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The extraction of barrier pillars between adjacent longwall panels at The Durban Navigation Collieries (Pty) Ltd

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SYNOPSIS

The practice of leaving barrier pillars between adjacent longwall panels at The Durban Navigation Collieries (Pty) Ltd (Durnacol) has resulted in a considerable loss of coal reserves.

Durnacol has now modified the layout of its longwall panels to allow the concurrent mining of barrier pillars and the extraction of the longwalls. The implementation of the new panel layout has increased the percentage extraction of reserves and will result in an extension in the life of the mine.

The method of extracting barrier pillars between adjacent longwall panels is described in this paper.

SAMEVATTING

Die gebruik om grenspilare te laat tussen aangrensende strookafboupanele by The Durban Navigation Collieries (Pty) Ltd (Durnacol) het 'n aansienlike verlies aan steenkoolreserwes tot gevolg gehad.

Durnacol het nou die strookafboupaneeluitleg verander om die gelyktydige verwydering van die grenspilare met die strookafboupanele te bewerkstellig. Die implementering van die nuwe paneeluitleg het die persentasie herwinning van reserwes vergroot en sal gevolglik die lewe van die myn verleng.

Die metode wat gebruik word om die grenspilare tussen aangrensende strookafboupanele te verwyder word beskryf.

Introduction

The Durban Navigation Collieries (Durnacol) is situated in the Dannhauser Magisterial District of Natal and supplies coking coal to Iscor. The Colliery produces 225 kt of run-of-mine coal per month by conventional methods and longwalling. The retreat method of longwalling is used, and two sections together produce 51 kt of run-of-mine coal per month.

This paper should be read in conjunction with two previous papers on longwall mining at Durnacol that have been published in the *Journal*. The first paper, 'The pioneering of fully mechanized longwall coal mining in South Africa' by R.T. Naudé and M.J. Deats, was published in the February 1967 edition, and the second paper, 'A follow-up report on longwall coal mining at Durban Navigation Collieries (Pty) Limited' by M.J. Deats, was published in the April 1971 issue.

The adoption of a new panel layout, allowing the extraction of longwall barrier pillars concurrently with the main panel, represents the only major change in longwall practice since the previous papers were published.

Owing to the relative scarcity of reserves of good-quality coking coal in South Africa, Iscor's policy is to maximize the extraction of reserves at Durnacol. The new longwall layout was devised in accordance with this policy, and has been adopted successfully at the mine.

Geology

Two thin seams, known as the Top Seam and the Bottom Seam, of the Klip River coalfield are exploited. The Top Seam has a thickness of 0,75 to 1,10 m, and the Bottom Seam a thickness of 0,75 to 1,35 m. The Bottom Seam contains a hard, sandy shale parting, known as the No. 1 Shale Band, which is usually 0,1 m thick. A typical section of the mining horizon containing the coal seams is shown in Fig. 1.

