North Africa Research Group

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Fieldwork

Extensive fieldwork on the Cretaceous and Jurassic sections in Morocco, see latest publications now out

New project to commence on Triassic Synrift

New Projects

Sampling in Mauritania. Reconnaissance studies in Senegal (page 4)

New Sponsors

Statoil and Woodside become new NARG sponsors

New Starts

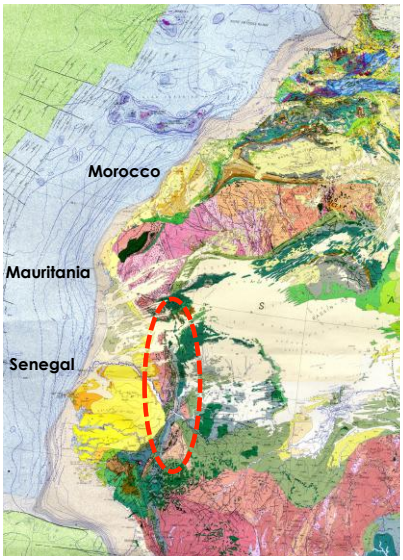
Emmanuel Roquette and Max Casson join the team Three other PhDs expected to commence in 2017

Dr Luc Bulot (CNRS Research Fellow) relocates to Manchester (page 8)

Building collaboration in Senegal and Mauritania as we extend studies along the Atlantic Margin

Regional studies integrating onshore / offshore geology

- A PhD has commenced working on regional tectonostratigraphy of the MSGBC Atlantic margin, integrating onshore and offshore data from Senegal, Mauritania and The Gambia.
- Collaboration with Universities in Dakar (UCAD) and government bodies Petrosen and Petrogaz
- Field sampling onshore Mauritania has been carried out, with samples now in TuDelft for analysis. This work will extend our apatite and zircon fission track (FT) analysis, to generate the first subsidence history profiles of the MSGBC margin
- Research projects initiated examining the main plays along the margin (see page 4)



Welcome to our New Sponsors

Statoil

woodside

New publication on Lower Cretaceous biostratigraphy for NW Africa

A revised ammonoid biostratigraphy for the Aptian of NW Africa: Essaouira-Agadir Basin, Morocco

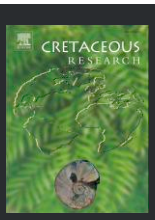
Luber et al, 2017: Cretaceous Research doi.org/10.1016/j.cretres.2017.06.020
The first in a series of papers presenting a type section for the Early Cretaceous Aptian section in NW Africa.

The research integrates ammonite stratigraphy with nannoplankton, foraminifera and carbon isotopes.

More details on Page 2

Lower Cretaceous - Essaouira Agadir Basin

Published:



Luber et al., 2017: A revised ammonoid biostratigraphy for the Aptian of NW Africa: Essaouira-Agadir Basin, Morocco. Cretaceous Res.: doi.org/10.1016/j.cretres.2017.06.020

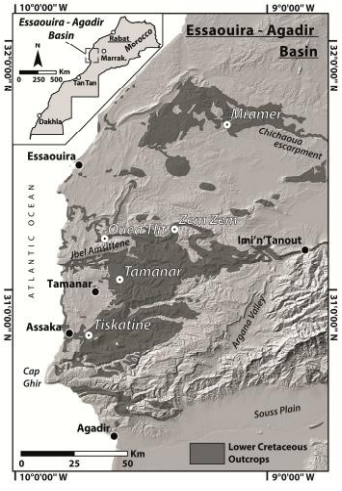
Upcoming Paper/Manuscript:
Luber et al., 2017. Integrated stratigraphic study for the Aptian of NW Africa:

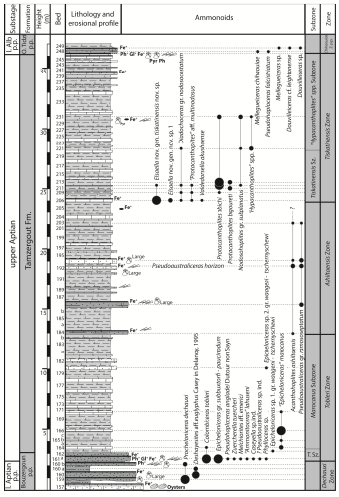
The first phase of the Lower Cretaceous study in the Essaouira Agadir Basin (PhD student **Tim Luber)** is nearing completion. The project, was based on extensive fieldwork and multi-disciplinary analysis, drawing in researchers from different disciplines. This highly significant work offers a type section for the Aptian biostratigraphy of NW Africa, with application offshore and along the Atlantic margin.

Important deliverables from the project:

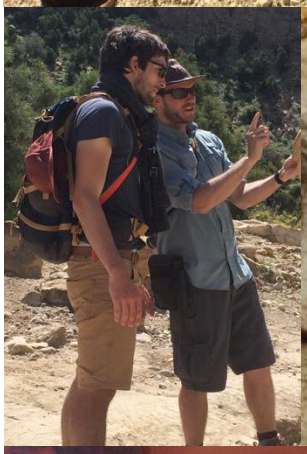
- First high-resolution ammonoid biostratigraphic framework for the Aptian of NW Africa.
- A regional chronostratigraphic framework based on bio, chemo, litho, and sequence stratigraphic analysis of outcrops.
- Investigation extended to offshore DSDP wells
- Palaeogeography constraints for the Early Cretaceous, focussing on the late Barremian to Aptian.
- Identification of the main phase of coarse clastic delivery, mapping of the associated fluvial system, understanding of sequence stratigraphic evolution.
- Extensive sample database to allow continued provenance work.

Tim Luber (3rd year PhD) and Dr Luc Bulot sampling and recording the biostratigraphy during this years field season.



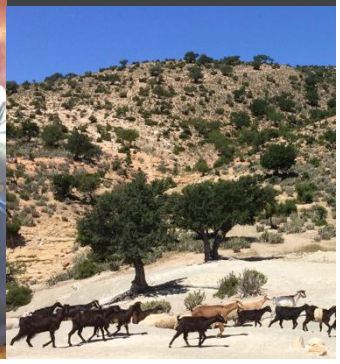


Location of study area and an example of the high-resolution sedimentology and biostratigraphy, detailed in the first papers to be published.



