Mine Safety

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

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Investigation report - Report into the deaths of James Mitchell and Phillip Grant at the Austar Coal Mine,

Paxton NSW on 15 April 2014

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Mine Safety Investigation Unit, Thornton NSW

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Acknowledgments

The Investigation Unit wishes to acknowledge the contribution to this report of Emeritus Professor Jim Galvin and Professor Bruce Hebblewhite.

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. [5]

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.[6] 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.[7]

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.[8] An effective safety system must identify all plausible risks[9]. 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:[10]

- 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.

[6] 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.

[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.

[9] Department of Industry, Mine Safety, *Guide to Reviewing a Risk Assessment of Mine Equipment and Operations MDG 1014*, July 1997, p.1; NSW Government WorkCover, *How to Manage Work Health and Safety Risks Code of Practice*, December 2011, p.7.

[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.

Contents

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.

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[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.

[13] Department of Industry Skills & Regional Development, *Colliery Holding Register*, Paper No.s 06/6585 – M67/8424, 29 July 2014.

[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.

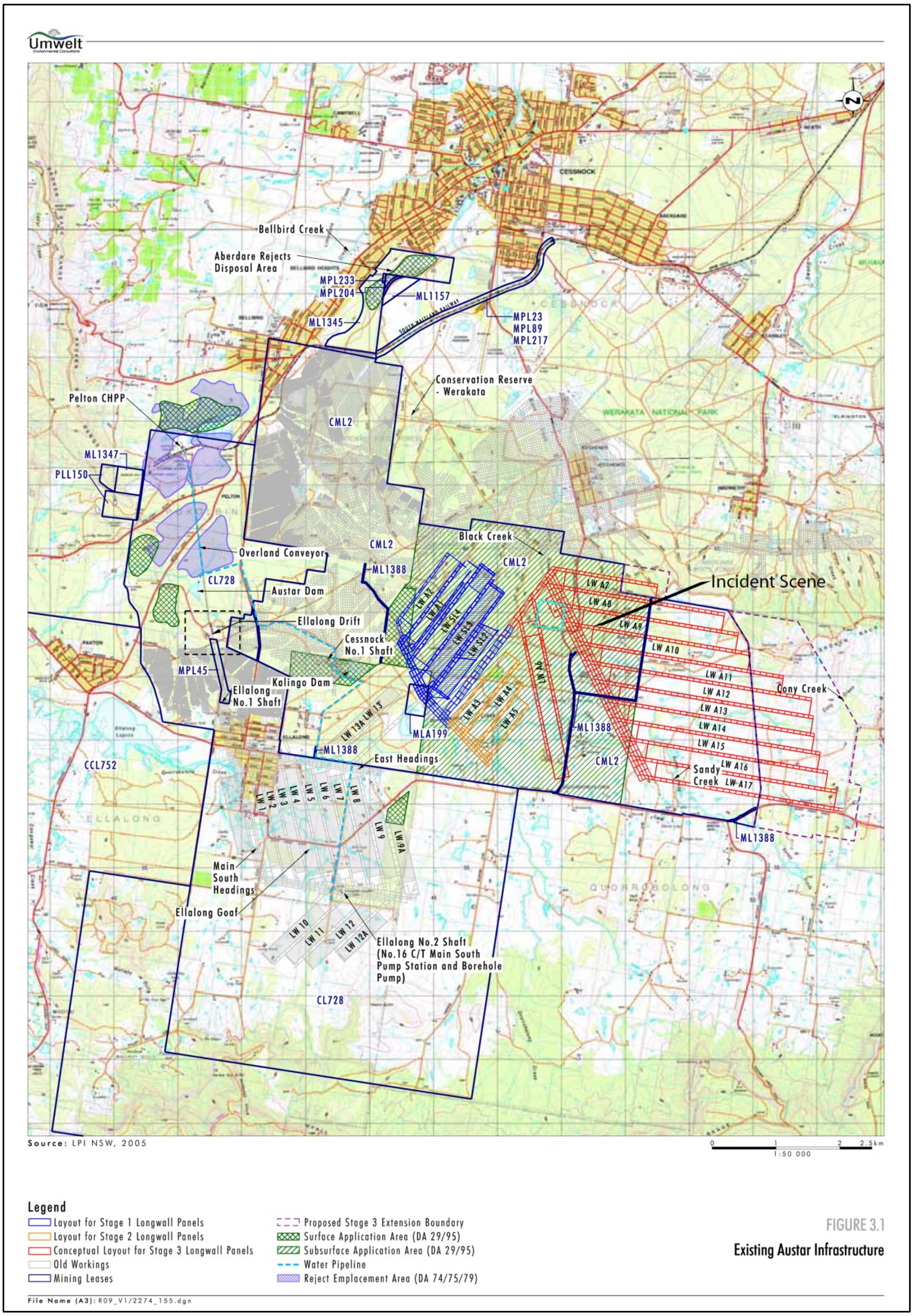
On the day of the incident, both men were fulfilling their general duties as part of the production crew in Maingate A9 (MG A9) and were on the left-hand side of the mining machine in preparation to begin the next round of roof and rib support.

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.[19]



[19] Austar Coal Mine website, www.austarcoalmine.com.au, accessed 13 January 2015.

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.

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[20] Austar Coal Mine website, http://www.austarcoalmine.com.au, accessed 13 January 2015.

[21] NSW Department of Trade and Investment, Comet incident database.

[22] Austar Coal Mine, *Annual Environmental Management Report*, July 2013 – 2014, www.austarcoalmine.com.au/Portals/3/pdfs/environment/AEMR_2013-2014/AEMR%202013-2014%20-%20Main%20Text.pdf, accessed 6 February 2015, p.18.

[23] Austar Coal Mine, Austar Coal Mine project – *Stage 3 Environmental Assessment*, October 2008, p.1-2, www.austarcoalmine.com.au/Portals/3/pdfs/stage3/Main%20Text_Exec%20Summ%20-%20Section%201.pdf, accessed 6 February 2015.

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. [24]

Austar Coal Mine Pty Limited is the nominated operator of the Austar Coal Mine.[25]

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'.[26]

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.[27] 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 [28].

Yanzhou owns and operates 21 coal mines across China and Australia, along with significant coal reserves and exploration rights in each country.[29]

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.[30]

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).[31]

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. [32]

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[24] *Coal Mine Health and Safety Act 2002* (NSW) s.17.

[25] Austar Coal Mine, *Nomination of Operator*, 23 June 2008.

[26] *Coal Mine Health and Safety Act 2002* (NSW) s.20.

[27] Department of Industry Skills & Regional Development, *Colliery Holding Register*, Paper Nos: 06/6585 – M67/8424, 29 July 2014.

[28] Australian Securities and Investment Commission, *Current Company Extract for Austar coal Mine PTY Limited*, 28 January 2015, asic.gov.au.

[29] Yanzhou coal mine company limited, www.yanzhoucoal.com.cn/en/profile/node_132.htm, accessed 6 February 2015.

[30] Yanzhou coal mine company limited, www.yanzhoucoal.com.cn/en/node_121.htm, accessed 6 February 2015.

[31] Foreign Investment Review Board, www.firb.gov.au/content/default.asp, accessed 6 February 2015.

[32] Takeovers Panel, www.takeovers.gov.au/content/DisplayDoc.aspx?doc=about/about_the_panel.htm , accessed 6 February 2015.

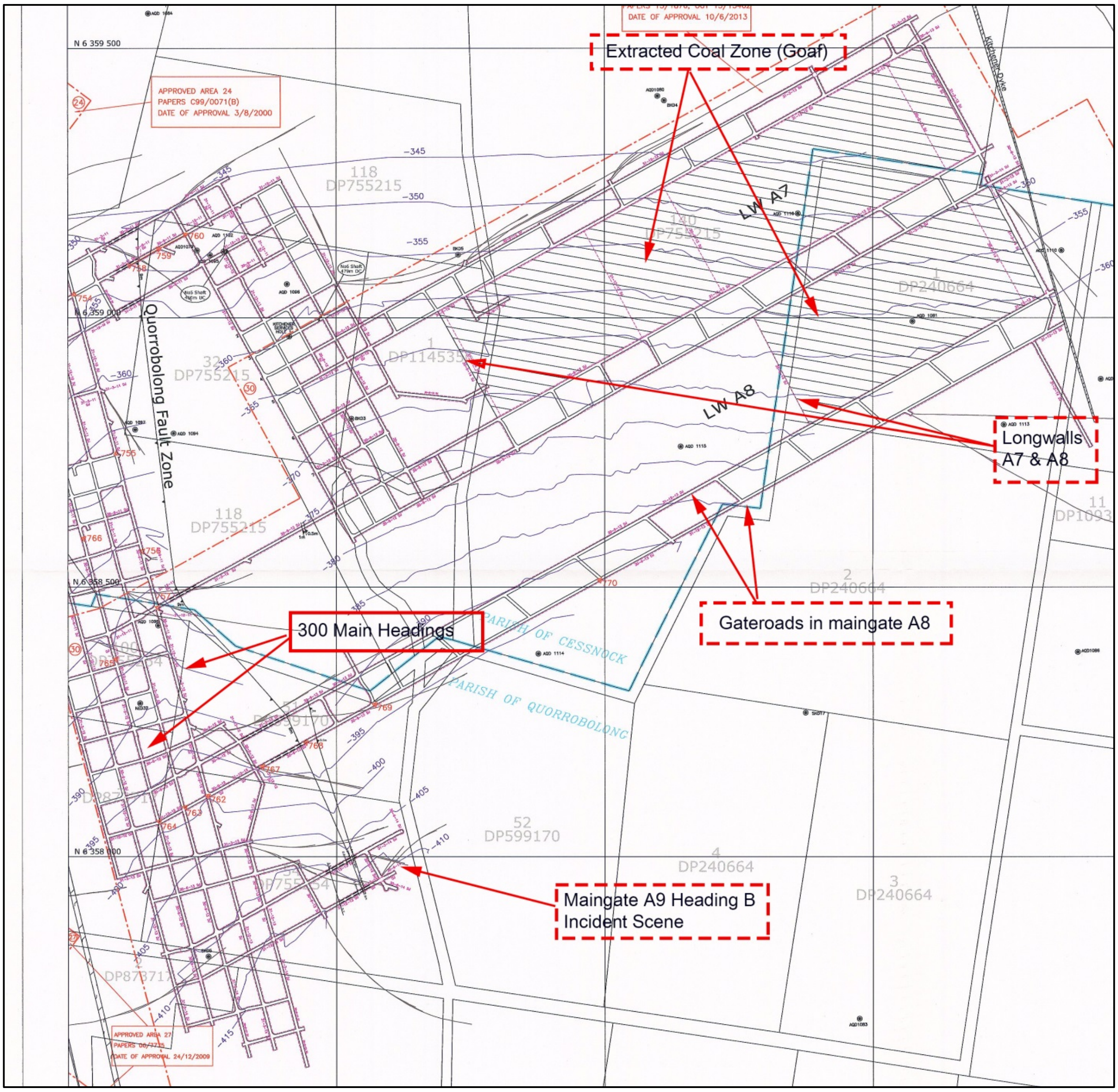
6 Mining methods

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).

Figure 4 Left-hand side of ABM 25 bolter miner from rear of 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.[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.[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'.[36] Three of the reported incidents are known to have involved failure of sides that may have involved a pressure bump or burst.[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.[38] This fault is characterised by a series of smaller geological structures surrounding an upthrow fault of 7.5 m vertical displacement.[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.

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[34] Hawcroft Consulting International, Yancoal Australia Ltd Austar Coal Mine, *Risk Survey Underground, CHPP & Surface Operations Final Report*, June 2013, pp.59.

[35] Hawcroft Consulting International, Yancoal Australia Ltd Austar Coal Mine, *Risk Survey Underground, CHPP & Surface Operations Final Report*, June 2013, pp.58-59.

