# Variability of Coal Seam Parameters as They Impact on Outbursts

**ACARP Project C11030**
**CSIRO Petroleum**

***Mike Wold,***
***Luke Connell and  Xavier Choi,***

# Context of the Outburst Problem

- Safety is paramount – must maintain or improve
- Economic pressure to increase development rates
- New mines are approaching outburst conditions
- Every mine has its own conditions
- Variability of conditions within mines
- Existing controls may be conservatively uniform
- Potential to further optimise outburst management

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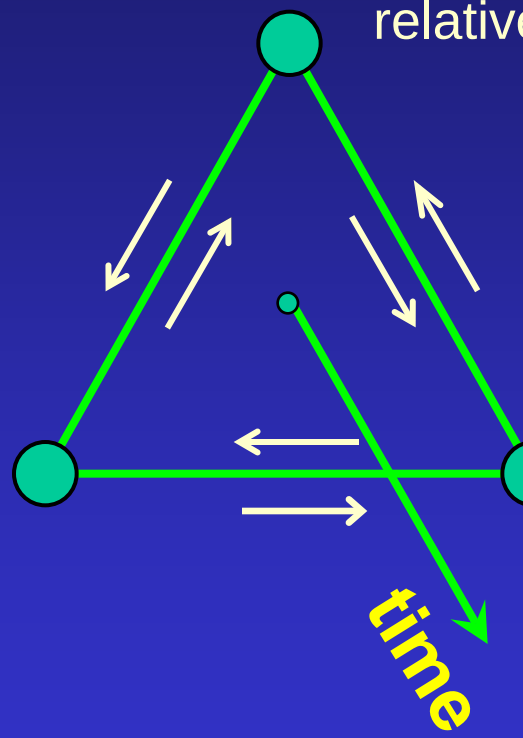
# Interactive factors in outburst mechanisms

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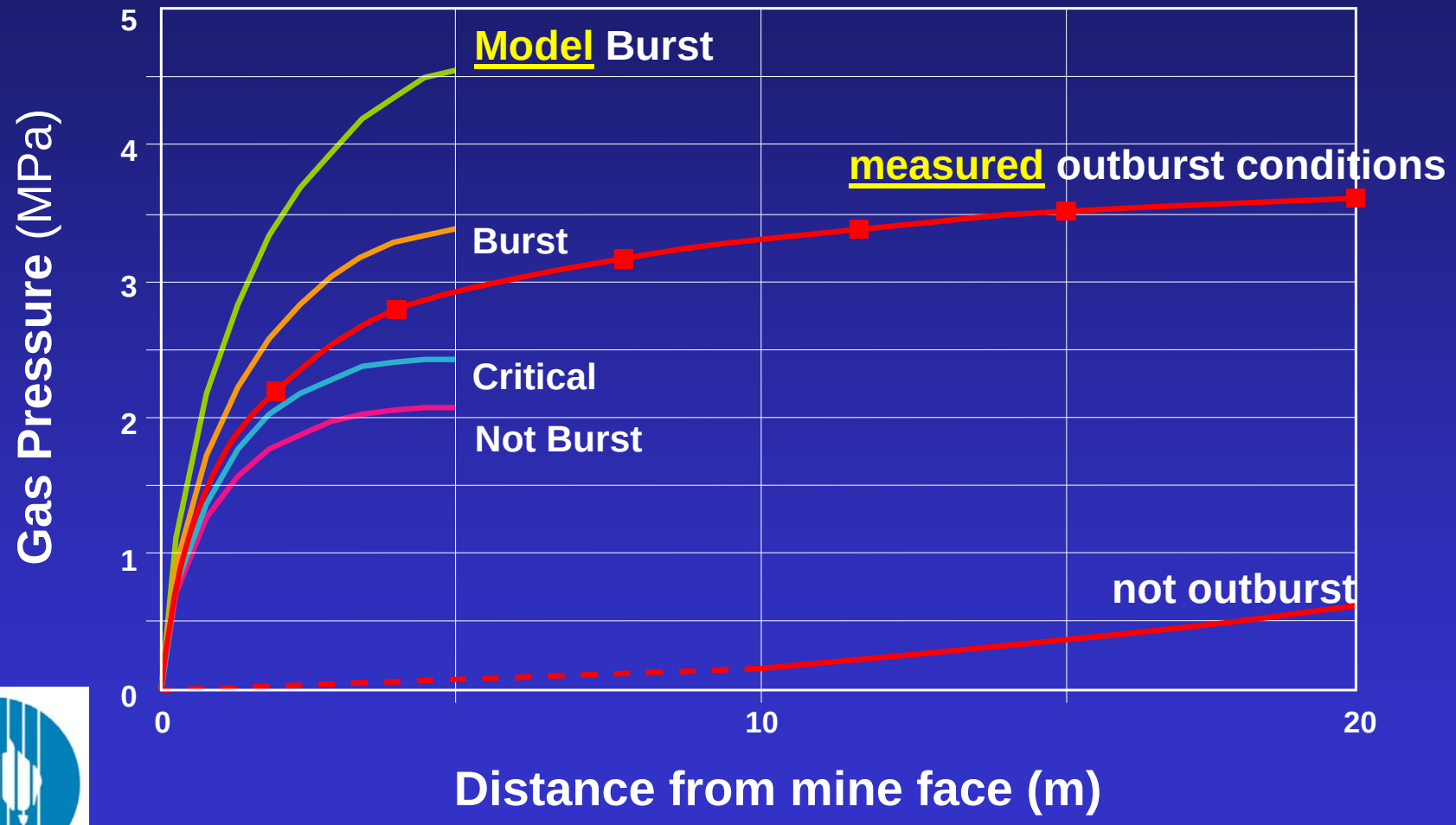
# Influence of gas pressure gradient on outburst initiation

