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CONTROL OF GAS OUTBURSTS AT MOUNT DAVY MINE

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ABSTRACT

Mount Davy Mine was begun in the mid 1990's to exploit a high quality coking coal reserve on the West Coast of the South Island of New Zealand. Between November 1997 and July 1999, twenty one outbursts of gas and coal or rock occurred during drivage of the drifts and pit bottom roadways. The largest of these involved 600 tonnes of coal and 12,400 m³ of methane. Attempts to characterise the gas outbursts highlighted significant differences compared with European and Australian outburst experience. The outbursts were clearly associated with the severe stressing of the seams by both folding and faulting. This paper describes the occurrence of the outbursts, the measures pursued to prevent the outbursts and the measures adopted to minimise the hazards to the workforce. A practical method of prevention of outbursts was not developed. Gas drainage investigations to attempt to prevent outbursts were not completed.

KEY WORDS

Outbursts; gas content; V_{30}-value, k_t-value, shotfiring.

INTRODUCTION

Mount Davy Mine is located 14 km north of Greymouth on the West Coast of the South Island of New Zealand. The mine is situated on the bank of the Seven-Mile creek amongst mountainous terrain. Coal mining has been conducted in the valley since the beginning of the 20th century.

The mine was developed to access low sulphur, high fluidity coking coal from the Sub Morgan seam for export. Drivage to the reserves was via two 1100 m cross measure drifts at a gradient of 1:5 and 1:6. Work began at the mine in May 1995 and the mine was closed August 1999. Prior to Mount Davy mine no record of gas outbursts had been encountered in the 123 years of coal mining in New Zealand. Between October 1997 and July 1999 21 outburst incidents occurred. Tragically, one outburst resulted in two fatalities.

GEOLOGY

The coal deposit is from the upper Cretaceous period in the Paparoa Group. The Morgan coal measures are the lowest in the sequence within the Paparoa Group, beneath the Rewanui and Brunner coal measures. Access to the Morgan coal measures was through the "R6" fault. This fault had been identified as a reverse fault having approximately 200 m displacement.

The Sub Morgan seam is typically 5 m thick with a strong sandstone roof. The nearest coal seam is the 3.5 m thick McArthur seam approximately 90 m above in the Rewanui coal measures.

PROJECT FEASIBILITY STUDY

The project plan proposed that Drift 1 would be driven to intersect the Sub Morgan seam at a depth of approximately 700 metres. Once in the seam a pillar would be established from which geotechnical trials would be conducted. The trials were intended to establish the coal permeability, gas content, outburst propensity, roof support requirements and provide a bulk sample of the Sub Morgan coal. If conditions were proven favourable, the second drift would be constructed to establish an air circuit.

Hydraulic mining was proposed to exploit the deposit, utilising high-pressure water to extract the coal. The pit bottom location was planned as the lowest point in the deposit in order to facilitate flume transport of the coal.

The feasibility study for the project had identified the potential for outbursts in the Sub Morgan in relation to a measured methane content of 9.4 m³/tonne and the rank of the coal (vitrinite reflectance of 1.28). This was related to the Australian upper threshold for mechanised mining in outburst prone deposits of 9.0m³ of CH_4 per tonne.

PRELIMINARY CONTROL MEASURES

The leading Australian consultancy in the field of outburst control, GeoGAS Pty Ltd, was engaged to assist with designing safety measures to mitigate the hazard. The hazard was considered present in both the Sub Morgan and McArthur seam horizons. These horizons were planned to be driven using shotfiring techniques, this effectively ensured that personnel were not exposed to the hazard when outbursts could be expected to occur. A laboratory was established at the mine site for conducting gas content measurements. The geotechnical programme envisaged preparation of five inseam boreholes, 150 metres long to obtain core samples and gas flow measurements. This would be used to ascertain the coal permeability and propensity to outbursting.

DRIFT 1 OUTBURSTS

Drift 1 was driven east of the R6 fault by shotfiring methods. Intersection with the 3.55 m McArthur seam at 900 m presented no significant problems. The roof of the Sub Morgan seam was encountered at 1050 m on the 8th October 1997. Figure 1 indicates the location of the first three incidents.

Outburst "SM1"

The face was advanced shotfiring full face rounds comprising 800 gram cartridges of Powergel permitted explosive. On 14.10.97 at 05.45 hrs a round of 26 holes in a part coal part stone face was detonated from the surface of the drift. Upon re-entering the drift at 07.10 hrs the CH_4 level was found to be 4% at the 850 m sub station. The CH_4 general body level remained at ~4.5% until 11.06 hrs.

Based on the records of a portable data logging methane detector, the methane emission during this period was 2800 m³ above the normal emission. No excess coal was recorded as having come from the shot. Following this incident the size of the round was reduced to a maximum of eight holes.

Outburst "SM2"

By the morning of 17.10.97, Drift 1 had advanced to 1072 m. A round of eight shots was detonated at 0730 hrs from the 850 m substation in the drift. Upon examination of the face the supervisor found 13% CH_4 and 18% O_2. The crew remained at the face in front of the ventilation ducting until the general body oxygen increased above 19%.

