Stereotomography

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ABSTRACT

Stereotomography was proposed 10 years ago for estimating velocity macromodels from seismic reflection data. Initially, the goal was to retain the advantages of standard travel-time tomography while providing an alternative to difficult interpretive traveltime picking. Stereotomography relies on the concept of locally coherent events characterized by their local slopes in the prestack data cube. Currently, stereotomography has been developed in two and three dimensions, and precious experience has been gained. The expected advantages have been demonstrated fully (in particular, the efficiency and reliability of the semiautomatic stereotomographic picking strategies), and further studies have increased the method’s potential and flexibility. For example, stereotomographic picking can now be done in either the prestack or poststack domain, in either the time-unmigrated or depth-migrated domain. It appears that the theoretical frame of stereotomography can reconcile, very satisfactorily and efficiently, most methods proposed for velocity-macromodel estimation for depth imaging. Moreover, an extension of the method to full-waveform inversion already exists and opens the way for very interesting developments.

INTRODUCTION

We initially proposed stereotomography (Billette et al., 1997) as a robust tomographic method for estimating velocity macromodels from seismic-reflection data. At that time, we recognized the potential efficiency of traveltime tomography (Bishop et al., 1985; Farra and Madariaga, 1988) and difficulties associated with a highly interpretive picking (which explains why traveltime tomography does not form the base of conventional velocity-model-building today). Selected events must be tracked across a large extent of the prestack data cube, which can be challenging for noisy or complex data (Ehinger and Lailly, 1995).

The idea was to use locally coherent events characterized by their slopes in the prestack data volume. Such events can be interpreted as pairs of ray segments and can provide information about the velocity model independently from each other (Figure 1). The idea had been investigated by Riabinkin (1957) and revived by Sword (1986, 1987), who called it the common-directional-reception (CDR) method. Since the time of Sword’s work, variations and improvements of CDR have been proposed.

Several velocity-model-building methods, based on the use of locally coherent events, are variations of CDR. For example, in Guillaume et al. (2001), the velocity-model update is based on locally coherent events in common-offset gathers. These events are obtained by picking facets on initial common-offset depth-migrated results. These initial migrated facets are kinematically demigrated into kinematic invariants corresponding to locally coherent events in the common-offset trace gathers. The kinematic invariants are the basis of the tomographic update. They can be kinematically remigrated in any velocity model, allowing an assessment of quality in terms of alignment of migrated facets for different offsets.

In a strategy proposed by Fei and McMechan (2006a, 2006b), facets are picked on an initial common-offset depth-migrated image. For each facet, a common-reflection-point trace gather is built by kinematic demigration. Finally, the velocity model is updated to maximize the stack along traveltime curves in common-reflection-point gathers. Fei and McMechan (2006a) mention that maximizing the stack implicitly means fitting the local traveltime shape of the event and consequently its slope, showing strong roots with CDR.

Several studies attempt to improve the CDR method. For example, Whiting (1991, 1998) introduces a better constraint of the velocity-model update (use of entropy constraints and stages of decreasing model-space smoothing); whereas, Biondi (1992) combines CDR with a process that maximizes the semblance in beam-stack panels to be less sensitive to the quality of data when picking locally coherent events. Another very important contribution, by Chauris et al. (2002a, 2002b), demonstrates that CDR picking could be done equally in the time-unmigrated or depth-migrated domains, which reconciles time- and depth-domain-picking velocity-model-building approaches.
In fact, stereotomography is a generalization of CDR, with the added benefits of robustness and simplicity (the extension to three dimensions, for example, is straightforward [Chalard et al., 2000]). The introduction of paraxial ray tracing (Cerveny et al., 1977; Farra and Madariaga, 1987) was the other significant improvement because it provided an efficient solution for numerically computing Fréchet derivatives (the stereotomographic matrix) (Billette and Lambaré, 1998). Note that Chauris et al. (2002a, 2002b) also introduce paraxial ray tracing in CDR.

