

South Australian Energy Exploration Opportunities

Energy Roundtable

Geological Survey of South Australia

Chris Cubitt | 22 October 2024



Disclaimer

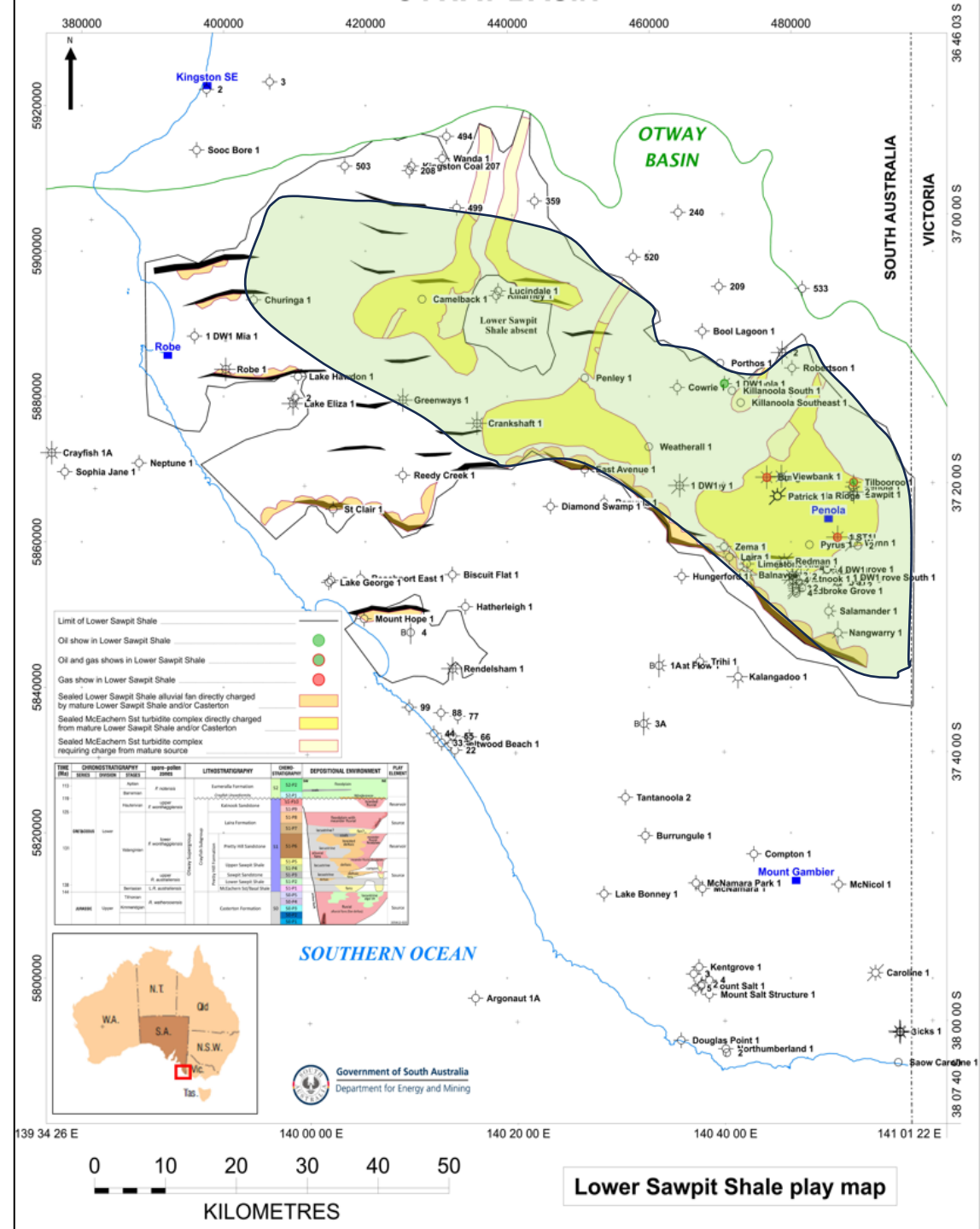
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Agenda

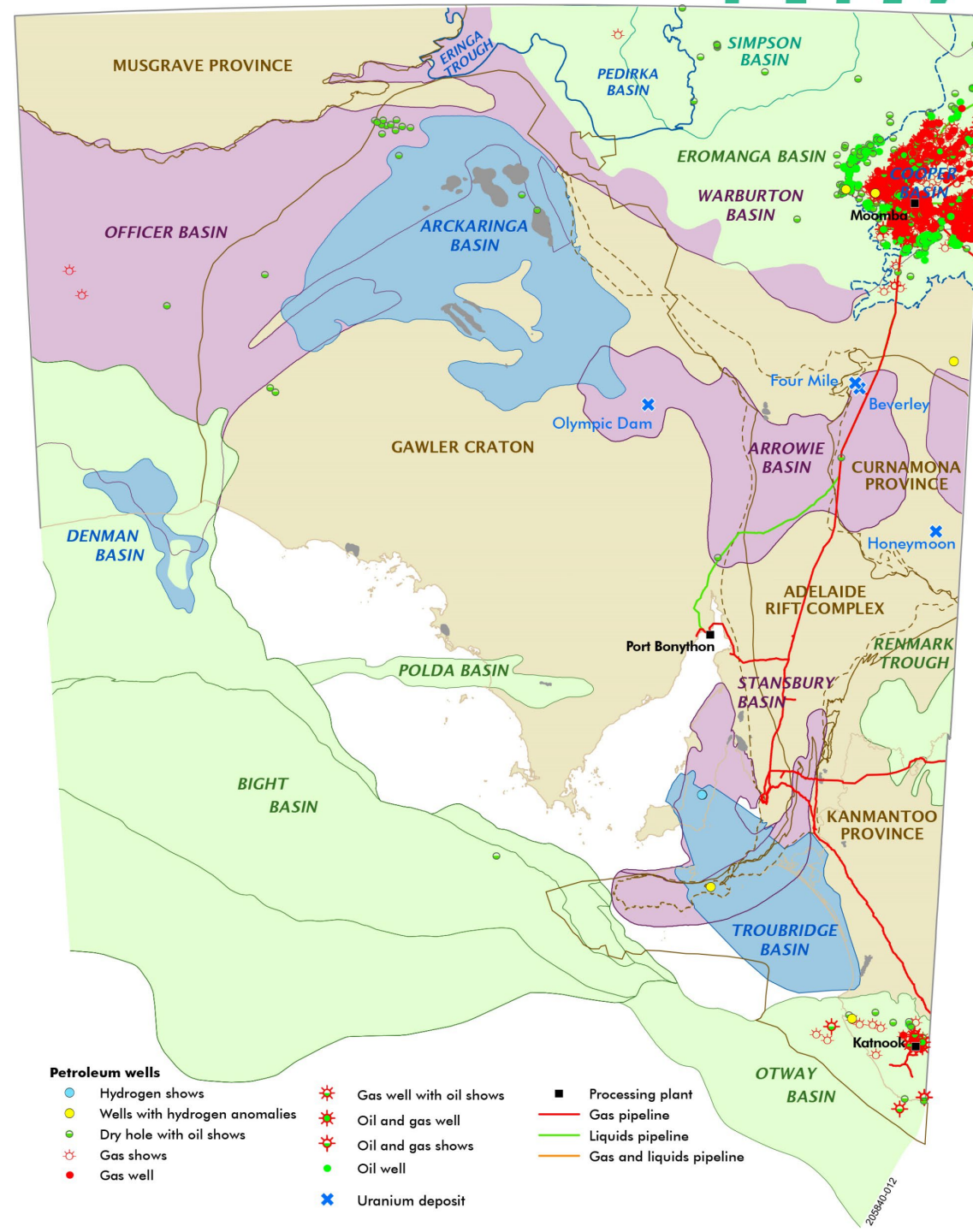
- Introduction
- Natural gas opportunities
 - Otway Basin
 - Cooper Basin
 - Warburton Basin
 - Frontier Basins
- Gas storage
- Carbon capture storage (CCS)
- Natural hydrogen exploration update



South Australia offers...

- Proven gas basins with infrastructure
- Tested and new oil and gas plays
- Opportunities in frontier basins with *bona fide* oil and gas shows

- Gas storage, CCUS, enhanced oil recovery (EOR) and natural hydrogen licensing regime in place
- Energy transition ready legislation *Energy Resources Act 2000* in place



Energy Resources Act 2000 is now in effect

The *Energy Resources Act 2000* and updated regulations came into force on 11 April 2024

For more information



Significant amendments

- **Regulated substances licences now available (e.g. oil, gas, hydrogen, helium)**
- **Transmission pipelines now allow for transport of manufactured hydrogen and imported substances (e.g. LNG)**
- **Ministerial approval required for >20% change in control of a licence**
- **The Crown has priority over a licensee's property in event of bankruptcy**

The onshore Otway Basin | A new opportunity

Whole of basin PSM

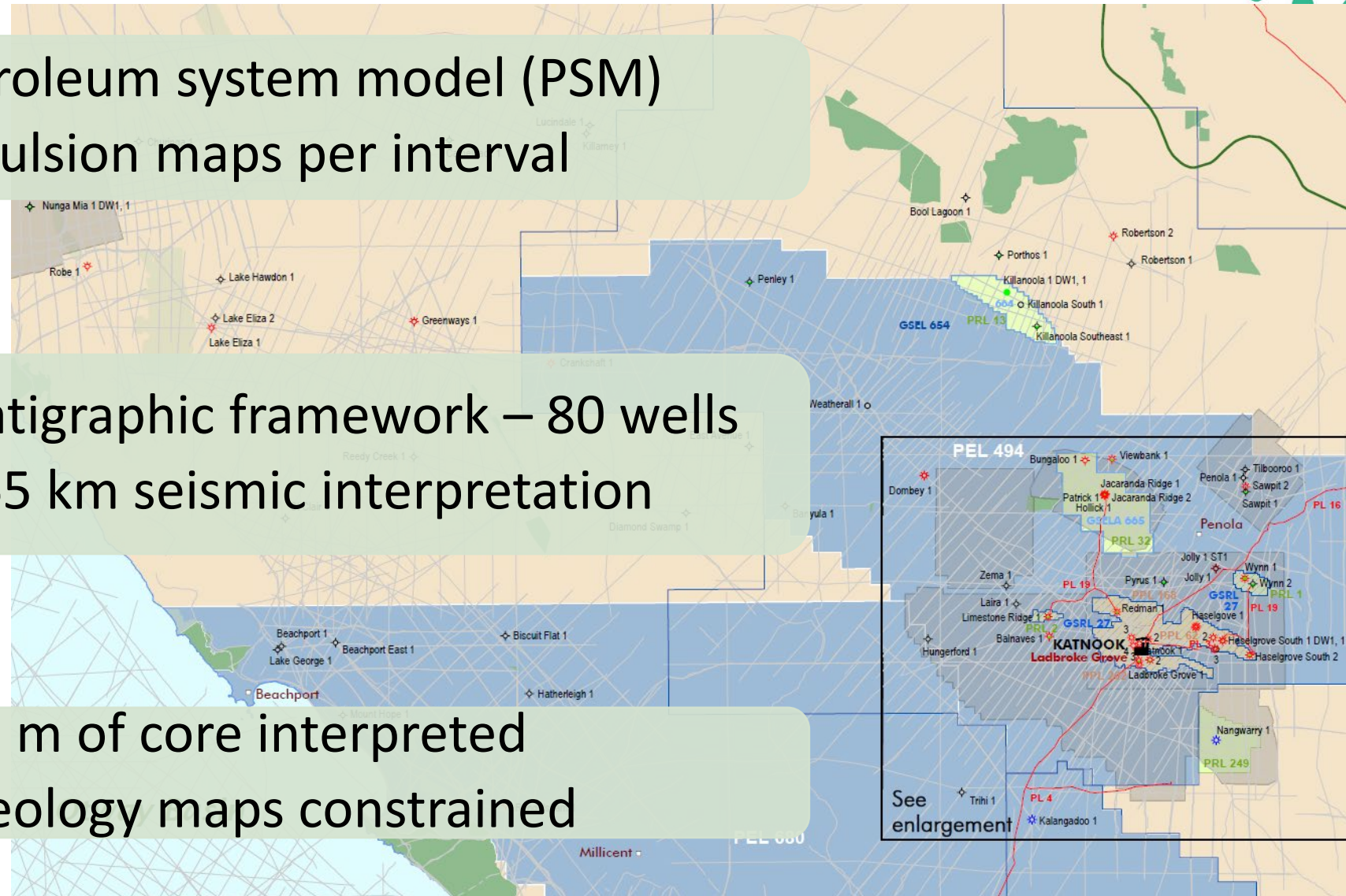
- Petroleum system model (PSM)
- Expulsion maps per interval

Seismic and wells

- Stratigraphic framework – 80 wells
- 7965 km seismic interpretation

Cores and maps

- 772 m of core interpreted
- 6 geology maps constrained



A new play defined!

