



## ORAL PRESENTATION

---

**Day 1: 3<sup>rd</sup> April 2019**

### **Session 4: East Indonesia and Timor Sea**

---

**Chairs: Colin Murray – SundaGas, Melissa Johansson – Geode Energy**

---

15:40	New Seismic imaging Reveals Opportunities in Asia Pacific	Michael Cottam	BP Exploration
16:05	The Seram Fold Belt: An Emerging High Impact Play in Eastern Indonesia	Kim Morrison	Lion Energy
16:30	Geological Development and Hydrocarbon Prospectiveity of the Southern Banda Arc	Peter Baillie	CGG
16:55	West Malita Graben – The Ugly Duckling or Another Phoenix?	Julian Mather	Spectrum Geo



## ORAL PRESENTATION

### New Seismic imaging Reveals Opportunities in Asia Pacific

Michael Cottam<sup>1</sup>, Bryan Ritchie<sup>1</sup>

<sup>1</sup>BP Exploration, UK

*michael.cottam@uk.bp.com*

Through its heritage companies, BP has 50 years of operating history in Indonesia. Current activities are dominated by our exploration and production business, particularly the Tangguh LNG plant.

Tangguh started LNG production in 2009, just four years after its initial sanction by the Government of Indonesia. Its performance is best in class in safety and reliability and it recently achieved a milestone of 1000 cargoes delivered successfully to its customers. In 2016 the Tangguh Expansion Project to build a third liquefied natural gas (LNG) train was sanctioned.

Since their discovery in the 1990s, the Tangguh gas fields have faced seismic imaging challenges due to a number of factors including shallow water, strong currents, shallow gas, karst overburden and faulting.

An ultra-high-density Ocean Bottom Node survey using BP Independent Simultaneous Source technology (ISS®) was acquired in 2017/18 to support future development of the Tangguh LNG gas fields. Utilizing this advanced acquisition technology enabled a step change in data density, cost efficiency and data quality. The ultra-dense wide azimuth data appears ideally suited for fast-track imaging. Despite the huge amount of data to process, fast-track products were provided within 4 months of the last relevant node retrieval, which is equivalent to an 80% cycle time reduction versus vintage OBC processing flows. This acceleration of data delivery supports timely well planning and field development decision making.

Reprocessing of legacy Ocean Bottom Cable data acquired in 2010 has also proved successful in the greater Bintuni basin. The reprocessing project was completed in 2016 and the improved imaging led to the drilling of Ubadari Deep - BP's first exploration well in Indonesia for 5 years.

Elsewhere in Asia Pacific, BP has been in Australia for 100 years and is a founding member of the North West Shelf Venture (NWSV). In 2014 the NWSV partners funded the acquisition of the Fortuna 3D seismic. The previous seismic survey over the acreage (Demeter) was conducted just over a decade prior in 2003. The improved subsurface imaging has led to a refreshed portfolio of exploration prospects and the first of those to be drilled is Achernar which will be drilled in 2019.

The reprocessing of legacy 3D seismic in the North Carnarvon Basin has also led to the identification of new exploration opportunities. The Olympus 3D dataset, which BP licensed from Spectrum in 2016, covers almost 20,000 km<sup>2</sup>, combines 19 3D surveys and is broadband processed from field tapes to create a unified PSDM volume. The continuous, high-quality seismic volume has enabled BP to access the Ironbark prospect and identify additional prospectivity close to the NWSV.

#### SPEAKER BIOGRAPHY

Mike Cottam is a Senior Geologist within BP Exploration's Asia Pacific New Ventures team based in Sunbury, UK. After initially joining BP in the North Sea region, Mike has spent the last five years working across BP Exploration as both an integrated geologist and a structural geology specialist.

Prior to joining BP Mike worked in academia for several years, undertaking field and laboratory based geological research with the SE Asia Research Group based at Royal Holloway University of London, UK. Mike holds a MGeol undergraduate degree from the University of Leicester, UK and a PhD in Tectonics & Structural Geology from Royal Holloway University of London, UK.



