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A Computational Method for 3D Anisotropic Travel-time Tomography of Rocks in the Laboratory

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True triaxial loading in the laboratory applies three principal stresses on a cubic rock specimen. Elliptical anisotropy and distributed heterogeneities are introduced in the rock due to closure and opening of the pre-existing cracks and creation and growth of the new aligned cracks. The rock sample is tested in a Geophysical Imaging Cell that is armed with an Acoustic Emission monitoring system which can perform transducer to transducer velocity surveys to image velocity structure of the sample during the experiment. Ultrasonic travel-time tomography as a non-destructive method outfits a map of wave propagation velocity in the sample in order to detect the uniformly distributed or localised heterogeneities and provide the spatial variation and temporal evolution of induced damages in rocks at various stages of loading. The rock sample is partitioned into cubic grid cells as model space. Ray-based tomography method measuring body wave travel time along ray paths between pairs of emitting and receiving transducers is used to calculate isotropic ray-path segment matrix elements (Gij) which contain segment lengths of the ith ray in the jth cell in three dimensions. Synthetic P wave travel times are computed between pairs of transducers in a hypothetical isotropic heterogeneous cubic sample as data space along with an error due to precision of measurement. 3D strain of the squeezed rock and the consequent geometrical deformation is also included in computations for further accuracy. Singular Value Decomposition method is used for the inversion from data space to model space. In the next step, the anisotropic ray-path segment matrix and the corresponded data space are computed for hypothetical anisotropic heterogeneous samples based on the elliptical anisotropic model of velocity which is obtained from the real laboratory experimental data. The method is examined for several different synthetic heterogeneous models. An “Inaccuracy factor” is utilized to inquire the accuracy of inversion results and to obtain an optimal number of singular values for inversion as well as the minimum heterogeneity percentage that can be recovered. Furthermore, the computational codes are developed as a ray-based tomography tools to implement any set of transducer distribution and any 3D model space resolution of cubic samples in a true triaxial test.