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Building Macro-models for Waveform Inversion using Strip-off Controlled Directional Reception Velocity Analysis

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The controlled directional reception (CDR) method is a velocity analysis method using ray-tracing. It is one of the tomographic methods that use slope (or ray parameter), so it is often called the "slope tomography method". It does not require a pre-picking operation like traveltime tomography does. Auto-picked information from the local slant stack is regarded as more reliable than reflection traveltime picked directly from the seismic data. The method also provides more detailed information about the moveout than the imaging operator in migration-based velocity analysis (MVA). Therefore, we constructed a velocity macro-model using this strip-off CDR velocity analysis. When compared to the conventional CDR method, it increased the resolution of common receiver gathers (CRG) data and reduced computer storage space dramatically. Additionally, it improved the accuracy of the velocity model by using the migrated image as a background panel during the velocity analysis.

The results obtained by this method were applied to full waveform inversion (FWI) as the initial velocity model. In FWI, an exact initial model is important because it reduces instability and increases the probability of convergence to the global minimum. It is significant that the CDR model is first applied as the initial model of FWI. We confirmed good inverted results from two realistic synthetic data tests by comparison with the results obtained using the conventional initial models. In particular, the CDR macro-model has great value on its high accuracy. It is expected to provide good results with difficult data, such as seismic data with a weathered zone or short offset, and so increase the accuracy compared with the conventional method. Furthermore, it is possible to apply to multi-parameter inversion.

In summary, the macro-model obtained from strip-off CDR velocity analysis is suitable for frequency domain FWI. Three-dimensional exploration and exploration in complex terrains are being conducted more often, so seismic data with short offset or recording time are also encountered more frequently. This method will demonstrate strength with these seismic data. Additionally, it can be expected to be applicable to land seismic or ocean bottom seismic (OBS) data and also extend into other inversion fields such as multi-parameter inversion.