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Time-Lapse inversion of EM Tomography data for polymer-injected hydrocarbon reservoirs

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Polymer flooding is a method to increase the production of hydrocarbon reservoir by injecting polymer solution into the reservoir. For a study on the monitoring fluid variation within the reservoir, we first make analysis on seismic- and electromagnetic (EM)- tomography responses for seismic and electrical-resistivity rock physics models (RPMs) of the reservoir considering polymer fluid. Constructing RPMs are dependent on not only geologic characteristics of reservoir but also reservoir parameters such as fluid-type, fluid saturation, pressure and temperature. When making RPM for monitoring analysis, we assume the geology does not changes while reservoir parameters change to affect responses of seismic and EM tomography data. Specifically when constructing electrical-resistivity RPM, we consider three different types of hydrocarbon reservoirs, which are clean sand, shaly sand, sand-shale lamination, while considering two different types of waters (fresh water and salt water) to make 2wt% polymer solution.

To compute time lapse EM and seismic tomography responses for corresponding RPMs of polymer-injected reservoirs, we used 2.5D finite element EM modeling algorithm and staggered-grid finite difference elastic modeling algorithm, respectively. Comparison between sensitivities of seismic and EM tomography to polymer injection confirms that EM tomography is more sensitivity to the polymer injection. For the evaluation of the potential of EM tomography to monitor polymer flooding, this study subsequently develops an efficient time-lapse EM tomography inversion algorithm based on the 2.5D EM tomography modeling. Using the inversion algorithm, we inverted the time-lapse EM tomography data to construct true resistivity models of polymer-injected reservoirs and analyze differences between them. From the time-lapse inversion results, we can observe the differences in time lapse responses between using fresh water and salt water have been decreased in the inverted time-lapse sections. Even though EM tomography has larger sensitivity than seismic tomography, EM tomography still has limitation in monitoring polymer flooding in a sense that the method simply detects changes due to the injection of fresh or salt water rather than polymer solution directly. However, the time-lapse inversion method developed in this study has many applications in monitoring fluid variation in other engineering fields.