BURSTS IN COAL AT LEICHHARDT COLLIERY, CENTRAL QUEENSLAND
AND THE APPARENT BENEFITS OF MINING BY SHOTFIRING

By

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ABSTRACT

More than 200 bursts in coal occurred at Leichhardt Colliery prior to December 1978 during mine development in the 6 m thick Gemini seam at depths approximating 400 m. Three large bursts each displaced more than 300 tonnes of coal and stone. Two of these which occurred in continuous miner developments, are described and compared. Geological settings, mining strains including induced cleavage and roof failures associated with bursts are described.

A shotfiring technique replaced mechanised mining following a major incident at the colliery. Present mining procedures, the apparent improvement in stability of workings and ongoing geotechnical monitoring programme are discussed.

INTRODUCTION

Mine workings at Leichhardt Colliery, located 15 kms south of Blackwater in Central Queensland (Fig. 1) are in the Gemini seam of the Upper Permian Rangal coal measures. The Colliery has a history of bursts since 1974 when the first burst was recognised. It is probable that smaller bursts occurred prior to 1974 but were not recognised as such. Since 1974, more than 200 bursts have been recognised ranging in size from less than one tonne up to 500 tonnes of material displaced.

Mining methods were varied considerably in attempts to alleviate the burst problem. Most drivage was made with a Joy 10CM continuous miner cutting rectangular roadways 3 m high with nominal widths of 5 m to 6 m. Roadways were driven at various levels within the 6 m thick seam. Some drivage was made with an Alpine AM50 miner cutting an arched roadway 5 m high. Simultaneous shotfiring was used in late 1974 to induce bursts. Degassing/destressing boreholes were drilled ahead of faces from late 1975 to 1978 with questionable success. Shotfiring is in current use and the shotfired roadways are free from bursts and exhibit minimal mining strain.

Geotechnical investigations are proceeding currently into the burst situation and related hazards. Their aim is the establishment of the parameters controlling safe mining in the Leichhardt Colliery environment so that safe techniques for development and extraction, free from bursting and strata control problems can be established. Achievement of this aim will provide a basis not only for mining at Leichhardt Colliery but for the safe recovery of the vast underground coal resources in the complex central part of the Bowen Basin.

GEOLOGICAL SETTING

Leichhardt Colliery is situated on the 3^{o} dipping eastern limb of the Comet Ridge and western limb of the Mimosa Syncline. Fifty kilometres to the east is the well defined

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Folded Zone (Hawthorne, 1975) which trends approximately 150^{o} (Dickins and Malone, 1973) (Fig. 1).

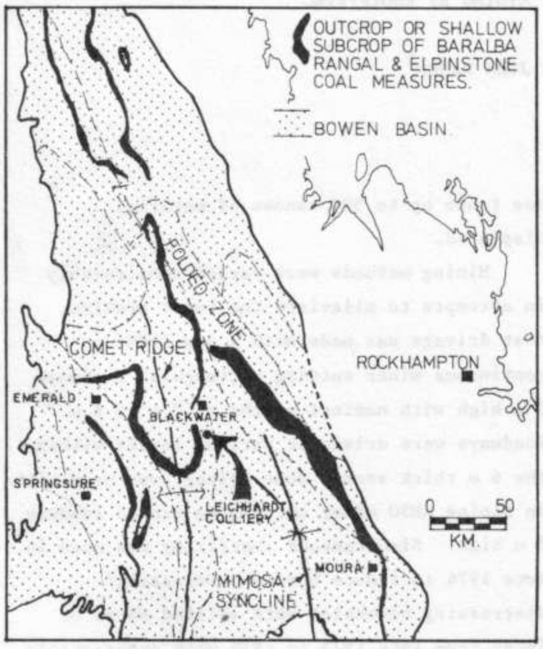
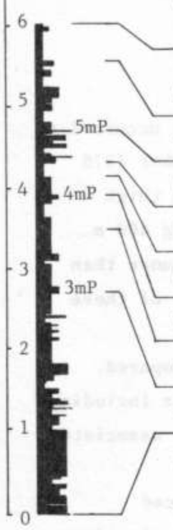


Fig. 1 - Regional Geology

The mine workings are in the Gemini seam which averages 6 m in thickness over the 350 m to the 410 m deep colliery workings. Vitrinite reflectance ($R_o$max) of the seam averages 1.25%. Table 1 gives representative Gemini seam analyses and a graphic section of the Gemini seam showing roof partings. Above the Gemini seam is the 2.5 m thick Aries seam which contains only limited drivage. The interval between the two seams varies from 15 m in the west to 39 m over the present workings. The interval consists of lithic sandstone, shale and siltstone. In the area of thickest interseam interval, the strata consists of up to 70% sandstone deposited in a meandering palaeoriver channel.

