PS Lab Measurements of Gas-Liquid Relative Permeability in Coals*

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Abstract

The feature of water-gas two-phase flow through coal seams determines the water depletion and gas production associated in coal seam gas recovery. Therefore, coal relative permeability is crucial for studies of two-phase flow behaviour in coal, which is greatly influenced by water/gas saturation and coal ranks. In this study, a permeability model incorporated with cleat size distribution and cleat tortuosity was developed to predict the relative permeability of gas and water in coals. An unsteady-state method has been applied to investigate the relative permeability of gas and water in coal samples from Surat Basin through water replacement with gas. A series of relative permeability curves for selected coals have been obtained. The measured pore size distribution, porosity and irreducible water saturation percentage are used to correlate the permeability of gas and water with gas saturation by modelling.

An unsteady-state core flooding experiment in which water is displaced from the coal by gas was used measure gas-water relative permeability and to determine capillary pressure in coals from the Surat Basin. The effects of effective stress, coal wettability and saturation on relative permeability will be investigated. ED005 exhibited a higher gas relative permeability due to its larger porosity and higher absolute permeability. The convex relative permeability curve ofED017 suggests that gas flow is not only through the main cleat pathways. The next phases of this project will investigate and validate new models including coal wettability and pore structure information (size distribution and tortuosity), to describe the gas-water behaviour in coal cleat networks.

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Lab measurements of gas-liquid relative permeability in coals

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Project motivation and objectives

This project aims to improve understanding of gas-water relative permeability behaviour in coal to aid the development of better predictive reservoir models for coal seam gas production.

The research objectives include:

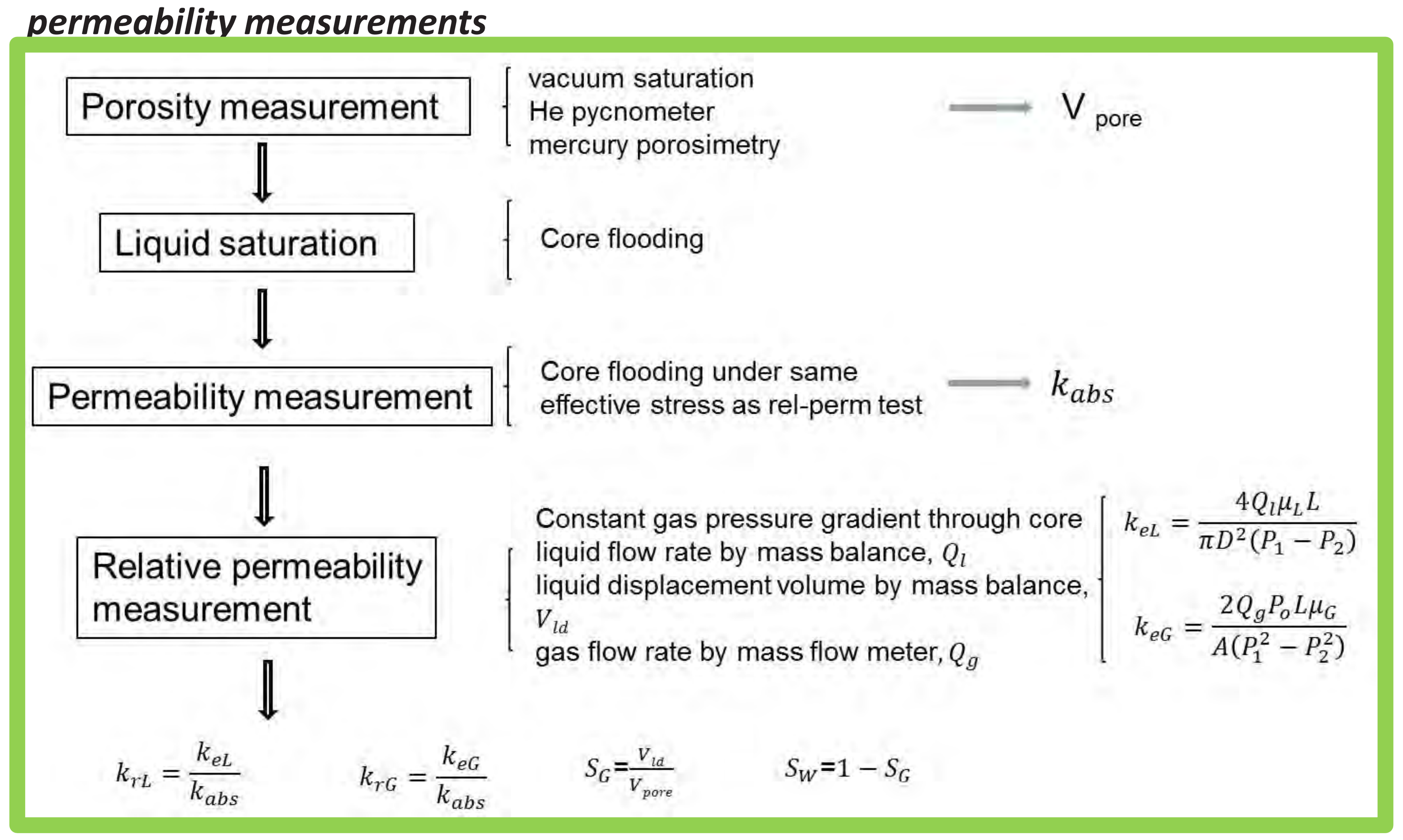
1. Develop improved laboratory techniques to measure, and interpret, relative permeability at a range of conditions including effective stress, coal type, water saturation.
2. Measure in the lab gas-water relative permeability of Surat Basin coals.
3. Develop a permeability model that considers cleat size distribution, cleat tortuosity and coal wettability to improve current models for coal relative permeability

