

# CASE STUDY CENTRAL COLLIERY QLD

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**ABSTRACT:** A coal mine outburst occurred on the 20<sup>th</sup> of July 2001, in 'B' heading of 310 panel. It is the first such incident to have occurred at the mine in its 17 year history. Mining has since the initial days progressed to deeper levels where now the workings are at some 425m below the surface. The issue of greater gas contents with depth is recognised where in-seam cross block drainage hole patterns are employed to drain and therefore reduce gas levels in the developing panels and in the longwall. The outburst incident was intimately related with a geological structure, which was covered by in-seam drainage boreholes. Subsequent to the outburst further training of the workforce and a full review of the coal mine outburst management plan was undertaken. Enormous experience was gained by all involved in the investigation process.

## INTRODUCTION

Central colliery is situated in Central Queensland approximately 250km north west of Rockhampton and is one of three mines comprising the German Creek Coal Mining operation plus one in the project phase. Central Colliery was the first mechanised longwall coal mine in Queensland with underground mining commencing in January 1984 and the first longwall coal produced in 1986. Fig. 1 shows the lease areas.

This paper aims to summarise the events of the 20<sup>th</sup> July 2001. It is also intended to describe the outcomes of the investigation process and what lessons have been learned as a result of the incident.

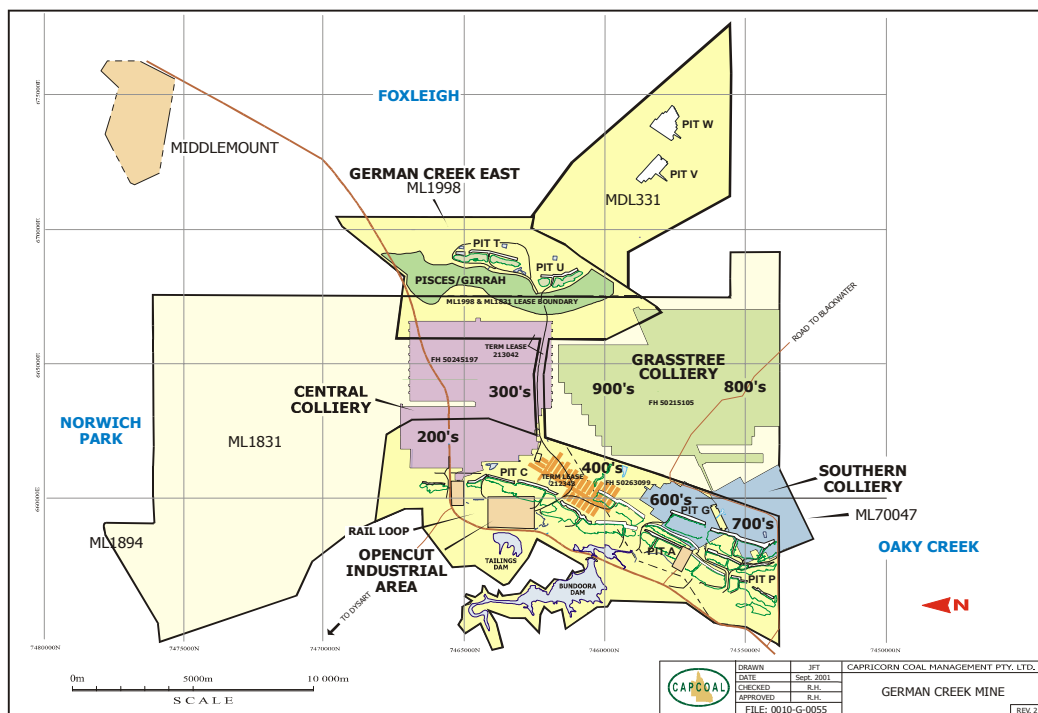


Fig. 1 CAPCOAL Leases

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### GEOLOGY

The geology of the German Creek operation is based on the reserves of the German Creek Formation and the Rangal Coal Measures. The former contains economic coal in the Pleiades, Aquila, Tieri, Corvus and German Creek seams. In the latter only the Middlemount seam is the seam of principal economic significance.

