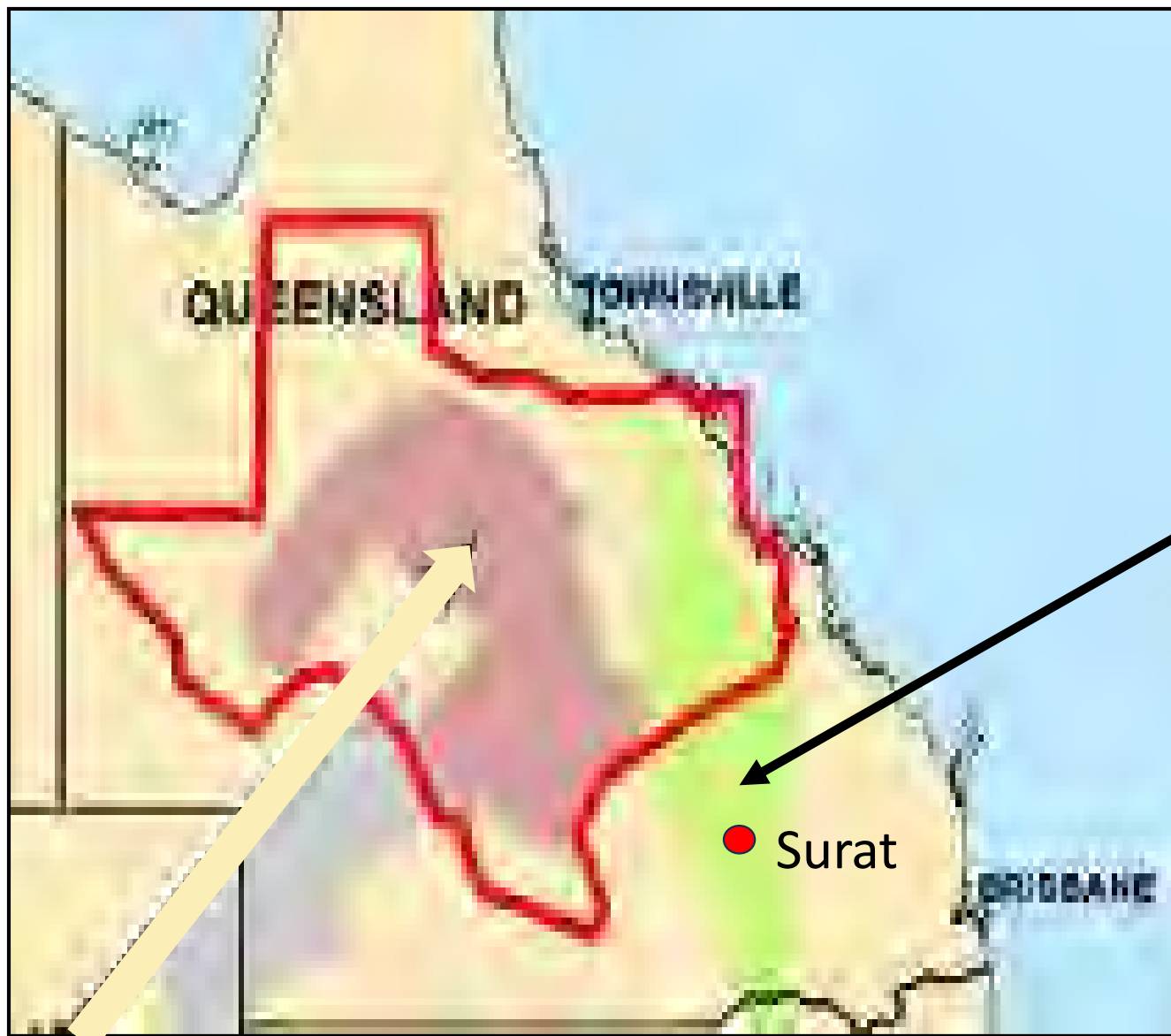


Surat Basin Queensland

Fossil Fuel Potential

Under the overburden



**Surat
Basin**

• Surat

How low can we go?

Australia onshore WA Perth Basin:

Eregulla Deep #1 at 5,000 m and 8,000 psi#

World's deepest onshore gas well: Bertha

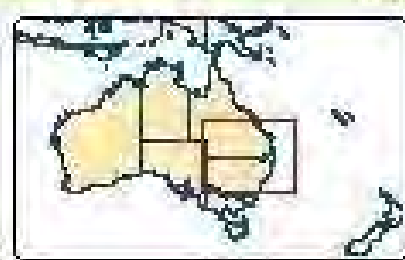
Rogers #1 Anadarko – 9,500m liquid SULFUR

Offshore Gulf of Mexico: sea floor at 3km

Gas Reservoir at 8,700m TVD

Surat Basin

Surat



0 100 200 300 400km

IDE AS9167-33

In 2021, onshore
2P CBM/CSG gas
reserves were
26.5 Tcf or 30k PJ

In 2021 Gas
production in Bowen
& Surat basins was
1.4 Tcf or 1.6k PJ close
to QLD Consumption

N W Shelf 67 Tcf
Or 75k PJ

Structural Elements & Field Location Map

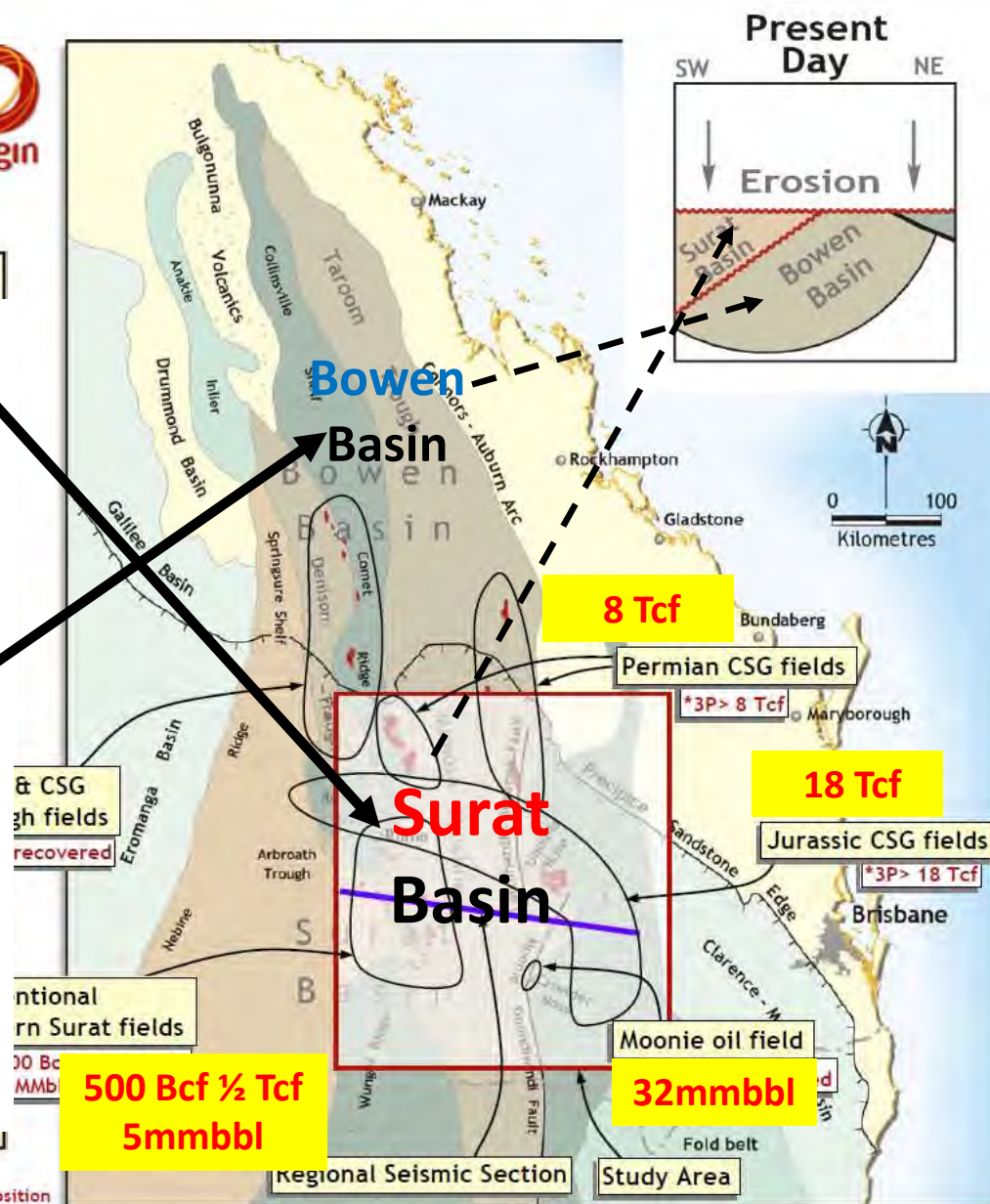


Stratigraphy of the Surat/Bowen Basins

Prov.	Age (Ma)	Palynology Zones	Stratigraphy
Surat Basin			
Bowen Basin			
Therapsid Belt			

Surat Basin
Jurassic &
Cretaceous

Bowen Basin
Permo-
Triassic



* Total industry declared reserves position

Surat Basin & Taroom Trough

HISTORY

Early Gas: Roma Shelf – Jurassic & Triassic - Cathedral

Early Oil: Cabawin, Moonie, Alton, Fairymount: Jurassic, Triassic & Permian

Oil & Gas Generation Primer Conventional & Unconventional

PVT exploration not mining

Vr, Coal Rank, Gas & Liquids,

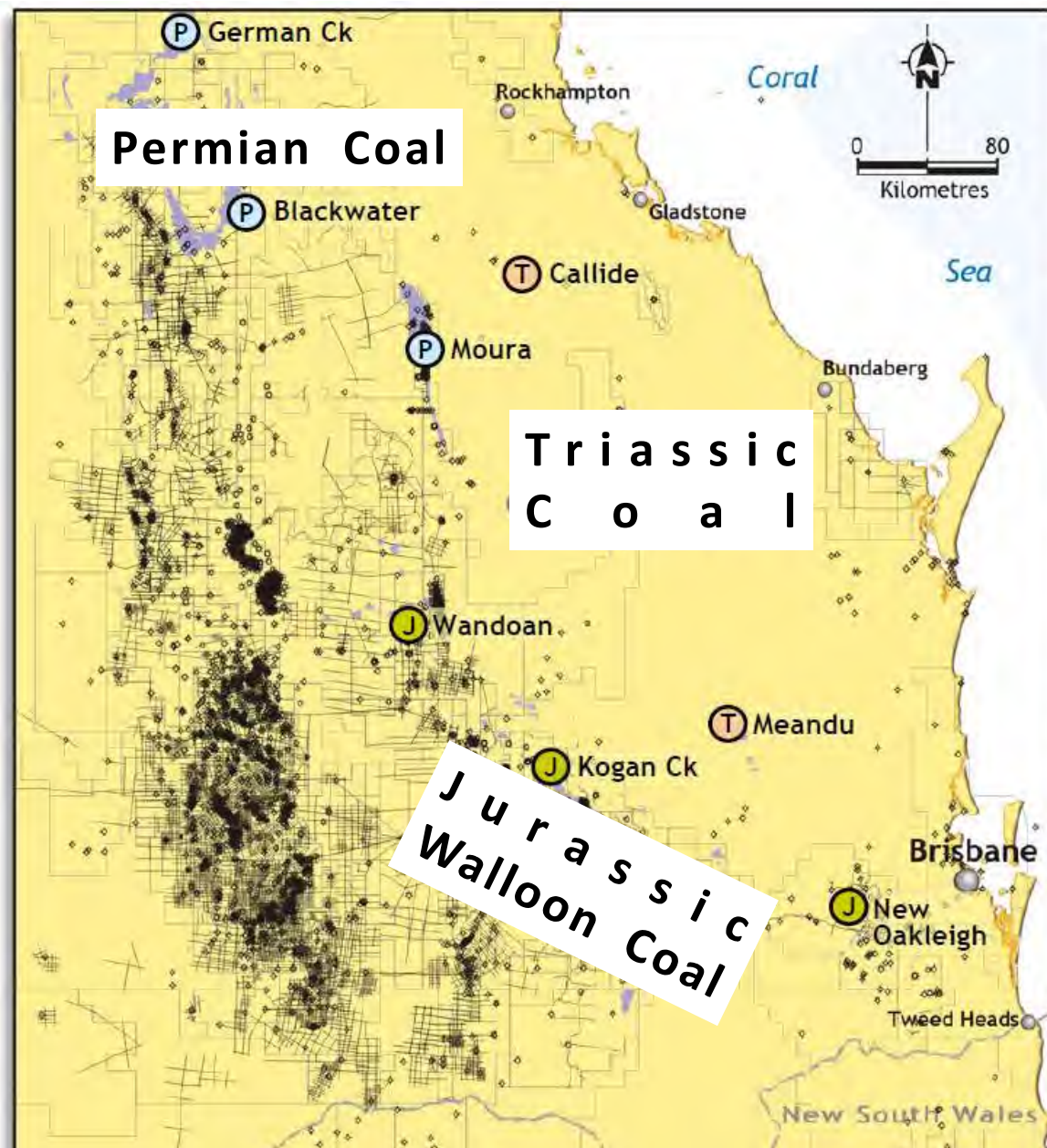
CBM biogenic - Coal Bed Methane: Cretaceous & Permian

CSG thermogenic - Coal Seam Gas : Permian

Oil Shale (Tertiary) & Shale Oil (Cretaceous)

CCS Carbon Capture and Storage

Future Potential & Problems

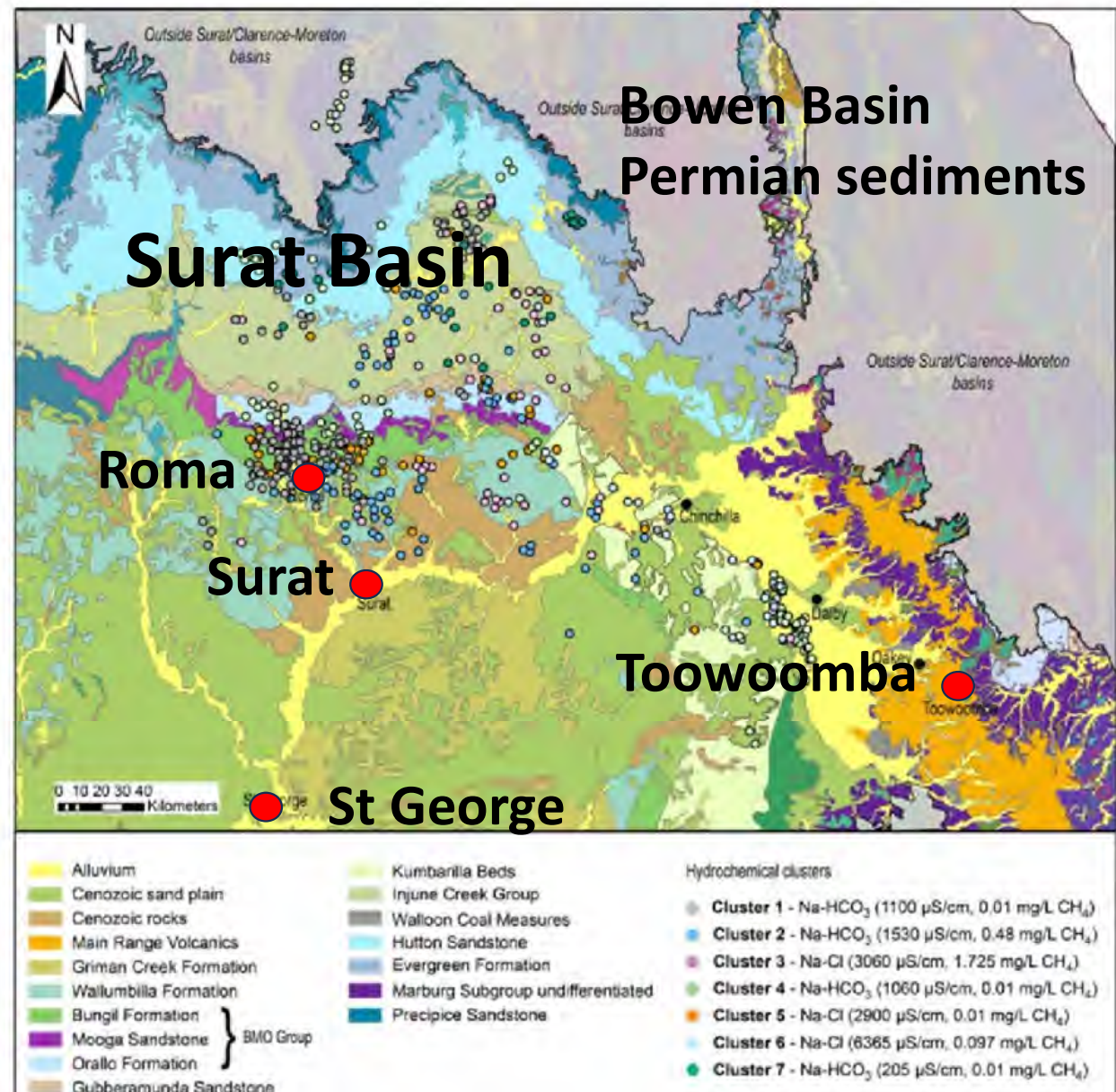


Many petroleum wells and coal bores have been drilled and many kilometres of seismic have been acquired in the greater Surat/Bowen Basin, over the last five decades

-  • Seismic in existing exploration permits
Conventional oil/gas and CSG
-  • Well coverage
-  • Coal lease coverage
-  • Major operating coal mine
-  Permian Coal
-  Triassic Coal
-  Jurassic Coal

**Cretaceous
Jurassic
Overlying
Triassic &
Permian

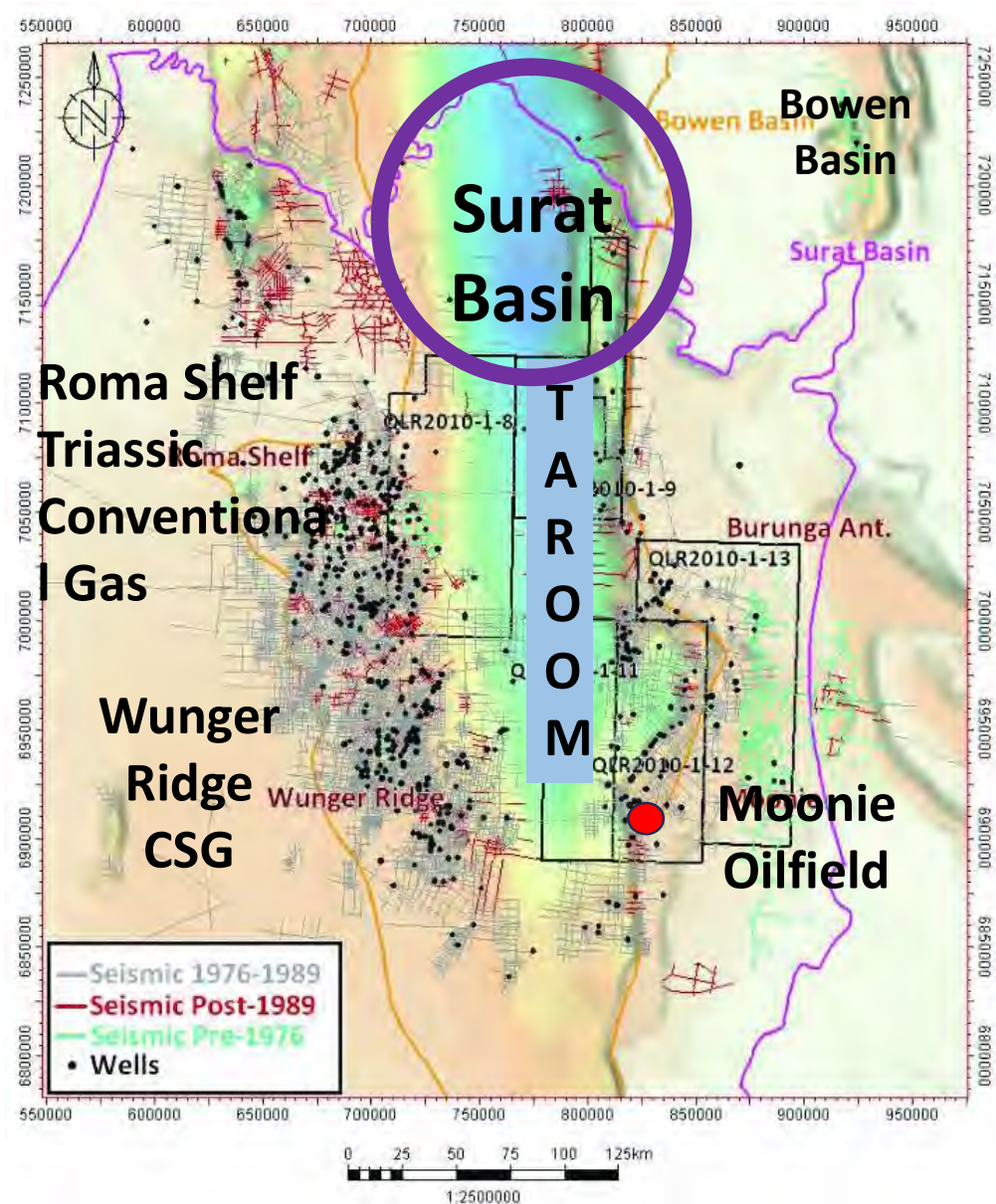
Sands
Shales &
Coal**



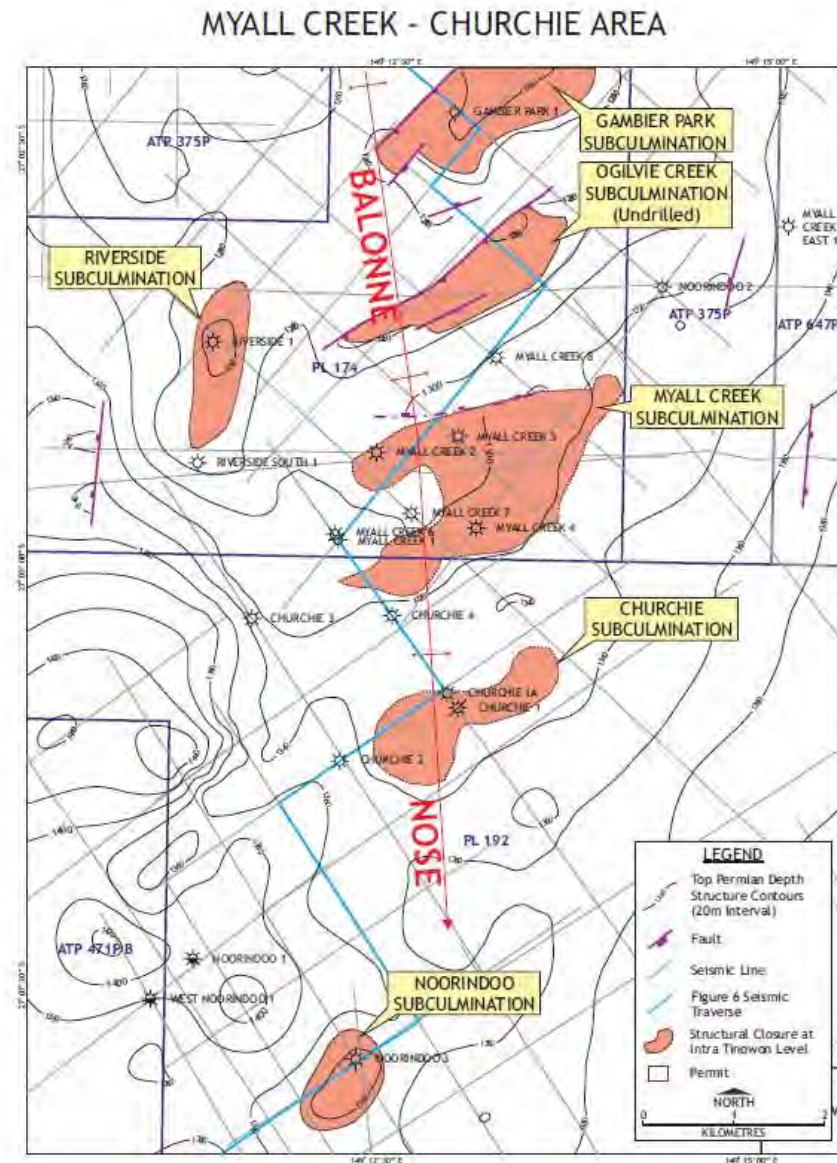
Surat Basin

Oil & Gas

500 Bcf
½ Tcf
5
mmbbl



Exploration
in western
Surat Basin
began in
1901 with
gas discovery
at Hospital
Hill in Roma
in
conventional
anticlinal
structural
traps

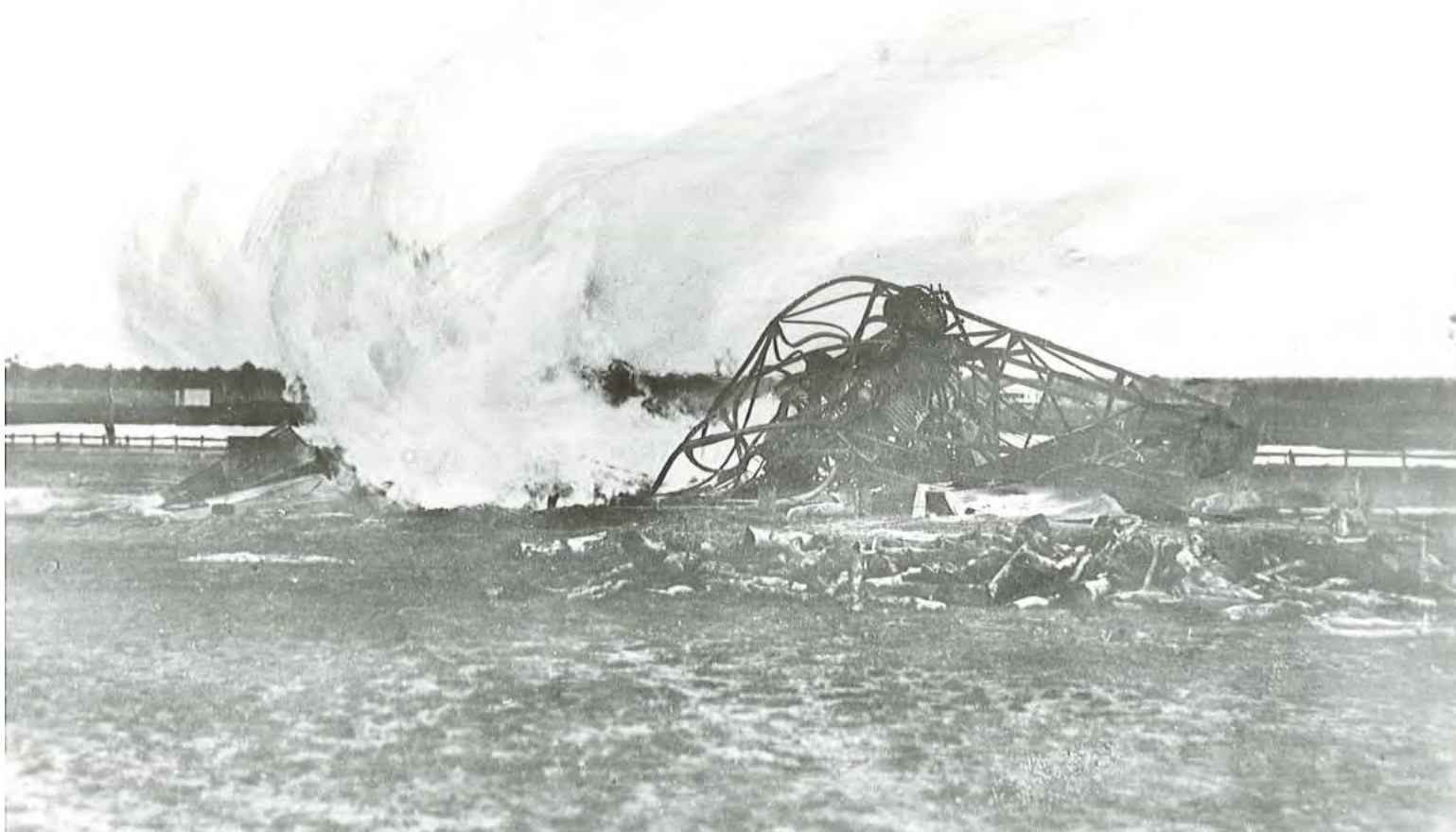


A cathedral named “Holy Name Cathedral” was to be built in Cathedral Place in the 1920’s by Archbishop James Duhig.