Tim Luber is congratulated by Leonardo on the Manchester Doctoral College award for "Best Contribution to PGR Environment "

The study is benefitting from international collaboration for biostratigraphy and carbon isotope studies, working with the following colleagues:
Jason Jeremiah (Golden Spike Ltd.), Mike Simmons (Halliburton), Camille Frau (PhD Student Heidelberg University), Moussa Masrour (Ibn Zohr University, Agadir, Morocco), Stéphane Bodin (Aarhus University, Denmark), Mike Bidgood (GSS International).



Redefining the stratigraphy of the Tarfaya Area

Angel Arantegui examining the newly defined Bathonian section near Ifni

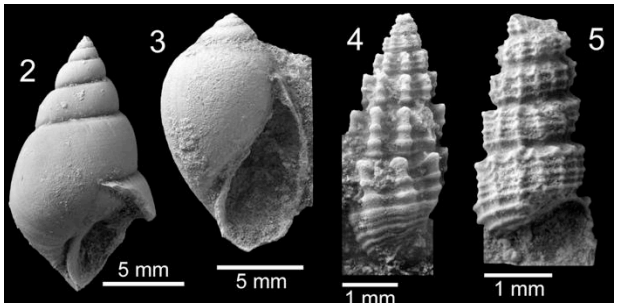
PhD student **Angel Arantegui** undertook further fieldwork in Nov 2016 (supported by Dr Luc Bulot and Jianpeng Wang) specifically targeting additional biostratigraphic sampling in the Ifni area and field correlation of the Tan Tan sections.

The study has resulted in re-dating of a large area that on the existing geological maps was noted as "Cretaceous Undifferentiated". The continental red beds at the base had no definitive dating, and are now interpreted to be Triassic to Liassic in age, based on superposition. The red beds are overlain by marine units, in which gastropods and bivalves collected by Angel and Luc have been definitively dated as Jurassic (Bathonian) in age by Prof. Stefano Monari and Dr. Roberto Gatto; Dipartimento di Geoscienze, Università di Padova, Italy.

The research is also generating:

- New litho- and sequence stratigraphic interpretation
- Better understanding of the evolution of depositional environments through time with implications for basin evolution and regional palaeogeography.

A key dataset to assess the delivery of clastics to the offshore deepwater province.

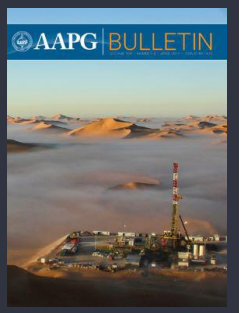


Jurassic, Craima Beach, nearr Ifni.

Jurassic Nerinella Facies, Craima Beach, near Ifni.

Other recent studies in NARG – Illizi Basin Algeria and Kotla Graben Libya

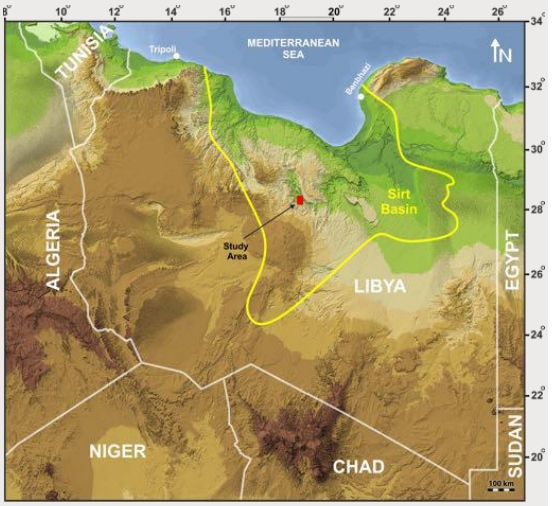
New papers on Illizi Basin



English, K.L., Redfern, J., Bertotti, G., English, J., and Yahi Cherif, R., 2016, Intraplate uplift: new constraints on the Hoggar dome from the Illizi basin (Algeria): Basin Research, p. 1-17.

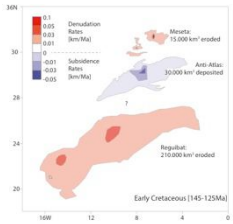
Controls on carbonate reservoir development, Kotla Graben, Sirt Basin, Libya.
Mohammed Salem (Final year) Libyan Government funded, data supplied by AGOCO:

The evolution of the Western Sirt Basin in the region of the Dahra Platform, Amin High and Kotla Graben is being evaluated, integrating 2D /3D seismic and data from 36 wells. Three tectonic styles identified include regional pre-rift intra-continental sag, complex multi-stage rifting and modification by wrenching. A major horst-graben system configuration has been delineated, which allows mapping fault distribution and timing throughout the area. These maps are being used to interpret the tectonic style and evolution and its control on accommodation, thickness and facies distribution of reservoirs throughout the Dahra Platform and Kotla Graben area.



Constraining the hinterland of the Moroccan Atlantic Margin

Mesozoic vertical movements occurring in Morocco and source-to-sink systems are being better defined and quantified with a project being undertaken by PhD **Remi Charton** at TuDelft supervised by Prof Giovanni Bertotti, and in collaboration with Dr Mohamed Gouiza at the University of Leeds. This integrates with the new provenance PhD at Manchester (Emmanuel Roquette, also supervised by Dr Stefan Schroeder and Prof Jonathan Redfern and Dr Shane Tyrrell at NUI Galway).



The study is improving understanding of the wavelength of the vertical movements in the hinterland. This has built on earlier work at TuDelft by Mohamed Gouiza and the first new results have been published in "Post-Variscan vertical movements of the Anti-Atlas" (Gouiza et al., 2017). Other studies have addressed the link between the exhuming and subsiding domains along the Morrocan margin. A paper on the the Ifni transect across the continental margin has been submitted to Terra Nova in April.

Detected exhumation and subsidence patterns are not explained in classical tectonic models and call for a new look on patterns of terrigenous sediments production and dispersion

Recent Conference Presentations

- Deciphering Phanerozoic km-scale vertical movements in Morocco: A qualitative and quantitative study of Post-Variscan Source-to-Sink systems.
Remi Charton, Giovanni Bertotti, Tim Luber, Angel Arantegui, and Jonathan Redfern
AAPG/SEG International Conference and Exhibition (ICE) 2017, London, October (15-18) 2017 (Accepted for oral presentation, 17th October).

