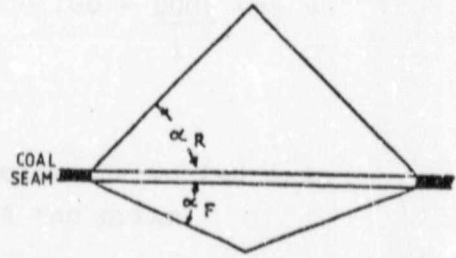


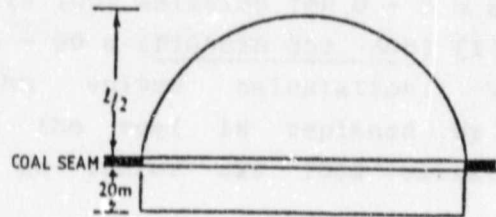
a) FLÜGGE, Triangular prisms

	A	B	C
α_R	50 gon	60 gon	65 gon
α_F	25 gon	25 gon	25 gon

- A No drainage
B Medium drainage
C Intensive drainage



b) SCHULTZ, Semicylinder



c) WINTER, Rectangular prism

$$A_R = 100 \exp(-\mu(h-20))$$

$$A_F = 100 \exp(\mu(h+8))$$

	A	B	C
μ_R	0.016	0.014	0.012
μ_F	0.070	0.030	0.030

- A Strong strata
B Medium strength strata
C Weak strata

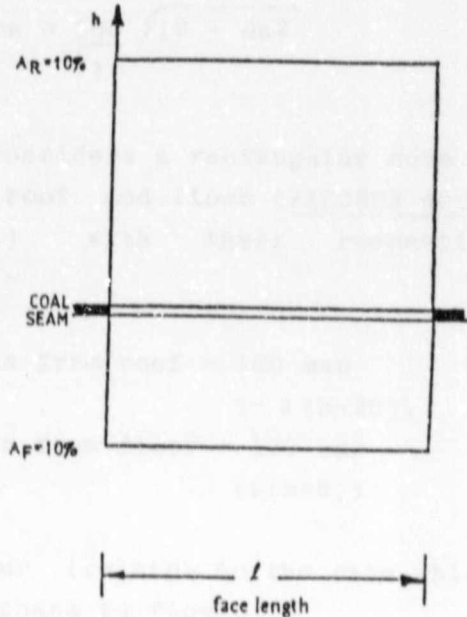


FIGURE 40 The zones of gas emission used in the FRG, shown as vertical sections through the longwall face (14).

$$\% \text{ degree of emission} = 100 \cdot \frac{200h \cot \alpha}{l}$$

l - face length

h - distance above/below the worked seam

α - internal angle of the prism

- ii) Employing rock mechanics vault theory, Schulz considers 100% emission from a semi-cylinder superimposed on workings, and a rectangular zone in the floor with 100% emission for 0 - 5 m and 100% - 0% from 5 - 20 m (FIGURES 35e, 40b) (14). To simplify the volume calculation, the semi-cylinder in the roof is replaced by a rectangle which no longer has 100% emission but:-

$$\% \text{ degree of emission} = \frac{100}{l} \sqrt{12 - 4h^2}$$

- iii) Winter's method considers a rectangular zone of emission in the roof and floor (FIGURES 40c, 35f) (14, 140, 141) with their respective emissions given by:-

$$\% \text{ degree of emission from roof} = 100 \exp(-\mu(h-20))$$

$$\% \text{ degree of emission from floor} = 100 \exp(\mu(h+8))$$

μ - weakness number (relates to the ease which fractures permit methane to flow).

The limits of this emission zone are defined by a minimum degree of emission of 10% (In FDR this is considered to be 164-212 m in the roof and 41-85 m in the floor).

- iv) Koppe has devised a graphical method for emissions from the floor (FIGURES 35g, 41, 42) (14, 117).

$$\% \text{ degree of emission from floor} = 131,6 + 3,84h + 0,024h^2 + 0,15(100 - y)^2$$

h - vertical (not perpendicular) distance from seam worked (-ve sign because below in the floor).

$$y = \left(\frac{\text{distance from centre line of the face}}{\text{face length}/2} \right) \times 100\%$$

This now supersedes methods (i), (ii) and (iii) for emission in the floor.

The extent of the emission zones has been revised by Noack as 130 m above and 50 m below workings with a lateral limit of 30 m beside and ahead of workings (FIGURES 15, 16). In the FDR coal is found to have a residual gas content of 30% - 70% of the original methane content when it leaves the district (FIGURE 43). The slower the desorbition rate, the greater this amount of residual gas. 50% is assumed if the desorbition rate is unknown.

If old workings intercept the zone of emission of new workings predictions are made for:-

- i) the previously worked seam
- ii) present workings allowing for the degree of predrainage caused by the old workings.

Non-coal strata are considered as having 1 - 10% of the methane content of coal, 4% overall generally giving

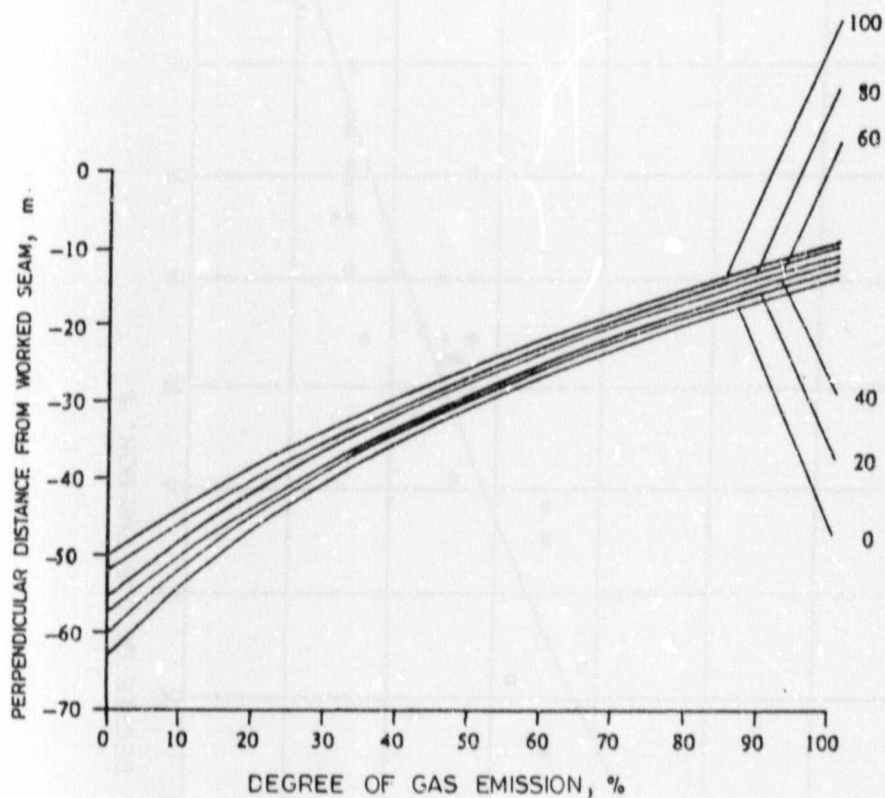


FIGURE 41 Koppe's curves for the degree of gas emission in floor strata (117).

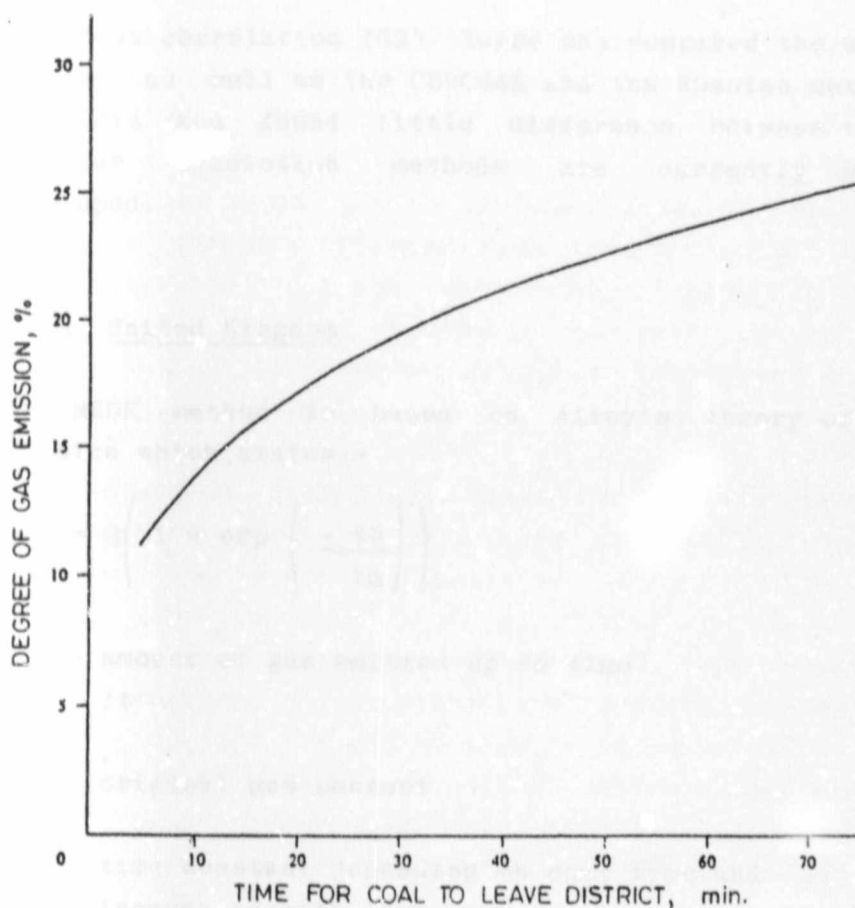


FIGURE 43 An example curve for the degassing from a bintuminous coal during conveyor clearance (14).

the best correlation (62). Koppe has compared the above methods as well as the CERCHAR and the Russian methods of Lidin and found little difference between them. Computer prediction methods are currently being developed.

