RESIDUAL PRESTACK MIGRATION AND INTERVAL–VELOCITY ESTIMATION

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ABSTRACT

Migration uses a model of wave-propagation velocities in the Earth (also called interval velocities) to convert seismic reflection data to an image of subsurface reflecting horizons. When geological structure is complex and interval velocities vary laterally, prestack depth migration with an accurate interval-velocity model is needed to form an accurate image of the subsurface. The interval velocities of the subsurface are usually not known in advance; separate processing steps are required to find the interval-velocity model to use for prestack depth migration. As long as lateral velocity variation is mild, conventional velocity-analysis techniques based on simplified models of wave propagation work well; but when lateral velocity variation is significant, when prestack depth migration is needed, conventional methods do not give adequate interval-velocity estimates.

Fortunately, the output of prestack depth migration can be used for velocity analysis. When the correct velocity model is used to depth-migrate a data set before stack, the images of a reflector on the output migrated constant-offset sections are located at identical positions. If the velocity model is inaccurate, the images of a reflector will have residual moveout over offset. Residual prestack migration measures residual moveout and hence velocity errors by applying kinematic corrections to the migrated constant-offset sections and measuring the coherence of their stack. Applying only the residual-NMO and residual-DMO parts of residual prestack migration performs residual-velocity analysis for fixed reflection events from the migrated constant-offset sections. Thus, velocity analysis is not confused by reflector movement caused by the zero-offset residual-migration component of residual prestack migration.

Residual velocity, the measure of residual moveout, like prestack time-migration velocity or stacking velocity is not an interval velocity itself, but is a function of the interval-velocity model. The residual velocity that best stacks the image of a reflector is related to an interval-velocity model by a filtered traveltime-tomography operator. The operator is similar to conventional traveltime tomography, but in addition the operator has terms that convert changes in traveltime into changes in residual velocity and terms that account for the movement of reflector images as the velocity model changes.

The velocity-analysis method of this thesis begins by depth-migrating the constant-offset sections of the data and applying residual NMO+DMO to perform residual-velocity analysis. To convert the residual-velocity information to an updated interval-velocity model, I invert the filtered traveltime-tomography operator. To verify the new interval-velocity model's correctness, I remigrate the constant-offset sections with it. Any remaining residual moveout will appear in a new residual-velocity analysis; the entire process iterates until an accurate image is obtained.

Results from field data and synthetic data indicate that the velocity-analysis method successfully estimates interval-velocity models that lead to depth-migrated images with no residual moveout. However, if the reflectors are sparse, or data quality is poor, this interval-velocity model is non-unique. Then, additional information about the interval-velocity model or the positions of reflectors must be supplied to obtain the correct interval-velocity model and structural image of the data.

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Table of Contents

List of Figures