CHAPTER 2

EVIDENCE PRESENTED TO THE MINING WARDEN'S INQUIRY 1987

By
I. Roberts

2.1 Summary of Report and Processes Leading to Information Presented to Inquiry

Introduction

The mine undermanager who had been in the Main Dips Section approximately 50 minutes before the explosion stated that the situation in the Section was normal. Post disaster inspection revealed that the face equipment had been withdrawn in an orderly manner. A goaf fall had been anticipated and the evidence suggests that it did occur.

When the explosion occurred personnel on the surface including the mine undermanager, who had been in the Main Dips Section some 50 minutes earlier, considered that the incident was a goaf fall. It was not until more than one hour had elapsed that it was realised that an explosion had occurred.

Methane levels in the section return airways prior to the explosion were recorded as normal and there was nothing to suggest that an explosive mixture existed prior to the disaster. This suggests that something had occurred suddenly to provide an explosive mixture of methane and/or coal dust and that the most likely cause of that was a goaf fall.

That the explosion occurred without any warning of danger or of any evidence of such warning rendered the presentation of evidence difficult. Consequently the Warden's Inquiry could only conclude on probable causes of the explosive mixture and its ignition.

The evidence provided to the Warden's Inquiry and the method in which it was gathered is discussed below. The attempted rescue operations and recovery of the Main Dips Section is also discussed.

2.1.1 Description of Mine and Events Preceding the Explosion

These matters are covered fully in the Warden's Report dated 12 June 1987. For ease of reference a brief description of the mine and of events preceding the explosion is provided below.

The extent of the mine workings is shown in the accompanying plan (Appendix A) of development in the C seam described as "fairly gassy". The seam is overlaid by seams A and B which are respectively 75 and 60m above C. A and B have not been mined. C seam is approximately 7m thick and free of intrusion by dykes or sills. Reverse faults exist and are associated with rolls in the seam. Only the upper part of the seam was mined on advance. In the retreat operation of pillar extraction the basal section of the seam was mined as appropriate.

All mining has been bord and pillar by continuous miner units with face haulage by shuttle cars. Normal roof support during advance was by roof bolting. During pillar extraction additional timber roof to floor supports were used.

A gas monitoring system was in use for CO and CH_4. Recorded results were examined daily and management advised. The continuous miners were equipped with CH_4 monitors designed to isolate electrical power at a concentration of 2% or higher. Other equipment used included flame safety lamps, Sieger automatic detectors and Auer 502 methanometers. The ventilation survey carried out approximately three weeks before the explosion indicated adequate ventilation in the main dips where the explosion occurred. CH_4 in the return airways was recorded at 0.2 and 0.3% respectively. Air flow in those airways was recorded at 28 and 34m³/sec respectively.

It is considered that the ventilation of the main dips on the morning of the accident would have been similar to that reported from the above survey. Face ventilation was reported that morning to be very good.

The original main development was discontinued for coal quality reasons and the Main Dips Section was commenced some years prior to the explosion. Between c/t Nos.22 and 23 a fault was encountered. Beyond that fault a marked increase in virgin seam gas content was noted. Values in excess of 7m³ of methane per tonne of coal were recorded. Mainly because of gas emission problems development proceeded slowly. Mining was suspended at No.28 c/t line in late 1983. A methane drainage program commenced in December 1983 to evaluate techniques for degassing the seam in advance of the standing faces. This work continued until mining recommenced in January 1986 and further development continued.

In April 1986 development ceased when No.30 c/t was formed between No.1 South Return Road and No.3 Belt Road. A fault was predicted ahead and this combined with the prospect of mining into a non-drained area caused management to decide to extract pillars.

In May 1986 circumstances allowed an extraction system without regard to surface subsidence whereas prior to this time subsidence had been a major constraint on the method of extraction. With that constraint removed and roof weighting evident in the panel where no major goaf fall had occurred, management decided to maximise extraction of the formed pillars on the following basis commencing 30 June:

- Extraction on two shifts per day.

- Three splits in each pillar with fenders to be totally extracted.

. Progress to be monitored over a two weeks trial period.

This method continued without major roof control problems up to 16 July - the date of the explosion. Regular inspections of the working area and goaf were conducted by the Mine Planning Engineer and the Geologist. Observations on the day before the accident confirmed a belief that a goaf fall would soon occur in the area bounded by Nos.26 & 27 c/t and Nos.1A South Return Road and No.2 Transformer Road. It was expected that this would relieve the abutment loadings on the pillars.

On the morning of the accident the undermanager left the Main Dips Section at 10.15a.m. when the crew was operating normally. He had inspected the goaf edge and believed that a goaf fall would occur on that shift. At 10.30 a.m. the gas monitoring system indicated normal levels for CO and CH4.

At 11.05 a.m. the explosion occurred. Of the 20 men underground at that time 12 were in the Main Dips Section and lost their lives. The other 8 persons made their way to the surface.

In addition to the plan of the complete mine the following plans are attached:

. "No.4 Underground Mines Rescue Plan Main Dips Pre-Disaster Plan" (Appendix B).

. "Moura No.4 Underground Mine Disaster Plan" (Appendix C).

The Pre-disaster Plan shows the area of pillar extraction which had been completed at the time of the explosion. In particular it shows the location pre-explosion of the mine rover vehicle and that it was facing the goaf - consistent with the photographic evidence.

The Disaster Plan graphically demonstrates the result of what was obviously a violent explosion. It shows the positions of victims' bodies and equipment as well as various materials.

2.1.2 The Situation in the Main Dips Section Immediately Prior to the Explosion

Evidence was given at the Warden's Inquiry to the effect that the face ventilation in the Main Dips Section was good. The mine undermanager spent approximately two hours ending 10.15am on the morning of the explosion in the Main Dips Section. During that period mining continued without incident. He neither saw nor heard anything to cause undue concern but stated in evidence that he thought that there would be a (roof) fall (in the goaf) sometime during the shift. At approximately 11.05am an explosion occurred. The mine's gas monitoring system had been checked just 35 minutes earlier with no abnormal result.

Appendix C shows the survey map of the victims and equipment after the explosion.

Appendix D shows the approximate caving sequence of the Main Dips Section goaf.

2.1.3 Initial Examination of Workings

Blast damage was evident throughout the main airways of the Main Dips Section. (See Appendix C.). The casing of the main fan was destroyed by blast. Three explosion doors were blown off and the internal baffles were blown about 25m. Close examination of the roadways inbye of the portals revealed heavy deposits of dark grey dust, rubbish, dislodged timber and steel objects scattered about. This debris increased markedly inbye of the Main Dips Section 3 conveyor drive head. The conveyor belt system was severely damaged and where belt rollers remained in place, these were covered with thick fine dust.

