A FRESH LOOK AT THE SOUTH AUSTRALIAN ONSHORE OTWAY BASIN

POWERFUL INSIGHTS FROM DEM's PETROLEUM SYSTEMS MODEL PROJECT





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Otway Basin: Project Aim

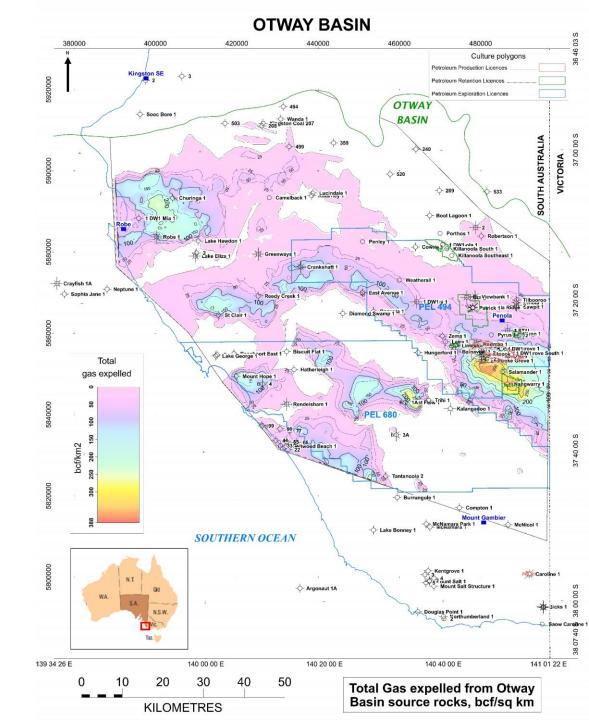
Aim:

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

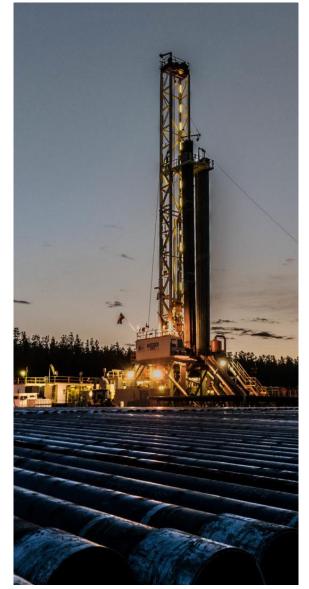
Commenced: 2020

Completion: Q4 2023





Project Fast Facts



Whole of Basin PSM

- Petroleum system model
- Expulsion maps per key intervals

Seismic & Wells

- Stratigraphic framework 80 wells
- 7965km seismic interpretation

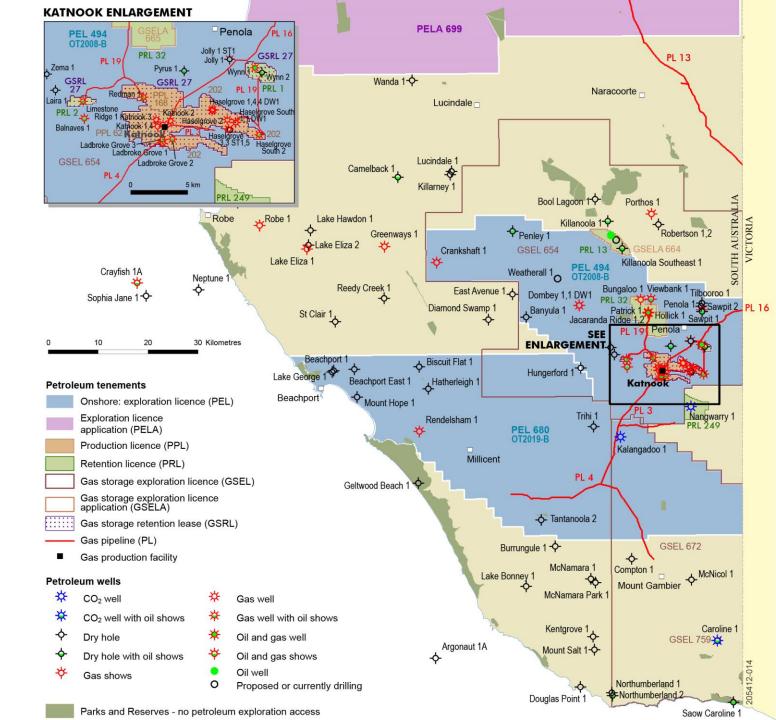
Cores & Maps

- 772m of core interpreted
- 6 geology maps constrained

Otway Basin

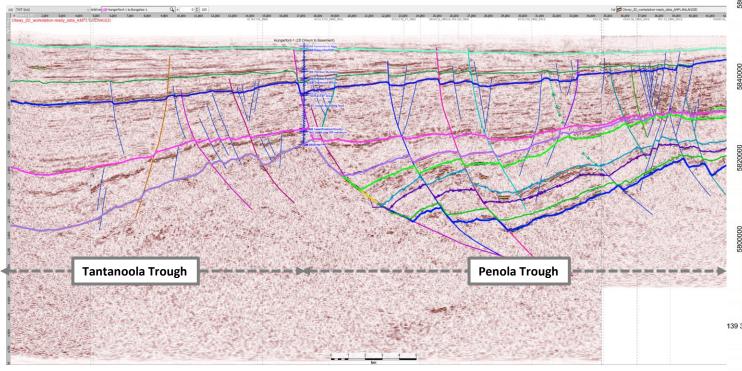
- Oil and gas production from 6 hydrocarbon fields
- ~63 BCF of natural gas produced
- The Katnook gas facility is currently mothballed

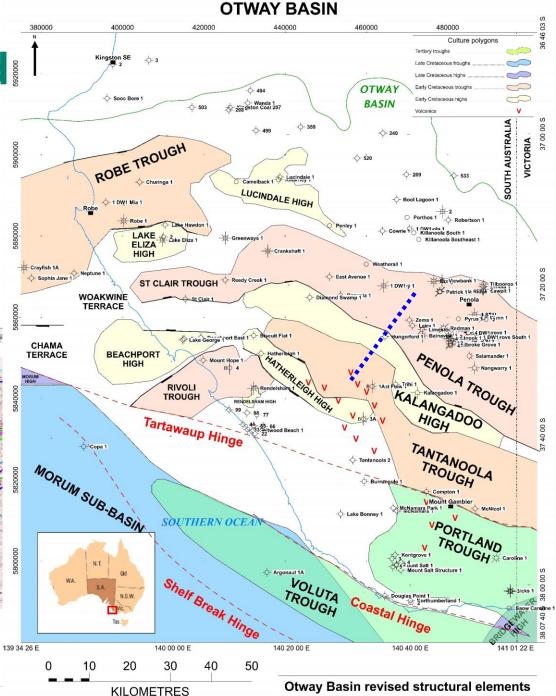




Otway Basin Structure Updated

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

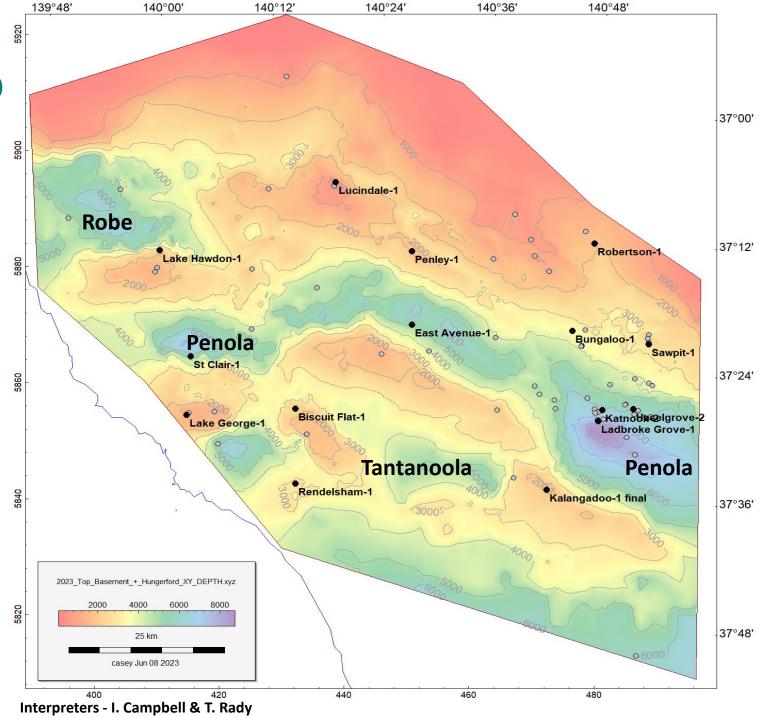




Otway Basement Map The 2023 Update!

