CHAPTER 3

FUEL SOURCES FOR THE MOURA EXPLOSION

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3.1 Sources of Methane

3.1.1 General Body Concentration

The general body concentration of methane in the period between 2 July and the date of the explosion on 16 July 1986 for both the Main Dips south and Main Dips north roadways was less than 0.5%. Brady (1986) in his report of the investigation, concluded that the concentrations of methane were consistent with the mining extraction activities carried out over this period of time.

Even on the morning of the explosion at 10.30am the methane concentration in the Main Dips South was 0.30% and in the Main Dips North, 0.15%.

Prior to 16 July, regular inspections of the Main Dips Section were carried out by various mine officials, experienced miners, inspectors of mines and district and local check inspectors. No persons who had carried out these inspections reported the presence of any abnormal concentrations of methane in the goaf area.

A Deputy inspected the workings on two occasions during the night shift of 16 July 1986 and reported that the goaf was very quiet and well stone dusted and that no flammable gas (methane) was detected.

There is no evidence prior to the explosion that methane concentration was abnormally high and nothing to suggest a build up of methane in the return airways from whatever cause.

3.1.2 Methane Layer in Goaf

In the area of the fall the strata dips inbye and also to the north. During mining of this area some extraction had taken place in the lower section of the C seam.

Although persons sampled the atmosphere in the goaf area to the dip it is not certain that samples would have been taken at or near full roof height, particularly in the area which was expected to fall on 16 July 1986.

It is well known that methane layering can occur in roof cavities and in dip roadways where a roof layer is able to form and in some circumstances can migrate upwards against the direction of the roadway ventilation.

The fact that a number of persons were able to inspect the dip workings safely in an atmosphere with sufficient oxygen concentration indicates quite clearly that ventilation of the extracted dip workings was occurring naturally. The explosion occurred during the winter when the intake air would be much cooler than the return air. By virtue of the difference in density, some portion of the cooler intake air would sink slowly inbye towards the extracted dip workings where it would be gradually heated. Any methane produced from the coal ribs would tend to migrate to roof level due to the lower relative density of methane compared to air.

The degree of mixing of gases is given by the Froude number where:

$$F = U^2 / \left(g \frac{Dp}{P} A^{0.5}\right)$$

where F = Froude number
U = average air speed
$\frac{Dp}{P}$ = density difference between methane and air divided by the density of air
A = cross sectional area of excavation.

For the flow in the goaf area U is very small, Dp/P is less than 1 and A is very large, with the result that F is very small. This indicates that little mixing would occur between the methane and the air in the goaf area. Conditions therefore existed in the goaf and in the working area for methane layering to occur.

If the assumption is made that the layer of methane was pure seam gas (99% CH_4) and that the depth of the layer was 1m and extended over a diameter of 50m, then the volume of gas could have been approximately 2000m³.

why not 1&4 [illegible]?

With nominal roadway dimensions of 6.5m by 2.5m there may have been sufficient methane in 27 and 26 c/t and No.3 Belt Road when diluted to the lower explosive limit to provide the fuel for an ignition source.

3.1.3 Gas Outburst in Mine

Dr A. Hargraves examined the possibility that the gas may have arisen as an instantaneous outburst and also in the A and B seams above.

Experience in Australia suggests that outbursts in coal pillars usually occur in the early stages of pillar formation, before degassing of the pillars has had time to occur. The pillars at Moura were relatively small in size and had been developed for some years, a combination of factors indicating that a pillar outburst was most unlikely.

As to the B and C seams above they were of lower rank and therefore less prone to outbursting and also under shallower depth of cover with an associated lower gas content and lower in-seam stress.

It was concluded by Hargraves that it was unlikely that an instantaneous outburst had occurred in either A or B seam.

Some tests were conducted at Moura to test the possibility of an outburst from C Lower Seam in a goaf environment. These tests showed negligible gas issue and no development of gas pressures after several hours.

A less likely but not discounted consideration was the possibility of gas derived from floor movements below the goaf and the connection by various permeation paths to the underlying D Seam. In such a scenario de-gassing of the D Seam could have been a continuous process after the goaf area in the C Seam was established and the role of de-gassing would have been expected to decrease with time.

