CHAPTER 4: PREVIOUS AND CURRENT MINING METHODS.

4.1 Introduction

a.) Numerous coal-winning methods have been used on the mine during its four years of existence. The current methods must be judged on the economic factors and their advantages and disadvantages.

b.) During the history of the mine, rapid variations in seam heights were encountered. These were attributed to the irregular nature of the roof and floor. It has been proved that conditions improve as mining proceeds southwards. The roof conditions generally vary according to the mineable portion of the seam selected. Currently the whole seam is mined and the roof conditions have proved to be very good. Isolated instances of roof slumping have occurred, which in turn led to difficult mining conditions in those specific areas.

c.) Some areas have a mudstone roof but even this kind of roof has proved to be competent and the coal mineable.

d.) The floor is generally very competent sandstone.

4.2 Mining method and equipment

4.2.1 General

The bord and pillar mining layout will be maintained because of its reliability, flexibility, low capital cost, low working costs and large skills source availability (Woodruff, 1966). Increasing mechanization has resulted in an increasing production in the amount of the fine coal fractions, which attract significantly lower prices. The introduction of the continuous miner in some areas has decreased the amount of the higher valued coarser fractions. From the start a combination of two conventional drill and blast sections and one continuous miner with a continuous haulage were used. The haulage system was abandoned 1 year ago due to numerous breakages and expensive repairs and its inflexibility in problem areas. It was replaced with 3 Stamler thin seam battery haulers. A revolving stone crew undertakes the development of dykes and does the roof brushing to 1.8m in thinner seam areas. When the need arose a contractor was employed to catch up with the roof brushing and in some cases install additional roofbolts.

4.2.2 Continuous Miner Section

From early days on the trend in bord and pillar mining was towards continuous miners (Woodruff, 1966). More recently there has been an increasing trend in the industry to replace the traditional shuttle cars, battery cars and scoops by continuous haulage systems. The opposite took place at Dorstfontein Coal Mine where shuttle cars are preferred for their flexibility and low running costs.

In the CM-section the continuous miner cuts between 7 and 11 roadways, depending on the preferred layout at the time (Fig. 4.1, 4.2). Pillar and bord widths are 6.8m, giving a coal extraction in the region of 70 to 75%. In Figure 4.1it is illustrated that the CM cuts a split of 6.8m wide to the right of the travel road (marked 1) and while resin bolts are installed in this split the CM cuts a straight (marked 2) and another split (marked 3) of 6.8m wide. During the support of these last two cuts, the CM moves back into the right side of the panel and cuts numbers 4 and 5. Since it is illegal to work under unsupported roof, the CM has to wait while cut 4 is supported before moving to cut number 6 and 7. The whole cycle is repeated and the installation time of the support determines the cutting time of the CM.

Figure 4.2 illustrates the ventilation layout of the CM section. Ventilation is very important for a healthy working environment and even more important in thin seam mining were only small volumes of air can pass through the restricted and narrow workings. The intake air moves in on the right side of the section and ventilates the coal face, removes all the methane and dust and returns on the left side of the panel. Some leakage does occur since the temporary scoop brattices or curtains, installed to direct the air, are not airtight and sealed properly. Some of these temporary curtains are removed to allow the haulers to move from the face to the tip. These curtains are later replaced by brick walls as the section moves forward.