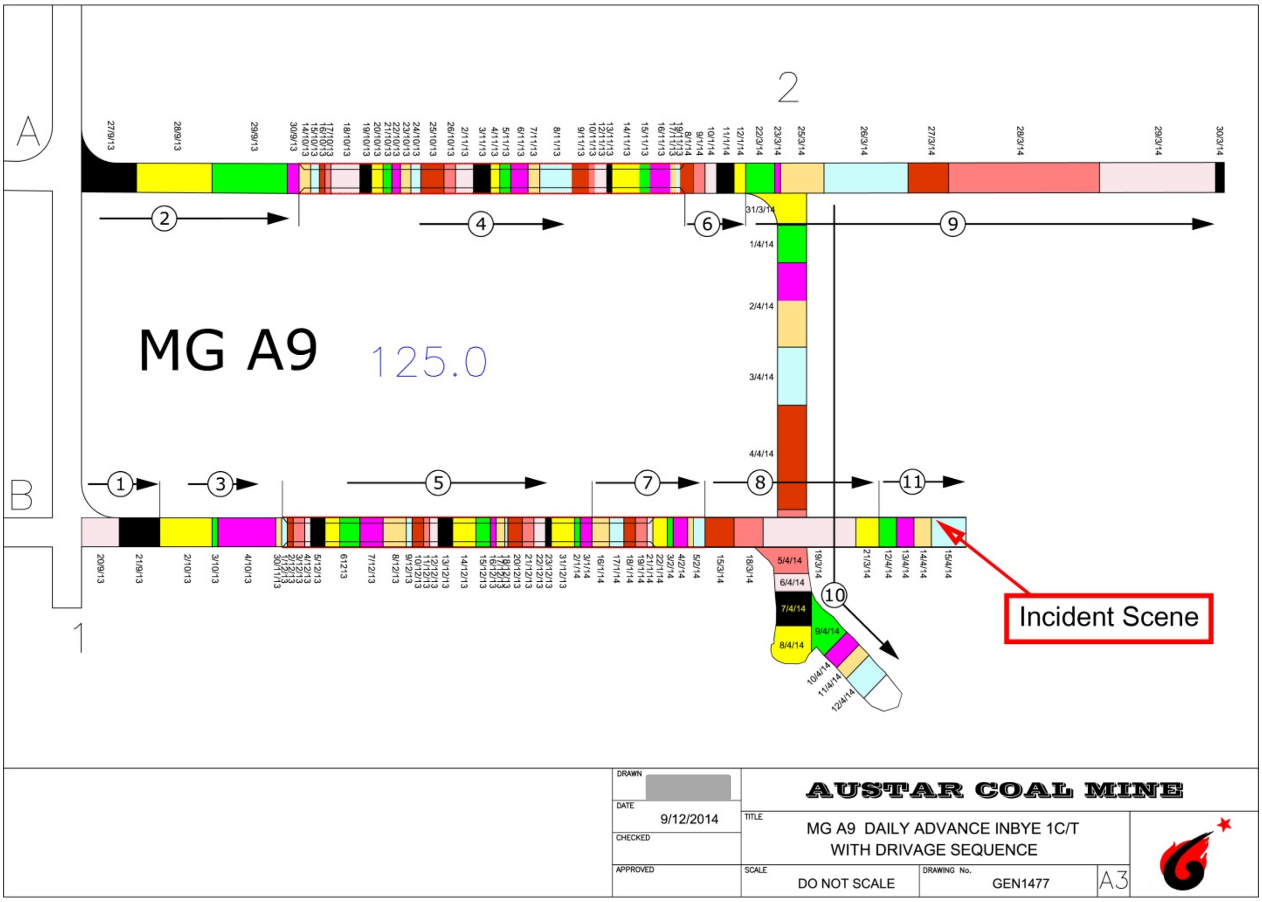
[36] Department of Trade and Investment, COMET incident database, April 2009–April 2014.

[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.

[38] Austar Coal Mine *Geological Plan*, 15 April 2014.

[39] Austar Coal Mine *Geological Plan*, 15 April 2014.

Figure 5 MG A9 daily drivage inbye 1C/T with drivage sequence. [40]



The reason for the slow advance between one cut through and two cut through was that a drift of approximately of 60 metres[41] 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.

[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.

Figure 6 Heading A face, intersection with the unanticipated fault.

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]

AUTHORITY TO MINE

AUSTAR COAL MINE

No 02 070314 ATM MG A9 2CT – 4CT REVISION 2

MG A9 2c/t – 4c/t

Revision 2 : Intersected fault in A heading requiring change of drivage sequence and fault mining process. Inseam drilling from B Hdg face has been inconclusive with further drilling required from A Hdg.

Driveage of Roadways:

- A9 MG drivage of sequences as per attached plan ATM1403 Revision 2.
- Sequence 1 – overdrive 2ct Bhdg to 20m.
- Breakaway left at 15m from B hdg centre to intersect fault.
- Minor variations to the sequence of drivage may only be authorised by the Development Superintendent, Production Superintendent or Mine Manager.
- Fault drivage to be driven as per the Development shift notes.
- Horizon to be driven as per the Development shift notes.

Geological & Geotechnical Information

- The unfaulted seam thickness is about 6.3m.
- There has been a fault interested in A heading the displacement of the structure is unknown and drilling will be undertaken to confirm the displacement and location (strike) of the fault in both A and B headings. Fault appears to be an upthrow normal fault with a displacement of 3.5 - 5.5m.
- In A heading adjacent to the current face, the 12cm band is about 1.1m below the stone roof, with the Upper Dosco 0.7m below the 12cm. The lower Dosco is indistinct or scrubbed out by shear movement but where present in MGA8 was 0.3m below the upper Dosco.
- Inseam drilling ahead of A heading face has cleared the planned 2 CT location of major faulting but roof conditions in MGA8 inbye the Quorrobolong fault zone were poor as a result of small scale structures, so conditions need to be monitored carefully in development.
- Variations in coal roof will be due to roof channels and sandstone dykes similar to those encountered in MGA8 and 300 mains.. These will have roof cutters adjacent to them.
- Roof rolls , variations in coal roof thickness and variations in roof rock hardness up bolt holes need to be noted in deputies reports, as these may indicate roof channels with potential to affect the longwall operations (similar to LWA7 issues).
- The normal immediate roof is fine to medium sandstone with coaly partings and is lower strength when affected by structures.

Strata Management Information

- Confirmed Support Rules and TARP's must be followed at all times.
- Code orange support is to be installed 5m either side of the intersection centre line – extend past ribline of intersection and 10m outbye and inbye of the fault zones in A and B heading.
- Drivage sequence 1 to be all code orange with telltales to be installed at 10m intervals.
- Tell-tales to be installed in all intersections and mid pillar. Deputies must also arrange for a telltale to be installed in response to any un-characteristically poor roof conditions or geological structures which could cause roof instability.
- Roof bolt encapsulation must be checked regularly on the bolts and results recorded on the Deputies Panel Report. Encapsulation testing should be increased in poorer roof conditions.
- Deputies to continue to report roof and rib conditions, Tell tale data and any geological anomalies on their reports.
- Code Orange support in intersections to be grouted prior to commencing breakaways.

Inrush Information

- Mining authorised by this Authority to Mine is outside the Inrush Control Zone.
- The TARP for Inrush Prevention, First Workings must be followed at all times in this area in accordance with the "Austar Coal Mine Inrush Management Plan SMP009".
- An inseam borehole (A9-MG-02) drilled from the stub in 13c/t Z Hdg 300 Mains should be evident in 2c/t overdrive at approx. 8m in RH ribline in Sequence 1. Refer to SWP 787 for intersection of borehole.Gas Data
- Borehole AQD1114, adjacent to the ATM area has gas content of 4.42m^3/tonne, with a composition of about 55:45 CH_4 and CO_2. Gas contents from samples taken via inseam drilling are much lower. (1.29m^3/tonne and 1.37m^3/tonne 20m and 250m IB 2 CT).

Spontaneous Combustion Information

- Drivage is to be undertaken as per the Spontaneous Combustion Management Plan and TARP's.

Ventilation Information

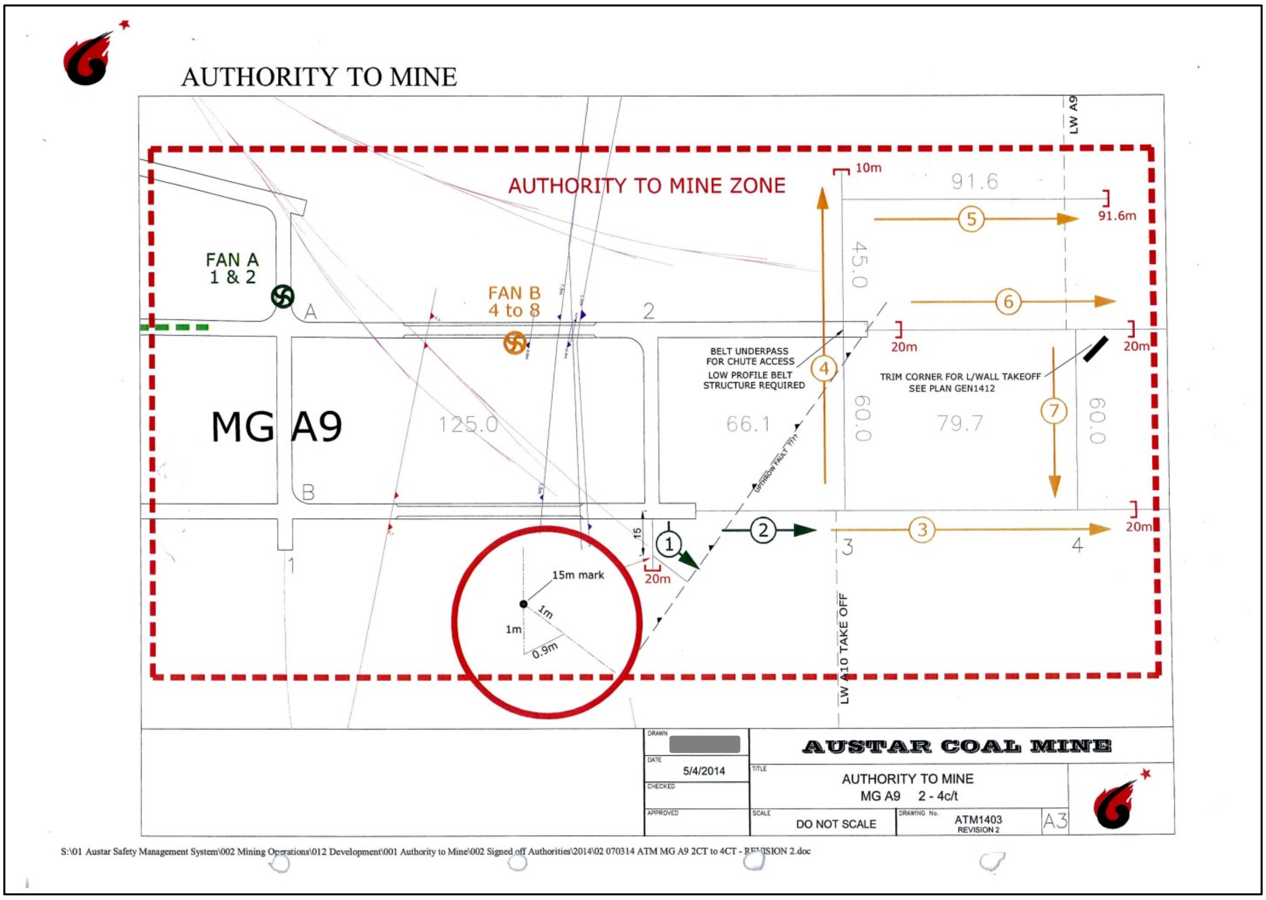
- Ventilation is to be conducted as per the Ventilation Arrangements SMP and associated TARP's.
- All sequences are to be ventilated with an auxiliary fan.
- Aux fans are to be operated at a minimum of 17m3/s.
- All standing places to be positively ventilated. Minimum of 1 m^3/s as per CMHSR2006.
- The fan is to be positioned as per ATM1403 Revision 1.

