Influence of Rank and Lithotype on Coal Wettability

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Research Aims

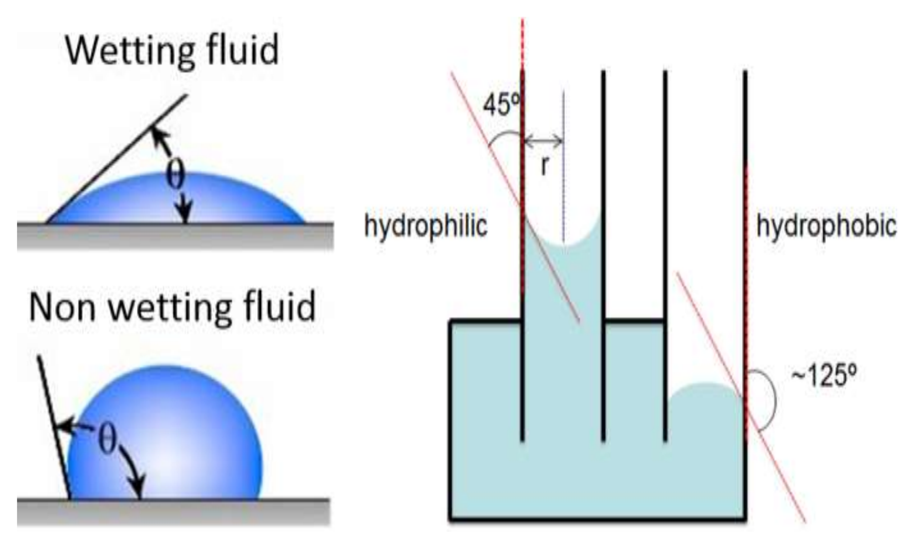
This project seeks to understand the effect of coal rank and lithotype banding on coal cleat wettability.

The results of this study may help develop better models of the physics of gas-water flow and improve relative permeability models.

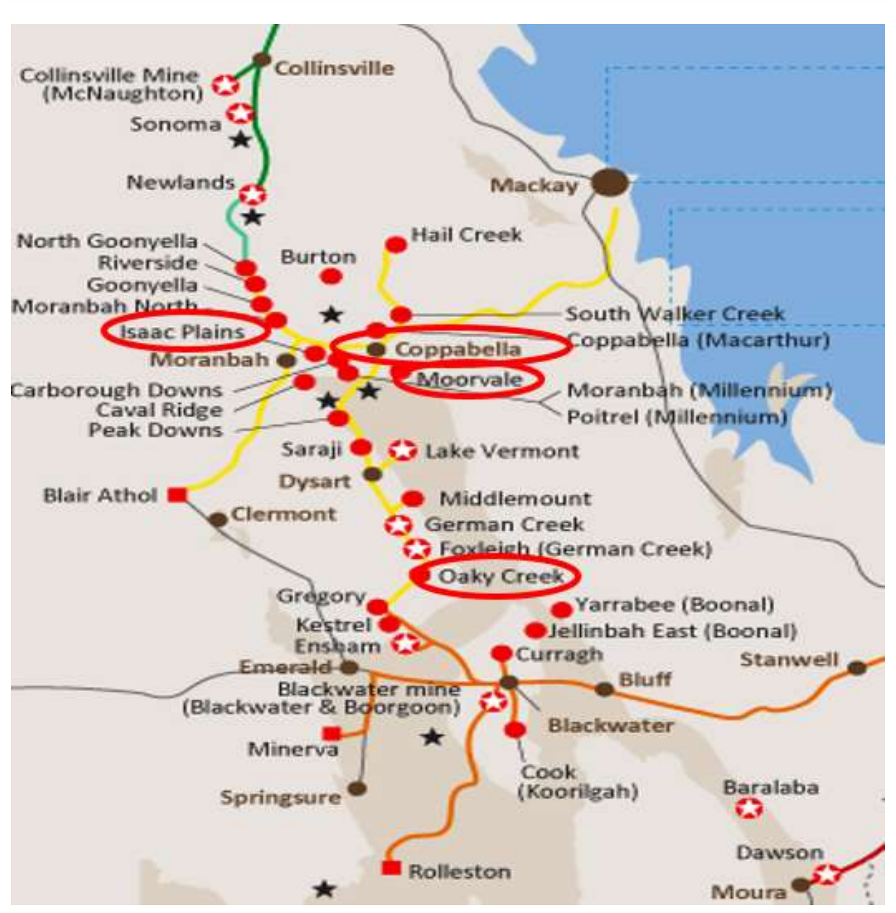
Wettability and Relative Permeability

Wettability is a physical characteristic of the system influenced by solid-fluid and fluid-fluid interactions.

