Microbial Activity in Australian CBM Reservoirs*

Mohinudeen Faiz[1] and Phil Hendry[1]

Search and Discovery Article #80033 (2009)
Posted January 20, 2009

*Adapted from oral presentation at AAPG Annual Convention, San Antonio, TX, April 20-23, 2008

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Abstract

Coalbed Methane (CBM) in Australian basins consists of methane, carbon dioxide, ethane and higher hydrocarbons. Gas and coal geochemistry data indicate extensive microbial activity, especially in coal seams shallower than about 600 m. Microbial activity causing secondary biogenic gas generation possibly occurred subsequent to uplift of the eastern Australian basins during the Late Cretaceous and Tertiary. Stable isotope data indicate that CO_2 reduction is the main pathway of secondary biogenic methane generation in the eastern Australian coals.

The gas saturation levels of coal seams are highly variable depending on the thermal maturity, burial history, and groundwater flow. In coal seams that have been uplifted and where meteoric water recharge has occurred, secondary microbial activity has enhanced the methane saturation levels. Without such secondary gas replenishment, however, many of these coals remain significantly undersaturated. In the Sydney Basin, for example, the CBM production rates are up to an order of magnitude higher in areas where coal seams have been re-saturated with secondary biogenic gas compared to areas containing only thermogenic gas.

The types of microflora that are generating gas in Australia CBM reservoirs are unknown. The CSIRO is currently investigating the processes of biogenic gas generation in Australian coals including the ability of the indigenous microflora in a range of Australian coals to generate methane under laboratory conditions. Experiments will also be conducted to assess the viability of injecting suitable micro-organisms and/or nutrients into depleting and under-saturated coal seams to enhance methane production.

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[3]Energy Transformed Flagship

CSIRO

Synopsis

- **CBM is an important energy source for Australia**
- **Biogenic CH_4 and CO_2 are significant components in Australian coal seam gas reservoirs**
- **“Sweet-spots” for CBM production mainly related to zones of secondary biogenic gas generation**
- **Microbiological studies indicate the presence of a great diversity of prokaryotes**

