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

**Project Title**:
Pore-Scale Imaging of Cross Fault Flow in High Porosity Sandstones using High Pressure-Temperature Fluid Tomography

**Host institution: University of Durham**

**Supervisor 1: Dr Kate Dobson**

**Supervisor 2: Dr Thomas Seers (Texas A&M University at Qatar)**

**Additional Supervisor (s): Dr Branko Bijelic (Imperial College)**

**Project description:** Applied stresses within high porosity granular rocks (> 15% void fraction) result in characteristic deformation responses; namely granular flow (*rigid grain reorganisation*) leading to compaction, dilation or isovolumetric strain, and cataclasis (*grain fracturing and/or crushing*) emanating from elevated stress concentrations at grain contacts. The strain localisation features produced by these processes are generically termed deformation bands, which occur as narrow tabular (typically ~1mm thick) regions of disaggregated, rotated and/or crushed grains. These features are ubiquitous in high porosity sandstone reservoirs and aquifers, where they have implicated in negative impacts upon hydrocarbon production, and are a major source of uncertainty in terms of predicting the behaviour of an injected $CO_2$ plume for the geologic storage of carbon dioxide. As a consequence, deformation bands are of considerable economic and scholarly interest. The aim of this study is to investigate the roles that macroscopic and microscopic variability in deformation band structure plays in fluid entrapment and flow within sandstone aquifer and reservoir settings.

The PhD candidate will develop, perform and analyse a series of ground breaking experimental datasets that enable the behaviour of geo-fluids to be observed under reservoir conditions. To do this, the candidate will integrate 4D (3D+time) imaging using both laboratory and synchrotron X-ray tomography (at Durham and Diamond Light Source) and a bespoke high pressure-temperature flow rig capable of replicating subsurface reservoir conditions. They will build on existing dynamic (time lapse) X-ray microtomography data to track the injection of simulated geofluids ($scCO_2$-brine / n-decane-brine) into varying configurations of deformation bands. The candidate will perform 4D (3D +time) image analysis of the experimental data (using commercial software and in-house developed tools) to develop a quantitative understanding of the evolution of the controls on fluid distribution and flow behaviour in the pore network. The 4D data will then be used to gain an improved understanding of (1) the influence of high entry pressure deformation bands upon immiscible (multiphase) pore fluid displacement processes within sandstones, (2) the microstructural controls on fault breaching in such settings, (3) the influence of deformation bands upon key reservoir properties (irreducible water and residual oil saturation), and (4) geomechanical controls upon the oil column storage capacity of (shear) deformation bands (isolated vs. conjugate vs. clustered deformation bands corresponding to different sections of a fault damage zone). The student will then work to implement numerical models of pore-scale flow through the imaged pore networks that will allow a broader scale application of their work, and deeper insight into the controls of deformation bands over multiphase flow.

**CDT Research theme(s)**: This research applies to theme **b** (extending the life of mature basins: esp. UK sector), through the development of an improved understanding of reservoir behaviour.

**Research context:** The student will join the multidisciplinary group involved in oil & gas research. £2000 costs for CT scanning at Durham. Joint supervision provides input and access to specific expertise and equipment.

**Career routes**: Students graduating from this field have a strong history of employment as geoscientists in research/exploration, petrophysics both by international majors and a range of larger and smaller service providers, as well as research organisations and the environmental sector, (i.e. hydrogeology).