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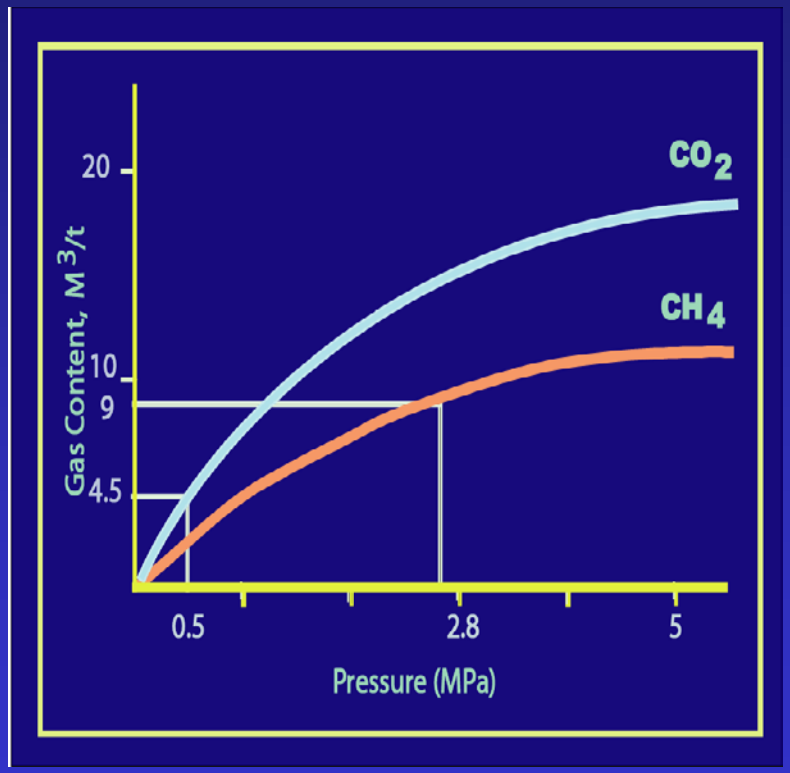
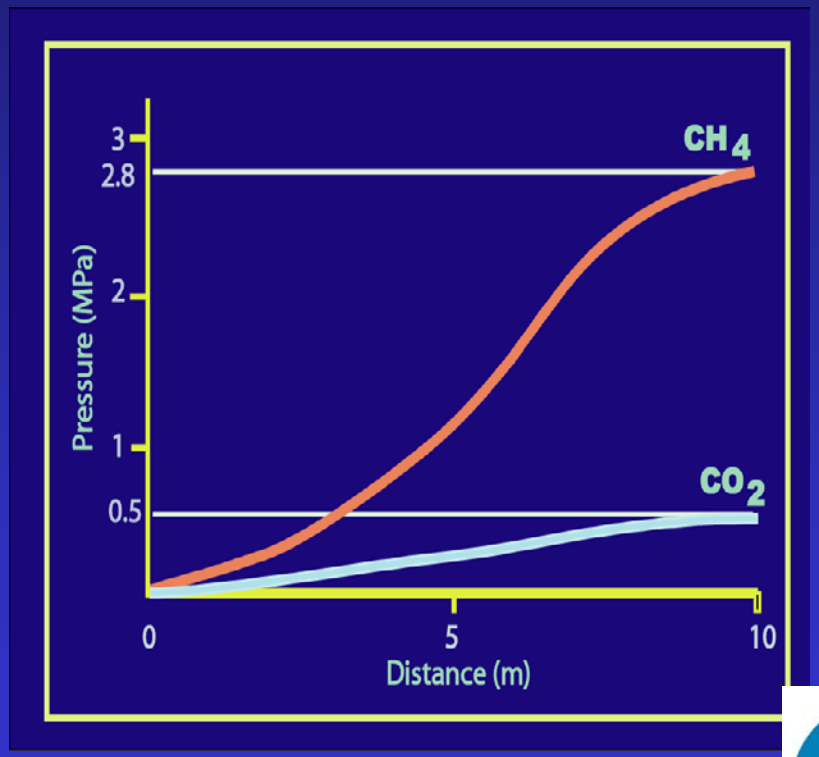
Field measurements by Wood and Hanes, 1982

# Impact of gas composition and drainage on pressure gradient

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# After initiation – dynamic evolution model

- Gas desorption
- Coal deformation and failure
- Coal fragmentation
- Gas dynamics and transport of outburst coal
- Integrated model (initiation + evolution)