Ten years after our first paper on stereotomography, we have gained significant experience from practical and theoretical applications. Stereotomographic algorithms have been developed in two and three dimensions, and they have been applied on various synthetic and field data sets (Chalard et al., 2002; Alerini et al., 2003; Billette et al., 2003; Lambaré et al., 2004a; Lambaré et al., 2004c; Le Béga et al. 2004; Lambaré and Alerini, 2005; Shen et al., 2005a; Alerini, 2006; Dümmond et al., 2007). Stereotomography also has been extended to the analysis of converted waves (Alerini et al., 2007, 2008), direct arrivals (Gosselet et al., 2003, 2005), and anisotropic propagations (Barbosa et al., 2006; Nag et al., 2006).

However, the most interesting extensions certainly revolve around picking concepts. Initially introduced in the prestack time unmigrated domain (Billette and Lambaré, 1998; Billette et al., 2003, Lambaré et al., 2004b), it has been demonstrated that stereotomographic picking could be done in the depth-migrated domain (Chauris et al., 2002a; Nguyen et al., 2003, 2008), in the poststack time domain (Lavaud et al., 2004; Neckludov et al., 2005, 2006), or even in the prestack time migrated domain (Lambaré et al., 2007) (Figure 1).

In this paper, I first review the basis of stereotomography. Then, I present various developments of the method, leading to a very efficient and general frame for velocity-macromodel estimation. Finally, I discuss advantages and challenges of stereotomography and offer perspectives.

**STEREOTOMOGRAPHY**

**A slope tomographic method**

Stereotomography belongs to the family of slope tomographic methods (Riabinkin, 1957; Sword, 1987; Billette and Lambaré, 1998). The basis of these methods is to recognize that any locally coherent event in the prestack unmigrated domain, characterized by its traveltime and slopes, provides information on the velocity model. A stereotomographic data set \( d \) consists of a set of parameters corresponding to \( N \) picked locally coherent events \( d_n \):

\[
d = \left[ d_n \right]_n=1^N.
\]

Each locally coherent event,

\[
d = (s, r, T_{sr}, p_s, p_r),
\]

is described by the source and receiver positions \( s \) and \( r \), two-way traveltime \( T_{sr} \), and slopes of the event in the common-receiver and common-shot directions \( p_s \) and \( p_r \) (Figure 2). It is what we call a stereotomographic pick. Any event can be associated in the exact velocity model with a pair of ray segments parameterized by

\[
(X, \beta_s, \beta_r, T_s, T_r),
\]

where \( X \) denotes the position of the reflector/diffractor; \( \beta_s, \beta_r \) are ray-shooting angles from \( X \) toward \( s \) and \( r \); and \( T_s, T_r \) are two one-way traveltimes from \( X \) toward \( s \) and from \( X \) toward \( r \).

There are many ways to use information from stereotomographic picks. CDR considers the misfit on a single type of data parameter (traveltime, slope, or position). In stereotomography, the cost function consists of squared misfits on all types of data parameters, i.e., positions, slopes, and traveltimes. This introduces uncertainties on all types of data and theoretically ensures robustness of the local optimization (Billette and Lambaré, 1998). But as a consequence, pairs of ray segments must be optimized jointly with the velocity macromodel, increasing the number of model parameters.
Then, the stereotomographic model is a combination of the velocity macromodel, described by a set of velocity parameters $V_m$, (typically weights associated with a basis of B-spline functions used for describing the velocity model) and a set of pairs of ray segments associated with each picked event,

$$m = \{(V_m)_{m=1}^M, \{(S, r, T_s, T_r)\}_{m=1}^N\}.$$  \hspace{1cm} (4)

For any a priori pair of ray segments and velocity model, the set of stereotomographic parameters corresponding to a stereotomographic pick can be calculated:

$$d_{calc} = (s, r, T_s, T_r)_{calc}.$$ \hspace{1cm} (5)

