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# Application of Outburst Thresholds to Non-Bulli Seam Mines

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## Scope

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

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## 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

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## Early Bulli seam gas content thresholds

- Lama circa 1991
- Desorbable gas content thresholds
  - Structured coal
    - 4 m<sup>3</sup>/t (100% CO<sub>2</sub>)
    - 8 m<sup>3</sup>/t (100% CH<sub>4</sub>)
  - Unstructured coal
    - 7 m<sup>3</sup>/t (100% CO<sub>2</sub>)
    - 10 m<sup>3</sup>/t (100% CH<sub>4</sub>)

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## Bulli seam threshold origins

- Bulli seam experience
- Overseas experience (Re; Table 6 of Lamas 1995 paper)
  - Ibbenburen (Germany) 9 m<sup>3</sup>/t (100% CH<sub>4</sub>)
- Collinsville EV meter read (100% CO<sub>2</sub>)

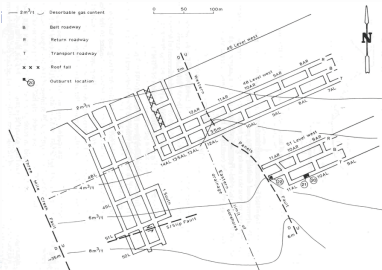


Fig. 6. Mining plan layout for areas monitored

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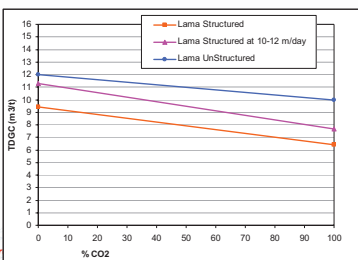
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## Desorbable to TDGC

Thresholds in structured coal		
	CH <sub>4</sub>	CO <sub>2</sub>
Desorbable gas content (m <sup>3</sup> /t)	8	4
Residual (x, m <sup>3</sup> /t)	2	2.4
Total Desorbable gas content (m <sup>3</sup> /t)	10 (9.4)	6.4

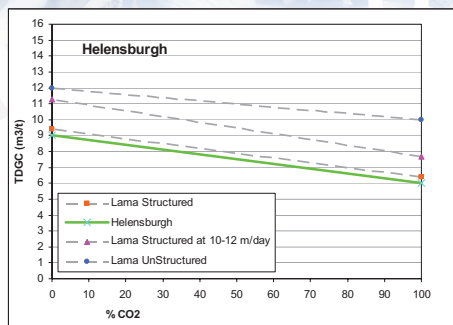
Thresholds in unstructured coal		
	CH <sub>4</sub>	CO <sub>2</sub>
Desorbable gas content (m <sup>3</sup> /t)	10	7
Residual (x, m <sup>3</sup> /t)	2	2.4
Total Desorbable gas content (m <sup>3</sup> /t)	12	9.4

(Lama 1995)	CH <sub>4</sub>	CO <sub>2</sub>
Dry isotherm	2.21	6.76
Moist isotherm	1.67	3.72
UG cores	2.01	1.96
UG cores (other lab)	2	2.9
Surface cores	2.13	1.09
Mean	2	3.27

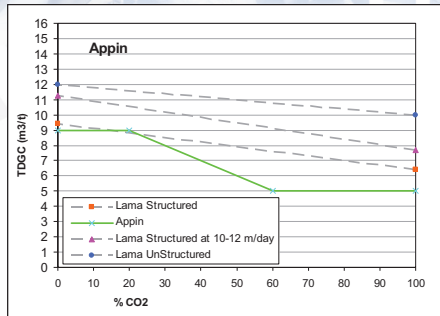


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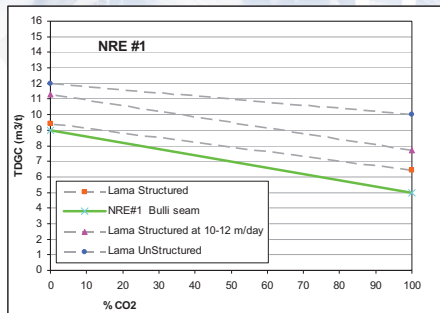
### Thresholds adopted - Helensburgh