Acknowledgements

AGL Energy

Australian Coal Seam Methane Ltd

BHP Billiton

Macquarie Energy

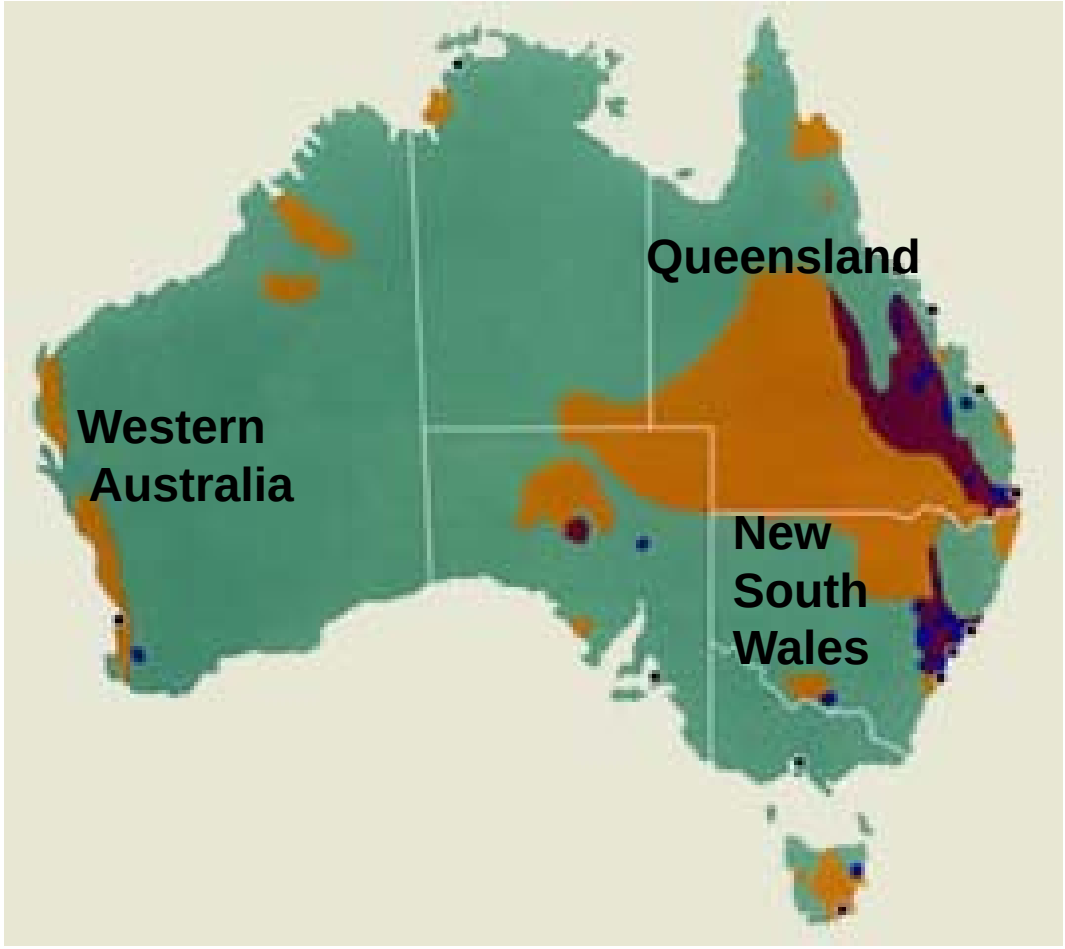
Maddingly Brown Coal Ltd

Origin Energy

Santos Ltd

Sydney Gas Ltd

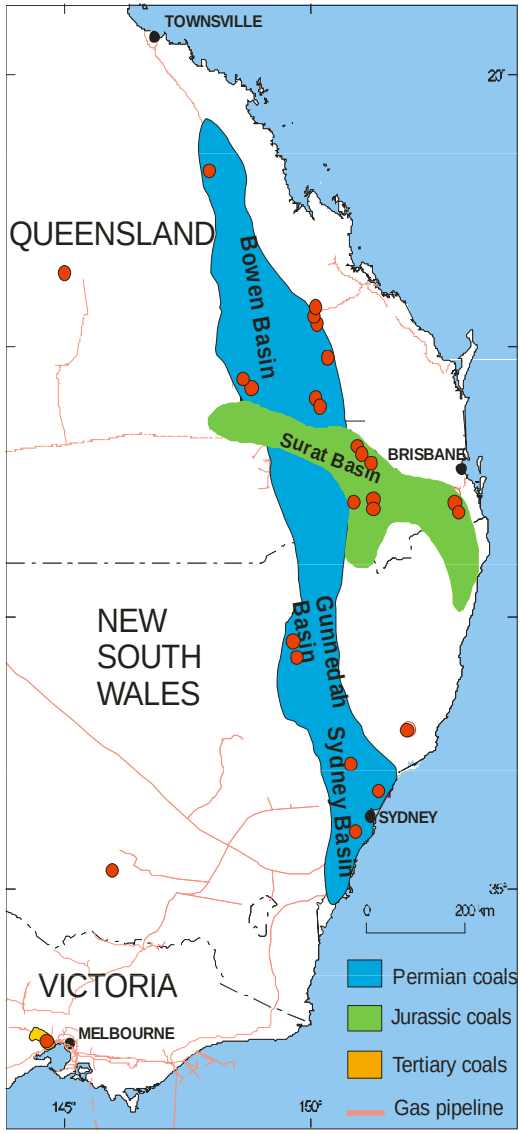
Coal Deposits in Australia



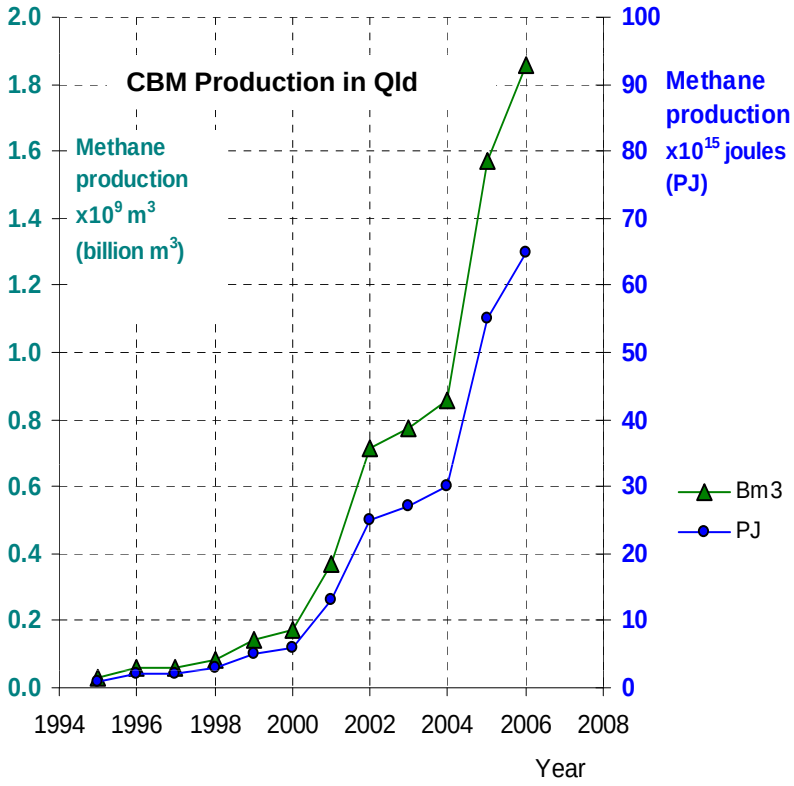
High rank Coal

Low rank Coal

CBM Methane Production



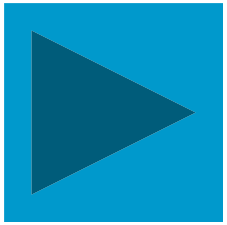
CSIRO



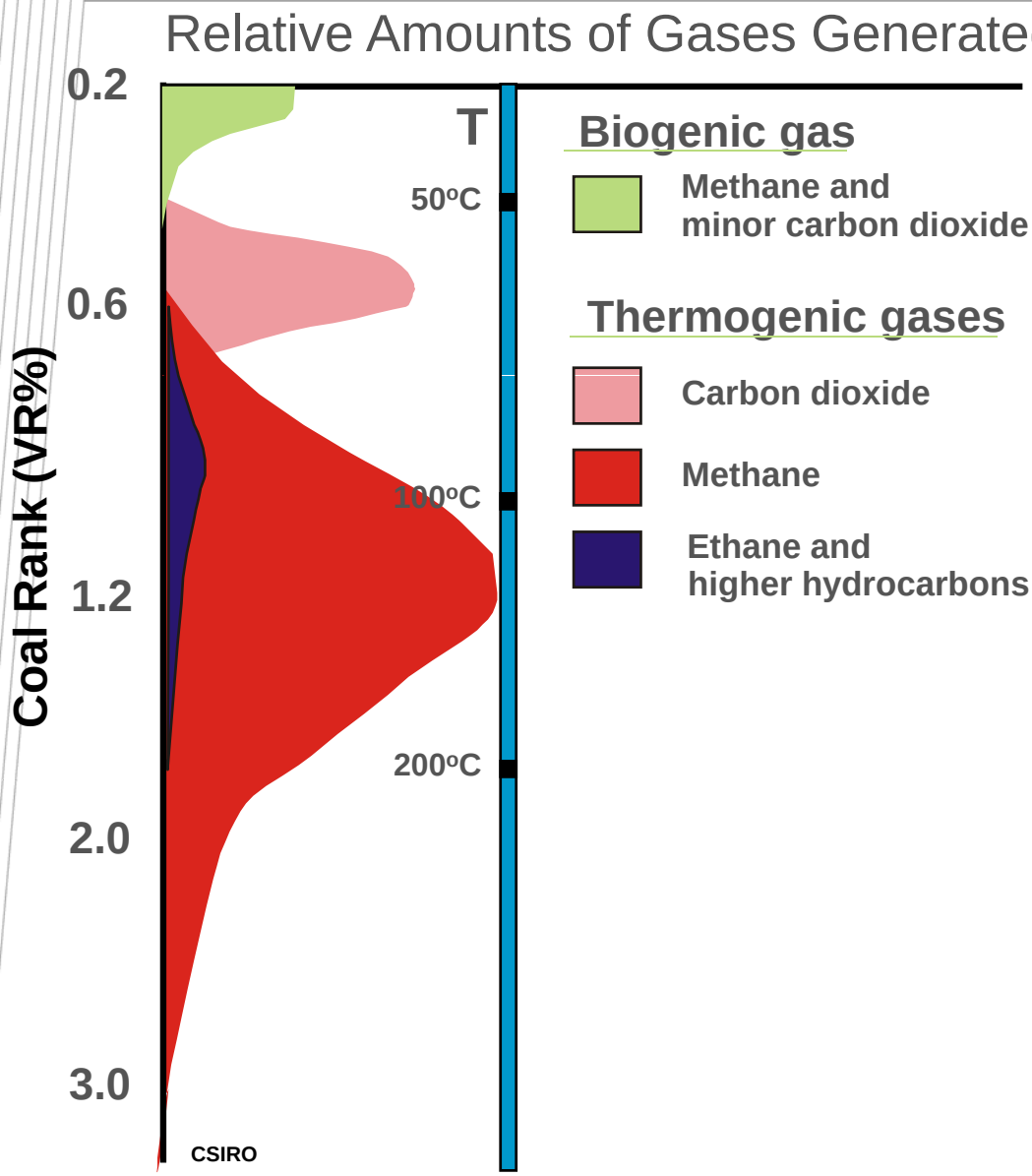
~80% of used in QLD comes from CBM

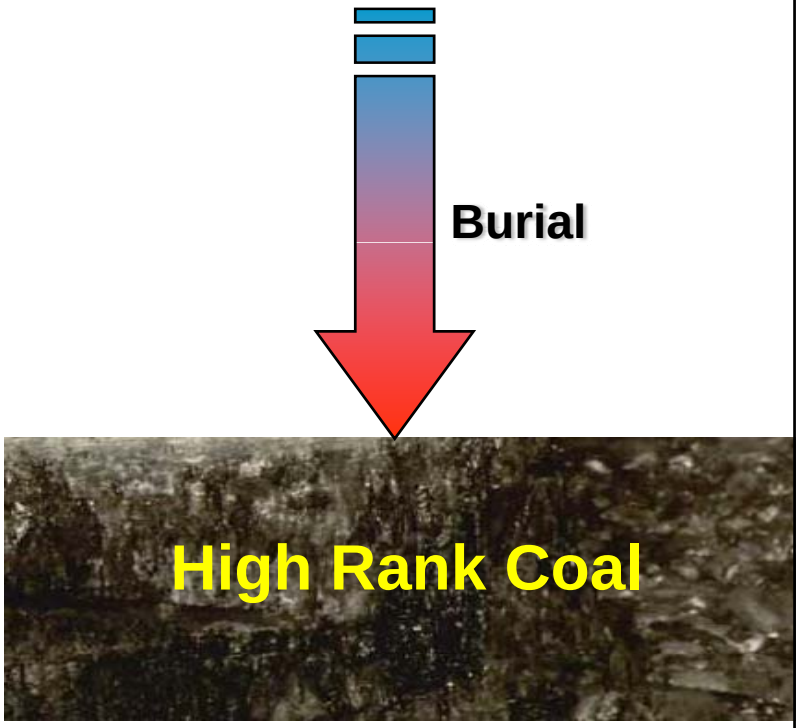
Background

Origin of gas in coal

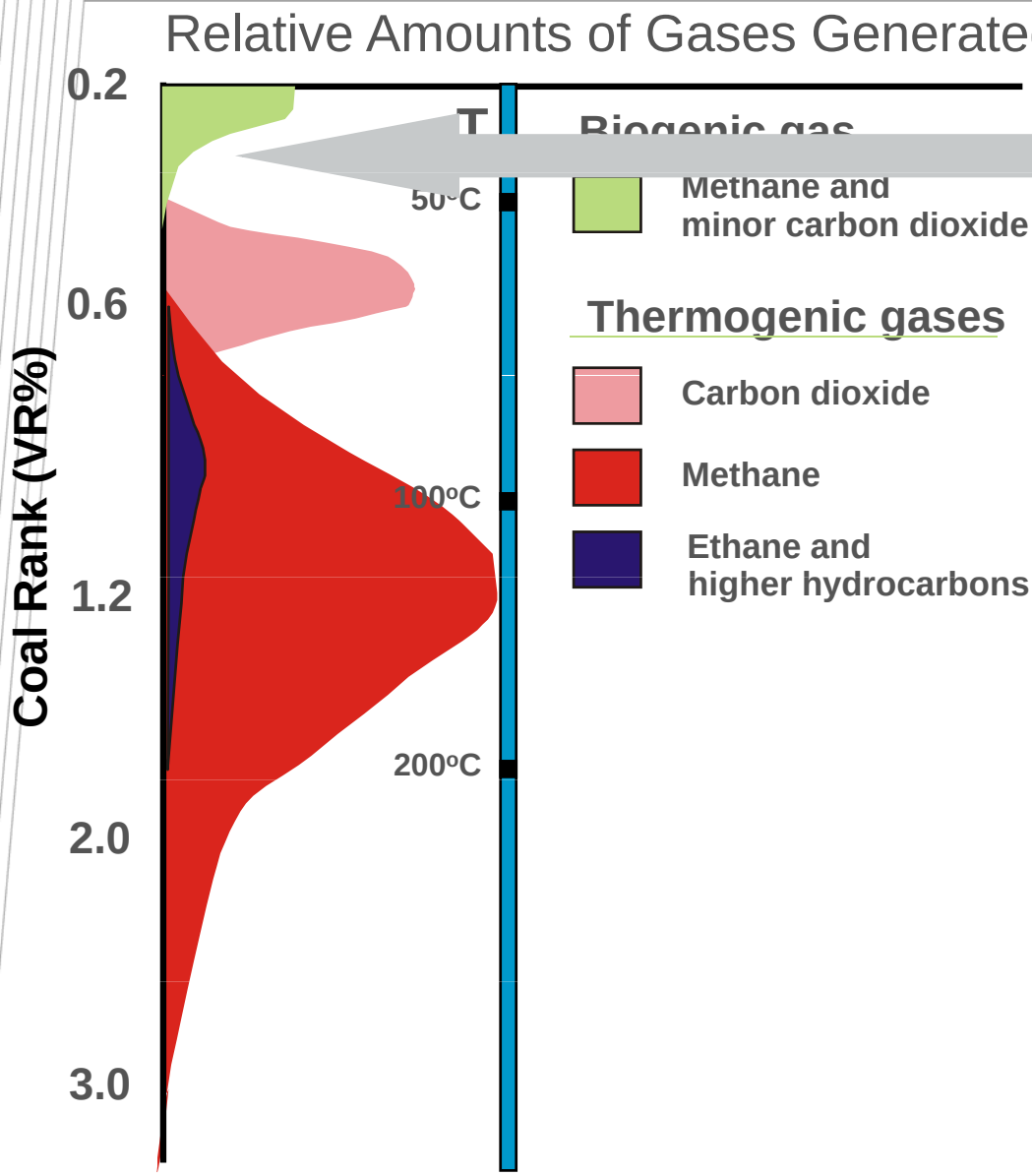


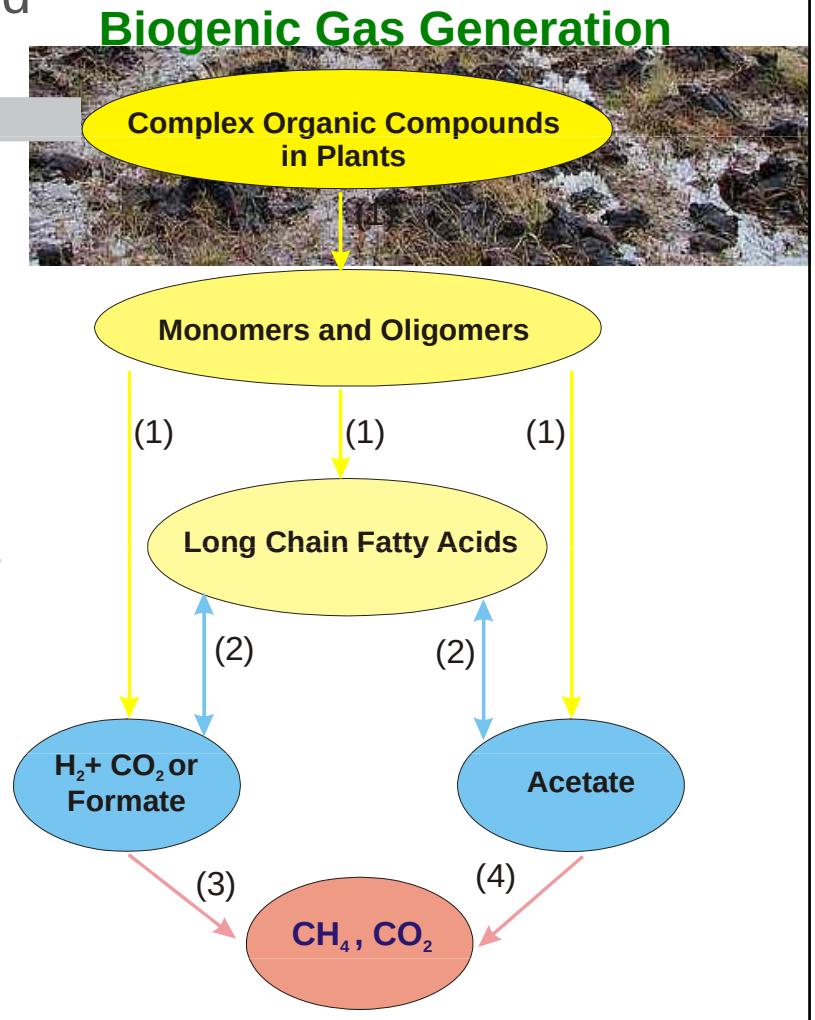
Burial History and Sources of Coal Seam Gas