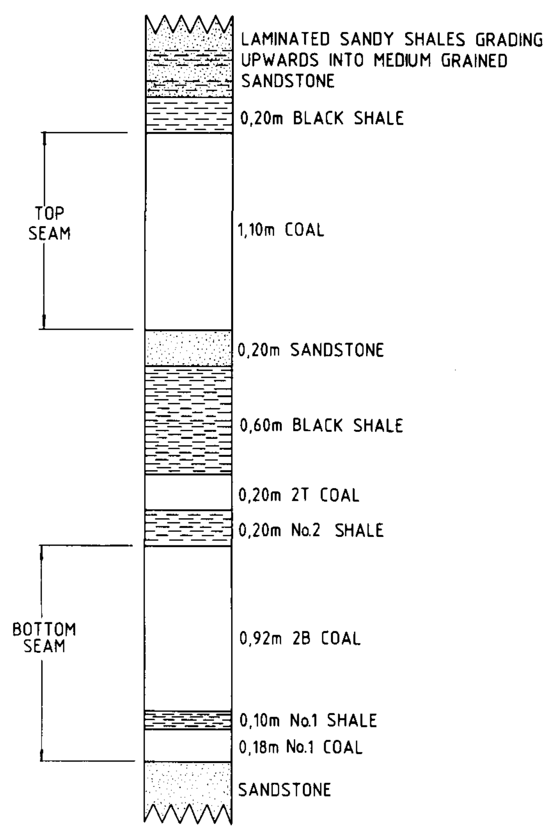

Fig. 1—A general section through the coal seams at Durnacol

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The two seams are separated by a parting, which is normally 1,2 m thick, consisting of sandstone, shale, and a minor coal seam of variable thickness. The seams together with the intervening parting are generally contained in a 3,5 m section, but this can increase to more than 5,0 m when the parting becomes thicker.

The coal seams are gently undulating and lie at a depth of 170 to 270 m, the overlying strata being of alternating sandstone and shale into which dolerite sills have intruded. The main sill in the area, the Ingogo sill, has a thickness of 80 m and lies some 94 m above the coal seams. A typical section of the overlying strata is shown in Fig. 2.

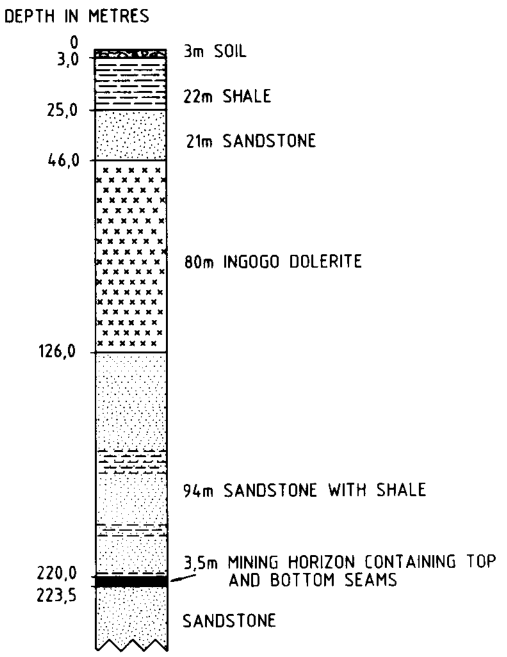

Fig. 2—A general stratigraphic section through the overlying strata

Layout for Adjacent Longwall Panels

In the original panel layout, the two seams were extracted by the non-simultaneous multi-slice method. The development carried out at first was for longwalling of the Top Seam, and, after the extraction of the panel, the goaf was allowed to consolidate for a period of about two years. Gate roads in the lower panel were offset by 10,4 m inside those of the extracted upper panel to avoid the abutment stresses created by longwalling of the Top Seam. The sandstone and shale parting between the seams was not extracted and remains in the goaf. The positions of the gate roads in the mining horizon of the Top and Bottom Seams are shown in Fig. 3.

The original layout for adjacent panels is shown in Fig. 4. The tailgate companion road, to serve both the upper and the lower panels, is required for ventilation and for the transportation of material. A belt road was developed in the Bottom Seam to serve the two adjacent upper and two adjacent lower panels.

In the exploitation of both the Top and the Bottom Seam, inter-panel barrier pillars were left between the longwalls. Although the practice of leaving such pillars to control strata, subsidence, and ventilation is common

