COAL AGE
A McGRAW-HILL PUBLICATION
MARCH 1976

FIVE MINES LOOK AT SHORTWALL FIVE DIFFERENT WAYS

BERGBAU '76

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Here's how five different mines apply shortwall methods to mine coal

Shortwall mining is a compromise that avoids some problems of longwall mining while improving the production output from a continuous miner section. Among five mines using the method, four like it, while the fifth is completing its studies.

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ONE OF THE MOST TALKED ABOUT new mining methods that has great potential in increasing production is shortwall mining. The method is actually a hybrid between continuous mining and longwall mining. Briefly, it is a short-length longwall face supported by specially designed, self-advancing powered supports that provide an extensible canopy so that coal can be cut by a continuous miner while its operator is under a continuous roof support.

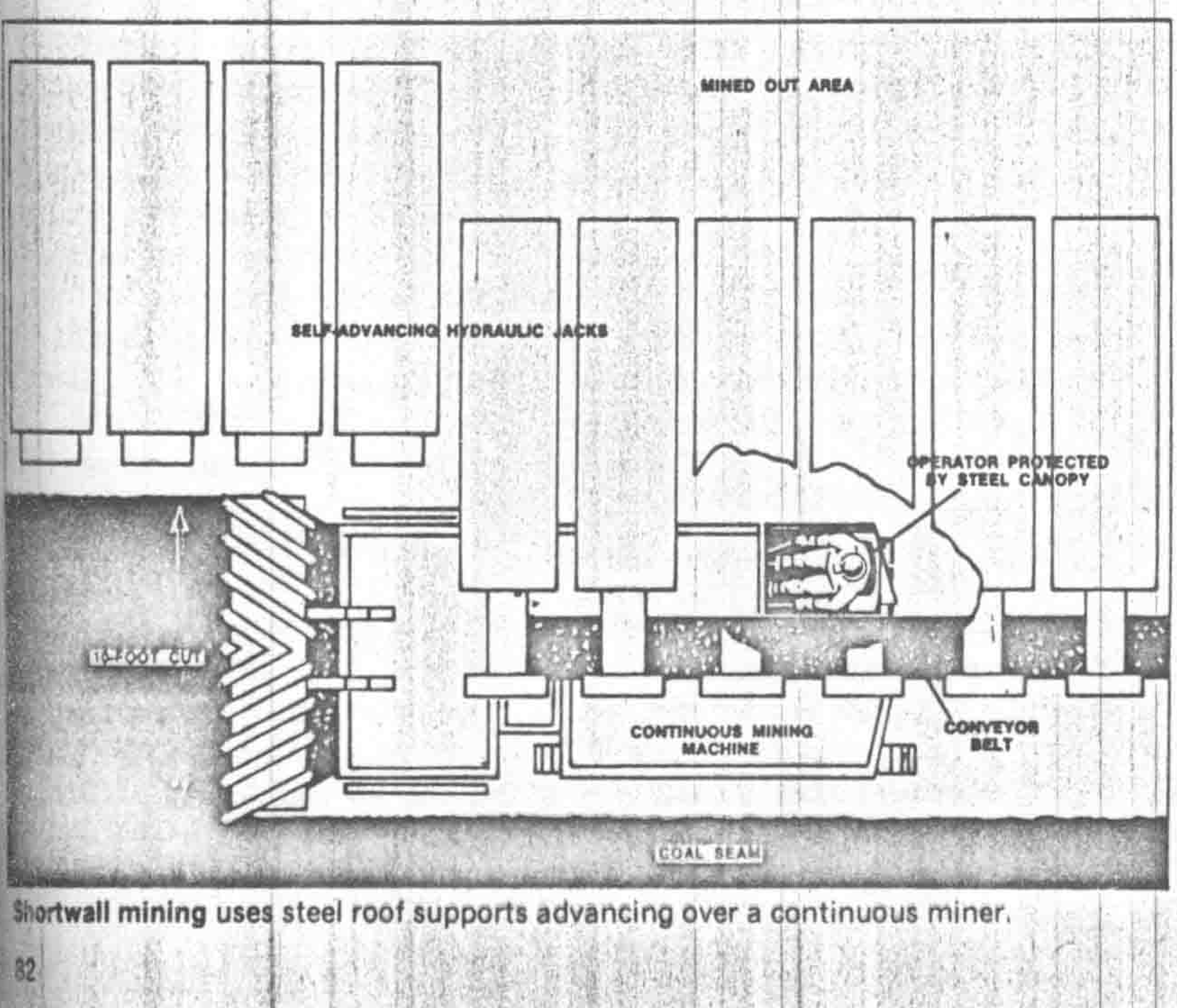
Shortwall mining, therefore, combines the advantages of the longwall and continuous mining methods. The most obvious ones are that there is increased recovery of coal (almost all the coal is recovered from a section, leaving few pillars), miners work continuously under full support, and the training period for crew members is shorter than with longwall because fewer pieces of new equipment are involved. Fewer new equipment means less initial investment for switching from one mining method to another. This could be a big plus for smaller companies.

But how well is shortwall mining doing? A survey was made by the author under a Bureau of Mines grant of all the mines in this country using the shortwall concept. Purpose of the survey was to find out the most suitable conditions for conducting a shortwall operation. Since shortwall mining involves the effective control of roof strata, the survey emphasizes the roof control aspects of the operations.

