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THE COAL RESOURCES OF NEW SOUTH WALES

(Draft)

by

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INTRODUCTION

This Record is the draft copy of Section B of Chapter 5 - Australian Sources - of the Bureau of Mineral Resources Summary Report - COAL, which is to be published soon.

The information in this record is liable to slight modifications at a future date after further discussion with the Geological Survey of N.S.W. and the Joint Coal Board from whose published and unpublished reports much of the information has been obtained and whose assistance is gratefully acknowledged.

B. NEW SOUTH WALES.

New South Wales ranks as the foremost coal-producing state in the Commonwealth. From 1796 when coal was first discovered near Newcastle until the end of 1952 a total of 587,175,700 tons of coal valued at £435,454,721 was produced. Average yearly production for the five years ending 1952 was 12,758,124 tons with an average yearly value of £25,012,197.

Coal is known to occur in sediments of Carboniferous, Permian, Triassic, Jurassic, and Tertiary age. Of these only the Permian coal measures are of major economic importance: the Triassic and to a lesser extent Jurassic coal measures are of local importance in the north-east corner of the State; the Carboniferous seams are few and very localised; there is no known Tertiary deposit of economic proportions although small lignitic beds occur near Kiandra, Orange, Gulgong, and Inverell. In the deep lead at Kiandra there are two 8-foot lignite seams and a 29-foot impure lignite seam.

Peat occurs at a number of places throughout the State, including small seams in the coastal sands in the Sydney Metropolitan area, but none of these is of more than academic interest.

The economic deposits of coal in the State vary in rank from semi-anthracite to sub-bituminous. The greater number fall within the medium-volatile and high-volatile bituminous groups.

The areas of commercial coal-bearing lands in New South Wales have been divided into four geographical provinces, which have been named Main, Riverina (or Coorabin), Ashford, and Far North Coast (or Clarence). The Main Province contains coal of Carboniferous, Permian, and Mesozoic age; the Ashford and Riverina Provinces contain only Permian coal, and the Far North Coast the only Mesozoic coal measures worked in the State.

The Main Coal Province is the most important producing area; it has been divided for the sake of convenience somewhat arbitrarily into six coalfields, Northern North-Western, Central, Western, Southern, and South-Western.

The State produces a wide range of bituminous coal suitable for most purposes. Most other States depend on New South Wales for gas and coking coals. The Maitland-Cessnock-Greta District produces a high-volatile bituminous coal which meets most of the gas coal requirements of the Commonwealth. Over a third of the State's total coal production comes from this field.

The New South Wales production of the various ranks of coal for the last 3 year is given in the following table:-

TABLE 5B.1

Rank	1950		1951		1952	
	Tonnage	Value	Tonnage	Value	Tonnage	Value ✱
Semi-anthracite	-	-	234	842	420	925
Bituminous	12,785,684	22,102,758	13,508,460	29,317,114	15,008,489	41,601,577
Sub-bituminous	12,537	18,568	4,550	7,899	13,191	27,490

✱ Tentative value only.

Good quality metallurgical coking coal comes mainly from the Bulli Seam in the Illawarra District of the Southern Coal-

field and the Borehole and Young Wallsend Seams in the Newcastle District of the Northern Coalfield. Portions of the Lithgow Seam of the Western Coalfield and Australasian Seam of the Newcastle District are also suitable, and the Four-Foot, Wongawilli, and Tongarra Seams of the Southern Coalfield have given good coking results. Blends containing the Victoria Tunnel Seam of the Newcastle District or some of the other seams are used during periods of scarcity.

The best steaming coal for general power-house use comes from the Greta Seam of the Maitland-Cessnock District, from portion of the Lithgow Seam of the Western Coalfield, and from the Bulli Seam of the Burragorang area of the South-Western Coalfield.

Coal for the manufacture of cement comes from the South-Western, Western, and Northern Coalfields. The cement kilns at Berrima receive coal from mines on the Wongawilli Seam at Canyon Leigh and Berrima, and the new cement plant at Maldon draws coal from its own mechanised Loch Catherine Colliery at Berrima. The Kandos cement works draws its coal from nearby collieries working the Lithgow Seam. The Sulphide Corporation plant, at Cockle Creek on the Northern Coalfield, mines the Hartley Hill Seam from beneath the factory site.

Underground mining in New South Wales in 1950 produced 11,197,600 tons of coal and open-cut mines yielded 1,601,000 tons. Open-cut mining would probably have produced nearly 2,000,000 tons if the year had not been a particularly wet one. The main areas of open-cut mining were Muswellbrook, Ravensworth, and Liddell on the Northern Coalfield and the area from Lithgow to Ben Bullen on the Western Coalfield. Smaller open-cuts operated at Cessnock, Minmi, and Swansea on the Northern Coalfield. Open-cut mining in the Muswellbrook, Ravensworth, Liddell, Minmi, Lithgow and Ben Bullen areas is expected to decline slightly in the next few years and possibly to increase in the Cessnock, Greta, East Maitland, and Cardiff areas. The recent introduction of large drag-lines and similar equipment has brought greatly increased reserves within the scope of economic open-cut mining.

In the post-war years an acute shortage of coal developed in New South Wales; this was at its worst in 1950 when it was estimated that the production of 12,799,200 tons was approximately 3,000,000 tons short of requirements. It was estimated then that by 1954 requirements of New South Wales coal would have risen to 23,400,000 tons. A plan including labour recruitment, improvements to railway and loading facilities, expansion of mechanisation, and development of open-cut coal production from 1,601,600 tons in 1950 to 5,000,000 tons in 1954, was prepared to meet this increase. However in late 1951 and early 1952 increased production began to out-strip consumption, which had unexpectedly dropped, and in September 1952, when New South Wales coal stocks stood at about 2,000,000 tons, the New South Wales Coal Requirements Committee issued a revised estimate of future requirements which is given in the following table:-

TABLE 5B.1a

Consumer	Actual Usage 1951 thousand tons	Requirements - thousand tons			
		1953	1954	1955	1956
New South Wales	10,748	12,062	12,773	13,215	13,617
Victoria	1,517	1,846	1,853	1,675	1,315
South Australia	959	973	1,002	1,007	1,084
Other States	150	150	150	153	154
Limited Export Trade	98	130	130	130	130
Total	13,472	15,161	15,908	16,180	16,300

Producing capacity of all underground collieries in the State combined was 52,483 tons per day in June, 1950. This figure covers only the mechanical capacity of the mines which could be worked by the average labour force available. Owing to industrial disputes, coal produced was over 2,500,000 tons less than the capacity of the industry. The daily capacity rose by about 2,500 tons on the average for 1949 and for 1950. Annual capacity of the total open-cut section was 2,000,000 tons in June, 1950, and the 1950 production fell short of this by 400,000 tons. Altogether, the industry produced more than 3,000,000 tons less than it was equipped to, and had this deficiency been made good, it would have covered the estimated over-demand for coal.

During 1951 a complete change took place in the coal position and by September 1952 the combined actual production of underground and open-cut mines was 37,000 tons a week in excess of consumption. Since September 1952 this excess production has been reduced largely by curtailing open-cut production and by reducing underground labour by granting accumulated long-service leave.

The reserves of New South Wales as a whole are large, as is shown in Table 5B.2. In view of the wasteful mining practice in most of the collieries, however, these figures are appreciably exaggerated. The method of bord and pillar mining which is almost universally practised in this State is hampered by reluctance on the part of the mining unions to extract pillar coal by machinery, by the State legislation governing the size of pillars to be left at the first working and the issue of permits for mechanical pillar extraction, by ventilation difficulties which would be encountered in certain collieries if longwall mining was substituted for bord and pillar, and by the fact that longwall development of lower seams would in some mines hinder upper seam development by causing subsidence. In the last few years a concerted effort was made to prove open-cut reserves of coal which could be quickly developed, and so to raise production rapidly to meet the deficiency in coal production until the underground mining section could be more fully mechanized and re-organised to supply the increased quantity of coal. At the end of 1950 reserves of 110,000,000 tons with overburden ratios not exceeding 10:1 had been almost completely proved; of this figure about 18% occured on the Western Coalfield and 82% in the Northern Coalfield.

The ash content of some of the more important seams is quite high and the rapid expansion of mechanisation in the industry over the last few years has increased the problem by raising substantially the ash figure of the coal produced. The establishment of cleaning plants has fallen behind the mechanisation programme and only now is any serious attempt being made to overtake this lag. At the moment large cleaning plants treat all coking coal entering the B.H.P. Steelworks at Newcastle and the A.I.S. Steelworks at Port Kembla. Some hand cleaning is done also at the John Darling, Bloomfield, Richmond Main, and Abermain No.3 Collieries. The New South Wales Mining Co. has recently started to operate heavy-medium cleaning plants at Wallerawang and Liddell. But most of the steaming coal is not cleaned. It is hoped that in the next few years cleaning plants will be opened at Cardiff and Corrimal to treat the large reserves of coal in these areas.

The Fuel Technology Branch of the Joint Coal Board, which has paid considerable attention to the matter of coal quality, has come to the conclusion that despite the introduction of coal-cleaning plants it will not be possible to produce coal of pre-1939 quality in the quantity necessary to meet the States' increased demand. The only answer to this is to modify old and new equipment consuming the coal to burn the lower-grade product more efficiently.

The relative importance of the coal production of each

TABLE 5B.2. ⁄

The Coal Reserves of New South Wales.ẅ

Coalfield	District	Measures	Actual		Probable		Possible	
			Million Tons		Million Tons			
Northern	Newcastle	Upper (Newcastle)	A.	495	A & B	1220	A.B.C.	Large
	East Maitland	" (Tomago)	A.	80	A & B	190	A.B.C.	Moderate
	Singleton	" (Newcastle & Tomago)	A & B	100	A & B	150	A.B.C.	Small
	Gunnedah-Curlewis	" (Newcastle)	A.	40	A & B	30	A. Small; B & C Moderate	
	Werris Creek	" "	-		-		A.B.C.	Very Small
	Muswellbrook	" (New. & Tomago)	A & B	70	A.B.C.	100	A.B.C.	Very Large
	Muswellbrook	Lower (Greta) øø	A.	150	A.	150	A.	Moderate
	Maitland-Cessnock	" (Greta)	A.	1015	A.	305	A.	Large
Central	Sydney	Upper (Newcastle)	A.	90	A.	450	A.	Very large
Southern	Illawarra	" "	A.	600	A.	1000	A & B Large; C. Very large	
	Clyde River	Lower (Greta)	-		-		A.	Very small
South Western	Wollondilly	Upper (Newcastle)	A.	100	A.	900	A.B.C.	Very large
	Moss Vale-Berrima	" "	A & B	75	A.B.C.	250	A. Very small; B & C Moderate	
Western	Lithgow	" "	A & B	450	A.B.C.	350	A. Moderate; B & C Large	
	Kandos	" "	A.	50	A & B	90	A.B.C.	Small
	Ulan-Wollar	" "	A & B	15	A.B.C.	50	A.B.C.	Large
	Talbragar	" " and Mesozoic.	-		B & C	50	B & C	Moderate
Ashford		Lower (Greta)	A.	5	-		A.	Small
Coorabin	Coorabin	" (Greta)?	-		B & C	795	B & C	Large
North-Eastern	Clarence Basin	Mesozoic	-		-		A. Small; B. Moderate; C.Large	
		Totals	3,335		6,080			

Note: A. Indicates Grade A coal; B. Indicates Grade B coal; C. Indicates Grade C coal.

Grade A. - The best coal of each field suitable for steam-raising, gas-making, coking amd household purposes, with ash contents ranging from 5 to 14 percent, and a calorific value of 11,500 to 13,,500 B.Th.U's per pound.

Grade B. - Coals with lower calorific value and higher ash contents than those of Grade A, but suitable for use in the condition as mined. Ash contents ranging from 15 to 20 percent, calorific value from 10,000 to 11,500 B.Th.U's per pound.

Grade C. - Coals from inferior seams generally with high ash contents, but suitable for use after washing or flotation. Ash percentage exceeding 20.

ẅ For the purpose of these calculations the maximum workable depth and the minimum thickness of coal have been taken as 4000 ft. and 4 ft. respectively.

Actual reserves include the coal within colliery holdings proved for the most part by underground workings and partly by borings.
In the preparation of these estimates only the tonnage of coal in the seam or seams actually worked is taken into account, although other seams of commercial coal may be known to exist within the colliery holdings.
The average total thickness of the seam as opposed to the thickness actually worked in the colliery has been taken as the basis of the calculation and would thus tend to make the actual reserves somewhat larger than the tonnages which may be won from the seams now being worked.
For the estimation of tonnages the specific gravity of the coal in each individual colliery has been considered.

