METHANE DRAINAGE EFFECTIVENESS WITH REGARD TO DIFFERENT MINING SYSTEMS IN POLISH COAL MINES

By

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ABSTRACT

The longwall system with caving is the most common mining system in Polish Collieries and the extraction is carried out simultaneously on several levels and in different seams.

The extent and diversity of the methane hazard occurring is strictly connected to the specific geological and gas conditions as well as to the applied mining methods.

Taking these factors into consideration the following methane drainage methods are applied as additional means of combatting the methane hazard in Polish gassy coal mines:

1. predrainage by means of boreholes drilled from the surface,
2. predrainage from stone drivages and development workings,
3. degasification of coal extraction workings, and
4. degasification of sealed-off areas/old goaves.

Predrainage gave satisfactory results when holes were drilled from the surface or from underground workings, but only to depths to 300 m. It was necessary to adapt methane drainage methods to the geological and mining conditions as gassiness increased with depth.

The results of methane capture, both predrainage and post drainage were obtained by investigating several gassy mines.

The analysis of methane drainage in more than 40 longwalls, with caving, allowed the possibility of capturing methane in different geological, gas and mining conditions to be assessed.

There is a relationship apparent between methane capture by degasification, total methane make and other factors. From the recovery rate of methane by degasification for the various mining systems empirical formulas establish relationships between the various parameters. Of the various methods of methane capturing, of particular importance are longwall systems with caving where drainage holes are drilled from underground workings.

INTRODUCTION

In Polish gassy coal mines with average daily coal output 8,000 to 10,000 tonnes, the total daily methane emission amounts to 2.2 x $10^6 m^3$. In mines with drainage approximately one third of this is captured. Under conditions of high methane content in the range 4 to 20 m^3/tonne ash free dry, the methane quantities released into the mine workings are so high that it is impossible to dilute them by ventilation air to below the permissible level. In order to eliminate or diminish the methane hazard, depending on the geological and mining conditions, different degasification methods are applied.

In Poland, the Rybnik Coal area, lying in the Upper Silesian Coal Basin is the most characteristic and most gassy region both with regard to the amount and the diversity of methane emission into the mine workings.

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The extent and diversity of methane hazards occurring in the Rybnik Coal area result from the specific geological and gas conditions. Methane occurs mainly in the coal seams in the physico-chemically adsorbed form and also as free gas in barren rock in strongly weathered, cracked and fissured roof sections of Carboniferous strata. Such a Carboniferous strata covered with impermeable overburden of Miocene layers approximately 250 m thick constitutes an additional convenient way for the migration of methane from deeper lying parts of the Carboniferous strata. Under these conditions it was possible to perform mining activities, and above all development work, only when using methane drainage - predrainage. Methane drainage safeguarded the coal winning operation at those depths. Yet at depths of 400 m to 500 m and in inclined Carboniferous strata, when extraction was nearing miocene overlain zones, the seams that had not been drained prior to mining caused an increased methane emission amounting up to 100,000 m^3/day. This made it necessary to apply special degasification technologies.

In the Rybnik Coal Area two strongly saturated gassy parts of the Carboniferous strata were noted:

1. the below overburden section at depths of depths of 150 m to 350 m with free and adsorbed gas, and
2. deep section 700 m to 1,000 m, characteristic also for the remaining Polish coal basins with methane mainly adsorbed in the seam (Grebski, 1975).

At these depths, characterized by a much lower strata permeability, methane problems occur principally in coal winning operations. Large quantities of methane are released chiefly by the first seam in the given group of seams which destresses the adjacent coal layers in the roof and the floor. At those depths higher methane saturations were stated also in the neighbourhood of some faulty zones (geologicel dislocation).

GAS CONTENT INVESTIGATIONS

Gas content investigations are carried out by means of surface boreholes as soon as geological studies are commenced. This makes it possible to feed this data into the colliery construction plan. Methane content investigations are made for nearly every workable seam. For this purpose coal samples are placed in airtight containers. After their degassing in the laboratory by means of the desorbometric method which enables the indirect determination of the pressure under which gas is sorbed in coal, the direct determination of methane content in the sample is possible. The knowledge of the above pressure and of the previously established sorption isotherms enables the evaluation of gas content in the seam to be determined. In addition, a large number of tests are carried out underground during the major development stage and during panel development. The aim is to investigate the gas content in the seam every 300 m in the headings and every 100 m in cross measures driven in virgin areas. The other method is also applied with the exception that the samples are taken from holes with a diameter of 42 mm and drilled only in working faces to a depth of 6 m.

FORECASTING OF METHANE EMISSION

Precalculation of methane emission is done in two stages.

1. during the construction phase of new collieries or levels, and
2. during the coal extraction phase.

In the first stage the total average methane emission from the whole colliery or the new level is investigated, and in the second stage the maximum emission from the individual coal extraction workings is determined. At the second stage methane emission forecasts are required by Regulations in collieries where total gas make will be over 10 m^3/tonne of coal.

At the first stage, the geological documentation includes the following data:

1. geological and recoverable coal reserves,
2. methane content in seams, and
3. methane hazard categories.

From this information the average relative gassiness of the mine in m^3/tonne of coal output is calculated to find the relationship between the geological reserves of methane and the recoverable reserves of coal. When a more detailed recognition of the distribution of methane content in the deposit is required, this value can be calculated also for the specific areas of the colliery. Thus a more rational distribution of output is possible when taking into consideration the application of methane drainage.

When expanding the colliery to new parts or levels, use is made of statistical material incorporating the results of observations made on the development of gassiness to that stage in mines with methane drainage.

