ORAL PRESENTATION

Day 3: 9th March 2023

Session 9: TECHNOLOGY AND TECHNIQUES

Co-Chair: Dave Goulding, Sharp Reflections

Co-Chair: Roy Kitrell, Bell Geospace

08:45	Implications of Elastic Anisotropy in Direct Probabilistic Inversion; Examples from Offshore Australia	Partha Pratim Mandal	Qeye and Santos
09:10	Integrating Emerging Well Logging and Core Analysis Technologies for Improved Evaluation of Unconventional Reservoirs	James Davidson	NSAI
09:35	Integrated Stratigraphic and Provenance of the Cuu Long Basin, Offshore Vietnam	Dave Riley	Chemostrat
10:00	Chronostratigraphic, landscape and tectonic perspective of the Oligocene to late Eocene non-marine Cuu Long Basin, offshore Vietnam using integrated sequence biostratigraphy and chemostratigraphy	Bob Morley	Palynova

ORAL PRESENTATION

Implications of Elastic Anisotropy in Direct Probabilistic Inversion; Examples from Offshore Australia

Partha Pratim Mandal [1], Andre Eduardo de Souza[1], Rob Ross[1], Shane Squire[2], and Yahya Basman[2]

[1] *Qeye,* [2] *Santos*

ppm@qeye-labs.com

It is an industry common practice to consider subsurface as a combination of several isotropic stacked layers when characterizing reservoirs with quantitative interpretation workflow with techniques such as wavelet estimation, well-tie analysis, deterministic AVO inversion, forward modelling, etc. By selecting an angle-dependent wavelet, the associated error generated from isotropic assumption of subsurface units are partially mitigated.

In the presence of thick overburden shale above the reservoir sandstones, the isotropic AVO response differs most for the vertical transverse isotropic (VTI) response in the mid and far angle ranges in the vertical transverse isotropic (VTI) media, introducing mismatch between observed seismic and synthetic seismogram.

To understand overall impact of an isotropic vs VTI anisotropic model in a reservoir characterization project a comparison of isotropic and VTI Direct probabilistic inversion (DPI) is made in an offshore field in the North West Shelf (NWS) of Western Australia. Elastic anisotropy parameters delta and epsilon were accessible from tomography velocity modelling in the absence of necessary wireline logs. The extracted wavelet from each angle stack with Ruger's formula in VTI media showed much improved far angle wavelet estimation and a decrease in far angle wavelet amplitude, despite the simple low-frequency anisotropy profiles used. In addition, an improvement in synthetic seismic cross-correlation is noticed from mid to far angle ranges. When anisotropic parameters are introduced in DPI, facies prediction improves greatly in the reservoir, overburden and underlaying strata in comparison with isotropic case.

SPEAKER BIOGRAPHY

Partha Pratim Mandal is a senior Geophysicist at Qeye. Previously he worked for six years as project Geophysicist at PGS/DUG both in India and Australia on delivering optimum subsurface image of the rock formations. Partha holds a PhD in resource engineering (Geomechanics) from the Curtin University and MSc Tech in Applied Geophysics from the IIT (ISM), Dhanbad, India.

ORAL PRESENTATION

Integrating Emerging Well Logging and Core Analysis Technologies for Improved Evaluation of Unconventional Reservoirs

James Davidson [1] and Jonathan Markell [1]

[1] *Netherland, Sewell & Associates Inc.*

jdavidson@nsai-petro.com

Significant advances have been made with multi-frequency dielectric measurements, pulsed neutron and gamma ray spectroscopy measurements, high-resolution NMR measurements, and pyrolysis procedures for unconventional reservoir rocks. By integrating these new measurements with traditional well log and core measurements, it is possible to derive a much more complete description of the reservoir pore system as well as more accurate estimates of the oil, gas, bitumen, and water saturations within the formation. More importantly, most of the critical core measurements can be conducted with rotary sidewall core samples, which vastly improves the possible vertical coverage of the reservoir description measurements. Important rock types can be identified with the open-hole logs and then samples can be obtained with the rotary sidewall coring tool. This provides a more complete database for the calibration of well log-based petrophysical models.

Recommendations for logging and coring analysis programs are provided as well as descriptions of the necessary data integration procedures.

