CASE STUDY MANAGEMENT OF OUTBURST RISK AT TAHMOOR COLLIERY

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INTRODUCTION

Tahmoor Colliery mines the Bulli Seam at a depth of 400-440m and has had to manage the risk of outbursts since it commenced production in the early 1980's. Of necessity, it has been at the forefront of the development of systems to reduce outburst risks and has made many significant contributions to the industry in this regard. In the 1980's, the general strategy for addressing these risks was that outbursts were "inevitable" and so most effort went into protection against their consequences. By the 1990's, this approach was no longer acceptable and there was a major redirection of effort towards the prevention of outbursts. This effort has been highly successful and there has not been an outburst at Tahmoor since 1992, when predrainage of development commenced. Prior to 1992, outbursts were occurring at an average rate of about 10 per year.

SUMMARY OF TAHMOOR OUTBURST HISTORY

Critical events and stages of outburst management at Tahmoor include:

- 1981 – first recorded outburst
- 1985 – continuous miner driver killed by outburst whilst cutting dyke
- 1985 – encapsulated continuous miner introduced for cutting outburst structures
- 1982 to 1992 – averaging 10 outbursts per year crossing structures
- 1992 – introduced ABM20 continuous miner
- 1992 – commenced predrainage of coal around structures
- 1992 – draft Outburst Management Plan
- 1992 – remote mining through fault, last prepared a recorded outburst
- 1992 to 1997 – ongoing refinement of drilling techniques
- 1994 – Outburst Management Plan formalised
- 1999 to 2001 – grunching through "tight" coal zones

TAHMOOR OUTBURST ENVIRONMENT

The Bulli Seam mined at Tahmoor is between 1.8 and 2.3m thick. The incidence of geological anomalies such as faults and dykes is probably about average for current Bulli Seam mines. The virgin gas content is typically 12 to 13m^3/tonne. The relatively unique feature of Tahmoor is the high proportion of carbon dioxide in the Bulli Seam gas. For all the coal mined to date, the Bulli Seam has probably averaged about 65% CO_2 and 35% CH_4. In the last two years, this ratio has typically been 90% CO_2 to 10% CH_4. For the Tahmoor North area some four kilometres to the north of current mine workings, where longwall extraction will commence in 2004, the ratio gradually changes to become methane-rich, at 30%CO_2 to 70%CH_4,. This high proportion of CO_2 makes the gas drainage task harder for several reasons. Firstly, the gas threshold to which to drain is around 6.5m^3/tonne, whereas if the gas was 100% CH_4, it would be 9.5m^3/tonne. Secondly, CO_2 is inherently harder to drain because the coal has a greater affinity for CO_2 than for CH_4. Consequently, it is necessary at Tahmoor for the drainage holes to be more closely spaced and left on suction for a significantly longer time, compared to mines where the seam gas is predominantly CH_4.

[1] Austral Coal

Several common factors have been associated with all outbursts that have occurred at Tahmoor:

- They were invariably associated with the actual cutting of coal. None occurred when the face was being bolted or on non-production activities.
- They were invariably associated with either a fault or a dyk. It is not known for them to occur because of variations in the coal texture, eg mylonite zones, as occurred at some other Bulli Seam mines.
- High gas content.

In the last three years, some zones of coal which are abnormally difficult to drain have been encountered in the Southwest portion of the lease. This change in drainage characteristics does not appear to be related to any increase in outburst proneness, but results in the need for much-increased drainage effort and/or special mining techniques. This "tight" coal is the subject of ongoing research.

SIGNIFICANT TAHMOOR CONTRIBUTIONS

Because Tahmoor had a significant outburst problem from the early 1980's and they were few systems available to the industry at this time, systems had to be developed locally to enable mining to continue with reasonable levels of risk. Of necessity, Tahmoor has been responsible for many innovations including:

- Design and development of the encapsulated continuous miner concept.
- Introduction of Ripu Lama's gas content thresholds in conjunction with Westcliff.
- Introduction of the first outburst management plans in conjunction with Westcliff.
- The first remote mining of outburst structures and the first televised outburst.
- First large-scale use of grunching, as an outburst mining technique.