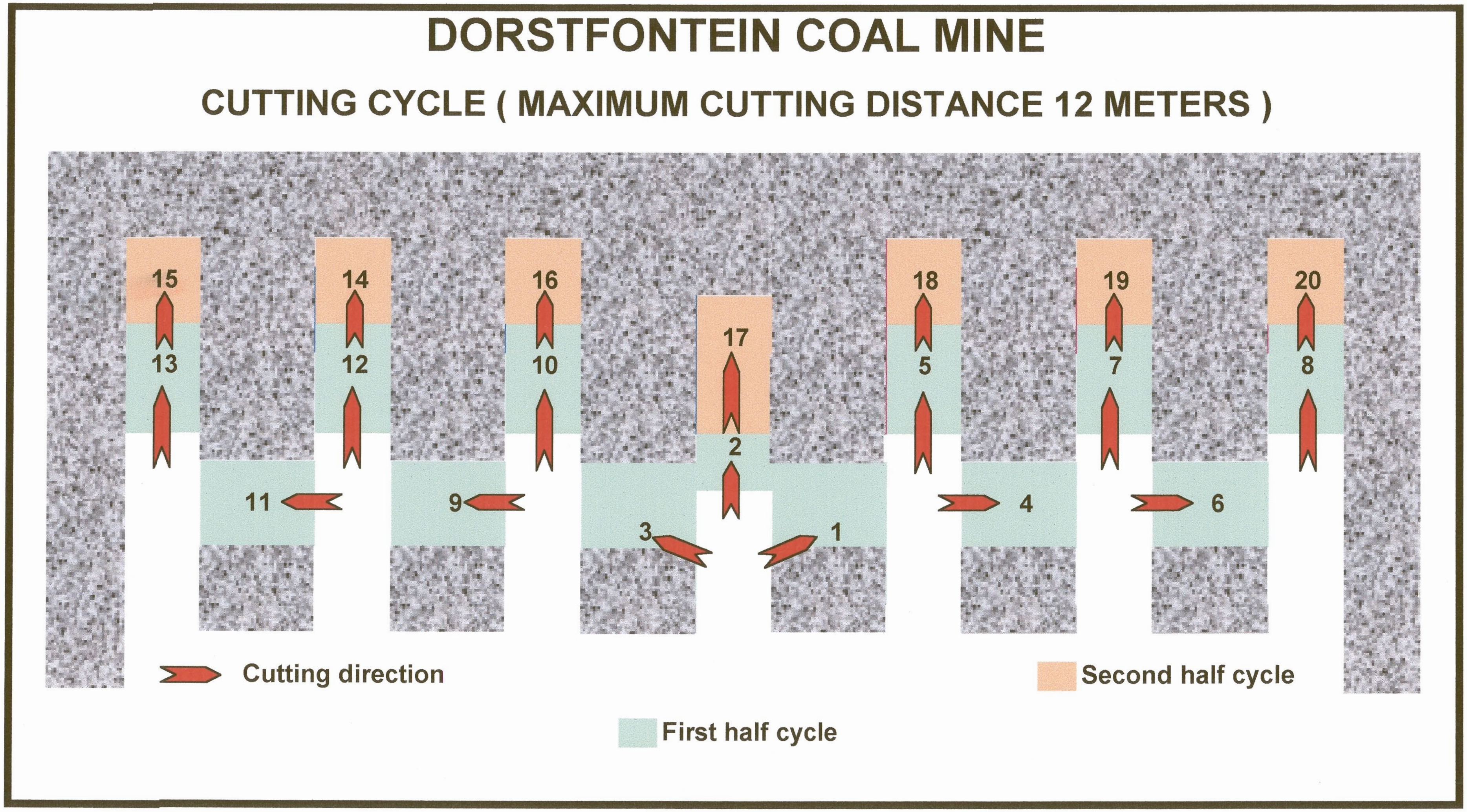
The section is equipped with the following:

- 1 x Joy 12HM15 Continuous miner with a 1,12 meter drum.
- 3 x Thin seam Stamler BH10 Battery Haulers (1m high).
- 1 x Self-propelled thin seam roofbolter.
- 1 x Battery scoop.
- 1 x Feeder-Breaker.
- 1 x Mobile 750 KVA transformer.
- 1 x Mobile switch trailer with flameproof gate end boxes.
- 1 x Portable jet fan.

The manpower is:

- 1x Miner.
- 1x CM operator and assistant.
- 1 x Cable handlers.
- 3 x Hauler drivers.
- 1 x Roofbolter operator and assistant.
- 2 x Feeder-Breaker operators.
- 7 x General labourers.

The total number of persons per shift is 16.



DORSTFONTEIN COAL MINE

CUTTING CYCLE (MAXIMUM CUTTING DISTANCE 12 METERS)

Fig. 4.1. Cutting sequence for CM section (Van Zyl, 2001)

