

# **OUTBURSTS IN LEICHHARDT COLLIERY : LESSONS LEARNT**

**John Hanes**

## Outbursts in Leichhardt Colliery: Lessons learnt

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**ABSTRACT:** Leichhardt Colliery experienced in excess of 200 outbursts during its short history until 1982. A considerable research effort was applied in its later years to understand how outbursts occur and how to prevent them. The paper describes the outbursts and relevant signs as well as the geological and gas settings. The attitudes of the time contributed to the difficulties of overcoming the outburst problem. Some of these attitudes still exist in the industry.

### 1 INTRODUCTION

Leichhardt Colliery, located south of Blackwater in the Bowen Basin, in Central Queensland, mined the 6m thick Gemini seam between 1970 and 1982. During this time it experienced in excess of 200 outbursts, the largest of which involved approximately 350 tonnes of coal and claimed the lives of two miners. Much was learned about outbursts and the contributions of stress and gas to the phenomenon, but it was difficult to raise interest or heed in the rest of the Australian coal mining industry except at a couple of mines which were not overcoming outbursts. Following the fatal outburst in December, 1978, considerable effort and money were expended on outburst research by BHP, the operators of Leichhardt and the Commonwealth. By the mid 1980's, interest in outbursts in Australia had died.

### 2 HISTORY

Mining by contractors commenced at Leichhardt in 1970 using a Joy 6CM miner to drive initial pit bottom developments. This work was accompanied by high gas emissions and some small conical cavities, similar to outbursts. Mining by BHP with Joy 10CM miners commenced in 1973 and outbursting commenced in 1974 when the workings extended beyond the zone of stress and gas reduction associated with the initial workings.

Mining continued until December 1978 mainly with the Joy 10CM's, but also with trials of an Alpine miner to cut an arched roadway and some advance by shotfiring. Advance drilling of methane drainage holes was conducted using various diameters and delay periods in an attempt to alleviate the outburst risk. On 7th December 1978, a major fatal outburst

occurred. From 1979 until the mine closed in 1982, the only advance was by shotfiring.

### 3 MINING STRAIN

An anisotropic stress field dominated the mining strain (Figure 1). The principal stresses measured in the sandstone roof were 30MPa (horizontal), 20MPa (horizontal) and 10MPa (vertical). Stresses in the coal were of lower magnitude than in the stone, but of similar anisotropy. The Gemini seam varied in strength (UCS) from 5MPa for bright coal to around 20MPa for dull coal. Tensile strength varied from 0.2MPa to 0.6MPa. Mining strain phenomena included roof sag and guttering with several falls, mining induced cleavage in the stone and coal, hard ribs and crushed ribs and outbursts.

Mining induced cleavage of the coal and stone were first described in Australia at Leichhardt (Hanes and Shepherd, 1981). Intense mining induced cleavage in the coal, especially the dull coal at the top of the seam was prominent in areas that outburst. The cleavage planes were as closely spaced as 1mm or less. Conjunction of the fractures produced large curvilinear fractures which defined detached slabs of coal. The fractures curved about the face and were most intense on the side which first intersected the maximum principal stress trajectory. Where mining induced cleavage did not occur, outbursts also did not occur. Thus their presence was an indication of outburst proneness.

Rib crush coincident with mining was a safety sign indicating the lack of outburst danger. It typically occurred in drives parallel to maximum stress direction. "Hard" ribs and face which stood solidly and showed pick marks over the full height were a warning sign. Outbursts commonly occurred subsequent to such signs of face "hardening".

Over 200 outbursts occurred, most on continuous miner development. The bursts ranged from less than one tonne to in excess of 350 tonnes. Most were less than 100 tonnes. They occurred with their cavity axis perpendicular to the most prominent discontinuity in the coal, ie perpendicular to the direction of least constraint. Most bursts occurred with their axis perpendicular to the prominent face cleat. They typically occurred from the face or rib which first intersected the cleat as a violent buckling and ejection of the cleated and fractured coal. Few outbursts occurred with development of the arched roadways driven by the Alpine miner which was possibly a function of the stronger roadway shape and the slower advance rate. Outbursts also occurred with shotfiring when gas conditions were appropriate.

