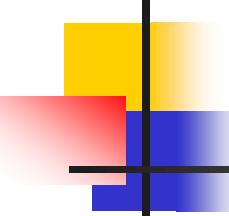


Improved Application of Gas Reservoir Parameters

ACARP Project C10008

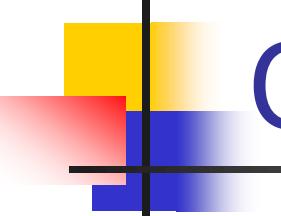
May 10th 2002

Mackay



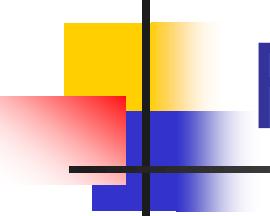
The Team....

- Applicant Organisation - GeoGAS Systems Pty. Ltd.
Ray Williams, Eugene Yurakov
- Supporting Organisations –
 - CSIRO Energy Technology North Ryde
Abou Saghafi
 - Multiphase Technologies Pty. Ltd.
David Casey
 - James Cook University
Peter Crosdale
- \$141,159
- 1 Year



Objectives

- Improving the quality of input data in key areas.
- Obtaining a clearer understanding of the combined effects of sets of gas reservoir parameters.
- Producing a set of sensitivity matrices that can be used as an improved guide in modelling and in identification of the most important data to acquire.

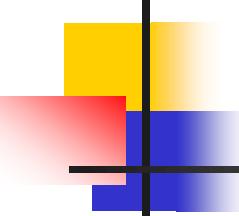


From the ACARP Submission

“..... the importance of considering the gas implications is widely recognised. What is not generally recognised, is the variability in the gas reservoir and the processes and limitations of the tools available to undertake modelling assessments.”

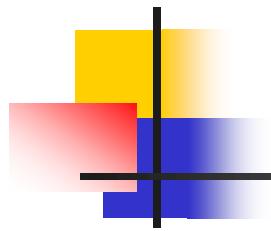
From GeoGAS/CSIRO SIMED Procedure Manual 1998

Parameter	Sensitivity of results to parameter			Obtaining likelihood		
	Low	Middle	High	Low	Middle	High
Seam dimensions			Red			Red
Roadway dimensions			Red			Red
Gas composition		Green	Red		Green	
Porosity	Cyan	Green			Green	
Permeability			Red		White	Red
Langmuir isotherm		Green	Red		Green	
Desorption time constant		Green		Cyan	Green	
Desorption pressure		Green		Cyan		
Reservoir temperature	Cyan	Green			Green	Red
Gas content			Red			Red
Relative permeability		Green		Cyan	Green	
Pore pressure	Cyan	Green			Green	
Compressibility	Cyan	Green			Green	
Matrix shrinkage		Green		Cyan		
Pore pressure	Cyan	Green		Cyan	Green	
Transmissibility	Cyan	Green		Cyan	Green	



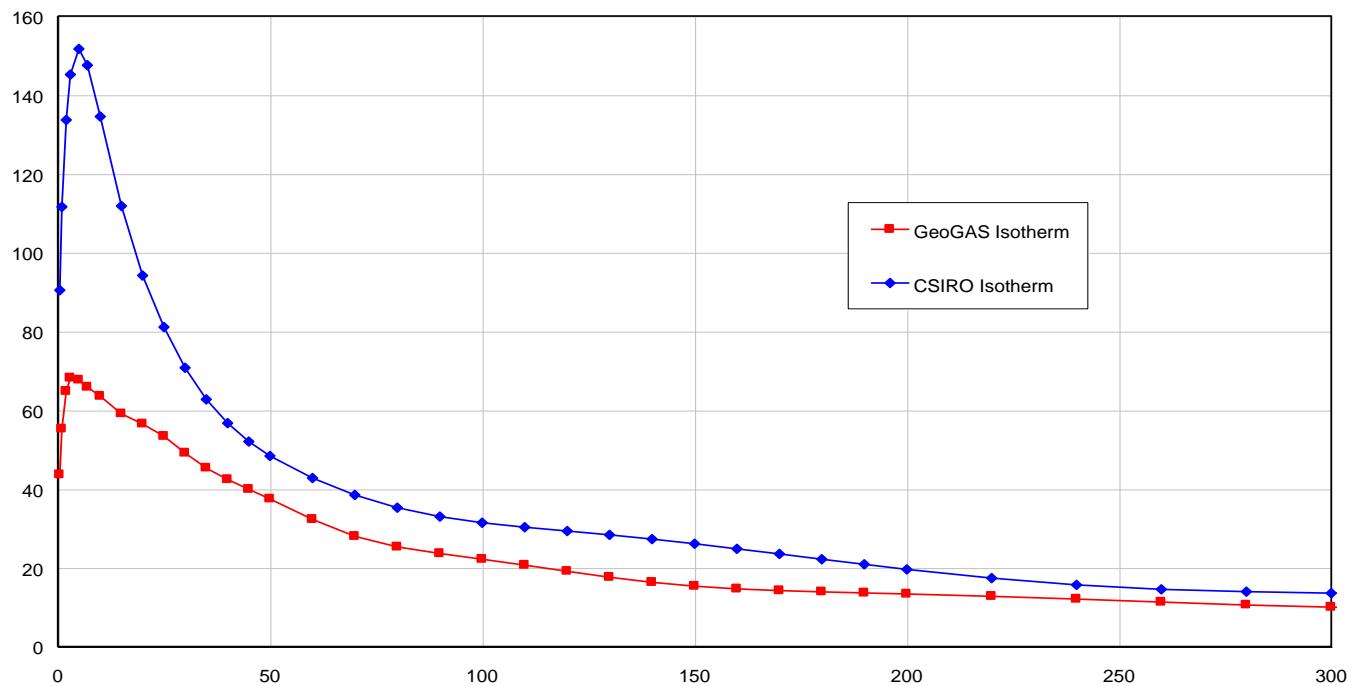
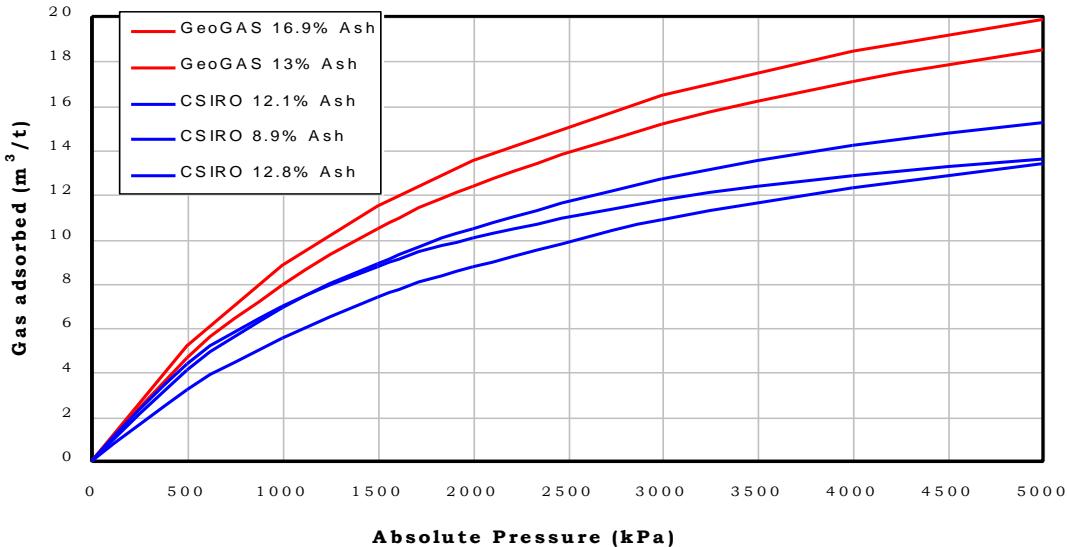
For this project we look mainly at:

- Gas sorption isotherms
- Use of multiphase testing to:
 - Validate gas sorption isotherms
 - Generate relative permeability curves
- Assess desorption time constant τ
- Gas drainage borehole recharge
- Other important stuff –
 - Permeability, porosity, compressibility
- **Sensitivity analyses**

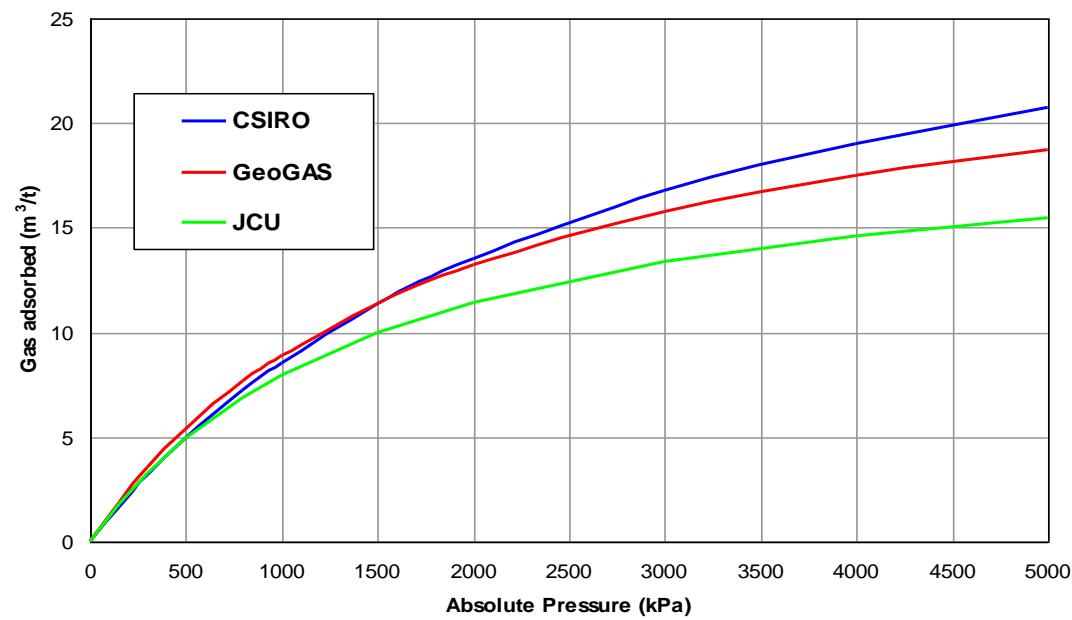
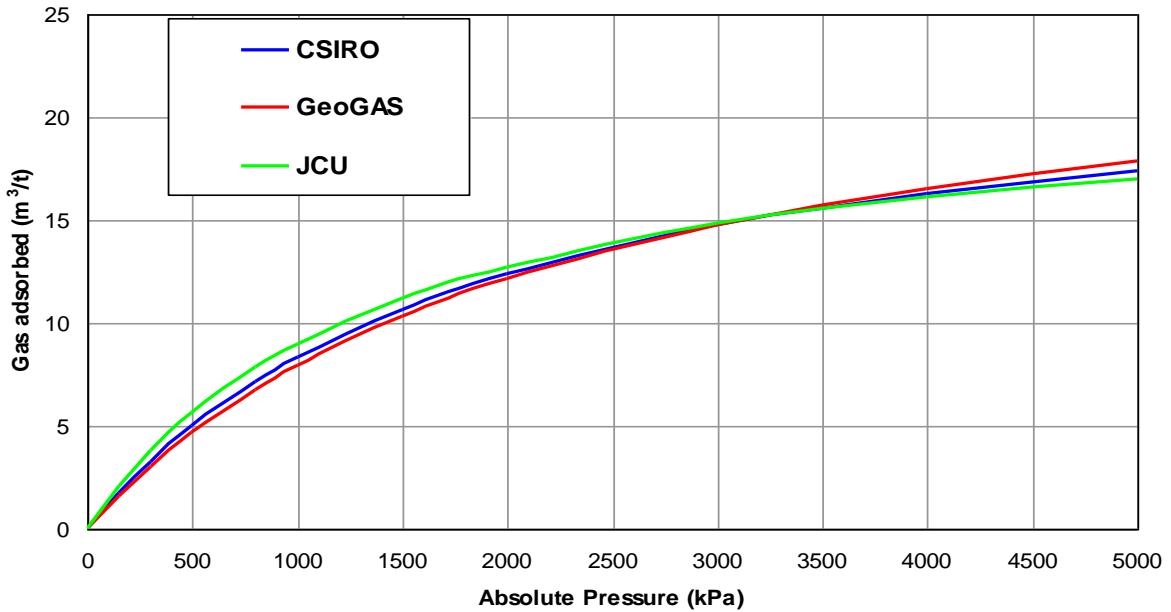