SPEAKER BIOGRAPHY

James holds B.S., M.S and PhD. degrees in petroleum engineering from Texas Tech University and the University of Texas at Austin. He worked for Atlantic Richfield in West Texas, California and Indonesia. He performed research in fluid movement and geomechanics in shales at the University of Texas and the Bureau of Economic Geology. He now works at Netherland, Sewell and Associates as a Vice President and Senior Technical Advisor specializing in petrophysics.

ORAL PRESENTATION

Integrated Stratigraphic and Provenance of the Cuu Long Basin, Offshore Vietnam

David A. Riley[1], Maximilian Franzel[1], Tim J. Pearce[1], Anh Nguyen[1]. Nathan Bruder[2], Gregory Fraser[2], Robert J. Morley[3], & Harsanti P. Morley[3]

[1] *Chemostrat Ltd*
[2] *Murphy Oil Corporation*
[3] *Palynova Ltd*

davidriley@chemostrat.com

Well to well correlations of the Cuu Long Basin are typically challenging, due to the highly variable nature of the wireline signature and resolution of the seismic data. Traditionally the Cuu Long Basin is subdivided based on Seismic Groups; Seismic Group G, which rests on crystalline basement, Seismic Groups F and E which represents the main extensional phase of rifting and Seismic Groups D and C which represent the thermal subsidence and extension phase of basin development. These seismic groups also have lithostratigraphic equivalents, the Ca Coi, Tra Cu, and Tra Tan Formations, respectively. Recently a sequence biostratigraphic approach has utilized palynology to provide an improved perspective of the age of Seismic Groups B to D, by reference to age-calibrated eccentricity-driven climate cycles, however, this approach is inherently weak in Seismic Groups E, F and G, due to limited palynomorph recovery.

Within this study a holistic approach is taken to establish an integrated stratigraphic framework using whole rock elemental chemostratigraphy, biostratigraphy, seismic and wireline data, for the Cuu Long Basin, Offshore Vietnam. In addition, selected samples have been analysed by automated Raman heavy mineral analysis to further refine the provenance of key sandstone intervals.

Key ratios, from the whole rock elemental dataset, effectively represent changes in sediment provenance, weathering, and geological process have been used to geochemically define a series of chemostratigraphic super-groups, groups, and packages from selected well penetrations across from the study area. The stratigraphy has been divided into two chemostratigraphic super-groups; the first (MS1) is broadly consistent with the occurrence of Seismic Groups G through E, which are inferred to be mineralogically and texturally immature relative to the second mega-unit. The second chemostratigraphic super-group (MS2) is consistent with Seismic Groups D and C; these sediments are characterised by sediments which are geochemically inferred to be more texturally and mineralogically mature.

These chemostratigraphic super-groups are then further subdivided into a series of chemostratigraphic groups, which are recognised as being broadly equivalent to the established seismic groups. In addition, these chemostratigraphic groups are further subdivided into numerous chemostratigraphic packages demonstrating a robust and high resolution chemostratigraphic scheme for the Cuu Long Basin. Chronostratigraphic control is defined by the additional use of sequence biostratigraphy based on palynology on twelve of the twenty-two wells evaluated for chemostratigraphy. The holistic approach of biostratigraphy and chemostratigraphy efficiently utilises two tools, which complement each other in the correlation of the study wells.

These geochemically characterised boundaries are demonstrated to be consistent across the study area and are consistent with seismic picks. One such example is the boundary between the super-group MS1/MS2, which is consistent with the Seismic Groups D/E boundary. Geochemically, a distinctive increase in weathering indices, and Fe/Mn ratios is observed across this boundary going up-section. Furthermore, heavy minerals, from automated Raman analysis, demonstrates a clear change in the heavy mineral assemblage across this stratigraphic surface. Heavy mineral assemblages below the MS1/MS2 boundary consistently reflect a sediment with abundant epidote and titanite to a sediment with abundant zircon. Incidentally, the MS1/MS2 boundary is consistent with the initiation of thermal subsidence and extension.

