

# **COAL AND GAS OUTBURST COMMITTEE**

## **HALF DAY SEMINAR – Wollongong 25th November, 2015**

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## **Coalbursts Overview and ACARP Coal Bursts Projects**

**Brad Elvy, South 32**

### **Questions and Discussion**

**John Hanes, Outburst Seminar Committee and editor – Post script** - Brad, from what you describe in your presentation on the “burst” in the Appin case study, I cannot see what is different from what has happened in some events in the past in the Bulli seam and at Leichhardt Colliery. In the 1970’s the term “outburst” was not preferred for the events occurring in the Gemini seam. So we used names such as “coal burst” and others. In the end of the 1980’s, the second Outburst Advisory Committee (the first was in 1979 or 1980 around the time of the Aus.IMM Outburst Symposium held in Brisbane) was established to determine what work was needed to research and to regulate outbursts, especially in the Illawarra. This was extended, after the fatal outburst at West Cliff in 1994 and the outcome was discussed at the 1995 International Symposium-cum-Workshop on management and Control of High Gas Emissions and Outbursts in Underground Coal Mines. What was known at that time was summarised by Lama and Bodziony in their book of 1996. I would expect any mining engineer or geologist who is working in the Bulli seam or in other mines with the potential to burst, by gas and or stress to have read this book as part of induction before being allowed to apply their skills in a mine.

## Discussion on the Relationships Between Coal Bursts and Outbursts

Jeff Wood, Sibra

### Questions and Discussion

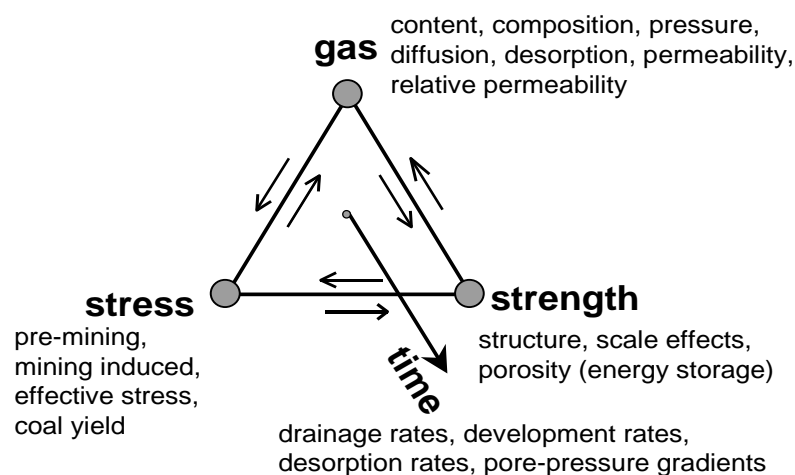
**Alan Phillips, Outburst Seminar Committee** - Where there is stress, should the volume of cuttings produced when drilling be measured?

**Jeff Wood**— Measuring cuttings is more appropriate to outbursts than rockbursts. The coal produced is fine material that is accumulated. The best way to look at highly stressed areas is to look at the bigger cuttings. If they are flat oval shaped bits, they represent a stress breakout in the borehole and the other obvious feature in stressed coal is discing in cores.

**John Hanes, Outburst Seminar Committee and editor – Post script**

Jeff, I congratulate you in your presentation and explanation of how the “bursts” experienced in general, but I believe particularly in the Bulli seam and at Leichhardt and Cook Collieries in Queensland in the 1970’s, are produced by a combination of gas and stress as part of a continuum. I do not like the tendency to refer to a “coal burst” if stress concentration is involved and an “outburst” only if a large volume of gas is released. I understand these are two ends of the spectrum that you described and which was also very well defined by Wold and Choi of CSIRO based on our measurements at Leichhardt Colliery.

