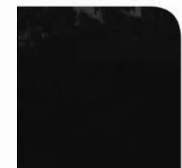
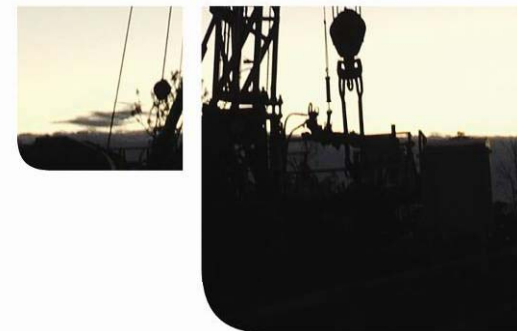
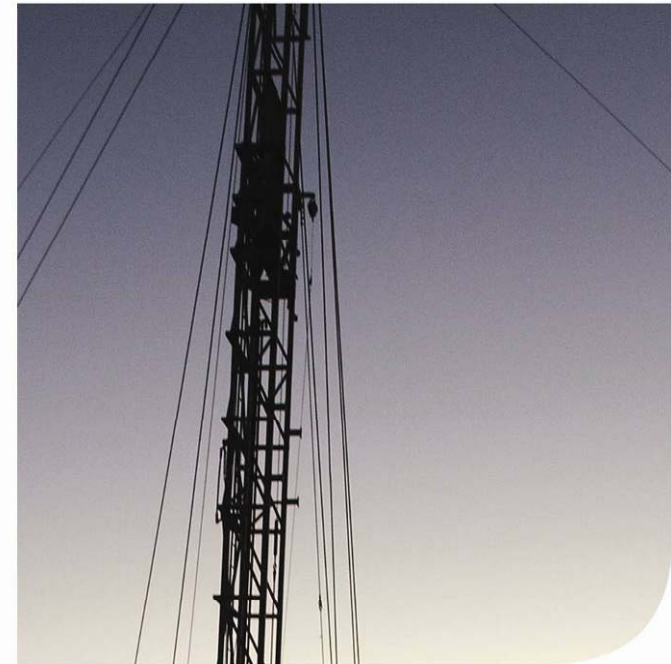


# AGL Energy Limited

## CSG Exploration in the Hunter Valley

Dr Andrew Falkner  
Head of Exploration - Upstream Gas

Bulga Community Consultative Committee  
AGL Energy – August 2009



# Summary

- › **Sydney Basin exploration history**
- › **The coal seam gas exploration process**
- › **What differentiates the good from the bad**
- › **Questions?**

- 
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# Sydney Basin Exploration History



## Historical Exploration

- > Over 20,000 coal & minerals exploration boreholes have been drilled in the northern Sydney Basin in the last 150 years
- > The majority of these have been drilled to identify the vast coal resources currently being mined today
- > In contrast, only ~70 boreholes had been drilled for petroleum with ~20% of these specifically targeting coal seam gas (CSG)
  - > Equivalent to 1 CSG well every 768km<sup>2</sup>, just within AGL's permits
- > To date, no commercial reserves of conventionally reservoired oil, gas or coal seam gas exist within the northern Sydney Basin
- > Recent CSG exploration undertaken by AGL and its previous joint venture partner Sydney Gas has nearly doubled the number of CSG exploration wells over the past 5 years

