

Play mapping workflow: a practical example from the onshore Otway Basin, South Australia

Discovery Day 2024

Geological Survey of South Australia

Paul Strong | 28 November 2024

Acknowledgements | Chris Cubitt, Rob Kirk and Tim Rady



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South Australia

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Disclaimer

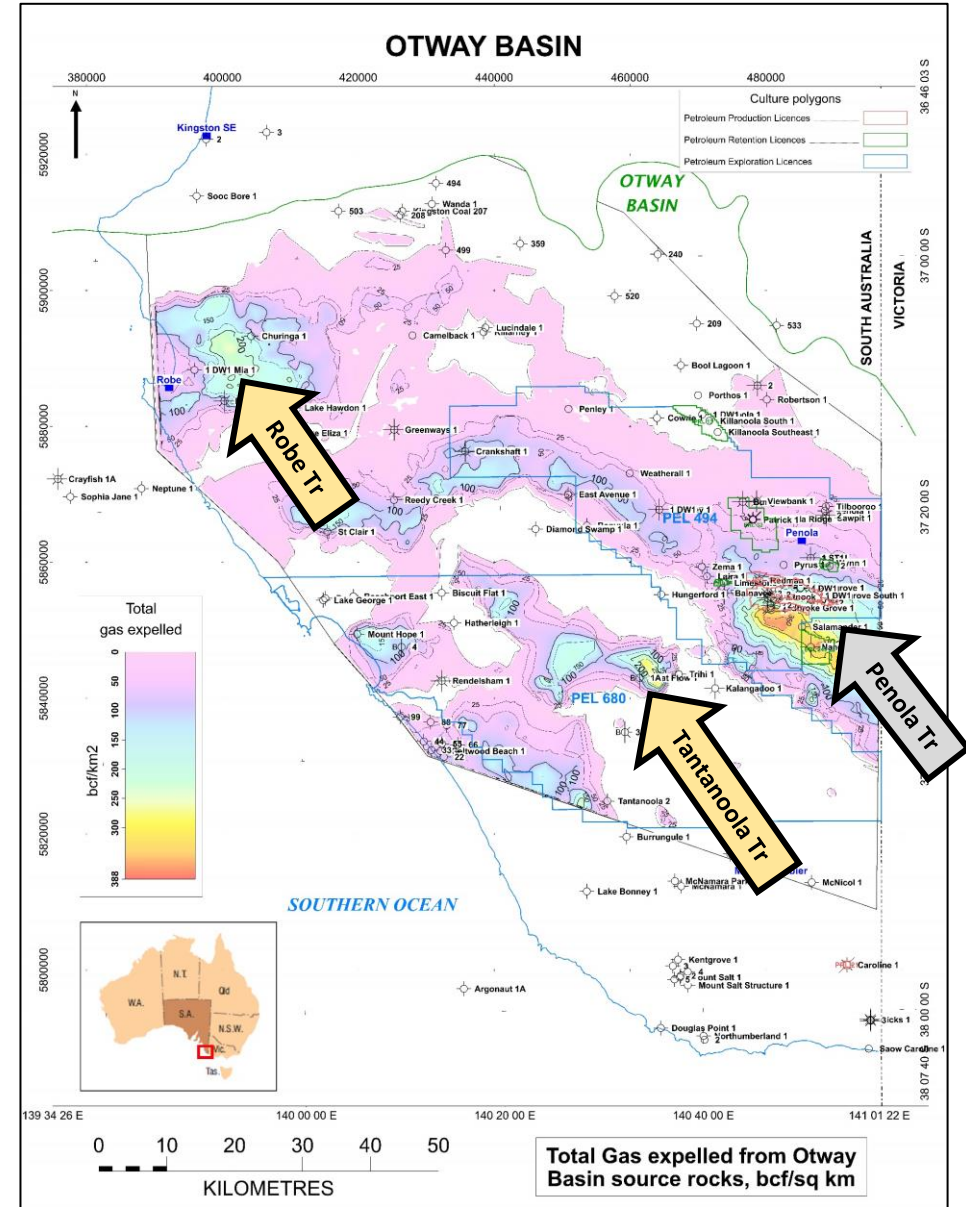
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Background Part of the Otway Project

- Whole of basin petroleum system model
- Commenced 2020 and completed Q4 2023
- Generate new datasets
- Generate new exploration concepts
- Stimulate the next phase of exploration in the onshore Otway Basin
- Play analysis conducted in 2024
 - Play-Based Exploration Overview
 - Otway Basin Plays Reviewed
 - Play Analysis example – Pretty Hill Sandstone



[Click here for link to Otway Basin Petroleum Systems Model 2023 data](#)

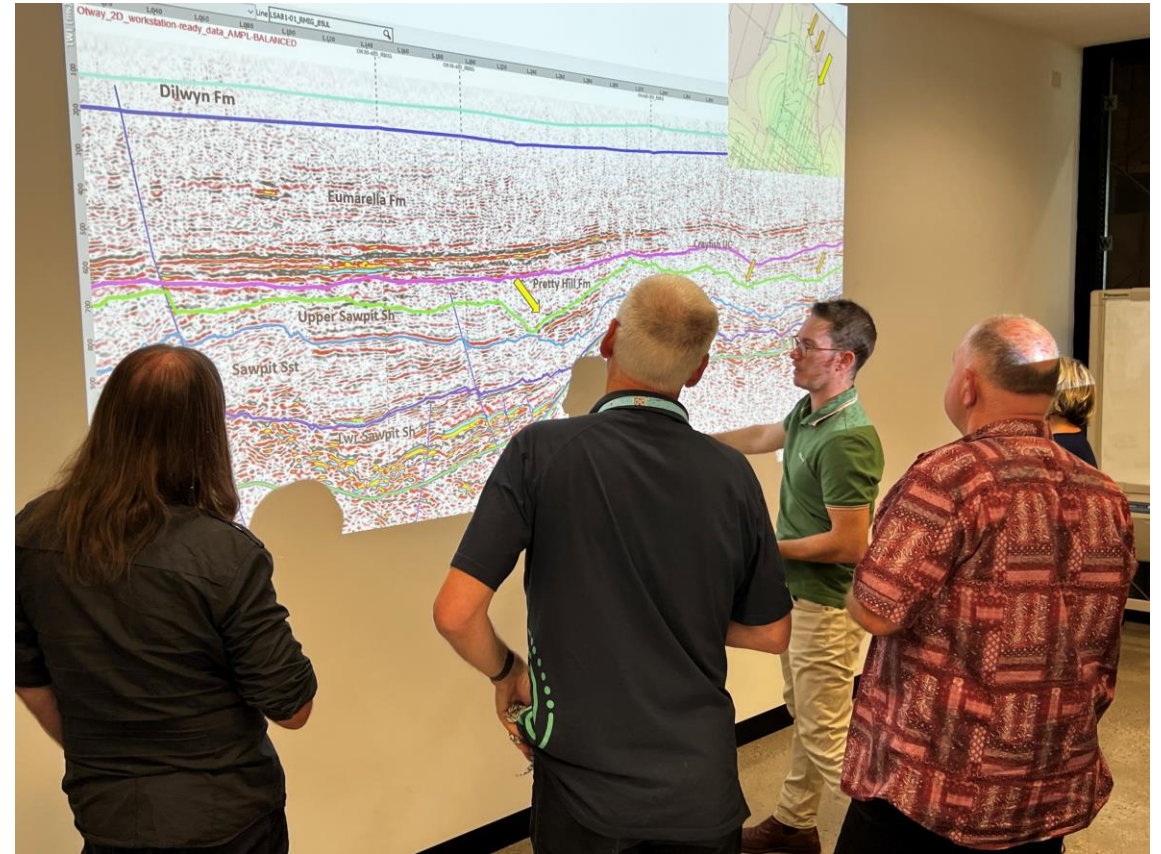


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Slide 3 | 28 November 2024



Revisiting the rocks and seismic



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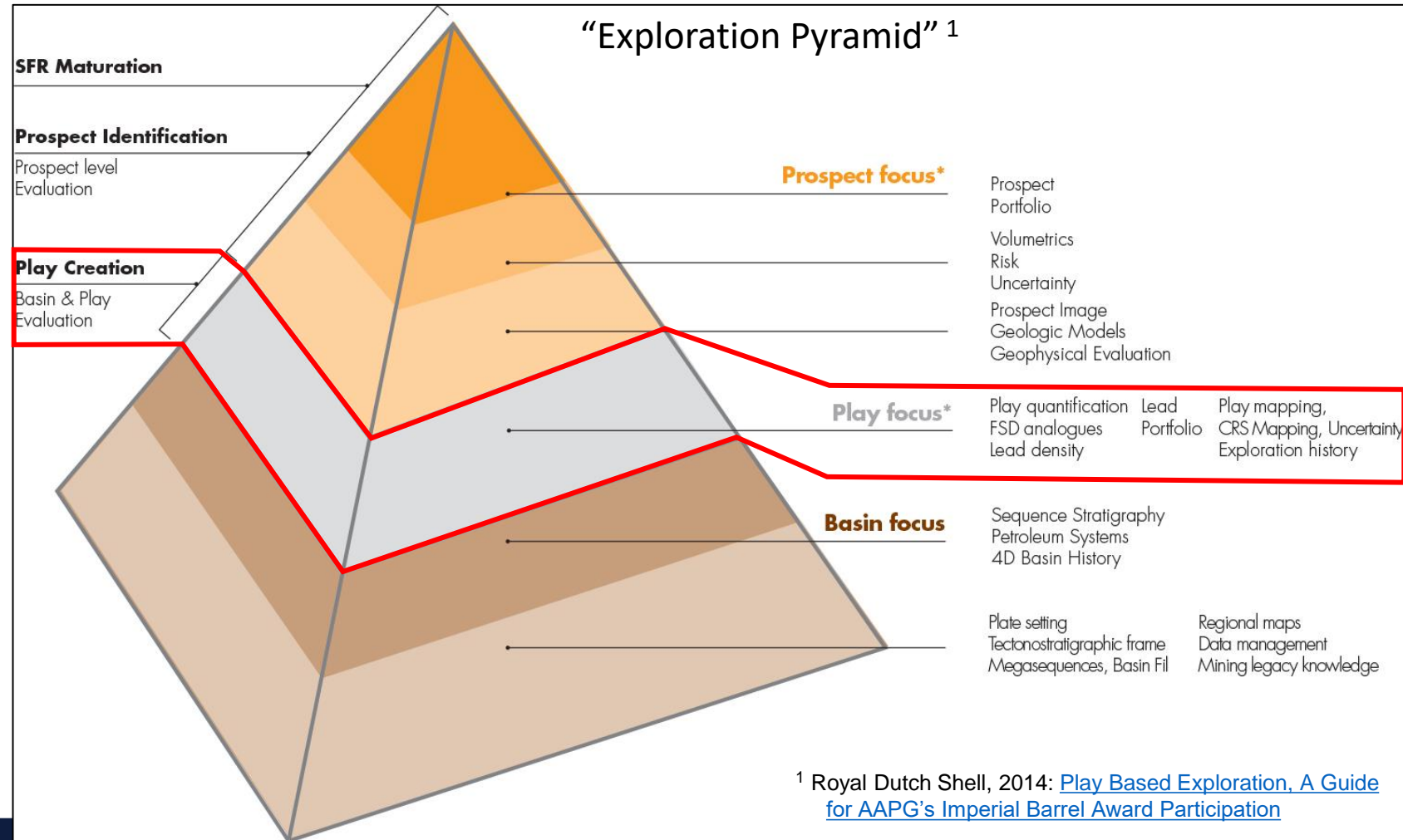
Play-Based Exploration Overview 1

