Ganguddy-Kelgoola Coal Resource Assessment

AUTH 230

October 2021

Published by Regional NSW

Title: Ganguddy-Kelgoola Coal Resource Assessment

Subtitle: AUTH 230

Department reference number: DOC21/883426

Executive summary

The ‘Ganguddy-Kelgoola’ release area (AUTH 230) is located approximately 9 km east of Rylstone and mostly within the Mid-Western Regional Local Government Area, but small sections fall within Muswellbrook, Singleton and Lithgow Local Government Areas.

In 2000 the Geological Survey of NSW (GSNSW) completed a resource assessment of the ‘Ganguddy-Kelgoola’ release area based on all available information. No new exploration data has been collected since this date. The resource estimate has now been refined, in particular for the Lithgow Seam.

Based on the available data, the estimated in-situ coal resource in AUTH 230 is 500 million tonnes (Mt) in the Lithgow Seam, and a total of 470 Mt in the Katoomba, Mt Brace and Lidsdale seams that are of poorer quality than the Lithgow Seam (Table 1). This area may be amenable to underground longwall mining. However, due to numerous intrusions in the area, further exploration would better define their extent and impact.

Table 1. Inventory resource estimation for Ganguddy-Kelgoola (AUTH 230)

Seam	Average Thickness (m)	Relative Density (g/cc)	Moisture (%, ad)	Raw Ash (%, ad)	Volatile Matter (%, ad)	Calorific Value* (MJ/Kg)	Inventory tonnes (Million tonnes)
Katoomba	2.56			25.5	23.7	23.7	50
Mt Brace	1.81			23.0	24.6	24.6	70
Lidsdale Upper	2.74			28.5	22.6	22.6	90
Lidsdale Lower	2.20			28.6	22.6	22.6	270
Lithgow	2.66	1.45	2.10	16.10	27.50	27.0	500

- *The 2000 resources (Katoomba, Mt Brace, Lidsdale Upper and Lidsdale Lower seams) were constrained by a minimum thickness of 1.5m and a maximum raw ash of 35 per cent*
- *The 2021 estimate (Lithgow seam) was constrained to a minimum 0.3 m ply thickness, 35 per cent raw ash and a maximum depth of 600m*

**The calorific value has been calculated from raw ash.*

The Lithgow Seam is a low to medium ash thermal coal that would meet export market specifications. A high-level conceptual underground mine plan, for the Lithgow Seam, shows that approximately 150 Mt of run of mine (ROM) coal could be extracted, supporting an annual production rate of around 4 Mt and a mining life of greater than 20 years.

The conceptual mine plan also identified that coal could be exported through either the port at Newcastle or Port Kembla, both would involve similar rail distances. However, potentially railing to and shipping from Newcastle may be more favourable, since it is likely less rail upgrading is needed. Furthermore, any potential new coal operation in the Ganguddy-Kelgoola release area would require a new rail spur of around 20 km in length to link to the existing rail line.

A high-level costing assessment was undertaken for the Ganguddy-Kelgoola release area based on a similar analysis done for the nearby Hawkins Rumker coal area, due to the geological and geographical similarities between the two areas. The free-on-board (FOB) cost for an operating mine at Ganguddy-Kelgoola site is estimated to be A$80 per product tonne. This estimate is at the upper end of the range of the cost curve for the majority of export thermal coal mines in NSW. The likely capital cost to establish a mine at Ganguddy-Kelgoola could be around A$775m (in 2020 dollars), including a coal handling and preparation plant (CHPP).

Any mining operation in the area would require substantial infrastructure investment in the form of rail upgrades, development of a new spur railway line and building a CHPP, to ensure that the coal meets market expectations. Consequently, it is possible the capital and operating costs for the potential resource would be much higher than other comparative longwall greenfield projects in the state.

In addition to the infrastructure requirements, a key unresolved geological issue is the extent and impact of the intrusions throughout the area. The presence of intrusions can negatively impact the coal quality, mine layout and the optimal operation of longwalls.

The geography of the area is mostly forested, rugged hills. This would present surface access challenges for any future exploration and mine operation. Furthermore, cliff lines and ravines would likely restrict mine plan options, due to the need to manage subsidence for any proposed underground mining.

The coal resource has the potential to provide continuity of high-quality thermal coal supply from NSW, commencing in about 15 to 20 years. This lead time is estimated based on the current timeframes to complete the required exploration, mine planning and environmental studies to lodge a development application for a proposed new mine. In this time frame the global seaborne thermal coal market is forecast to be smaller than today. This could present challenges for any new greenfield coal mine competing with established operations in NSW and/or internationally in a contracting market.

The findings in this report are based on a high-level assessment of available data and are constrained by the limited available geological data and lack of detailed financial modelling. Thus, the commercial competitiveness and economic viability of a greenfield underground coal mine in the Ganguddy-Kelgoola release area remains highly uncertain. All costs estimated in this high-level report are indicative only.

Contents

List of tables

List of figures

Introduction

Coal mining is an important industry for NSW and is a significant source of employment and economic activity in regional NSW.

Coal mining in NSW occurs mainly in the Sydney, Gunnedah, and Gloucester basins.

NSW is a controlled release area for coal. New coal exploration licences can only be allocated after Ministerial consent in granted and via one of three release pathways:

1. **Strategic release framework**: defined by the *Strategic release framework for coal and petroleum exploration*.
2. **Operational allocation framework**: defined by 13C of the *Mining Act 1992*, cl 20 of the Mining Regulation 2016 and the *Guidelines for coal exploration licence applications for operational allocation purposes*.
3. **Competitive allocation pathway**: defined by the *Guideline for the competitive allocation of coal*.

The coal resource in the Ganguddy-Kelgoola area, within Authorisation 230 (AUTH 230) was identified as an area for potential release for coal exploration under the *Strategic release framework for coal and petroleum exploration* in the NSW Government's Future of Coal Statement (June 2020).

Location and land use

The Ganguddy-Kelgoola coal resource area is located approximately 150 km northwest of Sydney and 60 km south-east of Mudgee (Figure 1). Rylstone is approximately 9 km to the west. In the south, east and north the area is bounded predominantly by the Wollemi National Park. South-west of the boundary, the western tip of the of the area and to the west is agricultural land.

The central part of the area is covered by the Nullo Mountain State Forest and in the south-east the area includes the majority of the Coricudgy State Forest. Exploration and mining can occur within State Forest areas.

The area is mostly forested, rugged hills, becoming flatter in the west as topography becomes less steep. Pockets of agricultural land exist in the low lying, flat valleys between the hills. Access to the resource area is via Narrango Road and Nullo Mountain Road from the west. Land use in and around the area is characterised by a combination of agriculture, forestry, mining, tourism, small-scale hobby farms, and conservation.

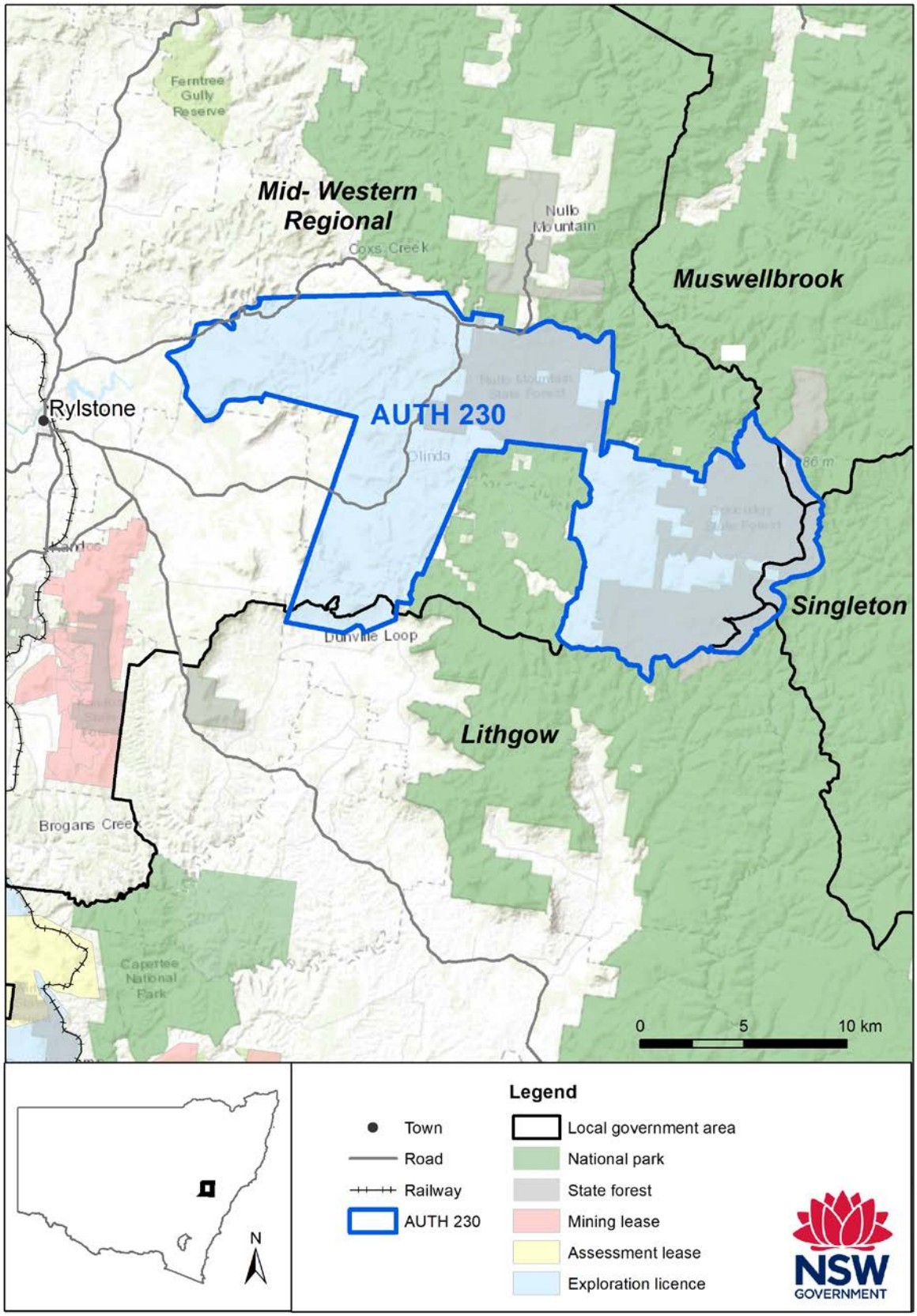

Figure 1. Location of the Ganguddy-Kelgoola release area (AUTH 230).

