Investigation report

Report into the deaths of James Mitchell and Phillip Grant at the Austar Coal Mine, Paxton, NSW on 15 April 2014

Report prepared by the NSW Mine Safety Investigation Unit
1 Executive summary

Incident overview
At 9:05 pm on 15 April 2014, James Mitchell (49) and Phillip Grant (35) died when a major rib/sidewall pressure burst occurred in a longwall development roadway (known as a gate road) during mining operations at the Austar Coal Mine, near Cessnock in the NSW Coalfields.

At the time of the incident, seven workers were operating a bolter miner and shuttle car to develop a gate road for a future longwall panel. The bolter miner had bolting rigs attached to each side for installing bolts in the roof and ribs to support the strata.

Mr Mitchell and Mr Grant were on the left side of the bolter miner when a major pressure burst of coal from the rib occurred. A large section of the left rib, which was supported with steel bolts and mesh, moved sideways into the roadway where the two men were working. Both men were engulfed by the rib material and died at the scene. The incident scene is depicted in Figure 14 of this report.

Co-workers attempted to rescue the men but the area was deemed unstable. The mine’s emergency procedures were initiated. Their bodies were recovered during the following days.

The incident occurred in a development panel known as Maingate A9 longwall development roadway, B Heading, about 25 metres inbye from the second cut-through. The incident site was approximately 10 kilometres in from the mine’s entrance and 555 metres vertically below the surface. At this depth, the sidewall (rib) and roof strata of the coal seam was subject to significant stress.1

Maingate A9 was in a geologically disturbed area near an upthrow fault and shear zone. The workers were mining toward the upthrow fault when the incident happened.

The roof and ribs at the incident site were supported by steel mesh and bolts. The roof was supported by a combination of steel mesh and chemically anchored roof bolts and cable bolts. The rib was supported by a combination of steel mesh and chemically and mechanically anchored bolting systems.

Investigation observations
The incident was a result of a pressure burst within the Greta Seam. A pressure burst is described as a dynamic energy release in the surrounding rock mass resulting in a rock/coal failure ejecting the failed material into the mine roadway at high velocity.2

The pressure burst was of such a magnitude and volume that it rendered the installed rib support ineffective.3

The Austar mine operator was aware of the frequent relief of stress within the rib strata at the mine. These phenomena were commonly referred to as ‘pressure bumps’ and occurred regularly.

A previous major incident of rib failure occurred in July 2011, which was investigated by the mine. From this investigation, the mine operator formed the view that the pressure bumps indicated that the strata had settled and that these bumps did not represent a risk to people at the mine.4

The methodology for ranking risk was confined only to considering occurrences in Australia. However, the geological conditions at Austar may not have been encountered previously in

1 J Galvin, B Hebblewhite, Pressure Burst Incident at Austar Coal Mine on 15 April 2014, March 2015, p.39.
2 J Galvin, B Hebblewhite, Pressure Burst Incident at Austar Coal Mine on 15 April 2014, March 2015, pp.3-4.
3 J Galvin, B Hebblewhite, Pressure Burst Incident at Austar coal Mine on 15 April 2014, March 2015, p.36.
4 J Galvin, B Hebblewhite, Pressure Burst Incident at Austar Coal Mine on 15 April 2014, March 2015, pp.80-82.
Australia and overseas lessons were not taken into account. Therefore, pressure bursts were not identified as a risk.  

International research reveals that pressure bursts in coal mines generally occur at depths of more than 300 metres, with the majority of burst occurring at depths of more than 400 metres. That research also shows that the risk of a pressure burst is increased in areas of significant geological disturbance and the presence of massive strata in close proximity to the seam. The incident occurred at a depth of 555 metres in an area of the mine subject to disturbed structural geology and variable thickness massive sandstone units in the near roof overburden.

A significant pressure bump had occurred on the afternoon shift 24 hours before the incident in B Heading of MG9 in close proximity to the incident scene. This was noted on the report of the deputy but there was no further action by senior management as the reporting of the pressure bump only went as far as the undermanager on the shift.

Austar’s safety management reporting systems did not instruct the deputies, undermanagers or other production staff at the mine on whether to report these pressure bumps or not. If they did report the pressure bumps through the reporting system, they were not acted upon in a planned or methodical manner.

Austar had a strata control management plan but it did not explicitly identify the risk of pressure burst. An effective safety system must identify all plausible risks. By not adequately identifying the risk and then not seeking to fully understand the nature of that risk, it was not possible to manage that risk. As a result, the Austar safety management system could not properly respond to the pressure burst-prone conditions it encountered.

Contributory factors to the incident

The investigation identified the following contributing factors to the incident:

- High levels of pre-mining vertical stress due to the depth of mining (+500 m).

- Potential additional stress contributions (in both magnitude and direction) due to the presence of disturbed structural geology in the region, and variable thickness massive sandstone units in the near roof overburden. Floor geology could also have been a factor, with evidence of massive sandstone and conglomerate units present in the floor, in close proximity to the Greta Seam in this region of the mine.

- Presence of a large scale zone of regional structural faulting represented by the Quorrobolong Fault Zone, together with off shoot faulting in the vicinity of Maingate A9.

- Presence of an intense and highly disturbed localised structural geology domain inbye of 2 cut-through, Maingate A9, as evidenced by a highly variable cleat pattern.

- The smooth and dominant shear surface presented by the Dosco Band within the Greta Seam, which appears to have acted as a dynamic shear failure plane once some form of triggered loading (or unloading) event occurred.

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5 J Galvin, B Hebblewhite, Pressure Burst Incident at Austar Coal Mine on 15 April 2014, March 2015, pp.80-82.
7 J Galvin, B Hebblewhite, Pressure Burst Incident at Austar coal Mine on 15 April 2014, March 2015.
8 Austar Coal Mine, Stata Failure Hazard Management Plan, 3 September 2013.
10 J Galvin, B Hebblewhite, Pressure Burst Incident at Austar coal Mine on 15 April 2014, March 2015, p.84.
• Reduction in confinement of the highly vertically stressed coal in the ribs due to the development mining process within the above complex geological environment.

**Recommendations**

The following recommendations are advanced to improve industry safety and reduce the likelihood of similar incidents occurring in the future.

When considering the recommendations below, mine operators are reminded of their obligation to manage risk in a systematic manner and take a combination of measures to minimise the risk, if no single measure is sufficient for that purpose. At a minimum, mine operators must apply the hierarchy of controls set out in the work health and safety legislation or equivalent to eliminate or minimise risk.

1. When developing strata control plans, mine operators should consider the following:
   a) Research that considers all relevant information from Australian and overseas sources.
   b) The history of the seam to be mined.
   c) The provision of high level geotechnical support and the use of comprehensive geological data and mapping to inform strata management decisions.
   d) Integration of the plan within the safety management system to ensure linkages with supervision, communication, training, monitoring/review and the management of major hazards.
   e) Significant changes in strata conditions and/or geological conditions, such as rapidly increasing and decreasing depth of cover that triggers appropriate review and redesign of the strata control plan.
   f) The presence of geological structures such as faults and dykes.
   g) Increasing depth over 300 metres including static and dynamic pressure, coal composition and strata types of the roof, floor and rib structures.
   h) The direction and nature of jointing of strata around the seam and cleating within the seam, especially localised changes in cleat direction, jointing and orientation.
   i) The use of inseam exploration drilling to confirm geological structures in and around the coal seam.
   j) The hierarchy of controls for managing risk.

2. When encountering pressure burst conditions, mine operators should consider the following:
   a) Develop a pressure burst management plan that takes into account a complete worldwide literature search of publications relating to pressure bursts.
   b) Review the history of pressure bumps and bursts in the seam to be worked across the mining district.
   c) Identify all areas in the mine that may be subject to burst conditions.
   d) Rate each identified pressure burst zone from low to high risk and develop appropriate controls as the level of risk rises.
   e) Record the location, frequency and intensity of strata noise events (such as bumps).
   f) Prevent entry to and remove people from identified hazardous zones.
   g) Minimise the tasks to be conducted in the identified hazardous zones.
   h) De-stress the identified high risk zones via drilling, water infusion, hydraulic fracturing and/or shotfiring.
   i) Implement remote bolting and remote mining techniques.
   j) Review temporary rib support and guarding on continuous miners.
   k) Review overall mine design.
   l) Use micro seismic monitoring systems (pre-mining and active mining).
   m) Weigh exploratory drill cuttings to determine volume of cuttings per metre of the in-situ coal.
   n) Review the mine’s communication system to ensure it is accurate, consistent and informs all levels of the workforce with relevant and timely information.
2 Purpose of the report
This report concerns the deaths of James Mitchell and Phillip Grant at the Austar Coal Mine (Austar), at Paxton NSW on 15 April 2014.

3 Investigation parameters

The department’s Investigation Unit
The unit investigates the cause and circumstances of major accidents and incidents in the NSW mining and extractive industries.

Its role is to carry out a detailed analysis of incidents and report its findings to enhance industry safety and to give effect to the department’s Enforcement Policy.

The unit is autonomous within the department and reports directly to the Secretary. It is separate from the department’s Mine Safety Inspectorate and is not involved in the activities of the inspectors, or the day-to-day inspection of mines.