Play-Based Exploration

- Understanding of petroleum system in basin
 - identification, mapping and quantification of plays
- Maps:
 - Play elements
 - Summary play maps
 - Common risk segments
 - Identification of sweet spots

Analysis of plays using this process is **not static**

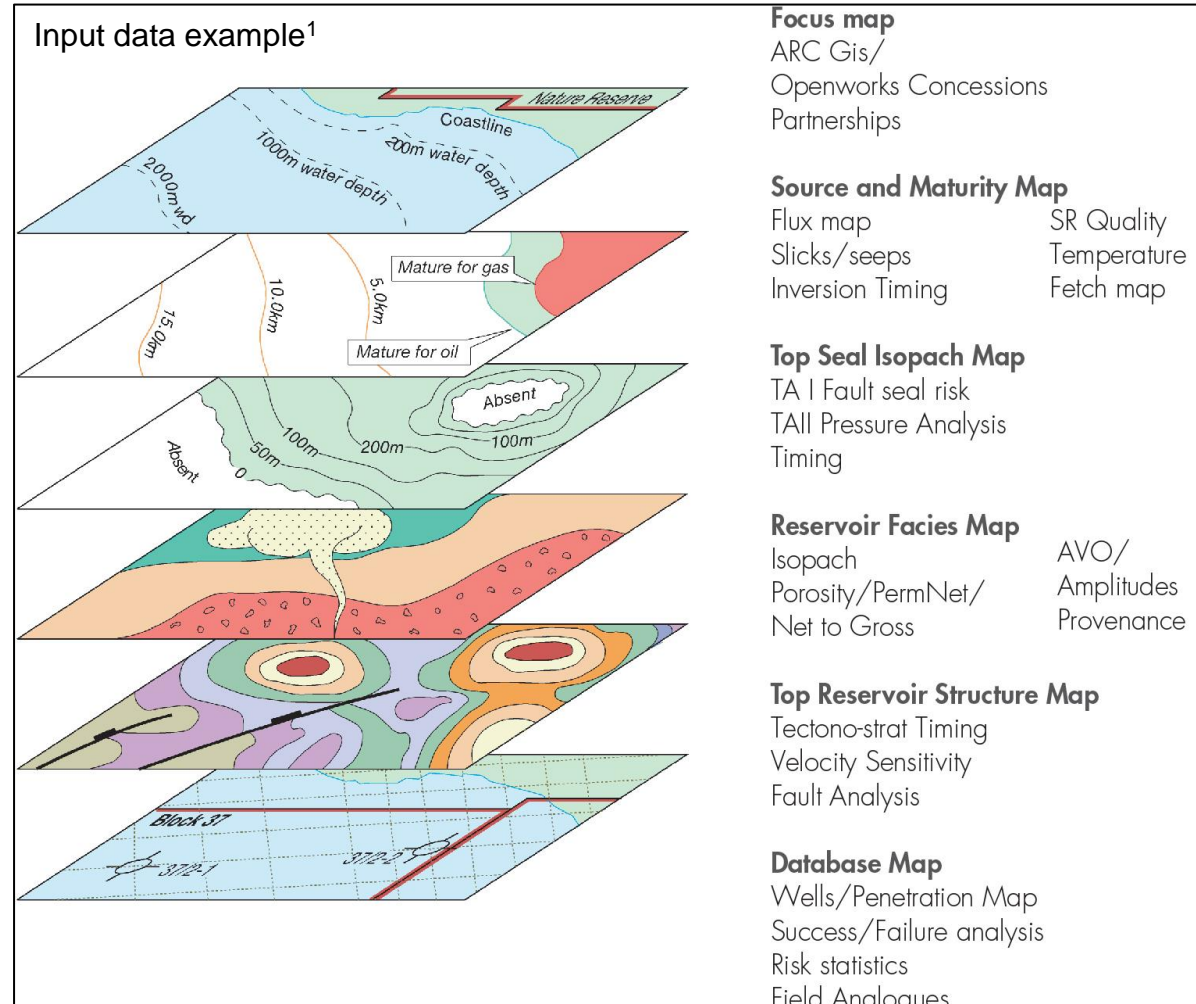
- Iterative feedback required following new information



Play-Based Exploration Overview 2

Geological boundaries required for all elements of Petroleum System:

- Extent and type of Reservoir interval
- Hydrocarbon Charge:
 - Extent of likely Source Rock
 - Maturity of Source Rock
 - Limits of potential migration from Source Rock
- Entrapment:
 - Extent of Sealing interval
 - Structural elements



¹ Royal Dutch Shell, 2014: [Play Based Exploration, A Guide for AAPG's Imperial Barrel Award Participation](#)



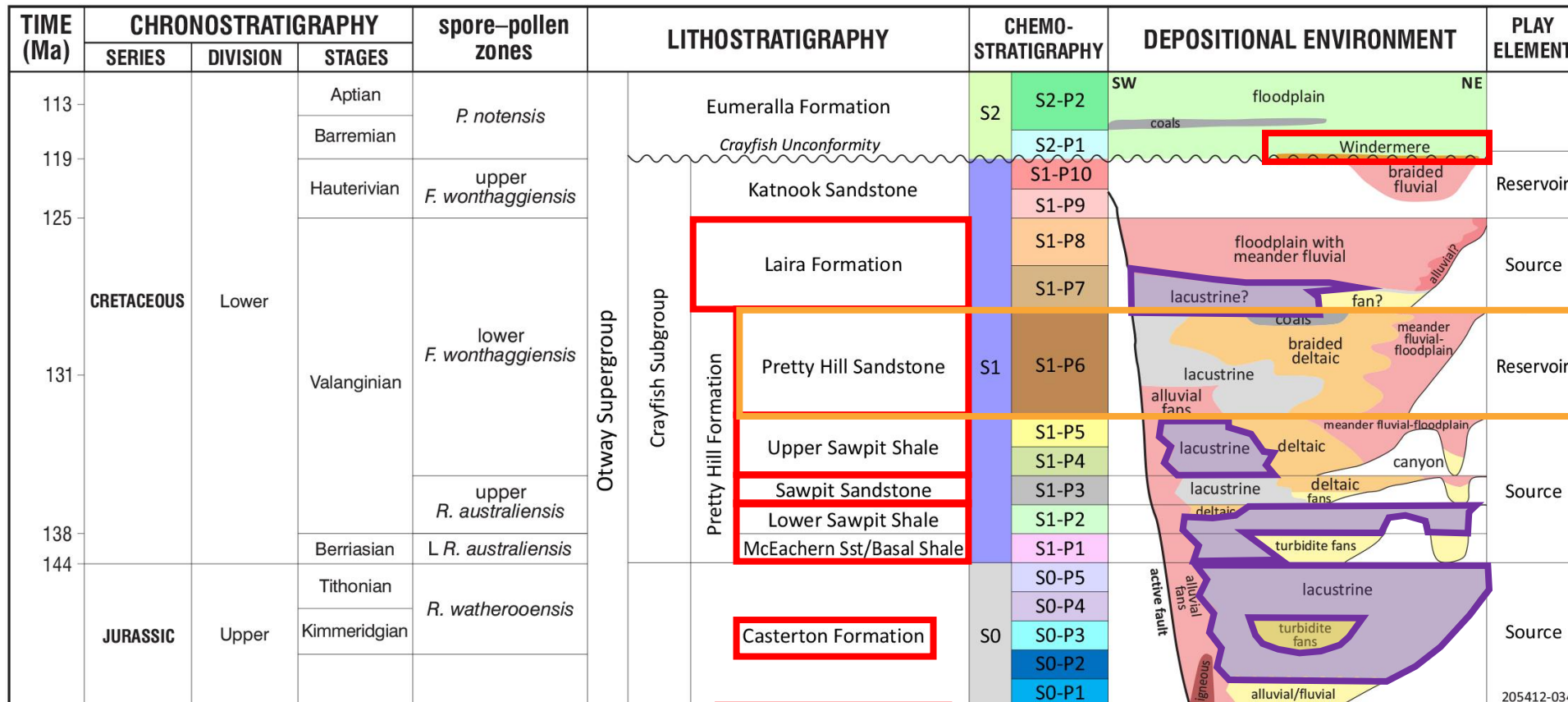
Otway Basin Stratigraphy



Plays reviewed



Source rocks



Play analysis example shown in this presentation

Fractured Basement

After Kirk (2024)