## Interactive factors in outburst mechanisms



Interactive factors in outburst mechanisms (after Wold and Choi, 1999)

Based on the presentations today, I have to say that most of the 200 plus outbursts I mapped at Leichhardt were coal bursts (which I called them in my paper with Rod Moore, 1980) as the coal in the cones was mainly fractured but not pulverised. But with gas content of around 15 m<sup>3</sup>/tonne CH<sub>4</sub> and pressures in the face over 2 MPa, we know they had a large gas component. I saw and recorded a similar event at Appin (just east of the old Appin pit bottom) in the second half of the 1980's and at Tower, in the NW headings (driven in the late 1970's I think) just inbye the pit bottom fault. In this drive at Tower, the coal was cleaved by mining induced stress the same as it was at Leichhardt. I refer you also to Barry Condran's presentation a couple of years back to an Outburst Seminar – see inclusion after the Appin Case Study by Brad Elvy.

**Jeff** - I agree that there is no clear cut distinction. The so called bursts at Appin are odd in that they had little gas measured. Because of the complex structural setting this may be due to a sampling problem but still only a small quantity of gas was measured in the ventilation.

The problem is that there are so few stress (or elastic property) measurements in coal and the reliance on breakout (from acoustic scan data) gives the impression of comprehensive knowledge of the horizontal stress regime while really it gives the direction of the maximum stress in strata that could be quite remote from the working seam and no idea of relative magnitude.

## **Coal Bursts in Australia**

**Justine Calleja, Lecturer, Mining Engineering, University of Wollongong**

### **Questions and Discussion**

**Steve Pratt** – I would like to comment on deep mines in Utah, USA. 600 m depth, 18 m wide chain pillars with 380 m wide longwalls contribute to coal bumps. Mine design is critical. Australian mines have bigger chain pillars. A chain pillar of 18 m width in a seam around 4 m thick is not much of a pillar to support abutment stress from a 380 m wide longwall.

**Justine** – Mine planning is going to be very important for managing this problem. We need to develop guidelines for mine planning to consider predicting how much stress mining will create including changes in both vertical and horizontal stresses. In terms of pillar size, we need to keep in mind that coal bursts tend to be worse in pillars that have width to height ratios between 5 and 20 where most of our mines tend to operate. Very small pillars fail under low loads. They cannot store much strain energy. Medium sized pillars can store a lot of strain energy. We teach that pillars with width to height ratios larger than 8 are safe because they will not fail catastrophically, but under coal burst conditions these are the worst. To avoid catastrophic failure under coal burst conditions, those dynamics are not good. There have been cases where really large pillars burst as well. So having a large pillar is not necessarily protective. If there is enough vertical loading nearby, and a dynamic event occurs, the pillar can burst.

**Chris Harvey, Wollongong Coal** – Could you comment on the magnitude of coal bursts and the amount of material dislodged in the Australian and other events.

**Justine** – At Austar, based on the investigation report which can be accessed on line, the coal burst affected the area right beside the miner. The men standing on the side of the miner next to the burst were crushed. The men on the opposite side of the CM were fine. The burst did not propagate a long way. This is typical of overseas occurrences as well. The people at highest risk of being injured or killed are those who are cutting the coal or near the stress concentration zones. If people are far enough away from the risk zone, coal bursts can occur without injuring people. Additional information: The fatalities at Austar in 2014 were a result of a coalburst of 38 cubic metres of coal (around 50t). My personal experiences of face coalbursts on development at Austar in the early 2000s involved ejection of 20-30t of coal. However, the worst coalburst incidents have been pillar bursts, such as Crandell Canyon, where large areas of pillars have burst and would have involved much larger volumes of coal than the largest outburst events we have experienced.

**Jun Han, Assoc. Prof., University of Wollongong** – The energy of coal burst is from the deformation of coal (rock) under loading. The in-situ stress higher, the energy is more. The main source mechanisms are usually associated with local underground geometry of the cavities, structural elements like pillars and the existing geology. The rockburst (coal burst) is usually classified as a strain burst, pillar burst or fault slip burst. The horizontal stress has less influence on pillar burst but it is important for strain burst and fault slip burst.

