TOMOGRAPHIC DETERMINATION OF STRUCTURAL VELOCITIES FROM DEPTH-MIGRATED SEISMIC DATA

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ABSTRACT

One of the main goals in seismic data processing is to estimate seismic velocities of geological structures in the Earth. Structural velocities are needed for depth migration, the process that converts seismic data, recorded as a function of time, into a depth image of the subsurface. Conventional velocity-analysis methods generally assume flat-layered geology and mild lateral velocity variations. In areas with structurally complex geology, these methods often fail, and more sophisticated techniques are required. One of these techniques, seismic tomography, compares observed traveltimes, measured for each source-receiver experiment, with expected traveltimes, computed by ray tracing through an assumed velocity model; the differences are projected back over the traced ray paths to produce an update to the model.

However, traveltime tomography has some drawbacks. First, picking traveltimes can be cumbersome for data recorded in structurally complex regions. Second, in reflection seismology reflector positions are generally unknown, and ray paths cannot be accurately determined. Third, ray tracing may be complicated in areas with strong lateral velocity variation and large velocity contrasts at structural boundaries.

The tomographic velocity-analysis method presented in this thesis overcomes the above limitations. In contrast to traveltime tomography, I interpret seismic data *after* depth migration. More specifically, I pick reflectors in depth-migrated constant-offset sections, which are easier to interpret than unmigrated data gathers. Because the constant-offset sections all image the same subsurface area, they should be identical after migration if the correct velocity was used. Consequently, discrepancies between the reflectors in the different sections indicate errors in the velocity model used for migrating the data. I correct the migration-velocity model by an iterative optimization technique that minimizes these discrepancies. The optimization scheme is a conjugate-gradient method, where the gradient operator linearly relates perturbations in velocities to changes in reflector positions. In calculating this linear operator, I use the migrated reflectors to reconstruct the rays, and, furthermore, I include ray bending effects by incorporating movement of the reflectors as a function of velocity. The calculations do not require an elaborate ray tracing scheme: instead, I use an upwind finite-difference algorithm that computes seismic traveltimes directly on a grid model of the subsurface.

The method succeeds in estimating structural velocities for a data set recorded over a salt structure in the deep Gulf of Mexico.

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