In the second stage of forecasting, that is, in the phase of panel development, use is made of prevailing investigations of gas content in the seam and of stratigraphic recognition of the layers. As mining practice has shown, the detailed and proper understanding of these data is the factor which most significantly decides the exactitude of the forecast. The maximum gassiness in coal extraction or development workings is calculated from well established formulas. Various methods are used for these calculations.

The gassiness of coal extraction workings is calculated by the "simplified mining practice calculation method". This method takes into consideration only gas liberated from the mined coal and gas released into the longwall workings through the fissures and cracks which arise during mining, from over and underlying seams subsequent to their destressing. This method is used for output of 500 tonnes/day. For other outputs an empirically determined relation between total methane make and output is used. Figure 1 provides this relationship.

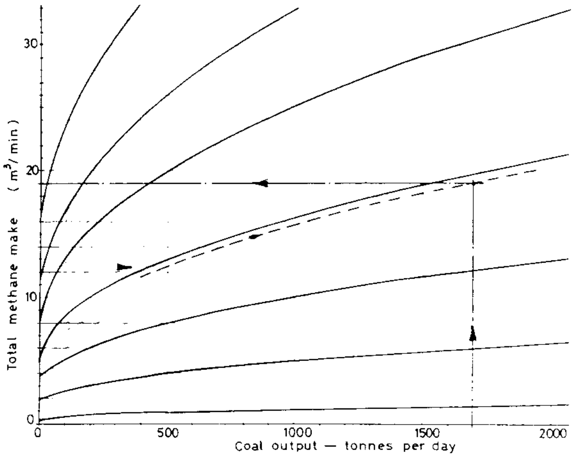

Fig. 1. The relation between coal output and total methane make (longwalls with caving)

For Polish collieries (Myszor, 1974). A special computer program has been written for the calculations.

CRITERIA FOR APPLYING DEGASIFICATION

During all the phases of colliery development different degasification methods were needed, according to the various changing geological conditions.

The classification of methane drainage methods is based on the phase during which degasification is performed in relation to the extraction, as follows:

1. predrainage by boreholes drilled from the surface,
2. predrainage from development workings,
3. degasification from extraction workings, and

4. degasification of sealed-off areas/ old goaves.

During the planning and construction phases of the collieries, the decision whether to apply degasification or not is made on the basis of the assessment of the conditions which may be expected and on the basis of the preliminary gassiness forecast. The general criterion for the need of degasification is the methane hazard category; either if the average methane content in the seam is above 8 m^3/tonne ash free dry or if there is the probability of gas bleeders or if the relative gassiness is above 15 m^3/tonne mined for outputs of 1,000 tonne/day. At the coal extraction phase, if a degasification system in the colliery is already in operation (pipeline network and degasification station) then degasification for extraction workings is used when the gassiness is above 5 m^3/min and for development workings the gassiness is above 2.5 m^3/min in single heading development.

In collieries which have not been prepared earlier for methane drainage, the criteria for applying degasification are the results from the mine working gassiness forecasts and the possibility of diluting methane to permissible limits by the ventilation air.

METHANE PREDRAINAGE

Owing to specific geological and gas conditions in the Upper Silesian Coal Basin, large quantities of methane have accumulated under the impermeable overburden. Methane has collected mainly in the roof consisting of Carboniferous strata where the weathering zone is about 30 m thick and the permeability and porosity are very high.

Methane content in these coal seams goes up to 20 m^3/tonne ash free dry and large quantities of free methane occur in eroded layers of sand formations.

The complex tectonic structure with numerous fissures and cracks accounts for high and often sudden methane emission into drivages. Particularly high gassiness has been encountered during panel development and extraction workings and the highest levels were in the vicinity of the roof of the Carboniferous strata.

With increasing depth of extraction the fissures disappear and the gas permeability of coal seams and surrounding strata decreases.

These geological conditions, the nature of methane occurrence and the longwall systems of extraction used in Polish collieries, are the main factors which determine the methods of combatting methane hazard by means of predrainage. The term "predrainage" refers to a methane drainage technology (especially coal seam drainage) before extraction under conditions of natural pressures in the strata and its natural methane content.

For local geological, gas and mining conditions, three methods of methane predrainage can be applied:

1. boreholes drilled from the surface,
2. drainage boreholes drilled in the strata during drivages and panel development, and
3. drainage boreholes drilled in the unrelaxed zone of the working seam from development workings.

BOREHOLES DRILLED FROM THE SURFACE

Methane predrainage from surface boreholes was applied in Poland in three districts of the Upper Silesian Coal Basin. Although the drainage hole diameters and the lengths of the boreholes were approximately the same and the extraction depths of the horizon were the same, the drainage results obtained differed considerably. The best results were achieved on the reserve field of Marcel-Marklowice Colliery where geological investigations and the sinking of a ventilation shaft in 1923 indicated a considerable methane content as well as high

