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Gas and Coal Outburst Committee Seminar
11/11/09 – Illawarra Master Builders Club

Gas & Coal Outburst Committee Seminar

Biogenesis of Methane & Bio-alteration of Tight Coal

Chris Rogers – Head of Operations
Apex Energy NL

November 2009

Disclaimer & Important Notice

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Investment Group

Pintail Laboratories

- Biogeneration & Remediation

Lateral Technologies International

- Lonestar Lateral Drilling (Zero Radius Drilling)

Apex Energy NL

- Australian CBM Leases

CSM & CMM

Illawarra and Burragorang

Areas

	km²
PEL444	32
PEL442	172
Metropolitan	58
Huntley CCL700	19
PEL454	168
BVC CCL740	36
Total	**485**

Reserves/Resource

2P = 58 PJ
3P = 210 PJ
C = 1360 PJ

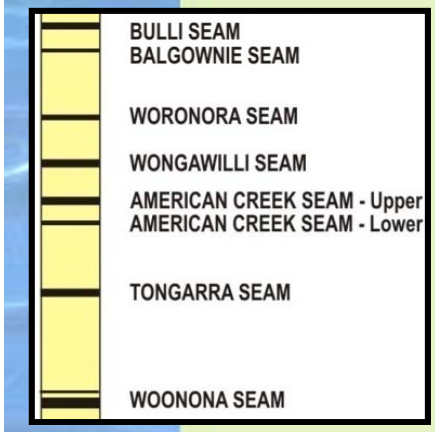
MHA Petroleum Consultants

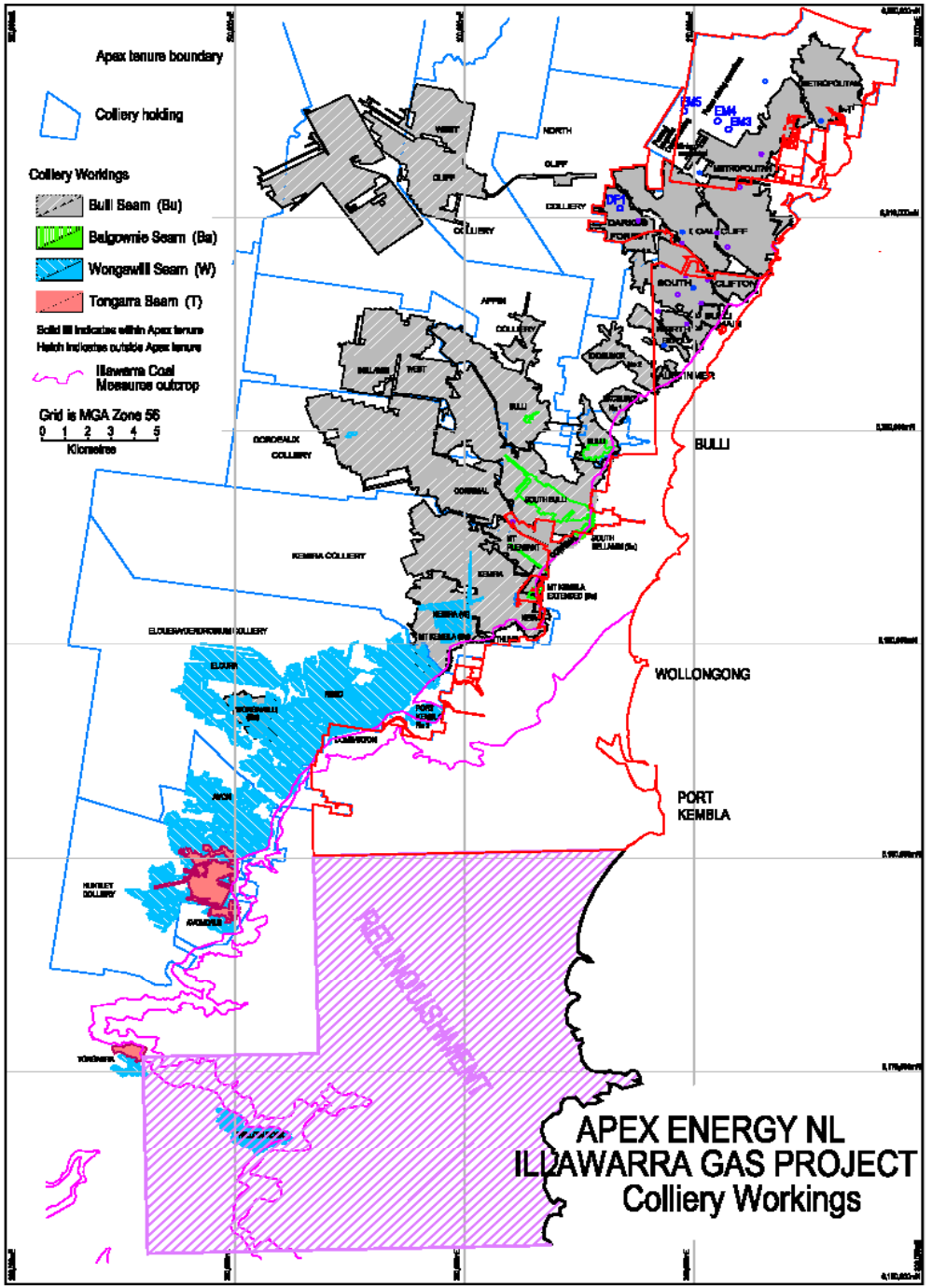
Coal – Circa 9 billion tonnes

GIP – Circa 2.5 TCF

Illawarra

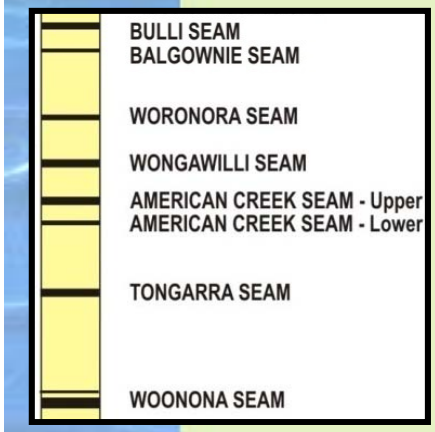
- Multiple Coal Seams
- Abandoned Mines
- Goafs
  - 4 x Active mines
  - >20 Abandoned mines
  - Multiple gassy goafs

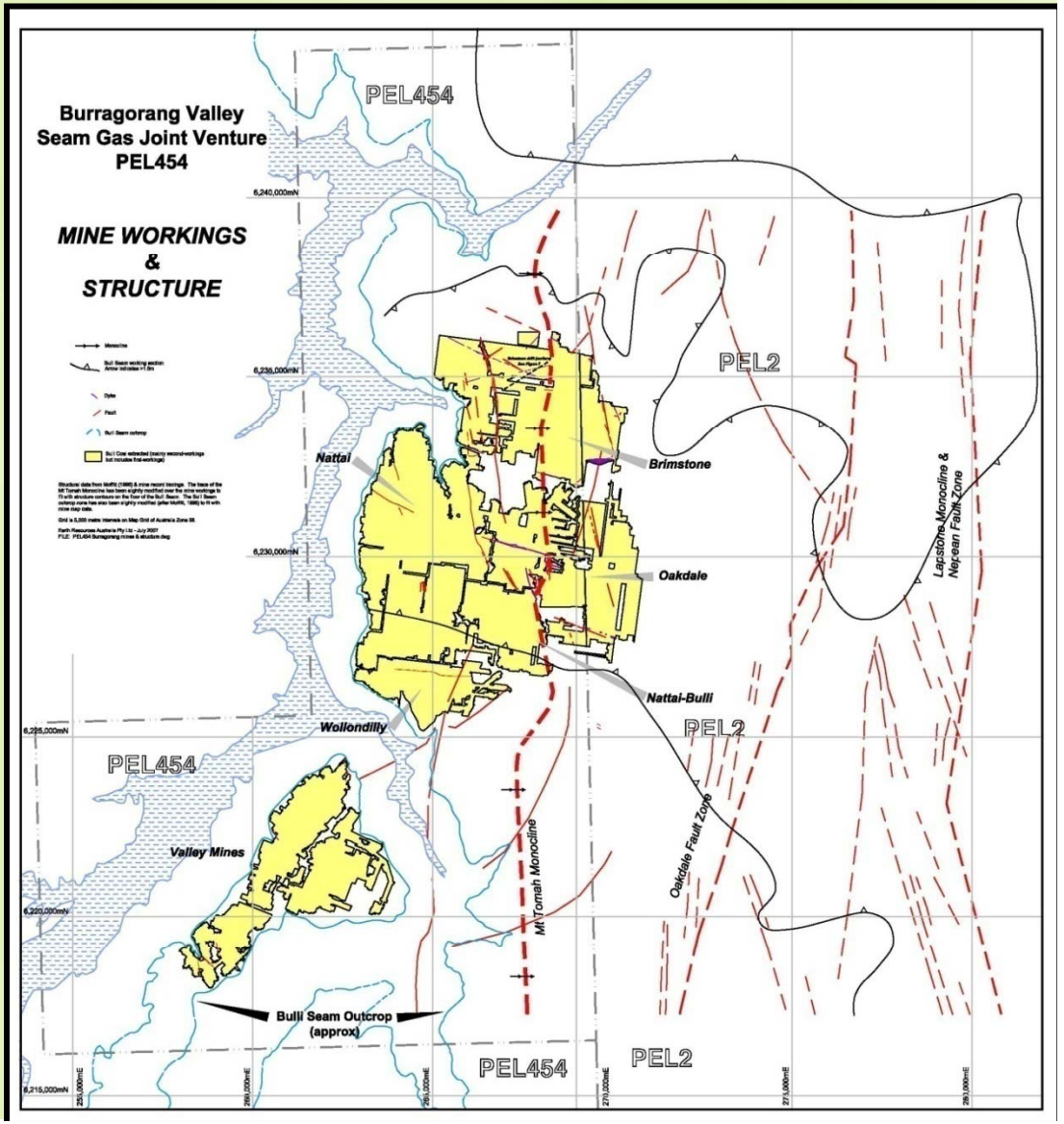




Burragorang

- Multiple Coal Seams
- Abandoned Mines
- Goafs
  - 8 x Abandoned mines





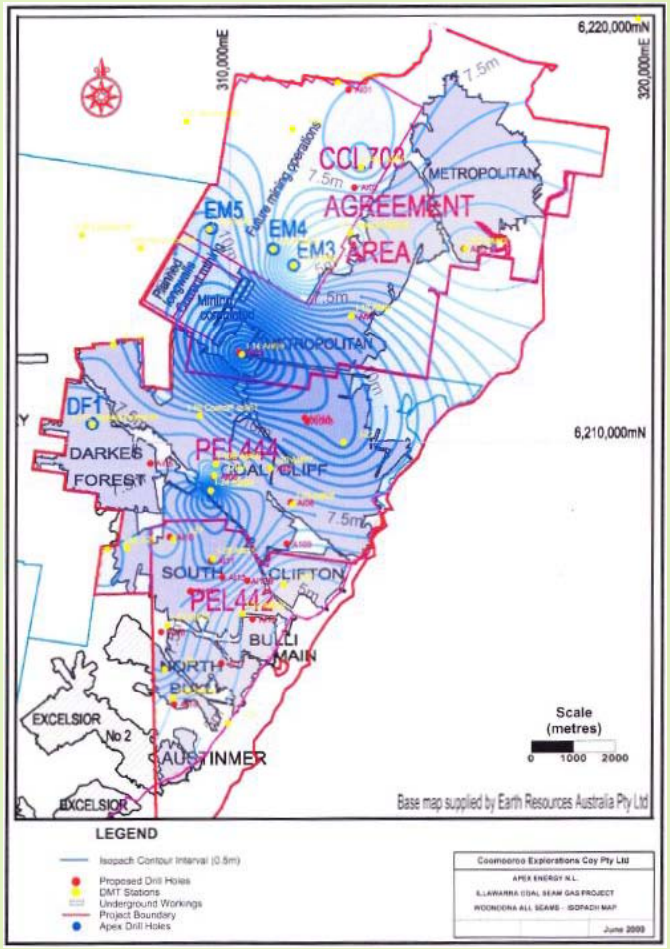
Apex Energy Activity

- Resource Evaluation
  - Digital Magnetotelluric Survey (DMT)
  - Goaf System Contact Study
- Drilling project
  - Pt 3A – Proj 07013 – Approval Granted 24/9/09
  - Fund Raising
  - Contractor Engagement
- DF #1 Well – Production Ready

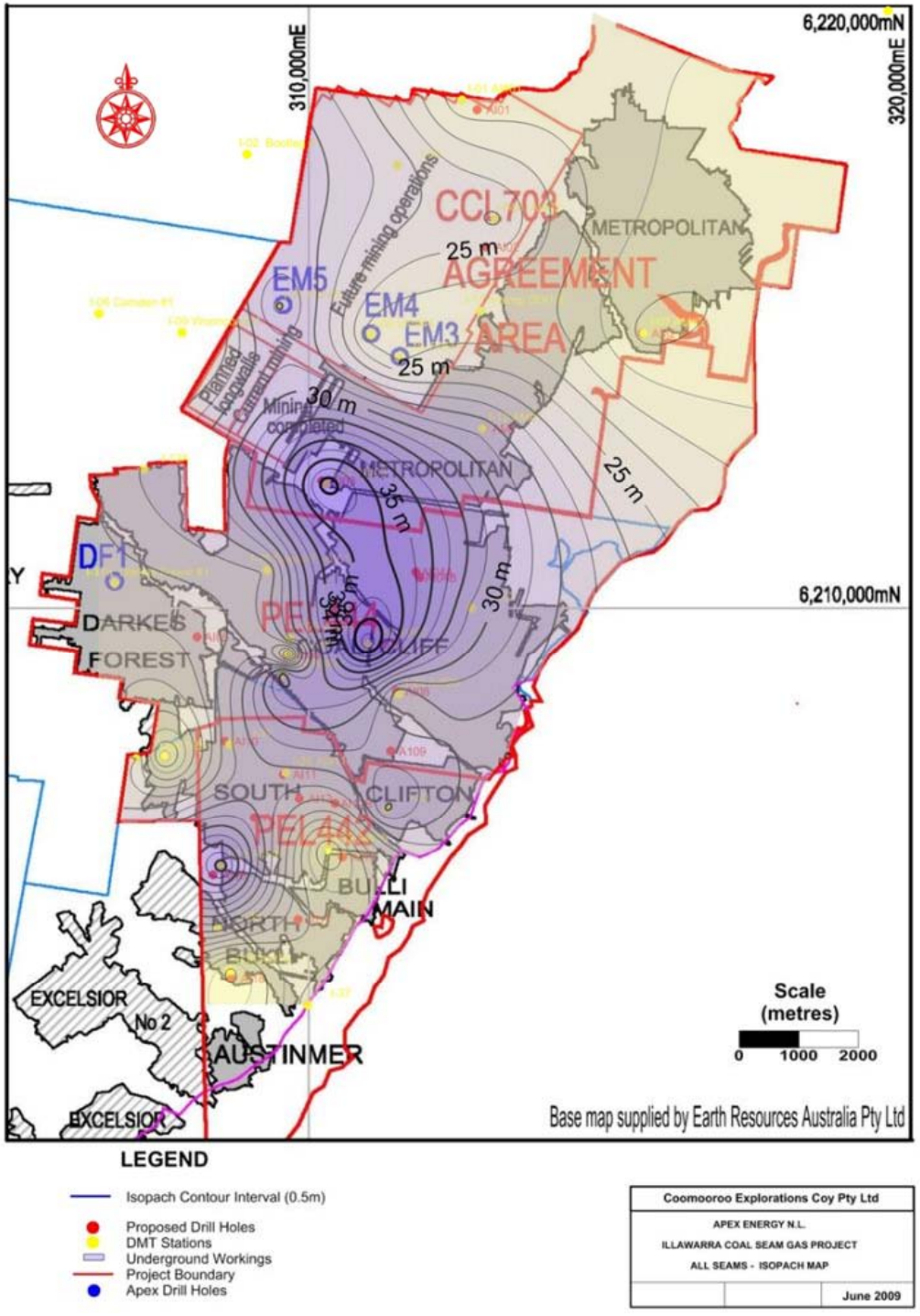
DMT Survey

Digital Magnetotelluric (DMT) survey

Seam Isopachs



Woonona Seam



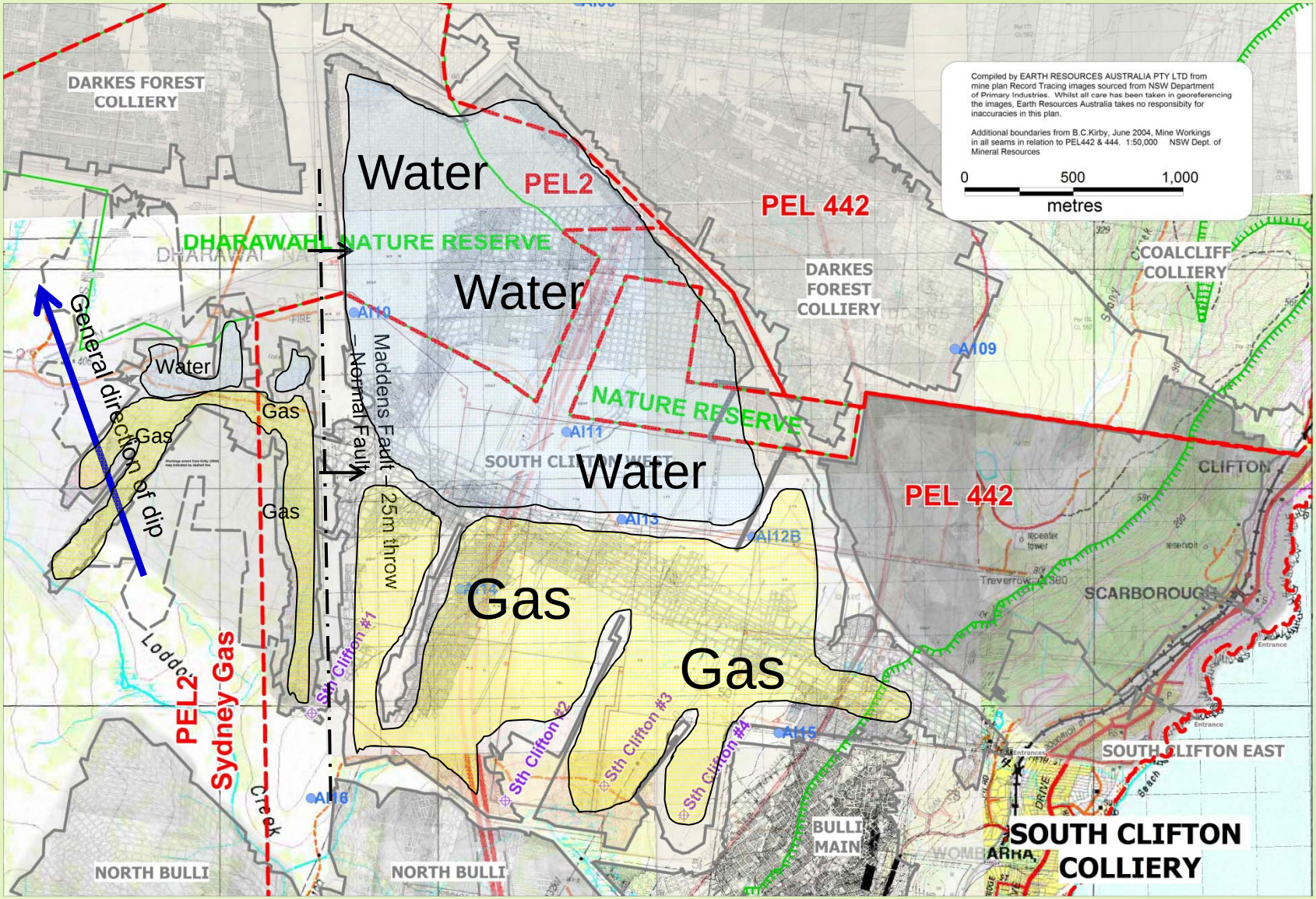
Goaf system

Significance

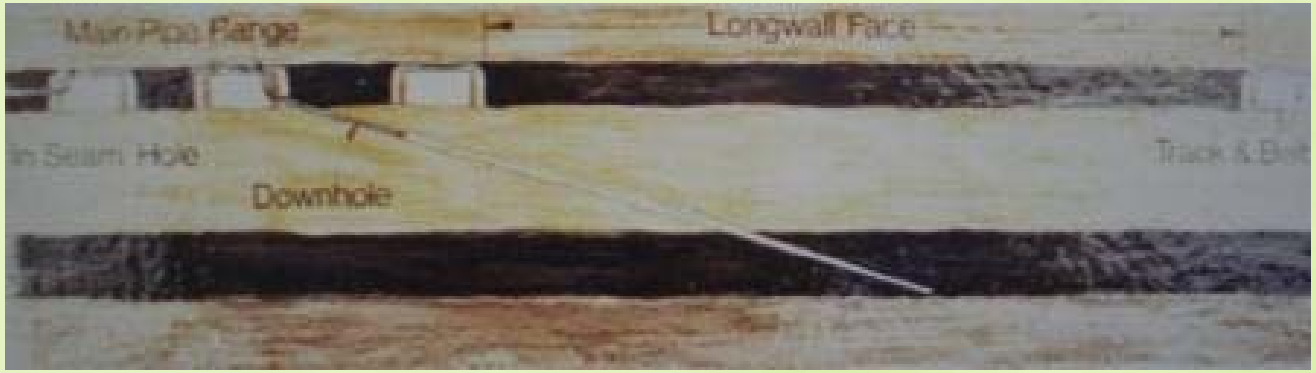
Why are goafs and abandoned mine workings important to Apex Energy?

