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Rib-pillar mining at Sigma Colliery

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SYNOPSIS

The paper describes the rib-pillar extraction method now used at Sigma Colliery in the Orange Free State. In this method, access roadways (with a high safety factor) are developed into a block of coal suitable for total extraction; pillars that have a low safety factor are then formed and extracted immediately. The method, together with the current practices of labour management, has resulted in better utilization of the coal resources and capital, increased production and labour productivity, and improved safety.

SAMEVATTING

Die referaat beskryf die strookpilaarmynmetode wat tans by die Sigma-steenkoolmyn in die Oranje-Vrystaat gebruik word. Volgens hierdie metode word daar hooftoegangspaaie (met 'n hoë veiligheidsfaktor) in 'n blok steenkool, wat vir algehele uitmyning geskik is, in ontsluit; daar word dan pilare met 'n lae veiligheidsfaktor gevorm wat onmiddelik uitgemyn word. Hierdie metode het, tesame met die huidige arbeidsbestuurspraktyke, gelei tot die beter benutting van die steenkoolhulpbronne en kapitaal, hoër produksie en arbeidsproduktiwiteit, en verbeterde veiligheid.

Introduction

Sigma Colliery is situated in the Sasolburg area, south of the Vaal River in the Orange Free State, and is the sole supplier of coal to the Sasol One Works at an annual production rate of approximately 7 Mt.

During the 1960s, it was realized that a large portion of the coal reserves were being wasted by the bord-and-pillar method of mining then in use. At that time, the extraction of the total coal reserves was calculated to be only 11 per cent, and total extraction methods such as longwalling and pillar extraction were therefore introduced to improve the percentage extraction. However, these mining methods were found to have limited application on Sigma Colliery, and the rib-pillar method was introduced in 1980. To date, 17,37 Mt of coal have been produced by this method on Sigma Colliery.

The adaptation of rib-pillar mining to the requirements at Sigma Colliery is discussed in this paper.

Geology

The Sigma Coalfield is situated approximately 70 km south of Johannesburg in the Orange Free State (Fig. 1). The Sigma basin is situated along a north–south line at the western edge of what is known as the Vereeniging–Sasolburg Coalfield. The pre-Karoo rock of the Vredefort Dome outcrops along the western boundary, and the eastern extremity is defined by a prominent ridge of pre-Karoo Ongeluk lava. Further to the east, are the Cornelia, Coalbrook, and New Vaal Collieries.

The coal-bearing strata in this area were deposited some 200 million years ago within the Vryheid and Dwyka formations, which are part of the Karoo supergroup of sedimentary rock. The sedimentary rock contains vestiges of glacial, fluvial, and open-water depositional activities.

There are four mineable coal seams in the Sigma Coalfield. These are identified, from the base upwards, as number 1, 2A, 2B, and 3 coal seams. The coal seams

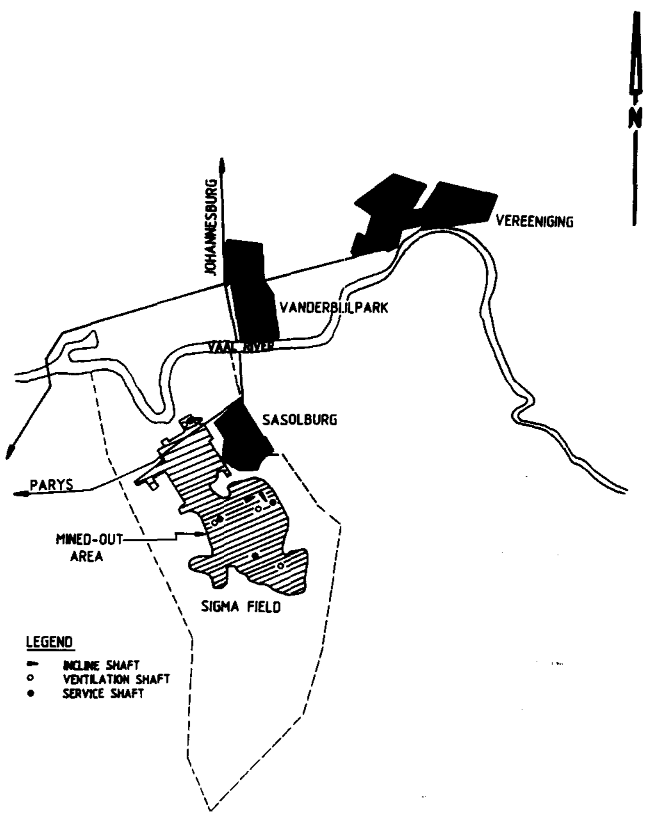

Fig. 1—Locality of Sigma Colliery

extend over an area of approximately 300 km^2, at between 20 m and 250 m below surface. The wide variation in depth below surface results from a general southward dip in the strata, coupled with a northward-sloping land surface, which drains towards the Vaal River.

Number 2A, 2B, and 3 coal seams occur throughout the basin (Fig. 2). The parting between the respective coal seams is variable and, in the case of number 2B and 3 coal seams, increases to the south. In the parting between number 2A and 2B coal seams there is seldom more than 100 cm of mudstone. In some areas, the parting between