Approvals Information

- Strata Failure Management Plan.
- Roof TARP for Gateroad Development.
- Rib TARP for Gateroad Development.
- SUP1421A, B, C and D.

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

Figure 8 Authority to mine for MG A9 district page 2.[43]



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.

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

Figure 9 The 'stub' heading showing where CM 35 withdrew from before returning to B Heading.

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 [redacted] 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.

---

[44] P. Gattinoni, E. Pizzarotti, A. Scesi (2014), *Engineering Geology for Underground Works*, Springer p.194.

[45] WC Smith, Bureau of Mines, United States Department of Interior, *Rib Stability: Practical Considerations to Optimize Rib Design*, 1992, p.13, https://scholar.google.com.au/scholar?q=forepoling+australian+coal&btnG=&hl=en&as_sdt=0%2C5.

[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 [redacted] he was on the left-hand side, by himself, and [redacted] 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. [redacted] was there, our deputy, everyone was there, [redacted]... Yeah, after that big pressure bump [redacted] told us, [redacted] 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]

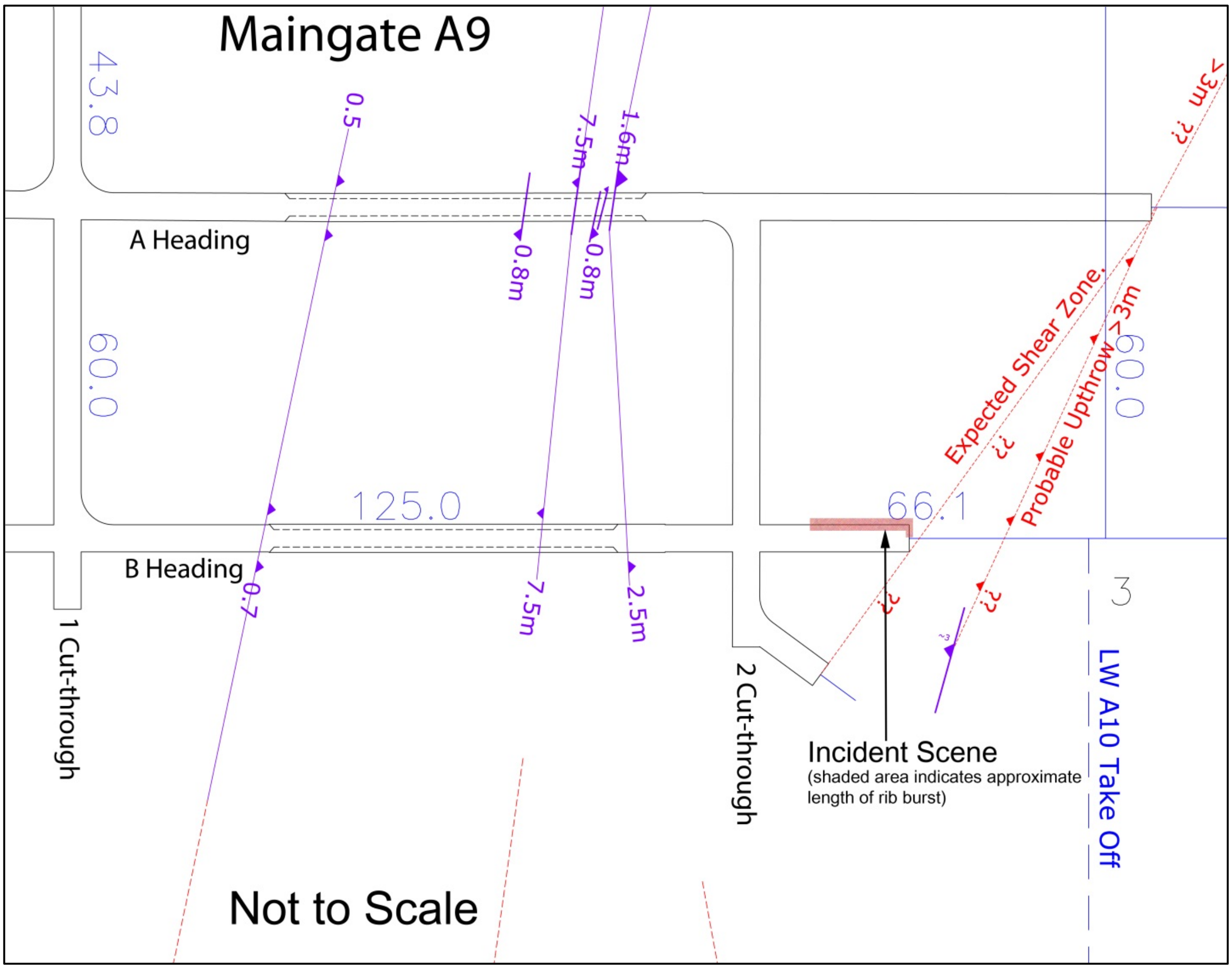


Figure 10 shows the incident scene in MG A9. It also depicts the faulting between 1 cut through and 2 cut through and the anticipated location of the fault struck in Heading A inbye of 2 cut through.

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]

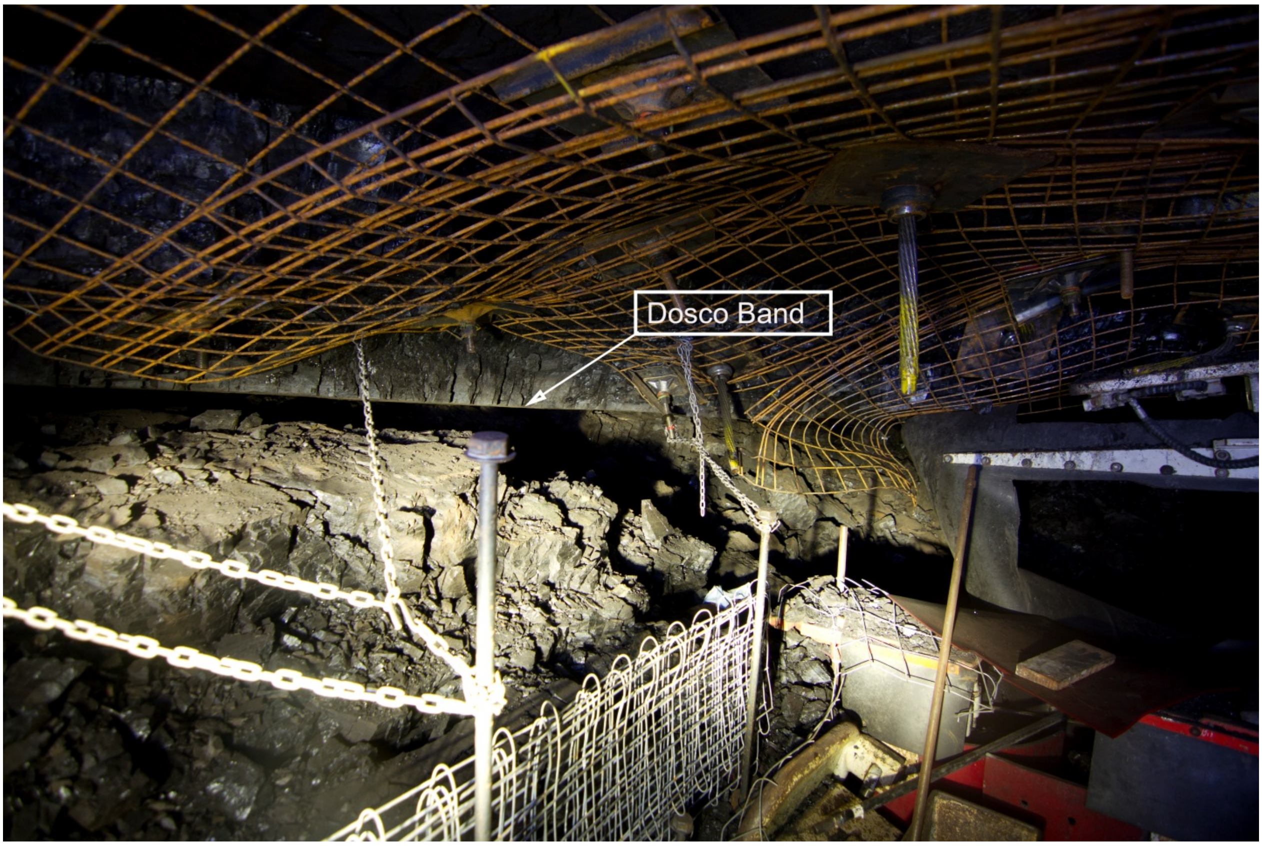
[47] Austar Coal Mine, *Basic Geology A9 MG Plan*, 15 April 2014.

[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.

Figure 13 Incident scene showing the left-hand side of continuous miner after 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:

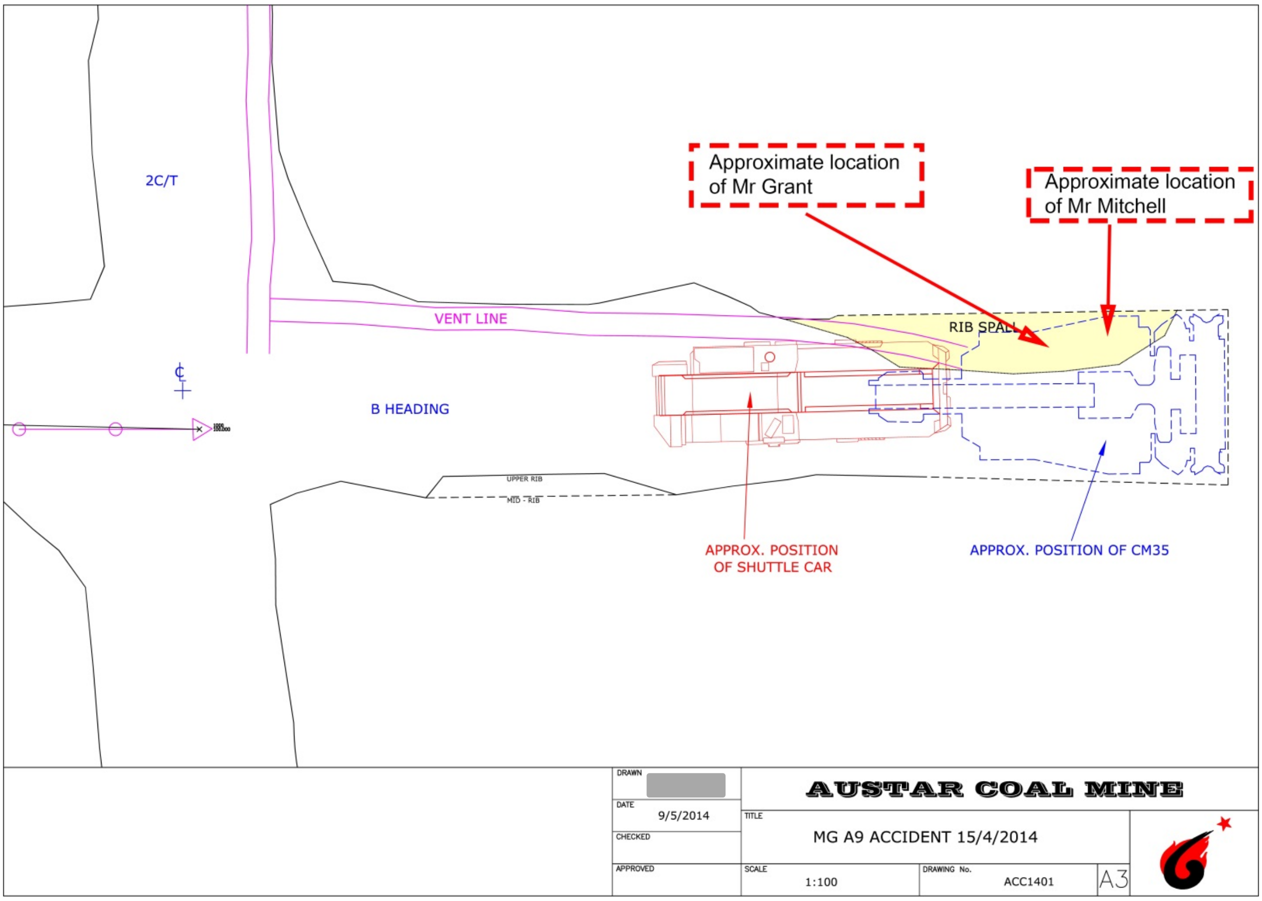
> So he's jumped in the car. I've got up in the miner, 'cause he's brought the car up behind the miner. I started the head again. I was up about, as I said I went to about 240 centimetres, which is my normal cut, for an undercut. Got it 240. I've gone in about 50 centimetres, I've gone down to 20 centimetres 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 [redacted] yell out, 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[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.[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.[52]

The pressure burst was of such a magnitude and volume that it rendered the installed rib support ineffective.[53]

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[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.