- Readily accessible gas reserves
- Localised increased permeability
  - Lower seam gas transmission
- Gas storage potential

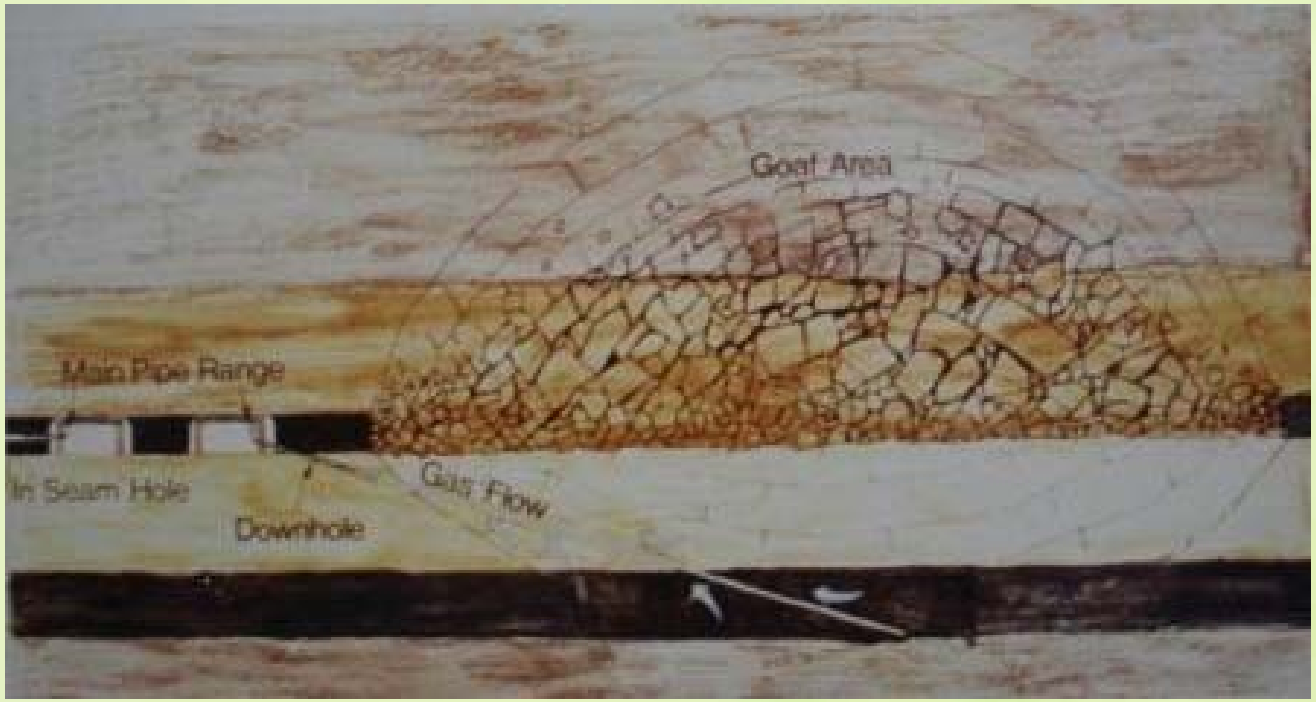
South Clifton Mine Plan



Goaf Behaviour - Relaxation Zones



Pre-extraction strata – shows an inactive gas borehole

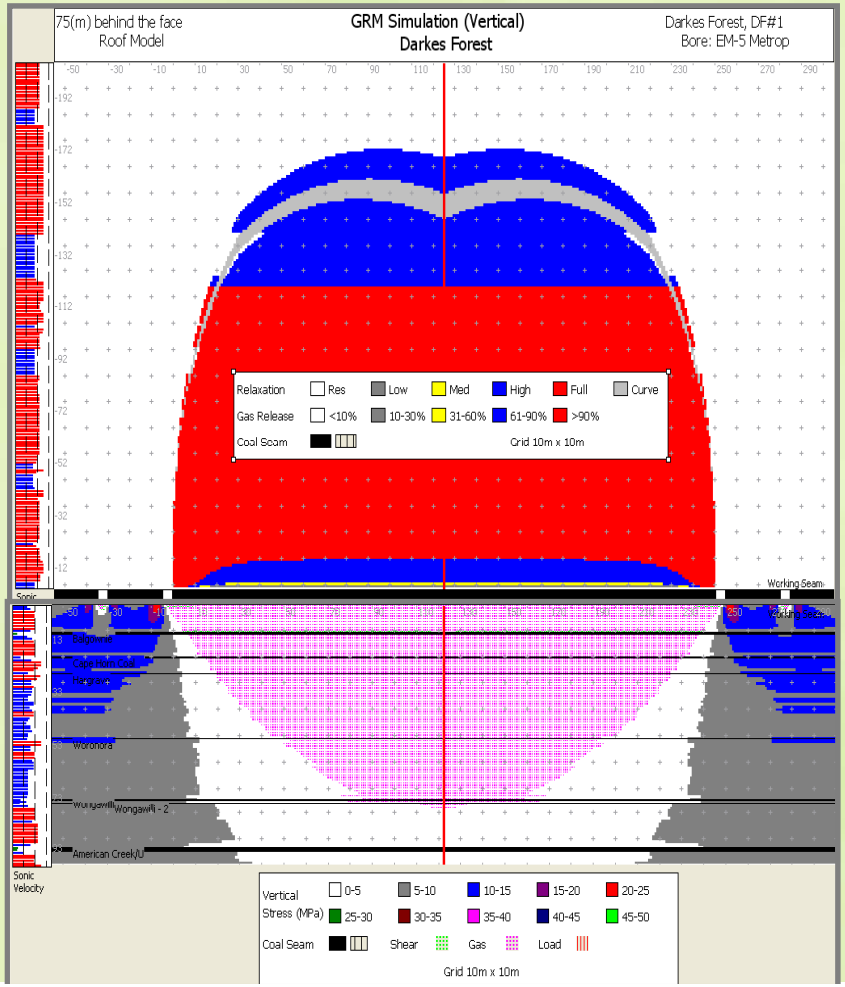


Post-extraction strata – shows gas borehole now flowing

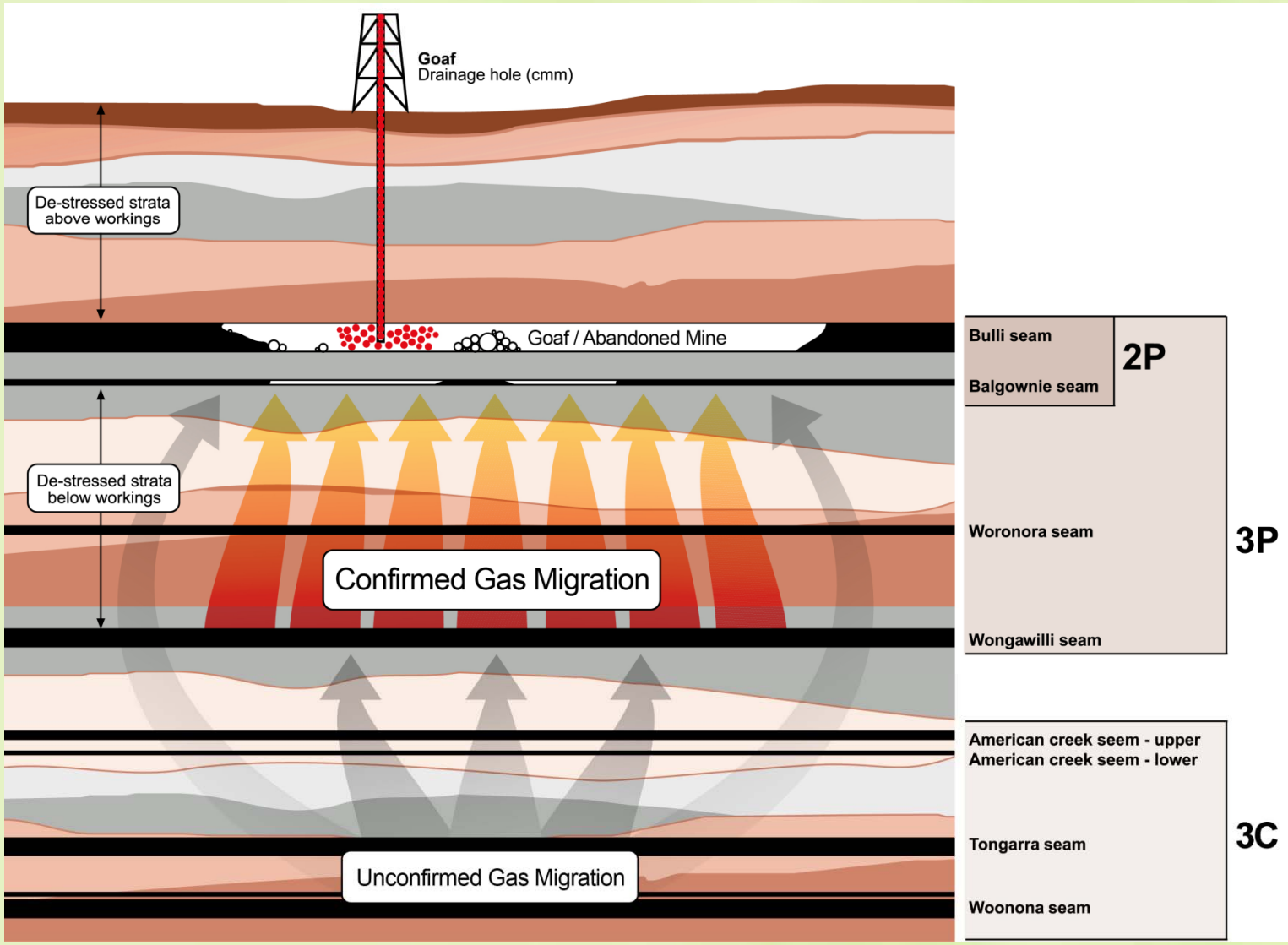
Strata Relaxation Modelling

Lunargas Pty Ltd

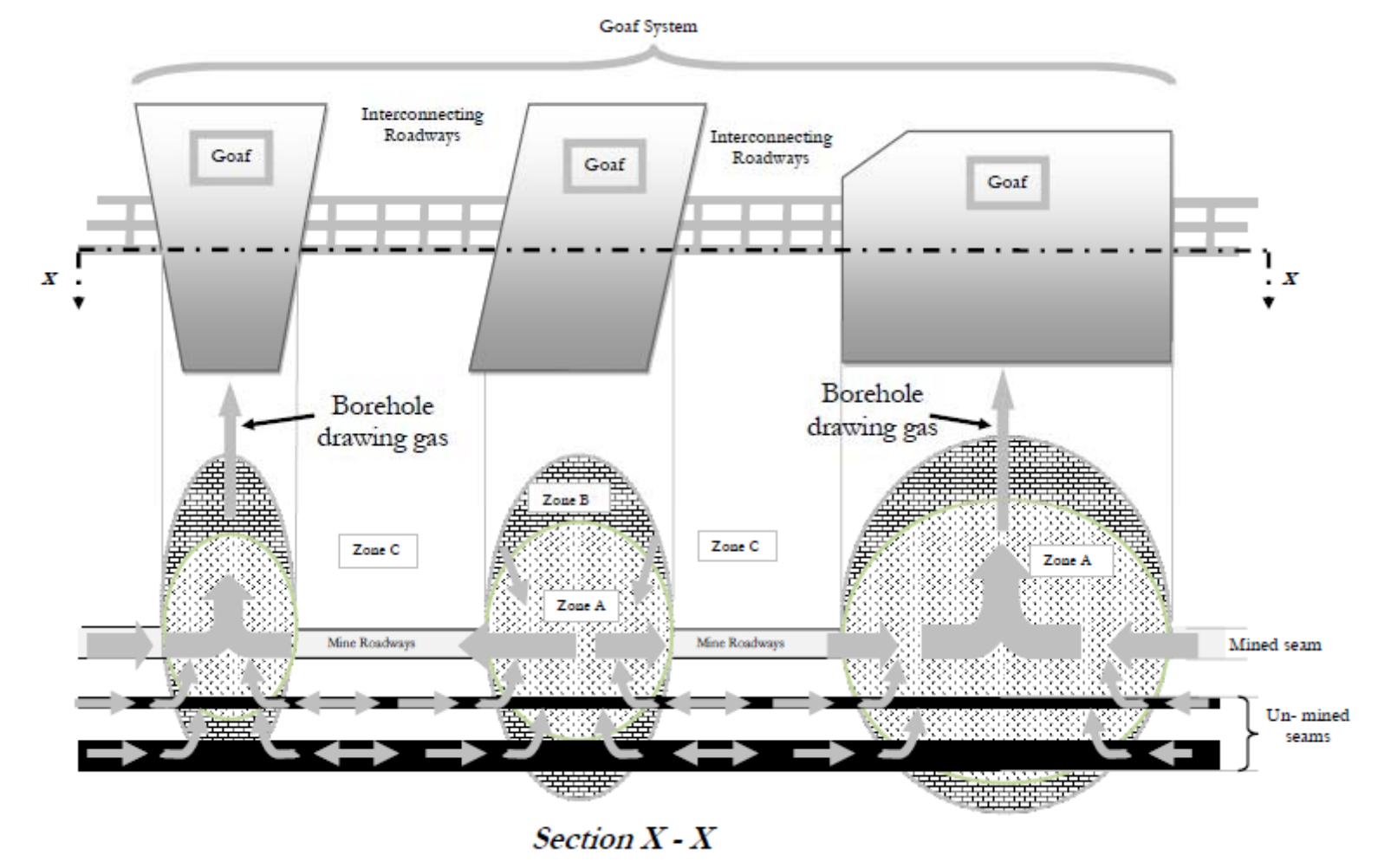
130m wide face – 75m behind face



Goaf Gas Migration Model



Goaf System Contact Theory



Section X - X

APEX

Drilling Program

Stage 1 & 2

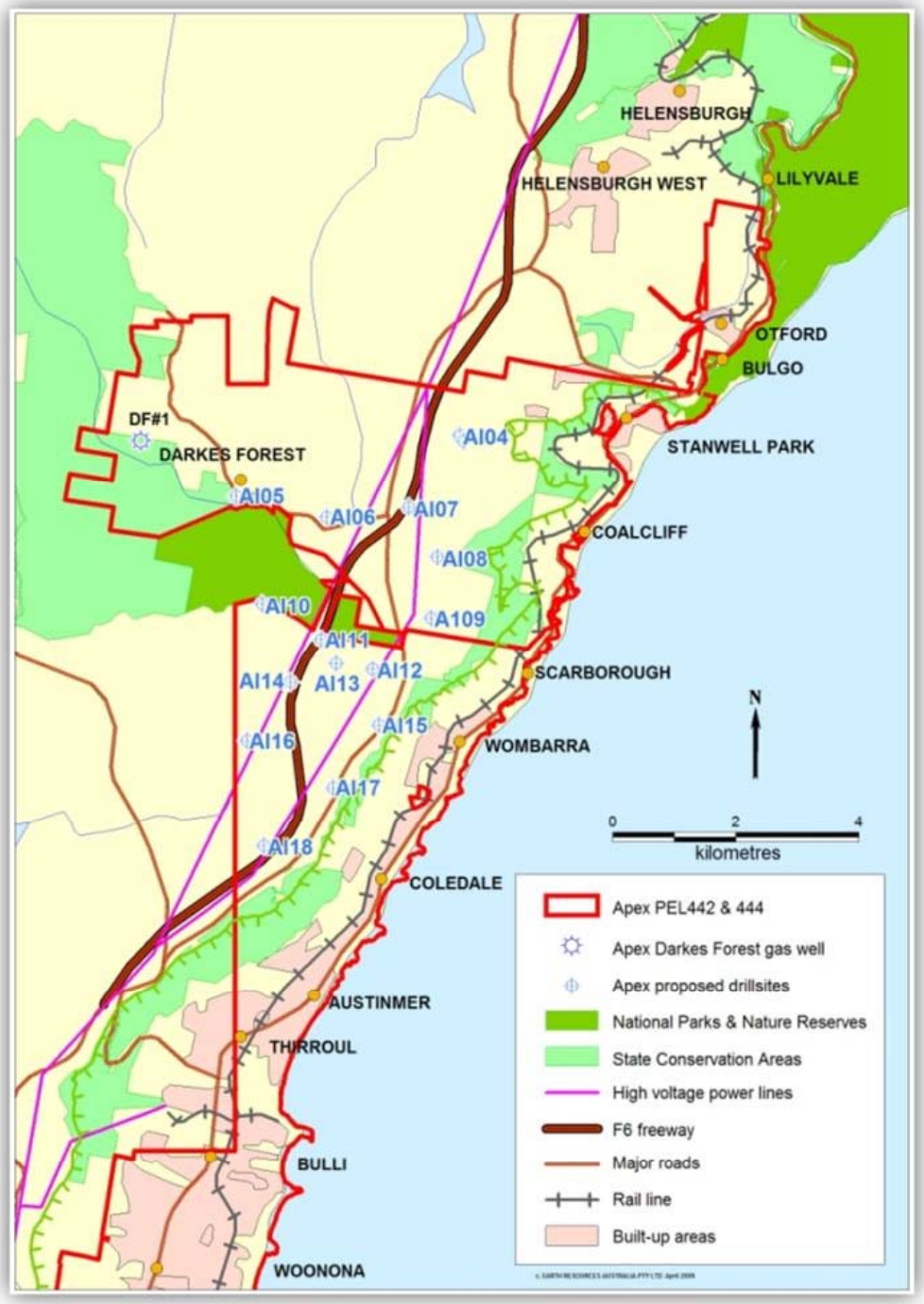
15 Well Drilling Program

Stage 1

- 10 wells (5 goaf & 5 core)