Legislative authority to investigate
At the time of the incident, the Coal Mine Health and Safety Act 2002 (CMHSA) applied to all places of work at which coal was mined, that were within a Colliery Holding.11 The site of the incident is within Consolidated Mining Lease No2 (CML2), which is held by Austar Coal Mine Pty Limited.12 CML2 forms part of the Austar Coal Mine Colliery Holding of which Austar Coal Mine Pty Limited is the registered colliery holder.13

A coal workplace was defined by the Work Health and Safety Act 2011 (WHSA) to mean a place of work to which the CMHSA applies.14 The regulator of a mining workplace or a coal workplace was (and is) the head of the Department of Industry, Skills & Regional Development.15 The head of the department is the Secretary.

The CMHSA provided for the appointment of government officials to have oversight of mines.16 A person who is appointed as a government official under the CMHSA is deemed to be a coal mines Work Health and Safety (WHS) inspector for the purposes of the WHSA. A coal mines WHSA inspector has the power and functions of an inspector under the WHSA, including the function of investigating contraventions of the WHSA.17 18

As the incident involved the death of two people within the department’s enforcement jurisdiction, departmental policy requires the incident to automatically result in an investigation by the Investigation Unit.

The department’s response to the incident
The department’s inspectors and investigators, the NSW Police Force and Coal Services Mines Rescue responded to the incident immediately and worked with mine personnel during the recovery efforts.

The bodies of the two workers were trapped and recovery efforts began immediately. Mr Mitchell’s body was recovered approximately 32 hours after the incident. Mr Grant’s body was recovered approximately 42 hours after the incident.

11 Coal Mine Health and Safety Act 2002 (NSW) ss.3-4.
12 Austar Coal Mine Pty Limited, Consolidated Mining Lease No. 2 renewal, 4 December 2008.
14 Work Health and Safety Act 2011 (NSW) s.4.
15 Work Health and Safety Act 2011 (NSW) s.4: Coal Mine Health and Safety Act 2002 (NSW) ss.3-4.
16 Coal Mine Health and Safety Act 2002 (NSW) s.144.
17 Work Health and Safety Act 2011 (NSW) s.156A (3).
18 Ibid. s.160.
During the process of recovering the bodies, the investigation into the incident began. The investigation was conducted in consultation with stakeholders. Investigation activities included:

- incident scene analysis and photography
- conducting interviews with workers
- issuing statutory notices to the mine operator, supplier and individuals to produce information and documents
- obtaining plans of the incident site
- obtaining records from police, coroner and emergency services
- inspecting departmental files relating to the mine
- analysing information and records obtained during the investigation
- examining the mine’s risk control measures
- identifying if this incident was reasonably foreseeable
- identifying the causal chain of events (system failures) that led to the incident occurring
- identifying what risk control measures were introduced post incident
- engaging Emeritus Professor Jim Galvin and Professor Bruce Hebblewhite to assist the investigation and examine the geotechnical and risk management aspects of the incident.

Investigation Unit information release

An Investigation Information Release was published on 9 May 2014. The information release set out the general circumstances surrounding the incident and outlined the course that the investigation would follow.

The information release made the following observations:

- The incident was unlikely to be the result of a gas outburst
- The investigation would focus on the suitability of engineering and strata controls, systems of mining and safe work procedures related to the mining activities.

4 The deceased workers

Employment profile

Both Mr Grant and Mr Mitchell were employed to work as technicians at Austar Coal Mine. This involved operating machines underground and general labour. Both had received training in operating machinery at the mine. Their training records show that they were trained in the operation of the mining machine they were working with (Sandvik Bolter Miner ABM 25 or CM 35 as named by Austar) and the roof and sidewall (rib) bolting devices attached to that machine. Their records also reveal that their competency to operate those drilling rigs had been assessed regularly.

Mr Grant worked at Austar Coal Mine for eight years. Before this, Mr Grant had not worked underground. Mr Mitchell had worked with Austar Coal Mine for nine years and was a miner with many years of experience in the underground coal mining industry. Both men were highly regarded by their work colleagues and the community.

On the day of the incident, both men were fulfilling their general duties as part of the production crew in Maingate A9 (MG A9) and were on the left-hand side of the mining machine in preparation to begin the next round of roof and rib support.

Nature of injuries causing death

Post mortems for both Mr Grant and Mr Mitchell revealed extensive crush injuries consistent with a large volume of material being ejected from the rib.
5 The Austar Coal Mine

Figure 1: Austar Coal Mine showing Colliery Holding boundary, lease information and incident scene.\(^\text{19}\)

The mine’s history

The Austar mine was formerly known as the Southland Colliery and before that as Ellalong Colliery. Ellalong Colliery opened in July 1979 before becoming the Southland Colliery in January 1998 and finally the Austar Coal Mine in March 2005. Before the opening of the Ellalong Colliery, mining in the Greta seam in that area had been taking place since 1916.

The Austar mine website provides the following information about the mine:

Austar Coal Mine (Austar) is a deep underground coal mine located approximately 10 km southwest of Cessnock in the Newcastle Coalfields of New South Wales, Australia.

Austar Coal Mine is owned by Yancoal Australia Limited, an Australian-Chinese partnership. Yancoal purchased the mine in December 2004 and renamed it Austar Coal Mine.

Austar commenced mining operations in April 2005 undertaking underground mining activities within the company’s existing mining lease area and introduced a new technology called Longwall Top Coal Caving (LTCC) technology in September 2006.

Introduced in France, and further refined in China for the last 15 years, top coal caving uses a modified longwall mining system. LTCC technology is ideal [sic] in thick seams and enables significantly greater resource recovery is [sic] seams such as the Greta Seam. Austar has successfully used LTCC technology in Stage 1 to Stage 3 of the Austar Coal Mine.20

Mining at Austar has progressed in three stages as follows:

Stage 1 This mining area included two longwall panels below the former Aberdare State Forest. Mining was completed in this area in December 2008.

Stage 2 The mining area comprises three longwall panels beneath privately held small rural residential properties at Quorrobolong. The modification to allow for an increase in the height of extraction to 6.5 m using LTCC methodology was granted approval in June 2008. Mining began in Stage 2 area in February 2009 and was completed in January 2013.

Stage 3 Extension of mining to an area east of the existing operations. Planning approval was granted by the NSW Minister for Planning in September 2009. A modification to the Stage 3 approval to reorient the longwall panels was approved in March 2012. Mining in Stage 3 began in June 2013.21

Austar produced 1.5 million tonne of raw coal in 2013-14.22 The Stage 3 development of the mine, which includes Maingates A7 to A14, has a stated capacity to produce up to 3.6 million tonnes of raw coal a year.23 The location of the mine and the incident location are shown in Figure 1 above.

21 NSW Department of Trade and Investment, Comet incident database.
The companies involved

The operator
The CMHSA required that a colliery holder must not undertake any mining at a coal operation, or allow any other person to undertake any mining unless the colliery holder nominated one person who is the employer with the day-to-day control of the mine as the operator of the mine.  

Austar Coal Mine Pty Limited is the nominated operator of the Austar Coal Mine. 
The mine operator must prepare a health and safety management system for the coal operation that sets out how 'people who work at the coal operation, or are directly affected by the coal operation will be protected'.

The lease holder/colliery holder
Austar Coal Mine Pty Limited is the holder of Consolidated Mining Lease CML 2, which forms part of the colliery holding of the Austar Mine. The incident scene falls within these boundaries.

The corporate structure
Austar Coal Mine is wholly owned by Yancoal Australia Limited (Yancoal). Yancoal is an Australian publicly listed company. Yanzhou Coal Mining Company Limited (Yanzhou) is the majority shareholder of Yancoal.

Yanzhou owns and operates 21 coal mines across China and Australia, along with significant coal reserves and exploration rights in each country.

According to the Yanzhou website:

Yanzhou Coal Mining Company Limited is a listed company held by Yankuang Group Co., Ltd. in controlling shares, whose shares has been listed in Hong Kong, New York, Shanghai in 1998.

The relationship between and the percentage of ownership of Yanzhou, Yancoal and its Australian investments is the subject of regulation by the Australian Government through the Foreign Investment Review Board and the Takeovers Board (FIRB).

Yanzhou has voting power in approximately 78% of Yancoal’s shares. Yanzhou is 56.52% owned by Yankuang Group Corporation Limited, a Chinese state-owned corporation.

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24 Coal Mine Health and Safety Act 2002 (NSW) s.17.
26 Coal Mine Health and Safety Act 2002 (NSW) s.20.
6 Mining methods

MG A9 was part of the stage 3 approval to mine. This is depicted in Figure 1 showing longwalls MG A7 through to MG A14 (drawn in red). Approval to mine this area was granted in June 2013. The stage three approval was to extract coal from that area via the LTCC method of extraction.

Longwall mining

The practice of longwall mining consists of driving two sets of roadways (known as gate roads) to form up a block of coal for a mechanised longwall shearer to extract. As the longwall extracts the coal, the remaining strata caves behind large hydraulic shields forming a goaf, this is known as the retreat longwall mining method.

Figure 2 - Longwalls A7 and A8 at the Austar mine showing the gate roads and longwall face at 31 October 2014, six months after the incident.33

33 Austar Coal Mine, excerpt from Mine Plan, 31 October 2014.
**Development mining**

Gate roads are driven using a continuous miner and shuttle car arrangement (this is known as development mining). Coal mined by the continuous miner is then loaded into the shuttle car for transport to the conveyor system, which takes the coal out of the mine. At the incident scene an ABM 25 bolter miner was deployed (CM 35). This type of continuous miner is able to insert roof and rib support as it is cutting coal or, if conditions require, place the supports closer to the face before cutting the next sequence. Pictures of an AMB 25 bolter miner can be viewed at Figures 3 and 4.