## ORAL PRESENTATION

### The Seram Fold Belt: An Emerging High Impact Play in Eastern Indonesia

Kim Morrison<sup>1</sup>, Anthony Gartrell<sup>2</sup>

<sup>1</sup>Lion Energy, Australia

<sup>2</sup>PetroStruc, Australia

[kmorrison@lionenergy.com.au](mailto:kmorrison@lionenergy.com.au)

The Seram fold belt is a proven yet underexplored play with world class marine source rocks and large inversion and thrust faulted anticlines clearly visible at the surface. Located on the northern part of the Banda Arc, the play covers over 30,000 km<sup>2</sup> on the northeast of Seram Island, while also extending offshore. The area shares geological affinities with prolific oil and gas provinces in Irian Jaya and Papua New Guinea (Figure 1). Of interest, some compelling similarities are also noted in terms of Late Triassic – Middle Jurassic paleogeographic setting, stratigraphy and structure with the Zagros fold belt of the Arabian plate.

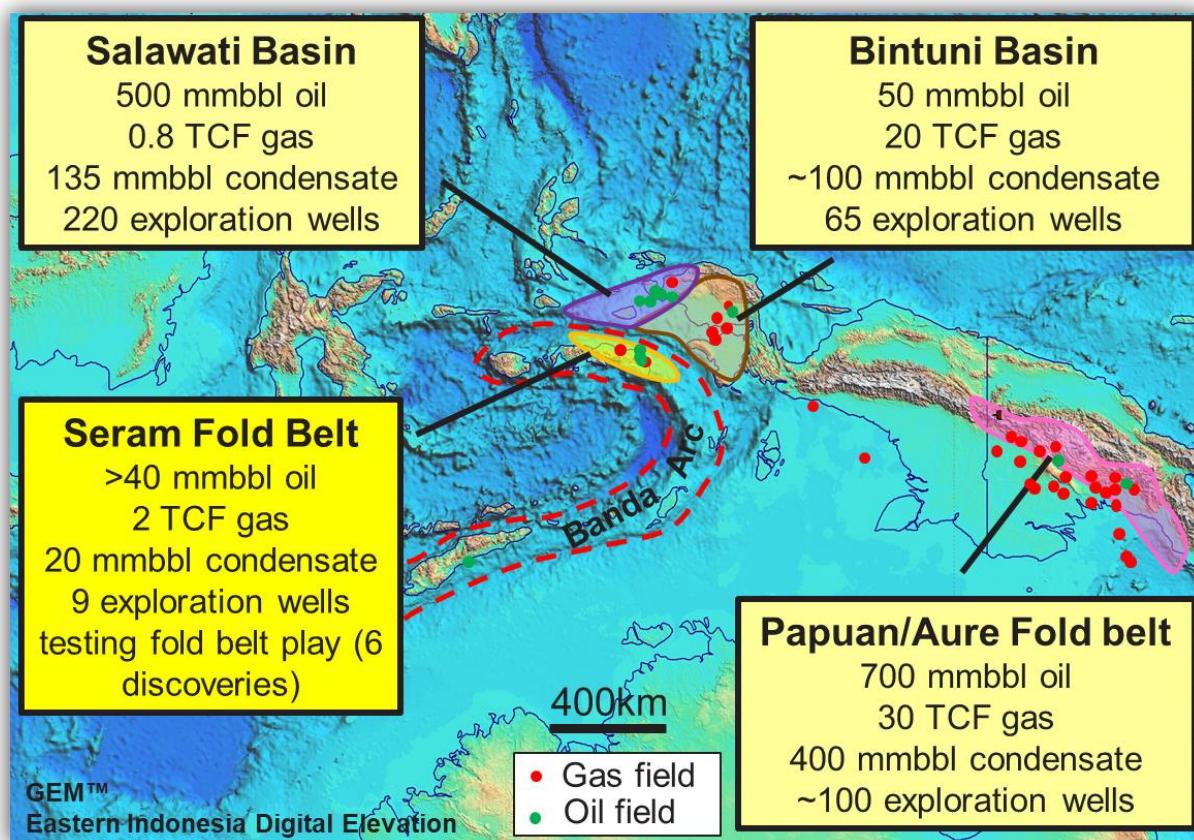


Figure 1. Regional setting of Seram Fold Belt

Collision of the northerly moving Australian plate with Indonesian micro-continents in the late Tertiary resulted in the inversion and uplift of the Permian to Early Tertiary Australian passive margin section. This collision was initially manifested in