OUTBURST RISK MANAGEMENT IN THE 1980'S

The first outburst occurred not long after mining of the seam commenced. It soon became apparent that outbursts were to be expected whenever a fault or dyke was encountered. They could be anywhere from a bucketful to many tonnes of coal and came to be accepted as just part of working at Tahmoor. All this changed in 1985 when a fatality occurred whilst a dyke was being cut by a continuous miner. This involved over 200 tonnes of ejected coal and was violent enough to move the 45-tonne continuous miner back more than a metre. This event caused a rapid rethink about the outburst risk. The encapsulated continuous miner was quickly developed as a tool to enable structures to be safely mined. The key features of this system were:

- It was limited to only the miner driver at the face when cutting the structure.
- Radio communications to the miner driver.
- Independent filtered compressed air supply to the miner cabin and backup air supply in bottles.
- Physical protection of the cabin with Lexan screen and steel door.
- A standby squad of rescue personnel at the fresh air base, wearing breathing apparatus, ready to assist anyone at the face, should an outburst occur.

The encapsulated miners were used to traverse scores of faults and dykes and withstood many actual outbursts, without injury to personnel. The concept was soon copied by other Bulli Seam mines and "bomb squad" conditions became the standard way of handling perceived zones of high outburst risk. Whilst proving to be a reasonably safe technique for known zones, there was still no defence against a previously unidentified structure encountered without warning during coal cutting. This risk to be later highlighted by the multiple fatality at South Bulli, in 1992.

At the time, the encapsulated continuous miner was a significant advancement. The underlying philosophy was that outbursts were not preventable and so the best risk management strategy was to provide protection against their consequences. This was made somewhat more palatable to the crews involved by the payment of outburst allowances. Whilst these were often dressed up as allowances for extra skills, they were in fact "danger money" and rewarded people for taking risks. Meanwhile, outbursts continued to occur at the rate of about 10 per year at Tahmoor and the frequency at other mines was increasing, as they steadily progressed westwards into deeper coal with higher gas content.

OUTBURST RISK MANAGEMENT IN THE 1990'S

By the early 1990's, risk assessment techniques from outside industries started to be applied to coal mining and Tahmoor conducted a risk assessment for the introduction of a new type of continuous miner. The ABM20 was radically different in the fact that it was actually continuous, coal cutting and roof support took place simultaneously. There were to be four operators installing bolts from a platform located about 1m back from the cutting head. It soon became evident these operators would be exposed to an unacceptable risk of an outburst resulting from an unexpected occurrence of a structure in the coal face. Systems had to be introduced to address this risk. It would not be feasible to protect these operators from the consequences of an outburst. The strategy had to change immediately to preventing the outburst occurring. We were fortunately able to draw on the work of Dr Ripu Lama, who had put massive effort into reviewing the worldwide experience with outbursts and their control. Probably the most significant single conclusion from Dr Lama's work was that if you remove sufficient of the gas from the coal, an outburst cannot occur.

Trials were conducted as soon as the necessary drilling equipment could be acquired. Gas drainage was initially done around known faults and dykes, as these were perceived to constitute the biggest risk. This original drilling and drainage was rather hit-and-miss, as there was a lack of ability to accurately steer the hole. Even so, it appeared effective from the very early stages, as structures which had previously outburst on nearly every encounter were now being mined without outbursts occurring.

Combining Dr Lama's work with local experience, Tahmoor developed the first draft of our Outburst Management Plan. To have an outburst at Tahmoor two things were necessary, high gas, plus the existence of a fault or dyke. Because both these were necessary for an outburst, controlling either should be sufficient to prevent an outburst. A "belt and braces" approach ws adopted to address both, to allow a margin for error. The prime objectives of the Plan should thus be – reduce the gas content and find the structures (so that they can be avoided or mined with special techniques). Concurrently with Westcliff, we drafted and implemented Outburst Management Plans. These draft plans soon became the template for the mandatory Plans required by the DMR in the Bulli Seam. The Tahmoor Outburst Plan remains essentially in the same format today, with minor amendments and refinements.

Throughout the 1990's there was continual improvement in drilling techniques for predrainage. Initially, any gas drained was a plus, but by the mid-1990's, predrainage of all development was a necessity. The most critical factor in this improvement was the capability to survey and steer the hole. Drilling was originally rotary, with single-shot survey. As more and more drilling was undertaken, the limitation of these techniques became evident. This was because single-shot survey severely reduced drilling availability as holes became longer and, because it was not real-time, it could not be used to actively steer the hole. It only recorded where the hole had been. There was a progressive transition to down-the-hole motors with electronic real-time survey tools. These have enabled faster, more accurate and more consistent drilling. Given the right circumstances, roadways can now be predrained up to 800m away from the drill site. The progressive improvement in drilling techniques is well illustrated by Fig.1. It can be seen that in 1994 (right hand side of diagram), some areas were overdrilled, whilst others were underdrilled and thus drainage was less than optimum. By 2001 (left hand side), the patterns are very evenly spaced, giving almost perfect coverage of the areas to be drained. The accuracy achieved in the drilling is impressive as drillholes are typically encountered during mining to be within 2m of where the survey indicates. Annual drainage hole drilling typically exceeds 60km and requires some 12 employees.