Operational parameters for all of the five mines using shortwall mining methods are listed in Table 1. Although the particular mines are not identified, the mining companies involved are Valley Camp Coal Co., Delta Mining Co., Eastern Associated Coal Corp., US Steel Corp., and Bethlehem Steel Corp.

Generally speaking, retreat shortwall is employed in all five cases. This involves driving three entries on both sides of the shortwall panel which ranges from 110 to 200 ft in width and 800 to 2400 ft in length. Coal seams mined are at least 4 ft thick and up to a maximum of 9 ft thick. The overburden thickness varies widely from mine to mine and ranges from 90 to 1200 ft. The cutting widths of continuous miners range between 6 to 10 ft.

The following is a more specific description of each mine:



Shortwall mining uses steel roof supports advancing over a continuous miner.

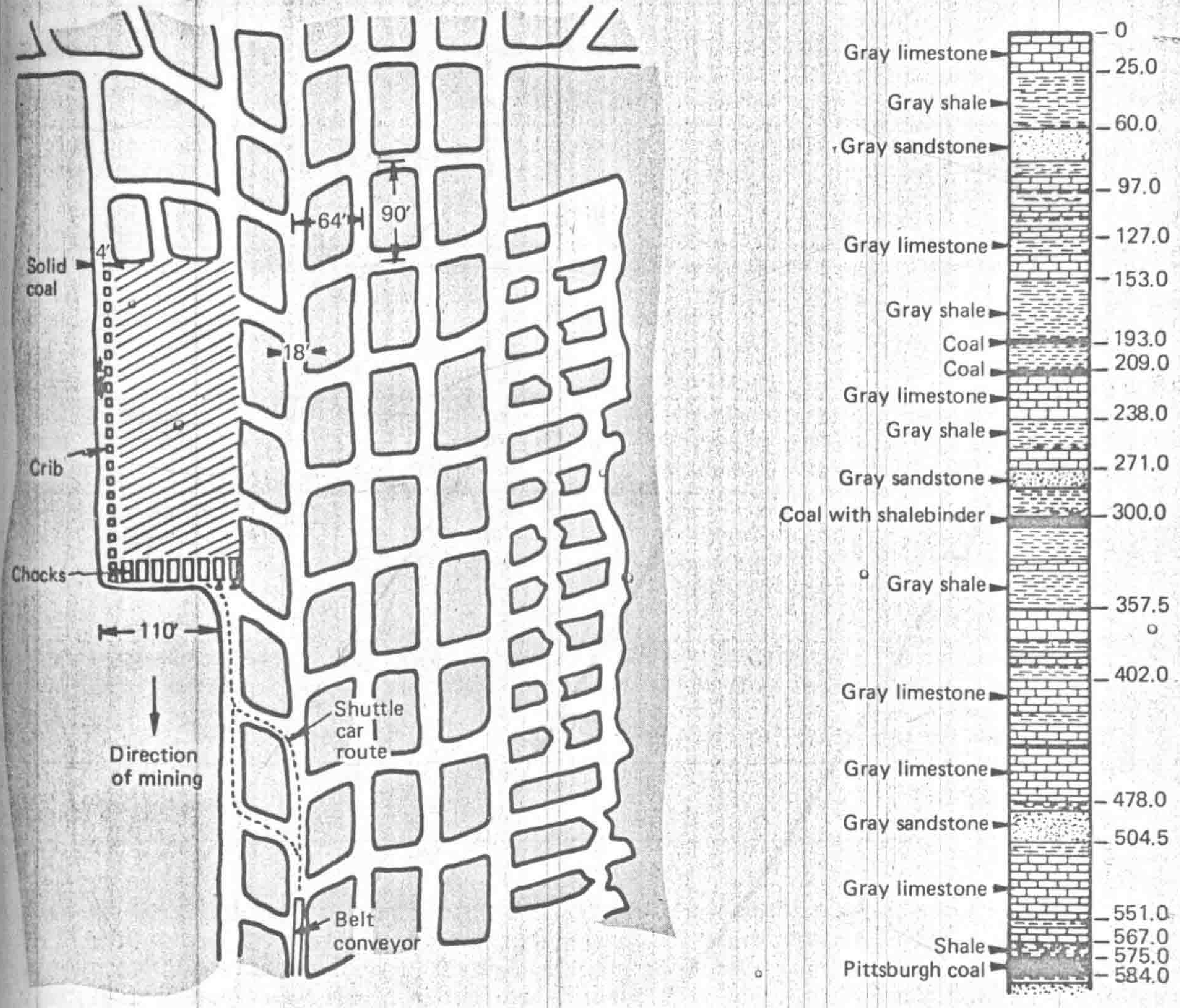
Mine No. 1

Complete layout and the stratigraphic column of the 3 Rt panel is shown in Fig. 1. The immediate roof is a weak limey shale overlain by strong limestone. Notice that the 4-ft-wide tail entry is not predeveloped. It is formed as the face retreats by cribbing.

Roof support

Face: The mine is using Gullick

Fig. 1 Face Layout and Stratigraphic Column for Mine # 1



four-leg, 500-ton chocks (see Table 2 for chock specification). There are 27 pieces spaced at 4-ft centers, which requires two laps of advancement per cut at 4 ft each. This leaves approximately 2 ft without roof support between the tip of the extension canopy and the face line. The roof caves immediately behind the chocks. However, at the beginning of the panel, roof remains at a 150- to 200-ft span before the first cave-in is initiated.