The No.4 Supply Road, was littered with twisted steel supports, timber and other materials which were used to build the structures under the "Taj Mahal" between 22 and 23 c/t. Electrical cables from the section transformer, which was located in 22 c/t No.4 Supply Road, had been flung outbye with considerable force.

In the conveyor belt roadway, No.3 Belt Road, the damage to the belt structure was most severe. The force of the blast waves had broken the belt and structure inbye of 23 c/t, pushing most of it outbye to 21 c/t. This debris made access and examination very difficult and time consuming.

By careful examination of the dust patterns on roof bolts and props it was possible to ascertain the direction of the strongest blast wave. These deposits were in many instances, on both sides of the prop or roof bolt and this could cause confusion and uncertainty. However, the blast wave direction as shown in the Mines Department report is considered to be accurate.

Inbye of 23 c/t, visibility was improved greatly by a thin coating of fly ash which had drifted throughout the workings. This fly ash had been pumped down a borehole to cover a residual fire which was located in 24 c/t. It was recognised that the fly ash would have an adverse effect on the incombustible content of the dust in the workings. However, the improved visibility far outweighed this disadvantage.

Large items of equipment were found in No.4 Supply Road and the adjacent c/t inbye of the "Taj Mahal". Some of these had been shifted a considerable distance and most had been subjected to considerable heat and physical damage.

A mine rover No.9, was found inbye of 26 c/t No.4 Supply Road. This too, had been damaged by heat and the force of the explosion. A light-gauge, steel plate, later identified as a lid from the fitter's bench (outbye of the vehicle) was found in the back of the mine rover.

A similar steel plate was found in No.4 Supply Road about 300m outbye. This and many other smaller items found during this preliminary examination indicated a complex blast wave pattern.

In 26 c/t from No.4 to No.3 Belt Road, the vast majority of the blast debris was located adjacent to the lower inbye rib, with most items displaying varying degrees of physical and heat damage. The shuttle cars (s/c), units 30 and 31, were located on the intersection of 26 c/t and No.3 Belt Road with s/c No.30 shunted in 26 c/t No.3 Belt Road to No.2 Transformer Road and s/c No.31 close to the corner of No.3 Belt Road.

An inspection of the operators' controls revealed:

	S/c No.30	S/c No.31
Park Brake	on	on
Conveyor	off	off
Lights	on (rear bright)	off
Traction	Fast	off
Main Switch	Tripped	on

There was no evidence to suggest that either shuttle car had been moved by the force of the explosion and the unusual parking position for s/c No.31 could not be explained.

Following advice from rescue team No.12, regarding the position of Mr Steven Hull's body, the front of s/c No.31 was closely examined by the investigating officers. There was no visible evidence which would suggest that Hull was struck by the car prior to the explosion. However, dust deposits in the immediate vicinity were consistent with a body being trapped in this position immediately prior to or during a severe wind blast.

A further eight bodies had been recovered from this area. Each location has been marked with reflective arrows, with the point of the arrow signifying the victim's head.

A damaged 1kv. power cable was observed in 26 c/t between No.3 Belt Road and No.4 Supply Road.

The Joy 12CM Continuous Miner (cm) was in No.3 Belt Road between 26 and 27 c/t. It appeared that the machine had been withdrawn from the face in an orderly fashion. The slack miner power cable and compressed-air hose had been positioned over the front and cutter heads of the machine. This is normal operating procedure when withdrawing machines from the face.

The operator's control switches were all in the reset position. This is normal practice when the power supply to the machine and its cable is isolated or tripped back at the transformer. Before the power supply can be restored to the machine all the control switches must be in the reset position.

The machine is fitted with a mini methane monitor which interrupts the power supply to the machine automatically should the methane concentration in the air around the machine exceed 2.0% by volume. When this occurs a "flag" is displayed in a cubicle on the off driver's side of the machine. Before the power can be restored the deputy must unlock the control switch and reset the "flag". The control switches in the operator's cabin must also be set to the reset position before the power from the section transformer can be restored.

The monitor "flag" was not showing and the reset switch was locked. This would suggest that had the power to the machine been interrupted by the monitor, the "flag" had been unlocked and reset or, after withdrawing the machine from the face area, the operator had pushed the earth leakage or continuity button, thereby tripping the power from the machine and the cable. He then would have set all the control switches to the reset position.

The Multi Purpose Vehicle (M.P.V.) supply module had been pushed inbye towards the rib and its load of props were scattered about. An inspection of the fender which was being extracted immediately prior to the explosion revealed that a lift, possibly the third, had been started. It is estimated that about one shuttle car load of coal had been removed from this lift prior to the cm being withdrawn.

The roof of the c/t, including the strip exposed when the width of the fender was reduced, had been well supported with roof bolts and butterfly plates. However only two props remained in the immediate face area.

It was evident that the roof in this area had fallen sometime after the explosion. Fresh, clean sandstone was noted for a considerable distance inbye of the lip of the fall, whilst the underside of the fallen roof rock was burnt and sooty.

Inbye of 27 c/t the roof is intersected by a number of near vertical, well-defined strike slip faults. The fresh, clean breaks in the sandstone indicated that the roof in this area fell, sometime after the explosion.

Further inbye of 28 c/t and beyond, evidence of fresh roof falls was observed, with the underside of fallen material burnt and sooty.

The joint planes in the fallen roof material are very well defined, however, it was noted that the joint faces were not slicken-sided or greasy. Scratch marks were observed on the joint planes and in some instances these had been caused by roof bolts and butterfly plates.

The conveyor belt was situated in No.3 Belt Road, ending about 15m outbye of 26 c/t. Damage to the system was extensive and there was considerable evidence which indicated blast wave movement in both directions. A heavy, well-constructed "grizzly" which had been positioned on top of the boot end structure had been thrown about 10 metres inbye, whilst the end plate of the boot end and the tail roller had been pushed outbye with considerable force.

Outbye of the boot end, it was apparent that the top belt had been dislodged towards the south rib and the damage to the system increased markedly outbye of 25 c/t.

The remains of three miners' helmets, that had been severely deformed by heat were found on the belt structure. One of these helmets had been wrapped around the troughing idler support whilst the remaining two were resting on the idler support brackets.

The fly ash which had been pumped down the boreholes to cover the fire area had assumed an angle of repose of about eight degrees. This had completely covered the belt structure at 24 c/t before tapering off about 20 metres inbye along No.3 Belt Road.

Outbye of 24 c/t, the damage to the conveyor system was most severe. Both the top and bottom belts had broken and these and most of the structure and rollers were missing.

Evidence of high velocities in this roadway was noted on the roof bolts, butterfly plates and the water barrier support brackets had been bent outbye to an angle of about 45 degrees.

