Mine Gas Control

Gas flow behaviour in longwall goafs

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Need for understanding of gas flow behaviour in longwall goafs

- Gas control
  - Development of effective goaf gas control techniques – high gas
  - Optimisation of gas control methods and LW ventilation
- Spontaneous combustion control in working LW goaf
- Prevention of heatings in sealed goafs
- Optimisation of inertisation operations
- Longer and wider LW panels
- Difficult geomechanical conditions
- Gas migration

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Technologies – Goaf gas flow characterisation

- Goaf gas distribution monitoring -with LW retreat
- Ventilation studies
- Face gas patterns
- Tracer gas studies
- Longwall geomechanics
- CFD (Computational Fluid Dynamics) modelling
  - Goaf gas flow modelling
  - Extensive parametric studies
- Field studies -with various gas drainage designs/ systems

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Goaf gas monitoring

- Continuous monitoring
  - Tube bundle system
  - > 10 tubes used for one LW panel goaf
- Gas monitoring on both sides & middle of the goaf
- Tubes shifted with face retreat
- Additional weekly monitoring of all seals
- Ventilation system monitoring
- Effect of changes in mining parameters on goaf gas patterns

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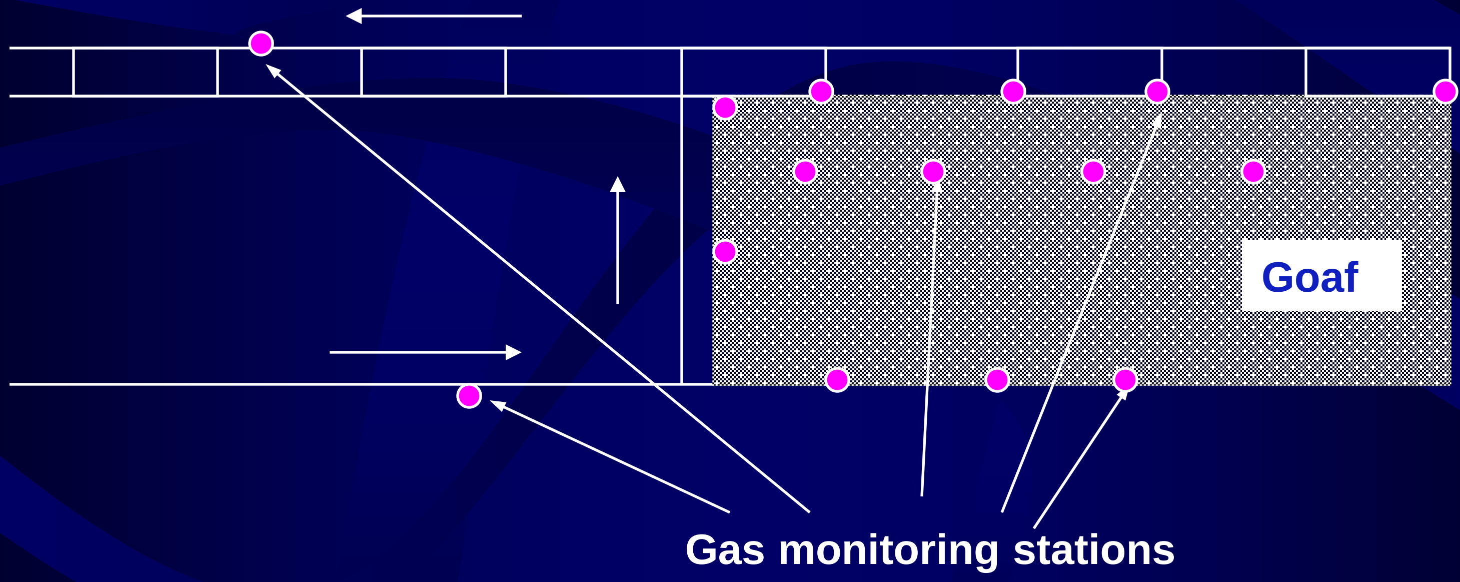
Goaf gas monitoring - Plan



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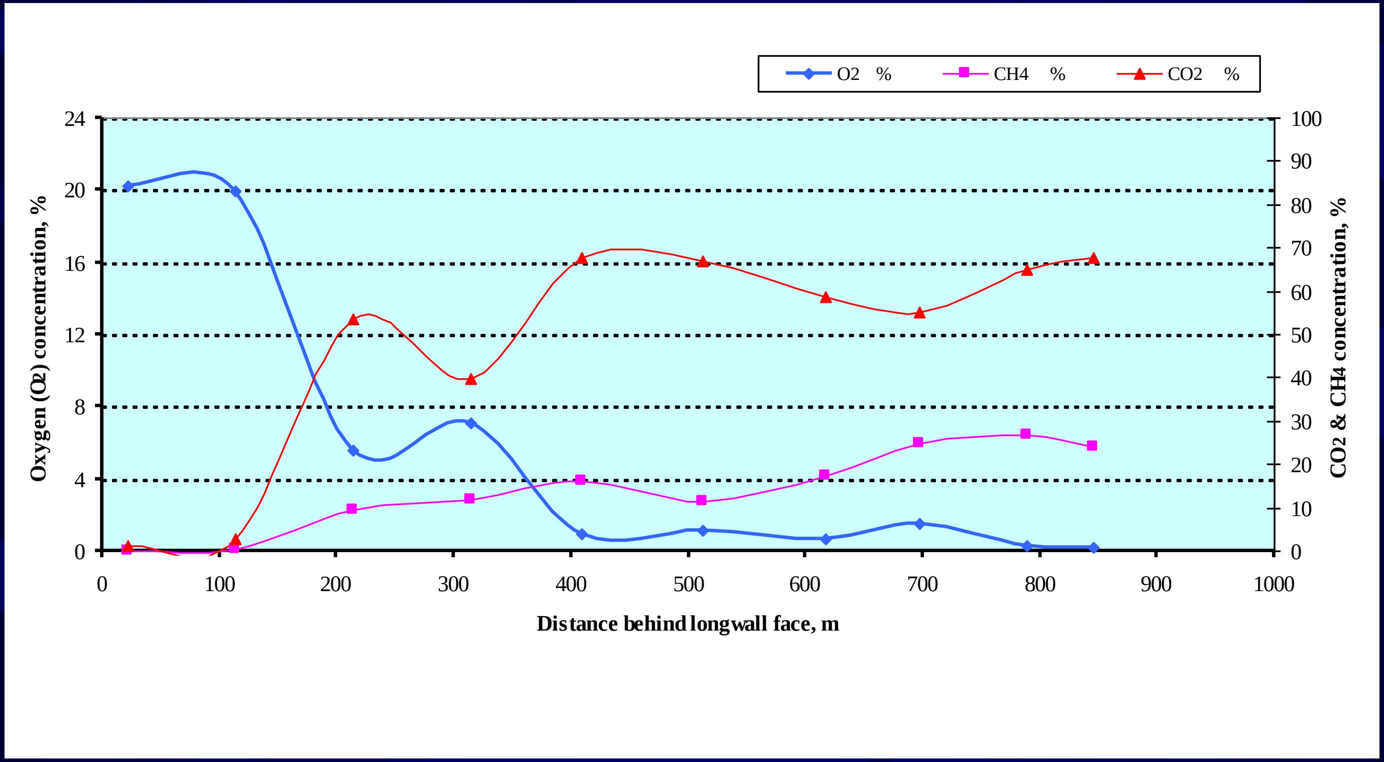
Goaf gas distribution

