MSc Petroleum Geoscience Symposium

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Programme
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	Queen's Lecture Theatre			
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Eleanor Lashko

Inversion-induced salt tectonics and the impact on potential chalk reservoirs on the Cleaverbank and Central Offshore Platforms, southern North Sea

For the southern North Sea, the Upper Cretaceous was a period of widespread inversion, rejuvenated halokinesis and, consequential reworking and fracturing of coeval chalk sediments. These deposits are highly successful reservoirs for numerous hydrocarbon fields in the Danish and Norwegian Central North Sea. With creaming of the mature North Sea basin, focus is now turning to the prospectivity of chalk in the Netherlands; an underexplored region for this play. Using PGS MegaSurvey data and state-of-the-art analytical techniques, this thesis aims to address the lack of understanding of the chalk sediments on the Cleaverbank and Central Offshore Platforms. An array of slumps, slides, contourites, clinoforms and fractures uncovered in the Chalk Group all indicate a highly dynamic seafloor environment and a consequential broad range of reservoir types. Both salt tectonics and basement fault inversion are paramount to chalk reworking, highlighting the mutual influence of thin- and thick-skinned tectonics. These findings have implications not only for the prospectivity of the Dutch sector, but also for the current depositional model of chalk in an epeiric sea.

Supervisor: *Jürgen Adam (RHUL)*

Data provided by: *PGS*

Intan Mashitah Amir Basha

Tectonostratigraphy and hydrocarbon potential of the SE sector of the Mid North Sea High, southern North Sea

The Mid North Sea High is a structurally elevated area that is surrounded by basinal depocentres and was underlain by a granite batholith. The study of the Paleozoic basement is necessary to understand the whole structural and stratigraphic framework of the area. The structural deformation of the study area has been influenced by different tectonic phases, mainly the Caledonian Orogeny, Variscan Orogeny, Permian intracontinental basins, Triassic-Early Cretaceous multi stage rifting and lastly the Late Cretaceous-Cenozoic inversion. Detailed interpretation of faults using attribute analysis has been done to understand the style and timing of the deformation in order to develop kinematic model. It is understood that the effects of the low density of the Caledonian batholith at the basement has influenced the depositions of the sediments underlying it to uplift and eroded especially sediments that was deposited during extension where fault activities are active. The principle risk for the Lower Carboniferous is the hydrocarbon charge. This is due to its high topography which had caused most of the Westphalian source rock to be eroded due to the Variscan uplift. However, other alternative source rock could provide the hydrocarbon charge for the Lower Carboniferous play. A potential exploration site is proposed at the western part of the survey area which is located in the Uranian Graben due to its good reservoir and trapping potential.

Supervisors: *Jürgen Adam & Nicola Scarselli (RHUL)*

Data provided by: *PGS*

Sam Head

Numerical modelling of hydraulic fractures within the Leman Sandstone reservoir, southern North Sea

Tight sandstone reservoirs of the Rotliegend Group in the Sole Pit Basin of the southern North Sea, are commonly hydraulically fractured to improve productivity. Hydraulic fractures are susceptible to arrest or deflection in heterogeneous and anisotropic (layered) reservoirs. Numerical models can be used to forecast propagation paths of hydraulic fractures in layered reservoirs. Here reservoir layering is interpreted from well-log data and combined with static and dynamic elastic parameters as input for numerical models for simulating propagation pathways of hydraulic fractures within the Lower Leman Sandstone reservoir at the Babbage field and the Cobra prospect. Numerical results suggest primarily vertical propagation paths, hydraulic fractures being able to penetrate mudrock layers and the overlying Silverpit Claystone top seal. Hydraulic fracture penetration of the mudrock interbeds should increase the permeability and flow rates from the tight reservoir. However, the results also forecast mechanical breaching of the top seal, implying potential tertiary leakage and reduced resources.

Supervisors: *Agust Gudmundsson (RHUL); Graham Yielding (Badley Geoscience) & Brian O'Sullivan (Premier Oil)*

Data provided by: *Premier Oil and Badley Geoscience*

Richard Turner

Seismic Interpretation of the Palmers Wood Oil Field: implications for field compartmentalisation and future development

Future commercial oil production from Palmers Wood requires identification of areas for secondary recovery. The field comprises two uplifted, tilted fault blocks, separated by a central sealing fault. Integration and interpretation of multi-disciplinary data has provided a new structural interpretation of the field, demonstrating the potential for greater injector-producer communication in the northern fault block. A series of structural explanations are presented to explain fluid baffles inferred by production data and highlight areas that have historically been under-utilised. Recommendations for how to test these hypotheses have been made, including technical workflows using seismic, well and production data, data acquisition and reprocessing. This work demonstrates that the potential to enhance recovery at Palmers Wood remains.

Supervisors: *Saswata Hier-Majumder (RHUL); Rachel Pickering & Eduardo Aguirre (IGas Energy Plc)*

Data provided by: *IGas Energy Plc*

Raqiba Al Tobi

An integrated petrophysical evaluation and facies classification in a heterogeneous carbonate reservoir, onshore UK

Facies classification plays a crucial role in reservoir characterisation. In heterogeneous carbonate reservoirs, defining facies using conventional well log interpretation methods is notoriously challenging owing to spatial diagenetic textures and complex pore system. A new workflow is developed to enable integration of multiple datasets with various scales and resolutions. Classical electrofacies clustering methods are improved by utilising multivariate statistical analysis. Principal Component Analysis is applied to reduce data redundancy, and the K-Means algorithm is then used to cluster the data, with minimal requirement for supervision. Using conventional logs from a key well, this method is applied to generate electrofacies groups which are calibrated to core-based facies from the same well. The electrofacies clustering method was applied to a second well using Nuclear Magnetic Resonance (NMR) and Dielectric Dispersion logs. The predicted electrofacies were then correlated to image facies from the same well. Interpretation of image logs enabled effective integration between the electrofacies classes from conventional logs and core facies. These images provide textural and lithological information that could be directly correlated to similar information derived from core. Seven electrofacies clusters were identified in both wells. These clusters were correlated to six bed-scale image facies. A reliable prediction of the dynamic petrophysical properties of the reservoir facies was achieved from NMR and Dielectric Dispersion measurements. The results can be expanded to predict the dynamic behaviour of the reservoir units across the field including, wells where only conventional logs exist. This can be achieved by calibrating rock classes obtained from conventional logs, to facies predicted from core, borehole images and NMR logs.

Supervisors: *Saswata Hier-Majumder (RHUL); Michel Claverie (Schlumberger); Carole Reynaud (Perenco)*

Data provided by: *Perenco*

Richard Burton

3-D seismic analysis of the Rogaland Group, northern Norwegian North Sea; implications for hydrocarbon prospectivity

The underexplored Rogaland Group in the northern Norwegian North Sea was deposited as a westwards prograding wedge of siliciclastic sediment sourced from Fenno-Scandinavia. Gravity-driven deposition of coarse clastic material in a slope to basin floor environment provides the potential for productive reservoirs such as those present elsewhere in the North Sea. Previous studies have produced chronostratigraphic frameworks and suggestions of sediment geometries, using 3-D seismic and well data. These studies have been focused on a local scale; or undertaken as a broad overview. Advanced attribute analysis within a 30,300 km^2 3-D megamerge seismic cube enables high resolution imaging of depositional and post-depositional sediment geometries and architectures regional scale, beyond those observed in previous seismic studies.

