Geophysical Research Abstracts
Vol. 19, EGU2017-14165, 2017
EGU General Assembly 2017

Dynamic rupture modeling of seismic events nucleating due to stress changes caused by gas withdrawal from a faulted porous reservoir

Loes Buijze (1,2), Peter van den Bogert (3), Brecht Wassing (1), and Bogdan Orlic (1)

(1) TNO, Utrecht, the Netherlands (loes.buijze@tno.nl), (2) HPT laboratory, Faculty of Geosciences, Utrecht University, the Netherlands, (3) Shell Global Solutions International B.V., Rijswijk, Netherlands

The withdrawal of gas (or other fluids) from the subsurface causes stress changes that can lead to the occurrence of seismic events. Such events have been observed in the USA and in Northwestern Europe (Netherlands, Germany, France), and may be large enough to cause mild damage at the surface. An important question is how these events originate, how large they may become, how they depend on the specific reservoir properties, and how much of their seismic energy is radiated to the surface. To investigate this we designed a two phase finite-element model (2D) approach where we first model in detail the poro-elastic stress changes resulting from gas withdrawal from a typical porous Rotliegend sandstone reservoir in the Netherlands (e.g. the well-known Groningen field) cross-cut by a slip-weakening fault. Subsequently, once the nucleation criteria for seismic instability have been met, we model the induced seismic rupture in a fully dynamic manner. Sensitivity of the nucleation process and the propagation of the dynamic rupture to the reservoir geometry, the weakening properties of the fault and the in-situ stress was investigated. The results show how the nucleation process is strongly affected by the stress changes related to the reservoir characteristics, in particular the offset along the fault cross-cutting the reservoir, in combination with the weakening properties of the fault. These stress changes that developed during depletion also exert a strong control on the propagation and arrest of the dynamic rupture, together with the amount of weakening on the fault (the stress drop). Most modeled events remain within the reservoir formation. However, the larger the stress drop or the more critical the background stress, the more rupture can propagate outside of the reservoir, emphasizing the importance of constraining these parameters from for example field measurements and lab experiments. Furthermore it was observed how velocity contrasts in the stratigraphic may trap a large amount of the radiated seismic energy in low velocity formations. The results are consistent with seismological observations such as the magnitude, stress drop, and source location, and the observed trends provide valuable input for seismic hazard analysis.