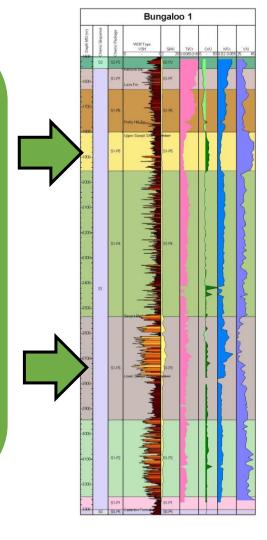
- The Penola Trough extends to the west and includes the St Clair Trough
- The Tantanoola Trough is a distinct depositional centre
- The Robe Trough is more extensive and deeper than previously understood

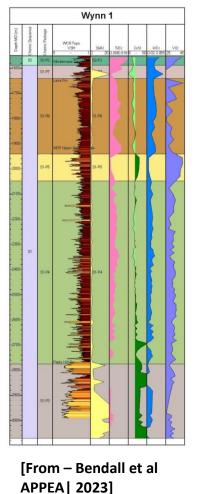


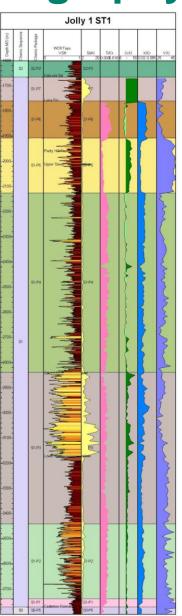


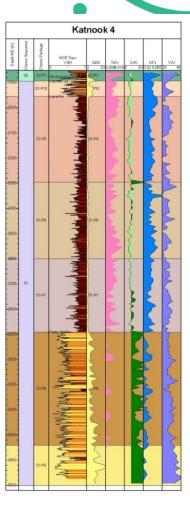
A New Approach to Otway Well-Based Stratigraphy

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













Onshore Otway Basin (SA) Stratigraphy: Updated!

spore-pollen

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

TIME

CHRONOSTRATIGRAPHY

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

(Ma)	SERIES	DIVISION	STAGES	zones		LI	1110	SINAHUNAFIH	STR	ATIGRAPHY	DEFOSITIONAL ENVIRONMENT	ELEMENT
113 -			Aptian	P. notensis			Eur	meralla Formation	S2	S2-P2	floodplain	
110			Barremian				Cr	ayfish Unconformity		S2-P1	Windemere	
119 -			Hauterivian	upper F. wonthaggiensis				Katnook Sandstone	\hlimat{\chi}	S1-P10 S1-P9	braided	Reservoir
125 –								Laira Formation		S1-P8	floodplain with meander fluvial	Source
	CRETACEOUS	Lower				dn				S1-P7	lacustrine? fan?	
131 -			Valanginian	lower F. wonthaggiensis	Supergroup	Crayfish Subgroup	Hill Formation	Pretty Hill Sandstone	S1	S1-P6	alluvial fans	Reservoir
					Otway (Cra	Hill Fo	Upper Sawpit Shale		S1-P5 S1-P4	lacustrine deltaic canyon	
				upper	Ó		Pretty	Sawpit Sandstone		S1-P3	lacustrine deltaic fans	Source
138 -				R. australiensis			Pre	Lower Sawpit Shale		S1-P2	deltaic	
144 -			Berriasian	L R. australiensis				McEachern Sst/Basal Shale		S1-P1	fans	
177			Tithonian	R. watherooensis						S0-P5 S0-P4	active fault fluvial	
	JURASSIC	Upper	Kimmeridgian	n. watherooensis				Casterton Formation	S0	S0-P3	fluvial alluvial fans (fan deltas)	Source
										S0-P2 S0-P1	isneous	205412-023

LITHOSTRATIGRAPHY

CHEMO-

PLAY

DEPOSITIONAL ENVIRONMENT



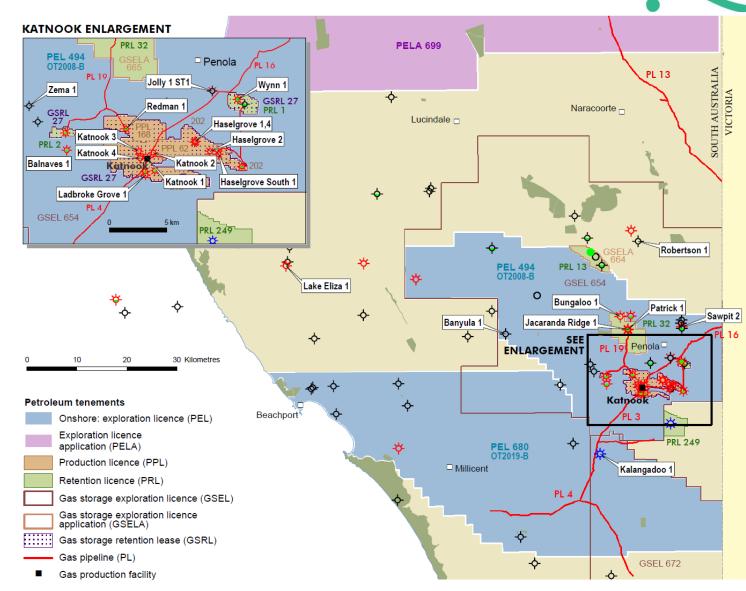


Core: Reservoir and Source Rocks

~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

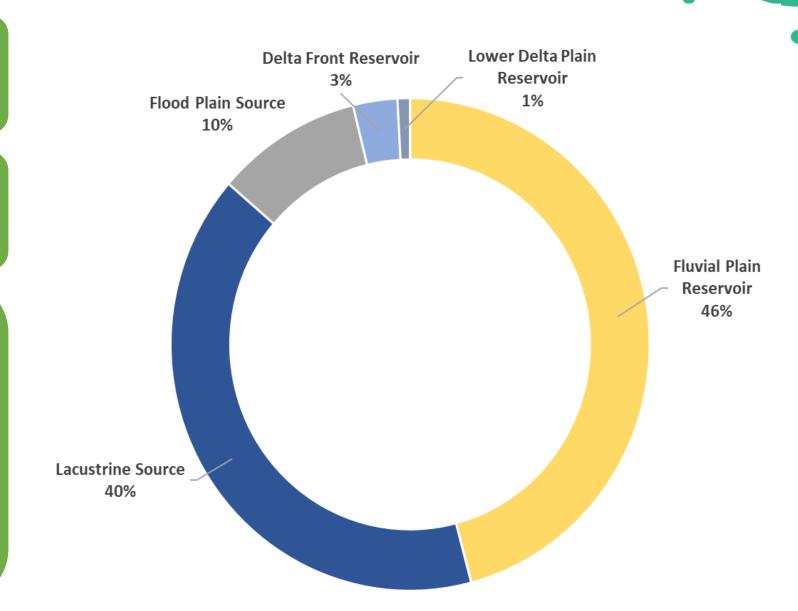


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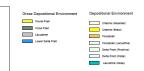
Core Description Katnook 2 Pretty Hill Fm.