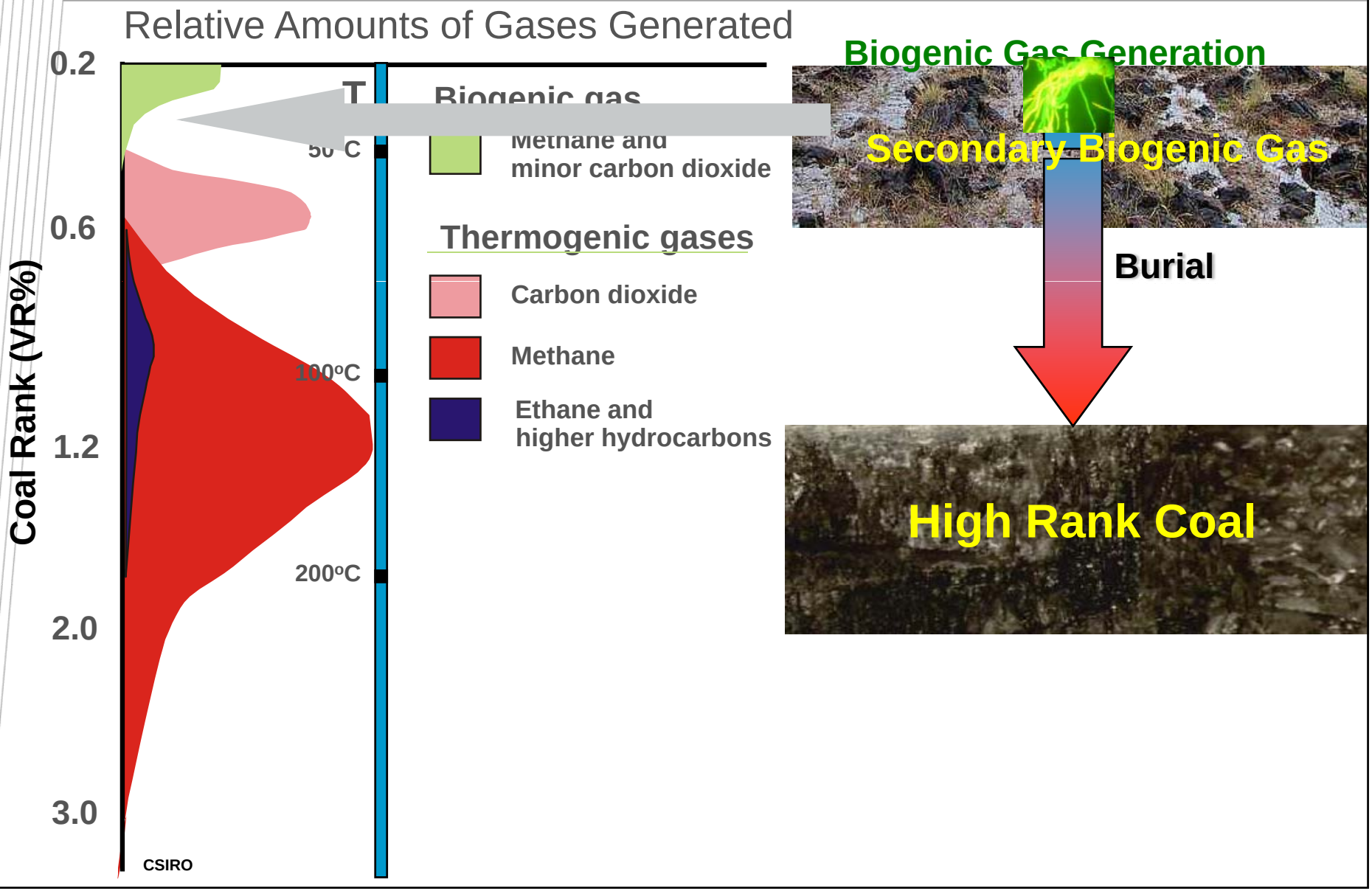
Burial History and Sources of Coal Seam Gas





(1) fermentative anaerobes (2) H_2 producing acetogens
(3) H_2 consuming methanogens (4) acetotrophic methanogens

Burial History and Sources of Coal Seam Gas



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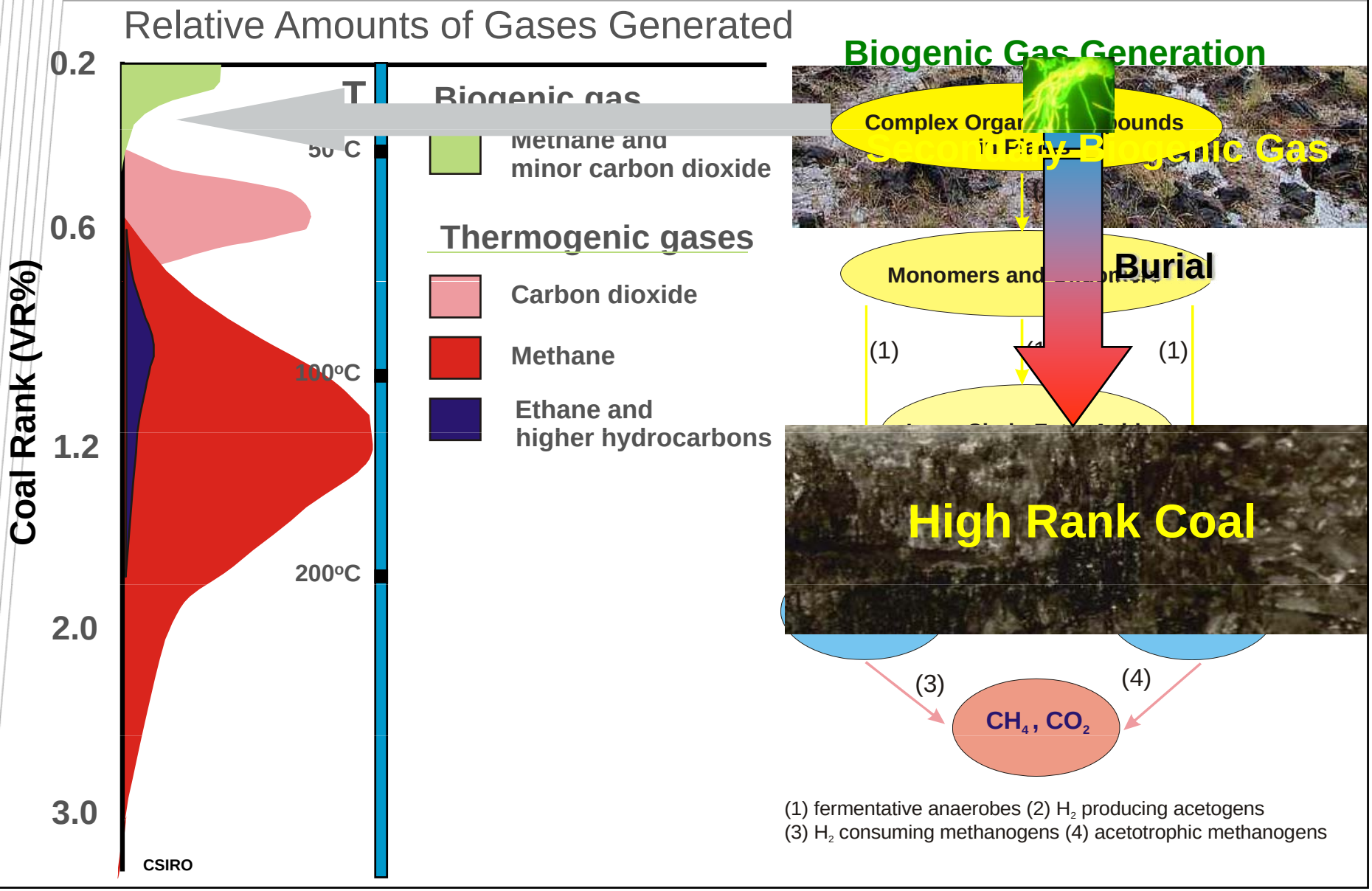
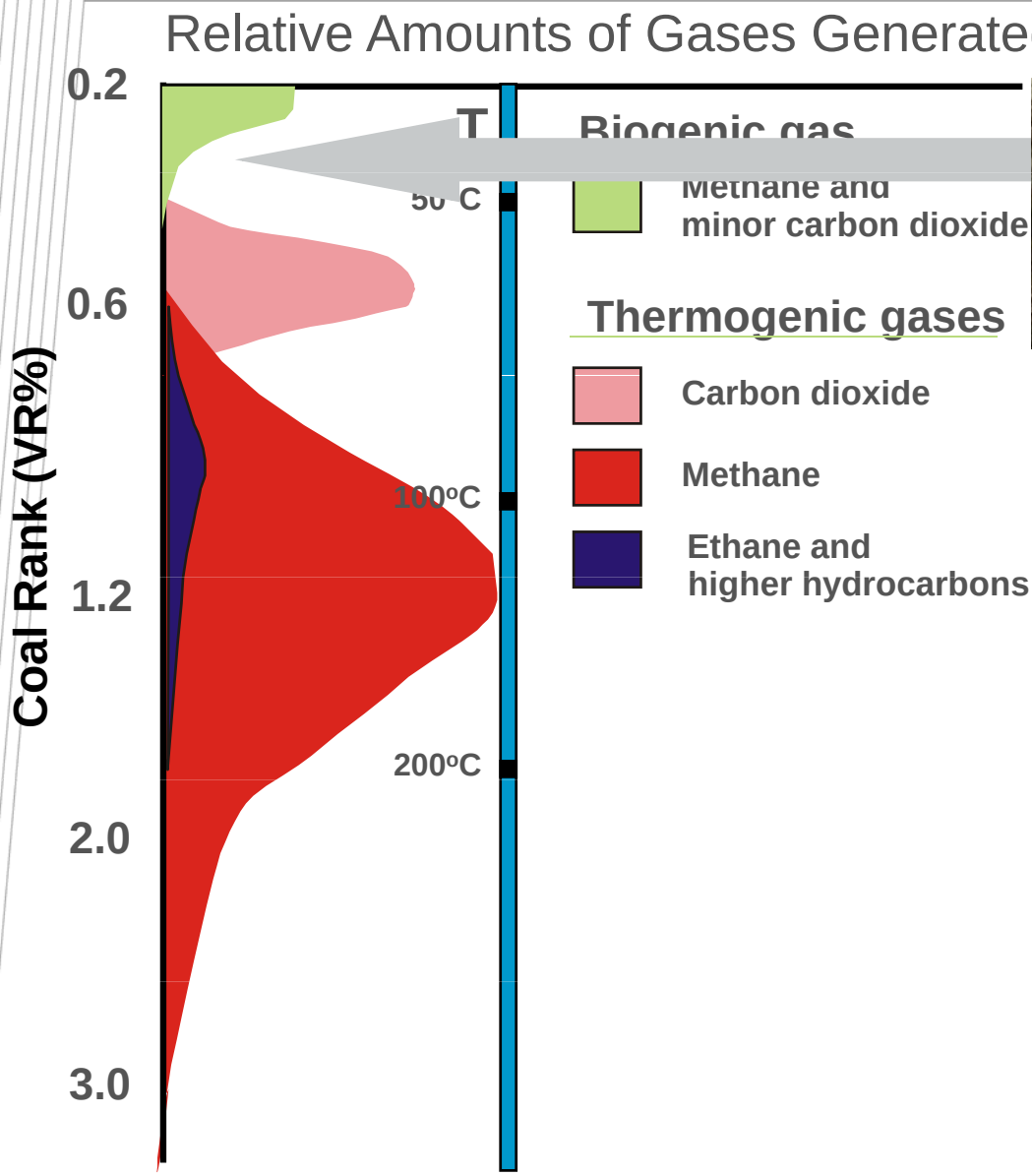
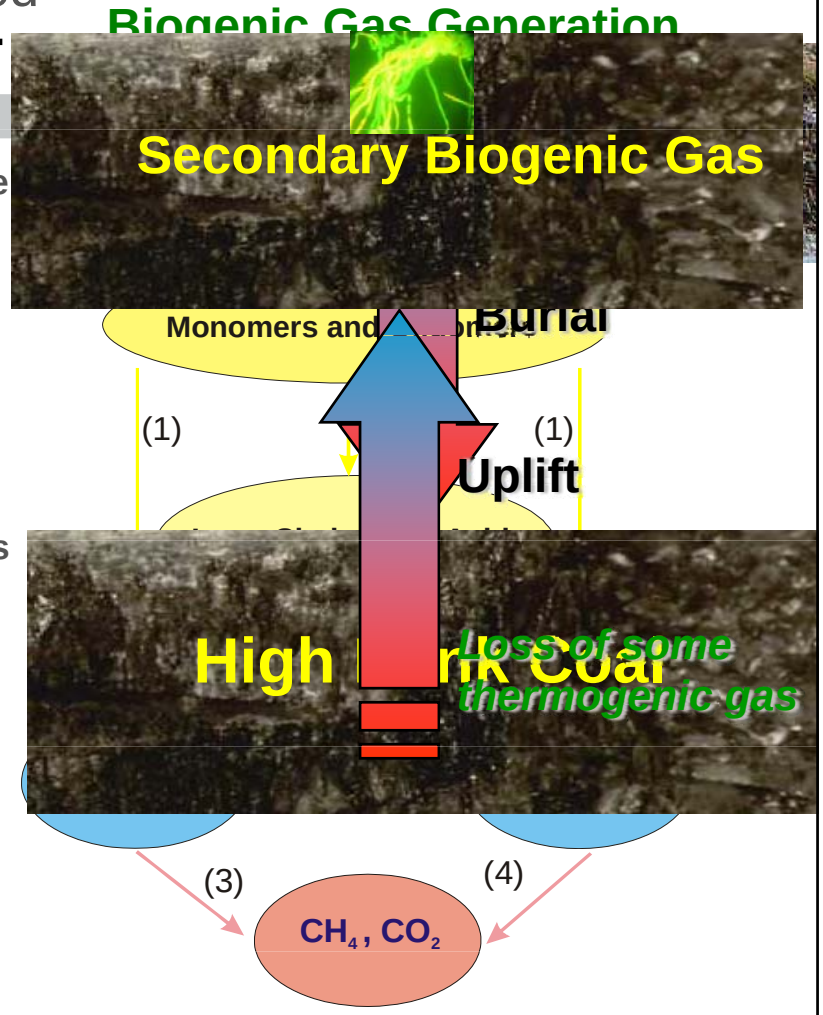