Many examples of heat damage were observed and these were closely examined, mapped and sampled.

In the stub end of No.1A South Return Road 25 c/t the remnant of a small fire was observed in the floor coal. this covered an area of about two square metres. However there was no evidence which would indicate a deep-seated heating.

Considerable floor heave had occurred in No.1A South Return Road between 25 and 26 c/t.

In 26 c/t between No.1 South Return Road and No.1A South Return Road, the goaf fall had broken off adjacent to the supported roof of the c/t. The fallen material was burnt and sooty indicating that this fall had occurred before or during the explosion. The flame had swirled about in the cavity and blast debris had been deposited against the goaf edge and on top of the fall.

2.1.4 Dust Sampling

It was recognised that the introduction of fly ash into the Main Dips

Workings would increase the incombustible content of the coal dust to an artificially high level, therefore this indicator could not be used to determine the extent of the flame. Coal dust does however, contain volatile matter and when this dust is exposed to heat or flame it loses some of that volatile matter. Therefore if the loss of volatile matter in the coal dust remaining after an explosion is determined, an approximation of the extent of the heat and flame may be made.

Owing to high blast velocities and turbulence the behaviour of coal dust in this explosion is not known and it would be fair to assume that the dust may have been carried for great distances. It is also possible that turbulence or swirling may cause completely erroneous results. (However this indicator has been successfully used by Ellis in his investigation of the Appin and West Wallsend explosions in New South Wales.)

Initially, a total of 105 dust samples was collected from the mine and the percentage of dry ash free volatile matter (% DAFV) remaining in the minus 250 micrometre portion was determined. Spot samples of about 500 grams were collected from the ribs and a similar quantity collected from the floor to a depth of about 30mm.

The volatile matter content of run of mine coal from Moura No.4 Mine had been established as 32.2% in December, 1985, whilst the volatile content of post explosion coal dust ranged from 18.5% to 34.6%.

The results of the initial sampling program indicated a lower post explosion volatile content in the dusts inbye of 26 c/t. However, it was apparent that there was insufficient data available for the roadways immediately outbye of 27 c/t. It was therefore decided to resample this area to rectify this problem. A total of 55 additional samples were collected from the floor and ribs of the roadways immediately outbye of 27 c/t. Floor samples in this sampling program were taken to a depth of about 6mm.

The volatile content of the minus 250 micrometre portion of these samples ranged from 20.2% to 35.5%.

A graphic presentation of Dry Ash Free Volatile Content of the post explosion coal dust is contained in Appendix E.

This interpretation may not be entirely valid. Nevertheless it is felt that this method provides for a better understanding of a complex problem.

The result of a statistical analysis of the dust samples is contained in an appendix to this document, Appendix F.

2.1.5 Extent of the Flame

There were many examples of heat and flame damaged materials throughout the Main Dips Workings. However, it would appear that the temperature, duration and path of the flame was extremely variable.

The best indicators were plastics, insulation, rubber hoses, brattice, synthetic rope, coked coal dust and teflon friction washers which are used between the nut and the steel washers of roof bolts.

Miners' helmets had been completely deformed and plastics items such as lunch bags and sandwich boxes had melted. However newspaper found in the immediate vicinity was either undamaged or only slightly charred at the edges.

There was no evidence of flame damage to the insulation surrounding electrical cables in the immediate face area. However blistering of insulation surrounding small electric light cables and telephone wires was noted about 15 metres outbye of 23 c/t.

Teflon friction washers were severely damaged by heat in some areas whilst other washers in the immediate vicinity appeared unaffected. This and many other examples of varying degrees of heat damage depict a very complex and sometimes confusing flame path.

From the evidence collected and the observations made a plan showing the extent of the flame was prepared and is included in Appendix F.

2.1.6 Arrest of the Explosion

There was no evidence of flame nor of in-situ heat damaged materials outbye of 22 c/t. There was evidence of weak flame at about 20 metres outbye of 23 c/t.

It was therefore concluded that the explosion was arrested just inbye of 23 c/t.
22

2.1.7 Blast Waves

There is considerable evidence which would suggest that blast waves have been multi-directional inbye of 24 c/t and in particular No.1 South Return Road, No.2 Transformer Road, No.3 Belt Road, No.4 Supply Road and to a lesser extent No.5 North Return Road. Blast waves in the c/t displayed distinct swirling patterns whilst those in the headings were more streamlined.

In Appendix H photographs with descriptions shows the blast damage.

Blast patterns in the roadways adjacent to the crib room, i.e. 26 c/t between No.4 Supply Road and No.5 North Return Roads, were very complex and sometimes confusing. It would appear that severe turbulence had displaced both small and large items in all directions as indicated below:

. Steel tool box lids from the fitters' bench, were located in No.4 Supply Road between 20 and 21 c/t and in the back of the mine rover.

. Glass from the crib room table lights was found in the north rib of No.3 Belt Road between 26 and 27 c/t, whilst the flameproof ends of the light were located adjacent to the inbye rib of 26 c/t between No.3 Belt Road No.4 Supply Roads.

. Other flameproof lights from the crib room area were located between 24 and 25 c/t in No.4 Supply Road.

. An M.P.V. supply module loaded with timber props had been parked in 25 c/t adjacent to the brick stopping between No.4 and No.5 North Return Roads. This had been moved from one side of the roadway and deposited upside down adjacent to the inbye rib of 25 c/t between No.3 Belt Road and No.4 Supply Roads. On closer examination it was revealed that this module had also been turned end over end.

Similar observations were made in roadways 1, 2 and 3. Blast debris had impacted against the goaf edge in 26 c/t from No.1A South Return Road to No.2 Transformer Road and an examination of the top of the goaf fall revealed broken props, wedges and an empty stone dust bag.

In No.3 Belt Road the grid or "grizzly" from the top of the boot end was located upside down and about ten metres inbye of the boot, whilst the small angle iron stand which had been located immediately adjacent to the boot was found outbye of the boot end and on top of the bottom conveyor belt.

The deputy's flame safety lamp was located under the shuttle car and behind the off driver's side front wheel s/c No.31. His automatic firedamp detector (A.F.D.) was located about ten metres inbye of the rear of s/c No.31. Other personal effects, e.g. spectacles and a ball point pen were found inbye of s/c No.31.

A plan showing the known location of various items immediately prior to the explosion has been prepared and is shown in Appendix B.

A detailed survey was conducted of No.3 Belt Road and No.4 Supply Road and the post explosion location of all major items of equipment were plotted. This plan, described as the Moura No.4 Disaster Plan is shown in Appendix C.