**Chris** – The reason I asked the question is that in Australian experience of outbursts, the largest outburst in the Illawarra was about 400 tonnes of coal liberated and about 60,000 m<sup>3</sup> CO<sub>2</sub> (Editor: Leichhardt Colliery, Queensland 500 tonnes and about 1500 m<sup>3</sup> CH<sub>4</sub>). The overseas experience is an order of magnitude higher, so around 4,000 tonnes of coal and 600,000 m<sup>3</sup> of gas.

**Justine** – With development face or rib coal bursts there seems to be much less coal ejected than in outbursts. See additional information above: Pillar bursts and coalbursts around longwalls have led to very large volumes of ejected coal internationally.

**John Weissman, Mackay** – Some mining companies are using fracking to induce breaks in massive rock beams above longwall goafs. Does such a fracture act as a barrier to seismic propagation?

**Justine** - Fracking and blasting are typical methods used overseas to prevent coal bursts. The mechanism involves reducing seismic energy transmission or reducing the potential to build large cantilevers that can concentrate stress.

**John Hanes, Outburst Seminar Committee and editor – Post script**

From your definitions of coal burst (with seismic event) and outburst (no seismic event), Australian coal mining personnel must be very confused. It seems that based on definitions in your slides, we have historically had relatively few outbursts and many, many coal bursts. Ask the miners (of old) from Appin, West Cliff (+200 bursts) and Leichhardt (+200 bursts) if the outburst events they experienced were accompanied by seismic events. I refer you to my papers listed in the appendix and to Barry Condran's presentation to the Outburst Seminar. Appended.

The fracturing in core on slide 14 showed axial fractures which occur in the Sigma 1-2 plane i.e. perpendicular to Sigma 3. Those fractures are the same as I mapped and defined at Leichhardt Colliery as mining induced cleavage back in the 1970's. They are curvi-planar about the direction of advance and were more prominent in the rib that first intersected the maximum horizontal stress. I also observed them at the old Tower Colliery in about 1984.

**Justine** - In terms of the seismic event vs no seismic event. Coalbursts have been known to cause Magnitude 5-6 events which have been felt as earthquakes on the surface and through the mine. Mining seismic events are often the cause of coalbursts. Coalbursts can also occur purely as a result of high static stress. Coalbursts which occur due to static stress create their own seismic event proportional to the size of the coalburst. These can be in the range of magnitude 2 and lower. I haven't collected any data on the magnitude of seismic events created by outbursts, but they have been collecting this data in China so I should be able to put it together for future presentations. I should probably re-word the distinction to "relatively little seismic reaction" for outbursts or better yet quantify it once I have collected some data.

I think it is quite possible that many of the "outbursts" we have had in the past were actually coalbursts or a mixed event. It is recognised that there is an overlap where gas pressure in the

coal adds to high stress to create a burst which is a combination process i.e. a coal-gas-burst. This type of bursting is particularly important for deep gassy coal mines such as those on the south coast. Our coal burst research in this area will need to draw on all of the previous outburst research work.

## **Coal Burst at Appin Colliery: A Case Study**

**Brad Elvy, South 32**

### **Questions and Discussion**

**Student**– You mentioned a spike of gas before the event and that you were trying to decide what caused it. It seems to be evidence of a coal burst. Coal bursts and rock bursts occur as a redistribution of stresses. You asked what causes the redistribution of stresses. A fracture could do this as could mining activity. So the spike you saw could be associated with damage that had occurred. The release of the small amount of gas was indicative it was a coal burst and not an outburst.

**Brad** – The 21 m<sup>3</sup> occurred over about 30 minutes, so it wasn't a sudden event.

**Student** - But it was still an active sign of a changing stress field.

**Brad** – We are looking at the permeability and would think that in a stressed environment that as strain energy builds in solid coal, the permeability will change and become locked in. So the gas would not want to come out.

**John Weissman, Mackay** – Regarding the gas spike, in the early days at Tahmoor, just before the longwall face reached an old borehole, as the abutment passed over the hole, the hole would reactivate. On the photos you showed there was a roof bolt extending down from the roof. Was there any difficulty installing the roof bolts?

