A FRESH LOOK AT THE SOUTH AUSTRALIAN ONSHORE OTWAY BASIN

POWERFUL INSIGHTS FROM DEM's PETROLEUM SYSTEMS MODEL PROJECT

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Government of South Australia
Department for Energy and Mining

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Otway Basin: Project Aim

Aim:

- Generate new datasets
- Generate new exploration concepts
- Stimulate the next phase of gas exploration in the onshore Otway Basin to supply South Australian customers

- Commenced: 2020
- Completion: Q4 2023

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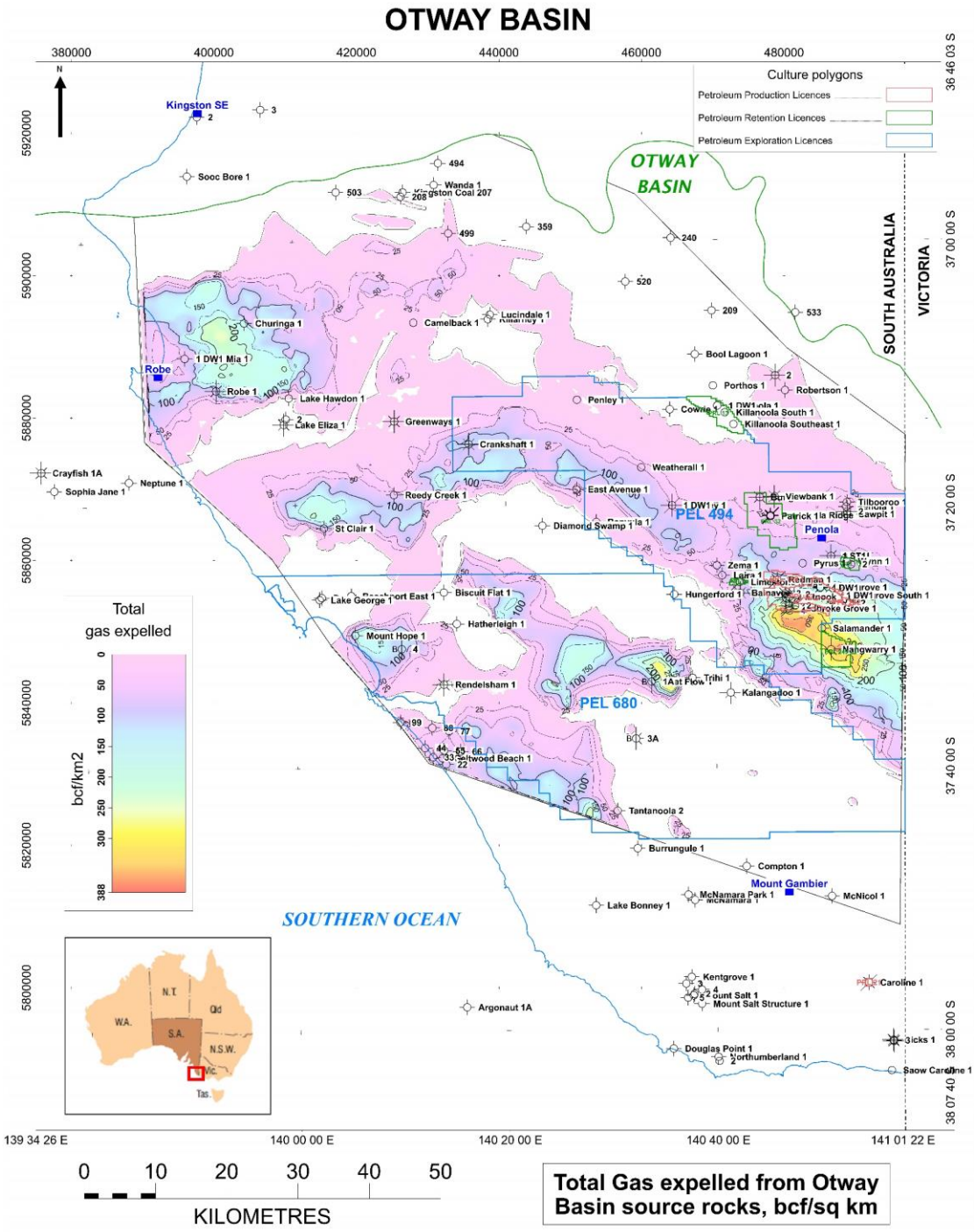
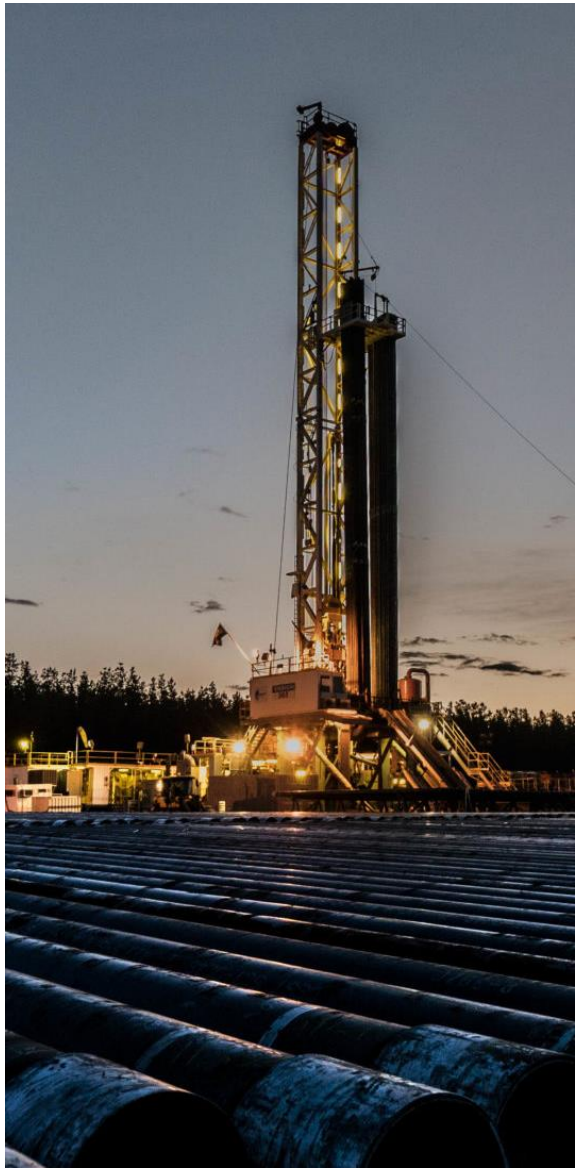


Project Fast Facts



Modified from Beach Energy

Whole of Basin PSM

- Petroleum system model
- Expulsion maps per key intervals

Seismic & Wells

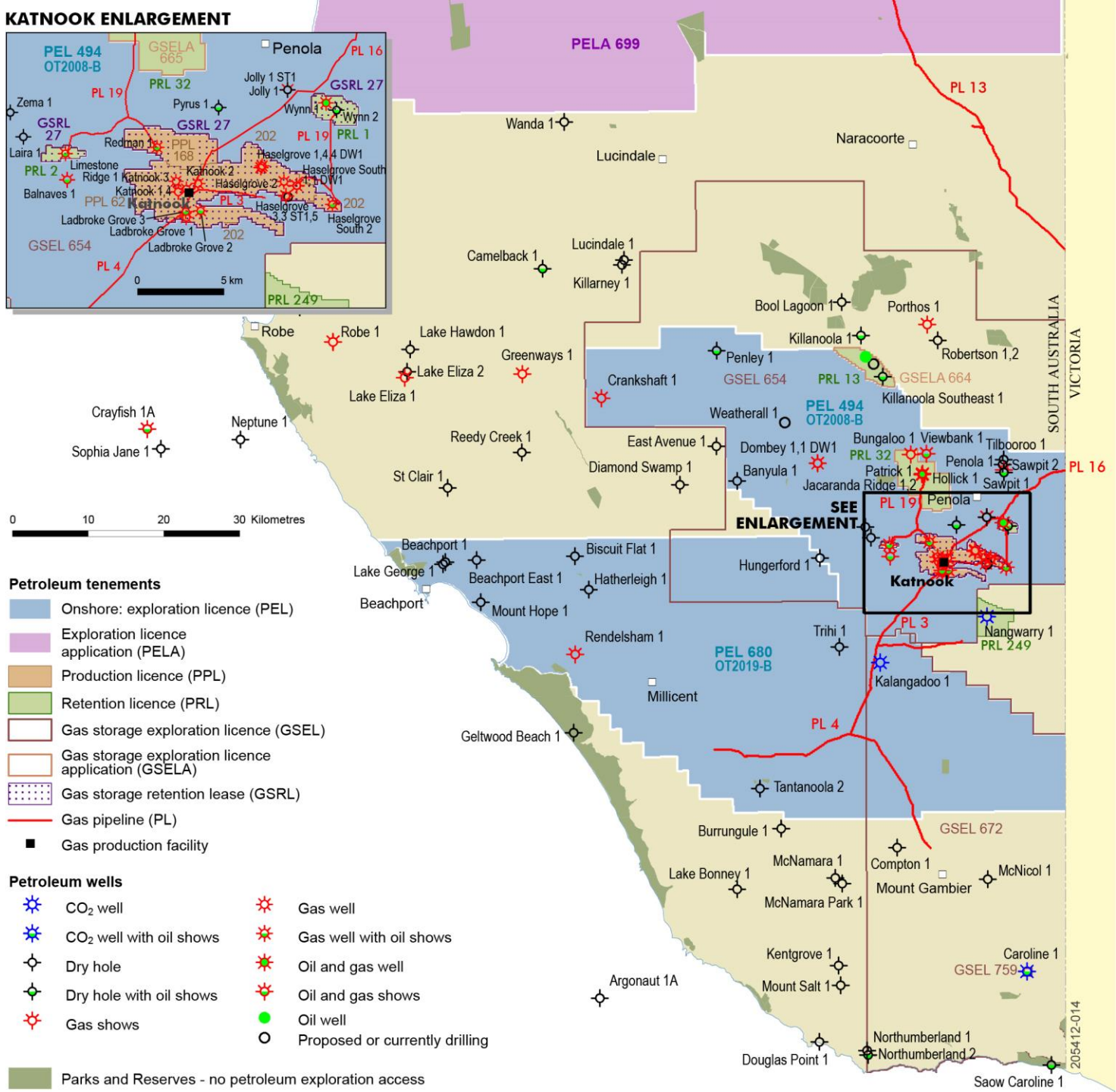
- Stratigraphic framework – 80 wells
- 7965km seismic interpretation

Cores & Maps

- 772m of core interpreted
- 6 geology maps constrained

Otway Basin

- Oil and gas production from 6 hydrocarbon fields
- ~63 BCF of natural gas produced
- The Katnook gas facility is currently mothballed



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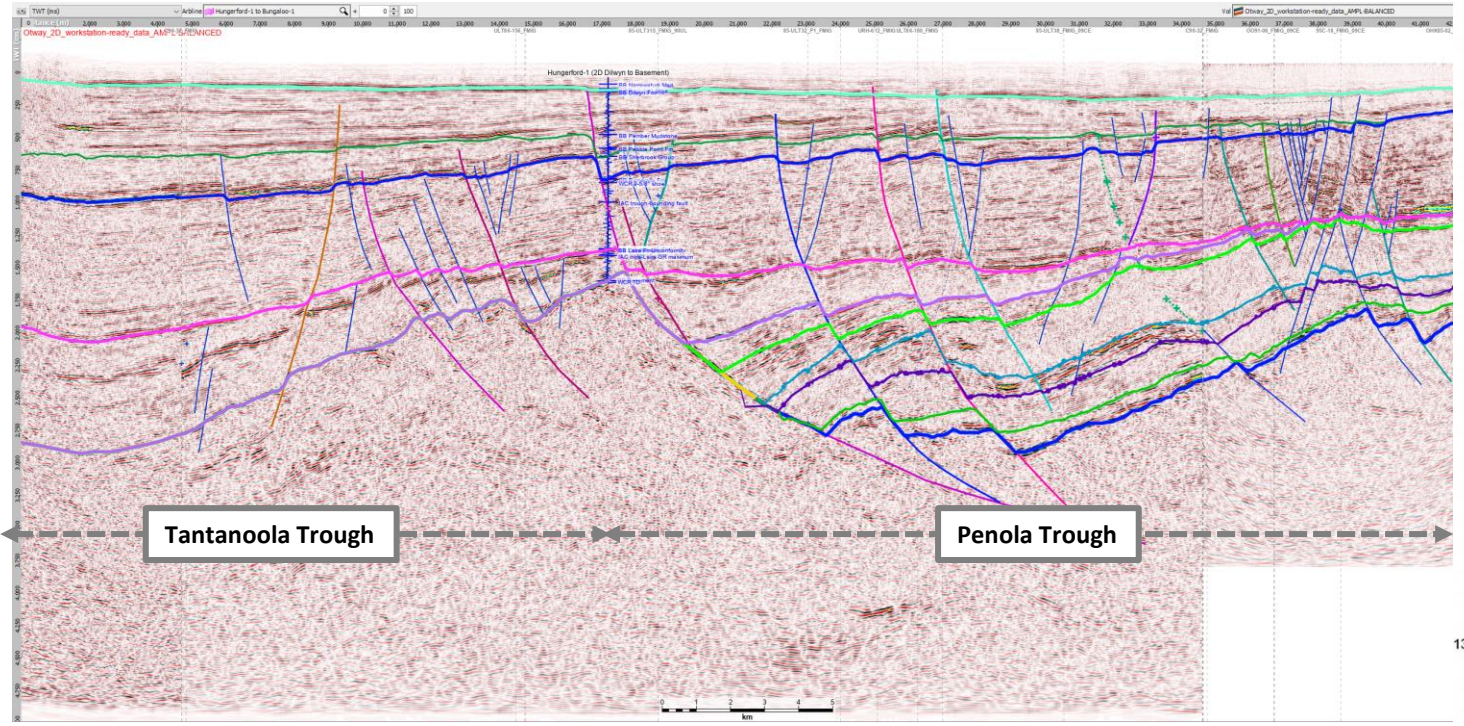
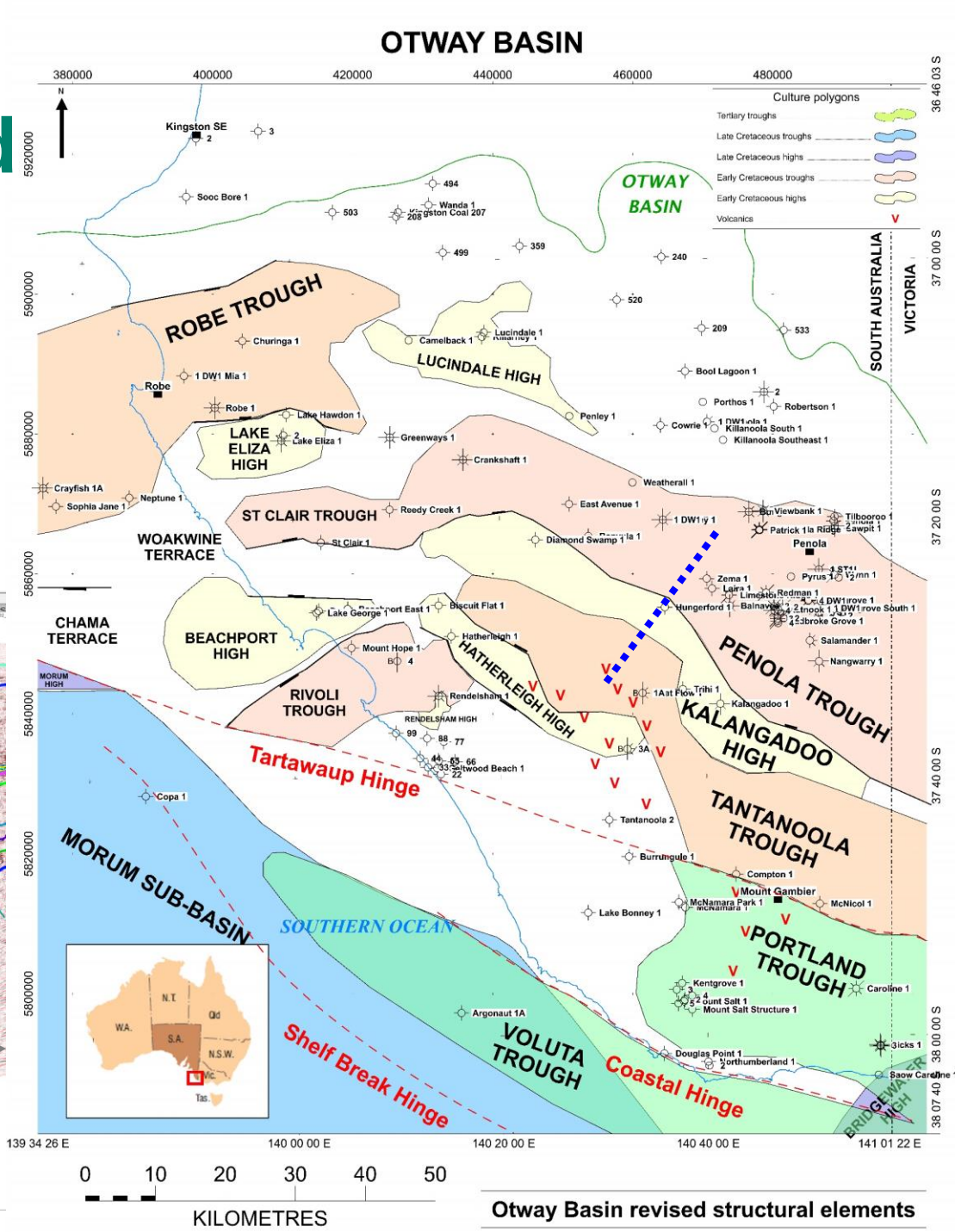
Otway Basin Structure Updated

The Otway Basin is made up of a series of (curvi-linear) buried hills and valleys (troughs) that have been filled in over time