The deposits consist of a mixture of mass transport complexes (20-40 km diameter), lobate fans (1-3 km diameter), sheet fans (20-40 km diameter) and injectites (1 -15 km diameter). Mass transport complexes and gravity wasting are the products of subaqueous erosion related to the unconformable base of the Rogaland group. Submarine fans initially prograded basinwards as the delta front shifted into the available accommodation space, before backstepping as the sequence moved towards a relative highstand. Injectites were triggered by overpressure and seismicity related primarily to tectonic uplift and subsidence events on the basin flanks. Differing depositional and post-depositional processes and stacking patterns have led to a very complex internal architecture within the Rogaland Group.

The work has highlighted the architectural complexity of the Rogaland Group, bringing a chronological explanation to sediment geometries that have, until now, been poorly imaged and understood. This analysis has major implications for hydrocarbon prospectivity, especially towards further understanding of reservoir characterization and trapping styles.

Supervisors: *Ian Watkinson & Jürgen Adam (RHUL)*

Data provided by: *Spectrum*

Oliver Last

Evolution of the submarine gravity flow deposits of the Rogaland Group in the Southern Viking Graben, Northern North Sea

Rogaland submarine gravity flow deposition can be sub-divided into four periods, the Ty, Heimdal, Hermod and Odin deposits. The Ty deposit formed from the margins of the Utsira High onto its flanks. The Heimdal submarine gravity flows sourced from the Shetlands located to the west of the Viking Graben, forming fairly lobate geometries that suggest high density turbidites and potentially debris flows. The Hermod submarine gravity flows also sourced from the Shetlands and show the greatest volume of sediment imaged of the four formations within the Rogaland Group, and were elongate with bird-foot morphology, suggesting low density turbiditic flows. The Odin fan deposition has been masked by the tuffaceous marker beds that deposited at the top of the Balder mudstones and their true extent is unclear. The faulted margins of the Utsira High and the Fladen Ground Spur are buried progressively buried over the Rogaland Group and sedimentation from the Utsira High reduces over time. The evolution of the Rogaland Group is analogous to the Mississippi Delta which transitioned from lobate to elongate in the Holocene.

Supervisors: *Jürgen Adam & Ian Watkinson (RHUL)*

Data provided by: *Spectrum*

Joelle Way

Sills as fractured reservoirs and heat sources for hydrocarbon maturity: a 3-D seismic case study from the Faroe-Shetland Basin

Thick sills are currently functioning as hydrocarbon reservoirs in many sedimentary basins worldwide. They have well-interconnected fracture networks and high permeability, as well as the capability to function either as seals or fractured reservoirs. For this reason, igneous sills are likely to become of significantly greater interest as exploration targets in the coming years. This study focuses on sill emplacement and geometry, the role of sills as fractured reservoirs and seals and their thermal impact on hydrocarbon maturation within a petroleum basin.

Large volumes of intrusive magma were emplaced in the Faroe-Shetland Basin during the Paleocene-Eocene (56-54 Ma) continental rifting and break up in the NE Atlantic. This study used high–quality, 3-D seismic reflection data from the Faroe-Shetland Basin to analyse sill emplacement and their thermal effects in regards to maturity within the basin. Twenty igneous sills within the Cretaceous and Paleocene strata were used in the study. High-amplitude saucer-shaped reflections observed in the seismic data depict igneous sills between 28 m-143 m thick and ranging in diameter from 1153 m-6006 m.

In the Faroe-Shetland Basin, sills greater than approximately 100 m thick would commonly be ideal as fractured reservoirs. Their thickness would indicate that the surround host-rock is most likely matured, therefore hydrocarbons may be present in this basin within the sills themselves, stored up against sill margin contacts or they have migrated to shallower reservoirs.

Supervisor: *Agust Gudmundsson (RHUL)*

Data provided by: *PGS*

Durrah Nafeesah Idris

Hydromechanical evolution of fault zones, with application to sealing effects and reservoir compartmentalization, onshore & offshore Norway

The Halten Terrace, offshore mid-Norway is a major petroleum province holding several fault bounded pressure compartments. These pressure compartments influences maturation, migration and trapping history of hydrocarbons. Compartments are considered high risk with possible seal failure and fluid leakage especially within the highly overpressured western Halten Terrace (RFTs exceeding 30 MPa). Several wells drilled within highly overpressured areas have proven to be devoid of hydrocarbon accumulations. However, recent discoveries have eliminated pore pressures as the dominant control on hydrocarbon entrapment.

This study aims to investigate the effects of NW-SE orientated mid-Atlantic ridge-push compression on the local in situ stress conditions on Halten Terrace. Assessment on whether these stress concentrations and fracture orientation will facilitate local fracture propagation within fault zones thus enabling determination of the extent of fault sealing and compartmentalization.

Numerical modelling of offshore Norwegian fracture network is undertaken to investigate the effects of in-situ stress fields. Fieldwork data from onshore Norway, analytical techniques and well data were integrated to in assessing in-situ stress on the hydromechanical effects of a fault zone.

Results shows that 1) Spatial variation in stress concentration is observed due to intrinsic layering of fault zone with distinct mechanical properties 2) Stress concentration on marginal bounding fractures results in internal faults to be within the 'stress shadow' (low stress concentration) 3) intensified stress concentration and homogenized stress field is necessary for fracture propagation resulting in compartment connectivity. 4) With depth, redistribution of stress is observed due to changing mechanical properties of the fault zone as a result of increased cementation.

Positive correlations can be drawn from these numerical models with hard data such as dry hole analysis. Multivariate testing of lateral fault seal is crucial in understanding fault seal risk, a necessary step during exploration phase. Therefore, numerical modelling is an advantageous supplement in de-risking lateral seal capacity.

Supervisor: Agust Gudmundsson (RHUL)

Data provided by: Norwegian Petroleum Directorate

Rosina Maslin

Uralian versus Caledonian sedimentary sources and the impact on Triassic clastic reservoir quality on the Barents Shelf

Located east of the Norwegian and Greenland seaway and west of Novaya Zemlya, the Barents Sea is a prolific hydrocarbon province which has yielded great success. Investigations are necessary into what variables influence reservoir quality in order to produce successful world class reservoirs such as the Fruholmen, Sto and the Kobbe. If we understand how environment and tectonics influence reservoir quality, is it possible to successfully predict where these optimum reservoirs are deposited? Focusing on the Triassic Kobbe and Snadd formations and how depositional environment impacts formational thickness variations, compositional content and porosity and permeability, it is determined that depositional environments and ultimately reservoir quality is strongly influenced by provenance.