The common method to describe wettability is to measure contact angle (θ) of a polished surface by sessile drop: *This method doesn't capture heterogeneity or geometry of coal cleats very well.*

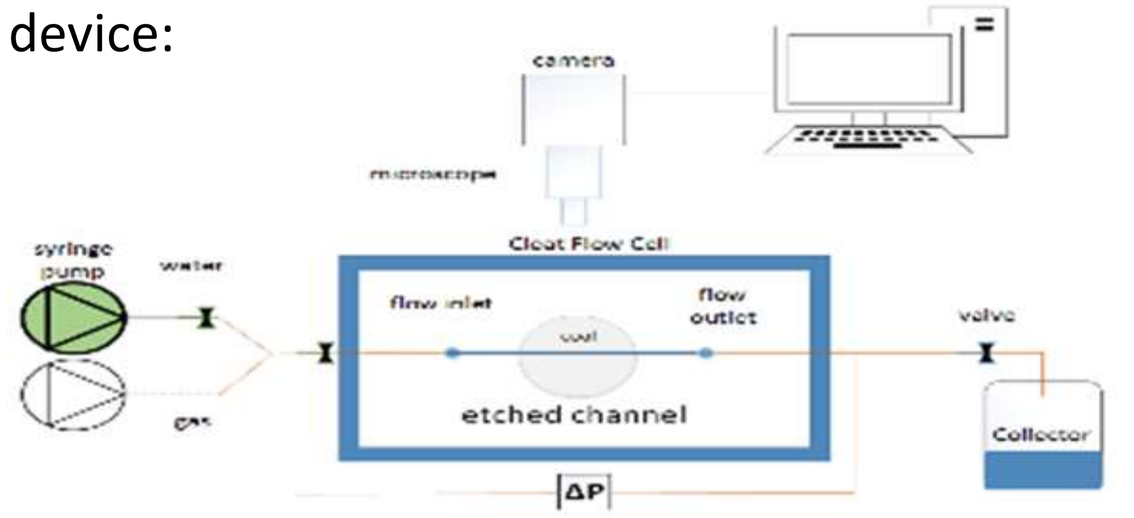


Materials



Methodology

- Artificial cleats with widths 20-30 µm prepared by Reactive Ion Etching.
- Flow of gas-water interfaces through cleats observed in a microfluidic Cleat Flow Cell (CFC) device:



SEM: Natural versus Etched cleat

We observed vitrinite-rich bands were of a smoother texture than inertinite-rich bands in both a natural cleat and in the etched cleats.

