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Non-extensive statistical physics properties of acoustic and pressure-stimulated current emissions measured concurrently during triaxial deformation experiments on marble and limestone samples

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We present preliminary results from triaxial compression experiments on samples of marble and limestone, recording concurrently for the first time both acoustic and electric current signals emitted during the deformation process.
The expression 'pressure-stimulated currents' describes the emission of a small (peak values of 10-12 – 10-9 A) transient, polarising electric current from a solid containing charged defects and undergoing a gradual change in pressure. Experiments to date on non-piezoelectric rocks such as marble, amphibolite and cement-based materials have shown that these currents accompany the process of crack formation and growth during rock deformation. Further understanding of the processes that generate these currents and how they relate to the cracking process is particularly important for the study of seismic precursors.
Constant strain rate experiments were conducted in a triaxial deformation apparatus at room temperature with effective confining pressures of 30 MPa (c.f. 3 km depth) on both dry and saturated samples. Strain rates were varied from 10-6 – 10-4 s-1 in order to investigate the dependence of pressure-stimulated current emissions on strain rate and their non-extensive properties in comparison with those of the associated acoustic emissions. The non-extensive q-parameter was determined using the q-logarithm function from analysis of the cumulative distribution function, P(>x), of the energy distributions of the laboratory data. Results are discussed in the frame of non-extensive statistical physics.
Non-extensive statistical physics has previously been used to study patterns of seismicity, since rock deformation involves complex non-equilibrium phenomena such as multi-fractal distributions, self-organized criticality, long range interaction and intermittency. The approach offers a consistent theoretical framework to analyse rock fracture populations, which exhibit power law behaviour.
Electrical emissions occur during the non-linear region of mechanical behaviour related to slip or dislocation mechanisms at an atomic level and are associated with changes in acoustic emissions phenomena. The non-extensive evaluation of these data sheds new light on deformation mechanisms with respect to the cracking process.

Selected References

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