GEOS3102: Global Energy & Resources Labs

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Lab Overview

	Exercises	Weight	Due Date	Submission
Lab 1 (Week 8)	Intro to Global Petroleum Resources and iPython	10%	Thursday May 11 @ 9am	Madsen Dropbox
Lab 2 (Week 9)	Badlands	15%	Thursday May 18 @ 9am	Madsen Dropbox
Lab 3 (Week 10)	Seismic Reflection Surveys	15%	Thursday May 25 @ 9am	Madsen Dropbox
Lab 4 (Week 11)	Well Log Analysis	15%	Thursday June 1 @ 9am	Madsen Dropbox
Lab 5 (Week 12)	Arafura Basin Petroleum Systems	15%	Thursday June 8 @ 9am	Madsen Dropbox
Lab 6 (Week 13)	Tectonic Subsidence and Arafura Basin Report	30%	Thursday June 15 @ 9am	Email amy.ianson@sydney.edu.au

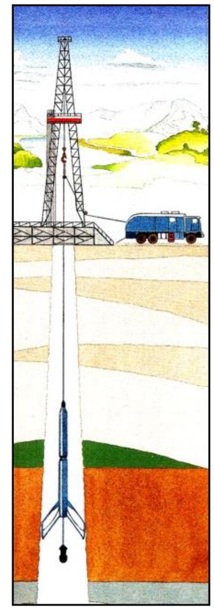
Each week a paper copy of the exercise will be provided for you. Please write neatly and clearly, messy and illegible reports will not be marked. You are also welcome to complete the exercise in the pdf available online. Remember to attach relevant maps and data.

Exercises are shown in grey boxes, answer in the space provided or attach your answer to the lab sheet.

Your assignment is due Thursday the following week at 9am! 10% will be deducted per day late.

Please note: You do not need to include your script for iPython practicals unless a question states "**Include your script**" in which case you only need to include the relevant portion of your script (please do not waste paper and print the entire script).

Lab 5: Arafura Basin Project

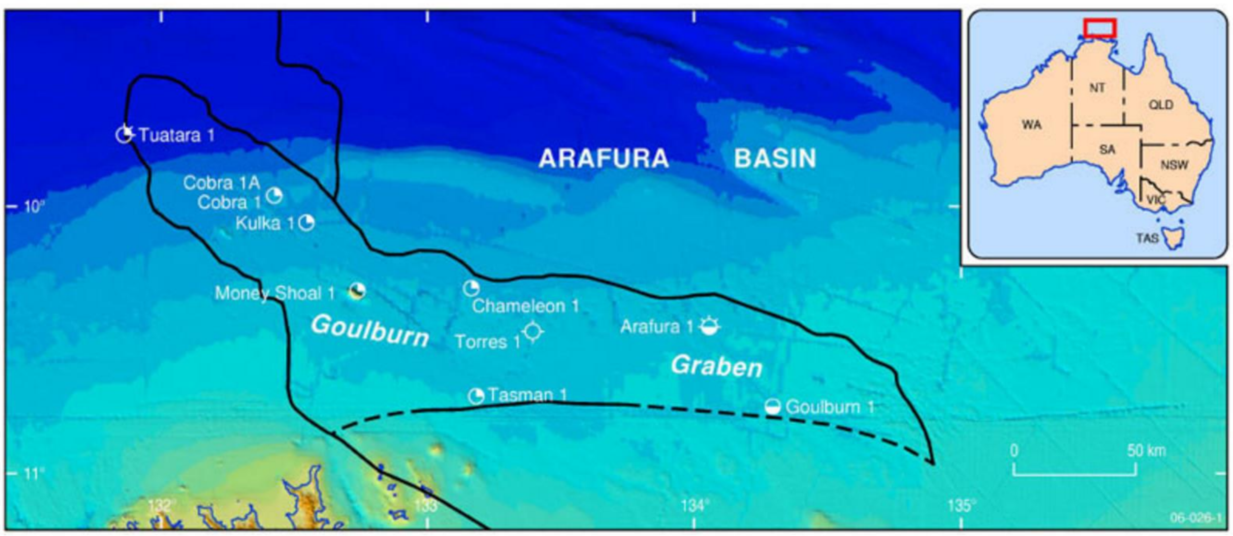


For the remainder of the labs we will be investigating the Arafura Basin in the Northern Territory. In the final week you will be required to draw upon lab 5/6 in a report on the Arafura Basin.

