Krauklis wave initiation in fluid-filled fractures by a passing body wave

Marcel Frehner[†*]

[†]Geological Institute, ETH Zurich, Switzerland, marcel.frehner@erdw.ethz.ch

Krauklis waves are a special wave mode bound to and propagating along fluid-filled fractures. Their propagation properties (e.g., velocity dispersion) have been well studied analytically [1], but only for the theoretical case of straight infinitely long fractures. For the more realistic case of finite fractures analytical methods fail, but numerical wave-propagation models [2] reveal the behavior of Krauklis waves at a fracture tip. Krauklis waves are of great interest because when propagating back and forth a finite fracture, they may fall into resonance and emit a seismic signal with a characteristic frequency. This resonant behavior can lead to strongly frequency-dependent propagation effects for seismic waves and may explain seismic tremor generation in volcanos [3] or in fluid reservoir rocks [2].

All existing studies assume a Krauklis wave initiation inside the fracture, for example by hydro-fracturing. Here, Krauklis wave initiation by a passing plane body wave is studied systematically. For example, Figure 1 shows the case of a plane P-wave passing a water-filled fracture with 45° inclination. The P-wave is scattered and diffracted at the fracture, but also, two Krauklis waves are initiated, one at each fracture tip (i.e., diffraction-points of the fracture). For more realistic rough fracture surfaces and/or intersecting fractures, more diffraction-points increase the probability of initiating Krauklis waves by a passing body wave. The fact that body waves can initiate Krauklis waves has important implications for Earthquake signals propagating through fluid-bearing fractured rocks (volcanic areas, fluid-reservoirs) or for active seismic surveys. The presented study shows how Krauklis wave initiation depends on fracture orientation and the incident wave mode (P- or S).

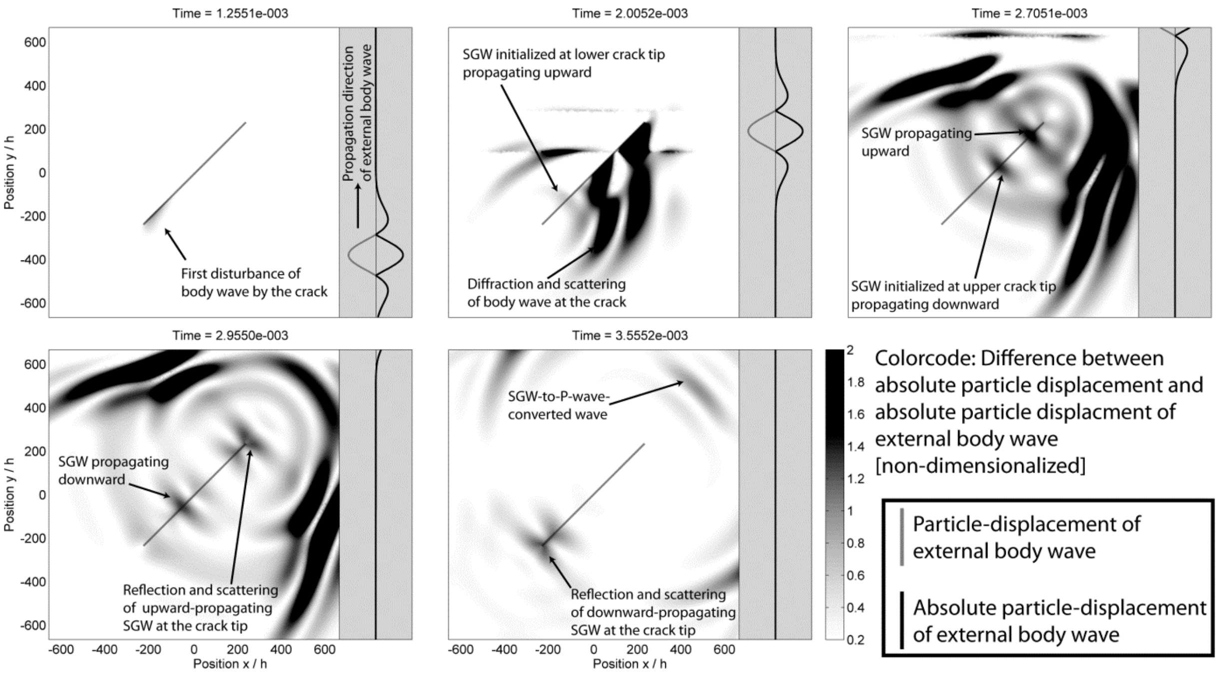

Figure 1: Finite-element simulation snapshots of Krauklis waves being initiated by a passing plane P-wave. The external P-wave (2nd derivative of a Gaussian) is incident from below the model and its profile is shown in the gray sidebars. In each simulation snapshot the signal of the passing P-wave is subtracted from the total absolute particle displacement for better visibility of the scattered and diffracted body waves and of the Krauklis waves.

References

[1] V. Korneev: Slow waves in fractures filled with viscous fluid. *Geophysics*, 73 (2008), N1–N7.
[2] M. Frehner and S.M. Schmalholz: Finite-element simulations of Stoneley guided-wave reflection and scattering at the tips of fluid-filled fractures. *Geophysics*, 75 (2010), T23–T36.
[3] B.A. Chouet: Long-period volcano seismicity: Its source and use in eruption forecasting. *Nature*, 380 (1996), 309–316.