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Ultra high pressure acoustic emission monitoring of the olivine to wadsleyite transition and its application to deep focus earthquakes

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We present a new acoustic emission (AE) monitoring technique to study ultra high pressure (P>2 GPa) microseismicity in multi-anvil rock deformation experiments. The application of this technique is aimed at studying fault mechanisms of deep focus earthquakes that occur during subduction at depths up to 650 km. AEs were collected using an 8 PZT transducers, located on the back truncations of the tungsten carbide anvils. Data were recorded and processed using a high-speed AMSY-5 acquisition system from Vallen-Systems, allowing waveform collection at a 10 MHz sampling rate for each event signal.

We tested the new technique by performing axisymmetric deformation experiments on 3 mm long, 1.5 mm wide cores of San Carlos olivine polycrystals at temperatures of 1173-1273 K and pressures of 6-14 GPa. The experiments address the possible effect of the olivine-wadsleyite transition on the remobilization of pre-existing olivine faults in the lithosphere during subduction into the Earth's transition zone.

Cold axisymmetric compression of olivine to 6 GPa pressure results in a conical fault system that crosscuts the sample. AE hypocenters locate near faults and indicate high P-low T frictional sliding. The fault zones consist of fine-grained olivine gouge with a fractal dimension of 2.6±0.1 between 0.1-10 μm grain sizes. The gouge has a random CPO after isothermal compression from 6 to 7 GPa at 1173 K in 1 hour. AE signals from the fault zones during hot compression were indistinguishable from those observed during cold compression and near consistent with stick-slip behaviour. Subsequent isothermal compression into the wadsleyite stability field shows no AE-activity. A pre-existing olivine fault zone deformed at 14 GPa and 1173-1273 K was replaced in 20 minutes by wadsleyite with a narrow grain size range ($\sim$0.8-1.0 μm). Fault zone wadsleyite has a clear CPO with a- and b-axes oriented in the direction of and perpendicular to the shear direction respectively. This suggests that wadsleyite accommodated renewed fault displacement by dislocation creep. Wadsleyite outside the fault zones does not have a CPO. Thus, under these conditions, fault zone wadsleyite appears weaker than the "wall rock" olivine, suggesting a mechanical weakening during the transition. Such a shear localization process on old faults might contribute to seismogenic slip within the Earth, where run-away processes are possible.