Supervisors: *Saswata Hier-Majumder (RHUL); Helen Smyth (Halliburton)*

Data provided by: *Halliburton STEPS*

Aisyah Nordin

Hydrocarbon prospectivity evaluation of the Domo Sandstone in the Sofala Block, Mozambique

The Sofala Block is part of the prolific Mozambique Basin, located approximately 7 km east of Mozambique in water depths < 200 m. Gas production from the Pande and Temane fields within the basin and recent giant discoveries from other nearby basins make the area more attractive for new exploration venture.

Previous exploration focused on the Maastrichtian Lower Grudja Formation where the current production level is. Now the exploration target is expanded to include the underexplored Senonian –Turonian Domo Sandstone Formation, a slope marine fan reservoir that was deposited during a short regression time interval. Thick and homogeneous shale of Upper Domo Shale Formation that conformably overlies the reservoir is expected to be a sufficient top seal for any potential leads or prospects. Two trap styles are identified in the area: fault dependent, three-way dip closures, and up-dip pinching-out stratigraphy. Reservoirs at this level have a good chance of being charged by hydrocarbons, as they are located directly above matured source rock, the Lower Domo Shale Formation. Migration of hydrocarbons into these traps is expected to occur through deep seated faults and along permeable beds. Potentially, shale smearing along the fault and sand to shale juxtaposition will be the mechanism for lateral seal.

Five leads have been identified based on sparse 2-D seismic data interpretation and amplitude anomaly analysis. Four out of five are structural trap: Sofala West 1, Sofala West 2, Nemo North West and Nemo West. While the other is Sofala East Strat, a stratigraphic trap identified by a strong amplitude anomaly. Trap integrity and effectiveness is the main risk for each leads, secondary risks include timing and migration. Results from risking analysis and ranking indicate that the stratigraphic lead has the highest possibility of success at 20%. Prospective resources for the Sofala East Strat lead is estimated at a mean volume of 7.4 TCF GIIP (200 Bil m^3) - a high risk, high reward lead.

The Sofala Block has moderate hydrocarbon exploration potential. It is a proven working petroleum system, although some elements remain poorly understood. Further analysis on attribute analysis and migration pathways needs to be done to reduce the uncertainty in these leads.

Supervisors: *Ian Watkinson (RHUL); Sarah-Jane Kelland (ERCL)*

Data provided by: *ERCL*

Alex Onianwa

Prospectivity evaluation of the Domo Sandstone, Njika area, South Mozambique Basin

Recent discoveries of multi-trillion cubic feet of gas accumulations offshore Mozambique in the Rovuma basin has resulted in Mozambique becoming a new frontier hydrocarbon exploration location. Results from this study indicate paleoslope controls deposition and distribution the poorly penetrated slope - basin floor fan turbidites (Domo Sandstone Formation) offshore in the central part of the Mozambique basin. Prospect definition via AVO analysis, 3-D seismic interpretation and 3-D reservoir deposition modelling allows identification of three fan shaped, stratigraphically trapped, high impedance gas bearing sands (Class I) within the formation. Areal extent of stratigraphic trap is the main risk as trapping is believed to form as a result of temporal and spatial variation in facies.

Supervisors: *Ian Watkinson (RHUL); Sarah-Jane Kelland (ERCL)*

Data provided by: *ERCL*

Joshua Ssuubi

Structural analysis of the Pakwach Basin, Albertine Graben, Uganda

This study examined the structural setting and evolution of Pakwach Basin, Albertine Graben. The dominance of the structural hydrocarbon trapping in the discoveries made to date implies that the structural setting has contributed greatly to hydrocarbon accumulation in the area. Interpretations of the structural setting and its evolution were made from seismic cross sections, surface and attribute maps for Middle Miocene to Pleistocene times that were generated using both 3-D and 2-D seismic data. The seismic data are consistent with the existing knowledge of the two troughs (Pakwach and Pokwero) that are bounded by the Pakwach-Panyimur, Rubi and Twol faults. The results have shown that the Pakwach basin has an asymmetric half graben geometry and has undergone an Early Miocene extension event, like it is documented to have affected the entire Albertine Graben during its initiation. This tectonic regime is typified by NE–SW and N-S trending fault patterns that have cut both the Pre-Cambrian basement and the overlying sedimentary packages forming horst and graben structures. In addition, the results provide evidence for the dying out of some NE-SW trending faults with the N-S fault trend taking over particularly between the two troughs that are separated by a structural high. These could represent a zone of accommodation, or transfer zone, where extension could be transferred across the basin.

A later en-echelon array of NNW– SSE trending faults is noted during Late Miocene. The extension episode was followed by a subtle inversion during Late Pliocene to Pleistocene that has been interpreted to result from the oblique reactivation of Miocene-Pliocene fault pattern as transpressive structure due to the rotation of the extensional vector.

These relatively low-angle separated fault trends (NE-SW and N-S), interpreted to be coeval, have formed some narrow structural nose at their convergence location that ensures the trapping of hydrocarbons where faults are potentially sealing faults; controlled by throw amount and/or clay smearing.

Supervisor: *Saswata Hier-Majumder RHUL)*

Data provided by: *Petroleum Exploration Development and Production Department (PED&PD),*

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Sascha Roest-Ellis

Evolution of the Albian and implications for prospectivity - Greater CI 513 Area, Ivorian Basin, Cote d'Ivoire

The poorly understood western Ivorian basin in deep-water, offshore Cote d'Ivoire is in the early stages of frontier exploration. Two wells; Saphir-1XB (Total) and Morue-1X (Anadarko) have proven working petroleum systems in the study area; however Rubis1X (Total) drilled 2 km from Saphir-1XB was dry. Seismic reflection and well data were analysed, supported by potential field data, and analogues to investigate the complex poly-phase evolution of the Albian. This is pivotal to understanding subsequent petroleum systems in the Albian and used to address questions around prospectivity of the greater CI-513 study area held by Ophir Energy. The important findings presented from this research include:

I. The identification of east-west extension and dextral-transform-fault structural regimes. The interaction between these regimes creates three different crustal types within the study area; Crust-1) hyper-extended-continental-crust; Crust-2) exhumedcontinental-mantle to hybrid-proto-oceanic-crust and Crust-3) attenuated-extendedcontinental-crust with locally necked lithosphere and upwelled mantle.

II. A high geothermal gradient (calculated at 41°C), and modelling provides evidence for a probable high palaeo and present-day heat-flow.

III. Maturity maps demonstrate the position of active source rock kitchens consistent with the presence of hydrocarbons identified at Saphir-1XB.

VI. 3-D seismic interpretation and dataset integration indicates the geodynamic history of the Albian; the margin evolved from a magma-poor hyper-extended margin to a margin with an increased magma supply where the St. Paul's Fracture Zone (FZ) intersected and offset hyper-extended crust. Lithospheric shearing, mantle upwelling and adiabatic decompression resulted in mantle melting, magmatic intrusions, and also triggered extrusive volcanism.

iiV. Three source rocks are identified in the Albian, and three reservoir facies are inferred and subsequently three new structural-stratigraphic play concepts are proposed; which have access to a possible Albian source and a regional Upper-Albo-Cenomanian seal.

