PHOENIX SOUTH :
A NEW PETROLEUM SYSTEM IN THE BEDOUT SUB-BASIN

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Outline and Acknowledgements

1. Introduction
2. Petroleum System Elements
3. Reservoir
4. Structure and Geomechanics
5. Seals and Pressures
6. Hydrocarbons and Charge
7. Summary and What's Next

Quadrant Energy

FINDER EXPLORATION

CARNARVON PETROLEUM LTD

JX Nippon Oil & Gas Exploration

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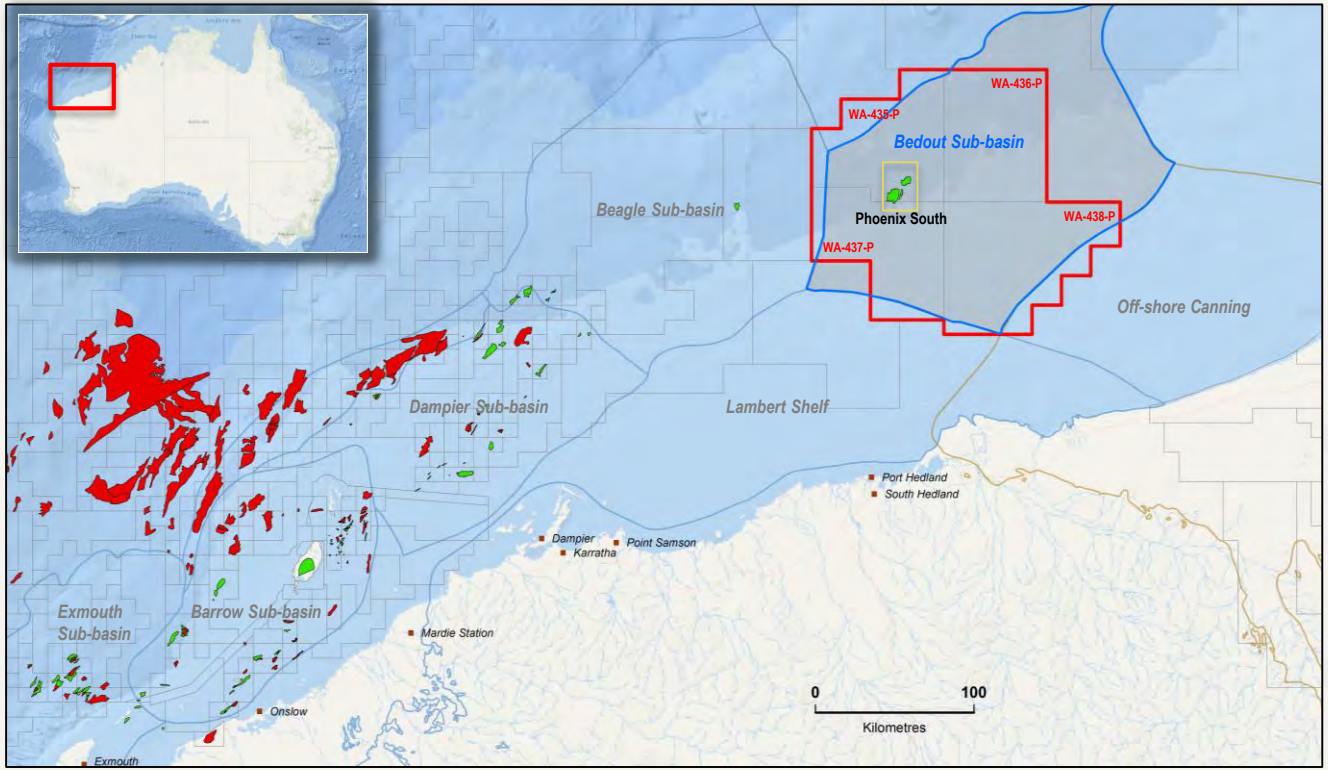

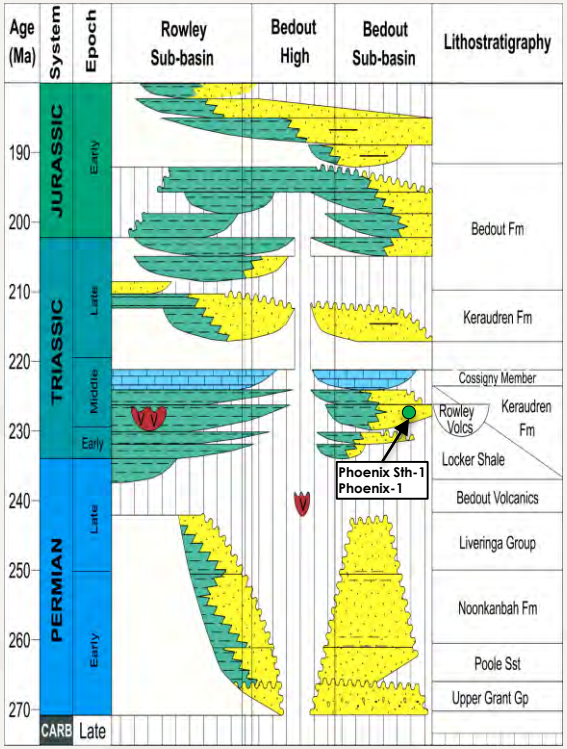

Geoscience Australia 2008

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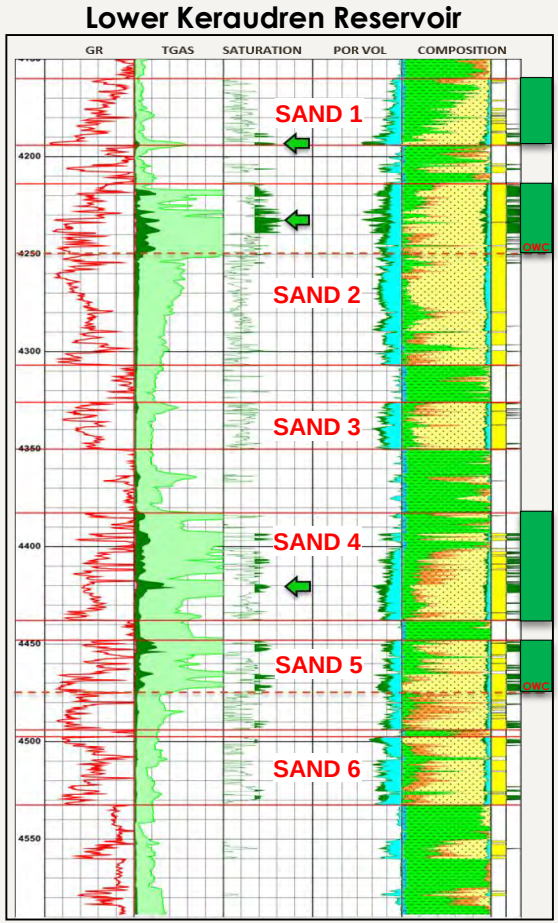
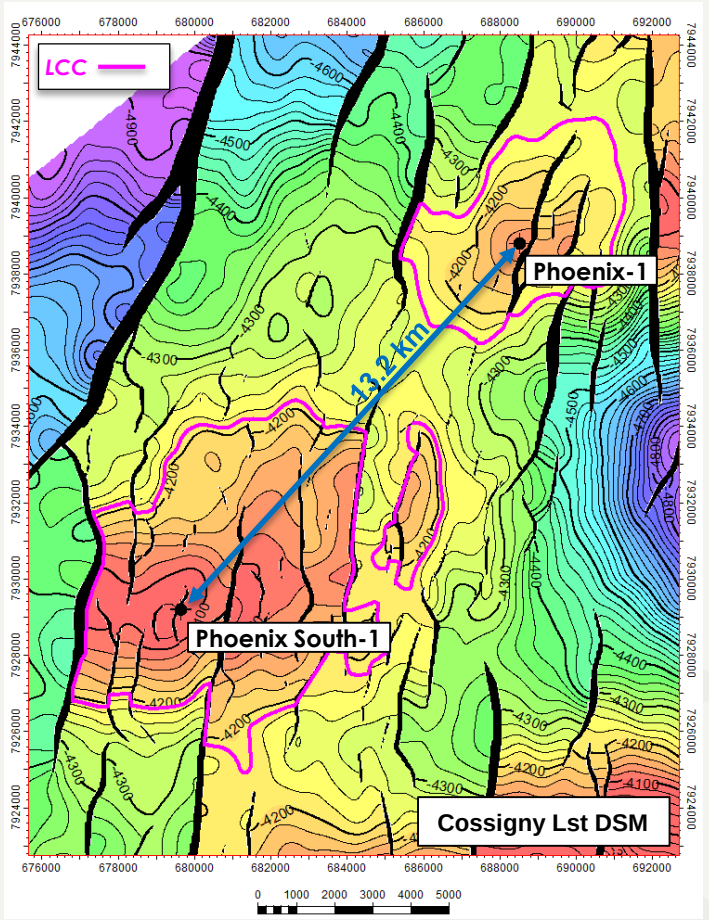


Phoenix South-1 (2014) well results support the presence of an active oil dominated petroleum system in the Bedout Sub-basin.