The methane emission from this event was estimated as 2580 m³ over the four hours between 0730 and 1145 when the general body reading was 2.0% CH_4. No significant excess coal was identified upon examination of the face.

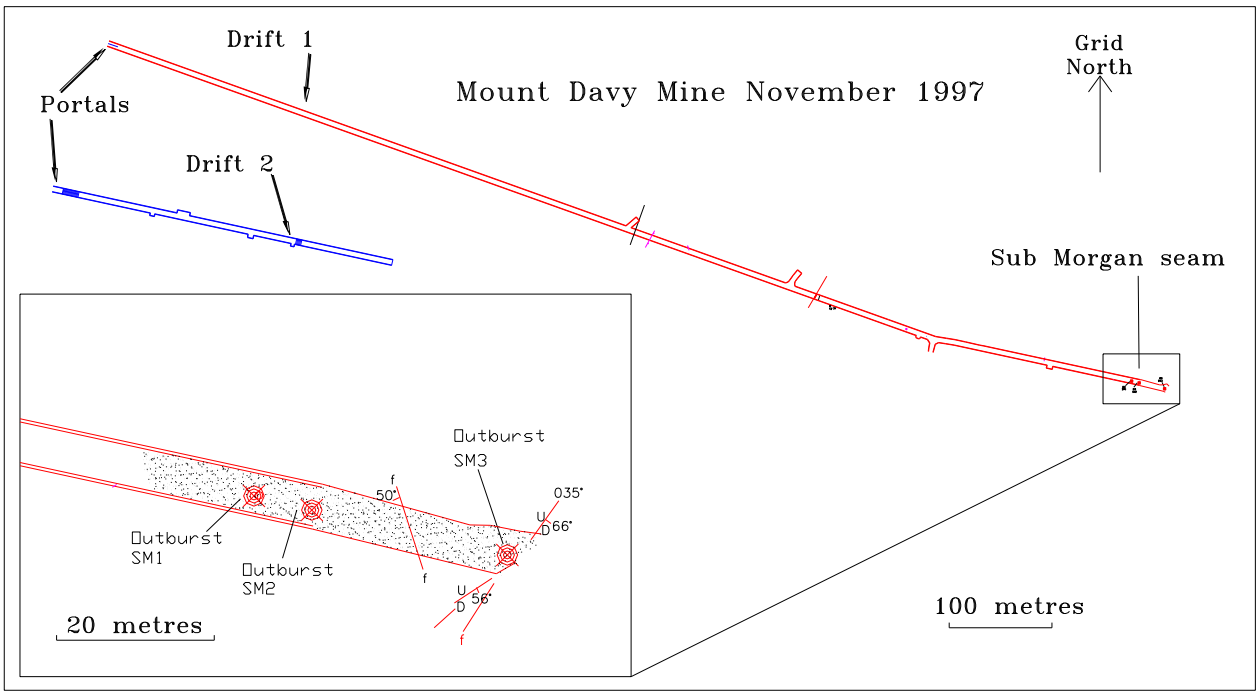

Figure 1. Plan of Mount Davy Mine at 4th November 1997, showing location of outbursts 1 to 3.

After this incident, the face was advanced using single shots. The first two incidents were not initially identified as outbursts.

Outburst "SM3"

Development of Drift 1 in seam continued using single shot firing, advancing and supporting one side of the face before completing the other side. On 04/11/97 the face was at 1091m when, at 2150 hrs, the final shot of six holes was detonated. The crew was sheltering 70 m from the face to fire the shot. The supervisor reported:

> *"Fired shot, went off alright, waited a few seconds, started to bump and rumble, then air rushing (like a ventilation ducting), coal movement, then a large bang followed by coal dust and air movement."*

The crew evacuated the drift with an oxygen reading of ~16% and methane reading of 13%. The drift was degassed by 0923 on the 5/11/97. Upon examination, 25 m of roadway at the end the drift was found to be filled with fine coal. Approximately 300 tonnes of outburst coal was removed from this area. A four meter throw normal fault was identified obliquely across the face, with a 300 mm diameter hole in the rib at the seam/fault intersection. It is assumed that a large portion of the coal fines were transported by the outburst gasses along the fault plane and into the drift via this hole.

Following this incident development in the Sub Morgan seam was suspended until a ventilation circuit with Drift 2 was established at the 850 m position. It was clear that the sub Morgan seam was prone to outbursts and that continued drivage was likely to encounter further outbursts with the associated hazards of flammable and asphyxiant gas mixtures. It was agreed that adopting the Australian practice of pre-drainage would be desirable and necessary to prevent outbursts. A surface methane drainage plant was started to enable pre-drainage trials to be conducted. A management system referred to as "Authority to Mine" was implemented which specifically detailed the extent and approved procedures for further development in the Sub Morgan and McArthur seams.

Initial Drilling Experience

Inseam drilling in the sub Morgan seam to obtain core samples and define seam structure commenced on 13.12.97 whilst development work continued joining Drift 1 and Drift 2. Drilling was conducted with a Longyear LM37 rotary drill rig. Drilling conditions were described as "severe". Frequent seizing of rods occurred with high-pressure gas venting from the holes preventing drilling. The longest hole, at 117 m, took 13 days to drill. 479 m of holes were drilled in the Sub Morgan seam and 171m in the McArthur seam.

