Journey to the centre of the earthquake; what affects earthquake source properties and radiated wavefields?

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Introduction:

Earthquakes have the potential to cause enormous human, structural and economic devastation. The frequency and magnitude of the seismic waves produced are a product of the earthquake source – the fault zone that is slipping – and the path along which the seismic waves travel. Little is known about the seismic source, in particular how the characteristics of a fault zone affect the slip kinematics of an earthquake. In principal both the frictional properties of the fault plus the elastic properties of surrounding rock, which will have been modified by fracture damage, will contribute to the nature of the rupture properties. These properties, such as stress drop and rupture velocity, will dictate the source character of the earthquake (e.g., how energetic the rupture is) and the resultant radiated wavefield.

This project will use a combination of laboratory experiments and numerical modelling to understand how the properties of the earthquake source are affected by the country rock surrounding a fault. Simulated spontaneous earthquakes will be produced in the laboratory where key properties of the system can be carefully controlled and measured. The elastic properties of the blocks surrounding the slipping fault will be varied to observe the resultant properties of the rupture (velocity and amplitude). Numerical modeling of the ruptures will be developed so that upscaling of the results can be made to predict the larger-scale behaviour of earthquake ruptures.

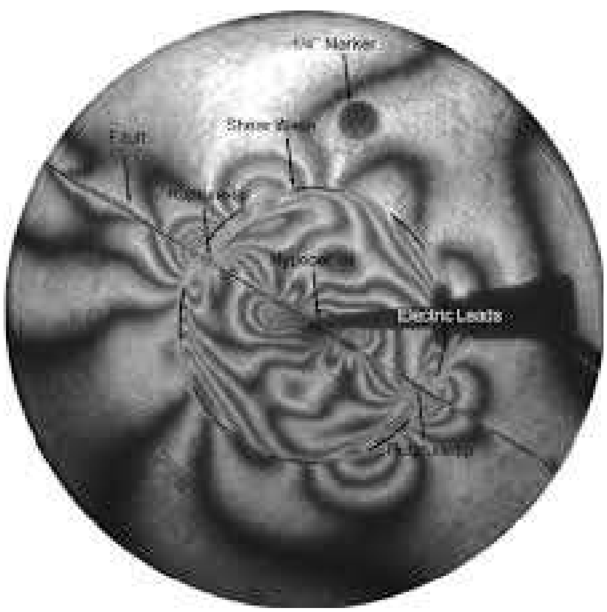

Figure 1. Earthquakes in the laboratory captured using high-speed photography. The fringes shown illustrate the strain field around the propagating rupture in a photo-elastic material.

Project Summary

The properties of earthquake ruptures affect the nature and variability of seismic radiation such as the frequency and amplitude, properties that must be known for accurate seismic hazard assessment. The rupture characteristics are a product of the strength evolution of the fault (the sliding interface) and also of the elastic and inelastic deformation that occurs in the surrounding country rock. Where elasticity is low, the rupture velocity will slow, and this will be exacerbated by any inelastic deformation of the surrounding rock that will act as an energy sink for propagation. We will study spontaneous ruptures in the laboratory. Stick-slip instability in laboratory experiments is recognized as an analogue for earthquakes and the properties of ruptures, such as the rupture velocity, and even the stress field surrounding the rupture tip, can be recorded. Sensors placed around a laboratory triaxial sample have been used to record the passage of an earthquake tip and have documented super-shear ruptures, where the rupture velocity exceeds the local shear wave velocity. The use of strain gauge rosettes attached close to the sliding surface can record the 2D strain field and the associated stress field can be computed from the elasticity of the slider block material.

Liverpool has a strong profile in the study of earthquakes and seismic hazard. High-pressure high-temperature experimental apparatus capable of performing unique experiments that simulate earthquake conditions are available in the Rock Deformation Laboratory.

Students with a strong background in geophysics, geology, maths, physics, or engineering are encouraged to apply.

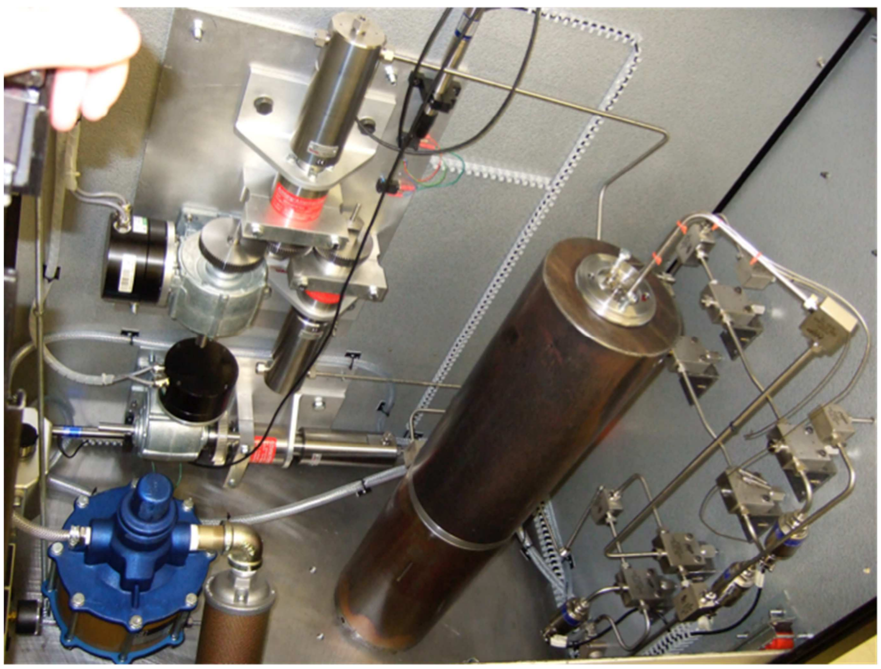

Figure 2. One of the high-pressure high-temperature triaxial deformation apparatus in Liverpool. The Rock Deformation Laboratory is one of the best equipped in the world and at the forefront of technical developments n order to perform new and novel experiments.

Background reading

Biegel, R. L., C. G. Sammis, and A. J. Rosakis (2008), An experimental study of the effect of off-fault damage on the velocity of a slip pulse, J. Geophys. Res. Earth, 113(B4), doi:10.1029/2007jb005234.

Livne, A., E. Bouchbinder, I. Svetlizky, and J. Fineberg (2010), The near-tip fields of fast cracks, Science 327, 1359–1363.

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Sammis, C. G., A. J. Rosakis, and H. S. Bhat (2009), Effects of Off-fault Damage on Earthquake Rupture Propagation: Experimental Studies, Pure Appl. Geophys., 166(10–11), 1629–1648, doi:10.1007/s00024-009-0512-3.