ORAL PRESENTATION

Day 3: 5th April 2019

Session 9: Showcasing G&G Techniques in SE Asia

Chairs: Alasdair Duncan – Mandala Energy, Jo McArdle - PGS

9:00	Reservoir Characterisation with Ocean Bottom Seismic: A South East Asia Case Study	Rob Ross	Qeye
9:25	Validation of Fault Seal Mechanisms: An Outcrop and Subsurface Perspective	Titus Murray	Southern Highlands Structural Geology
9:50	Depositional Architecture, Sequence Stratigraphy and the Quantification of Hydrodynamic Fractionation as a Tool for the Prediction of Reservoir Quality in a Deep Marine System: An example from the Miocene Moki Formation in the Maari/Manaia Field Area, Southern Taranaki Basin, New Zealand	Alex Wunderlich	OMV
10:15	Application of Machine Learning to Facies Classification of Carbonate Core Images	Sharinia Kanagandran	Imperial College, London (now Schlumberger)

ORAL PRESENTATION

Reservoir Characterisation with Ocean Bottom Seismic: A South East Asia Case Study

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Ocean bottom seismic has seen a renaissance in recent years. Acquisition companies have developed technology for faster deployment and recovery, more innovative shooting geometries leveraging increased sensor inventories, compressive sensing and simultaneous sources. It has thus become more economically viable to acquire larger nearfield exploration ocean bottom datasets.

Reservoir areas obscured by gas anomalies are a common challenge in South East Asia. Extensive AVO compliant preconditioning and a simultaneous PP-PS elastic inversion enable a clearer reservoir interpretation in the gas obscured areas. This is demonstrated by improved well ties over the PP inversion and by more geologically consistent elastic properties within the layers.

In our case study, we demonstrated that density estimated from PP-PS simultaneous inversion of multicomponent seismic data is superior to one obtained from PP (P-wave only) seismic inversion (see Figure 1). Superior results are obtained even in the gas cloud areas. The density estimated from PP PS simultaneous inversion was used in reservoir delineation and characterization.

SPEAKER BIOGRAPHY

Rob Ross started his career in what was then Geco-Prakla in 1997. He worked in many locations onshore and offshore in a range of operational and managerial roles mostly focussed on the sales and execution of projects based on new technology. In 2011 he left Schlumberger and joined TGS in the newly formed Reservoir Services division where he was responsible for design and delivery of client solutions using the newly acquired Stingray fibre optic sensing system. In 2015 he joined Qeye, a quantitative interpretation company headquartered in Denmark.

Rob is currently the MD of Qeye for South East Asia, based in Perth. Rob is an active member of SEAPEX, PESA, EAGE and SEG and holds a M.Eng degree from University Cambridge (UK) and an MBA from Erasmus University Rotterdam (NL).