Resource assessment

An initial resource assessment was completed by the Geological Survey of NSW (GSNSW) in 2000 (Tadros et al 2000). Resources provided within this report for all seams, except the Lithgow Seam, are from this initial assessment. The Lithgow Seam resources were revised, because the previous resource areas went beyond the current area covered by AUTH 230, held by the Secretary of Regional NSW.

Coal resource estimates within this report were prepared with reference to the '*Australian Guidelines for the Estimation and Classification of Coal Resources*'. The estimates are for 'Inventory Coal', a term that describes an estimate of the unconstrained coal tonnages in-situ. The term 'Inventory Coal' is used when reporting to Government or for the purpose of strategic planning internally within companies.

The assessment completed in 2000 provides a high-level summary of the quantity and quality of inventory coal within the Ganguddy-Kelgoola release area, based on the available information at that time. This includes:

- an assessment of the quality and quantity of inventory coal within the proposed release area;
- identification of geological constraints on coal extraction that may inhibit release of the area; and
- high-level assessment of mining opportunities at the site, including commentary of coal market conditions.

Exploration history

A total of 60 coal exploration holes and one petroleum well (Table 2, Figure 2) have been drilled within the AUTH 230 area, between 1972 and 1992. AUTH 230 was granted on 4 August 1980 and was last renewed on 24 March 2021 until 4 August 2025. The authority was originally 351 km^2 in area and has been reduced in size three times since grant to 276 km^2 (DRNSW 2021).

Fifty eight of these holes have been drilled by the NSW government and 3 by companies. In 1997 the Department conducted an airborne magnetic / radiometric geophysical survey to help identify igneous intrusions that may negatively affect the coal seams.

Table 2. Historic drilling by the Department within AUTH 230 (including relinquished areas).

Drill Program	Number of holes	Year drilled
Wancol - Kandos	2	1972
JDP - Ulan	3	1975
Rylstone Stage 1	5	1980-1981
Rylstone Stage 2	15	1981-1982
Rylstone Stage 3A	13	1983
Rylstone Stage 3B	22	1986
Pacific Power - Hunter Coricudgy	1	1996

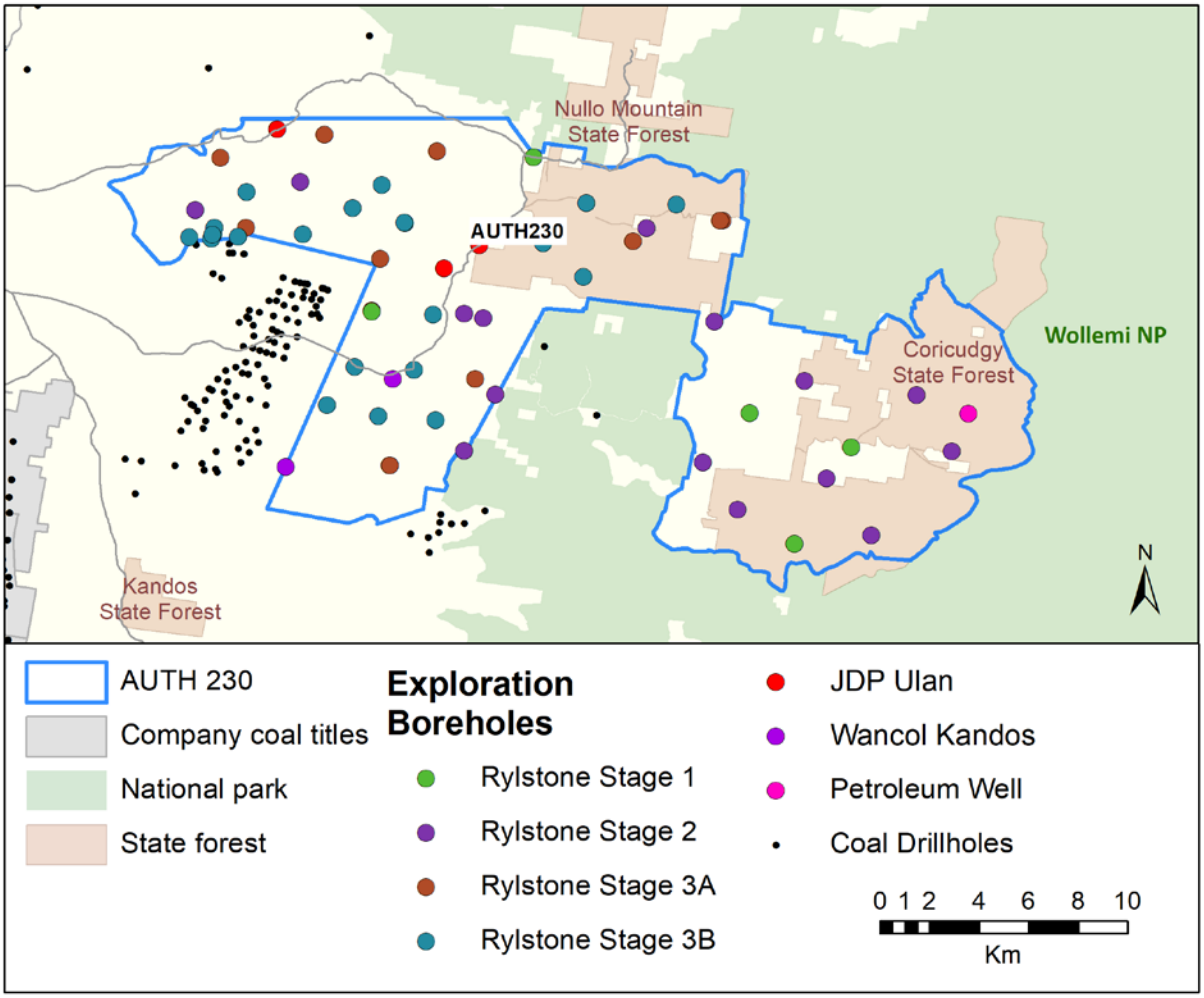

Figure 2. Department drilling within the Ganguddy-Kelgoola release area (AUTH 230).

Local geology

The Ganguddy-Kelgoola release area (AUTH 230) is located within the Western Coalfield of the Sydney Basin, near its western limit. The basin deepens towards the south-east in conjunction with thickening of the basin units. West of the Sydney Basin in this area is the Late Cambrian to Carboniferous Lachlan Orogen.

The stratigraphy of the Sydney Basin in this area is shown in Figure 3. The surface geology is dominated by the sandstones of the Triassic Narrabeen Group (Figure 4), often forming cliffs or pagoda style landforms. The underlying Late Permian Illawarra Coal Measures, that contain the coal seams in this area, are exposed in the valley floors. These include a range of sedimentary rocks such as shales, sandstones, conglomerates, carbonaceous mudstones and coal seams.

There are several small, scattered areas of Cenozoic basaltic outcrop, often forming topographic highs, spread from the western to the eastern boundary of the area. The largest is approximately 3.5 km by 1.5 km. Diatremes are another igneous surface feature. These are usually circular in shape, (generally less than 1 km in diameter) and often form areas of depression due to preferential weathering/erosion.

Structurally the sediments are gently folded about the Mount Coricudgy Anticline that trends in a northeast direction. The Mount Tomah monocline runs across the area in a northerly direction (Figure 4).

Intrusions

Geological mapping in the Rylstone area identified numerous intrusions indicating a high level of igneous activity during the Mesozoic and Tertiary periods. The mapped igneous features include diatremes and basaltic plugs, caps and flows. Sills are only exposed at a few locations however they have been intersected in drill holes. Diatremes and basaltic plugs, have not been intersected in previous exploration drilling.

In 1997, the Department completed a 5,500 km airborne geophysical survey over the area (ENCOM 1997). This survey aimed to identify and map these igneous intrusions. The interpretation of this aeromagnetic survey showed numerous diatremes and some are intruded by basaltic plugs (Figure 5). The impact of these igneous intrusions on the coal resources was assessed and included within the Tadros et al. (2000) resource estimate. However, further targeted drilling into the interpreted intrusions would be required to properly quantify the impact of intrusions on the coal seams and possible future mining.

Period	Group	Subgroup	Formation	Member	Primary Lithology
Triassic			Napperby Formation		Sandstone, siltstone
			Hawkesbury Sandstone		Sandstone
	Narrabeen Group		Digby Formation		Sandstone, claystone, siltstone
Late Permian	Illawarra Coal Measures	Wallerawang Subgroup	Katoomba Seam		Coal
			Farmers Creek Formation		Claystone, shale, mudstone, siltstone and sandstone
				Burragorang Claystone	Claystone
				Middle River Coal	Coal
			Gap Sandstone		Sandstone
		Charbon Subgroup	State Mine Creek Formation		Claystone, mudstone, siltstone
				Moolarben Coal Member	Coal
			Watts Sandstone		Sandstone
			Denman Formation		Shale, siltstone, sandstone
			Glen Davis Formation	Bungaba Coal Member	Coal
					Claystone, siltstone, mudstone, sandstone
			Newnes Formation		Sandstone, mudstone, siltstone, claystone
			Long Swamp Formation	Irondale Coal	Coal
					Claystone and siltstone, tuff, sandstone, coal
				Ulan A	Coal
					Claystone and siltstone, tuff, sandstone, coal
				Ulan B - C	Coal, tuff
		Cullen Bullen Subgroup	Ulan Coal Lower	Ulan E - D	Coal
				F Ply	Tuff
				Ulan G	Coal
			Blackmans Flat Formation		Sandstone, conglomerate
			Lithgow Seam		Coal
			Marrangaroo Formation		Sandstone
		Nile Subgroup	Gundangaroo Formation		Claystone, sandstone
			Coorongooba Creek Sandstone		Sandstone
			Mount Marsden Claystone		Limestone, dolomite, claystone, siltstone
Mid Permian	Shoalhaven Group		Berry Siltstone		Siltstone
			Snapper Point Formation		Sandstone, conglomerate

Figure 3. Stratigraphy of the Western Coalfield of the Sydney Basin. After Yoo et al. (2001).