Another interesting development during the 1990's was the development of remote mining. With the introduction of the radio controlled ABM20's, it was suggested that they could be automated, to enable a be mined with nobody at the face during actual cutting. Tahmoor staff developed a system to drive the ABM20 remotely and it was used to traverse a 3m fault in the Eastern part of the mine. The system involved a lot of complex gear including video cameras,and signal systems, that had never been applied to underground coal. Successful mining was carried out part of the way through the fault, but then, as anticipated, an outburst of about 60 tonnes occurred, damaging the ABM20. This outburst was viewed remotely by the operators, but could unfortunately not be recorded. We believe this to be the world's first televised outburst. This project was successful in proving that remote mining of outburst prone zones was possible. In 1993, an ACARP grant was received to fund the further enhancement of remote mining. The major addition was the "separately-ventilated" control room. This was a caravan-like trailer from which the face equipment was controlled. By drawing fresh air from well outbye, the need to use special flameproof equipment was avoided and also the operators were relieved of the need to continuously wear breathing apparatus. This system was successfully applied to the crossing of a dyke in the Longwall 14 gateroads.

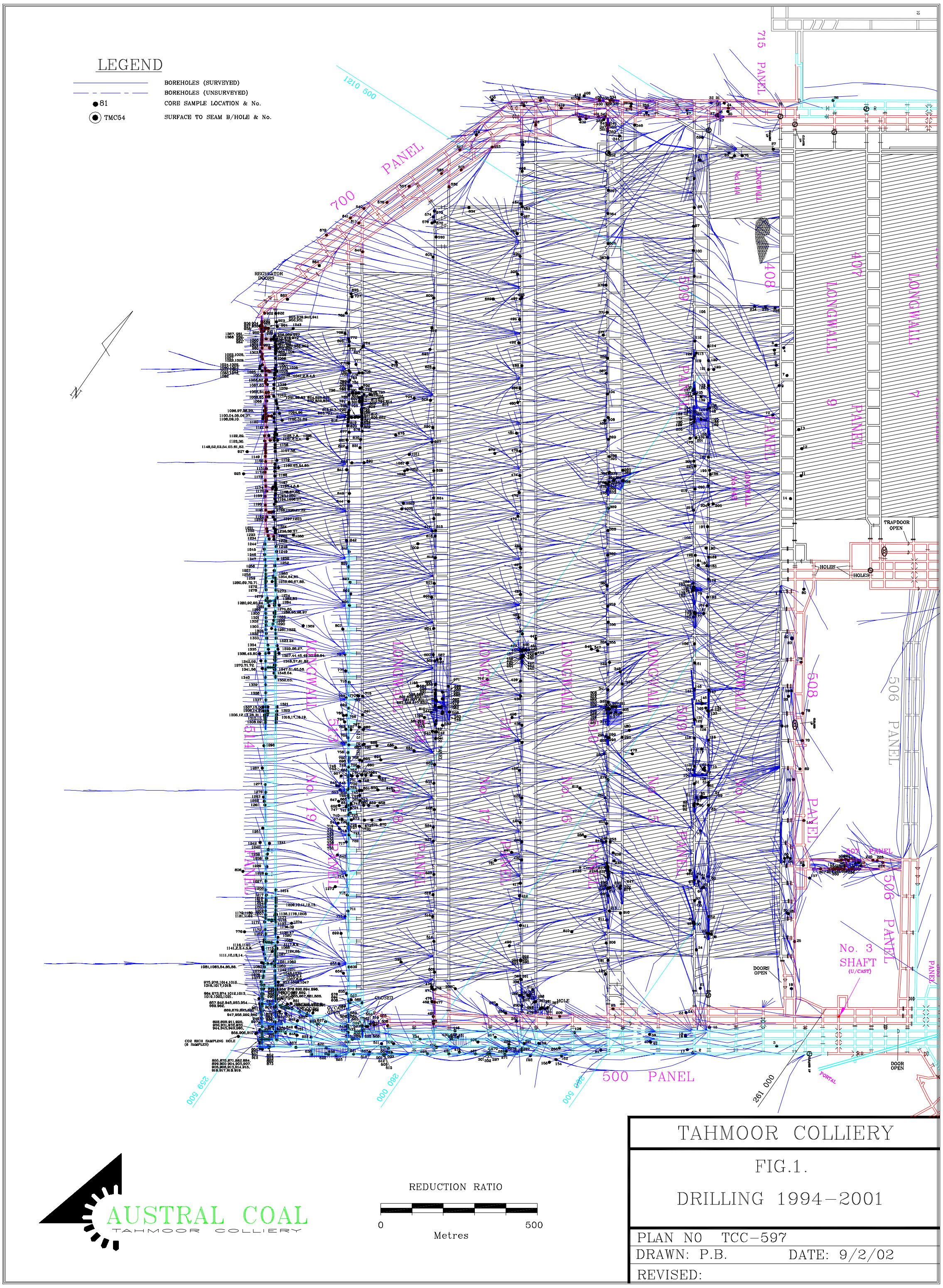

Fig. 1 Drilling Techniques

THE TAHMOOR OUTBURST MANAGEMENT PLAN

The essential elements of the Plan are:

1. Drill and predrain the coal which typically requires holes at about 20m spacing on suction for 3 to 6 months. The location of every hole must be surveyed, so that there are no patches of coal left undrained.
2. Monitor borehole flow. If these are less than expected additional measures may be required, eg redrill at closer spacing.
3. Drill "scout" hole as a final check for structures, then take and analyse core sample.
4. If samples pass and scout holes are accurate and clear, authorise each pillar length's advance for each panel. This involves at least three individuals, to minimise the chance of error.
5. Quality system issues such as audits, training, reviews and document control are included.

The requirements of the Outburst Management Plan are onerous. I would estimate that it requires several hours involvement per week for the manager, development superintendent, mine geologist and the drilling superintendent. Of all the systems in place at Tahmoor, it is probably adhered to most rigorously, as it is literally a life-and-death matter. A typical Authorisation plan is shown in Fig 2. On the back of this, and as part of the Authorisation, is the drilling and drainage data, shown as Fig 3. This diagram shows where samples were taken, location of "scout" holes and where intersections of drillholes should be expected. This gives some idea of the background work necessary for each authorisation.

The last outburst was in 1992. There have been no outbursts since the initial Outburst Management Plan was introduced. As there has been no overall change in the outburst potential of the coal mined, this success can only be attributed to the effectiveness of the Plan. Had we not had the Plan, with its associated drainage, outbursts would still almost certainly be occurring at the rate of 10 per year.