2.7.4 United Kingdom

The MRDE method is based on Airey's theory of gas emission which states:-

$$Q_t = Q \left(1 - \exp \left(- \frac{t^n}{t_m} \right) \right)$$

Q_t - amount of gas emitted up to time
't'

Q - original gas content

t_m - time constant depending on coal type and
increasing with lump size.

n - an index depending on the uniformity of
structure of coal (= 0,33 for bituminous
coal, = 0,5 for anthracite).

A time factor incorporates the age of the worked district and the rate of advance. The MRDE model considers emissions from the worked seam and adjacent strata ahead of the face to enter the ventilation system. Factors considered are:

- i) Emission of the worked seam as a decreasing function of advance rate (FIGURE 36).

- ii) Emission from over and underlying seams (FIGURE 37a) together with a depth correction factor (FIGURE 37b). A major proportion of gas make in the UK comes from adjacent seams. If any of these seams are to be mined later, the decrease in emission because these have become partially degassed, can be determined. FIGURE 37b shows that emission increases as the age of the district increases. Emission from other strata can be incorporated.
- iii) Emission from broken coal during clearance. This is dependent on how long the broken coal is exposed to ventilating air.
- iv) Methane drainage. If methane drainage is practiced, a factor is applied whereby a percentage of gas emitted by adjacent strata, is also considered to enter the drainage system. (Using FIGURE 37b the difference in emission between the zero age curve and the curve for the actual age of workings, gives the predicted flow into the drainage system).
- v) The variation in emission over a weekly cycle. Emission builds up to a maximum on Thursday/Friday and falls over a non working weekend. A factor for each day of the week is used and considers each day as having the same production rate calculated by:-

$$\text{Daily production} = \frac{\text{total weekly production}}{7 \text{ days}}$$

$$\text{Emission for day 'n'} = \text{factor } (f_n) \times \text{daily production}$$

For ventilation requirements the irregularity or peak factor (FIGURE 39) is also used in the UK.

2.7.5 Poland

Two methods are used:-

- 1) Barbara mine method. Four categories of coal seams are classified according to methane content or gas emission (TABLE 10). In Poland emission appears to be related to the area of coal exposed and not production or advance rate. In-situ gas content, multiplied by a factor of gas emission per unit area of face ($\text{m}^3/\text{m}/\text{min}$) is used. Emission from the walls decreases with time so emission from roadways which have been developed well in advance, is considered to be negligible.

The degree of gas emission (FIGURE 35j) is given by:-

% degree of emission from roof $AR = 64.7 \exp(-0.03957 h/t)$

% degree of emission from floor $AF = 54.1 \exp(-0.03721 h/t)$

h - distance from the worked seam

t - thickness of the worked seam

No adjacent strata other than coal is included in this method. 80% of the remnant gas still existing in cut coal is estimated to enter the ventilation.

Category of methane hazard	Methane content of worked seam m^3/t	Specific measured methane emission in a development heading, m^3/t
Non-gassy seam	less than 0.02	—
I	0.02 to 2.50	less than 5
II	2.50 to 4.50	5 to 10
III	4.50 to 8.00	10 to 15
IV	more than 8.00	more than 15

Table 10 The classification of coal seams used in Poland (12)

To calculate ventilation requirements the irregularity or peak factor is employed. This is 1,65 for development roadways and 4,6 for longwall gate roadways.

- ii) Ajruni method. This method is based on gas pressure. The virgin pressure is proportional to depth. The residual pressure after mining operations is shown in FIGURE 44. The virgin and residual pressures for the worked seam and for adjacent seams are plotted (FIGURE 45). The emission for a seam is obtained by superimposing the change in pressure between the virgin and residual condition on the adsorption isotherm. The total emission is the sum of the emissions of the worked and adjacent seams.

2.7.6 United Soviet Socialist Republic (USSR)

The Lidin prediction method (14) only considers longwall mining and incorporates a coefficient for the mining method. Emission in Russian coals only correlates with the percentage volatiles. Three areas of emission are considered:-

- i) The working district. Methane make is the difference between the in-situ methane content and the residual gas content of coal leaving the district.
- ii) Development roadways. The emission from the freshly exposed coal surface ($\text{m}^3/\text{m} / \text{min}$) is a function of roadway dimension, coal seam thickness and advance rate. Gas emission from the broken coal in developments is also taken into account.

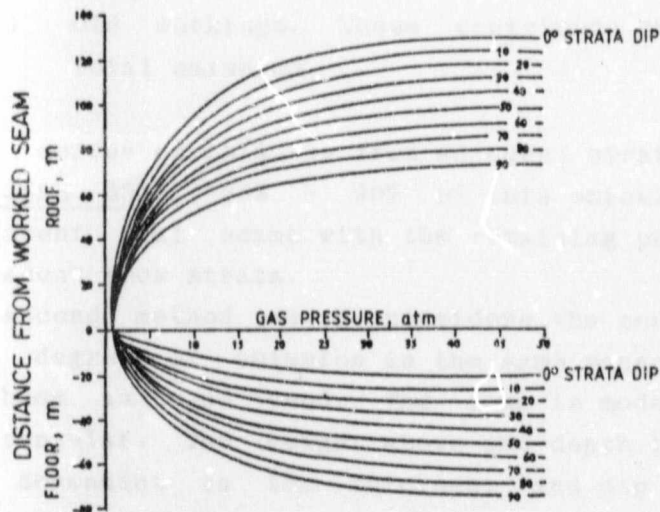


FIGURE 44

Curves for the residual methane pressure in adjacent coal seams as a function of strata dip (14), the ratio of distance from the worked seam to the extracted thickness is used in the roof strata.

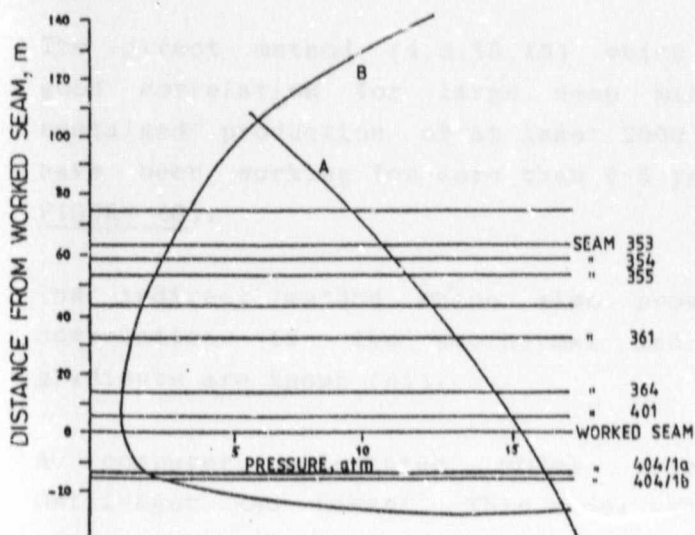


FIGURE 45

Example of the pressure difference prediction method (14)
 A - original in-situ methane pressure curve
 B - residual methane pressure curve after mining

- iii) Old workings. These contribute 5% - 20% of the total emission.

The degree of emission from adjacent strata is shown in (FIGURE 35h). 85% - 90% of this emission comes from adjacent coal seams with the remaining percentage from adjacent rock strata.

A second method which considers the zone of emission and degree of emission in the same manner as European methods is also used. The zone is modelled as being rectangular. The height above and depth below workings is dependent on the thickness and dip of the worked seam and whether caving or stowing is practiced.

