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Fracture-related seismic propagation effects studied by combining numerical modeling and laboratory measurements

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Understanding seismic wave propagation phenomena, such as dispersion and attenuation, in fluid-saturated fractured reservoir rocks is essential for various applications, for example CO_2-sequestration, hydrocarbon exploration, or nuclear waste disposal. One particular seismic phenomenon in fractured rocks is the Krauklis wave, which is a unique seismic waveform bound to and propagating along fluid-filled fractures. Due to these propagation characteristics, Krauklis waves can resonate in a fracture and emit seismic signals with a signature frequency. Identifying this Krauklis wave-related frequency in the coda of recorded seismograms might be one of the keys to reveal fracture-related petrophysical parameters of fluid reservoirs.

We combine numerical modeling results with laboratory experiments to study, visualize, and quantify fundamental fracture-related effects on seismic wave propagation. For a better comparison, we set up similar numerical and laboratory experiments using homogeneous samples with a single fracture. Using finite-element wave-propagation simulations, the initiation of Krauklis waves by an incident P- and S-wave is studied in detail (Frehner, 2014). We found that body waves can indeed initiate Krauklis waves, yet this initiation is strongly angle-dependent. Nevertheless, we expect to also initiate Krauklis waves in the laboratory experiments.

For the laboratory study, we use Plexiglas as the homogenous medium. The single fracture is manufactured by cutting the sample at 45°, milling a 0.1 mm deep elliptical hole into one side, and gluing the two parts back together with chloroform. We record the seismic signals after propagating ultrasonic waves along samples with and without a fracture. Preliminary experimental results indicate that the fracture leads to a frequency-dependent attenuation and a slight frequency shift of the peak seismic amplitude.

By comparing numerical modeling and experimental results we aim at extracting fracture-related information, such as fracture-orientation, from the recorded seismic signals.

REFERENCE

Frehner M., 2014: Krauklis wave initiation in fluid-filled fractures by seismic body waves, Geophysics 79, T27–T35.