Figure 3 ABM 25 cutting drum and left-hand side of bolter miner. Picture by Investigation Unit (April 2008).
History of pressure bumps in the Greta seam

Pressure bumps are a phenomenon associated with mining in both coal and metalliferous mines. Professors Galvin and Hebblewhite describe pressure bumps and the larger and more dynamic pressure bursts:

Both terms refer again to dynamic energy events associated with stress levels in the rock mass, which includes coal seams. However, the commonly accepted difference between a pressure bump and a pressure burst relates to the magnitude and hence consequence. A pressure bump is a dynamic release of energy within the rock mass in a coal mine, often due to intact rock failure or failure/displacement along a geological structure, that generates an audible signal; ground vibration; and potential for displacement of existing loose or fractured material into mine openings. (A pressure bump is also sometimes referred to a [sic] bounce).

On the other hand a pressure burst is a pressure bump that actually causes consequent dynamic coal/rock failure in the vicinity of the mine opening, resulting in high velocity expulsion of this broken/failed material into the mine opening. The energy levels, and hence velocities involved here can cause significant damage to, or destruction of conventionally installed ground support elements such as bolts and mesh.

History of gas outbursts in the Greta seam

The possibility that this incident was due to a gas outburst is detailed in section 8.2 of this report. It is important to note that there is only one recorded instance of a gas outburst in the Greta seam. This occurred on 6 February 1994 at the inbye end of longwall 12 maingate, which is a significant distance from the incident scene. A general rule of thumb is that in situ gas
concentrations need to be above 7 m$^3$/tonne for outburst conditions to exist at this depth.\textsuperscript{34} In situ gas concentrations in the stage 3 district varied between 1 and 4 m$^3$/tonne, which meant that there was a low likelihood of an outburst occurring.\textsuperscript{35}

Recent history of pressure bumps at Austar

Department records show that in the five years before the incident there were four reported incidents of unplanned fall of roof or sides that impeded passage or ‘disrupts mine ventilation or extends beyond the bolted zone’.\textsuperscript{36} Three of the reported incidents are known to have involved failure of sides that may have involved a pressure bump or burst.\textsuperscript{37} One of the three events occurred in July 2011 while developing the 300 Mains roadways (approximately 500 m from the incident scene). This incident involved the loss of the sidewall of the roadway for about 50 to 60 m, resulting in the sidewall needing to be resupported.

History of Maingate A8 and 300 Mains

Figure 2 shows the location of MG A7, MG A8, MG A9 and 300 Mains.

MG A8 was developed before MG A9 and encountered a number of geological conditions not dissimilar to those encountered in MG A9. Both developments experienced geological difficulties at the start of mining encountering a zone of geological disturbance called the Quorrobolong fault.\textsuperscript{38} This fault is characterised by a series of smaller geological structures surrounding an upthrow fault of 7.5 m vertical displacement.\textsuperscript{39} Once this fault zone was breached in MG A8, no further significant geological structures were encountered. However, interviews with workmen who drove those gate roads reveal that pressure bumps occurred (some severe) during and after passing this zone.

Pressure bumps were also reported by workers in the 300 Mains development adjacent to both these panels on a regular basis. Workers with considerable experience mining the Greta seam at Austar have said that pressure bumps were common and it was not unusual to get large pressure bumps at the mine.

All people working underground at Austar who were spoken to by investigators reported that strata bumping was common and large bumps were not unusual for the mine.

History of Maingate A9

Development in MG A9 began in September 2013. Figure 5 below depicts the location of the face of MG A9 at the end of every shift up to the time of the incident. As can be seen below, it took Austar approximately four months to advance 1 cut-through.

\textsuperscript{34} Hawcroft Consulting International, Yancoal Australia Ltd Austar Coal Mine, Risk Survey Underground, CHPP & Surface Operations Final Report, June 2013, pp.59.


\textsuperscript{36} Department of Trade and Investment, COMET incident database, April 2009–April 2014.

\textsuperscript{37} Department of Trade and Investment, COMET incident database, incident no. 317620406001, 27 March 2013; Department of Trade and Investment, COMET incident database, incident no. 317610267001, 2 March 2012.

\textsuperscript{38} Austar Coal Mine Geological Plan, 15 April 2014.

\textsuperscript{39} Austar Coal Mine Geological Plan, 15 April 2014.
The reason for the slow advance between one cut through and two cut through was that a drift of approximately 60 metres was driven to breach the Quorrobolong fault that had a vertical displacement of 7.5 metres. Once this was driven, the coal seam was intersected and A and B headings were driven in coal, at a distance of approximately 20 metres to 2 cut through. Heading A then advanced until it intersected with an unanticipated fault. The unexpected fault was estimated to be a three metre upthrow fault trending south. This fault was not anticipated in the mine’s planning and fell at the juncture of the next intersection (3 cut through) where it was planned that the take-off road for longwall MG A8 would intersect Heading A. Figure 6 below shows the fault intersected in Heading A.

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40 Austar Coal Mine, MG A9 daily drivage inbye 1C/T with drivage sequence, GEN 1477.

41 Austar Coal Mine, Authority to Mine No. 02 070314 MG A9 2ct- 4ct Revision 2, 5 April 2014.
Heading A and Heading B were then connected via a cut-through (known as 2 cut-through). As a result of the fault struck in Heading A, the decision was taken to change the design and sequence of the panel layout so that the fault’s characteristics could be proved. The decision was taken to drive 15 metres from Heading B down 2 cut-through toward MG A10 and then breakaway at an angle of 45 degrees to the left. This is shown in the Authority to Mine (ATM) in Figures 7 and 8.
Figure 7 Authority to mine for the MG A9 district page 1.42

Austar Coal Mine, Authority to Mine No. 02 070314 MG A9 2ct - 4ct Revision 2, 5 April 2014.

42 Austar Coal Mine, Authority to Mine No. 02 070314 MG A9 2ct- 4ct Revision 2, 5 April 2014.
The ATM shown in Figures 7 and 8 is the one that was in place at the time of the incident. The ATM is a crucial document in the mine’s safety management system and all activity in the development district is controlled through this document. Of particular note in Figure 7 is the information with respect to geotechnical matters and strata control.

The roof conditions in the stub drivage (as it was referred to at the mine) deteriorated rapidly until at 20 metres CM 35 was withdrawn, as the roof could not be supported and returned to B Heading to attempt to intersect the fault. Figure 9 shows the stub heading and the deteriorating strata conditions encountered in the ‘stub’ heading. The decision was taken at this time to forepole as B Heading was advanced.

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43 Austar Coal Mine, Authority to Mine No. 02 070314 MG A9 2ct- 4ct Revision 2, 5 April 2014.
Forepoling is:

…a technique allowing the installation of metal tube-shaped elements with longitudinal strike on the outside of the excavation perimeter, while advancing with respect to the excavation, aimed at protecting the cavity from material falling from the ceiling before lining the installation.44

The forepoling used at Austar consisted of installing flexible wire tendons (mega bolts) at a low angle in the roof to give an effective beam over the area being mined. It is a well-known method for mining in difficult conditions. Forepoling has been used in coal mining in circumstances of difficult roof and rib conditions for many years.45 46

The next three shifts preceding the incident were dedicated to advancing B Heading to the fault. During the course of these preceding shifts a number of pressure bumps were reported by the deputies of MG A9 and especially during the process of cutting coal.

The shift 24 hours before the incident was an afternoon shift with the same crew that was present when the incident occurred. On this shift the deputy reported a large pressure bump in B Heading while cutting was taking place. The extent of the bump was revealed by the operator of CM 35:

…and we had a big bump, it was big enough that we actually, a bolt come out and actually knocked on the elbow, bent the plates around and a few of the bolts. This was on the right-hand side. It felt, everything felt it was on the right-hand side.

46 S Schaller, G M Savidis, Roof Falls in Australian Longwalls, paper presented on Ground Movement and Control related to Coal Mining, AusIMM Illawarra Branch, August 1986.
And I've called over to__, he was on the left-hand side, by himself, and __ usually fairly jumpy on bumps, he wasn't, he said oh no. So it felt like everything was on the right-hand side.

It was a big bump, real big one. Like I've been on the miner when a few real big ones have lifted up 20 sheets of roof mesh and things like that before down there. This was, it was getting up there to being a real big bump.

Every time we started a cutter head and started cutting in we were getting some big bumps. Usually just one every car, one big one every car......

The bump was of such intensity that a decision was taken by the deputy and the operator of CM 35 to stop bolting while cutting, as identified by the following extract from another operator:

At that time, on the Monday, yeah, I'm used to the pressure bumps now, they are pretty regular, but this one was a really big pressure bump. __ was there, our deputy, everyone was there, __... Yeah, after that big pressure bump __ told us, __ told us to, instead of cutting and bolting at the same time, just to bolt up first. After we cut the metre, go in and bolt up, bolt all the ribs, bolt all the roof. Install all the roof bolts and rib bolts before we start cutting out for the next metre, because that's when the bigger pressure bumps were, was when we, obviously when that started, the heads were starting up, cutting through the coal.

The operator of CM 35 later explained one of the main reasons behind the decision:

Because of the bumps. Contain our ribs. Mainly on my side, everyone was stopped. Yeah, to contain that slabbing. So it's all meshed up. 'Cause when you cut the bump, when it bumps it will slab off... It'll go on the tracks, the miner will start leaning up and, yeah, so keep pulling back, clean up. So [put] it all up then do your cutting.

What the operator was referring to was that each time there was a pressure bump any rib that was not secured with mesh would fall down, creating difficulties for the operator in keeping the machine level and on the correct horizon. This was apart from any other risk the falling material created.