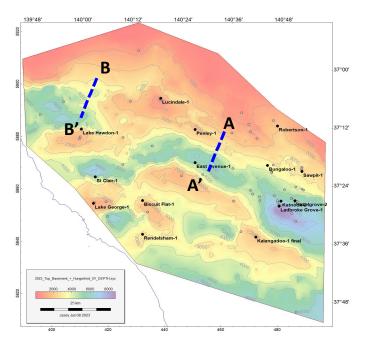


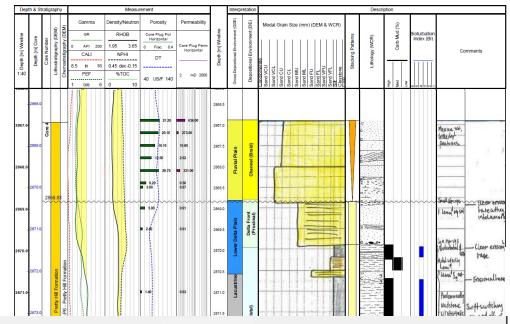


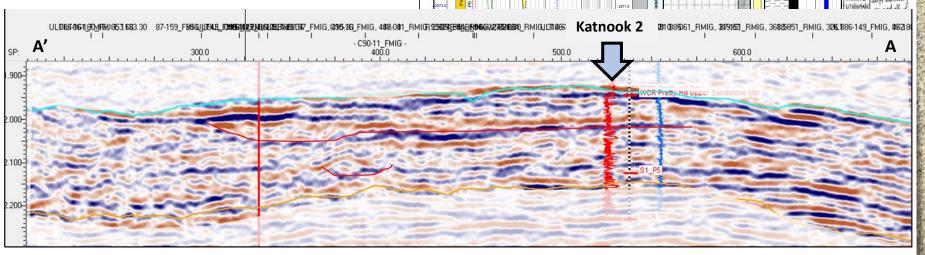
Australia (South Australia) 01/12/1988 Permit (2022): 3,478.073m C3/-0.6m & C4/-1.5m

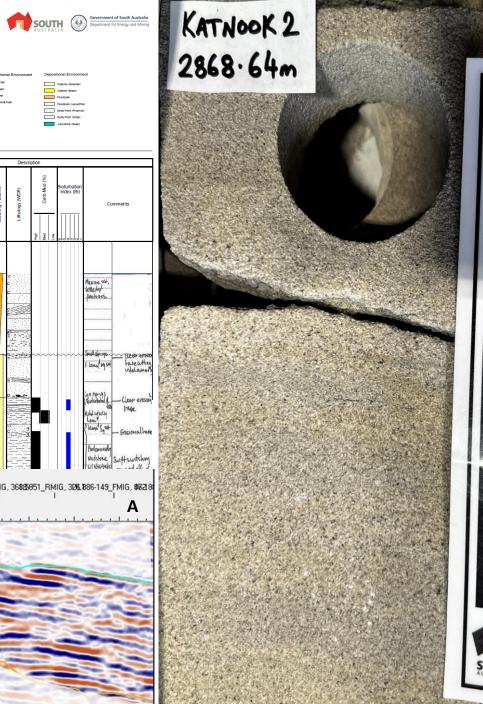
Author: Ultramar & P. Strong (DEM-July 2023) Scale: Compiled By: C. Cubitt [DE-GDE] (SADEM - July 2023)

