NERC Centre for Doctoral Training in Oil & Gas (2017 start)

Project Title: U**nravelling the contributions of source terrains, palaeoclimate, and diagenesis through formation-scale changes in clay mineralogy of shale**

Host institution: University of Exeter (Camborne School of Mines)

Supervisor 1: Steve Hesselbo (Exeter, Camborne School of Mines)

Supervisor 2: Kate Littler (Exeter, Camborne School of Mines)

Project description: Mudrock texture and composition is key to understanding and predicting the properties of hydrocarbon source rocks and cap rocks. Observations on mudrock successions such as the Lias or Kimmeridge Clay of southern UK, show evidence of systematic stratigraphic changes in clay mineral content interpreted to result from palaeoclimatic imprint on original source mineralogy, and subsequent modification by diagenetic change (e.g. Hesselbo et al., 2009, Late Jurassic palaeoclimatic change from clay mineralogy and gamma-ray spectrometry of the Kimmeridge Clay, Dorset, UK, *JGSL* v.166, p.1123–1133). Such mineralogical changes occur through formations at a variety of scales reflecting Milankovitch and tectonically-driven forcing factors. Until now, investigation of clay mineral and lithologic trends has had to rely on a combination of 'spot' observations of texture and chemical composition at the SEM scale, combined with mineral XRD determinations from larger sample sets.

Advances in automated SEM-EDS analysis are challenging the limitations of this approach. New algorithms allow detailed mineralogy, including clay group level mineralogy, to be automatically mapped, whilst in parallel capturing textural data. By integrating automated mineralogy and backscatter electron imagery, mapping the distribution of inorganic and organic components can also be achieved. Datasets generated this way can be compared with high-resolution geochemical data from hand-held XRF and mineralogy from XRD to understand how elemental composition corresponds to the mineral carriers.

In this studentship, the primary aim will be to combine advanced automated SEM-EDS analysis of mudrock mineralogy and texture with well-established field and laboratory approaches including XRD analysis. The student will carry out extensive fieldwork and using cores representing different source areas, will determine palaeoclimates, diagenetic pathways, burial history, and maturation characteristics. Analysis of depositional environment and collection of samples within an accurate stratigraphic framework will be key activities. The outcomes will include both understanding of individual formations and technique development.

The project will be undertaken with significant scientific input from **Alan Butcher** (FEI) and **Jenny Huggett** (Petroclays).

CDT Research theme(s): Both a) 'effective production of unconventional hydrocarbons' and b) 'extending the life of mature basins' are addressed in this proposal.

Research context: The student will join an active research group (4 PhD students) working on Deep Time Global Change, including current the CDT student. CSM has been at the forefront, in conjunction with industry partners, in the development and application of automated mineralogy based on SEM-EDS analysis. This technology has been widely utilised by existing PhD students at CSM.

Research costs: The application requires access to a state-of-the-art FEI QUANTA 650 FEG-SEM installed Summer 2015 at the University of Exeter, Penryn Campus. Lab costs = ~5K pa, travel and subsistence = ~1.5 K pa.

Career routes: Industry is widely embracing the application of automated mineralogy but a global shortage of staff familiar with the instruments and their outputs is problematic. Career paths would thus include specialist service providers, major oil companies buying into the technology, research institutions and universities and the SEM manufacturers.