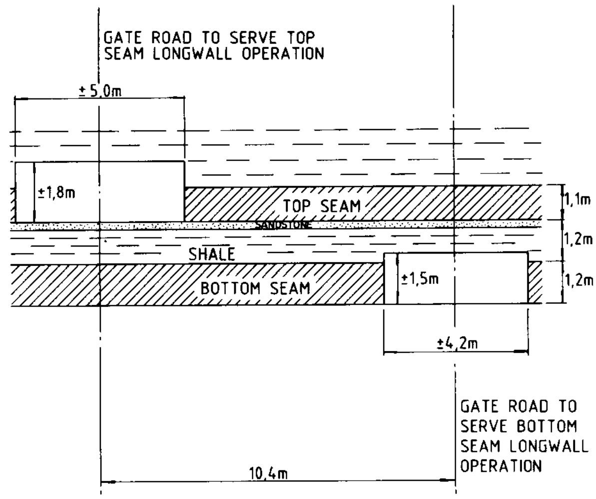

Fig. 3—The position of the gate roads in the seam horizon

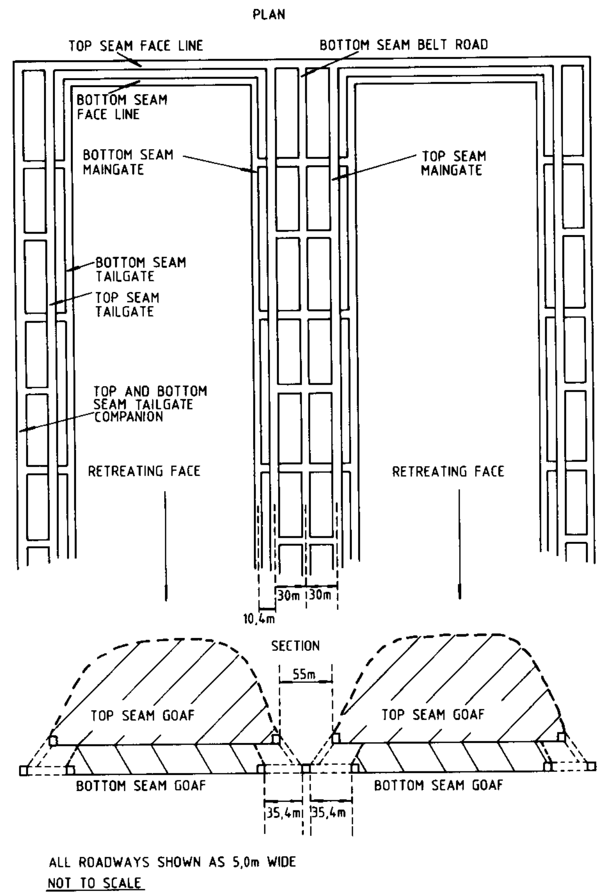

Fig. 4—The original panel layout in the Top and Bottom Seams

to most collieries employing the longwall method, substantial reserves of coal are not recovered. A total of 500 kt of sales coal have been lost at Durnacol in these inter-panel pillars to date, which represents a considerable loss of revenue.

It can be seen from Fig. 4 that a 55 m pillar of Top Seam coal and a 70,8 m pillar of Bottom Seam coal are lost in each inter-panel barrier pillar.

Modified Layout for Adjacent Longwall Panels

During 1979, a plan was devised to reduce the amount of coal left in inter-panel barrier pillars by modification of the panel layout. The development of the first panel according to this new layout started during 1979, and longwall mining commenced in March 1981.

The two seams are extracted by the non-simultaneous multi-slice method, as in the original panel layout. However, the modified layout allows the mining of the inter-panel barrier pillar in the Top Steam concurrently with the extraction of the longwall panel. In addition, the layout substantially reduces the width of the barrier pillars in the Bottom Seam, and reduces the amount of development required by 15 per cent.

Longwalling of the Top Seam

The modified layout for panels in the Top Seam is shown in Fig. 5. The roadways are developed with a rectangular profile by use of a Joy continuous miner, or by drilling and blasting. The maingate and tailgate are developed at a height of 1,8 m and a width of 5,0 m. Gate roads are supported by split poles with resin-anchored roofbolts and timber props.

