ORAL PRESENTATION

Day 1: 3rd April 2019

Session 2: Regional Frameworks

Chairs: Nick Comrie-Smith – Premier Oil, Ian Collins – Indosean Resources

10:45	Plate Tectonic Reconstructions of SE Asia: Bacon, Salami or Baloney?	Robert Hall	SE Asia Research Group, Royal Holloway, University of London
11:10	Integrating Basin Evolution and Plate Tectonics in SE Asia	Jon Teasdale	Geognostics
11:35	Final Separation of Eastern Gondwana - Plate Kinematics and their Implications for Frontier Exploration	Jamie Higton	Halliburton
12:00	A New Direction for Asian Stratigraphy	Peter Lunt	Universiti Teknologi Petronas

The Seapex Exploration Conference
SEC2019
For the Industry : By the Industry

SEAPEX Exploration Conference
Fairmont Hotel, Singapore
2nd – 5th April 2019

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Plate Tectonic Reconstructions of SE Asia: Bacon, Salami or Baloney?

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In recent years it has become much easier to make plate tectonic reconstructions. Reconstruction software has become much simpler to use, fragment details are relatively easy to acquire or define, and integration with GIS software is increasingly common. For these reasons there is now a plethora of tectonic models for SE Asia, which has always been a challenging region to reconstruct. Some models have been published and are peer-reviewed, while others are commercial products of uncertain quality.

We have produced plate tectonic models of SE Asia for many years, and our work is underpinned by our own field studies, including much new dating and sediment provenance work. With the help of industry, we have also been able to use seismic and multibeam bathymetry data, as well as publicly available shuttle and satellite topographic data. All these have contributed to an improved understanding of regional geology and tectonics and identified areas where new studies can contribute to improving our knowledge. There are many outstanding puzzles, but our ongoing work has shown that much information in the literature concerning the region is wrong, incomplete or needs reconsideration. Many 'established truths' are statements that are believed simply because they have been so often repeated and not challenged.

In contrast, many reconstructions available on the internet or as commercial packages rely on data compiled from the literature or undefined sources, and are commonly flawed, use outdated information, or are based on models now known to be wrong. They are produced by skilled computer users who have had little or no contact with SE Asia and are usually dependent on a mixture of old data. The bacon (or salami) slicer model for eastern Indonesia is one example. This model suggests that eastern Indonesia was assembled from tectonic fragments sliced from New Guinea and transported west to be accreted to the Sundaland margin. Fifty years ago, when first proposed and until quite recently, this was a plausible model. Recent work has shown it is no longer realistic. High precision dating of rocks and minerals, previously undated or dated by problematic techniques such as the K-Ar method, has revealed that they are much younger than assumed. Instead of a model of convergence and multiple collisions, a model of convergence associated with subduction-rollback and extension offers a better explanation of the region.

All reconstructions can be improved, and improvements will be based on first-hand knowledge of the region, accompanied by new studies, particularly field-based work and the use of samples from offshore. Such work requires the support of SE Asian governments and industry to help acquire samples and continue to fund new work by young scientists, working with international groups through which SE Asian students can gain access to skills and equipment not yet available in the region.

SPEAKER BIOGRAPHY

Robert Hall is Director of the SE Asia Research Group at Royal Holloway University of London, which has conducted field-based research in SE Asia for many years. Robert has been working in the region since 1984.

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Integrating Basin Evolution and Plate Tectonics in SE Asia

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SE Asia is the most geologically complex region on Earth due to the three-way convergence of the Indo-Australian, Eurasian and Pacific plates. Unravelling its tectonic and structural history via high resolution plate tectonic modeling is the best way to start to understand this complexity, but how can this be optimised to help exploration?

Most exploration in SE Asia (both for hydrocarbons and minerals) has largely been undertaken empirically, driven by smaller-scale, 'grass-roots', data-intensive exploration that incrementally steps out from the 'known'. These exploration strategies obviate the need to have a good regional geological understanding and are successful up to a point. Can we move beyond 'empirical' exploration in SE Asia into the realm of 'predictive' exploration that unlocks the exploration white-space that remains in the region? For that matter, is there any exploration white-space left? The only way to adequately address these questions starts with a good regional tectonic model that is a base for understanding paleogeography, basin evolution and petroleum systems.