The Arafura Basin is located on the northern margin of Australia in the Arafura Sea and extends from the onshore Northern Territory to offshore northern Australia and beyond the Australian-Indonesian border, covering approximately 200 000km^2 in Australian territory.

The Arafura Basin is underexplored, and we know very little about it, only 9 wells being drilled in the 10km of sediment – it is also very old! There have been oil and gas shows but no discoveries (yet?). The Neoproterozoic to Palaeozoic Arafura Basin is underlain by the Proterozoic McArthur Basin and the Archean to Proterozoic Pine Creek Inlier, and overlain by the Mesozoic to Recent Money Shoal Basin. The structure of the Arafura Basin is dominated by the highly deformed Goulburn Graben.

The Goulburn Graben is a northwest trending asymmetric feature, over 350km long and up to 70km wide, and contains a sedimentary section in excess of 10km thick (GA, 2012).



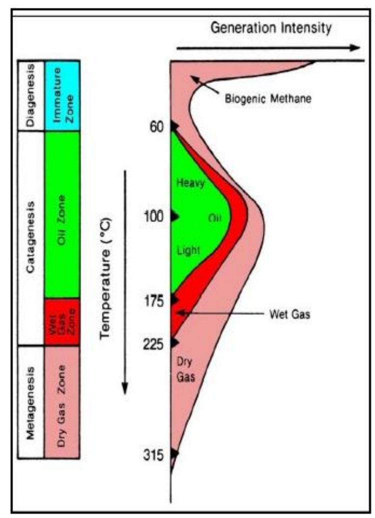
Petroleum Systems Background Information

The petroleum system is a unifying concept that encompasses all of the elements and processes of petroleum geology, including: the essential elements (source, reservoir, seal, and overburden rock) and processes (trap formation, generation-migration-accumulation). We generally analyse petroleum systems in the following subcategories;

Source (consider quantity & quality, maturity, migration, evidence of presence)

In petroleum geology, source rock refers to rocks from which hydrocarbons have been generated or are capable of being generated. They form one of the necessary elements of a working petroleum system. They are organic-rich sediments that may have been deposited in a variety of environments including deep water marine, lacustrine and deltaic.

To evaluate source rock potential we use organic chemistry of the source rock;



- Source Richness and Quality Measures
  - The total organic carbon (TOC) content of rocks is obtained by heating the rock in a furnace and combusting the organic matter to carbon dioxide
  - The S2 yield in the lab is the amount of hydrocarbons generated through thermal cracking (mg/g) – provides the quantity of hydrocarbons that the rock has the potential to produce through diagenesis
  - Calculated results include the Hydrogen index. HI = 100(S2) / TOC%
- Source Maturity – The hydrocarbon potential of organic carbon depends on the thermal history of the rocks containing the kerogen. Both temperature and the time at that temperature determine the outcome. Medium temperatures (< 175 C) produce mostly oil and a little gas. Warmer temperatures produce mostly gas. (right)

Reservoir (where we consider thickness, porosity, permeability)

We need to determine if the reservoir can hold hydrocarbons, to do this, we take both indirect and direct measurements of porosity and permeability, informed by an interpretation of depositional environment.