This research has significant implications for prospect identification and current exploration of deep-water Cote d'Ivoire and more regionally for the West-African-Transform Margin. The study may also give insight into the evolution of the conjugate Barreirinhas and Pará-Maranhão basins of Brazil.

Supervisors: *Saswata Hier-Majumder RHUL); Stephen Wood & Par Malmborga (Ophir Energy Plc)*

Data provided by: *Ophir Energy Plc*

Glenn Morley

Optimising seismic visualisation and the influence of geophysics on complex structural analysis: Thali Block, Rio del Rey sub basin of the Niger Delta, shallow offshore Cameroon

The Rio del Rey is an eastern sub basin of the prolific Niger Delta petroleum system, shallow offshore Cameroon, and has been explored, as has the Niger Delta, for the last 50 years. The Thali (formally Dissoni) block sits over the Rio del Rey basin, and is currently (2015 onwards) owned by Tower Resources Plc (London - UK) but previously owned by oil majors Elf, Shell, TOTAL and others with 4 failed attempts at finding commercial quantities of hydrocarbon since the late 1960's.

The interplay of geophysics and geology, technology and breakaways from traditional interpretation methods, is shown to lead to a better understanding of the structure and evolution of this massively complex mobile shale / toe and thrust area on Thali block, which will ultimately lead to a better understanding of the petroleum system and identifying reservoirs and traps. An interesting initial attempt of this is shown by a combination of two components: (1) A relatively new and exciting interpretation software (Eliis Paleoscan™) that rapidly picks ALL horizons in a 3-D seismic cube automatically, creating an initial 3-D 'Relative Geological Time Model' (3-D GeoModel™) and then allows rapid iterative updates to that model from user picked faults and partial surfaces. (2) The use of heavy high cut filtering (data conditioning) allowing for better visualisation of the structure in the seismic as well as helping the PaleoScan™ software to create the 3-D GeoModel™ in areas of poor signal-to-noise.

This then leads to multiple convincing interpretations and helped to locate the major thrust sheets in the deep overpressured Akata shale formation as well as shallower formations. The post-stack geophysical filtering method mentioned above suggests the 1990's seismic data has not reached its full potential due to non-optimum pre-stack sequences which will, once improved, ultimately lead to even better imaging and thus better interpretation and prediction of the location of hydrocarbons in the sub-surface.

Supervisors: *Ian Watkinson (RHUL); Paul Bellingham (PDF Ltd)*

Data provided by: *PDF Ltd UK*

Alexander Kurobasa

The impact of Cretaceous volcanism on the hydrocarbon prospectivity of the North Gabon Basin using broadband 3-D seismic and potential field data

This study focuses on understanding the timing of volcanism in the North Gabon Basin and its effects on hydrocarbon prospectivity. The deepwater area of the North Gabon Basin is underexplored and recent exploration wells have proven that the prolific hydrocarbon province of the Ogooué Delta does not extend this far offshore, owing to the complexity of the geodynamic history of the area. Analysis of potential field data provides a regional structural framework and the position of the continent-ocean transition to be established. Interpretation of a 3-D seismic survey supplied by Ophir Energy allowed identification of intrusive and extrusive events that punctuate the syn-rift and post-rift stratigraphy, along with the origin and timing of the enigmatic Loiret High pluton. Dry hole analysis of the Affanga Deep-1 well shows poor source rock characteristics in the Turonian source rock, which is prolific in the Ogooué Delta region and across the South Atlantic. The presence of a lower thermogenic source interval alludes to the presence of an Albian source rock interval located stratigraphically above the seaward-dipping reflectors in the area, which is prolific in the conjugate Sergipe-Alagoas Basin. Spectral decomposition analysis has allowed definition of Miocene submarine channels in the area and offer a new fairway for exploration, which focuses on large turbiditic complexes forming a series of confined to semi-confined stacked channels, providing the integrity of an effective seal and migration pathways. Volcanism has limited effects on the level of maturity of source rock intervals, however reservoir provenance and diagenetic overprint of the stratigraphy in the area are key considerations to take forward for hydrocarbon prospectivity.

Supervisors: *Agust Gudmundsson & Bernie Vining (RHUL); Will Parsons (Ophir Energy Plc)*

Data provided by: *Ophir Energy Plc*

Selma Usiku

Morphology of deepwater clastic systems within the Petroleum Exploration Licence Area 30 along the northern margin of the Walvis Basin, offshore Namibia

Deepwater clastic hydrocarbon plays have gained exceptional interest in recent years and the Namibian offshore margin remains one of the few frontier regions with untapped potential. This study aims to characterize the morphology and distribution of the main Cretaceous siliciclastic depositional systems along the Northern margin of the Walvis Basin, offshore Namibia. The elongate SSE-NNW trending Walvis Basin is bounded to the North by the Volcanic Walvis Ridge and attributes its wedge-shaped post rift succession of Early Cretaceous to recent sediments to a prolonged history of rift related volcanism, subsidence, uplift and denudation.

Based on amplitude anomalies and sequence stratigraphic principles two main gravity flow dominated depositional systems are defined; a distal lobate fan system averaging 165 km^2 and a sinuous amalgamating slope channel complex dominating the NE-SW length of the 3-D survey area. The use of seismic facies analysis has proved vital in decoding the paleo depositional environment while a variety of seismic attributes greatly enhanced the visualization of features identified from seismic interpretation. The study presents conceptual sedimentary models to account for the distribution of these Cretaceous turbidites.

Supervisors: *Nicola Scarselli & Bernie Vining (RHUL)*

Data provided by: *Azinam*

William Yancey

Extensional fault architecture and the 4-D evolution of the outer Beagle Sub-basin, NW Shelf, Australia

The outer Beagle sub-basin is a Mesozoic rifted depocentre covering approximately 30,000 km^2 and situated in the eastern margin of the Northern Carnarvon Basin in the North West Shelf of Australia. The outer Beagle Seismic represents the structural transition between the Beagle Sub-basin and the Exmouth Plateau.

Structural analysis the Canning TQ3D survey reveals four distinct extensional fault populations in the Neogene to Triassic units: (1) Triassic to Upper Jurassic north-south trending faults formed during the syn-rift phase (2) non-colinear Triassic to Upper Jurassic northeast-southwest trending normal faults (3) Lower Cretaceous to Middle Miocene nontectonic polygonal faults formed during the passive margin phase and (4) Neogene en echelon conjugate faults formed during the passive margin phase.

Detailed fault analysis was undertaken to evaluate the complex interconnected fault network in the study area by examining the geometric, connectivity and displacement relationships of the complex extensional fault networks in the survey to further refine the interpretation of the study area's structural evolution. Results demonstrate a complex interconnected extensional fault network characterised by multi-directional cross-cutting fault traces and rhomboidal architecture.

