The Thick and Thin of Australian Coal Mining: A Comparative Mining History of the South Maitland and Powlett River Coalfields

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During the second half of the nineteenth century and early twentieth century, the demand for black coal grew dramatically in a rapidly industrialising Australia. Coal was required for metallurgical purposes, to manufacture gas, to drive the wheels of industry and to provide the essential fuel for the expanding rail network. In the years from 1880 to 1930, the Northern Districts of New South Wales produced the lion's share of this coal. From the 1890's on an increasing proportion was produced from the Maitland District. By 1910 the Maitland District was responsible for approximately half of the total production from the Northern Districts. Between 1910 and 1930, output from the Maitland District increased to a point where 50 per cent of NSW production was coming from this area. During these years, 25 privately owned collieries were established in the triangle between Maitland, Branxton and Cessnock to exploit the seams of the Greta Coal Measures.[1]

From the 1850's, the infant colony of Victoria attempted to exploit its relatively meagre resources of black coal in Gippsland with the aim of gaining independence of supply from NSW. Early attempts were plagued by difficulties, to the point that by 1880 all serious attempts at a home grown coal industry were put on hold. Increasing industrial problems in NSW toward the end of the century, coupled with new promising discoveries in Gippsland, prompted a more vigorous attempt at a local coal industry from the mid-1880's. Private development of these new discoveries during the 1880s and 1890s culminated in a position of relative self-sufficiency from 1896 to 1902. Decline in production from these operations after 1903, together with an imminent threat to supply from NSW, eventually led to the setting up of the Victorian State Coal Mines on the Powlett River Coalfield in 1909. From 1910 to 1930, local black coal production in Victoria increased to a level equivalent to 60 per cent of the tonnage then imported into Victoria from NSW, reflecting a determination to maintain a degree of leverage over NSW supplies. Almost all production in this period came from the State Coal Mines.[2]

As these statistics suggest, from about 1910 on, the Maitland District mines and the Victorian State Mines grew in parallel. On the Victorian market the two regions were rivals throughout these years. Their respective histories with regard to mining practice were, however, markedly different. The impact of pre-existing mining practice in each of the regions on the eventual evolution of mining methodology is discussed below.

An underlying characteristic of mining operations in the two regions was the push to recover as much as possible of the in-situ reserve. In the Victorian case, much of the reserve occurred in relatively thin and discontinuous seams, emphasising the importance of maximising recovery from each area of coal developed. By contrast, the Maitland District was characterised by the widespread occurrence of thick and continuous seams of coal. The vast majority of coal won in the Maitland District was from seams much thicker than the two to three metres generally considered optimum for mining at the time, placing an onus on operators to avoid wastage when applying mining methods developed for seams around the optimum thickness. A feature of the evolution of the industries in the respective regions was the public interest shown in the issue of recovery, most evident through the number of Royal Commissions and other public enquiries held over the years. The relative success of the respective mining practices in achieving optimum recovery is examined.

General history of the Maitland District

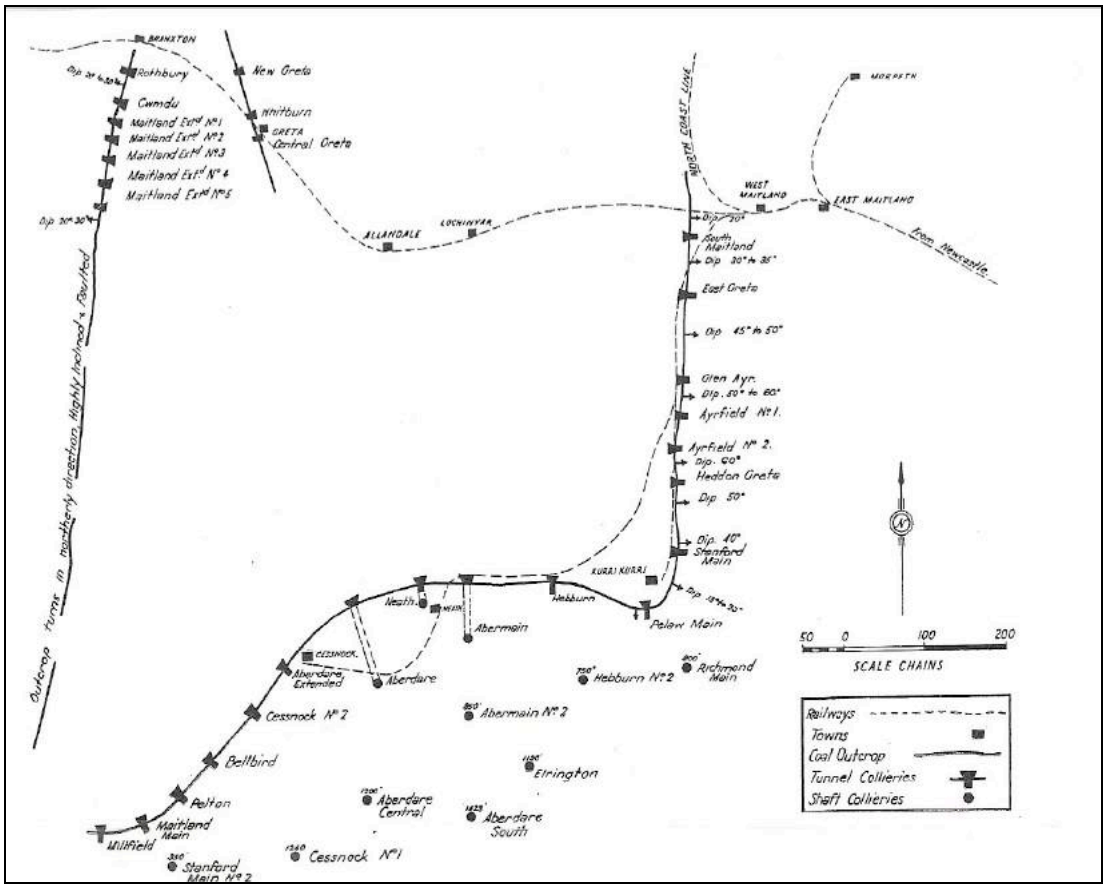
From their comprehensive definition by Prof. Edgeworth-David in 1886,[3] the Greta (or Lower) Coal Measures of the Sydney Basin were of obvious commercial value. The Greta coal proved to be of an excellent character for a range of uses, notably gas making, where it gained an international reputation, and steam raising, particularly for the railways. The comparatively great thickness of the two main seams (Greta and Homeville) and the relatively large extent and freedom from geological complications made the Greta Coal Measures a very attractive target for mining.

The first recorded commercial mining of the Greta Coal Measures is attributed to William Farthing, who in 1864 commenced supplying the Australian Steam Navigation Company from his Anvil Creek Colliery located on the northern outcrop of the coal measures near the town of Greta.[4] According to Davies and Tonks, the pioneer operation in the Maitland area was the East Greta Coal Mining Company, which commenced operations in 1891 at the site of East Greta No. 1 Colliery (see Figure 1).

Their operations were in the more steeply dipping, northern, portion of the field. Operations in the flatter, southern, part of the field commenced soon after.

Once the market attractiveness of the Greta coal became apparent, the level of activity increased rapidly. In the more steeply dipping areas a variety of mining methods evolved over time. These methods were developed to cope with specific circumstances and did not necessarily reflect any direct extrapolation of prior mining practice in the region. In the flatter part of the field, however, a more or less consistent mining methodology did grow up, based on the previous mining history of the nearby Newcastle District. The flatter part of the field south-west of Kurri Kurri became known as the South Maitland District. It was this region that ultimately became the most important producer during the period of interest from 1910 on.

Figure 1: *Collieries of the Maitland.*



Source: H.S. Elford and M.R. McKeowen, *Coal Mining in Australia*, Tait Publishing, Melbourne, 1947.

Background to mining practice in the South Maitland District

The genesis of the mining methods used in the South Maitland District lay in the fact that early development of the Maitland District was undertaken by groups emerging out

of Newcastle.[5] By the time that operations got underway in the Maitland District, the bord and pillar system had become firmly entrenched as the method of choice for extracting the generally two to three metre thick seams of the Newcastle Coalfield,[6] despite the fact that this system was by then losing favour in the UK.[7]

The concept behind the bord and pillar system as it was then practiced is summarised in coal mining texts of the time.[8] A regular grid of pillars was first formed, on advance, by driving a network of headings and cut-throughs (bords) in the coal until the boundary of the area to be extracted was reached. This process was termed 'first working or working the solid'. During the second phase, termed 'second working or working the broken', an attempt was made to extract as much as possible of the standing pillars, on retreat, by either a series of open-ended lifts taken from the outside of the pillar, or by splitting the pillar and then removing the pillar coal remaining on each side of the split. As the pillars were progressively extracted, roof support was removed and the overlying strata allowed to collapse in a controlled fashion to form a weight bearing goaf.