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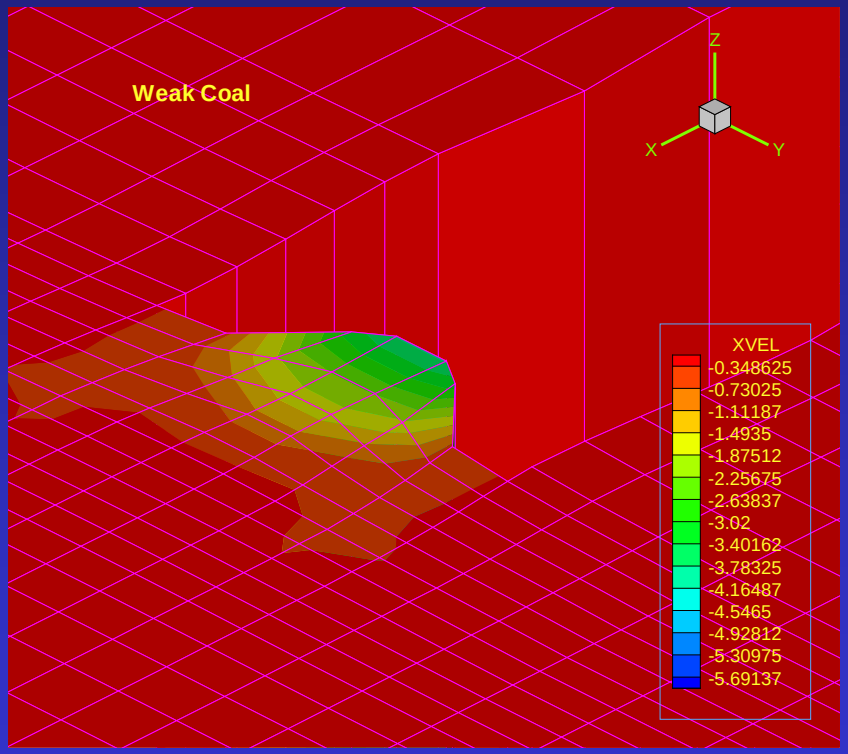
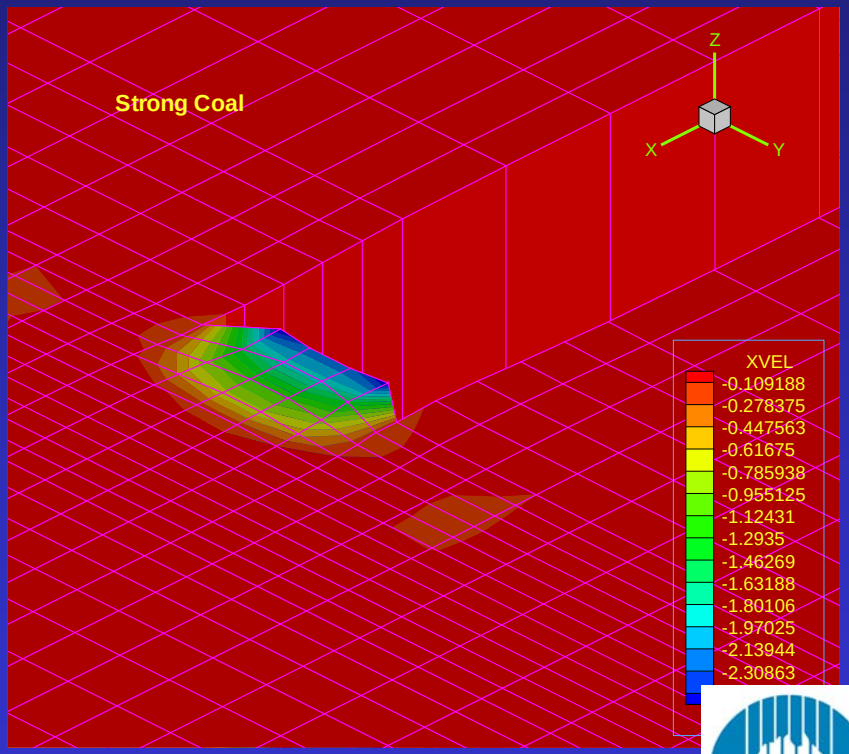
# Dynamic evolution model

weak coal

strong coal

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# Seeking options for expanded criteria – taking a mechanistic view

| Stage of evolution | Driving force | Resisted by | Important variables |
|---|---|---|---|
| Initiation | Quasi-static pressure gradient within intact and yielding coal | Tensile and compressive *strength* | • Reservoir pressure<br>• *Permeability*<br>• Isotherm<br>• Composition |
| Post-initiation dynamic | Dynamic energy release of compressed gas in rapidly fragmenting coal | Remnant strength<br><br>Fracture toughness | •Isotherm<br>•*Composition*<br>•Desorp. rate<br>•Diffusion rate<br>•Strain rate<br>•Particle size |

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# Elements of current project

- Statistical model of spatial variability
  - measure permeability and strength
- Sensitivity to variability
  - apply quantitative models
- Input to risk analysis
  - integrate with outburst risk management

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# Measured variability of permeability and porosity