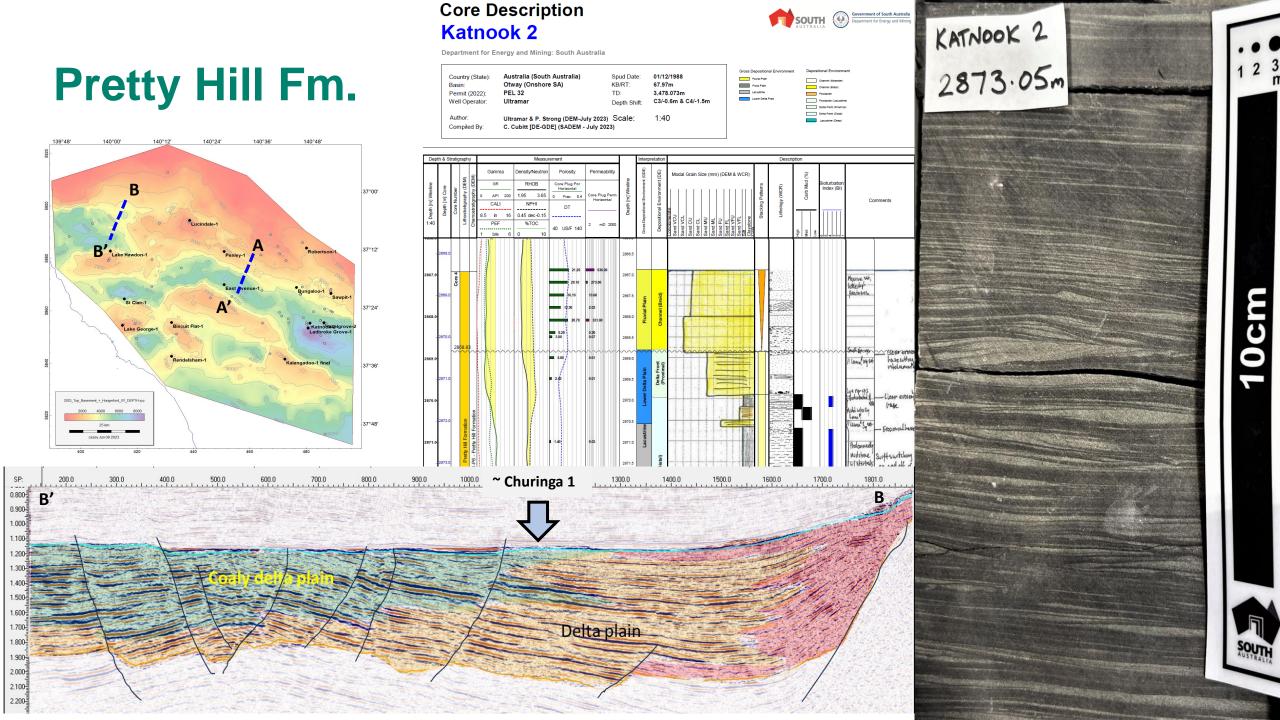








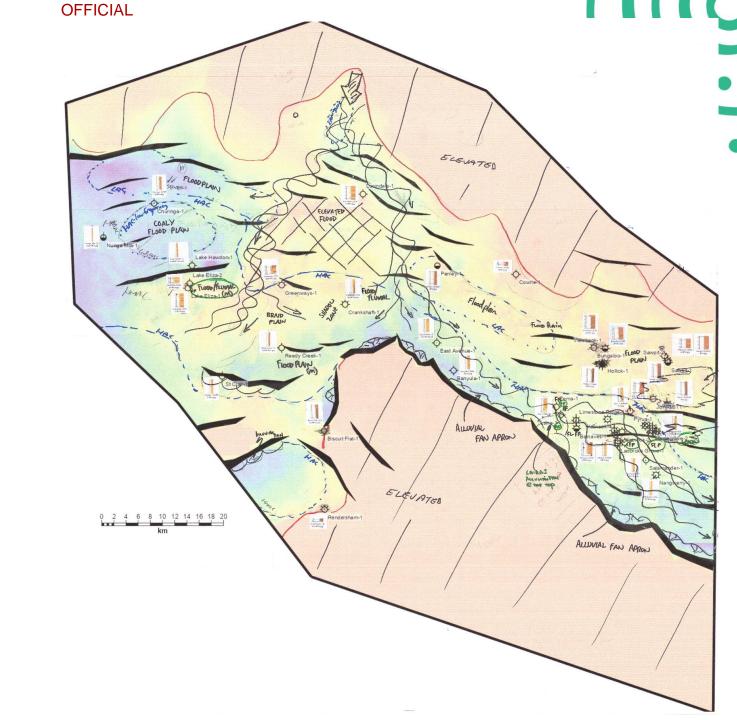




Pretty Hill Fm. Distribution

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

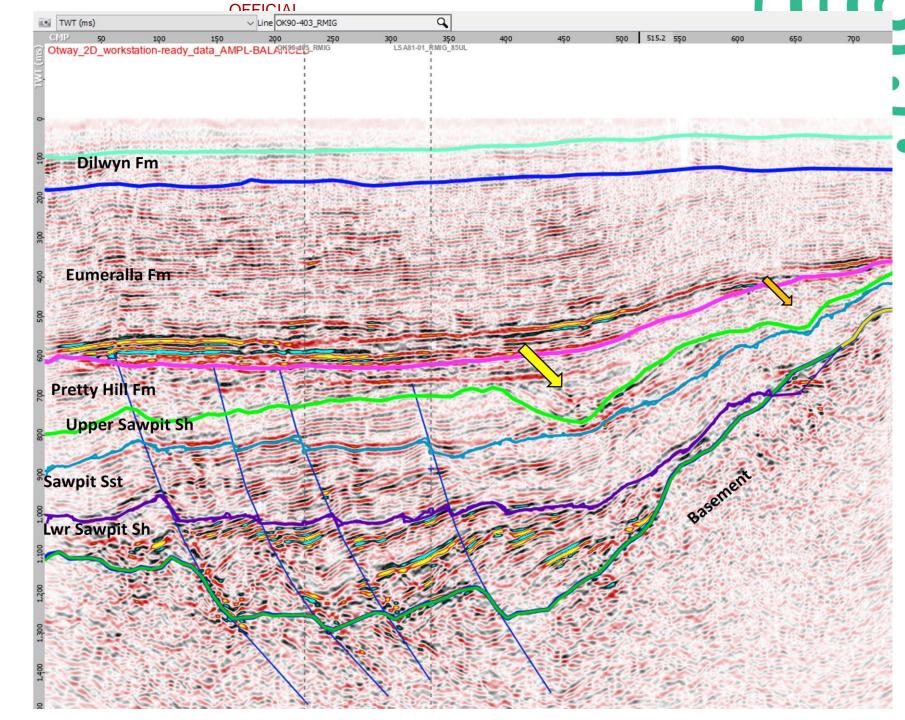




Pretty Hill Fm. Distribution

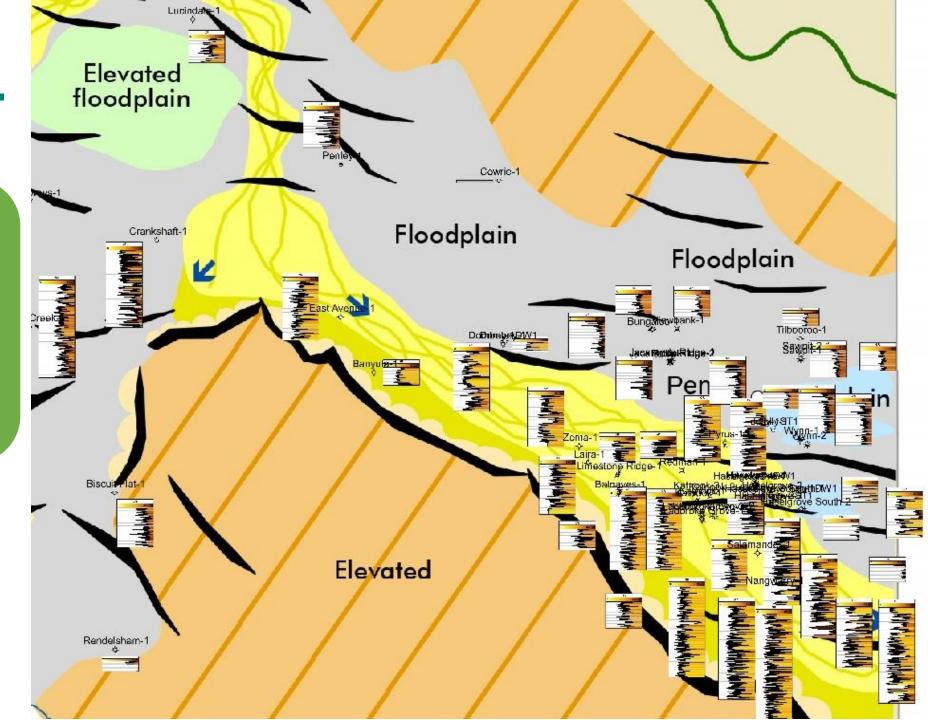
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Core Description Bungaloo 1

SOUTH (



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

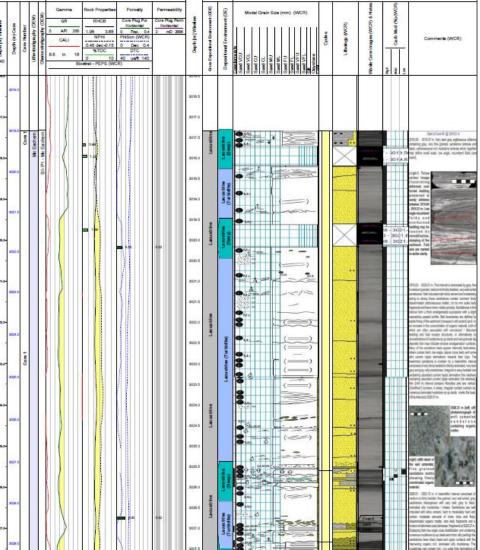
 Previously interpreted as terrestrial crevasse splays a fresh look at the McEachern Sst interval has revealed an extensive interbedded deep lacustrine turbidite package Department for Energy and Mining: South Australi

ry (State): Australia (South Ai Otway (Onshore Si t (2022): AAL-P 199 Operator: Beach Energy Limi

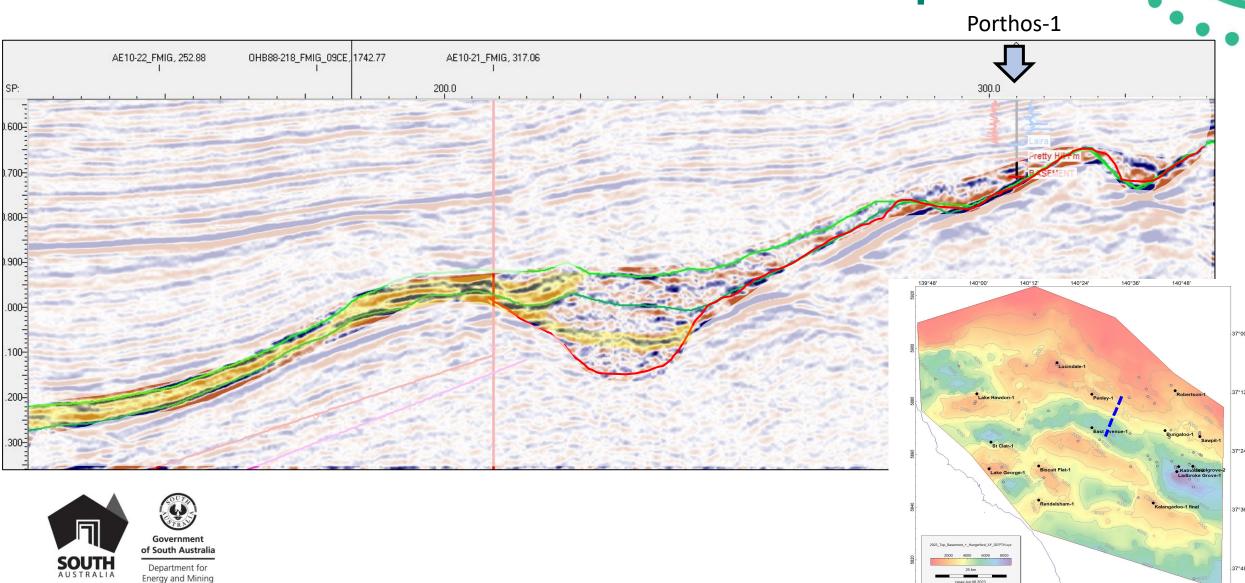
Spud Date: 19/04/2014
KB/RT: 62.70m
TD: 3,713.00m
Depth Shift: C1/-1.6m, C2/-2.4m, C3-

or: TASK (I. Molyneux Sept 2014 - WCR) plied By: Chris Cubitt [DE-GDE] (SADEM - July 2 :4/0.5m



