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Microstructural records of earthquakes and fluid-driven metamorphism in lower crustal plagioclase

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Damage associated with earthquakes in the lower continental crust is accompanied by annealing and fluid-mediated metamorphism that influence the physical and chemical development of the continental crust on regional scales. A transition from brittle deformation to crystal-plastic recrystallization is a characteristic of rocks affected by intermediate-depth earthquakes and is observed in plagioclase adjacent to lower crustal pseudotachylytes in granulite anorthosites from the Bergen Arcs, western Norway. The microstructural and petrological records of this transition were investigated using scanning electron microscopy, electron microprobe analysis, and electron backscatter diffraction analysis. Micro-fractures associated with mechanical twins are found within plagioclase and contain fine-grained aggregates that formed by fragmentation in the absence of major shear deformation. The presence of feather features, which are described for the first time in feldspar, suggest that wall rock pressures approached 10 GPa in the immediate vicinity of the earthquake slip plane before dropping to an ambient pressure <1.8 GPa. Grain size insensitive recrystallization took place within the timeframe of seismic slip, and the local formation of high angle grain boundaries reflects the onset of grain size sensitive deformation and the transition from micro-fracture to shear zone. Near ambient conditions, the micro-fractures functioned as fluid pathways facilitating the epitactic replacement of plagioclase by alkali feldspar and the nucleation of clinozoisite, kyanite and quartz in varying amounts. The grain size reduction and fluid-driven crystallization associated with the micro-fractures triggered grain size sensitive deformation and illustrates the ability of the micro-fractures to localize strain within the plagioclase-rich lower crust.