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P- and S- ultrasonic velocities and focal mechanisms of acoustic emission events in triaxial compression of granite samples.

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The formation of shear fractures was investigated using simultaneous monitoring of Acoustic Emission (AE) and ultrasonic velocities during triaxial compression of granite samples. We have found that regardless of applied boundary conditions and loading rates, the process of brittle failure of rocks can be separated into two main stages: (1) the accumulation of uncorrelated tensile cracks and (2) the appearance of shear cracks interconnecting a network of previously formed tensile cracks.

Cylindrical samples of 50 mm diameter and 100-125 mm length were fractured at confining pressures of 5 - 40 MPa. Twelve P-wave sensors, eight S-wave sensors and four strain-gages were glued to the surface of rock samples to monitor AE, velocities and local strain during the fracturing. At the fracture initiation we observed appearance of stress-induced anisotropy of P-wave velocities and S-wave splitting. Stain measurements indicated compaction of the rock, and acoustic events were widely distributed in the sample volume. Analysis of first motion polarity of AE events allowed discriminating between tensile, shear and pore collapse source types, indicating that during fracture initiation more than 50% of all AEs could be identified as tensile events. The slope of frequency-amplitude distributions (b-value) is about 1.6-1.8 during first stage of fracture, and fractal dimension (d-value) is about 2.7-2.8, indicating non-correlated and randomly distributed cracking of the sample.

Subsequent fracture propagation involves significant crack-induced dilatancy in agreement with observed decreasing P- and S- wave velocities. Decrease of b-values prior to sample failure suggests the enlargement of cracks during fracture propagation, and a decrease of fractal dimension indicates shear fracture localization. First motion polarity analysis of AEs showed significantly reduced fraction of tensile events, and shear-type AE sources dominate during the later fracturing. Analysis of focal mechanisms of shear events shows that P-axes orientation distribution is broad during fracture initiation and narrows during fault propagation.