3.2 Sources of Coal Dust

It is known from mining experience in both longwall and room and pillar mining that large goaf falls are capable of producing dense clouds of dust. Some of this dust is due to fragmentation of the rock but most of it is raised into the airstream as a cloud from the interaction of the blast produced by the fall and the dust in the goaf and on the floor, roof and ribs of the mine roadway.

The action of the belt conveyor, the dumping of shuttle cars at the boot end all contribute float dust which can be considered to be less than 20 micrometre in diameter, and this dust is deposited as a continuous film, particularly along the belt road and in the goaf area.

Dawes and Wynn [4] conducted research into the problem of raising dust clouds from surfaces. They demonstrated that dust could become airborne by erosion in which single particles of dust are raised from the surface of a deposit, and by denudation by which large agglomerations of dust are torn away from the surface. According to Dawes a cloud of coal dust can be raised with an air velocity as low as 5m/s while a cloud of stone dust needs a velocity of 8m/s. The process of denudation is facilitated when the surface is rough, as it is in a mine and responsible for raising the dust as a cloud when it is wet or present in the form of a mud. A goaf fall is capable of producing air velocities much in excess of 8m/s since persons have been knocked over by the force of the air blast and this requires a velocity of the the order of 25m/s. Persons who have been involved with goaf falls can testify that visibility may be reduced to zero following the fall and may remain at very high concentrations until the main ventilation has been able to reassert its influence and dilute the dust with intake air. This experience suggests that dust concentrations may approach the lower limit of explosibility for coal dust following a goaf fall.

'Float dust' will be raised preferentially during a goaf fall because of its smaller particle size. The initial dust cloud caused by the fall could have a size distribution with a relative large surface area per unit mass and quite different from that occurring during the explosion process.

It is also known that a sudden release of the load on the coal pillars following a roof fall causes a reaction in the pillars and a slight movement upwards which causes some of the dust on the rib to become airborne as a dust cloud.

The dust deposited in at least part of the goaf area would tend to be relatively dry due to the action of the ventilation airstream across the goaf from 27 c/t to No.1A South_ Return Road.

Experience at Tremonia, Mine Barbara, Buxton, Lake Lynn and Bruceton explosion galleries indicates that the flame can exceed the initial length of coal dust by a factor of 3 or more. In other words, the spread of flame from a 100m zone of coal dust distributed over the floor, walls and roof of the explosion gallery could reach a distance of 300m.

3.3 Methane/Coal Dust

If it is accepted that methane was necessary for an ignition at Moura it follows that some mixing of methane and coal dust could have occurred during the turbulent movement of air during and after the fall.

Low concentrations of airborne coal dust affect ignition sensitivity and pressure development. The minimum CH_4 concentration required for ignition decreases from 5.4% to zero as the airborne dust concentration increases from zero to $50 g/m^3$. An explosive methane/coal dust concentration could be formed in a mine roadway at a concentration of 3% CH_4 and $12.5 g/m^3$ of coal dust. It is known that excessive quantities of dispersed dust tend to inhibit ignition and retard the explosion by absorbing energy. With an excess of fuel (high gas or coal dust concentration) the ignition is more difficult and the explosion less severe [5].

It is more difficult to prevent propagation of a coal dust explosion when methane is present simultaneously. Research carried out by the Bureau of Mines in the two decades following the construction of the Bruceton explosion gallery showed that substantially more inert dust was needed to prevent propagation of a methane/coal dust explosion [6]. An additional 10% of inert dust above that needed to prevent propagation of a coal dust explosion is required for each 1% of methane present.

Four Moura No.4 Mine the incombustible content required by legislation was 72%. The presence of 3% methane in the dust cloud would have required the addition of 30% inert dust. Even with a mine roadway freshly stonedusted the percentage of inert dust could have been insufficient to prevent propagation of an explosion.

For coal/dust methane explosions at Buxton, Lunn and Roberts [7] showed that the maximum temperature within the reaction zone was 2000° K. This is appreciably higher than the corresponding figure of 1600° K for a coal dust explosion.

3.4 Gases from Mine Fires or Spontaneous Combustion

There was no evidence from routine air monitoring to indicate any gases from either a mine fire or spontaneous combustion. No subsequent examination underground suggested any evidence of heating from any mechanical or electrical components.

3.5 Other Fuel Sources

Consideration was given to the Entonox bottle as a potential fuel source but was discarded for various reasons as discussed in 4.5.