In the Newcastle District by the 1890s, mining practice had come to be based on a system of relatively wide bords and narrow pillars to maximise recovery during first working.[9] While this had proved adequate while workings were shallow, problems had begun to become apparent as the depth of mining increased. The Chief Inspector of Coal Mines gave a contemporary account of these problems in 1897:

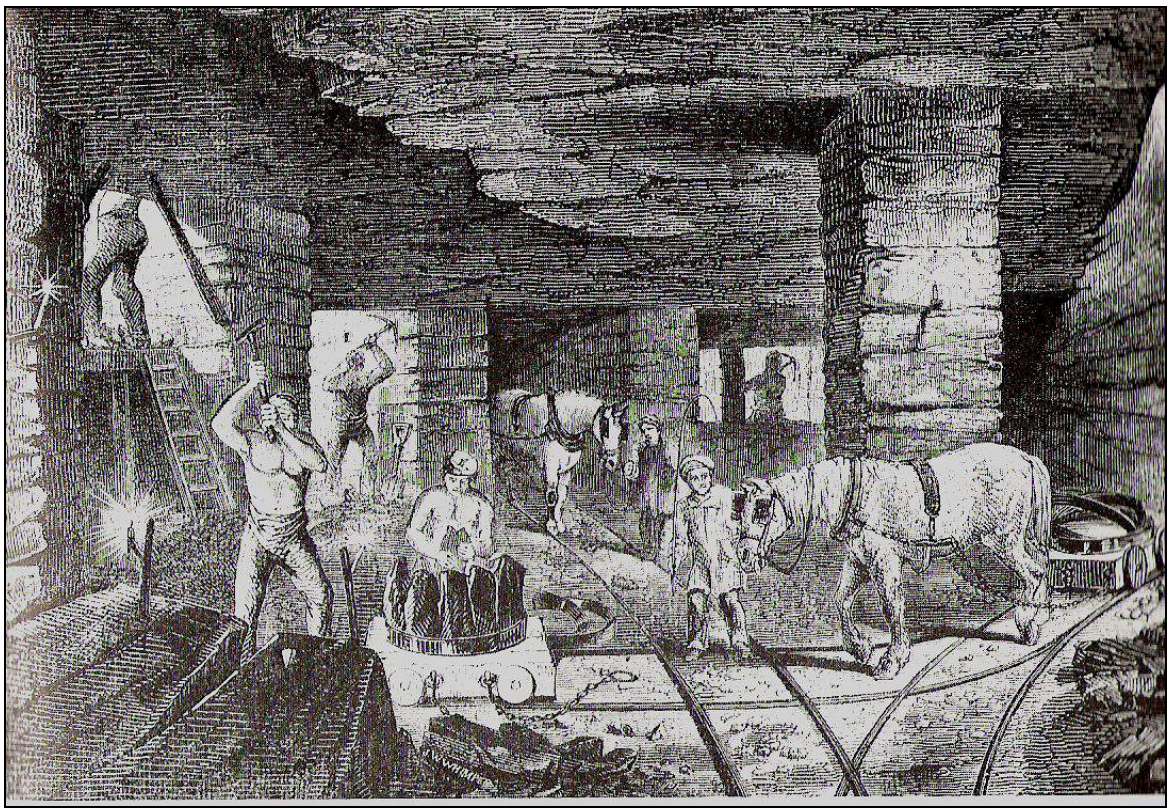
> In the very shallow workings it was customary to get as much coal out as possible in the whole or first working, leaving only thin ribs of coal between the bords, and there is no intention, in most of these cases, to get any of the coal in these ribs by working the broken. As the deeper coal had to be worked, sufficient attention was not given to the additional amount of weight to be supported by the coal pillars, in consequence of the extra depth: and as a result of this the superincumbent strata crushed the pillars down, causing what is known in mining language as a "thrust" or "creep", by which all the old bords and walls which had been formed closed up, and in some instances resulting in loss of life and property … In addition to the advisability of leaving larger pillars to prevent "thrusts" or "creeps", there are other reasons which might be urged in favour of larger pillars … especially in those cases when it is intended to remove them.[10]

Although many mine managers continued to operate without adequate attention to the problems that were emerging, there was a growing awareness during the 1890's that a more scientific approach needed to be adopted to ensure that premature pillar failure did not occur.[11] The changing awareness of the importance of maintaining

adequate pillar size was reflected by an insertion placed in mining leases by the NSW Mines Department:

> And shall an will extract the coal from the land hereby demised in the most economical manner possible consistent with safety: and should the pillar and [bord] system of working be adopted, the percentage of the coal to be left in the pillars after the bords, headings, drives or other workings are constructed shall be as follows:- Where the depth from the surface does not exceed two hundred feet, fifty percent; from two hundred to five hundred feet, in the proportion of from fifty to sixty percent; from five hundred to one thousand feet, in the proportion of from sixty to seventy percent; from one thousand to two thousand feet, in the proportion from seventy to eighty percent.[12]

Figure 2: *Mining a thick seam in Staffordshire using the bord and pillar system.*



Source: J. Temple, *Mining, an International History*, Ernest Benn, London, 1972.

While these rules helped to put some sort of framework around safe proportional extraction of a coal seam on a plan basis for seams around two to three metres thick for which the vast majority of local empirical experience had been gained, they did not specifically address the impact of pillar height on stability. The latter was an issue that was to prove of great importance as development of the South Maitland District proceeded. While experience had been gained in the UK using the bord and pillar

system to extract thick seams,[13] little direct experience had been gained locally in thick seams.

This then was the prevailing climate when mining activities got underway in earnest in the South Maitland District in the first decade of the twentieth century. By this time a potentially serious problem had been revealed. The Greta Sequence seams had been shown to be prone to spontaneous combustion when opened up, due to relatively high sulphur content in places, leading in some instances to mine closures.[14]

By around 1910, the South Maitland District was well established and sufficient experience had been gained to encourage the NSW Government to hold a Royal Commission in 1911 into the best ways of 'Working Thick Coal Seams in the Maitland-Cessnock District' with a view to maximising overall recovery while maintaining safety.[15]

The 1911 Royal Commission

The 1911 Royal Commission studied in detail six collieries then operating in the South Maitland District. All of these were operating the bord and pillar system, with workings divided into panels bounded by substantial barriers of coal as a precaution in the event that problems occurred and the panel had to be abandoned. Only a very limited amount of pillar extraction had been attempted at shallow depth in one operation. The maximum depth worked up to that point in these mines had been 155m, with seam thickness up to 7.6m. A generally consistent approach was being taken to first working, with bords from 2.1 to 3.3m high being formed near the base of the seam section, followed, commonly, by the 'top coal' being dropped to form pillars up to 5.5m high (see Figure 3). In some cases the top coal was being left for subsequent removal in conjunction with pillar extraction. The proportion of coal (on a plan basis) left in pillars to this time varied from 50 to 65 per cent, depending on depth. This was in general accord with the lease condition discussed above.

Based on the evidence of a number of persons involved in various capacities in the mining of the Greta Sequence seams, and in light of the relative freedom from problems up to that date in the South Maitland District, the Commission came up with a series of recommendations for on-going practice that essentially regularised what had become the general practice for first working in the mines studied. The Commission gave most attention to examining alternate schemes for extracting as much as possible of the thick seams. Four alternate schemes were considered, which in broad terms could

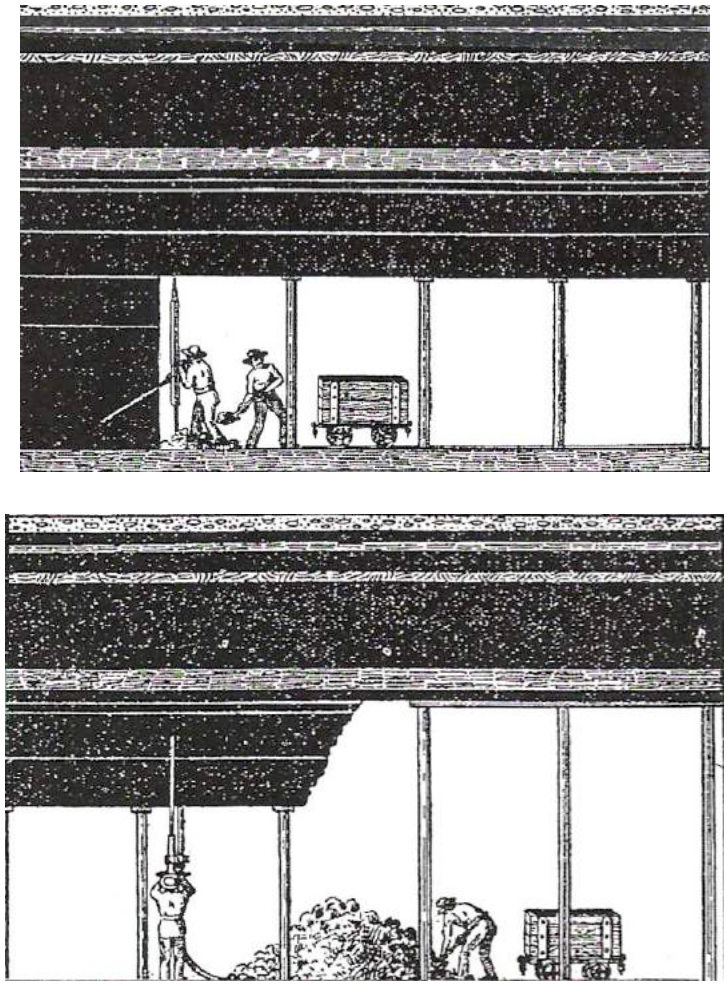
be categorised as some form of extraction of pre-formed high pillars, working within the bord and pillar context, involving simultaneous removal of the full working height in two or more segments (see Figure 4), or a system of working the seam from the top down in sequential slices of 'conventional' height, with extraction completed in the upper slice prior to starting the next slice down.

The former approach above reflected a practical miners perspective, despite the obvious difficulties inherent in ensuring adequate support. The latter approach would rely on the goaf formed during mining of the top slice consolidating to a sufficient extent to provide a suitable roof for removal of the lower slice. This concept was proposed by the mining inspectorate and was probably too radical for the time, given the general scepticism about whether the massive conglomerate roof rock of the Greta Sequence could ever consolidate into a suitable roof. In the event, it was the former approach that was favoured by the Commission, and that subsequently became the norm for the South Maitland District, with its associated potential for problems associated with pillar failure as the depth of mining increased.

The 1911 Royal Commission provided the framework for subsequent development of the South Maitland District for the next two decades. The practice of dropping top coal during first working became increasingly popular, forming pillars up to 9m high. This latter activity was often prompted by the inability of mine managers to get clearance from the Mines Department to extract pillars unless full recovery was anticipated (an onerous expectation in the circumstances). Dropping the top coal was seen as a way of increasing production without having to undertake pillar extraction at that point in time or to contravene lease conditions with regard to percentage extraction during first working. As a result, large areas of relatively slender (compared to previous experience) standing pillars were created. As workings got deeper, these slender pillars began to crush in many instances, leading in some cases to progressive pillar failure and spontaneous combustion of the fragmented, sulphur rich coal.