A plan was also prepared showing the location of damaged stoppings. Two types of stoppings were erected in the c/t's between intake and return roadways. Four stoppings were constructed of mesh and a plaster product "Rockhard". These were located in the c/t's outbye of 20 c/t. The remainder of the stoppings were constructed of "rock blocks" and mortar. Individual blocks measured 400 x 200 x 100 mm and weighed about 22 kg. The effect of the explosion on the stoppings is detailed in Appendix E.

As a result of observations made during the course of this investigation a plan detailing the direction of the major explosion airflows has been prepared and forms Appendix G.

2.1.8 Type and Source of Fuel

The investigation left no doubt that all the roadways (including the goaf area) inbye of 23 c/t were affected to varying degrees by flame. The fuel in the explosion most probably consisted of methane and coal dust.

There was evidence of coal dust, coal, oil, insulation, polyurethane foam and wood having been consumed in the explosion and/or the subsequent fire, or both.

2.1.9 On-Site and Laboratory Investigations

A preliminary examination indicated that an explosion of moderate force had affected the face area and the roadways outbye. A detailed investigation was later conducted with its primary objectives to establish:

. The extent of the flame and blast waves.

. The type and source of the fuel.

. The source of ignition.

The extent of the flame and the force and direction of the blast waves was assessed by:

. General observation.

. Examination of dust and heat damaged materials.

. Recording the physical conditions including the location of all major items of equipment and materials.

Dust samples were collected systematically throughout the section of the mine affected. These were analysed to obtain information on the type and source of fuel.

Ignition sources considered were:

. fire/spontaneous heating
. electrical apparatus
. electrical cables
. mechanical equipment
. conveyor belt system
. frictional sparking
. electrostatic sparking
. aluminium alloys
. contraband
. flame safety lamp
. explosives

The investigation was carried out by the then Queensland Department of Mines (now Department of Resource Industries). The organisation of on-site activities was controlled by Inspector of Coal Mines Mr J. Brady. They included collection and sifting all possible evidence, obtaining witnesses' statements, procurement of all relevant mine records, and inspection of all mechanical and electrical equipment by Mechanical and Electrical Inspectors respectively.

Detailed scientific examination of items of evidence such as the flame safety lamp were sought and co-ordinated by the then Chief Inspector of Coal Mines, Mr G. Hardie.

Experts who conducted investigations were able to give evidence relating to their work and conclusions. They included

Dr A. Ansford
Government Pathologist who carried out post mortem examinations of the bodies of the victims.

Mr J. Brady
Government Inspector of Coal Mines responsible for on-site investigation of the explosion.

Messrs A. Hepburn and A. McMaster
Government Inspectors of Coal Mines at Rockhampton who were responsible for examining mechanical and electrical equipment which had been in use in the Main Dips Section at the time of the explosion.

Mr T.G. Hislop
Senior Inspector Electrical Testing at SIMTARS who conducted tests of various electrical apparatus found at the explosion site.

Mr I. Poppitt
Geologist with T.D.M. who examined the fallen goaf area after the explosion and carried out a series of experiments in order to assess the incendivity of Moura sandstone, and its propensity to ignite methane.

Dr A. Joyce
Principal Operator in Geochempet Services, who gave evidence on the petrological nature of Moura sandstone.

Mr P. Green
Geologist with the Geological Survey of Queensland who also gave evidence as to the petrological nature of Moura sandstone.

Mr R.H.M. Thomas
Technologist in the Department of Mechanical Engineering of the Capricornia Institute of Advanced Education, who gave details of examination of a damaged Entonox cylinder found near the site

of the disaster.

Dr P. Golledge
Chief Engineer at SIMTARS, who with the aid of video explained a series of experiments carried out to investigate the possibility of the flame safety lamp being the source of ignition.

Mr S. Bell
Senior Chemist at SIMTARS, who was responsible for sampling and analysis of roadway dust after the explosion and the plotting of variations in D.A.F.V. values.

Dr A.J. Hargreaves
Senior Engineering Consultant who gave evidence as the possible source of fuel for the explosion.

Dr A.R. Green
Senior Projects Officer (Combustion), Londonderry, N.S.W., who studied evidence related to the path of heat and pressure resulting from the explosion.

A written report was also received from **Dr A.F. Roberts**, Health and Safety Executive from Buxton, United Kingdom.

The Inquiry received evidence not only from the abovenamed experts but also from employees of Thiess Dampier Mitsui Coal Lty Ltd (TDM), both management and miners, mines rescue personnel, Union representatives and Police.

Following are some comments in Summary from the reports and from the evidence given by the above witnesses.

The Government Pathologist carried out detailed post-mortem examinations of the disaster victims.

As a result of investigations carried out by the Mechanical and Electrical Inspectors they determined that the mechanical and electrical equipment played no part in the explosion.

Mr Hislop investigated possible effects of static electricity and tested digital watches. He found nothing to suggest that either of these contributed to the explosion.

The work conducted by Mr Poppitt is discussed in section 6.7 of this report titled "Frictional Ignition". Evidence by Messrs A. Joyce, P. Green and R.H.M. Thomas are similarly included in section 4.7.

Dr Golledge's work at SIMTARS on the flame safety lamp as a possible source of ignition resulting in the explosion is fully discussed in section 4.8.

Mr S. Bell Senior Chemist, also of SIMTARS provided evidence on the sampling of roadway dust and determination of dry ash-free values (DAFV's) for the investigation of the explosion.

Dr A.J. Hargreaves was commissioned by the mining company to advise on the source of fuel for the explosion.

Dr A.R. Green determined the extent of flame and estimated the explosion pressures. This work along with a study of major explosion airflows suggested that the development of the explosion was consistent with ignition in the goaf area by incendive rocks.

Explosion and Rescue/Recovery Operation

At about 11.05am on Wednesday 16 July 1986 an explosion occurred in the Main Dips Section of Moura No.4 Mine. Twelve persons were fatally injured but another eight persons working in other parts of the mine at the time of the explosion managed to get to the surface.

At the time of the explosion, a number of personnel on the surface saw what appeared to be a thick cloud of dark grey dust rising from the mine. A goaf fall had been expected in the Main Dips Section and for some time it was not realised by personnel on the surface that an underground explosion had occurred.

Following advice that the main fan had ceased to operate, an inspection was made and it was found that massive damage had occurred. The mine's emergency procedure was implemented. Telephone contact was made with five men in 3 South Section of the mine. They were advised to proceed to the surface. Contact could not be made with anyone in the Main Dips Section.

Two men arrived at the main portal from belowground and reported a very strong blast accompanied by thick dust and a strange smell. Two other men travelled from the surface in a vehicle, a distance of about 100m into the mine. Poor visibility forced them to return to the surface. They observed a junior miner emerge from the conveyor portal. These two men' then entered the mine via the conveyor belt roadway.

After travelling some distance they advised the surface of very poor visibility and a strange smell. On request a flame safety lamp was dispatched to them. The time was 11.35am.