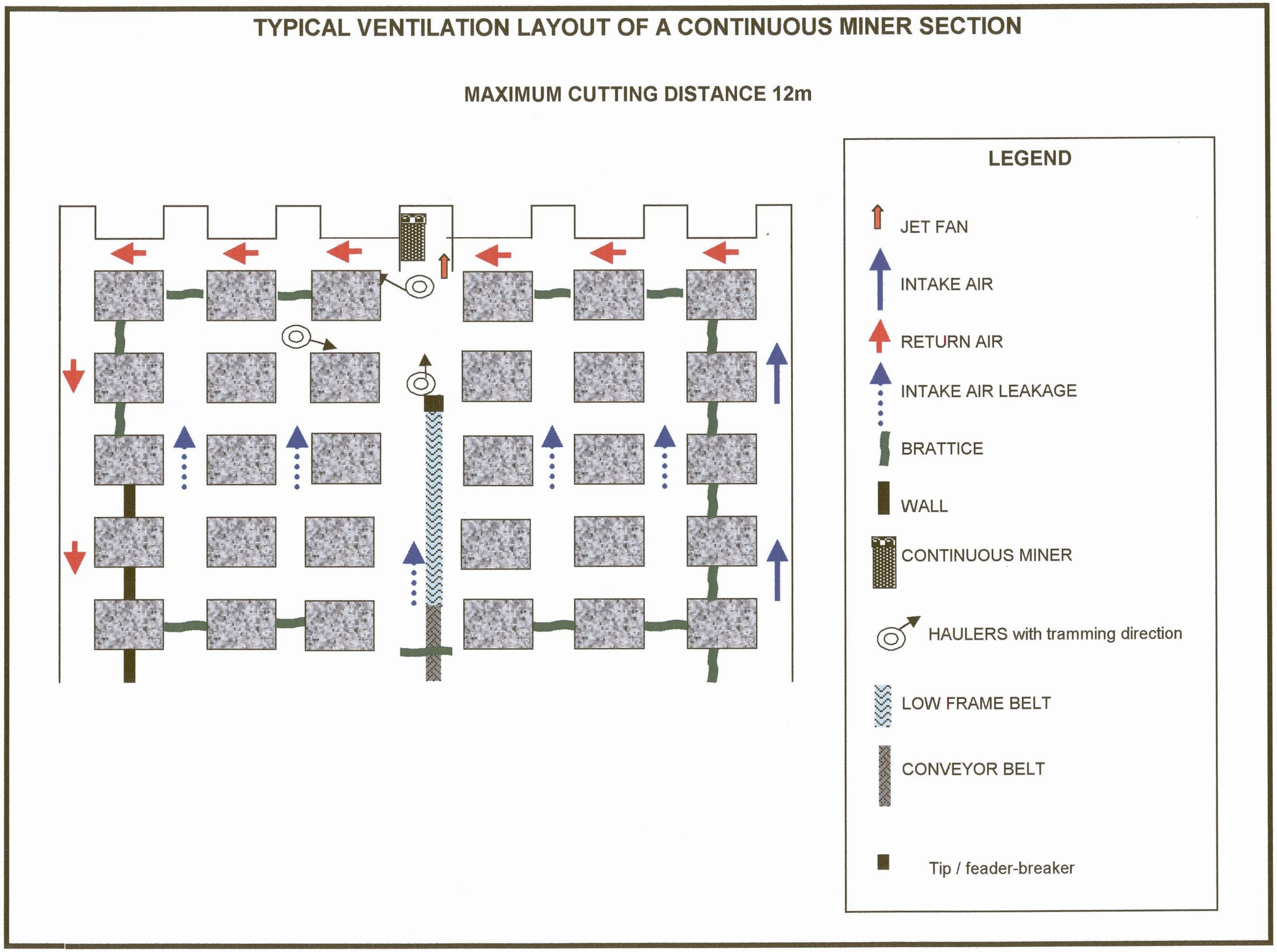


Fig. 4.2. Ventilation layout (Van Zyl, 2001).

4.2.3 Conventional Drill and Blast Section

The flexibility of the conventional drill and blast sections in negotiating geological obstacles together with the improved creation of the financially attractive coarser fraction product, is still important factors in the use of this method of mining. Unfortunately this method only works effectively for seam heights above 1,6m as production rates decrease exponentially with the reduction of heights. In the current thin seam area the parting is included in the mining to provide the necessary height for this section. The yield decrease is significant by including this parting.

In this section an amount of 11 roadways are been mined with pillars width 6.8m and bords 6.8m, giving an extraction in the region of 70 to 75%.This section is equipped with the following:

- 1 x Coal loader.
- 1 x Roofbolter.
- 1 x Feeder- Breaker.
- 1 x Coal Cutter.
- 2 x Joy Shuttle Cars.
- 2 x Electric Coal Drills.
- 1 x Mobile 750 KVA transformer.

The manpower is:

- 1 x Miner
- 2 x Electric Coal Drill operators and 2 x assistants.
- 2 x Drill assistants (jackhammer).
- 1 x Coal Cutter operator and assistant.
- 1 x Coal Loader operator and assistant.
- 2 x Shuttle Cars drivers.
- 1 x Feeder-Breaker operator.
- 1 x Roofbolter operator and assistant.

- 5 x General labourers.

The total number of persons per shift is 21.

4.2.4 Stone Work Team

The mine has a dedicated stonework team, whose duties include:

a.) Mining through dykes exposed by coal winning.

b.) Brushing and supporting of the roof to 1.8m heights in roadways and belt roads.

c.) Brushing and supporting of the roof designated for ventilation and mine infrastructure e.g. air crossings.

d.) Installation of superior and additional support in areas where poor roof conditions prevail.

The stonework team is operating on a single shift but can be changed to a double shift when conditions dictate. Additional contractors were introduced to help with specialized support and to assist where additional support was required.

The stonework team is equipped with the following:

- 1x Self propeller roofbolter
- 1x Mobile 500 cpm compressor
- 3x Pneumatic drills (jackhammer) and air legs
- 1x Mobile switch trailer with flame proof gate end boxes
- 1x Mobile 500 kVA transformer
- 1x Portable explosives magazine

The manpower is:

- 1x Miner
- 2x Drill operators (jackhammer)
- 2x Drill assistants (jackhammer)
- 2x General labourers

The total number of persons per shift is 7.

All external waste mined, such as roof rock, dyke material and burnt coal is stowed underground in such a manner so as to minimize the risk of spontaneous combustion.

4.3 Risks.

4.3.1 Geological.

a.) In-seam partings. These partings result in a drop of yield and cause materials handling problems, which in turn adds to the cost of maintenance on equipment and conveyor belts.

b.) Roof slumping and compaction structures. Sudden changes in roof heights lead to difficult mining conditions. This so-called "pinching" of seam heights creates difficult working conditions for hauler- and shuttle car operators.

c.) Unexpected laminations in the roof. Thin laminations of silty material in the roof lead to dangerous conditions as delamination of the roof can result in rock falls, which can cause injury and fatalities.

d.) Changes in coal quality. The drop in product yield directly results in an increase in production costs. Unexpected quality changes might result in dissatisfied customers, which can result in the cancellation of contracts. The highest risk in this category is the possibility of high sulphur values.

e.) Floor rolls. These occurrences are as unpredictable as their extent is limited. Floor rolls caused dangerous conditions during machine movements. The continuous miner had difficulty moving over these rolls as the length of this machine caused the rear end to "hang up" on the roof as the front-end traverse down the slope of a roll.

f.) Dykes. Dolerite intrusions normally cause a section to come to a halt as the roads need to be developed through the dyke by the stone crew. Dykes result in burned or devolatilised coal, which can not be sold. Dykes form gas traps for methane and often have bad roof conditions associated with them.