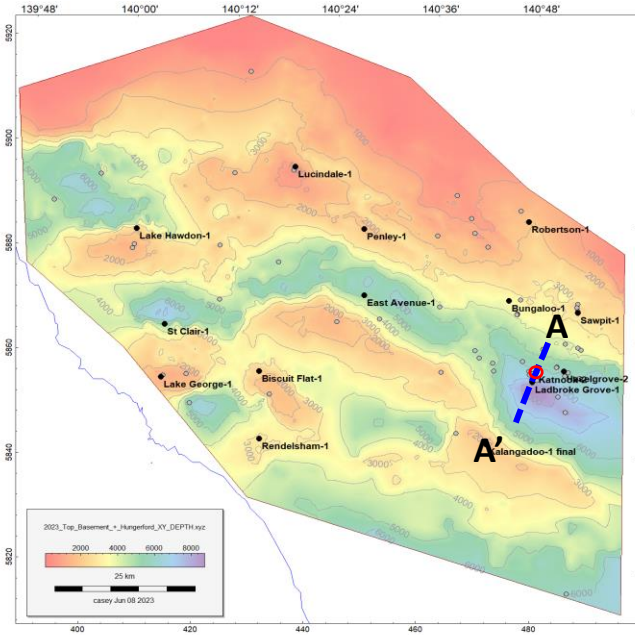
Core to seismic 1

Core Description Katnook 2

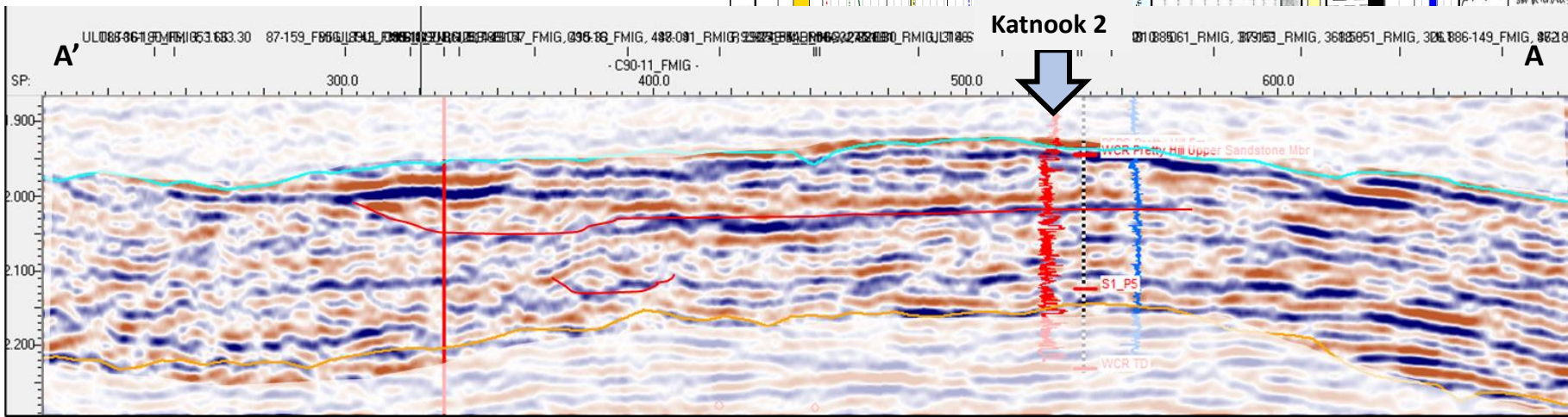
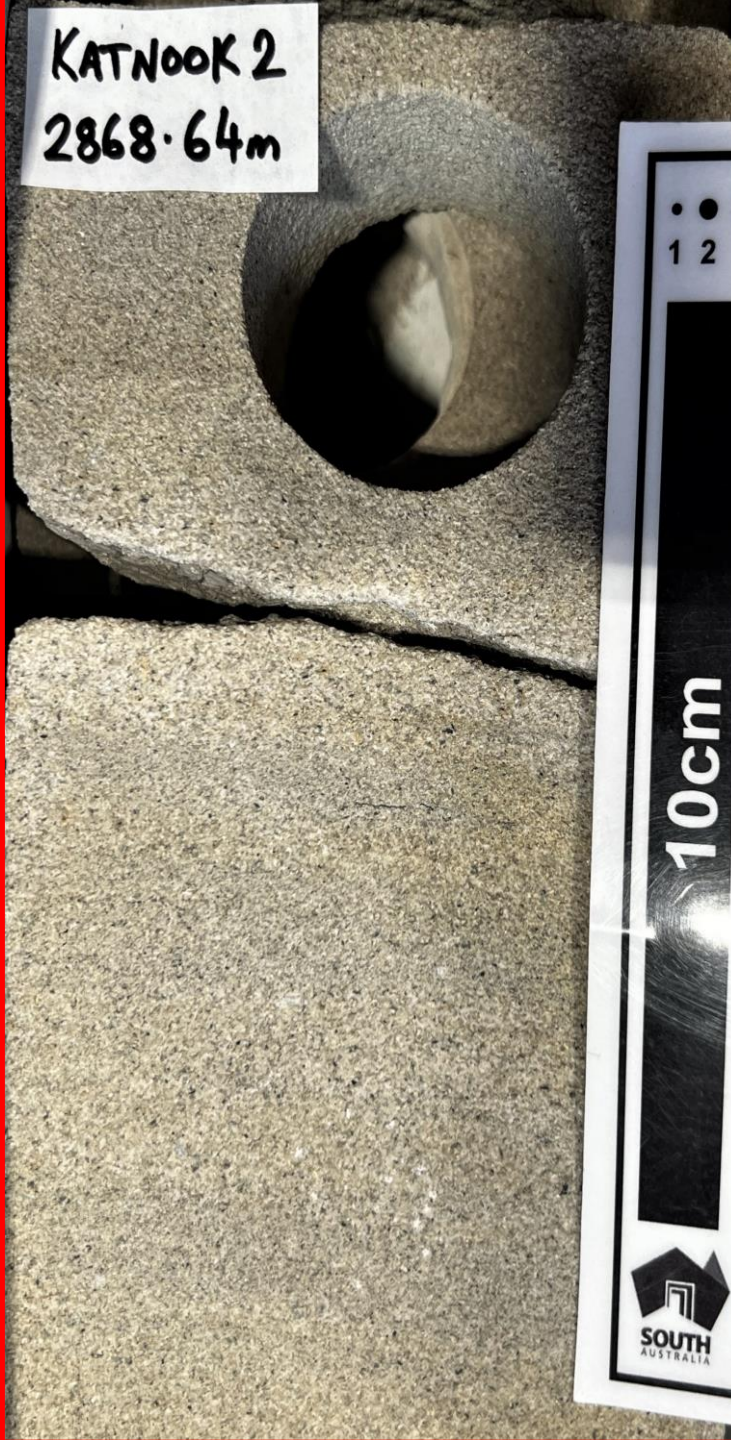
Department for Energy and Mining: South Australia

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 (Distal)



Depth & Stratigraphy		Measurement				Interpretation		Description							
Depth (m) Wellhead	Depth (m) Core	Core Number	Gamma	Density/Neutron	Porosity	Permeability	Depth (m) Wellhead	Gross Depositional Environment (GDE)	Depositional Environment (DE)	Modal Grain Size (mm) (DEM & WCR)	Stacking Patterns	Lithology (WCR)	Clay Mud (%)	Bioturbation Index (BI)	Comments
			GR	RHOB	Core Plug For Horizontal	Core Plug Perm Horizontal									
1.40			0	API 200	1.95	3.65	0	Frac. 0.4							
			CALI	NPH		DT									
			8.5	16	0.45 dec-0.15										
			PEF	%TOC		40 USIF 140									
			1	b/c	6	0	10								
2888.0		Core 4					2886.5	Fluvial Plain	Channel (Braid)						
2887.0							2887.0								Messive var. little clay concretions
2886.0							2886.0								
2885.0							2885.0								
2884.0							2884.0								
2883.0							2883.0								
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2873.0							2873.0								