The Geognostics Earth Model (GEM) is a high resolution 4D view of global geology constructed from the bottom-up by interpreting basement terranes and major structures, then spatially reconstructing them back in time by undoing deformation patterns and basin evolution. GEM is particularly detailed in SE Asia; the result of years of collaboration with our clients exploring the region. The model includes high resolution analysis of major plate movement (including the Pacific), as well as more than 200 separately moving microplates. Key features of the model include:

- Progressive rotational extrusion of Sundaland then Indochina driven by the collision of India, opening the main petroleum basins in the Gulf of Thailand and South China Sea in the Late Eocene – Early Miocene.
- A shift in Pacific plate dynamics in the Mid Miocene triggered a major regional readjustment in SE Asia, with East to West convergence causing widespread terrane collision in Eastern Indonesia, the Philippines and Sabah, as well as basin inversion throughout the region.

We have leveraged GEM, along with public domain geophysical data (particularly gravity), numerous publications and interaction with our clients to produce a new regional interpretation of the basins of SE Asia. While in its early stages, our interpretation shows key depocentres evolving through time, qualitatively subdivided by basin thickness and basin type. It forms a powerful base for new paleogeographic mapping, and we show examples of how plate tectonics and paleogeography can be combined to generate new play concepts.

SPEAKER BIOGRAPHY

Jon has a PhD in hard rock structural geology from Adelaide University and more than 20 years' experience consulting across many industry sectors, including oil, minerals, coal, geothermal and wine. A founding member of Frogtech in 2004, he then worked as Global Geological Consultant in Shell for a decade, before founding Geognostics in 2017. He has extensive experience on regional structural geology and basin framework of SE Asia for both oil and mineral company clients.

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Final Separation of Eastern Gondwana –

Plate Kinematics and Their Implications for Frontier Exploration

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The protracted separation of Australia, Antarctica and Zealandia spanned a period of over 100 Ma from Late Jurassic until the early Paleogene. Several key tectonic events punctuate this interval and have direct consequences for the plate kinematics and paleogeographic evolution of the southern / eastern Australian and New Zealand passive margin basins. Whilst existing hydrocarbon plays in the shallow waters of the Otway, Gippsland, and Taranaki basins offer great analogues for neighbouring deep-water frontiers, there are many significant risks to be addressed. A greater knowledge of the age, duration, and regional interaction of the various tectonic events, placed in the context of a high-resolution plate model, is a crucial first step in understanding basin histories and potential play types.

Extensive syntheses of public-domain stratigraphic, geochronological, and geophysical datasets have been incorporated into a revised plate model for the region. Revised continent-ocean boundaries have adjusted the pre-rift fit of respective margins and an integrated approach to modelling the entire set of rift systems has produced a more robust kinematic model. Global consistency is maintained through plate circuit constraints, whilst high-resolution regional kinematics help visualise tectonic events critical for creating, preserving, or destroying potential hydrocarbon play elements.

Several case studies will be used which highlight both the data underpinning the model and the importance of plate kinematics as tools for understanding prospective petroleum plays. Using the existing stratigraphic framework developed for basins along the southern margins of Australia and seismic examples from both here and the conjugate Antarctic margin, it is possible to assess recent models proposed for break-up. The preferred model has important consequences for deposition and preservation of speculative Late Cretaceous marine organic-rich units, the presence of which is a key risk in the deep-water frontier Bight Basin.

Assessing the rift and break-up model for the Tasman Sea allows for the evaluation of discrepancies in structural trend and burial history of the depocentres in the Taranaki Basin. As all potential thermogenic source rocks in the adjacent deep-water province are likely to reside in the syn-rift section, it is important to consider maturity risk of different depocentres. The variance between kitchens that are at maximum burial versus those that have had a more complex history is probably a far more complex situation than envisaged.

The Great South Basin of New Zealand contains a well-documented, thick prograding wedge of deltaic clastic lobes deposited during the Late Cretaceous and early Paleogene. The source of these potential reservoir units is unclear, and the present-day topography and drainage patterns of the margin are a false reflection of the likely situation at their time of deposition. Examining the relative kinematics of the north and south Zealandia continental blocks during their break-up and dispersal sheds light on likely zones of localised convergence that may have formed a paleo-hinterland source responsible for clastic supply.