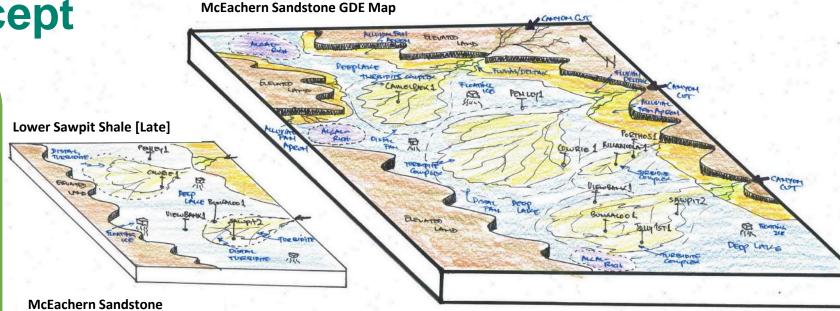


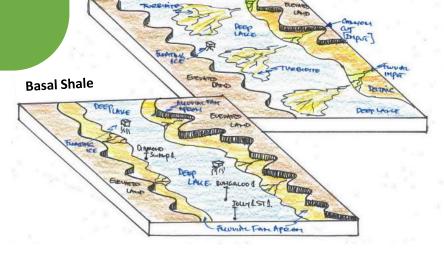
McEachern Sst Distribution: Sediment Input

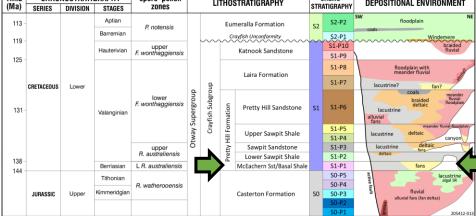


McEachern Sst Distribution A New Play Concept

- 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







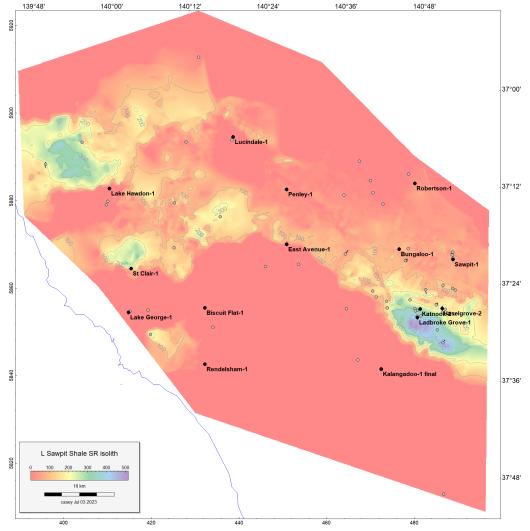
spore-poller



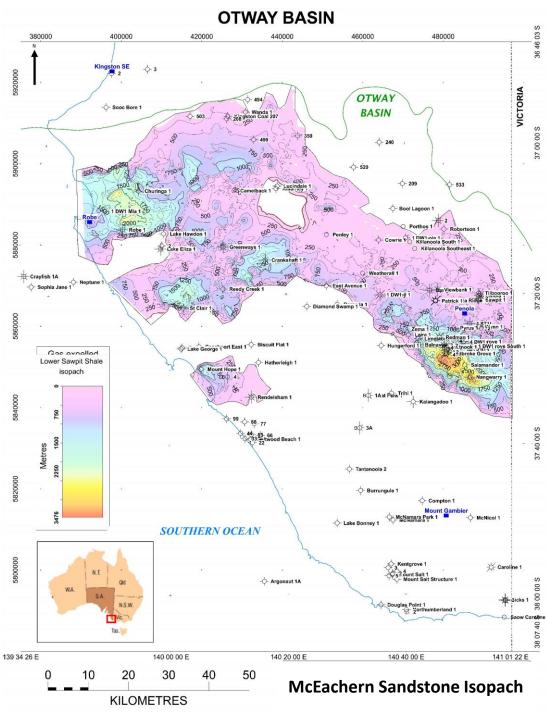




Lower Sawpit Shale/McEachern St Distribution



McEachern Sandstone SR Isolith



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

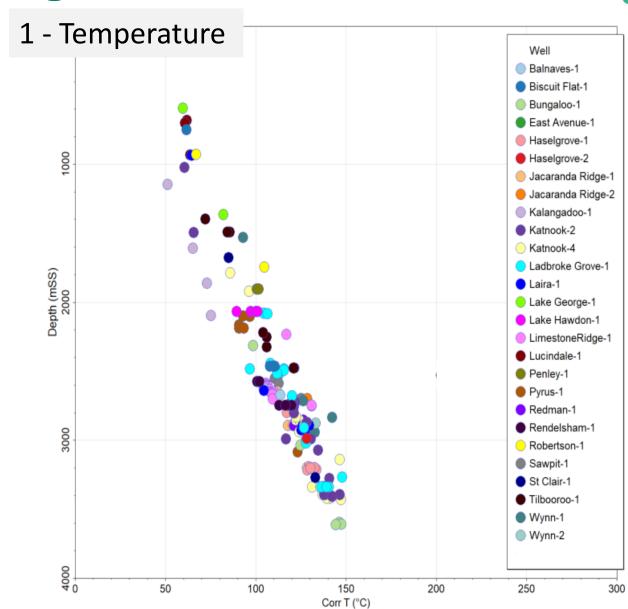
- TOC/HI/Vitrinite
- Wireline/Core/Tops
- Seismic
- Temperature/Pressure

PSM workflow and metrics:

 15 1D (dimensional) models were built







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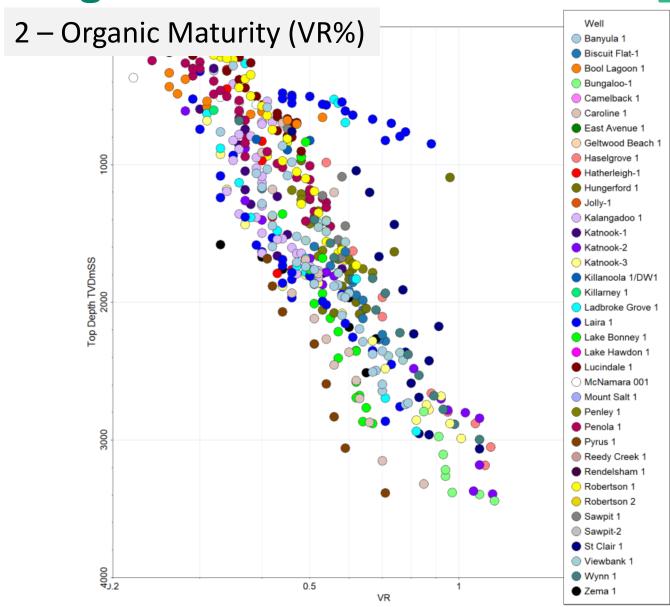
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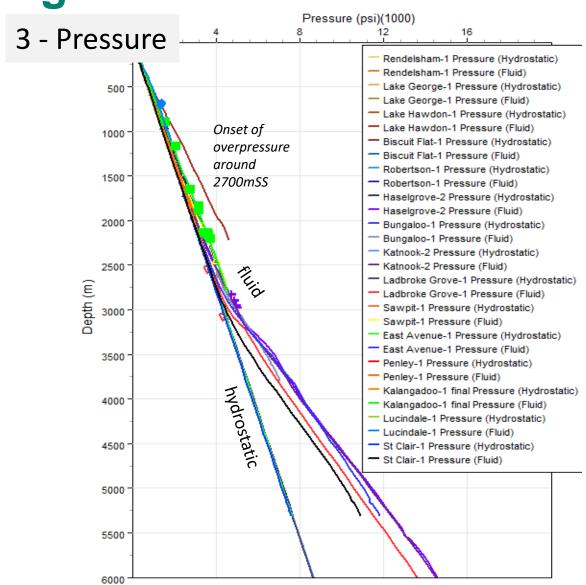
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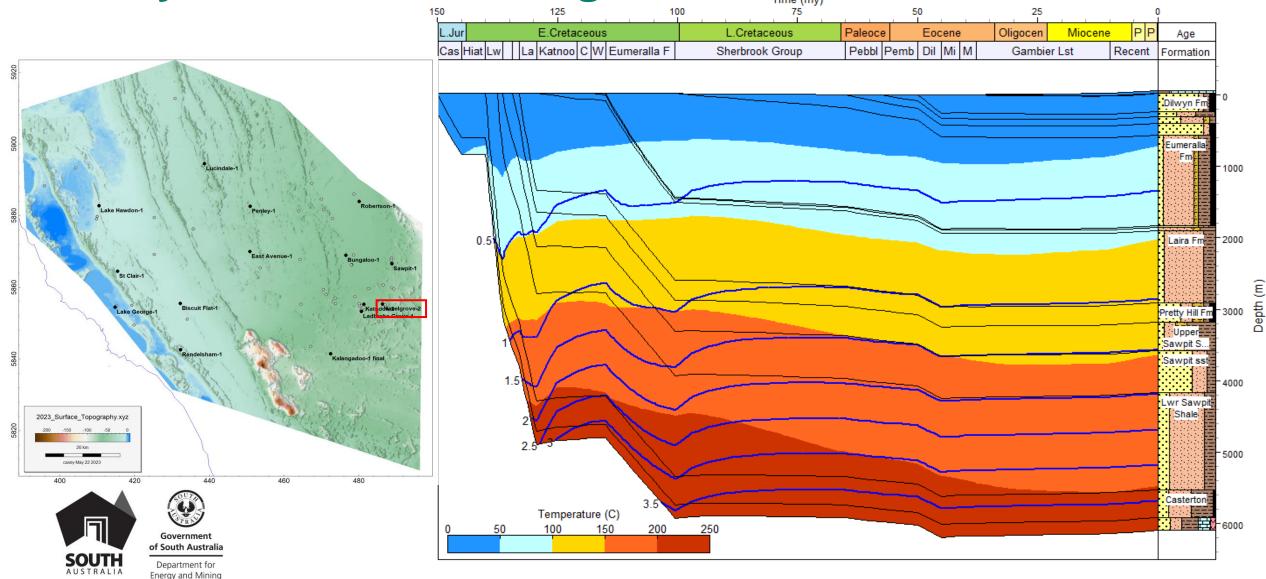
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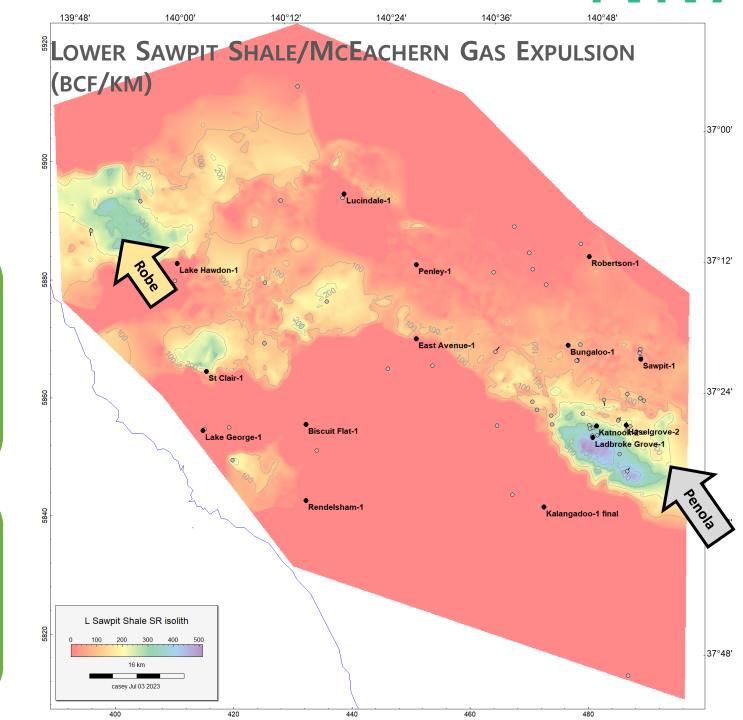
Expulsion: Lower Sawpit/McEachern Sst [Robe Trough]