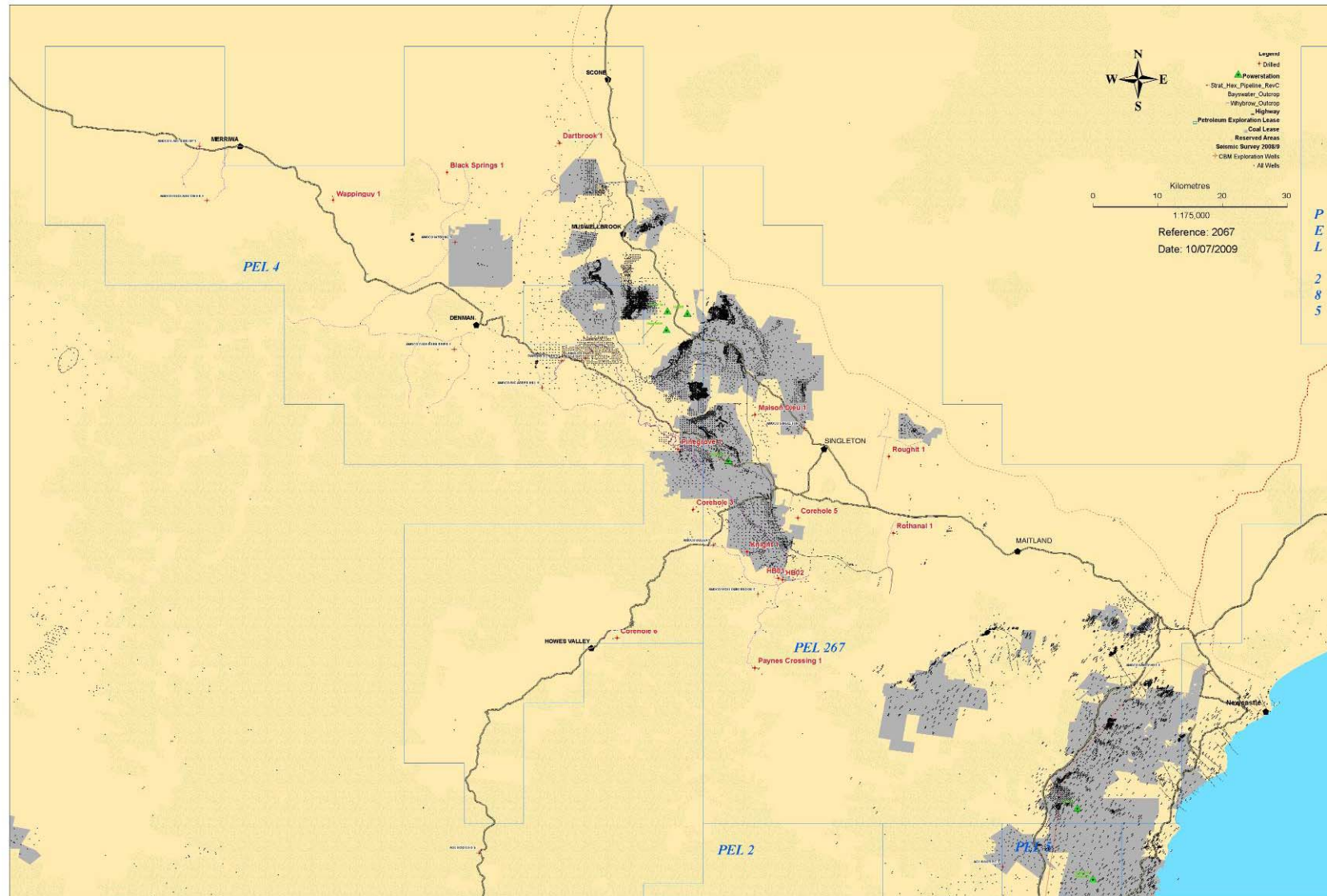
GENERELAISED STRATIGRAPHY OF NORTHERN SYDNEY BASIN									
AGE	NEWCASTLE AREA	HUNTER VALLEY AREA	ENVIRONMENT	SEDIMENTARY FACIES	SOURCE	RESERVOIR			
MIDDLE TRIASSIC	WIANAMATTA GROUP		COASTAL PLAIN	MEANDERING STREAMS, LEAVES, BACK SWAMPS, LAGOON, PEAT MARSH, BARRIER ISLAND COMPLEX					
	HAWKESBURY SANDSTONE		ALLUVIAL PLAIN	BRAIDED STREAM, MEANDERING STREAM, FLOOD PLAIN		①			
	GOSFORD SUBGROUP	NEWPORT FM FM	TERRIGAL	LOWER DELTA PLAIN	INTERDISTRIBUTARY BAY, DISTRIBUTARY CHANNEL				
EARLY TRIASSIC	NARRABEEN GROUP	PATONGA CLAYSTONE		ALLUVIAL PLAIN	FLOOD PLAIN DEPOSITS	③			
		TUGGERAH FORMATION		UPPER DELTA PLAIN	FLOOD PLAIN DEPOSITS				
		MUNMORAH CONGLOMERATE			ALLUVIAN FAN	⑤			
		DOORALONG SHALE		LOWER DELTA PLAIN MARINE INCURSION	BRAIDED CHANNELS, FLOOD PLAIN, ESTUARINE DEPOSITS				
PERMIAN	NEWCASTLE COAL MEASURES	SUBGRP		ALLUVIAL PLAIN	SHALLOW SWAMP / LACUSTRINE	①			
		BOOR		UPPER DELTA PLAIN	MEANDERING STREAM DEPOSITS: OVERBANK, SWAMP, COAL SWAMP	GAS			
		ADAMSTOWN SUBGRP							
