PRE-DRAINAGE OF METHANE IN WEST GERMAN COAL MINING

By
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At the beginning of the seventies pre-drainage of methane was introduced in West German coal mining in order to reduce the gas emission from the worked seam. After three pilot tests on the "Rheinland" Colliery (86 boreholes in seam "Prasident"), "Bergmannsgluck/ Westerholt" Colliery (23 boreholes in seam "Gustav") and "General Blumenthal" Colliery (27 boreholes in seam "Hugo" and 170 boreholes in seam "Karl") systematic large scale tests with extended investigations were carried out on the "Rheinland" Colliery (127 boreholes in the seams "Anna", "Blucher", Prasident"). During this time an analogous test was carried out on the "Consolidation" Colliery (21 boreholes in seam "B"). In these studies and tests the technical feasibility, efficiency and economy could be proved, so that pre-drainage of methane starts spreading. On the "Rheinland" Colliery pre-drainage has become common practice in gassy seams. Mainly two points impede a faster spreading of method:-

1. In many cases the necessary requirement, that one or both of the gate roads should be driven 6 to 12 months before the face is worked, is missing. This is mainly due to the difficulty of retreat mining in gassy seams.
2. There is not yet a fully developed method for the determination of the in situ permeability of a seam.

The mining conditions for the tests carried out up till now are given by the following data:

thickness of seams	- 1.5 to 3.1 m
gently dipping seam	- i.e. 0 to 20 gon
depth	- 600 to 1 000 m
rank of coal	- bituminous coal, gas coal.
volatile matter	- 20 to 35%
desorbable gas content	- 3.8 to 11.5 m^3/t

The in seam boreholes were made solely from previously developed gate roads in front of the face, parallel to the direction of the later longwall face. Generally the boreholes were slightly inclined from the lower gate road in order to facilitate a possibly necessary dewatering. The drilling was carried out with carriage drilling machines by Schmidt, Kranz & Company, with hollow drill rods and a so-called seam going tungsten carbide drill bit. For this purpose scrolled drill rods proved advantageous, because of the reaming effect of the welded on worm which prevents a jamming of the drill rods in the abutment pressure zone of the roadway. The boreholes were fitted out with plastic standpipes at a length of 10 m. The annular space between the plastic tube and the borehole was sealed by rubber sleeves and filled partially with polyurethane foam. Figure 1 shows the presently used type of standpipe, the sealing of the boreholes and their connection to the

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drainage range. Borehole diameters were 45, 65 and 95 m, maximum length of boreholes was 120 m; distances between the boreholes were 5, 10 and 15 m.

The results are widely spread. The reduction of initial gas content varied from 6% (60 days degasification period) to 84% (degasification period more than 42 weeks). This was mainly dependant on the degree of overworking which influences the in situ permeability of a seam (Figure 2). A similar tendency was found with the methane flow rate (m^3 per m borehole and day. These values varied from 0.06 to 3.5 m^3/m . d.

The following conclusions have been drawn for bituminous coal deposits in the Ruhr area:

- The optimum hole diameter is about 65 mm, the optimum hole distance 10 m (Figure 3).
- The methane flow-over-time curve can be approximated by an exponential function (Figure 4).
- An overworking even in a vertical distance of 180 m leads to a more rapid pre-drainage (Figure 5).
- One hundred days are regarded as the minimum pre-drainage period.
- Under these conditions one can expect a reduction of 15% of the initial gas content in the case of no overworking (i.e non-permeable seams) and a reduction of 30% if there is an overworking (i.e. permeable seams).

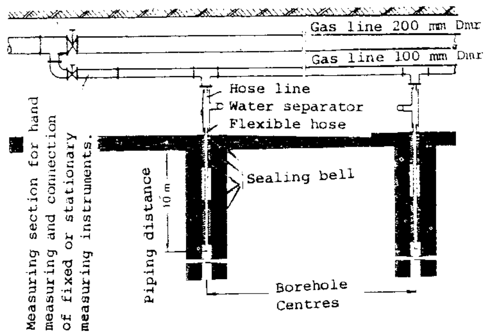


Figure 1. Schematic of the piping, sealing and connection for the suction boreholes.