Traps and Seals

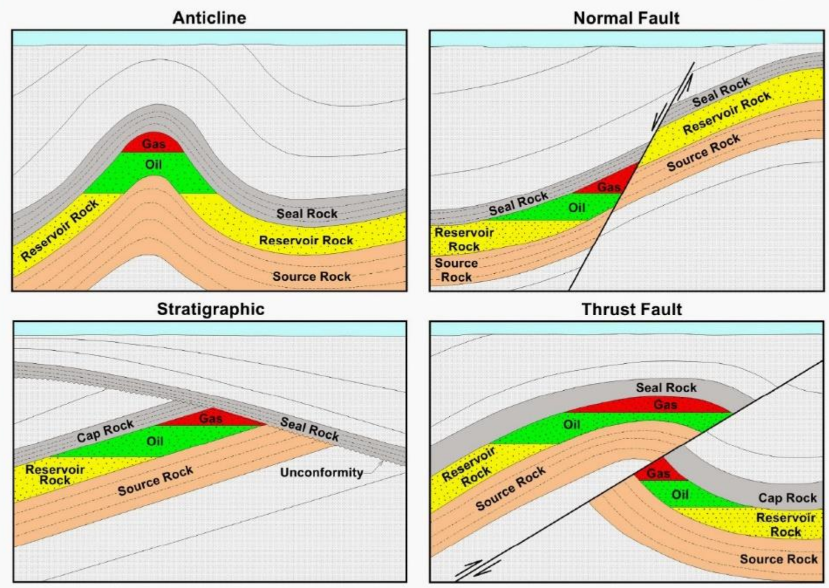
A trap forms when the buoyancy forces driving the upward migration of hydrocarbons through a permeable rock cannot overcome the capillary forces of a sealing medium. The timing of trap formation relative to that of petroleum generation and migration is crucial to ensuring a reservoir can form.

Petroleum geologists broadly classify traps into three categories that are based on their geological characteristics: the structural trap, the stratigraphic trap and the far less common hydrodynamic trap. The trapping mechanisms for many petroleum reservoirs have characteristics from several categories and can be known as a combination trap.

Structural traps = Fold (structural) trap and Fault (structural) trap

Structural traps are formed as a result of changes in the structure of the subsurface due to processes such as folding and faulting, leading to the formation of domes, anticlines, and folds. Examples of this kind of trap are an anticline trap, a fault trap and a salt dome trap.

They are more easily delineated and more prospective than their stratigraphic counterparts, with the majority of the world's petroleum reserves being found in structural traps.



Simplified cartoons showing some common types of hydrocarbon traps recognized in producing oil and gas fields around the world.

Stratigraphic traps

Stratigraphic traps are formed as a result of lateral and vertical variations in the thickness, texture, porosity or lithology of the reservoir rock. Examples of this type of trap are an unconformity trap, a lens trap and a reef trap.

Seals

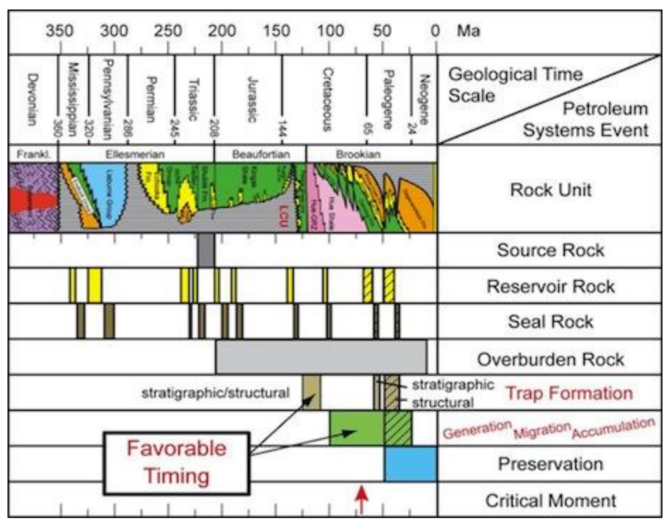
The seal is a fundamental part of the trap that prevents hydrocarbons from further upward migration.

