[EFFECTIVE STRESS DROP OF INJECTION INDUCED SEISMICITY]

Tomas Fischer

Charles University, Prague, Czechia

fischer@natur.cuni.cz

Keywords: injection induced seismicity, seismic source, stress drop

ABSTRACT

The concept of effective stress drop of a seismic sequence is based on the cumulative seismic moment and area activated by seismic ruptures. The analysis of end-member cases of clustered seismicity shows that the estimated effective stress drop of a cluster is only in agreement with the stress drop of a single event rupturing the same area if no aseismic deformation takes place and rerupturing of asperities occurs during the sequence. The evolution of the cumulative seismic moment release as function of the cluster radius can be used to discriminate different processes: the exponent of seismic moment scaling with radius indicates if the ruptured area is uniformly loaded or whether external loading takes place or if the seismicity is driven by asperity breakage or by creep. Our analysis of 15 sequences ranging from injection-induced activity to natural swarm and aftershock activity shows standard cubic scaling of the total seismic moment in most cases. Slightly higher exponents in the case of injection-induced sequences are indicative of the ongoing local forcing related to the massive fluid injections during the cluster evolution, while lower exponents down to 1 in the case of creeping events might be related to a decreasing/fractal asperity density. Three seismicity groups can be distinguished: a normal-stress-drop group of geothermal injections, swarms and mainshock- aftershock sequences, a low-stress-drop group of shale and gas fracking, and the very low-stress- drop case of creeping events. For several data sets geothermal-related seismicity we compared the effective stress drop of the cluster with the static stress drop of individual events and found that the two types of stress drops are similar, which points full release of stress by brittle deformation. On the other, hand the extremely small effective stress drop of oil/gas induced seismicity indicates large portion of creep in the total slip.

REFERENCES

Fischer T., Hainzl S., 2017. Effective Stress Drop of Earthquake Clusters. Bull. Seism. Soc. Am., 107, No. 5, pp. 2247–2257, doi: 10.1785/0120170035