- The Ifni Transect across the Morocco passive continental margin: syn- and post-rift anomalous vertical movements in the eastern Central Atlantic passive margin.
Remi Charton, Giovanni Bertotti, Angel Arantegui, Tim Luber, and Jonathan Redfern
EGU General Assembly 2017, Vienna, April (23-28) 2017 (Poster presentation)

- Deciphering Phanerozoic km-scale vertical movements in Morocco: A qualitative and quantitative study of Post-Variscan Source-to-Sink systems
Remi Charton, Giovanni Bertotti, Joep Storms, and Jonathan Redfern.
PGK Monthly Lecture, The Hague, February (15) 2017 (Oral presentation).

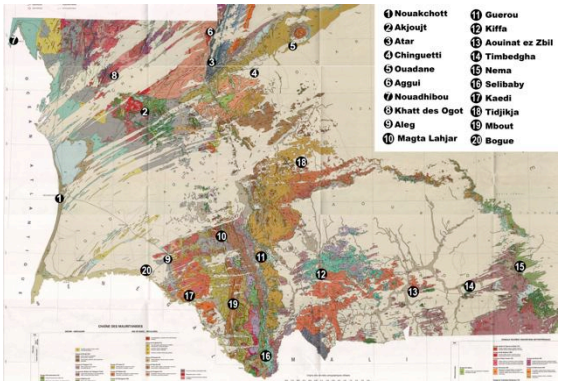
Extending the study down the NW Africa Margin

Extending NARG activities into Mauritania is a key step in expanding the knowledge and source-to-sink models developed in Morocco to the entire rifted margin of NW Africa. Two components have been identified:

i) Constraining vertical movements in the areas of potential sediment source using low-T geochronology tools and
ii) Seismic data to constrain the geometry of siliciclastic sediments in the offshore and how they are linked to the source areas.

Establishing contacts with the relevant Mauritanian authorities and organisations eventually led to a two-week mission in February 2017. The fieldwork undertaken by Dr. M. Gouiza (University of Leeds) and Prof Giovanni Bertotti was only possible because of the great support provided by Mr *C. Lekhbir* of the Ministry of Petroleum and Energy Resources.

Low-T geochronology. Samples were collected and exported for low-T geochronology, taken from all relevant units stretching from the Reguibate Massif in the North (already relatively well known from previous studies) to the basement outcrops at the boundary with Senegal in the South (target of the next campaign). These samples will form the first database worldwide on low-T geochronology data from Mauritania.



Nearly 100kg of rocks were collected, representing the first database of this kind.

First analytical results are expected in 3Q 2017. Complete dataset ready in January-February 2018, followed by interpretation and modeling

Building Collaborations

Fieldwork would not have been possible without the support of the *Office Mauritanien des Recherches Geologiques* of the I.R of Mauritania.

The Director *El Hachemy Ould Sidaty* and the adjunct Director *Abdellahi Ahmedou Bellal* of the OMRG are gratefully thanked for the support they have given.

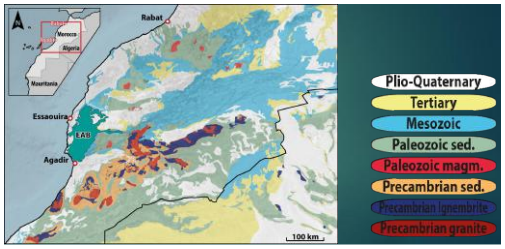
Provenance of Lower Cretaceous Fluvial Systems

This integrated regional analysis is being undertaken by **PhD Emmanuel Roquette** who started in January 2017. It builds on the work of Tim Luber who has defined the depositional systems and stratigraphy, and initial concepts on the drainage system, and the work of Remi Charton at TuDelft on the low T-geochronolgy of the hinterland, generating information on the likely source areas.

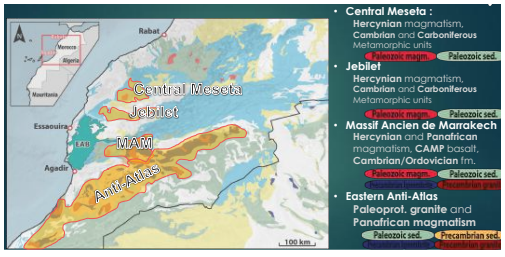
The aims are to: (i) develop a robust regional palaeogeography and tectonostratigraphic model highlighting the evolution from source to sink, (ii) understand the controls, timing and volume of the sediment supply to the margin delivered via fluvial systems and (iii) constrain the importance of sediment recycling, mixing and storage, and how they are influenced by the tectonostratigraphic evolution of the margin.

Deciphering the shallow-marine to fluvial transition zone in deep time along continental margins is key in unlocking the potential of Source-to-Sink studies. This provides vital information on the distribution of reservoir sandstones. The Mesozoic basins along the Moroccan Atlantic margin combine outstanding outcrops and continuous Triassic to Late Cretaceous stratigraphy.

The Early Cretaceous shallow marine to fluvial coarse clastic successions are an exploration target offshore, but limited successful drillings reflect the poor understanding of the depositional systems and its links to the eroding hinterland.



Potential Provenance Terrains of EAB



This highlights the need of a more holistic approach, tracing sediment routeing and the main input points through time.

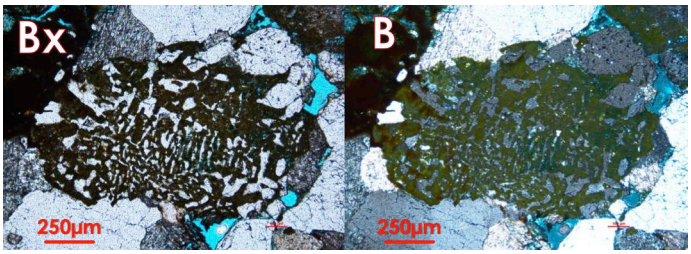
Middle Jurassic to Early Cretaceous tectonic movements have controlled subsidence within the basins, erosion of the provenance terrains and let to conditioning of the delivery system. This in turn has influenced the location and timing of sandstones deposition during the Jurassic and Cretaceous.