[51] NSW Mines Rescue Service, Captain's report.

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

[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.[54]

Professors Galvin and Hebblewhite identified the following contributing factors to the event:[55]

- 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.[56]

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.[57] 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[58]
- the distance from the active longwall abutment pressures to the incident scene was approximately 800 metres.[59]

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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.

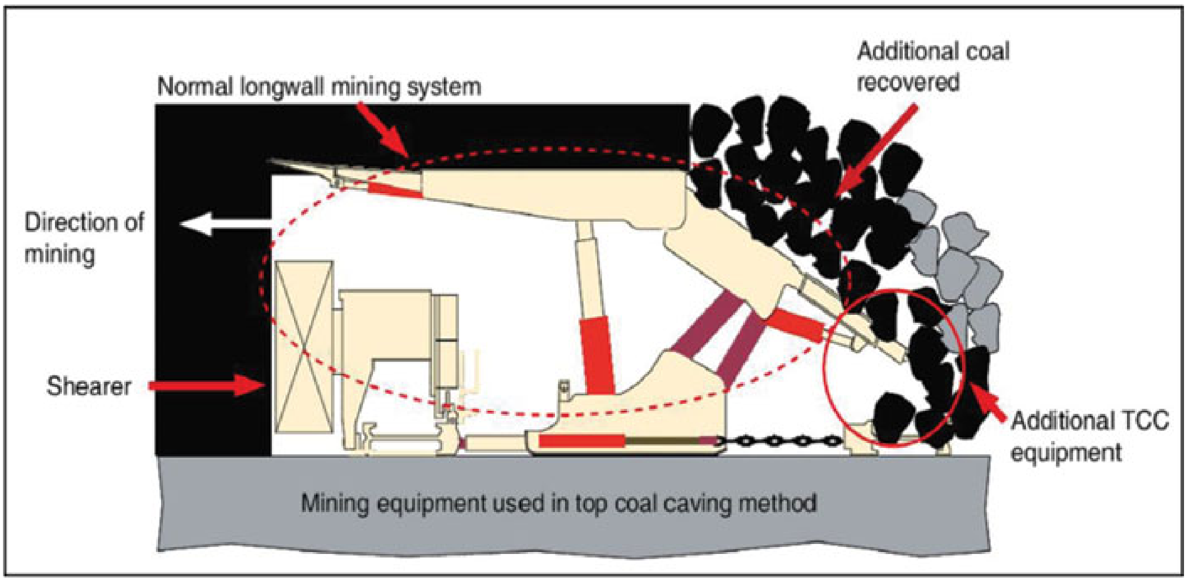
[56] Yancoal Australia Ltd, www.yancoal.com.au/page/key-assets/technology/LTCC, acessed 22 May 2015.

[57] D Page, 'Austar's Record One of Mine closures and Accidents', *Newcastle Herald*, Newcastle NSW, 17 April 2014, p.6.

[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.

Figure 15 The Austar Longwall Top Coal Caving method.[60]



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.[61]

Gas outbursts are a well-known phenomenon in Australian coal mines and, indeed, coal mines around the world.[62] 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 (CH_4) and/or carbon dioxide (CO_2).

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'.[63] Clause 28(b)(vi) of the CMHSR designates outbursts of coal and gas being a prescribed major hazard.[64]

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[60] Yancoal Australia Ltd, www.yancoal.com.au/page/key-assets/technology/LTCC, accessed 22 May 2015.

[61] University of Wollongong, *Coal Mine Outbursts*, 14 August 2007, outburst.uow.edu.au, accessed 14 April 2014.

[62] 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), 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.[65] 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.[66]

In the area adjacent to the incident, samples from in seam drilling revealed very low gas volumes of $1.29m^3$/tonne to $1.37m^3$/tonne. However, samples from borehole AQD1114 adjacent to the incident had a gas content of $4.42m^3$/tonne[67], which is still low and unlikely to cause a gas outburst.[68]

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 CO_2 or CH_4.

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% CH_4, depending upon the setting at the mine. When the level of CH_4 reaches 2%, the machine is shut down.[69] 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 CH_4 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 CO_2 and CH_4 before, during and after the incident.

Figures 17, 18, 19 and 20 below graph the readings of CH_4, CO_2 and O_2 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.

66 *Hawcroft Report*, June 2013, pp.58-59.

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.[70]

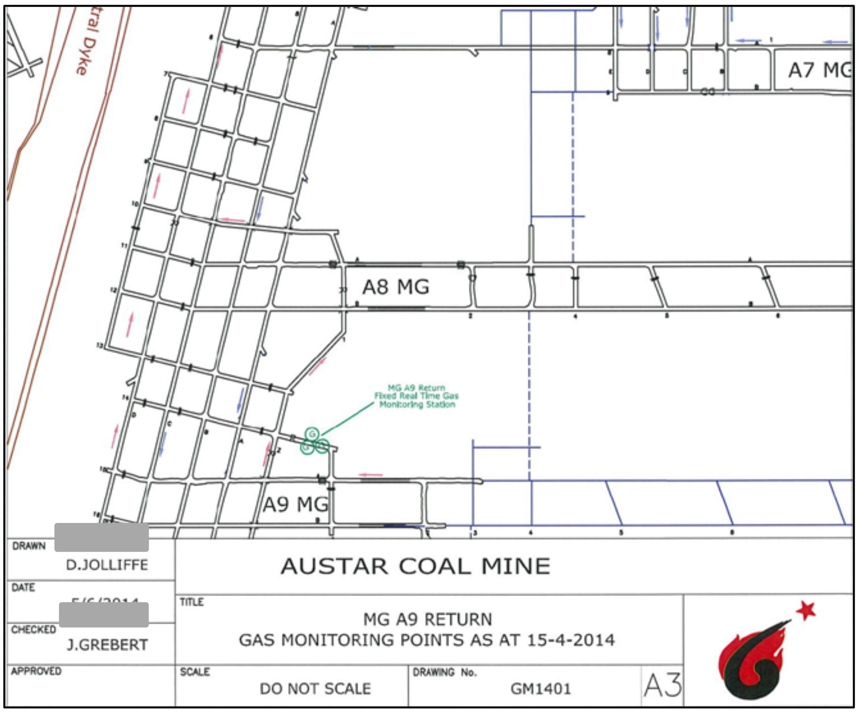
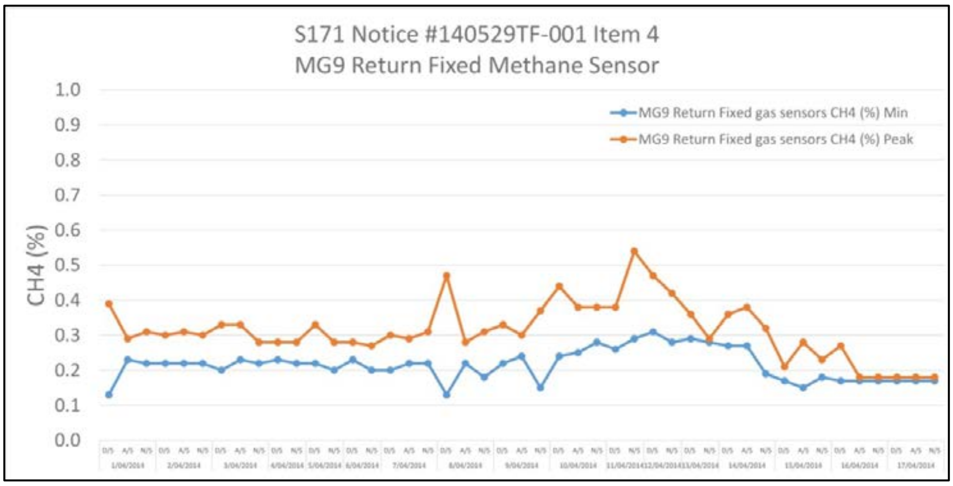


Figure 17 MG A9 return fixed methane sensor.[71]



[70] Austar Coal Mine, *MG A9 Return Gas Monitoring points as at 15 April 2014*, 5 June 2014.

[71] Austar Coal Mine, MG A9 Return Fixed methane sensor, 14 May 2014.

Figure 18 Tube bundle point 13 Oxygen.[72]

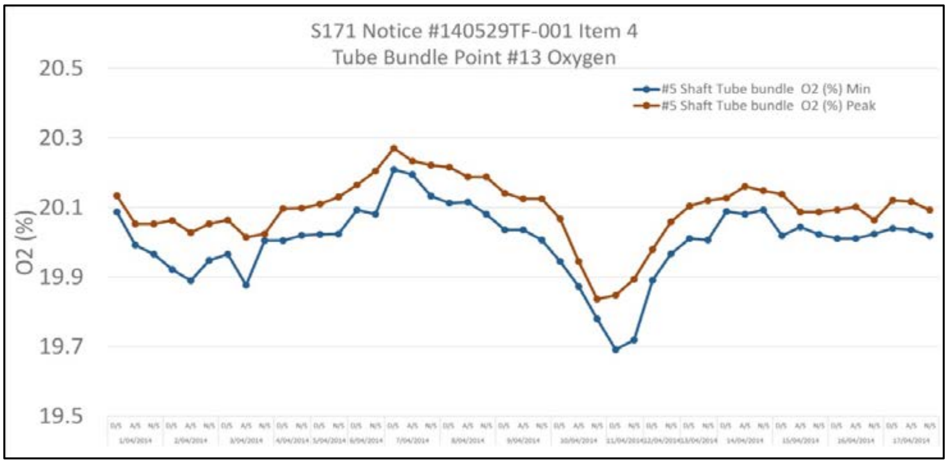


Figure 19 Tube bundle point 13 Carbon Dioxide.[73]

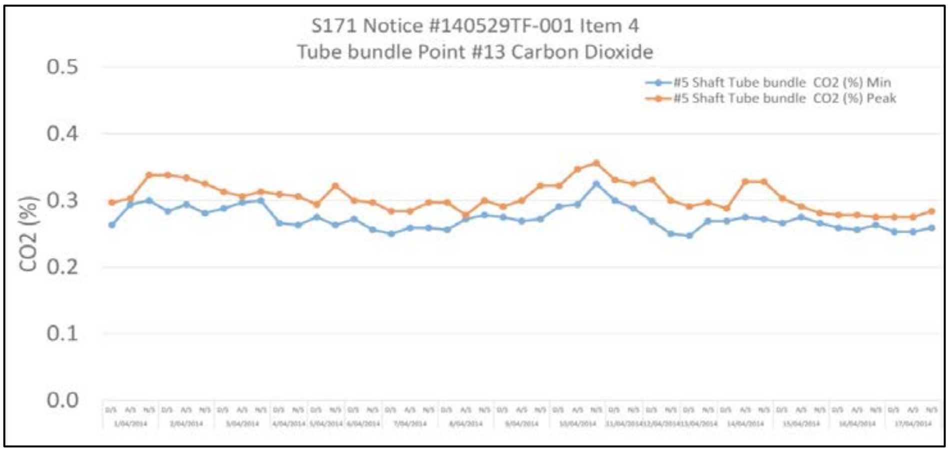
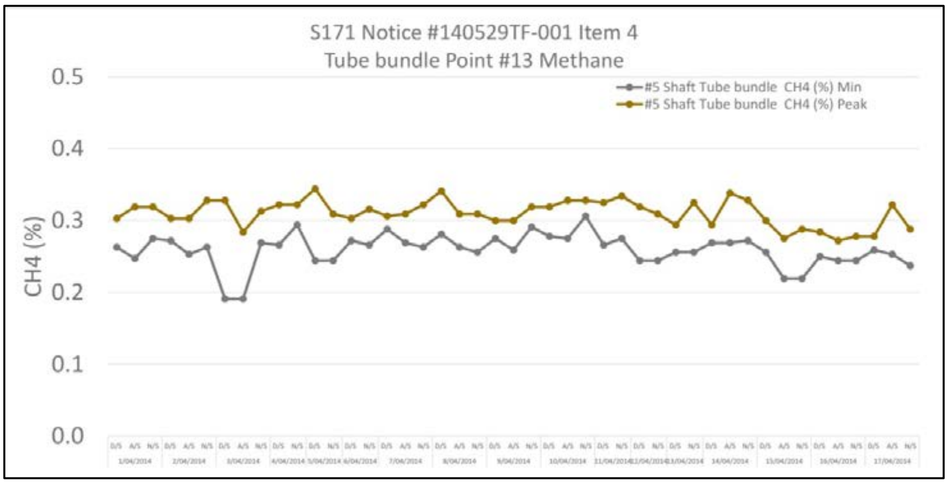


Figure 20 Tube bundle point 13 Methane.[74]



[72] Austar Coal Mine, Tube bundle point 13 Oxygen, 14 May 2014.

