GEOLOGY AND COAL MINING IN THE HUNTER VALLEY 1791 - 1861

by

D. F. BRANAGAN

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INTRODUCTION

This monograph deals with the growth of knowledge concerning the geology of the Hunter Valley, in particular the understanding of the coal seams and their associated rocks. This growth, like other aspects of the expansion of Australian scientific knowledge, has not been systematic. Before the advent of the trained scientist it depended on the work and interest of explorers, public officials, military officers, convicts, clergymen, gentlemen of leisure and miners.

Fortunately many of the original documents telling this story remain and it is possible to pick up and follow a thread which leads from the first discovery of coal in Australia to the present development of the coal industry in Newcastle. Probably of greatest scientific import was the long fought battle about the geological age of the coal measures in the Hunter Valley. The implications of this argument for theories of continental drift and the origin of the continents are considerable.

This monograph covers the development of our geological knowledge to about 1880, although it deals in particular with the period prior to 1860, as the following twenty years require a monograph to themselves.

GEOLOGY AND COAL MINING IN THE HUNTER VALLEY, 1791 - 1861

Discovery of coal near Newcastle

The first recorded coal discovery by white men in Australia is mentioned in the journals of Bligh and Tobin and refers to the find made on the banks of a small creek about thirty six hours sail north of Port Jackson on 30 March, 1791:[1]

> Walking along shore towards the entrance of the Creek we found several large pieces of coal - seeing so many pieces we thought it was not unlikely to find a mine, and searching about a little, we found a place where we picked up with an ax as good coals as any in England - took some to the fire and they burned exceedingly well.

This find was made by a party of escaping convicts, led by William and Mary Bryant - the latter was later befriended by James Boswell - on their epic voyage in an open boat to Timor, a distance of three thousand miles from Sydney. Bligh stated 'the Journalist remarks that it was with difficulty he got the boat into the Creek, there being shoal water across it, but he backed the boat without receiving any damage'. Bligh also commented that 'the circumstances of the coals being found may make the account valuable, but I am sorry I could not ascertain its exact situation'. Although the actual location is in doubt a likely spot is near the entrance to Glenrock Lagoon. The only likely alternative is the mouth of Lake Macquarie, the extent of which cannot be realized at the entrance.

The news of their discovery did not travel back to Sydney at the time. Similarly the discovery of coal by J-J.H. de La Billardière in south east Tasmania on 3 January, 1793, was not noticed in Australia and later finds of more practical

importance are still often referred to as the first discoveries.[2]

In June 1796 David Collins, the Judge Advocate of the Colony, noted in his diary[3] that 'the people of a fishing-boat returned from a bay near Port Stephens, and brought with them several large pieces of coal, which they said they found at some little distance from the beach, lying in considerable quantity on the surface of the ground'. However, there was no official reaction to this report until 20 August, 1796, when Governor Hunter wrote to Sir Joseph Banks:[4]

> I will send a specimen of that Coal mark'd, Hawkesbury river, and a piece of another, and I think a better kind, found by my Fishing Boats Crew a little to the Southward of Port Stephens in a small Bay where they had occasion to land, and where they assured me they coud [sic] have loaded the Boat, it lay above the Surface in loose pieces, and considerable quantity. I confess that I am a little doubtful at present of this last Coal, the fellows are so full of trick and deception that untill [sic] I have some further proof of the truth of this discovery, I shall not give it perfect credit. If there be much coal hereabout the Strata cannot be very far from the Surface. Though easily obtained if wanted, it appears that it has been long above the earth by its being so much worne [sic] by time.

The coal industry had its beginning in the following year. In June 1797 three shipwrecked sailors were rescued by fishermen near Wattamolla, twenty miles south of Sydney. They had made an incredible journey along the coast from near Wilson's Promontory, Victoria. They reported having found coal the day before their rescue.[5] With the permission of Governor Hunter[6] this locality was visited by George Bass and two of the shipwreck survivors. He described the seam and its occurrence thus:

> This Vein of Coal or at least the northernmost end of it that we could see commences about 20 miles to the

> Southward of Botany Bay. The land there is nearly twice the height of the north head of Port Jackson, not a steep cliff like it, but has here and there small slopes and lodgments on which trees and shrubs grow; the sea washes up so close to the foot of it that it is no more than barely passable without some danger in blowing weather. About 20 feet above the surface of the sea, and within reach of your hand as you pass along, is a Vein of Coal of about six or seven feet in thickness; the rock below it is slaty; but above it is of the common rockstone of the country. The vein does not lay perfectly horizontal but goes on declining as it advances to the southward until at the end of about two miles it becomes level with the surface of the sea, and there the lowest rock you can see when the surf retires is all Coal.

In fact a large fault occurs at Clifton which displaces the Bulli Seam and exposes the Wongawilli Seam. Bass, who believed the two seams to be one, commented that they were well situated for mining but that they probably extended further along the coast and how far inland he could not tell. He said: 'it is probable they extend a considerable way, for I am much mistaken if it will not be found that the Blue Mountains wind round to this place, and of course end there. If so, this stratum of coal may possibly run through the whole range'.[7]

Bass brought back three bags of the coal which proved to 'burn capitally' despite the fact that the specimens were 'unavoidably taken from the outside' and were 'rather injured by the weather'.[8] His report about the location was sent by Governor Hunter to the Colonial Office and to Sir Joseph Banks.

Hunter was becoming enthusiastic about the mineral possibilities of the colony. On 1 August, 1797, he wrote to Banks 'we have much ore in the land beside Iron, at least I think so, this would be good amusement for a mineralogist'.[9]

Shortly afterwards, in September 1797, an important discovery was made. Lieutenant John Shortland, R.N., had been sent north in an unsuccessful attempt to recapture convicts who had stolen and escaped in a boat.[10]

> Mr Shortland's pursuit, however, had not been without its advantage; for on his return he entered a river which he named Hunter river about ten leagues to the southward of Port Stephens, into which he carried three fathoms water, in the shoalest part of its entrance, finding deep water and good anchorage within. The entrance of this river was but narrow, and covered by a high rocky island, lying right off it; so as to leave a good passage round the north end of the island, between that and the shore. A reef connects the south part of the island with the south shore of the entrance of the river. In this harbour was found a considerable quantity of very good coal, and lying so near the water side as to be conveniently shipped; which gave it, in this particular, a manifest advantage over that discovered to the southward. Some specimens of this coal were taken to Sydney.

The coal seam discovered at Newcastle by Shortland was probably Dudley Seam, for many years called the Dirty Seam. Exploitation of the seam was facilitated because the outcrop occurred inside a sheltered harbour and was accessible from fairly high ground that was suitable for adit or drift mining. Moreover, the presence of fresh water made the site attractive to settlement. On Nobby's Island the Nobby's Seam is exposed at sea level but was obviously less accessible for mining.

Although Governor Hunter forwarded Shortland's specimens of coal from Newcastle to Sir Joseph Banks in England, there was no organized attempt to work the seam for some time. For the next two years or more the only coal obtained from Newcastle was that gathered or picked from the surface by crews of ships making occasional visits there. Hunter reported later:[11] 'The boats frequently went to load with

coal for the purpose of supplying the ships in Port Jackson going to India as an article for sale. They usually broke it from the cliffs with a pickaxe into the boat, or got it from an island mostly composed of coal, lying at the mouth of the river.'

In this period Governor Hunter was under pressure from the Duke of Portland, Secretary of State for the Colonies, to obtain coal for export to the Cape of Good Hope[12] but found himself unable to do so. Apart from a lack of ships to carry the coal, his excuse to the Duke was that:[13]

> The coal discover'd to the southward was inaccessible, being upon an abrupt dead coast where there is no inlet to secure a boat in; but that discover'd to the northward may be got at. I have not yet had an opportunity of examining that place myself, therefore cannot say in what quantitys [sic] we may be able to procure it, and what may be the most safe and eligible way of providing a cargo for a ship; but the experiment shall be tried, my Lord, and I will endeavour myself to obtain the local knowledge requisite for ascertaining to what extent your Grace's desire can be carried into effect.

It was not until September 1800 that Governor Hunter succeeded in dispatching a vessel officially to obtain coal from Newcastle.[14] Captain William Reid, in charge of the Martha, was assigned the task. His expedition was noteworthy in that he discovered coal elsewhere at a place he mistook for Newcastle. Sailing north from Port Jackson, he rounded Green Island, now Moon Island, which he thought was Nobby's, and entered the inlet of Lake Macquarie, to the south of Newcastle. The coal he found probably came from the Pilot Seams on the southern side of the inlet, near the site of the later Pilot Station. For many years the general area was known as Reid's Mistake.

Taking of coal from the land surface at Newcastle occurred intermittently until 1801. The work was done by 'individuals',

as described in the official reports, without governmental control. In fact, the businessmen involved were assisted by the government which provided the services of a c vict named John Platt, the only experienced coalminer in the colony, to inspect the seams.[15]

Organization of the coal industry came with Governor Philip King who succeeded Hunter in 1800. King had the advantages of changing circumstances and of personal interest stemming from his upbringing in the mining area of Cornwall.

Subsurface Exploration, 1799-1800

By 1799 coal had been discovered north and south of Sydney and fragments had been picked up in the rivers west of the tiny settlement. These discoveries aroused interest in the prospect of finding coal closer to Sydney, which would provide an impetus to the colony.

Sir Joseph Banks, who had travelled with Captain Cook to Australia in 1768-1770, continued to take a great interest in the country's scientific and technological advances and was closely in touch with all coal developments.[16] In March 1799 he approached the Navy Board in England seeking aid in the search for coal nearer Sydney 'at a more convenient place than where the present mine has been discovered',[17] but no particular location was specified. He was given permission to order some equipment. The price of a complete set of boring rods and parts, capable of reaching 100 yards and weighing eight hundredweight, was £40 if delivered within a fortnight. For £28 'a set of joints, taps and screws with wrenches, bits, drills etc', weighing five hundredweight, was available. Banks decided that iron rods could be obtained in the colony, and ordered the cheaper set of equipment from Wapshott, the only drill manufacturer in London. This was

probably the first drilling equipment to be sent to Australia, for even in England the use of drilling in coal exploration was relatively new and inefficient. Modern drilling practices began in France during the 1840's.

Some of the boring equipment must have been sent with great haste for on 20 November, 1799, we find Lieutenant Colonel William Paterson writing to Banks:[18] 'I have got 2 miners and next week intend trying the boring rods on the Banks of the Hawkesbury and by the next opportunity it is probable I shall be able to transmit you some information on that subject'. He wrote again on 20 February, 1800,[19] 'my excursion to the Hawkesbury was chiefly to exaimen [sic] the Terrace for Coal. I got down 150 feet through blue slate and got to a very hard rock from what came up with the bore, it appeared to be a sort of Granite the River rose so high that I was obliged to give up the pursuit for the present.'

More of the drilling apparatus reached Sydney in April 1800[20] and King wasted no time in putting the equipment into action, although Hunter continued to govern till September. Under the charge of the only miner in the colony, John Platt, eleven convicts were put to work boring at George's River,[21] near the mouth of Prospect Creek, about fifteen miles southwest of Sydney and inland from the coastal outcrops described by Bass. King wrote to Banks:[22]

> Unfortunately we have only one miner in the country, who is a convict for life. He is very clever, and is now boring over a seam of coal at the head of George's River, which is on the south-west side of Botany Bay. I send a small sample of the coal procured there in the box, which appears to be much superior to that found to the northward. As the miner is intelligent and master of his business, I hope we shall get at that article, but our great want will be engines, for no doubt the water will come upon us. The situation is handy for loading, and for vessells lying in Botany Bay.

Platt, our first coal miner, had been sentenced for life at Lancaster in 1798 and in 1800 arrived in Australia.[23] At George's River he first put down a shaft to thirty feet and then continued boring for a further sixty eight feet passing through two 'thin stratas of a very fine coal'; he considered the possibility of striking workable coal to be good. As he undoubtedly knew of the coal discoveries north and south of Sydney it is possible that Platt's practical experience suggested some sort of basin structure containing coal beneath Sydney, an idea vaguely foreshadowed by Bass. Furthermore it is probable that he recognized the freshwater nature of the sediments in the Sydney area and equated them with coalbearing rocks he had seen in the British coalfields.

The rocks penetrated by Platt belong to the Wianamatta Group of Triassic age and contain occasional lens shape masses of coal a few inches thick, but there is no extensive development of coal in the group. Platt very much underestimated the depth to coal: the Liverpool-Moorebank bore sunk between 1888-1890 reached coal at 2,494 feet.[24]

The northern find, variously called Hunter's River, Coal River, Coal Harbour, King's Town and later Newcastle, at the mouth of the Hunter River, although much further from Sydney than Coal Cliff in the south, was to assume major importance because of its better harbour facilities, and more suitable location for a settlement, although the treacherous river entrance made entry difficult even to vessels as small as forty tons.[25]

In April 1801 Hugh Meehan succeeded in taking a vessel, the Anna Joseph, into the mouth of the Hunter River and with the aid of convicts mined and loaded coal[26] unlike the weathered surface coal which held 'little or no bitumen' and was

therefore, 'totally unfit for the forge'.[27] The discovery and mining of coal brought in its wake a local demand for iron to make grates and other equipment.[28]

Early in 1801 King had written regarding Platt[29] - 'If he should in the end fail here [George's River] I shall remove him and his men to the northward of the rivers' [i.e., the Hunter River]. Political reasons hastened their removal.

The large number of Irish political prisoners had caused some uneasiness in official circles - 'there is much reason for apprehending that the principal people among them have been irritating the restless disposition of these people' - and to separate the ringleaders King decided to 'set up a coal works' at Newcastle.[30] The expedition under the charge of Lieutenant Grant set off on Wednesday, 10 June, 1801.[31] Also in the party was Lieutenant Colonel William Paterson, now Lieutenant Governor, who was to note 'the nature of soils in general [and] the quantity of coals that may be procured there'. Paterson, a confidant of Banks, had already proved himself a useful observer and collector of natural material in Africa and Norfolk Island.[32] Ensign Barrallier acted as surveyor and among the convicts were John Platt and his crew.

Reports written by members of the expedition outline their progress and contain information about the coal seams, although topographic details are not very specific. Paterson recorded in his journal on 15 June, 1801, that he had:[33]

> Landed and examined the point of land where the coals are, and likewise the sea coast to the southward, where there is a continuation of the same strata, with this difference, that as the land becomes higher a fourth stratum makes its appearance, and much superior to the other three; but, unfortunately, from the constant surfs it is not possible they can be conveyed from where they are, but by land carriage.

Paterson and Platt examined Nobby's for its possibilities of coalmining, and decided that the coal on the island was inferior to that on the mainland, as well as being harder and more dangerous to get. A site opposite on the mainland to the south was then chosen and digging began. Grant recorded:[34]

> I this day [4 July, 1801] visited the coal miners, and found them hard at work. They had found a strata of coals nearly four feet in thickness and of excellent kind. It was entirely from side to side through the hill - that is to say, from the harbour side to the sea on the opposite side; and on the low side which faces the harbour the miner informed me that they were not above ten yards down. This consequently will yield a supply of coals for a great deal of time. The miner informed me they were equal to any bed of coals he had ever seen in England. I saw a lump of them. It was clear and transparent, free from earth and smut, and no doubt will answer for any use whatever.

A further description of the area generally was given by Barrallier in a report to his patron Charles Greville:[35]

> The entrance to Hunters River lat. 32.57S is distinguished by an Island on its Southern side, which on coming from the Northward appears like a Castle being a perpendicular cliff of 203 feet on the South Side. The North Side is not steep and covered with grass. It is the highest land from Sidney [sic] to the entrance of Port Stephens from which it is distant 6 Leagues. The intermediate space is a vast plain... Coal is found on the South Side of the mainland called Colliers Point and is also found on Coal Island. It is got with great ease and the more they approach the level of the Water the better its quality. The same strata are found on Coal Island and the reefs you see marked on the Map are all coal as is also the Southside of the Island forming a sort of Tongue between the sand and the Island. This stratum is on the Level of the Water and small vessels may easily be laden.