Burial History and Sources of Coal Seam Gas





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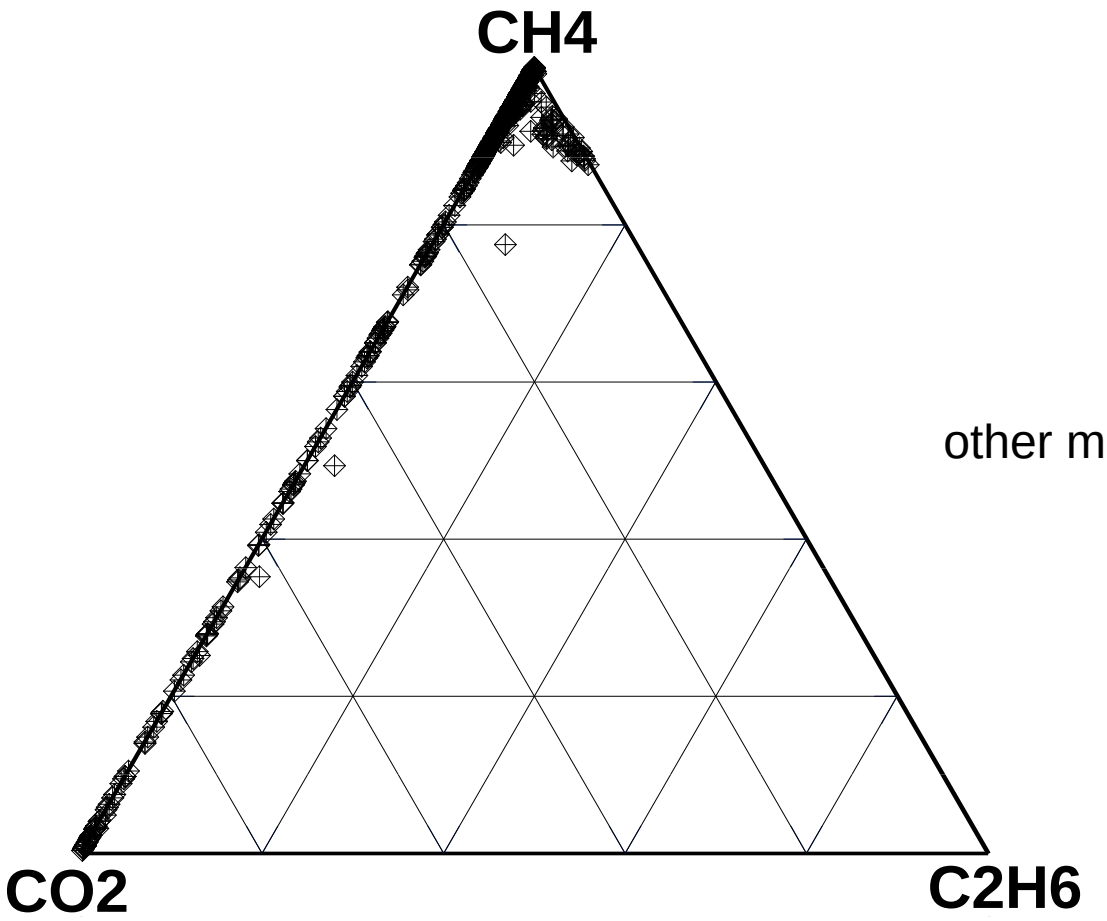
Coal Seam Gas Composition- Australian Coals

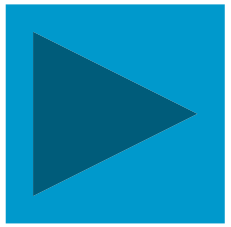


other minor gases: N_2, C_{2+}, H_2S

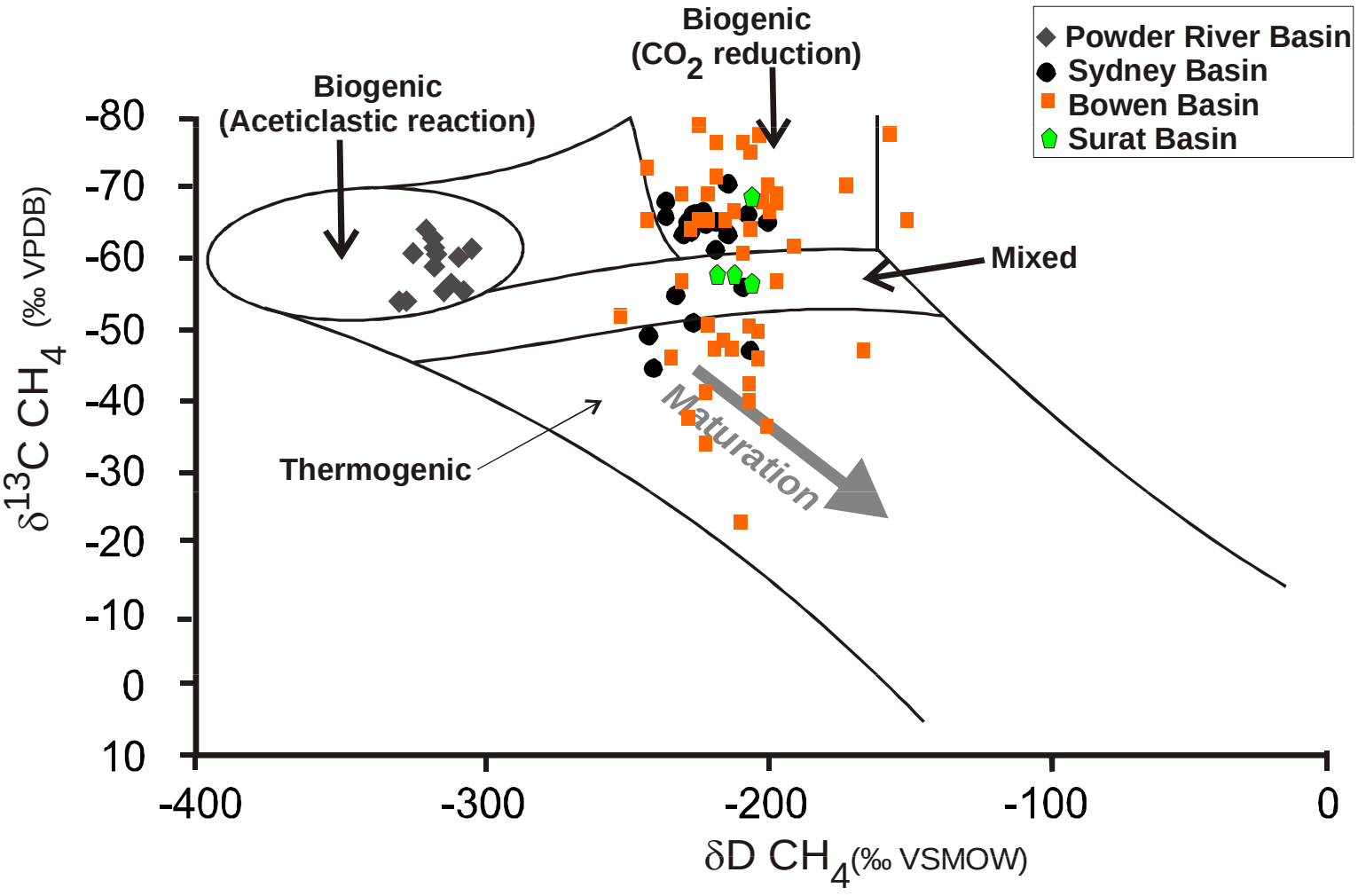
Australian coal seams comprise a mixed gas composition

Stable Isotope Compositions

Source of gas in coal seam gas reservoirs



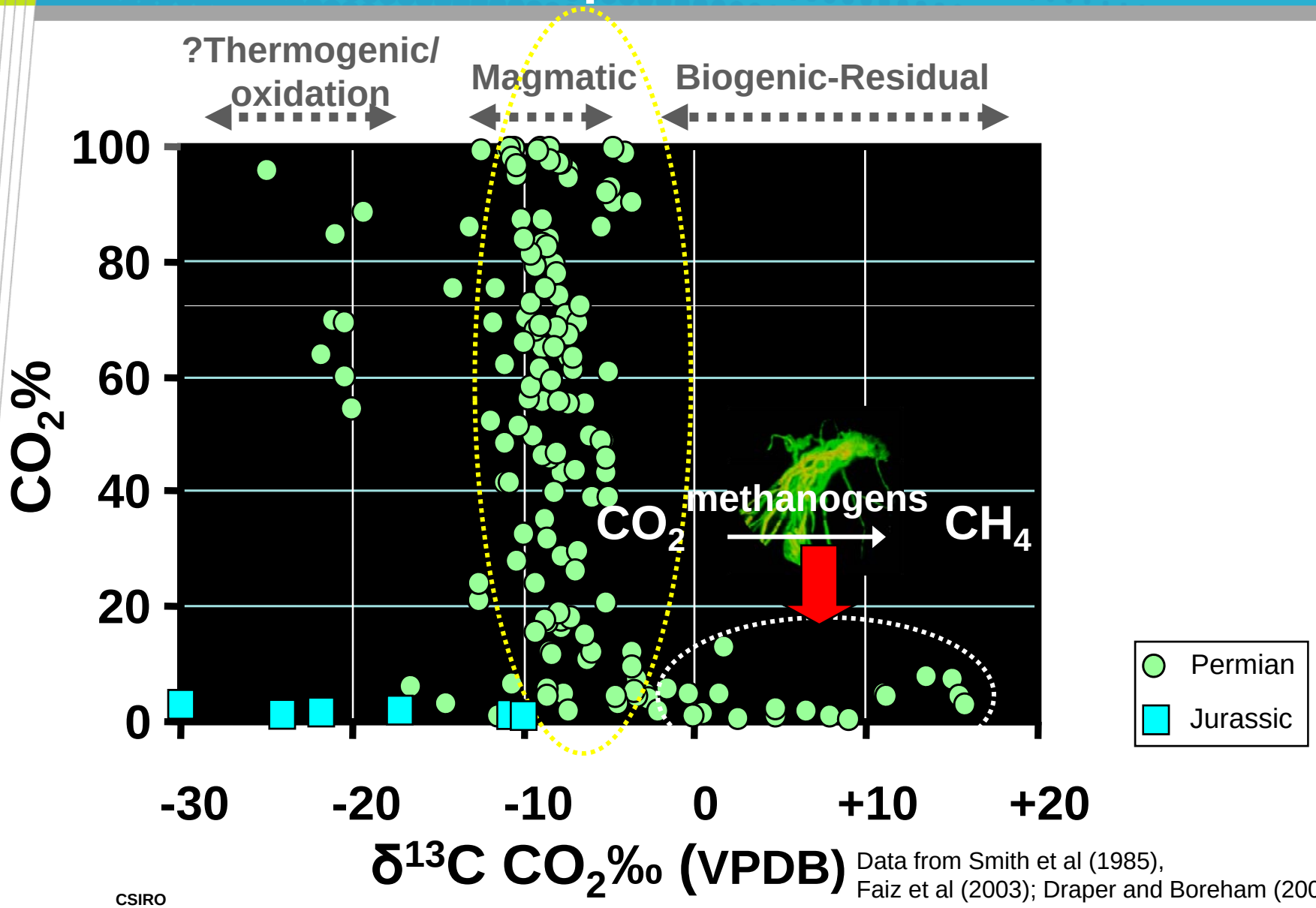
Carbon and Deuterium Isotopes



Classification system from Whiticar et al., (1986)