A lot of time ~ 30million years

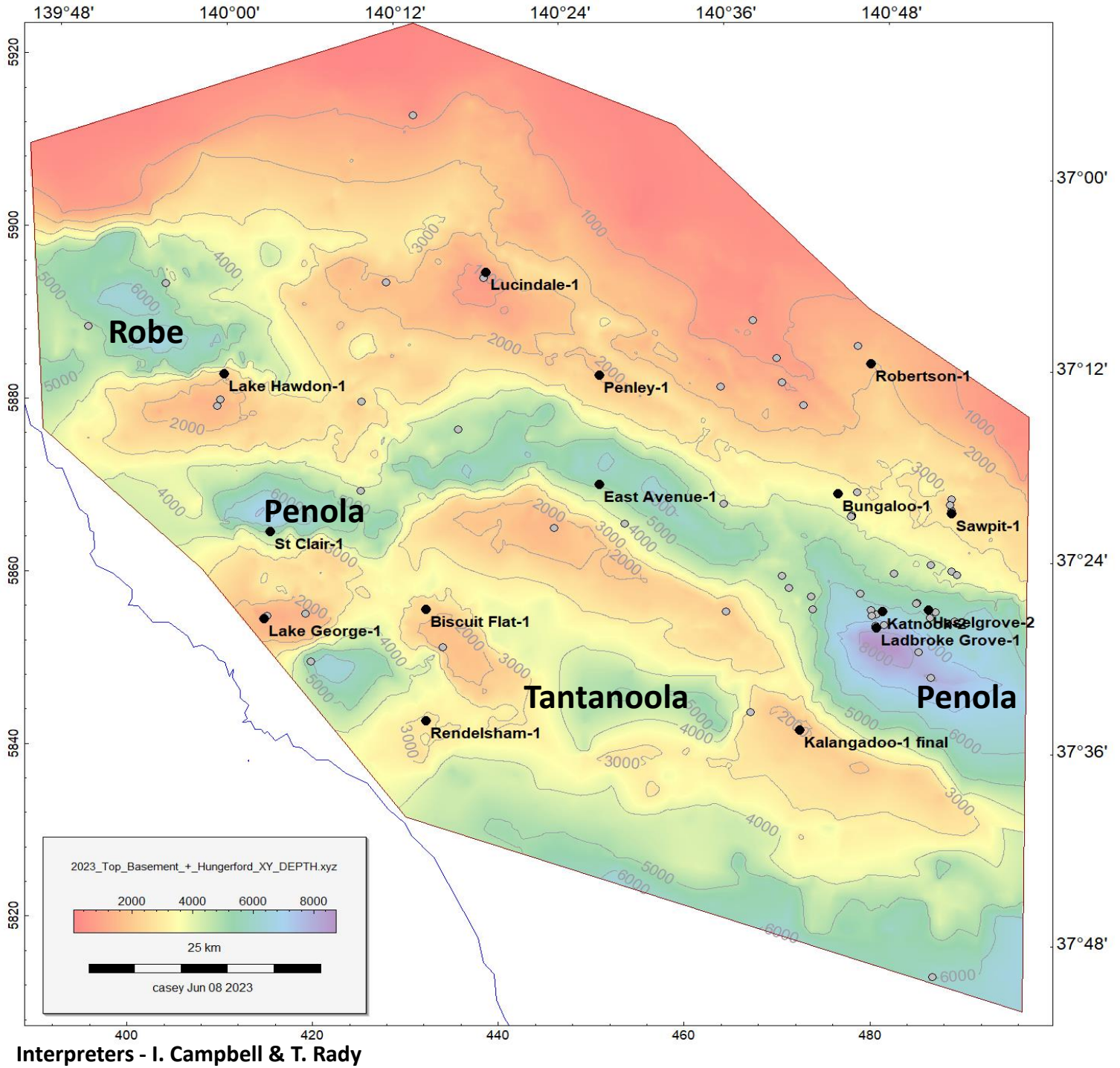




Otway Basement Map
The 2023 Update!

- The Penola Trough extends to the west and includes the St Clair Trough
- The Tantanoola Trough is a distinct depositional centre

- The Robe Trough is more extensive and deeper than previously understood



Interpreters - I. Campbell & T. Rady

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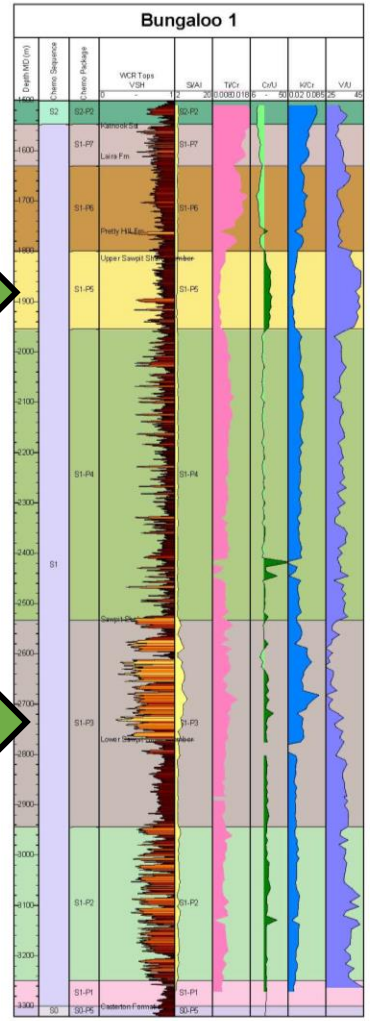
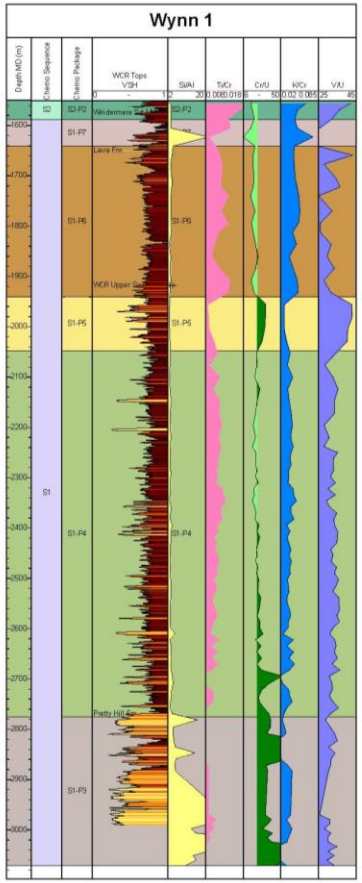
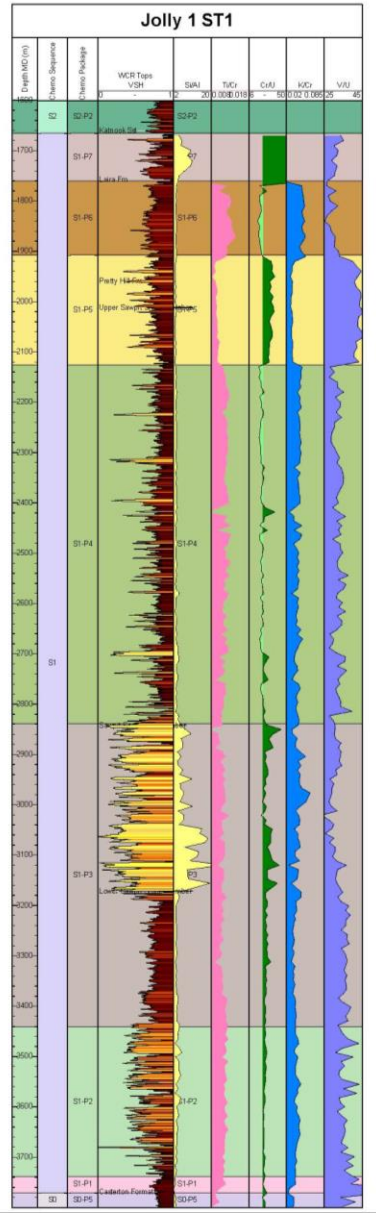
A New Approach to Otway Well-Based Stratigraphy

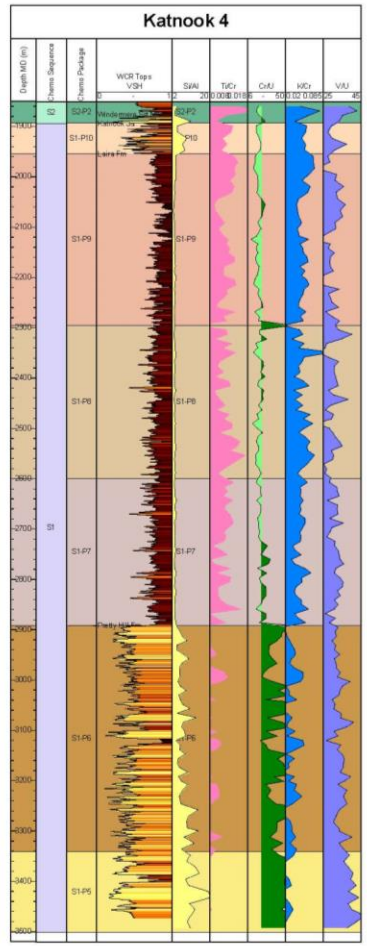
- Consistent stratigraphic markers (arrows) were correlateble in key wells.
- Subsequent seismic interpretations have been unable to ‘break” chemostratigraphic interpretations





[From – Bendall et al APPEA| 2023]





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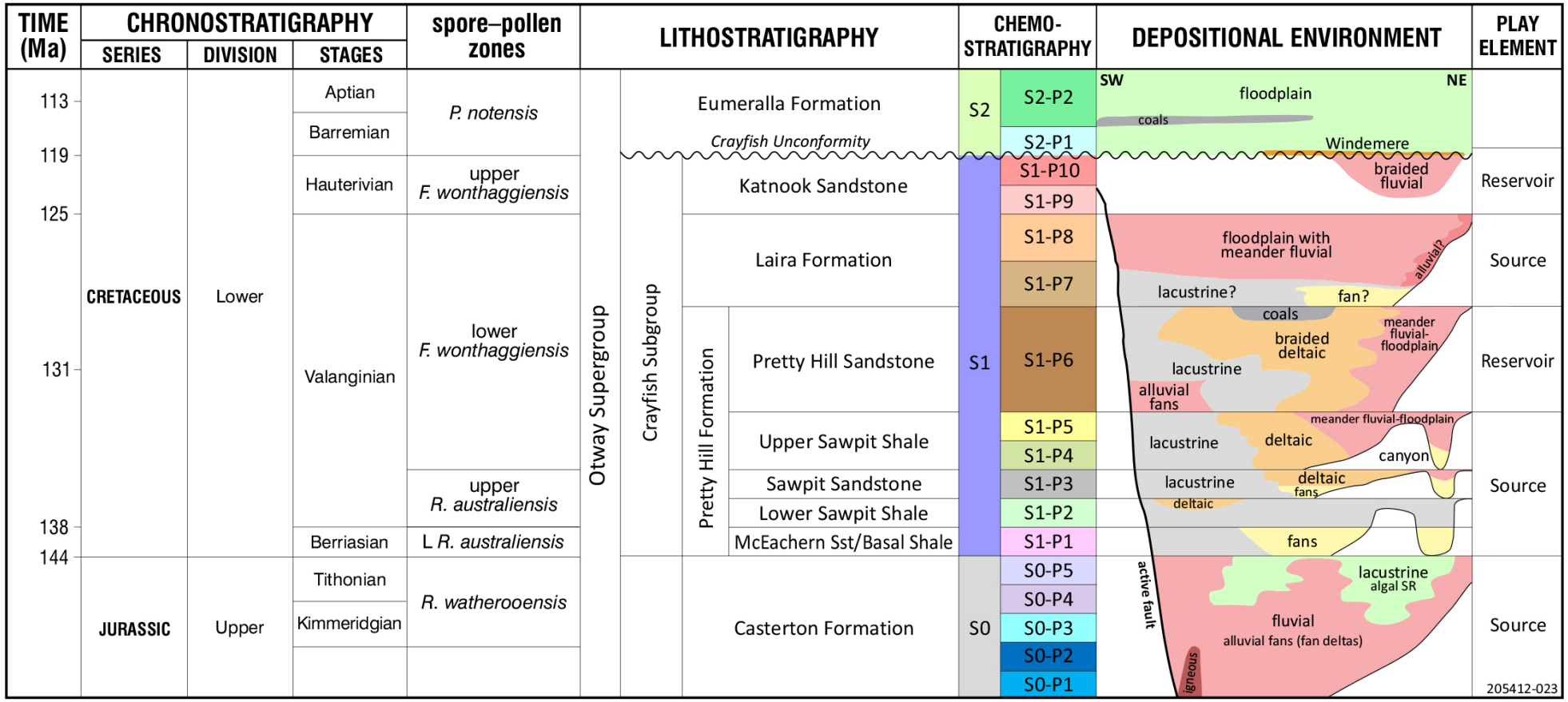
Onshore Otway Basin (SA) Stratigraphy: Updated!

A new understanding of the stratigraphic order of petroleum source and reservoir rocks has been developed

This provides for the fundamental understanding of drilling depth to potential new targets



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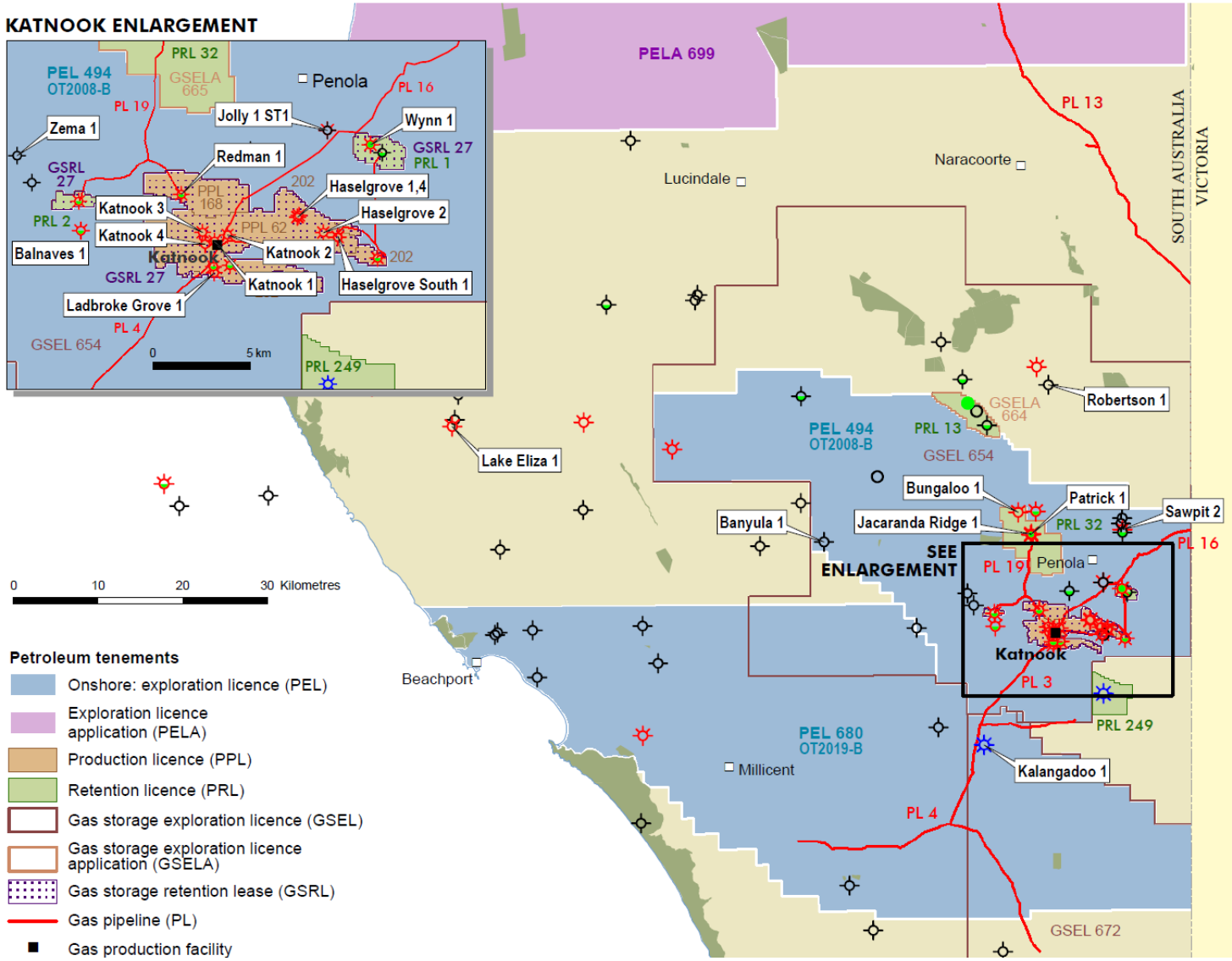
Core: Reservoir and Source Rocks

~770m of core from 23 wells across the basin in all intervals

Conventional reservoir rocks are deposited in fluvial channel fairways

- Good quality source rocks are deposited in deep rift lakes (algal)
- Moderate quality source rocks were deposited on flood plains associated with fluvial channel fairways



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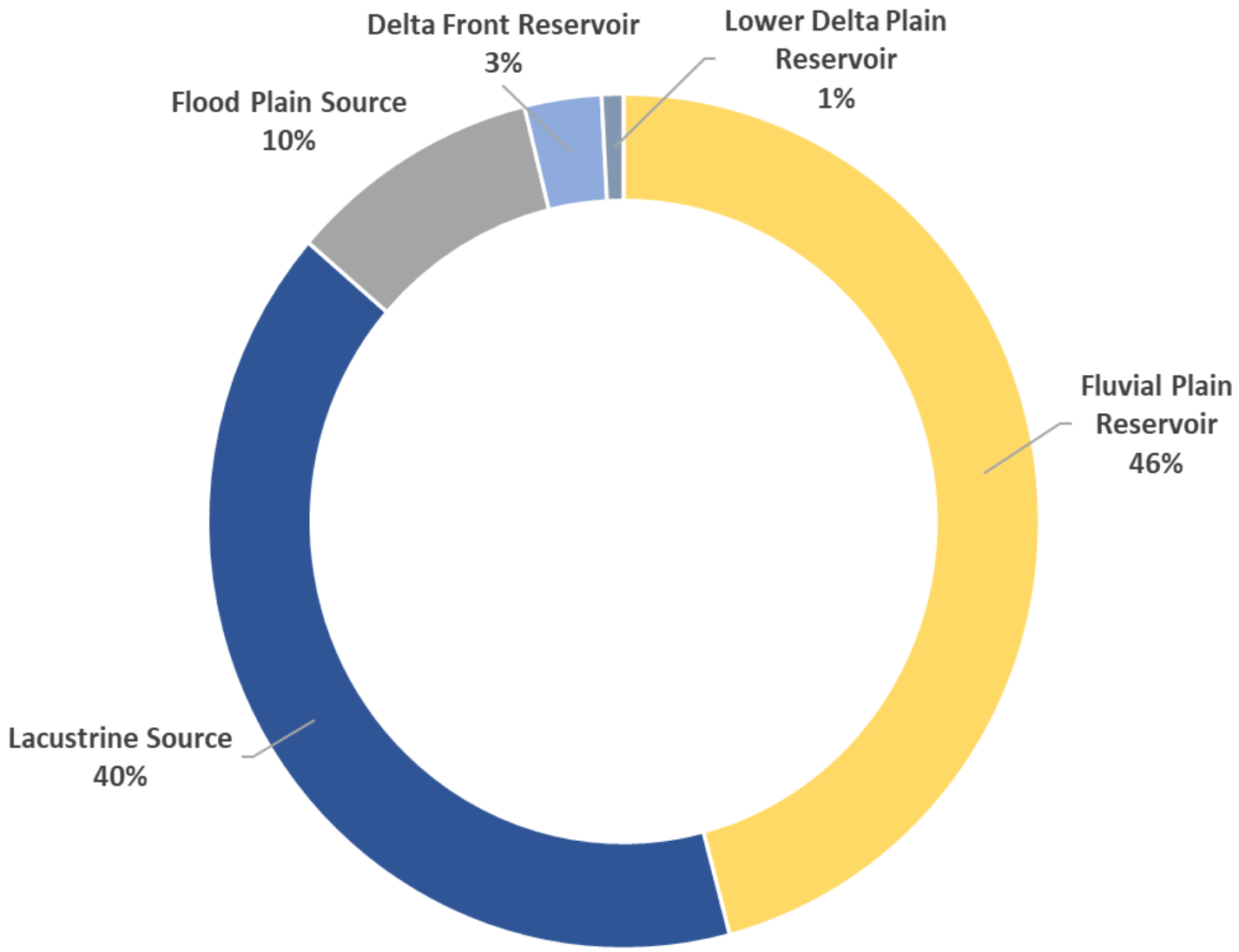
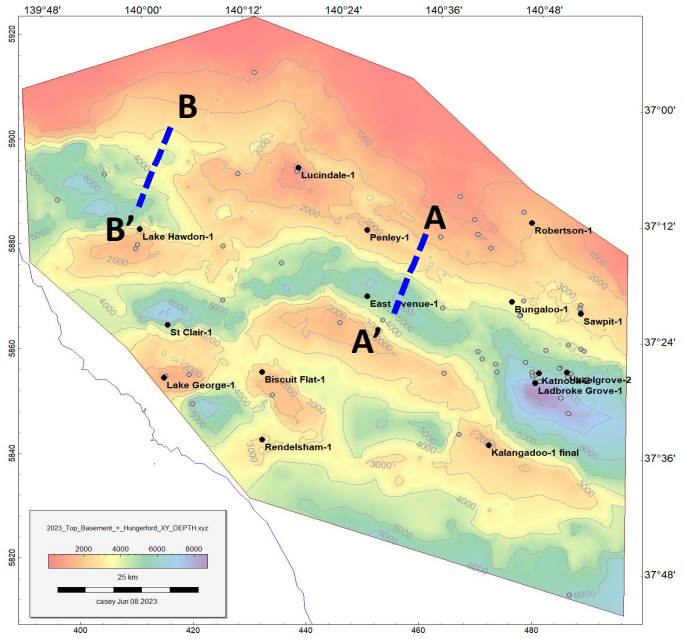


Pretty Hill Fm.



