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A SUMMARY OF COAL OCCURRENCES IN AUSTRALIAN SEDIMENTARY BASINS

by

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ABSTRACT

Summary geological descriptions of the on-shore coal measures in Australian sedimentary basins are tabulated. All known deposits of coal are included, irrespective of their size and economic importance. The information has been collated mainly from major monographs and the information is presented systematically so that a rapid assessment and comparison may be made. Where possible information on the deficiencies in geological knowledge is assessed. The principal sources of information are listed for each deposit, and tables and plates are included to show coal measure correlations for each period, location of major coal occurrences in Australia, and operating and proposed mining areas in the Sydney and Bowen Basins.

Many of the problems associated with the exploration and exploitation of coal measures can be solved by a thorough understanding of the controls exerted by structure and depositional environments on the distribution and quality of coal in coal measure sequences. In many basins it is apparent that the influence of these geological constraints has not been assessed owing to the lack of detailed information on the sedimentary sequences, and conflicting correlations and confusing nomenclature within sedimentary basins.

A Summary of Coal Occurrences in Australian Sedimentary Basins

Introduction

This report presents the results of a brief review of the occurrence of coal in the on-shore sedimentary basins of Australia. The scope of the report is intended to include all known deposits regardless of whether they are major economic deposits or minor occurrences, subeconomic, deep or worked out.

The data are organised under a standard set of headings arranged in the same order for each deposit so that the relevant information can be found quickly and a comparison and rapid assessment made. Wherever possible notes have been compiled on both geological and mining problems remaining to be resolved.

The data have been extracted mainly from monographs which give major reviews of coal deposits with the addition of data on recently discovered deposits or known areas where significant new information has been obtained. Compilation of an exhaustive bibliography, and the relatively detailed information that could be gained from it, was outside the scope of the report.

The primary aim was to assess the current status of geological information and where possible to identify deficiencies in knowledge.

Geological and related mining problems that have been mentioned in the literature are indicated at the end of the description of each coal basin or field. Many of the potential hazards pertaining to the exploitation of the coal can be directly related to different inter-seam rock types, igneous intrusions, and structure. Prediction of the problems to be encountered ahead of mining is an important aspect of geological investigations.

A great deal of fundamental geology remains to be resolved in the study of coal bearing sedimentary basins. The most apparent are discrepancies and lack of information on the precise correlation of coal seams and stratigraphic sequences throughout the basin, lack of uniformity in stratigraphic nomenclature and proliferation of stratigraphic names and terminology.

The work of the coal geologist is primarily to map and analyse sedimentary and structural features with a view to predicting the continuity of coal deposits, and predicting conditions of coal mining to the encountered. Other aspects include core logging, coal quality control sampling, airphoto interpretation and geophysics.

The correlation of the major coal measures of the Early and Late Permian, Triassic, Jurassic, Cretaceous and Tertiary periods is presented in Tables I to VI.

The location of the major deposits is shown in Plate I, and the main operating and proposed mining areas in the Sydney and Bowen Basins are shown in Plates II and III.

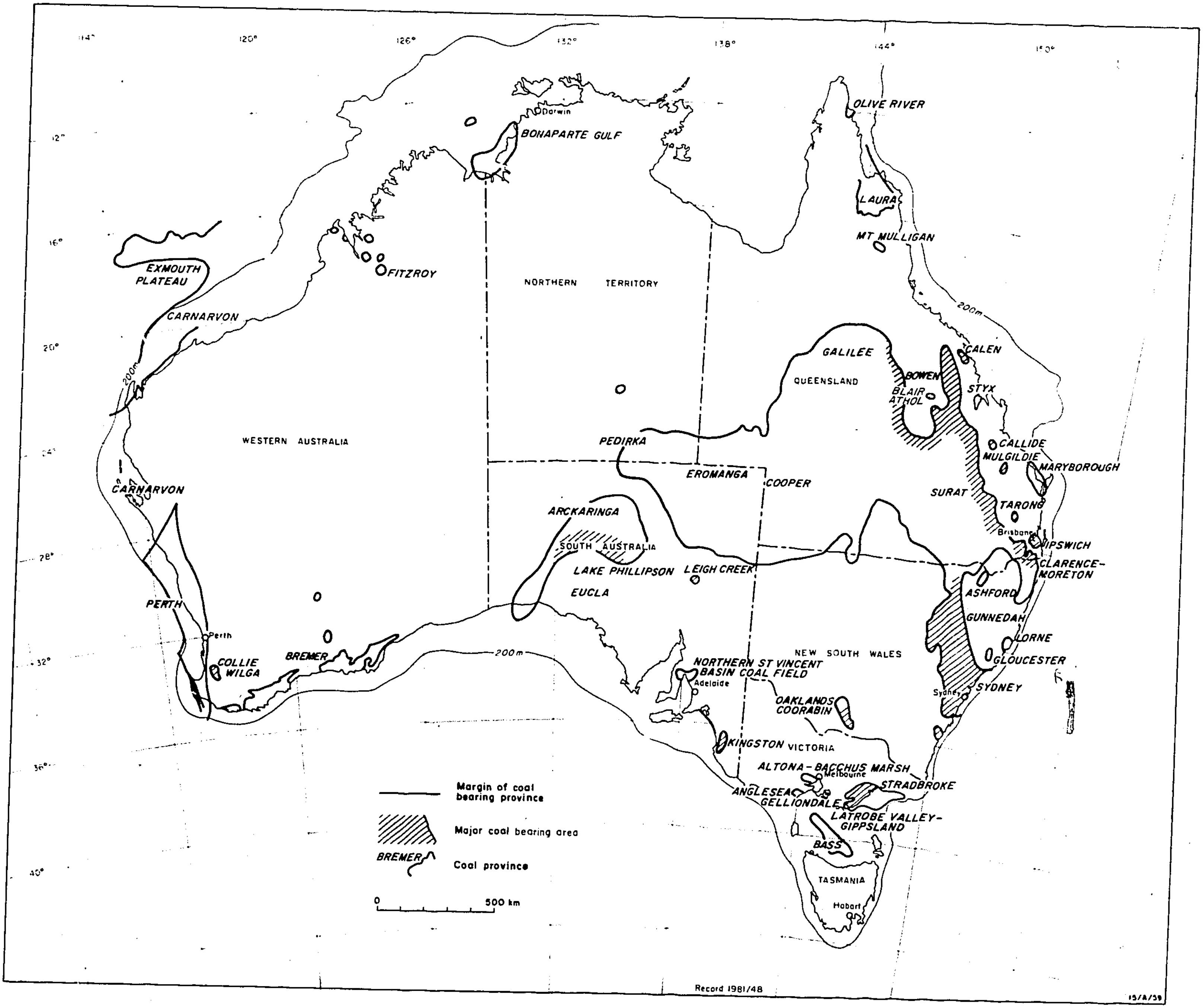

FIG. I - LOCATIONS OF MAJOR COAL OCCURRENCES IN AUSTRALIA

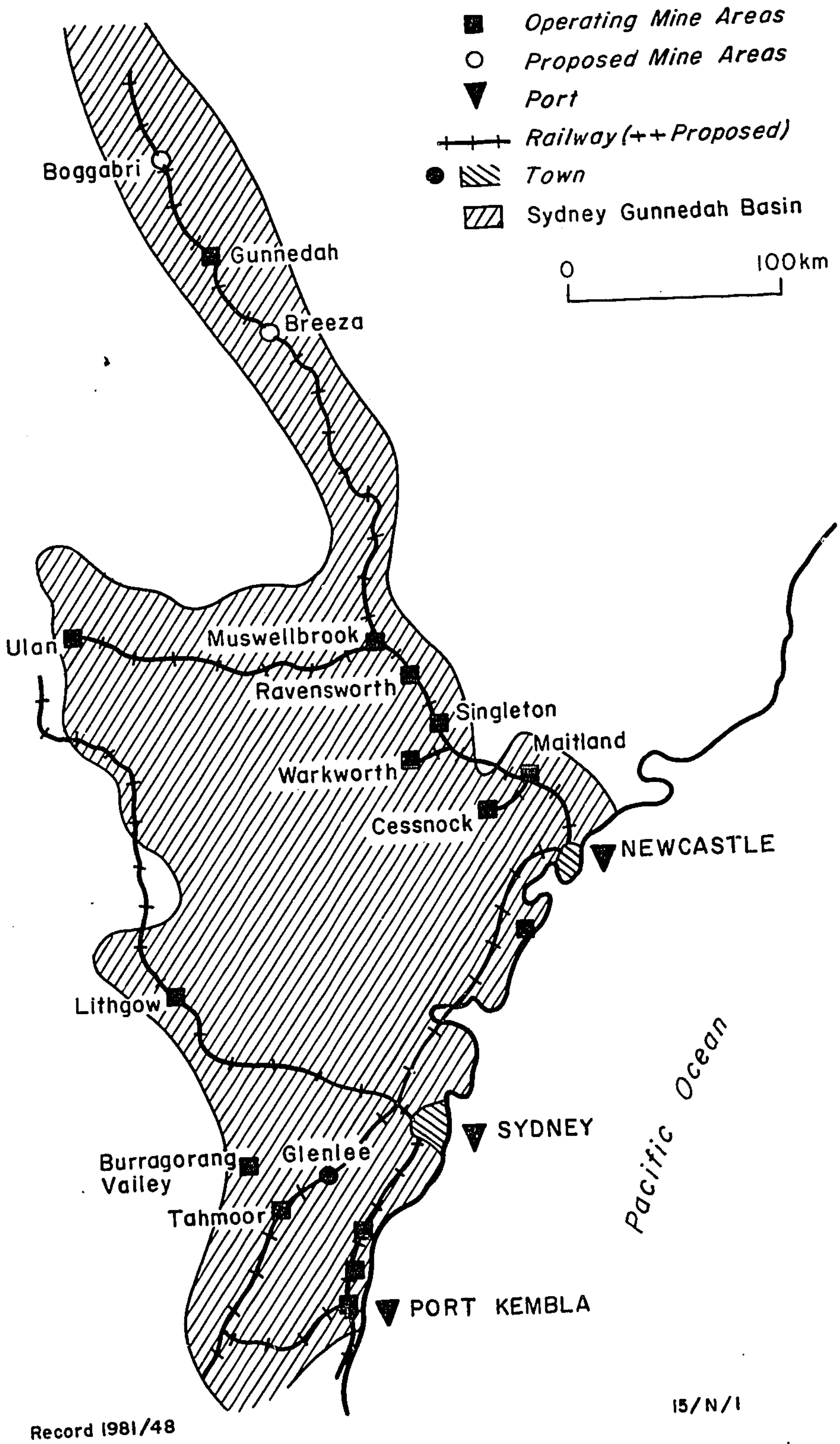

Fig. II - Operating and proposed mining areas in the Sydney Basin

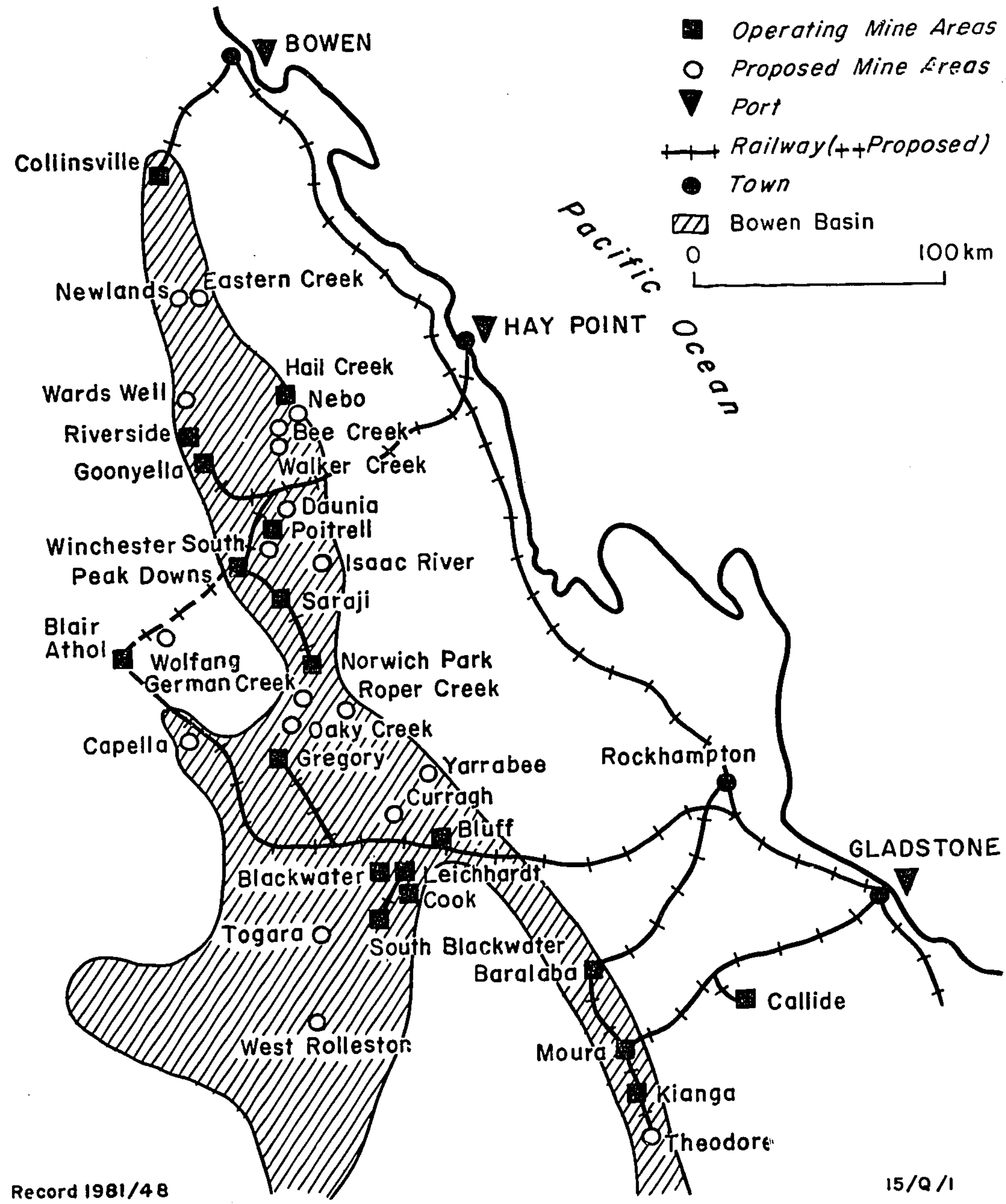

Fig. III - Operating and proposed mining areas in the Bowen Basin

CARBONIFEROUS COAL MEASURES

In contrast to the abundant economic Carboniferous coals of Europe and North America, the known coals of this period in Australia are of only minor significance. The coal has a very small extent, the seams are thin and generally high in ash yield. The Carboniferous sequences, which contain the coal measures, comprise marine and freshwater sediments and volcanics. Carboniferous coals occur in the Pascoe River area of northern Queensland and the Balickera area in the Hunter Valley. The Hunter Valley coals occur mostly in the Upper Carboniferous sequence which displays both paralic and limnic environments of deposition.

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BASIN/FIELD	Balickera, Hunter Valley, New South Wales
MINING	Carboniferous coals have been mined on a very small scale at Dungog in NSW.
SEDIMENT SEQUENCE & AGE	NSW - Carboniferous of the Hunter Valley (1)
	No meaningful stratigraphic table of the Hunter Valley Carboniferous encompassing all the named rock units is published, and the regional stratigraphic data is presented as a composite type section shown below. (1)

Late Carboniferous	Seaham Formation	several lenticular coal seams in the region north of Raymond Terrace and west to Mt. Dyrring.
	Paterson Volcanics	
	Mount Johnson Formation	Several coal seams in the sequence flanking the Gloucester Trough (McInnes Formation) and near Paterson.
Early Carboniferous	Gilmore Volcanics	
	Flagstaff Sandstone Wallaringa Formation	Rare coal seams east of Dungog (Conger Formation) and north of Gresford.
	Bonnington Siltstone Ararat Formation	mainly marine
	Bingleburra Formation Wootton Beds	

The Early Carboniferous sequence is dated by marine faunas; the continental sequences are correlated by sporadic plants and spores, and isotopic dates on the volcanic units.

OUTCROPS	Coal is present in outcrop on the Stroud-Dungog Road; most other Hunter Valley Carboniferous coals crop out in stream banks.
DISTRIBUTION	Coal is developed in many seams over a stratigraphic interval of 3000 m in the Carboniferous sequence of the Hunter Valley. (2)
STRUCTURE	The Hunter Valley Carboniferous is folded and gently to steeply dipping, commonly brecciated and sheared; the coals commonly acted as glide planes during deformation.

ENVIRONMENT

Hunter Valley - The Early Carboniferous coals are parlic deposits; seams form only a very minor part of the total sequence.

The coals in the Early Carboniferous Wallaringa and Flagstaff Formations were formed in near marine shoreline positions. (3) They are therefore paralic deposits laid down in coastal marshes and lagoons; the presence of pyrite in some seams indicates a marine influence.

The source of the Early Carboniferous coals was an arboraceous flora of Lepidodendron and Rhacopteris; many tree trunks are included in the coal seams and interseam sediments. Pitys is a common tree trunk genus.

Coals are more numerous in the Late Carboniferous and a continental influence is more pronounced. They retain a paralic influence although several occurrences, noteably the Seaham Formation, probably formed in limnic environments on flood plains away from the coast; seat earths with rootlets in growth positions are present.

In the Late Carboniferous there was a decrease in trees, and coal was probably derived from reeds eg. Calamites.

Seat earths, usually sandy, with well developed rootlets in growth positions are common throughout the Carboniferous sequence.

COAL SEAMS

Coal seams in the Hunter Valley Carboniferous are restricted in thickness and lateral extent; seams are gnerally no more than 1 m thick.

Occurrences of Early Carboniferous coals include Balickera Canal, Stroud-Dungog Road, and Allyn Brook. Coals are more numerous in the Late Carboniferous and occur at Paterson, Raymond Terrace, Washpool Road and Dungog 1 mile Sheet, Balickera Canal, Breakneck Syncline, 20 km north of Singleton, and Mirannie Creek.

COAL QUALITY

The Hunter Valley Carboniferous coals are generally of inferior quality, thin and high in ash. The high ash content is probably a result of widespread tectonic instability of the area and reflected in rapid facies changes and large amount of extrusive igneous rocks.

There appears to be little correlation between the stratigraphic position, or depth of burial, of Carboniferous coals and their degree of coalification. Offler & Diessel (1976) suggest

COAL QUALITY (Cont.)

that the rank of plant material in this region has been affected by metamorphism from a subsurface heat source, such as a subsurface extension of the Permian Barrington Granodiorite. (4)

The coals occur in folded and steeply dipping strata and are commonly brecciated and sheared, acting as easy glide planes during tectonic deformation. Because of weathering and shearing most coals are dull and show little differentiation into lithotypes. The coals show cleating, small scale faulting and plastic deformation with micro-folds which disrupt the depositional fabric.

The rank of the Permian and Carboniferous coals do not differ greatly along the southern fringe of the outcrop area but a strong break is found on the western flank of the Gloucester Syncline. This break may be caused by a fault or thermal metamorphism.

PROBLEMS

The coals are of restricted lateral extent, too thin, or too high in ash to be workable. They are of academic, but minor economic, significance.

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(3) ROBERTS, J., & OVERSBY, B., 1973 - The early Carboniferous palaeogeography of the southern New England Belt, New South Wales. Journal of the Geological Society of Australia, 20, (2), 161-173.

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BASIN/FIELD	Pascoe River, Queensland
SEDIMENTARY SEQUENCE & AGE	Pascoe River District
	Mesozoic sediments and Permian to Carboniferous lavas and pyroclastics
	________ unconformity ________
Early Carboniferous	Pascoe River Beds - fresh water sediments with coal
	________ unconformity ________
	Basement of metamorphic rocks and Devonian adamellite.
LITHOLOGY	Pascoe River Beds - coal and carbonaceous shale occur at the base of the sequence which is graphitic in places.
OUTCROPS	Discontinuous outcrops occur in the Pascoe River Valley.
STRUCTURE	The regional structural trends in the Pascoe River Beds are north-northwest with similar fold axis trends. Dips vary from 10-60° and minor faulting is common.
ENVIRONMENT	The Pascoe River Beds are probably entirely freshwater.
INTRUSIONS	The Pascoe River Beds are slightly metamorphosed by quartz-porphyry dykes.
COAL SEAMS	In the Pascoe River area two seams 3.7 m and 2.4 m thick occur in the area of Hamilton Creek.
COAL QUALITY	Float material in the Pascoe River Valley ranges from carbonaceous shale to semi-anthracite, with low to moderate ash yield and high calorific value.

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CARR, A.F., 1975 - Pascoe River District, Queensland. In TRAVES, D.M., and KING, D., (Eds.), ECONOMIC GEOLOGY OF AUSTRALIA AND PAPUA NEW GUINEA. Australasian Institute of Mining and Mètallurgy, Monograph 6, Volume 2 Coal, 56-57.

PERMIAN COAL MEASURES

Introduction

The major economic coal deposits of Australia are located in Permian sediments. The principal occurrences are concentrated on the eastern part of the continent; coal is being exploited from the Sydney and Bowen Basins and Galilee and Arckaringa Basins are presently being explored; smaller deposits occur as far north as the Olive River area, and to the south in Tasmania. Permian coals occur in minor basins in all other states except Victoria. The Permian Collie Coal Measures in the relatively small Collie-Wilga Field is the only operating coal-mine in Western Australia.

In many coal basins the tectonic setting and structural framework determine the extent and quality of coal because of the influence on the relative and absolute rates of subsidence and consequently effect the rates of sediment supply and water levels. The best coals occur on the stable elements of the craton.

The Late Lower Permian was a period of widespread coal formation, although it appears that coal-forming periods throughout Australia were not exactly contemporaneous although in several cases both inter and intra-basin correlations are not established. Late Permian coal measures were also widespread and in some places coal deposition extended into the Early Triassic.

The waning of continental glaciation marked the beginning of the first Permian coal-forming period, and Early Permian floras flourished in latitudes around 65-70°S with optimum conditions of the water and carbon cycles. The coals accumulated at continental edges as a result of sea level fluctuations, and were deposited in lacustrine, fluviatile and paludal environments.

Deposition of the Early Permian coals appears to have been controlled by three main types of environment. It has been postulated that one group was controlled by a glaciated topography - for example the Collie Coal Measures are underlain by tillites and occupy fiord like valleys or glacially over-deepened depressions. Deposition of some coals occurred in grabens - for example the Mount Toondina Beds in the northern Boorthanna Trough. Other widespread deposits formed on the continental edge as a result of slow transgression or regression. The Greta Coal Measures are an example of the last group and are probably controlled by eustatic or tectonic events or the effects of both.

From the mid-Permian onwards widespread coals formed during a series of transgressive and regressive cycles. Some coals were transported and others formed in situ. The rates of accumulation and relation to water level, control the initial quality as well as quantity of coal.

The Permian coals that formed in tectonically active zones including graben-like structures are higher in rank and structurally more complex than those in other settings.

The Middle to Late Permian included both shoreline and tectonic coals. The climate has mainly controlled the quality of coal deposited and it only had minor effects on the accumulation of carbonaceous matter.

The various types of environments deduced that influence coal type and rank include -

1. Ridges where non-coking coals develop.
2. Troughs with little subsequent uplift and erosion where non-coking coals develop.
3. Troughs with subsequent uplift and erosion in which coking coals form.

However there are inconsistencies and the essential factor controlling rank is depth of burial and heat. Tectonic zones can control rank - for example coals at different stratigraphic levels in the Bowen Basin are of similar rank near tectonic zones.

Some authors reject the effects of subsurface heat sources as affecting rank, but it has been accepted by others.

The evidence supporting the contribution of subsurface heat sources includes -

1. The wide variation in heat flows from the oceanic crust.

2. The long period of heat flow from intrusives.
3. The high concentration of radioactive minerals in Mesozoic intrusives and the shorter decay time for intrusive energy.

Hence heat sources may have affected local areas of sedimentary basins e.g. the higher rank coals in parts of the Sydney Basin, the west Moura area of the Bowen Basin and parts of the Perth Basin. This indicates that persistent sources of high heat flow may have concentrated below areas such as the Sydney and Bowen Basins during Mesozoic times. The alternative postulate is deep burial, uplift and erosion.

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BRANAGAN, D.F., 1975 - Distribution and geological setting of coal measures in Australia and Papua New Guinea. *In* TRAVES, D.M., and KING, D., (*Eds.*), ECONOMIC GEOLOGY OF AUSTRALIA AND PAPUA NEW GUINEA. *Australasian Institute of Mining and Metallurgy, Monograph 6*, Volume 2 Coal, 25-51.

BASIN/FIELD	Bowen Basin, Queensland
AREA	75 000 km^2
MINING	Present mining areas are at Moura, Blackwater, Goonyella, Peak Downs, Saraji, Hail Creek, Norwich Park, Gregory, Riverside, Poitrel, Collinsville, Blair Athol, Bluff and Baralaba. Potential mining areas include Yarrabee, Theodore, Togara, Rolleston, Capella, Roper Creek, Walker Creek, Bee Creek, Newlands & Eastern Creek, and Wolfang, German Creek, Oaky Creek, Curragh, Winchester South, and Wards Well.
SEDIMENT THICKNESS & AGE	6000 m of Permian and Triassic sediments and volcanics.
COAL MEASURE UNITS	The major coal groups in the basin are -
Late Permian	(Group IV - Rangal, Elphinstone and Baralaba Coal (Measures (top of Blackwater Group), & Bandanna Formation. (Group III - Fair Hill and German Creek (Formations (base of Blackwater Group and top of (Back Creek Group), and Moranbah Coal Measures.
Early Permian	(Group II - Collinsville and Blair Athol Coal (Measures, Aldebaran Sandstone. (Group I - Reids Dome Beds.
COAL DISTRIBUTION	GROUP I COALS The Early Permian Reids Dome Beds are confined to the Denison Trough. They are best known at the northern end of the Trough near Capella although thicker coals occur in bores in the southern part. GROUP II COALS The Early Permian coals in the middle part of the Back Creek Group occur in several small areas along the western side of the basin. They occur at Collinsville near the main basin axis, Capella, Blair Athol and Rugby. GROUP III COALS The Late Permian coals in the base of the Blackwater Group and top of the Back Creek Group extend throughout the northern half of the basin. They are best developed on the Collinsville Shelf, and equivalent aggregate thickness in thinner but more numerous seams in the Nebo Synclinorium. All but the upper seams pass into the German Creek Formation on the Comet Platform with total coal thickness decreasing to the south where marine conditions are prevalent.

GROUP IV COALS

The Late Permian coals occur in the top of the Blackwater Group. They are of basinwide extent, and therefore the most extensive of the Groups.

STRUCTURE

The western part of the basin formed over an existing platform and the eastern part over a marginal foredeep. The eastern part subsided rapidly and was strongly folded in the Mesozoic.

The western part, or roughly half, of the Bowen Basin comprising the Collinsville Shelf, Comet Ridge and Denison Trough formed over the Clermont Stable Black, and the sedimentary sequence is little deformed.

A more mobile zone in the east, located over a foredeep, received a thick sequence of sediments, particularly in Late Permian and Triassic.

The Eungella-Cracow Mobile Belt in the east was initially a zone of deep subsidence, later uplifted and eroded, and partly faulted against the Synclinorium on its western flank.

Faulting. Reverse faulting is present on the boundary of the Comet Ridge/Collinsville Shelf with the Folded Zone. Upthrow on the faults is 600 m to the east and possibly genetically related to the hinge line between the shelf and foredeep.

Folding. Is most intense in the Folded Zone and Nebo Synclinorium, both of which originated in the foredeep. Intensity of folding decreases to the north and west in the Folded Zone. Folding in Late Permian and Early Triassic was more intense than in the Late Triassic in the Nebo Synclinorium. Gentle folding occurred on the Collinsville Shelf and Comet Ridge. Broad, low amplitude folds in the Denison Trough are possibly caused by uplift of the western boundary fault.

Seismic evidence shows that basement below the Denison Trough consists of a number of horsts and grabens. Compression on these basement blocks has caused the folding. (Bauer & Nelson, 1980, Paten et al. 1979).

Broad warping along meriodional axes occurred in the Triassic and Early Cretaceous with folding along northwesterly axes, especially in the centre of the basin, and associated thrust faults at the edge of the Clermont Stable Block. The eastern edge of the basin is a structural edge, whereas the western edge approximates the depositional edge.

Basement features control coal characteristics. On the Collinsville Shelf and Comet Platform in the west there are uniform seams in thickness and quality. In the Taroom and Denison Troughs coal seams are equally extensive though generally inferior and more variable in quality.

ENVIRONMENT

Group I Coals - The Denison Trough contains dominantly non-marine sediments, and rare marine intercalations.

Reids Dome Beds - mainly fluviatile, with extensive developments of coal forming swamps.

Group II Coals - Coal forming deltaic complexes occur along the cratonic margin. Blair Athol coal measures deposited in adjoining intracratonic basin. Partly marine interseam sediments.

Collinsville Coal Measures - probably deposited in swamps at the back of a large delta or between the main distributary channels. Both autochthonous and allochthonous coals postulated.

Rugby - deposited on irregular basement floor.

Blair Athol Coal Measures - Maritime basin set in a drainage system deeply incised into the Permian coastline. Isolated basin within Anakie Metamorphics.

Aldebaran Sandstone - deltaic to fluvial conditions during a regressive phase. Freitag Formation deposited during following transgression with minor regressions in places. This transgression ended minor coal formation.

Group III Coals - Deposition on shelf, platform and synclinorial areas.

German Creek Formation - deposited in paralic environment during a regressive phase followed by marine transgression. Coal seams deposited in swamps associated with deltas. The German Creek Formation becomes progressively more marine to the south. (3).

Fair Hill Formation - fluvial environment in the north with associated flood plain and lacustrine deposits. Partly paralic environment in the south with some pyroclastic activity which is also associated with Burngrove Formation and Fort Cooper Coal Measures.

Hail Creek Beds - fluvial and may be partly a piedmont deposit.

South of Norwich Park, from the Collinsville Shelf onto the Comet Platform, there is a marine intercalation, the MacMillan Formation, between the German Creek and Fair Hill Formations.

Group IV Coals - A period of widespread emergence in which the most extensive coals of the basin formed. The Rangal Coal Measures-accumulated in flood plain, swamp and shallow lake environments. Rangal Coal Measures at Blackwater (1) were deposited in a fluvial system. Vertical succession of beds in the coal measures is characteristic of that produced by a meandering river. Coal seams and interbedded fine clastics formed on a flood plain and lenses of clastic rocks in carbonaceous beds were originally deposited in small subsiding lake basins in a peat swamp. (1)

Baralaba Coal Measures - meandering fluvial conditions which allowed very extensive coal swamps to develop on flood plains.