- **Gas concentration behind the face - on intake side**



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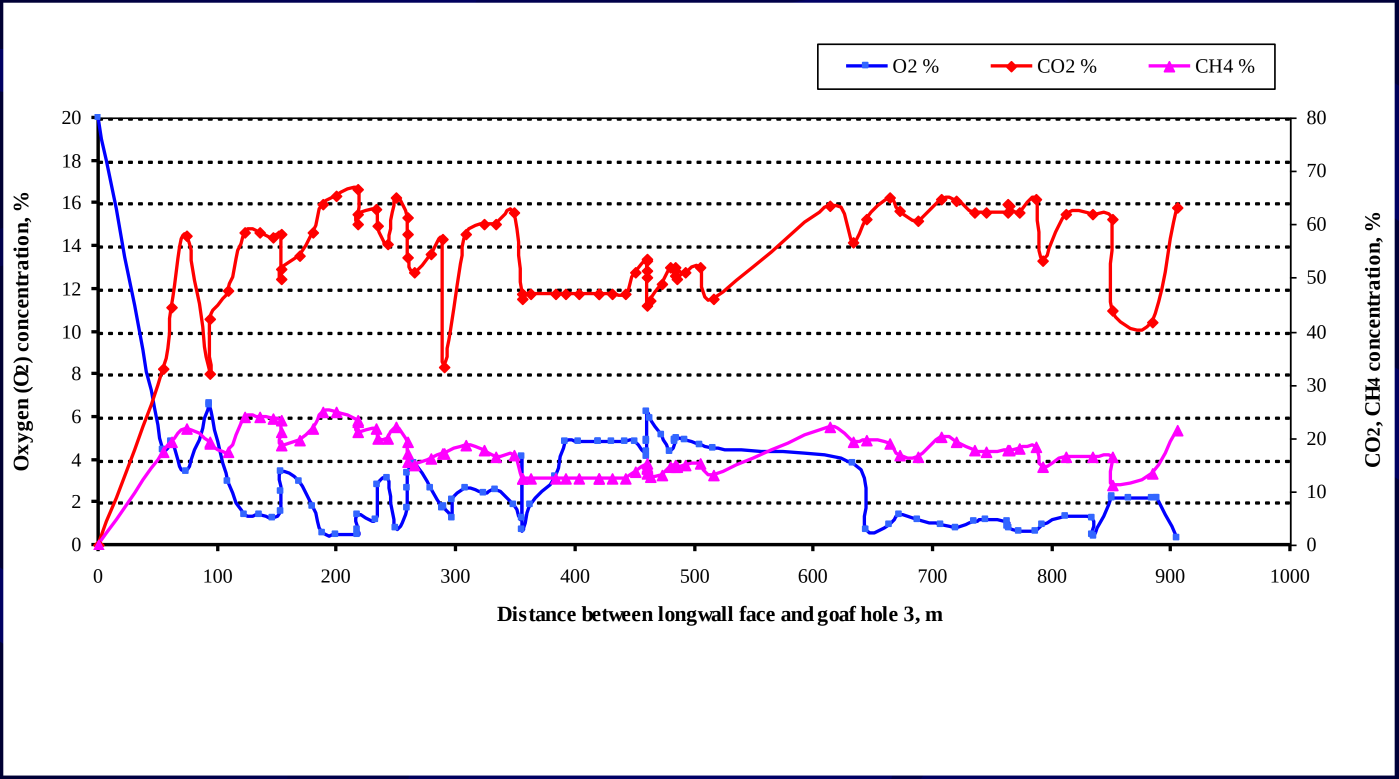
Goaf gas distribution

- **Gas conc. behind the face** - at 60 m from return side gateroad



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Goaf gas distribution - Outcomes

- O_2 concentration in goaf - on intake side
  - 10 - 15 % even at 100 m behind the face – depending on goaf condition
  - depends on intake air quantity/ velocity
- O_2 concentration in goaf - on return side
  - 8 - 12% at 150 m behind the face - two cut-throughs open
  - 2 - 4 % when only one cut-through is open for back return
- Curtain between last chock and rib - good to reduce O_2 ingress
- Only one cut-through should be open for back-return