Head entry: Roof bolting is at 4-ft centers with 8- and 10-ft lengths so that the bolts anchor at different horizons. During mining, the entry roof is reinforced by additional bolting with wooden planks inserted across the entry between bolt heads and roofs. This reinforced area is always kept at 1½ pillar lengths ahead of the face.

Tail entry: No tail entry is predeveloped. The advancing tail entry is established by setting cribs (4 x 4-ft size) at 4-ft centers leaving an entry width of 4 ft. Generally two cribs are made for each cut. This entry was kept open throughout the whole working length of the panel.

Special remarks

• Some difficulty was encountered to cut and maintain a smooth floor to facilitate the advancement of chock moves.

• Different sizes of "white rock" tend to fall on top of the chocks, which requires cribbing on top of canopy. White rock is very tough to break.

• There are clay veins running obliquely through the coal seam. These fall off immediately after the coal is cut out, which creates a "hole" in the roof that adds to support problems.

• Roof shale is fairly well slickensided; it requires strong immediate support especially at the T-junction.

Mine No. 2

The first panel layout and the stratigraphic column of the roof is shown in Fig. 1. The immediate roof is the weak, thinly laminated and highly slickensided dark shale, extending all the way up to the No. 5 seam. Pillar sizes are different for tail and head entries. In the

Table 1—Operational shortwall coal mines in the United States

Mines and locations	Seam	Over-burden (ft)	Panel dimension (ft)	Continuous miner	Cutting width (ft)	Coal handling	Face cleanup	Crew No.	Average production (tons per shift)
Mine #1 W. Va.	Pittsburgh 8'-9' thick	300-600	110 x 2200	Lee-Norse 35Y	9½	Miner ⟶ Loader ⟶ Shuttle cars ⟶ Entry belt conveyor	Loader continuously cleans up loose coal on the floor	7	300 (400)*
Mine #2 W. Va.	Pocahontas #4 6'-9' thick	200-300	200 x 1000	Lee-Norse 47	8½	Miner ⟶ Surge car ⟶ Entry belt conveyor	Loose coal is pushed up against the solid coal face by dozer blades	6	(1000)*
Mine #3 W. Va.	Pittsburgh 7'-8' thick	760-900	150 x 2000	Jeffrey 120M Heliminer	6	Miner ⟶ Loader ⟶ Shuttle car—Sliding monorail ⟶ Entry belt conveyor	Loader continuously cleans up loose coal	10	400 (900)*
Mine #4 Pa.	Lower Kittanning B 6'-7' thick	83-220	180 x 800	Lee-Norse 106 Hardhead	10	Miner ⟶ Surge cars ⟶ Mobile belt conveyor ⟶ Entry belt conveyor	At the end of each cut, the miner is backed out to clean up loose coal	9	(500)*
Mine #5 Ky.	Elkhorn #3 4'-5' thick	150-800	150 x 2400	Joy 11 CM	10	Miner ⟶ Shuttle cars ⟶ Entry belt conveyor	At the end of each cut, a scoop is used to clean up loose coal	10	560 (900)*

* Maximum production

head entries, pillars are staggered to form three-way intersection to reduce roof fall. Notice head entries are on the left-hand side of the panel. The operator's operating position of the continuous miner has been changed from the right-hand to the left-hand side of the miner.

Roof support

Face: The mine is using Hemscheidt four-leg, 600-ton chocks (see Table 2 for chock specification), spaced at 4-ft centers. This requires three laps of advance at 2½ ft for each cut. The roof shale caves immediately behind chocks as mining progresses from the start of the panel.

Head entry: Two types of resin bolting are used during development: 6-ft point-anchored bolts (anchored length is 2 ft) spaced at 4-ft centers across the entry, and 4-ft bolts, also spaced at 4-ft centers across the entry. These two rows of bolts are alternatively bolted along the length of entry at 2½-ft centers. During mining, roof bolts are bolted obliquely into the roof above the coal along the ribs at various spacing, but they are always kept 20 to 30 ft ahead of the mining face. A steel band, 2 in. wide x 0.040 in. thick is then tightened at 8000 lb between the adjacent bolts.

Tail entry: Same technique is employed as in the head entry during development. But 20 hydraulic props of 50-ton capacity are erected at or near the T-junction. In addition, cribs are set at 6-ft centers along the centerline of the entry.

Special remarks

The roof shale is thinly laminated and highly slickensided, and extends all the way up to 40 ft thick. It is therefore very weak and forms small pieces when breaking. The T-junctions are the most difficult places to maintain, since roof falls occur there often. The rear boom of the continuous miner has been shortened to 8 ft so that the radius of the cutting curvature from head entry into the face and the width of the entry could be made smaller. This preventive measure, plus rib roof banding, seems to control the roof effectively. However, roof falls occur frequently at the intersection of entry and crosscut, and the height of the fall often reaches the slate formation above Pocahontas No. 5 seam.

Mine No. 3

Notice in the partial layout of the shortwall section (Fig. 3) the frequent encounter of oil wells and the large size of the pillars left behind for protection.

Roof support

Face: The system employs Westfalia six-leg, frame-type, self-advancing supports (see Table 2 for chock specification), with 720-ton capacity and spaced at 8½-ft centers. There is a total of 24 pieces. For every cut by the continuous miner, forward movement of the supports is completed in three steps: two steps of 39½ in. each are made after passing of the continuous miner, and the third forward step is performed when the miner pulls out. The roof caves in right behind the support. When the panel first starts, the roof is sustained about 40 ft before cave-in begins. Gullick chocks are being used for the new panel. Its operation is similar to Mine No. 1.