**Brad** – No.

**Anon** – On reviewing the history of outbursts in Australia, we find that around shear zones, pulverised fine coal is ejected, but around dykes the ejected material is of larger chunkier sizes.

**Brad** – The picture I showed of an outburst occurred on a thrust fault zone and the coal was pulverised. I think the gas is locked into the molecular structure of the coal and when the burst occurs, the gas expands rapidly causing more fracturing and expansion and internal explosion of the coal producing the finer coal. The gas throws the coal out carrying the finer coal particles further. In a coal burst, the gas pressure is not there to internally fracture the coal into finer particles. Winton gale said that according to his computer modelling, about 8 m/tonne of gas in the small localised area would have provided enough energy, along with stress to move the large lump of coal (shown in the photo) the distance it was thrown from the face.

**Peter Robbins, Coal Services** – You mentioned coal thickness and strength for coal, but have you tested strength of the cinder?



**Brad** – We took cores of the cinder and tested for strength, but it was not much different from coal. My first impression was we were mining towards a structure around which there were stress concentrations. Most people talk about the vertical stress component, but I feel the horizontal stresses played a more prominent role in this case. Why did the coal pop out from the left corner of the face? The stresses were probably more concentrated on that side. An alternative view is that there was a massive dyke in front that could handle the concentrated stresses, so the stresses in the coal would have been relieved, allowing it to pop out. A lot more research is needed to help us understand what happens around structures. One thing we have learned is that as we had little problem on intersecting the structure in A heading, we should not have anticipated the same lack of problems when we intersected the structure in B heading. When I talk to the deputies, I emphasise the need to recognise and manage change. The change was there to see: the low gas make, the ribs standing nice and straight.

### **John Hanes, Outburst Seminar Committee and editor – Post script**

Brad, this burst does not seem to me to be much different from what I have seen at Leichhardt, Appin and Tower during the years I worked for BHP (1966 to 1992). You had reduced the gas level (interpreted by Winton's model as around 8 m<sup>3</sup>/tonne), and you seemed to have had stress concentrated in the left corner of the face.

In the photo of the first event in A heading, pick marks can be clearly seen down the face and right rib, indicating to me that stress is loading the coal ( "hard" ribs = potential outburst indicator). In the late 1980's or 1990-91 I mapped mining strain in the old Tower workings (internal BHP Coal Geology report) and I think the interpreted orientation of maximum principle horizontal stress was roughly SE. If the stress was similarly oriented in the current working area, A heading would have been subject to stress concentrations in the left side of the face. However, the driving of A heading would not have shielded B heading as it would not have shadowed the principal stress trajectory. However, this is based on memory of mapping from around 25 years ago.

According to definitions used in this seminar, coal bursts, are associated with seismic events and stress, whereas outbursts do not have the seismic events and are caused by gas. In mining, such definitions rank (in my old mind) with fantasy. I know we prefer black and white definitions but... I have been at the face during many outburst events in Leichhardt Colliery. With every one, there was a loud bang as the coal failed and was ejected. The lumps were generally large and in place. The coal at the face of the outburst was generally fractured by stress and gas but the coal further into the cone was not. I have appended references where I describe some of these events. Barry Condran was a miner driver at West Cliff on the Bomb Squad. His presentation to the Outburst Seminar (appended) described the seismic events associated with what we called outburst, but now should be called coal bursts. Especially see the last paragraphs.

## **Recent Legislation Changes**

**Dave McPherson, NSW Department of Mine Safety Operations**

### **Questions and Discussion**

**Brad** – In the Illawarra, we tend to use total gas content to define thresholds. Why did they include the DRI with recent legislation changes.

**Dave** – The decision was made to include DRI into the thresholds. We thought to just use the DRI as one of the few numerical models adopted by this department. It is a very conservative model. The use of total gas content was included after discussion with industry. I would prefer to have just the DRI because the use of Bulli seam information developed empirically in any coal seam may be faulty in different locations. The HRA does not prevent mining above the threshold level.