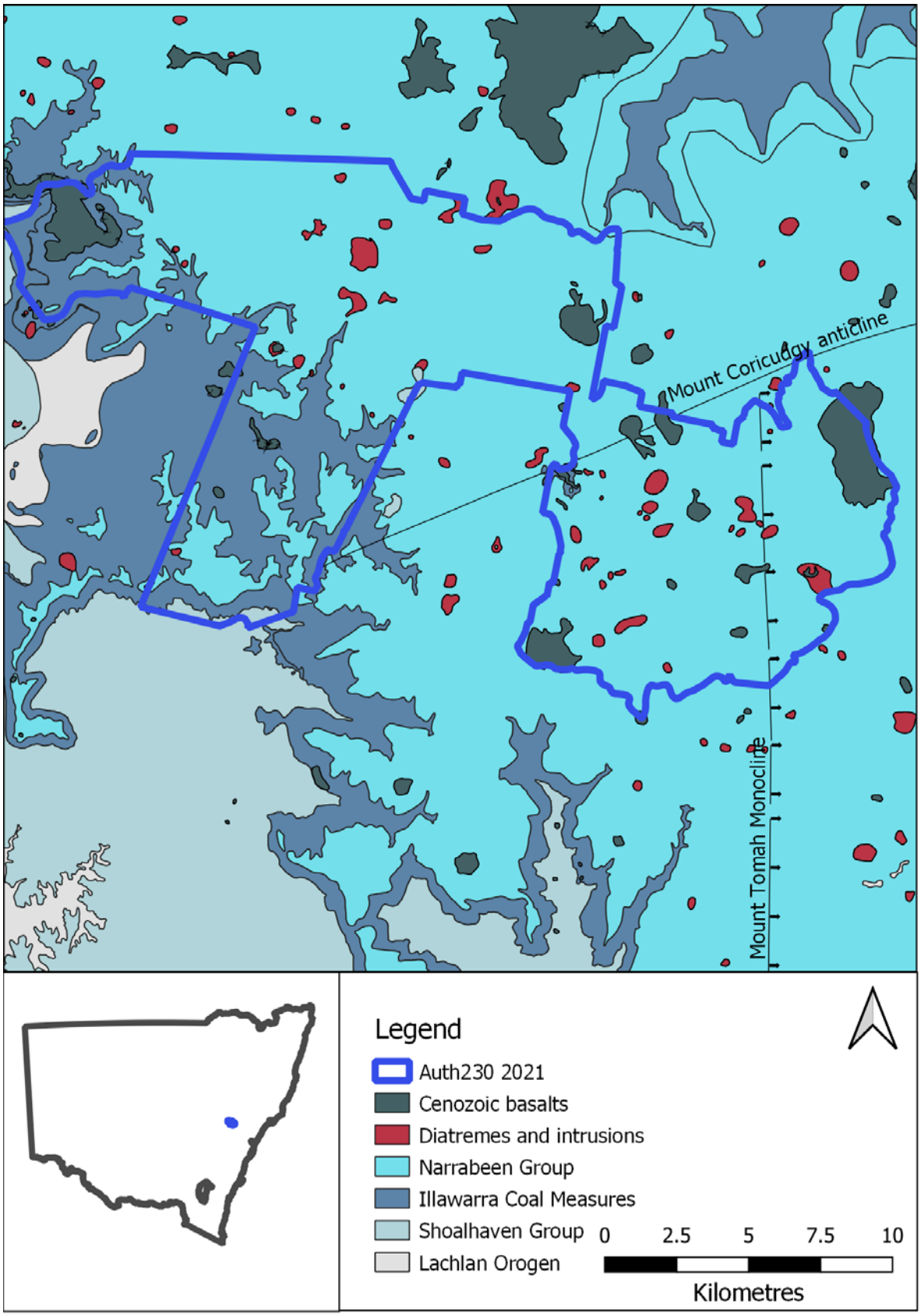

Figure 4. Surface geology of Ganguddy Kelgoola (AUTH 230).

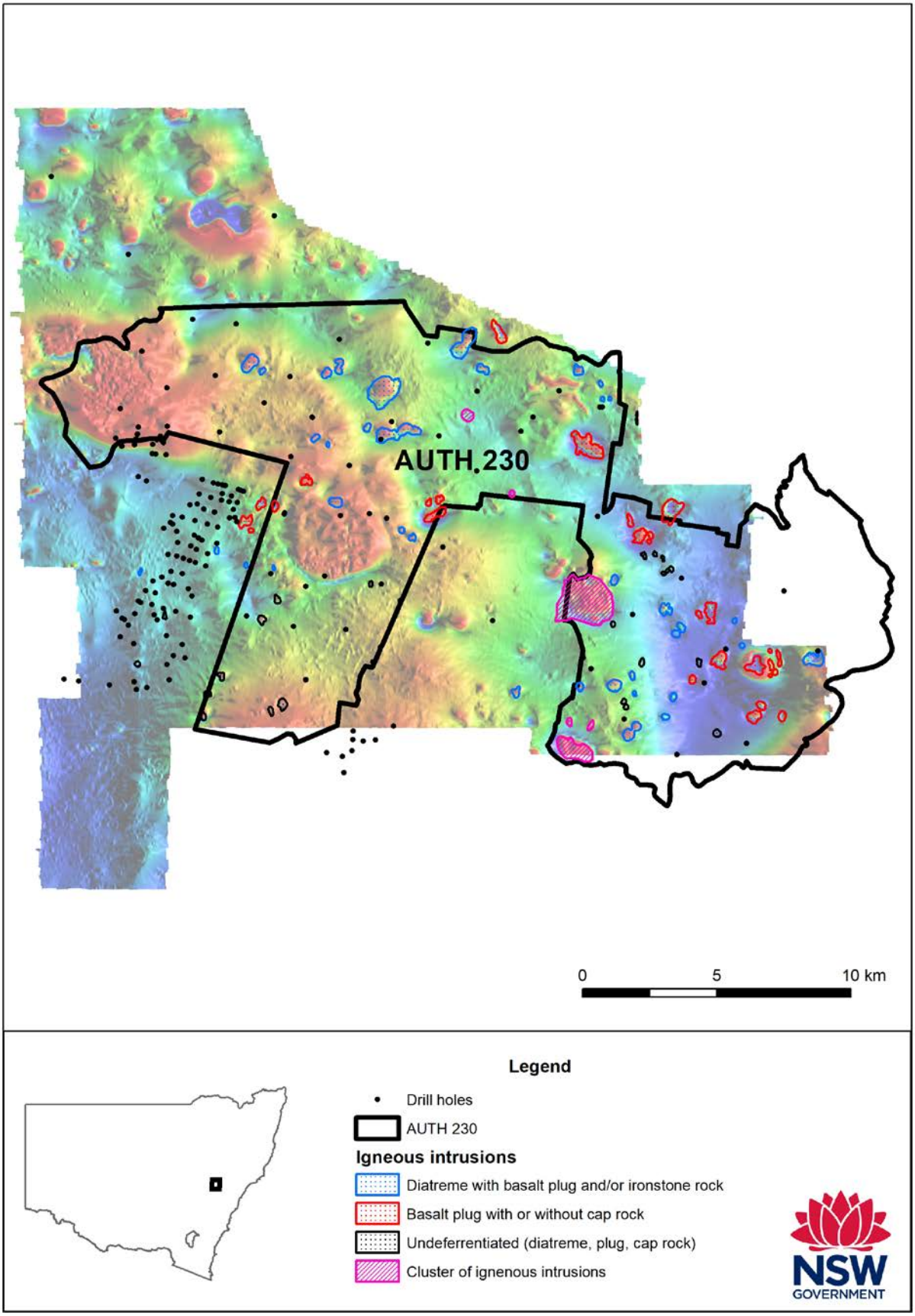

Figure 5. Interpretation of 1997 airborne magnetic survey, indicating types and location of intrusions.

Coal geology and quality

The Illawarra Coal Measures are exposed at surface within AUTH 230 (Figure 4). They outcrop in the valleys and on the side of the ridges on the western side of the authorisation and dip to the east, becoming over 1,000 m deep.

The modelling of Tadros et al. (2000), identified areas, or resource blocks, for each of the seams that had similar characteristics (Figure 6).

The seams with potential for mining are discussed below.

Katoomba Seam

The Katoomba Coal seam is the uppermost seam of the Illawarra Coal Measures. In places it grades down to a thick coaly and carbonaceous sequence. The seam is predominantly dull coal with some bright coal bands and common thin tuff bands (Figure 6). The top of the seam is sometimes eroded in places from the deposition of sandstones of the overlying Narrabeen Group. Three resource blocks were defined in the resource estimation, namely the Coolcalwin, Kelgoola West and the Kelgoola East Resource blocks.

Coolcalwin resource block

This block is located on the western side of AUTH 230. It covers an area of 4.6 km^2. The depth of the Katoomba seam in this block is between 0 and 200 m. The modelled mineable seam thickness averages at 2.44 m. The modelled raw ash averages at 29.4 per cent and the energy averages at 22.3 MJ/Kg.

The Coolcalwin resource block is only marginally affected by intrusions.

Kelgoola West resource block

This block is located on the eastern side of AUTH 230. It covers an area of 15.2 km^2. The depth of the Katoomba seam in this block is between 86 and 543 m. The modelled mineable seam thickness averages at 2.43 m. The modelled raw ash averages at 25.1 per cent and the energy averages at 23.2 MJ/Kg.