Unfortunately, he put the money into gas well drilling in & around Roma

and lost it all

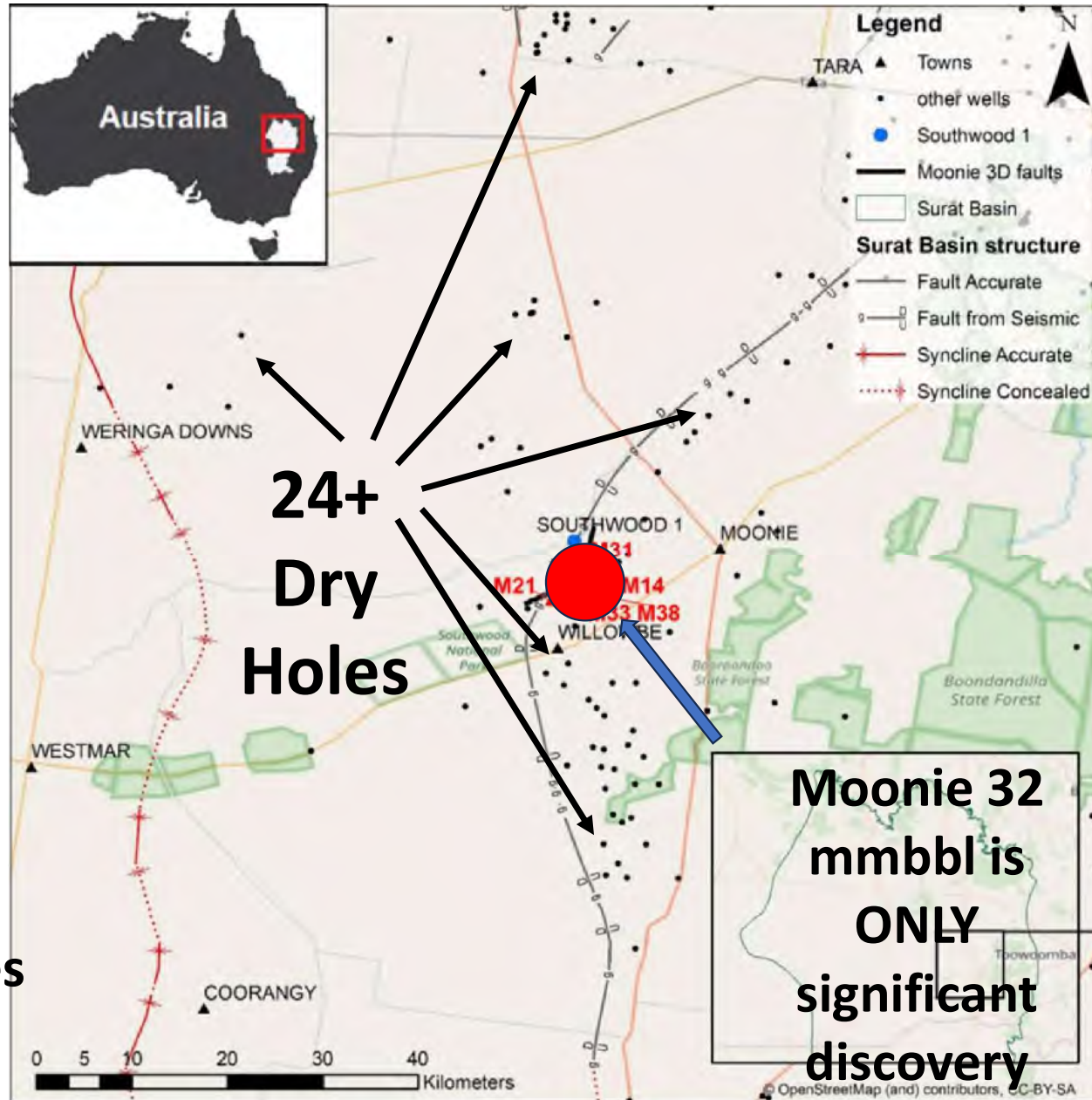
Hospital Hill 1908 successful gas well - **burned for 45 days**



**Cabawin #1
Union Oil's
1st well
1st Oil in
Permian
1960**

**Then Moonie
Alton &
Conloi
in Jurassic**

THEN 24 dry holes



BASIN	ENV	AGE	UNIT	LITH.	HYDROCARBONS
SURAT BASIN	MARINE	E. CRET.	ROLLING DOWNS GROUP	GERMAN CREEK FORMATION SURAT SILTSTONE WALLUMBILLA FORMATION	
	FLUVIAL PARALIC	M. JURASSIC E. CRETACEOUS	BLYTHESDALE GROUP	SUNGBI FORMATION MOOGA SANDSTONE ORALLQ FM.	
	COAL SWAMP	M. JURASSIC	INJUNE CREEK GROUP	WESTBOURNE FORMATION SPRINGBOK SS. WALLOON COAL MEASURES	Pleasant Hills
	FLUVIAL	ASSIC	HUTTON SANDSTONE		Leichhardt, Xy1-X
					Allian, Kincora, Carleton, etc.
					Roma Shelf, Bennett, Moonie, Avondale, Kincora, Pleanlinnie, Moonie
					Kincora
					Muthulla, Kincora
					New Royal, Boxley, Silver Springs, etc.
					Roma Shelf, etc.
BOWEN BASIN	RED BEDS	EARLY TRIASSIC	REWAN GROUP	CABAWIN FORMATION	Parneak, Redbank, Tinker, Sunnybank
					Arcturus, Auroras, Bollestone, Downlands, Mya Creek, Beranga South, Glenloch, Downlands East, Spring Grove
					Wallumbilla South, Moorindoo, Merrivale, Burunga, Glenloch, Pleanlinnie
	SHALE	PERMIAN	BASINMENT		Pringle Downs, Dirinda, Namarah, Scotia

Figure 2. Stratigraphy of the western Taroom Trough, Bowen Basin (after

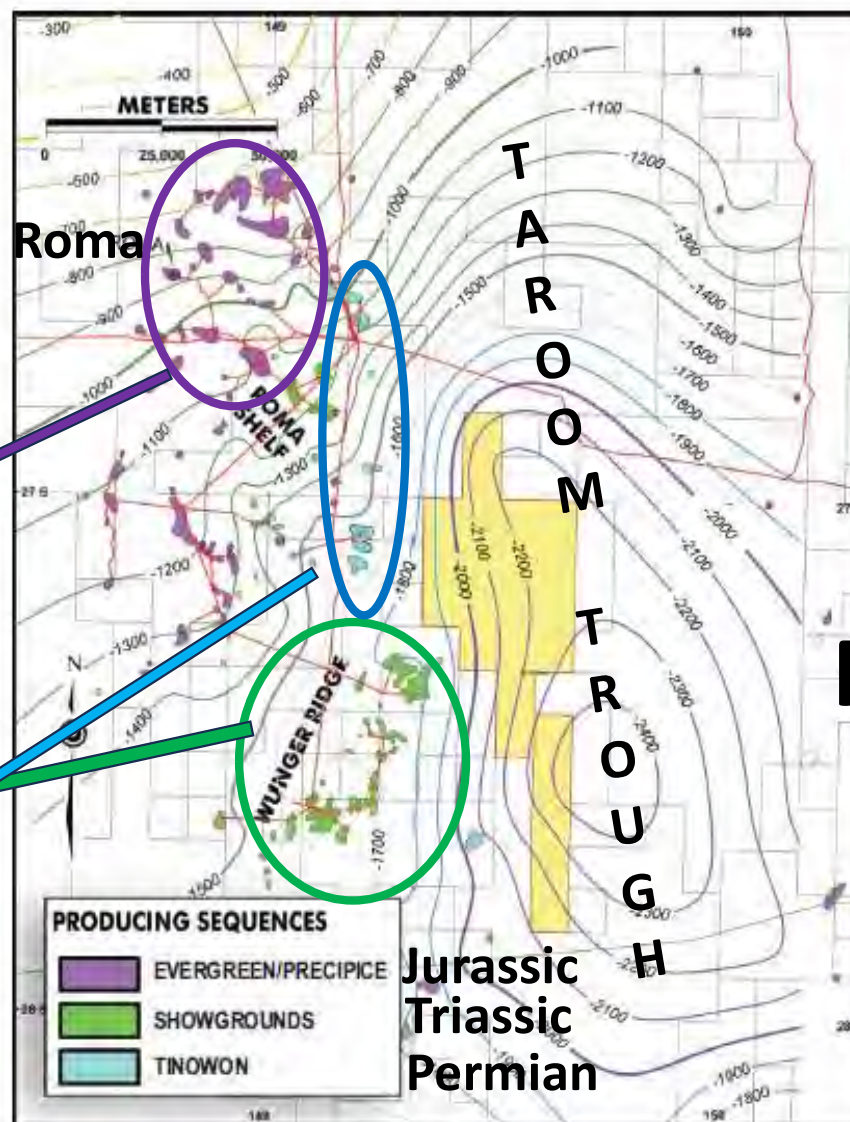


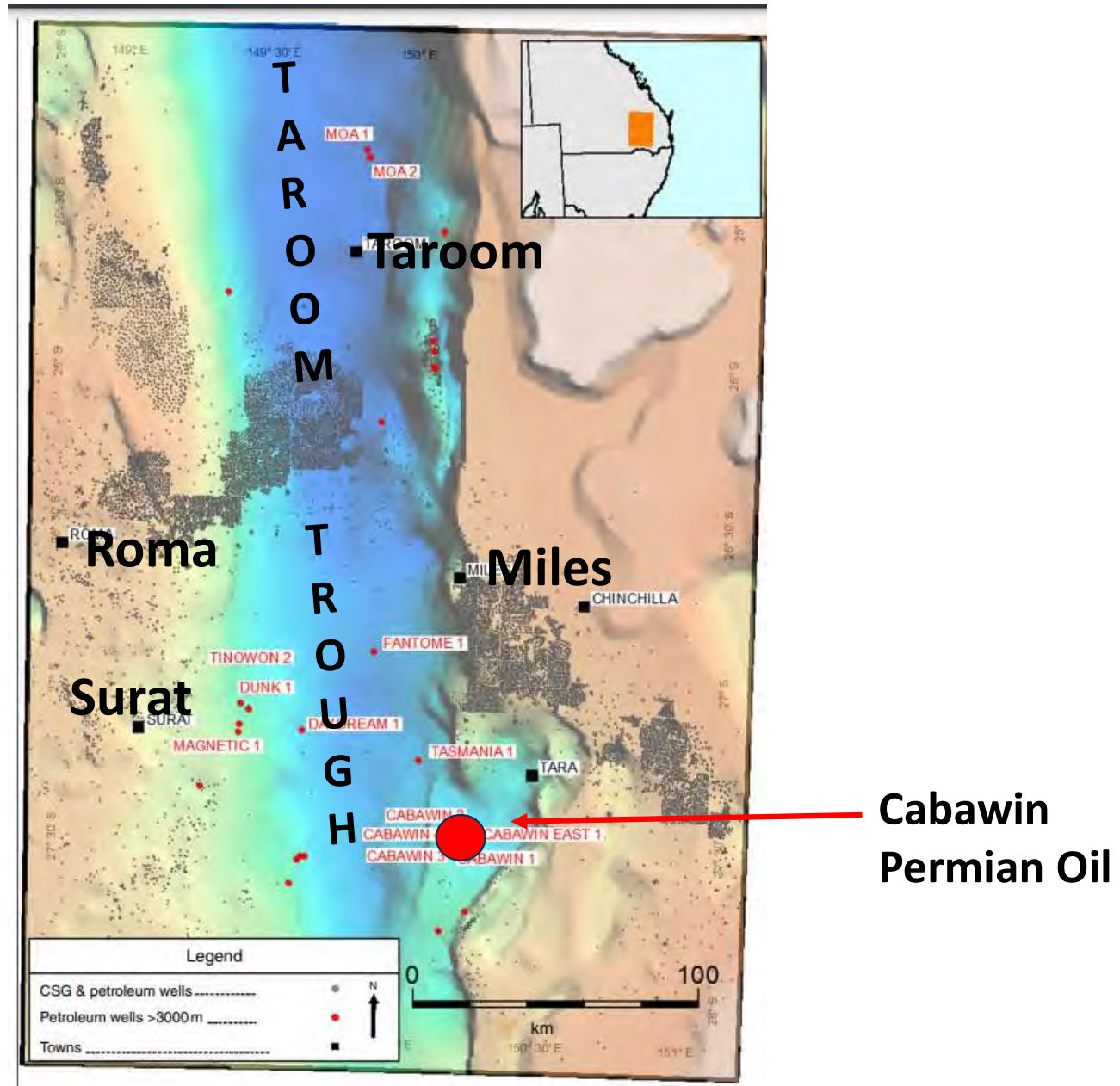
Figure 4. Pressure-depth plot calculated from mud weights, southwestern Bowen Basin. The pressure gradient in the Upper Permian is about 0.55 psi/ft.

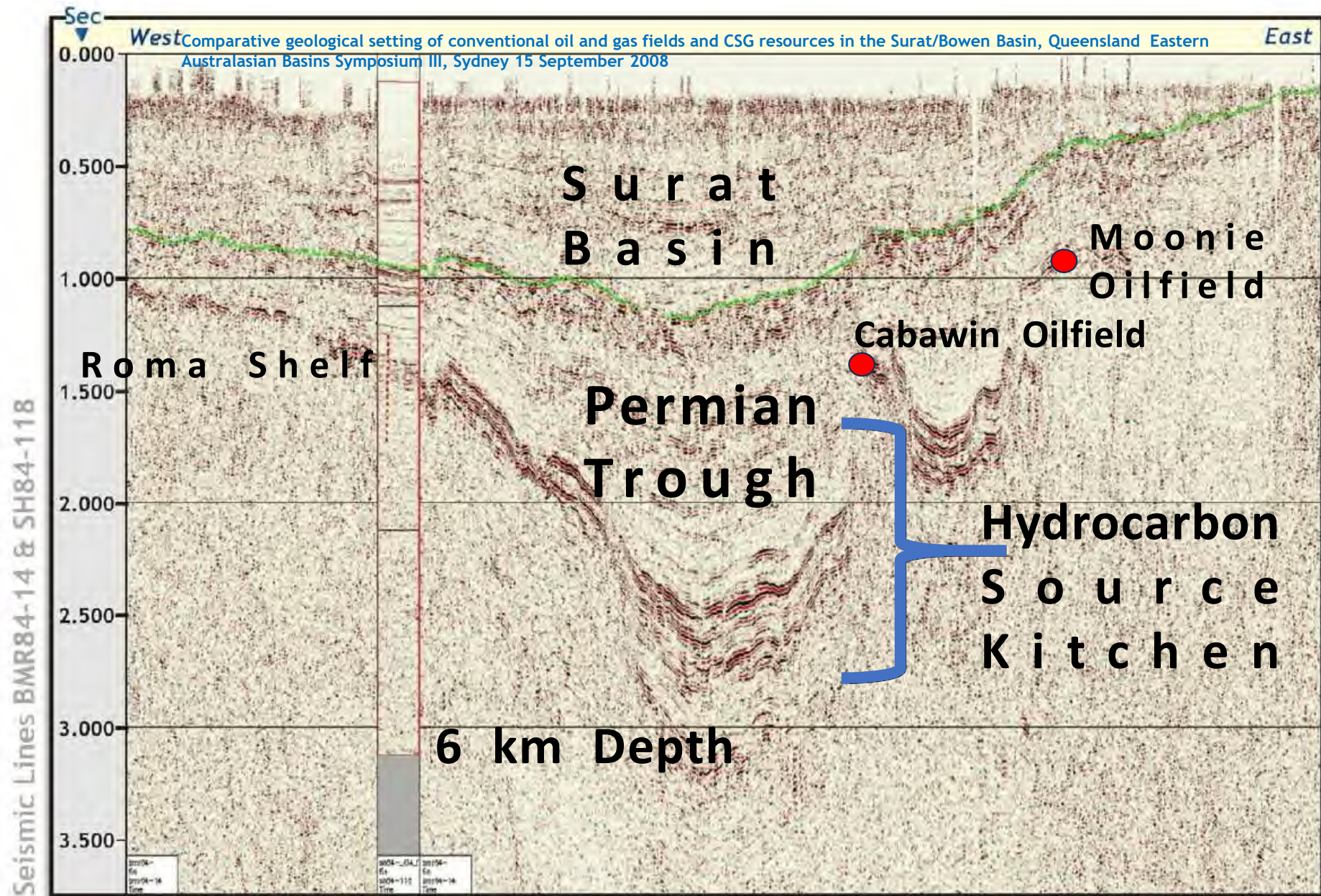
Roma Shelf Gas Provinces

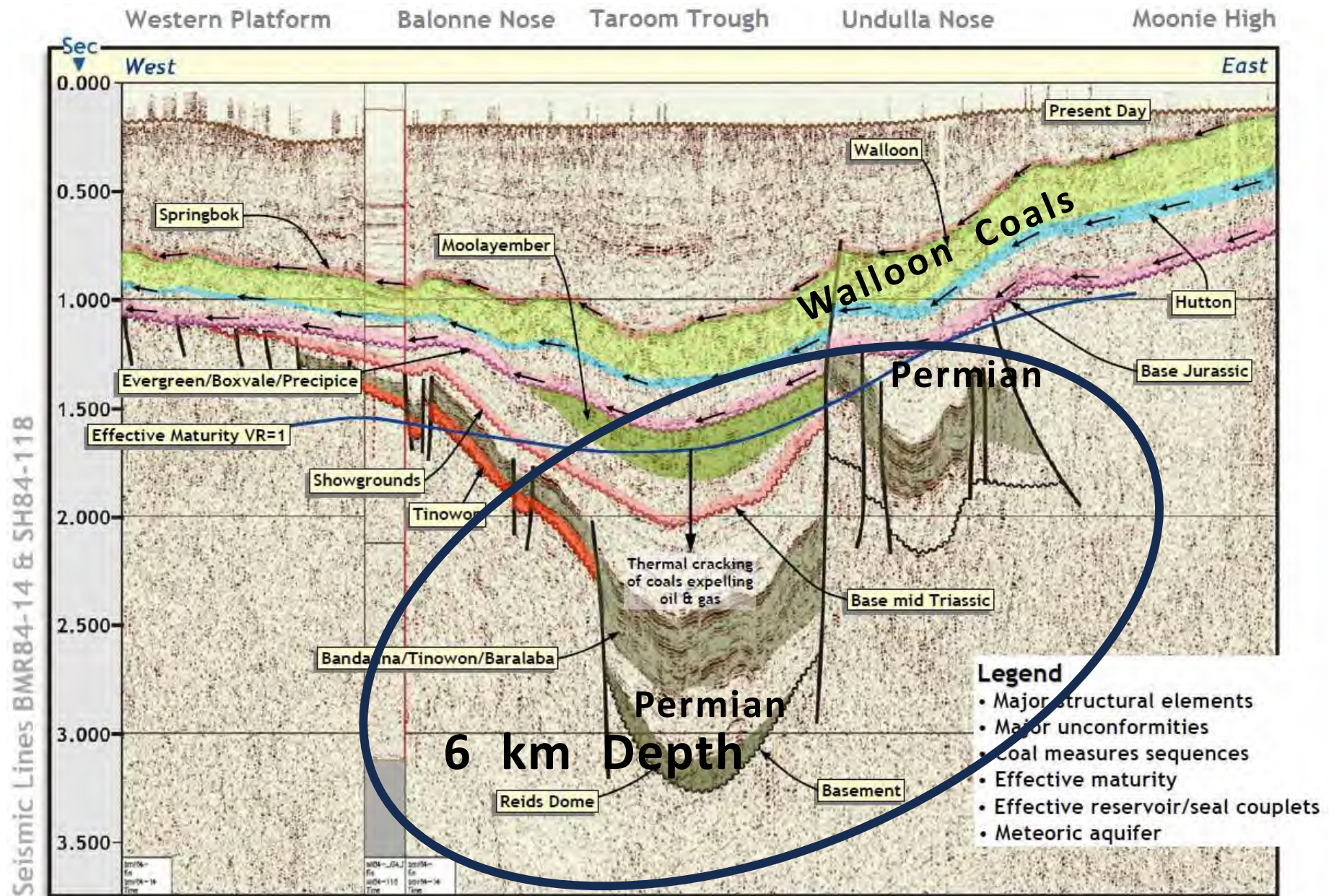
**500 Bcf
½ Tcf 5
mmbbl**

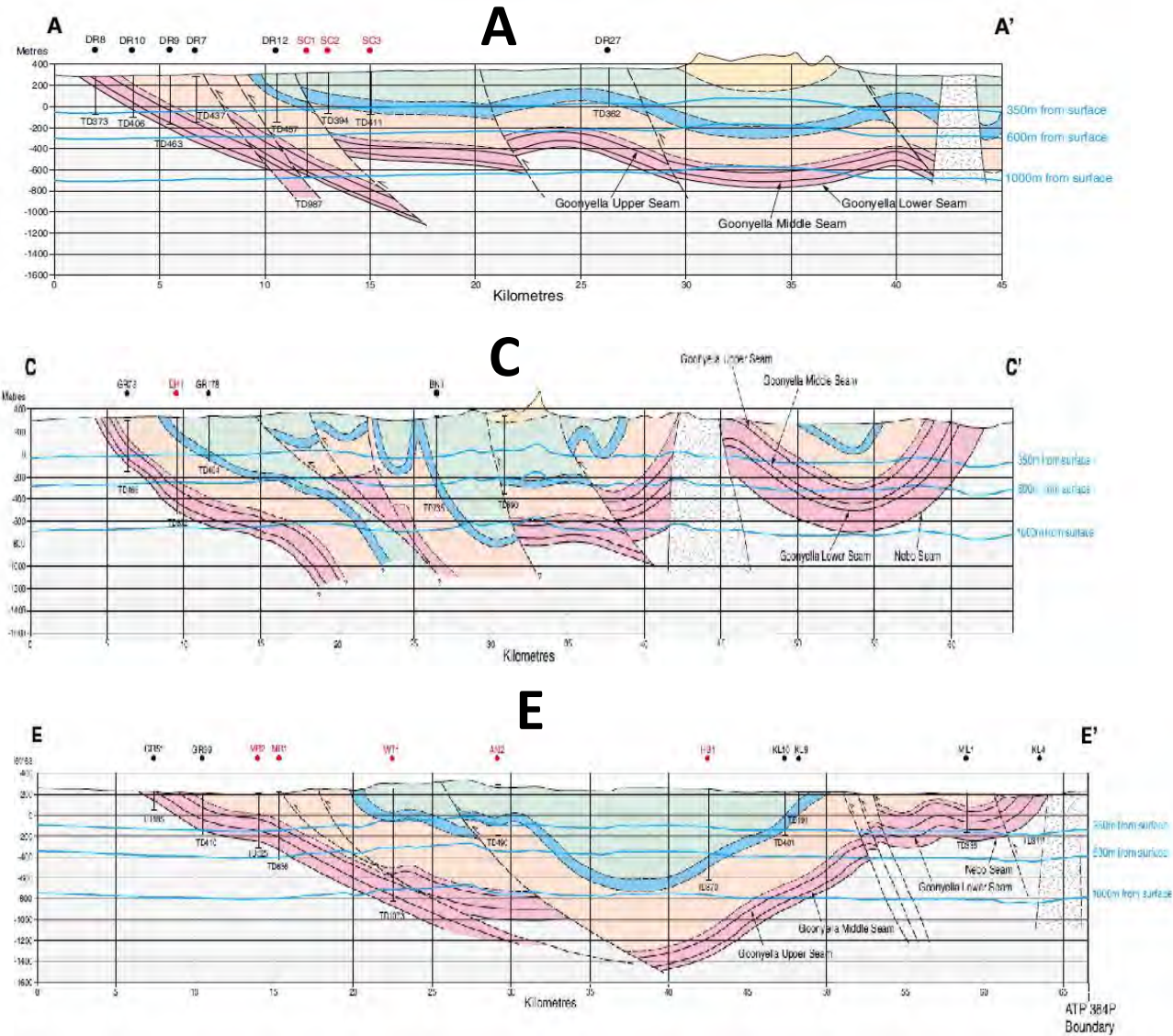
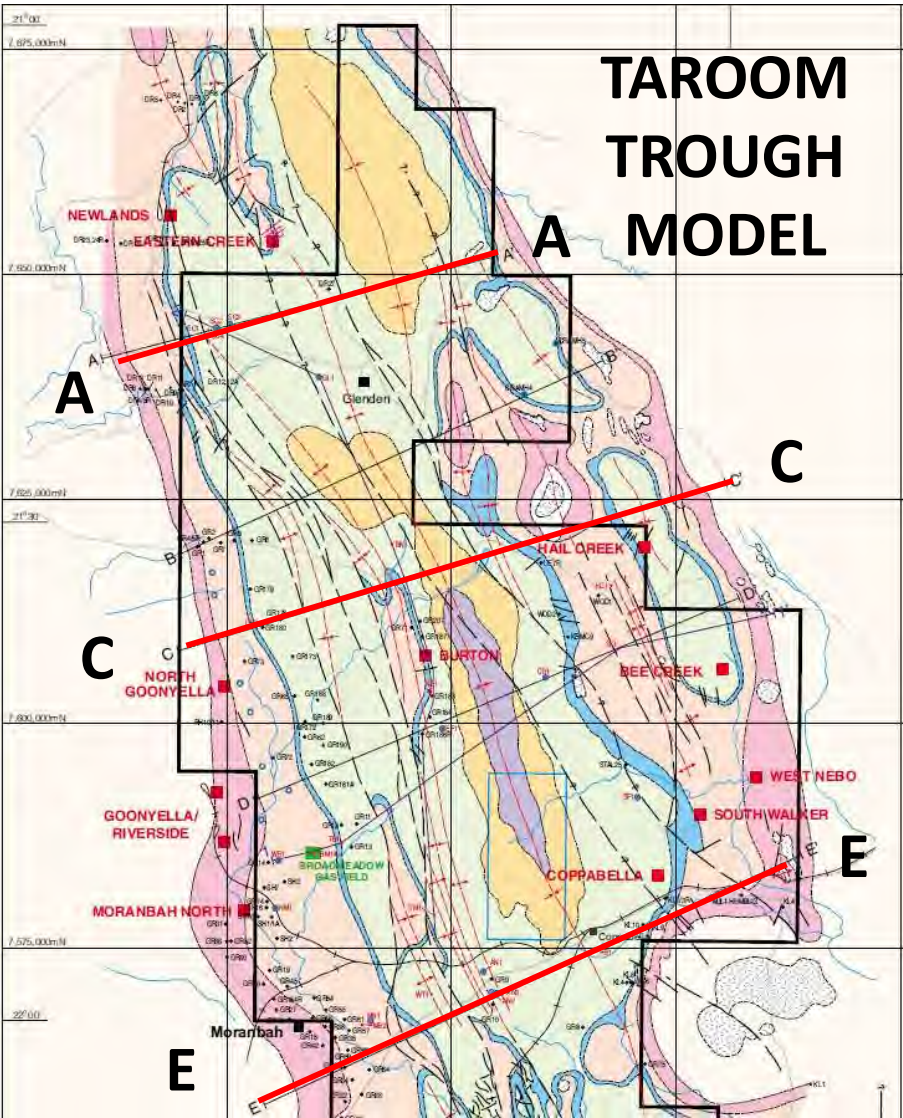
**Jurassic
Triassic
Permian**