TABLE 1

The characteristics of surface gas boreholes at Marcel Marklovice Colliery

Depth of productive levels (m)	Date of commencement of gas extraction	Head pressure at the holes (kPa)	Initial methane flow rate m^3/min	Total volume of methane to June 1974 $m^3 \times 10^6$
276.20 to 204.90	26/03/52	226	27.0	10.166
290.60 to 217.70	-	98	3.5	piezom. hole
280.50	-	98	4.6	piezom. hole
221.20 to 201.85	4/07/53	343	10.0	6.672
240.40 to 210.27	12/09/51	137	22.0	9.243
301.00 to 201.46	1/10/58	147	10.7	3.226
221.00 to 206.00	28/03/52	157	32.6	5.099
238.50 to 200.24	9/08/51	206	48.0	7.031
278.80 to 180.90	1/01/52	196	5.6	5.179
219.30 to 202.30	2/05/51	157	32.6	10.846
178.90 to 141.72	2/05/51	177	63.0	5.689
288.00 to 263.74	2/05/51	157	53.0	11.134
188.00 to 165.00	20/09/51	196	68.0	14.091
183.50 to 153.35	2/05/51	147	45.2	6.067
231.10 to 150.65	2/01/52	284	25.0	7.398
252.00 to 200.67	10/02/52	255	29.7	7.754
192.00 to 155.16	5/02/52	98	77.8	16.105
130.00 to 121.78	10/02/52	98	118.0	25.899
220.40 to 149.99	10/02/52	127	49.1	14.479
201.50 to 124.24	10/02/52	69	119.0	12.238
239.40 to 220.28	20/12/53	863	54.1	12.042
233.72 to 227.60	20/7/52	59	39.6	13.127
302.00 to 205.49	10/09/53	59	56.2	8.661
217.60 to 172.48	1/12/61	59	56.0	3.275
251.90 to 210.84	1/02/61	49	48.0	3.119
206.60 to 200.60	2/01/55	59	74.0	9.149
240.50 to 200.00	1/05/62	49	77.7	3.587

porosity and permeability.

Test drilling of the coal deposit started in 1948 and the methane emission quantities were of industrial importance in only the first two holes. As a result, 44 surface boreholes were drilled, of which 30 were connected to the surface gas range for continuous exploitation. The average depth of the holes was 150 m to 250 m and the hole diameters were 150 mm to 250 mm (Table 1) (Grębski, 1975).

In the years 1950 to 1975, 330 x $10^6 m^3$ of CH_4 was captured from these holes, that is

$13.2 \times 10^6 m^3$/year or 25 m^3/min. At first the gas was captured and transported under its own pressure and in later periods was captured under suction (Fig. 2) (Grębski, 1975).

The pressure in the coal deposit was lowered by 686 kPa and the methane content in the coal was reduced by 5 m^3/tonne ash free dry. Panel development and extraction were started in 1972 and despite the application of methane predrainage from the surface and preliminary capture of $330 \times 10^6 m^3$ of CH_4, the introduction of methane drainage was necessary during developments at depths of 200 m and 400 m.

Approximately 30 m^3/min of CH_4 (maximum 50 m^3/min) were captured by drainage boreholes drilled from cross-measure headings and drivages to the roof.

In 1981 about 10 m^3/min of CH_4 were captured from active surface boreholes and 20 to 25 m^3/min from underground drainage holes. Yet, even with many years methane extraction from surface boreholes, the strata has not been degasified sufficiently to avoid methane drainage from underground workings. On the lease of another colliery (Silesia) which lies a distance of 50 km from Marcel-Marklovice Colliery with similar gas and geological conditions, four surface boreholes were drilled, from which $6.5 \times 10^6 m^3$ of CH_4 were captured (maximum yield 7.6 m^3/min), in the six years preceding panel development work. Further, methane drainage with underground drainage boreholes was needed both during panel development and extraction.

In Moszczenica Colliery, 20 km south of Marcel-Marklovice, during panel development at depths of 130 m and 250 m, methane was emitted as blowers in quantities as high as 40 m^3/min in a single cross measure heading. Besides applying a very intensive underground methane drainage program, six boreholes were drilled from the surface to a depth of 280 m, however their output was very low (0.5 m^3/min) and did not reduce methane hazard.

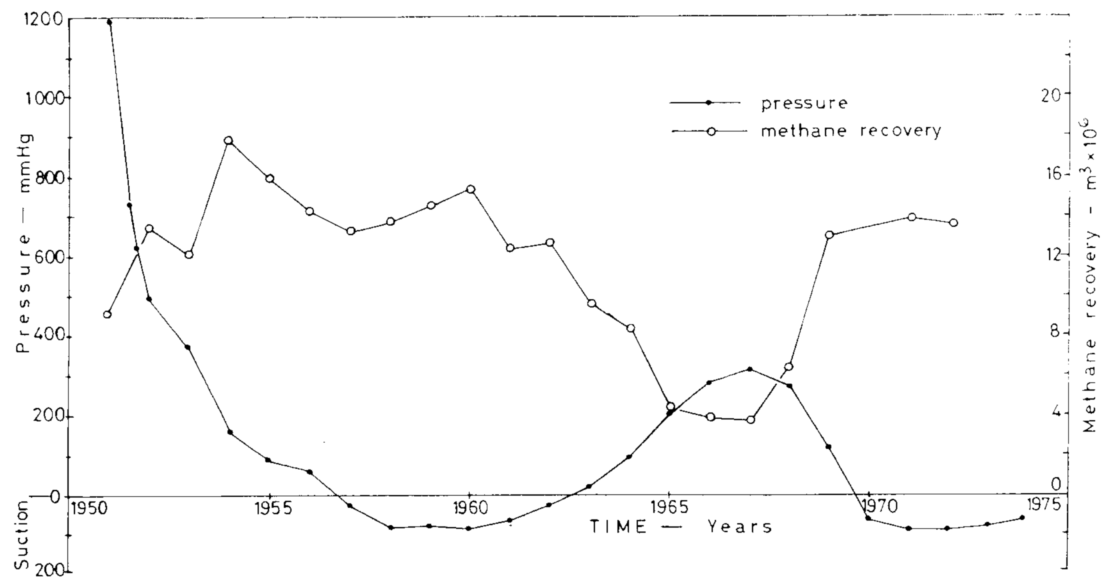

Fig. 2. Total methane recovery and pressure of 'Marcel-Marklovice' field

STRATA PREDRAINAGE DURING DRIVAGES AND PANEL DEVELOPMENT WORK

In several collieries carrying out panel development at relatively shallow depths (130 m to 350 m) the strata demonstrated good permeability conditions and a high methane content in the range 15 to 18 m^3/tonne ash free dry.

