Simultaneous estimation of subsurface properties from CSP gather

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Seismic reflection survey is one of the most well-practiced methods to visualize subsurface structure for exploring oil and natural gas resources. In a chain of seismic reflection data processing, seismic migration is an essential step to migrate reflection events to right location to visualize an accurate underground structure. Equivalent offset migration (EOM), which is one of pre-stack migration methods, is known as a simple and effective wave-equation-based method to deal with complex underground structures without any interpolation techniques. We started looking into EOM, and found out the method is also applicable to S-wave velocity analysis and for AVO for CSP gathers of the horizontal that is the core part of EOM. First, S-wave velocity structure is of importance to evaluate lithological properties such as porosity or shear modulus for analyzing petrophysical properties. In practice, however, there are few implementation of horizontal components in land seismic exploration because of high-cost survey using multi-component sensors. Therefore, in our study, we would like to demonstrate the effectiveness of utilization of horizontal components in seismic survey using numerical experiments. Then, we use a layered model with inclined layer boundaries just as general target structures for the application of EOM. To estimate physical properties, AVO has been used to estimate the kinematic parameters of the two layers interfacing at a boundary generating reflection signals. Finally, we introduced an inverse method in the estimation of the kinematic parameters of each layer through the minimization of the L2-norm error in the full-waveforms of received data. After the application of a generalized linear inverse theory, our results show that the proposed strategy could estimate physical properties with high accuracy than any simple AVO comparing just amplitudes.

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