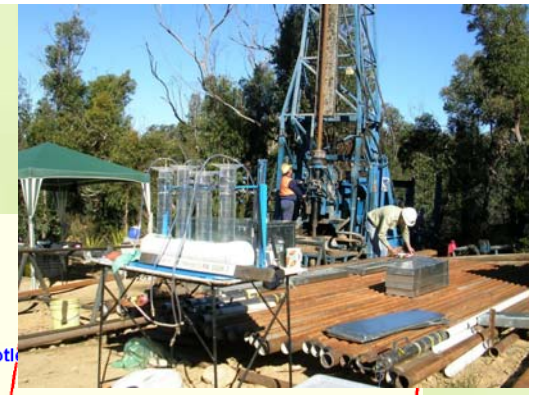
Stage 2

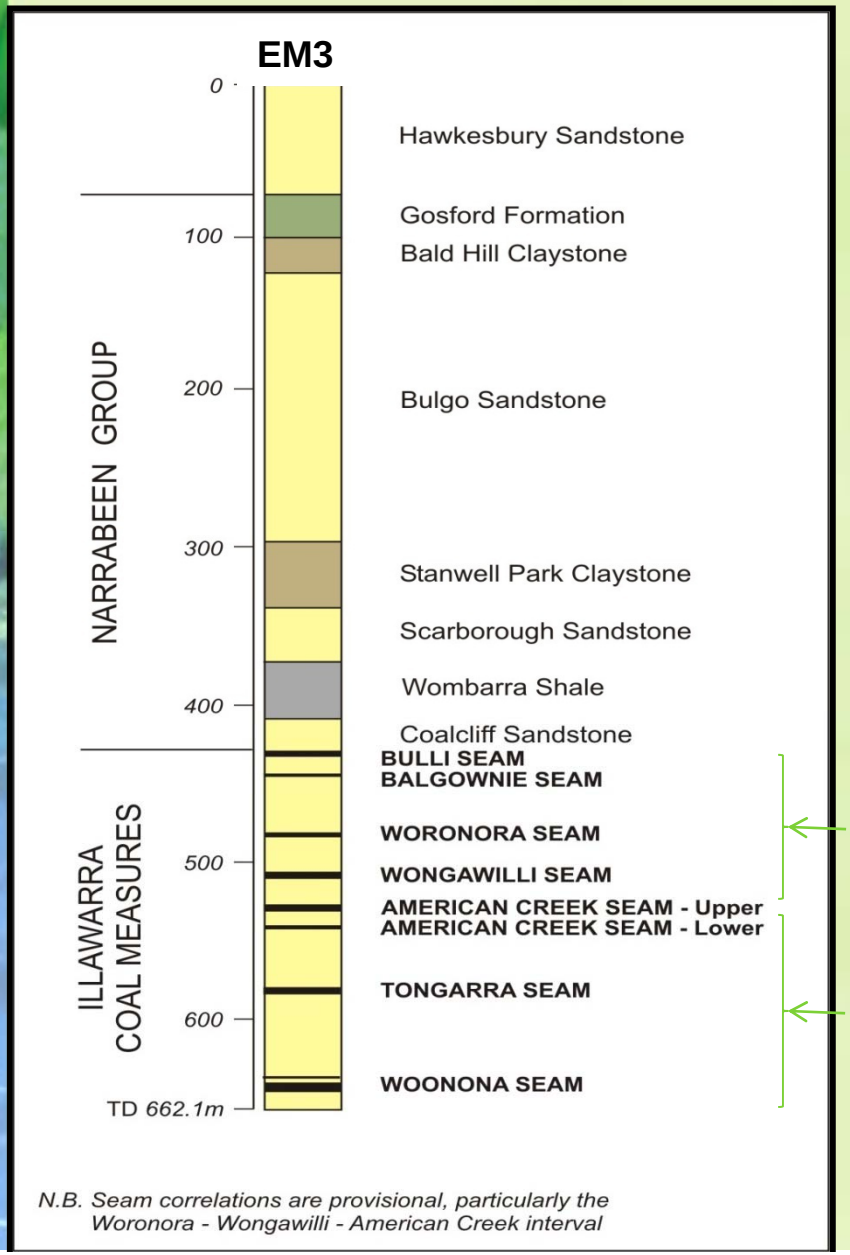
- 5 goaf wells

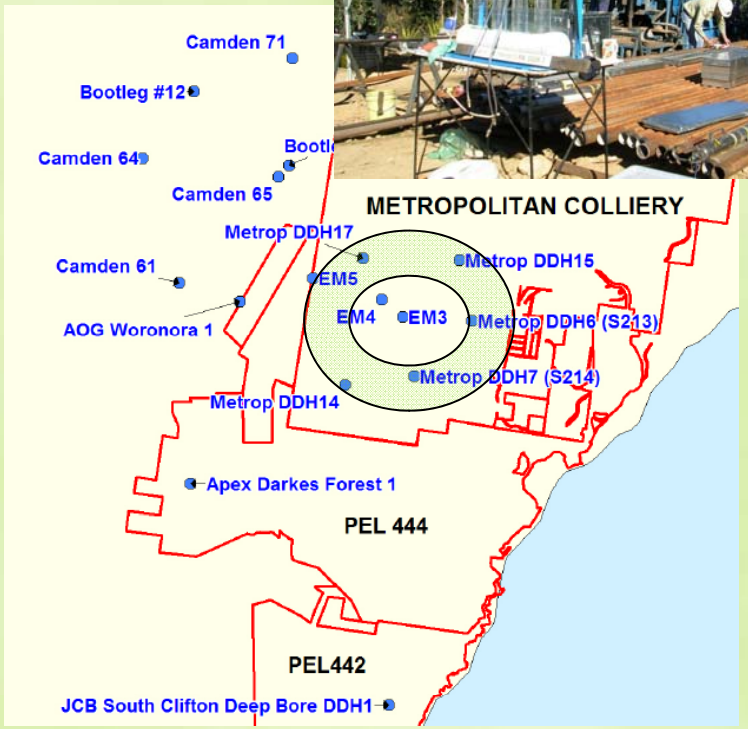


Sydney Basin Coalbed Methane

Sources of Gas



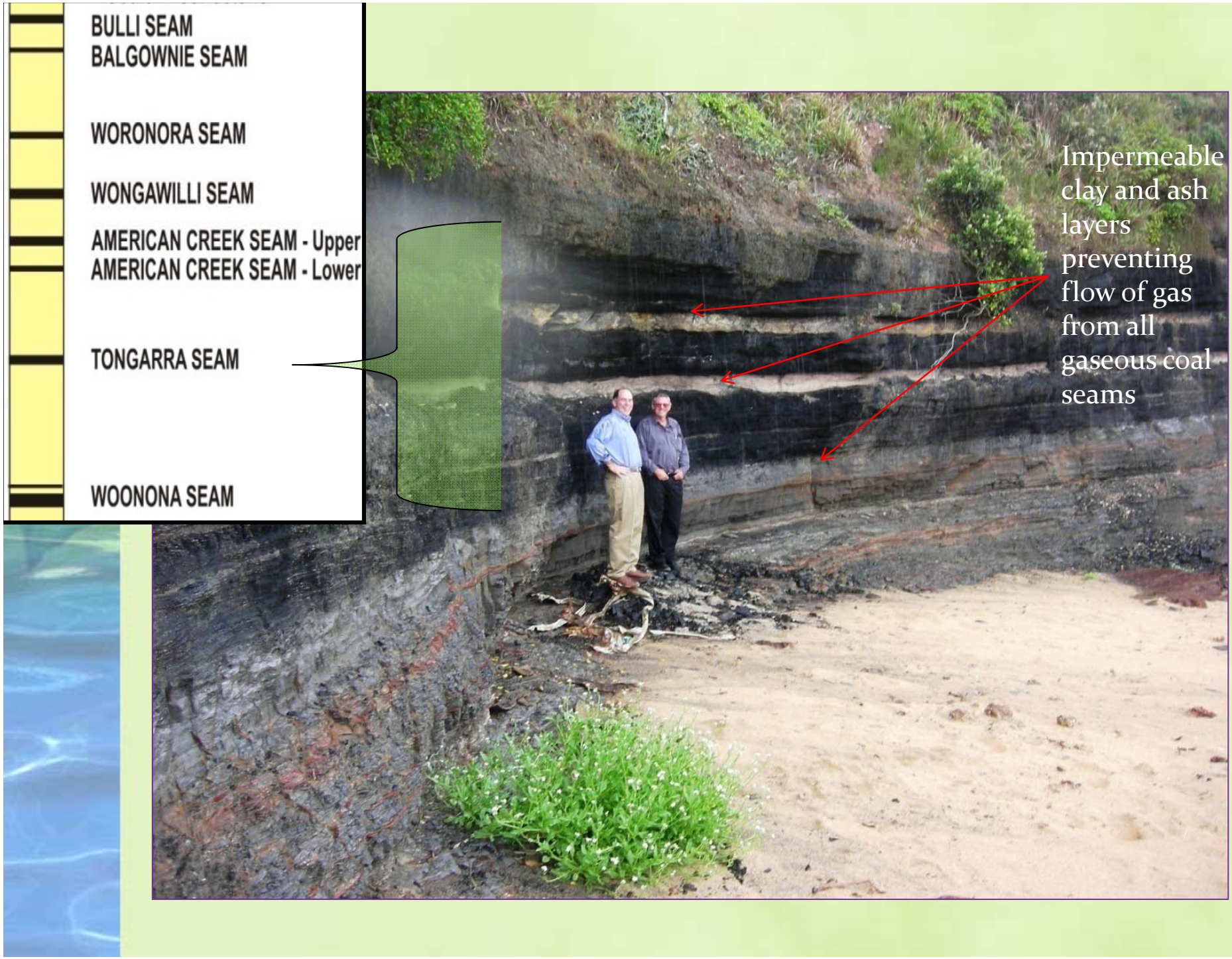




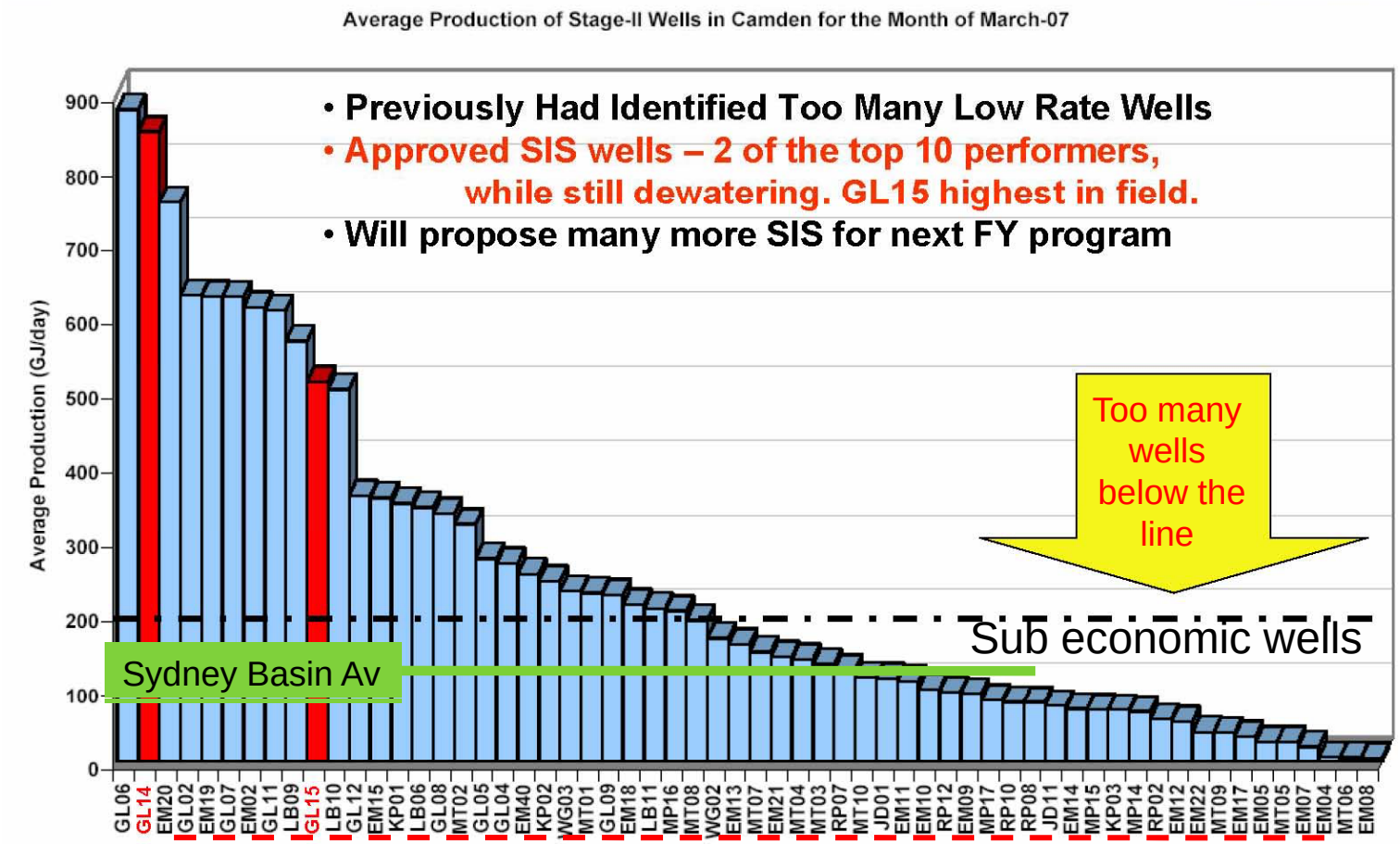
18.00m coal
Source:
*Minarco

12.41m coal
Source: *ERA

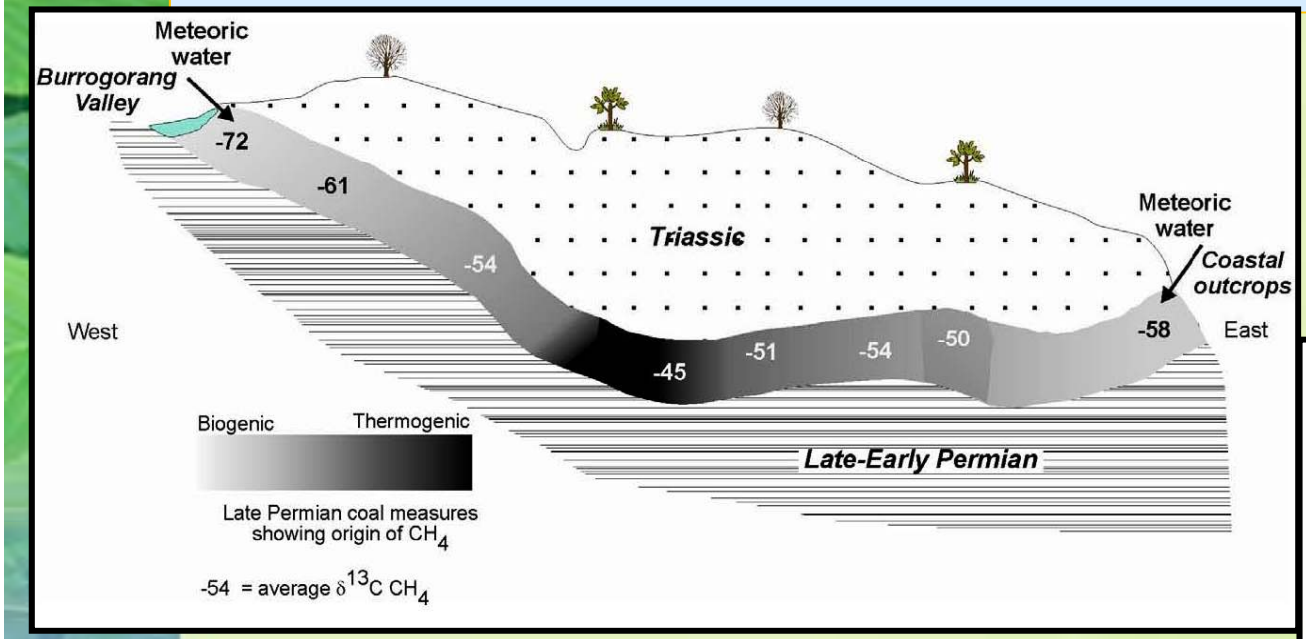
Circa 30m coal


BULLI SEAM
BALGOWNIE SEAM
WORONORA SEAM
WONGAWILLI SEAM
AMERICAN CREEK SEAM - Upper
AMERICAN CREEK SEAM - Lower
TONGARRA SEAM
WOONONA SEAM
Impermeable clay and ash layers preventing flow of gas from all gaseous coal seams

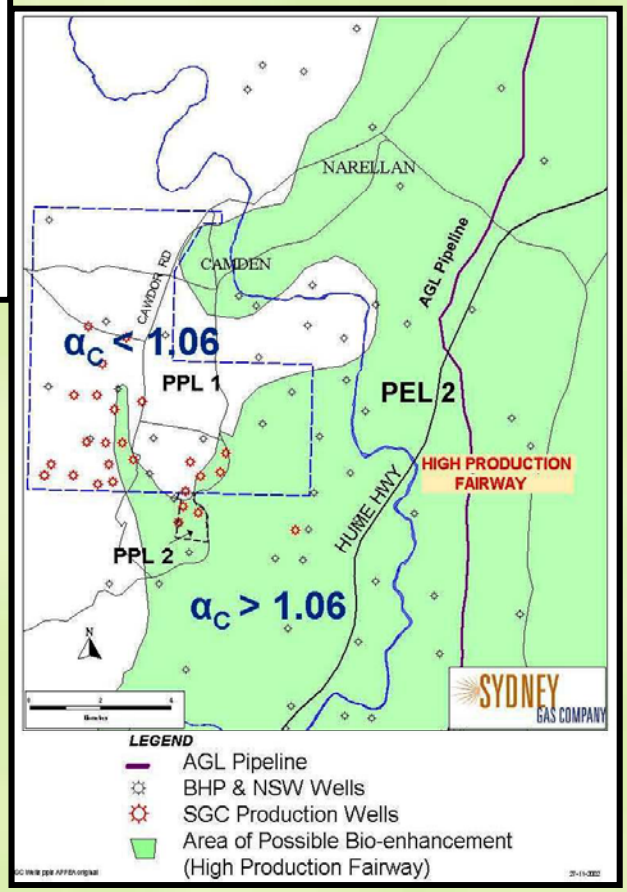
Sydney Gas Overview
Average Well Rates in Stage II