- A new interpretation, based on core, has been made for the McEachern Sandstone interval of the Lower Sawpit Shale

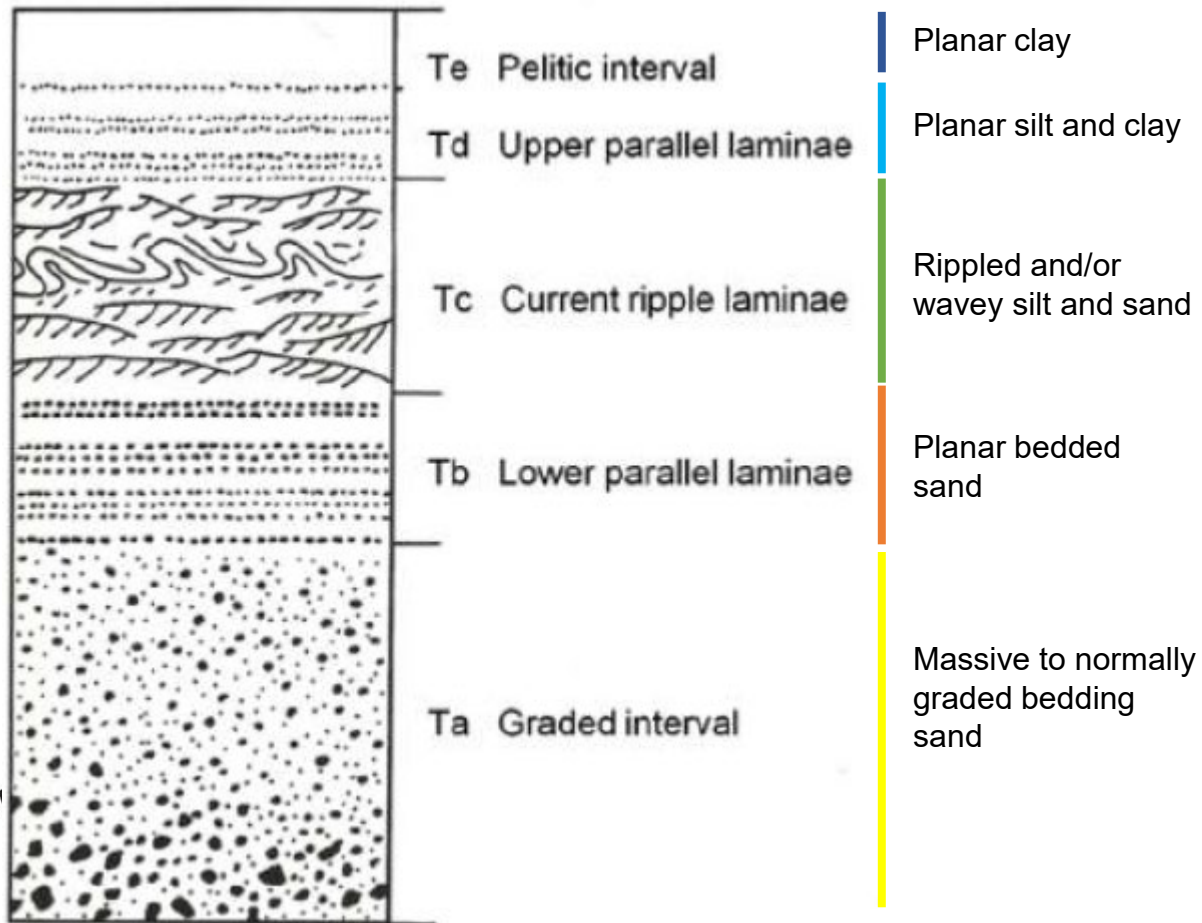
TIME (Ma)	CHRONOSTRATIGRAPHY			spore-pollen zones	LITHOSTRATIGRAPHY	CHEMO-STRATIGRAPHY	DEPOSITIONAL ENVIRONMENT	PLAY ELEMENT				
	SERIES	DIVISION	STAGES									
113	CRETACEOUS	Lower	Aptian	<i>P. notensis</i>	Eumeralla Formation	S2	S2-P2	SW floodplain NE				
119			Barremian		Crayfish Unconformity	S2-P1	Windermere					
125			Hauterivian	upper <i>F. wonthaggiensis</i>	Katnook Sandstone	S1-P10	braided fluvial	Reservoir				
						S1-P9						
						S1-P8	floodplain with meander fluvial	Source				
						S1-P7	lacustrine? fan?					
131				Valanginian	lower <i>F. wonthaggiensis</i>	Pretty Hill Sandstone	S1	S1-P6	lacustrine braided deltaic meander fluvial-floodplain	Reservoir		
						Upper Sawpit Shale	S1-P5	S1-P4	alluvial fans lacustrine meander fluvial-floodplain	Source		
						Sawpit Sandstone	S1-P3	S1-P2	lacustrine deltaic deltaic fans	Source		
138				Berriasian	upper <i>R. australiensis</i>	Lower Sawpit Shale	S1-P1	S1-P1	deltaic turbidite fans			
144	JURASSIC	Upper	Tithonian	<i>L.R. australiensis</i>	McEachern Sst/Basal Shale	S0-P5	S0-P5	active fault alluvial fans lacustrine				
			Kimmeridgian		<i>R. watheroensis</i>	Casterton Formation	S0	S0-P4	S0-P3	S0-P2	S0-P1	turbidite fans alluvial/fluvial

From Kirk (2024)

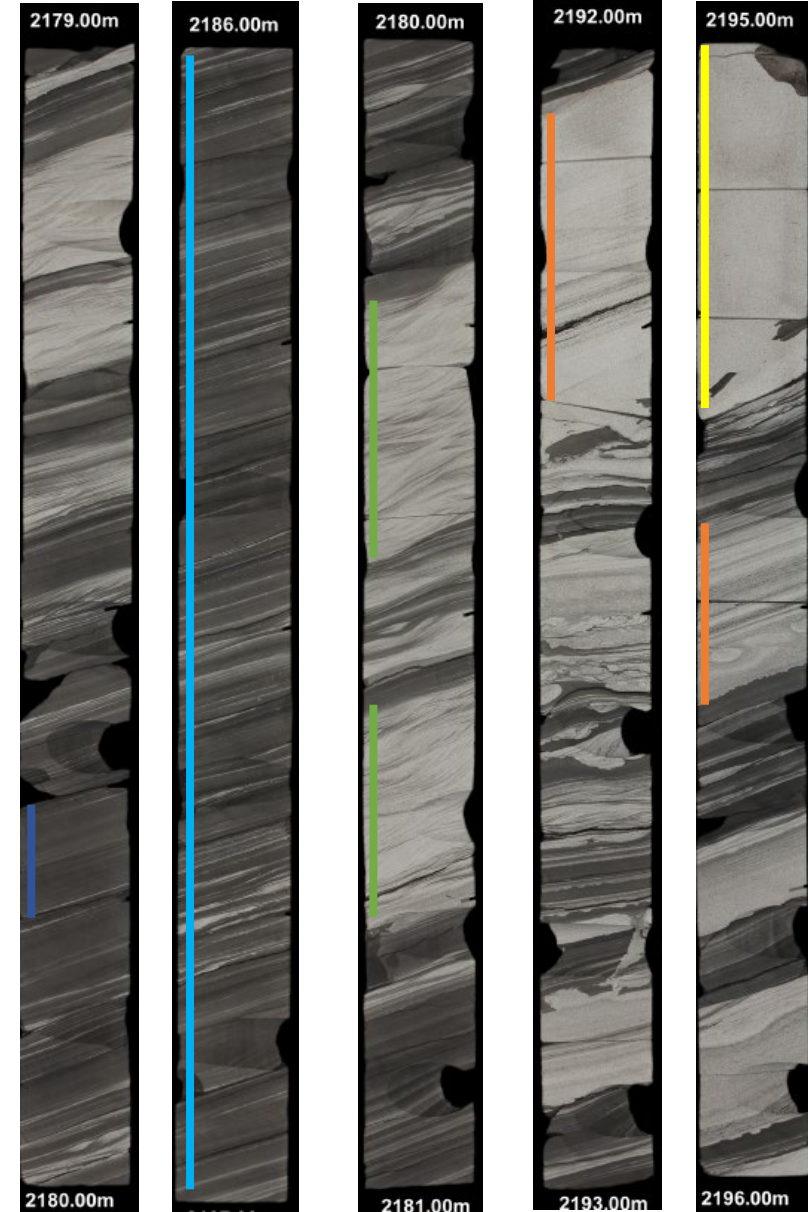


Lacustrine turbidites

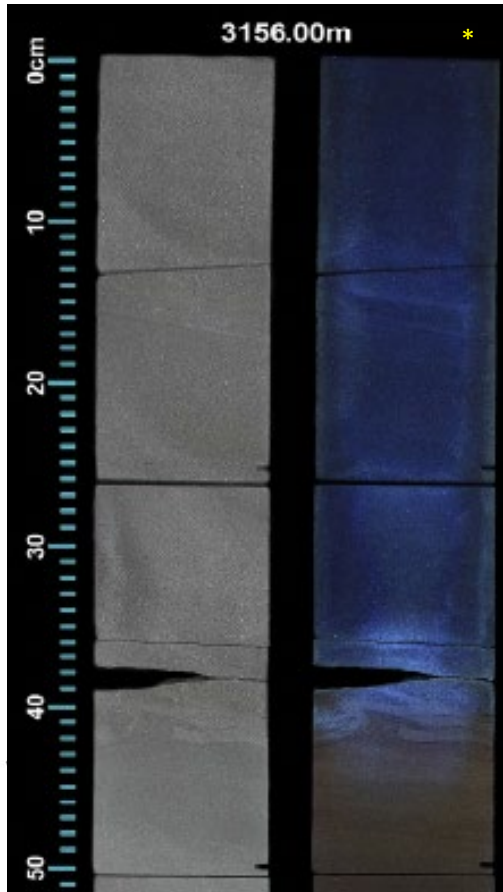
Sawpit-2



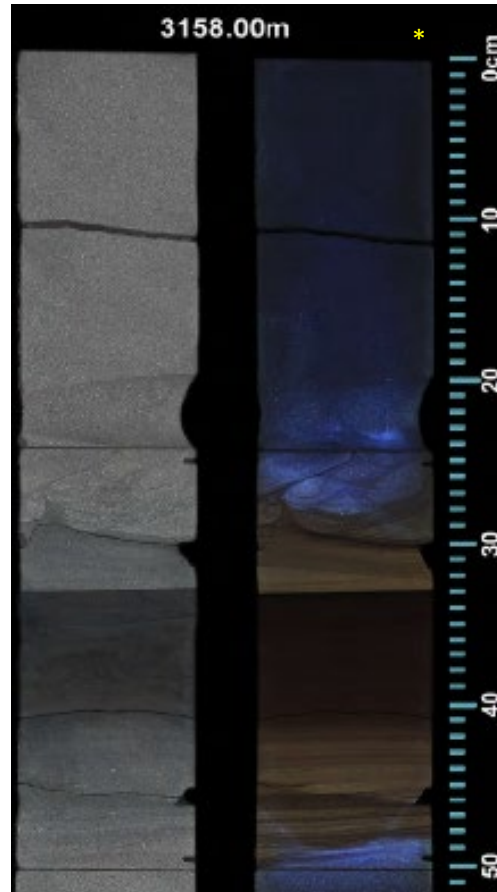
Soft sediment deformation/loading/flames



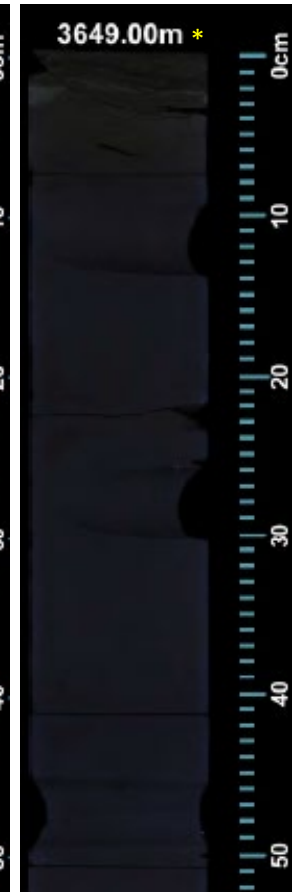
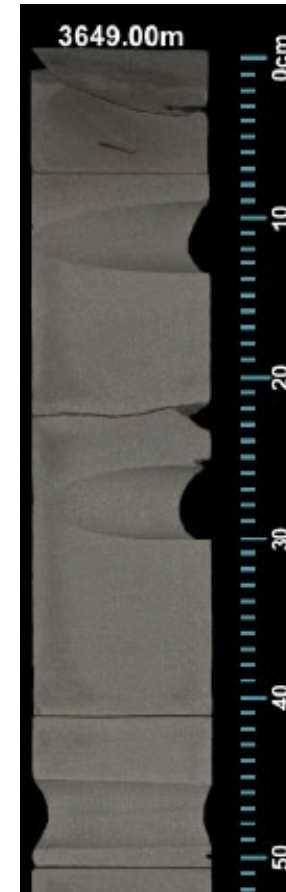
An active hydrocarbon system Observed at Bungaloo-1 and Jolly-1ST1



Bungaloo-1
Left and right
Blue fluorescence
under UV light *
Gas summary (ppm)
3148-3161 mDD
C1 7823, C2 1,614, C3
1113, iC4 190, nC4
303, iC5 91, nC5 88
70/14/10/2/3/1/1