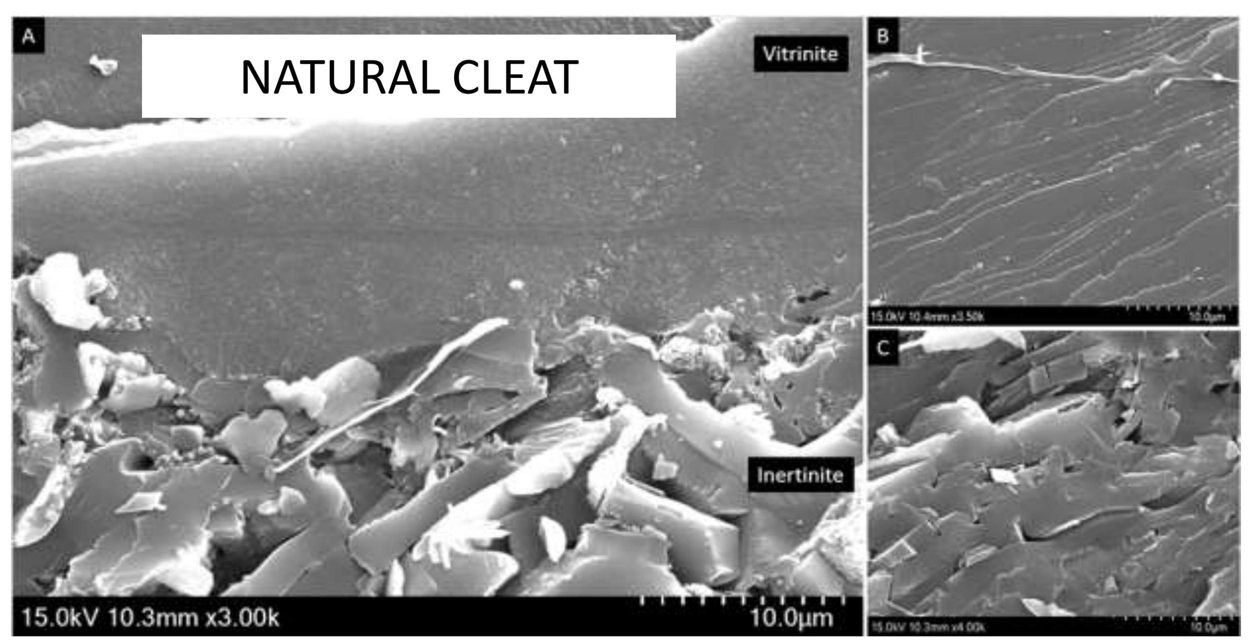


Fig.1: (A) Boundary between "smooth" vitrinite band and "rough" inertinite band in a **natural** cleat (IPN). **(B)** Vitrinite band. **(C)** Inertinite band.

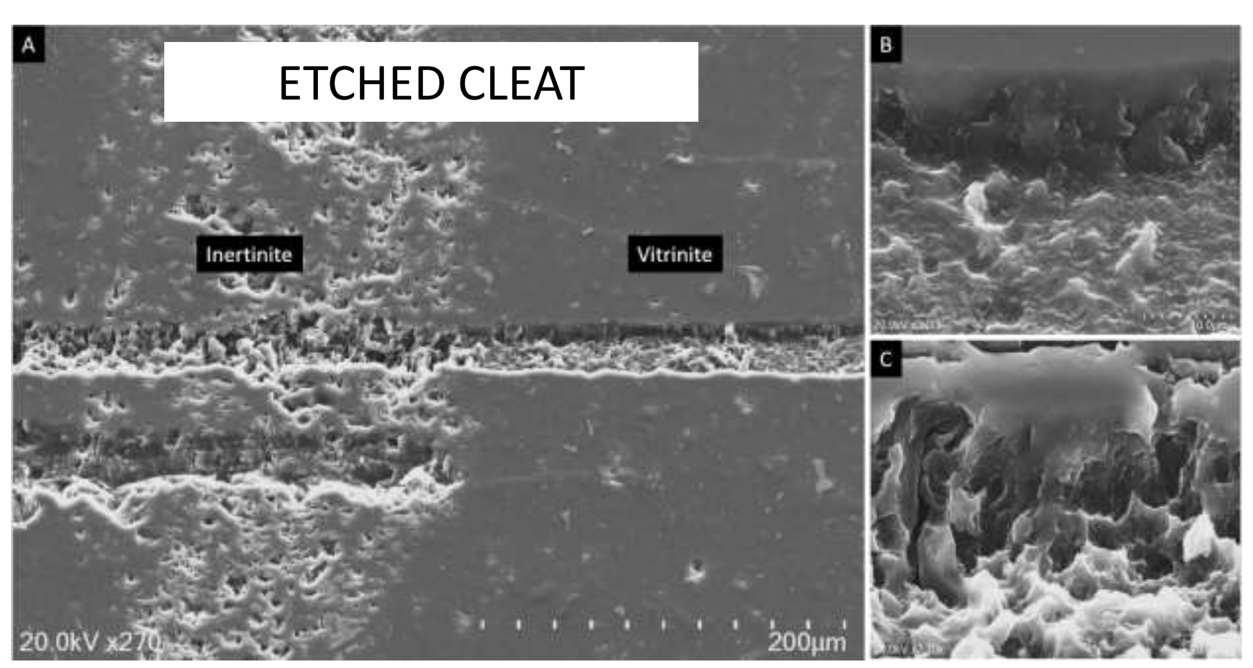


Fig. 2: (A). Boundary between vitrinite band and inertinite band in the **etched** IPN cleat. **(B)** Vitrinite etched cleat **(C)** Inertinite etched cleat.