**Jeff Wood, Sigra** – I do not agree with what you said about the DRI. With all the work done on gas thresholds over the last 10 years, it is becoming more apparent that the original work based on gas content is much more applicable than the DRI approach. I also think that the transference of the Bulli seam thresholds through the DRI to places in Queensland is so conservative that much money is being wasted.

**Dave** – When you have a DRI above 900, it means to a mine in that area, that how to mine that coal safely needs to be considered. It does not mean that the coal has to be remotely mined or grunched. It just means that there has to be a plan to safely mine the coal. It is deliberately conservative. It does not mean mining is banned. We, as the regulator, are interested in high risk activities. We see mining, at or approaching high levels of gas that could cause an outburst, as a high risk activity and something we need to have an oversight of. The mine then needs to submit their plans for development of the area so we can oversight that work. It does not prevent mining. The aim is to be conservative. DRI 900 is conservative and most people agree at that level there has to be a plan of how the risk of outburst is to be handled. The mines in the Bulli seam have a long history of planning. Some are mining above the thresholds and it is not hard for them to submit their HRA as it is the same as they are doing now. Outbursting is the best managed hazard in the South Coast. It gets a lot of attention from all the workforce. However, for a new mine, it is not so simple. So that is where our group is coming from.

**Peter Robbins, Coal Services** – Based on previous speakers, what do you see as the regulators' concern regarding seismic activity plan being a requirement?

**Dave** – It was interesting that the seismic activity plan got in. Tasmania wanted it included post-Beaconsfield. It was knocked back by the other non-mining states. They asked us if we would include it in the Tri-state for the states that were not interested in picking up individual causes from the Tri-state work in their regulations. That is why it is in our regulations as we saw it particularly important for our metal mines. Since Austar, we are glad we included it as

it is obviously a principle mining hazard in coal mining. The thing will be how people go about assessing their risk. We know now that Appin has the risk as does Austar, but there are potentially other mines also.

**Mark Blanch** – I agree with Jeff in that using the DRI 900 as single indicator to define if an area is should be classified as an outburst risk zone may not be the best means of doing so, but for a different reason. The main issue being that the DRI900 value will vary considerably for the same coal seam and same gas content due to variation in sample fraction and variation in sample moisture. A better option may have been to use the gas content threshold defined using the DRI method.

The DRI provides a rational method for transferring empirically supported Bulli seam thresholds to non-Bulli seams which will generally have quite different desorption characteristics and in turn outburst risk. Its best use is in defining outburst gas content thresholds using a significant data set of results which takes into account the scatter around the mean; the scatter a result of test methods, sample selection, moisture content and size.

I disagree with the argument that it adds another layer of conservatism or that all the work that has been done over the last 10 years suggests that the early gas content thresholds are more applicable.

The DRI900 is a simple means of transferring gas content thresholds from the Bulli seam to other seams based on the other seams' desorption characteristic, which varies from seam to seam and by gas composition. There is no addition for safety, it is a direct transfer based on the linear relationship between gas content and desorption rate for each particular seam.

For most mines the argument that gas content thresholds are overly conservative and money is being wasted on gas pre-drainage to those levels has no basis at all. Most if not all Queensland mines to date at least drain seam gas contents down to between 2 and 4 m<sup>3</sup>/t, well below defined outburst thresholds. If they didn't they wouldn't be able to mine to planned production rates due to gas emission rates on gate road development and / or gas emission rates on longwall extraction.

**Dave** – There was a lot of discussion about whether DRI should be included. In the end it was decided to include it. We were asked to include a trigger. Could we include in the HRA a trigger for an outburst control zone without defining an “outburst control zone”? No we cannot. The Regulator wanted to know about it. That is where it came from. If people have a better way to do it, but which is still conservative, we could consider it. The public submissions showed the Bulli seam mines did not want to be tied to DRI. We thought their argument was valid.

**Darryl Smith, Sibra** – As coal bursts seem to be stress related, do you foresee stress monitoring being needed in the regulation?