2.7.7 United States of America (USA)

Four methods have been used. These are:-

- a) The direct method (4,5,16,18) which provides good correlation for large deep mines with a sustained production of at least 2000 t/d which have been working for more than 4-5 years. (See FIGURE 46).
- b) The indirect method which also provides good correlation if the geothermal and pressure gradients are known (41).
- c) A computer orientated model developed by Owili-Eger and Ramani. This model assumes that temperature changes underground which affect the gas flow rate, are small. It is not suitable for very deep mines where large temperature variations can occur. This program covers both steady and unsteady state conditions. The input requirements are:-

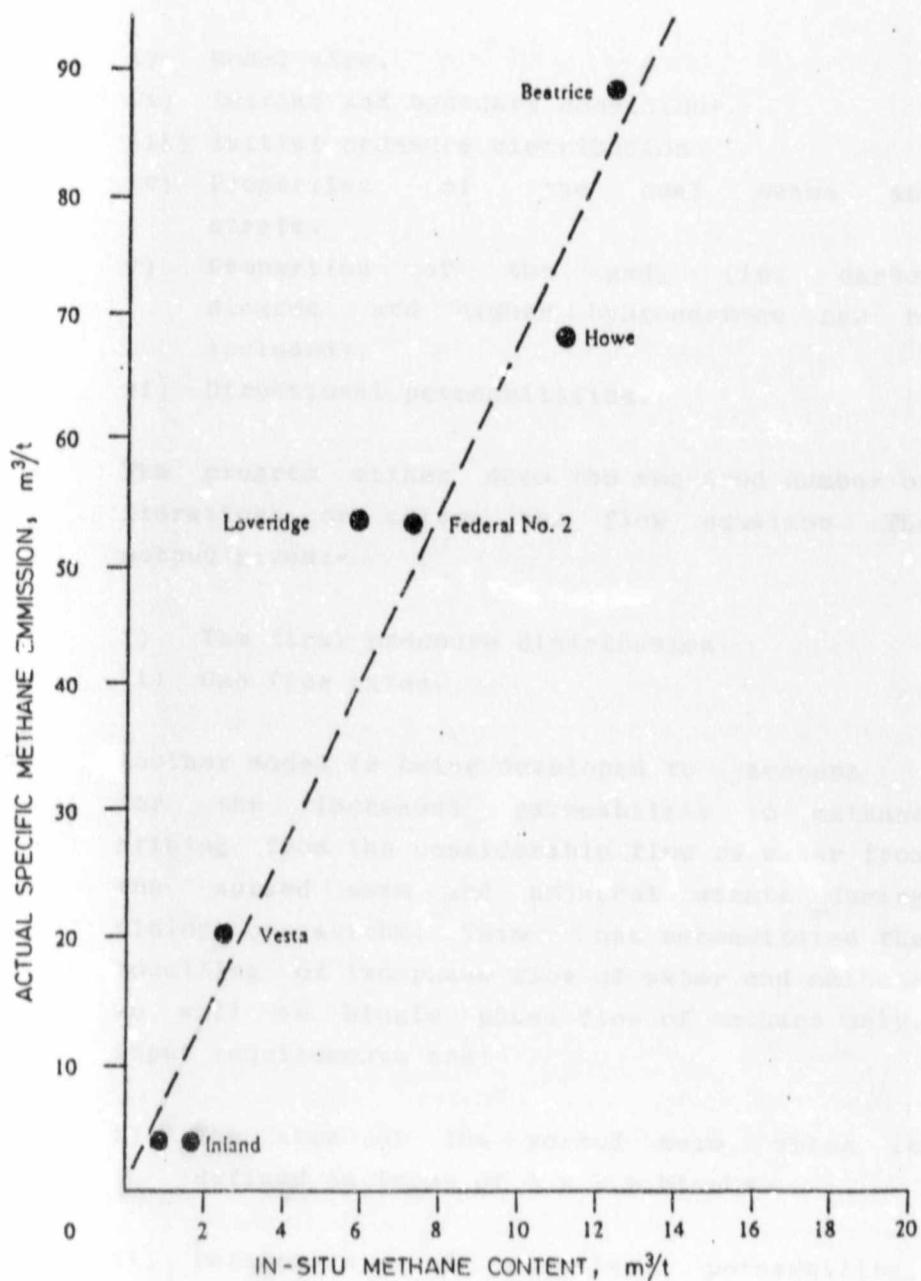


FIGURE 46 Comparison of the methane content obtained with the direct method and the actual methane emission in some US mines (45).

- i) Model size.
- ii) Initial and boundary conditions.
- iii) Initial pressure distribution.
- iv) Properties of the coal seams and strata.
- v) Properties of the gas, (ie. carbon dioxide and higher hydrocarbons can be included).
- vi) Directional permeabilities.

The program either does the required number of iterations or solves the flow equation. The output gives:-

- i) The final pressure distribution.
- ii) Gas flow rates.

d) Another model is being developed to account for the increased permeability to methane arising from the considerable flow of water from the worked seam and adjacent strata during mining operations. This has necessitated the modelling of two-phase flow of water and methane as well as single phase flow of methane only. Input requirements are:-

- i) The area of the worked seam, which is defined in terms of 3 x 3 m blocks.
- ii) Parameters of porosity, permeability, thickness and elevation for each block.
- iii) The coal seam which is defined by final boundaries.
- iv) The workings which are defined by moving boundaries.

The model then simulates the coal desorbing and the methane exhibiting laminar flow in the fissures according to Darcy's Law. The outputs are:-

- i) Methane concentration gradients.
 - ii) Pressure distribution in the worked seam.
 - iii) The flow of methane and water with respect to time.
- e) The latest computer model developed by the USBM is called METHPRO (42). It can be used on a microcomputer and consists of:-

- i) A knowledge base. It contains facts on methane content, ventilation and production. Heuristics are used (rules of thumb eg. deep coals are usually gassier than shallow ones).
- ii) A control structure. This provides a strategy for drawing inferences from production information stored in (i) and new data supplied by the user.
- iii) A working memory. It provides easily understandable questions and answers to the user when inputting data, and keeps track of the problem status.
- iv) A natural language processor. This is the part that gives the questions and answers for (iii) above.

This model was completed in 1987 and is available to users for about \$ 100-00.

2.8 Methane Control

Methods used to control methane emissions are:-

2.8.1 Machine Mounted Diffuser Fans

A continuous miner in a heading blocks most of the ventilation from reaching the face. An improvement of up to 70% has been achieved by placing fans on the machine as shown in FIGURE 47 (53).

2.8.2 Aligned Water Nozzles

Water nozzles on machines are offset slightly in the direction of air flow. The nozzles on the intake are completely aligned in the direction of air flow. Improvements of 75-85% have been noted when using this technique with continuous miners (FIGURE 47 a,b) and 80% with longwall shearers (FIGURE 48).

2.8.3 Dust Scrubbers

These are good in moving air which is otherwise still.

2.8.4 Brattice Curtains

Brattice curtains are used as an aid to course ventilation to or from the face. (58) There are basically four categories of face brattice construction:-

- i) Simple suspension of the curtain from roof bolts with the bottom edge lying on the floor.

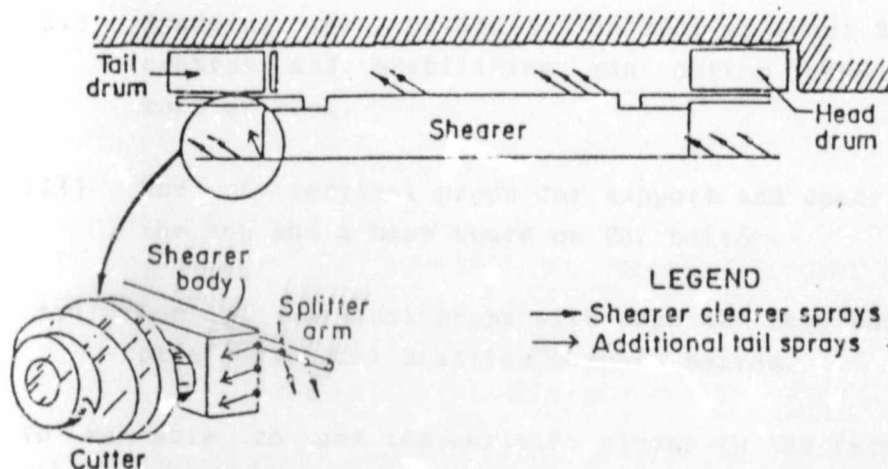


FIGURE 48 Water spray set-up on modified shearer clearer to direct more available airflow to the face. (79)

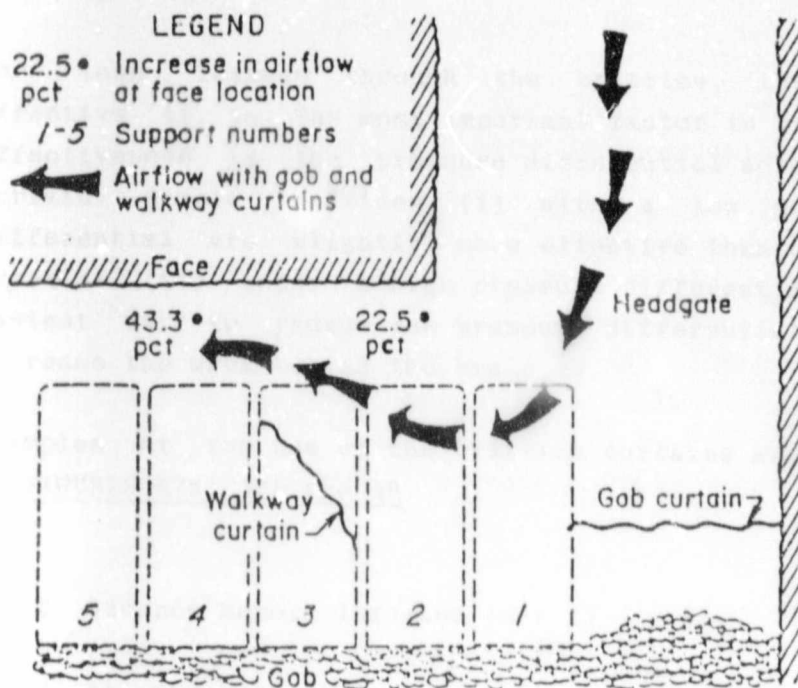


FIGURE 49 Effect of walkway curtain in increasing the airflow at headgate face area. (79)

- ii) Spadding the curtain to the roof at about 30 cm centres and stabilizing the bottom edge with wood or rock.
- iii) Use of vertical props for support and spads for the top and a base board on the bottom.
- iv) Use of vertical props with caps and base boards plus horizontal brattice support boards.