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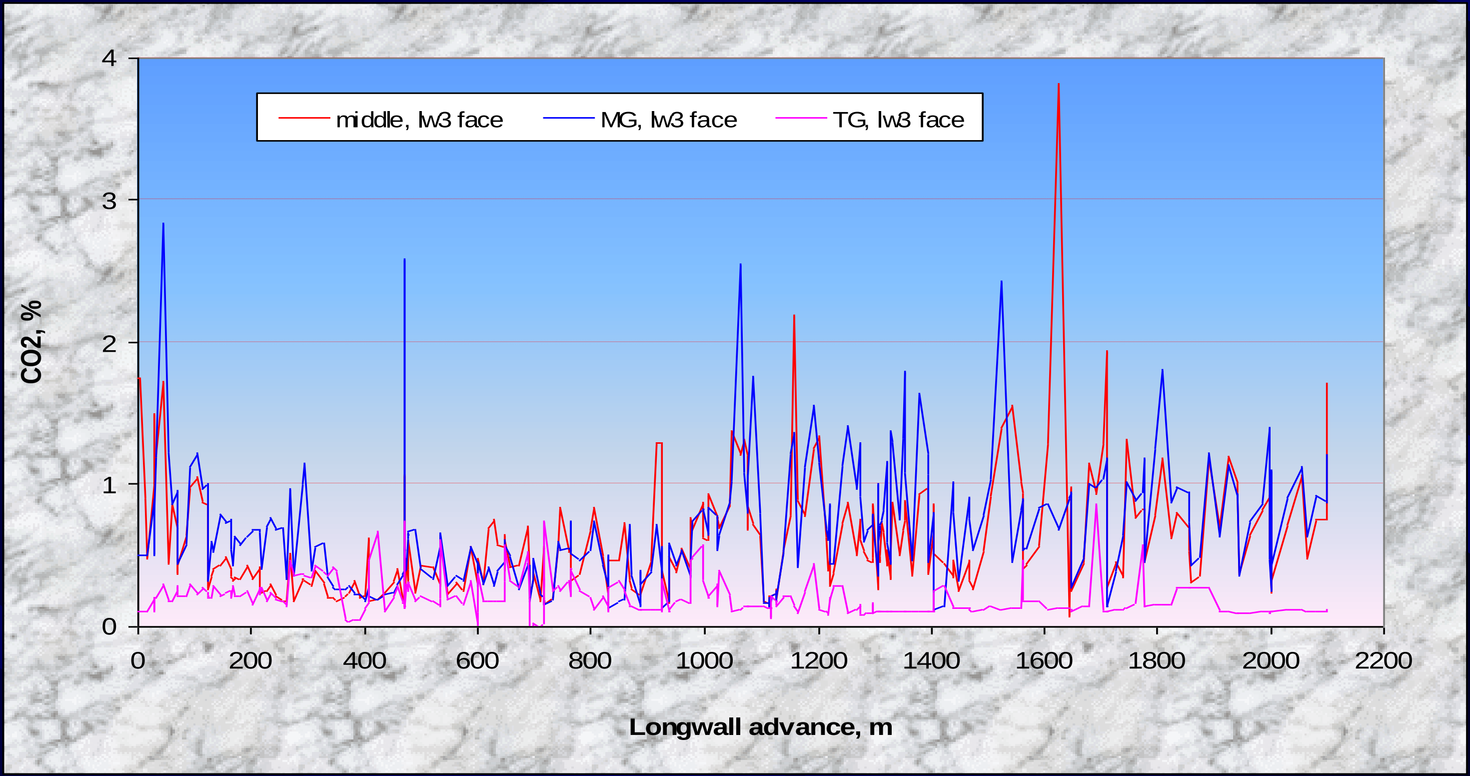
Face gas profiles

- Face gas levels with LW retreat - TG, mid-face, MG



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Face gas distribution

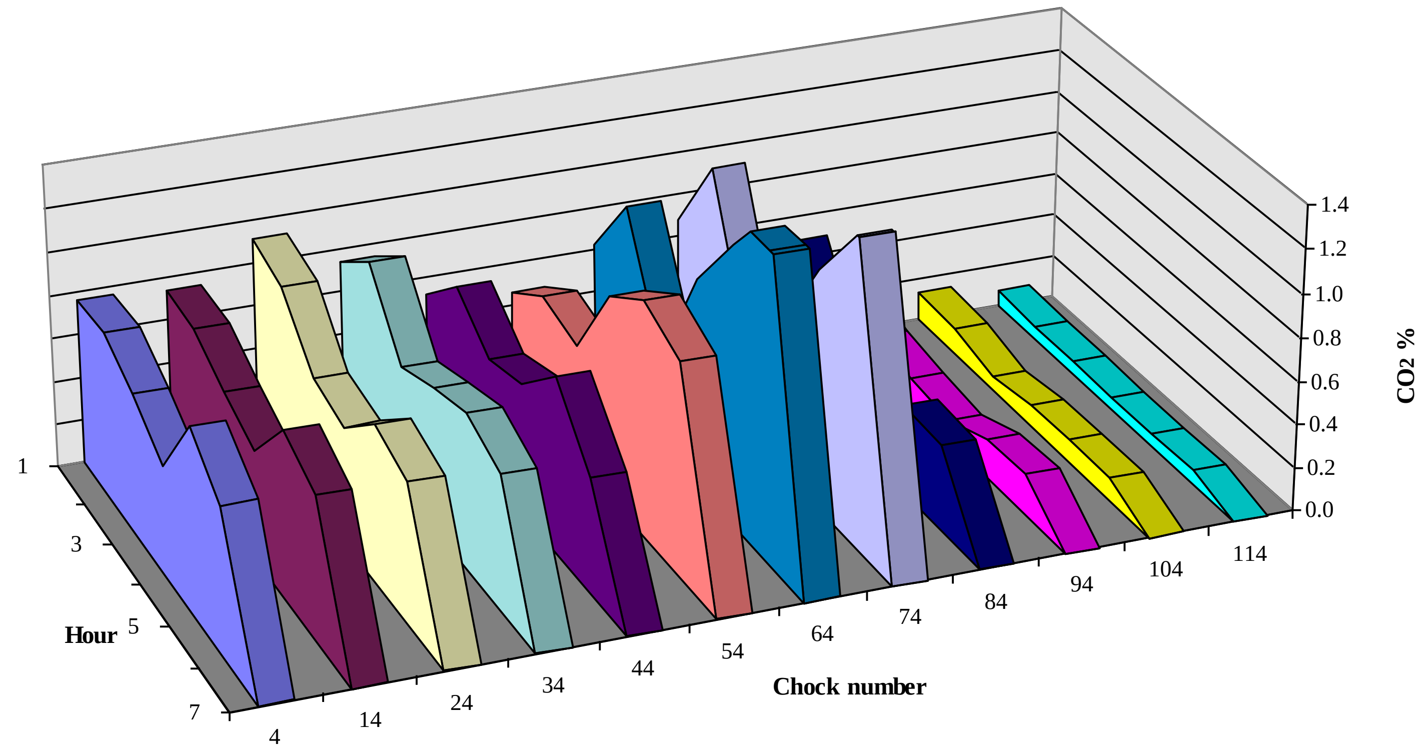

Figure 4.4.2 Longwall face CO_2 gas survey results on night shift

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Face gas profiles - Outcomes

