NERC Centre for Doctoral Training in Oil & Gas (2018 start)

Project Title: How responsive are coastal carbonate depositional systems to relative sea-level change?

Host institution: University of Aberdeen

Supervisor 1: Rob Butler

Supervisor 2: John Howell (UoA), Rosanna Maniscalco & Agata di Stefano (Univ. Catania)

Project description: Carbonate depositional systems at coast lines are highly sensitive to relative sea level change – caused globally and in response to local tectonics. Once calibrated, they can provide exceptional high-resolution records not only of vertical movements and tilt-rates but also of climate and oceanographic change back in geological time. These insights can in turn be taken into the subsurface to reduce uncertainty in the interpretation of subsurface stratigraphy. The challenge is to understand these responses – the aim of this PhD project. The project provides training in understanding the controls on fine-scale architecture and continuity of analogues for shallow-water carbonate reservoir rocks (and aquifers).

Uplift of the submarine thrust system of Sicily during the Plio-Quaternary is marked by a major regressive depositional system that is capped by coastal packstone carbonates that record sea-level change, modulated by local growth-folding, over c 4 million years. Spectacular parasequences exposed in cliff-sections reveal internal stratal architectures (clinoforms, top-lap and erosional surfaces, storm dune-systems) with micro-habitat variations evidenced by trace fossil assemblages and shell preservation. Existing bio and magneto-stratigraphic work shows the cyclicity relates to precession. Parasequence stacking patterns can be linked to the interplay between regional tectonic uplift, global sea-level change and local thrust-related fold amplification. Collectively the parasequences can be used to reconstruct coastal dynamics (physical and biological) and relate these not only to the tectonic history of the deforming substrate but also to high frequency (precession cycle; c 23 kyr) sea-level change. This project will build a multi-scale survey of these, using high-resolution digital mapping tools (UAV and ground-based photogrammetry) allied to sedimentological/palaeobiological fieldwork. Fieldwork will involve detailed sedimentological-structural surveys, tied to sedimentary logging and correlations. A variety of outcrop locations will provide resolution in space and time. The data will answer questions such as: how rapid is coastal migration, does it vary in time; does clinoform advance relate to top-set erosion and/or biological production; how frequent are storm events, does this vary with time within a precession cycle, and between cycles; do intra-parasequence coast-line migrations relate to their stacking patterns on active structures (which impacts on reservoir compartmentalization); are differences carbonate production (biological efficiency) related to different parts of a precession cycle? Collectively the answers will explore the coastal response to tectonics and sea-level change at high temporal resolution. The diachroneity of outcrops will show how these responses have varied through time, with applications to subsurface and palaeogeographic/temporal settings elsewhere.

CDT Research theme(s): This project ties into the CDT Research Theme**: Extending the Life of Mature Basins** – by providing tools and analogues for complex stratigraphic architectures in carbonate reservoirs. Shallow-water carbonates host economic accumulations of shallow gas in the Adriatic region and elsewhere. It also shows how industry-relevant research can provide important insights into palaeoclimatic variations, the better to calibrate understanding of the impact of climate change on coastal areas.

Research and training context: The project builds on qualitative studies involving RWHB and colleagues in Catania University in the 1990s in Sicily. This project will rejuvenate this collaboration, bringing high-resolution digital mapping, together with linked sedimentological and palaeobiological fieldwork, to quantify processes for the first time. Fieldwork is possible year-round. Training will be given in sequence stratigraphy, field sedimentology, UAV- and ground-based digital mapping, model-building, interpretation and visualization. The project explores the forcing of depositional systems by tectonics and climate, to improve predictions of stratal architectures in subsurface settings. Digital outcrops will be shared through existing knowledge exchange platforms.

Research costs: Fieldwork costs can be met from the research budget of the studentship. Additional support is available through the SAFARI project, though this project is explicitly designed to stand-alone

Career routes: The training (including 3D visualization and interpretation) is generally valued for careers in exploiting subsurface geology – not only within the energy sector but also more widely, including academia. Expertise in digital mapping technologies offer much wider employment opportunities throughout the environmental monitoring sector.

Submissions must conform to this single-sided A4 format. The Awards Committee reserves the right not to consider submissions that do not adhere to this condition.