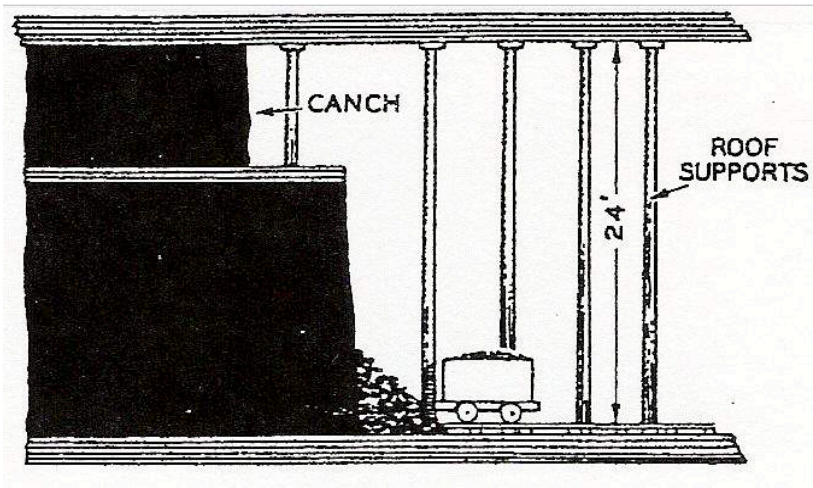
The situation was generally exacerbated when pillar extraction of high pillars was attempted by a method such as that illustrated in Figure 4. For various reasons, the miners union insisted that pillar extraction by such methods be carried out entirely by hand, with limited miners working in an area at any one time. This led to the prolonging of the pillar extraction process and consequent compromising of scheduling aimed at avoiding the onset of excessive weighting of transient pillar fragments. The

Figure 3: *Typical scheme of first working in the South Maitland.*



Source: L.J. Jones, '*The Coal Resources of the Southern Portion of the Maitland-Cessnock-Greta Coal District, Mineral Resources Bulletin no 37, Dept. of Mines, New South Wales,* NSW Government Printer, 1939.

Figure 4: *The Canch System for simultaneous extraction of high pillars.*



Source: H.S. Elford and M.R. McKeowen, *Coal Mining in Australia*, Tait Publishing, Melbourne, 1947, pp. 146-62.

delay also increased the chances of spontaneous combustion by prolonging the incubation time. In some cases, the situation was made worse by the practice of robbing pillars to increase the proportion of coal recovered without there being the intention of anything like complete pillar extraction. Pillars often began to crush during extraction, giving rise to 'creeps'. The net result was that large areas of pillars were often abandoned, panels sealed, and a substantial proportion of the resource effectively sterilised.[16]

The obvious wastage of a valuable resource caused much alarm amongst the mining and wider community. This feeling is manifest in a number of articles published at the time, such as that by J.T. Watson in 1924:

> If the methods of mining now in operations were the only ones applicable under the conditions existing in the district, no exception could be taken to them, and the consequent heavy loss of coal would have to be accepted as unavoidable. However, that such is not the case is perfectly well known to every manager who has kept in touch with modern developments in other countries. … Methods of mining have been devised in other countries which not only permit of a high percentage of extraction of coal, but almost completely eliminate the dangers and losses due to gob [goaf] fires, and would effect a marked improvement in the direction of decreasing the number of fatal and serious accidents due to falls of roof, so much in evidence under existing conditions. [17]

The situation became so alarming by the mid 1920's that the NSW Government convened further Royal Commissions in 1925[18] and 1929[19] to look into alternative extraction schemes.

The 1925 and 1929 Royal Commissions

By the time of these Commissions it was evident that only about 20 to 30 percent of the available coal in place was being won in the South Maitland District, mainly from first workings, and that a large proportion of the remaining coal was being lost to posterity.

The 1925 Commission investigated pillar extraction then taking place in South Maitland operations and came to the view that only very limited success was being had, and only when the working height was not excessive. After looking into a range of options, the Commission suggested that a radically new approach be instigated. Acting upon the results of the Commission, and based on the results of an overseas inspection of thick seam mining operations, the then Minister for Mines in NSW, J.M. Baddeley, came to the conclusion that most appropriate approach would be to institute hydraulic stowing (filling), working in slices of about 2.5m from the base of the seam up.[20] In

such a scheme, the fill would be placed in the openings created during extraction of the lower slice to form the floor for subsequent operations in the next slice up. As well as providing a potential means of maximising recovery in virgin areas, this scheme was also seen as a basis for safely extracting the standing pillars already left in the extensive first workings undertaken in the field to date. The prospects for implementing hydraulic stowing were the subject of much debate during the Commission. While it was felt that the method might be applicable in the more steeply dipping mines, potential problems were foreseen in the flatter portions of the field.

The 1929 Commission reiterated the serious concern with regard to coal wastage. Again, a number of variations on the existing theme for removing pillars during bord and pillar operations were raised before it was concluded that some form of stowing might ultimately be the only answer to maximising recovery. Some investigations had by this time been conducted into possible sources of suitable filling materials. Based on these studies, the Commission came to the view that hydraulic stowing was unlikely to be economically viable in the context of the current private enterprise operations in the South Maitland District. The Commission did, however, recommend that experimental trials of stowing be undertaken, along with any other possible alternative means of extracting thick seams, and that a financial incentive be given to encourage this. In the event, it was not until the mid 1940's that trials of stowing were commenced.

Meanwhile, while all this debate was going on, the extent of standing pillars being produced during first working by the ever expanding level of activity was increasing dramatically. Mines were getting deeper and the problems of creeps and spontaneous combustion ever present. A variety of hybrid schemes were being employed by the mine operators in an attempt to extract pillars, generally with limited success. These schemes were tailored to specific conditions and/or prejudices, with the result that no obviously preferable general practice had emerged. By the 1940's, the vast extent of potentially irrecoverable standing pillars threatened the future of the field and the loss of an immensely valuable national resource. With this background, the Federal Government instituted yet another Royal Commission in 1945.

The 1945 Royal Commission and beyond

The 1945 Royal Commission[21] devoted a lot of its effort to looking into the historical operations in the South Maitland District. They found vast areas of standing pillars had

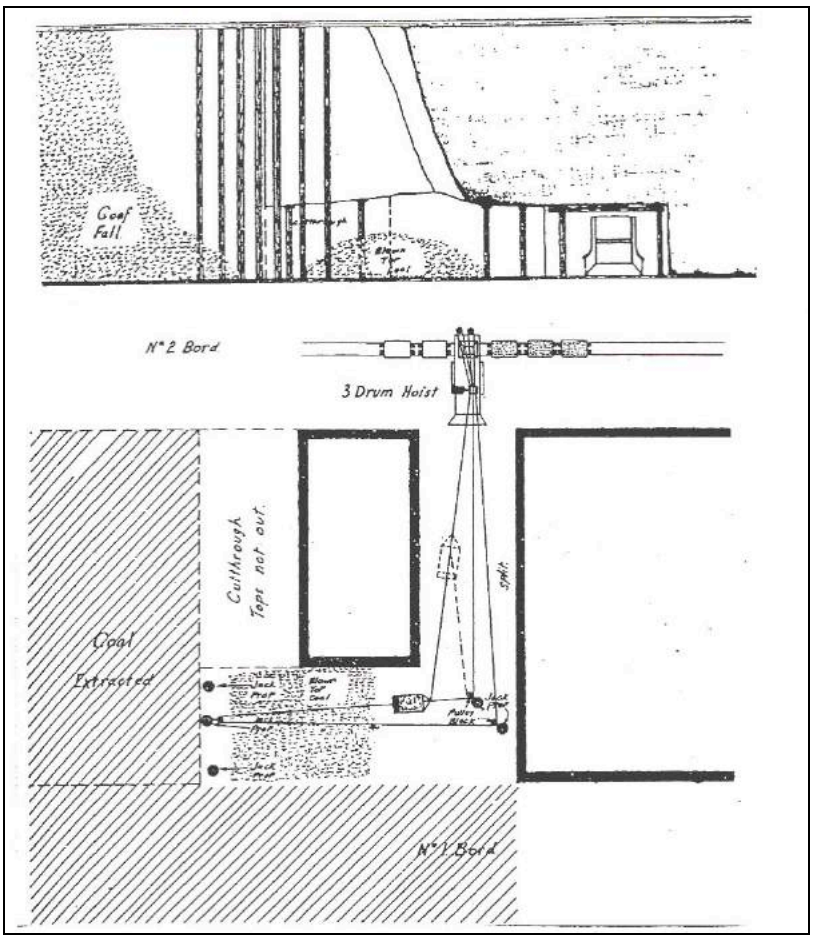
been left and pillar extraction delayed indefinitely, against the unanimous view of the time that pillar extraction should proceed in an orderly and continuous way as soon as possible after the pillars had been formed. The Commission saw the problem as being due to the often unreasonable intervention of the mining inspectorate and the entrenched interests of the mining unions in persisting in bans on mechanised pillar extraction, rather than fundamentally rooted in the details of the mining methods employed. The Commission considered the view put by mining experts that with modern mechanised techniques it would be possible to extract up to 70 per cent of the coal without recourse to costly alternatives such as stowage. Even though trials of hydraulic stowing had commenced at the time, the Commission held out little hope that such a method would ever find wide spread acceptance in the Australian economic environment. The Commission recommended that restrictions on mechanised pillar extraction be removed to allow experiments to be conducted.

In 1947, Elford and Mckeowen[22] conducted a review of the state of mechanisation in the South Maitland District. The activities of two established collieries working seam sections from 3.5 to 5.5 metres high were described (Richmond Main and Abermain No. 2). In both these operations, pillar extraction appeared to be undertaken successfully shortly after first working, using a combination of track mounted electric coal cutters and loaders, and/or scraper-loaders (see Figure 5). Around the same time, trials of hydraulic stowing had got to a stage where placement of fill had been successfully undertaken at Aberdare Extended Colliery[23] but the impact of this on the recoverability of pillars and the costs involved had not been evaluated.

