Petroleum Geoscience MSc Online Symposium 2020

Department of Earth Sciences

Thursday 3rd September 2020, 9:30 AM

We are pleased to invite you to the online MSc Symposium featuring students of the Petroleum Geoscience programme at the Department of Earth Sciences, Royal Holloway University of London.

The Symposium is an opportunity to see the results of our students' independent research projects on basins all over the world. It is also an opportunity to network with our graduating students and industry collaborators who kindly provide project data or teach on the course.

Special thanks to all those organisations who have kindly contributed to projects this year:

ROYAL HOLLOWAY UNIVERSITY OF LONDON

Register here
https://www.eventbrite.co.uk/e/petroleum-geoscience-msc-online-symposium-2020-tickets-114857287238

Presentations from 09.45 AM on Teams

Introduction & welcome at 09.30 AM

Full symposium schedule below

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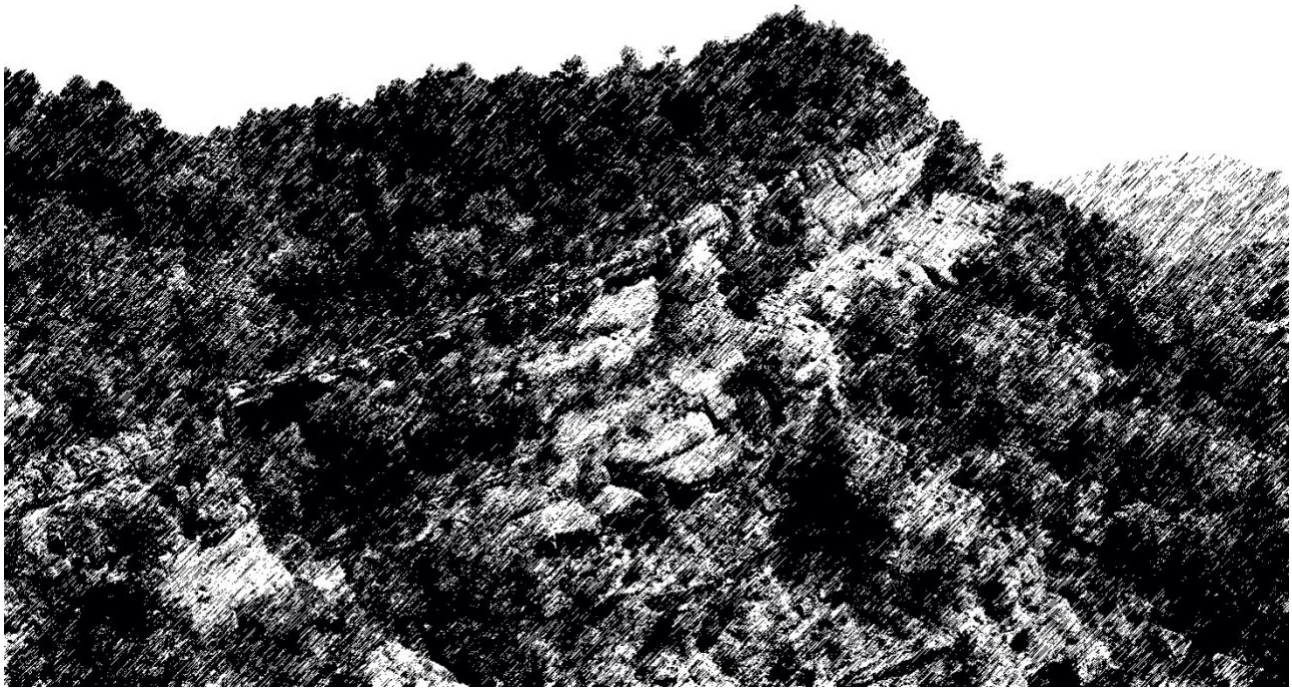
Petroleum Geoscience MSc