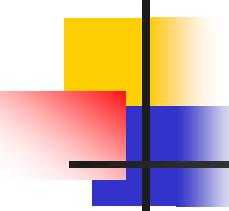
Gas Sorption Isotherms

An Example – The Isotherm Shock



Start of Comparisons

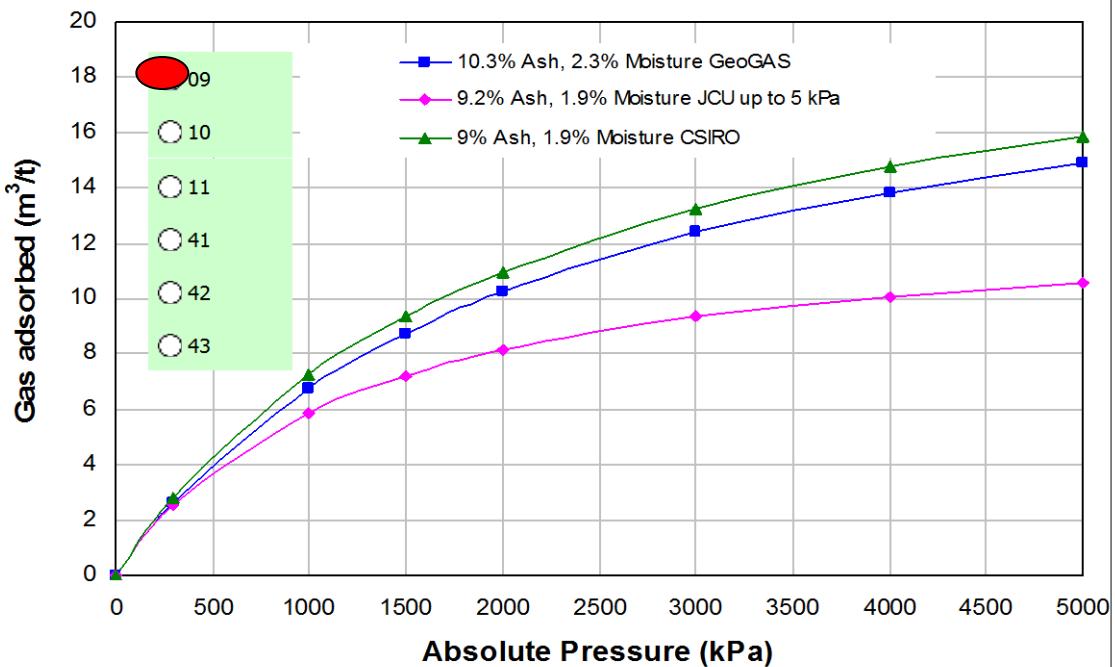




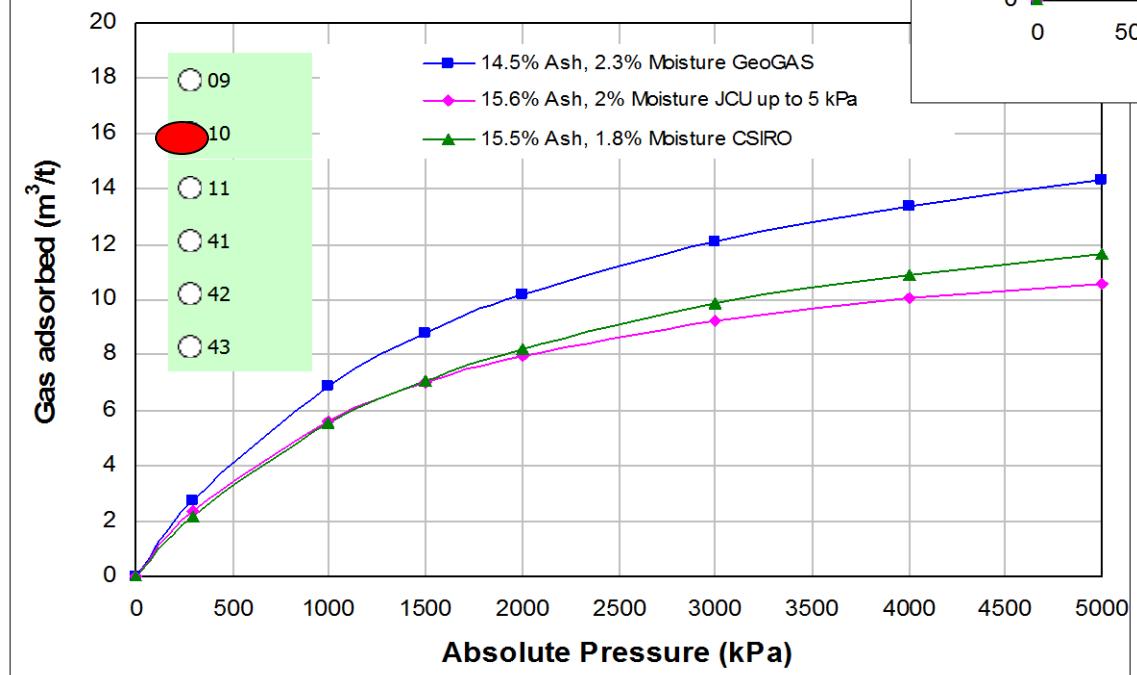
Isotherm Comparison Tests – Factors Considered

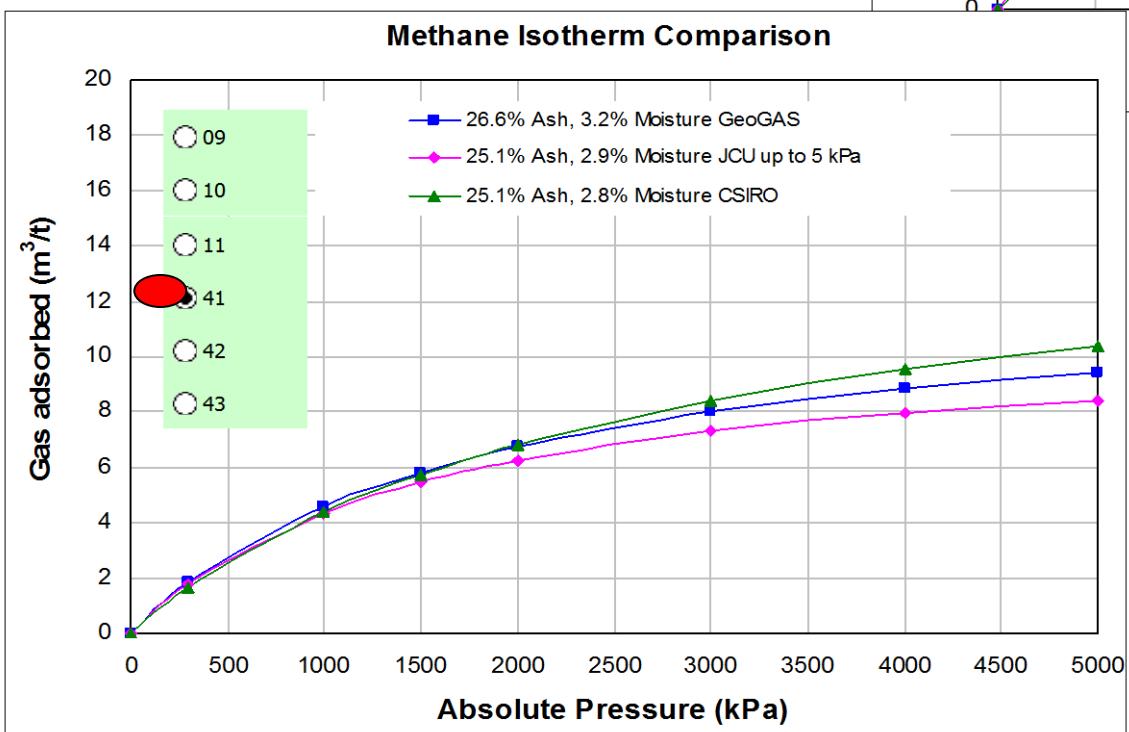
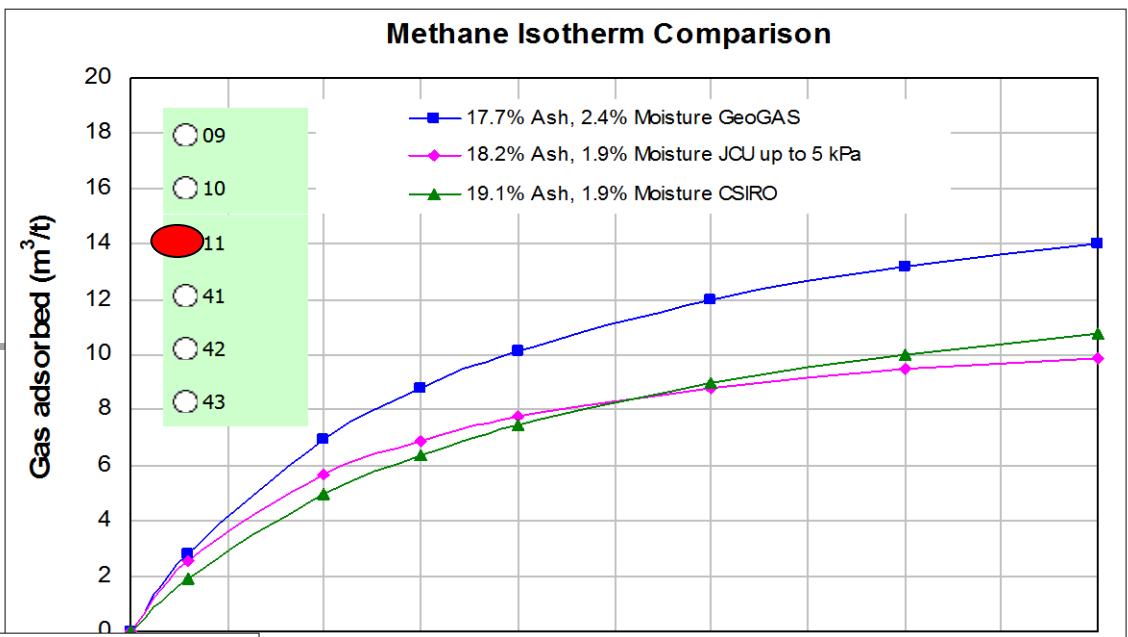
- Method – all essentially the same (gravimetric)
- Grainsize distribution of tested coal
- Moisture before during and after testing, including equilibrium moisture
- Consistency between distributed samples