Despite concerted attempts, introduction of mechanised bord and pillar mining in the South Maitland District lagged behind progress elsewhere in NSW. The first continuous miner was not introduced until 1958, at which time nearly half the coal being won in the District was still being mined by hand.[24] Trials of hydraulic stowing continued into the 1950s, but never reached a point where the technique could prove its general benefit to the recovery of the Greta Sequence seams.[25] By the 1960s the field was in rapid decline due to dwindling reserves of virgin coal and the lack of a satisfactory method of extracting high standing pillars, accentuated by loss of markets to alternative energy sources. As a postscript, in the 1980s the Newcastle Wallsend Coal Co. opened its modern mechanised longwall retreating operation at Ellallong Colliery in the Greta Seam. Although not free of problems, the relative success of this operation in recovering a high proportion of the seam emphasises the importance of innovative

thinking when it comes to choosing an appropriate mining method for a particular set of conditions.

Figure 5: *Mechanised scraper-loader extraction of high pillars in the South Maitland District, circa 1940s.*



Source: H.S. Elford and M.R. McKeowen, *Coal Mining in Australia*, Tait Publishing, Melbourne, 1947.

General history of coal mining in Gippsland

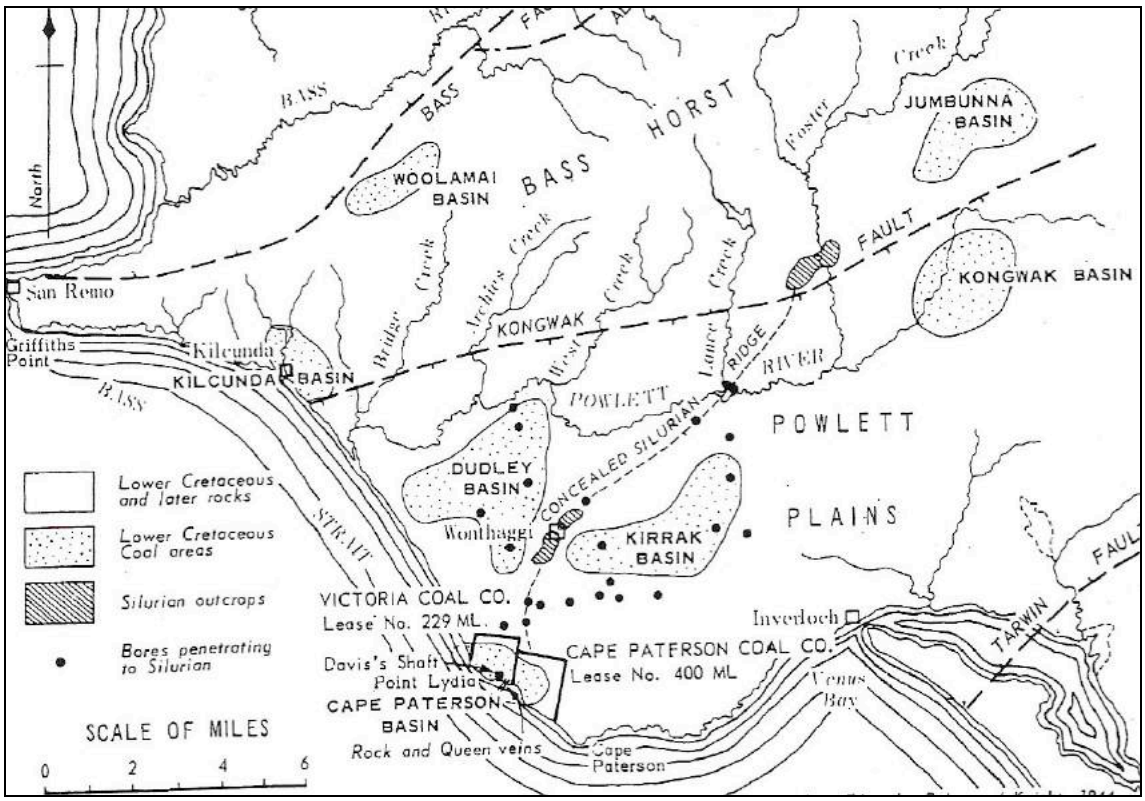
From the earliest days of black coal exploration in Victoria the relative paucity of workable seam thickness evident in successive discoveries was an issue. By the late 1880's this issue had reached a point where the Victorian Government was moved to set up a Royal Commission to look into matters relating to the mining of thin seams.[26] Even though there was a prevailing optimism that thicker seams would eventually be found, there was a realisation that mining methods applicable to the potentially costly complete extraction of thin seams, often truncated by geological discontinuities, would have to be embraced. The mining of thin coal seams, while not unheard of elsewhere in Australia, reached its greatest importance as a percentage of total production in Gippsland. Apart

from seam thickness, the quality of Gippsland coal compared to that from NSW, particularly Maitland, was a topic of debate during the Royal Commission. The Victorian Railways, which was the major market for Gippsland coal, maintained a policy of competitive sourcing of their coal supplies, consistently claiming Maitland coal to be superior to Gippsland coal for their purposes. Although disputed, the net result was that the value of Gippsland coal was effectively discounted and the competitiveness of the Victorian industry compromised. Despite these drawbacks, there was a strong underlying sense of the importance of having a local coal industry in Victoria, as witnessed by the Royal Commission's recommendation that a differential government bonus based on seam thickness be paid to encourage production from thinner seams.

The first attempt at commercial black coal mining started in Victoria when the Victorian Coal Co. was formed to mine the relatively thin seams outcropping along the southern Gippsland coast near Cape Paterson (see Figure 6). Between 1859 and 1864, when the company was wound up, a total of 2,000 tons of coal was extracted and shipped to Melbourne with great difficulty and expense.[25] In 1865 coal was found outcropping at Kilcunda to the west of Cape Paterson (see Figure 6). The Westernport Coal Co. was formed to mine the thin Kilcunda Seam and managed to produce 15,000 tons and ship it to Melbourne by 1877.[27] The driving force behind these early efforts was the collection of government rewards. While Cape Paterson was never to become a sustainable source of commercial coal, Kilcunda did continue as an intermittent commercial mining centre exploiting thin seams into the 1960s.

During the 1870's and 1880's, a number of new discoveries were made throughout Gippsland and a number of small-scale mining activities commenced.[28] By the 1880's the main focus had become the Narracan Valley on the northern slopes of the Strezleki Ranges. In 1883 the Moe Coal Co. was formed to work a 0.6m seam to the west of Narracan Creek[29] and became the major producer of a group of companies located around the town of Coalville. Relying entirely on the extraction of thin seams, these companies became the nucleus of Victoria's first serious attempts at what could be called a truly commercial coal industry. By 1887 the Narracan Valley Railway had reached Coalville and regular shipments of coal began to the State Railways. The signing of the contract for the supply of coal to the railways by the Moe Coal Co. can probably be taken as the real start of commercial black coal mining in Victoria, even though the financial return to the investors was minimal.

Figure 6: *Location of main black coal mining centres in Gippsland (Note Korumburra, Outrim and Coalville off drawing to north-east).*



Source: J.M. Coghlan, *The State Coal Mines and Wonthaggi*, *1909-1968*, B.J. Clancy, Wonthaggi, 1979.

By the mid 1890s the Narracan Valley mines were in decline and the centre of gravity of black coal mining in Victoria had moved to the Korumburra/Jumbunna/Outrim area (see Figure 6). Coal had been discovered in this area as early as the 1870s, but significant exploitation did not start until the 1890's with the formation of the Coal Creek Prop. Co. Ltd, followed by the Jumbunna Coal Co. and the Outrim, Howitt and British Consolidated Mining Co.[30] A feature of the development of this area was the siting of initial developments on relatively thicker seam sections compared to previous experience in Victoria (but not compared to NSW and elsewhere). This allowed for very profitable operations during the early years of these mines until thinning of the seams and disruptions by faulting occurred as operations progressed away from the starting point. High initial profits led to the payment of excessive dividends, leading in turn to a lack of investment in long term development. When this behaviour intersected with increasingly difficult mining conditions, the inevitable end point was a pressure on profitability and a serious deterioration in industrial relations. A prolonged miners strike starting in 1903 eventually prompted the Victorian Government to convene another Royal Commission in 1905.[31] The 1905 Commission examined a

wide range of technical and labour related issues afflicting the privately operated Victorian coal industry, with a view to establishing a framework to ensure on-going viability of the industry. Despite this, production in the Korumburra area never returned to pre-1903 levels and the field went into progressive decline.

Responding to a perceived threat to coal supplies from the problems facing the privately operated industry in Victoria and increasingly uncertain continuity of imports from NSW, the Victorian Government authorised the Mines Department to begin extraction of black coal from the Powlett River area (see Figure 6) in November 1909.[32] In ensuing years, the State Coal Mines came to overwhelmingly dominate black coal mining in Victoria and provide a model for the importance of appropriately selected mining methodology and technology in overcoming difficult mining conditions.

Background to mining practice on the Powlett River Coalfield

Although the bord and pillar system was applied successfully throughout the life of the State Mines for extracting the relatively thicker areas of coal (greater than 1.1m on average),[33] it was the application and development of the longwall advancing technique for extracting thin seams that came to typify the operations. By the time that activities started on the Powlett River Coalfield there already existed in Victoria a strong tradition for the use of this method. Although it is not clear exactly what mining methods were employed in the earliest Victorian operations, it is clear that the advantages offered by the use of longwall advancing in thin seams, as practiced in the UK, were appreciated at the time.[34] The first contemporary documented accounts of the use of longwall advancing in Victoria are for the Narracan Valley mines. In a mine surveyor's report dated 31 December1890, the following account is given of a visit to the Moe Coal Co's operation.