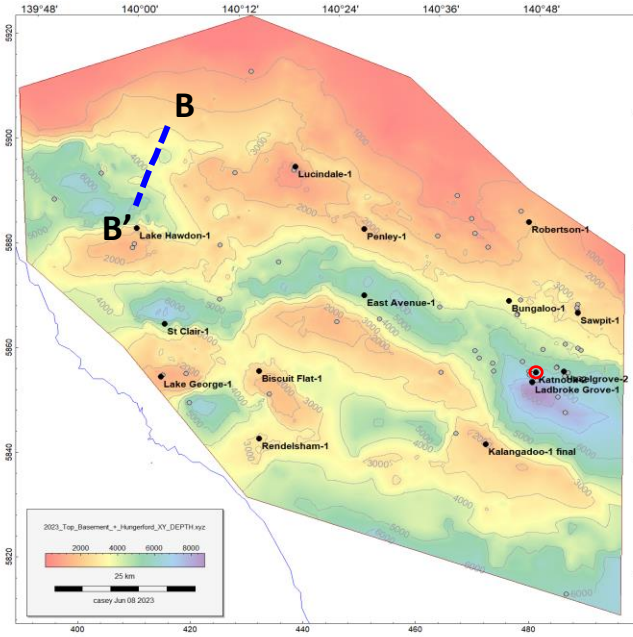
Core to seismic 2

Core Description Katnook 2

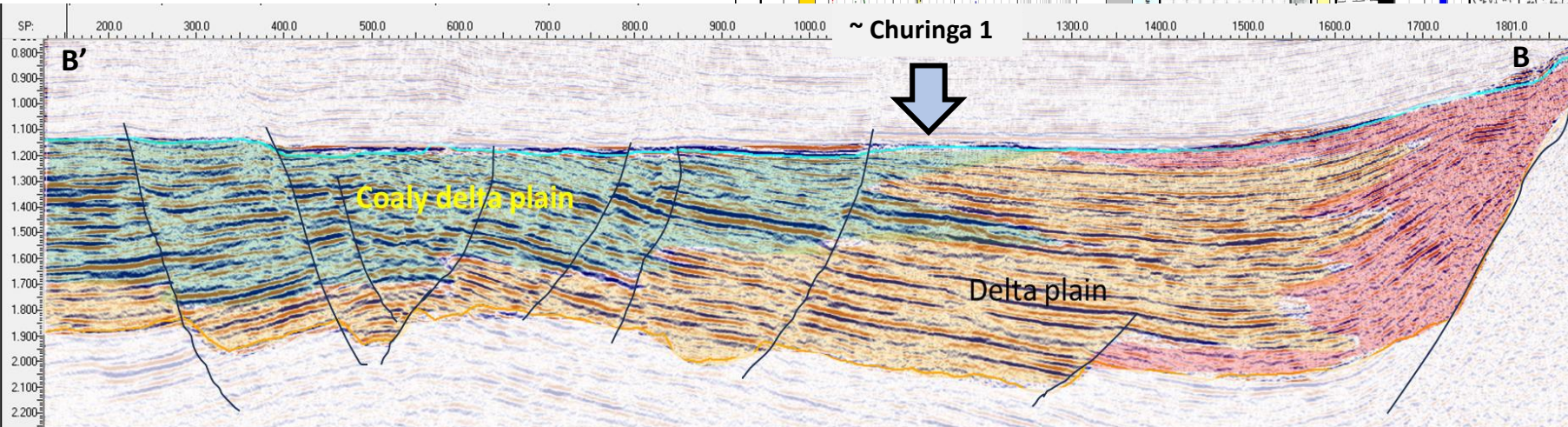
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- Gross Depositional Environment
 - Fluvial Plain
 - Flood Plain
 - Lacustrine
 - Lower Delta Plain
- Depositional Environment
 - Channel (Braid)
 - Channel (Belt)
 - Floodplain
 - Floodplain (Lacustrine)
 - Delta Front (Proximal)
 - Delta Front (Distal)
 - Lacustrine (Distal)

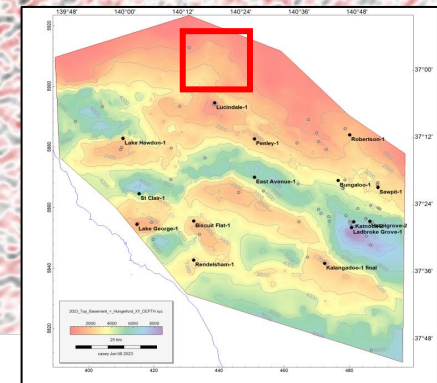
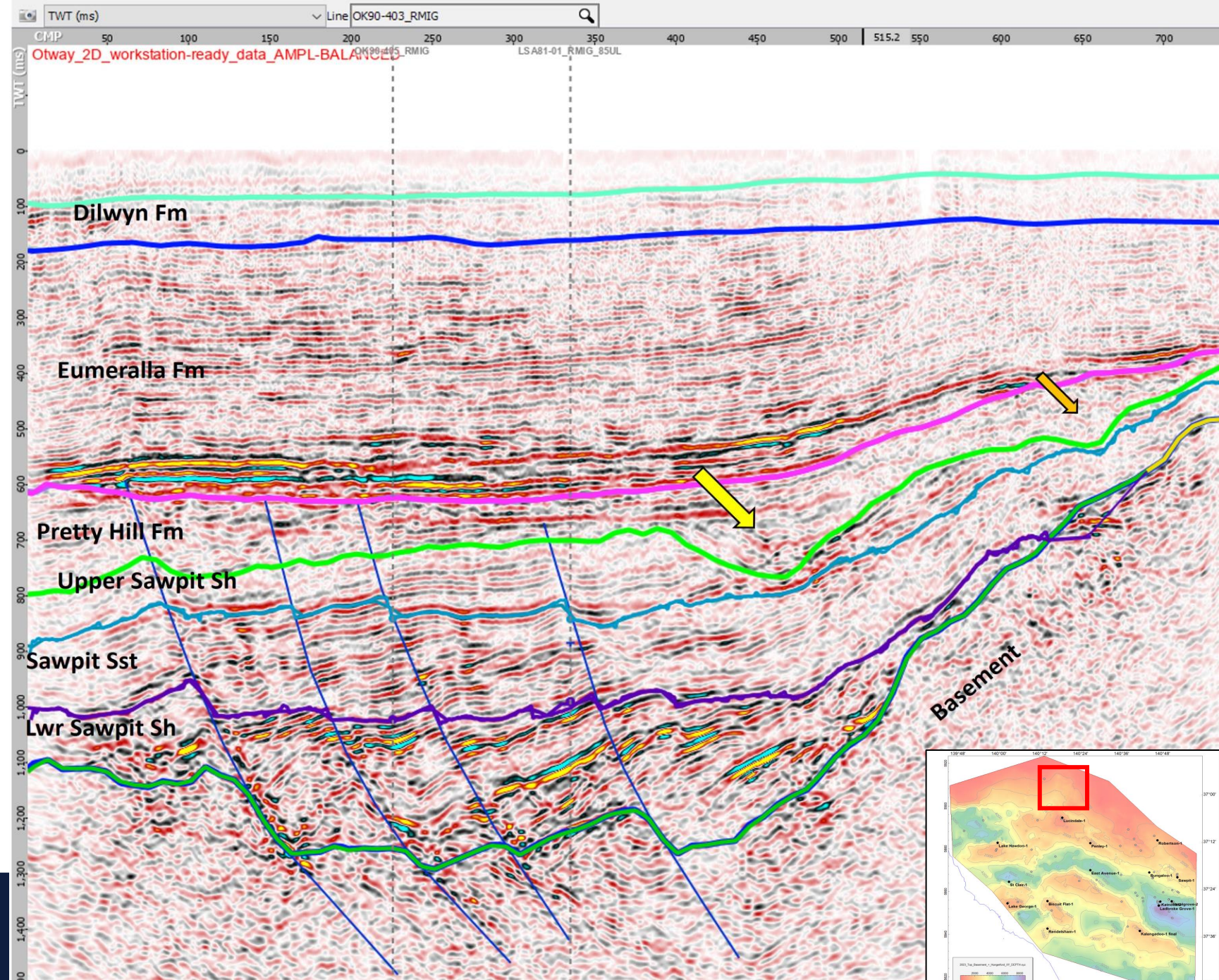
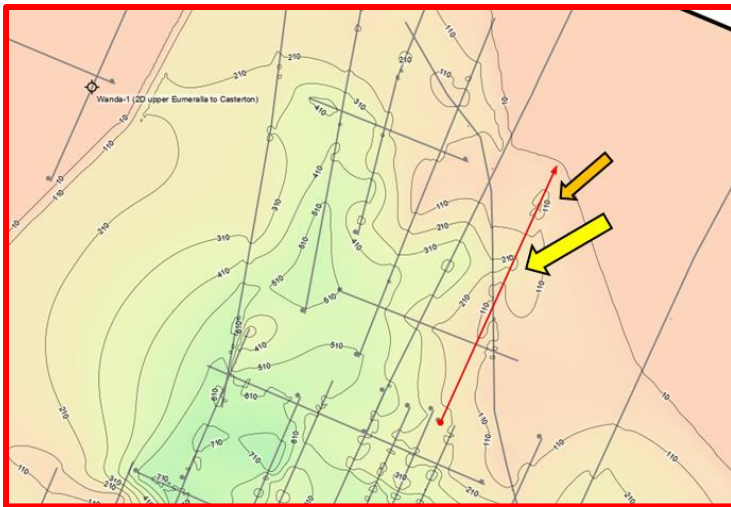


Depth & Stratigraphy		Measurement				Interpretation		Description						
Depth (m) Wireline	Depth (m) Core	Core Number	Gamma	Density/Neutron	Porosity	Permeability	Depth (m) Wireline	Depositional Environment (DE)	Modal Grain Size (mm) (DEM & WCR)	Stacking Patterns	Lithology (WCR)	Clay Mud (%)	Bioturbation Index (BI)	Comments
			GR	RHOB	Core Plug For Horizontal	Core Plug Perm Horizontal								
1.40			0	API 200	1.95	3.65	0	Frac. 0.4						
			CALI	NPH	0.45 dec-0.15	DT								
			PEF	%TOC		40 US/F 140								
			1	b/c	6	0	10							
2868.0							2866.5	Fluvial Plain						
2867.0							2867.0	Channel (Braid)						Massive, var. lenticular bedforms
2866.0							2865.5							
2865.0							2864.5							
2864.0							2863.5							
2863.0							2862.5							
2862.0							2861.5							
2861.0							2861.0							
2860.0							2859.5							
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2838.0							2837.5							
2837.0							2836.5							



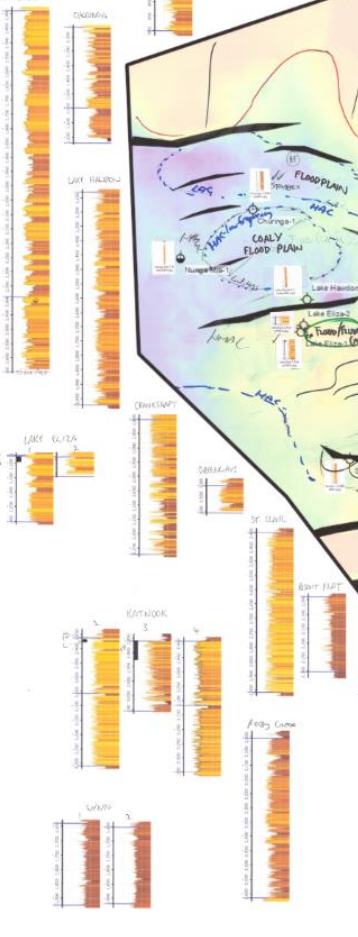
Pretty Hill Sst Distribution

Sediments enter basin via canyons east of Wanda 1 and disperse to the west (Robe Trough) and east (Penola Trough)