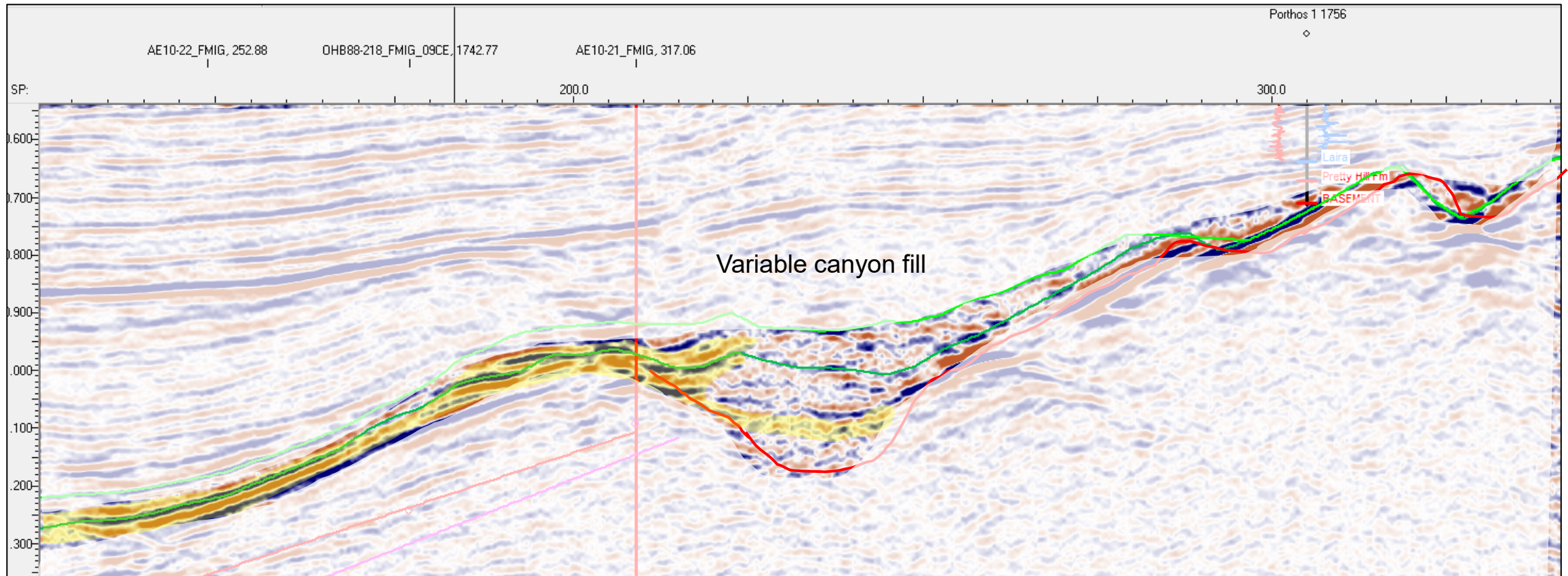
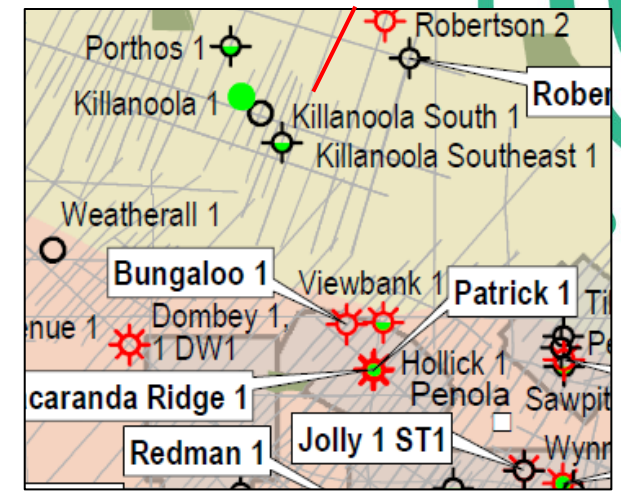


Jolly-1ST 1
Right
Dull blue fluorescence
under UV light *
Gas summary ppm
3640-3667 mDD
C1 38526, C2 4577,
C3 1015, iC4 230, nC4
121, iC5 68, nC5 19
86/10/2/1/<1/<1/<1



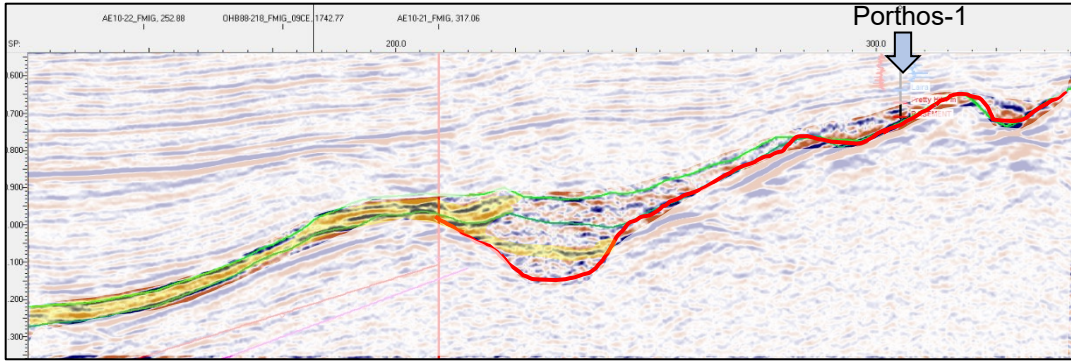
Away from well control

Seismic supports the new play



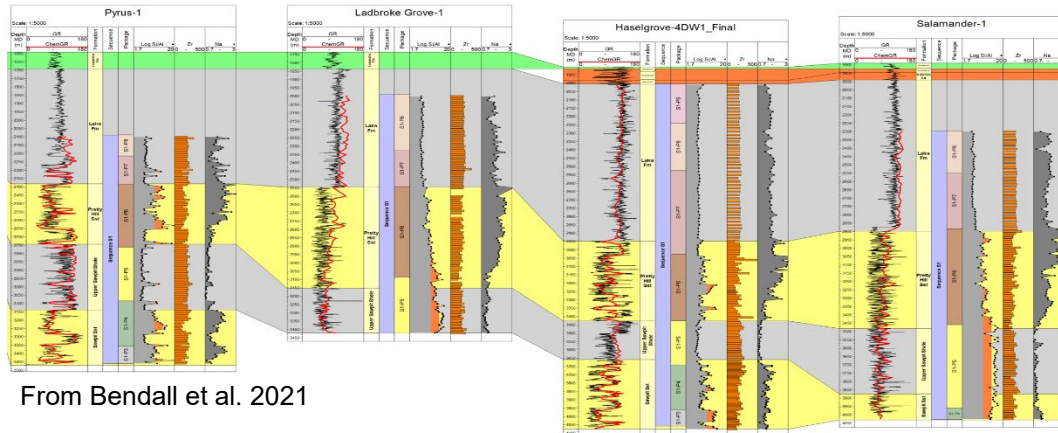
Otway Basin PSM project

Seismic – infill - horizons, faults and seismic facies mapping



From Tiainen et al. 2024

Wells – framework - provided the fundamental correlation

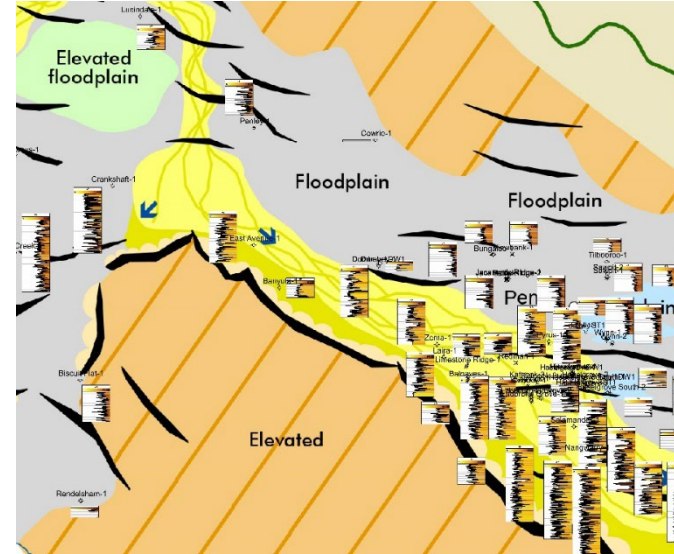


From Bendall et al. 2021

Core – ground truthing - depositional environment

Vertical label: Pretty Hill Sandstone – GDE map

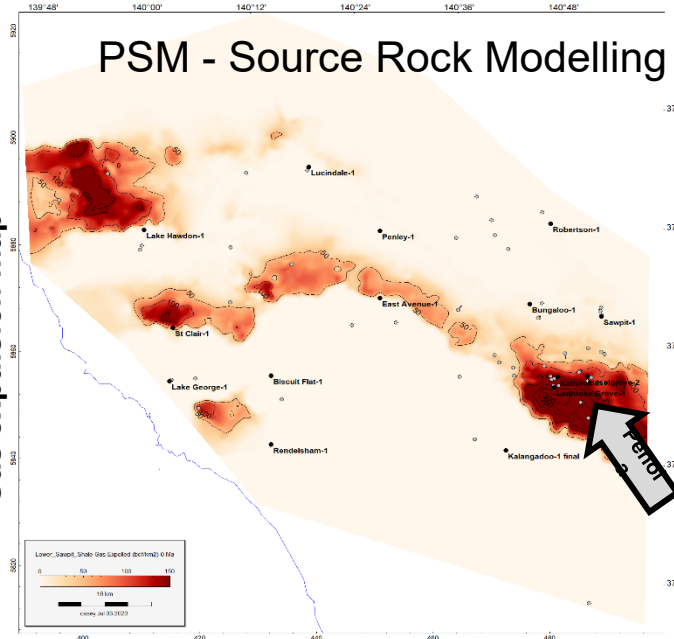
GDE Mapping | All levels



From Cubitt et al. 2024

Vertical label: Lower Sawpit Shale/McEachern - Gas expulsion map

PSM - Source Rock Modelling



From Edwards et al. 2024

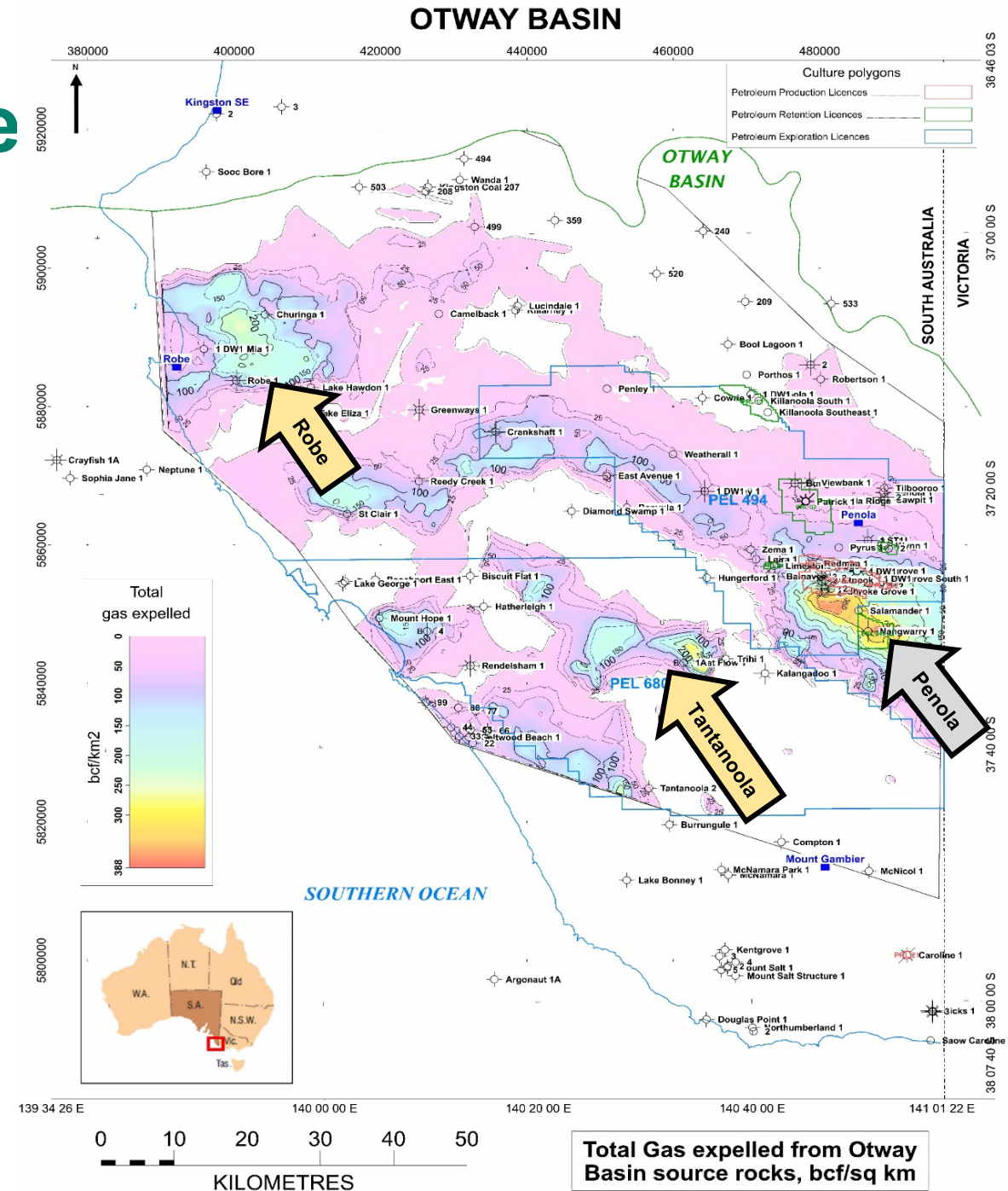
New Otway opportunities

- Petroleum
- Gas storage
- Geothermal
- Hydrogen?

