STRATEGIC SEISMIC IMAGING - A STEPWISE APPROACH TO IMAGING COMPLEX 3D STRUCTURES

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INTRODUCTION.

The general problem of depth imaging is composed of two parts:

- 1) the definition of the velocity model necessary to properly image the area of interest (model building),
and
- 2) the depth migration itself.

The first step requires a great deal of interpretative expertise which should be exercised within a user friendly interactive package including various applications, which, when dealing with 3D data is certainly a challenge. The second step requires large computing resources in terms of powerful CPU's to process billions of seismic samples and fast I/Os.

With current graphic workstations and vector supercomputers pre-stack depth imaging is no longer a challenge in 2D (Jeannot, et al, 1986; Audebert & Diet, 1990). It has already been successfully used for some years to solve complex structural problems such as those related to salt tectonics and overthrust areas. In completing such tasks people grew acquainted with the new experience of processing in conjunction with interpretation, whereby a combined expertise in both domains is mandatory to achieve satisfactory results and avoid the various traps inherent in any inversion-like problem. Experience with the Marmousi synthetic data set greatly enhanced peoples understanding of some of the pitfalls involved in the 2D approach.

The still increasing power of graphic workstations, allowing fast scrutinization of 3D seismic volumes, along with the development of massively parallel processing technology, now makes 3D pre-stack depth imaging an attainable goal. However, the interactive trial and error approach, loosely guided by inversion theory, which is common practice in 2D, cannot yet be seriously considered in 3D.

On the contrary, a carefully designed stepwise approach, whereby an initial velocity model is progressively refined using increasing amounts of the information contained in the seismic data, has to be used (Cabrera, et al., 1992; Johnson, 1992; Ratcliff, et al., 1992; Wyatt, et al. 1992).

In this paper we present an overview of one such global seismic imaging strategy, focusing attention with a case history approach outlining the possibilities in building the velocity model by:

- picking horizons from time migrated data,
- map-migration of picked time horizons,
- 3D tomographic inversion of zero-offset times and stacking velocities.

We then move-on to refining reflector geometries by layer-stripping post stack 3D depth migration, allowing for the possibility of restarting the tomographic inversion with updated horizon picks. And finally we progress to the pre-stack 3D depth migration, using image gathers as a criterion to assess validity of the model.

THE STRATEGY.

A conventional post-stack 3D time migration is the starting point for the model building exercise. From the time migration, we can pick initial reflector geometries to allow a first estimation of the interval velocity structure via Dix inversion of stacking velocities. Zero-offset time picks can then be obtained by de-migration of time-migrated picks.

The next step consists in building-up a initial depth model using map migration techniques of zero-offset travel times. This is followed by 3D tomographic inversion of zero-offset travel time and stacking velocities to derive an updated model. At this point in the exercise, well ties may be included.

We then progress to post-stack depth migration using this last model. This migration could use the layer-stripping strategy (described by Jones, 1993) in which case the updated reflector geometries, picked directly in depth migrated space, can be used to feed back into the 3D tomographic inversion so as to refine the interval velocity model.

Using sparse-grid low frequency data volumes in the layer-stripping depth migration permits turnaround of a few hours so that iterative updating of the model is feasible.

At this stage all the information contained in post-stack data, along with any available a-priori knowledge, has been used to get the best possible post-stack seismic image. At the same time, problems related to post-stack imaging limitations are identified and areas affected by travel path anomalies due to velocity variations can be delineated.

Having obtained an acceptable velocity model with this strategy, we progress to the target oriented pre-stack depth migration, the targets being those areas previously identified as requiring pre-stack imaging (the use of a Kirchhoff algorithm makes this task of selective imaging quite practical).

Migration velocity panels can be displayed in different ways to assess the model: absence of any significant residual move-out indicates that the same model which has been used for post-stack migration can also be used to image pre-stack data. If however, residual move-out can be observed, it means that derivation of the model has been biased by the data reduction involved in stacking.

In the absence of a general method to invert the residual move-out information, some approximations could be used, such as to consider the residual errors as residual normal move-outs and use conventional techniques to update interval velocities.

RESULTS.

We present real and synthetic examples of the various stages in velocity model elaboration, and target oriented pre-stack 3D depth migration.

BACKGROUND READING.

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