Numerical modeling and laboratory measurements of seismic properties in fractured fluid reservoirs

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Understanding fluid-saturated reservoir rocks is essential for the applications of, for example, CO_2 sequestration, hydrocarbon exploration, or underground nuclear waste disposal. Seismic waves are influenced by the fluids in reservoir rocks, leading to dispersion and frequency-dependent attenuation (Biot, 1962). A reliable rock characterization can be obtained if the effects of fluids filling the pore and fracture space on the seismic response are well understood.

The Krauklis wave is a unique seismic waveform, which is bound to fluid-filled fractures and propagates along fractures. It can resonate and emit seismic signals with a signature frequency. This resonant behavior should lead to a strong frequency dependence, enabling their identification in the coda (Korneev, 2008). The characteristics of Krauklis waves might be one of the keys to reveal fracture-related petrophysical parameters of reservoirs.

Several theoretical studies have demonstrated analytically the dispersion behavior of Krauklis waves in infinitely long and straight fractures (e.g., Korneev, 2008). However, purely analytical methods cannot reveal the realistic fracture geometries or finite-length fractures. Therefore, we combine numerical modeling results with laboratory experiments to visualize fracture-related effects on seismic wave propagation in reservoir rocks. Frehner and Schmalholz (2010) demonstrated that the Krauklis wave can be detected as a converted body wave as a result of scattering at the crack tip. The study also shows that the reflection behavior of the Krauklis wave depends significantly on different crack geometries and different fluids in the crack. For laboratory studies, we simulate similar conditions for a homogenous media (e.g., Plexiglas) as in the numerical experiments. We record the signatures obtained from the propagation of ultrasonic waves along samples with and without a crack, with different crack geometries and different fluids filling the crack. The design of the experiment setup thus allows us to observe and compare the effects of fluids in fractures. The comparison of numerical modeling and preliminary experimental results will be presented.

REFERENCES

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