Paterson recorded in his journal on 15 June, 1801, that:[36] 'The Point of land where I put the colliers to work I have called Colliers' Point...The soil is a light black mould about

a foot and a half deep, after which is the stratum of stone and clay above the coal, as it appears in the accompanying sketch.' The diagram Paterson included 'although crude' is significant in being the first geological section made in the Hunter Valley. In it he showed the relative positions of the coal seams.

Fortunately for Platt, another miner named Broadbent arrived in Sydney about this time and was sent to join him.[37] Platt and his men began work near the present Fort Scratchley. Their original workings were found again in 1881 when the foundations of the Fort were being constructed.[38] The tunnels varied in height between four and seven feet. The seam they worked was the Dudley, probably the upper split.

Despite trouble with the convicts, the community left in charge of Corporal Wixtead from June to September, 1801, and then under Surgeon Martin Mason from September to December, continued to produce coal under the primitive conditions prevailing. Some of Wixtead's correspondence has survived: in one letter he wrote suggesting that 'sum [sic] of the loose women of Sydney town' might be sent to Newcastle to act as coal wheelers.[39] In October three miners were working an adit and coal was being carried to the shore in baskets at the rate of three tons a day. Mason obtained improvements; a slab path for the carriers and a stone and sand wharf. He requested small candles, scales and weights, wheelbarrows, seven-pound hammers, a blacksmith, a broad axe and adzes, compasses, rule, oilstone and chalk line.[40] On 21 November, 1801, Mason wrote to King:[41]

> I have 3,820 baskets of coal at hand, or 190 tons...With three minors [sic] and three carriers I rais [sic] 180 baskets, or 9 tons a day. They can do this in five hours. One mine is 34 yards under ground; one do., 31; one do., 27; one do., 10. I can set nine more minors to work

immediately, and with one drawer for each can rais 190 tons per week. The strata of coal we are now working is 3 foot high, out of which there is 14 inches of clay and other rubbish, so we have but 22 inches of neat coal; over this there is a strata of 18 inches of good coal. In Fresh Water Bay I can open a mine where there is a strata of 3 foot neat coal under the above two stratas; the coals are of supereor [sic] quality. I send one cask as a specimen by this conveyance...Plat [sic] is a good working minor; I believe him to be a good man, but he cannot see much further into the ground than his pick cuts.

During 1801 coal was shipped to Sydney and 100 tons of coal were freighted to the Cape of Good Hope fetching six pounds sterling per ton. Early in 1802 crews from any available ships were sent to mine coal with pickaxes from the cliffs at Nobby's and Colliers' Point with the object of selling it for export to India and the Cape.

When Francois Peron was in Port Jackson, Sydney, in 1802 he saw vessels loaded with coal for the Cape and India.[42] Although this suggests that coal quickly became an article of export it is not borne out by King's report to the Colonial Treasurer[43] in which he states that bad success attended attempts to sell coal in India and the Cape. At this time King had sent samples for testing at the Shipyards, probably Greenwich, England, the results to be forwarded to the Colonial Secretary.

Regular mining ceased temporarily in 1802 when Governor King withdrew the soldiers and convicts[44] but ships occasionally called there after this to obtain coal.

Platt apparently was allowed to move fairly freely as he accompanied J. Palmer's party up the Hunter River in 1803. In May the Sydney Gazette recorded enthusiastically:[45]

A new Mine has been found at Hunter's River, which is likely to yield an abundance of the finest coal that has

> ever been witnessed. The discovery was made by J. Platt, a miner in the employ of J. Palmer, and a quantity of the coal brought round by the Edwin. A sample will be sent home by His Excellency, in His Majesty's Ship Glatton, and from the accounts given of the mine, we have every reason to affirm, that it will prove highly beneficial to the general interests of the Colony. The coal resembles that found in the Colliery at Leith, near Edinburg, but more flexible, is of a rich appearance, and easy to be worked.

Where this coal was found is not clear: it may have been as far upstream as Morpeth.

The reopening of the settlement and mine in March 1804 under Lieutenant Charles Menzies was a political move to offset the effects of the Irish convict outbreak at Castle Hill which occurred that month.[46] 'By removing the most daring characters (to the Coal River)...every future inclination of the kind will be removed.' No private persons were to be allowed to dig for coals without a permit from the Governor, who ordered that if any private vessel put into the port without a licence the crew was to be confined and the ship scuttled.

Menzies was soon able to report in the following terms:[47]

> An excellent mine has been opened, the strata of which continued a yard six inches thick [probably a part of the Dudley Seam]. This shall be worked in a regular manner, so as to enable us, at a future period, to carry it on in a most extensive manner.
>
> The mines have hitherto been dug by individuals in a shameful manner. Never have they been at the trouble of leaving proper supports, leaving them to fall in anyway, but until I receive your Excellency's commands on this head, the chief miner shall take care that this is not done in future.
>
> Fifty more convicts, if sent here, could be worked to great advantage, as I could wish to keep a quantity of cedar and coals always at hand.

No reports appear to have been sent to Governor King by the Secretary of State for the Colonies about the coal tests made in 1802, and on 14 August, 1804, King sent a specimen of coal for Sir Joseph Banks - 'There is also in the same box [with the beche-de-mer specimens] the specimen of a production at the coal-mines, 80 feet deep...at Newcastle'.[48] Despite the reference to depth all the early mines were tunnels and not shafts.

Some time previously, ex-Governor Hunter had written to Under Secretary King:[49]

> There are so many specimens of this coal in England that its qualities are known, and, I believe, considered very fine. If the coal-tar is considered any object, any quantity might be provided from this coal, and I apprehend the cinders, after the tar is extracted, would answer every purpose of an iron foundry, which might be carried on to any extent Government wished, the country abounding with so much of that ore.

Hunter's claims about iron ore proved to be rather extravagant, but they reflect an interest in this material which continued for many years.

The Development of Mining

From the beginning of settlement in Australia the British Government had been interested in the possibility of finding minerals, and appears to have made attempts to appoint official experts in mineralogy and mining many years before such posts were created in England. How far this may have been influenced by the very good scientific work carried out in the southern oceans by various French expeditions has still to be determined. The 1802 French expedition under Baudin recorded 'masses of schist bitumineaux which burned with a lively flame, giving off thick smoke and an odor of bitumen, found at the foot of the mountains near Parramatta'.[50] The

report published in 1807 is the first specific reference to kerosene shale in Australia, and probably refers to material carried down the Warragamba or Colo Rivers from Joadja, Newnes or Glen Davis.

Banks wrote in January 1801, to William Milnes of Ashover, Derbyshire, about appointing a miner John Allen to accompany Flinders on his circumnavigation of Australia. Allen was to take specimens of all rocks and particularly the contents of all mineral veins he found.[51] Although Allen went on the voyage his contribution was not significant, being subordinate to the work of Robert Brown, the botanist, who also described rock and mineral specimens.

The interest in mineral development in Australia by the Home Government was stressed when Lord Hobart wrote to Governor King in February 1803:[52] 'with a view to afford you the most efficacious aid in ascertaining the mineral productions of your Government, His Majesty has been pleased to appoint Mr A.W.H. Humphery [sic], a person in every respect well qualified for the duty, to be his mineralogist in the territories of New South Wales'.

Adolarius William Henry Humphrey[53] was the son of George Humphrey, the conchologist, and obtained his position, as had Barrallier, by the patronage of C.F. Greville.[54] He had very little scientific training and did not carry out his duties energetically. Apart from some examinations in the Port Phillip and Port Dalrymple regions, reports on salt deposits in Tasmania and on Norfolk Island, and a report on the specimens found on Barrallier's expeditions southwest of Sydney he did little geological work.[55] He resigned his position on the plea of ill health in 1812 after arguments with Governor Macquarie regarding free transport of his mineral collection to England.

No appointment to a similar position was made until 1823, although the Secretary of State for the Colonies, Earl Bathurst had suggested to Governor Macquarie in 1816 the appointment of a former convict named John Hutchison. Hutchison had come to the colony recommended by the Society of Arts but Macquarie rejected him and asked for a better qualified person.[56]

During A.W. Humphrey's period of office, John Platt continued to secure useful geological data. An interesting report of the coal deposits appears in the Sydney Gazette of 5 May, 1805,[57] under the heading 'Account given by John Platt, a Miner, of the Coal-mines at Newcastle':

> The coal mines on the sea side Government House, Newcastle, are 3½ feet thick, solid coal, and resemble those of Bushy Park, between Warrington and Prescot. - The same mine is also in Lord Derby's Park, near Prescot, called Nozely Park. - These coals are of the best quality, and are used for furnaces, malt-houses, etc. being free of sulphur.
>
> Those at the Harbour, by the Salt-pan, called New Discovery, from its being like a delf in Weston, near Prescot in Lancashire, are of a bad quality, having as much dirt as coal and fit for burning bricks, fire engines, etc.

The New Discovery was probably near the present intersection of Hunter and Brown Streets. The seam referred to was probably the lower split of the Dudley Seam. Comerford suggests that this might be regarded as the first technical report on the working mines at Newcastle.[58] No further record of Platt's activity in coal mining has been found. He received a free pardon in 1809 and died in Sydney two years later.

Bigge's report of 1822[59] tells us 'that the first coal mined was obtained from a seam level with the shore under what is now Flagstaff Hill and this stratum was worked until 1817',

and also that until 1817 mining continued to be 'by a drift made on the sea shore, and level with it, penetrating a seam of coal that showed itself under the large mass of superincumbent sandstone that forms the south headland of the entrance to Hunter's River'. The thickness of the seam was three feet one inch.

There is no evidence to dispute this information, despite occasional confusion in terminology whereby mention is made of shafts before 1817. The earlier mines were horizontal or inclined adits or tunnels made for their ease of access, and were not vertical in the usual sense of mining shaft. The so called Market Place 'shaft', between the present King and Hunter Streets, which was one of the first mines opened away from the Colliers' Point area, was probably that referred to by Grainger in his evidence before Bigge[60] as being abandoned after several floodings. Lieutenant Scottowe, who became commandant of the Newcastle settlement in 1811, opened another new mine but its precise location is not known. Certainly it was not inland where a shaft would have been necessary, because Jeffries' map of 1816 shows no mine inland, and Meehan's map of 1822 shows only one mine inland which is identified as a shaft opened by Wallis in 1817.[61]

Wallis' shaft was started by Thompson in 1814,[62] perhaps in consequence of an arrangement made by Governor Macquarie to export 154 tons of coal annually to Calcutta in exchange for Bengal rum.[63] It is interesting to conjecture whether this pleasant exchange eventuated, because three years later Wallis reported to Campbell: 'I am glad to inform you we have succeeded at last in procuring coals at the shaft commenced during Capt. Thompson's command after an excessive expenditure of gunpowder and labour'.[64]

Further details of this shaft were given by Grainger in evidence before Bigge.[65] It was 111 feet deep; eight 'professional' convict miners worked in it cutting coal in a place four and a half feet high; the coal was wheeled in barrows 100 yards to the bottom of the shaft, and raised by windlass. About twenty tons of coal were produced per day, each miner being required to cut two and a half tons. A drift to the shore was used to remove excess water. Location of this shaft is revealed by Meehan's map, by Close's panoramic view of Newcastle painted in 1821, and by subsidence that occurred in 1943.[66] The site was just inside the Watt Street entrance of the present mental hospital.

There are some complications in interpreting the early records of seam workings, because, between Shepherds' Hill and Hunter Street, the Dudley Seam changes dip and also splits into two sections which at times are separated by thirty feet or more of strata. The coal seams are also displaced by faults. The lower split of the Dudley Seam is generally poor coal and was probably not worked, with the possible exception of the 'shaft' sunk at the 'Market Place'. The seam mined here was either the lower split of the Dudley Seam or the Yard Seam.

Although the upper split of the Dudley Seam generally consists of good quality coal it deteriorates in the vicinity of Watt Street. Nobby's Seam was quite accessible and would almost certainly have been prospected, specially in the region of the present King Edward Park.

In general it can be stated that the Dudley and Nobby's Seams would most likely have been opened up first because of their accessibility. The better quality upper split of the Dudley would have been generally preferred.

The even better coal of the Yard Seam would have been worked only when shaft sinking came into operation. This seam outcrops at Shepherds' Hill but goes below sea level in the vicinity of Newcastle Beach. Openings along the sea cliff on this seam would have been too exposed to storms to allow safe mining. Nevertheless, it is probable that parts of both the Yard and Dudley Seams were being worked by 1822, while the Nobby's Seam may have been opened also.

As none of the officers in command was an experienced miner it is probable that the charges of poor working methods later made[67] were justified. However, although there were several changes of command at Newcastle between 1810 and 1820 some continuity in mining practice was assured by Benjamin Grainger who supervised the coal mine at least between 1812 and 1820.[68] He gained coal mining experience in Staffordshire and despite his inability to write was reasonably knowledgeable about mining matters. His evidence at the Bigge Enquiry contains many interesting snippets of geological information. When asked about the use of a boring rod Grainger commented 'we have never had one' indicating that the equipment used by Platt was not passed on, or wore out and was not replaced.

The mine being worked in 1820 was a shaft 'thirty seven yards' deep sunk in 1817 to a seam 'three feet and an inch' thick, probably the Yard Seam. Formerly a 'drift' almost at sea level 'at the bottom of the cliff' had been used to mine the same seam from its outcrop. Apparently the drift and shaft were connected because water which accumulated in the shaft was dammed and then moved by bucket into the drift 'by which it is carried to the sea'. This implies that the 'drift' was inclined towards the sea. There is a

contradiction in this information however because the seam dips towards the south west - Grainger also states this - and one would expect the drift to follow the seam inclination down dip away from the shore. However, a figure submitted to the 1908 Royal Commission[69] on subsidence at Newcastle by A.A. Atkinson, Chief Inspector of Coal Mines, gives a possible answer. The drift or adit leaves the seam and continues horizontally to connect with the shaft. This indicates it was constructed for drainage.

Paterson, in 1801, had given a brief description of the stratigraphic succession at Colliers' Point, separating clearly the seams, and mentioning the intervening strata, and Surgeon Mason had described the coal in the actual mine workings, but no attempt seems to have been made by the officers to study the seams and record their position in outcrop while the mine remained under military control. Doubtless they had many problems to attend to, and the recording of surface geological data on plans, rather than sections, was very little developed at that time even in Europe.

The quality of the coal, although often lauded in official documents, seems to have displeased many users. In March 1826 the Australian referred caustically to the 'mixed masses of incombustible rubbish and occasional clods of sulphureous stuff, which are too characteristic of the produce of the Newcastle mines at present'.[70]

Between 1817 and 1819 the upper Hunter Valley was opened up by the journeys of William Parr and John Howe. William Parr had previously accompanied John Oxley on his inland excursion as 'Mineralogist'. Parr seems to have been interested in the chemical testing of minerals but no

discoveries of note can be attributed to him. He pioneered part of the route via Putty later successfully followed by Howe.[71]

Negotiations for Private Ownership

The report made by Commissioner Bigge to the Home Government in 1820,[72] which commented so unfavourably and unfairly on many of Governor Macquarie's activities, recommended that the coal mines be leased to private individuals, but it was several years before this recommendation was acted upon.

Governor Brisbane wrote on 14 May, 1825:[73] [The coal mine] 'has been hitherto kept in the hands of the Government as there is no fit person to lease them on the usual principles of a Lordship, and, if let to [an] unskilful Individual, might inundate and destroy the mine: Coals are very productive revenue'.