The ease of gas migration in the strata resulted from a complex tectonics environment and the presence of numerous cracks, fissures and faults. During panel development and drivages large quantities of methane were emitted from the roof rocks and ribs, and the total methane make recorded from drivages and cross measure headings was up to 40 m^3/min, a quantity impossible to dilute such a large amount of methane by ventilation air only.

The special methane drainage used consisted of drilling boreholes from offsets in ribs (Fig. 3 and Fig. 4) both into the roof and the floor in the direction of the adjacent seams and geological disturbances. Methane was captured from the holes with a suction of 13.3 to 20 kPa.

Borehole parameters including the length, the angle of inclination and azimuth as well as the number of holes required were determined individually with reference to geological, mining and gas conditions.

The best results with this method were achieved in cross measure headings where the recovery rate of methane by degasification i.e., the ratio of the captured methane to the total methane make emitted into a given working (methane captured plus ventilation) was of the order of 85 to 95 per cent. In coal-stone headings recovery rates of 50 to 70 per cent were attained. (Cias, 1976)

At the Moszczenica Colliery 73 x $10^6 m^3$ of CH_4 were removed in two years of methane drainage during preparation for coal extraction. This amount of captured methane lowered methane content in this section of the strata to such a degree that it was not necessary to apply methane drainage during coal extraction. Table 2 shows typical methane drainage results obtained in one of the drivages of Moszczenica Colliery.

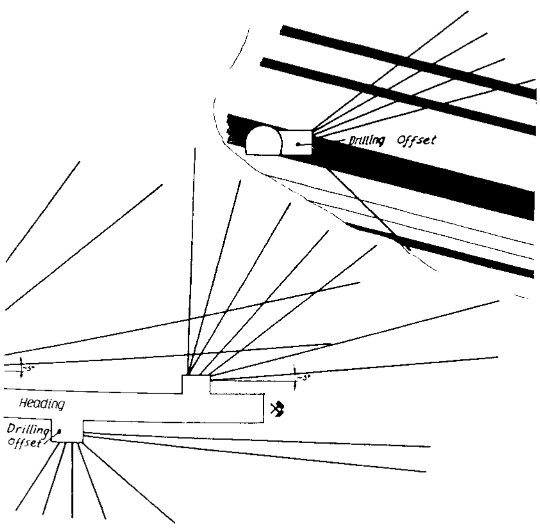

Fig. 3. Strata predrainage during development.

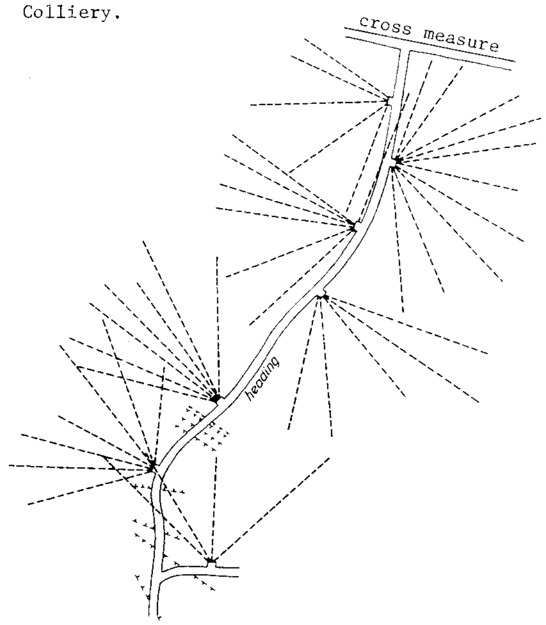

Fig. 4. Strata predrainage during drivages and panel development.

TABLE 2

Typical methane drainage results obtained in one of the drivages of Moszczenica Colliery

Month	Methane Output: In Drainage	Methane Output: In Ventilation	Methane Output: Total	Boreholes: Number	Boreholes: Total Length	Entry Advance (m)
	m3/month					
Dec	-	88,300	88,300	-	-	50
Jan	41,700	66,960	108,660	5	405	81
Feb	27,600	54,290	81,890	5	405	81
Mar	31,200	49,100	80,300	5	405	81
Apr	40,100	46,650	86,750	11	860	174
May	97,700	28,570	126,270	25	2,161	266
Jun	130,000	43,200	173,200	35	3,007	353
Jul	212,000	66,960	278,960	53	4,432	406
Aug	237,400	60,206	297,664	69	5,796	473
Sep	197,800	64,800	262,600	77	6,395	560
Oct	287,700	71,870	359,570	88	7,348	623
Nov	295,900	38,880	234,780	95	8,013	623
Dec	339,700	101,780	441,480	95	8,013	623

PREDRAINAGE OF WORKING SEAM AFTER PANEL DEVELOPMENT BUT PRIOR TO EXTRACTION

With a seam thickness greater than 2 m and in conditions of sufficiently high permeability of the coal, predrainage of the working seam is applied. It has been proved that for mining conditions in Polish collieries this method gives satisfactory results in some seams but only if the depth is less than 350 m.

It has been applied most frequently in seams of greater than 3 m thickness mined using the longwall system (face parallel to strike) with hydraulic stowing or caving.