In total 39 gas content tests were conducted indicating a maximum of 9.16 m³/tonne. The distribution of gas contents is shown in Figure 2. A typical gas chromatographic analysis of the seam gas indicated in Table 1.

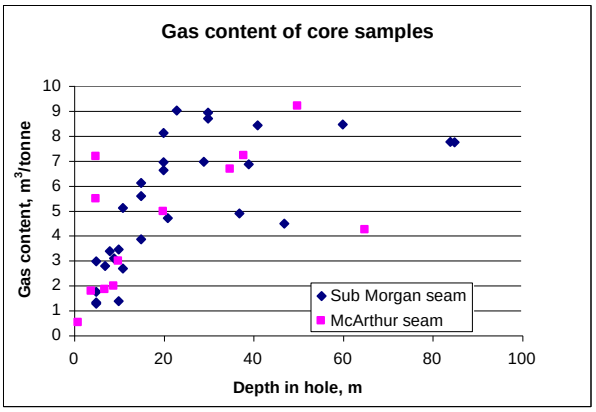

Figure 3. *Gas content of core samples*

Table 1. Sub Morgan seam gas analysis.

Gas	CH_4	C_2H_6	C_3H_8	CO_2
%	91.2	6.75	1.29	3.9

DRIFT 2 OUTBURSTS

Drift 2 was started in January 1996 in order to maintain the mine development schedule. Following experience of ground conditions gained in Drift 1 a medium duty, remote controlled roadheading machine was purchased for Drift 2. Outburst events were not expected to be encountered in Drift 2 for two reasons: Drift 1 had not experienced gas emission problems in the similar strata; and the accepted opinion was that the outburst hazard was associated with the thick coal seams.

Outburst 4

On the night shift of 28.05.98 the Drift 2 roadheader electrical interlock tripped the machine after an emission of coal and gas from a 0.1m seam in the face at 680 m. Approximately 50 kg of fine coal was expelled from the seam onto the left hand side of the machine. Drivage in the heading was discontinued until a risk assessment had been conducted.

The immediate 15m in front of the drivage was drilled with a pattern of 9 holes to detect the presence of coal seams. Drilling indicated that no coal seams were present along the centre of the drift, however coal less than 1 m thick was contacted in the right hand side of the drift. The conclusion of the risk

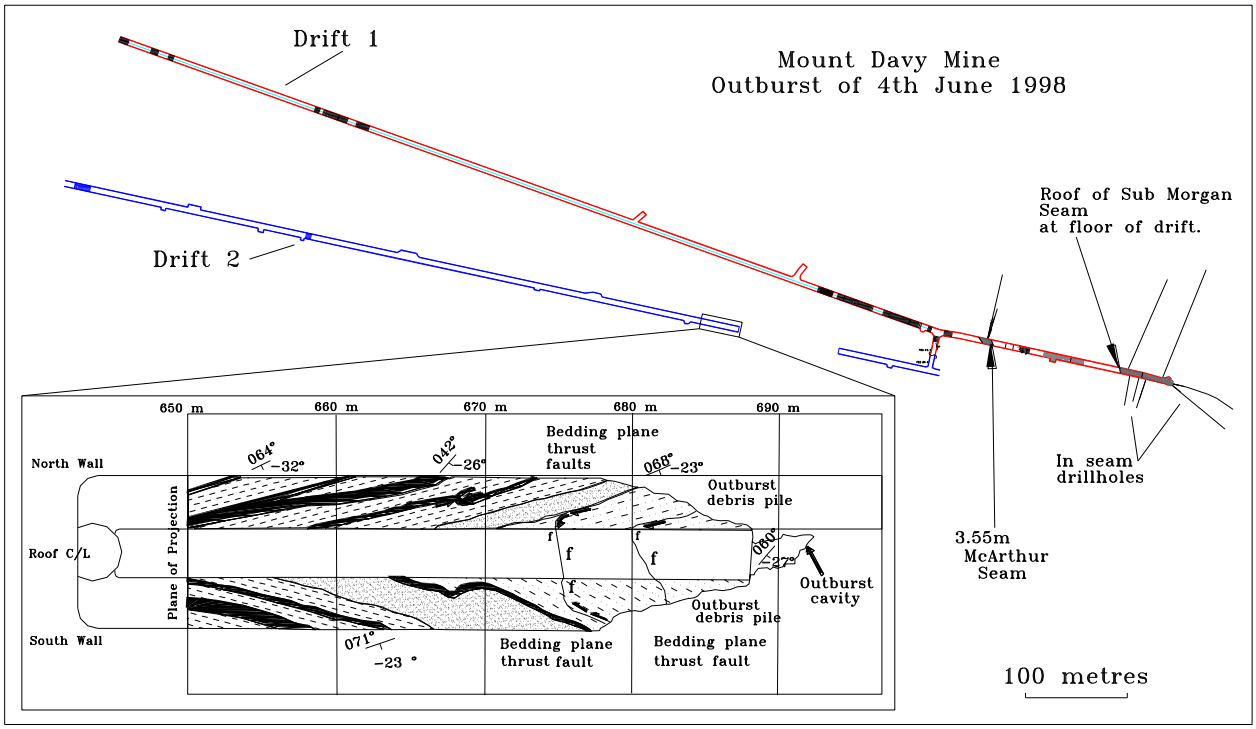

Figure 2. Site of Outburst 5 in Drift2, showing geological structure at outburst site.

assessment was to continue the drivage using the roadheader whilst repeating the advance drilling to maintain a minimum of five metres overlap using 10 m long exploratory holes.