4.3.2 Production.

Many of the production problems encountered at Dorstfontein mine were associated with geological features. Unexpected thin seam conditions (1.5m and thinner) resulted in a sudden halt of production in many sections. For a continuous miner section a serious geological thread is the appearance of an in-seam parting. Production losses may be as much as 50% when these features occur in the CM-section. For the conventional sections the most deleterious conditions are sudden drops in seam height due to roof slumping. The fixed set of mining equipment in a conventional section makes it almost impossible to negotiate this kind of problem. Production losses may be as much as 70% of normal production as roof stripping needs to be done for the haulers to move around. A loss of production means less product coal to sell which results in a loss of income. Production losses also mean an increased unit cost, as the fixed cost component remains constant.

4.3.3 Safety.

Many of the geological risks may result in a serious injury or fatality. Currently Dorstfontein mine has a very good safety record with almost 2000 fatality free shifts (will be achieved June 2003) and a lost time injury frequency rate (LTIFR) below 2. This has only been achieved by the continuous awareness of the workers of the difficult mining conditions encountered so far. Another factor contributing to the good safety record is the fact that during most of the mine's life it has been producing in the higher seam areas (1.5 - 2.5m). The occasional, unpredicted and localized geological problems were negotiated in a safe and efficient manner. The largest part of the remaining reserve will be in similar or even better conditions. The risks, which may possibly result in injury or fatality, have been identified and are well managed by a dedicated management team and workforce.

4.3.4 Costs.

High costs are a fact of mining but sudden increases in working cost is a huge risk for a small operation. Unexpected changes in geological conditions, the drop of production rates, fluctuations of the exchange rate and increased cost of maintenance due to damage caused by mining conditions, may unexpectedly increase working costs to a point where it may spiral out of control. The management of costs and the above mentioned risks is of the utmost importance to keep the mine running for its planned life. All above mentioned risks contributed to the cost of mining at Dorstfontein and the management of these risks has so far lead to a productive and economically successful mine. In Fig. 4.3 it can be seen how the run of mine cost escalates with a decrease in production.

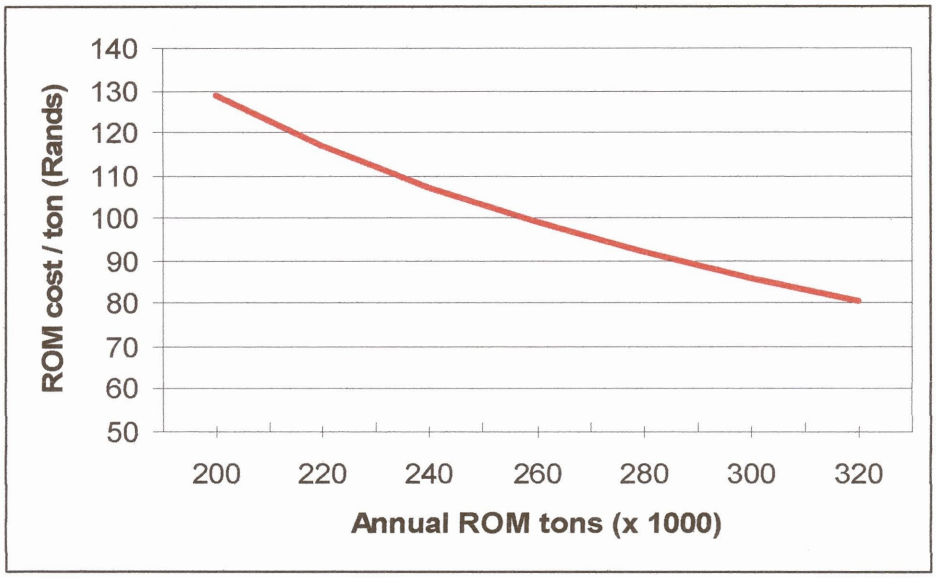


Fig. 4.3. Cost : Volume relationship.

The greatest risk may be regarded as managerial risks where people become lax and relaxed due to a good safety record. This may very easily develop in to an unconcerned attitude towards risks. It is difficult and challenging to keep people motivated and vigilant towards the risks and dangers involved in coal mining.

CHAPTER 5: THIN SEAM RESOURCES.

5.1. International.

They are only 3 main areas in the world where significant quantities of thin seam coal are mined namely the U.S.A., Europe and the former U.S.S.R. (Clarke et al., 1982). Of these the former U.S.S.R. produced more than 75 percent of all thin seam coal worldwide and that mainly from the Ukraine. In Europe the mining techniques have been developed for deep mining conditions while in the U.S.A. shallower and flatter seams have allowed for room and pillar methods.

