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

Project Title: **Prediction of optimum brine composition for controlled salinity waterflooding**

Host institution: Imperial College London

Supervisor 1: Matthew Jackson (ICL)

Supervisor 2: Eric Mackay (Heriot Watt)

Additional Supervisor (s): Jan Vinogradov (Aberdeen University), Sebastian Geiger (Heriot Watt)

Project description: Modifying the composition of the brine injected during waterflooding in 'controlled salinity waterflooding' (CSW) can yield improved oil recovery (IOR). However, results published to date are inconsistent and contradictory: some laboratory experiments have shown improved recovery by simple dilution of formation brine, switching to seawater, or dilution of seawater; conversely, other studies have found no improvement. Some studies have found improved recovery by changing the concentration of specific ions such as calcium or sulphate. Experiments are not always repeatable across different reservoir rock samples, crude oils, experimental conditions and research groups.Recent experiments at Imperial College London (ICL, supported by Aberdeen University, AU), using an internationally leading core-flooding set-up, have demonstrated that IOR during CSW is correlated with changes in zeta potential at both the mineral-water and oil-water interfaces. The zeta potential is a measure of the electrical potential at the interface. At the same time, mineral surface to core- and reservoir-scale numerical simulations at Heriot-Watt University (HWU) have demonstrated that changes in brine composition during CSW reflect complex reactions at the mineral-brine interface. To fully understand IOR during CSW requires integration of ICL's core-scale experiments and HWU's mineral surface to core- and reservoir-scale numerical modelling.The aim of this project is to determine the optimal injection composition for CSW in a given crude-oil-brine-rock (COBR) system. Within this broad aim, the research will address the following objectives: (i) identify and quantify the relationship between IOR and zeta potential at both the mineral-water and oil-water interfaces, (ii) link zeta potential changes and IOR with changes in brine composition and reactions at the mineral surfaces, and (iii) use these relationships to predict how the CSW composition should be modified for a given COBR system.

The student will use data from previous core-flooding experiments, and conduct new core-flooding experiments where necessary in the IC laboratory, to correlate changes in zeta potential with IOR and effluent brine composition. The experimental data will be used to constrain and test models of surface complexation and ion exchange reactions at the mineral-brine interface. The models will be used to understand the mineral-surface to core-scale mechanisms that underpin IOR during CSW (i.e. understand when and why is oil released from the mineral surface, as observed in experiments) and deliver a predictive model for the optimum CSW brine composition to maximize IOR during CSW than can be deployed by industry.

CDT Research theme(s): B. The project will yield improved predictions of the optimal brine composition required for improved/enhanced oil recovery in sandstone and carbonate reservoirs, extending field life in mature basins including UKCS.

Research context: ICL and HWU have large, active groups in the proposed research area; the project will combine and leverage the existing expertise at each institution. The student will join 2 PDRAs and 3 PhD students at ICL, and work with 4 related (PD)RAs and 5 PhD students at HWU.

Research costs: 1. Computing – high performance workstation (3K in year 1). 2. Experimental – consumables for laboratory experiments (2K per year for first 3 years). 3. Collaborative travel to HWU/IC/AU for student and staff (2K per year). 3. Conference travel (2K per year for final two years).

Career routes: Demand for scientists/engineers with high end skills in experimental and computational IOR/EOR and the practical application of these is exceptionally high. Career paths are numerous and varied: specialist research (e.g. ExxonMobil URC), service provider (e.g. Schlumberger), reservoir engineer (numerous companies).