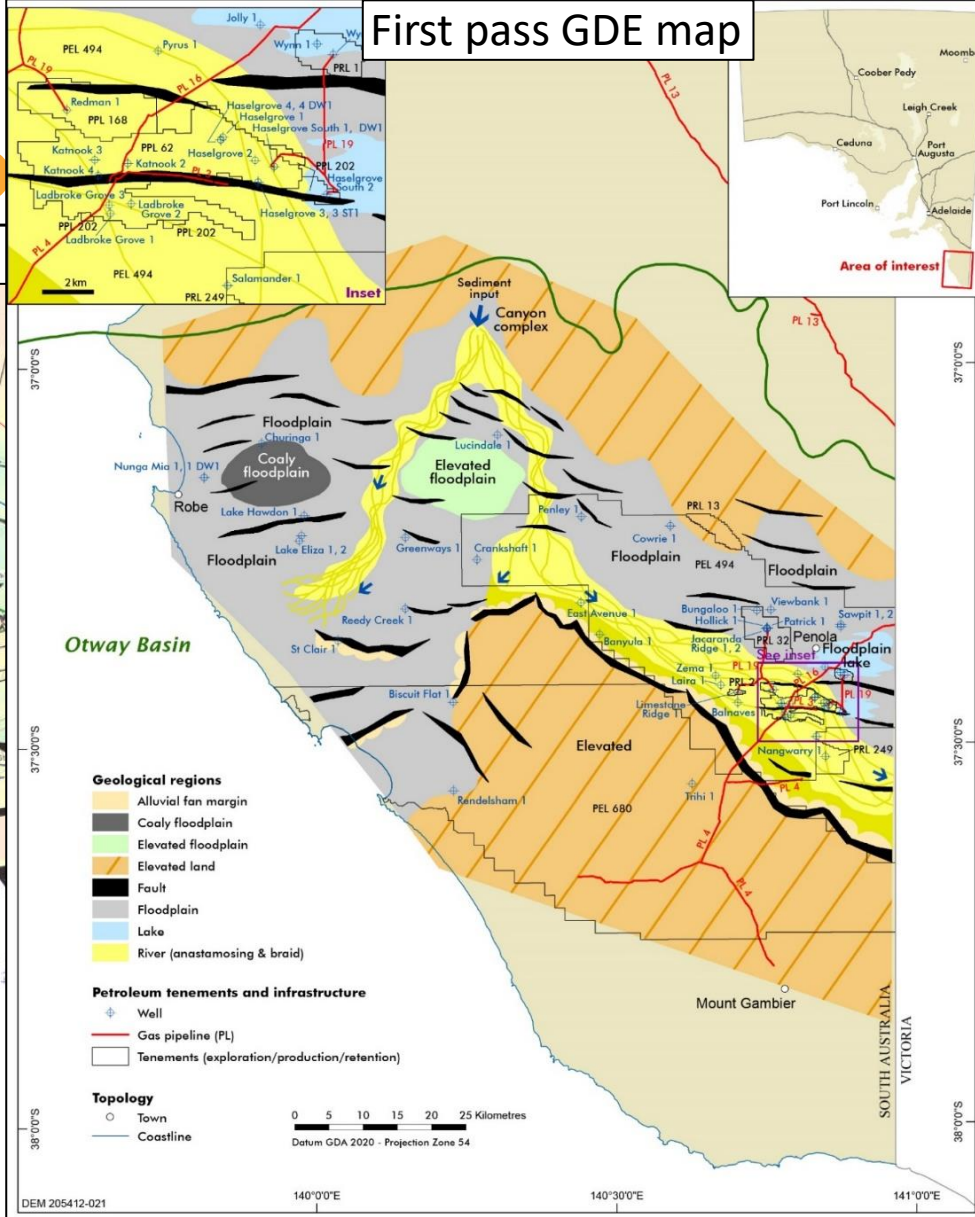


Iteration

Data and working



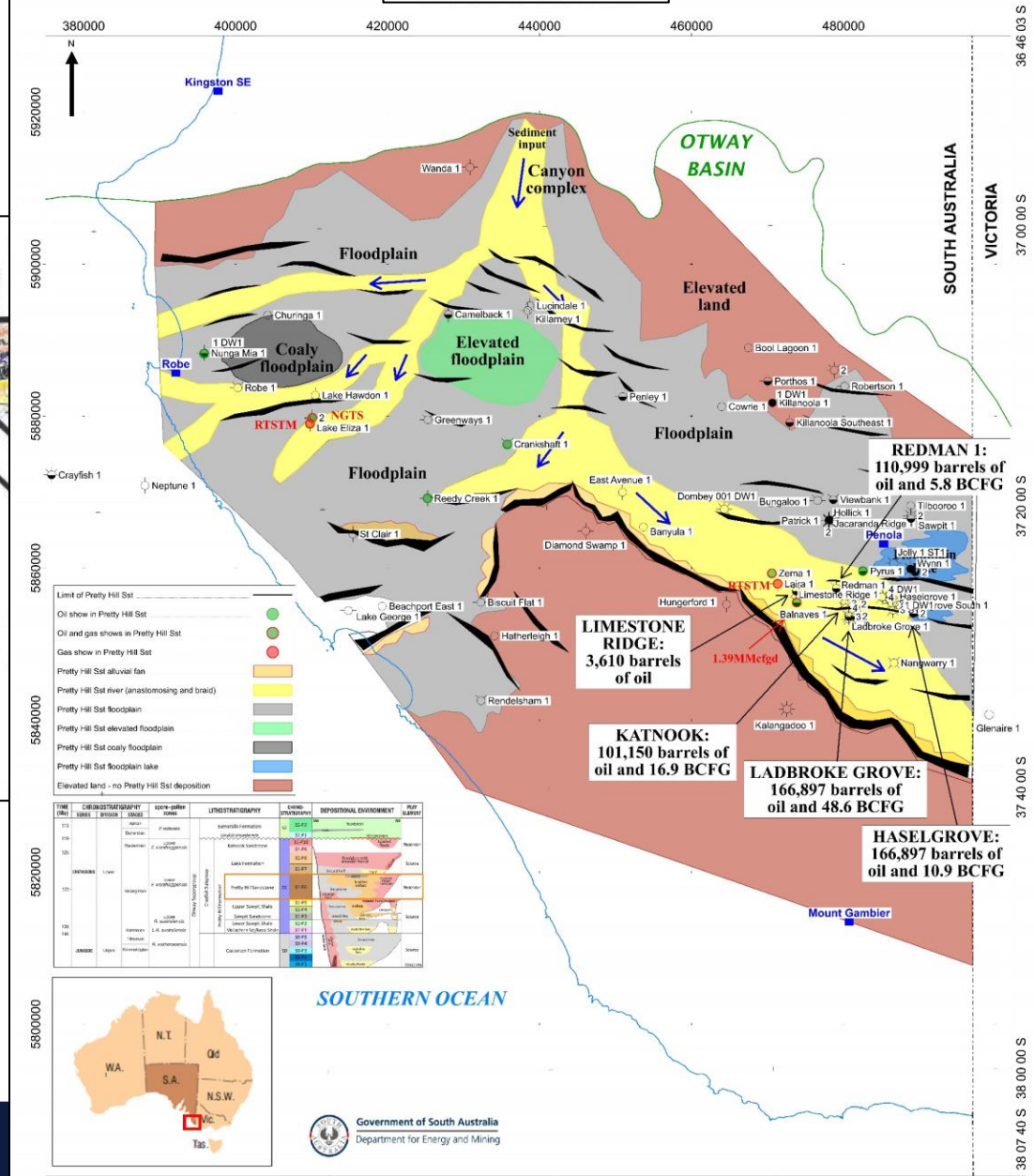
First pass GDE map



GROSS DEPOSITIONAL ENVIRONMENT (GDE) PRETTY HILL FORMATION

Government of South Australia
Department for Energy and Mining

Final GDE map



Pretty Hill Sst gross depositional environments

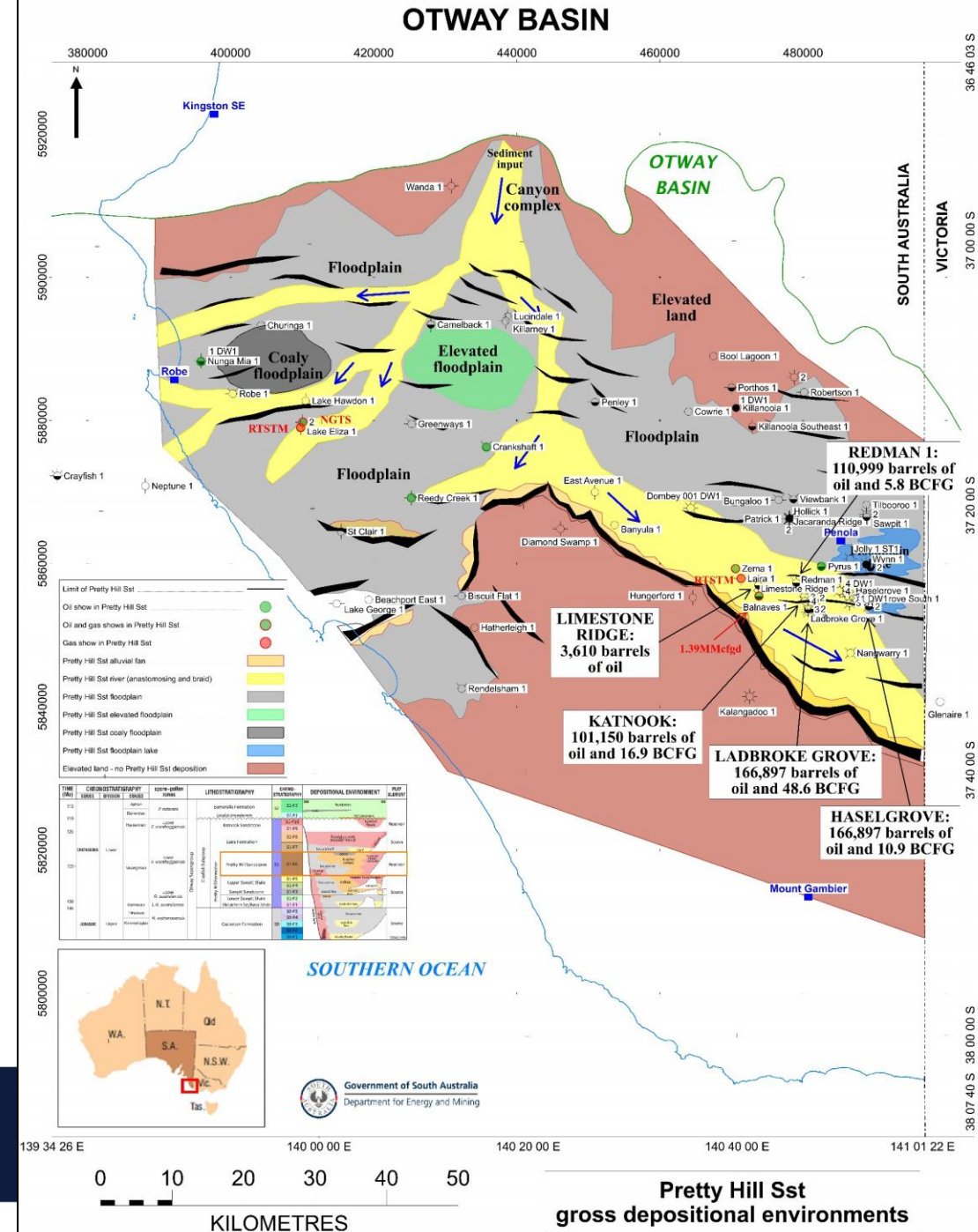
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Department for Energy and Mining



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Pretty Hill Sst Play Elements: Reservoir

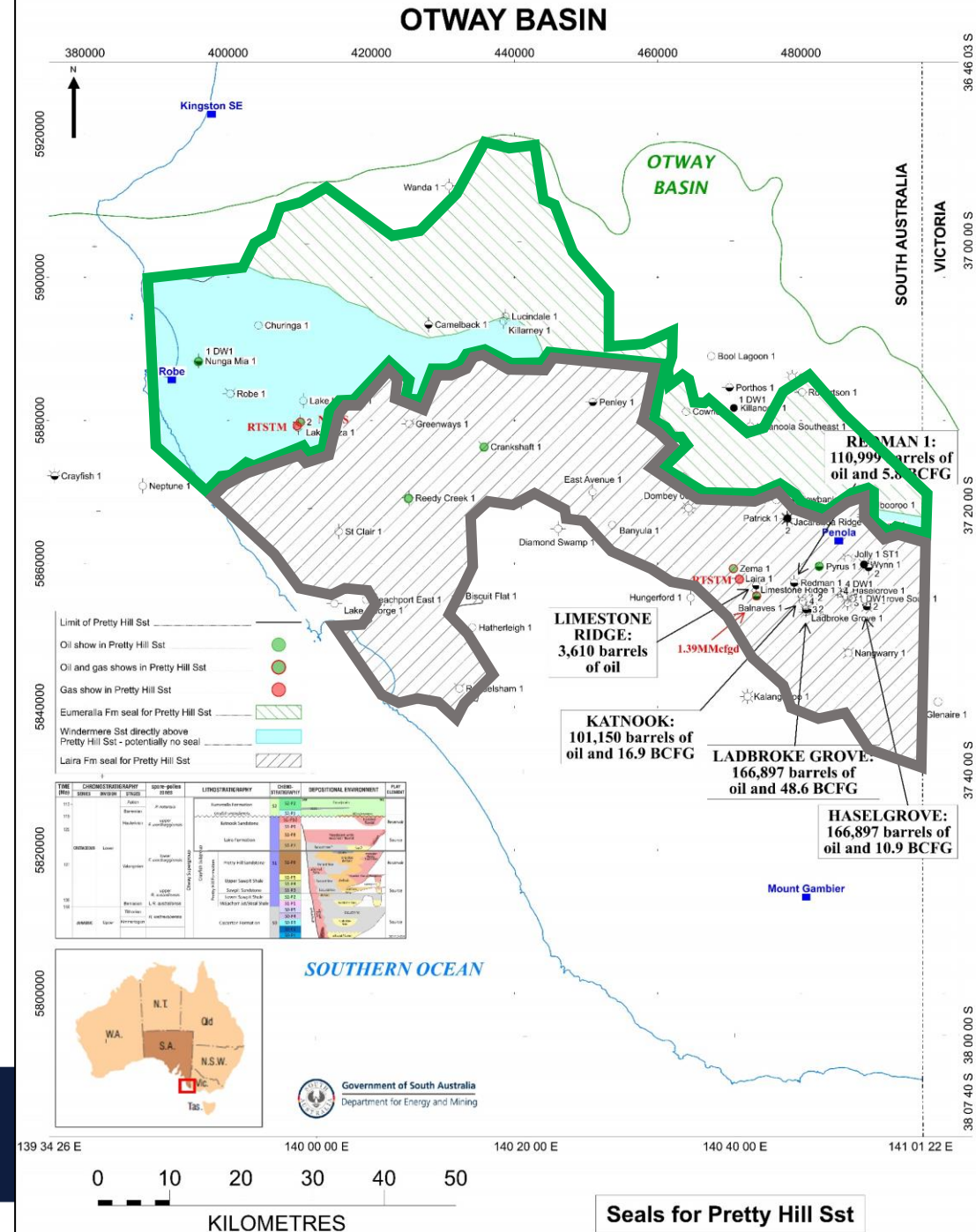
LITHOSTRATIGRAPHY		CHEMO-STRATIGRAPHY		DEPOSITIONAL ENVIRONMENT		PLAY ELEMENT
Otway Supergroup	Crayfish Subgroup	Eumeralla Formation	S2	S2-P2	floodplain	Reservoir
			S2-P1	Windermere		
		Katnook Sandstone	S1-P10	braided fluvial	Source	
			S1-P9			
		Laira Formation	S1-P8	floodplain with meander fluvial	Reservoir	
			S1-P7	lacustrine? fan?		
			S1-P6	braided deltaic meander fluvial-floodplain		
		Pretty Hill Formation	S1-P5	lacustrine	Source	
			S1-P4	deltaic		
			S1-P3	deltaic		
S1-P2	deltaic					
