

## Digging up the dirt on Western Australian coal exploration, northern Perth Basin

by

AS Millar

The first reported coal discovered by Europeans in Western Australia was in the Irwin River by explorers A and FT Gregory in September 1846 (Le Blanc Smith and Mory, 1995) within what is now known as the Permian Irwin River Coal Measures. Thin seams of Permian coal were also intersected in the Irwin River Coal Measures in drillholes located on the Beagle Ridge (MacTavish, 1965; Romanoff and Shepherd, 1974). Discussion of the exploration of these Permian coals will be covered in a separate Record which is anticipated to be published in 2017. This extended abstract covers the discovery, exploration, evaluation and basic geology of the coal within the Mesozoic of the northern Perth Basin and is part of an ongoing project to document the coal resources of Western Australia.

### Early exploration

Mesozoic coal was first intersected in petroleum exploration well Eneabba 1, drilled by West Australian Petroleum Pty Ltd (WAPET) in 1961 (Pudovskis, 1962) (Fig. 1). The section was not cored and was interpreted from basic wireline logs as containing 11.5 m of coal in five seams ranging from 1 to 3.3 m in thickness within the interval 1942.5 – 1963.2 m. The coal was considered high quality with weak coking properties which encouraged WAPET to explore known outcrops of the ‘Cockleshell Gully Formation’ in the Hill River area. WAPET completed two programs of stratigraphic and shallow test drilling; however, final results indicated the shallow coal was of poor quality and structurally complex, prompting WAPET to withdraw from the program in late 1963. No further exploration occurred in the area until the early 1970s, following the discovery of shallow coal in a water bore near Eneabba and a reinvestigation in the late 1970s and early 1980s of the areas previously explored by WAPET to the south in the Gairdner Range and Hill River areas. Exploration targeting coal on the Greenough Shelf farther north commenced in 1980 following the reporting of Jurassic coal in petroleum well Bookara 3 drilled by WAPET in 1967 (Bowering, 1967).

### Eneabba

Gold Fields Exploration Pty Ltd (GFEL) completed an extensive evaluation program at Eneabba during the early 1980s. By the end of November 1981, GFEL had drilled at

total of 14 550 m in 139 holes in and immediately around the defined coal area. The drilling density was considered sufficient for seam correlation, structure definition for ‘reserve calculation’ purposes, and for analytical testing. The deposit was estimated to contain about 153 Mt of coal to a maximum depth of 195 m or 123 Mt to a depth of 130 m (Morgan, 1981).

In 2004 Aviva Corporation purchased the now-named Central West Coal project and recommenced an evaluation program. In 2007, Aviva announced total Coal Reserves (JORC, 2004) of 72 Mt within a 130 m deep pit at strip ratio of 7.2 m<sup>3</sup>/run-of-mine (ROM) tonne. The resource was updated in 2008 with Aviva reporting a resource (JORC, 2004) calculated to a depth of 130 m to the floor of the Eneabba Main Seam (EMS) split G of 89.3 Mt total Coal Resources (McElroy Bryan Geological Services Pty Ltd, 2008). In April 2009 Aviva released the project Public Environmental Review (PER) documents for public review. In October 2009 Synergy informed Aviva that it was not the preferred tenderer for the 2009 electricity supply procurement program, hence removing the potential market for electricity produced from the Coolimba Power Project associated with any mine development. In February 2011 the Environmental Protection Authority (EPA) recommended that the Minister for Environment not approve the Central West Coal Pty Ltd proposal to mine and supply coal to the proposed Coolimba Power Project.

### Gairdner Range – Cowla Peak – Brazier

Numerous exploration companies explored the broader area during the late 1970s and 1980s resulting in only one other major discovery in the Gairdner Range – Cowla Peak – Brazier area south of the defined Eneabba Deposit. This project was formed from a number of joint ventures and led by the then CRA Exploration which estimated a non-JORC resource in excess of 500 Mt of coal over five adjacent deposits, of which about 90 Mt was considered to be extractable by opencut mining. The project was taken through a full evaluation process from 1988 to 1991. Approximately half of the identified resource (Compston, 2002) now lies within the boundaries of the Mt Lesueur National Park which was gazetted in 1992. The main coal deposits remain under title; however, little additional technical work has been completed.

