Coal matrix shrinkage and its effects on cleat porosity, permeability and late life coal behaviour

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Goals

1. Use an X-ray transparent device (Fig 1) to load coal samples with methane at various pressures and measure cleat apertures as methane pressure decreases.
2. Develop new scientific knowledge on the factors affecting cleat aperture (and therefore permeability) during desorption, including the effect of coal molecular structure and how the coal responds to competing forces (adsorption forces and cleat pressure forces)

Fig 1: X-ray transparent device, showing coal and PEEK tubing set in resin. Tested to 700 psi

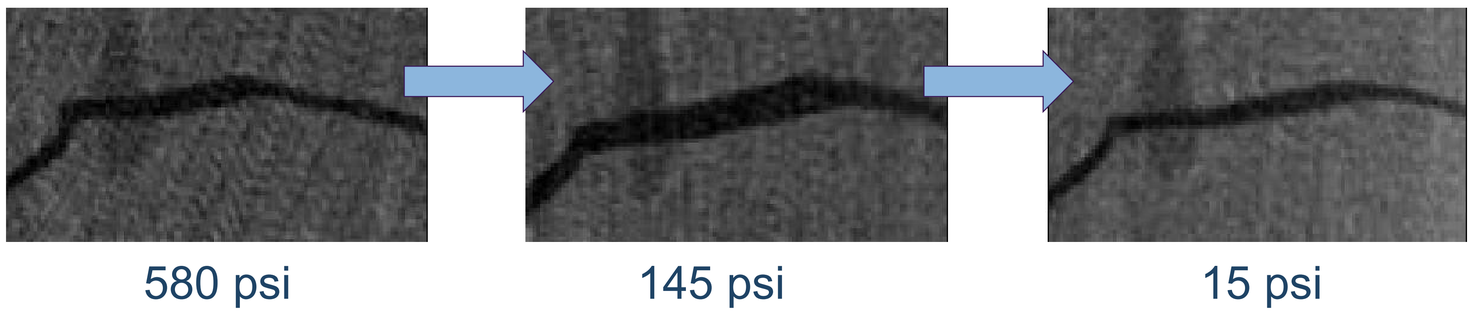

Fig 2: X-ray micro-CT scans (Surat coal, perpendicular cleat) showing increase in cleat porosity (by 32%) from 580 psi to 145 psi and decrease (by 11%) to 15 psi.

Expected Outcomes

Use the knowledge gained to:

1. Understand why a particular well (or particular region) is behaving a certain way.
2. Re-evaluate and improve existing permeability prediction models and/or devise better mechanistic models that are based on fundamental coal property information.

Improved permeability models, allowing:

1. Different regions to be properly evaluated and allows accurate calculations to be made on the long-term production profiles for a given well, all of which has enormous cost benefits.
2. Improved CSG field developments through optimising well-spacing, dewatering and surface facilities planning.

Key Findings to date

Coal type	Cleat direction (parallel or perpendicular to bedding plane	Pressure (psi)	Change in cleat volume wrt 580 psi (%)
Surat	Parallel	145	34
		15	13
	Perpendicular	145	32
		15	-11
	Parallel	145	23
		15	19
Bowen	Perpendicular	145	35
		15	25
	Perpendicular	145	-8
		15	11
	Perpendicular	145	150
		15	100
	Parallel	145	46
		15	51
	Perpendicular	145	71
		15	-23

- Non-linear changes to cleat volume with decreasing pressure. Attributed to competition of cleat pressure force and methane adsorption force. Expected to influence permeability during drawdown and gas recovery over well life.
- Bowen coal cleats expand more than Surat coal cleats during depressurisation. Likely due to increased number of micropores in Bowen coals. Molecular structure may also play a role. Need greater knowledge to improve predictions.

Focus for Further Work

- Study more sample types
- Take measurements at increased number of pressure increments and obtain pressure vs cleat volume relationships. Compare relationships to pressure vs gas uptake relationships (from adsorption isotherms).
- Examine pore properties using BET surface area and Small Angle X-ray Scattering (SAXS) to obtain number of pores and pore size distribution for different coals.
- Examine molecular structure. For shrinkage to occur the macromolecular structure must relax/deform into the micropore space. This ability is expected to depend on the flexible aliphatic and rigid aromatic structures. In addition to petrographic analysis to determine rank and maceral composition, ultimate analysis to obtain the C,H,N,S and O contents, we aim to use FTIR, ^{13}C NMR, and XPS to obtain a model of the molecular structure for given coal types.
- Use all results to resolve behaviour observed for different coal types, including adsorption pressure vs cleat pressure.

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