To be able to get the curtains closer to the face, a stiff cantilever from which the curtain is hung, is used. It is placed close to the face ahead of the rest of the curtain, which has been constructed as above. If the brattice is used for exhausting air, it is necessary to weight the bottom to prevent it being sucked closed.

The less leakage through the brattice, the more effective it is. The most important factor in brattice effectiveness is the pressure differential across the curtain. Simple brattices (i) with a low pressure differential are slightly more effective than complex curtains (iv) under a high pressure differential. The easiest way to reduce the pressure differential is to increase the area behind the brattice.

Examples of the use of the brattice curtains are shown in FIGURES 47a, 47b and 48.

2.8.5 Advance Remote Infusion (a r i)

Water is pressure injected into the coal to form a continuous water blockage across the width of the section (53). The amount of pressure required depends on whether the coal is blocky or friable, friable coals requiring 3 - 4 times the pressure required for

blocky coals. Drainage holes can then be drilled at the outbye ribs and the methane behind the water blockage will be collected here (FIGURE 50). The cleat orientation relative to the direction of face advance and hence the water is important. Using a.r.i. when the primary cleats are parallel to the direction of face advance, achieves no significant reduction in emission. When the primary cleats are approximately 90° to face advance, an 80% reduction of emission is possible.

Other benefits of a.r.i. are easier and quicker penetration by mechanised methods and dust is reduced.

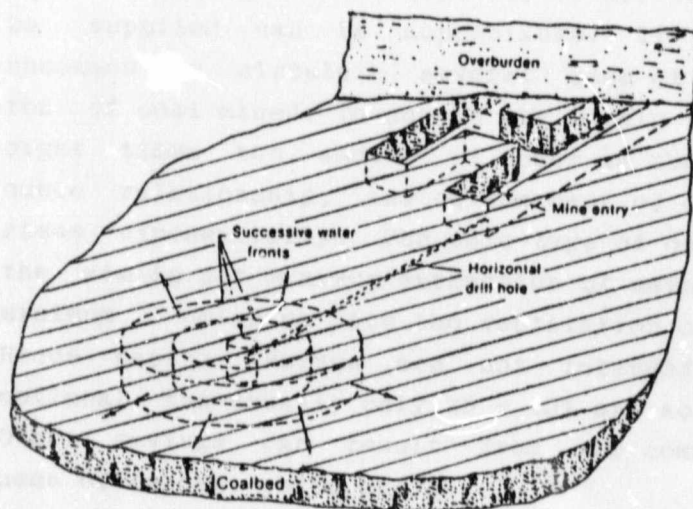
2.8.6 Methane Drainage

Methane drainage is employed where:-

- i) The velocity of air supplied to sufficiently dilute the methane being emitted, exceeds the statutory limitations.
- ii) Excessive coal face emissions occur. Especially where sparks can be caused by mechanised mining methods with a consequent risk of explosions, the need to reduce emissions is vital.
- iii) Large rapid changes in emission rate occurs.

Extensive tests have led researchers to realise that the distribution of methane patterns can only be obtained fairly generally. Patterns of emission within a mining district are indelible in most coalfields.

Methane drainage can achieve significant cost savings in some cases. Production may be



Water-injection pumps water into the coalbed to divert methane away from areas of active mining. (72)

FIGURE 50

interrupted until emission falls below the acceptable limits, which causes financial losses. Savings on the quantity of air that must be supplied can be appreciable. It is not uncommon to circulate several tons of air per ton of coal mined. To double air supply requires eight times the amount of power as there is a cubic relationship, and so the cost of doing so rises exponentially. For this type of operation the aim is not maximum extraction of methane but minimum emission into the ventilation current. Hence capture valves are not intended to be optional and usually only 25 - 40% are achieved. Other savings can result from the commercial uses of methane which are:-

- i) Liquid petroleum gas (LPG). The composition and calorific value (30kJ/m^3) of coal gas is very similar to natural gas therefore it can be converted to LPG or used as in (ii) below.
- ii) Use of a network joining several gassy mines such as in Belgium, makes this system very effective.
- iii) Fuel for gas turbines to produce electricity.
- iv) Boiler fuel at the coal drying plant, steam for winding engines and hot water.
- v) Chemical industry for chemical fertilizers, producing plastics and synthetic fibres, etc.
- vi) Firing of furnaces, ovens and kilns.

Drainage rates and purity in some US coal mines, where the coal is generally more permeable than

elsewhere, are comparable with a small gas well. The sale of this drained gas could exceed the cost of recovering it by 5 to 1 (85).

Purity ranges from 80% - 99% methane. If carbon dioxide percentages become too high it can be reduced by an adsorption trap. Water can be removed by a standard water trap. Coal gas does not contain carbon monoxide, sulphur compounds or nitrous oxides so it does not require cleanup before it is used commercially.

2.8.6.1 Methane Drainage before Mining Commences

- i) Vertical boreholes from surface. Here drainage is not dependent on local conditions and commences about 3 - 5 years before mining reaches the area. The borehole goes through and drains all the strata in the roof which may have contributed to emissions as well as through the worked seam. Spacing of 250-500 m for boreholes is normal. Virgin coal's low permeability normally causes very low flow rates and hydraulic or foam stimulation is usually necessary (FIGURE 51). Both methods cause fracture propagation by injecting fluid under pressure (± 100 MPa) and this increases the drainage radius of the borehole. Foam stimulation (56) is the same as hydraulic stimulation except that foam is added to the water to increase its sand carrying capacity, reduce fluid loss and enable quicker fluid recovery.
- ii) Directional slant holes (62). The holes are deflected to penetrate the coal bed parallel to

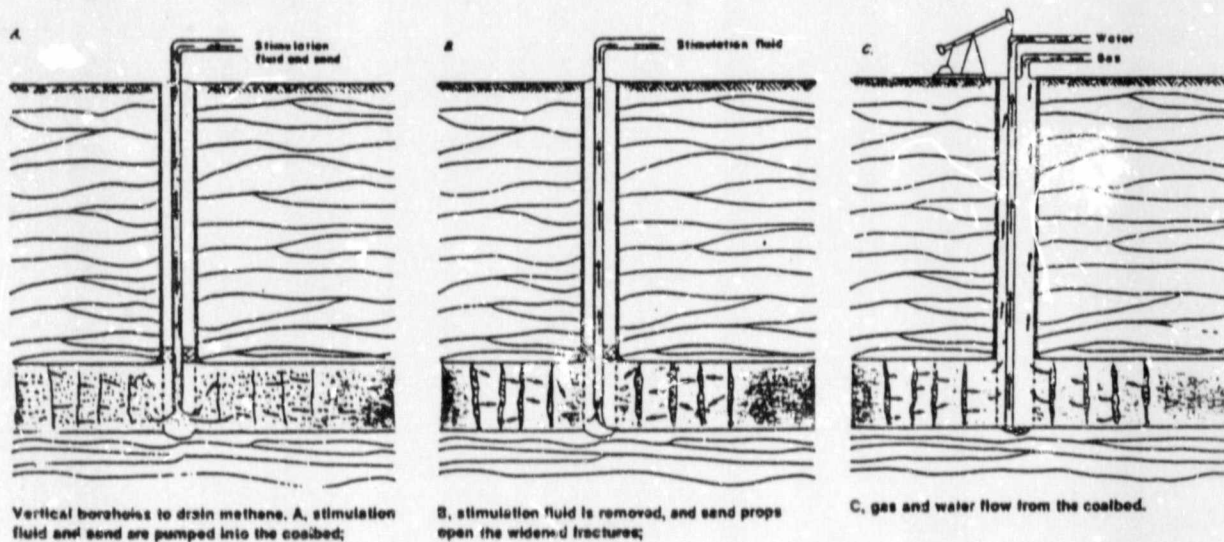


FIGURE 51 Drainage through Vertical Boreholes using Foam Stimulation. (72)

its bedding plane (FIGURE 52). Before this method can be effective problems of downhole surveying, bit control and dewatering must be solved).

- iii) Shafts. (75) The shaft is sunk 3 - 5 years before it is needed for ventilation and horizontal holes are drilled into the virgin coal from the bottom (FIGURE 53).