Research approach

An unsteady-state core flooding experiment in which water is displaced from the coal by gas was used measure gas-water relative permeability and to determine capillary pressure in coals from the Surat Basin. The effects of effective stress, coal wettability and saturation on relative permeability will be investigated.

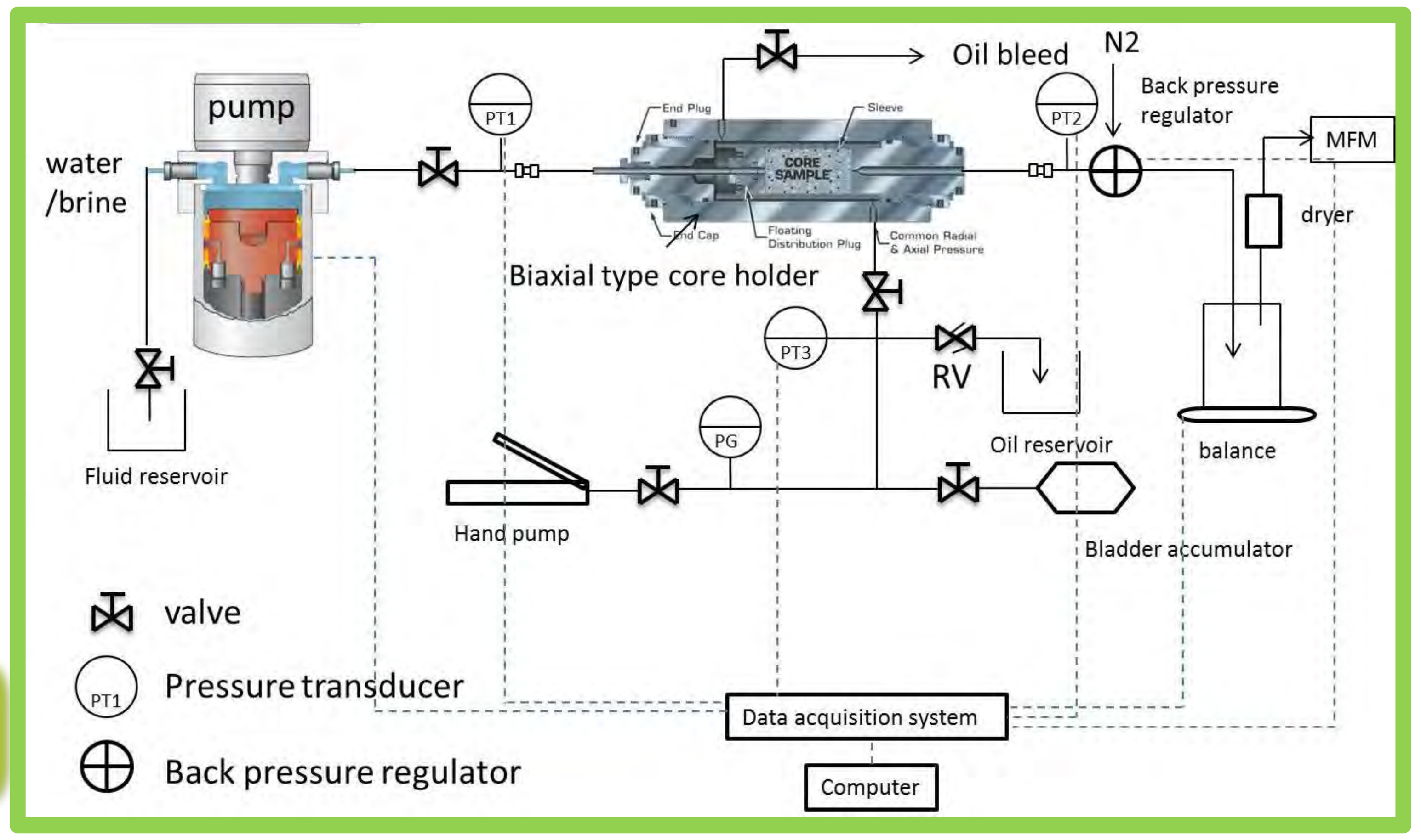
Figure 1 provides an overview of the work flow once a coal samples is selected:

Fig. 1. Experimental work flow for coal sample characterisation and relative permeability measurements



Relative permeability measurement apparatus

Fig. 2. Schematic of core flooding rig used to perform relative permeability measurements.



Commissioning tests: Hutton sandstone and Guluguba coals

Commissioning tests of the relative permeability apparatus were performed with a Hutton sandstone and two samples of Guluguba coal described in Table 1. The cleat volume was evaluated by the vacuum saturation process.

Table 1 Coal characterisation results

Coal sample	ED005	ED017
Location	Guluguba, QLD	Guluguba, QLD
Coal formation	Juandah coal measures	Taroom coal measures
Depth	163.61~163.74	278.66~279.26 m
Test sample before resin coating		
Test sample after resin coating		
Cleat volume	17.4 ml	12.8 ml
Absolute permeability	4.73mD	0.63mD

Results of preliminary measurements

Fig. 3. Demonstration of apparatus capability by measurement of relative permeability curves for gas and water in Hutton sandstone.

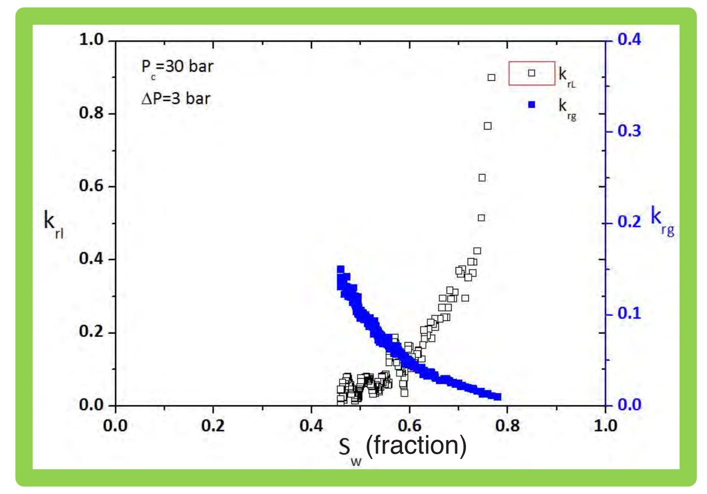
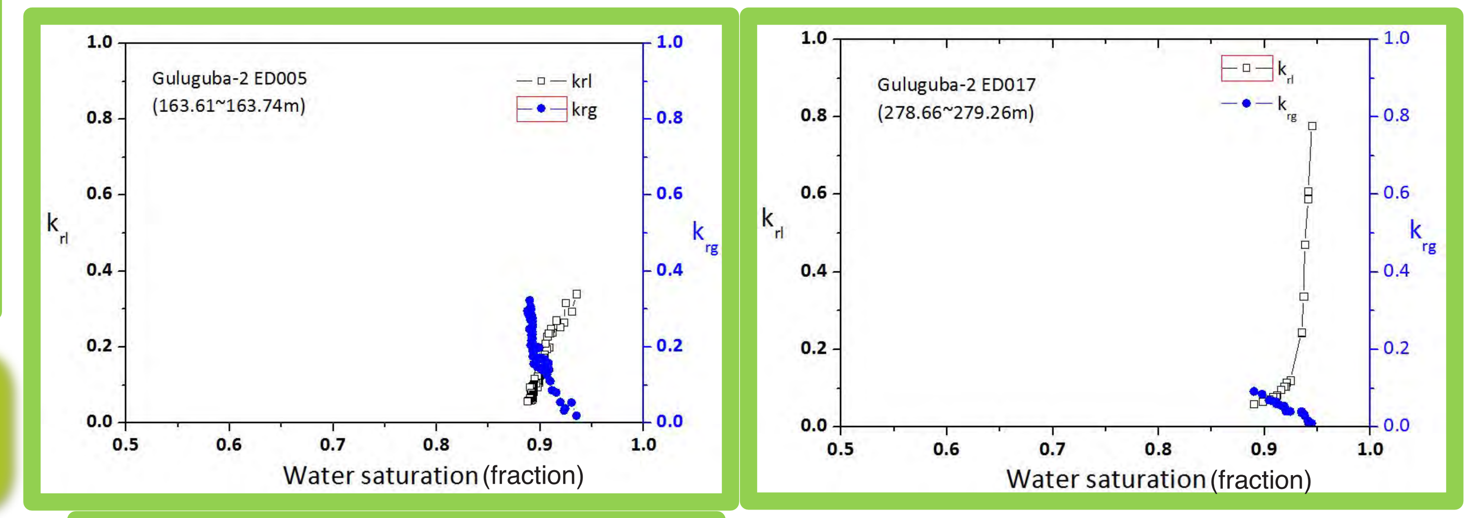


