Portable Quick Crush Gas Content Measurement
A Step Change for the Coal Industry

Dr Basil Beamish MAusIMM CP (Min) RPEQ
B3 Mining Services Pty Ltd
PO Box 1565, Toowong BC QLD 4066
basil@b3miningservices.com
Mobile: 0488 708 949

A/Prof Mehmet Kizil
School of Mechanical and Mining Engineering
The University of Queensland
Presentation outline

• Why do we need a portable gas content measuring device?
• Does such an instrument exist?
• What does it look like and how does it work?
• What do the results look like?
• Do the results fit accepted theories on gas desorption?
• Case study results
• Conclusions
Existing gas content measurement and limitations

- Slow desorption method for measuring $Q_1$, $Q_2$ and $Q_3$
- Fast desorption method made possible with quick crush to speed up obtaining results. Developed in early 1990’s and refined over the years, but still dependent on samples being sent to laboratory
- Need for measurements on site, preferably at the mining face in the case of rapid results for compliance
- Should be capable of establishing total gas content and desorption rate data
- A portable gas content device was developed sometime ago for measuring $H_2S$ content of coal
Portable Gas Content Analyser (PGCA)

- Early prototype PGCA
- Consists of robust crushing head, sturdy stainless steel chamber and fittings for gas flow control
- Portable gas analysing system
- Upgraded version now available
High volatile bituminous coal (352m)

CH4 (m³/t) CO2 (m³/t) Total gas (m³/t)
Gas desorption model

- Simple unipore diffusion model fails to describe the complete gas desorption from coal
- Bidisperse pore model is more appropriate
- Consists of macropore (rapid) diffusion described by
  \[ \frac{V_a}{V_{a\infty}} = 1 - \frac{6}{\pi} \sum_{n=1}^{\infty} \frac{1}{n^2} \exp \left[ -n^2 \pi^2 D_{ea} t \right] \]
- Micropore (slow) diffusion described by
  \[ \frac{V_i}{V_{i\infty}} = 1 - \frac{6}{\pi} \sum_{n=1}^{\infty} \frac{1}{n^2} \exp \left[ -n^2 \pi^2 D_{ei} t \right] \]
Desorption model curve-fitting

\[ CH_4 = 2.398 - 6.218e^{-2.094t} - 1.534e^{-0.129t} \]

\[ CO_2 = 4.79 - 10.465e^{-1.341t} - 1.258e^{-0.109t} \]
Gas contents from borehole cores

![Graph showing gas contents from borehole cores with depth. The graph plots gas content (m$^3$/t) against depth (m). Different markers represent GeoGAS and PGCA data points.]
Gas composition trend

![Graph showing CH₄/(CH₄+CO₂) ratio against depth (m) with data points for GeoGAS and PGCA.]

©B3 Mining Services Pty Ltd   Gas and Coal Outburst Committee Seminar
Wollongong, November 2012
Schematic of mixed $\text{CH}_4/\text{CO}_2$ desorption (Crosdale, 1998)

1. Initial state at end of adsorption
2. Pressure reduction permits desorption of more weakly bonded $\text{CH}_4$, freeing up some sites for the more strongly bonding $\text{CO}_2$
3. Continuing pressure reduction results in release of less strongly adsorbed $\text{CH}_4$, coal retains mostly $\text{CO}_2$
4. Sudden release of $\text{CO}_2$ at low pressure completes the desorption
Desorption rate and gas content

\[ y = 0.0102x \]
\[ R^2 = 0.8047 \]

\[ y = 0.0072x \]
\[ R^2 = 0.9286 \]
Reactive lignite gas content and CO production

![Graph showing gas content and CO production over time.](image)

- **Gas content (m³/t)**
- **CO make (L/t)**
- **Time (mins)**

**Graph Legend:**
- CH₄
- CO₂
- CO₂ + CH₄
- CO
Examples of gas content and sponcom results for various coals

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>CH\textsubscript{4} (m\textsuperscript{3}/t)</th>
<th>CO\textsubscript{2} (m\textsuperscript{3}/t)</th>
<th>CH\textsubscript{4}+CO\textsubscript{2} (m\textsuperscript{3}/t)</th>
<th>H\textsubscript{2}S (L/t)</th>
<th>CO make (L/t)</th>
<th>Graham’s ratio</th>
<th>R\textsubscript{70} (°C/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CLER13#</td>
<td>0.24</td>
<td>0.12</td>
<td>0.35</td>
<td>0.12</td>
<td>3.77</td>
<td>0.25</td>
<td>5.96</td>
</tr>
<tr>
<td>CLER16#</td>
<td>0.25</td>
<td>0.07</td>
<td>0.32</td>
<td>0.00</td>
<td>3.70</td>
<td>0.19</td>
<td>5.69</td>
</tr>
<tr>
<td>CLER17#</td>
<td>0.24</td>
<td>0.12</td>
<td>0.35</td>
<td>0.00</td>
<td>2.82</td>
<td>0.23</td>
<td>5.08</td>
</tr>
<tr>
<td>NARR1B5#</td>
<td>0.48</td>
<td>2.40</td>
<td>2.88</td>
<td>0.00</td>
<td>4.12</td>
<td>0.23</td>
<td>7.69</td>
</tr>
<tr>
<td>NARR2B5#</td>
<td>0.23</td>
<td>3.21</td>
<td>3.44</td>
<td>0.00</td>
<td>4.21</td>
<td>0.22</td>
<td>7.59</td>
</tr>
<tr>
<td>PI22SP1A*</td>
<td>0.00</td>
<td>0.29</td>
<td>0.29</td>
<td>0.61</td>
<td>91.99</td>
<td>2.97</td>
<td>26.17</td>
</tr>
</tbody>
</table>

#values obtained after 20 hours; *values obtained after 4 hours
Conclusions and PGCA potential

- Accurate gas content results
- Rapid determination of gas drainage effectiveness
- Potential for quick desorption rate index assessment for outburst proneness
- Identifies hydrogen sulphide prone areas
- Preliminary sponcom indication
- Can distinguish between coal types through the seam profile
- Can be used for greenhouse gas inventory
References

Questions?