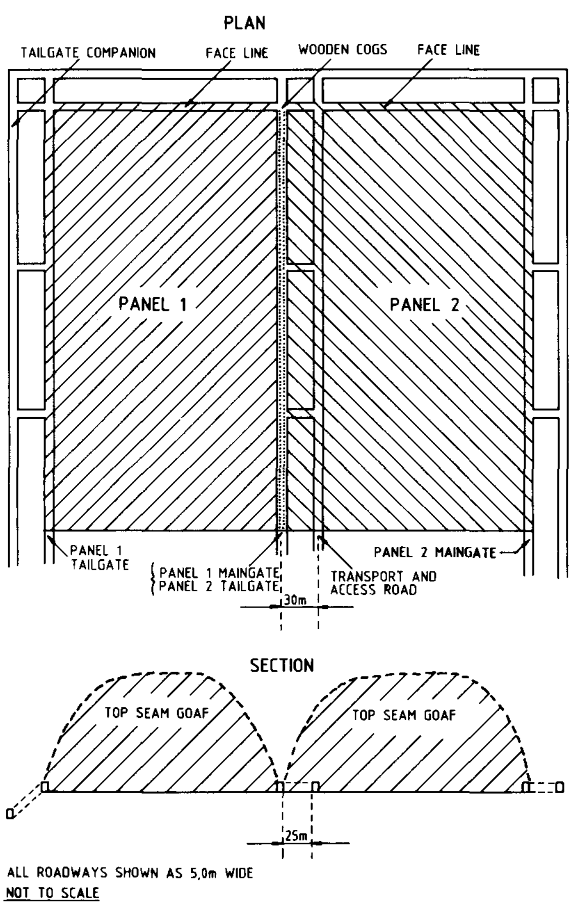

Fig. 5—The modified panel layout for the Top Seam

Single-gate roads developed the full length of a panel, according to the practice in European collieries, are not permitted under the Mines and Works Regulations. Gate roads are therefore developed in pairs, with connecting crosscuts for ventilation purposes. By exemption, the Colliery is permitted to develop single-entry headings a maximum of 300 m in advance of the last through ventilation. In practice it has been found desirable to develop crosscuts at intervals of 250 m.

The first Top Seam panel in a block of adjacent panels developed to the modified layout is mined conventionally, i.e. the inter-panel pillar is not extracted. The maingate roadway of this panel is supported behind the face with two rows of packs constructed of timber blocks or cogs. These cog packs are installed immediately behind the gate chocks as the gate road is retreated. This allows the roadway to be used as a tailgate return airway in the subsequent extraction of the adjacent panel and barrier pillar. Previous experiments indicated that the most suitable pack configuration is a 9-pointer pack of double, flat blocks 1,0 m long.

After the first panel has been extracted, the inter-panel pillar is mined concurrently with the adjacent panel. The roadway between the main panel and the inter-panel pillar is used as a transport and access road to the tailgate side of the section.

The method of mining a Top Seam longwall section and accompanying pillar is shown in Fig. 6. The main face is normally about 240 m in length, and the pillar is 25 m wide. Panel lengths vary from 500 to 1200 m. Separate shearers are used to cut the main face and the pillar face.