Bandanna Formation - uniform fluvial environment throughout most of depositional area, and the Denison Trough had ceased as a separate area of active downwarp.

Elphinstone Coal Measures - deposited in a fluvial environment.

INTRUSIONS

Early Cretaceous intrusion north of latitude 21^{o}S, uplift and deformation in the Eungella-Cracow Mobile Belt was accompanied by widespread intrusion in the northern Bowen Basin. Numerous structurally aligned stocks and laccoliths of about 125 m.y.old occur in the northern Nebo Synclinorium and caused partial loss of coal by doming and shattering. Associated sills and dykes over a wide area producing high-ash natural coke occur in north.

Coal seams offer little resistance to invading magmas and have been preferentially intruded and metamorphosed on a large scale.

Early Permian Collinsville Coal Measures are not as severely intruded as the Moranbah and Rangal Coal Measures.

Basic sills were the most destructive. Natural coke is hard, dense, heavily impregnated with carbonates but retains much of its specific energy. In the south at Norwich Park, coals are damaged by sills (about 70 m.y.old) and similar intrusions with coked coal occurs in surrounding areas.

Tertiary volcanics blanket some coals e.g. Rolleston, Blair Athol-Capella, Wards Well-Suttor Creek, Nebo. In places they preclude mining of surface coals. Related sills and dykes have invaded and coked areas of coal especially in the north of the basin. Ages are 20-33 m.y. (Oligocene to early Miocene).

In the Taroom Trough and Comet Ridge coal measures are altered by intense heat; near Cracow, sandstone and mudstone have been baked, fused and brecciated. (3)

COAL SEAMS

Lower Permian

GROUP I

Reids Dome Beds - Maximum thickness is 2760 m in the southern Denison Trough. Coal occurs in the upper part and is best developed in the southern Denison Trough where topmost seam is 20-30 m thick, but occurs at depths of 1000 m. Coals west of Capella are thinner but can be open cut. Thin uneconomic seams occur on the Springsure Shelf.

GROUP II

Collinsville Coal Measure - The upper and lower coal measures are separated by marine sandstone. The coal measures are up to 250 m thick and thin basinward; they contain 10 coal seams, 4 in the upper part, 6 in the lower part.

Rugby - the coal has a maximum thickness of 9 m and splits laterally.

Blair Athol Coal Measures - contain 4 coal seams with possible unconformity in the sequence above the seams. The Big Seam which has a maximum thickness of 33 m, is the second lowest seam and is the only one worked; it is equivalent to the Aldebaran Sandstone although it is possibly somewhat earlier.

Aldebaran Sandstone and Freitag Formation - thin coal seams in upper (third) unit of Aldebaran Sandstone in the northern Denison Trough and adjacent Comet Ridge, but in general coal lenses can occur at any level in the Aldebaran Sandstone.

Upper Permian

GROUP III

German Creek Formation - coal seams pass laterally into the Moranbah Coal Measures to the north. Coal seams are in the upper half, with the lowermost, the German Creek Seam, of economic interest. The coal measures are 170-280 m thick.

Fair Hill Formation - three coal seams more than 3 m thick are present including those mined at Goonyella and Peak Downs. The formation is 215 m (at Goonyella) to 370 m thick (45 km further north). Minor coal occurs to the south where the formation is 75 m thick at Emerald, to 180 m thick north of Blackwater. The formation is probably younger in the south than in the north.

Hail Creek Beds - the beds are 500-1000 m thick with coal up to 7 m. The Beds are approximately equivalent to the Fair Hill Formation.

GROUP IV

Baralaba Coal Measures - the Kaloola Member at the base is equivalent to the Fort Cooper Coal Measures and Burngrove Formation and upper part is equivalent to the Rangal and Elphinstone Coal Measures. The Kaloola Member (30-40 m) has silicified siltstone with fossil leaves and thin coals. The upper part has thick coals.

Bandanna Formation - the Lower Bandanna Formation is equivalent to the upper Burngrove Formation and the Upper Bandanna Formation is equivalent to the Rangal and Elphinstone Coal Measures, and constitutes the topmost coal measures of the Bowen Basin. The formation has a maximum thickness of 125 m with coal seams to 4 m thick and local oil shale.

Rangal Coal Measures - coal seams are up to 8 m thick and the coal varies in type and quality due to splitting and lateral and vertical variations. The coal measures are 40 - 175 m thick, with northward thickening. The top of formation is indistinct which is common to all equivalent coal measures.

Elphinstone Coal Measures - Important localities and known coal seam thicknesses are -

Exmoor - 30 m of coal measures with one thick coal seam. Hail Creek - 85 m of coal measures with two economic seams. Collinsville Shelf - 40 m of coal measures with one seam. Nebo Synclinorium - 120-180 m of coal measures with two seams.

QUALITY

High volatile bituminous to anthracite in rank. 73% of measured reserves are classified as coking coal.

The rank of the coals has been related to structural deformation (7), to depth of burial (3) and depositional tectonism (4).

In other parts of the world low rank coal occurs in severely deformed terrains, proving that pressure is not important in determining rank. Temperature is the significant factor, and in the Bowen Basin the rank trend is probably the result of a parallel trend in depth of burial. The trend in structural deformation is coincidental.

Distribution

Best quality and thickest coal occurs in the Early Permian of the Denison Trough, and in the Late Permian on the eastern margin of the Collinsville Shelf and Comet Ridge adjacent to a foredeep. On the stable basement the seams are thinner, as they are also in the rapidly subsiding parts of basin where the inorganic content is high.

Rank

Sub-bituminous to anthracite.

1. Low rank on the western margin of the basin where subsidence is slow and there is a thin overlying sequence.

2. In the intermediate areas there are low to medium volatile bituminous rank coals due to greater thickness of overlying sediments in areas between the stable margin and the rapidly subsiding eastern part.

3. The Folded Zone and Nebo Synclinorium have higher rank coals due to a thicker overlying sequence.

4. In other areas rank does not correlate with maximum depth of burial of coal and differences in rank of coal at different stratigraphic levels are anomalous. The anomalously high ranks could be due to different geothermal gradients, different conductivities of basement rocks or later igneous activity.

RESERVES (NEAC REPORT)

Measured and indicated reserves are -

In situ - 21 899 million tonnes
Recoverable - 12 361 million tonnes (NEAC, 1981)

Inferred in situ resources are very large, i.e. in excess of 10 000 million tonnes.

Measured and indicated reserves in situ are 22,678 megatonnes (QDM, 1981).

About 2/3 of the reserves can be classed as coking coal. The figures given are considered to include only a small fraction of the total coal resources of the basin.

EXPLORATION

21% of total coking coal reserves down to 100 m depth can be extracted by open cut. The high ratio of open cut to underground extraction indicates youthful stage of exploration in the basin.

PROBLEMS

A great deal of fundamental geology remains to be resolved because of the meagre outcrop particularly of coal measure sequences. A few of the major geological problems are -

1. Discrepancies of dating between macrofossil and palynological determinations.

2. Seam correlations from area to area are not resolved.

3. Discrepancies in the picking of boundaries between formations both in outcrop and drillholes.

4. Non uniformity of stratigraphic nomenclature.

The lack of uniformity in the interpretation of the stratigraphy of the Late Permian sequence on the Collinsville Shelf has been cited as a specific problem. (4)

The extreme thickness of the Big Seam (Blair Athol Basin), its uniform, durainous profile and low ash pose intriguing problem in the interpretation of its sedimentological history.

Some of the factors controlling mining are as follows:

1. Mining on the western shelf area is simpler because of less disturbance, but mining is possible on the gently folded regions of the trough.

2. Mining difficulties in the northern Bowen Basin because of variable distribution of igneous intrusions in coal.

3. Seam splitting and faulting are not major factors in mine geology; the main problems are high wall and spoil heap instability.

4. There are vast reserves of gas-bearing coal deposits in the basin which produce unsafe underground mining conditions.

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BASIN/FIELD	Sydney Basin, New South Wales
AREA	29 000 km^2
MINING	In mid-1979 there were eighty-three mines in operation including thirteen open cuts. Buchanan Lemington and Ravensworth No 2 were the largest producing mines in 1978-79.
SEDIMENT THICKNESS & AGE	Permian and Triassic sediments up to 5900 m thick in the northern part of the basin and 4800 m in the south.
COAL MEASURE UNITS	Generalised coal measure stratigraphy and correlation.

Late Permian	Illawarra Coal Measures	Singleton Super Group	(Wollombi Coal Measures	Newcastle Coal Measures
			(Wittingham Coal Measures	Tomago Coal Measures
Early Permian				Greta Coal Measures
	Clyde Coal Measures			

The Late Permian Singleton Super Group is divided into the Newcastle & Tomago Coal Measures in the Lower Hunter area and equivalent Wollombi and Wittingham Coal Measures in the Upper Hunter Area. The Newcastle Coal Measures are roughly equivalent to the upper 2/3rds of the Sydney Sub-group of the southern coalfield. The Illawarra Coal Measures of the Western Coalfield and Burragorang Valley appear to be equivalent to both the Newcastle and Tomago Coal Measures.

The Early Permian Greta Coal Measures of the Northern Coalfield correlate with the Muswellbrook (North Western) and in part with the Clyde (Southern Coalfield) Coal Measures. Alternatively if the Greta Coal Measures are equivalent to the Snapper Point Formation then the Clyde Coal Measures are older.

LITHOLOGY	Singleton Super Group - they are thicker, contain a variable but high concentration of coal beds, and have a characteristic stratigraphy that distinguish them from equivalent coal measures. The coal measures are characterised by splitting of coal seams and rapid facies changes in the inter-coal strata e.g. the Foybrook Open Cut.

Newcastle Coal Measures - coal seams occur in a sequence of conglomerate, sandstone, mudstone, shale claystone and tuff.

Tomago Coal Measures - numerous coal seams are interbedded with sandstone, shale, mudstone, claystone and conglomerate. The conglomerate content is minor compared to the Newcastle Coal Measures. There is one recorded occurrence of marine fossils within the Tomago Coal Measures in a bore hole. Units in the Tomago Coal Measures are - Dempsey Formation, Four Mile Creek Formation and Wallis Creek Formations.

The Kulnura Marine Tongue occurs in the Tomago Coal Measures and may indicate a major facies change in an offshore direction. Marker beds of sandstone underlain by worm burrowed mudstone occur at the base of the Bayswater Seam (Wittingham Coal Measures), and another at the base of the Wollombi and Newcastle Coal Measures which appears to be distributed throughout the Sydney Basin.

Greta Coal Measures - interseam sediments comprise mainly conglomerate and sandstone with minor shale, siltstone and mudstone. The conglomerates contain abundant volcanic pebbles derived from Carboniferous volcanics to the north and northeast with a decrease in pebble size to the south.

Wollombi Coal Measures - differ from the Wittingham in that tuffaceous claystone is abundant, coal seams are excessively banded and few seams are commercially significant. It has been postulated that the tuffaceous material was responsible for depositional stability by levelling areas of differential subsidence of the Wollombi Coal Measures.

Wittingham Coal Measures - numerous coal seams in two sub-groups of continental coal measure sequence predominantly with fluvial components. The lower part of the Wittingham Coal Measures commence with a sandstone transitional from the underlying marine sequence. The two sub-groups are separated by transitional lagoonal and probable lacustrine phases and terminate with bioturbated marine-like strata that are probably intertidal.

Illawarra Coal Measures - comprise quartz and quartz lithic sandstone, shale and tuffaceous material which contains thick coal seams (e.g. Wongawilli Coal). Rapid vertical and lateral changes in lithology indicate marginal conditions of sedimentation.

Clyde Coal Measures - comprise interbedded sandstone siltstone, shale, mudstone and claystone with mostly thin inferior coals and kerosene shales and some isolated clean coal.

OUTCROP

Outcrops of the coal measures are widely distributed around the margins of the basins in both natural and man made exposures.

In the southern coalfield the Illawarra Coal Measures intersect sea level 20 km north of Wollongong, extend along the Illawarra Range for 40 km to the south, and then the outcrop turns westward to form the north side of the Shoalhaven River Valleys.

The Wongawilli is the best exposed seam in outcrop in the Burragorang Valley and Lower Blue Mountains, in cliffs and gullies. Other seams of the Sydney Sub-Group are rarely found in outcrop. The coal measures persist to the Kanangra Walls but are too thin and inferior for development. The Bulli Coal is well exposed in gullies beneath the cliffs.

The Clyde River Coal Measures crop out in dissected plateau country around the headwaters of the Clyde River.

In the western coalfield the Illawarra Coal Measures are exposed along the western edge of the coalfield and in river valleys.

The coal measures of the Singleton Super Group crop out from Pokolbin to Murrurundi in the Upper Hunter Valley, and the Wittingham Coal Measures are best developed near Bulga. The Greta Coal Measures are accessible for mining around the Muswellbrook and Lochinvar Anticlines.

DISTRIBUTION

The Late Permian Coal Measures in the Sydney Basin contain the major part of the coal resources. In the Upper Hunter Area the potential of the Early Permian Greta Coal Measures is small compared to Wittingham Coal Measures and Singleton Super Group. Extracting the Greta Coal Measures will involve mostly underground mining and hence there will be an increase in emphasis on the Singleton Super Group, particularly as recent exploration has revealed new seams in the Group with coking blend coals. The coal bearing sequence in the Wittingham . The coal measures thins to the southwest, where seams are thinner and more dispersed throughout the sequence.

In the Burragorang Valley the Bulli Seam is shown to continue from the Burragorang and Jamieson Valleys to the Lapstone Monocline/ Oakdale Fault.

The distribution of the Clyde River Coal Measures is poorly known. No coal measures were intersected in a drill hole 12 km west of Nowra, so they do not appear to be continuous with coal measures known to the north of Nowra.

STRUCTURE

The Sydney Basin is essentially a half graben which originated as a linear molasse foredeep between an active hinterland (New England Fold Belt) and a cratonised foreland (Lachlan Fold Belt). The thickest sediments occur in the northeast next to the Hunter Thrust System. A shelf area borders the craton to the southwest. Dips are usually less than 5^{o} but the sequence is considerably more deformed at the northern margin with large scale movements, volcanic activity, a complex pattern of faulting and a sedimentary succession that reflects the unstable northern margin. The northwestern margin laps onto the Lachlan Fold Belt and comprises a relatively thin sequence of Permian and Triassic rocks. The basement has probably been stable since the Permian. The southern margin overlies older Palaeozoic rocks, and displays extensive igneous activity and faulting. The continental shelf edge is the eastern extent of the basin.

Varying rates of basement subsidence, caused by epeirogenic movements, formed a number of structurally independant sub-basins. Growth structures with sediment thinning are probably related to uplift of the New England Block e.g. the Tomago Coal Measures around the Lochinvar Anticline. The Hunter Valley anticlines do not show structural growth and are probably younger, formed by late Triassic movement of the mobile block. A related effect of structural growth is an improvement of seam quality and thickness in synclines as apposed to anticlines.

The Sydney Basin appears to be tilted to the south-west; isopachs indicate tilting and corresponding changes in thickness during deposition. Marker beds in the coal seams are in places known to correspond to a vertical change in coal seam quality from coking to non-coking. This is attributed to tilting movements causing widespread depositional changes and corresponding changes in plant types.

ENVIRONMENT OF DEPOSITION

The Early Permian Coal Measures were deposited in fluvial and deltaic environments. Deposition of the Late Permian Coal Measures, also fluvial and deltaic, is attributed to a back swamp setting with initially a very wet environment becoming drier towards the top of the Late Permian coal measures.

INTRUSIONS

Dykes, necks and sills with ages ranging through Permian, Triassic, Jurassic Prospect sill, Cretaceous and Tertiary. They are mainly concentrated along the northern and southern margins.

The Permian igneous rocks occur as dykes, sills, flows and some laccoliths of shoshonitic composition. Triassic basaltic diatremes occur in the central basin and tholeiitic basalt flows in the south. Tuffaceous beds occur in the Narrabeen Group. Cretaceous stocks, sills and dykes occur mainly in the South Sydney Basin in the Illawarra Coal Measures.

Dykes and sills, mostly of unknown age, occur as swarms in the eastern part of the basin where they adversely effect the Illawarra and Newcastle Coal Measures. Some intrusions in the Newcastle Coal Measures are dated as Cretaceous and others in the Wittingham Coal Measures are Tertiary.

Cainozoic basalt flows occur in mid-Eocene to Miocene interval. Tuffaceous layers occur in the Late Permian coal measures as bands in seams and claystone beds in interseam sediments.

Igneous rocks have in places cindered coal seams over large areas although the width of the affected zone varies according to the composition of the intrusion. An increase in coal rank occurs in places e.g. a syenite sill near Mittagong in the Wongawilli Seam has increased coal rank to semi-anthracite.

COAL SEAMS

<u>Newcastle District</u> - 14 main seams and several minor seams occur in the Newcastle Coal Measures.

<u>East Maitland-Tomago District</u> - numerous coal seams occur in the Tomago Coal Measures.

<u>Wattagan District</u> - correlatives of Tomago and Newcastle Coal Measures are present but thickness of cover to the uppermost coal seams is usually greater than 600 m. The Greta Coal Measures are probably not present because the contemporaneous sediments are probably marine.

Maitland-Cessnock-Greta District	- the Greta Coal Measures are the source of coal. The Wollombi and Wittingham Coal Measures thin and in places pinch out around the Lochinvar Anticline.
Singleton-Muswellbrook District	- The Wittingham Coal Measures of the Singleton Super Group are of current economic interest. The super group contains 28 named coal seams or members which commonly have several splits. The Wollombi Coal Measures have few seams that are commercially significant. The Bayswater Seam is the major source of open cut, steaming coal for power generation in the Hunter Valley and is one of the most persistant and distinctive marker beds in the Wittingham Coal Measures; the Liddell Seam is one of the best documented. The Greta Coal Measures occur at depths mostly in excess of 600 m except on major anticlines at Balmoral, Muswellbrook, Glendonbrook and Wingen.
Central Coalfield	- correlatives of the Newcastle and Tomago Coal Measures are present but the lower coal measures may be largely absent due to facies change. An additional 30 m or so of coal bearing strata, including an uppermost coal seam, may overly the Bulli Seam in the northern part of the area. The Bulli Seam is probably a correlative of the Wallarah Seam of the Newcastle Coalfield. (Stuntz, 1975)
Southern Coalfield	- the coal seams are concentrated in the Sydney Sub-Group of the Illawarra Coal Measures. The Bulli and Wongawilli Seams are the most important.
Burragorang Region	- seams occur in the Sydney Sub-Group of the Illawarra Coal Measures, with coal won from the Bulli Seam.
Berrima District	- coal occurs in the Illawarra Coal Measures but because sedimentation ceased after the Wongawilli Seam was deposited the upper Bulli, Balgownie and Burragorang seams of the southern coalfield are missing. The Wongawilli Seam is present only in the east and northeast and thickness in the southwest is reduced by erosion beneath the Hawkesbury Sandstone.
Clyde River Coal Measures	- coal seam development is generally poor although substantial seams occur over restricted areas of reasonable coal. The best coals occur in the Clyde Valley but pinches out in 0.4 km. The seam thickness, including three shale plies, aggregates 0.36-17.3 m.

Western Coalfield - main coal worked is the Lithgow Seam of the Illawarra Coal Measures. It has been mapped along strike for 50 km between Lithgow and Ben Bullen. Exploitation is limited by seam deterioration down dip to the east and northeast, but the overlying seams improve. A 13 m seam of steaming coal occurs at Ulan at the same stratigraphic level as the Lithgow Seam.

QUALITY

Regional Analysis - 65% of 1st Category reserves have coking properties ranging from prime quality, low-volatile coking coals in the Southern Coalfield to medium volatile coking coals in the Burragorang Region of the Southwestern Coalfield. The largest deposits of steaming coals are found in the Western and Northwestern Coalfields and especially in Singleton - Muswellbrook Region. Anthracite is found locally in the Mittagong area near igneous intrusives.

The coals are generally representative of the numerous black, bright seams formed under active geosynclinal conditions. (2)

In general hard, coking coals occur in the south Sydney Basin, medium strength and soft coking coals in the west and north, and soft coking coals in the Gunnedah Basin.

Hard to medium coals in the southern and western Sydney Basin occur on or near a tectonic shelf and higher temperatures caused by igneous intrusion and/or depth of burial may have had a considerable influence. The Permian sediments in the south Sydney Basin are more consolidated than in the north suggesting removal of thick cover.

Soft coking coals occur in the northeast or fore-deep part of the Sydney and Gunnedah Basins and the changed environment in this region has effects on plant types.

Steaming coals are locally interbedded with coking coals and lateral changes from non-coking to coking can occur in one seam in a short distance i.e. over a distance of about 300 m.

District Analysis

Newcastle - the top seams in the Newcastle Coal Measures are sources of fuel coal and the lower seams yield high volatile coking coal.

East Maitland-Gomago - high volatile coal for coking blends in the Tomago Coal Measures.

Maitland-Cessnock-Greta District - high volatile, low ash coals with 60-70% vitrinite that vary only slightly in rank. R_o^{max} 0.6 - 0.7% i.e. lower rank than Newcastle Coal Measures to the east. The rank probably increased down dip. The coals are useful for coking blends within limitation of low rank and high sulphur content.

Singleton-Muswellbrook - the Singleton Super Group yields coals with marginally acceptable coking properties but rank is generally lower than Queensland coals. The Greta coals are used principally for steam raising or blending with other coals. They are low rank (R_o^{max} 0.49%).

Central Coalfield - coal has strong coking qualities and the rank increases with depth.

Southern Coalfield - most seams provide low volatile, hard coking coals together with some steaming coals. Seams are meta-bituminous and have the highest rank of NSW coals with rank increasing to the northwest.

Burragorang Region - the Bulli coal is a medium to high volatile, bituminous coal and quality variation is small. It deteriorates to the west and under the central and southern parts of the Blue Mountains National Park, and passes into shale to the northeast and southwest. Fluctuations in seam thickness are caused by lensing dull coal components.

Berrima - comparatively low-rank coal except near syenite sills. Ash yields are highly variable and coking properties weak. It is suitable for blending with high rank or inert-rich coals.

Clyde River Coal Measures - the coal is similar to the Greta Coal Measures but are probably older.

Western Coalfield - the Lithgow Seam is a medium volatile steaming coal with raw ash from 13-22%. A similar coal occurs in the Katoomba Seam which has a small coking fraction in some areas. The top sub-section of the Wolgan Seam is best quality, high volatile vitrain rich, coking coal.

RESERVES

Measured and indicated reserves are 21 234 million tonnes in situ and 11 001 million tonnes recoverable; Inferred resources in situ are 377 617 million tonnes which includes some coal at depths greater than 1000 m. Most of the reserves and resources are contained in the Wittingham Coal Measures.

Coals in both categories are classified as bituminous coals. Of the recoverable measured and indicated reserves of marketable coal high volatile coking coal comprises 4 149 million tonnes, medium volatile coking coal 508 million tonnes, and low volatile coking coal 744 million tonnes. Non-coking coal comprises 3 149 million tonnes. The principal black coal reserves and resources occur in the Singleton - North West Region, followed by the Newcastle Region. (Joint Coal Board, 1980).

PROBLEMS

An overview of the Sydney Basin has indicated the following problems - discrepancies and lack of information on the precise correlation of coal seams and stratigraphic sequences throughout the basin - lack of uniformity of stratigraphic nomenclature - proliferation of stratigraphic names and confusing terminology.

The following problems pertaining to mining are apparent - washouts, stone rolls, differential compaction, sedimentary dykes, and varying roof rock types present problems and potential hazards during mining. Stone rolls often occur in swarms and cause badly broken immediate roof strata and damage to continuous miners.

Exploitation can be limited by roof problems which can be directly related to rock types, for example -

- shale and mudstone display weaknesses due to planes of discontinuity.

- laminite is subject to fracturing and bedding plane separation.

- sandstone failure is determined by its lithological variability. Sandstone coverage can be mapped to indicate roof conditions.

- coal may be pliable and subject to bed separation; failure usually follows tension cracking in separated beds.

Roof failures and floor heave can be attributed in many instances to abnormally high horizontal stress and structural anisotropies and also to bed separation and igneous intrusions.

A depth of 500 m is considered the maximum for containing the superincumbent loading. Stress can be due to over burden as well as residual stress from tectonic deformation.

Faults, joints, igneous intrusions and sedimentary structure produce anisotropies and influence mining conditions. A well defined geometrical relation exists in the roof strata between palaeocurrent direction and spacial attitude of joints, and similarly large-scale folds and faults are inter-dependant and often control the strike of igenous intrusives.

The behaviour of necks and plugs and other intrusives in many areas of coal measures is unknown. Cinder caused by igneous sills can cover zones up to 1 km wide.

Natural gas and coal outbursts are associated with structural phenomena in seams, and gas emissions are present in the permeable lenses in the overlying sandstones in places.

The task of coal geologists in the Sydney Basin mines is primarily to map and analyse sedimentary and structural features with a view to predicting conditions ahead of advancing faces. Other aspects include core logging, coal quality control sampling, airphoto interpretation and geophysics.

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BASIN/FIELD	Arckaringa Basin, South Australia
AREA	70 000 km^2
SEDIMENT THICKNESS & AGE	1200+ m of Permian and Triassic sediments. In the Phillipson Trough about 35-50 m of Mesozoic sediments overlie about 1000 m of Early Permian section.
COAL MEASURE UNITS	Coal seams occur in the Mount Toondina Beds of the Boorthanna Trough.
LITHOLOGY	The sequence in Cootanoorina No. 1 well comprises siltstone, sandstone, carbonaceous shale and coal. (1)
OUTCROP	Mount Toondina in the Arckaringa Basin is the only known outcrop.
COAL DISTRIBUTION	Mount Toondina beds in the Mount Toondina Structure, Cootanoorina No. 1, Boorthanna No. 1, Karkaro No. 1, and Mount Funer No. 1. Shallow coal could occur over a wide area of the central Arckaringa Basin. Coal has been proved over about 200 km^2 of the Phillipson Trough.
STRUCTURE	Regional dips are 1-2^o in the Phillipson Trough of the southern part of the Arckaringa Basin. Coal occurs in two shallow elongated sub-basins, one 60 km long, and the other 35 km long. The coal seams are little affected by faulting (SADME).
ENVIRONMENT OF DEPOSITION	Freshwater, lacustrine/swamp environment.
	Mount Toondina - Late Permian coal occurs in six seams totalling 9.9 m with the thickest two seams each 2.3 m thick (SADME).
COAL SEAMS	Phillipson Trough - black bituminous coal in several seams 0.3 - 8.7 m thick from 50 - 143 m, with the thickest from 69 - 77 m, were penetrated in a water bore drilled in 1905 in the Phillipson Trough. The sequence is overlain by 50 m of Mesozoic rocks. (2) In the main basin of the Phillipson Trough coal occurs in 11 seams from 1.5 to 9.0 m thick, with depths of overburden ranging from 50 m to in excess of 150 m (SADME). The base of the coal measures is about 200 m below the surface in the centre of the Arckaringa Basin. The coal measures are 170 m thick and comprise 10 coal seams (A-J) with coal predominating in C, F and I seams. Coal seam thicknesses are C (2m), F (4.5 m, thins locally to 3.5 m and occurs 50 m below C), I (2-3 m, 40 m below F). (2) Cootanoorina No. 1 - 14 seams of coal 10 cm to 2 m thick in the interval 190 - 350 m. Boorthanna No. 1 - formation 600 m thick; several seams but thinner than in Cootanoorina No. 1 Karkaro No. 1 - two seams 1 and 2 m thick in the interval 70 - 74 m.

Mt Furner No. 1 - five seams 1-3 m thick in the interval 130 - 170 m.

Coal seams up to 10 m thick at depths in excess of 200 m have been located in other parts of the Arckaringa Basin (SADME).

QUALITY

The majority of seams in the Phillipson Trough are more than 50% carbonaceous shale and generally low rank, high volatile and moisture content, non-coking coal.

RESERVES

Measured and indicated reserves exceed 600 mega-tonnes in situ. (SADME).

Indicated in situ resources are 2 600 mega-tonnes of steaming coal in the Phillipson Trough. (NEAC, 1981)

PROBLEMS

The Basin is currently under exploration but isolation and low quality of coal are inhibiting factors. Deposits near the Tarcoola/Alice Springs railway are sought. (2).

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BASIN/FIELD	Ashford Coal Field, New South Wales
AREA	Coal measures extend over a distance of 56 km.
MINING	Potential fuel coal for power generation in Ashford - Inverell area. The Ashford Seam, the only economic seam, is extracted by open cut.
COAL MEASURE UNITS	Ashford Coal Measures. In places overlain by marine glacial sequence which is similar to Maitland Group where it overlies Greta Coal Measures in Hunter Valley .
	Generalised stratigraphic table -
Permian	Ashford Coal Measures - maximum 300 m thick.
	unconformity
Early Carboniferous	Beacon Mudstone
	Permian granite intrudes the Beacon Mudstone and is faulted against the coal measures but does not intrude them. The top of the Coal Measures are eroded.
LITHOLOGY	Ashford Coal Measures - interbedded shale, sandstone, conglomerate with coal seams, some carbonaceous shale.
COAL DISTRIBUTION	Narrow discontinuous strip of Permian Coal Measures 56 km long.
STRUCTURE	The coal seams are unusually complex. They dip at $20-40^{o}$ to 300^{o} with local syncline near Arthurs Seat. Strong deformation is evident in the open cut.
COAL SEAMS	Thin coal seams throughout measures but only economic near Ashford. The Ashford Seam ranges from 2 m up to 16 m thick, and is separated by an interval of 35-50 m from the Bonshaw Seam.
QUALITY	Extremely variable. Black carbonaceous shale is commonly included in the coal as they are difficult to distinguish. The coal has some coking qualities and potential for blending with other coals, for coking (1). Relatively high rank, high vitrinite content, low sulphur content, and moderately good ash yield. (3)
RESERVES	Measured, plus indicated reserves are 0.8 million tonnes in situ. Inferred resources are 6 million tonnes in situ. (2)

EXPLORATION

Further exploration has emphasised variability of main seam and its limited potential away from the worked area.

PROBLEMS

1. Unusual structural complexity of coal seams.
2. Wide variation in thickness of coal seams.
3. Sporadic and variable occurrence of coal.
4. Difficult underground mining conditions.
5. Limited reserves.
6. Remoteness from coal markets.

All the above factors indicate that the field has little economic significance.

