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Earthquakes with variable stress drops: influence of pore pressure

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We analysed the seismicity that occurred during a circulation test in 2010 in the Soultz-sous-Forêts geothermal field. From the local network, 411 earthquakes were detected and located in the reservoir during this time period. The magnitudes of these earthquakes range from M -0.3 to 2.3. We performed a mutliplet analysis in order to identify similar events based on coherence higher than 90% at least at two stations in the frequency range [10-40] Hz. We isolate several groups of events sharing very similar waveforms. Relative relocation of the events of each group highlights their very close proximity of less than 100m. We also estimated source dimension for each event and noticed that most of the events of each group share a source area of almost the same dimension.
Interestingly, we noticed that despite sharing a similar waveform shape, source area and being located at the same location, events in each group have very large difference in waveform amplitude. This variation in amplitude is thus directly related to relative variation of the average slip during each earthquake in a given group. We evidenced almost a factor 200 of slip variation between two events of the same group that could also be interpreted as a variation of stress drop. We interpret the observed variations of stress drop as resulting from change of pore fluid pressure during the injection. It shows that beyond scaling law, the earthquake stress drop can be affected by environmental conditions.