		LAMBION SUBGRP							
	WARAISH SANDSTONE								
	LATE PERMIAN	TOMAGO COAL MEASURES	SINGLETON SUPER GROUP	JERRYS PLAIN SUBGRP		U.D.P.	OVERBANK, SWAMP, COAL SWAMP	④	
				ARCHFIELD STN			CHANNEL TO CREVASSE SPLAY	④	
				VANE SUBGRP		L.D.P.	BLACK SWAMP, LAGOON	OIL	
				BULGA FM			DISTRIBUTARY CHANNEL, CREVASSE SPLAY	④	
				FOYBROOK FM		PLAIN	INTERDISTRIBUTARY BAY	?OIL	
				SALTWATER CR FM		MARINE SHELF	COAL SWAMP	GAS	④
				MALBRING SILSTONE		PRODELLA	BLACK SWAMP, LACUSTRINE, DELTA MARGIN	GAS	
				MUREE SANDSTONE		MARINE SHELF	INTERDISTRIBUTARY BAY, CREVASSE MEANDERING STREAM DEPOSITS, FRONTAL SPLAY		④
	BRANXTON FORMATION				GAS, OIL	④			
EARLY PERMIAN	GREATA COAL MEASURES	PAXION FM		U.D.P. LOWER DELTA PLAIN	NEARSHORE SAND	④			
		KITCHENER FM			SHALLOW MARINE	④			
		KURRI KURRI CONG			BEACH, NEARSHORE SAND BARS	④			
	DALWOOD GROUP	NEATH SANDSTONE		U.D.P. ALLUVION PLAIN	NEARSHORE SAND	INTERFAN COAL SWAMP	①		
		FARLEY FM							
		RUTHERFORD FM							
		ALLANDALE FM							
LAOCHINVAR FM		GYARRAN VOLCANICA	SHORELINE	?OIL					