Online Symposium 2020

4th September 2020

Programme and abstracts booklet



Programme

				Session Chair
	09:30	**Introduction & welcome**		*Domenico Chiarella*
Tectonics & Stratigraphy	09:45	Uthman Ali Hussain	Geomorphic expression of Quaternary tectonic processes within the London Basin	*Ian Watkinson*
	10:05	Blake Middleton	Gateway evolution of the offshore Catanzaro Strait (Southern Italy)	
	10:25	Al Muathir Al Kindi	Tectono-stratigraphy of the onshore Makran accretionary prism	
	10:45	Conall Cromie	Tectono-stratigraphic evolution and hydrocarbon prospectivity of the offshore Makran accretionary wedge	
	11:05	*Break*		
Sedimentology & Reservoir Analysis	11:15	Laurence Young	Cenozoic depositional sequences of the Stybarrow field, Exmouth sub-Basin, NW Australia	*Javier Hernandez-Molina*
	11:35	Veronika Kustkova	Assessing Upper Cretaceous-Cenozoic plays offshore Denmark	
	11:55	Alysia Jade Stringer	Microfacies and petrographic characteristics of sandy contourite channel fill deposits in Morocco	
	12:15	Jaspreet Kaur	Late Miocene turbidite depositional system in the deep Algarve Basin, northern Gulf of Cadiz: conceptual and economic implications	
	12:35	*Break*		
Subsurface Storage & Georesources	13:05	David Whitworth	Compressed Air Energy Storage (CAES) potential of salt anticlines and diapirs in the coastal areas of the Sole Pit High and Silver Pit Basin, UK Sector, Southern North Sea	*Dave Waltham*
	13:25	Jodie Mcnamara	Carbon capture and storage (CCS) – predicting hydraulic fracture interaction with faults	
	13:45	Adil Ekab	Geothermal energy resources and their technology, with application to the United Kingdom	
	14:05	*Break*		
Source rocks	14:15	Kivanc Yuksel	Geochemical characterisation of the Early Jurassic marine sediments in the Lower Saxony Basin, Northern Germany	*Alex Dickson*
	14:35	Mesut Gokhan Gumruk	Geochemical characterisation of marine sediments of the Early Toarcian oceanic anoxic event in Lombardy Basin, Northern Italy	
	14:55	David Eastwell	Class IV AvA anomalies in high total organic carbon shale. A case study from the Orange Basin, Offshore West Africa	
	15:15	**Award of prize & closing remarks**		*Domenico Chiarella*

Acknowledgements

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TGS
Petroleum Agency SA

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Petroleum Experts

We are grateful to our friends in various companies who have helped so much by contributing to teaching during the year or giving us valuable data to make sure that our courses keep up-to-date.

In addition to company supervisors listed in this booklet, we would also like to thank numerous other people who have dedicated so much time and energy to our MSc projects this year, notably: John Hughes, Ashley Price, Bernie Vining, Jonathan Craig, Lorenzo Meciani, Lawrence Gill, Paul Chernik, Ken Kasriel, Martin Insley, Leigh Truelove, Mike Simmons, David Griffiths, Mike Bidgood, Adam Law, Philip Hirst and Zhi Lin Ng.

Many others in the department of Earth Sciences also were generous with their time, and we would particularly like to thank: researchers from the Drifters Research Group, SE Asia Research Group and the Fault Dynamics Research Group. Lynne White, Kevin D'Souza, Frank Lehane, Mark Longbottom, Diane Serpant and Izzy Martin are also all thanked for the considerable technical and practical support that they have provided during the projects and throughout the MSc year.

Uthman Ali Hussain

Geomorphic expression of Quaternary tectonic processes within the London Basin

Landscape evolution is often studied to discern the competition between steady-state and transient tectonic processes. River longitudinal profile analysis is capable of determining the presence of these processes which govern the geometry of the basin. A 2 m spatial resolution LiDAR dataset covering the Ravensbourne River, a tributary of the River Thames in SE London, was conditioned to carry out hydrological and terrain analysis. Delineation of the drainage network for the Ravensbourne catchment and regression analysis of slope and area shows a faint tectonic signal within the landscape. Through morphometric analysis of these profiles, logarithmic steepness values of 8.83-15.52 were identified. A series of base-level reconstructions were also created to outline the competition between steady-state topography and distinct local vertical motions caused by fault related instability. Topographic perturbations are profound and changes in bedrock seem to correlate with knickpoints along river profiles. However, it is challenging to infer a structural signal from topography using this analysis because of competing processes such as post-glacial isostatic rebound, lithologic heterogeneity and human impacts on landscape and drainage. The spatial resolution of the dataset is pivotal to obtaining accurate results for catchment scale analysis. Using this workflow, it is possible to tentatively elucidate the position of faults within an urbanised basin with strong influence from cultural objects. It is important that even slow-moving active faults in an urban setting like London are brought to public attention to prevent catastrophic disasters at the surface as well as the subsurface.