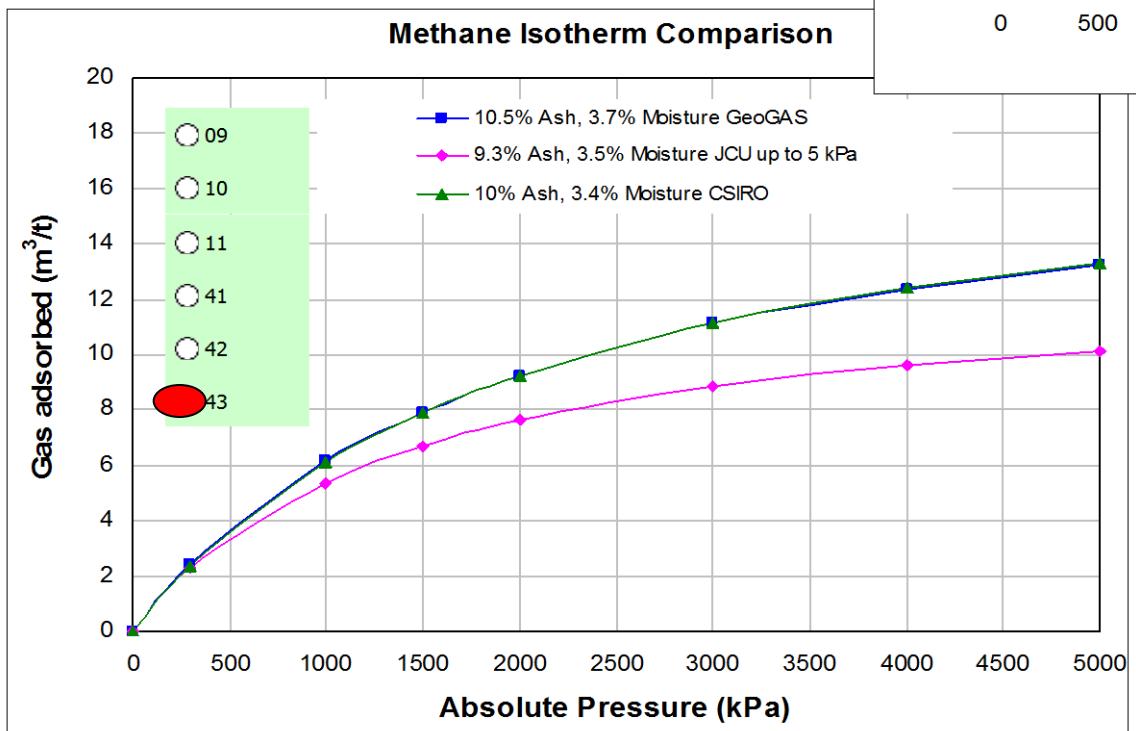
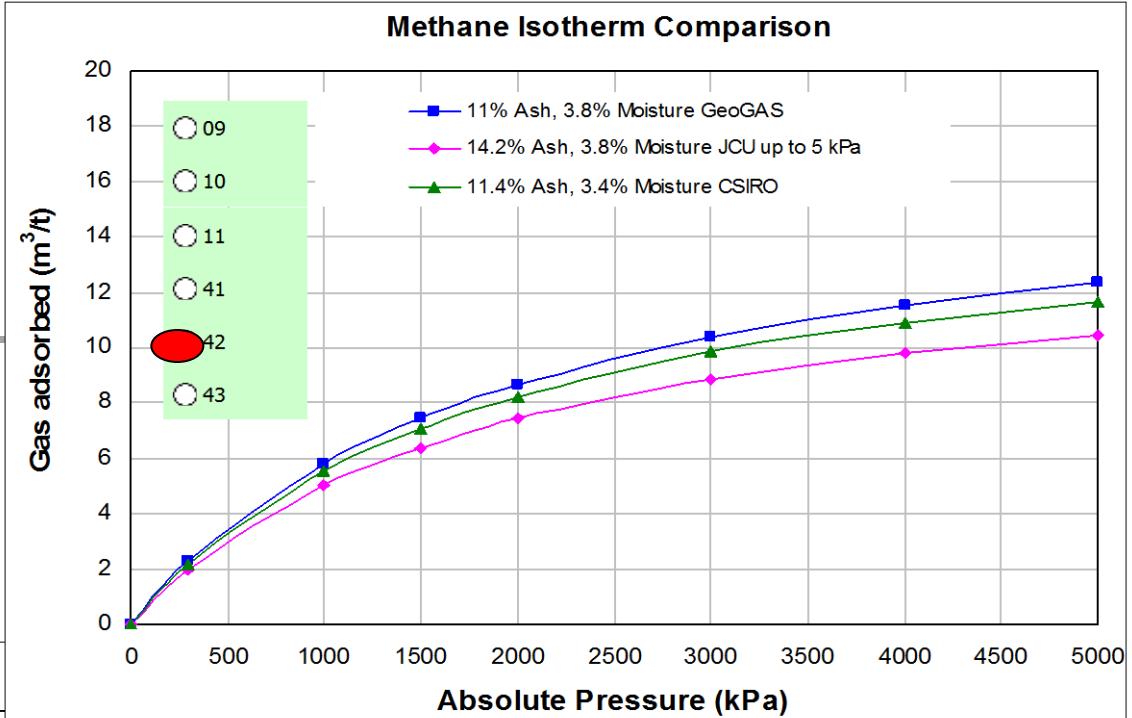
Methane Isotherm Comparison



Methane Isotherm Comparison







Density Comparisons of Sub Samples

Adsorbed CH₄ Densities
CSIRO 0.415 g/cc
GeoGAS 0.6189 g/cc
JCU 0.3196 g/cc

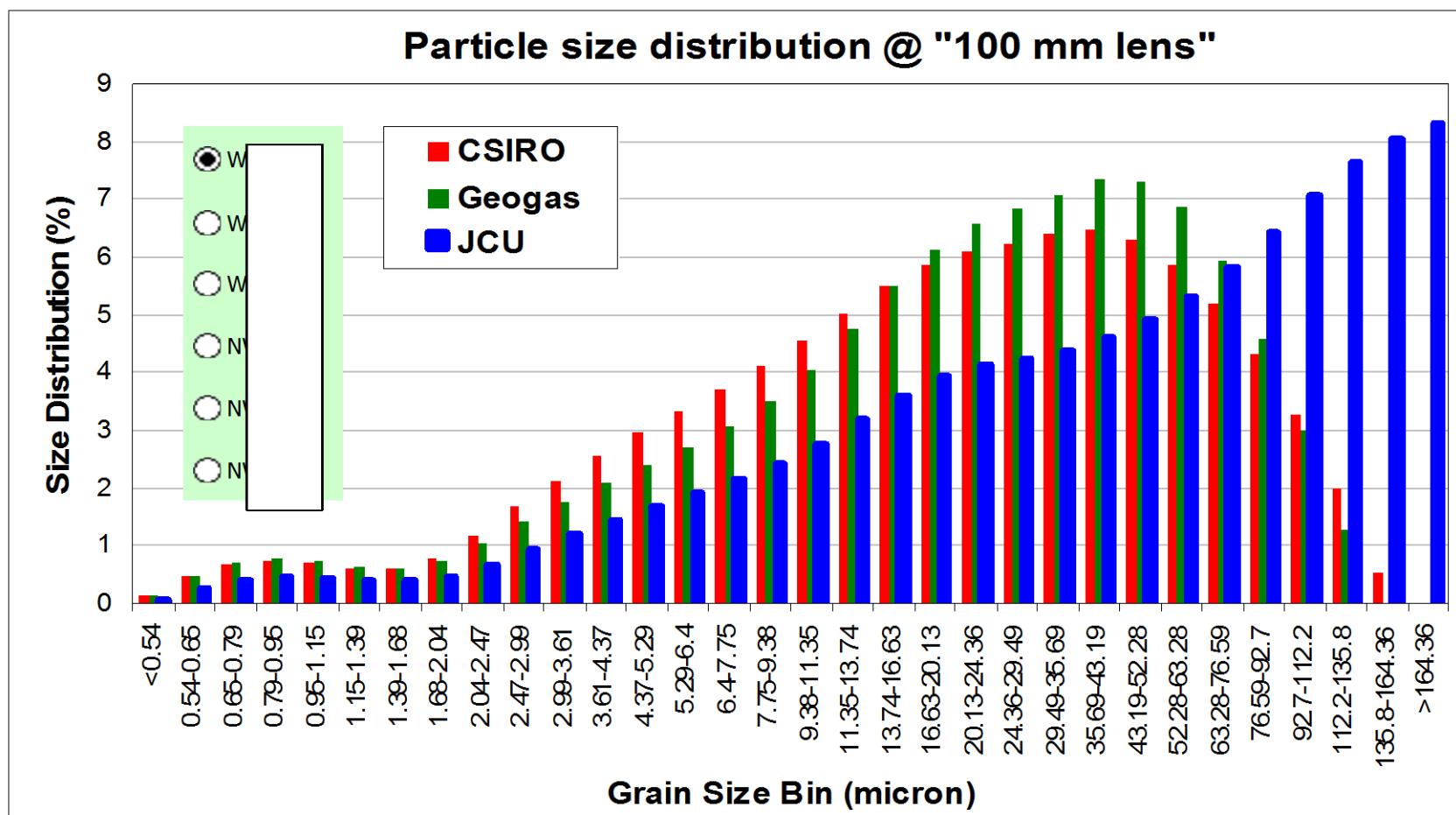
Relative Densities (g/cc)

Laboratory	9	10	11	41	42	43	Average
GeoGAS	1.39	1.40	1.32	1.64	1.41	1.41	1.43
JCU	1.45	1.50	1.52	1.59	1.47	1.46	1.50
CSIRO	1.35	1.41	1.40	1.59	1.41	1.37	1.42

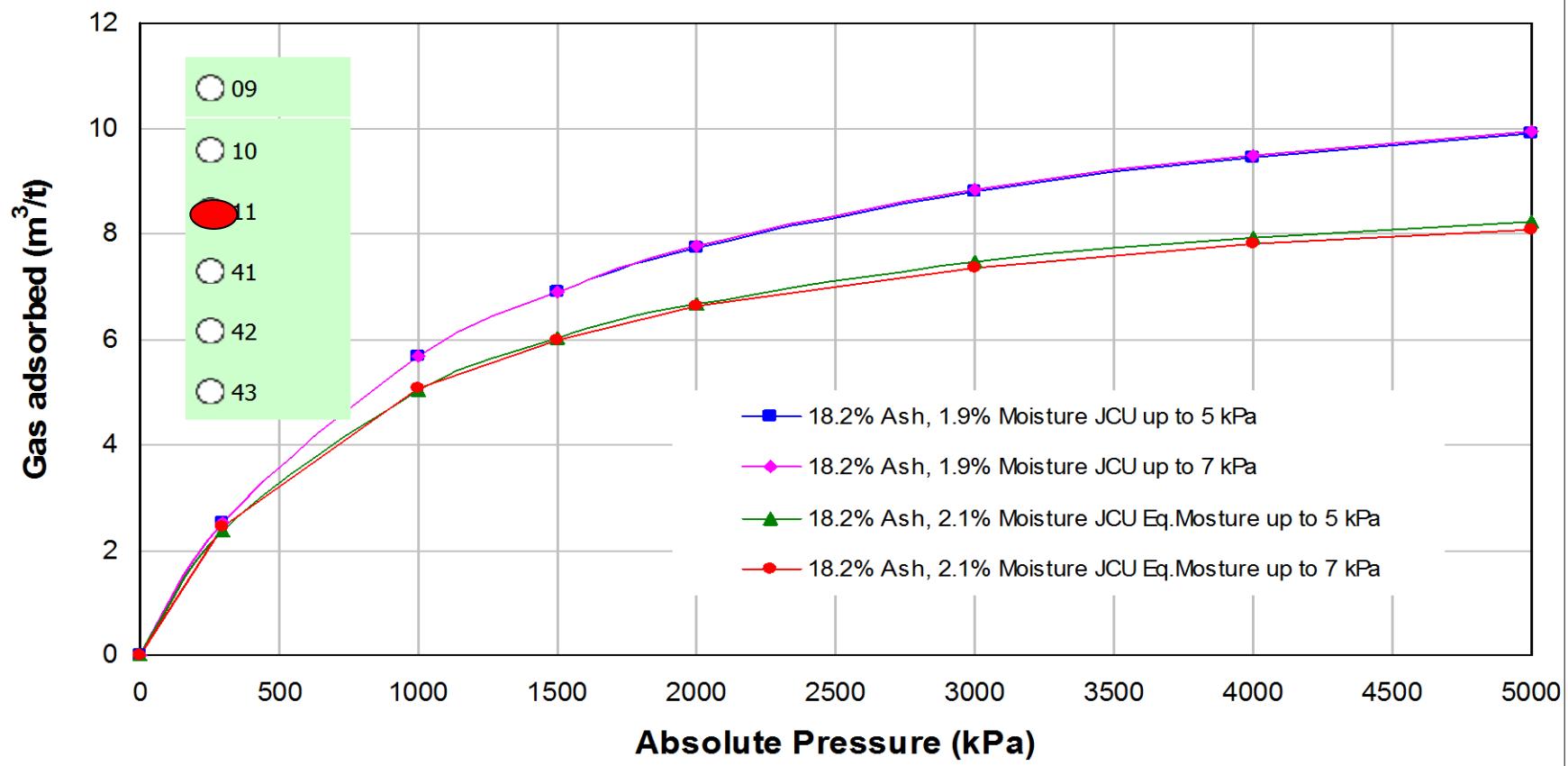
Isotherms shown to be quite sensitive to density. A change of 0.1 g/cc results in around 6-18% change in sorption capacity. Replots by Crosdale and Yurakov showed reduced scatter using the same density.