Fig. 4. Relative permeability curves for gas and water in Guluguba coals ED005 and ED017. ED005 exhibited a higher gas relative permeability due to it's larger porosity and higher absolute permeability. The convex relative permeability curve ofED017 suggests that gas flow is not only through the main cleat pathways.



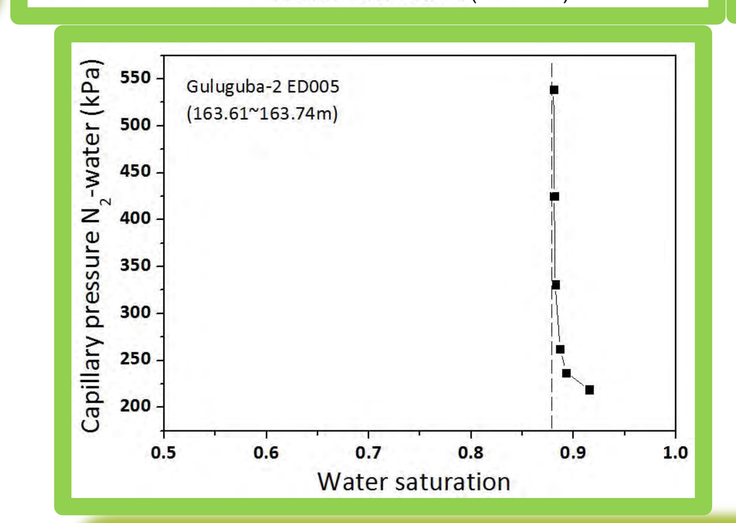


Fig. 6. Drainage capillary pressure curve of ED005 Fig.6 represents the capillary pressure curve between water and N2 at atmospheric conditions in ED005. The residue water saturation percentage is estimated as 87% in Fig.6, which is consistent with the value in relative permeability curves (Fig.5).

Conclusion and Future Work

1. An experimental apparatus was designed and commissioned for two-phase unsteady state fluid flow experiments.
2. As expected the relative permeability curves for coal are very different shapes to those of sandstone. The next phases of this project will investigate and validate new models to describe the gas-water behaviour in coal cleat networks.

These experiments and modelling activities are undertaken in parallel with our microfluidic experiments that examine flow through individual cleats.

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