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Acoustic and pressure-stimulated current emissions from triaxial compression 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.
Mechanisms for the generation of these currents have been proposed, such as the motion of charge edge dislocations during crack formation and propagation or the flow of defect electrons (positive holes) resulting from the breaking of peroxy bonds under stress. 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. Acoustic emissions, pressure-stimulated currents and mechanical loading information were recorded simultaneously to examine specifically how electrical emissions relate to the cracking process.
Strain rates were varied from 10-4 – 10-6 s-1 in order to investigate the dependence of pressure-stimulated current emissions on strain rate and confirm, under triaxial conditions, the findings of previous uniaxial experiments. These previous studies observed a linear relationship between the magnitude of electric current emissions and the strain rate in cement-based materials and also between electrical charge and strain in marble, supporting the theory of moving charged edge dislocations causing local polarisation during crack formation and propagation.
The 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 evaluation of the electrical emissions together with the concurrent acoustic activity sheds new light on deformation mechanisms with respect to the cracking process.

Selected References

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