Accumulation/Timing (preservation of hydrocarbons)

All of this needs to happen in the right order!

The expulsion of oil in the Goulburn Graben occurred in the Late Devonian and Carboniferous.

We are going to consider each of these remaining petroleum systems elements for the Arafura Basin. You may want to spend some time investigating the OrgChem and ResFacs from the GA database for the remainder of the wells, this will help you write a comprehensive report in Week 6. It is useful practice to label your basemap with the different parameters to get a sense of the spatial distribution of source/reservoir facies.



Lab 5 Exercises

NAME: ________________________________ SID: ________________________________

Q1. Using the interpretation from Kulka-1, interpret the stratigraphy at Chameleon-1.

Q2. Using the interpretation from Cobra-1A, interpret the stratigraphy at Tuatara-1.

Q3. Familiarise yourself with the remaining wells. Note where the oil shows and flows are. How are the shows and flows distributed stratigraphically?

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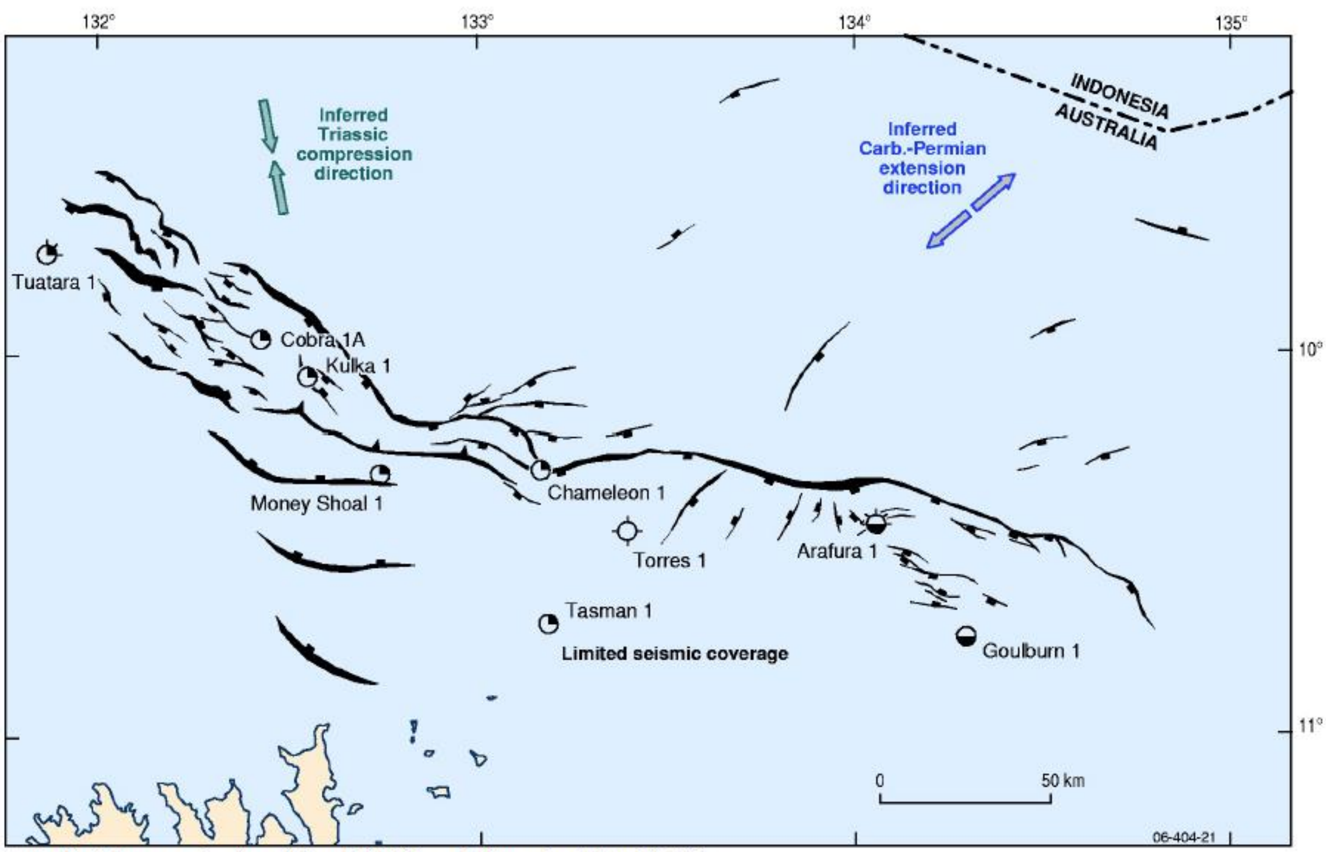
Q4. How is the stratigraphy distributed spatially? Do you notice any trends in the occurrence of oil shows? Summarise this information on the base map below.