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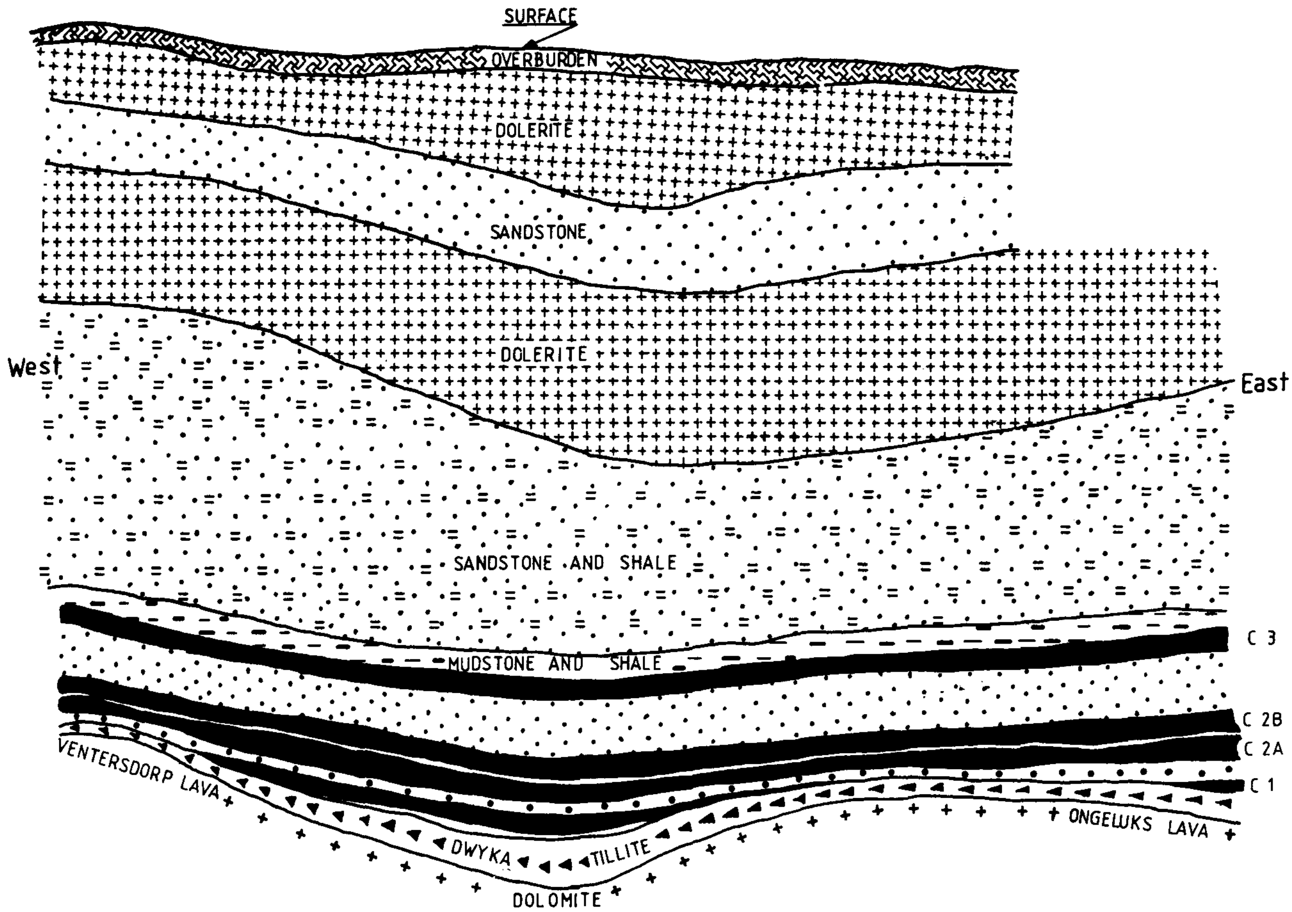

	Average thickness m	Cumulative depth m
Overburden	4,0	4,0
Dolerite	40,0	44,0
Sandstone	6,0	50,0
Dolerite	45,0	95,0
Sandstone and shale	40,0	135,0
Coal	0,5	135,5
Mudstone and shale	8,0	143,5
No. 3 coal seam	4,0	147,5
Sandstone	16,0	163,5
No. 2B coal seam	5,0	168,5
Mudstone	0,5	169,0
No. 2A coal seam	3,5	172,5
Conglomerate	3,0	175,5
No. 1 coal seam	3,0	178,5
Tillite	20,0	198,5

Fig. 2—Simplified stratigraphic profile at Sigma Colliery

number 2B and 2A coal seams is non-existent, resulting in a combined seam thickness of 6 m and more.

The overburden consists generally of medium- to coarse-grained sandstone, dolerite, siltstone, mudstone, and shale while, in the extreme northern areas, there is a thick, unconsolidated sand unit. Dolerite sills, up to 35 m thick, cover extensive areas in the Coalfield, and their presence has a profound influence on the volatile content of the coal in areas where the parting becomes less than 30 m. The dolerites also affect the rock-mechanics conditions of the mining operations.

The composition of the rock in the roof strata of each seam has a significant influence on the stability of the mining bord. Structurally weak carbonaceous shale and mudstone occur throughout the area underlain by number 3 coal seam. Number 2B coal seam, however, is overlain by a mixture of channel sandstones, siltstone, and mudstone, while the brown mudstone of the floor of number 2B coal seam forms the roof of number 2A coal seam.

Strata Control in Rib-pillar Mining

The success of the rib-pillar method of extraction depends to a large extent on the balance between the rate of mining and the onset of roof failure. The creation of any excavation underground leads to instability of the overlying strata. The time of failure depends on a number of factors—mainly those involving the characteristics of the roof rock and the size of the excavation.

In rib-pillar extraction, the onset of roof instability occurs within minutes of the enlargement of the excavation. This implies also that the locality of instability is very close to the working area at any time.

Because a geological material is involved, deviations from 'normal' behaviour are bound to occur. This means that failure will sometimes be retarded and at other times accelerated. However, this does not imply that man has no control over the deviations. On the contrary, an understanding of the basic procedure of rock failure indicates certain good and bad practices that have a bearing on the time and locality of roof failure. Although there are still certain important gaps in our understanding of the changes in the rock environment brought about by rib-pillar extraction, enough is known to minimize the incidence of unplanned roof failure. Certain work has also been initiated to increase the extent of current understanding.

Regional Changes in Stress Distribution

As with any maximum-extraction mining method, such as stooping or longwalling, rib-pillar extraction results in the creation of a large cavity underground, which requires a major redistribution of stresses while significant magnitudes of displacement also occur. Two basic periods can be distinguished before major goafing occurs.

The first phase covers the period of development, during which minimal changes take place. This is because of the large size of the pillars and the wide spacing of the entries. The regional stress distribution can be regarded as being unaffected.

The second phase covers the period from the initiation of mining to the formation of the first major goaf. This period is characterized by an increase in stress on successive fenders and the surrounding solid areas. The stress will continue to increase as the size of the mined-out area increases, until the first major goaf occurs. The ultimate level of stress will thus be governed by the ability of the roof to goaf: the presence in the roof of a dolerite sill or a very competent sandstone layer will inhibit goaf formation and may cause very high stresses to develop.

Local Changes in Stress Distribution

During the mining of fenders, the size of the overall excavation is increased in small steps. The overall changes that occur in a regional sense are therefore small in magnitude. However, when one considers that all the changes occur in the immediate working area, and that local roof overhangs can have dramatic effects on the small area in which people and machines are located, even if it only has a minimal effect on the regional situation, then a consideration of the stress changes in the immediate working area assumes great importance.

Obviously, because the immediate area is located within this regional area, consideration of the former must also take the latter into account.

To simplify the discussion, only the general case will be considered where a major goaf has already formed and no abnormal overhangs are present. The concept for the other cases will generally be the same, but the magnitude of the stress may be meaningfully different.

Immediately after a slice has been taken off a fender, the roof thus created is unsupported. Owing to the imbalance between the load on the roof plate and its support, both tensile and shear stresses are generated in the area close to the nearest solid. This eventually leads to failure, and the roof collapses. The magnitudes of the stresses that eventually cause failure are governed by the magnitude of the force imbalance. Therefore, the size of the unsupported plate is a very important parameter. The larger the plate, the higher the stresses that eventually cause failure, and the greater the extent of the fractures that develop and, consequently, the more dramatic the effects become.

