Mines Gas: Managing Scotland’s Mining Legacy

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Presentation Content

1. Introduction and the mines gas hazard

2. Coal mining legacy within the UK & Scotland

3. Gas protection measures

4. The Gorebridge incident
Sept 2013 - Gorebridge
Council tenants overcome by mines gas and taken to hospital
Location of UK during the late Carboniferous (about 300 ma)

60 million years of alternating shallow seas, mangrove swamps and forests
Coal and Gas Formation

Plant material buried and subjected to:
- Time,
- Pressure
- Heat

© Steve Greb, Kentucky Geological Survey
Extensive coal fields throughout:

• Central Scotland
• Northern and Central England
• North & South Wales
Increasing Depth, Pressure and Temperature

- Peat
- Lignite
- Sub-bituminous
- Bituminous
- Semi-Anthracite
- Anthracite
- Meta-Anthracite

Methane Content (per tonne of coal worked)

- Coal formed with natural gas:
  - 80-95% methane
  - some higher chain alkanes
  - Some nitrogen
  - Some carbon dioxide

50 to 100 m³/tonne
Hazardous Mine Gases

Both Chronic & Acute Risks

Firedamp
Blackdamp or Stythe gas
Afterdamp

Methane
Carbon Dioxide & Nitrogen
Carbon Monoxide

CH$_4$
CO$_2$
N$_2$
CO
UK Mines Gas Incidents

• Between **1851 and 1980** - 186 coal mine explosions causing 10,000 fatalities *(CIRIA 152)*

• **1980** – Evacuation of homes in Rotherham *(Guardian, 31.1.2001)*


• **1988** – Demolition and relocation of entire village of Arkwright *(DoE 1996)*

• **1995** – Fatal asphyxiation in stable in Widdrington *(DoE 1996)*

• **1998** – Fatal asphyxiation in service trench in Barnsley *(NCE, 1999)*

• **2000’s** – Explosion in home in Workington *(Allerdale BC, 2006)*

• **2000’s** – Demolition and rebuild of school in Workington *(Allerdale BC, 2006)*

• **2013** – Hospitalisation of council tenants in Gorebridge *(IMT, 2017)*
Blantyre Mining Disaster, 1877
South Lanarkshire
Scotland's worst ever mining accident

- On 22 October 1877, Pits No. 2 and No. 3 of Blantyre Colliery were the site of an explosion.
- A total of 207 miners were killed, the youngest being a boy of 11.
- It was known that firedamp (methane) was present in the pit and it is likely that this was ignited by a naked flame.
Auchengeich Colliery Disaster 1959
North Lanarkshire

47 men died in the colliery fire in
18th September 1959
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11% of the UK is occupied by the UK coalfield

172,000 recorded mine entries

7 million properties lie within Britain's coalfield

130,000 properties lie within 20 metres of at least one mine entry

360,000 abandoned mine plan

Coal Authority Data
Coal Mines Regulation Act, 1887

Progression from:
• workings at coal outcrop
• single shaft ‘bell pits’

to:
• ‘pillar and stall’ workings

and finally
• ‘long wall’ mining

172,000 recorded mine entries
Probably same number of unrecorded pre-1887 entries
Early Coal Mining

- Initially worked from outcrop
- Then via ‘Bell Pits’
- No records
Pillar and Stall Workings

• Typically 30% coal extraction

• If shallow can lead to crown-hole surface collapse

• If pillars ‘robbed’ through retreat mining surface subsidence occurred
Long wall mining

Total extraction with progressive subsidence at the surface
Scottish Coal Field
UK coal production peaked in 1913 at 287 million tonnes.

When the coal industry was nationalised in 1947, there were 225 collieries in Scotland.
North Lanarkshire Area

The Coal Authority

Interactive Map  Enter location

[Map Image]
North Lanarkshire Area

Shallow mine workings (recorded)
North Lanarkshire Area

Shallow mine workings (probable)
North Lanarkshire Area

The Coal Authority

Interactive Map  

Coal outcrops
North Lanarkshire Area

All opencast, shallow and probable mined areas
North Lanarkshire Area

Recorded mine entries: Adit x
(Post 1887 Act) Shaft x
Development Challenges in Former Mining Areas

Issues

• Long term settlement (opencast back fill)
• Subsidence and crown-hole collapse
• Shaft infill collapse (recorded shafts)
• Shaft infill collapse (unrecorded shafts)