2.8.6.2 In-mine Drainage

- i) Horizontal holes ahead of advance workings (FIGURE 55). This method works well in more permeable coals such as in the USA but not well in less permeable coals such as the UK, Europe and SA. It is difficult to keep the hole inclination such that it remains in the worked seam. It is considered impractical for rapidly advancing faces.
- ii) Inclined holes behind advance workings. These holes are drilled into the relaxed zone behind the face (FIGURE 54) from the intake and return airways (FIGURE 56). The length, angle and spacing of the holes is based on experience but generally they are 50 - 80 m long and angled at 45° - 60° to the horizontal. Diameter of holes range from 4,8 cm to 11,4 cm.
- iii) Inclined holes in front of retreat workings. Often the upholes are broken by strata movement when the hole is crossed by the face. To minimise this problem holes can be angled towards the face at a shallower angle to reach and drain the distressed zone before the hole

its bedding plane (FIGURE 52). Before this method can be effective problems of downhole surveying, bit control and dewatering must be solved).

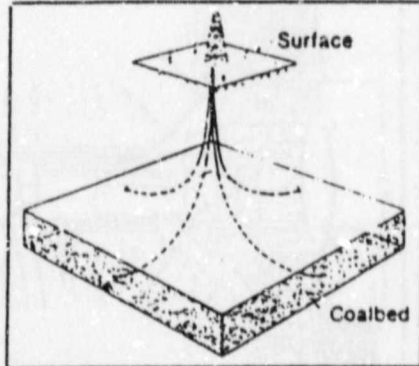
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NOTES

FORMATION DATA ARE FROM A CORE HOLE
APPROXIMATELY 1,000 ft FROM THE DRILLING SITE
WELL PLOT ASSUMES 5° SURFACE DEVIATION OF
DRILL RIG 6° PER 100-ft DEVIATION
PLOT BASED UPON 100-ft STATIONS WITH STRAIGHT-
LINE SEGMENTS BETWEEN STATIONS



When the slant hole technique is full operational, a site that would accommodate only one vertical borehole can be used for several slant holes.

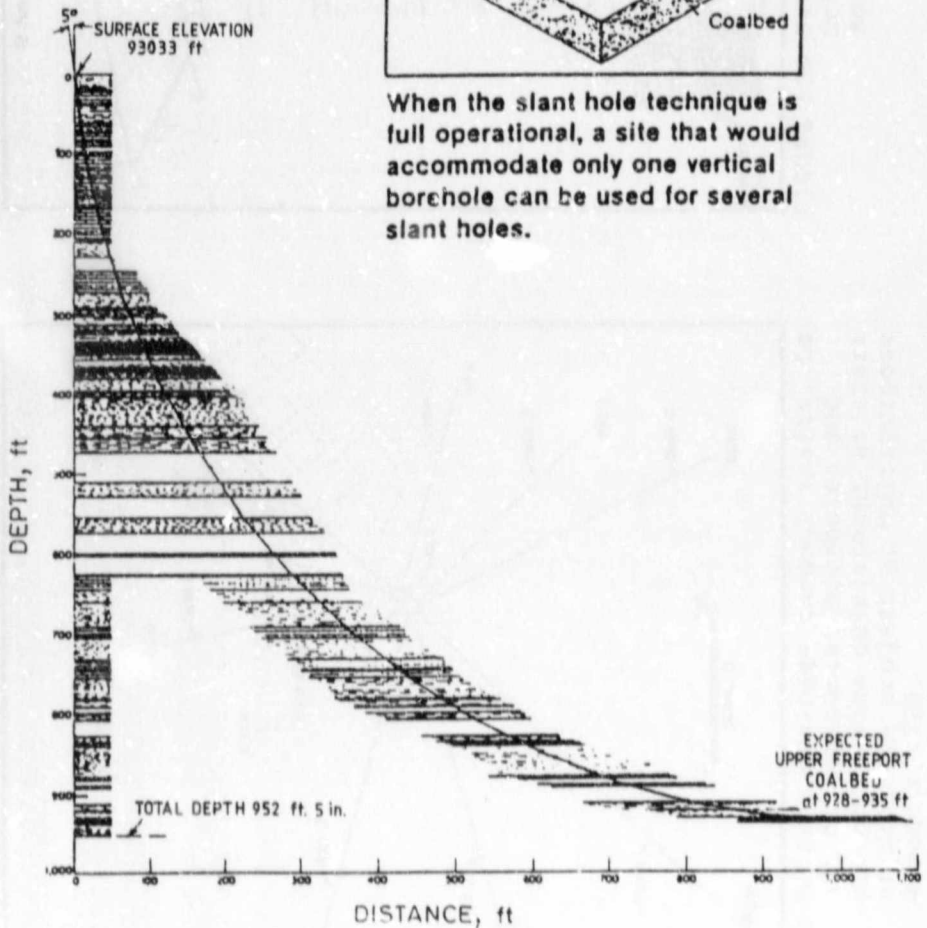


FIGURE 52 A directional slant hole is drilled from the surface at an angle to intercept the target coalbed horizontally (72).

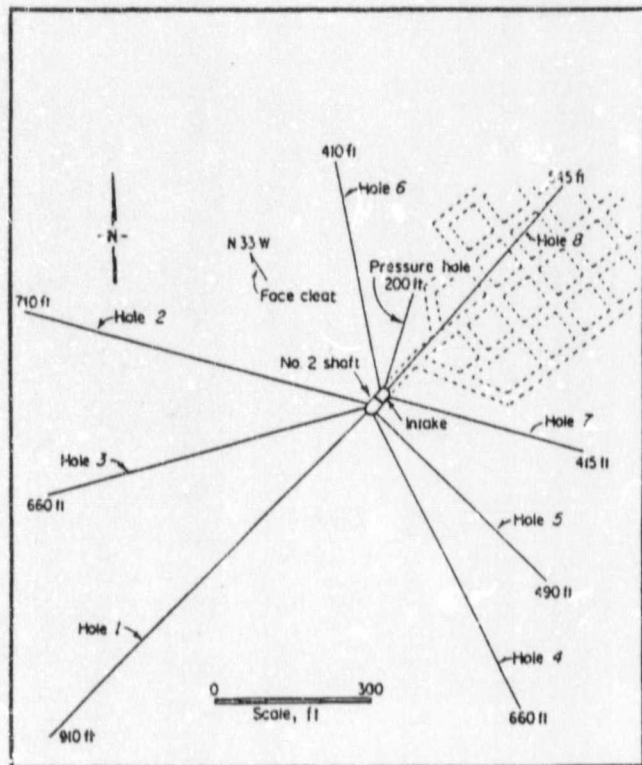


FIGURE 53a Methane drainage through shafts. Layout of horizontal boreholes and projected mine development at start of drainage project at Multipurpose Borehole (72).

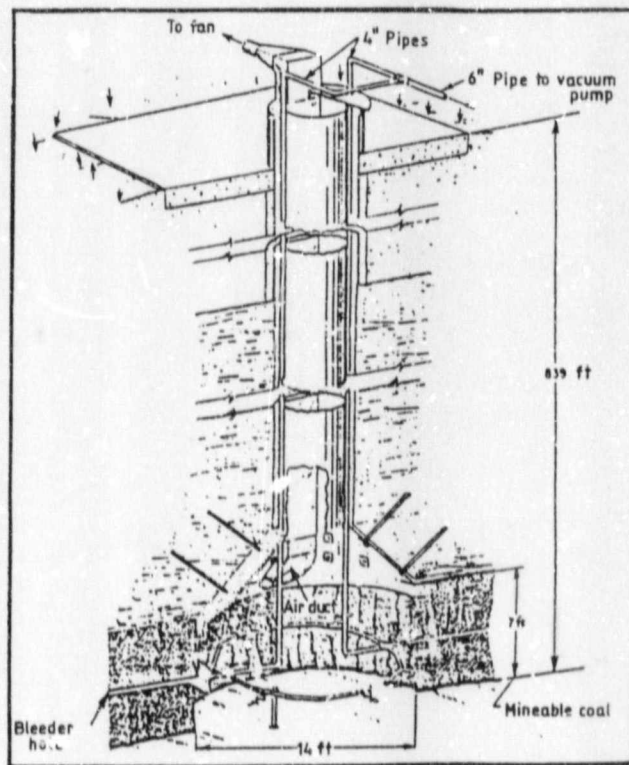


FIGURE 53b Methane drainage through shafts Schematic of Multipurpose Borehole (72).

