Durham University
Department of Earth Sciences

Stefan Nielsen, Nicola de Paola (Earth Sciences)

PRECEDING EARTHQUAKE RUPTURE. WHERE TO EXPECT IT AND HOW LARGE IS IT?

1. Background

Deformation on major tectonic faults is accommodated by co-seismic slip (earthquakes), and aseismic slow slip (creep) during the earthquake cycle. Acceleration of creep preceding earthquakes is predicted by theoretical models and in laboratory experiments, and recently observed before natural large magnitude earthquakes (e.g. Tohoku 2011, Iquique 2014). However the magnitude and the prevalence of pre-slip remain unclear. The aim of this project is to place bounds on the magnitude of the expected pre-slip in earthquakes, based on realistic fault structures which are strongly heterogeneous. Uncovering the physics of pre-slip would allow a deeper understanding of the earthquake cycle; understanding its role in earthquake triggering would improve its integration in probabilistic forecasting and contribute to build resilience.

2. Aims and methods

The student will conduct carefully controlled and monitored laboratory experiments on pre-slip and fault failureat the cm scale, and numerical simulations at the hundred-km scale, using them jointly to develop and constrain new models of earthquake nucleation. Large earthquakes are frequent enough to cause substantial damage and life loss, but not frequent enough to provide a statistically-significant catalogue .Experiments can provide a large number of observations.

3. Training

The student will be trained in different disciplinary fields as field structural geology, earthquake mechanics, laboratory mechanical experiments and fluid flow modelling. Importantly, he or she will learn to use high pressure rock deformation apparatuses and techniques which are widespread not only in the world of academic research but also that of technical expertise and industry. In addition, he or she will develop skillsto undertake microscopic analysis of rock formations and the interpretation of the deformation microstructures.

5. Further reading & information

✦ Guérin-Marthe, S., Nielsen, S., Bird, R., Giani, S., & Di Toro, G. (2019). Earthquake nucleation size: Evidence of loading rate dependence in laboratory faults. Journal of Geophysical Research: Solid Earth, 124, 689–708. https://doi.org/10.1029/2018JB016803

✦ Harbord C., Nielsen S., De Paola N., Holdsworth B. (2017). Earthquake nucleation on rough faults. Geology, 45 (10): 931–934. doi: https://doi.org/10.1130/G39181.1

For further information contact: Prof. Nielsen, Dept of Earth Sciences, University of Durham, tel. no 0191 334 4308. Stefan.nielsen@durham.ac.uk