McEachern Sst/Basal Shale	S1-P1	turbidite fans	Source			
Casterton Formation	S0-P5	lacustrine				
	S0-P4					
	S0-P3	turbidite fans				
	S0-P2					
S0-P1	alluvial/fluvial					



Pretty Hill Sst Play Elements: Seal

		LITHOSTRATIGRAPHY	CHEMO-STRATIGRAPHY	DEPOSITIONAL ENVIRONMENT	PLAY ELEMENT		
Otway Supergroup	Crayfish Subgroup	Eumeralla Formation	S2	S2-P2	SW floodplain NE		
		<i>Crayfish Unconformity</i>		S2-P1	Windermere		
		Katnook Sandstone	S1-P10		braided fluvial	Reservoir	
		Pretty Hill Formation	Laira Formation	S1-P8		floodplain with meander fluvial	Source
			Pretty Hill Sandstone	S1-P7		lacustrine? fan?	Reservoir
				S1-P6		coals braided deltaic meander fluvial-floodplain	
			Upper Sawpit Shale	S1-P5		lacustrine alluvial fans meander fluvial-floodplain	Source
		Sawpit Sandstone	S1-P4		lacustrine deltaic canyon		
		Lower Sawpit Shale	S1-P3		lacustrine deltaic fans		
		McEachern Sst/Basal Shale	S1-P2		deltaic turbidite fans	Source	
Casterton Formation	S0-P5		lacustrine				
	S0-P4		turbidite fans				
	S0-P3		turbidite fans				
	S0-P2		alluvial/fluvial				
	S0-P1		alluvial/fluvial				