transpressional fault reactivation and folding of a thick Late Triassic to Jurassic syn-rift carbonate dominated section. Continuing shortening resulted in detachment and low-angle overthrusting of older Middle Triassic sediments, producing the complex structures evident in outcrop and on seismic on Seram Island. The Late Triassic to Early Jurassic Manusela Formation, a shallow marine fracture enhanced limestone over 1500 m thick, is the primary objective, sealed by the Late Jurassic marine Kola Shale and sourced by rich Triassic / Jurassic anoxic algal marine carbonates. Based on observations from multiple seismic sections across east Seram a new tectono-stratigraphic model has been constructed (Figure 2).

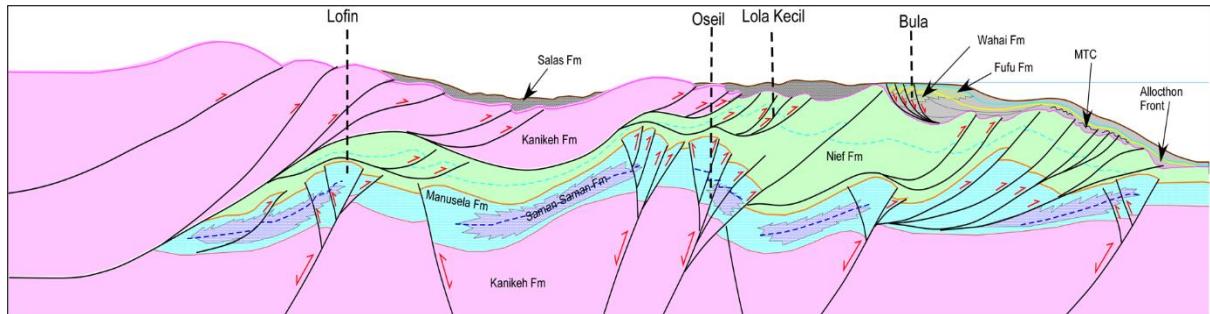


Figure 2. SW-NE trending tectono-stratigraphic model for Seram Island showing deep inverted rift structures and over-riding fold-thrust duplexes. The Lofin and Oseil fractured Manusela limestone fields are shown as well as the shallow Bula oil field within the Plio-Pleistocene thrust foreland basin.

While there have been approximately 30 exploration wells testing the shallow Plio-Pleistocene thrust foreland basin on the northeast of Seram Island, with the most notable success being the 20 mmbbl Bula oil field, just nine exploration wells have been drilled to test the deep Mesozoic play. Of these, only six wells have penetrated the Manusela limestone and all have been discoveries, with over 420 mmboe found to date. A new phase of exploration has now commenced, spurred by granting of new production sharing contracts, continuing good performance of the Oseil oil field and the recent 2.0 TCF Lofin gas/condensate discovery.

## SPEAKER BIOGRAPHY

Mr Kim Morrison is currently Exploration Manager of ASX listed Lion Energy Ltd which has exploration and production interests on Seram Island through participation in the Seram (Non-Bula) PSC and as operator, with 100% interest, in the recently signed East Seram PSC.

Kim has a successful 30-year career involved in many oil and gas discoveries working in senior technical and managerial positions with majors through to small cap companies in locations throughout the world. He has been actively involved in Indonesian exploration and development for the last 10 years and remains optimistic on the potential of the many underexplored regions of the country.



## ORAL PRESENTATION

# Geological Development and Hydrocarbon Prospectivity of the Southern Banda Arc

Peter Baillie<sup>1</sup>, Paul Carter<sup>2</sup>, Pedro Martinez Duran<sup>3</sup>

<sup>1</sup>CGG, Australia

<sup>2</sup>PC Energy, Perth, Australia

<sup>3</sup>CGG Geoconsulting, Crawley, UK

[peter.baillie@cgg.com](mailto:peter.baillie@cgg.com)

The horseshoe-shaped Banda Arc situated north of Australia and including parts of eastern Indonesia and Timor Leste, one of the most geologically-complex areas on Earth, is the product of complex Neogene collision between the Indo-Australian, Pacific and Eurasian tectonic plates.

