OUTBURSTS IN UNDERGROUND COAL MINES

Outbursts are expulsions of gas and coal from the working face. They are energy release phenomena that can have catastrophic consequences. These may cause serious or even fatal injuries by mechanical force or through asphyxiation. Uncontrolled gas release may reverse ventilation and in the event there is an ignition source lead to an explosion.

Most severe outbursts occur on geological structures in the coal seam that contain gouge (ground up) material. Some however occur from solid coal which fragments during the outburst. Examples of two kinds of outburst can be seen below.

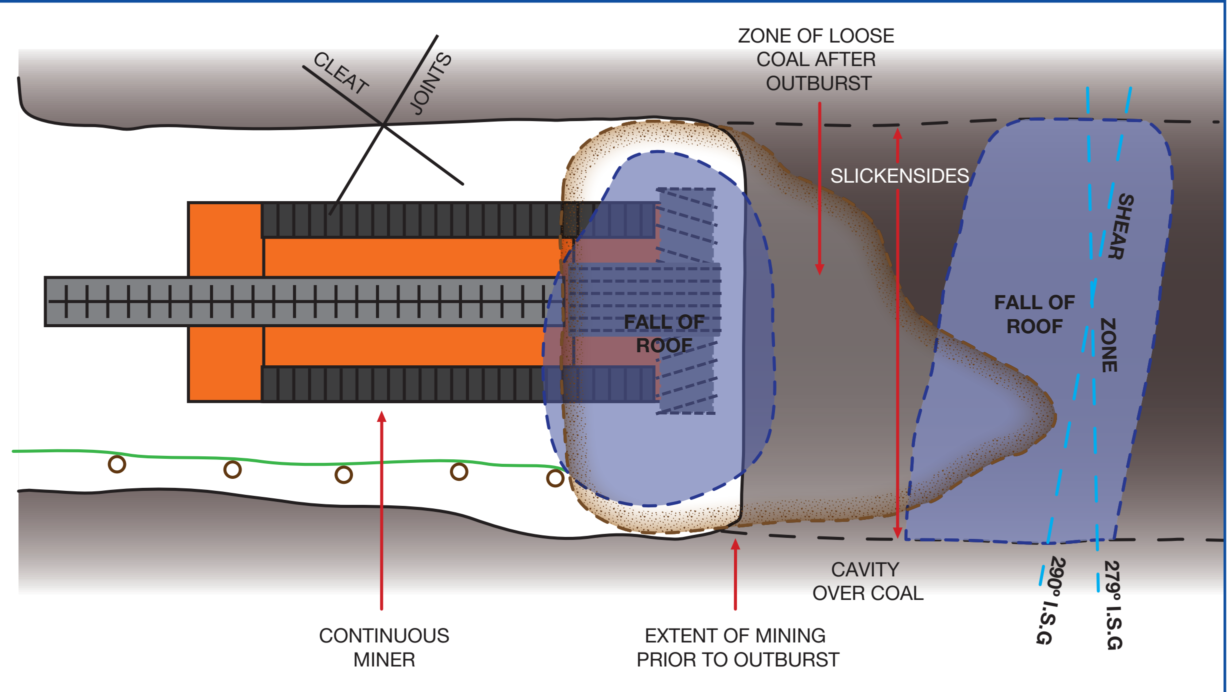

Figure 1. A plan of an outburst that occurred at Westcliff Colliery (Adapted from Marshall et al, 1980).

Figure 1 shows a sketch of an outburst that occurred at Westcliff Colliery, NSW which moved the continuous miner backwards. The energy source of this outburst was a sheared zone of coal behind the face.

Figure 2 shows a sketch of a typical outburst that occurred from solid coal at Leichhardt Colliery, Queensland. Here the outbursts always occurred across the cleat, often preceded by an onion ring appearance in the face before buckling outwards leaving a cone in the ribside. The size of these outbursts varied from 1 to 350 tonnes.

For an outburst to occur, failure of the coal must first take place. Failure is commonplace in mining and is due to the effective stress in the coal exceeding its strength. In an outburst, the failure is accompanied by the release of energy and gas. The key to understanding outbursts is determining the likely sources of energy release while the key to controlling them is in minimising the potential for energy release.

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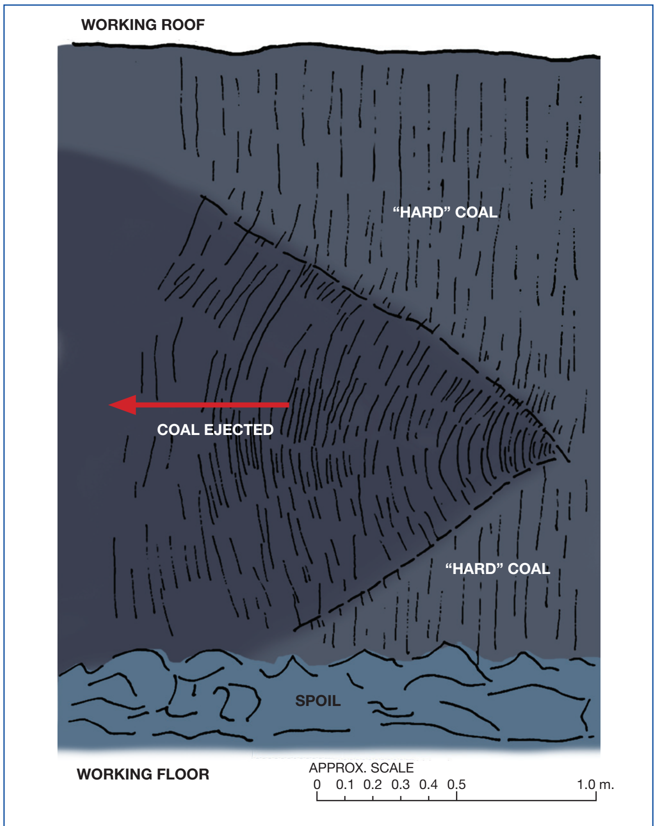

Figure 2. An typical view of the ribside after mining through small outburst cone at Leichhardt Colliery (Adapted from Moore and Hanes, 1980).