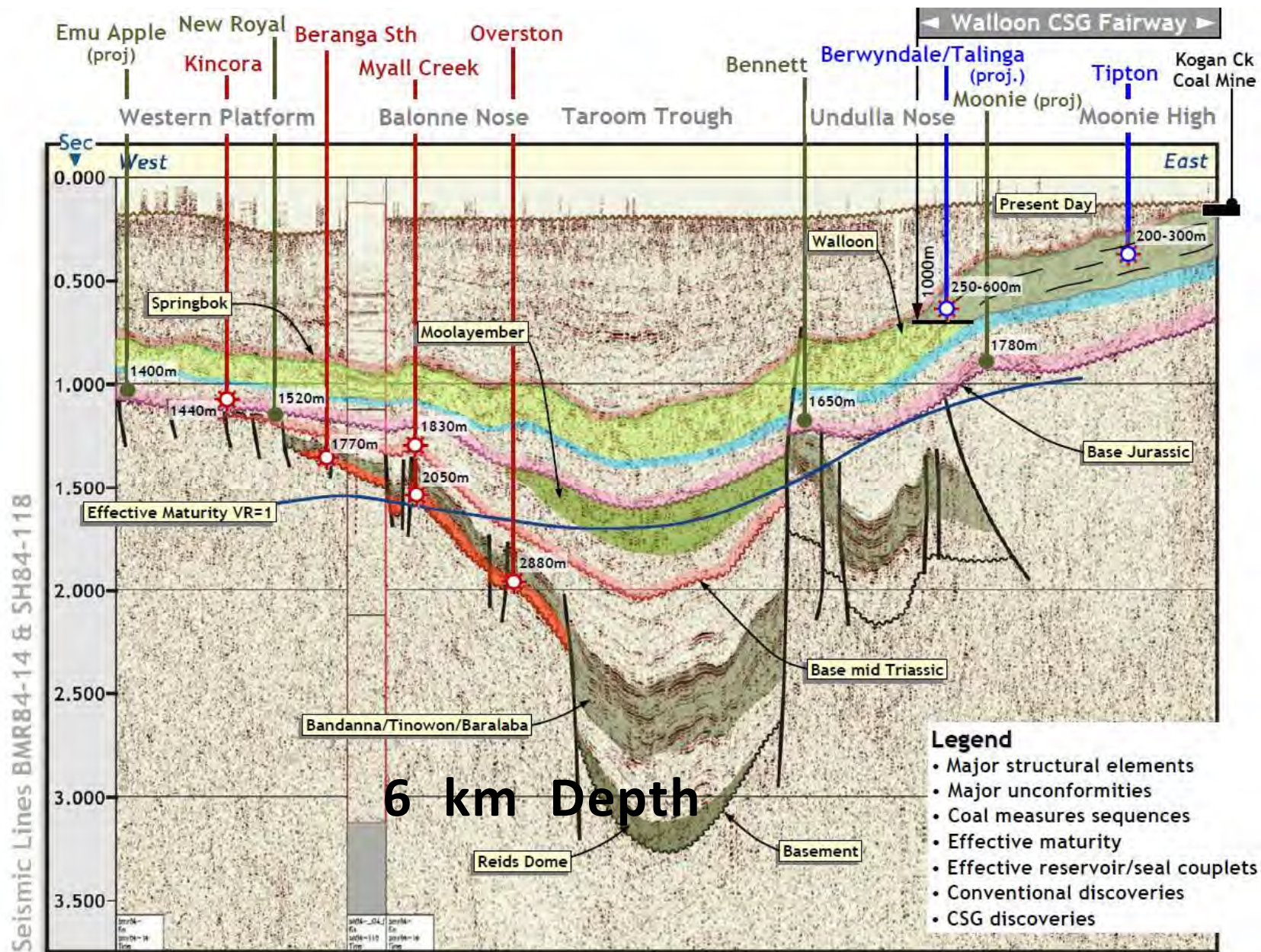
CSG & CBM
Plays have
thousands
of relatively
shallow
boreholes



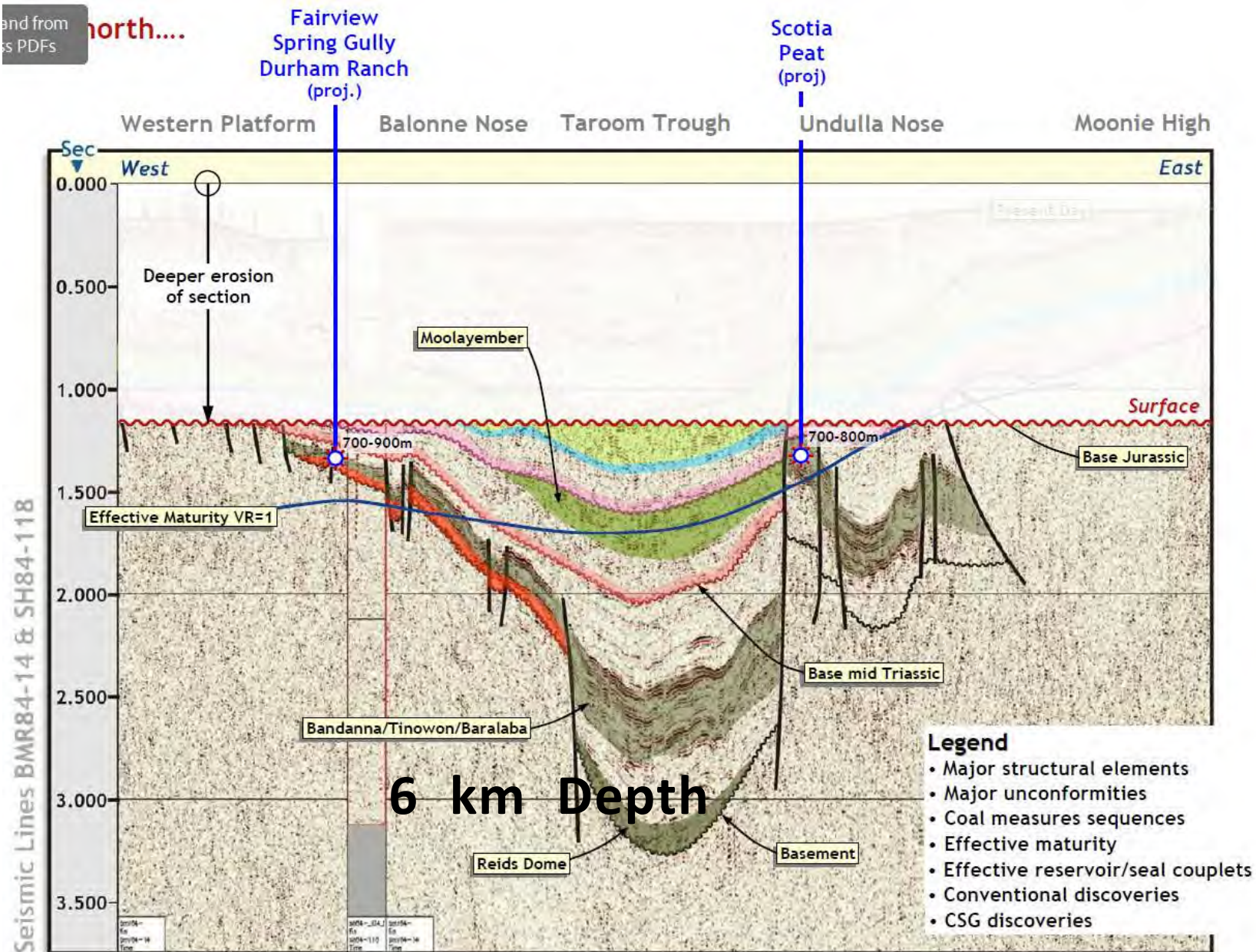


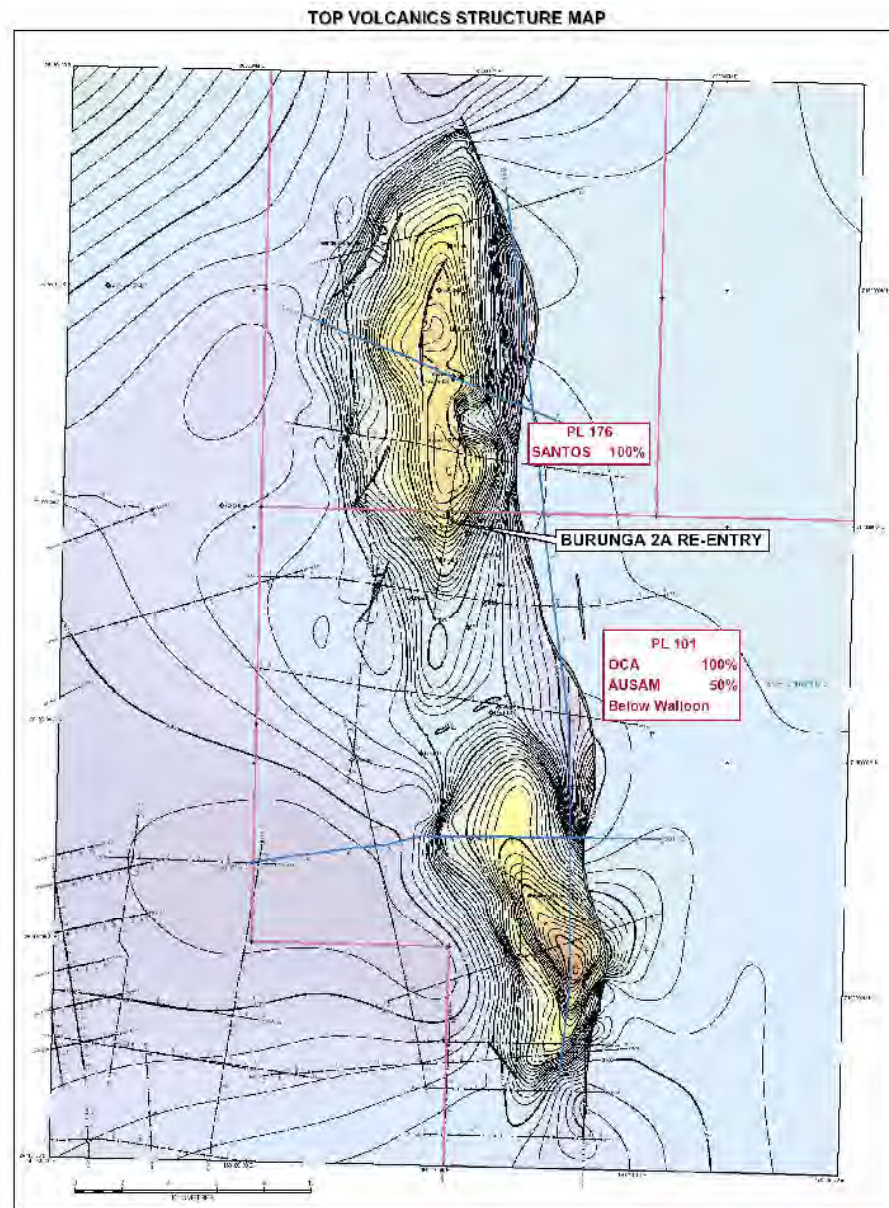






north....





Peat
&
Scotia
CSM
Fields
Burunga
Anticline

Gas or Water

1: Initial Gas Production

2: Then Water Production

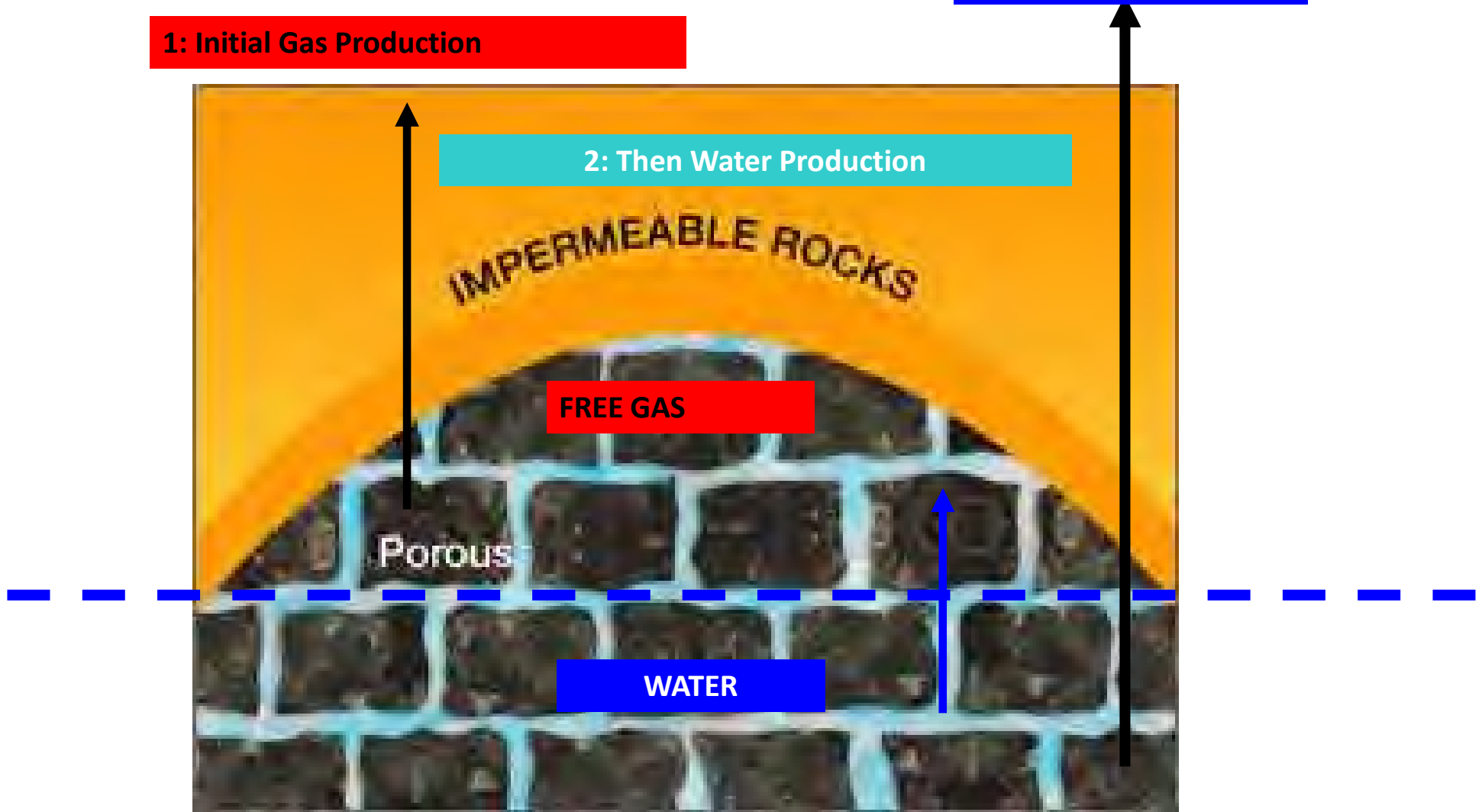
3: DE-WATER

IMPERMEABLE ROCKS

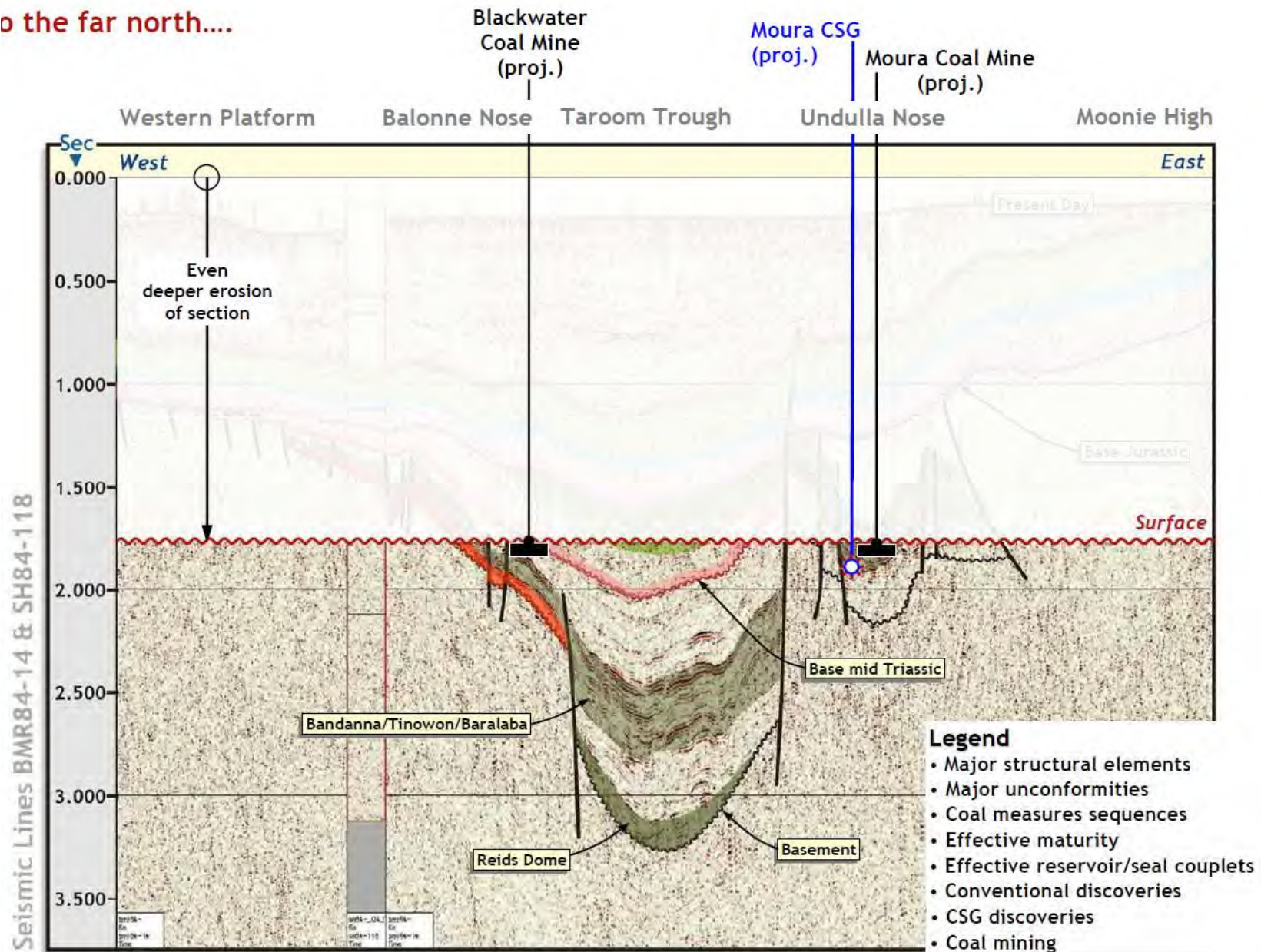
FREE GAS

Porous

WATER



o the far north....