This resource block is severely affected by igneous intrusions.

Kelgoola East resource block

This block is located on the eastern side of AUTH 230. It covers an area of 39 km^2. The depth of the Katoomba seam in this block is between 271 and 555 m. The modelled mineable seam thickness averages at 2.79 m. The modelled raw ash averages at 24.3 per cent and the energy averages at 24.1 MJ/Kg.

This block is situated outside the area covered by the aeromagnetic survey, it is close to the large basaltic intrusion of Mt Coricudgy. The information on the igneous intrusions in this block shows that, like the others, it is affected by numerous intrusions.

Mt Brace Seam

The Mt Brace seam consists of a banded basal section and an upper coaly section (Figure 7). The non-coal bands are mostly claystone and tuff. The seam is best developed in an area north of DE Rylstone DDH 17 and while present elsewhere it is usually too thin for mining.

Coolcalwin West resource block

This block is located on the Western part of AUTH 230. It covers an area of 39 km^2. The depth of the Mt Brace seam in this block is between 6 and 526 m. The modelled mineable seam thickness averages at 1.66 m. The modelled raw ash averages at 23 per cent and the energy averages at 24.5 MJ/Kg.

The Coolcalwin West resource block appears to be moderately affected by diatremes, plugs and vents scattered throughout the central and eastern parts of the block.

Lidsdale Upper Seam

The Lidsdale Upper Seam is poorly formed over most of AUTH 230. It generally consists of a thin coal band overlain by mudstone or carbonaceous mudstone (Figure 8). The seam thickens significantly in the south of the Kelgoola area.

Kelgoola South resource block

This block is in the southern area of the Kelgoola area. It covers an area of 26.6 km^2. The depth of the Lidsdale Upper seam in this block is between 355 and 817 m. The modelled mineable seam thickness averages at 2.7 m. The modelled raw ash averages at 27 per cent and the energy averages at 23.1 MJ/Kg.

The Kelgoola South resource block appears to be moderately affected by diatremes, plugs and vents mainly in the central and northern parts of the block.

Lidsdale Lower Seam

The Lidsdale Lower Seam has variable thickness across AUTH 230. The seam consists of dull coal with minor bright bands (Figure 8). The Lower Lidsdale is between zero and seven metres below the Lidsdale Upper Seam. Three resource blocks identified.

Coolcalwin West resource block

This block is located on the eastern side of AUTH 230. It covers an area of 42.8 km^2. The depth of the Lidsdale Lower Seam in this block is between 44 and 542 m. The modelled mineable seam thickness averages at 2.2 m. The modelled raw ash averages at 25 per cent and the energy averages at 23.8 MJ/Kg.

The Coolcalwin West resource block appears to be less affected by diatremes, plugs and vents. In all, there are two clusters, located in the north-east and south. However, there is an igneous sill which occupies a large area in the south-east.

Coolcalwin East resource block

This block is in the central area of AUTH 230. It covers an area of 13.4 km^2. The depth of the Lidsdale Lower Seam in this block is between 292 and 717 m. The modelled mineable seam thickness averages at 2.2 m. The modelled raw ash averages at 33 per cent and the energy averages at 21.0 MJ/Kg.

Coolcalwin East appears to be affected to a very limited extent by diatremes, plugs and vents. In all, there are some five small intrusions, three of which affect the thin edge of the working section in this resource block.

Kelgoola West resource block

This block is located on the western side of AUTH 230. It covers an area of 42.8 km^2. The depth of the Lidsdale Lower Seam in this block is between 280 and 746 m. The modelled mineable seam thickness averages at 2.1 m. The modelled raw ash averages at 30 per cent and the energy averages at 22.07 MJ/Kg.

The Kelgoola West resource block appears to be the most affected by diatremes, plugs and vents. In all, there are 25 individual and clustered intrusions that severely impact the mining potential of this resource block.

Lithgow Seam

The Lithgow Seam conformably overlies the Marrangaroo Formation and typically consists of dull coal with minor bright bands, carbonaceous claystone and stony coal (Figure 9). Three resource blocks were delineated.

Coolcalwin resource block

This block is located on the north eastern side of AUTH 230. It covers an area of 74.7 km^2. The depth of the Lithgow Seam in this block is between 160 and 600 m. The modelled mineable seam thickness averages at 2.68 m. The modelled raw ash averages at 15.3 per cent and the energy averages at 27.3 MJ/Kg.

Much of the Coolcalwin Resource Block area has been interpreted as underlain by two types of igneous intrusions in the form of sills. These are either sills at depth with a high probability of significant thickness. Alternatively, thin sills that do not affect the coal seams.

Drilling in this block has indicated that the Lithgow seam is free of igneous intrusions and that the sills have been emplaced at higher stratigraphic levels within the coal measures affecting some of the seams above the Lithgow seam.

Burrowoury resource block

This block is located on the south eastern side of AUTH 230. It covers an area of 41.4 km^2. The depth of the Lithgow Seam in this block is between 0 and 480 m. The modelled mineable seam thickness averages at 2.52 m. The modelled raw ash averages at 19.9 per cent and the energy averages at 28.1 MJ/Kg.

The Burrowoury resource block appears to be the least affected by igneous intrusions. In all, there are ten scattered, generally widely spaced small size igneous intrusions affecting the Lithgow seam.

Kelgoola resource block

This block is located on the western side of AUTH 230. It covers an area of 43.2 km^2. The depth of the Lithgow Seam in this block is between 293 and 600 m. The modelled mineable seam thickness averages at 3.65 m. The modelled raw ash averages at 23 per cent and the energy averages at 28.0 MJ/Kg.

The Kelgoola resource block appears to be the most affected by igneous intrusions. In all, there are nine individual and eleven clusters of igneous intrusions that may affect the Lithgow seam.

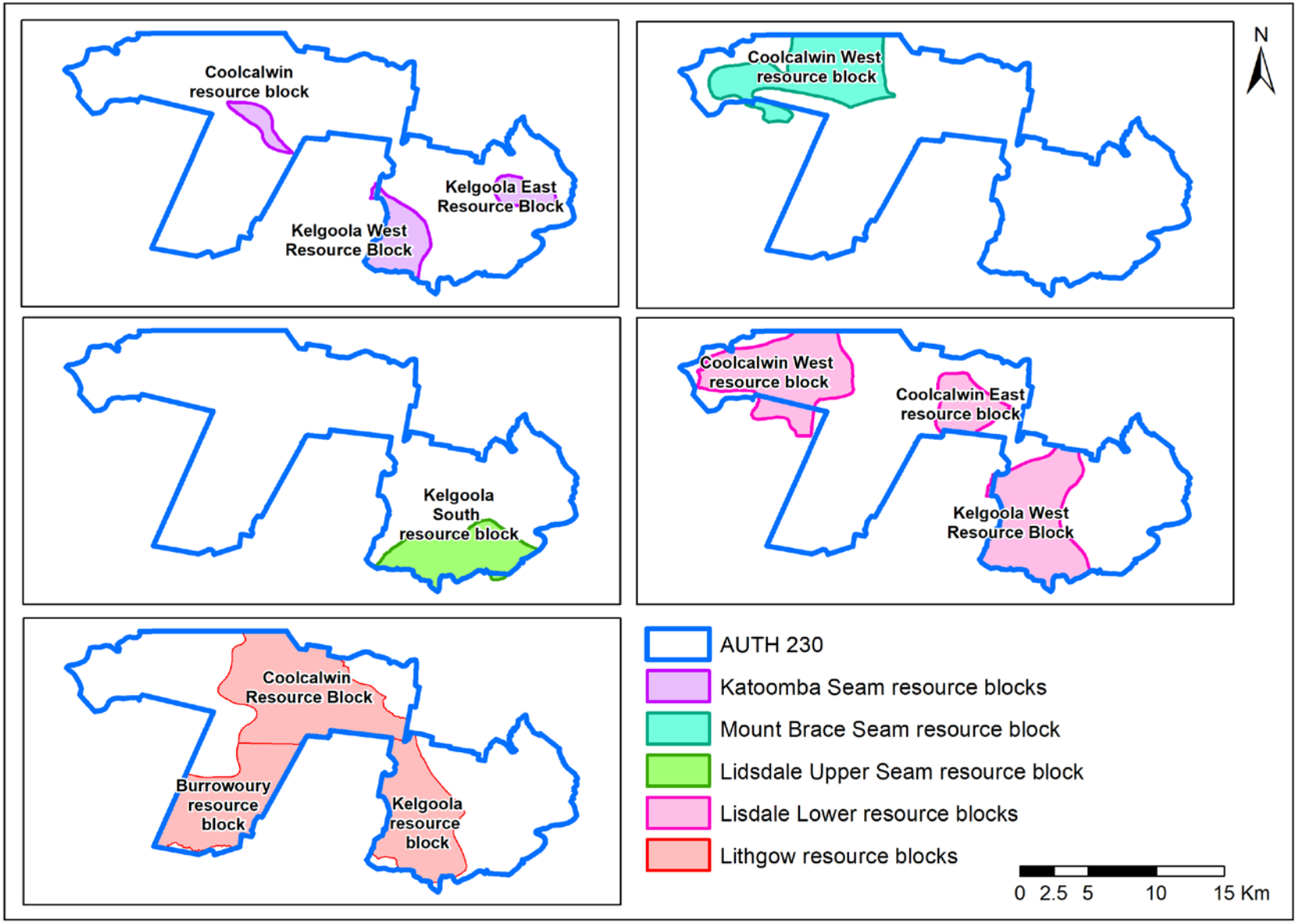

Figure 6. Diagram showing the extent of the resource blocks, by seam, from Tadros et al. (2000). report