Supervisor:
Ian Watkinson (RHUL)

Data provided by:
Environment Agency, UK

Blake Middleton

Gateway evolution of the offshore Catanzaro Strait (Southern Italy)

The Catanzaro Strait in the Squillace Gulf of Southern Italy is a young (Neogene-Quaternary) basin, which is a fragment of the connection of the Alpennine chain and Maghrebian chain and contains a highly complex structural framework. The area of study is focused between the Stilo Swell and Crotone Swell and contains extensional phases of tectonics (Early - Middle Miocene) in the form of stacked listric faulting with distinct rollover anticlines and growth strata in the western half. There is a sediment depocentre loading onto an underlying unconsolidated mud detachment creating mud diapirsm and contractional phases in tectonics leading to inversion of normal faults in the region (Early - Middle Pliocene). The eastern half of the Squillace gulf contains little rollover anticlines and growth strata but, might related to a thrust belt causing basin inversion of the area.

Supervisors:
Domenico Chiarella (RHUL)

Data provided by:
Eni

Al Muathir Al Kindi

Tectono-stratigraphy of the onshore Makran accretionary prism

The Makran accretionary prism is a domain of structural and stratigraphic complexity that deserves detailed studies, particularly for its largely under-studied hydrocarbon potential. The overall range trends east-to-west parallel to the coastline of southeastern Iran and southern Pakistan The area of focus in this study is the onshore extent from Gwadar peninsula to the easternmost fringes of the accretionary prism.

Since the tectono-stratigraphic setting and hydrocarbon potential in this region is under-explored in contrast to other similar settings worldwide, this study is to aims to further investigate it using satellite imagery and digital elevation models, to determine its structural and stratigraphic architecture and the petroleum system elements within them.

Three cross sections have been constructed parallel to the general strike of the range; Line A extending northwards from the Gwadar peninsula, Line B extending northwards from the Ormara peninsula and Line C extending SE-NW from the coast at the eastern end of the range. Those lines were the focus of remote-sensing-based tectono-stratigraphic analysis, along with the notable features between them.

The range is composed of a series of broad east-to-west plunging synforms, bounded by sharp thrust-related antiforms, likely fault propagation folds in the hangingwalls of north-dipping thrusts. The cross-section lines intersect large-scale synforms, representing prism-center wedges that mark a change in thrust dip direction, from north-dipping in the south to south-dipping in the north

Reservoir potential is likely to be hosted on the lower Pangjur Formation turbidites, as well as limited nearshore localities where the lower to middle Talar Formation is still unbreached. Source potential is best in the Hoshab shale, followed by shale members of the lower Parkini Formation. Faults, primarily thrusts and associated perpendicular strike-slip faults, could provide migration pathways. Traps are also provided by thrusts, in the wedge-tip anticlines or by thrust contacts that could also enhance reservoir volume by duplication of strata. Mud volcanism is also relevant, particularly in the domain of less-developed thrust systems in the eastern side, due to gravitational load combined with shale liquefaction from the Pangjur or Hoshab formations. These units could also have some seal potential as the fault permeability breach risk is reduced.

Supervisor:
Ian Watkinson (RHUL)

Data provided by:
Google Earth

Conall T. D. Cromie

Tectono-stratigraphic evolution and hydrocarbon prospectivity of the offshore Makran accretionary wedge

