

REPORT TO MR G. E. HARDIE CHIEF INSPECTOR OF COAL MINES
REVIEW OF EVIDENCE IN THE MOURA MINE DISASTER 16 JULY
1986

DR SALLY LEIVESLEY AND DR K. ROMANIUK

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Thank you for your assistance in providing photographs and other information relating to the Moura Mine Disaster.

BACKGROUND TO THIS REPORT :

We have undertaken to review the information on the Moura explosion and in particular the evidence of the blast and heat patterns, the disposition of the bodies and equipment wreckage in the mine, the post mortem and police photographs of the 12 casualties and the post mortem reports of Dr A. Ansford, Government Pathologist.

Dr Leivesley commenced this investigation in July 1988 after on viewing photographs showing the blast effects of the Moura explosion. She had read the Warden's Report of the Inquiry and heard a detailed scientific paper on the involvement of the flame safety lamp at a Department of Mines Spontaneous Combustion Seminar.

The Chief Inspector of Coal Mines had allowed Dr Leivesley access to the Warden's Inquiry and to obtain copies of photographs of the explosion following a request. This information was required for the development of a detailed emergency planning training programme by Dr Leivesley for managers and miners in underground mines. Once the photographic evidence was viewed Dr Leivesley decided that there were indications that the initiation of the disaster was not related to findings of the scientific reports to the Warden's Inquiry.

The Chief Inspector of Coal Mines was consulted and he made available additional map information and agreed for Mr Mel Bell to contribute his expertise to part of the investigation. Mr Mel Bell has assisted with information on the underground scenario which he saw after the explosion and details from his area of expertise.

The analysis of the information was pursued until there was adequate factual information, the initial hypothesis established by Dr Leivesley had been

considered alongside alternative hypotheses, and there was agreement that the evidence was of sufficient significance to bring to the attention of the Chief Inspector of Coal Mines.

Dr Romaniuk was involved with Dr Leivesley in the detailed analysis because he had been present as the Forensic Odontologist at the post mortem examinations of the Moura casualties and because he was able to contribute considerable forensic expertise to the further analysis of the photographic and other evidence.

PROCEDURES FOR THE REVIEW OF THE EXPLOSION

Our review commenced with Mr Bell, Dr Romaniuk and Dr Leivesley viewing the mine map and enlarged photographs of the wreckage and attempting to determine the direction of blast.

In this session the evidence of the map and the photographs of the wreckage suggested that the incident commenced forward and to the right of the rover.

In subsequent sessions photographic evidence was obtained from the post mortem photographs that Dr Romaniuk had arranged when assisting as the forensic odontologist at the post mortem of the 12 men.

Photographs of the Bodies:

These photographs showed the type of injury the men had sustained, the pattern of burning on the bodies, the blast pattern including whether the clothes were shredded from blast, whether the body appeared to have moved along the ground under blast pressure, where the body may have encountered solid objects under pressure of the blast and what parts of the body were untouched by blast or fire.

A second set of photographs was obtained after Dr Leivesley had visited Moura and realised that the police had a different set of photographs that had been taken prior to the post mortem when the bodies had been brought to the surface. These photographs provided clearer detail of the bodies and in particular showed the direction of the blast and some additional details on the damage to clothing.

Post Mortem Reports:

Post mortem reports were obtained from Dr A. Ansford the Government Pathologist and these were examined to

determine the degree of blast pressure and burning, the site of fractures and injuries to the head and other parts of the body, the evidence in the lungs of the proximity to fire and of the severity of blast.

Mine Map showing position of all Casualties and Wreckage :

An enlarged mine map was obtained from the Chief Inspector of Coal Mines which assisted in viewing the pattern of movement of the bodies under blast.