A specific question is whether differential uplift in the hinterland resulted in a change of sediment sources and reorganization of sediment routing across the margin. This project applies sandstones petrography and geochemistry (including detrital feldspar and zircon geochronology) to trace sandstones provenance and to establish a source-to-sink model for the Mesozoic succession.

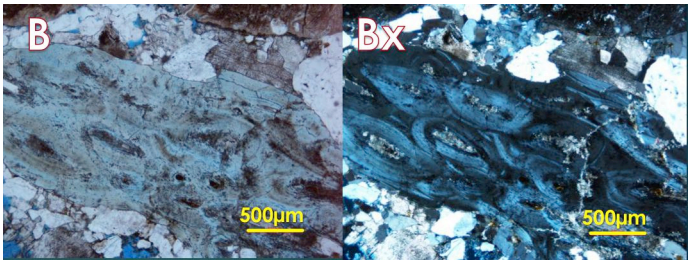
Preliminary results show diagnostic age trends in each of the potential source massifs : (a) Hercynian ages in the Northern massifs (Meseta), (b) mixed Pan-African and Hercynian ages in the High Atlas and (c) Panafrican magmatism associated with Palaeoproterozoic granites in the Anti-Atlas.

The distinct age signature should be recorded in detrital zircon populations and thus enable the testing of the model predicting Jurassic provenance mainly from the south (Anti Atlas, potentially Reguibat Shield), followed by Cretaceous provenance mainly from the east/northeast (Meseta, Massif Ancien).

Petrographic work on the Barremian to early Aptian clastic succession has already identified potentially distinct clast populations with volcanoclastics likely derived from ignimbrites or Central Atlantic Magmatic Province (CAMP) basalts of the Anti-Atlas and High-Atlas. Intrabasinal derived material is also recognised; carbonate clasts, likely from Jurassic or Cretaceous formations.



Above: Granophyric texture Presumed source: Ignimbrite of the Anti Atlas or MAM



Above:Undifferentiated carbonate clasts : Assaka section

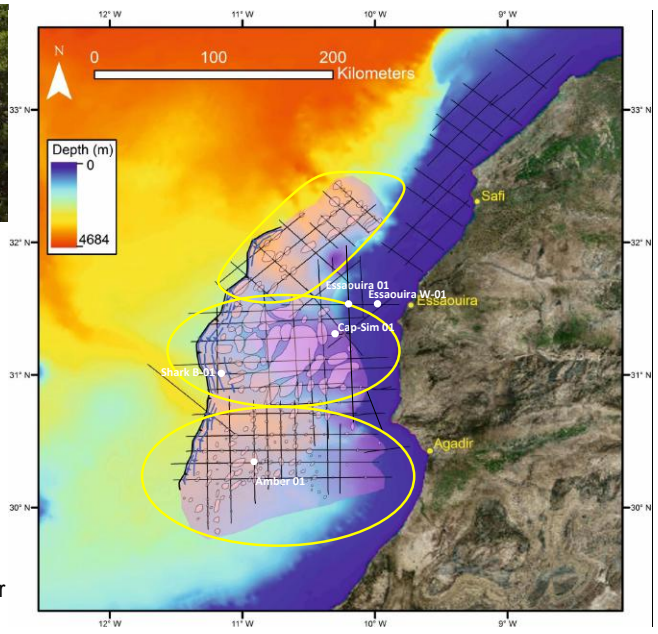
The project is moving forward quickly with the beginning of the sample processing phase for the extraction of the heavy minerals. The petrographic work on the thin sections has already identified potentially important populations of grains (suspected volcanoclastics), to be clarified by the use of SEM and QEMSCAN.

Emmanuel with Tim - great Moroccan cuisine.

NUI Galway
OÉ Gaillimh

The project is being undertaken in collaboration with Dr Shane Tyrrell, at NUI Galway, who brings a wealth of experience and facilities including lead isotope analysis of detrital feldspars. We also are grateful for support from Stephen Crowley (Senior Experimental Officer at the University of Liverpool).

Modelling salt tectonics offshore Morocco



Insights from Seismic interpretation and discrete-element modelling.

As part of this study, **Leonardo Muniz Pichel** working with Mads Huuse, Emma Finch, and Jonathan Redfern, is applying novel methodologies for modelling salt tectonics and its interaction with sedimentation by utilising a Discrete-Element Modelling technique.

This numerical approach allows the generation of dynamically scaled models and the development of realistic deformational processes of the overburden (i.e. brittle deformation), which are not properly reproduced by other numerical modelling techniques and are important to understand reservoir characteristics and distribution at the flank and roof of diapirs.

Results are easily reproducible and simulate accurately the geometric and kinematic behaviour of salt diapirs rejuvenated by shortening. Moreover, we assess the interplay between salt mobilization and sediment aggradation by simulating different timing and volumes of sedimentary input and sedimentation rates. The results are comparable to many natural examples of diapirs around the world.

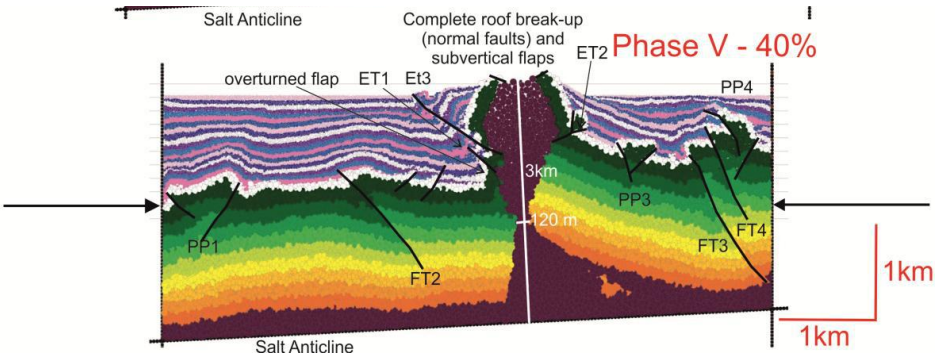
This research provides a guide for seismic interpreters working on salt tectonics as it explains the distribution of distinct diapirs geometries along continental margins by different sedimentation patterns. Furthermore, this novel technique can be extended to different scenarios of salt tectonics and basin deformation and help improving our current understanding of deformation mechanisms, basin geometries and sediment distribution.