The holes were drilled in the seam directly from inclines and parallel to the face at spacings of 5 m to 20 m or fanwise from special drilling offsets situated every 50 m to 70 m (Fig. 5). The variables which influence the

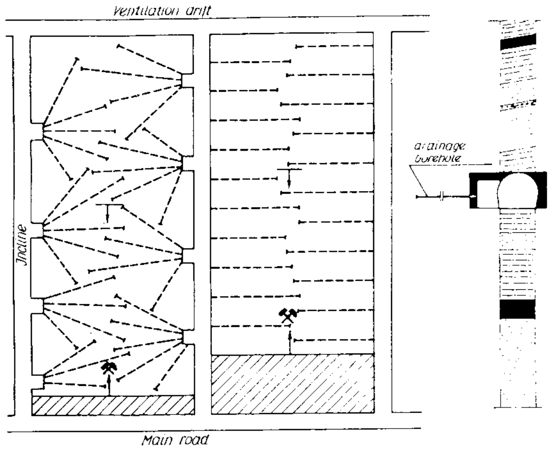

Fig. 5. Predrainage of working seam after panel development but prior to extraction.

drilling conditions are:

1. the length of boreholes drilled in the seam depending on the mining and technical conditions,
2. drainage holes diameters 65 mm to 100 mm,
3. optimum suction 3 to 16 kPa, and
4. the length of standpipe 1 m to 6 m.

Even in the same group of seams and at approximately the same depths in various collieries the recovery rate of methane by predrainage varied from 8 to 40 per cent while in other geological conditions it was not at all possible to drain an unrelaxed seam. Table 3 gives details of predrainage effectiveness of an unrelaxed seam in longwall system (face parallel to strike) ready for extraction in Jastrzebie Colliery. Table 4 gives the calculated percentage of methane extracted from the original deposit for periods of methane capture in Jastrzebie and Moszczenica Collieries.

If the coal seam permeability is high enough the effectiveness of predrainage depends mainly on two factors:

1. lead time available for predrainage, and
2. the number of drainage holes.

The length of boreholes is limited by the size of the longwall block and the suction is decreased in the hole at a certain distance from the rib. The borehole diameter is of very slight importance. The spacing between the holes depends on the permeability of the seam and on the mutual influence of the holes when the suction is applied.

The level of suction which should be applied depends on the sealing ability of the standpipe, on the methane content of the seam and on the permeability. For Polish conditions the steps for applying predrainage of the seam are as follows:

1. drilling 3 to 5 test boreholes in the seam,
2. carrying out tests on methane capturing under suction conditions,
3. minimum effective output for a single borehole should be 60 l of CH_4/min, and
4. total output for a single borehole after the full period of CH_4 capturing should be at least 25,000 m^3 of CH_4 (Myszor, 1977-79).

THE ROLE PLAYED IN METHANE CONTROL BY DEGASIFICATION OF COAL EXTRACTION WORKINGS

During mining of seams at depths greater than 250 m, emission of methane from the seams and adjacent strata into the mine workings was so high that it was not possible to maintain safe working conditions exclusively by ventilation means. With many faces, only after introducing additional methane drainage from coal extraction workings during mining was it possible to take advantage of their full coal production capacities. Due to the low permeability of seams and rocks the effectiveness of predrainage was minimum.

In degasifying from coal extraction workings advantage is taken of the phenomenon of increased strata permeability, mainly that of coal, due to stress relaxation of roof and floor rocks caused by extraction. This relaxation brings about degassing of the layers and this process lasts from the onset of relaxation to the renewed stressing of strata during settling.

For Polish collieries the optimum emission was found to be from when the longwall face was 10 m ahead of the hole to 50 m behind the hole. The methane emission from the relaxed zone tapers off at a distance of 120 m to 300 m behind the longwall face.

TECHNOLOGY OF COAL EXTRACTION DEGASIFICATION

In Polish coal mines two basic methods are used for the degasification of stress relaxed strata directly from the mine workings.

1. Degasification by drainage holes drilled

TABLE 3

Methane emission, amount of methane captured by drainage, and methane drainage parameters in a longwall system (face parallel to strike) with hydraulic stowage

Longwall	Year	Month	Methane Output: In Drainage	In Ventilation	Total	Number of productive drainage boreholes	Suction kPa	Recovery rate of methane by degsfcn. %
			m^3/day					
Longwall 12b/Jas.	1972	Jan	2,894	3,096	5,990	36	5.72	48
		Feb	2,707	5,400	8,107	36	5.98	33
		Mar	2,577	4,104	6,684	36	7.98	39
		Apr	2,549	3,008	5,645	33	8.65	45
		May	1,728	5,400	4,128	32	9.57	24
		Jun	1,425	4,104	5,529	26	11.44	26
		Jul	850	2,880	3,730	24	11.31	26
		Aug	288	4,190	4,478	17	9.98	7
		Sep	374	3,554	3,931	17	9.44	10
		Oct	274	4,190	4,464	17	9.04	5
		Nov	259	3,686	3,945	17	11.31	6
		Dec	346	5,500	5,846	17	12.64	7
	1973	Jan	187	4,435	4,622	8	13.83	6
Longwall 9b/10a/Jas.	1971	Sep	1,843	2,722	4,565	22	5.98	40
		Oct	1,757	3,442	5,199	22	6.12	39
		Nov	1,843	2,376	4,219	22	4.65	43
		Dec	2,074	2,434	4,508	22	5.19	46
	1972	Jan	763	3,888	4,651	19	3.72	16
		Feb	590	3,946	4,536	17	4.26	13
		Mar	331	2,131	2,4 2	17	3.06	13
		Apr	360	2,462	2,822	9	4.65	12
		May	346	3,010	3,355	9	5.98	10
		Jun	360	3,154	2,514	6	6.38	10
Longwall 10b/Jas.	1972	Aug	778	5,688	6,466	15	8.65	12
		Sep	1,454	6,077	7,531	15	11.44	19
		Oct	1,411	6,322	7,733	15	7.18	18
		Nov	1,426	6,134	7,580	15	8.38	19
		Dec	1,325	6,710	8,035	17	12.24	16
	1973	Jan	1,051	3,053	4,104	5	13.70	26
		Feb	518	3,326	3,844	5	15.30	13
		Mar	245	3,347	3,586	5	10.77	7
		Apr	230	3,485	3,775	5	13.57	6
		May	230	4,219	4,449	5	14.36	5

