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A review of the geomechanics aspects of a double fatality coal burst at Austar Colliery in NSW, Australia in April 2014

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ABSTRACT

A coal burst occurred on 15 April, 2014 at the Austar Coal Mine, located west of Newcastle, NSW, Australia. The burst resulted in fatal injuries to two men working as part of the mining crew at the development face. At the time, a continuous miner was being used to mine a longwall development gate road through heavily structured coal, at a depth of approximately 550 m. A number of pre-cursor bumps had occurred on previous shifts, emanating from the coal ribs of the roadway, in proximity to the coal face. This paper reviews the geological, geotechnical and mining conditions and circumstances leading up to the coal burst event; and presents and discusses the available evidence and possible interpretations relating to the geomechanical behaviour mechanisms that may have been critical factors in this incident. The paper also discusses some key technical and operational considerations of ground support systems and mining practices and strategies needed for operating in such conditions in the future.

1. Introduction

Austar Coal Mine is an underground longwall coal mine located near Cessnock in the Hunter Valley of New South Wales (NSW), Australia and is the only underground mine still extracting the Greta Seam in this region. The mine was the first in Australia to adopt the Chinese-developed longwall top coal caving (LTCC) method for thick seam extraction. Typically seam thickness ranges from 4 to 7 m and depth of mining from 480 to 560 m, with future mining planned down to depths of up to 700 m, making it one of the deepest operating coal mines in Australia.

On 15 April 2014, a pressure burst occurred in the left hand rib at the active mining face of B Heading, 2–3 cut-through, maingate A9 panel, during development of the gateroads for the ninth longwall top coal caving panel. Strata in the general vicinity was affected by disturbed geology and multiple geological structures. Fig. 1 shows a section of the mine plan as in October 2014 (six months after the accident), indicating the current longwall extraction panel (A8) and the development panel A9 where the accident occurred (note: neither development nor longwall face positions changed significantly between the time of the accident and the date of this plan). At the time of the accident the current longwall face was in excess of 1000 m away from the Maingate A9 development panel face position.

When the accident occurred, the development face was being advanced by a crew of seven mine workers. Messrs Jamie Mitchell and Phillip Grant were located on a working platform on the left hand side of the ABM25 continuous miner (bolter-miner), immediately adjacent to a ribline that had already been supported with bolts and mesh (rib bolting consisted of 1.5 m mechanically anchored bolts in the lower and upper sections of the seam, supplemented by 2.1 m chemically anchored bolts in the mid-seam section). The two men were engulfed by material ejected from the ribline during the pressure burst and died at the scene.

The accident was reported by the NSW Mine Safety Investigation Unit (MSIU) following an extensive investigation, which included a detailed technical report prepared by Galvin and Hebblewhite [1,2].

1.1. Terminology

In any situation, four conditions have to be satisfied simultaneously in order for a dynamic (violent) rock failure to occur. The first is self-evident and implicit in the other three conditions reported by Salamon and Wagner [3]. These four conditions are:

(1) The stress environment must be sufficiently high to result in rock failure.

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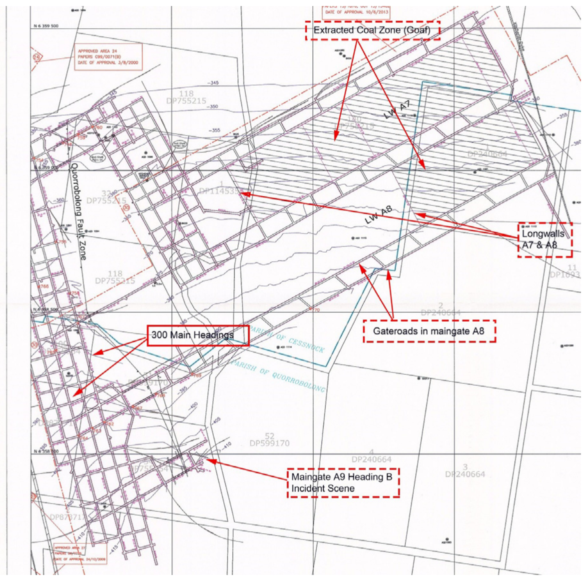

Fig. 1. Extract from Austar Mine Plan (31 October 2014) (after NSW MSIU (2015).