The Makran Accretionary Wedge, south of Pakistan and Iran, is the product of subduction of the Arabian Plate under Eurasia, which is currently active and has been developing from the Eocene. Combining 2D seismic interpretations and well data, findings indicate that a major period of accretion was occurring from the mid-upper Miocene, identified by major growth formations which is summarised in an evolutionary model. Imbricate thrust faults originate from depth in the region with piggy-back basins being preserved in the hanging-walls of these faults, displaying growth strata which is mid-upper Miocene in age. Prograding units have been identified and large submarine canyons within these units illustrate an input of sediment from the north. Furthermore, large fluid escape features have been observed in the seismic and are interpreted to contain hydrocarbons from a thermogenic source; ascertained from heavier fractions of hydrocarbons present in the well reports. This source fluid has been observed to originate from depth - migrating through fault propagation anticlines which lack seal integrity. Hanging wall anticlines remain the principle trapping mechanism, with the Panjgur turbidite formation representing the primary reservoir target. Amplitude anomalies have been observed within certain anticlines; critically lacking clear fluid escape features - which should be targeted in exploration. An alternative petroleum play is proposed within topsets of the clinoforms in the Chatti and Omara formations, which display amplitude anomalies adjacent to gas chimneys; a result of hydrocarbon charging. To conclude, it is proposed that the region has a high hydrocarbon prospectivity due to evidence of an active petroleum system and variety of possible trapping mechanisms.

Supervisors:
Nicola Scarselli (RHUL) and
Jonathan Craig (RHUL, Eni)

Data provided by:
Petroleum Pakistan Limited and
Directorate General of Petroleum
Concession, Pakistan

Laurence Young

Detailed description of the Cenozoic depositional sequences of the Stybarrow field, Exmouth sub-Basin, NW Australia

The Stybarrow Field in the Exmouth Sub-basin of the Northern Carnarvon Basin in North-West Australia is a proven hydrocarbon producer. The Cenozoic interval, in this area, has no exploration value, but understanding the evolution of the basin is important for understanding maturation of the source rocks beneath it and is of interest when planning wells. The data available consists of a very high quality 60km2 seismic cube accompanied by well logs from 2 wells. The dataset is 65 km North West of onshore Exmouth, and measures 12 by 5 km. This report intends to understand better the subtle changes within the Cenozoic interval, by means of surgically mapping the interval, to produce maps and interpretations of features and rocks deposited since the Cretaceous. This will be accompanied by assessing well logs alongside a detailed literature review. The Cenozoic interval shows multiple stages of tectonic activity including regional and widespread tilting and erosion, as well as evidence of marine transgressions/regressions affecting the types of deposit and structure seen within the geological record. I conclude that the Exmouth-Sub basin of the Australian North West slope has undergone four significant tilting events caused by reactivation of extensional rift faults formed when Australia rifted from India.

Supervisor:
Domenico Chiarella (RHUL), Ashely Price (RHUL) and John Hughes (RHUL)

Data provided by:
Geoscience Australia

Veronika Kustkova

Assessing Upper Cretaceous-Cenozoic plays offshore Denmark

Production of hydrocarbons in Denmark commenced in 1972 and made the country self-sufficient in the 90s, producing enough oil from the Danish offshore fields for country consumption. However, the country's production has been in decline for over 10 years as the basin turned to maturity. A new approach is anticipated in order to revitalize the oil and gas sector in the country, with the focus on Jurassic reservoirs in particular. The Chalk Group has been the main reservoir unit in offshore Danish fields for decades. Cenozoic discoveries were also made, mostly associated with the Salt Dome Province in the south of Danish waters. The northern study area lacks salt diapirism. Therefore a stratigraphic approach needs to be taken for the search of potential leads. The Chalk Group reservoirs have been extensively studied for Danish hydrocarbon potential and Jurassic reservoirs are one of today's topics.

The analysis of a PSDM 3D seismic volume over an area 2862 km^2 of the northern part of the Danish waters, adjacent to the UK, Norway and German country boundaries showed a graben structural framework of the NW-SE dipping normal fault system ranging from 16 to 57km long, with the Tail End Graben faults reaching the highest of over 60 km long two normal bounded faults. The accompanied sedimentary infill was studied on top. The main source rock from the Farsund Formation (Late Jurassic) has been identified and mapped across the study area further confirming the potential of oil and gas accumulations. Several large structures were identified within the Chalk Group in the study area, including observations about the proven Svane 1 gas discovery. These are located in the Maastrichtian strata and include up to 20 km^2 gentle anticlines and anticlinal features terminated by existing faults, both as a result of the Cretaceous inversion period. The Cenozoic succession consists of highly faulted Eocene-Oligocene claystones followed by a prominent prograding units towards the basin depocenter to the southwest. It was inferred that progradation commenced in Early Miocene and continued into Pliocene producing over 1000 m strata, based on the seismic reflectors. Smaller structures of Miocene age were identified above the polygonal faulting as channel fills with the width reaching 500 m and approximately 3 km length with depths of an individual channel reaching 150 m within the Norland Group concession for consideration. However, they are of much smaller extent only reaching 1.5 km^2 areas and may not be economically interesting in the current environment.