The time of failure is a function of the characteristics of the roof rock. The weaker the roof, the more readily will it fail. If the immediate roof is very competent, it may not fail even if the unsupported plate (or overhang) is relatively large. It will then have a dramatic effect on the next fender if that has already been developed. The fender may crush significantly, and the removal of that fender will then permit bending of the roof strata until the roof eventually reaches the stage where it has to fail. Under these conditions, the collapse may be dramatic and could affect a wide area.

At the other end of the scale is the situation where a joint or a slip occurring at a ribside will induce premature failure of the roof, since the roof then has no cohesive strength at the point where the failure-inducing stresses develop. It is therefore of the utmost importance to recognize such features and to install additional support ahead of time.

Rib-pillar Mining at Sigma Colliery

Rib-pillar extraction is a total-extraction system of coal in which access roadways (with a high safety factor) are developed into a block of coal suitable for total extraction. Pillars that have a low safety factor are then formed and extracted immediately.

The access roads mined in rib-pillar extraction consist of primary development, which is normally 4-road development and 3-road secondary development.

Since the implementation of rib-pillar mining in 1980, the method has been continuously adapted to conform to local conditions and to ensure safe, productive mining with a relatively high utilization of the reserves.

Responsible Utilization of Reserves

Since the Industrial Revolution, coal winning has been exceeding the coal-forming process. With historical extraction ratios as low as 11 per cent, it became essential to investigate and implement alternative mining methods such as rib-pillar extraction to increase the utilization of reserves. To optimize rib-pillar mining, the selection of equipment is of utmost importance since the equipment must be mobile, flexible, and robust.

There are cases when restrictions such as seam heights, remnant size, surface protection, and geological occurrences limit the use of conventional mining methods such as mechanized bord-and-pillar, longwall, and pillar extraction but could be favourable for rib-pillar extraction.

The principle of rib-pillar extraction at Sigma Colliery is to minimize development and to maximize extraction.

The undermining of longwall, pillar-extracted, rib-pillar-extracted, and bord-and-pillar workings with continuous-miner rib-pillar sections has been implemented successfully for the past three years on Sigma Colliery. The utilization of reserves is therefore increased considerably, the inter-panel extraction rate being as high as 85 per cent.

Production Rate

In any process, there is always a yet smarter way of achieving results. In rib-pillar extraction at Sigma, this was also the case. In 1981, the rate was 8 kt per week on a three-shift basis. For 1989/90, the average production rate was 14 kt per week on a three-shift basis—an increase of 75 per cent.

The evolution of the rib-pillar practice was due to creative and innovative personnel. The production output increased annually by an average of 24,6 per cent. This trend was achieved through the measuring of performance and the setting of sound and achievable objectives.

A realistic unit to express the utilization of available production time is tonnes per minute (t/min). With all the restrictions included, such as cable handling, tramming, sweeping, and roof trimming, the planned rate for developing is 1,8 t/min and 2,5 t/min for extracting pillars. Tramming and roof support are the two major production restrictions at present, and new methods and alternative roof-support systems are being investigated.

The annual production growth of rib-pillar mining was from 420 kt per annum in 1980 to 4,1 Mt per annum in 1989/90, as illustrated in Fig. 3.

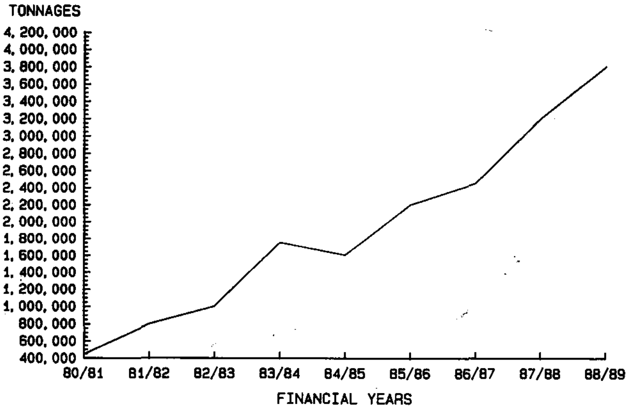

Fig. 3—Production growth at Sigma (the tonnages include rib-pillar development and pillar extraction)

Labour Productivity

Labour productivity is measured in tonnes per manshift. The in-section productivity with the rib-pillar method increased rapidly during the first six years from 24 t per manshift to 51 t per manshift. From 1986 to 1990, the improvement was only 8 t per manshift, as indicated in Fig. 4.

A fine labour balance is maintained at Sigma between the developing phase and the actual pillar-extraction phase. In the developing phase, the emphasis is on roof support and the creation of a sound in-section infrastructure. During pillar extraction, the emphasis is on controlled roof failure, which consists of the systematic installation and removal of breakerlines.

The labour complement on the in-section production of a standard rib-pillar section on Sigma is 11, being made up as follows:

1 miner (two sections—double continuous miner)
1 continuous-miner operator
1 cable handler
2 shuttle-car operators
4 roofbolt operators
2 general workers (ventilation, stonedust, ventilation walls, and pumping).

The utilization of multi-purpose construction teams has proved successful, and is being investigated to replace all general work inbye the section. In this way, the total labour complement can be optimized.

A specialized, roving engineering-service team operates effectively, the equipment being serviced and repaired weekly during a maintenance shift. The engineering complement during afternoon and night shifts consists of one artisan for three sections, together with an engineering aid and an assistant per section. As a result of the more intensive and constant maintenance, the availability of the equipment has increased by 5 per cent and is being maintained at above 82 per cent.

Utilization of Capital

Although the outlay for a continuous-miner section is high, it is only 31 per cent of that required for a longwall section. The production rate of a rib-pillar section is half that of a longwall section.

Production Costs

The mining production costs (in 1989 terms) for rib-pillar mining are in the region of 200 cents per tonne delivered at the section belt. This figure increases to 310 cents per tonne when labour is included. The engineering cost, which is mainly for the maintenance and repair of the production equipment, is 580 cents per tonne. The total unit cost for rib-pillar mining is 890 cents per tonne on Sigma Colliery. Wastage and rework are reduced to an absolute minimum because of the results achieved by the quality-improvement process that was introduced during 1986.