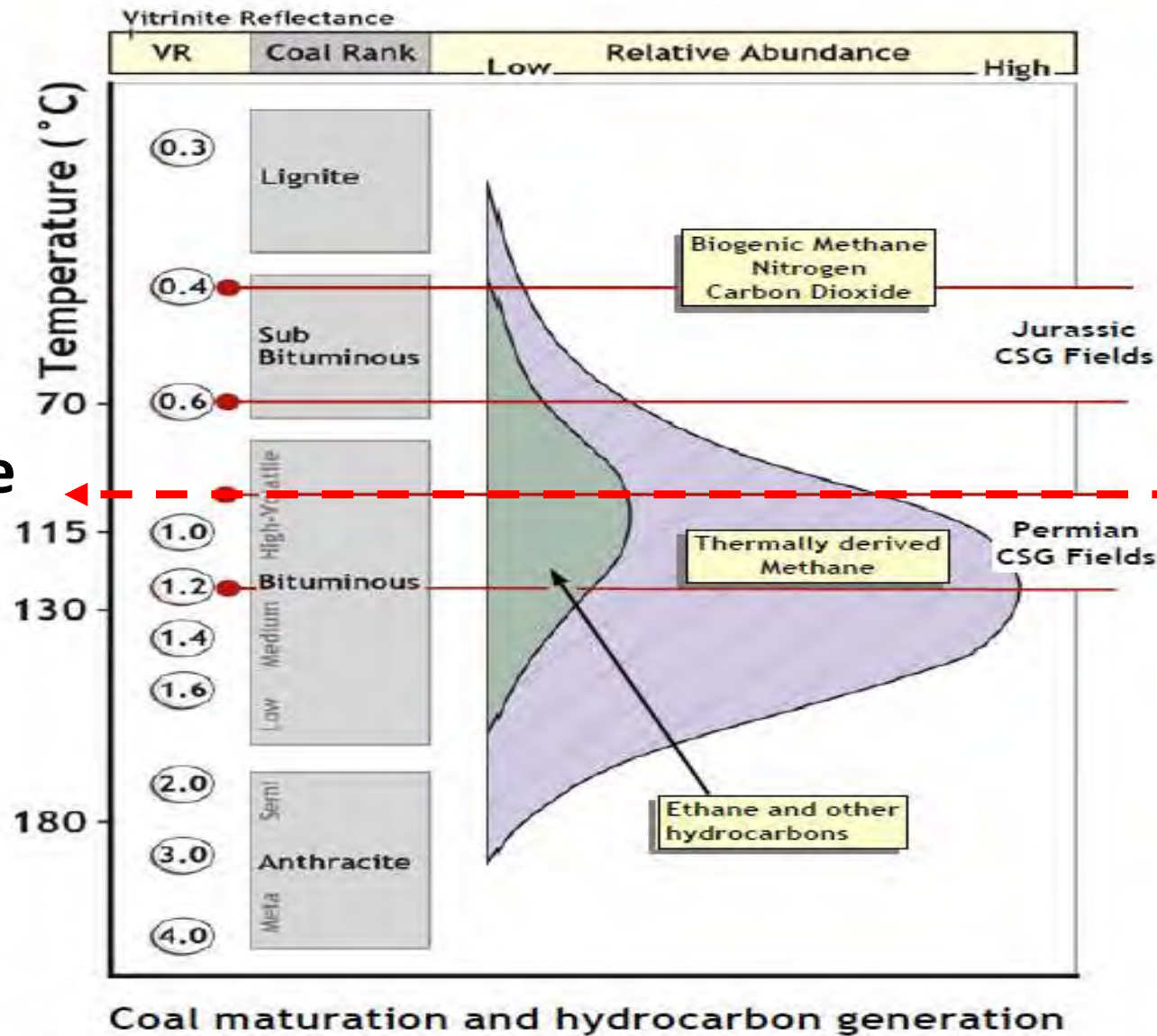


Conventional Hydrocarbon Exploration

**Mature Source Rock
Migration
Reservoir Poroperms
Sealed Trap**

Source
Maturity

Vr > 0.9
Vitrinite
Reflectance
Maturity
Temp
~100 degC

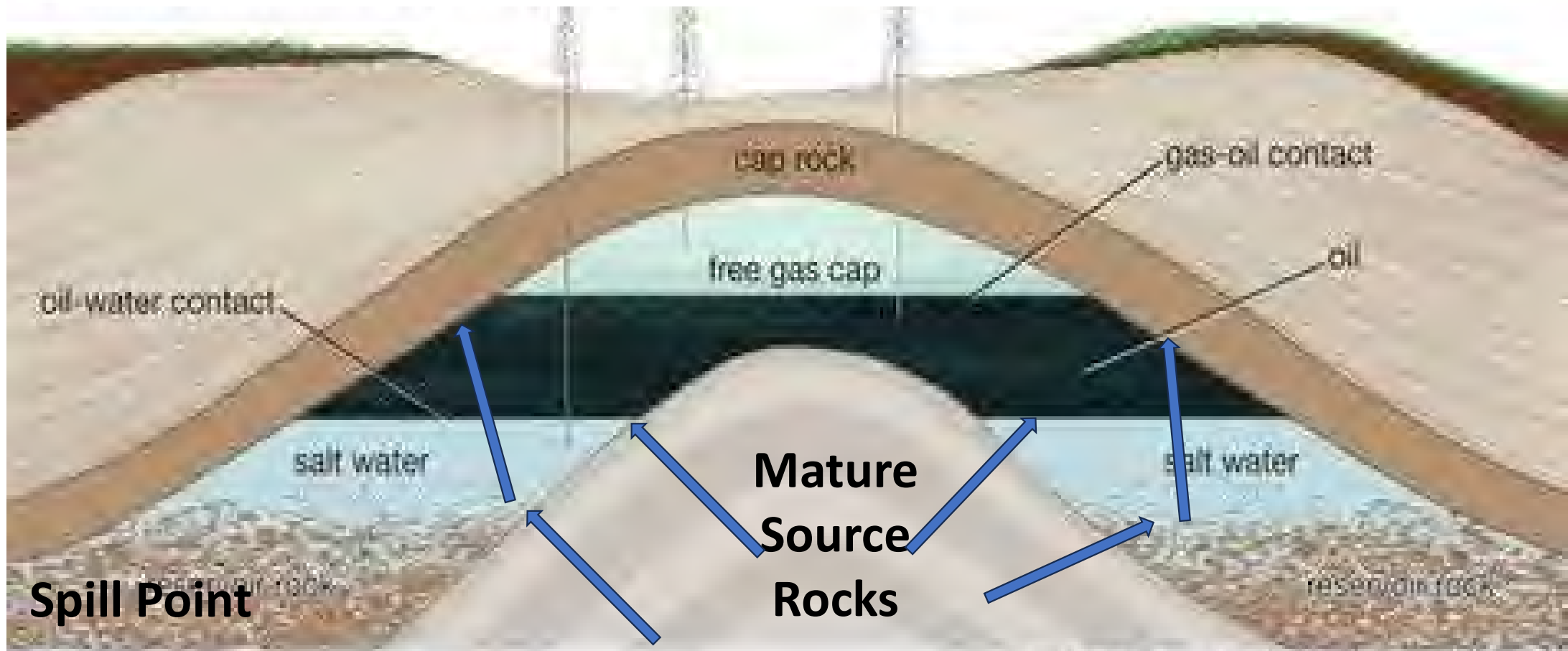


CBM Biogenic
low temp low
pressure
Russia
Italy

CSG Thermogenic
high temp & high
pressure

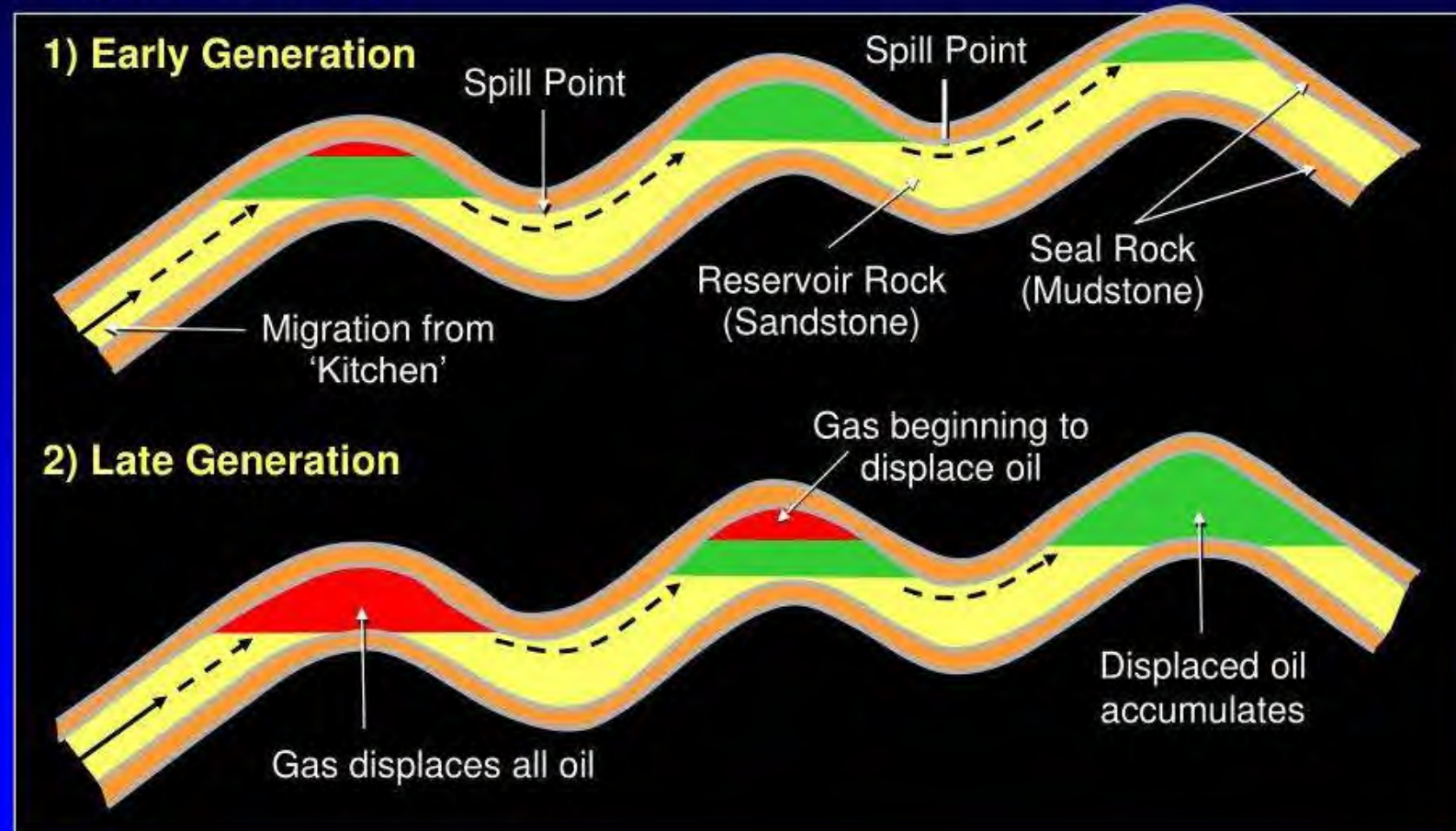
as conventional
oil & gas

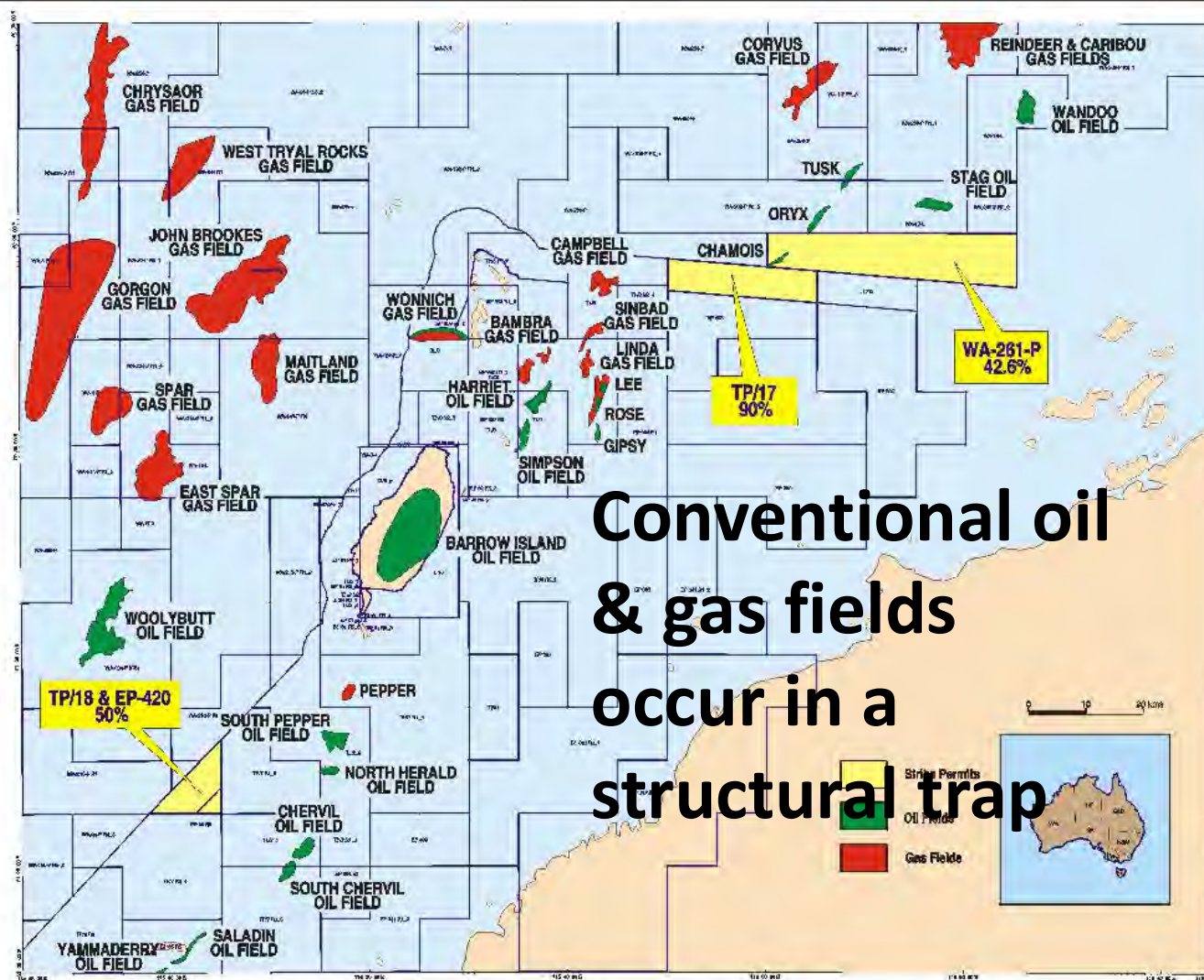
Hydrocarbons migrate from mature source rock into pores in reservoir rocks in a trap, then migrate elsewhere when OWC/GWC reach Spill Point



Petroleum System

A Dynamic Entity





**Conventional oil
& gas fields
occur in a
structural trap**

In 2021, NW Shelf had 93% of Australia's conventional 2P gas of 83,307 PJ (74.07 Tcf)

Production 4,039 PJ (3.59 Tcf).

In 2021, 2P unconventional (CBM) gas was 29,752 PJ (26.45 Tcf),

Unconventional Hydrocarbon Exploration

**Source Rock
No Migration
Reservoir
Hydrostatic Head**

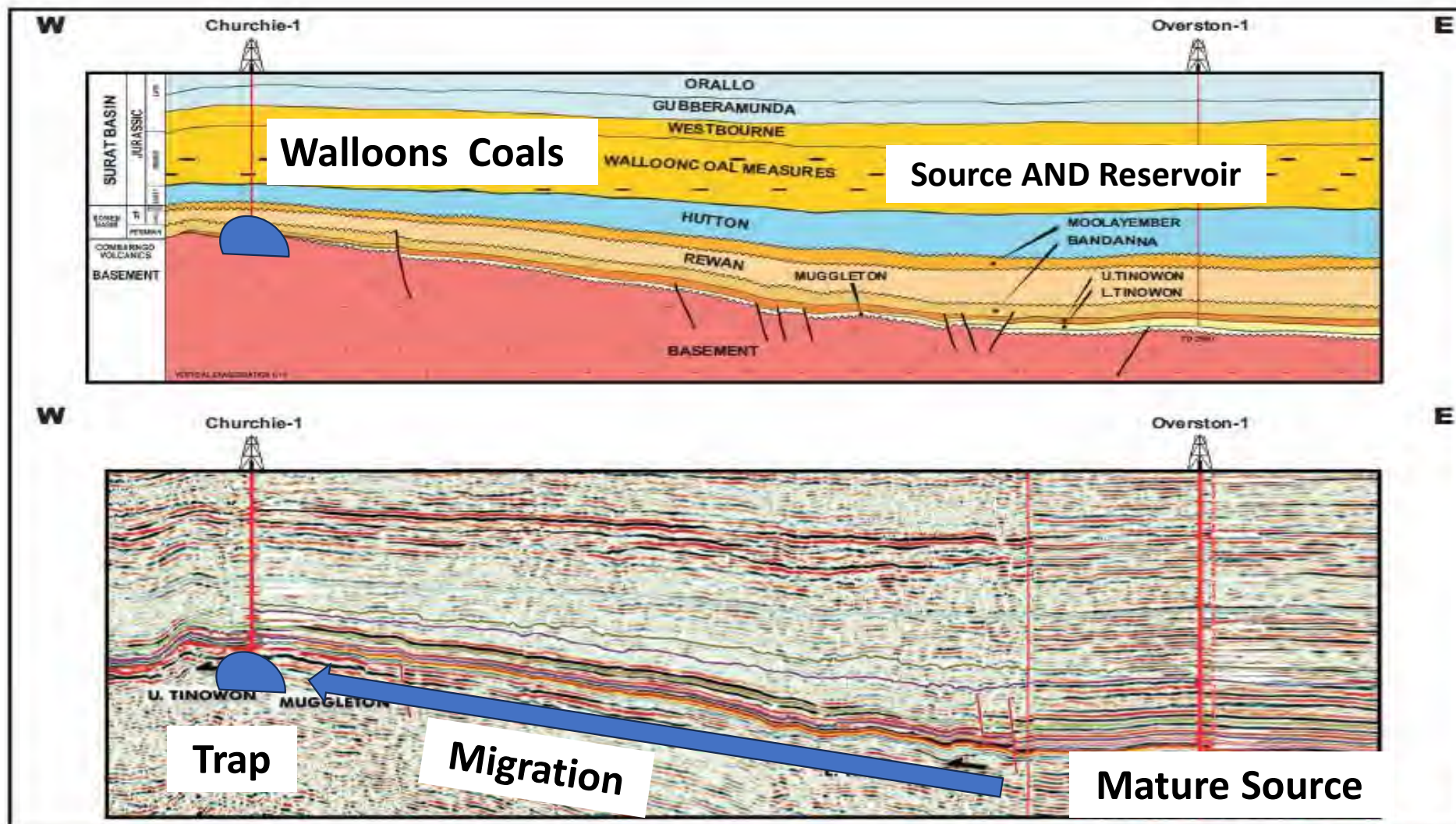
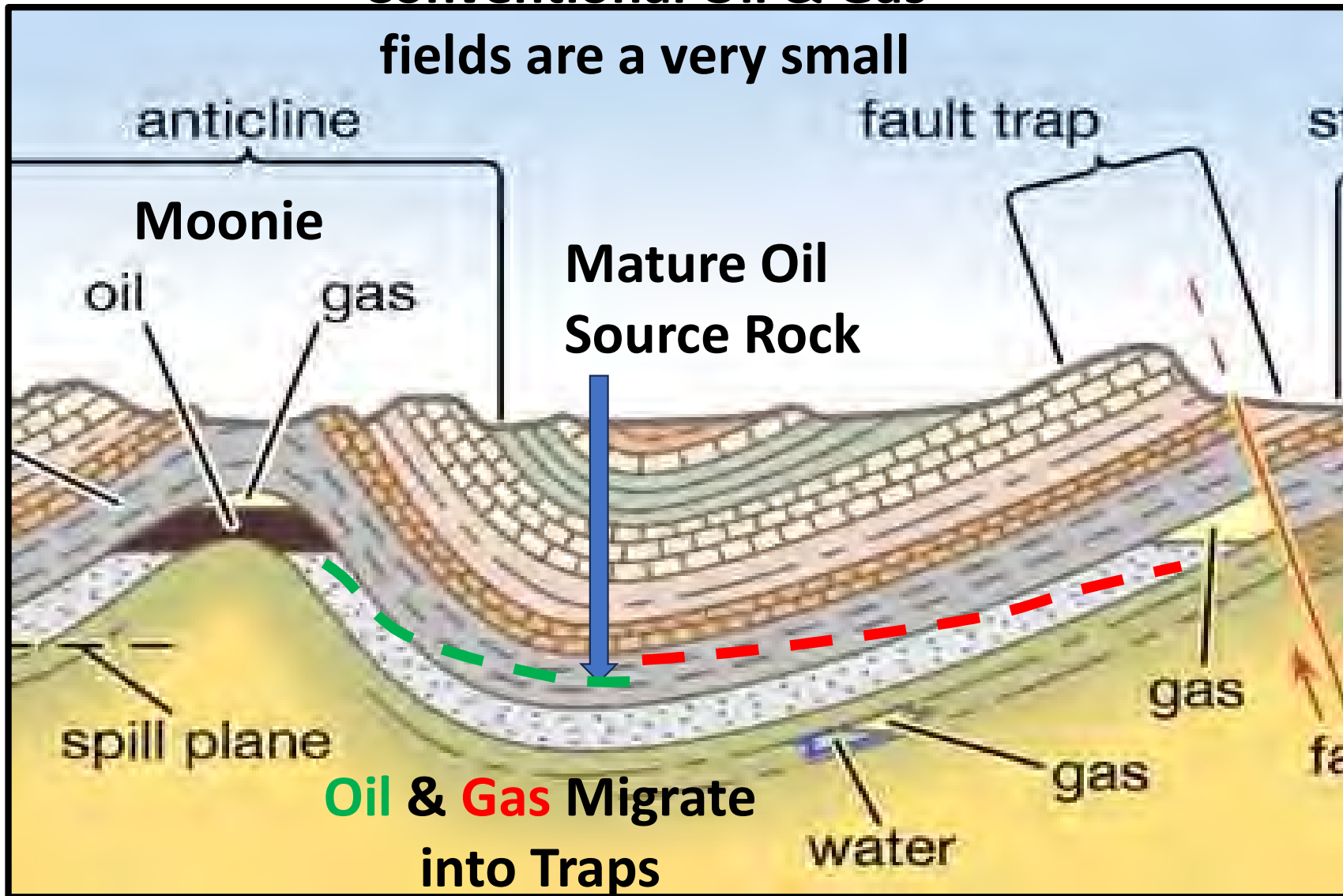
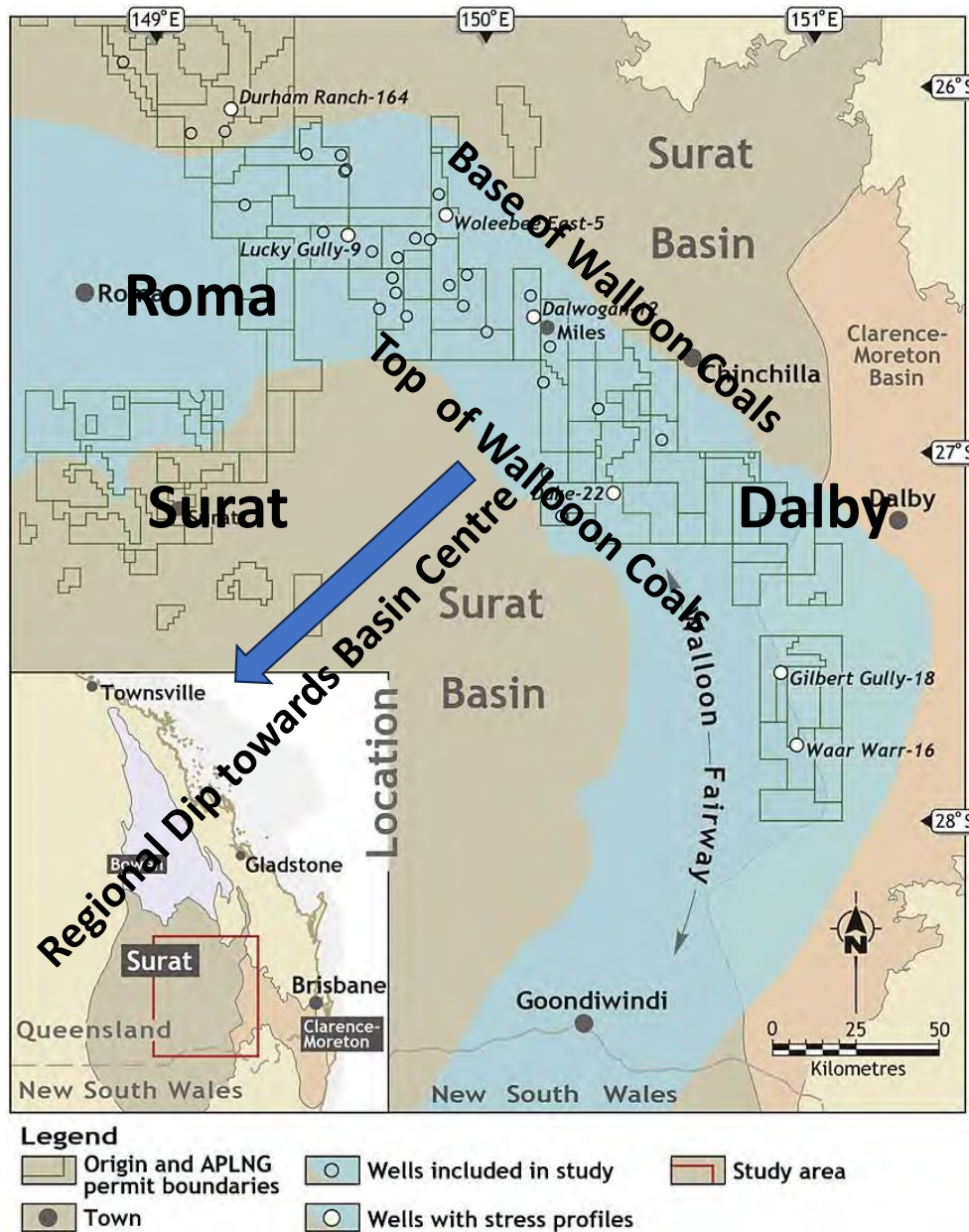


Figure 5. Schematic cross section and 2D seismic line from Overston-1 to the Churchie Field. Note the parasequences onlapping from east to west in the