The shift directly preceding the incident was the day shift of 15 April 2014. There was no production on this shift as it was a planned maintenance shift. There is no record by the deputy on this shift of any pressure bumping.

The incident shift

The afternoon shift of 15 April 2014 began at 3 pm. The crew rostered on was the B crew. At the start of the shift, pit top meetings between the oncoming deputies and the undermanager of the previous shift occurred, along with communications meetings with people about to go underground. These shift meetings have two stages. The first meeting takes the form of a general communication or a shift report by the shift undermanager. The second meeting is what Austar call ‘I centre’ meetings where each work group discuss specific tasks for the day. On the shift of the incident the crew in MG A9 were informed of the maintenance that had taken place on the previous shift and the further work required before production could begin. A number of members of the crew recall discussing the ongoing pressure bumps in the district and the decision to modify their method of mining.
7 Circumstances of the incident

The location

Figure 10 Plan showing layout and some geological features of MG A9.47

Figure 10 shows the incident scene in MG A9. It also depicts the faulting between 1 cut through and 2 cut through and the anticipated location of the fault struck in Heading A inbye of 2 cut through.

Pictured in Figures 11, 12 and 13 is the incident scene from various perspectives. Figure 11 gives an overview from behind the shuttle car. Figure 12 was taken from the same side as Mr Mitchell and Mr Grant were on, after their bodies and the material that was covering the bodies was removed. Figure 13 shows the incident scene from the other side of the miner and gives a good view of the marker band in the Greta seam known as the ‘dosco band’ which according to Professors Galvin and Hebblewhite presented a smooth and dominant shear surface and appears to have acted as a shear failure plane.48

47 Austar Coal Mine, Basic Geology A9 MG Plan, 15 April 2014.
48 J Galvin, B Hebblewhite, Pressure Burst Incident at Austar Coal Mine on 15 April 2014, March 2015.
Figure 11 The incident scene showing the location of the shuttle car and continuous miner CM 35 before recovery of Mr Grant and Mr Mitchell. Note severe rib deformation on the left-hand side of the rib.

Figure 12 Incident scene showing the left-hand rib after the recovery of Mr Grant and Mr Mitchell.
The incident

The incident occurred at 9.05 pm in B Heading inbye of 2 cut through of MG A9 at a depth of approximately 555 m. Mr Mitchell and Mr Grant were both on the left-hand side of CM 35. The operator of CM 35 had just completed loading the shuttle car and had raised the cutting-head to the roof to park the cutting head. As soon as he turned off the conveyor, the incident occurred.

The following is an account by the operator of CM 35 of what took place at the time the incident:

So he's jumped in the car. I've got up in the miner, 'cause he's brought the car up behind the miner. I started the head again. I was up about, as I said I went to about 240 centimetres, which is my normal cut, for an undercut. Got it 240. I've gone in about 50 centimetres, I've gone down to 20 centimetres and I've sumped back, back in again, all the way, loaded the car right up. I had the conveyor still running when I was lifting the head up, just to park the head until the car came back again. I started lifting up and then I've flicked the conveyor off. As soon as I flicked the conveyor off that's when they had this huge pressure bump. It was like hitting a switch, it was, like almost instant at the time I've flicked that switch. Enormous pressure bump.

It sort of knocked me back onto the rail and I sort of ducked down, just out of habit, like coal sort of flying down your back and all that sort of stuff. Within seconds I heard [masking] yelling you, you know, you right, you right.

Approximately 38 cubic metres of coal was ejected from the left-hand side wall. The exact force and speed of the ejection is not known, but it is clear from the eye witness accounts that the coal ejected from the side wall with significant force. The deputy in charge of MG A9 B crew (the deputy) was driving the shuttle car at the time of the incident and describes the event as follows:

It was like there was an explosion. It was, there was massive, I was sitting in the shuttle car, it blew me into the mesh guarding on the shuttle car. I lost my helmet. When I sort of, after it, it was like a split second, it was just that quick and that intense and it just, I sort of gathered myself.
Mr Mitchell and Mr Grant were both at the point where the rib burst occurred and were buried as a result of the burst. Figures 11 above and 14 below show CM 35 and the shuttle car in B Heading immediately after the incident.

Figure 14: Plan of the incident.49

Immediately after the incident the roadway was full of dust. As the dust cleared, the remaining members of the crew attempted to establish where each of the other members of the crew were located. The following is an account of the immediate events after the incident by the deputy:

I couldn’t really see anything up there, the dust was that thick. Then I did see, after a couple of seconds I did see the light on the right-hand side. I was just screaming out, ‘Get out of there, just get out of there’.

It soon became apparent that Mr Mitchell and Mr Grant were buried on the left-hand side of CM 35.

After quickly assessing the situation, the deputy made the decision to withdraw the remaining workforce outbye of two cut-through and call in the emergency. The following is his account:

At that point I jumped up onto the shuttle car, had an XAM, jumped on the shuttle car, sort of straight up over the miner and I was standing on top of the mesh on the miner. I could see the boys, where they were. They were very visible, easy to see where they were. Immediately, as soon as I seen them I’ve had grave concerns of their safety. I knew it wasn’t good…

…the roof was still doing a bit of, making a bit of noise at that time, it was still bumping…

…Got back to there, I said to the boys to stay there, don’t move. They were standing outbye of the intersection. I said to stay there, don’t move, don’t let anyone through.

49 Austar Coal Mine, plan of MG A9 incident scene, 9 May 2015.
The deputy then returned to the continuous miner to see if he could gain a response from either Mr Mitchell or Mr Grant. The deputy formed the view that he could not guarantee the safety of the rest of his crew if they attempted to rescue the two men. The deputy had formed the view that both men were deceased, and it was not clear what had just occurred, and if indeed another similar incident would occur once they attempted a rescue/recovery.

By this time the mine’s emergency system had been triggered. The undermanager and deputies from other districts made their way into MG A9 to see if they could assist. Mines Rescue\textsuperscript{50} had been notified along with the department’s Inspector of Coal Mines, NSW Police and senior management of the mine.

Mr Mitchell’s body was recovered at 5.35 am on 17 April 2014 and Mr Grant’s body was recovered at 3.40 pm the same day.\textsuperscript{51} This task was undertaken by the Austar Mine with the assistance of Mines Rescue and overseen by NSW Police.

The investigation into the post incident emergency response revealed that the mine’s emergency management systems operated as per design. The mine uses a system of duty cards and reporting protocols that appear to have been followed in this instance.

8 Scope of the investigation

The investigation focused upon the type of mechanism that caused the side wall of the drive to fail. The following issues were examined:

- pressure burst
- gas outburst
- possible failure of installed support

**Pressure burst**

Determining the cause of the incident entailed a detailed examination of the nature of the overall geology of the mine and the forces and load distributions at the depth that the mine was operating. A thorough examination of the strata control in place at the mine was also required to identify if it was adequate in the circumstances.

As stated earlier, mining in the Greta seam in the Cessnock area has been undertaken for the last 100 years. The seam is well known to have poor quality ribs and in particular to suffer from a phenomenon known as pressure bumps. These bumps are generated by stress in the surrounding strata.

Understanding the forces at work in this context is a highly technical and specialist area of mining. Consequently, Emeritus Professor Jim Galvin and Professor Bruce Hebblewhite assisted with the investigation and examined the geological and risk management issues involved in the incident.

Professors Galvin and Hebblewhite concluded that the event that led to the death of Mr Mitchell and Mr Grant, was clearly a pressure burst, within the accepted terminology. A pressure burst is described as a dynamic energy release in the surrounding rock mass resulting in a rock/coal failure ejecting the failed material into the mine roadway at high velocity.\textsuperscript{52}

The pressure burst was of such a magnitude and volume that it rendered the installed rib support ineffective.\textsuperscript{53}

\textsuperscript{50} Mines rescue is part of the NSW government Coal Services group and provides underground incident response to coal mines in NSW, www.minesrescueservices.com, accessed 10 April 2015.

\textsuperscript{51} NSW Mines Rescue Service, Captain’s report.

\textsuperscript{52} J Galvin, B Hebblewhite, *Pressure Burst Incident at Austar Coal Mine on 15 April 2014*, March 2015, pp.3-4.

\textsuperscript{53} J Galvin, B Hebblewhite, *Pressure Burst Incident at Austar coal Mine on 15 April 2014*, March 2015, p.36.
International research reveals that pressure bursts in coal mines generally occur at depths of more than 300 metres with the majority of burst occurring at depths of more than 400 metres. That research also shows that the risk of a pressure burst is increased in areas of significant geological disturbance and the presence of massive strata in close proximity to the seam.  

Professors Galvin and Hebblewhite identified the following contributing factors to the event:

- High levels of pre-mining vertical stress due to the depth of mining (+500 m).
- Potential additional stress contributions (in both magnitude and direction) due to the presence of disturbed structural geology in the region, and variable thickness massive sandstone units in the near roof overburden. Floor geology could also have been a factor, with evidence of massive sandstone and conglomerate units present in the floor, in close proximity to the Greta Seam in this region of the mine.
- Presence of a large scale zone of regional structural faulting represented by the Quorrobolong Fault Zone, together with off shoot faulting in the vicinity of Maingate A9.
- Presence of an intense and highly disturbed localised structural geology domain inbye of 2 cut-through, Maingate A9, as evidenced by a highly variable cleat pattern.
- The smooth and dominant shear surface presented by the Dosco Band within the Greta Seam, which appears to have acted as a dynamic shear failure plane once some form of triggered loading (or unloading) event occurred.
- Reduction in confinement of the highly vertically stressed coal in the ribs due to the development mining process within the above complex geological environment.