First Publications

The first paper has been submitted "The Influence of Sedimentation on Rejuvenation of Salt Diapirs" (Journal of Structural Geology) - the paper uses a novel numerical modelling technique to investigate the deformation styles of the rejuvenation of diapirs by shortening and their interaction with sedimentation and depocentre evolution and compare models results to examples from W Africa, Gulf of Mexico and North Sea.

Example of Results

The figure to the right shows an image from the discrete-element modeling; part of the sequential evolution of the system. Salt is in magenta and pre-kinematic layers range from orange, yellow, green and white. Syn-kinematic sediments are represented by smaller radii elements and range from pink, blue, purple, white and dark blue colours. Faults are represented by black lines.



Offshore well and 2D seismic data to evaluate the Moroccan Atlantic margin salt basins has been kindly provided by ONHYM.

ONHYM
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Leonardo has been awarded a travel/conference grant of $500 to present at the Penrose Conference "Advances in salt tectonics: observations, applications, and perspectives: In honour of Martin P.A. Jackson"
This will be held in February, 2018

Leonardo is funded by the Conselho Nacional de Desenvolvimento Cientifico e Tecnologico and NARG

CNPq
Conselho Nacional de Desenvolvimento Científico e Tecnológico

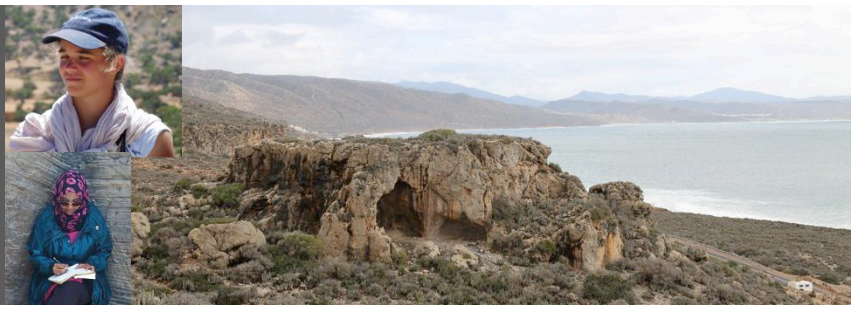
GIS Database

A pilot study has now been completed, initiated by Carmen Luber and Kofi Owusu to develop a GIS database that incorporates the extensive field data (samples and analytical results) acquired by NARG, integrated with published data across the region. All new projects are now utilising ArcGis to archive data and provide rapid access to research information.

esri ArcGIS®

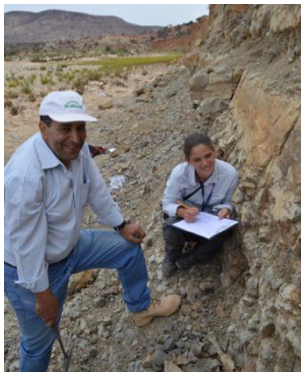
Jurassic Carbonate Reservoir Study

Investigating the depositional style, evolution and diagenetic history of Atlantic Margin Carbonates

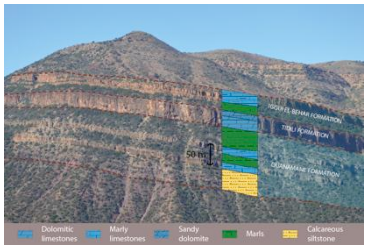


Aude Duval-Arnould (3rd year PhD supervised by Stefan Schröder, Jonathan Redfern and Luc Bulot) undertook 7 weeks fieldwork in October and November 2016 and a further 4 weeks fieldwork in March 2017. The aim was to examine the proximal part of the Jurassic carbonate system in the Agadir Basin, logged in two localities: Tikki and Tizgui N'Chorfa. The lateral evolution of each formation has been better constrained. The south of the basin has been studied in the centre of the Lgouz Anticline where the entire Jurassic succession is outcropping.

The study of the north of the Amsittene Anticline examined the same formations, to identify potential for syn-sedimentary diapirism. Different periods of siliciclastic influx have also been identified around the anticline. The North of the Anticline was influenced twice by strong siliciclastic influx, but only one episode of siliciclastic influx has been identified in the South, an argument for the presence of Jurassic structural highs.

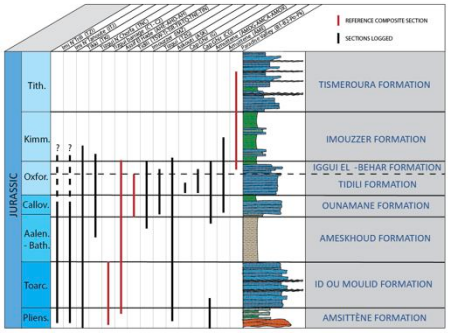


Aude and Moussa Massrour from the University of Agadir



Tizgui N'Chorfa section overview: Proximal part of the basin

Three weeks of paleontological fieldwork aimed to clarify the ages and evolution of the different Jurassic formations. Hundreds of brachiopods were collected along four sections. The evolution of brachiopods assemblages in these sections, together with identification of ammonites should help correlate the different logs across the basin. Bivalves and gastropods identification can help in the recognition of ages and variations in the depositional environment when brachiopods and ammonites are missing. Echinoderms often appear to be present with brachiopods and may help to identify the environment of deposition.



Schematic reference sections with interval logged for each section.

Further biostratigraphic data and developing a microfacies analysis will allow correlation more accurately across the basin and construction of a coherent sequence stratigraphic framework. Depositional models for each formation will be generated to understand the general stratigraphy and construct GDE maps and paleogeography maps.

Aude presented some of these results at the EAGE Paris 2017

Nawwar Al-Sinawi (2nd year PhD) is working on the project **Dolomitization of Jurassic Carbonates in the Western High Atlas of Morocco: processes and implications for reservoir properties,** supervised by Cathy Hollis, Stefan Schröder and Jonathan Redfern. Fieldwork in November 2016 focused on the Pleinsbachian-Toarcian and Callovian- Oxfordian dolomites. The field analysis comprised detailed logging, mapping and sample collection of the Jurassic dolomites in different areas (Tidili, Imouzzer, Cap Ghir, Barrage Aquesri) within Agadir-Essaouira basin. Ongoing research is focused on the sedimentological, climatic and structural controls on dolomitization by focusing on the distribution and origin of dolomites. Extensive post field petrographical and geochemical analysis has been carried to further understand dolomite environmental and facies control with constraints to reservoir properties.