- Face gas profiles depends on
  - ventilation system, caving characteristics, ..
- Face gas level increases linearly
  - - near start-up area + near strong roof/ flat areas
- Face gas level reaches max. at 1/3rd from intake
  - at this mine -in normal conditions
  - indicates goaf gas coming back onto face at 1/3rd dist.
  - goaf caving close to face - within 20 - 30 m behind face

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Tracer gas studies - Gas flow patterns

- SF_6 and He gases were used as tracer gases
- Tracer gas released
  - in the intake of LW
  - in the goaf
- Samples collected from the goaf (& old goaf)- various locations
- Gas sample analysis detection limit - 1 ppb
- 8 tests were conducted successfully in various mines

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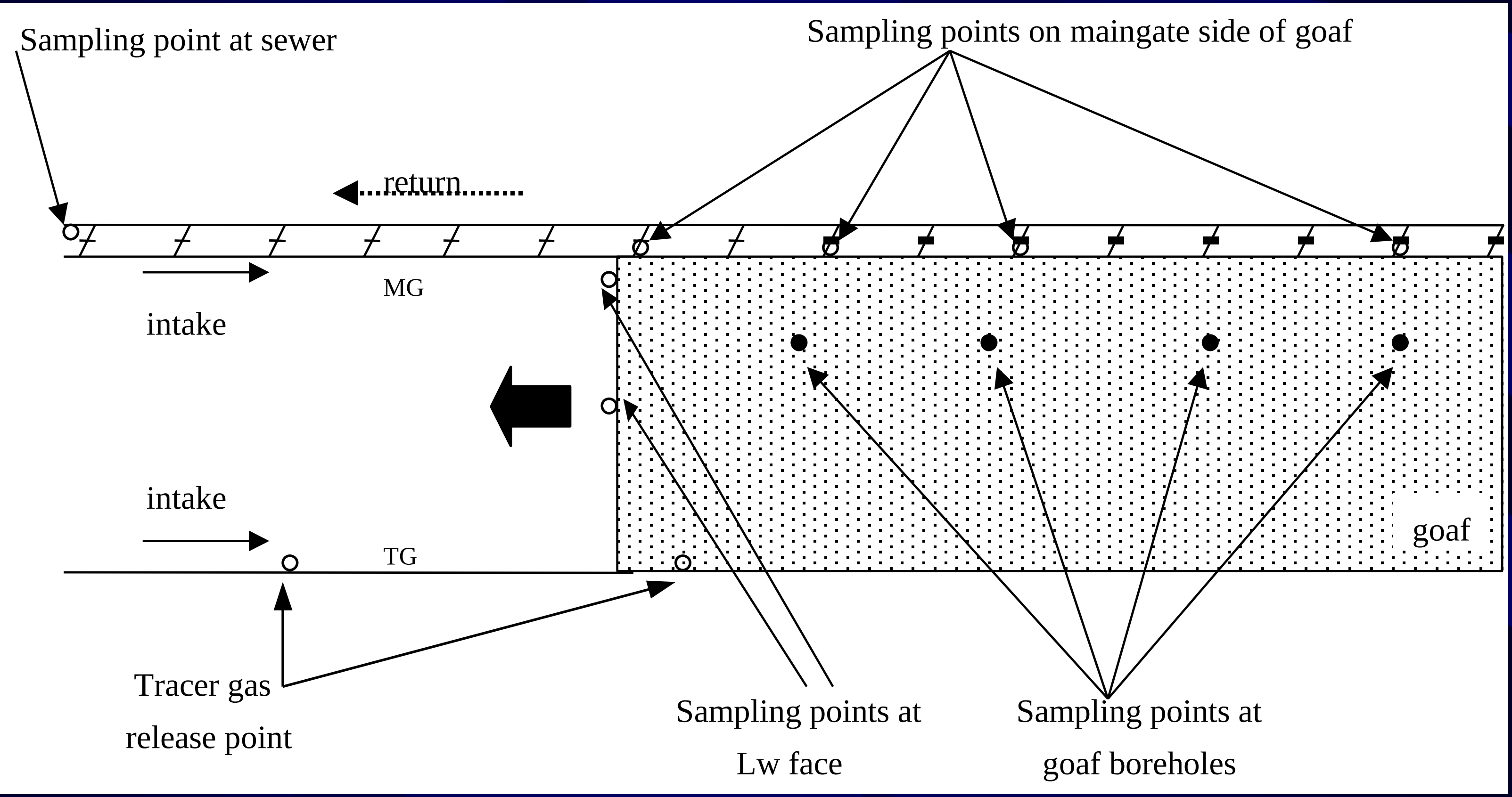
Tracer gas studies - Plan