Supervisors: *Ken McClay & Nicola Scarselli (RHUL)*

Data provided by: *Geoscience Australia*

Jonathon Tracy

The tectonostratigraphic evolution of the Malita Graben and implications for hydrocarbon prospectivity

The Malita Graben is a sub-basin complex belonging to the North West Shelf of Australia; a world-class hydrocarbon prospective area. The development of such a region spans 350 million years of extensional and collisional tectonics that initiated with the break-up of the Pangean supercontinent, ultimately giving rise to the shallow marine shelf seen today. This thesis primarily aimed to complete a comprehensive structural restoration through 2-D seismic interpretation, integration of well log data, facilitated by the mapping of key megasequence horizons across the basin.

Fault set analysis, horizon maps and isochron thickness images depict an extensional basin forming at the height of the Jurassic and into the Early Cretaceous, evident from syn-kinematic growth strata and fault displacement interpretation. This expansion occurred in the style of several NE-SW trending sub-basins developing at different rates; the inboard half-grabens were most active relatively. Passive extensional margin settings dominated through the remainder of the Mesozoic, providing a decoupling surface for collision-related faults of the Neogene.

Exploitation of underlying fault systems occurs throughout the Malita Graben's history, with significant implications on hydrocarbon play stability. Identification of a potential lead toward the southern boundary of the region possesses all the characteristics and elements of a prospective hydrocarbon prospect.

The tectonic evolution of the Malita Graben leads to vast future exploration potential, with an abundance of Jurassic source rock and significant structural trapping likely.

Supervisors: *Nicola Scarselli & Ken McClay (RHUL); Mike Cottam (BP)*

Data provided by: *BP*

Benedict Hughes

Insights into the tectono-stratigraphic evolution of the Exmouth Plateau (NW Shelf of Australia) using the Claudius 3-D survey

As hydrocarbon exploration in the highly prospective Northern Carnarvon Basin edges toward the furthest reaches of the continent-ocean boundary, understanding the structural architecture and evolution of sites become of huge economic importance.

Inherited fabrics exert a fundamental control on the tectono-stratigraphic evolution of the outboard Exmouth Plateau. Using recently acquired, outstanding quality 3-D seismic this study analysed the Claudius 3-D Survey in the southwestern p art of the Exmouth Plateau.

The Claudius survey provided spectacular imaging of the principal ~N-NNE trending, heavily segmented half-graben border faults that formed during Triassic to Cretaceous breakup of Eastern Gondwana and subordinate ~NNW internal faults. The investigation involved thorough quantitative and qualitative seismic analysis of structural and stratigraphic elements to construct a 4-D evolutionary model and assess the hydrocarbon potential of the study area. Seismic facies analysis of Triassic strata highlighted several stratigraphic elements including structurally controlled isolated carbonate reef structures in the west of the survey, igneous intrusions and fluid escape structures. The Late Triassic reef structures represent an exciting, new hydrocarbon play on the outboard Exmouth Plateau.

Detailed structural analysis using amplitude extractions of the four major megasequences reveal the major control underlying 'pre-existing' fabrics have on Mesozoic and Cenozoic sequences. The proximity of the Claudius survey to the incipient Cape Range Fracture Zone during asymmetric rifting of Australia and India formed a unique structural trend oriented oblique to that of the regional. This study proposes potential causes for this local extension direction change; however further analysis of internal fault orientations along the Cape Range Fracture Zone is required to confirm them.

This project highlights several structural and stratigraphic elements of varying risk within Triassic prospective play targets. With a proven petroleum system present in the area, the economic viability of exploration in such an outboard area, far from existing infrastructure appears, to be the major obstacle to hydrocarbon extraction.

Supervisors: *Ken McClay & Nicola Scarselli (RHUL)*

Data provided by: *Geoscience Australia, FDRG*

Peter Harrison

Structural style and evolution of the Timor Trough accretionary wedge system, NW Australia

The Timor Trough symbolises the tectonic collision zone between the Banda Arc Terrane and the northern Bonaparte Basin of the North West Shelf of Australia. The boundary is defined by a complex configuration of interacting extensional and contractional structural elements which are pinpointed around an accretionary wedge complex. The structural style and evolution of this collision zone has been long debated.

Cutting-edge depth migrated 2-D broadband seismic data across the eastern trough is critically analysed to gain new insights into the behaviour of the colliding systems. This is achieved by characterising the coexisting structural features and constructing 2-D and 3-D evolutionary models.

Three ENE-WSW trending extensional fault populations within the Bonaparte Basin sequence, together with the southeast verging imbricate thrust population of the Timor accretionary wedge, have been directly related to the breakup of eastern Gondwana and diachronous arc-continental collision. The accretionary wedge itself presents characteristic along strike variations in the structural arrangement, from basinward gravitational collapse to closely spaced imbricate thrust stacks. These can be modelled based on the critical state of the wedge and the influences of syn-kinematic sedimentation. These dramatic changes in the geometries of the colliding systems along strike have a profound effect on the source rock functionality within the study area, and allow the identification of two potential petroleum systems.

Supervisors: *Ken McClay & Nicola Scarselli (RHUL); Steve Toothill (CGG)*

Data provided by: *CGG*

Adi Patria

The origin and significance of the Seram Trough, Indonesia

The Seram Trough is situated in a complex area where convergence between the Eurasian, Indo-Australian and Pacific plates has been active since the Late Oligocene. It has been interpreted as subduction trench and a deformation front of intra-plate shortening and strike-slip zone. Many studies have been conducted in the Banda Arc, especially the Seram Trough, focusing in geological evolution and model but the nature of the boundary remains enigmatic. The new high resolution multibeam bathymetry and seismic data in this study offer an opportunity to assess different hypotheses related to the character and significance of the Seram Trough. The offshore interpretation was then linked with onshore structure to understand relationship between deformation in Seram Island and the Seram Trough. Modern earthquakes and GPS observations were also analysed to understand the present-day tectonic activity. Only few earthquakes were observed at the trough and the north of the trough is almost aseismic. The study area can be divided into two discrete regions based on its deformation style. (1) The Offshore Seram Region is characterized by E-W to N-S thrust faults and folds with influence of strike-slip faults and (2) the Buru Basin is dominated by E-W extensional faults. The Seram Trough is a deformation front in front of fold thrust belt resulting from an oblique convergence between the outer Banda Arc and Bird's Head of New Guinea. The Buru Basin is not a continuation of the Seram Trough. The study area can be sub-divided into five tectonic deformations: (1) continental-oceanic transition and (2) oceanic crust formation in Buru Basin, (3) oblique convergence in the south and west of the trough, (4) subsidence and tilting in the north the trough and Kai Arch, (5) basin opening in the east of Kai Arch. Contraction in the Late Miocene has folded and formed MOKR then followed by formation of Early Pliocene Unconformity. The development of the Seram Fold Thrust Belt has begun since Late Pliocene. Thrusting in Seram has increased crustal loading and caused subsidence and tilting to the north and east of the trough. Thrusting at the trough started in the Late Pleistocene. The fold thrust belt zone is narrower in the west and widens to southeast. Later deformation is strike-slip faulting. In the north of west Seram, left-lateral strike-slip faults indicate that the trough is beginning to develop into Buru Basin.