**Longwall top coal caving**

Longwall top coal caving (LTCC) is a method of longwall mining that facilitates a greater recovery of the coal seam and is an enhancement of current longwall mining practices. This method of extraction is used in thicker seams where it is not practicable to construct longwall chocks and shearer of sufficient size to recover the full height of the seam. Full recovery of the seam is achieved by allowing the remaining coal in the top of the seam to fall behind the chocks onto a conveyor as depicted below in Figure 15.  

It was noted in media reports after the incident that the Austar Mine used the LTCC system of mining and there was conjecture that LTCC may have had some role in the incident. Professors Galvin and Hebblewhite did not identify LTCC or abutment stress associated with past development or the current longwall as a contributing factor to this incident. It is further worth noting:

- the longwall in MGA7 had ceased operation and was in the process of being dismantled and transported to MGA8 for installation at the time of the incident.
- the distance from the active longwall abutment pressures to the incident scene was approximately 800 metres.

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54 C Mark, Coal Burst in Deep Longwall Mines of the United States, 33-39, Ausrock 2014 Third Australian Ground Control in Mining Conference 5-6 November 2014, Sydney, Australia.
55 J Galvin, B Hebblewhite, Pressure Burst Incident at Austar coal Mine on 15 April 2014, March 2015, p.84.
58 Austar Coal Mine, Undermanagers shift address and report afternoon shift, 15 April 2014.
59 Austar Coal Mine, Record Tracing RT No.281, sheet 20 of 42.
Examination of the possibility of a gas outburst

The first obvious response for those conversant with the various types of failure that occur in the coal mining industry is the possibility that the cause of the incident was a gas outburst.

Outburst has been defined as a spontaneous ejection of gas and coal from the solid face, where the gas is a mixture of methane and carbon dioxide. This definition is questioned in the use of the term ‘spontaneous’, as this suggests an outburst occurs without triggering when an outburst can be provoked with the use of explosives or during the cutting of coal. Thus, outbursts have also been defined as a phenomenon characterised by ejection from the solid face into the mine as a mixture of broken rock and gas.

Gas outbursts are a well-known phenomenon in Australian coal mines and, indeed, coal mines around the world. The mechanism that drives a gas outburst is the differential in pressure between the gas in the seam and adjacent strata and the atmosphere in the void. As the mining void approaches the trapped gas, there is a point where the stored energy in the coal seam and surrounds becomes greater than the surrounding strata can withstand and the gas is released under pressure into the void. The size and destructiveness of the outburst is dependent upon the amount of gas trapped in the strata and the nature of the strata itself. Gas outbursts are therefore characterised by the often violent release of large volumes of gas during and after the event. The gasses generally associated with these events are methane (CH₄) and/or carbon dioxide (CO₂).

All coal mines in NSW at the time of the incident were regulated under the CMHSA and CMHSR. Section 36 of the CMHSA prescribed that all coal mines must have major hazard management plans that manage major hazards and that those plans are: ‘to state how the health and safety of the people who work at or are affected by the coal operation will be protected from the major hazard’.

Clause 28(b)(vi) of the CMHSR designates outbursts of coal and gas being a prescribed major hazard.

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62 R.D.Lama & J. Bodziony, Outbursts of gas, Coal and Rock in Underground Coal Mines (Weston Print Klama for the Joint Coal Board and Australian Coal Association 1996), preface.
63 Coal Mine Health and Safety Act 2002 (NSW), s.36.
64 Coal Mine Health and Safety Regulation 2006, cl.28 (b) (vi).
On the basis of this general understanding, investigators proceeded to obtain all the gas monitoring data available at the mine before during and after the incident.

The investigation established that while the Austar Mine had issues with spontaneous combustion, the mine had never had any issues with large volumes of gas being present in the in-situ coal. As noted earlier, the Greta seam had only one recorded instance of gas outburst and on that occasion the volume of gas present in the seam was substantially greater than that encountered at the incident scene.

In the area adjacent to the incident, samples from in seam drilling revealed very low gas volumes of 1.29m³/tonne to 1.37m³/tonne. However, samples from borehole AQD1114 adjacent to the incident had a gas content of 4.42m³/tonne, which is still low and unlikely to cause a gas outburst.

Mine deputies who worked in MG A9 before the incident reported that gas make for the unit were within normal range and that there had been no sudden increases in quantity of the gasses monitored before the incident.

Examination of deputies' statutory reports in MG A9 before the incident show no elevated readings of either CO₂ or CH₄.

The hand-held gas detector XAM 5000 used by the deputy during the shift the incident occurred had all its retained data downloaded and no evidence could be found of any gas reading that outside those normally experienced at the Austar Mine.

When the deputy present at the time of the incident was asked if the audible alarm on his XAM 5000 had sounded at any time before during or after the incident, he responded that it had not.

CM 35 is fitted with a Trolex methane monitor with four monitoring points around the machine. The monitors alarm at 1.25% and 1.5% CH₄, depending upon the setting at the mine. When the level of CH₄ reaches 2%, the machine is shut down. CM 35 records these alarms and shutdowns within an internal hard drive or logic box. This logic box was removed from CM 35 and examined with the assistance of the original equipment manufacturer. There were no CH₄ faults or alarms logged within the logic box for the period just prior to the incident. As a result of the incident, the power was turned off by the electrician working in B crew and therefore there is no data for the period after the incident.

Figure 16 below shows the location of the fixed real time monitors in the return airways at the outbye end of MG A9. Data from these monitors and from the tube bundle monitoring point 13 located outbye at the up-cast shaft, show relatively low and constant levels of CO₂ and CH₄ before, during and after the incident.

Figures 17, 18, 19 and 20 below graph the readings of CH₄, CO₂ and O₂ outbye of MG A9 for the period from 1 April 2014 through to 17 April 2014. As can be seen, there are no elevated readings or unusual spikes within the outbye gas monitoring system.

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65 Hawcroft Report, June 2013, pp.56-57.
67 Austar Coal Mine, Authority to Mine Revision 2 ATM1403, 5 April 2014.
68 R.D.Lama & J. Bodziony, Outbursts of gas, Coal and Rock in Underground Coal Mines (Weston Print Kiama for the Joint Coal Board and Australian Coal Association 1996).
69 Sandvik, Operating Manual ABM 25, 16 October 2010, ABM 25-35-1-Safety, 39-40 in 20140416TR001 and 2 s.178 seizure notice WHSA.
Figure 16 Austar Coal mine MG A9 gas monitoring points.\textsuperscript{70}

Figure 17 MG A9 return fixed methane sensor.\textsuperscript{71}

\textsuperscript{70} Austar Coal Mine, MG A9 Return Gas Monitoring points as at 15 April 2014, 5 June 2014.

\textsuperscript{71} Austar Coal Mine, MG A9 Return Fixed methane sensor, 14 May 2014.
Figure 18 Tube bundle point 13 Oxygen.\textsuperscript{72}

Figure 19 Tube bundle point 13 Carbon Dioxide.\textsuperscript{73}

Figure 20 Tube bundle point 13 Methane.\textsuperscript{74}

\textsuperscript{72} Austar Coal Mine, Tube bundle point 13 Oxygen, 14 May 2014.

\textsuperscript{73} Austar Coal Mine, Tube bundle point 13 Carbon Dioxide, 14 May 2014.

\textsuperscript{74} Austar Coal Mine, Tube bundle point 13 Methane, 14 May 2014.
Further, when the incident occurred, two other people were in close proximity to the incident: the deputy, who was on the shuttle car behind CM 35 and CM 35 operator who was on the right-hand side of the machine. If the incident had been the result of a gas outburst it was possible that both of these people could have been killed or at least seriously affected by the dramatic drop in the percentage of oxygen present in the air. Neither person reported feeling any ill effects of this nature at the time of the incident.

On the basis of the above information there is no evidence to support the theory that the incident was the result of a gas outburst.

Possible failure of installed support

The investigation examined all aspects of roof and rib support at the Austar Mine. This included examination of the methods of support, the machines used to install the support and the auditing of the support.

Examination of the initial scene did not reveal any obvious failure of the installed support system. The bolts that were installed in the ribs at the scene of the incident showed no sign of stress failure. The point at which the rib had failed was well beyond the zone of influence of the installed bolts. Consequently the support that was in place had little impact upon the event occurring as the bolts were ejected with the rib coal.

At the time of the incident, the ribs were being supported to a standard set out in the mine’s roadway support rules. The required standards for supporting the rib and roadway in the mine are shown below in Figures 21 and 22.

The upper and lower bolts in the rib were 1.5 m mechanical bolts with butterfly plates and the middle rib bolt was a chemical anchor, X grade, 2.1 m x 24 mm diameter with 100 mm minimum dome washer.

At the time of the incident, MG A9 was following the orange support plan for the roof and the yellow support plan for the ribs. According to members of the crew present that night, the rib on the left-hand side was in better condition than would normally be the case as demonstrated by the deputy’s response below:

The rib, the left-hand side rib was, it was, yeah, it was good drilling, holes were staying open. It was good. The right-hand side was slumping a little bit, but it was still going well.

Even though the rib code was yellow, members of the crew had decided to add extra support in the ribs, because of the previous bumping and the propensity for the rib to quickly deteriorate.