Four independent oil columns encountered in the well within the Middle to Lower Triassic Keraudren Formation over a 315 metre gross interval with a combined 151.4 metre oil column, showing first impressions based on sparse and incomplete data are not always correct.

Re-examination of the Phoenix-1 well data indicates it is most likely an oil discovery too!!

MDT Oil Samples



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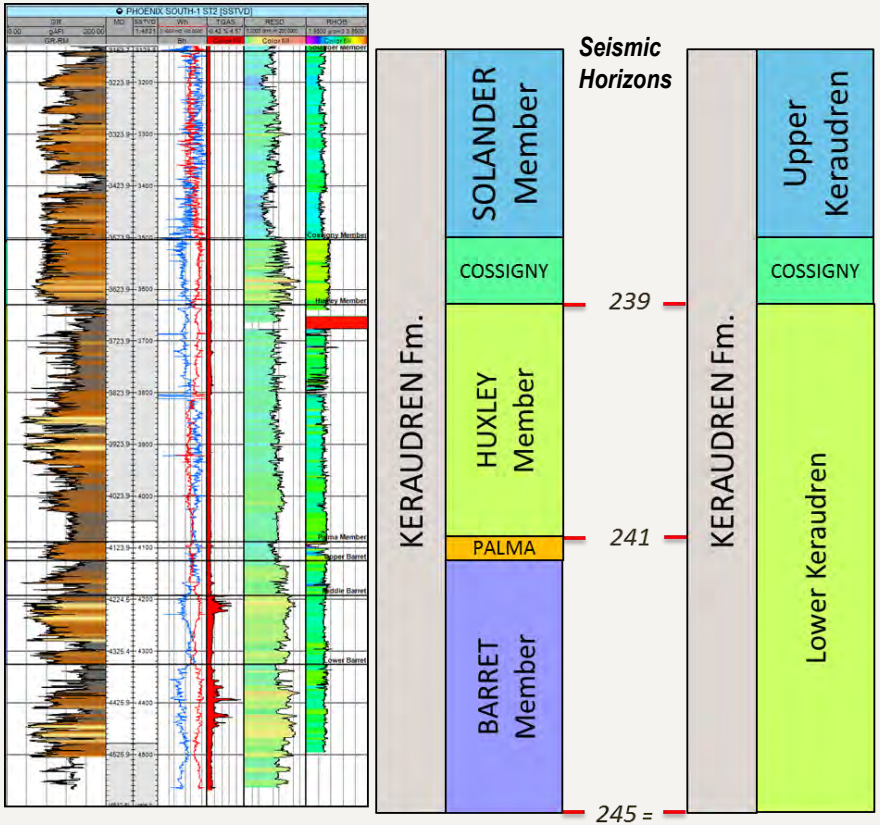
PRE-DRILL EXPECTATIONS *Higher risk, deep, tight gas*		POST-DRILL ACTUAL *New oil province*
Reservoir – Stacked thin, sands with low porosity and permeability with uncertain depositional system	→	**Reservoir** – Better developed N:G, some mod. permeability streaks and fracture perm potential in marginal marine to fluvial setting
Structure – Large faulted anticline	→	**Structure** - Large faulted anticline and low rock strength
Seal – single large gas column, overpressure	→	**Seal** – multiple oil columns with pressure differences, but not significantly over-pressured
Charge – Triassic gas with potential for liquids	→	**Charge** – under saturated oil from Lower Keraudren aged source rocks

RESERVOIR

Keraudren Formation – Informal Sub-Division



Early-Middle Triassic Keraudren Fm

Sub-division based on paly, chemostrat and seismic.

Solander equivalent to U. Keraudren (S. speciosus)

Cossigny and ***Palma*** are both regionally correlatable marine incursions, with the Cossigny being the more significant

Huxley between the Cossigny and Palma (S. quadrifidus)

Barret below the Palma and above the 245 seismic marker (T. playfordii). Oil accumulations all in this unit.

Named after 17th-18th Century Naturalists

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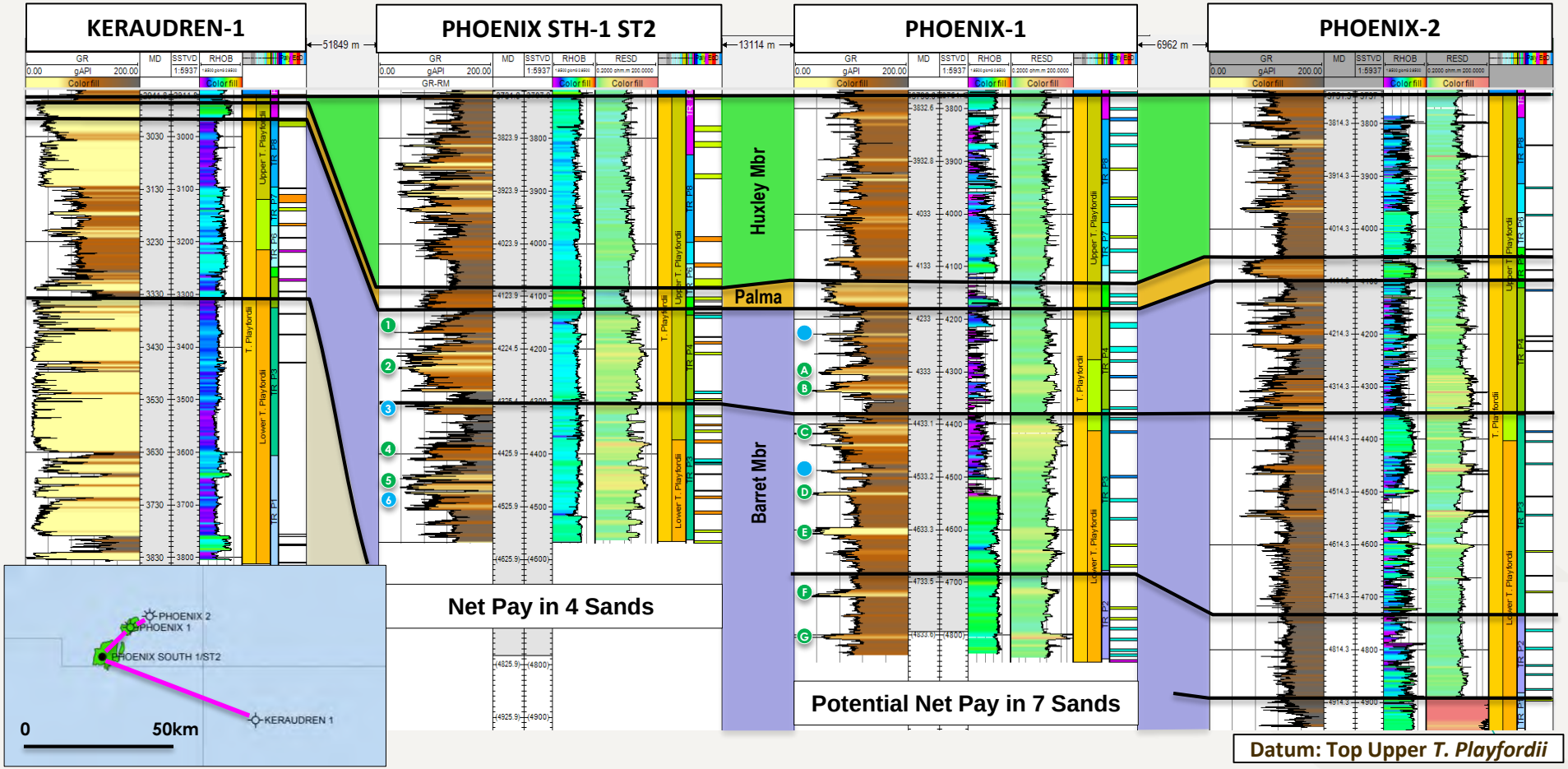
Lwr Keraudren Regional Correlation - Paly and Chemostrat



