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# Early detection of stress changes and failure using acoustic measurements

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Local stress changes in a rock can cause irreversible damage by the formation of micro-cracks. The first formed micro-fractures are precursors to the real large scale failure of the sample. Therefore, the detection of the transition from the elastic to the inelastic deformation is crucial for measuring the formation of micro-cracks and predicting the imminent failure. During fracturing, the strain energy is also released as an acoustic emission (AE). In the laboratory the failure process can be measured using AE (passive) and ultrasonic (active) method combined.

In this study within the DeepNL project, we used an ultrasonic pulse transmission method to record the change in waveform across this transition during the fracturing process in combination with AE monitoring. The most important observation we have made so far is that we can see from the changes in the wave amplitude of the direct wave and even more so in the characteristics of the scattering coda of the p-wave when the very first micro-fractures are formed. However, s-waves are expected to be more sensitive to material changes, therefore, we investigate the change of s-waves during fracturing.

We use simultaneous acoustic emission monitoring and active acoustics to determine relationship between (micro-)seismicity and precursory signature of acoustic measurements. Additionally, results from uniaxial tests showed that the cumulative count of AE can be related to the failure phase.