Conventional Oil & Gas fields are a very small



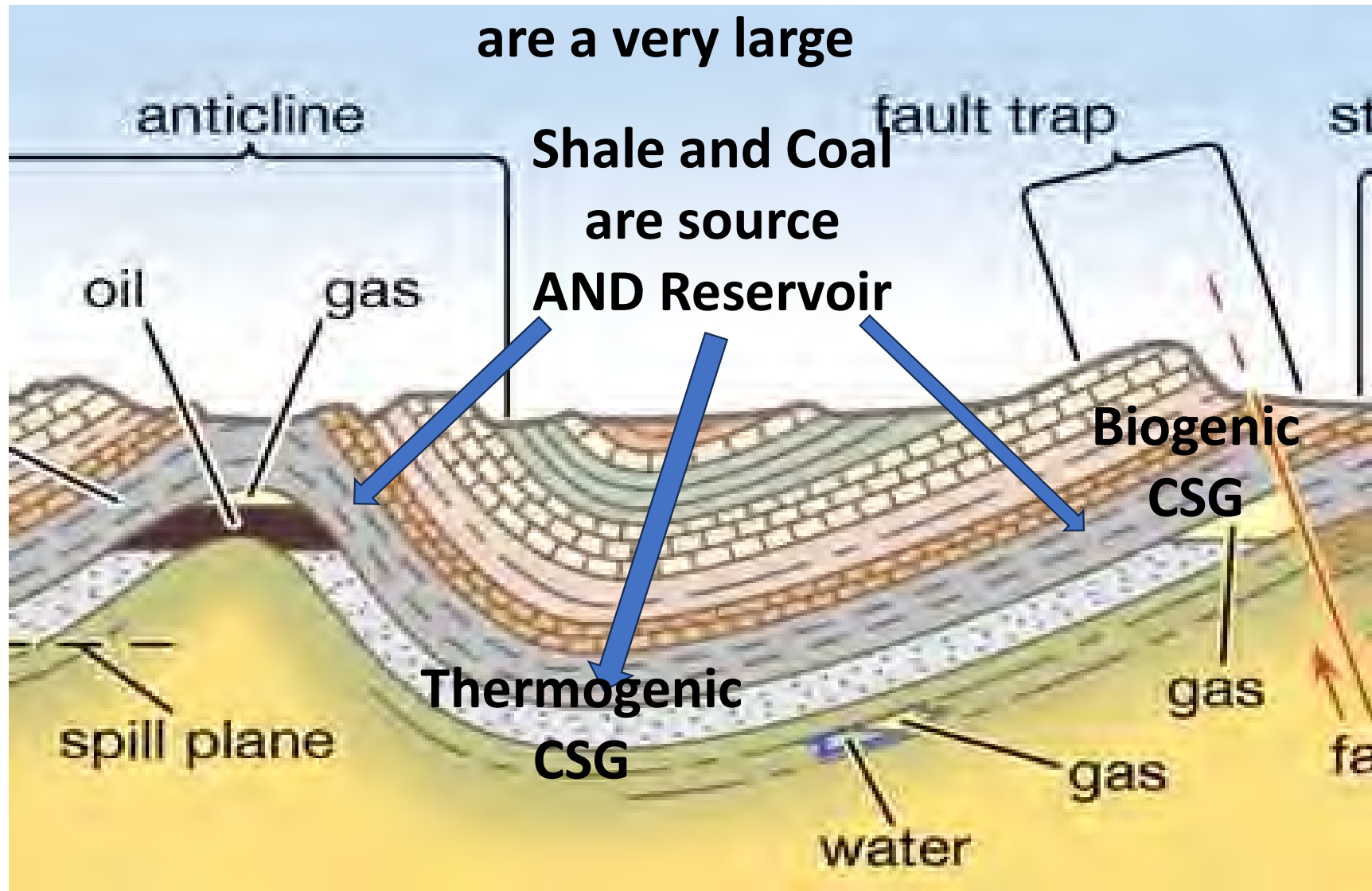


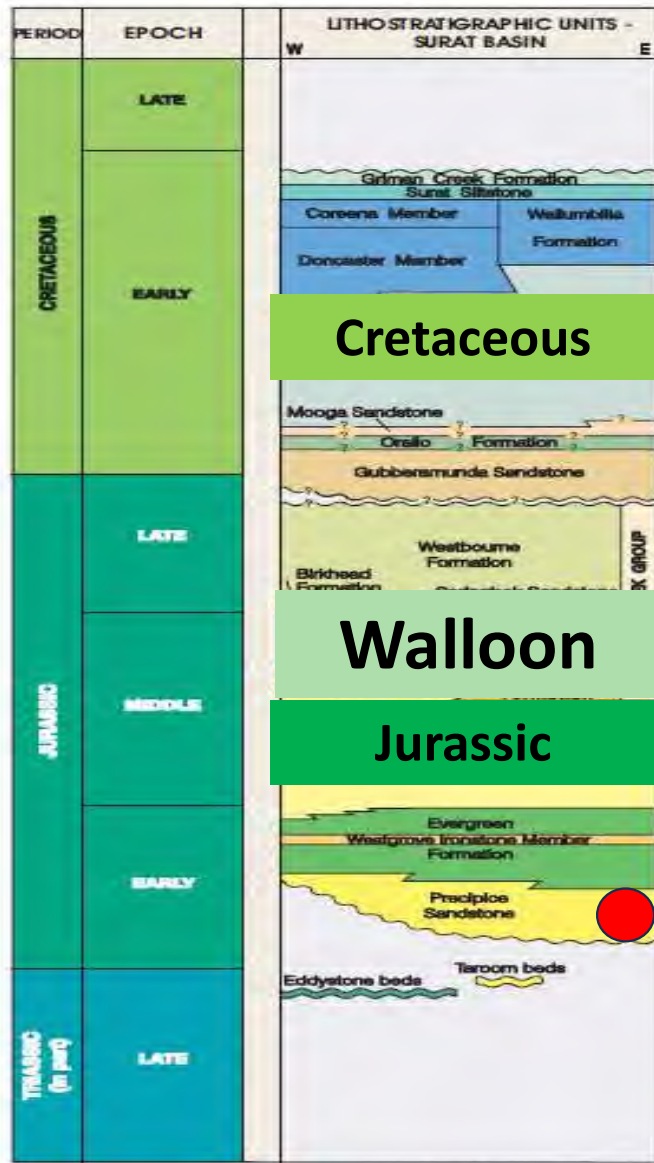
**Trap not
needed**

**CBM/CSG
produce gas
from the
whole
sequence**

**Vastly
larger
reserves**

Un-conventional gas and oil fields are a very large



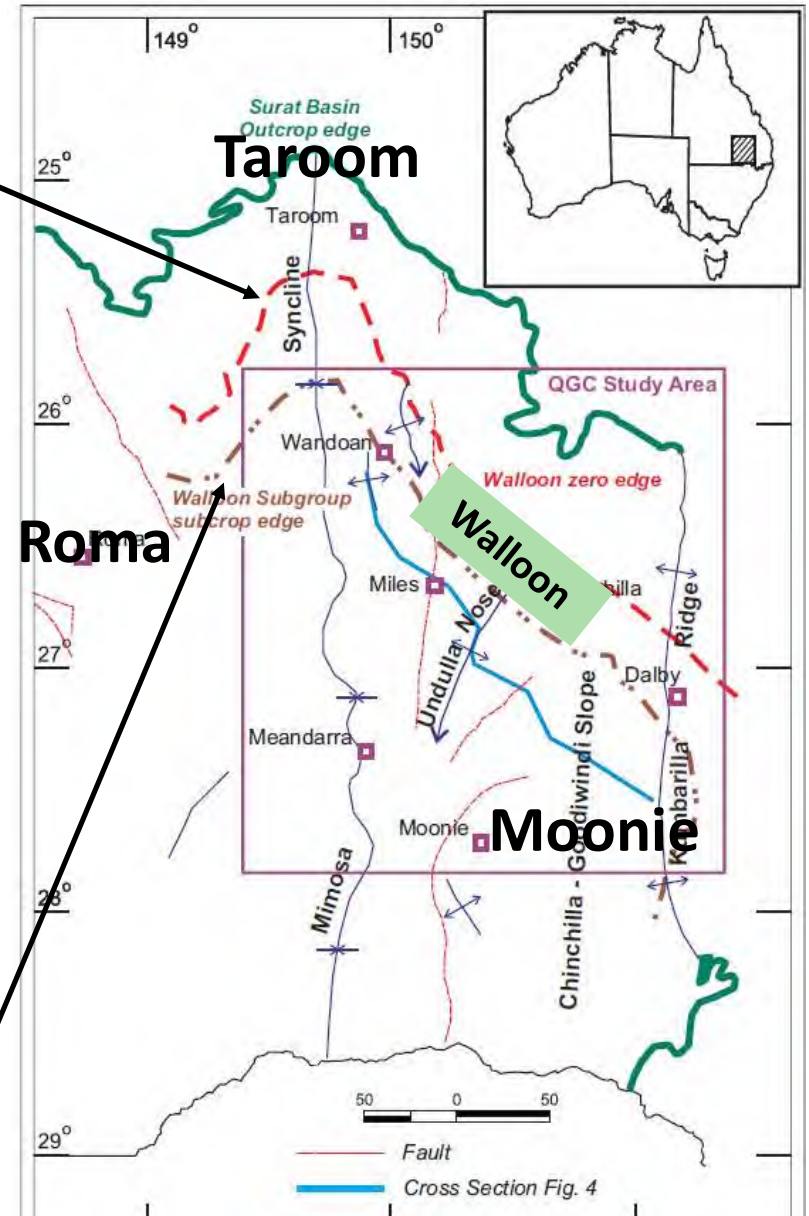
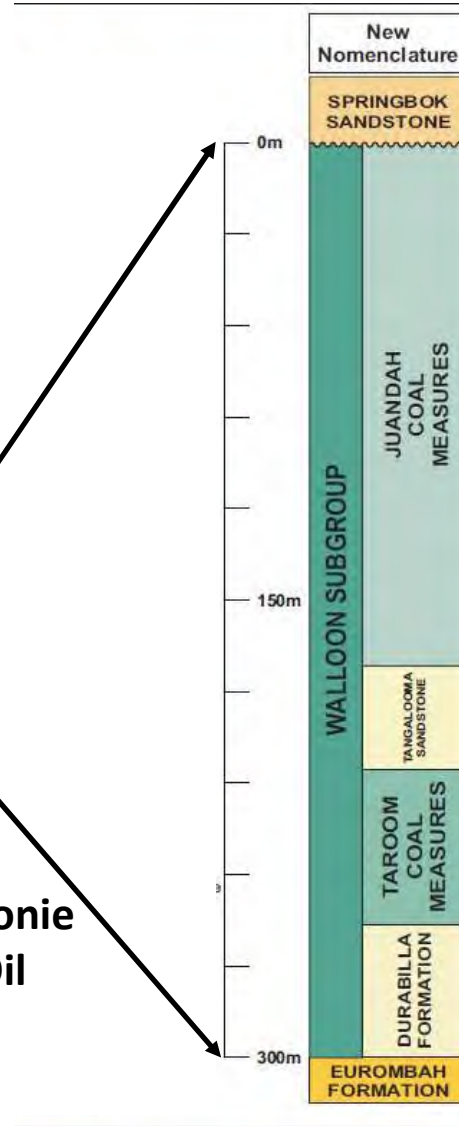


Cretaceous

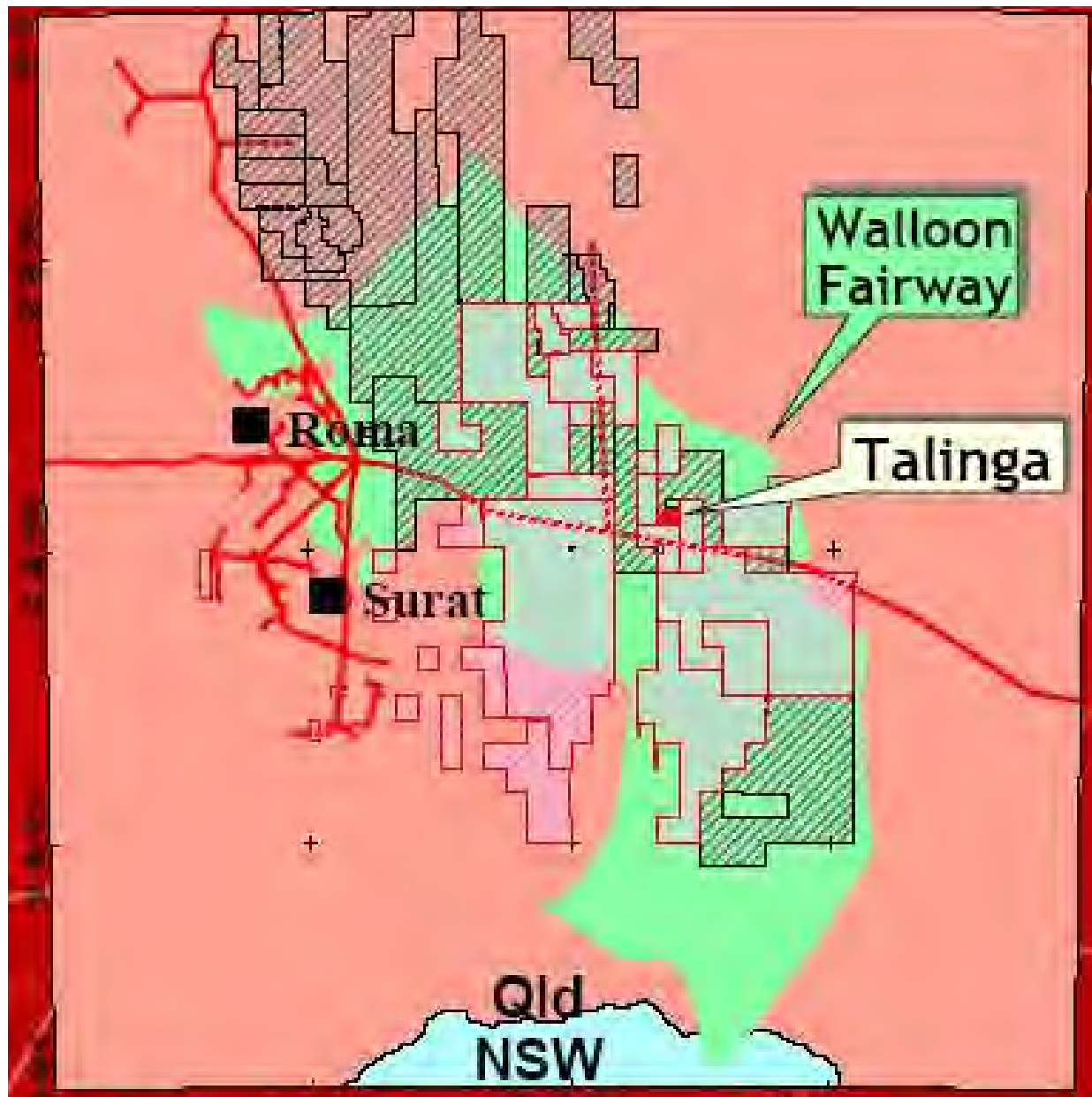
Walloon

Jurassic

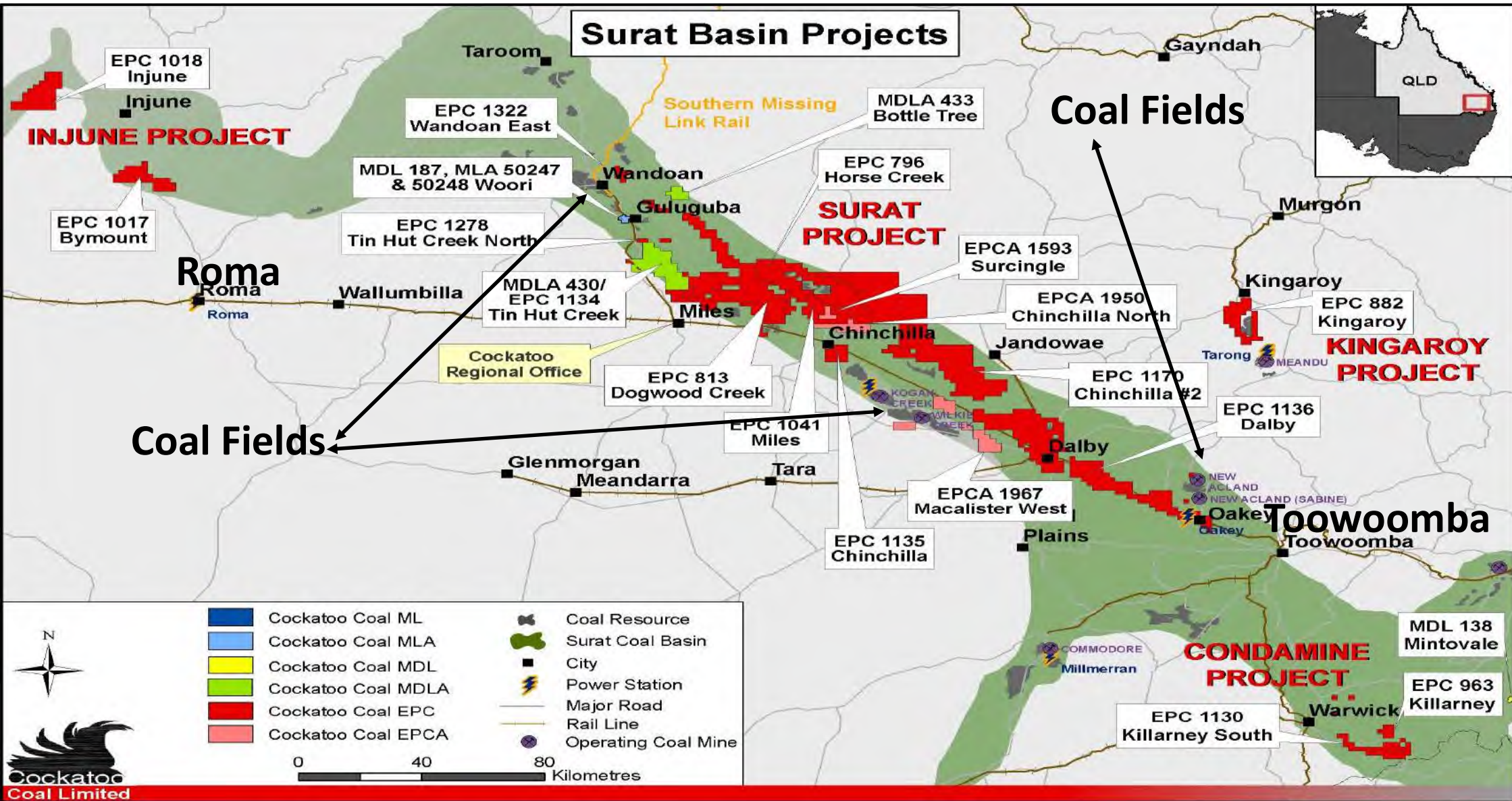
Moonie Oil







Arrow
Shell
QGC
Strike
CBM

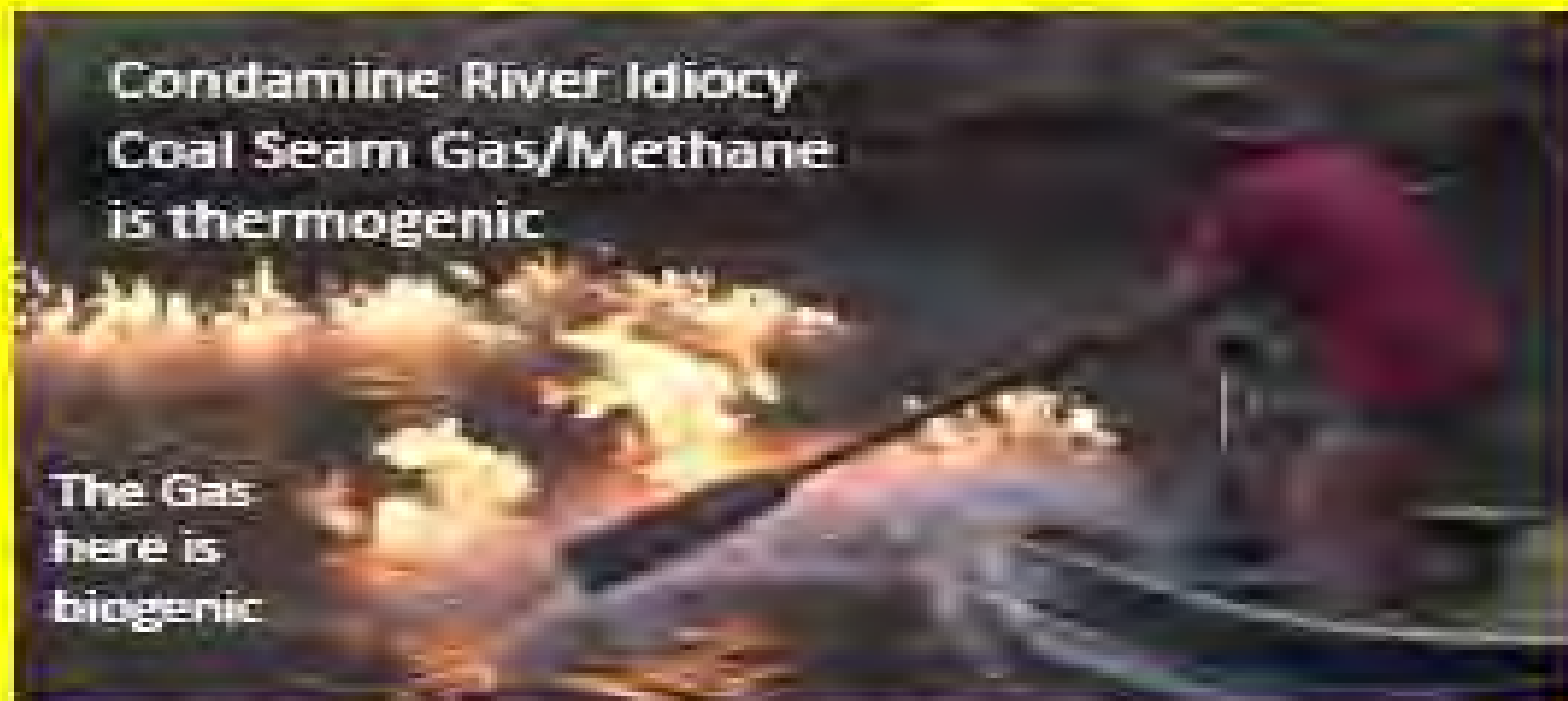


CBM: Coal Bed Methane

&

CSG: Coal Seam Gas

Watch A Queensland River Catch On Fire
Because Of Fracking (gizmodo.com.au)



Condamine River Idiocy
Coal Seam Gas/Methane
is thermogenic

The Gas
here is
biogenic

Methane from decomposing vegetable matter after flooding
Has different isotopes – as different as a Rolls and a Mini



Clean Hi Quality Gas
Pale blue – yellow
smoke free flame

CBM - CSG

Coal Bed Methane

shallow, biogenic
origin from bacteria and
fresh water

Coal Seam Gas

thermogenic origin
pressure heat and
saline water

Coal Quality: Rank

- Vitrinite Reflectance (V_r) = Rank
- Sub Bituminous 0.4 – 0.5
- Hi Volatile Bituminous 0.6 – 1.1
- Med Vol Bituminous 1.1 – 1.5
- Low Volatile >1.5

Permian $V_r > 1.0$ Thermogenic Deeper Gas
Walloons V_r 0.4 to 0.7 Biogenic shallow gas < 600m

Walloon CBM Coals have Hi Permeability and low overburden pressure

CSM New Units & Old

New U

CU or FU

1 GJ (10^9 joules)	1 mcf (10^3 ft³)
1 TJ (10^{12} joules)	1 mmscf (10^6 ft³)
1 PJ (10^{15} joules)	1 bcf (10^9 ft³)
1,000 PJ	1 tcf (10^{12} ft³)
1.055 MJ	1,000 btu/ ft³
1,000 joules	0.9478673 btu
1 m³	35.314659 ft³

1 Mega pascal (Mpa)

145 psi

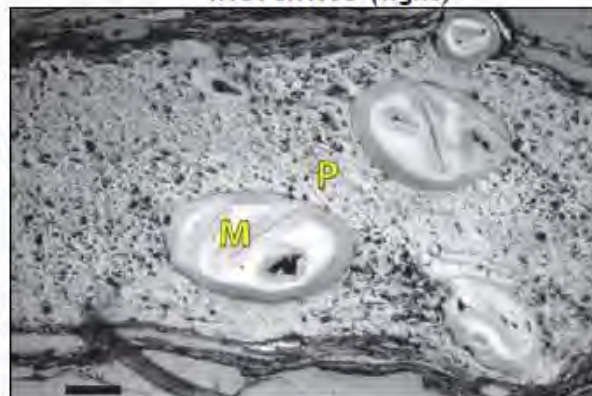
Coals Source & Reservoir

- Gas Storage Properties
 - Gas Content m^3/tonne
 - Microporosity – Critical
 - Adsorption – Critical
 - **Monolayer of gas adsorbed /condensed on coal surfaces**
 - **Surface area ~50 – 300 m^2/gm**
 - Macro-Porosity & Cleats
 - Absorption - Negligible
- Gas Flow Properties
 - Diffusivity – Essential
 - **Gas first desorbs then moves by molecular diffusion across a concentration gradient**
 - Permeability- Critical
 - **Once in cleats gas moves physically from higher to lower pressures**
 - **Anthracite too tight**
 - Millidarcie

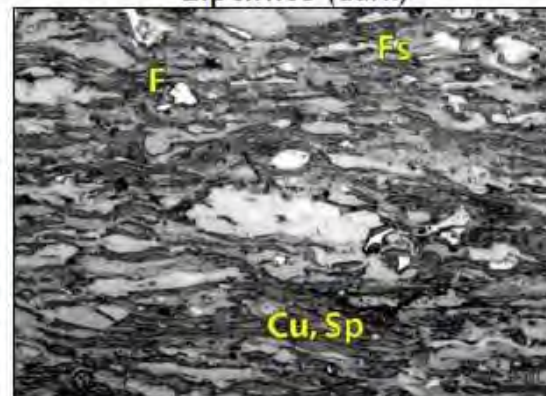
Vitrinite (midtones)



Inertinite (light)



Liptinite (dark)



Permian-Average coal composition

Vitrinite	69%
Liptinite	4%
Inertinite	27%

Jurassic-Average coal composition

Vitrinite	77%
Liptinite	19%
Inertinite	4%

Key to Macerals

Vitrinite Group

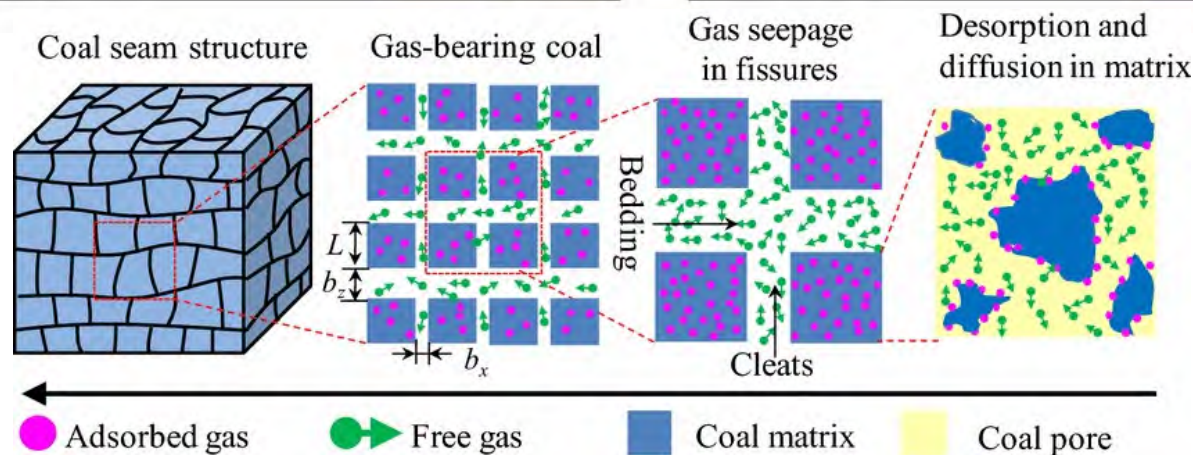
- T Telocollinite
- G Gelocollinite
- C Corpocollinite

