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Dynamic triggering during rupture nucleation in sandstone

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Fluid induced stress perturbations in the crust at seismogenic depths can be caused by various sources, such as deglaciation unloading, magmatic intrusion or fluid injection and withdrawal. Numbers of studies have robustly shown their link to earthquake triggering. However, the role of small periodic stress variations induced by solid earth and oceanic tides or seasonal hydrology in the seismic cycle, of the order of a few kPa, remains unclear. Indeed, the existence or absence of correlation between these loading phenomena and earthquakes have been equally proposed in the literature. To investigate this question, we performed a set of triaxial deformation experiments on porous water-saturated Fontainebleau sandstones. Rock samples were loaded by the combined action of steps of constant stress (creep), intended to simulate tectonic loading and small sinusoidal pore pressure variations with a range of amplitudes, analogous to tides or seasonal loading. All tests were conducted at a regulated temperature of 35C and a constant 35 MPa confining pressure. Our experimental results show that (1) pore pressure oscillations do not seem to influence the deformation rate at which the rock fails, (2) they correlate with acoustic emissions. Even more interestingly, we observe a progressive increase of the correlation coefficient in time as the rock approaches failure. The correlation coefficient is also sensitive to the amplitude of pore pressure oscillations as larger oscillations produce higher correlation levels. Finally, we show that, in the last hours of creep before failure, acoustic emissions occur significantly more when the pore pressure is at its lowest. This suggest that the correlation of small stress perturbations and acoustic emissions depend on the state stress of a rock and the amplitude of the perturbations and that emissions occur more likely when cracks are unclamped.