In August, 1823, Under Secretary Horton had written to Brisbane[74] notifying him of the appointment of John Busby as Mineral Surveyor and Civil Engineer with an annual salary of £200 stg., 'who it is conceived may be most advantageously employed in the management of the coal mines'.

However Lord Bathurst envisaged Busby in a prospecting role, writing to Brisbane in February 1825:[75]

> Some portion of the attention and labor of Mr Busby... should be appropriated to the Colony of Van Diemen's Land... by which his professional assistance may be rendered in exploring that settlement so far as Minerals and Geology are concerned, more especially with respect to Coals and Iron, of the existence of which strong indications have appeared in the Southern part of the Island.

En route to Sydney, Busby had taken advantage of his ship's delay in Hobart to examine some of the coal bearing strata in

eastern Tasmania, upon which he wrote an official report.[76] Shortly after his arrival in Sydney he proceeded to Newcastle and in May 1824 wrote a report on his examination of the pier and the repairs necessary, on possible iron ore deposits, and on the coal mines.[77] His appraisal of the mines, working methods and suggested improvements indicate his previous training in the industry. His desire that the mine should return a profit to His Majesty's Government might have been partly prompted by thoughts of a future position of responsibility. Several extracts from this important report follow:

> I proceeded to examine the coal mines. The country around Newcastle presents an extensive coalfield, and to the south of it four seams have been discovered though no more than two are met with where the shafts have been sunk, and of these the undermost only has hitherto been considered worth working. It has been worked by a shaft a little to the westward of the commandant's residence. At the period of my arrival all the coal which could be kept water free by a mine driven in from the shore was exhausted. The seam had even been followed eighty yards to the dip, which is there one in fifteen and it was thus necessary to bale the waters five yards in perpendicular height. The quantity of coal free from water charge being thus exhausted a new shaft or pit had been sunk at a situation more to the south east, and from a ravine to the south a mine was driven to join it, where it passes the higher of the two seams which is there twenty yards from the surface, and the workings are thus relieved from all the water above its level - It was the intention of the overseer to keep the understream free of water by pumps for which he had made a requisition to the chief engineer at Sydney, and in the meantime, he was endeavouring to keep the pit clear by drawing the water in buckets to the top. As I found that the pillars of the old mine on which they had for sometime depended for a supply of coals were nearly wrought out, and that the means employed to relieve the new mine from water were inadequate to that end, I caused a cistern to be constructed in the timber yard, and placed where the mine joins the shaft on the upper seam - the water being discharged into this, a saving

> of twenty yards was effected in drawing it and the pit was soon cleared... The appearances of ironstone in the coalfields at Newcastle are such as I consider to merit no mention. What I have observed is very poor and from its situation (being chiefly embedded between the strata of sandstone) it would not be worth working even though its quantity were more abundant and its quality better.

He also suggested changes in mining techniques which would improve production.

Several years later Busby was a little more enthusiastic about the iron possibilities:[78]

> In the neighbourhood of Newcastle and embedded in the Sandstone connected with the Coal, an Argileaceous Ironstone is found in Nodules, and tabular pieces and in petrifactions of Wood, but the quantity is not considerable; it contains from seven to ten per cent of Iron, and together with what might be obtained from Reids Mistake or Lake Macquarie where it is found of a richer quality, might keep a Small Furnace in operation.

According to Dr J. Mitchell in his evidence before the Coal Inquiry of 1847,[79] Busby had expressed interest in taking over the mines himself and paying a rental, which 'would have been a saving to the public'.

In January 1826 John Busby's son James noted[80] that the Australian Agricultural Company 'have applied to my father respecting the coal which they have leased from the Government and from their anxiety to secure both his and my brother's services there is no doubt a very beneficial arrangement will be made - in fact while I am writing I believe the directors are applying to the Governor for leave to employ him [John Busby] at present'. Although Busby did not join the Company, he was in touch with developments at Newcastle[81] during the protracted period of negotiations between the various parties concerned with transfer of the mines from the Government to the Company. In February 1826 Busby was permitted by

Governor Darling to inspect the mines on behalf of the Company but Darling strongly opposed the proposed monopoly.[82]

During October 1827 Busby was informed that his 1824 recommendations for improving the workings had been put into effect.[83] Busby recommended that although the new workings were ready the old pits should be connected to the new and then worked out or worked until they were filled with water. He also obtained miners from Newcastle to work on the Sydney water supply tunnel but rejected some who were offered because of their inexperience.

Later in the same month he supplied information about the Newcastle coal measures in a report summarizing his knowledge of mines and quarries in the colony:[84]

> The only mines which, as far as I know, or have been able to learn, - have been worked in the Colony are those of Coal at Newcastle. The Coal-field is extensive, terminating to the Northwards near Port Stephens, where the Skirts of the Coal Metals are observable, and where the primary rocks commence. To the Southward I have not been able to ascertain its extent, but I have learned that Coal-Seams are visible to the South of Botany Bay in an inaccessible situation. From the Country within these limits, and extending inwards to the Blue Mountains, being altogether of this secondary formation, I think it probable that the whole is one extensive Coal-Basin; and that there is a probability of Coals being obtainable in many situations were trials made. I have seen a specimen of Coal from the Upper branches of Hunter's River, and the concomitants of that Mineral are very observable near Liverpool. I have also seen a specimen of very pure Cannel Coal from Mount York one of the most inland Mountains of the dividing Range.

At Newcastle where the Coal has been worked there are three Seams of different degrees of thickness: the deepest Seam from the Surface only has been worked, it is about three feet in thickness and is of the same nature, and nearly equal in quality to the best Newcastle Coal in England. The annual produce has not exceeded 3500 tons annually for the last 7 years; the increased demand for Home consumption being balanced by a proportionate falling off in that for Export to India: its value as delivered at the Wharf within one mile of the pit mouth is 10/6d. per ton, making the Annual value of its produce in round amount about £1850.

Near Lake Macquarie about fifteen miles to the South of Newcastle, there is a Seam of Coal, ten feet in thickness, consisting, first, of Bad slaty Coal 2 feet 9 inches, second, of Coal similar to that at Newcastle above described 3 feet 9 inches, and third of Cannel or Candle Coal of superior quality 4 feet 6 inches thick.

This report is a useful summary of Busby's knowledge of the local geology and is reasonably accurate. It is difficult to be sure how much other data Busby had about the region. With the pressure of work concerned with the Sydney Water Supply he would not be likely to write an extensive 'academic' report. In May 1828 Busby travelled to Newcastle to help open the new pits he had recommended earlier.[85] The Government continued to work the mines until 1831 when the Australian Agricultural Company finally brought their mine into operation.

John Henderson, colliery manager for the A.A. Co., arrived in April 1830.[86] He had spent some time in Australia earlier for the A.A. Co. before the agreement with the Government was finally reached and therefore had been forced to remain idle. On his return he carried out some boring, reaching a five feet seam, the Dudley, formerly Dirty Seam, at fifty three feet on the west side of Shepherds' Hill, later the site of the A.A. Co.'s "B" pit, and examined the Government workings which were regarded as unsatisfactory by the Company because of the

inferior quality of the coal and the method of working. A feature of all the early reports seems to be the ready criticism of all work carried out by previous workers! Consequently the A.A. Co's "A" pit was sunk under Henderson's charge near the corner of the present Brown and Church Streets. This shaft was 9 feet in diameter and reached the Dudley Seam at forty six feet. Nearby was a narrower ventilation shaft. Coal was raised to the surface by an engine and sent to the wharf by one ton trucks.

Because of the lack of suitable labour, shaft sinking was slow. In July 1831 Sir Edward Parry, Commissioner of the A.A. Co., wrote that 'by the middle of October the Company's mines will be in readiness to supply the public with coals in any quantity... the top of the... (wharf) is about 13 ft. above high water-mark, with a good contrivance for shooting the coals into a ship'.[87] On 20 September, 1831, the Company began selling coal from a higher seam, probably Nobby's, which although 'of indifferent quality [was] much superior to the produce of the old pits'. In 1831, although the works were now in the charge of John Henderson, Busby was asked his opinion of the depth at which coal could be worked at Newcastle without endangering the buildings above. By December the same year the mine was at work producing from the Dudley Seam.

The formal opening of the coal works on 10 December, 1831, was a gala occasion when the wooden bridge carrying coal trucks across Hunter Street to the wharf was also opened. The Sydney Gazette reported:[88]

> Sir Edward Parry, Surgeon George Brooks, Reverend Lancelot Threlkeld and several other gentlemen of respectability boarded the 'Sophia Jane' and as she proceeded majestically toward the wharf 2 waggons,

each containing a ton of coal, were seen descending the inclined plane from the pit's mouth with flags flying, and amidst the cheers of the Company's servants.

This was the first coal sent to Sydney from the A.A. Co's mine. Over 7,000 tons were sold by the Company up to 31 December, 1832, but small coal was not in demand and the Company decided to manufacture salt as a means of using the smalls profitably.[89] Despite the short-lived nature of the salt venture production of coal increased steadily during the following year. Henderson died in 1835 and it was not until September 1836 that Alexander Brown was appointed overmanager and sent out from England. Brown should not be confused with his namesake, the brother of James Brown who later opposed the A.A. Company monopoly.

In 1835 Henry Dumaresq, the A.A. Co. Commissioner, gave details of production and some difficulties:[90]

> The 'Task' of a getter and wheeler is 2½ tons per day, and, although I have had recourse to expedients... some have done little more. A good workman, when the coal is easy to procure, will however get much more... It was impossible to raise the coal required, and at the same time continue the work at the Fault, or prepare for sinking a second shaft.

Unfortunately further details about the 'Fault' were not provided.

Early Geological Observations

Probably the first to interest himself in the geology of the Hunter River area, on a purely academic basis, was Alexander Berry who had studied geology in his medical courses at St Andrews and Edinburgh, and first came to Australia in 1808.[91] In an interesting paper given before the Philosophical Society in 1822 he described some features of the Newcastle coalfield:[92]

> The country immediately to the south of Hunter's River is (as is well known) an extensive coal-field. The cliffs on the sea-shore present a most interesting section of the coal-field strata... I traced the strata for nine miles, when they abruptly terminated by suddenly bending downwards, and sinking below the level of the sea. From this place a long sandy beach and low land extends to the entrance of Lake Macquarie (called also Reid's Mistake). The south head of Lake Macquarie rises into high cliffs, into which the coal strata again present themselves. Dr Hutton would have given much for a single day's walk along this shore ... Between the coal-beds we find strata of sand-stone and beds of slate-clay with vegetable impressions; sometimes (but more rarely) indurated clay-stone. Embedded in these strata, there is found abundance of argillaceous iron ore. This is occasionally cellular and in layers; but for the most part it appears in the form of petrifactions of trees and branches, irregularly dispersed...
>
> The vegetable impressions in the slate-clay under and over the coal are no less worthy of an attentive consideration. I have seen some of these subterranean plants in full flower, so that a skilful botanist might ascertain even their species. I think that I have been able distinctly to recognise the leaf of the zamia spiralis.

It is a pity for Australian geology that Berry's preoccupation with trade prevented him doing more geology.

In 1824 the Rev. T.H. Scott included some remarks on the geology of Newcastle in his Sketch of the Geology of New South Wales and Van Diemen's Land:[93]

> The Coast of New Holland from Cape Howe to Port Stephens, including Botany Bay, Port Jackson etc... consists of an uninterrupted series of the coal measures. At Illasvarro [Illawarra] or the five islands, a seam of coal is found at the surface. Between Broken Bay & Port Hunter, a horizontal seam of coal is bared by the action of the seas on the cliffs. Very good coal is worked at Newcastle on Hunters River 37 yards from the surface 3 feet 1 inch thick, it is intersected by trap dykes in some places; and vegetable remains of a large leaved fern, thought

by the people to be an Eucalyptus, are picked up at the base of the cliff. Limestone alternates with the sandstone and iron ore occurs.

Another 'academic' was the Rev. C.P.N. Wilton, M.A., who had studied natural history at Cambridge. His four articles[94] published between 1828 and 1833 on the Burning Mountain of Wingen, a coal seam on fire since presettlement time, and others on The Fossil Woods at Newcastle (1834), show a keen scientific approach to natural phenomena. He recorded the occurrence of coal at various localities in the Upper Hunter, described the unusual glendonites of Glendon Brook, and also briefly described the cliff section at Newcastle.[95]

> I saw stumps of trees standing upright in the ground, apparently petrified on the spot where they grew. In the bed of the Hunter at Mr Scott's of Glendon, the fracture of rounded fragments of this kind of petrifaction presents various stripes and bands, like a beautifully watered ribbon, capable of a very fine polish. In some places the wood is strongly impregnated with iron. About 3 miles on the coast south of Newcastle I discovered, in an upright position at highwater mark, under the cliff, and beneath a bed of coal, the butt of a tree, which, upon being broken, was of a fine black, and passing into the state of jet. On the top of the cliff at Newcastle, on which the telegraph stands, I noticed, imbedded in about a foot beneath the surface, lying in an horizontal position, nearly at right angles to the strata of the cliff, the trunk of a petrified tree, finely grained, white, and traversed by veins of calcedony. The coal, which is exposed to view on the face of the cliffs on the Newcastle coast, is of the independent formation, and appears to run generally in three parallel horizontal beds, but in some places it has an occasional dip. It alternates in one part of the cliff with slaty-clayey sandstone and shell with impressions of leaves; at another with millstone grit, and a hard cherty rock.
>
> A rock of gritty sandstone, of a large schistose structure, outcrops beneath the coal of the Telegraph hill, and in one part a coarse grit abounds with specks of coaly matter. Nodules of clay, ironstone,

and trunks and stems of arundinaceous plants in ironstone, are seen in abundance in the alternating strata of the cliffs and in one place a narrow bed of iron stone bearing impressions of leaves, was remarked while thin laminae of iron stone, the surface of which is traversed by square, and variously-shaped sections, are seen on several parts of the shore, both in the face of the cliff parallel with the beds of coal, and extending into the sea forming the strand at low water...

At Glendon, in the bed of the Hunter, about 60 feet below the bank, is a singular formation of limestone. It appears in the shape of round and oval masses from two to twelve feet in diameter. The surfaces of these are rounded, and if broken, the fractures are concave; and, in more than one instance, I noticed that the stone split in concentive bands. The masses are traversed by veins of calcedony of a lamellar form, some of them being two thirds of an inch in thickness. There are upwards of fifty of this lusus naturae, and the appearance of them resembles that of the kraals of a Hottentot village. It is clear that they do not owe their form to any recent action of the waters of the river upon them, for you find others of similar shape at the same level, just appearing from beneath the clay of the Eastern bank of the river. Amongst these, I picked up a curious growth of crystals of limestone, in figure resembling the ore of sulphur of iron, or pyrites, so common in the chalk of the counties Surrey and Sussex. From the several beds of the Hunter, Westbrook and Kingdon Ponds, I collected boulders of granite, both white and red, porphyry, sienite, white and red quartz and breccia.

Although Wilton proposed to write a longer description and discussion for the Cambridge Philosophical Society's Journal this article was published by the London and Edinburgh Society.[96]

Wilton sent specimens of fossil wood to Professor Jameson at Edinburgh and they were examined by William Nicol together with specimens sent by Mr Burnet of Sydney. Nicol wrote in his report to Professor Jameson:[97] 'In the coal formation of New South Wales, as well as in the older and newer

deposits of mineral in this island, coniferous fossils are the only remains of ligneous bodies, retaining an organised structure, that have hitherto come under my observation'. Nicol commented on the paucity of conifers among living trees in Australia and noted that 'various speculations might be indulged as to the cause of this prevalence of Coniferae in coal deposits'. Nicol's descriptions are accompanied by excellent figures showing the structure of some fossil wood specimens.

