

## What Can $M_w$ -4 Lab-Quakes Teach Us About Deep-Focus Earthquakes?

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In recent years, several experimental studies have shed new light on possible faulting mechanisms responsible for intermediate and deep-seated earthquakes. These studies rely not only on the traditional analysis of mechanical data and recovered microstructures, but also on the in situ collection of acoustic data –in the form of Acoustic Emissions (AEs)– used to identify possible co-seismic faulting, i.e., brittle failure.

I will give an overview of this recent work and detail how, recently, deep-focus earthquakes mechanisms could be investigated at 1.5 GPa and 750-900°C, in a new-generation Griggs-type apparatus using sintered  $Mg_2GeO_4$  samples. This compound is an analogue of natural olivine for which the transition towards the high pressure phase (spinel structure) occurs at atmospheric pressure, instead of ~14 GPa for the silicate. This transition induces a mechanical instability –the so-called *transformational faulting*– that leads to macroscopic failure of the samples in a narrow temperature window. The boundaries of this brittle window, as for other reactions (quartz-coesite, antigorite dehydration, plagioclase breakdown and so on), are defined by the reaction kinetics. Here, faulting only occurs in cases where spinel nucleates but hardly grows, i.e., when reaction rates are slow.

At 900°C mechanical data show a softening, indicative of ductile plastic flow, whereas large amounts of hardening followed by rapid stress drops (and audible stick slips) are recorded at 750°C. AEs were detected in both cases and differences between P and S waves arrival times suggest that the majority of AEs originate inside the sample. Coherence analysis of the AEs seems to suggest that some bursts of events have similar sources. Surprisingly, AEs are more numerous (~600) at higher temperature, where deformation takes place in a ductile way, accommodated by the development of a wide mylonitic shear band. However, at 750°C, far more energy is released acoustically upon brittle faulting despite a lower number of AEs (~100). Therefore, higher temperatures favor larger reaction rates, which, in turn, allow the growth of ductile fine-grained spinel. Our results confirm that the brittle temperature window (1) is a function of both equilibrium overstep (reaction kinetic) and strain rate and (2) seems to shift towards lower temperatures with decreasing strain rates, which may explain how earthquakes can occur in a slowly reacting metastable olivine wedge at strain rates orders of magnitude lower than in the lab.

Keywords: deep focus earthquakes, high pressure deformation experiments, transformational faulting, olivine spinel transition, acoustic emissions