Liptinite Group

- Sp Sporinite
- Cu Cutinite

Inertinite Group

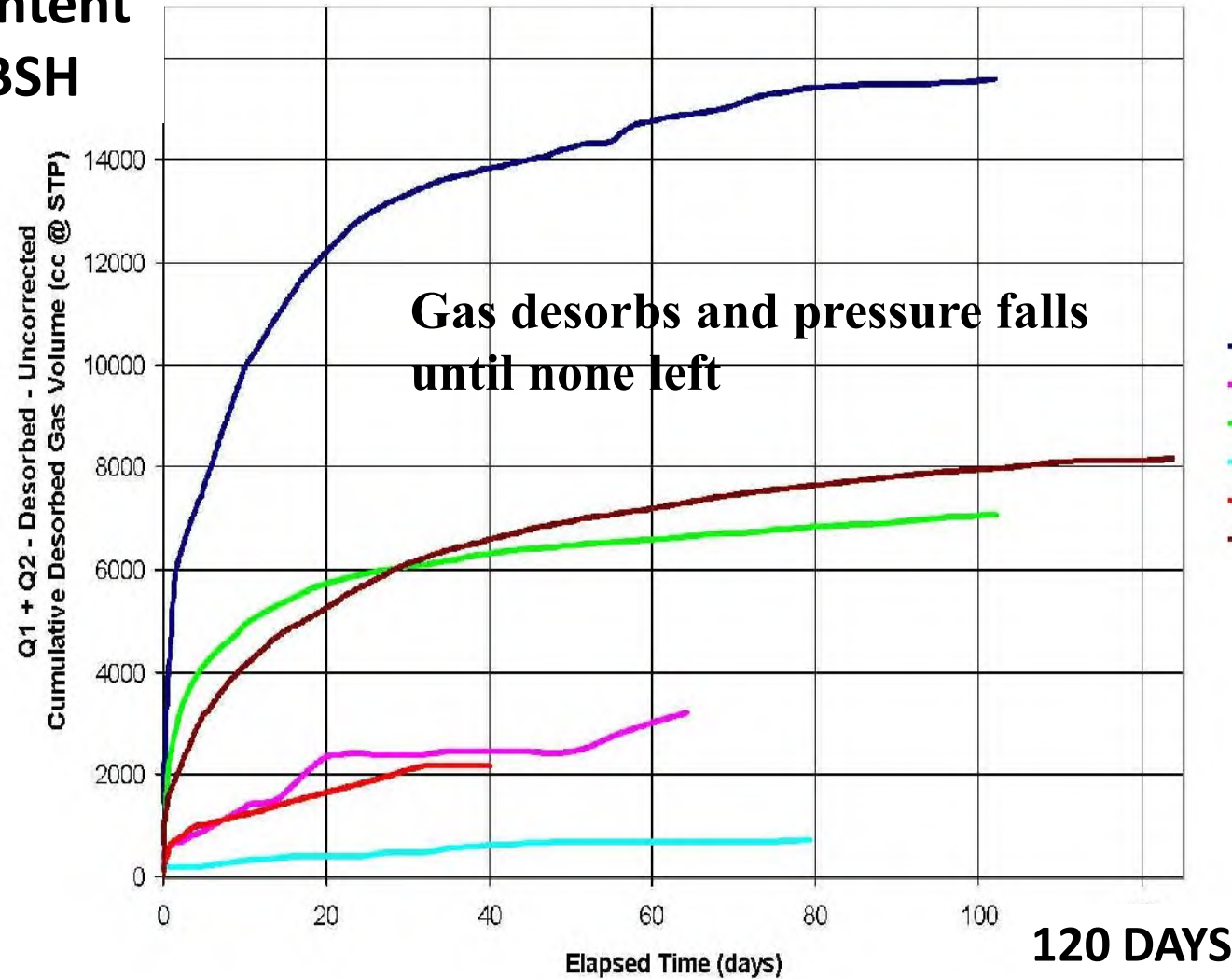
- F Fusinite
- Fs Semifusinite
- P Pyrofusinite
- M Macrinite





Gas Content BSH

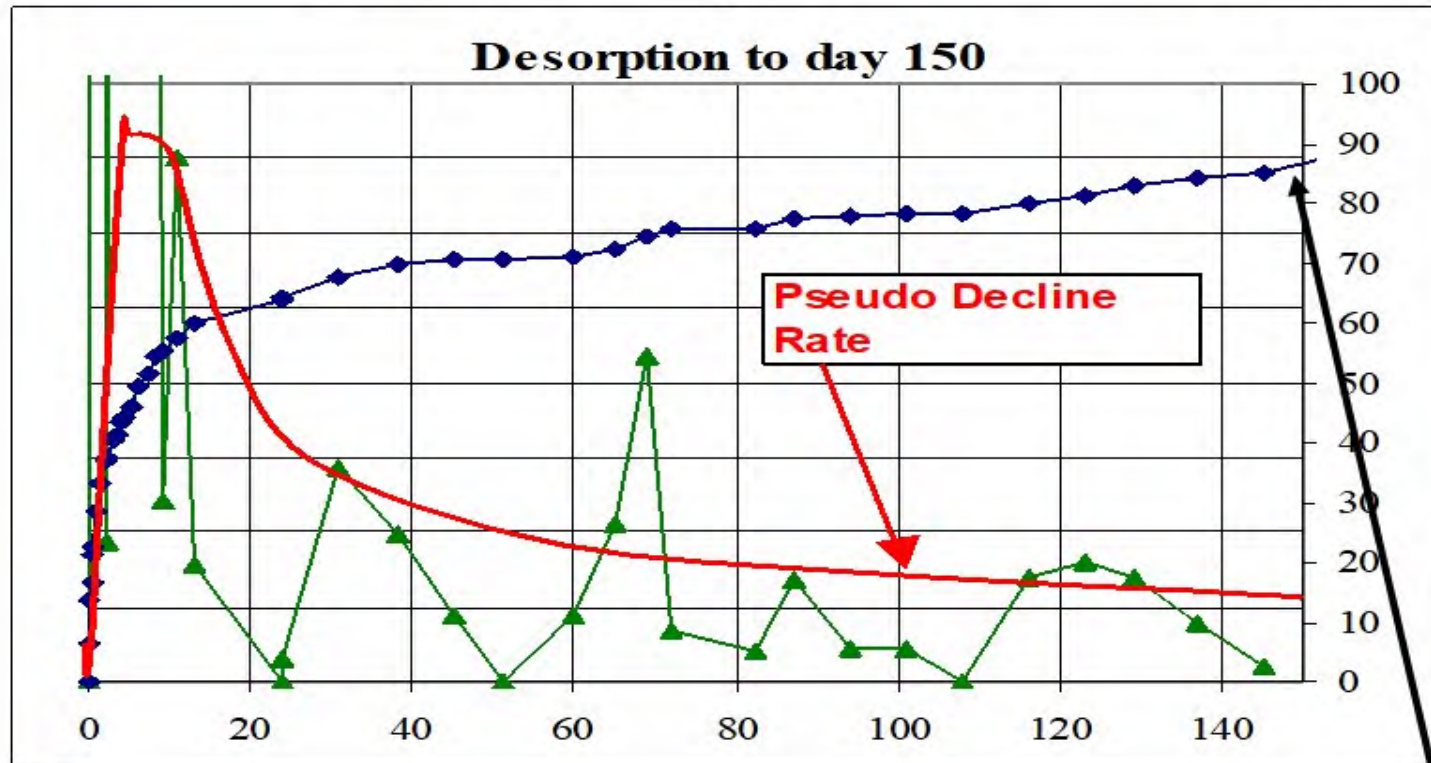
**GAS DESORBED FROM COAL CORES OVER TIME (Q3)
TO DERIVE IN SITU GAS CONTENT PER CUBIC METRE**



**Need to add
Q1 loss on retrieving core
Q2 Lost in transit
Q3 Collected and Measured**

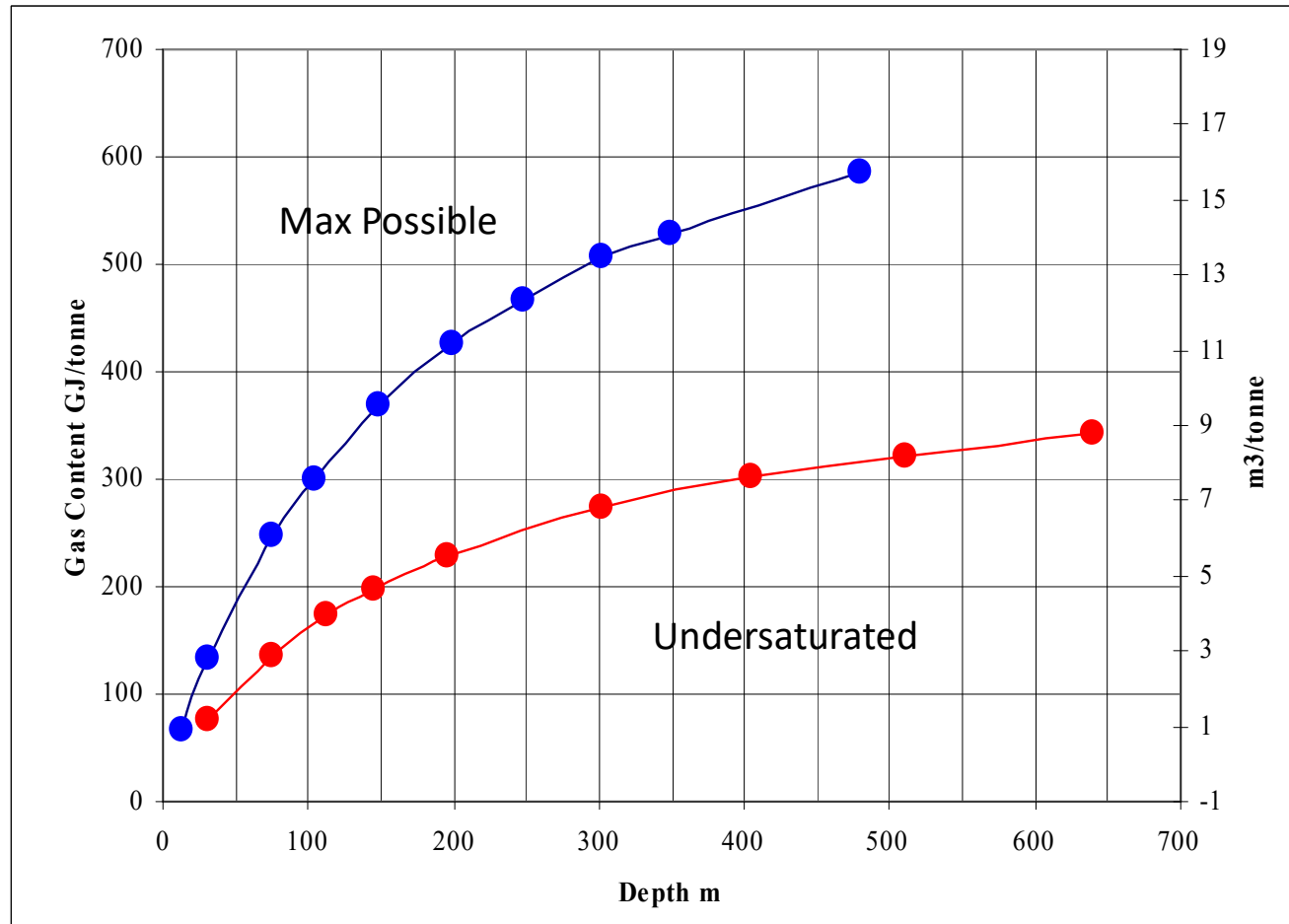


One Sample: One Value



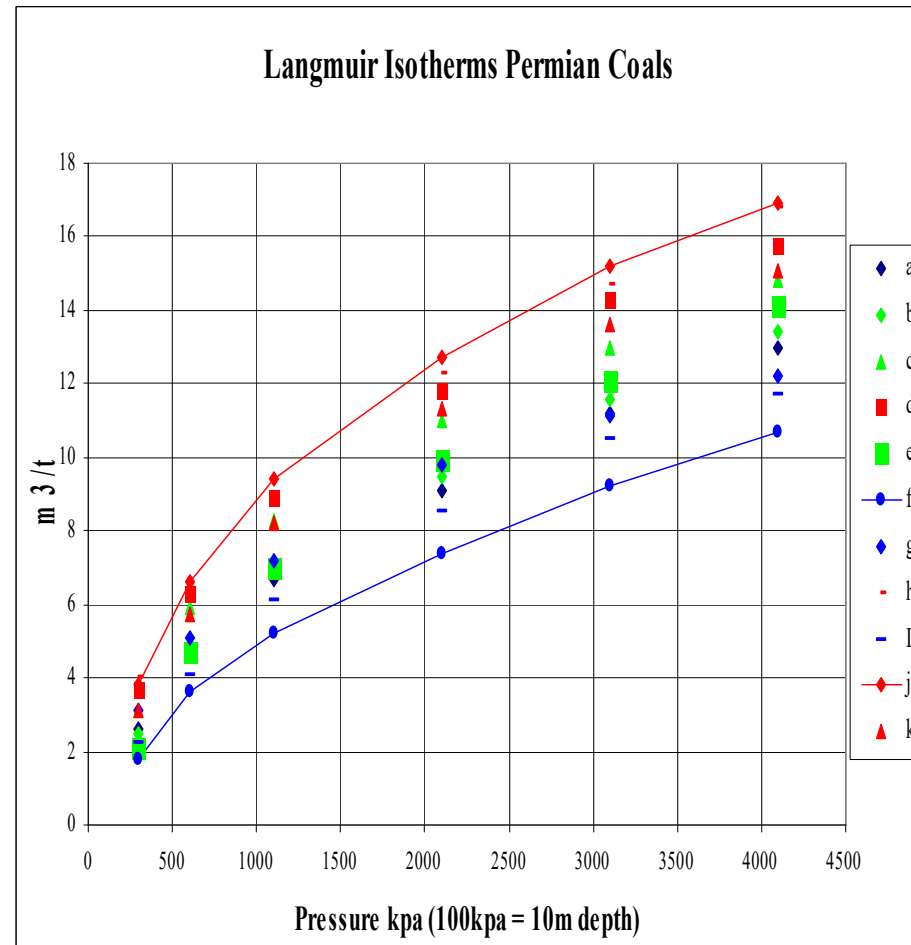
Cumulative gas produced Q3 (plus Q1 & Q2 minus residual gas) gives a gas content in m^3/tonne or ft^3/ton of coal

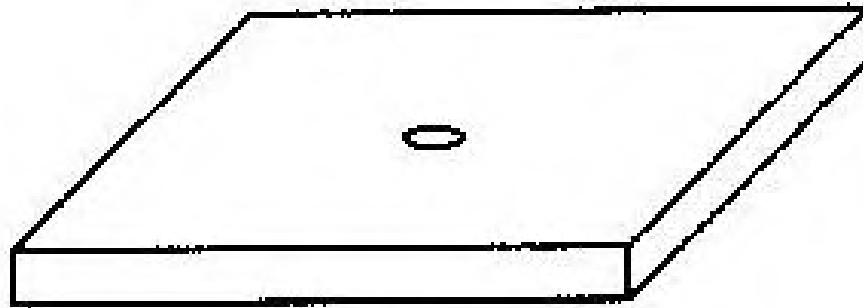
Gas Saturation



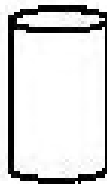
Gas Adsorption

- Coal Crushed
- Gas injected in stages
- Adsorbed back onto coal
- At Reservoir Pressure
- Gives theoretical Gas Content v Depth.
- Volume - Pressure Plot is Langmuir Isotherm:





1 km² area = 19 million tonnes



1 coal core = 180 kilograms

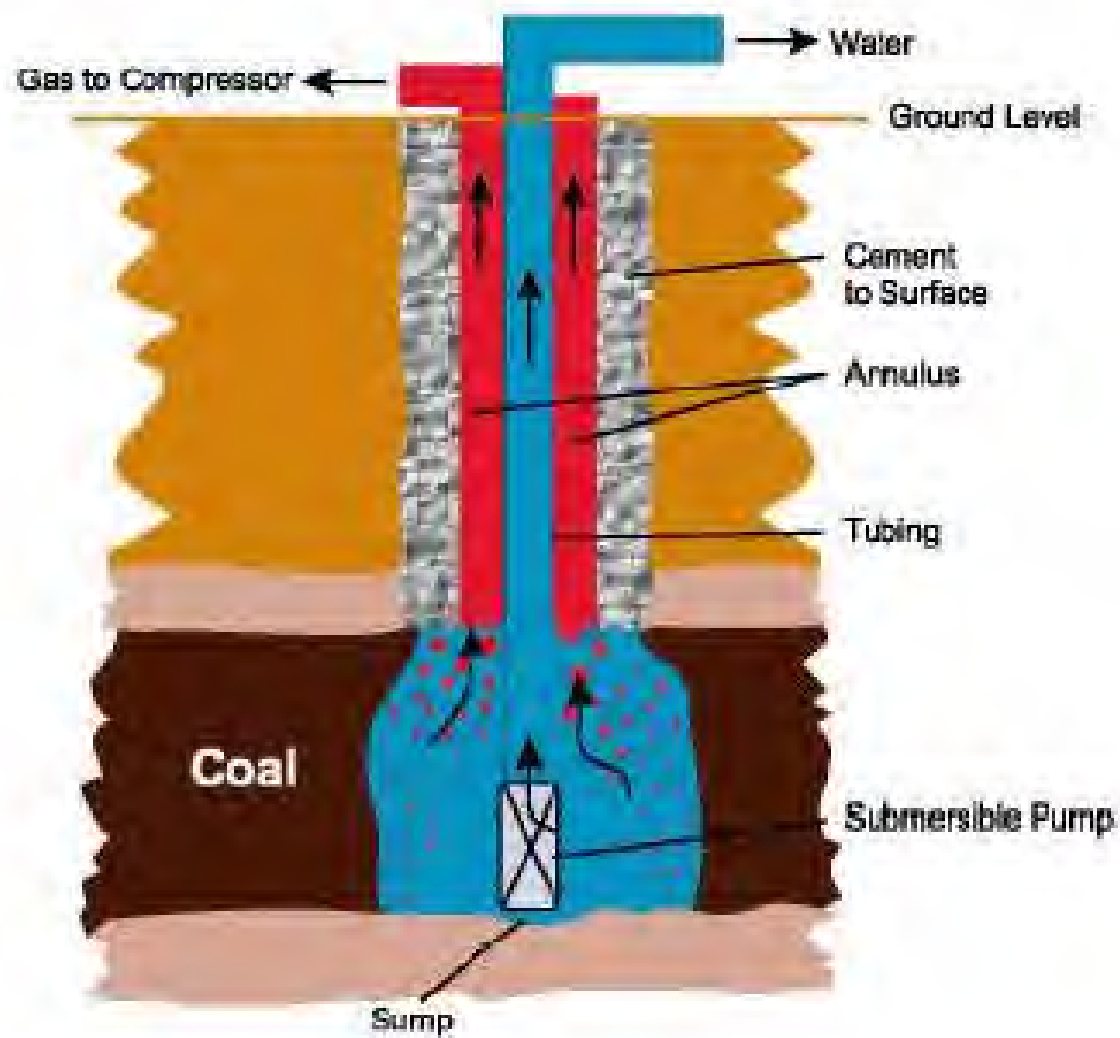


1 coal sample = 100 grams

Senex

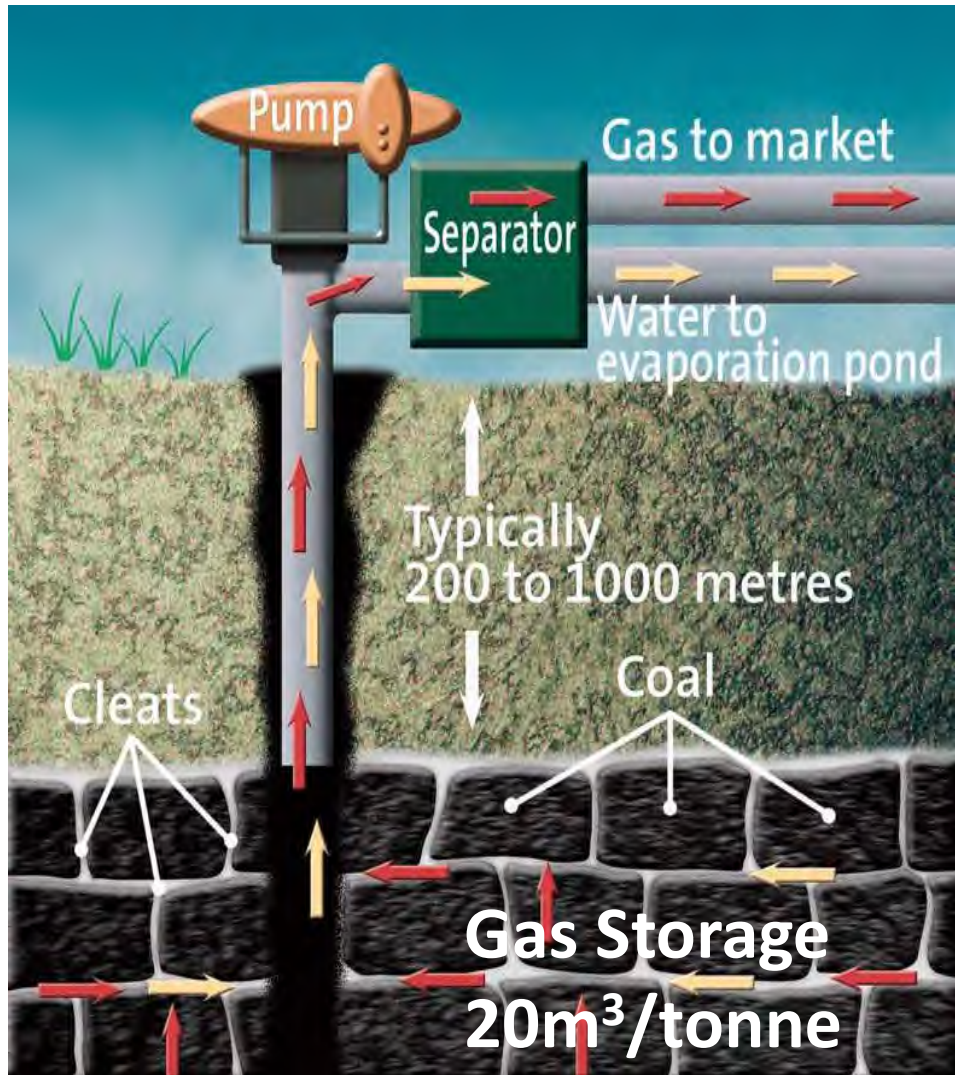
Senex Energy Limited



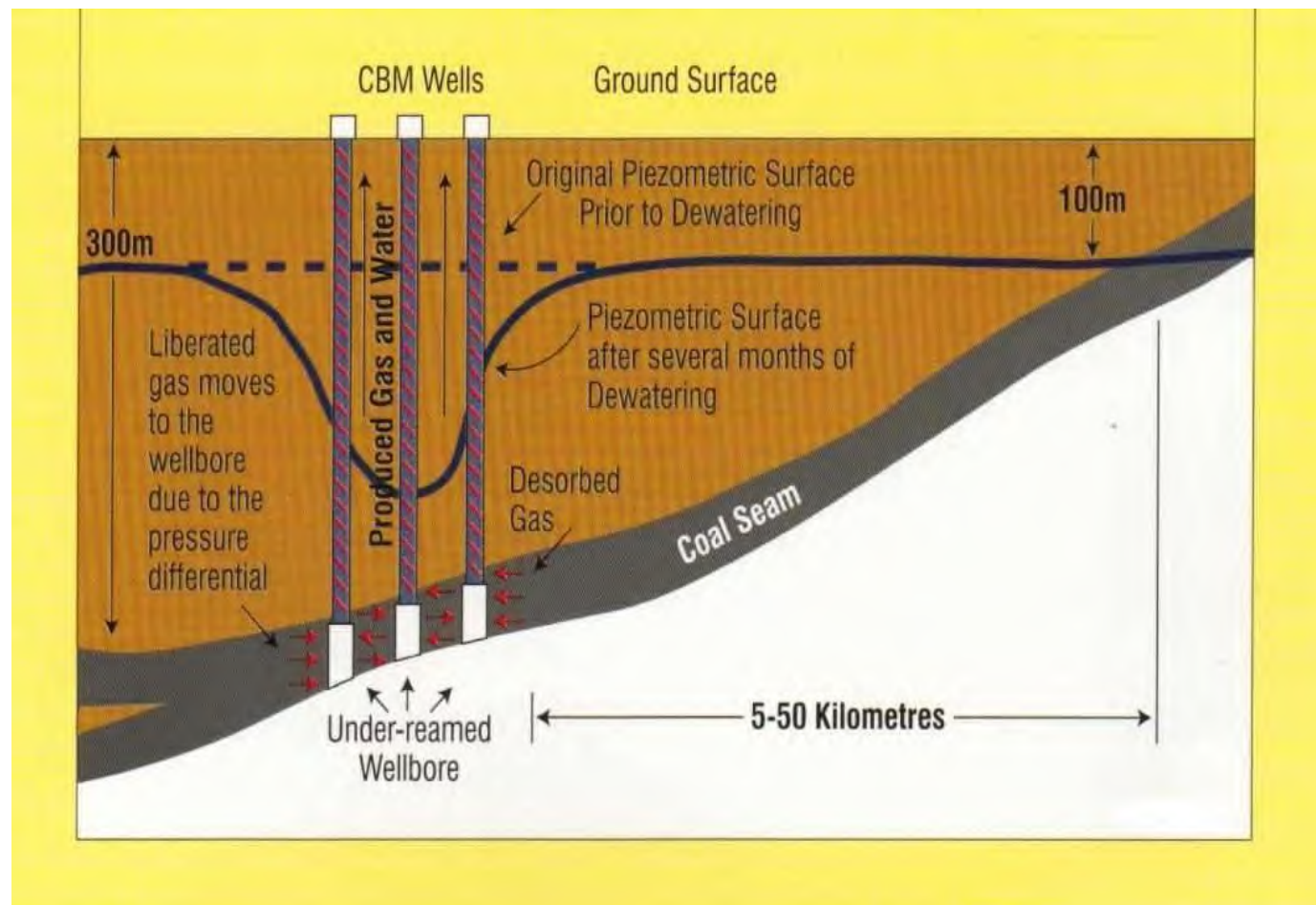
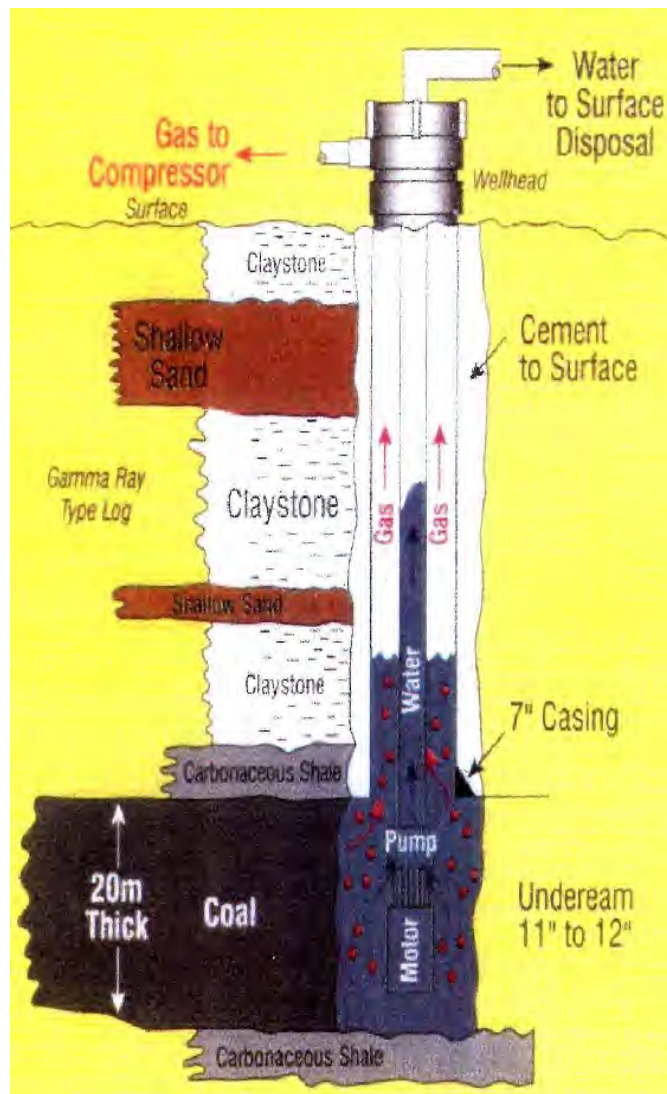