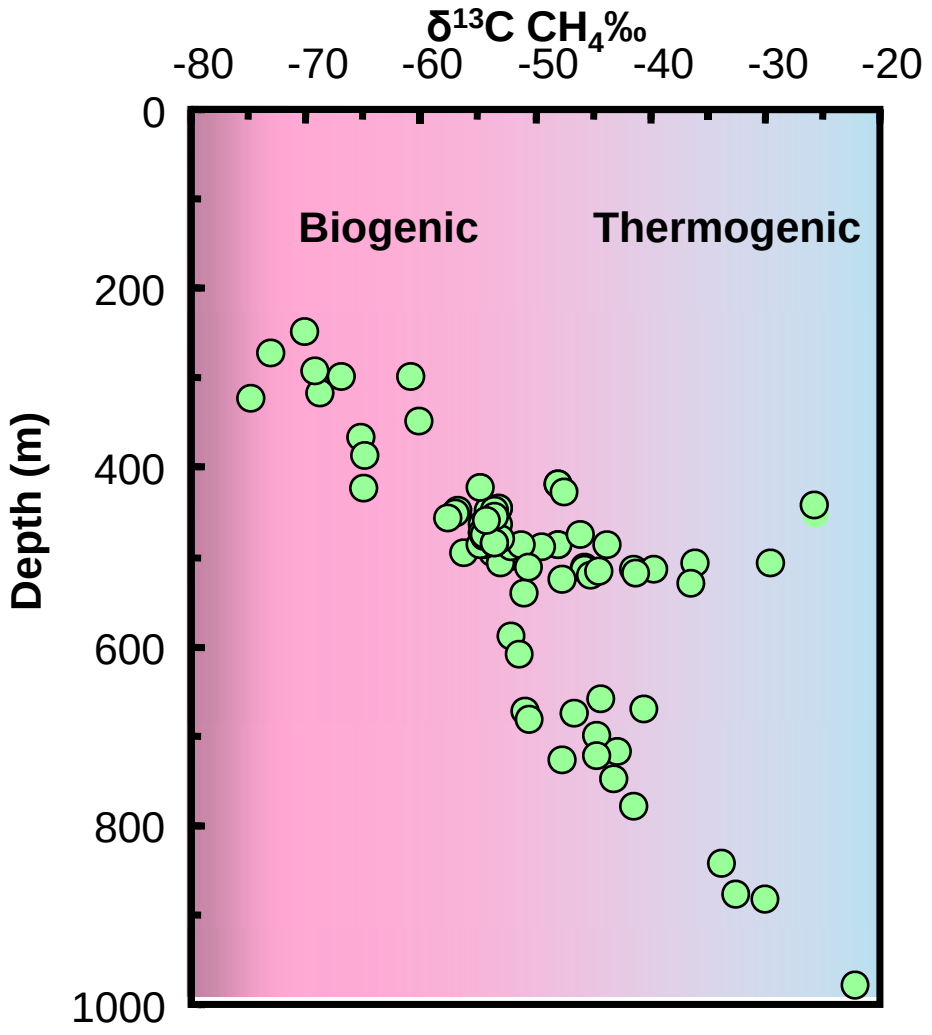
Data from Smith et al (1985), Faiz et al (2003); Draper and Boreham (2006), Gorody (1999)

Origin of CO_2 in Australian Coals - Based on $\delta^{13}C$ Isotopes



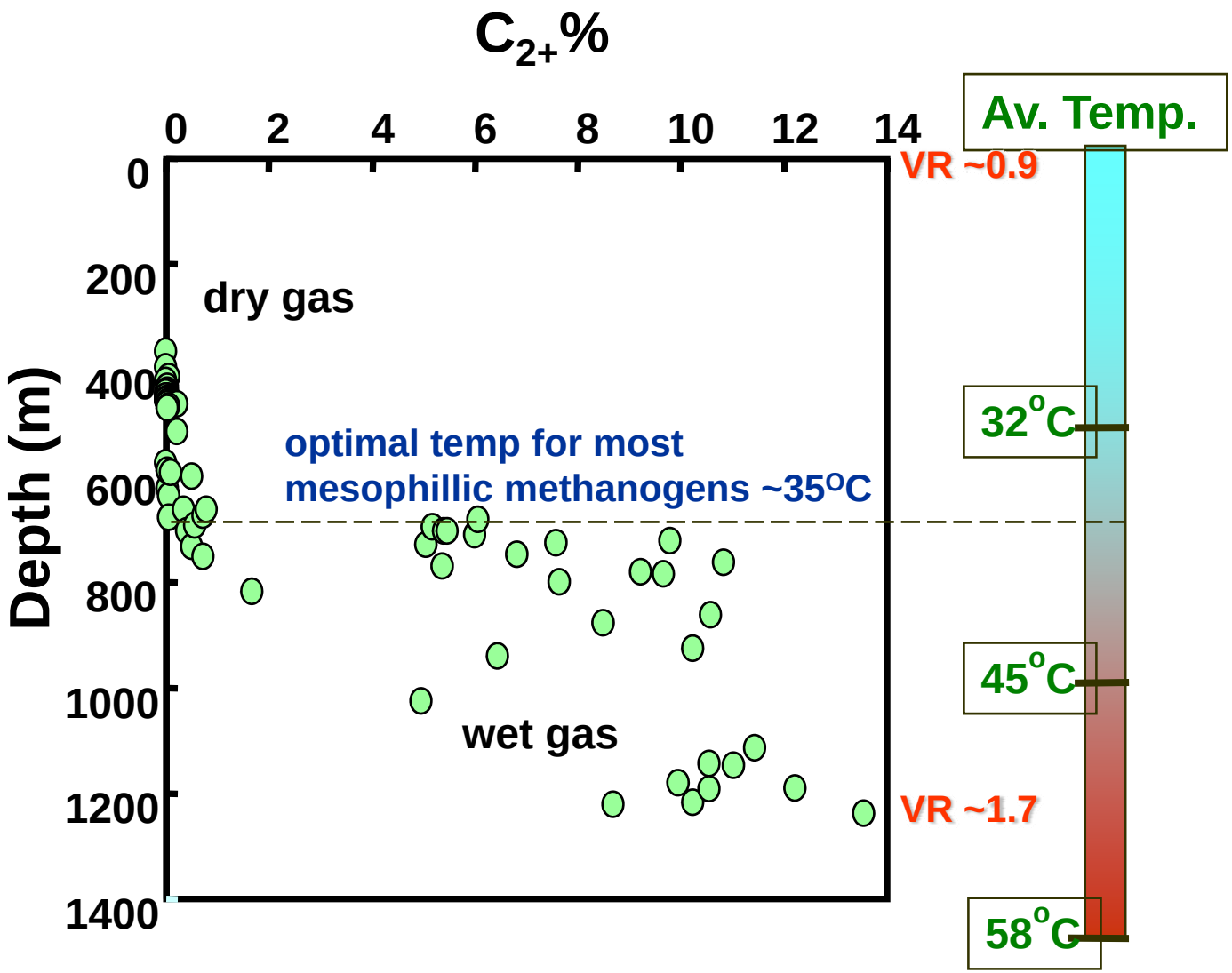
Data from Smith et al (1985), Faiz et al (2003); Draper and Boreham (2006)

