GeoGAS

Application of Outburst Thresholds to Non-Bulli Seam Mines

Mark Blanch – Ray Williams
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Scope

- Bulli seam thresholds
- Desorption rate fundamentals
- Non Bulli seam thresholds
- Outburst management in thick banded seams
- Comment and opportunities
GeoGAS – our involvement

- Gas content and isotherm testing
- Quick crush method
- Desorption Rate Index (DRI)
- Outburst investigations, risk assessment, OMPs, definition of outburst thresholds
- Gas drainage design & gas management
Early Bulli seam gas content thresholds

- Lama circa 1991

- Desorbable gas content thresholds
  - Structured coal
    - 4 m³/t (100% CO₂)
    - 8 m³/t (100% CH₄)
  - Unstructured coal
    - 7 m³/t (100% CO₂)
    - 10 m³/t (100% CH₄)
Bulli seam threshold origins

- Bulli seam experience
- Overseas experience (Re; Table 6 of Lamas 1995 paper)
  - Ibbenburen (Germany) 9 m$^3$/t (100% CH$_4$)
- Collinsville EV meter read (100% CO$_2$)
### Desorbable to TDGC

#### Thresholds in structured coal

<table>
<thead>
<tr>
<th></th>
<th>CH₄</th>
<th>CO₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desorbable gas content (m³/t)</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>Residual (x, m³/t)</td>
<td>2</td>
<td>2.4</td>
</tr>
<tr>
<td>Total Desorbable gas content (m³/t)</td>
<td>10 (9.4)</td>
<td>6.4</td>
</tr>
</tbody>
</table>

#### Thresholds in unstructured coal

<table>
<thead>
<tr>
<th></th>
<th>CH₄</th>
<th>CO₂</th>
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</thead>
<tbody>
<tr>
<td>Desorbable gas content (m³/t)</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>Residual (x, m³/t)</td>
<td>2</td>
<td>2.4</td>
</tr>
<tr>
<td>Total Desorbable gas content (m³/t)</td>
<td>12</td>
<td>9.4</td>
</tr>
</tbody>
</table>

(Lama 1995)

<table>
<thead>
<tr>
<th></th>
<th>CH₄</th>
<th>CO₂</th>
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</thead>
<tbody>
<tr>
<td>Dry isotherm</td>
<td>2.21</td>
<td>6.76</td>
</tr>
<tr>
<td>Moist isotherm</td>
<td>1.67</td>
<td>3.72</td>
</tr>
<tr>
<td>UG cores</td>
<td>2.01</td>
<td>1.96</td>
</tr>
<tr>
<td>UG cores (other lab)</td>
<td>2</td>
<td>2.9</td>
</tr>
<tr>
<td>Surface cores</td>
<td>2.13</td>
<td>1.09</td>
</tr>
<tr>
<td>Mean</td>
<td>2</td>
<td>3.27</td>
</tr>
</tbody>
</table>

![Graph showing TDGC and % CO2](image)
Thresholds adopted - Helensburgh

Helensburgh

% CO2

TDGC (m³/t)

Lama Structured
Lama Structured at 10-12 m/day
Lama UnStructured
Thresholds adopted - Appin

![Graph showing TDGC (m3/t) vs % CO2 for Lama Structured, Lama Structured at 10-12 m/day, and Lama UnStructured at Appin site.]
Thresholds adopted – NRE#1

NRE #1

% CO2 vs. TDGC (m³/t)

- Lama Structured
- NRE#1 Bulli seam
- Lama Structured at 10-12 m/day
- Lama UnStructured

GeoGAS
Part of the Runge Group
Thermal profiles – West Cliff

- West Cliff L1
- West Cliff L2
- Lama Structured
- Lama Structured at 10-12 m/day
- Lama UnStructured

% CO2 vs. TDGC (m3/t)
Part of the Runge Group

Thresholds adopted – Tahmoor

Tahmoor

Lama Structured

Tahmoor Structured but limited advance rate

Lama UnStructured

Tahmoor UnStructured but limited advance rate

TDGC (m3/t) vs. % CO2

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

0 10 20 30 40 50 60 70 80 90 100

GeoGAS

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Factors of safety

- Difficulties in clearly defining origins
- Perceptions of absolute accuracy
- Apparent factors of safety
  - “...too small to cause any major damage or endanger life of personnel”
  - “....thresholds can be increased by multiplying by a factor of 1.2 where development rates are reduced to be 10-12 m/day..” based on mathematical modelling undertaken at the time
GeoGAS approach

- A line in the sand, combined with OMPs and systematic drainage programs & decision making processes
- GeoGAS would argue
  - No Gas Dynamic Incident are acceptable
  - Geological structures can’t be defined to the required degree of certainty
  - Development rate has in some incidents little to do with outburst initiation
  - It is pointless to debate definitions of outburst. Uncontrolled gas events require careful consideration
Desorption Rate

- Outburst thresholds in Australia have been based on gas content for the past 20 years
- Desorption rate has long been regarded as significant to outbursting:
  - Hargraves EV meter, Polish Desorbometer, V30, ...
  - CO₂ >> CH₄
- GeoGAS DRI900 transfer BU seam thresholds to non-BU seam mines
Gas desorption rate is

- The rate at which gas diffuses from the coal matrix into the cleat system, it is effected by:
  - Gas content
  - Gas composition
  - Inherent coal properties
  - Particle size
  - Moisture
  - Temperature

- Described by Ian Gray as “.. a combined measurement of the crushability of coal, diffusion coefficient and gas content rolled into one “
Measuring desorption rate