Head entry: The system is employing roof bolts 6 ft long spaced at 5-ft centers during both development and retreating mining.

Tail entry: The roof bolting pattern is the same as for the head entry. Five-foot cribbings at 8-ft centers are set up along the centerline of the entry.

Special remarks

The mining management likes the system because it is very flexible, especially where active gas wells are located within the panel. The law requires that around the gas well a 250-ft square block of coal be left untouched. The shortwall method can cope with this situation very well.

One problem with the system is keeping the supports advancing along a straight line. Because the system does not have any guiding device, the supports at times tend to run into each other, which can cause some maintenance and lost-time problems.

The tail entry shows considerable closure both from roof and floor, even with the intensive cribbing system. The closure is considerable, and the possibility of losing the support at the T-junction made the company try a new support system at this junction. It calls for the removal of one self-advancing support, while leaving behind an 8 x 10-ft pillar every other cut.

Mine No. 4

Layout of a typical shortwall panel is shown in Fig. 4.

Roof support

Face: The mine is using 39 Hemscheidt 600-ton chocks with setting pressure at 5000 psi. The chocks are placed at 51¼-in. centers (see Table 2 for the essential characteristics of the chocks). There is a 2½-ft roof unsupported

Fig. 2 Face Layout and Stratigraphic Column for Mine # 2

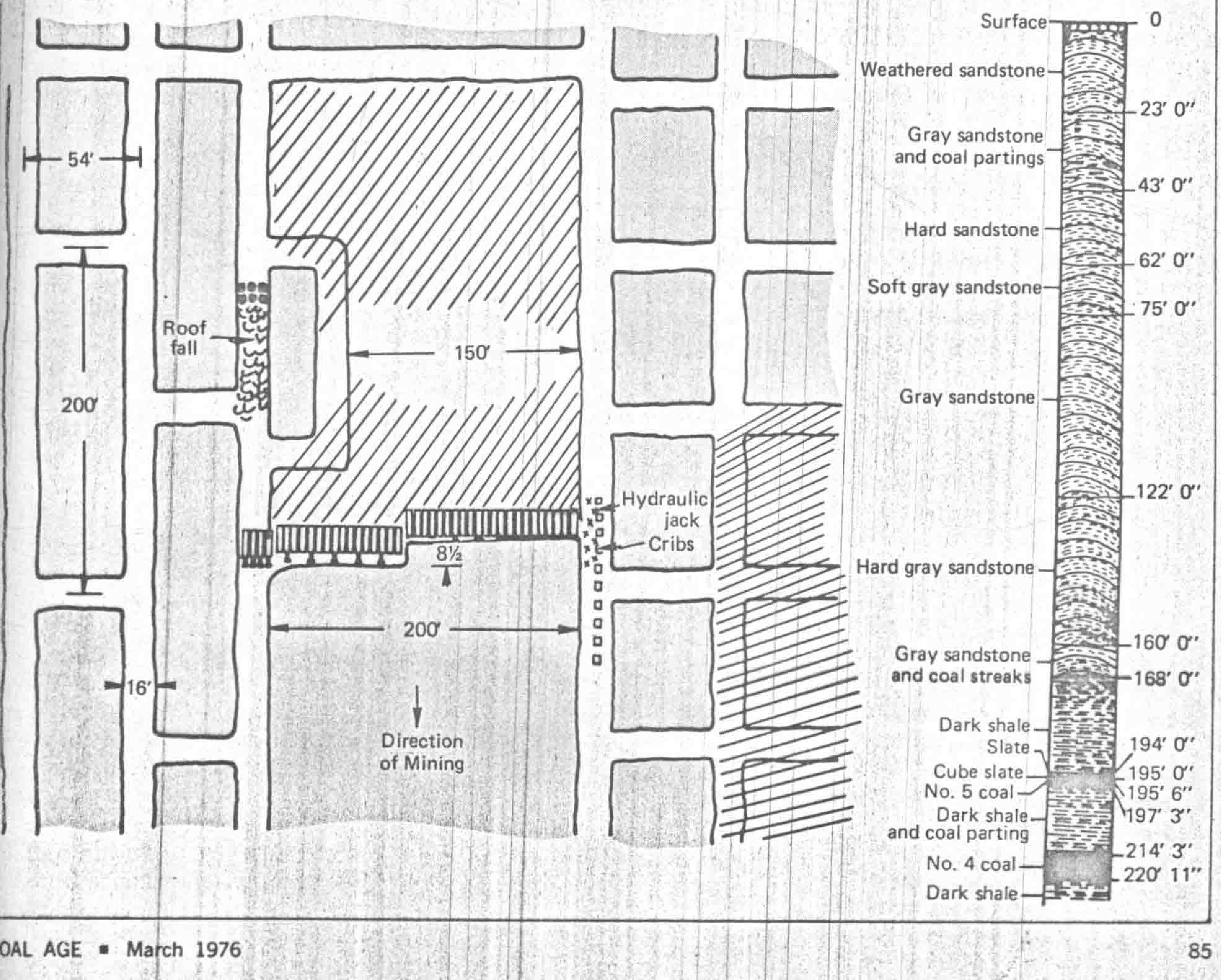