#### Stratigraphy

Central Colliery is situated in the centre of the Bowen Basin and the operation is worked over a 12km-strike length. The seams dip to the east at an average grade of 5°. The strata containing the German Creek Group of seams are hard to very hard, well lithified, interbedded claystones, siltstones and sandstones with some massive sandstone beds overlying the German Creek, Tieri and Aquila seams. The sedimentary strata is well jointed with the primary joint set trending northeast and a well defined secondary set trending southeast. In the mine area, sediments were deposited in a fluvio-deltaic environment. The massive sandstone units found in the area have been attributed to beach bar deposition. Coal seams worked range in thickness from 0.5 to 4.0m (Figure 2).

A rider seam, the German Creek Upper, of approximately 0.3m thickness, splits away from the main German Creek seam in the southern side of the main lease to a height of greater than 8m to the north. The immediate roof to the south of the seam split comprises a thin mudstone unit which gives way to interlaminated fine grained micaceous sandstone and siltstone averaging 50Mpa UCS. To the north of the split line the roof comprises a carbonaceous siltstone interburden, averaging 60Mpa UCS which is overlain to the north by laminated sandstone and siltstone. The immediate floor is comprised of a dark grey carbonaceous siltstone averaging 50Mpa UCS, although in places this floor is substantially weaker.