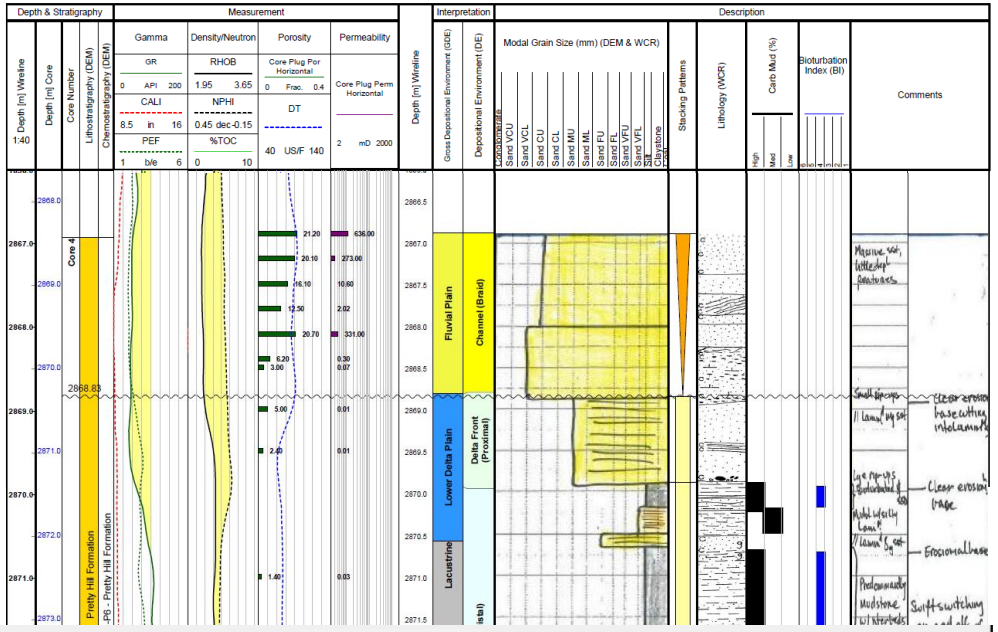
Core Description
Katnook 2

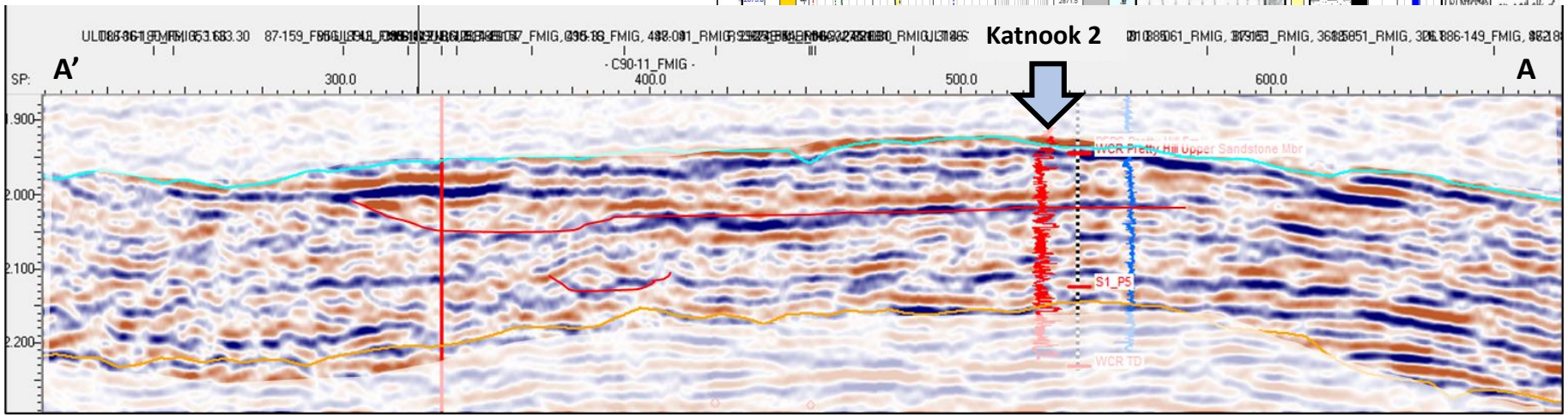
Department for Energy and Mining: South Australia

Country (State):	Australia (South Australia)	Spud Date:	01/12/1988
Basin:	Otway (Onshore SA)	KB/RT:	67.97m
Permit (2022):	PEL 32	TD:	3,478.073m
Well Operator:	Ultramar	Depth Shift:	C3/-0.6m & C4/-1.5m
Author:	Ultramar & P. Strong (DEM-July 2023)	Scale:	1:40
Compiled By:	C. Cubitt [DE-GDE] (SADEM - July 2023)		

Gross Depositional Environment: Fluvial Plain; Flood Plain; Lacustrine; Lower Delta Plain

Depositional Environment: Channel (Meander); Channel (Braid); Floodplain; Floodplain (Lacustrine); Delta Front (Proximal); Delta Front (Distal); Lacustrine (Deep)





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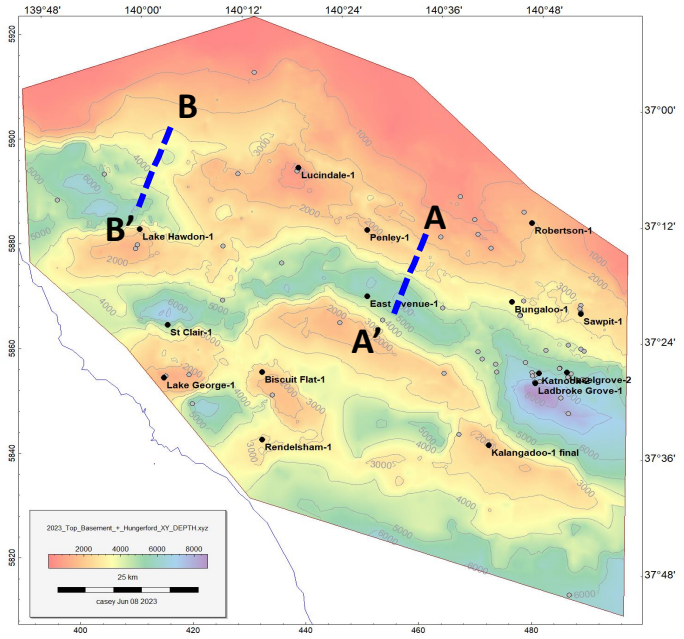

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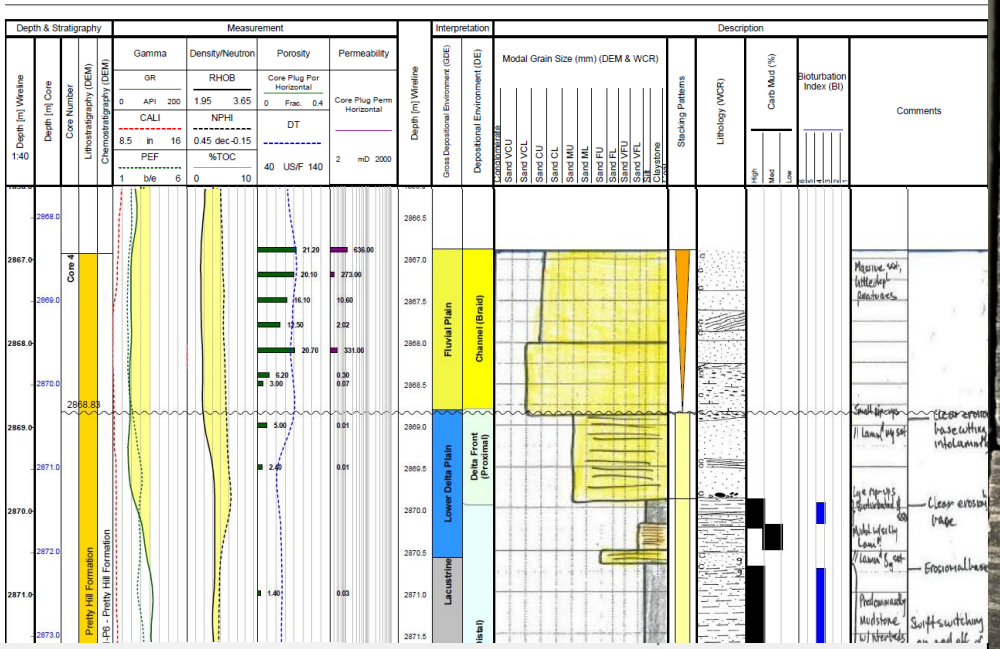
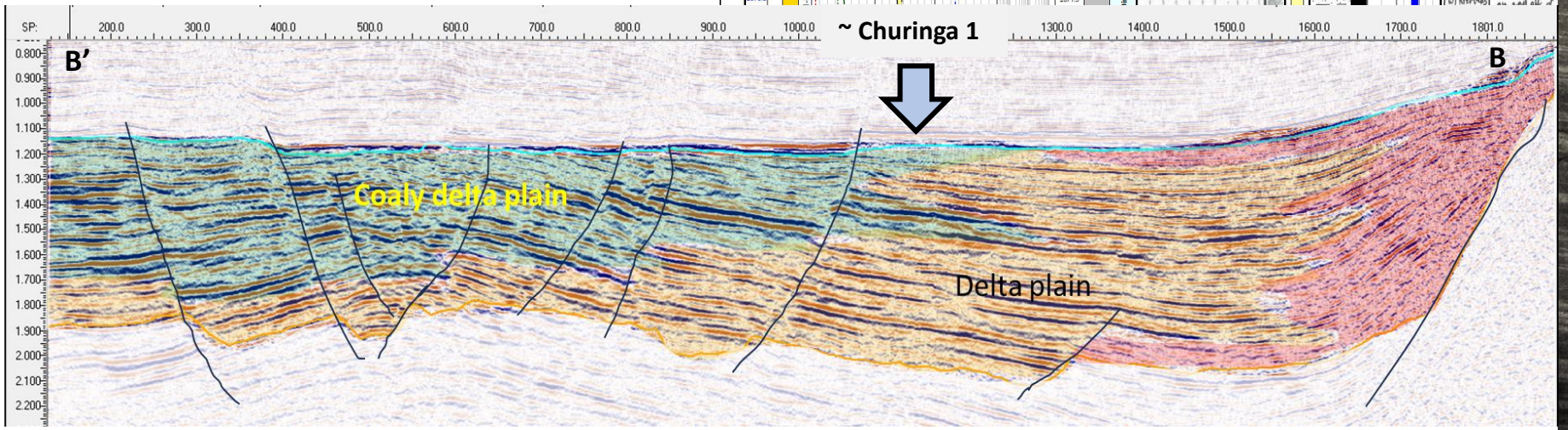
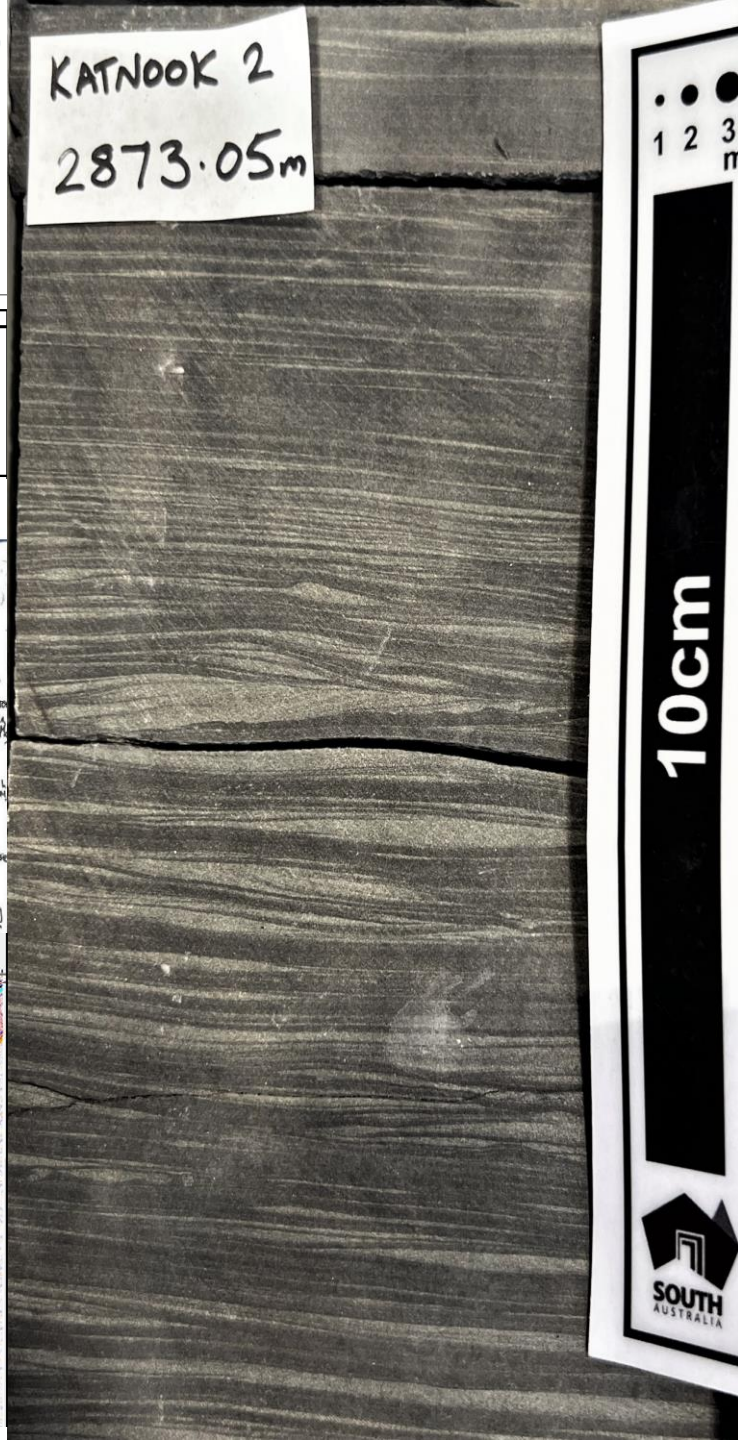
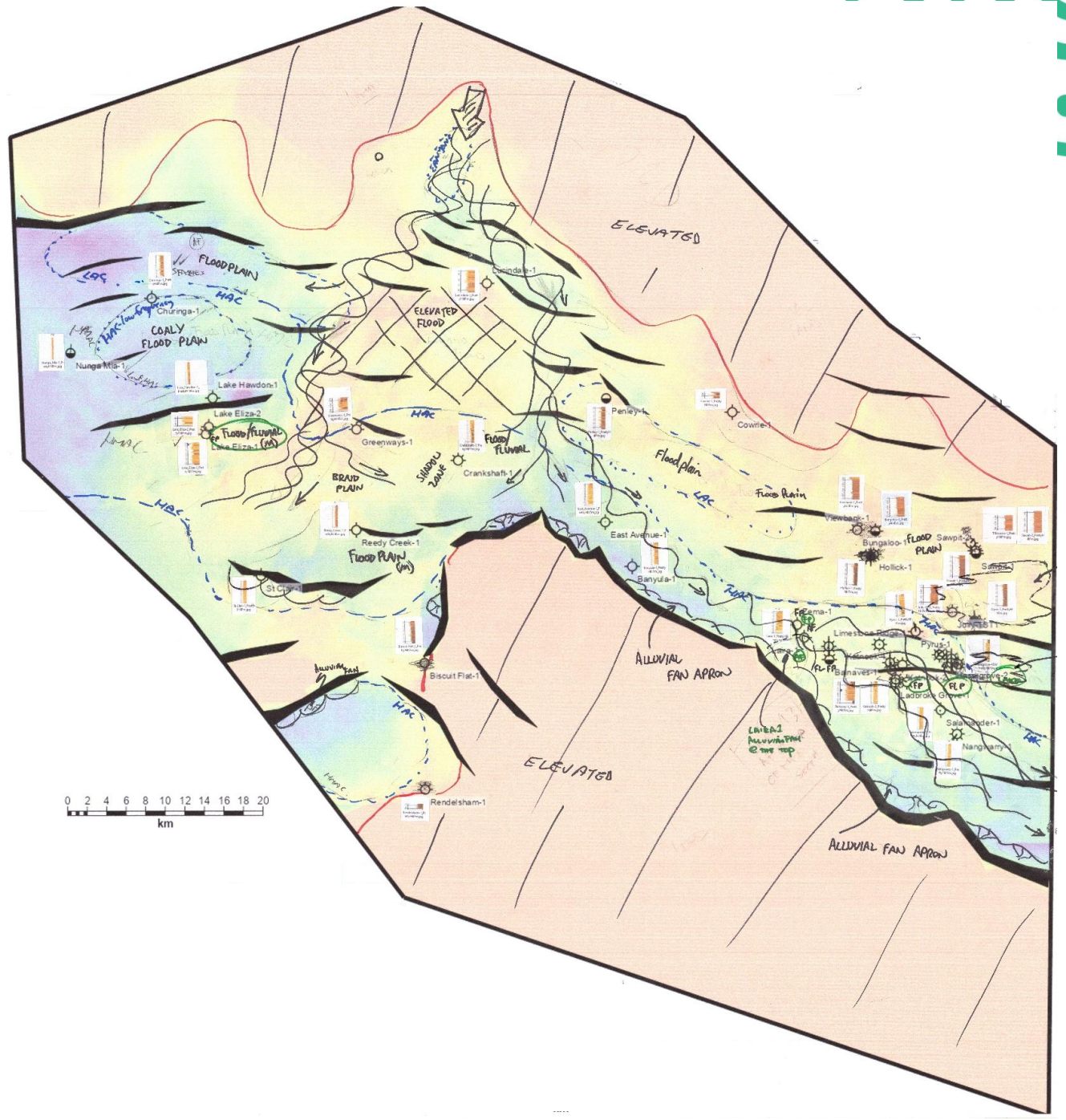