Bacteria active since uplift in Tertiary creating pathways for gas to well bore



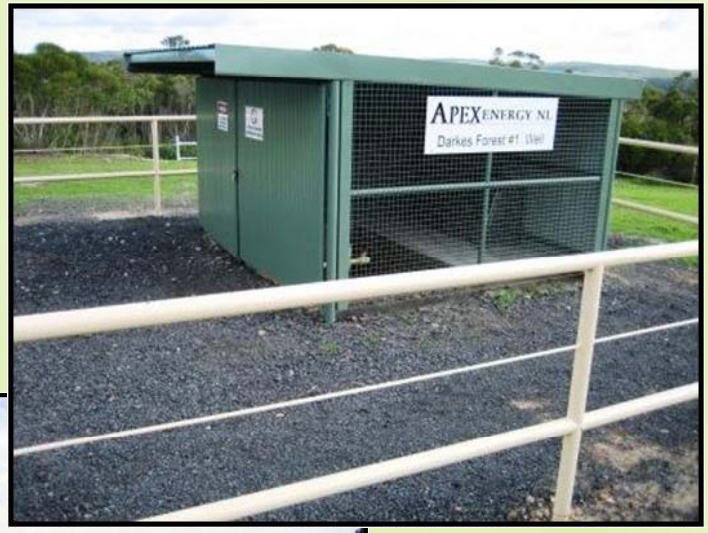
High Production Fairway in Sydney Basin Confined to Areas of Secondary Biogenic Gas Generation

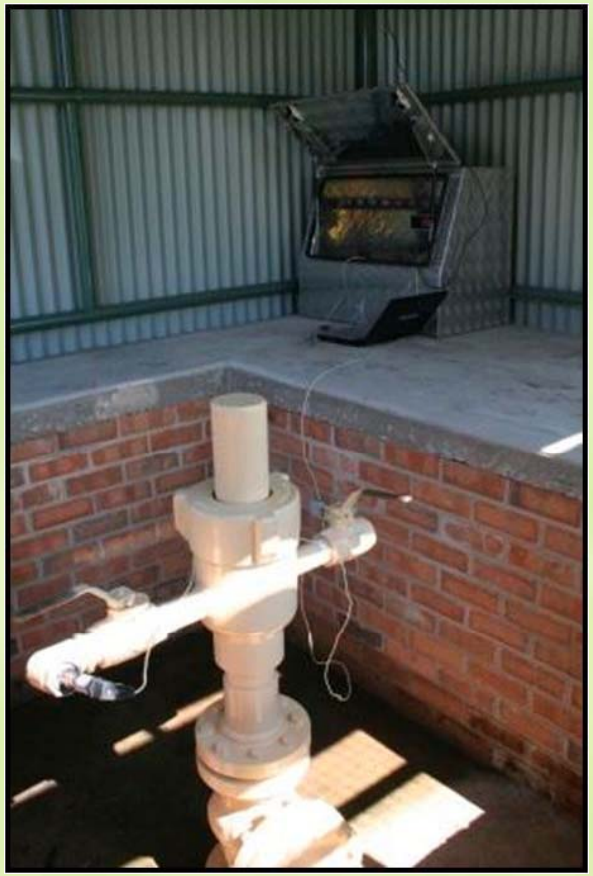


Bacteria, introduced through influx of meteoric waters, is responsible for bio-enhancement of mylonitised coals, leading to higher gas production fairways being created on Sydney Gas Limited/AGL Limited joint venture (Source - Faiz, 2007 CSIRO).

Darkes Forest #1 Well

- Production ready

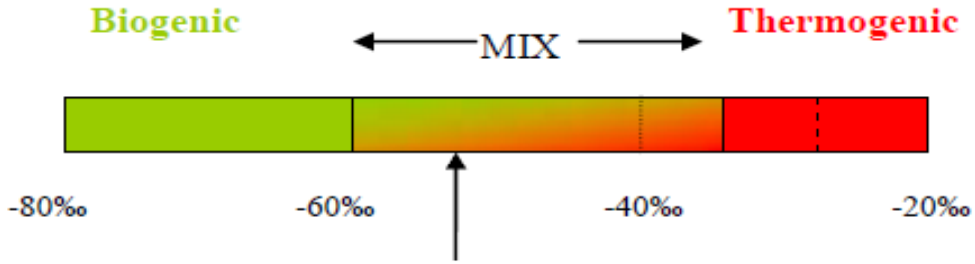


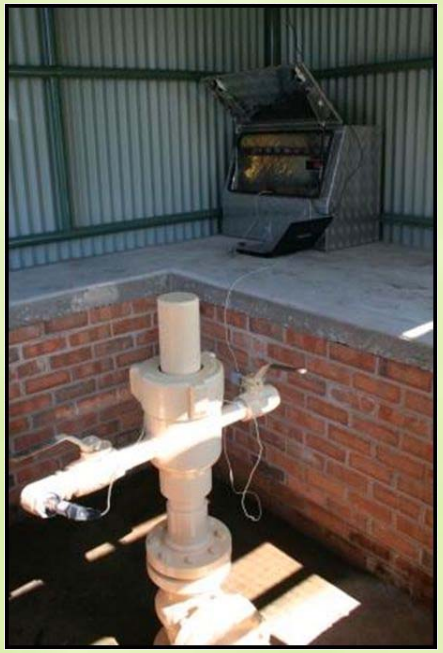


CSIRO Carbon Isotope Tests at Darkes Forest #1 Well – March 2005

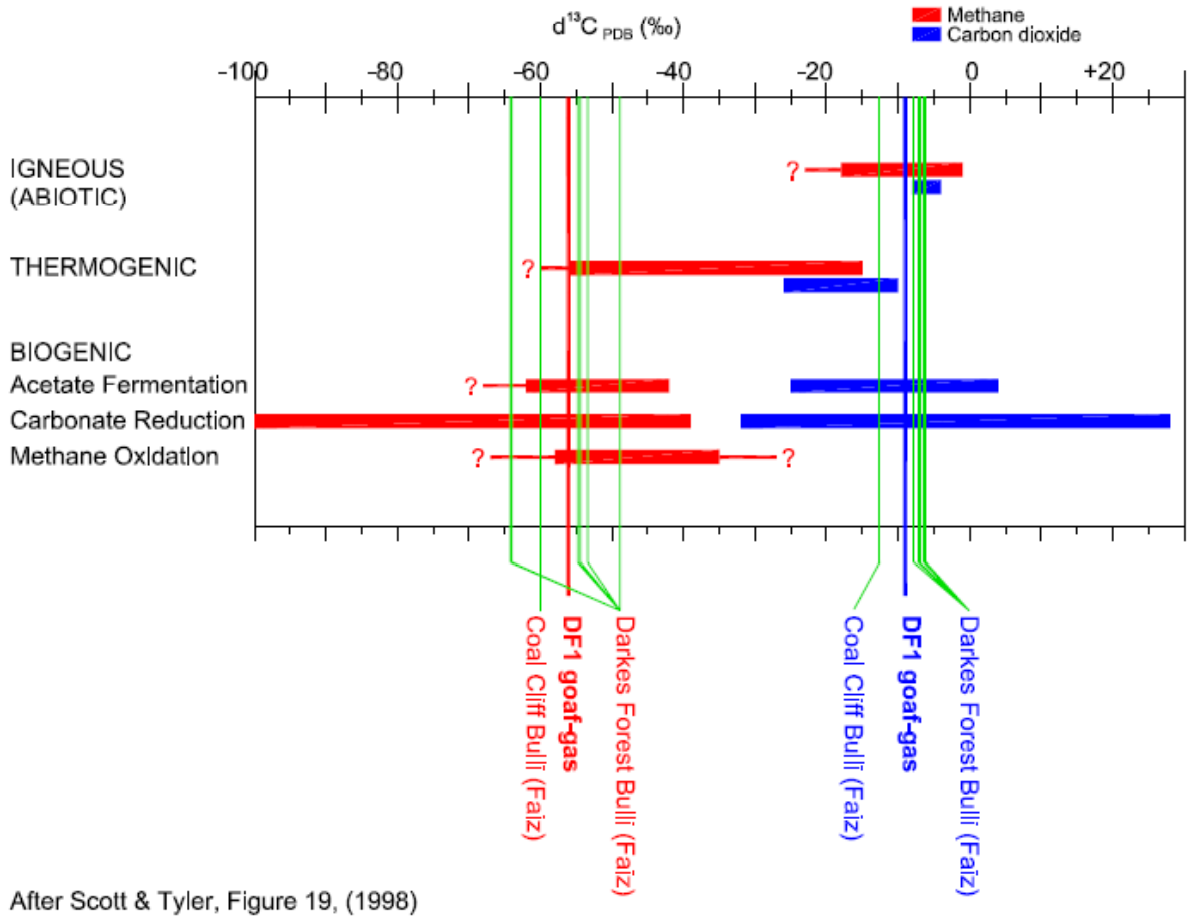
Carbon Dioxide $\delta^{13}C$	VPDB = Vienna Standard Pee Dee Belemnite
0‰ VPDB	Indicative of marine carbonate source
-60‰ VPDB	Biogenic source
-25‰ to -40‰ VPDB	Terrestrially sourced thermogenic gas
-35‰ to -50‰ VPDB	Thermogenic gas from marine organic matter

The carbon isotope data for the gas from the Darkes Forest-1 well appears most likely to be a mixture of biogenic and thermogenic gas, with biogenic gas being the major component.





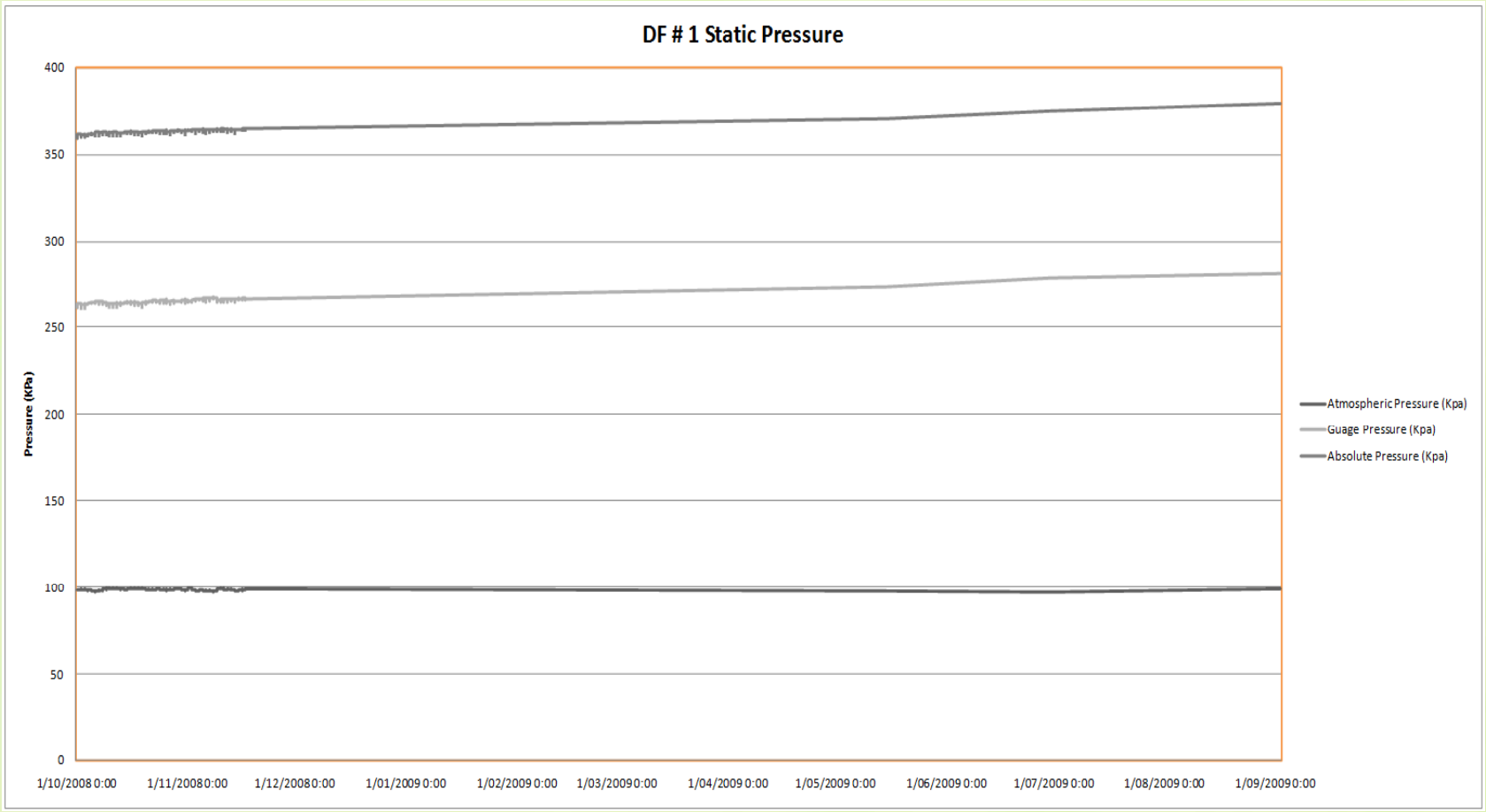
Origin of Methane & Carbon Dioxide - Darkes Forest #1



After Scott & Tyler, Figure 19, (1998)

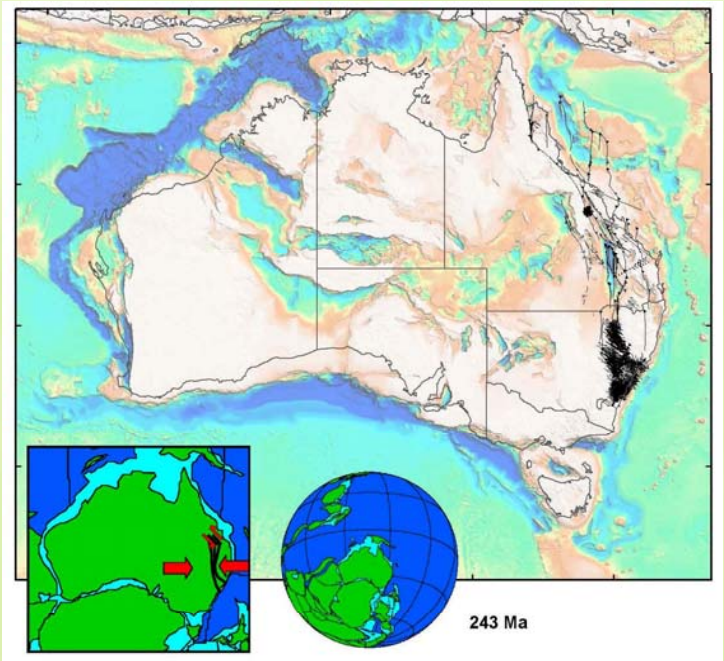
Scott, A.R. & Tyler,R., 1998 Coalbed methane short course, Geological & Hydrologic Controls Critical to Coalbed Methane Production & Resource Assessment, Brisbane, Australia.

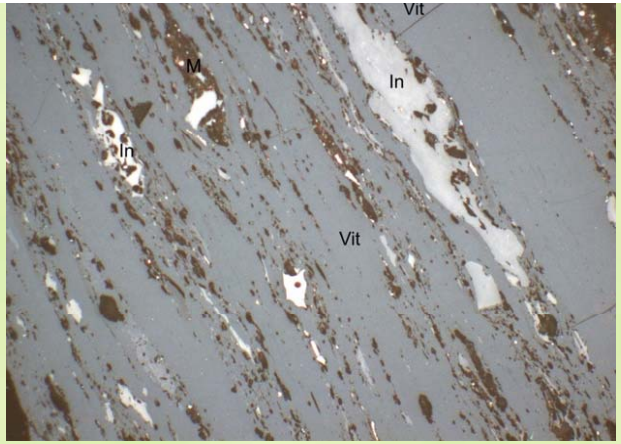
Pressure Trends



Sydney Basin Coals

- Natural fracture system removed by tectonic action
- Coal lacks a well-developed fracture or cleat system for gas delivery
- Coals are generally high gas content.





APEX

LATERAL
Technologies
International

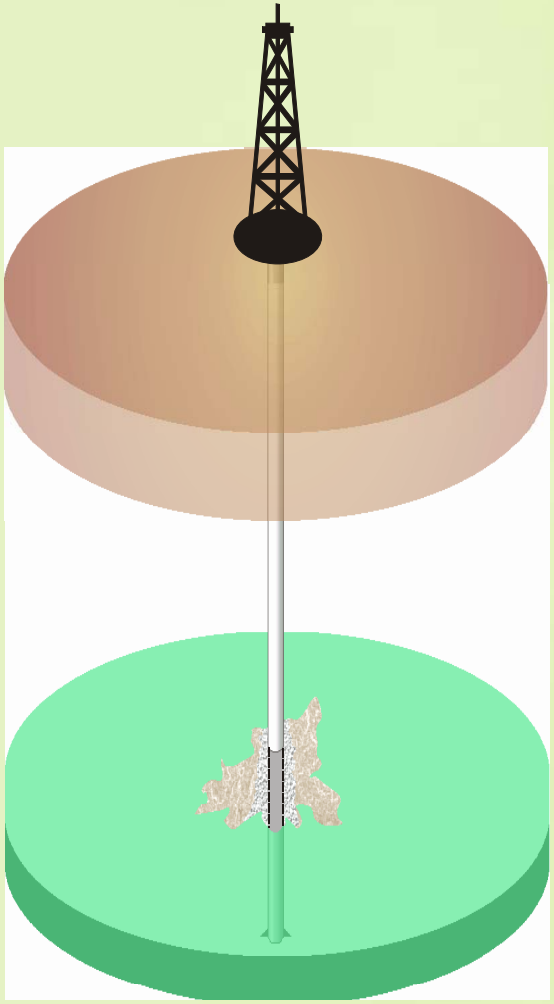
Going Forward

Exploration, gas exploitation and enhancement

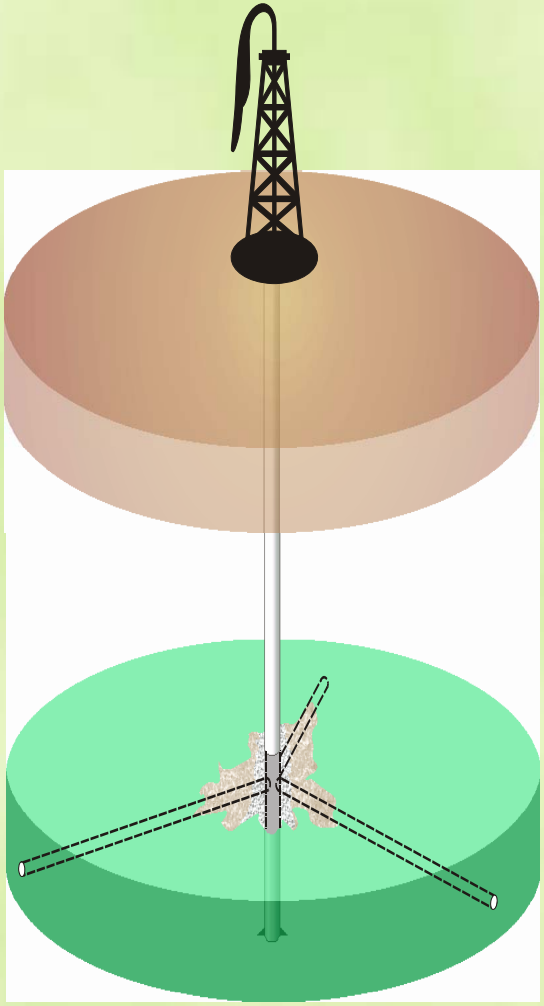
- Multiple coal seams
  - Low permeability
  - High gas content
- Extensive abandoned mines and goafs