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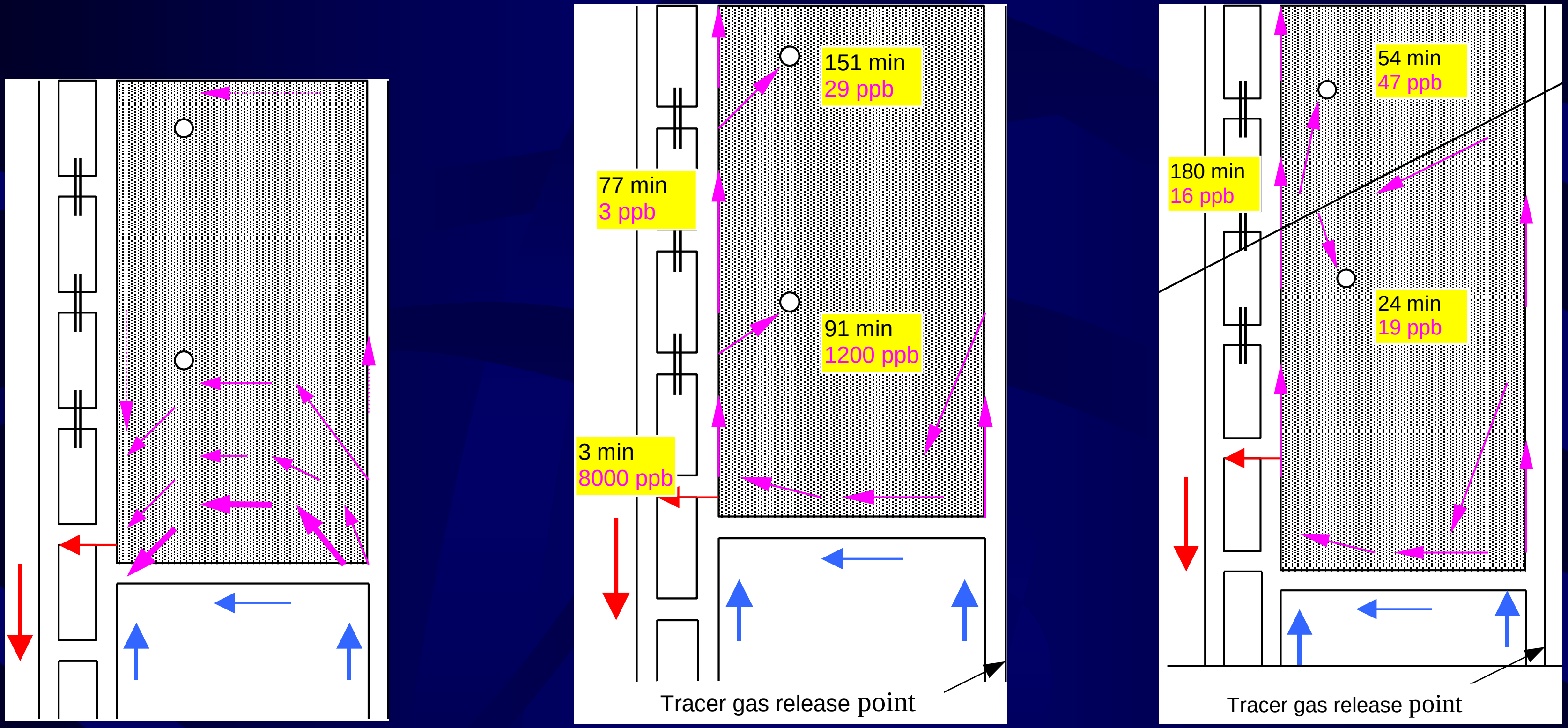
Variations in goaf gas flow patterns



(a) Assumption - simplistic (b)Flow paths – typical – mine A (c) Flow paths near dykes

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Tracer gas studies - Results

- SF_6 reliable tracer gas - detected at all sampling locations
  - He - detected at only few locations + interpretation difficult due to background levels present in coal mines
- Detection times varied from 2 minutes to 10 hours
  - gas detected even at 1,000 m behind the face in 10 hours
- Goaf gas flow velocities at various locations calculated
  - varied from 0.02 m/s to 0.5 m/s
  - used for calibration of CFD models

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CFD modelling studies

- Longwall goaf gas flow model development
- Calibration and fine-tuning - using field data
- Parametric studies
  - effect of ventilation parameters, - system, Quantity, ..
  - effect of mining parameters - cut-throughs,
  - gas emission patterns, gas drainage flow strategy, ...
- Design of gas control techniques/ strategies
  - optimisation

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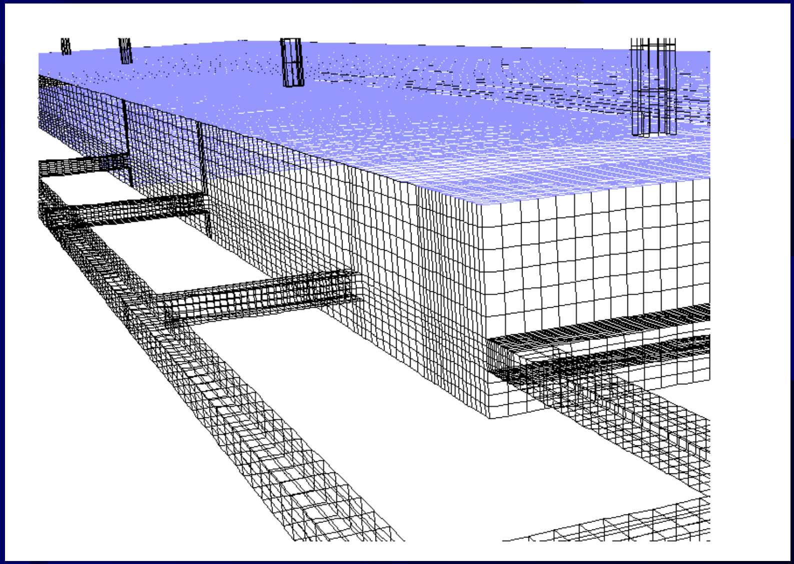
CFD modelling - Model development

- Longwall goaf gas flow model
  - 3D model with > 100,000 cells
  - Sun workstation with 2MB RAM
  - block model - to - continuous model
  - sub-routines developed
- Flow modelling
  - turbulent near face
  - laminar in goaf
- Multi-gas components
  - CH_4, CO_2, O_2, N_2, ...



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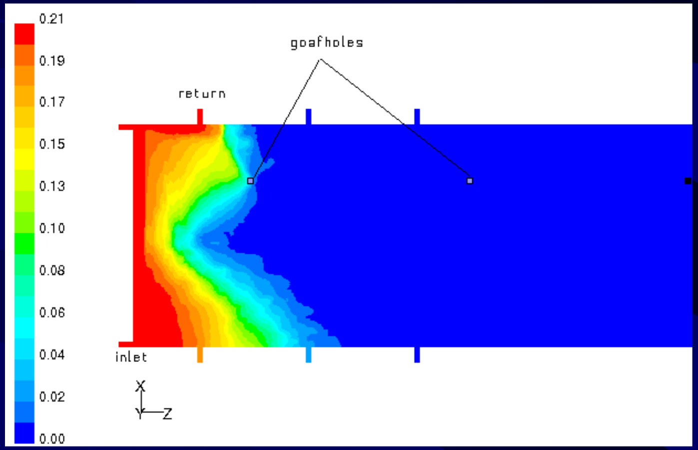
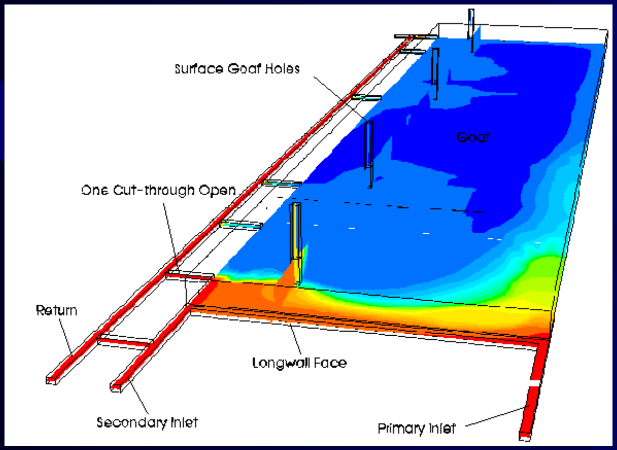
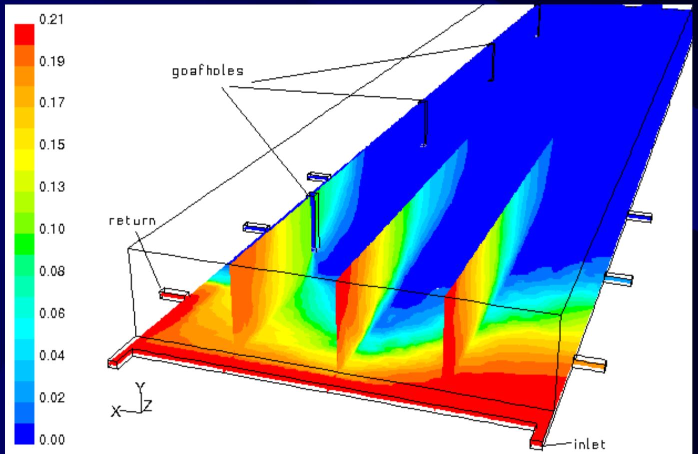
CFD modelling - Results