Pretty Hill Fm. Distribution

- Pretty Hill Fm. sediments enter the basin via canyons near Wanda 1 and disperse to the west (Robe Trough) and east (Penola Trough)



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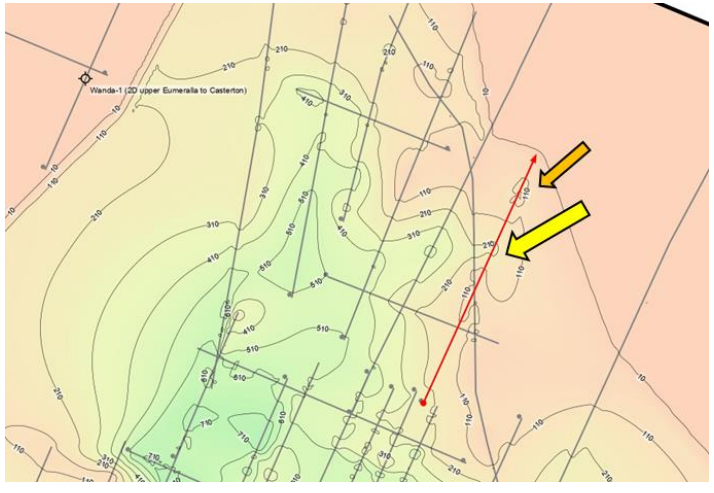

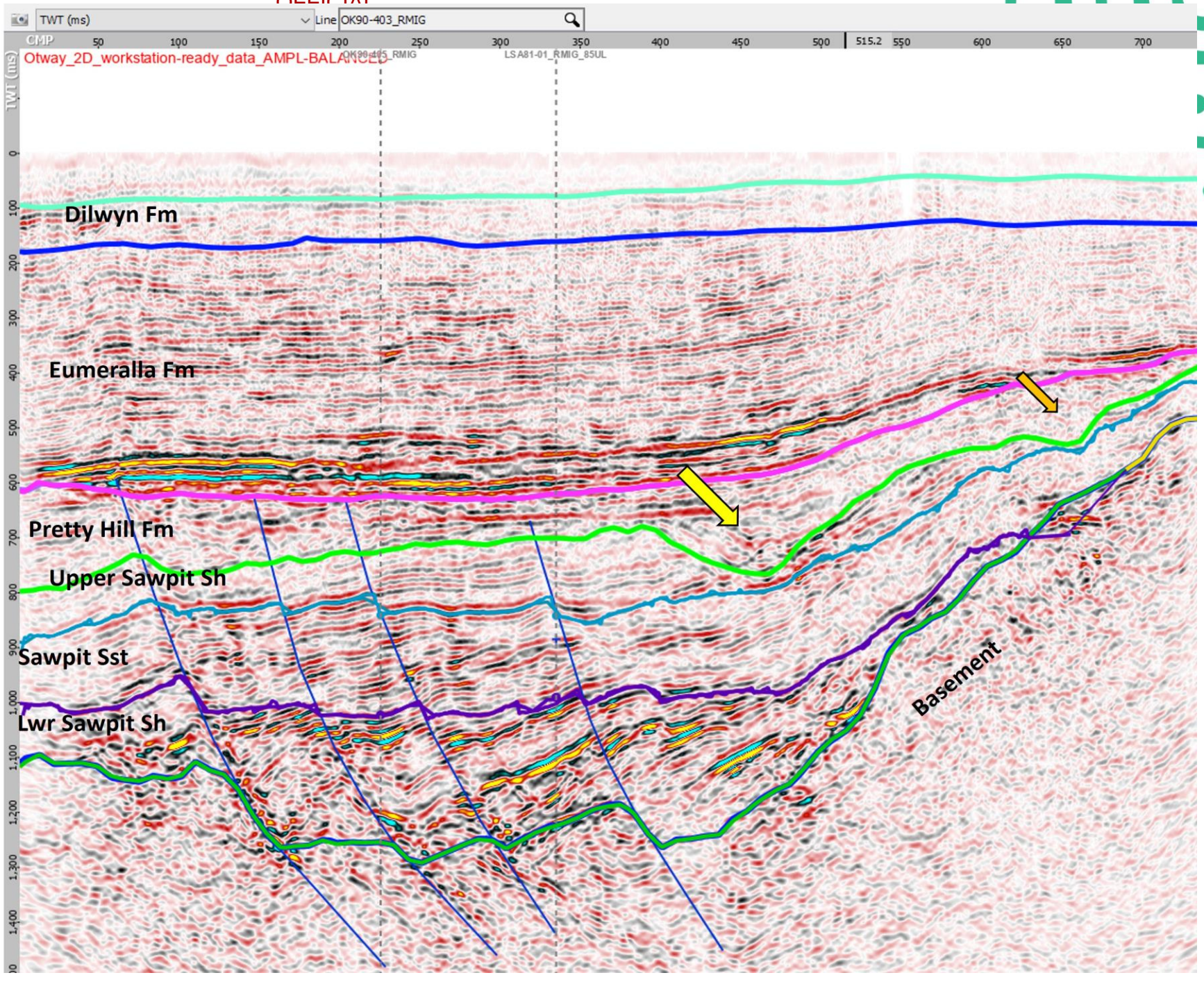

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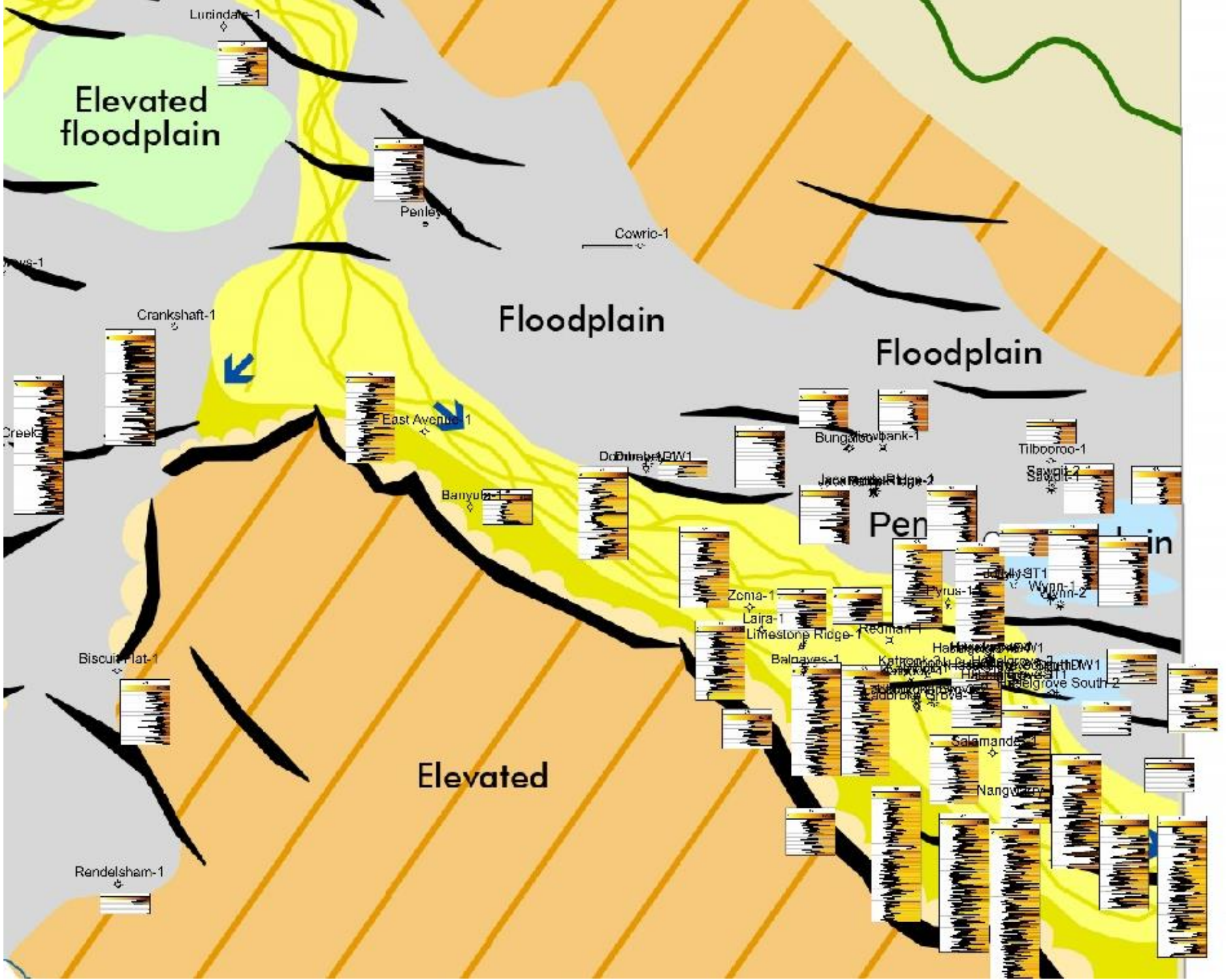

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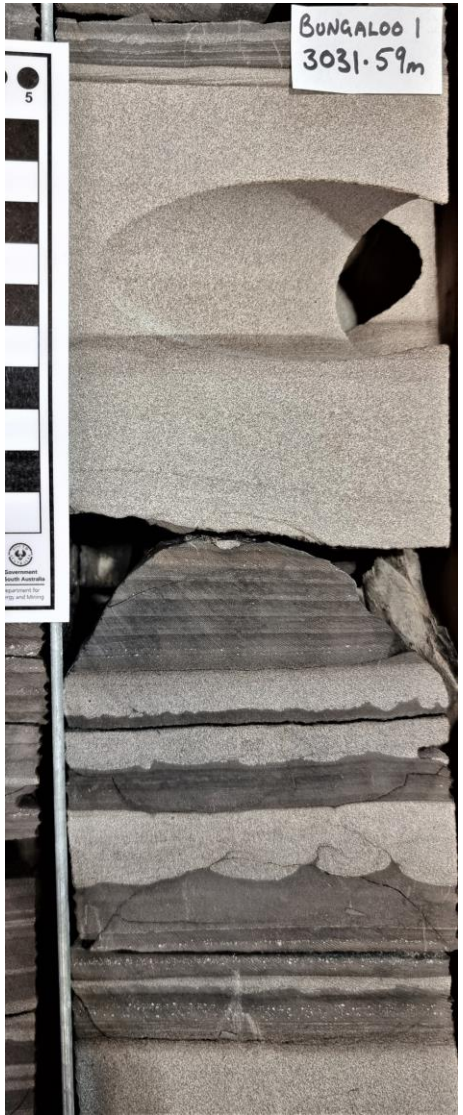
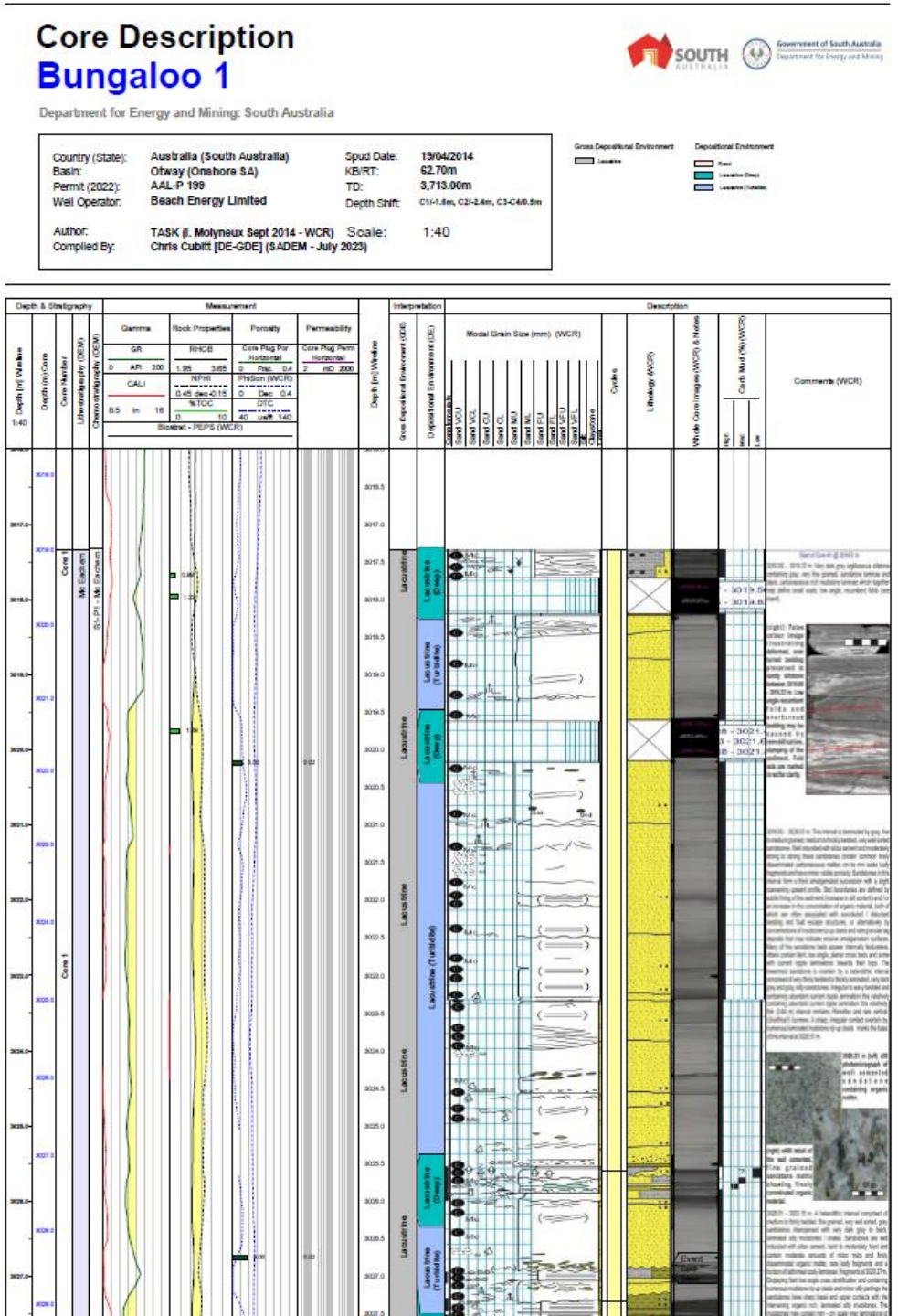
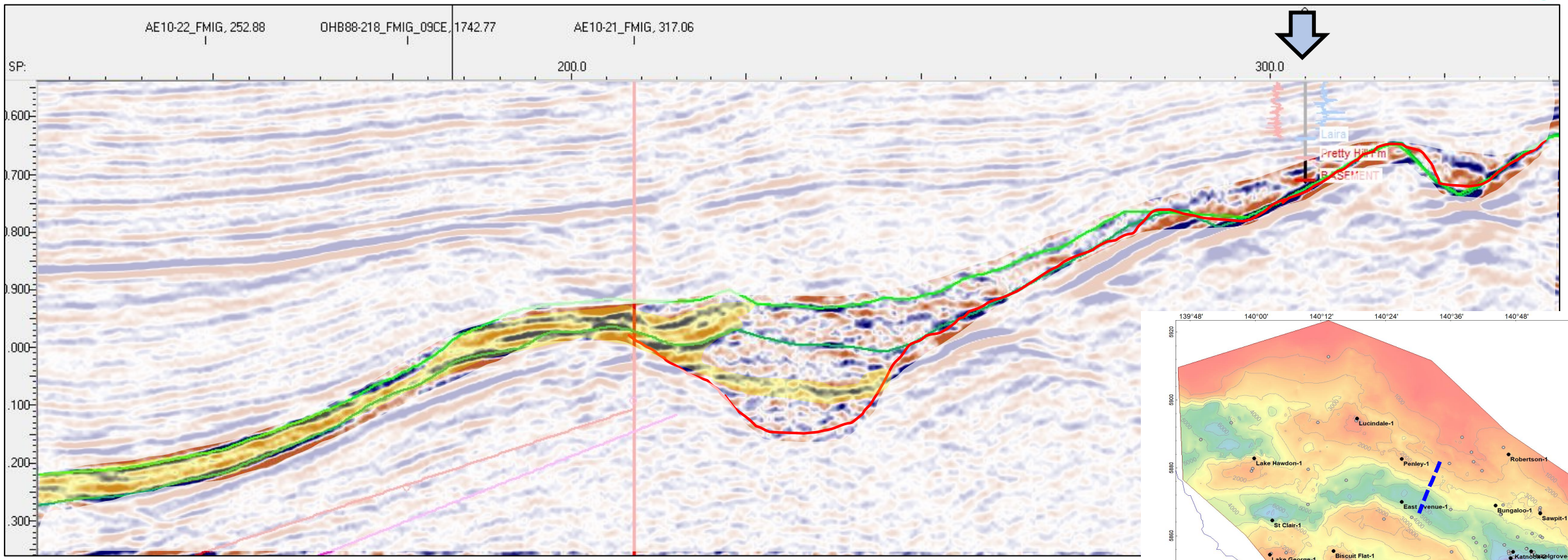
Lower Sawpit Shale [McEachern Sandstone] : A Fresh Look