Ultra-Short-Radius Lateral Jet-Drilling System

THE PROBLEM:

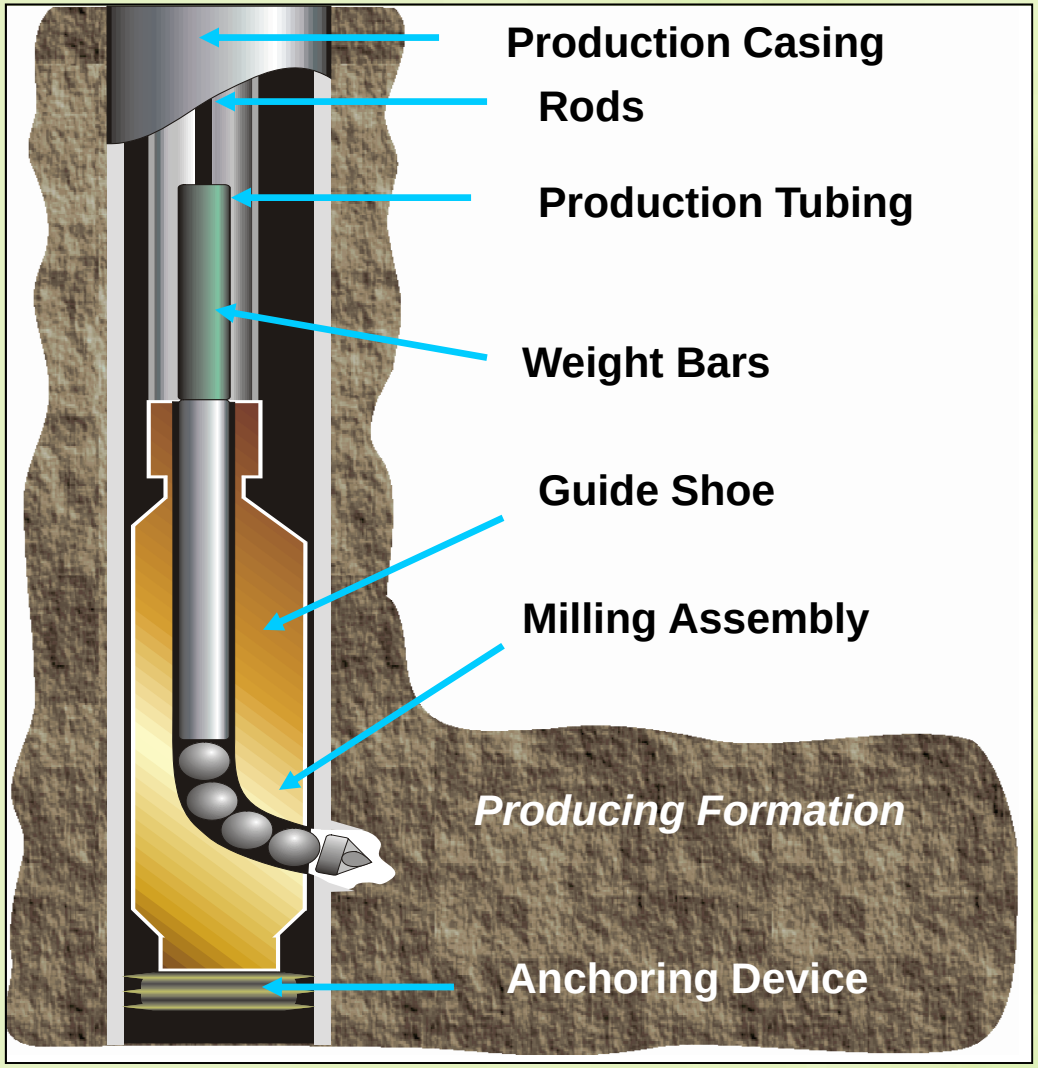


THE SOLUTION:



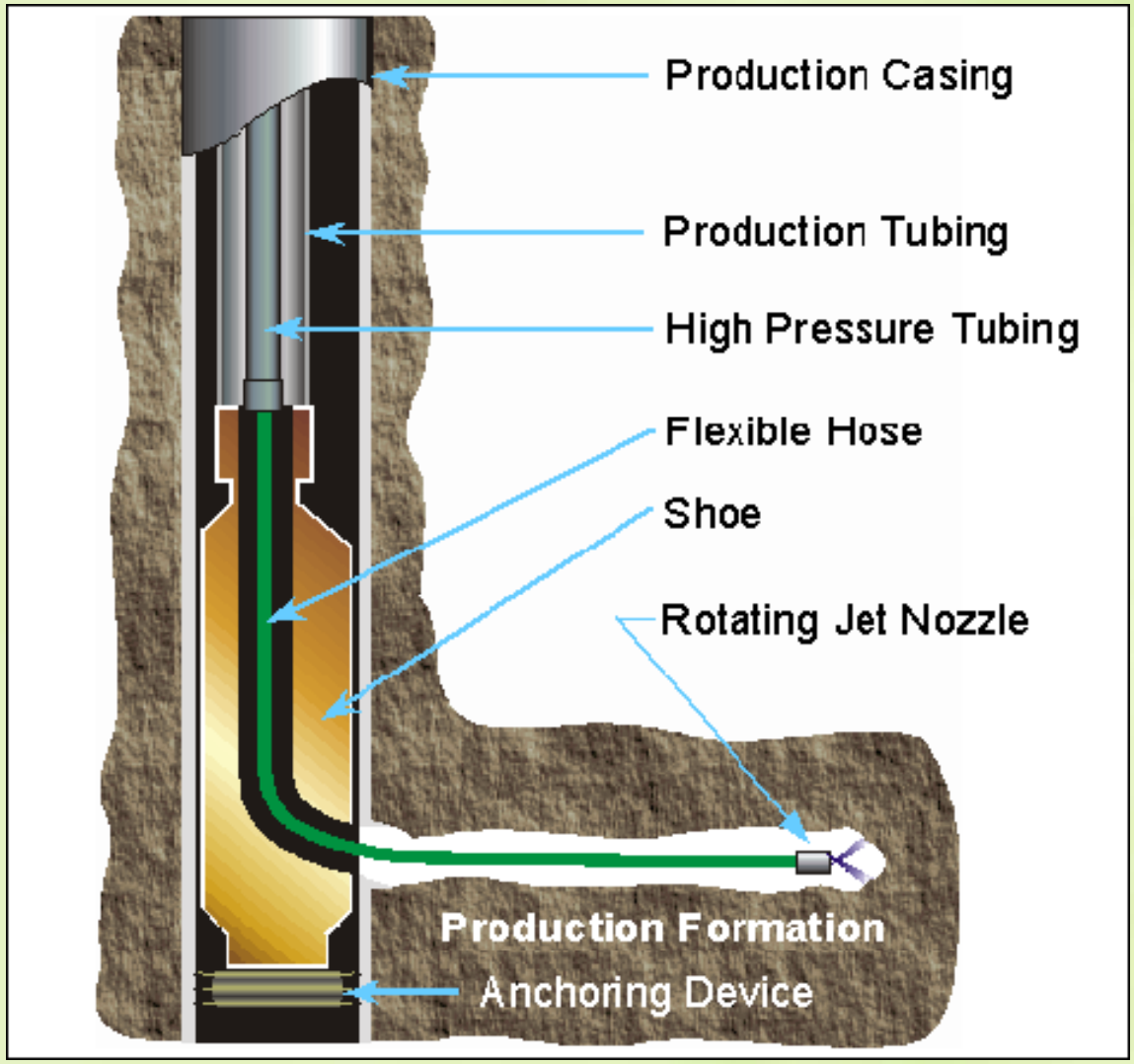
Cutting-edge Technology to Increase Oil & Gas Recovery

Perforating Assembly



Ultra-Short Radius Lateral Jet-Drilling System

Lateral Jet Drilling Assembly

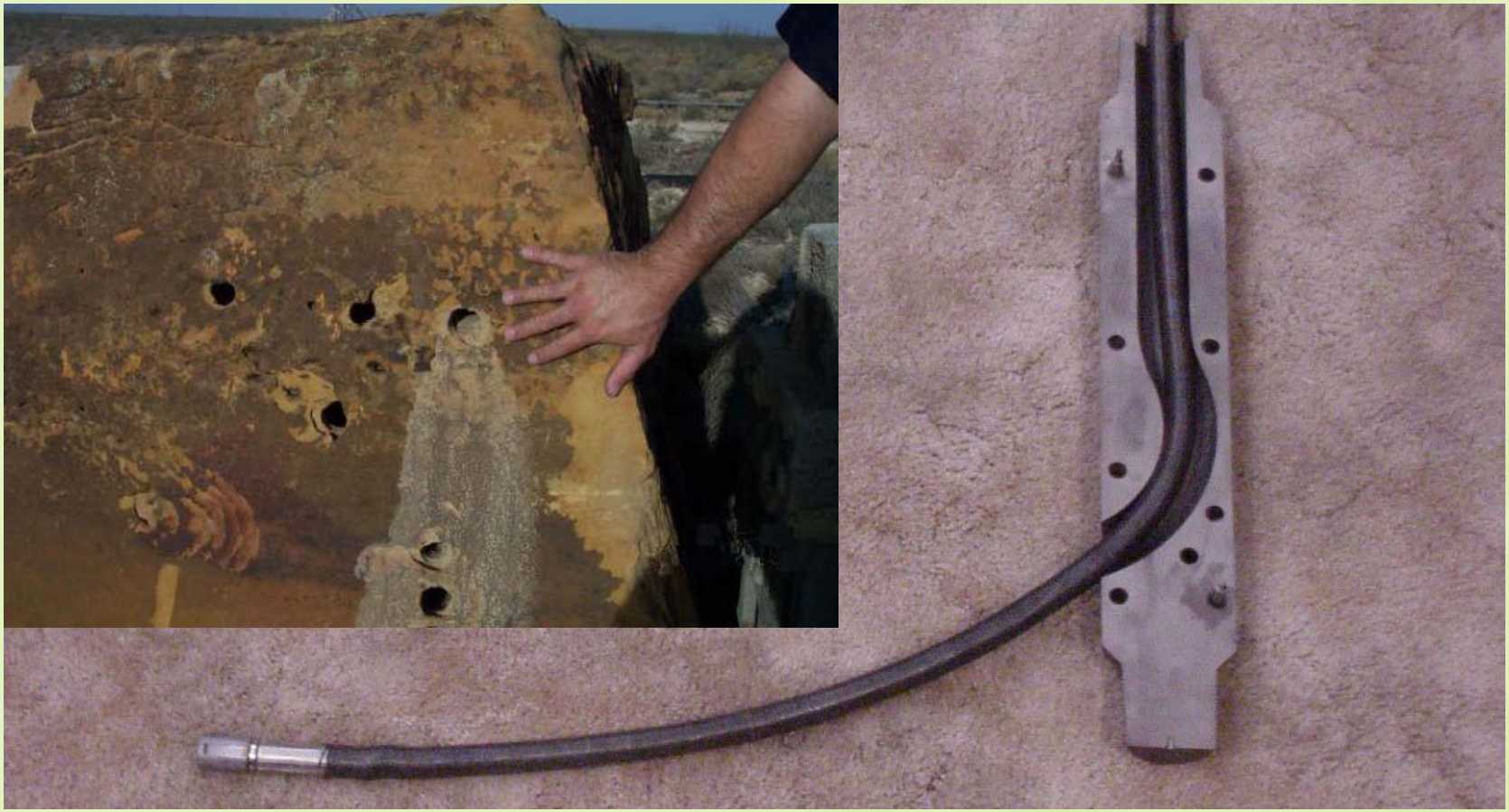


Jet-Drilling Nozzle & Square Spring Drill-string

Lance comprises square spring steel

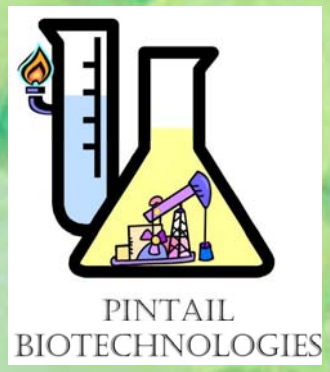
High Pressure Hose Wrapped with Square Spring to Facilitate Pushing Nozzle into Formation

With cross-section of Guide-Shoe



Lonestar Cutting Tool Demonstration

Pintail Biotechnologies

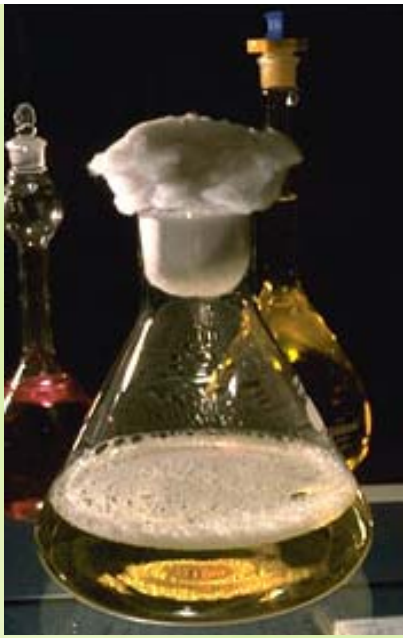


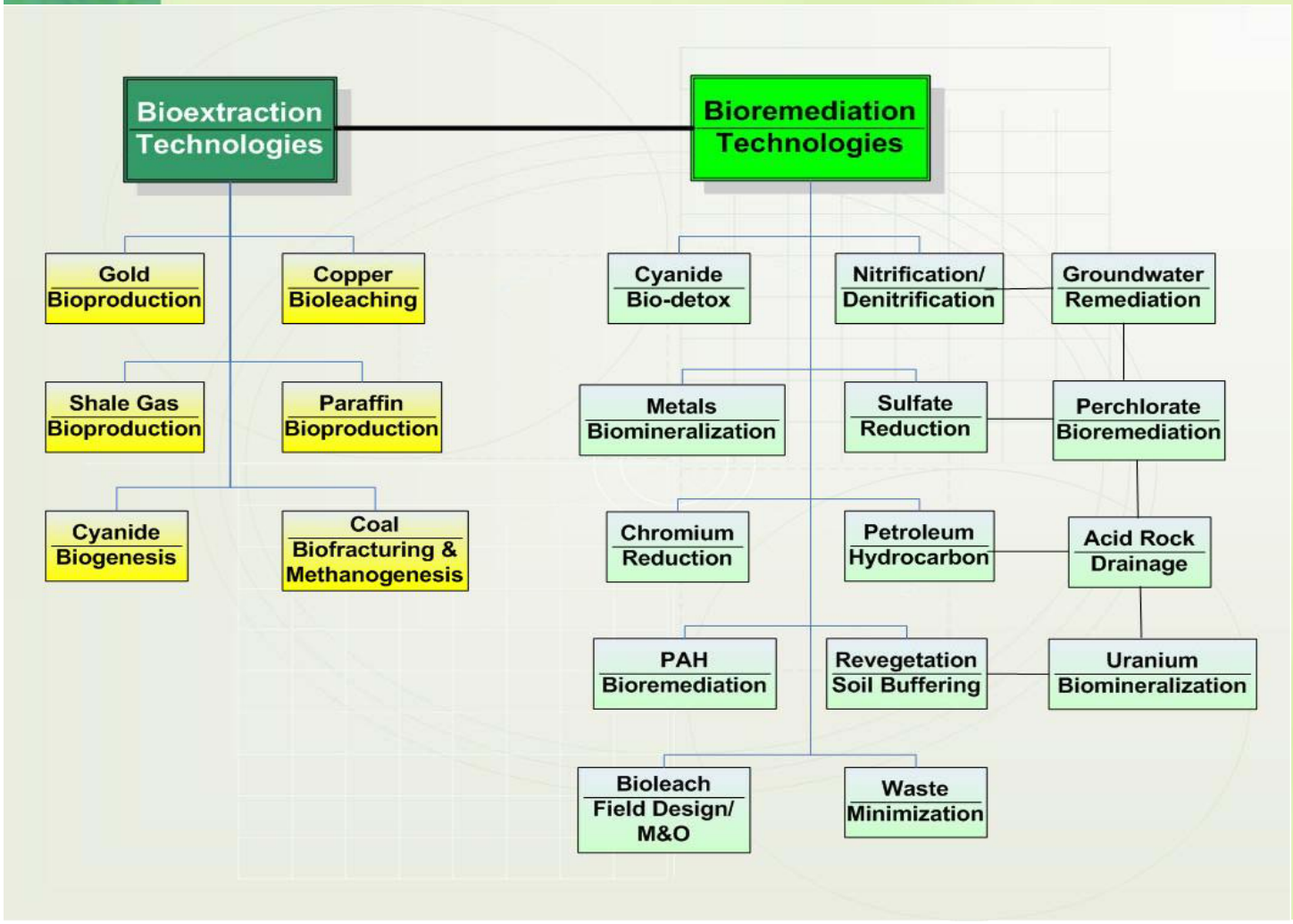
Technology Development and Opportunity

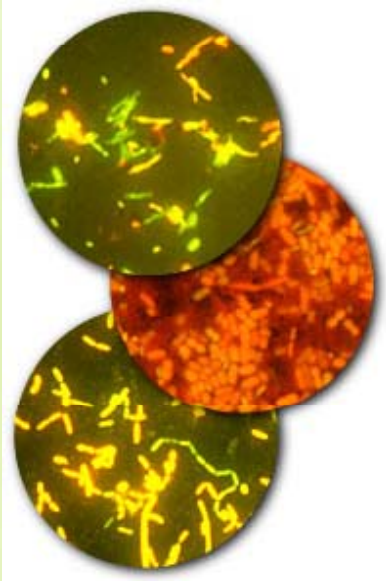
Coalbed Methane, Shale Gas Production and Petroleum Bioremediation

Pintail Introduction

- Company founded in 1987







Mine Projects (partial list)

	Client	Heap Tons	Contaminants	Gold Recovery
Yellow Pine	Hecla	1.3 million	Cyanide, nitrates	Yes
Copperstone	Cyprus	2.1 million	Cyanide, copper	Yes
Cripple Creek	CC&V	5 million	Cyanide, nitrates	Yes
Summitville	EPA	10 million	Cyanide, copper	Yes
McCoy Cove	EPA SITE & MWTPP	Process solution	Cyanide, nitrates, metals	Not applicable
Hayden Hill	Kinross Gold	30 million	Enhanced gold recovery	Project cancelled