All Sigma employees have been trained in the quality-improvement process, and senior employees, from the

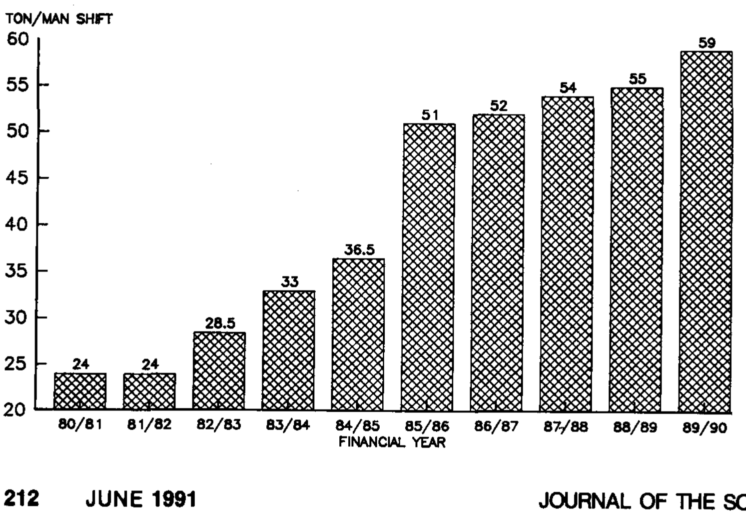

Fig. 4—Manpower productivity at Sigma

level of shiftboss upwards, have been thoroughly trained in productivity, costs, and profits. On Sigma, each section shiftboss is regarded as a cost centre, and is responsible for his own budget, cash flow, control, and cost discipline. His prime objective is to meet the 'bottom line' as far as production, safety, and costs are concerned. Wastage is restricted by the man on the floor and is controlled by him.

Safety

Any mining operation, which is an unnatural event, bears the risk of injuries, damages, and fatalities. To deal with such risks, it is of utmost importance that all the personnel should be involved in the prevention of accidents.

The workers on Sigma Colliery have proved that they are committed to safety. (They were the co-winners of NOSA's National Mining Competition for 1990.) During September 1990, 1 million fatality-free shifts were worked, and 2 million disablement-free manhours were achieved during October 1990.

More than 60 per cent of the coal produced on Sigma Colliery is mined by the rib-pillar extraction method. Although strata failure during rib-pillar extraction is dangerous, the risk of accidents is reduced by a sound support rule, thorough training of the personnel, and skilled supervision.

Description of Rib-pillar Mining

Panel Layout and Cutting Sequence

The area allocated to rib-pillar mining is divided into workable sections, and the primary development normally consists of four roadways from the main development to the limit of the remnant. The two outer roads are utilized as return airways, and the two inner roads as travelling and conveyor-belt roads. The inner roads also serve as intake airways (Fig. 5).

The secondary development consists of three roads, two being intake airways and one a return airway. Cross conveyor installations are used to ensure that the tramming distance for shuttle cars is minimized.

Rib-pillar mining, owing to its flexibility, is practised in several combinations. A single section can develop and extract the pillars in a small remnant. In larger areas, two sections can operate in tandem and, in ideal situations, the system consists of three sections—one developing and two working in tandem, and 'leapfrogging' down the panel.

Fender extraction on Sigma Colliery has been developed through trial and error and in consideration of the basic principles of strata control. The production aim is to develop the minimum and to extract the maximum.

The cutting sequence for the extraction of fenders and a single fender are shown in Figs. 6 and 7 respectively. At Sigma not more than two fenders are pre-developed and, if the geological and mining conditions are not favourable, only one fender is developed and extracted immediately.

With the existing system, the goafline is always straight and the panel widths have been increased to 450 m. Because the layout had been optimized, it was possible to concentrate on the development of manpower, the upgrading of infrastructure, and the implementation of quality- and loss-control principles.

Back-to-back Mining

In back-to-back mining, two fenders are extracted from the same entrance, creating an increased stress zone. Owing to the complexity of the geological features at