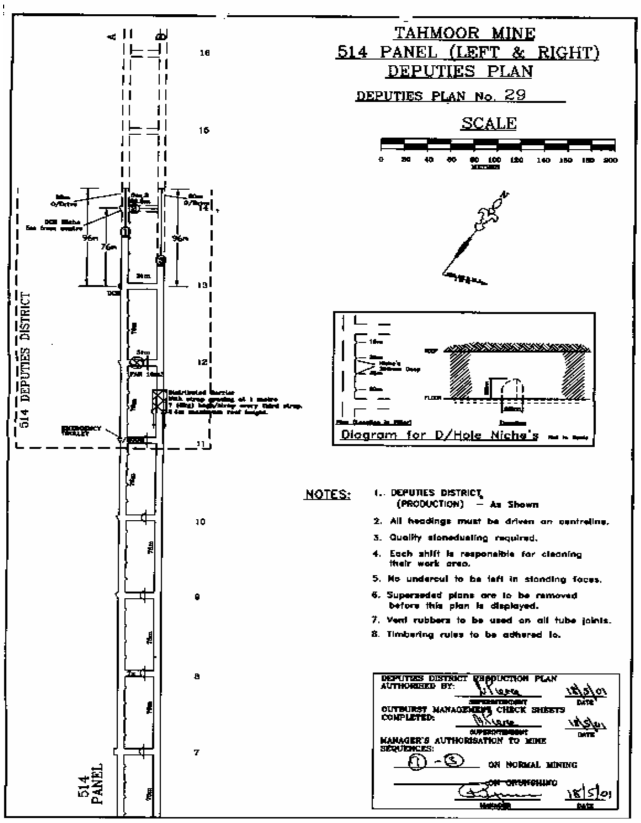

Figure 2 – Typical Outburst Authorisation

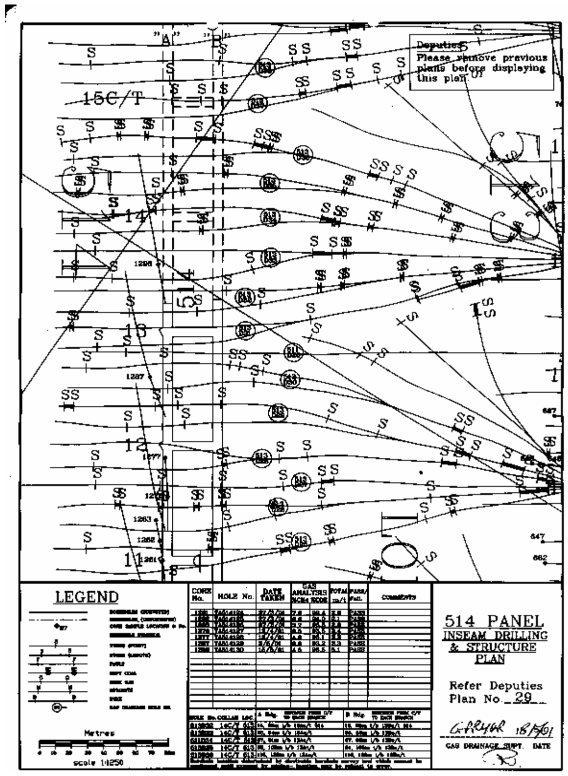

Figure 3 – Typical Drilling Information Accompanying Outburst Authorisation

GRUNCHING

By the late 1990's the Outburst Risk problem appeared to be largely resolved. Drilling patterns were close to perfect with very evenly spaced holes and no undrilled patches. Drilling was getting progressively further ahead, giving increased drainage times and enabling uninterrupted development. However Mother Nature had a surprise in store to prevent things getting too easy. Patches of coal that would just not give up gas, despite being well drilled were encountered. Initially, in the Longwall 18 gateroads, these patches were relatively small and infrequent. At first, it was not possible to overcome this "tightness" by closer hole spacing and/or longer drainage time. However, in the Longwall 19 gateroads, this "tight" coal became more widespread and would not drain even after nine months at a 6m hole spacing. A method had to be devised to enable safe mining through coal that was above the threshold otherwise, longwall extraction would soon be halted. The use of high-pressure water to cut "slots" around the drillholes was trialed, as a research project. It was considered these could lead to stress relaxation in the proximity of the hole, opening up the coal and thus enabling increased gas flow. Whilst slots were successfully cut to about 1m from holes, no increased gas flow was stimulated.

The D.M.R. Section 63 of 1994 decreed that development through "above-threshold" coal could only occur by means of remote mining. Tahmoor had previously used remotely controlled mining equipment and it was certainly technically possible. However, it was not considered practical to utilise this extensively, as it was just too complicated to keep operating on an ongoing basis. Grunching (excavation of coal with explosives) was proposed as an alternative. It was considered as remote because the shot is initiated from a remote mining location and so nobody is at the face when the coal is excavated. Grunching had the advantage that the gear is simple and the change from