The area is of great interest to petroleum explorers because of abundant onshore (including Timor and Seram) and offshore oil and gas seeps and similarities with geologically contiguous Mesozoic and Cenozoic successions in Australia, where numerous petroleum systems exist and have been exploited. Exploration of the offshore Banda Arc has previously been limited because of water depths, remoteness and seismic imaging problems associated with a zone of deformation occurring between a series of fore-deeps (Timor, Tanimbar and Seram ‘troughs’, in reality fore-deeps) and the Banda Sea.

South of the Timor Trough, exploration drilling has shown that much of the Mesozoic section (and in particular the Jurassic) is immature for hydrocarbon generation. The formation of a fold-and-thrust belt between 5.0 and 3.0 million years ago over relatively undeformed Mesozoic section has pushed Jurassic and Triassic source rocks into the oil window and explains the presence of oil seeps such as found in the deep-water Raksasa mud-volcano, east of Timor.

Potential traps north of the Timor Trough include horsts and fault-related features in the Mesozoic section beneath the fold-and-thrust belt and structural highs associated with large normal faults observed to be present within the deformed zone. Mapping of multiclient 2D datasets has revealed several large fault-dependent anticlinal leads, up to 250 km<sup>2</sup> in areal extent, with Jurassic Plover Formation and Triassic reservoir targets.

## SPEAKER BIOGRAPHY

Peter Baillie holds degrees from the University of Tasmania (B.Sc. 1970, geology) and Macquarie University in Sydney (M.Sc.Hons 1988, sedimentology and basin analysis). He has been employed by CGG since August 2012 where he is SVP Business Development in the Multi-Client & New Ventures Division.

He has been actively involved with many professional associations and has held positions of Secretary of the Geological Society of Australia, President of the AAPG Asia Pacific Region and President of SEAPEX.



## ORAL PRESENTATION

### West Malita Graben – The Ugly Duckling or Another Phoenix?

Julian Mather<sup>1</sup>, Nicolas Hand<sup>1</sup>

<sup>1</sup>Spectrum Geo, Asia – Pacific, Australia

julian.mather@spectrumgeo.com

The western half of the Malita Graben is part of a major northeast-trending rift system that lies between the Petrel Sub-Basin and the Sahul Platform, within the Bonaparte Basin on the north west shelf of Australia (Figure 1). The graben contains a thick (up to 10,000m) succession of Mesozoic and Cenozoic sediments that are underlain by a considerable section of Pennsylvanian–Permian sediments (Figure 2). Within and along the margins of the western half of the graben there have been no major discoveries, Chuditch-1 a gas discovery drilled by Shell in 1998 is the most significant and reported by them to have a mean gas in place volume of 1.17Tcf. Durville-1 drilled by Total (2011) is the most recent discovery with a 36m gas column and a possible residual oil column of over 40m in a small closure. A dozen other wells have been drilled around the flanks with those to the northwest all having shows, while those along the southeast having been P&A'd dry for various reasons. Laperouse-1 (Total 2011) is the most recent well, drilled immediately after Durville-1, in the southwest corner (P&A) and since then there has been very little activity with only one new licence picked up by Santos over the northeast end of the graben.

The main objective is the Jurassic Elang and Plover formations which provide the principal reservoirs and source rock for the majority of discoveries and fields including Chuditch (Figure 3). The exceptions are those in the Petrel Sub-basin which are predominantly Permian in age. Secondary objectives are a series of sands that were laid down in the late Jurassic Tithonian: Flamingo Sands, and the early Cretaceous Berriasian: Sandpiper and Echuca Shoals Sands. On the structural highs these sands are often thin or absent due to either erosion or non-deposition, but within the graben wells such as Durville and Laperouse have encountered unexpectedly thick sections of Sandpiper Sands for example, confirming that the graben acted as a sink for sands not only from the Australian continent but also possibly at times from the nearby exposed highs and in particular the Sahul Platform. These secondary plays are poorly understood within the graben, but if a trapping mechanism is present, they have good potential to be directly charged with hydrocarbons from the encasing marine shales, most likely from the underlying Frigate Shales. Oil typing work done in the adjacent Bayu-Undan field, just to the north has also confirmed an early contribution of oil from the Echuca Shoals Shales, (Burns & Krieger 2003).