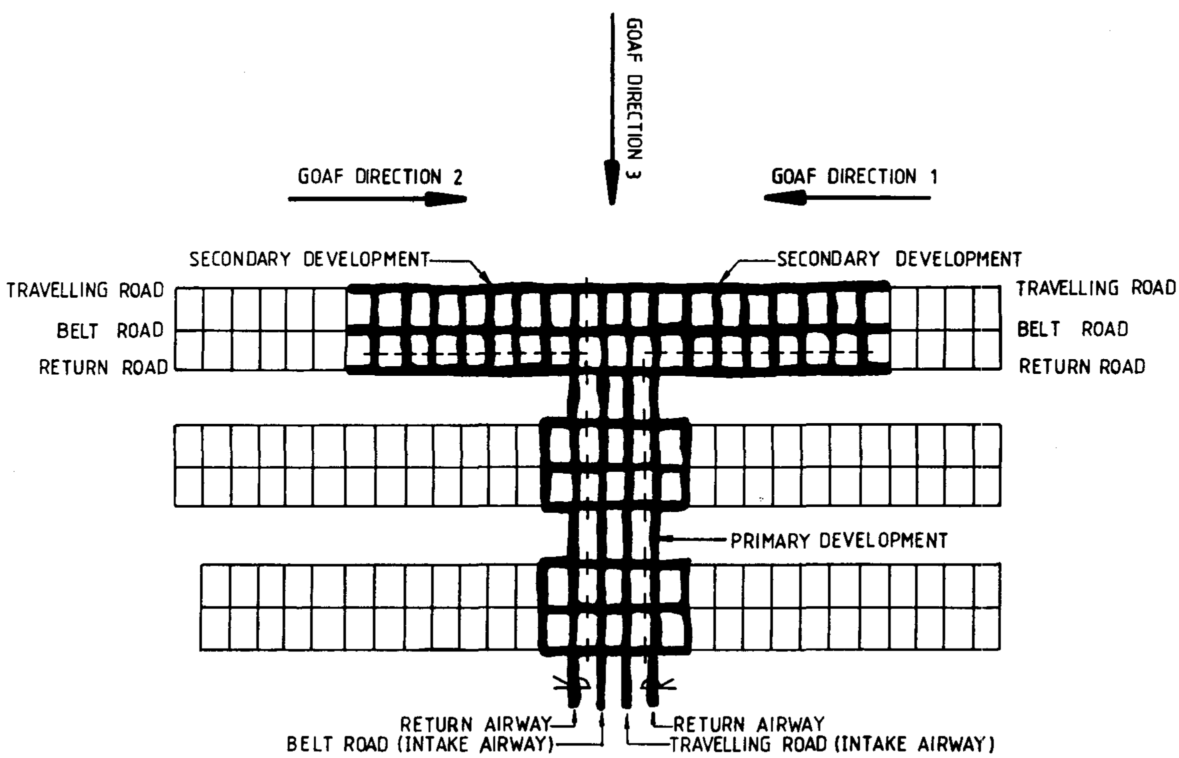

Fig. 5—Layout of rib-pillar panels at Sigma

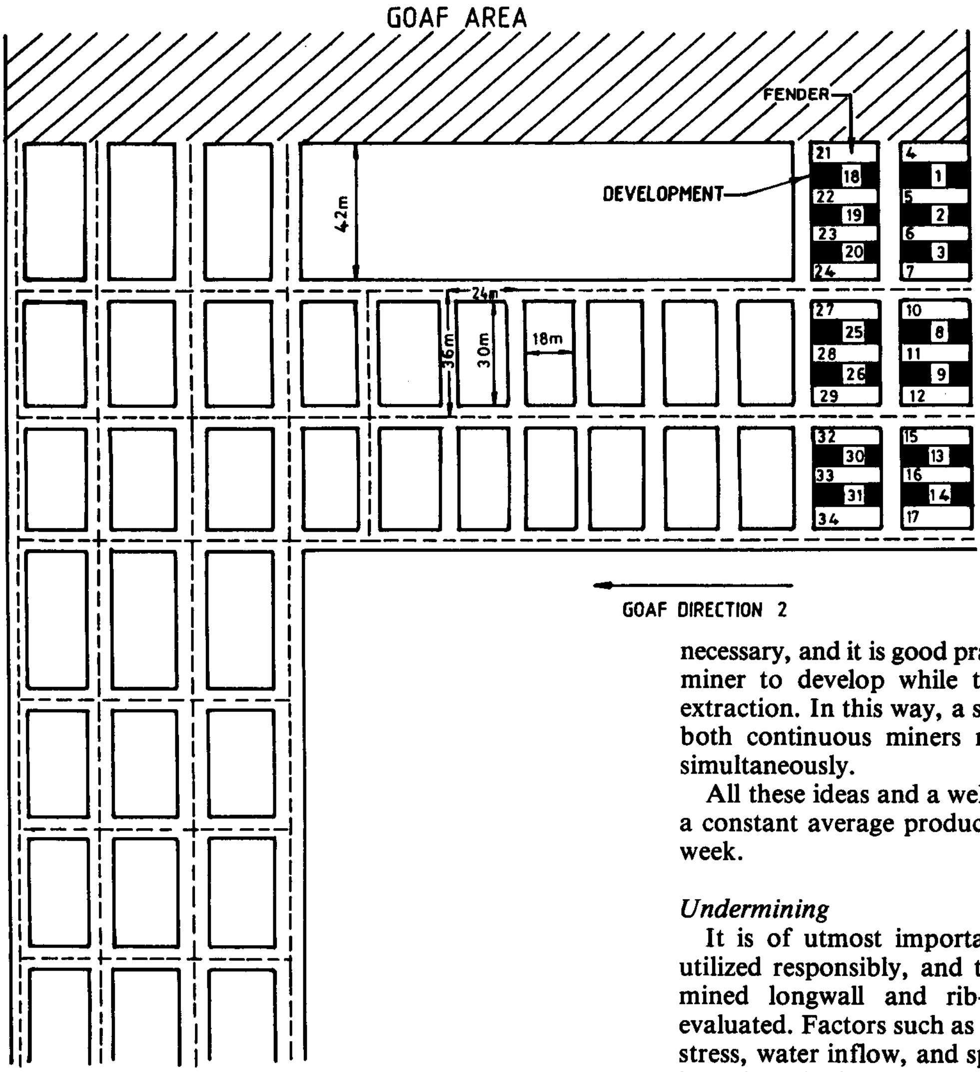

Fig. 6—The mining cycle for rib-pillar extraction

Sigma, back-to-back fender extraction is limited and done only in specific situations in order to maximize the fender extraction in a rib-pillar panel.

Disciplined use of fingerlines considerably reduces the risk of machines being trapped in the goaf area. The micro back-to-back sequence is illustrated in Fig. 8. This method is resorted to only in very exceptional circumstances such as when the fender road of a potential fender is not available owing to bad roof or floor conditions. However, its application is not recommended as a general rule.

The successful application of the macro back-to-back sequence (Fig. 9) led to the development of the latest panel layout for a double continuous-miner section. The primary development is in the centre of the panel, with secondary development to the sides. Pillars are being mined towards the primary development, which creates a high stress area once the two goafs get close to each other. At first, because the estimated risk was too high, it was planned to leave two rows of pillars. However, once such a macro back-to-back situation was reached, it became clear that the pillars could be extracted safely. During the past two years, the system has proved itself.

By the splitting of a block of ground in the middle, a considerable amount of development is saved and each section has its own dedicated return. No air crossings are necessary, and it is good practice to allow one continuous miner to develop while the other one is doing total extraction. In this way, a situation does not arise where both continuous miners reach the back-to-back area simultaneously.

All these ideas and a well-motivated team have led to a constant average production of 14 kt per section per week.

Undermining

It is of utmost importance that reserves should be utilized responsibly, and the risk of undermining pre-mined longwall and rib-pillar areas was therefore evaluated. Factors such as gas inflow, and areas of high stress, water inflow, and spontaneous combustion were investigated. Since 1987 undermining has been conducted successfully. As the risk is higher than in normal pillar mining, it is important that safe standards and sound practices should be maintained. Areas of high stress due to snooks left during primary mining and water accumulation in the top goaf proved to be the main problem areas. The superimposition of roads and water-drainage holes has been found to be sufficient to maintain rib-pillar mining of the bottom seam.

Planning

Section positions are planned six months in advance, and the panel layouts are designed by the shiftbosses, miners, and machine operators. A system has been introduced in which all new and inventive ideas are passed on to the mine overseer for consideration and sifting before they are implemented. Thought is continuously given to the impact on the extraction of the overlying and underlying coal seams.

The final planning is done by the shiftboss, who circulates detailed plans to the mine overseer, survey, geology, strata-control, and ventilation departments.

When initially developing a panel, the continuous miner develops loops to allow for the installation of section belt drives and air crossings if necessary. By doing this, the extraction section in which two sections are working in tandem is not affected by belt installation, and the downtime is reduced.