Carbon Isotopes for Methane - Sydney Basin

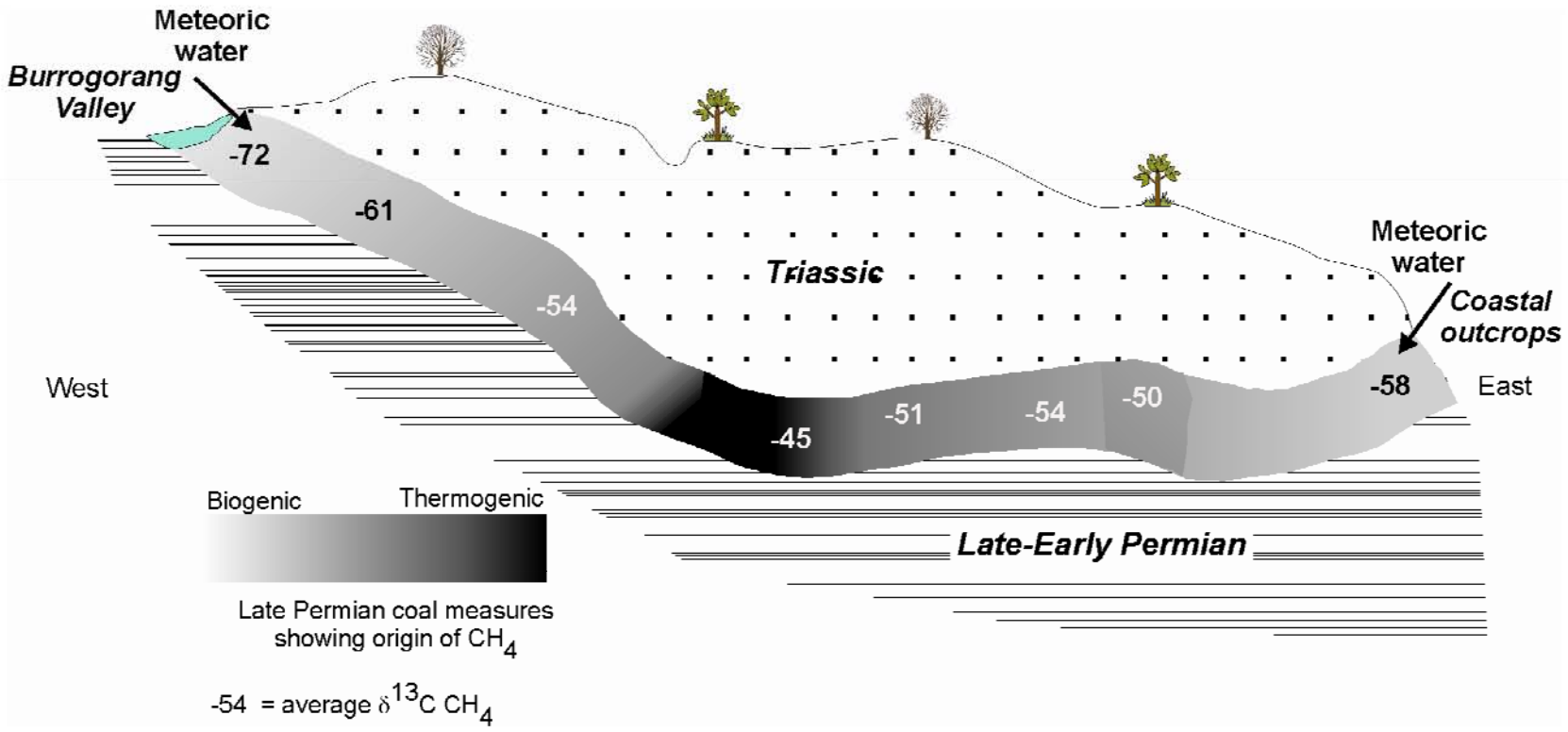


High–Low Volatile Bituminous Coals

Higher Hydrocarbons and Depth - Sydney Basin



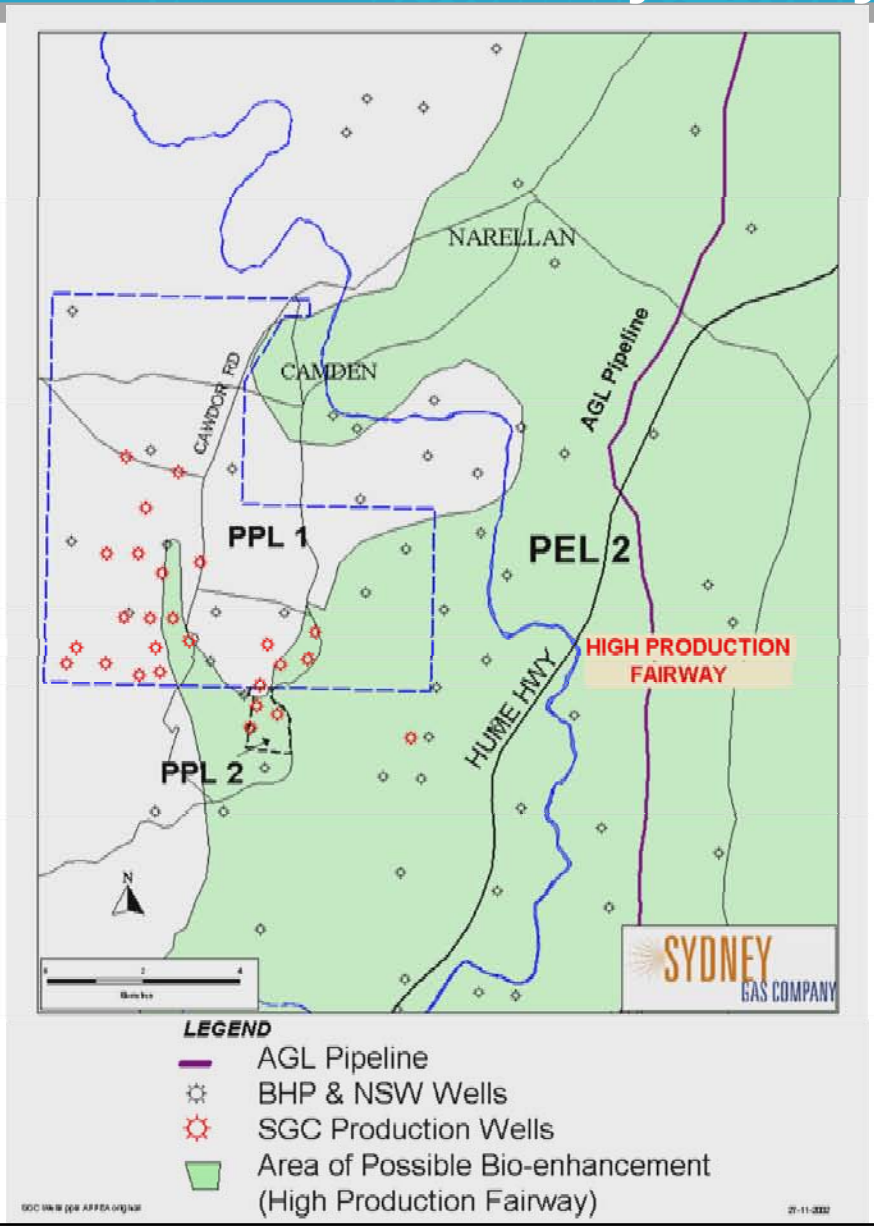
Cross-section of Average Carbon Isotopes for CH_4



Importance of Biogenic Gas for CBM Production

“Sweet-spots” for methane production in many Australian basins are related to areas with secondary biogenic gas

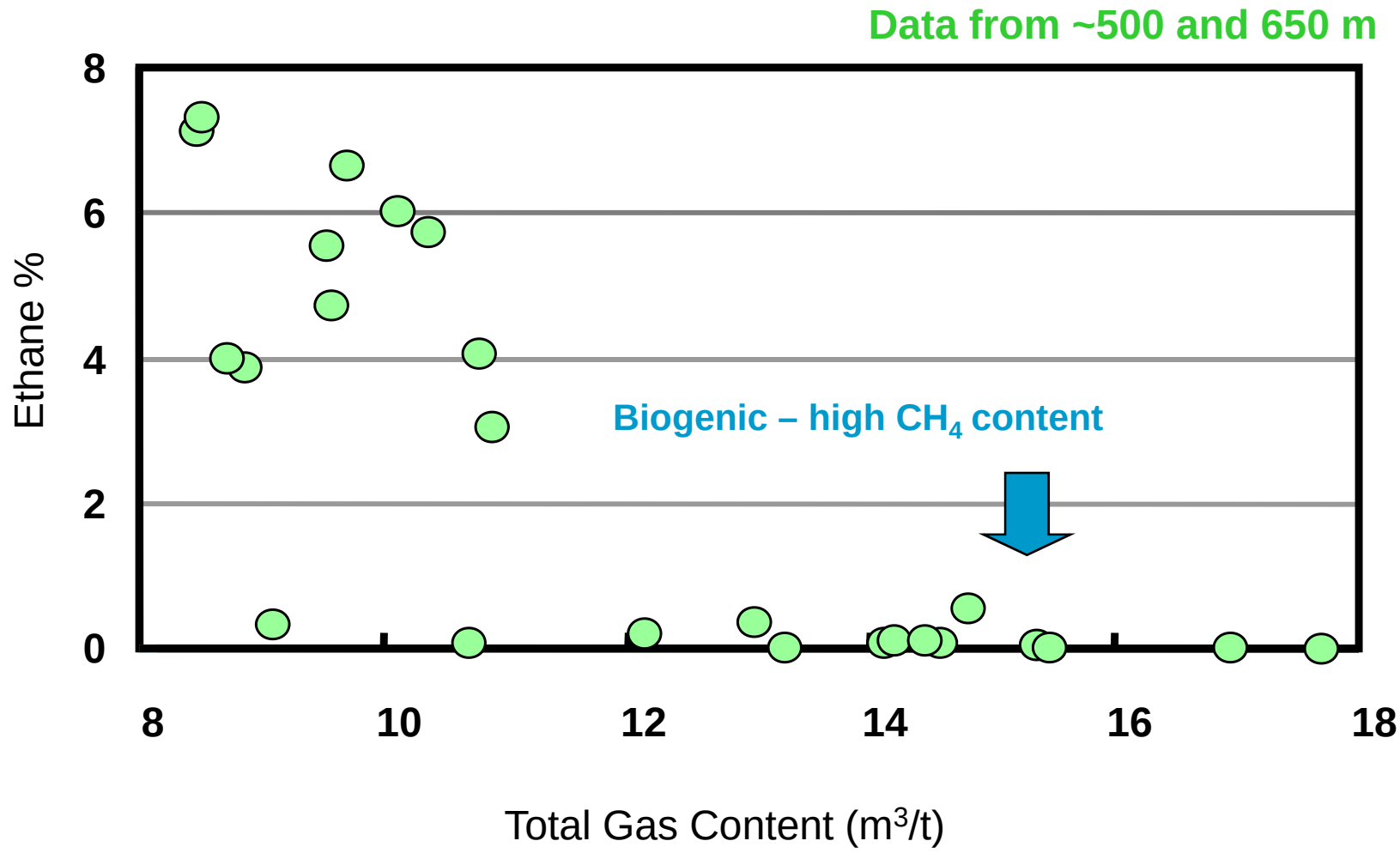
Example:
Camden CBM Project, Sydney Basin



"High Production Fairway" is confined to areas of secondary biogenic gas generation

Modified from Faiz et al (APPEA, 2003)

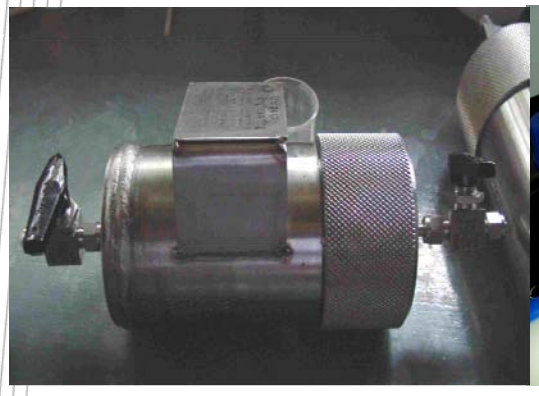
Wet Gas and Total Gas Content - Sydney Basin

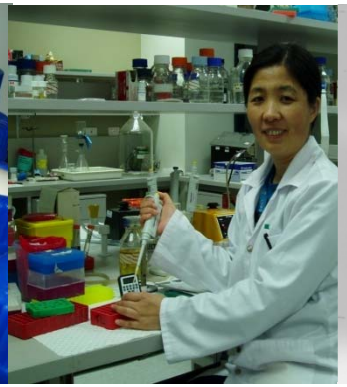


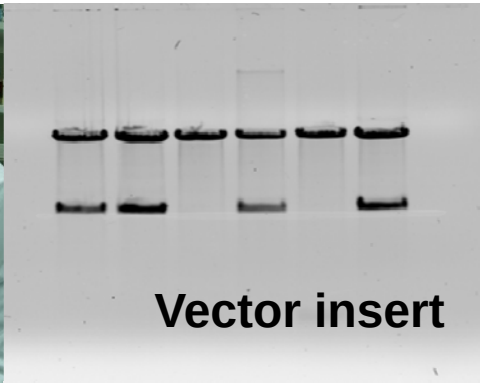
Microbiology of Australian CBM Reservoirs

- Preliminary studies to characterise microbial diversity in CBM reservoirs

  - **Coal and associated formation water samples analysed**
  - **Anaerobic culturing**
  - **DNA extracted, cloning and sequencing**

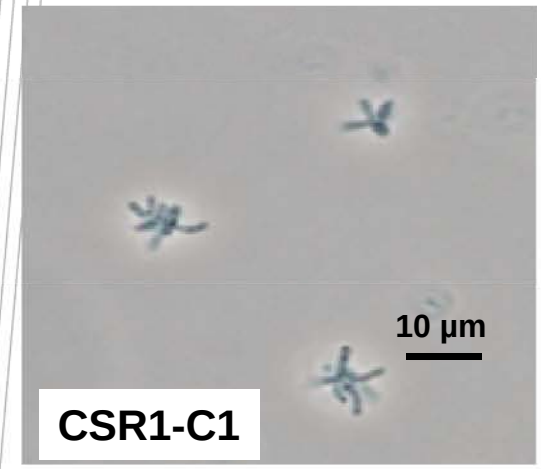


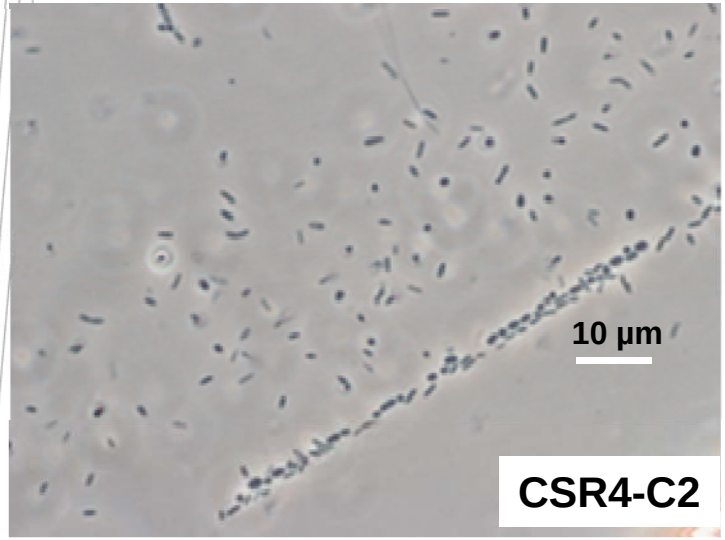




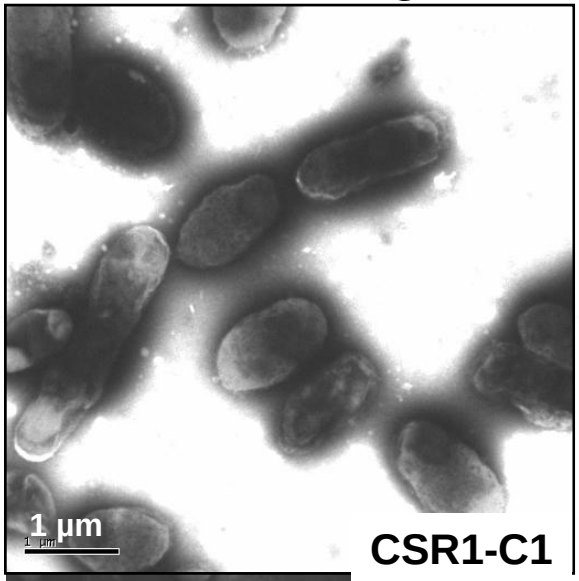
Microbes in Formation Water Samples – Australian CBM Reservoirs