TABLE 4

Calculated percentage of methane extraction from original deposit in Jastrzebie and Moszczenica Collieries

Working	Methane m^3	Coal tonne	Capture (months)	Methane captured by degasification m^3	Percentage of methane extracted %
Incline No. 9 Seam 505/1 Jas.	2,115,500	148,800	3	91,500	4
			6	189,200	9
			9	423,300	20
			12	575,600	28
			15	739,800	35
			18	876,200	42
Incline No. 12-13 Seam 505/1 Jas	2,605,300	187,200	3	101,700	4
			6	191,500	7
			9	312,900	12
			12	436,100	17
			23	1,137,200	43
			26	1,432,900	55
Gate 1 Seam 505/1 Mos.	4,773,600	368,300	3	229,400	5
			9	708,800	15
			15	1,660,300	35
			21	2,673,600	56
			30	4,235,300	88
Main Gate Z 1 Seam 510/Mos.	14,882,400	1,148,400	3	153,000	1
			6	617,300	4
			9	1,318,700	9
			11	1,619,200	11

from underground workings. This method consists in capturing methane from the relaxed strata directly from the sources of methane emission.

2. Degasification from behind stoppings. This method consists in capturing methane which has previously been released into mine workings and goaves.

The degasification method that is most frequently used, particularly in deep mines (below 350 m), is drainage of longwall faces by boreholes drilled from underground workings, and methane capture from strata relaxed by mining activities. These boreholes are generally drilled into the surrounding gas-bearing strata with diameters 42, 65 or 80 mm, lengths 50 to 150 m and angle of inclination -35^{o} to $+75^{o}$.

Each borehole is sealed with a standpipe and connected to the underground degasification pipeline network. On the surface or underground, gas pumps or compressors are installed with the necessary monitoring and measuring system (methane drainage plant).

In all cases the methane is captured and transported by means of suction from the degasification stations equipped either with gas pumps with a water ring, or with rotary compressors with sliding blades and permitted for compressing flammable gases.

The surface, shaft and underground pipeline networks are made of steel pipes having diameters of 400, 300, 200 and 150 mm. Depending on the requirements three types of degasification stations are used:

1. Ejector stations for local degasification in collieries underground (most often for one longwall). Maximum suction 13 kPa, Pressure - on the vent.
2. Degasification stations on the surface with water-ring pumps. Maximum suction 50 kPa, Pressure 40 kPa.
3. Compressor degasification station on the surface. Maximum suction 50 kPa, Pressure 120 kPa.

Each station is instrumented with control, monitoring and protective equipment and also an automatically controlled suction valve. At present in Poland 20 surface degasification stations are in operation with five underground ejector stations. The total capacity of those stations is 3,000 m^3/min.

In all cases the methane - air mixture is sucked into the degasification pipelines whenever the CH_4 level is over 30%.

The choice of the degasification method depends upon the gassiness predictions, methane balance data, geological and mining conditions and the effectiveness of methane drainage.

The following technical parameters are individually determined for each particular longwall:

1. drilling site,
2. angles of inclination and deflection of boreholes (vertical and horizontal),
3. length of boreholes and range in relation to the source of methane,
3. drainage hole diameters,
5. spacing of boreholes,
6. length and type of borehole sealing (stand pipe),
7. magnitude of suction, and
8. CH_4 content in the mixture.

It is very important to maximise the life of the drainage holes by protecting the headings from which the holes are drilled and by allowing the capture of methane at least in the relaxed zone.

METHANE DRAINAGE EFFECTIVENESS WITH REGARD TO MINING SYSTEMS

In Polish collieries, the following mining systems are applied for gassy seams requiring methane drainage during extraction.

1. advancing and retreating along-the-strike longwall systems with caving, and
2. longwall systems with face parallel to strike and hydraulic stowing or caving.

Taking into consideration the degasification technologies applied, and the sources of gas emission, the following classification of mining systems in collieries with methane drainage has been accepted.

1. Degasification of adjacent seams and associated rocks
   a) advancing along-the-strike longwall system with caving and maintaining ventilation drift in the goaf area (Fig. 6),
   b) retreating along-the-strike longwall system with roof caving and double ventilation drift, and partially maintaining it in the goaf area (Fig. 7), and
   c) retreating along-the-strike longwall

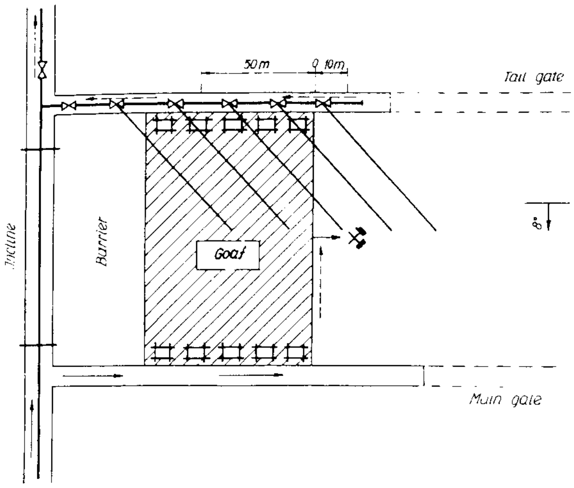

Fig. 6. Advancing along-the-strike longwall system with roof caving

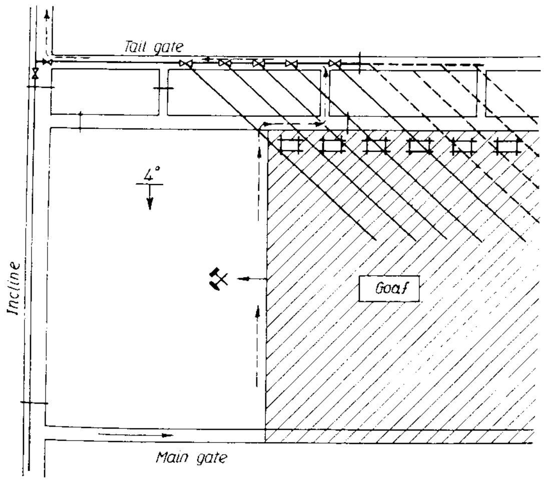

Fig. 7. Retreating along-the-strike longwall system with roof caving and double ventilation drift

system without the ventilation drift in the goaf area (Fig. 8).