Otway PSM | Out of Acreage Opportunities

Significant potential remaining in the Penola Trough (grey)

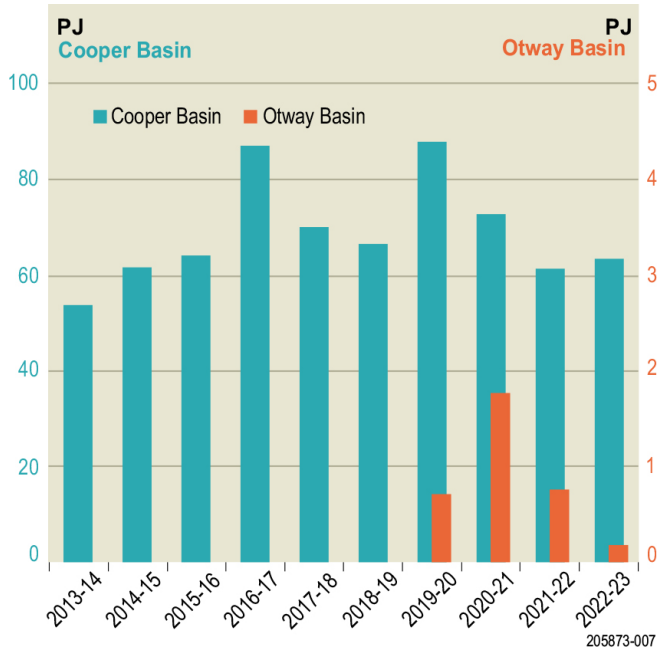
The under-explored Robe and Tantanoola Troughs (yellow arrows) have been identified for the first time as regions of significant gas expulsion



The Cooper Basin | SA's gas engine

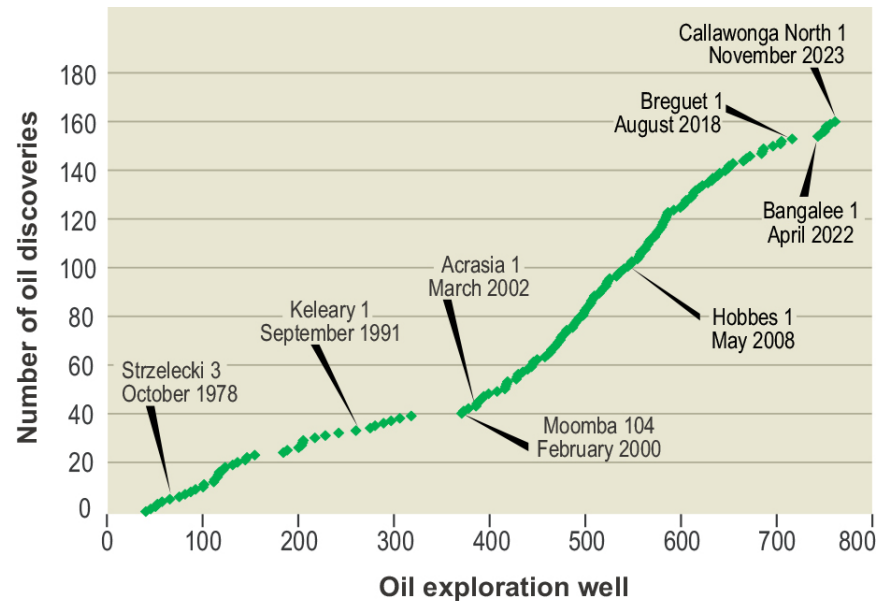
The SA Cooper Basin offers a variety of established oil and gas plays with opportunities for CCUS and net zero petroleum projects

DEM - From PESA News – May 2024

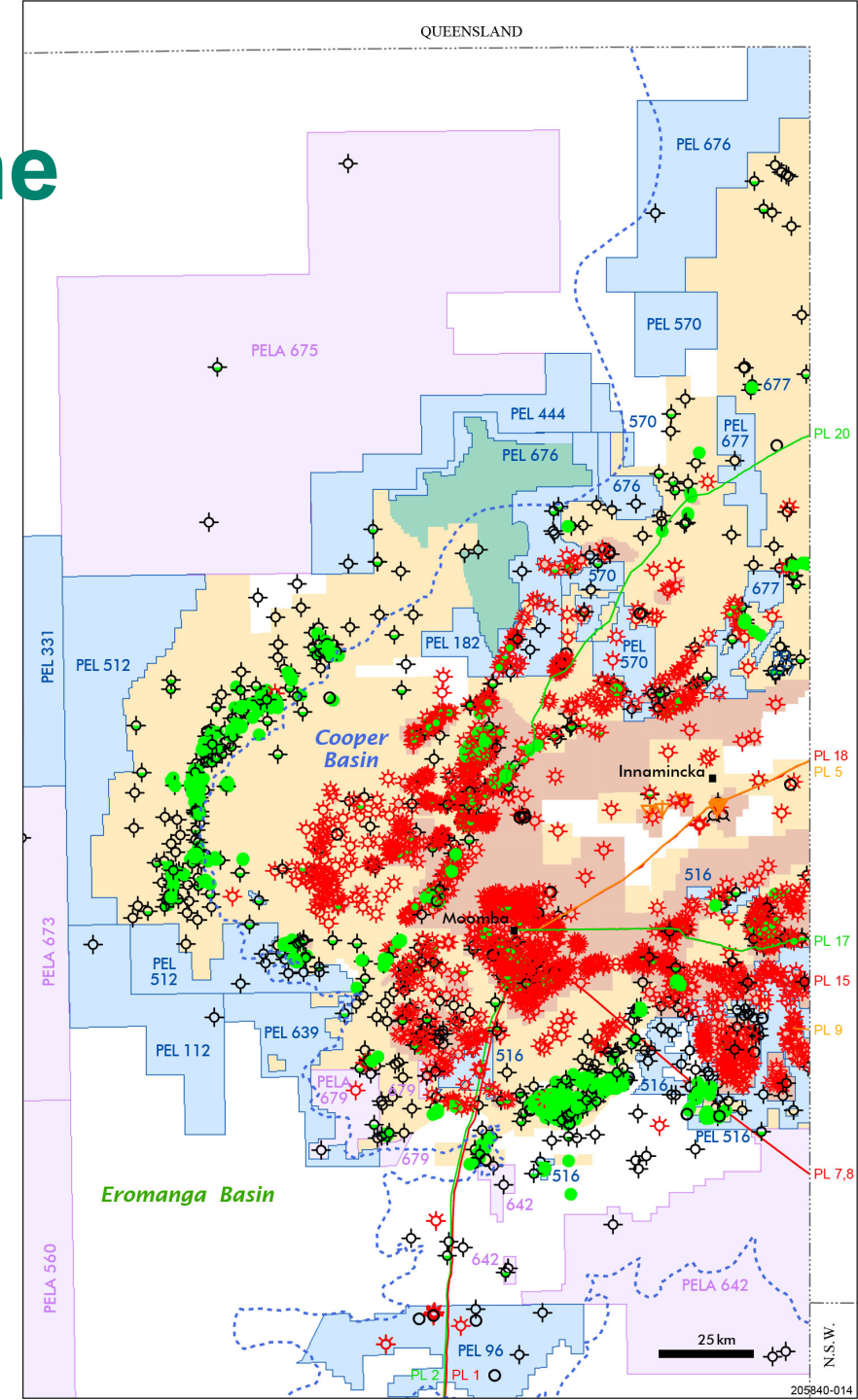


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DEM - From PESA News – May 2024



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Warburton Basin | Daralingie Shelf

Aim - generate new datasets and new exploration concepts to stimulate the next exploration phase in the Warburton and Cooper Basins

Publications

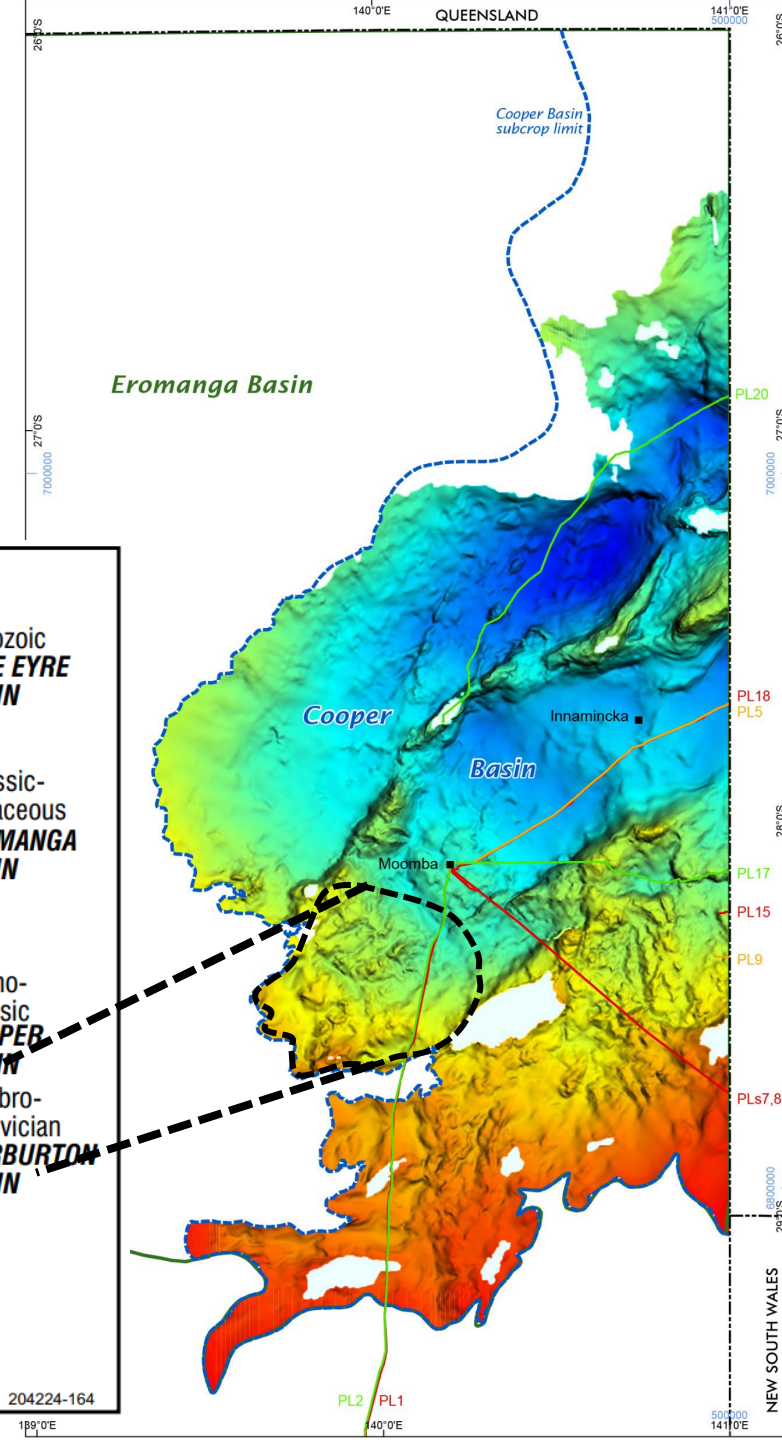
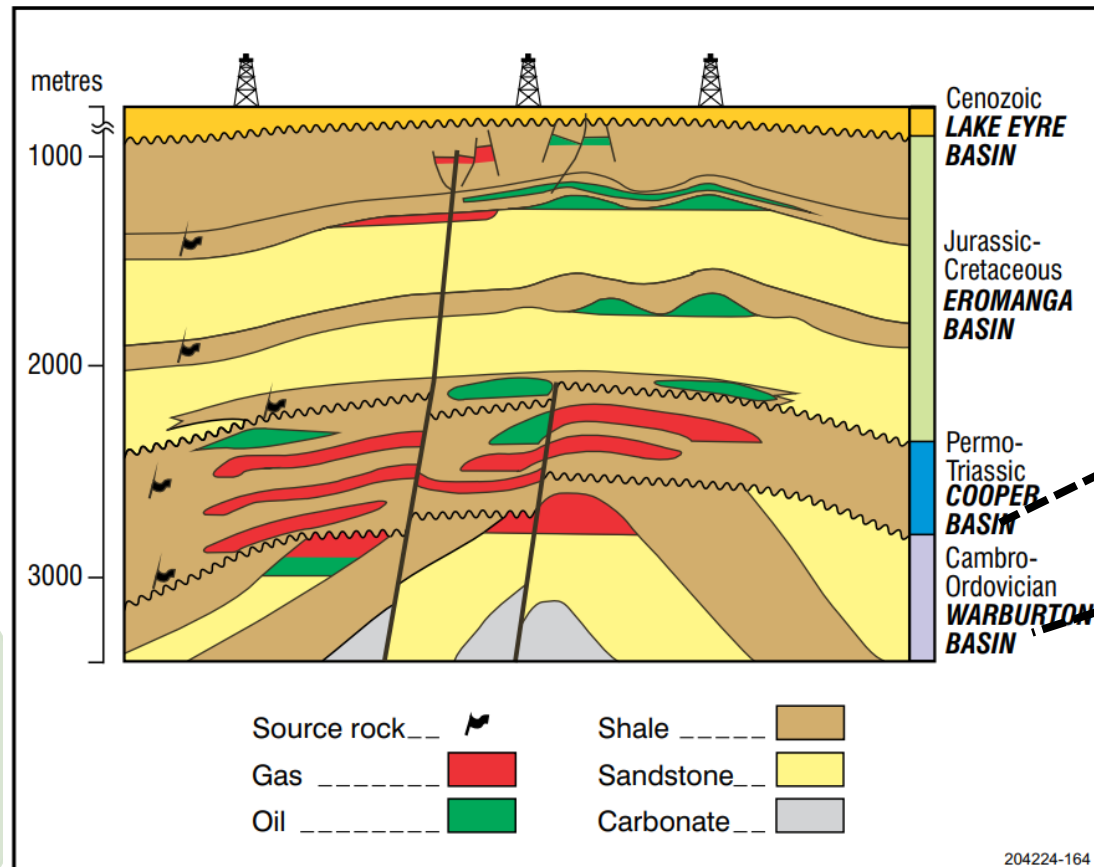
- Outcomes of all major studies will be incorporated