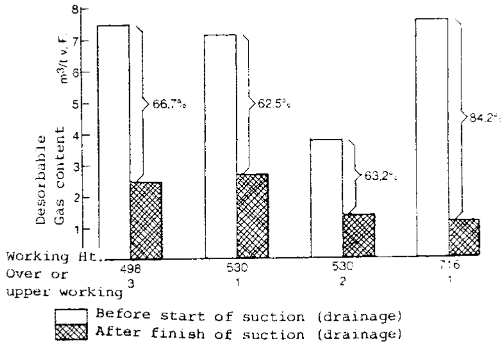


Figure 2. Subsiding of the desorbable gas content by suction.

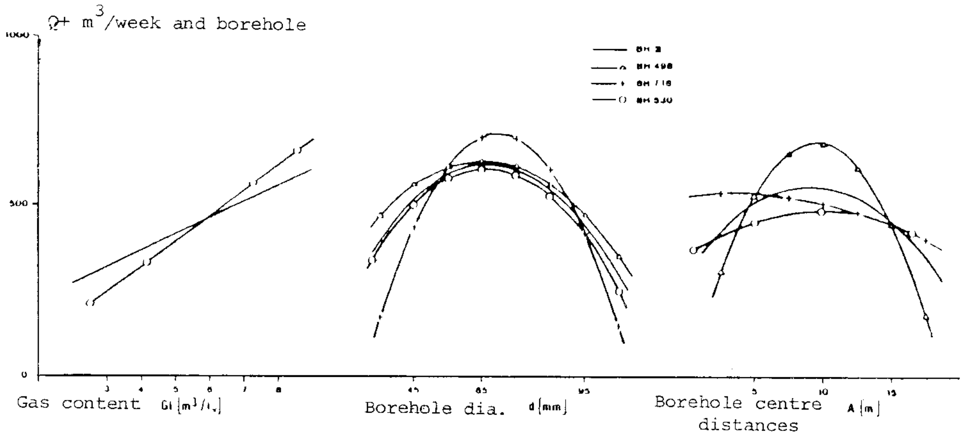
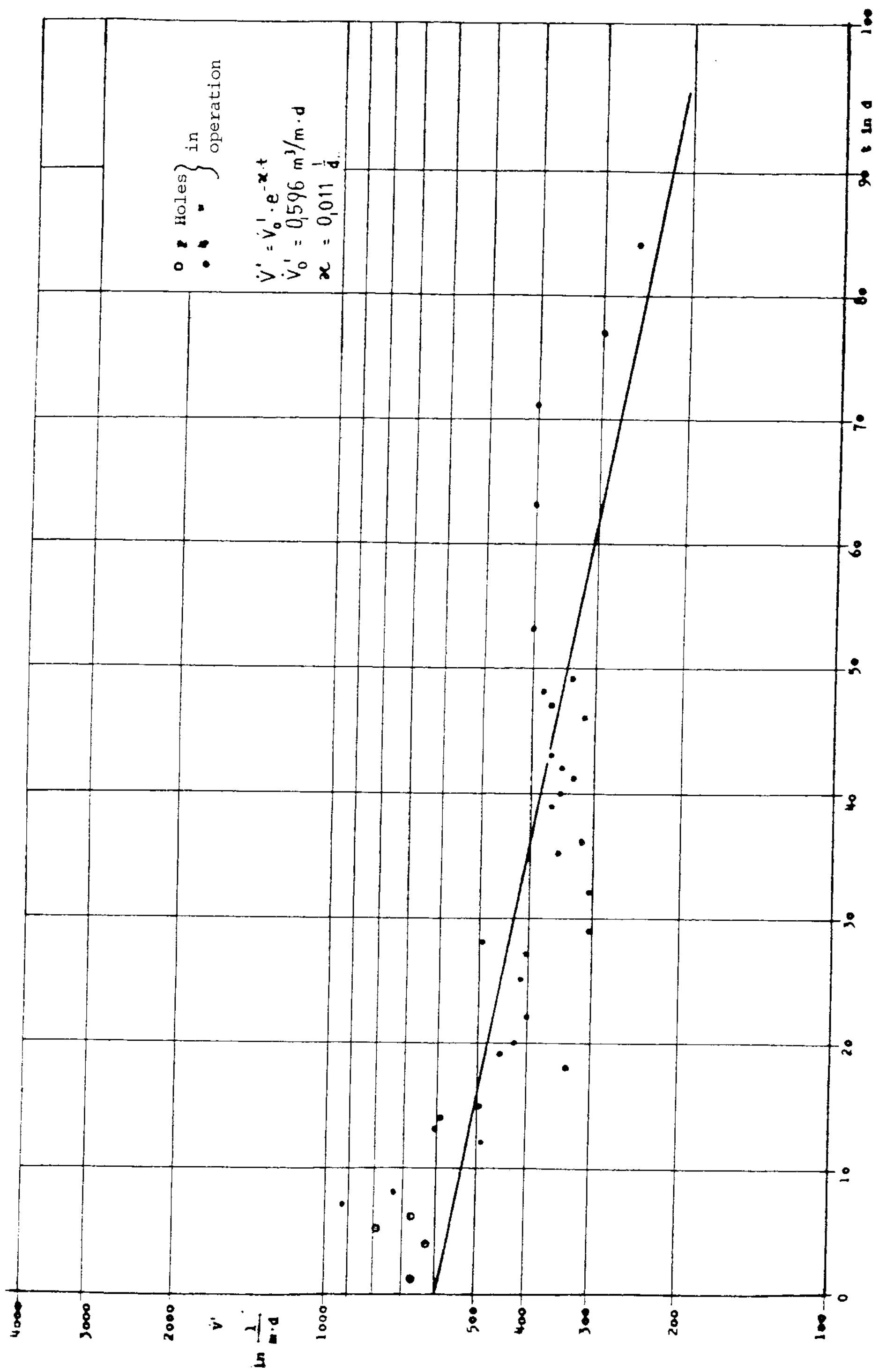