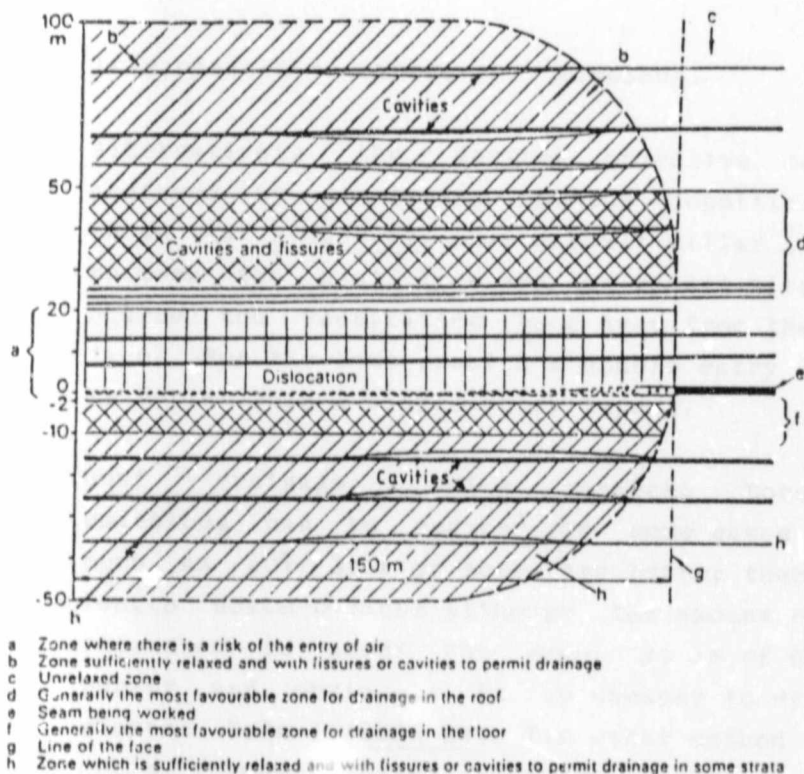
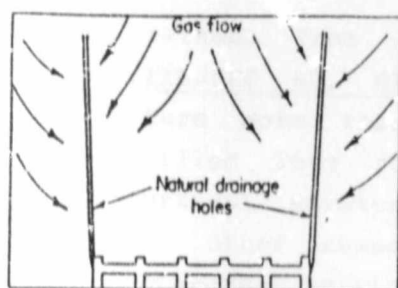


FIGURE 54 Longitudinal Section showing Gas Emission Zones for a Face (81)



Horizontal boreholes drilled in an active mine are used to drain methane away from the working face. (72)

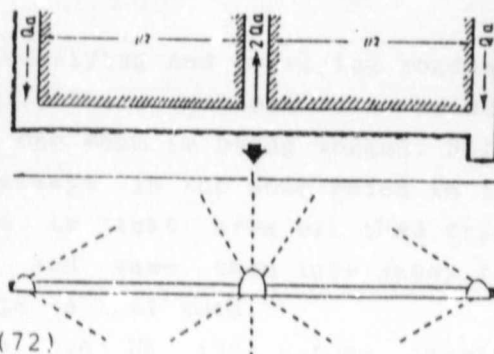


FIGURE 56 Borehole Pattern for a Face with W-Ventilation (81)

is subjected to severe rock movement.

Alternatively the desired objective can be achieved by simulating advance conditions as shown in FIGURE 57. Here a small pillar is left between the coal face and the return airway to course the ventilation back away from the coal face. For the best results a double entry layout is better than a single entry layout.

iv) Goaf drainage. Using vertical boreholes emissions can be reduced in some cases by as much as 50%. Shorter holes are better than full length holes because although the amount of gas recovered is about the same, it is of higher purity and obviously it is cheaper to drill a shorter hole (FIGURE 58). The other method is to drain through sealed stoppings (FIGURE 59). Gas obtained from goaf drainage is not very useful commercially. It can only be used for boiler fuel since the methane percentage can drop from 100% to 50% within a few months.

v) Drainage from underlying and overlying roadways (FIGURES 60, 61). These methods can be used where more than one seam is being worked. Holes drilled from roadways in the seam which is the furthest advanced in that area can then drain the other seams and make them less gassy for subsequent workings in that seam.

In collieries in the UK and Europe in-mine drainage at depths greater than 250 m used in conjunction with longwall mining is not very effective. The best results are achieved when the longwall advances on strike as drainage is then possible along the whole of the relaxed zone.

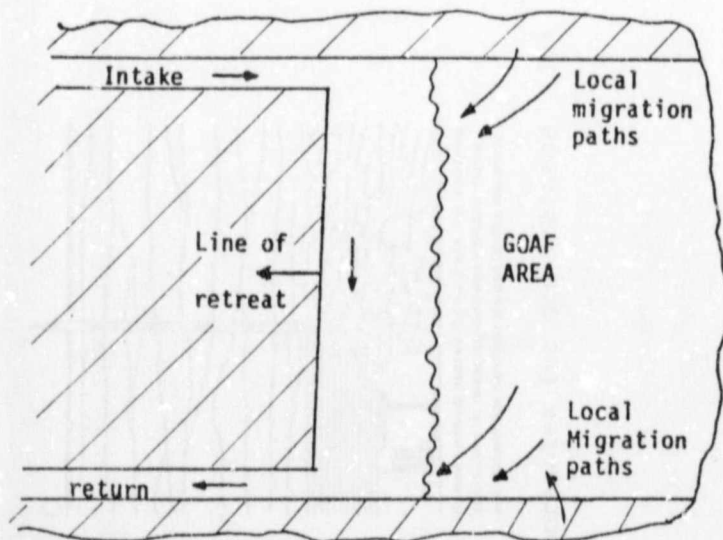


FIGURE 57a Conventional retreat panel. There is no ventilation pressure across the goaf and so there is very little goaf drainage (77).

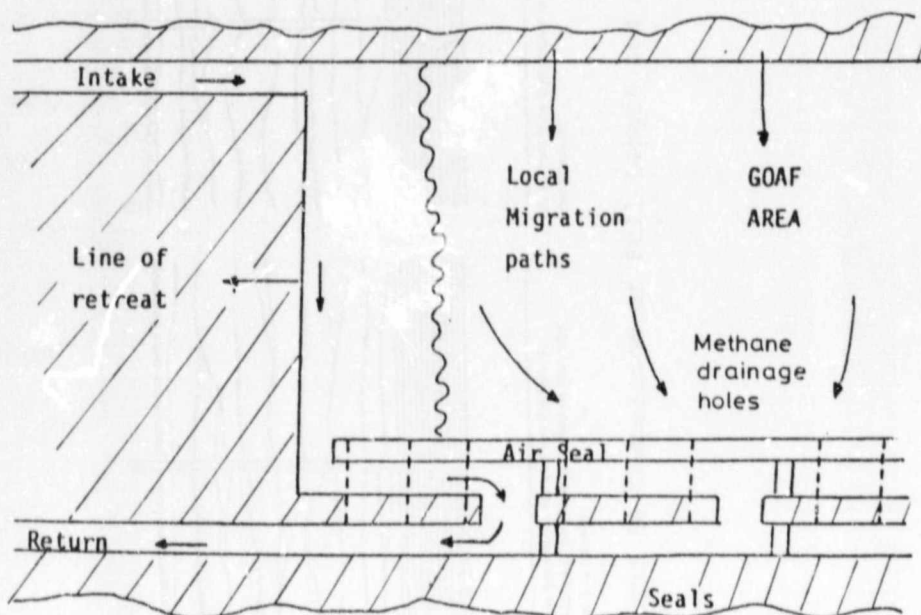


FIGURE 57b Retreat panel using coal pillars and an air seal to simulate an advancing panel by causing migration paths away from the coal fac (77).

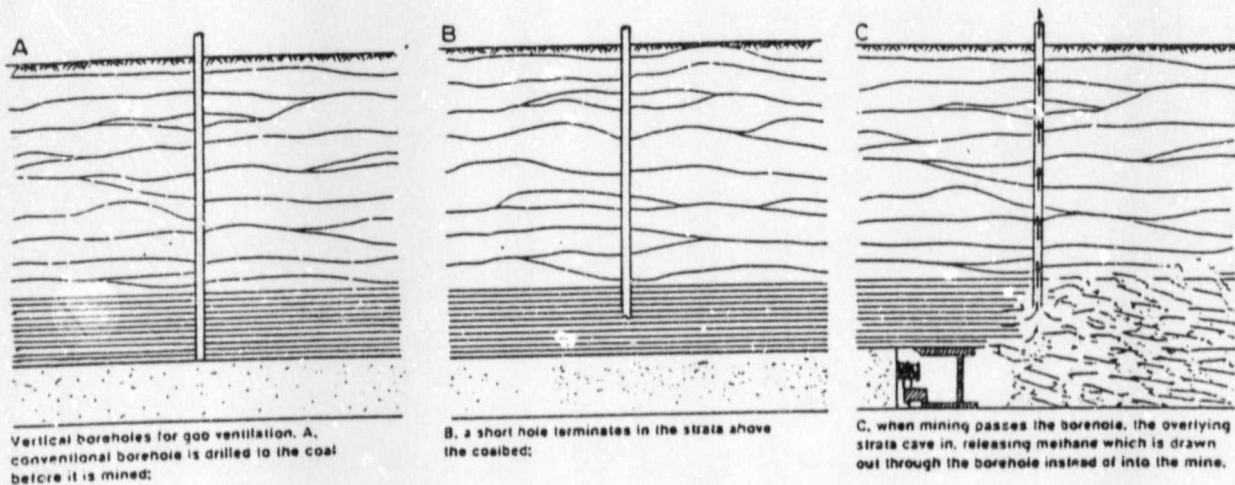
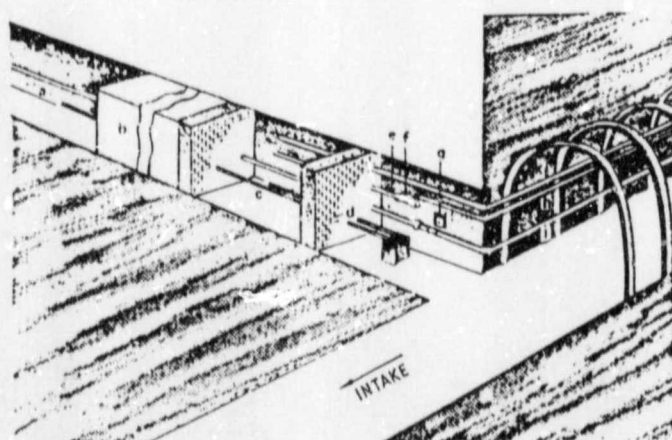