Datum: Top Upper *T. Playfordii*

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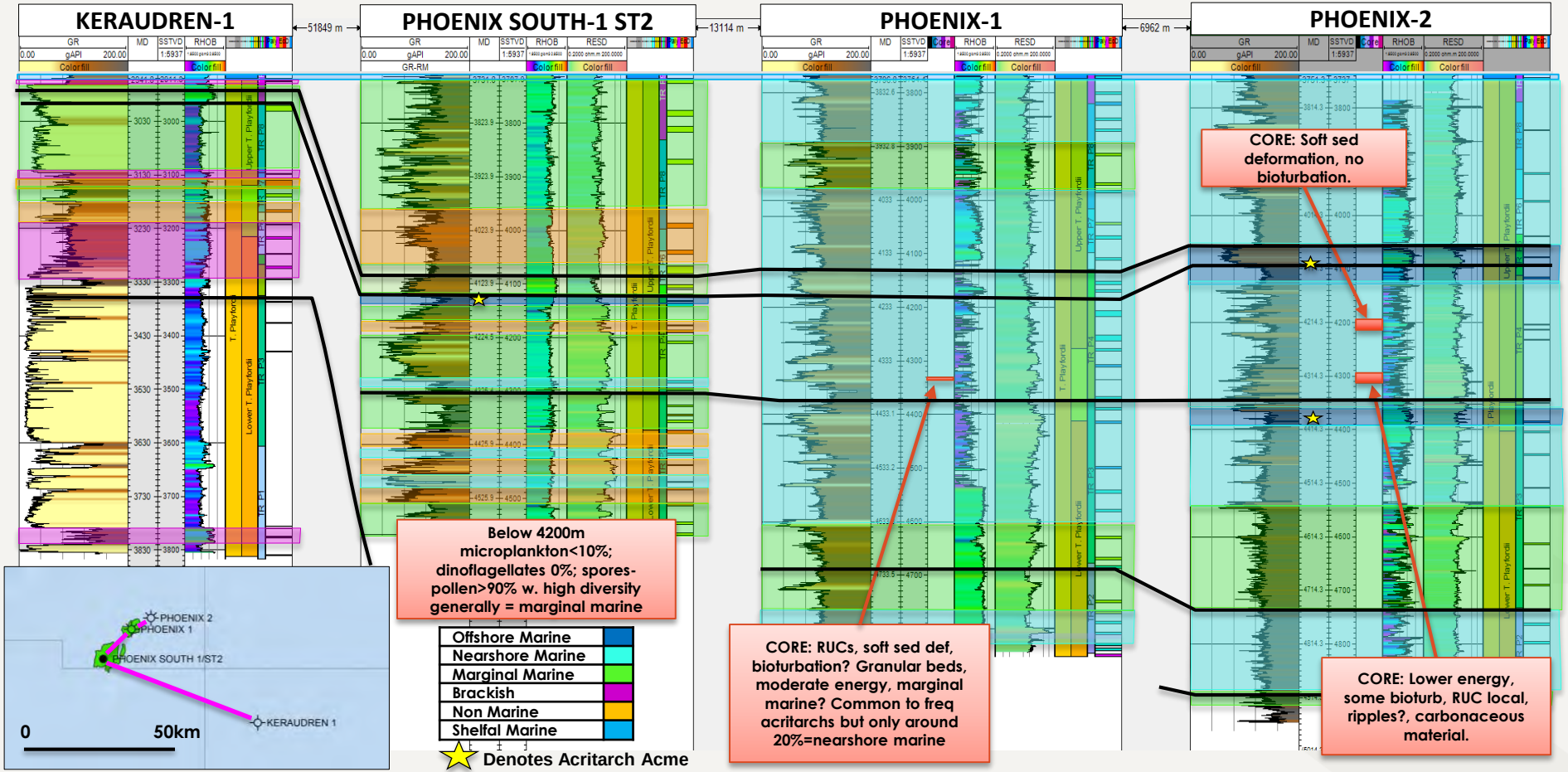
Depositional Environments –FMI and Paly



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Depositional Environments II

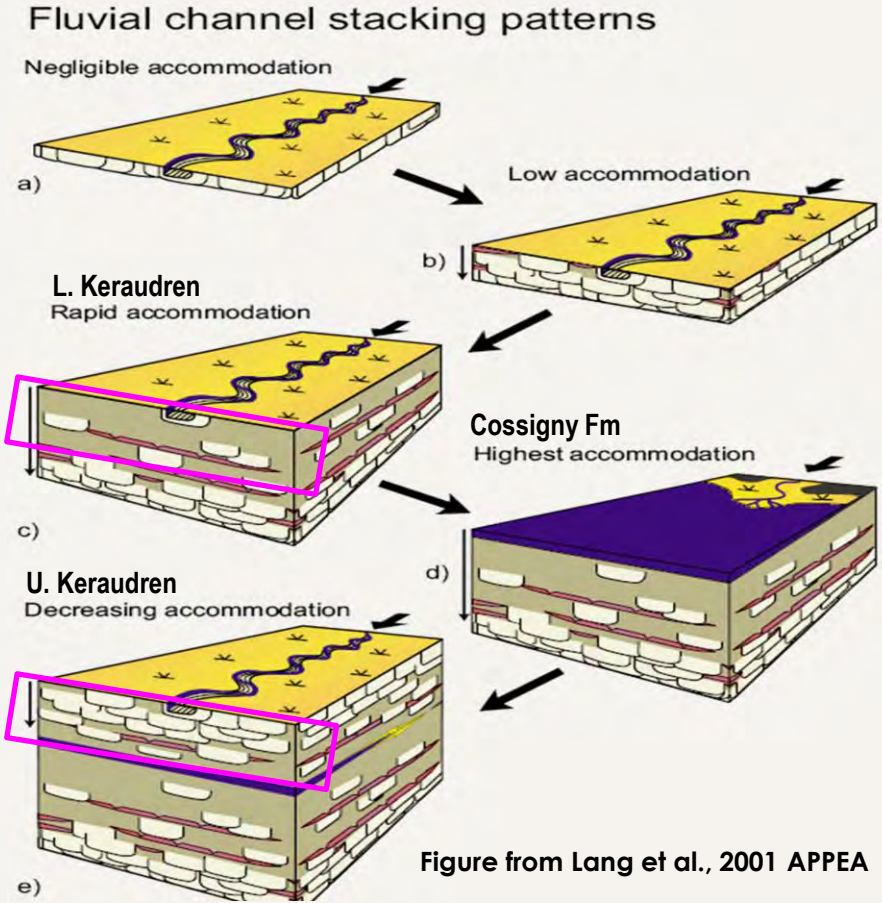

Figure from Lang et al., 2001 APPEA

- **Depositional environments within the Keraudren Fm are a mixture of channel, swamp, floodplain, brackish marginal marine, marginal marine and marine environments**
- **Thin, fining upwards, sandstones seen in the Barret and Huxley (Lwr Keraudren) suggestive of a deposition in an overall retrogradational phase with increasing accommodation**
- **Retrogradational phase culminating in deposition of the Cossigny Fm carbonate following an earlier Palma sub-regional marine incursion.**
- **Blocky sands seen in Upper Keraudren suggestive of an overall progradational phase with decreasing accommodation**