Possible engineering solutions

• Reprofiling site and re-compacting
• Dynamic compaction or vibro piles
• Grid drilling & grouting
• Piled foundations
• Raft foundations
Mines Gas Issues (S-P-R)

• Open voids in abandoned mine workings
• Large volumes of gas potentially accumulating
• Preferential gas migration pathways to the surface
  • e.g. shafts and adits
• Pressure driven migration along pathway

Additional factors – introduction of preferential pathways and migration drivers:

• Site investigation boreholes,
• Ground improvement works e.g. drilling & grouting
• Foundation design e.g. vibro-piles, rafts etc.
• Gas migration drivers
  • e.g. pressure falls, rising ground water etc
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To date the UK contaminated land regime is based on:

- Risk based regulation
- Site specific risk assessments
- Source – Pathway – Receptor (Pollutant Linkage Model)
- Tiered risk assessments in accordance with CLR 11 i.e.
  - Tier 1 – Is there a credible pollutant linkage
  - Tier 2 – Generic risk assessment
  - Tier 3 – Detailed site specific (quantitative risk assessment)
- Receptor monitoring
So if so many homes are in former mining areas why haven’t there been more problems?

Older homes were often:

- Built on shallow strip footings
- Had elevated suspended ground floor
- Ventilated sub-floor voids (solum)
- Poorly insulated
- Draughty!
Principle of Passive Dilute and Disperse in Ventilated Void

Plan
Zone of positive pressure

WIND

Zone of negative pressure (suction)

Roof pitch > 30°

Inlet

CIRIA 149, 1995
Protecting the Building Envelope

A) Dilute and disperse (provide a preferential pathway to atmosphere)
B) Exclude ground-gases
Is it all about getting the detailed design right?
Building Gas Protection

Investigate
Building Gas Protection

- Investigate
- Risk
- Assess
Building Gas Protection

- Investigate
- Risk Assess
- Design
Investigate
Risk Assessment
Design
Install

Building Gas Protection
Building Gas Protection

- Investigate
- Verify
- Install
- Risk Assess
- Design
Building Gas Protection

- Investigate
- BS8576: 2013
- CIRIA - C665
- Risk
- Assess
- Verify
- CIRIA C735 2014
- Install
- Design
- BS8485 2019
- BRE 414 2001
Unqualified
• ground-worker

Qualified
• National Occupational Standards VR 612 and VR 613
• NVQ level 2 qualification in gas membrane installation
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Gorebridge Incident

- New housing estate built in 2009
- 7 Sept 2013 council tenants overcome by gas and taken to hospital. Families decanted to alternative accommodation
- April 2014 IMT set up
- Houses demolished in 2016
Scottish Government appointed consultants to carry out a study into carbon dioxide hazards in former mining areas.
Based on Scottish Government guidance on managing public health incidents, the remit of IMT was to:

- Minimise the number of cases of illness...
- Minimise mortality...
- Inform the patients, public etc. of the health risks...
- Collect information for the use in better understanding...

Not to consider who, if anyone, was culpable.
Gorebridge – Coal mining in the area

The Coal Authority
Development Chronology

- 2006 Desk Study identifies possible mines gas
- 2006 SI included spot monitoring on 5 occasions during high atmospheric pressure
- Consultants conclude CS1 ‘low ground-gas risk’ and recommend, ‘no gas protection measures required’
- 2009 sixty four homes built
2013/14 Coal Authority Investigations

87 Newbyres Crescent property inspection of 2 Oct 2013 found:

- 8% CO₂ in downstairs toilet
- 12% CO₂ in Lounge (where son had been sleeping)
- 19% CO₂ beneath kitchen flooring
- 21% CO₂ measured in hole drilled through raft
- 23% CO₂ in wall cavity

Borehole drilled to the shallowest coal seam at 13m bgl:

- 25.1 % CO₂ & 4.6% O₂
- No grout was found in the coal seam
Continuous gas monitoring

Gorebridge Gas Data-87 Newbyres Crescent (under stairs)
2017 IMT Report Conclusions

- Source confirmed as worked coal seam
- Workings not fully grouted
- Grout holes beneath houses possibly not sealed
- SI boreholes beneath houses may not have been sealed
- Vibro stone column foundations
- Service entries through raft not sealed
- No gas protection measures installed
- Highest CO$_2$ associated with falling atmospheric pressure

(IMT Report – from Fairhurst)
Thank you

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