Probable reserves include the tonnages of coal within areas in which particulars as to thickness and quality of seams have been obtained definitely from evidence afforded by outcrops, prospecting shafts, and tunnels, and by bores. An area of 1 square mile around a locality where a seam has been proved is taken generally as the limit of probable reserves. In some instances however geological conditions of an exceptionally favourable nature have allowed these limits to be extended.
In calculation of probable reserves an estimate of 1500 tons per acre foot has been employed.

Possible reserves include the quantities of coal within these areas in which the coal measures are known to exist, but in which the evidence as to thickness and extent of coal seams is not sufficient to allow a definite estimate to be given. These reserves are expressed in relative terms only.

In addition to the areas embraced by the districts included in the table there remains a very large area approximating 14,000 - 15,000 square miles within the Main Coal Province in which the Upper Palaeozoic Coal Measures are known to exist. Very little information as to the thickness, extent, and quality of the coal seams within this vast area is available at present, but there is a reasonable expectation of obtaining an enormous quantity of good coal far exceeding the combined actual and probable reserves given above, within depth (4000 ft.) accessible by present methods of mining.

øø Tentative estimate only. May be reduced when limits of extensive cindering have been determined.

⁄ Prepared by the Geological Survey Branch, New South Wales Department of Mines.

coal province in New South Wales is shown in the following table:-

TABLE 5B.1b

Province	Production in 1951
	tons
Main	13,490,800
Far North Coast	17,900
Riverina	4,500
Ashford	Nil.
Total	13,513,200

THE MAIN PROVINCE

The Main province covers an area of about 16,000 square miles, and contains 3,330 million tons of proved reserves, which is over 99% of the total proved reserves of the State. In 1952 it produced over 99% of the State's total output.

This province is an elongated sedimentary basin having a general north-north-westerly to north-westerly trend. It is semi-elliptical in shape with its main axis running in a north-westerly direction and has Sydney approximately at its focus. The deepest portion of the basin lies somewhere near Sydney. The main structure and subsidiary warps, folds, and faults have been produced by movements ranging from Permian to Tertiary time. Some of the folding which began in Permian time continued into Triassic time. The details of the tectonic history are still a matter of controversy.

The boundary of the basin extends from Ulladulla on the South Coast through Tallong, Berrima, Yerranderie, Jamieson Valley, Hartley, Hassans Walls, Lithgow, Ben Bullen, Kandos, Lue Dubbo, Narrabri, Werris Creek, Scone, Muswellbrook, and Greta, to Port Stephens on the North Coast.

Adjoining the main basin and north of Newcastle and Greta respectively lie two small subsidiary basins known as the Stroud Gloucester Trough and Cranky Corner Basin. The Carboniferous rocks containing the coal seams near Werris Creek are generally described with the Permian rocks nearby in the main basin.

The main development of Permian sediments is found in the Hunter Valley from Newcastle to Muswellbrook. Altogether in this area 14000 feet of marine, freshwater, and volcanic beds of Permian age occur. Raggatt and Fletcher (1937) summarize this sequence as follows:-

TABLE 5B.3

Series	Stage	Thickness in feet.	Lithology
Upper Coal	Newcastle	400-1500	Shales, sandstones, conglomerates, cherts, and coal seams.
	Tomago	500-3000	Mainly shale with thin beds of sandstone and coal seams.
Upper Marine	Mulbring	1000-2000	Shales with calcareous concretion horizons. Glacial erratics near base.
	Muree	200- 400	Sandstone, argillaceous and calcareous in places. Shales in middle part. Glacial erratics common.
	Branxton	2000	Alternation of shales with beds like those of Muree Stage. Well marked *Fenestella* shale beds 1550 feet above Greta Coal. Glacial erratics common.
Lower or Greta Coal		100- 300	Fine conglomerate, sandstone, shale with thick coal seams.
Lower Marine		4800	Shales and sandstones with flows of basalt. Lochinvar glacial shales at base 200 feet thick.

Northwards from Muswellbrook to Murrurundi no effort has been made to differentiate between the Newcastle and Tomago Stages of the Upper Coal Measures. South and south-east of Muswellbrook field conditions in the past prevented an accurate surface examination of large areas of the Upper Coal Measures and exact mapping of the Newcastle-Tomago boundary. The Lower Coal Measures also are exposed over a considerable area in the Muswellbrook and Cessnock districts.

The section of the basin north of Murrurundi forms what is termed the North-Western Coalfield and is stratigraphically considerably different from the type area. The Lower Marine Series is represented by freshwater, marine, and volcanic beds. The Lower Coal Measures attain a much greater thickness than in the type area, but are of little economic importance. The Upper Marine beds occur in a very attenuated form. The main coal seams are found in the Upper Coal Measures which in the opinion of F.N. Henlon (1947-50), correspond to the Newcastle stage of the type section.

In the metropolitan area of Sydney testing has been limited to the Upper Coal Measures. The deepest bore yields information only of beds above the Upper Marine Series. No attempt has been made to divide this section of the Upper Coal Measures into stages.

South of Sydney from Stanwell Park to Ulladulla fairly complete sections of the Permian deposits are available; in these only beds of the Newcastle Stage of the Upper Coal Measures and Upper Marine series are well developed. Small areas of coal-bearing sediments which have been correlated with Greta Coal

Measures also occur. Some two hundred feet of freshwater sediments which have been assigned to the Tomago Stage occur in the vicinity of Bulli Point but die out further south.

In the South-Western and Western Coalfields only the Newcastle Stage and the Upper Marine Series are definitely known. However, towards the north-eastern corner of the field in the Goulburn Valley two miles upstream from its junction with Bylong Creek, Dulhunty mapped beds possibly forming the south eastern edge of the Tomago Stage of the Hunter Valley.

The whole coal basin is serviced by a well-placed transport system. Harbour facilities are located at Newcastle, Sydney, and Port Kembla, and sea jetties are available at a number of places. Railways run from the ports to practically all the major coal mines. Increased volume of traffic on some of these rail lines in recent years has led to serious problems in bringing coal from the Western Coalfield to Sydney and from Muswellbrook and Singleton to Newcastle. Immediate future development of the Main Province will be influenced by the degree of saturation of particular railway lines and the distance that rolling stock, of which there is by no means enough, will have to travel. The electrification of the Sydney-Lithgow railway will permit a large increase in coal traffic from the Western Field when completed in 1954.

Most of the mining is restricted to areas along the coastal margin and the inland fringe of the basin where erosion coupled with folding and warping has brought the Permian coal measures to within suitable mining depth.

The relative importance of the six coalfields of the Main Province is shown in the following production table for 1950.

TABLE 5B.4

Coalfield	Production
Northern	8,190,800
Southern	1,857,800
Western	2,068,400
South_Western	525,000
North-Western	124,500
Central	Nil

NORTHERN COALFIELD

The Northern Coalfield is divided into seven coal districts. The division is largely artificial, using as it does a combination of geological and geographical boundaries. The seven districts are known as Newcastle, East Maitland, Cessnock-Maitland-Greta, Glendonbrook, Cranky Corner, Stroud Gloucester and Singleton-Muswellbrook. Between them these districts produce almost half of Australia's bituminous coal and the two districts of Newcastle and Cessnock-Maitland-Greta produce over 90% of this. In 1951 the total production of the Coalfield was 8,399,900 tons and Newcastle and Maitland-Cessnock-Greta produced 7,052,000 tons of this. The coal is produced from seams in both the Tomago and Newcastle Stages of the Upper Coal Measures and in the Lower Coal Measures. The Muswellbrook-Singleton District is developing rapidly and is capable of growing to be at least as great a producing area as Newcastle or Maitland-Cessnock-Greta.

Newcastle District.

The Newcastle District stretches from Port Stephens in the north to near Broken Bay in the south and from the coastal shelf in the east to the western fall of the Sugarloaf Range in the west. Mining at present is confined to the 300 square miles

north of Catherine Hill Bay, but most of the mining in the past took place north of Teralba. Large scale development in the Awaba - Fassifern and Swansea areas recently has extended the active mining area further south.

The coal measures mined in the District belong to the Newcastle Stage. Greta Coal Measures probably occur, but over most of the field are at a depth far beyond mining possibilities. The Tomago Stage also exists, but at great depth over much of the field. It shows no signs of containing economic seams in this area.

The Newcastle Stage attains a thickness of 1300 feet in the vicinity of Seaham, but $2\frac{1}{2}$ miles to the west, on the flank of the Lochinvar Structure, it has thinned to 600 feet.

In all there are fifteen main seams on the field and some of these, such as the Pilots and Australasian, are multiple coal seams. Details of the fifteen seams are given in Table 5B.5.

TABLE 5B.5.

Seam	Usual Thickness Worked.	Number of Collieries Working.	Output 1951	Reserves *		
				Actual	Probable	Possible
Wallarah	7'-14'	2	363,200	A. 40,000,000 B. 80,000,000	A & B. 210,000,000	A. Small B & C. Moderate
Great Northern	9'-14'	11	1,005,200	A.114,000,000 B. 36,000,000	A & B. 105,000,000	A. Small B & C. Large
Fassifern (Holme's)	8'-9'	1	182,100	A. 8,000,000 B. 7,000,000	A & B. 40,000,000	A. Small B & C. Moderate
Pilots	-	-	-	-	-	-
Hartley Hill	6'3"-7'	2	27,300	A. 7,000,000 B. 33,000,000	A & B. 120,000,000	A. Small B & C. Large
Australasian	6'-8'	6	142,900			
Montrose	Unknown	1	4,500	-	A & B. 75,000,000	B & C. Large
Wave Hill	6'-6'6"	2	16,500	-		
Fern Valley	-	-	-	-		
Victoria Tunnel (Burwood)	5'6"-7'	8	815,000	A. 60,000,000	A & B. 130,000,000	A. Moderate B. Large
Nobby's	4'-4'6"	2	14,600	A. 2,000,000	A & B. 10,000,000	A, B & C. Small
Dudley	4'9"-6'	1	15,400	B. 5,000,000	A & B. 80,000,000	A. Small B & C. Large
Yard	-	-	-	-	A. 5,000,000	A. Small
Young Wallsend	5'3"-8'	2	78,800	B. 8,000,000	B. 120,000,000	A. Very Small B & C. Moderate
Borehole	3'6"-7'	17	1,128,900	A. 95,000,000	A & B. 325,000,000	A. Moderate B & C. Large

Note. See table 5B.2. for definition of terms A, B & C.
* All these reserves lie within 1000 feet of the surface.

The Wallarah Seam is the top seam of the Stage and occurs immediately below the base of the Triassic. The quality of the band-free coal is shown in the table of typical analyses. The seam gives rise in a number of places to two splits which consist mainly of carbonaceous shale. In the area between Swansea and Catherine Hill Bay the upper split increases in importance to the south and the lower split dies out. The Wallarah seam is thought to be of commercial value only in the Swansea-Munmorah area.

The Great Northern Seam lies 150 feet below the Wallarah Seam. With bands included the seam occurs through a large part of the mining area but in places is too dirty without washing, or too thin, to be mined. The best area of the seam is west of Lake Macquarie from Awaba and Teralba under the Sugarloaf Range to its most northerly point. It has been mined in the past mainly around Teralba, Fassifern, and Rhondda. It is now being exploited on a large scale in the Fassifern, and Awaba area.

The Fassifern Seam lies from 40 to 70 feet below the Great Northern Seam. The seam ranges in thickness up to about 22 feet 5 inches and crops out in the vicinity of Killingworth, Teralba, Speers Point and north of Belmont near Croudace Bay. Southwards towards Catherine Hill Bay the seam thins to about 3 feet. The mines around Belmont produce coal from this seam. The most suitable area for future development is considered to be the Teralba-Rhondda-Fassifern district.

The Pilot Seams are two or more in number and occur at varying depths below the Fassifern Seam. Most of the seams are too dirty to be mined. They are separated from the Australasian Seam by the Seaham Sandstone: this unit, however, is not easy to identify over much of the area and consequently the Pilots are often confused with the top splits of the Australasian.

The Hartley Hill Seam is considered to be the topmost of two or three upper splits of the Australasian Seam which only attain economic proportions over a limited area. The seam has been worked mainly at South Cardiff and Cockle Creek.