> Accompanied by the mining manager (Mr W. Burns) I have made a careful examination of this mine. A tunnel 6 feet by 5 feet [1.8 by 1.5m] has been driven from the out-crop, about 1 mile [1.6km] north-west of Coalville Railway Station, the total length from the mouth to the present face of coal being about 23 chains [463m]. The coal is being worked on the "long-wall system" which (in a thin seam) is more adaptable as regards economy and for ventilation purposes.[35]

When operations started in the Korumburra area, the bord and pillar system found advantageous initial application in relatively thicker seam sections.[36] The scope for the use of this method was, however, limited. In the case of the Outrim, Howitt and British

Consolidated Co., it appears that although using the bord and pillar system in 1896,[37] by 1897 the longwall advancing system was in use.[38] By the time the 1905 Royal Commission was taking evidence, it is clear that all the major mines in the district had for some time been working thin seams using the longwall advancing system.

According to Temple,[39] the longwall method was in use in the UK from the seventeenth century, and had the established reputation as potentially allowing most, if not all of the coal to be recovered in one continuous operation (at least if the seam was not too thick). By the time operations started in the Narracan Valley, longwall advancing had effectively completely replaced bord and pillar in the UK.[40] The longwall system was seen as having less potential to be wasteful than the bord and pillar system, this was a paramount consideration in the context of the limited resource available in Gippsland. The system as practiced at this time in the UK (see Figure 7) involved:

> coal being cut by a team of hewers working side by side at a long coal face. The working space, running the length of the face, was supported by wooden props, and, as the work advanced further into the seam, the props were moved up and the empty space behind them filled with the waste, the gob or goaf. The coal face was reached from the shaft by roads kept open through the goaf.[41]

Figure 7: *Longwall advancing in a UK Mine.*

Source: J. Temple, *Mining, an International History*, Ernest Benn, London, 1972.

Regardless of the mining method employed, in thin seam mining it is unavoidable that some rock will have to be removed from the floor and/or roof of

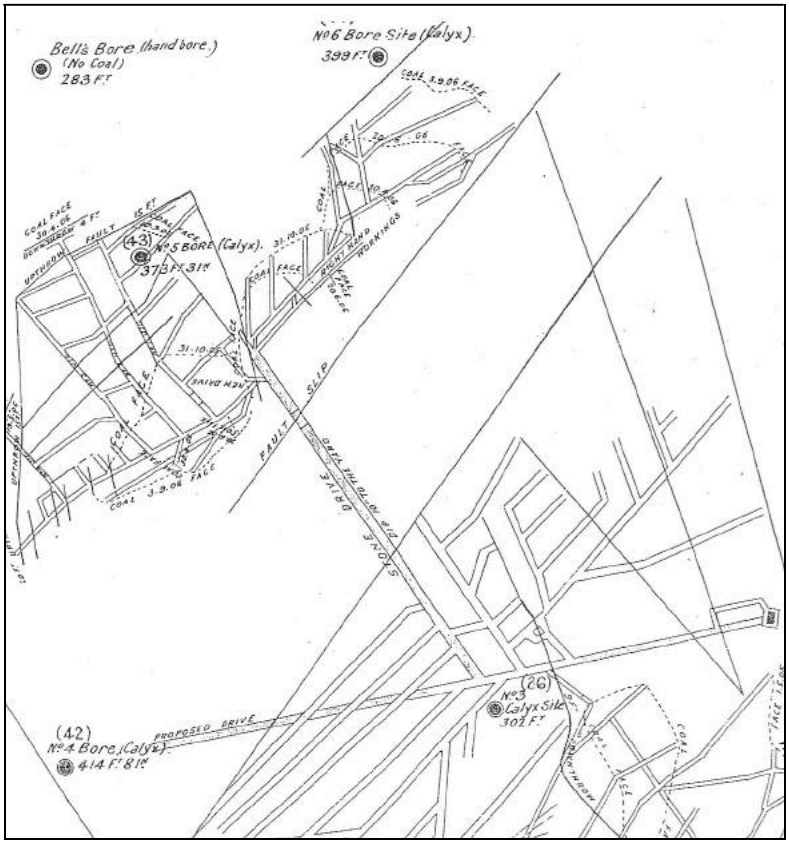
openings to accommodate men and equipment, as well as to facilitate adequate ventilation. This process, called brushing, produces a substantial volume of waste material that has to be dealt with. The average seam thickness of the Narracan Valley mines over their life was around 0.6m. In some areas, however, a seam thickness as little as 0.2m was worked. In such circumstances, the longwall advancing system offered the advantage to mine operators of using the waste material to help maintain the integrity of roadways through the goaf and to save on removal costs.

All factors considered, the choice of the longwall advancing system by the Narracan Valley mine operators was a logical one. The technique established a precedent that was built on when the Korumburra area mines turned to longwall advancing as seam thickness progressively decreased with time.[42] The details of the mining practice employed in the Coalville district are not clear from the limited documentation available, but some idea can be gleaned from a series of articles published in the *Narracan Shire Advocate* throughout 1890, under the by-line of 'Black Diamond',[43] and from evidence given to the 1891 Royal Commission.[44] In essence, it would appear that the system employed was based on contemporary practice in the UK as described in mining texts of the time.[45] Likewise, there is little published detail of the methodology used in the Korumburra area mines. A portion of the mine plan from one of these operations (see Figure 8) does, however, give some insight into the layout employed and the rate of advance of the face line. The importance of planning layouts to accommodate the numerous faults typical of Gippsland coalfields can be appreciated from this plan. This latter issue was one that remained of concern to the State Mines operators in later years.[46]

In the Narracan Valley mines, all coal hewing was done by hand by holing (undercutting) the seam, usually in the bottom section of the seam and then allowing/encouraging the undercut coal to collapse. This process ensured that a maximum proportion of coal would be produced as a coarse fraction rather than as low value slack (fines). The relatively friable nature of Gippsland coal compared to elsewhere, particularly Maitland, made the problem of fines production an on-going issue. By the time of the 1905 Royal Commission, coal winning in the Korumburra district was increasingly making use of mechanical coal cutters. The manager of the Jumbunna mine was particularly vocal in his assertion that these machines would be the saviour of their mine in particular, and thin seam operations in Gippsland in general.[47] In the event, this was demonstrably not the case, but never-the-less, mechanical coal

cutters of one type or another did subsequently become a feature in most Gippsland operations where they were claimed to reduce the amount of fines production.

Figure 8: *Section of mine plan from Coal Creek Mine, c.1906.*



Source: Final Report of the '1905-06 Royal Commission appointed to inquire into and report upon the Coal Industry', Parliament of Victoria, Victorian Government Printer, 1906.

By 1909, the principles of longwall advancing inherited from the UK had been blended with local experience to produce a mining methodology suited to the extraction of the thin Gippsland seams with all their peculiarities. This foundation was reflected in the subsequent refinement of thin seam mining practice at the State Mines.

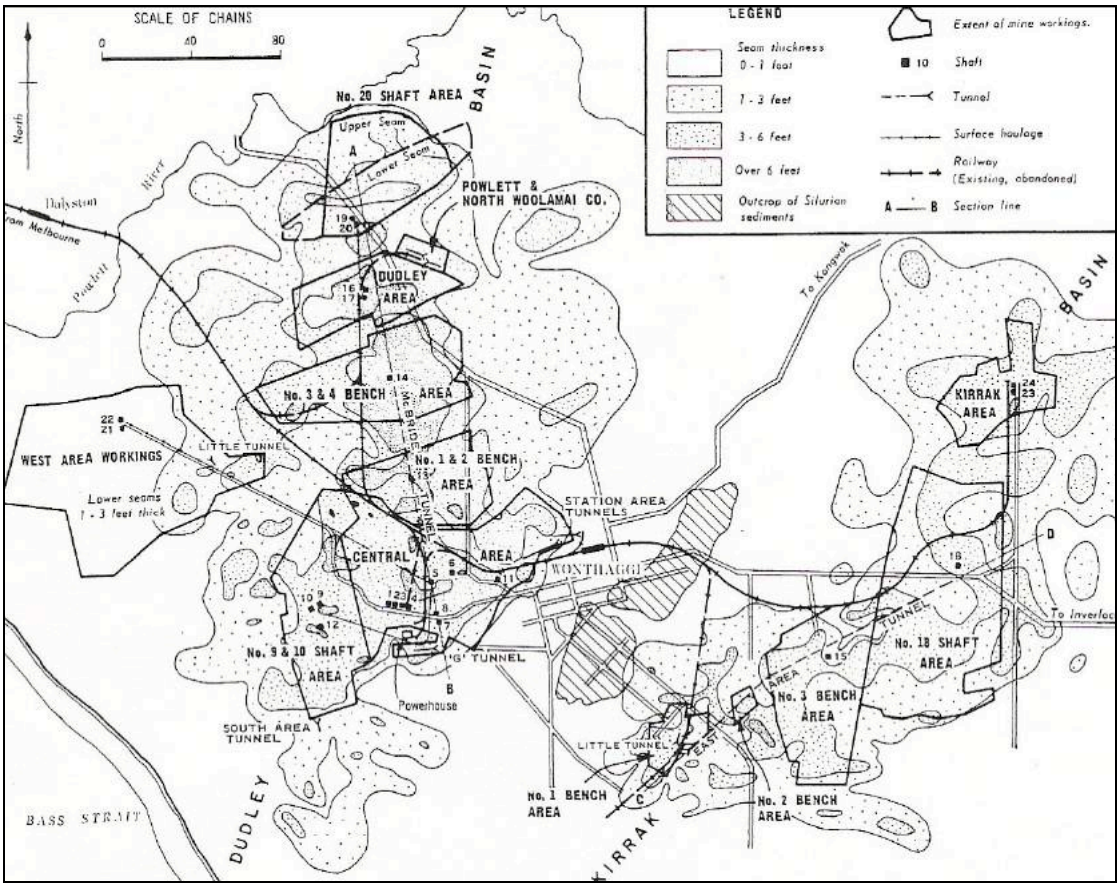
The Victorian State Mines

Prior to commencement of operations by the State Mines, the Victorian Mines Department had undertaken enough exploration drilling of the Powlett River Coalfield to prove that substantial reserves of good quality black coal existed. As luck would have it, however, it was the sinking of a water well and its chance intersection of a 1.8m seam at shallow depth that provided the incentive to set aside a mining reserve and dictated the site for initial mining activities.[48] As with previous experience in the Korumburra area, this fortuitous circumstance gave the fledgling enterprise a boost. Unlike the

former area, however, the early good fortune in the Powlett River area was built on by the State Mine operators to develop a sustainable, long-lived enterprise that was able to tackle the recovery of coal in increasingly thin and discontinuous seams.