CSM
Prod
Well

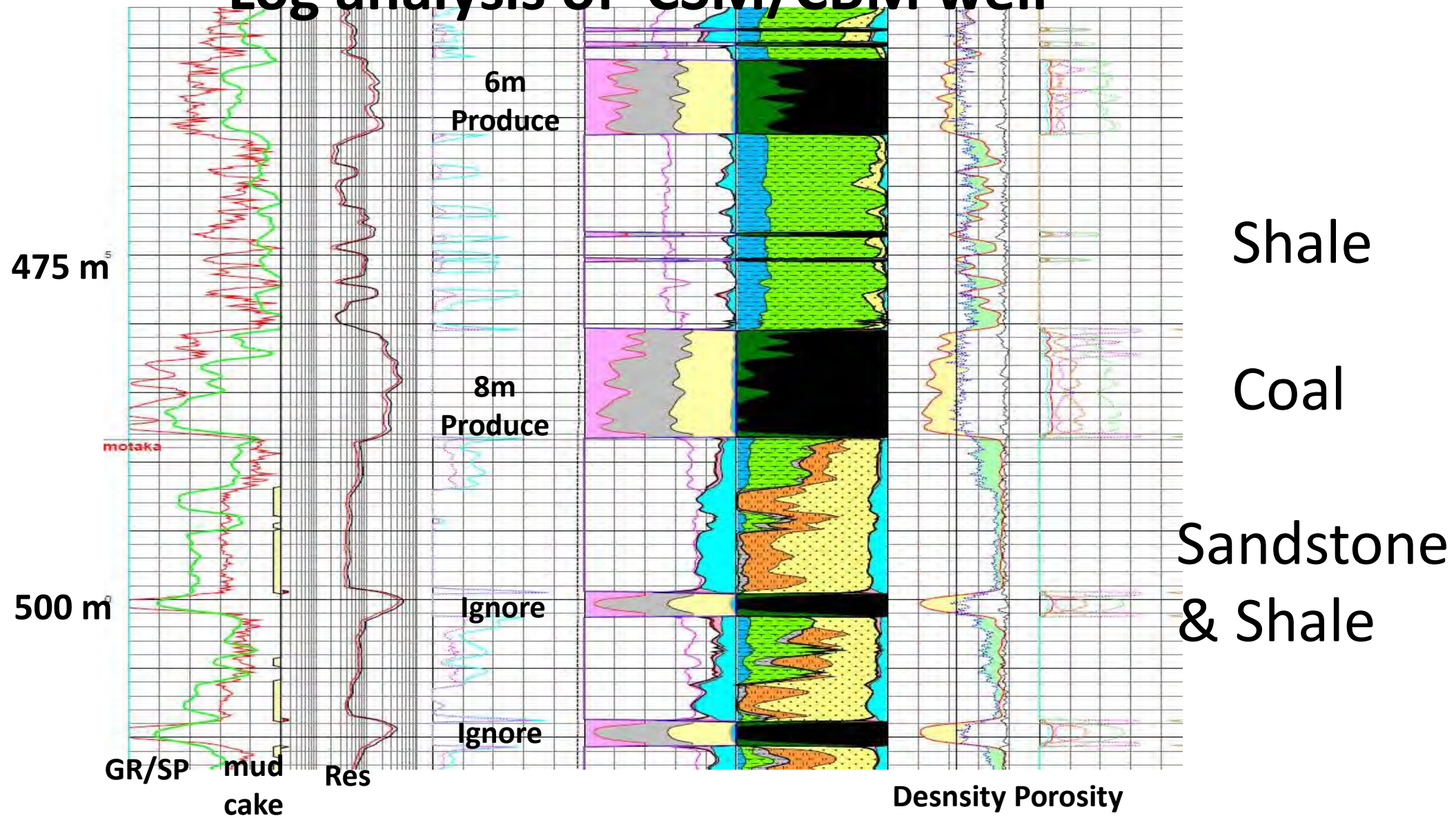
COAL SEAM METHANE/GAS

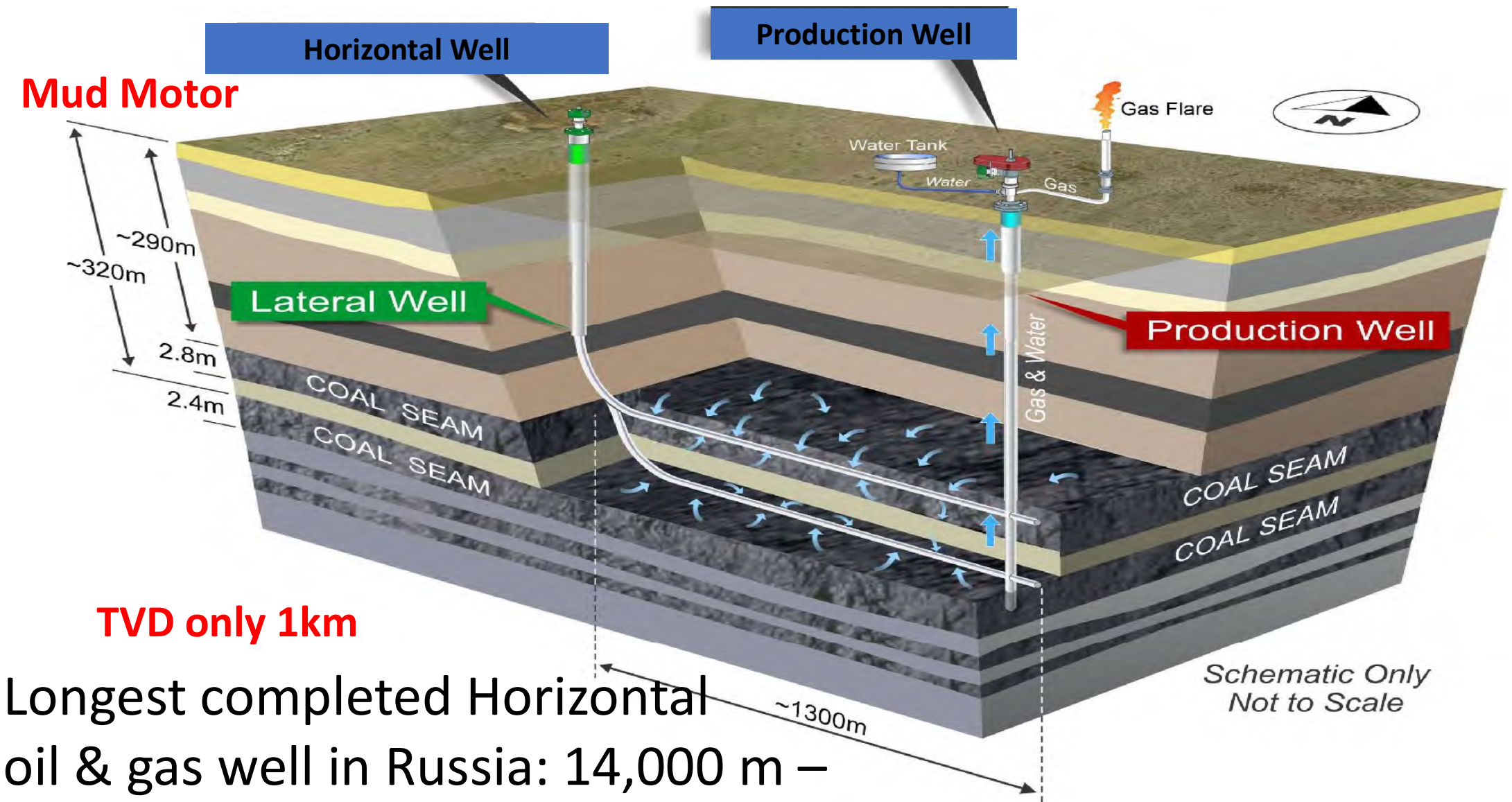


- Methane adsorbed on coal surfaces held on as monomolecular layer by Van der Waals force – gecko's feet
- Gas held in place by hydrostatic head
- Extracted by pumping water from cleats, lowering water pressure allowing desorption off the coal surface along a concentration gradient just like a chromatograph
- Can hold $> 5 \times$ more gas as an equivalent volume of sandstone at shallow depths



Log analysis of CSM/CBM well

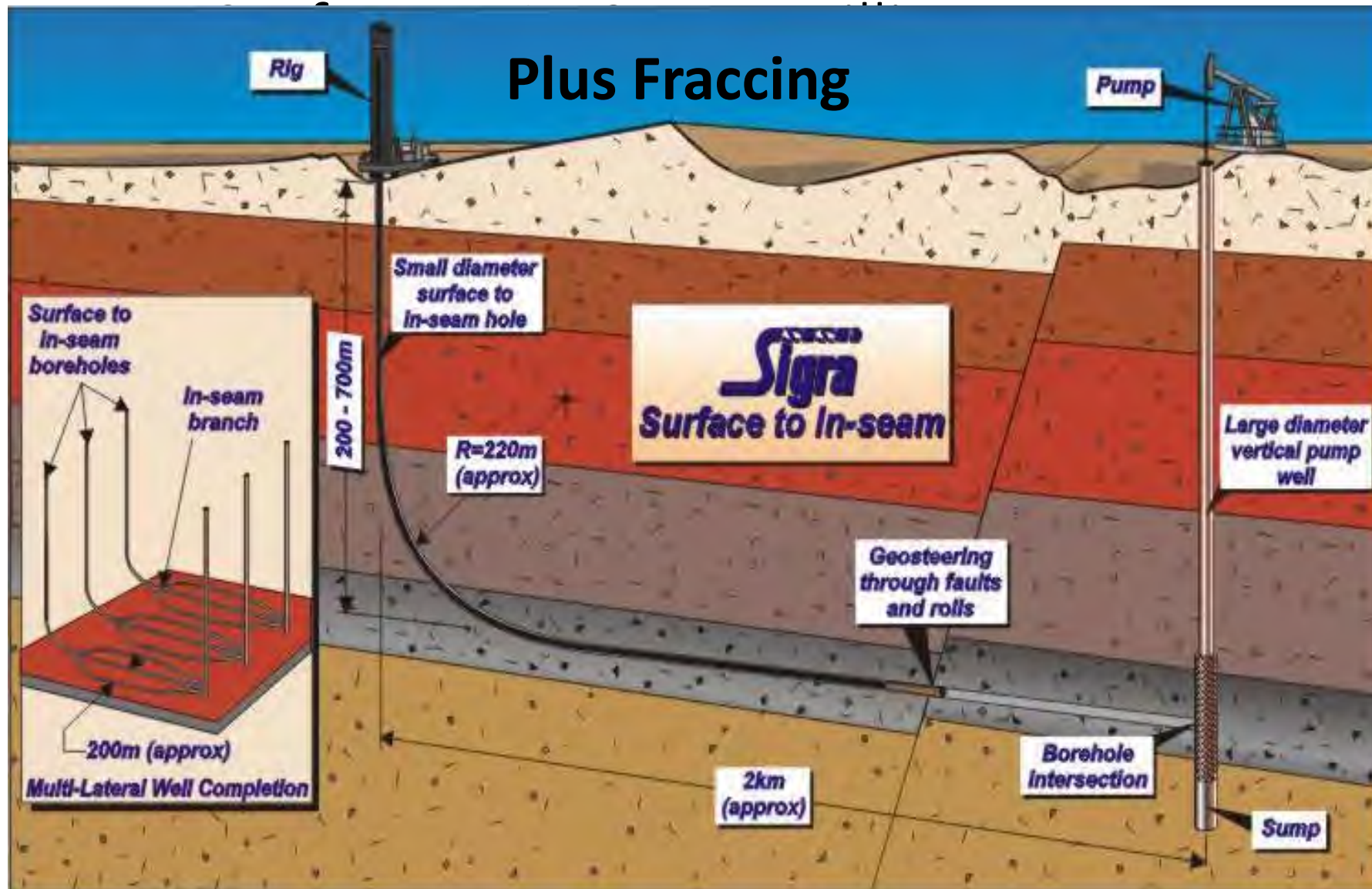




TVD only 1km

Longest completed Horizontal oil & gas well in Russia: 14,000 m –
>from Chapel Hill to downtown David Jones men's shoes dept!

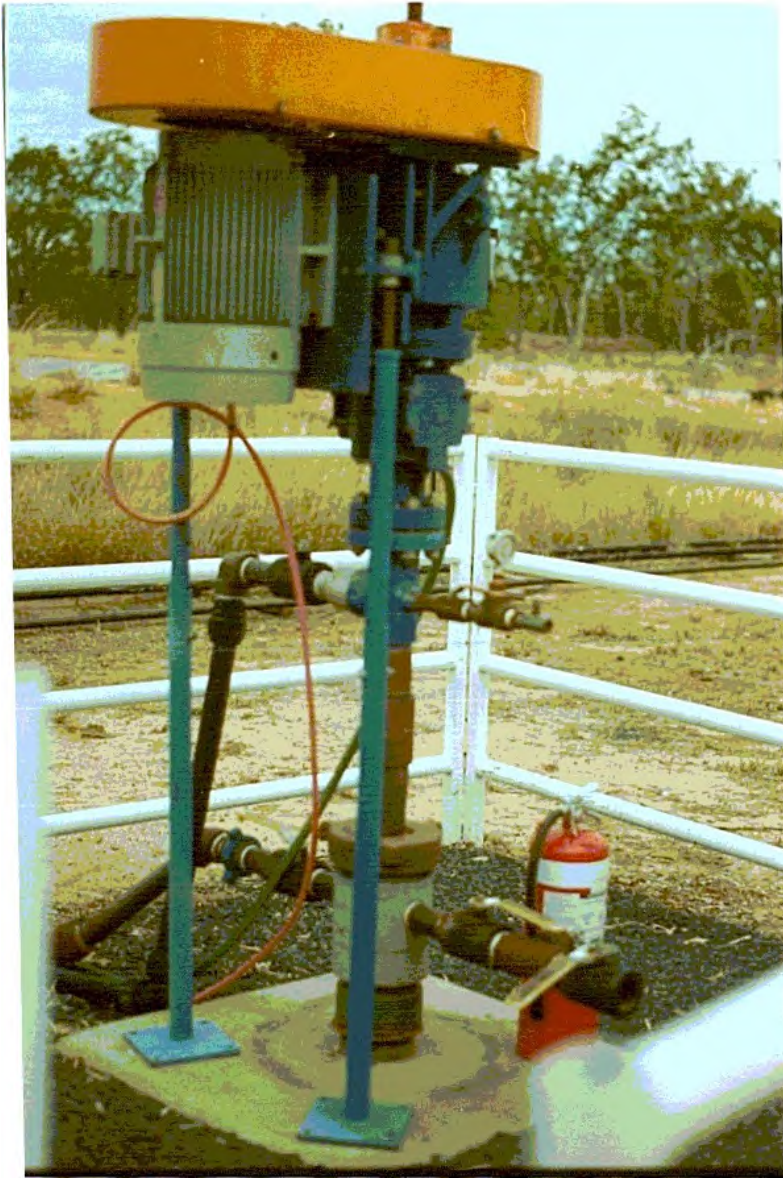
Plus Fraccing





Horizontal Well Footprint at Surface



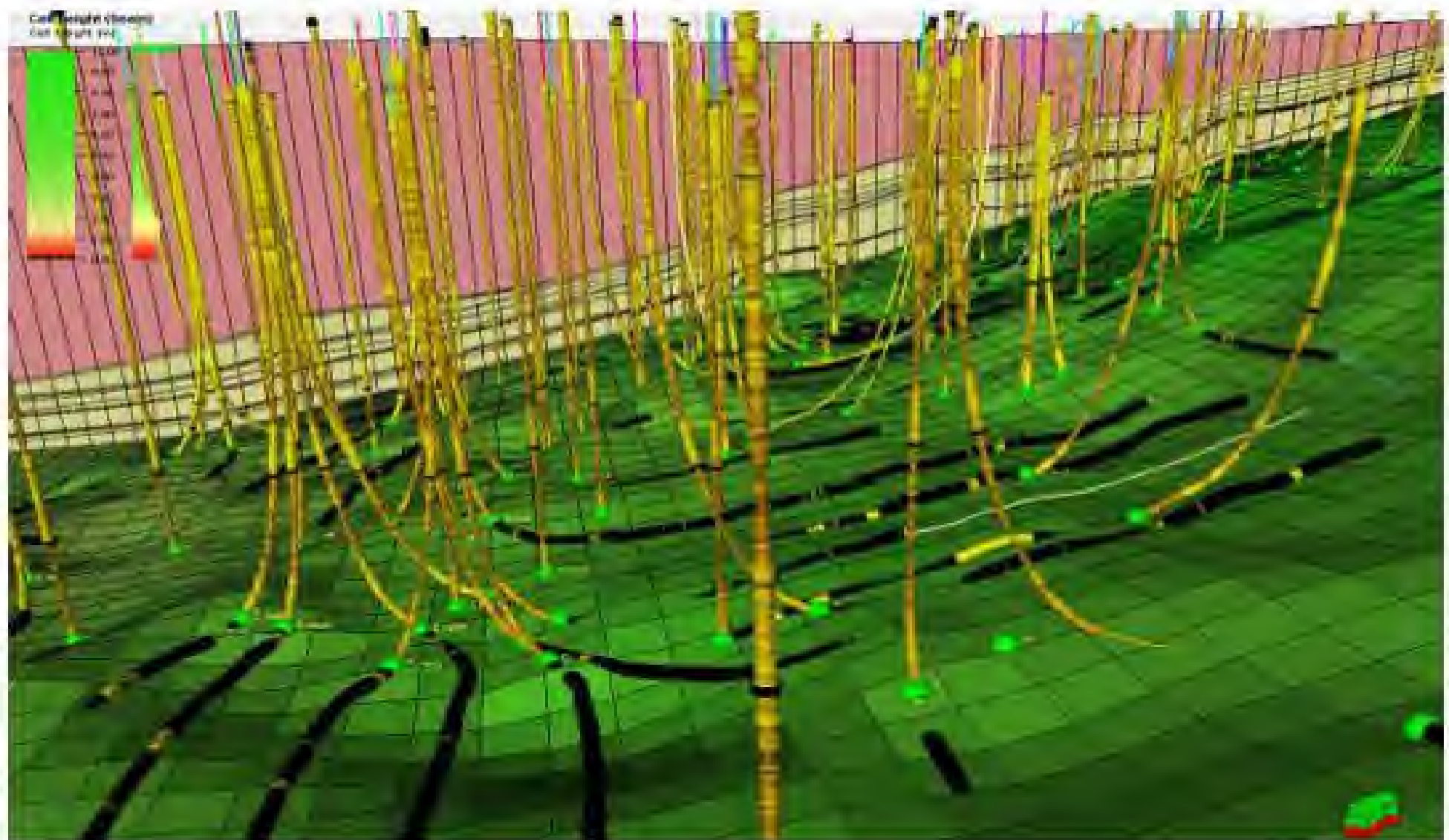


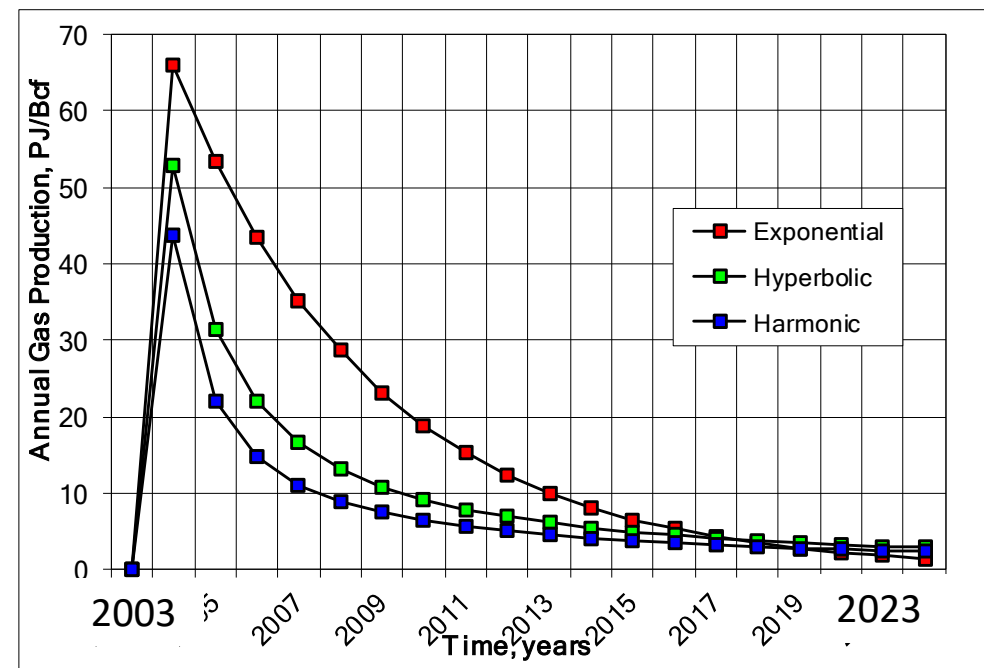
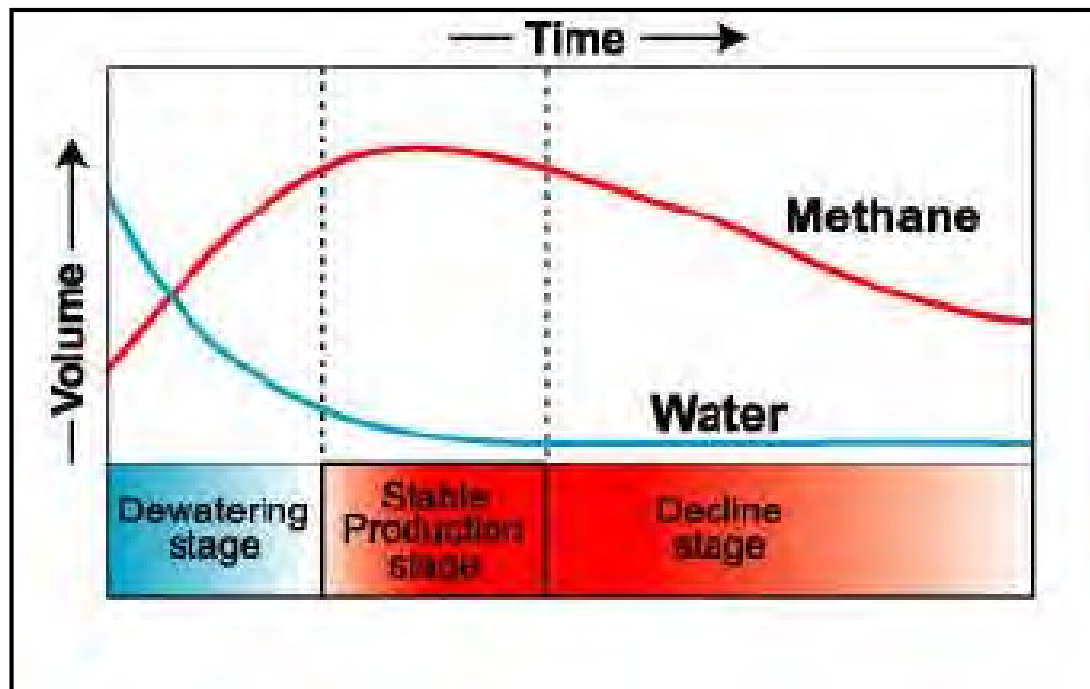
Producing
CBM
Well Head
Footprint
CSG has
larger BOP

