



Effect of Anisotropic Velocity Structure on Acoustic Emission Source Location during True-Triaxial Deformation Experiments

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Although true-triaxial testing (TTT) of rocks is now more extensive worldwide, stress-induced heterogeneity due to the existence of several loading boundary effects is not usually accounted for and simplified anisotropic models are used. This study focuses on the enhanced anisotropic velocity structure to improve acoustic emission (AE) analysis for an enhanced interpretation of induced fracturing. Data from a TTT on a cubic sample of Fontainebleau sandstone is used in this study to evaluate the methodology. At different stages of the experiment the True-Triaxial Geophysical Imaging Cell (TTGIC), armed with an ultrasonic and AE monitoring system, performed several velocity surveys to image velocity structure of the sample. Going beyond a hydrostatic stress state (poro-elastic phase), the rock sample went through a non-dilatational elastic phase, a dilatational non-damaging elasto-plastic phase containing initial AE activity and finally a dilatational and damaging elasto-plastic phase up to the failure point. The experiment was divided into these phases based on the information obtained from strain, velocity and AE streaming data. Analysis of the ultrasonic velocity survey data discovered that a homogeneous anisotropic core in the center of the sample is formed with ellipsoidal symmetry under the standard polyaxial setup. Location of the transducer shots were improved by implementation of different velocity models for the sample starting from isotropic and homogeneous models going toward anisotropic and heterogeneous models. The transducer shot locations showed a major improvement after the velocity model corrections had been applied especially at the final phase of the experiment. This location improvement validated our velocity model at the final phase of the experiment consisting lower-velocity zones bearing partially saturated fractures. The ellipsoidal anisotropic velocity model was also verified at the core of the cubic rock specimen by AE event location of transducer shots. AE of the rock during the whole experiment recorded by the surrounding transducers were investigated by location methods developed for anisotropic heterogeneous medium where, the M-shape fracture pattern was observed. AE events occurred in the vicinity of the dilation pseudo-boundaries where, a relatively large velocity gradient was formed and along parallel fractures in the σ_1/σ_2 plane. This research is contributing to enhanced AE interpretation of fracture growth processes in the rock under laboratory true-triaxial stress conditions.