Outburst 5

At 1604 hrs on 04.06.98, an outburst of coal and gas occurred at 687 m in the face of Drift 2. Approximately 30 tonnes of fine coal was ejected from a 0.8 m seam in the upper left-hand side of the face onto the heading machine. Two operators of the machine were asphyxiated by the methane and buried by the coal towards the rear and to one side of the machine. The quantity of gas emitted by the outburst was estimated as 1529 m^3 in the first 30 minutes. Records from a data-logging instrument at the face show that oxygen fell to 5% at the beginning of the outburst. Examination of the coal seam indicated it to be intensely sheared, having an ash content of 55%, and a vitrinite reflectance of 0.92.

Precautionary measures. Following the fatal outburst, the roadheader was removed and only shot firing was permitted for the development of all drives at Mount Davy until a preventative system could be established. The method of shot hole drilling was considered with respect to the likelihood of initiating an outburst. No reference could be found in mining literature to outbursts being induced by drilling of shot holes. Drilling was conducted using a twin boom flameproof drill jumbo with a compressed air supply to the operators cab.

Outbursts 6 & 7

Two outbursts of sandstone occurred in Drift 2 prior to contact with the sub Morgan seam. Outburst 6 occurred on 27.10.98 at 950 m and yielded 50 tonne of rock and 1096 m^3 CH_4, the second occurred on 16.12.98 at 1010 m, and yielded 136 tonnes of rock and 259 m^3 CH_4. Both outbursts were induced by shotfiring and resulted in dome shape roof cavities above the drive. The ejected sandstone formed thin sheets giving an "onion peel" appearance.

An interesting characteristic of the sandstone outburst was that all of the methane was released in a short period of time. During the outburst of the 27th October the methane readings returned to normal after 18 minutes, this contrasts with periods of three to fifteen hours for the coal outbursts.

McARTHUR SEAM

Between September and December 1998 150 metres was driven in coal in the McArthur seam. No outbursts were experienced. Drivage was by shotfiring, detonation of the rounds was from a shot firing station on the intake drift. The shot holes were drilled by hand. After the rounds were fired, grab samples were taken from the face at tested for gas content. The grab sample average gas content was 5.3 m^3/tonne.

