Geophysical Research Abstracts
Vol. 15, EGU2013-13515, 2013
EGU General Assembly 2013

Macro- and micro-scale mechanisms of time-dependent fracturing in rocks

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We performed a series of brittle deformation experiments in porous sandstones, in creep and constant strain rate conditions, in order to investigate the relationship between their short- and long-term mechanical behaviour. Elastic wave velocities measurements indicate that the amount of microcracking follows the amount of inelastic strain in a trend which does not depend upon the timescale involved. The comparison of stress-strain curves between constant strain rate and creep tests allows us to define a stress difference between the two, which can be viewed as a difference in energy release rate. We empirically show that the creep strain rates are proportional to an exponential function of this stress difference. We then establish a general method to estimate empirical micromechanical functions relating the applied stresses to mode I stress intensity factors at microcrack tips, and we determine the relationship between creep strain rates and stress intensity factors in our sandstone creep experiments. We finally provide an estimate of the sub-critical crack growth law parameters, and find that they match –within the experimental errors and approximations of the method– the typical values observed in independent single crack tests. Our approach provides a comprehensive and unifying explanation for the origin and the macroscopic manifestation of time-dependent brittle deformation in brittle rocks.