

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

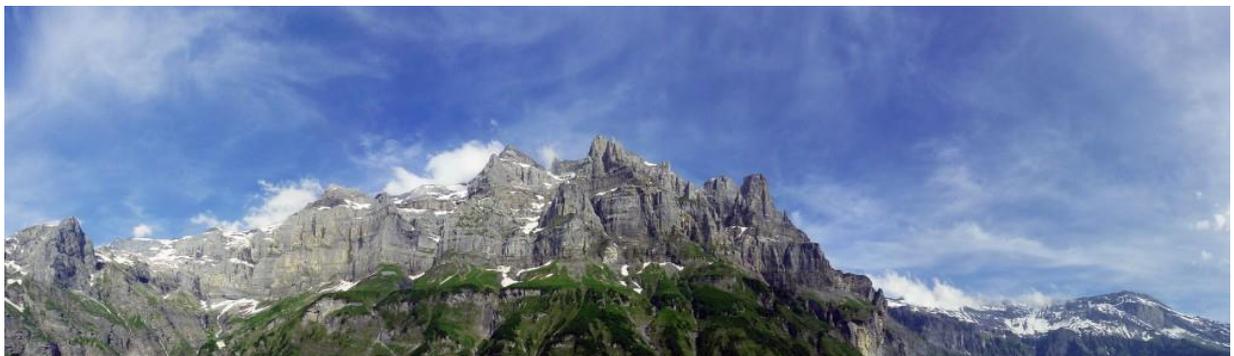
### Deformation localisation in thrust-stacked carbonates – an investigation of mechanical stratigraphy and thermal maturity

*Supervisors: Drs Clare Bond and Dave Muirhead*

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 thrust 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.



Cirque du Fer a Cheval, Haut Giffre

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**Research context:** The student will join a growing cohort of PhD and PDRA students and researchers using virtual outcrop geology to capture geometric and geomechanical data from outcrops, lead by Bond. 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 Hydrocarbon focused PhD students, including PhDs and a PDRA studying fold-thrust belts, as well as those utilising raman spectroscopy and fluid inclusion analysis.

The field area is mountainous with significant opportunity for fieldwork in high and remote areas.



Genairon, Haute Giffre

The project bridges the following **CDT Research theme(s): Mature Basins** - through improved understanding of deformation localization and the 3D geometries of structures. **Unconventionals** – by improved understanding of deformation in multi-layers, and fracture fluid history.

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