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BASIN/FIELD	Blair Athol, Queensland
AREA	36 km^2
SEDIMENT THICKNESS & AGE	The maximum depth of the basin is about 250 m. Generalised stratigraphic sequence -
Tertiary	60 m - two levels of basalt with intervening and underlying sediments
	______ unconformity ______
Late Permian	40 m - 'White' section rests directly on the Big Seam in places
	______ ? short period of erosion ______
Early Permian	95 m Blair Athol Coal Measures. About 55 m basal conglomerate
	______ unconformity ______
Early Palaeozoic	Anakie Metamorphics
	Palynology indicates that the Early Permian Blair Athol Coal Measures are equivalent to Upper Stage 4a, about the same age as the Aldebaran Sandstone.
COAL DISTRIBUTION	The coal bearing strata occupy only the central 12 km^2 of the basin. Coal measure sediments are also known at the Miclere Goldfield 16 m north, and at Black Ridge 8 km northeast.
STRUCTURE	Blair Athol is a semi-isolated small Permian basin in the Early Palaeozoic Anakie Metamorphics, beyond the western margin of the Bowen Basin. The basin is elongated north-south with coal restricted to a circular depression south of its centre. The sediments are draped over an undulating basement and are mostly flat lying. Minor faulting is present, two with throws of 4-6 m, that trend about northeast and define a central horst.
LITHOLOGY	The Blair Athol Coal Measures form an upward fining sequence containing four major coal seams.
ENVIRONMENT	Blair Athol is considered to be a maritime basin set in a drainage system deeply incised into the Anakie coast line. Deltaic conditions are evident at Capella, Rugby bore area, and Collinsville in Aldebaran ties along the palaeoshoreline.
	It has been decribed as a limnic basin in the marginal uplands of the Bowen Basin, possibly at the confluence of major tributaries of the river system debouching at the Capella Delta. Fluvial conditions on a levelled landscape prevailed in the basin at the time of a marine transgression in the Bowen Basin and possibly resulted in a

rise in the water table and development of coal swamps along the drainage system. Differential subsidence may have isolated Blair Athol from the main Bowen Basin. The durainous massive coal and lenticular development suggests deposition in and around shallow subsiding lakes in which algal and herbaceous material accumulated. This was followed by a return to fluvial conditions indicated by ripple drift structures, possibly river side level deposits.

INTRUSIONS

Coked coal at the northern end of the field may be associated with a volcanic plug; a possible altered dyke occurs in the same area.

COAL SEAMS

Only the Big Seam has economic potential. It is lensoid in the main basin, and thins rapidly towards the margins of the central depressions and pinches out below ground level. A lower split occurs in the south. The maximum depth to the top of the Big Seam is 53 m where the seam is 25.1 m thick.

QUALITY

The Big Seam is clean throughout; it comprises mainly dull coal with subordinate brighter streaks, and three or four 1 - 3 cm mudstone bands in the lower third. Fusain is common on the bedding planes.

The coal is medium to high volatile, bituminous, low rank, sub-hydrous, durainous, non-coking coal. International Classification - 501, HGI71.

RESERVES

Proven reserves are 240 mega-tonnes including 5 mega-tonnes in No's 1 and 2 seams, calculated as lying within the area of the 3.3 m isopachyte and minable by open cut with overburden to coal ratio of 1.35:1.

PRINCIPAL REFERENCE

OSMAN, A.H., & WILSON, R.G., 1975 - Blair Athol Coal Field. In TRAVES, D.M., & KING, D., (Eds.), ECONOMIC GEOLOGY OF AUSTRALIA AND PAPUA NEW GUINEA. Australasian Institute of Mining and Metallurgy Monograph 6, Volume 2 Coal, 376-380.

BASIN/FIELD — Bonaparte Gulf Basin, Western Australia and Northern Territory

AREA — 260 000 km^2

SEDIMENT THICKNESS & AGE — The maximum thickness of Palaeozoic rocks in the basin is about 3700 m.

The Early Permian onshore sedimentary sequence comprises the Sugarloaf and Kulshill Formations.

Sugarloaf Formation	(Shale Member	
	(Sandstone Member	(Upper Sandstone Unit
		(Sandstone & Shale Unit
		(Lower Sandstone Unit
		(2)

Kulshill Formation	(Greywacke Member
	(Microconglomeratic Shale Member
	(1)

The units of the Sandstone Member of the Kulshill Formation are traceable on air-photos.

The Sugarloaf Formation is 127.7 m thick in two coal bores at Cape Hay near Port Keats and contains thin seams and streaks of coal.

The Kulshill Formation is 274.3 m thick in Kulshill No's 1 and 2 and contains bright, bituminous coal.

COAL MEASURE UNITS — Coal occurs in the Early Permian Sugarloaf and Kulshill Formations onshore and Early and Late Permian coal bearing sequences occur in offshore well sections.

The most prospective coal bearing formation is the Greywacke Member of the Kulshill Formation (2).

The Greywacke Member has a variable carbonaceous content and the only true coal intersections occur in the southern area. (2)

LITHOLOGY — The Sugarloaf Formation comprises marine sediments and non-marine quartz sandstone, and thin black shale with coal.

The Kulshill Formation comprises non-marine, fine grained lithic sandstone and mudstone with thin coal beds.

Lacrosse No. 1 well section -

Late Permian (3000 m) - sandstone, black shale, with coal in the middle part of the section.

unconformity

Early Permian (1000 m) - sandstone, carbonaceous siltstone, thin coal seams, grading downwards to coarse grained sandstone with pebble bands.

The upper 400 m of the Early Permian sequence is marine, and the remainder non-marine. These can be equated with the on-shore marine and non-marine sections.

Fine grained sandstone of the Greywacke Member of the Kulshill Formation grades northward along strike into a conglomeratic sequence in Cliff Head No. 1 bore.

OUTCROP

There are unconfirmed reports of coal outcrops around the Billawock Hills, and the coal is reported to have burned at one stage. (2)

The limit of oxidation of the Greywacke Member of the Kulshill Formation is about 15-18 m, and the Sandstone Member of the Sugarloaf Formation is completely oxidised. (2)

COAL DISTRIBUTION

Thin coal seams occur in drillholes along the coast, in the Greywacke Member of the Kulshill Formation in Moyle River No. 1, Kulshill No's 1 and 2, Lacrosse No. 1, and Comapny exploration drillholes.

The coal interval was not intersected 26 km north-northeast on the northern traverse. (2)

STRUCTURE

The axis of the Bonaparte Gulf Basin trends northeast from the Victoria River area. (2) The eastern edge of the basin is bordered by a north trending fault complex with a thin Permian sequence overlying basement east of the fault (3). Dips in the sediments are mostly in the range of $1-3^{\circ}$. (2)

ENVIRONMENT

Coal in Moyle River No. 1 is vitrain rich which requires anaeorobic conditions and probably formed in localised depressions in a sandy environment.

COAL SEAMS

Three coal intersections occur in Moyle River No. 1 with the deepest and most significant at 213.4 m. Coal occurs in small 'penny bands' or discrete layers in unconsolidated white quartz sand. Two other intersections are at 153.9 m and 176.8 m. (Note - the coal intersections in Moyle No. 1 were found to be grossly overlogged). (2)

The thickest (0.3 m) coal in Moyle River No. 1 occurs in a possible beach sand and is probably not significant. 0.3 m of coal occurs in a carbonaceous interval 4.6 m thick about 14.6 km further north, indicating improved coal sequences in this direction. Carbonaceous intervals which occur above the 'beach sandstone' in Moyle No. 1 are insignificant, but appear to thicken to the north. (2)

Coal Seams 0.8-1.1 m thick were penetrated in Kulshill No. 1 at 356.6 m, 362.7 m, 396.2 m and 402.3 m in the Sugarloaf Formation.

Coal in Kulshill No. 2 include a 1.5 m seam at 131.1 m, 1.5 m seam at 167.6 m and 3.05 seam at 396.2 m, and one thin coal bed at 533.4 m, in the Kulshill Formation.

Coal in partings, thin lenses and seams less than 60 cm thick were intersected in the area explored by Utah. (3) Thin seams occur in the Shale and Sandstone Member of the Sugarloaf Formation.

Poor quality coal 60 cm thick in the interval 167-167.6 m occurs in Kuriyippi No. 4 bore.

QUALITY

Coal cuttings from Moyle River No. 1 are low rank with about 40-45% volatile matter, i.e. much lower than Newcastle Coal. (2)

EXPLORATION

Early (1905-1909) exploratory coal bores include the Port Keats coal bores 1-4 drilled along the coast in the Anson Bay, Cliff Head area.

Petroleum exploration wells that yielded information on the Permian coal bearing sequences included AAP Kulshill No's 1 and 2, Moyle River No. 1, and Lacrosse No. 1.

Thiess Bros Pty Ltd drilled Kuriyippi coal bores No's 1-5 to test coal intersections in Kulshill No's 1 and 2. The thickest coal was 0.6 m in black 'clay' of the Sugarloaf Formation.

A total of 810 m of drilling in 5 holes was carried out by Utah Development Co. in Coal Licence Area 172 to test coal intersections in the Greywacke Member of the Kulshill Formation in Moyle River No. 1. The formation was explored for 100 km along strike and located several seams but none exceeded 1 m in thickness.

PROBLEMS

The limited amount of drilling precludes any definite assessment of resources.

The area between the southern and northern traverses has not been tested and may not be non-prospective.

The area further north may be more prospective, where the radius of the basin is larger.

Coal seams apparently deteriorite to the east and open cut prospects are limited to areas where the Sugarloaf Formation has been removed from the Greywacke Member in the west where seams are presumably better developed. (2)

Coal was not intersected on Utah's Northern Traverse Line and if it is present west of the line the Sandstone Member (Sugarloaf Formation) overburden will be too great for open cut extraction. If coal of acceptable quality and thickness is developed then the area where the sandstone Member has been eroded far enough west must be found. (2)

The unconsolidated sediments in the sequence indicate -

1. The coal may be lower in rank than anticipated,
2. difficult underground mining conditions may be experienced,
3. problems of ground water inflow.

The southern half of the area is non-prospective. (2)

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(2) WILLIAMS, P.R., 1972 - Report on the 1971 drilling programme on coal licence 173, Bonaparte Gulf Basin, Northern Territory. Utah Development Co., Report No. 193 (unpublished).

(3) LALOR, R.M., 1967 - Report on coal exploration in portion of coal licence 172, Port Keats area, Northern Territory. Geotechnics (Aust.), Pty Ltd, (unpublished).

PRINCIPAL REFERENCE

KOPPE, W.H., 1975 - Calen Coal Measures, Queensland. In TRAVES, D.M., & King, D., (Eds.), ECONOMIC GEOLOGY OF AUSTRALIA AND PAPUA NEW GUINEA. Australasian Institute of Mining and Metallurgy, Monograph 6, Volume 2 Coal. 250-251.

BASIN/FIELD	Canning Basin, Western Australia
AREA	415 000 km^2 onshore
SEDIMENT THICKNESS & AGE	Ordovician to Permian with Mesozoic and Tertiary thin cover.
COAL MEASURE UNITS	Mainly Artinskian and Kazanian continental sediments in the Fitzroy Graben. Carbonaceous material is present in the Jurassic Wallal Sandstone but the formation has not been drilled extensively. Thin coal seams and carbonaceous material were intersected in a BMR stratigraphic hole that penetrated the Poole Sandstone in the Noonkanbah/ Mount Bannerman area. Condren Sandstone of the Liveringa Group - coal measures (coal seams and carbonaceous shales) near the base of the Formation and thin seams and shales near the top of the Formation. Lightjack Formation - coal in the middle part of the Formation. Grant Group - some carbonaceous material.
OUTCROP	Outcrops of Permian continental sediments are widespread over the Fitzroy Graben but are generally weathered to depths of 15-30 m.
COAL DISTRIBUTION	Coal measures are widespread but only known in the Fitzroy Graben.
STRUCTURE	Dips in known coal bearing beds in the Condren Sandstone are 7° or less.
INTRUSIONS	Widely separated igneous plugs of leucite lamproite and rocks of kimberlitic affinities, but effects on coal not known.
EXPLORATION	Australian Inland Exploration drilling six core holes in the Liveringa Group in 1972, and sampled and tested coal intersections. In 1974, Esso-Dampier carried out detailed drilling in the Liveringa Group of the central part of the Fitzroy Graben and intersected very sandy and shaley coal intervals. Exploration carried out by Carr Boyd Minerals and BHP in the Meda-Jarraji area, 100 km northeast of Derby revealed sub-bituminous to semi-anthracite, high ash coal. (Mining Review, June 1981). The extent and age of the coal is not certain.

BASIN/FIELD	Calen Coalfield, Queensland
AREA	240 km^2
MINING	Calen Colliery produced 522 tonnes from a 2.6 m seam between 1927 and 1928. Fleetwood Colliery produced 9006 tonnes from a seam of similar thickness from 1932 to 1939.
SEDIMENT THICKNESS & AGE	Sediments and volcanics of Late Devonian, Early Carboniferous and Early Permian age.
COAL MEASURE UNITS	Calen Coal Measures are 300 m thick.
LITHOLOGY	Quartzose sandstone, siltstone, carbonaceous shale and coal.
OUTCROP	Coal Measures crop out 30-60 m below prominent marker quartzose sandstone bed.
COAL DISTRIBUTION	Coal Measures occur in two separate blocks in a north-westerly trending belt measuring 57 km long and 13 km wide.
STRUCTURE	The Calen Coal Measures are the youngest strata in the Midgeton Block, a remnant of a Late Devonian, Early Carboniferous and Early Permian basin which may have originally formed within the depositional area of the Bowen Basin. The Coal Measures are bounded by faults and the regional southwesterly dip has been modified by faults and intrusions. The northern block shows the most deformation with vertical coal measures on the downfaulted western margin.
INTRUSIONS	Small granite stocks and other igneous rocks of Early Permian and Early Cretaceous age.
COAL SEAMS	The Calen Colliery has a seam 2.6 m thick and a similar seam thickness occurs in the Fleetwood Colliery. Only thin seams of inferior coal occur in the southern block.
QUALITY	Low volatile bituminous. The seam in the Calen Colliery contains 270 mm of bands in 2.6 m of coal.
PROBLEMS	1. The lateral continuity of the coal measures beneath the quartzose marker bed has not been demonstrated. 2. Extensive faulting and coking by dykes and sills occurs in the collieries. 3. Further exploration is discouraged by steep dips in the northern area. 4. Prospects in the southern area are poor because of deformation, igneous intrusions, and the occurrence of thin inferior coal.

Unconfirmed reports of 20 m coal (F.R. July). Very variable seam thickness but mostly very thin. Best seams 1-2.2 m thick.

Crusader Oil (11th Annual Report, 1980) report "21 m of coal in a continuous seam only 12 m below the surface". Coal in Meda-Jarraji area.

Unconfirmed report of 3.7 m coal seam at depth of 15.2 m in well on Lower Liveringa Station. Sequence comprises grey shale and thin bands of poor quality non-coking coal.

Coal reported in other water bores.

PROBLEMS

Further exploration should be directed towards other areas of Permian where there may have been a different sedimentary environment and structual history to provide conditions for the development of thicker and higher grade coal.

PRINCIPAL REFERENCE

LORD, J.H., 1975 - Canning Basin, W.A. In TRAVES, D.M., & KING, D., (Eds.), ECONOMIC GEOLOGY OF AUSTRALIA AND PAPUA NEW GUINEA. Australasian Institute of Mining and Metallurgy, Monograph 6, Volume 2 Coal, 277-279.

BASIN/FIELD	Carnarvon Basin, Western Australia (for general basin geology see under Triassic Coal Measures)
DISTRIBUTION	Shallow Permian in a thin strip along the western side of the Byro Sub-basin extending north for a short distance from the Coolcalalaya Sub-basin to the Carrandibby Inlier.
EXPLORATION	Some intersections of coal seams of sub-bituminous rank have been encountered in current coal exploration in the western part of the Byro Sub-basin but no mineable reserves have yet been reported. (WAGS).

BASIN/FIELD	Collie and Wilga Basins, Western Australia
AREA	The Collie Basin covers an area of 228 km^2 and lies 35 km east of the Darling Fault. The Wilga Basin is small and poorly defined.
SEDIMENT THICKNESS & AGE	A maximum of 1050 m of Permian and late Tertiary deposits.
MINING	Two open cuts operating in the Collie Basin (1975); the Wilga Basin is non-economic.
COAL MEASURE UNITS	Early to Late Permian Collie Coal Measures.
	Generalised stratigraphic table for the Collie Basin. -
?Late Tertiary (?Late Miocene)	Nakina Formation - 4-35 m of conglomerate, sandstone and clay.
Early to Late Permian	Collie Coal Measures - coal seams in sandstone, siltstone and some conglomerate.
Early Permian (Sakmarian)	Stockton Formation - diamictite and glaciofluvial sediments.
	unconformity
Precambrian	Crystalline rocks
OUTCROP	Collie River only.
STRUCTURE	Basin is considered to have originated as ice scoured depressions in the Precambrian Yilgarn Block. (2) An alternative interpretation is by half graben formation. The Collie Basin is two northwest elongated sub-parallel troughs which converge in the northwest and are deepest in the southeast. Minor folds which converge in the northwest are attributed to compaction, and slumping and faults are attributed to steep depositional surfaces. Normal faults with a few centimetres to 150 m of throw are aligned with the northern margins of the basin. (2) The southwesterly dip of about 8^o, except near the graben boundary faults where the strata dip steeply northeasterly, is attributed to maximum subsidence in each graben along the southwestern edge.
ENVIRONMENT	Coal is thought to be allochthonous i.e. of drift origin. Early sedimentation was contemporaneous over the area and disconnected basins formed at a later stage.

COAL SEAMS

Coals restricted to three comparatively thin, widely spaced, horizons containing from three to nine seams. Fourteen seams are recognised in the Main (Cardiff) Basin and twenty in the Muja-Shotts Basin. Seam thickness varies from 0.6 to 11.5 m and most between 1.5-3.0 m. (1)

Members of the Collie Coal Measures in each basin with total thickness and aggregate thickness of coal are -

Sub-basins	Cardiff	Muja	Shotts
	Cardiff Member 138 m, 11 m coal	Muja Member 142 m, 30 m coal	
Collie Coal Measures	Collieburn Member 335 m, 18 m coal	Premier Member 220 m, 12-15 m coal	Premier Member 12 m coal
	Ewington Member 57 m, 10-12 m coal	Ewington Member	Ewington Member

The Muja Member includes the thickest seam in the basin, the Hebe Seam, which averages 12 m.

Sedimentation in the three Sub-basins was contemporaneous but they were probably not connected after the Ewington Member.

Wilga Basin sediments may be equivalent to the Cardiff Member.

QUALITY

The coal is black, sub-bituminous, non-coking, low ash, with medium volatile content and high moisture. The best quality coal occurs mostly in the lower members with slight deterioration in seams southeast across the basin.

The coal is used for char and power generation.

RESERVES

Total reserves are estimated to be 1,907 x 10^6 tonnes (3) and a later investigation gave 1,915 x 10^6 tonnes. Of these reserves 282 x 10^6 tonnes are considered to be extractable. (2)

Demonstrated economic resources are 496 megatonnes <u>in situ</u>, 362 mega-tonnes recoverable, and other resources <u>in situ</u> are 1504 mega-tonnes. (NEAL, 1981).

PROBLEMS

The basic picture of seam behaviour is known. Further investigations are necessary only to provide the detail required to develop a particular mining operation.

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(3) LOW, G.H., 1958 - Collie Mineral Field. Geological Survey of Western Australia Bulletin 108, pt 2.

BASIN/FIELD	Cooper Basin, South Australia and Queensland
AREA	130 000 km^2
SEDIMENT THICKNESS & AGE	Early Lower Permian to Middle Triassic sediments up to about 2100 m thick.
COAL MEASURE UNITS	Gidgealpa Group - the Early Permian Patchawarra and Late Permian Toolachee Formations contain coal measures.
LITHOLOGY	The Patchawarra Formtion comprises sandstone, shale, coal, siltstone and minor conglomerate. Upper Unit - shale in transitional unit. Middle Unit - thickly interbedded sandstone, shale with thick coal units. Lower Unit - carbonaceous shale, thin coals and minor sandstone. The Toolachee Formation comprises two units. Upper Unit - carbonaceous shale, sandstone and coal. Lower Unit - dominantly sandstone with some interbedded shale and coal.
COAL DISTRIBUTION	Coal in the Patchawarra Formtion has its greatest development in the northwestern sector of the basin where the formation is 250-500 m thick. The formation is widespread in the basin but absent on the crests of folds. The Toolachee Formation is also widespread and onlaps the Early Permian in the southern part of the basin except where it was removed by erosion after the Triassic. The formation is 117 m thick in the Moomba gasfield.
STRUCTURE	The rapid thinning of the Patchawarra Formation onto most structures is caused by uplift and erosion. In the southeast thinning is caused by onlapping onto pre Permian structures. The Toolachee Formation is absent by non-deposition over some highs. The thickness variation is due to compaction over basement except where it has been eroded.
ENVIRONMENTS OF DEPOSITION	The Patchawarra Formation was deposited by meandering rivers and the Toolachee Formation deposited on a flat land surface with rivers flowing from west to east. (5)

The Patchawarra Formation was deposited in an upper deltaic and flood plain environment. It contains fining upwards cycles and shows a quadripartite zonation typical of point bar deposits. Thick conglomeratic of point bar deposits. Thick conglomeratic sandstones are probably valley fill deposits. Channel sands are formed in places at the base of the lower unit; the upper unit is transitional from deltaic sediments to lake deposits. (1)

The Toolachee Formation was deposited in a floodplain environment. The sandstone of the upper unit was deposited in a regressive lake shoreline environment, and point bar sandstones up to 12 m thick occur in places. The lower unit was possibly deposited in a high energy, fluvial flood plain with a series of point bar and channel sandstones. (1)

COAL SEAMS

The middle unit of the Patchawarra Formation contains coal up to 25 m thick but elsewhere it is generally less than 3 m and in places up to 9 m. (1) The total thickness of seams is about 50 m and the thickest seam extends over an area of at least 1500 km^2. (5)

The Toolachee Formation contains 10 seams of bituminous coal with an aggregate thickness of 13 m and the thickest seam 5 m; in places the coal is gradational with carbonaceous shale. (5)

QUALITY

Inertinite and vitrinite make up 90% of the dispersed organic matter and exinite the remainder. The vitrinite reflectance data indicates that present day geothermal gradient is the maximum that has ever occurred. (3)

RESERVES

The volume of coal in the South Australian portion of the Cooper Basin is estimated to be 1.1 x 10^{12} tonnes. (3)

PROBLEMS

Mining by conventional methods is impractical owing to the great depth of the coal seams. The Patchawarra Formation occurs at depths of 2000 - 3000 m and the Toolachee Formation from 2000 - 2500 m below the surface.

PRINCIPAL REFERENCES

(1) BATTERSBY, D.G., 1976 - Cooper Basin gas and oil fields. In LESLIE, R.B., EVANS, H.J., & KNIGHT, C.L., (Eds.), ECONOMIC GEOLOGY OF AUSTRALIA AND PAPUA NEW GUINEA. Australasian Institute of Mining and Metallurgy, Monograph 7, Volume 3 Petroleum.

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(3) SCHWEBEL, D.A., DEVINE, S.B., & RILEY, M., 1980 - Source, maturity and gas composition relationships in the southern Cooper Basin. APEA Journal, 20, (1), 191-200

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(5) THORNTON, R.C.N., 1979 - Regional stratigraphic analysis of the Gidgealpa Group, southern Cooper Basin, Australia. Department of Mines and Energy, Geological Survey of South Australia. Bulletin 29.

BASIN/FIELD	Galilee Basin, Queensland
AREA	110 000 km^2
SEDIMENT THICKNESS & AGE	2000 m of Permian and Triassic rocks mostly buried beneath Jurassic, Cretaceous and Cainozoic sequences of the Great Artesian Basin.
COAL MEASURE UNITS	Unnamed Late Permian coal measures in outcrop probably equivalent to Blackwater Group. Mid. Early Permian Aramac Coal Measures at depth.

Generalised stratigraphy, northern Galilee Basin. (4)

Triassic		Moolayember Formation Clematis Group Rewan Group	
Late Permian	Betts Creek Beds	Bandanna Formation correlative 56-198[a] Colinlea Sandstone correlative 53-126[b]	
	Disconformity		
Early Permian	Joe Joe Group	Aramac Coal Measures	26-100m[a] 80-272m[b]
Late Carboniferous			

Coal occurs in the Aramac Coal Measures, and the correlatives of the Bandanna Formation and Colinlea Sandstone. The Betts Creek Beds, the formal name applied to the outcrop section, is approximately equivalent to unnamed coal measures in the Alpha area. (a = thickness recorded in Koburra Trough - Maneroo Platform; b = thickness recorded in Lovelle Depression).

LITHOLOGY

The Late Permian coal measures comprise light grey and white sandstone, interbeds of mudstone and light grey siltstone. Coal seams constitute about 17% of the formation.

OUTCROP

Outcrop of the coal measures is rare because of the Tertiary and post Tertiary superficial cover up to 137 m thick.

Outcrop and subcrop of the Late Permian coal measures occurs along the eastern margin of the basin over a distance of not less than 440 km in a north-south direction.

Thin high ash coal seam in Porcupine Creek, two seams at Oxley Creek and torbanite 51 km south-south-east of Alpha.

COAL DISTRIBUTION

The mid-Early Permian Aramac Coal Measures are preserved in two separate areas of down warping chiefly on the downthrown areas adjacent to major faults.

The Late Permian coal measures have a much wider distribution but the sediments are not very thick. Downwarping was greatest along the eastern margin and adjacent to the Cork fault, Pleasant Creek Arch and on the Springsure Shelf.

STRUCTURE

Faults with northeasterly to northwesterly trends in the northern part of basin. Monoclines evident in post Triassic sediments are probably faults at depth. Anticlines are rare in the northern Galilee Basin, relatively small, and faulted at depth. Most structures have a history of growth. Initial movements on north-east trending faults were mainly reverse, but subsequent deformation was by flexuring. Evolution of Galilee Basin has been attributed to the effect of a north-north westerly trending right lateral shear couple. (2)

A regional west south-westerly dip of $\frac{1}{2}^{o}$ in the south and dips of $2\text{-}3^{o}$ to the east further north near Lake Galilee.

ENVIRONMENT OF DEPOSITION

Aramac Coal Measures are fluvial with channels predicted to radiate from northeast to southeast in the Koburra Trough and southwest to southeast in the Lovelle Depression. (4)

Late Permian coal measures (=Bandanna Formation) deposited on a broad delta plain. (4)

COAL SEAMS

Numerous water bores have intersected coal seams at shallow depths close to the eastern margin of the basin notably near Wendouree. The Queensland Mines Department has proved coal of economic quality in the Late Permian sequence of the south-east part of the Galilee Basin in ten drill holes.

In the Oxley Creek area only the lower seam, which is 4.9 m thick with a 2.2 m lower workable section, appears to have economic potential. The upper seam is very poor quality and comprises 1.6 m of coal and ironstone.

The Alpha Torbanite occurs in a lenticular band up to 1.2 m thick in a coal seam with sub-bituminous coal 0.9 m thick above, and 0.3 m thick below.

In the Wendouree Area there are five coal seams 5.1, 6.6, 8.6, 5.2 and 2.1 m thick with respective workable sections of 2.4, 3.3, 2.1, 4.7 and 1.5 m thick. The upper two seams coalesce to the north to form a 15.4 m seam, and further north the lower seams thicken and split into three with a total thickness of 12.1 m, and the upper two seams thin to a total of 9 m.

Coal has been intersected in the following oil wells (1) -

Allandale No. 1 - 3 m of coal at the top of the Permian and traces in the Colinlea Sandstone and Joe Joe 'Formation'.

Koburra No. 1 - Coal in Late Permian and upper part of Early Permian over an interval of 159 m.

Lake Galilee No. 1 - Coal and carbonaceous material over an interval of 1449 m. Coal (3) in the Aramac Coal Measures was intersected in Marchmont No. 1, and the Coal Measures were intersected in Aramac No. 1 and Glenaras No. 1. Coal in the Colinlea Sandstone was intersected in Jericho No. 1.

QUALITY

Generally high moisture content decreasing gradually to the north with slight increase in ash; the ash content is largely inherant.

Classification (1) - sub-bituminous A (ASTM): ortholignitous to sub-lignitous (Seyler); sub-hydrous with low sulphur.

There appears to be little likelihood of obtaining coking coal, and suitable exploitation may involve liquefaction and gasification techniques.

In the south-east Galilee Basin the coal is mainly dull with bright bands, and brighter coal more common in the lower part of the seams. Shale beds are uncommon in the workable sections.

RESERVES

Very large inferred reserves between Wendouree and Laglan. (1) Measured reserves in the Alpha area are 1,260 million tonnes (mid 1981). Seam A has measured reserves of 63.5 million tonnes to an overburden limit of 90 m; Seam B has measured reserves of 395.7 million tonnes to an overburden limit of 110 m. (F.R., 1981)

EXPLORATION

Exploration is currently in progress in the Wendouree area north of Alpha and in the northern part of the basin near Pentland.

PROBLEMS

The structural style and tectonic evolution of the basin are not fully understood and is derived largely from one widespread seismic reflector which originated from the Late Permian coal measures. Structure beneath this reflector, in the Late Carboniferous and Early Permian sequence, is poorly known.

The widespread Tertiary and post Tertiary water bearing sediments may preclude open cut extraction.

Liquefaction, gasification and petrochemical production require large quantities of easily mined cheap coal to be economic. Further drilling, geological examination and evaluation are required to determine the feasability of such an operation.

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BASIN/FIELD	Gloucester Basin, New South Wales
AREA	38 km long; 9.5 km wide.
SEDIMENT THICKNESS & AGE	Permian, 180-2400 m thick.
COAL MEASURE UNITS	Gloucester and Craven Coal Measures.

Generalised stratigraphic table -

Cainozoic	Cainozoic sediments
Permian	Craven Coal Measures Two coal measure intervals each overlain by conglomerate. About 760-1060 m thick, thickest in east. Seams up to 2.75 m thick. Wards River Conglomerate - good stratigraphic marker 67 m thick. Gloucester (Avon (3)) Coal Measures - coal with seams up to 2.5 m thick at several levels. Maximum 760 m thick in east, thinner in west.
	disconformity
Carboniferous	Alum Mountain Volcanics

LITHOLOGY

Craven Coal Measures - lithic sandstone and siltstone, with some mudstone and coal seams in both upper and lower parts. Intervening conglomerates are coarse with clasts of volcanic origin.