Hypothesis Testing :

With the increasing amount of information, the initial hypothesis from the first inspection of the map and the photographs of wreckage could be tested. The procedure was that an initial hypothesis was established that the explosion initiated forward and to the right of the rover. Further hypotheses were tested to assess whether other sites of explosion were possible i.e. at the crib, the miner, the shuttle cars, the belt end or from the direction of 25 c/t. With these alternative sites there were no items in the map, photographs or post mortems that would allow another hypothesis to be established. The area of the two shuttle cars was viewed in greater detail than the other alternatives because of current findings on the explosion of a flame safety lamp in that vicinity. No evidence could be found in the pattern of injury on the men to support this contention.

Evidence was found that some bodies had travelled a distance down the 26 c/t and had been stopped by the No. 31 shuttle car. It was assumed that the clustering of bodies around these two cars had led to some previous assumptions on the activities of the miners and how the flame safety lamp had initiated the blast : i.e. there had been an assumption that the bodies and wreckage presented a static picture of the pre-blast activities rather than the final pattern of blast which would have moved bodies.

In this report it has been assumed that the blast may have moved bodies in one direction and in some cases pushed them in another direction as the air flowed back to fill the vacuum.

The items that were looked for in the pattern of injuries on the bodies were firstly, to identify where bodies had a pattern of burning, as this would suggest that they were closer to the initiation of the incident and were in the ambit of the flame front. This type of analysis enables assumptions to be developed on which

bodies were close to and which were on the periphery of the flame front and which ones were affected by the ongoing coal dust explosion. A differentiation was made in one case between burns from the flame front and contact burns from hot metal or other items which came in contact with the body.

Bodies which showed fewer blast injuries than others were then looked at in relation to the other evidence to see either what physical protection was between them and the blast or flame front or whether they were away from the immediate area and were on the periphery of the explosion. In most cases the body injuries presented a significant pattern which indicated their position in relation to the blast pressure at the onset of the incident and how the injuries were then acquired.

THE EVIDENCE OF THE INITIATION OF THE INCIDENT FORWARD AND TO THE RIGHT OF THE ROVER

The photographic evidence of the rover vehicle indicated that :

1. At the onset of the explosion one person was sitting in the driver's seat and another in the extreme left hand passenger seat and no person was present in the middle seat.

Evidence : The back of the driver's seat shows the outline of the head of the driver which was burnt by the initial flame front which preceded the explosion.

The head of Mr Sleep when viewed in post mortem photographs shows an exact fit with a piece of cloth on the right hand side of the head fitting exactly the shadow on the burnt seat.

The shadows on the seat are similar to those produced in Hiroshima from an initial extreme heat and then blast from the A-Bomb in World War 11.

The rover seat also shows the spokes of the steering wheel in a certain position at the time of the flash.

2. The direction of the explosion was from the front and to the right side of the driver.

Evidence: The damage to the struts of the right side of the vehicle, the direction of the tears in the cloth in the seats of the vehicle all show the

direction of extreme heat from the flame front preceding the blast.

Hypotheses which were explored to arrive at these conclusions :

1. The evidence on the vehicle and the pattern of burns on the men suggest that this incident commenced with a flash of flame forward of the vehicle and to the right. The initial flash was limited to a sheet of flame and followed by a blast which may have increased in magnitude further past the rover. The flame front was a self-limiting one which did not continue i.e. in all probabilities one sheet of flame and the continuing damage was from an accelerating explosion through the mine.

2. The pattern of burning on the seat suggested that the occupant would have burns to the head and more to the right arm and top of leg because of the direction of the flame front.

3. The person in the left seat would not have a pattern of burning as the condition of the seat showed that he had been protected by the driver's body.

The photographs of Mr Sleep show a body with a piece of material around the head which has been burnt severely. On examination it was found that the configuration of the cloth fitted the shadow on the seat. In addition the right side of the body was extensively burned with some clothing remaining on the left upper part of the body.

The body of Mr Friske was down on the left side of the vehicle and unburnt. The left side of the face shows the body has been pushed with considerable force against something solid. It is further hypothesised from this that Mr Friske was sitting on the extreme left passenger side of the rover, was protected from the flame front by Mr Sleep and was pushed at a force into the rock wall and fell beside the left side of the vehicle. Mr Friske's body showed that the damage was to the left side of his upper body i.e. the left side of the face and the left shoulder. The right arm was thrown up to protect his face against the flash forward and to the right of him. The blast force would have been very high to throw him with the force which flattened the left side of his face.