The five men earlier located in 3 South Section now reached the surface bringing the total number to eight. This meant that there were still twelve men underground. By this time it was also established that:

. A massive airblast accompanied by thick dark grey dust had occurred. Only one witness thought that it may have been smoke and dust.

. The main fan would require time to be repaired.

. The survivors reported no noise, just a pressure wave, wind and dust.

. Underground power supply including that to the gas monitoring system had been interrupted.

. Dust had cleared from the portals.

Thus it was assessed that a major fall had occurred in the Main Dips Section goaf and the following priorities were set:

. Provide air to the men in the Main Dips Section using a rescue team and by repairing the fan housing.

. Restore electric power and including that to the gas analyser.

At 12.05pm a rescue team (No.1) entered the mine in a personnel vehicle. A second team (No.2) entered the mine at 12.15pm. An inspection of the main fan portal revealed CO in the atmosphere in excess of 700 ppm. All personnel were withdrawn from the area.

Telephone reports from the two rescue teams described poor visibility -generally below 20m in high dust concentration. No.1 team advanced to within approximately 250m of the face area where the Main Dips Section crew had been operating. The captain reported nil visibility beyond that point and blast damage with debris preventing further progress toward the face.

By about 1.00pm the No.2 team arrived at the tail end of Main Dips Section 2 Conveyor. Atmosphere tests revealed >700ppm CO, 16.5% O_2 and 2.2% CH_4. Teams Nos 1 and 2 were instructed to withdraw from the mine and arrived at the surface at 1.30pm.

It became apparent at the debriefing that an explosion of gas and/or coal dust had occurred and there were grave fears regarding the twelve miners unaccounted for. Because of the risk of a second explosion, further attempts at rescue were suspended. Pending arrival of the gas chromatograph from the SIMTARS, equipment available at the mine was used to monitor the mine atmosphere in the main fan drift with the following result - >5000ppm CO, 18.0% O_2 and 1.7% CH_4.

There was obvious concern about the integrity of the mine's tube bundle system following the explosion. However the system was used to draw samples from the two return airways of the Main Dips Section where the explosion had occurred, with the following result at 2.47pm.

	South Return	North Return
CO	> 5000 ppm	> 5000 ppm

O_2	15%	18%
CH_4	4%	0.5%

At 3.00pm the drilling of a hole from the surface to the dip Section workings was commenced. The depth was estimated at 166m and it was planned to complete drilling in twelve hours.

At 5.00pm the results of laboratory analyses were received on three samples of mine atmosphere. These were assessed and it was decided that the mixtures were outside the explosive range. Later calculations of Tricketts ratio for these three samples indicated that an explosion had occurred followed by a fire consuming gas, coal dust, and possibly coal, oil, conveyor belting etc.

Gas monitoring was continued and it was established that natural ventilation of 8m³/s existed. Plans were made for sealing of the mine portals in a manner that would allow access at a later date. Construction of these seals commenced about 8.00pm.

Shortly after 10.00pm the first chromatograph results were received indicating a marked reduction in CO content but increasing concentration of CH_4. The work of determining the mine air status at hourly intervals and plotting the results on the Ellicott Diagram was commenced and continued throughout the night.

Recovery Operations

These extended over twelve days from 17 to 28 July 1986.

17 July

Borehole No.1 was complete at 4.00am and found to be exhausting high gas concentrations. This was not remarkable as coal seams above the seam mined were known to have high methane content. The results of the first gas sample at 6.30am from the borehole near the working face were

CH_4%	H_2	CO ppm	O_2%	N_2%
0.3	Nil	450	20.2	77.7

At about 7.30am a second sample from the borehole confirmed that the atmosphere was relatively good although samples from the tube bundle system indicated much higher concentrations of methane e.g.,

	CH_4%	H_2	CO ppm	O_2%	N_2%
South Return	4.4	Nil	600	19.4	76.5
Fan Portal	2.8	Nil	400	19.7	77.1

It was recognised from tests conducted through the early hours of the morning that the natural ventilation flow had increased to 14m³/s.

As there was no evidence of an explosive atmosphere it was decided to send a rescue team into the mine to examine from the portals to the site of the 4 South Seals. The team entered the mine at 9.30am and returned to the surface at 11.10am.

The team reported on their findings including the following:

. 4 South overcasts damaged - blue haze in the area containing 1.8% CH_4 and 500 ppm CO.

. Other stoppings between intake and return were intact to 12 c/t.

Analysis of air samples collected by the team confirmed readings taken underground and it was decided to:

. Effect temporary repairs to the main fan to allow it to operate at low speed.

. Despatch another rescue team to inspect between 12 and 21 c/t.

The team entered the mine at 12.55pm, returning to the surface after one hour. The team reported on various disruptions to the ventilation - some of which had been attended to. After consideration it was decided to despatch another team (No.5) to explore beyond 21 c/t.

This team entered the mine at 2.55pm but was recalled when analysis of a sample from the 4 South tube bundle line indicated an explosive atmosphere. At 9.00pm it was clearly established that the development of this explosive atmosphere was a result of variation in atmospheric pressure. Contact with the Department of Aviation revealed that the next low would be at about 4.00am on the next day. It was decided to take advantage of this seven hours window and team No.6 was despatched.

Despite unfavourable conditions the team reached 27 c/t and on returning to the surface at midnight reported that:

. Ten bodies had been located near 26 c/t.

. Visibility beyond 23 c/t was 3m maximum.

. All ventilation stoppings destroyed.

. The face equipment had been withdrawn from the working area.

. There was no evidence of fire. All believed that the smoke reported earlier was in fact dust.

It was now confirmed that an explosion had occurred and that all twelve lives had been lost. There was no evidence that the men had any warning of impending danger and no-one had attempted to use his self rescuer.

18 July
A fall in barometric pressure resulted in an increased methane level in the atmosphere outbye of 4 South seals. This had been anticipated and the expected result confirmed, namely the atmosphere had again become explosive.

The main fan was re-activated at 5.00am and the speed increased until 0.3 inches of water was measured. Shortly afterwards the methane level in the mine air decreased to 1.2% outbye of the 4 South seals. Rescue team No.7 was then despatched underground at 9.05am. The team established that ventilation to 15 c/t in the Main Dips Section was satisfactory. In the Main Dips Section south return airway smoke restricted visibility. The team extended the tube bundle line to 19 c/t in the South return and arrived back at the surface at 11.00am.

It was established that there was an active fire in the Main Dips Section which had not been detected by exploration teams nor by use of the gas monitoring system. All personnel were withdrawn from the mine for reassessment of the situation. The tube bundle line had become unreliable and it had become necessary to establish some other sampling point at 25 c/t in the South return airway. It was decided to drill another hole (No.2) to achieve this. The drilling commenced at 9.00pm to a depth of 152m and estimated to take 12 hours.