- Gas flow patterns and distribution in LW goaf in 3D
  - oxygen penetration
    - -more on intake side - varies
  - gas layering - buoyancy effect







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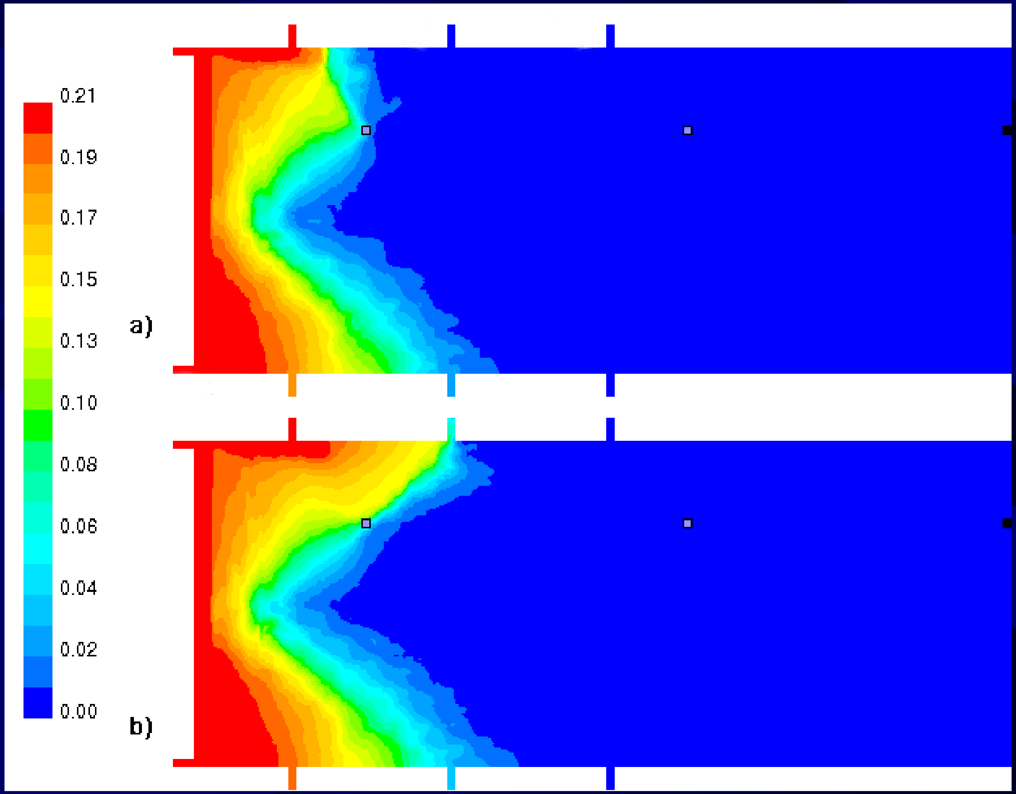
CFD modelling - Typical parametric study

- Effect of number of cut-through's open behind face

(a) 1 c/t open

(b) 2 c/t's open



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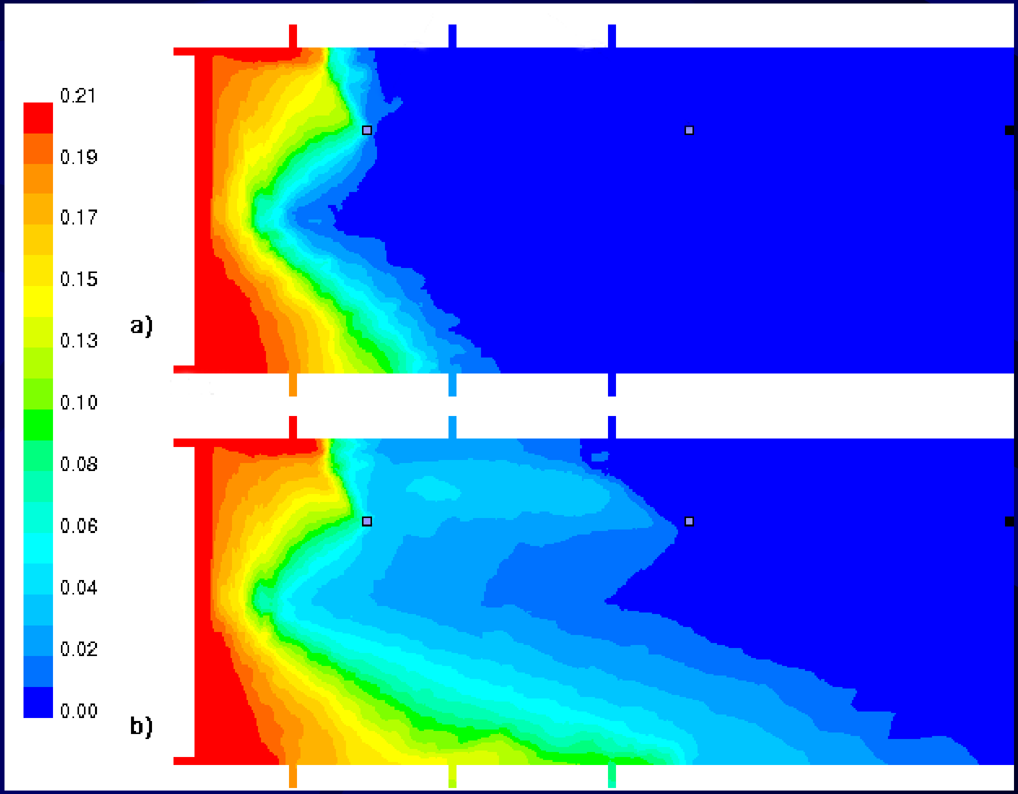
CFD modelling - Typical parametric study