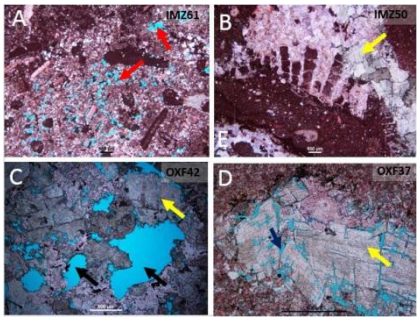
Initial results suggest that early Jurassic dolomites are stratabound whereas the Middle-Upper Jurassic dolomites are non stratabound. Dolomites are closely related to faults with temperature control proved by petrographical analysis. Other controls to be identified by geochemical analysis and further petrography techniques. Dissolution of dolomites in addition to corals enhance reservoir quality in reefal boundstones, whereas over-dolomitisation in other carbonate facies occlude porosity.

Above: Nawwar and Aude in the field.

Upcoming plans:

Detailed geochemical analysis using X-ray diffraction, Electron Microprobe, Isotope analysis, fluid inclusion and cathodoluminescence microscopy to identify origin of dolomitisation. A second field season is planned for November 2017, accompanied by Cathy Hollis, Giovanni Bertotti and other field assistants, with the aim of constraining the structural relationships.

Right: Stefan, Cathy and Aude looking of Oxfordian dolomitised reefal boundstone, Tidili roadcut, Morocco

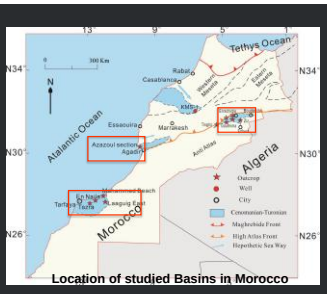


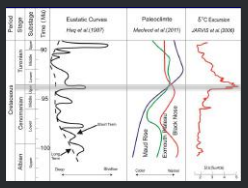
Above: Oxfordian dolomites in Imouzzer and Amisttene areas. A) Mouldic porosity in packstone, B) Anhedral dolomite replacing coral boundstone, C) Vugs (black) in brecciated boundstone caused by dissolution of saddle dolomite (yellow) and calcite, D) Intercrystalline porosity (blue) caused by dissolution of Saddle dolomites (yellow) in pink dolomitized reefal boundstone

Source Rock Hunter- Controls on Cenomanian-Turonian source facies development

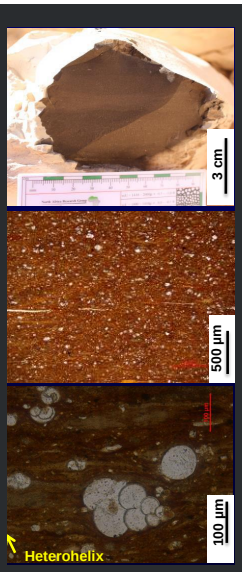
PhD **Jianpeng Wang** is undertaking a regional evaluation of the OAE2 interval, supervised by Prof Jonathan Redfern, Kevin Taylor and Dr Luc Bulot, a project that spans the Cenomanian-Turonian to examine depositional controls on source rock development, comparing the development along the Tethyan and Atlantic margins.
Key aims:

- Source rock timing
- Controlling factors of black shale deposition and quality
- Global controls (OAE2) vs local controls on source richness.
- Paleoenvirionmental controls to optimize source development, shallow and deep marine
- Productivity, preservation, terrigenous influx
- Role of C/T boundary





Location map (above) and global CT climate and isotopic excursion data (left)



Example of black mudrocks sample south of Errachidia

Calcite-rich, mudrocks, laminated.

Variable bioturbation

High abundance of planktonic foraminiferal

High TOC values from 9.64%-15.82%

The project is undertaken in collaboration with ONHYM, through Directeur de l'Exploration Pétrolière M. Mohamed Nahim and Zakaria Yousfi

Expanding NARG Biostratigraphic Capability

Dr Luc Bulot has relocated to Manchester to lead up NARG Biostratigraphy Research. He has been working with NARG for two years on projects in Morocco, but this move will allow us to expand our activities and work even more closely. Luc is a CNRS Fellow, with 25+ years experience and specialises in Cretaceous ammonite stratigraphy.

Dr Bulot's involvement with the group commenced with the development of new projects on the Mesozoic of Atlantic Morocco. NARG projects required biostratigraphic expertise and first contact was made with Dr. Bulot at the end of 2014. Since this first contact, we have developed an extensive and fruitful collaboration and he is now leading our biostratigraphic team involving a collaboration of international academics. His range of activities within the group include management and development of the NARG biostratigraphic network, co-supervision of PhD students (field work and laboratory), and participation / organisation of seminars, steering meetings and workshops.

Besides his own contribution to develop a high resolution biostratigraphic framework for the Callovian, J/K boundary and early Cretaceous of the Essaouira-Agadir Basin, Dr Bulot is directly involved in the co-supervision of four of our PhD students and often supports them in the field:

- Tim Luber: Characterisation of Early Cretaceous Depositional Systems along the Atlantic Passive Margin, Morocco. The Essaouira - Agadir Basin.
- Angel Arantegui: Characterisation of Early Cretaceous Depositional Systems along the Atlantic Passive Margin, Morocco. The Tan Tan- Tarfaya Basin.
- Aude Duval-Arnould: Control on stratigraphic development and reservoir distribution of shelf-margin carbonates: Jurassic Atlantic Margin, Western Morocco.
- Jianpeng Wang: Controls on the distribution and quality of the Cenomanian/Turonian source rocks in Morocco.

Dr. Bulot's contribution to NARG research in Morocco has resulted in significant scientific output already. He has co-authored five talks and posters presented at conferences (including the International Association of Sedimentologists and American Association of Petroleum Geologists). A first palaeontological paper sponsored by the NARG was published in the March issue of the Neues Jahrbuch für Geologie und Paläontologie. Three other articles on the Cretaceous stratigraphy of Algeria and Morocco are in the submission process of peer-reviewed journals (the first accepted in May 2017 in Cretaceous Research).