Figure 3. Entry of desorbable gas content Gl, for borehole diameters d and the borehole centre distances A on the mid-weekly drained methane volume for each borehole $\bar{Q}t$ after the total regression.



Drainage Seam B

Figure 4. Specific methane flow distribution for borehole group II.

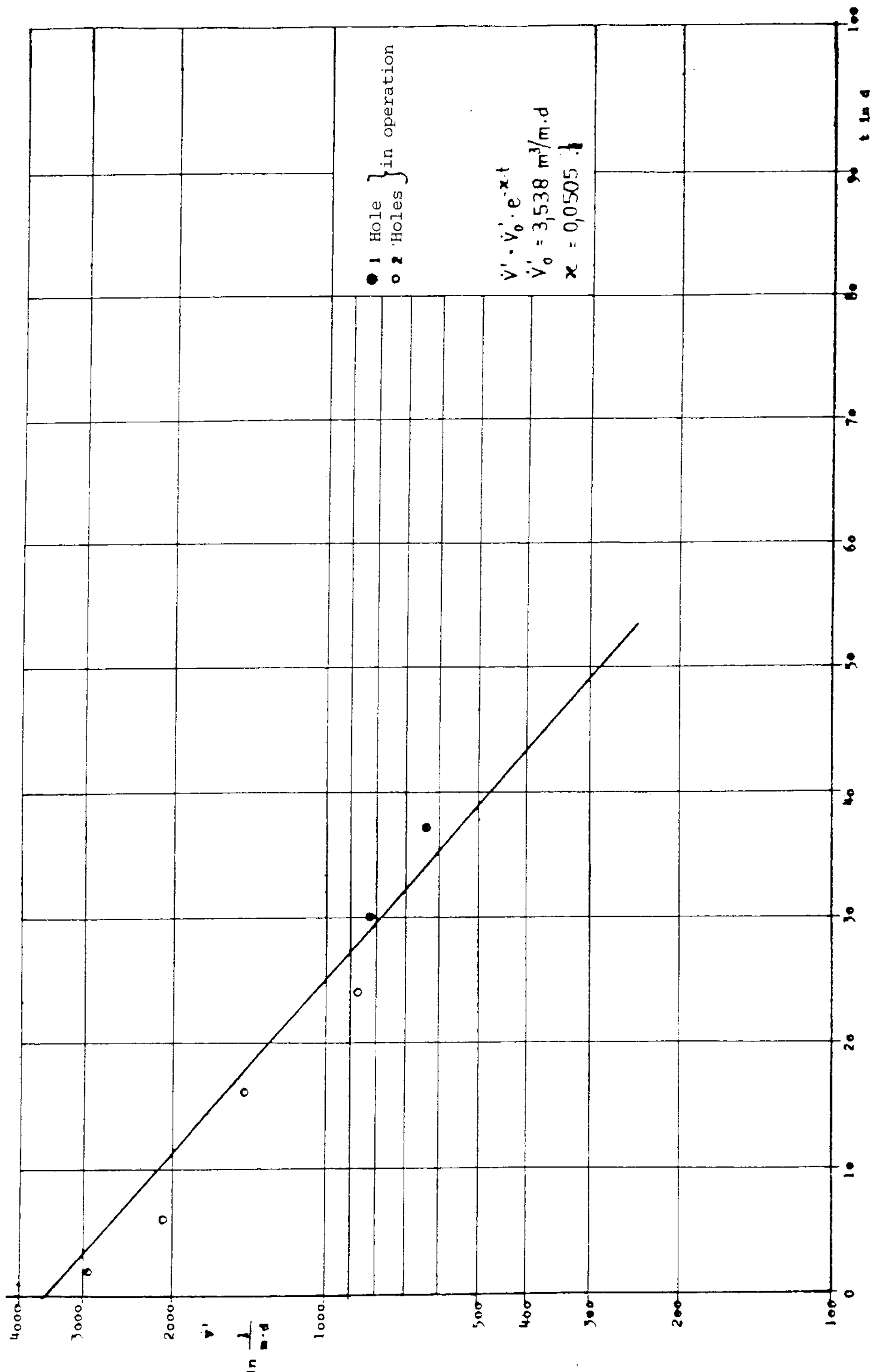


Figure 5. Specific methane flow distribution for borehole group VI

DISCUSSION

G. MOULD (Department of Industrial Relations): Have the plastic pipes used in the standpipes and also in the roadways, been approved by the Mines Departments and are they in fact anti-static? Also, when the boreholes are closed off for any particular reason, what is the maximum pressure developed within the hole, does it go up to the seam gas pressure or does it leak past the standpipe into the airway, thus giving pollution of gas in that particular airway?

K. NOACK (Westfalische Berggewerkschaftskasse, West Germany): In Germany there are two different qualities of plastic tubes which are approved to be used in the strata, but none to be used as methane drainage lines in the roadways. These two different qualities are antistatic. One has a coating of antistatic material which must remain undamaged. Therefore drilling through this sort of standpipe is not allowed and in this case the borehole must be drilled to its whole length before setting the standpipe. The other type of tube is fully antistatic and there are no such constrictions as with the first one. The tubes are delivered by the firms Korfman in Witten and Muller and Borggrafe in Gevelsberg.

The second question deals with a possible pressure build-up in shut holes. Yes, there is a pressure build-up in the holes but there is not much additional flow into the roadways because of the tightness of the seals. Pressure does not reach a dangerous level in normal cases but that is a question of location. For instance at Ibbenburen Colliery where there are outburst problems, yes probably a dangerous pressure could build up in outburst prone zones.