[73] Austar Coal Mine, Tube bundle point 13 Carbon Dioxide, 14 May 2014.

[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.[75] 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.

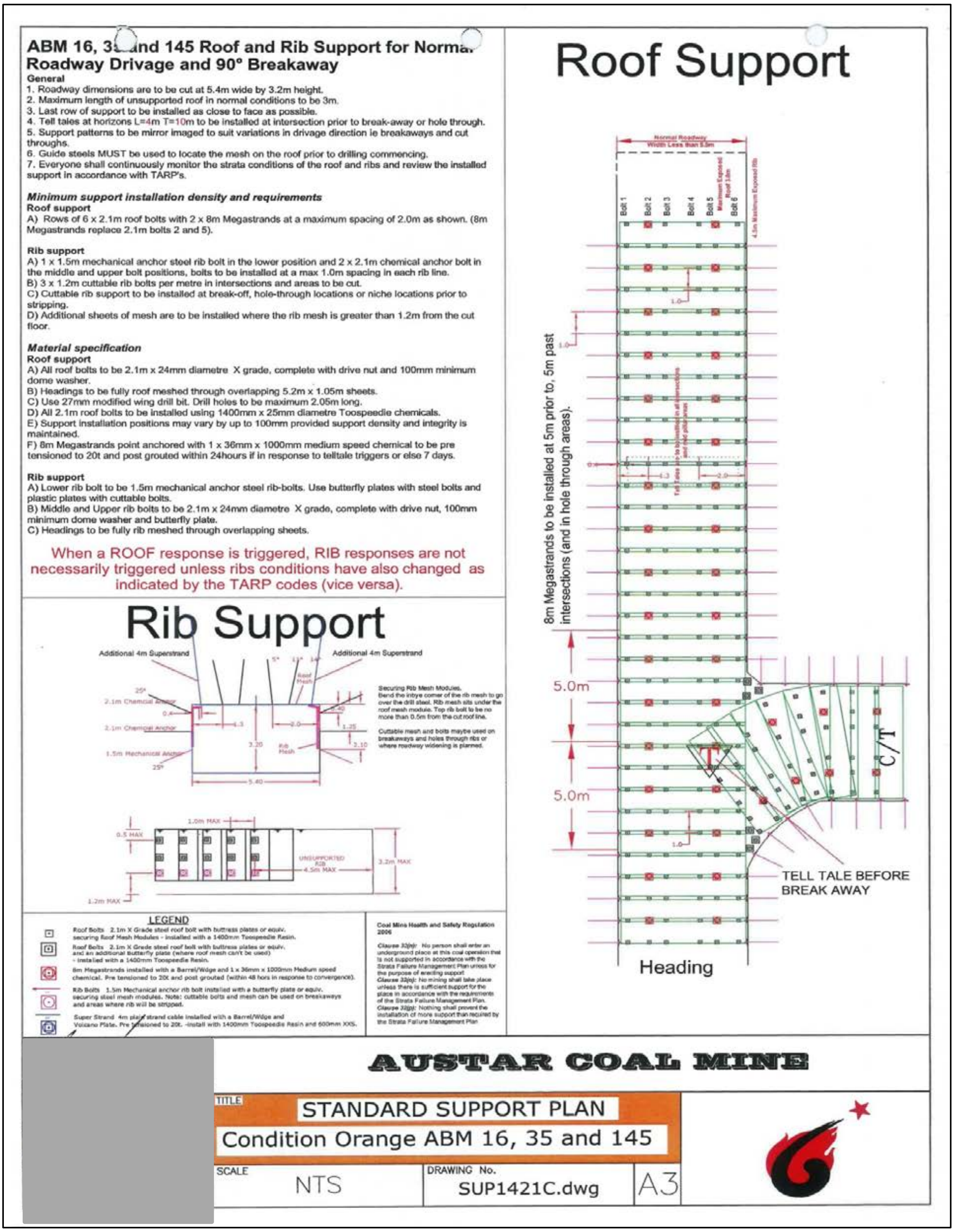
At the time of the incident, MG A9 was following the orange support plan for the roof and the yellow support plan for the ribs. According to members of the crew present that night, the rib on the left-hand side was in better condition than would normally be the case as demonstrated by the deputy's response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

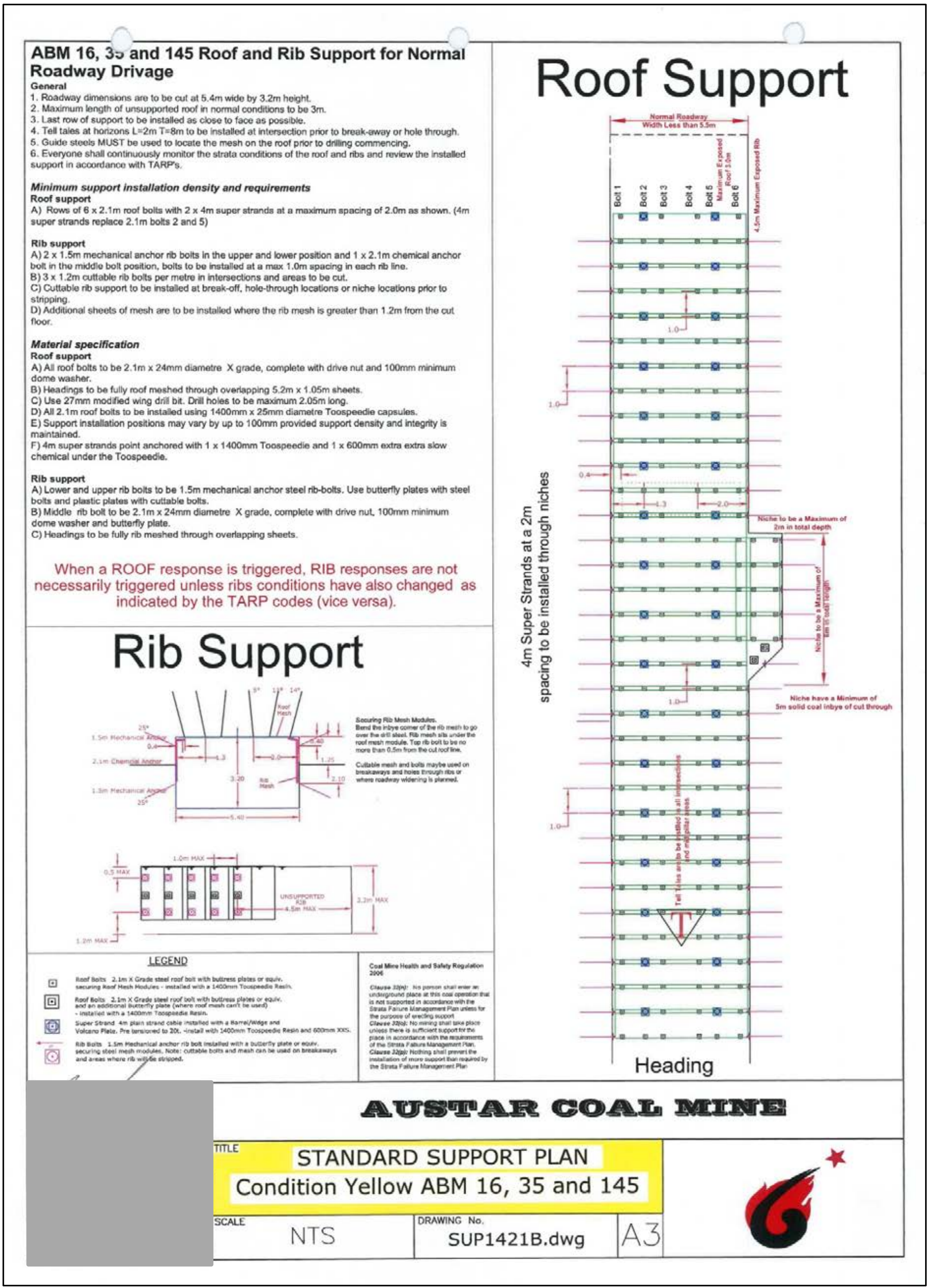
[75] J Galvin, B Hebblewhite, *Pressure Burst Incident at Austar coal Mine on 15 April 2014*, March 2015, p.36.

Figure 21 Condition orange standard support plan.[76]



[76] Austar Coal Mine, *Condition Orange Standard Support Plan ABM 16, 35 and 145*, SUP1421C.dwg.

Figure 22 Condition yellow standard support plan.[77]



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77 Austar Coal Mine, *Condition Yellow Standard Support Plan ABM 16, 35 and 145*, SUP1421B.dwg. '

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.[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.

[78] J Galvin, B Hebblewhite, *Pressure Burst Incident at Austar coal Mine on 15 April 2014*, March 2015, p.36.

Figure 24 Example of bolting in the adjacent A Heading of MG A9.