Table 2—Characteristics of shortwall chocks

Mine	Man	Type	Capacity (tons)	Height (in.)	Length[1] (in.)	Width (in.)	No. of chocks	Chock spacing (in.)	Extensible canopy Length (in.)	Extensible canopy Tip Load[2] (tons)	Load density[3] Tons per sq. ft.
Mine #1 W. Va.	Gullick	4 legs Chocks	500	41½-59½	164½	42	27	48	48	4.3	9.11
Mine #2 W. Va.	Hemscheidt	4 legs Chocks	600	67-114	220	55.2	39	60	83.5	8.0	6.55
Mine #3	Westfalia	6 legs Frame support	720	62-164	175	81	24	102	39⅜		5.80
W. Va.	Gullick	4 legs Chocks	800	48-84	208	42	42	57	39	4.03	9.72
Mine #4 Pa.	Hemscheidt	4 legs Chocks	700	66-88	227	41¾	42	51½	83.5	8.0	7.39
Mine #5 Ky.	Gullick	4 legs Chocks	500	41½-59½	164½	42	42	48.5	48	4.3	9.19

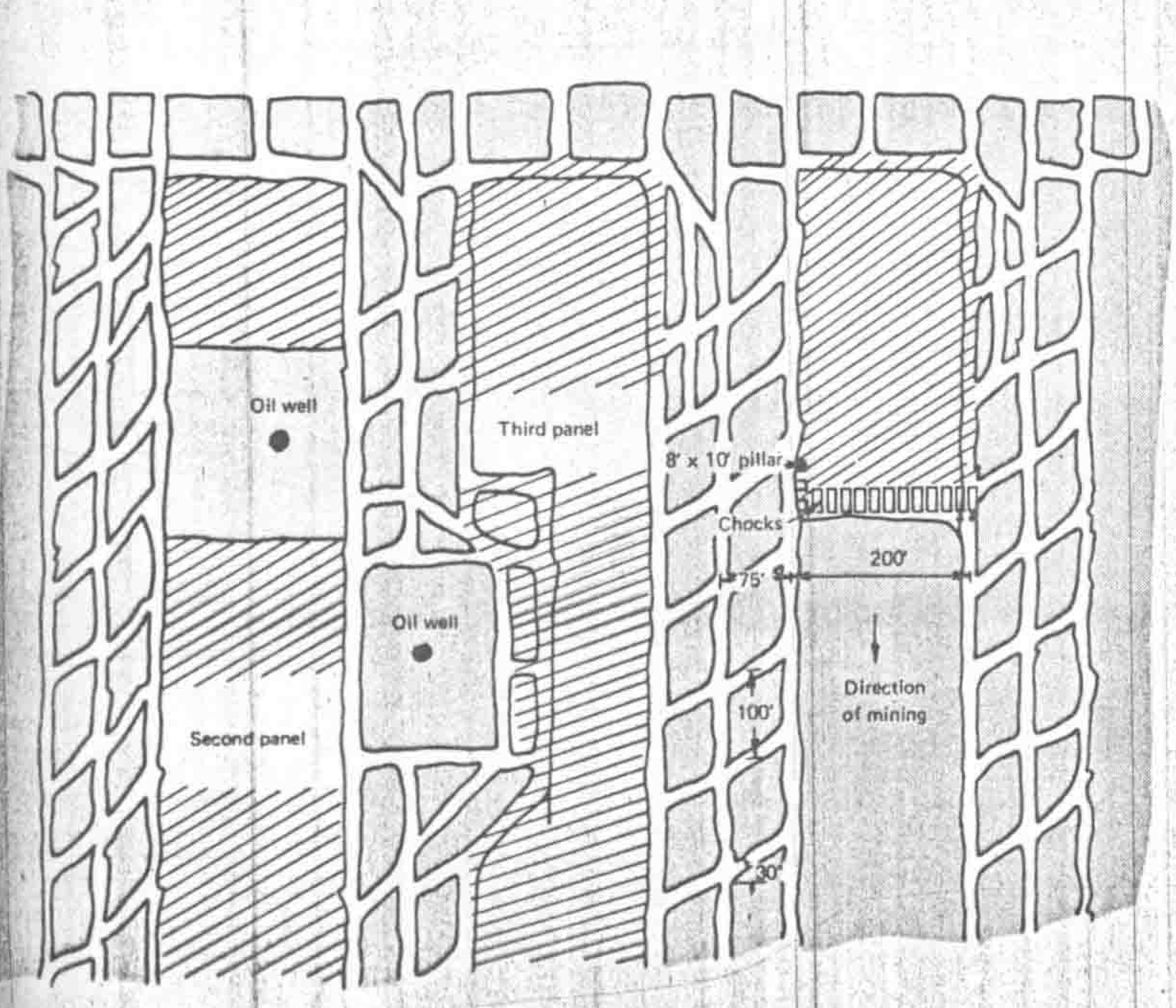
[1] Length of canopy including extensible canopy in fully extended position. [2] Tip yield load at fully extended position. [3] Rated yield load density.

between end of front canopy and face line.

Headgate: During the development, the roof is bolted with 4- to 5-ft bolts, spaced at 4-ft centers. During mining, two rows of temporary hydraulic jacks are set at 4-ft centers in an area of 30 ft, advance of the face line.

Tailgate: Support is the same as for the headgate during development. During mining, wooden posts are set at 4-ft centers in an area of 30 ft ahead of face line.

Fig. 3 Face Layout for Mine #3



Special remarks

• The mobile belt conveyors have been breaking down too often, which accounts for most of the lost time.

• Sand rock in the roof falls off as soon as coal is mined. This requires cribbing on top of chock canopy.