THE EVIDENCE WHICH SUGGESTS THAT THE EXPLOSION DID NOT ORIGINATE AROUND THE JUNCTION OF 26 C/T AND THE BELT ROAD IN THE VICINITY OF THE TWO SHUTTLE CARS

The initial viewing of the map shows that there are angles to the equipment and to the position of the bodies which can be related to blast patterns.

The evidence :

1. Angle of the rover and the No.31 shuttle car (see map reference). A pattern of blast can be traced which comes from the front right of the rover pushing the nose to the wall, coming down the 26 c/t and hitting the No. 31 shuttle car which was at the time parallel to the wall and in the centre of the roadway. The shuttle car was then pushed into the corner of the roadway and formed a partial barrier to wreckage and bodies which was coming in the same direction from the blast.

The angle of the shuttle car is equal to and exactly opposite to that of the rover which confirms this blast wave pattern.

~~Further Hypotheses on Blast Movement of the Bodies:~~

The bodies of Mr Keyworth and Mr McPherson travelled down the 26 c/t at high velocity and when they hit the No. 31 shuttle car their final angulation is consistent with being stopped by the obstacle. These angles are different to those of Mr McCulloch, Mr Holton , Mr Waning and Mr Laing whose bodies represent the actual direction of the blast wave. However this group of men was either further up the cut through, more to one side of the cut through or they experienced a lower blast pressure as they did not hit the vehicle. Further information was available on the patterns of blast on these bodies to suggest which ones were together at the time of the blast.

The pattern of bodies at the junction of the Supply Road and 26 c/t suggests that Mr Sainsbury was in the path of the flame front but not exposed in the same way as Mr Sleep. It is hypothesised that he was in the back left hand seat of the rover or standing at the back of the rover but it is more likely that he was in the seat. His left arm has singeing suggesting that he threw his arm up to protect himself from the flash - his face and

hair were not singed i.e. protected by the arm. The vehicle shielded his lower body from the flash. He had no blast shredding of clothes on his lower body and had just severe blast effects to his head.

The reason that it is more likely that he was in the back or at the back of the rover is that the blast wave has carried him across the c/t. With Mr Sleep there had been two movements - the initial throw out of the vehicle and then the blast wave down the 26 c/t.

A viewing of the map suggests that from the pattern of burning on the bodies that Mr Keyworth was towards the junction of the Supply road and 26 c/t and on the very periphery of the flame front. He has singeing in a very minor way to his hair. His face and hair are not burned. There is evidence of tissue loss on his left leg from the body being dragged down the c/t.

Information later in this report suggests that Mr Waning was also close to the rover and caught the flash in his face but the rest of his body was not burnt.

REVIEW OF THE BODY OF MR KEYWORTH, THE DEPUTY MINE WHOSE FLAME SAFETY LAMP HAS BEEN RELATED TO THE INITIATION OF THE BLAST

An hypothesis was tested to see the pattern of injuries on Mr Keyworth and to ascertain whether these were consistent with an ignition commencing on a lamp on his person. In particular a pattern of burning in the waist or pelvis area were looked for with shredding of the trousers and upper clothing and significant damage to the tissues of his body.

Mr Keyworth's injuries were similar to those of Mr McPherson. There was no possibility of blast damage to his lower body i.e. below the waist. His self rescuer and battery were intact and all clothing on his back and the back of his legs was intact. The appearance of the body suggests that he fell onto his face and was dragged on his front with the blast impact. His loss of tissue on his left leg suggests the body was dragged a distance along the c/t. He had multiple fractures of the skull and facial bones. These fractures are the result of being smashed against a solid object and he hit this object with a much greater force on the right side than the left. His right mandible was fractured. It is hypothesised that the injuries are consistent with hitting the No. 31 shuttle car on the right hand side of his face with a great force.