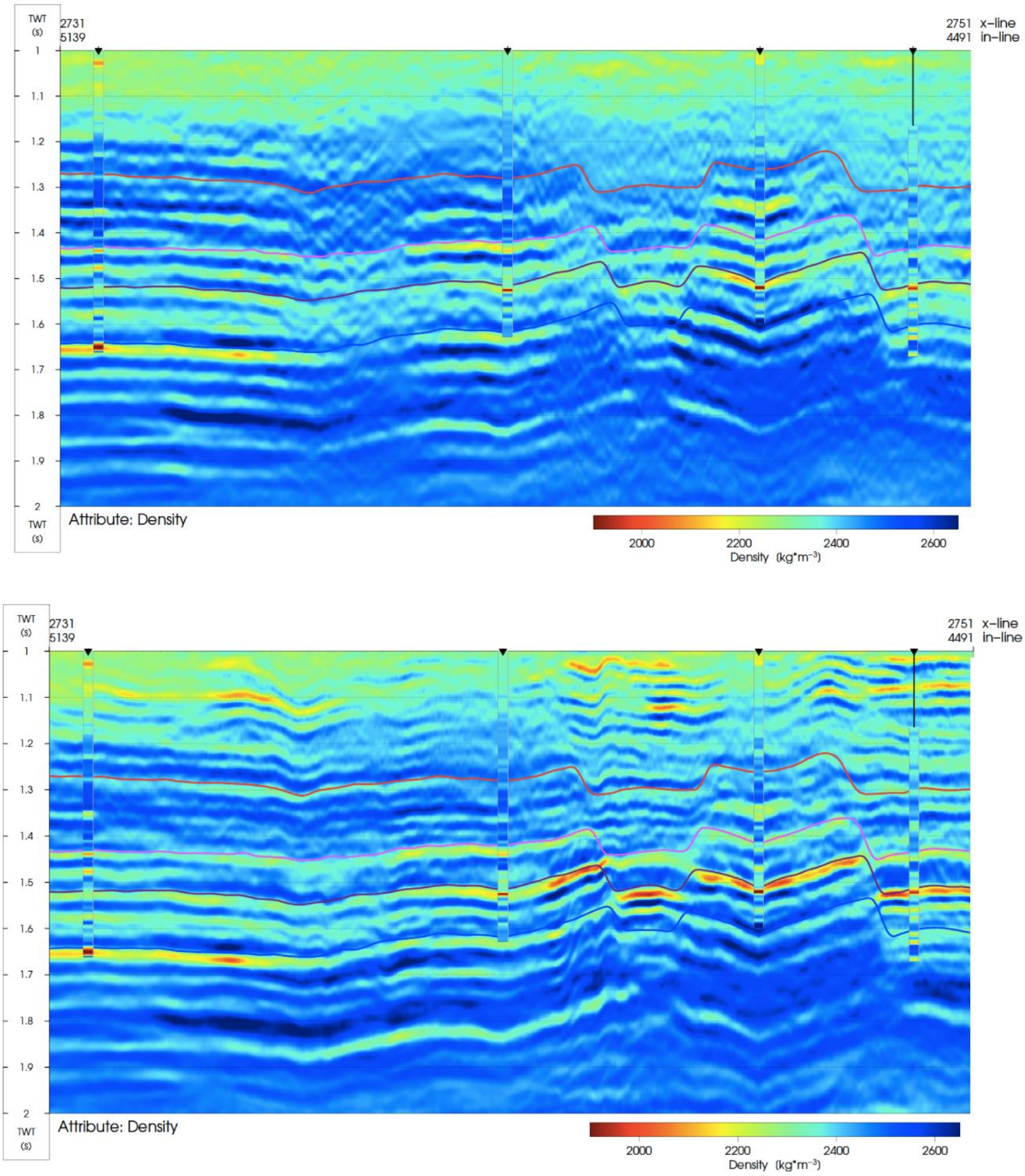

Figure 1. Absolute density inversion results – (top) PP (bottom) PP-PS. Note the improved resolution in the PP-PS events for example in the central graben structure and across the E8 horizon. Four well traces are inserted for comparison purpose.