#### 4 PREVENTATIVE MEASURES

Various sections of the seam were mined in an unsuccessful attempt to find a benign section. In 1975, following a large outburst, 200m of advance was made by shotfiring. This initiated outbursts which severely damaged the roof and the technique was abandoned.

Large diameter auger hole boring commenced with 300mm diameter holes, but because of the difficulties associated with the larger holes, various hole diameters and patterns were trialled, without measurement of the effects on the gas and stress states. Gas could not be heard or measured emitting from the holes and most holes showed no signs of crushing. A pattern of two layers of five 100mm holes, each 28 to 30m long was finally adopted for protection of working faces. The effects of these holes on gas and stress were not measured. It was assumed that a face could be advanced in "safety" after the holes had been drilled accepting that effectiveness would be better the longer the delay.

Where mining closely followed drilling, outbursts typically occurred. Long standing times after drilling reduced the frequency and size of outbursts. This was demonstrated by Wood and Hanes, 1982 when summarising events leading up to the fatal outburst of December 1978. "In A North Intakes, the heading in which the major 500 tonne outburst of 1/12/78 occurred, 100mm relief holes produced a positive effect. The face was drilled in June 1978 with ten 100mm holes each about 28m long and left to stand until 7th November. The advance of the section covered by the holes was under good conditions and rate of advance increased. Mining induced cleavage was absent until near the end of the holes and the ribs tended to spall rather than be 'hard', ie pickmarks over their full height. Near the end of the holes the ribs 'hardened' and some mining induced cleavage occurred. A further five holes were then drilled and mining recommenced. Three bursts occurred in the following three days with drivage over 12 m. The bursts ranged in size from 50 tonnes to 500 tonnes. It is concluded that the holes drilled and allowed to

stand for four months were successful in preventing outbursts and in minimising outburst related strain".

#### 5 GAS

The Gemini seam contained up to 15 m<sup>3</sup>/tonne of 100% methane at a virgin fluid pressure of 3.8 MPa, equivalent to hydrostatic head. The coal was water saturated.

Early attempts at determining the gas parameters of the coal were frustrated by the lack of sophisticated equipment and techniques available today. Shotfired drive for research purposes after the 1978 fatal outburst were accompanied by detailed measurements of gas pressure gradients, flow gradients and the Hargraves Emission Index. Pressure and flow measurements were conducted using the (then) newly available inflatable packers. These measurements revealed that gas played a dominant role in outburst conditions.

#### 6 BENIGN TO PRONE

Development of the 1 South Panel after the fatal 1978 outburst was conducted by shotfiring. Figure 2 shows conditions experienced by workings driven by shotfiring and the changes associated with the onset of outbursts. Mining conditions were initially very good with minimal mining strain. Mining induced cleavage was essentially absent. The coal cuttings drilled for the Hargraves Emission Index were dry and yielded less than 0.1cc/g of gas. These workings were within the cleat related "shadow" of adjacent workings. They had been drained of gas and water. When the development passed beyond this "shadow" zone, conditions changed dramatically. Mining induced cleavage and outbursts reappeared. The coal cuttings for the emission test were wet and the Hargraves Emission Index increased to in excess of 1.0cc/g until the wet cuttings invalidated the test. The gas pressure gradient steepened dramatically.