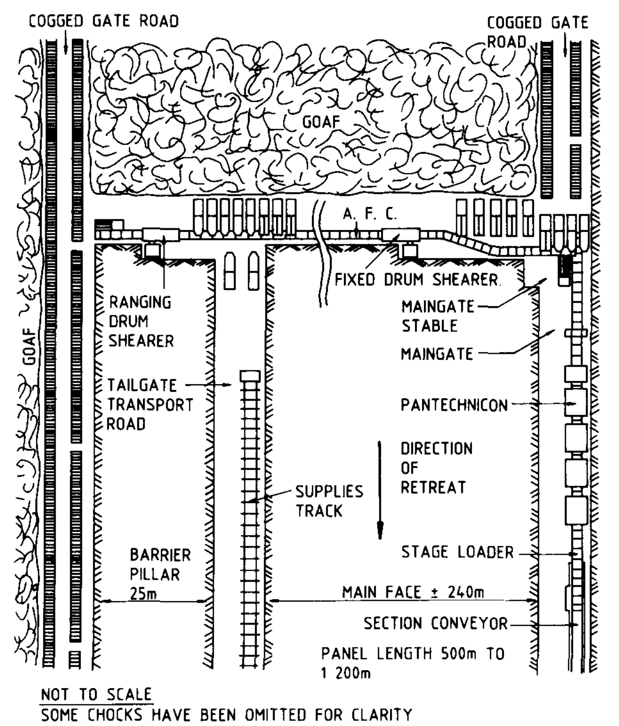

Fig. 6—The method for the mining of barrier pillars between adjacent longwalls

The main face is extracted by an AB 16 Anderson Mavor single-ended fixed drum shearer, which cuts bidirectionally. The shearer is mounted on a 500 mm wide Dowty Meco armoured face conveyor (AFC) with a capacity of 225 t/h. The shearer can cut a theoretical web width of 0,75 m, but in practice a 0,6 m wide web is taken on each pass. The cutting drum is positioned at the maingate end of the machine, and a small stable is maintained.

The main face is supported by Gullick Dobson 6-leg hydraulic chocks, with a yielding force of 350 or 464 t. These chocks are self-advancing, with uni-directional adjacent control. Three larger chocks, with a yielding force of 510 t, are used for support at the maingate face end.

chocks, with a yielding force of 510 t. These chocks are used in preference to the 350 or 464 t chocks that are employed on the main face because a larger cutting drum is fitted to the AMBROAS. The higher yielding force of the 510 t chocks is also desirable in that a greater pressure is experienced on the face of the barrier pillar.

Both shearers operate on separate 18 mm haulage chains. The haulage chain for the main face machine is tensioned at the maingate by a tensioning spring, and runs to the tailgate AFC drive, where it is tensioned hydraulically. The shearer extracting the barrier pillar operates on a short length of untensioned chain anchored at the tail drive unit, and at another anchor point attached to the AFC in the main face close to the tailgate material road. The arrangement of the haulage chains is shown in Fig. 7.

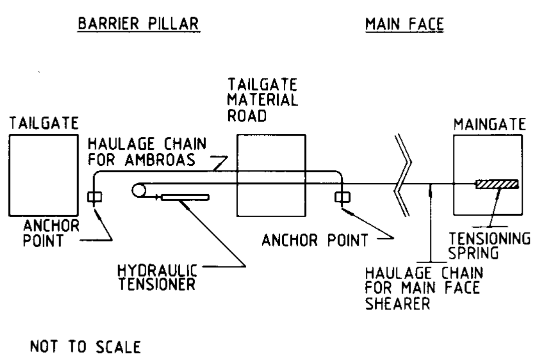

Fig. 7—The arrangement of the haulage chains

The sequence of cutting operations of the two shearers is as follows.

(1) The main face shearer, having cut into the maingate stable, is snaked over and cuts back towards the tailgate transport road. At this stage both faces should be level, with the AMBROAS snaked over into the transport road.
(2) The AMBROAS cuts into the barrier pillar face by 15 m before the main-face shearer cuts into the tailgate transport road.
(3) When the main-face shearer has cut into the transport road, it is snaked over and proceeds to cut a web back to the maingate.
(4) The AMBROAS finishes cutting the barrier-pillar face, flits back to the tailgate material road, and is snaked over.

not been cut down to leave a more competent roof.

Problems were also experienced at the face ends of the barrier pillar owing to large blocks of laminated sandstone falling between the face and the chocks, which resulted in damaged equipment. Several occurrences of large blocks jamming between the AFC and the underframe of the main face shearer have been recorded. This problem was solved by the cutting down of bad roof at the face ends, with the ranging drum of the AMBROAS, to leave a stronger sandstone roof.

The barrier pillar has 4,4 m wide crosscuts at intervals of about 250 m, which can cause production delays when they are mined through. The crosscuts are supported by timber packs arranged in a half-pack stagger so that, when one row of packs is removed, the next row is only 0,5 m ahead. As the longwall face passes through the crosscut, the packs are loosened by the pulling out of blocks with two hydraulic rams positioned on the face for that purpose. The packs are then removed by hand, and the AFC and chocks are advanced.