ORAL PRESENTATION

Validation of Fault Seal Mechanisms: An Outcrop and Subsurface Perspective

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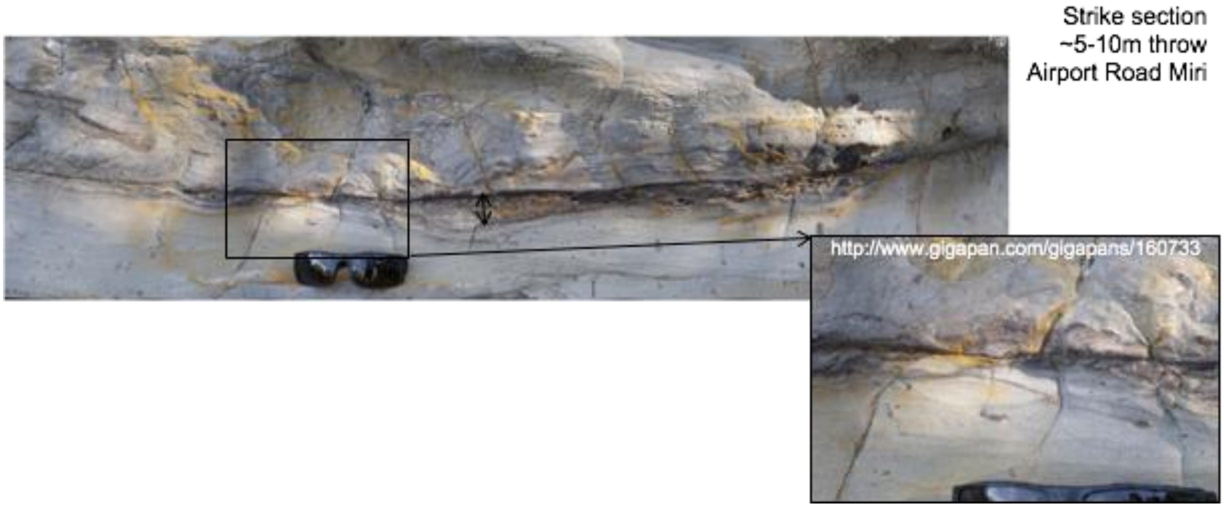
Assessing exploration risk requires an analysis of trap, seal, and charge as well as reservoir issues. When risking fault bounded structures, across-fault juxtaposition and / or fault membrane seal are key issues. Generally, this work is done on a single "best-guess" technical model.

A very large number of studies have considered membrane sealing. Many engage in back calculating the pressure capacity by using a Shale Gouge Ratio (SGR) algorithm, and then providing a forecast of hydrocarbon column height. Importantly, this back-fitting of SGR and seal capacity is almost always conducted using single "best" technical models with no direct modelling of uncertainty. It is suggested that fault and stratigraphic uncertainties are significant and need to be explicitly included in the modelling of fault seal risk and inferred column heights.

In general, the application of SGR methods in reservoir / seal systems that have moderate Vshale values artificially increases predicted column heights and enhances the pre-drill estimates of success relative to a simpler and more direct juxtaposition analysis of cross-fault leakage. In well run risking processes these large columns are generally discounted through other geologic risk factors. When shorter columns are found during drilling, they are often "explained" by issues of charge or trap breach.

Whilst geologists commonly use cross sections to describe structures and traps it is vital in fault seal analysis to consider the strike variability of fault rock properties. A series of faults in Miri, Sarawak, have been systematically mapped in great detail to measure the strike variability of fault rocks. This work greatly helps to understand the limitation of membrane seal algorithms.

To illustrate the implications to subsurface risking, a validation will be presented in which observed hydrocarbon water contacts are compared with probabilistic models for both juxtaposition and SGR. A comprehensive review of a set of fields in The Timor Sea shows that probabilistic juxtaposition models more accurately predict hydrocarbon water contacts than calibrated SGR single "best" technical models. Stochastic trap analysis generates smaller, lower risk targets that are more likely to accurately predict final exploration outcomes.



SPEAKER BIOGRAPHY

Titus is a structural geologist with extensive experience in the study and characterisation of faulted and fractured reservoirs in over 30 countries. Providing services and tools that improve oil and gas discovery and production as well as ground water industries. A key part of this is the development of new algorithms to describe structures and fluid flow. Most recently he has started an active Research and Development program to develop technology to characterise groundwater flow across and through faults.

Another key part to his practice involves 2D and 3D Structural restorations. These projects are either in offshore frontier exploration based on deep seismic data, or onshore complex fold and thrust belts based on borehole and outcrop data.