The largest producers of thin seam coal are the former U.S.S.R. and the U.S.A. Other countries produce smaller tonnages but still have significant output. Countries like Spain, the U.K., Czechoslovakia, Poland and Colombia produced significant quantities of coal from thin seams. In the late 1980s and during the 1990s most of the U.K. mines were closed principally because of economic reasons following decreases in state subsidy. Some of the old mines like Trimdon Colliery (1840 – 1925) worked seams with heights of 3 feet 8 inches (1.11m) at depths of 195m using drill and blast methods. Very small tonnages are still produced in the U.K. and this country has become a net importer of coal.

Table 4. Thin seam definition in various countries (Clarke et al., 1982).

COUNTRY	m	in
Belgium, U.S.A.	0.60	24
Germany	0.70	28
U.K.	0.91	36
France, Poland, Ukraine, Czechoslovakia	1.00	39
Former U.S.S.R.	1.20	48
Bulgaria	1.30	51

Table 5. Thin seam output as percentage of total coal output. (Clarke et al., 1982)

COUNTRY	% OF RESERVES
Spain	70.0
Colombia	50.0
Former U. S. S. R.	47.6
Belgium	38.4
Czechoslovakia	30.0
U.S.A.	10.8
France	7.8
U.K.	7.0
Poland	2.0
Germany	1.1

Since thin seam mining has become unfavourable due to its low production rate and output, these figures could have changed subsequently, as some countries have closed their thin seam mines. Countries like France, Belgium and Germany produced significant tonnages from thin seams in the 1960s but have ceased production from these mines. In Annexure 1 the various thin seam reserves are described.

No information about thin seam mining in China could be obtained. It is not even known if they do mine thin seams, as information coming from that country is either non-existent or not translated. It is well known that China has almost tripled its coal production and has become one of the major coal producing countries.

In Australia collieries are focused on high output from 30m seams and consist mainly of opencast mines. Some information about Australian thin seam mining was obtained from the Internet (http://fueltaxinquiry.treasury.gov.au/content/Submissions/Industry/NewHope_294.asp). This article was about a proposal to introduce tax incentives and a fuel rebate at the Jeebropilly, New Oakleigh and New Acland Mines in the Walloon Coal Measures of the Surat-Moreton Basin. It appears that multiple thin seams are being mined in open pits and that the greatest cost is diesel for the equipment. Since no information on the Australian definition of a thin coal seam could be found and multiple publications exist about their high coal production and exports, the assumption must be made that in Australia the true thin seam coal mine does not exist.

It can safely be assumed that both China and Australia do not have major output from thin seam mines.

In the U.S.A. the following eight states contain together 86% of the total U.S.A. thin seam resources.

Table 6. Distribution of thin coal seams in the U.S.A. (Clarke et al., 1982)

STATE	% OF STATE RESOURCES
Alabama	41.0
Indiana	6.0
Kentucky	41.0
Missouri	67.0
Ohio	35.0
Pennsylvania	21.0
Virginia	52.0
West Virginia	16.0

Other states with potential thin seam mines do exist and their potential was investigated in more recent times. In Annexure 1 it can be seen that West Virginia has introduced a tax reduction and new tax formula for thin seam mines. Other states have made similar proposals to their legislators in order to keep thin seam mining and their communities alive and to promote the opening of new thin seam mines.

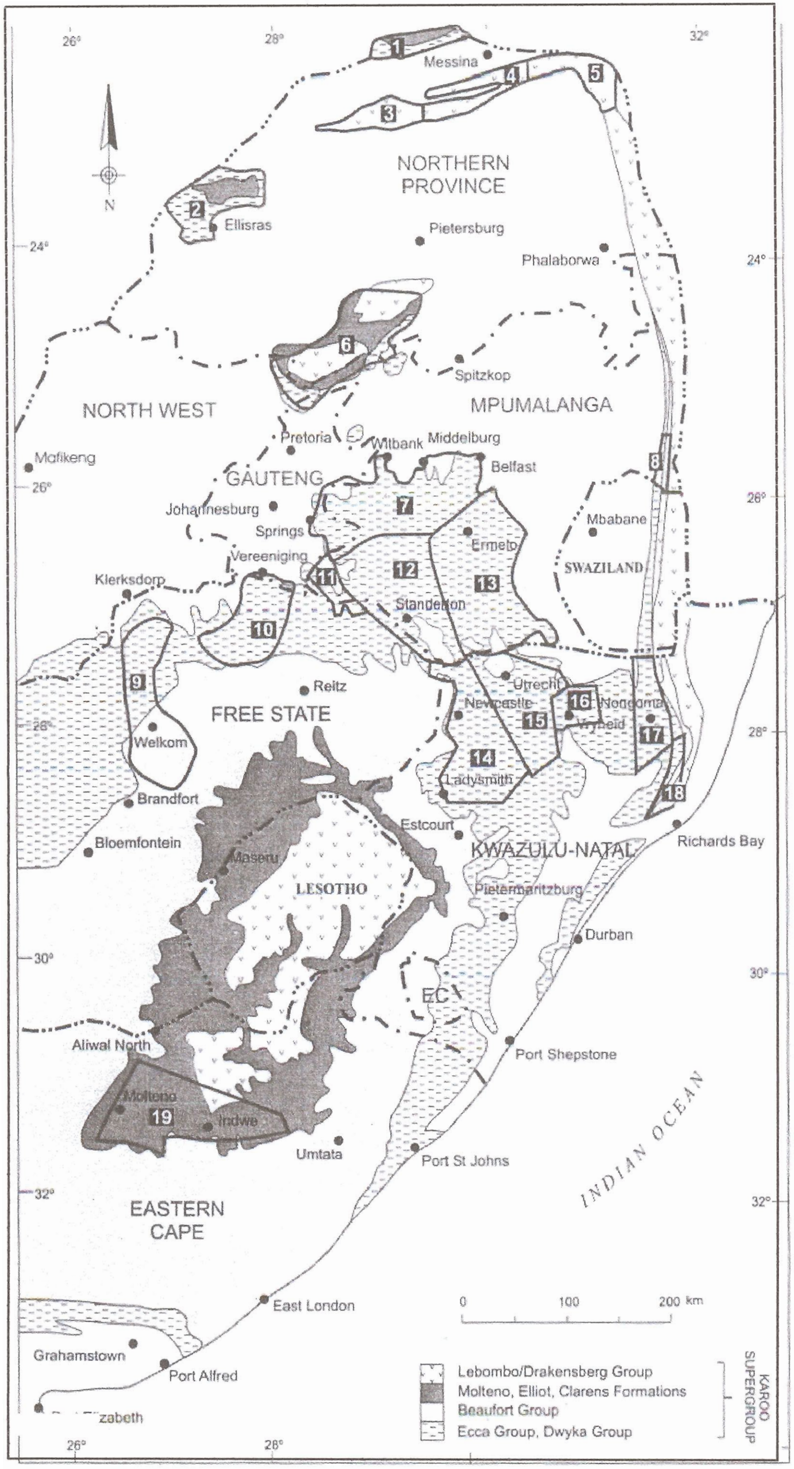
5.2. Republic of South Africa. (See fig. 5.1)

