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Experimental evidence for wall rock pulverization during dynamic rupture at ultra-high pressure conditions

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The mechanisms triggering intermediate and deep earthquakes have puzzled geologists for several decades. There is still no consensus concerning whether such earthquakes are triggered by brittle or ductile mechanisms. We have performed a deformation experiment on a lawsonite-bearing blueschist at a confining pressure of 3 GPa and temperatures from 580 to 1,073 K. The deformed sample reveals conjugated faults showing dissected and displaced garnet crystals. Adjacent to the slip surface, garnet grains reveal microstructures that resemble natural pulverization structures as well as partial amorphization. At low confining pressures such structures require high strain rates > 10^2 s^{-1} to form and are explained by the propagation of a dynamic shear rupture associated with extreme strain rates around the crack tip. Due to the absence of large amount of shearing in the pulverized wall rock, those structures pre-date the subsequent heat-producing frictional slip. The similarity between the micro- and nano-structural observations found in the sample deformed under high pressure presented in this study and natural pulverization structures emphasizes the role of brittle deformation at depth way beyond the normal seismogenic regime.