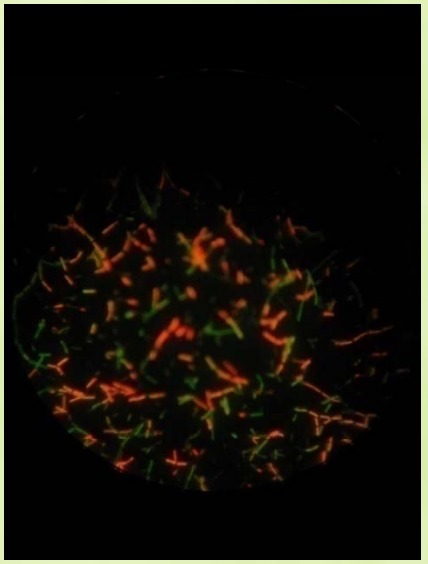
All remediation/mine closure projects were successfully completed to client and regulatory satisfaction

TPH Bioremediation Projects

	Contaminant	Starting conc, mg/kg	End conc., mg/kg
Boise Road Maintenance Yard	Heavy oil, asphaltenes	23,000 – 43,000 mg/kg	<500 mg/kg
Oregon Diesel Spill	Diesel	8,300	300
Denver Federal Center	Cutting oil	12,500	475
Getchell Mine	Heavy oil, diesel, hydraulic fluid in arsenic sediment	3,000 – 5,000	<250
McCoy Cove Mine	Diesel, heavy oil	>3,000	<500
Scotland Land Development	Diesel, and oil	>5,000	<500
Fallon Naval Air Station	Jet fuel, heavy oil, diesel	1,300 – 1,900	Non detect

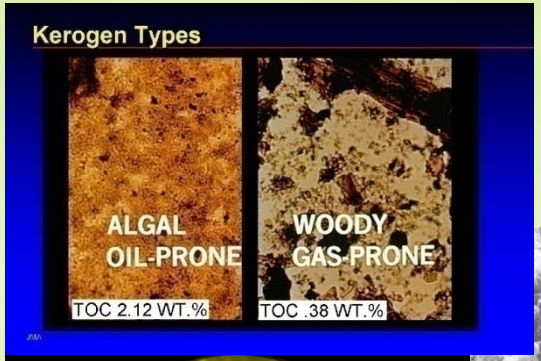
Significance of Biotech Approach to Gas Extraction Enhancement

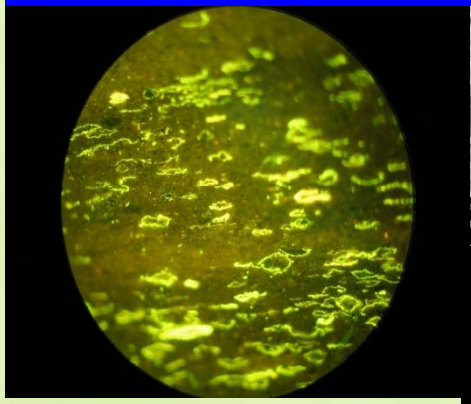
- Delivery of gas-in-place by:
  - Mineral/coal bio-fracturing
    - Alteration of fouling minerals
    - Clay Stabilization
    - Clay Removal
    - Calcite Degradation
    - Etc.
  - Bio-refining of kerogens

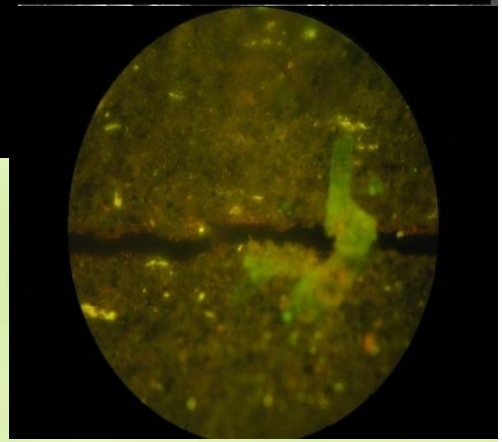


Geology, Engineering and Geomicrobiology

- We need to think beyond porosity, permeability and fractures
- We need to understand gas diffusion and adsorption in coal
- We need to understand the reservoir at the molecular level





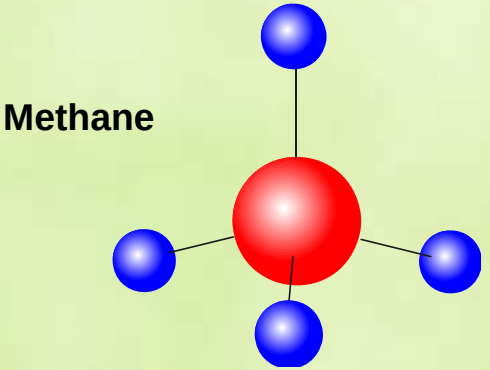


Methanogenesis

- Methane produced by coalification process
  - Release can be assisted by
    - Alteration of fouling minerals (Calcification etc)
    - Bio-refining of Kerogens in coal/shale
- Biogenesis
  - Production of Methane by bacterial action
    - Occurs naturals
    - Becoming better understood
    - Gas produced is young relative to coalification gas
    - Identified by Carbon Isotope testing (Carbon dating)

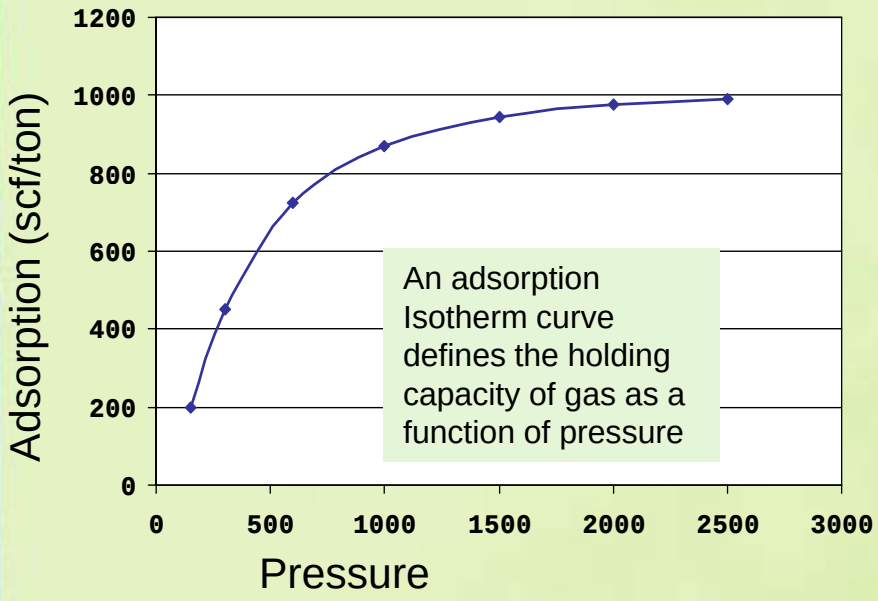
Methane Storage in Coal

- Methane in coal is:
  - Adsorbed on the surfaces and organic matter of the coal
  - Stored as free gas in cleats and open pores
- Adsorption types between gas phase and coal:
  - Physical Adsorption
    - Gas trapped in micropore matrix (5-500 angstroms)
  - Chemical Adsorption
    - Stored in molecular structure of ***kerogen*** in coal
    - Sorbed on internal surfaces of coal, sorbed to minerals and within micropore matrix

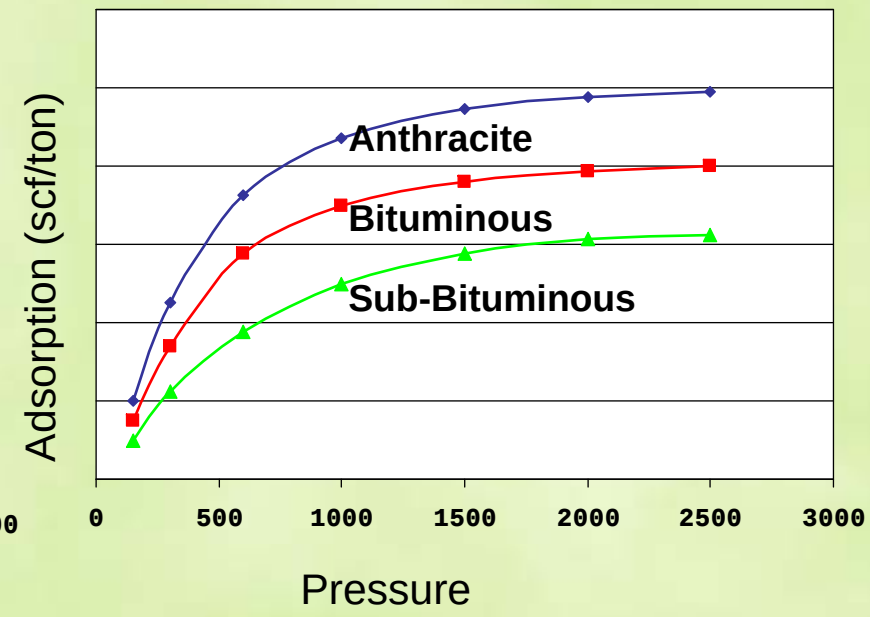


Adsorption Capacity and Coal Rank

Adsorption Capacity



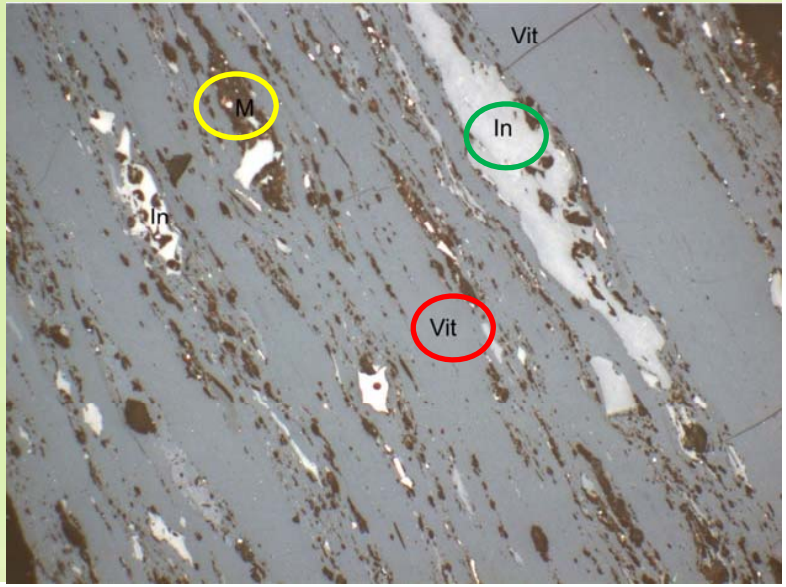
Adsorption vs coal rank



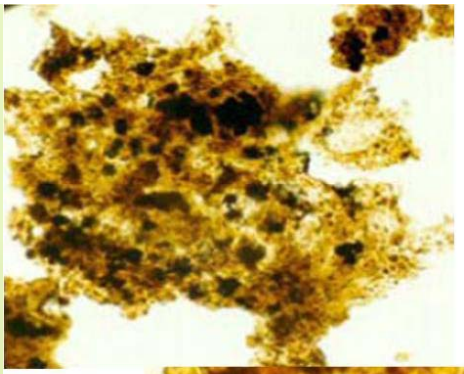
Macerals

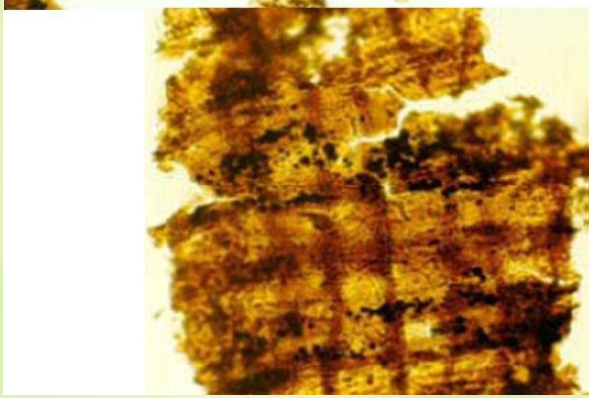
- Organic units of coal or oil shale composition
- The term 'maceral' in reference to coal is analogous to the use of the term “mineral” in reference rocks.

- Types of Macerals
  - Vitrinite – cellular material - roots, bark, plant stems and tree trunks
  - Inertinite - equivalent of charcoal and degraded plant material
  - Liptinite - decayed leaf matter, spores, pollen and algal matter



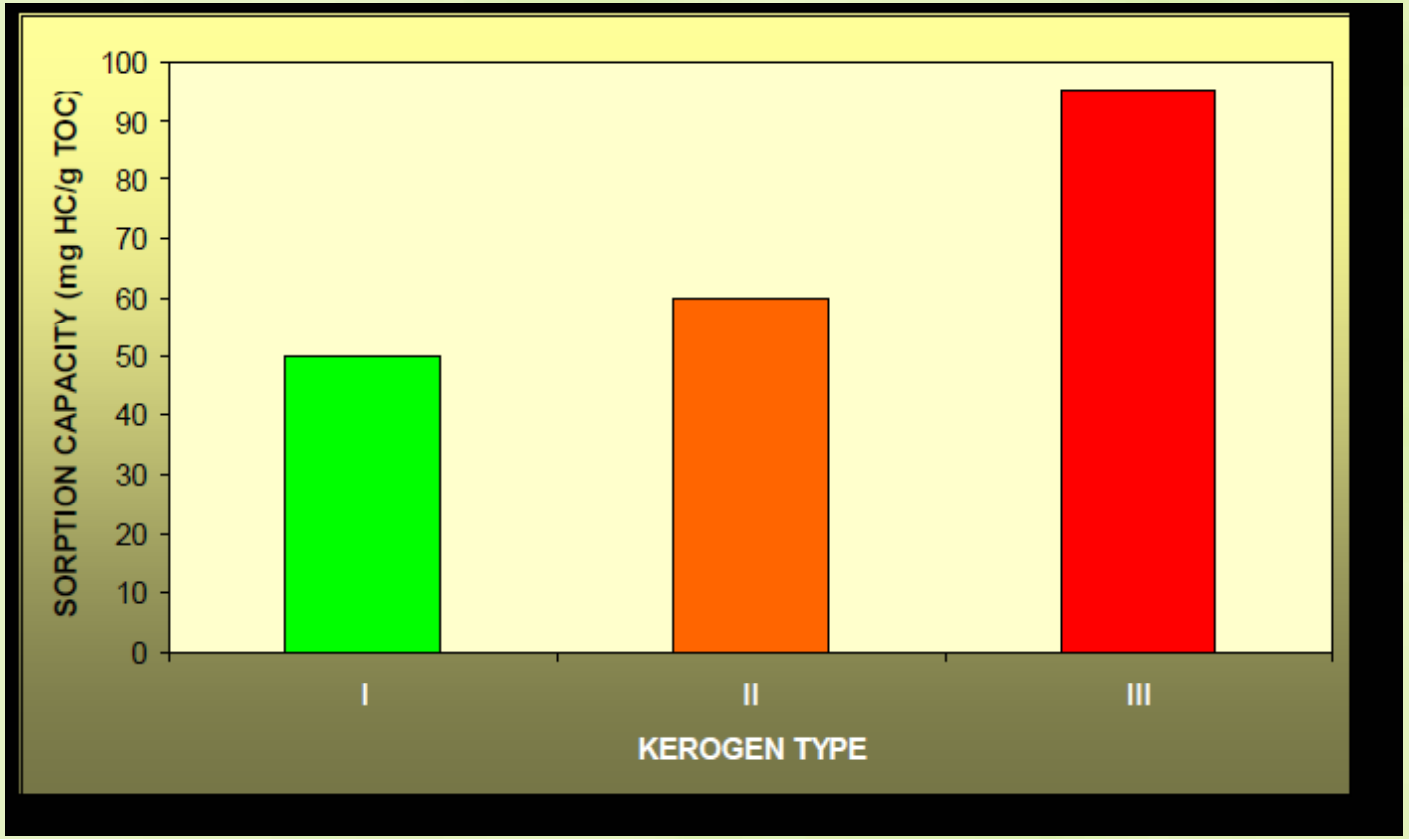
Kerogen





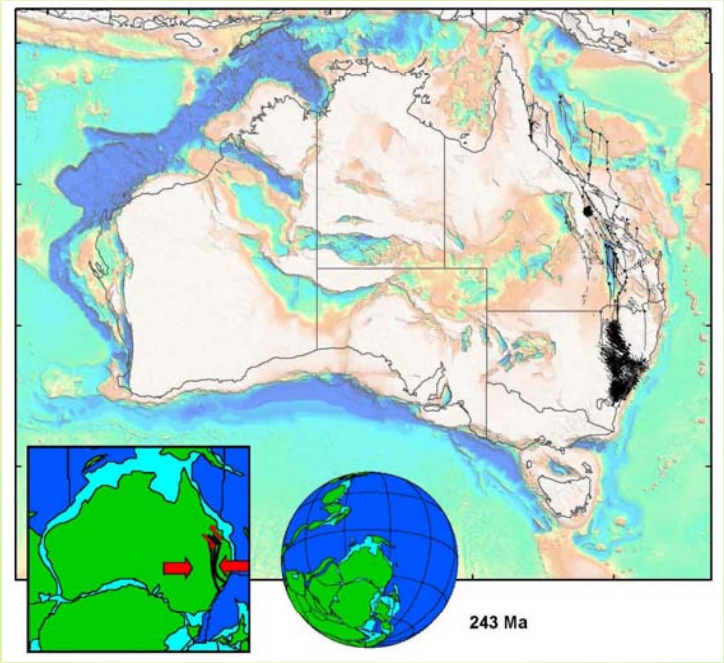
- Kerogen is a mixture of organic chemical compounds that make up a portion of the total organic content
- Some types of kerogen release crude oil or gas (hydrocarbons)
- Methane adsorbs to kerogen
- Hydrocarbons can be released by microbial digestion/refining processes
- Most kerogens are type 2/3