This computation only requires tracing two ray segments from the common point $X$ toward the surface with initial directions $\beta_s$ and $\beta_r$ and with lengths corresponding to one-way traveltimes $T_s$ and $T_r$, respectively. The stereotomographic cost function is the squared misfit function between calculated and observed data,

$$C(m) = \frac{1}{2}(d_{calc}(m) - d_{obs})^T C_D^{-1}(d_{calc}(m) - d_{obs}),$$ \hspace{1cm} (6)

where $C_D$ denotes the a priori covariance matrix for data parameters (Tarantola, 1987) (typically a diagonal matrix with the square of a priori errors on observed parameters of stereotomographic picks) and $T$ denotes the transposition.

**Stereotomographic optimization**

As in standard traveltime tomography, an iterative nonlinear local optimization scheme is used to update the stereotomographic model. Quasi-Newton optimization schemes have been used until now, requiring the computation of Fréchet derivatives of data $d$ (equation 1) with respect to model $m$ (equation 4):

$$\frac{\partial d}{\partial m}.$$  \hspace{1cm} (7)

A derivation of Fréchet derivatives is detailed in Billette and Lambaré (1998). It is based on paraxial ray tracing (Farra and Madariaga, 1987) and requires some smoothness of the velocity macromodel. In our numerical implementations, we use smooth-velocity macromodels defined by cubic-cardinal B-splines (de Boor, 1978). There is no need for interfaces, but they could be introduced if they are sufficiently smooth (Farra et al., 1989).

In our local optimization scheme, we first optimize pairs of ray segments fixing the velocity macromodel to its initial value to mitigate the nonlinearity. This step is called the localization step. It can be seen as a generalization of the kinematic migration used, for example, in Guillaume et al. (2001). The same cost function as for the global update is used, but the velocity model is fixed and we independently only optimize the ray segment parameters to fit the source and receiver positions, two-way traveltimes, and slopes according to the a priori covariance matrix. In a standard common-offset kinematic migration, only slopes in common-offset gathers are considered, which means introducing very large relative a priori errors on remaining slopes for our localization scheme. Note that in the standard process, the a priori covariance matrix is a diagonal matrix with the square of the error observed for each data parameter.

The stereotomographic algorithm consists of three steps (Figure 3) (Billette et al., 2003):

1. Initialization to build the initial model (pairs of ray segments and velocity model). In practice, we use simple initial models, e.g., a homogeneous velocity model and ray segments derived from simple geometric considerations.
2. Localization of events in the initial velocity model. This is done using a quasi-Newton nonlinear optimization. Because all events can be localized independently, we use singular-value decomposition (SVD). The localization step leads to an important reduction of the cost function.
3. Joint iterative inversion of ray segments and velocity-model parameters. This is realized using the LSQR scheme (Paige and Saunders 1982). The LSQR optimization scheme is widely used for seismic tomographic problems because it is well adapted to tomographic problems with large and sparse Fréchet derivative matrices. A Laplacian regularization term is introduced for the velocity model.

For tuning the LSQR algorithm, we use recommendations of Paige and Saunders (1982); for the Laplacian regularization, we use the empirical law given by Wang (1993). Practically, a weighting factor is applied to the Laplacian regularization so that the energy of components of Fréchet derivatives associated with the Laplacian regularization is between one and one-tenth of the energy associated with misfits on the stereotomographic data parameters. In practice, such criteria can be used as a black box. Finally, we also use a multiscale approach for the velocity macromodel to mitigate nonlinearity (Alerini et al., 2002; Billette et al., 2003; Lambaré et al., 2004a).