• When the seam bottom of the coal encounters some curvature, the neighboring chocks tend to squeeze each other and bend up the chock legs.

Mine No. 5

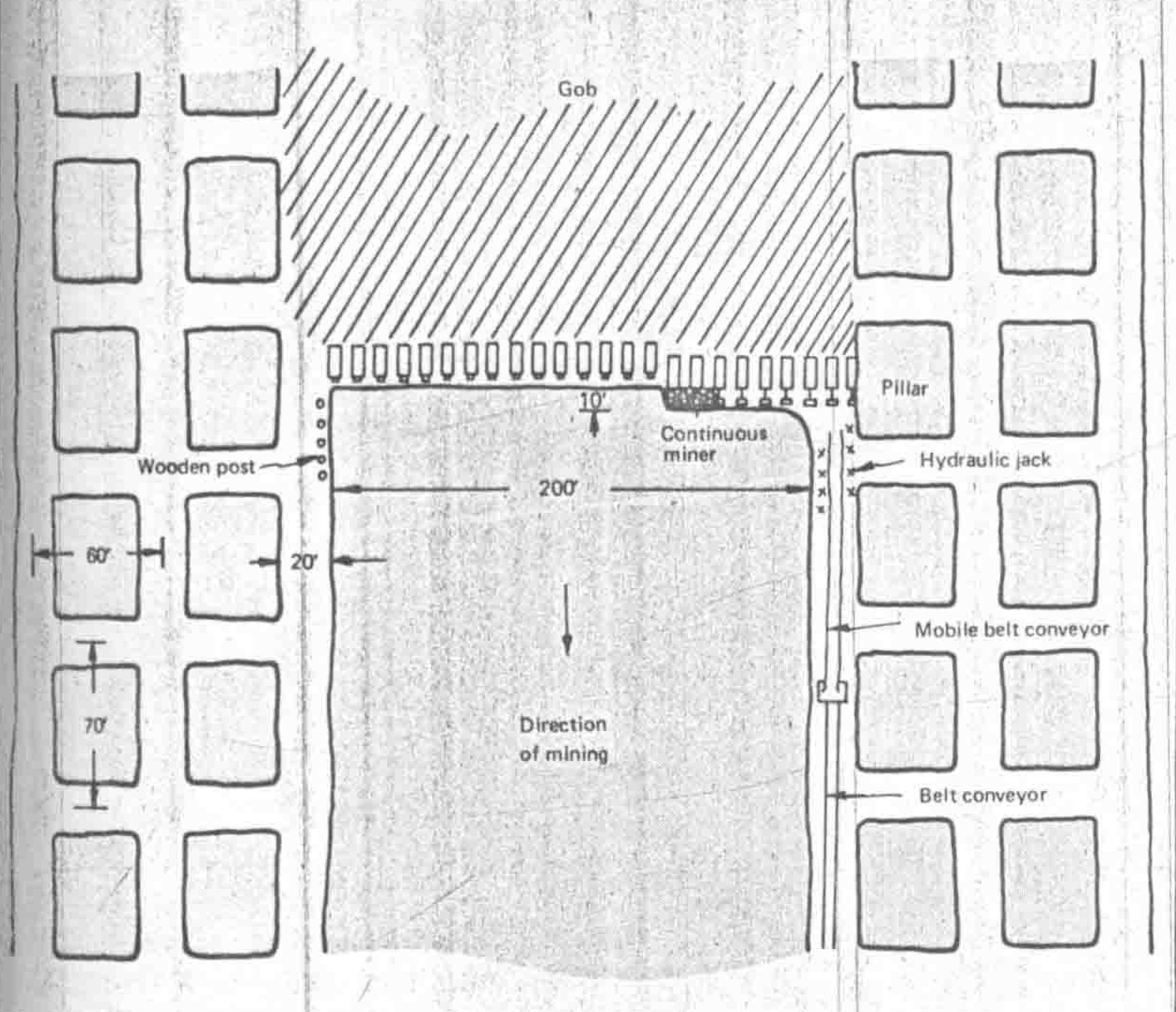
The immediate roof is the firm black slate overlain by strong dark sandy shale (see Fig. 5).

Roof support

Face: The system uses 42 Gullick chocks along the face (see Table 2 for chock specification). Operational procedures are similar to those used in Mine No. 1.

Head entry: During development, 6-ft bolts are used, spaced at 4-ft centers. A couple of 20-ton single props protect the T-junction at the head entry during mining. The unprotected distance from the turn at the start of the shortwall

Fig. 4 Face Layout for Mine #4



face to the opposite corner runs approximately 30 ft.

Tail entry: The bolting pattern is similar to the head entry during development. During mining, two cribs are installed in the mouth of break.

Special remarks

The shortwall methods in this mine work remarkably well because the geological conditions are ideal. Average production output for the first panel is 412 tons per shift, the second panel is 515 tons per shift, and the current third panel is approximately 600 tons per shift.