The Malita Graben also suffers from a large contribution of inert gases proposed to be sourced by the cracking of Permian carbonates from deep within the graben (up to 20-40% CO<sub>2</sub>). However, away from basin centred deep rooted faults, the inert influence drops off significantly, with Chuditch recording 18% CO<sub>2</sub> and Bayu-Undan and Sunrise-Troubadour fields dropping to 6 and 5% respectively. This and the observation that the GCR improves to the southwest towards the Bayu-Undan field makes the north margin of the West Malita Graben quite attractive. Furthermore, with the potential for large oil rich stratigraphic traps on the margins in the late Jurassic and early Cretaceous, isolated from inert gas contamination, there is a significant upside for standalone low cost developments.

The regional 2D open file data is notoriously difficult to interpret with confidence due to a very complex shallow seafloor (50-150m) with drowned carbonate reefs and numerous canyons dramatically distorting the underlying seismic image. It is further complicated by loss of signal strength due to two velocity inversions from Tertiary paleo carbonate platforms that built across the area, which in places are also quite rugose scattering the signal further. The Chuditch discovery is a classic example with a sea floor canyon appearing to split the field in two with large low relief features to the north and southwest. If connected and present in depth this could potentially more than double its size.

With this in mind the 9,000km<sup>2</sup> Kyranis MC survey was acquired in 2012 and processed through to PSTM with impressive imaging results although some depth issues still remain. Mapping has also highlighted a number of larger untested horst

blocks along the northern margin to the southwest, plus the potential for closures with large stratigraphic upsides within the graben.

Now that the economic climate is improving and the dispute over the boundary of the Joint Petroleum Development Area (JPDA) between Australia and Timor-Leste has reached its resolution (awaiting final ratification at the time of writing) and the favourable geological address, (surrounded by multi Tcf gas or gas-condensate discoveries) it is time the graben shook off its ugly duckling status. And who knows, like the Phoenix South-1 well which pulled the Bedout Sub-basin from the ashes with the subsequent Dorado-1 oil discovery, the Malita Graben with good exploration work and a reprocessed PSDM broadband data set could unlock riches previously not thought possible.