**Stereotomographic picking**

Stereotomographic picks are locally coherent events in the prestack unmigrated time domain. In this domain, they can be more naturally picked with the advantage of considering the exact acquisition geometry. Because stereotomography aims at deriving velocity macromodels for depth migration, which is a stacking process over traces (at least in its high-frequency asymptotic assumption), it is natural that picking locally coherent events is based on a local stacking process over traces. In fact, in most of our applications of ste-
reotomography, we use stereotomographic picking on local slant-stacked panels (more precisely, the envelope of the local slant-stacked traces) (Billette et al., 2003) (Figure 4). Automatic picking can be done, and then various selection criteria can be applied prior to or during the stereotomographic optimization (Lambaré et al., 2004b) (Figure 5).

Set-up and tuning of the various selection criteria are key points for the success of the stereotomographic update. First, outliers can be eliminated considering the general distribution of picked parameters, but additional parameters can be associated with the picks and also used for the selection. For example, parameters associated with the equivalent medium (Billette et al., 2003), allowing interpretation of any individual stereotomographic pick as a pair of ray segments in a homogeneous velocity model, can be used advantageously for selecting the picks (Lambaré et al., 2004c). Moreover, after the localization or joint optimization steps, we have access to local parameters within the depth-migrated cube, which also can be helpful for selecting stereotomographic events during optimization. For example, the local slope in common-image gathers (CIGs) can be used to discriminate primaries from water-bottom multiples (Figures 6–8) or PS from PP events in PP-PS stereotomography (Lambaré and Alerini, 2005).

In parallel to developments to improve the stereotomographic picking in the prestack data cube, important studies also have been done to investigate stereotomographic picking in the prestack depth-migrated cube, which is frequently recognized as the most natural domain for the velocity-model-building process. Indeed, the pre-

Figure 4. Stereotomographic picking on local slant stack panels in the time domain. The same trace is displayed in its common-shot (left panel with axis $[x,t]$ within the left box) and common-receiver (left panel with axis $[r,t]$ within the right box) gathers. Slant stacking allows defining slopes of events. Local slant stack panels are shown at the right of the left and right boxes with axis $(p_{sx},t)$ and $(p_{rx},t)$, respectively. They display the envelope of the local slant stack (Billette et al., 2003).

Figure 5. Selection of stereotomographic picks within the stereotomographic sequence. The selection during optimization loops can be based on information obtained from pairs of ray segments. Figure 4 displays the QC window showing the automatic picking.

Figure 6. Application of 2D stereotomography with a semiautomatic picking to the 2004 BP velocity benchmark data set (Billette and Brandsberg-Dahl, 2005). Final stereotomographic model with dip bars (migrated facets) superimposed. Water-bottom multiples were not removed from the data set prior to the stereotomographic picking. A selection of events according to their slopes in CIGs allowed identification and elimination of most multiples from the stereotomographic data set (Lambaré et al., 2004b).

Figure 7. Application of 2D stereotomography with a semiautomatic picking to the 2004 BP velocity benchmark data set (Billette and Brandsberg-Dahl, 2005). Final depth-migrated image.
3D stereotomography

Stereotomography was first implemented in two dimensions (Billette and Lambaré, 1998; Billette et al., 2003), along with automatic slope-picking. As mentioned in the introduction, an advantage of stereotomography, compared with other slope tomographic methods, is the a priori straightforward extension to three dimensions. Although it is straightforward theoretically, it is less evident practically because most acquisition geometries do not provide access to all slopes that would be a priori required for 3D stereotomography. For example, in conventional narrow-azimuth marine acquisitions, the crossline slope at the shotpoint cannot be estimated precisely because the shot-line distance is too large. Therefore, it was important to demonstrate that stereotomography could be extended to 3D, even if only a single lateral slope is available from the acquisition geometry (Figure 10). This is the important contribution of Chalard et al. (2000), who also show the first application of 3D stereotomography to a field data set (Chalard et al., 2002).

