TO Brownbag Seminar
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Advances in laboratory source seismology

Recent advances in high frequency acoustic experimental techniques now allow to study rupture processes on small rock specimen, and in controlled laboratory conditions, revealing details on the earthquake source physics at a scale that was still completely inaccessible until a few years ago. During this seminar, I will present two recent collaborative efforts which, I believe, illustrate best this statement.

In a first part, I will show that, during stick slip experiments on centimetric Westerly granite samples, supershear ruptures are systematically observed when the normal stress exceeds 100MPa, with observed resulting stress drops of the order of 2 - 40MPa, i.e. quite comparable to stress drops inferred by seismology for typical crustal earthquakes. This is consistent with the fact that one can show theoretically that the critical transition length from sub-Rayleigh to supershear in rocks can be of a few millimeters only, this under typical upper crustal conditions. This suggests, in turn, that the rupture velocity inferred at large scale might be a crude average, while rupture of small asperities at the centimetric scale along a fault may well happen, locally, at supershear velocities.

Second, mineralogy matters, even in seismology. One perfect illustration is the debate on whether deep focus earthquakes are triggered by olivine phase transformations in the mantle transition zone (400-700 km). Here, we provide definitive experimental evidence that, in the 2-5 GPa range at around T=1150±50K, shear fractures can nucleate and propagate, without frictional resistance, and under moderate shear stress, at the onset of the olivine -> spinel phase transition in the Mg_2GeO_4 analogue system. The propagation of these fractures is highly dynamic, radiating energy in the form of intense acoustic emissions, which share important of similarities with deep focus earthquakes. For instance, in our millimeter-sized specimens, these acoustic emissions follow the Gutenberg-Richter law over 4 orders of moment magnitudes and display focal mechanisms requiring double couple type sources.

An important general conclusion drawn by these two very distinct experimental studies is that the general features of dynamic rupture patterns are, to a certain extent, truly scale independent."