Supervisor: *Robert Hall (RHUL)*

Data provided by: *TGS & GDV*

Isaac Kenyon

Tectonostratigraphy and inverted fault architecture of the Taranaki Basin, offshore New Zealand, using the Maari 3-D Survey

The Maari Field is a large oil and gas field located in the Southern Inversion Zone of the southern Taranaki Basin, New Zealand. The field is bounded by two major structures, the Eastern Mobile Belt and Western Stable Platform and produces 40,000 BOPD (Barrels of Oil per Day) from reservoirs in the Moki Formation. The field is distributed along the southern and central Taranaki shelf. 3-D seismic data and well logs were recorded by the Geco-Prakla Company and provided for analysis of the tectono-stratigraphic evolution of the Taranaki Basin, a sub-basin within the New Zealand region. The Maari Field contains in excess of twenty faults that all play an important role in petroleum systems of the Taranaki Basin. Faults in this structurally complex region act as both barriers and conduits to the flow of hydrocarbons. An understanding of the relationship between fluid and gas migration and accumulation with faulting is often required during hydrocarbon exploration and production, and CO_2 storage.

Supervisors: *Ken McClay & Nicola Scarselli (RHUL)*

Data provided by: *Geoscience New Zealand*

Vienna McAndie

Can the proven Neogene deep marine sand reservoirs in the Taranaki Basin be successful in the southern part of the Northland Basin, New Zealand?

The Northland Basin, located offshore northwest New Zealand is the relatively underexplored northern extension of the Taranaki Basin. The two basins are separated by a northwest-southeast trending regional high known as the West Norfolk Ridge. As the Taranaki Basin is a proven petroleum province with 22 successful producing fields, there is growing interest in the prospectivity of the basin directly to the north. Five wells have been drilled in the Northland Basin since 1988, targeting potential Pliocene, Miocene, Eocene and Cretaceous reservoirs. One of these encountered a sub-commercial biogenic gas discovery and another encountered minor biogenic methane shows in a younger unit than the target; the other three wells were dry.

There has been extensive volcanism in the basin over the last 23 million years which could be a significant risk to reservoir potential. This study aims to understand the regional tectonic and local magmatic events that have shaped the Northland Basin to evaluate the quality of the Neogene deep marine sandstones and assess the possibility that these could be prospective.

Two Neogene deep marine sands have been identified as potential exploration targets due to their expected high quality reservoir properties. The sources of both formations are inferred to be more distal, resulting in cleaner sands and their depocentres are located away from major active volcanism. The timing of deposition was within the late Miocene to Pliocene and so they have experienced minimal burial, preserving primary porosity and retaining good reservoir quality.

Supervisors: *Javier Hernandez-Molina (RHUL); Helen Smyth, Stefanie Clayton & Graeme Nicoll (Halliburton)*

Data provided by: *STEPS, Halliburton-Landmark*

Jun Sasamura

Late Miocene to present-day sedimentary stacking patterns in the Algarve basin (south of Portugal): implications for hydrocarbon exploration

The Algarve basin and other surrounding Neogene basins have undergone a very complex geodynamic evolution since the Late Miocene. This is associated mainly with the ~50 km of convergence between the Eurasian and African plates that has occurred during that period (Dewey *et al*., 1989). The complexity of this period is not only influenced by tectonic activity, however. Climatic, eustatic, and oceanographic processes have been prevalent, creating the diverse depositional systems that we see in the basin today. These include downslope (turbidite, mass transport deposits), along slope (contourite), and mixed (along-downslope) systems. The main objectives of this project are to understand the sedimentary stacking patterns of the Late Miocene to present day successions, while considering the tectonic and oceanographic processes that formed them. Understanding these processes will aid in developing a sedimentary model for the Algarve Basin and its implications on hydrocarbon prospectivity.

Supervisor: *Javier Hernandez-Molina (RHUL)*

Data provided by: *REPSOL, TGS & IODP*

Jamie Beagle

Late Miocene to present-day stratigraphic evolution of the Alentejo Basin (SW Portugal): conceptual implications for hydrocarbon exploration

This study documents the tectono-stratigraphic evolution of the Alentejo basin (SW Iberian margin) from the Late Miocene to present with a focus on the conceptual implications for hydrocarbon prospectivity. The area is relatively under-studied; however data quality is extremely good, showing clearly the continuity of seismic reflections and their geometry, thus allowing a good analysis to be carried out both in shallow and deep morphological provinces.

The basin is largely the consequence of multi-phased rifting during the Mesozoic. However much of the basin morphology is influenced by slope gradient, the opening and closing of oceanic gateways, sediment supply and lastly, neotectonic features which create physiographic barriers to the flow of bottom currents.

Similarly, during the Pliocene-Quaternary, glacio-eustatic variations led to a distinguishable overprint on the Neogene structure. This overprint has caused several morpho-sedimentary and stratigraphic features, including erosion of the continental shelf and coastal areas, progradation of sedimentary bodies onto the shelf edge and upper slope and also incision of major submarine canyons and gullies on the continental slope.

A mixed system sedimentary model takes into account the interaction of sediments deposited along slope due to bottom currents, in conjunction with downslope gravitational processes and sediments deposited by vertical pelagic settling. This has implications for the hydrocarbon reservoir and seals.

Supervisor: *Javier Hernandez-Molina (RHUL)*

Data provided by: *REPSOL, TGS & IODP*

Sataphon Suklap

Microfacies analysis of turbidites and sandy contourites from the Lefkara Formation, Cyprus: sedimentary characteristics and reservoir implications

The Lefkara Formation, Cyprus, was deposited as a carbonate succession in a deep-sea environment. It was controlled by various types of sedimentary processes; bottom currents, turbidity currents, and pelagic settling. To better understand the different features of each deposit, the investigations of microfacies characteristics are employed for this project. The diagnostic criteria that are used for classifying microfacies are mainly based on limestone classification, sedimentary structure, and their composition. Petrographic results reveal two major type of microfacies with distinctive sedimentary structures; microfacies with bands and microfacies without bands. It can be interpreted that the banded microfacies which lack mud matrix were reworked and winnowed by bottom currents. The free band microfacies with shallow marine materials were likely to have been influenced by turbidity currents. In addition, porosity was determined in terms of potential reservoir implications. The pore volume was directly measured from rock samples. Porosity types were observed from the thin section samples. The laboratory result revealed good porosity in each rock sample and the thin sections also exhibited good connection between grains. Considering all components: microfacies characteristics, porosity, together with the lateral continuity of contourite and turbidite beds, the Lefkara Formation is a good candidate for a potential reservoir.

Supervisors: *Javier Hernandez-Molina (RHUL); Heiko Huneke (Greifswald University, Germany)*

Data provided by: *Contourite Group*

Brian Docherty

From hemipelagic deposits through silty to coarse sandy calcareous contourites (Lefkara Formation, Cyprus): Implications for hydrocarbon exploration.