Seismic and Wells

- Stratigraphic framework ~100 wells
- 2D cubed seismic interpretation

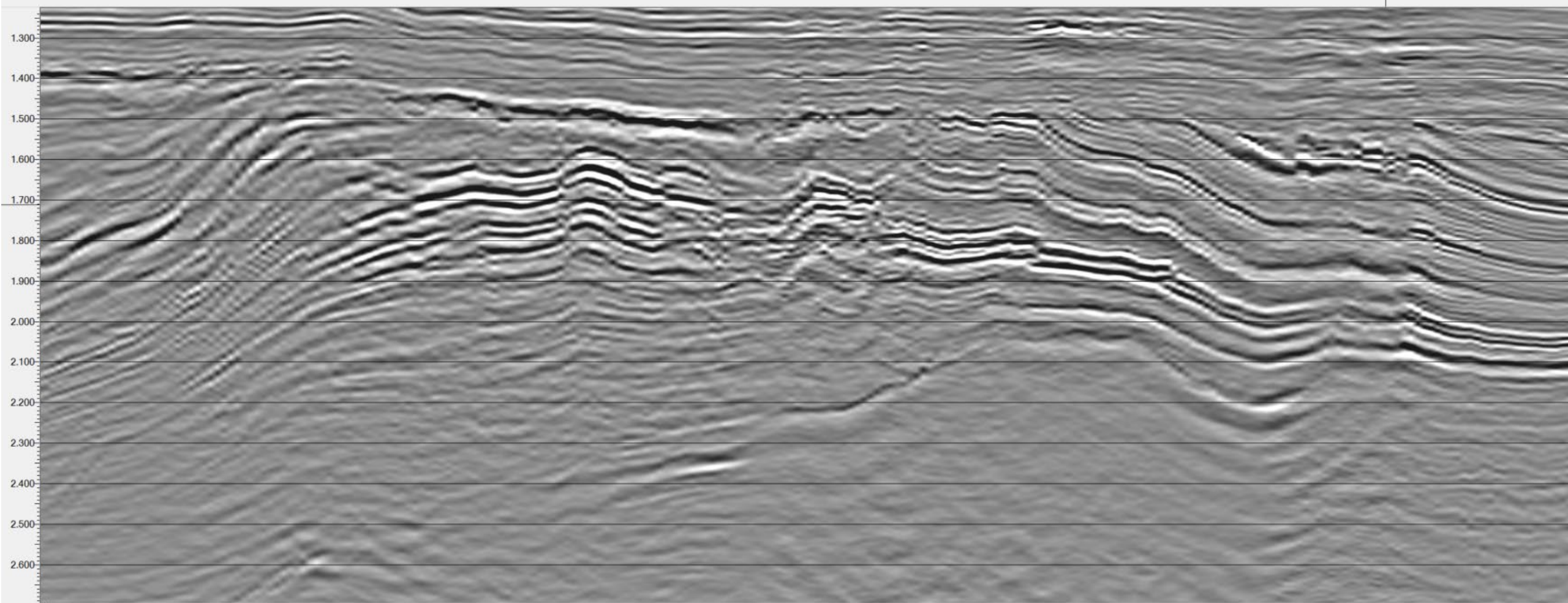
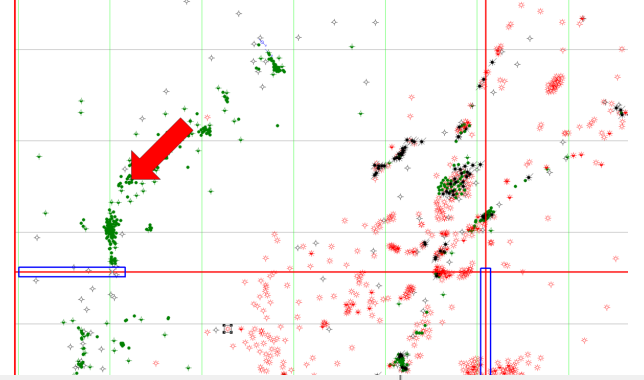
Cores and Maps

- ~400 m of core from 25 wells - standardised interpretation
- Sub-crop maps constrained



Warburton Basin | Daralingie Shelf

Seismic



Frontier areas | Officer Basin

Approx well location
(10km NW of Marla)

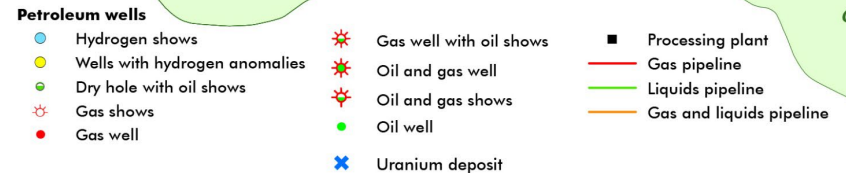
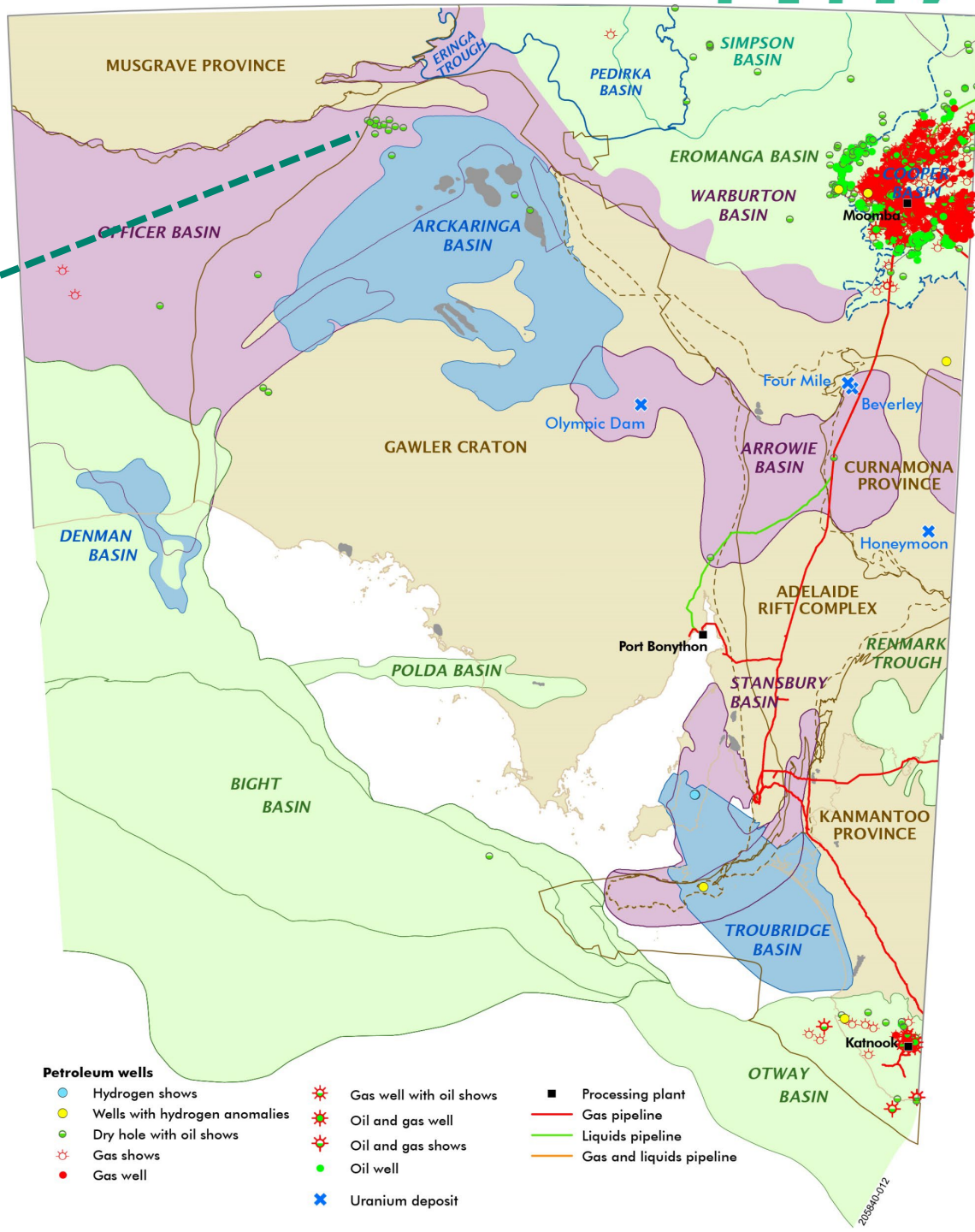
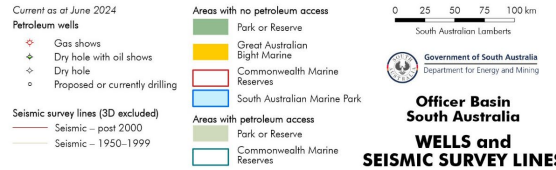
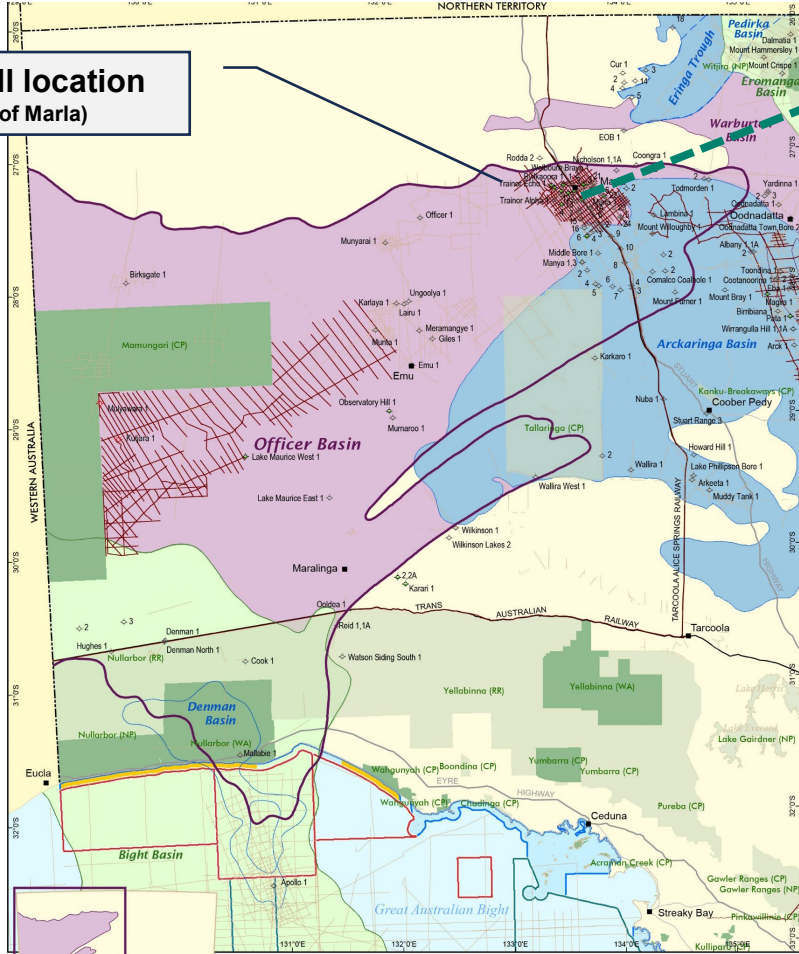
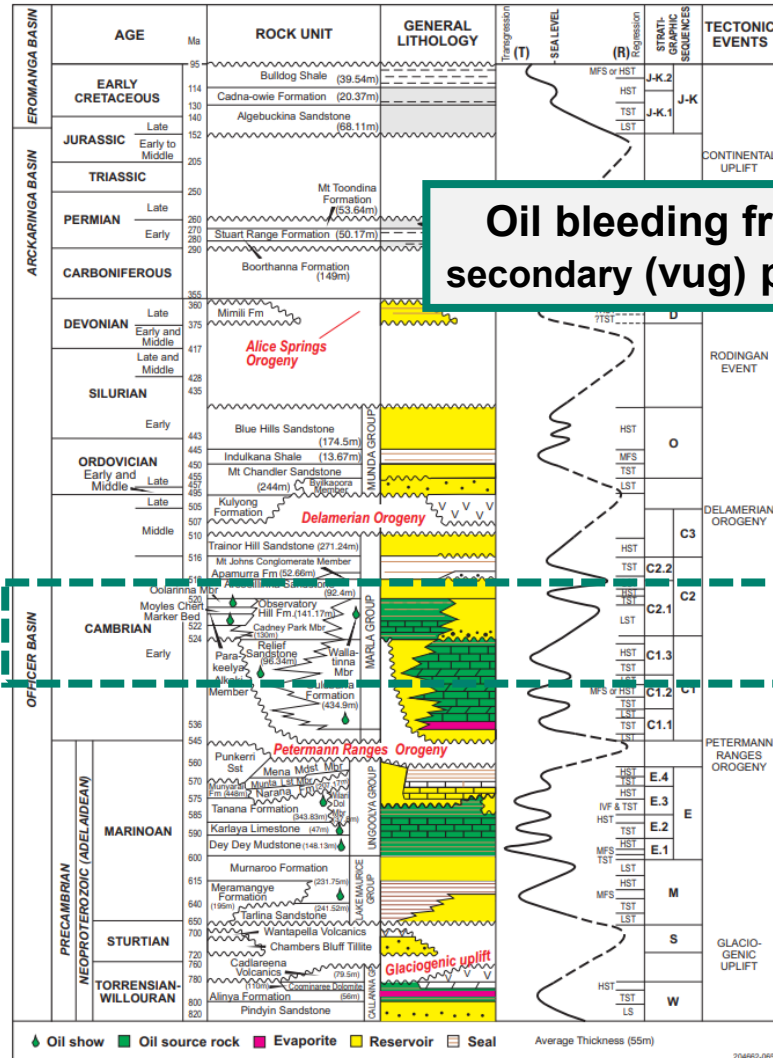