Table 1

Gemini seam representative brightness profile and analyses



Thickness (m)	Ash (d.b.)	Volatile (d.b.)	Swell	Vitrinite
0.5	16	19	1	23
0.8	7	22	6½	46
0.4	6	23	7	44
0.2	7	21	1½	23
0.2	6	23	5½	42
0.4	9	22	2	30
0.7	5	23	5½	43
2.8	7	23	8	50

3mP - 3 metre Parting
4mP - 4 metre Parting
5mP - 5 metre Parting

The colliery is structurally complex with numerous faults of less than 10 m throw striking predominantly northwest. Three faults of significant throw were intersected in the colliery workings (Fig. 2). Two are steeply dipping normal faults with throws greater than 10 m. The third is a shallow dipping reverse fault with throw 3.5 m and is associated with a sandstone filled channel in the seam roof. Shallow dipping slickenside planes striking approximately northwest are common over the western side of the mine.

Cleating is common. The high frequency face cleat strikes 040^{o} to 100^{o} with a mean of 066^{o}. Cleats with strike length greater than 1 m (many in excess of 6 m) occur at average spacings of less than 2 m in the pit bottom area with decreasing frequency in the north and east.

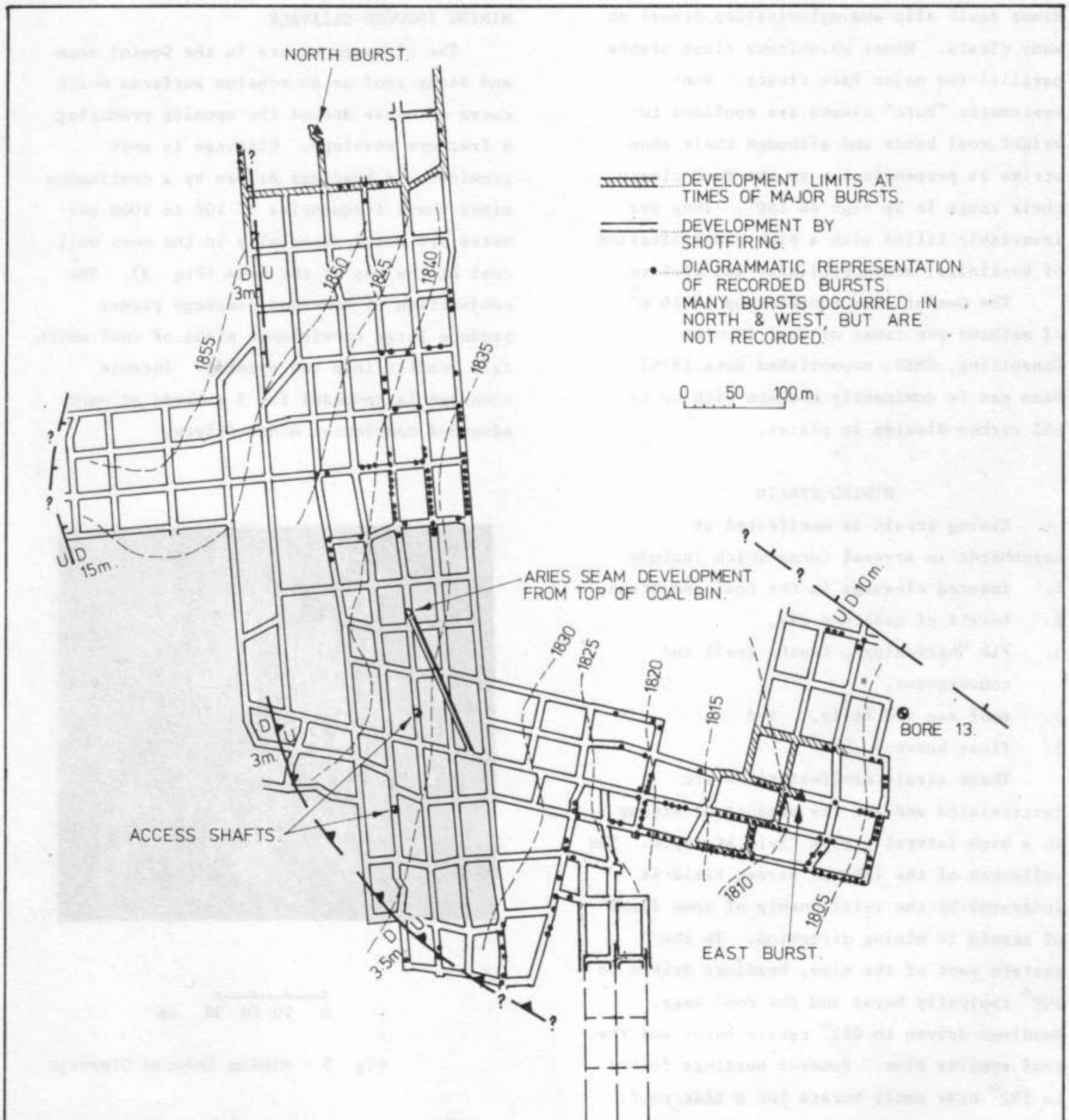


Fig. 2 - Leichhardt Colliery Workings

Minor fault slip and mylonisation occurs on many cleats. Minor ubiquitous cleat planes parallel the major face cleats. Non-systematic "butt" cleats are confined to bright coal bands and although their mean strike is perpendicular to the face cleats, their range is as high as 180°. They are invariably filled with a pink mineralisation of kaolinite, montmorillinite and dickite.

