PROJECT TITLE: Postseismic Deformation and Earthquake Triggering
DTP Research Theme(s): Solid Earth

Lead Institution: University of Bristol
Main Supervisor: Dr. Max Werner, School of Earth Sciences
Co-Supervisor: Dr. Juliet Biggs, School of Earth Sciences
Co-Supervisor: Dr. Ake Fagereng, School of Earth & Ocean Sciences, Cardiff University
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Project Background
Aftershock sequences offer a unique opportunity to understand the physics of what causes earthquakes: information is pouring out of the Earth in the form of seismicity and postseismic deformation. Aftershocks can also be very damaging, occasionally eclipsing the damage caused by a mainshock. Recent examples of damaging earthquake sequences include the 2010-12 Christchurch (New Zealand) earthquakes, the 2015 Nepal earthquakes, and the 2016-17 Amatrice (Italy) earthquakes.

Current physical models of aftershock clustering, however, are limited by simplistic assumptions. For example, the changes in the stress and strain fields caused by a mainshock are calculated assuming a homogeneous elastic crust; postseismic deformation is usually neglected; and the mainshock rupture is modelled as a 2D plane with a smooth slip distribution. Meanwhile, space geodesy and earthquake geology recording more and more earthquake sequences that reveal more complex behaviour. These data require the development of a new generation of physics-based models of earthquake sequences.

Project Aims and Methods
This PhD project aims to improve time-dependent seismic hazard estimates by developing physics-based models of aftershock triggering that are informed by geological fieldwork, constrained by geodetic observations of postseismic deformation and validated against observed aftershock sequences.

The student will investigate several aftershock sequences that were well captured by InSAR and GPS observations, including earthquakes in Alaska (2002 Denali), California (1992 Landers, 1999 Hector Mine), Tibet (Manyi), Taiwan (Longitudinal Valley Fault) and New Zealand (2010 Darfield). The objective is to model the evolution of stress during these sequences as a result of co-seismic as well as postseismic deformation. Postseismic deformation includes afterslip, distributed visco-elastic deformation as well as secondary stress changes due to aftershocks. This will require using and refining models of the mainshock sources, the crustal rheologies and the fault zones. The source and crustal model will be informed by geological observations of exhumed fault systems that reveal information...
about the rheological and structural properties of fault zones and the frictional properties of faults. For this purpose, students will perform about 4 weeks of fieldwork. The calculated stress changes will be compared with the observed evolution of aftershock seismicity and surface deformation during the aftershock sequence to evaluate and validate the models. This PhD project offers unique opportunities for integrating different approaches to improve seismic hazard and risk estimates.

**Candidate**

We seek an enthusiastic student with broad interests in solid-earth geophysics and earthquake geology, with a first degree in physics, geophysics, (quantitative) geology, maths, or other quantitative subject. The ideal candidate will have some experience in numerical modelling, and a strong interest in constraining computer models with geodetic and geologic observations. The candidate will communicate effectively in verbal and written form, and present their work at international conferences. We seek a person that is highly motivated to work independently as well as in a team.

**Case Award Description**

Willis Towers Watson (WTW) is supporting this CASE PhD project. WTW is a leading global risk advisor, insurance and reinsurance brokerage company headquartered in London. Its Willis Research Network supports risk quantification through open academic research and the development of new risk models and applications. The student will spend between 3 and 9 months at WTW in London for one or more internships to contribute to the translation of academic knowledge about earthquake clustering to practical risk views in the re/insurance world.

**Training**

Students will be trained in numerical modelling (computing), data analysis, space geodesy and structural geology. Main supervisor Dr Max Werner will support the student in numerical modelling of the stress field under a variety of assumed rheologies and mechanical properties. He will also train the student in the quantitative analysis of aftershock seismicity with Matlab, R or Python. Co-supervisor Dr Juliet Biggs will provide training in InSAR and GPS geodesy, including data collection, analysis and inverse modelling. Co-supervisor Dr Ake Fagereng will train the student in fieldwork in earthquake geology.

**References / Reading List**


**Links**

School webpage: [http://www.bristol.ac.uk/earthsciences/courses/postgraduate/](http://www.bristol.ac.uk/earthsciences/courses/postgraduate/)

NERC GW4+ DTP Website: [http://nercgw4plus.ac.uk/](http://nercgw4plus.ac.uk/)

Bristol NERC GW4+ DTP Prospectus: [http://www.bristol.ac.uk/study/postgraduate/2017/doctoral/phd-great-western-four-dtp/](http://www.bristol.ac.uk/study/postgraduate/2017/doctoral/phd-great-western-four-dtp/)

**Application deadline:** 23.59 GMT, Sunday 7 January 2018

How to apply to the University of Bristol: [http://www.bristol.ac.uk/study/postgraduate/apply/](http://www.bristol.ac.uk/study/postgraduate/apply/)

**General Enquiries:**

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