In the South African scenario most of the thin seam coal mining took place in the KwaZulu-Natal Coalfields. Some thin seam mining of the No. 5 Seam took place in the Highveld and Witbank Coalfields for example the old Blesbok, Landau, Springbok and Greenside collieries. The No. 5 seam does not fit our definition of the thin seam as the average thickness of this seam in the Highveld and Witbank regions is 1.8m (Jordaan, 1986). Even today some successful mining of the No. 5 Seam (1.5 – 1.8m thick) is taking place at Bank Colliery and with variable success at Matla Coal Mine (1.8m thick).

The two largest collieries in the Eastern Transvaal Coalfield (Greenfields, 1986), namely Usutu and Ermelo Mines, were closed due to adverse geological conditions. These two mines occasionally mined thin seams although their focus was not exclusively thin seam mining (Jacobs, 1989). At Ermelo Mines some roof brushing had to be done when 1.2 m seam thicknesses were intersected. As this mine was not equipped and focused on thin seam mining, this development was mainly done to work through thin seam areas to access thicker seams beyond. Similar conditions prevail at the currently operating Spitzkop and Strathrae collieries (Fig. 5.2) (Greenshields, 1986). Carolina Coal Company produces (drill and blast method) 11,000 ton per month from the 1.0m thick C-Seam and 16,000 tons per month from the 1.45m thick B-Seam. Eastside Colliery has similar seam heights but only produce from an open pit (Mr. J. Ackerman - Owner/operator, 2003, Pers. comm.)

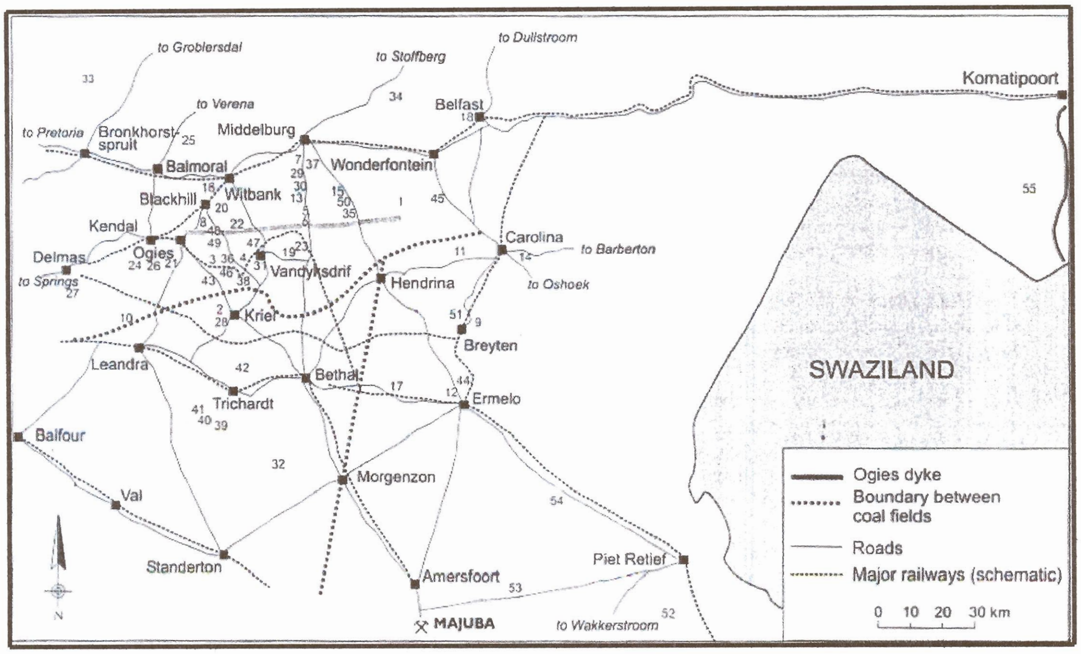
It is therefore safe to say that a very small amount of coal is produced from thin seam mining in the Highveld, Witbank and Eastern Transvaal Coalfields.