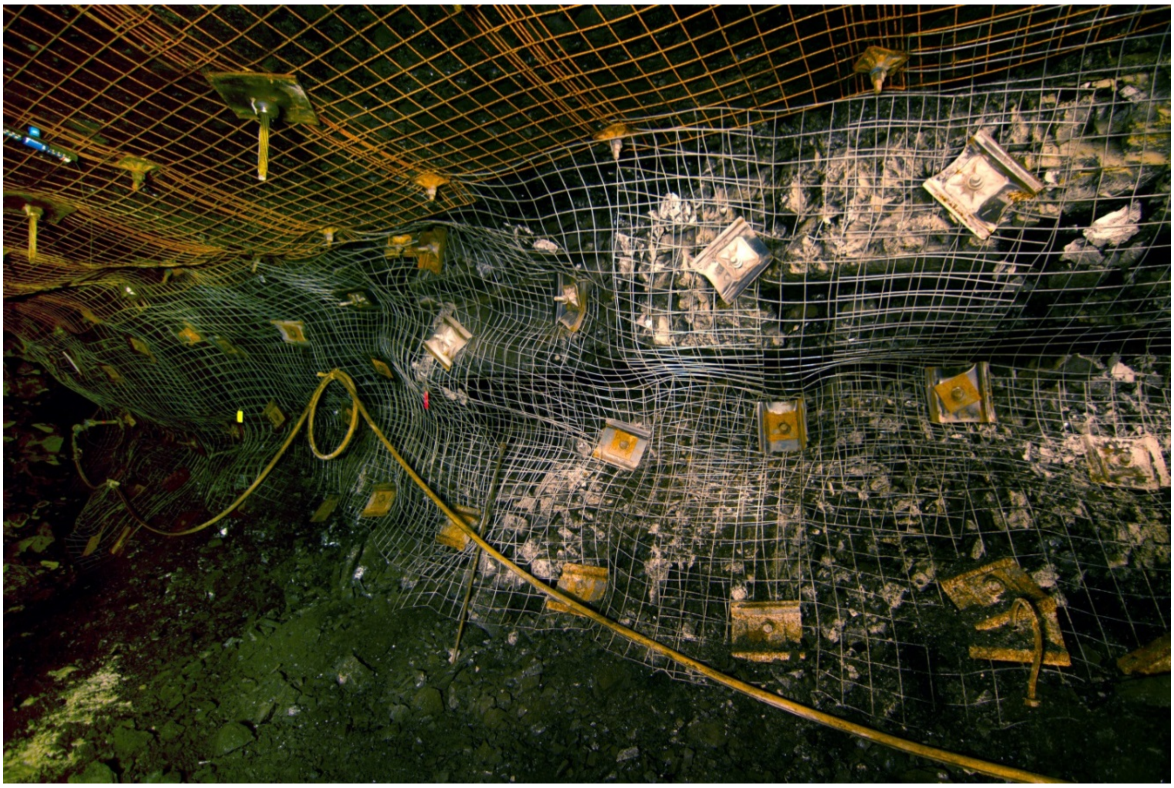
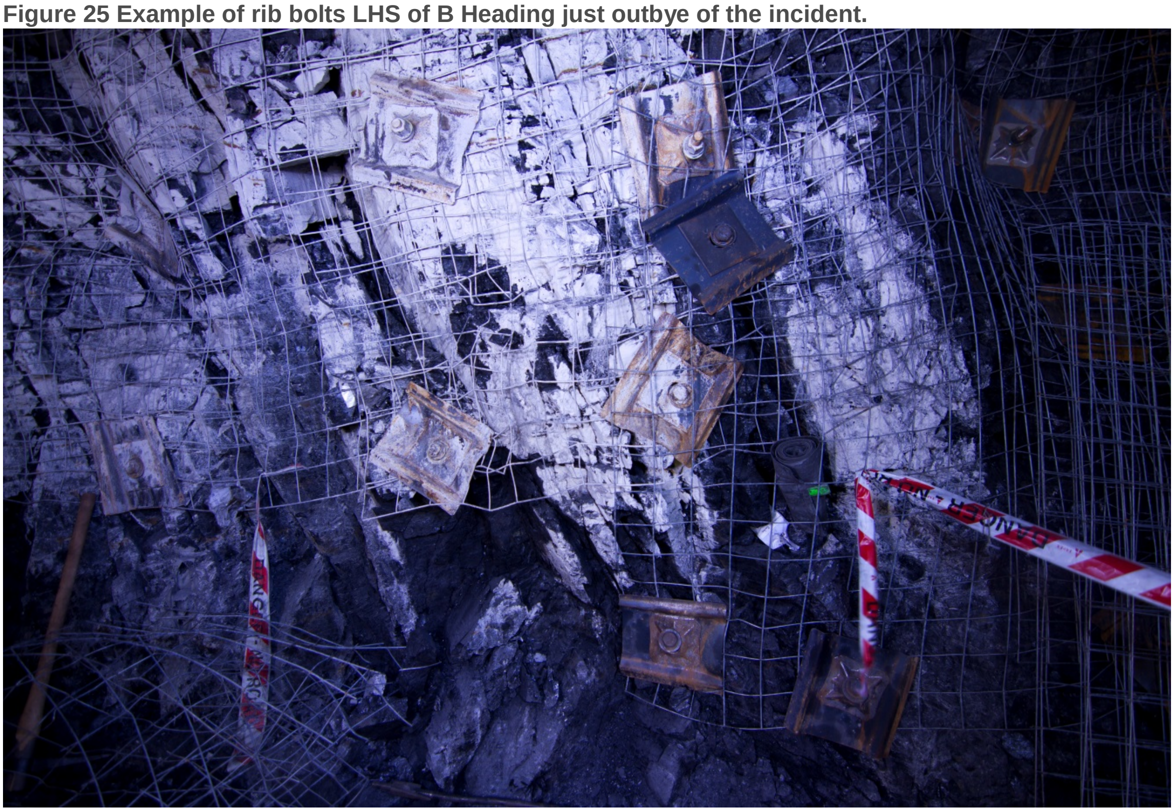


Figure 25 Example of rib bolts LHS of B Heading just outbye of the incident.



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.

Figure 26 Austar Mine support installation audit tool.[79]

Austar Coal Mine Pty Ltd
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Austar Coalmine Roof Support Installation Audit

Operators Name [redacted]

Date 12-4-14

Panel MG9 Continuous Miner No 35

ABM 25

Job Task	YES/ NO	Action Taken
• Designed Guide Steels being used	Yes	
• Are Spade or Modified Spade bits in drill steels	Mod.	
• Are the drill rigs under the last row of bolts when the Mesh module is placed in the rigs	Yes	
• Is the TRS set to the roof before positioning the rib mesh	Yes	
• Is Rib Mesh secured to Roof Mesh before Rib bolting	Yes	
• Are Outer Roof Bolts being installed whilst Rib Mesh is being positioned	No	
• Is operator handling the roof mesh whilst operating Drill rig	No	
• Men inbye of the rib bolter whilst it is in operation	No	
• Is Communication evident between CM operator & Bolter operator	Yes	
• Are the Extension Steels separated by using the Gripper Jaws and Drill rotation controls	Yes	
• Is there no more than 1 operator in control of a rig – (2 person operation)	Yes	
• Are Roof & Rib Bolts installed to Support Plan	Yes	
• Are the Roof & rib bolts installed to the installation SWP	Yes	

Signature Deputy / ~~Undermanager~~ [redacted]

S:\Undermanagers\Templates\Roof Support Installation Audit Sheet - Draft.doc

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

[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.[80]

Torque Wrench Reading (Roof) 300 panel A to Z 16CT 70M inbye

Bolt No	Bolt Location	Nm	Tons	Comments
1	LHS	300	8.87	Satisfactory
2	RHS	300	8.87	Satisfactory
3	LHS	300	8.87	Satisfactory
4	LHS	300	8.87	Satisfactory
5	RHS	300	8.87	Satisfactory
6	RHS	300	8.87	Satisfactory
7	LHS	300	8.87	Satisfactory
MB1	LHS		20T	Tensioned
MB2	RHS		20T	Tensioned

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

RHS **Inbye** **Roof**

50Nm 100Nm 300Nm

2.1m 150Nm 120Nm 2.1m 50Nm

140NM 120Nm 100Nm

LHS **Inbye**
Roof

100Nm 300Nm 120Nm

0Nm 2.1m 350Nm 2.1m 300Nm

150Nm 100Nm 0Nm

Solutions from Materials Technology

ORICA
A member of the Orica Group

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

[80] Austar Coal Mine, *Minova Visit Report – To carry out resin audit and torque test in 300 panel*, 18 December 2013.

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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[81] *Austar Coal Mine Mechanical Report Sandvik ABM 25, CM 35 Strata Support Equipment*, 6 February 2015, p.2.

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.[82]

[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.[83] 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.[84]

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.[85] 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.

[84] Austar Coal Mine, *Training Records*, s155 notice 141203TF001, 3 December 2014.

[85] Austar Coal Mine, *Strata Failure Management Plan*, Revision 3 3 September 2013 pp. 22, 23.

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.

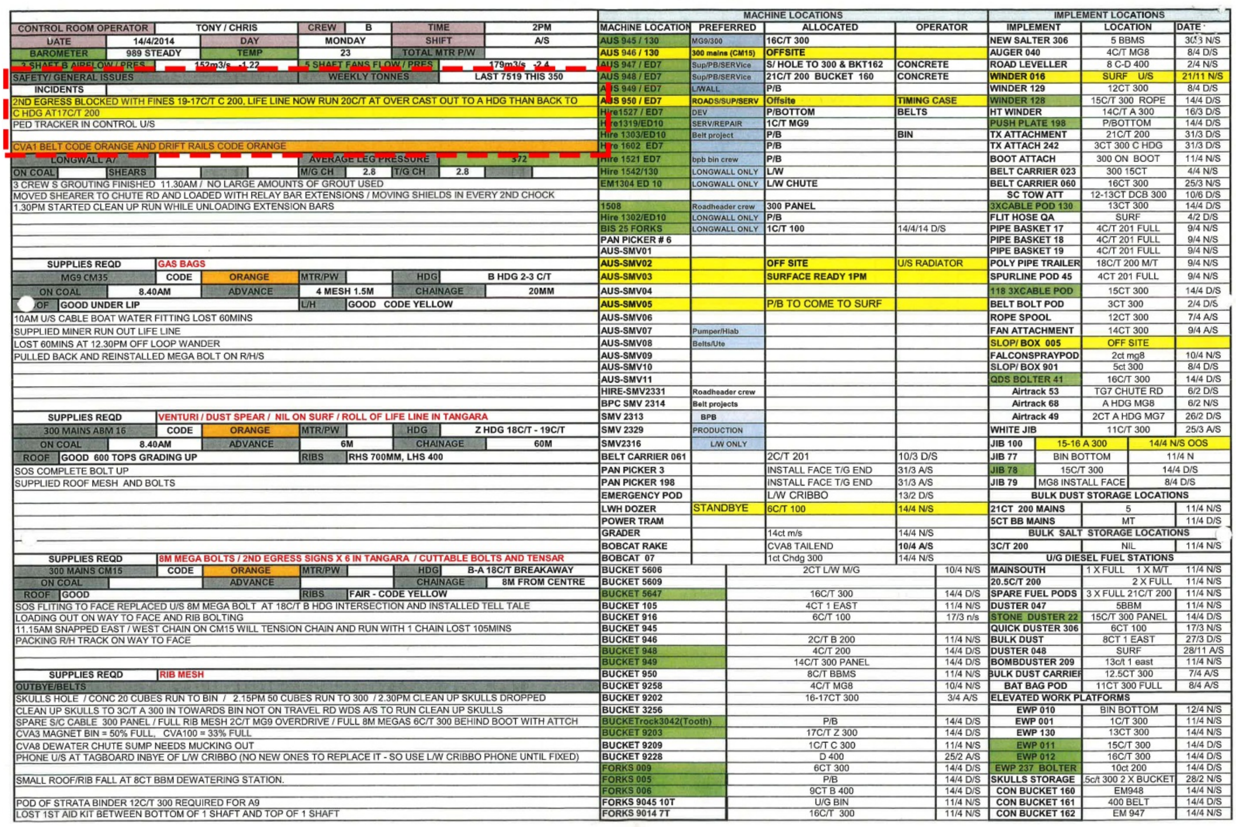
The control room log sheet was supplemented with a work sheet that had the location of all machines in the mine and the allocation of people to those machines. This document also formed part of the daily undermanagers' report.

