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Fluids in brittle faulting – what do earthquake source mechanisms tell us?

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The occurrence of crack opening became a focus of many recent seismological studies. While the crack opens, a tensional normal stress acts on the fault plane. Thus, the slip vector during the earthquake deviates from the fault surface. In terms of the seismological terminology, this is reported as the non-double-couple component. The crack opening is possible in extensional stress state only, which is characterized by a negative normal stress acting on the fault plane. Because negative stresses in large depths are improbable, the tensile components of earthquakes are usually explained by a high fluid pressure in the fault zone. However, despite frequent fluid involvement in source processes, only few source mechanisms studies show doubtless non-DC components of the moment tensors. This holds also for the microseismicity accompanying the hydraulic fracture stimulation of hydrocarbon and geothermal reservoirs. We join the typical seismological and geomechanical approaches in order to improve our understanding of the presence of crack opening in natural and injection induced earthquakes. We explain the relation of the shear and normal tractions on the fault plane to the occurrence of tensile events and show the reason for seldom occurrence of crack opening. Further we propose a method for assessing the fluid involvement in the fracture process using the focal mechanisms and apply it to a suitable data set of injection-induced seismicity.