The Gemini seam contains up to 16 m^3 of methane per tonne of coal (Montan Consulting, GMBH, unpublished data 1976). Seam gas is dominantly methane with up to 15% carbon dioxide in places.

MINING STRAIN

Mining strain is manifested at Leichhardt in several forms which include

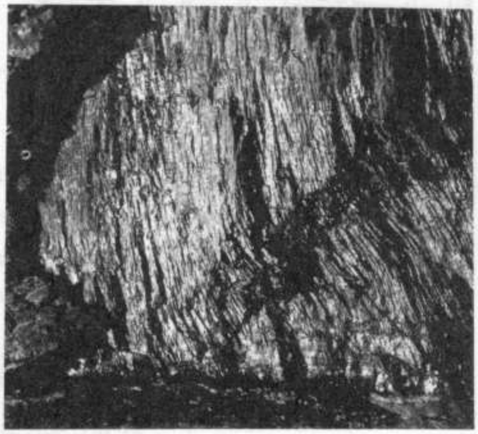
1. induced cleavage in the coal and stone,
2. bursts of coal and gas,
3. rib "hardening", crush, spall and convergence,
4. roof sag and falls, and
5. floor heave.

These strain manifestations are interrelated and are the product of mining in a high lateral stress field at depth. The influence of the lateral stress field is indicated by the relationship of some forms of strain to mining direction. In the eastern part of the mine, headings driven to 102° typically burst and the roof sags. Headings driven to 012° rarely burst and the roof remains flat. However headings driven to 192° have small bursts but a flat roof. Many roof falls throughout the mine and some coal roof burst cavities have eliptical horizontal sections with long axes oriented to the northwest, approximately perpendicular to the inferred maximum principal stress (σ_1).

The two forms of mining strain most pertinent to the topic are induced cleavage and bursts of coal and gas.

MINING INDUCED CLEAVAGE

The cleavage occurs in the Gemini seam and stone roof as en echelon surfaces which curve en masse around the opening producing a fracture envelope. Cleavage is most prominent in headings driven by a continuous miner where frequencies of 100 to 1000 per metre are noted, especially in the very dull coal at the top of the seam (Fig. 3). The conjunction of numerous cleavage planes produce large curviplanar slabs of coal which fall readily into the opening. Intense cleavage is recorded for 3 m ahead of many advanced continuous miner drives.



0 10 20 30 cm

Fig. 3 - Mining Induced Cleavage

The sections driven with an Alpine miner show a similar cleavage pattern around the opening, but the cleavage is less intense and more closely parallels the opening.

The cleavage produced in the shotfired openings is less intense with frequencies of only 10 to 20 per metre produced in places.

The cleavages are thought to be produced as extension fractures in the σ_1 - σ_2 plane of the locally concentrated lateral stress field produced about the opening. In a continuous miner drivage, this stress concentration is thought to occur in the coal within a few metres of the face and occasionally right at the face. It is considered that when the stress zone occurs at the face in sufficient magnitude, the coal bursts into the opening.

A similar pattern is believed to exist around the Alpine drive headings but of lower apparent intensity owing to the arched shape of the driven section and the curved face line.

In the headings driven by continuous miner, visual differences in rib appearance occur. In places the ribs crush on mining and no bursts occur. In other places, the ribs stand "hard" and this is followed in many instances, by a burst.

The slow rate of advance and possibly the method of drivage of the shotfired openings are thought to produce a zone of progressive stress relaxation about the opening. Investigations of abutment configurations are in progress.

COAL BURSTS

The first bursts recognised at Leichhardt occurred when the workings were 175 m from No. 2 Shaft (Fig. 2). Although some small burst-like structures are recognised in earlier workings, all definite bursts occur beyond the areas enclosed by circles 155 m to 175 m radius centred on the two shafts (Fig. 2). Redistribution of stress about the shafts is inferred.