Figure 1

2024/01/2

Byilkaora 001



Oil bleeding from secondary (vug) pores

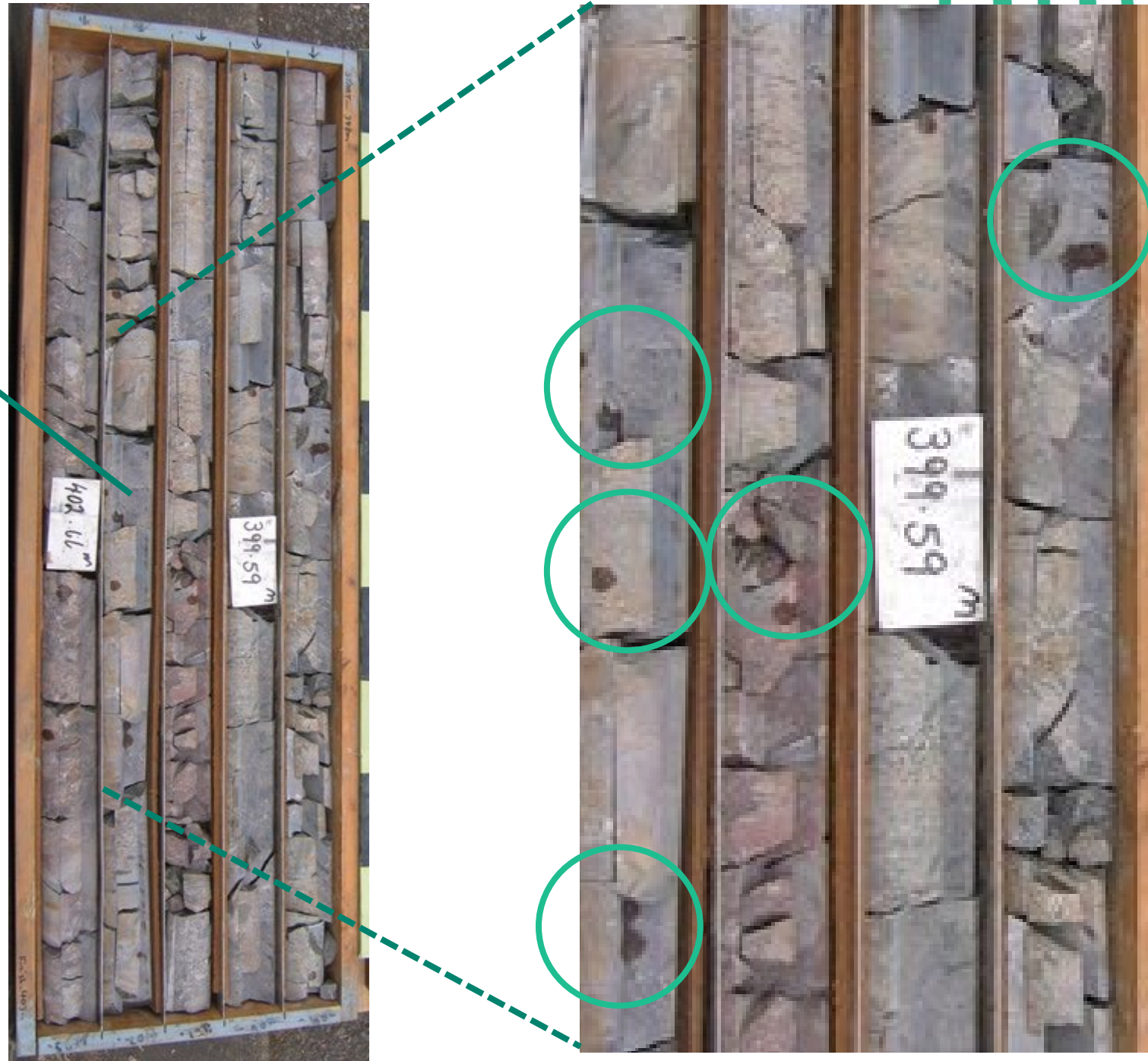


Figure 3 Geological summary of the Officer Basin.

Gas storage licences

Petroleum Exploration Licences **do not** include gas storage rights

If a PEL holder also wants to evaluate CCUS or regulated substance storage potential, a gas storage exploration licence (max 2,500 km²) is required