R. KING (U.S. Bureau of Mines): The plastic pipes are not approved for static electricity by the U.S. Mines Safety and Health Administration which is the regulatory body. They do recognise in the ventilation plans that the mine operators will make some type of static electricity check. In other words it is ignored; that is exactly what happens. In reality it is ignored pretty much and so there has only been one steel pipeline (which was illustrated) and the rest have been plastic. The standpipes are kept as long as possible and are grouted in as well, because emissions will occur around that pipe. That is right.

L. LUNARZEWSKI (Visiting Polish Methane Drainage Specialist to B.H.P): For what values of permeability was the distance of 10 m between bore holes optimal?

K. NOACK: The three tests with predrainage have been done in three different collieries and then the great investigation was done in one colliery but in different seams. The permeability was not measured in any of these cases but it was certainly far below one millidarcy. But although no measurements were made for each of the sites it is believed that the permeability of our seams when not overworked is quite similar from one site to another. That may be the reason why at all the test sites the best centre distance of 10 m was obtained. This was found also in the Consolidation Colliery test where 95 mm diameter boreholes were used. There, in the not overworked district the 10 m distance was optimum also.

L. LUNARZEWSKI: Were the investigations conducted in a virgin area, unrelaxed by mining of the seams in the roof or the floor?

K. NOACK: Strictly speaking, the situation was not virgin as the sites were developed longwall blocks where the gateroads were already driven and in this sense it was not virgin. The boreholes were made in all cases ahead of a longwall working in zones which were influenced sometimes only by the gateroad itself, sometimes by a lateral working, sometimes by an overworking but never by an underworking.

L. LUNARZEWSKI: That is, it was panelling?

K. NOACK: It was real predrainage, that means it was not a drainage in the destressed zone over the goaf.

I. GRAY (A.C.I.R.L.): Two different flow decline curves were shown, with the explanation that in the overworked area the flow decline was much faster, was that the same seam?

NOACK: Yes, it was the same seam.

I. GRAY: And would the same conditions have been expected without the overworking?

NOACK: Yes. The difference is due to the fact that permeability is much higher in an overworked zone than in a virgin zone.

B. HEBBLEWHITE (A.C.I.R.L.): Referring to the effect of hole diameter, the conclusion was that 65 mm was an optimum. Greater than that diameter the results fairly conclusively show that flow actually decreased. What is the explanation for why that happened?

K. NOACK: The explanation is difficult. For instance when this test was done at Consolidation Colliery with 95 mm diameter boreholes the results of this test were as good as those with the great investigation. Therefore these results must be reviewed because the shape of the curve depends on the mathematical approach to the values. By the way it must be said that much of this work is done not only by WBK but also by the Rhineland Colliery and especially by Dr. Guntau, ventilation engineer of this mine.

I. GRAY (A.C.I.R.L.): A long planned experiment, thwarted by various practicalities is to be able to set a drill up, drill a hole, allow it to reach a semi-steady state such that the flow will be predictable, then to ream it, pick up the flow again and ream it again. Because certainly theoretically a better flow should be obtained with a larger diameter hole. All operators able to do so should give it a go.

K. NOACK: That is a good idea.

A.J. HARGRAVES (B.H.P.): Such an experiment is described in the paper by Battino and Hargraves to follow. Hole diameters were from 43 mm to 125 mm and although flow increased with diameter there was no simple relationship.

R. KING (U.S. Bureau of Mines): The U.S. Bureau of Mines has found in the Jim Walters mines, which are deeper with higher overburden stresses that the holes will squeeze and that may be what happens here. The larger hole was drilled but when the rods were withdrawn, the overburden pressures caused the holes to squeeze so an effectively smaller hole resulted. So that is something to be realised that of course the larger and larger and larger the diameter the more gas should issue, but pretty soon the hole is not self-supporting any more. For that structure, that hole inside there it is just a matter of strength of materials and it will start to squeeze or cave.