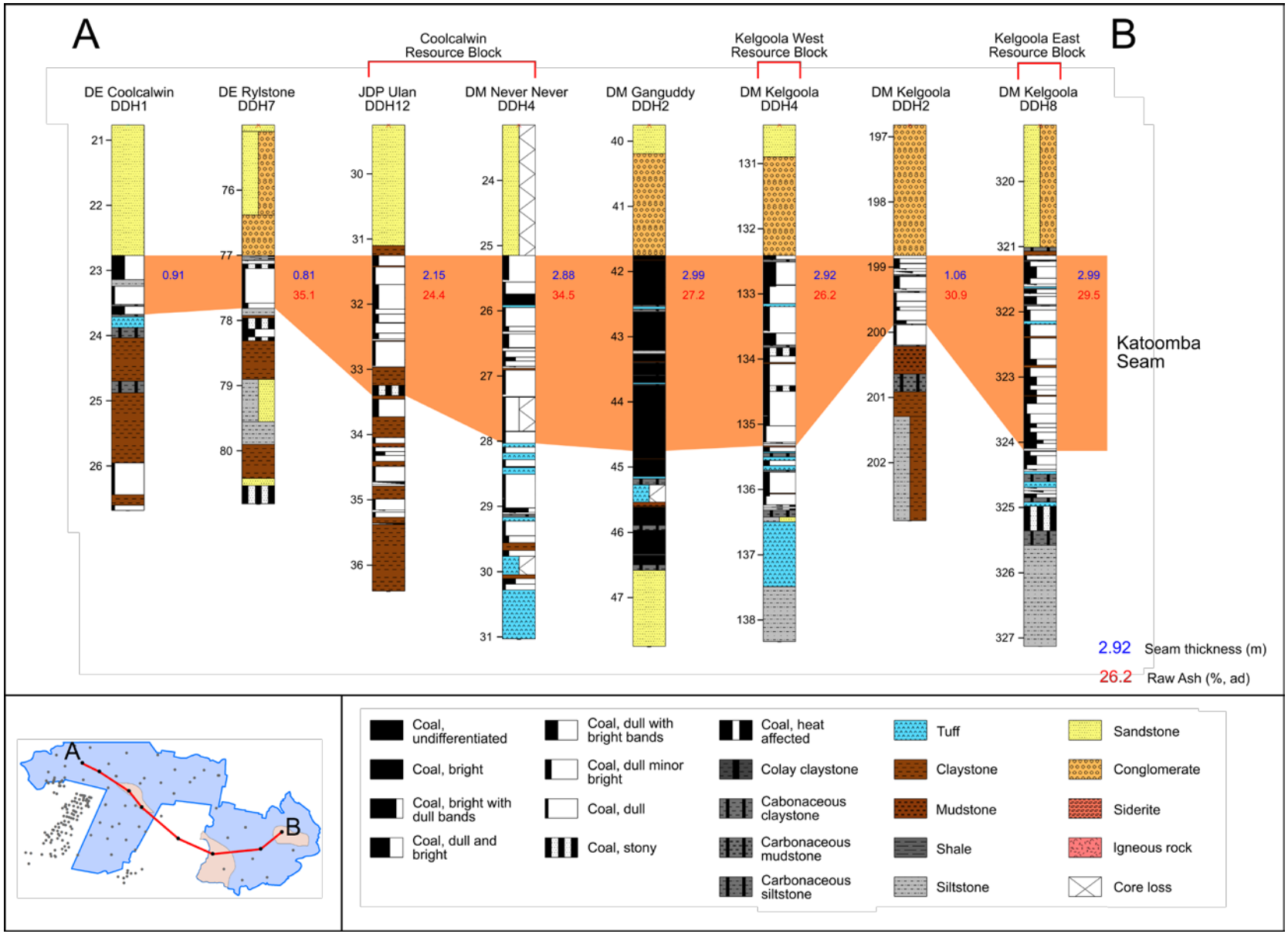

Figure 7. Seam correlation across Ganguddy-Kelgoola release area (AUTH 230) through resource blocks - Profile of Katoomba seam (no horizontal scale).

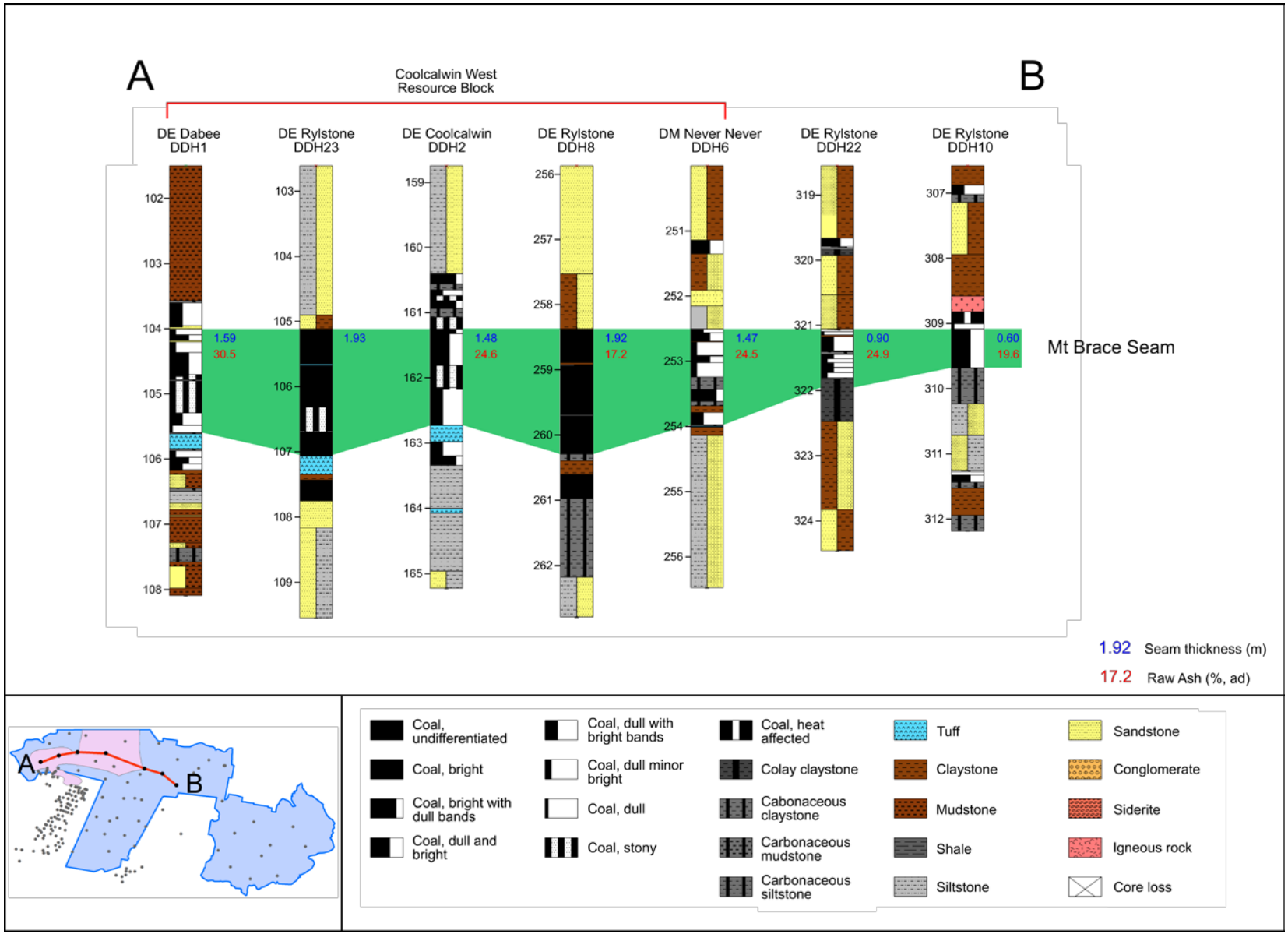

Figure 8. seam correlation across Ganguddy-Kelgoola release area (AUTH 230) through the resource block- Profile of Mt Brace Seam (no horizontal scale).