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# Northern Sydney Basin Exploration and Borehole Distribution

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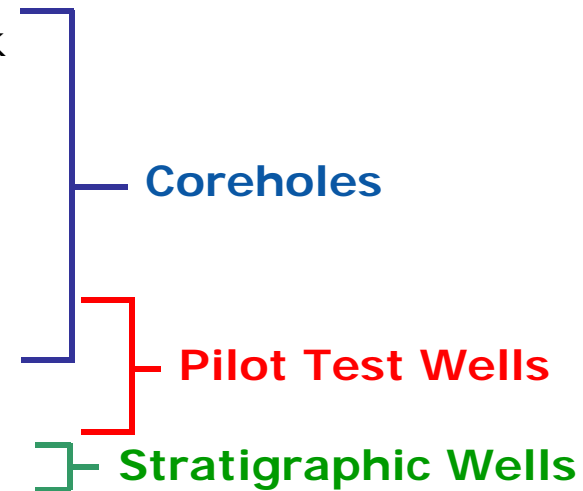
# Coal Seam Gas Exploration



## What Do We Look For

> Defining a CSG field requires an understanding of many parameters including:

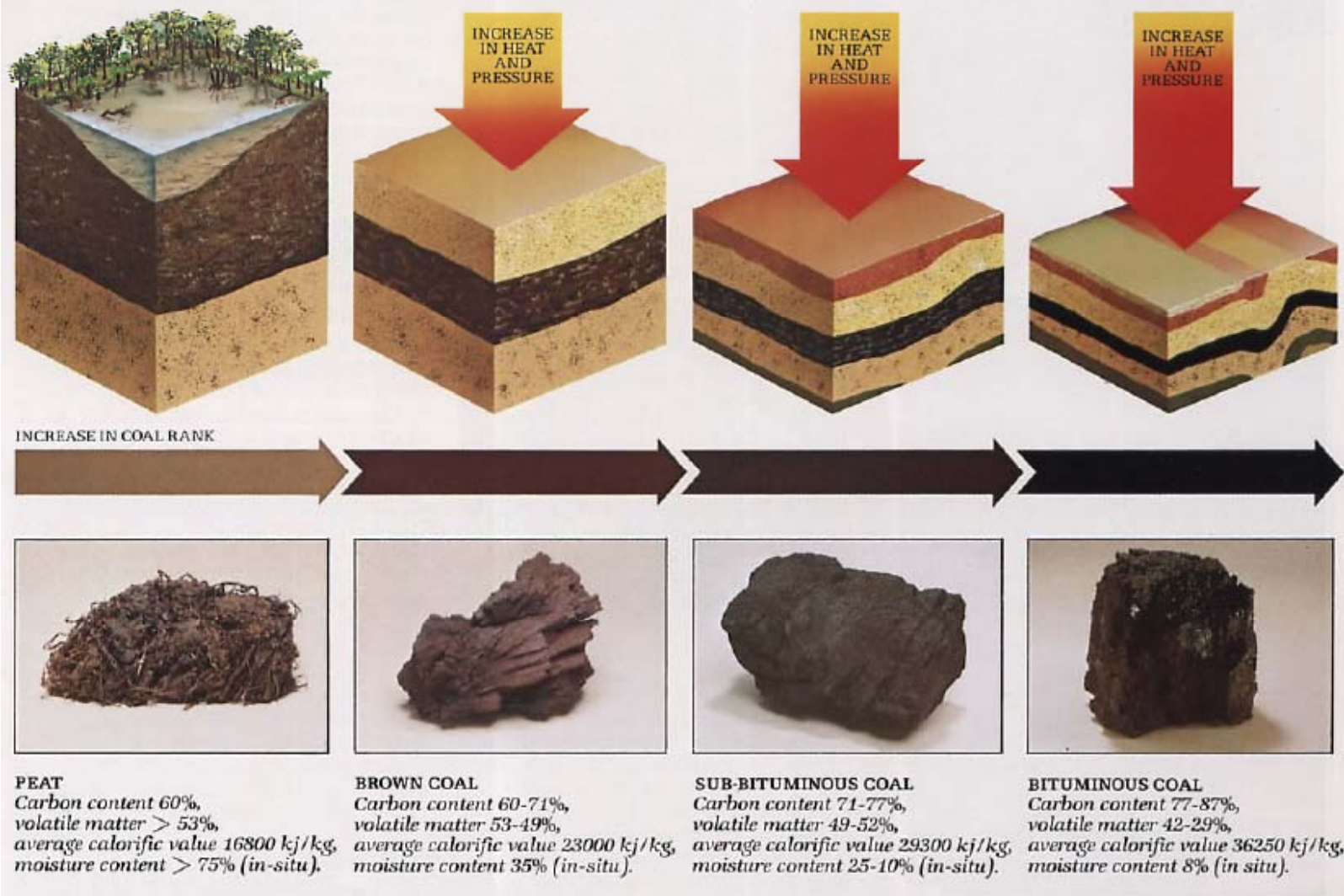
- > Reservoir (coal) thickness, composition & rank
- > In-situ gas content
- > Gas saturation
- > Gas composition
- > Reservoir permeability
- > Reservoir deliverability
- > Extent of the field



> Each of these parameters are determined by retrieving samples for measurement in a lab or testing in the field through the drilling of coreholes, test wells or stratigraphic holes

A single negative result in any one or all of the parameters above may deem the area unsuitable for CSG production

