New insights into early diagenesis through space and time: diagenetic atlas and geobody characterisation

Supervisors:
Dr Fiona Whitaker (School of Earth Sciences, University of Bristol) – Main supervisor
David Katz (Chevron, Houston, USA)
Host institution: University of Bristol

Project description: Diagenesis can significantly modify the distribution of reservoir quality established during carbonate deposition. The distribution of diagenetic pore types is challenging to predict but can be critical for the prediction of reservoir volumes, net-to-gross and connectivity. Such parameters are critical for the effective management of hydrocarbon reservoirs, CCS and aquifer remediation.

Alteration of reactive young sediments by active fluid circulation can be a key control on later diagenesis, hydrocarbon emplacement and extraction. Comparing platforms from different paleo-environmental settings suggests a number of key controls. For example, greatest dissolution occurs within aragonitic systems where high amplitude sea-level fluctuations lead to extended subaerial exposure, thick soils and a humid climate ensure a high flux of aggressive fluids, and slow subsidence enhances overprinting. Understanding hydrological/geochemical processes driving diagenesis enables us to unravel these complex controls, understand their interactions and infer the resulting distribution of diagenetic products. Recent advances in process-based modelling offer the potential to predict broad spatial patterns of reservoir quality.

This project will develop 1. An atlas of early diagenetic patterns in time and space, to evaluate control by platform configuration, climate and relative sea-level, and secular changes in ocean chemistry; 2. A suite of rules for input into reservoir models relating the sizes, shapes and distributions of diagenetic geobodies to sequence stratigraphy and/or geophysical data.

Phase 1 will characterise diagenesis in recent/modern carbonate systems across a range of environments. Fluid chemistry is a sensitive tracer of water-rock interaction, provides clues about controlling processes, and can be combined with fluid flux to derive distributed reaction rates. Modern systems will be compared to characterise hydrochemical processes under different climatic conditions and their impact on diagenesis. The project will synthesise the wealth of disparate existing data for individual systems and compare key case studies.

Phase 2 involves process-based modelling linking depositional to diagenesis. Hydrochemical data will be used to constrain reactive transport models (RTMs) of individual time slices, and forward sedimentological-diagenetic models (FSDMs) of temporal evolution. RTM simulations assuming a simple distribution of rock properties will examine extrinsic controls on the distribution of diagenesis. This will inform FSDMs of platforms to explore diagenetic in platforms of contrasting facies distributions and platform architectures. RTMs based on these heterogeneous detailed synthetic stratigraphies will predict the geometry, distribution and continuity of diagenetic geobodies. Finally, these predictions will be compared with observations of diagenetic geobodies from recent and ancient outcrop analogues.

Whitaker F, and Smart P, 2007. Geochemistry of meteoric diagenesis in carbonate islands of the northern Bahamas: 1. Evidence from field studies. 2. Geochemical modelling and budgeting of diagenesis *Hydrological Processes,* 21, 949-966 & 967-982.

Paterson R, Whitaker F, Smart P, Jones D, and Oldham D, 2008. Controls on early diagenetic overprinting in icehouse carbonates: insights from modelling hydrological zone residence times using CARB3D+. *Journal of Sedimentary Research,* 78, 258-281.
Al-Helal A, Whitaker F, and Xiao Y, 2012. Dynamic interactions between geothermal circulation and brine reflux: reactive transport modelling of dolomitisation, anhydrite precipitation and porosity-permeability evolution. *Journal of Sedimentary Research* 82, 196-215.