Summary

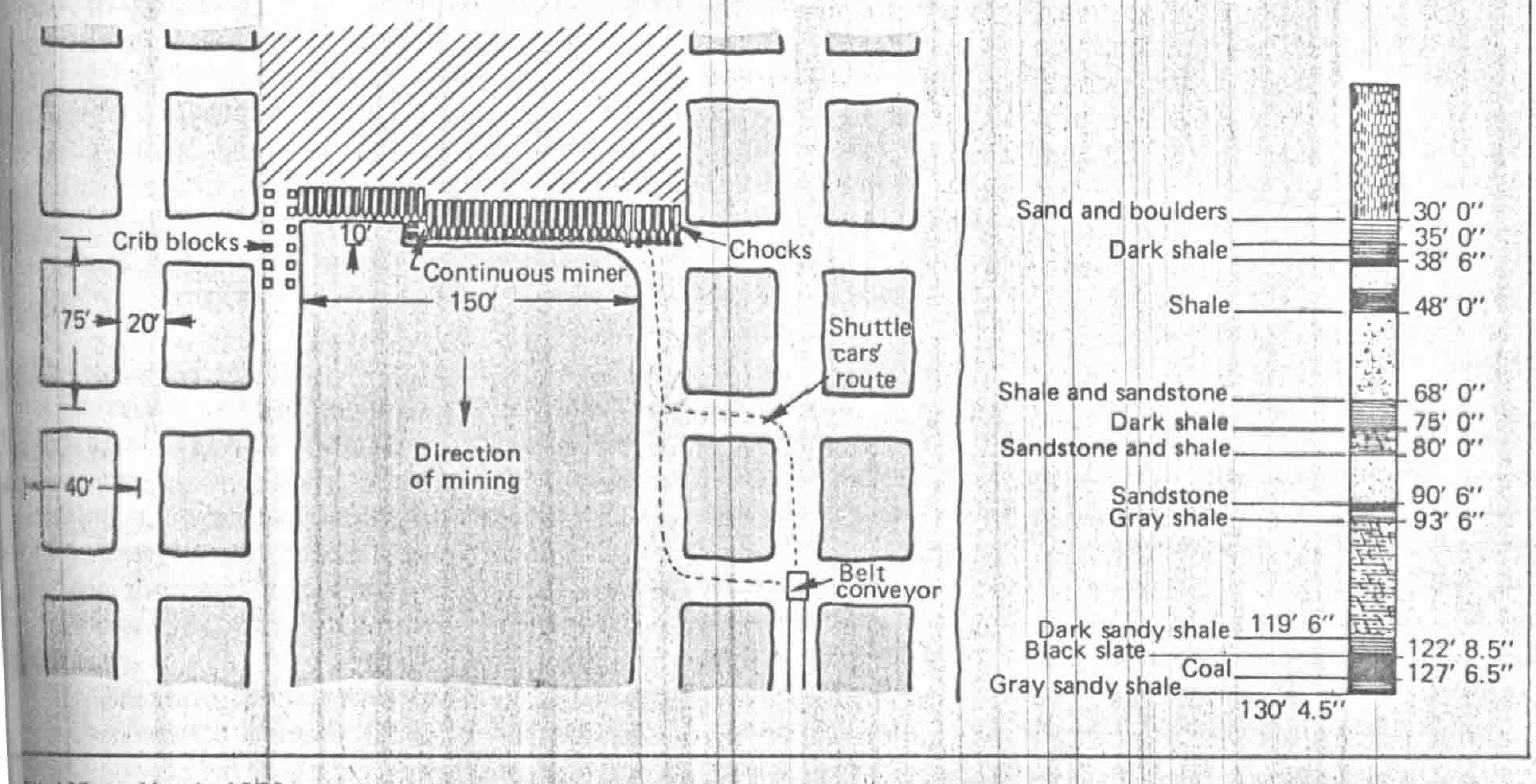
Among the five mines visited, four have concluded that the shortwall method is working out very well, and they intend to operate the system continuously. Operation at the other mine is still too early for definite conclusions.