Mr Keyworth's lungs were free of soot which suggest that he did not inhale close to the flame front . The amount of singeing to his head is very small and the back of his head shows all hair fully intact and hair is present on the front of his head. His hair was exposed to intense heat and is described as singed . The conclusion from this is that he was further removed from the flame front than than Mr Sleep or Mr Sainsbury and was not in the direct line of flash i.e. he was on the periphery.

EVIDENCE THAT THE DEATH OF MR HULL WAS PART OF THE BLAST PATTERN AND NOT A PRE-BLAST ACCIDENT

The blast pattern suggests that No. 31 shuttle car was in the junction of the belt road and the 26 c/t and was pushed to the side by the force of the blast. It was hypothesised that Mr Hull was on the driver's side of the vehicle and was run over by the vehicle when it was pushed by the blast.

Evidence:

Examination of Mr Hull's body shows that he was run over by the front right wheel of the vehicle which left his body forward of the front left vehicle wheel because of the vehicle moving over him to hit the wall. Mr Hull's forehead and skull show the pattern of the wheel. He shows no evidence of the blast patterns in the other bodies. His CO level suggests that he was protected under the vehicle and with massive head injuries had very shallow breathing until he died of asphyxia.

EVIDENCE FROM THE 12 BODIES ON THE NATURE OF THEIR INJURIES AND THE RELATIONSHIP BETWEEN THESE INJURIES AND THE PATTERN OF BLAST

MR KEYWORTH NO. 5, MR HULL NO. 4, MR SAINSBURY NO. 9, MR SLEEP NO. 10 AND MR FRISKE NO. 2 - Evidence from the re-examination of these persons has been discussed in the preceding sections.

MR FECHNER NO. 1

An hypothesis can be made that Mr Fechner may have been driving the No. 31 shuttle car at the time of the impact of the blast wave. When the vehicle is redrawn on its normal position parallel to the walls the position of the body of Mr Fechner could be consistent to being blown out of the driving seat and ending up in line

with the back of the vehicle. The alternative hypothesis is that his body came down the 26 c/t with those of Mr Keyworth and Mr McPherson .

Mr Fechner had no shirt and showed lower limb damage around his pelvis. It is suggested that this may have been created by being blown from the seat . He had a fractured skull which was a Y shape from above the left eye to the left ear and parietal bone. There is also a fracture of the right temple. These suggest he has hit something with his head. The lungs suggest he has had a significant blast.

The primary hypothesis is that he was thrown out of his vehicle and landed on his face with the left side taking more of the impact. A secondary hypothesis is that he has a similar pattern of injuries to Mr Keyworth and Mr McPherson and was blown down with them as the position of his body is in the same angle. However the different item - the injuries around the pelvis - could be more consistent with his ejection from the vehicle.

MR HOLTON NO. 3

Mr Holton was lying in a position which was parallel to the walls of the 26 c/t but into the junction of the belt road and 26 c/t. He had an arched back suggesting he had been facing the blast and had been blown backwards. All his clothing was in good condition which suggests he had not moved a lot. He had a contact burn on one arm which suggests that a piece of hot debris had come into contact with the arm.

MR MCPHERSON NO 8

Most of Mr McPherson's injuries are to the right hand side of the body. He was hit severely in the right occipital region and shows a very high force to the head. His body is very similar to Mr Keyworth i.e. in the way the bodies were lying face down and the injury to the head on the same side.

MR LAING NO. 6

Mr Laing was found in the same direction as Mr Holton, Mr Mc Cullouch and Mr Waning i.e. parallel to the walls of the 26 c/t but at the intersection of the c/t and the belt road. Mr Laing had a defect on his left side. His clothes were shredded from either blast or being dragged on his front or a combination of both. He had more damage to his trousers than the others which may

be consistent with travelling further along the road or being closer to a greater blast pressure. Whereas the majority of the casualties showed the blast had been at head height his clothing may suggest a blast which was greater than that experienced by most of the others. It is hypothesised that this may be related to the fact that he had more coal dust in his lungs i.e. in an area where a greater volume of coal dust has led to a more intense ongoing explosion of the coal dust.