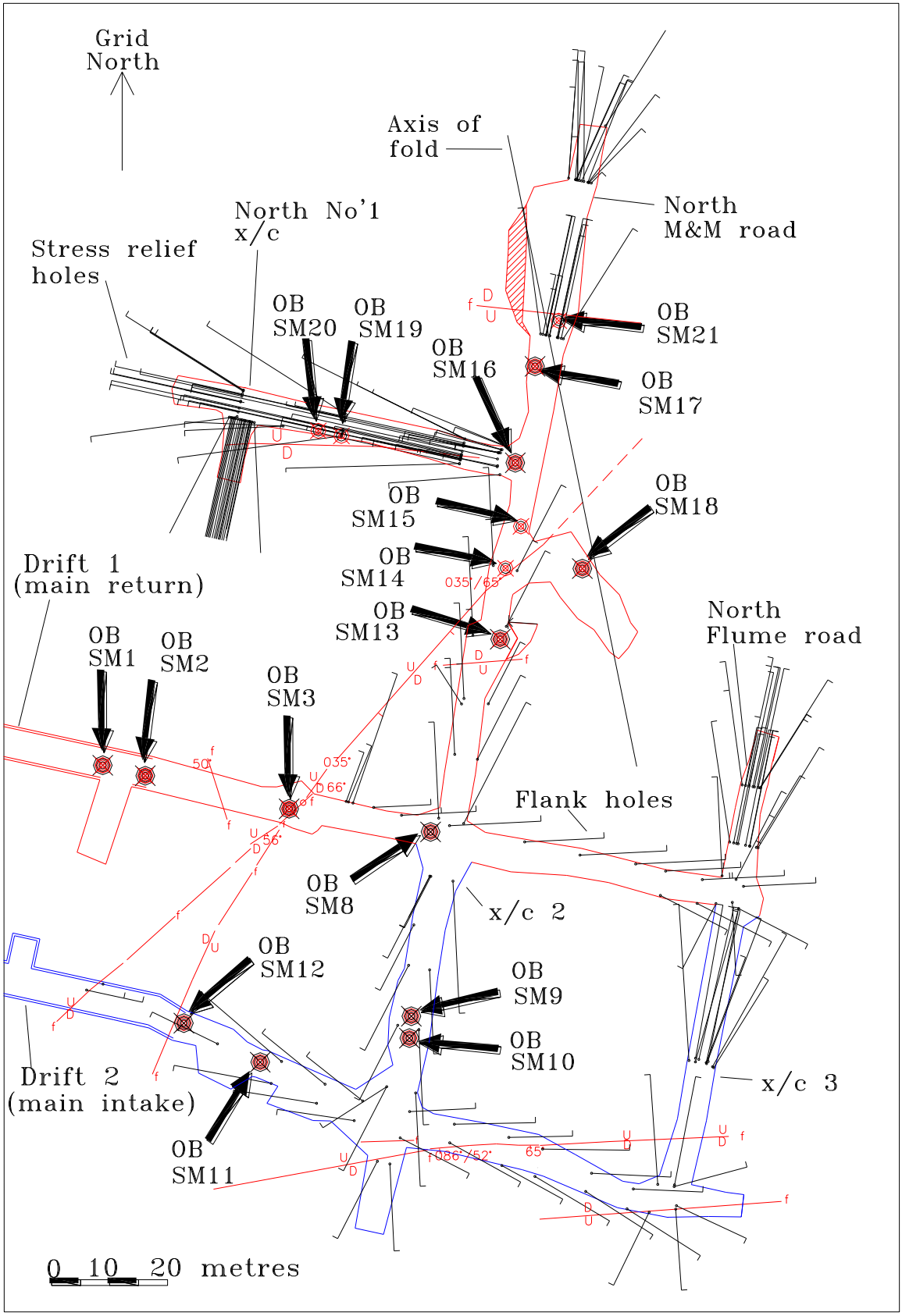

Figure 4. X/C 2 and North M&M drivage outbursts, showing stress relief holes.

SUB MORGAN SEAM OUTBURSTS

Subsequent outbursts in the sub Morgan seam occurred in two locations, in cross cut two drivage connecting the two drifts and in the North M&M drivage. Development in the sub Morgan seam recommenced in December 1998 with the intention of establishing a circuit to Drift 2. The locations of the outbursts are shown in figure 4.

X/C 2 outbursts

The cross cut 2 incidents were relatively small outbursts between 5 and 90 tonnes with total gas emissions varying between 1080 and 1788 m³ (gas emission outburst "SM10" occurred over 30 hours). Outbursts "SM9" and "SM10" occurred at the site of a small step in the roof. Details of the outbursts are shown in table 2. Flank hole drilling was conducted prior to drivage in order to identify faulting in advance of the heading. The holes were drilled with a rotary 65mm drill. Drilling rates were slow due to high-pressure gas and water venting.

Table 2. X/C 2 outbursts

Outburst No'	Date	Gas Emission, m³	Coal ejected, tonnes
SM8	08.01.99	1,080	26
SM9	20.01.99	1,148	5
SM10	22.01.99	15,940	80
SM11	15.02.99	1,165	42
SM12	21.02.99	1,788	90

North M&M Outbursts

The North M&M experienced outbursts associated with both faulting and bedding plane shears. The shear zones were noted parallel to the seam roof, typically 0.3 m thick. An asymmetric fold in the seam existed to the east of the drivage, resulting in the seam dipping at 30° to the east. The north M&M drivage encountered the axis of the fold in the region of outburst 17 and 21. Along this axis outbursts occurred involving the ejection of substantial quantity of the shear zone, often extending 10 m into the rib side.

Outburst "SM18". On the 22.04.99 a large outburst resulted 422 tonnes of fine coal filling 70 meters of roadway. Hitherto, the outbursts had resulted in localised flammable mixtures, with CH_4 concentrations in the main return drift typically reaching 4%. This outburst resulted in 12.5% CH_4 in 80 m³/s airflow in the return drift; 5% CH_4 was identified in the surface fan house adjacent to the drift; 1% was detected at the shotfiring station in the intake drift outbye of 1 cross cut. Development was suspended pending an assessment of preventative options and further consideration of the upper size of outbursts that might be anticipated.

Stress relief drilling. Following consultation with GeoGAS, and in conjunction with DMT a system of stress relief drilling was implemented as an outburst preventative measure. A pattern of eight holes, 25 metres long and 95 mm diameter was implemented for stress relief in the immediate face. Monitoring of cutting volume and gas liberation was systematically recorded to indicate potential outburst zones. A system of dry drilling using 87 mm diameter scroll rods and a 95 mm tri-cone bit was developed to overcome the problem of seizing of rods caused by gas pressure and flushing fluid. Development restarted on 8 June 1999. A "real-time" methane monitoring system was commissioned on 24 June providing readings every 60 seconds.

Outbursts SM19 and 20. Two comparatively small outbursts were induced during drivage of No1 cross cut north. The second incident clearly demonstrated one mechanism causing outbursts. A vertical, 0.1 m throw, East/West trending fault, had been intersected in the drive. On 29.06.99, when the round was detonated, 1380 m³ of CH_4 was released from the fault plane in the rib side seven metres outbye of the face. On examination the butterfly plates and rib mesh were found to have "ballooned" out into the roadway, with no apparent outburst cavity at the face. The rib bolts had remained securely anchored in the coal beyond the fault plane. This incident demonstrated that fault planes could act as conduits of gas outbursts without coal ejection.