Wilton also made some observations about coal seams which had been on fire in the vicinity of Newcastle, particularly at Redhead.[98] Wilton's geological observations, based largely on his own fieldwork, are of quite a high standard in contrast with the Rev. T.H. Scott's remarks which are almost all second-hand.

In 1829 Sir Thomas Mitchell had also visited Mount Wingen and prepared a plan of the mountain.[99] He visited the site again in 1831. On the latter occasion he collected and described briefly a number of specimens of Glossopteris and fossil wood from the Hunter Valley region.

Newspaper articles at this time continued to add to the geological knowledge of the colonists and coal discoveries were newsworthy events; typical is the report from the Sydney Gazette on 15 June, 1830:[100] 'Coal has been found on the farm of Mr Yeomans, Hunter River. The quality of the coal is said to be superior to that in common use and will ignite the same as pitch'. In October of the previous year the Gazette also published[101] some interesting comments on the burning cliff - coal seam - on the coast near Redhead, south of Newcastle.

The New South Wales Magazine, one of the numerous short-lived periodicals launched in New South Wales, first appeared

in 1833 edited by Wilton and with a Natural History Department conducted by Dr John Lhotsky. The first issue briefly reviewed the mineralogy of Australia.[102] Listed among the minerals is a number from Newcastle, Hunter River and Mount Wingen.

A summary of Australian geology as it was known about the mid 1830's was given in French by Dumont d'Urville in 1839. It includes fairly long quotations from Wilton's previous writings on the Hunter Valley, and also notes the presence of kerosene shale near Mt York, at Hartley in the Western Coalfield.[103]

No other work of significance concerning the region appears to have been done until J.D. Dana, a member of the Wilkes' Expedition of 1839-1842, made a number of pertinent observations at Newcastle in 1840.[104] Dana, 1813-1895, was a graduate of Yale and had studied with Professor Benjamin Silliman, founder of the American Journal of Science. Dana was already well known for his remarkable System of Mineralogy published when he was only twenty four, yet he did not feel confident about joining the expedition. In 1837 he wrote to his friend James Hall:[105] 'I feel but poorly prepared for the laborious and responsible duties that will be required of me in the Southern Seas... I fear that I am venturing beyond my depth'. Despite his trepidation the material he gathered and finally published can only be regarded as monumental. However in relation to Newcastle, Dana's work was not published until 1849, after several other important publications had appeared. The information recorded by Dana shows that some geological features were mapped by the A.A. Co., prior to 1840. James Steel, the Superintendent of Coal Works, provided for Dana a plan of the workings showing the arcuate pattern of faulting, five faults occurring in

260 yards, curving from north north west to north, each being downthrown on the west. These faults caused inconvenience in working the western part of the colliery as water drained in this direction and could not be easily pumped away. Dana also commented on the jointing and concretions seen. He was fortunate to obtain one of the few fish specimens, Urosthenes Australis (Dana), ever found in the Newcastle Coal Measures. This had been found while sinking the A.A. Co's B. Shaft in 1837 and presented to the local Mechanics' Institute by Mr Steel. Unfortunately this fossil was lost in a fire.

Dana also briefly outlined exploration methods used in Newcastle at this time, which suggests that the boring method used by Henderson in 1830 had been mostly discarded:[106]

> The principal explorations at Newcastle are carried on by sinking shafts. Large excavations have been made in the cliffs: but the difficulties arising from the thinness of the bed [probably the Yard Seam] and the slight coherence of the roof rock must soon put a stop to these quarryings. ... Operations had been carried out by means of a single shaft, from which excavations had been extended around over twenty four acres. A second shaft was just completed, and preparations were making to commence mining... they were removing coal which had been left to support the roof [in the old pit].

Included in the report are analyses of coals made by B. Silliman Junior: figures quoted for ash content of three Newcastle seams are 3.0%, 5.8%, 42.3%.

The sketch section showing the coal seams drawn along the coast by Dana is essentially the same as that shown by Strzelecki, but Dana's descriptions are more accurate. Dana thought incorrectly that the conglomerate overlying the coal seams at Newcastle was part of the Hawkesbury sandstone which he called the Sydney sandstone.

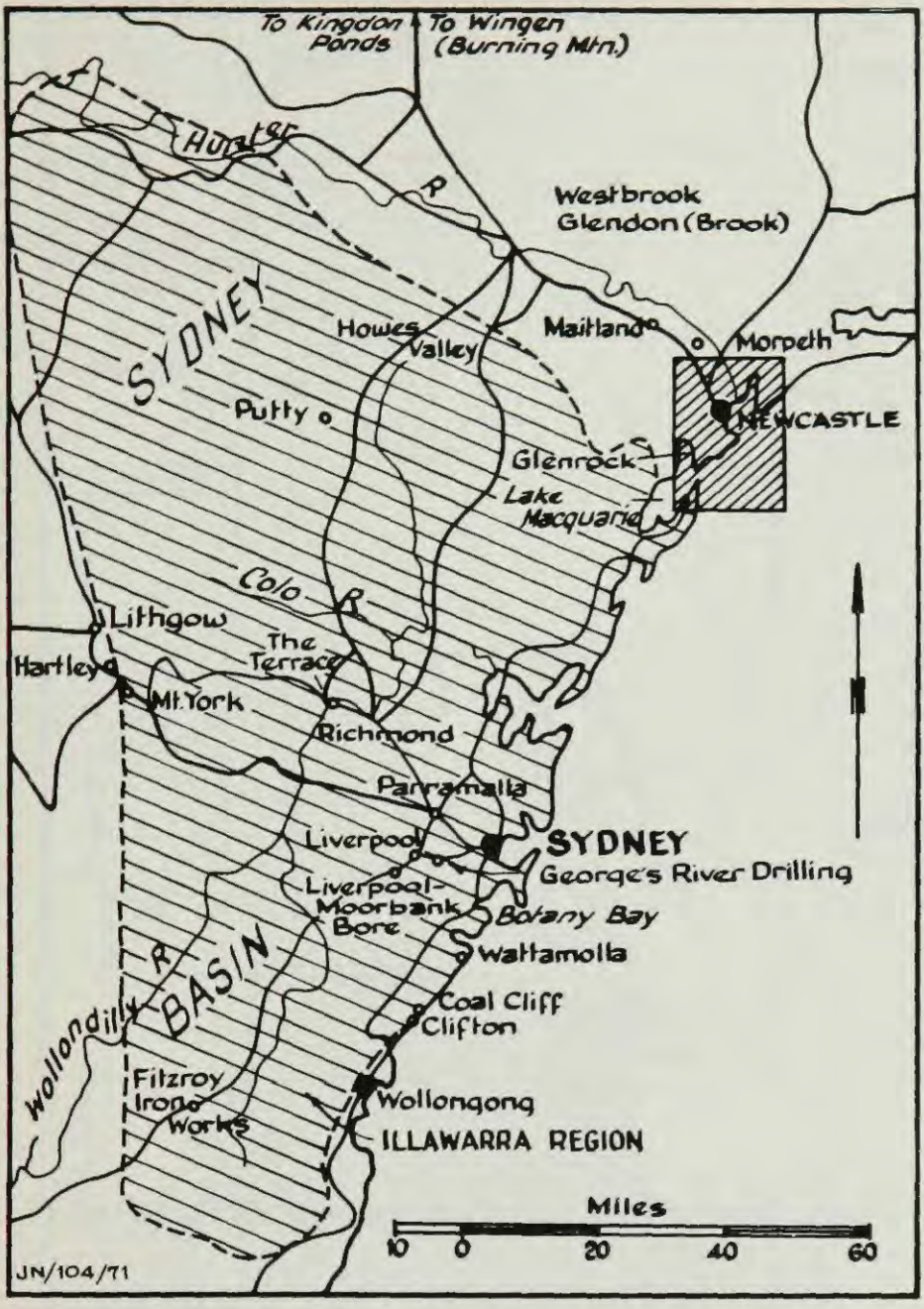
Geological Work in the 1840's

During the 1840's a considerable amount of geological information began to accumulate, particularly dealing with the fossil assemblages which always created great interest overseas. In the vanguard was the Rev. W.B. Clarke who was to play a large part in the growth of Australian geology in the following 30 years. His first publication bearing on the coal measures was published in 1843.[107]

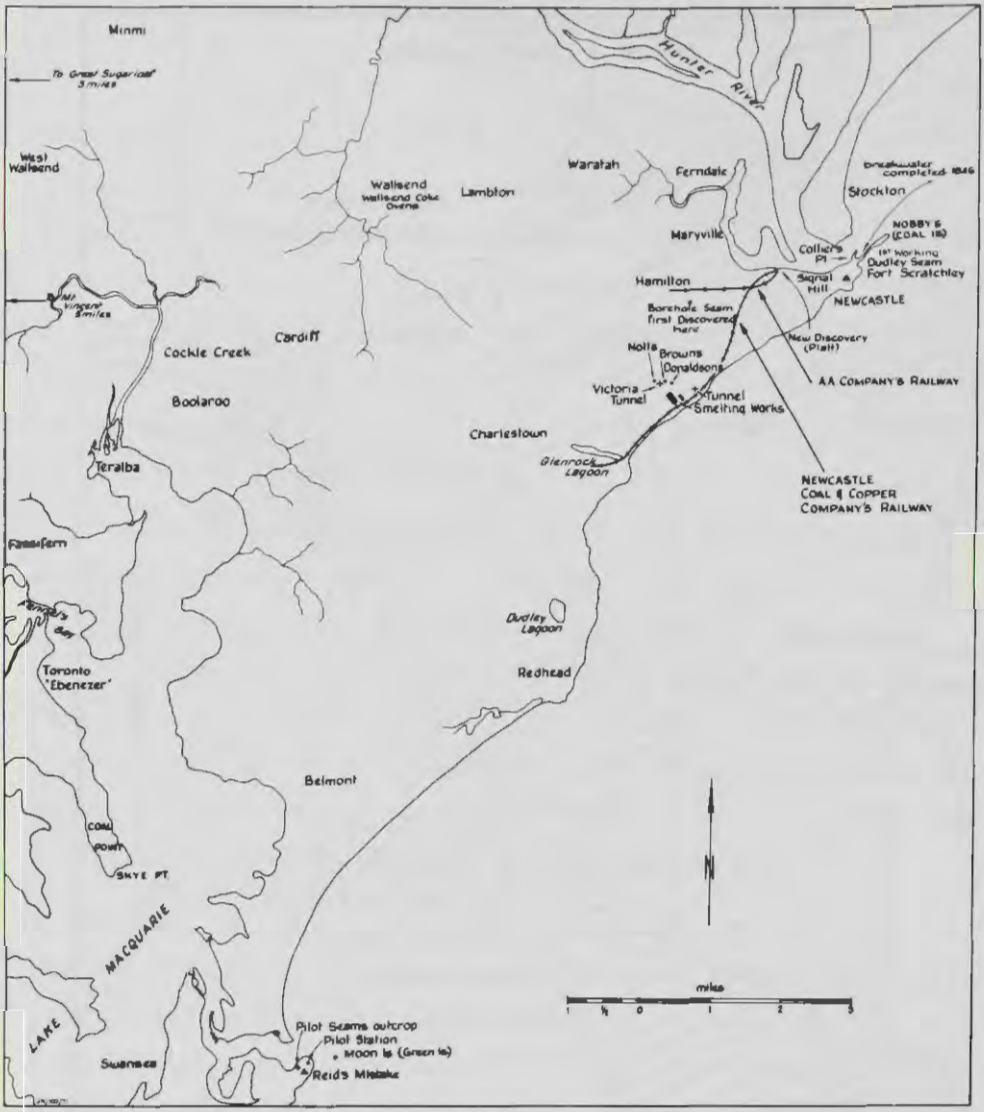
In 1839-40 Clarke, with Dana, collected extensively, and among the specimens described from Newcastle were six species of Glossopteris, with the comment 'Glossopteris Browniana constituting 9/10th or perhaps 99/100ths of all the fossil leaves in these districts'.[108] This species does constitute the majority of the fossil leaves found in the coal measures. The specimens of Glossopteris collected earlier, in 1831 by Mitchell were classified as of Carboniferous age.[109]

Adolphe Brongniart, the French scientist, had earlier described and classified the type specimens of Glossopteris from India and several from New South Wales as being Carboniferous.[110] Dana, in 1840, considered the coal measures containing these plant remains might be Permian not Carboniferous, mainly on the basis of the fish he had described, but about 1854[111] he suggested that the measures might be Triassic in age. In a later publication, 1875, he returned to a Permian age for these rocks.[112] In the 1840's the Permian was not well known in Europe and America, and Dana's remarks were not influential in clarifying the age of the coal measures in Australia.

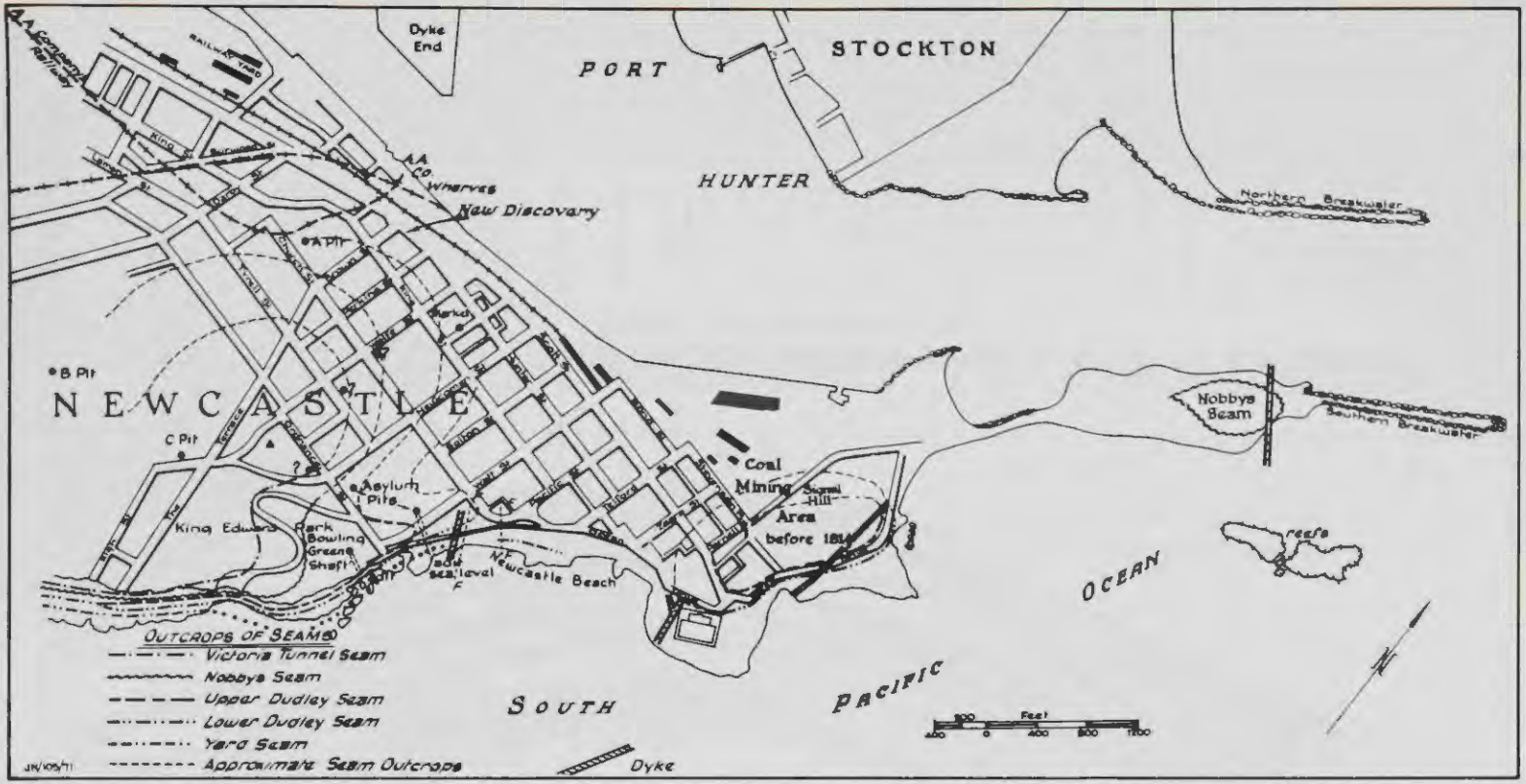
The ill-fated explorer and scientist Dr Ludwig Leichhardt studied the coastal sections at Newcastle and Lake Macquarie during 1842-43. He made many pertinent observations prior to



