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Slow Aseismic Rupture in the Laboratory: an Analog for Slow Earthquakes?

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Interest in the brittle-ductile transition has increased considerably in recent years, in large part due to the fact that the maximum depth of seismicity corresponds to a transition in the crust and in the upper mantle from seismogenic brittle failure to aseismic cataclastic flow, i.e. from localized to homogeneous deformation. The mechanics of the transition depends both on some extrinsic variable (state of solid stress, pore pressure, temperature, fluid chemistry and strain rate) and intrinsic parameters (crack and dislocation density, modal composition of the rock or porosity for example).
In the present study, two triaxial experiments were performed on Carrara marble at room temperature. The rock samples, first deformed in the cataclastic regime, were brought back **at constant differential stress** into the the brittle field by solely reducing the effective mean stress. In both experiments, compressional wave velocities evolution shows evidence of severe aseismic damage accumulation. Reducing the mean stress, both samples exhibited a fast acceleration in axial strain which lead to tertiary creep. The nucleation and propagation of a brittle failure was accompanied by stress drops of the order of $150\,MPa$ and centimetric slips. A complete 2 minutes acoustic recording of failure shows that rupture propagated slowly (over one minute) and aseismically (at least two orders of magnitude lower than what is generally observed on a sandstone or a granite). Elastic properties, macroscopic strain, AE recordings and post-deformation microstructural analysis are here put together and show what we believe are the first experimental evidence of slow aseismic failure in the laboratory.
While our work examines aseismic rupture and creep events in the laboratory, it may well have implications for the occurrence of similar events near the bottom of the seismogenic zone of faults where a transition occur from velocity weakening to velocity

strengthening behavior. Creep events, including slow earthquakes, near that transition, may be common on timescales of days to months but relatively little experimental data exist however on their mechanisms.