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



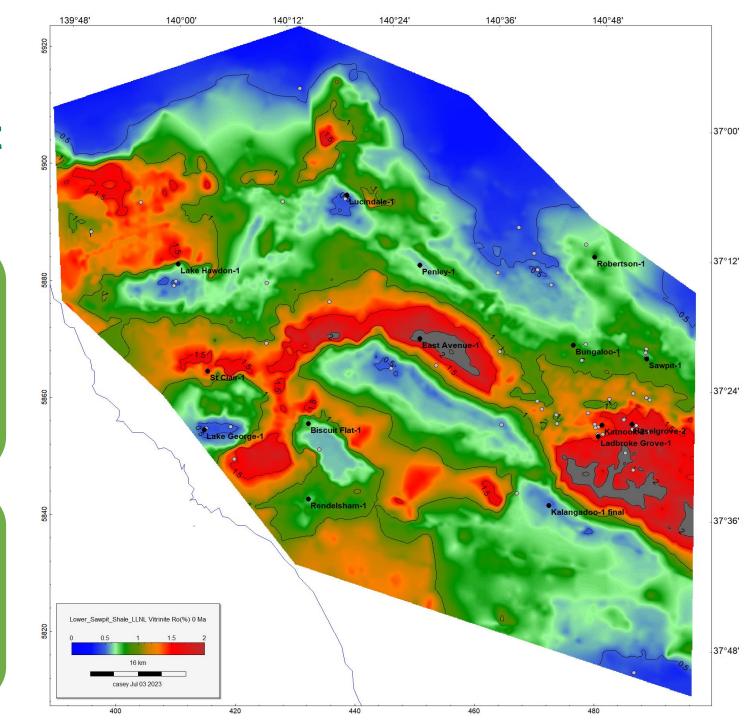
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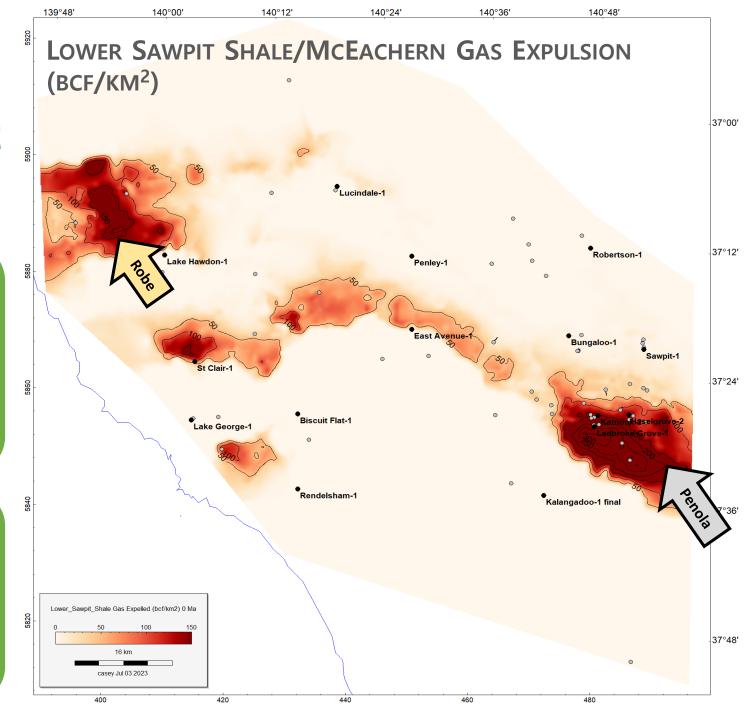
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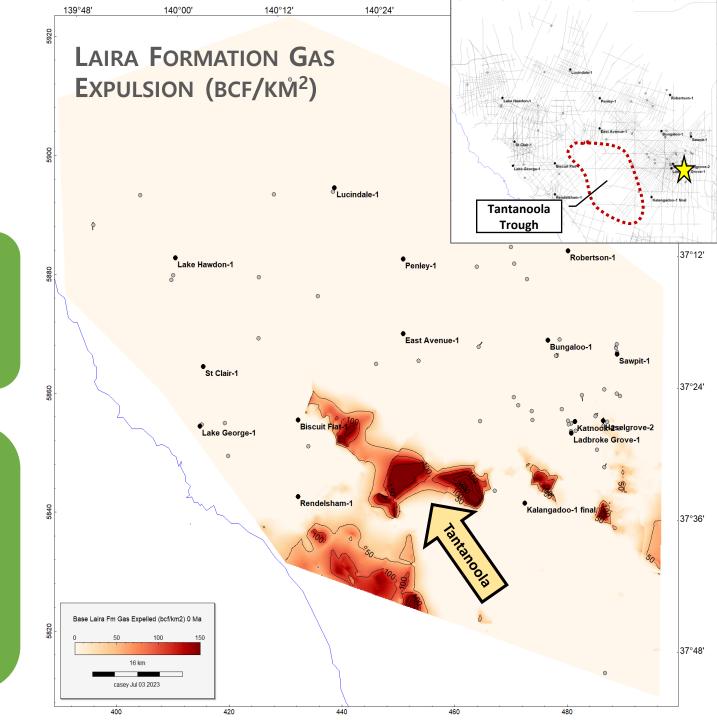


Expulsion: Laira Formation [Tantanoola Trough]

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

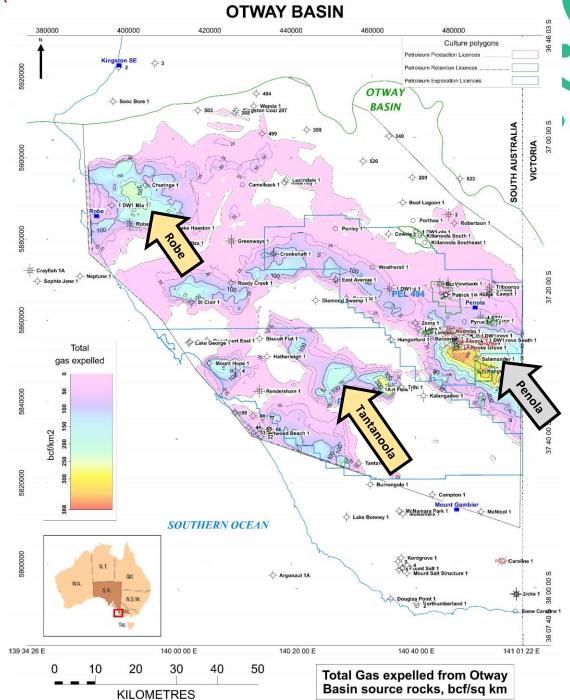
Gas expulsion occurs from four intervals:

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

Gas expulsion occurs mainly from the:

Lower Sawpit Shale/McEachern Sst



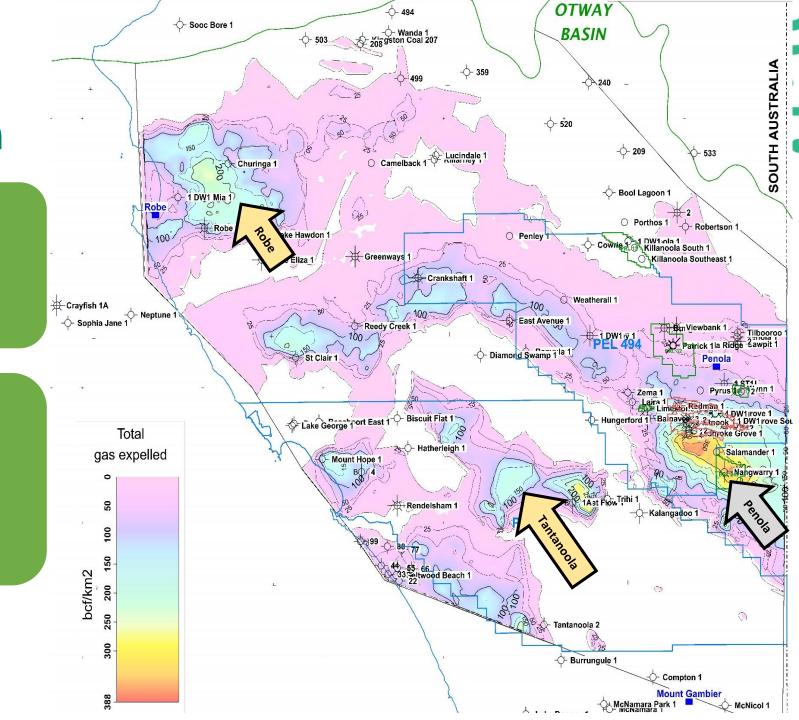


Otway Basin Total Gas Expulsion

 Significant potential remaining in the Penola Trough (grey)

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

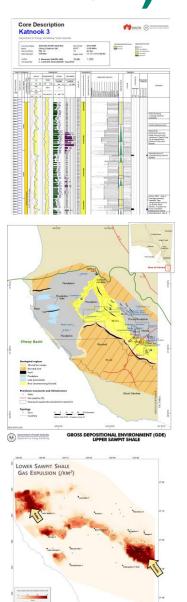


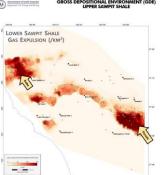


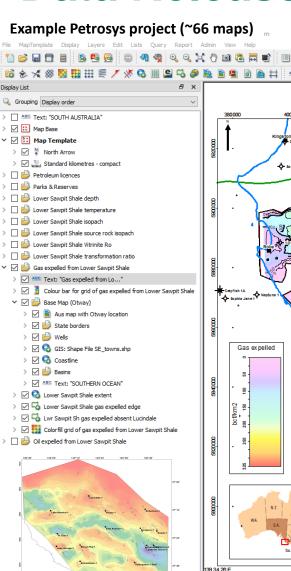
Otway Basin (Onshore SA) – Data Release

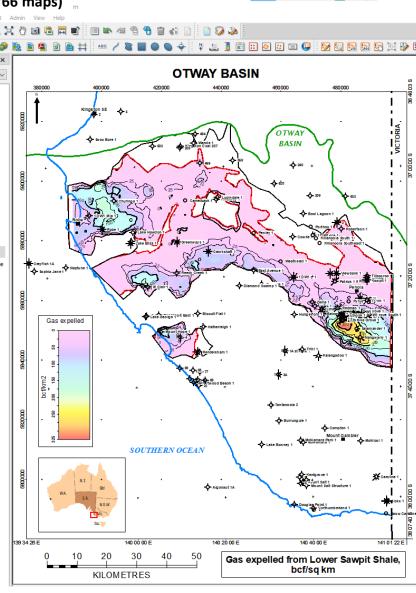
DEM will be presenting its latest technical analysis of the onshore Otway Basin (SA) and highlighting regions of prospectivity. This release will include:

- 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











Up Coming Publications

Upcoming Publications:

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

In Press!