Wards River Conglomerate - conglomerate with interbedded sandstone and siltstone.

Gloucester Coal Measures - lithic sandstone, siltstone, mudstone, coal seams and conglomerate.

Dewrang Formation - lithic sandstone with conglomerate, siltstone and mudstone.

STRUCTURE

Meridional Stroud-Gloucester Syncline, continuous with Medowie Syncline of Sydney Basin. Gloucester Basin in north of Stroud-Gloucester Syncline defines limits of known coal bearing sediments. Flank dips of 60-70^{o} flatten towards the fold axis. There are extensive strike and transverse faults (e.g. Avon fault).

Dips in the Basal Seam of the Dewrang Formation around the southern closure average 45-55^{o}.

Seams in the Gloucester Coal Measures on the eastern side of the basin dip at about 40^{o} but locally flatten along 2 km of strike length.

INTRUSIONS	Igneous intrusions are uncommon and do not materially affect coal seams. Two narrow (0.6 m) dykes.
COAL SEAMS	The Basal Seam is the only significant coal seam in the Dewrang Formation. At least fifteen seams (3) occur in the Gloucester Coal Measures and up to thirty thin seams occur mainly in the lower part of the Craven Coal Measures.
QUALITY	Consistantly high C.S. No's. (6-9 for beneficiated low-ash material) and can be broadly classed as coking coals. Seams have high ash yield due to presence of numerous clastic bands and high inherant ash. Only few economic seams with less than 10% ash. Medium to high volatile content, sulphur content medium to low for Gloucester and Craven Coal Measures but up to 3% in raw coal from Dewrang Formation. Phosphorous generally 0.1%. Calorific values for 10-12% ash coals are 29.7 - 32.6 MJ/kg. Gloucester Seam has satisfactory coking properties.
RESERVES	Proved reserves very small.(5) Demonstrated economic resources are 36 mega-tonnes in situ, and 33 mega-tonnes recoverable (NEAC, 1981).
EXPLORATION	Noranda Australia Ltd. 1970/71. Significant seams of medium to high volatile coking coal but steeply dipping with high and variable ash yield. Noranda drilled 366 non-cored and 66 cored holes.
PROBLEMS	No satisfactory correlation with Sydney Basin. Palynology indicates a broad affinity with the Tomago - Newcastle Coal Measures. (1) Steep dips would complicate mining and reduce open cut potential. Great deal of exploration will be necessary to establish ultimate potential of the basin. (5)

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BASIN/FIELD	Gunnedah Basin, New South Wales
AREA	North-Western Coalfield
MINING	Coal is mined at Curlewis and Gunnedah, and has been mined in the past at Werris Creek. (1)

The generalised stratigraphic sequence is - (2)

Jurassic		J6 Orallo Formation
(Surat and Coonamble Basins)		J5 Pilliga Sandstone
		J2-4 Purlawanugh Formation - minor coal
		(188.8 m.y.) Garrawilla Volcanics - maximum 180 m thick.
		---- unconformity ----
Triassic		Napperby Formation - 213 m
		Digby Conglomerate 70 m
		---- unconformity ----
	Upper Stage 5	Black Jack Formation - 472 m in Quirindie No. 1; coals.
	Lower Stage 5	Watermark Formation - 152 m in outcrop 169 m in subsurface; thin poor coals.
	Lower Stage 5	Porcupine Formation - 183 m in outcrop.
		---- Pensioners Hill disconformity ----
Permian	Upper Stage 4	Willow Tree Coal Measures and equivalent Werris Creek and Wean Coal Measures. (= Maules Creek Formation)
	Lower Stage 4	Lower Coal Measures - 109 m; coal (= Maules Creek Formation)
	"	Maules Creek Formation - maximum 500 m; coals. (= Nandewar Group, Wean Formation and Vickery Conglomerate)
	"	Leard Formation 9 m; minor dull coal
		---- nonconformity ----
	Stage 3	Boggabri Volcanics
	Stage 2*	Werrie Basalt Temi Formation; oil shale, coal.

* Date from Bohena No. 1 - a possible correlative of Werrie Basalt.

SEDIMENT THICKNESS & AGE	A generalised composite Permian sequence, and equivalent units in the Hunter Valley are - (1)	
	Black Jack Coal Measures	Singleton Coal Measures
	Watermark Formation) Porcupine Formation (marine))	Maitland Group
	Nandewar Group including laterally equivalent Werris Creek, Wean, and Willow Tree Coal Measures)	Greta Coal Measures
	Boggabri Volcanics and Werrie Basalt Temi Group)	Dallwood Group

COAL MEASURE UNITS

There are two productive coal measures, the upper Black Jack, and older Werris Creek and equivalent Coal Measures, separated by marine beds. A lower marine and volcanic unit at the base contains sediments deposited in freshwater but no commercial coal seams are known. (1)

The Hoskisson's Seam of the Black Jack Coal Measures is worked near Black Jack Mountain and Curlewis. The lower Melville's seam is inferior in quality and was only worked in a small area at Gunnedah. (1)

COAL DISTRIBUTION

The Black Jack Coal Measures are known from Breeza to Narrabri and an equivalent unit was intersected in Quirindi No. 1 bore south of Breeza. (1)

Permian coal measures from about 520 m to 620 m thick were penetrated in petroleum exploration bore Wee Waa No. 1, Bohena No. 1 and in Pilliga No. 1. (1)

No Permian rocks were intersected in Barradine No. 2 and Sandy Camp No. 1 where Mesozoic rocks rest directly on Devonian basement rocks. (1)

STRUCTURE

The coal measures lie west of the Hunter-Mooki Thrust System, with the exception of the Werrie and Temi Synclines where the coal measures disconformably overlie Carboniferous rocks. (1)

Dips are mostly low to southwest, west and northwest, but vertical next to the Mooki Thrust. Minor folds are superimposed on the low regional dips. Faulting is relatively minor. Two basement highs are known, the Boggabri Ridge and Rocky Glen High. Basement deepens considerably to the south of Gunnedah. (2)

INTRUSIONS

The Permo-Triassic section contains intrusions of inferred Tertiary age. They have been intersected in Wee Waa No. 1, Bohena No. 1, Weetaliba DDH 1, Wondobah DDH 1, Quirindie No. 1, Waverton No. 1 and 2, New Windy No. 1, New Windy No. 2C, Quirindie DDH 2, Quirindie DDH 4. (2)

Intrusions are mostly of basic composition, and described as dolerites and teschenites. They frequently cause updoming or warping of the sediments with associated faulting and steep dips. (2)

The Temi Group coal seams are cindered by igneous intrusions. The overlying Werrie Basalt is possibly up to 1500 m thick in the Werrie Syncline and less than 750 m at Willow Tree. (1)

The Black Jack Coal Measures are intruded by basaltic and other igneous rocks including numerous sills. Three sills occur near Black Jack Mountain; the Sylvandale Sill underlies and possibly intrudes the Hoskisson Seam and carbonised the coal to a variable degree. Sills underlying the coal appear to have more effect on the coal than overlying sills. (1)

COAL SEAMS

The Temi Group contains coal and oil shale, and exposed seams are cindered by intrusions. The Group thins to the north and is overlapped. (1)

The Willow Tree Coal Measures are the most southerly exposure of coal and are probably greater than 320 m thick; they contain at least one coal seam 4.8 m thick overlain by oil shale. (1)

Maules Creek Formation - contains numerous seams of bright coal up to 7 m thick, and may constitute up to 10% of the sequence. (2)

Lower Coal Measures - the upper sequence contains bituminous coals up to 5 m thick. (2)

The Werris Creek Coal Measures contain three coal seams and the lowermost 2.5 m of the upper seam was worked. (1)

The Wean Coal Measures are the main coal measure outcrop in the Gunnedah area. The Stratford Coal Member and Shannon Harbour Coal Member contain adequate coal thickness and quality for mining to 200 m. The Stratford Seam to 2.3-3.3 m thick and thickens to the north and east. The Shannon Harbour Seam is 1.3-2.2 m thick and persists to the north. (1)

The Wondoba Coal Member of the Black Jack Coal Measures comprise almost 20 m of poor quality coal. The Hoskisson's Coal Member is about 30 m thick with 2-3 m worked at the base. The Melville's Coal Member is up to 7 m thick in two subsections and 2.5 m of the upper sub-section may be worked but the lower subsection is better quality. (1)

Black Jack Formation - Bituminous coals occur in the upper part of the formation in Bohena No. 1 and Pilliga No. 1. Coal seams are most abundant in the southeastern portion of the Gunnedah Basin, decreasing to the north and west. The Black Jack Coal Measures is frequently a favourable level for intrusion. (2)

The Booroomin Group in the Boggabri area contains two coal seams but they have no economic interest. (1)

QUALITY

Werris Creek Coal Measures - coal is hard and dull, low volatile, steaming, low rank and durain rich. (1)

Wean Coal Measures - coal is low ash, high volatile, coking. (1)

Black Jack Coal Measures - the Wondoba Coal Member contains poor quality coal. Coal in the Hoskissons Coal Member is bright, vitrinite rich, and has coking properties, except where intruded by igneous sills, and is very clean; it grades into dull, low vitrinite coal at the top. High volatile coking coal occurs down dip away from the Sylvandale Sill. The Melvilles Coal Member is generally of inferior quality to the Hoskissons Seam. (1)

RESERVES

Demonstrated economic resources of the Black Jack Coal Measures are 112 mega-tonnes *in situ* and 37 mega-tonnes recoverable; inferred resources are 54,460 mega-tonnes *in situ*. (1)

Demonstrated economic resources of the equivalents of the Greta Coal Measures are 860 mega-tonnes _in situ_ and 600 mega-tonnes recoverable; inferred resources are 47,684 mega-tonnes (NEAC, 1981).

EXPLORATION

Considerable exploration including drilling has been carried out in holdings at Curlewis and Gunnedah but the regional coal potential is still unknown. (1)

The Coal Strategy Group of the NSW Geological Survey have initiated a detailed exploration programme of seismic surveys and drilling. (1)

Future coal drilling should be carried out down dip from the Breeza - Caroona area where the number and thickness of coal seams is known to be high. (2) Equivalents of the Maules Creek Formation could be drilled in the area bounded by Pilliga No. 1, Borah DDI 1 and Emerald Hill DDH 1, and the area west of Pilliga No. 1 and Bohena No. 1 where the formation occurs at about 500 m below sea level. (2)

PROBLEMS

The widespread and intensive volcanic activity has complicated the otherwise simple stratigraphic Coal Measure sequence. (1)(3)

The nature of the boundary between the Black Jack Coal Measures and underlying formations is not known. (1)

The Triassic sequence requires further study to establish the stratigraphic sequences, establish the correlation of surface and subsurface sequences, and the correlations with the Sydney Basin. (2)

Precise dating is required in the Permian Maules Creek Formation to Black Jack Coal Measures sequence to resolve the stratigraphy, to aid correlation with the equivalent sequence in the Hunter Valley and provide data for palaeogeographic reconstructions. Structure contour and isopach maps need to be revised using the seismic data. (2)

The existance of three interpreted thrust faults needs to be verified as they will have important consequences for exploration in the basin.

Drilling complete sequences through the Black Jack Formation is required to assess its coal potential, including any intrusions whose thickness and extent will be use ful in assessing the formation. (2)

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BASIN/FIELD	Little River-Oakey Creek District, Queensland
COAL MEASURE UNITS	Permian Little River Coal Measures and Normanby Formation (formerly Oakey Creek Coal Measures)
LITHOLOGY	Little River Coal Measures - thick bedded, medium to coarse grained, feldspathic and lithic sandstone, grey silty shale, interbeds of dark impure limestone, fine grained sandstone and thick, poor quality coal. Normanby Formation - thin micaceous sandstone, thick feldspathic sandstone, dark silty shale, thick labile pebble conglomerate, thin impure limestone, impure coal and rhyolitic rocks. Shallow marine sequence in lower part of southern outlier. Marina No. 1 and Breeza Plains No. 1 - moderately steeply dipping sediments, hard tuffaceous sandstone and siltstone, shale interbeds, minor coal.
STRUCTURE	The Permian sediments form part of the uneven basement of folded Palaeozoic sediments and granite, unconformably beneath the Mesozoic sediments of the Laura Basin. Little River Coal Measures - structurally complex, downfaulted block along part of the Palmerville Fault System, near the western margin of the Laura Basin. Normanby Formation (formerly Oakey Creek Coal Measures) - three small faulted outliers on south-eastern edge of Laura Basin. Marina No. 1 and Breeza Plains No. 1 - moderately steep dips.
COAL SEAMS	Little River Coal Measures - poor quality coals, up to 6 m thick. Normanby Formation - impure, poor quality coal, up to 30 m thick, high ash. Marina No. 1, Breeza Plains No. 1 - carbonaceous material and coal traces.
EXPLORATION	The Laura Basin has been explored for coal in recent years chiefly by Utah Development Co., and to a lesser extent by C.R.A. Exploration Pty. Ltd. (1)
PROBLEMS	Coal recovered is poor quality and no economic deposits are known. Discouraging results from exploration drilling.

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BASIN/FIELD	Mount Mulligan Coalfield, Queensland
MINING	The earliest mine commenced operations in 1914, was acquired by the Queensland Government in 1923 and closed in 1957. King Cole Colliery opened in 1941. Total production from the field was 981 007 tonnes.
COAL MEASURE UNITS	Permian Mount Mulligan Coal Measures
	Generalised stratigraphic table -
Triassic	Pepper Pot Sandstone
	______ slight unconformity ______
Permian	Mount Mulligan Coal Measures
	______ unconformity ______
Devonian	Hodgkinson Formation
LITHOLOGY	The Mount Mulligan Coal Measures consist of a lower lensing conglomeratic section up to 190 m thick, and an upper section, also lensing, of interbedded shale, mudstone, sandstone and coal, from 0-35 m thick.
OUTCROP	The Mount Mulligan Coal Measures are preserved in a mesa about 300 m high with coal exposed at the base of cliffs on the northern and eastern sides of Mount Mulligan.
COAL SEAMS	State Mine
	No. 1 Seam - up to 1.1 m worked thickness. Three lenticular stone bands with proportion increasing to the north.
	No. 2 Seam - average worked thickness 1.7 m with a total of 0.4 m of stone bands.
	No. 3 Seam - 0.4-0.9 m of clean coal.
	No. 4 Seam - thin dirty coal, not worked.
	King Cole Mine
	Top Seam - 0.8-2.1 m thick, contains a few lenticular stone bands; deteriorates to the west and south. This was the only seam worked in the mine.
	Bottom Seam - 1.4 m thick in adit, elsewhere 0.4-0.7 m thick, poor quality, possibly equivalent to the No. 3 Seam of the State Mine.

QUALITY	High volatile A bituminous (ASTM) 711(5) (ACC). Used for steam raising, and locally for coke manufacture for a short time.
EXPLORATION	Five drill holes by the Department of Mines in 1951 over a strike length of 1.5 km north of the State Mine only found one potential workable coal section thicker than 1 m although the prospective strata ranged up to 5.8 m thick.
PROBLEMS	Seams drilled in exploration programme could not be correlated with those in the State Mine. The coal measures appear to lens out to the west and it is unlikely that significant mineable reserves remain.

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BASIN/FIELD	Oaklands-Coorabin, New South Wales
AREA	Riverina District of New South Wales
MINING	Discovered 1915, mining ceased 1959. Total production 125 000 tonnes.
SEDIMENT THICKNESS & AGE	1500 km^2 with Triassic and Permian sediments up to 500 m thick suggested by geophysics. Drilling has confirmed coal over an area of 260 km^2.
COAL MEASURE UNITS	Coorabin Coal Measures

Tertiary (Eocene-Pliocene)	Generalised Stratigraphic Sequence Wunghun Group Renmark Group	
	?unconformity	
Triassic	Jerilderie Formation Nowranle Creek Formation	
	?unconformity	
Late Permian	Upper Stage 5	Coreen Creek Coal Member Longhmore Formation
	?unconformity	
	Coorabin Coal Measures	Lanes Shaft Coal Member
	Lower Stage 5	Narrow Plain Formation
	?unconformity	
Early Permian	Stage 3	Includes deltaic? marine, paralic? and marine (glacigene) sediments
	?unconformity	
	Metamorphosed sediments and granite.	

LITHOLOGY	Permian grey claystone, with some sandy sections, up to 300 m thick; metamorphic basement at 365 m. Coorabin Coal Measures towards top of Permian sequence are unconformably overlain by Tertiary at basin margin. No erosion in central part of basin and seams are thicker here.
OUTCROP	Permian coal in water bores at depths of 70 m. Depth to coal measures 69 m in south to 370 m further north.

COAL DISTRIBUTION

Chiefly in Ovens Valley Graben, but occurs also just east of graben but extent unknown. Permian strata may extend west of basin and in area north of Hay. (3)

STRUCTURE

Area of major Permian sedimentation in Ovens Valley Graben. Permian coal measures within graben lie in an open syncline with shallow NW to NNW plunge. (3) The sediments are mostly flat lying.

ENVIRONMENT OF DEPOSITION

Inter-montane basin formed on a stabilised craton indicated by relatively few, but extensive dull coal seams in a terrestrial sequence. (5)

Fully cored holes show the coal to be the top of a point bar sequence (Morgan, 1977; Palese, 1974). Smyth (1980) proposed a stillstand and raised bog origin for the coal, which has formed in a basin on stable basement rocks.

COAL SEAMS

Three intervals of coal are known in the Coorabin Coal Measures with 1 m mudstone splits. The major seam, the Oaklands Seam which has an average thickness of 9 m, maximum 19 m, and depth of cover from 40-360 m. (6) The average thickness of this seam in the southern part of the basin is 10 m. (5)

Minor coal measure sequence 17 and 27 m above main coal seam noted in some bores.

QUALITY

Lithotype - dull coal 85%, banded dull coal 10%, banded bright and bright coal 5%, with increase in brighter bands towards base. Dirt bands rarely exceed 100 mm.

Seam floor - Variable - Soft carbonaceous mudstone and sandstone to moderately consolidated fine-grained sandstone.

SAA No 90? (5) - (6)
Recent information indicates that coals have good potential for conversion. (2)

RESERVES

Measured plus indicated coal reserves 500 million tonnes, <u>in situ</u>, and 450 mega-tonnes recoverable. (NEAC, 1981)

Inferred coal reserves 10 000 million tonnes in situ. (Joint Coal Board, 1980).

Total in situ reserves in seam 3 m thick is 1400 million tonnes - (300 million tonnes measured and indicated + 1100 million tonnes assumed and inferred). Some may be recoverable by open cut. (1)

EXPLORATION

Restricted to small area around Oaklands and Coorabin. Twenty two bores drilled by NSW Dept. of Mines in 1973-74 in Oaklands, Berrigan, Jerilderie area.

Exploration is currently being conducted by

a. Kembla Coal and Coke (Pacific Coal) Pty. Ltd. (A Division of CRA).

b. Mitsubishi Development Pty. Ltd., - exploration includes hydrological investigations.

c. The Coal Strategy Division of the NSW Department of Mineral Resources is currently drilling six holes in an area north of the present area of exploration in an attempt to extend the northern limit of the coalfield.

The proximity to the Sydney-Melbourne railway line, the possible liquefaction potential, and large reserves have encouraged continuing investigation of the feasibility of renewed mining.

PROBLEMS

The southern margin is reasonably well defined (3) but the northern margin is very poorly known.

Stratigraphy imperfectly known because of wide drillhole spacing and difficulty in picking the Triassic/Tertiary contact without palynological control.

Difficult to relate geophysics to drilled sections because of unconsolidated aquifer bearing Tertiary sediments, weathering of Permian, and basement at much shallower depths than anticipated.

Area of potential economic coal limited by lack of drill information in western and southern parts of basin.

Low grade of coal, great distance from markets; occurrence of clay and underground water in the overburden above the coal seam could cause problems both in underground and open cut mining.

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BASIN/FIELD	Olive River and Eastern Carpentaria Basins, Queensland
AREA	
SEDIMENT THICKNESS & AGE	Jurassic and Late Permian sediments about 1000 m thick.
COAL MEASURE UNITS	Coal occurs in the Late Permian sediments, the Jurassic Garraway Beds, and to a lesser extent in the Gilbert River Formation.
	Generalised stratigraphic table -
Jurassic to Early Cretaceous	Rolling Downs Group-Early Cretaceous, marine. (E. Carpentaria Basin only).
	Gilbert River Formation - Late Jurassic, very minor coal, glauconitic in upper part.
	Helby Beds - Middle Jurassic-marine marker bed.
	Garraway Beds - Early to Middle Jurassic - coal seams in upper part.
Late Permian	Sediments equivalent to the Pascoe River Beds.
Palaeozoic/Proterozoic	Granite - Early Palaeozoic.
	Volcanics - Carboniferous to Early Palaeozoic.
	Sefton Metamorphics - Proterozoic.
	Triassic sediments may be present in the central part of the basin.
OUTCROP	The Permian and Mesozoic sequences are concealed in the Olive River Basin.
COAL DISTRIBUTION	A total of 92 holes, some re-drilled, giving an actual total of 86. ? 5 holes with coal in Permian, and ? 23 holes with coal in Jurassic.
STRUCTURE	The Olive River Basin is a small oval depression within the Weipa Depression on the eastern margin of the Carpentaria Basin. Shallow westerly dip. A major fault on the eastern side of basin which apparently controlled deposition of the Permian. There are, apparently, no faults in the Jurassic section.
SEAMS	Only minor occurrences of coal stringers were intersected in the eastern Carpentaria Basin but the exploration program in the Olive River Basin was more promising.
	Permian seams occur over a restricted area in the Olive River Basin. 2.35 m of coal occurs in two plies 0.9 and 1.44 m thick separated by 0.29 m of mudstone but coal was not intersected in nearby holes; coking coal.

Jurassic Garraway Beds contain a small area of coal south of northeastern margin. Coal thickness is variable and splits are common; maximum thickness about 1.5 m - single seam 0.84 m cored (230.83-231.67 m) non-coking coal.

In an area where the seam attains an average thickness of 1 m its depth is greater than 200 m.

Permian coals occur at depths ranging from 98 m-364 m and Jurassic coals from 159.3 m-376.0 m.

QUALITY

Permian coals are coking quality and Jurassic non-coking.

Vitrinite Reflectance -

Ro (max)	RI(oil)
0.81	1.513
0.80	1.513

Seyler Classification - on 1.60 floats - meta-lignitious, perhydrous (estimate on one sample only).

EXPLORATION

Utah Development Company.

PROBLEMS

The exploratory drilling has yielded poor results and further work in the area is considered to be uneconomic. Geophysical investigations are recommended in areas where seam thickening is indicated and may prove areas for further drilling if overburden is not too thick.

PRINCIPAL REFERENCE

MURPHY, R.W., - Final report on exploration in the Olive River and Wenlock River areas, north Queensland. Utah Development Company, Exploration Department, Report No. 327.

BASIN/FIELD	Pedirka Basin, Northern Territory and South Australia
AREA	150 000 km^2
SEDIMENT THICKNESS & AGE	700+ m of Permian and Triassic sediments.
COAL MEASURE UNITS	Early Permian Purni Formation. An Artinskian age is suggested. (2)
COAL DISTRIBUTION	Uppermost member of Purni Formation contains up to 15% of coal. (1) The upper unit of the Purni Formation has been intersected in McDills No. 1, Perni No. 1, Mokari No. 1 and possibly Hale River No. 1. The coal bearing strata of the upper member of the Purni Formation have been identified by seismic work in much of the South Australian portion of the basin. The coaly beds thicken by the addition of younger sediments eastwards from Mokari No. 1 with the maximum known thickness of Permian sediments of 760 m on the NT/SA border at 137°E. Thickness on seismic records decreases eastwards and southwards from this point and the coal measures possibly terminate inside the Permian basin edge. Older Permian sediments probably occur between the coals and the western margin of the basin. Increased Permian section including coals occur to the west of the McDills Trend. (3)
LITHOLOGY	The Purni Formation comprises three members, with coals in the youngest member. The formation contains sandstone, siltstone, shale and coal generally in thin interbeds. It is conglomeratic at the base sandy in the middle unit, with coals at the top. (3)

PRINCIPAL REFERENCES

(1) BRANAGAN, D.F., 1975 - Distribution and geological setting of coal measures in Australia and Papua New Guinea. In TRAVES, D.M., & KING, D., (Eds.), ECONOMIC GEOLOGY OF AUSTRALIA AND PAPUA NEW GUINEA. Australasian Institute of Mining and Metallurgy Monograph 6, Volume 2 Coal.

(2) WILLIAMS, G.E., 1973 - The Simpson Desert Sub-Basin - a promising Permian target. APEA Journal, 13 (1).

(3) YOUNGS, B.C., 1976 - The geology and hydrocarbon potential of the Pedirka Basin. Geological Survey of South Australia, Report of Investigations 44.

BASIN/FIELD	Perth Basin, Western Australia
AREA	58 000 km^2 (onshore)
SEDIMENT THICKNESS & AGE	15 000 m of Ordovician-Silurian, Permian, Triassic, Jurassic and Cretaceous sediments.
COAL MEASURE UNITS	Late Permian Wagina Sandstone; Early Permian (Artinskian) Irwin River Coal Measures (Maximum known thickness 123 m) and equivalent Sue Coal Measures.
OUTCROP	The Irwin River Coal Measures crop out in the north branch of the Irwin River.
COAL DISTRIBUTION	Eradu - coal occurs in the Wagina Sandstone at the northern end of the Dandaragan Trough. Irwin River - thin, lenticular seams occur in the Irwin River Coal Measures. Bunbury Trough - there are no Permian outcrops but coal seams in the Sue Coal Measures (= Collie Coal Measures) were intersected in Sue No. 1, Blackwood No. 1, Whicher Range No. 1, Wonnerup No.1, Alexander Bridge No. 1, Quindalup No. 1 and 2. Other occurrences are at Fly Brook, Vasse River near Wonnerup, Donnybrook, Bibilup, Millbrook, Jarrahwood, Boyanup and Capel, although the age is uncertain.
COAL SEAMS	Eradu - A seam 5.34 m thick was encountered in a shaft but this and other seams were found to be lenticular. Coal occurs at 398 m and 112 m in Quinalup No's 1 and 2. The type section of the Sue Coal Measures is from 1219-3057 m in Sue No. 1 where 85 m of coal occurs in 70 seams.
QUALITY	The coal is poor quality with high moisture and ash particularly in the northern portion of the basin, and would be suitable only for power generation. Eradu and Irwin River - poor quality coal with high moisture and ash. Bunbury - poor quality.
EXPLORATION	Late Permian coal was located in the Eradu area in a calyx bore near the northern end of the Dandaragan Trough in 1896; drilling followed in 1926-27 and two shafts in 1943.

Coal was discovered in the Irwin River in 1846 and subsequently investigated by drilling, adits and shafts. An adit 55 m long was driven into a seam on the north branch of the Irwin River in 1944.

Coal measures are known to occur at reasonable depths for prospecting in the northern part of the Perth Basin near Beagle Ridge, and in the Bunbury Trough. (2)

The western side of the Bunbury Trough near Quindalup No's 1 and 2 wells is probably the best prospecting target in the Perth Basin for concealed blocks of Permian coal measures.

PROBLEMS

The great depth of burial and poor quality of coal in the Bunbury Trough has discouraged attempts to elucidate complicated sub-surface structure and stratigraphy or to identify accurately numerous reported coal seams.

PRINCIPAL REFERENCES

(1) KANTSLER, A.J., & COOK, A.C., 1979 - Maturation patterns in the Perth Basin. APEA Journal 19, (1), 94-107.

(2) LORD, J.G., 1975 - Perth Basin - Permian W.A. In TRAVES, D.M., & KING, D., (Eds.), ECONOMIC GEOLOGY OF AUSTRALIA AND PAPUA NEW GUINEA. Australasian Institute of Mining and Metallurgy Monograph 6, Volume 2 Coal, 269-272.

BASIN/FIELD	Tasmania Basin - Permian Coal Measures
AREA	40 000 km^2
MINING	Cannel coal (tasmanite) was mined from 1910 - 1934 and mining of Permian coal ceased in 1960.
COAL MEASURE UNITS	Two principal intervals of Permian coal measures in a Parmeener Super Group - Cygnet Coal Measures (Tatarian) - maximum 100 m thick in northwestern part of basin. Widely distributed but discontinuous due to pre-Triassic erosion. They are approximately equivalent to the Newcastle and Tomago Coal Measures.
	Mersey Coal Measures (Late Sakmarian to Early Artinskian) - 25-67 m thick; pre date the Artinskian Greta Coal Measures.
	Quamby Group (Sakmarian) - up to 215 m thick.
LITHOLOGY	Cygnet Coal Measures - well sorted siliceous sandstone, with feldspathic sandstone, siltstone and coal.
	Mersey Coal Measures - well sorted, siliceous, cross-bedded and ripple marked sandstone.
	Quamby Group - medium to dark grey mudstone.
COAL DISTRIBUTION	Cygnet Coal Measures - best coal in two seams at Cygnet. Equivalent coal measures occur at Firewood Siding, Pelion Range, Bruny Island, Gordon and Mount La Persouse.
	Mersey Coal Measures - coal occurs in the northwestern part of the basin.
	Quamby Group - cannel coal (tasmanite) 9 - 15 m above the base of the Quamby Group occurs in the Devonport area where it averages 1.0 m thick and has a maximum thickness of 1.8 m.
STRUCTURE	Tertiary block faulting is oriented northwesterly with graben formation, and the sequence is broken into a large number of isolated areas.
	The Mersey Coal Basin is flat-lying but faulted, although at Preolenna dips are 20°. The Cygnet Coal Measures have shallow dips and are also faulted.
INTRUSIONS	Jurassic dolerite is intruded in massive sills with an aggregate thickness of abour 460 m.

COAL SEAMS	Cygnet Coal Measures - two seams 0.3 and 0.9 m thick; only the thicker upper seam has exploited.
	Mersey Coal Measures - four seams 0.2-0.6 m thick occur at Barn Bluff, and two seams both less than 0.6 m thick in the Devonport area (Illamartha Colliery) with the lower thicker seam the most important. At least four seams occur at Preolenna but they are very thin. Thin bituminous coals occur at Barn Bluff and Mount Pelion, and oil shale and cannel coal occur at Barn Bluff (pelionite), at Nook (Don Valley Black Shale) and Lilydale (oil shale).
	Quamby Group - cannel coal in the Devonport area averages 1.0 m thick and has a maximum thickness of 1.8 m.
QUALITY	Cygnet Coal Measures - anthracite to sub-anthracite rank caused by Jurassic dolerite intrusion.
	Mersey Coal Measures - sapropelic coal at Barn Bluff, humic coal in Devonport area.
	Quamby Group - cannel coal (tasmanite).
RESERVES	Reserves in both the Mersey Coal Masin and Cygnet Coal Measures are small but unknown in detail.
PROBLEMS	Extensive faulting, dolerite intrusion, thin seams and small reserves have discouraged exploration. All old workings are now inaccessible.