The bursts are mostly conical. The boundaries of the bursts are defined by induced fractures, separating the relatively solid coal from the coal within the burst cone which, although heavily fractured and bulged outwards into the opening, is not necessarily completely ejected (Fig. 4). The coal in and immediately around a burst cone is intensely

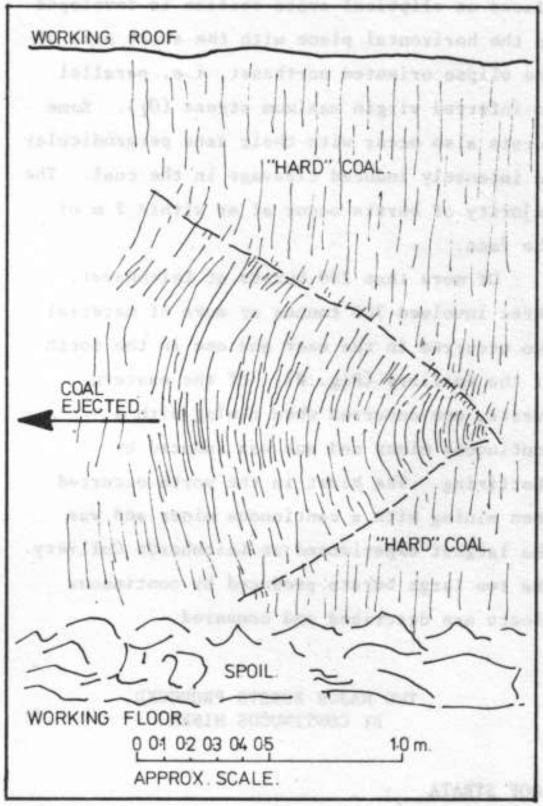


Fig. 4 - Cross section of typical burst cone

cleaved parallel to the face cleat, the cleavage being induced by a high induced stress differential ($\sigma_1 - \sigma_3$) within the region of the burst.

Bursts occur with their cavity axes perpendicular to the most prominent discontinuity in the seam, i.e. the axes are parallel to the direction of least constraint. The axes of most bursts are perpendicular to the face cleat direction and these bursts occur from the ribs or face generally on the side which first encounters the cleat. Many bursts occur from the coal roof when the 3 m, 4 m or 5 m partings are used as mine roof. Their axes are perpendicular to bedding. In places an eliptical cross section is developed in the horizontal plane with the short axis of the elipse oriented northeast, i.e. parallel to inferred virgin maximum stress (σ_1). Some bursts also occur with their axes perpendicular to intensely induced cleavage in the coal. The majority of bursts occur at or within 2 m of the face.

Of more than 200 bursts at Leichhardt, three involved 300 tonnes or more of material. Two occurred in the east and one in the north of the Colliery (Fig. 2). Of the eastern bursts, one occurred when mining with a continuous miner and one was induced by shotfiring. The burst in the north occurred when mining with a continuous miner and was the largest experienced at Leichhardt Colliery. The two large bursts produced by continuous miners are described and compared.

TWO MAJOR BURSTS PRODUCED BY CONTINUOUS MINER

ROOF STRATA

The immediate roof of the northern burst is medium bedded, medium grained, lithic sandstone with some thin interbeds of siltstone. The interval between the Gemini seam and overlying Aries seam is approximately 33 m thick containing 70 percent sandstone.

The immediate roof of the eastern burst is thinly interbedded siltstone and fine grained lithic sandstone. The Aries to Gemini interseam interval is approximately 36 m and contains 55 percent sandstone.

FLOOR STRATA

The immediate floor of the area of the northern burst is shale up to 3 m thick, underlain by a thick sandstone filled channel. The exact location and nature of the edge of the sandstone channel cannot be determined from the broadly spaced data available, but the edge is apparently close to the burst area.

The immediate floor of the area of the eastern burst is essentially shale which is approximately 5 m thick in Bore No. 13, 120 m northeast (Fig. 2) where it is underlain by a thick sandstone bed. The floor strata sequence at the burst site is not precisely known.

One hypothesis to be investigated is that both large bursts occurred as the workings crossed the edges of thick sandstone deposits in the floor.

GEMINI SEAM

In the vicinity of the northern burst the Gemini seam averages 5.7 m thickness. Over the inbye end of the burst cavity the seam is an anomalous 6.9 m thick (Fig. 5). The increase in thickness probably is associated with local reverse faulting.

The thickness of the seam at the eastern burst is 6.3 m which is normal for the area.

STRUCTURE

FAULTS

In the vicinity of the northern burst, shallow dipping reverse faults of minor displacement (less than 0.2 m) and associated slickensided planes in the coal are prevalent. Most of the slickensided planes strike 167° and dip 29° northeast. Only one 0.15 m reverse fault intersects the sandstone roof. The palaeostress (σ_1) which produced the reverse faults was near horizontal and oriented 094°.

