The estimation possibility of reservoir property from micro seismic wave caused by fluid flow

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In recent years, hydraulic fracturing method has attracted attention in the stimulation of reservoirs of natural resources such as conventional or nonconventional hydrocarbon development, enhanced geothermal system, etc. Passive monitoring has also drawn the attention to estimate the spread of artificial fractures through the observation of acoustic emissions from the fractures and associated rock failures. Through the practice of passive observation, geophysicists have noticed there is a method called passive seismic emission tomography (PSET) that could be employed to observe seismic waves caused by fluid flow in a crack and grasps the crack distribution in their reservoirs.

Although subsurface areas of fluid movement have been well imaged in oil fields, researches focusing the attention on the elastic wave originating from the fluid flow has merely been conducted and the theoretical confirmation is known indispensable to expand the knowledge in this field. Also, it is important to see if PSET, currently in practice in the field for imaging the zone of fluid movement with oil production could be utilized to estimate unknown parameters such as fluid viscosity, fluid velocity, or any other reservoir parameters. We hypothesize that there is relationship between this fluid motion and the induced seismic waveform. We conduct a series of numerical experiments to prove the hypothesis through the simulation of seismic waveforms generated by fluid flow through a pore throat and to see if there is relation between frequencies of seismic signals and fluid properties such as flow channel shape, flow velocities through the throat. In this study, assuming under the oil production situation, we calculate the stress disturbance on the fracture wall caused by the fluid flow in the multi-phase flow of water-oil by numerical simulation and investigate what type of seismic wave is generated. As a numerical analysis method, for reasons that parallelization and setting simplicity of boundary conditions, we use a lattice Boltzmann method for calculating fluid flow in pore throat. We obtain the seismic wave generated by a passing droplet through the throat. We conduct a similar simulation by changing fluid properties and channel shape and make those micro seismic waveforms' running spectrum using the maximum entropy method (MEM). We investigated the possibility of estimating information on reservoirs such as flow velocity and channel shape from the received waveform by observing the change of waveform from frequency domain using running spectrum. As a result, it was suggested that the seismic waves observed in PSET is caused by fluid flow, and that elastic waves contain information about flow path shape and flow velocity.

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