**Dave** – The requirement is for appropriate monitoring. What is appropriate is not defined. It is not prescriptive.



## **Outburst Mining Challenges in Queensland at Oaky No1 Mine M/G33A**

**John Weissman – Consultant & Logan Mohr – Glencore**

### **Questions and Discussion**

**Stephanie** - have you taken cores around the areas around the fraccing? Have you searched for the fractures to see what they were like? Did you check on changes to the physiology of the area after fraccing?

**Logan** – No. Basically, all I needed to know was compliance. We did not go back and look at it in any detail. Hopefully that is the last time I will see the area. The longwall will soon mine through the area and everything will be gone.

**John** – The picture you saw of the sand filled fracture was a generic one we got from CSIRO. It was not from Oaky.

**Logan** – I saw the fracture in the rib and it did look similar to the one in the photo. I only saw it in the cutthrough so I know nothing about its extent.

**John** – When we did our first fracc, I was expecting the adjacent hole which was 7.5 m away from the fracc hole, to produce water straight away. It did not, but I did find water coming out of a hole 50m away on the other side of the panel. Why the water took that path and did not come out of the intervening holes I do not know. The coal seam is not a homogeneous body. At Dartbrook, they fracted in the Bayswater seam which is much tighter. The fracc extended a longer distance. When the fracc has to be done in a tight space between drainage holes and so on, the chance for short circuits is high.

**Logan** – In hindsight, if we had targeted fraccing from the start we would have got a better result. But as it was the third cab off the rank, the results were not as good as they could have been.

**Dennis Black, Consultant** – regarding the path of the water flow, one of the challenges is the fracc that starts vertically oriented then becomes horizontal. The fracture can also be affected by coal type, being different in brighter than duller coal and by existing cleats.

**John** – Oaky North mine may encounter ground similar to the area which we fracted so what could we learn from this exercise for Oaky North? We cannot see anything in the area to show why the coal would not drain. The depth is only 160 m so it is not deep. Perhaps if 3 years ago, we had put the SIS hole in the right spot, drainage might have been less problematic.

**Ting Ren, University of Wollongong** – You said there was no obvious differences in the coal to explain why it would not drain. Is that based on observations, on measurements or microscopic studies? It is important to understand the microstructure of the coal. Some coal might have so little structure (too tight) and might not respond to fraccing. So microscale studies might be useful for understanding.

**John** – Observations revealed nothing. There could be value in further studies.

**Brad Elvy, South 32** – Did you consider nitrogen injection?

**John** – Yes. But we would have probably got similar results with short circuits into adjacent in-seam holes. The aim of fracking or N<sub>2</sub> injection is to drive the water and sand or nitrogen out as far as possible into the surrounding coal. Nitrogen was trialled at Oaky North some years ago by Russell Packham as part of his doctoral studies. We had SIS holes 100 m apart and that was difficult enough. Getting nitrogen on site is not easy, but CSIRO had the fracking gear readily available.

**Alan Phillips, Outburst Seminar Committee** – Did you consider using remote mining to cross the poorly drained zone?

**Logan** – That was plan F. We were in touch with the people from Tahmoor to give us a hand if we needed it. We reviewed our procedures to include grunching if necessary, but in the end we did not need it.

**Alan** – could you give an idea of cost of the exercise?

**Logan** – from deciding to getting the gear down the hole took 3 to 4 weeks. The sand had to come from South Australia. Cost wise, including drilling probably around \$1M to \$1.5M.

**Alan Phillips and Chris Harvey, Outburst Committee** – Thanks to everyone for attending this seminar which represents 20 years of the Outburst Seminar being held in Wollongong twice per year.

## **Appendix – Some references of interest regarding the terms “coal burst” and “outburst”.**

Moore, R.D. and Hanes, J., 1980: Bursts in Coal at Leichhardt Colliery, Central Queensland and the Apparent Benefits of Mining by Shotfiring. In The Aus.I.M.M The Occurrence of, Prediction and Control of Outbursts in Coal Mines Symposium. Note: This paper was appended to the Discussion notes for Outburst Seminar, November, 2014 which is posted on the Wollongong University Mining Website.