Sorption Capacity of Different Kerogen Types

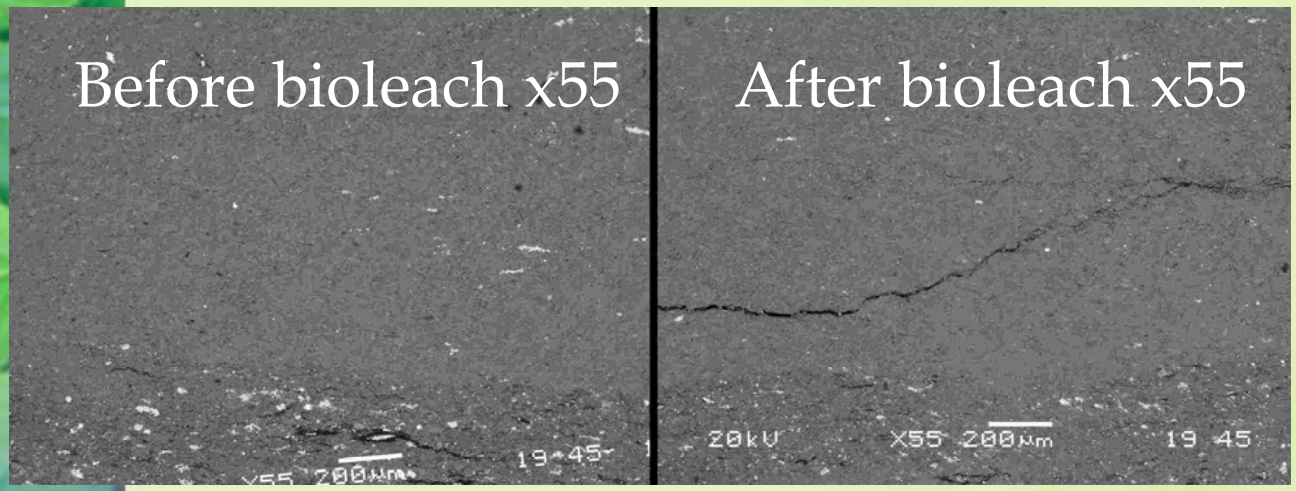


Microbiological Action

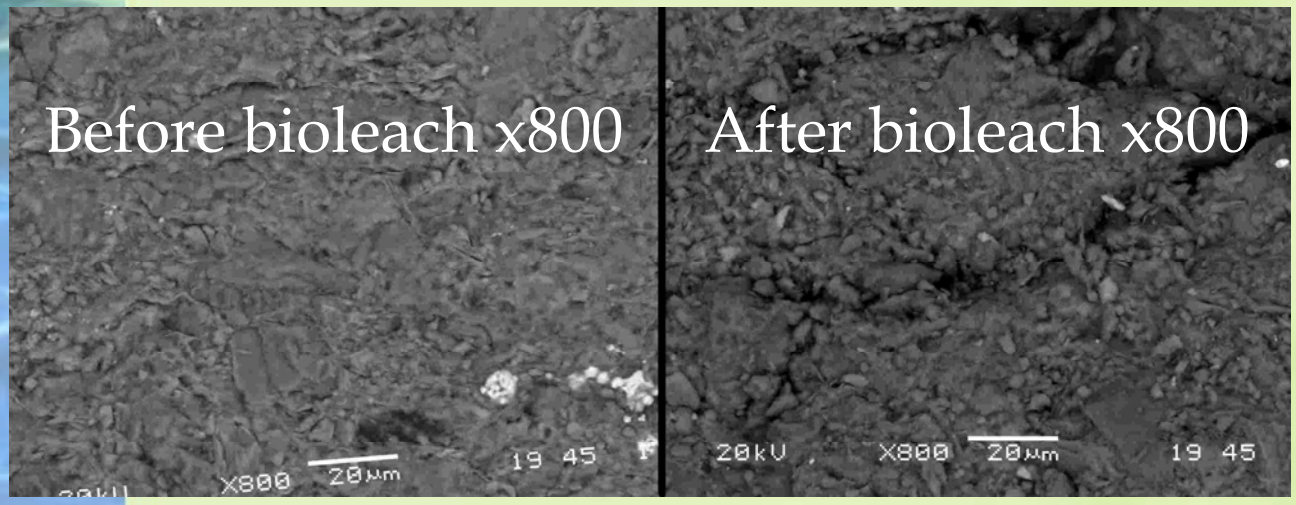
- It is critical to look at the microporosity system, kerogen content and macerals for storage and/or generation sites for methane.
- Gas generation will come from contact of methane-producing bacteria with organic material.
- Produced gases will generate fractures in coal which will produce more surface area contact and more gas generation



Bacterial Biofracturing of Oil Shale

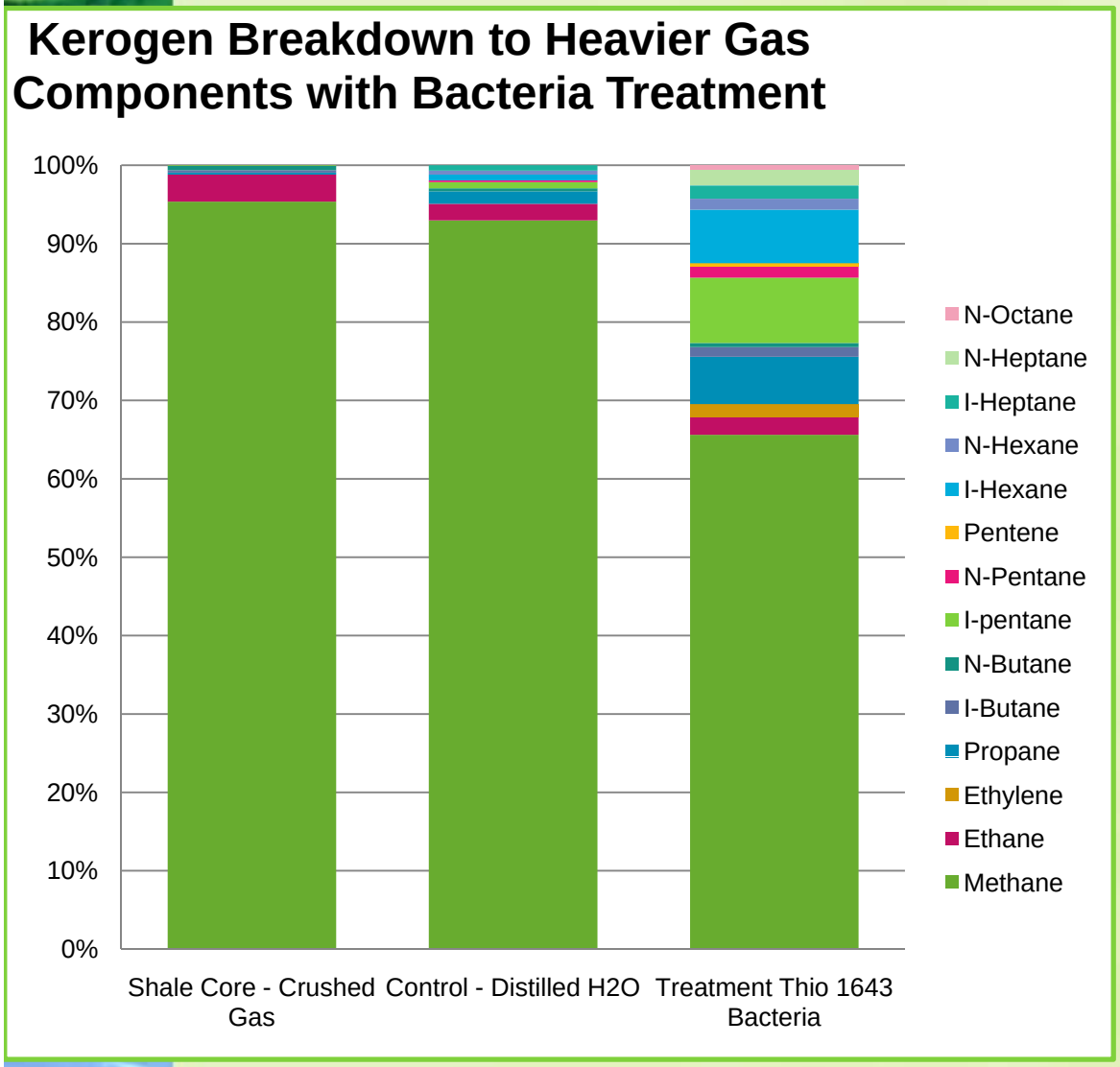


Bacteria generated macroscopic fractures to aid gas flow within 2 months after injection



Bacteria generated microscopic fractures by removing organic material (kerogens) and producing further methane within 2 months

Changes in Gas Composition with the Application of Methanogenic Bacteria



1. Samples from the New Albany Shale, Indiana, USA
2. Crushed gas analysis of the core established methane at about 94%
3. Treatment with distilled water as control did not change the high methane composition
4. Treatment with bacteria resulted in breakdown of the kerogens which act as gas movement inhibitors and % methane dropped
5. Result is now higher gas flow from shale
6. Result is higher calorific value from heavier gas ends

Coal Sample Collection

- Gujarat NRE 50kg – Raw Coal Stock Pile

- Taiyuan Coal samples
  - Henan Provincial CSG Development & Utlisation Ltd

- Zhengzhou Coal Samples
  - Shanxi Energies Industrial Group Ltd

Feasibility Process

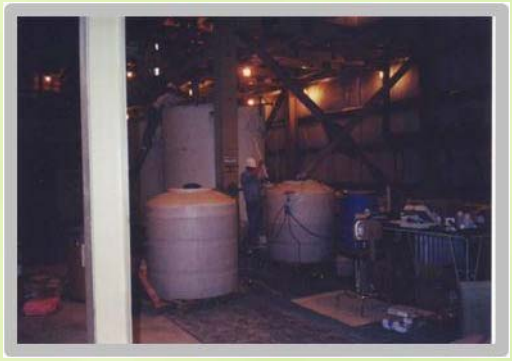
- **Phase 1**
  - Microbe Isolation
  - Match to chemically-defined nutrient formulae

- **Phase 2**
  - 100mL serum cultures
  - Nutritional Microbe/Archaea ID
  - Preliminary Gas Generation Studies

- **Phase 3**
  - 2.5 L Bioreactor Studies
  - Coal Mineral Alteration
  - Gas Generation (methane, C2-C6, H_2, CO_2

1st stage - Isolating correct bacteria

2nd stage - culture ready to up scale



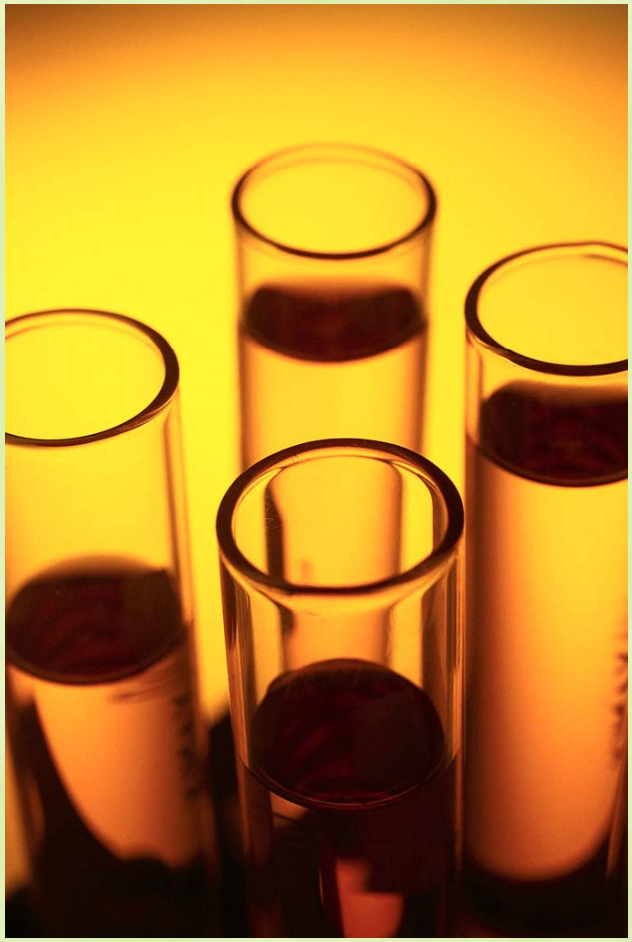
3rd stage - up scaled to medium tanks

4th stage – up scaled to tanks or ponds

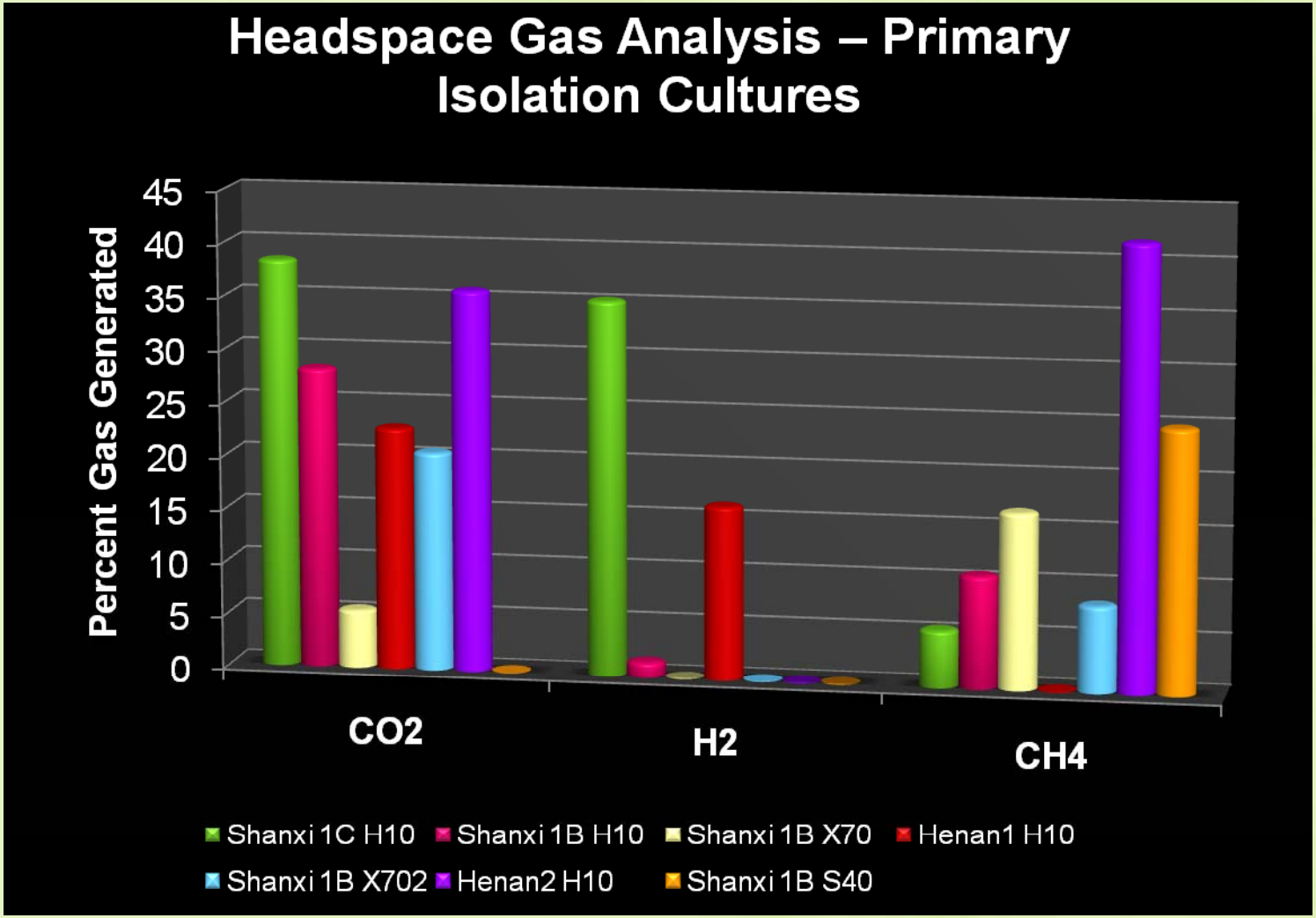
To application

Pintail Bio-remediation and bio-extraction
up scaling bacteria to heap leach capabilities

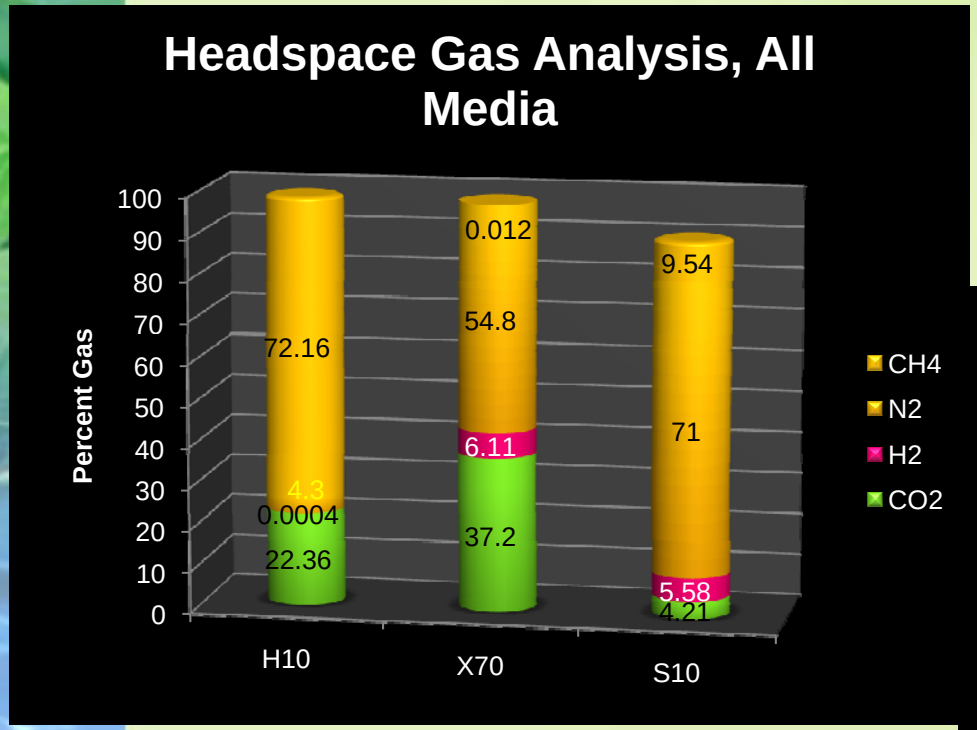
RESULTS SO FAR

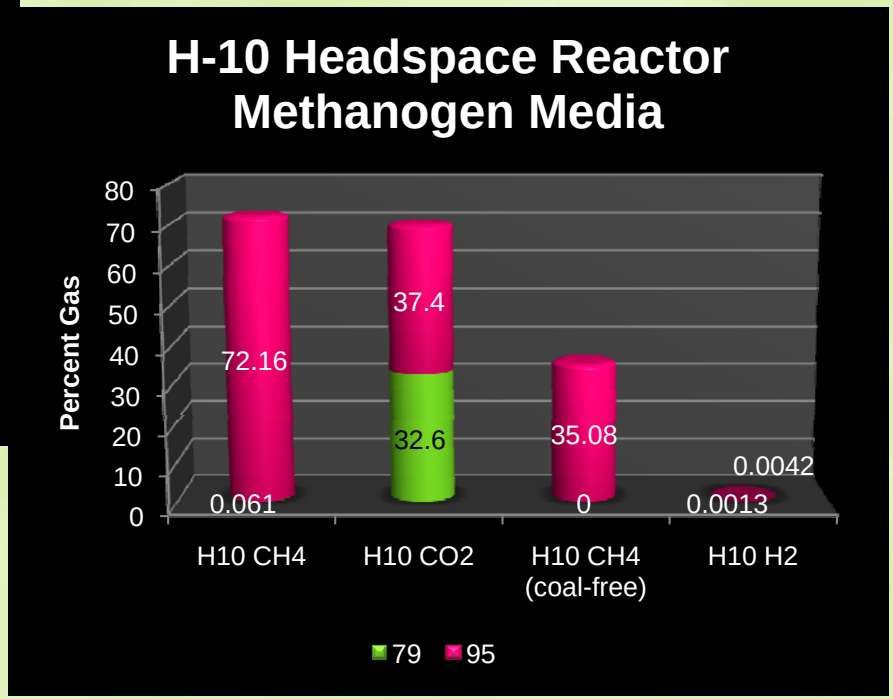


Coal Gas Release and Generation
Chinese Anthracite Samples



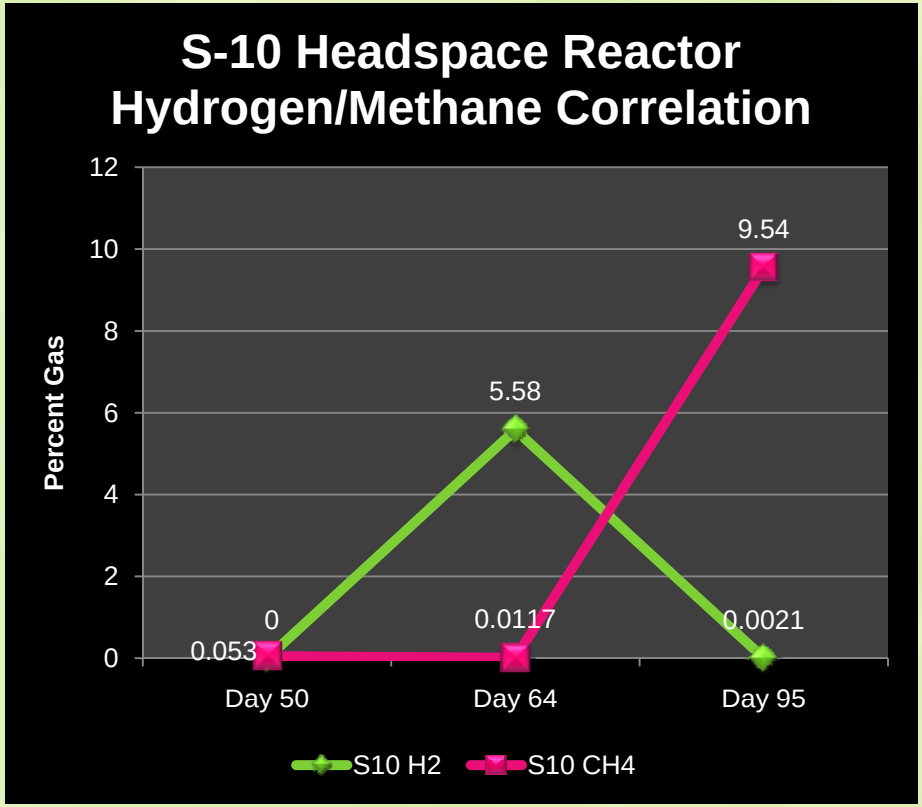
Gas Analysis by Media & Methanogen Media Sequential Analysis – Gujarat NRE Sample(Wongawilli Seam)





