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Damage and Rupture Dynamics at the Brittle/Ductile Transition: the Case of Gypsum

Nicolas Brantut, Alexandre Schubnel, and Yves Guéguen
ENS Paris - CNRS, Laboratoire de Geologie, Paris, France (aschubnel@geologie.ens.fr)

Triaxial tests on gypsum polycrystals samples are performed at confining pressures Pc ranging from 2 to 95 MPa and temperatures up to 70 degrees C. During the tests, stress, strain, elastic wave velocities and acoustic emissions are recorded. At Pc $\leq$ 10 MPa the macroscopic behaviour is brittle, and above 20 MPa the macroscopic behaviour becomes ductile. Ductile deformation is cataclastic, as shown by the continuous decrease of elastic wave velocities interpreted in terms of microcracks accumulation. Surprisingly, ductile deformation and strain hardening is also accompanied by small stress drops from 0.5 to 6 MPa in amplitude. Microstructural observations of the deformed samples suggest that each stress drop corresponds to the generation of a single shear band, formed by microcracks and kinked grains. At room temperature, the stress drops are not correlated to acoustic emssions (AEs). At 70 degrees C, the stress drops are larger and systematically associated with a low frequency AE (LFAE). Rupture velocities can be inferred from the LFAE high frequency content and range from 50 to 200 m/s. The LFAEs amplitude also increases with increasing rupture speed, and is not correlated with the amplitude of the macroscopic stress drops. LFAEs are thus attributed to dynamic propagation of shear bands. In Volterra gypsum, the result of the competition between microcracking and plasticity is counterintuitive: dynamic instabilities at 70 degrees C may arise from the thermal activation of mineral kinking.