Numerical analysis of passive seismic emission tomography method using oscillation caused by multiphase flow

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Recent years, passive seismic emission tomography, which utilizes seismic signals induced by fluid flow inside reservoirs, has drawn attention to visualize the subsurface. For example, Ted et al. (2016) use the oscillation caused by the oil flowing in the production well to estimate the position of the production well. They detect production well correctly even in the noisy situation near the highway. They conclude that in future they might be able to detect the location of cracks, through which fluid pass through, created by hydraulic fracturing. In addition, Erokhin et al. (2014) estimates the reservoir’ s location and extent using a long period of time records on surface receivers. However, these attempts are experimental, and it is not sufficient to theoretically elucidate the mechanism of oscillation caused by fluid flowing. In this study, we calculate two-phased flow i) oil-water flow model and ii) gas-oil flow model using Lattice Boltzmann Method (LBM) to observe oscillation caused by fluid flowing. LBM is a method to simulate Newtonian fluid with collision models such as Bhatnagar-Gross-Krook. We adopted LBM because it is good at parallel calculation and it can easily deal with multiphase flow. After calculating the seismic waves caused by the stress disturbance occurred in the pore throat using LBM, we calculate waveforms at receivers using the wave propagation solution using Green function under the assumption of isotropic homogeneous medium.
In oil-water flow model, we detect induced waveform with the maximum amplitude of about 30 Pa when an oil droplet passes through the pore throat. On the other hands, we detect 250 Pa of maximum amplitude when a gas bubble passes through the pore throat. Since we can observe the substantial changes of received waveforms due to the difference of fluid property, it suggests the possibility to estimate the change in the properties of the fluid in the reservoir from the observed micro seismic waves. Using those micro seismic waves, we estimate the location of the reservoir. Next, we record micro seismic waves while the reservoir size is gradually expanded. As we change the using record duration for estimate reservoir location, the estimated result is changed and it was consistent with the simulation model. This result shows the effectiveness of PSET using fluid flowing for monitoring reservoir which is producing oil.

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