Final report VISTA 2015

Project title: **Carbonate – Siliciclastic – Evaporite Systems in Rift Basins: The Miocene El Qaa Fault Block, Suez Rift, Egypt**

Project director:	Rob L Gawthorpe
Postdoc/ scholar:	Martin Muravchik
Institution:	University of Bergen, Norway
Project duration:	01-09-2012 to 31-07-2015
Technical contact person in Statoil:	Ian R Sharp
Division head:	Lasse Amundsen
Project number:	6261

1. ½ A4 page with a popular presentation of the project (to be written by the scholar)

Rift basins are topographic depressions that originate from extension and thinning of the lithosphere, leading to the deposition of sediments and the accumulation of some of the world's most prolific hydrocarbon fields. Siliciclastic, carbonate and evaporite deposits within rifts are generally studied in isolation from one another, yet analysis of modern depositional systems from arid rifts, such as the Red Sea and Gulf of Suez, reveals a complex 'mixed' assemblage of siliciclastic fan deltas, sourced from the rift margin, evaporite-rich sabkhas and shallow marine coral and algal carbonates. In recent years much interest has been generated by sub-salt hydrocarbon plays in the South Atlantic where a detailed understanding of mixed carbonate-siliciclastic-evaporite rift to post-rift successions is critical to reducing exploration risk and improving success. However, due to limited well penetrations and the problems of imaging in seismic data beneath salt, it is difficult to develop the necessary level of geological knowledge directly from subsurface datasets. Outcrop-based sedimentary and structural analyses still constitute the only means to fully understand the vertical and lateral variations in the sedimentary deposits and their relation with the deformational structures in rift basins at the resolution of fault zones and sedimentary facies (i.e. decimetre to tens of meters horizontal and vertical).

This research project applied field-based geological and digital surveying methods to exceptional exposures of mixed carbonate-siliciclastic-evaporite sequences from the Miocene of the Suez Rift to understand the sedimentary and tectonic evolution of these systems. The overall aim of the project was to determine the location, geometry, heterogeneity and inter-relationships of the major sedimentary environments within mixed carbonate-siliciclastic-evaporite depositional systems in rift climax to early post-rift basins and quantify the controls on their development. Developing an integrated, process-based understanding of mixed carbonate, siliciclastic and evaporite systems in rift basins is both of academic and industrial importance. The study is of direct relevance to increasing the understanding of hydrocarbon prolific pre-salt petroleum systems of the South Atlantic, as well as Miocene systems of SE Asia. Obtaining a correct understanding of the interrelationship between carbonate, siliciclastic and evaporate sedimentary systems is also of benefit to environmental studies of marine areas under arid climatic settings.

2. Have there been any changes in the objective/goals during the project period? Did you achieve what was promised in the project description? (to be written by the scholar)

There were no major changes to the original generic objectives of the project. However, the situation of political and social unrest following the 'Arab Spring' in Egypt, in particular following the military overthrow of President Morsi in the summer of 2013, increased security risks in Sinai that prevented us from completing the final stages of our planned fieldwork in 2014. Field data collected during 2012 and 2013 allowed us to complete 80-90% of the originally proposed fieldwork. Similar security risks exist along other regions along the Red Sea, so we chose the Corinth Rift in Greece as an alternative field area towards the end of the project to extend our observations from the Suez Rift and make them more generic and applicable to rifts in general. Our observations in the area allowed us to better contrast the depositional style of arid settings (Suez Rift) with those developed in more humid areas (Corinth Rift).

Despite the security problems in Sinai and changes to the final year of the project, almost all of the planned research objectives in the original project description have been attained. The results of the project offer new interpretations that improve the understanding of mixed (carbonate-siliciclastic-evaporite) sedimentary systems in rift basins and, in particular, those subject to arid climatic conditions. The changes in project direction has led to some delay in publication of the results of the project in high-impact geoscience journals, although presentation of interim results at major international geoscience meetings has progressed well through the project (See Section 3). Preparation of manuscripts for publication is still on going and is estimated that these will be completed and submitted for peer-review by early 2016 (See Section 3).

3. Publications (scholar)

Papers in journals (in preparation – all to be submitted by early 2016)

Muravchik, M., Gawthorpe R.L. and Sharp, I. Mixed carbonate-siliciclastic-evaporite systems in rift basins: The Miocene of the El Qaa Fault Block, Suez Rift, Egypt. To be submitted to Basin Research.

Muravchik, M., Gawthorpe R.L., Sharp, I., Rarity, F. and Hodgetts D. Accommodation space controlled deltas in arid extensional basins, El Qaa Fault Block, Suez Rift, Egypt. To be submitted to Sedimentology.

Muravchik, M., Gawthorpe R.L., Sharp, I., Rarity, F. and Hodgetts D. Fringing syn-rift shoreline and shallow marine deposition along a hangingwall dipslope: The El Qaa Fault Block, Suez Rift, Egypt. To be submitted to Sedimentology.