normal mining can be effected quickly. It was also expected to give more than the 1 to 2m advance per shift achieved with the previously used remote mining system. Its principal disadvantage was that it was labour intensive and hence would have a low rate of advance, compared to normal mining. Grunching was previously only allowed with P5 explosives. However, these were not available at the time and it was decided to use P1 explosives. This generated considerable discussion, but for once our high CO_2 content worked in our favour. The CO_2:CH_4 ratio exceeded 4:1, and so it would be impossible to ignite the seam gas. On this basis, the DMR did not stop the use of P1 explosives.

Grunching proceeded and did enable Longwall 19 to be developed on time. About 1600m of grunching, about 500 shots was done in all. This was achieved without incident. Grunching proved to be an effective, reliable but slow (3m/shift) means to traverse "tight" coal and will be utilised again in the future if necessary. Relocation to a new longwall domain, which is draining normally is currently occurring and hence widespread grunching in the near future is unlikely.

CONCLUSIONS

The outburst risk is now minimal, but this requires constant vigilance and considerable effort to maintain standards. As was experienced with the Longwall 19 "tight" coal, subtle variations in the geology can require refinement of techniques and there can never be surety that outburst problem is solved. Issues that will be pursued in the near future include:

"Tight" coal

- What are the characteristics that enable it to be identified well in advance of mining? (This is one aspect of a current research project).
- Once its characteristics are understood, what techniques can be applied to drain it with minimal impact on mining?

Threshold Limits

- Can a case be established for incremental increases in the threshold limit, to gradually decrease the drainage burden?
- Should the limit be higher for CO_2 than for CH_4? Whilst the consequences of a CO_2 outburst are obviously more severe, is an outburst more likely in a CO_2-rich seam than in a CH_4-rich seam? Some research suggests not! This needs to be investigated.