The Australasian Seam lies about 100 feet below the Pilot Seams and almost immediately over the Redhead Conglomerate. It attains the great thickness of 50 feet; much of this thickness is carbonaceous shale and claystone bands. The banding is so heavy over much of the area as to make the seam unworkable in those parts. The area bounded by Cardiff, Toronto and Swansea is considered to be the limit of economic development. Working of the seam at the moment is restricted to the Cardiff collieries where a fairly clean section near the base of the main Australasian is worked.

The Montrose Seam ranges from 3 feet to 18 feet 9 inches in thickness and lies very close to the base of the Redhead Conglomerate. It commonly splits and contains thin bands and partings of shale. Only limited areas exist in which it could be worked without washing. Like the underlying Wave Hill and Fern Valley Seams it only occurs in the central and eastern portion of the field.

The Wave Hill Seam has a thickness of from 4 to 10 feet including bands. It has mainly been worked in the Dudley-Charlestown area but extends as far south as Toronto and Belmont. In the Dudley area it lies 100 feet below the Montrose Seam. Some people consider the two seams in the Cardiff area which are separated only by a 6-foot parting and underlie the Redhead Conglomerate to be the Montrose and Wave Hill Seams almost combined. Jones (1929, 1930) however holds that this is not the two seams combining but the Montrose splitting.

The Fern Valley Seam lies about 160 feet below the Wave Hill Seam and ranges from 4 to 12 feet in thickness. The seam is subject to splitting. It has been mined in the past but is

not being mined at present. Outcrops of the seam can be followed from north of Redhead westwards to Kotara; it appears to die out towards Cardiff, and extends to Belmont in the south.

The Victoria Tunnel or Burwood Seam ranges up to a maximum of 14 feet 6 inches in thickness including bands. It lies from 20 to 190 feet below the Fern Valley Seam. The seam outcrops from the vicinity of Redhead Bluff and Little Redhead on the coast and westwards south of Adamstown and New Lambton towards Minmi. It also outcrops on high ground near Newcastle. The seam appears to deteriorate west of Cardiff. In the south it appears to split near Swansea and to die out between Fassifern and Awaba.

Nobby's Seam lies from 180 to 400 feet beneath the Victorian Tunnel Seam. Including bands the seam ranges from 3 to 7 feet in thickness. It outcrops in the vicinity of Newcastle and also from just north of Glenrock Lagoon westwards round Merewether until it is lost in the vicinity of Adamstown. Southerly the seam is known to exist as far as Dudley, and southwest as far as the Snake Creek Bore. The areas of this seam which can be worked are limited; it is worked around Glebe.

The Dudley or Dirty Seam occurs from 40 to 90 feet below Nobby's Seam. It ranges from 5 to 14 feet in thickness. The quality varies considerably and the seam is subject to splitting; good quality coal occurs in certain areas of the seam such as Murdering Gully. The outcrop of the seam is largely obscured by alluvium in the vicinity of Merewether but can be followed from there northwards to Flagstaff Hill and southwards to Glenrock Lagoon; it also outcrops in a number of places between the coast and Minmi. The seam extends as far south at least as Swansea but its extent in a south-westerly direction is unknown.

The Yard Seam lies about 110 feet below the Dudley Seam and ranges from 1 foot 6 inches to over 4 feet which includes up to 3 feet of clean coal. It is too thin for exploitation on present standards.

The Young Wallsend Seam lies from 27 to 56 feet beneath the Yard Seam and ranges from 3 feet 4 inches to 8 feet 10½ inches. It is considered to be an upper split of the Borehole Seam. It is only known in the western portion of the field and has not been identified much to the east of Cardiff. It is inferior in quality to the Borehole, from which it is separated by sediments ranging from a few inches to 70 feet. The seam is noted for being "gassy" and for spontaneous combustion. Where the seam immediately overlies the Borehole Seam several fires have occurred. Once regarded as having poor coking properties, the Young Wallsend coal is now in demand for coking.

The Borehole Seam, considered by some to be the basal seam of the Newcastle stage, is the most important seam of the Newcastle District: its coking properties make it the most sought after for the production of metallurgical coke in Newcastle. The seam varies considerably in thickness, attaining a maximum of 18 feet in the vicinity of Newcastle. Although the seam is of excellent quality for the most part, areas occur in which it is below commercial grade. Large areas of the seam have been worked out in the north and "wash-outs" are common in the old Delta Collieries in the vicinity of the Hunter River. The seam occurs as far north as Stockton, Wallsend, Minmi, and Stockrington, and round the western edge of the Sugarloaf Range. It extends as far south as Awaba and Bungaree Norah but deteriorates below commercial standards in that area. Workings of the seam have extended in the north as far as a mile out under the sea, where it is found to have a thickness of 8 to 9 feet. Borehole coal in fairly large quantities is used also for brick manufacture in the Newcastle District.

The Permian sediments in the Newcastle District form a

subsidiary southerly pitching syncline on the north-eastern flank of the Province's basin-like structure. This syncline is divided at its northern end by a minor northerly striking anticlinal fold. The dip of the coal seams is generally low, about 1^{o} - 2^{o}, but increases to about 10^{o} west of the Sugarloaf Range. Pronounced rolling occassionally occurs and causes some difficulty in mine layout. Faulting is present but not to the extent of providing a serious mining problem. Igneous intrusions are mainly restricted to dykes, some of which are over 20 yards wide and run for 1 to 5 miles. These intrusions provide mining difficulties, but in only a very small part of the District.

The most important group of collieries on the field is owned by the Broken Hill Pty. Ltd. to supply coal to their Newcastle Steelworks. The group embraces Burwood, John Darling, Lambton, and Stockton Borehole Collieries. These pits are for the most part highly mechanised and restricted to the Borehole, Victoria Tunnel, and Young Wallsend Seams.

Plans have been prepared by J. & A. Brown and Abermain Seaham Collieries Ltd. to reorganise and mechanise the important Stockrington pits which work the Borehole Seam and to instal a cleaning plant with the object of greatly increasing the supply of coking coal to the Broken Hill Pty. Ltd. steelworks.

The Stroud-Gloucester District.

The Stroud-Gloucester district lies from 60 to 90 miles north of Newcastle by way of the North-Coast Railway which traverses the axis of the trough-like structure of the coal measures of the district. The coal measures attain a thickness of 1,000 feet and are thought to correspond roughly with the Upper Coal Measures. The sediments form a basin about 35 miles long by 5 to 8 miles wide lying in a basement of Carboniferous rocks and separated from the main basin by about 25 miles. The marginal dips of the coal measures are high, being of the order of 60^{o}. Minor folding occurs as part of the main structure. Several large faults break the margin of the trough.

At Gloucester twelve seams of from 1 to 12 feet crop out. In the old Gloucester Colliery five seams ranging from 3 feet 3 inches to 6 feet 8 inches in thickness occur, dipping at 64^{o}. Much thicker banded seams of up to 30 feet have been reported from other parts of the syncline but no detailed geological work has yet been done on them.

Analyses available from the Gloucester Colliery show the coal to be a medium-volatile bituminous coal and to have a rather high ash and sulphur content. No coal is being mined at present (1953) in this district.

East Maitland District.

West of the Newcastle District the Newcastle Stage overlaps to a large extent the beds of the Tomago Stage. Farther north, however, the overlap decreases and the Tomago Stage beds are exposed over a fairly large area east of Maitland. Limited boring, working, and outcrops indicate that this stage contains eight principal seams. It is still a matter of debate whether or not the uppermost seams, the Sandgate Seams, are the basal beds of the Newcastle Stage. Details of the seams are given in Table 5B.6.

TABLE 5B.6.

Seam	Usual Thickness Worked.	Number of Collieries	Production in 1951
Sandgate	-	-	-
Buttai	-	-	-
Donaldson's (Top)	7'-8'6"	1	64,100
Tomago Thick (Big Ben)	7'-8'	1	147,300
Tomago Thin	-	-	-
Scotch Derry	-	-	-
Rathluba	5'6"-6'9"	4	39,600
Morpeth	-	-	-

Donaldson's, Tomago Thick and Tomago Thin Seams are often referred to as the Four Mile Creek Series. The former two of these have been the main producing seams of the field. Total District production since mining began is between 4 and 5 million tons.

The Tomago Stage attains a thickness of about 2,000 feet in this area and is mainly sandstone, shale, mudstone, and coal seams.

The beds form portion of the north-eastern flank of the main syncline of the Newcastle District but where tested near Newcastle have only yielded thin coal bands. The seams as a whole are very irregular in thickness and quality and split rapidly. Mining is at present restricted to the East Maitland, Bloomfield, and Thornton triangle.

The Sandgate Seams (Upper and Lower) lie from 100 to 200 feet below the Borehole Seam. The Upper Sandgate Seam lies about 10 to 90 feet above the Lower Sandgate Seam. The seams are heavily banded - 2 feet being the maximum thickness of clean coal - and are not of commercial grade.

The Buttai Seams lie about 40 feet or more above Donaldson's Seam and on present knowledge only attain economic thickness in the Stony Pinch - Buttai area, where several prospecting tunnels have been driven.

Donaldson's or Top Seam ranges from 4 feet to 7 feet 9 inches in thickness and is worked in one colliery. It is fairly banded, some bands being over 1 foot thick. Generally the lower portion of the seam is worked.

Tomago Thick or Big Ben Seam lies from 30 to 100 feet below the Donaldson's Seam, and ranges from about 7 to 10 feet in thickness. It contains a number of bands.

Tomago Thin Seam is only about 3 feet thick including bands and lies 40 feet below the Tomago Thick Seam. It contains a cannel-like coal in some areas and may actually be a split of the Big Ben.

Scotch Derry Seam contains 9 to 10 feet of coal and many bands and lies 90 to 140 feet beneath the Tomago Thick.

The Rathluba Seam is the most important seam of the field. It ranges from 4 feet to 7 feet 9 inches in thickness and ranks as the third most important producing seam of the East Maitland Field. It contains a number of bands up to 6 inches in thickness.

The Morpeth Seam lies about 80 to 140 feet below the Rathluba Seam and is the basal coal seam in the Upper Coal Measures in this area.

The dip of the coal seams is low. Their main area of development is between East Maitland and Morpeth and it is considered that the limits of economic coal are restricted to the area enclosed by Morpeth, East Maitland, Buchanan, Buttai and Thornton. In the Hexham and Ash Island area volcanic dykes have coked and cindered considerable portions of the seams.

The East Maitland coal is a medium-volatile bituminous coal with slow-burning properties. Though of high ash content it is fairly free from clinker trouble. The average volatile content is about 34% and ash content about 13-14%. The coal is used for power boilers, bunkering and brick manufacture.

The Maitland-Cessnock-Greta District.

The Maitland-Cessnock-Greta District lies immediately west of the Newcastle and East Maitland Districts and covers an area of 390 square miles. The quality and quantity of coal produced places this District slightly above Newcastle as the most important coal-producing area in Australia. These two fields are the major producers of the special coals required for gas and coke manufacture as well as general steam coal. As a result the heavy industries of Australia rely greatly on supplies from this Lower Hunter River area, and any interference caused by industrial trouble, or by weather affecting mining, transport to Hexham or Newcastle, or loading in the poorly protected harbour of Newcastle, is generally felt throughout the Commonwealth.

The coal occurs in the Greta or Lower Coal Measures. The geology of the coalfield is dominated by the Lochinvar Structure, which is a southerly pitching anticline. On the south-eastern flank of this structure, between Cessnock and Kurri Kurri, there is a superimposed synclinal fold pitching south-east wherein lie some of the best developments of the Greta seams.

The beds of the Upper Coal Measures which adjoin the Lochinvar Structure on its eastern flank vary in thickness and increase in dip as they approach it. To the south of the anticline the overlying Triassic beds are folded apparently concordantly with Permian beds to form the Kulnura Anticline. This regional evidence indicates that the Lochinvar Structure has been more or less active through Permian to Tertiary time.

The Greta Coal Measures form an almost continuous outcrop around the eastern, southern, and western sides of the Structure. They attain a maximum thickness of about 300 feet and contain two coal seams, Main Greta or Top Seam and Homeville or Lower Seam. The former lies from 21 to 120 feet above the latter. It is the opinion of Jones (1939) that the Homeville may be a split of the Main Greta Seam.