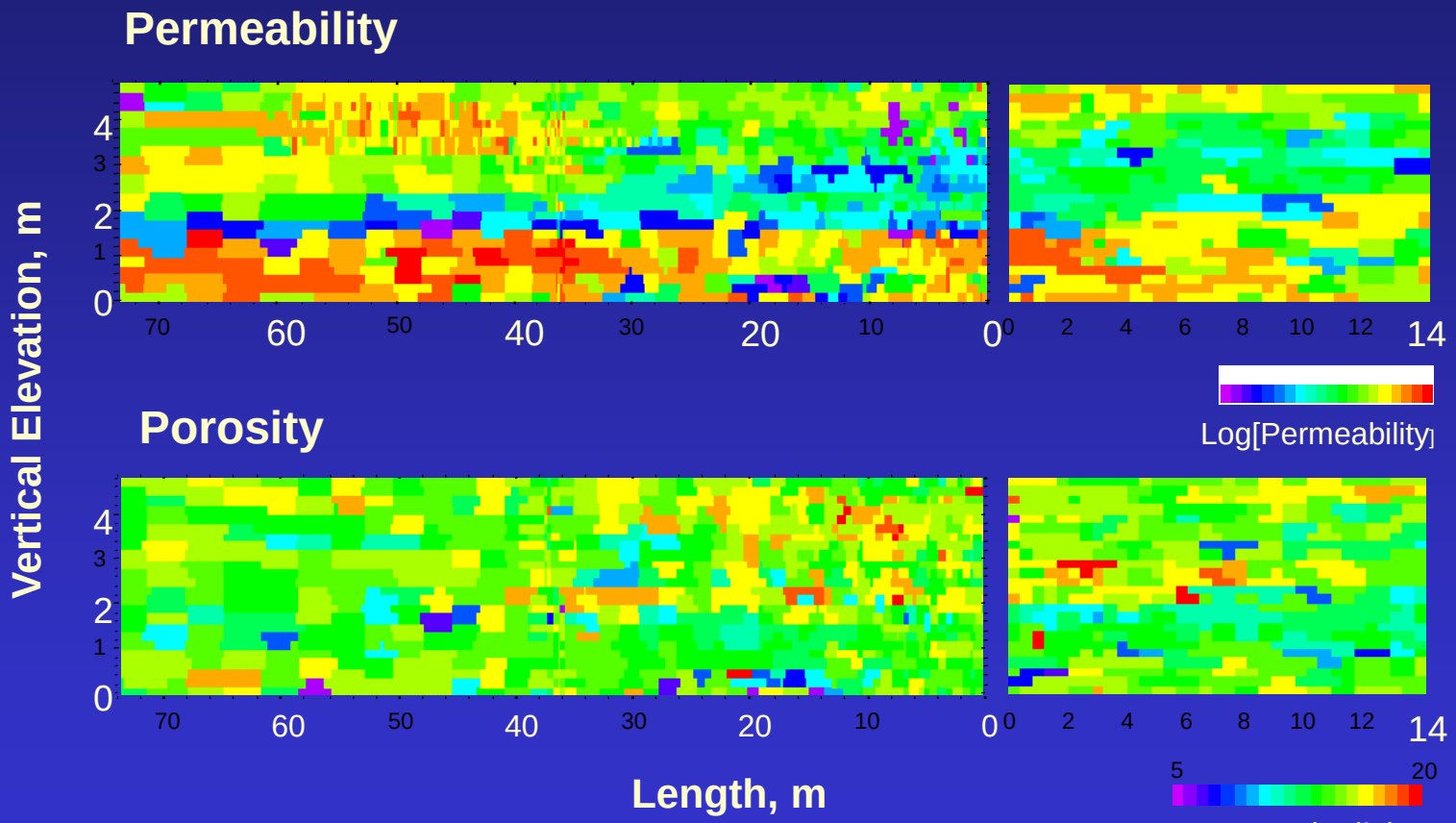
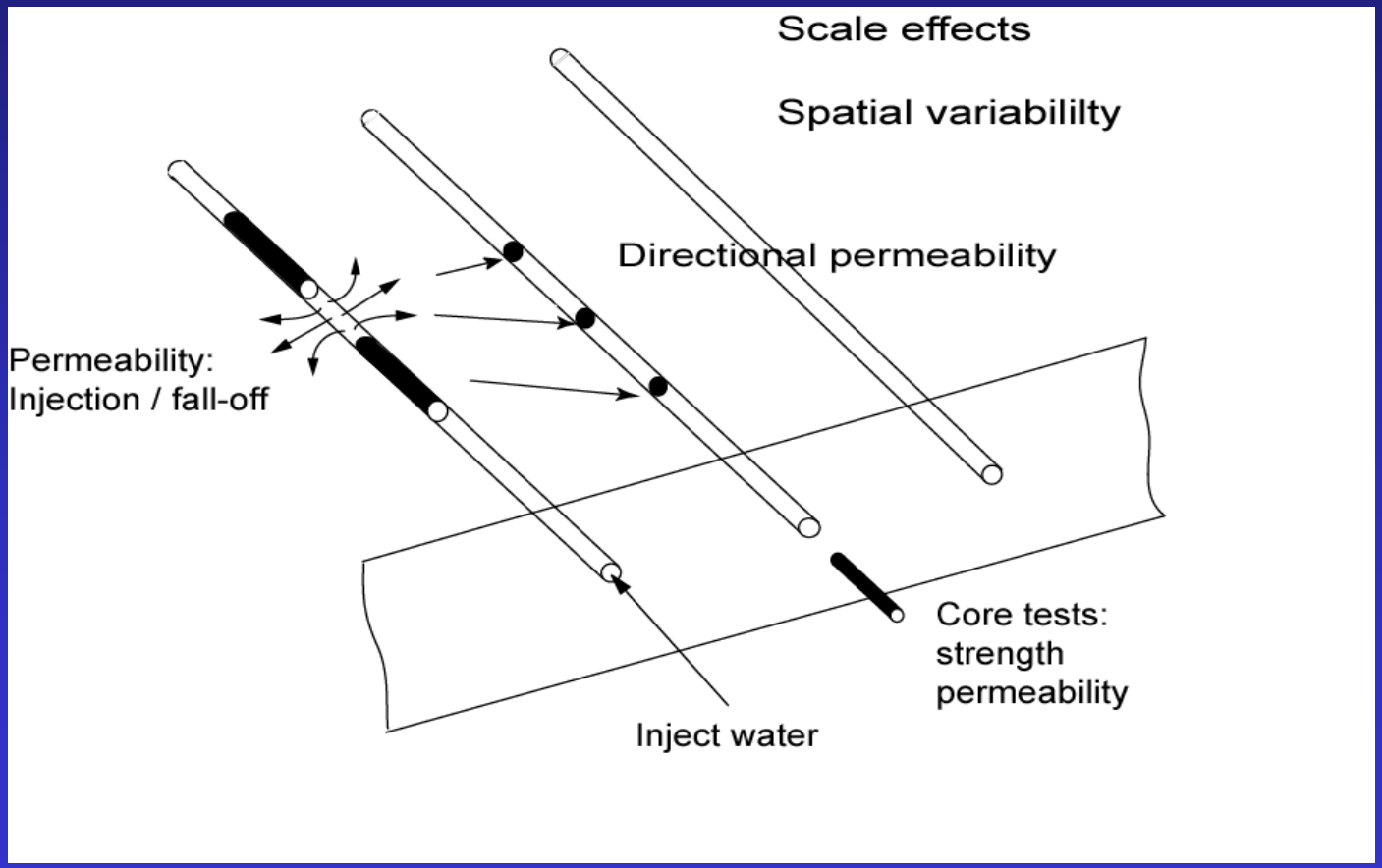