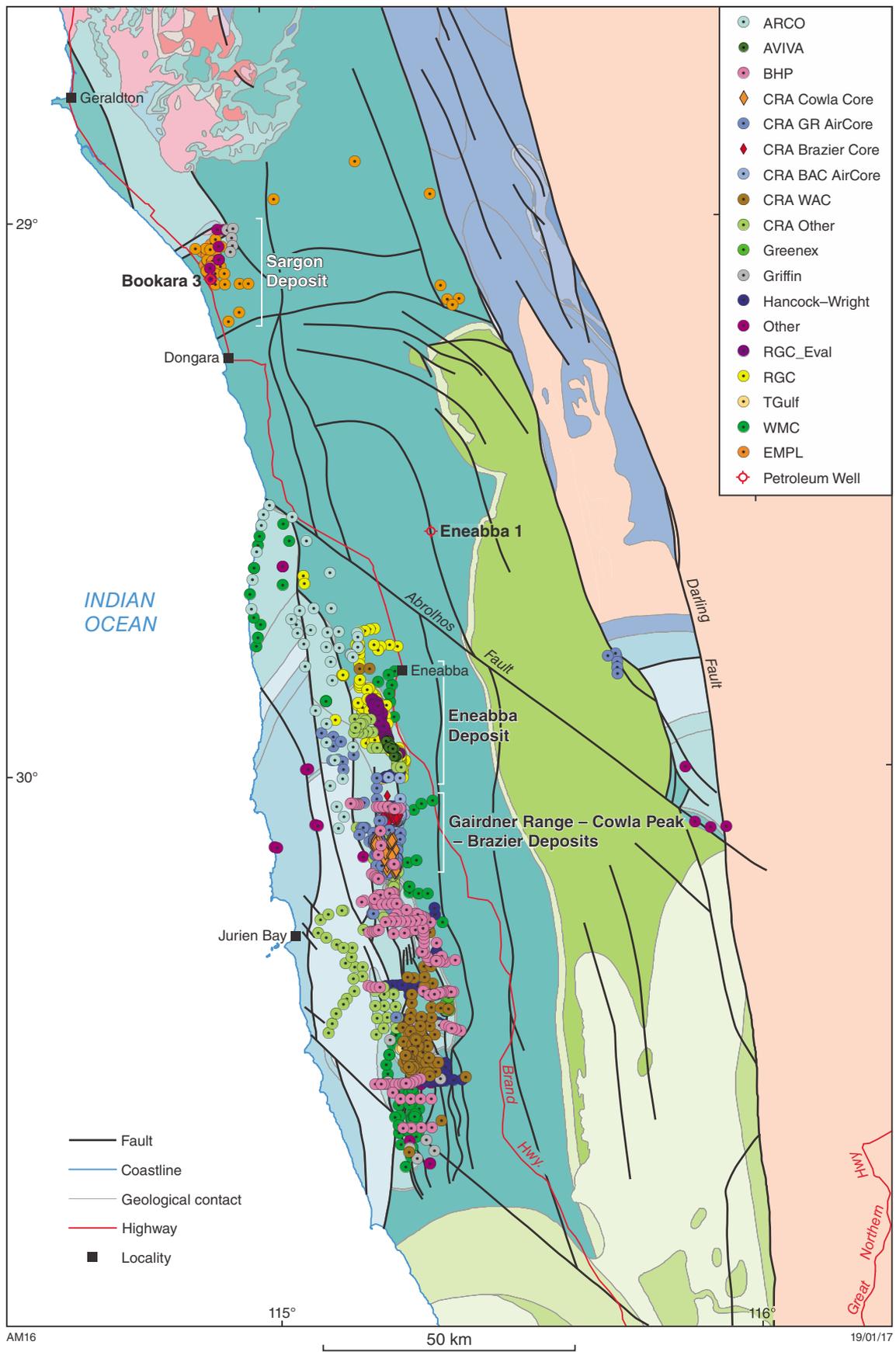


Figure 1. Location of drillholes targeting Mesozoic coal in the northern Perth Basin, coloured by company and main drilling method. Background image 1:500 000 geology (GSWA, 2016)