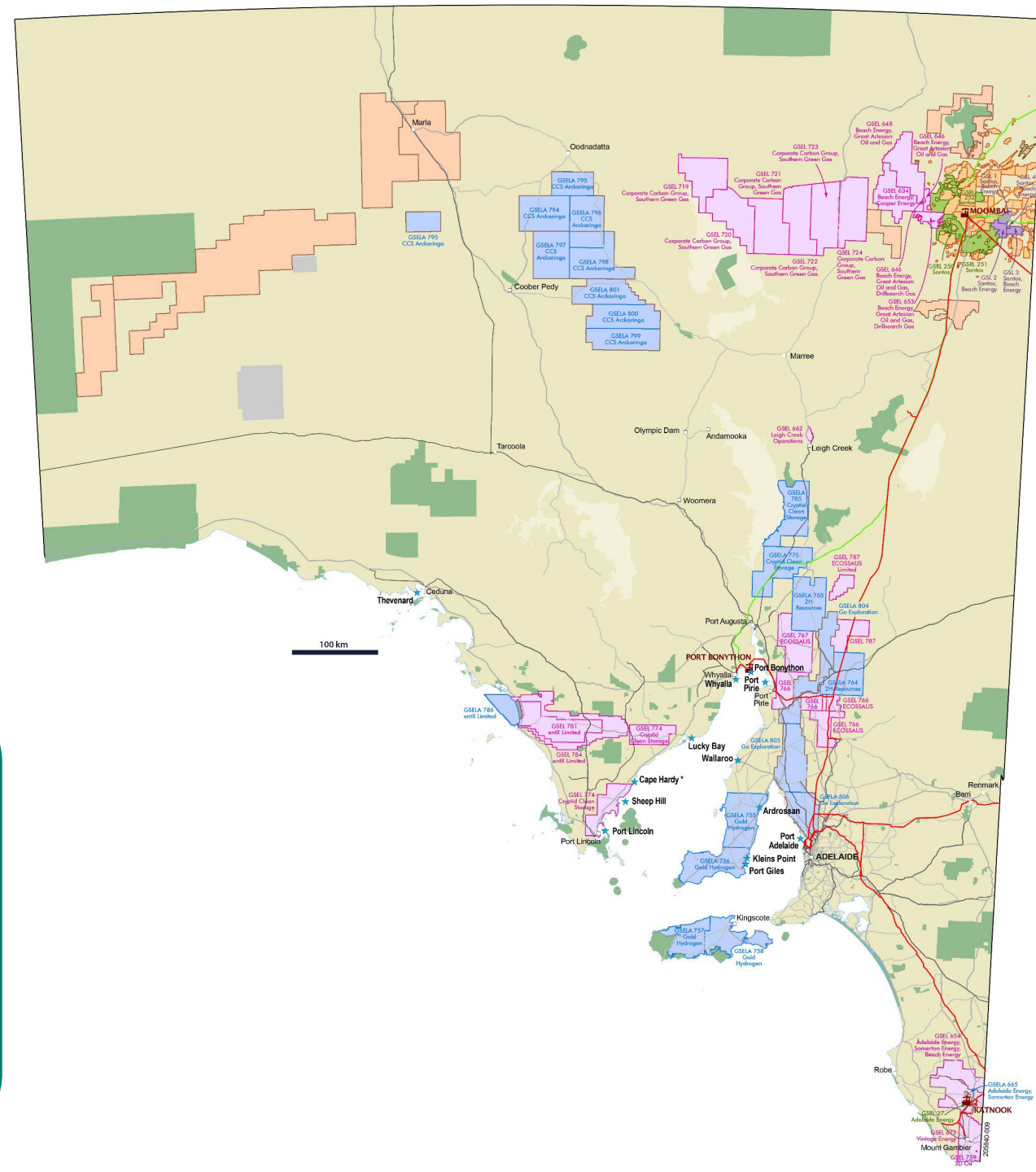
Storage targets

Depleted fields

- Cooper Basin and Eromanga Basin
- Otway Basin

Intra or sub-salt storage

- Polda Basin
- Officer Basin



Gas storage | Polda Basin

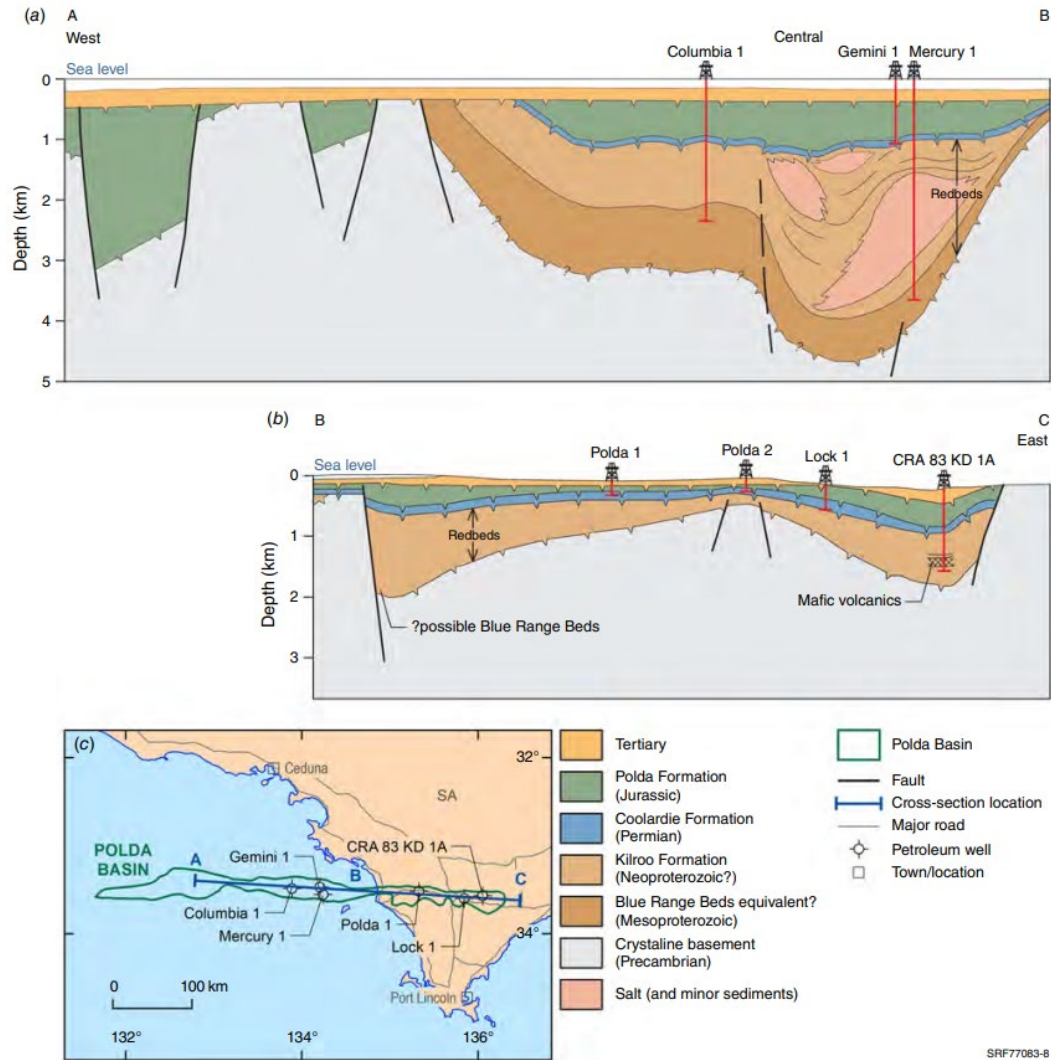
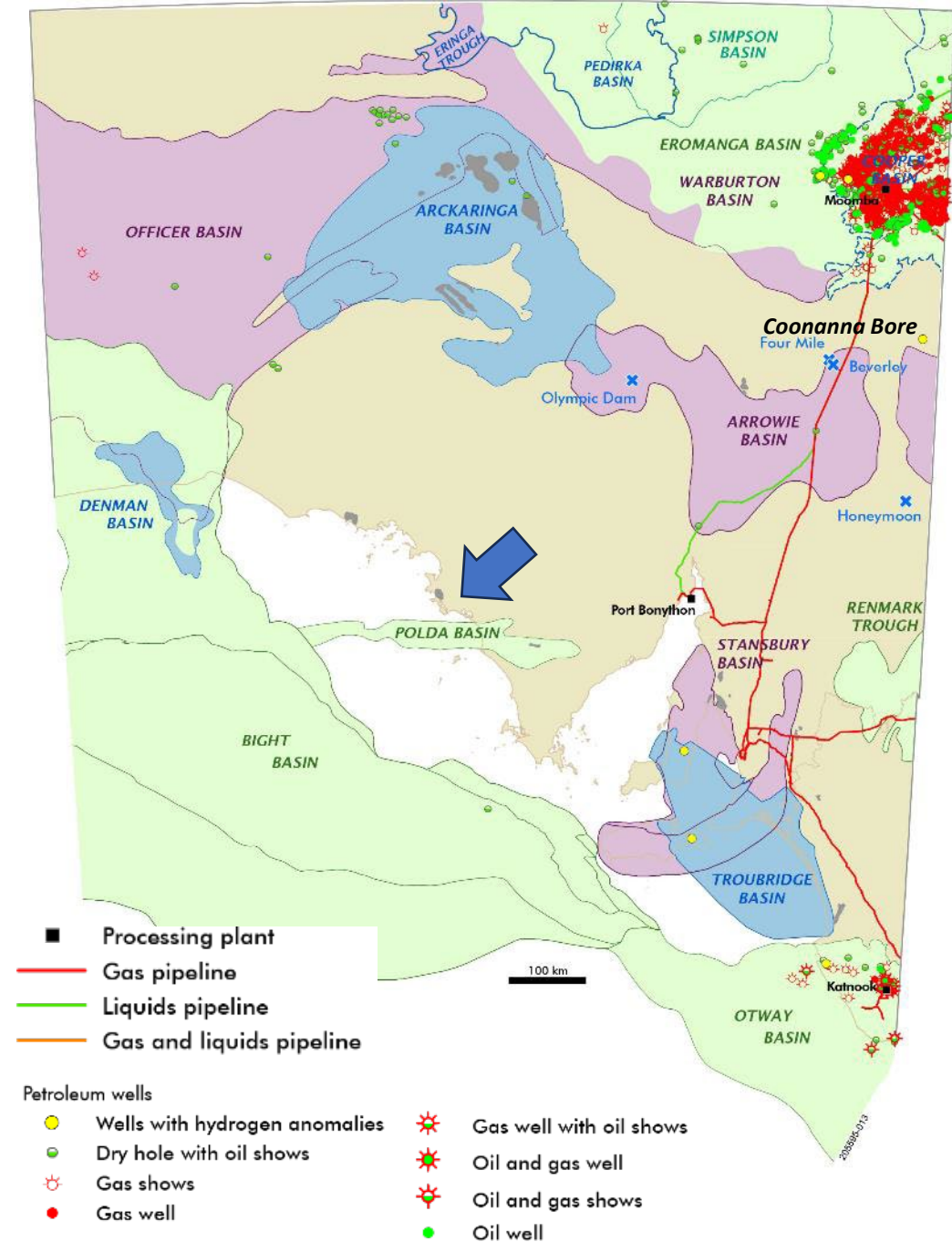


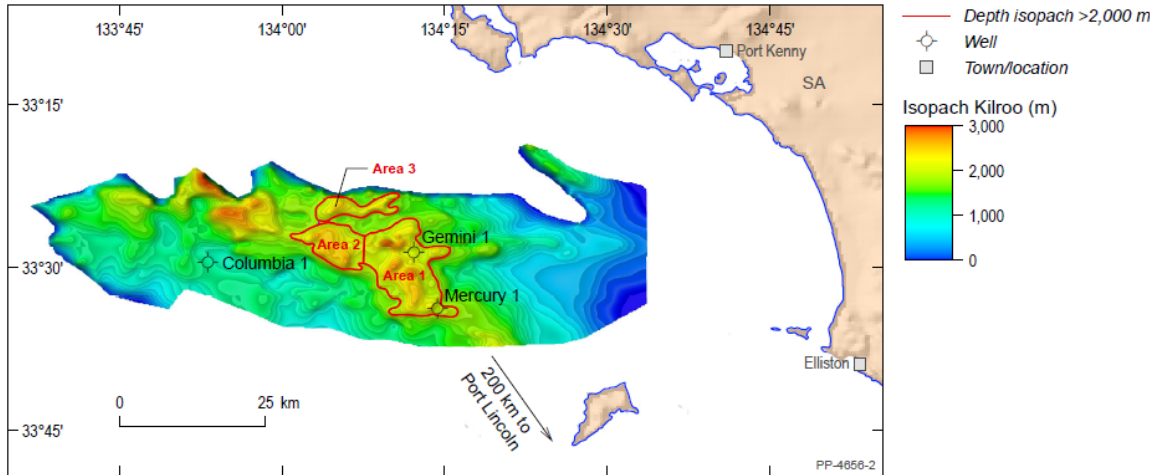
Fig. 5. (a) and (b) are the Polda Basin cross-section from west to east and wells locations (South Australia Department for Energy and Mining 2021). (c) Map showing the Polda Basin location and the cross-section A-B-C line shown in (a) and (b). Mercury 1 is located offshore, approximately 60 km from the Eyre Peninsula.



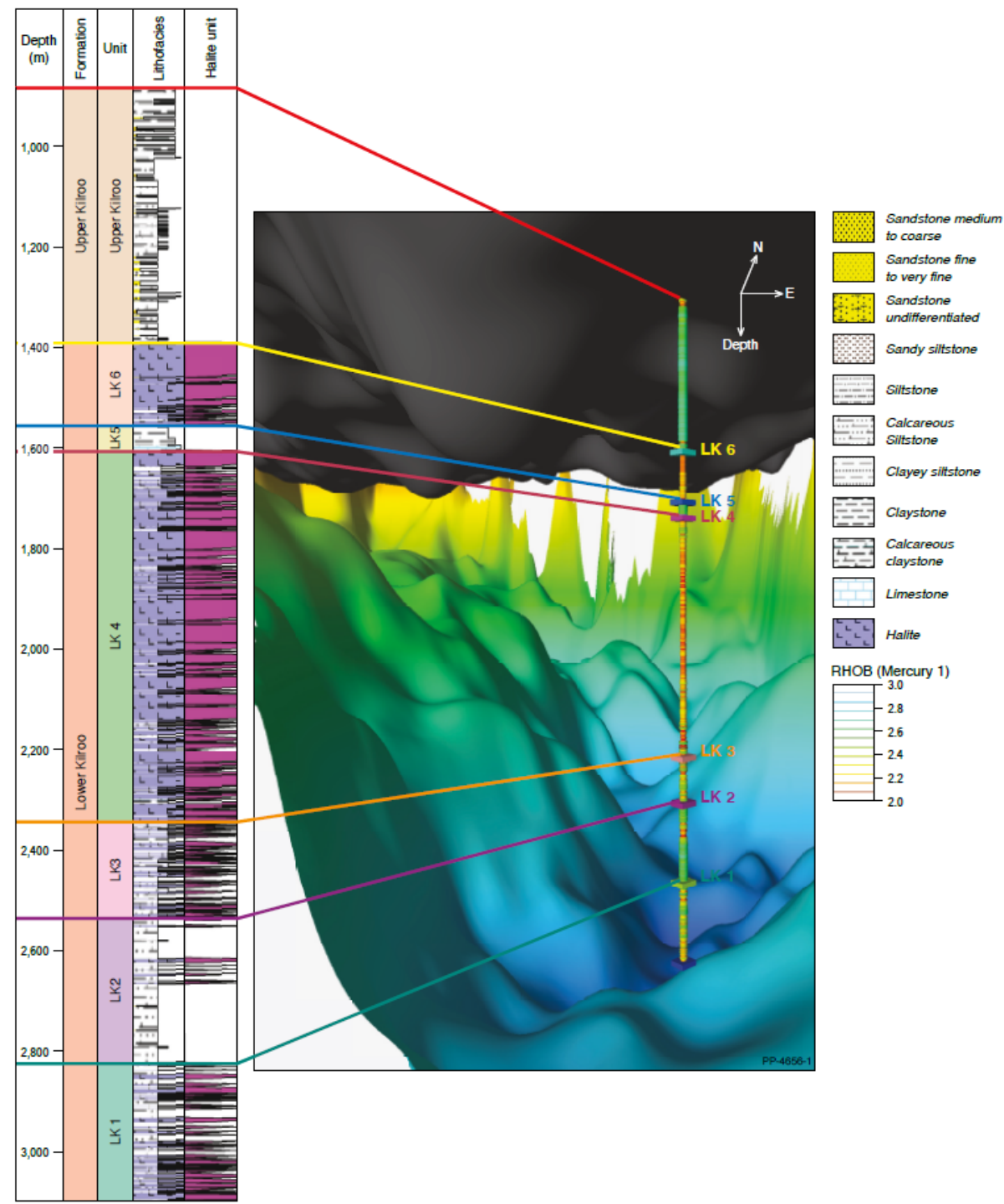
Gas storage | Polda Basin

Internal units	Top depth (m)	Thickness (m)	Halite/Gross Thickness Ratio	Net halite thickness (m)	Description
LK_6	1393	163	0.935	152.33	Massive halite (pillows) with minor thin clastic interbeds
LK_5	1556	51	0.003	0.15	Interbeds of calcareous (dolomitic) siltstone/claystone with 11 m of black limestone. Minor methane (40 ppm, 0.2 unit) was detected on the limestone interval.
LK_4	1607	793	0.85	673.71	Massive halite (pillows) with minor thin clastic interbeds
LK_3	2400	155	0.403	62.46	Interbeds or pillows of halite and clastics
LK_2	2555	269	0.056	15.02	Mainly calcareous/dolomitic siltstone with interbeds of halite and sandstone
LK_1	2824	276	0.467	128.78	Mainly halite with interbeds of calcareous siltstone/claystone.