The sources of energy for an outburst are:

Strain Energy from Rock and Coal – This is dependent on the state of stress in the coal and its elastic properties. The state of maximum stress is often limited by failure at the face. In the case of outbursts that progressively erode from the face into solid coal, the state of stress varies from that at the face, which is limited by the unconfined coal strength, to that in the virgin condition. Strain energy may also be supplied to an outburst by the movement of the surrounding strata.

The Expansion of Gas from Free Void Space – This comes from the adiabatic expansion of gas from the free void space (cleats). It is nearly a linear function of void space and gas pressure. If the coal is water saturated then there is no gas in the cleats to expand.

The Diffusion of Gas from Coal Particles – Gas may diffuse from the coal particles to an intermediate pressure within the void space of failing coal mass in an outburst. This gas may then expand adiabatically to provide energy. The key to the energy release is the gas content which is linked to the gas pressure through the sorption isotherm, the coal particle size distribution and the diffusion coefficient. These factors determine the rate of gas release.

There is also significant energy absorbed during the failure process which reduces the total outburst energy. It is related to the toughness of the coal. Toughness is by definition a measure of energy absorbed in causing failure.

Determining the Outburst Hazard

The process of determining the level of risk from an outburst is one of estimating the energy release per unit volume of the outburst and the likely volume that may be involved.

The energy release per unit volume is calculated by the determination of the stress within the coal and its elastic properties. The free void space is usually a very small component and may be ignored while the diffusive behaviour of the coal is important. It requires the measurement of gas pressure and content, the initial diffusion coefficient of the coal and the determination of likely particle sizes that will be produced during an outburst. Air drilling simulates an outburst and the collection of particles from such drilling gives a conservative (fine) indication of the particle sizes that may be generated. In the case of fault gouge material the particle size distribution is determined by measurement or estimated from historical data.

The energy absorbed by coal failure per unit volume is difficult to measure but indications of the coal toughness may come from grindability testing, drop hammer tests or by gassing up solid stressed coal and suddenly releasing the pressure to determine the level of fracturing that may occur.

The size of a potential outburst is also important as this directly effects the total energy release.

As failure is related to effective stress and strength the likely failure zone may be calculated bearing in mind that the fluid pressure contributes to effective stress. Most outbursts are however associated with fault gouge material and the size of such zones has a great bearing on the severity of outbursts occurring from them. Therefore the determination of the likely gouge material volume is important.

The approach to outburst management may be to drain gas to a low level throughout the seam so that even if gouge zones are mined they will not produce an outburst of any severity. This may however be impractical in coals of low permeability where the solid coal could be safely mined at a higher threshold. In this case a multiple gas threshold level may be adopted to suit solid coal or coal in faulted zones. The important control on this is the detection of such faulted zones and therefore the confidence in the exploration procedure needs to be very high. This can only be achieved with a combination of approaches using in-seam drilling with measurement and geophysical techniques.

The Importance of Coal Permeability

The permeability of the coal has no direct bearing on the severity of an outburst at a given gas content and level of stress. However coals with low permeabilities are far more prone to outbursting because they are much harder to drain.

The Dangers of Shotfiring through Outburst Prone Coals

The approach of shotfiring through outburst prone coals should not be followed. Historically outbursts have occurred after shotfiring catching the returning crews unaware. Indeed in some cases the outbursts have occurred from the ribside behind the face where a roadheader is operating. In other instances the outburst initiated by shotfiring is so large that it has totally overtaken the mine's ventilation system and led to an explosion.

Sigra's Approach

Sigra's approach to outbursts is to first understand the geological conditions, then to measure the coal stresses and its elastic and post elastic properties to understand the net strain energy available when failure occurs. This is followed by careful testing to determine the gas storage and desorption behaviour of the coal, including its fragmentation behaviour on sudden desorption. From these measurements we can determine risk and recommend levels to which gas should be drained to minimise the risk of outbursts. It is important to recognise that a single gas content threshold level does not suit all conditions.

Sigra can characterise the coal seam reservoir behaviour and design the most appropriate drainage system to suit the mine.

References

Marshall P, Griffiths L and Lama R D (1980). Occurrence of Outbursts at West Cliff Colliery. Papers Presented at the Symposium on The Occurrence, Prediction and Control of Outbursts in Coal Mines. AusIMM Southern Queensland Branch, September 1980.

Moore R D and Hanes J (1980). Bursts at Leichhardt Colliery, Central Queensland and the Apparent Benefits of Mining by Shotfiring. Papers Presented at the Symposium on The Occurrence, Prediction and Control of Outbursts in Coal Mines. AusIMM Southern Queensland Branch, September 1980.