MR TURNER NO. 11

Mr Turner was at an angle to the No.31 shuttle car which was different to that of Mr Keyworth and Mr McPherson. He had a scalp injury the nature of which suggests he has hit metal or a hard object with his head at high blast pressure. The clothing has been blasted from the front of his body. It is hypothesised that the blast hit his head and threw him backwards onto the No. 31 shuttle car and he collapsed backwards.

MR MCCULLOUGH NO 7

McCullough was arched back in the same pattern as Mr Laing. He had suffered very severe blast. He had no shirt. The blast appears to have been bad to the chest and legs with full frontal shredding and very high force to the head. There were large quantities of coal dust in his lungs.

MR WANING NO. 12

Mr Waning was in a position parallel to Mr Holton and Mr Laing slightly in the No.3 belt road towards the goaf and not directly in the intersection of the belt road and 26 c/t. His stance shows that he was hit full front on and pushed back with an arched body. His face was charred on the right hand side and right collar was torn. The damage was confined to his upper chest. The right upper side of the body took the greatest impact. His arching is similar to Mr Holton's and it may be hypothesised that Mr Holton, Mr Laing, Mr Waning and Mr McCullough were facing the same direction and blown in parallel with each other down the 26 c/t .

It is hypothesised that Mr Waning was closer to the flame front than Mr Keyworth as he had a charred face and he may also have been in the back of the back of the rover or behind the rover. He had a projectile in his face. The defect is on the left hand side of the face, similar to Mr Laing.

SUMMARY AND RECOMMENDATIONS

In summary, while we cannot comment on what caused the ignition we can provide the hypothesis that the initiation of the explosion was forward and to the right of the rover. There were two men sitting in the front of the rover and there may have been one or two men sitting facing towards the north return in the back of the vehicle. These men were either caught in the full flame front, were fully or partly protected by objects or were on the periphery with little evidence of burning.

Other men were coming up the 26 c/t towards the rover or the crib and were not involved in the flash but were caught by the ongoing coal dust explosion and blown down the 26 c/t. Some men were closer to the blast than others and this may reflect differential blast effects in coal dust explosions or distance from a high blast pressure.

One man may have been driving the shuttle No. 31 shuttle car and would have seen the flash and then been hit by the blast and either driven or been pushed into the corner of the junction of 26 c/t and the belt road. This action ran over one man who was not hit by the blast but was run over by the forward right hand wheel of the shuttle car.

The blast pressures blew men from the rover, firstly in the direction taken by the flame front, and then in the direction of the ongoing coal dust explosion which went down the 26 c/t to the belt road. Some men were blown at such force that they landed against the No.31 shuttle car and finished at an angle to it.

There is no evidence to suggest from this information that an ignition started close to the shuttle car and then proceeded throughout the mine.

It is recommended that the Chief Inspector of Coal Mines consider the following items :

1. Whether the details of this report warrant further investigation. It is suggested that blast experts from the British Home Office including forensic experts review the information as they are skilled in interpreting the pressures and differential impact from blast. In addition, the National Coal Board would have experts who have investigated blast patterns and the specific pattern of blast in mines.

2. Whether it is advisable to make this information known to the Minister and available to industry for comment. It is considered by the authors that an incorrect judgement on the role of the flame safety lamp could mean that false assumptions are being made in industry on the causes of the Moura mine explosion.

3. The authors stress that the investigation has been undertaken for the purpose of determining whether other hypotheses could be developed which would counter the present assumptions about the Moura mine explosion. It is further suggested that the finding of the origin of the explosion being forward of the rover establishes another hypothesis which should be examined by the relevant experts until there is conclusive evidence on the cause of the Moura mine explosion.

The authors emphasise that this has been a limited study which requires much more detailed analysis.

SIGNED :

Sally Lewesby —
H. Remaun