The Main Greta Seam ranges from 6 to 34 feet in thickness with bands included. The seam occurs in most places at the top of the Coal Measures, but at Gretamain, where upper splits may have been eroded, it is overlain by the Greta conglomerate. The seam is split generally into two or more parts. Maximum thickness is attained in the southern half of the field between Cessnock and Kitchener. A notable feature of the seam is the so-called "brassy tops": these take the form of half-inch bands of hard bituminous coal containing layers of marcasite and pyrites about one eighth of an inch thick, and occasional concretions of pyrites about one third of an inch in diameter. These bands occur over a thickness ranging from a few inches to one foot four inches in the top of the seam. Together with the high volatile content of the coal these are suspected of causing many of the fires and heated areas which frequently occur in the workings and lead to the sealing off of large sections of developed collieries. In the southern half of the field, where most of the mining is located, the Top Seam varies considerably in thickness. The seam is 7 feet 6 inches in the vicinity of Stanford Merthyr and thickens

to 34 feet near Cessnock, but thins again westwards to 17 feet at Bellbird No. 2 Colliery. West of Bellbird the seam yields three splits of which the lowest is 14 feet 9 inches thick at Pelton. At Gretamain no splits are found and the seam is only 11 feet 6 inches. In the west at Milton Vale the seam is only 7 feet thick. A local deterioration of the seam sufficient to make it uncommercial is noticeable just east of Hebburn.

Greta coal is mined also to a lesser extent on the western side of the structure in the vicinity of Greta and north-west of Rothbury. Underground collieries also worked the eastern flank of the structure between West Maitland and Kurri Kurri but most of these mines are no longer operating.

The Homeville or Lower Seam ranges from 1 foot 6 inches to 15 feet 6 inches in thickness and like the Main Greta Seam is subject to splitting. At Stanford Merthyr it attains a thickness of 22 feet and averages 18 feet 6 inches thence to Pelaw Main Collieries. From Pelaw Main westwards toward Hebburn it breaks into two splits of 8 feet and 6 feet. West of Hebburn the top split rapidly thins to below commercial limits. The lower split extends through Abermain maintaining a thickness of about 6 feet, but by Aberdare it has thinned to 2 feet 10 inches and is not known west of Cessnock. The main area in which the Lower Seam is worked lies between Abermain and Stanford Merthyr.

The Greta Coal Measures outcrop intermittently north-east of the Lochinvar Structure from Maitland through Gosforth to near Paterson, at which point they are overlapped by the Upper Marine Series. One seam at least is known to occur in this area but it is poor in quality. About 7 miles north of Raymond Terrace an 11 foot seam known as Garretts' Seam occurs; this may correspond to the Greta Seam.

Igneous intrusions are limited to dykes which are only a minor feature on this field. The dykes have a general north-westerly trend.

The Lochinvar Structure is terminated at its northern end by the Hunter Overthrust Fault where Carboniferous rocks have been thrust over the Permian rocks. The western side of the structure is marked by the Matthew's Gap Fault which has a throw of up to a thousand feet. As a result the Greta Coal Measures do not crop out over a distance of about four miles northwards from Cedar Creek and the seams have been displaced to a depth of about a thousand feet. Northwards in the vicinity of Greta the north-south outcrop of the Measures along the western flank has been offset a distance of two miles by a dip fault. Smaller cross-faults with throws of up to a hundred feet are quite common throughout the field.

The dips of the Coal Measures on the flanks of the Lochinvar Structure are quite steep. On the eastern side they range from 20° to almost vertical and on the western flank from 20° to 30°. The two subsidiary anticlinal folds developed on the southern end of the main structure in the main mining area have in places more gentle dips of 3° to 7°.

West of the Matthew's Gap Fault the Greta Coal Measures have been proved by deep bores to continue in a series of northerly-striking folds, but are overlain by the Upper Marine Series and Upper Coal Measures, and do not crop out until they reach Muswellbrook, where erosion around the Muswellbrook Dome and associated faults have again exposed large areas of coal-bearing sediments of Greta age.

The method of mining used is, with the exception of a few open cuts, restricted to the bord and pillar method. Much coal is left in the form of roofs and pillars. State mining legislation governs strictly the amount of coal that must be left in

pillars at the first working and the nature of the Greta seams often brings about heating and necessitates sealing off the heated area, before pillar extraction by hand methods begins. As a result large quantities of valuable coal are lost and further development of the pits is made more difficult.

The further development of this field to provide the necessary additional gas and first-grade steam coal is providing the biggest mining problem of New South Wales coal industry today.

By far the largest producing group of collieries on the field is that operated by J. & A. Brown and Abermain Seaham Collieries Ltd. It comprises the three Abermain collieries and Pelaw Main, Richmond Main, Stanford Main, and Stanford No. 2 collieries. The next largest but much smaller group consists of the three Aberdare collieries and Caledon Colliery, operated by Caledon Collieries Ltd. These two groups between them produce well over half of the production of the field.

The coal is an excellent high-volatile bituminous coal. It has an ash content generally less than 7% and a calorific value of over 13,000 B.Th.U's/lb. Sulphur content is generally relatively high by New South Wales standards and is often about 1.4%. Cannel and kerosene shale bands occur associated with the coal. The coal is used for gas, steam, and household purposes. In gas manufacture it provides an excellent by-products yield; out of 452,000 tons used for gas manufacture by one company in 1928 318,280 tons of household coke, 9,000,000 gallons of tar and 13,000,000 lbs of sulphate of ammonia were recovered.

Glendonbrook District. The Glendonbrook area is a small basin isolated by faulting from the main areas of coal measures. The basin is 8 miles long and up to 4 miles wide. The centre of the area lies about 6 mile north-north-west of Branxton. The main faults bounding the coal measures are the Hunter Overthrust on the north-east, the Mindawah on the west, and Main Greta on the south. At least 18 seams known as the Westbrook Seams occur in the north-west of the area. These seams have thicknesses of 20, 5, 3, 6 (Scott's Seam), 7, 4, 27, 3, 3, 3, 8, 11, 4, 24, 9, 11, 12 and 8 feet. Thus in 880 feet of the Upper Coal Measures in this area there exists 120 to 140 feet of coal. Faulting however may have caused serious errors in measuring these seams. Scott's Seam was worked for a short time. In the south of the basin a heavily banded 7 foot 9 inch seam of coal dipping at $54\frac{1}{2}^{o}$ is known. Recent drilling for open-cut coal indicates that the seams are overlain by a considerable thickness of barren sediments in the central part of the basin where they are farthest from the marginal faults and likely to be least broken. Contortions in the barren sediments however suggest that the central area may also be considerably disturbed. The quality of coal in the field has not been adequately tested but it is quite likely that some of it is of workable standard.

The Cranky Corner District.

About 10 miles north of Branxton there is a small structure known as the Cranky Corner Basin which contains Permian sediments lying in a basement of Carboniferous rocks. This basin is truncated on the west by the Webber's Creek Fault. The Permian sediments consist of the Lower and Upper Marine Series separated by 150 feet of Greta Coal Measures. Two coal seams have been observed, one of which appears to be of 10 to 15 feet in thickness. The coal measures have been considerably disturbed and dips of between 20° and 50° are common. Only one colliery is working in the district.

Muswellbrook-Singleton District.

Coal seams of both the Upper and Lower Coal Measures outcrop over an area of about 800 square miles of the Hunter

Valley stretching from the western boundary of the Maitland-Cessnock-Greta District to Aberdeen. The Main Northern Railway and a branch line to Merriwa provide rail transport through most of this area.

The Greta Coal Measures occur at great depth over a large portion of the area but only outcrop near Muswellbrook. They lie, however, within mining depth on the Belford, Loder, and Sedgefield Domes between Branxton and Singleton. A hole drilled on the Loder Dome intersected a banded seam 6 feet thick at 1977 feet, and several smaller seams; total depth of the hole was 2391 feet. The Belford No. 1 Bore encountered a 7 foot 4 inch seam at 1458 feet and a 10 foot 4 inch seam at 1477 feet. This hole was completed at 1550 feet without passing to the base of the Greta Measures. Belford No. 2 Bore was sunk deeper and encountered the following section:-

TABLE 5B.7.

Seam	From	To	
7 feet 1 inch	1452 ft. 2 ins.	1459 ft. 1 in.	)Correspond to seams in No.1 Bore
9 feet 7 inches	1504 ft. 9 ins.	1514 ft. 4 ins.	)
3 feet	1542 ft. 6 ins.	1545 ft. 6 ins.	
4 feet 10 inches	1563 ft.	1567 ft. 10 ins.	
7 feet 8 inches	1649 ft.	1656 ft. 10 ins.	

The quality of coal in these holes, although slightly high in sulphur, was excellent, having a high calorific value and a volatile content of about 32% to 44%.

In the Muswellbrook area considerable mining of the Greta Coal Measures by one large open cut and three underground collieries is taking place. The open cut is working toward the northern nose of the northerly-striking elongated Muswellbrook Dome and the underground collieries are working on the flanks of the structure. Production from these collieries fell from 627,589 tons in 1948 to 610,900 tons in 1951.

The Greta beds outcrop for a distance of about ten miles along the dome and about two miles across. The coal measures also outcrop along the sides of a smaller structure, the Brougham Syncline, about 2 miles to the east.

The Savoy Sill and smaller sills and dykes have destroyed much of the coal in the southern half of the Muswellbrook Dome but the northerly region in which the opencut lies is free from intrusions. Recent correlation of the seams at the northern end of the dome by F.W. Booker shows the presence of four seams, of which the top contains two splits. In all in this northern area there are up to 90 feet of coal in about 200 feet of sediments. Geological knowledge suggests that there is an area of about six square miles around the Muswellbrook Dome in which the Greta coal seams will lie within 1,200 feet of the surface and which is well worth prospecting.

Greta seams may be expected to occur within working depth over a total area in this district of a 100 square miles.

In the broad, roughly synclinal, area lying between Liddell and Singleton and extending southwards into the Jerry's Plains area the Tomago Stage of the coal measures is well developed and attains a thickness of about 2,000 feet. A generalized section of these sediments is as follows:-

1200 feet: Six coal seams contained mainly in the upper 300 feet. Rest mostly sandstone and conglomerate.

450 feet: Six seams contained in this portion of mainly shale and sandstone.

350 feet: Barren shale and sandstone.

At Rix Creek near Singleton underground mining of the Tomago Measures took place for many years. There are four seams in the area so far mined and three of these have been worked. The seams that have been worked are: the Main Seam which is banded and contains a working section of about 6 feet of coal; the Dulwich Seam which is about 6 feet thick and lies about 45 feet below the Main Seam; and the Nundah Seam which is 3 feet thick. A 1-foot seam lies between the Dulwich and Nundah Seams. These seams are considered to be in the lower portion of the Tomago Measures and roughly on the same stratigraphical level as the Liddell seams.

Ravensworth and Liddell are two railway stations on the Main Northern Railway, 161 and 165 miles respectively from Sydney. Two deep drill holes were put down at Ravensworth and encountered a considerable number of seams. The results of these holes are shown in Table 5B.8.

TABLE 5B.8.

Bore No. 1.		Bore No. 2.	
Thickness of Seam	Depth of Seam	Thickness of Seam	Depth of Seam
5'9"	327'	4'1"	31'2"
20'8"	422'	3'4"	92'
11'10½"	518'	2'5"	103'5"
12'6"	591'	14'4"	184'5"
9'9"	709'9"	4'11"	262'7"
7'11"	733'	3'0"	293'9"
2'10"	750'	7'9"	351'8"
4'7"	785'	16'6"	477'5"
11'9"	835'	2'7"	510'
3'2"	913'11"	4'8"	564'
		15'6"	654'
		21'	768'3"
		7'5"	835'
		3'2"	891'11"
		2'2"	898'4"

Intensive drilling of the large open-cut reserves in Liddell-Ravensworth area in the last few years has permitted identification of six main seams.

The Ravensworth Seam is of the order of 12 feet in thickness and contains 20 and 23% of ash which is mainly inherent.

The Bayswater Seam lies 50 feet below the Ravensworth Seam and is about 20 feet in thickness. It has a high ash content of about 16 to 30%. The Bayswater Seam has been worked at the Bayswater Colliery and is now worked at the New Raven Open Cut.

In approximately 800 feet of strata between the Bayswater and Artie's Seam at least four seams of 6 to 12 feet in thickness are known. These include the Pike's Gully Seam, which attains a thickness of about 10 feet in its best area of development near the head of Pike's Gully. It lies about 40 to 80 feet above Artie's Seam.