Many slickensided planes in the north converge with the 5 m parting which was used as mining roof prior to the burst. Outbye the burst area, the coal below the 5 m parting is essentially free from structural shearing. However, brecciated coal to 0.5 m thick with

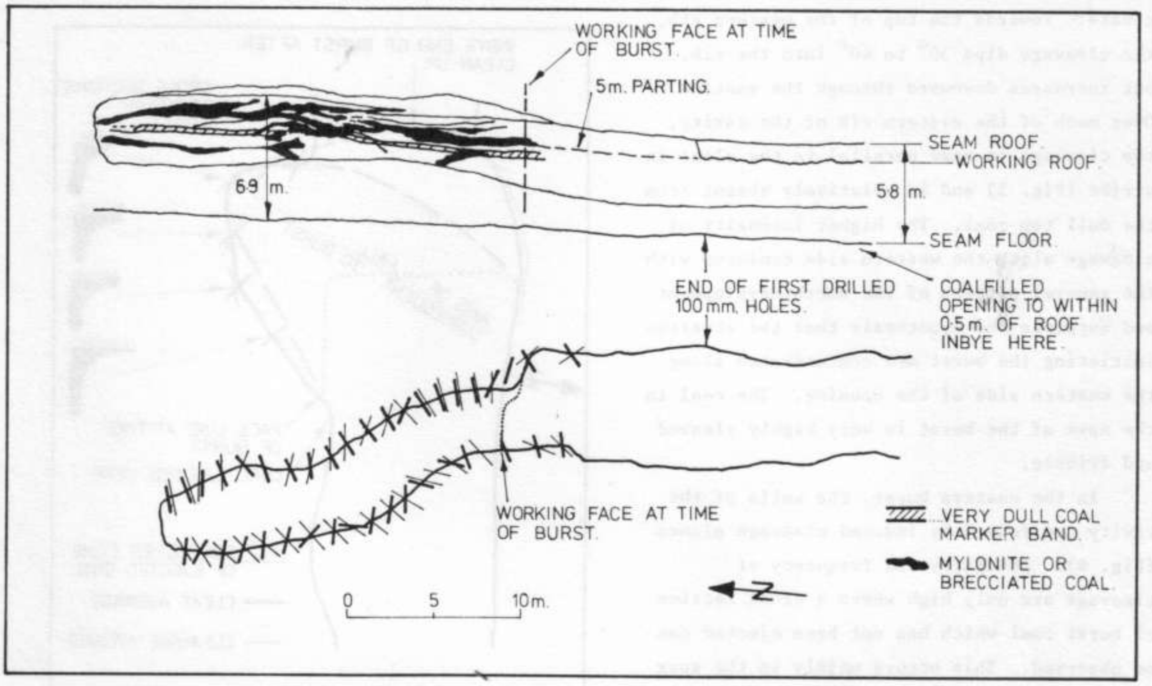


Fig. 5 - Northern burst, structural details

associated slickensided planes occurs immediately above the 5 m parting on the eastern rib at the face where the northern burst commenced. Inbye, the prominence of shearing with associated brecciated coal and mylonite increases throughout the section to around twenty percent of total mass (Fig. 5). The seam grades steeply to the east at approximately 1 in 7 (Fig. 2).

The walls of the east burst cavity exhibit no geological anomalies. Shearing and mylonite are absent. The seam grades to the east at 1 in 17 (Fig. 2).

CLEATS

In the north burst, face cleats have lengths of less than 1 m and a frequency of 10 to 20 per metre. Minor (shorter than 0.1 m) face cleats are more frequent. Four statistically significant strike concentrations occur at 074^{o} (dominant), 112^{o}, 022^{o} and 122^{o}. Dips are near vertical. Calcite mineralisation is common, especially in the very dull top coal.

In the east burst, cleat frequencies and intensities are similar to the north burst, however mean strike is 060^{o} with much less variation and dips are near vertical. Calcite is present, especially in the very dull top coal.

INDUCED CLEAVAGE

In the north burst, the pattern of cleavage changes from non-existent 20 m outbye to intense at the burst site. Along the walls of the burst cavity the cleavage is more intense on the western side where in the dull top coal it is easily differentiated from cleats. Towards the top of the western rib, the cleavage dips 30° to 40° into the rib, but increases downward through the section. Over much of the eastern rib of the cavity, the cleavage is near parallel to the cleat in strike (Fig. 5) and is relatively absent from the dull top coal. The higher intensity of cleavage along the western side conforms with the general pattern of the north development and supports the hypothesis that the stresses initiating the burst are concentrated along the western side of the opening. The coal in the apex of the burst is very highly cleaved and friable.

In the eastern burst, the walls of the cavity are formed by induced cleavage planes (Fig. 6). Intensity and frequency of cleavage are only high where a cross section of burst coal which has not been ejected can be observed. This occurs mainly in the apex of the burst where induced cleavage parallel to cleat produces a very friable coal section with cleat/cleavage planes at approximately 1 000 per metre frequency.

