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Microseismic emissions during pneumatic fracturing: An experimental and numerical study

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Fluid induced brittle deformation of porous medium is a phenomenon commonly present in everyday life. From an espresso machine to volcanoes, from food industry to construction, it is possible to see traces of this phenomenon. In this research, we investigate pneumatic fracturing of a porous medium experimentally and numerically in a Hele-Shaw cell.

In experiments: We are doing air injection in a rectangular Hele-Shaw cell with three closed boundaries and one semi-permeable boundary filled with a fine porous medium in which the air should travel through the porous medium to reach to the atmosphere through the semi-permeable boundary. We observe these fluid/solid mechanical interactions using two monitoring techniques; optical imaging using a high speed camera (1000 fps), and 4 shock accelerometers Bru¨el & Kjaer 4374 (Frq. Range 1 Hz – 26 kHz) with 1 MHz sampling rate.

In the simulations: We have developed a numerical model in two steps (1) a poro-elasto plasticity based model to explain dynamic fluid pressure variations and (2) a solid stress model based on Janssen's theory. The different pressure sources (air in channels, solid stress etc.) are computed separately everywhere inside the Hele-Shaw cell. Afterwards, the variations of the normal stress exerting on the plates are convolved with a Green's function approximating the far field Lamb Waves to generate acoustic emissions numerically.

To see the evolution of the power spectra with the evolving porous medium, we discretized the raw signal into 8 ms time windows. We observed a peak at 57 kHz in the power spectra obtained from the numerical simulations (due to air pressure and total stress separately) and in the power spectra of experimental recordings. The frequency bands and the peaks (in the power spectrum) are observed to be influenced by the size of the carved channels, aperture of the plates, friction parameters of the medium, the characteristics of the injected fluid etc.

Moreover, we tried to explain the evolution of the spectra using two power law fits. A corner frequency for each time window is defined where the two power law fitting curves intersect. We saw that the corner frequency fluctuates while the channel network is being established and gets more stable afterwards. This can be explained with the fractal nature of the channel network.