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]



CONTROL ROOM OPERATOR	TONY / CHRIS		CREW	B	TIME	2PM	
DATE	14/4/2014	DAY	MONDAY		SHIFT	A/S	
BAROMETER	989 STEADY	TEMP	23		TOTAL MTR P/W		
3 SHAFT B AIRFLOW / PRES	152m3/s -1.22		5 SHAFT FANS FLOW / PRES			179m3/s -2.4	
SAFETY/ GENERAL ISSUES			WEEKLY TONNES			LAST 7519 THIS 350	
INCIDENTS							
2ND EGRESS BLOCKED WITH FINES 19-17C/T C 200, LIFE LINE NOW RUN 20C/T AT OVER CAST OUT TO A HDG THAN BACK TO							
C HDG AT17C/T 200							
PED TRACKER IN CONTROL U/S							
CVA1 BELT CODE ORANGE AND DRIFT RAILS CODE ORANGE							
LONGWALL A7			AVERAGE LEG PRESSURE			372	
ON COAL		SHEARS		M/G CH	2.8	T/G CH	2.8
3 CREW S GROUTING FINISHED 11.30AM / NO LARGE AMOUNTS OF GROUT USED							
MOVED SHEARER TO CHUTE RD AND LOADED WITH RELAY BAR EXTENSIONS / MOVING SHIELDS IN EVERY 2ND CHOCK							
1.30PM STARTED CLEAN UP RUN WHILE UNLOADING EXTENSION BARS							
SUPPLIES REQD	GAS BAGS						
MG9 CM35	CODE	ORANGE	MTR/PW		HDG	B HDG 2-3 C/T	
ON COAL	8.40AM	ADVANCE	4 MESH 1.5M		CHAINAGE	20MM	
ROOF	GOOD UNDER LIP		L/H	GOOD CODE YELLOW			
10AM U/S CABLE BOAT WATER FITTING LOST 60MINS							
SUPPLIED MINER RUN OUT LIFE LINE							
LOST 60MINS AT 12.30PM OFF LOOP WANDER							
PULLED BACK AND REINSTALLED MEGA BOLT ON R/H/S							
SUPPLIES REQD	VENTURI / DUST SPEAR / NIL ON SURF / ROLL OF LIFE LINE IN TANGARA						
300 MAINS ABM 16	CODE	ORANGE	MTR/PW		HDG	Z HDG 18C/T - 19C/T	
ON COAL	8.40AM	ADVANCE	6M		CHAINAGE	60M	
ROOF	GOOD 600 TOPS GRADING UP		RIBS	RHS 700MM, LHS 400			
SOS COMPLETE BOLT UP							
SUPPLIED ROOF MESH AND BOLTS							
SUPPLIES REQD	8M MEGA BOLTS / 2ND EGRESS SIGNS X 6 IN TANGARA / CUTTABLE BOLTS AND TENSAR						
300 MAINS CM15	CODE	ORANGE	MTR/PW		HDG	B-A 18C/T BREAKAWAY	
ON COAL		ADVANCE			CHAINAGE	8M FROM CENTRE	
ROOF	GOOD		RIBS	FAIR - CODE YELLOW			
SOS FLITING TO FACE REPLACED U/S 8M MEGA BOLT AT 18C/T B HDG INTERSECTION AND INSTALLED TELL TALE							
LOADING OUT ON WAY TO FACE AND RIB BOLTING							
11.15AM SNAPPED EAST / WEST CHAIN ON CM15 WILL TENSION CHAIN AND RUN WITH 1 CHAIN LOST 105MINS							
PACKING R/H TRACK ON WAY TO FACE							
SUPPLIES REQD	RIB MESH						
OUTBYE/BELTS							
SKULLS HOLE / CONC 20 CUBES RUN TO BIN / 2.15PM 50 CUBES RUN TO 300 / 2.30PM CLEAN UP SKULLS DROPPED							
CLEAN UP SKULLS TO 3C/T A 300 IN TOWARDS BIN NOT ON TRAVEL RD WDS A/S TO RUN CLEAN UP SKULLS							
SPARE S/C CABLE 300 PANEL / FULL RIB MESH 2C/T MG9 OVERDRIVE / FULL 8M MEGAS 6C/T 300 BEHIND BOOT WITH ATTCH							
CVA3 MAGNET BIN = 50% FULL, CVA100 = 33% FULL							
CVA8 DEWATER CHUTE SUMP NEEDS MUCKING OUT							
PHONE U/S AT TAGBOARD INBYE OF L/W CRIBBO (NO NEW ONES TO REPLACE IT - SO USE L/W CRIBBO PHONE UNTIL FIXED)							
SMALL ROOF/RIB FALL AT 8CT BBM DEWATERING STATION.							
POD OF STRATA BINDER 12C/T 300 REQUIRED FOR A9							
LOST 1ST AID KIT BETWEEN BOTTOM OF 1 SHAFT AND TOP OF 1 SHAFT							

MACHINE LOCATIONS			
MACHINE LOCATION	PREFERRED	ALLOCATED	OPERATOR
AUS 945 / 130	MG9/300	16C/T 300	
AUS 946 / 130	300 mains (CM15)	OFFSITE	
AUS 947 / ED7	Sup/PB/SERVice	S/ HOLE TO 300 & BKT162	CONCRETE
AUS 948 / ED7	Sup/PB/SERVice	21C/T 200 BUCKET 160	CONCRETE
AUS 949 / ED7	L/WALL	P/B	
AUS 950 / ED7	ROADS/SUP/SERV	Offsite	TIMING CASE
Hire1527 / ED7	DEV	P/BOTTOM	BELTS
Hire1319/ED10	SERV/REPAIR	1C/T MG9	
Hire 1303/ED10	Belt project	P/B	BIN
Hire 1602 ED7		P/B	
Hire 1521 ED7	bpb bin crew	P/B	
Hire 1542/130	LONGWALL ONLY	L/W	
EM1304 ED 10	LONGWALL ONLY	L/W CHUTE	
1508	Roadheader crew	300 PANEL	
Hire 1302/ED10	LONGWALL ONLY	P/B	
BIS 25 FORKS	LONGWALL ONLY	1C/T 100	14/4/14 D/S
PAN PICKER # 6			
AUS-SMV01			
AUS-SMV02		OFF SITE	U/S RADIATOR
AUS-SMV03		SURFACE READY 1PM	
AUS-SMV04			
AUS-SMV05		P/B TO COME TO SURF	
AUS-SMV06			
AUS-SMV07	Pumper/Hiab		
AUS-SMV08	Belts/Ute		
AUS-SMV09			
AUS-SMV10			
AUS-SMV11			
HIRE-SMV2331	Roadheader crew		
BPC SMV 2314	Belt projects		
SMV 2313	BPB		
SMV 2329	PRODUCTION		
SMV2316	L/W ONLY		
BELT CARRIER 061		2C/T 201	10/3 D/S
PAN PICKER 3		INSTALL FACE T/G END	31/3 A/S
PAN PICKER 198		INSTALL FACE T/G END	31/3 A/S
EMERGENCY POD		L/W CRIBBO	13/2 D/S
LWH DOZER	STANDBYE	6C/T 100	14/4 N/S
POWER TRAM			
GRADER		14ct m/s	14/4 N/S
BOBCAT RAKE		CVA8 TAILEND	10/4 A/S
BOBCAT 07		1ct Chdg 300	14/4 N/S
BUCKET 5606		2CT L/W M/G	10/4 N/S
BUCKET 5609			
BUCKET 5647		16C/T 300	14/4 D/S
BUCKET 105		4CT 1 EAST	11/4 N/S
BUCKET 916		6C/T 100	17/3 n/s
BUCKET 945			
BUCKET 946		2C/T B 200	11/4 N/S
BUCKET 948		4C/T 200	14/4 D/S
BUCKET 949		14C/T 300 PANEL	14/4 D/S
BUCKET 950		8C/T BBMS	11/4 N/S
BUCKET 9258		4C/T MG8	10/4 N/S
BUCKET 9202		16-17CT 300	3/4 A/S
BUCKET 3256			
BUCKETrock3042(Tooth)		P/B	14/4 D/S
BUCKET 9203		17C/T Z 300	14/4 D/S
BUCKET 9209		1C/T C 300	11/4 N/S
BUCKET 9228		D 400	25/2 A/S
FORKS 009		6CT 300	14/4 D/S
FORKS 005		P/B	14/4 D/S
FORKS 006		9CT B 400	14/4 D/S
FORKS 9045 10T		U/G BIN	11/4 N/S
FORKS 9014 7T		16C/T 300	11/4 N/S

IMPLEMENT LOCATIONS		
IMPLEMENT	LOCATION	DATE
NEW SALTER 306	5 BBMS	30/3 N/S
AUGER 040	4C/T MG8	8/4 D/S
ROAD LEVELLER	8 C-D 400	2/4 N/S
WINDER 016	SURF U/S	21/11 N/S
WINDER 129	12CT 300	8/4 D/S
WINDER 128	15C/T 300 ROPE	14/4 D/S
HT WINDER	14C/T A 300	16/3 D/S
PUSH PLATE 198	P/BOTTOM	14/4 D/S
TX ATTACHMENT	21C/T 200	31/3 D/S
TX ATTACH 242	3CT 300 C HDG	31/3 D/S
BOOT ATTACH	300 ON BOOT	11/4 N/S
BELT CARRIER 023	300 15CT	4/4 N/S
BELT CARRIER 060	16CT 300	25/3 N/S
SC TOW ATT	12-13CT DCB 300	10/6 D/S
3XCABLE POD 130	13CT 300	14/4 D/S
FLIT HOSE QA	SURF	4/2 D/S
PIPE BASKET 17	4C/T 201 FULL	9/4 N/S
PIPE BASKET 18	4C/T 201 FULL	9/4 N/S
PIPE BASKET 19	4C/T 201 FULL	9/4 N/S
POLY PIPE TRAILER	18C/T 200 M/T	9/4 N/S
SPURLINE POD 45	4CT 201 FULL	9/4 N/S
118 3XCABLE POD	15CT 300	14/4 D/S
BELT BOLT POD	3CT 300	2/4 D/S
ROPE SPOOL	12CT 300	7/4 A/S
FAN ATTACHMENT	14CT 300	9/4 A/S
SLOP/ BOX 005	OFF SITE	
FALCONSPRAYPOD	2ct mg8	10/4 N/S
SLOP/ BOX 901	5ct 300	8/4 D/S
QDS BOLTER 41	16C/T 300	14/4 D/S
Airtrack 53	TG7 CHUTE RD	6/2 D/S
Airtrack 68	A HDG MG8	6/2 N/S
Airtrack 49	2CT A HDG MG7	26/2 D/S
WHITE JIB	11C/T 300	25/3 A/S
JIB 100	15-16 A 300	14/4 N/S OOS
JIB 77	BIN BOTTOM	11/4 N
JIB 78	15C/T 300	14/4 D/S
JIB 79	MG8 INSTALL FACE	8/4 D/S
BULK DUST STORAGE LOCATIONS		
21CT 200 MAINS	5	11/4 N/S
5CT BB MAINS	MT	11/4 D/S
BULK SALT STORAGE LOCATIONS		
3C/T 200	NIL	11/4 N/S
U/G DIESEL FUEL STATIONS		
MAINSOUTH	1 X FULL 1 X M/T	11/4 N/S
20.5C/T 200	2 X FULL	11/4 N/S
SPARE FUEL PODS	3 X FULL 21C/T 200	11/4 N/S
DUSTER 047	5BBM	11/4 N/S
STONE DUSTER 22	15C/T 300 PANEL	14/4 D/S
QUICK DUSTER 306	6CT 100	17/3 N/S
BULK DUST	8CT 1 EAST	27/3 D/S
DUSTER 048	SURF	28/11 A/S
BOMBDUSTER 209	13c/t 1 east	11/4 N/S
BULK DUST CARRIER	12.5CT 300	7/4 A/S
BAT BAG POD	11CT 300 FULL	8/4 A/S
ELEVATED WORK PLATFORMS		
EWP 010	BIN BOTTOM	12/4 N/S
EWP 001	1C/T 300	11/4 N/S
EWP 130	13CT 300	14/4 N/S
EWP 011	15C/T 300	14/4 D/S
EWP 012	16C/T 300	14/4 D/S
EWP 237 BOLTER	10ct 200	14/4 D/S
SKULLS STORAGE	5c/t 300 2 X BUCKET	28/2 N/S
CON BUCKET 160	EM948	14/4 N/S
CON BUCKET 161	400 BELT	14/4 D/S
CON BUCKET 162	EM 947	14/4 N/S

[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.[87] 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.[88]

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.[89]

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.[90] That notice still stands but has been amended on a number of occasions to allow Austar to recommence development production in a staged manner.

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[87] J Galvin, B Hebblewhite, *Pressure Burst Incident at Austar coal Mine on 15 April 2014*, March 2015, pp.25-29.