- The GeoGAS DRI is calculated from the quantity of gas desorbed after 30 seconds of crushing a 150 g sample, normalised to the measured gas content of the sample.
Outburst initiation

- Normal mining is characterised by relatively low gas content gradient ahead of the face and regular stress distribution.
Approaching an outburst structure the coal hardens in response to increased stress, permeability declines and the gas content gradient steepens.
• With continued mining the highly stressed barrier suddenly fails:
  • The stress is suddenly reduced
  • The ambient fluid pressure on the coal changes from being mostly above desorption pressure to suddenly being well below the desorption pressure for the gas content of the coal
  • The rapid increase in gas pressure (free gas) in the fractured coal over comes the resistance of the weakened coal mass, resulting in the sudden release of large volumes of gas with entrained coal particles
  • The **initiation of the outburst is defined by the rate of gas desorption** and in turn the rapid increase in gas pressure in combination with the strength of the confining coal barrier
In assessing gas content data from the Bulli seam using cores derived initially from West Cliff Colliery it was found that:

- The relationship between gas content and desorption rate was linear.
- The desorption rate for CO2 was higher than for CH4.
- A gas content of 9.5 m3/t (CH4) has essentially the same desorption rate as a gas content of 6.2 m3/t (CO2).
- The threshold values coincide with a DRI of 900.
BU seam checks

Gas content threshold @
100% CH₄ = 9.4 - 9.7 m³/t

Gas content threshold @
100% CO₂ = 6.9 - 7.1 m³/t
Non Bulli seam thresholds

- DRI900 has been used to establish outburst thresholds in the Wongawilli seam, Hunter Valley seams, Gunnedah and Bowen Basins seams
- No GDIs regardless of the severity of other factors
- Thresholds vary by seam and by composition
**WW seam thresholds**

- 6.5 – 7.5 m³/t
- 0 – 65% CO₂
- Little variation in desorption rate with gas composition
• 10 – 11 m³/t
• 95 – 100% CH₄
• 8.4 m³/t
• 80% CO₂
Thresholds – Hunter Valley Mines

![Graph showing Qm at 900 DRI (m³/t) vs. CO2 (%) for various mines in the Hunter Valley. The mines include Lama Structured (BU), Wambo, Middle Liddell, Barrett, Hebden, Kayuga/Mt Arthur, Vaux, Blakefield, Glen Munro, Woodlands Hill, Bayswater, and Edinglassie.]
Thresholds – Gunnedah Basin

- 6.2 m³/t
- 67 - 93% CO₂
Thick banded seams

- Characterized by:
  - 8 – 11 m thick
  - Lithological variation, banded upper sections
  - Outburst thresholds 6 – 7.5 m3/t
  - Gas reservoir size 40 – 140 m3/m2 and 30 – 90 m3/m2
Thick banded seams – OB management

- Challenges presented by seam lithology:
  - Testing and characterising the gas reservoir
  - Gas drainage
  - Outburst barrier definition
  - Gas content testing for compliance
  - Authority to mine procedures
Closing comments

- DRI900 provides a means of transferring the BU seam thresholds to other seams utilising seam specific criteria.
- The desorption rate method is arguably simplistic but does to some extent incorporate the parameters of:
  - Gas content
  - Gas composition
  - Coal strength
  - Diffusivity
- To date it has proven successful in combination with modern gas drainage programs and rigorous risk management systems.
- Hard to see a move away from the gas content / desorption rate based thresholds given the success achieved to date and the need to validate any new form of threshold.
- Ian Gray’s work on thresholds based on potential energy release offers some promise but at this stage it is not clear that it will provide a practicable or verifiable solution.
- The most certain path to raising thresholds is to clearly define unstructured coal.
Opportunities

- Opportunities that exist to improve our management of the outburst risk:
  - Systematic and long term monitoring program of West Cliff & Tahmoor to prove through quantification the safety of raised thresholds
  - Critical assessment of the work done by CSIRO and Gray to determine if it can be incorporated into mining operations
  - Development of our understanding of the causes of variation in measured gas desorption rates
  - Definition of appropriate barrier sizes in non-Bulli seams
  - Gas / Outburst risk management in thick banded seams presents itself as one of the industries next big challenges and is likely to progress our outburst management practices. It is also likely that Engineering Solutions will precede scientific solutions
Thankyou
Since 1994

Since the last fatal outburst at West Cliff in January 1994 (ex the twin fatality at Mt Davey) and the implementation of OMP there has been a significant reduction in the occurrence of outburst in Australia

- **Ellalong** (Greta seam) (1994)
  - 5 outburst (up to 30t) associated with bedding plane shearing and high stress
  - Measured gas content ranged from 4.9 m3/t to 7.2 m3/t (80% CO2)

- **Mt Davey NZ** (Sub Morgan seam) (Nov 1997 – July 1999)
  - 21 outbursts, twin fatality (30t) during drift development
  - Maximum gas content measured 9.6 m3/t, predominately CH4

- **West Cliff** (BU seam) (April 1998)
  - Outburst on face of LW23, bedding plane fault, up to 22 m3/t 100% CO2

- **Tower** (BU seam) (Dec 2000)
  - Outburst on a dyke during remote mining, up to 13.5 m3/t 92% CH4

- **Central** (German Ck seam) (20 July 2001)
  - Outburst on a strike slip fault, 6.9 m3/t to + 8-9 m3/t 100% CH4

- **North Goonyella** (GM seam) (22nd Oct 2001)
  - Outburst on a strike slip fault, 6.5 m3/t 100% CH4

- **Appin** (BU seam) (18th March 2002)
  - Outburst on a shear structure during remote mining, up to 12-14 m3/t 95% CH4

- **Appin** (BU seam) (2009)