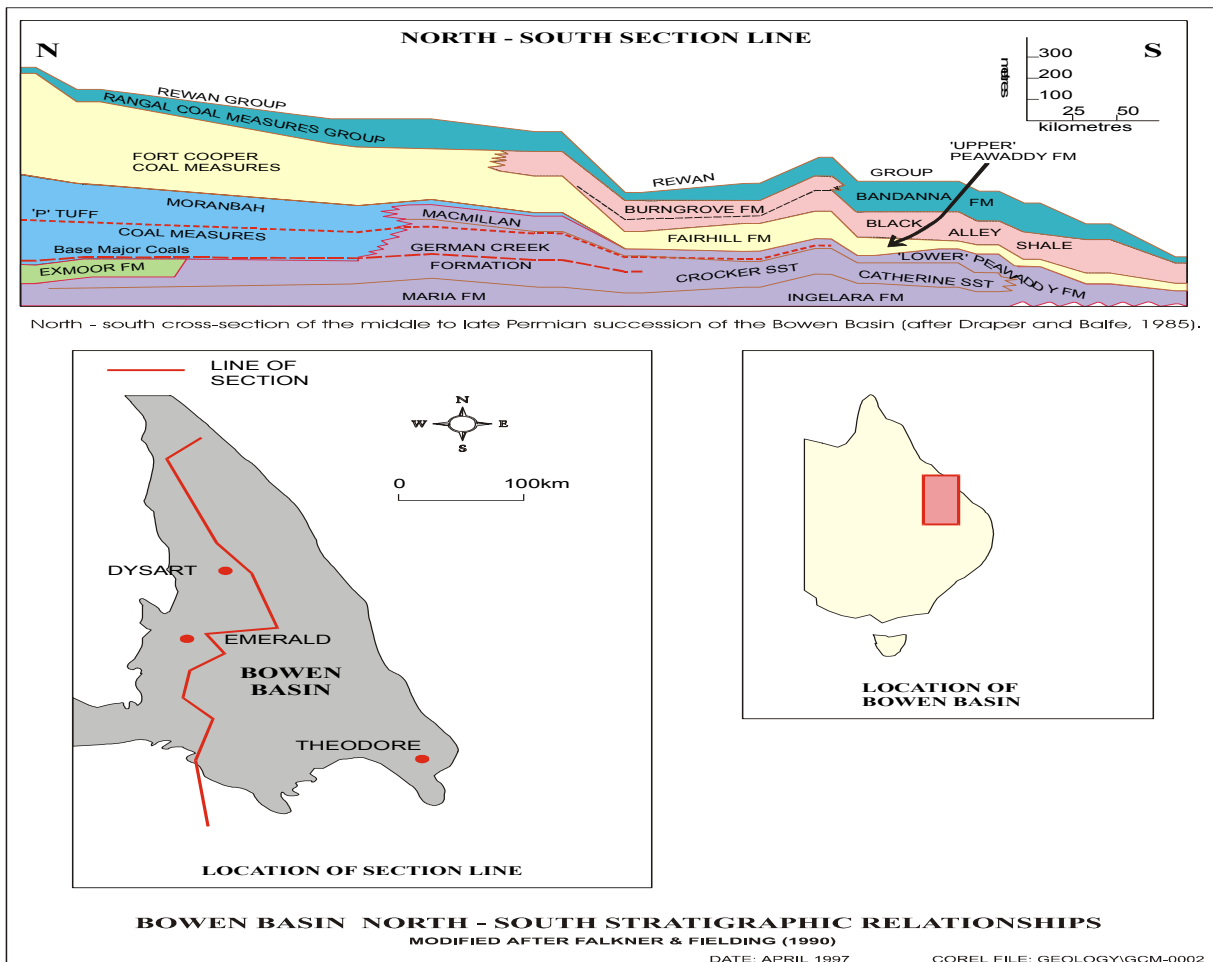


Fig. 2 Bowen Basin North – South Stratigraphic Relationship

## IGNEOUS ACTIVITY AND STRUCTURE

Structures in the form of folds, faults, shears and jointing are present throughout the mining lease. Intrusions in the form of dykes and sills span the lease area. As can be seen in Figure 3, these nominally follow a northeast – southwest trend, and are common to distinct structural domains, which often gives rise to adverse roof conditions when mining. Current depth of mining is about 430m with the principal horizontal stress oriented in a north-northeast direction at approximately 24Mpa. The horizontal to vertical stress ratio is some of 2 to 2.5 to 1.

## SEAM GAS

At Central Colliery, gas levels, which are at present in the order of 12m<sup>3</sup>/t to 15m<sup>3</sup>/t, of mainly methane gas increase with depth. Gas chromatography data indicates that CO<sub>2</sub> is a minor contributor to the total gas make.

A gas drainage system has been in place since the 306-longwall block where face parallel drainage holes were employed, having an average length of 260m. From longwall block 307 to the current 311 longwall blocks, a fan pattern of in-seam drainage holes was used, to aid drainage efficiency and minimise the problem of relocating the rigs.

The spacing was progressively reduced from an average of 50m in LW306 to LW310, to a spacing of 40m for longwall block 311. This is in recognition of the fact that increased virgin gas contents are present at depth and thus the frequency of drainage holes would have to be increased in order to achieve a post-drainage gas content of less than 7.5m<sup>3</sup>/t within the time period available for effective drainage. The spacing of each fan pattern of 5 holes has also been progressively reduced so that these occur at every second cut-through (Fig. 3). In addition, these boreholes have been oriented through the subsequent panel so that their intersection is at right angles to the development direction, which in turn has alleviated the problem of having gas leakage into the development workings during development. The German Creek seam at Central Colliery has a permeability of between 3 – 10mD.