## CHANGES IN RANK OF COAL

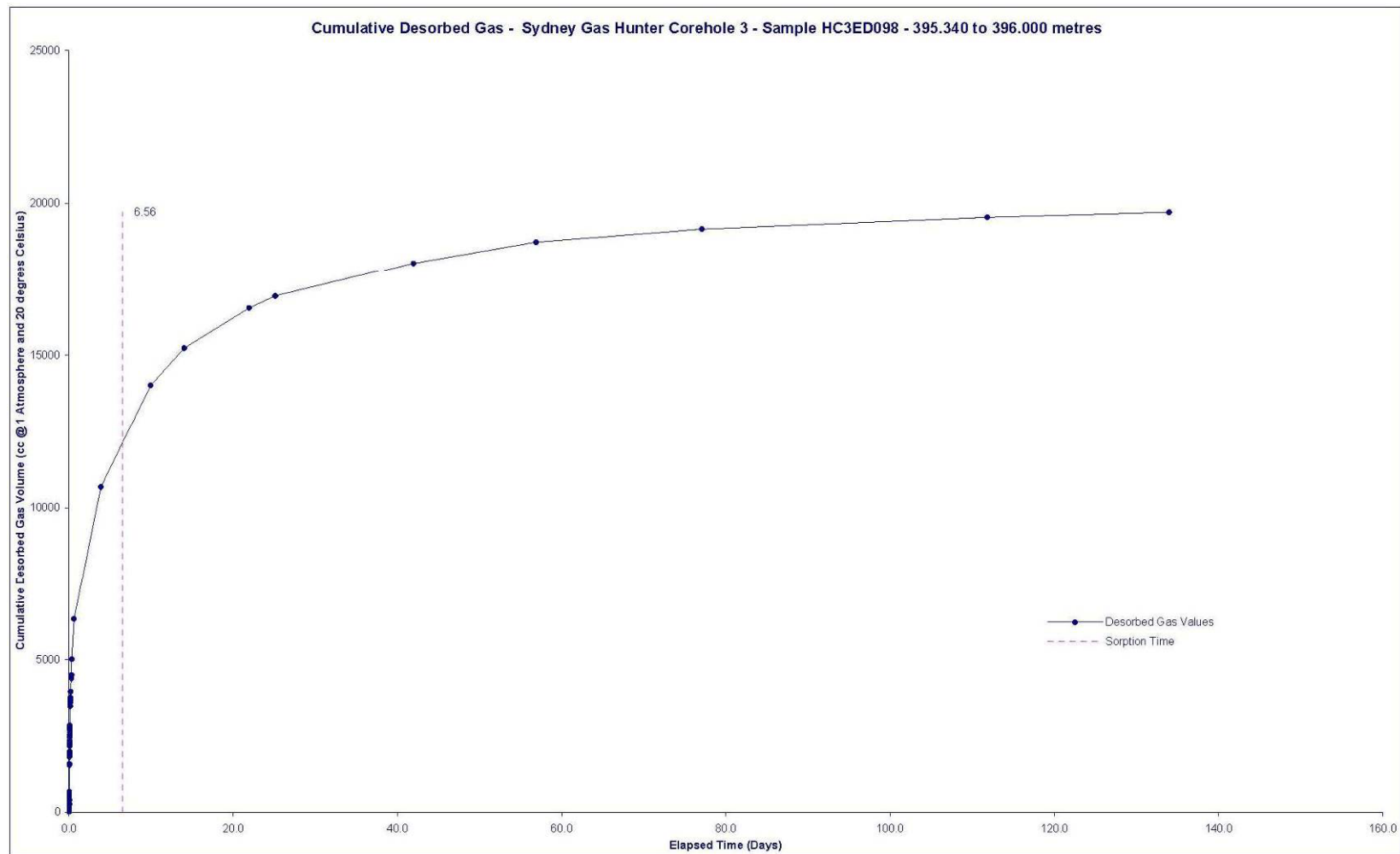


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## In-Situ Gas Content

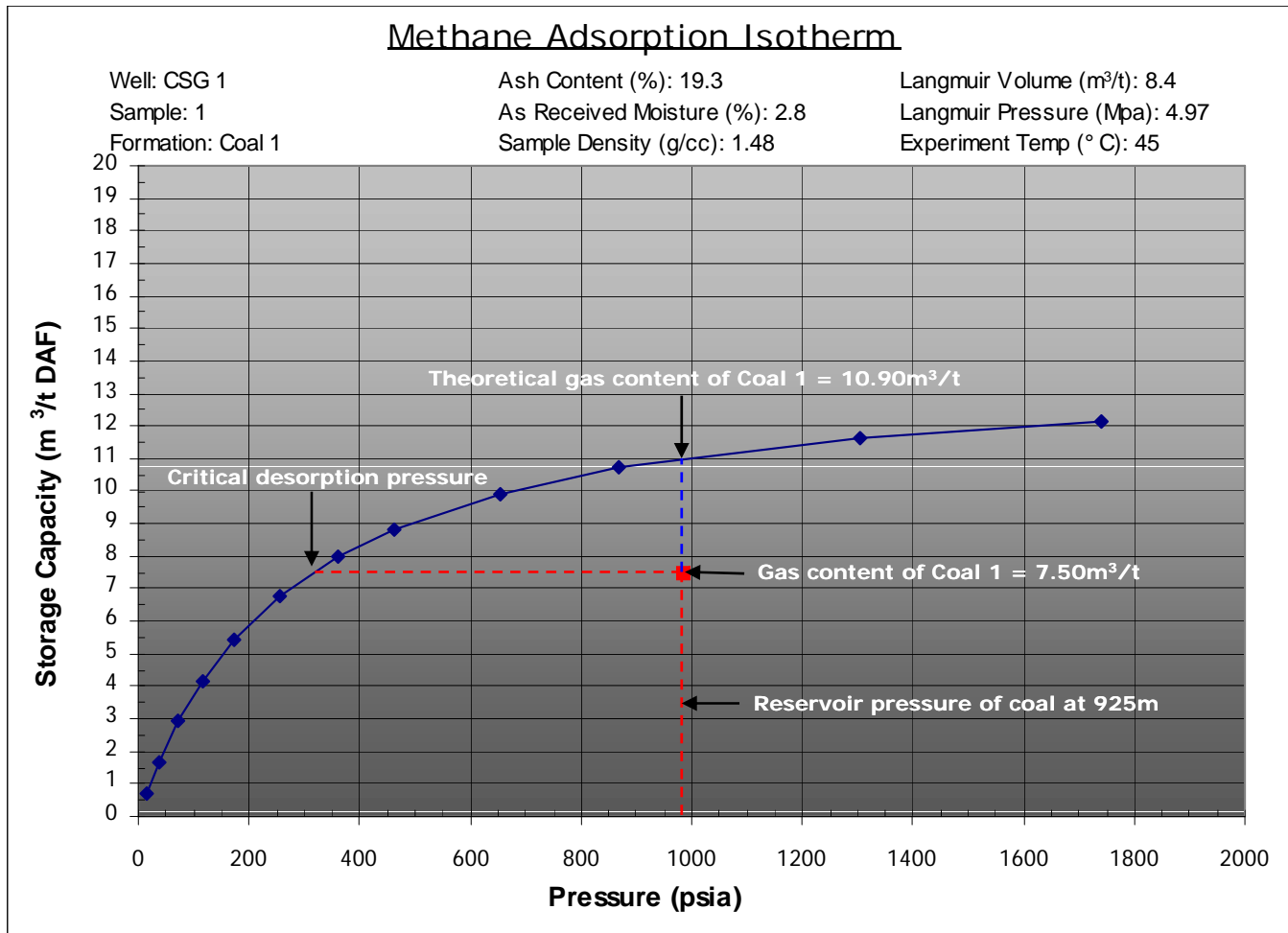
- > Gas content is a measurement of how much gas is held in the coal
- > Gas is stored or “adsorbed” to the surface of the coal matrix
- > As the surface area available for adsorption is large, coal reservoirs are far superior gas reservoirs over conventional sandstone reservoirs which store the gas within pore spaces between the grains of sand
- > Gas is held in the adsorbed state by pressure, which increases with depth
- > As a result, gas content will theoretically increase with depth
- > Total gas content ( $Q_t$ ) is measured by:
  - > Retrieving the coal core from the corehole quickly to minimise the lost gas ( $Q_1$ ) which is eventually back calculated
  - > Measuring how much gas desorbs from the coal over a 2 - 4 month period ( $Q_2$ )