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75 J Galvin, B Hebblewhite, Pressure Burst Incident at Austar coal Mine on 15 April 2014, March 2015, p.36.
Figure 22 Condition yellow standard support plan.77

All witnesses spoken to after the incident that had observed the scene confirmed the view that the rib supports they had observed among the debris after the incident had no sign of mechanical failure of either the bolts or the plates. They also confirmed the view that the point of failure in the rib was at a point well beyond the effect of the rib bolts.\textsuperscript{78}

Figure 23 The chemical anchor bolts removed from the incident scene. Note each bolt appears to have full encapsulation of chemical resin.

Due to the soft broken nature of the ribs at Austar it was common for the operators of the bolting rigs to encounter problems when setting the rib supports. All operators spoken to insisted that if a chemical or mechanical anchor was not properly secured, a new bolt would be installed next to it. This contention is supported by observation of the support outbye of the incident as demonstrated in Figure 24 below.

\textsuperscript{78} J Galvin, B Hebblewhite, \textit{Pressure Burst Incident at Austar coal Mine on 15 April 2014}, March 2015, p.36.
As detailed earlier, each of the operators using the bolting equipment had undergone training in roof and rib support. Austar had a daily audit program for the installation of roof and rib support seen in Figure 26 below.
A further part of the Austar’s management of roof and rib installation was the regular auditing of the installed bolts by the contract firm supplying the bolts. These audits involved physical testing.

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79 Austar Coal Mine, Austar Coal Mine Installation Audit, 12 April 2014.
of the bolts with pull tests and torque setting test. An extract of a typical audit document is shown below in Figure 27:

Figure 27 Extract of Minova Visit Report – To carry out resin audit and torque test in 300 panel.

<table>
<thead>
<tr>
<th>Bolt No</th>
<th>Bolt Location</th>
<th>Nm</th>
<th>Tons</th>
<th>Comments</th>
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</thead>
<tbody>
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<td>300</td>
<td>8.87</td>
<td>Satisfactory</td>
</tr>
<tr>
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<td>RHS</td>
<td>300</td>
<td>8.87</td>
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</tr>
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<td>300</td>
<td>8.87</td>
<td>Satisfactory</td>
</tr>
<tr>
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<td>LHS</td>
<td>300</td>
<td>8.87</td>
<td>Satisfactory</td>
</tr>
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</tr>
<tr>
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<td>RHS</td>
<td>300</td>
<td>8.87</td>
<td>Satisfactory</td>
</tr>
<tr>
<td>7</td>
<td>LHS</td>
<td>300</td>
<td>8.87</td>
<td>Satisfactory</td>
</tr>
<tr>
<td>MB1</td>
<td>LHS</td>
<td></td>
<td>20T</td>
<td>Tensioned</td>
</tr>
<tr>
<td>MB2</td>
<td>RHS</td>
<td></td>
<td>20T</td>
<td>Tensioned</td>
</tr>
</tbody>
</table>

**Torque Wrench Reading (Ribs) 1.5M Mechanical / 2.1M resin anchored bolts**

<table>
<thead>
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<th>RHS</th>
<th>Inbye</th>
<th>Roof</th>
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</thead>
<tbody>
<tr>
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<td>100Nm</td>
<td>300Nm</td>
</tr>
<tr>
<td>2.1m 150Nm</td>
<td>120Nm</td>
<td>2.1m 50Nm</td>
</tr>
<tr>
<td>140NM</td>
<td>120Nm</td>
<td>100Nm</td>
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</tbody>
</table>

<table>
<thead>
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<th>Inbye</th>
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</thead>
<tbody>
<tr>
<td>Roof</td>
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</tr>
<tr>
<td>100Nm</td>
<td>300Nm</td>
</tr>
<tr>
<td>0Nm</td>
<td>2.1m 350Nm</td>
</tr>
<tr>
<td>150Nm</td>
<td>100Nm</td>
</tr>
</tbody>
</table>

**Solutions from Materials Technology**

Minova Form No: MA-MK.690 Issue No 003

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As part of the mine’s Strata Failure Management Plan, a monthly strata management meeting was required to be held where results of the above testing and installation auditing were to be reported and analysed. The minutes from the November 2013 strata failure management meeting noted the results of testing of the installed support by Minova for the October 2013 bolt audit. It is worth noting that no further meetings of this group took place from November up to the time of the incident. Therefore, the results of the above December audit were not discussed at any time before the incident. Although this may not be a crucial factor in the cause of the incident, it is a breakdown of the administrative controls designed to prevent such an incident from occurring. This issue is detailed in section 9.1 below.

**Functionality of CM 35 strata support equipment**

As part of the investigation, CM 35 was removed from the scene of the incident and taken to a safe place where testing of the bolting rigs was undertaken. Testing revealed that all bolting apparatus was working in accordance with the manufacturer’s design specifications.

The SANDVIK Continuous Bolter Miner ABM 25 CM 35 in Maingate 9 Development Panel at Austar Mine overall condition was within acceptable limits with no obvious defects detected or observed during the function testing process:

- The rib bolting rig on the left-hand side of the continuous miner operated without defect, was fully functional and performance criteria specifications was achieved.
- The inboard roof bolting rig on the left-hand side of the continuous miner operated without defect, was fully functional and performance criteria specifications was achieved.
- The outboard roof bolting rig on the left-hand side of the continuous miner operated without defect, was fully functional and performance criteria specifications was achieved.
- The Temporary Roof Support of the continuous miner operated without defect and was fully functional and within design limits.
- The Temporary Rib Protection of the continuous miner operated without defect and was fully functional. Albeit the vertical shield showed signs of inward deflection when compared to the right-hand side temporary rib protection.
- The operator’s platform on the left-hand side of the continuous miner operated without defect and was fully functional and within design limits.
- The mega bolt tensioner operated without defect and was hydraulically fully functional and within design limits.

The maintenance system in practice at Austar Mine appears to be achieving the desired outcomes. This was demonstrated by the system detecting an incomplete step in a maintenance procedure activity, the raising of a subsequent corrective work order to complete the outstanding activity, scheduling the activity and completing the task.

The analysis of the maintenance system and the physical function testing confirmed that the strata support equipment installed on ABM25 CM 35 on the 23rd of June 2014 were being routinely inspected, tested, maintained and operated within the acceptable performance criteria set by the O.E.M. pre and post incident date.81

Figures 28 and 29 below show CM 35 after being moved from the incident scene. Figure 28 shows significant damage to the hand rails, while Figure 29 captures the bent rib shield on CM 35.

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Figure 28 CM 35 post incident; note the bent handrails and rib guard.

Figure 29 CM 35 after being moved from the incident; note rib guard is bent into the machine, the inflection measuring 110 mm.\textsuperscript{82}

\textsuperscript{82} Austar Coal Mine Mechanical Report Sandvik ABM 25, CM 35 Strata Support Equipment, 6 February 2015, p.10.
9 Safety Management Systems

The investigation also examined Austar’s safety management system. At the time of the incident, Austar had an extensive safety management system, the ‘Austar Coal Mine Health Safety Management System’, as required by WHSA and CMHSA. The system consisted of a combination of hazard management plans and major hazard management plans as required by the legislation. Central to the understanding of this incident is the strata failure management plan, the inspection program, supervision arrangements, information, communication arrangements and auditing of the system. Each of the major hazard management plans require training for persons working under the plan.

Strata failure management plan

The mine had extensive documented material on strata control within the Austar Mine.

Training in the strata failure management plan

Mr Mitchell and Mr Grant went through an extensive induction in the mine’s various systems of work and received subsequent ongoing training in the operation of a variety of underground machinery.

That training encompassed strata management, which included basic training in understanding the type of roof conditions to be expected within the Austar mine and the operation and installation of roof and rib support.

Austar had a regime of assessing the quality of the roof and rib bolting operations every shift. As one of their tasks, the deputies in the panel had an assessment sheet that they filled out on a regular basis. The deputies were required to conduct a number of task observations as part of that assessment (see Figure 26).

During the course of the investigation, each of the operators of the bolting machines on CM 35 were asked about the training that they had received and questioned about how they installed the required roof support. The responses from all of the operators demonstrated a sound knowledge of the proper installation of roof and rib support.

However, it was identified that while training in the strata failure management plan was quite extensive at the start of employment at the mine, formal ongoing training every 18 months as required under the strata failure management plan was not being achieved.

Communication arrangements within the strata failure management plan

The strata failure management plan sets out a communication strategy that involves the following:

- start of shift communication
- daily review and distribution of information
- weekly planning meetings and distribution of information
- monthly technical service meetings and subsequent distribution of information.

The plan also requires that records of all communications involving strata control should be kept as a reference. Investigators required production of all mine records of all communications referred to in the strata failure management plan. These records identified that there had been no monthly strata meetings since November 2013 despite the mandated requirement within the mine’s strata failure management plan.

As discussed above, there was a visual audit document (see Figure 26) used by the mine deputies to assess the competence of operators when installing roof and rib support. However

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83 Austar Coal Mine Pty Ltd, *Austar Coalmine Roof support installation Audit*, 140514TF001 s 171 Notice WHSA 2011, 14 May 2014.
some senior managers had no knowledge of its existence. This lack of knowledge of what was being done within another area of the mine’s management systems highlights a lack of communication across the mine’s technical and supervisory management streams. It further denies the technical support team of vital information about the conformity of installation of roof support within the mine.

Communication and consultation procedure
The communication and consultation procedure is part of the mine’s health and safety management system and is intended to outline the various forms of communication and consultation within the Austar mine. This forms an integral part of the management of information and how it is distributed within the organisation. It is a vital part of the mine’s safety management systems and was required under the CMHSA and regulations. It also forms a critical feedback component of the continual improvement loop outlined in AS/NZS 4801:2001.