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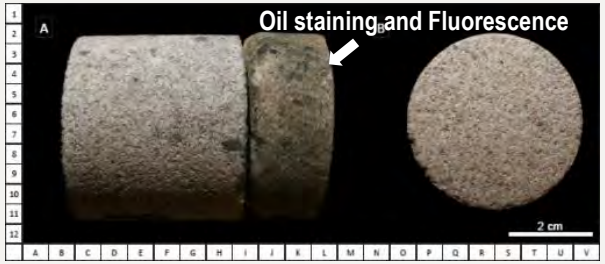
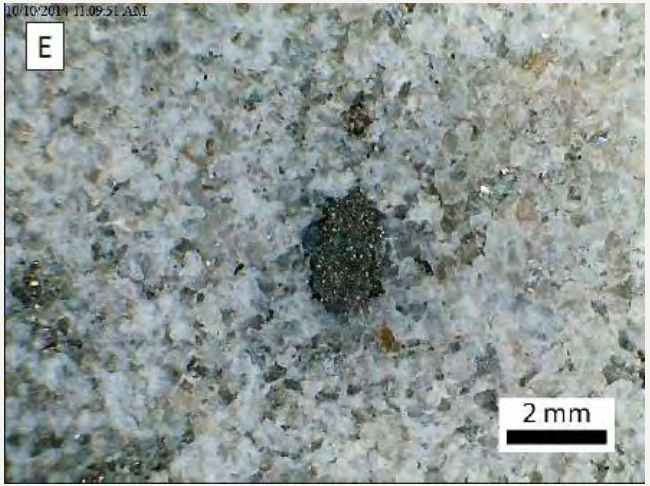
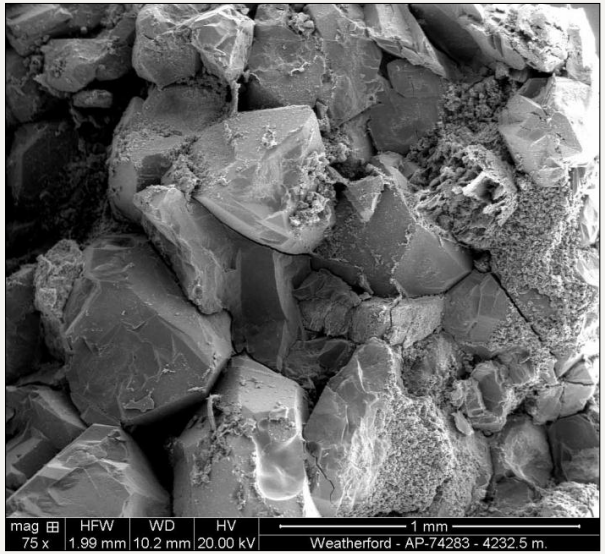
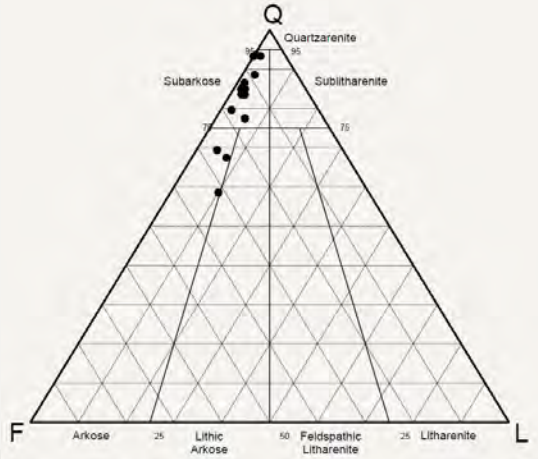
Reservoir quality

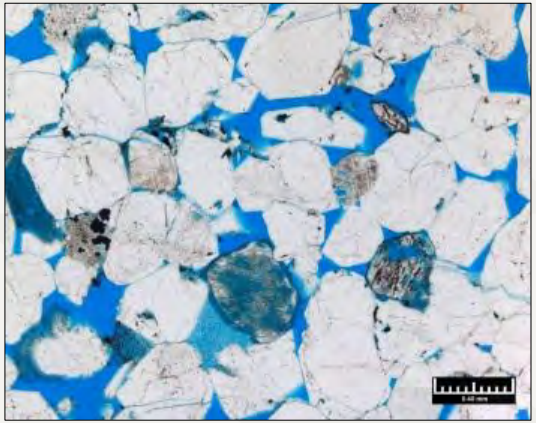
Medium grained subarkose sandstones dominate











Example Sand 2 - Poor-well sorted, sub-angular & low sphericity. FMI shows parallel-laminated sandstone.

Oil recovered on MDT

XRD - 89% quartz with <5% of K-feldspar, Plagioclase, Chlorite & Kaolinite

Dominantly quartz overgrowth cements with some secondary porosity from feldspar leaching

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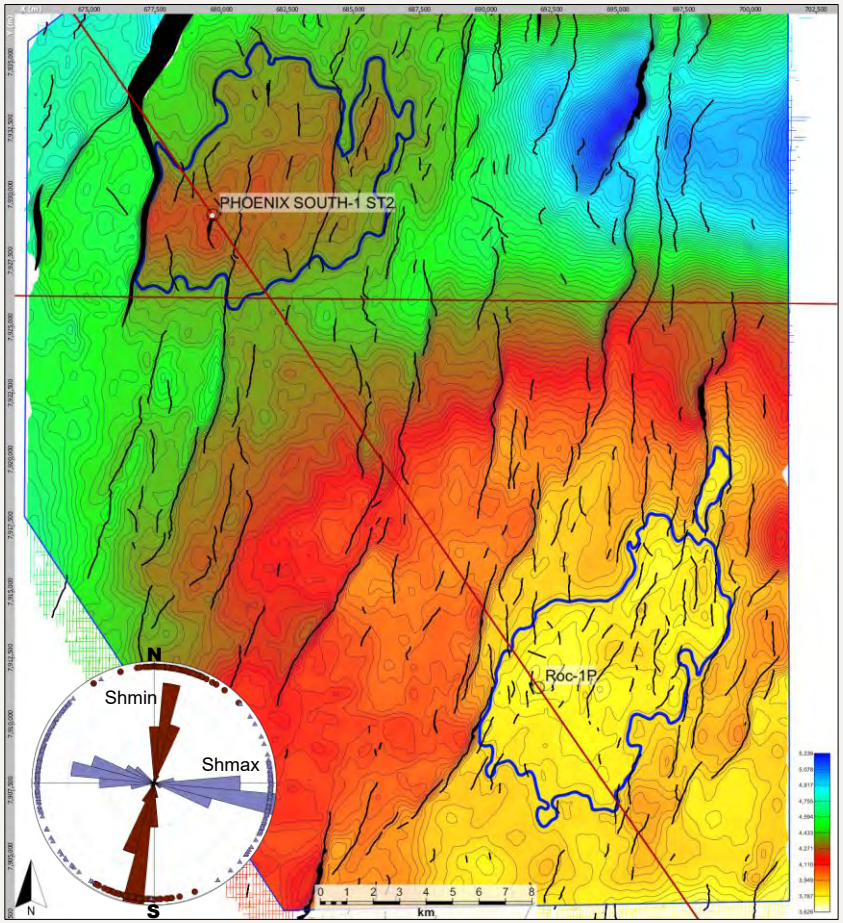
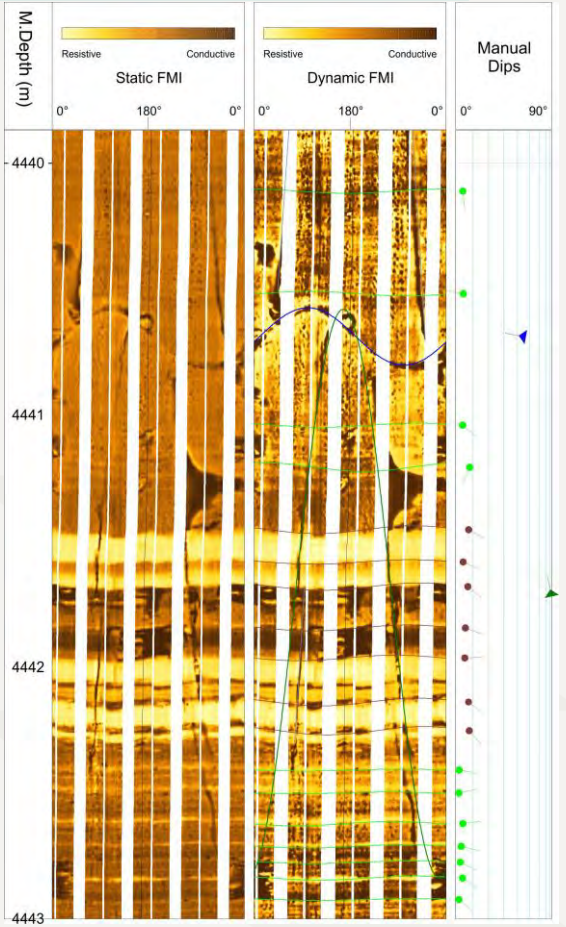
Depth Structure and Stress Field



Borehole breakout was strongly apparent in a near N-S orientation (007o +/-15o), defining the orientation of the minimum horizontal stress (Shmin).