Results show that the study area can be reconsidered for further studies on several aspects. First, the Chalk Group can be re-examined with promising available structures. The Miocene channels can be looked at as potential reservoirs for both small scale hydrocarbon accumulations as well as potential for carbon capture and storage. Lastly Jurassic plays have a potential for new unknown hydrocarbon accumulations.

Supervisors:
Nicola Scarselli (RHUL) and Paul Bellingham (ION)

Data provided by:
ION

Alysia Jade Stringer

Microfacies and petrographic characteristics of sandy contourite channel fill deposits in Morocco

The Riffian Corridor was an active gateway between the Mediterranean and the Atlantic during the Miocene. During this time sandy contourite channels formed from analysing two fossilised sandy contourite channels present in the Southern Rifian Corridor (SCR) each with three stacked units which are located onshore Morocco and a modern sandy contourite channel in the strait of Gibraltar. Microfacies can be assigned, and comparisons can be drawn; between the modern and fossilised channels. These comparisons were conducted by analysing field photos, thin sections were taken from each accessible unit within the channel. These fossilised sandy contourite channels are the only outcrops of their kind seen exposed for studying. The two fossilised channels were analysed individually then compared; the analysis showed the dominant lithology present is a calcarenite packstone dominant in quartz, glauconite and bioclasts. Microfacies were determined and correlated between the two sites showing deposition due to composition, sorting, rounding and texture. Six microfacies associations were determined termed MF1-MF6. These microfacies support the hypothesis of out of phase behavior occurring between the two channels during deposition. The study also indicates the provenance of the minerals present. This allowed for sediment sources to be indicated. The microfacies allows a model to be generated which will allow more accurate prediction of hydrocarbon potential in areas with sandy contourite channels as well as allowing evidence for potential reservoirs and seals being present within the contourite channels. The petrophysical analysis shows that porosity in Kirmta and Sidi Chahed while variable between 5-40% is high enough on average across all units for reservoir potential to be present.

Supervisor:
Javier Hernandez Molina (RHUL)
and Wouter De Weger (RHUL)

Data provided by:
Drifters Research Group

Jaspreet Kaur

Late Miocene turbidite depositional system in the deep Algarve Basin, northern Gulf of Cadiz: conceptual and economic implications

Turbidite systems or sub marine fans are the deemed to be the most crucial clastic accumulations in the deep sea. The sediments building these elements are derived from gravity flow. The Spanish region demands a remarkable locale for studying Messinian turbidites. The seismic interpretations of the Messinian turbiditic sediments are conducted at Algarve- 2 in Gulf of Cadiz. The margins of Algarve basin are studied by 2D and 3D seismic data associated with well logs. The emphasis is made on the Late Miocene for identifying the basinal and turbiditic characters of Messinian sediments. The three-dimensional seismic data comprehend with well logs to integrate the presence of Messinian turbidites. The seismic sections reveal that the best exploration prospects are involved in Late Miocene. The turbiditic elements in the area studied illustrates the sparse portion from the whole sequence and succession remain same throughout. The comprehensiveness of the sequence remains persistent throughout the seismic sections, although, the incomplete stratigraphic units are the evidences caused by the truncation at upper intervals or omission of lower sequences. Huge amplitude contrast and deformations are analysed within the turbiditic system clearly demarcating them from the overlying and underlying sequences. The surface maps for each unit and the thickness for top and bottom surfaces within the Messinian turbidites are constructed to provide an overview for hydrocarbon explorations.