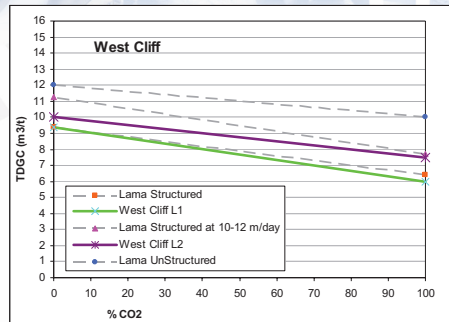
### Thresholds adopted - Appin



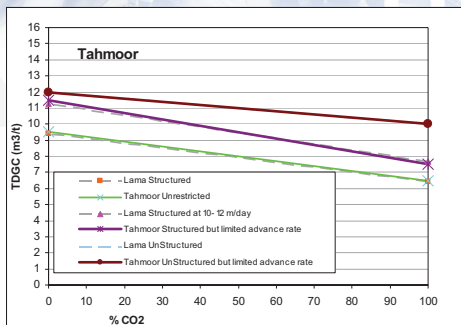
### Thresholds adopted - NRE#1



### Thresholds adopted - West Cliff

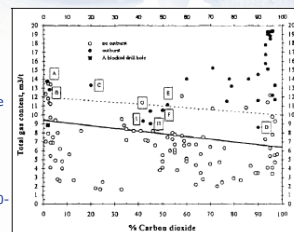


### Thresholds adopted - Tahmoor



### 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, ...
  - CO<sub>2</sub> >>> CH<sub>4</sub>
- GeoGAS DRI900 transfer BU seam thresholds to non-BU seam mines

### Gas desorption rate is

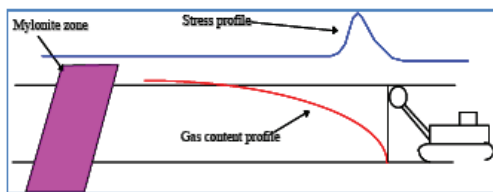
- The rate at which gas diffuses from the coal matrix into the cleat system, it is effected by:
  - Gas content
  - Gas composition
  - Inherent coal properties
  - Particle size
  - Moisture
  - Temperature
- Described by Ian Gray as "... a combined measurement of the crushability of coal, diffusion 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

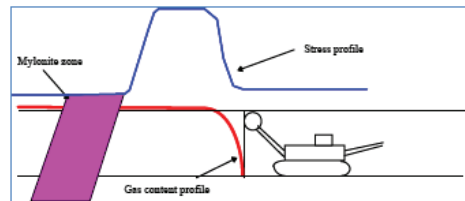


### Outburst initiation



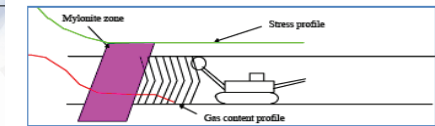
- Normal mining is characterised by relatively low gas content gradient ahead of the face and regular stress distribution

### Outburst initiation



- Approaching an outburst structure the coal hardens in response to increased stress, permeability declines and the gas content gradient steepens

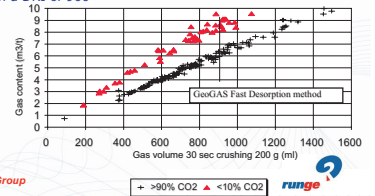
### Outburst initiation



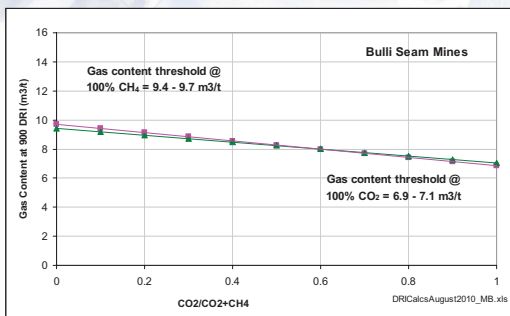
- With continued mining the highly stressed barrier suddenly fails:
  - The stress is suddenly reduced
  - The ambient fluid pressure on the coal changes from being mostly above desorption pressure to suddenly being well below the desorption pressure for the gas content of the coal
  - The rapid increase 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

### DRI900

- 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 CO<sub>2</sub> was higher than for CH<sub>4</sub>
  - A gas content of 9.5 m<sup>3</sup>/t (CH<sub>4</sub>) has essentially the same desorption rate as a gas content of 6.2 m<sup>3</sup>/t (CO<sub>2</sub>)
  - The threshold values coincide with a DRI of 900



### BU seam checks



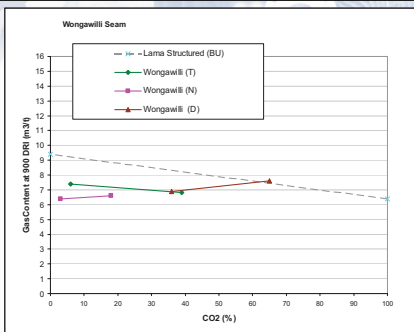
### Non Bulli seam thresholds

- 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



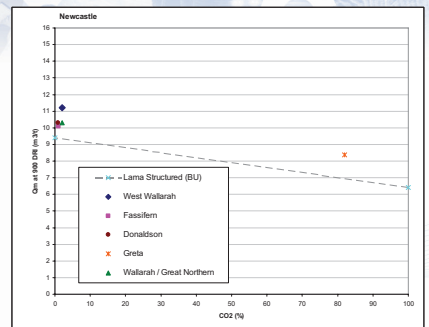
### WW seam thresholds

- 6.5 – 7.5 m<sup>3</sup>/t
- 0 – 65% CO<sub>2</sub>
- Little variation in desorption rate with gas composition