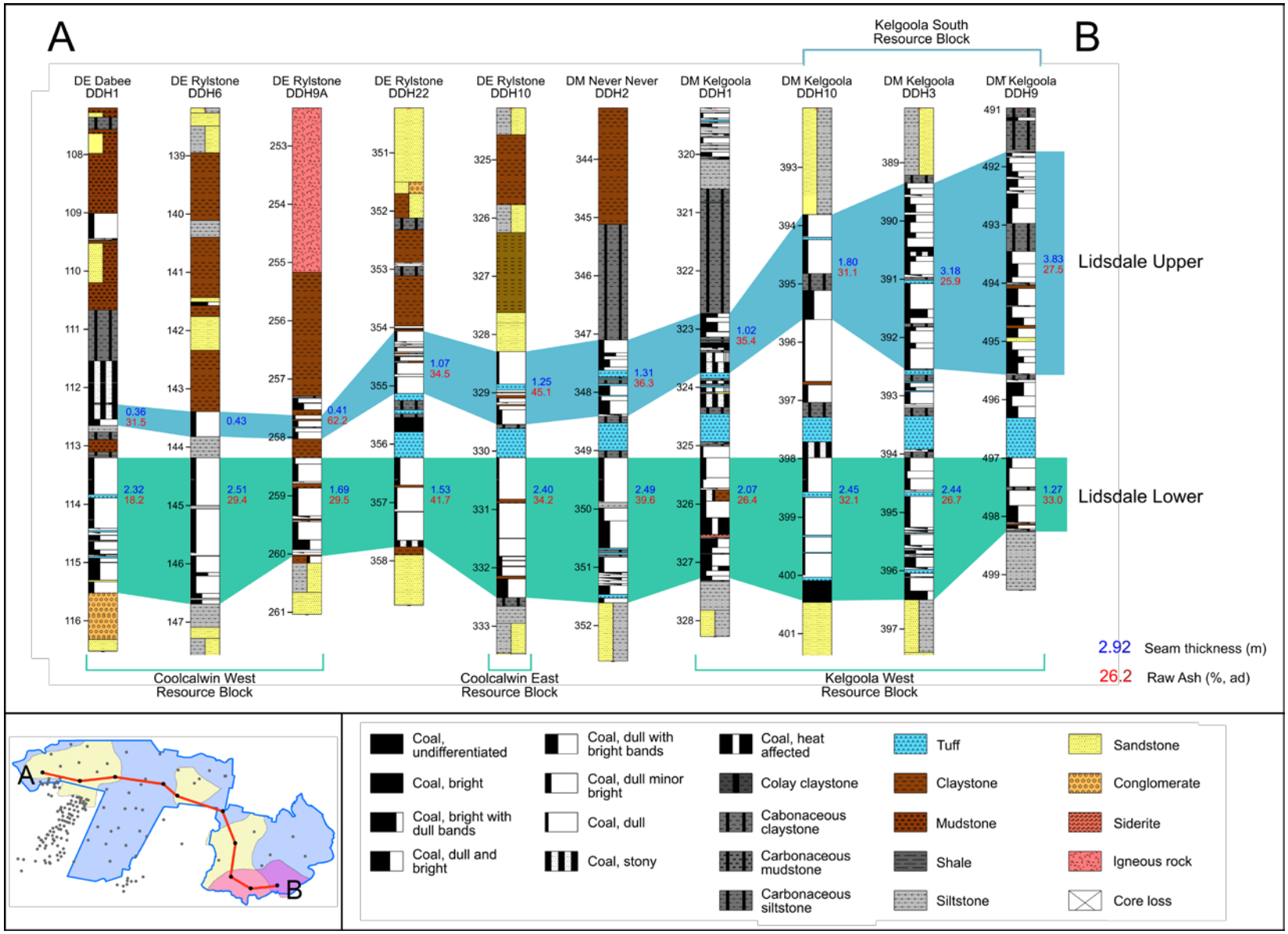

Figure 9. seam correlation across Ganguddy-Kelgoola release area (AUTH 230) through the resource blocks - Profile of Lidsdale Upper and Lower seams (no horizontal scale).

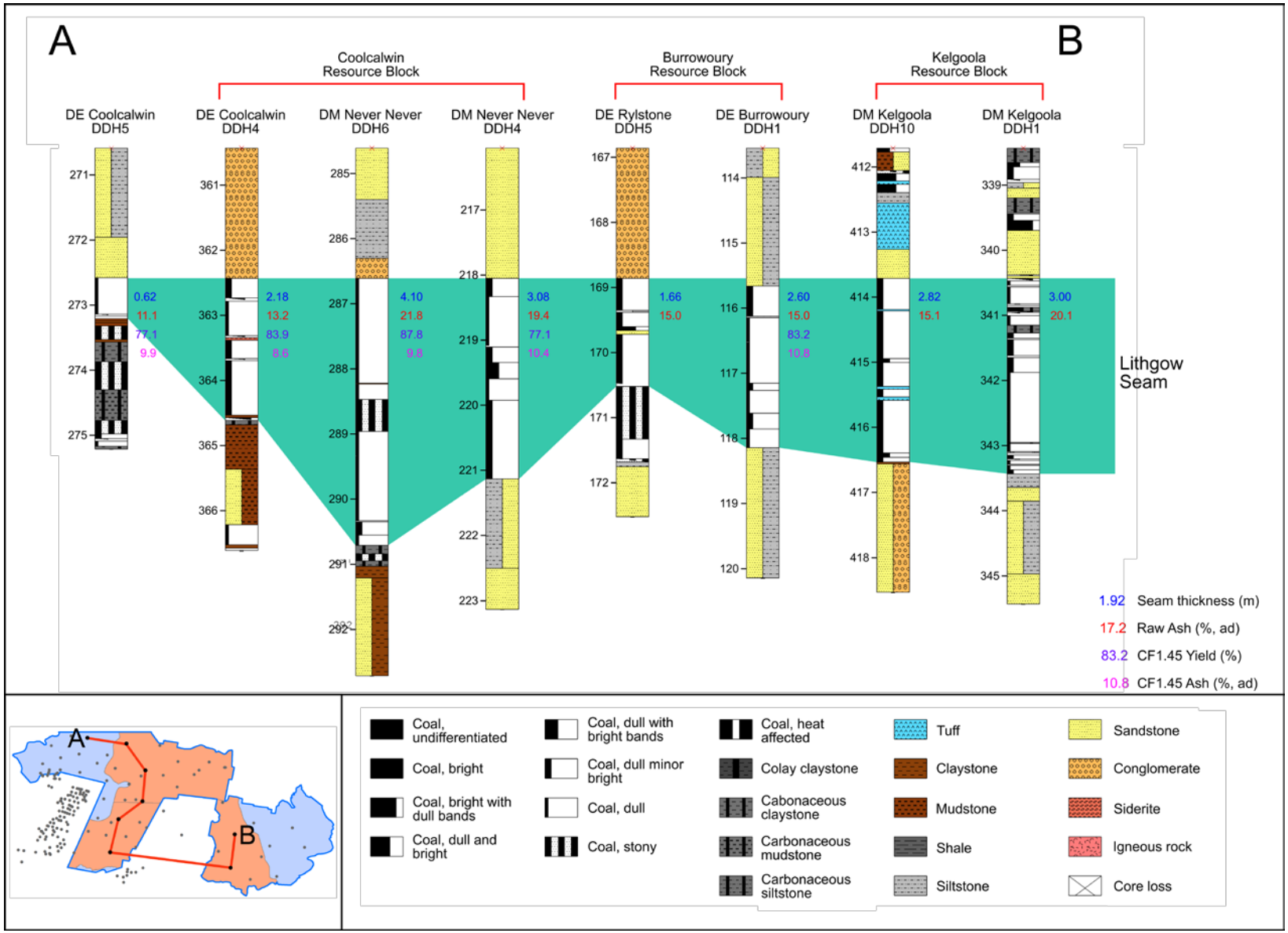

Figure 10. seam correlation across Ganguddy-Kelgoola release area (AUTH 230) through the resource blocks- Profile of Lithgow Seam (no horizontal scale).

Geological constraints

The main geological constraint in this area are the numerous intrusions that impact these seams to varying degrees in different locations. In addition to the direct impact of intrusions there is known doming of sediments due to igneous intrusions, that may impact seam structure and thus mining operations. No significant faulting has been identified from boreholes or geological mapping.

Potential development, products and market

These seams can only be extracted by underground mining methods.

The coal has no metallurgical properties and therefore could only be sold as thermal coal for power generation. This coal could be sold into domestic or export thermal coal markets, however the coal would require beneficiation to meet export specifications. The Lithgow Seam has the highest potential for development and would produce a low ash thermal coal product. In contrast, the other seams would produce high ash thermal coal.

The Lithgow Seam is the most continuous seam and has the highest quality. If this seam was extracted first it would sterilise the poorer quality seams above due to subsidence effects.

The expected closure timeframes for NSW coal power stations suggest that it is unlikely that any coal produced from this area, would find a domestic market, since it would be 15-20 years until potential first production. Therefore, any coal produced here would need to be sold on the export market.

Inventory Coal Estimation

The main seams with economic potential are the Katoomba, Lidsdale and Lithgow seams. The Geological Survey of NSW has identified the Lithgow Seam as being the most prospective seam. The seams are not uniformly developed in AUTH 230 and only attain sufficient thickness and quality in certain areas (Figure 6).

The resources estimated for the Katoomba, Mt Brace and Lidsdale seam have not changed from that estimated by Tadros et al. (2000). The Lithgow Seam has been re-estimated for this report as the Tadros et al. (2000). resource estimate included areas outside the current boundary of AUTH 230, principally to the north into the Rumker resource area, that had not been identified until 2017.

Coal inventory resource estimates are summarised in Table 3 and Table 4. The estimates for the Katoomba, Mt Brace and Lidsdale seams were constrained by a minimum 1.5 m thickness, a maximum 35 per cent raw ash and no depth cut off. The re-estimated resources for the Lithgow Seam had a minimum 1.8 m thickness, a 35 per cent raw ash and a 600 m depth cut off.

Table 3. Inventory coal resource estimates by Tadros et al. (2000) Inventory coal resource estimates for Katoomba, Mt Brace and Lidsdale seams at Ganguddy-Kelgoola (AUTH 230).

Seam	Resource Block	Average Thickness (m)	Raw ash (%, ad)	Calorific value* (MJ/Kg)	Inventory tonnes (Mt)	Total tonnes (Mt)
Katoomba	Kelgoola West	2.46	25.2	23.8	20	50
	Kelgoola East	2.87	25.0	23.8	20	
	Coolcalwin	2.32	26.7	23.3	10	
Mt Brace	Coolcalwin West	1.81	23.0	24.6	70	70
Lidsdale Upper	Kelgoola South	2.74	28.5	22.6	90	90
Lidsdale Lower	Coolcalwin West	2.24	26.4	23.4	130	270
	Coolcalwin East	2.20	32.3	21.3	40	
	Kelgoola West	2.14	29.9	22.1	100	

The resources were generated with a minimum thickness of 1.5m and a maximum raw ash of 35 per cent

**The calorific value has been calculated from raw ash.*

Table 4. Inventory coal resource estimates for the Lithgow Seam revised (2021) for the Ganguddy-Kelgoola resource area (AUTH 230).

Resource Block	Average Thickness (m)	Relative Density (g/cc)	Moisture (%, ad)	Raw ash (%, ad)	Volatile Matter (%, ad)	Calorific Value* (MJ/Kg)	Inventory tonnes (Mt)	Total tonnes (Mt)
Coolcalwin	2.93	1.45	2.1	15.5	28.4	27.2	240	500
Burrowoury	2.59	1.45	2.1	15.5	27.0	27.2	120	
Kelgoola	2.41	1.46	2.3	17.4	27.0	26.5	120	

This estimate was constrained to a minimum 1.80 m ply thickness, 35 per cent raw ash and a maximum depth of 600 m.