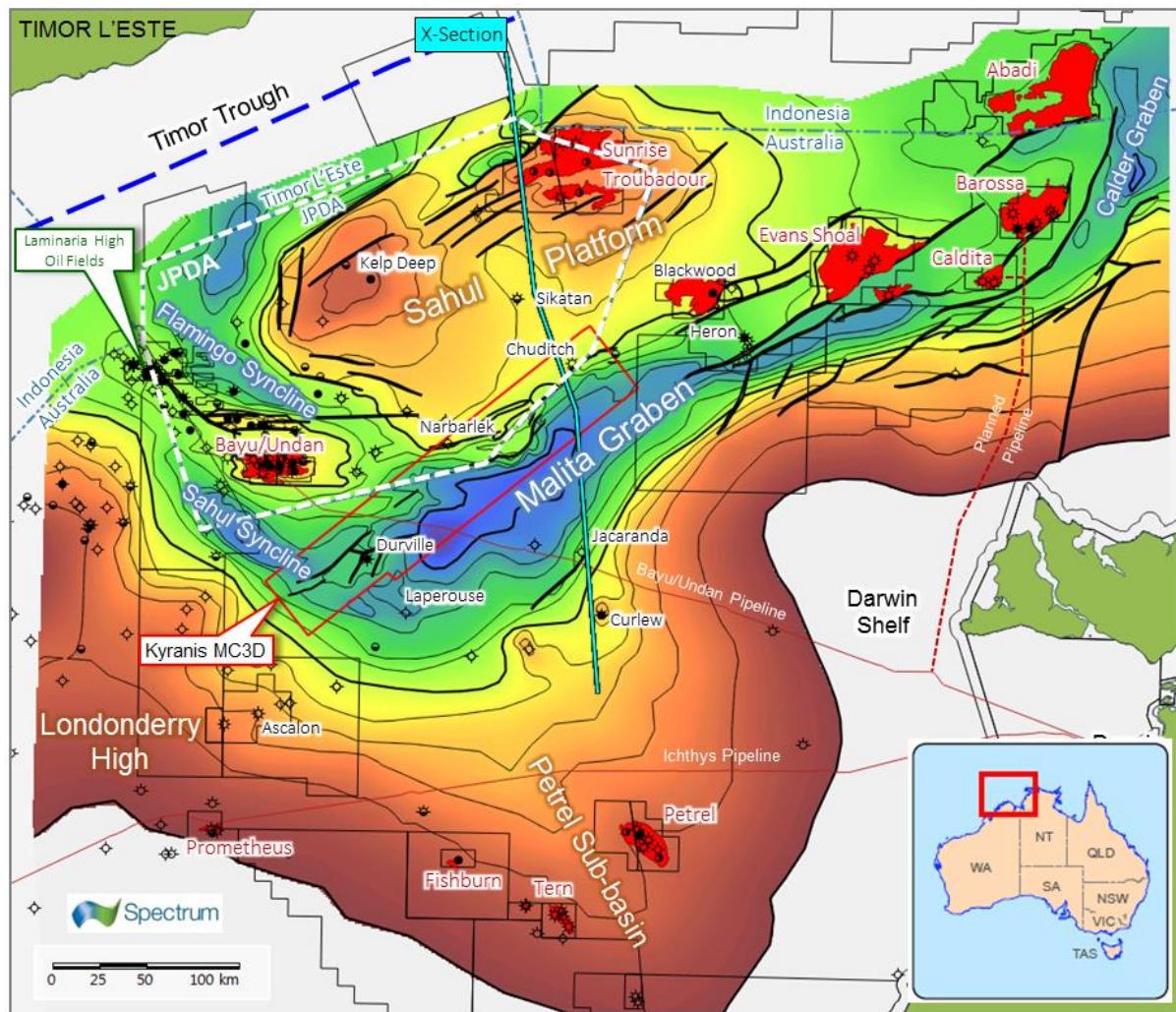


Figure 1. Jurassic Oxfordian Unconformity (JO) TWT map, showing the regional setting of Malita Graben and location of the Kyranis multi-client 3D.

