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Three dimensional location and waveform analysis of micro-seismicity in multi anvil experiments

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Acoustic emission monitoring (AE) during rock deformation experiments has been applied extensively before to study brittle failure and frictional sliding of rocks and the origin and characteristics of crustal earthquakes. Here, we present a new AE-technique to study high pressure ($P > 1$ GPa) micro-seismicity in multi anvil rock deformation experiments. The application of this technique is aimed at studying the fault mechanisms of deep focus earthquakes that occur during subduction at depths up to 650 km.

Acoustic emission monitoring in multi anvil experiments is challenging because source locations need to be resolved to less than the millimetre scale due to the small size of the experimental assembly. We collected microseismic events at seven possible receivers that are attached to the back the truncations of tungsten carbide anvils. Each receiver contains a piezo-electric transducer with a 1-5 MHz bandwidth. Signals were recorded and processed using the high-speed AMSY-5 acquisition system from Vallen-Systeme GmbH. In this setup, microseismic signals can be recorded at a 10 MHz sampling rate, in addition to full waveform collection for each event signal.

Travel times and average velocities from receiver to receiver were calibrated with waveform measurements using both a fast digital oscilloscope and the Vallen system data. Arrival times of seismic events at each receiver are determined by automatic waveform analysis. Assuming the cell and sample have a velocity of approx. 6.6 km/s, three-dimensional hypocentres of events in the assembly are calculated using standard seismological algorithms. We are currently in the process of extending these algorithms to include a more precise velocity model that reflects the different assembly materials.

We have applied the technique to locate three dimensional fault planes during axial compression and extension of 3 mm long x 1.5 mm diameter alumina rods and cores of San Carlos olivine polycrystals. The faults were generated during cold compression to approx. 1 GPa confining pressure or by pre-cutting the samples before the experiment. Subsequent seismic events at higher pressures of 1 to 10 GPa were found to originate from these pre-existing faults and exhibit high pressure stick-slip behaviour. Frictional behaviour appears to persist in faulted olivine to temperatures up to 900°C. This is in contrast to wadsleyite filled faults, which deform by a dislocation creep mechanism. Further work is required to delineate the mechanism of seismogenesis in wadsleyite dominated assemblages. Future results at transition-zone pressures will be applicable to the triggering of deep seismicity, elucidating details of seismogenesis and fault generation under the conditions of the subducting slab.