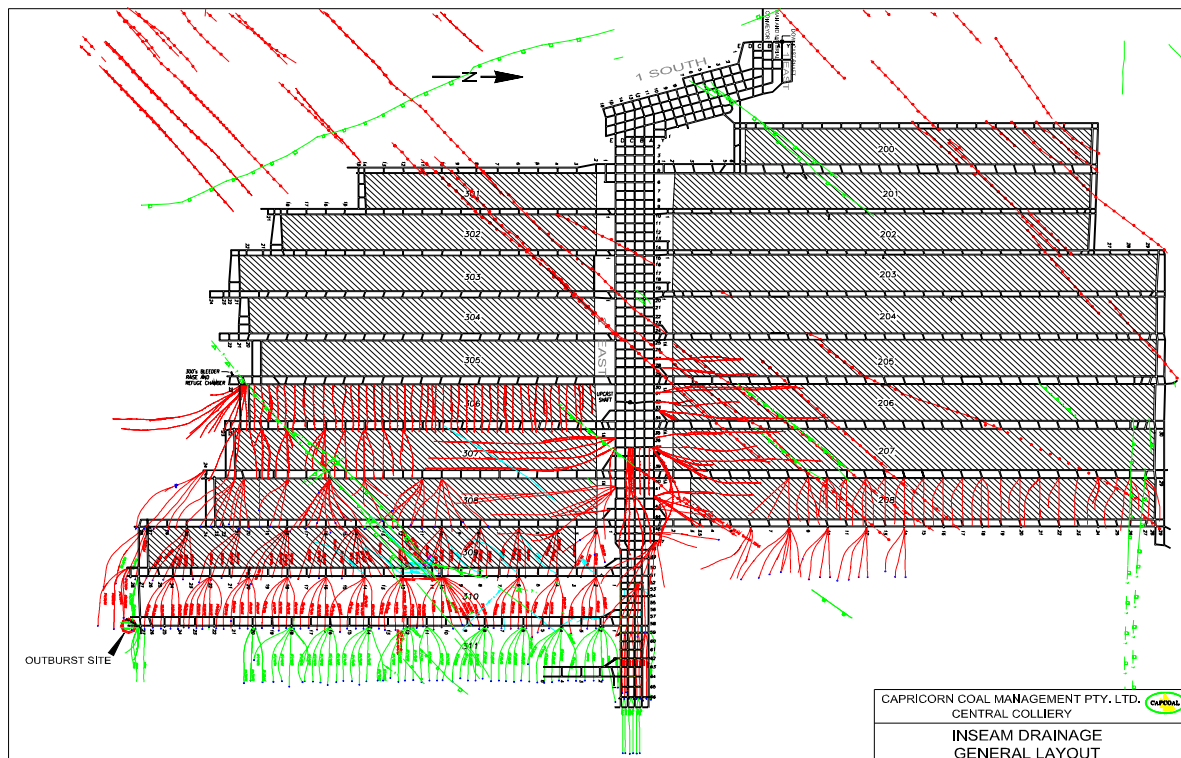


Fig. 3 Central Colliery Workings and General Seam Gas Drainage Hole Patterns

## THE OUTBURST

An outburst occurred on the 20<sup>th</sup> July 2001 in 'B' heading of 310-maingate development panel, where initial reports suggest that the amount of coal expelled was in the vicinity of 50 tonnes. Later after some of the broken coal was removed, it was estimated that 80 to 90 tonnes was displaced. No injuries resulted from the incident with the exception of a few minor bruises and scrapes.

### Background

Events leading up to the outburst were that the 2-entry panel was to be extended to 28 cut-through, with normal mining proceeding at that particular stage. Inseam drilling was in place to determine the gas content levels. The area had been drained by the standard cross panel drainage holes drilled to a spacing of 40m. Drainage is normally quick and efficient. The 12 to 15m<sup>3</sup>/tonne are usually reduced to 3 to 4m<sup>3</sup>/tonne within 6 to 8 month's time. A core taken from a vertical hole prior to mining, just outby of the outburst site had a gas content of 6.8m<sup>3</sup>/tonne. The next test core, some 140m inbye had a content of 7.8m<sup>3</sup>/tonne. The gas content threshold is 8m<sup>3</sup>/tonne.

The face was driven about a pillar length inbye of 27 cut-through. The outburst occurred from the right hand rib / face junction. The drainage holes on either side of the outburst were checked two shifts prior to the outburst, where the flow had considerably reduced but no blockages were indicated. All holes were on suction.