As development of the Powlett River Coalfield progressed, the degree to which the seams were displaced by faults of varying magnitude became obvious. The strategy adopted to deal with this was to break the area up into a number of discrete packages and set up stand-alone operations in each. In the end, a total of twelve such entities became recognised collectively as the State Mines.[49] The relatively large area of thin seam mining undertaken over the life of the State Mines can be gauged from Figure 9.

Figure 9: *The State Mines.*

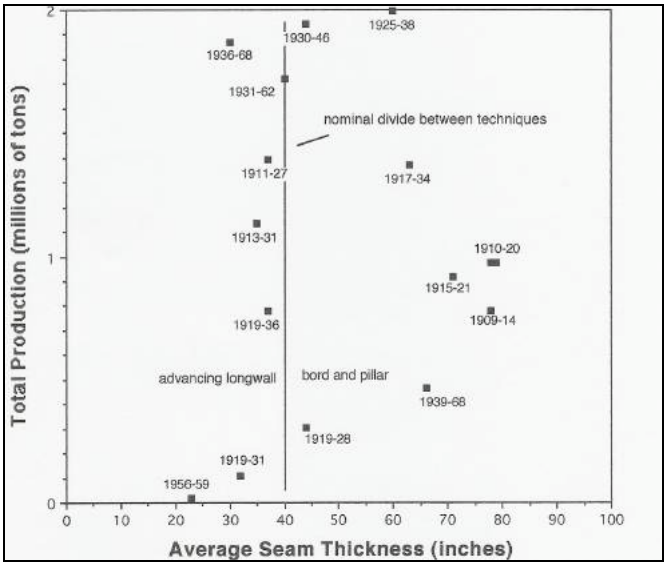


Source: J.M. Coghlan, *The State Coal Mines and Wonthaggi*, *1909-1968*, B.J. Clancy and Co., Wonthaggi, 1979.

As in the Korumburra area, the bord and pillar system was used in the initial activities of the State Mines to good effect.[50] In the early workings of the pioneer mines in the Central Area. bord and pillar and longwall advancing operations were carried out simultaneously, with the former output predominating. As time went on and operations

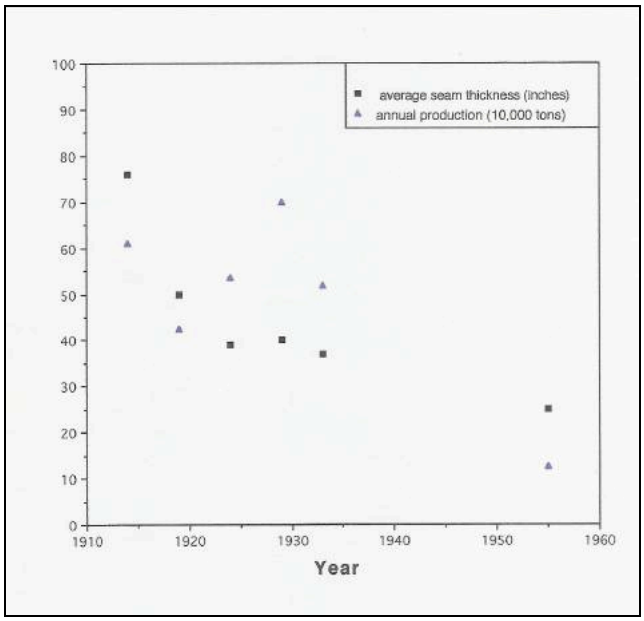
in other areas commenced, average seam thickness reduced and output from longwall advancing became relatively more important as illustrated by Figures 10 and 11.

Figure 10: *Total production over mine life from various producing centres at the State Mines versus corresponding average seam thickness, showing notional division of production between mining techniques.*



Source: J.M. Coghlan, *The State Coal Mines and Wonthaggi*, *1909-1968*, B.J. Clancy, Wonthaggi, 1979.

Figure 11: *Gross annual production and corresponding average annual seam thickness extracted at the State Mines versus year, showing progressively decreasing seam thickness during period of approximately constant production up to 1930, reflecting increasing importance of longwall advancing.*

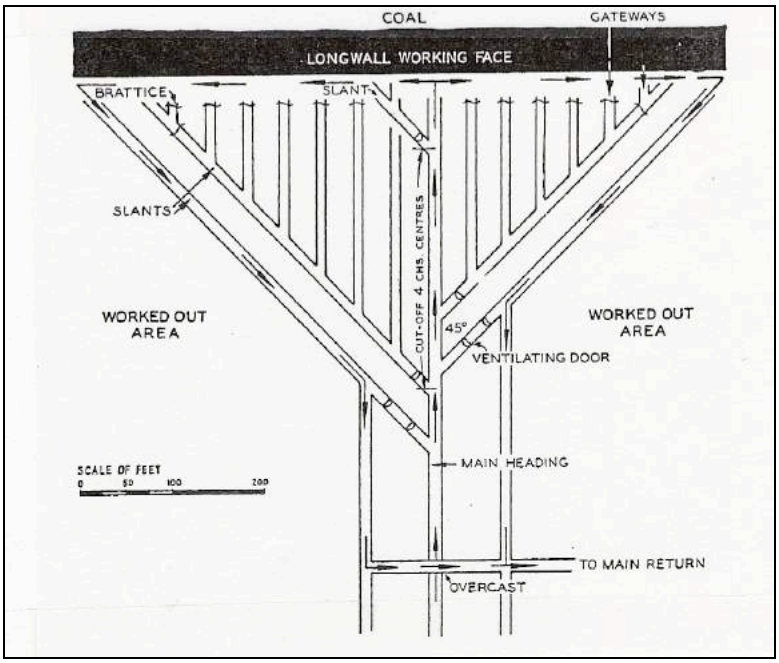


Source: Statistics from J.L. Knight, 'Problems Affecting the Black Coal Industry in Victoria', Unpublished Report, Victorian Department of Mines, 1956.

Longwall Advancing at the State Mines

At the time that the State Mines commenced operations, only a handfull of mines elsewhere in Australia were using longwall advancing to extract thin seams, notably Newcastle A and B and Stockton Borehole in the Newcastle District.[51] In no other major mining district in Australia did longwall advancing subsequently reach the level of importance that it did in the Powlett River Coalfield. As discussed above, the fundamentals of the method had already been worked out for Gippsland coal seam conditions prior to the State Mines commencing operations. During the life of the State Mines the technique was continuously refined to cope with an improving understanding of the mechanics involved and to cope with technological developments. The longwall operations of the State Mines acted as a model for other mining regions. The essential elements of longwall operations at the State Mines are well summarised in a number of retrospective accounts.[52]

Figure 12: *Arrangement for longwall advancing at the State Mines.*



Source: H.S. Elford and M.R. McKeowen, *Coal Mining in Australia*, Tait Publishing, Melbourne, 1947.

The idealised layout shown in Figure 12 illustrates the general geometric arrangement. After driving main headings to the selected starting position, slant roadways were broken away on both sides at an angle varying from 90 to 45 degrees. Off these, gateways were broken off as shown, at spacings of approximately 10 to 12m, until the desired length of the working face was defined. As the working face was

advanced, the gateways were maintained through the worked out area (goaf) until their length became excessive (typically around 80m) at which time a new set of slants would be developed from the main headings and the sequence repeated. When working by hand, two men would operate in each gateway, each being responsible for approximately five to six metres of face to one side or the other of the gateway. The geometry was critical in this situation since the coal had to be thrown manually from the face back to the gateway for transport out, five to six metres being the limit for this if the production of excessive fines was to be avoided. When mechanised coal loading was employed, the geometry was more flexible. The length of a working face and its orientation was generally dictated by the prevailing geological discontinuities. Considerable effort was devoted to advance delineation of discontinuities by exploratory drilling to avoid interruptions to production once a face was initiated.[53]

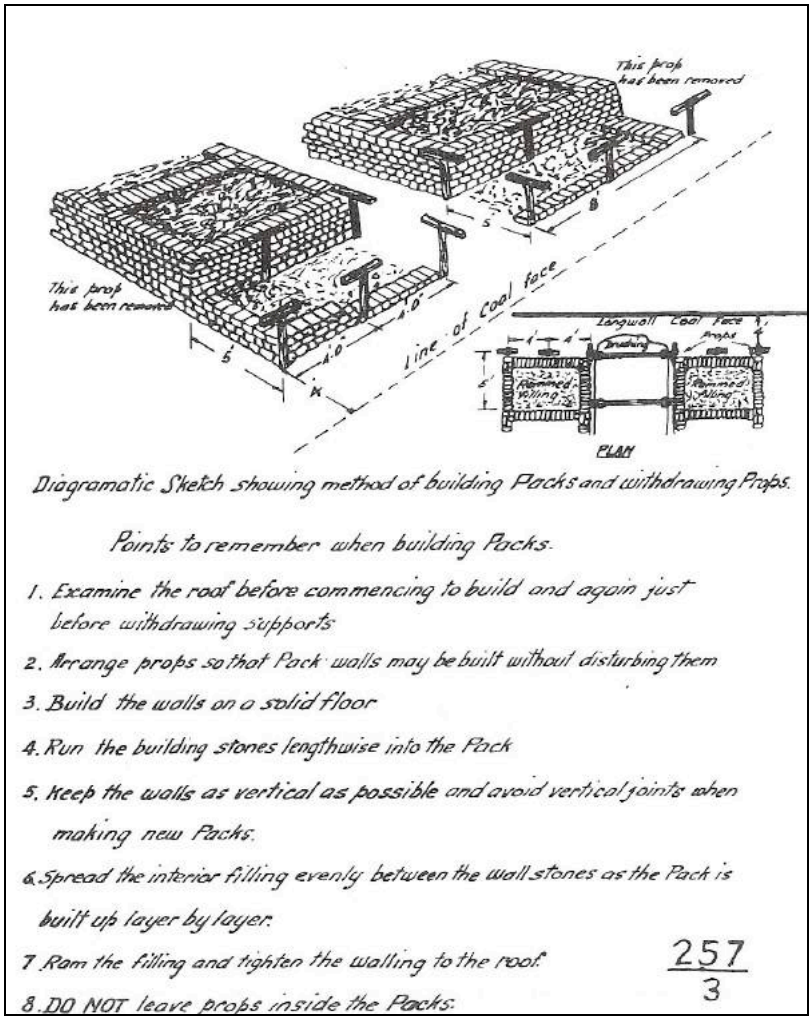
As mining proceeded on the face, a continuous program of stone pack wall construction and stone infilling of these was carried on behind the face to maintain the integrity of the various roadways as practical transit and ventilation ways through the progressively forming goaf (see Figure 13). The material for the pack walls and infilling was obtained by removing (brushing) roof and/or floor rock from the various openings as mining proceeded. This process not only produced the required material for the pack walls but ensured that sufficient head room was maintained in the roadways. Brushing was not only carried out during the initial mining cycle, but intermittently thereafter to maintain the main roadways in serviceable condition.