Coal density inconsistencies identified as probably the most significant contributor to isotherm differences.

Grainsize Comparison

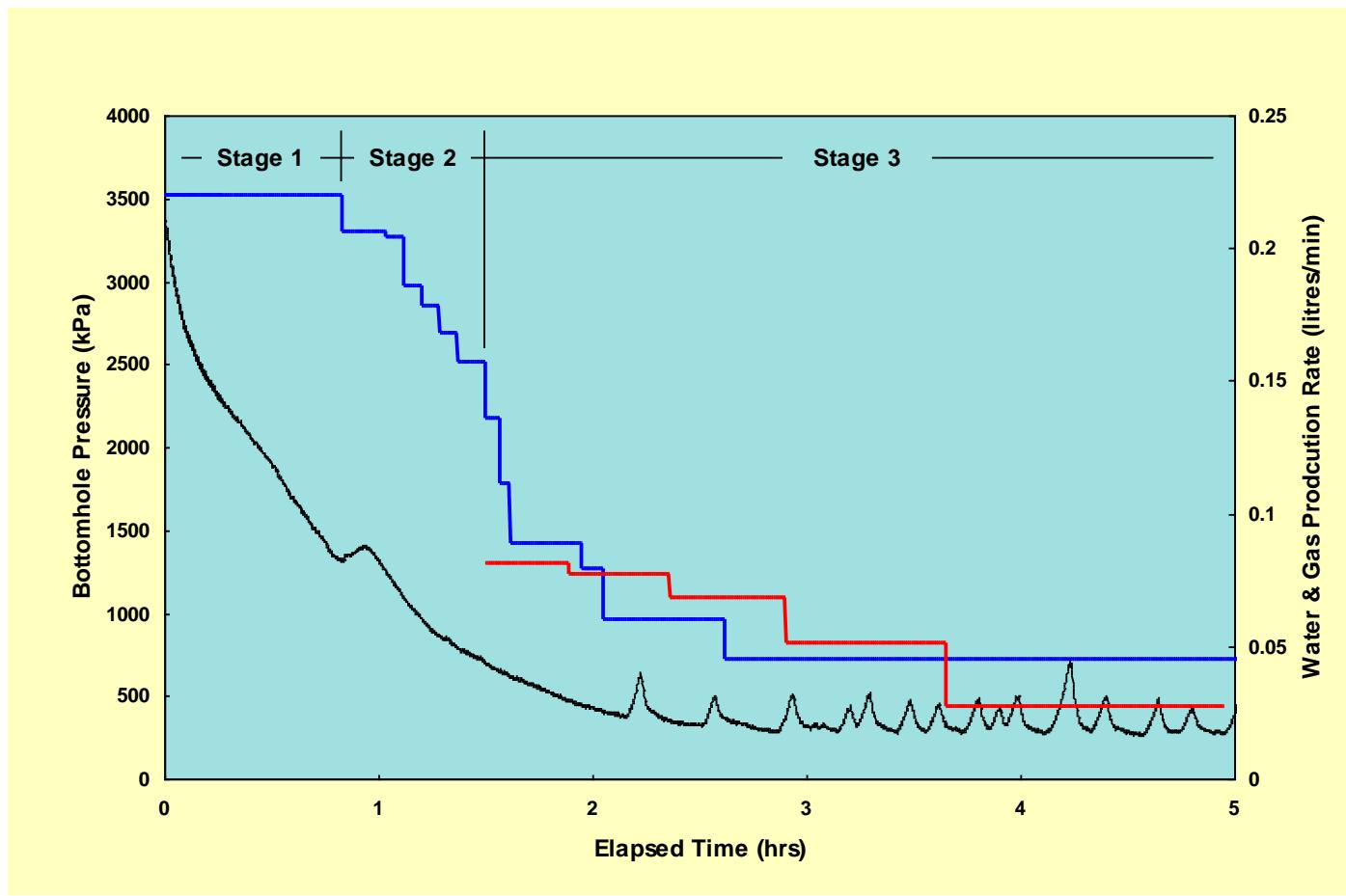


JCU Isotherm "As Received" and "Equilibrium Moisture" Assessment

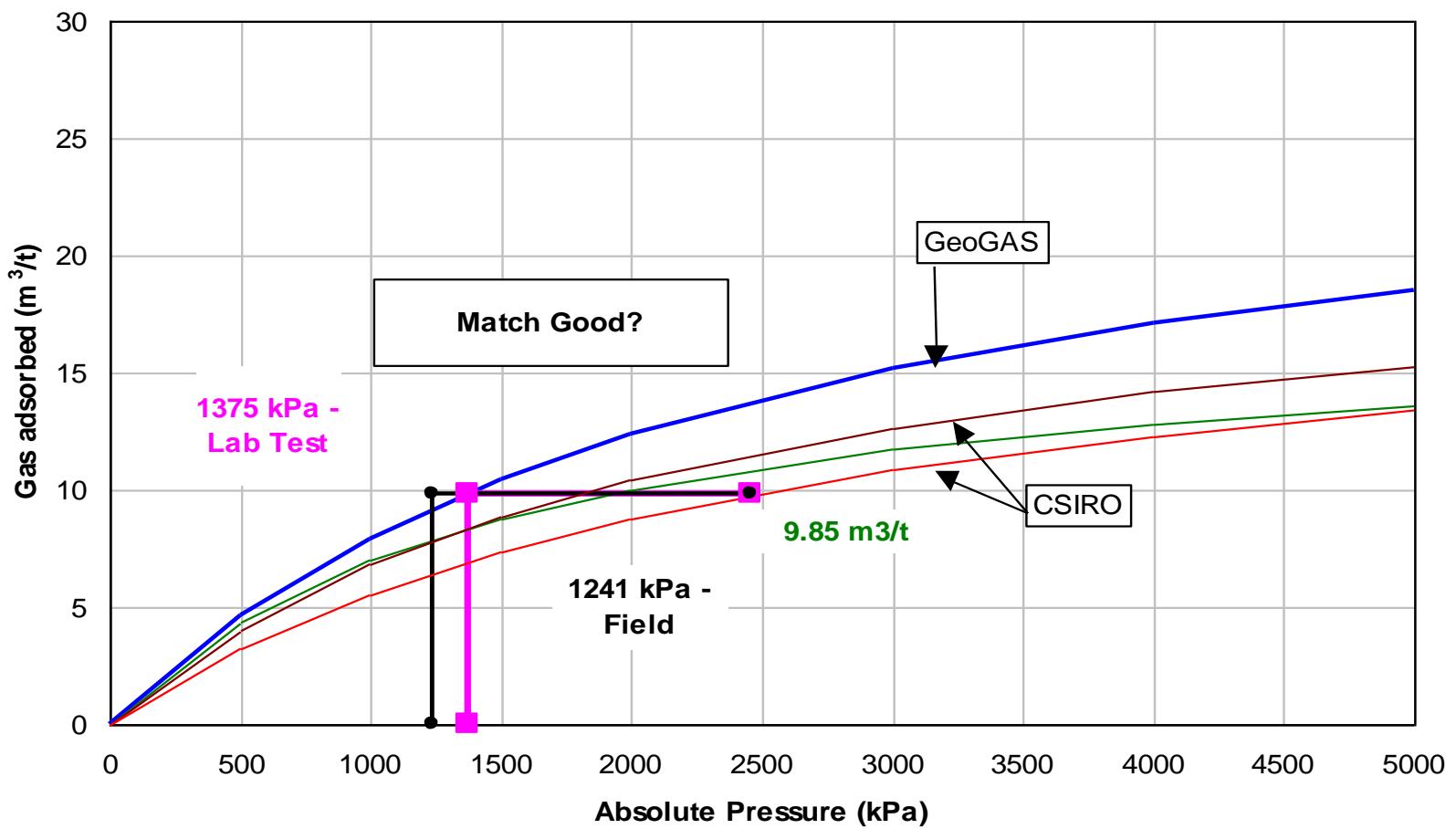


Isotherms

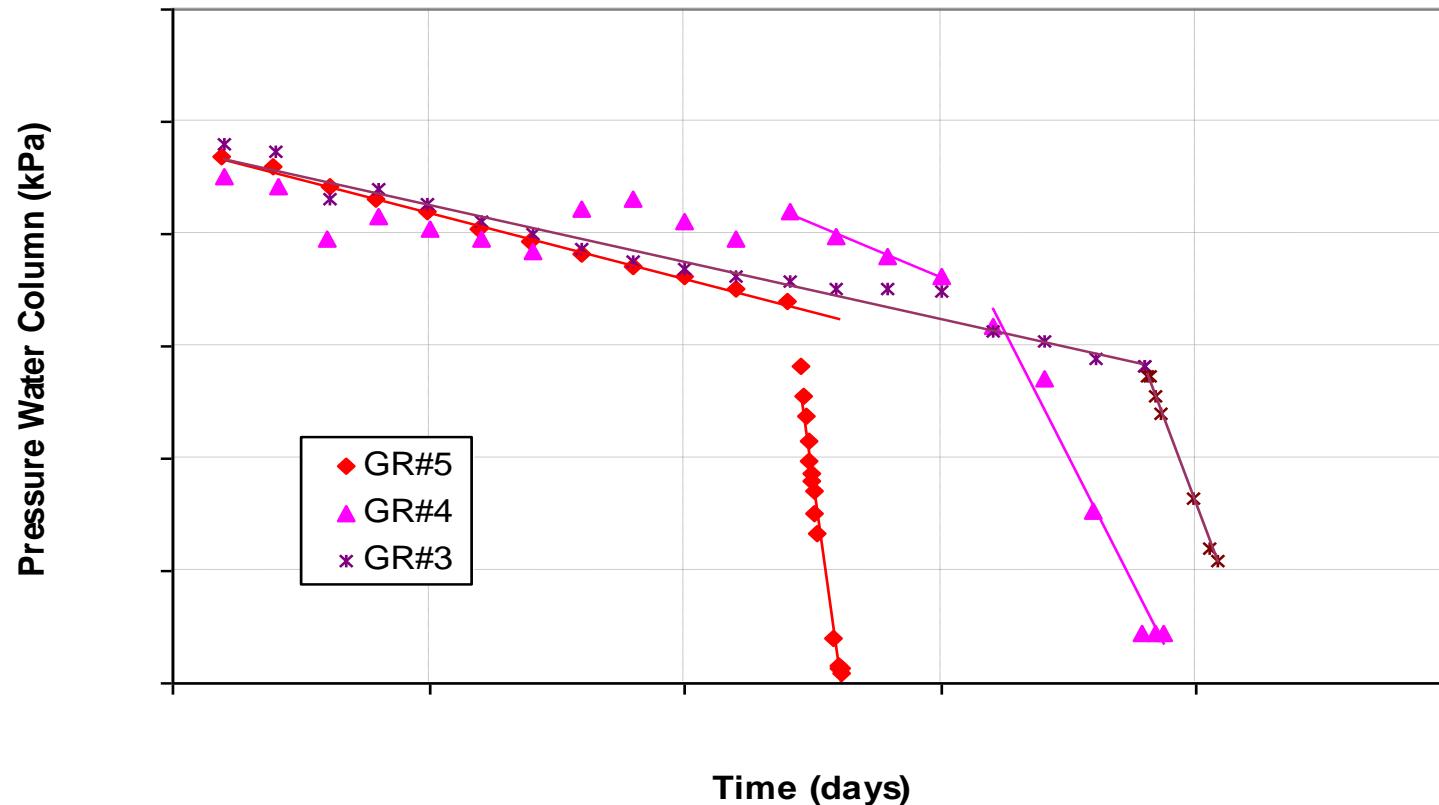
Field-Lab Desorption Pressure Comparisons