Consultation, communication and reporting are a designated requirement of any health and safety system as per the AS/NZS 4801:2001.

Reporting of statutory officials
The communication and consultation procedure did not include in its scope the collection, reporting and distribution of information within the mine’s statutory reporting regime.

The investigation disclosed a number of areas of concern with respect to the following:

1. Mine deputies reported the strata bumps in the mine on an ad hoc basis, with some deputies reporting the bumps as part of their daily reports and others not.
2. The mine undermanagers, like the deputies, had an ad hoc approach to the reporting of bumps from the deputies.
3. Where information concerning strata bumps was recorded, no further investigation by the mine occurred. Further, this information was passed to oncoming crews in an ad hoc manner. There was no firm guideline as to what information was presented at prestart meetings or, indeed, to senior management.
4. Senior technical staff did not access the available information on a regular basis nor did they track the frequency of bumps within the strata.
5. Because senior technical staff did not access this information, vital information contained within the deputies’ reports was not reviewed, which meant that when they reviewed the mine’s strata failure management plan they were not sufficiently informed of all the relevant factors impacting upon support within the mine. Therefore a vital link in the risk management loop was missing.

Undermanagers’ daily reports
The undermanagers’ reports form a vital part of the communication system and therefore it is important that as much information as can be gathered from the operation is reported and recorded in these reports.

During the course of the investigation, the process whereby information was collected from each shift was examined.

This process involved the gathering of information during the course of the shift from a number of different mechanisms. The mine has a central control room that is manned whenever people are underground. The control room operator monitors what is happening underground throughout the shift with each of the underground production districts and inspection areas of the mine reporting to the control room throughout the day. The control room then keeps a log of each of the major events on the shift as well as monitoring the mine’s gas monitoring system. The control room log records where people, machines and materials are within the mine at any given time and how they were being deployed. The log is updated at the end of each shift and formed the basis of the oncoming undermanagers’ daily plan and subsequent report.
The control room log sheet was supplemented with a work sheet that had the location of all machines in the mine and the allocation of people to those machines. This document also formed part of the daily undermanagers’ report.

The undermanager also had a work sheet that they filled out with relevant data during the course of the shift and recorded information provided from the mine deputies both verbally and via their statutory and production reports. The undermanagers’ end of shift report also included the undermanagers’ shift address.

The undermanagers’ report varied from undermanager to undermanager depending upon how they wished to structure it. The undermanagers did not have any guidance on the content or the structure of these documents. It became apparent during the course of the investigation that a significant amount of the detail contained within the undermanagers’ reports was discretionary. There was no attempt to distil the large volume of information into one readable and coherent document. The document itself appears to have been essentially a production tool with minimum focus on the critical safety issues at the mine.

The investigation also found that the undermanagers received little or no feedback on the information contained within their reports. When questioned, a number of the undermanagers were not aware of who read their reports or how their reports were used by other management personnel.

Figure 30 Undermanager’s report; note the area marked with the red outline devoted to safety.86

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86 Austar Coal Mine, Undermanagers Report, 14 April 2014.
**Reporting of pressure bumps**

It was noted that each deputy and undermanager viewed the reporting of pressure bumps differently. An example of this is demonstrated by the responses of three deputies below. Deputy No. 1 reports pressure bumps occasionally:

Q45  …So I’m just trying to work out what are the triggers that make you, you know, put that down on your report sheet?

Answer
Deputy No 1  Yeah, it’s hard to quantify. When it’s probably unusual or large, and I’d say the frequency.

On the other hand, Deputy No 2 does not report bumps as he believed that it was not necessary:

Q 299 Now on those reports that you've actually got there I did note that you, when I went through, that there’s no bumps, or you haven’t noted any pressure bumps during the course of the time, those four weeks or so that I went through the reports.

I was just trying to get a feel, when would you note a pressure bump down on your stat report?

Answer
Deputy No 2  It would have to be something out of the ordinary.

Deputy No.3 had reported pressure bumps on a regular basis in the period leading up to the incident:

Q 156  Well that was the question I was actually going to ask. Why you wrote it down on the night, you know, what brought your, you know, what made you think it was worth noting?

Answer
Deputy No 3  Well like I said, it's a common thing. Because our coal was that soft, 600 [sic] is not, you know, uncommon. If you went down there you’d find a lot of areas where we’ve actually put up extra, if our rib blows out too much and we do go to this extra support, you know, we put in extra mesh and extra bolts and things like that, you’d see a lot of areas like down there. It's quite common.

The inconsistency with the deputies reporting on pressure bumps is replicated when similar questions were asked of the undermanagers.

As outlined earlier, 24 hours before the incident there was a significant bump in the same roadway and with same crew. The bump was of such magnitude that it appeared to those present that the rib moved outwards with the bump and then returned to its former position. The bump was recorded in the deputy’s report and the deputy passed on the information to the oncoming deputy. The report was not noted by the undermanager anywhere and no one in senior management was aware of its occurrence before the incident. It was therefore impossible for anyone in senior management or any of the technical staff to analyse the incident or to take any action to control any adverse outcomes from such a bump.
10 Causal factors

Incident analysis
To understand how this incident occurred it is necessary to look over the history of strata control and pressure bumps/bursts at the Austar Coal Mine and its antecedent, Ellalong Colliery.

The Greta seam was mined continuously in the Pelton and Ellalong areas of greater Cessnock over the past 100 years. The seam is well known for the strata noise that it makes when mining is occurring.

Professors Galvin and Hebblewhite noted a long history of the dynamic release of energy within the rock mass or, as it is referred to, a pressure bump, within the Austar mine leading up to the incident. The Austar Mine did not identify the risk associated with this release of energy. In fact the workforce was encouraged to view these events in a positive light as they indicated a relieving of pressure in the strata. Although what this really meant was not clear to the people who were interviewed.

No matter how loud the pressure bump or how frequent, there was no planned response at the mine other than for it to be noted in the deputies’ reports and sometimes in the undermanager’s production records. It should be noted that the undermanager’s reports were made up of various forms that the undermanagers filled in their shift information. This process was more about the collection process than a considered report by each undermanager of the shift’s significant events and forward planning of future tasks. For this reason, coalescing this information into one coherent report and analysis of each shift was neither achieved or attempted. Further to this, it would appear that no attempts were made to correlate and analyse significant events from this data.

On the occasion in 2011 when a significant bump/burst occurred in the 300 Mains, there was a concerted response by the mine by way of investigation and analysis of the incident. The conclusions of this analysis led to the belief that a pressure burst was not possible within the Greta seam (even though some form of bump or burst had just occurred, resulting in significant rib collapse). However, the mine did not access known sources of information from overseas on the occurrence of pressure bursts.

The information that the mine used to formulate the strata control systems was incomplete. Consequently it did not matter if the implementation of the management plans were well carried out and adhered to, as there was a failure at the start of the process to identify all the risks. Therefore, it was not possible for the mine to put in place controls when the risk was not properly identified. Research should have alerted management to the risk of pressure bursts.

11 Remedial actions

Remedial actions by the mine
Immediately after the incident, the mine was issued with a non-disturbance notice by the department. On 16 April 2014, the department issued a clause 51 notice under the CMHSR setting out that no further development mining was to take place at the Austar mine until the mine had produced two independent geotechnical reports detailing how further mining was to take place safely. That notice still stands but has been amended on a number of occasions to allow Austar to recommence development production in a staged manner.

88 J Galvin, B Hebblewhite, Pressure Burst Incident at Austar coal Mine on 15 April 2014, March 2015, p.82.
89 J Galvin, B Hebblewhite, Pressure Burst Incident at Austar coal Mine on 15 April 2014, March 2015, p. v.
90 CMHSR Cl 51 notice, 16 April 2014.
On 13 October 2014, Austar submitted two geotechnical reports to the department as required under the notice.

After further consultation, Austar submitted a proposal to vary the notice to allow development of 120 metres of roadway in the mine. Further meetings between the department and Austar followed in early December 2014. On 11 December 2014, the Chief Inspector issued a variation to the notice to Austar allowing it to mine the 120 metres of roadway based upon the changes to safety management systems proposed by Austar. Further minor adjustments were made to the safety controls proposed by Austar before production began on 15 December 2014.

The proposed drivage was limited to roadways required by the mine to complete recovery roads at the outbye end of longwall MG A8. Before Austar began this work, a risk assessment was conducted considering the issues identified in the two reports commissioned by the mine. From this an authority to mine was created to guide special features of the development such as anticipated geology, the proposed sequence of drivage and any further safety controls to be deployed beyond the mine’s standard safety systems.

At the time of writing, Austar was permitted to further mine in another part of the mine known as Bellbird South. The mine has to adhere to the following conditions:

1. The development is limited to that shown in drawing ATM 1412 400 Mains dated 9/12/2014.
2. The development is not to commence until a mine inspector attends the panel and permits the commencement of mining.
3. The authority to mine document No. 05 091214 is to be strictly complied with.
4. The Development Coal Burst Trigger Action Response Plan (Coal Burst TARP) Version 1-09/12/2014 is to be strictly complied with.
5. 400 Mains Development Implementation Plan Revision 2 issued 11/12/2014 is to be strictly complied with.
6. The results of the cuttings tests (when undertaken) must be emailed to the mine inspector and industry check inspector on a daily basis.
7. Any non-compliance with the above conditions is to be notified immediately to the mine inspector and industry check inspector.