Table 3. North M&M Outbursts

Outburst No'	Date	30 minute gas emission, m³	Tonnes ejected.
SM13	19.03.99	2,505	240
SM14	07.04.99	635	-
SM15	09.04.99	537	-
SM16	12.04.99	1,802	170
SM17	21.04.99	3,290	147
SM18	22.04.99	6,993	422
SM19	24.06.99	672	-
SM20	29.06.99	1,380	-
SM21	01.07.99	12,474	600

Methane yields from shotfiring. The "real time" monitoring system enabled the gas emissions from each round to be measured. The average methane emission during the 30 minutes after shotfiring (excluding outbursts) was 49 m³. Monitoring sites were established in the intake drift in order to provide an automated electrical isolation facility. During outbursts "SM18" and "SM21" 5% methane was identified at the substation at the bottom of the intake drift indicating that methane had travelled against the main ventilation flow.

Prior to the outburst incident "SM20" the emission from the previous round released 109 m³ of CH_4. The monitored gas levels in the main return resulting from this emission and that of the outburst "SM20" are shown in figure 5. Calculated gas emissions subsequent to shotfiring are shown in table 4.

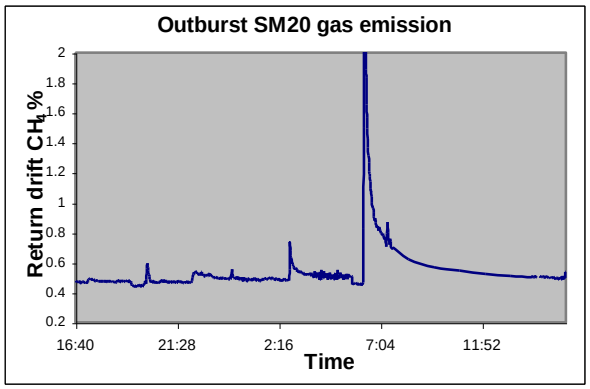

Figure 5. Outburst SM20 gas emission.

Outburst "SM21". The final outburst at the mine occurred in the North M&M on 01.07.99. The place had been fired twice with no monitored gas emission resulting from the rounds. After the detonation of the third round the CH_4 in the return drift increased from 0.4% to 90%. The power to the mine was isolated whilst the gas cleared the ventilation circuit.

Upon examination, the outburst had ejected some 600 tonnes of coal from a bedding shear zone at least 25 by 30 metres in area. The outburst occurred where the axis of the fold previously mentioned crossed the drivage. A 0.4 metre, down throw fault was evident across the drivage. It is speculated that the liberation of the free gas along the fault plane stimulated the spontaneous fluidisation of the fine coal and desorbed gas in the bedding shear zone.

CHARACTERISATION OF THE SUB MORGAN OUTBURST ENVIRONMENT

Characteristic Features of the Deposit

After outburst "SM21" further investigations to characterise the outbursts were conducted in conjunction with DMT GmbH. The following essential characteristic features of the deposit were established:

The Mt. Davy deposit shows the traces of an intense tectonic stress that has led to bedding shear zones in Sub Morgan seam. These bedding shears are most pronounced in areas of folding. In addition to the folding, the rock is interspersed by faults, which are partly of a normal and partly of a reverse nature. Altogether, six downthrows faults were identified in the Sub Morgan seam.

The total gas content measured in Sub Morgan seam is 9.6 m^3/t. The desorbable gas content was determined as 7.1 m^3/t from the volatile matter content of the coal (30.6 % waf). The gas pressure prevailing in the seam was determined, from the measured sorption isotherms, as 20 to 25 bar.

Desorption Values

The proneness of the coal to gas outbursts was estimated by determining the desorption characteristics V_{30} and k_t respectively.

Desorption characteristic V_{30}: The desorption characteristic V_{30} is used in the German coal mining industry for road headings driven by shotfiring. It relates to the gas emission within the first 30 minutes after firing. The V_{30}-value is the measured gas emission as a percentage, of the desorbable gas content (in m^3/t) of the mass of coal that has been excavated by the round.

Table 4. Gas emission & V_{30} values after shotfiring.