Artie's Seam is separated from the overlying Bayswater

Seam by about 800 feet. It is from about 6 to 15 feet thick. At Parnell's Creek, south of Liddell, Artie's Seam gives rise to upper and lower splits measuring 5 feet 6 inches and 7 feet 1 inch excluding bands. The seam has not been mined. Indications are that the quality of the coal is good; in an area of over 100 acres tested in the Parnell's Creek area the upper split has a volatile content 36.2%, ash of 10.5% and calorific value of 12,620 B.Th.U's/lb. and the lower split of 30.4%, 23.0% and 10,630, both excluding bands.

Liddell Seam lies about 40 to 120 feet below Artie's and ranges from 10 to 30 feet thick. It attains its best development in the Foybrook area, north of Liddell. It has an ash content of about 11% and calorific value of about 13,000 B.Th.U's/lb. In this area it is a good gas coal after washing and is also suitable for coking. It is being mined at the Foybrook Open Cut and immediately south at Durham Open Cut and Liddell Colliery. Further south at Parnell's Creek an area of about 200 acres was tested recently and it was shown that the Liddell had split into upper and lower units of 7 feet 6 inches and 4 feet 6 inches respectively. The upper split had a volatile content of 36.5%, ash of 11.9% and calorific value of 12,370 and the lower of 33.7%, 14.9% and 11,850; both excluding bands.

Barrett's or Newdell Seam lies about 40 to 100 feet below the Liddell Seam and ranges from about 7 to 12 feet in thickness. The seam approaches good gas coal quality but troublesome bands found in some areas would probably require washing. It has been worked in the Newdell Open Cut. At Parnell's Creek in an area of 460 acres tested Barrett's Seam had a thickness of 7 feet 11 inches, volatile content of 35.3%, ash content of 10.8% and calorific value of 12,710 B.Th.U's/lb. with bands excluded.

A number of seams have been located beneath Barrett's Seam near Liddell but insufficient drilling has been done to permit the correlation and determine the continuity of these.

Production of the Liddell-Ravensworth seams is shown in the following table:-

TABLE 5B.9.

Seam	1950	1951
Ravensworth	-	-
Bayswater	181,500	379,000
Pike's Gully	-	-
Artie's	-	-
Liddell	68,300	107,000
Barrett's	43,800	-

J.C.B., N.S.W.

The seams generally have a low dip to the south east.

About 4 miles north-east of Muswellbrook a small area measuring about 3 miles by 3 miles near Lupton Park contains Upper Coal Measures. This area was formerly worked on a small scale but mining has since ceased. A smaller area of a lower portion of the same coal measures occurs about ½ mile to the south-east but apparently does not contain coal. Both these areas are cut off on the north-west by the Muscle Creek Overthrust Fault.

In the southern part of the Muswellbrook-Singleton area the exact boundary between the Tomago and Newcastle Stages has not been accurately mapped.

At Ovingham, 5 miles south-west of Minimbah, a number of seams have been seen in outcrop or proved by drill holes. Near

the Triassic cliffs three seams are known, one thin seam underlain by a 7 foot 6 inch seam, and 50 feet below that a 12 foot banded seam. Two miles from these across the strike a 7 foot 6 inch seam dipping at 6° to 16° occurs and is underlain by another thin seam. Two holes were drilled by the New South Wales Department of Mines in the Ovingham-Broke area; one of these encountered eight seams varying from 8 inches to 4 feet 7 inches and the other 8 seams varying from 6 inches to 7 feet 6 inches.

A seam known as Grieg's Creek Seam outcrops at the base of Vere Mountain and runs for 12 miles from North Wambo Creek to Grieg's Creek. It has thickness of 10 feet and contains good quality coal. It is thought to be the top unit of the Permian in this area.

Drilling has revealed the presence of at least three seams varying from 4 to 10 feet thick in the vicinity of Warkworth, about 8 miles west of Singleton.

At Denman, 14 miles South-west of Muswellbrook, at least two seams, measuring 5 feet 10 inches and 5 feet 11 inches, are known.

At Roxburgh, Overton, and Kayuga, which are all within 10 miles west of Muswellbrook, collieries have mined seams dipping at 3° to 5° to the west. The seams occur near the base of the Upper Coal Measures. The seam at Roxburgh is 5 feet 7 inches and contains about 5 feet of coal. At Piercefield near Roxburgh drilling has proved a seam of 5 to 8 feet thick. The coal is suitable only for local use.

At Coffin Gully, west of Aberdeen, a seam occurs roughly on the same stratigraphical level as the Grieg's Creek Seam. In the ½ mile down hill from this outcrop three other seams are known.

The effects of igneous intrusions on the coal deposits in the Muswellbrook Dome have already been described. Other instrusions are knwon in the area between Muswellbrook and Singleton and to the south and west of the Muswellbrook Dome. Near Liddell there is a volcanic neck, and at Ravensworth a number of small dykes occur. South of the Muswellbrook Dome, the Plashett and Carrington Sills have intruded large areas of the Upper Coal Measures. Further east near Broke the Fordwich Sill has also intruded the Upper Coal Measures over a considerable area. South of Edinglassie numerous small sills occur.

Upper and Lower Coal Measures also outcrop from Aberdeen to Scone and Murrurundi. Shafts near Blandford passed through coal up to 34 feet thick in the Lower Coal Measures and much thinner seams are reported from the Upper Coal Measures.

In the Scone-Wingen area the Greta Coal Measures dip steeply. A seam of 6 to 11 feet at Wingen is known; this seam has been burning along the outcrop for as long as records exist. Seams up to 30 feet have been reported from the coal measures in this area. The Greta Coal Measures of the Northern Coalfield are cut off to the north by the Murrurundi Fault.

Coal seams have also been reported associated with the shale oil deposits at Baerami and Widdin Brook, south-west of Muswellbrook.

THE CENTRAL COALFIELD.

The Central Coalfield is bounded approximately on the north by the Hawkesbury River, on the south by Port Hacking and on the west by the western fall of the Blue Mountains.

It is a concealed coalfield with a cover up to 3000 feet

thick of Triassic sediments, and drills have only penetrated the Upper Coal Measures. Coal was mined formerly in a colliery opened at Balmain, a suburb of Sydney. This colliery was worked by vertical shafts sunk about 2,900 feet to a seam proved originally by drilling in the suburb of Cremorne; the two drill holes proved a seam of 7 feet 3½ inches and 10 feet 3 inches. The seam encountered by the shafts was as follows:-

Coal	:	2 feet 9 inches
Shale	:	2 feet 11 inches
Coal	:	10 inches
		6 feet 6 inches

About a mile towards Cremorne, along a drive, the seam improved to 6 feet 9 inches and there was a marked decrease in the shale band. The seam is known as the Cremorne Seam and is very gassy. It occurs within about 6 feet of the top of the Upper Coal Measures, and has been correlated by different authors with the Bulli, Balgownie, and Wongawilli Seams of the Southern Coalfield.

A hole drilled from the base of the Birthday Shaft of the Balmain Colliery is reported to have encountered coal seams at the following depths: 3,006 ft., 3,029 ft., 3036 ft., 3118 ft., 3,144 ft., 3,154 ft., 3,158 ft., 3280 ft., 3,287 ft., 3,305 ft., 3,315 ft., 3,453 ft., 3,602 ft., 3,958 ft., 4,259 ft., 4,330 ft., 4,395 ft., 4,443 ft. and, 4,484 ft. Maximum depth of the hole was 4,935 feet and it was considered that the drill passed from sediments definitely of the Upper Coal Measures into marine sediments of the Upper Marine Series somewhere between 4,543 ft. and 4,750 ft.

The field has been tested towards its southern limits by the Dents Creek and Liverpool-Moorebank Bores, on the western limits by the Penrith Bore, and on the northern boundary by Windeyer's Bore on the Hawkesbury River. Coal seams were encountered in all of these. Brief details of the bores are given in Table 5B.10.

TABLE 5B.10.

DENTS CREEK BORE		LIVERPOOL MOOREBANK BORE		PENRITH BORE		WINDEYER'S BORE	
Thickness of Coal Seam	Depth to Top of Seam	Thickness of Coal Seam	Depth to Top of Seam	Thickness of Coal Seam	Depth to Top of Seam	Thickness of Coal Seam	Depth to Top of Seam
4 ft. 2 ins.	2228 ft.	1 ft. 5 ins.	2493 ft. 6 ins.	14 ft.	2523 ft.	3 ft. 3 ins.	2322 ft. .
5 ft. 3 ins.	2296 ft.	1 ft. 4 ins.	2507 ft. 7¼ ins.			8 ft. 5 ins.	2359 ft. 3 ins.
		6 ft. 6½ ins.	2584 ft. 10 ins.	Maximum Depth 2700 ft.		1 ft. 2 ins.	2405 ft. 3 ins.
Maximum Depth 2307 ft. 8 ins.						1 ft. 9 ins.	2529 ft. 6 ins.
		Maximum Depth 2601 ft. 6 ins.				2 ft.	2543 ft. 9 ins.
						4 ft. 11 ins.	2598 ft. 11 ins.

The coal is a steam coal of good quality. No accurate figures of reserves are available owing to paucity of information.

Dykes are known to intrude the Cremorne Seam in the vicinity of Cremorne and as dykes often occur through the Triassic sediments of the coastal area nearby most of these will also be found intruding the coal measures at depth. In the Botany Bay area drilling has revealed that the seams have probably suffered from intrusions of sills.

The correlation and continuity of the seams of the Northern, Western, Southern, and South-Western Coalfields is far from established. As correlation of the seams is largely hypothetical and based mainly on a few drill holes between the known portions of the coalfields the more important of these holes will be quoted in Tables 5B.10, and 5B.12.

The bores connecting the information about the Central and Southern Coalfields are given in Table 5B.11, which lists the more important bores in the Heathcote and National Park area.

Between the Western and Central Coalfields two major bores, Woodford Nos. 1 and 2, have been drilled. One of these penetrated to a depth of 1656 ft. and encountered coal seams of 3 ft. 11 ins., 1 ft. 8 ins., 4 ft. 6 ins., 8 ft. 8 ins., 3 ft. 6 ins., 3 ft. 3 ins., 7 ft. 7 ins., and 2 ft. between the depths of 1205 ft. and 1441 ft.

The main drill holes connecting the seams of the Lake Macquarie area (shewn in Table 5B.11a) in the southern part of the Newcastle District with the seams of the Central and Western Coalfields are the Bungaree Norah Bore, near Tuggerah Lakes, and the Kulmura Bore near Kulmura, west of Tuggerah Lakes.

Coal has been reported in the Triassic Wianamatta Series of the Sydney basin. A 4 foot impure seam has been reported in South Creek which flows through St. Marys, a small town about thirty miles west of Sydney.

THE SOUTHERN COALFIELD.

The Southern Coalfield extends southwards from its junction with the Sydney Coalfields on the southern side of Botany Bay through the Illawarra District to Ulladulla, on the far South Coast. It extends inland to meet the South-Western Coalfield on a line running approximately through Picton and Kangaroo Valley. The working collieries of the field stretch from Helensburgh in the north to Tongarra in the south - a distance of about 33 miles. All these collieries lie within easy reach of the Sydney to Nowra coastal railway which in turn is linked to the Main Southern Line by a branch line from Moss Vale to Port Kembla.

The Upper Coal Measures range from 40 to about 1500 feet where they occur in the Illawarra and Douglas Park Districts and contain the only seams being worked. Outcrops are restricted mainly to the scarp of the coastal plateau and cliff faces of the Shoalhaven River and its tributaries in the Illawarra District. As a result with the exception of the Metropolitan Colliery at Helensburgh all underground workings are of tunnel entry type. The amount of open-cut coal available is almost negligible being mainly limited to outcrops on spurs and saddles. Only one small open-cut has been worked. The nineteen collieries working the field in 1950 produced 1,857,844 tons.

In all the Upper Coal Measures on the Southern Coalfield contain seven main coal horizons. Only the top four of these - the Bulli, Balgownie, Wongawilli, and Tongarra Seams - have been worked. A start was made during 1951 to prospect Nos. 5 and 6 Seams in the vicinity of Nebo Colliery.

TABLE 5B.11

HEATHCOTE BORE		NATIONAL PARK NO. 1 BORE		NATIONAL PARK NO. 2 BORE	
Thickness of Coal Seam	Depth to Top of Seam	Thickness of Coal Seam	Depth to Top of Seam	Thickness of Coal Seam	Depth to Top of Seam
4ft. 8½ins.	1513ft.	6½ins.	1012ft. 3ins.	3 ft.	1822ft. 6ins.
6ft. 1 ins.	1577ft. 9 ins.	5ft. 4 ins.	1087ft. 9ins.	5ft. 6ins.	1893ft. 6ins.
	2	2ft. 9 ins.	1111ft. 6ins.	1ft. 3ins.	1927ft.
Maximum Depth 1585ft. 7ins.		13ft. 6 ins.	1236ft. 3ins.		
		4ft.	1336ft. 6ins.	Maximum Depth 1953ft. 3ins.	
		13ft. 6 ins.	1410ft.		
		Maximum Depth 1436ft.			