Supervisor:
Javier Hernandez Molina (RHUL)
and Zhi Lin Ng (RHUL)

Data provided by:
Repsol

David Whitworth

Compressed Air Energy Storage (CAES) potential of salt anticlines and diapirs in the coastal areas of the Sole Pit High and Silver Pit Basin, UK Sector, Southern North Sea

This project seeks to evaluate salt structures such as diapirs and anticlines, both concordant and discordant, for their potential as storage sites for storage of compressed air energy (CAES). Salt caverns, excavated via solution mining, have already seen widespread use for natural gas storage in the UK and globally. However there has been little consideration of the potential for peak load shifting of intermittent wind power generation, via the use of compressed air energy storage locally to offshore windfarms. This project focusses on the coastal areas of the Sole Pit High and Silver Pit Basin, offshore of the East Midlands, in the UK Southern North Sea, with respect to their suitability for local CAES implementation. The aims of the project are (1) to map subsurface salt structures, and define different salt 'play' types for energy storage solutions; (2) to produce volumetric and geomechanical analyses of the described leads; (3) to relate the study area to previous work in play fairway-style analysis of existing localities; (4) to carry out a 1st order economic assessment of the leads, considering existing infrastructure, and energy storage capacity of calculated volumes.
The results of this study, following a novel lead characterization scheme found 26 leads, of which 11 showed only low to moderate risk of failure. A geomechanical analysis of the two most promising leads showed potential for hexagonal distribution of at least 783 caverns, with a total theoretical storage volume of 294 million m3 of compressed air, equivalent to c.267 GWh of exergy (useful work done extracted from a system). This is enough to store over 10 hours of the entire UK energy demand.

Supervisor:
Jürgen Adam (RHUL)

Data provided by:
Oil & Gas Authority, UK

Jodie Mcnamara

Carbon capture and storage (CCS) – predicting hydraulic fracture interaction with faults

CCS has been identified as a critical technology in the effort to reduce anthropogenic CO2 emissions and mitigate severe climate change. This thesis initially reviews the most significant developments and learnings in CCS to date. Then, focusing on geological storage, the storage site criteria that are needed to make CCS successful are presented. The most significant risk when choosing a storage site is CO2 leakage to other formations or the surface. This is most likely to happen by faults reactivating and CO2 using them as migration pathways. Hydraulic fractures are created on injection of CO2, and if allowed to propagate, may inject pre-existing faults. This thesis presents an analytical model to predict if induced hydraulic fractures (or hydrofractures from increased pore pressure across the reservoir) will use surrounding faults as part of their propagation pathways. Knowing, if at certain conditions, hydraulic fractures would not inject faults, injection rates may be increased at storage sites so that a more considerable amount of CO2 may be sequestered, or a higher, induced permeability may enhance flow. Results, from the modelled conditions in this thesis, show that the most likely fault types to allow hydraulic fracture injection are steeply dipping normal faults (>70°). Models like this may be used to evaluate regions for their suitability before storage sites are chosen.

Supervisor:
Agust Gudmundsson (RHUL)

Adil Ekab

Geothermal energy resources and their technology, with application to the United Kingdom