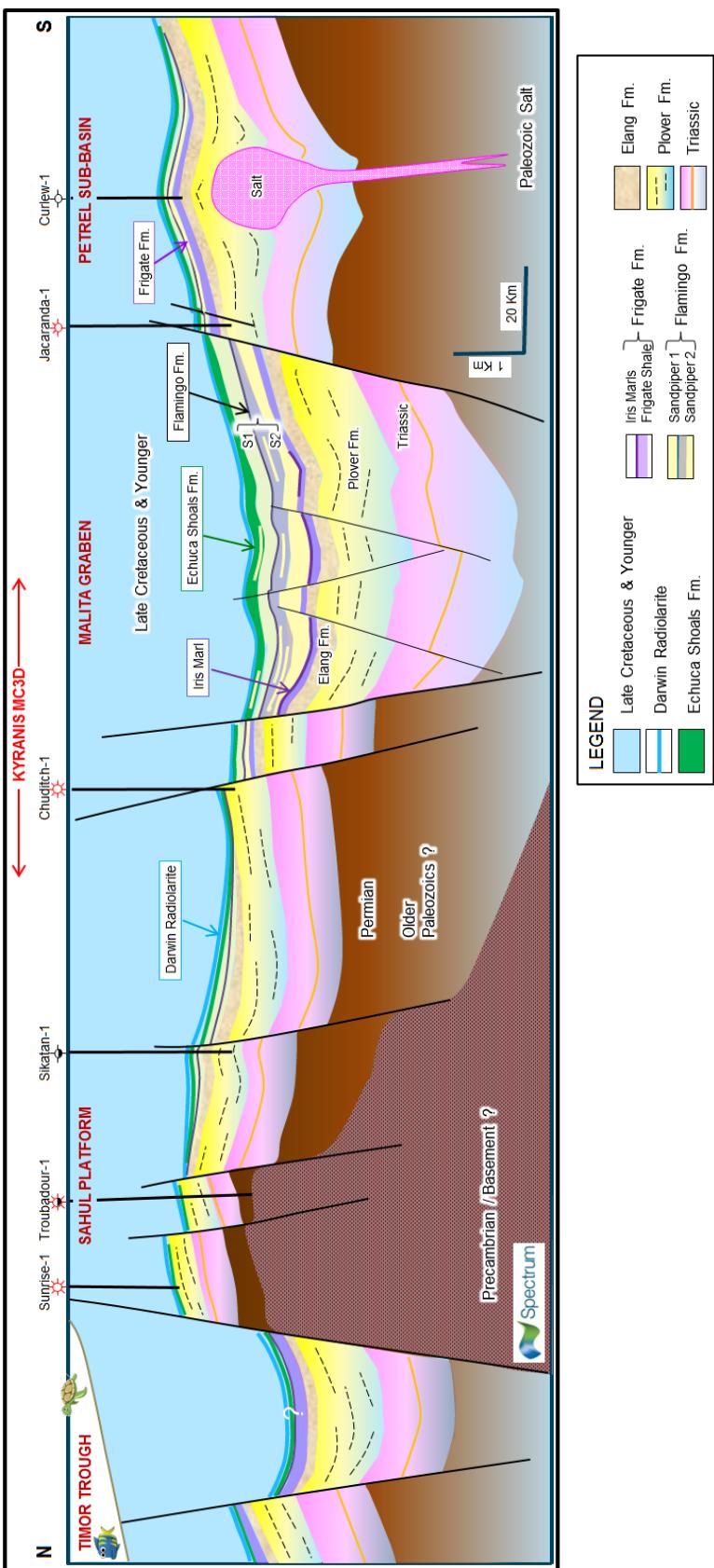


Figure 2. Regional X-section running N-S across the Sahul Platform, Malita Graben and ending in the Petrel Sub-basin. See Figure one for X-Section location