Marshall, P., Griffiths, L., Lama, R.D., 1980: Occurrence of Outbursts at West Cliff Colliery. In The Aus.I.M.M The Occurrence of, Prediction and Control of Outbursts in Coal Mines Symposium.

Hanes, J.1995, Outbursts in Leichhardt Colliery: Lessons Learnt. International Symposium-cum-Workshop on management and Control of High Gas Emissions and Outbursts in Underground Coal Mines. Note: copy included in presentations.

### **Recollections of Mining Through Outburst Conditions**

**Barry Condran, retired miner driver, West Cliff Colliery**

**Outburst Seminar, Wollongong, November 2009**

**Introduction by Bob Kininmonth** - Barry is a 4<sup>th</sup> generation coal miner. He started his mining at Mt Kembla in 1962 in the pick and shovel days. He then spent the last 23 years of his mining life at West Cliff as a miner driver during the times of the first outbursts.

#### **Barry Condran**

I was one of the first people employed at West Cliff which was a new mine at the time (1976).

We developed No. 1 Area which went well without problems. We then developed in No. 4 Area. One afternoon shift, we had a blowout on a mylonite zone. Nobody had experienced one before, so we collected whatever information we could and the consensus was that, if the coal was drilled, the gas pressure would be reduced and blowouts should be prevented. So the next time we had to drive through the zone, we pre-drilled it. Mining was occurring in the panel. One of our fitters went out to get a bolting machine and as he was walking back to the face there was a blowout through vibration in the borehole. Fines were ejected from the hole which knocked the fitter over. He still has the scars on his face. Back to the drawing board. I felt I did not want to be a miner driver staring down the barrel of hole into the face which could act like a choke on a shotgun targeting me.

We then formed a small crew of experienced miner drivers, Gordon Vivian, Stan Boag and myself. We were the ones who had to mine through the zones to develop through experience, as safe a

method as possible for mining them. We noted that each mylonite zone seemed to blow out differently from other mylonite zones. Some would just blow gas, some mainly coal and others a mixture of gas and coal. We had to devise a method for safe mining that could be easily understood by other miner drivers in the pit. We developed a code of precautions. We trained miner drivers to recognise such warnings as changes in the coal during mining, gas fluctuations on the monitors, a red tinge on the roof or “stretch marks” on the roof. These indicated a mylonite zone was coming. We added the precaution **“If you are not sure, DON'T”**. It was considered the best thing to do if a miner driver was not sure about what was in front, was to get the specialised crew which later became known as the “bomb squad”, to mine through the zone.

We had a lot of close shaves. In one case, we had to cut a turn near a mylonite zone which was close on the driver's side. This is a hairy situation. The burst occurred sooner than expected. The shuttle car was cross-ways under the back of me. When the burst occurred it pushed the continuous miner and shuttle car about 3m across the heading and took out a row of props on the other side. I was in the cabin and too close to the outburst zone. There were a lot of fines in the cabin and up the side. After that, we did all we could not to hit a zone on the side again and only mined them head on i.e. with the zone straight across the face. One zone was along a belt road so mining it it could not be avoided. We mined along it for a week. Mining was slow and only on day shift. The coal had time to partly drain between mining shifts. The mine manager had never experienced an outburst, so he stayed with us all week to see one. But he had to go up early on the Friday afternoon for a meeting and when he reached the dolly car, we had an outburst. (Editor's note – In the Illawarra, it was said that outbursts seemed more common towards the end of the week when mining was being conducted in coal that had had the least time to drain).

Sometimes when we struck a mylonite zone and expected a lot of coal to be ejected, we would just get a rectangular tube blow out with a lot of gas while the coal around it remained solid. Sometimes we would get what we called a puffer: a big amount of coal would slump off the face and release some gas, but that would be the end of it.

As the pit expanded, I spent a week with some shift crews for training. We had a bomb squad on each shift. This was when the longwall blocks were being developed in Area 4.