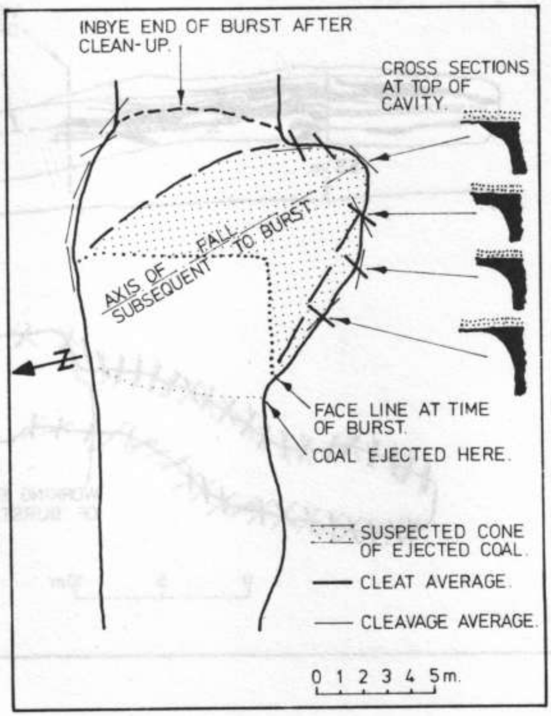


Fig. 6 - Eastern burst, structural details

BURST CAVITY

The cross section of the north burst cavity is barrel shaped with the ribs concave into the opening. The roof and mined floor are relatively flat. The initial burst cavity extended up to the base of the very dull top coal (Table 1) leaving approximately 0.6 m of coal in the roof. The unsupported coal and up to 1.2 m of stone fell subsequent to the burst. The ribs of the cavity are rough owing to the high angles of intersection with cleats and cleavage (Fig. 5). The orientation of the burst cavity was controlled by cleat and fault orientations (Fig. 5). The cavity axis is approximately perpendicular to the dominant cleat directions over most of its length and it is also near parallel to the mean strike of slickensided planes in the cavity walls.

In the eastern burst, the cavity initially extended ahead of the mined face and mainly off to the right hand side (Fig. 6). The cavity now extends up into the stone roof, but it is believed that the burst was confined to the seam section and that up to 1 m of stone roof fell subsequent to the burst. The mined roof is 0.8 m below the stone roof. The ribs of the burst cavity are smooth over most of their length and formed by induced cleavage parallel to the ribs (Fig. 6). However, in the apex of the burst, the cleavage and cleats are parallel and the coal is severely broken (Fig. 6). The coal surrounding the original burst cavity is believed to have been loaded out in subsequent mining thus leaving well formed cleavage as walls. The suspected initial burst cavity is indicated on Fig. 6.

An elongated roof fall to 1 m height occurred subsequent to the eastern burst with the axis of elongation oriented 165° (Fig. 6). This is believed to be approximately perpendicular to the virgin maximum principal stress (σ_1) at the time of the burst.

GAS

An estimated 10 000 to 12 000 m^3 of methane and up to 1 500 m^3 of carbon dioxide was released instantaneously by the northern burst (methane as per methane monitor, carbon dioxide estimated on normal $CH_4:CO_2$ ratio).

The volume of gas released by the eastern burst was not determined.

MINING

Six months prior to the northern burst, A North Intakes heading was temporarily terminated and ten 100 mm diameter holes, each 28 m long, were drilled into the face and allowed to stand for five months. These holes penetrated to within eight metres of the start of the major burst (Fig. 5). Subsequently, the section containing the bores was mined to the 5 m parting as working roof by continuous miner with few signs of burst proneness. When the face was advanced 25 m and was within 3 m of the end of the 100 mm holes, a further five holes were drilled. It is suspected that at least four of these holes passed below the eventual major burst cavity. Mining recommenced immediately and when the workings advanced 5 m to just beyond the first drilled holes, a burst occurred from the left hand side of the face dropping approximately 1 m of roof coal. Some 50 tonnes of coal were released in the burst. The following day during cleaning up, another burst occurred ejecting approximately 90 tonnes of coal.

On the following day, Friday, 1st December 1978, when the workings had advanced a total of 36 m, 21 tonnes of coal were loaded out of the burst affected left hand side of the face and the miner moved to the right hand side of the face which was described as standing tightly with the coal appearing solid and hard. When the miner picks were three-quarters of the travel down the face the major burst occurred, commencing as a "rolling out" of the top part of the left hand half of the face. The burst apparently increased in magnitude and violence within seconds. The deputy reported a series of double bang noises and on close inspection of the burst cavity during later excavation, it was possible to see where five distinct bursts could have occurred. The coal from the burst completely covered the miner and shuttle car, filling the heading to within 0.6 m of the 5 m parting roof to 18 m outbye the face (Fig. 5).

Prior to the eastern burst, the nearby cut-through and the first 12 m of the heading drive had been standing for approximately two months (Fig. 2). No preboring was conducted. On 17th July, 1975, approximately 10 m of drivage was made grading down from the stone roof to leave 0.5 to 0.8 m of coal in the roof. On 18th July, a small burst occurred from the right hand rib and ten minutes later, a major burst occurred burying the miner with loose coal, completely covering it to behind the driver's cabin (Fig. 6). It is believed that the burst occurred as the miner picks touched the face. The coal roof prior to the burst was supported to within 4 m of the front of the miner, but was sagging and contained open fractures.