Geothermal energy is a renewable, sustainable form of energy that provides a continuous and uninterrupted supply of heat that can be used for general space heating, such as homes and; office buildings, and to generate electricity. The earth contains an enormous source of heat, which is continually generated by the decay of long-lived radioactive isotopes of uranium, thorium and potassium. The urgent need for clean energy was one reason for the development of geothermal energy. The first experiment to exploiting geothermal resources was at Larderello in northern Italy in 1904. The presence of geothermal resources is either close to the surface of earth (shallow), where ground source heat pumps can be used to extract the heat or at considerable (kilometres) depths, where sophisticated and costly methods of deep drilling hydraulicfracturing and hydroshearing are used to increase the permeability of rock. Geothermal resources are convenient for many different types of uses but are usually divided into two categories, high enthalpy and medium to low enthalpy, according to their energy content. High enthalpy resources (>150 °C) are suitable for electrical generation with conventional cycles, medium to low enthalpy resources (<150 °C) are used for direct heating and electricity generation using a binary fluids cycle. Although the UK is far away from volcanic regions, there is still substantial geothermal energy at comparatively shallow depths in plutons and sedimentary basins for Enhanced Geothermal Systems (EGS) – earlier known as Hot Dry rock (HDR) systems. These occur in certain areas of the UK. But very shallow geothermal sources (depth of meters to tens of metres). For ground source heat pumps are basically everywhere in the UK and their use is increasing at a fast rate (as elsewhere in Europe). There are different types of systems which can be classified into closed-loop systems and open-loop systems. This study critically assesses the geothermal resources, including the main sites that contain potential for deep geothermal energy, in the UK. I explain and illustrate the concepts of (EGS) and (HDR), and discuss the present development of major EGS project in Cornwall South west England. I also estimate the geothermal resources and discuss the current and likely future developments of geothermal energy in the UK, taking into account the advantages and disadvantages and risks associated with this energy source. In particular, I analyse quantitatively the conditions for a hydraulic fracture, used to increase the permeability in an EGS, entering a fault with the potential risk of generating earthquakes. The present study concludes that the UK has considerable geothermal potential. In particular, deep geothermal sources are available in many parts of the country, offering the possibility of electricity production in addition to space heating. Furthermore, very shallow geothermal energy, through heat pumps, is available practically everywhere in the UK. Geothermal energy is a steady (always available) renewable energy source, and thus an ideal combination with non-steady renewable sources such as solar and wind energy. For further development of this sector, it is important to inform decision-makers, investors and the general public about the opportunities offered by geothermal energy in the UK.

Supervisor:
Agust Gudmundsson (RHUL)

Kivanc Yuksel

Geochemical characterisation of the Early Jurassic marine sediments in the Lower Saxony Basin, Northern Germany

The Early Toarcian Oceanic Anoxic Event (T-OAE, ~ 183 Ma) is a period that was characterized by the spread of marine anoxia and euxinia across the world. This event has gained much attention in the geological community as it predicts the economically valuable wide-spread formation of organic-rich marine black shales. However, this event is not only a responsible key factor for governing the formation and preservation of these important deposits, but also local controls play a significant role in this regard. This study aims to examine whether the deposition of Early Jurassic in age organic-rich marine black shale, known as Posidonia shale, in the Lower Saxony Basin (LSB) coincides with the T-OAE. Also, it intends to identify the source rock potential of the studied samples and uses geochemical proxies to determine the depositional environment and redox conditions during the accumulation of the succession. The organic-carbon isotope stratigraphy of the Posidonia Shale and surrounding units reveals that the T-OAE is recognized at the beginning of the formation of Posidonia shale. Additionally, the combination of carbon isotope data together with calcareous nannofossil biostratigraphy and TOC data shows that the age of the succession varies from the Late Pliensbachian NJ5 zone to the Late Toarcian/Aalenian NJ8 zone and that the deposition of the organic-rich Posidonia shale occurred from Early Toarcian to Middle-Late Toarcian. The bulk-organic geochemical proxies from Rock-Eval pyrolysis indicate that Posidonia shale samples have very high TOC content and have a potential as source rock to generate oil; however, they are thermally immature. The use of trace element concentrations and geochemical proxies suggests that during the deposition of Posidonia shale, persistent euxinic (sulfidic) conditions and hydrographic restriction existed in the LSB, which resulted in the preservation of organic matter burial. In contrast, other samples were formed under lack of sulfidic conditions. Further, iron-speciation confirms that the euxinia started to develop with the Posidonia shale deposition and remained until Late Toarcian in the LSB.

Supervisor:
Alex Dickson (RHUL) and
Domenico Chiarella (RHUL)

Data provided by:
Alex Dickson

Mesut Gokhan Gumruk

Geochemical characterisation of marine sediments of the Early Toarcian oceanic anoxic event in Lombardy Basin, Northern Italy