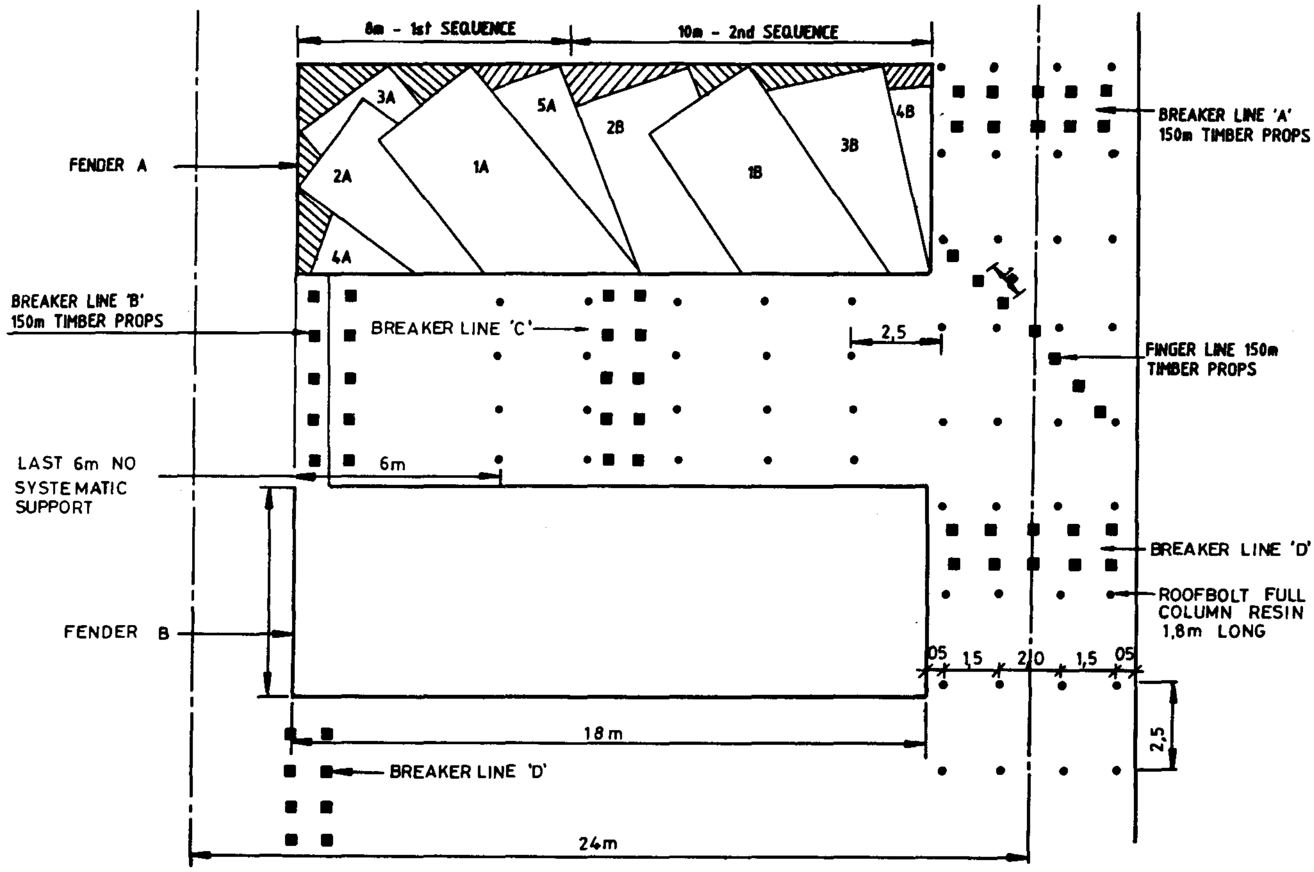

Fig. 7—Systematic support and cutting sequence in rib-pillar extraction

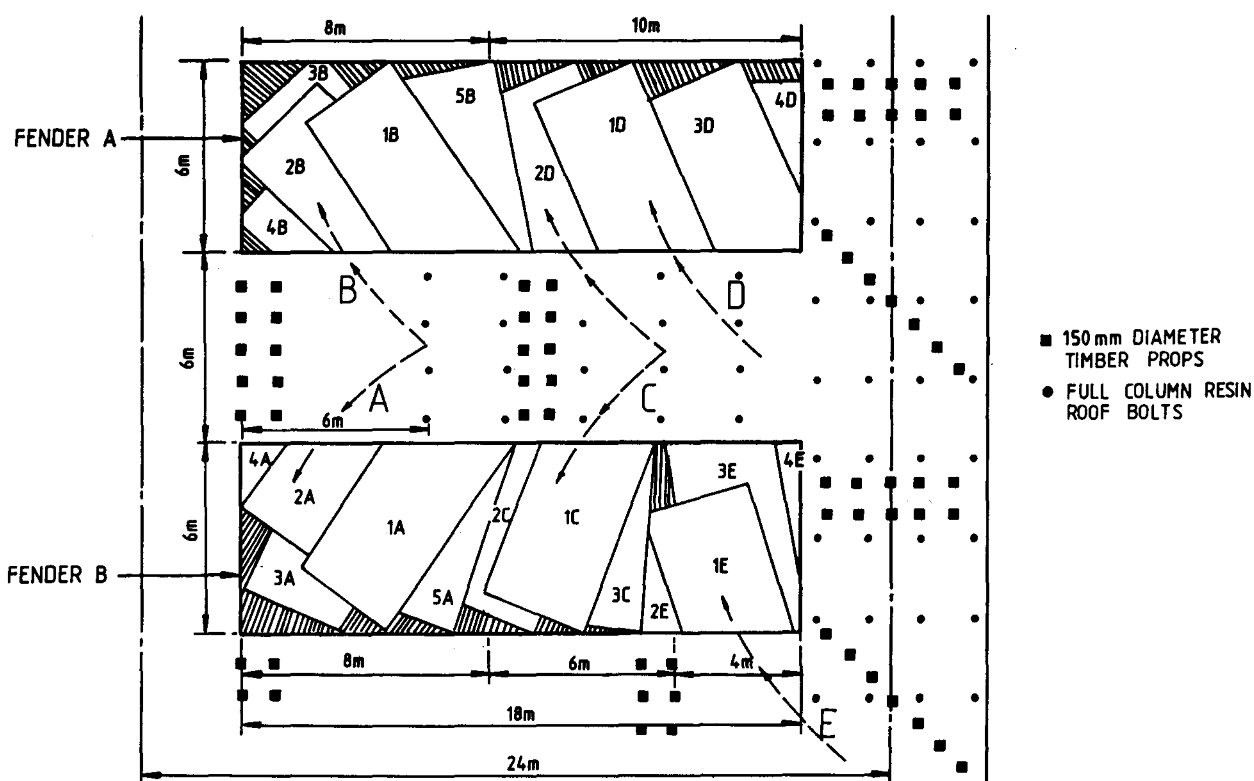

Fig. 8—Micro back-to-back cutting sequence from A to E

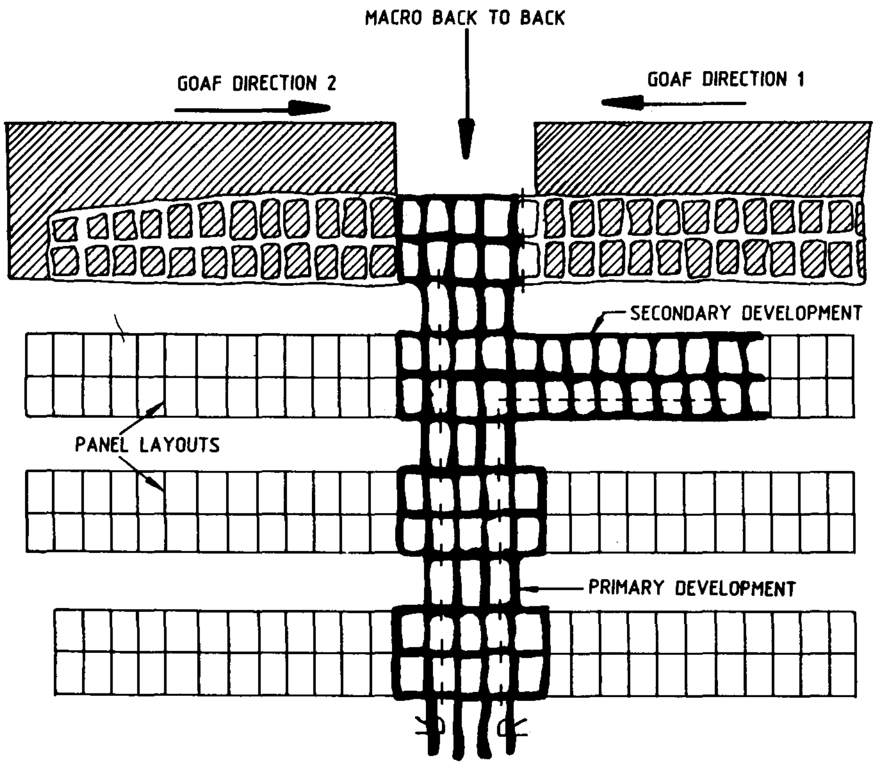

Fig. 9—Macro back-to-back cutting sequence

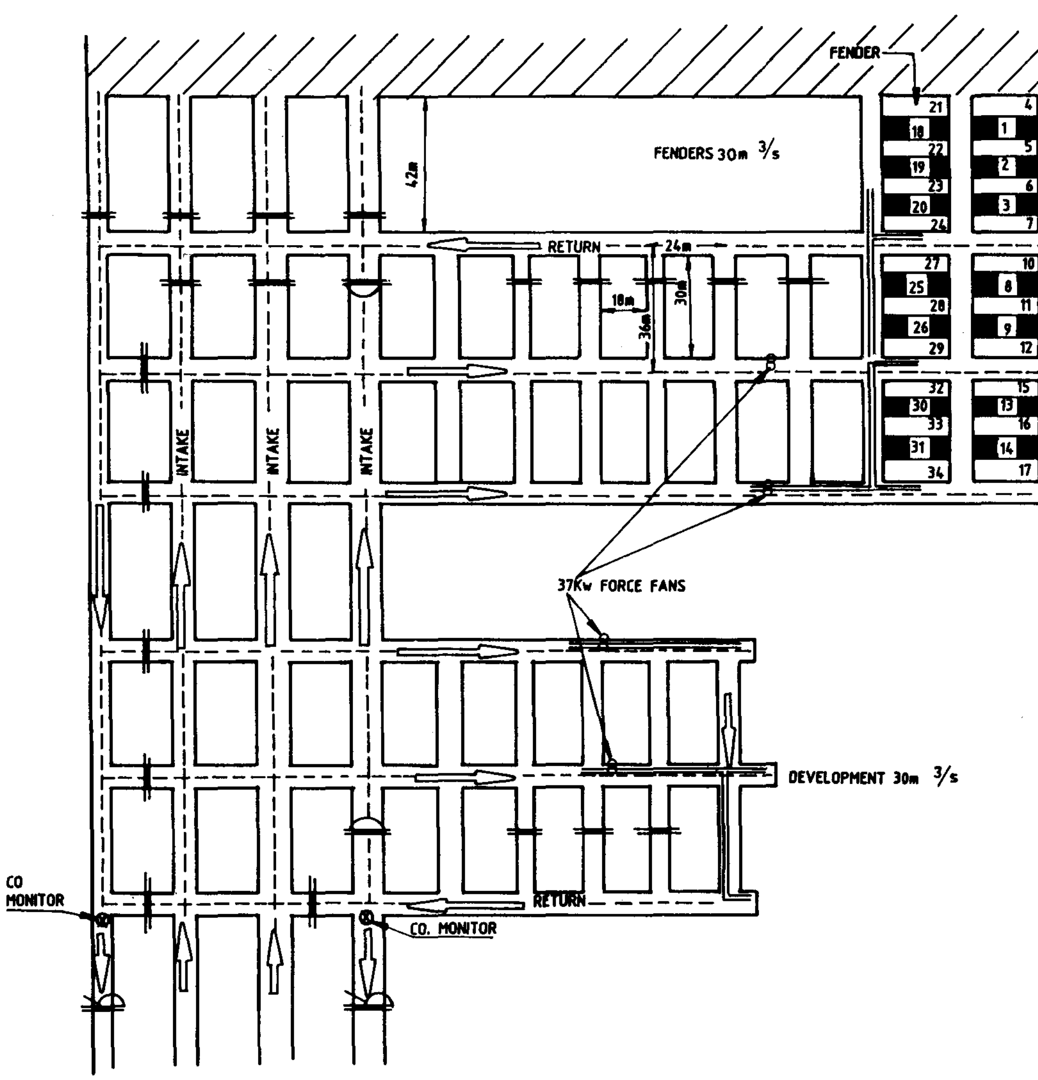

Fig. 10—Ventilation layout and distribution in rib-pillar extraction

Infrastructure

It soon became clear that the most important rule in rib-pillar extraction (if not in any mining method) is to maintain a sound infrastructure. Inefficiences in water handling, belt availability, road usage, power supply, or material shortage have a large impact on the final results. Specialized crews under the supervision of a senior shift-boss are solely responsible for maintaining the driveheads, belts, and water-handling equipment. Section belt availability is 98 per cent at present. All section equipment, such as waiting places, fans, stores, and workshops, are mobile, and all the material is containerized. The total material-handling network is controlled by the shaft technical assistant, who also has other duties.

Load-haul dumpers (LHDs) are circulated daily through all the sections to clean the tramming roads and maintain optimal tramming operations. On day shift, the LHDs are utilized for belt extensions, which are done during the maintenance shift.

Environmental Control

An air volume of 30 m^3/s is circulated through each continuous-miner section, resulting in a velocity in the last through road of 1,5 m/s; 22 and 37 kW fans and ducting are used to force fresh air into each heading (the goaf edges being treated as a working end). The average volume per heading is 2,6 m^3/s (Fig. 10).

Wetting agents introduced into the mine service water reduce the dust generated during the cutting operation by as much as 40 per cent.

During undermining operations, as is often necessary in multi-seam mines, special attention must be given to the sudden inflow of gas from the pre-mined panels or goafs. Half and full drop-line brattices are being used effectively to reduce the high quantities of flammable gas (Fig. 11).

Hand-held portable continuous instruments are used by the supervisory personnel to detect noxious and flammable gases. A centralized monitoring system with audio-visual alarm facilities for methane, carbon monoxide, changes in barometric pressure, and reduction in airflow were installed during 1988/89, and the system is operating effectively.

Stonedusting is a statutory requirement, and must be maintained up to the last through road with a maximum of 50 m from the working face. (Sigma has been exempted from Regulation 10:24:11 of the Mines and Works Act, which requires a maximum distance of 10 m from the working face.)