TABLE 5B.11a.

Lake Macquarie Field Section		
SEAM	THICKNESS	
Wallarah	11 ft. 2 ins.	
Great Northern	20 10	
Fassifern	24 7	
- - -	6 11	
- - -	1 9	
Upper Pilot	2 8)	
	4 0)	
Lower Pilot	44 0	with bands
Australasian (Upper split)	7 4	
Australasian (Lower split)	14 8	
Victoria Tunnel	13 5	
Nobby's	9 10	Coal and Shale
Dudley	10 7	
Yard	2 2	
Young Wallsend	9 10	
-	3 0	Coal and Shale
Borehole	4 9	

It is planned to use the Tongarra Seam mainly for the proposed Tallawarra Power Station on Lake Illawarra, in order to preserve the coking coals of the Bulli and Wongawilli Seams for the local steel industry. The 1959 coal requirements of the power station were estimated some years ago at 525,000 tons. respectively.

The Bulli Seam forms the top beds of the Upper Coal Measures. It contains a valuable coking coal which produces a good slow-burning metallurgical coke, and is the most important seam of the field. It is worked from Helensburgh, 29 miles south of Sydney, to Mount Kembla, 24 miles further south. Beyond Mt. Kembla it deteriorates below economical standards. The seam is free of splits and attains a thickness of 12 feet. The average thickness worked is about 6 feet 6 inches. In the neighbourhood of Mt. Kembla it has suffered considerably from contemporaneous erosion. Stone rolls are very pronounced. These rolls rise anything from a foot from the floor in some places to almost roof-height in others leaving so-called "swallows" or masses of coal between adjoining rolls. They follow a fairly regular pattern and in the past, before mechanisation, largely governed the direction of the bords. The rolls range in width from 9 to 21 feet and the swallows range from 27 to 75 feet. With the introduction of mechinery, however, the parallel arrangement of bords and rolls has been largely abandoned in favour of a layout suitable to transport gradients and other requirements. The 1950 production from this seam was 1,203,025 tons.

The Balgownie Seam. (formerly called Four Foot or No. 2 Seam) is not being worked at present. It lies about 25 feet below the Bulli Seam and ranges in thickness from 3 to 5 feet. Average thickness worked inthe past was 4 feet 5 inches. Its area of main development coincides with that of the Bulli Seam, but it does not deteriorate as rapidly as the latter does to the south.

The Wongawilli Seam, or Dirty Seam as it was formerly known, lies about 90 feet below the Four Foot Seam. It is heavily banded and quite friable in part. It ranges from 14 to 34 feet in thickness and has been worked on the average thickness of just under 7 feet. It contains about 60% more ash than the Bulli Seam coal. The ash of the worked portion ranges from 15 to 25% and the calorific value from about 10,000 to 11,000 B.Th.U's/lb. A characteristic feature of the seam over a considerable area is a sandstone band which occurs in about the middle of the seam and is often indurated. Stone rolls also occur in it. The Wongawilli Seam is worked in three collieries and in 1950 produced 583,543 tons or about 31% of the field's output. The commercial area of the seam lies south of a line which runs westerly from Nebo Colliery on the coast to Berrima on the South-Western Coalfield.

The America Creek Seam was formerly called the No. 4 Seam by Harper who considered it to be the same seam as the Tongarra Seam to the south. The seam has been traced on the outcrop from Clifton to the Tongarra Colliery. It lies from 20 to about 40 feet below the Wongawilli. The seam is composed of oil shale and carbonaceous shale with coal bands. The proportion of each is quite variable. The seam ranges from 8 to 25 feet thick.

Tongarra Seam (formerly called No. 4 Seam) lies about 35 to 65 feet below the Wongawilli Seam and has only been developed in recent years, by three collieries in the vicinity of Tongarra about 8 miles west of Albion Park. These collieries produced in 1950 71,000 tons. The coal is inferior but the new Tallawarra Power Station will have boilers designed specially to burn it. It is strongly coking, but because of its high ash content is used only in coking blends. It has a maximum thickness of 16 feet 3 inches of coal and bands at Tongarra. The maximum thickness worked is 9 feet, but sections as thin as 4 feet are worked; the worked section is at the top of the seam. The ash

content ranges from 15 to 25% and calorific value from 10,000 to 13,000 B.Th.U's/lb. The main area of development of the seam lies between the Macquarie and Bong Bong Passes. The workable section thins to the south and appears to split to the north.

The No. 5 Seam lies generally 25 to 90 feet below the Tongarra Seam and consists of 4 to 14 feet of coal and bands.

The Woonona or No. 6 Seam lies about 55 to 100 feet below the Tongarra Seam and generally contains 2 to 7 feet of coal and bands. However, in the Upper Cordeaux Bore it has a recorded thickness of 16 feet 3 inches of inferior coal and a 1 inch band. It has been worked on a small scale, the worked thickness being 9 feet.

The No. 7 Seam lies about 180 to 220 feet below the No. 6 Seam and contains only about 4 feet of coal and bands. It does not appear to be of commercial grade.

A lower seam of 7 feet of coal bands was reported from a drill at Bulli and was considered to belong to the Tomago Stage of the Upper Coal Measures. It only contains about 3 feet 5 inches of coal altogether.

The Douglas Park District.

The Douglas Park District of the Southern Coalfield lies between the Illawarra District of the Southern Coalfield and the Wollondilly District of the South-Western Coalfield. It has as its centre the town of Douglas Park, which is on the Main Southern Railway 43 miles south from Sydney.

The coal measures are a concealed continuation of the Upper Coal Measures of the South Coast lying beneath a cover of about 1800 feet of Mesozoic sediments. The field has been partly tested by a number of drill holes and interpolation from measurements on exposures in the cliff sections in the Southern and South-Western Coalfields. It is considered that reserves of more than 100,000,000 tons of coal exist in the Bulli Seam area proved by the Appin, Menangle, Douglas Park, and Bargo Bores, the results of which are listed in Table 5B.12. This coal resembles the Bulli Seam of the coastal area and provides an excellent reserve of steaming and coking coal within easy reach of Sydney. The lower seams of the series have not been fully tested.

In the Appin Bore the 8-foot seam has been correlated with the Bulli Seam, the 3-foot seam with the Balgownie Seam and the 21-foot with the Wongawilli Seam of the Illawarra District.

The Clyde District. The coal measures of this area, which lies at the head of the Clyde River, 4 miles south of Sassafras on the Braidwood-Nowra Road, are confined to beds corresponding to the Greta or Lower Coal Measures of the Northern Coalfield.

The Clyde Coal Measures form part of the southern margin of Permian basin and dip gently north and east towards the centre of the basin.

Several seams occur. The bottom or No. 1 Seam contains about 8 feet of coal split by shaly bands. The No. 2 Seam lies about 50 feet above the No. 1 Seam and contains about 3 feet of good quality coal.

The coal is a medium-volatile bituminous coal; it has a volatile content of about 30% and an ash content of 7%. Like the Greta Coal it contains 1.3% of sulphur, which is high for New South Wales coals.

It is a good all-purpose coal. No information is available about reserves. The seams in the area could be worked

TABLE 5B.12.

APPIN BORE		DOUGLAS PARK BORE		MENANGLE BORE		BARGO BORE	
Depth to Top of Seam	Thickness of Seam	Depth to Top of Seam	Thickness of Seam	Depth to Top of Seam	Thickness of Seam	Depth to Top of Seam	Thickness of Seam
1614ft. 9ins.	8ft. 3ins	1687ft. 9½ins.	8ft. 10½ins.	1794ft. 6ins.	8ft. 9ins.	1279ft.	5ft.
1647ft. 5ins.	3ft. 4ins.	1728ft. 8ins.	1ft.4ins.	1838ft. 0ins.	2ft. 10¼ins.	1312ft.	1ft. 6ins.
1710ft. 0ins.	21ft. 6ins.					1392ft.	14ft.
1940ft. 0ins.	4ft. 4ins.	Maximum Depth of Hole 1730 ft.		Maximum Depth of Hole 1843 ft.		Maximum Depth of Hole 1410 ft.	
Maximum Depth of Hole 2295 ft.							

profitably but inaccessibility of the occurrence has prevented development to date.

A hole drilled 16 miles north-east at Wandandian in 1890 intersected a 13 foot 5 inch seam of the Clyde Coal Measures at a depth of 1331 feet. The seam was heavily banded. Field observations show that the Greta-Clyde Coal Measures are not continuous in the Southern Coalfield but occur as small isolated basins in the older Palaeozoic basement rocks.

The Southern Coalfield contains abundant reserves in all seams of steam coal. Gas coal is essentially limited to the Clyde River seams and large reserves of excellent coking coal occur in the Bulli and Wongawilli Seams.

Faulting is common in the coastal area of the Illawarra District and increases in intensity from Albion Park northwards. Two main groups of faults exist: (a) A series of low-angled faults striking 125°, and having vertical displacements of from 20 to 223 feet and, (b) a series striking 15° and having vertical displacements of from 5 to 30 feet. Many faults whose strike does not conform to these groups also occur. The usual dip of the seam is 1° or 2° with a wide variation from these figures owing to rolls, faults, and intrusions.

Igneous activity has been considerable within the Southern Coalfield and large areas of coal have been coked or destroyed. The intrusions are mainly in the form of dykes and sills, confined to a coastal belt and decreasing in number inland. Activity is found more than about 10 miles inland. The cindered areas of the seams caused by intrusive sills have been shown to occur at structurally high points.

Much of the South Coast coal is of a friable nature and has caused considerable dust trouble. In one colliery at Coalcliff there were at one time as many men on compensation - mostly because of dust trouble - as there were working at the coal face.

A successful method of water infusion of pillar and solid coal was finally developed in this colliery and is now used in other dusty mines in the area.

The most important group of collieries is that of Australian Iron and Steel Co. Ltd., who operate five collieries which are highly mechanised, employing diesel and electric underground haulage, mechanical loaders and cutters, and power borers. A continuous mining machine was employed for some time but was temporarily withdrawn owing to dust trouble. The collieries, with one exception, are being linked by a private railway over which most of the coal will be hauled by diesel locomotive directly to the coal washery at the Company's Port Kembla steelworks. An ultimate daily target of 11,000 tons has been set for the A.I.S. chain of collieries; Mt. Nebo alone will contribute 3,000 tons.

SOUTH-WESTERN COALFIELD.

The South-Western field adjoins the Southern Coalfield on the east and the Western Coalfield at the north near Wentworth Falls. It is divided into two districts: the Moss Vale - Berrima and the Wollondilly - Nattai. The field is traversed from north to south by the Main Southern Railway; branch lines run from Moss Vale to Berrima and Port Kembla, and an additional line is planned from Thirlmere to Burragorang Valley.

The coal-bearing sediments except for a small area at Tallong all belong to the Upper Coal Measures which range in thickness from 0 to 1000 feet in the area. The only working centres on the field are Canyon Leigh, Berrima, and Burragorang Valley. Old disused collieries exist in the area between

Bundanoon and Moss Vale.

The systematic geological survey of the coalfield is still in the early stages, but indications from places where the field has been tested are that it contains large quantities of coal amenable to selective underground mining.

Production from the field rose from about 372,000 tons in 1948 to 525,000 tons in 1950. Although most of the coal is suitable only for steam raising and cement and brick manufacture, and much of it has a high ash content, the future will see large developments in this area. The railway from Thirlmere to Burragorang will provide a direct link for the mines of the Burragorang Valley, where an excellent steam coal within easy reach of Sydney is being mined.

At Bundanoon, 99 miles by rail from Sydney, two coal seams outcrop on the cliff walls of Christmas and Bundanoon Creeks. The seams are lenticular and non-persistent and the quality of these coal seams at Exeter, about 3 miles north of Bundanoon, is still fairly poor. Only the upper or Top Seam appears to be of commercial standard. It is thought to correspond to the Wongawilli Seam of the Southern Coalfield. In the past three coalmines were opened in the vicinity of Bundanoon and Exeter but only worked for a very short time. Twelve miles south-west of Bundanoon, a prospecting tunnel was driven in an outcrop of cannel coal near the town of Tallong. The seam was only 2 feet thick and the tunnel was abandoned. The seam has been correlated tentatively with the Lower Coal Measure seams of the Clyde River.