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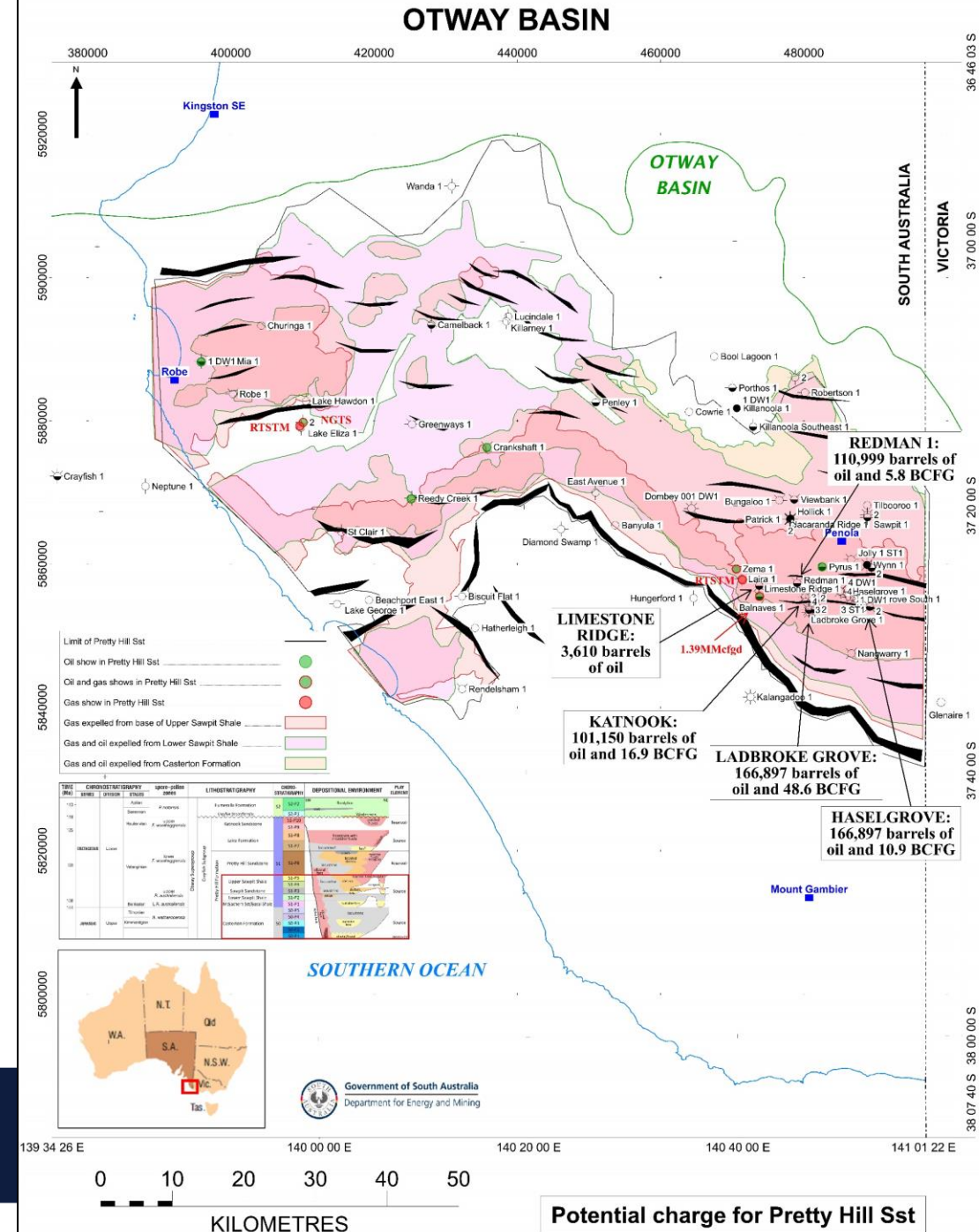
Seals for Pretty Hill Sst



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Pretty Hill Sst Play Elements: Source rocks

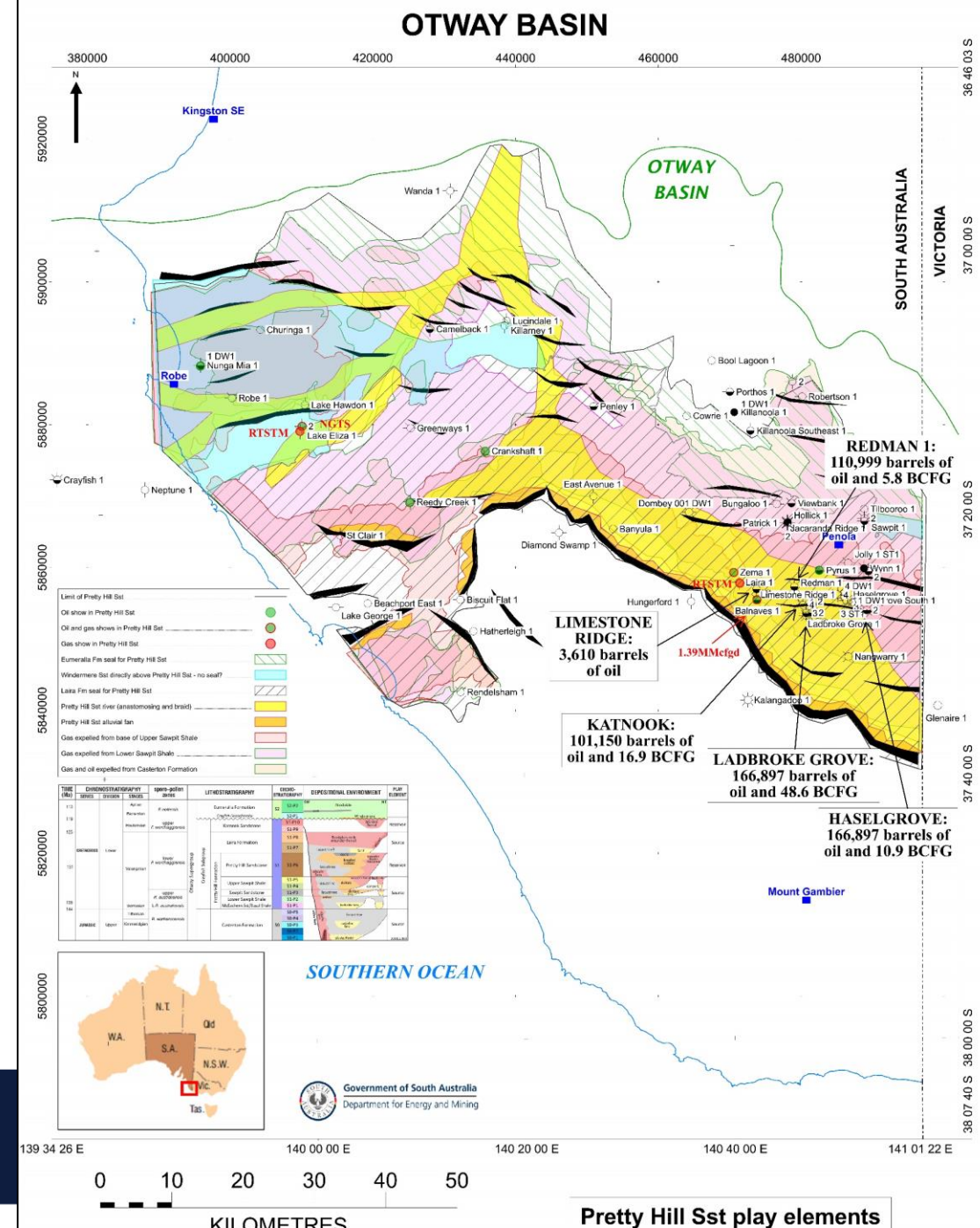
LITHOSTRATIGRAPHY		CHEMO-STRATIGRAPHY		DEPOSITIONAL ENVIRONMENT		PLAY ELEMENT	
Otway Supergroup	Crayfish Subgroup	Eumeralla Formation	S2	S2-P2	SW floodplain NE	Reservoir	
				S2-P1	Windermere		
		Crayfish Unconformity	Katnook Sandstone	S1	S1-P10	braided fluvial	Reservoir
					S1-P9		
		Pretty Hill Formation	Laira Formation	S1	S1-P8	floodplain with meander fluvial	Source
					S1-P7	lacustrine? fan?	
					S1-P6	meander fluvial-floodplain	
					S1-P5	braided deltaic	
		Upper Sawpit Shale	Sawpit Sandstone	S1	S1-P4	lacustrine deltaic	Source
					S1-P3	lacustrine deltaic fans	
					S1-P2	deltaic	
					S1-P1	turbidite fans	
Casterton Formation	S0	S0-P5	lacustrine	Source			
		S0-P4					
		S0-P3	turbidite fans				
		S0-P2					
		S0-P1	alluvial/fluvial				



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Pretty Hill Sst Play Elements

LITHOSTRATIGRAPHY		CHEMO-STRATIGRAPHY		DEPOSITIONAL ENVIRONMENT		PLAY ELEMENT
Otway Supergroup	Crayfish Subgroup	Eumeralla Formation	S2	S2-P2	SW floodplain NE	Reservoir
		<i>Crayfish Unconformity</i>		S2-P1	Windermere	
	Katnook Sandstone	S1	S1-P10	braided fluvial	Source	
	Laira Formation		S1-P9	floodplain with meander fluvial		
	Pretty Hill Formation	Pretty Hill Sandstone	S1	S1-P8	lacustrine? fan?	Reservoir
				S1-P7	meander fluvial-floodplain	
				S1-P6	braided deltaic	
				S1-P5	lacustrine	
				S1-P4	meander fluvial-floodplain	
				S1-P3	deltaic	
Upper Sawpit Shale	S0	S0-P5	alluvial fans	Source		
Sawpit Sandstone		S0-P4	lacustrine			
Lower Sawpit Shale		S0-P3	deltaic			
McEachern Sst/Basal Shale	S0	S0-P2	turbidite fans	Source		
Casterton Formation		S0-P1	lacustrine			
		S0-P5	alluvial fans			
		S0-P4	turbidite fans			
	S0-P3	alluvial/fluvial				