In addition to the ongoing palaeontological and biostratigraphical investigations in Morocco, Dr. Bulot will actively participate in new NARG projects on the tectono- stratigraphic evolution of the West Africa Mauritania-Senegal-Guinea Bissau and conjugate continental margins.

cerege
CENTRE EUROPÉEN DE RECHERCHE ET D'ENSEIGNEMENT DES GÉOSCIENCES DE L'ENVIRONNEMENT

Luc has pulled together a global team of experts able to offer dating using Ammonites, Foraminifera, Nannoplankton, Gastropods, Bivalves and Brachiopods.
Details available on the website.

2017 NARG Morocco Workshop and Field course

*A shorter version of this trip is being offered for the London AAPG Conference in October, ICE FT 10 | Atlantic Margin Petroleum Systems: Morocco Field Course and the NARG trip will run again for sponsors in **2018***

In April 2017 we organized a 1-day workshop in Marrakech followed by a 5-day field course for sponsors of NARG and invited guest. Attendees included 15 representatives from Statoil, Chevron, Cairn, Sound Energy, Genel, Maersk, CNSOPB (Nova Scotia), Dalhousie University, University of Barcelona, NUI Galway and ONHYM (location map and itinerary below)


Workshop


Dr Nadine Mader from Maersk (a former NARG PhD), led the day to the Argana Valley Triassic continental clastics.

Dr Luc Bulot (ably supported here by Tim Luber and Aude Duval-Arnould) explains the new research findings on Aptian Ammonite biostratigraphy at the type section in Tiskatine.

Examining exceptional Triassic exposures of the High Atlas near Oukaimeden (left) and (below) Argana Valley (the latter led by former NARG PhD student Dr Nadine Mader).

Knowledge Exchange and Impact


Jurassic reefal architecture examined at Tidili

After a hot morning in the field, lunch under the shade of an Argana tree

Recent Publications and Upcoming Conference Presentations

Published:

Luber T, L., Bulot, L.G., Redfern, J., Frau, C., Arantegui, A., Masrour, M., 2017. A revised ammonoid biostratigraphy for the Aptian of NW Africa: Essaouira-Agadir Basin, Morocco. Cretaceous Research. doi: 10.1016/j.cretres.2017.06.020

Newport, R., Hollis, C., Bodin, S and Redfern J., 2017, Examining the interplay of climate and low amplitude sea-level change on the distribution and volume of massive dolomitization: Zebbag Formation, Cretaceous, Southern Tunisia: The Depositional Record, Volume 3, Issue 1 June 2017 p 38–59 DOI: 10.1002/dep2.25

Mader, N. K., Redfern, J. & El Ouataoui, 2017, Sedimentology of the Essaouira Basin (Meskala Field) in context of regional sediment distribution patterns during upper Triassic pluvial events: In Journal of African Earth Sciences. 130, p. 293-318 26 p. DOI: 10.1016/j.jafrearsci.2017.02.012

English, K.L., Redfern, J., Bertotti, G., English, J., and Yahi Cherif, R., 2016, Intraplate uplift: new constraints on the Hoggar dome from the Illizi basin (Algeria): Basin Research, p. 1-17. DOI: 10.1111/bre.12182

English, K.L., Redfern, J., Corcoran, D.V. English, J., and Yahi Cherif, R., 2016, Constraining burial history and petroleum charge in exhumed basins: New insights from the Illizi Basin, Algeria. AAPG Bulletin, v. 100, No. 4 (April), p. 623-655.

English, K.E., English, J.M., Bonnell, L., Lander, R.H., Hollis, C., Redfern, J., Guirdham., C., Garnham., J., Yahia Cherif, R., Controls on reservoir quality in an exhumed basin (Ordovician sandstones, Illizi basin, Algeria). : Marine and Petroleum Geology. 80, p. 203-227 25 p. DOI: 10.1016/j.marpetgeo.2016.11.011

English, K.E., English, J.M., Hollis, C., Redfern, J., Corcoran, D., Oxtoby, N., Yahia Cherif, R., Remobilization of Deep Basin Brine during Exhumation of the Illizi Basin, Algeria. Marine and Petroleum Geology.

In Press / Submitted:

Muniz-Pichel , L., Finch, E., Huuse, M and Redfern, J. 2017 (In Press), The Influence of Sedimentation on Rejuvenation of Salt Diapirs" ,Journal of Structural Geology

Charton R, Bertotti, G., and Arantegui. A. in review, The Ifni transect across the rifted margin of Morocco (Central Atlantic): Syn- and post-rift vertical movements constrained by low-temperature geochronology. *Submitted to Terra Nova*

Luber et al., 2017. Integrated stratigraphic type section for the Aptian of NW Africa. Submission to Cretaceous Research.

Examples of Conference Presentations

Leonardo Muniz-Pichel et al.,
5th Conjugate Margins Conference (Brazil)
- Salt-related Structural Styles and Sequential Generation of Allochthonous Salt Sheets on the Conjugate Margins of Morocco and Nova Scotia
- Salt-detached Ramp Syncline Basins on the Brazilian and W Africa Margins

Emmanuel Roquette et al.,
Poster presentation to the Goettingen Provenance workshop and courses (University of Göttingen) 19th-Sept-2017
- "Strategy for a large-scale multi-proxy provenance analysis of the Early Cretaceous fluvial formation exposed on the Moroccan Atlantic Margin."

Abstract accepted for the International Meeting of Sedimentology 2017 (Toulouse, France), October-2017
- "Multi-proxy provenance analysis along the Moroccan Atlantic Margin: tracing source areas for Lower Cretaceous reservoirs in the Essaouira-Agadir Basin (EAB)."

Nawwar Al-Siinawi et al.,
Abstract accepted for the International Meeting of Sedimentology 2017 (Toulouse, France), October-2017
- Dolomitization of Jurassic carbonates in the Western High Atlas of Morocco: processes and implications for reservoir properties

Luber et al.,
Poster, PESGB HGS 16th African E&P Conference, London,
- An integrated source to sink analysis of Early Cretaceous depositional systems along the Central Atlantic

Exhumation and sediment production during the late syn-rift and early post-rift evolution of the Moroccan Atlantic margin
Giovanni Bertotti[1,3], Angel Arantegui[2,3], Remi Charton[1,3], Tim Luber[2,3] and Jonathan Redfern[2,3]
PESGB meeting London – August 2017

For more details visit our booth at the PESGB Africa Conference and AAPG ICE London

NARG Activities in MSGBC - Mauritania, Senegal and The Gambia

Ongoing Research Activities:

Mr Max Casson started his PhD with NARG in May 2017 on the tectonostratigraphic evolution of the MSGBC margin. We have access to a 3D seismic survey from TGS in The Gambia, and interpretation has commenced on this, plus building the regional database. Other work includes reviewing all the DSDP wells and sampling for improved biostratigraphic and reservoir provenance.