In fact, 3D stereotomography exhibits very important specificities. Let us consider a set of prestack traces corresponding to an acquisition geometry. We assume this set of traces can be ordered according to parameters \( n_1, n_2, \) and \( n_3.\) For a single shot-line gather of traces in a narrow-azimuth multistreamer marine acquisition, \( n_1 \) could be the shot number, \( n_2 \) the receiver number along a streamer, and \( n_3 \) the streamer number (Figure 11). For a single-streamer ocean-bottom cable (OBC) acquisition, \( n_1 \) could be the receiver number, \( n_2 \) the inline shot number, and \( n_3 \) the crossline shot number (Figure 12). Around a central trace defined by \( (n_1,n_2,n_3),\) gathering traces in terms of common \( (n_1,n_3), \) common \( (n_1,n_2), \) or common \( (n_1,n_2,n_3) \) allows to pick a stereotomographic pick as

\[
(n_1,n_2,n_3, T_{\text{obs}}) \frac{\partial T_{\text{obs}}}{\partial n_1}, \frac{\partial T_{\text{obs}}}{\partial n_2}, \frac{\partial T_{\text{obs}}}{\partial n_3}. 
\]

Such a locally coherent event can be observed on the traces. But for use in a stereotomographic optimization, we need to have access to the geometric information, i.e., shot and receiver positions.

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Figure 8. Application of 2D stereotomography with a semiautomatic picking to the 2004 BP velocity benchmark data set (Billette and Brandsberg-Dahl, 2005). CIGs in angle domain obtained with the final stereotomographic model (Figure 6). We see that water-bottom multiples, which were not removed from the data set, have a significant curvature, whereas primaries are rather flat.

Figure 9. Stereotomographic picking in the depth-migrated domain. There is a link between a locally coherent event in the prestack unmigrated time domain (a) and a locally coherent event in the prestack migrated depth domain (b). The slope in the common-offset time domain is connected to the dip in the common-offset depth-migrated domain (indicated in orange in both domains). Then, given previous slope and dip, the slope in the common-shot (or common midpoint) time domain is connected to the slope of the event in the CIG (indicated in yellow in both domains).
s = (x, y, z) and r = (x, y, z), and differential quantities
\[ \frac{\partial s}{\partial n_i}, \frac{\partial s}{\partial n_j}, \frac{\partial s}{\partial n_k}. \]

With this information, calculated stereotomographic slopes are obtained from
\[ \frac{\partial T_{\text{calc}}}{\partial n_i} = p_s \cdot \frac{\partial s}{\partial n_i} + p_r \cdot \frac{\partial r}{\partial n_i}, i = 1, 2, 3, \quad (10) \]

where \( p_s \) and \( p_r \) are slowness vectors at ending points of the pair of ray segments (Figure 13). Equation 10 allows us to understand how stereotomography can be extended to data sets in which slopes of the event are not considered in the horizontal plane (Lambaré et al., 2005). In this case, topographical variations have to be introduced within differential quantities (equation 10).

Finally, note that for full azimuth acquisition, when source and receiver positions cover independently the entire acquisition surface, an additional numbering parameter \( n_s \) can be introduced and 3D stereotomography can then be done in the more natural way, considering four slopes instead of three.

Very few 3D stereotomographic results have been published up to now (Chalard et al., 2000; Chalard et al., 2002). I reproduce on Figures 14–17 some results presented in Chalard and Lambaré (2005) that demonstrate the ability of 3D stereotomography to recover a 3D velocity model when just a single lateral slope is available. Figure 14 shows the exact pairs of ray segments computed from a regular grid of reflecting points in a smoothed version of the EAGE/SEG overthrust model (Aminzadeh et al., 1997). Figure 15 shows an inline and a crossline section of the velocity model with the location and dip of the regular grid of reflecting points. Slope components used in the stereotomographic data set are \( p_{sx}, p_{sy}, \) and \( p_{rz} \) \((p_{r3} \) is not considered). Figure 16 shows the same sections for the final stereotomographic model. The general structure of the velocity model has been recovered except for the deeper part and the boundaries of the model that were not sufficiently constrained by the data set. Figure 17 shows the final pairs of ray segments to be compared with the exact ones on Figure 14. We observed some lateral shift of the reflecting point positions when compared with the exact ones (see Figures 16 and 17). Again, this is because of limited constraints on the stereotomographic model from the stereotomographic data, as for any tomographic tool addressing velocity-model building from limited-aperture seismic-reflection data. Appropriate a priori information should be introduced for better matching.