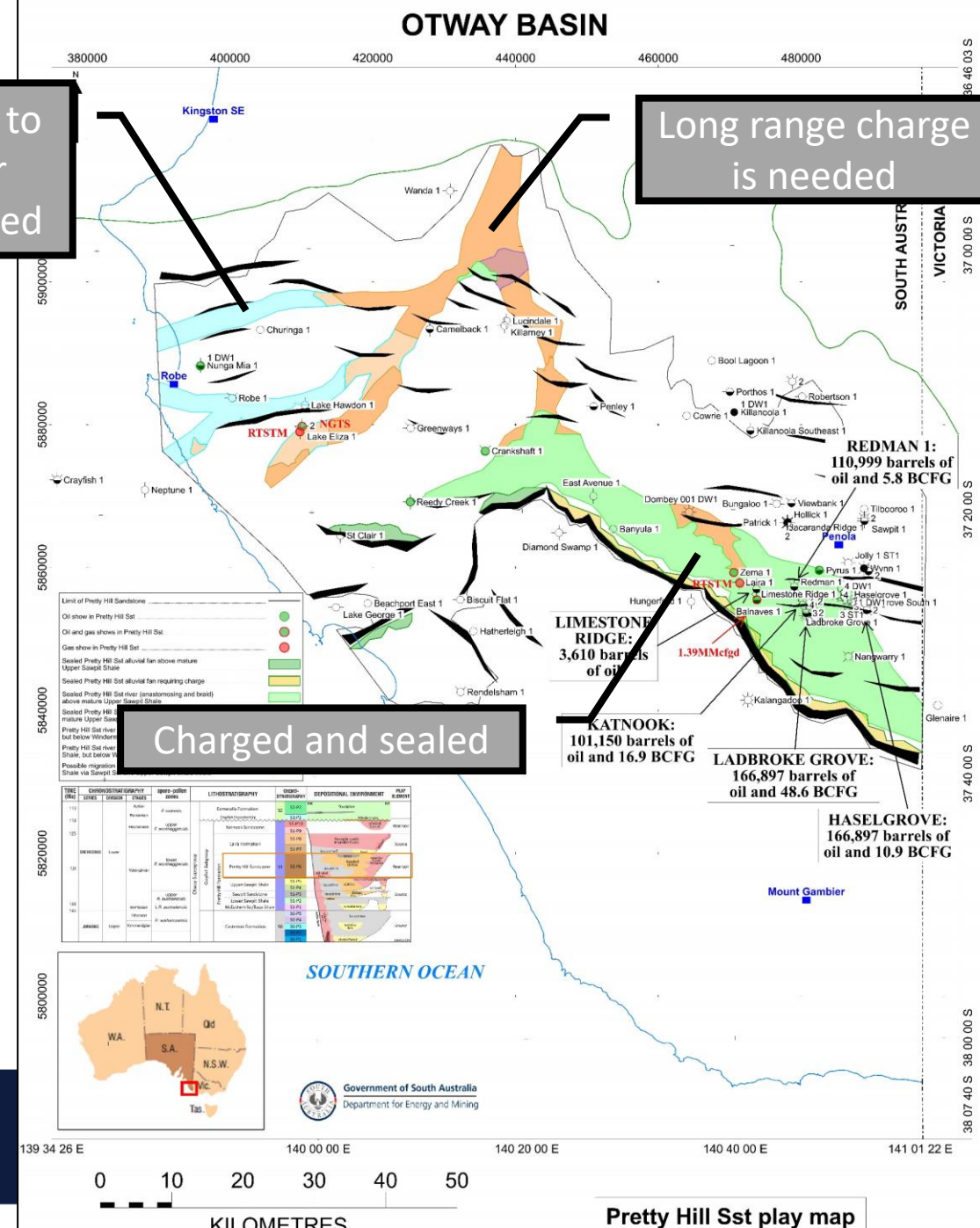
Pretty Hill Sst Play Map

- Limit of Pretty Hill Sandstone
- Oil show in Pretty Hill Sst
- Oil and gas shows in Pretty Hill Sst
- Gas show in Pretty Hill Sst
- Sealed Pretty Hill Sst alluvial fan above mature Upper Sawpit Shale
- Sealed Pretty Hill Sst alluvial fan requiring charge
- Sealed Pretty Hill Sst river (anastomosing and braid) above mature Upper Sawpit Shale
- Sealed Pretty Hill Sst river possibly charged by mature Upper Sawpit Shale - migration required
- Pretty Hill Sst river above mature Upper Sawpit Shale, but below Windermere Sst - potentially no seal
- Pretty Hill Sst river possibly charged by mature Upper Sawpit Shale, but below Windermere Sst - potentially no seal
- Possible migration into Pretty Hill Sst from Lower Sawpit Shale via Sawpit Sst and Upper Sawpit Shale rivers

Seal needs to be better characterised

Long range charge is needed

Charged and sealed

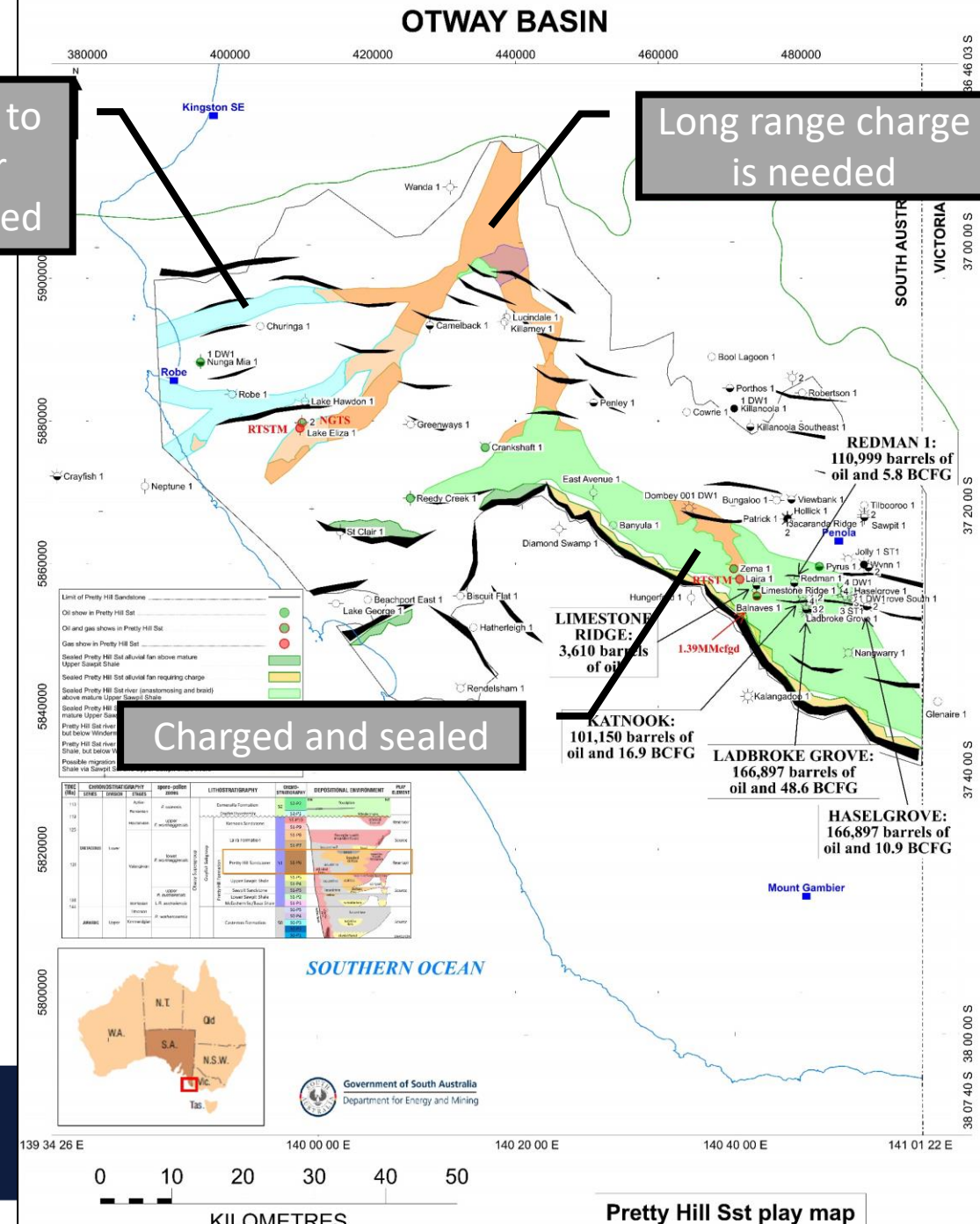


Onshore Otway Basin Play Analysis Summary

- Play-Based Exploration:
 - Understanding of petroleum system in basin
 - Play summary maps:
 - Identification of sweet spots
 - **Not static** - Iterative feedback required following new information
- Onshore Otway Basin:
 - Petroleum system model completed Q4 2023
 - Play analysis conducted in 2024
 - Rocks and seismic are the key
 - 7 depositional intervals + Fractured Basement
 - Stimulate next phase of exploration in basin

Seal needs to be better characterised

Long range charge is needed



Onshore Otway Basin Play Analysis Data Available

All plays reviewed in this study are documented on the DEM Energy Resources website under individual Basins:

<https://www.energymining.sa.gov.au/industry/energy-resources/geology-and-prospectivity/mesozoic-basins/otway-basin>

MESA Journal research article 3 (17–28) by Paul Strong and Chris Cubitt, November 2024 on this presentation:

[MESAJ098017-028_11_2024.pdf](#)

(https://sarigbasis.pir.sa.gov.au/WebtopEw/ws/sa/mref/sarig1/image/DDD/MESAJ098017-028_11_2024.pdf)

The screenshot displays the website interface for the Otway Basin. At the top, there is a navigation bar with the Government of South Australia logo, the 'ENERGY & MINING' title, and a search box. Below this is a secondary navigation menu with links for News, About, Consumers, Industry, Public consultations, Investors, and Quick links. The main content area features a breadcrumb trail: Home > Industry > Energy resources > Prospectivity > Mesozoic Basins > Otway Basin. The page title is 'Otway Basin'. A left-hand sidebar contains a menu with categories like Energy resources, Investment, Licensing and land access, Regulation, Prospectivity, Mesozoic Basins (with sub-items Eromanga Basin, Otway Basin, and Simpson Basin), Renmark Trough, Polda Basin, Bight Basin (Ceduna Sub-basin), Bight Basin (Duntroon Sub-basin), Late Paleozoic basins, Neoproterozoic - Middle Paleozoic basins, and Geothermal. The main content area includes a section 'On this page' with links to Onshore Otway Basin plays, Summary, New Petroleum Systems Model 2023, Figures, and Prospectivity. Below this is a paragraph stating 'The Otway Basin is a Jurassic - Late Cretaceous basin.' followed by a detailed description of the basin's geological context and a reference to the 'Petroleum geology of South Australia, Volume 1: Otway Basin (Second edition)'. A map of the Otway Basin is shown on the right. At the bottom, there is a section titled 'Onshore Otway Basin plays' with a list of links for various plays: Location, Geological Setting, Windermere Sandstone play, Laura Formation play, Pretty Hill Sandstone play, Upper Sawpit Shale play, Sawpit Sandstone play, Lower Sawpit Shale play, Casterton Formation play, and Fractured Basement play.



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Thank you ... and don't forget to look at the rocks and seismic!