Figure 4

# Measuring variability of permeability and strength

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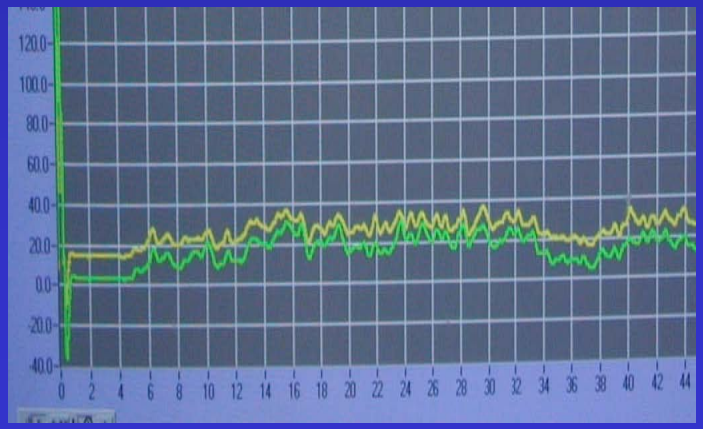
# Strength measurement on site

- rapid, portable
- assess spatial variability

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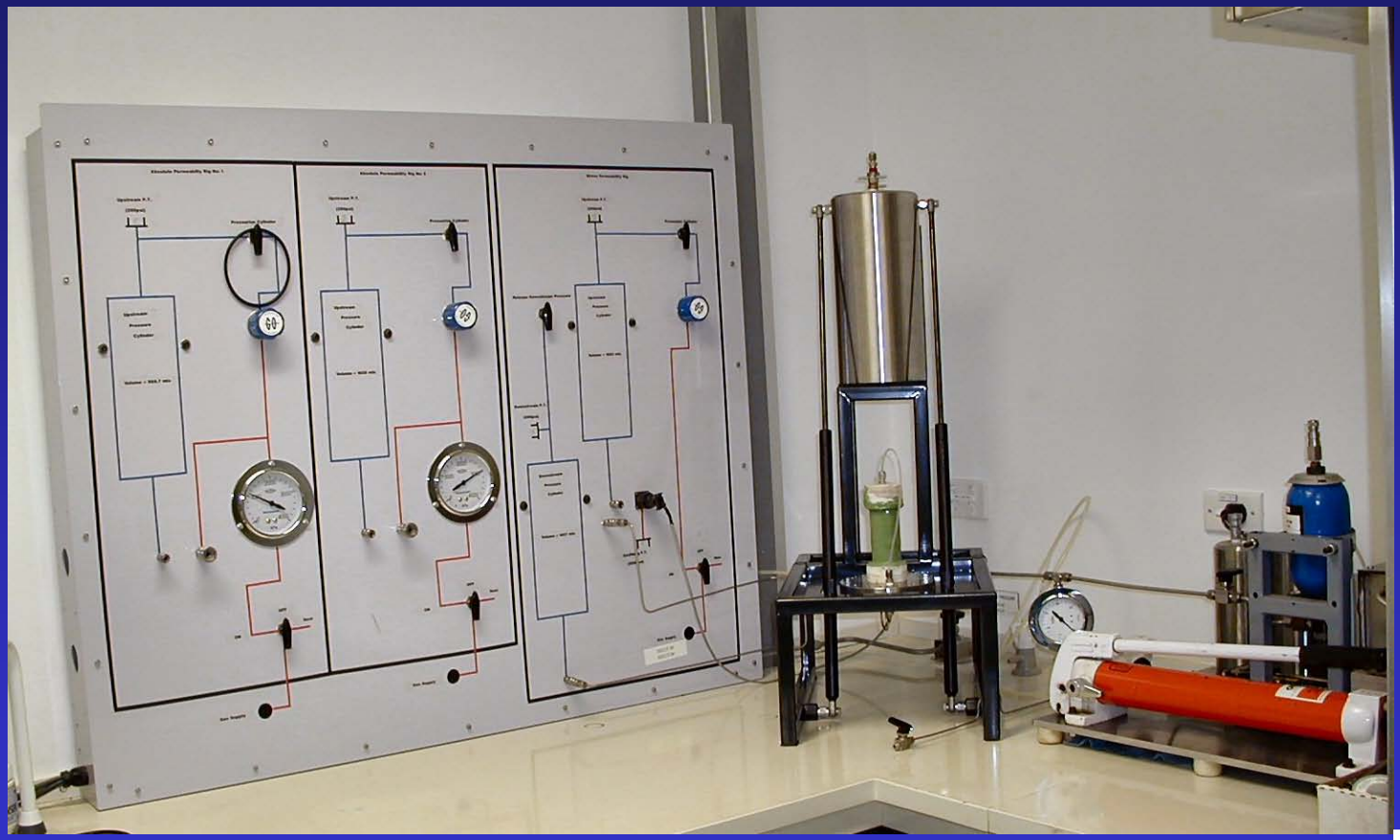
# Core Permeability