Muravchik, M., Gawthorpe R.L. and Sharp, I. Sedimentary and structural evolution of a fault degradation complex: The Coastal Fault Belt, Suez Rift, Egypt. To be submitted to Basin Research.

Muravchik, M., Rarity, F., Gawthorpe R.L., Hodgetts, D. and Sharp, I. 2015. Early syn-rift shallow marine deposition in structural embayments and straits: Nezzazat Fault System, Suez Rift, Egypt. To be submitted to Basin Research.

Conference presentations

Muravchik, M., Gawthorpe R.L., Sharp, I. 2015. Accommodation space controlled delta progradation in arid extensional basins, El Qaa Fault Block, Suez Rift, Egypt. AAPG Annual Convention and Exhibition, May 2015, Denver, USA.

Muravchik, M., Gawthorpe R.L., Sharp, I., Hodgetts, D. 2015. Structural embayments and straits control on early syn-rift shallow marine deposition: Nezzazat Fault System, Suez Rift, Egypt. AAPG Annual Convention and Exhibition, May 2015, Denver, USA.

Muravchik, M.; Gawthorpe R.L.; Sharp, I. 2014. Sedimentary evolution in arid rift basins, El Qaa Fault Block, Suez Rift, Egypt. 19th International Sedimentological Congress, August 2014, Geneva, Switzerland.

Muravchik, M.; Gawthorpe R.L.; Sharp, I. 2014. Internal structure of a fault degradation complex, Coastal Fault Belt, Suez Rift, Egypt. Geometry and Growth of Normal Faults, Petroleum Group, The Geological Society, June 2014, London, UK.

Muravchik, M.; Gawthorpe R.L.; Sharp, I. 2014. Carbonate and siliciclastic clinothem cycles and their relation with evaporite deposition. El Qaa Fault Block, Suez Rift, Egypt. AAPG Annual Convention and Exhibition, April 2014, Houston, USA.

Muravchik, M.; Gawthorpe R.L.; Sharp, I. 2013. Mixed siliciclastic-carbonate-evaporite depositional systems in extensional settings, El Qaa Fault Block, Suez Rift, Egypt. 30th IAS Meeting of Sedimentology, September 2013, Manchester, UK.

Muravchik, M.; Gawthorpe R.L.; Sharp, I. 2013. Evaporite-Carbonate-Siliciclastic Interactions in Extensional Settings, El Qaa Fault Block, Suez Rift, Egypt. AAPG Annual Convention and Exhibition, May 2013, Pittsburgh, USA.

Muravchik, M.; Gawthorpe R.L.; Sharp, I. 2013. Structure and Evolution of a Fault Degradation Complex, Coastal Fault Belt, Suez Rift, Egypt. AAPG Annual Convention and Exhibition, May 2013, Pittsburgh, USA.

4. Reflections on continuation of the project (to be written by the project director)

The spectacular level of exposure and lack of structural inversion in the Suez Rift make it a unique field laboratory for the study of syn-rift deposits and normal fault networks. Unfortunately, the current security situation in Egypt, and particularly Sinai, make it impossible to safely undertake fieldwork in the Suez Rift, and this situation does not look like it will improve in the near- to mid-term. The digital outcrop data and samples obtained as part of this project will continue to be worked on by the Project Director in the coming years, particularly with a focus on investigating the controls on cyclicity within syn-rift depositional systems. When the opportunity arises to undertake field-based studies in the rift again, the work undertaken during this project (the data generated and the publications [listed in Section 3]) will form a solid foundation for future research projects on a range of rift-related structural and sedimentary topics. Furthermore, with new subsurface data being collected in the South Atlantic providing sub-salt well penetrations and improved sub-salt seismic imaging, our Suez-based outcrop studies provide a foundation for new research projects working on these subsurface datasets.

The comparative research undertaken in the Corinth Rift, during the latter stages of this project, provided initial observations of Plio-Pleistocene, syn-rift shallow- and deep-water depositional environments in a humid climate that contrast with the semi-arid/arid climatic setting of the Suez Rift. Based on the Corinth research that has been undertaken as part of the VISTA project, we have recently submitted a proposal to the Research Council of Norway to investigate shallow- and deep-water depositional systems in the Corinth Rift, focusing on isolating structural and environmental (i.e. climate and base-level) controls on their evolution. The VISTA Scholar, Martin Muravchik, has been fully involved in developing this project proposal and is named as a co-investigator/researcher in the research proposal. If successful, this new proposal will provide a further three-years of employment for him at UiB, allowing him to gain experience of new techniques and to interact with a new set of international researchers from the UK, France and Greece. The combined expertise gained from the VISTA Scholar position and this new project will give Muravchik very strong tectonic and sedimentary geology expertise, as well as a set of major papers in specialist international geoscience journals, that will be of relevance to either an academic or industry career.