Any change to the currently identified risk levels must be notified to the mine inspector and industry check inspector as soon as is practicable.91

The Coal Burst TARP and the Authority to Mine set out a number of administrative controls designed to assess the level of risk of each new area mined and put in place further controls. All available geological data has been reviewed and a risk profile developed for the area to be mined. The Coal Burst TARP and the Coal Burst Hazard Plan for the Bellbird South extension is shown below in Figures 31 and 32.

91 Department of Trade and Investment, Variation to clause 51 notice No 05901, 22 May 2015
Figure 31 Bellbird South Development Coal Burst TARP.

Austar Coal Mine, Bellbird South Development Coal Burst TARP, 5 May 2015.
Figure 32 Bellbird South Geological and Coal Burst Hazard Plan.93

93 Austar Coal Mine, Bellbird South Geological and Coal Burst hazard Plan, 1 May 2015.
Further testing of the strata is done via a cuttings volume test, measuring volume of drill cuttings per metre of borehole drilled into the coal in the adjacent pillar as the roadway is developed. This is done by drilling horizontal boreholes into the rib for a distance of 13 metres. The cuttings from these boreholes are collected and the volume determined for each metre of the hole. The results of these cuttings tests are then evaluated against a TARP developed for the Austar mine based upon the mine’s history and the experience of the volumes per metre associated with coal burst control in Germany and Poland.94

In the first proposal put by Austar and agreed to by the department, the number of people allowed to be at the face while cutting is taking place was limited to two and no other people were allowed to enter within 16 metres of the face while cutting was taking place. In the Bellbird South proposal the standing zones are determined by the TARP ranking applying to the zone being mined.95

Austar has also developed a guide to assist supervisory staff rate bumps on frequency and intensity so that they can be reported with greater accuracy.96

**Other risk management controls**

Professors Galvin and Hebblewhite suggest that a number of other possible controls ought to be considered in similar mining circumstances:

- Two controls that could have assisted in quantifying this uncertainty were absent at Austar Coal Mine, these being microseismic monitoring and the use of drilling techniques to monitor the state of stress about working faces.97

The second of these two suggested methods of assisting in the prediction of the possibility of a pressure burst has been engaged by Austar. However, the use of microseismic monitoring had not been adopted at the time of writing. Microseismic monitoring was not suggested as a total solution to the prediction of these events. It was however suggested that monitoring of the strata over time in the development panels would build up a base of knowledge with respect to the mines strata behaviour, which should assist in the prediction and management of these events.

At the time of the incident, the risk management controls in place were mainly administrative in nature. Using the hierarchy of controls and starting with the elimination of the risk entirely would, in this case, require not mining. Therefore, if mining is to continue, lower levels of control are required to minimise the risk so far as is reasonably practicable.98

The question of strata support being completely automated has been the subject of research and development by the major original equipment manufacturers and the subject of a number of research projects.99 Whether the development of a fully automated machine is possible in the near future is uncertain. The Australian Coal Industry Research Project (ACARP) has been conducting a research and development project in this area since 2007 with the commencement of stage 1. The project was at stage 3 at the time of writing. The following extract from the ACARP website titled *Stage Three Report: Automated Bolting And Mesh Handling On A Continuous Miner* sets out the current state of that project:

Roadway development rates across the industry are failing to keep pace with modern longwall systems and are unlikely to sustain further improvements in longwall productivity unless step change improvements to roadway development equipment and practices are

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96 Ibid. p.18.
97 J Galvin, B Hebblewhite, *Pressure Burst Incident at Austar Coal Mine on 15 April 2014*, March 2015, p.82.
98 Work Health and Safety Regulation 2011 NSW cl. 35.
realised. Bottlenecks which constrain improved production and impact the safety of operators have been identified through a series of industry surveys, with the manual installation of strata support materials off the continuous miner being identified as a major inhibition to improved development performance.

Stage 1 of Project C17018 Automated Bolt and Mesh Handling commenced the development of first generation enabling technologies with the objective of automating current roadway development roof and rib support installation processes, with the joint aim of developing a high capacity roadway development system (10 MPOH advance rate) and removing personnel from hazards in the immediate face area, particularly those associated with working in a confined working environment in close proximity to rotating and moving equipment.

Stage 2 of the project continued development of these enabling technologies and culminated in a series of laboratory trials and demonstrations early 2011 that successfully demonstrated the various prototype manipulators that comprise the integrated strata support consumables handling system. Whilst these trials clearly demonstrated that the entire consumables handling function could be automated, they also identified a number of refinements which could improve both cycle times and system reliability. These refinements were progressively developed over the balance of Stage 2, including fully detailed engineering design and computer simulation of the second generation enhancements.

Stage 3 of the project extended the earlier stage objectives to manufacture and demonstrate the second generation automated bolt and mesh handling technologies and include additional automation which would simulate an entire one metre advance cycle (installation of 23 consumables) for both left and right sides of the machine. During the three month period between December 2013 and February 2014 a series of industry and academic above ground demonstrations where conducted to demonstrate and validate a complete full cycle, simulating five metres of unmanned roadway, and to bring the project to a point of ‘technology transfer’ to industry. The demonstrations conducted were successful, with many key representatives from industry having the opportunity to view the operation in its entirety, provide feedback and express interest to progress the technologies commercially.

After the final surface demonstration using the mobile platform and simulated roadway, the University of Wollongong now aims to assist the transfer of intellectual property to parties interested in commercialising the technologies.100 It may not be that long before it is possible to remove people from the face during the mining process. Removal of people from the area altogether would eliminate the risk. Unfortunately the technology has not yet evolved to install the strata support remotely. Therefore when mining in burst-prone conditions, bolting and cutting should not be carried out simultaneously and the bolting crew should be removed from the continuous miner when cutting. Further, improved guarding or shielding should be considered to protect the bolting crew from the exposed rib-side, whether or not it has been bolted.

The development of improved protection for the drill rig operators would also assist in dealing with the further issue of knowing how long one should wait before it is safe to return to the side of the miner to install support after cutting.

However, the difficulty exists in engineering a barrier of sufficient strength and size may reduce the space available to install the bolts and mesh and may further limit the manoeuvrability of the machine, which is required to be able to turn sufficiently to construct 90° cross cuts between the advancing headings.

A further consideration is the well-understood tenet of strata control: The sooner support is installed, the sooner any movement in the strata can be controlled and therefore the greater the stability of the strata.101 This factor should be considered in future improvements in technology.

A further matter to be considered is that the possibility exists that a failure of the rib due to additional abutment loading may occur at a much later time when people are present in the roadway.

It is therefore difficult to balance these competing needs. As noted earlier, Austar has removed all unnecessary people from the face area when mining is taking place.102

Other controls that may be considered to reduce the risk of a pressure burst involve destressing the area to be mined via drilling, water infusion, hydraulic fracturing and shotfiring. Austar has not adopted any of the above practices at this time.103 These methods have had varying levels of success in Germany, Poland and the United States.104

12 Recommendations

The following recommendations are advanced to improve industry safety and reduce the likelihood of similar incidents occurring in the future.

When considering the recommendations below, mine operators are reminded of their obligation to manage risk in a systematic manner and take a combination of measures to minimise the risk, if no single measure is sufficient for that purpose. At a minimum, mine operators must apply the hierarchy of controls set out in the work health and safety legislation or equivalent to eliminate or minimise risk.

1. When developing strata control plans, mine operators should consider the following:
   a) Research that considers all relevant information from Australian and overseas sources.
   b) The history of the seam to be mined.
   c) The provision of high level geotechnical support and the use of comprehensive geological data and mapping to inform strata management decisions.
   d) Integration of the plan within the safety management system to ensure linkages with supervision, communication, training, monitoring/review and the management of major hazards.
   e) Significant changes in strata conditions and/or geological conditions, such as rapidly increasing and decreasing depth of cover that triggers appropriate review and redesign of the strata control plan.
   f) The presence of geological structures such as faults and dykes.
   g) Increasing depth over 300 metres including static and dynamic pressure, coal composition and strata types of the roof, floor and rib structures.
   h) The direction and nature of jointing of strata around the seam and cleating within the seam especially localised changes in cleat direction, jointing and orientation.
   i) The use of inseam exploration drilling to confirm geological structures in and around the coal seam.
   j) The hierarchy of controls for managing risk.

2. When encountering pressure burst conditions, mine operators should consider the following:
   a) Develop a pressure burst management plan that takes into account a complete worldwide literature search of publications relating to pressure bursts.
   b) Review the history of pressure bumps and bursts in the seam to be worked across the mining district.
   c) Identify all areas in the mine that may be subject to burst conditions.

103 Golder Associates, The Causal factors Associated with the Coal Burst in MG A9 and the anticipated impact on future roadway development at the mine, October 2014.
104 C Mark, Coal Burst in Deep Longwall mines of the United States, 33-39, Ausrock 2014 Third Australian Ground Control in Mining Conference 5-6 November 2014, Sydney, Australia.
d) Rate each identified pressure burst zone from low to high risk and develop appropriate controls as the level of risk rises.
eg) Record the location, frequency and intensity of strata noise events (such as bumps).
f) Prevent entry to and remove people from identified hazardous zones.
g) Minimise the tasks to be conducted in the identified hazardous zones.
h) De-stress the identified high risk zones via drilling, water infusion, hydraulic fracturing and/or shotfiring.
i) Implement remote bolting and remote mining techniques.
j) Review temporary rib support and guarding on continuous miners.
k) Review overall mine design.
l) Use micro seismic monitoring systems (pre-mining and active mining).
m) Weigh exploratory drill cuttings to determine volume of cuttings per metre of the in-situ coal.
n) Review the mine’s communication system to ensure it is accurate, consistent and informs all levels of the workforce with relevant and timely information.