Results of Imbibition Experiment

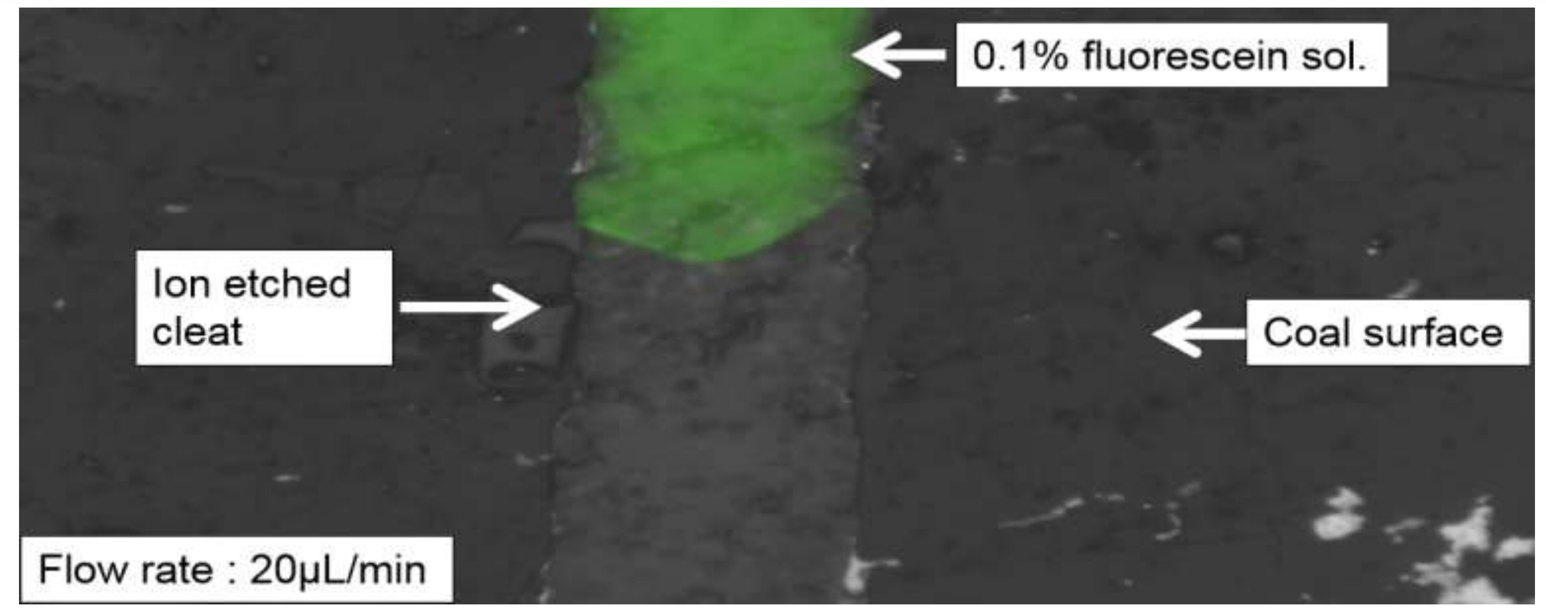


Fig. 3: Imbibition experiment showing a continuous water phase displacing gas in the etched cleat (OAK).