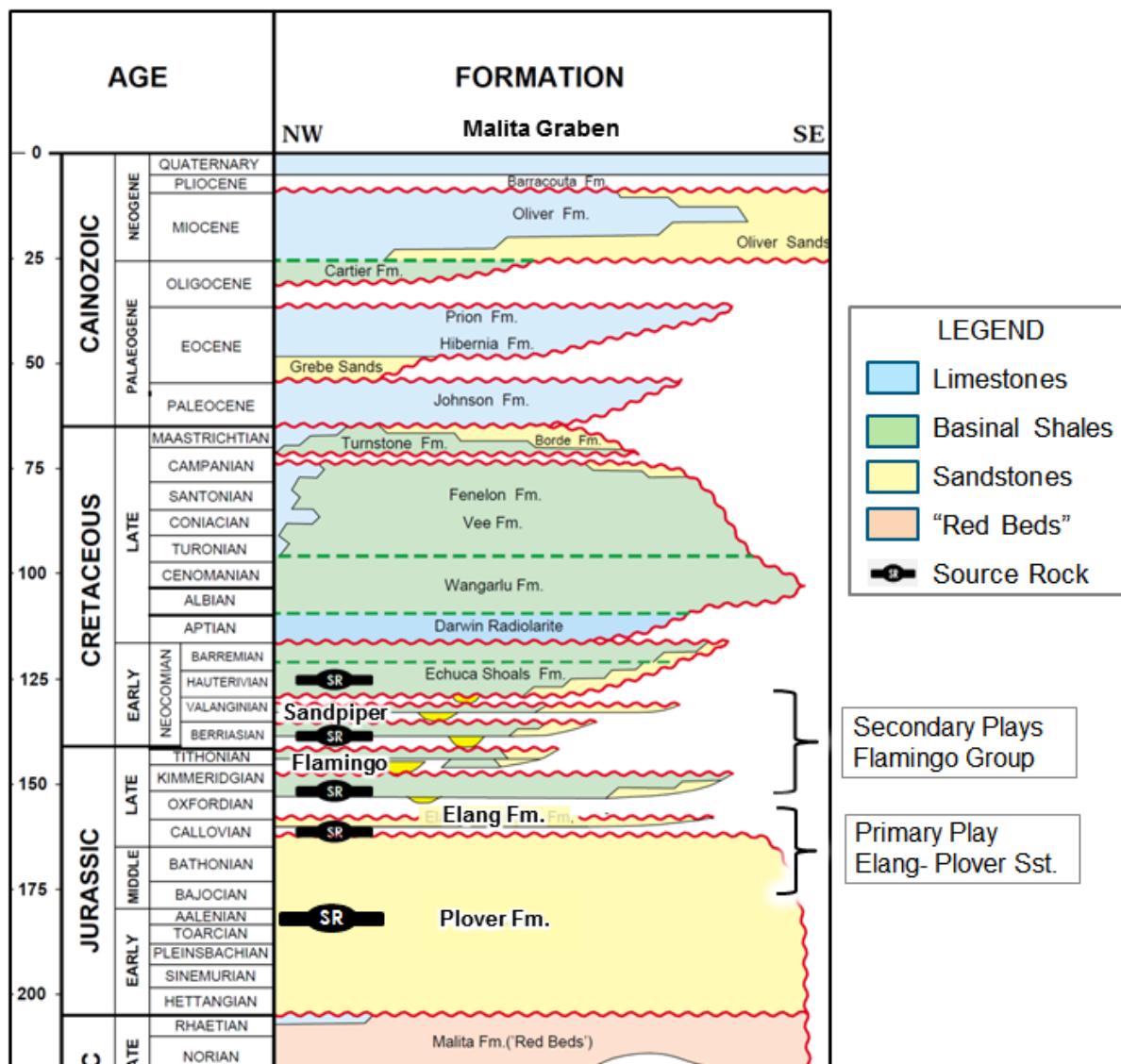


Figure 3. Litho-Chronostratigraphy of the Malita Graben region with the main plays and source rocks highlighted

## REFERENCES

Barber, P., Carter, P., Fraser, T., Baillie, P.W. AND Myers, K., 2004—Under-explored Palaeozoic and Mesozoic petroleum systems of the Timor and Arafura seas, northern Australian continental margin. In: Ellis, G.K., Baillie, P.W. and Munson, T.J. (eds), Timor Sea Petroleum Geoscience, Proceedings of the Timor Sea Symposium, Darwin, Northern Territory, 19–20 June 2003. Northern Territory Geological Survey, Special Publication, 1, 143–154.

Burns, E. and Krieger, W., Assessing degrees of marine influence on fluvio-deltaic strata in the Bayu-Undan Field, Timor Sea using ichnology: Implications for field-scale correlation and reservoir modelling. In: Ellis, G.K., Baillie, P.W. and Munson, T.J. (eds), Timor Sea Petroleum Geoscience, Proceedings of the Timor Sea Symposium, Darwin, Northern Territory, 19–20 June 2003. Northern Territory Geological Survey, Special Publication, 1, 483–502.

## SPEAKER BIOGRAPHY

Julian Mather is currently consulting to Spectrum Geo as the Asia-Pacific, Senior Geoscience Advisor, in Perth, WA. Julian gained global industry experience as a geophysicist after graduating from the University of Tasmania (UTAS) in 1984 with a BSc. in Geology and BSc. Hons in Geophysics. He started his career as a field geophysicist in Africa before moving to

London and joining Elf Aquitaine as a junior interpreter. Over the next 25 years he worked in many different roles and different subsidiaries around the world as Elf became part of Total-Fina-Elf and then finally Total. In 2009 he landed back in Australia to be part of the newly opened Total E&P office in Perth where he spent the majority of his time as Head of Geophysics and the Offshore NWS New Ventures team until 2015. As a consultant his roles are now quite broad but currently it is primarily focused on working on Spectrum's extensive Multi-client seismic library and looking to unlock value and help develop new projects in the APAC region.