**The calorific value has been calculated from raw ash.*

Mining considerations

The Department of Regional NSW (the Department) has conducted a high-level conceptual mining assessment ("**consideration study**") of the Ganguddy-Kelgoola release area (AUTH 230). This consideration study is not a commercial viability assessment. This study is constrained by limited available geological data and has only considered the resource at a scoping study level, therefore the potential rail transport, infrastructure, tailings, gas drainage, and water supply options were analysed broadly and at a high level. The limited number of drillholes in the area is unable to robustly define geological features such as faults and intrusions. Further exploration may identify additional geological features and variations in seam quality, thickness and continuity.

A detailed financial analysis was not conducted in this study due to limited data. Furthermore, the results would be highly sensitive to forecasts for commodity prices and exchange rates, as well as capital and operational costs. These are highly uncertain given the estimated project lead time of typically 15-20 years from exploration to first production for mining projects.

Conceptual mine plan

A high-level conceptual mine plan was developed as part of this consideration study. The consideration study has identified that the Ganguddy-Kelgoola release area (AUTH 230) contains a coal resource with the potential to recover up to 150 Mt million tonnes of ROM coal from the Lithgow Seam.

Potential extraction areas were identified within the Lithgow Seam only. Three resource blocks were identified within Ganguddy-Kelgoola; Kelgoola in the west; Burrowoury in southern part of the east; and Coolcalwin in northern part of the eastern area (Figure 11). The main constraints considered in the extraction areas (which equate to these three resource block areas) were coal seam thickness, depth and coal quality parameters (raw ash and specific energy).

Assumptions

The potential extraction incorporated the following cut-offs and assumptions:

1. Mining within the Lithgow Seam only
2. > 600 metre depth of cover to the Lithgow Seam
3. < 1.8 m Lithgow Seam thickness
4. > 35% raw ash
5. < 20 MJ/kg Specific Energy.
6. No constraints were considered in relation to a 38 degree angle of draw from subsidence sensitive surface features
7. Subsidence is permissible in State Forests
8. The seams dip gently to the south, at approximately 2 degrees
9. Coal quality is consistent throughout the project area, and there is no significant seam splitting

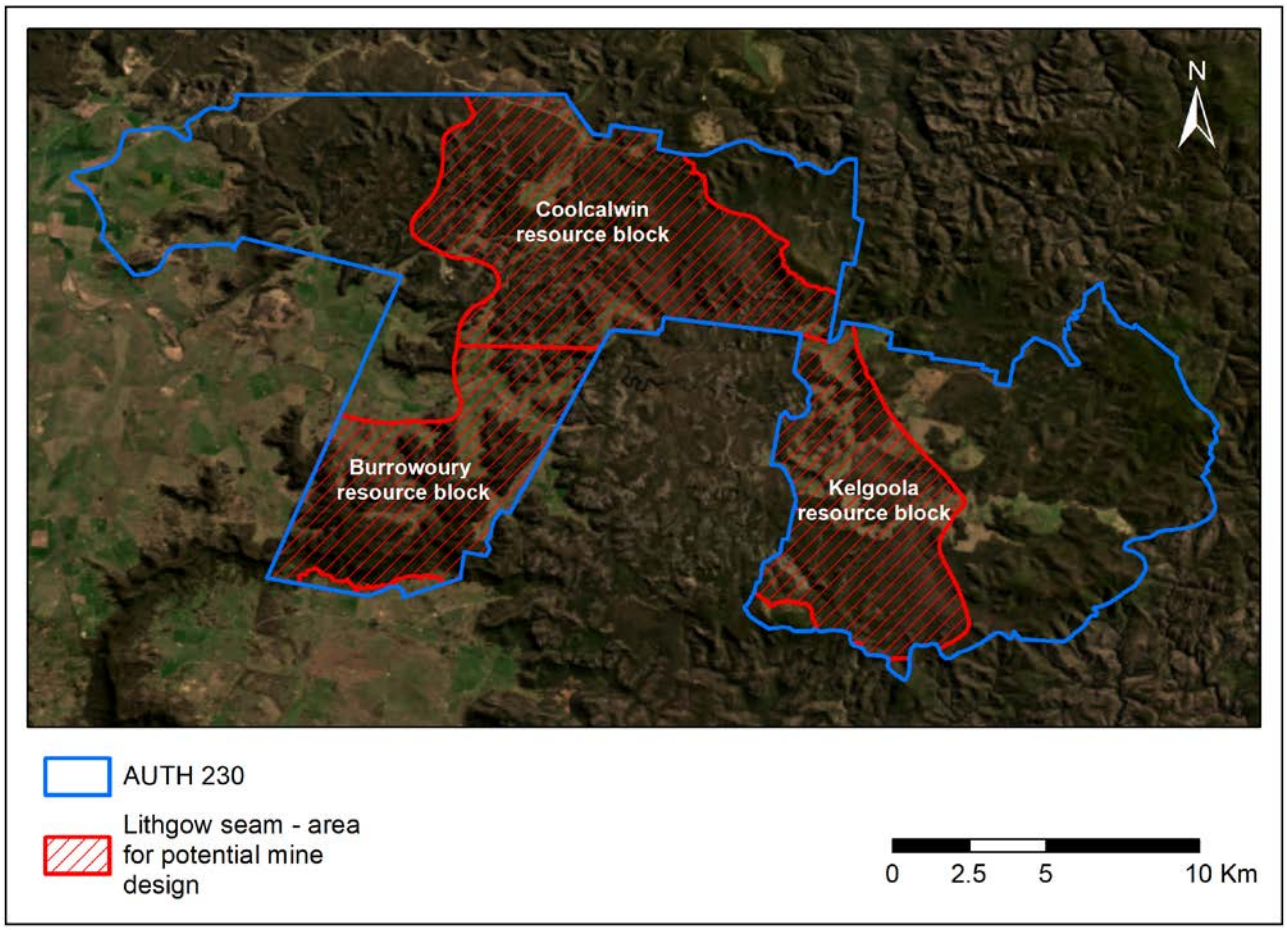

Figure 11 Ganguddy-Kelgoola release area, and resource blocks for l a conceptual mine plan.

Run of Mine output

This study identities that it is possible that the resource could support an underground longwall mining operation with an average ROM production rate of 4 Mtpa, utilising a single longwall. No development direction or longwall sequence was developed for this study. The rate was considered appropriate for the area based on outputs from the Springvale longwall mine in 2016-17 which also mines within the Lithgow seam. The 4 Mtpa rate also represents the maximum output.

The produced high-quality low ash coal is assumed to be suitable for export thermal markets.

For the purposes of this study, it is assumed that the Ganguddy-Kelgoola release area is suitable for longwall extraction. However, further geological studies may suggest that longwall mining could be an inappropriate method due to the high risk of extensive igneous intrusions. If that were the case, the option of bord and pillar mining with some limited pillar extraction would be the preferred method. If a bord and pillar mining method was assumed, the likely ROM would be significantly less. Based on similar operations in NSW in the western coalfield, this could be around 2 Mtpa. It should be noted that any new stand-alone bord and pillar mine would most likely have a pithead cost that is very high on the international cost curve. A bord and pillar operation would still require the same capital expenditure relating to transport infrastructure and CHPP build as a longwall operation. There are currently no new stand-alone bord and pillar operations planned for the NSW coal industry. The lower production rates from bord and pillar mines in general tends to make them unattractive to potential coal operators in NSW.

Infrastructure

It is assumed that mined coal from the site would be exported through the ports. This could include the option of Port of Newcastle, via rail links to the north to Mudgee and then east, or Port Kembla via rail links to the south via Sydney. Both involve similar rail distances and may have similar costs. However, railing to and shipping from Port of Newcastle may be more favourable as it is likely less rail upgrading is required. In contrast the track south via Sydney would likely be subject to community resistance, more expensive upgrades and greater risk of delays.

Furthermore, the Rylstone-Mudgee line is currently closed and requires significant upgrading to carry coal export tonnages. The now closed Charbon mine (the nearest operation to Ganguddy-Kelgoola) is 15 km south of Rylstone. Previously the Charbon mine railed all its export coal via the rail line link to Port Kembla. No detailed rail costings options have been made by the Department in this consideration study. Of note is that any potential new coal operation in the Ganguddy-Kelgoola release area would require a new rail spur of around 20 km in length to link to the existing rail line.

Estimated mine costings

This study has estimated operating and capital expenditure costs for the Ganguddy-Kelgoola release area (AUTH 230). The costs were derived from those used in the Hawkins Rumker Commercial Viability Assessment conducted by Geos Mining in March 2018 (Todd and Brady, 2018). The Hawkins Rumker coal area was selected as a possible analogue due to its close proximity to the Ganguddy-Kelgoola release area and similar geology.

In broad terms the Department has not found any major differences between the Ganguddy-Kelgoola and Hawkins Rumker areas in relation to potential estimation of free-on-board (FOB) costs. Both areas would most likely have a FOB cost in the vicinity of A$80 per product tonne. This estimate is at the upper end of the range of the cost curve for the majority of export thermal coal mines in NSW.

In the Hawkins Rumker study, the total capital expenditure for the base case scenario was estimated at A$683m in 2018 dollars, for an operation producing similar ROM output as the Ganguddy-Kelgoola release area. This did not include a CHPP, which under the low ash scenario (preferred option) would have been built in year 17 of the project. In contrast, any mine that would be established in the Ganguddy-Kelgoola release area (AUTH 230) would require a CHPP to produce a low ash product to meet current market expectations. This also would potentially need to be built earlier in the mine life. The estimated cost of a CHPP for the Hawkins Rumker area was A$75m in 2018. A CHPP for the Ganguddy-Kelgoola release area would be expected to have similar costs, given the similar ROM and product throughput tonnages and CHPP yields. As such, the total capital cost estimate including a CHPP for the Ganguddy-Kelgoola release area would be approximately A$775m (in 2020 dollars). However, this value is only indicative and remains highly uncertain.

Developing Ganguddy-Kelgoola would potentially have a slightly higher capital cost associated with its longer rail spur to transport product coal compared to the Hawkins Rumker area. This additional cost could be of the order of A$30m, and this difference is not considered by the Department to be significant.