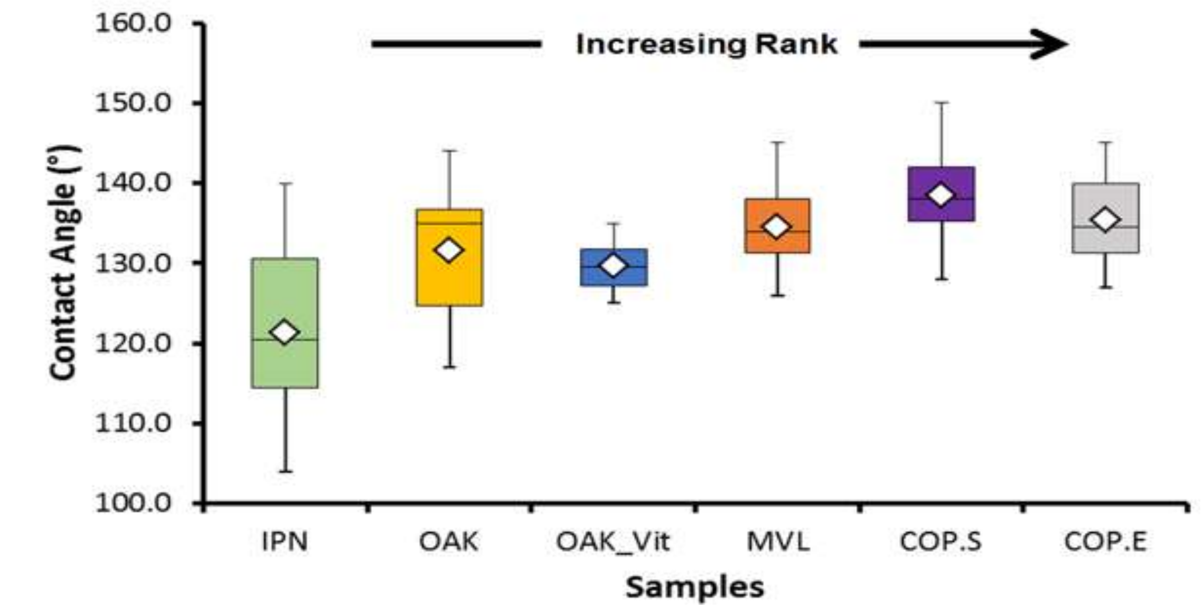


Fig. 4: Contact angles, and therefore hydrophobicity, increased with coal rank.