Throughout geological history, there have been periods when lithologies rich in organic matter were widely developed. These periods are called Oceanic Anoxic Events (OAEs). Schlanger and Jenkyns introduced the concept of Oceanic Anoxic Events (OAEs) in 1976. These periods reflect the presence of abnormal climatic conditions. Oceanic anoxic events might reflect both climatic and paleogeographical situation of the world and irregularities in the global carbon cycle as well (Jenkyns, 2010). These periods also lead to enhance organic matter burial either by increasing organic matter production or by enhancing the preservation of organic matter under conditions of oxygen depletion. The OAE concept has crucial importance on the oil and gas industry because it predicts that economically valuable source rocks should be clustered into intervals of time when these widespread environmental change events took place. In this study, data from the Sogno Core-3 Well in Lombardy Basin in Northern Italy have been evaluated. There are three main aims, which are characterisation of local depositional conditions, age control and characterisation of quantity and composition of organic matter. First, the concentrations of trace elements were evaluated in detail for characterising local depositional conditions. The average of V/Cr and Ni/Co are 1.45 and 1.81, respectively, which indicate the oxic environment. Additionally, while the reducing conditions of the storage environment are determined by using Co/Al, Ni/Al, V/Al and Zn/Al ratios, organic productivity in the storage environment has been evaluated with Ba/Al and P/Al ratios. Secondly, when the organic carbon and carbonate carbon isotopes are evaluated, there are some negative values in the stratigraphic succession. This situation might be associated with the beginning of the Toarcian OAE. Finally, according to the results of the Rock-Eval pyrolysis analysis, the TOC values varied between 0.05% and 2.45%, while the average was calculated as 0.75%. HI values varies between 3–438 mgHC/gTOC and its average value is 175 mgHC/gTOC. OI values calculated as 1–356 mgHC/gTOC, and average OI value is 68 mgHC/gTOC. The organic matter types of Sogno Core-3 well are both Type II and Type III kerogen. Tmax values of the samples vary between 425–439 °C, and average Tmax value is 433 °C.

Supervisor:
Alex Dickson (RHUL) and
Domenico Chiarella (RHUL)

Data provided by:
Alex Dickson

David Eastwell

Class IV AvA anomalies in high total organic carbon shale. A case study from the Orange Basin, Offshore West Africa

The ability to quantitatively or qualitatively map source rock presence and quality in frontier marine margins in the absence of substantial borehole and geochemical data remains a major source of risk in hydrocarbon exploration. Conventional AvA (Amplitude vs Angle) analysis is typically used to establish the variation in fluid content across a clastic hydrocarbon reservoir. However, a substantial body of work has been produced within the last decade establishing rock-physics relationships and models for shale source rocks therefore allowing for measurement of shale rock properties using AvA techniques. This study practically applies the theoretical process of evaluating shale high TOC% source rocks as proposed by Loseth et al. 2011 and additional studies by Avseth and Carcione 2015 and Qin 2013 which have begun to propose rock physics models that correlate TOC% with variations in physical elastic parameters. The area of study, the Barremian-Aptian Shale Source Rock in the frontier Orange Basin, Offshore South Africa, remains a "frontier margin", where source presence has been observed, however regional distributions and variations in quality are not well understood. The primary objective of this study was to understand if variations in the magnitude of observed AvA parameters related to variations in Total Organic Carbon % (TOC%) at the source rock level. As no rock pyrolysis data were available for this study, calculations of TOC% were derived using the Waples 1980 TTI (Time Temperature Index) 1D basin modelling method to determine inferred source maturity, and TOC% was calculated using the Passey ΔLogR 1990 and the Schmoker and Hester 1983 methods. Measurements of AvA attribute values Intercept "A" and Gradient "B" were taken at the base-source rock horizon at four well tie locations (A-C1, A-D1, K-A2 and K-D1) and cross plotted against calculated TOC%. Little to no observable correlation was recorded in the results between Intercept and Gradient, and TOC%. However, it cannot be concluded that no correlations exist due to both the low variation in observed range of TOC% values (approximately 1-5%) and the sparse quantity of measured data points (4). A secondary outcome however was the observation that in both the calculation of TOC% and the correlation of Intercept and Gradient to inferred maturity, at higher maturity the fluid effect on both density and the bulk modulus of the source rocks appears to play a pronounced role in the rock properties of shales. This was shown in the observation that in low TOC% (1-2%) and High Maturity (LOM 12-13) an AvA class IV response was still observed. Therefore, maturity should be considered a primary driving factor in the rock physics responses of potential source rocks within a basin.

Supervisor:
Jürgen Adam (RHUL) and Nicola Scarselli (RHUL)

Data provided by:
TGS and Petroleum Agency SA