When we approached the major structural zone in Area 4, the regular crew would stop mining 20 m from the zone. Our bomb squad then took over. We squared the face off as we could not have an undercut. We kept the brattice as close to the face as possible with an extra prop set. We trimmed the face. We knew that when we got 3 or 4 m past the first cracks in the roof (joints) we expected an outburst. We trimmed only a little bit of the face at a time. At times we had to back off to allow the ventilation to take the gas away. When we thought we were ready to go with the burst, we sheared down and took a deeper undercut at the floor so that when we hit the miner into the zone, the blade would go in deeper and give more of a bang on the face. On the day we had the big outburst, I



was driving. I sheared down to the bottom and made sure it was deep enough. I stopped and made sure all was ready. I got the cable hand back out of the road. I dropped the head down about a foot below the roof so it would not hit the roof and cause sparks which could cause an ignition. I hit the face and the last thing I usually got was everything stopped because the pressure coming out of the face was greater than the pressure going in. This meant the zone was coming. There was a bit of a delay. First I would see the whole face area drop from the roof and push the miner back. Just behind that a big rectangular channel would blow out and then would come the noise. A big bang. Then it was over. In the big outburst, we loaded out 35 cars and still had more loose coal sitting there. Because the zone was straight across the heading, and with the miner head up, a lot of coal would blow under the head and push the miner back about 4m in this case. 9 brattice props were blown out. There was a compressed air blanket in the cab operated on demand by the miner driver.

People say we cannot see gas, but it was like a heat haze coming out of the hole. It continued to bleed out for several shifts with the constant "heat haze". After this, methane drainage caught up with us and took most of the pressure off the coal.

In most of the outbursts I mined, they came mainly from the top of the seam. Some came from the bottom or from one side. In some cases it was like a disc of coal blown out from the rib. On the little faults we had small CO<sub>2</sub> blowouts.

We were very lucky in those early days. We had our code of precautions and nobody was gung-ho about it. The outbursts frightened everyone. I know they frightened me. After the methane drainage caught up, there were still outbursts occurring but they were not as big or as severe. After the mylonite zones were mapped properly, they were projected on the maps and the normal crews stopped mining and handed over to the bomb squad prior to intersection of the zones.

That is how the bomb squad came into being at West Cliff.

## Questions

**Maarten Velzeboer** – I admire your courage.

**Barry** – It was not courage. Nobody had seen a mylonite zone or an outburst before, so it was a learning process. We had another experience when putting a cutthrough towards another panel. I was on the shuttle car and the miner was in two miner lengths. The miner driver was going to double the brattice at the turn while I emptied the car of coal. When I was at the boot end, I heard a loud bang. I thought "we aren't mining!". When I got back to the face I found that big flat discs of coal had blown off the face and back to the turn (15 to 20 m) and knocked the miner driver off the stand

he was on to fix the brattice. The vibrations from the nearby panel had initiated the burst. From then on, there was no mining side by side.

**Tin Ren, University of Wollongong** - What would you like to see in the way forward. What would you expect from researchers?

**Barry** - I thought gas drainage would eliminate outbursts. But at the last Outburst Seminar in June, I heard how Appin had just had an outburst which was not prevented by drainage, but was safely mined by radio controlled remote mining. Ripu Lama designed a radio system with a microphone in the miner driver's helmet with a receiver outbye. It was designed to test whether the sounds of mining changed when cutting through an outburst zone. I don't think it worked. I have been retired 10 years and I was hoping there would be no more outbursts. I hope there will be no more outbursts.

Ray Williams – Acoustic or microseismic was tried at Collinsville with Byron McCavanagh and he used it before then at West Cliff. It was inconclusive. The big problem was that nobody wanted to base a management system on an alarm going off a few seconds before an outburst and everyone having to run. It is possibly a reasonable research tool, but not a practical management tool.

**John Hanes, Outburst Seminar Committee** – Could you explain the big flat discs that burst.

**Barry** – It was sheets of 4 or 5 inches of coal which blew off as big pieces and a big bang but no signs of an obvious outburst.

John Hanes – 2015 – I suspect these discs were curvi-planar and produced by stress concentration.