Department for **Energy and Mining**



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

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:					
	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 reinterproted.				

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



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 Taianen, Sharon; Department for Energy and Mining, Senior Geologist - Exploration Assessment Mineral Exploration Mineral Resources					
Keywords:						
Abstract:	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 a sto 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, essemic horizon/fault mapping, essemic 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 plai and ribbon-like alluvial fan aprons. Well penetrations were used to control seismic horizon picking with separations of deposition. The resulting isospachs and interval-active (growth) faults functioned as the backforp for well signature maps. Independent core interpretation was then used as primary depositional evidence, giving sostale context and locally informing essmic facies. Subsequently seismic facies interpretations were made away from well control allowing for complete GDE man 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 Edwards¹, Tim Rady³Chris Cubitt², Rob Kirk⁵Sharon Tiainen²



Source Geoscience Pty Ltd. 2. Department of Energy & Mining, Government of SA, 3.Geomorph Energy, S, Rob Kirk Consulting

ridded this contributes and assolitation parts by the MMV transfalling factoring large, in the South Australian portion of this Contribute contributes and assolitation parts by the MMV transfalling factoring large contributes and associated by the MMV transfalling factoring large contributes and transfalling factoring large contributes and transfalling factoring f neralla Formation. The Late Cretaceous Sherbrook Group is developed predominantly in the offshore portion of the Obsey Seals, and along with Pelaeocene to Microsne marine sedimentation and recent volcanism (SMa), was not considered in detail for this study. Sel

1. PROJECT AREA OF INTEREST AND AVAILABLE DATABASE

- Temperature data was complied from open file reports and corrected using Homer or
- strationarily study undertaken in 2000

3. GEOCHEMISTRY REVIEW AND

- wises, with multiple wells being or unseems concerning to week the wident in several wells (e.g. Mount Salt-1) and the data from these wells was treated with caution. Initial RE screening (that did not take a
- duction in source rock quality due to sturation into consideration)
- good quality, liquids prone, costy
- Gas composition and isotope data indicate the majority of gas recovered from the AOI is light and relatively dry. with the exception being Jacaranda lidge, which shows the addition of dry
- Indicate Squids recovered from Nunga Mis-1, Kathook, Redman-1, Sawpit-1, Haseigrove and Haseigrove South were
- gas, suggesting a complex charge histori in the Pencia Trough which includes a
- late dry get drarge. sement' at Sawpit-1, which is
- representing the initial, cold climate rif



4. SOURCE ROCK MODELS Sequence stratigraphy and geochemistry indicate potential good quality, lecustring indicate potential good quality, lecutorin source rocks are present in the Jurasitic aged Cartecton Formation, (SO-PS) and it Early Cretaceous aged Lower Savpit Sha (S3-P1/S3-P2), (Pigure 7a). These were modelled as a C Organofacies in the Pepper and Corvi (1995)⁸ scheme, with generation and expulsion of predominant iquid hydrocarbons at a meturity equivalent to around 0.7-0.72% VR (or 115

Poorer quality, gas prote source rocks were modelled in the Vallenghrian Upper Sewpit Shale (SLP4/SLP5), (Figure 76) and Heutenivier Lains Formation (SLP6 to SLP-FIO), with generation of predominantly gas taking place from a U/E Organofacies at a maturity equivalent of around 1.0% VIII (or 1.35%). A section of the section of the control of the 1.35%. 145°C). A possible lecustrine factor at the Mid-Laire formation level (approximately 51-P7/51-P8) was also included after being

Group sequences (Figure 3). To dete, the Penola Trough is the most significant hydrocerbs

sions with non-commercial oil at Killanonia and lacaranda Didea

related half grabers under fluvial and lacustrine conditions, with low sinussity channels a floodplain development strongly controlled by local tectonics and basin accommodation.



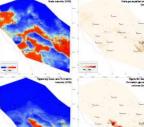
6. MAP BASED MATURITY AND EXPULSION MODELLING

Fifteen 1D models were built at well locations (Figure 2) and extended to besement using Meturity modelling suggests the Casterton Formation, Lower and Upper Sewpit Shale an

the lower Lairs Formation are mature for generation and expublion of hydrocarbon.

Expulsion modelling inclinates the might fly of liquid displanations were generated and expulsed from the Lower Surph State Members 122 and 2024, with the greatest new expulsion also took piece from the Upper and Lower Surph State in the Hencie and Rober expulsion also took piece from the Upper and Lower Surph State in the Hencie and Rober Trough, with weaponist complete by an and 2004e, (Figures 9, Cpt. 97). Up to 2004CH 2014 or 10 per land 10 per land

A pseudo intra-Laha depth surface was created to test the maturity of the Mid-Laha Formation source rock model, with the sequence showing early to mid-maturity for liq seneration and expulsion in the Tentanpole Trough.



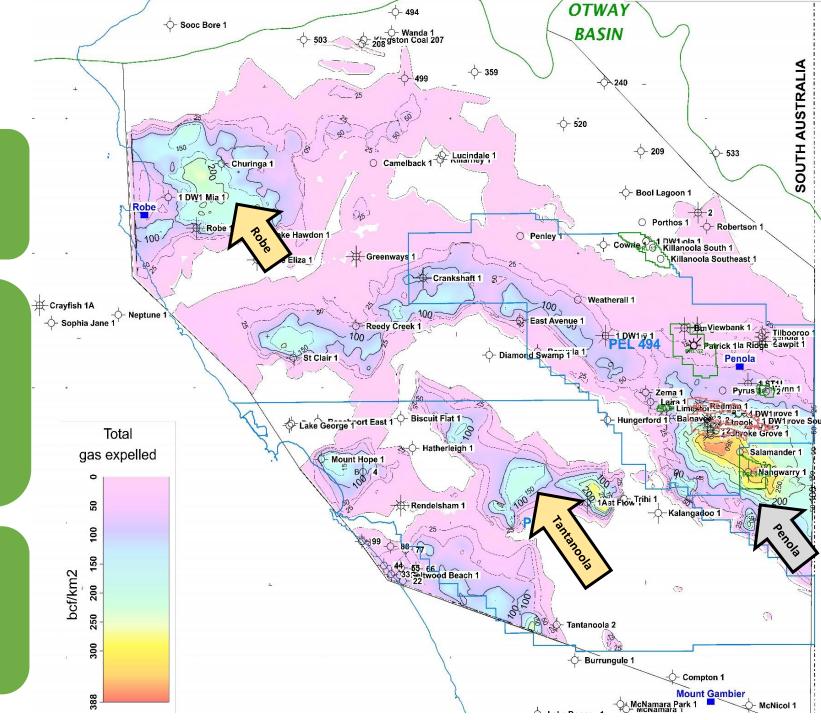


Final Messages

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



Acknowledgements!

Project Lead

· Chris Cubitt

Seismic Team

- Iain Campbell
- Tim Rady
- Rob Kirk

Wells Team

- · Betina Bendall
- · Chris Cubitt

Core Team

- · Chris Cubitt
- 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

- Steven Curnow
- Jess Bonsell
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