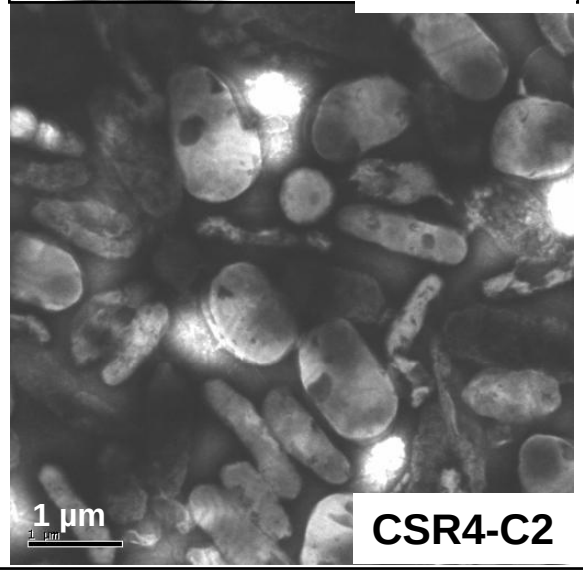
Light microscope images



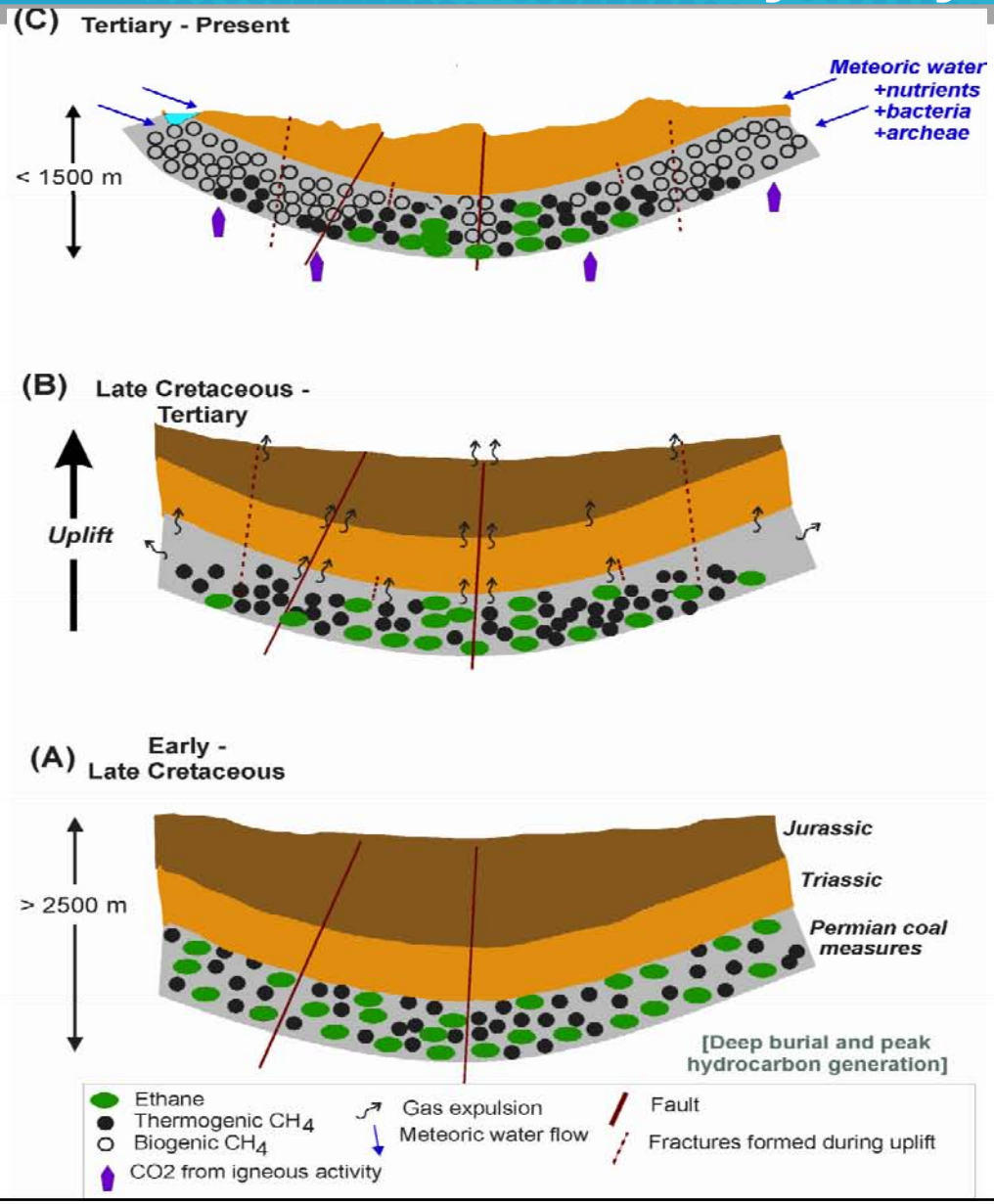


TEM images



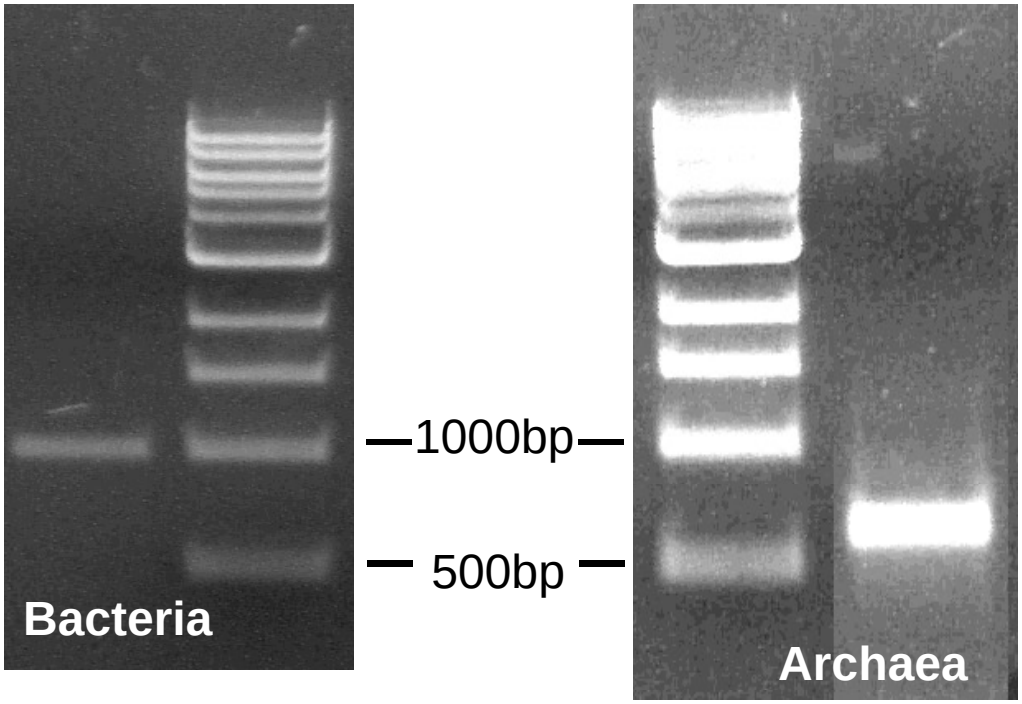


Coal Seam Gas model for Sydney Basin



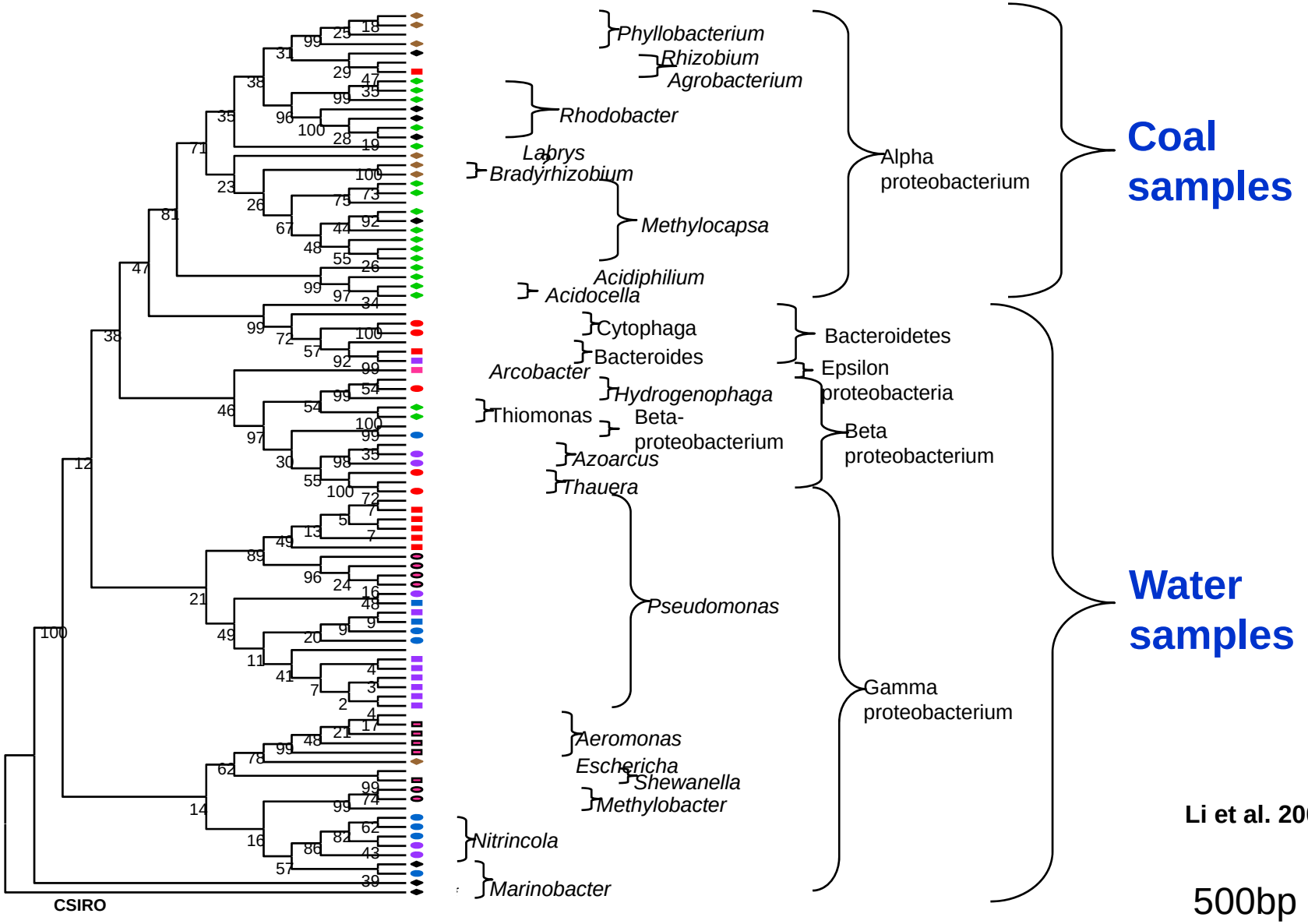
Faiz and Hendry (2006)