From Multiphase
Technologies Pty. Ltd.
David Casey



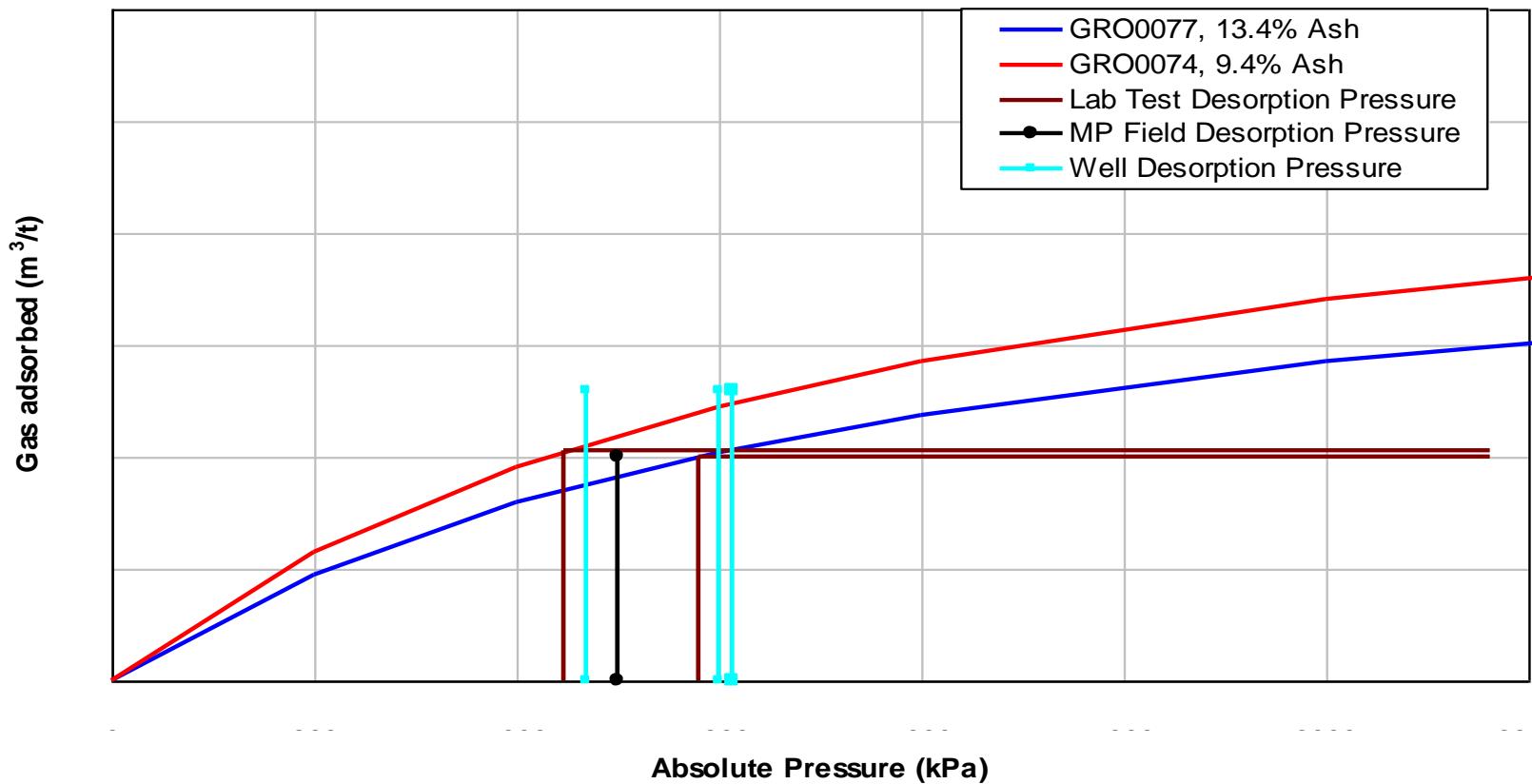
CH4 Grosvenor Desorption Pressure During Well Production

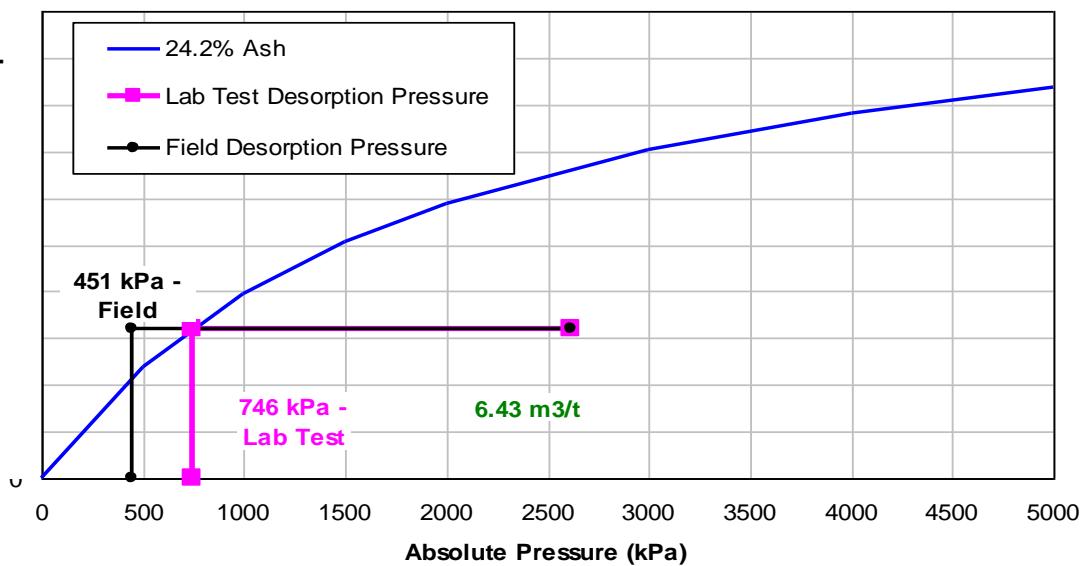
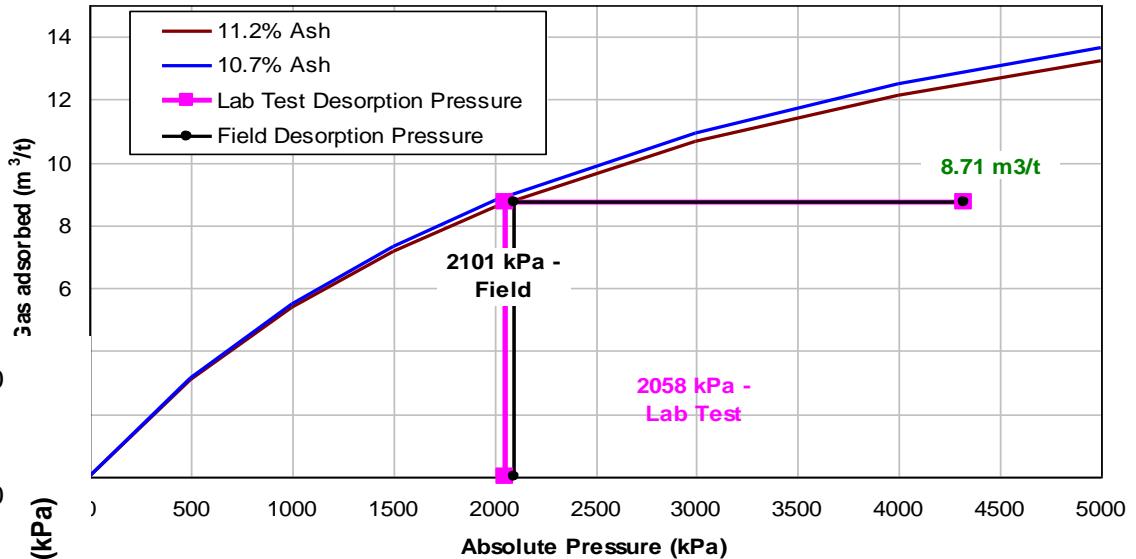
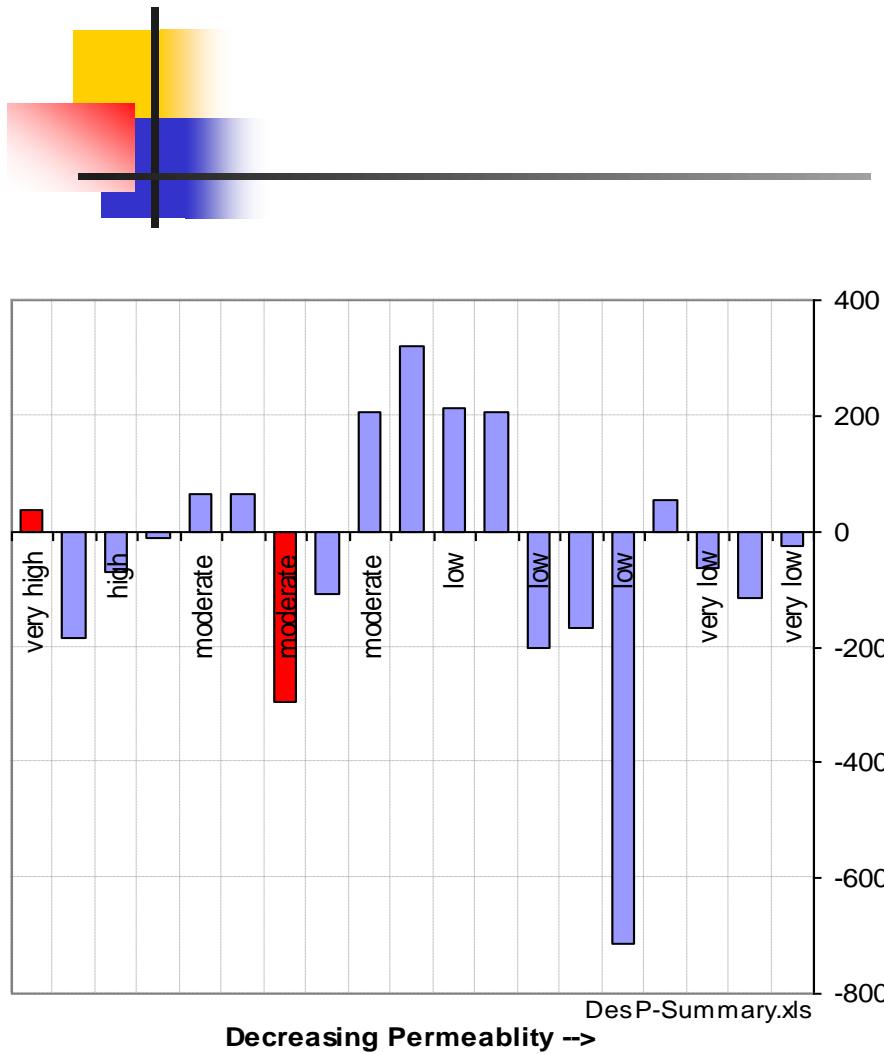


Comparison Desorption Pressures

– Well, Multiphase, Laboratory

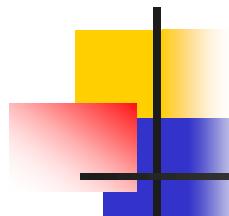
Methane Isotherm Goonyella Middle Seam Borehole GR01