## Bookara

Exploration for coal on the Greenough Shelf in the Bookara area was initiated in the early 1980s with limited economic success. In 2004 Eneabba Gas Limited commenced exploration for coal seam methane (CSM) on their Sargon Project. Initial results from this program indicated that coal rank was low and that the gas content was very low to non-existent. The project then changed to targeting coal suitable for Underground Coal Gasification (UCG). By 2008 the company had completed an evaluation program allowing them to define a coal resource suitable for UCG, resulting in the reporting of a total Coal Resource of 194 Mt, which was revised up to 205 Mt in 2012 (Eneabba Gas Ltd, 2012; Westblade, 2013) under the now superseded 2004 JORC Code (JORC, 2004, 2012).

## Geology

All of the defined Mesozoic coal resources are located on the Greenough Shelf and Cadda Terrace and almost all of the coal exploration has been within these structural units and the adjacent Beagle Ridge, with only minor targeted coal exploration elsewhere.

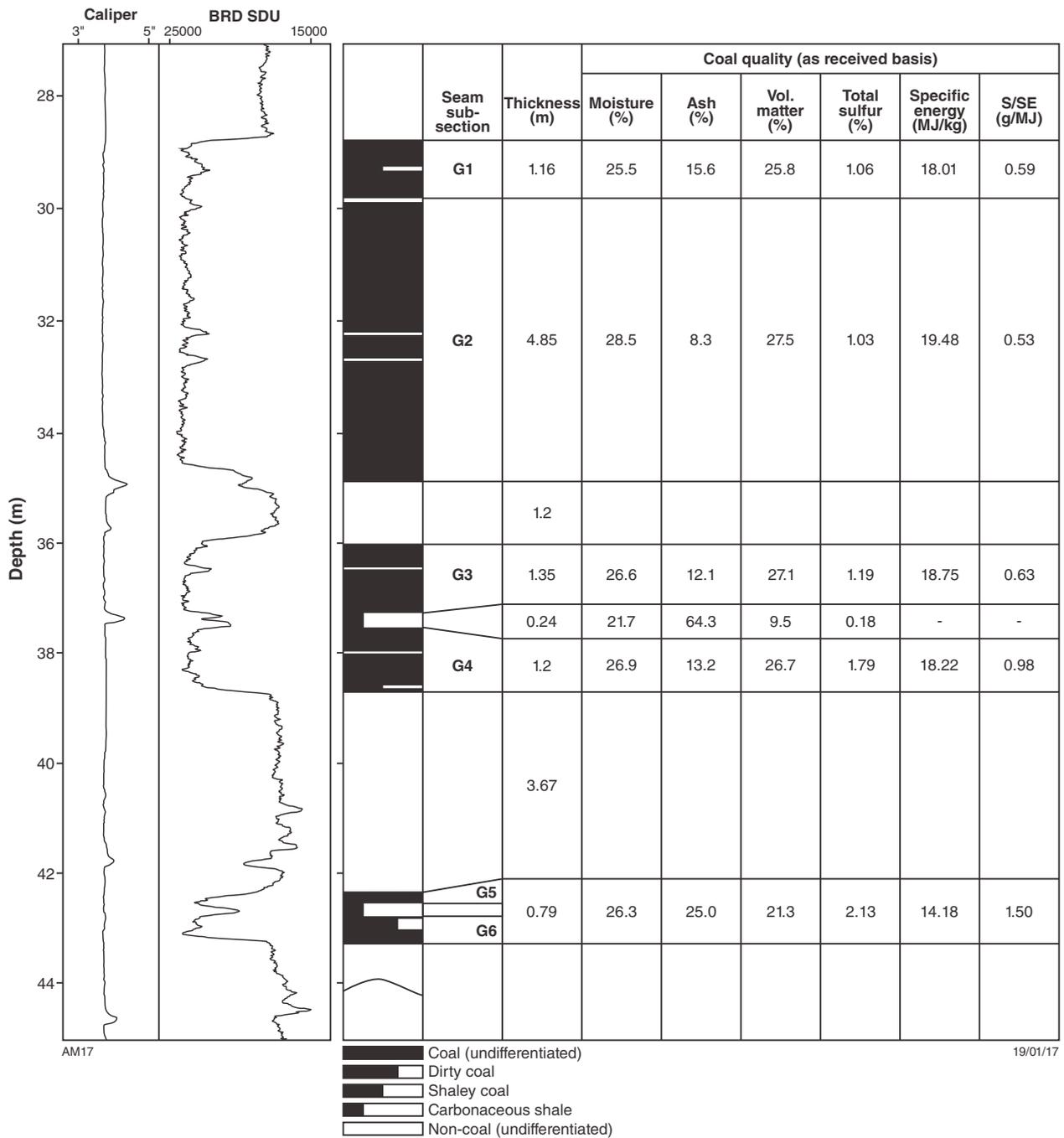
The Cattamarra Coal Measures is the principal coal-bearing unit within the Mesozoic of the northern Perth Basin. Originally named the 'Cattamarra Coal Member' for the coal-bearing unit within the Lower Jurassic 'Cockleshell Gully Formation', the name 'Cockleshell Gully Formation' was abandoned and formally replaced with the Cattamarra Coal Measures and the Eneabba Formation by Mory (1994a,b). However, the use of the abandoned terminology persists in some reporting and the historical 'Cockleshell Gully Formation' is not subdivided in most old reports.