Exclusive thin seam mines were those operating in the KwaZulu-Natal Coalfields. Many of these mines are now defunct with only a handful still producing low tonnages for strategic purposes. In the past most of these mines supplied anthracite and coking coal to the then fully operational Newcastle steelworks of ISCOR and the export anthracite market. As ISCOR has closed down and scaled down many of their operations it directly affected the production of the thin seam collieries in the KwaZulu- Natal Coalfields. A downturn in the international anthracite market as well as the introduction of new metallurgical processes, such as direct reduction and briquetting in the steel industry, has obviated the need for coking coal. Small output from these collieries would not make them economically viable for the inland market only. Most of them were kept open for strategic reasons and heavily subsidized by a captured market (the then government-owned ISCOR). ISCOR found alternative sources for coking coal, Grootegeluk at Ellisras and Tsikondeni near Mussina, and could therefore close down not their Natal mines.



The distribution of coal fields in the five relevant provinces. 1. Tuli, 2. Ellisras, 3. Mopane, 4. Tshipise, 5. Pafuri, 6. Springbok Flats, 7. Witbank, 8. Kangwane, 9. Free State, 10. Vereeniging–Sasolburg, 11. South Rand, 12. Highveld, 13. Ermelo (formerly Eastern Transvaal), 14. Klip River, 15. Utrecht, 16. Vryheid, 17. Nongoma, 18. Somkele, 19. Molteno–Indwe.

Fig. 5.1. Coalfields of South Africa (Snyman, 1998)



Collieries in Mpumalanga. 1. Anglo Power (Arnot), 2. Anglo Power (Kriel), 3. Arthur Taylor, 4. ATCOM, 5. Bank 2, 6. Bank 5, 7. Blackwattle, 8. Boschmans, 9. Bothasrust, 10. Delmas, 11. Dover, 12. Driehoek (Wesselton), 13. Duvha, 14. Eastside, 15. Eikeboom, 16. Elandsfontein, 17. Ermelo, 18. Glisa, 19. Goedehoop, 20. Greenside, 21. Khutala, 22. Kleinkopje, 23. Koornfontein, 24. Lakeside, 25. Landau (Kromdraai), 26. Leeuwfontein, 27. Leeuwpan, 28. Matla, 29. Mavela, 30. Middelburg, 31. New Clydesdale, 32. New Denmark, 33. Northfield, 34. Olifantslaagte. 35. Optimum, 36. Phoenix, 37. Polmaise, 38. Rietspruit, 39. Secunda: Bosjesspruit, 40. Secunda: Brandspruit, 41. Secunda: Middelbult, 42. Secunda: Syferfontein, 43. South Witbank, 44. Spitzkop, 45. Strathrae, 46. Tavistock, 47. Van Dyks Drift, 48. Waterpan, 49. Witbank Consolidated, 50. Woestalleen (Noodhulp Section), 51. Consbrey Dump, 52. Protea, 53. Mpisi, 54. TBS, 55. Nkomati Anthracite (after Smith and Whittaker 1986; Jordaan 1986; Schoeman and Boshoff 1996)

Fig. 5.2 Collieries in Mpumalanga. (Snyman, 1998)

Currently there are only a handful of operating collieries of which Zululand Anthracite Colliery (ZAC) is the largest (Fig. 5.3) producing 60 000 tons per month from various drill and blast as well as continuous miner sections. In recent years many of these mines have changed hands from larger to smaller companies, for example the selling of Utrecht Colliery by Ingwe to Kangra. Some of these smaller operators try to keep these mines open by opencasting the sub-outcrop coal. Most of the old mines were only successful by mining the thicker seams above the thin Gus and Dundas Seams. These thin seams range in thickness from 0.7 to 3.3m, with an average of 1.0m for the Gus and 0,7m for the Dundas Seam (De Jager, 1976). The main mining method was bord and pillar with a very few mines using longwall methods. Seam thickness, dolerite intrusions and seam dips made mining very difficult and expensive.