SELECTED REFERENCES

(1) BLAYDEN, I.D., 1975 - Geology of Australian coalfields - some other coal basins. In COOK, A.C. (Ed.), - AUSTRALIAN BLACK COAL - its occurrence, mining, preparation and use. Australasian Institute of Mining and Metallurgy, Illawarra Branch, 19-30.

(2) NOLDART, A.J., 1975 - Permian coal in Tasmania. In TRAVES, D.M., & KING, D., (Eds.), ECONOMIC GEOLOGY OF AUSTRALIA AND PAPUA NEW GUINEA. Australasian Institute of Mining and Metallurgy, Monograph 6, Volume 2 Coal, 264-265.

BASIN/FIELD	Wolfang Basin, Queensland
SEDIMENT THICKNESS & AGE	The coal bearing sequence comprises Early Permian basal or near basal conglomerate, sandstone siltstone, mudstone and coal seams.
Tertiary	Basalt with an average thickness of 53 m and a basal clay up to 29 m thick with a thin coal in places at the top.
Early Permian	Coal bearing sequence at the top up to 165 m thick with the main (Big) Seam at the base which averages 30 m thick. The underlying sequence is mainly conglomerate with the exception of a thin basal sequence. __________ unconformity __________
Cambo-Ordovician	Chlorite schists which are structurally part of the Anakie Inlier. The maximum thickness of the Permian is not less than 430 m in the western part of the basin.
COAL MEASURE UNITS	The major part of the sequence is equivalent to the Blair Athol Coal Measures and the main (Big) Seam at the base of the coal bearing sequence is equivalent to the Blair Athol Big Seam. The thin basal sequence below the conglomerate is correlated with the Reids Dome Beds.
COAL DISTRIBUTION	The Big Seam underlies over 4 km of the basin and has been intersected in eleven drill holes. The Top Seam is present over the southern 2/3 of the basin.
STRUCTURE	The Wolfang Basin is a semi-isolated Permian Basin underlain by metamorphics of the Anakie Inlier. Gravity anomalies indicate that the basin is roughly elliptical in outline and elongated in a northerly direction. It has a sharp, steep western boundary and a more gently rise to the east and north. Dip of the coal seams is mainly gentle. An irregular basement topography is indicated by drilling. Faulting of the Big Seam has been documented in drill holes. Although faulting has been suggested as controlling sediment deposition and formation of the Big Seam, a glacial origin for the basin has been postulated. The northern and southern margins are not well defined. The basin may have been connected at times with the Clermont Shelf to the south. The marine sequence found at Clermont is not represented in the Wolfang Basin and coastal water fluctuations probably had no influence on coal deposition in the Wolfang Basin.

ENVIRONMENT	The beds were deposited in a freshwater lacustrine environment. The lack of stone beds and exceptional thickness of the Big Seam indicates an autochthonous origin. The dirtiest section of the seam lies at the northern end of the basin and the sediment source probably lay in this direction. Thick seams indicate a large rise in water level and are probably caused by repetitive fault movements.
INTRUSIONS	The basin is obscured by Tertiary volcanics but no intrusives are known in the coal.
COAL SEAMS	Two principal coal seams have been outlined by drilling, the Big Seam and the Top Seam. The Big Seam has an average thickness of 30 m and maximum thickness of 38.4 m; it thins to the east, south, and north. It is about 10 m thick in the north. The Top Seam ranges from 1-3.5 m thick, averages 2.75 m and thins from north to south. The ratio of overburden to total coal, by volume is 4.3:1. Average overburden thickness is 140 m, and maximum drilled thickness is about 186 m.
QUALITY	Big Seam - The Big Seam is a low rank bituminous coal, suitable for power generation, and benefication is not required. The seam is mainly very clean with thin mudstone beds mainly in the lower part. The coal is mainly dull with thin bright bands in the lower half. Fusain beds are common especially in the centre of the basin where seven beds are present but are apparently not correlatable; they are unusually thick averaging 50 mm and ranging up to 160 mm. The rank is relatively low and is classified as a medium to high volatile bituminous B coal. Vitrinite reflectance is 0.72%R^{o} max, ash yield 6.2-26.2% (av. 9.7%) and sulphur and phosphorus content low. It has no coking or conversion potential and is suitable for steam raising and benefication is unnecessary for this purpose. Top Seam - the top seam is a relatively clean section of workable coal; it is mainly dull, and includes many thin bright seams. The vitrinite content is 70% and much higher than the Big Seam. A ganister like sandstone occurs near the top. The coal is high volatile, bituminous B, marginally lower than the Big Seam. It is subhydrous which limits its use for conversion feed stock, despite the high content of macerals compared to the Big Seam.

RESERVES

In situ measured reserves are -

Top Seam - 10.3 mega-tonnes
Big Seam - 174 mega-tonnes

EXPLORATION

The original lease was held by the Dampier Mining Company who were prospecting for gold in Permian conglomerates. Gravity surveys indicated sedimentary basins beneath the Tertiary basalts and drilling discovered coal.

Twenty three holes have been drilled by the Queensland Mines Department.

PROBLEMS

Waterflows up to 4200 g.p.h. from basalt along the eastern margin of the basin may pose some problems for open cut mining.

The large thickness of overburden precludes open cut mining with the present techniques.

Underground mining would be enormously wasteful.

PRINCIPAL REFERENCES

(1) CARR, A.F., 1980 - Coal resources of the Wolfang Basin. *Geological Survey of Queensland, Record Series* 1980/17 (unpublished).

(2) COOK, F.W., & TAYLOR, C.P., 1979 - Permian strata of the Wolfang Basin. *Queensland Government Mining Journal,* 80, 342-349.

TRIASSIC COAL MEASURES

Introduction

Coal formation declined markedly in the Triassic. Black coal of economic significance occurs in South Australia, parts of Queensland and to a lesser extent in Tasmania. The change to an arid climate and environment of deposition in the Triassic resulted in an absence of coal.

Minor coals occur in the middle Triassic for example in the Esk Trough in Queensland, a downfaulted structure developed as a result of tension during a late orogenic transitional phase in parts of the Tasman Orogenic Zone to the east, as it progressed towards cratonic stability during the Triassic.

Coals of greater economic significance occur in isolated intermontane basins in the post orogenic phase of the Tasman Orogenic Zone, for example at Callide, Tarong, Ipswich, and Nymboida. Other local coal bearing sequences in intermontane basins may be concealed elsewhere. In Tasmania localised deposition of Late Triassic coal occurred in coal swamps.

In South Australia, Late Triassic coal is preserved in depressions caused by folding of the Precambrian basement. Possible Late Triassic coal occurs in the Carnarvon Basin in Western Australia.

PRINCIPAL REFERENCE

WOODS, J.T., 1975 - Triassic Coal Measures - an introduction. In TRAVES, D.M., & KING, D., (Eds.), ECONOMIC GEOLOGY OF AUSTRALIA AND PAPUA NEW GUINEA. Australasian Institute of Mining and Metallurgy, Monograph 6, Volume 2 Coal, 282.

BASIN/FIELD	Callide Basin, Queensland
AREA	Callide Coal Measures occupy an area 22.5 km long by 8 km wide.
MINING	Open cuts at Peterson Gully - Dunn Creek area. The coal is supplied to the Calcap Power Station.
SEDIMENT THICKNESS & AGE	Generalised stratigraphic table -
Tertiary	Basalt and sediments.
Triassic	Callide Coal Measures - middle to early Late Triassic, equivalent to the Ipswich Coal Measures.
	unconformity
Triassic	Muncon Volcanics - occur in the southeastern Callide Basin. Early and Middle Triassic plants occur at the base of the volcanics.
	unconformity
Early and Late Permian and Early Carboniferous	Yarrol Basin Sequence

COAL MEASURE UNITS

Late Triassic Callide Coal Measures.

Coal is restricted to the lower half of the coal measures southeast of the Callide open cut. Sandstone in the lower part of the sequence exhibits massive cross-bedding which dips towards the axis of the basin. Conglomerate is present at the base southeast of the Callide Open cut.

In the northwest and southeast (Trap Gully area) the coal measures unconformably overlie the Triassic Muncon Volcanics. In the southwest they are unconformable on the Permian Rainbow Creek Beds and in the Oakey Creek area overlie volcanics and sediments probably of the Permian Youlambie Conglomerate.

The coal measures are greater than 300 m thick near the axis of the basin, thin towards the southern and northern margins and are eroded to the west.

OUTCROP

Outcrops occur in Callide Creek and Dunn Creek. The depth of weathering varies from about 15 m in the valley floors to about 35 m under the higher ground and is generally above water table and the base of the Callide Seam within the mine area. Weathering at depths exceeding 50 m occurs in sheared and fractured zones. Normally only the upper part of the Callide Seam is affected by weathering where it is less than 15 m deep.

COAL DISTRIBUTION

Coal Seams of the Callide Coal Measures are best developed in the Peterson Gully, Dunn Creek and Trap Gully.

STRUCTURE

The Callide Basin formed by downwarp of Palaeozoic sediments of the Yarol Basin in the early Triassic; and is bounded by these sediments in the north, east and southeast. The remaining boundaries are covered by thick Tertiary deposits. The structure is relatively simple with strata dipping at less than 10^{o} towards the axis of the northwesterly trending, elongated asymmetrical synclinal basin. The eastern limb dips at 5^{o}, and a more steeply dipping faulted western margin. The syncline pitches at about 5^{o} northwest at the southeast end. The eastern margin is faulted and basement faulting may extend into the coal measures.

COAL SEAMS

The Callide Coal Measures contain four seams -

Top Marker
Callide - the only economic seam
Sawmill
Bottom

The Callide Seam is 10-26 m thick in the Callide mine area. In the Oakey Creek area the seam is 3.3-7.5 m thick. The seam splits to the east and west of the mine into two, and in places there are three major splits. Splitting is common elsewhere in the basin.

Other seams rarely exceed 3 m thick and their irregularity and poor quality preclude mining under existing conditions.

QUALITY

The Callide Seam lithotype is predominantly durain accompanied by fusain, some clarain and very thin vitrain interbands. It contains irregular dirt bands and few ironstone bands. In the Callide mine area - semi-fusinite is the predominant maceral with a slight increase in vitrinite and brighter coal towards the base of seam. Vitrinite is low rank Ro^{max} 0.496%. The coal is sub-bituminous class A ASTM and SAAK184 500(3). The Callide seam is a medium-ash, high volatile, low sulphur, non-swelling coal.

RESERVES

In situ indicated reserves of Callide Seam coal are about 280 million tonnes (1972). This total includes 40 million tonnes of in situ, potential open cut coal with a maximum overburden cover of about 60 m.

Large underground reserves will be the future development.

Demonstrated economic resources are 230 million tonnes *in situ* and 161 million tonnes recoverable (NEAC 1981). Other *in situ* resources are large (100-10 000 million tonnes).

QDM (1981) figures for measured and indicated reserves *in situ* are 205 mega-tonnes.

PROBLEMS

The development of the large underground reserves.

PRINCIPAL REFERENCES

(1) QUEENSLAND GOVERNMENT MINING JOURNAL, 1978 - Queensland coal mining areas, 79, (917), 148-149.

(2) QUEENSLAND GEOLOGICAL SURVEY, QUEENSLAND COAL BOARD, 1978 - Queensland - Mining for Export. *World Coal*, 4(7).

(3) SVENSON, D., and HAYES, S., 1975 - Callide Coal Measures, Queensland. *In* TRAVES, D.M., & KING, D., (*Eds.*), ECONOMIC GEOLOGY OF AUSTRALIA AND PAPUA NEW GUINEA. *Australasian Institute of Mining and Metallurgy Monograph 6*, Volume 2 Coal. 283-287.

BASIN/FIELD	Carnarvon Basin, Western Australia
AREA	300 000 km^2
SEDIMENT THICKNESS & AGE	Silurian to Recent Sediments. Over 6000 m of Palaeozoic sediments in southern sub-basins, over 8000 m of Jurassic and Neocomian marine and fluvial sediments in northern sub-basins, and 3000 m of Cretaceous and Tertiary carbonates along the present day shelf edge.
COAL MEASURE UNITS	Middle to Late Triassic Mungaroo Beds which in places ranges into the Early Jurassic. Middle and Late Jurassic Learmonth Formation.
LITHOLOGY	Mungaroo Beds - alternations of fine to coarse grained clean sandstone with red and brown claystone interbeds, and rare coal. Learmonth Formation - kaolinitic sandstone and siltstone with coal interbeds.
COAL DISTRIBUTION	Triassic sediments are confined to the northern Carnarvon Basin in the Exmouth, Barrow and Dampier Sub-basins and on the highly faulted eastern and western flanks (Peedamullah Shelf and Rankin Platform). The Learmonth Formation is present along the southern and eastern margins of the Exmouth Sub-basin, and a similar unit is present in the northeast Dampier Sub-basin (Legendre Formation).
STRUCTURE	Elongate crustal depression along the central West Australian coastline. The major structural trends are related to break up of the continental margin and block faulting which took place in the Jurassic.
ENVIRONMENT	The Triassic sequence is one of gradual regression. The Mungaroo Beds were deposited in deltaic to fluvial conditions. The Jurassic Learmonth Formation is a sandy paralic facies, and the Legendre Formation was probably formed in fluvial and deltaic conditions. The Jurassic was a period of sustained subsidence and rapid sedimentation.

EXPLORATION

Otter Exploration NL have reported some seams of poor quality coal at Byro in the Ashburton Region (Mining Review, June, 1981).

PROBLEMS

The great depth of the Mesozoic sediments and the sparse coal seams make the sequence an unattractive exploration target.

PRINCIPAL REFERENCES

(1) GEOLOGICAL SURVEY OF WESTERN AUSTRALIA, 1975 - GEOLOGY OF WESTERN AUSTRALIA: West Australia Geological Survey, Memoir 2, 541 p.

(2) THOMAS, B.M., & SMITH, D.N., 1974 - A summary of the petroleum geology of the Carnarvon Basin. The Australian Petroleum Exploration Association Journal, 66-76.

BASIN/FIELD	Ipswich Coal Field, Queensland
AREA	250 km^2
MINING	The Ipswich Coal Measures are presently mined on the south end of the Bundamba Anticline where coal is mainly won from the Bluff, Four Feet and Bergin Seams in the Blackstone Formation. At North Ipswich coal is won from seams in the underlying Tivoli Formation.
SEDIMENT THICKNESS & AGE	The Late Triassic Ipswich Coal Measures comprise 1250 m of continental, notably lenticular, sediments. The unconformable overlying Late Triassic to Early Jurassic Bundamba Group is about 30 m thick. The coal measures unconformably overlie the Devonian - Carboniferous Neranleigh - Fernvale Beds.
COAL MEASURE UNITS	The Brassall Sub-group of the Late Triassic (Carnian) Ipswich Coal Measures contains the productive coal seams.

	unconformity	
	Brassall Sub-group	
	Blackstone Formation (max. 240 m)	Contains the major producing coal seams of the Bundamba district. Eroded to Bergin Seam in places.
Ipswich Coal Measures	Cooneana Formation (about 240 m)	Covered in part by Tertiary basalts. Contains coal seams but only the Cochrane Seam worked.
	Tivoli Formation (480 m)	The upper 320 m contains all the productive coal seams of the North Ipswich district. Lenticular sandstone beds occur in the Formation. The Waterworks Seam occurs at the base.
	conformity	
	Kholo Sub-group	Contains thin uneconomic coal seams.

LITHOLOGY

The Ipswich Coal Measures comprise continental shale, sandstone and coal seams; tuff, conglomerate and breccia occur in the basal units. The sediments are lenticular, particularly the sandstones.

COAL DISTRIBUTION

Over 20 seams occur in the Ipswich Coal Measures with most coal won from the Bluff, Four Feet, and Bergin Seams in the Blackstone Formation mainly from collieries at the South end of the Bundamba Anticline. Seams contain many lenticular shale and mudstone beds, but also contain fawn shale or mudstone marker beds.

STRUCTURE

A regional south to south-southeast dip is modified by folds, with axes parallel to the regional dip. North-northwest trending faults are prevalent. The most important fold is the Bundamba Anticline; it is traversed by a north west trending fold at its southern end which forms a barrier to coal exploration.

Faults hinder coal mining; they trend mainly northwest in the north Ipswich district, with secondary east-northeast in the Bundamba district. The faults are mostly normal, some reverse, commonly with rapid lateral variation in displacement.

The western margin of the Ipswich Basin is formed by steeply dipping beds of several ages along the West Ipswich Fault.

INTRUSIONS

The sediments of the Ipswich Basins are overlain, in part, by Tert'ary basalts. Igneous dykes and some sills cause local metamorphism of the coal seams.

COAL SEAMS

Tivoli Formation. The coal seams exhibit rapid lateral variation in thickness and composition. They are affected by washouts and replaced partly or wholly by coarse grained sandstone. Seam splitting and rejoining is common in the uppermost seams, the Garden and Tantivy; they combine east of the Boxwood Fault to form a workable seam [illegible] m thick.

The Fiery Seam is banded, up to 7 m thick, commonly split, washed out west of the Boxwood Fault, and replaced in whole or part by an igneous sill to the east.

The Waterstown Seam is about 2 m thick; better quality coal occurs in the upper part.

The Tivoli Seam contains sections 1.2 to 1.5 m thick that have been mined in the past for coking coal. A section 3 m thick is mined east of the Boxwood Fault where it has coalesced with underlying coal beds.

The Eclipse Seam is economically the most important and is up to 4.6 m thick with the lower 3 m worked; the upper part is commonly banded. Splitting occurs in the seam.

The Benley Seam is the lowest worked seam; the upper part is washed out in places.

Cooneana Formation

The Cochrane seam is worked on the axis of the Bundamba Anticline. It is about 2 m thick in the mine, and thickens to the east where it combines with the underlying coal and shale bands.

Blackstone Formation

The Thomas Seam is only known on the west flank of the Bundamba Anticline but is eroded elsewhere; maximum thickness is 10 m and it splits into two sections in the west.

The Abendare Seam contains two 2 m sections separated by 0.3 m of thin coal and shale. The seam splits in places on the western limb of the Bundamba Anticline or combines with the Thomas Seam to form a thick composite seam.

The Bluff Seam comprises three sections that total 10 m. Splitting occurs in the southeast so that the lower two sections are separated by 20 m. Most coal in the Ipswich Coal Field is from the Bluff, Four Feet and Bergin Seams. The Blackheath Sandstone Member is a marker bed between the Bluff and Four Feet Seam.

The Four Feet Seam top section is 3.6 m thick and the bottom section up to 2.5 m thick. The sections split to the east and south of the Bundamba Anticline and may be separated by 30 m of strata in which case the Four Feet overlies the Bergin Seam.

The Bergin Seam has a maximum thickness of 6 m and splits in two sections in the southwest.

The Striped Bacon, and Rob Roy Seams are separated in the northeast part of the Bundamba Anticline, with 2-3 m workable sections; they coalesce in the west and southwest to attain 15 m.

QUALITY

The Ipswich coals have a high ash yield and washing is necessary to reduce the content to less than 23%. The high mineral content cannot be reduced by washing. Coals are mainly bright with numerous shale and mudstone beds they have high vitrinite and volatile matter content and low sulphur and chlorine.

Rank is high volatile bituminous (ASTM) and they are used for steam raising and power generation.

RESERVES

	In situ reserves. (million tonnes)	
	Measured	Indicated
Bundamba	386	92
North Ipswich	33	5
	419	97

Demonstrated and economic resources are 490 million tonnes in situ, and 245 million tonnes recoverable (NEAC, 1981).

EXPLORATION

587 cored boreholes by the Department of Mines and Queensland Coal Baord.

PROBLEMS

1. Faults cause considerable hindrance to coal mining.

2. Splitting and rejoining of coal seams cause difficulties in seam correlation.

3. Lenticular clastic beds, particularly sandstones, causing marked thickness changes of strata between coal seams, and lenticular shale and mudstone within seams.

4. Dykes and some sills in seams cause local metamorphism.

5. Rapid lateral variation in thickness and composition of some seams.

6. Some seams affected by washouts.

7. Causes of coal splitting, and lenticularity of beds not described.

PRINCIPAL REFERENCE

MENGEL, D.C., 1975 - Ipswich Coal Field, Queensland, In TRAVES, D.M., & KING, D., (Eds.), ECONOMIC GEOLOGY OF AUSTRALIA AND PAPUA NEW GUINEA. Australasian Institute of Mining and Metallurgy, Monograph 6, Volume 2 Coal, 290-297.

BASIN/FIELD	Leigh Creek Coalfield, Boolcunda and Springfield Basins, South Australia
AREA	Basins up to 25 km^2 in area.
MINING	Coal is won from the Telford Basin and North Field at Leigh Creek but there is no exploitable coal in the Boolcunda and Springfield Basins. 28 million tonnes of coal were mined up to the end of 1972 involving the removal of 75 million tonnes of overburden.
SEDIMENT THICKNESS & AGE	Quaternary 10 m
	unconformity
	Jurassic
	unconformity
Late Triassic	Leigh Creek Coal Measures
	unconformity
	Adelaidean Sequence
COAL MEASURE UNITS	Coal occurs in the Late Triassic Leigh Creek Coal measures and deposition of carbonaceous sediments continued into the mid-Jurassic.
LITHOLOGY	Grey carbonaceous shale, siltstone, sand, grit and coal seams. The structure is outlined by sporadic outcrops of ferruginous shale, sandstone and ironstone.
STRUCTURE	The structure comprises the infolded roots of four circular intramontane basins in Adelaidean rocks. They were part of a once more extensive sequence deposited in freshwater lakes, now preserved by down folding during the Jurassic. The basin sediments are unconformably overlain by Late Jurassic Sandstone at Copley.

The structure and dimensions of individual basins are:-

Copley Basin - 7 km^2, 205 m deep, dips $10\text{-}40^{\circ}$.

Telford Basin - 25 km^2, 1000 m deep, asymmetrical, dips $15\text{-}20^{\circ}$ on south and southwest margins. Faulting has dislocated main seam on periphery of basin, but apparently absent elsewhere.

North Field, Lobe C - dips $5\text{-}40^{\circ}$.

North Field, Lobe D - 120 m deep, dips mostly less than 10°.

Boolcunda Basin - 4 km^2, dips 50-60°.

Springfield Basin - 10km^2, 600 m deep, dips 20-40°.

ENVIRONMENT

'The Leigh Creek Coal Measures probably accumulated within a shallow intramontane basin related to Late Triassic faulting. It is assumed that the coal measures are swamp deposits associated with a river system: all sediments are non-marine as indicated by the occurrence of the freshwater mussel Unio eyrensis. Overbank flooding episodically invaded an otherwise quiet swampy environment, resulting in extensive shale and some sand deposition'. (2)

Two main depositional phases are interpreted for the three main groups of coals with intervening uplift and partial erosion. Subsequent minor tectonic movements probably in the mid-Jurassic terminated depositon of the coal measures.

COAL SEAMS

Exploitable coal occurs in three of four basins at Leigh Creek but not at Springfield and Boolcunda.

Copley Basin - one seam up to 6 m, at depths mostly greater than 30 m; other thin seams. Dips 10-40°.

Telford Basin - minor dirty seams,and several seams up to 8 m separated from the Telford Seam above by 100 m of shale. The Telford Seam is 6-18 m (average 12 m) thick with lenticular shale partings in the north and east, but thin and deteriorates to south and west. Overlying shale 120-600 m thick, overlain by three principle upper coal seams up to 6 m thick.

North Field, Lobe C - high ash and sulphur coal seam 1.6-16 m thick on southern and western margins, amendable to open cast extraction.

North Field, Lobe D - two principal coal seams; lower seam 6-8 m with shale parting averaging 0.6 m thick, upper seam 9 m thick. Clinker and fused shale are present in the upper seam (also at Springfield and Mount Toondina).

Boolcunda Basin - 300 m coal measures including 90 m of carbonaceous shales with thin coals.

Springfield Basin - thin seams of dirty coal, seams mostly less than 0.3 m, thickest seam 5 m at 77 m but deteriorates rapidly laterally.

QUALITY

The calorific value is comparatively low (14-22 MJ/Kg), the moisture content high (30-40%) in the coal as mined; ash yield is high, and sulphur, phosphorus and chlorine content is high in some seams.

RESERVES

Proved 51.58 x 10^6 tonnes; Indicated 56.25 x 10^6 tonnes; Inferred 320 x 10^6 tonnes.

Demonstrated economic resources are given as 120 million tonnes *in situ*, and 120 million tonnes recoverable; and 300 million tonnes of other resources *in situ*. (NEAC, 1981)

EXPLORATION

No coals have been located beneath Quaternary sediments to the north towards Farina.

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(2) TOWNSEND, I.J., 1979 - The correlation and depositional history of the Leigh Creek Coal Measures. *Geological Survey of South Australia, Quarterly by Geological Notes* 70, 5-10.

BASIN/FIELD	Lorne Basin, New South Wales
AREA	800 km^2
SEDIMENT THICKNESS & AGE	Early Triassic sediments, 90 m thick.
	CAMDEN HAVEN GROUP - 200 m of terrestrial sediments.
Early Triassic	Grants Head Formation 75 m Lauriton Conglomerate 45-210 m Camden Head Claystone 0-75 m
	______unconformity______
	Early Permian and older Palaeozoic rocks.
COAL MEASURE UNITS	The stratigraphic position of the coal is unknown, and the occurrence is uneconomic.
COAL DISTRIBUTION	Coal is found in rail cuttings and shafts in the Johns River area and rail cuttings between Herons Creek and Wauchope.
STRUCTURE	The Lorne Basin is an intramontane Triassic basin formed on the cratonized New England Fold Belt. Terrestrial activity was probably initiated by further movements along surrounding major faults and serpentinite belts, in the Early Triassic. There has been slight subsequent deformation with peripheral dips of 15 to 20° towards the centre of the basin which may be in part a depositional dip. Vertical dips occur around one laccolith.
INTRUSIONS	Large alkaline intrusives of Late Triassic or Early Jurassic age (194 $\pm$ 6 m.y. (3)) occur along the eastern part of the basin, and form topographic features up to 500 m high.
	Numerous porphyritic rhyolite plugs intrude the western part of the Lorne Basin.
COAL SEAMS	Minor thin coals less than 0.3 m thick.
PROBLEMS	Age, extent and stratigraphic position of the coal is unknown.

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(1) HERBERT, C., 1974 - Lorne Basin. In MARKHAM, N.L., & BASDEN, H. (Eds.) THE MINERAL DEPOSITS OF NEW SOUTH WALES. Department of Mines, Geological Survey of New South Wales.

(2) PRATT, G.W., & HERBERT, C., 1973 - A reappraisal of the Lorne Basin. Records of the Geological Survey of New South Wales 15, (2), 205-212, 4 figs.

(3) THOMPSON, J., 1974 - Results of radiometric dating programme, 1971-1973. Records of the Geological Survey of New South Wales, 16, (3), 239-244.

BASIN/FIELD	Nymboida Coalfield, New South Wales
AREA	90 km^2 (Nymboida Coal Measures)
MINING	The Nymboida Colliery was the last mine operating in the field.
SEDIMENT THICKNESS & AGE	About 1000 m of sediments, with evidence for a Late Triassic age in the lower 600 m.

The stratigraphic sequence (1) in the Nymboida Coal Measures is -

Nymboida Coal Measures (Maximum 1050 m)

Basin Creek Formation

Georges Knob Conglometre Member
Farquhars Creek Seam

Copes Creek Tuff
Bardool Conglomerate

Goolang Siltstone Member

Cloughers Creek Formation

________ unconformity ________

Fitzroy Beds

The coal measures are about 1050 m thick in Cloughers Creek, and the type section is from near the Nymboida Hydroelectric power station to the head of Cloughers Creek.

Basement rocks in the area comprise strongly folded Palaeozoic metamorphic and igneous rocks.

COAL MEASURE UNITS

The Nymboida, Red Cliff and Evans Head Coal Measures, and the carbonaceous plant bearing shales of the Chillingham Volcanics are equivalent units.

The full section of the Nymboida Coal Measures is correlated with the Ipswich Coal Measure. A coal seam at Nymboida at the base of the sequence in the Cloughers Creek Formation overlies Palaeozoic basement rocks.

LITHOLOGY

The Nymboida Coal Measures comprise sandstone, shale conglomerate, tuff and coal. The dominant lithology is quartz-lithic sandstone and polymictic conglomerate. A rhyolitic tuff marker bed (Copes Creek Tuff) is 25 m thick.

The Red Cliff Coal Measures comprise shale, sandstone breccia, and coal and occupy an area 2.4 km wide by 19 km long.

The base is not exposed and they are overlapped by the Early Jurassic to Late Triassic Tabulam Group. The maximum thickness is 600 m. They contain a torrential breccia, and fossils are dated as Triassic. Dips range from 20-25° west; they are folded and show some faulting which is vertical in places; they are associated with movement on the Coast Range Fault, and the western boundary outcrop corresponds to the continuation of this fault.

The Evans Head Coal Measures comprises coal bearing sandstone and shale. 45 m of sandstone is exposed at Evans Head and dips west at 20°. The total thickness is about 300 m. The coal measures are overlain by the Tabulam Group but the contact is not exposed. An angular unconformity is present with the Brisbane Metamorphics. A Triassic age is assumed by anology with the position of the equivalent Red Cliff Coal Measures below the Tabulam Group and Nymboida Coal Measures below the Bundamba Group.

OUTCROP

Outcrops are present at Nymboida, Red Cliff, Evans Head and west of Murwillumbah (Chillingham Volcanics). The belt is 6 km wide extending southwest and northwest for 30 km.

Outcrop is marginal to the unconformably overlying Late Triassic-Cretaceous Bundamba Group of the Clarence-Moreton Basin.

COAL DISTRIBUTION

Presumed equivalents of the Nymboida Coal Measures occur at Red Cliff and Evans Head. Plant bearing shales with Chillingham Volcanics west of Murwillumbah are probably of equivalent age. The Nymboida and Ipswich Coal Measures are concealed. Working extend over about 3 km in the Farquhars Seam of the Nymboida Coal Measures.

STRUCTURE

The sequence is moderately folded with dips commonly in excess of 20°. Major normal faults with throws of about 600 m occur in the coal measures. The basal seam is commonly contorted.

INTRUSIONS

One basalt layer 15 m thick, and a marker tuff bed, the Copes Creek Tuff, 25 m thick.