This corresponds with the majority of seismically mappable faults and indicates they would generally be under compressive stress.

Area has an uncharacteristically low fracture gradient that may be bounded at the low end by frictional equilibrium conditions (essentially the lowest possible fracture gradient). Significant and repeated losses while drilling.



Fault imaged by the FMI at 4440.7 m within the Barret reservoir section. Major loss zone after drilling through this fault.

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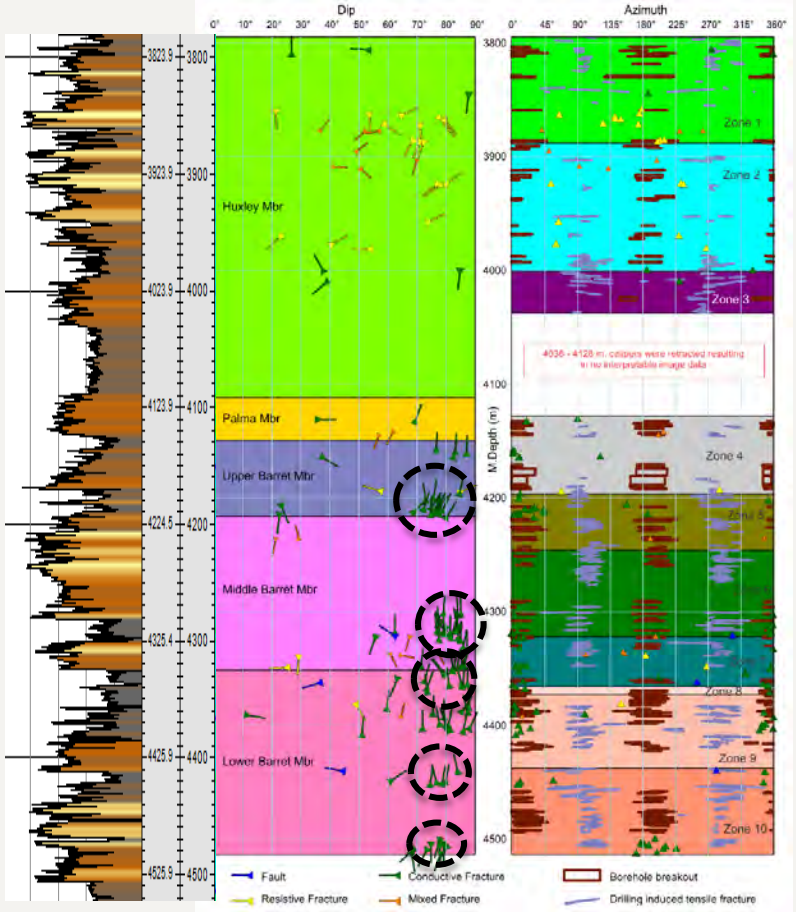
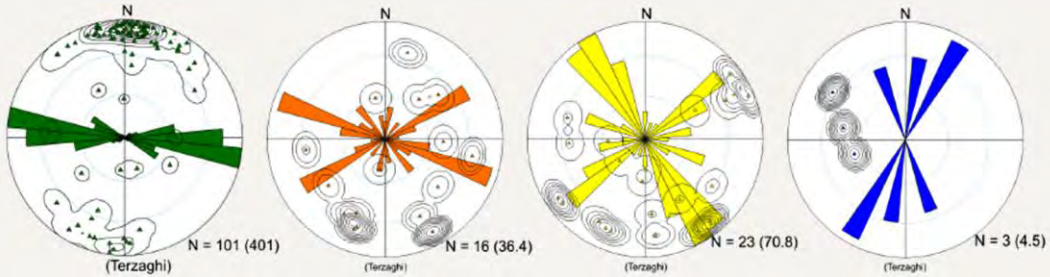
Fractures and Faults



Fracture Orientations



- More resistive fractures in the Huxley
- Fractures more common in lower section & broadly cluster in 5 areas
- DITF mainly in argillaceous intervals

- Low fracture gradient offers potential to easily induce fractures to improve connectivity, and hence productivity and recovery in the reservoir

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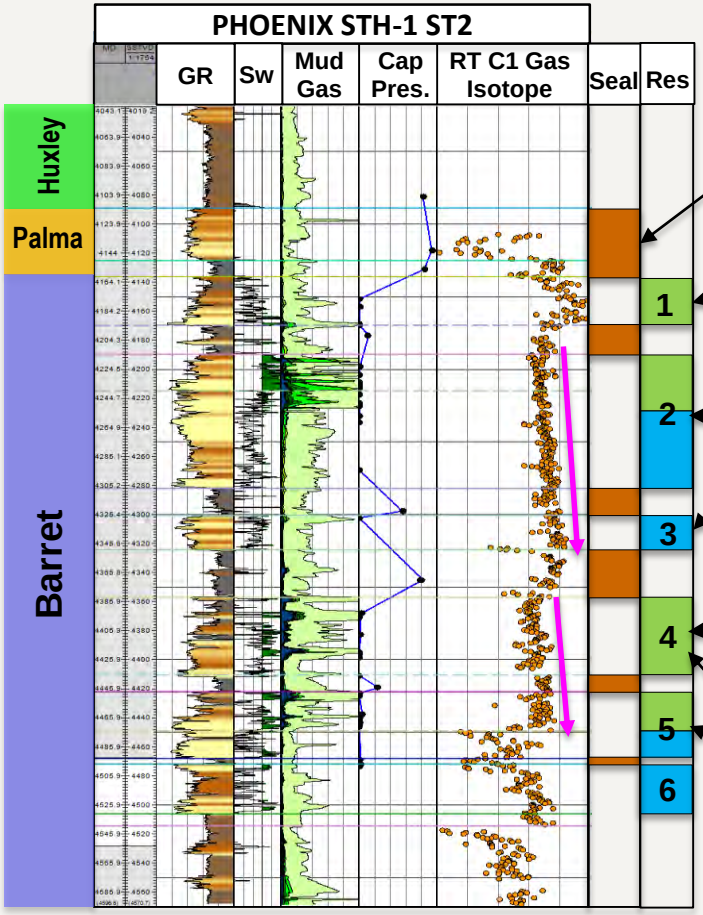
Seals and Pressures



While the Cossigny Limestone major transgression is the regional seal to the Lwr Keraudren, the overall top seal to oil accumulations is the **Palma** Member, a shale with highly cemented clastics (semi-regional marine incursion).

Sand 1 is isolated in a separate pressure compartment from MDT & isotope data – top and base seal effective.

Sand 2 has an OWC in the sand and appears to be in the same pressure compartment as Sand 3 from isotope data, but cap pressure indicates good seal between – cross fault juxtaposition leakage?

Subtle differences between Sand 4 and Sand 1 & 2 oils, plus a gradient change on isotope data and good cap pressure indicates a separate compartment.

