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Results obtained using active seismic source signals prior to and during the STIMTEC experiment

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Active seismic source signals obtained prior to and during stimulation stages can provide valuable additional information to the passive seismic data associated with hydraulic fracturing. For example, hammer hits recorded as part of the stimulation experiment at the Äspö Hard Rock Laboratory, Sweden, allowed for velocity model validation for location and magnitude determination of acoustic emission events.

During the first phase of the STIMTEC underground experiment at the Reiche Zeche underground laboratory in Freiberg, Germany, active source signals were systematically generated using a sledge hammer and a commercial metal processing center punch, referred to as ‚Körner'. Advantages of the Körner over the sledge hammer include the simple handling of the tool, and, more significantly, the generation of a repeatable signal with a defined impact force of 50N. Signal repeatability is needed to detect and measure small changes in the seismic response of the rock volume as a result of the stimulation. In addition, the spectrum of the Körner impulse signal contains more high frequency energy compared to that of a hammer impulse, its frequency range extends into that of acoustic emission events. We investigate the impact signal of the Körner in time and frequency domains.

Travel-time analysis of hammer hits for which origin times were recorded reveal a strong elastic wave anisotropy controlled by the foliation of the rock. P-wave velocities from impulse measurements are higher parallel to the strong host rock foliation compared to ray traces at a large angle to the foliation. This is in good agreement with laboratory measurements on drill cores from the Reiche Zeche. The spectral analysis of the Körner signals result in attenuation properties of the rock volume similar to those obtained for the GFZ-Underground-Lab adjacent to the study area from tomographic inversion using vibroseis sources despite different but overlapping frequency ranges. Our results show that Körner and hammer hits provide a simple means of obtaining high quality data from which valuable and complementary information on the rock properties such as velocity and attenuation structure can be obtained at a small cost.