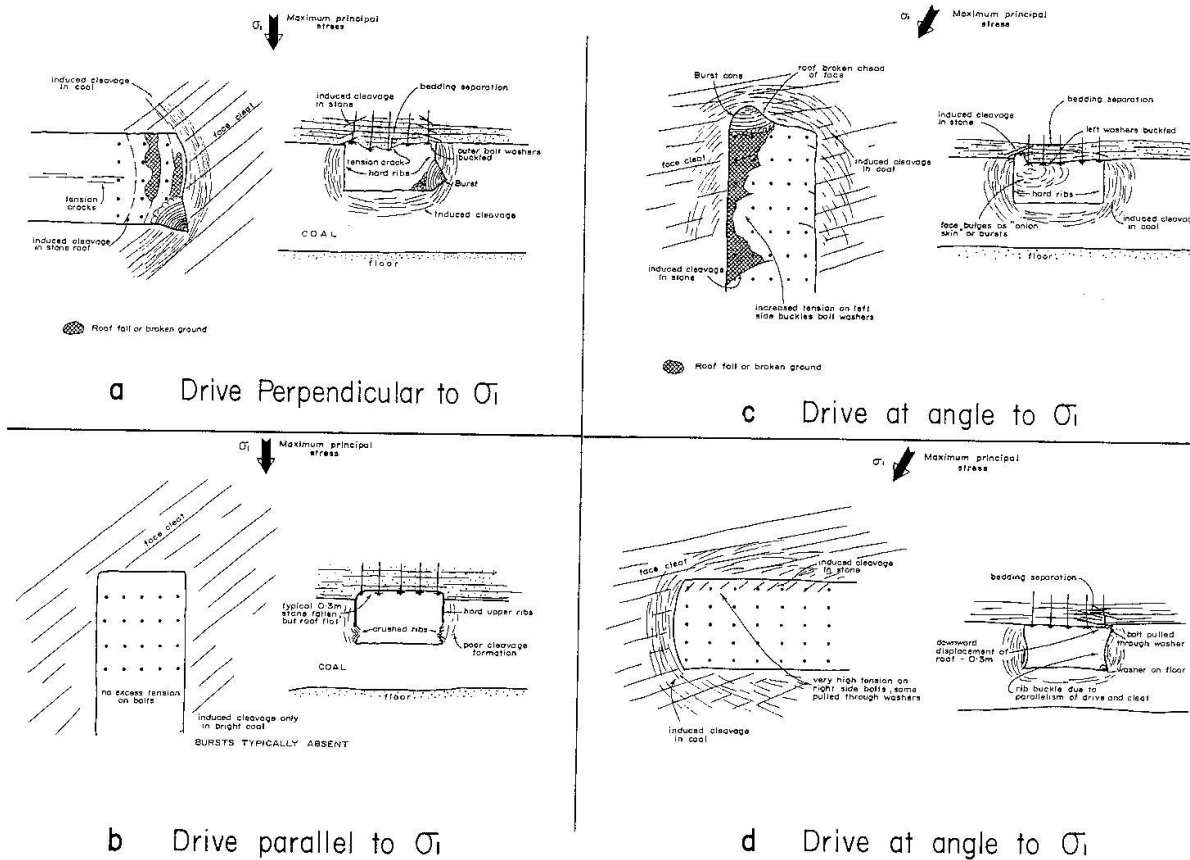
Figure 3 summarises pressure gradients for outbursting and non-outbursting conditions and clearly shows that gas pressure gradient was the dominant controller of outbursts.

#### 7 LESSONS

In retrospect, there are some lessons to be learned from Leichhardt which were not necessarily obvious during the years of mining. The following observations are in hindsight and are not intended as a slight on the people involved at Leichhardt who persisted with difficult mining conditions at an isolated location to apply the most appropriate methods known at the time. Conditions, knowledge and investigative technology then were very much different from what they are today.

Insufficient exploration and definition of geological conditions were conducted prior to taking a decision

Figure 1. Mining Strain Patterns Directionally controlled.