Sand 4 and 5 may be in communication, but inconclusive due to poor RFT data

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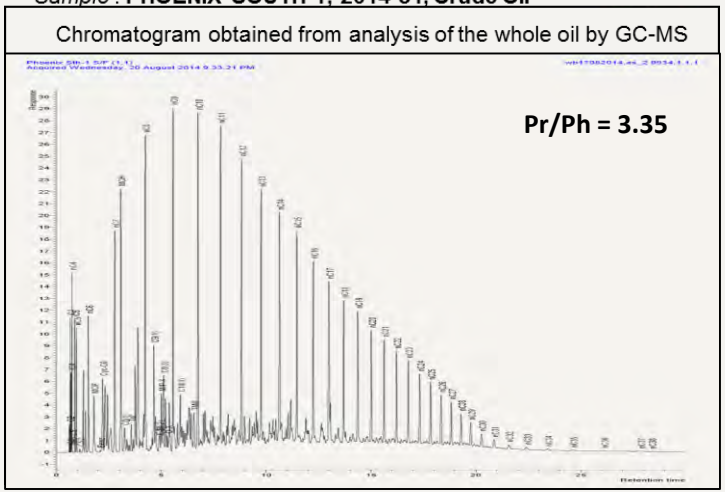
Hydrocarbons and Charge

Sample : **PHOENIX SOUTH-1, 2014-31, Crude Oil**

Chromatogram obtained from analysis of the whole oil by GC-MS



API Gravity – 45-47.8 º

GOR – 600 -1150 scf/bbl

Pr/Ph Ratio – 3.36-4.06

- Mixed marginal marine-terrestrial source (Type II/Type III) indicated from analysis of oils – Pr/Ph, C27/C29 steranes
- 3 oil samples from Sand 1, 2 & 4 very similar with some subtle differences between Sand 1 and 2 oils vs Sand 4 oil (CSIA). All under-saturated.
- Aromatic biomarker ratios indicate oil is of lower maturity (0.7-0.8 Ro equivalent).
- Gases and oil co-genetic (CSIA/Gas Isotope)

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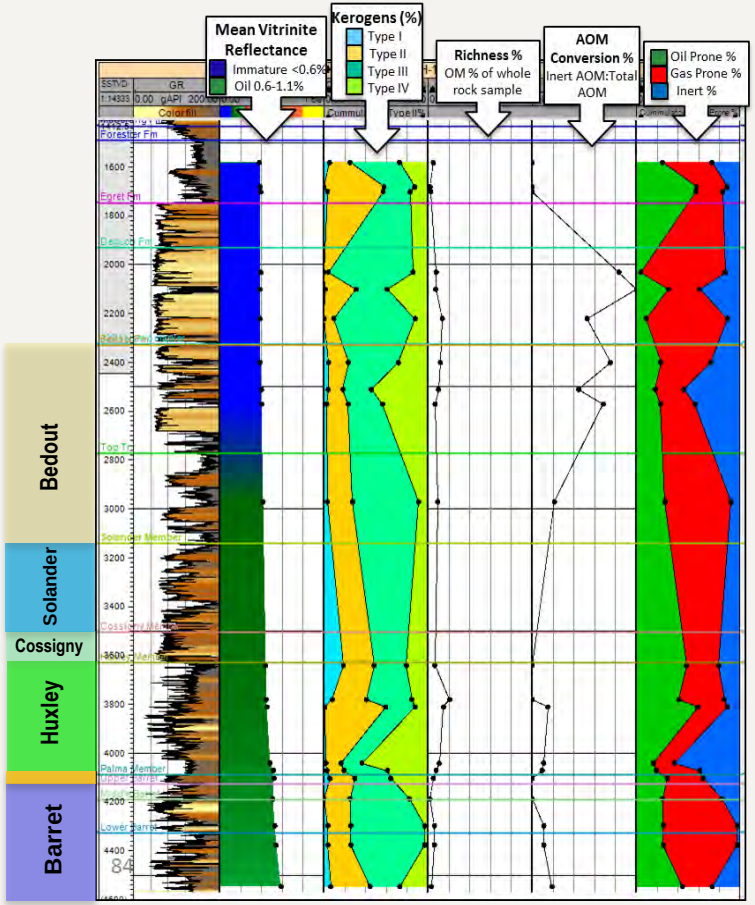
Source Rock Characterisation



Huxley and Barret investigated for source rock potential

- TOC's 1.2 - 2.4%
- Mix of Type II and III Kerogens with significant inertinite content in places. Likely to have impacted calculated HI values with average ~140 and max 177.
- S2 up to 4 with average around 2
- Pr/Ph ratios 1.29 – 3.86 with lower values in Barret and values in Huxley most similar to oils
- VRo values from 0.66% @ 3600m to 0.9% @ 4600m.

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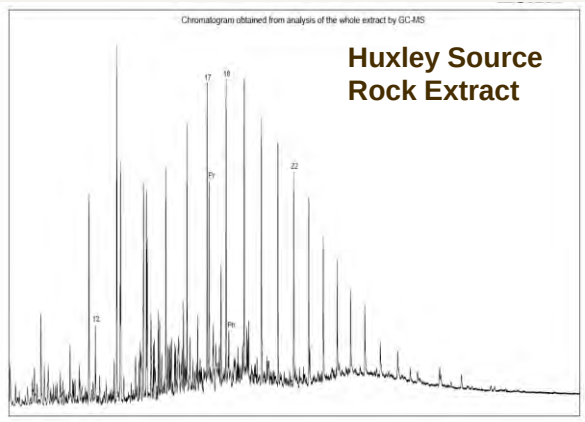
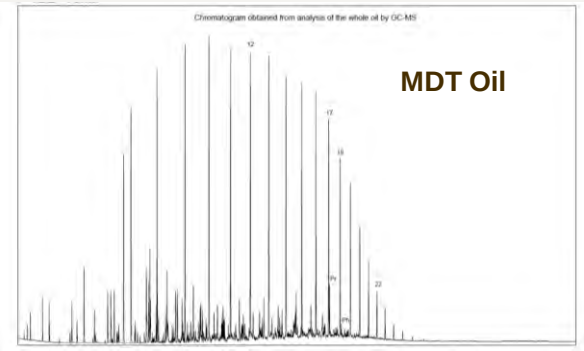
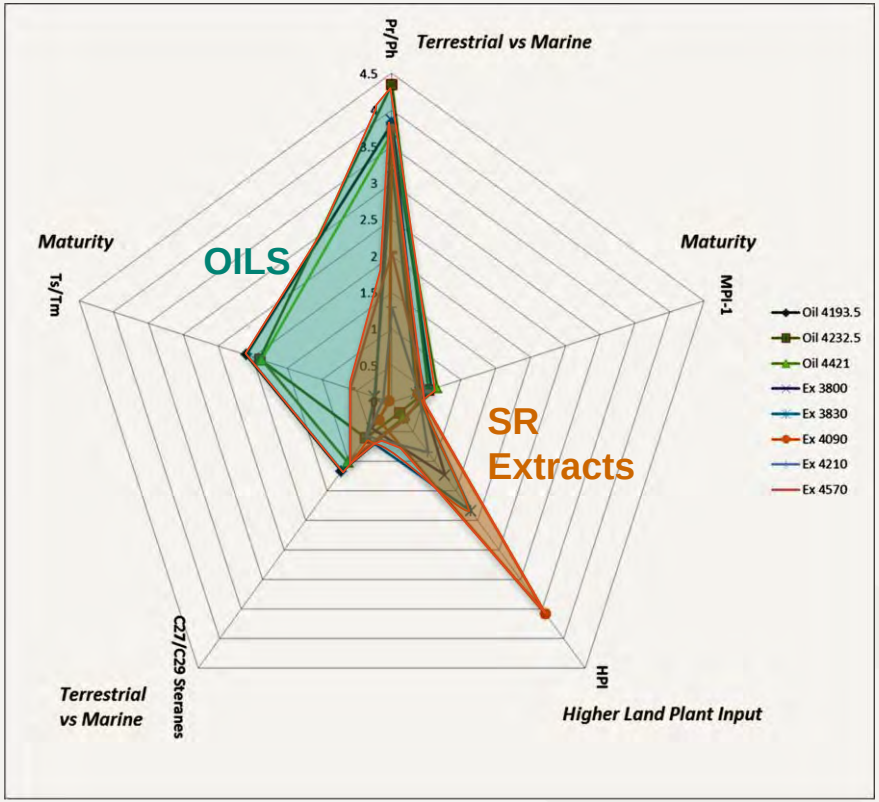
Oil to Source Rock Comparison



Some similarities but ……..





Biomarkers indicate specific facies that produced the oil has not be intersected in the well.