  - > Measuring how much gas is liberated from crushing at the end of desorption ( $Q_3$ )

# Typical Desorption Curve



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# Sorption Isotherm & Undersaturated Coal Seam



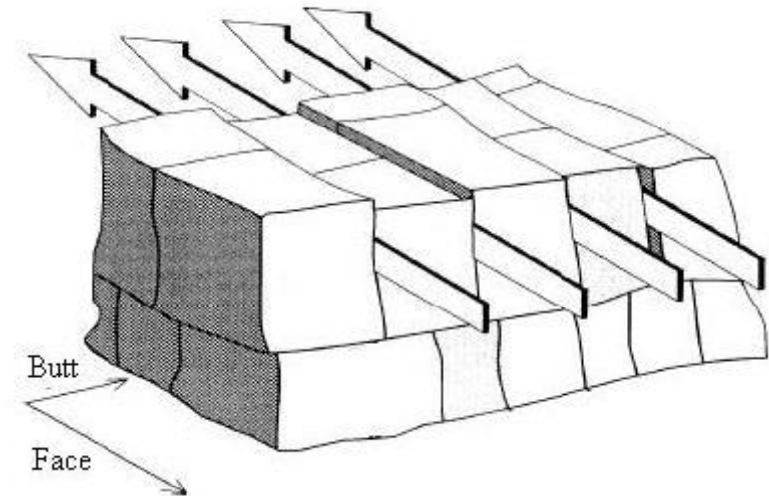
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## Gas Composition

- > Methane is the main gaseous “by-product” of the coalification process, however, higher hydrocarbons and inert gases such carbon dioxide and nitrogen also remain adsorbed to the coal
- > These inert gases lower the energy value whilst also limiting the potential end use to power generation
- > Carbon dioxide is particularly an issue for coal reservoirs as they can store twice as much CO<sub>2</sub> than CH<sub>4</sub> and also its ability to displace and replace methane
- > During times of regional igneous activity, secondary CO<sub>2</sub> may be added to the coal seams