ORAL PRESENTATION

Depositional Architecture, Sequence Stratigraphy and the Quantification of Hydrodynamic Fractionation as a Tool for the Prediction of Reservoir Quality in a Deep Marine System: An Example from the Miocene Moki Formation in the Maari/Manaia Field Area, Southern Taranaki Basin, New Zealand

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The Maari/Manaia depocentre of the Southern Taranaki Basin preserves a well-penetrated 500m thick succession of Middle Miocene deep marine strata that record the filling of the basin, triggered by the first phase of the Tasman Bay convergence. Uniformly fine-grained sandstones of the Moki Formation were derived from metasedimentary and volcanic sources and form the reservoirs for the producing Maari Field as well as for the Manaia Discovery.

A rigorous interpretation of the sequence stratigraphic framework by integration of high-resolution 3D seismic data, core data, petrographic analysis, biostratigraphy and well correlations, that identifies key stratal surfaces and their correlative deposits, revealed the deposition of three sequences grouped into a composite sequence. The three sequences contain bundles of sand-prone sequences deposited during sea level lowstands and overlying thicker claystones deposited during transgressions and sea level highstands. The predictable stacking pattern of those claystones sandwiched between each of the sequences are seismically traceable and correspond to 4^{th} order maximum flooding events grouped into the 3^{rd} order composite sequence of the Moki Formation.

The Moki Formation is believed to be deposited in an overall progradational context within the Maari/Manaia Field Area, changing from distal outer lobe complex position in the lower and older sands into channel lobe transition zone position in the youngest sands. Additionally, it can be documented how reservoir quality changes laterally and longitudinally, due to a systematic axis-to-margin change in the petrographical character of individual reservoir units, attributed to hydrodynamic fractionation of minerals and textures.

SPEAKER BIOGRAPHY

Alexander Wunderlich is the Geoscience Team Lead for Australasia in OMV New Zealand. Alex holds a MSc in Geology from the TU Bergakademie Freiberg in Germany and the Colorado State University in Fort Collins, USA. He has worked in New Zealand since February 2015, having previously worked for OMV in Madagascar as an Exploration Geologist for the Company's operated and non-operated interests in the Morondava Basin, Eastern, and Western Africa. Prior to joining OMV Alex has worked in technical exploration positions for operating companies in Norway and Germany, focusing on the North Sea, Norwegian Sea, and the Barents Sea.

ORAL PRESENTATION

Application of Machine Learning to Facies Classification of Carbonate Core Images

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In recent years, the use of machine learning in petroleum geoscience has risen, especially for seismic and wireline data interpretation. Companies like IBM and Schlumberger have applied machine learning to seismic data and managed to decrease interpretation time by up to 80% (Lomas, 2018). Moreover, published research regarding machine learning on wireline data has existed since the 1980s. However, there are limited published studies on the application of machine learning to core data, in particular, carbonate cores.

Core classification is a key building block of geological models and is used to define petrophysical classes. However, a 2016 study (Lokier & Junaibi) found high classification inconsistencies with classification of carbonate thin sections. Due to this, a study was conducted into the classification of carbonate facies according to the Dunham classification scheme in high-resolution core images using machine learning techniques.

The study evaluated two commonly used machine learning algorithms, Random Forest (RF) and Convolutional Neural Networks (CNNs), to identify facies in high-resolution carbonate core images through a number of methods. CNNs were ascertained as the superior algorithm, achieving 89.2% accuracy for identification of Mudstone to Rudstone and Crystalline Dolomite and producing results which were sensible from a geological point of view. The main misclassification was between matrix and grain supported facies, and fine and coarse grained facies, adjacent in the Dunham scheme.

A survey of the algorithm's commonly misclassified images was conducted with geologists who had carbonate classification experience. Experienced geologists attained an accuracy only 20% greater than the algorithm, with the same misclassification bias observed in both the geologists and the algorithm. Moreover, a Turing Test was carried out to verify whether the algorithm could pass for a geologist and the algorithm went on to pass the test. The results of this study show great potential for the use of machine learning in carbonate core classification in a fast and high-resolution manner, with a level of accuracy approaching experienced geologists.

SPEAKER BIOGRAPHY

Sharinia recently graduated from Imperial College London, where she carried out her thesis applying machine learning to carbonate cores. She is from Malaysia and is currently a Borehole Geologist with Schlumberger in KL. In her free time, she continues to find new algorithms and improve image classification using machine learning.