Eastwards from Moss Vale and Exeter towards Fitzroy Falls and Meryla there is a distinct improvement in the Upper Coal Measure coal seams and it is likely that there are large reserves of coal suitable for underground mining in this area.

Westward from Bundanoon the Canyon Leigh Colliery is working the upper 12 feet of a 30-foot seam of coal which is considered to be an extension of the Wongawilli Seam.

North of Canyon Leigh and 5 miles west of Moss Vale lies Berrima, where two collieries produce coal from the Wongawilli Seam for the cement works at Berrima and Maldon. The Bulli Seam does not outcrop in this area because it has been overlapped by the Triassic sediments or eroded before they were deposited. Much of the coal produced from the Wongawilli Seam at Berrima has an ash content exceeding 20%.

Further north at Joadja the Wongawilli Seam ranges from 38 to 44 feet in thickness including bands and lies immediately below the base of the Triassic. A number of thin seams are known to lie below this thick seam but have not been prospected very thoroughly. Among these thin seams is a continuation of the Lithgow Seam of the Western Coalfield, which here attains a thickness of 4 feet.

At Mittagong, 80 miles from Sydney on the Main Southern Railway, drill holes have shown the Wongawilli Seam to have a thickness of from 32 to 36 feet including bands. The lower portion of the Seam appears to be the best. The Tongarra Seam is also considered to be present about 80 feet below the Wongawilli. A laccolith of sölvsbergite has partially changed a seam on southern side of the gorge near the top of the Nattai River into a coal of anthracitic to semi-anthracitic rank which is being developed by a small adit colliery. This seam is probably the Wongawilli.

At Colo Valley both the Bulli and Lithgow Seams have been recognized. The Bulli Seam is about 5 feet thick and the Lithgow Seam is 6 feet thick. The Bulli Seam is considered to be absent in the area bounded by the Nattai River, Little River,

and Blue Gum Creek.

Wollondilly-Nattai District.

In this section of the South-Western Coalfield the Bulli Seam is again strongly developed. At Burragorang, the centre of the district, about 20 miles due west of Camden, two mines working in 1950 produced about 380,000 tons. They are working the Bulli Seam which, although it has an average thickness of about 7 feet in the District, is only about 6 feet thick in the Burragorang area. The seam produces an excellent steam coal. In Brimstone Gully, north of Burragorang, the seam is about 7 feet 4 inches thick. The coal is of medium-volatile bituminous rank and said to be of good quality.

At Riley's Gully, 4 miles south of Brimstone Gully, four seams crop out. The top or Bulli Seam attains a thickness of 5 feet 10 inches of high-grade coal with only one band. Thirty feet below this seam lies the probable equivalent of the Balgownie Seam of the Southern Field. In this locality it contains only a few inches of coal in carbonaceous shale. The Wongawilli Seam is represented by 20 feet of coal and bands lying 50 feet below the Balgownie Seam. The lowest seam lies about a hundred feet below the Wongawilli and contains about 3 feet of coal. It is probably the Lithgow Seam, which can be traced intermittently from the Western Coalfield.

In the Burragorang Valley in general the Lithgow Seam averages about 5 feet of coal and shale with the latter predominating. At Higgins Creek, near Mount Tonalli on the western side of the Burragorang Valley, the Lithgow Seam is reported to consist of 10 feet of coal.

WESTERN COALFIELD.

In the more deeply dissected gorges of the Blue Mountains plateau coal measures of the Western Coalfield are exposed from Wentworth Falls to the vicinity of Dubbo, which is a rail town on the Main Western Line, 287 miles from Sydney. The commercial centre of the field is Lithgow, which is 97 miles by rail from Sydney. Most of the coal from the field is transported by a branch line running from Mudgee to Wallerawang and thence by the Main Western Line to Lithgow and Sydney.

The Upper Coal Measures range from about 200 to 1000 feet through the area but in the main area about Lithgow only about 300 feet of the Coal Measures occur. These contain seven coal horizons, but only five of these are important.

The majority of the Western collieries are working in the area between Lithgow and Ben Bullen. The most northerly operating colliery is at Kandos; and prospecting which has produced promising results is taking place at Ulan further north. Prospecting on the Talbragar River near Ulan did not produce very hopeful results.

The Katoomba Seam or No. 1 Seam, as it is sometimes called, occurs immediately below the base of the Triassic and was originally opened up in 1882 at Katoomba. The main area of development is from Hartley to Katoomba and the Grose River. The seam is now worked only at Hartley and Glen Davis. It thickens from about 3 feet at Hartley to 6 feet in the Grose Valley. At Glen Davis an 8-foot band splits the seam into an upper split of 5 feet and a lower split of 6½ feet. Only the lower split is worked, the upper split being inferior. The seam is practically unworkable towards Lithgow, in the Wolgan and Capertee Valleys, and at the head of Widdin Brook. In 1951 the Katoomba Seam yielded 18,6000 tons of coal.

The No. 2 Seam is 25 to 40 feet below the Katoomba and

only contain 1½ to 3½ feet of coal and bands.

The Dirty or No. 3 Seam occurs 20 to 30 feet below the No. 2 Seam and contains about 8 to 18 feet of coal and shale. The shale banding is particularly heavy. It is too dirty to work without beneficiation.

The Irondale Seam or No. 6 Seam lies about 120-140 feet below the Dirty Seam. The intervening strata contain one or two thin coal seams of no immediate importance. The Irondale Seam ranges in thickness generally from 4 to 7 feet and is divided into an upper and lower split. It is not being worked but some of it may be mined by open-cut methods in the future. The most important development of the seam is in the central portion of the Lithgow-Lue area. It is well developed in the vicinity of Lithgow, Capertee Valley, and Kandos, but near Katoomba it is difficult to trace. It is considered that the 7 foot 3 inch seam encountered in the Woodford bore may be the Upper Irondale Seam.

The Lithgow Seam is the most important seam on the Western Coalfield production of 2,447,100 tons. North-west of Lithgow towards the edge of the Basin in the Lidsdale-Blackman's Flat area the seam is split into an upper and lower portion. The Upper portion is known as the Lidsdale Seam and ranges from about 2 to 7½ feet. The main Lithgow Seam ranges from about 3 to 8 feet in the area of splitting. In the central portion of the field the lower parts of the seam are of better quality than the upper. South and south-east of Lithgow the seam thins gradually. At Hassans Walls the seam is 8 feet 4 inches thick and at Katoomba it is 7 feet; but at Victoria Pass it is only 2 feet 1½ inches.

The 8-foot coal seam struck in the Woodford Bore and the 4-foot seam struck in the Eureka Bore are thought to represent the continuation of the seam eastwards to Penrith.

Northwards from Lithgow the seam attains a thickness of about 10 feet at the Invincible Colliery, Cullen Bullen. In the Capertee and Grose Valleys the seam thins considerably. At the western head of Nellie's Glen it consists of about 6 feet of carbonaceous shales with bands of bituminous coal. From Rylstone to Lue the seam contains a fairly constant thickness of about 5 feet of coal. At Tong Bong Mountain in this area, the seam is 12 feet 9½ inches thick. However, from Lue to Cooyal it is noted for its variability, attaining up to 7 feet of coal in places, and only coaly streaks in carbonaceous shale in others. At Ulan north of Cooyal the Lithgow Seam, locally known as the Ulan Seam, attains a thickness of 25 to 30 feet. The lowest 3 feet 8½ inches is of better quality and is the section mined. The coal produced is a steam coal but may have some coking properties. At Airly Mountain the Lithgow Seam is 8 feet 2 inches thick and contains large valuable reserves of steam coal. The lower section of 3 feet 11 inches of this seam yields a coal superior to run-of-mine coal in most of the Western pits. Coal of the Lithgow Seam also outcrops at a number of other points in the Wollar and Goulburn Valleys and near their tributaries east of Ulan. At the head of Growee Creek the seam is 5 feet, and northwards on the eastern side of the gap between the Wollar and Goulburn Valleys the seam only consists of 3 feet of carbonaceous shale.

The Western Coalfield is remarkably little disturbed structurally. Igneous activity has affected some areas, mainly in the northern part of the field. Volcanic plugs are found in the central part of the area. Dips on the whole are low and rolls almost insignificant. Wash-outs or contemporaneous erosion channels occur occasionally but are not serious.

Large quantities of open-cut coal occur in the valleys of the Western Field. Most of the reserves occur in the Lithgow, Lidsdale, and to a lesser extent in the Irondale Seams. The underground collieries are worked by tunnel entries into the cliff sides.

The Western coal is essentially a steam coal but contains some coking coal, and is used locally for gas.

The completion of the railway from Sandy Hollow to Maryvale will ultimately open up for prospecting large areas of the Upper Coal Measures in the Goulburn and Wollar Valleys.

NORTH-WESTERN COALFIELD.

North-Western Coalfield. The most northerly section of the Main Coal Province, stretching from Murrurundi in the south to the Nandewar Mountains, 150 miles to the north, and then south-westerly to Dubbo, has been designated the North-Western Coalfield.

The greater portion of the Coalfield is capped with Mesozoic sediments which for the most part contain no commercial coal seams. Ther Permian and Carboniferous sediments are only visible where erosion has removed the younger sediments along a thin belt of country lying 20 miles on either side of the Main Northern and North-Western Railways.

Collieries have been worked or started at Gunnedah, Curlewis, Werris Creek, Currabubula, and Breeza. Coal is now mined only in two collieries in the Gunnedah-Curlewis area and in one at Werris Creek. Coal production for the whole coalfield rose from 102,756 tons in 1948 to 139,900 tons in 1951.

The Carboniferous coal seams are limited to an area north-east of the Werris Basin.

The Permian coal seams occur in beds corresponding to both the Lower and the Upper Measures of the Hunter Valley. The Lower Coal Measures are developed and outcrop in a narrow belt of country from Willow Tree to Currabubula, where they attain a thickness of about 550 feet. A seam thought to be of poor quality was opened about 1926 near Currabubula. The Lower Measures are also developed from north of Gunnedah to the Nandewar Mountains, where about 1000 feet of these sediments occur. The Upper Coal Measures outcrop from about 10 miles south of Breeza to about 12 miles north of Boggabri, parallel to and west of the Namoi and Mooki Rivers.

At Willow Tree near the New England Highway and the Main Northern Railway crossing the Upper Coal Measures contain a very steeply dipping seam 10 feet in thickness and of good quality. The occurance of a 15 foot seam at a depth of 100 feet has been reported also in the same district.

At Werris Creek a small outlier of Upper Coal Measures known as Colliery Basin occurs. The following table shows the location of the seams in the coal measures of this basin:

TABLE 5B 13.

Thickness of Seam.	Height Above Base of Measures.
12 feet	154 feet.
3 feet	95 feet.
4 feet 8 inches	4 feet.

A fourth seam possibly occurs 33 feet above the base of the Measures.

The Werris Creek Colliery is working the Top or Tunnel Seam. The section mined is 10 feet thick and contains a medium-volatile bituminous coal with low ash content. In 1951 a total of 21,000 tons of coal was produced from this seam. Dykes have cindered considerable areas of the seam

and small faults occur.

The Gunnedah-Curlewis area is the most important section of the coalfield. No seams are known in the Lower Coal Measures outcropping in this area. The known coal seams occur in the upper 500 feet of the Upper Coal Measures outcropping south-west of Gunnedah and extending to the north-west of Curlewis. There are two seams which have been widely tested:

Hoskisson's Seam, sometimes known as Gunnedah, Curlewis, or Pryor's Seam, is the upper of two tested seams and lies from 240 to 300 feet below the top of the Coal Measures. It has been the greatest producing seam in the district. The seam is up to 16 feet thick. Sections of up to 9 feet but on the average only 7 feet 6 inches are being worked in the two collieries. The upper 1 to 1½ feet of this section was rejected formerly because of its low ash-fusion temperature. In 1951 112,500 tons of coal were produced from Hoskisson's Seam.

Melville's Seam, lies about 150 to 190 feet below Hoskisson's Seam. It has produced very little coal; 1951 production was only 6,400 tons. The seam is banded and considered inferior to Hoskisson's. The quality of the coal is stated to be good. Measurements so far indicate a seam thickness of about 6 to 8½ feet.

A seam of 12 to 15 feet containing many bands is recorded as being 190 feet above Hoskisson's Seam at Curlewis. Another seam 5 feet thick is recorded 90 feet below Hoskisson's Seam.