FIGURE 58 Comparison of Full Length and Short Hole Boreholes for Gob Drainage. (72)



- a Open ended Methane Range
- b Main Stopping
- c Pressure Chamber
- d Sample Pressure Tube to Inclined Gauge
- e Shutter
- f Venturi
- g Flowmeter
- h Compressed Air or Electricity Power
- i Methane Range
- k Pressure Reducing Pipe

FIGURE 59 Pressure Balance Stopping. (81)

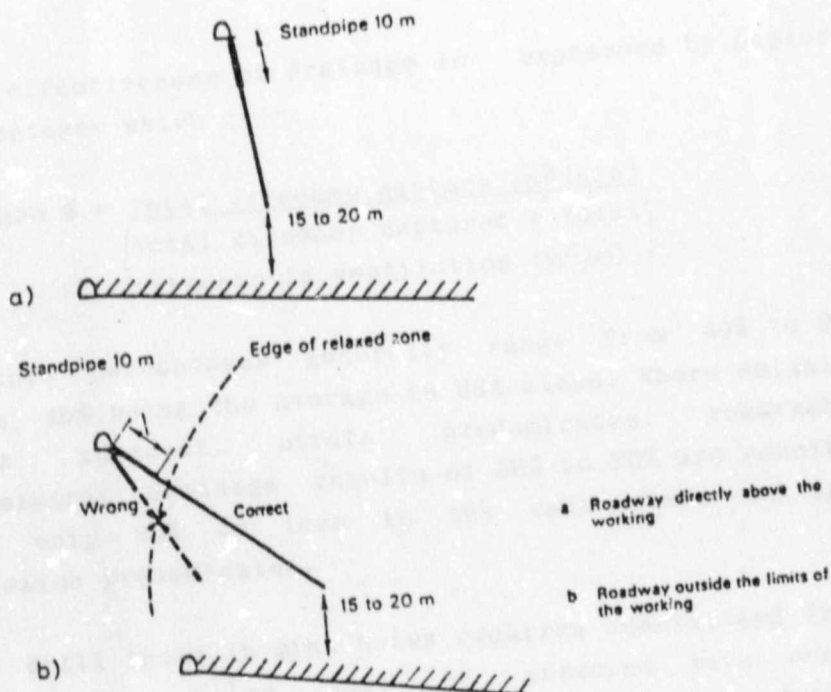


FIGURE 60 Firedamp Drainage from an Overlying Roadway using Downholes. (81)

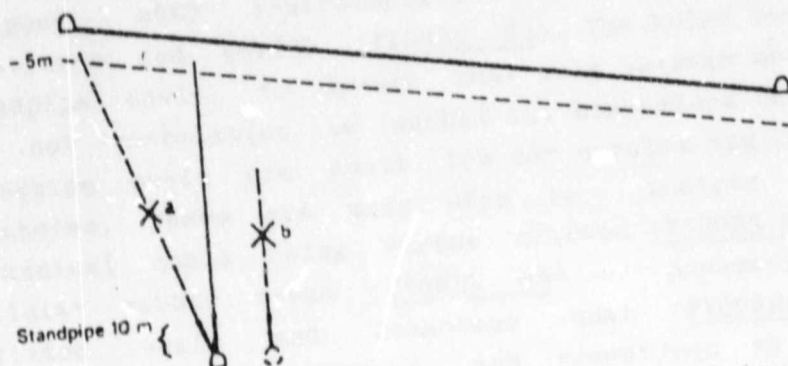


FIGURE 61 Firedamp Drainage from an Underlying Roadway using upholes. (81)

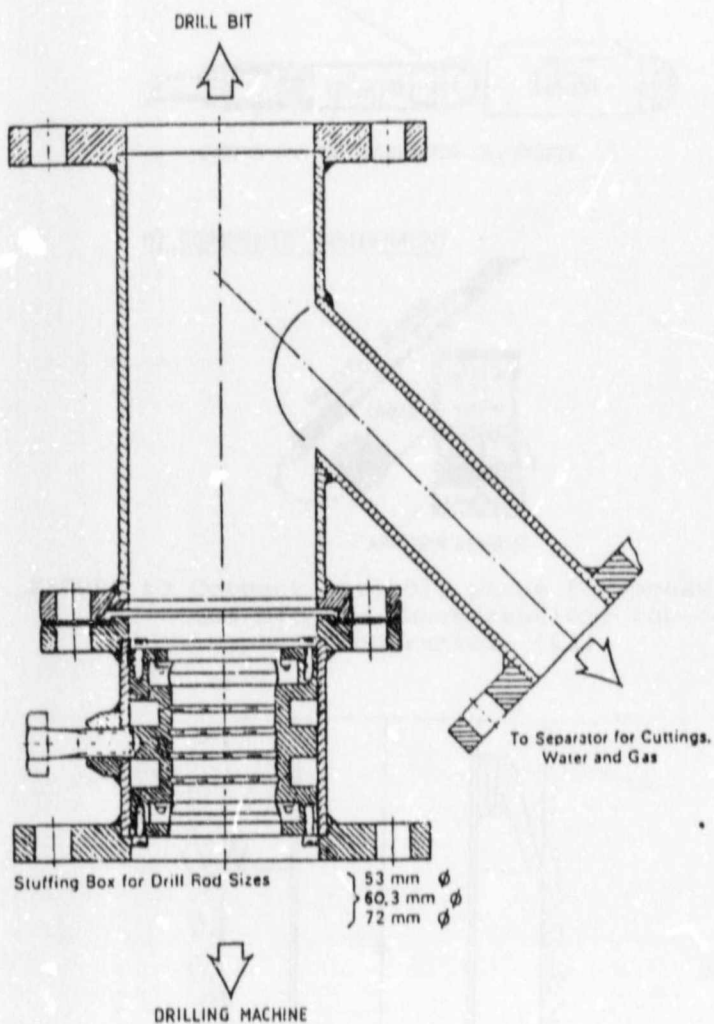
The effectiveness of drainage is expressed by capture percentages which is:-

$$\text{Capture \%} = \frac{\text{Total firedamp capture (m}^3\text{/min)}}{\left(\frac{\text{Total firedamp captured + total}}{\text{firedamp in ventilation (m}^3\text{/m)}} \right)}$$

Capture percentages generally range from 40% to 90% with 40% being the average in USA mines. Where emission from adjacent strata predominates, remarkably consistent drainage results of 50% to 70% are possible but only 30% or less in the case where coal face emission predominates.

To drill these in-mine holes requires specialised drill rigs. The holes must be surveyed with survey instruments and logged to check to see if the desired horizons have been intersected. Drilling should be done through a stuffing box (FIGURE 62) in case a high pressure gas pocket is intercepted. Then the holes are equipped with instrumentation to measure flow quantities and purity (FIGURE 63). The holes require standpipe seals, to ensure that only in-seam methane and not ventilation is sucked in. Dimensions for the standpipe seals are about 10m for upholes and 4m for downholes. There are many ways to achieve this. Mechanical seals using rubber sleeves (FIGURE 64) or cellular rubber rings (FIGURE 65) or pneumatically inflated seals and Densotape seal (FIGURE 66). Alternatively cement/grout and cement/ash mixtures (FIGURE 67) can be used. Downholes also require drainage using low maintenance automatically controlled pumping.