- A new interpretation has been made for the McEachern Sandstone intervals of the Lower Sawpit Shale interval
- Previously interpreted as terrestrial crevasse splays a fresh look at the McEachern Sst interval has revealed an extensive interbedded deep lacustrine turbidite package





McEachern Sst Distribution: Sediment Input



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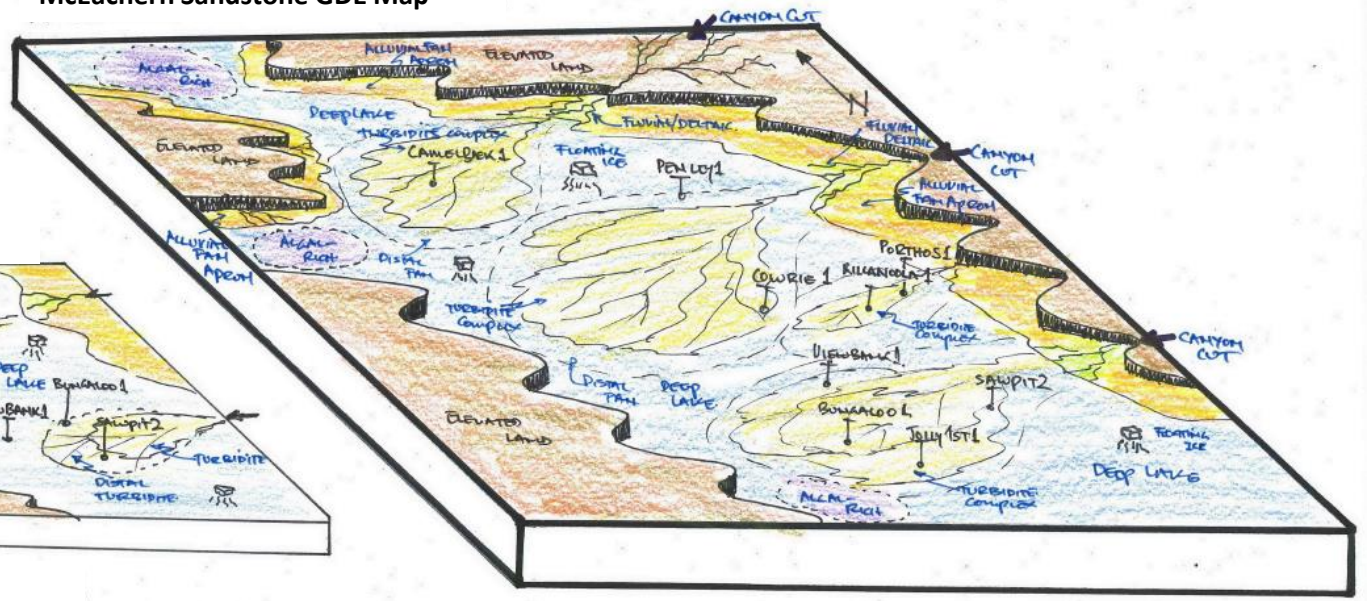
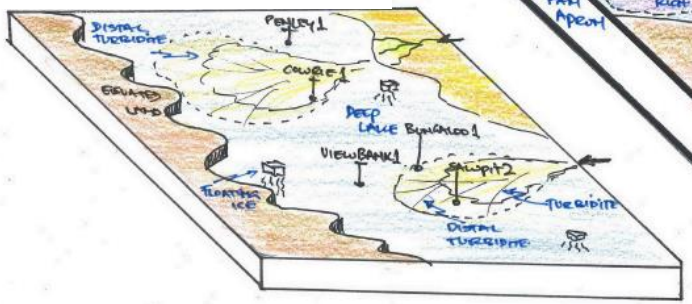
McEachern Sst Distribution
A New Play Concept

- Deep lacustrine turbidite intervals were interpreted in three regions of the Lower Sawpit/McEachern interval (core and seismic facies)
- Lake Thingvallavatn in Iceland is a good analogue

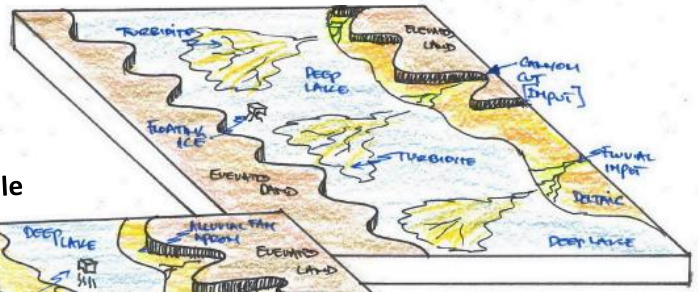
McEachern Sandstone GDE Map



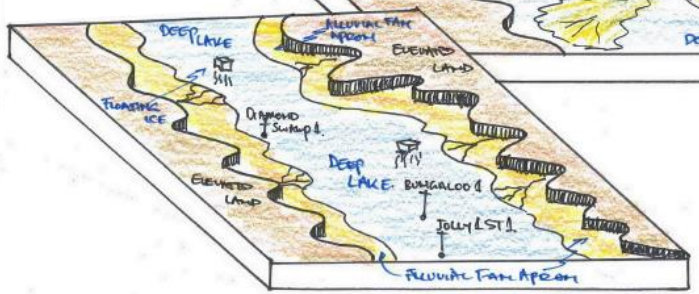
Lower Sawpit Shale [Late]

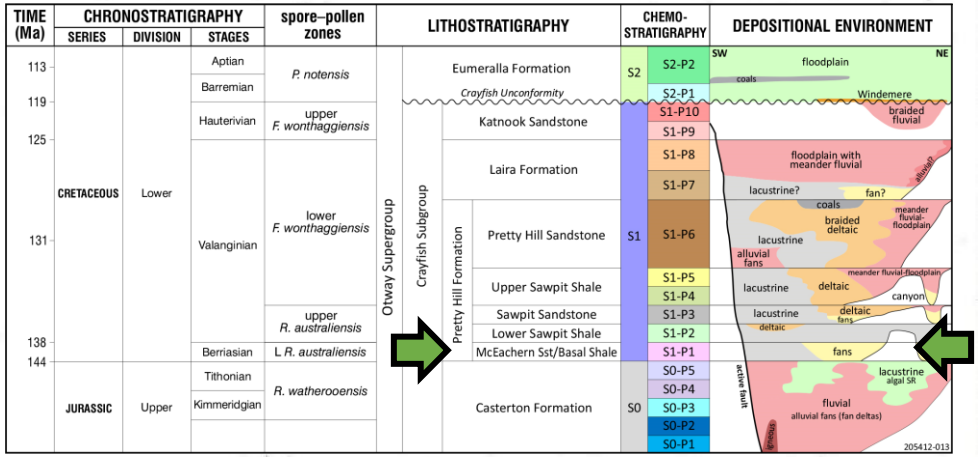


McEachern Sandstone



Basal Shale





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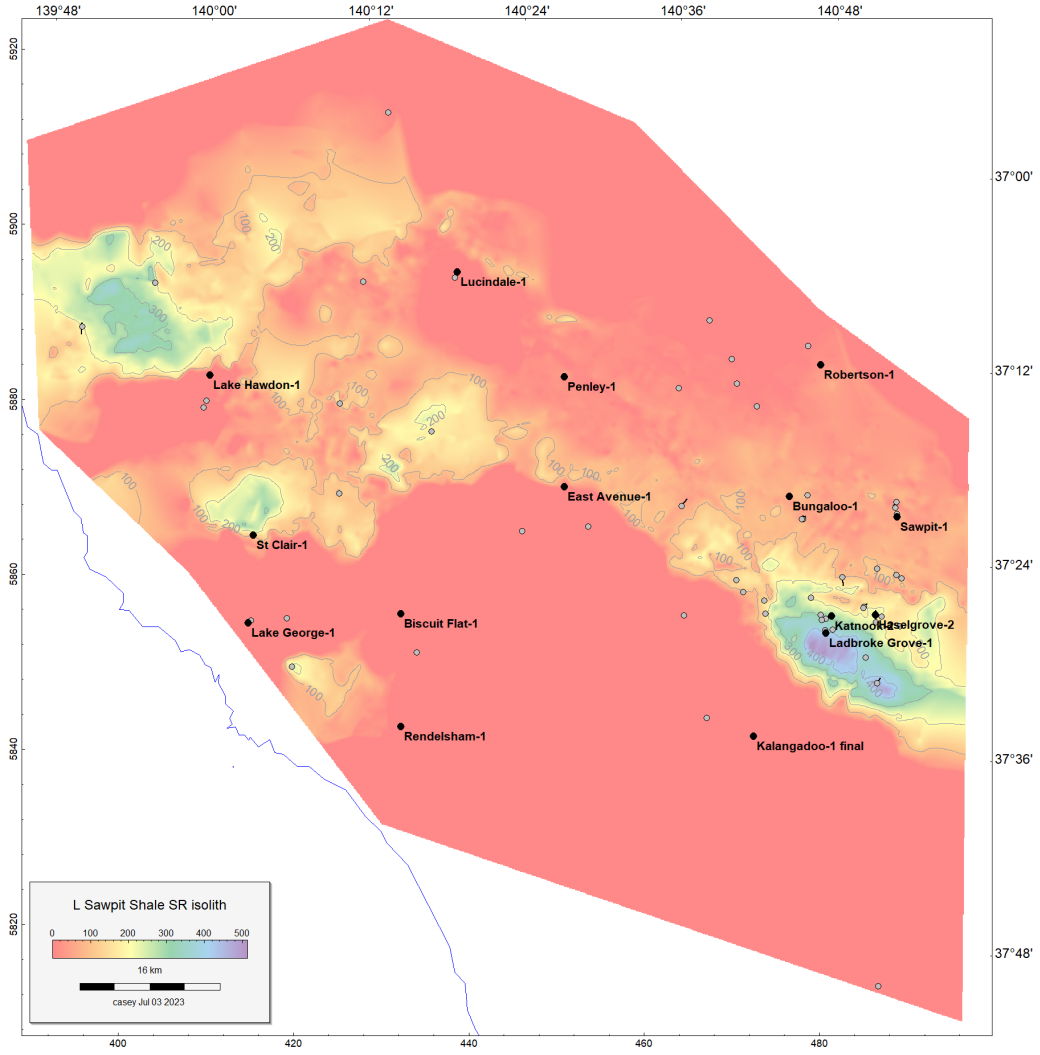
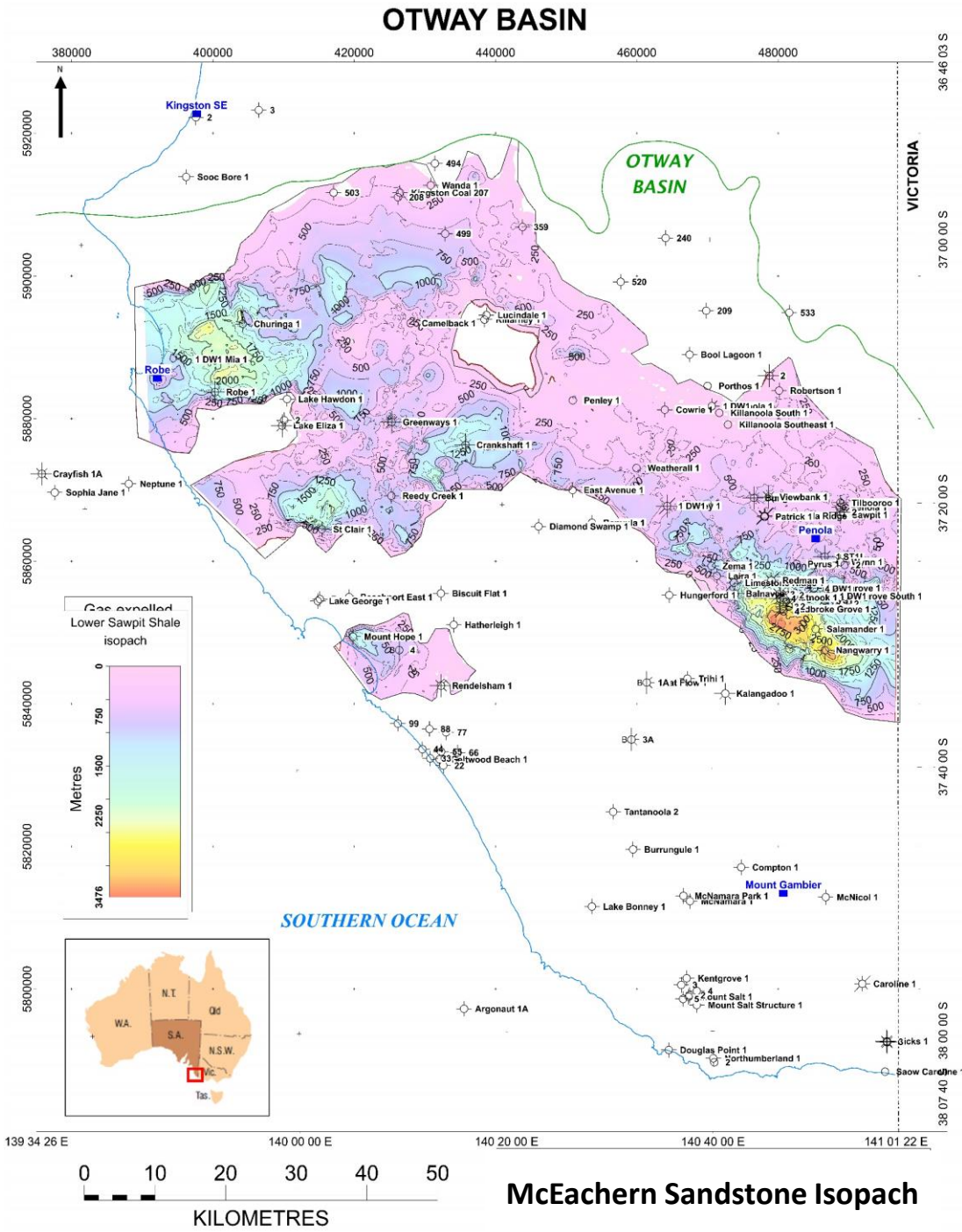
McEachern Sst Distribution
A New Play Concept

Lower Sawpit Shale/McEachern Sst Distribution



McEachern Sandstone SR Isolith



McEachern Sandstone Isopach

Otway: 1D PSM Modelling - Wells

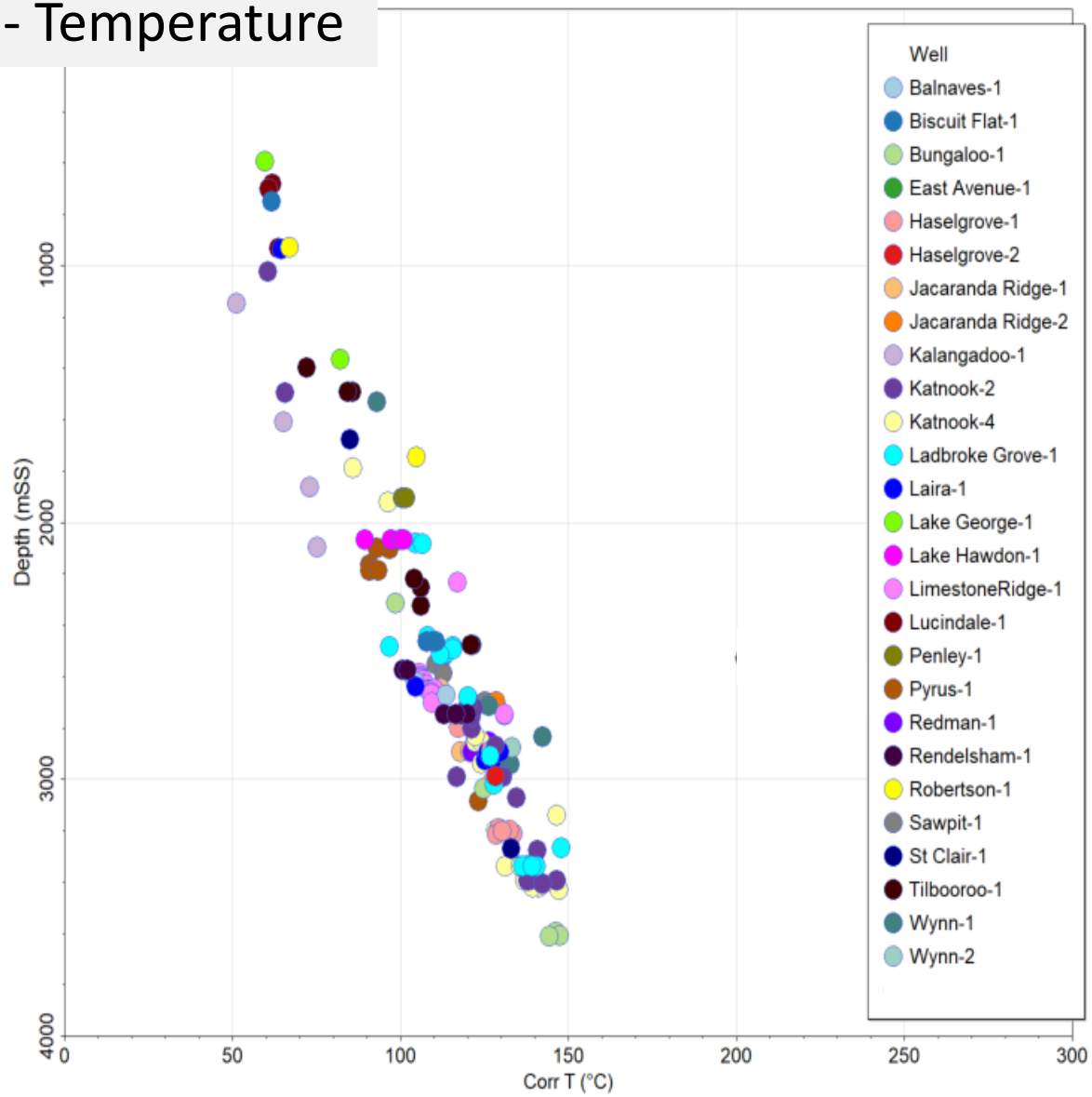
All source Rock Information was verified and used as model inputs:

- TOC/HI/Vitrinite
- Wireline/Core/Tops
- Seismic
- Temperature/Pressure

PSM workflow and metrics:

- 15 1D (dimensional) models were built

1 - Temperature



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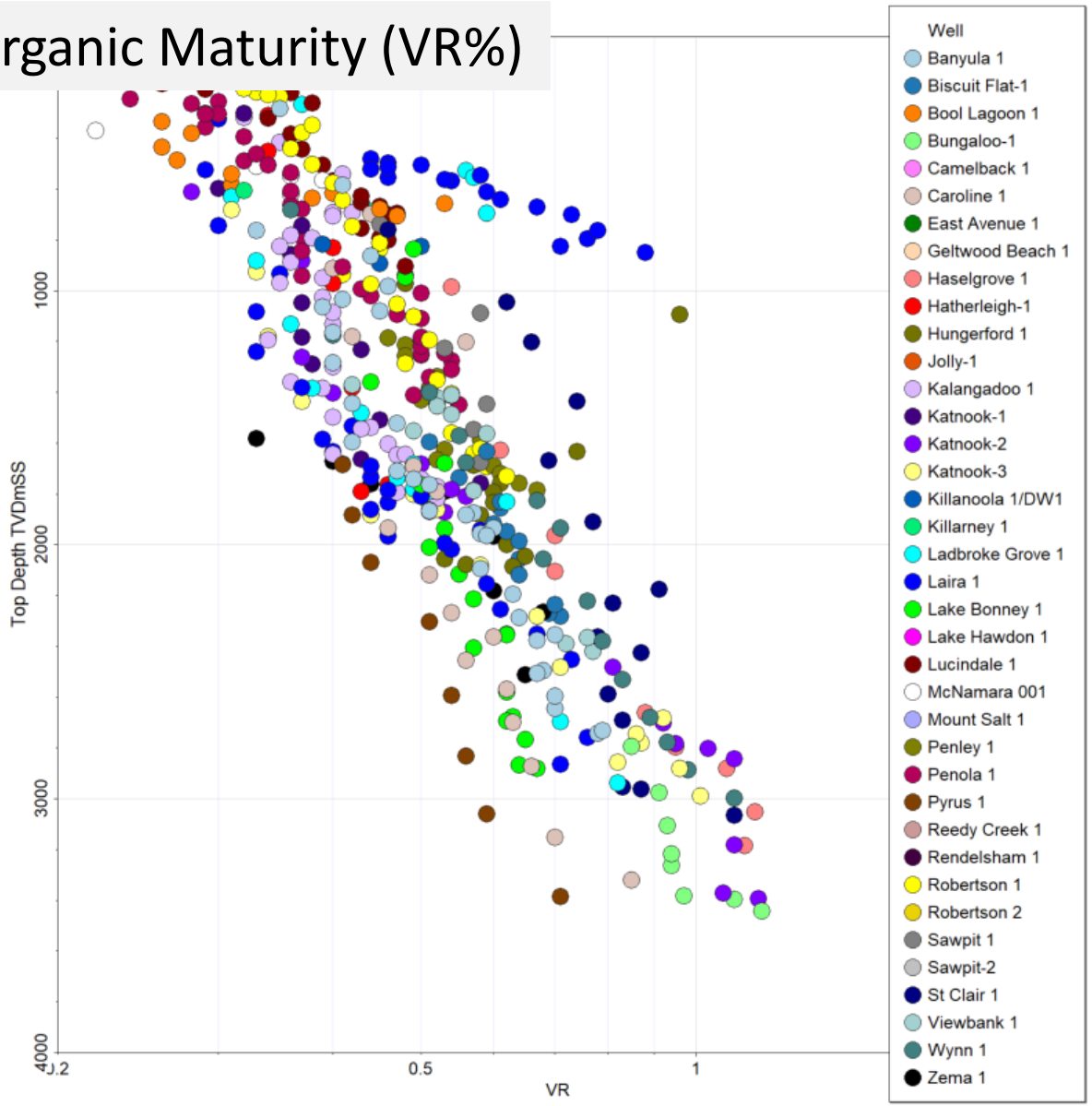
2 – Organic Maturity (VR%)



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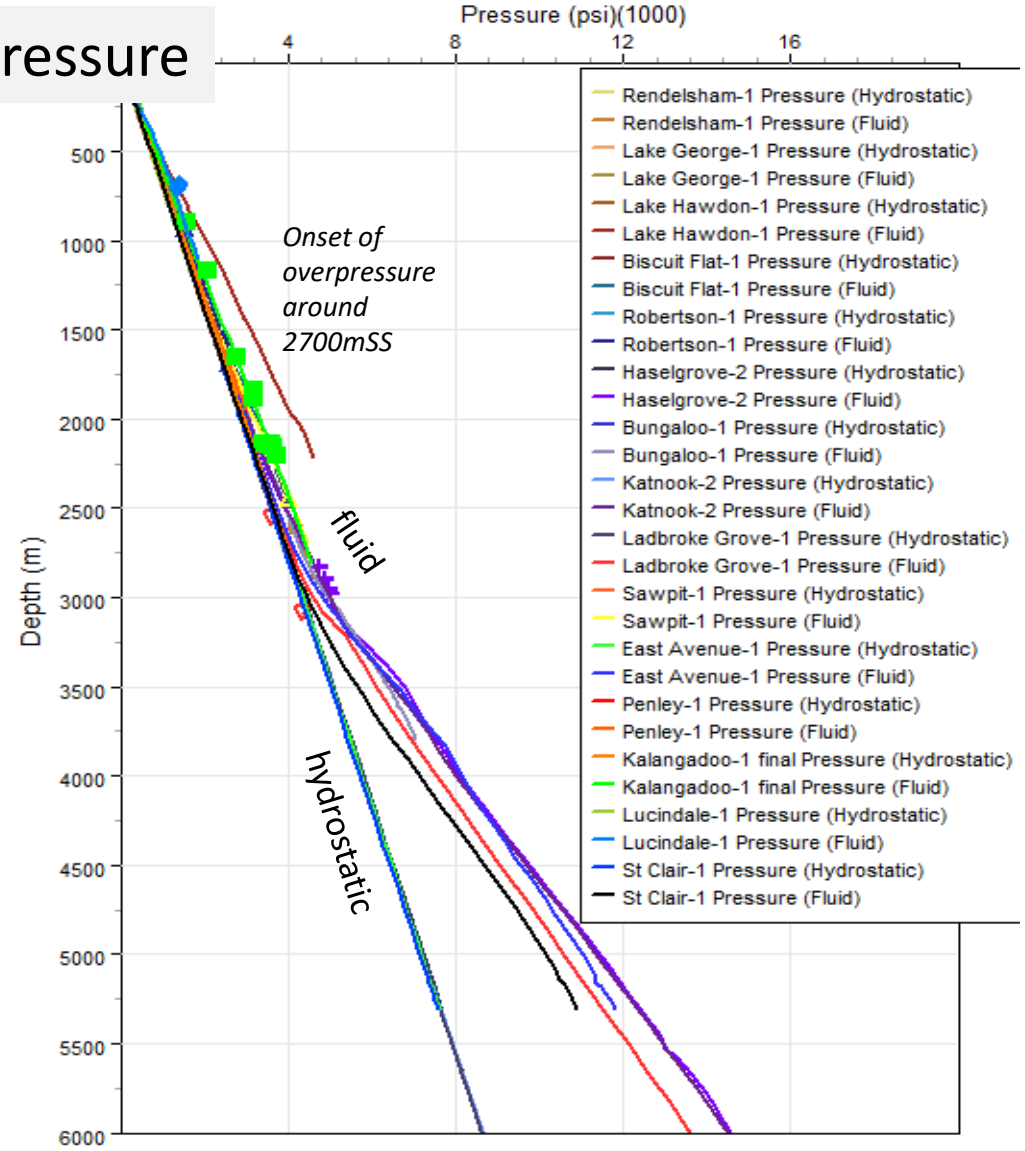
3 - Pressure



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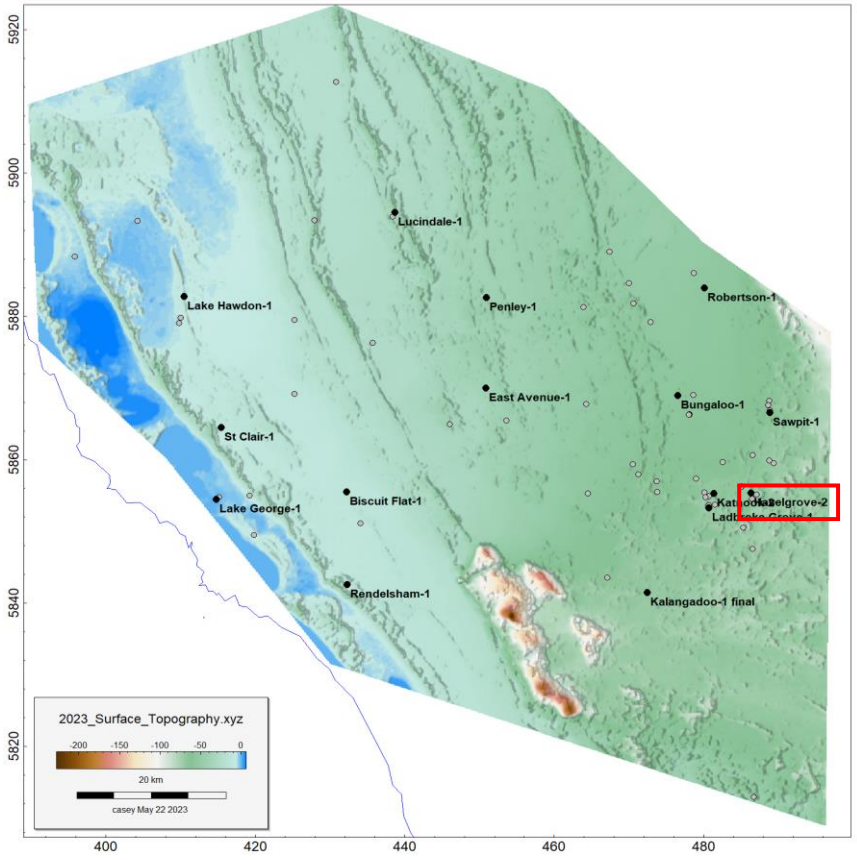

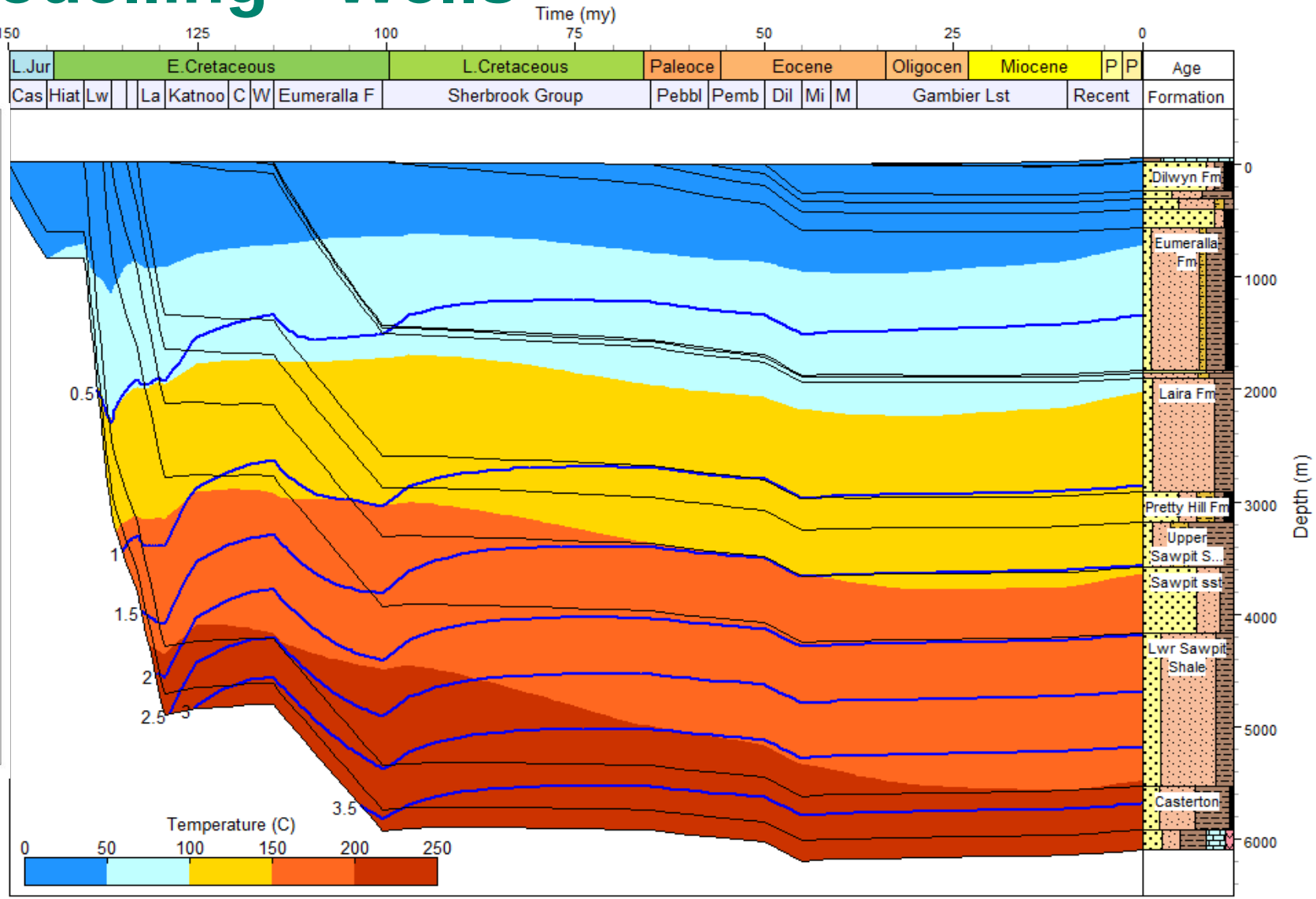

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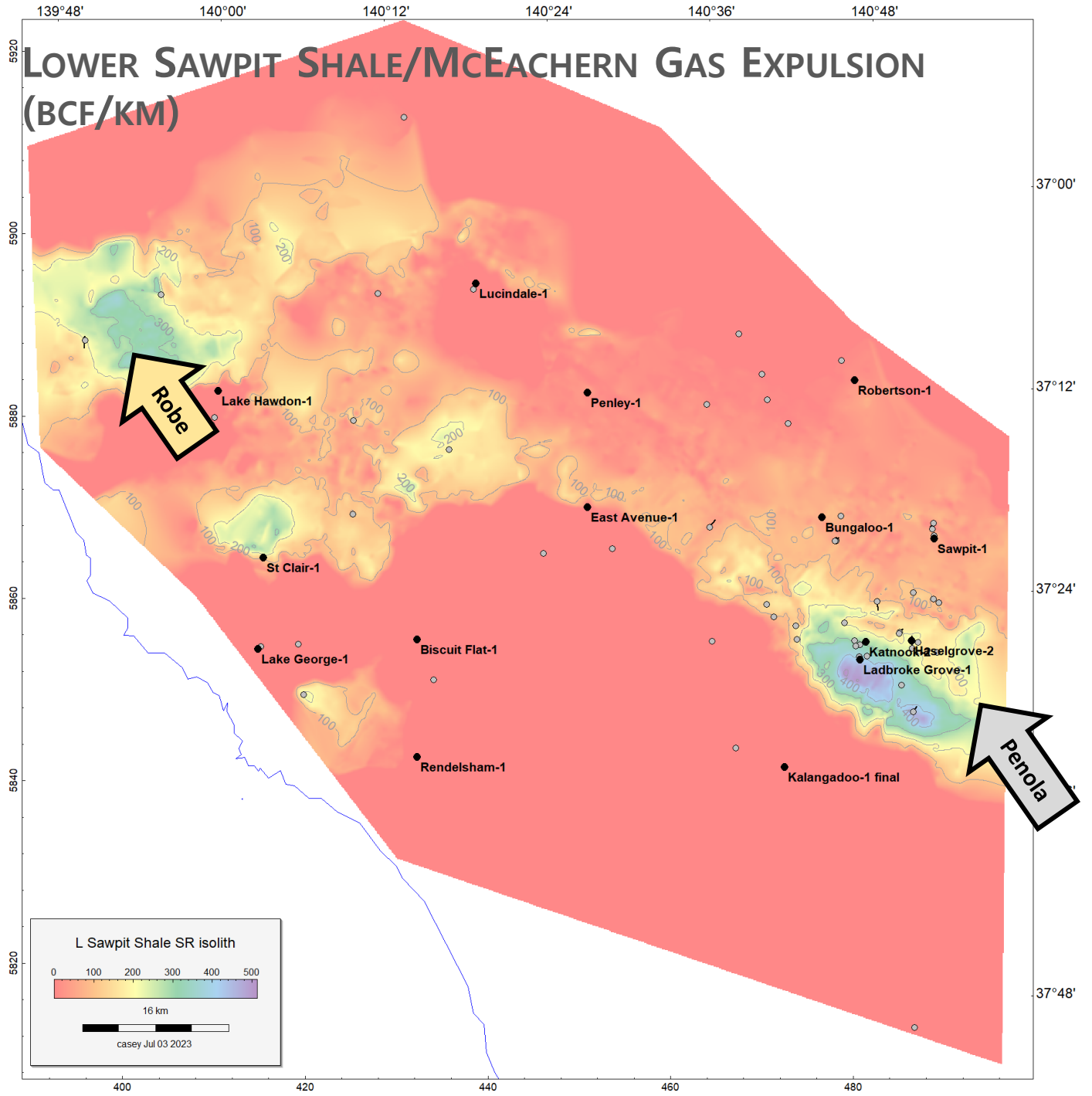
Expulsion: Lower Sawpit/McEachern Sst [Robe Trough]

DEM's modelling reveals

- Previously unknown gas expulsion from the Lower & Upper Sawpit Shale in the Robe Trough (~ the Penola Trough)

The Robe Trough has:

- Reasonable seismic coverage
- A small number of peripheral wells



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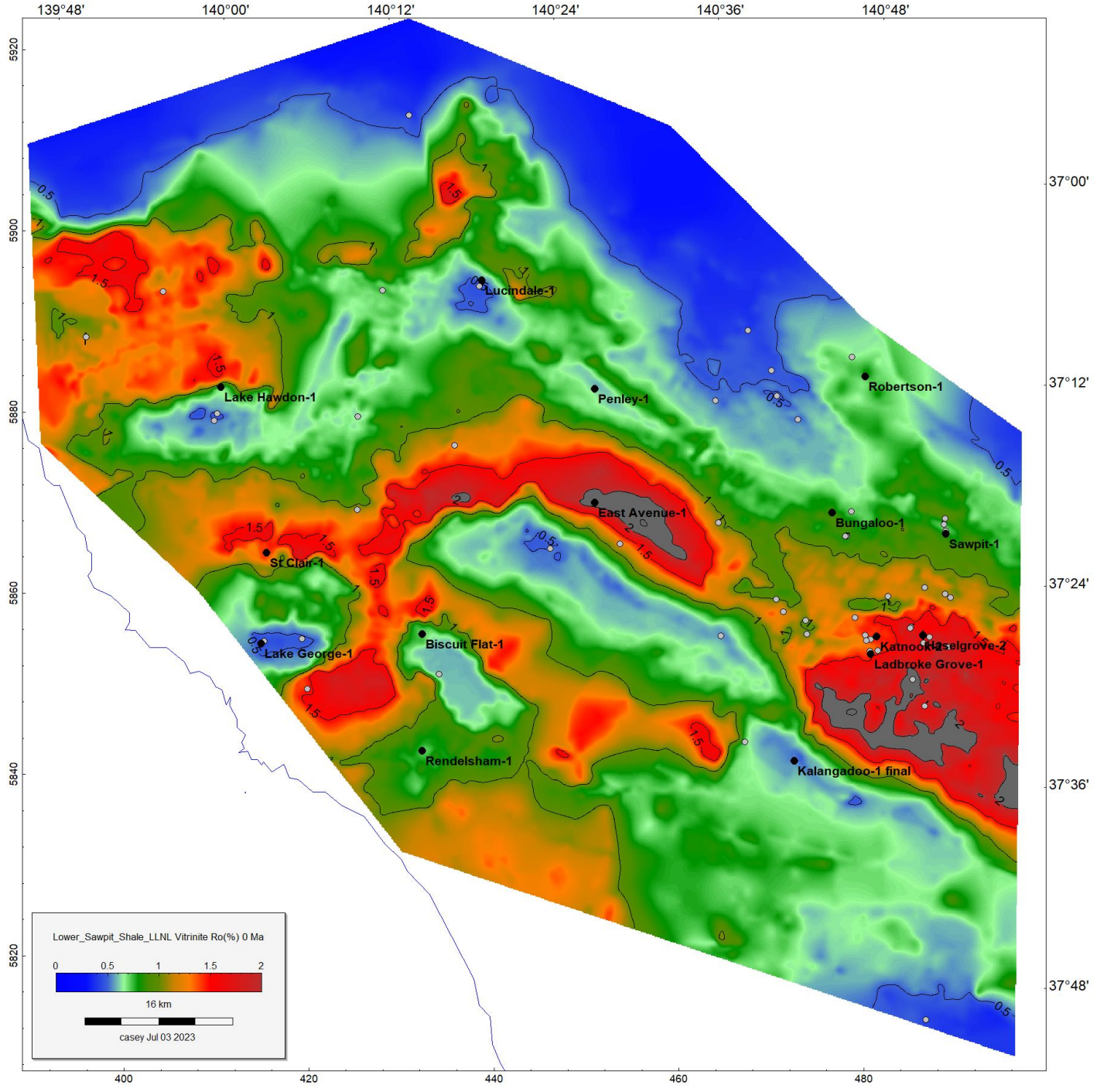

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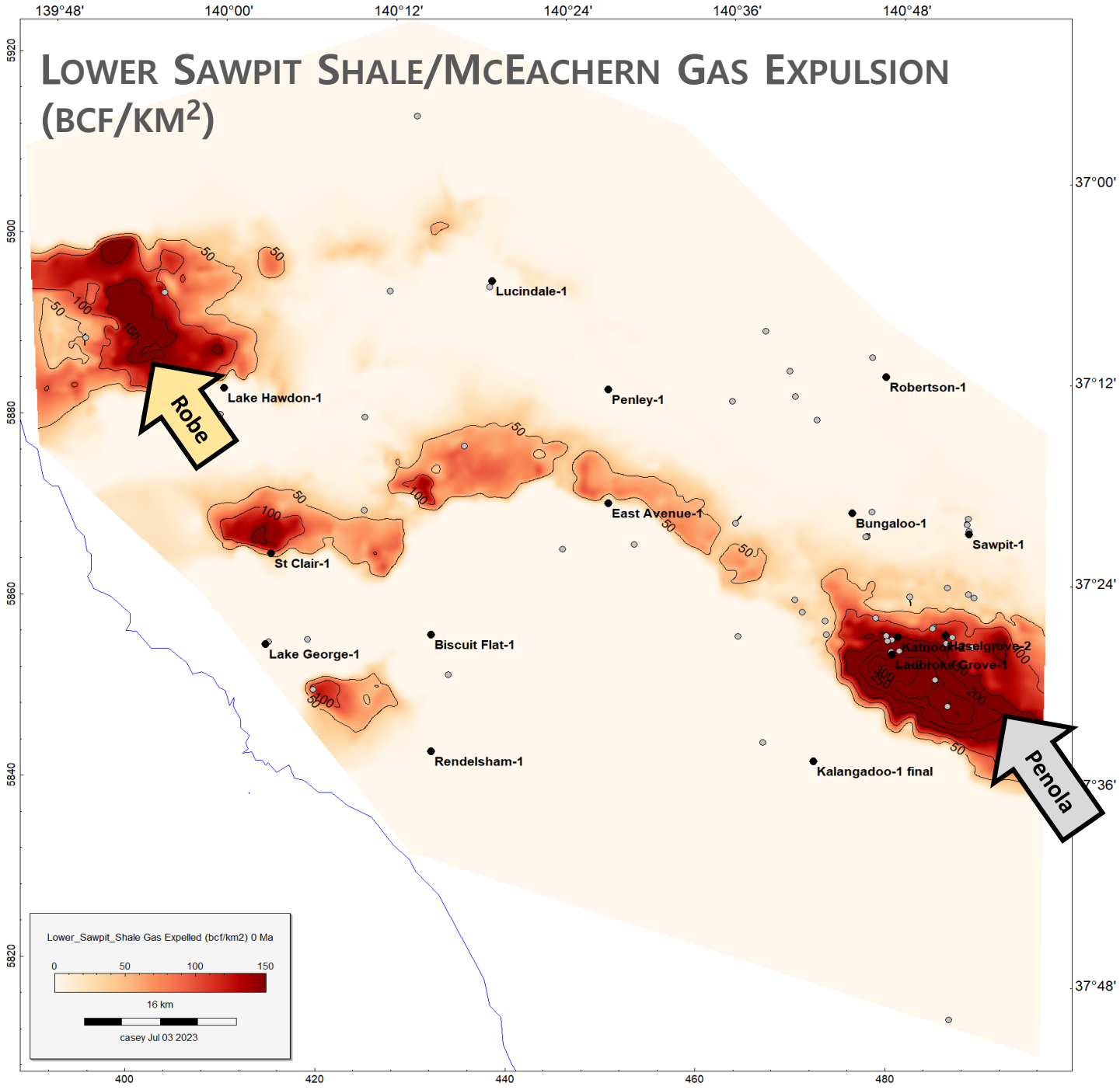
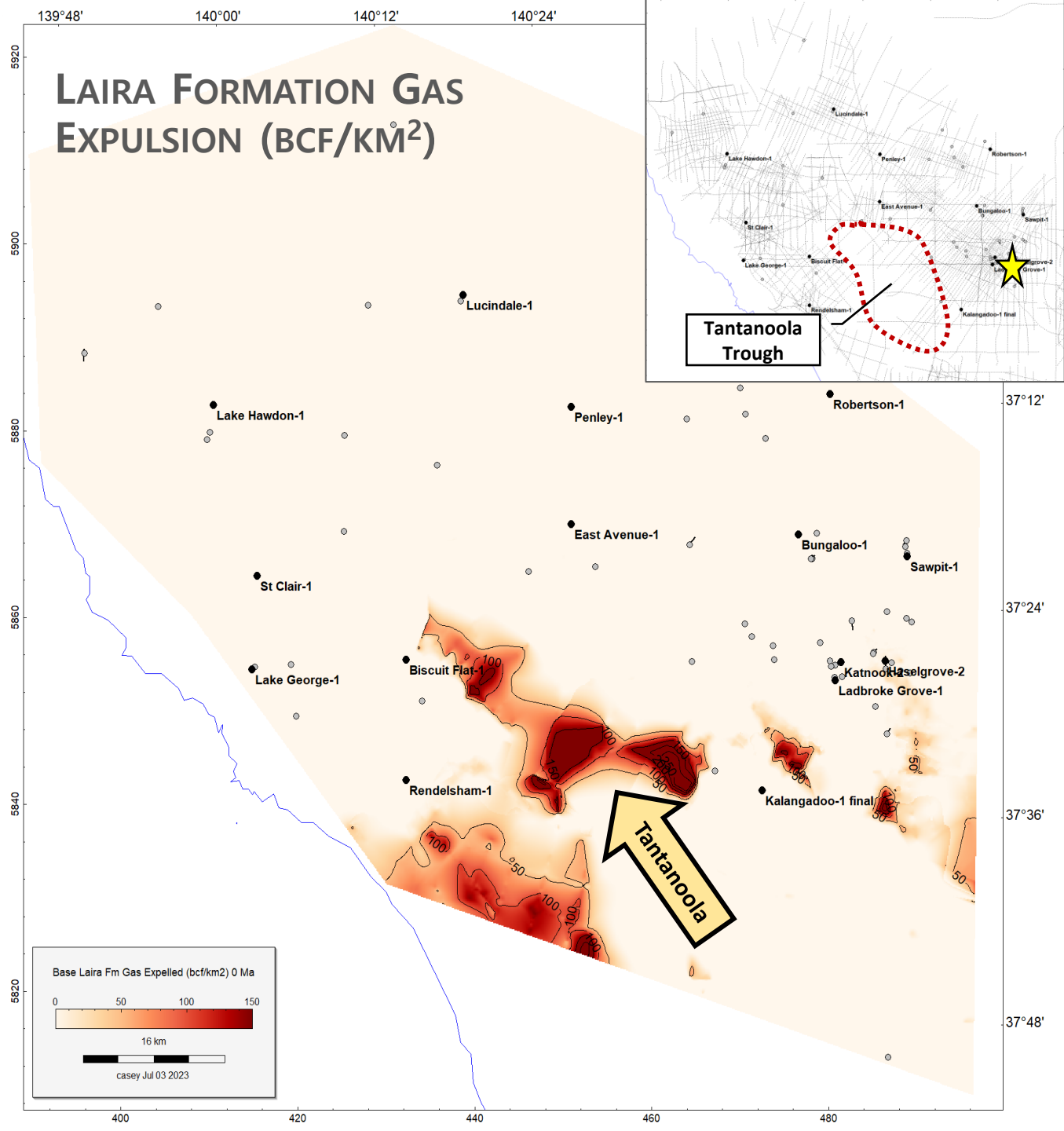


Expulsion: Laira Formation [Tantanoola Trough]

DEM's modelling reveals significant gas expulsion from the Laira Formation in the Tantanoola Trough

The Tantanoola Trough (TT) has:

- Limited seismic coverage (no through lines!) [red dash area]
- No wells [red dash area]
- The TT is ~ 30km from the Katnook gas plant



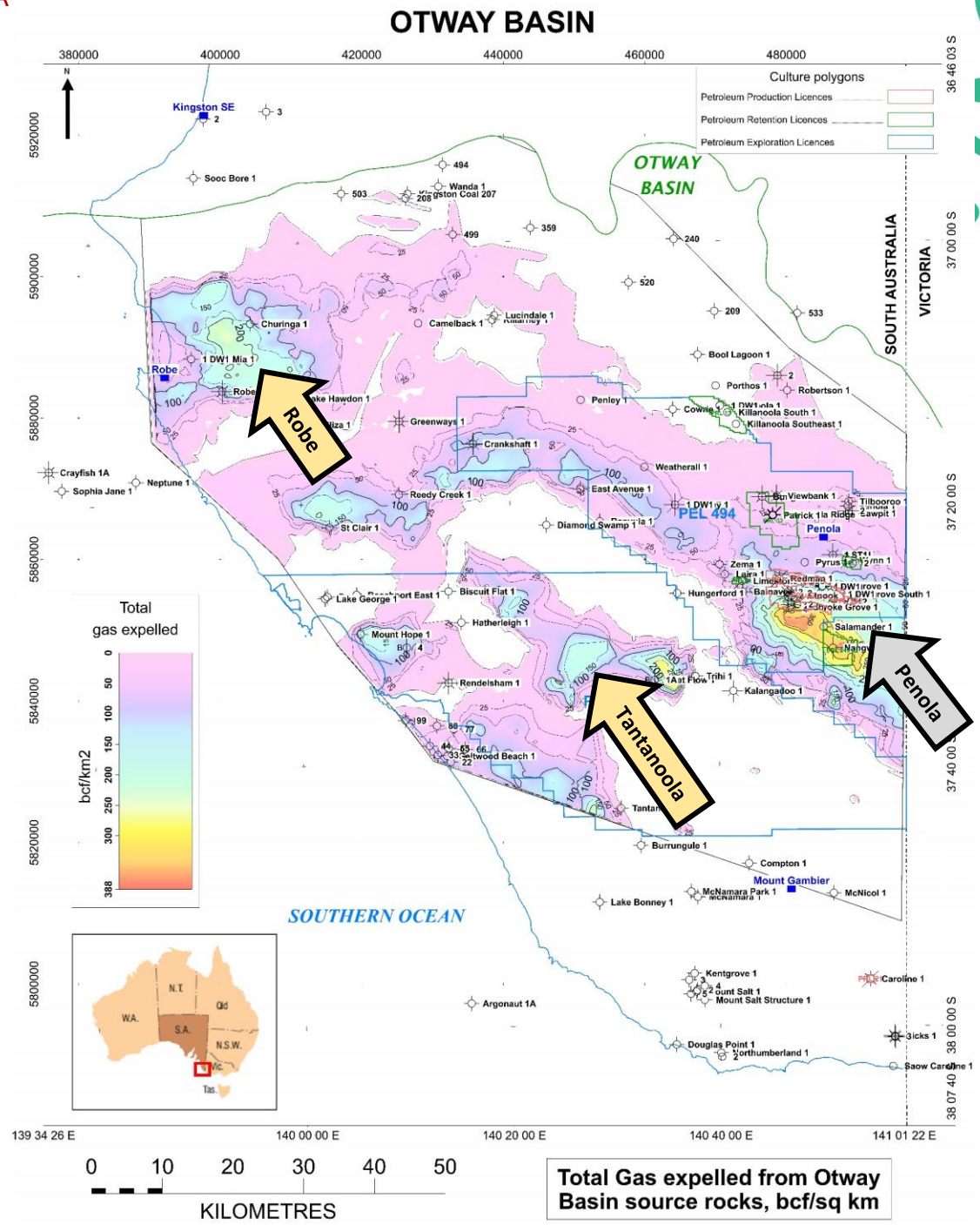
Otway Basin
Total Gas Expulsion

Gas expulsion occurs from four intervals:

- Laira Formation
- Upper Sawpit Shale
- Lower Sawpit Shale/McEachern Sst
- Casterton Formation

Gas expulsion occurs mainly from the:

- Lower Sawpit Shale/McEachern Sst



Total Gas expelled from Otway Basin source rocks, bcf/sq km

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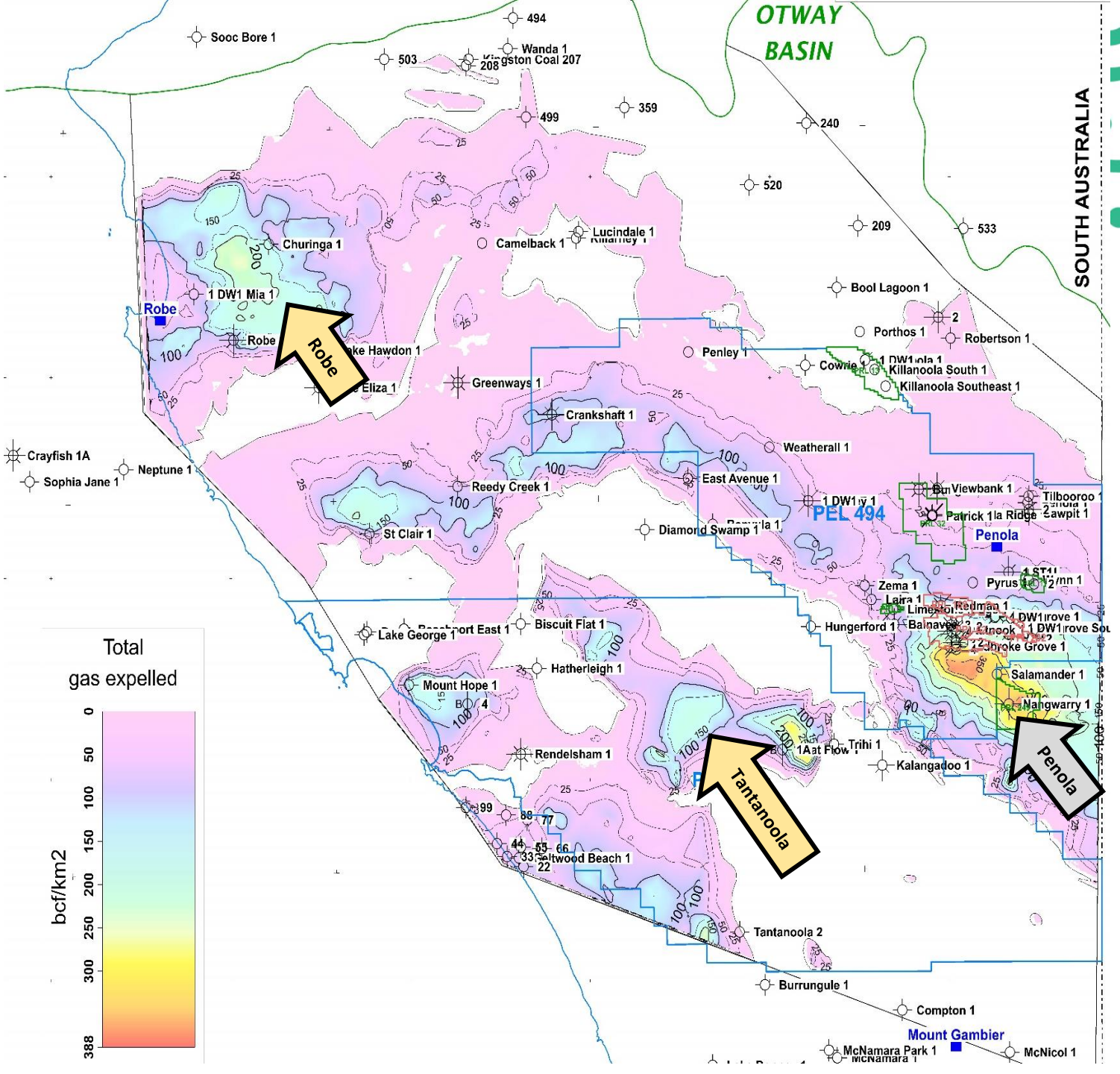
Otway Basin
Total Gas Expulsion

- Significant potential remaining in the Penola Trough (grey)

- Two regions (yellow) have been identified with significant un-explored gas expulsion