ACTIVITIES AFTER DECEMBER 1ST, 1978

Subsequent to the north burst of December 1st, 1978 operations at the Colliery were held for a period to a care and maintenance basis.

The burst cavity was cleaned of coal and debris and supported, followed by detailed investigations of the nature of the cavity and immediate environment.

Whilst investigations and examinations took place, the Colliery workforce was deployed on general underground duties. Workforce morale was at a very low level during this period and the Colliery lost a large percentage of experienced employees, including skilled tradesmen.

At that time, a method of safe roadway development utilising mechanical techniques within the Gemini seam was not available and major items of mining machinery were transferred to other operations.

During April 1979, management investigated the possibility of employing a shotfiring roadway advance technique. After dialogue with the Queensland Department of Mines, a method was developed which was seen as a safe and viable means of face advance within the context of the Gemini seam.

The method commenced on April 26th, 1979 in the northern workings of the Colliery (Fig. 2) using the 5 m parting as a roof. A 40 m by 65 m pillar was completed with the technique (Fig. 2).

SHOTFIRING TECHNIQUE

After the successful trial of the technique in the north area, it was decided to utilise the shotfiring system in the geologically interpreted areas in the southeast extremities of the Colliery workings (Fig. 2) to develop a 600 m, three heading panel suitable for later full seam extraction.

To achieve this result, modifications and refinements were added to the technique and a standard "shotfiring round" was established.

To ensure all coal was deposited in the centre of the opening to expedite subsequent loading, a wedge pattern of shotfiring off the solid face was designed (Fig. 7). It was thought that the action of mechanically undercutting or centre cutting the face had a potential of inducing a burst while men were at the face, so this was not attempted. The optimum length of all holes in the round was established at 2.13 m, thus providing a round which left a relatively square face with the minimum amount of "bulling" in top and side holes. The top holes are bored to 0.3 m from the roof horizon parting, and in all cases (5, 4 and 3 m partings) a level and secure working roof is obtained.

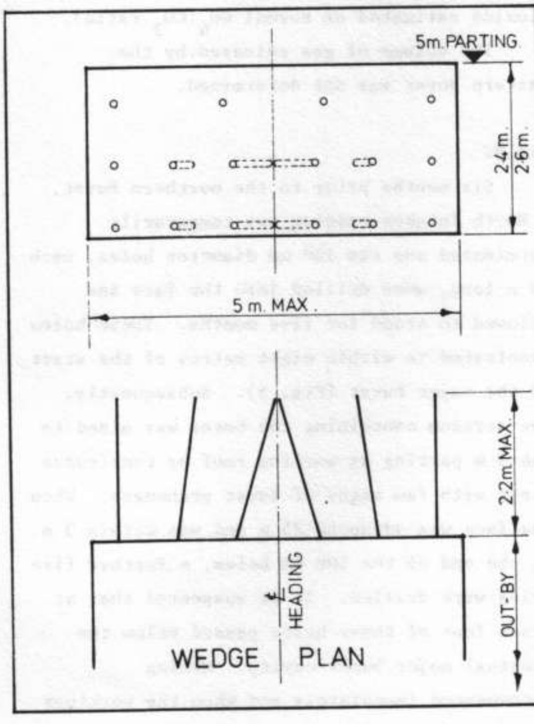


Fig. 7 - Standard shotfiring round

The permitted explosive used ("Morcol") is a semi-gelatinous explosive with high power (bulk strength fifty percent B.G.) and good water resisting qualities. All holes are charged with 800 gms of explosive and inversely initiated with delay action carrick detonators with an overall delay time of 100 milliseconds. Each round is initiated with a "Beethoven Mark II Exploder", via a twin twisted 2/70 - 2 mm shotfiring cable at a distance of 200 m from the face.

Each round creates opening dimensions of width 6 m and height 2.8 m, and with overbreak, an advance of 2.5 m per round is achieved, which yields approximately 50 tonnes per round at 0.32 kg of explosive per tonne of coal mined.

RESULTS OF DELAY SHOTFIRING

Immediately shotfiring within the Gemini seam commenced, it was apparent that a change in environment around the opening occurs.

The roof behaviour immediately altered from a roof which was inclined to flake away or immediately fail after mining with a fixed head continuous miner, to a level easily supported horizon. This condition prevails at all roof partings attempted within the seam (i.e. 3, 4 and 5 m partings) and subsequently at roof stone horizon.

The nature of the coal ribs (sides of roadways) also changed. Bursting does not occur and induced cleavage is less intense. In its place is an apparently failed rib which, if correctly spragged back off the timbers, remains safe and stable.