The Cattamarra Coal Measures consists of fine- to coarse-grained sandstone interbedded with carbonaceous mudstone and seams of coal (Kristensen, 1983). Based on detailed lithotype, microlithotype and maceral analyses at the Gairdner Range – Cowla Peak – Brazier Deposit, the depositional environment is interpreted as a telmatic wet forest swamp of a brackish to upper-lower delta plain (Suwarna, 1993, 1999). Trace element analysis, palynology, the common association of bioturbation of sediments, and elevated organic sulfur levels in the coal indicate a marine influence during peat deposition.

Coal rank varies throughout the deposits, generally in the range of sub-bituminous B to sub-bituminous A (ASTM classification) with some areas of the Gairdner block of Gairdner Range – Cowla Peak – Brazier Deposit reaching high-volatile bituminous C (Kristensen, 1991). The coals are high in vitrinite and inertinite and typically low in liptinite. Vitrinite reflectance values range from 0.3% at Bookara and Eneabba up to 0.5% for the Gairdner Range – Cowla Peak – Brazier Deposit. Figure 2 is a combined plot of short spaced density (uncalibrated) and caliper logs alongside a simplified coal lithology log with summary coal quality data for the main seam (Seam G) for drillhole CPCH 23, Gairdner Range – Cowla Peak – Brazier Deposit (Park, 1987; Kristensen, 1991).