Longwalling of the Bottom Seam

The modified layout for Bottom Seam panels is shown in Fig. 8. Although Bottom Seam development started only recently, the new layout is expected to be successful.

Gate roads are developed under the goaf of the upper panel after consolidation has taken place. Owing to the pressure acting on the cog packs that remain in the Top Seam goaf, a permanent inter-panel barrier pillar with a width of 15 m must be left below. Bottom Seam longwalls are therefore mined conventionally as in the original layout. The gate roads and face lines round the periphery of a block of panels are offset by 10,4 m inside those of the extracted upper panels.

Bottom Seam entries are developed with a rectangular profile by drilling and blasting. Gate roads are developed 1,5 m high and 4,2 m wide, and are supported by split poles and timber props.

The extraction of the Bottom Seam panels developed by the modified layout has not yet commenced. However,

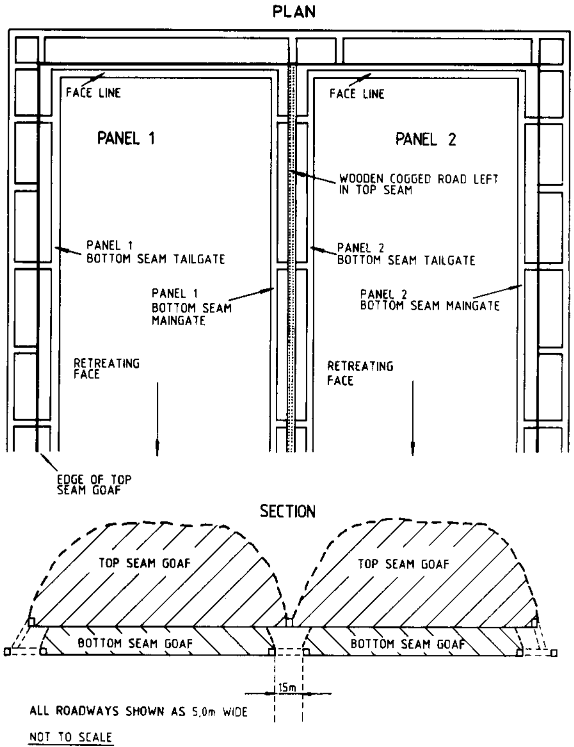

Fig. 8—The modified panel layout in the Bottom Seam

the method of mining will be the same as that practised in the original layout.

Because of the presence of a hard shale parting in the Bottom Seam, lower slice faces will be cut in two passes, as shown in Fig. 9. An AB 16, single-ended, ranging drum will be used with a 0,91 m cutting drum, which is smaller than that used for the Top Seam panels.

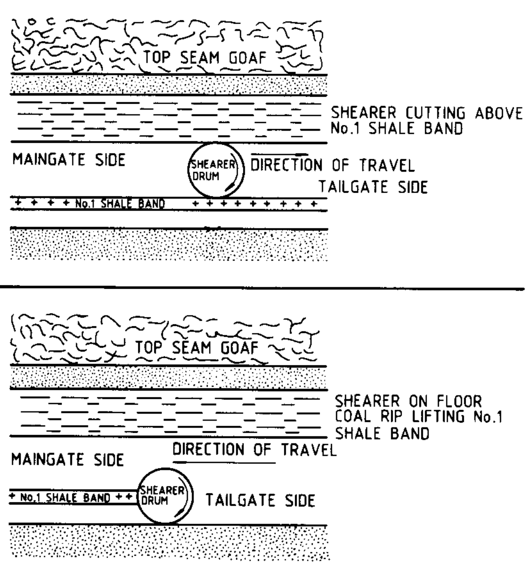

Fig. 9—Two-pass cutting of the Bottom Seam

The cutting drum is positioned on the maingate side of the machine, and a tailgate stable is maintained. The shearer cuts from maingate to tailgate with the cutting drum above the shale band, and with the drum rotating from roof to floor. When the machine reaches the tailgate stable, the drum is lowered and the shearer cuts from tailgate to maingate, ripping up the floor coal and shale band into the top cut and thus facilitating fairly fast cutting speeds. On reaching the maingate, the shearer is snaked over on the AFC and the sequence is repeated.