Figure 10. 3D stereotomography. Slopes \((p_{sx}, p_{sy}, p_{rz})\) correspond to the value of the projection of source and receiver rays slowness vectors at the surface on directions of the acquisition geometry. A single lateral slope is sufficient to constrain a 3D velocity macromodel (here \( p_{rz} \)). Three-dimensional stereotomography can then be applied to 3D narrow-azimuth marine acquisitions.

Figure 11. 3D acquisition ordered as \( n_1, n_2, \) and \( n_3 \) for a single-line multistreamer narrow-azimuth marine acquisition; \( n_1 \) is the shot number, \( n_2 \) the receiver number along a streamer, and \( n_3 \) the streamer number.

Figure 12. 3D acquisition ordered as \( n_1, n_2, \) and \( n_3 \) for a single receiver line 3D OBC acquisition; \( n_1 \) is the receiver number, \( n_2 \) the inline shot number, and \( n_3 \) the crossline shot number.

Figure 13. Computation of calculated slopes in 3D stereotomography. Slowness vectors associated with source and receiver rays at the acquisition surface are \( p_s \) and \( p_r \). Differential quantities \( \frac{\partial s}{\partial n_i} \) and \( \frac{\partial r}{\partial n_i} \) required by equation 10, the expression of calculated stereotomographic data, are indicated in orange.
DISCUSSION AND PERSPECTIVES

Several years of developments, investigations, and practice of stereotomography significantly changed our assessment of the method. We successfully demonstrated these expected advantages of the method:

- Robustness and easy extension to 3D when compared with original CDR (Chalard et al., 2000);
- Easier and denser picking when compared with standard travel-time tomography (Lambaré et al., 2004a).

In addition, a powerful theoretical and practical framework has emerged. Now, stereotomography allows reconciling time- and depth-domain methods, and poststack and prestack methods. The concept allowing these reconciliations is the local aspect of data analysis. Practically, most types of information used in the other ve-

Figure 14. Exact pairs of ray segments for 3D stereotomography. They were built shooting upward from a regular grid of reflecting points with purely inline ray shooting angles at the reflecting point.

Figure 15. Exact velocity model and dip bars for 3D stereotomography. Inline (a) and crossline (b) section of the exact smooth-velocity model. Dip bars corresponding to the exact position and dip of reflecting points are superimposed. No dips are considered and reflecting points are located on a regular grid.

Figure 16. Estimated velocity model and dip bars using 3D stereotomography. Figures can be compared with those in Figure 15. We see the good quality of the estimated velocity model with the exception of areas with poor ray coverage, i.e., the deep part and boundaries of the model. We also observe some shifting of recovered dip bars that cannot be perfectly constrained from the stereotomographic data set.

Figure 17. Estimated pairs of ray segments using 3D stereotomography. When compared with Figure 14, we see the good quality of recovered pairs of ray segments, except for some slight shifts in depth where the ray coverage is not sufficient to constrain the stereotomographic model.
Locality-macromodel-estimation methods (residual curvature of CIGs, stacking velocities, prestack times, etc.) can be used in stereotomography. The only requirement is that the data set contains sufficient local information, i.e., local derivatives. This great characteristic of the approach results from the very simple and direct connection between the data and velocity model through concepts of locally coherent events and pairs of ray segments. Several variations of slope tomography have been proposed (Biondi, 1992; Guillaume et al., 2001; Duveneck, 2004; Lavraud et al. 2004; Fei and McMechan, 2006a and 2006b), somehow dropping the local aspect of the methods. I am convinced that this characteristic should be preserved, at least in the inner core of the algorithms. I encourage further developers of numerical algorithms for velocity-macromodel estimation to base them on stereotomography (or at least on CDR), and to use conversion schemes to transfer kinematic information into stereotomographic data.

