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4D seismics in the laboratory: Imaging using acoustic emission tomography

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Over the past three decades, there has been tremendous technological developments of laboratory equipment and studies using acoustic emission and ultrasonic monitoring of rock samples during deformation. Using relatively standard seismological techniques, acoustic emissions can be detected, located in space and time, and source mechanisms can be obtained. In parallel, ultrasonic velocities can be measured routinely using standard pulse-receiver techniques.

Despite these major developments, current acoustic emission and ultrasonic monitoring systems are typically used separately, and the poor spatial coverage of acoustic transducers precludes performing active 3D tomography in typical laboratory settings.

Here, I present an algorithm and software package that uses both passive acoustic emission data and active ultrasonic measurements to determine acoustic emission locations together with the 3D, anistropic P-wave structure of rock samples during deformation. The technique is analogous to local earthquake tomography, but tailored to the specificities of small scale laboratory tests. The fast marching method is employed to compute the forward problem. The acoustic emission locations and the anisotropic P-wave field are jointly inverted using the Quasi-Newton method. I will present benchmark tests, as well as a real-life example showing the propagation of a compaction front in a porous sandstone.