Sandy contourites are vast deposits that may have the potential to become economically viable deep sea plays of the future but are poorly understood as interpretation of all contourites in the sedimentary record is problematic. A lack of preserved sedimentary structures in ancient outcrop can cause ambiguity in identifying sandy contourites whilst finer grained contourites are very difficult to distinguish from other deep sea sedimentary units due to similar characteristics. A microfacies study of the Lefkara Formation in Petra Tou Cyprus, analysing seventy seven thin sections is made to further the research into their identification and key petrophysical properties.

Seven microfacies identified range from hemipelagic muds through to turbidites and sandy contourites. Reworking and winnowing of turbidites and hemipelagites in conjunction with a change in bottom current velocities and pelagic sedimentation has been interpreted. Density of planktonic foraminifera species whose inclusion has been key to a new technique to separate hemipelagic muds from muddy contourites appears to control grain size. Porosity values in excess of 10% are found in the calcareous sandy contourites localised in discreet bands not conforming to the current characteristics within the present standard contourite depositional model. Exploration within nearby frontier regions such as the Levantine Basin may prove to be worthwhile targets if these characteristics are replicated. It is possible that these may have been affected by the same hydrodynamic regimes and have vast sand bodies capable of hosting economically viable volumes of oil and gas

Supervisors: *Javier Hernandez-Molina (RHUL); Heiko Huneke (Greifswald University, Germany)*

Data provided by: *Contourite Group*

Viet Son Tran

Evolution and karst development in a Paleozoic carbonate platform

The Pre-Caspian Basin is a palaeo-depression located in the western part of Kazakhstan and Russia, bounded by the Palaeozoic carbonate platform of the Volga-Ural province to the north and west, and by Hercynian fold belts to the east and south. The basin hosts one of the largest hydrocarbon reserves in central Asia, principally within the excellent reservoirs of the Upper Devonian-Lower Permian carbonate platforms on the basin margins. The aim of this study is to understand the evolution of a carbonate platform in the northern portion of the Pre-Caspian Basin with particular attention on the processes of karstification in the Early Permian that, whilst enhancing the characteristics of potential carbonate reservoirs, may also result in complex fluid flow regimes more difficult to predict.

Modelling of the platform evolution and controls on karst development are addressed through seismic interpretation in conjunction with seismic attribute-based morphological analyses. Isopach and attribute maps show that platform transformation was driven by the development of margin build-ups, and the palaeokarst surface comprised three morphological zones, characterised by unique feature classes, with some influence by structural lineations.

The platform is proposed to have evolved from an Upper Devonian carbonate to an Early Permian carbonate rimmed shelf, before the Kungurian subaerial exposure caused by the isolation of the Pre-Caspian Basin from the Tethys led to intensive karstification. Analogues suggest that karst development was controlled by facies distribution, substrate lithologies and fracture networks, with high fracture-related permeability predicted for the platform margin. The results of this study have a positive impact on the understanding and reduction of the uncertainty associated with behaviours of fluid flow within karst-related structures, and provide valuable geological inputs for future reservoir characterisation and modelling. Similar regions of limited data that have hydrocarbon potential within karstified carbonate reservoirs can also benefit from the approach of this research.

Supervisors: *Nicola Scarselli (RHUL); Alberto Riva & Paolo Pace (GEPlan Consulting S.r.l., Italy)*

Data provided by: *GEPlan Consulting S.r.l.*

Daniela Vendettuoli

What is the depositional and architectural signature of repeated turbidity current activity? New insights from the most extensive dataset yet recorded

Turbidity currents transport large amounts of sand to deep-water, typically via submarine channels. Their deposits ('turbidites') host significant reserves of hydrocarbons worldwide. Understanding the stacking pattern of turbidite channel-fill and spatial trends in grain size is important as they are major controls on reservoir connectivity and quality. However, conventional data such as seismic data and outcrops are often limited in their resolution. Hence numerical models are employed to understand these systems more holistically and to reduce drilling risk. But are the initial conditions that are set appropriate for forward modelling? This has been difficult to answer as few field-scale studies exist to sufficiently calibrate such models.

In this study, a unique data set is analysed to provide the first field test of turbidite channel stacking patterns using direct monitoring of turbidity currents. Ninety-three daily high resolution seafloor surveys were performed at the Squamish submarine delta in British Columbia providing evidence of >100 turbidity currents within three submarine channels. First, difference maps were generated to determine the change between successive days. Second, an algorithm was developed to build a stratigraphy from repeated surveys to account for aggradation and erosion effects. Third, stratigraphic profiles were constructed for cross-channel and along-channel sections, to understand the lateral and vertical variations in stratigraphy for the entire turbidite system. The results of this study sees the proximal part of the slope featuring complex laterally offset channel-infill packages, in a predominantly erosive regime with very low preservation potential. In the mid-slope, aggradation is more common, with increased preservation potential in on-axis locations. Distal lobe locations are dominated by aggradation. Cyclic step bedforms within the channel axes are expected to be associated with high lateral variations in grain size. The analysis of the derived stratigraphy also proved the high variability of stacking patterns over the length of the channels, implying a high variability of the reservoir distribution and connectivity which may lead to the risk that facies at the base of channels may act as permeability barrier. Direct monitoring of dataset, such as the one performed at Squamish Delta, may provide new insights into the characterisation of turbidite deposits for hydrocarbon exploitation.

Supervisors: *Dave Waltham (RHUL); Mike Clare, Matthieu Cartigny & Peter Talling (NOCS, Southampton)*

Data provided by: *NOCS, Southampton & University of Hampshire, USA*

Christina Nadeau

The structural and tectonic influences of the Sweetgrass Arch on the Lower Paleozoic formations in the Knappen area, SE Alberta: Significance for hydrocarbon exploration

The aim of this project is to investigate the structural and tectonic influences of the Sweetgrass Arch in the Knappen Area of SE Alberta and discuss the implications for future hydrocarbon exploration in the Lower Palaeozoic formations. This has primarily been done using wireline log data and producing schematic models which show the structural evolution and depositional patterns at the target intervals. On the basis of isopach and structure maps, local fault patterns have been interpreted; resulting in identification of NW-SE trending normal fault sets. Furthermore, intervals of particular interest for exploration have been highlighted based on porosity. Paleozoic fault orientation correlates with regional basement extension faults, indicating reactivation of a pre-existing structural regime. These findings have implications for prospectivity in the Knappen Area, particularly migration of hydrocarbons via fault pathways from flanking basins and trapping in tilted fault blocks.

Supervisors: *Agust Gudmundsson (RHUL); Jody Smith (Natural Gas and Petroleum Resources)*

Data provided by: *Natural Gas & Petroleum Resources*

Christopher Graham

Structural evolution of offshore Newfoundland and comparison to its conjugate Iberian margin

The rift basins situated along the magma-poor passive margin offshore Newfoundland, Canada, have been prolific exploration targets in recent decades, with interest along the margin growing to date. This is matched by increasing exploration along its conjugate Iberian margin, with both margins being subject to multiple stages of rifting throughout the Mesozoic and Pangaea breakup.