Measurement of permeability under simulated *in situ* stress

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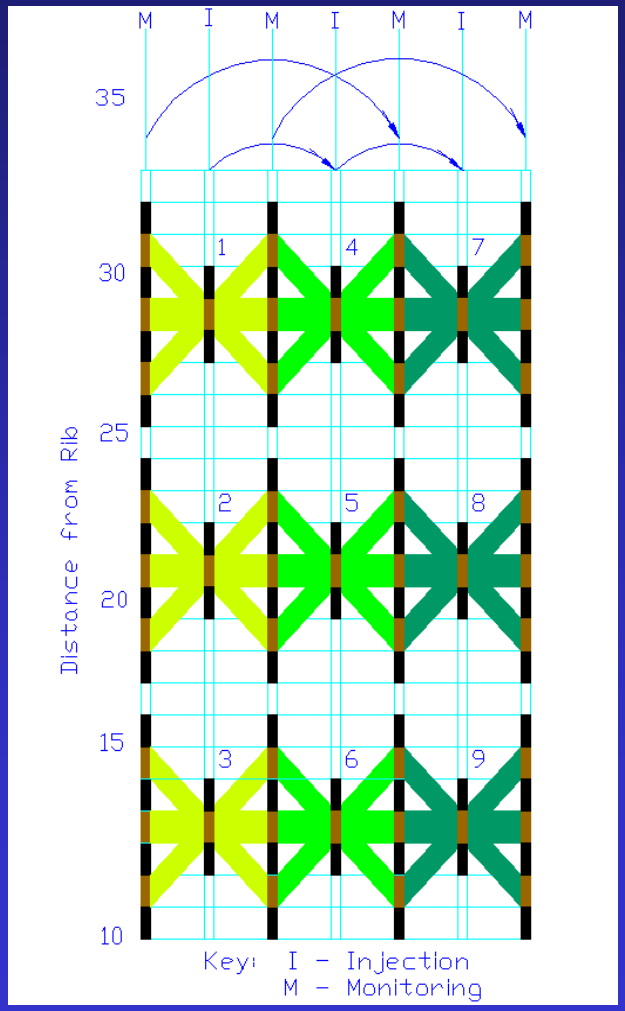
# Well Test Schematic

7 in-seam holes @ 2m spacing, 35m depth from rib, 9 interference tests

Plus

Pair of  in-seam holes, upper and lower, vertical perm. component

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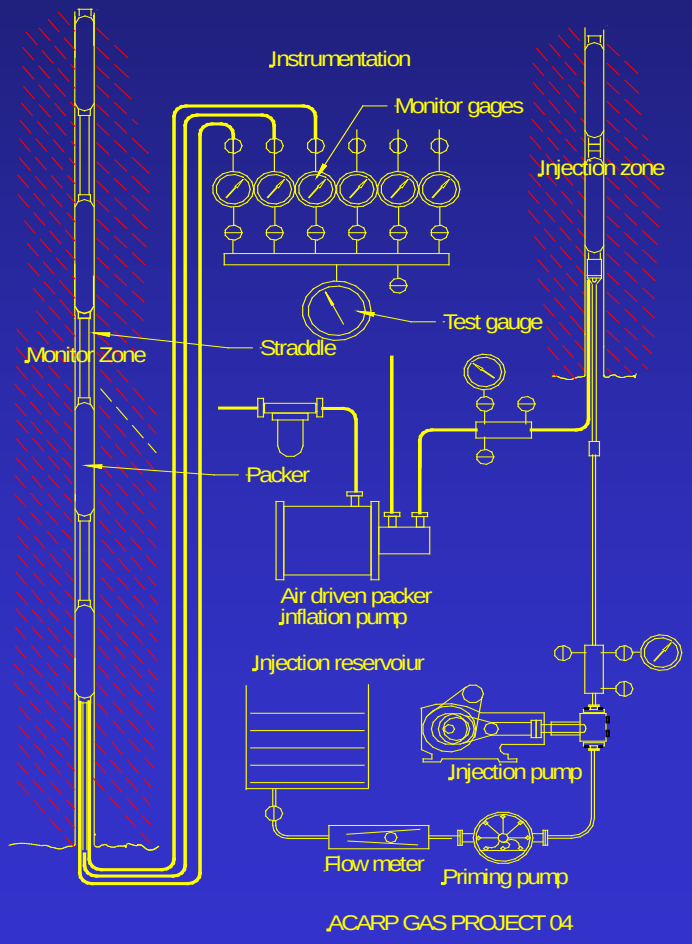
# Well test equipment developed for this project

