The calm before the storms - early Permian coal seam development along the western margin of the Bowen Basin

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Introduction

The western margin of the Bowen Basin preserves a high latuitude stormy coastline at the Cattle Creek Formation level formed during the last stages of mechanical extension and thermal relaxation of the Bowen Basin. Underlying the Cattle Creek formation and its lateral equivalents, thick coal seams of APP3.2 age are preserved at locations up to 400km apart in the Reids Dome beds in the Denison Trough and Blair Athol Coal Measures in the Blair Athol and Wolfang sub-basins. Up to 35 m of coal have been intersected in these thick seams with limited clastic partings, which represents up to 500,000 years of slow and steady subsidence and peat formation prior to the final marine incursion of the Cattle Creek Formation.

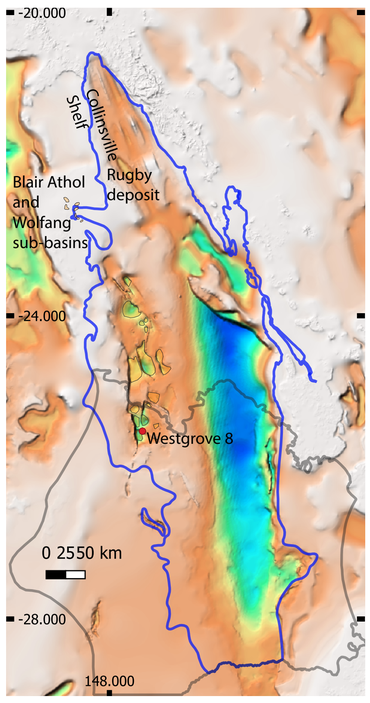


Figure 1: Map of the Bowen Basin over OzSEEBASE depth to basement model (Geognostics, 2021) showing the regional locations of early Permian thick coal seams. Outlines of known early Permian sub-basins near Blair Athol after Sorby and Scott (1987). Other possible early Permian depocentres interpreted from OzSEEBASE for this project.

Geological Setting

- Denison Trough is the major western depocentre of the Bowen Basin
- Deposition began in the early Permian in isolated graben and half graben
- Reids Dome beds up to 2700 m thick, but no formalised stratigraphic framework
- Upper section is age-equivalent to other early Permian thick coal seams, but exact correlation is largely unconstrained
- Coal seams in Aldebaran Sandstone and Collinsville Coal Measures formed in paralic environments during marine regression
- Early Permian depositional system terminated by the “Aldebaran event” and a major regional unconformity

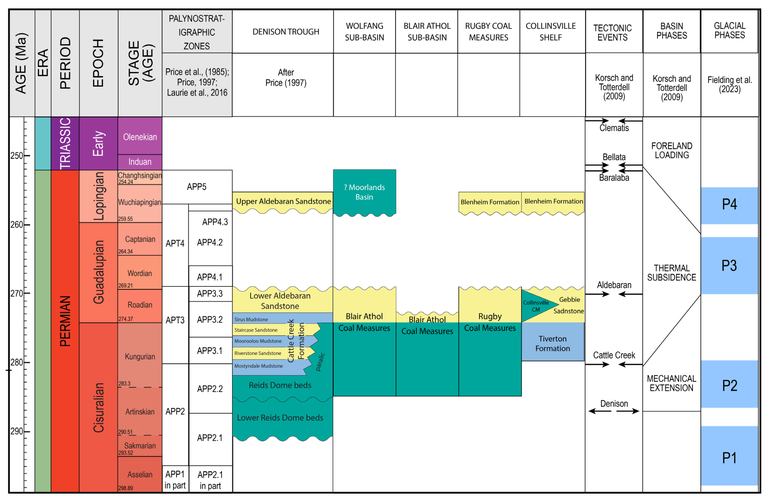


Figure 2 Stratigraphic framework for the early Permian Bowen Basin and outlying troughs. The upper part of the Bowen Basin stratigraphic framework is not included here for clarity of the early Permian and upper Aldebaran Sandstone section. Palynostratigraphic zones and stratigraphy of the Denison Trough is after Price (1997). Stratigraphic placement of the Blair Athol Coal Measures is after Foster (1979). Age constraint on the Moorlands Basin and Blenheim Formation is scarce, though they are noted as being unconformable on the underlying coal measures. They have been tentatively placed as correlative with the upper Aldebaran Sandstone as this unconformity is regionally pervasive throughout Permian basins of Australia.