COAL SEAMS

Nymboida Coal Measures

The Cloughers Creek Formation contains lenticular seams of coal; for example the thickness varies from 2.1 m to less than 0.6 m over a distance of 15.2 m, and in another case it varies from 2.1 m to 1.2 m over a distance of 2.7 m and in this instance thinning is caused by a lens of lithic sandstone near the roof of the seam. 'Greasy backs' occur at the intersections of harder and softer coal where slickensides are developed. Coal occurs within a few centimetres of the Palaeozoic basement.

The Farquhars Creek Seam occurs 213 m above the base of the Basin Creek Formation. It can be traced for 13 km from the Nymboida River to Kangaroo Creek and averages 1.5 m thick. It is the only proven economic source of coal in the southern part of the basin. It contains numerous thin bands of shale which thicken rapidly away from the Nymboida Colliery.

The Red Cliff Coal Measures contain two seams 1.2 m and 2.4 m thick of poor quality coal with many bands.

The Evans Head Coal Measures comprises coal bearing sandstone and shale.

QUALITY

Rank

The Farquhars Seam comprises a medium volatile bituminous coal, with a high calorific value of up to 36.3 MJ/kg dmmf basis, and high ash yield.

The basal seam has low volatiles and high calorific value and approaches semi-anthracite in rank.

Lithotype

Coal in the Cloughers Creek Formation contains duro-clarain and irregular lenses of vitrinite and semi-fusinite with much micrinite. Sclerotic material is common.

The Farquhars Creek Seam of the Basin Creek Formation comprises semi-fusinite with vitrinite, micrinite and resin. Coal has clarain, duro-clarain and durain. (1)

RESERVES

Reserves in the Farquhars Creek Seam are less than 1 million tonnes.

PROBLEMS

The Basal Seam is lenticular and has variable stone bands. Greasy backs constitute an access hazard on floors of adits and weakness in mining procedures.

Extensive coal deposits are present but have only been worked on a very small scale. The Nymboida Colliery, the last worked colliery in the Clarence-Moreton Basin has almost exhausted its economic reserves with less than 0.1 mt. remaining.

Little is known of the subsurface stratigraphy within the basin.

The basin is sparsely prospected but present indications are that while the discovery of significant economic coal resources is not impossible the prospects cannot be rated as encouraging.

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BASIN/FIELD	Tarong Coal Field, Queensland
MINING	Potential coal supply for power station.
SEDIMENT THICKNESS & AGE	Recent - Soil and alluvium Tertiary - basalt Jurassic - Oakvale Conglomerate Triassic - Tarong Beds, 250 + m thick _____ unconformity _____ Silurian metasediments and Palaeozoic granite. The Tarong Beds are equivalent to the Tivoli Formation at Ipswich.
COAL MEASURE UNITS	Tarong Beds
LITHOLOGY	The Tarong Beds are predominantly arenaceous with a basal conglomerate. The comprise a fining upwards sequence - basal conglomerate, pale grey sandstone, dark grey siltstone and mudstone with at least six coal seams.
STRUCTURE	The Tarong Basin is developed on a basement of Silurian metasediments which crop out along the eastern margins, and Palaeozoic granite to the west. The sequence is gently folded and faulted with two fault directions - northwest and northeast; dips are variable. Gentle folding probably preceeded faulting with structural axes aligned along the present strike direction. The basin margins are possibly fault controlled. Dips in the Tarong Beds are gentle with coal measures confined to three synclinal sub-basins - the north, central and southern coal basins. Faulting dissects the Tarong South Basin into several separate blocks.
COAL SEAMS	At least six coal seams occur at Tarong South - King Seam 12-16 m coal with bands Rider Seam 0.3-2.5 m coal with bands Queen Seam 3.75-9 m coal with bands Joker Seam 1-6m coal and black shale Prince Seam 0-12 m coal with bands Meandu Creek Seam 10-34 m coal with bands The seams are separated by intervals of sandstone siltstone and mudstone from 15 to 45 m thick; seams highly banded, partings 2-20cm thick, but rarely exceeding 30 cm in any coal seam.

The Prince and Meandu Creek Seams may possibly be the same stratigraphic horizon.

QUALITY

All seams are dirty with raw coal ash values in the range 25-45% (air dried). Non-coking coal can be enchanced by washing, e.g. floats at SG 1.8 average 70% recovery with air dried ash of about 22%, and at a SG1.6 recovery averages 60% with about 5% air dried ash. Quality varies in the same seam.

RESERVES

Ten separate fault blocks at Tarong South (designated A to K) each contain one economic seam. The blocks contain 100 million tonnes of raw coal workable by open cut with overall overburden to coal ratio of 2.5:1. Six blocks A-F, contain 80 million tonnes of raw coal in the King and Meandu Creek Seams with an overall ratio of 2:1.

Measured and indicated reserves are 280 million tonnes *in situ*, (QDM, 1981) and 210 million tonnes recoverable. Other resources *in situ* are large (100-10 000 million tonnes) (NEAC, 1981).

EXPLORATION

Scout drilling in 1969 and 1970 located coal seams greater than 10 m thick at shallow depths. Parts of the basin have been held under authority to prospect by CRA Exploration Pty Ltd (336, 338, AESIS special list No. 5).

PRINCIPAL REFERENCES

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(2) WILSON, R.G., 1975 - Tarong Coalfield, Queensland. *In* TRAVES, D.M., & KING, D., (*Eds.*) ECONOMIC GEOLOGY OF AUSTRALIA AND PAPUA NEW GUINEA. *Australasian Institute of Mining and Metallurgy, Monograph 6*, Volume 2, Coal, 288-290.

BASIN/FIELD	Tasmania Basin (Triassic Coal Measures)
AREA	
MINING	Only mine working at present is the Duncan-Fingal Colliery at Fingal. About 90% of production in Tasmania in 1972 was from the Triassic. Main centres of coal mining have been in the St. Marys - Fingal - Avoca district. Past mining areas include Seymour, Coles Bay, Schouten Island , Buckland, York Plains, Colebrook, Hamilton, Sandfly, Esperence, Saltwater River and Newtown.
SEDIMENT THICKNESS & AGE	The coal measures are Late Triassic in age and possibly equivalent to the Nymboida and Ipswich Coal Measures. The Triassic rocks are 330 m thick in the Fingal area.
LITHOLOGY	Triassic rocks comprise pale quartzose sandstone overlain by quartz-feldspar-mica sandstone with thick shale and coal.
COAL DISTRIBUTION	Triassic coal fields are confirmed to east and northeast Tasmania.
ENVIRONMENT	Coal seams formed separately in interconnected depressions.
INTRUSIONS	Jurassic dolerite sills up to several hundred metres thick overly the Triassic sequence. Triassic basalt and acid ignimbrite have been located during recent mapping (GGC, 1981).
COAL SEAMS	Seam thickness is variable e.g. possibly same seam at Cornwall, Duncan, and Dalmeyne are 1.5 m, 2.1 m and 4.9 m thick. Economic coal occurs at several levels in the upper lithic sandstone.
QUALITY	Ash yield is commonly high, sulphur content low, and calorific value is low. The coal is used for steam raising and domestic use. Sandfly coal is low volatile with up to 63% fixed carbon. At New Stanhope there is one seam of semi-coking coal.
RESERVES	Triassic coal resources in Tasmania were estimated in 1961 to be - indicated 21 million tonnes; inferred 120 million tonnes. (1) Demonstrated economic resources are 139 million tonnes <u>in situ</u> and 69 million tonnes recoverable. Other resources include 200 million tonnes <u>in situ</u> (NEAC, 1981).

EXPLORATION

Gravity surveys have been used in recent exploration to direct drilling at avoid intruded areas. A computer programme has been designed by the Tasmanian Department of Mines to indicate the downward continutation of dolerite bodies. Aeromagnetic surveys have also been evaluated.

PROBLEMS

Large variation in seam band thickness and roof composition. Faulting and rolling is prevalent and correlation of seams is difficult and unreliable.

Exploratory drilling in the coal measures is commonly wasted by intersecting dolerite feeders and low level intrusions which cut out coal measures.

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JURASSIC-CRETACEOUS COAL MEASURES

Introduction

Jurassic coals are widely distributed and second only in aerial extent to the Permian. In general they are thinner, more lenticular, higher in ash, and lower in rank than Permian coals. They are only of economic importance in Queensland.

Cretaceous coals are even more widespread and have been worked in Queensland and Victoria.

In the mid-Jurassic large deposits of high volatile perhydrous coals formed. There is probably further scope for prospecting Jurassic coals in the northern Eromanga Basin.

The Maryborough Basin was more active tectonically than other basins in the Cretaceous with coal formed during a regressive phase in the late Early Cretaceous. Similar high volatile bituminous coal occurs in the Styx Basin.

The greatest spread of Cretaceous coals are in the Cenomanian, with regression in the Eromanga Basin to form the Winton Formation, which contains thin coals, but high in ash, and low rank.

Late Jurassic coal occurs in the Otway Basin, and continued through into the Cretaceous. Restricted coal occurs in the Early Cretaceous of the Gippsland Basin; they are bituminous coals but thin.

In Western Australia Early Jurassic fluviatile coals occur in the Perth Basin - Dandaragan and Bunbury Troughs. The Cattamarra coal measures in the Dandaragan Trough, with sub-bituminous coal near Eneabba, are probably the most important. Early Cretaceous coal occurs in the north Perth Basin.

Jurassic coals are known from the Exmouth Plateau and offshore portions of the Bonaparte and Canning Basins.

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BASIN/FIELD	Clarence-Moreton Basin, New South Wales and Queensland.
AREA	50 000 km^2
MINING	Coal is presently mined in the Oakey/Acland and Rosewood/Walloon coal fields. Large deposits of coal are present at Millmerran on the western margin of the basin. Past mining areas include Bundamba, Tannymorel and Toowoomba in Queensland and Bonalbo , Coaldale, Ramornie, Nimbin-Tyalgum, Glenreach and Moonem in New South Wales.
SEDIMENT THICKNESS & AGE	About 3000 m of Late Triassic (probably Rhaetian) to Cretaceous sediments.

The generalised stratigraphic sequence in the southern part of the basin is -

Jurassic-Cretaceous	Grafton Formation
	Kangaroo Creek Sandstone
	----- unconformity -----
Jurassic	Walloon Coal Measures, 120-600 m thick Towallum Basalt Marburg Formation Bundamba Group

Lithological equivalent units of the Walloon Coal Measures are the Mulgildie Coal Measures the lower Injune Creek Beds and Birkhead Formation in the Mulgildie, Surat and Eromanga Basins.

The type section of the Walloon Coal Measures is DDH NS 84 in the Ebenezer District. (1)
The top of the formation is not developed at this locality. The type area of the Walloon Coal Measures was nominated as the area around Walloon township in earlier references. (3).

An Oxfordian - Kimmeridgian age is indicated by palynology on samples collected about 45 m below the contact with the Kangaroo Creek Sandstone. The Coal Measures may be in part Early Jurassic.

COAL MEASURE UNITS	Present production is from the Middle to Late Jurassic Walloon Coal Measures. There has been minor production in the past from the Late Triassic Raceview Formation in the Bundamba area. Minor coal occurs in the Marburg Formation and Kumbarilla Beds.
LITHOLOGY	The Walloon Coal Measures comprise labile sandstone, siltstone, mudstone and coal, with minor impure limestone and ironstone.

Marker beds of thin montmorillonitic clay bands are used for correlation of coal seams in the Rosewood - Walloon Coal Field.

OUTCROP	The total length of outcrop is about 300 km and average width 2-30 km. The Walloon Coal Measures weather deeply to produce undulating relief. In places they are preserved on steep slopes beneath the Tertiary Main Range Volcanics. 'The Walloon Coal Measures crop out over most of the Queensland portion of the Basin'.
COAL DISTRIBUTION	Seams occur throughout the whole area of outcrop of the Walloon Coal Measures.
STRUCTURE	The structure is dominated by meridional folds and faults with the intensity of deformation increasing from west to east. Steep dips occur locally adjacent to Tertiary intrusives.
ENVIRONMENT	Paludal and flood plain environment with little surface relief. The main coal deposits were formed in back swamps between stream channels. Minor contemporaneous volcanism is suggested by the presence of thin montmorillonitic clay bands. Deposition within a meandering stream and flood plain environment with channel overbank and back swamp facies has been recognised in the Oakey-Dallay Region (8).
INTRUSIONS	Pyroclastic and effusive igneous activity occurred during deposition. A large number of basic and intermediate sills and dome like intrusions occur mostly in the northwest and northeast. The Clifton Dome is probably underlain by a doleritic intrusion which was intersected at depth. A dolerite sill occurs in the Grafton No. 3 bore. Tertiary intermediate and basic lavas and pyroclastics overlie the coal measures in the north.
COAL SEAMS	Bundamba Coal was mined from the Late Triassic Raceview Formation of the Bundamba Group; the Little West Moreton Seam is about 0.5 m thick. Rosewood-Walloon Eighteen coal seams occur in a sequence 150 m thick; 17 have been worked and 5 seams are presently mined. The seams seldom exceed 0.6 m thick. Oakey-Acland The bottom 2 m of the 20 m thick, banded main seam is extracted. It is underlain by a few thin banded seams, some of which are exploited in the southern part of the field.

Tannymorel

The Walloon Coal Measures are 155 m thick and contain two and possibly three seams; there is no significant coal in the lower 100 m of the coal measures. The main seam is 2.1 m thick and the top metre is extracted.

Millmerran

One major coal seam between 2-9 m thick. (7) The average seam thickness with shale bands is 6 m with 10-74 m of overburden.

New South Wales

Only one mine at Bonalbo was successful where a seam 1.5 m thick occurs.

Grafton No. 3 bore penetrated four coal bands less than 10 cm thick and two very thin bands in the Walloon Coal Measures.

QUALITY

The coals are high volatile A and high volatile B bituminous (ASTM classification), strongly perhydrous, with high tar and gas on carbonitisation. They are good gas making coals, and require blending to produce satisfactory coke.

The coals have high vitrinite and exinite content and low inertinite. (6) They consist predominantly of clarain. (3)

Coal from Bonalbo has a very high volatile matter content and is weakly coking, high volatile bituminous coal. Other collieries in NSW produced weak to medium coking, high volatile bituminous coals with lower volatile matter but higher calorific value compared to the Bonalbo Coal.

RESERVES

Measured and indicated in situ reserves for the Injune, Taroom, Wandoan, Dalby areas are 1193 mega-tonnes (QDM, 1981).

Rosewood-Walloon

Measured in situ coal reserves are 5.8 mega-tonnes amenable to underground mining.

Oakey-Acland

Measured reserves are 13.5 mega-tonnes - underground mining.

Oakey-Dalby

Aggregate open cut reserves of over 1000 mega-tonnes in a number of deposits delineated by drilling. (8)

Millmerran

Measured reserves 60 mega-tonnes of open cut coal, and 20 mega-tonnes from underground mining. Three smaller deposits with total indicated reserves of 20 mega-tonnes to the southwest.

EXPLORATION

Several potentially economic coal deposits amenable to surface mining have been located in the Millmerran-Toowoomba-Warwick regions. (7)

No economic seams have been revealed by diamond drilling in the Moonem and Coaldale-Glenreagh belt.

Areas recommended for further research include the Grafton and Lismore - Casino areas. (4)

PROBLEMS

The several following major problems have been outlined by several authors -

1. A detailed sedimentological study of the Walloon Coal Measures is needed to understand the palaeogeography and depositional history of the coal measure basin.

2. The rapid lateral changes in seam quality and the intercalation of shale bands is of major significance in the development of Jurassic coal seams. (4)

3. The lenticular nature of the coal measures makes prediction and location of workable seams very difficult.

4. The drilling of the Walloon Coal Measures has not so far located any workable deposits.

5. The limited aerial extent and splitting of seams is common to the coal measures.

6. There are numerous mudstone and carbonaceous mudstone bands in the coal.

7. In the area south of Gatton large areas of Marburg Formation have been erroneously mapped as Walloon Coal Measures.

8. There is insufficient data available to estimate the workable reserves in other promising areas of the basin. (5)

9. The economic status of the coal seams is poor and a programme of prospecting is recommended to assist in the assessment of reserves. (4)

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BASIN/FIELD	Eromanga Basin, Queensland
AREA	518 000 km^2
SEDIMENT THICKNESS & AGE	Jurassic-Cretaceous sediments with a maximum thickness of 1830 m.

A typical section in the Eromanga Basin is -

Cretaceous	Rolling Downs Group - marine except for the Winton Formation.	
Jurassic to Cretaceous	Hooray Sandstone	continental
Jurassic	Injune Creek Group Hutton Sandstone	continental

pre-Jurassic basement.

LITHOLOGY

The Birkhead Formation (lowermost Injune Creek Group) comprises fine to medium grained labile sandstone which is calcareous in part, siltstone, minor mudstone, shale and coal.

The Winton Formation (uppermost Rolling Downs Group) comprises fine to very fine grained labile sandstone which is calcareous in part, siltstone, mudstone, intraformational conglomerate and coal.

STRUCTURE

The Eromanga Basin is an intracratonic basin with dips mostly less than 1° basinwards. Drape folds and basement faults passing up into monoclines are present.

The Eromanga Basin is continuous with the Surat Basin over the Nebine Ridge and the Carpentaria Basin to the north over the Euroka Ridge. It overlies older beds of restricted intracratonic basins.

ENVIRONMENT

The Birkhead Formation is mainly lacustrine with minor fluviatile and coal measure phases. A possible marine incursion occurred in the lower part.

The Winton Formation was deposited in lacustrine paludal and fluviatile environments.

COAL SEAMS

Coal has been reported from petroleum and water bores in the Winton Formation and Birkhead Formation. Thin lenses and seams up to 1 m thick occur in the Hutton and Hooray Sandstones and correlatives.

The Birkhead Formation contains very thin coal seams with the maximum thickness 1.5 m.

The Winton Formation is thickest in the southwest where it is up to 910 m. Coal seams are commonly 1.5 m thick, but seams up to 7.6 m are reported in the lower part of the formation in the deeper southwestern part at depths of about 600 m. At Winton 36.5 m of coal occurs in the interval 34.9-91.4 m. In the Augathella/Adavale area bores have intersected poor quality lignite up to 2.1 m thick.

PROBLEMS

Coal seams up to about 1 m thick, comprising interbedded dull black lignite and carbonaceous-mudstone with an overall ash content of 54%, were intersected in ten exploratory drill holes in the Winton area of Western Queensland. (2)

Coal prospects in the Eromanga Basin, based on present information, appear to be poor. Prospects of finding economic reserves near outcrop of the Birkhead Formation appear also to be poor.

The coal potential of the Winton area is regarded as very poor but the basin-wide potential of the Cretaceous Winton Formation remains largely untested. (2)

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BASIN/FIELD	Laura Basin, Queensland
AREA	About 20 000 km^2
SEDIMENT THICKNESS & AGE	A maximum thickness of 1000 m of Permian and Mesozoic sediments. The generalised stratigraphic sequence is -
Early Cretaceous	(Wolena Claystone - richly fossiliferous marine (clay. ((Battle Camp Formation - 350 m of marine sediments (in Marina No. 1.
Jurassic	(Dalrymple Sandstone - 550 m in Marina No. 1, (Sandstone, shale, siltstone and minor lenticular (conglomerate. Thin lenses of coal in basal (portion.
LITHOLOGY	The basal part of the Jurassic Dalrymple Sandstone is commonly conglomerate with thin lenses of grey, coal-bearing shale.
OUTCROP	The Dalrymple Sandstone is exposed in the eastern and southern parts of the basin.
STRUCTURE	The Laura Basin is a broad synclinal depression of Jurassic and Early Cretaceous sediments, trending and plunging north-northwest and extending offshore. Mesozoic rocks unconformably overlie an uneven basement of folded Palaeozoic sediments and granites.
COAL SEAMS	The coal seams occur in the lower part of the Dalrymple Sandstone; traces of coal in the upper 60 m of sandstone in Breeza Plains No. 1, and coal laminae in Marina and Crusader Lakefield No. 1. Traces of coal occur in the Battle Camp Formation within 70 m of the lower sandy part of the formation in Breeza Plains and Lakefield No. 1.
QUALITY	Ash yield ranges from 8-26%. Traces of pyritic coal with subconchoidal fracture are reported from the Dalrymple Sandstone and Battle Camp Formation in Breeza Plains No. 1.
EXPLORATION	The coal deposits of the Laura Basin have been prospected by Utah Development Company (AESIS, 1979, 426, 433).

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BASIN/FIELD	Maryborough Basin, Queensland
AREA	24 300 km^2 (onshore)
MINING	Two-mines, Burgowan No. 12 and 13 were operating in 1975. Production in the past has been limited to the Burrum Syncline.
SEDIMENT THICKNESS & AGE	A minimum thickness of 7100 m of Jurassic and Early Cretaceous sediments. Stratigraphic sequence -
Tertiary	Elliot Formation
	______________ unconformity ______________
Early Cretaceous	Burrum Coal Measures, 1650 m, freshwater.
	Maryborough Formation - marine.
Jurassic-Cretaceous	Grahams Creek Formation.
COAL MEASURE UNITS	Coal occurs in the Burrum Coal Measures, Maryborough Formation and Tiaro Coal Measures.
LITHOLOGY	The Burrum Coal Measures comprise fine and medium grained quartzose and liabile arenites siltstone, shale, mudstone and coal together with minor coarse grained labile arenite, fine grained glauconitic arenite, and intraformational conglomerate. Plant fossils and burrows are common.
OUTCROP	The coal measures are restricted to the flat coastal area but exposure is poor because of superficial sediment cover.
COAL DISTRIBUTION	The coal measures are preserved in north-northwesterly trending asymmetrical en echelon synclines.
STRUCTURE	The Maryborough Basin developed as a structural entity in the Jurassic and was subjected to post Aptian asymmetrical folding.
ENVIRONMENT	The basin contains marine and freshwater sediments. The greater part of the Burrum Coal Measures are continental in origin but organic burrows and glauconitie in the beds suggest that paralic and marine conditions may have prevailed for short periods.
COAL SEAMS	Burrum Syncline The best coals occur over 500 m near the middle of the Burrum Coal Measures. The seams are thin and lenticular. Those most extensively exploited are in a 160 m interval. Thirteen

seams are identified, six of which have been mined. The seams vary in thickness and quality and are workable only over limited areas. Seams of workable quality nowhere exceed 2 m and mostly about 1 m.

Central and Northern Maryborough Basin

The extent of coal seams is known from exploratory drilling. Three seams of mineable thickness occur in a 50 m sequence on the western flank of the Goodwood Anticline but are variable in quality and are lenticular. The lowest seam is the most promising economically. It has a maximum thickness of 3.5 m with 0.5 m mudstone, but only exceeds 1 m thick over a very small area. The middle seam is banded and up to 1.85 m thick. The upper seam has a maximum thickness of 0.9 m. Only one significant seam occurs in the Pig Creek Syncline; it tends to split but in one area consists of 1 m of very clean core.

QUALITY

Burrum Coal Measures. The seams comprise bright, medium to high volatile, bituminous coals with high calorific value that is used for steam raising. It forms soft coke and could be blended, except coal from the north which has a high phosphorus content.

Burrum Syncline. Mainly bright coal with a few dull bands, medium volatile a bituminous rank (ASTM). It is used for steam raising and gas making to a lesser extent.

The coal has a high calorific value, low ash fusion temperature, with a tendancy to clinker. Although phosphorus content is high it can be used in boilers without the formation of excessive phosphatic deposits. The coal shows high swelling indices at high heating rates, but not high fluidity and produces coke with poor shatter resistence. Vitrinite content is high at 79%.

Goodwood Anticline

The raw coal has a variable ash yield but can be upgraded to about 8% ash with 75% recovery. Medium volatile bituminous (ASTM); Phosphorus content is high.

Pig Creek Syncline

Very low ash yield and no benefication required but seam deteriorates laterally; Phosphorus content is satisfactory.

RESERVES

The total measured reserves of the Burrum Syncline are estimated to be six million tonnes of in situ coal suitable for underground mining.

The central and northern Maryborough Basin have very small indicated and inferred reserves.

PROBLEMS

The thin lenticular coal seams render mining expensive, and with cheaper alternative power increasingly available in the district, production is declining.

The lenticularity of the coals and variable interseam sediments make correlations difficult.

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BASIN/FIELD — Mulgildie Basin, Queensland

AREA — About 20 km long and 5 km wide.

MINING — Coal has been worked in the past at the Burnett Colliery, near Selene.

SEDIMENT THICKNESS & AGE — The generalised Jurassic stratigraphy of the Mulgildie Basin is -

Mulgildie Coal Measures - greater than 150 m thick.

Jurassic	Hutton Sandstone	150-275 m
	Evergreen Shale	75-260 m
	Precipice Sandstone	60-150 m
	disconformity	
Triassic	Coal Measures (?equivalent to the Callide Coal Measures).	

COAL MEASURE UNITS — Jurassic Mulgildie Coal Measures.

LITHOLOGY — The Mulgildie Coal Measures comprise light grey shales, soft calcareous sandstone, ironstone and coal seams. They are lithologically identical to the Walloon Coal Measures.

OUTCROP — Outcrop of the Mulgildie Coal Measures is sparse.

COAL DISTRIBUTION — The main coal bearing area occurs east and southeast of Mulgildie. The Mulgildie Coal Measures were probably at one time continuous with the Walloon Coal Measures of the Surat Basin.

STRUCTURE — The Mulgildie Basin is a narrow outlier of the Eromanga Basin with the Auburn Granite Complex to the west and Yarrol Basin to the east. The Mulgildie Coal Measures occupy a shallow meridionally trending fault controlled basin bounded by the Mulgildie Thrust Fault to the east and a normal fault to the west.

Northeast trending faults with southeast down throw occur between Mulgildie and Selene.

INTRUSIONS — Parts of the southern margin of the basin are covered by Tertiary basalt flows.

COAL SEAMS — The coal seams are markedly banded, display splitting and grade laterally with carbonaceous shale. Five main seams are present in the Mulgildie Coal Measures, A to E; only the B seam has any economic potential; it has a maximum thickness of 10.25 m and comprises up to four bands in shale. The third coal band from the top of the B seam was extracted in the Selene Mine. This band varies from 1.8 - 2.7 m thick north and northeast of the mine and locally coalesces with the lowest coal band.

QUALITY

The coal is non-coking, sub-bituminous in rank and classified as 70 - (6) (SAA - K184). It is suitable for steam raising and petrochemical feedstock; it yields 110 litres of oil per tonne plus 120 litres of mixed liquids (water, ammonia, alcohols).

	raw coal	washed coal
Gross Calorific Value (MJ/kg)	19.84-23.60	27.46
Volatile Matter(%)	32.40-37.90	43.40

RESERVES

In situ measured B seam coal reserves are 12.7 million tonnes over 1510 hectares northeast and north of the Selene Mine where the mineable thickness exceeds 1.5 m at depths of 12-40 m.

QDM (1981) figures for measured and indicated in situ reserves are 15 mega-tonnes.

PROBLEMS

Drilling and testing have indicated that coal reserves are insufficient for current economic development.

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BASIN/FIELD	Perth Basin, Western Australia
COAL MEASURE UNITS	Early Jurassic Cattamarra Coal Measures and Late Jurassic to Early Cretaceous Yarragadee Formation.
COAL DISTRIBUTION	The Cattamarra Coal Measures occur in the Dandaragan Trough and an equivalent sequence is known in the Bunbury Trough. Minor coal seams occur in the upper part of the Yarragadee Formation in the Dandaragan Trough, and coals of uncertain age occur in the Nannup Region and at Fly Brook.
COAL SEAMS	Dandaragan Trough - Cattamarra Coal Measures -

1. 22 coal seams in Eneabba No. 1 in the interval 1843 - 1963 m, giving an aggregate thickness of 12 m.

2. Drilling in the Hill River area identified Coal Measures but seams are shaly and structurally complicated.

3. 8 km southeast of Eneabba the Cattamarra Coal Measures occur beneath 15-27 m of Quaternary sands which dip at about 10^{o} to the east. There are two seams with probably one splitting to give a third seam. A total of 6-9 m coal is present which is sub-bituminous, non-coking, with high ash, moisture and sulphur. It is possibly suitable for on-site power generation.

Yarragadee Formation - Seams are less than 1 m thick, lignitic, and non-commerical.

Bunbury Trough

1. The equivalent of the Cattamarra Coal Measures occurs in Blackwood No. 1, Whitcher Range No. 1 with lignitious coals.

2. Soft coal and carbonised wood in the upper part of the Yarragadee Formation in these wells.

Minor lenses of coal in the Yarragadee Formation (1) and thin coal seams in the Cattamarra Coal Measures (3), (4), (6) have been reported from exploratory water bore drilling.

QUALITY

In the Eneabba area the Cattamarra Coal Measures are similar to Collie Coal, with weak coking properties in the well section, and non-coking near the surface. In general the coals are poor quality, contain high moisture and ash yield. If commercial they would be suitable only for power generation.

RESERVES

In situ reserves of the Cattamarra Coal Measures in the Eneabba area are estimated at 38 million tonnes with a maximum of 91 m of overburden, or 28 million tonnes with a maximum of 61 m of overburden.

PROBLEMS

A great deal more prospecting is required before the potential of the Jurassic-Cretaceous coal measures can be assessed, and to prove additional reserves.

EXPLORATION

A large part of the Perth Basin has been explored by petroleum exploration wells, and a Western Australian Government exploratory water bore drilling programme from 1962-1969. (1)(2)(3)(4) (6)(7).

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BASIN/FIELD	Polda Basin, South Australia
STRUCTURE	Lock Coal Deposit
	Jurassic Coals of the Lock Coal Deposit in the Polda Basin, have accumulated in a long and relatively narrow east-west trending depression. The coal occurs predominantly in a single, flat to gently dipping zone.
COAL SEAMS	The numerous coal seams vary rapidly in thickness and quality both vertically and horizontally such that thick and persistent individual seams are not common. The seams range in thickness from 0.5 to 2 m with the thickest individual seam being 6 m. Cumulative coal thickness reaches a maximum of 17 m. Separating the coal seams are numerous partings often less than 0.5 m thick that grade from weakly carbonaceous to very high ash coal. The overburden varies in depth from 30 to 230 m but is commonly between 50 to 130 m.
QUALITY	The coal which is of low rank, averages 31% ash, 0.6% sulphur and 0.7% sodium on a dry basis, and *in situ* averages 31% moisture and has a specific energy of 14.6 MJ/kg.
RESERVES	Total *in situ* resources are estimated at 320 mega-tonnes with 260 mega-tonnes at measured status.

