Geophysical Research Abstracts
Vol. 20, EGU2018-4631, 2018
EGU General Assembly 2018

Time-dependent deformation of a low porosity sandstone subjected to pore pressure oscillations

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Fluid pressure is acknowledged as a key parameter affecting rupture phenomena in the upper crust (e.g. earthquake or landslide). Moreover, on the contrary to lithostatic or tectonic stresses, fluid pressures are more prone to fluctuation in space and time (e.g. oceanic tides, seasonal hydrology, cyclic fluid injection in reservoirs). It has recently been suggested that small pore pressure perturbation in order of few kPa may dramatically affect the mechanical integrity of a rock mass. While pore pressure is indeed expected to modify the effective normal stress acting on rock mass, cyclic perturbations were shown to enhance such effect in dramatic ways. However, only few experimental studies have aimed to understand rock behaviour when subjected to pore fluid oscillations and resulted in diverging conclusions.
To investigate this phenomenon, we performed brittle creep experiments, applying either constant or cyclic (sinusoidal oscillations) pore fluid pressures. The experimental study was conducted on samples of Fontainebleau sandstone, a clean (99.9% quartz), homogeneous and isotropic rock. For all the experiments, stresses conditions were chosen to be at a Terzaghi effective pressure (Pc-Pf) of 30 MPa. During the sample deformation, the rock mechanical properties and induced high-frequency acoustic emission signals were monitored to investigate the physics underlying the rupture processes at hands. Our experimental results show that, as expected, strain rate, Acoustic Emission (AEs) rate and time to failure are sensitive to confining pressure, pore pressure level and applied differential stress. However, preliminary results show that: (1) the dependence of strain and AEs rate on pore fluid pressure do not fully fit with the expectations using Terzaghi effective pressure laws; (2) pore pressure oscillations do not affect the long-term behaviour of this rock, whichever the amplitude of fluid pressure oscillations imposed.