SEISMIC VELOCITY ESTIMATION BY BEAM STACK

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By
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ABSTRACT

Imaging seismic data requires detailed knowledge of the propagation velocity of compressional waves in the subsurface. In conventional seismic processing, the interval velocity model is derived from stacking velocities. Stacking velocities are determined by measuring the coherency of the reflections along hyperbolic trajectories. This conventional method cannot be applied in geologically complex areas because the conversion of stacking velocities to interval velocities assumes a horizontally stratified medium and mild lateral velocity variations.

The tomographic velocity estimation proposed in this thesis can be applied when there are dipping reflectors and strong lateral variations. The method is based on the measurements of moveouts by beam stacks. A beam stack measures the local coherency of the reflections along curved trajectories (hyperbolic or parabolic). Being a local operator, the beam stack can provide information on non-hyperbolic moveouts in the data. This information is more reliable than the traveltimes of the reflections picked directly from the data because many seismic traces are used for computing beam stacks. The resolution of local coherency operators can be improved by substituting non-linear coherency criteria for conventional stack. At the end of this thesis, I present a new method for estimating coherency spectra based on the eigenstructure of the covariance matrix of the data.

I estimate seismic velocity by iteratively searching for the velocity model that best predicts the events in the beam-stacked data. The estimation method does not require a preliminary picking of the data because it directly maximizes the beam stacks energy at the traveltimes and surface locations predicted by ray tracing. The advantages of this formulation is the possibility of guiding the detection of the events in the beam-stacked data by imposing physical constraints on the velocity model. I solve the maximization problem using optimization algorithms based on the derivatives of the objective function with respect to the velocity model. To compute these derivatives I derived a linear operator that relates perturbations in velocity to the observed changes in beam stacks kinematics.

The proposed tomographic method successfully estimated velocity anomalies from synthetic data and field data.

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