- Effect of "CAN" supports in TG intake

(a) base model

(b) high permeability in TG



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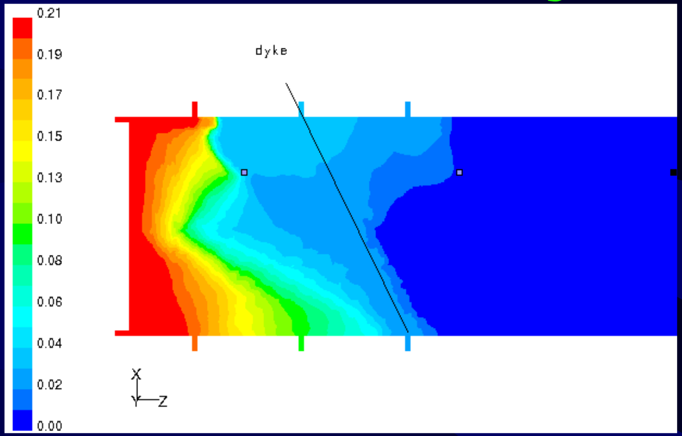
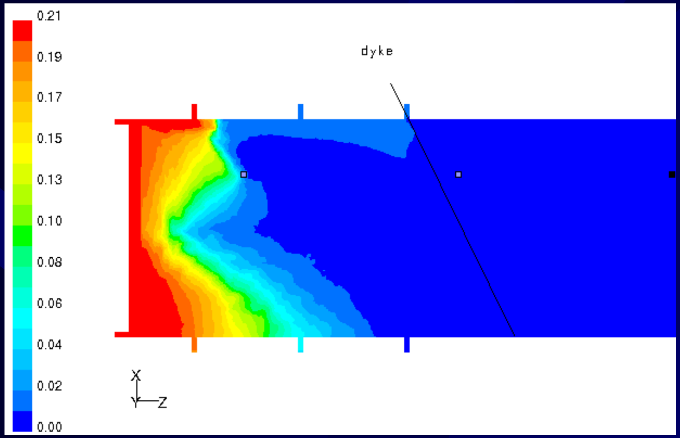
CFD modelling - Typical parametric study

- Effect of "Dykes" in the goaf

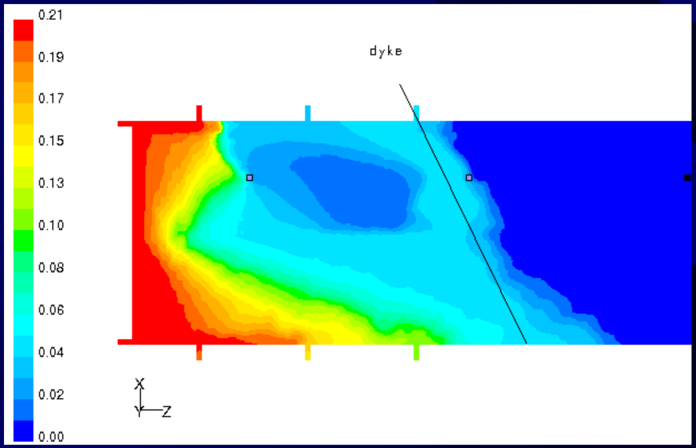
(a) Dyke at 200 m behind



(b) Dyke at 300 m behind



(c) Dyke at 300 m behind + CAN's in TG



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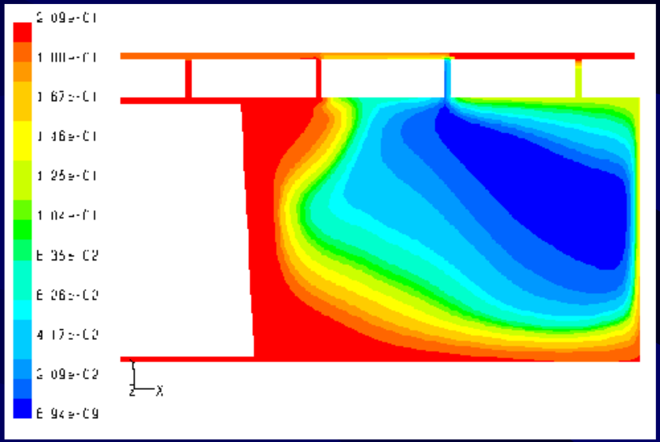
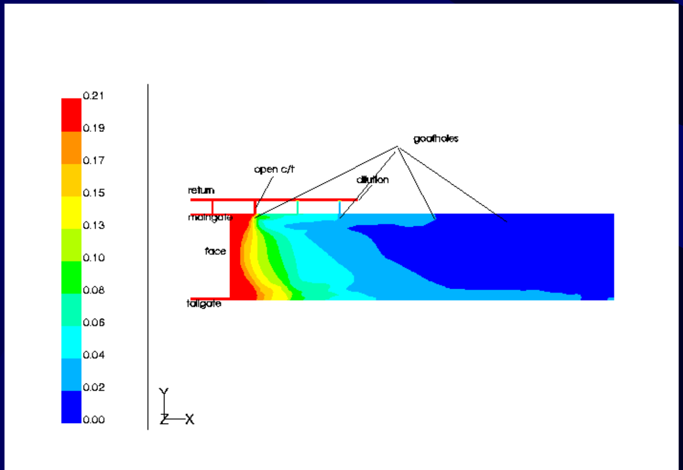
CFD modelling - Goaf hole design

- **Goaf hole location investigations**



O2 distribution - start-up area



Effect of goaf holes on goaf gas distribution

CFD modelling studies - Outcomes

- Goaf gas flow patterns characterised
  - including buoyancy effect
- Showed effect of changes in mining parameters -on goaf gas flow distribution
  - strategies for goaf drainage
  - strategies for spontaneous combustion control
- Goaf hole design
  - indicated optimum values
    - 40 to 50 m from gateroad