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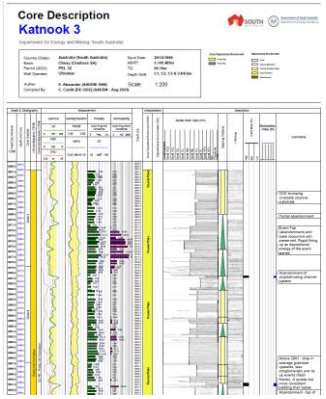
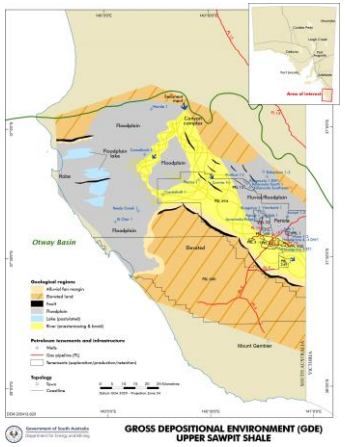
Department for Energy and Mining

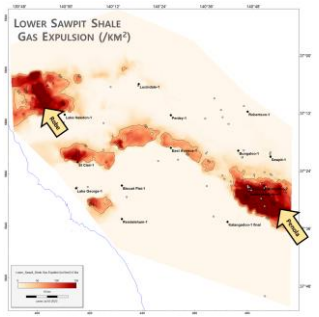
Otway Basin (Onshore SA) – Data Release

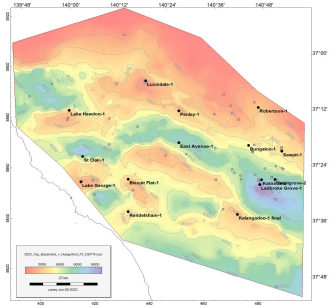
DEM will be presenting its latest technical analysis of the onshore Otway Basin (SA) and highlighting regions of prospectivity. This release will include:

- Petroleum systems modelling (PSM) – Trinity files, movies and summaries
- Regional seismic interpretation – Horizons, faults, grids
- Chemostrat-based well tops – all wells
- Integrated core logs – from 23 wells
- Detailed and missing core imagery
- GDE maps – of all key intervals covered
- Arcmap and Petrosys projects

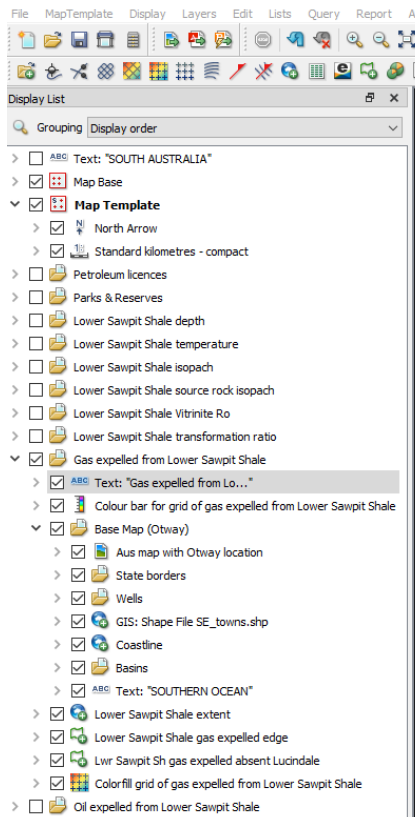


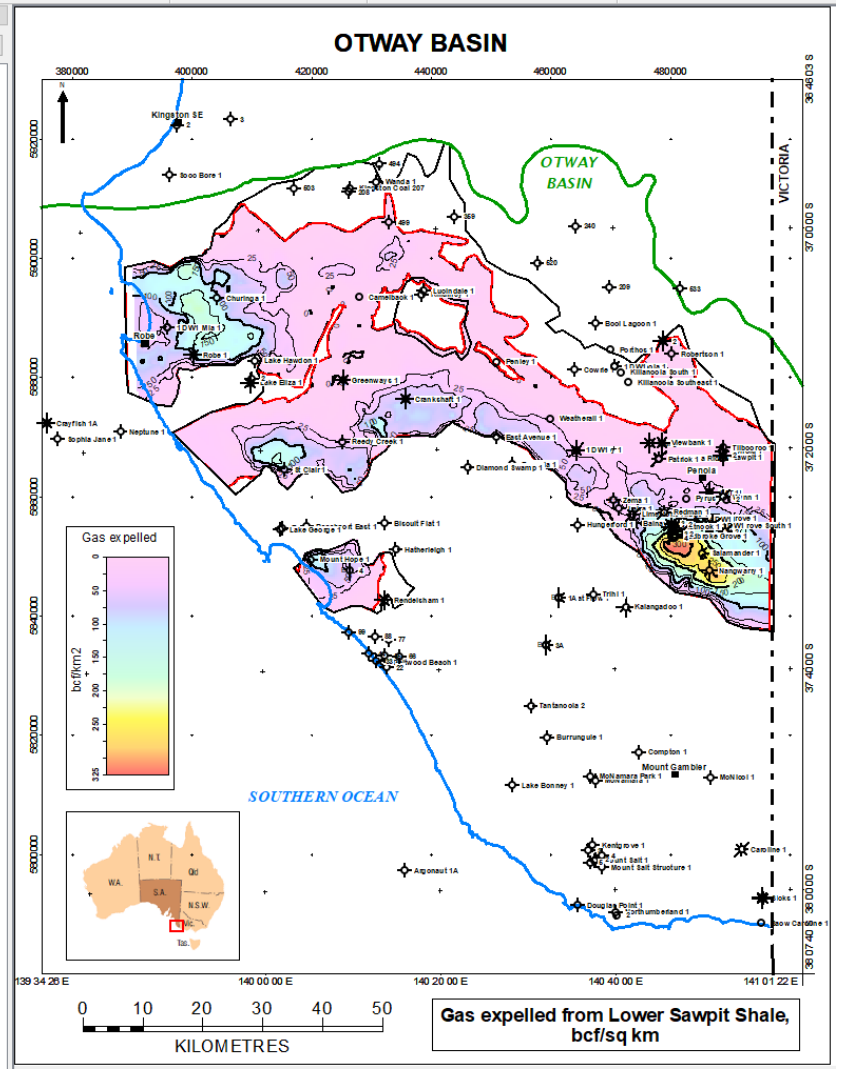






Example Petrosys project (~66 maps)





Up Coming Publications

Upcoming Publications:

- APPEA 2024 - PSM
- APPEA 2024 – McEachern Sandstone turbidites
- APPEA 2024 - GDE

In Press!

CSIRO PUBLISHING

The APPEA Journal

Revisiting the rocks discovers turbidites and a new exploration play in the Penola Trough, Otway Basin, South Australia

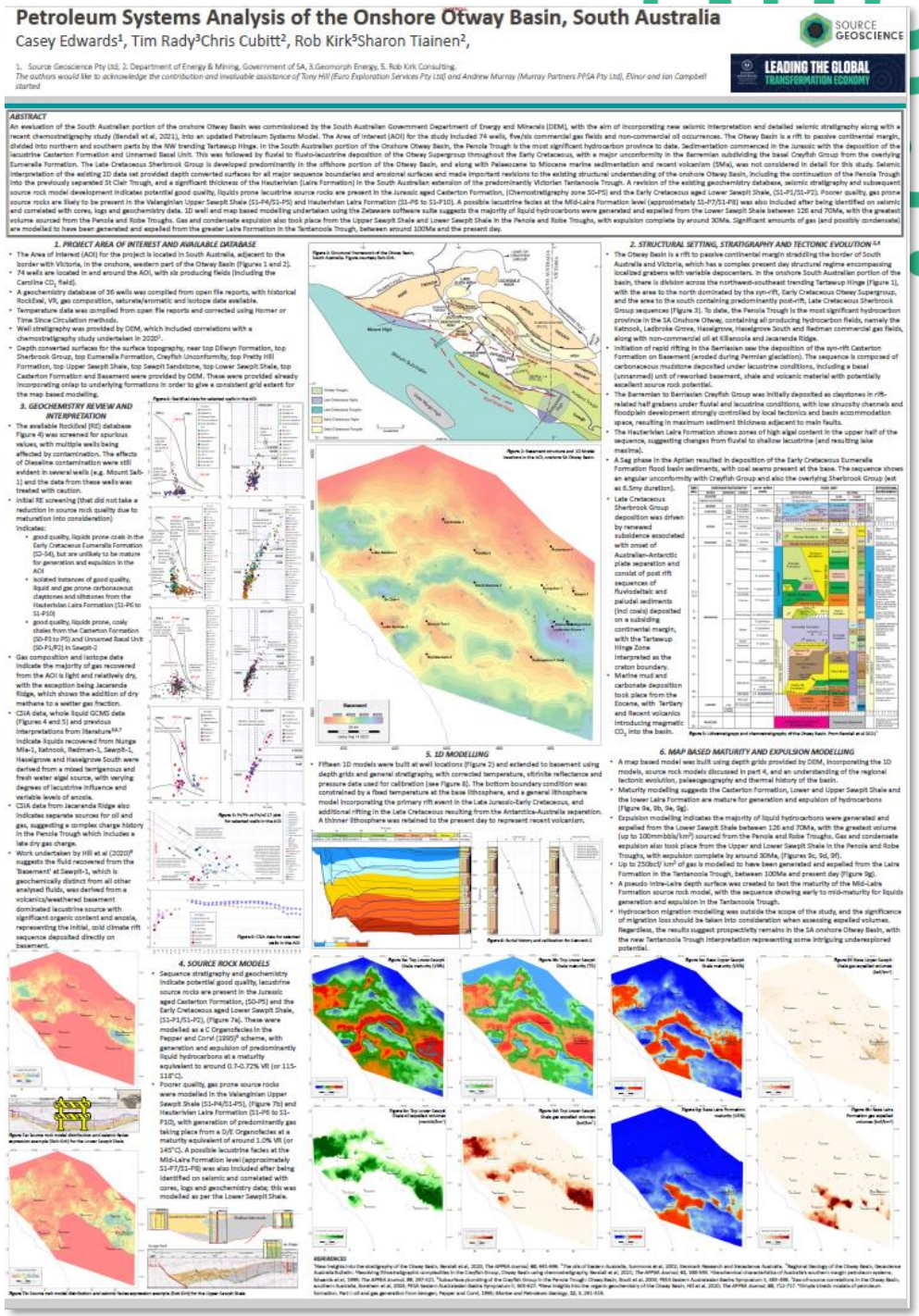
Journal:	*APPEA Journal*
Manuscript ID	Draft
Manuscript Type:	Paper Proposal
Date Submitted by the Author:	n/a
Complete List of Authors:	Tiainen, Sharon; South Australia Department for Energy and Mining kirk, rob; South Australia Department for Energy and Mining Cubitt, Chris; South Australia Department for Energy and Mining Rady, Tim; Geomorph Energy Pty Ltd
Keywords:	
Abstract:	As part of an integrated geological, geochemical, and geophysical study, conventionally cored intervals from the lower-most stratigraphic section of the onshore South Australian part of the Penola Trough, Otway Basin have been reviewed and reinterpreted. The three cored wells; Bungaloo-1 (cores 3 and 4), Jolly-1ST1 (cores 1, 2, 3 and 4) and Sawpit-2 (cores 1, 2 and 3), were described using a 'quick-look' approach to determine gross lithological and sedimentological information. Seven lithology types were observed: claystone with horizontal lamination, claystone with horizontal lamination and dropstones, clay/silt stone with massive-horizontal lamination, silt/sandstone with horizontal lamination, sandstone with ripple lamination, sandstone with parallel

CSIRO PUBLISHING

The APPEA Journal

Gross depositional environment (GDE) mapping of rift fill intervals in the onshore South Australian Otway Basin: an example of data integration

Journal:	*APPEA Journal*
Manuscript ID	Draft
Manuscript Type:	Paper Proposal
Date Submitted by the Author:	n/a
Complete List of Authors:	Cubitt, Chris; Department of Energy and Mining, Geoscience and Exploration Branch | Energy Resources Division - DEM kirk, rob; Rob Kirk Consultants Rady, Tim; geomorph Tiainen, Sharon; Department for Energy and Mining, Senior Geologist - Exploration Assessment Mineral Exploration | Mineral Resources
Keywords:	
Abstract:	Gross depositional environment (GDE) maps were made for six key intervals in the onshore portion of the Jurassic to mid-Cretaceous Otway Basin in South Australia. The Department for Energy and Mining (DEM) has undertaken this comprehensive review (including a petroleum systems model – PSM) so as to stimulate conventional oil and gas exploration but also to inform Carbon Capture and Storage and subsurface hydrogen storage plays. The GDE maps are the culmination of geological understanding in each interval with results from whole of-basin (chrono-stratigraphic) well correlation, seismic horizon/fault mapping, seismic facies interpretation and core interpretation integrated. Also, where available, interval-specific bore hole image (BHI) derived paleo-current directions were added, along with petrology and biostratigraphic information. The mapping reveals varied GDEs including deep lacustrine affected by ice, a lacustrine turbidite system, extensive fluvial/lacustrine, fluvial/flood plain and ribbon-like alluvial fan aprons. Well penetrations were used to control seismic horizon picking with syn-depositional faulting a key driver in understanding both the style and axes of deposition. The resulting isopachs and interval-active (growth) faults functioned as the backdrop for well signature maps. Independent core interpretation was then used as primary depositional evidence, giving spatial context and locally informing seismic facies. Subsequently seismic facies interpretations were made away from well control allowing for complete GDE map coverage for all six intervals. These powerful integrated datasets together with the PSM are focussed at firstly stimulating renewed explorer interest in this basin and then



Petroleum Systems Analysis of the Onshore Otway Basin, South Australia

Casey Edwards[1], Tim Rady[3]Chris Cubitt[2], Rob Kirk[5]Sharon Tiainen[2],

SOURCE GEOSCIENCE

LEADING THE GLOBAL TRANSFORMATION ECONOMY

ABSTRACT

1. PROJECT AREA OF INTEREST AND AVAILABLE DATABASE

2. STRUCTURAL SETTING, STRATIGRAPHY AND TECTONIC EVOLUTION

3. GEOCHEMISTRY REVIEW AND INTERPRETATION

4. SOURCE ROCK MODELS

5. 1D MODELLING

6. MAP BASED MATURITY AND EXPULSION MODELLING

REFERENCES

Government of South Australia

Department for Energy and Mining

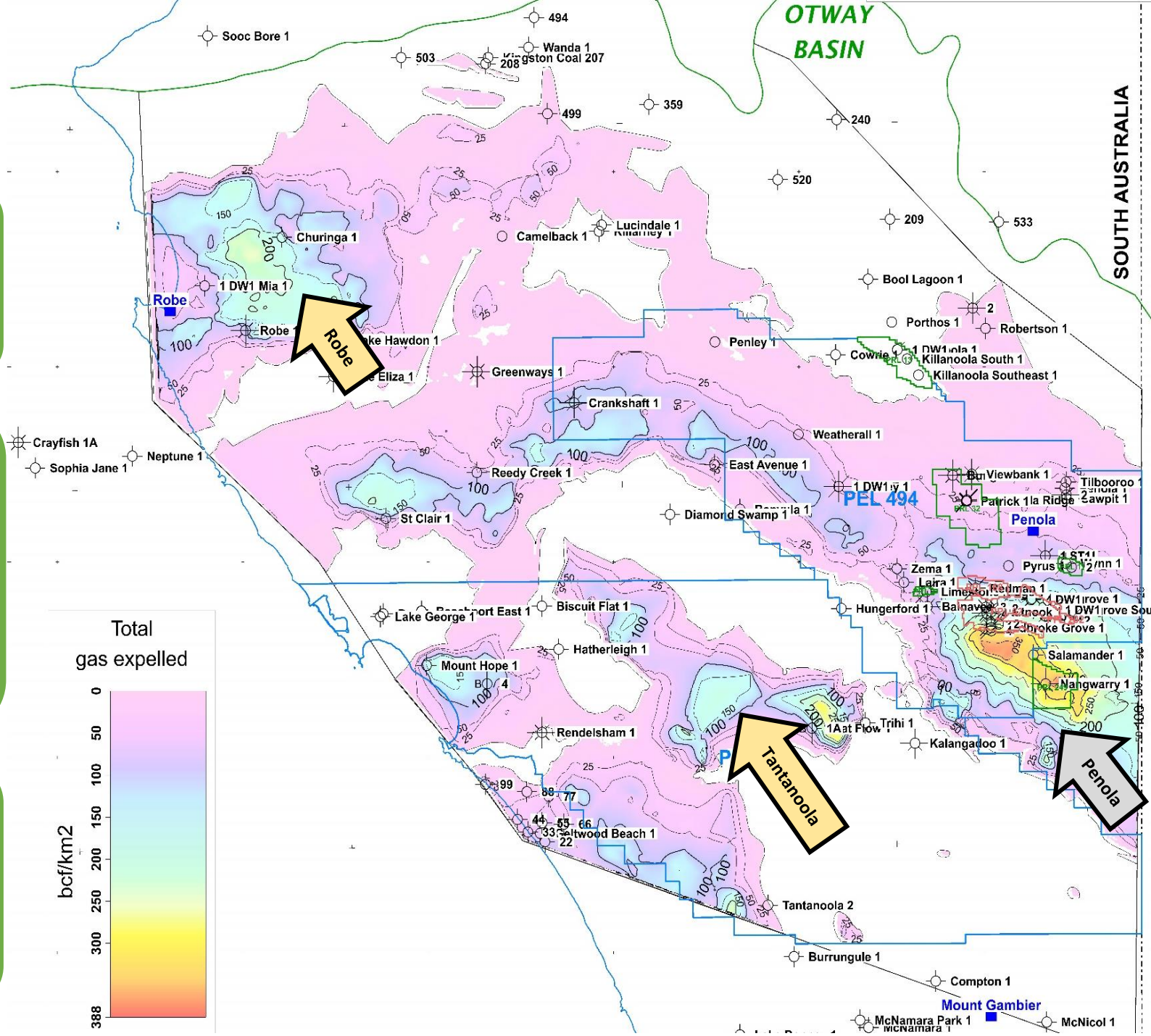
SOUTH AUSTRALIA

Final Messages

A significant DEM study has revealed that SA's onshore Otway has……

- Significant potential remaining in the Penola Trough
- Two regions (yellow) have been identified with significant un-explored gas expulsion

All data and modelling files associated with the PSM modelling will be released to the public



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- Rob Kirk

Wells Team

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- Chris Cubitt

Core Team

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- Paul Strong
- Sharon Tiainen
- Dave Groom/Dale Groom (and the entire Tonsley core team)

PSM Team

- Casey Edwards/Tony Hill

GDE Mapping Team

- Chris Cubitt
- Tim Rady
- Rob Kirk
- Sharon Tiainen

GIS Team

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- Jess Bonsell
- Paul Strong/Tim Rady

Photography/DB Team

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- Witold Seweryn
- Jess Bonsell
- Alan Sansome

Products Team

- Chris Cubitt
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- Jess Bonsell
- Steven Curnow
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SOUTH AUSTRALIA

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