2. Degasification of sealed-off areas and goaves
   a) system of isolating goaves and workings by stoppings, and
   b) system of leaving protective pillars of coalwinning panels and drilling drainage holes above the pillars to the relaxed zone (Fig. 9).

Depending on the mining system and the geological conditions, different degasification results are obtained. The measure of the optimum degasification is the recovery rate of methane by degasification; it represents the percentage of the captured methane in relation to the total methane make.

Due to the great number of factors influencing the variation of this rate, statistical investigations were made on the effectiveness of methane drainage for the individual mining systems used in Polish gassy mines. The

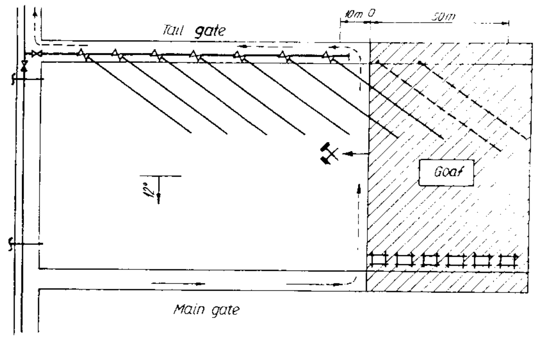

Fig. 8. Retreating along-the-strike longwall system with roof caving

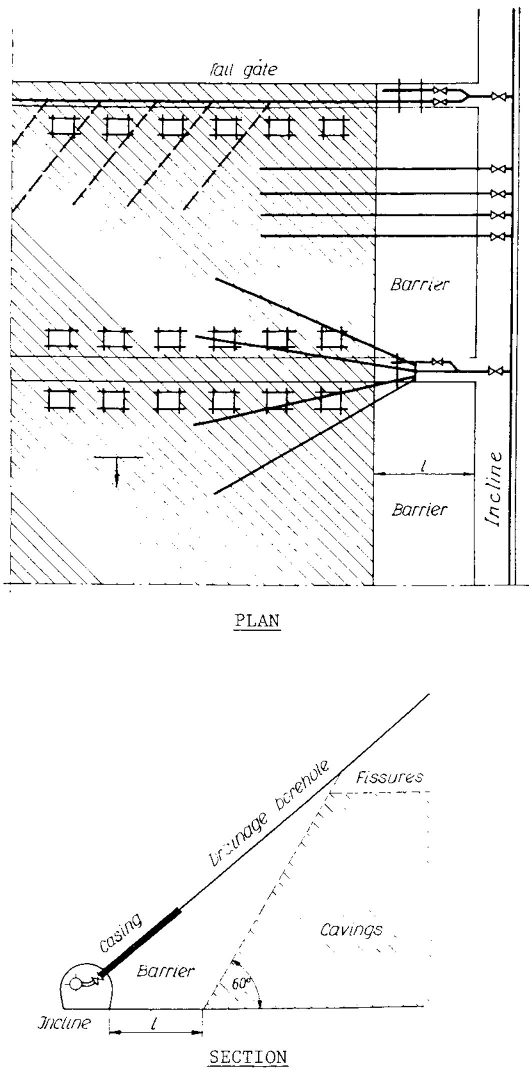

Fig. 9. Goaf Degasification

a) from behind stoppings

b) by means of drainage boreholes

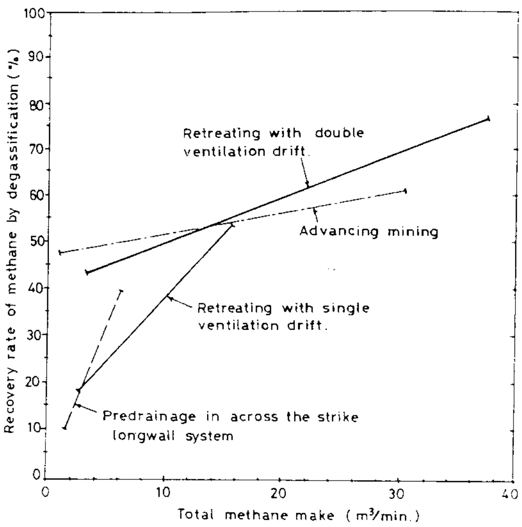

Fig. 10. Cumulative characteristics of recovery rates of methane by degasification at variable total methane make at different mining systems

(L.W. Lunarzewski, 1976)

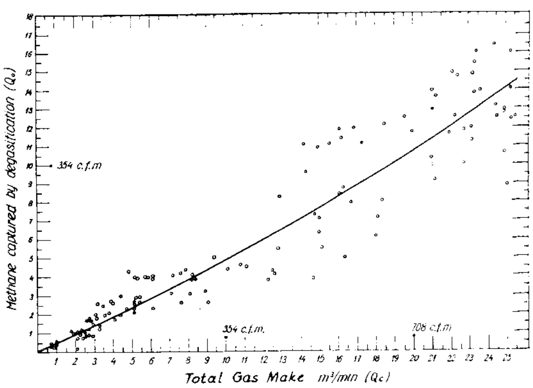

Fig. 11. The relation between the quantity of methane captured by degasification and total gas make. Advancing along-the-strike longwall system with roof caving

exemplary results are shown in figs. 10 to 13.