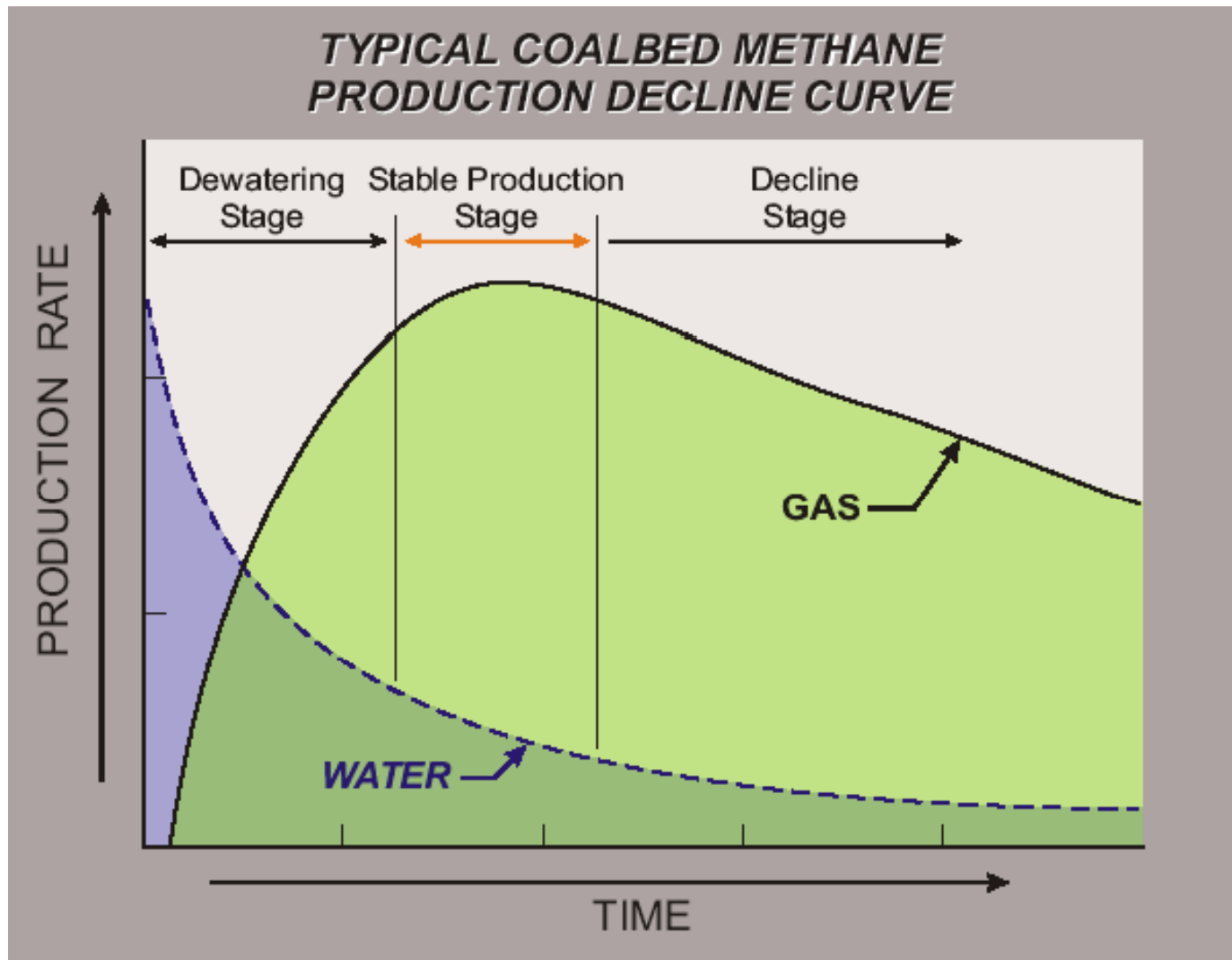
## Permeability & Deliverability

- > Permeability is a measurement of the coal's ability to convey gas and water
- > The permeability of the coal is the primary factor influencing a well's deliverability or production rate
- > Factors that influence permeability include depth, intensity of cleat within coal as well as the regional and local stresses
- > Tectonic fractures or joints can also act as a pathway for gas and water and act as a secondary permeability mechanism
- > Permeability can be measured in the field to infer a well's production potential
- > Deliverability can only be determined through drilling and production testing