## References

- Bowering, OJW 1967, Bookara No.3 Stratigraphic Well, Northern Perth Basin. Well Completion Report; West Australian Petroleum Pty Ltd: Geological Survey of Western Australia, Statutory petroleum exploration report, W 385 A1.
- Compston, DM 2002, Combined Annual Report, M70/381, M70/382, M70/383, M70/490, M70/491, M70/492, M70/543, M70/639, c71/1999 for the period 8 May 2001 – 7 May 2002; Australian Gold Resources Ltd: Geological Survey of Western Australia, Statutory mineral exploration report, A65371.
- Eneabba Gas Ltd 2012, Coal Resource on Sargon Tenements increased to 205 million tonnes: Report to ASX, 27 November 2012.
- Geological Survey of Western Australia 2016, 1:500 000 State interpreted bedrock geology of Western Australia, digital data layer, <www.dmp.wa.gov.au/geoview>.
- JORC 2004, Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves (The JORC Code): The Joint Ore Reserves Committee of The Australasian Institute of Mining and Metallurgy, Australian Institute of Geoscientists and Minerals Council of Australia.
- JORC 2012, Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves (The JORC Code): The Joint Ore Reserves Committee of The Australasian Institute of Mining and Metallurgy, Australian Institute of Geoscientists and Minerals Council of Australia.
- Kristensen, S 1983, Annual Report for 1982 on Coal Mining Leases 70/2284-91, 70/3980-89, 70/4047-78, Cowla Peak Coal Prospect, Hill River, Western Australia. Report 11924; CRA Exploration Pty Ltd: Geological Survey of Western Australia, Statutory mineral exploration report, A36063.
- Kristensen, SE 1991, Annual Report for 1990 on the Hill River Project - Group 1 Tenements. Report 17170; CRA Exploration Pty Ltd: Geological Survey of Western Australia, Statutory mineral exploration report, A36318.
- Le Blanc Smith, G and Mory, AJ 1995, Geology and Permian coal resources of the Irwin Terrace, Perth Basin, Western Australia: Geological Survey of Western Australia, Report 44, 60p.
- MacTavish, RA 1965, Completion Report BMR 10 and 10A, Beagle Ridge, Western Australia: Bureau of Mineral Resources, Geology and Geophysics 80.
- McElroy Bryan Geological Services Pty Ltd 2008, Statement of Coal Resources, Central West Coal Project, Western Australia. Prepared for Aviva Corporation Ltd. Appendix 1; Aviva Corporation Ltd: Geological Survey of Western Australia, Statutory mineral exploration report, A82840.
- Morgan, AM 1981, Eneabba Coal Project, Geology and Reserves, November 1981; Gold Fields Exploration Pty Ltd: Geological Survey of Western Australia, Statutory mineral exploration report, A36032.
- Mory, AJ 1994a, Geology of the Arrowsmith – Beagle Islands 1:100 000 sheet: Geological Survey of Western Australia, 1:100 000 Geological Series Explanatory Notes, 26p.
- Mory, AJ 1994b, Geology of the Hill River – Green Head 1:100 000 sheet: Geological Survey of Western Australia, 1:100 000 Geological Series Explanatory Notes, 29p.
- Park, WJ 1987, Annual Report for 1986 on 70/2284-2291, 3980-3989, 4047-4050, 4052-4054, 4060, 4061, 4064-4068, ELA 70/236, Cowla Peak, Hill River, SH-50-09, Western Australia. Report No. 14402; CRA Exploration: Geological Survey of Western Australia, Statutory mineral exploration report, A36067.
- Pudovskis, V 1962, Eneabba No.1 Well Completion Report; West Australian Petroleum Pty Ltd: Geological Survey of Western Australia, Statutory petroleum exploration report, W 34 A2.



**Figure 2. Combined plot of short spaced density (uncalibrated) and caliper logs alongside a simplified coal lithology log and summary coal quality data for the main seam (Seam G) for drillhole CPCH 23, Gairdner Range – Cowla Peak Deposit (modified after Park, 1987 and Kristensen, 1991)**

Romanoff, A and Shepherd, N 1974, Green Head Coal Prospect, Green Head, Western Australia, Final Report; AMAX Exploration (Australia) Inc.: Geological Survey of Western Australia, Statutory mineral exploration report, A35874.

Suwarno, N 1993, Petrology of Jurassic Coal, Hill River Area, Perth Basin, Western Australia: Curtin University of Technology, Perth, PhD thesis (unpublished).

Suwarno, N 1999, Jurassic coal in Western Australia and its depositional environment, in GEOSEA '98: Geological Society of Malaysia; Bulletin 45, p. 275–289.

Westblade, D 2013, Sargon Project, Annual report for the period 15 November 2011 to 14 November 2012, E70/2758; Eneabba Mining Pty Ltd: Geological Survey of Western Australia, Statutory mineral exploration report, A96234.