[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.[92]

Version 2-15/05/2015

BELLBIRD SOUTH DEVELOPMENT COAL BURST TARP

The Pre-mining TARP triggers are based on the pre-mining assessment and included on the ATM as per the Coal Burst Management Plan. The During Mining TARP triggers are for use during roadway development to enable variation to the ATM set TARP level and controls based on actual observed conditions relating to Coal Burst potential and risk.

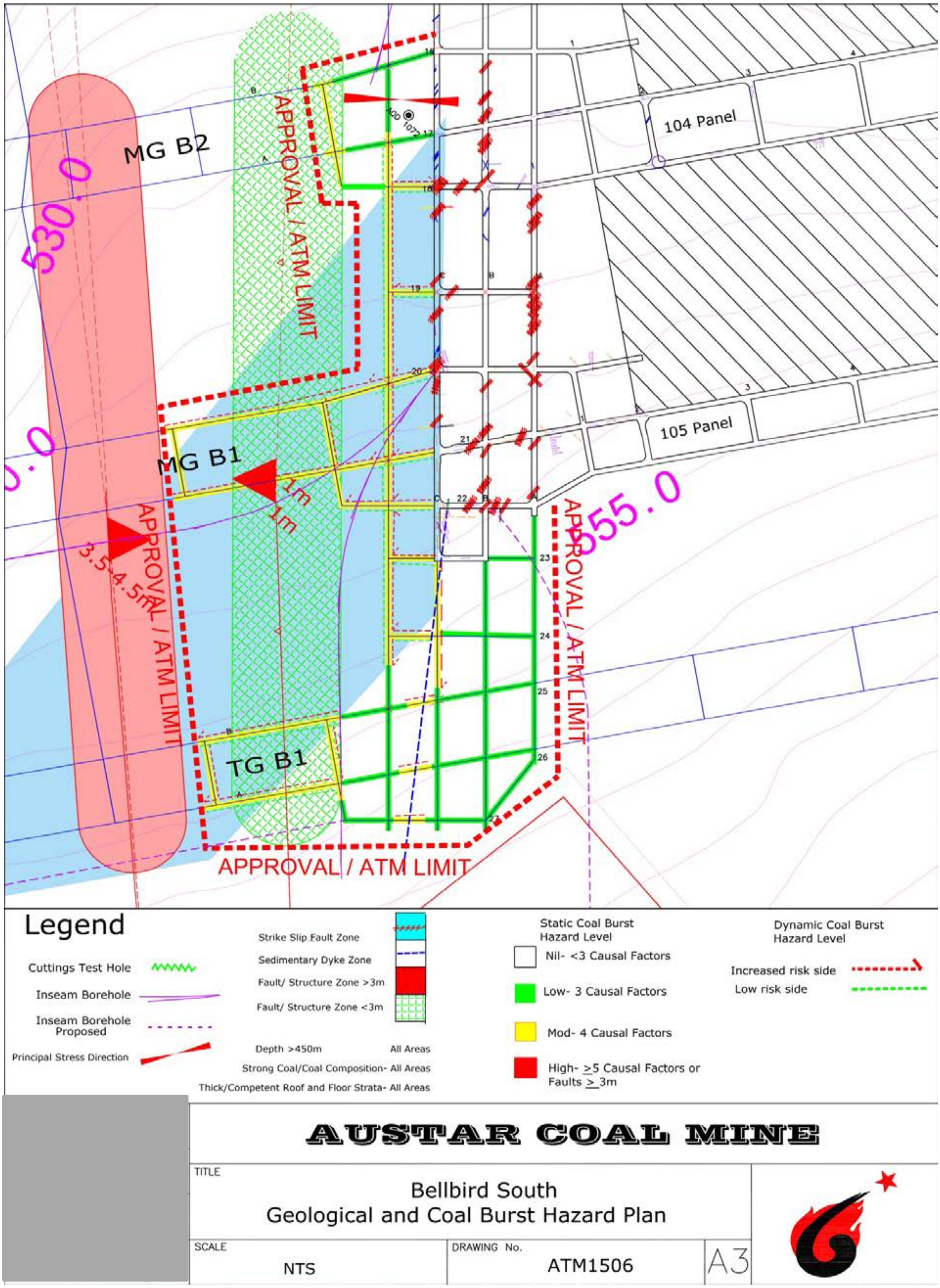
	TARP LEVEL	Low Level Hazard	Moderate Level Hazard	High Level Hazard
Triggers	Pre-Mining Assessment	3 causal factors	4 causal factors OR Any zone with identified or suspected strike slip faulting or faults between 1m and 3m throw	5 or more causal factors OR Faults zones ≥3m throw or Dyke ≥0.5m thick OR Zone of strike slip faulting which has significant gouge (+0.5m)
	The following triggers when NOT identified in the Pre-Mining Hazard Assessment shall cause a rise in the ATM established Hazard Level			
	Geological Structures	Faulting <3m Igneous Dykes <0.5m thick	Seam Roll Sedimentary Intrusion >100mm thick	Stress joints in roof with curved appearance
		NOTE: If faulting >3m or dykes >0.5m thick is encountered unexpectedly, then immediately trigger to a High Level Hazard		
	Competent Roof or Floor Strata	5m of continuously hard drilling with slow drill rates within 15m of seam Note: Hard strata must be a single continuous units for 5m as identified by the drill returns. If suspected to be the case increase Hazard Level appropriately until results are confirmed		
	Strong Coal or Changes in Coal Composition	Cleat becomes poorly defined Coal becomes unusually dull	Increased number of stone bands visible than normal Cleat takes on a 'shardy' appearance	Coal becomes unusually dry or dusty
	Confinement State	"Good" Ribs = <0.1m spall or buckling over minimum 20m Stone band contacts with rough or undulating contacts	Dosco band changes from puggy to hard with dull rough surfaces	
	The following triggers will cause an automatic rise to the corresponding TARP level			
	Cuttings Test	≥5kg/m but <10kg/m beyond 7m into the rib	4-5kg/m within first 4m of ribline OR ≥5kg/m between 4-7m into the rib	≥5kg/m within first 4m of ribline or ≥10kg/m within 13m of rib with an associated bump during drilling (trigger to be confirmed with a check of cumulative mass)
	Roadway Observations		Rib or face remains vertical and intact where otherwise was deteriorating **AND** plates show heavy load OR Abnormally large and frequent strata bump noises in close proximity to production face OR Localised rib failure/crush contained by mesh associated with large bump noise OR Appearance of red dust on coal to stone or stone band contacts or cleat faces	Ribs or face grinding and working heavily or spitting coal OR Small burst of coal or sudden failure of rib and support (with associated material ejection and bump noise) OR Large area of sudden and significant floor heave OR Appearance of red dust on coal or stone band contacts and cleat. Visible with associated bump noise/coal slump or face spitting
	Geological		Change in mapped stress direction or rapid changes in cleat (direction and dip) indicating potential upcoming fault OR Any zone with identified or suspected strike slip faulting or faults 1-3m throw	Fault zones ≥3m throw or Dyke ≥0.5m thick OR Zone of strike slip faulting which has significant gouge (+0.5m)
Response	Mining Operations	Normal mining standards	Normal mining standards	**When an additional High Level Hazard Trigger occurs During Mining ->** **Stop production.** No road high level risk area and move personnel to place of safety immediately. Contact Undermanager and confirm TARP level. Monitor for change and strata noise. Risk based plan to be developed for re-entry/ cutting/ stress relief in Manager Mining Engineering/Production Super / Dev Super/ Technical and external experts as appropriate ATM to be issued for High Level Hazard zones outlining required controls
	Safe Standing Zones	Normal mining standards	No one standing beside shuttle car No one to enter or exit safe standing area during cutting	As per ATM for High Level Hazard Area
	Inspections	Weekly inspection and mapping by Technical or mining	Daily inspection and mapping by Technical or mining management	As per ATM for High Level Hazard Area
	Monitoring	Cutting test drilling Left and right ribs every 40m and with change in TARP level	Cuttings test drilling left and right ribs every 15m and with change in TARP level	As per ATM for High Level Hazard Area
Change Authority	Change Conditions Up and Down	1. The miner driver or Deputy and Undermanager has the authority to change condition up.	1 The miner driver or Deputy and Undermanager has the authority to change condition up. 2. The Undermanager or Production Manager have the authority to change in consultation with the Manager Mining Engineering and Technical Services	1. The Manager Mining Engineering has the authority to change condition in consultation with the Technical Services
Responsibilities	Mineworker Technician	1. Mine to the Authority To Mine. 2. Continuously monitor as per TARP and report any sign of **IMMEDIATELY** to the Deputy 3. Follow Safe Standing protocols	As per Low Level Hazard	As per low level hazard Follow Deputy instructions and move to place of safety
	Deputy	1. Complete monitoring as per the TARP conditions. 2. Copy of the TARPs, and hazard plans to be in the cribroom. 3. Note current TARP condition in the Statutory Book along with relevant observations 4. Follow the ATM	1. Informs Undermanager of Moderate Level Hazard. 2. Enforces access requirements. Erect signage and barricade 3. Audits support against required standards 4. Inspect district after audible noise or event that may trigger a TARP change 5. Complete coal burst observation proforma 6. Inform crew of event and intended actions	1. Production is to be stopped and face to be secured. 2. Restrict access to area 3. Inform Undermanager of High Level Hazard ASAP. 4. Participate in formulating a response plan. 5. Appropriate responses as outlined is implemented
	Under Manager	1. TARP conditions and access requirements are to be followed at all times. 2. **Audit compliance with ATM and take corrective** action as required	1. Where possible visit the affected area in the shift it was reported. 2. Where more than one roadway observation is present consult Manager Mining Eng and Tech Manager to determine if Hazard level should be further or further controls to moderate are required.	1. Visit the affected area ASAP. 2. Participate in formulating a response plan. 3. appropriate responses as outlined is implemented
	Technical Services Manager/Mine Engineer-Geologist	1. Weekly inspect the panel and communicate conditions. 2. Undertake the pre -mining assessment and ATM assessment	1. Inspect affected areas daily	1. Visit the site ASAP. 2. Participate in formulating a remedial response plan. 3. Engage external consultants as required to assist with developing response plan
	Production Super	1. TARP conditions are to be followed at all times. 2. Weekly inspect the panels. 3. Participate in the ATM process	As per Low Level Hazard	1. Visit the site ASAP. 2. Lead the response team in formulating a plan. 3. Appropriate responses as outlined is implemented
	Manager Mining Engineering	1. Sign off on hazard plan. 2. Sign off on TARP 3. Weekly inspect the panels. 4. Participate in ATM process	As per Low Level Hazard	1. Participate in formulating a response plan.

RESPONSES REQUIRED ONLY IN AREA RELEVANT TO TRIGGER. ALL REQUIREMENTS OF LOWER TARP LEVELS MUST ALSO BE MET WHEN COMPLETING ACTIONS

		Checked Development Superintendent:	**Date:**
Checked Engineering Geologist:	**Date:**	**Checked Production Superintendent:**	**Date:**
Checked Technical Services Manager:	**Date:**	**Approved Manager Mining Engineering:**	**Date:**

[92] 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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[94] Austar Coal Mine, *Austar Coal Mine Development Strategy*, October 2014.

[95] Austar Coal Mine, *Bellbird South Development Coal Burst Management Plan*, 15 May 2015, p.17.

[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.

[99] Van Duin, S, Meers, L & Gibson, G (2013), *Hard automation trends in Australian underground coal mines*, 30th International Symposium on Automation and Robotics in Construction and Mining (pp. 150-159), International Association for Automation and Robotics in Construction, p.1, introduction.

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^{o} 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.

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[100] *Stage Three Report: 'Automated Bolting And Mesh Handling On A Continuous Miner'*, March 2014, www.acarp.com.au/abstracts.aspx?repId=C17018, accessed 10 June 2014.

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.

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[101] R J Kinnimonth E Y Baafi, ‘Australian Coal Mining Practice*, AusIMM Australian Institute of Mining and Metallurgy,* 2009, p.292.

[102] Austar Coal Mine, *Bellbird South Development Coal Burst TARP*, 15 May 2015.

[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.
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.