Results of Drainage Experiment

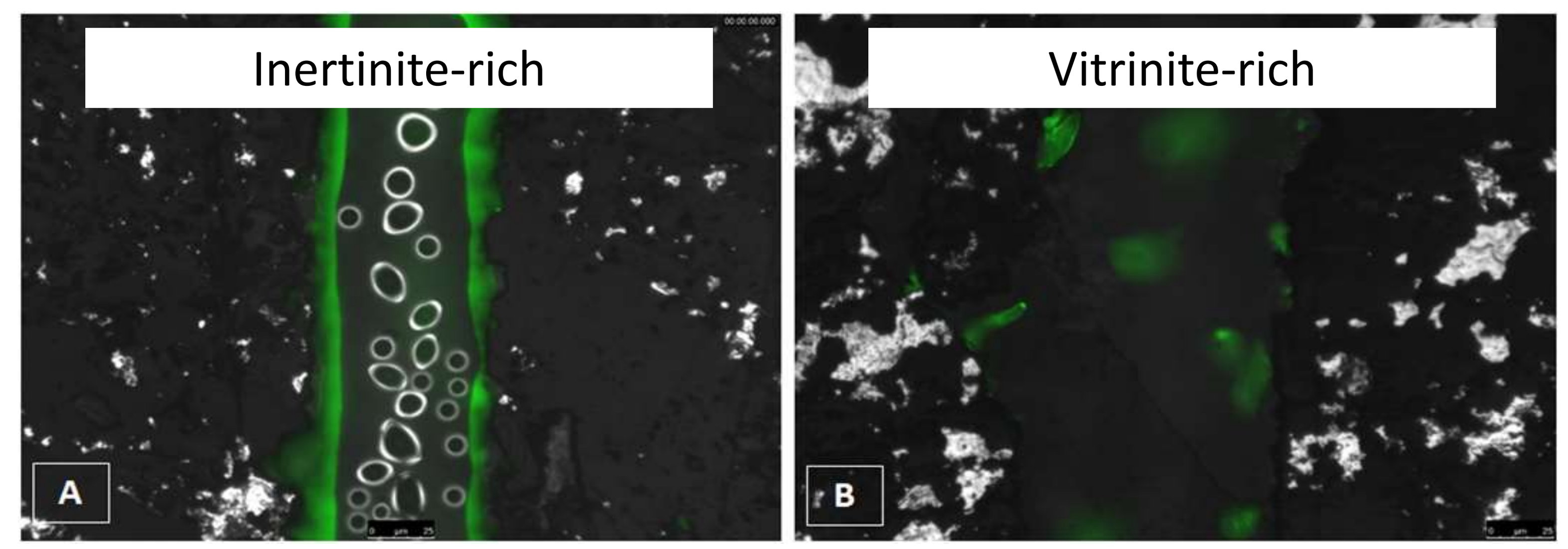


Fig. 5 (A). A residual water film in drained inertinite-rich bands of IPN coal, but **(B)** such a film was not observed in vitrinite-rich bands of the same coal.

Mineralisation of Etched Cleats

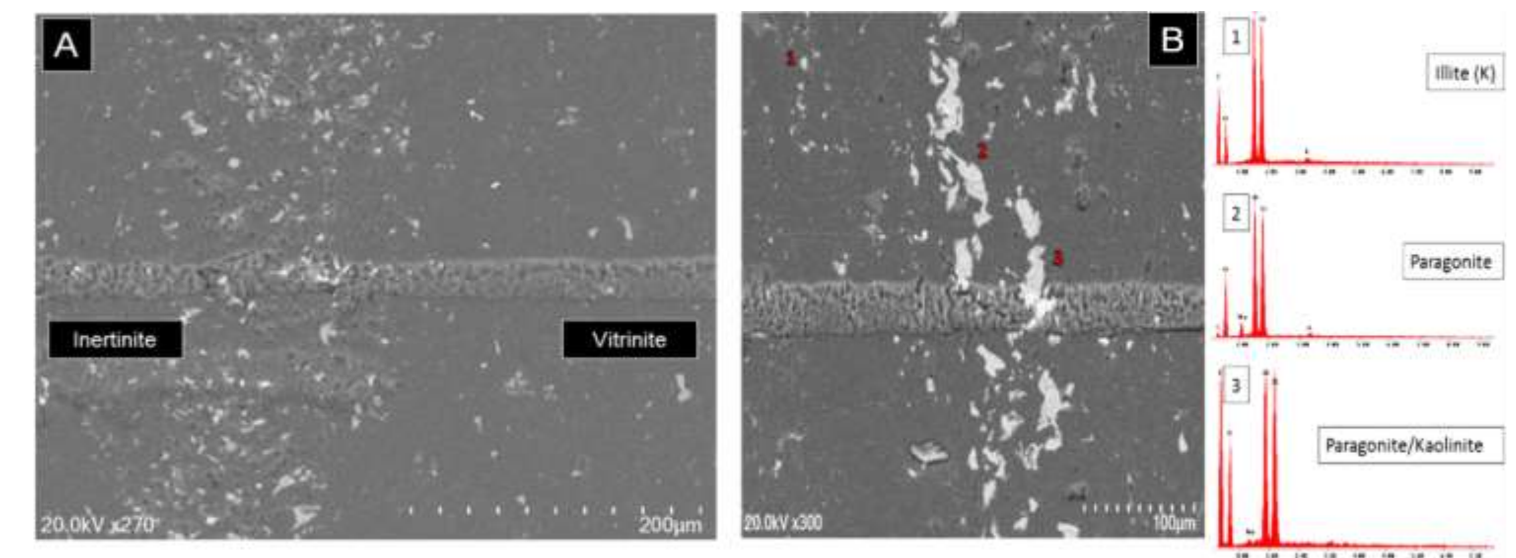
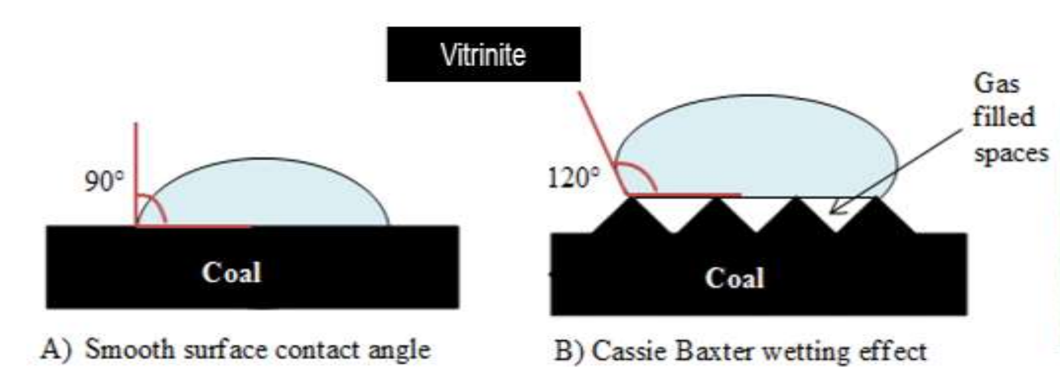
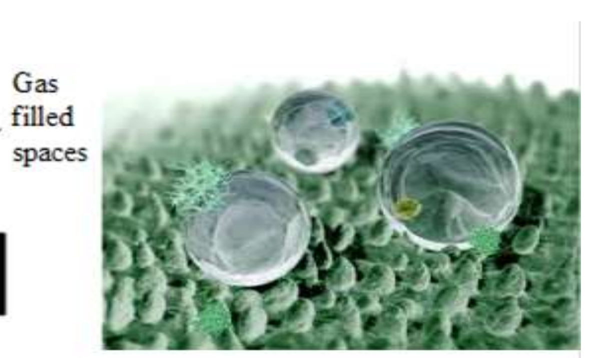


