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Damage localization during uniaxial compressions of anisotropic rocks

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Uniaxial compressive experiments have been conducted on gneissic rock samples for research on the influence of inherent anisotropy on the damage location and processes in the context of a rock slope stability study (case of the Rochers de Valabres slope in the Southern Alps, France). Damage in crystalline rocks under stress is related to crack nucleation and growth. These processes, when they occur quickly, generate transient elastic waves called Acoustic Emissions (AE). AE constitute a non-destructive tool for studying damage, 3-D AE hypocentre locations are an estimation of the damage spatial distribution during a mechanical test. From a macroscopic point of view, damage induces elastic property changes. Uniaxial experiments of fracturation have been performed on samples with particular orientations, with the gneiss foliation sub-orthogonal or sub-parallel to the load direction. Samples are cylinders of about 100 mm in length by 50 mm in diameter. The loading consisted in successive loading-relaxation-unloading cycles, with increasing axial load until failure. The relaxation phase allows the release of delayed elastic strain and therefore an appropriate determination of the elastic modulus during the unloading phase with reduced hysteresis. The axial load as well as four strain gauges and LVDT outputs, are collected by an acquisition system. Eight piezoelectric transducers, with 100 kHz - 1Mhz spectral band-pass and major resonant frequency at 300 kHz, were coupled around the sample. They function as receivers and thus constitute a mini-seismic network. A fast acquisition system detects, digitizes and stores the acoustic emission data during mechanical test. This system allows us to digitize the AE waveforms at a rate of 10 MHz for each channel. P wave velocity measurements were performed in a longitudinal direction before each compression experiment. The apparent Young's modulus and the apparent Poisson's ratio have been estimated by linear regressions performed at each unloading phase of the cycles. Concerning AE events, the first arrival times of the signals were automatically picked using a short time average/long time average algorithm, these picks were used in the hypocentre localization algorithm. Mechanical behaviour depends strongly on the foliation orientation. The compressive strength is higher for samples with the foliation sub-orthogonal to the load direction (sub-orthogonal samples). In opposition to the mechanical behaviour of sub-orthogonal samples, the stress-strain curves of samples with the foliation sub-parallel to the load direction (sub-parallel samples) present a clear dilatancy. Elastic property variations during deformation of sub-parallel samples and sub-orthogonal samples are also different, suggesting different damage processes. The acoustic activity (cumulative AE events) during the experiment is also affected by the foliation orientation. However, 3-D AE hypocentre locations do not show particular spatial structures for sub-parallel samples or for sub-orthogonal ones. Influence of the inherent anisotropy orientation is clearly observed through macroscopic mechanical results (stress-strain curves, elastic property variations). The analysis of thin sections will allow the estimation of Modes of cracking and crack orientations and thus to determine if the inherent anisotropy orientation impacts damage processes at a microscopic scale.