(2) A situation must exist which can result in a state of unstable equilibrium. This could be a low friction bedding plane, for example, where the potential exists for the coefficient of friction to drop rapidly from its static to dynamic value once movement is initiated along this plane.
(3) A change in the loading system. Potential triggers include, for example, a reduction in system strength due to a local change in rock mass material or structural properties; an increase in system stress associated with a local geological structure; or a decrease in confinement due to the formation of one or more excavations.
(4) A large amount of energy has to be stored in the system. This energy can be generated, for example, by depth of mining, bridging strata or geological structures.

Whilst these conditions were applied by Salamon and Wagner to rock burst behavior in hard rock mines, they are also potentially applicable to similar dynamic, stress-driven events in underground coal mining.

There are a number of terms used across the international underground mining industry (including both hard and soft rock mining) that are of relevance to any discussion of dynamic ground failure events in underground mines, including the type of event that occurred at Austar Coal Mine on 15 April 2014. It is important to clarify and adopt a consistent set of terms used in the context of such dynamic rock failures. It must be recognised that there is no universally accepted and unique set of definitions for all of these terms, however the following descriptions are widely regarded as appropriate–at least within the Australian mining context.

The terms to be discussed are as follows: (1) rock burst, (2) strain burst, (3) pressure bump, (4) pressure burst, (5) shake-down, (6) outburst, (7) coal bump, (8) coal burst, (9) pillar bump, and (10) pillar burst.

All of the above describe events associated with some form of dynamic energy release, usually associated with intact rock failure. This release of energy can vary greatly in magnitude and may or may not generate a measurable seismic signal.

Rock bursts and strain bursts are terms used to describe such dynamic energy releases and rock failure associated with hard rock mining. The source of the energy is directly related to stress levels within the rock, albeit that the manifestation of the stresses and the triggers for the release of the energy can be quite complex, involving many factors. The difference between a rock burst and a strain burst is simply one of consequence scale, due to different energy magnitudes–with strain bursts being of much lower energy magnitude, such that the resulting rock damage is far less than for a typical rock burst. These terms are not generally used in underground coal mining, although the geotechnical mechanisms involved may be very similar to the coal mining equivalent events summarized below.

The next two terms are those most commonly used to describe dynamic energy releases in underground coal mining–pressure bumps and pressure bursts. Both terms refer again to dynamic energy events associated with stress levels in the rock mass, which includes but is not limited to the 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 (or coal) 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 as a bounce. On the other hand, a pressure burst is a pressure bump that actually causes consequent dynamic rock/coal failure in the vicinity of a 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 conventional installed ground support elements such as bolts and mesh. A shake-down is another term taken from the hard rock mining sector, referring to damage caused by a bump event, where existing broken rock material is destabilized and collapses into the mine excavation.

An outburst in Australian mining terminology is also a dynamic energy release that can lead to some form of rock failure, however the source of energy is primarily associated with in situ gas pressure, sometimes also supplemented by stress-related energy. Therefore, outbursts are normally only associated with coal mining (where there is more prevalence of in situ gas), and usually only occur within the coal seam. Caution is emphasized with the use of the term 'outburst', when reviewing international literature. Whilst most European deep coal mining industries adopt the terminology as described above, the US coal industry often uses the term 'outburst' more broadly, to describe dynamic events that are purely stress driven as the energy source–events that in Australia would be referred to as a pressure burst or a coal burst.

The terms coal bump and coal burst, together with pillar bump and pillar burst are generally synonymous with pressure bump and pressure burst-and are all terms used to describe such dynamic events in underground coal mining. These terms are in some ways an alternative name for a sub-set of the more general events covered by pressure bump and pressure burst. Coal bumps and bursts are specific to events emanating from within the coal seam (as opposed to roof or floor origin); while pillar bumps and bursts relate to events within pillars as opposed to either in solid development drivage or on a longwall face, for example.

1.2. Mining background

The following background information is provided regarding the mining operations at Austar Coal Mine (Austar). Austar is a deep underground coal mine located approximately 10 km southwest of Cessnock in the Newcastle Coalfields of New South Wales, Australia. It is owned by Yancoal Australia Ltd., an Australian-Chinese partnership. Yancoal purchased the mine (formerly known as Southland Colliery) in December 2004. Austar commenced mining operations in April 2005 and in September 2006 became the first mine in Australia to adopt the mining method called longwall