With sparse data control, the vast offshore region from the Great Australian Bight to the Chatham Rise is currently deemed high risk for exploration. The use of high-resolution plate models supported by multi-disciplinary datasets can be a powerful tool for evaluating potential source rock deposition, preservation, and burial history, as well as hinterland uplift and clastic reservoir supply. By gaining a greater understanding of the region's paleogeographic and kinematic evolution, it becomes possible to begin the process of de-risking prospective plays and opening up the potential of one of Earth's largest underexplored offshore provinces.

SPEAKER BIOGRAPHY

Jamie joined Neftex (now part of Halliburton) in 2006 and has worked the majority of time since then on the geology of the Asia-Pacific region. Originally developing sequence stratigraphic and tectonic frameworks for Southeast Asia, he is now helping to build industry-focussed plate models.

ORAL PRESENTATION

A New Direction for Asian Stratigraphy

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New ideas or new data are required to break out of the creaming curve. Exploration risks need to be re-ranked and, ideally, new plays found, or the explorer is condemned to find ever-diminishing returns

In basins with over a century of exploration one naturally assumes that basic geology is well known, that the diminishing returns have already been raked over many times, and therefore we have to explore the expensive frontier areas to add significant value. But what if we could demonstrate both gaps in our basic geological knowledge, and also the inability of our present work processes to see these deficiencies? Such flaws can be demonstrated to have survived unchallenged in many Asian basins containing giant and super giant fields, so what could we have missed, under-valued or over-risked?

Examples from across Sundaland have recently been published or are in press, identifying problems stemming from how we interpret our data. Stratigraphic methods based on depositional sequence models are explicitly stated to assume geological conditions that we know do not correspond to much of the geological history of SE Asia, yet the models are still made to fit. These assumptions include curvilinear to almost sinusoidal sea level change with a fractal-like scaling of magnitude, with sediment source and depocentres remaining in approximately the same locations (a 2D proximal to distal direction of sedimentation). Another early assumption, that eustasy was an important driver leaving a correlatable signature in the stratigraphic record, has faded in the past decade and been replaced by the term relative sea-level change. It is time to critically re-examine the other fundamental assumptions.

There is an underlying problem in scientific philosophy. We have been using deductive processes for nearly three decades, which assumes a reliable model and uses new data to reach a conclusion in light of the established model. The complexity and high number of localised special cases in SE Asian geology requires that we use an inductive method, with a minimum number of assumptions, and giving priority to observed evidence. These inductive models are tested by comparison with other data sets such as tectonic evidence, using quantitative techniques such as geohistory plots. SE Asia is fortunate in having Cenozoic tropical microfaunas providing exceptionally good age and facies control. These enrich the stratigraphic dataset with qualities and properties that cannot be observed on seismic or wireline logs. With input from all these independent disciplines the new inductive models have become very robust, as shown by examples from several Sundaland basins.

The new stratigraphic approach resurrects ideas developed many decades ago in the region, such as the Cycles of Sarawak, and finds they merge with modern sequence stratigraphic techniques being developed internationally (e.g. Embry and Johannessen 2017). Tectonism is identified as the largest controlling factor on stratigraphy at the level of petroleum systems and plays, and initial work has already found important new links between tectonic models based on plate-scale studies and local stratigraphic data sets. It is this linking of disciplines that will allow prediction of stratigraphy into under-explored areas, or better understanding of geological risks in explored regions.

SPEAKER BIOGRAPHY

Peter Lunt has 30 years' experience in SE Asian geology, has seen many ideas come and go and is now trying replace the dogma of eustasy-related sequence stratigraphy with something more robust and locally applicable. Peter is an industry consultant and adjunct lecturer in stratigraphy at Universiti Teknologi Petronas. He has just completed a series of regional papers on tectonic controls on sedimentation, including the first draft of a major book on the South China Sea and Borneo and will be spending the next few years helping to set up UTP as a global "centre of excellence" for sedimentary geology and stratigraphy, especially for carbonate rocks.