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

Project Title:
Deformation localisation in thrust-stacked carbonates – an investigation of mechanical stratigraphy and thermal maturity.

Host institution: University of Aberdeen

Supervisor 1: Dr Clare Bond

Supervisor 2: Dr David Muirhead

Additional Supervisor (s):

Project description:
Understanding how deformation partitions and fractures and faults develop and grow in multi-layered stratigraphy is important for predicting flow behaviour in the sub-surface. Multi-layers with different mechanical properties will localise deformation differently to homogenous isotropic rocks. Existing models of fault and fracture initiation and development, which are generally based on homogenous porous media, are unlikely to be representative of the fault and fracture geometries in multi-layers, particularly in carbonates. Further rock competence will change with temperature, which is of particular importance in thrusted sequences, where burial through over-thrusting occurs. Thrust and fold sequences in carbonates exposed on cliff faces in the Haute-Giffre, French Alps will be used to build a 3D picture of thrust geometries and localised deformation within the stratigraphy. The student will gain excellent understanding of complex 3D structural geometries through field mapping and the creation of large scale (whole-mountain) virtual outcrop models; applicable to the interpretation of 3D seismic data. The student will create 2D cross-sections and 3D geological models enhanced by stratigraphic and structural logging; providing training for core analysis and the understanding of carbonates and small scale deformation. Training in the use of geochemical techniques (raman spectroscopy and fluid inclusion analysis) will provide the student with a broad range of expertise in applications used in industry to assess thermal maturity and fluid-flow. The student will collect rock samples to perform total organic carbon (TOC) analyses and raman on solid carbon to gain understanding of maximum temperatures. Fluid inclusion work will aid in determining the temperature of mineralizing fluids and the timing of fracture growth. The combined analysis will be used to construct a 3D picture of thrust evolution and thermal maturity (from data and modelling) and deformation partitioning within the multi-layer sequence. The use of raman in structural studies to determine thermal maturity is in its nascence and the student will have the opportunity to play a leading role in the development and application of this technique to structural studies.

CDT Research theme(s): Mature Basins: **50%**. Improved understanding of deformation localisation, 3D geometries of structures. Unconventionals: **20%**. Improved understanding of deformation in multi-layers, and fracture fluid history;

Research context: Bond utilises virtual outcrop geology to capture geometric and geomechanical data from outcrops; several PhD students and a PDRA are using this technique. The student will build on the initiation of new work by Bond, Muirhead and others applying raman to thrust systems in the sub-alpine chain. Muirhead's research focuses on the use of raman spectroscopy. The student will join a large cohort of HC focused PhD students, including PhDs and a PDRA studying fold-thrust belts, as well as those utilising raman spectroscopy and fluid inclusion analysis.

Research costs: Field work (£8k), laboratory costs (£6k). UoA will fund extra costs. UoA has relevant software licences, and kit – LiDAR/photogrammetry for virtual outcrop geology. **Career routes**: The student will be well placed for a career in research, exploration & production geoscience, and specialist structural geology or geochemical consultancy. The project includes the use of industry software, such as: Photoscan Pro and Move and understanding of methods and techniques used in industry to predict fracture damage for reservoir enhancement and thermal modelling.