**Thrust localisation and linkage through rheological multilayers**
Supervisors: Rob Butler & Clare Bond (University of Aberdeen), Herfried Mandritsch (NAGRA)

**Project outline:**
Understanding of how thrust systems form and develop increasingly relies on theoretical descriptions which, although providing attractive models and animations, commonly fail to match up against actual geological structures. Testing ideas on how thrust faults develop, especially through rheological-layered sedimentary successions is important, not only for understanding thrust belts in general but also for being able to make better forecasts of subsurface structure. There is a pressing need for this work, not least because plastic clay-rich formations are being developed for the long-term geological storage of industrial waste: CO2 (in underlying porous formations) and nuclear materials. So, this PhD project will examine how faults connect through rheological multilayers such as thick limestone formations separated by incompetent shales, and well-bedded sandstone-shale successions. Current understanding is heavily weighted towards normal faults. This project will test existing conceptual models of how thrust arrays grow – as shown below:

Do new thrust segments propagate upwards through layers; or do thrusts localise in mechanically competent rheologies then propagate up and down to form linked faults? Tests will use well-exposed case studies in different successions (platform carbonate/shale systems; turbidite sandstones – examples from the French Alps), together with 3D seismic and well data from the sites under consideration for underground nuclear waste storage (in the Swiss Jura).
Fieldwork will use high resolution photogrammetry, tied to direct observation and measurements (e.g. kinematic fault plane data) so that deformation can be mapped layer by layer, identifying fault segments in each. Fault-propensity” will be calculated and fault displacement measured for different layers. The role of incompetent units as detachment surfaces will be evaluated by screening for layer-parallel simple shear (detectable by tracking cleavage orientations) and discrete layer-parallel
shears. The result will be documentation of quantified patterns of contractional deformation for a given multilayer sequence. These patterns may be compared with those deduced from subsurface imaging of contractual systems, using especially in interpretations of seismic attributes as proxies for distributed structure damage. High resolution 3D seismic data together with borehole (core, logs) are available from NAGRA. After successful completion of the PhD the student will be well-placed to develop a career in a range geological industries, regulators and academia.

**Training and wider impact**

The student will join a vibrant group of PhD students engaged in subsurface interpretation, broadly facing the energy sector. Structural geology and the development of virtual field resources are research strengths in Aberdeen. Training will be given in surface and subsurface structural geology. The project is thematically linked to subsurface evaluation by NAGRA, the Swiss agency responsible for underground nuclear waste storage and their work forecasting engineering responses in the subsurface. Their challenge is to assess the degree of tectonic overprint of the Opalinus Clay (potential repository formation) sandwiched between limestones adjacent to Jura fold-thrust belt. What are the risks this formation being compromised by faults imaged seismically in surrounding formations? The research impacts on this and other appraisals of clay formations as appropriate geological containers of waste but also in forecasting seal integrity for other subsurface engineering projects globally (e.g. CO2 sequestration).

**Recent relevant research from the team:**


This is a full-funded 4-year PhD opportunity starting October 2020 as part of the Centre for Doctoral Training (CDT) in Geoscience and the Low Carbon Energy (GeoNetZero). The project is hosted at the University of Aberdeen. The CDT partnership is run by Heriot-Watt University. [https://geo-net-zero.hw.ac.uk/](https://geo-net-zero.hw.ac.uk/)

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Applications to: [https://www.abdn.ac.uk/pgap/login.php](https://www.abdn.ac.uk/pgap/login.php)