BASIN/FIELD Styx Basin, Queensland

AREA Approximately 320 km^2 (40 x 8 km).

MINING Previously extracted from small mines in the Ogmore Area. Total production 1.76 million tonnes.

SEDIMENT THICKNESS & AGE Stratigraphic sequence -

Quaternary - 45 - 120 m

Early Cretaceous - Styx Coal Measures - 390 m proved, total 900 m?

__________ unconformity __________

Early Late Permian (undifferentiated - Back Creek Group - 60+m?, variable.

Late Permian - Boomer Formation - 390 m measured, 900 m maximum.

Early Permian - Carmila Beds - 3048 m.

Devonian-Carboniferous - Connors Volcanics ?

COAL MEASURE UNITS Early Cretaceous Styx Coal Measures.

LITHOLOGY The Styx Coal Measures Comprise quartzose, calcareous, green, lithic and pebbly sandstone, conglomerate, siltstone, carbonaceous shale and coal.

OUTCROP Poorly exposed south of St. Lawrence, and coal occurs in Deep and Waverley Creeks.

STRUCTURE The Styx Basin is a gently north plunging elongate basin within the Strathmuir Synclinorium, which trends north to northwest. The structure is more complex in the north at St. Lawrence where Permian sediments occur in a broad east trending syncline, which together with the Strathmuir Syncline plunges under the coal measures to the south. Tight folds occur on the western flank of the synclinorium.

An unconformity is present between the Back Creek Group and Styx Coal Measures in the southwest. High angle reverse faulting has been postulated on the eastern side of the Styx Basin where the coal measures abut the uplifted Back Creek Group. Minor faulting of the Styx Coal Measures is indicated in two areas.

COAL SEAMS Three Commercial Seams 0.61 - 1.22 m thick occur at Ogmore, and numerous thin seams are known further north. Nine seams occur at Tooloombah Creek with four potentially economic seams 1.22 - 2.74 m thick. The upper seam at Waverley Creek is 0.38 m thick and the lower seam 2.14 m thick; the seams are interbanded and dirty.

QUALITY

The coals are intermediate to low rank, high volatile (A-B), bituminous (ASTM) and 63 - (3) (SAA - K184). Coals in the Ogmore/Tooloombah Creek areas are non-coking to weakly coking.

The Tooloombah Creek coals show alternating thin bands of durain and vitrain with a high spore content.

RESERVES

Measured reserves for the main seam at the Styx State No. 3 colliery are 0.51 million tonnes *in situ*.

QDM (1981) figures for measured and indicated reserves *in situ* are 4 mega-tonnes.

EXPLORATION

Exploratory drilling has indicated considerable lateral variation in seams, and no economic potential.

PROBLEMS

The coal measures contain many seams of variable thickness and lateral extent, and correlation is unreliable.

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BASIN/FIELD	Surat Basin, Queensland.
AREA	130 000 km^2
MINING	Coal has been mined in the past at Warra and Injune. Prospective mining areas are located at Taroom and Brigalow.
SEDIMENT THICKNESS & AGE	2 500 m of Jurassic and Cretaceous sediments. Generalised stratigraphic sequence.

Early Cretaceous		(Griman Creek Formation - minor thin seams (Surat Siltstone (Wallumbilla Formation (Bungil Formation - minor thin seams (Mooga Sandstone
Middle and Late Jurassic		(Orollo Formation - Minor seams (Gubberamunda Sandstone
	(Injune Creek Group	(Westbourne Formation - seams in lower part (Springbok Sandstone - minor seams (Walloon Coal Measures (Eurombah Formation
Early Jurassic		(Hutton Sandstone (Evergreen Formation (Precipice Sandstone

The Walloon Coal Measures grade laterally westward into the Birkhead Formation; and they are correlated with the Gowen Beds (Oxley-Coonamble Basin), and the Purlawaugh Beds and Pilliga Sandstone (East Coonamble Basin). The thickest sequence in the Walloon Coal Measures is about 600 m in the Taroom Trough; they are 518 m thick in the Wandoan area and 244 m in the Injune area.

COAL MEASURE UNITS	The principal coal bearing sequence is the Walloon Coal Measures. Minor coal occurs in the Evergreen, Westbourne, Orallo, Bungil and Griman Creek Formations and the Hutton and Springbok Sandstones.
LITHOLOGY	The Walloon Coal Measures comprise sandstone, siltstone, mudstone and coal, with minor impure limestone and ironstone. The sandstone is fine to medium grained, labile, argillaceous and sporadically calcareous.
OUTCROP	The Walloon Coal Measures crop out in a belt up to 70 km wide along the eastern and northern margins of the basin. The formation grades into the Birkhead Formation on the western margin of the basin by reduction in thickness and in the proportion of coal. To the east they are continuous with the Walloon Coal Measures of the Clarence-Moreton Basin.

COAL DISTRIBUTION

The thickest coal seams can generally be expected where the coal measures are thickest and the isopach maps of coal measures should be a guide in prospecting for coal deposits. (2)

Westward thinning of the Walloon Coal Measures occurs by shelving onto the Nebine Ridge; they are eroded beneath the Springbok Sandstone in the south and the southwest on the margins of the Walgett Shelf.

No Injune Creek Group or equivalent is present north of the Barcaldine Ridge but it extends in this direction in the subsurface (Vine, 1966).

In the Mimosa Syncline, between Wandoan and Injune, coal seams are developed in two distinct units which are separated by an arenaceous interval.

The lower coal unit is about 122 m thick in the Wandoan-Taroom Area but thins westward. The main seam at Taroom and the seam worked at the Maranoa Colliery occur in this unit.

The upper coal is 220 m thick in the Wandoan-Taroom area and significantly more arenaceous on the western flank of the syncline. This unit contains the Brigalow coal deposit and the seams worked at Warra.

STRUCTURE

The Walloon Coal Measures dip gently to the southwest, south and southeast in outcrop into the basin. Small scale normal faults and minor undulations occur at the Maranoa Colliery and at Injune.

ENVIRONMENT

The Walloon Coal Measures were formed in a paludal and flood plain environment with little surface relief. The Birkhead Formation is probably lacustrine.

Coals in the upper unit are fluvial with swamps developed in the interdistributing depressions. Isolated swamps formed during regression of the fluvial system and a series of isolated swamps developed with the formation of thick peat.

The lower unit was formed in a fluvial environment and overbank deposits are especially abundant.

The environment of deposition of the Austinvale deposit is interpreted as lower fluvial. The coal sequence is preceded by migrating point bar sequences whose associated channels were stabilised during coal seam deposition, allowing thick peat accumulation in four episodes, with minor interruption by overbank type deposits. Coal deposition was interrupted by migrating point bar-channel facies of the Springbok Sandstone. (10)

COAL DEPOSITS

Austinvale - Shallow, thick, lenticular coal deposit. Two principal seams with a third seam. All the seams thin and split outward from their individual centres of deposition. (10)

Taroom - the deposit has a lenticular form and comprises a single seam with an average thickness of 5.2 m. Over 150 mega-tonnes within a 30 km^2 area of near surface subcrop. (9)

Brigalow - the main seam is lenticular and dips gently southwest. The seam averages 10.7 m thick, has a maximum thickness of 15.9 m, and a net maximum thickness of 12.5 m coal is present.

Maranoa - the seam previously worked has a maximum thickness of 1.4 m and is divided by 0.3 m of shale; it occurs 23-35 m below the surface in the mine area.

Warra - a top seam at 45 m is 1.2 m thick and a seam at 61 m is 0.6 m thick; the deposit is not worked.

The thickest coal intersection in the Walloon Coal Measures so far is 11.3 m at 271.5 m in GSQ Roma No. 4.

QUALITY

Coal from the Walloon Coal Measures is high volatile bituminous in rank (ASTM Classification). It has a high yield of gas and tar and may be suitable for petrochemical industries.

Sapropelic cannel coal with a high volatile content occurs at Taroom. It is suitable for steam raising and for conversion to synthetic liquid and gaseous fuels.

Coal from Brigalow is mostly clarain with minor free vitrain (3), whereas Millmerran coal has high exinite, together with vitrinite. (4)

Oil shale and kerosene shale have been reported from the Walloon Coal Measures in the Injune Area and from the Orallo Formation in the Orallo area. (1)

RESERVES

Measured and indicated reserves in situ in the Dalby, Millmerran, Acland and Rosewood areas are 1235 million tonnes (QDM, 1981).

In situ reserves of over 1700 mega-tonnes have been identified in the northeast Surat Basin. (8)

Taroom - measured reserves to a depth of 55 m are 50 million tonnes.

Brigalow - probable and indicated reserves are about 130 million tonnes in the main seam, which is partly amenable to open cut extraction. Additional reserves are available from a seam of 18.3 m below the top of the main seam.

The total coal reserves of the Walloon Coal Measures was estimated to be about 2000 million tonnes in mid 1979. (2)

EXPLORATION

Extensive stratigraphic drilling has been undertaken by the Geological Survey of Queensland (Allen, 1971; Gray, 1972; Swarbrick, 1973) and by private companies (McDonald & Svenson, 1975).

The new discoveries indicate that companies have probably closely prospected outcrops.

PROBLEMS

The main problems are similar to those encountered in the Clarence-Moreton Basin. A sedimentological study of the Walloon Coal Measures could be extended to the Surat Basin with emphasis mainly on the study of deep petroleum exploration well sections in addition to outcrop studies.

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BASIN/FIELD	Tiaro District, Queensland (Western margin of Maryborough Basin)
MINING	Only graphite bands up to 1.2 m thick have been worked at Mount Bauple, South of Tiaro.
SEDIMENT THICKNESS & AGE	The continental sediments of the Tiaro Coal Measures are of Jurassic age, 1200-1500 m thick, and possibly equivalent to the Walloon Coal Measures. The conformable sequence is - Grahams Creek Formation (top) Tiaro Coal Measures Myrtle Creek Sandstone
COAL MEASURE UNITS	Jurassic Tiaro Coal Measures
LITHOLOGY	The Tiaro Coal Measures comprise mudstone, siltstone, quartzose sandstone, coal seams and volcanics, minor limestone. The mudstone and shale contain coal lenses.
OUTCROP	Outcrops occur on the western margin of the Maryborough Basin in a belt 1-13 km wide.
STRUCTURE	The Maryborough Basin has a structural origin and was formed by Jurassic normal faults trending northwest and downthrown to the east. The coal measures strike north northwest and dip to the east and in places are vertical; dips are 10-15^{o} in the south but steeper in the north. The extensive faulting and variable dips are caused by past Aptian movements. The Tiaro Coal Measures are downfaulted against the Musket Flat Granodiorite in the northwest and faulted against indifferentiated Mesozoic sediments in the east. Complex fault/fold structures occur in the Gundiah Embayment southwest of Tiaro. The most important fault the Benargie Fault has downthrown the coal measures into the Myrtle Creek Sandstone.
INTRUSIONS	Interbedded pyroclastics, and intermediate flows occur at the top of the formation. Extensively intruded by Jurassic-Cretaceous hornblende andesites in the Tiaro - Mt Bauple area and in turn by the Mt Bauple Syenite.
COAL SEAMS	Thin lenticular coal seams occur throughout the Tiaro Coal Measures but none are economic.
QUALITY	The coal is classified as medium volatile bituminous. The low volatile content and higher rank are caused by Jurassic-Cretaceous igneous activity, and at Mount Bauple alteration has progressed sufficiently to produce anthracite and graphite bands.

EXPLORATION — AESIS LIST No. 5 (331,347,443).

PROBLEMS — The extensive faulting and igneous activity have a considerable effect on the economic significance of Tiaro Coal Measures.

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BASIN/FIELD	Western Gippsland Basin, Victoria. Wonthaggi, Korumburra, Jumbunna-Outtrim, Kilcunda-Woolamai.
MINING	Coal has been mined in the past at Wonthaggi, Korumburra, Jumbunna, Outtrim, Kilcunda, Woolamai and Coalville. There was minor production from Berrys Creek, Boolarra and Cape Paterson.
SEDIMENT THICKNESS & AGE	Early Cretaceous Strzelecki Group.
LITHOLOGY	Principal rock types in the Strzelecki Group are feldspathic sandstone (arkose), and interbedded mudstone, with greywacke, grit, conglomerate, carbonaceous layers and minor coal. (2)
OUTCROP	Seams crop out on cliffs and along wave cut platforms between San Remo and Cape Paterson.
COAL DISTRIBUTION	Black coal is present in most Strzelecki Group outcrop areas. All the seams of any size are near the base of the section.
STRUCTURE	In the western onshore part of the Gippsland Basin most major structural features trend northeasterly, paralleling trends in the eastern part of the Otway Basin. Outcrop is delimited by major faults, many with prominent scarps, and consists essentially of two major horsts or uplifted blocks in the Strzelecki Ranges, separated by the Tarwin Sunkland. Folding is apparently of little importance to the basic structure. (2) There were two periods of Tertiary faulting. Tension faults with little vertical movement are represented by a swarm of northwesterly trending basaltic dykes. Later normal faults have throws of up to 230 m. Major faults with throws greater than 30 m with north-south and east-west strikes cut the coal basins into rectangular blocks. In the Wonthaggi area a ridge of Silurian rocks separates the Dudley and Kirrak Basins. The coal measures dip to the south and strike faults dip 65^{o} north, normal to the coal seams. The faults are in antithetic relationship to the Kongwak Fault. The thickness of interseam sediments increases to the north towards the northern boundary of the coalfield at the Kongwak Fault indicating movements during sedimentation.

Coal measures in the Korumburra and Jumbunna-Outtrim coal fields dip to the northwest, and to the north-northwest in the Kilcunda-Wollamai areas.

ENVIRONMENT

With the exception of Jumbunna and Outtrim the coal measures were probably deposited in separate basins.

A drift origin has been postualted for the coal because of the absence of seat earths, presence of strong cross-bedding, and abundant scattered fossil plant debris including roots and branches in the coal measures. However seams in some areas (Korumburra, Rintouls Creek and Midland Highway east of Boolarra) have underclay and show evidence of deposition <u>in situ</u>. (2)

INTRUSIONS

Swarms of basaltic dykes, and Early Tertiary 'Older' basalt flows.

COAL SEAMS

Wonthaggi Coalfield.

The Dudley Basin contains eight seams in a sequence of 300 m. The lower seam splits into a Top Seam (1.5-2.6 m, maximum 3 m thick) and the Bottom Seam (0.62-1.7 m thick) and both were extensively worked.

The Kirrak Basin has two persistent seams separated by 150 m of arkose. The lower seam is equivalent to the Top Seam of the Dudley Basin.

The Korumburra Coalfield has five recognisable seams and the Top No. 1 and Main (No. 2) Seam were extensively worked.

The Jumbunna-Outtrim coalfield contains two seams, the Main Seam (1-1.5 m) that thins rapidly towards the margins of the basin, and a thick (0.5 m) Upper Seam present at the eastern margin of the field. The field is an extension of the Korumburra area.

The Kilcunda-Woolamai Coalfield is the westernmost exploited black coal in the State. The Kilcunda and the Woolamai areas each have thin single seams.

Thin seams have been worked at Coalville, Boolarra, and Mirboo North, and several other minor occurrences are known. (1)

QUALITY	The coal is banded, bituminous, with medium moisture and volatile hydrocarbon content, and medium to high ash yield. It is inferior to New South Wales coals. It is good quality steam raising coal, but is unsuitable for gas making and mostly non-coking.
RESERVES	Remaining reserves in the Wonthaggi area are estimated at 6.8 million tonnes (gross). (1) Gross amount of coal in other areas indicated by drilling is about 2.7 million tonnes. (1) There are a number of areas of potentially extractable coal including pillars from old mines.
EXPLORATION	About 1600 holes were drilled in the Wonthaggi area.
PROBLEMS	The main problems are thin seams, the frequency of faulting, washouts, and the difficulties encountered in the mechanisation of the mines. The mines became uneconomic once the thicker seams were worked out.

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TERTIARY COAL MEASURES

Introduction

Victoria has very large reserves of brown coal variously estimated between 11 000 and 100 000 Mt (million tonnes). Although they have a low specific energy and high water content they are competitive because they can be extracted by large scale, low cost mining, transport costs are negligible, and there is no competition from higher grade fuels.

Climatic conditions and the structural setting favoured the accumulation of widespread lignites across southern Australia, mainly in the Eocene.

There are differences in age but most accumulated in a short time span of about 30 m.y. (million years). Latrobe Valley deposits have a maximum thickness of 400 m which represents an enormous thickness of peat. The accumulation and preservation of these deposits required slow steady subsidence in an anaerobic environment and a stable tectonic history to limit both depth of burial and later exposure and destruction. These conditions prevailed in a few areas of the continent.

The warm climate postulated for the Tertiary appears to conflict with the higher latitudes than at present indicated by palaeomagnetic data. The explanation may be warmer global climates than at present, higher rates of photosynthesis caused by higher atmospheric CO_2 content, and a relation with the crustal break of Australia from Antarctica.

Interest in brown coal is concentrated in areas where more attractive fossil fuels are absent. Bass Strait gas has superseded brown coal gasification but otherwise the Latrobe Valley still remains the primary energy source.

A large amount of exploratory drilling of brown coal took place in South Australia in the first two decades of the century but none have so far been exploited successfully.

The brown coals have a significant place in a perspective of total Australian resources of fossil fuels. Up until recent years the known deposits, apart from those in Victoria, were too small, deep or high in sulphur or salt to be exploited.By-products such as the use of overburden for cement manufacture, and extraction of montan wax were suggested as a means of offsetting costs. Large deposits have recently been delineated of Wakefield, Mannum and Kingston in South Australia and Esperence in Western Australia.

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BASIN/FIELD	Anglesea Coal Field, Victoria
AREA	15 km^2
MINING	Coal field is operated by Alcoa Australia Ltd., for the production of aluminium at Point Henry.

SEDIMENT THICKNESS & AGE

Oligocene to Lower Miocene	Torquay Group	- marine
Eocene	Demons Bluff Formation	
Eocene to Palaeocene	Eastern View Formation	- maximum thickness of 470 m; contains brown coal
	unconformity	
Mesozoic (Early Cretaceous)	Otway Group	

COAL MEASURE UNITS	Early Tertiary, Eocene to Palaeocene Eastern View Formation.
LITHOLOGY	The Eastern View Formation comprises mainly quartz sand and gravel, silt, clay and brown coal.
COAL DISTRIBUTION	The deposit of Early Tertiary coal occurs as several seams at relatively shallow depths over an area of about 15 km^2.
STRUCTURE	The centre of the field is a broad syncline pitching at a low angle to the south or southeast. On the western flank the seams dip east at 2-5^{o}, are flat on the eastern flank, and further east the seams thin out and the structure is obscure.

The basin is bounded by the Cretaceous Otway Group in the Otway Ranges to the west.

COAL SEAMS

Coal seams occur in a sequence 140 m thick and are divided into an Upper and Lower Group.

Upper Group - the Upper Group of seams occur in a sequence 65-80 m thick.

1. The main upper seam is 24-36 m thick and can be traced for 2-5 km; overburden thickness varies from 12-30 m.

2. A thin discontinuous seam occurs a few metres below the main upper seam.

Lower Group - the Lower Group of seams occur in a sequence 60-75 m thick; the top of the group lies 20-45 m below the upper group.

It comprises 3-6 seams that lens out over short distances, and the maximum aggregate coal thickness is in places greater than 30 m. The seams are well developed on the western margin of the field where they occur at a depth of about 10 m, and here occur beneath an erosion surface on which Pliocene to Quaternary sediments rest.

QUALITY

The seams contain the highest rank brown coals being mined in Victoria and petrologically is approaching a hard brown coal.

The brown coal has a natural bed moisture content averaging 44%. It is harder and drier than Latrobe Valley coals and is classified as a soft brown coal.

RESERVES

Reserves of mineable economic coal are 160 million tonnes of which 70 million tonnes occur in the main upper seam, and 90 million tonnes occur in the lower group.

The coal can be won by open cut as it occurs at depths of less than 150 m.

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BASIN/FIELD	Bremer Basin, Western Australia
SEDIMENT THICKNESS & AGE	Plantagenet Group (Pallinup Siltstone ((Werillup Formation - contains lignite (Nanarlup Limestone Member The Plantagenet Group is correlated with the Eundynie Group and part of the Eucla Group. In South Australia the closest correlative of the Werillup Formation is the Tortachilla Limestone. Eocene clays and lignites occur in the Pidinga Formation, Knight Group, and in later equivalents of the North Maslin Sand. (1)
COAL MEASURE UNITS	Coal occurs in the Werillup Formation. The formation is Late Eocene in age; microplankton, spores and pollen have been recovered from the lignites, and forams and bryozoan in the siltstone. (1)
LITHOLOGY	The Werillup Formation comprises grey and black clay, siltstone, dark sandstone, and carbonaceous siltstone with some lignite. (1)
OUTCROP	Lignite crops out in the Fitzgerald River area, Nornalup Inlet, Denmark and Esperance. It also occurs in bore holes near Neridup northeast of Esperance. (4)
COAL DISTRIBUTION	Apart from the outcrops and borehole occurrences there may be thicker and more continuous sequences on the continental shelf. (4)
STRUCTURE	The Werillup Formation fills depressions in the irregular basement floor. (4)
ENVIRONMENT	The Werillup Formation contains both marine and non-marine strata. It was deposited in isolated hollows in the Precambrian surface. The peat swamps were subsequently flooded by the sea and in some cases an area became land locked and swamp conditions developed after an initial marine phase. The transgressive sea laid down silt, sand and clay. (1)
COAL SEAMS	Lignite occurs near the top of the Werillup Formation and is up to 3 m thick. (4)
QUALITY	The lignite has high moisture content and ash yield, and low volatile matter and fixed carbon, compared to commercial lignites. It contains about 2.3% montan wax. (4)
RESERVES	Estimated inferred reserves at the Fitzgerald River are 1.1 million tonnes with a lignite overburden ratio of 1:4. (4)

EXPLORATION

Western Collieries Ltd, a subsidiary of CSR carried out 2776 m of drilling near Esperance in the December quarter of 1980. A significant deposit of brown coal was reported (Fin. Rev., 20 Jan., 1981).

From the most recent drilling up to 1975 the only lignite reported was a 3 m bed in only two out of 15 holes. (4)

PROBLEMS

The lignite has a limited and irregular distribution owing to lateral facies changes to carbonaceous clay, and sand with carbonaceous fragments, lensing out of the formation against basement highs and loss by erosion. (4)

There is no likelihood of larger workable deposits because of the limited distribution of the Werillup Formation. (4)

No information is available on the offshore area where a greater thickness and more continuous section may be present.

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BASIN/FIELD	Eastern Otway Basin, Victoria
MINING	Coal has been mined in the past at Altona, Bacchus Marsh (Maddingly, Star, Lucifer, Boxlea), Lal Lal, Wensleydale, Benwerrin, Deans Marsh - Bambra. (2)
COAL DISTRIBUTION	An area of about 50 000 ha between Altona and Bacchus Marsh is probably coal bearing.
STRUCTURE	Lal Lal is a geologically complex basin of limited extent. At Bacchus Marsh the coal seams thin rapidly to the north suggesting warping of the floor and subsequent erosion. They are possibly partly redistributed in the marine Newport Formation.
INTRUSIONS	The Early Tertiary Newer and Older Basalt flows cover large areas. A shaft at Bacchus Marsh passed through 79 m of basalt and reached a depth of 156 m in coal. (2)
COAL SEAMS	Coal occurs in the Early Oligocene Altona and Bacchus Marsh Seams; the overlying impure seams are Early Miocene (Longfordian). (2) Newport-Bacchus Marsh - coal seams 1-40 m thick occur in drill holes between Newport and Bacchus Marsh, west of Melbourne. Bacchus Marsh - 7 m of coal occurs at 13 m, 6 m of coal at 28 m at the Parwon Creek Viaduct; about 30 m of coal occurs at Lucifer. Lal Lal - 12 m seam occurs at 20 m; a 35 m seam at 33 m; a 45 m seam at 21 m. The coal is exceedingly variable in ash yield and composition. Wensleydale - the upper seam has a maximum thickness of 40 m with 3-15 m of overburden; the deepest workings in this seam occur at 60 m. The lower seam is 12 m thick and occurs 10 to 25 m below the upper seam. Benwerrin - a seam 2-3 m thick occurs at 33m and rests on Mesozoic rocks. Deans Marsh-Bambra - the coal is about 9 m thick and overlain by 20 m of overburden. Altona - coal occurs at Williamstown, Laverton and Newport; it is about 22 m thick where worked and the maximum recorded thickness is 43 m in a drillhole; the coal interval deteriorates into five seams with the thickest 2.4 m in an overall thickness of 34 m. (2)

QUALITY

Altona and Bacchus Marsh - bands of lignitic and earthy coals with a higher ash yield than Latrobe Valley coals but less than Gelliondale and Lal Lal. Altona coals are harder, have a subconchoidal fracture and a satin lustre, whereas those from Bacchus Marsh are earthy with woody horizons.

Coals from Lal Lal are exceedingly variable in ash yield and composition.

Benwerrin - coals have a lower moisture and higher calorific value than any other Victorian brown coal. (2)

RESERVES

Reserves at Bacchus Marsh are estimated at 100 million tonnes including 25 million tonnes beneath irrigated land.

Inferred reserves in the Altona-Bacchus Marsh area are 7500 million tonnnes. Reserves at Lal Lal are 2 million tonnes and estimated reserves at Benwerrin are 75 000 tonnes. (2)

Demonstrated measured economic resources at Bacchus Marsh are 20 mega-tonnes.

Demonstrated measured sub-economic resources at Bacchus Marsh-Altona are 80 mega-tonnes, and inferred resources 7500 megatonnes.

Demonstrated measured sub-economic resources at Anglesea are 350 mega-tonnes. (1)

PROBLEMS

The main problem is the limited amount of drill information. In particular there is insufficient drilling between Bacchus Marsh and Altona to indicate the reserves. (2)

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BASIN/FIELD	Gelliondale, Victoria
AREA	Southwestern part of the Gippsland Basin.
MINING	A small amount of coal has been extracted from open cuts near Alberton West. The coastal area has the greater potential for open cut extraction.
SEDIMENT THICKNESS & AGE	Generalised stratigraphic sequence -

Tertiary	3-5 m	Sand, clay, gravel and lignitic sand ---------erosion surface on--------- top of coal
	10-40 m	Sandy clay, lignitic clay and sand. One coal seam with bands of lignitic clay or woody material.
	5 m	Blue-grey, feldspathic, sandy clay ---------unconformity---------------
Early Cretaceous		Strzelecki Group - non-marine arkose, mudstone, carbonaceous mudstone.

The maximum thickness of Tertiary sediments from bores in the Gelliondale area is 244 m. The depth to bedrock is greater than 1000 m about 20 km to the east in Woodside oil bores.

COAL MEASURE UNITS	Early to Late Eocene lignite.
COAL DISTRIBUTION	Coal has been proved over an area 11 km long by 1.5 km wide. Coal which could be economically worked would be confined to parts of the coastal plains with an elevation of 15 m.
STRUCTURE	The coal field is bounded to the north by the Early Cretaceous of the South Gippsland Highlands and extends offshore. Structure contours on the Mesozoic surface show an elongated east-west trending trough with the coal seam isopachs following the same trend. The thinnest seams are draped over a buried Mesozoic ridge. Faulting has contributed to the origin and shape of the basin but there has probably been no faulting since the deposition of the coal seams. The thickness of both the coal and overburden increases to the south and east indicating movement on the Balook Fault in the Early Tertiary.

INTRUSIONS	Thin flows of Older Basalt occur on Early Cretaceous outcrops near Gelliondale and basalt was intersected in two bores.
COAL SEAMS	The thickness of coal varies from a few metres up to a maximum of 134 m (bore 141), and averages 40 m over a wide area. In the Welshpool area 60 m of coal occurs at a depth of 14 m, and a shaft near bore 111 intersected 41 m of coal at 5 m.
QUALITY	The coal has high moisture content (67.1%) and relatively low calorific value (25 MJ/kg, dry basis). An ash yield of 5-7% is common, and up to 13% in coal near the margins of the basin. High sulphur content in some coals is caused by pyrite nodules.
RESERVES	Measured reserves of the central area are 420 million tonnes with coal to overburden ratio of 4.7-2.9:1. Indicated *in situ* reserves in adjacent areas is 500 million tonnes. Recoverable reserves are probably much less particularly near the coast.
EXPLORATION	Part of the central area is under lease (1975) to International Oil Exploration Ltd who propose to produce electrode and industrial carbon and possibly liquid fuels.

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BASIN/FIELD	Gippsland Basin, Victoria Latrobe Valley Depression.
MINING	Coal is presently mined at Morwell, Yallourn and Yallourn North.
SEDIMENT THICKNESS & AGE	The maximum thickness of Tertiary Latrobe Valley Coal Measures is 670 m. The Tertiary sequence unconformably overlies Early Cretaceous basement. The generalised stratigraphic sequence is -
?Pliocene	Haunted Hill Gravels - 9-90 m thick
	unconformity
Eocene-Miocene	Latrobe Valley - up to 670 m thick Coal Measures
	unconformity
Early Cretaceous	Basement
	The Latrobe Valley Coal Measures comprise the Traralgan and Hazelwood Groups, and the Morwell and Yallourn Groups of the Upper Latrobe Valley Coal Measures.
COAL MEASURE UNITS	Late Eocene to Late Miocene Latrobe Valley Coal Measures. <u>Thorpdale Area</u> - brown coal up to 10 m thick occurs at the base of the Oligocene Narracan Group. The coal has been mined in the past but reserves are unknown. <u>Yallourn-Morwell Area</u> - the Hazelwood Group at the base is 150 m thick but contains no major coal seams. The Morwell Group comprises a thick persistant complex system of coals with aggregate thickness decreasing westwards. Coal of the Yallourn Group is preserved in the Yallourn Syncline but the Group has been eroded from the southwestern and southern part of the depression. <u>Loy Yang Area</u> - The Traralgan Seam at the base contains major seams that are not represented in the Yallourn-Morwell area. Both the Yallourn and Morwell Groups are represented by thick seams. <u>Gormandale Area</u> - the main development of the Traralgan Group occurs in this area with up to 240 m of coals and interbedded clays and sediments.

Coolungulun Area - coals in two seams are considered to be an easterly extension of those in the Traralgan Group.

OUTCROP

The Yallourn Seam crops out in the Latrobe Valley near Yallourn.

STRUCTURE

Uplift and folding occurred after the coal measures were deposited. The major structures are monoclines probably reflecting faulting in the basement. This was followed by considerable erosion and rejuvenation of the landscape by differential movements.