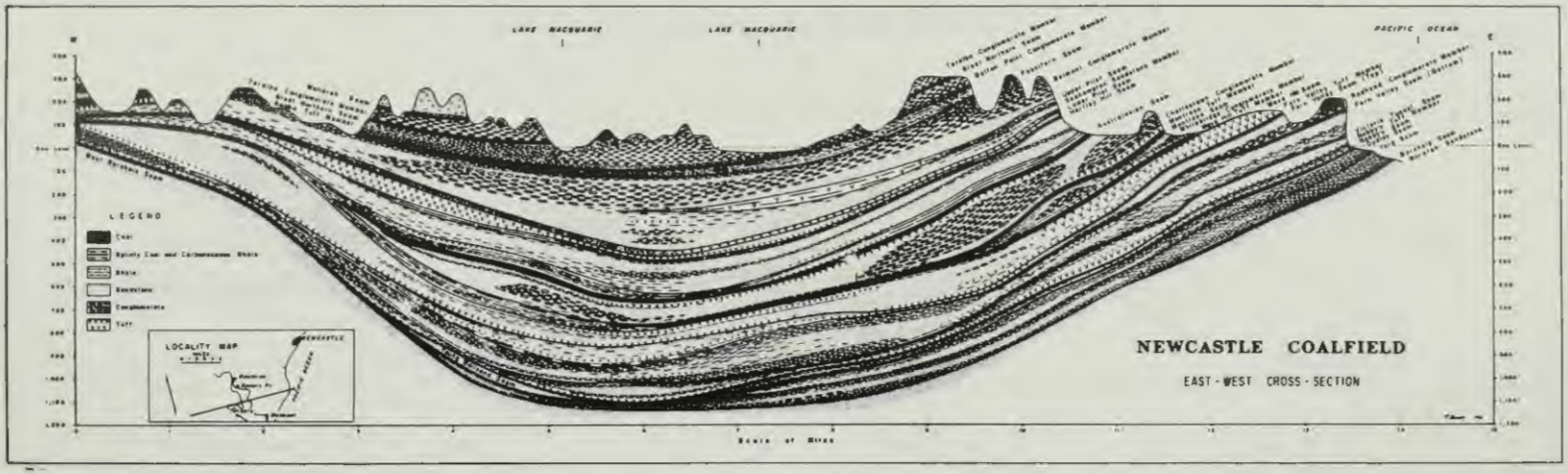
COAL INDUSTRY HISTORIC LOCATIONS IN THE SYDNEY BASIN



EARLY COAL INDUSTRY LOCALITIES IN THE NEWCASTLE DISTRICT



EARLY COALMINES IN NEWCASTLE



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NEWCASTLE COAL MEASURES; VERTICAL SECTION

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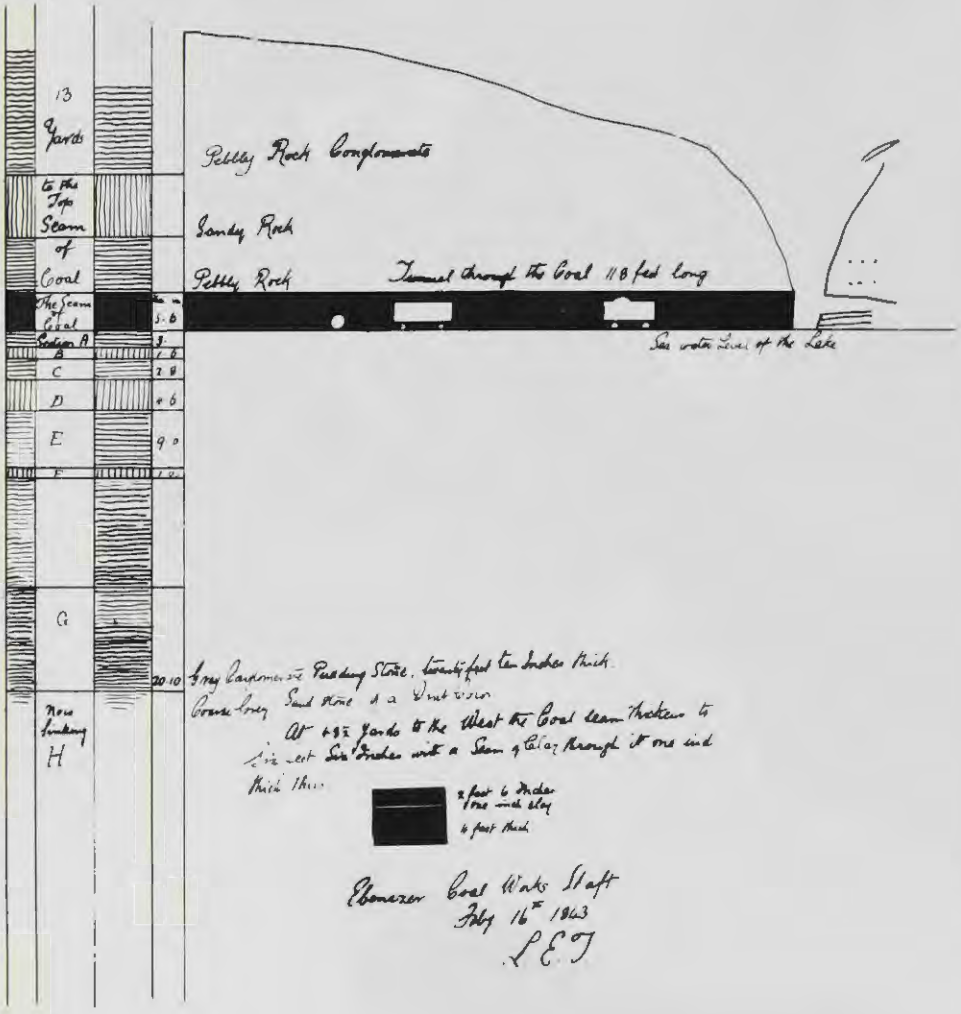
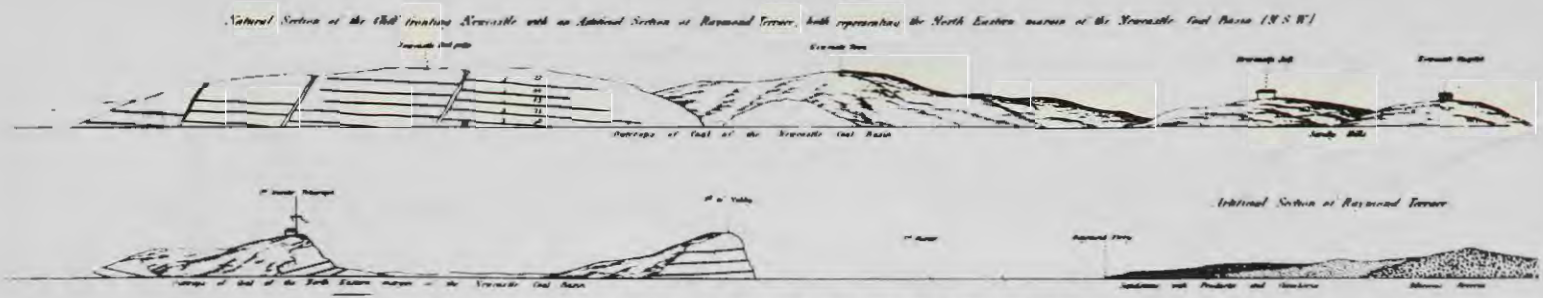
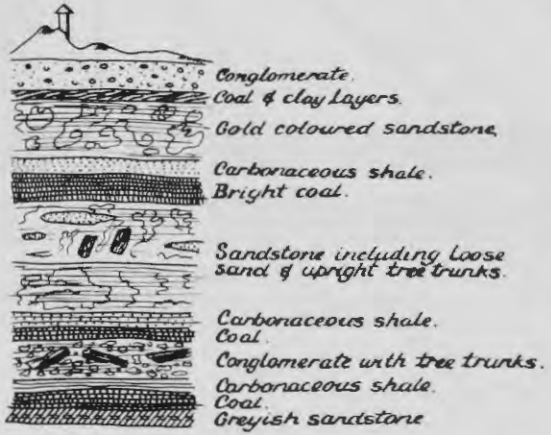


THRELKELD'S SECTION OF EBENEZER COALMINE, 1843
Newcastle Public Library



NEWCASTLE CLIFF SECTION DRAWN BY STRZELECKI

Fig 1.



View of the Strata beneath the Beacon, South Head - Newcastle, (Signal Hill).

Fig 2.

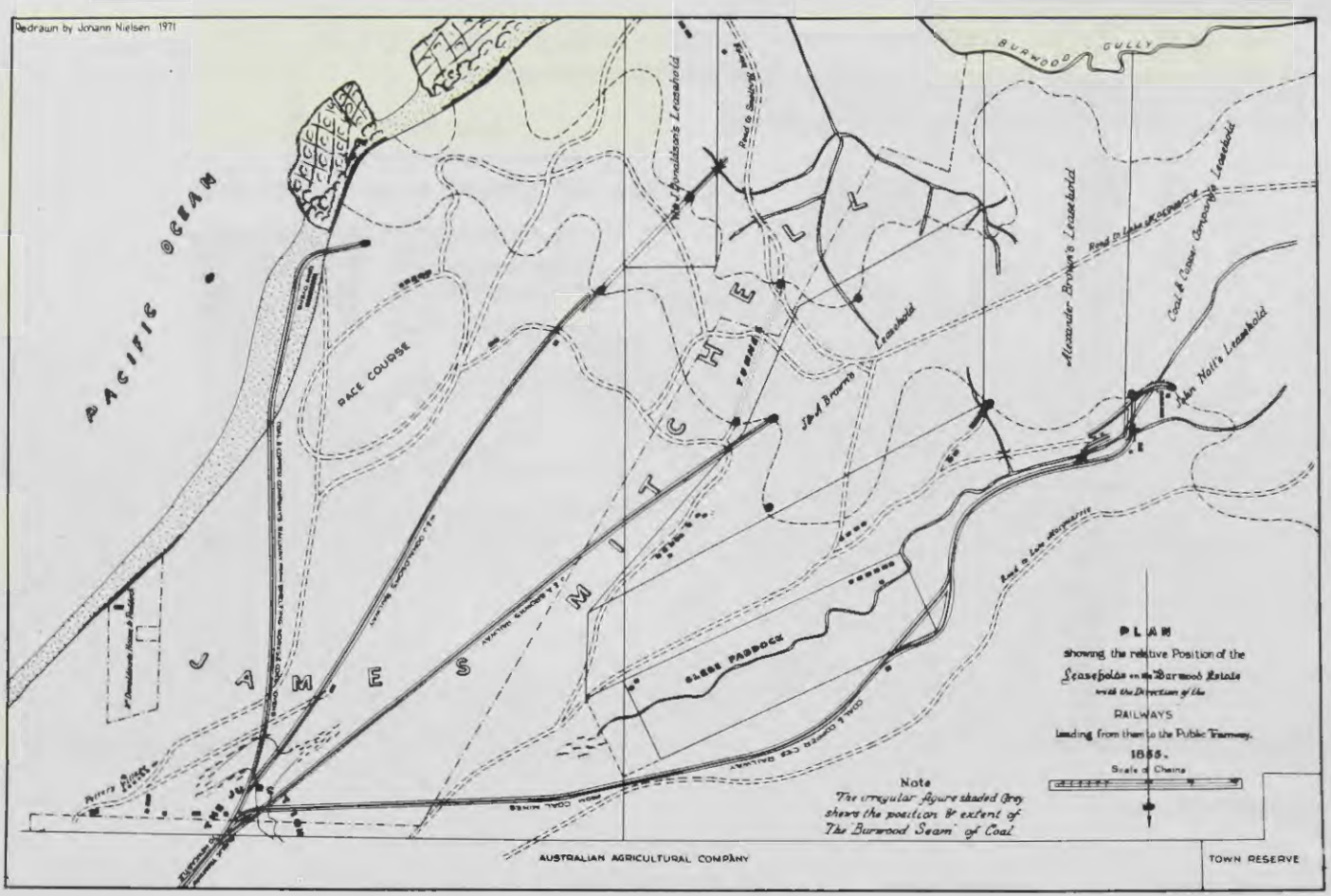
An idealised cross-section showing the relationship I believe to exist between the coal beds at Newcastle, the conglomerates near Tuggerah and the Hawkesbury sandstone.

Fig. 3

The Entrance to Lake Macquarie

LEICHHARDT DIAGRAMS, redrawn

by J.A. Nielsen, English captions by D.F. Branagan



BURWOOD SEAM, 1855

redrawn by J.A. Nielsen
Merewether Estate Archives,
Newcastle Public Library

VERTICAL SECTION

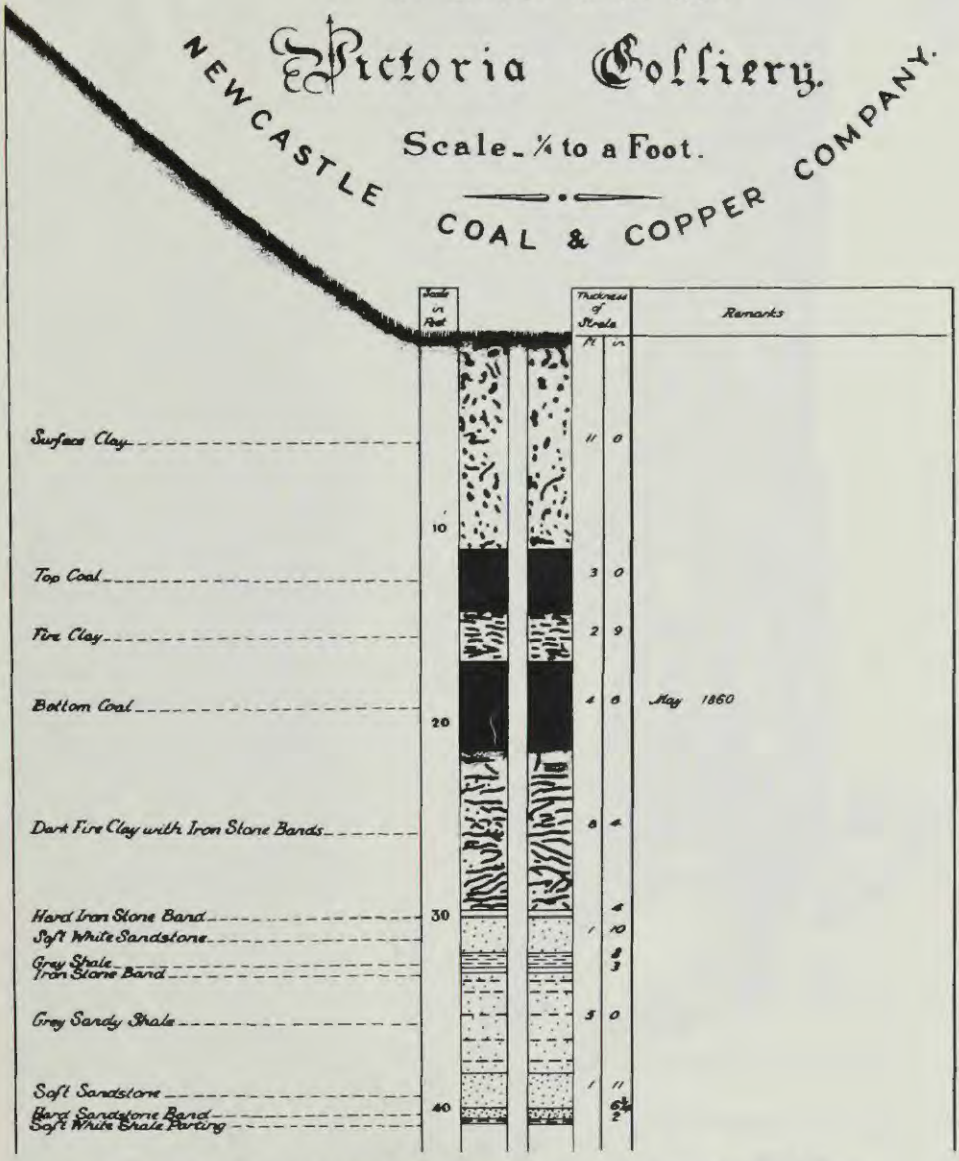
OF STRATA IN BURWOOD GULLY

AT END OF MAIN RUN

Victoria Colliery.