Once the holes have been drilled they are connected to a pipe network. The diameters of these pipes are related to the length of piping, the expected capture



Stuffing Box to allow Firedamp Drainage whilst Drilling. (81)

FIGURE 62

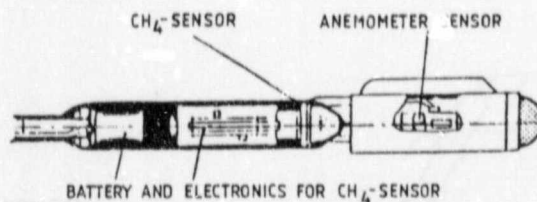
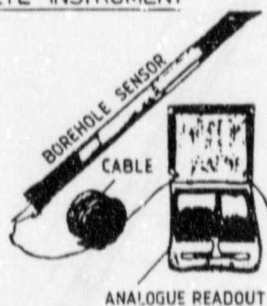
a) DIAGRAMb) COMPLETE INSTRUMENT

FIGURE 63 Compact borehole probe for measuring gas flow and methane concentration; top, diagram, below, complete instrument. (63)

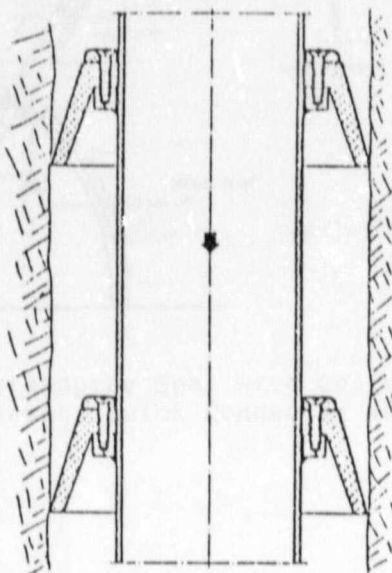


FIGURE 64 Standpipe Seal using Rubber Sleeves. (81)

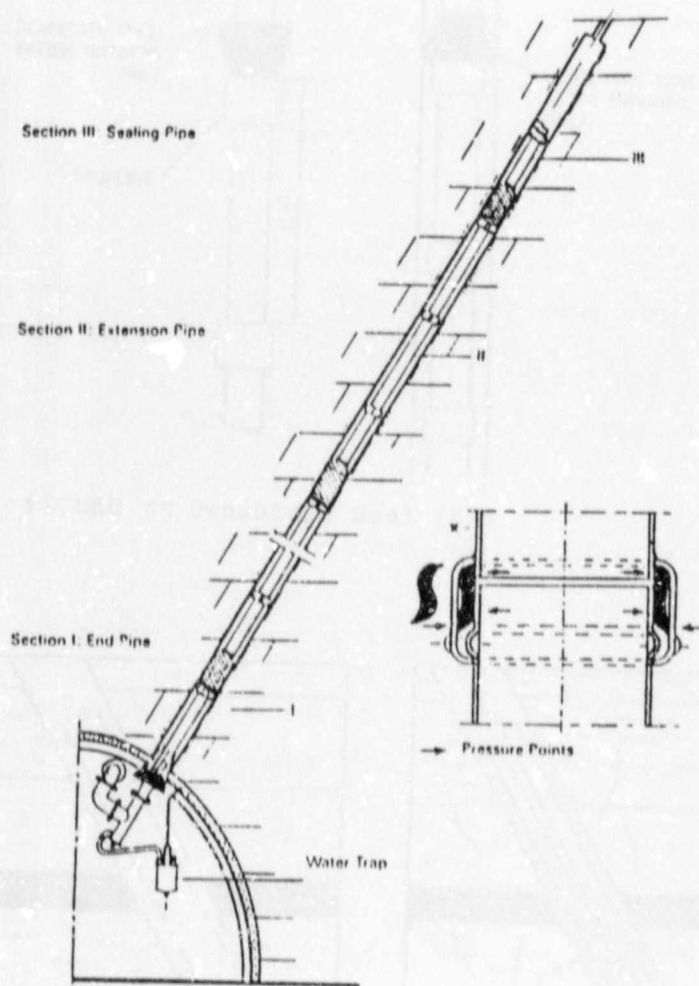


FIGURE 65 Standpipe Seal with Cellular Rubber Rings.
 Inset: Quick Connector with a 3 lip seal (81)

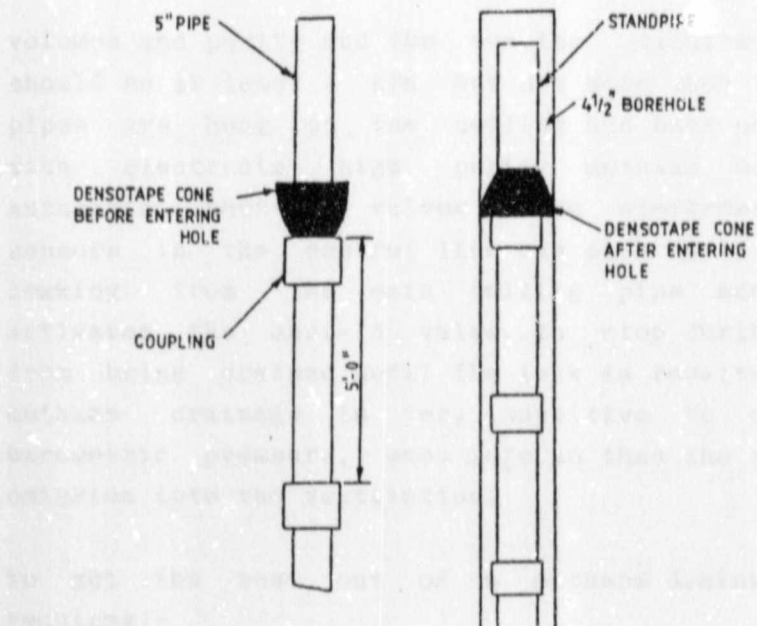


FIGURE 66 Densotape Seal (67)

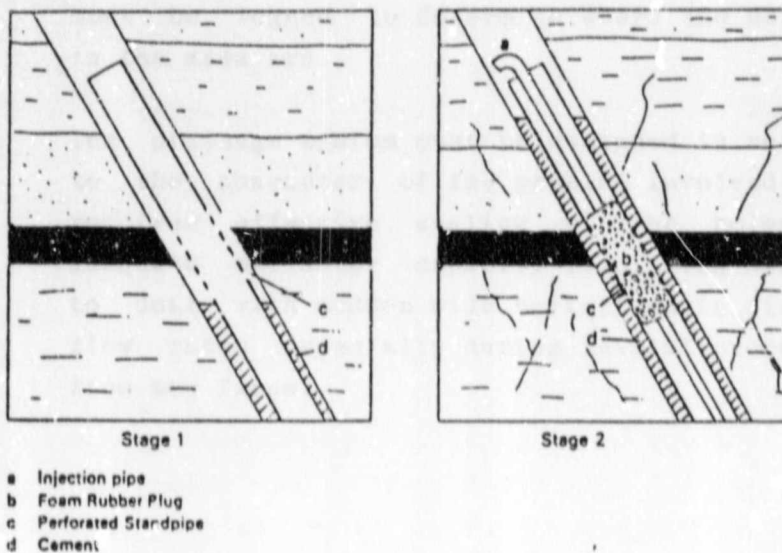


FIGURE 67 Standpipe Sealing using a Two Stage Cementing Process (81)

volumes and purity and the suction required. Suction should be at least 4 kPa but not more than 10 kPa. The pipes are hung on the ceiling and have control line with electronic high purity methane sensors and automatic shut-in valves. The electronic methane sensors in the control line can pick up if methane is leaking from the main ceiling pipe and then it activates the shut-in valve to stop further methane from being drained until the leak is repaired. In-mine methane drainage is very sensitive to changes in barometric pressure, even more so than the rest of the emission into the ventilation.

To get the best out of a methane drainage network requires:-

- i) Improved capture percentage values. The drainage holes must make contact with the firedamp horizons and to ensure this. Some of the holes must be logged to determine where the horizons in the area are.
- ii) The drainage system must be designed in relation to the character of the problem involved. This requires effective sealing of the holes and adequate extractor capacity (including standby) to deal with sudden wide variations in firedamp flow rates especially during initial production from new faces.

3. TEST FACILITIES

3.1 Methane Sorption Test Apparatus - Indirect Method

3.1.1 Coal Crushing Apparatus

Large lumps of coal are first hammered with the geology sampling hammer to small enough lumps to fit in the container of the Seibtechnik T 250 disc mill. The timer and speed control was set to run on fast for 2 minutes, long enough to crush the coal to a fine powder. The equipment is illustrated in PLATES 13 and 14.

3.1.2 Thermostat Controlled Circulator and Bath

A Jalabo VC 1 circulator (Item 2) (PLATE 5) mounted on a bridge plate, controls the temperature of a water bath from 0 to 100°C to within $\pm 0.02^\circ\text{C}$. It has provision for coupling to an external cooling unit, an external temperature recorder, a PT 100 external temperature transducer, and to a programmer to control the Jalabo's operation. Adjacent to its own temperature transducer is a 2 kilowatt heating element. Setting of the required temperature and the present water temperature are read from an L.E.D. display. The water circulating rate is 10 l/min. If the bath water level drops below a minimum allowable by the Jalabo's float, the pump switches off and an alarm is triggered. The 40 l Labotec bath 132A (Item 6) (PLATES 1, 2 and 4) has fibreglass insulation on the bottom and sidewalls. The inside walls are stainless steel which are argon welded together and the outside walls are anti-rust treated with baked enamel. It has a stopcock fitted and there is provision for adjustable level control. The layout

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