Hydrogen and Methane Observations

- Hypothesis: Hydrogen will be produced first and then methane in carbon dioxide reduction pathways
- As hydrogen is converted to methane, hydrogen drops in headspace gases and methane increases
- Sequential headspace gas analysis will confirm reaction sequence and by-products



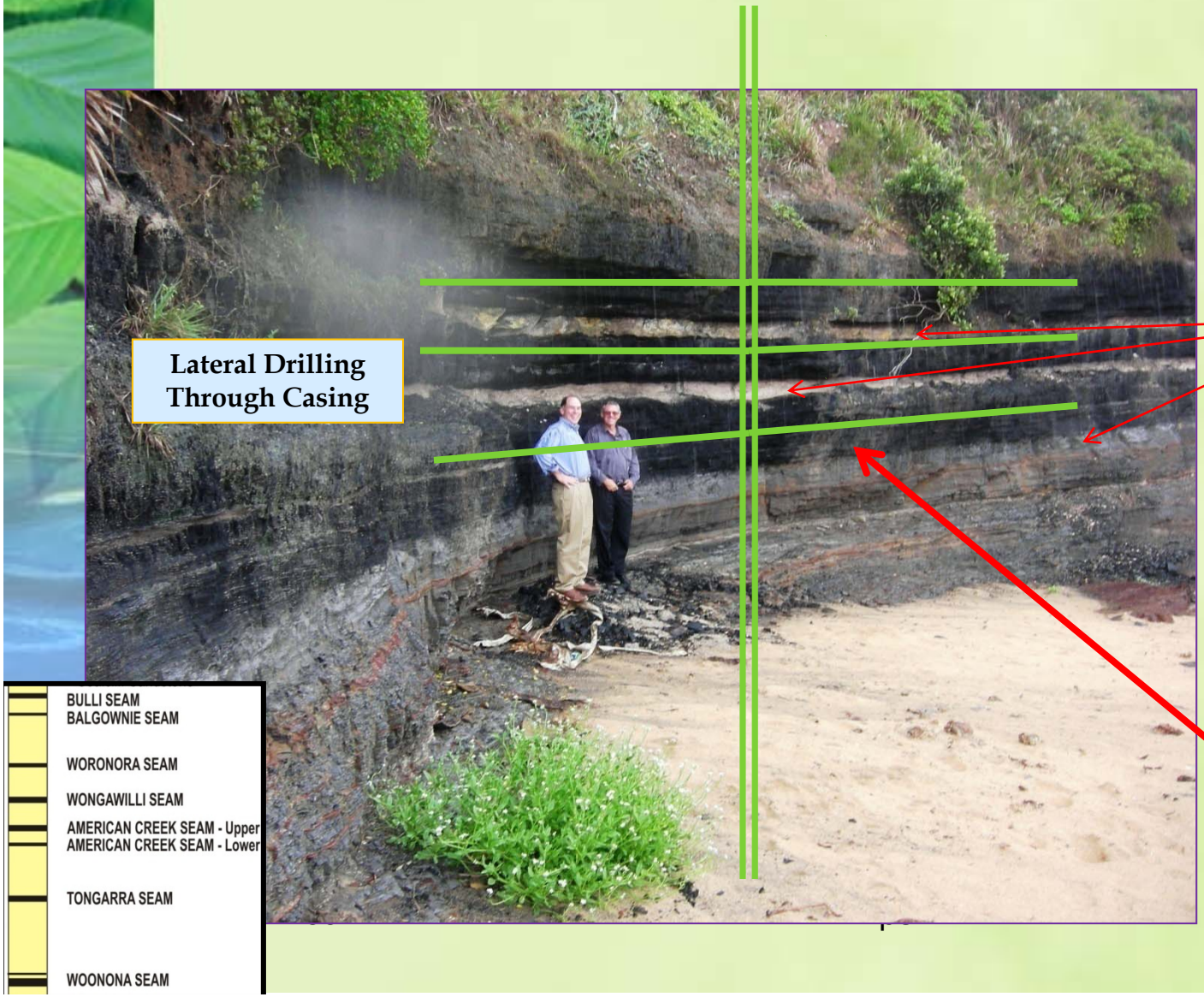
Feasibility Summary

- Tests to-date have generated positive data using microbial processes to enhance methane release/generation in Bulli and Chinese coals
- Up to 72% methane has been generated in serum bottle reactor headspace
- Up to 6% hydrogen has been generated in serum bottle reactor headspace
- Best methane generation is in H10 methanogenic media
- Best hydrogen generation is in X70 chemolithotrophic media and S10 halophilic media
- Methane production via release of chemically-bound methane from coal appears to account for about 50-60% of methane and other methane generation appears to account for about 40-50% of the methane in preliminary tests

Technology Application

Illawarra Scenario

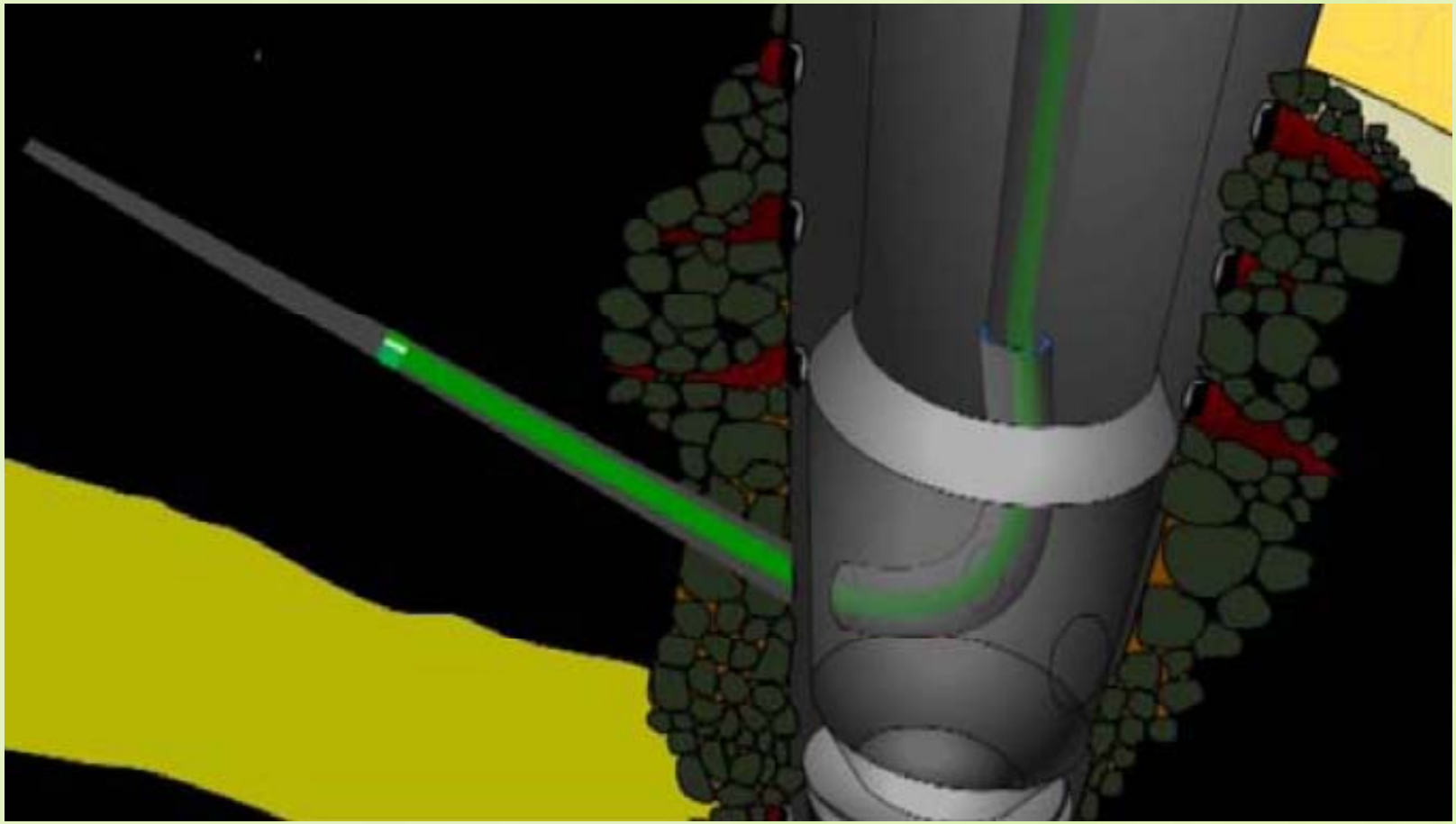
IMPROVING GAS FLOW THROUGH USE OF LONE STAR MULTIPLE LATERALS IN OPEN HOLE CONFIGURATION



Impermeable clay and ash layers preventing flow of gas from all gaseous coal seams

High pressure laterals drilled into every coal seam and sub seam to improve gas flow – between
40-60 laterals in 2 days

IMPROVING GAS FLOW THROUGH USE OF LONE STAR MULTIPLE LATERALS IN OPEN HOLE CONFIGURATION



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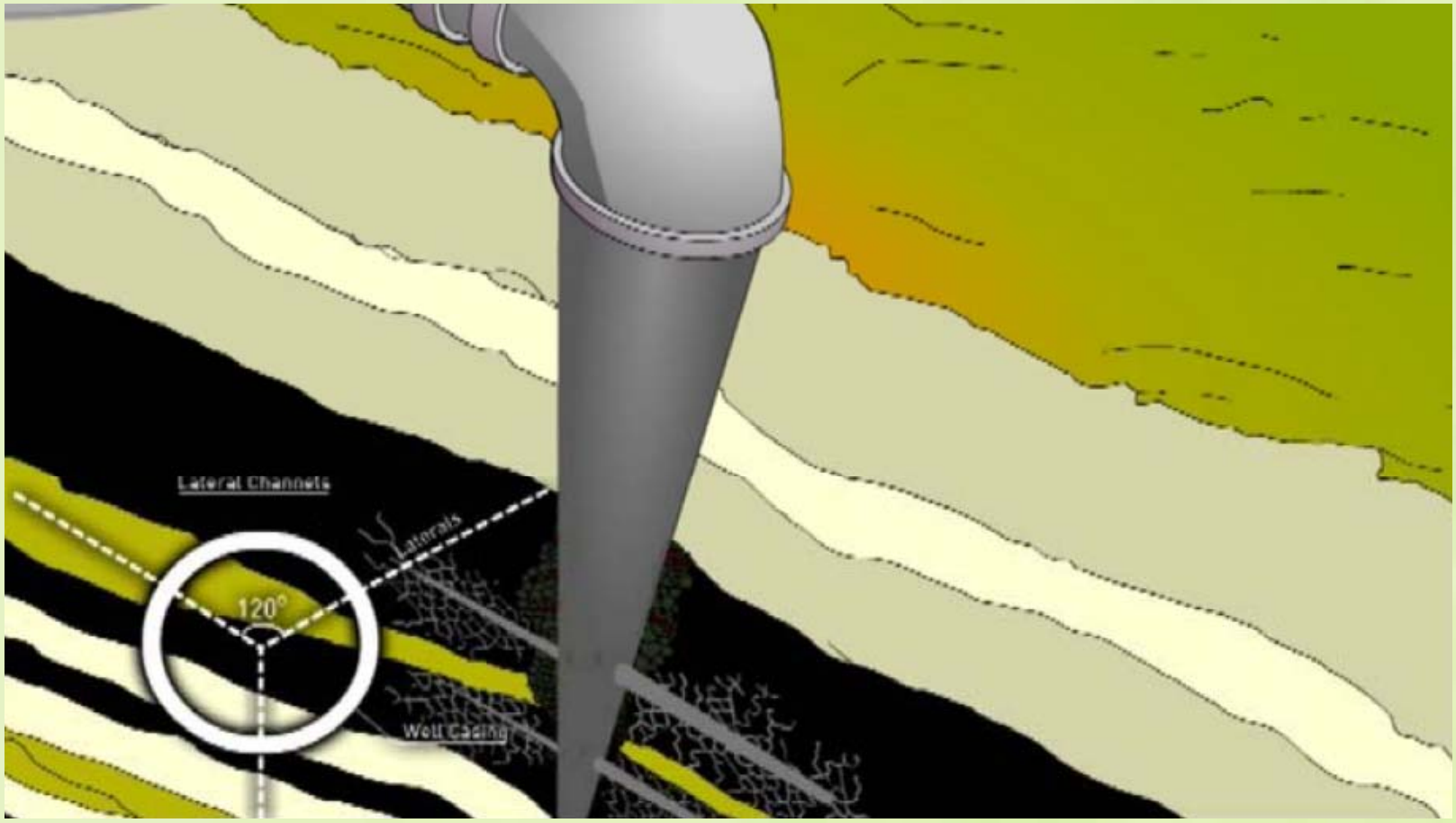
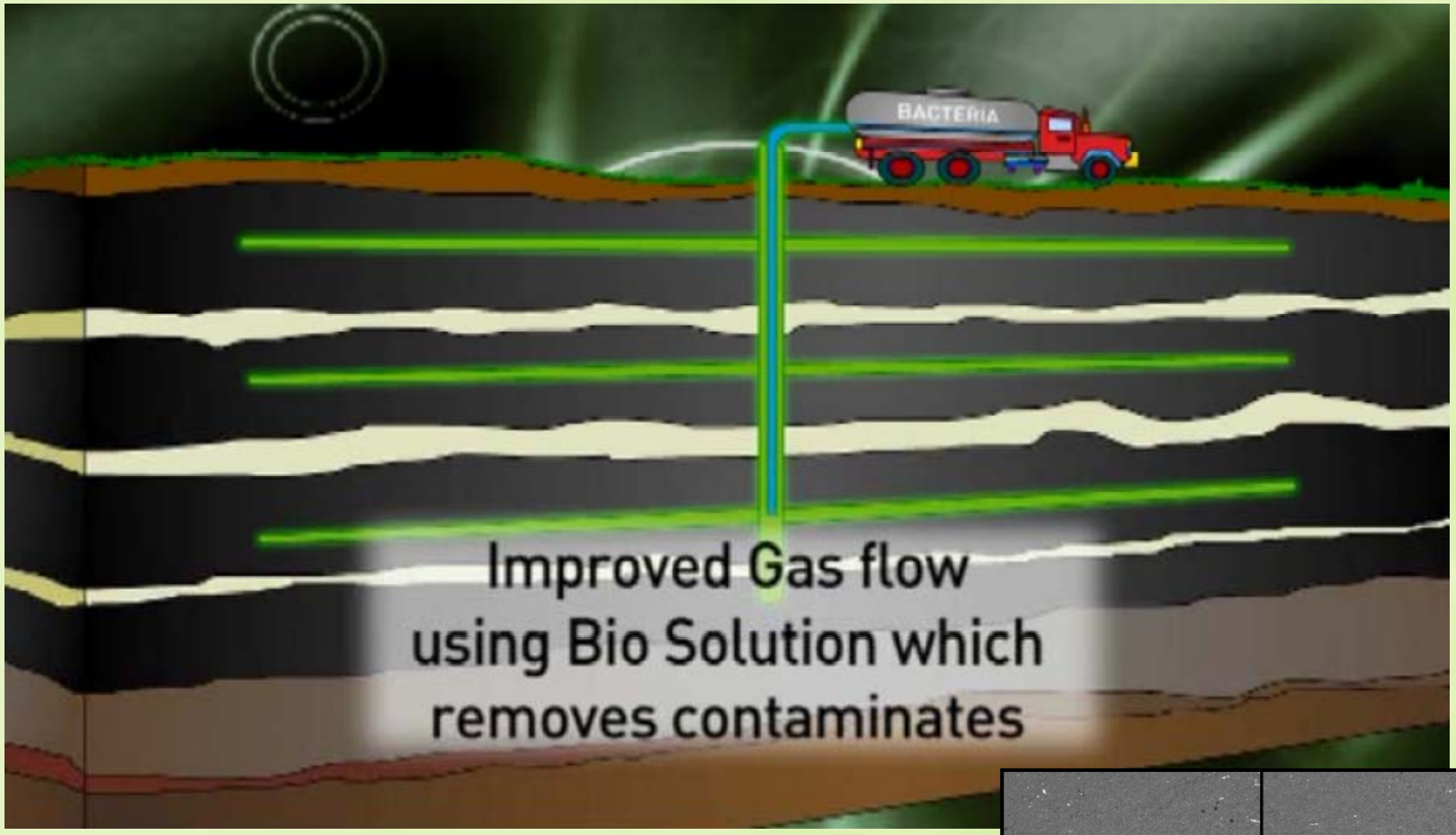
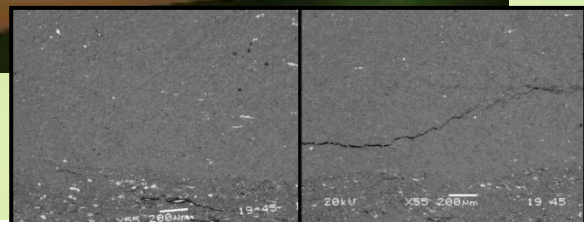


FURTHER GAS FLOW ENHANCEMENT THROUGH THE APPLICATION OF BACTERIA VIA MULTIPLE LATERALS





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