Although the parting between the panels of the Top and Bottom Seams is only 1,0 to 1,5 m in thickness, very few roof problems have occurred to date. The pressure on the faces of the Bottom Seam is considerably less than that experienced on the faces of the Top Seam, and the production is therefore generally higher, even though the face must be cut in two passes. Better face conditions are found in the Bottom Seam because the roof breaks immediately behind the chocks and a steeper goafing angle is obtained.

Subsidence

Surface subsidence is greatly influenced by the massive dolerite sill overlying the coal seams. This sill is very competent and often bridges the goaf of narrow longwall panels. When this occurs, the stratum above the coal seams caves up to the base of the sill, and a gap is formed. If failure does not occur, the sill subsides to a limited extent, giving a maximum surface subsidence of approximately 10 per cent of the extracted seam height.

The dolerite sill generally fails when wide faces of more than 200 m in length are extracted. Failure can occur quickly, but is not violent and does not cause problems at the face. Greater subsidence is recorded above panels where the sill has failed, and subsidence is more pronounced above panels where the inter-panel barrier pillars have been extracted. In the first block developed to the modified layout, three adjacent Top Seam panels and two inter-panel pillars have been extracted at a depth of 220 m. An average cutting height of 1,1 m resulted in a maximum subsidence on surface of 0,55 m.

A more uniform subsidence profile is achieved when inter-panel barrier pillars are extracted. This results in less damage to surface roads and farmland, and will be of particular benefit to mines extracting thick seams at shallow depths.

Ventilation

Ventilation of Top Seam panels, where intervening barrier pillars are extracted, is by the bleeder system, shown in Fig. 10. Both the maingate and tailgate material road are intake airways, while the cogged tailgate acts as the main return. The maingate intake supplies 10 m^3/s of air, and the tailgate material road supplies 3 m^3/s. Ventilation courses along the face from the maingate to the tailgate return, and an air quantity of approximately 7 m^3/s through the face is achieved, giving an air velocity of 2 m/s. Air is also drawn from the face, over and through the goaf and along the cogged roadways, to the bleeder road. Bleeding through the goaf in this way removes methane, which might otherwise form dangerous accumulations.

Ventilation on the face of the inter-panel barrier pillar can become sluggish when the longwall approaches and passes through a crosscut in the pillar. Roof movement causes damage to the brick stoppings that are used to seal the crosscuts, and this allows air to short-circuit from the tailgate material road directly into the tailgate return. Brattice cloth is therefore erected to help improve the coursing of ventilation air.

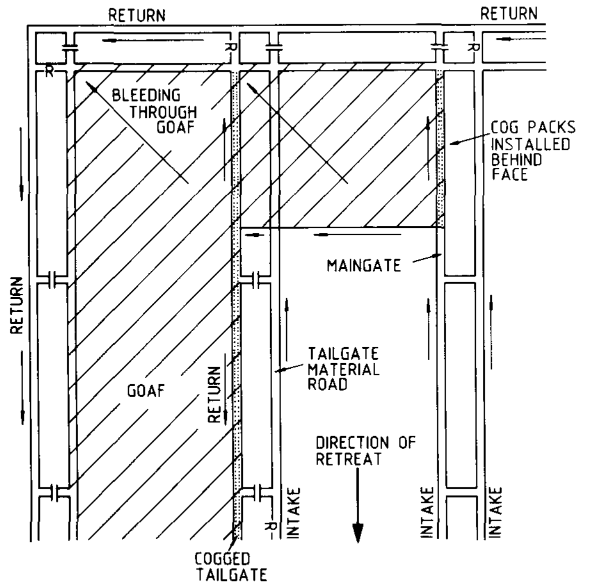

Fig. 10—The arrangement of longwall ventilation in the Top Seam

Regular tests are made for methane, carbon monoxide, and carbon dioxide in the bleeder road to monitor the effectiveness of the bleeder ventilation. The bleeder ventilation is increased if the concentrations of methane rise to an unacceptable level. Rapid rises in the readings for carbon monoxide and carbon dioxide would indicate the presence of spontaneous combustion in the goaf, which would require remedial action. No spontaneous combustion has occurred in any of the Top or Bottom Seam panels extracted to date.