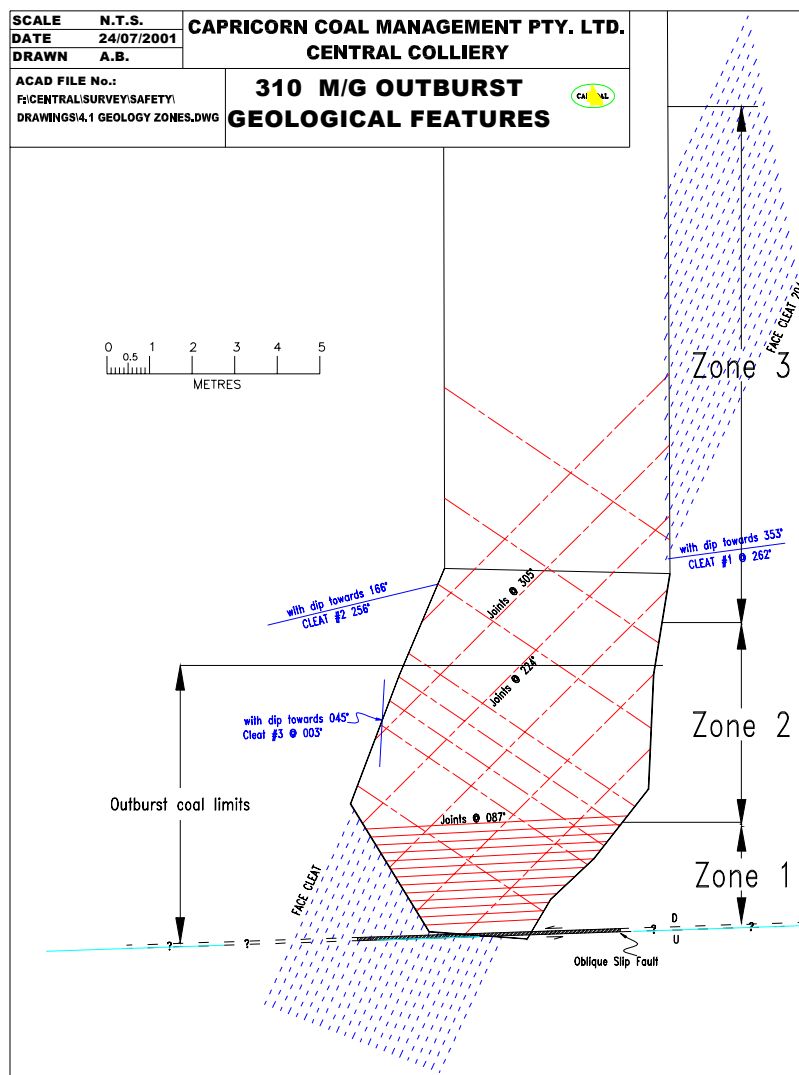
Just prior to the outburst, a number of events occurred. The first event was a loud "bang" which caused the continuous miner driver to put the miner into reverse high tram. The noise itself appeared to be "deep and appeared to emanate from the roof". Then cracking in the rib was noticed and the rib was noted to be fretting as a result. The second event took place some seconds later, when another loud "bang" occurred which was described as being louder than the first. At that particular stage the miner had traveled backwards some 2 metres, and some small pieces of coal was being thrown towards the miner. A distinct pressure change had resulted in the ambient atmosphere, where personnel reported the 'popping of ears'. The third event was described as a type of "suction towards the face" with the majority of the face coal having been thrown out by that stage.

As these events were occurring, the personnel in the adjacent heading also heard these three waves of noise, they also trammed backwards, thinking it was a roof fall about to happen or a coal mine outburst.

Most of the displaced coal was of blocky consistency. A structural change in the local geology had been noticed over the last 30m of the development. The normal cleat is first intersected by the left rib, but additionally, another three cleat orientations were noticed as shown in Fig. 4. Some of these additional cleat orientations have been present at times elsewhere in the mine, but at this location it is remarkable how consistently they occur in their attitude (strike and dip), persistence and spacing. In addition, the roof joint pattern appeared to alter, in terms of spacing from a normal one every three to six metres to approximately one every metre. In the outburst cavity itself these joints appear at a spacing of only 30cm semi-parallel to the identified outburst structure.

The main structure associated with the outburst is interpreted to be a strike slip fault, with a nominal dip slip component. The axis of the outburst was perpendicular to the structure, and it could be said that some nine metres of the seam outbye of this main feature was affected by the geological disturbance. Subsequent to the outburst drilling using Pro Ram holes ahead of the two faces bogged in the approximate locations of where the main structure is located. In one particular instance in one of these boreholes, a gas push, through the drill string was recorded. Subsequent testing of this area indicated a content of 11.68m<sup>3</sup>/tonne of mainly methane gas in the down dip side of 'B' heading.

Information from further investigations using a 'Fault Tree Analysis' system post the outburst event, indicated that a greater knowledge of the gas regime in the area was required.