Face and Butt cleat in coal structure( Scott,1994)

# Test Well Production Profile

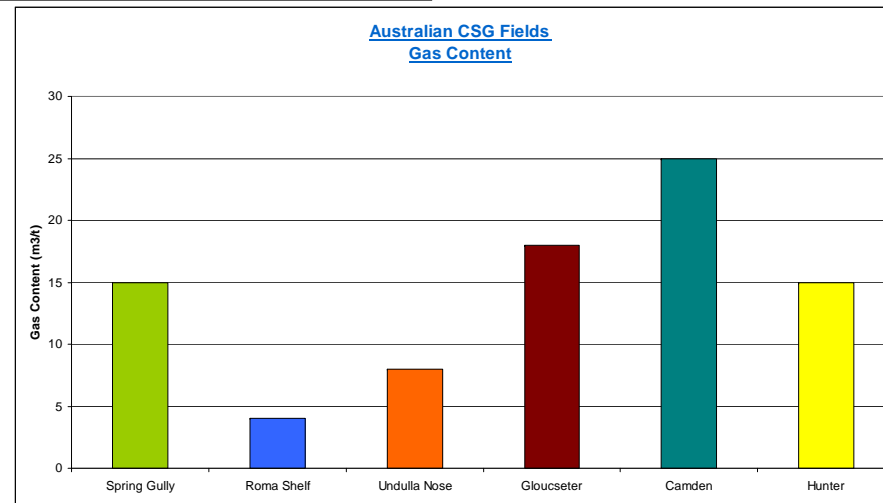
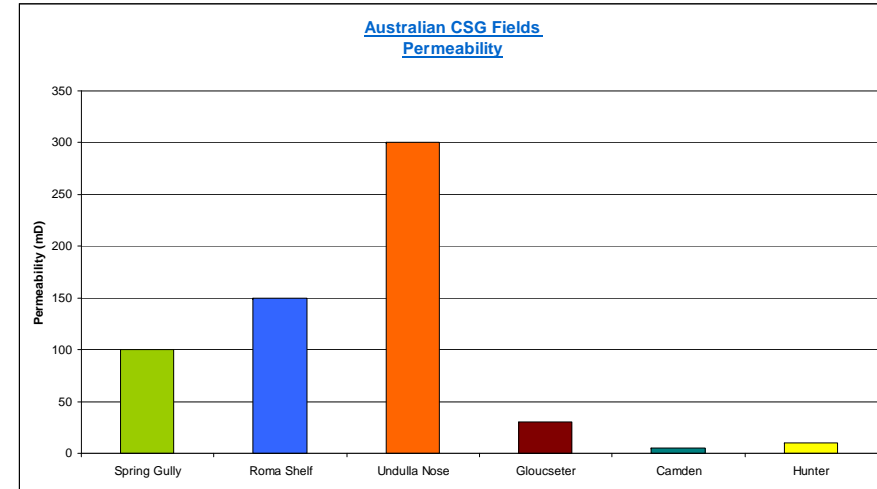
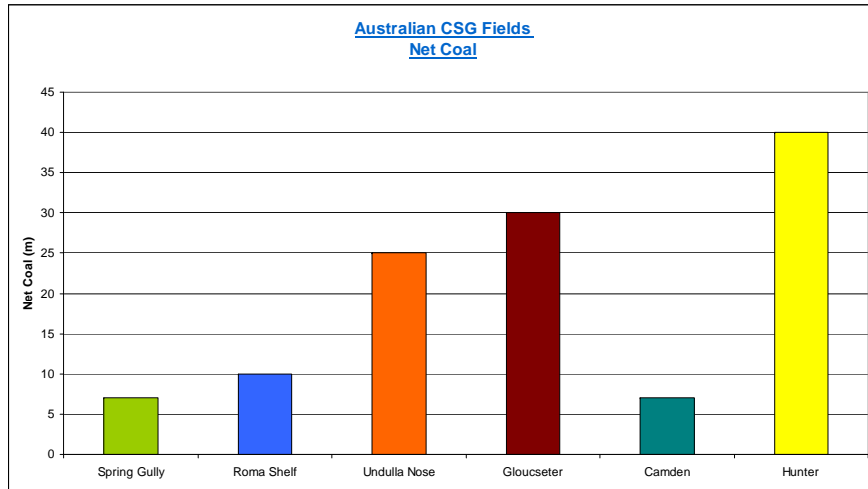


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Defining the good from  
the bad



# CSG Fields of Australia



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Questions?