The seams of the area have suffered considerably from igneous intrusions in the form of dykes. Faulting is also common and faults with throw up to 75 feet have been encountered in the workings.

In the Breeza area coal has been struck in several wells and encountered in the course of prospecting operations. It is thought that either Hoskisson's Seam is splitting in this area or that additional seams have been formed. Melville's Seam has also been prospected.

In the Boggabri district only the Upper Coal Measures are present. An 8-foot seam has been reported about 750 feet beneath the top of the Coal Measures. Another seam possibly corresponding to Hoskisson's Seam occurs about 100 feet from the top of the Measures. A number of bores in the district have also struck coal but the information obtained has not yet been fully compiled.

In the Narrabri District only the Wean Formation of the Lower Coal Measures contains coal. Seams of up to 5 feet, of unknown quality and with shallow dips, have been reported in the Killarney Gap and Rocky Creek areas and further south.

At a point about 9 miles north-east of Werris Creek, Carey (1937) has reported a number of impure coal seams near the base of Lower Kuttung Series of the Carboniferous. They are at least four in number and the highest is about 6 feet thick.

In the western section of the North-Western Coalfield about the Coonabarabran and Binnaway districts the Purlawaugh or Gowen Beds of Jurassic age, which attain a thickness of 200 feet, contain a number of coal seams of little or no economic importance.

THE ASHFORD PROVINCE.

Coal measures of Lower Permian age occur intermittently in a narrow belt of country running from Texas on the Queensland border to Inverell in the near north-west of New South Wales.

The main known reserves of coal in the Province occur 8 miles almost due north of Ashford in the vicinity of the Severn River. In 150 acres of the coal measures tested by drilling in this locality indicated reserves of 4½ million tons have been established in the Ashford Seam.

The Ashford Seam is the only known seam of importance on the field. It occurs north of Ashford and is generally found within 80 feet of the base of the coal measures. It ranges from 7 to 51 feet in thickness and contains an excellent low-volatile bituminous coal which has a high calorific value and possesses some coking properties.

The only other seam present in the Ashford area is the Bonshaw Seam which lies about 130 to 170 feet above the Ashford Seam. It is largely composed of shale bands.

The Coal Measures in the Ashford area form a narrow belt of sediments running northwards and attain a thickness of about 1000 feet. They rarely exceed 1200 feet in width. The measures are cut off on the west by a large fault known as the Severn Fault. The eastern boundary is an unconformable junction with Carboniferous sediments. The seams dip on the average at about 26° to the west.

At Arthur's Seat, 9 miles south of Ashford, a small basin of Permian sediments occurs but seems to contain no workable coal.

At Arrawatta, 10 miles north of Inverell, a small area of Permian sediments contains near the base a 10-foot seam of coal of excellent quality dipping 55° to 60° west at the outcrop. The area is largely obscured by alluvium but the sediments appear to be faulted on the west against granite. The dip of the beds appears to diminish towards the western boundary.

The coal seams of the Ashford Province have been regarded as corresponding to the Greta or Lower Coal Measures of the Main Province.

About 20 miles west of Ashford in the vicinity of Ena Creek near Wallangra seams of good quality coal have been encountered in wells. Little is known of these seams, which may be either in the Jurassic sandstones of that area or possibly an extension of the Ashford Coal Measures.

Coal is not being mined in the Province at present. The difficulties of transport to market and of mining the steeply-dipping thick friable seam have been a considerable barrier to development. It is planned to re-open the Ashford Seam near the old Ashford Colliery to supply a proposed power station near the Severn River.

THE RIVERINA PROVINCE.

This isolated province lies in the far south of New South Wales and has only been developed in the area around Oaklands and the neighbouring rail siding of Coorabin. Oaklands itself is an important rail junction between the different railway gauge systems of New South Wales and Victoria. It is 35 miles north of the Murray River and 55 miles north-west of Albury. The junction is 200 miles from Melbourne and 417 miles from Sydney.

The coal is of Permian age and is thought to correspond to the Upper Coal Measures of the Main Province. The coalfield is concealed. The Permian sediments lie in a basement of metamorphic sediments and granite, and are overlain unconformably by Tertiary sediments. These overlying sediments contain aquifers which limit the mining area to those sections above the water-table or beneath sufficient cover of Permian shales.

The coal measures are known to contain three seams in the full sequence; in places they almost coalesce to form a single seam. The total thickness of the seam generally ranges from 20 to 55 feet including shale bands. To the north and east of Coorabin the seam thins and deteriorates and was subjected to erosion before the deposition of younger sediments. Lanes Colliery, the more important of the two main collieries which worked in the area, is working an 8-foot section of a possible workable 16 foot section in the seam of 28 feet total thickness. As far as is known the field has suffered no large-scale faulting, igneous intrusions, or pronounced folding. The dips of the coal seam are gentle for the most part and follow the basin-like structure of the basement.

The coal is non-coking and varies from low-grade bituminous to sub-bituminous rank and has a decidedly woody appearance.

Pyrox Ltd. of Melbourne have had experiments carried out by the Lurgi Co. in Germany on briquetting Coorabin coal. The report showed that a hard briquette could be manufactured but would not stand exposure to weather. However if the briquette is carbonised in a flushing gas immediately on manufacture a very hard and resistant coke is formed, suitable for domestic and many industrial purposes.

The exact boundaries of the basin are unknown. Indications from geological and geophysical information are that the field is probably limited to the north-east of Coorabin by Billabong Creek and that it does not reach further west than 6 to 8 miles west of Savernake. To the south the basin may extend as far as the Murray River.

Production from the one underground colliery on the field in 1951 totalled 4,500 tons which showed a considerable decrease on the 1950 figure of 12,500 tons. The field is geographically important as a source of low-grade bituminous coal handy to the transport systems of New South Wales and Victoria. Reserves available around Lanes Colliery are limited to 100,000 tons and any large-scale development of the field would require the construction of new pits. The possible reserves of the entire basin may amount to several thousand million tons. Drilling during 1950 proved the existence of reserves of 793,000,000 tons in an area of 25square miles around Oaklands and Coorabin.

THE FAR NORTH COAST PROVINCE.

An area of 7500 square miles in the north-east corner of New South Wales is covered by Mesozoic sediments. These beds are continuous with the Mesozoic sediments of Ipswich, Killarney and Beaudesert in Queensland. The area is hyperbolic in outline, opening on the Queensland border and stretching for 120 miles in a southerly direction, attaining a maximum width of 65 miles. Mining is restricted to the vicinity of Bonalbo and Nimbin, where Jurassic coal is mined, and to Nymboida where the producing coal measures are of Triassic age. The three collieries which worked in this Province in 1951 produced 17,900 tons, which was more than three times the 1948 production of 4,950 tons.

The Triassic sedimentary basin is considered to have been smaller than the Jurassic basin and had its axis running from Nymboida to a point between the Richmond and Clarence Rivers, whereas the Jurassic basin had a more northerly striking axis and largely overlapped the Triassic beds. Consequently Triassic beds have so far only been located at Nymboida, at Buchanan Head and Red Cliff 8 to 10 miles south of Yamba, north of Evans Head, and possibly at a depth of 3,400 feet towards the centre of the basin in the Grafton Bore.

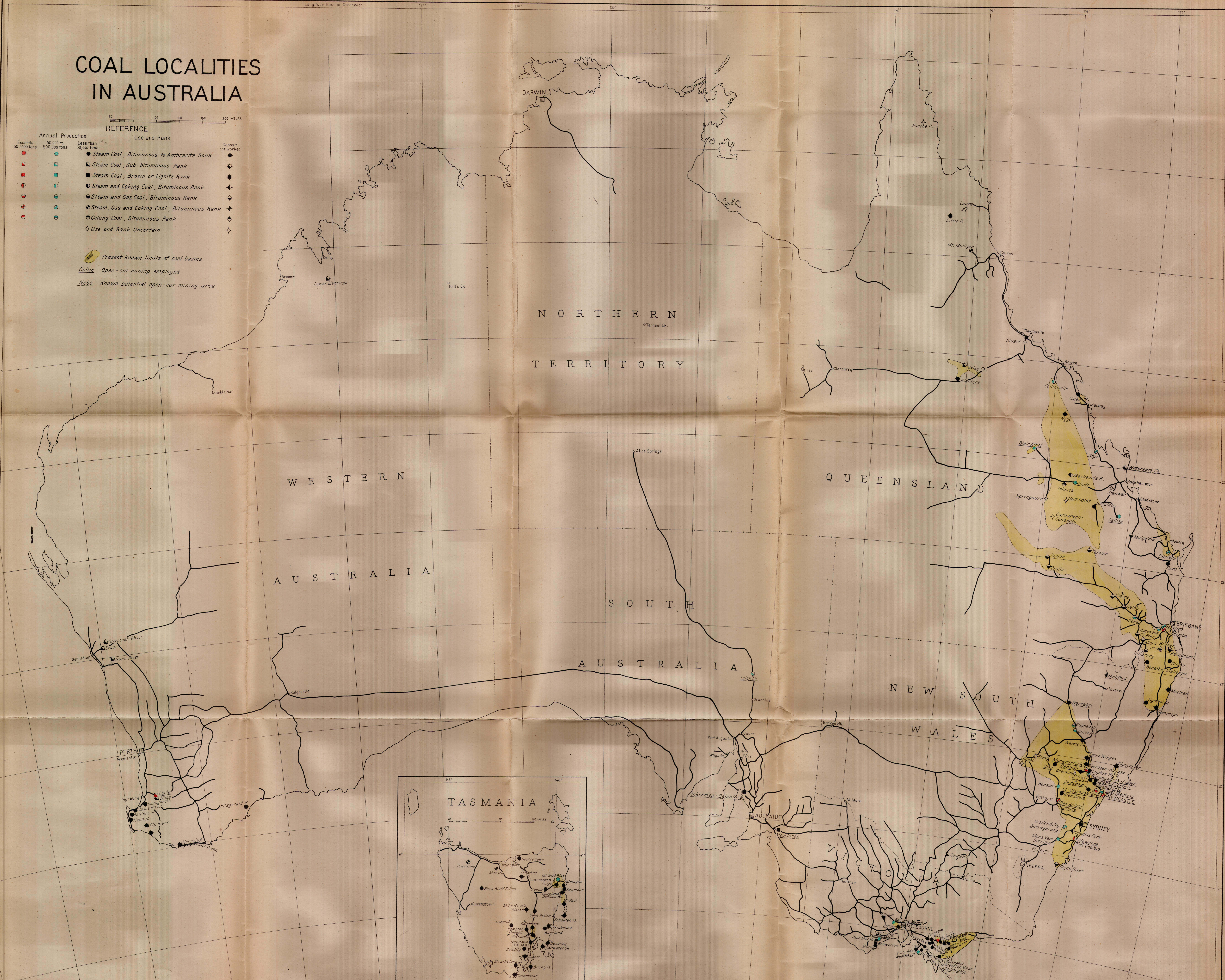
The coal-bearing Jurassic Mallanganee Stage of the Clarence Series corresponds to the Rosewood Stage of the Rosewood and Walloon District near Ipswich in the West Moreton Coalfield of Queensland. It contains a number of seams up to 7 feet thick which are lenticular and heavily banded. It is unusual to find plies of more than a foot of clean coal. Ash content of the clean coal is in the vicinity of 25%.

The Triassic beds lie beneath a basal Jurassic massive conglomerate and other beds which correspond to the Bundamba Stage of the Ipswich Coalfield. The Triassic coal seams occur in the upper portion of a stage corresponding to the Ipswich Stage. These seams are few in number but contain fair quality coal. They range up to 4 feet in thickness generally and have an inherent ash content of about 15%. The main seam worked is known as the Nymboida Seam or the Farquhars Creek Seam and ranges in thickness from 3 to 5 feet. It yielded 15,000 tons of coal in 1951. The Grafton Bore intersected a 7-foot seam at 3,419 feet.

The dip of the coal measures in the basin is generally less than 10° and a few anticlinal flexures are present. Faults are only of a minor nature. Towards the Queensland border large areas of the basin have been disturbed by igneous intrusions.

The coal has a good calorific value and with beneficiation is quite suitable for local use. Rapid variability of the quality and thickness of the seams of this area requires care in estimation of reserves and developmental planning.

It has been estimated that Farquhars Creek Seam contains 200,000 tons of extractable reserves east of the present Numboida Colliery. In the Moovern area near Coraki a 10-foot seam of inferior quality exists in the Jurassic sediments. Only the lower portion of the seam is workable.



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H.J.