From Fietz et al (2022)



From Fietz et al (2022)

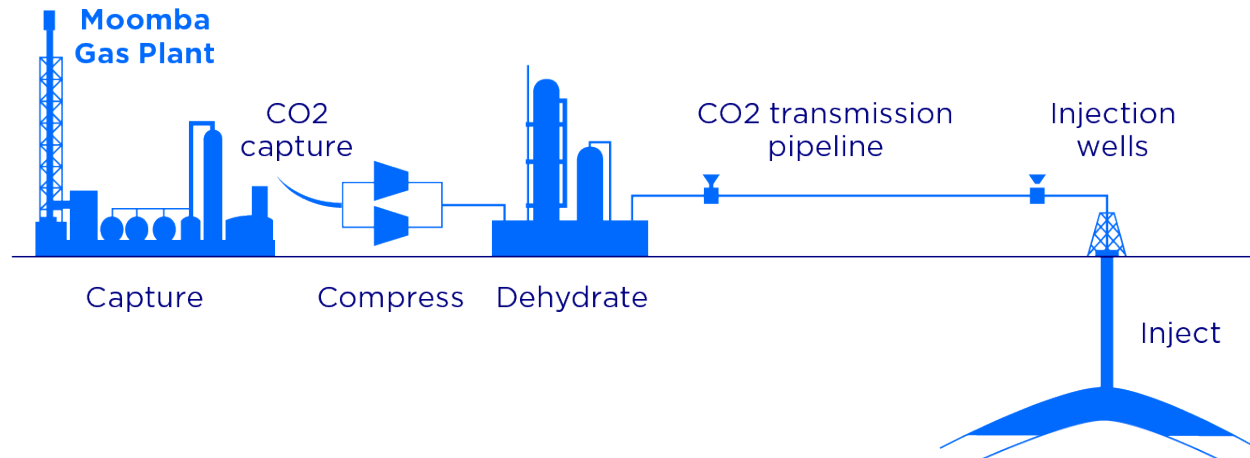


Cooper Basin | CCUS

- The Moomba CCS project has been commissioned with first CO₂ injection occurring on Sept 30th 2024 (Beach Energy ASX release)
- The project is aiming at storing 1.7million tonnes of CO₂ per year

FACILITY	COUNTRY	FACILITY STATUS	OPERATIONAL DATE	FACILITY INDUSTRY	CAPTURE CAPACITY (Mtpa CO ₂)	FACILITY TYPE
SHUTE CREEK GAS PROCESSING PLANT	USA	Operational	1986	Natural Gas Processing	7	Enhanced Oil Recovery
PETROBRAS SANTOS BASIN PRE-SALT OIL FIELD CCS	Brazil	Operational	2011	Natural Gas Processing	7	Enhanced Oil Recovery
LOUISIANA CLEAN ENERGY COMPLEX	USA	In Construction	2026	Various	5	Dedicated Geological Storage
CENTURY PLANT	USA	Operational	2010	Natural Gas Processing	5	Enhanced Oil Recovery
GORGON CARBON DIOXIDE INJECTION	Australia	Operational	2019	Natural Gas Processing	4	Dedicated Geological Storage
GREAT PLAINS SYNFUELS PLANT AND WEYBURN-MIDALE	USA	Operational	2000	Synthetic Natural Gas	3	Enhanced Oil Recovery
QATAR LNG CCS	Qatar	Operational	2019	Natural Gas Processing	2.2	Dedicated Geological Storage
SANTOS COOPER BASIN CCS PROJECT	Australia	In Construction	2024	Natural Gas Processing	1.7	Dedicated Geological Storage
ALBERTA CARBON TRUNK LINE (ACTL) WITH NORTH WEST REDWATER PARTNERSHIP'S STURGEON REFINERY CO ₂ STREAM	Canada	Operational	2020	Oil Refining	1.6	Enhanced Oil Recovery
NORTHERN LIGHTS - STORAGE	Norway	In Construction	2024	Various	1.5	Dedicated Geological Storage
QUEST	Canada	Operational	2015	Hydrogen Production	1.3	Dedicated Geological Storage
NORTH FIELD EAST PROJECT (NFE) CCS	Qatar	In Construction	2025	Natural Gas Processing	1	Under Evaluation

DIAGRAMMATICAL REPRESENTATION OF MOOMBA CCS



From PESA News - May 2024

¹ Global CCS Institute status report 2023



Photo credit – Beach Energy 2024

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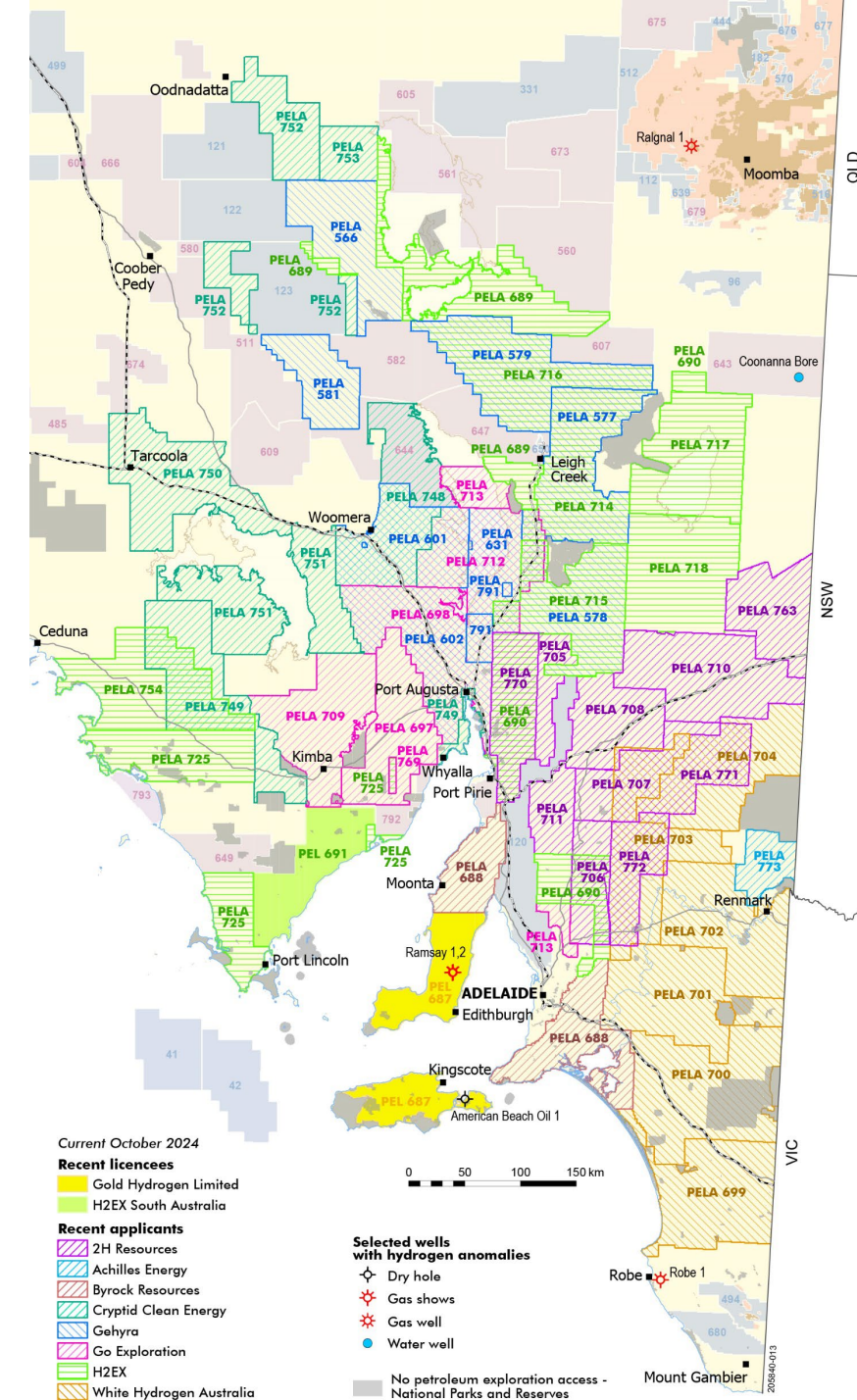
Natural hydrogen (and helium) exploration

40 PEL applications targeting hydrogen and/or helium lodged

- PEL 687 (yellow) granted to Gold Hydrogen in 2021, Ramsay 1 and 2 drilled in late 2023, phase 1 flow testing completed
- PEL 691 (light green) H2EX, soil gas, passive seismic



The new from the old – Ramsay 1 from the Ramsay oil bore (1931)
Photo credit – Gold hydrogen 2023



Natural Hydrogen Conference

Inaugural event being held in Adelaide



SESSION 1: AUSTRALIAN EXPLORATION

- 09:00 AM Keynote Speaker - Chris Cubitt | DEM
- 09:20 AM Keynote Speaker - Frank Glass | Gold Hydrogen
- 09:40 AM Marshall Hood | Natural Hydrogen exploration in SA - a perspective from Australia's largest exploration license holder
- 10:00AM Grant McMurtrie | 2H Resources: Geological Insights & Technological Advancements in Hydrogen and Helium Exploration
- 10:20AM Peter Haines | Meda 1 and 2, Canning Basin: historical hydrogen reports and modern investigations

10:40AM Morning Tea - Sponsored by SGS

SESSION 2: AUSTRALIAN EXPLORATION CONTINUED

- 11:10 AM Keynote Speaker- Andrew Feitz | Geoscience Australia
- 11:30 AM Ema Frery | A multidisciplinary approach to unravel geological hydrogen systems, based on Australian case studies
- 11:50 AM Leon Normore | Implications of Fluid Inclusions stratigraphy for natural hydrogen and helium systems within the Perth and Officer Basins
- 12:10 PM Mark Bunch | Hydrogen Gas Storage Fairways in South Australian Petroleum Basins
- 12:30 PM Julien Bourdet | Ramsay hydrogen accumulation, new insights into a hydrogen system

12:50 PM Lunch - Sponsored by Gehyra Flux

SESSION 3: AUSTRALIAN EXPLORATION CONTINUED

- 01:50 PM Mohinudeen Faiz | Hydrogen in unconventional gas reservoirs
- 02:10 PM Timothy Rady | The Underground Gas Storage and Natural Hydrogen Potential of Polda Basin
- 02:30 PM Cecilia Loyola | In situ Rb-Sr dating of basement in the hydrogen and helium-rich Jacko Bore 1 (Mt Kitty 1) well, Amadeus Basin, Australia
- 02:50 PM Zak Milner | Origins of Natural Hydrogen in the Adelaide Superbasin

03:10 PM Afternoon Tea - Sponsored by Xcalibur Smart Mapping

SESSION 4: RESOURCE ASSESSMENT, REGULATORY FRAMEWORKS AND DEVELOPMENTS

- 03:40 PM Keynote Speaker - Owen Sharpe | AGIG
- 04:00 PM Elizabeth Harvey | Examining the regulatory landscape governing exploration, production and distribution
- 04:20 PM Adam Craig | Natural hydrogen - Estimating the resource, some case studies.
- 04:40 PM Greg Horton | Prospective Resource Mapping for Natural Hydrogen

- 08:30 AM Opening Address - Kris Waddington | Mitsui E&P

SESSION 5: ADVANCES IN RESEARCH

- 08:40 AM Keynote Speaker - Lionel Esteban | CSIRO
- 09:00 AM Claudio Delle Piane | Hydrogen migration in the upper crust: the role of fractures and aqueous fluids
- 09:20 AM Krista Davies | Natural Hydrogen Anomaly or Artifact?
- 09:40 AM Anna Gubina | Discovering natural hydrogen in continental interiors
- 10:00 AM Emma Black | Influence of mineral catalysts on natural hydrogen generation in Australian subsurface environments

10:20 AM Morning Tea - Sponsored by SGS

SESSION 6: ADVANCES IN RESEARCH & INTERNATIONAL EXPLORATION

- 10:50 AM Keynote Speaker - Mengli Zhang | Colorado School of Mines
- 11:10 AM Keynote Speaker - tbc | Koloma
- 11:30 AM Alireza Keshavarz | Leveraging Hydrogen-Rock Interactions for Natural Hydrogen Production: Insights from Underground Hydrogen Storage Research
- 11:50 AM John Watkins | Geological storage of gas: evaluation of seal properties for containment of Carbon Dioxide, Methane and Hydrogen
- 12:10 PM Paul Dial | Use of high resolution magnetic/gravity data to better define potential geologic hydrogen resources- Midcontinent Rift, USA

12:30 PM Lunch - Sponsored by 2H Resources

SESSION 7: EXPLORATION TOOLS AND METHODS

- 01:30 PM Keynote Speaker - Max Brouwers | GeTech
- 01:50 PM Andy Wilson | Borehole Image Log Analysis of Ramsay-1 and Ramsay-2 part 1: Geological Structure and Sedimentology
- 02:10 PM Chris Boreham | Downhole profiling of hydrogen and helium during drilling and post drill
- 02:30 PM Irene Wallis | Borehole Image Log analysis of Ramsay-1 and Ramsay-2 Part 2: Comparison of Aperture Analysis Methods Used to Constrain Secondary Porosity

02:50 PM Afternoon Tea

SESSION 8: EXPLORATION TOOLS AND METHODS CONTINUED

- 03:10 PM Keynote - Ian Munro | Helios Aragon
- 03:30 PM Fariba Kohanpour | Mapping Hydrogen Source Minerals using NVCL and spectral data analysis
- 03:50 PM Relly Margiono | 3D MT mapping of natural hydrogen prospectivity in South Australia
- 04:10 PM David Seneshen | Hydrogeochemical Exploration for Helium and Hydrogen Deposits

SESSION CLOSE

- 04:30 PM Closing Address - Neil McDonald | Gold Hydrogen

South Australia's Energy Opportunities



For natural gas

- **Otway Basin – Significant hydrocarbons generated outside held acreage**
- **Cooper Basin – Multiple plays, gas storage and CCUS**
- **Warburton Basin – Multiple plays, prospectivity work ongoing**
- **Frontier Basins – Proven hydrocarbon systems, current exploration ongoing**

For gas storage and CCUS

- **Strategic locations in the Otway, Cooper and Polda Basins**

For natural hydrogen

- **Nation first exploration drilling along with a regulatory framework that allows for the exploration, production and transport of regulated substances**



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