In conclusion, this study has established a robust chemostratigraphic/biostratigraphic framework across the study wells within the Cuu Long Basin, which is supported by seismic and wireline validation. Utilization of chemostratigraphy, combined with selected provenance analysis, will allow improved well to well and well to seismic correlations, and will aid in defining stratigraphic traps, the understanding of play fairway distribution and the overall evolution of the basin.

SPEAKER BIOGRAPHY

David Riley is a staff geologist and the stratigraphy manager of Chemostrat Ltd, which provides chemostratigraphic, geochemical, mineralogical and provenance analysis for petroleum exploration companies. David graduated from the University of Leicester with a PhD in geochemistry in 2012, joining Chemostrat Ltd as a geologist. Since then, David has worked on multidisciplinary studies from Canada, North Sea, Europe, SE Asia and Australia.

ORAL PRESENTATION

Chronostratigraphic, Landscape and Tectonic Perspective of the Oligocene to late Eocene Non-Marine Cuu Long Basin, Offshore Vietnam using Integrated Sequence Biostratigraphy and Chemostratigraphy

Robert J. Morley[1], Harsanti P. Morley[2], Nathan Bruder[2], Gregory Fraser[2], Dave Riley[3], Tim Pearce[3], Anh Nguyen[3], Nguyen Thi Tham[4], Mai Hoang Dam[4], Nguyen Thanh Tuyen[4], Pham Thi Duyen[4]

[1] Palynova Ltd., [2] Murphy Oil Corporation, [3] Chemostrat Ltd., [4] Vietnamese Petroleum Institute

bobmorley100@gmail.com

The Cuu Long Basin offshore South Vietnam is a highly prospective hydrocarbon producing non-marine basin with world-class lacustrine source rocks. The whole stratigraphic succession has previously proved difficult to date as marine fossils are absent, but terrestrially derived pollen and spores and freshwater algal palynomorphs are abundant. A recent palynological study using a high-resolution sequence biostratigraphic approach relating multiple flood-fill packages to eccentricity-driven climate cycles, calibrated using index palynomorphs, has resulted in a much-improved chronostratigraphy for the basin. Palynomorphs are abundant within the mid and late Oligocene seismic groups B, C and D, where a confident chronostratigraphic framework has been developed, but are of limited occurrence in Seismic Groups E, F and G, which are currently being explored for hydrocarbons, and where increased stratigraphic resolution is needed to search for new targets.

A chronostratigraphic model for the whole stratigraphic succession has been developed by integrating palynological signals, which identify flood-fill packages, with a chemostratigraphic approach. Seismic Group D is divided into seven well-defined flood-fill sequences, and are integrated with six chemostratigraphic packages, that relate to both allocyclic and autocyclic events. Seismic Group C on the other hand is composed of five flood-fill sequences, and these are tied to three chemostratigraphic packages, that relate to the infilling and eventual drowning of the Seismic Group D palaeotopography.

Although the palynological record for Seismic Groups E, F and G is generally poor, it is good in some wells and assemblages there suggest that these sediments formed when the Cuu Long was an intermontane basin. The chemostratigraphic packages on the other hand permit correlation within these groups across the region.

The integration of sequence biostratigraphy with chemostratigraphy results in a chronostratigraphic framework which should enable detailed evaluation of stratigraphy throughout the Cuu Long stratigraphic succession, whether poorly or richly fossiliferous, and it is thought that this will considerably aid the current phase of exploration for hydrocarbons.

SPEAKER BIOGRAPHY

Bob Morley is director of *PALYNOVA* Ltd which provides expertise in biostratigraphy to petroleum exploration companies and government research laboratories. A major interest is to solve issues of Cenozoic stratigraphy using the approach of Sequence Biostratigraphy, which applies a holistic approach using foraminifera, palynology and nannofossils integrated with logs and seismic to provide accurate and consistent stratigraphic interpretations in all facies from non- to deep marine, and to test systems tract interpretations based on seismic.

An additional interest is to understand the mode of evolution of tropical rain forests, on which subject he wrote the now classic book 'Origin and Evolution of Tropical Rain Forests', published in 2000, and to clarify the pattern of evolution and development of tropical floras by integrating pollen and molecular data and on which subject he has authored over 100 peer reviewed papers. He is also lead author for a new comprehensive Pollen and Spore Atlas for Malaysia, which will be published shortly.