Gas make into the opening is substantially reduced using the shotfiring technique, as are the gas emission values taken before firing each round using the "Hargraves" emission meter (Table 2).

Continuous Mining North headings		Shotfiring, "C" North heading	
Date	Emission Value cc/gm	Date	Emission Value cc/gm
17/10/74	1.90	26/4/79	0.1
17/10/74	0.92	27/4/79	0.1
10/2/75	2.04	30/4/79	0.13
12/2/75	1.78	1/5/79	0.1
13/2/75	1.21	2/5/79	0.1
14/2/75	0.41	3/5/79	0.1
19/3/75	0.43	4/5/79	0.1
24/3/75	0.96	8/5/79	0.1
19/6/75	0.59	17/5/79	0.24
23/6/75	0.93	18/5/79	0.32
24/6/75	0.1	21/5/79	0.1
21/9/77	1.62	22/5/79	0.34
22/9/77	1.68	25/5/79	0.1
23/9/77	0.60	29/5/79	0.1
28/9/77	0.20	30/5/79	0.23
29/9/77	0.95	31/5/79	0.1
4/10/77	0.48	5/6/79	0.29
7/10/77	0.75	6/6/79	1.12
14/10/77	0.52	7/6/79	0.1
17/10/77	0.91	8/6/79	0.1
20/10/77	0.42	11/6/79	0.33
21/10/77	1.30	12/6/79	0.86
2/11/77	0.80	14/6/79	0.36
3/11/77	0.1		

Table 2

Comparison of relative Hargraves emission value results. Continuous mining and shotfiring.

EQUIPMENT DEPLOYED

The technique was initiated using "Joy" 14BU and 18HR gathering arm loaders for coal loading and a hand held "Victor" air operated borer for shothole boring. The method was then refined, and a 75 kW diesel "Eimco 913" load-haul-dump, front end loader utilised to load coal from the face and transport it to the conveyor belt system. A "Joy CD71" coal drill is currently employed to drill the shot holes. The machine is equipped with an automatic cable reeler and can be operated and trammed by one operator.

Roof support is achieved by the use of "Atlas Copco Roof Bolter" portable pneumatic roof bolting machines. "W" straps 5 m long, bolted with five 2.13 m chemical anchor rock bolts are used.

All operations (i.e. load out, support and bore/charge) are conducted simultaneously with a regular four man crew plus one deputy/shotfirer.

PANEL LAYOUTS AND SUBSEQUENT EXTRACTION

The future Gemini seam layout is planned to remain compatible with the following parameters

1. burst proneness,
2. 6 m thick seam (and subsequent extraction),
3. extensive faulting,
4. spontaneous combustion,
5. possible high methane emissions, and
6. strata competency.

The general aim of the layout is to achieve heading advance safely in the hazardous Gemini seam and subsequently fully extract the seam utilising a fixed head continuous miner and shuttle cars via a modified Wongawilli split and fender technique.

ARIES SEAM

A basic trial mining operation has commenced in the Aries seam utilising a shotfiring technique. This trial will provide information on the Aries seam regarding burst proneness, quality and general mineability.

RESEARCH AND INVESTIGATION

Investigations being conducted at Leichhardt Colliery are aimed at defining the geological environment, rock and coal physical parameters, the virgin stress and gas states and their variations with mining, and roof control parameters. The work is being conducted by Leichhardt Colliery staff and members of various research organisations.

The geological environment controls the reaction of the strata to mining. Geological mapping of structure, lithologies, sedimentology, petrology, and variations of these factors is continually updated to maintain all other investigations in their correct context. Mining strain is also mapped on a routine basis to differentiate geological fracturing and other phenomena from mining induced features. Mining strain mapping includes differentiation of induced cleavages from cleats or joints, recording of roof sag and floor heave, rib conditions, roof failure, etc. These data are collected by visual mapping, attitude measurement and the use of extensometers, rebound hammers, roof bolt tension meters, etc. As well as macrostrains, microstrains in coal and stone when relieved from confinement are also measured using relatively simple mechanical gauges.

Bore cores are collected for lithological data and mechanical property testing. Mechanical properties are determined from laboratory testing and from simple field tests such as point load.

Although the testing of virgin stress is currently fraught with difficulties, some testing will be conducted at Leichhardt Colliery to provide an indication of the virgin stress field. More importantly, stress change measurements using vibrating wire stressmeters and USBM hydraulic cells are conducted to determine the levels and locations of stress change ahead of advancing faces.

Definition of seam gas parameters is important for the understanding of bursts at

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REFERENCES

., and Malone, E.J., 1973. Geology
Bowen Basin, Queensland, Bulli Bur.
Resour. Geol. Geophys. Aust. No. 130

.L., 1975. Regional coal geology
Bowen Basin, in Economic Geology of
ia and Papua New Guinea, Volume 2
d. Traves, D.M., and King, D.).
ph Series No. 6, Australas. Instn.
tall., pp 68-77.