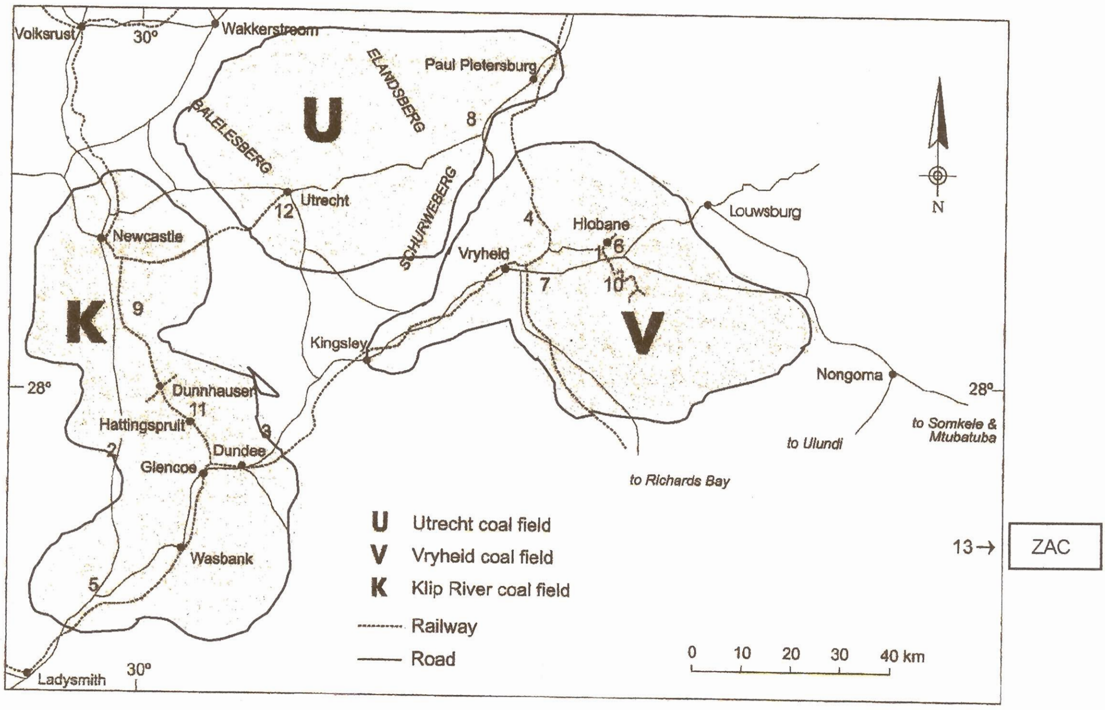


Fig. – Major coal fields (U = Utrecht, V = Vryheid, K = Klip River coal field) and more important producing collieries in KwaZulu-Natal. 1. Alpha Anthracite; 2. Durban Navigation; 3. Gladstone; 4. Heritage; 5. High Carbon (Newcastle–Platberg Dump); 6. Hlobane; 7. Jacksons Anthracite (Mpofini); 8. Long Ridge; 9. Macalman; 10. Rusplaas; 11. Springlake; 12. Umgala; 13. Zululand Anthracite (after Spurr et al. *1986; Bell and Spurr 1986a, b; Schoeman and Boshoff 1996).*

Fig. 5.3. Coalfields of KwaZulu-Natal (Snyman, 1998).

Table 7. Some defunct collieries in KwaZulu-Natal (Spurr et al., 1986)

Colliery	Coalfield	Date closed
Balgray	Utrecht	?
Boemendal Consolidated	Utrecht	1966
Constantia Coal Mine	Vryheid	?
Dumbe	Utrecht	1938
Dumbe	Utrecht	1975
Elandsberg Anthracite	Utrecht	1966
Enyati	Vryheid	1971
Hlobane	Vryheid	Late 1980s
Kilbarchan	Kliprivier	1990s
Kempslust	Utrecht	?
Longridge	Utrecht	Mid 1990s
Makateeskop	Utrecht	?
Mooihoek	Utrecht	1966
Mooiklip	Vryheid	?
Pivaan	Utrecht	1979
Vryheid Coronation	Vryheid	Late 1980s
Vryheid Coke	Vryheid	?
Vryheid Export	Vryheid	?
Weltevreden Anthracite	Vryheid	?

The above listed mines are not necessarily exclusive thin seam mines but most were a combination of thin and thick seams extracted simultaneously. Spurr et al., (1986) and Bell and Spurr, (1986) listed many other mines of which many were not exclusively thin seam mines. At Newcastle, in the Kliprivier Coalfield, the main seam mined was the Upper Seam. The Middle Seam is the thin seam, 0.94m thick, but was not always mined. The main coal produced from this area was anthracite and currently some small operators still reclaim dumps and mine small pits e.g. AfriOre at Springlake.

Table 8. Active collieries in KwaZulu-Natal (Pinheiro, 1999)

Colliery	Coalfield
CBR Mining	Kliprivier
Duiker Heritage	Vryheid
Duiker Nyembe	Vryheid
Durban Navigation	Kliprivier
Springlake	Kliprivier
Umgala	Utrecht
Welgedacht	Utrecht
Zululand Anthracite	Somkele

There are currently only 2 operating mines in the Vryheid area but in its prime this area had a huge output of coking coal and anthracite for the export market. In the whole KwaZulu–Natal Coalfield there are still some substantial thin seam resources left but no market exists for these costly to mine thin seams. The total indicated resource for all coal types in all the coal seams in the KwaZulu-Natal coalfields is 3,035 Mt in situ of which unknown proportions are thin seams (Barker, 1999).