Assessing the impact of provenance and sedimentary processes on sand delivery to deepwater basins:

Provenance of Early Cretaceous fluvial systems along the Moroccan Atlantic margin

Fully funded PhD studentship: *North Africa Research Group*
Host University*: University of Manchester, UK*
Supervisors: *Dr Stefan Schroeder, Prof Jonathan Redfern (University of Manchester), Dr Shane Tyrrell (NUI Galway), Prof Giovanni Bertotti (TuDelft)*

A fully funded PhD studentship to start in September 2016 or January 2017, to assess the impact of provenance and sedimentary processes (e.g. mixing, storage) on the calibre of sand ultimately delivered to a deepwater basin. The case study aims to establish the provenance of the Early Cretaceous succession exposed along the Atlantic margin of Morocco. Understanding the provenance of large drainage systems on the NW Africa margin is a critical element of our integrated regional study to evaluate the tectonic evolution of the Atlantic passive margin, and has major implications for constraining reservoir and source rock development in the subsurface.

The study will focus on establishing clastic source types, source ages, and sediment transport pathways using field- and laboratory-based techniques including petrography, geochemistry, detrital zircon geochronology and Pb isotopic analysis of feldspar. Application of a multi-proxy approach - utilising provenance signals that reside in minerals of variable stability will allow the source of the sediment to be established while also constraining processes such as recycling, mixing and prolonged storage. Heavy mineral analysis will be employed to reveal bulk correlateable fingerprints and also highlight trends in labile minerals which may be linked to storage phases. U-Pb zircon geochronology allows the ultimate sedimentary sources to be established but the robust nature of zircon means it can be recycled several times. In contrast, feldspar is unstable and likely of first-cycle origin, therefore it can be utilised to better constrain drainage pathways. Employed together, these techniques offer a valuable tool to assess sediment routeways, recycling, mixing and sand delivery to the margin, with implications for reservoir characterisation in the deepwater realm.

This multi-proxy technique is already been utilised with on-going provenance research based at Irish universities, and focussed on the western Irish Offshore basins further northward along the Atlantic Margin. Basins along the Moroccan Atlantic Margin are an excellent target for this type of approach, as they comprise a near complete section through the Lower Cretaceous. This allows for direct sampling of sediment potentially impacted/modified by hinterland and shelf processes.

The North Africa Research Group (NARG) is an integrated research group, currently with 11PhDs, established in 2000. This PhD study combines the strengths of the Universities of Manchester, TuDelft and the National University of Ireland, Galway. NARG are supported by a large consortium of industry companies. The PhD is fully funded, including all fees, living allowance and costs of fieldwork

and laboratory analysis. NARG has undertaken a number of extensive projects across North Africa, and we have recently embarked on a major series of studies examining Mesozoic depositional systems on/offshore western Morocco along the Atlantic seaboard. Morocco, together with comparable basins further south in Mauritania and Senegal, and the conjugate margin in Nova Scotia, are areas of active oil and gas exploration, and the results from this study will have an important input to understanding the petroleum system and development of the passive margin.

We seek a highly motivated candidate with the following skills:

- 1st or high 2.1 undergraduate or masters degree (or equivalent) in geology
- good background in sedimentology and/or sediment geochemistry, ideally having conducted similar projects at undergraduate or masters level
- ability to conduct field work in rural Morocco
- independent worker with good organizational skills
- team working skills, with ability to integrate with other team members and industry partners
- knowledge of provenance analysis or detrital mineral geochronology is an advantage
- knowledge of French is an advantage

The Basin Studies and Petroleum Geoscience Group at Manchester has 13 academic staff and over 35 PhDs, and offers access to world-leading facilities and research expertise for stratigraphic and sedimentological studies. Training is offered through specialist seminars within the group and the opportunity to take selected masters courses from the Petroleum Geoscience MSc. The successful candidate will also have opportunities to interact with and present results to industry partners, and will typically undertake a 3-month internship with one of our sponsor companies.

We have extensive facilities, as may be expected in a world leading University. This includes a mineralogical and geochemical laboratory, petrographic laboratory, an industry-standard petrophysical laboratory, and industry-standard software packages including Petrel™ , ArcInfo™ among others. NUI Galway will provide co-supervision and expertise/support in provenance analysis and analytical techniques.

Full scholarship: 3.5 years funding, includes all fees, living allowance and field expenses.

Selected References:

Bertotti, G, Arantegui, A, Charton, R, Luber, T & Redfern, J (2015). The upper Jurassic-lower cretaceous siliciclastic system in the Morocco offshore - Provenance, transport and deposition. In M Mozetic (Ed.), *Proceedings of the 77th EAGE conference and exhibition, 2015* (pp. 1-5). Houten: EAGE.

Gouiza, M., Charton, R, Bertotto G, Andriessen P and Storms J.E.A (2015) Post-Variscan evolution of the Anti-Atlas belt of Morocco constrained from low-temperature geochronology . Int J Earth Sci (Geol Rundsch)

Luber, T, Redfern, J, Bulot, L, Arentegui, A, Charton, R and Bertotti, (2016) Mitigating Early Cretaceous Reservoir Risk Along the Offshore Morocco Passive Margin Through Analysis of the Coastal Delivery Systems Exposed in the Agadir-Essaouira Basin. , **Conference Paper** DOI: 10.13140, AAPG Annual Convention and Exhibition, Calgary, Alberta, Canada

Tyrrell, S., Haughton, P.D.W., Souders, A.K., Daly, J. S. and Shannon P.M., (2012). Large-scale, linked drainage systems in the NW European Triassic: insights from the Pb isotopic composition of detrital K-feldspar. *Journal of the Geological Society of London*, **169,** 279-295.

Tyrrell, S., Haughton, P.D.W., Daly, J.S. & Shannon, P.M. (2012). The Pb isotopic composition of detrital K-feldspar: a tool for constraining provenance, sedimentary processes and paleodrainage. *In: Sylvester, P (eds). Quantitative Mineralogy and Microanalysis of Sediments and Sedimentary Rocks, Mineralogical Association of Canada Short Course Series, Volume 42 . Québec, Canada: Mineralogical Association of Canada.* 203-217.

Tyrrell, S., Leleu, S., Souders, A.K., Haughton, P.D.W. & Daly, J.S., (2009). K-feldspar sand-grain provenance in the Triassic, west of Shetland: distinguishing first-cycle and recycled sediment sources? *Geological Journal,* **44**, 692-710.

Further details of our research activity go to: http://www.narg.manchester.ac.uk/research/

North Africa Research Group Newsletter:
https://www.researchgate.net/publication/303898484_North_Africa_Research_Group_Newsletter_June_2016

Application: please apply online at: http://www.manchester.ac.uk/study/postgraduate/how-to-apply/ quoting this PhD advert and the lead supervisor Dr Stefan Schroeder. For additional details please email stefan.schroeder@manchester.ac.uk

Submission Date: Application should be submitted by September 1st 2016. Selected candidates will be called for interview shortly after that date.