Temporary timber props were used along the face to keep the working space open, and additional timbers (sprags) used to support the face coal if required. Care was taken to ensure that the back props were removed on a systematic basis as the face advanced to allow the overlying strata behind the face to collapse in a controlled fashion onto the packs to form a load bearing goaf. At the State Mines, this process was considered to be safer than pillar extraction during bord and pillar working, with the roof strata typically breaking at regular 3.5m intervals of face advance and therefore not placing excessive weight on the face supports or roadways.[54] The importance placed by management on not leaving behind occasional timber props in the goaf that might lead to erratic caving and consequent uneven loading of pack walls or face support can be judged from Figure 13.

The process of coal hewing practiced at the State Mines was in essence the same as had been used previously in Gippsland, involving undercutting of the coal face

followed by removal of the overhanging coal. Sometimes the top coal would collapse under the weight of the overlying strata, but usually it had to be induced down by drilling shot holes in it and blasting. In the early days hewing involved hand work using a pick to undercut, a process that involved miners often lying on their side with the roof hanging perilously overhead. This was often made more trying by the fact that the working place was wet. The broken coal was shovelled by hand to the gate road and hand loaded into skips brought to the face through the gateways by wheelers. Special

Figure 13: *Instructions for the construction of pack walls at the State Mines.*



Source: C. Fahey, *Wonthaggi State Coal Mine, A short history of the State Coal Mine and its Miners*, Conservation Forests and Lands, and the Wonthaggi Coal Mine Committee, B.J. Clancy, Wonthaggi, 1987.

allowances were made in the miners' contracts to compensate for working particularly thin seams.[55] From as early as 1912, however, the State Mines were fully electrified, allowing for the use of progressively more sophisticated coal cutting machines, initially to undercut the face, and scraper-loaders to move the broken coal to the loading point.[56]

The Decline of the State Mines

Production from the State Mines reached a peak around 1930. From then on production began to decline as black coal was displaced by exploitation of Victoria's massive reserves of brown coal.[57] The ever decreasing average seam thickness being worked inevitably led to a decrease in productivity, prompting the economic rationale for the State Mines to be questioned more and more. By some, the State Mines were seen as a socialist haven, while others reflected more on the relative security that had been offered to Victoria over the years by having a resource that could meet at least part of the state's energy needs. The State Mines were progressively wound down from the 1930s as a result of a series of political decisions until ultimate closure in 1968.[58]

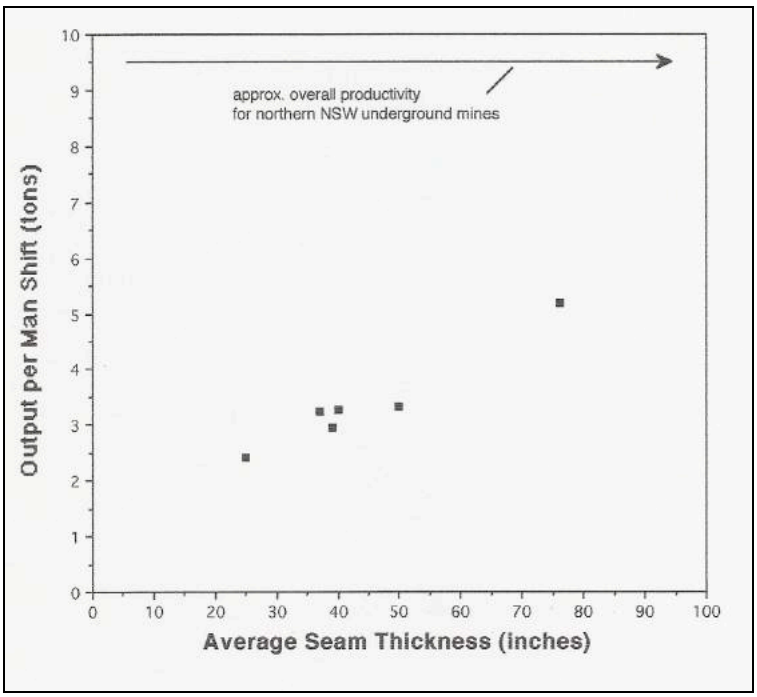
Comparative performance

The relative success of mining operations in the South Maitland and Powlett River areas can be judged by a number of criteria. In terms of total production, there is no doubt that the Maitland area was predominant, producing around 80 million tons between 1910 and 1930[59] compared to 12 million tons from the State Coal Mines over the same period.[60] In terms of productivity (see Figure 14), the much thicker seams of the Maitland District inevitably meant more economical production. Despite much lower relative productivity, however, the State Mines manage to operate at a 'profit', according to their own benchmarks, for all but seven of the years up to 1930.[61] With regard to recovery (see Figure 15), the picture is somewhat different. While relative recovery (measured as production per unit area extracted) at the State Mines varied from area to area depending on seam thickness, the overall average of about 10,500 tons per hectare[62] compares very favourably with the average recovery of the Maitland District at about 22,000 tons per hectare[62] when the difference in average seam thickness mined is taken into account (approximately 0.8m at the State Mines compared to 7.5m in the Maitland District).

Conclusion

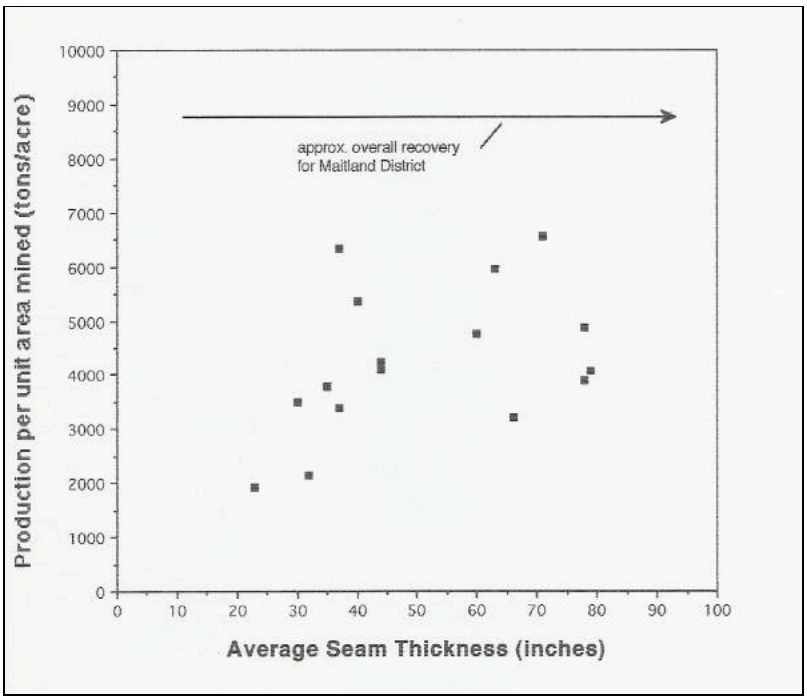
In both areas studied, mining practice had to be adapted to cope with extraction of seams that departed from the generally accepted ideal thickness (around 2 to 3m). Prior traditions in the respective regions clearly influenced the way that mining practice evolved. In the South Maitland case, a starting point bedded in the bord and pillar

Figure 14: *Output per man shift versus average seam thickness at the State Mines, with average productivity for Northern NSW underground mines superimposed.*



Source: Statistics from J.L. Knight, 'Problems Affecting the Black Coal Industry in Victoria', Unpublished Report, Victorian Department of Mines, 1956.

Figure 15: *Production per unit area mined for various areas at the State Mines, with average recovery for Maitland District superimposed.*



Source: Statistics from J.M. Coghlan, *The State Coal Mines and Wonthaggi, 1909-1968*, B.J. Clancy, Wonthaggi, 1979; C. Fahey, *Wonthaggi State Coal Mine, A short history of the State Coal Mine and its Miners*, Conservation Forests and Lands and the Wonthaggi Coal Mine Committee, B.J. Clancy, Wonthaggi, 1987.

system as practiced in the relatively thinner seams of the Newcastle District may be claimed to have ultimately contributed to the problems encountered when trying to extract the thicker Greta Sequence Seams. Despite an inordinate amount of discussion about more satisfactory mining methods, the momentum generated during the early years of the field using the bord and pillar system seems to have mitigated against the ultimate development of an optimum extraction technique, a situation exacerbated by extraneous agendas, indecision and obfuscation. In the Powlett River area, the fact that the longwall advancing method had already proved suitable for extracting the thin and discontinuous seams of the Gippsland region prior to the State Mines commencing operations placed the latter in a sound position to be able to tackle the recovery of the progressively increasing proportion of its precious resource residing in thinner seams as time went on.