We also are planning fieldwork to Cap Verde in the next three months to log and sample the Jurassic / Cretaceous sections. We hope in 2017 to access more regional 2D seismic in Senegal and Mauritania, through collaboration with government bodies and Universities, to allow extension of this work north. Up to 2 additional PhDs will start to support this.

We have four petroleum MSc students currently working on The Gambia data, looking at detailed seismic interpretation of the shelf and basin section, near surface analysis and building a petroleum system model. These will act as pilot studies for future studies.

Visit to Manchester by Petrogaz

We hosted a visit of Petrogaz to Manchester in March 2017, where we showcased our research capabilities. This was attended by the Mr Ousmane NDIAYE Permanent Secretary of the Strategic Orientation Committee for the Oil & Gas (COS-PETROGAZ) and Mr Mamadou Fall KANE, Assistant to the Permanent Secretary, Professor Cheikh DIENG, Senegalese Ambassador to UK and the UK Ambassador to Senegal, H.E. George Hodgson.

Prof Jonathan Redfern with the Petrogaz delegation, Manchester University in 2017.

Building research and training links in Senegal - June 2017

We have followed up the visit by Petrogaz to Manchester with our own visit to Dakar, led by Prof Jonathan Redfern and Dr Luc Bulot, to work towards establishing collaboration agreements with Petrosen and academic institutions in Senegal, and commence the NARG research projects. Below is a brief summary of activities:

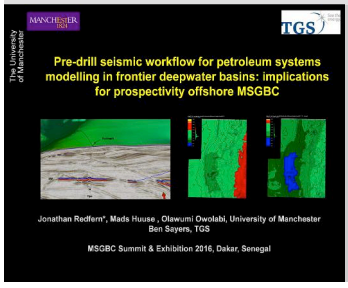
We held meetings with Petrosen, with the General Manager Dr Mamadou Faye and Mamoudou KA, their Data Centre Manager, in Petrosen's office. We had meeting with Mr Mamadou Fall KANE of Petrogaz, held at the Presidency. We also had a number of meetings with academics at the University of Dakar (UCAD) and held a research seminar in UCAD, with 20 plus students and staff attending. Finally we had a short reconnaissance field visit on with Prof Mamadou Fall and colleagues, looking at some of the outcrops of the Cretaceous sections near to Dakar.
We also sampled for biostratigraphy and reservoir studies, and obtained GPS locations etc for future more detailed work.

Research Seminar at UCAD, given by Prof Jonathan Redfern and Dr Luc Bulot, attended by Professorial staff and students. Dr Bulot explains importance of robust biostratigraphy, using our work in Morocco as a case study.

Many students undertaking masters and keen on further PhD or MSc research

Prof Mamadou Fall kindly took us out for a day to undertake reconnaissance of the sections near Dakar. Example from Cretaceous sections at Cap de Naze. Dr Bulot sampling for biostratigraphy.

Prof Redfern quenches his thirst on that famous Manchester drink "***Vimto",*** also a popular drink in Senegal!



MSGBC Conference Presentation

This study was presented at the MSGBC Summit and Exhibition in November 2016. It showcases a pre-drill, seismic-only workflow for petroleum systems analysis along frontier deepwater margins such as the MSGBC. We show first how the presence of a BSR can be used to derive shallow geothermal gradients and heat flow and then we utilize this information and seismic velocity information to derive the thermal structure of the subsurface including the temperature distribution along the Top Jurassic of two exploration blocks in the deepwater offshore The Gambia. Work is ongoing to refine the model, with a publication expected shortly. We intend to present further work at the next MSGBC Conference in Dakar in November. 2017.

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Dr Mike Bidgood (GSS International),
Prof Stefano Monari; Dr. Roberto Gatto (Università di Padova),
Prof Daniela Rehakova
Howard Feldman (AMNH)
Barabara Radulovic (University of Belgrade)

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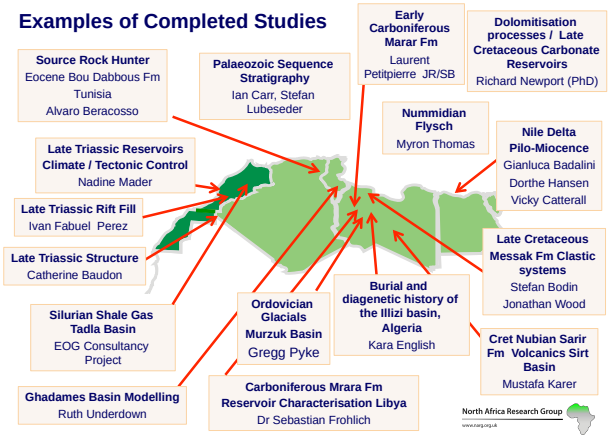
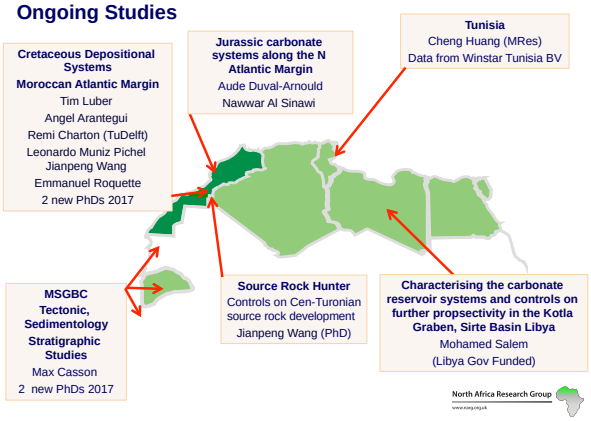
Examples of Completed Studies



Ongoing Studies



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