Utilising regional 2-D seismic reflection profiles and two Ocean Drilling Program drill sites to interpret pre-, syn- and post-rift horizons, this study focuses on the Newfoundland margin's evolution by identification of key rift geometries and geological features to better understand the North Atlantic rift system. Characterisation of different crust types along regional lines reveals variations in extension and segmentation of the margin, which are compared to regional lines of the northern Iberian margin. These findings are then compared to the conjugate Iberian margin to reveal similarities and differences in the rift system, and also explore the possibility of a deepwater petroleum system.

Supervisors: *Nicola Scarselli (RHUL); Raffaele Di Cuia & Angelo Ricciato (GEPlan Consulting S.r.l.)*

Data provided by: *GEPlan Consulting S.r.l.*

Tra-Mi Lam

Petroleum system modelling of the deep-water Salina del Istmo Basin, Gulf of Mexico

The Salina del Istmo Basin is a prolific oil and gas province in Sureste basin, southern Gulf of Mexico. The basin offers a large amount of undiscovered reserves ranging in water depth up to 3500 m. The Salina del Istmo Basin is a geologically complex area, having undergone Jurassic rifting and compressional events from the Paleocene through to the Miocene. Another element to this evolution is the presence of Callovian autochthonous salt and allochthonous salt. The combination of compression related features and salt creates numerous styles of plays. On the sea surface there are several seeps/slicks relating to hydrocarbons leaking from breached traps below the seabed. In order to understand the potential of these accumulations of hydrocarbons, interpretation of a 2-D data set and 1-D basin modelling establishes the relationship between hydrocarbon expulsion and trap preservation. Hydrocarbon expulsion from a Tithonian source rock occurred during the Eocene and continued until the present day. This relationship shows that the Miocene to present day traps are still being charged but due to active tectonics, many of the anticlinal structures above salt are at risk of seal breach and these tie with the seep data.

Supervisors: *Nicola Scarselli & Jürgen Adam (RHUL); Aruna Mannie & Tom Kenison (Premier Oil)*

Data provided by: *Premier Oil*

James Forbes

Hydrocarbon prospectivity analysis of the Miocene sands in the SW peninsula of Trinidad

The SW peninsula of Trinidad is within the north-eastern South American geological province, this is one of the most prolific oil habitats in the world. Analysis of seismic, well and full tensor gravity surveys reveals the complex tectonostratigraphic evolution and petroleum prospectivity of prospective Miocene reservoir sands. Miocene slope through to deltaic environments led to the deposition of Mid Miocene Herrera Fm. and Late Miocene – Early Pliocene Cruse Fm. prospective reservoir sands. Thrusting in the region, which initiated in the Mid Miocene due to the eastward movement of the Caribbean plate, created fault propagation fold traps within the Herrera Fm. whilst Recent normal faults and stratigraphic traps are found within the Cruse Fm. The transpressional regime gave rise to mud volcanism in the area which had an impact on the prospectivity by providing conduits for hydrocarbon migration. A new model for the formation of the Erin Syncline is also proposed in the form of a pop up basin as a result of over steepening of the original Los Bajos Fault causing underthrusting. Herrera and Cruse plays have a calculated chance of discovery of 0.1 and 0.1344 respectively. The primary risks within the SW peninsula are the definition of trapping structures and the sealing properties of faults. Whilst it is possible to utilise the existing dataset to establish leads within the Cruse Fm., additional research and data is required to define the presence and trapping of Herrera Fm. sands.

Supervisors: *Ian Watkinson (RHUL); Neil Ritson (LGO Energy Plc)*

Data provided by: *LGO Energy Plc*

Wilmer Espitia Saavedra

Cenozoic deformation In the Bahia area, Colombian Caribbean

The Bahia area is located in northern South America, where the Caribbean Plate subducts beneath the South American Plate, generating the South Caribbean Deformed Belt (SCDB). 2-D and 3-D seismic surveys were interpreted in order construct a 4-D tectonic evolutionary model of the area corresponding to the inner part of the SCDB. The Cenozoic sequence is deformed by NE-trending folds and thrusts accompanied by mud volcanism.

Interpretations show a compressive event forming structures perpendicular to the regional convergence of the Caribbean Plate during the early Early Miocene, leading to an angular unconformity. The Late Miocene thrusting in the frontal part of the SCDB formed piggyback basins and small deformation in the Bahia area. In the Latest Miocene and Early Pliocene, an event with major extension parallel to the regional compressive trend occurred. The Bahia Fault System (BFS) assumed the major extension with an important erosive event on the footwall. Also, it was highly affected by normal faulting and formation of depocenters in the hanging-wall.

The BFS was subsequently reactivated by right lateral displacement and perpendicular normal faults with rotational blocks and collapsed structures. By the end of the Pliocene and Early Pleistocene, compressive structures with a NE trend were formed and lateral displacement decreased. Low-angle normal faults were inverted and mud volcanism parallel to the regional trend became active.

This deformation history with complex extensive events encompassed into the compressional tectonic setting can be explained as a consequence of gravitational events as the response of thickening in the inner part of the accretionary prism.

Supervisor: *Ken McClay (RHUL)*

Data provided by: *Ecopetrol*

Guillermo Hernandez Ladino

The impact of diachronous collisions on clastic reservoir development along the sub-Andean trend

Phases of erosion and sedimentation record the Late Cretaceous-Cenozoic development of the sub-Andean basin trend, northern South America. Multiple datasets from across the sub-Andean basins, including 1-D basin models, reservoir data plus a synthesis of existing thermochronology and geochronology data give insights into this development, particularly the timing and impact of uplift in the northern Andes, resultant erosion and sedimentation rates, and petroleum prospectivity. They also provide constraint on the plate-scale geodynamic evolution of the region, and on sediment provenance and reservoir development in the foreland basin. Five significant uplift events affected the Andean Mountain Cordillera and had effects in the adjacent foreland basin. These events record the diachronous collision of crustal units associated with the Caribbean Plate, reflected by subsidence profiles and sediment accumulation rates in the northern sub-Andean basins. During the Late Cretaceous, the Napo Uplift developed in the Real Cordillera in Ecuador, corresponding to subduction of the Farallon Plate beneath the South American Plate. During the Paleocene, as a consequence of the closure of the Colombian Marginal Seaway the Central Cordillera in Colombia was uplifted. Throughout the Eocene the Eastern Cordillera was uplifted in response to deformation caused by the Central Cordillera uplift. During the Oligocene, in the north-east of the study area, the Merida Andes Uplift led to the separation of the Barinas-Apure Basin and Maracaibo Basin. The last event corresponds to Sierra del Interior Uplift as a result of interaction between the Caribbean Plate and the northern border of the South American Plate. These tectonic events led to basement exhumation and delivered significant volumes of sediment to the adjacent foreland basin. The variability of uplift (timing and rates) is recorded in the sedimentary successions in the foreland basins. A clearer understanding of the timing and rate of exhumation of the mountain belts and an appreciation of the composition of the material eroded allows a degree of predictability regarding when and where the most quartz-rich sandstones will have been deposited. Some of the most important petroleum reservoirs in the foreland basins are composed of quartz-rich sandstone derived from the surrounding or more distant crystalline basement rock.

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