Approach

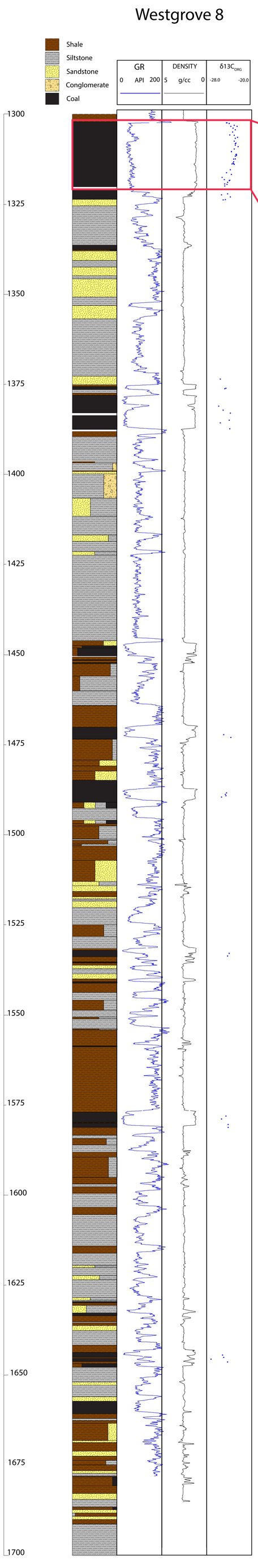
Westgrove 8 was identified as the best site to examine the upper Reids Dome beds thick seam.

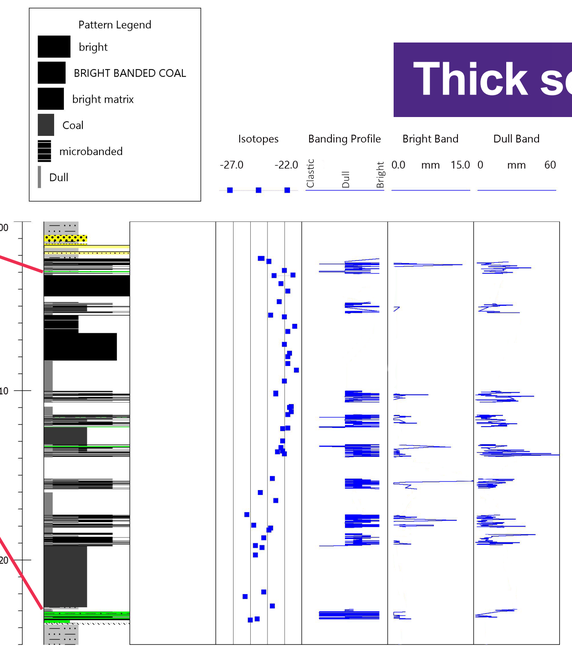
High resolution brightness profile

- Brightness profiles can reveal cyclicity within a coal seam that can be linked to climatic and vegetation changes within the original peat mire
- Slabbed desorption samples were logged at mm-scale resolution to examine fine-scale changes in lithotypes

Stable carbon isotope analysis

- Changes in $\delta^{13}C_{org}$ in deep time can be used to interpret paleoenvironment and paleoclimate at local and global scales
- Trends in $\delta^{13}C_{org}$ curves to depth or time can be utilised as a correlation tool
- Samples were selected from cored coal seams at Westgrove 8 for $\delta^{13}C_{org}$ analysis





Thick seam brightness

- mm-scale brightness log shows highly variabilty
- Dull overall with many very fine scale “microbands” <1mm thick of alternating vitrain and durain
- Isotopic trends do not follow brightness profiles or petrography - climate is the most likely driver

Figure 4: mm-scale brightness profiles, $\delta^{13}C_{org}$, banding profiles and bright and dull band thickness for the Westgrove thick seam.

Correlation to other coal measures

- Wolfang Main seam shows the same $\delta^{13}C_{org}$ cycles
- Both seams are similar thickness and APP3.2 age
- Also correlates to Blair Athol, Rugby and ?Calen coal measures
- Represent a period of approx. 250,000 to 500,000 years of peat mire development with limited clastic input prior to marine incursion
- Overlain by marine clastics equivalent to Cattle Creek or Aldebaran Sandstone
- Aldebaran Sandstone coals likely correlate to Collinsville Coal Measures

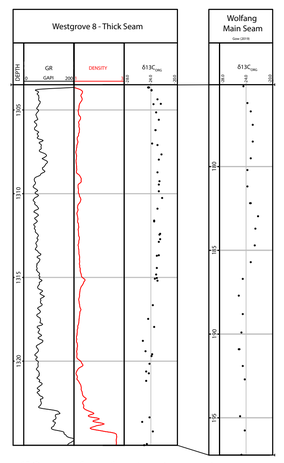


Figure 5: $\delta^{13}C_{org}$ profiles for Westgrove thick seam (this project) and Wolfang main seam (Gow, 2019) correlated to the isotope trends.