**Fig. 4 310 Panel Outburst Cavity – Geological Features**

Additional holes were drilled between the headings to establish gas contents and the location of any structures. The threshold for the area was temporarily reduced to 6m<sup>3</sup>/t, and if the core content from this area was greater than 5m<sup>3</sup>/t, then additional cores were to be taken at 25metre intervals. Fig. 5 shows the general arrangement of in-seam borehole locations pre – outburst, whereas Fig. 6, is the in-seam borehole and sampling arrangement post – outburst. Positive outcomes from the work were that the “geologically disturbed zone “ was positively identified from three in-seam intersections and seam gas contents dropped markedly away from this disturbance.

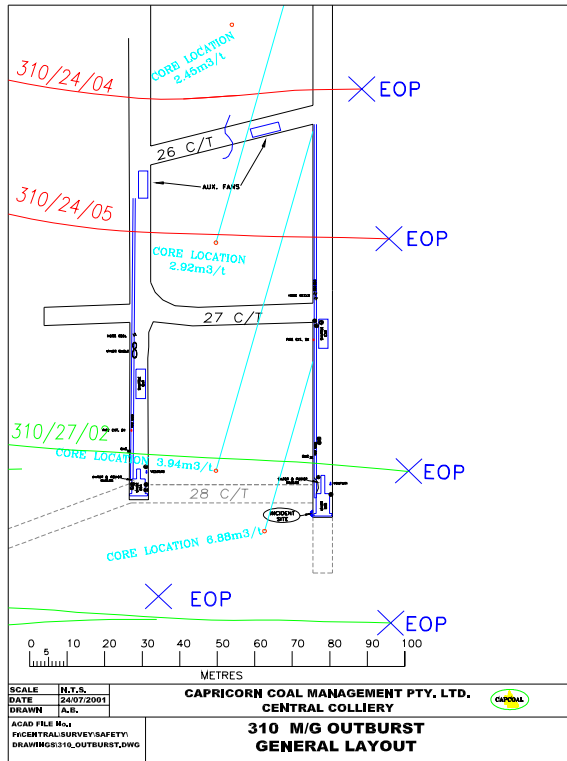


Fig. 5 Inseam Gas Content – Prior to Outburst

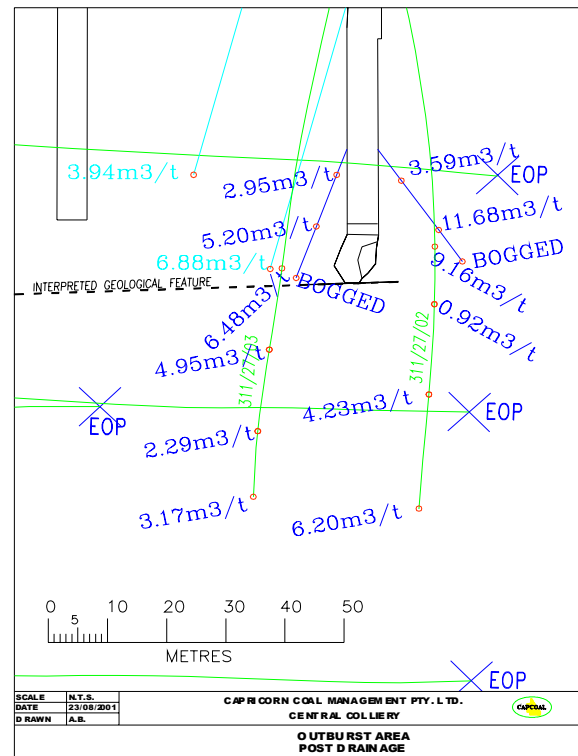


Fig. 6 Inseam Gas Content – After Outburst

### INTERPRETATION OF THE EVENTS

It is important to analyse the mechanism by which an outburst has occurred. It is suggested that the outburst mechanism for the 310-panel event can be divided into four stages.