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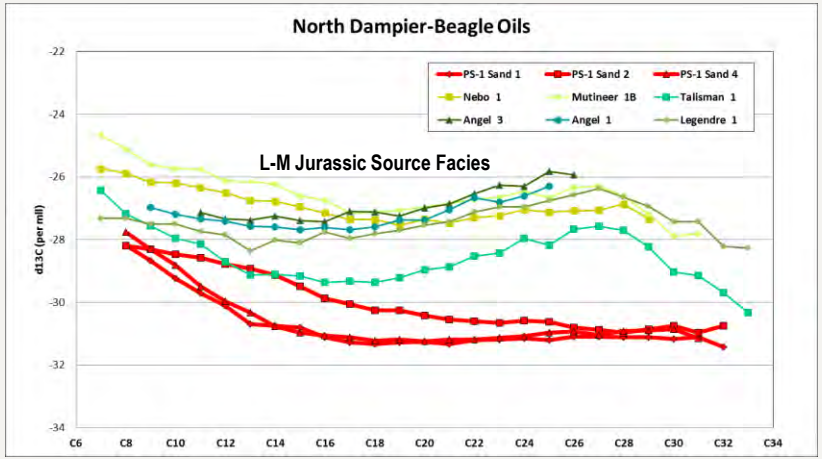
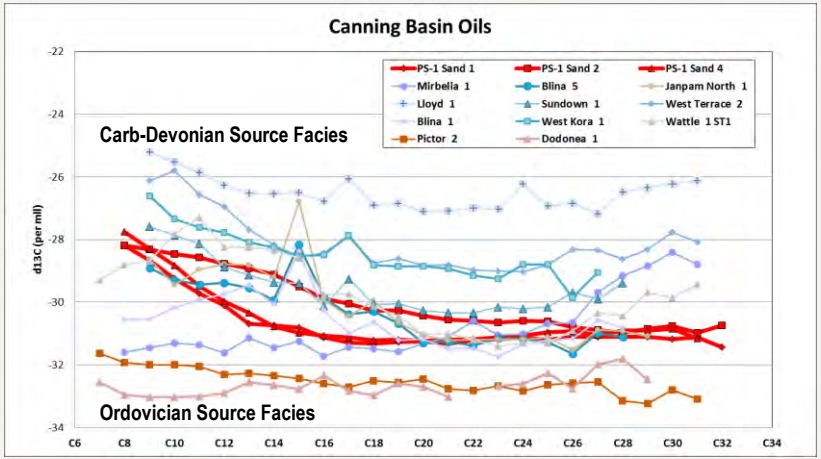
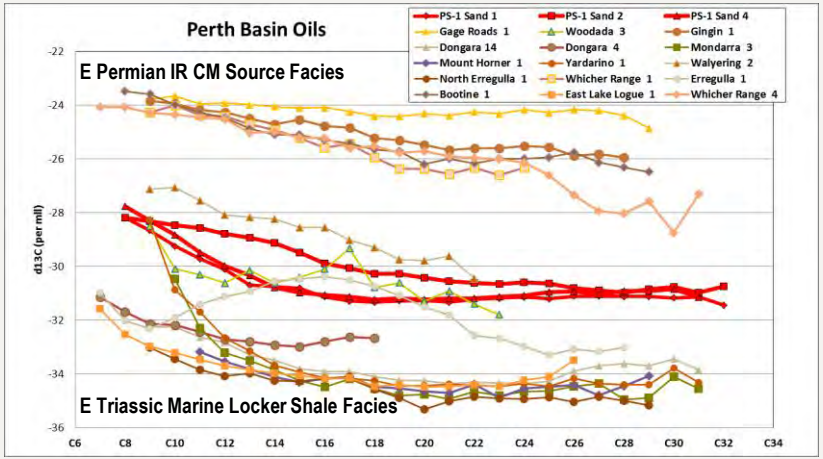
Isotopic Composition and Correlation





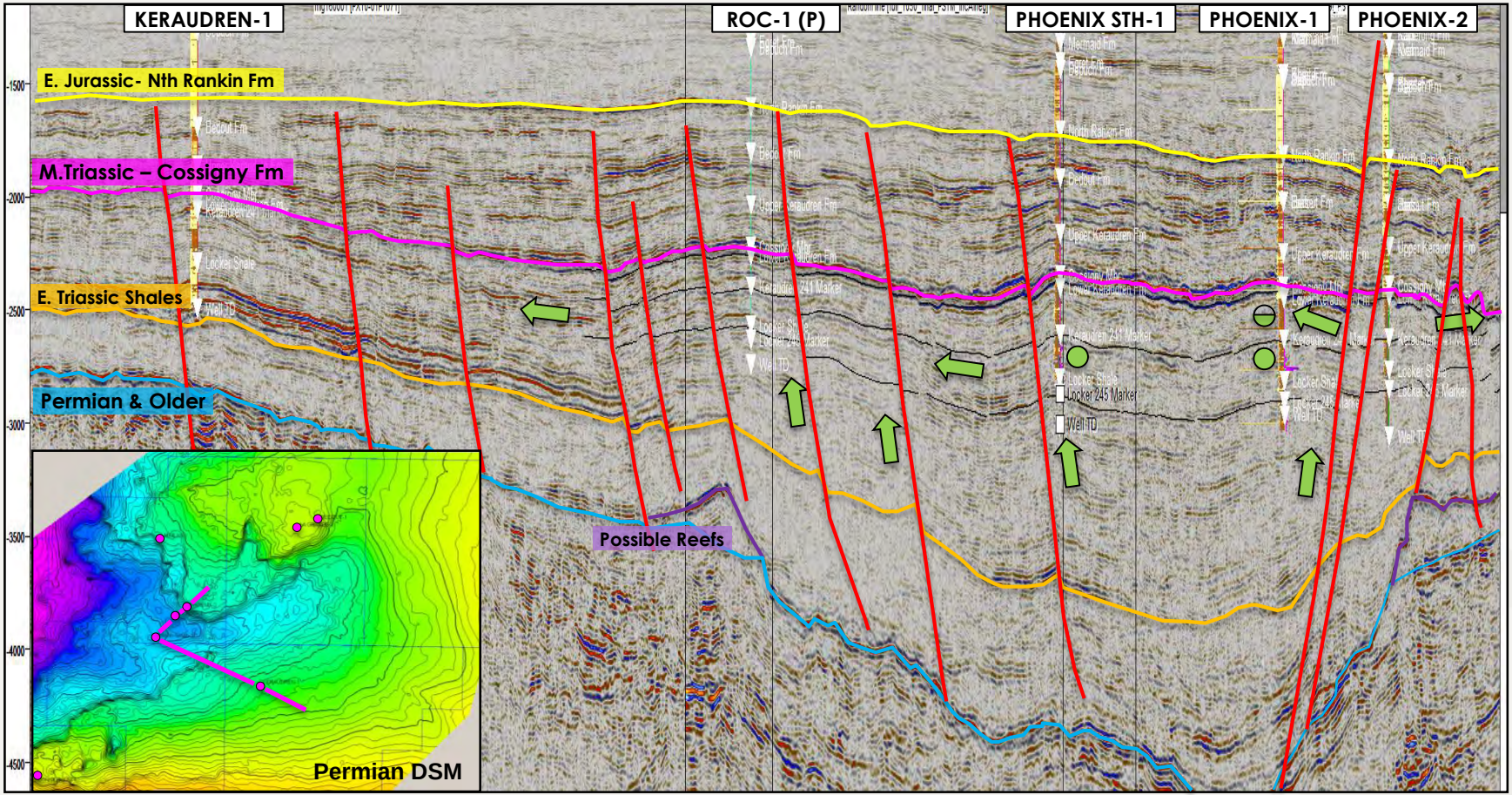


Phoenix South-1 oils compared to Geoscience Australia's Oils of WA II selected data.

Comparison of the various geochemical characteristics of the oils, including biomarkers and isotopes, to published data suggests that the source rock is not related to a known petroleum system previously encountered.