A feature of the histories of the two areas was the focus on resource recovery. In the event, the statistics discussed above suggest that recovery of the generally thin and discontinuous seams in the Powlett River area by a state run enterprise more closely approached the ideal objective of complete resource recovery than extraction of the thick seams in the South Maitland area by private mine operators. Throughout their life, the State Mines were constantly faced with the dilemma of striking a balance between maximising recovery of what was a very limited resource, and operating as efficiently as possible. Rather than abandoning resource in thin seams, the State Mines persisted with on-going refinement of the longwall advancing technique. The resolve of the State Mines to recover coal from thin seams can be judged from the effort devoted to building pack walls. Their tenacity is well illustrated by a comment contained in the manager's annual report of 1918, to the effect that more rock tunnelling had probably been carried out in the development of the State Mines to date than in the development of the whole Maitland field.

While setting out to develop/adapt methodologies to meet the particular situations facing them, the operators in both areas were also pioneering some of the principles that would underpin later technical development of the Australian coal industry. The importance of proper engineering design of coal pillars and the diligent sequencing of pillar extraction are lessons that have been learnt. The various multiple lift techniques for complete extraction of thick coal seams explored by the various public enquiries anticipated many of the possibilities currently being embraced. With respect to the longwall technique, the optimum arrangement of layouts to avoid

geological interruptions and the importance of a regular caving process are issues that are as important in modern mechanised longwall retreating as in longwall advancing.[63]

Endnotes

[1] Statistics taken from Appendices to the final report of the '1929-30 Royal Commission appointed to inquire into and report upon The Coal Industry', Legislative Assembly of New South Wales, NSW Government Printer, 1930.
[2] *Ibid.*
[3] T.W. Edgeworth-David, *The Geology of the Hunter River Coal Measures, New South Wales Geological Survey, Geological Memoir no. 4,* NSW Government Printer, 1907.
[4] Quoted in E. Davies and E.E. Tonks, 'The Development of the Greta Coal Measures of NSW', The *AustIMM Centenary Conference, Adelaide*, 1993, p. 353.
[5] For example, see discussion in *ibid*., p. 360, regarding formation of East Greta Coal Mining Company.
[6] M.H. Ellis, *A Saga of Coal*, Angus and Robertson, Sydney, 1969, p. 134.
[7] R. Lewis, *Coal Mining in the Eighteenth and Nineteenth Centuries*, Seminar Series in History, Harlow Longman, 1971, p. 42.
[8] See for example, H.W. Hughes, *A Text-Book of Coal Mining*, Charles Griffin, London, 1892.
[9] M.H, Ellis, *A Saga of Coal*, p. 136.
[10] A.A. Atkinson, Report on the Inspection of Mines under the Coal Mines Regulation Act, in the Colony of New South Wales, for the year ending 31st December 1897, NSW Government Printer, 1898, p. 26.
[11] T. Parton. 'Coal and Coal Mining in New South Wales', *Transactions of the Australasian Institute of Mining Engineers,* vol. X, 1905, pp. 242-45.
[12] *Ibid.*
[13] J. Temple, *Mining, an International History*, Ernest Benn, London, 1972, p. 38.
[14] Ellis, *A Saga of Coal*, p. 136.
[15] Final Report of the '1911-12 Royal Commission of Inquiry into the Working of Thick Seams, &c., Maitland-Cessnock District', Legislative Assembly of New South Wales, NSW Government Printer, 1912.
[16] Comments based on evidence to Royal Commissions, but also summarized in L.J. Jones, '*The Coal Resources of the Southern Portion of the Maitland-Cessnock-Greta Coal District, Mineral Resources Bulletin no 37, Dept. of Mines, New South Wales,* NSW Government. Printer, 1939, pp. 82-85.
[17] J.T. Watson, 'Waste of Coal', *Institute of Engineers, Australia*, vol. V, 1924, pp. 201-02.
[18] Final Report of the '1925-26 Royal Commission of Inquiry on Coal and Shale Mines in New South Wales', Legislative Assembly of New South Wales, NSW Government Printer, 1926.
[19] Final Report of the '1929-30 Royal Commission appointed to inquire into and report upon The Coal Industry', Legislative Assembly of New South Wales, NSW Government Printer, 1930.
[20] J.M. Baddeley, Report on the 'Winning and Workings of the Thick Coal Seams and the Utilisation of the Coal and Oil-shale Resources of New South Wales', Legislative Assembly of New South Wales, NSW Government Printer, 1927.
[21] Final Report of the '1945-46 Royal Commission appointed to inquire into and report upon The Coal Mining Industry', Parliament of the Commonwealth of Australia, Commonwealth Government Printer, 1946.
[22] H.S. Elford and M.R. McKeowen, *Coal Mining in Australia*, Tait Publishing, Melbourne, 1947, pp. 146-62.
[23] Activities described in an unpublished interim report of the 'Committee Appointed to Inquire into and Report upon the Adoption of Hydraulic Stowage in Coal Mines ... ', Department of Mines, New South Wales, 1949.
[24] Davies and Tonks, 'Development of the Greta Coal Measures', p. 365.
[25] C.H. Martin (ed.), *Australian Coal Mining Practice*, Monograph 12, Australasian Institute of Mining and Metallurgy, Melbourne, 1986.
[26] Final Report of the '1889-91 Royal Commission appointed to inquire into and report upon The Best Means of Developing and Promoting the Coal Mining Industry of Victoria', Parliament of Victoria, Victorian Government Printer, 1891.
[27] M. Halford, 'The Coal Industry of South Gippsland', in *The Land of the Lyer Bird*, Korunburra Historical Society, 1998, pp. 230-37.

[28] See Appendix 2, 1889-91 Royal Commission, which lists discoveries to that date.
[29] J. Adams, *So Tall The Trees, a centenary history of the southern districts of the Shire of Narracan,* Narracan Shire Council, 1978, p. 95.
[30] Halford, 'The Coal Industry of South Gippsland', pp. 230-37.
[31] Final Report of the '1905-06 Royal Commission appointed to inquire into and report upon The Coal Industry', Parliament of Victoria, Victorian Government Printer, 1906.
[32] J.L. Knight, 'The Closing of the State Coal Mines, Wonthaggi', Mines and Geological Journal, vol. 6, no. 6, 1970, p. 54.
[33] J. McLeish, 'Practical Underground Work at the State Coal Mine, Wonthaggi, Vic,' *Proceedings of the Australasian Institute of Mining Engineers,* vol. 14, 1914, pp. 229-33.
[34] See for instance evidence by Levi to the 1889 Royal Commission.
[35] L.D. Llewelyn, Report on the 'Coal Mines at Moe, Coalville, Boolarra, Korumburra and Jumbunna', Attached to the Mine Surveyor's Report for the Quarter Ended 31 December 1890, Victorian Department of Mines, Victorian Government Printer, 1891, pp. 41-42.
[36] See evidence by J. Ridley to the 1905 Royal Commission, pp. 244-54.
[37] J. Stirling, 'Operations of the Outrim Coal Mine', Unpublished Report, Victorian Department of Mines, 1896.
[38] For example, Half Yearly Report by the Mining Manager, Outrim, Howitt, and British Consolidated Coal Co., April 1897, Victorian Public Records Office, VPRS 567/781.
[39] Temple, *Mining, an International History*, p. 38.
[40] Lewis, *Coal Mining in the Eighteenth and Nineteenth Centuries*, p. 42.
[41] Temple, *Mining, an International History*, p. 38.
[42] J.L. Knight, 'Problems Affecting the Black Coal Industry in Victoria', Unpublished Report, Victorian Department of Mines, 1956.
[43] ' "Black Diamond", Review of Coal Mining in the Narracan Valley', *Narracan Shire Advocate*, Series of articles from May to November 1890.
[44] Evidence by W. Burns to the 1889 Royal Commission, pp. 145-46.
[45] See for example, Hughes*, A Text-Book of Coal Mining.*
[46] McLeish, 'Practical Underground Work'.
[47] See evidence by J. Ridley to the 1905 Royal Commission, pp. 244-54.
[48] Knight, 'The Closing of the State Coal Mines, Wonthaggi', p. 54.
[49] J.M. Coghlan*, The State Coal Mines and Wonthaggi*, *1909-1968*, B.J. Clancy and Co., Wonthaggi, 1979, pp. 16-17.
[50] G.H. Broome, 'History of the Victorian State Coal Mines', in *Coalfields and Collieries of Australia*, Critchley Parker, Melbourne, 1912, pp. 274-384.
[51] F.D. Power, *Coalfields and Collieries of Australia,* Critchley Parker, Melbourne, 1912, p. 284.
[52] Elford and McKeowen, *Coal Mining in Australia*; Coghlan*, The State Coal Mine and Wonthaggi, 1909-1968*; P. Harper*, The Wonthaggi Coalfields, A Story of the Men and the Mines*, Electrical Industry Advertising, 1987; C. Fahey, *Wonthaggi State Coal Mine, A short history of the State Coal Mine and its Miners*, Conservation Forests and Lands, and the Wonthaggi Coal Mine Committee, B.J. Clancy and Co., Wonthaggi, 1987.
[53] McLeish, 'Practical Underground Work'.
[54] Harper, *The Wonthaggi Coalfields,* p. 43.
[55] Penalty pay rates for miners working seams less than about 1 metre was a major issue addressed by the 1905 Royal Commission
[56] Martin, *Australian Coal Mining Practice.*
[57] Knight, 'Problems Affecting the Black Coal Industry in Victoria'.
[58] See for example, Harper, *The Wonthaggi Coalfields*.
[59] Statistics from 1929-30 Royal Commission.
[60] Statistics from Knight, 'Problems Affecting the Black Coal Industry in Victoria'.
[61] Harper, *The Wonthaggi Coalfields*, p. 41.
[62] Statistics quoted in Fahey*, Wonthaggi State Coal Mine*, p. 30.
[63]See for example, various reports authored by Enever and others in Geomechanics of Coal Mining Series published by CSIRO, Division of Geomechanics.