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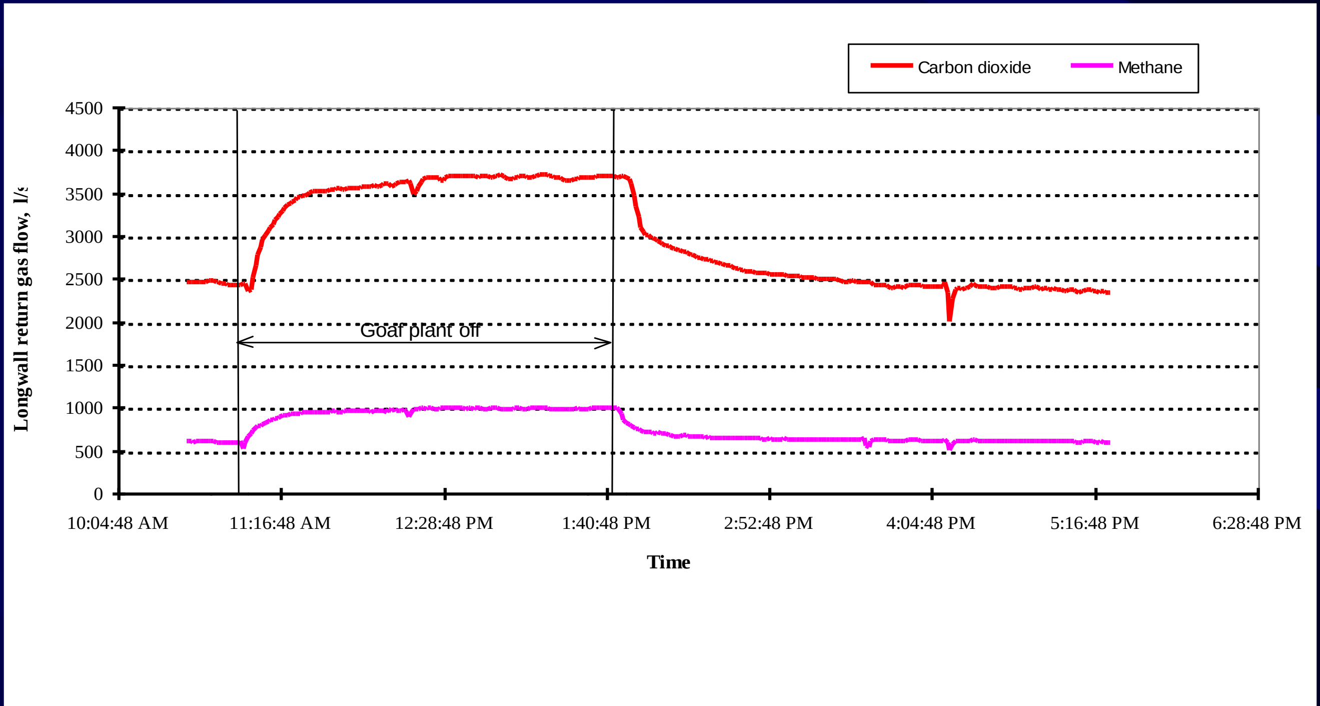
Surface goaf holes effectiveness

- Studies involved - reducing and increasing gas drainage flow (incl. stopping) + measuring gas flow variation in LW return



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Surface goaf hole tests - Results

- Surface goaf hole drainage stopped for testing
- LW gas levels started increasing immediately
  - response time - 5 min. to 2 hr to > day -to reach peak levels
    - depends on caving characteristic, bed separation, hole location, ..
  - > 80 to 90 % of gas plant gas migrated to LW return - for goaf hole at 100 to 200 m - within 30 min. to 3 hours
  - > 60 to 80 % - when goaf hole located at > 600 m.
- Goaf holes drainage reduces LW gas levels
  - not just extra gas drainage

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Gas Control – developments

- changes implemented in gas drainage system – using knowledge obtained from all the above studies

- Goaf hole casing slotted section reduced
- Goaf plants capacity increased
- Less number of goaf holes near the finish line (Total – reduced)
- Cut-through's behind face - to be closed as soon as possible
- Goaf holes drainage – continuous – as long as possible
- Goaf holes away 80 to 100 m away from faults/dykes

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Sponcom control - developments

- Sponcomb rate - high near geological disturbances - faults
- CO production depends on – ventilation, permeability, ..
- Oxygen in goaf holes – to be less than 4% O_2 – preferably
- Cut-through’s behind the face – to be closed as soon as possible
- Reduced intake airflow (+ less pressure differentials)
- Goaf holes away from faults/dykes
- Continuous monitoring of CO + O_2 behind (200 m) the face

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Project outcomes

- Fundamental understanding of goaf gas flow mechanics
  - + effect of various mining parameters (c/t's, Qty, ..)
  - O_2 ingress at different conditions (+ explosive fringe location)
- Goaf gas layering in mixed gas scenario - buoyancy..
- Goaf gas drainage technology improvement
  - for CO_2 gas + very high capacity (compared with other installations)
  - goaf drainage in sponcom environment (high capacity drainage)
- Tracer gas testing – for goaf gas flow characterisation
  - Flow paths, times, velocities, .. + gas migration between panels

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Project outcomes

- CFD modelling - successful application
  - for investigating the effect of various parameters on gas flow
  - for development/ optimisation of gas control strategies
- Effect of geomechanics on goaf drainage – caving, bed separation
  - effect on gas flow patterns, face gas profiles, goaf holes, ..
  - Effect of small geological features on gas flow + sponcom
- Effect of mining parameters – c/t's location, spacing, CAN's
- Spontaneous combustion control strategies
- Capability to deal with mine emergencies (Fires,.)
  - Optimisation of inertisation operations
- Capability to deal with other mine scenarios

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Project outcomes

- Goaf gas drainage performance – tripled
- Major reductions in air dilution ratio
- Spontaneous combustion risk reduced – less O_2 in holes
- Improved understanding of operational parameters
- Improvement in mine/LW productivity
- Major reduction in mine gas drainage cost
- Focus shifting from pre-drainage to post-drainage
- Demonstration of high capacity goaf drainage in a spontaneous combustion prone mine