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

Project Title: Relay zone kinematics during continental extension; implications for rift physiography, sediment supply and reservoir deposition

Host institution: Imperial College
Supervisor 1: Christopher Jackson
Supervisor 2: Rebecca Bell
Additional Supervisors: Joanna Faure Walker (UCL), Gerald Roberts (Birkbeck)

Project description: Large normal faults typically grow by the linkage of smaller precursor segments. Key processes occurring during this style of growth are the development and breaching of relay zones, with the formation of newly formed breaching faults facilitating physical linkage of older flanking faults. Local displacement deficits, which define breached relays, may persist on very large faults, despite such structures having been active for several million to tens-of-millions of years post-linkage. This observation is at odds with relatively limited geomorphic and geometrical observations from relatively young, well-exposed faults, which suggest displacement deficits could be removed from newly formed relay zones in as little as 106 years. We therefore know relatively little regarding the controls on the persistence of displacement deficits in relay zones; for example, do these minima persist because the breaching fault has no 'memory' of the mechanical and kinematic discontinuity formed during the earlier stage of fault growth? Or are slip rates higher on breaching faults compared to flanking faults in an effort to remove these displacement minima? Because these two kinematic scenarios make very different predictions regarding the physiography of continental rifts, sediment supply to and reservoir deposition in half-graben depocentres, and the timing of trap development along segmented fault systems, determining which of them is applicable to natural normal faults is important. In this project the student will use high-quality 3D seismic reflection volumes from offshore Australia, Norway and New Zealand and apply a range quantitative fault/strain analysis techniques to map the geometry and constrain the kinematics of large segmented normal fault systems. Particular focus will be placed on the temporal and spatial evolution of unbreached and breached relay zones. The case study locations have been carefully selected because high-quality 3D seismic data image segmented normal fault systems and associated growth strata, and borehole data constrain the age of growth strata and thus timing of fault development. The student will consider the implications of their observations for sediment supply to rifts and for earthquake hazard assessment in areas of continental extension.

CDT Research theme(s): The proposed project addresses two of the four key themes covered by NERC's Centre for Doctoral Training (CDT) in Oil and Gas: (i) Extending the life of mature basins – this project will utilise data from and has relevance to the Northern North Sea, a mature basin within which fault-related reservoirs and traps continue to play a key role in petroleum prospectivity; and (ii) Exploitation in challenging environments – this project focus on the geometry and kinematics of normal faults, which play a key role in the development of the subsalt petroleum system in, for example, HPHT regimes occurring in the Central Graben.

Research context: Imperial College has a large group (Basins Research Group) with active research interests and expertise in the subsurface analysis of normal fault growth and their role in the development of North Sea petroleum systems. Co-supervisors Joanna Faure Walker (UCL) and Gerald Roberts (Birkbeck) are experts in the field-based analysis of normal fault kinematics and earthquake hazards in areas of continental extension.

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Research costs: PC for subsurface data interpretation=£3000; costs associated with conference attendance for presentation of results=£2000.
Career routes: Academic (e.g. structural geology, geophysical data analysis) or industrial (e.g. structural geology, reservoir modelling, geophysical data analysis).