APPIN MINE
708D PRESSURE BUMPS

ROGER BYRNES – SUPERINTENDENT GEOTECHNICAL SERVICES, ILLAWARRA COAL

WOLLONGONG GAS AND COAL OUTBURST SEMINAR

22 NOVEMBER 2018
ABOUT SOUTH32

• South32 - a mining and metals company
• 12 operations in 7 countries across the continents of Australia, Africa and South America.
• 10 commodities are sold across the world and are used to make products that support everyday living:
  • Alumina, Aluminium, Energy Coal, Metallurgical Coal, Manganese Ore Manganese Alloy, Nickel, Silver, Lead and Zinc
• Australia, South Africa, Mozambique, Colombia, Brazil, Singapore, UK
• Approximately 25,000 employees (14,000) and contractors (9000) world-wide. Australia approx. 6,500 employees
• Australian Securities Exchange (ASX), Johannesburg Stock Exchange (JSE), London Stock Exchange (LSE)
OUR OPERATIONS

12 operations
10 commodities
7 countries (including Marketing)

- **Alumina and Bauxite**
  - Large integrated alumina refineries with high quality bauxite resources

- **Aluminum**
  - An aluminium producer with industry leading aluminium smelters

- **Manganese**
  - World’s largest producer of manganese ore and a top producer of alloy

- **Metallurgical Coal**
  - A major exporter of high quality metallurgical coal

- **Energy Coal**
  - Third largest energy coal exporter in South Africa

- **Nickel**
  - One of the world’s largest and lowest-cost ferronickel producers

- **Silver, Lead, Zinc**
  - World’s largest silver producer
ILLAWARRA COAL - WOLLONGONG

Legend:
- Existing Mine Workings
- Proposed Longwall Layout
- Locations Surface Facilities

Illawarra Coal Area of Operations
August 2018

Service Layer Credits: Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEROSGRID, IGN, and the GIS User Community
MINE LAYOUT
5 pressure bumps occurred in 26-25ct B heading roadway
1st event occurred on 27/5/18
  - Large bump noise
  - Slump of coal or coal pushed out against bolted support
  - Ejection of coal dust and small fragments
  - No injuries – operators adjacent to first event site

Prohibition Notice
Data collected
Expert opinion
Classified as a Pressure Bump
Processes and controls reviewed
Notice lifted July 2018
Recommenced mining (remotely)
EVENT DESCRIPTION – PRESSURE BUMP

- Event was preceded by 3 small bumps in preceding 2 hrs
- Bump occurred as miner started cut
- No injuries – 2 operators adjacent to 1st event site (Mining remotely after that)
- Large bump noise
- Slump of coal blocks
- Ejection of coal dust and small fragments
- Minor bump noise frequent in this roadway
EVENT DESCRIPTION – GEOLOGICAL ENVIRONMENT

- Faults adjacent to roadway
- Fault within 5m on right
- Minor structure in seam
- Joints with mylonite present
- Persistent roof striations in roof
- These running approx. 45° to roadway
- Rib condition “normal” locally
- Minimal gas detected after each event
- Not a burst event
Subsequently 3 more bump events reported while mining remotely, plus a large noise noted on stat report

- 2 x events resulted in slump of coal ahead of the bolted support
- 1 x event resulted in push of coal (small bulge) against bolt and mesh rib support
• Strong sandstone roof
• Bumping frequent in this roadway
• Approximately 4.5kms of roadway development in this roof environment
• One previous bump event recorded at 33ct
• Faults adjacent to roadway from 27-24ct
• Fault within 5m on right
• Minor structure in seam
• Rib condition “normal” locally
OVERBURDEN DEPTH – 565M
• 3 reported bumps were detected by seismic monitoring - Magnitude -0.2 to 0.2 ML

• 2 seismic events did not correspond to reported events

• Caution: Widely spaced network - x, y and z accuracy not high
SEISMIC EVENTS DETECTED

- 2 seismic events on 19/5/18 did not correspond to reported events
- 0.1 to 0.2 ML
• 5-8 seismic events detected, that (mostly) corresponded to reported bump events in 708D

• No other confirmed seismic events detected during development cycle (2013-2018)
**Pressure burst:**

A pressure burst is a generic term to describe a rock or strain burst in a coal mine, involving release of stored strain energy that causes dynamic failure or displacement of intact rock/coal, resulting in high velocity expulsion of this broken/failed/displaced material into the mine opening. The energy levels, and hence velocities involved here can cause significant damage to, or destruction of conventional installed ground support elements such as bolts and mesh.

**Coal burst:**

The term coal burst is synonymous with pressure burst, but refers specifically to a pressure burst event that expels coal into the mine opening, as opposed to rock from roof or floor.

**Pressure bump:**

A pressure bump is a lower level of dynamic energy release (compared to a pressure burst) within the rock (or coal) mass in a coal mine, often due to a more remote seismic event or displacement along a geological structure, that generates - an audible signal; ground vibration; and has the potential for displacement of existing loose or fractured material into mine openings. A pressure bump does not involve intact rock failure at the surface of an excavation and associated expulsion of the failed material (intact rock failure may occur remote from the excavation).

**Conclusion:**

The events in 708D were pressure bumps
Fault/structure characterisation
Stress cuttings holes
Gas characterisation
Roof lithology
Strength\Porosity (in progress)
Microfracture (in progress)
Additional gas content cores
Increased cuttings

Boggy drilling and high gas

Structure at top of SBS hole

Mapped location

Broken core

Inferred fault line based on line of boggy comments

Increased cuttings
Sandstone roof present right along 708D

Sandstone is thickly to massively bedded, typically with one or more siltstone beds within first 10m

Faulting/structure evident in top part of B26-30m
ROOF LITHOLOGY – SBS CAMERAS

Steep angled structure: Fault?
• Low gas pressures less than 300kPa consistent with drained coal.

• Variable gas pressures are consistent with the variability in permeability of the coal.

• Unusually high permeability 7-11m into the face
- 5 – 7.2m$^3$/t in hole ahead of face
- 7.9m$^3$/t in hole across from A hdg – high gas produced from hole, very boggy
Note elevated cores in area bounded in red compared to those bounded in pink despite similar drainage time / pattern – indicative of different coal properties / stress regime
• Yellow trigger reached on some intersections of inferred fault line

• Yellow trigger in B hdg face – high stress location?

• Green elsewhere – not indicative of high stress
INTERPRETATION
• Strong sandstone roof present
• Fault within 5m on right side of roadway
• Energy levels higher than “typical” for development (refer Gale, 2018)
• Events -0.2ML to 0.2ML
• Fracture size 10m+ diameter?
• Cyclicity to events 12-25m?
• Cycle of reduced confinement leading to seismic event?
• Seismic energy at upper end expected on development cycle
• A “perfect storm” of thick sandstone roof plus fault running close and parallel to the heading direction?
KEY CONCLUSIONS

• Pressure Bumps
• Most likely caused by failure of sandstone in roof
• → Seismic energy
• Not a coal burst (or outburst) event
• Fault was a key player
• Alternative conclusion – failure of coal between roadway and fault → seismic and strain energy
• Unusual gas regime – gas energy may have had an influence
• Potentially indicative of structure – not having homogenous drainage
Failure in sandstone during mining initiates a seismic pulse. This travels to seam, causing shakedown of the rib, and expulsion of dust and fine coal.
FREE GAS : ADSORBED GAS RELATIONSHIP

COMPARISON FREE GAS & ADSORBED GAS 708D 26 - 25 ATM1424

Q3 vs Q1+Q2

GAPS225

708D ATM1424

TG901
Surface geophone network

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