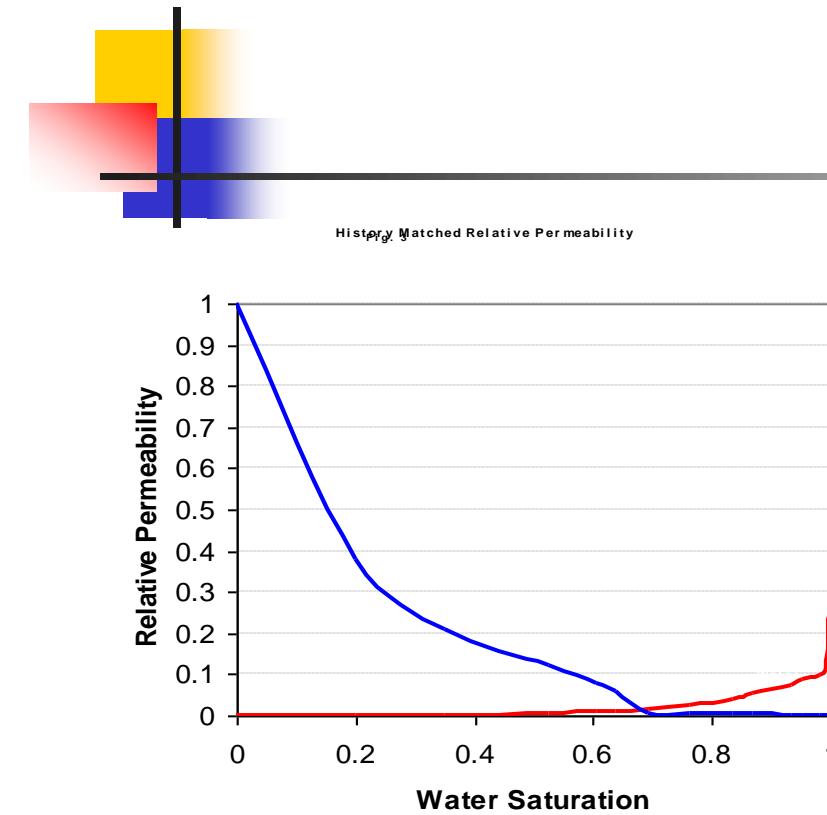
Relative Permeability from Multiphase Testing



Idea is to back out relative permeability curves from history matching water and gas production

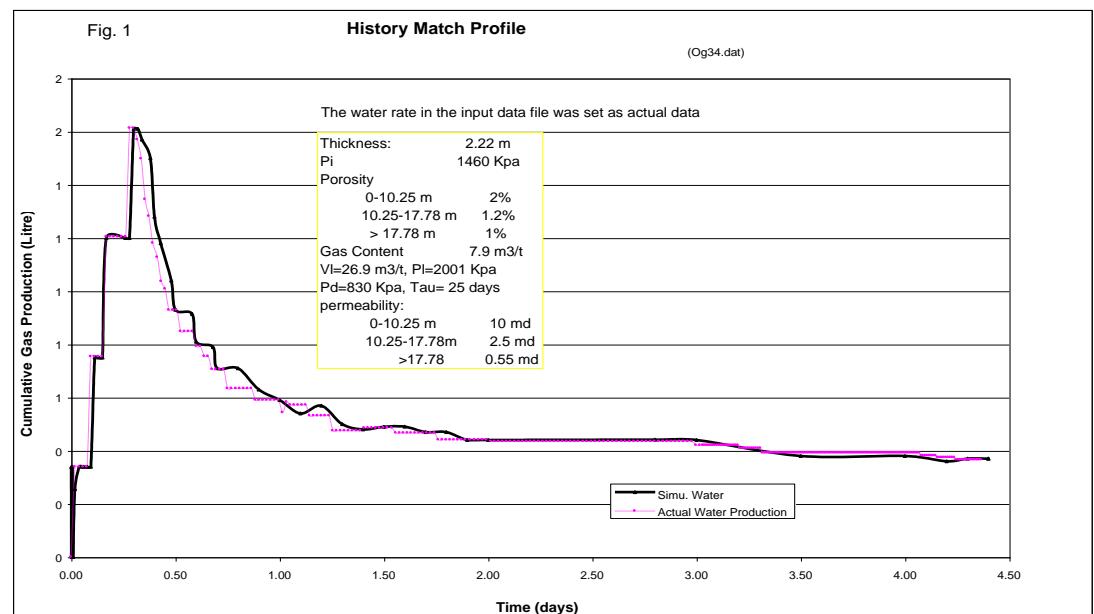
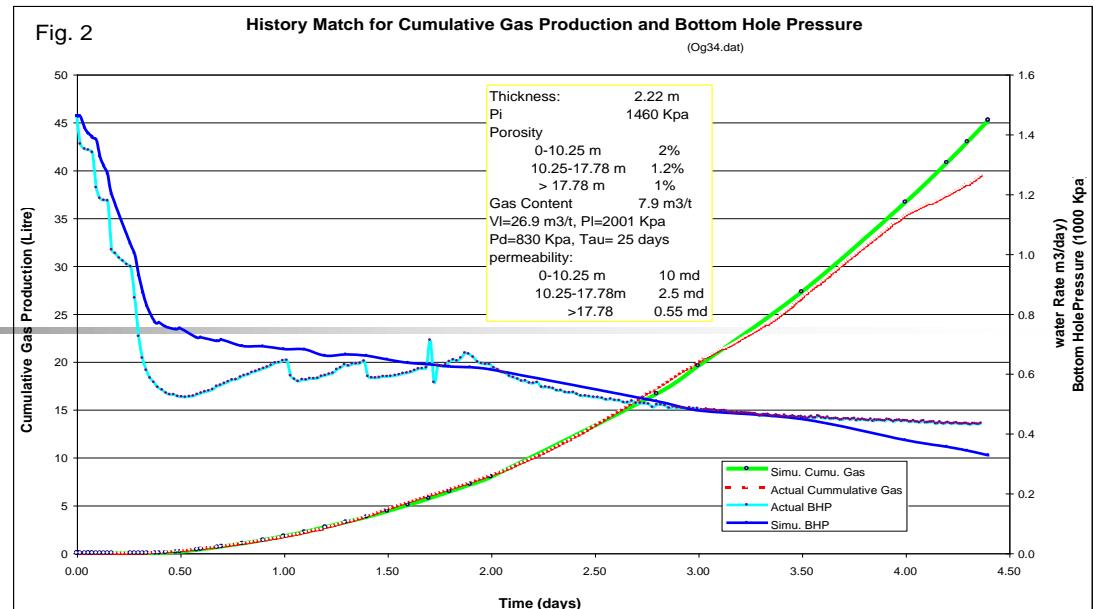
- Have had difficulty doing this with SIMED in moderate to high permeability coal.
- Same problem using EclipseCBM
- Have contracted Molopo (Wang Xingjin) to further SIMED curve matching

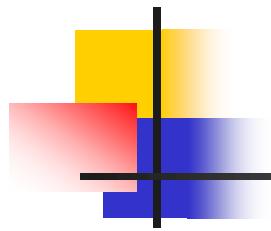
Matching per se is not the problem, it is getting a match using sensible parameters that is proving difficult.....



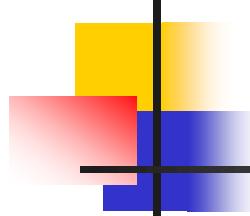
Parameters varied are:

- porosity
- permeability
- sorption time constant
- relative permeability





Desorption Time Constant - Tau



What is tau?

- Supposedly, the time taken for 63.2% of gas to desorb from a slow desorption gas content test

$$\tau = \frac{1}{\sigma D}$$

Where τ = desorption time constant

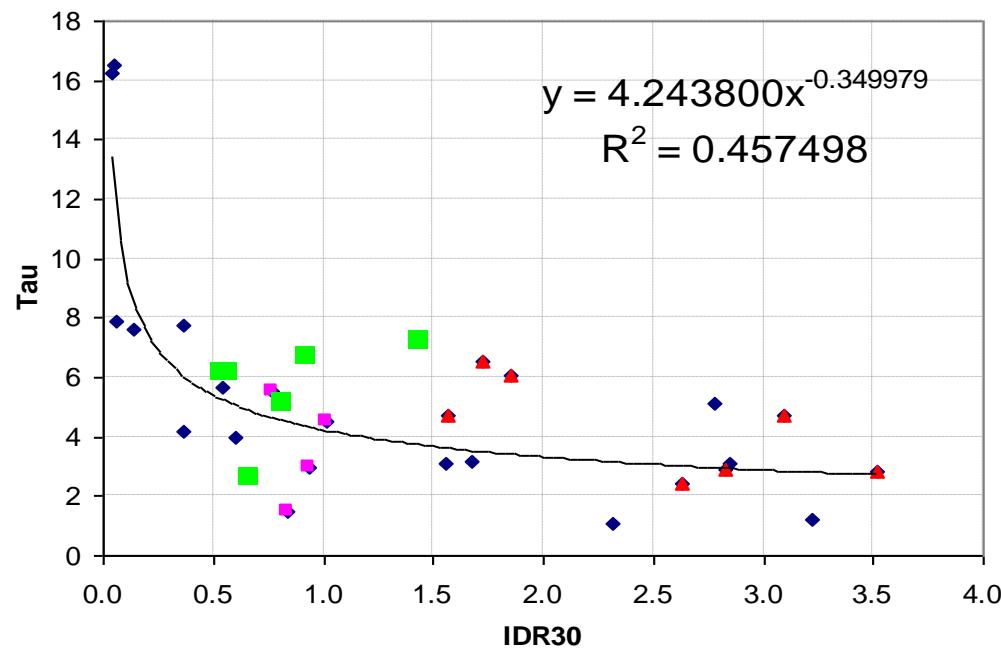
σ = coal matrix shape factor

D = diffusion coefficient

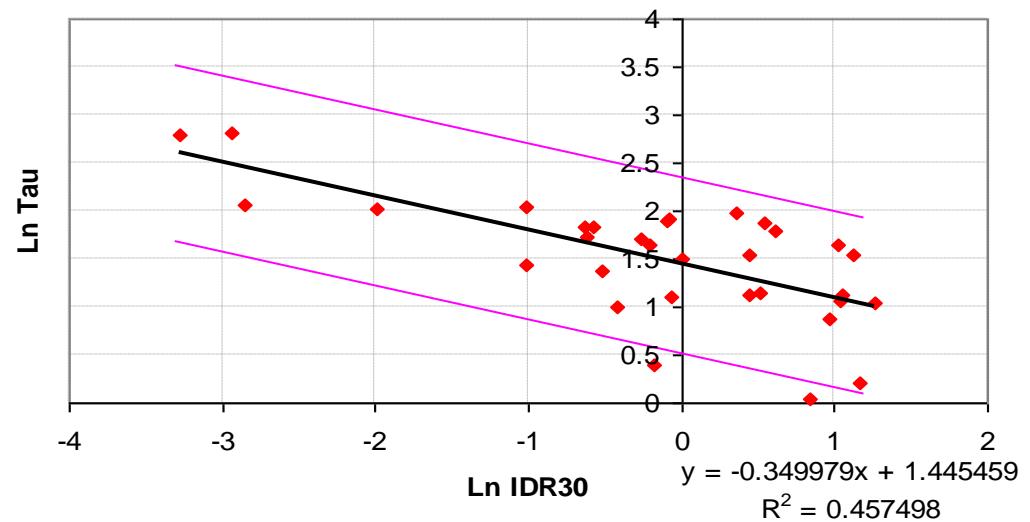
$$\frac{\Delta Q}{Q_0} = 1 - e^{-\sigma Dt}$$

$$\frac{\Delta Q}{Q_0} = 1 - e^{-1} = 0.632$$

- But is it 63.2% of Qm, Q1+Q2 or just Q2?
- We have related tau (from Qm) to IDR30.