System schematic




Inflatable packers

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# Well test hydraulic equipment

IS approved hydraulic power pack

Fluid injection pump

Packer inflation pumps


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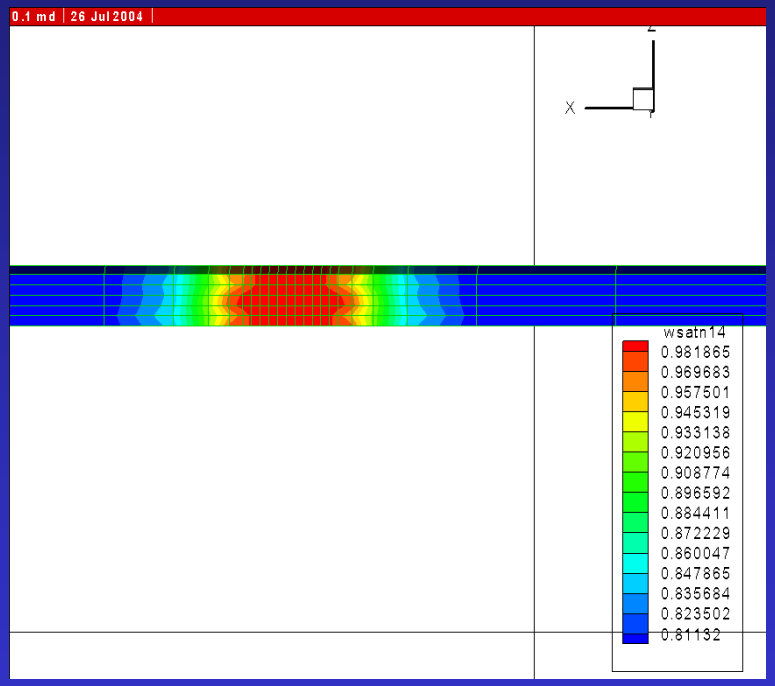
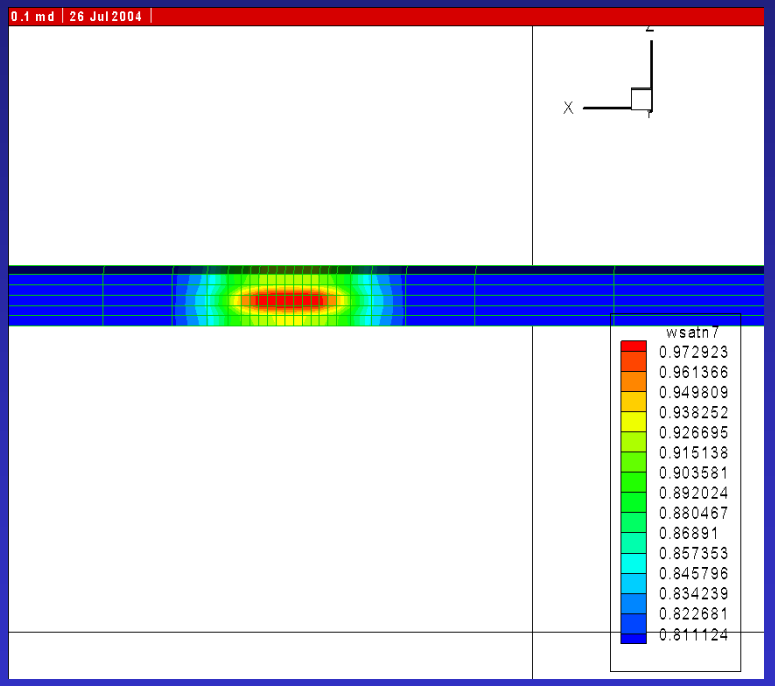
# Coal pre-saturation

