques to derive relative permeability curves of coal are: unsteady-state and steady-state, which are based on interpretation of experimental data, and history matching, based on field data as input. Each method has its limitations.

Most of these methods assume homogeneous permeability, linear pressure drop, uniform saturation, one-dimensional flow, and ignore capillary pressure.

The advantages of using a non-destructive technique such as X-ray Computed Tomography scanner are:

- Investigate the evolution of fluid phase saturation in situ of porous media providing a more accurate permeability estimation;
- Estimate relative permeability without typical assumptions or relying on inaccurate porosity-based methods for estimating permeability distributions;
- Analyse the influence of permeability and capillary heterogeneity at the sub-core scale on methods to calculate effective permeability measured in core-scale laboratory experiments.

## DESIGN OF XRT FLOW CELL

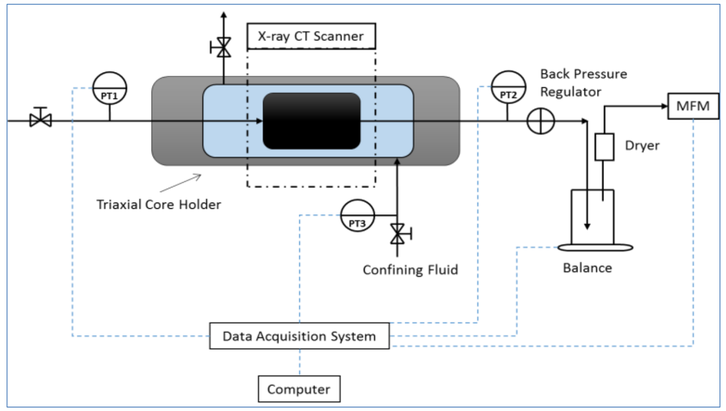


**Fig. 2:** Schematic diagram of the XRT Flow Cell.

The proposed core holder will be constructed in Beryllium and Alumina. It will allow measurements of water saturation during the experiment at a confining pressure of up to 70 bar.

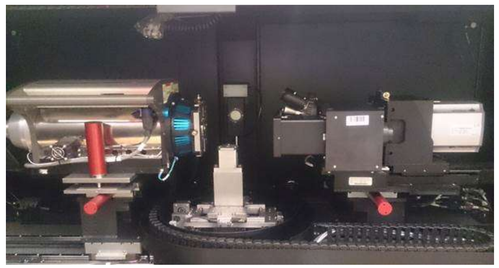

**Fig. 3:** X-ray CT scanner (Xradia Versa XRM-500), UQ.

## EXAMPLES FROM LITERATURE

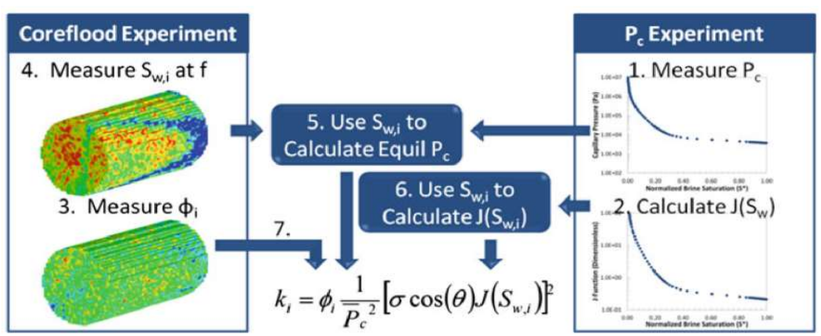


**Fig. 4:** Workflow of the permeability calculation procedure with steps numbered in order (Krause et. al, 2013).

## PRELIMINARY RESULTS

**Table 1:** Coal C-148 properties (Bowen Basin).

| Proximate | | | | Ultimate | | | Vitrinite Reflectance |
|---|---|---|---|---|---|---|---|
| Moisture | Ash | Volatile Matter | Fixed Carbon | Carbon | Hydrogen | Nitrogen | Random |
| (%ad) | (%ad) | (%ad) | (%ad) | (%ad) | (%ad) | (%ad) | (%) |
| 1.80 | 7.50 | 21.80 | 68.90 | 80.20 | 4.49 | 1.70 | 1.18 |

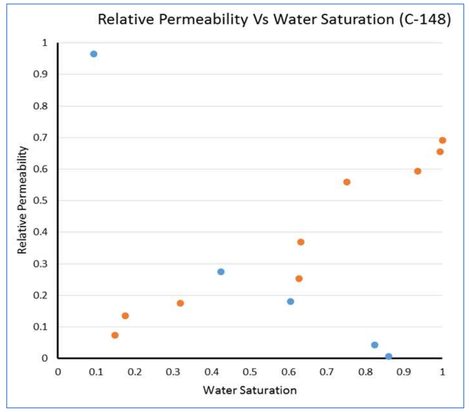


**Fig. 5:** Relative permeability vs mobile water saturation measured through steady-state core flooding experiment @ confining pressure of 30 bar.

**Learning:** Mobile water saturation is a more appropriate basis for a functional relative permeability relationship model than total residual water as the latter may include volumes of water adsorbed in the coal matrix and dead end cleats.

## FORWARD PLAN/ RECOMMENDATIONS

- Measure the evolution of fluid phase saturation in situ of porous media for interpretation of experiments;
- Start core flooding experiments using the new core holder and the X-ray CT scanner in early 2016;
- Analyse data (packed bed) and compare results with the previous experiments;
- Extend the analysis using natural coal to take into account cleat network.

## ACKNOWLEDGEMENTS

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