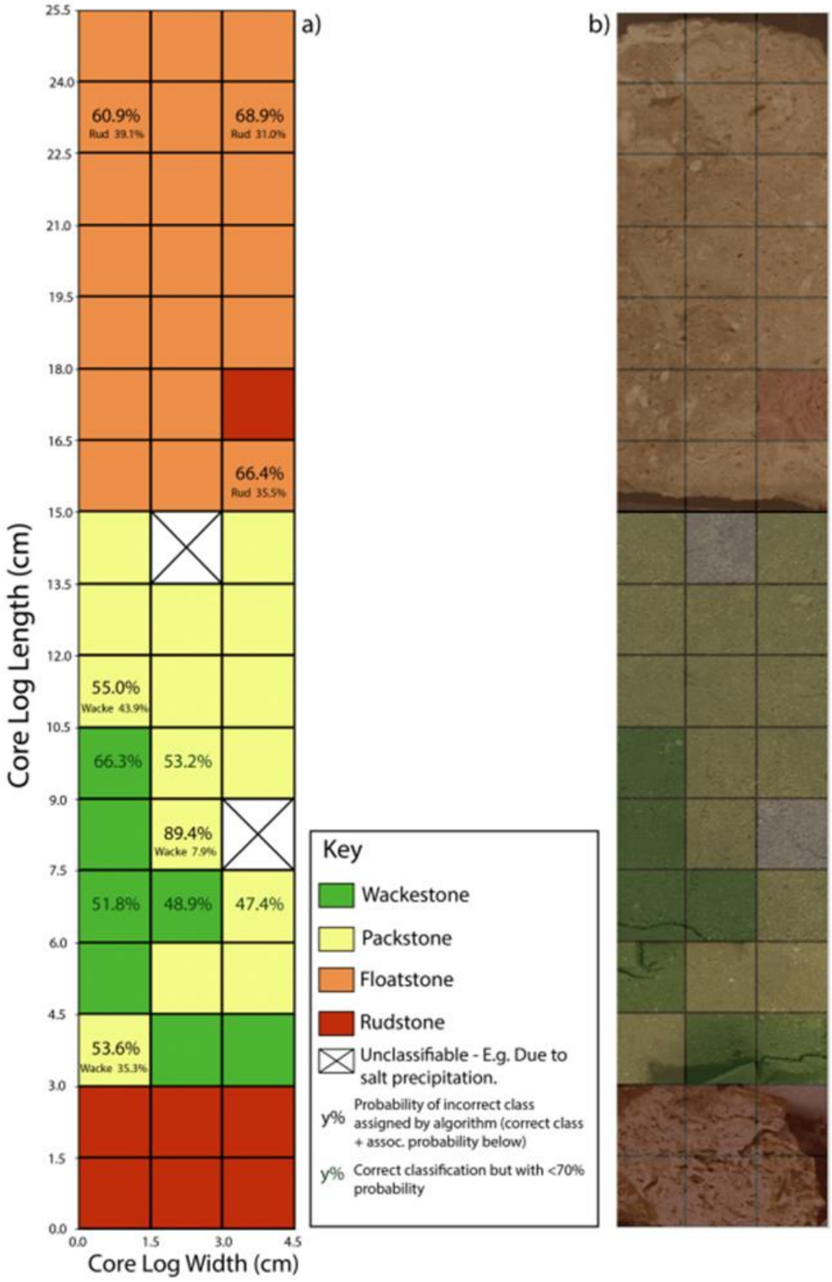

Figure 1. Result of classification by the algorithm of synthetic core section using core samples from the Marion Plateau. a) A high-resolution classification grid of the core – different colours indicate the algorithm's classification (Key). For incorrect classification (black text), algorithm's assigned probability is printed on grid with correct class and associated probability below. b) Classification overlain on synthetic core to emphasise classification resolution and show samples which were used