It was decided that:

. The safety of rescue personnel was paramount.

. The recovery of the mine was essential for investigation.

. Recovery of the twelve victims was very important but further lives would not be jeopardised.

A group was formed to consider use of inert gas and flooding with water to determine the best course for dealing with the problem. It was agreed to consider options on the next morning.

19 July
Discussion resulted in a decision to flood the dip Section goaf to about 27 c/t with water and to inertise the area outbye of that with nitrogen vapour.

Arrangements were made to obtain the "Mineshield" equipment and the necessary operators from the NSW Mines Rescue Service. The "Mineshield" equipment consists of a 40 tonnes liquid nitrogen mother tanker and a vaporiser which converts the liquid to nitrogen gas.

Boreholes numbered 3, 4, 5, 6 and 7 were planned and drill rigs assigned. Details of the holes are:

Target

No.	Diameter (mm)	Depth (m)	Location	Purpose
3	229	178	Most Inbye	Water injections
4	120	166	Most likely fall area	Sampling
5	108	169	Inbye, Rise side	N_2 injection
6	187	173	Inbye, Main Dips side	N_2 injection
7	187	161	Most likely fall area	Sampling

Borehole No.2 was completed and initial sample analysis showed 5+% CH_4 and 100 ppm CO.

Borehole No.3 had to be abandoned. Borehole No.4 commenced at 9.00am and reached a void - indicating a roof fall of about 7m height - at 3.45pm. The initial atmosphere sample analysis showed >5% CH_4 and 40 ppm CO.

Boreholes 5, 6 and 7 were commenced.

At 10.30pm when preparations for application of water were complete it was decided that the introduction of water might cause an explosive mixture to be passed over a possible heat source. It was decided to defer this pending arrival of the liquid nitrogen equipment - expected next morning.

20 July
By 1.00am five holes had been completed and drilling of the other two was in progress. Another two drill holes were planned. Monitoring of the mine atmosphere was being maintained and by 8.00am the "Mineshield" equipment arrived except for the propane gas tanker with fuel for the vaporiser. As a result of the non-arrival of this tanker it was decided to inject liquid nitrogen in two boreholes at a rate of 7 to 10 tonnes per hour whilst introducing water into two other boreholes.

The experiment was not successful. Holes became blocked by the nitrogen solidifying. Holes used for water injection were uncased and became blocked. By 6.00pm a total of 60 tonnes of liquid nitrogen had been consumed and injection discontinued. It was now necessary to recover the blocked holes and to continue monitoring the mine atmosphere pending the vaporiser becoming operational.

21 July
Drilling and re-drilling of holes continued. Monitoring of atmosphere from four boreholes at 10.00am indicated O_2 (20.4 to 20.6%), CH_4 (0.5 to 1.0%) and CO (10 to 120 ppm).

On this basis, a rescue team was prepared pending arrival of additional supplies of liquid nitrogen. At 11.15am results of mine atmosphere sampling from the same four boreholes were similar to those obtained at 10.00am. A rescue team was instructed to examine the dip Section workings and was accompanied by a Mines Inspector, Union Inspector and Mines Rescue Superintendent.

It was found that the end of one sampling tube was still in the drill hole having been obstructed by a roof bolt plate. Clearly the results of sampling from this hole were not indicative of the general atmosphere. Visibility was about 20m and thick bluish smoke and "fire stink" were present. Testing of the atmosphere revealed CH_4 0.9%, CO 190 ppm in an air flow of $14m^3/s$.

Earlier confidence in the analysis of atmosphere was destroyed, as it was clear that an active fire existed inbye of No.22 c/t. The team returned to the surface at 1.50pm and further exploration attempts were suspended.

At 4.15pm inertisation with nitrogen gas was commenced. There was difficulty with borehole back pressure up to 40 kpa and it was not until 6.00pm that the first significant injection rate of 5 tonnes/hour (t/h) was achieved. This rate increased gradually to 14 t/h at 8.00pm.

At 11.00pm it was recognised that due to logistics problems this rate could not be maintained and the injection rate was reduced to 5 t/h. At this time, the O_2 levels in the Main Dips Section had been reduced at four borehole sites to 16.2, 15.0, 15.9 and 17.5%. By midnight however the O_2 level at these respective sites had increased to 17.4, 18.0, 18.8 and 17.8%. Clearly the injection rate was inadequate.

22 July

By 2.00am the mine atmosphere had returned to the condition existing prior to injection. The air flow in the Main Dips Section was diluting the nitrogen vapour and it was established that nitrogen losses increased proportionally to the injection rate.

It was estimated that to maintain the O_2 level at 12.0% an injection rate of 18 t/h would be needed. This supply rate could not be maintained and it was decided to discontinue injection and consider other alternatives. These included:

. Reduce airflow.

. Flood lower inbye portion of goaf.

These were put into effect.

Other options considered were:

. Postpone further attempts at nitrogen injection until adequate supplies available.

. Abandon nitrogen injection and completely flood the Main Dips

Section.

. Erect brattice seals across all five roadways to retain the nitrogen.

The latter option was selected and two rescue teams instructed accordingly. A large area of smouldering floor coal was discovered along with evidence of timber props having been burnt. There was no open flame. All five roadways were sealed by 12.05pm.

While the teams were belowground the nitrogen injection rate had been maintained at 10 t/h. When the teams returned to the surface the rate was reduced to 4 t/h because of low stocks. Later these were exhausted and no further supply could be expected before 6.00pm. Every effort was made to expedite supply and police escort was arranged for transport from Brisbane and from Townsville.

Another drill hole (No.10) was arranged to intersect the workings at the heating for nitrogen vapour injection. By 9.00pm sufficient liquid nitrogen was available to enable injection at a rate of 2 to 3 t/h.

23 July

Injection was maintained through the early hours and at 5.30am results of atmosphere analyses from five bores were generally O_2 (14 to 15%), CH_4 (2 to 6%) and CO (130 to 320 ppm).

The completion of borehole No.10 was now critical. Prior to intersecting the workings the compressed air supply for flushing was replaced with nitrogen. At 8.20am the hole was completed and because of the urgency nitrogen was injected through the drill stem. By this time there was adequate nitrogen available at site and recovery of victims' bodies was arranged. Five rescue teams were briefed.

At 11.00am the nitrogen rate was increased to 12 t/h and generally maintained for two hours prior to reducing it to between 4 and 5 t/h for the remainder of the recovery operation.

At 12 noon oxygen levels at five borehole sites were 12.3, 13.7, 8.1, 11.7 and 16.9% respectively. Teams proceeded underground to the Fresh Air Base (FAB) at 12.45pm and there awaited the results of analyses at 1.00pm. These were satisfactory and the operation proceeded. Recovery of bodies was complete by 5.15pm.