The Tertiary sediments occupy an elongated, asymmetric, east pitching syncline, the axis of which runs just south of the Latrobe River.

The southern boundary of the Latrobe Valley Depression is the edge of fault bounded, basalt covered, Mesozoic sediments.

The northern boundary is a well defined structure that probably acted as a hinge line during development of the Gippsland Basin. Basalts are missing here and the Tertiary sequence rests unconformably on Mesozoic rocks.

Several en echelon monoclines and anticlines divide the area into a number of blocks, together with other broad open folds which pitch north to northeast or southeast. Major monoclines are considered to be subdued reflections of basement faulting with folds forming in response to differential movements.

Only minor faulting occurs in the Yallourn-Morwell and Loy Yang areas. Numerous small faults are present in the Morwell open cut but none in the Yallourn Open Cut.

The Coal seams are strongly jointed; joints are up to 800 m long, opened to 0.5 mm and filled with sand and secondary marcasite. Their orientation indicates a tectonic origin.

INTRUSIONS

Brown coal in the Childrens Group is overlain by the Thorpdale volcanics in the Thorpdale area.

COAL SEAMS

Yallourn-Morwell Area - the oldest seam, the Latrobe Seam, is preserved in three areas on the upthrown side of the Yallourn Monocline. Maximum thickness of the seam north of the monocline is 105 m, and 145 m in the Latrobe Syncline at a depth of 255 m. The seam splits east of the Morwell

River into the Morwell No. 2 Seam (lower), which thins from 90 m to less than 3 m in the west and south of the Latrobe Valley Depression. The upper split, or Morwell 1B Seam which joins with the Morwell 1A seam just north of Morwell to form the Morwell 1 seam, has a maximum thickness of 165 m but is eroded and thins to the south and west. Thin seams in the Moe Basin are probably equivalent to the Morwell 2 seam.

The Yallourn Seam of the Yallourn Group is thickest along synclinal axes; it is 97 m thick in the Yallourn Syncline. A seam up to 16 m thick underlies the Yallourn Seam near the Latrobe River.

Loy Yang Area - The Traralgan Seam is 60 m thick on the Loy Yang Dome. Up to 230 m of uniform low ash coals, with interseam sediments thin or missing, are present in the Yallourn and Morwell Groups, and up to 300 m of coal units with minor clay breaks. The Morwell No. 2 seam splits to the south but the Morwell 1B, 1A and Yallourn Seams are uniform in thickness except they split where they dip to the north beneath thick overburden cover.

Gormandale Area - the Traralgan No. 1 Seam reaches a total maximum thickness of 120 m and splits into 2 or 3 seams. The Traralgan No. 2 Seam is up to 70 m thick and is probably the oldest coal in the Latrobe Valley Depression. A 35 m seam above the Traralgan Seam is included in the Traralgan Group. It is succeeded, in the centre of the Gormandale Syncline by up to 210 m of Morwell Group with coal that are related to the Morwell 1B and 2 Seams.

Coolungoolun Area - The Traralgan 2 Seam has a maximum thickness of 45 m and the Traralgan 1 Seam is also present.

QUALITY

The Victorian brown coals have a low specific energy value and high water content. They are strongly banded and the different coal types are caused by variation in depositional conditions. Five lithotypes are recognised (using ICCP classification). Conifers form the greater part of the plant material but there is little well preserved angiosperm wood.

The low net, wet calorific value reflects high moisture content and low rank of the coals. Ash yield is mostly 1-4% (dry coal basis) and some as low as 0.5 and up to 5%. Sodium content is high in some areas. Moisture reflects the degree of consolidation due to the depth of burial or folding, and generally decreases with depth, but at a non-uniform rate and is locally reversed. Moisture content is from 48-70%. The Yallourn Seam shows lateral as well as vertical variations. Calorific value (dry) is 23.5 - 28.0 MJ/Kg with the lowest values in the Yallourn Seam, especially where moisture is low.

The increase in calorific value with depth is due to deeper burial and corresponding increase in rank. A calorific value of 5.8 - 11.5 MJ/Kg, on a net wet basis, and minor variations in moisture content, have a significant effect on the heat value of the coal as mined.

RESERVES

Reserves of coal, on a mining basis are 10 000 mega-tonnes, taking into account batter slopes, coal to overburden ratios, depth of open cut, location of towns, and rivers and so on.

On a geological basis proved reserves are 64 900 mega-tonnes, and 42 900 mega-tonnes inferred. Proved coal includes 35 200 mega-tonnes with less than 30 m overburden above the uppermost seam.

Total economic reserves including marginal and smaller deposits is estimated at 11 600 megatonnes. (2)

Latrobe Valley (1)

Demonstrated measured economic resources are 35 000 mega-tonnes. This figure includes about 5000 mega-tonnes of coal under the Latrobe Valley township and Yallourn storage dam, and 610 mega-tonnes of coal won to December 1978.

Demonstrated measured subeconomic resources are 29 900 mega-tonnes, and indicated subeconomic resources 42 900 mega-tonnes.

The total brown coal resources for the central Gippsland Region are demonstrated, measured 65 350 mega-tonnes, 44 430 mega-tonnes inferred, 5 090 mega-tonnes inferred, giving a total resource of 114 870 mega-tonnes.

An indication of coal reserves in the Latrobe Valley in relation to depth of overburden is shown in the table below. (3)

Overburden Thickness (m)	Proved	Inferred	Coal(mega-tonnes) Total
0-30.5	35 202	1 186	26 388
30.5-61	17 124	3 207	20 331
61 -91.4	9 697	5 716	15 413
91.4	2 900	37 814	35 714
Total	64 923	42 923	107 846

The bulk of the proved coal is in the Yallourn-Morwell and Loy Yang coalfields (16 400, and 12 450 mega-tonnes respectively).

Readily mineable reserves are estimated to be about 11 600 mega-tonnes. Of this quantity 7,900 mega-tonnes, plus 2 900 mega-tonnes marginal to these deposits is in the two major coalfields.

EXPLORATION

A drilling programme conducted by the State Electricity Commission of Victoria commenced in 1941 and is still in progress (1975).

A CSR Mitsui Joint Venture is undertaking a feasibility study on solvent refined coals, and the extraction of liquid fuels from brown coal. A commercial plant using 6 000 tonnes of dry coal per day, reaching 20 000 tonnes per day, is envisaged. This would amount to 7 to 24 mega-tonnes of raw coal per year. (Fin. Rev. 20 Jan. 1981).

PROBLEMS

There do not appear to be any insurmountable problems associated with the extraction of coal from the Latrobe Depression. The main problems appear to be involved in extracting coal beneath towns, and diverting rivers away from open cut mines.

Utilisation of the coal is enhanced by large scale, low cost mining, negligible transportation and absence of competition from higher grade fuels.

PRINCIPAL REFERENCES

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(2) GLOE, C.S., 1975 - Latrobe Valley Coal Fields, Victoria. In TRAVES, D.M., & KING, D., (Eds.), ECONOMIC GEOLOGY OF AUSTRALIA AND PAPUA NEW GUINEA. Australasian Institute of Mining and Metallurgy, Monograph 6 Volume 2, Coal. 345-352.

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(4) THOMPSON, B.R., 1979 - The Stradbroke Coalfield and comments on the brown coal potential of Victoria. In VICTORIA - EXPLORATION POTENTIAL. Australian Mineral Foundation and Victorian Department of Minerals and Energy. Seminar Paper No. 10.

BASIN/FIELD	Offshore Bass Basin, Bass Strait
SEDIMENT THICKNESS & AGE	
Tertiary	(Demons Bluff Formation - limestone and marls, (isolated volcanics. ((Eastern View Coal Measures - the main coal measure (section is 150 m thick and Early to Middle Eocene (in age.
Early Cretaceous	Otway Group
	The basin has only limited onshore connections. The Mesozoic and Tertiary sequence along the coastline from Anglesea in the area of the Torquay Embayment generally depict that present in the offshore Bass Basin.
	The coal measure sequence is up to 150 m thick.
COAL MEASURE UNITS	The major coal measure section occurs in the equivalent of the Eastern View Coal Measures which have been mined at Anglesea.
COAL DISTRIBUTION	The coal-bearing sequence is known from sixteen deep petroleum exploration wells and indirectly from about 15 000 km of seismic profiling.
	Coal is indicated by high amplitude seismic events, and where numerous they are highly reflective and effectively mask deeper events. Coal thickness is determined from the density log, in conjunction with the sonic and gamma ray logs. The coal measures appear to be concentrated on the eastern side of the basin.
I .iS	Isolated occurrences of volcanics occur in the sequence overlying the section in which the coal measures are concentrated.
	The coal is graphitic where it is intruded by igneous bodies.
COAL SEAMS	Minor coal seams a metre or so thick have been found throughout the sequence and in the Early Cretaceous.
	Individual coal seams are up to 25 m thick and an aggregate thickness of 60 m is common. The seams decrease markedly in thickness towards the western margin of the basin and only 17 m of coal was recorded in Aroo No. 1 and 3 m in Bass No. 3.
	The coal seams are overlain by 900 to 2000 m of overburden, and 100 m of water.

QUALITY

The coal is black to brown-black, with a shiny to dull lustre, and a ragged to conchoidal fracture.

Coal rank ranges from brown to low rank bituminous and graphitic where in contact with igneous intrusions.

Amber pellets are common in places and some coal seams have resulted from reworking of older coal beds.

PROBLEMS

The correlation of the sequence and seams with the onshore sequence and between wells is deficient.

The great thickness of overburden and water depths of 100 m make the possibility of exploration very remote.

PRINCIPAL REFERENCES

(1) BROWN, B.R., 1975 - Offshore Bass Basin, Bass Strait. In TRAVES, D.M., & KING, D., (Eds.), ECONOMIC GEOLOGY OF AUSTRALIA AND PAPUA NEW GUINEA. Australasian Institute of Mining and Metallurgy, Monograph 6, Volume 2, Coal, 364-365.

(2) KANTSLER, A.J., SMITH, G.C., & COOK, A.C., 1975 - Lateral and vertical rank variation: implications for hydrocarbon exploration. APEA Journal, 18, (1), 143-156.

EXPLORATION

The coal basins have been mapped from seismic and well data. The coal has a low seismic velocity and the velocity contrast provides high amplitude, reflection events. Coal beds can be identified on formation density and sonic well logs and allow thickness interpretations.

PROBLEMS

The large overburden thicknesses as well as the offshore situation make the possibility of exploitation very remote.

No precise correlation has been established with the onshore sedimentary sequence.

PRINCIPAL REFERENCE

BROWN, B.R., 1975 - Off-shore Gippsland Basin, Bass Strait. In TRAVES, D.M., & KING, D., (Eds.), ECONOMIC GEOLOGY OF AUSTRALIA AND PAPUA NEW GUINEA. Australasian Institute of Mining and Metallurgy, Monograph 6, Volume 2 Coal, 360-363.

BASIN/FIELD — Stradbroke Coalfield, Latrobe Valley

MINING

As well as the Stradbroke coal, other potential brown coal occurrences in Gippsland are limited to the margins of the basin where the coal bearing Latrobe Valley Group can be intersected as shallow depths.

The area north of the Rosedale Fault System and across the Lakes Entrance Platform has limited potential because the Latrobe Valley Group thins out and is absent in places.

Structures associated with the Balook Block have the most potential for brown coal discoveries. Areas south-west of the Won-Wron field probably contain large reserves similar to those of the Gelliondale Field.

Stratigraphic sequence

Cainozoic (Middle Miocene-Pliocene).	Haunted Hill Gravels Boisdale Beds Jemmy's Point Formation Tambo River Formation		
	unconformity		
Early Oligocene Middle Moicene	Seaspray Group	Gippsland Limestone Formation disconformity Lakes Entrance Formation	
	unconformity		
Late Palaeocene - Late Eocene	Latrobe Group	Latrobe Valley Coal Measures	Traralgon Seam
		disconformity	
			Older Volcanics
		Yarram Formation	
	unconformity		
Late Cretaceous		Strzelecki Group	

A water bore 15 km east of the Strzelecki Ranges intersected 150 m of brown coal beneath 300 m of Early to Middle Tertiary marine sediments of the Seaspray Group.

BASIN/FIELD	Offshore Gippsland Basin, Bass Strait
COAL MEASURE UNITS	The offshore sequence of the Latrobe Group contains abundant coals. Recent work has indicated that more than one period of coal deposition took place in the Latrobe Valley. The offshore sequence and the adjacent onshore areas are related to the older sequence and is no younger than Oligocene. The coal ranges in age from Late Cretaceous to Eocene.
LITHOLOGY	The coal measure sequence comprises predominantly arenaceous sediments with interbedded siltstone, rare shale and coals.
COAL DISTRIBUTION	Coals are absent from the high energy environment of the southern platform and only thin coals are present on the northern platform. Negligible coal thickness occurs over the marine edge of the basin where the major oil fields are located. The younger coal measures were not deposited in this region and the older beds only contain thin coals. The main coal basins are developed on the landward side of the oil fields. Coals were penetrated in Barracouta No. 3, Bream No. 3, Nanngai No. 1, Turrum No. 1 and Wahoo No. 1, but are absent in Kingfish No. 1, Mackerel No. 1, Mullet No. 1, Moray No. 1, and Wahoo No. 1.
ENVIRONMENT	The Latrobe Group consists of a complex of stream, tidal swamp, and littoral facies displaying rapid horizontal variations. The coals are concentrated in the section above the postulated mid-Eocene unconformity which is associated with channelling at the shoreline. The Early Tertiary coal deposits overlap throughout the basin indicating migration of coal swamp areas.
COAL SEAMS	The aggregate coal thickness is as much as 200 m with individual coal seams up to 30 m thick. Coal was deposited throughout the sequence but was concentrated above the postulated mid-Eocene unconformity which was associated with channelling. The offshore coal basin lies in water depths of 100 m and are covered by 1000-2000 m of overburden.
QUALITY	The offshore coals are higher in rank than the onshore Latrobe Valley equivalents. The coal is brown to black, dull to shiny, often with conchoidal fracture and contain some amber pellets. The coals range from hard brown coals, approaching sub-bituminous rank, to high volatile bituminous.

The coal is probably a continuation of the Traralgan Formation in the Coolungoolun Field to the north.

OUTCROP

Surface mapping in the area is impracticable because of the lack of outcrop. Limited outcrops of the Early Tertiary coal bearing sequence and Early Tertiary basalts are present on the eastern flanks of the Strzelecki Ranges.

STRUCTURE

Coal occurs on a partly downfaulted section of the Balook Block. The sequence plunges at 5° beneath the Tertiary marine sediments; Erosion has removed coal from the upfaulted block to the west.

The field is located on intermediate structural highs associated with the Balook and Nappacan Blocks rather than restricted to grabens as commonly believed. Coal in grabens is not economically recoverable while coal located across the major structural highs occurs as eroded remnants of what was probably a much more extensive cover.

COAL SEAMS

Two main seams of coal of Eocene age are present beneath a variable thickness of overburden. Up to 136 m of coal has been intersected at depths of less than 10 m in eroded valleys.

Up to 30 m of coal is present in bores on the upthrown side of the Won-Wron Monocline but has limited extent. The Won-Wron Field is on the same structure but has little potential.

QUALITY

Moisture content averages about 58% at 50 m on which compares favourably with Yallourn and Morwell coals; ash yield is about the same and sulphur higher at 1-4%.

RESERVES

Indicated Reserves (mega-tonnes)	Overburden Thickness	Coal to overburden Ratio
680	30 m	1:1
1470	50 m	0.5:1

EXPLORATION

The Geological Survey of Victoria commenced a re-appraisal of the brown coal potential of Victoria in 1974. Gravity contours in the Stradbroke area indicated a gradual shallowing of the sequence, from an occurrence in a bore 15 m east of the Strzelecki Ranges, against the uplifted Balook Block. An updip extension of the occurrence was found by drilling in 1974, at shallow depths in the Stradbroke Parish.

PROBLEMS

The coal beds are located above the local ground water table so that mining operations could be undertaken without the problems associated with dewatering high pressure aquifers commonly encountered in the Gippsland Basin.

Using the experience gained from the discovery of the Stradbroke deposit exploration for significant additional reserves of brown coal elsewhere can be undertaken in two stages. Firstly, a study of sedimentary formations within the Tertiary basin for lithological sequences and environments suitable for coal exploration, and secondly to locate structures that could have resulted in the elevation of such sediments to an economically workable depth.

PRINCIPAL REFERENCE

THOMPSON, B.R., 1979 - The Stradbroke Coalfield and comments on the brown coal potential of Victoria. *In* Seminar: VICTORIA - EXPLORATION POTENTIAL. *Australian Mineral Foundation and Victorian Department of Minerals and Energy*. Paper No. 10.

BASIN/FIELD	South Australian Tertiary Basins
MINING	Past mining areas include several localities in the St. Vincent Basin (Noarlunga, Hope Valley, Clinton, Inkerman-Balaklava, and Whitwarta) and in the Murray Basin (Moorlands, Bower, and Anna). Potential mining areas, which are amendable to open cut extraction, include Moorlands Inkerman-Balaklava and Wakefield which are close to Adelaide.
SEDIMENT THICKNESS & AGE	Eucla Basin - the basin contains Permian, Cretaceous and Tertiary sediments and the main period of subsidence was in the Late Mesozoic. Tertiary sedimentation began in the east in the Mid-Eocene.
Mid-Miocene	Nullarbor Limestone - shallow marine transgression
	unconformity
Mid-Eocene	Pidinga Formation - paralic, maximum thickness 50 m, brown coal deposited on undulating basement surface.
	unconformity
	Basement
	Eyre Peninsula - Gawler Block - concealed Tertiary basins with Eocene fluvial, lacustrine and marginal marine sediments are preserved in depressions on the old land surface. The near basal sections contain minor coal seams. St Vincent Basin - Blanche Point Marls - contain brown coals throughout in the northern part of the basin. South Maslin Sands -
Early to Middle Eocene	North Maslin Sands - exceed 33 m in thickness and contain coal locally. Murray Basin - coal occurs in the Late Eocene Member of the Palaeocene to Oligocene Renmark Beds. The member accumulated in restricted depressions in the basement floor.
COAL MEASURE UNITS	Mid Eocene Pidinga Formation (Eucla Basin); Eocene of Eyre Peninsula - Gawler Block; Blanche Point Marls and Early and Middle Eocene North Maslin Sands (St. Vincent Basin); Late Eocene Moorlands Lignite Members of the Renmark Beds (Murray Basin).

OUTCROP

The Early Tertiary sequences with coal measures are mostly obscured by younger sediments.

Brown coal occurs on the eastern margin of the Eucla Basin at Lake Pidinga, and lignite crops out at Coffin Bay on the Eyre Peninsula.

COAL DISTRIBUTION

Coal is present in the Late Eocene portions of Tertiary basins marginal to the present continental shelf and continental forelands.

STRUCTURE

The middle and Late Eocene sedimentary basins formed by rejuvenation adjacent to the present continental margin. The margins of most basins are defined by faults but the contained Tertiary sediments are undeformed.

ENVIRONMENT

The coals were deposited in estuarine and fluviatile environments, and generally accumulated in local depressions and along gently shelving basin margins.

COAL SEAMS

St Vincent Basin - Noarlunga Basin - upper seam with 4 m of coal at a depth of 15 m in two piles each 2 m thick. The lower seam is 1.1-6 m thick towards the northwest with 110 m or over.

Hope Valley Basin - Coal occurs over a limited area in two seams about 3 m thick at an average depth of 50 m. Lignite up to 30 m thick occurs on the Para Fault Block beneath Adelaide.

Clinton - up to five seams of coal present with the main seam averaging 6.7 m thick, lying beneath overburden with an average thickness of 90 m. A seam 20 m thick was intersected in the north.

Inkerman-Balaklava - an extensive seam 6-12 m thick with 52 - 82 m of overburden with a shallower seam 2.4-4.5 m thick.

Whitwarta - the seam averages 6 m thick under 36.5 m of overburden.

Murray Basin - Moorlands Coalfield - lenticular seams up to 16 m thick and overburden to coal ratio of about 5:1.

Bower Coalfield - three seams 1-7.5 m thick (average [illegible] m) at depths of 105-133 m.

Anna Coalfield - seam up to 8 m thick (average 4.3 m), under 56-87 m of overburden.

Eucla Basin - lignite seam up to 9 m thick at shallow depths and others up to ?40 m thick at depths up to 66 m along the eastern margin of the basin.

Eyre Peninsula - Gawler Block - Malbooma - coal in seams possibly up to 20 m thick occurs in depressions at depths less than 24 m.

Coppin Bay - lignite occurs in outcrop and reported in five seams the thickest being 4.2 m.

QUALITY

The South Australian brown coals are very similar in quality from one deposit to the next; they have a high moisture and sulphur content and high ash-yield. They are commonly friable, dull and earthy, chocolate brown, with woody structures, leaf remains, resin globules and pyrite. Several deposits are saturated with salt-water.

RESERVES

Noarlunga	- 1.5 mega-tonnes
Hope Valley	- about 0.33 mega-tonnes
Clinton	(- proven 32.5 mega-tonnes
	(- indicated 40.5 mega-tonnes
Inkerman-Balaklava	- 400 mega-tonnes
Whitwarta	- indicated 20 mega-tonnes
Wakefield (ETSA)	- indicated reserves of 2 billion tonnes with an overburden ratio of 5:1
Kingston (WMC)	- reserves of 950 mega-tonnes in a seam 10 m thick beneath 40-60 m of overburden. (Fin. Rev., 30-7-81.)
Moorlands	- 32 mega-tonnes
Bower	- 10 mega-tonnes
Anna	- 64 mega-tonnes

EXPLORATION

Most deposits have been discovered during the course of drilling for underground water in areas such as the Adelaide and Murray Plains, Eyre Peninsula and the eastern margin of the Nullarbor Plain.

Exploration in the Mannum area by CSR (Fin. Rev. Jan. 20, 1981) involved 61 m of core drilling. Five holes intersected clean brown coal 4-8.09 m thick at depths of 45-55 m.

CSR report (Fin. Rev., 23 July 1981) measured and indicated coal reserves of 212 million tonnes of brown coal in the Sedan area on Mannum, 100 km east of Adelaide. The coal is described as similar to other South Australian brown coals with high moisture, volatile and sulphur content but lower salt content.

Systematic drilling of the brown coal deposits has largely been carried out by the South Australian Department of Minerals and Energy.

PROBLEMS

Boring and sampling methods have provided few reliable records of many of the deposits.

Recovery of coal in the Inkerman-Balaklava area is difficult because of thick overburden and overlying coarse sand aquifers containing water under pressure. Water charged sands also overlie the coal deposits at Hope Valley, and the coal at Wakefield contains high salt water concentrations.

PRINCIPAL REFERENCE

JOHNS, R.K., 1975 - Tertiary coal in South Australia. In TRAVES, D.M., & KING, D., (Eds.), ECONOMIC GEOLOGY OF AUSTRALIA AND PAPUA NEW GUINEA. Australasian Institute of Mining and Metallurgy, Monograph 6, Volume 2 Coal. 366-371.

BASIN/FIELD	Waterpark Creek, Queensland
AREA	Basin area is 65 km^2.
COAL MEASURE UNITS	Coal seams occur in Tertiary sediments.
LITHOLOGY	The coal seams are interbedded with soft plastic shale, brown carbonaceous shale, and soft quartzose sandstone.
OUTCROP	Coal seams crop out on the faulted western margin of the basin, on the banks of Waterpark and Valentine Creeks.
STRUCTURE	Coal occurs in a small Tertiary Basin which is elongated north-northwest. It is downfaulted against granite and quartzite to the west and wedges out to the east against a rising basement of quartzite. The coal seams dip 70^{o} east-northeast adjacent to the fault and flatten out basinwards.
COAL SEAMS	Four coal seams with an aggregate thickness of 26 m occur in the sequence. The seams are lenticular and become thinner to the east. Seams 6.4 m and 5.5 m thick are present 200 m east of the outcrop at depths of 37.3 m and 51.4 m. Thin seams in the central and eastern region cannot be readily correlated with those near the outcrops.
QUALITY	The seams comprise soft, dark brown lignite with interbedded oil shale. Open cut mining in Valentine Creek revealed uneconomic highly banded seams.
EXPLORATION	Shallow drilling has been carried out by the Queensland Mines Department and Oilmin.
PROBLEMS	The presence of thin, highly banded seams of low rank coal over a small area offers little incentive for further exploration. The indications of oil shale in the basin are probably worthy of further investigation.

PRINCIPAL REFERENCE

KOPPE, W.H., 1975 - Waterpark Creek, Queensland. In TRAVES, D.M., & KING, D., (Eds.) ECONOMIC GEOLOGY OF AUSTRALIA AND PAPUA NEW GUINEA. Australasian Institute of Mining and Metallurgy, Monograph 6, Volume 2, Coal. 344.

Bonaparte Gulf Basin	Perth Basin	Collie Basin	Carnarvon and Canning Basins	Arckaringa Basin	Pedirka Basin	Cooper Basin	Galilee Basin	Springsure Shelf	Denison Trough	Northern Bowen Basin	Blair Athol Qld	Ashford NSW	North Western Coalfield NSW	Upper Hunter (Sydney Basin)	Lower Hunter (Sydney Basin)	Southern Coalfield (Sydney Basin)	Gloucester Basin	Tasmania
			Lightjack Formation			Daralingie Beds				Gebbie Subgroup (includes Collinsville Coal Measures)								
						Epsilon Formation			Aldebaran Sandstone ?		Blair Athol Coal Measures							
Kulshill & Sugarloaf Formations	Irwin River Coal Measures and Sue Coal Measures	Collie Coal Measures	minor coals (Carnarvon Basin)		Purni Formation	Patchawarra Formation						Ashford Coal Measures	Willow Tree Coal Measures		Greta Coal Measures	Clyde Coal Measures	Gloucester Coal Measures	
			Poole Sandstone (Canning Basin)	Mount Toondina Beds			Aramac Coal Measures										Dewrang Formation	Mersey Group
			Grant Group (Canning Basin)					Reids Dome Beds	Reids Dome Beds				Temi Group					Quamby Group

Table I – Correlation of Early Permian coal measures in Australia (modified after Branigan, 1975).

Cunning Basin	Bonaparte Gulf Basin	Cooper Basin	Galilee Basin	Denison Trough Springsure Shelf	Blackwater Area Bowen Basin	Northern Bowen Basin	South-eastern Bowen Basin	Mt. Mulligan Basin	Laura Basin	Olive River Basin	North Western Coalfield NSW		Upper Hunter	Lower Hunter	Western Coalfield	Southern Coalfield	Gloucester Basin NSW	Coorabin Basin NSW	Tasmania
													Sydney Basin						
					Rangal Coal Measures														
							Barralaba Coal Measures including Kaloola Mbr.	Mount Mulligan Coal Measures					Wollombi Coal Measures	Newcastle Coal Measures		Sydney Subgroup			Cygnet Coal Measures
				Blackwater Group		Blackwater Group					Black Jack Coal Measures	Singleton Super Group			Illawarra Coal Measures		Craven Coal Measures	Coorabin Coal Measures	
		Toolachee Formation	Bandanna Formation							Equivalents of Pascoe River Beds			Wittingham Coal Measures	Tomago Coal Measures		Cumberland Subgroup			
					Fair Hill Formation														
Condren Sandstone	Coal in unnamed beds								(Coals known only as Permian)										
					German Creek Coal Measures				Little River Coal Measures and Normanby Formation										
			Colinlea Sandstone																

Table II - Correlation of Late Permian coal measures in Australia (modified after Branigan, 1975)

	Carnarvon Basin	Leigh Ck Area	Cooper Basin	Callide Basin	Bowen Basin	Esk Trough	Tarong Basin	Moreton Area	Clarence Area	Lorne Basin	Sydney Basin	Tasmania
Late Triassic	Mungaroo Formation	Leigh Ck Coal Measures		Callide Coal Measures			Tarong Beds	Bundamba Group Ipswich Coal Measures	Nymboida Coal Measures		Wianamatta Group coals	Coals in Brady Formation and equivalents
Middle Triassic	(most coal in upper 200 m)				Moolayember Formation	Esk Formation				Coals		
Early Triassic			Nappamerrie Formation									

Table III - Correlation of Triassic coal measures in Australia (modified after Branigan, 1975)

	Canning & Bonaparte Gulf Basins	Perth Basin	Leigh Ck	Eromanga and Cooper Basins	Galilee Basin	Surat Basin	Mary-borough Basin	Mulgildie Basin	Laura Basin	Olive River Basin	Ipswich Area	Clarence Area	Dubbo Area
Late Jurassic		Yarragadee Formation								Gilbert River Formation			
Middle Jurassic	Coals Widespread			Birkhead Formation	Yongala Group (600 m)	Walloon Coal Measures (Injune Creek Group) (610 m)	Tiaro Coal Measures (1 380 m)	Mulgildie Coal Measures (150 m)	Dalrymple Sandstone (700 m)	Garraway Beds	Walloon Coal Measures (210 m)	---?--- Walloon Coal Measures (600 m)	
Early Jurassic		Cattamarra Coal Measures (Cockle Shell Gully Formation) (680 m)	Leigh Ck Coal Measures			Evergreen Formation (180 m)					Marburg Formation	Marburg Formation	Ballimore Coal Measures

Table IV – Correlation of Jurassic coal measures in Australia (modified after Branigan, 1975).

	Subdivision	Laura Basin	Perth	Eromanga Basin	Maryborough Basin	Styx Basin	Otway Basin	West Gippsland Basin
Late	Maestrichtian						Sherbrook Group	
	Senonian							
Cretaceous								
	Turonian							
	Cenomanian			Winton Formation		Styx Coal Measures		
	Albian				Burrum Coal Measures		? Upper part of Otway Group	
Early	Aptian							
Cretaceous	Neocomian	Battle Camp Formation	Yarragadee Formation				Lower part of Otway Group	Strzelecki Group (Wonthaggi Coals)

TABLE V - Correlation of Cretaceous coal measures in Australia - (modified after Branigan, 1975).

Waterpark Creek	Subdivisions	Anglesea	Gippsland Basin	Bass Basin	Murray Basin	Eastern Otway	Eastern (minor occurrences)	Minor SA Basins	Bremer Basin	Waterpark Creek
	Pliocene									
	Miocene						Bournda Beds			
	Oligocene		Latrobe Valley Coal Measures	Equivalent of Eastern View Coal Measures		Coal Seams				
	Eocene	Eastern View Formation	Coals in the 'Older Basalts'		Renmark Beds		Kiandra Beds	Coal sequences	Werillup Formation	Coal Seams
	Palaeocene		Childers Formation							

Table VI - Correlation of Tertiary coal measures (modified after Branigan, 1975).