1. The area ahead of the face behaves as a confined solid, whereby free water is present in the pore spaces and all gas is chemically adsorbed onto the coal maceral. The water that is present limits the free desorption of gas. At this stage the mining process in 'B' heading of 310 panel was too distant to affect this free desorption stage. That is, further than nine metres as indicated in the geological mapping of the outburst cavity with respect to where the continuous miner was positioned at the time of the event. Within the nine metres though, the geology appeared to be disturbed, with the inbye most three metres being particularly affected.
2. As the face advanced, confinement on the coal was reduced, loading becomes biaxial, tensile failure commenced in tandem with a reduction in pore fluid pressure around the tensile failure. At this stage gas desorption began with free gas accumulating at high pressure. The fluid pressure at any distance into the face is in equilibrium with the leakage / desorption rate. At the particular stage, when the loud roof noises were heard, failure of the roof inbye of the face area can be interpreted. This may have been due to some horizontal de-stressing, resulting in depressurisation of the area ahead of the miner position, and therefore somewhere in the outburst cavity there would have been a volume change. As this occurred, the fluid pressure lowered to below the gas desorption pressure of the coal during mining.
3. As the face advanced close to the high-pressure free gas accumulation, being essentially the highly fractured and somewhat mylonitised coal, mass movement may have taken place. The reservoir of expanding gas provided the stored energy required to propel the fractured coal into the opening. This can be related to a massive change in confinement which promotes a sudden large increase in gas desorption rate, to the extent that the gas desorption rate is fast enough to maintain a high pressure in the fracture network, thereby causing coal mass failure. This can be considered the final event during the 310-panel outburst. The severity of the expulsion of the coal particles depend on the steepness of the gas pressure gradient, the free storage capacity

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of the coal prior to the event, the desorption rate of gas from coal and the depth of the tensile failure into the face.

4. The gas emitted during the event and the outburst cavity size are dependant on the total surface area exposed and the permeability of the coal mass. Emissions continue until the gas pressure gradient migrates into the solid coal and equilibrium is attained with the permeability. This may take some time particularly with geologically disturbed areas, as the permeabilities are lower and the gas flow paths are essentially anisotropic.

These steps are fairly typical of other coal mine outbursts which have occurred. In an overall sense, the amount of gas liberated as recorded by the American Mining Research (AMR) is in the normal range, and comparatively, the amount of coal dislocated is relatively small when compared to the known previous occurrences.

### LEARNING OUTCOMES

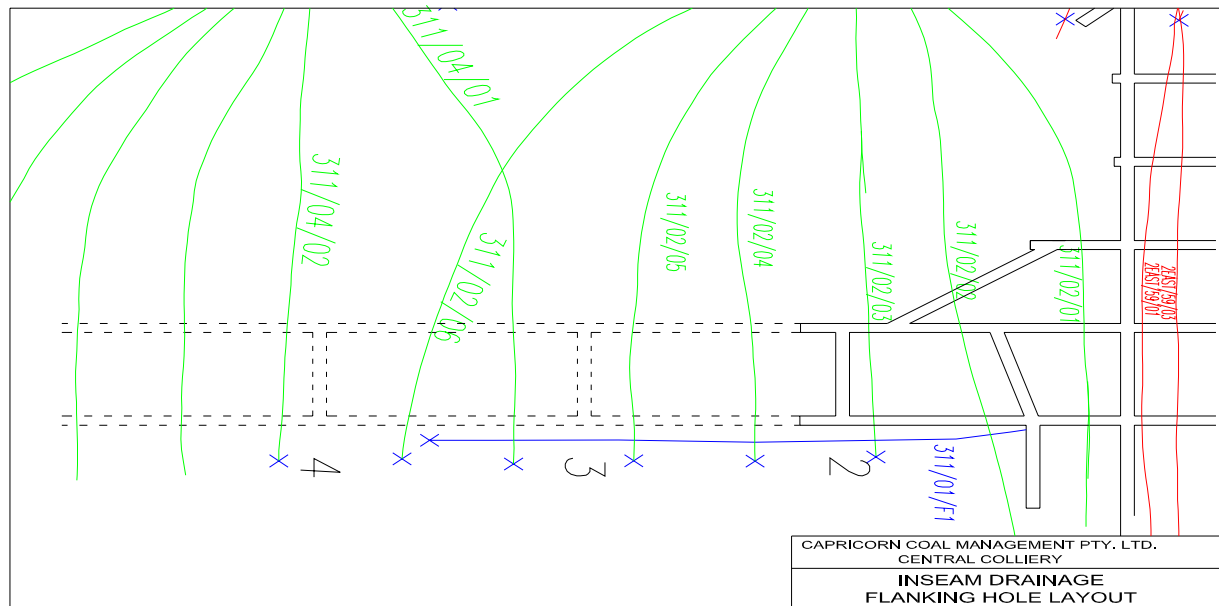
A number of initiatives were instigated after the outburst event. These include updated outburst awareness training to all the crews. The training package involved the explanation of what a "coal mine outburst" is. An attempt is made to heighten awareness of such phenomenon and explain that numerous such outbursts have occurred in the past, with common dominators with respect to their parameters and geological setting. An explanation of the association of structure, stress magnitude and direction and finally coal strength is explained. Finally the physical signs as a recognition tool, as employed in other coal mining districts in Australia, are given, namely spitting of the face, face bumps, calcite stringers, abnormal orientations of coal cleat or jointing to just name a few. In this way the crews are able to "see" potential problems and them accordingly for the Geologist to inspect, very much in the same vein as roof support issues.