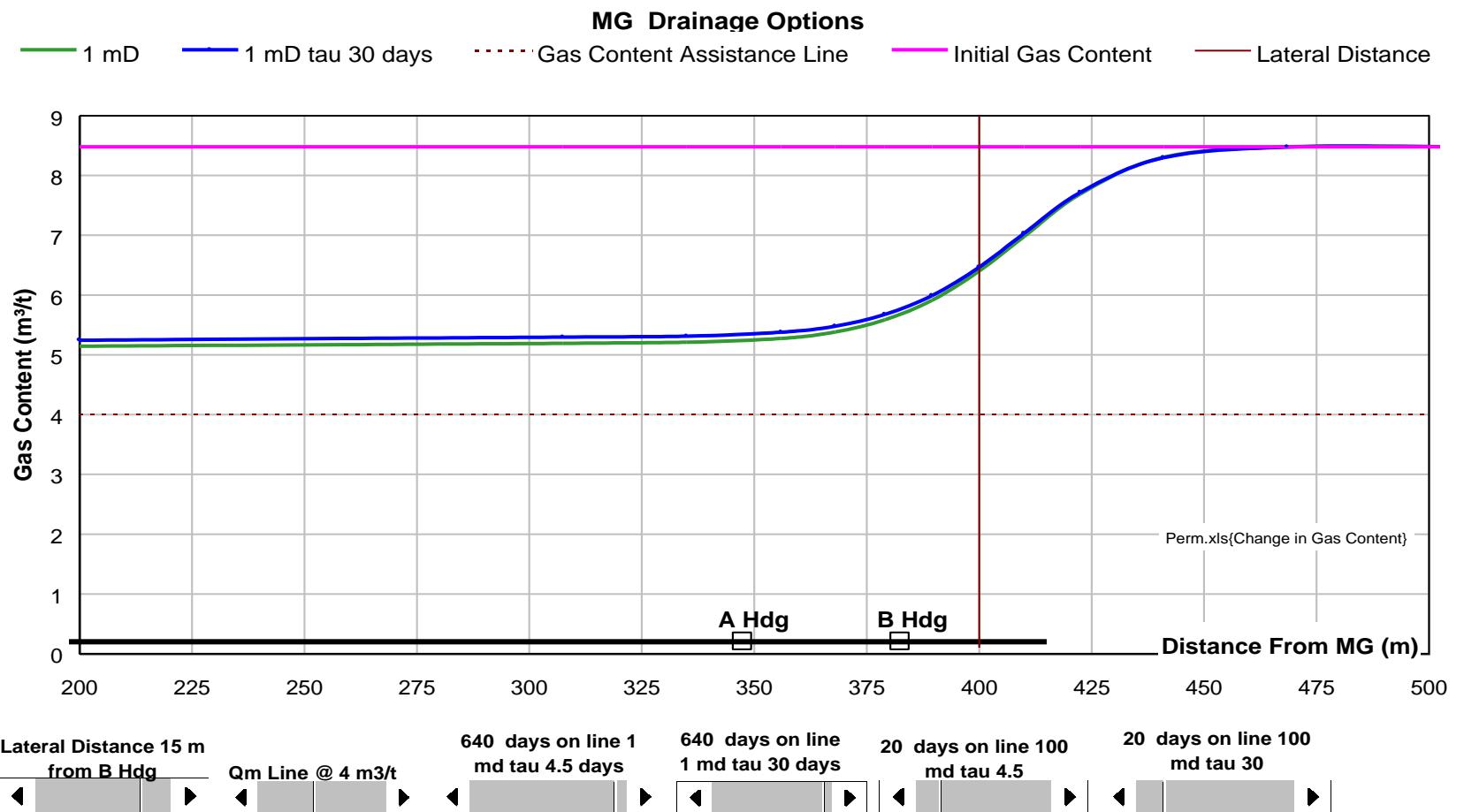


- Assessed the variability
- For a particular study area, define a range of tau's applicable to the gas content magnitude for that deposit for use in sensitivity assessments

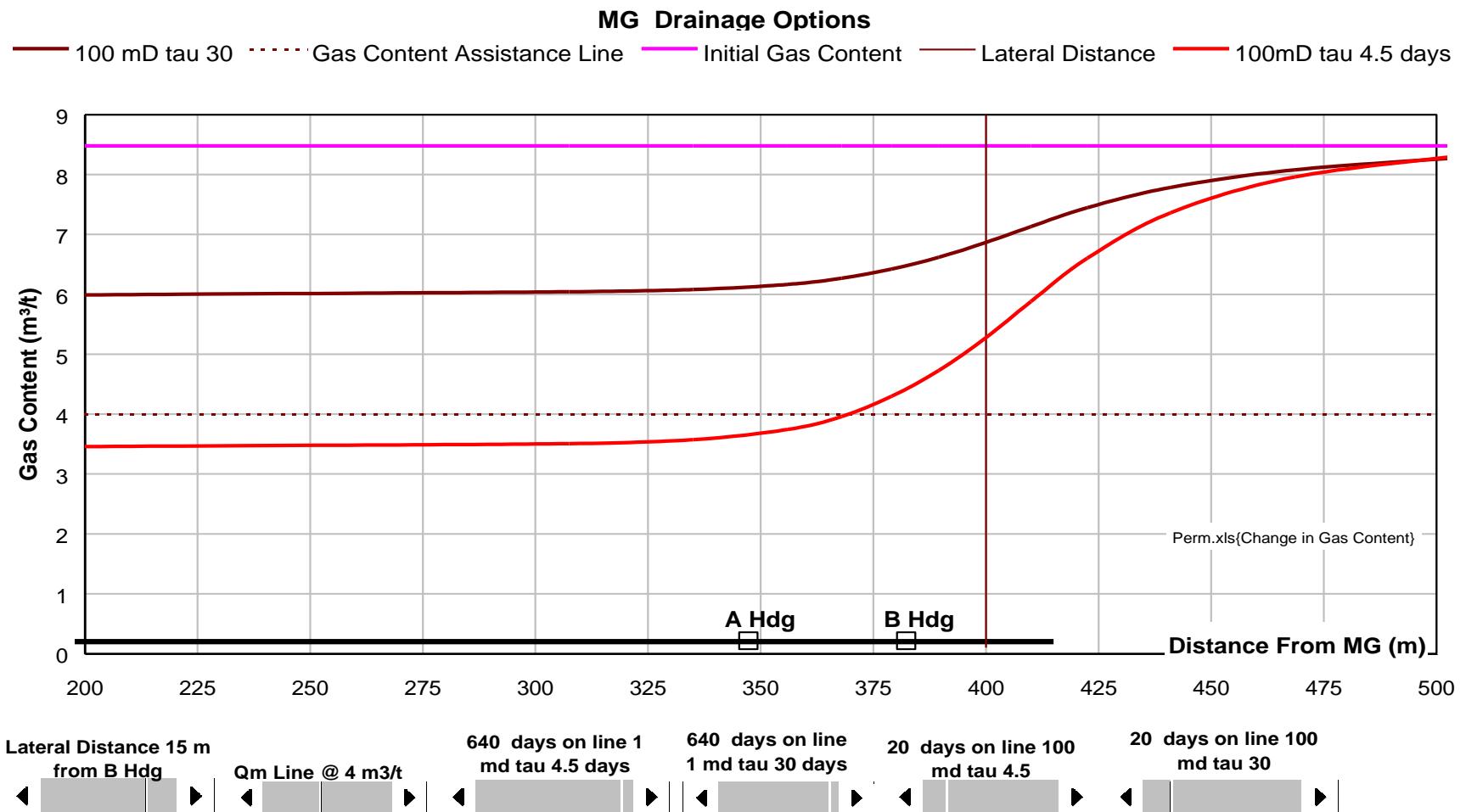


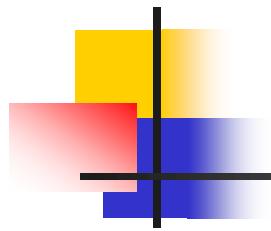
Qm mean	Tau hi	Tau mean	Tau low
3.36	23.8	9.5	3.8
4.58	18.7	7.5	3.0
6.81	13.5	5.4	2.2
8.50	10.7	4.3	1.7
9.47	9.2	3.7	1.5
10.01	8.3	3.3	1.3
10.38	7.7	3.1	1.2
10.63	7.2	2.9	1.2
10.83	6.9	2.7	1.1

At low perm (1mD, almost no difference between tau 4.5 and tau 30 days (8.5 m³/t)

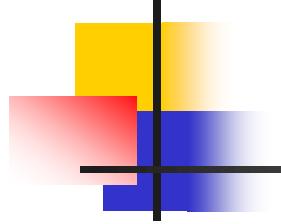


At high perm (100 mD, big difference between tau 4.5 and tau 30 days (8.5 m³/t)



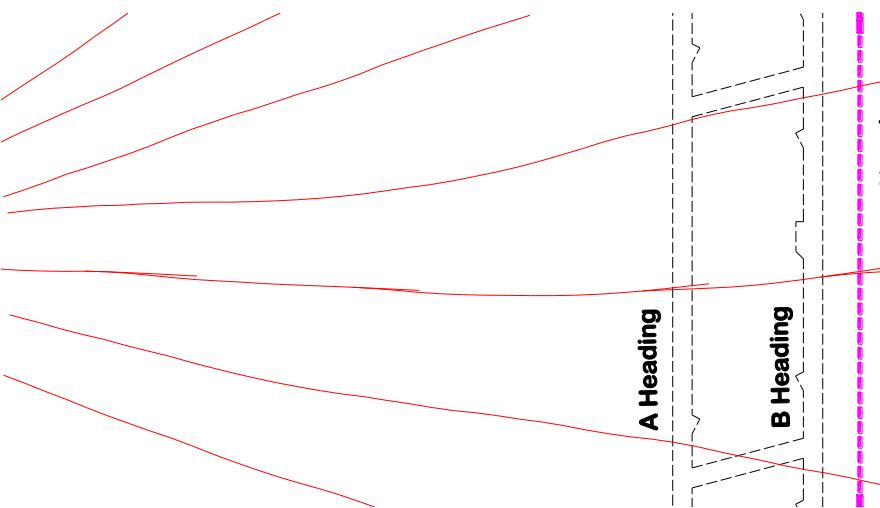
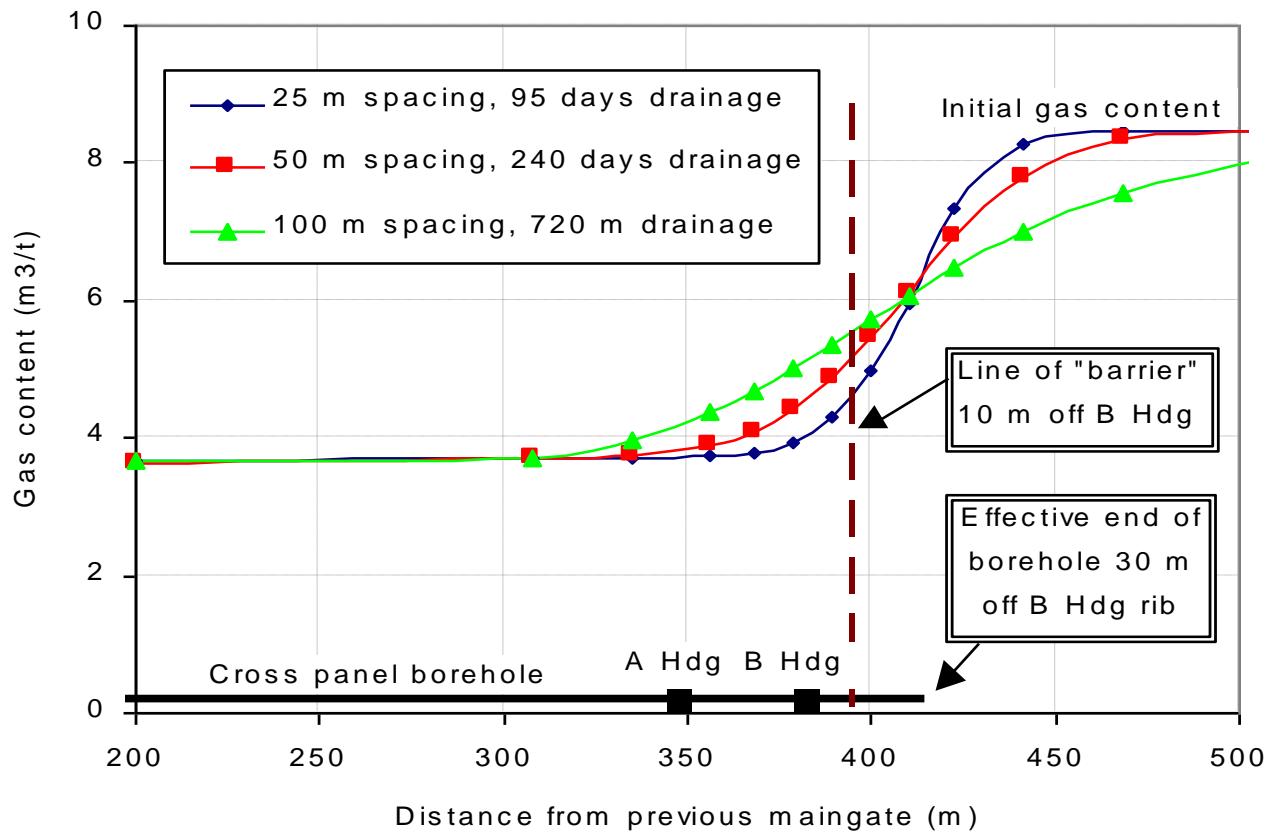