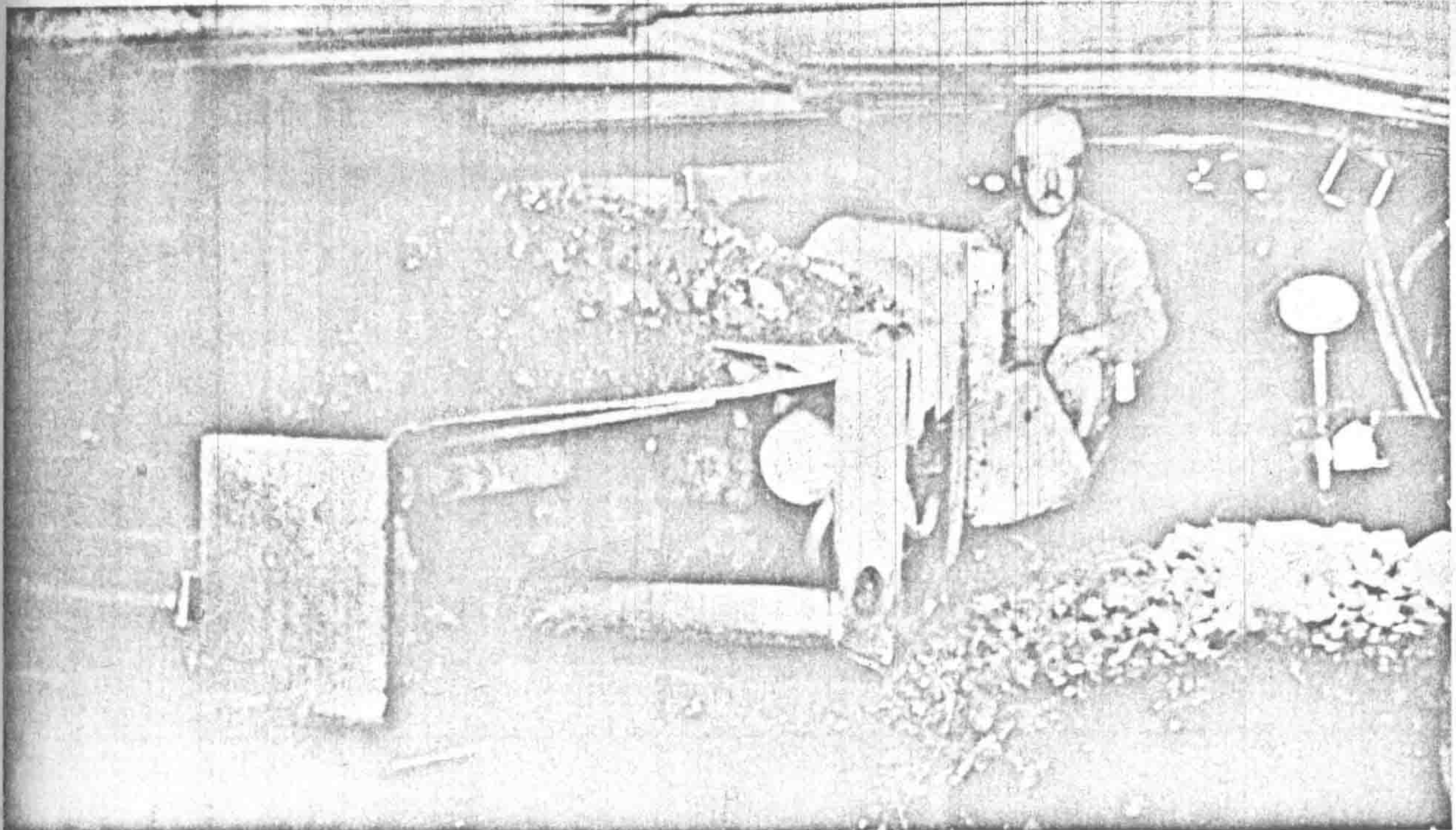
The most often cited advantages for shortwall mining over the continuous mining are higher recovery, higher clean-coal production, safer working conditions, less dust, and positive ventilation. Furthermore, in comparison with longwall, shortwall is highly flexible. Its face length can be changed instantaneously to suit local conditions in the panel. The initial capital is less for switching from continuous to shortwall than the longwall. And because fewer pieces of new equipment are involved, long training periods for the crew members are not required.

Because shortwalling is an adaptation of the longwall method, many of the problems encountered in shortwall mining resemble those in longwall. These are:

1. Starting with the second or third panel, high side-abutment pressure usually develops over the tail entry especially when there is a stronger layer formation overlying the immediate roof. This condition could cause considerable entry convergence, both from floor and

Fig. 5 Face Layout and Stratigraphic Column for Mine #5





Shuttle car operator works in safety under canopy of shields while hauling out coal at Beth-Elkhorn's Hendrix No. 22 mine, near Jenkins, Ky. Seam is 54 in. thick.

from the roof, especially at the tail-entry T-junction, that will greatly hinder the continuity of mining operation. In this respect, the shortwall system employed by Mine No. 3 is more flexible than the other arrangements.

2. The frequent advance of the face supports could cause the operation to deviate from a straight line, especially if the chockmen do not maintain constant alertness or when curved floor is encountered.

3. Premature breakage of the roof, or a local geological anomaly on top of or between the face line and the tip of chock canopy, could cause considerable delay in production time because the current method to cope with this problem is cribbing on the top side of the chock canopy, which is a time-consuming operation.

Some other problems pertaining to shortwall itself are:

1. The large curvature required for continuous miners to start a new cut at the head entry creates an excessively large roof span and greatly increases the potential of roof break at the head-entry T-junction.

2. The wide cutting web by continuous miners is to be supported by an extensible canopy specially designed for shortwall chocks. However, the extensible canopy of 4- to 6-ft length maintains only point contact with the roof at the tip. For a weak and friable roof, the point support is definitely not sufficient. Furthermore, the full tip supporting load will not be realized until after certain roof subsidence occurs due to the "softness" of hydraulic fluid in the system. The roof subsidence could be very small, but in the case of weak, friable roof, it could be enough to cause premature breakage.

Shortwall mining is operated under a wide range of overburden height, from 83 to 900 ft. Hence, one would tend to believe that the severity and number of roof-control problems are directly proportional to the height of overburden. This was not borne out by the current operational experiences. Instead, it appears that the characteristics (thickness, stiffness and geological features) of immediate roof play a key role in roof stability.

For example, in Mine No. 2 where the overburden is between 200 and 300 ft high, virgin ground pressure is not expected to be large enough to cause problems. Yet severe roof fall occurs frequently due to the existence of thinly laminated, highly slickensided dark shale as immediate roof.

In addition to recovering an increased percentage of the coal seam, the advancing tail entry system can reduce considerably the time for developing a panel. However, if the tail entry is to be used for escapeway, stronger and well-designed roof support systems are needed.

In mines where no roof problem occurs, the degree of high productivity will depend on the degree of continuity of coal transportation out of the face to entry belt conveyor and to a lesser degree on the ability to maintain face area clear of loose coal.

In spite of such problems, shortwall mining does have distinctive advantages over the continuous mining method under favorable conditions. It could produce considerably higher tonnage, improves health and safety records and obtains good recovery of coal reserves. The ideal conditions are a hard but flat floor, a seam height of at least 54 in., and an immediate roof not too weak nor too strong but one that will cave in right behind the supports. ■