Evaporation Pond & Pipework

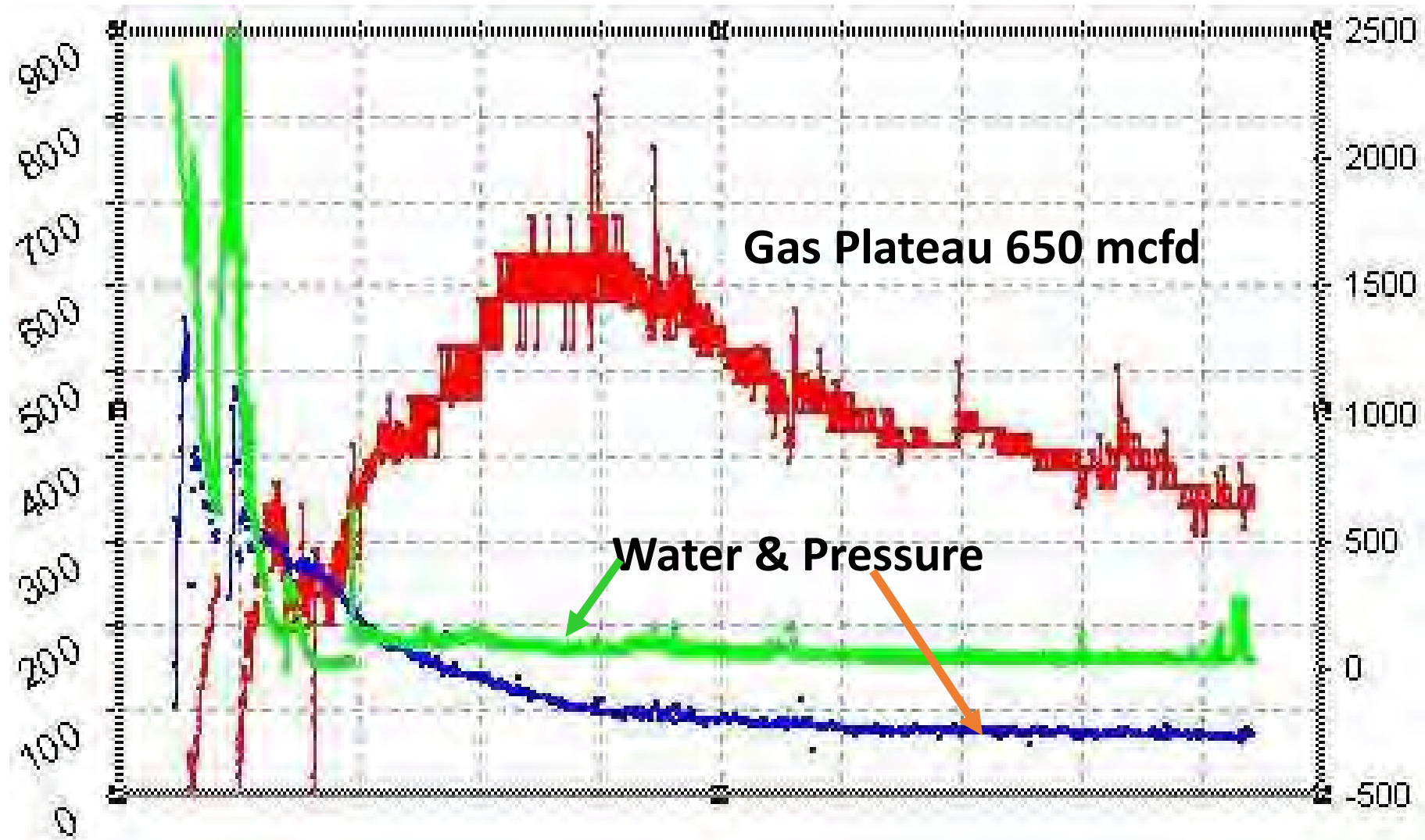




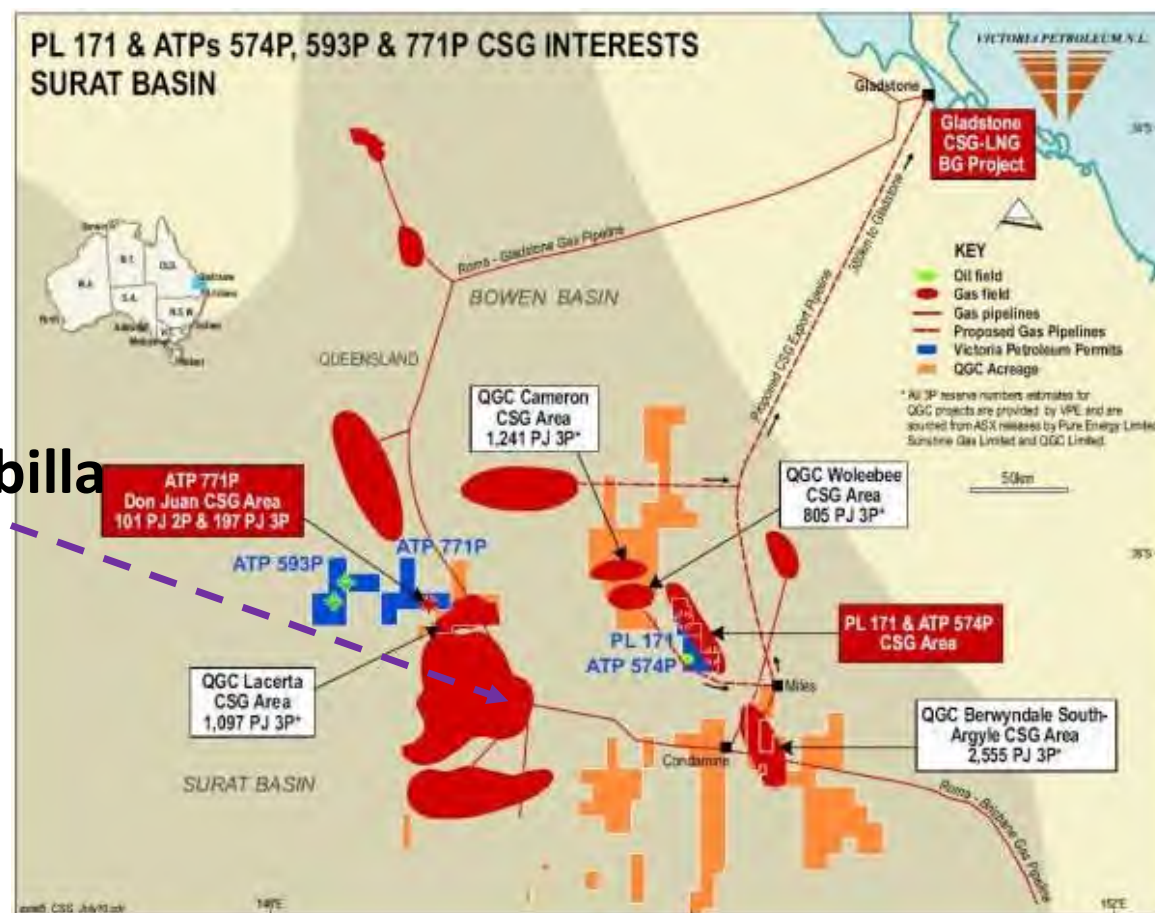
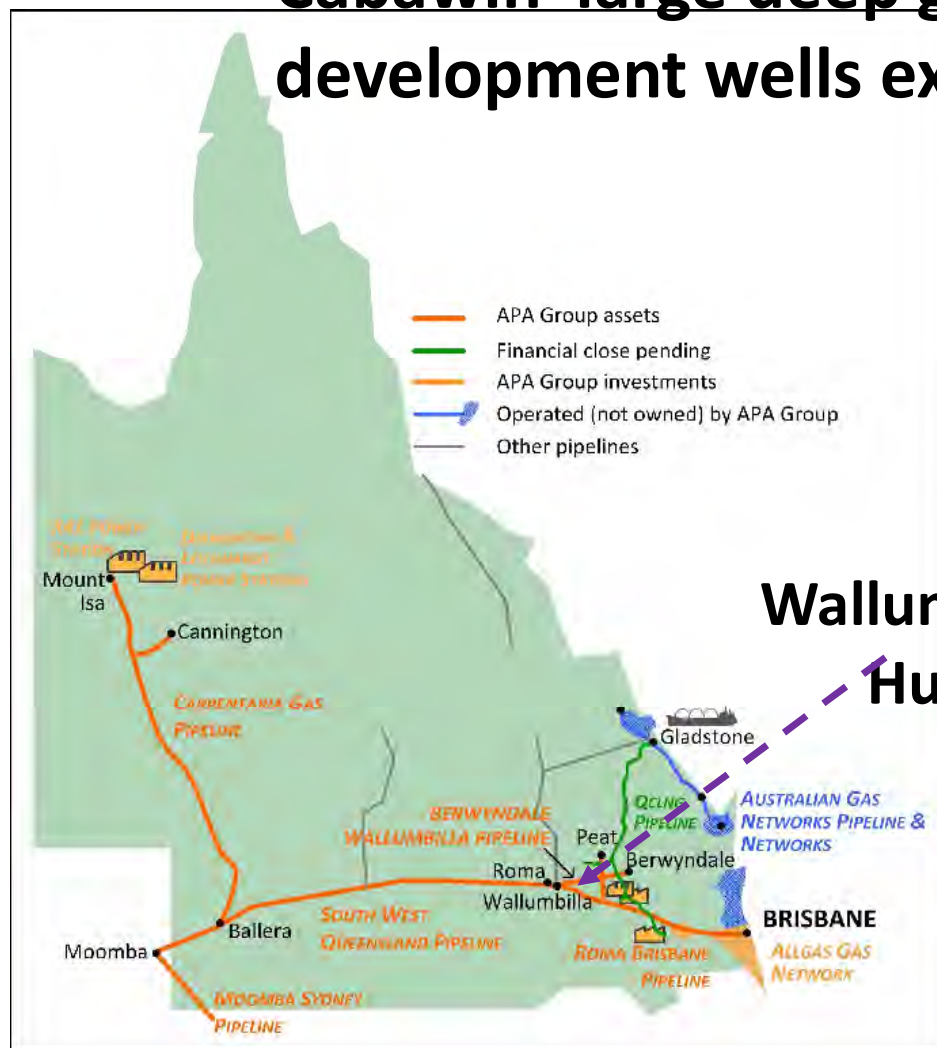


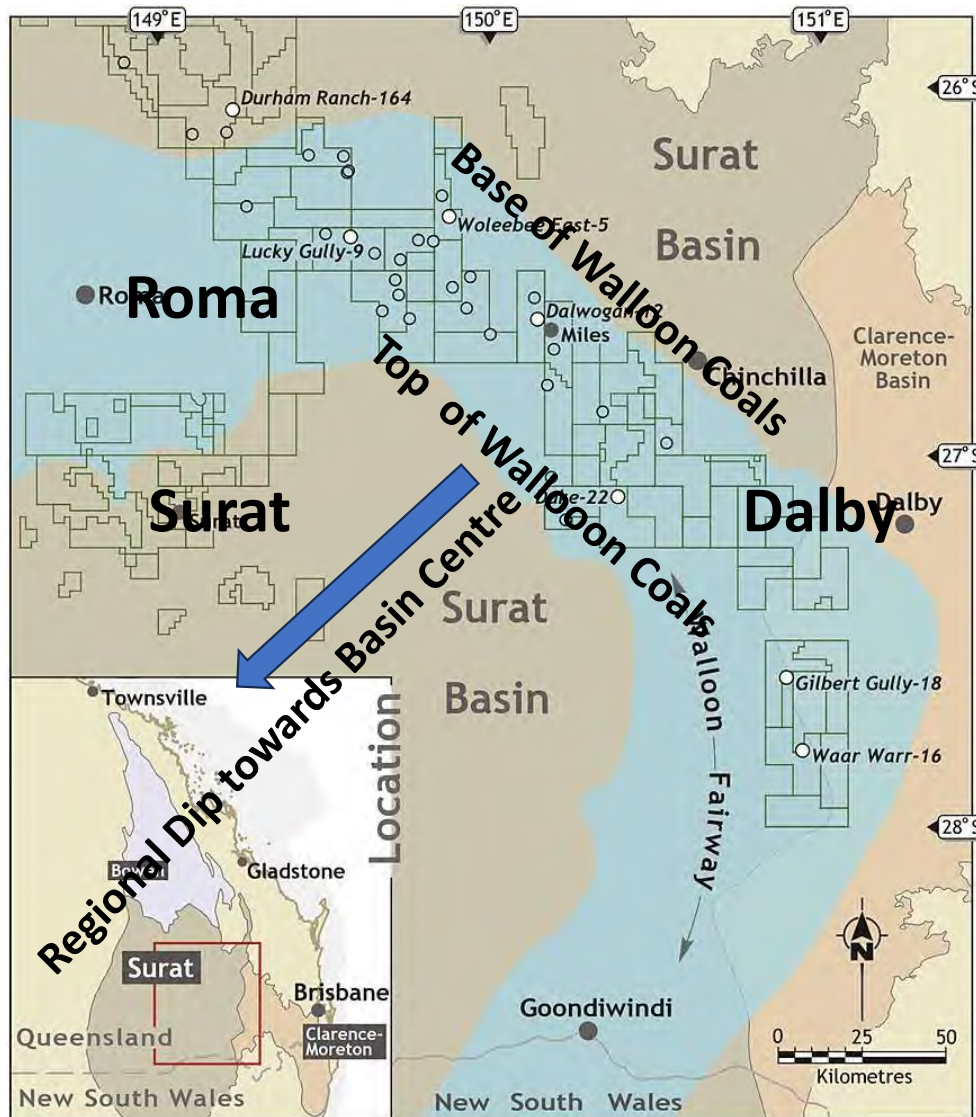


Gas, Water & Pressure Data



Cabawin large deep gas condensate discovery. Appraisal and development wells expensive, no pipeline available





Legend

- | | | |
|------------------------------------|----------------------------|------------|
| Origin and APLNG permit boundaries | Wells included in study | Study area |
| Town | Wells with stress profiles | |

As Walloon Coals get deeper to SW pressure and gas content increase, but permeability decreases

Phase 2 of Arrow/Shell Walloons Gas Project announced 12th Aug 2024

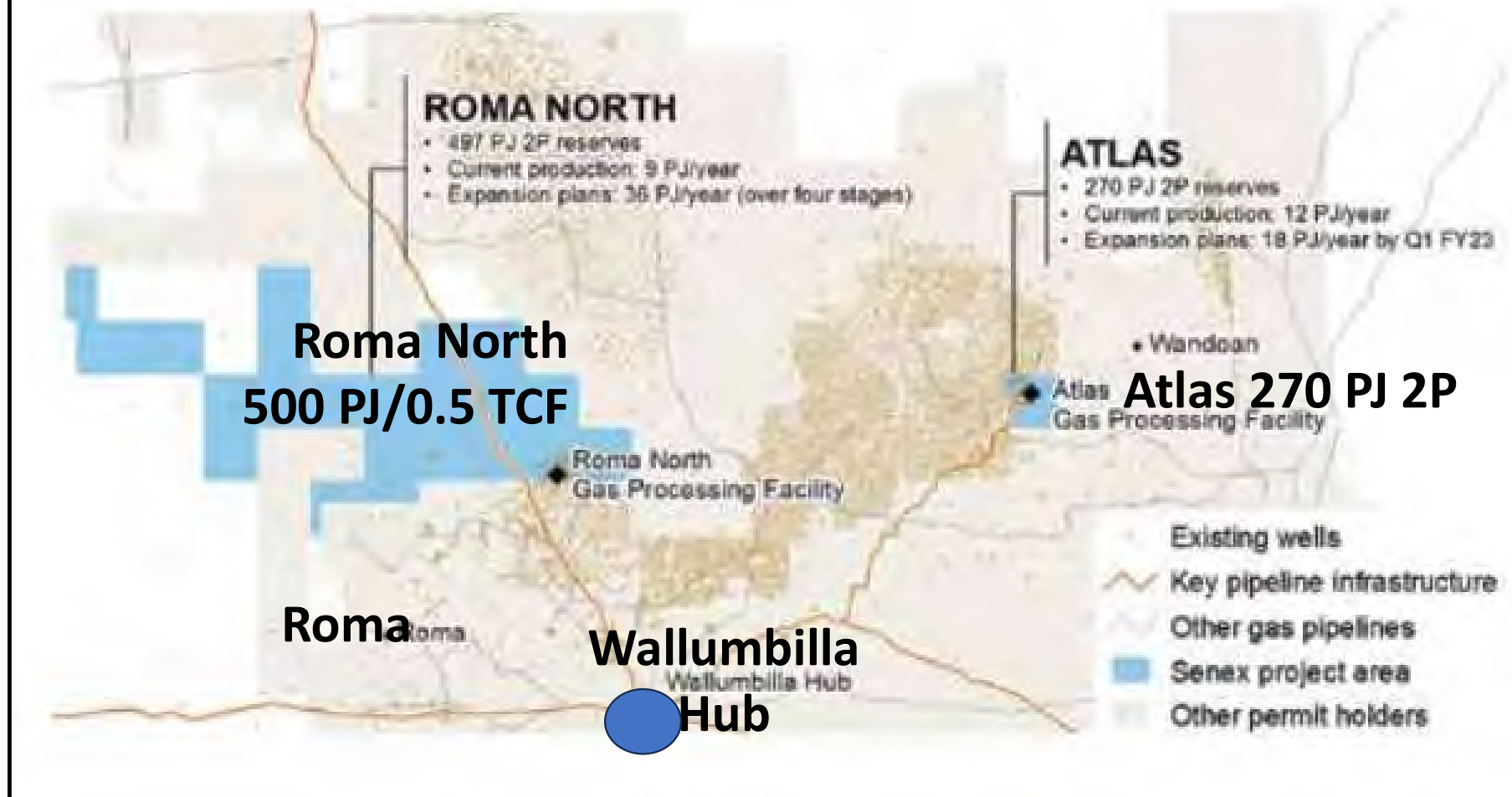
Gas from 450 wells to Shell-operated QCLNG liquefied natural gas (LNG) facility on Curtis Island, Gladstone.

27-year gas sales agreement. Peak Production ~22,400 boe/day (or 130 mmscf or 0.13PJ/d).

New field compression station, 27 km of new pipeline and road and infrastructure upgrades. **First gas in 2026.**

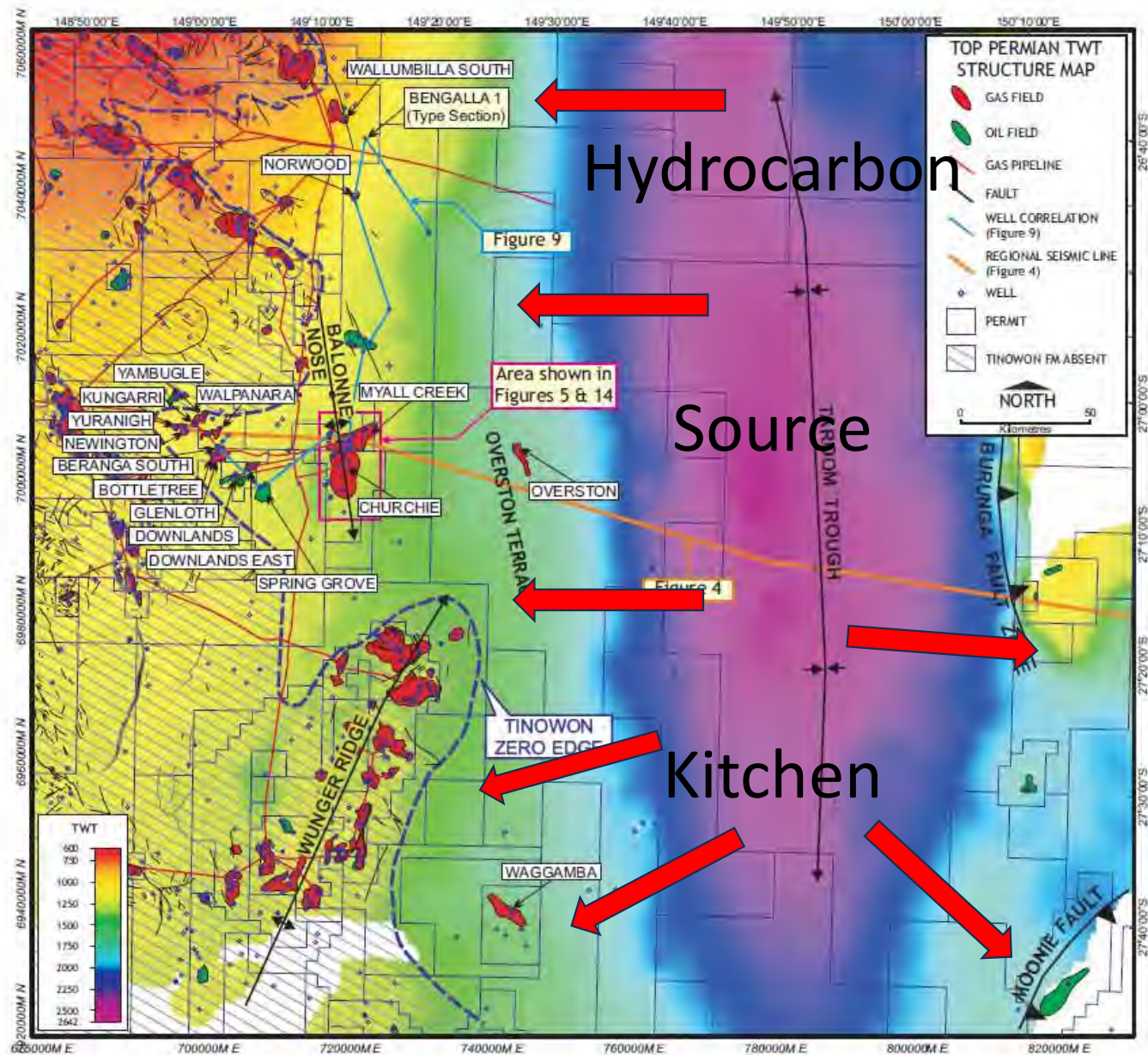
QCLNG 1000th cargo late 2023.

Senex Surat Basin development area **Senex Expansion ~650 Walloon CBM wells**



Future Prospectivity in and adjacent to Taroom Trough

- 1. Permian gas and Oil in overpressured Taroom Trough**
- 2. Permian CSG thermogenic Coal Seam Gas round flanks of Taroom Trough**
- 3. Walloons CBM down dip from existing production**
- 4. Oil Shale (Tertiary)**
- 5. Shale Oil (Cretaceous)**
- 6. Geothermal from Granites?**
- 7. Carbon Capture and Storage CCS - NEVER**



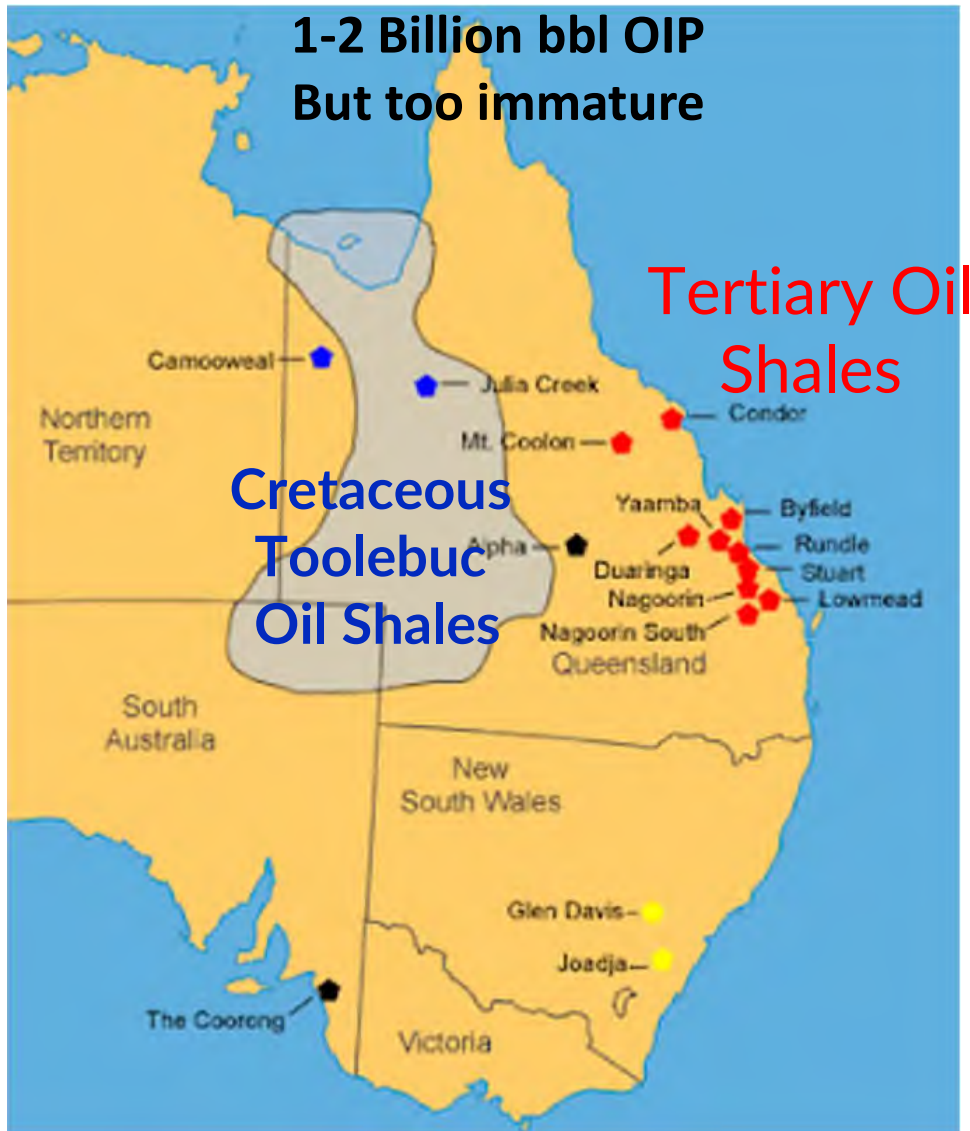
Hydrocarbon

Source

Kitchen

Cretaceous Toolebuc Oil Shale

**1-2 Billion bbl OIP
But too immature**



Kinta Hoffman MSc 1986

Upper Albian Toolebuc consists of upper interbedded chalk and Inoceramus-rich coquinite, overlying laminated, rich pelletal, kerogenous chalk/oil shale

Tertiary Oil Shales

Surat Basin & Taroom Trough

HISTORY

Early Gas: Roma Shelf – Jurassic & Triassic - Cathedral

Early Oil: Cabawin, Moonie, Alton, Fairymount: Jurassic, Triassic & Permian

Oil & Gas Generation Primer Conventional & Unconventional

PVT, Vr, Coal Rank, Gas & Liquids,

CBM biogenic - Coal Bed Methane: Cretaceous & Permian

CSG thermogenic - Coal Seam Gas : Permian

Oil Shale (Tertiary) & Shale Oil (Cretaceous)

CCS Carbon Capture and Storage

Future Potential & Problems



Only 1 in 10 conventional hydrocarbon wells are a success

Dilbert (Used with permission of United Feature Syndicate.)



CBM CSG Wells find coal 99% of the time

But not all of them are commercial.

Which
country
has NET
ZERO?