The longwall panels in the Bottom Seam have a conventional system of ventilation, with the maingate as the intake airway and the tailgate as the return. Bleeding through the goaf is still practised during longwalling of the Bottom Seam.

Before the extraction of a panel in the Top Seam, methane drainage holes are drilled from surface to assist with the removal of methane from the goaf. Two or more boreholes 75 mm in diameter are drilled to a depth of 1 m below the main dolerite sill. The number of boreholes used depends on the length of the panel, but is usually two or three. These boreholes normally start bleeding off methane when the position of the longwall face in the Top Seam is directly underneath the borehole. The gas is bled off to the atmosphere through a water trap, and methane concentrations of up to 98 per cent have been recorded.

Results

Good results have been obtained from the use of the modified panel layout to extract inter-panel barrier pillars in the Top Seam. Two longwall sections have been mined successfully, and a further two sections are in operation at present. Following the success of the trials, all the undeveloped longwall blocks are now being developed to the modified layout.

Longwall production has not declined with the added complication of extracting the barrier pillars, and a record monthly production was achieved by the first panel employing the pillar-extraction method.

Initially, problems were encountered during mining through crosscuts in the barrier pillar because these were developed at approximately 45 degrees to the development headings. All the crosscuts are now developed at 90 degrees to allow the longwall to pass through these problem areas as soon as possible.

The extraction of the inter-panel barrier pillars has also resulted in greater inflows of groundwater owing to extensive failure of the overlying impermeable dolerite sill. In the original layout, where inter-panel barrier pillars were left, the dolerite sill was supported and failure rarely occurred. Longwalls are therefore worked up-dip to avoid the accumulation of water at the face. However, water in the Top Seam goaf is a danger to operations in the Bottom Seam, and must be drained prior to development in the lower slice.

The modified panel layout has resulted in considerable improvement in the percentage extraction of the reserves. In the original panel layout, a 55 m pillar of Top Seam coal and a 70,8 m pillar of Bottom Seam coal were left in barrier pillars between adjacent longwalls. In the modified layout, only a 15 m wide pillar of Bottom Seam coal is lost. In one block of 5 adjacent panels with an average length of 1000 m, the percentage extraction will increase from what would have been 62 per cent if the original panel layout had been adopted to 83 per cent by the new method. The percentage extraction given here includes coal lost in barrier pillars that are left round the periphery of the block of longwall panels. The improved recovery will result in an extension in the life of the mine, and will bring in an additional 64 million rands in revenue.

Additional operating costs are incurred in the mining of the inter-panel barrier pillars because extra material and labour are involved. Extra material costs arise chiefly from the timber blocks and wedges used in the cog packs, and additional labour is required to transport and install the timber support, and to operate the AMBROAS shearer. Capital redemption costs are incurred from the purchase of the AMBROAS shearer and ancillary equipment.

The overall cost per sales ton of longwall production has increased by 2,4 per cent as a result of the implementation of the barrier-pillar extraction method. However, a discounted cash flow on the revenue of the additional reserves that will be recovered shows that the method is profitable.

Conclusions

The implementation of the modified panel layout for adjacent longwalls, allowing the extraction of inter-panel barrier pillars in the Top Seam, will raise the overall percentage extraction of reserves and result in an extension to the life of the mine.

Although the overall cost per sales ton of longwall production has increased by 2,4 per cent, a discounted cash flow shows the method to be profitable.

An additional advantage is that the environmental impact of subsidence damage is improved, which will be of particular benefit to mines extracting thick seams, at shallow depths, by the longwall method.

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