Support Practice and Equipment

The total support pattern was redesigned and approved by the Government Mining Engineer. The support rule provided for a uniform support culture on Sigma that is safest and easy.

The support rule provides for the installation of 1,8 m full-column resin roofbolts of 16 mm or 20 mm diameter at line-intervals not exceeding 2,5 m, and the end bolts not more than 0,5 m from the sidewall. These lines must be kept up to a maximum of 1,8 m from the working face.

The same principle is observed in rib-pillar mining. In fender development only 67 per cent of the road is supported with roofbolts. The remaining 33 per cent is supported by wooden props, which also serve as the first breaker line. During fender extraction, mine poles are utilized as sag-indicators, breaker lines, and finger lines. Once the fender has been extracted, and after a support breaker line has been installed, the breaker lines are removed with a steel cable hooked onto a filled shuttle car.

In areas where slips and faults are present, cable trusses are being installed 0,6 m apart for micro roof support.

Standard available equipment is used. A Joy 12HM9 or Jeffrey H2 continuous miner is used with two 10SC12 Joy shuttlecars, two Rham roofbolters, and a Stamler or Dowty feeder breaker unit. Melco-drives are generally used for the conveyance of coal.

Although everything possible is being done to prevent the entrapment of mining equipment, external factors, such as power failures, mechanical breakdown, and the failure of a shuttle car behind the production unit, can

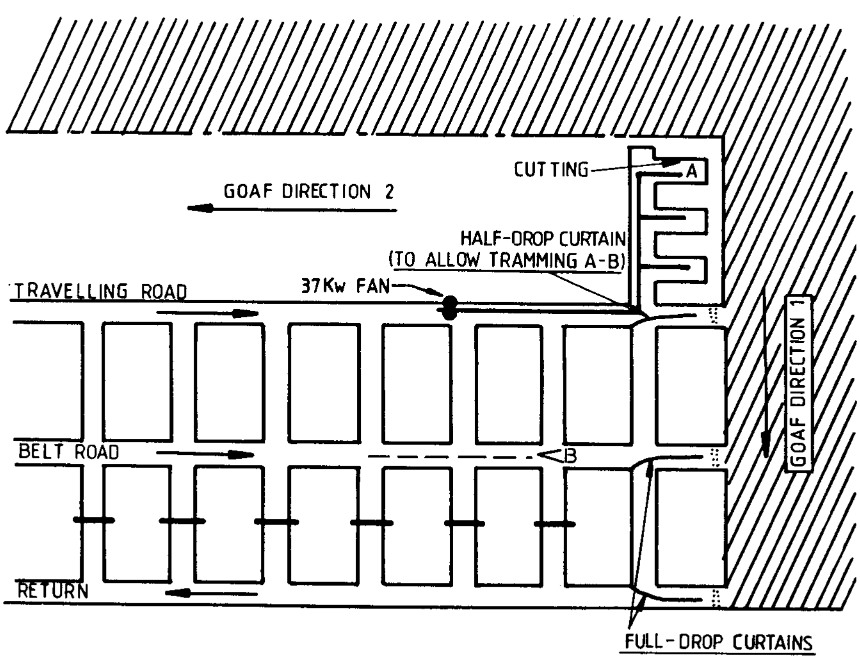

Fig. 11—Goaf-edge ventilation with bratticing

and will cause machines to be trapped in the goaf area.

A standard practice has been developed to reduce the loss when a machine is trapped. Use is made of a specialized pulling device with a pulling force of 942 kN. The golden rule is to maintain the roof brow and adjacent pillars after the fall of ground. Where necessary, steel sets with 6 m spiles are used to build a tunnel around the trapped machine before it is extracted. Continuous miners have been reinforced to such an extent that a machine is back in production only one shift after it has been extracted. It has, however, taken up to 42 eight-hour shifts to extract a continuous miner.

Future Development Areas

The following possibilities to improve production, costs, and reserve utilization are being investigated at present:

(1) replacement of the timber breaker lines with mechanical breaker lines,
(2) the use of a conveyor-belt take-up system capable of quick belt retreat during pillar extraction,
(3) block caving of thick coal seams,
(4) bottom coaling in place of rib-pillar extraction where the thickness and quality of the coal will allow this,
(5) crush-pillar mining in place of rib-pillar extraction,
(6) mechanized cable handling on continuous miners,
(7) mining of pillars with longwalling equipment.

New degree in mining surveying*

South Africa's only degree in mining surveying, offered at the University of the Witwatersrand, has been upgraded, and the discipline has been renamed mineral resources management. The degree course is offered by the Department of Mining Engineering. This change is the result of a rationalization move in which the Surveying Department in the Engineering Faculty, incorporating both land and mining surveying, has been closed.

In 1989 the Committee of University Principals recommended the closure of two of the four departments in the country offering land surveying. 'Our student numbers in land surveying had been relatively low for a number of years, and we had difficulty in attracting and retaining staff', explains Professor Huw Phillips, Head of the Department of Mining Engineering at Wits. 'However, the rationalization has allowed us to concentrate on making substantial improvements to the mining surveying course'.

According to Professor Phillips, the new degree in mineral resource management is designed to give mining surveying students a broad education in surveying, mineral reserve evaluation, and mine planning. 'We are confident that the new degree will attract the good-quality students needed to provide top-class professional surveyors. It will also improve career prospects for graduates, enabling them to advance into technical services management.'

The content of the degree has been planned in consultation with the mining industry, the Government Mining Engineer's office, and educational bodies.

The mining surveying staff complement of two has been increase to four for the course in mineral resource management. Dr Andrew Jarosz, one of the new staff members who is a specialist mine surveyor, was attracted from the Virginia Polytechnic Institute and State Univesity to join the Wits team.

The academic staff employed on mineral resource management are also responsible for the surveying courses required in other disciplines such as civil engineering, architecture, and building science.

* Issued by Lynne Hancock Communications, P.O. Box 3712, Honeydew 2040.

Minerals engineering

Two meetings on the above topic have been announced for 1991 and 1992.

The first is an international symposium on Reagents in Minerals Engineering, which is to be held at Camborne School of Mines in Cornwall (England) from 18th to 20th September, 1991.

This meeting, the third in the series of international symposia organized by *Minerals Engineering* and Camborne School of Mines, will deal with all aspects of reagent usage in mineral processing and extractive metallurgy.

The second is Minerals Engineering '92, which will be held in Vancouver (Canada) from 14th to 16th April, 1992.

Papers are invited for presentation at Minerals Engineering '92. These should deal with recent developments, practical applications, and the future potential of important areas of mineral and coal processing and extractive metallurgy.

Extended abstracts, of 500 to 600 words, should be sent to 'Minerals Engineering '92' by 26th July, 1991. Authors will be notified of the acceptance or otherwise of their papers by the end of August 1991, and full papers will be required by January 1992.

Details of the above meetings can be obtained from
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