K. NOACK: That is quite right.

R. LAMA (Kembla Coal and Coke): Kembla Coal and Coke has been looking to the question of optimising the parameters of longholes, and there are two things which come in. The first is resistance to flow. If the length of the holes is large and the diameter of the holes is small, resistance to flows is so high that effectively much less gas per metre length of the hole could be obtained. The second is the stability of the hole under those conditions. The diameter, similar to the question of stability of very large excavations in rock, the larger the diameter the lesser the stability. So both the things have to be looked at simultaneously. It is not always to say, well, drill a larger diameter hole and make a longer hole and hence have a better flow rate and better efficiency. But coming back to the basic, and comparing the data obtained at West Cliff Colliery and the German data, it looks that the flow rates per day, per metre length of the boreholes are pretty comparable.

NOACK: This is agreed.

R. LAMA: The C.S.I.R.O. conducted some studies on the pore size distribution of some Australian coals and also on samples from Canada, and one or two samples from U.K. These studies showed that the Australian coals had about 530 Angstroms (average pore size) whereas for some other Canadian and British coals the values were of the order of 900 to 1000 Angstroms. One Angstrom is 10^{-4} of a micron, so it is about 0.05 compared to 0.09 microns. That is the average pore size. Have any studies been done on American coals and on German coals?

K. NOACK: There are such studies resulting in figures from 10^2 to 10^6 Angstroms. Commenting on the last remark about diameter and resistance it does not appear that resistance plays an important role, considering the relatively small flow rates of in-seam boreholes. More important could be the bigger surface which is exposed with a greater diameter. This gives more chance for gas flowing in and chance for cracks intersecting the hole.

C. JEGER-MAIDOT (CERCHAR, France): First, in the presented case, the seam was probably destressed because it was two or three overlying workings. Is not it? Secondly, this sort of degasification by borehole in the seam seems to be only useful to avoid entry of gas into headings; but it cannot very much reduce the flow of gas due to the mining by longwall faces, because when mining longwall faces, the gas comes from overlying and underlying seams on very long distances (more than 100 m over and about 60 m under the mined seam). Nevertheless it is possible to obtain predegasification of overlying and underlying seams, by many boreholes crossing these groups of seams. In France, measurements of decreasing of content of seams were made in a case where predrainage was realised by such boreholes penetrating 10 seams lying each over the other under the mined seam. The boreholes were positioned at a small distance each from the other (60 m). The situation and the results are shown in Fig. 1.

In Fig. 2 there is a diagram indicating, for a predrained panel to be mined, on a cross section, parallel and in front of the next face, the values of the residual contents (curve 2) under the destressing goaf. On a wide distance, 200 m, the content decreased from 7-10 m^3/tonne to 2.5 - 3 m^3/tonne.

Other measurements reported in Fig. 3 show the same decreasing of content in all the underlying seams distributed between 50 and 120 m under the mined seam G2, the lowest seam lay more than 100 m under the goaf of the seam G2, the mining of which caused the destressing which increased the permeability of these seams enough to make predegasing effective in less than 18 months. Would it be possible to make the predrainage more effective by draining much more time or by driving more boreholes each one closer

