Chapter 4

Summary and Conclusions

I have shown that prestack migration can be used as a velocity analysis tool. Conventionally, normal moveout (NMO) has been used for this purpose. Using prestack migration instead of normal moveout makes it possible to do velocity analysis in areas where the structure is complicated, or where the velocity varies laterally. The reason for this possibility is that, unlike NMO, migration can be formulated for laterally-varying media.

There are several approaches for doing velocity analysis by prestack migration. All of these methods rely one way or another on this principle: after migration with the correct velocity model, an image in a common-receiver gather (CRG) is aligned horizontally, regardless of structure. This thesis discussed an iterative method in which an initial velocity model is used for migration and the error in the velocity model is estimated by examining the curvature in post-migration common-receiver gathers (CRG's). This scheme amounts to combining velocity analysis and imaging.

The first step in this iterative velocity analysis scheme is to relate the error in velocity with the curvature in the post-migration CRG's. This relation was established using kinematics. The estimation of the error in velocity is therefore approximate, which means that more than one iteration is needed.

The curvature in the CRG's was estimated by measuring the semblance along several trajectories. At each depth, the curvature of the trajectory which has the largest semblance is taken to be a measure of the velocity error at that depth. The velocity error at a given depth is cumulative of all velocity errors above that depth. The curvature in a CRG is therefore a measure of the error in the average velocity (or average slowness). By combining errors in average slownesses from all depths, the interval-velocity model is estimated.

The method proposed here is limited by its inability to resolve velocities at depths which have no images. The reason is that between two reflectors, various combinations of velocities that satisfy the velocity analysis principle can be found. Another limitation is the spatial smearing of velocity error, which is caused by the projection of the error onto rays which do not pass through an anomaly. This limitation is offset by the multiplicity of coverage of a particular location by many rays.

Field profiles were selected as the input to the velocity analysis method. There are two main reasons for this selection. First, sampling over the receiver axis is usually better than sampling over the shot or offset axis, thereby reducing the aliasing problem. Second, lateral velocity variations are better handled in the shot-geophone space.

Because prestack migration is used in the velocity analysis, the outputs of the method presented in this thesis are the velocity of the medium and the migrated profiles. In conventional interpretation methods, a concise output is obtained from these migrated profiles by stacking them over the shot axis. Interpretation can also be made using migrated CRG's. In this thesis, they were used to estimate the error in migration velocity. They can also be used for other purposes. For example, reflectivity as a function of angle can be measured from these gathers because they contain reflectivity information for a number of angles.

The velocity analysis concept discussed in this thesis can be extended to the 3-D surveys. In this case, the velocity used in migration is correct if the image in a CRG is a horizontal plane; error in velocity will make a curved surface. The analysis of velocity error is, however, more complicated.

This thesis also briefly discussed the possibility of using a search method in which the velocity of the medium is obtained by migrating and stacking profiles using a suite of constant velocities, and extracting an interval velocity model from those constant velocities.

In the field data set that was analyzed by the iterative method, convergence was obtained in three iterations. This data does not appear to have significant lateral velocity variations. It shows, however, that velocity analysis can be done by prestack migration. The method was also applied to synthetic data that has lateral velocity variations. It converged after five iterations, giving a velocity model that was close to the original model. The resulting model has some artifacts which do not exist in the original model. Most of these artifacts result from lack of constraints between reflectors. As mentioned earlier, the velocity can vary between reflectors without having an effect on the image in the CRG.