Inseam drilling crews have also been further updated in the detection of outburst prone structures. Some of the items to be recognised include the recognition of the inability to penetrate a known area, gas surging, bogginess, rods binding up and red-brown colouration of drill returns. As inseam drainage is the main weapon in combating gas levels, which may be too high for safe mining progress, this is of ultimate importance for the safe and efficient progress of the development cycle.

Inseam drilling does provide an initial identification of structural disturbances in training and potential outburst prone structures. It can give confirmation of the existence of such structures as are identified from remote detection techniques such as surface seismic and geological projections from adjacent panels. In addition the surveying of such boreholes has dramatically increased the confidence in the location of these structures, when in comparison, boreholes drilled using programs have little or no confidence assigned to them, as their drilling direction cannot be controlled. The in-seam gas test-sampling program is made very difficult, because of tight operational constraints.

The inseam borehole lengths were increased to run well past the target maingate, in an effort to minimise the drainage end effects. These boreholes are extended nominally 20 metres past the virgin side rib. In addition, as has been discussed above, the distance between these boreholes has been tightened to 40 metres, from a spacing of 50 metres in the past.

The core sampling strategy now involves the taking of compliance cores from "flank holes" Fig. 7. The logic revolves around the recognition of the regional to local geological environment in which Central Colliery operates. It can be said that a major proportion of all known structures including vertical igneous intrusions occurring in the Central Colliery mining area strike in a northeast – southwest orientation. The exception to date has been the intersected structure in 'B' heading of 310 panel, where the outburst had occurred. Its orientation is in an east-west orientation, thus using flank holes, it is expected that all other orientation of geological structures that may occur will be intersected. In addition, the sampling strategy has now a new focus, with the samples being taken in the worst possible location, between existing cross-block drainage holes and on the near virgin side of the adjacent longwall block.



**Fig. 7 Inseam Drainage Flanking Hole Design**

The sampling strategy also involves the taking of such sample within 15 metres of the solid rib off 'B' heading in areas of known outburst-prone structures. A barrier distance of 10 metres is in existence for areas of no known geological disturbances.

Finally the gas content threshold has been revised, based on a more conservative desorption rate index of 900 (Williams, 2001) to a maximum gas threshold of  $7.5\text{m}^3/\text{tonne}$  based on 100% methane gas.



**Photo 1 Outburst Area**





**Photo 2 Outburst cavity after cleanup**

### **CONCLUSIONS**

As can be seen from the forgoing, a great deal of work and learning has occurred as a result of the coal mine outburst at Central Colliery. Fortunately no one was seriously injured and the mine has benefited from the experience and lessons learned. As the mine gets deeper, new challenges will be faced. An understanding of all seam gas aspects of the local geological environment is essential in planning a safe approach to new mining areas. This is achievable if a rigorous and systematic approach to risk is adopted, and mine operators maintain awareness of emerging technologies and an increasing understanding of outburst mechanisms.

### **REFERENCES**

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- Lama R.D., Bodziony J., (1996) 'Outbursts of Gas, Coal and Rock in Underground Coal Mines', ACA, and Joint Coal Board, Wollongong.