Arafura Basin base map, showing with base Kulshill Group fault map from Totterdell, 2006

Q5. Using the Geoscience Australia database http://dbforms.ga.gov.au/www/npm.well.search characterise the source potential of any two wells in the Arafura Basin in terms of Source Richness and Quality/Maturity.

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Q2. Reservoir – Using your well logs and the GA database, characterise the reservoir facies for two wells of the Arafura Basin.

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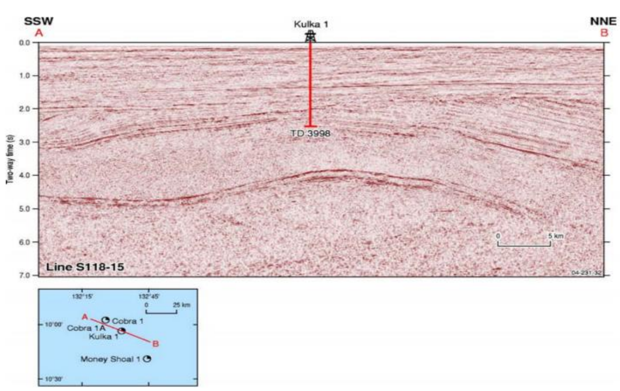
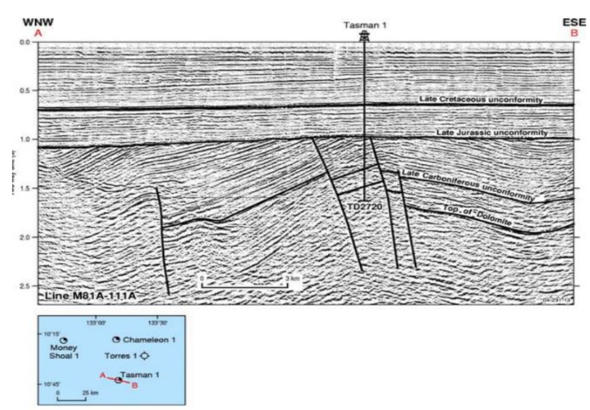
Q3. Traps – Looking at the seismic cross sections for Kulka 1 and Tasman 1, what type of trap was being chased in each? Label them.





Additional Information

In: Struckmeyer, H.I.M. (compiler), 2006. New datasets for the Arafura Basin. Geoscience Australia Record 2006/06.

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Chemical maturity assessment and oil correlation in the Arafura Basin

