“Depth Imaging Challenges” a.k.a. “The Three Stooges Meet Hercules”

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Summary
The Socrates Session addresses our ability to estimate accurate seismic images of the Earth’s reflectivity. Reliable seismic images created by depth migration require accurate velocity models, general algorithms, and reliable data. In such imaging problems, the processes of data processing and interpretation become intertwined. Several data examples exhibit the success and failure for case histories from the Foothills.

Introduction
Accelerated gas exploration in the Western Canadian Foothills has created a great demand for depth imaging of complex structures in order to better define drilling locations. Prestack depth migration provides solutions to these exploration problems – provided we obtain an accurate velocity model. This Herculean task involves an iterative and interpretive procedure in which geologists and geophysicists use combined skills.

Methodology
There are a number of good alternatives when it comes to choices in algorithms for depth imaging. A review of Kirchhoff, f-x, phase shift, and reverse-time depth migration methods is given in Lines, Gray, and Lawton (1999). My experience with data cases has been that all of these methods do a reasonably good job of migrating good data with an accurate velocity model. (At least, they give the same accurate answers on the same synthetic seismograms.) Two important problems remain. One is the important problem of acquiring good data and processing these data to obtain coherent signals. The other important problem involves producing a velocity model that makes geological sense, agrees with well log data, flattens the smiles and frowns in common image gathers, and which helps to provide a focused image. It may be necessary to utilize anisotropic velocity models.

Examples
In order to illustrate concepts on depth imaging, we examine model and field data examples. These include physical models, numerical models, and the Benjamin Creek, Caroline, and Shaw Basing field data sets. Examples contain steeply dipping beds, complex folds, and a series of thrust faults. Many of the rocks (especially shales) contain some degree of anisotropy. In almost all cases, the first images were obtained by poststack migration, but the images were (eventually) improved by iterative applications of prestack depth migration.

Conclusions
The trend in today’s exploration plays is to do prestack migration (in both time and depth). The success of the techniques depends on the velocity analysis tools which accommodate the migration. Success depends largely on our ability to automate the migration/velocity estimation and use general velocity models.

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Reference
Lines, L.R., Gray, S.H., and Lawton, D.C., 1999, Depth imaging of foothills seismic data: CSEG publication, Calgary, Alberta.