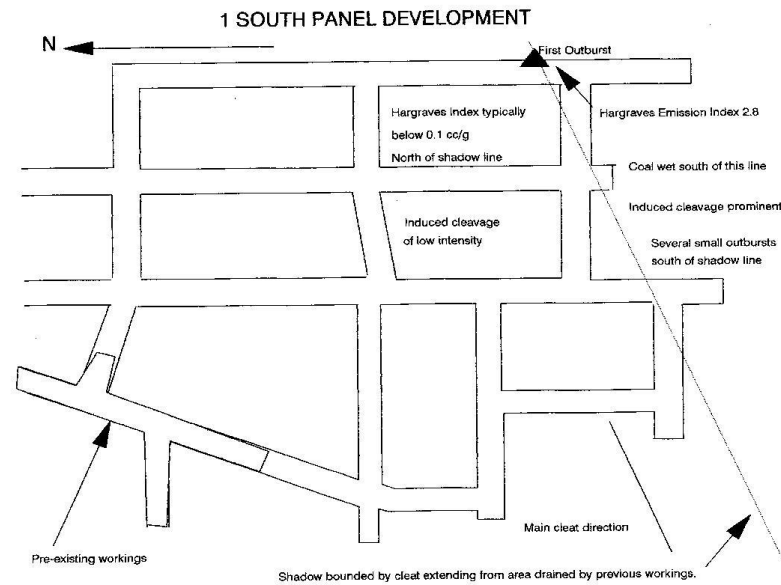


Figure 2. Benign to Prone

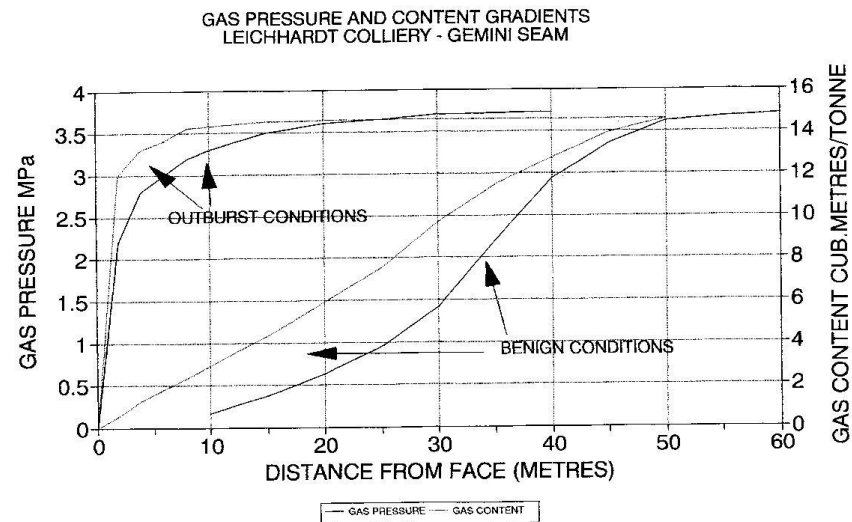


Figure 3. Gas Pressure Gradients

to mine. The mine was planned on 9 boreholes, at least two of which contained large thrust faults. Definitive gas investigations were not carried out mainly due to the lack of appropriate technology.

Daily production rate was the main goal of the mine from its commencement. Even when new methods of mining or gas drainage were introduced, the need for production was dominant in their application.

The need to measure geotechnical parameters was not initially recognised. It was assumed that experience of deep mining at Company mines in NSW could be directly applied to Leichhardt. When technology in the form of in-seam drilling was imported from NSW to address the outburst condition, detailed measurements were not conducted to define the similarities or differences in geotechnical conditions to which the technology was applied.

The miners and management tended to adopt an attitude of "We have experienced many outbursts and know how to handle them". This attitude is not acceptable today. Decisions must be based on continual measurements and retesting.

To be able to control or prevent outbursts requires a good understanding of the contribution of the various controlling factors and a constant vigilance of them. This requires continuing measurement of the relevant parameters and questioning of the validity of the theories which define outbursts and their management. When management, miners and technical staff believe they understand what is happening and that they have control of the situation, the danger rises.

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