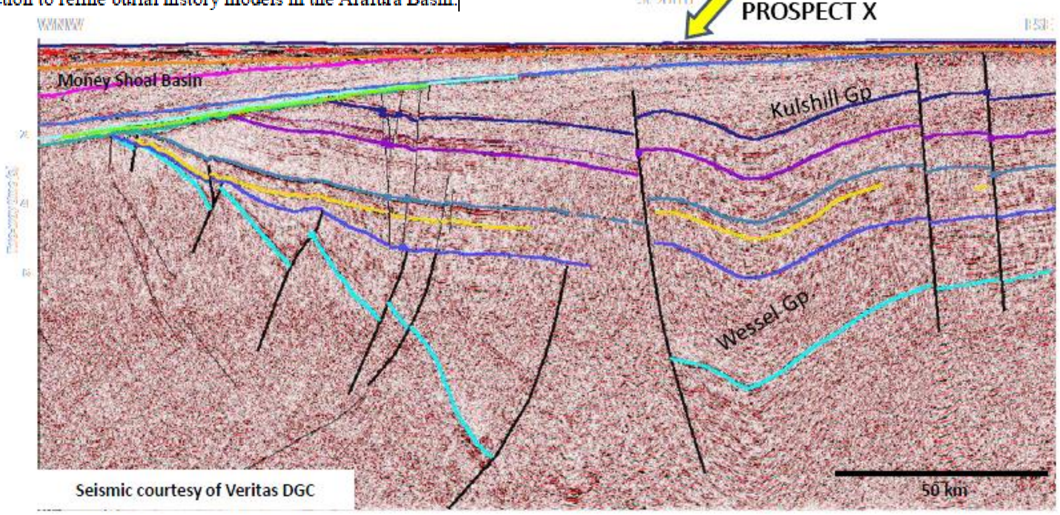
Chemical maturity assessment and oil correlation in the Arafura Basin

Christopher J. Boreham

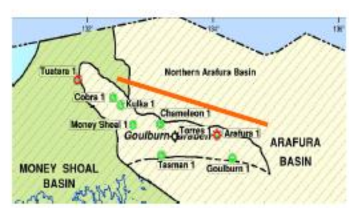
Geoscience Australia, GPO Box 378, Canberra ACT 2601

Executive Summary

New geochemical data were generated from cuttings and core samples from five wells and from oil stains in two wells in the Arafura Basin. The data underpin interpretations of source rock potential, chemical maturity and oil-source correlations. The sediment samples covered an age range from Neoproterozoic to Jurassic. Organic-rich rocks of Cambrian age were encountered in Arafura-1, however, these were deemed to contain dominant solid bitumen, being insoluble in organic solvents. Thus, the effective source rock for the oil stains in the Arafura Basin remains unresolved. Nevertheless, a Middle Cambrian source is likely by comparison with analogue Cambrian petroleum systems in the adjacent onshore Georgina Basin. Oil stains from Devonian reservoirs in Arafura-1 and Goulburn-1 and Ordovician reservoir rocks in Arafura-1 have very similar biomarker signatures, suggestive of a common source facies. Furthermore, the oil stains correlate strongly with numerous rock extracts in Arafura-1 from Neoproterozoic to Devonian aged samples, indicating the presence of pervasive vertical oil migration in this well. However, above the Devonian seal there is no further correlation with the oil stains, except at 690 m. Here, a major fault intersects the Arafura-1 succession providing the conduit for oil migration to shallow depths in the vicinity. Although there is a possibility that oil could continue to migrate up to the seafloor, stranded coastal bitumens in the region do not correlate with any Arafura Basin samples, indicating their remote origin. Chemical maturity estimates show a wide range from immature to overmature. Although, in most cases, maturity increases with depth were observed, the presence of pervasive oil staining, especially in Arafura-1, precluded a good comparison with vitrinite reflectance data derived from optical methods. Chemical maturity parameters from extractable organic matter reflect the maturity level of the source rock at the time of primary migration of the oil, whereas vitrinite reflectance reflects the maximum palaeotemperature of the indigenous organic matter. However, vitrinite reflectance values calculated from the chemical maturity parameters were of sufficient resolution to refine burial history models in the Arafura Basin.