A detailed financial assessment has not been conducted for the Ganguddy-Kelgoola release area as part of this study. Thus, it is difficult to judge the economic viability and competitiveness of the resource for an investor. A resource of this size would likely attract established coal mining companies operating in Australia.

Site specific opportunities

The Ganguddy-Kelgoola release area (AUTH 230) contains a large potential resource of high-quality thermal coal, in a mining region with skilled workforce, rail capacity, and mining service providers available.

Many NSW open cut mining operations are increasing in depth, geological complexity and cost, and further extensions may involve potentially un-approvable voids. There are also operations that will reach reserve exhaustion in the next 15 to 20 years. Any potential resource from the Ganguddy-Kelgoola release area (AUTH 230) may provide replacement capacity for existing mines that may be constrained within the next 15 to 20 years, providing continuity of thermal coal supply. Any potential development of Ganguddy-Kelgoola AUTH 230 may be able to leverage off some existing railway infrastructure.

Risks

Risks associated with potential development of Ganguddy-Kelgoola AUTH 230 include planning and other approvals, surface water and groundwater resources, infrastructure and access, potential land acquisition costs, water supply and transport corridors, unidentified geological features, gas drainage, and exploration in difficult terrain. In addition to uncertainties around key cost parameters, the commercial viability of the resource is dependent on timing of the potential resource development, and future demand for thermal coal.

Selection of a potential infrastructure area that is accessible and low impact on the local community and environment requires further assessment. Access to adequate and appropriate water supply and transport corridors / rail will also require further detailed study.

There is limited geological data available within Ganguddy-Kelgoola AUTH 230, but there are known geological features such as the most significant being intrusions. Further exploration would increase understanding of the geology of the area and confirm seam quality and continuity. Further exploration may identify features that reduce the development potential of the resource.

Further exploration within Ganguddy-Kelgoola AUTH 230 would be difficult. Access for potential drilling or seismic activities would be impacted by difficult terrain, heavy vegetation, and limited access tracks. Exploration drilling may further be impacted by significant depth to coal seams and potential unidentified structure and intrusions.

Further exploration and studies would reduce risk and increase confidence in potential commercial viability of the resource.

Trends in the thermal global coal markets

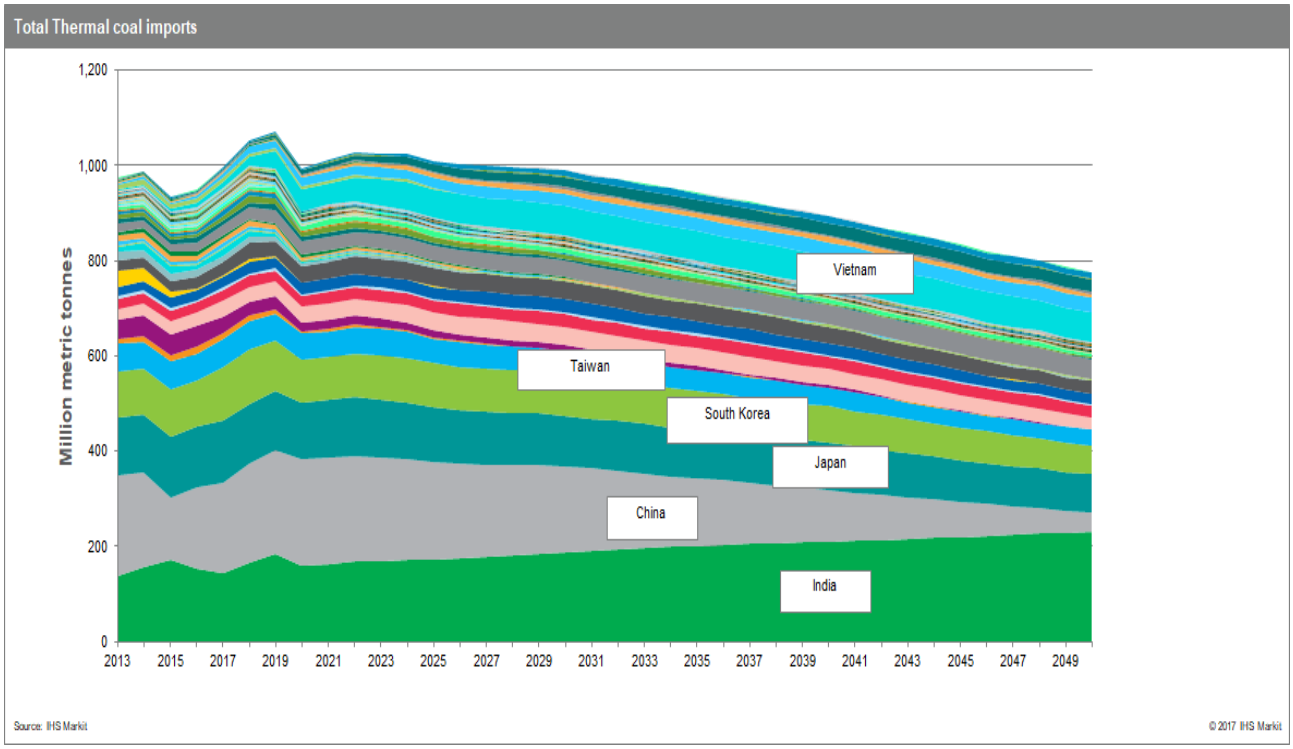

Figure 12. Long-term seaborne thermal coal outlook (IHS Markit, June 2021)

Figure 12 details total world thermal coal demand out to 2050. Modelling shows that total world thermal coal demand is expected to peak at just above 1,000 Mt in the early 2020's and fall away to below 800 Mt by 2050. In the mid 2030's, coal demand is expected to be around 900 Mt.

Based on a hypothetical exploration timing of 5-10 years, followed by 10-15 years for development approvals, it is assumed that any mine at the Ganguddy-Kelgoola release area (AUTH 230) would commence production around the mid 2030's at the earliest. The start date could possibly be delayed until 2040's depending on other considerations such as an investor receiving financing.

Although the seaborne coal market in the mid 2030's is expected to be smaller than it is today, this does not preclude NSW from sustaining a healthy market share. The demand for good quality coal (lower in ash content, lower in moisture and higher in specific energy) like the coal produced from NSW will mostly likely continue well into the 2030's and 2040's. NSW coal is the preferred import for its major customers such as Japan, Taiwan and South Korea, as well as a growing market in India.

The major competitor for NSW for its thermal coal is Indonesia which produces lower rank coal that has a significantly higher moisture content and a lower energy content. This dynamic increases the likelihood of ongoing demand for NSW thermal coal. The demand for NSW coal may not grow significantly and will diminish slightly over the next decades, it is expected to still remain strong over the medium term based on current modelling.

It is uncertain as to how competitive thermal coal mine from within the Ganguddy-Kelgoola release area would be with other NSW or overseas suppliers. Based on this high-level consideration study, it is likely that an operation in the area could have higher operating costs than other comparable longwall operations in NSW. However, as a detailed analysis of the costs has not been conducted, this remains a major unknown for any potential mine in the area.

Conclusions and recommendations

Geological and resource modelling completed by the GSNSW estimates 500 Mt of possible in-situ inventory coal resources all within the Lithgow Seam. The coal is a low to medium ash thermal coal that could be beneficiated for the export market. The inventory coal resource may support the extraction of up to approximately 150 Mt of ROM coal, with the possibility to support annual production of 4 Mt for a longwall project with a mining life of greater than 20 years.

In addition to the low ash inventory resource in the Lithgow Seam, there is also the potential for 400 Mt of high ash coal in the other seams present in the Ganguddy-Kelgoola area. However, this study did not assess the mining opportunities in these seams. If the Lithgow Seam was mined first then it may be possible that there would be subsidence impacts on the overlying seams thus rendering them not viable to mine.

One of the key constraints identified in the Ganguddy-Kelgoola release area (AUTH 230) is the numerous intrusions that may impact the ability to mine the Lithgow Seam economically.

The area is also mostly forested, rugged hills. This could present surface access challenges for any future operation. Furthermore, if cliff lines are present above the proposed underground mining, this could impact any longwall operation too as it would create restrictions to mining to avoid subsidence around these features.

Any mining operation in the area would require substantial infrastructure investment in the form of rail upgrades and development of a new spur railway line. In addition, the site would require a coal handling and preparation plant to ensure that the coal produced meets market expectations. Consequently, it is possible the capital and operating costs for the potential resource would be much higher than other comparative longwall greenfield projects.

The potential coal resource has the potential to provide continuity of high-quality thermal coal supply from NSW in about 15 to 20 years (based on the estimated time required to progress a greenfield site from exploration to production). However, a significant level of exploration and drilling would be required before a mine could become operational. At the same time, the global seaborne thermal coal market would be smaller than today. This could present challenges for any new greenfield operation in the area in competing with established operations in NSW and/or internationally.

The findings from this high-level assessment are constrained by limited available geological data. In addition, a detailed financial assessment and modelling was not undertaken for this study. Thus, the commercial competitiveness and economic viability of a greenfield underground coal mine in the Ganguddy-Kelgoola release area remains highly uncertain.

Further exploration drilling would provide greater confidence for the analysis provided in this high-level scoping study. A detailed financial assessment would support understanding of the commercial viability of the resource.

References

DRNSW. 2021. Annual Exploration Report Authorisation 230, Rylstone Western Coalfield. Reporting period 5 August 2020 to 4 August 2021.

Encom Technology Pty Limited. 1997. Interpretation of airborne geophysical data over the Rylstone area.

Todd A, Bradbury T. 2018. Commercial Viability Assessment - Hawkins Rumker. Geos Mining Mineral Consultants Pty Ltd.

IHSMarkit. 2021. Presentation to Division of Mining Exploration and Geoscience – Coal Market Update.

Tadros N, Bayly K. And Kirby B. 2000. Coal Resources of the Rylstone area. Unpublished

Yoo, E, Tadroz N, and Bayly, K. 2001. Compilation of the 1:100 000 Geology of the Western Coalfield (Notes to accompany the Western Coalfield Geology maps). New South Wales Department of Mineral Resources, Departmental Publications.