Bedout Sub-basin

New Lower Triassic Petroleum System



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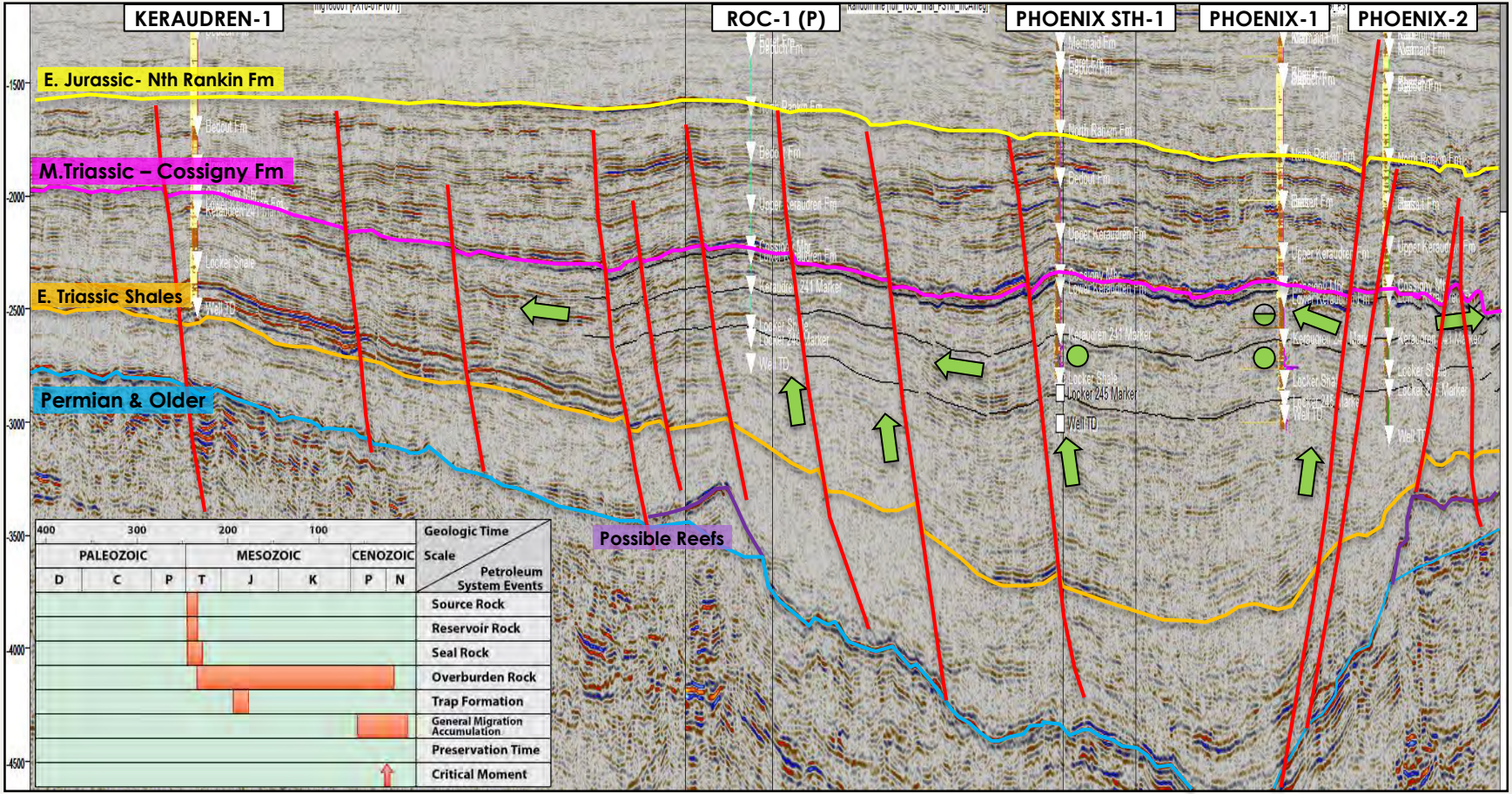

A New Petroleum System

Positives, Challenges and Remaining Uncertainties

Quadrant Energy

Positives

- Light Oil
- Large structures

Challenges

- Reservoir quality
- Formation stability

Remaining Uncertainties

- Contribution of fracture network to productivity
- Variation in reservoir quality spatially and with depth
- Source rock distribution and richness?

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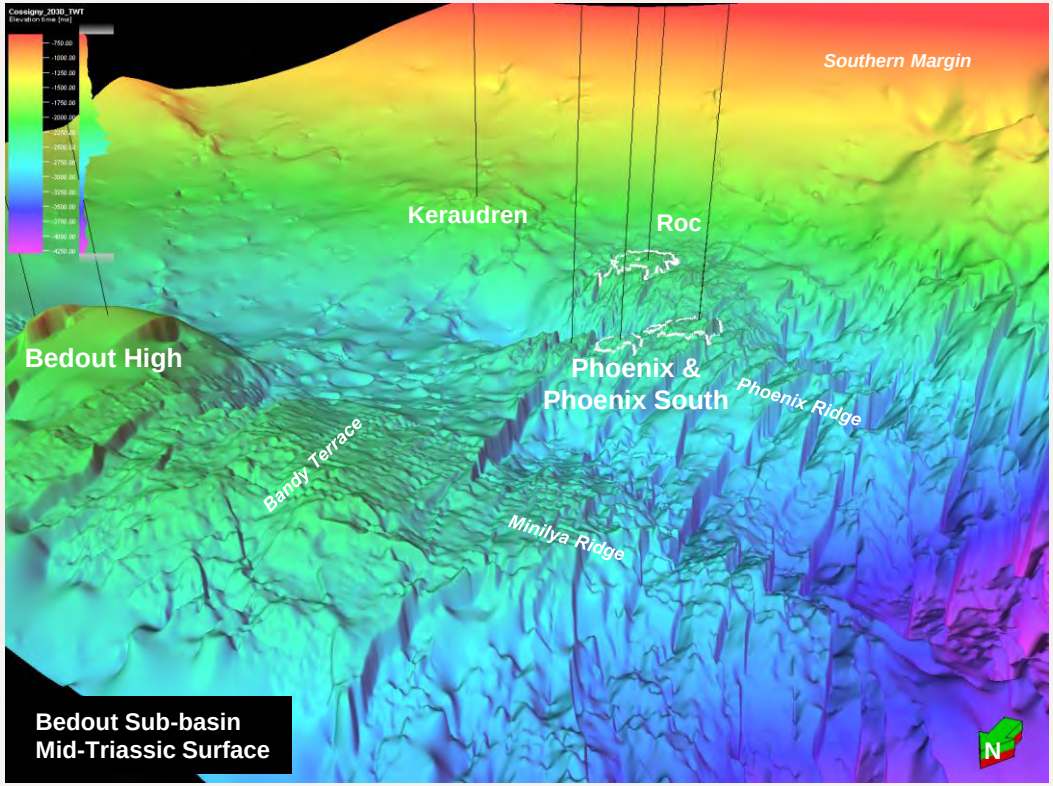
What's Next?



Drilling

- Roc-1drilling late 2015
- Next closure directly to the south of Phoenix South-1
- Reservoir ~400m shallower, more proximal to sediment source, along direct spill from PS and also access to lateral charge

Seismic

- Large 3D/2D seismic data sets acquired covering majority of Bedout Sub-basin

Modelling

- Phoenix South static and dynamic modelling

Other Plays

- E Triassic-Permian Carbonates where shallow enough
- Lower to Middle Jurassic in west

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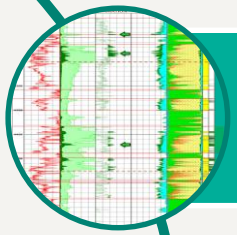
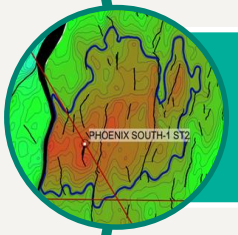
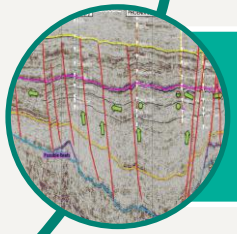
A New Petroleum System in the Bedout Sub Basin



The Triassic petroleum system in the Bedout Sub-basin is a new hydrocarbon province of interest



The Phoenix South oil discovery highlights the potential for non-traditional oil plays in older & deeper reservoirs to be effective



Prospectivity assessments based on sparse and incomplete data can be misleading; keep re-visiting the science and questioning the historical perception.

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