



Dynamic earthquake rupture in the lower crust

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Earthquakes in the continental crust commonly occur in the upper 15-20 km, but recent studies demonstrate that earthquakes also occur in the lower crust of continent collision zones, such as the Himalayas. These seismic events play a key role in infiltrating fluid and triggering metamorphic processes in the lower crust that subsequently modify its physical properties. However, details of the failure process and the sequence of events that lead to seismic slip in the lower crust remain uncertain. Here we present a fault zone from the Bergen Arcs, Western Norway, which constrains the chronology of failure processes of an earthquake at ca. 40 km depth. Our petrographic observations show that seismic slip and associated melting was preceded by fracturing, fragmentation and comminution of the wall rock caused by a dynamically propagating rupture. The studied asymmetrical zone of pulverized wall rock and fault bounding cataclasites are common features of faults in the upper crust. The grain size distribution of clasts within these zones additionally matches those reported from brittle pulverization experiments. Frictional melting of the fragmented material thus led to seismic slip rates and the injection of melt veins in the damaged wall rock. Our study emphasizes that numerous brittle failure mechanisms can be active in a portion of the crust that until recently was assumed to be characterized by ductile deformation, and that the structure and mechanics of earthquakes may be similar across a range of lithospheric depths.