Inertisation of the sealed area had succeeded and oxygen level maintained for safe operation by rescue personnel. It was now necessary to:

. Extinguish the heating/fire.

. Rebuild ventilation stoppings.

. Re-ventilate the workings.

After considering various alternatives it was resolved to use power station fly ash to cover the heated area. Arrangements were made to transport 200 tonnes from Gladstone whilst borehole No.10 was cased for injection of ash. In the meantime the injection of nitrogen and water was maintained.

24 July

Following some difficulty with the injection of fly ash in hole No.10, the hole was reamed and cleared by 9.00pm. Nitrogen was injected at a rate of about 5 t/h to maintain a satisfactory atmosphere. This rate appeared adequate to cope with leakage through the brattice seals.

25 July

Nitrogen vapour was used in the clearing of hole No.10 and to drill the final four metres of hole No.11. It was also used to apply the fly ash through the 50mm rods. The first attempt failed when the rods became blocked and a 25mm spear attached to a compressed air line was used to clear the blockage. It was found that condensation inside the drill stem had caused the blockage.

High pressure/high temperature nitrogen vapour was used to remove the condensation. With a reduced pressure fly ash was injected and although slow, was successful. By 6.00pm the first truck load of fly ash had been injected. Injection of fly ash and of nitrogen vapour continued throughout the night.

26 July

Borehole No.12 was completed at 2.00am and lining with 100mm steel casing commenced. Fly ash/nitrogen injection continued in hole No.10 and three rescue teams were detailed at 9.00am to:

. Inspect workings outbye of the brattice seals.

. Set up F.A.B. at No.21 c/t in No.4 Supply Road.

. Reinforce all seals with another layer of brattice.

. Erect an air lock in the seal in No.4 Supply Road.

. Install an air operated pump in the swilly in No.4 Supply Road between c/t 22 and 23.

Teams 17, 18 and 19 completed these tasks by 10.45am.

27 July

By 10.00am a total of 200 t of fly ash had been injected via hole No.10. Hole No.12 was prepared for injection but not used. Injection of nitrogen vapour continued in hole No.6 at about 2 tonnes per hour.
Rescue team No.20 entered the sealed area and established that the heated area had been completely covered with fly ash. There was no evidence of residual heat.

Rescue team No.21 entered the sealed area and erected five brattice stoppings in the c/t between No.4 Supply Road to No.5 North Return Road. The team returned to the surface at 2.10pm.

28 July
Rescue team No.22 entered the sealed area at 8.45am and completed erection of the remaining five stoppings between intake and return airways. The team returned to the surface at 10.45am.
Team No.23 was detailed to inspect all roadways inbye of the seals to ensure that there were no undetected "hot spots" prior to re-establishing ventilation in the now sealed area. The team reported that it was safe to re-ventilate. This was effected and nitrogen vapour injection continued until 4.00pm when it was established that the atmosphere had returned to normal thus completing the recovery operation.

On-site and Laboratory Investigations

Following completion of the mine recovery a detailed investigation was commenced to try and determine the nature and cause of the explosion. A preliminary examination of the affected areas indicated that an explosion had damaged the face area, outbye roadways and the casing of the main fan.

It was arranged that the investigation would be conducted by the Inspector of Coal Mines, Department of Resource Industries with the assistance of:

. Mine management, employees and their representatives.

. Staff of SIMTARS.

. Mr C. Ellis, Senior Scientific Officer, NSW.

. Dr A.R. Green, Senior Projects Engineer (Combustion) NSW.

. Dr A.J. Hargreaves, Consultant Mining Engineer, NSW.

. Dr A.F. Roberts, Director, Explosions and Flame Laboratories, Buxton, England.

The primary objectives of the investigation were to determine as far as possible:

. The extent of the flame and of blast waves.

. The type and source of the fuel.

. The source of ignition.

At the mine in the days following the explosion twenty statements were taken from mine management and employees, who were considered to have information relevant to the investigation. All pertinent records were impounded for examination including all statutory reports and mine plans.

A Government photographer was employed to compile a photographic record of the conditions in the explosion affected area of the mine. A total of 227 photographs was taken for later study.

The Extent of the Flame and Blast Waves

Following an initial inspection of the mine workings 105 samples of roadway dust were collected to determine the percentage of dry ash free volatile matter (% DAFV) in the minus 250 micrometre fraction. Spot samples of approx. 500 grams were collected from the ribs with similar samples from the floor to a depth of about 30mm.

To enhance the results a further series of 55 roadway dust samples was collected. Analyses revealed DAFV ranging from 18.5 to 35.5% in post explosion dust compared with a 32.2% volatile matter in run of mine coal established in December 1985. The result of this work is contained in Appendix E.

Inspection revealed many examples of materials damaged by heat and flame in the Main Dips Section. It appeared that the duration and path of the flame had varied considerably. Examples of heat affected material were pieces of paper, chock, plastics, insulation, rubber hose, brattice, synthetic rope, coal dust and teflon washers used with roof bolts. Helmets had been completely deformed as had plastic items such as food wrapping and boxes. However newspaper found in the affected area was either undamaged or slightly charred at the edges.

The insulation surrounding power cables in the working face area was undamaged but insulation of lighting and telephone cables was found to have blistered. Teflon washers were severely damaged in some areas whilst others nearby appeared unaffected. This example along with others indicated a complex and somewhat confusing flame path.

The examination of the workings indicated that the explosion had been arrested in the vicinity of No.23 c/t and that the water barrier plus water in floor depressions in the roadways had contributed to this. The standard of stone dusting in this mine was high and this probably assisted in the arrest of the explosion.

Considerable evidence suggests that blast waves were multi-directional inbye of No.24 c/t. There was a swirling pattern of blast waves in the c/t which was not evident in the headings. Small and large items of equipment/material had been displaced in various directions-some inbye (westerly) and others outbye (easterly). Other items had been blown along c/t in a southerly direction. One large item, a supply module loaded with wooden props, had been moved across the width of No.25 c/t and deposited upside down. Evidence indicated that it had also been turned end over end. This evidence is detailed in the Mine Disaster Plan prepared immediately following the recovery operation.

In almost all cases ventilation stoppings which had suffered explosion damage were blown towards the return airway. Observations made in relation to blast evidence enabled a plan to be prepared detailing the direction of major explosion airflows. This information is contained in Appendix G.

The Type and Source of the Fuel for the Explosion

All roadways inbye of No.23 c/t and the goaf area were affected by flame. The total volume of flame has been assumed to be about 100 000m^3 which could have resulted from the ignition of about 20 000m^3 of a mixture of methane (7%) in air. The volume of pure methane in such a mixture would be approx. 1 400m^3.