Date	Time	Heading	Advance [m]	Gas-volume in 30 min [m³]	V_{30}-value [%]
24.06.99	01:20	N No1 x/c			
28.06.99	08:30	N No1 x/c	1,4	0	0,0
28.06.99	20:02	N No1 x/c	1,6	27,1	11,8
28.06.99	22:13	N No1 x/c	1,4	109,61	54,5
29.06.99	05:45	N No1 x/c	outburst		
29.06.99	17:49	N No1 x/c	2	47,3	16,4
30.06.99	05:30	N No1 x/c	2,2	26,68	8,4
03.07.99	07:35	N No1 x/c	1,4	8,15	4,0
03.07.99	11:40	N No1 x/c	1,8	37,74	14,6
05.07.99	02:15	N No1 x/c	1,4	21,68	10,8
05.07.99	08:36	N No1 x/c	1,9	126,66	46,4
05.07.99	17:34	N No1 x/c	1,9	93,56	34,2
15.07.99	14:00	N No1 x/c	2	13,55	4,7
16.07.99	13:16	N No1 x/c	1,6	17,77	7,7
17.07.99	06:09	N No1 x/c	1,8	72,85	28,1
17.07.99	13:20	N No1 x/c	1,8	92,06	35,6
19.07.99	03:15	N No1 x/c	2,4	58,96	17,1
19.07.99	20:18	N No1 x/c	1,7	119,39	48,8
24.06.99	20:00	N Flume	1,8	0	0,0
25.06.99	05:30	N Flume	1,2	23,17	13,4
25.06.99	14:18	N Flume	2,5	173,26	48,2
26.06.99	09:36	N Flume	0,9	30,56	23,6
28.06.99	03:01	N Flume	1,4	21,6	10,7
29.06.99	02:45	N Flume	2,5	142	39,5
12.07.99	15:29	N Flume	1,1	0	0,0
13.07.99	10:38	N Flume	2,1	64,25	21,3
14.07.99	18:30	N Flume	1,5	109,79	50,9
21.07.99	00:45	N Flume	1,5	11,61	5,4
21.07.99	05:45	N Flume	2,7	25,66	6,6
21.07.99	11:02	N Flume	1,4	105,51	52,4
30.06.99	12:59	N M&M	1,1	7,1	4,5
30.06.99	23:10	N M&M	1,8	0	0,0
01.07.99	01:43	N M&M	outburst		

After the installation of the methane monitoring system, V_{30}-values were determined for all roadways headed by shotfiring (table 4).

Threshold V_{30}-values used in the German coal mining industry indicate:

- V_{30} value ≥ 40%, proneness to gas outburst
- V_{30} value ≥ 60%, acute outburst risk.

It can be seen that the V_{30}-value determined prior to outburst "SM20" was in excess of the 40% threshold. However, in the case of the outburst "SM21" on 1st July, the V_{30}-value of the previous round, had fallen to zero, even though the coalface had had little time to discharge gas. This indicates a blockage in the gas emission mechanism. Therefore, at Mount Davy, for gas outburst prediction using the desorption characteristic V_{30}, both excesses of the threshold value and substantial reductions, are relevant.

Desorption characteristic k_t: To estimate the gas-dynamic behaviour of Sub Morgan seam, coal samples were taken over the accessible seam profile at the face of the headings and examined for desorption behaviour of the coal by determining k_t-values. Measurement of k_t-values was developed in German coal mining to assess the proneness of the coal to gas outbursts. Experience gained in the German hard coal mining industry indicates:

- k_t-value between 0.61 and 0.68, normal gas-emitting coal.
- k_t-values > 0.68, tectonically stressed coal.
- k_t-values > 0.75, proneness to gas outbursts.

Figure 6 shows the schematic distribution of k_t values derived from the samples taken at three faces in Sub Morgan seam. High k_t-values were identified in the bedding shear zones, immediately beneath the roof of the seam at the face of North M+M and North Flume roads. The bedding shear zones were noticeably thicker in the bend from flat to inclined bedding, specifically in the North M+M road. The coal immediately below the shear zone was also tectonically stressed, but did not display the properties of coal prone to gas outbursts.

Modifications to stress relief drilling pattern.

Outburst "SM21" occurred despite the preparation of 12, 95mm diameter, stress relief holes in the face. It was considered that this was in part due to the strong sandstone roof preventing a re-distribution of stress around the relief holes.

In order to induce relaxation in the face and promote controlled methane desorption, modifications to the stress relief drilling pattern were developed in conjunction with DMT. The modifications proposed involved three stages, which would progressively increase relaxation of coal in the face.