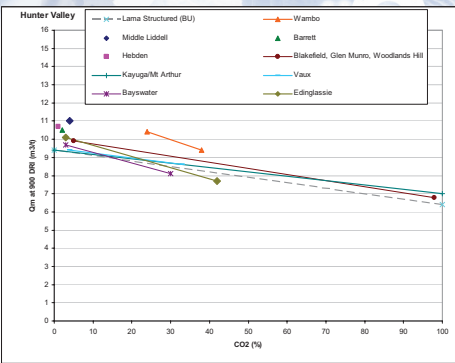


### Thresholds – Newcastle Mines

- 10 – 11 m<sup>3</sup>/t
- 95 – 100% CH<sub>4</sub>
- 8.4 m<sup>3</sup>/t
- 80% CO<sub>2</sub>

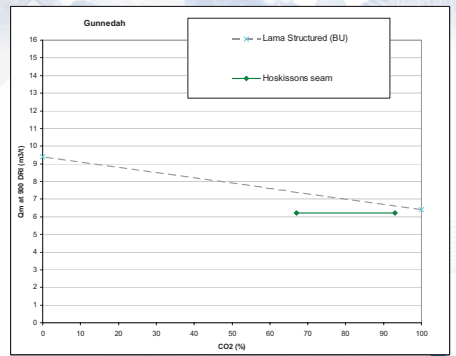


### Thresholds – Hunter Valley Mines

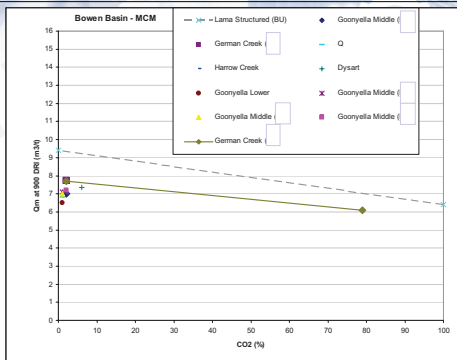


### Thresholds – Gunnedah Basin

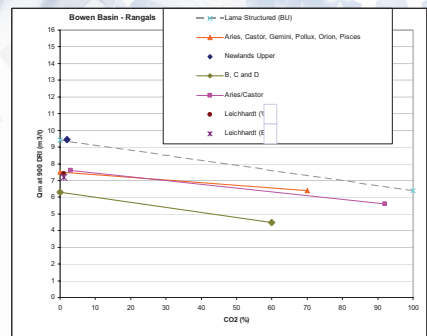
- 6.2 m<sup>3</sup>/t
- 67 - 93% CO<sub>2</sub>



### Thresholds – Bowen Basin (MCM)

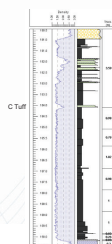
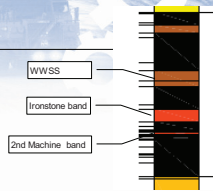


### Thresholds – Bowen Basin (Rangals)



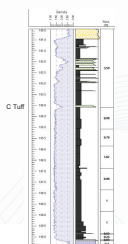
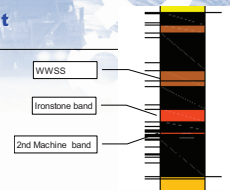
### Thick banded seams

- Characterized by:
  - 8 - 11 m thick
  - Lithological variation, banded upper sections
  - Outburst thresholds 6 - 7.5 m<sup>3</sup>/t
  - Gas reservoir size 40 - 140 m<sup>3</sup>/m<sup>2</sup> and 30 - 90 m<sup>3</sup>/m<sup>2</sup>



### 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

## GeoGAS

# 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 m<sup>3</sup>/t to 7.2 m<sup>3</sup>/t (80 % CO<sub>2</sub>)
  - **Mt Davey NZ (Sub Morgan seam) (Nov 1997 - July 1999)**
    - 21 outbursts, twin fatality (30t) during drift development
    - Maximum gas content measured 9.6 m<sup>3</sup>/t, predominately CH<sub>4</sub>
  - **West Cliff (BU seam) (April 1998)**
    - Outburst on face of LW23, bedding plane fault, up to 22 m<sup>3</sup>/t 100% CO<sub>2</sub>
  - **Tower (BU seam) (Dec 2000)**
    - Outburst on a dyke during remote mining, up to 13.5 m<sup>3</sup>/t 92% CH<sub>4</sub>
  - **Central (German Ck seam) (20 July 2001)**
    - Outburst on a strike slip fault, 6.9 m<sup>3</sup>/t to + 8.9 m<sup>3</sup>/t 100% CH<sub>4</sub>
  - **North Goonyella (GM seam) (22<sup>nd</sup> Oct 2001)**
    - Outburst on a strike slip fault, 6.5 m<sup>3</sup>/t 100% CH<sub>4</sub>
  - **Appin (BU seam) (18<sup>th</sup> March 2002)**
    - Outburst on a shear structure during remote mining, up to 12-14 m<sup>3</sup>/t 95% CH<sub>4</sub>
  - **Appin (BU seam) (2009)**