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Modelling the effect of fractures in geothermal reservoirs on the seismic wave field - anisotropy, scattering and localisation

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Fractures and cracks in rocks have a significant influence on the propagation of seismic waves. Their presence causes reflections and scattering of the waves and generates effective anisotropy within the rocks. In geothermics, gaining information on how a system of fractures affects the wave field is of great importance for reservoir characterisation. We present a numerical approach to the simulation of seismic wave propagation in fractured media that does not require explicit modelling of the fracture itself, but uses the concept of linear slip interfaces developed by Schoenberg (1980). This concept states that at an interface between two imperfectly bonded elastic media, stress is continuous across the interface while displacement is discontinuous. It is assumed that the jump of displacement is proportional to stress which implies a jump in particle velocity at the interface. We use this concept as a boundary condition to the elastic wave equation and solve this equation in the framework of a Nodal Discontinuous Galerkin scheme using a velocity-stress formulation. The concept of linear slip interfaces has been implemented into the 1D and 2D versions of the discontinuous Galerkin solver "NEXD". We verified the implementation for the case of an elastic linear slip interface. We use this concept to demonstrate the effect of fractures by the following examples: (1) A system of parallel fractures embedded in a homogenous background medium with a source in the center of the system and (2) varyingly oriented fracture systems embedded in a sample reservoir with layered velocity structure. We show that waves traveling perpendicular to the fractures experience high attenuation whereas waves traveling parallel to the fractures are almost not influenced. Synthetic seismograms show a distinct change in curvature of the wavefront when fractures are present, underlining the effective anisotropy caused by the fractures. In addition we show the contribution such systems have to the coda of the seismograms. In the reservoir case was also explore the effect of these networks on localising the source.