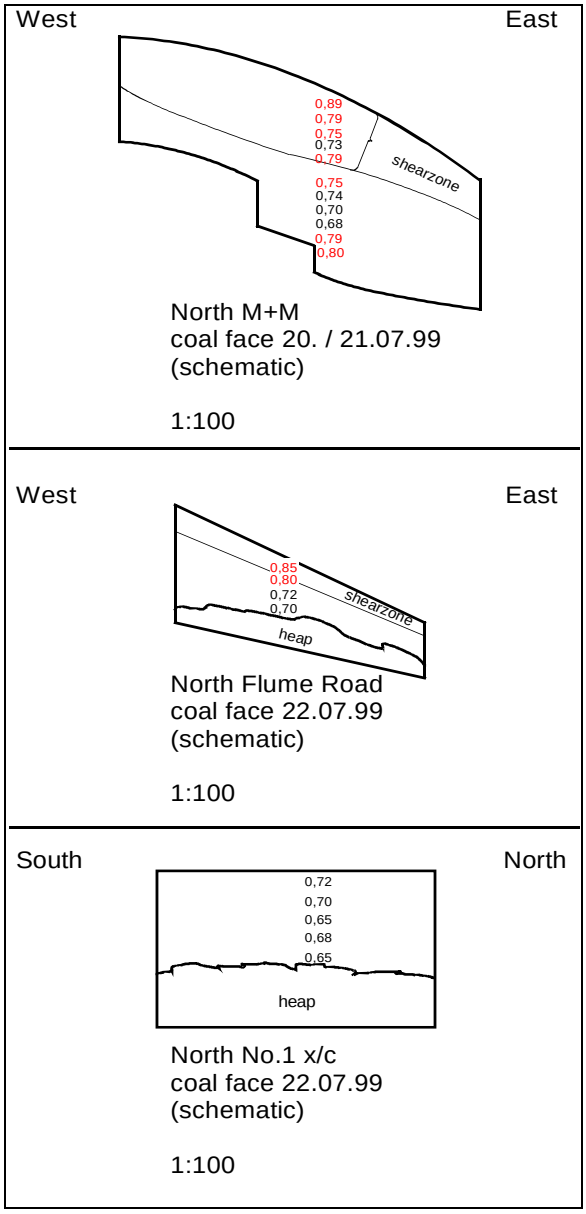

Figure 6. k_t desorption characteristics in Sub Morgan seam faces.

The proposed modifications involved:

- Altering the drilling pattern to focus in the bedding shear zones (see figure 7.)
- Increasing the diameter of relief holes to 140 mm.
- Preparation of a horizontal "slot" in the face across the base of the drivage.

These changes to the drilling pattern were accompanied by enhanced precautionary safety measures for the drilling crew. These involved, operation of the drill rig using a remote video monitor from behind an armoured barricade 20 m from the face and the use of compressed air breathing apparatus by the drill crew.

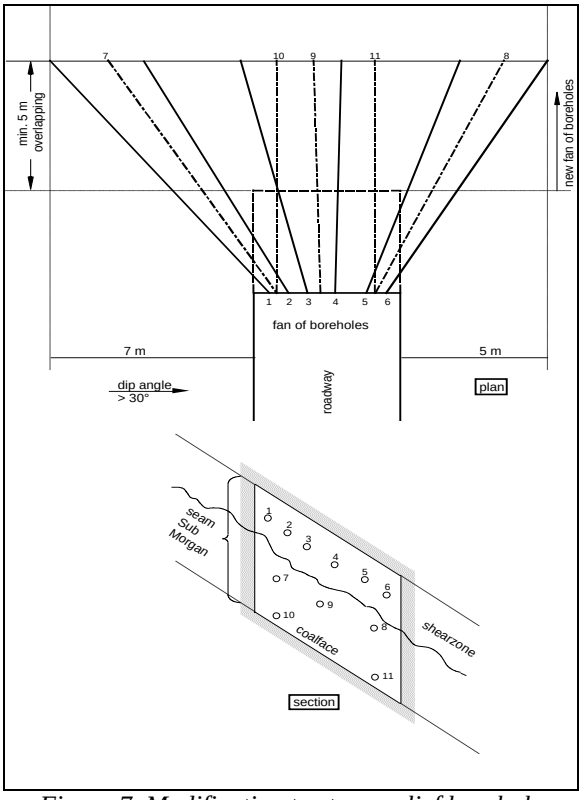

Figure 7. Modification to stress relief borehole pattern, Sub Morgan seam.

Trials with 140mm diameter relief holes and horizontal slot installation were conducted with apparent improvement in relaxation of the face. The trials were not conducted in locations of extensive bedding shear and remain inconclusive in relation to the ability to prevent outbursts.

COMPARISON OF THE GAS OUTBURSTS AT MT. DAVY WITH OTHER MINES

A number of points may be made with regard to Mount Davy in comparison to outburst mines in Germany, Poland, Australia, and Spain:

- Gas/coal outbursts here, as in other places, are linked mainly to tectonic induced shearing/faulting.
- Tectonic faults oblique to the stratification are comparatively easy to identify and define in terms of their position and formation.
- Gas outbursts at faults oblique to the stratification can normally be controlled by means of appropriately adapted drilling arrangements.
- At Mount Davy mine there is localised bedding shear parallel to the stratification; its occurrence is fold-dependent and it is distinct. Such shear zones are relatively rare in coal mines (Ibbenbüren, Asturias).
- The control of gas outbursts at shear zones parallel to the stratification is more difficult and requires greater effort than at locally defined tectonic faults, such as downthrows.

CONCLUSION

Observations at Mount Davy in comparison with other outburst mines throughout the world lead to the conclusion that the gas outburst hazard at Sub Morgan seam is unusually great due to a combination of factors: the deposit is located in a tectonically highly stressed environment which has resulted in folding, faulting and localised bedding shear in the Sub Morgan seam; the coal in the bedding shear zones has little cohesion; the gas reservoir is large, despite the modest gas content of the coal, due to the large seam thickness and the high insitu gas pressure.

Preventing gas outbursts by local measures in zones of large scale tectonic stress remains a significant challenge as experiences in other mines such as Ibbenbüren in Germany, show.

Following outburst “SM21” the mine viability was again examined. Although improvements in drilling rates had been achieved using scroll drill rods, the ability to systematically pre-drain gas from the seam had not been demonstrated due largely to difficulties in drilling. Neither had the practicality of preventing outbursts using de-stressing techniques been demonstrated. Due largely to these unresolved issues and the uncertainties of devising a safe and commercially viable mining method, the mine was shut on 1st of August 1999.

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