Gas Drainage Borehole Recharge

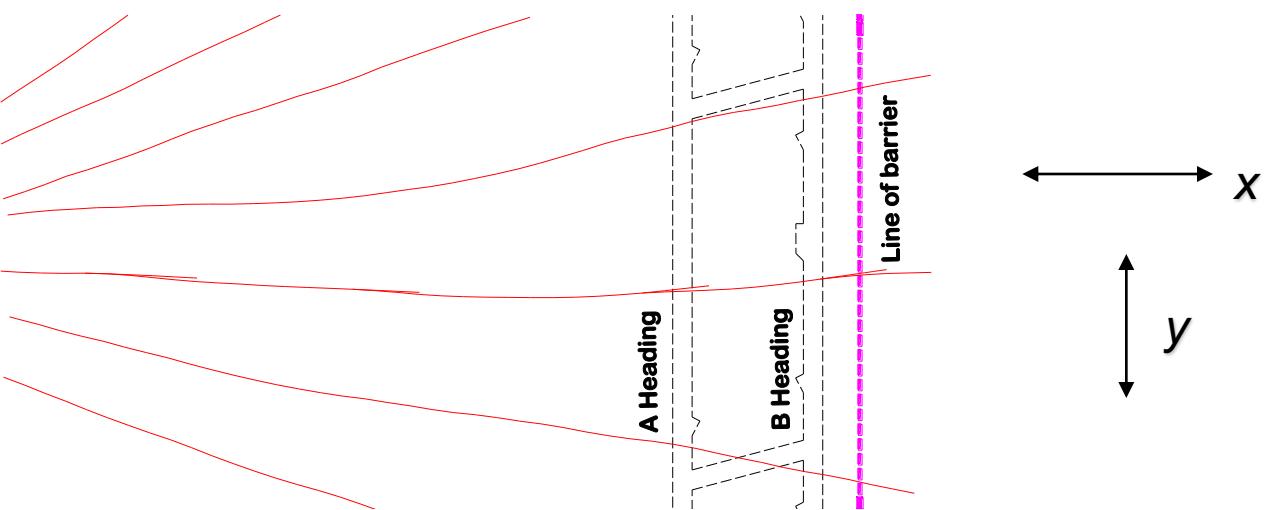
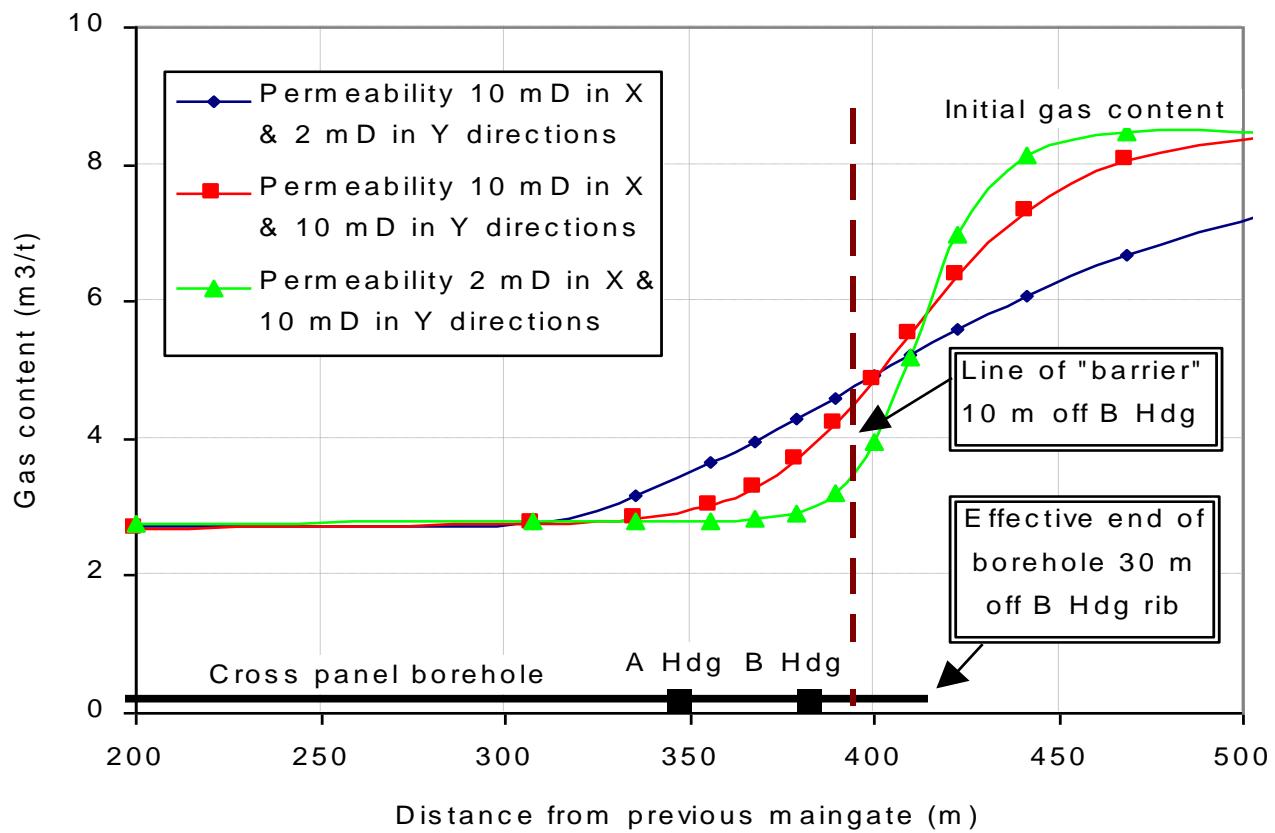


*Gas drainage efficiency diminishes
toward the end of boreholes,
Not from the end...*

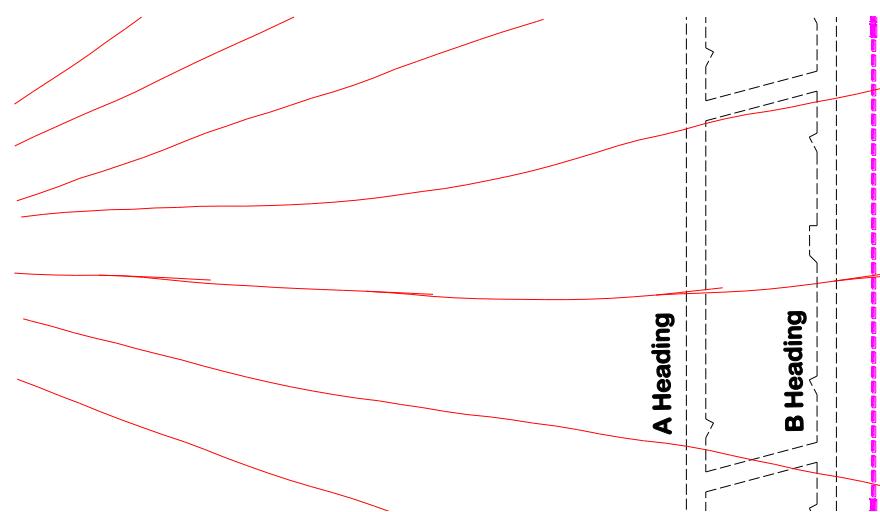
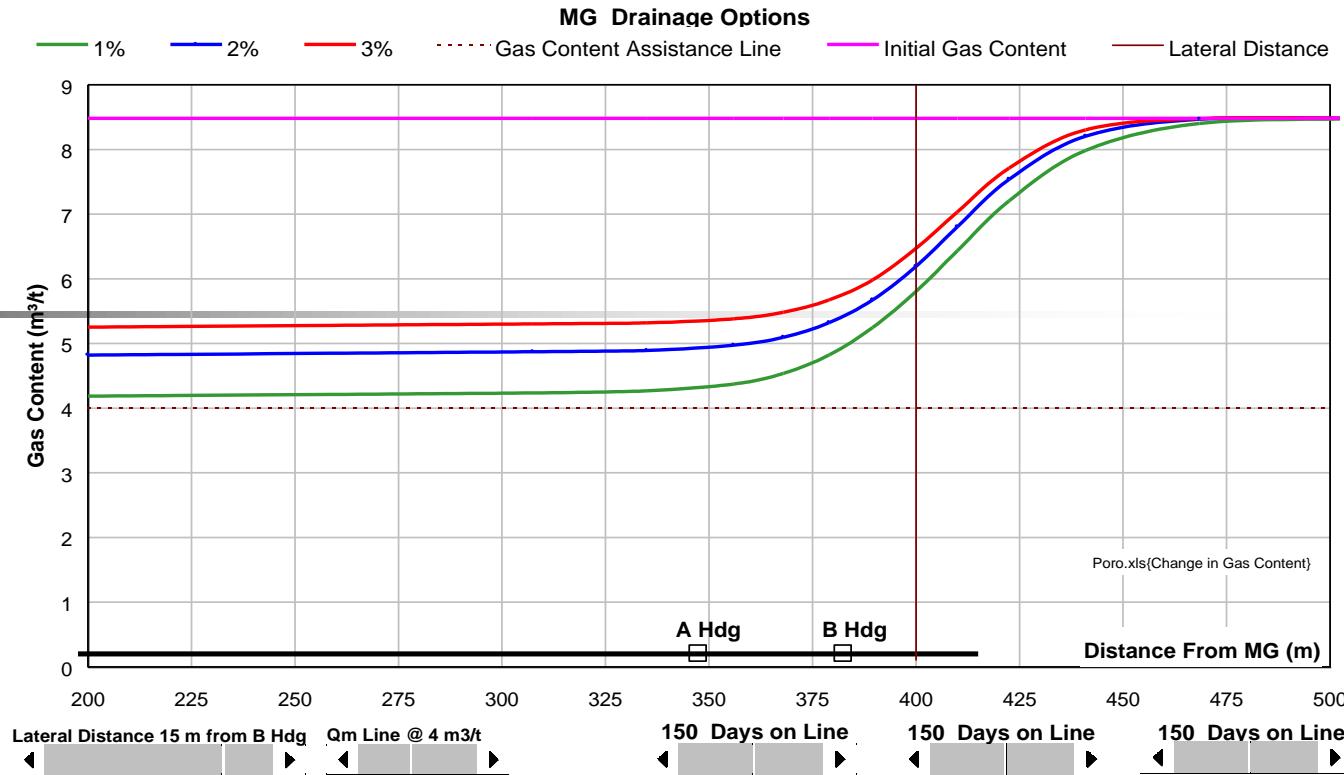
Effect Of Hole Spacing

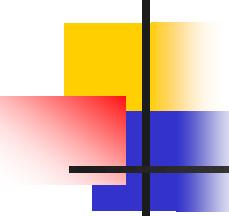


Effect Of Directional Permeability



Effect Of Porosity





Conclusions

- Hope to bring project to a close in next couple of months
- Scope to improve understanding and standardisation between labs on isotherm testing.
- Need to evaluate combinations of parameters eg as we did for ranges of tau at low and high permeabilities.
- A wider range of field measurements is important to lock down parameters. Eg measurement of both water and gas flow from in-seam boreholes greatly improves the robustness of the modelling.
- The bottom line is to create more robust modelling that is relevant. That means:
 - better input data
 - good modelling packages.
 - defining the approach to modelling that includes being critical every inch of the way, quantifying uncertainty.....