Fig. 6: (A) SEM EDS showing the difference in matrix mineralisation between vitrinite and inertinite rich bands (IPN). **(B)** Types of clays present in IPN inertinite band.

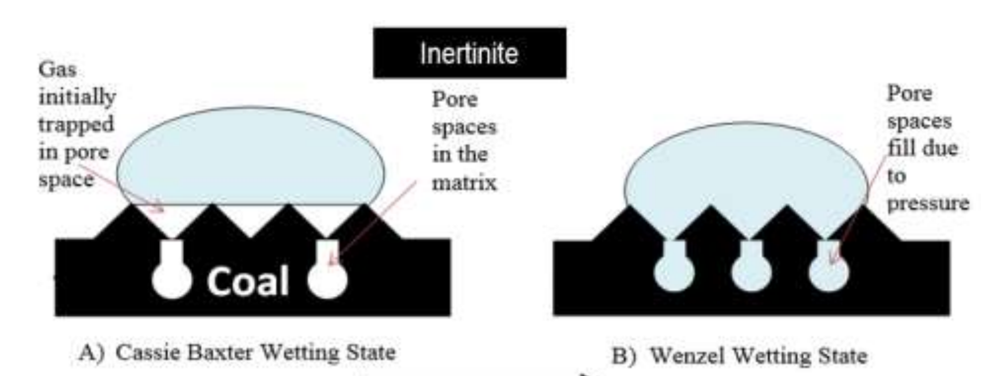
Summary & Conclusions

- **Residual water saturation may be lithotype dependant.** Variations in the pore texture of cleat walls and matrix mineralisation between dull banded inertinite-rich cleats and bright banded vitrinite rich cleats affects the behaviour of air-water interfaces.
- Vitrinite bands are less rough and gas may adhere more effectively to the smaller, discreet, pores on the coal surface simulating a lotus effect; which results in a lower breakthrough pressure to move a water slug through the vitrinite rich band than inertinite.





- Inertinite rich bands have greater roughness, porosity and mineralisation that enhance water penetration into smaller pores off the main cleat. While the main etched channel is still considered hydrophobic, the liquid phase would imbibe during drainage creating a residual film, or petal effect, as seen in Figure Five.



Acknowledgements

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