NEWCASTLE COAL & COPPER COMPANY.

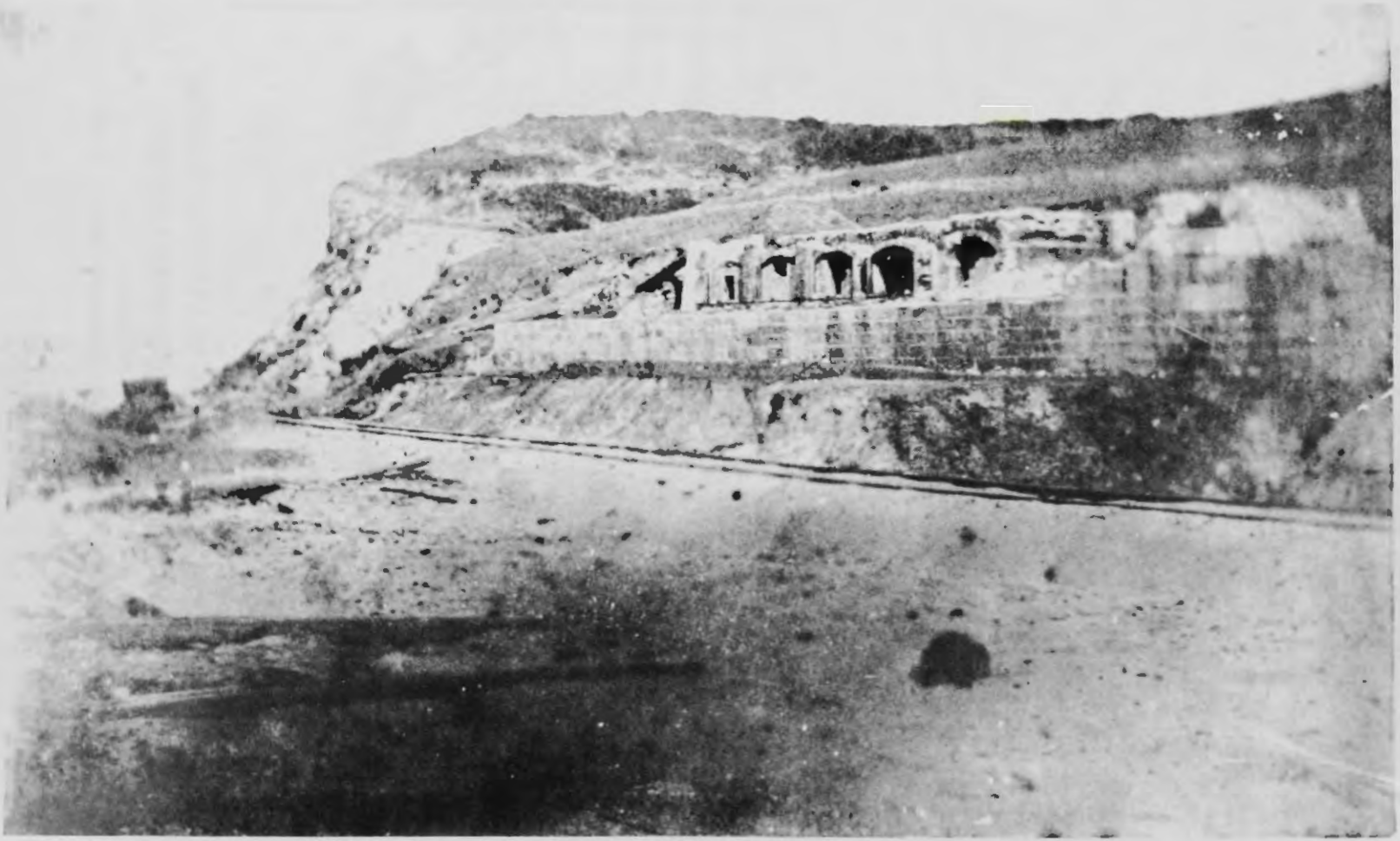
Scale - ½ to a Foot.



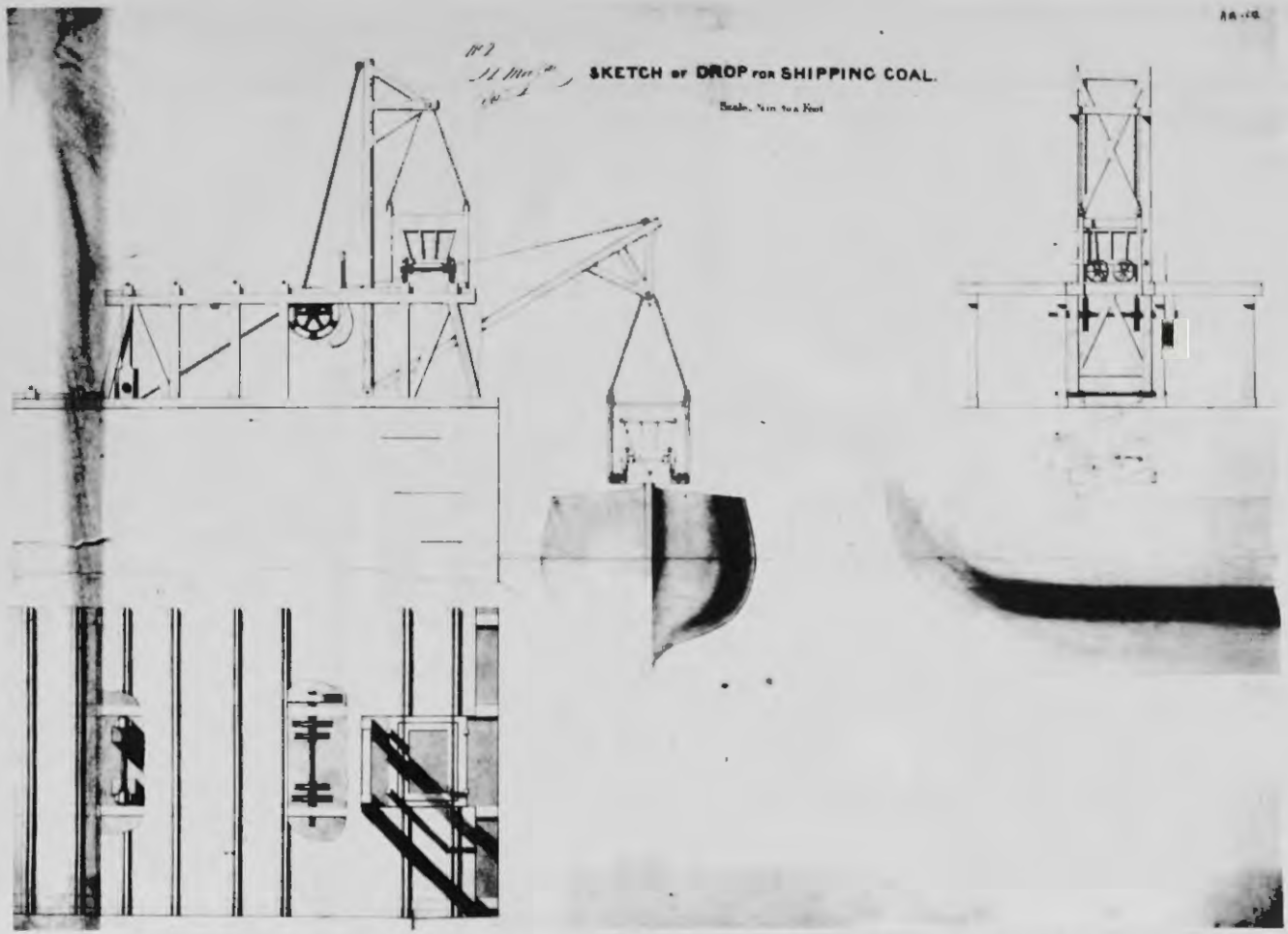
VICTORIA COLLIERY, PORTION OF VERTICAL SECTION BY NEWCASTLE COAL AND COPPER COMPANY

redrawn by J.A. Nielsen

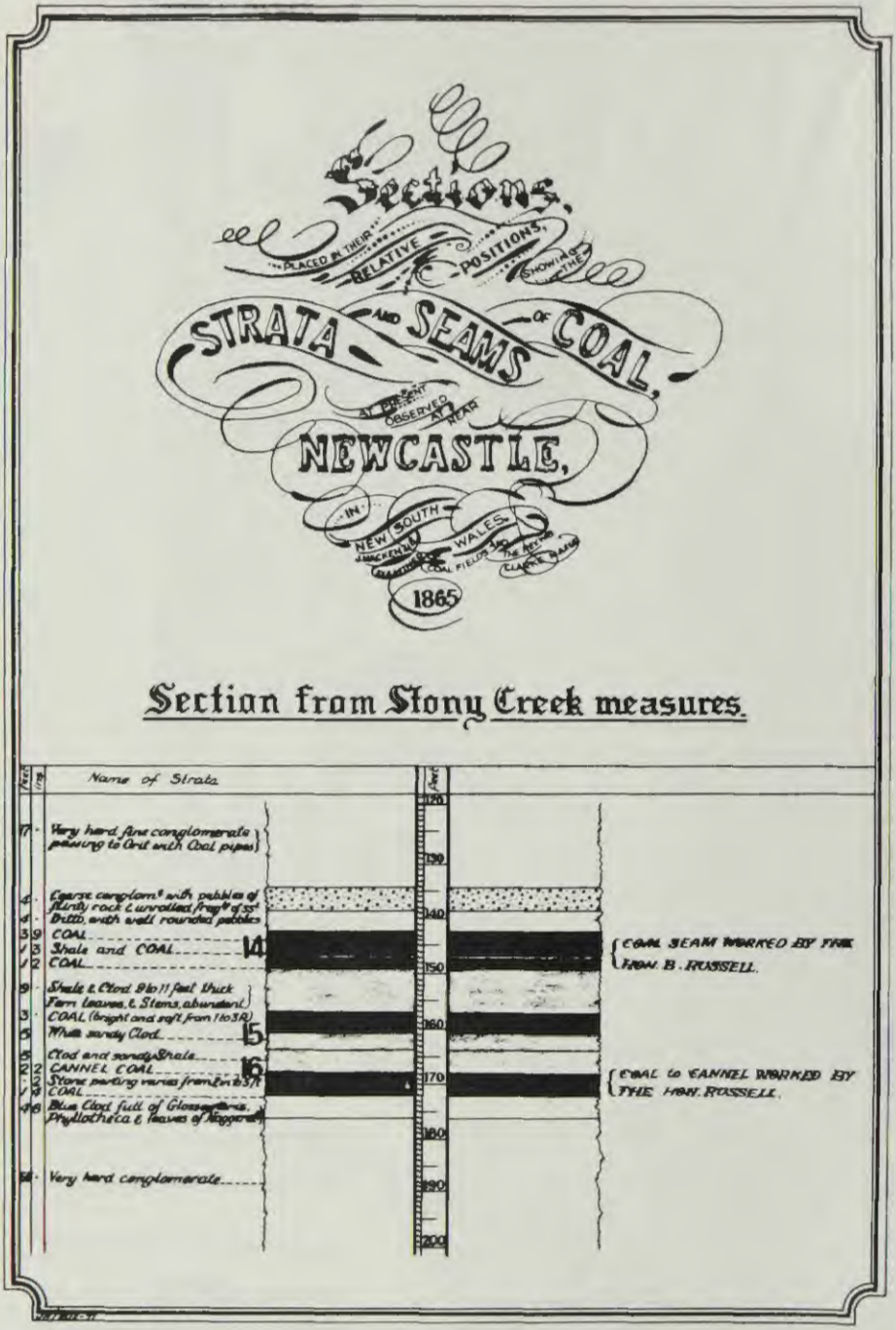
Merewether Estate Archives, Newcastle Public Library



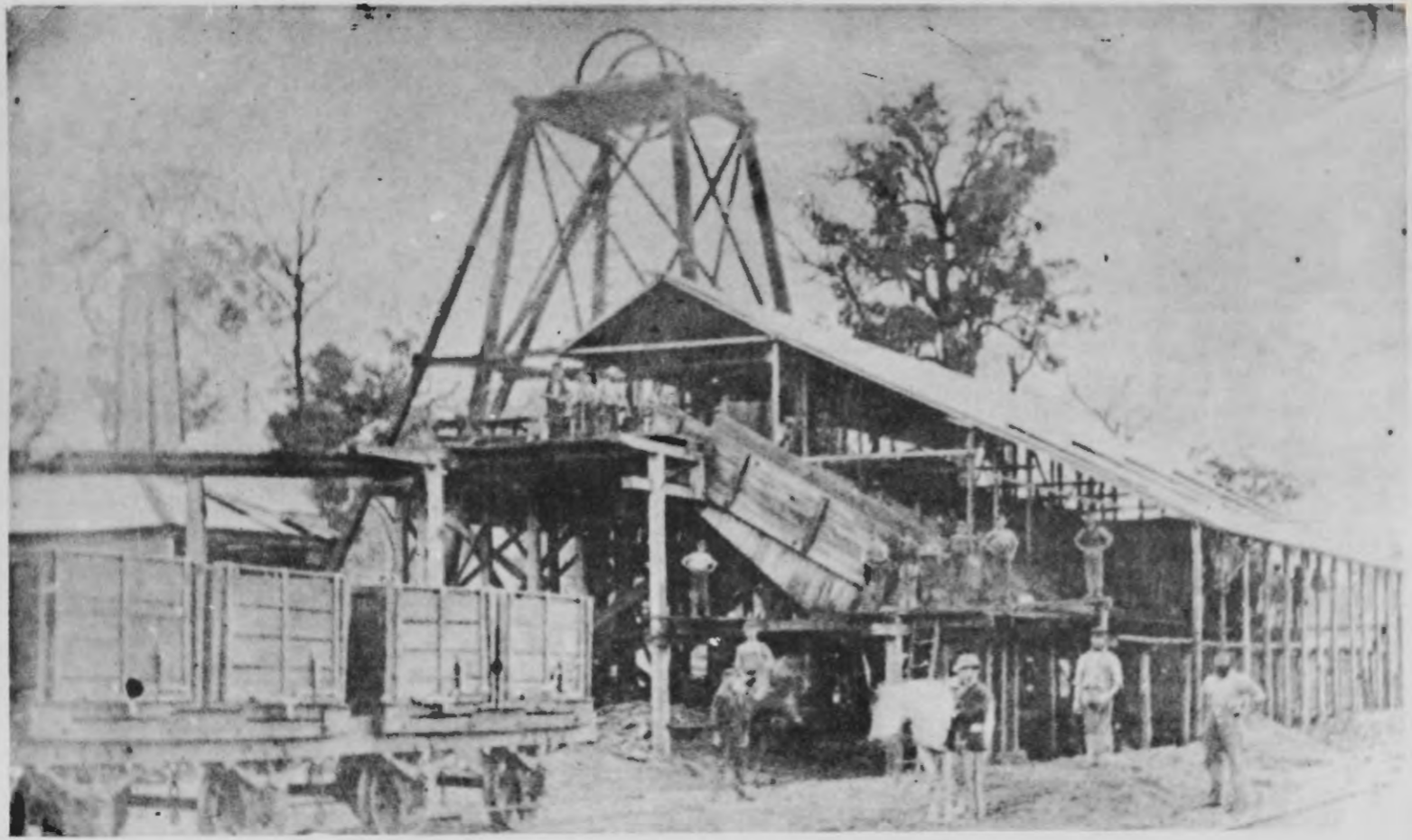
DR. MITCHELL'S COKE OVENS
Mitchell Library



SAMPLE OF NEWCASTLE COAL AND COPPER COMPANY'S DRAWINGS
Merewether Estate Archives, Newcastle Public Library



NEWCASTLE SECTIONS
by Mackenzie and Clarke, caption and portion only,
redrawn by J.A. Nielsen



BOREHOLE COLLIERY, 1868
Newcastle Public Library

NEWCASTLE COALFIELDS, 1865
Illustrated Sydney news,
16th August, 1865

his explorations in Queensland, where he discovered in the McKenzie River during 1845 'beds of coal indistinguishable from those on the Hunter at Newcastle'.[113] His published record of geological observations appears to be little known in Australia despite translation by G.H. Ulrich and editing by the Rev. W.B. Clarke.