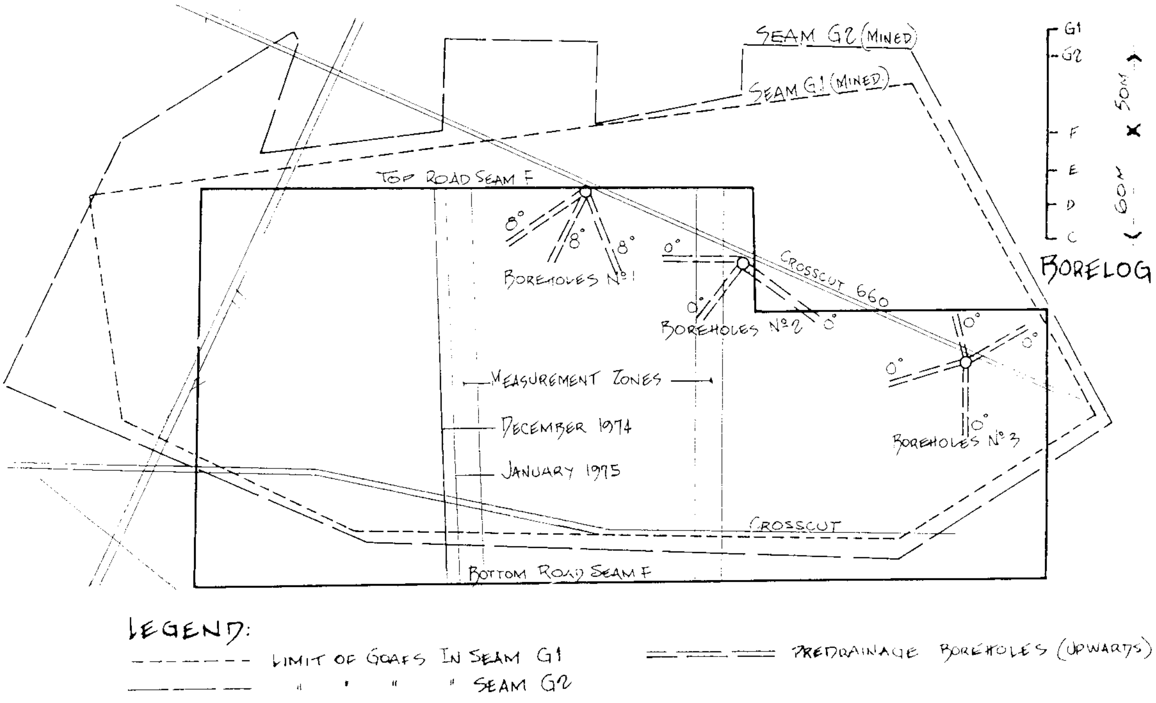


Fig. 1. Seam F Panel under overlying worked zone in seams G1 and G2

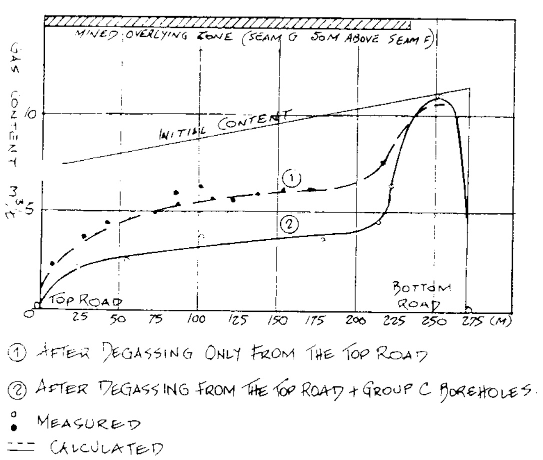


Fig. 2. Residual content in front of the coal face of seam F

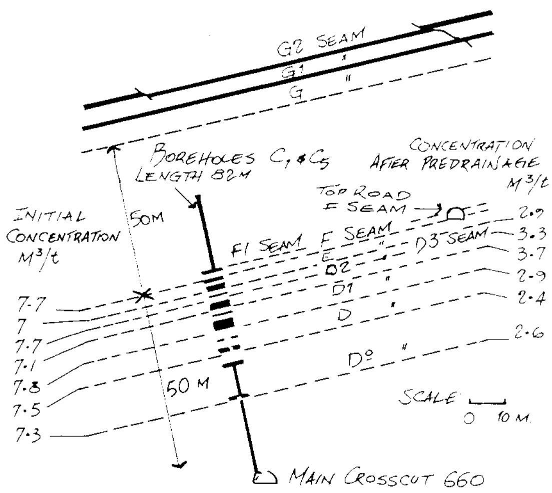


Fig. 3. Stratigraphy in boreholes, Block 1 at Marienau Colliery (Lorraine). Contents before and after predrainage.

from the other? The residual content was about 3 m^3/tonne. That is close to the limit ever measured in France. In degasified seams, after degasification, the residual desorbable content is normally not less. This limit is the adsorption corresponding to the pressure still remaining to cause the very small final flow, which is not sufficient to make a sensible further decrease of the content.