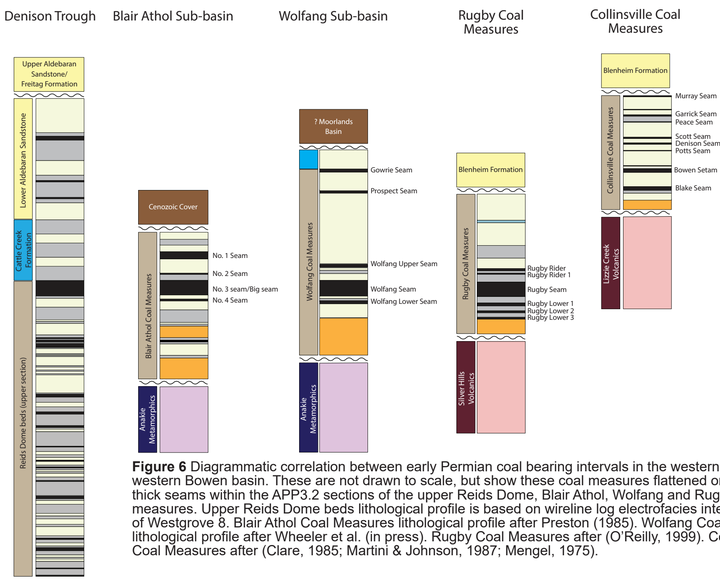


Figure 6 Diagrammatic correlation between early Permian coal bearing intervals in the western and north western Bowen basin. These are not drawn to scale, but show these coal measures flattened on the thick seams within the APP3.2 sections of the upper Reids Dome, Blair Athol, Wolfang and Rugby coal measures. Upper Reids Dome beds lithological profile is based on wireline log electrofacies interpretation of Westgrove 8. Blair Athol Coal Measures lithological profile after Preston (1985). Wolfang Coal Measures lithological profile after Wheeler et al. (in press). Rugby Coal Measures after (O'Reilly, 1999). Collinsville Coal Measures after (Clare, 1985; Martini & Johnson, 1987; Mengel, 1975).

Conclusions

- Thick coal seam development along 400km of Bowen Basin coastline during the early Permian represents a period of tectonic and climatic quiesence prior to marine incursion and the initiation of foreland loading in the Bowen Basin
- Thick coal seams present at the top of the Reids Dome beds, in the Blair Athol and Wolfang sub-basins and at the Rugby deposit are likely co-eval, representing a significantly long period of slow subsidence in small depocentres along the western margin of the Bowen Basin
- This is occurring at either the end of mechanical extension or the beginning of thermal subsidence in the Bowen Basin and is terminated by a marine incursion represented by the Sirius Mudstone Member or a transition to marine sedimentation in age-equivalent units
- Combination of palynological interpretation and stable carbon isotope analysis is an excellent tool for firming up the early Permian stratigraphic framework in the Bowen Basin

References

Clare, R. (1985). Geology of the Collinsville Coal Measures. Proceedings of the Bowen Basin Coal Symposium, 65–68. https://geoscience.data.qld.gov.au/data/report/cr072228

Foster, C. B. (1979). Permian plant microfossils of the Blair Athol Coal Measures, Baralaba Coal Measures and Basal Rewan Formation of Queensland (GSQ Publication 372). Geological Survey of Queensland.

Gow, E. (2019). Trends in δ13C Isotopes in the Wolfang Basin [Honours Thesis]. University of Queensland.

Martini, I. P., & Johnson, D. P. (1987). Cold-climate, fluvial to paralic coal-forming environments in the Permian Collinsville Coal Measures, Bowen Basin, Australia. International Journal of Coal Geology, 7(4), 365–388. https://doi.org/10.1016/0166-5162(87)90054-1

Mengel, D. C. (1975). Collinsville Coal Measures. In Economic Geology of Australia and Papua New Guinea Volume 2. Coal (1st ed., pp. 83–88). Australasian Institute of Mining and Metallurgy.

Preston, K. B. (1985). The Blair Athol Coal Measures. Proceedings of the Bowen Basin Coal Symposium, 59–64. https://geoscience.data.qld.gov.au/data/report/cr072228

Price, P. L. (1997). Permian to Jurassic palynostratigraphic nomenclature of the Bowen and Surat Basins. In P. M. Green (Ed.), The Surat and Bowen Basins, south-east Queensland (pp. 137–178). Queensland Department of Mines.

O'Reilly, K. (1999). EPC 581 Rugby—Relinquishment and final report for the period 26 July 1998 to 12 August 1999 (Queensland Exploration Report CR69180). BHP Coal Pty Limity. https://geoscience.data.qld.gov.au/data/report/cr069180

Santos Limited. (2014). PL 44, SSL WESTGROVE 8, WELL COMPLETION REPORT (Queensland Exploration Report CR093515). Santos Limited.

Sorby, L. A., & Scott, S. G. (1987). GSQ RECORD 1987/54: GEOLOGY AND COAL RESOURCES OF THE MOORLANDS BASIN, CENTRAL QLD (GSQ Record 1987/54; Geological Survey of Queensland Record). Geological Survey of Queensland.

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