From Struckmeyer et al 2006, GA Record 2006/06



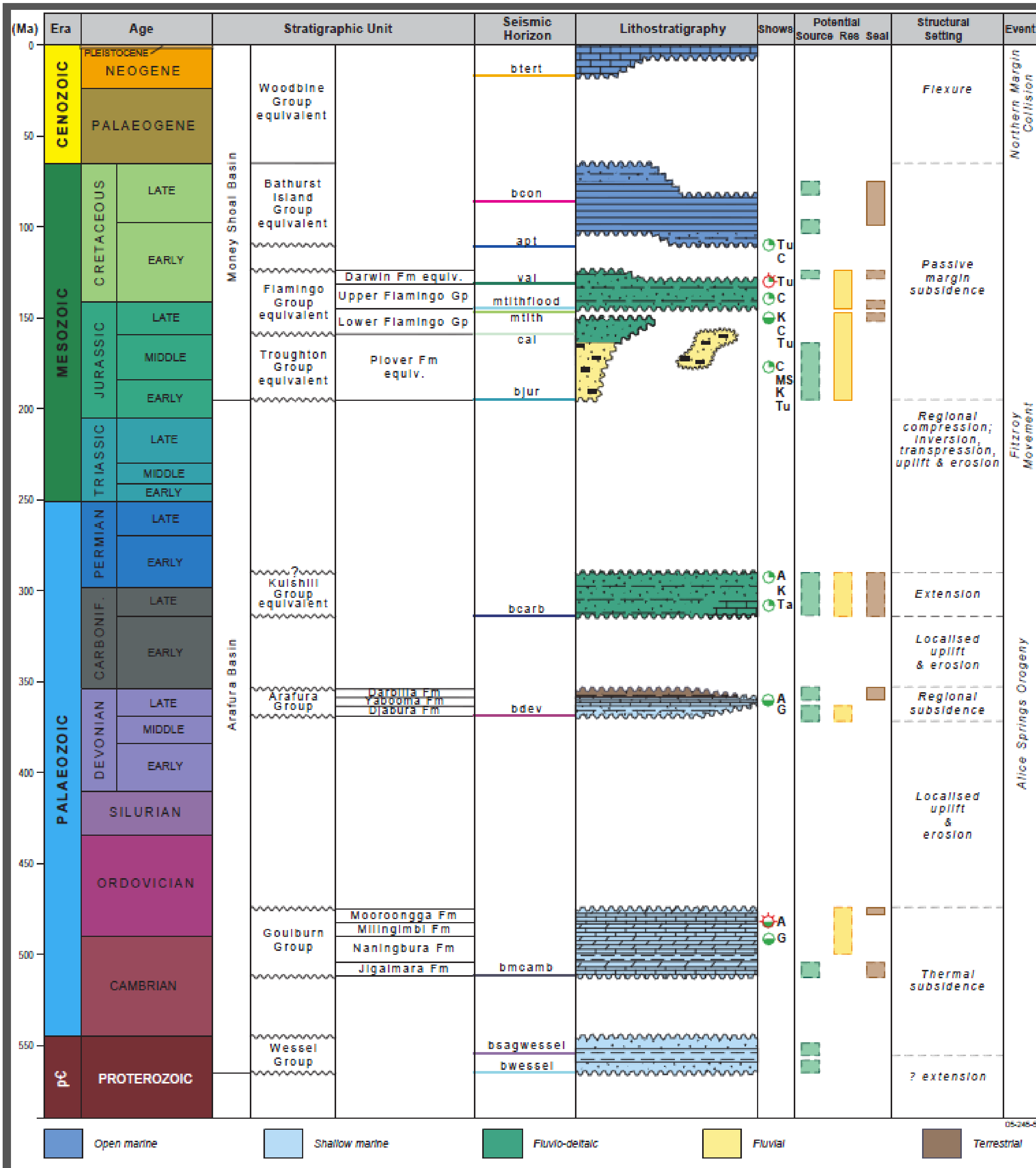


Figure 4. Stratigraphy of the Arafura and Money Shoal basins (Earl, 2006; Struckmeyer, 2006a, b).