Leichhardt stressed the importance of Newcastle:[114] 'I am convinced that the geology of Australia, must, in general, commence at Newcastle; and that the geologist must gradually proceed thence towards the North, South and West; because a series of beds are exposed at this locality, which neither Westward nor perhaps along the whole coast lines of Australia may appear again so completely exposed'. His self effacing interest in the results of other workers is a notable characteristic of his writing and suggests a personality rather different from that often presented.[115]

Count de Strzelecki published his Physical Description of New South Wales and Van Diemen's Land in 1845.[116] This includes a section and description of the coast at Newcastle, fossil illustrations and descriptions, and comparisons with the coal measures in Van Diemen's Land. His geological map of Eastern Australia is the first of any importance, and shows three divisions of the rocks. The inadequacies of mapping techniques of the period are clearly illustrated when this map is compared with the detailed sections which Strzelecki prepared. The latter are comparable with present day diagrams but the map would be regarded as quite inadequate today.

Similarly J.B. Jukes in 1847 prepared a geological map of Australia, and described fossils, in a paper Notes on the Palaeozoic formations of N.S.W. and Van Diemen's Land.[117]

These formations included the Hawkesbury and Wianamatta rocks of the Sydney District, now known to be Triassic. Jukes' work is an excellent compendium of the knowledge of Australian geology and it summarizes the geology of the 'coal basin' very well.

In the same year W.B. Clarke appeared before the Coal Inquiry as an expert witness, and stated his reasons for thinking the Newcastle coal to be 'carboniferous'.[118] About this time began a long association between Clarke and the Sydney Morning Herald. Clarke used the Herald to spread geological information, usually his own work, but also other material previously published elsewhere, as the copyright laws were rather vague at the time. Articles during 1847-48 on Geology: comparison of Russia and Australia - Carboniferous formations, The Carboniferous formation of New South Wales and The fossil botany of N.S.W.[119] are typical. He also used the paper to attack persons whom he disliked or who opposed his ideas.[120]

In 1847 Frederick McCoy, then at Trinity College, Dublin, published The fossil botany and zoology of the rocks associated with the coal of Australia[121] based on material collected by Clarke, in which he suggested that the coal measures were much younger than the underlying fossiliferous 'carboniferous' rocks. Clarke replied with several papers in the following year[122] supporting his opinion that the coal measures were Carboniferous. Thus began a controversy which lasted for nearly thirty years.

Melbourne University appointed McCoy as Professor of Natural Science in 1854[123] and the controversy with Clarke gradually became more heated, McCoy maintaining that the coals were 'Oolitic' or at least Mesozoic, Clarke arguing

for a Palaeozoic age, varying from Carboniferous to Permian. The invectives launched by the protagonists are a far cry from the rather polite scientific controversies of today.

Clarke was appointed by the Government to explore the southern part of New South Wales for gold in 1851 and his coal studies were consequently restricted.[124] However his publication in 1860 on the Southern Goldfields includes a full 'concise account' of the Carboniferous Formation.[125]

One of Clarke's supporters was John Mackenzie who later became Chief Inspector of Mines. Mackenzie was at work from the early 1860's for about thirty years and his influence was considerable. In 1863 he collaborated with Clarke in producing privately an enormous Column fourteen feet seven inches long, showing the various coal measure sections they had recorded[126] and stressing in particular the difference in age between the Stony Creek - [Greta] - and the younger coal measures.

In 1861 Clarke had shown in a section the relation between the Stony Creek coal measures and the overlying sediments,[127] features which were hotly contested from afar by McCoy and others,[128] who refused to go and see the field evidence. Clarke wrote[129] 'It will be seen... that about Maitland the Four Mile Creek, and Greenhill, coal seams of the Newcastle basin are separated from the Stony Creek coal by the Palaeozoic fossiliferous beds'.

Despite the assertions of the palaeontologists such as McCoy, Clarke continued to collect information to support his thesis and this was presented at every possible opportunity. In particular his classic Sedimentary Formations of N.S.W., which was revised and republished at least four times between 1867 and 1875,[130] presented the case for Permian or

Carboniferous age of the coals most strongly and reviewed the various steps in the controversy.

The subdivision of the rocks of the earth's crust into units of different ages took place in Europe during the first half of the 19th Century. Names such as Devonian or Permian were given to rocks found in particular parts of Europe, other names such as Carboniferous, i.e., coal bearing, or Cretaceous, i.e., chalk bearing, were given because of particular properties of each sequence. The growth of the time scale was haphazard but it was found that each sequence of rocks contained rather distinctive groups of fossils. Thus one group of fossils characterized Carboniferous rocks, another group Permian rocks.

Workers going into a new unmapped region used the knowledge of the original 'type areas' to determine the ages of the rocks by comparing the fossils they found with those described from the type areas.

Geologists who came to Australia tried to apply these 'principles' of mapping and fossil identification to the rocks they studied. However, there were many difficulties. In particular many of the fossils they found in the coal measures of Newcastle were quite different from those found in the coal measures in Europe.

Clarke believed there were enough similarities with the European fossils, particularly the marine fossils, for the rocks to be classified broadly as Palaeozoic and that the Newcastle coal measures would prove to be Permian if not Carboniferous. McCoy on the other hand believed the fossils, especially the plants, were comparable with fossils found in rocks of Mesozoic age in Europe. Mc Coy was led astray somewhat by fossils found in some of the Victorian coal

measures which were in fact Mesozoic and considerably younger that the coals at Newcastle. He therefore suspected Clarke's field evidence without, as far as can be ascertained, ever examining it.[131]

The Contribution of the Miners

In 1828 the surveyor Henry Dangar had commented on the mission station for aborigines set up at Lake Macquarie, on the present site of Belmont, stating that Kendal, i.e., Cannel, coal had been found there 'the first of that class yet known in the colony [an obvious error] which is of a superior quality, and will meet with a demand in Sydney: a trade in this article, may, therefore, in a short time be calculated upon'.[132]

This fact was known to the Rev. Lancelot Threlkeld who was in charge of the mission. Although Threlkeld worked for many years, his religious mission was not a success. However, he was the earliest systematic student of the aboriginal language and published a grammar of the local dialect, containing terms for local geological features such as the Fennel Bay fossil wood horizon, and some of the coal seams.[133]

In 1829 Threlkeld moved his mission to Ebenezer, the present Toronto, on the west side of the lake. The Government eventually withdrew its support of the mission in 1841 but, says Champion,[134] 'he [Threlkeld] took comfort when he remembered that beneath their very feet was a coal mine, which, with the blessing of God, would sustain them in their duties through life'. Threlkeld had seen the writing on the wall for the mission and in 1839 he had applied to the Crown for permission to work coal on the grounds that his lease had been granted prior to the A.A. Company's coal reservation being applied. His lease was exempted from the reservation, as were

those of Westmacott, Brooks and Warner.

In 1840 Threlkeld began to develop his mine, a drive into the Great Northern Seam.[135] In 1841 coal was being shipped to Sydney as advertised in the Australian.[136] The mine was situated on the south west side of the Coal Point Peninsula, at a point about a quarter of a mile north west of the southern extremity, often marked as Skye Point. The tunnel from the water's edge was 118 feet long and an air shaft '13 yards' deep was put in. The seam was 5'6" at the face. The shaft was continued down at least forty feet towards the underlying seam. A section of the mine was prepared by Threlkeld.

According to Threlkeld[137] the Ebenezer coal was equally in demand with Newcastle coal, with the 'drawback to the Ebenezer coal, it is what is called open burning coal, that is, it does not cake and therefore it is of no use to Smiths; it is nowever admirably adapted to furnaces, and anything in which it is not required that coals should clinker; it is adapted for smelting, and makes excellent coke.' Although it was not considered satisfactory by the Australian Gas Light Company Threlkeld thought it had not had a suitable trial.

About 1849 Dr James Mitchell leased part of his Burwood Estate to the Brown's, and to Donaldson and Nott who proceeded to mine the Victoria Tunnel Seam by tunnels.[138] Earlier a small amount of mining was being carried out near Maitland.[139] The areas worked on the Burwood Estate are shown on plans drawn in 1855 and preserved in the Newcastle Public Library.

The harbour entrance had been made safer for ships by the completion of a breakwater between Nobby's and the mainland in

1846, a project which had commenced in 1818 and completion of which had been strongly recommended by Busby and Wilton. In 1832 and 1833 Busby had been concerned with the pier and breakwater improvements at Newcastle and Nobby's. He pointed out the increased work and expense then involved in repairing the breakwater following neglect of his advice in 1824.[140]

On 2 October, 1848, Captain P.P. King, the Commissioner of the A.A. Co., wrote to the Company's London Office about a good seam of coal penetrated in a borehole.[141] This find was to prove an important event for the A.A. Co. and for coal mining at Newcastle, as this seam was that which later became known as the Borehole. The find does not appear to have been recorded in contemporary newspapers and it is not clear when the name Borehole Seam came to be regularly accepted as it was used alongside other names such as Company's Seam and Wallsend Seam.[142] The use of drilling in the search for coal at this time suggests that its value and economy were being realised and it now began to be a regular feature in the development of the coalfields after being neglected for some years.[143] The improved quality of cutting tools no doubt played some part in the revival of interest in drilling or boring.

Although the A.A. Co. had kept mine plans and recorded some geological features in the 1830's, the practice does not appear to have been kept up in the latter part of the 1840's when the Company had a period of bad management, and by 1853 these mines were in urgent need of reorganization.[144]

In 1853 the Newcastle Coal and Copper Company was formed by Dr Mitchell and others.[145] This acquired the smelting works Mitchell had commenced at Burwood in 1846[146] and completed about 1850. The Company bought Brown's developed colliery for £24,000 and also began opening another part of the area. A plan

of 1855 appears to be the first detailed surface geological map prepared in the district, and shows the general extent of the Victoria Tunnel Seam at Burwood.[147] For many years this seam was often called the Burwood Seam, but the original name is now used. This plan also shows the position of the Company's coke ovens, apparently the first erected in Australia and used for metallurgical purposes. Although erected prior to 1855 the exact date of construction of these ovens has not been established, but it may have been as early as the latter half of 1847 when Mitchell and lessee Donaldson first began to smelt the copper ores from Kawau, New Zealand and South Australia.[148] It is clear that coking was established earlier than suggested by some authors, e.g., L.F. Harper & J. Mingaye.[149] These ovens operated until about 1861 shortly before the Company went bankrupt.[150] Photographs of the ovens were used in the case Dibbs brought against the Company in 1862[151] for non payment of railway construction costs, and are probably the earliest photographic evidence used in an Australian court.

Although the Company appears to have been mismanaged it gave considerable thought to mining methods and machinery, and a number of beautifully executed drawings of coal loading and mining machinery is preserved in the Newcastle Public Library.[152] Also preserved are similarly drawn sections of the Victoria Tunnel workings in which detailed geological observations are recorded. These plans show an awareness of the value of geological data in many ways ahead of its time.

In 1857 the A.A. Co's coal, probably some of the best of the Borehole Seam, was examined at the Royal Arsenal, Woolwich, England, 'when it was shown to be equal in working effect to the Whitworth coal, which for steaming purposes was

then only second to West Hartley and Welsh coal'.[153] The introduction of gas in many towns towards the end of the decade, and the rapid expansion in population which encouraged local manufacturing stimulated the development of the coal industry. In 1859 the A.A. Co. erected coke ovens and two years later the coke industry became firmly established when the Newcastle-Wallsend Coal Mining Company set up ovens at Wallsend.[154] J. & A. Brown were also supplying coke in 1861.

By far the most important direct factor affecting coal production was the opening of railway lines - Sydney-Parramatta 1855, Newcastle-Maitland 1857. By 1861 there were 243 miles of railway in operation.[155]

By 1860 a number of mines was producing, although more than 90% of the production came from only four mines.[156] The Southern Coalfield had opened in earnest in 1857 and the Moreton field in Queensland was expanding significantly.[157]

Professional Geologists

In November 1850 Samuel Stutchbury arrived in Sydney as official geologist.[158] His appointment was related to the search for gold, but his first official, self imposed, task was a visit to Newcastle to report on the coalfield.[159]

Stutchbury's report of 1850 contains much interesting material. He described beds of shells at various levels and attributed their occurrence to changes in sea level; he warned against the dangers of soil erosion by the methods employed in clearing and cultivation and in doing so noted the changes which had occurred west of Flagstaff Hill since his previous visit in 1825. His description of the coal sequence and its abundant fossils is equally informative. He incorrectly attributed the cherty nature of the Nobby's Tuff on Nobby's to contact metamorphism by the large dyke which

outcrops there, and pondered on the likelihood of finding coal above the thick conglomerate outcropping on the hilltops. In fact there are numerous conglomerate members in the area.

After visiting 'Donaldson's Level', the original Victoria Tunnel, he expressed doubts about the efficiency of the 'pillar and stall' method and recommended the 'long wall' method in order to obtain larger coal. Concerning mine records his recommendations were equally important:

> I am not aware whether the proprietors have adopted the system of keeping plans and maps of the workings as they are extended, if such is not the case, I would suggest that it should be made imperative by legislative enactment as there can be no difficulty in so doing in a new country where mining operations are but just commencing. I do not in this suggestion mean to confine it to coal mining only, but to extend it to mining of every description, especially where the workings are underground. The want of such plans in a national point of view, is most severely felt in England and for some time has been, and is now, occupying the serious attention of the Imperial Government at home.

Unfortunately this advice, like many other sound suggestions Stutchbury made, was ignored.