K. NOACK: Regarding the commercial aspects of predrainage there is not much German experience about that because this technique is still in a research state and it is done primarily for safety and not for economic reasons. Nevertheless there should be good economic results because in the faces on the Rhineland Colliery the predrainage technique helps to avoid exemptions from the statutory limit which is 1 per cent in the general body of the air. If an exemption is needed they have to put in much more monitoring and sophisticated systems than without. Nevertheless Dr. Guntau has given some figures in his thesis about his research work on predrainage. The costs of predrainage were 1.12 DM per ton of saleable coal (at an average seam thickness of 1.62 m). The proceeds were 0.055 DM per 18500 kJ. This gives a profit rate of 7% or 0.078 DM per ton of saleable coal.

R. FRASER (Coal Cliff Collieries): It is very difficult to gauge the efficiency of gas drainage from the point of view of what would have happened had gas drainage not been practised. An objective look at this in Coal Cliff Collieries led to the conclusion that something in excess of 1,000 tonnes per day would not have been produced without gas drainage. It is very difficult to get an inter-company comparison on costs of gas drainage. The cost of gas drainage at West Cliff is something in the order of 80 cents to $1.00 per gigajoule drained. Are there any comparative costs from Germany and the United States?

K. NOACK: There are statistics but in Germany the situation is a little bit complicated because 67 per cent of the drained gas is used but mostly by the mines themselves for instance for pit bath heating and other purposes, and 33 per cent of the gas is blown off. So the economic situation depends on the proportion of utilisation at each mine.

Very often the whole methane drainage work is paid by using the gas, the improvement of production level underground being a surplus.

R. KING: In regard to vertical holes, the verticals economic stand point was spelled out with the advice that the U.S. Steel Corporation was going to put in 17 wells on their own. There is no way that an organisation like U.S. Steel would do this unless they felt that the return on their investment was money making. Also as a purely money making venture with hopes of later mining if the coal market stays around in the U.S., Jim Walters Resources, also in Alabama, has gone into a joint venture with a company out of Texas and formed an independent company. They have plans of putting in 700 vertical wells over the coal areas in advance of mining, right now they are producing 50,000 m^3/day and selling it at something like $5.00 a kJ. So they recognise that in that mine with the gassiness of the mine there is no way they could produce that coal without getting that gas out in advance, so therefore they are doing pre-drainage. They have decided that they would try to make money at the same time; they have a gas line that they are going to be making up very soon putting it into the market place.

In regard to horizontal holes the U.S.B.M. has completed some economic studies. The Bureau has got an economist on its staff and has been looking at capital investment of a new mine opening. It is difficult to go back and say that horizontal drainage added to a section only affects that section, so the decision was made to look at a new mine. All of its development cost and what it is going to require to gear up and to put in a methane drainage staff, because that is what must be done to put horizontal drainage into an active mine that is growing there must be people devoted to doing that and capital equipment is essential for doing all the maintenance. Pricing that out using all the new internal revenue service, tax laws and tax breaks where you can put your money, it looks as though about 20 per cent return is possible in the investment by selling the natural gas. Again, Australian natural gas should sell more than does U.S. natural gas because methane from coal is considered an unconditional natural gas in our country, therefore it is not regulated by the Federal Government's interstate gas regulations and it can sell for as much as 80 per cent of the No. 2 diesel fuel, whatever that can go for. Considering the equivalent kilojules in that, yes it is economical. It is necessary to look at it from the big picture and that is one of the things under scrutiny. To put in one little site in one section, it is very difficult to see money being made out of that but looking at it in a big picture and seeing how it fits into the entire mine plan, the plan of doing methane drainage and doing a good job of it, will pay off in the mine.