As it was introduced, stereotomography is a ray-based method, with the well-known limitations of ray-based methods in complex media. However, the principle of a local analysis of the data is not limited to picked data, and the potential extension of the method to full waveform inversion is recognized by Symes (1998) or Chauris (2000). They emphasize in particular the connection of stereotomography with differential semblance optimization (Symes and Carrazzone, 1991; Symes, 1998; Chauris and Noble, 2001; Mulder and ten Kroode, 2002; Foss et al., 2005; Shen et al., 2005b; Khoury et al., 2006; Li and Symes, 2007), which, therefore, could be the basis for a natural extension of the method to full waveform inversion.

Certainly, much remains to be done for the practical use of stereotomography. For example, we have never fully succeeded in recovering really complex velocity models such as Marmousi (Billette et al., 1998, Chauris et al., 2001). Is it because of the nonlinearity of the problem, an intrinsic limitation of ray theory, or the inefficiency of the stereotomographic picking? Further investigations are required.

Both steps of stereotomography certainly can be improved: stereotomographic picking and stereotomographic optimization. Picking still remains a serious bottleneck (even if it improved significantly compared with standard travelt ime tomography), and investigations should continue toward semiautomatic strategies mixing various types of kinematical information. Concerning optimization, improvements can be achieved through the introduction of reliable a priori information (on model and data) and more general velocity models including anisotropy and discontinuities. In addition, the combination of various types of data as wide angle (Trinks et al., 2003), vertical seismic profiling data (Gosselet et al., 2003), or multicomponent data in PP-PS stereotomography (Alerini et al., 2002 and 2003; Lambaré et al., 2004c; Lambaré and Alerini, 2005; Lambaré et al., 2005) already have demonstrated its potential and should be investigated further.

Finally, it is particularly interesting to see the present interest in the introduction of locally coherent events at all other steps of the seismic-processing sequence. In a very interesting paper, Fomel (2007) describes, for example, the potential of using the local slope of seismic events to improve time imaging. In the depth-migration arena, the success of Gaussian-beam migration proposed by Hill (1990 and 2001) offers great motivation for the development of various directional (Takahashi, 1995; Sun and Schuster, 2000) and beam migrations (Sun et al., 2000; Albertin et al., 2004; Notfors et al., 2006; Zhu et al., 2006). Gao et al. (2006) presents a fast-beam-migration method based on kinematic migration of stereotomographic events and is, without a doubt, a very serious step toward interactive imaging.

From my point of view, this trend exhibits the potential of considering locally coherent events in seismic imaging, which is likely to continue to increase in the future, with benefits even for methods not based on high-frequency asymptotic approximations (Jilek et al., 2007).

CONCLUSION

Stereotomography now has been established as a robust method for velocity-model building from seismic-reflection data. Its ability to handle numerous types of kinematic information picked in unmigrated or migrated, prestack or poststack domains makes it particularly attractive as the kernel for a velocity-model-building tool. Some work certainly remains to be done, e.g., the definition of criteria for a semiautomatic selection of stereotomographic events, introduction of appropriate a priori information, combination of various types of seismic data, or introduction of anisotropy.

Fundamentally, the main advantage of stereotomography (and other slope-tomography methods) comes from using locally coherent events. We already see a significantly increasing interest in all steps of the seismic-imaging flow from the exploration geophysics community. In this context, stereotomography should definitely be combined with beam-migration methods, but it also should be advantageous when used ahead of high-frequency asymptotic assumptions in which benefits of using locally coherent events will certainly be demonstrated in the coming years.

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