It is however likely that coal dust was involved in the explosion. The floor of workings in the Main Dips Section was predominantly coal and this would mitigate against treatment with stone dust and water to render the floor dust inert. If coal dust formed part of the explosive mix it follows that the volume of methane involved would be less than that indicated above.

Trickett's Ratio (TR) was applied to three mine atmosphere samples collected from the main return portal three hours after the time of the explosion. TR calculations for these samples were 1.176, 1.738 and 1.049 respectively. These results suggest that an explosion and fire had consumed methane, coal dust, possibly coal, oil, conveyor belting, insulation, polyurethane foam and wood. There was clear evidence of the consumption of coal dust, coal, oil, insulation, polyurethane foam and wood.

Another source of fuel for the explosion which has to be considered is a dense cloud of coal dust which could have resulted from a goaf fall. Experiments have shown that an ignition of a coal dust cloud can be achieved although this is a rare event.

Two possible sources of fuel for the explosion therefore have to be considered namely:

. Methane and air mixture with or without coal dust.
. A dense cloud of coal dust without methane or with minimal methane present.

Ventilation of the Main Dips Section was considered to be very good. The airflow recorded in a ventilation survey approx. 3 weeks prior to the explosion was 62m^3/s. There was nothing to suggest that there was not a similar flow on the morning of the explosion. Return airway methane monitoring for 14, 15 and 16 July 1986 provides a methane desorption rate of 0.085 to 0.153m^3/s.

These values suggest that a major failure of the ventilation system in the Main Dips Section would have had to precede an accumulation of methane necessary to fuel the explosion. There is no evidence to indicate such a ventilation failure.

Dr A.J. Hargreaves was commissioned to conduct an investigation into the source of methane and Dr A.R. Green was also commissioned to investigate the pattern and possible causes of the explosion.

The Source of Ignition

Possible sources considered were -- fire or spontaneous combustion; electrical apparatus and cables; mechanical equipment including the belt conveyor system, diesel engine and aluminium alloy; frictional sparking; electrostatic sparking; contraband; flame safety lamp; explosives.

Fire or spontaneous combustion -- although evidence of fire was found subsequent to the explosion there is absolutely nothing to suggest fire or heating prior to the disaster.

Electrical apparatus -- no defect was found which could have ignited an explosive mixture of gas and/or coal dust.

Mechanical equipment -- a detailed examination revealed no defect capable of providing the ignition for the explosion.

Frictional sparking -- the potential existed for ignition by the impact of rock on rock and of rock on steel when the goaf fall occurred. Investigation suggests that the fall occurred immediately prior to, or during, the explosion. Another possible source was aluminium alloy striking steel.

Electrostatic sparking -- after consideration the potential for ignition by this source was eliminated.

Contraband -- a search failed to locate any item which may have contributed to the explosion. Two electronic watches located after the mine recovery were examined at SIMTARS laboratory and certified safe. A third electronic watch continued to function after the explosion.

Flame Safety Lamp -- the only flame safety lamp in the Main Dips Section at the time of the explosion was examined at SIMTARS. When discovered in the aftermath of the explosion it had suffered severe external damage and was considered to be completely filled with coal dust.

Explosives -- it was established that explosives had not been used in the mine for two years and this potential source was thus eliminated.

General Observation -- the Inspector of Coal Mines observed in his report on the on-site investigation "I am of the opinion that an initial ignition of methane occurred during a goaf fall in the area between No.1A South Return Road and No.3 Belt Road and 27 to 28 c/t. The most likely ignition source being the hot surfaces of the vertical slip planes which resulted from rubbing friction generated during the fall."

2.2 Summary of Witnesses Examined and Evidence Given

Thirty-six witnesses gave evidence at the Warden's Inquiry and are listed below:

BRADY, John	Inspector of Coal Mines
EDWARDS, Glen Barry	Surveyor
MORRIS, Det. Snr. Sgt. Kenneth Cambadge	Police Officer
BLACK, Sgt. Dennis John	Police Officer
FOWLER, Donald	Manager
CAFFERY, Michael	Engineer
MASON, George Arthur	Under Manager
BLYTON, John William Thomas	Deputy
DULLAHIDE, John Robert	Driver
CADDELL, Michael Robert	Deputy
STRONG, Edward Clarence	Deputy
ZIEBELL, George Ronald	Miner (15 years experience)
GREAVES, William Octavorius Butler	Electrician
ATTO, Donald	Lamp Room Attendant
FODEN, Warren Michael	Miner (1 year experience)
BAYLES, Clarence Charles	Miner (7½ years experience)
HENDERSON, Alexander John	Fire Safety Officer
GUEST, Kenneth Neil	Deputy
REED, Phillip John	Manager
GLAZEBROOK, Christopher John	Open-Cut Examiner
ALLISON, William Mead	District Union Inspector
CUMNER, Leonard Frederick	Deputy Operations Manager
ANSFORD, Anthony Joseph	Specialist Pathologist
McMASTER, Allan Edgar	Elect Inspector of Coal Mines
HEPBURN, Allan Morten	Principal Mechanical Inspector of Coal Mines
THOMAS, Roger Henry Maitland	Technologist
JOYCE, Dr Alwyn Stanley - interposed	Principal, Geochempet Services
GOLLEDGE, Dr Peter - interposed	Chief Engineer, SIMTARS, Redbank
HISLOP, Thomas Graham	Senior Inspector, Electrical Testing, SIMTARS, Redbank
POPPITT, Ian Lindsay	Underground Geologist
GREEN, Peter Michael	Geologist, Geological Survey of Queensland
BELL, Stewart Lynn	Senior Chemist, SIMTARS, Redbank
HARGREAVES, Dr Allan James	Mining Engineering Consultant
GREEN, Dr Anthony Roland	Senior Projects Officer (Combustion) Londonderry Occupational Safety Ctr, NSW

(Roberts)

FORRESTER, Dr Ralph William — Senior Engineer, Cylinder Technology for Commonwealth Industrial Gases

HARDIE, Grahame Eric — Chief Inspector of Coal Mines

A report by the Inspector of Coal Mines on investigations conducted at the mine and elsewhere was provided in evidence. The author was examined on that report. Members of mine management and of the mine work force provided evidence on the circumstances in the mine prior to the disaster and the events that followed.

Other members of the Mines Inspectorate as well as the District Union Inspector gave evidence. Members of the SIMTARS organisation provided details of investigations relating to the flame safety lamp recovered from the mine, analysis of post explosion dust from the affected area and electronic equipment found in the mine.

Evidence was also given relating to possible sources of fuel for the explosion and potential ignition sources such as rock on rock and rock on steel impact, use of aluminium etc.