In 1854 a detailed examination of the A.A. Company's mine was made by Frederick Odernheimer, described as 'one of the most eminent men in his branch of science in Europe'.[160] He had been Ministerial Assessor and Director of Mines in the Duchy of Nassau, and had worked in Scotland before visiting Australia for the A.A. Company. His report contains a very careful summary of the geology of the Newcastle mine with recommendations on mining methods as well as data about the Company's properties at Port Stephens and Warrah. He insisted on the necessity for a skilled colliery manager, accurate surveys and maps of the workings, and the need to concentrate surface workings. The report shows the usual dependence on

vertical sections, and the concept of the surface map as a useful tool in understanding the geology does not appear to have been grasped, although mention is made of the extent of outcrop of some beds. Odernheimer correctly suggested that the Borehole Seam might be underlying the Yard or Company's Seam and the 'Dirty' Seam, but was not sure. This report is by far the most comprehensive prepared about the Newcastle coalfield up to that time.

William Keene played a considerable role in development of coal mining in the Hunter Valley. He arrived in N.S.W. in 1852 or 1853 and shortly after carried out an inspection of the FitzRoy iron mines near Mittagong and the coal deposits in the area.[161] In December 1854 he was appointed 'Examiner of Coal Fields' receiving 29/- per diem until 17 February, 1863.[162] On 18 February, 1863, he was appointed Examiner of Coal Fields, Hunter River District, and Keeper of Mining Records, with an annual salary of £600.

Keene spent much time in the field and in 1856 discovered coal in the South Maitland field. The Empire of 24 January, 1856, reported:[163]

> A few days since Mr Keene ... discovered close to Mr Knox Child's house, at Mt Vincent, [West of Sugar Loaf Range] in three creeks, five seams of coal, which he considered, from their bituminous quality, horizontal position, and geological formation to be the same seams that the Agricultural Company are now so profitably working at Newcastle, the upper Seam being above twelve feet.

About 1860 he prepared a geological map of the Wallsend area which unfortunately has not been found in the archives.

Although Keene's training in geology appears to have been rather sketchy, and many of his broader statements were not sound,[164] he collected systematic information from the various mines for many years.

Keene soon began a display of minerals which became a focal point for many visitors to the Newcastle district. The visitors' book in his Newcastle office,[165] commenced in January 1858, contains many notable names. Signatures include those of Rev. C.P.N. Wilton, Rev. W.B. Clarke, Dr Ferdinand Hochstetter of geological fame in New Zealand, A.R.C. Selwyn of the Victorian Geological Survey and later Director of the Geological Survey of Canada, Professor W.J. Stephens, the Governor General William Denison, Helenus Scott, James Brown, Robert Daintree and E.C. Merewether. A particular effort was made by Keene in 1866 in preparing a display of the State's mineral wealth. After causing favourable comment at the Singleton Show, it was sent to Melbourne for the International Exhibition and later to the Paris Exhibition of 1867.[166]

In December 1866 Keene's continuing employment was challenged in State Parliament by Mr J. Stewart in discussion of the estimates. Stewart expressed the opinion that:[167] 'he had little to do but to ride about enjoying himself... [Perhaps he] collected some information, but if he did he kept it to himself'. Stewart's motion was however strongly opposed by Mr Robertson pointing out 'The honourable member was mistaken, for Mr Keene, out of his zeal, was a perfect nuisance to the Minister in constantly dinning into his ears the information he had to impart', (Laughter). In the same session attention was drawn to the possibility of the State acquiring Keene's mineral collection. Similar discussion ensued at the time of Keene's death in 1872[168] but apparently nothing eventuated and the fate of the display has not been discovered. Unfortunately many of Keene's geological reports appear to have been lost or destroyed. Apart from his work on coal mines and regional geology, Keene carried out work on the supply of water from Redhead Lagoon to Newcastle[169] and

was an authority on wines, a topic with which he became familiar during a long sojourn in France prior to coming to Australia.[170] The fossil gastropod Keeneia which occurs in Permian rocks of the Hunter Valley was named by Etheridge in honour of him.[171] Stutchburia was also named to honour the pioneer worker.

There seems no substance in the comment by Heaton[172] that Keene was appointed Government Geologist in 1856. No geological appointments appear to have been made between 1855 when Stutchbury returned to England[173] and 1874 when C.S. Wilkinson began the first large scale geological survey.[174]

It is difficult to explain why the Government failed to follow up the work carried out by Stutchbury, and did not appoint a permanent Government Geologist in New South Wales. Probably there were a number of reasons. In the first place it is likely that the Rev. W.B. Clarke exerted some influence on the authorities and persuaded them that he was capable of carrying out all necessary work. Then there was the use to which the work would be put: there was no department of mines ready to take up the leads offered by Stutchbury and consequently his work was soon buried in a mass of Parliamentary papers. Thirdly there seems to have been a general decline in activity in N.S.W. compared with Victoria where A.R.C. Selwyn's excellent surveys produced many useful maps of the goldfields, during the 1850's and 60's.

The New South Wales Government seems to have been content to amble along with Keene's work, supplemented at times by Clarke's surveys. On the other hand Clarke's continuing efforts to obtain rewards from the N.S.W. Government for discovering or predicting the discovery of gold may have aroused antagonism against geology in general.

Conclusion

From the earlier discussion it is clear that knowledge of the geology of the coal measures as a whole, and of specific areas, grew haphazardly. It is impossible to state precisely at what points the various detailed terms of nomenclature which we now use became established. The Borehole Seam was also known as the Company's Seam, Wallsend Seam and Minmi Seam, with occasional rather vague comments on their similarity until the 1880's. The Dirty Seam, now the Dudley Seam, was also known in some areas before 1890 as the Diamond Seam and the Victoria Tunnel Seam had several pseudonyms, in particular Burwood, which name has persisted until very recently, and Gully Seam, while the Great Northern was often referred to as the Cardiff Seam.[175] In general, seams were often named after the local mine, such as Greenhill, and little importance was attached to correlation from locality to locality.

During the 1850 decade despite the great interest in the older Palaeozoic rocks in Eastern Australia which contained gold and other minerals, a few significant geological papers dealing with coal were published, in addition to those already discussed.[176] And between 1860 and 1880 interest in the coal measures was maintained by the work of many authors.[177]

In 1875 detailed mapping in N.S.W. became properly established with the work of C.S. Wilkinson. He mapped the developing Lithgow-Wallerawang area in the Western Coalfield and produced a map of high quality.[178] He considered the Wallerawang coal measures to be equivalent to those of Newcastle at this time but in later years was more cautious. By 1880 Clarke's point of view had become established and the Palaeozoic age of the coal measures was generally accepted. However the nomenclature was far from clear.

Clarke in 1861 had originally proposed the general terms Upper Coal Measures, Upper Marine Series, Lower Coal Measures, and Lower Marine Series, but had thought of the latter as at least as old as Carboniferous. In 1875[179] he modified these terms. This fourfold classification, originally in fact threefold, became accepted, but along with this, the coal measures in each locality examined were given a name. A surprisingly modern classification was given by Etheridge in 1891[180] covering all the known areas.

In 1892 R.L. Jack and R. Etheridge, Jnr.,[181] published descriptions of some coal measures in Queensland. Finding the fossils had rather a broad time spread and being a little unsure, they proposed to term the age of these coal measures Permo-Carboniferous. This unfortunate term was adopted by C.A. Sussmilch and T.W. Edgeworth David in 1919[182] for the Newcastle coal measures and has been perpetuated by other writers up till the last decade. Today we accept the Newcastle coal measures as being Permian.

It may well be asked if the study of geology ever contributed much to coal mining in the Hunter Valley, or if it just followed on the heels of practical mining. Geology contributed a great deal, but it could have given more if the practical miners had allowed it. Knowledge of the behaviour of a seam, such as its dip, the presence of faults or dykes, variation in thickness, the type of rock cover, help in deciding how to work the seam. Much fruitless energy was expended in opening up poor coal seams during the 19th Century, and inadequate exploration can also explain many more recent failures in coal development. The futile optimism of many miners is shown by the opening of at least 500 'mines' in the Hunter Valley since mining commenced. Few of these

achieved efficient economic production. The sensible advice of people like Busby, Stutchbury and Odernheimer could have saved much time and effort and resulted in efficient mining if implemented in full.

On the other hand there is no doubt mining provided much information for geologists, fresh exposures of rocks, the opportunity to view rock structures in three dimensions, and to obtain unweathered specimens, which they used to develop their understanding of the region and to predict the behaviour of the rocks over a wide area. The value of geology began to be appreciated with the development of the Borehole Seam in the 'Delta' Collieries beneath a cover of alluvium deposited by the ancient Hunter River and specially towards the end of the 19th Century.

The mining fraternity did not become convinced of the importance of geological knowledge until the disasters at Lithgow Valley and Ferndale Colliery and a near disaster at the Maryville Colliery in 1886 prompted Royal Commissions[183] which showed the inadequacies of knowledge and the need for specific mapping, particularly in the 'Delta' area of Newcastle where erosion had been considerable.

Soon after, the work of T.W. Edgeworth David and his associates began, published in detail in 1907,[184] and the solid foundations of our present knowledge were laid.

APPENDIX 1 - Table showing general succession of rocks in the Sydney Basin. From D.F. Branagan and G.H. Packham, Field geology of New South Wales. 2nd ed. Syd., Science Press, 1970.

Geological mapping has shown that the following sequence of rock units was deposited.

Time	Rock units	Probable environment	Maximum thickness	Locality of maximum development
Triassic	Wianamatta Group	freshwater (brackish)	800 ft	Razorback - Picton
	Hawkesbury Sandstone	freshwater (delta)	900 ft	Sydney
	Narrabeen Group	freshwater (lagoon and delta)	2,200 ft	Hawkesbury River - Gosford
Permian	Newcastle and Tomago Coal Measures (Lower Hunter Valley). Singleton Coal Measures (Upper Hunter Valley). Illawarra Coal Measures (remainder of basin).	freshwater and brackish	5,000 ft	Hunter Valley
	Maitland Group (Hunter Valley) - Shoalhaven Group (South Coast and West).	marine	6,400 ft	Hunter Valley
	Greta Coal Measures (Hunter Valley). Clyde Coal Measures (Far South Coast).	freshwater and brackish	400 ft locally thicker	Hunter Valley
	Dalwood Group	marine	5,000 ft	Hunter Valley

Basement rocks: Carboniferous, Devonian, Silurian, Ordovician and (?) Cambrian.

Total maximum thickness was probably 15,000 feet, the Triassic rocks being nearly 4,000 feet thick. The complete sequence has not been found at any single locality. There is clear evidence that earth deformation was occurring in some localities during Permian and Triassic times. It caused the formation of isolated basins and domes in some areas, resulting in variation in the thickness and lithology of sediments deposited.

APPENDIX 2 - Table of geological time. From D.F. Branagan and G.H. Packham, Field geology of New South Wales. 2nd ed. Syd., Science Press, 1970.

GEOLOGICAL TIME SCALE

Era	Period	Age at base x 10^6 yr	Life Development	Major features in N.S.W.
Cainozoic	Quaternary			
	Recent Epoch	0	man	
	Pleistocene	1	flowering plants dominant	glaciation in Kosciusko region
	Tertiary			
	Pliocene	12	primitive horses	Kosciusko uplift.
	Miocene	28)	advent of apes	formation of
	Oligocene	38)		duricrust
	Eocene	52	first mammals	
	Palaeocene	65	extinction of dinosaurs	volcanic activity in E. Australia
Mesozoic	Cretaceous *	135	climax of reptiles - first flowering plants	Great Artesian Basin
	Jurassic	180	first birds	
	Triassic	230	first dinosaurs	Clarence-Moreton Basin
Palaeozoic	Permian *	280	rise of reptiles, first land vertebrates, large non-flowering plants	coal (N.S.W., Q.), Sydney Basin begins. glaciation
	Carboniferous *	345	common land plants	glaciation. last folding of Lachlan Geosyncline
	Devonian *	405	fishes, land plants	extensive lakes - shallow seas

Era	Period	Age at base x 10^6 yr	Life Development	Major features in N.S.W.
Palaeozoic	Silurian *	425	first land plants corals dominant	intense volcanism. abundant marine life
	Ordovician *	500	invertebrates dominant, first corals	dominantly deep seas
	Cambrian *		first graptolites, trilobites	shallow sea in far west
Precambrian	Proterozoic *	?1,800	probable development of shelled animals	glaciation. metamorphic rocks - Broken Hill area
	Archaean *	?3,400	algae common, primitive life	

* Folding, uplift and granite intrusion occurred during these periods in different parts of Australia.

APPENDIX 3 - Table of rock succession in the Hunter Valley. From D.F. Branagan and G.H. Packham, Field geology of New South Wales. 2nd ed. Syd., Science Press, 1970.

STRATIGRAPHIC NOMENCLATURE AND CORRELATION OF THE PERMIAN ROCKS OF THE HUNTER VALLEY

Hunter Valley (David, 1950)	Lower Hunter Valley - present usage	Singleton - Muswellbrook present usage
(former) Upper Coal Measures: Newcastle stage	Newcastle Coal Measures (subdivision, P.J. McKenzie)	Singleton Coal Measures (subdivision, J. Robinson)
Tomago stage	Tomago Coal Measures (subdivision, J. Robinson)	
(former) Upper Marine Series: Mulbring stage	Maitland Group: Mulbring siltstone	Maitland Group: Mulbring siltstone - Branxton formation
Muree stage		
Branxton stage	Branxton formation (subdivision, M. McKellar)	
(former) "Lower Coal Measures"	Greta Coal Measures (subdivision, Basden, Shiels & Robinson)	Greta Coal Measures (subdivision, Basden, Shiels & Robinson)
(former) Lower Marine Series: Farley stage	Dalwood Group: Farley formation	
Rutherford stage	Rutherford formation	
		Gyarran volcanics
Allandale stage	Allandale formation	
Lochinvar stage	Lochinvar formation	

APPENDIX 4 - Table of rock succession in the Newcastle region. From D.F. Branagan and G.H. Packham, Field geology of New South Wales. 2nd ed. Syd., Science Press, 1970.

STRATIGRAPHIC NOMENCLATURE OF THE NEWCASTLE COAL MEASURES
(After P.J. McKenzie)

System	Group	Subgroup	Formation
Triassic	Narrabeen		Munmorah Formation
Permian	Newcastle Coal Measures	Moon Island Beach Subgroup (250ft)	(Wallarah Seam (Catherine Hill Bay Formation ((includes Teralba Conglomerate) (Great Northern Seam (Eleebana Formation (includes (Awaba Tuff) (Fassifern Seam
		Boolaroo Subgroup (300ft - 600ft)	(Croudace Bay Formation (includes (Belmont Conglomerate) (Upper Pilot Seam (Reid's Mistake Formation (Lower Pilot Seam (Warner's Bay Formation (Hartley Hill Seam (Mount Hutton Formation
		Adamstown Subgroup (500ft)	(Australasian Seam (Tickhole Formation (includes (Charlestown Conglomerate) (Montrose Seam) (Kahibah Formation) often (Wave Hill Seam) combined (Glebe Formation (Fern Valley Seam (Kotara Formation (includes (Merewether Conglomerate)
		Lambton Subgroup (200ft - 300ft)	(Victoria Tunnel Seam (Shepherd's Hill Formation ((includes Nobby's Tuff) (Nobby's Seam * (Bar Beach Formation (includes (Signal Hill Conglomerate) (Dudley Seam * (Bogey Hole Formation (Yard Seam * (Tighe's Hill Formation (Borehole Seam * (Waratah Sandstone (100ft)

Underlain by Tomago Coal Measures

* The Nobby's and Dudley Seams combine westerly to form the Young Wallsend Seam. The Young Wallsend, Yard and Borehole Seams combine westerly to form the West Borehole Seam.

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