The effectiveness of methane drainage and the value of the recovery rate for the various systems as a function of the total gas make and for the conditions of Polish gassy mines have been determined by the following empirical formulas:

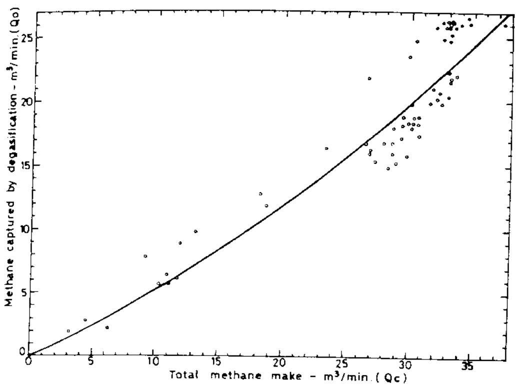

Fig. 12. The relation between the quantity of methane captured by degasification and total gas make retreating along the strike longwall system with roof caving and double ventilation drift.

Quantity of methane captured by degasification in coal extracting workings,

$$Q_o = a.Q_c + b.Q_c^{\,2} \quad m^3/min, \quad \text{and}$$

Recovery rate of methane by degasification,

$$E = \frac{Q_o}{Q_c} \cdot 100\% \qquad E = A + B.Q_c\%$$

The average values of recovery rates for the abovementioned systems are respectively:

1. advancing mining -
   $E_1 = 47.8 + 0.42\ Q_c$ (48 to 60%)
2. retreating with double ventilation drift -
   $E_2 = 41.2 + 0.91\ Q_c$ (44 to 75%)
3. retreating with single ventilation drift -
   $E_3 = 11.3 + 2.7\ Q_c$ (18 to 55%)
4. predrainage in seam -
   $E_4 = 1.2 + 6.4\ Q_c$ (11 to 40%)

where:

- Q_o quantity of methane captured by methane drainage, m^3/min of CH_4
- Q_c total methane make, m^3/min of CH_4 (methane captured and ventilation)
- E recovery rate of methane by degasification (%)
- a,b,A,B empirical coefficients determining the gas conditions as well as the mining, geological and technical conditions for the various mining systems.

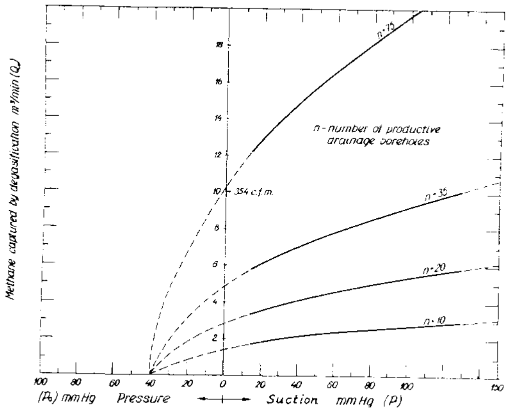

Fig. 13. The relation between the quantity of methane captured by degasification and the applied suction as well as the number of drainage holes. Advancing along-the-strike longwall system with roof caving.

The relation between the quantity of methane captured by degasification and the applied suction as well as the number of productive drainage holes has been determined by the empirical formula:

$$Q_o = A_1.n_o.\sqrt{P-P_o} \quad m^3/min, \text{ where } P>P_o \text{ for 3, and } P>0 \text{ for 1.2 and 4.}$$

The average volumes of methane captured by degasification for the various systems are:

1. advancing mining -
   $Q_o = 0.022\ n_o\sqrt{P + 41.3}$ m^3/min
2. retreating with double ventilation drift -
   $Q_o = 0.023\ n_o\sqrt{P + 45.6}$ m^3/min
3. retreating with single ventilation drift -
   $Q_o = 0.032\ n_o\sqrt{P - 8.9}$ m^3/min
4. predrainage in seam
   $Q_o = 0.006\ n_o\sqrt{P + 54.8}$ m^3/min, where:

Q_o	methane captured by degasification, m^3/min
n_o	number of productive drainage holes
P	value of the applied suction (mm Hg), and
A_1 and P_o	are empirical coefficients for various mining systems.

CONCLUSIONS

The above data show that the choice of the degasification system depends on the geological and mining conditions as well as on the effectiveness of methane drainage. In degasifying coal mine workings the quantity and recovery rate of methane captured by degasification vary for the different mining systems. The magnitude of quantity and recovery rate depend on the total methane make (methane content in seam), on the number of productive drainage holes and on the level of the applied suction. The gas as well as the mining, geological and technical conditions are also very important factors and their influence can be expressed mathematically. Due to the great number of factors influencing the variation in the recovery rate of methane by degasification, statistical analyses are used to assess the degasification effectiveness in Polish gassy mines for the various mining systems. Experiments have confirmed the commonly accepted rule that for the case of coal extraction workings, the best degasification results are echieved in advancing longwall and in retreating longwall systems with double ventilation drift. Less favourable results are obtained in retreating faces with single entry headings.

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DISCUSSION

I. GRAY (A.C.I.R.L.): In the actual drilling equipment used for drilling through fractured zones for post drainage, some people say drill before mining, some people say drill after the zone is caved and the holes don't close, but what does appear to be a problem - and it may not be - is the flushing medium. Is water lost in the fractures, is it a serious problem in over the goaf drainage? Are scrolls used or air flush and what is the thinking behind this question?

L. LUNARZEWSKI (Visiting Polish Methane Drainage Specialist to B.H.P. Steel Division Collieries): Only water flushing is used. (If fractured zones are too wide, the holes are drilled in the solid zone, before the face).