PCR Amplifications from Bacteria and Archaea



16S rDNA extracted, amplified, cloned and sequenced

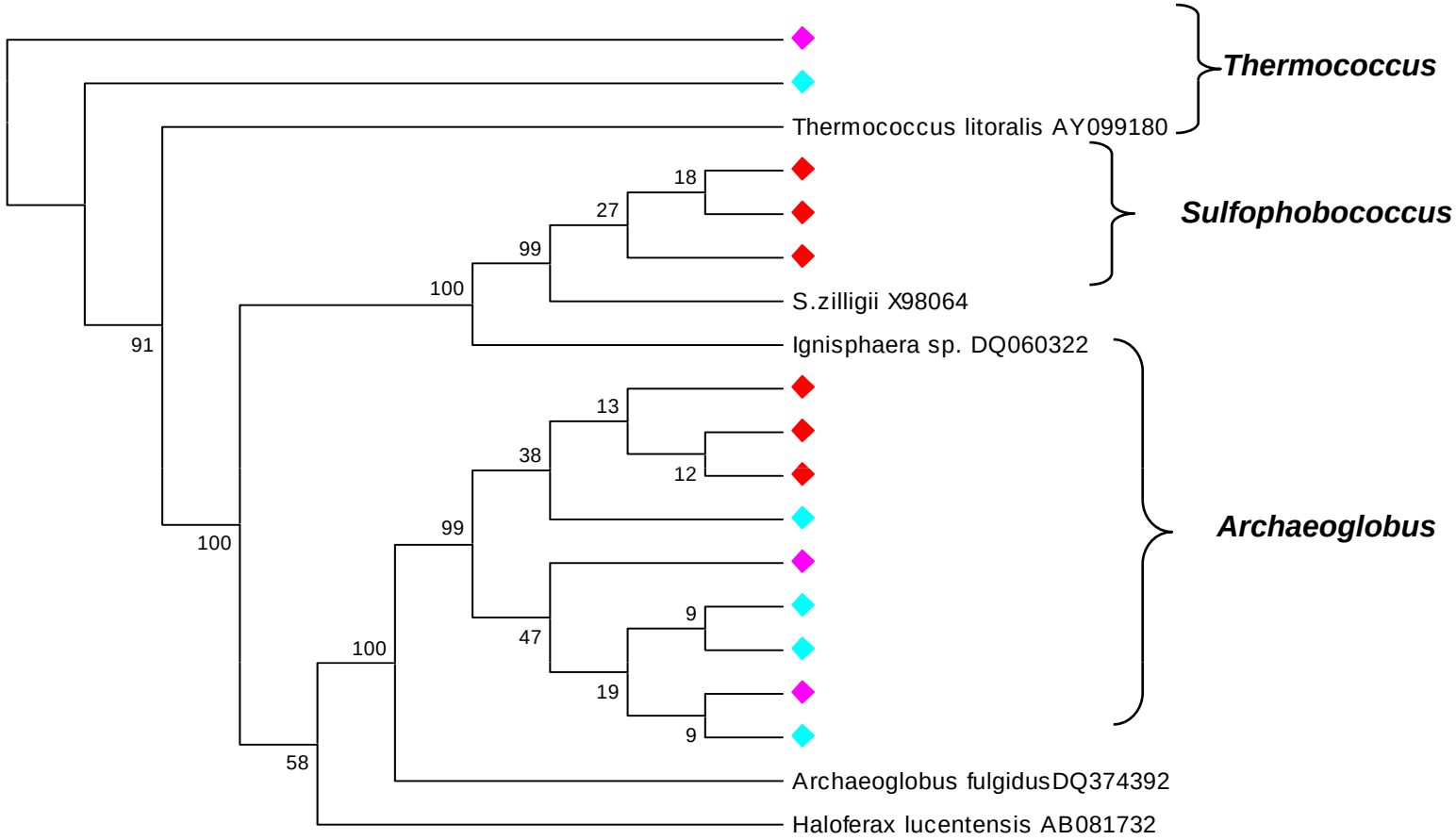
Phylogenetic Tree - Bacterial Amplicons



Li et al. 2008

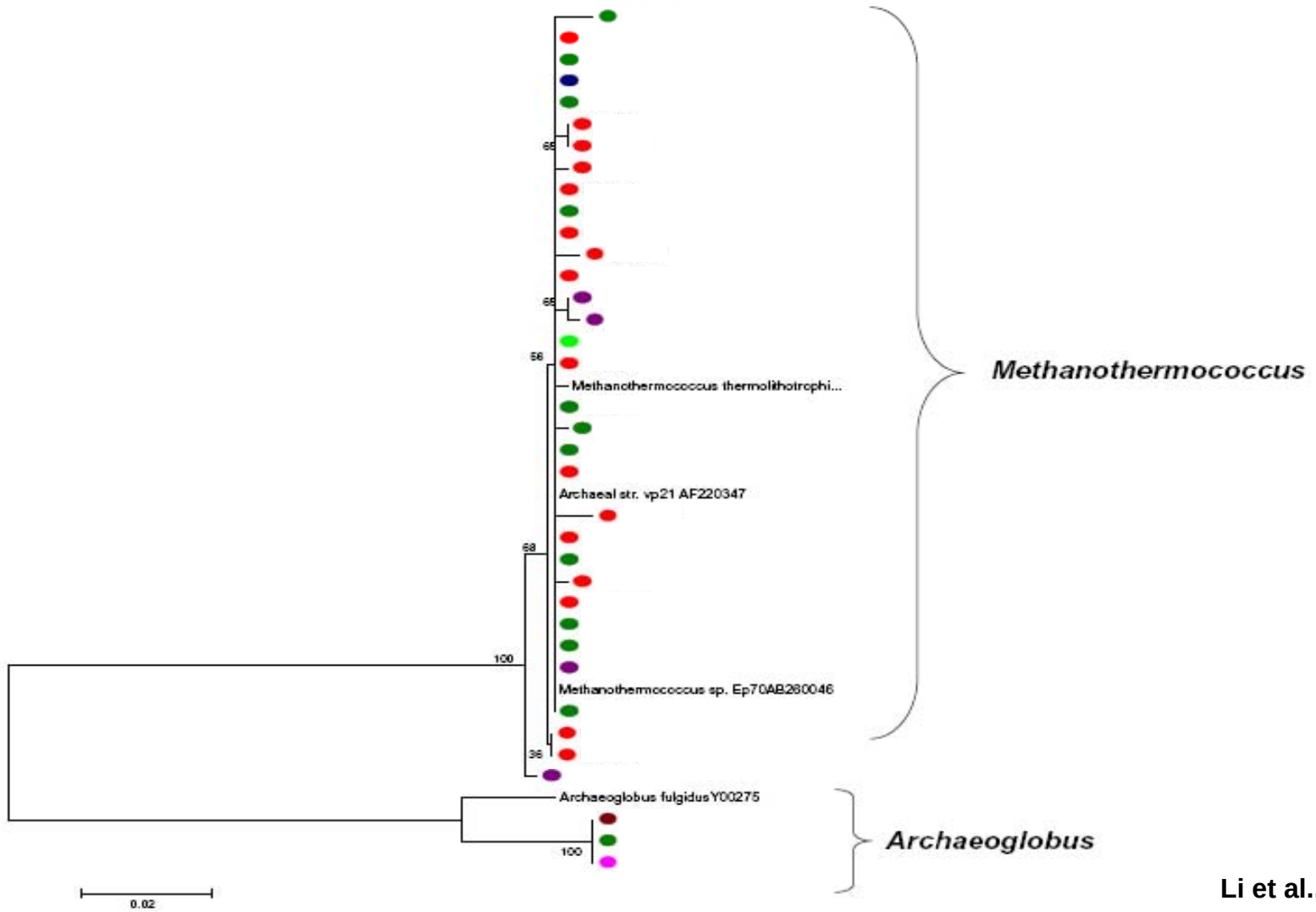
500bp

Phylogenetic Tree – Archaeal Amplicons Region - A



Li et al., 2008

Phylogenetic Tree – Archaeal Amplicons Region - B



Li et al., 2008

Summary

- Significant geochemical evidence exist for biogenic gas generation in Australian coals
- Secondary biogenic gas is important for achieving high methane saturation levels in most Australian coals
- Many “sweet spots” for CBM production related zones with secondary biogenic gas
- Further microbiological studies being conducted to determine the potential in-situ bio-gasification of deep coal seams

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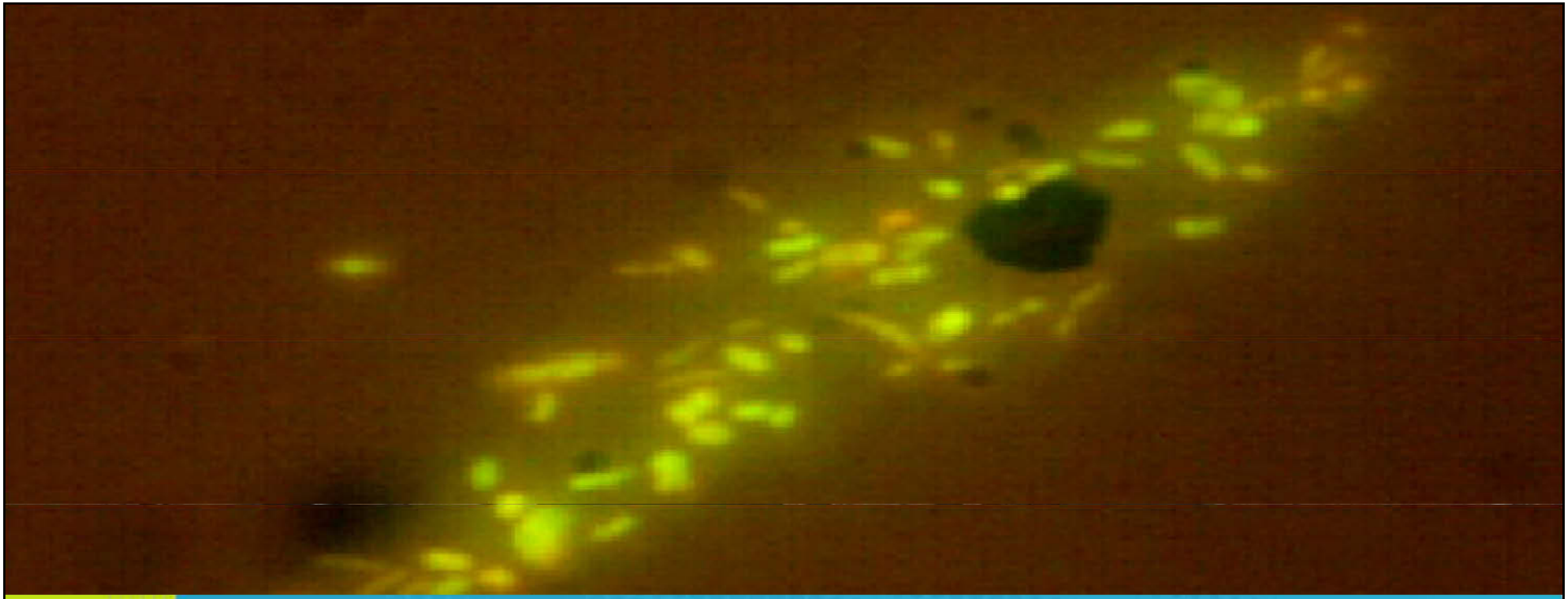

Thank you

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