- objective is single-phase flow conditions during well tests




Kh = 0.1md, Kv = 0.01md
Δp = 0.5MPa, t = 7 days

Kh = 0.1md, Kv = 0.01md
Δp = 0.5MPa, t=14 days

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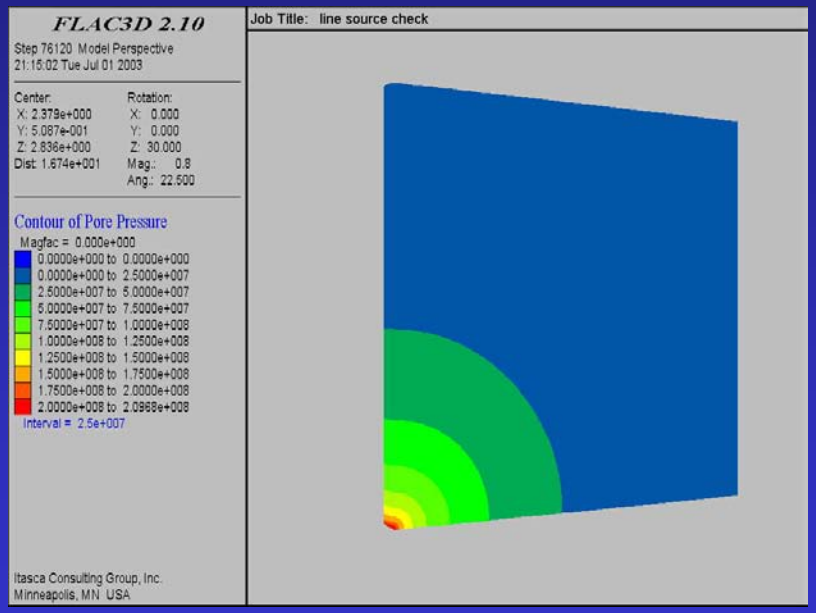
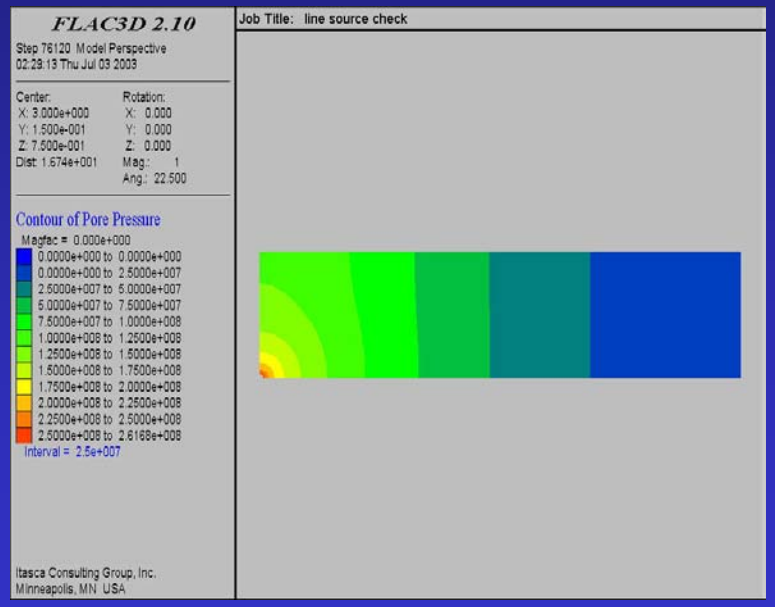
# Well test simulations: long horizontal well in extensive medium and layer of finite thickness




Extensive medium




Finite thickness

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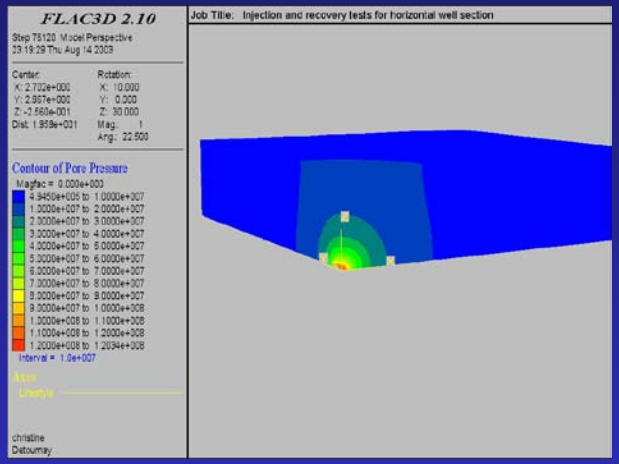
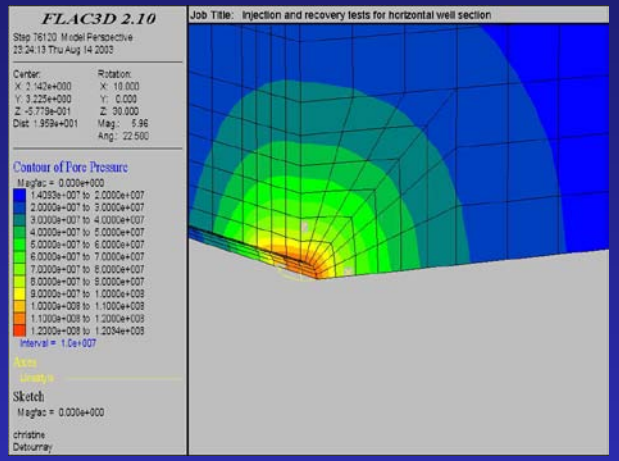
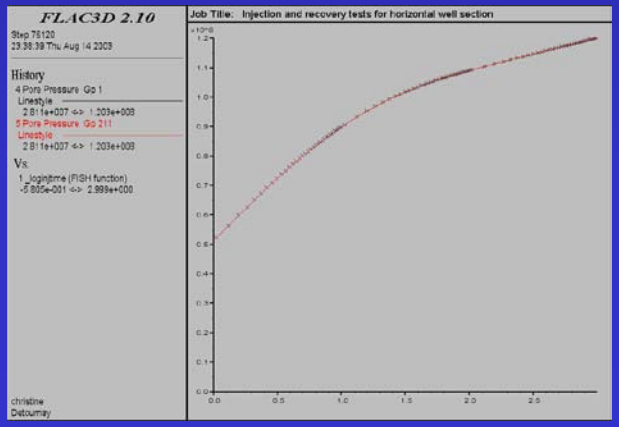
# Well test simulation: short horizontal well in layer of finite thickness




Pore pressure contours@ 1000s injection




Well pressure vs log ($t/t_0$)

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# SUMMARY$_1$

***General***

- There is scope  to refine and expand the threshold criteria, incrementally
- Safety is paramount
- Quantitative models have been developed (ACARP C6024 and C9023)
- Better understanding of CO2 in coal is required (ACARP C13012, current)
- Permeability and strength have potential for expanding the criteria
- Methods to account for spatial variability of data are needed

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# SUMMARY$_2$

***Current stage, ACARP C11030***

- Measurement of permeability and strength at field and laboratory scale

***Near future***

- Spatial variability analysis
- Quantitative modelling of sensitivity to variability

***Longer term***

- Application to outburst risk assessment and management

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