MIGRATION VELOCITY ANALYSIS FOR FACTORIZED ANISOTROPIC MEDIA

Ilya Tsvankin

Center for Wave Phenomena, Colorado School of Mines, Golden, USA

One of the main challenges in seismic imaging is simultaneous estimation of velocity gradients and anisotropy parameters from reflection data. A practical way to incorporate spatial velocity variations into anisotropic velocity analysis is by adopting the factorized model, in which the ratios of the stiffnesses (and, therefore, the anisotropy parameters) are constant. I discuss migration velocity analysis(MVA) of P-wave data for media composed of transversely isotropic(TI) layers or blocks with the linearly varying symmetry-direction velocity V_{P0} and constant parameters ϵ and δ. MVA is implemented as an iterative two-step procedure that includes Kirchhoff prestack depth migration followed by a linearized parameter update (Sarkar andTsvankin, 2004). The residual moveout of migrated events, which is minimized in the updating procedure, is described by a nonhyperbolic equation whose coefficients are determined from a semblance scan.

For piecewise-factorized TI media with a vertical symmetry axis (VTI), the algorithm estimates four parameter combinations in each block: (1) the normal-moveout velocity $V_{\rm nmo}$ at the top of the block; (2) the vertical gradient k_z of the velocity V_{P0}; (3) the combination $\hat{k}_x = k_x\sqrt{1+2\delta}$, where k_x is the lateral velocity gradient; and (4) the anellipticity parameter η. Inversion for η requires either long-spread horizontal events or reflections from dipping interfaces (Tsvankin, 2005). To resolve the parameters ϵ and δ and reconstruct the model in depth, it is necessary to include constraints on the vertical velocity (e.g., by assuming V_{P0} to be continuous across layer boundaries). Therefore, by approximating the subsurface with factorized TI blocks, it is possible to decouple heterogeneity from anisotropy with minimal *a priori* information.

Application of the method to an offshore data set from West Africa helped estimate the spatially varying parameters η, δ, and ϵ and achieve marked improvements in image quality. In particular, anisotropic MVA and imaging facilitated structural interpretation by eliminating false dips and properly focusing and positioning fault planes. These results demonstrate the potential of the developed algorithm in lithology discrimination and seismic interpretation in complex areas (Sarkar and Tsvankin, 2006).

For transverse isotropy with atilted symmetry axis (TTI media), the section is divided into “quasi-factorized” blocks, in which theparameters ϵ and δ are constant, while the symmetry axis is perpendicular to reflectors (Behera and Tsvankin, 2009). Synthetic tests for several typical TTI models (a syncline, a bending shale layer, and uptilted shales near a salt dome) confim that if the symmetry-axis direction is fixed and V_{P0} is constrained, the parameters k_z, k_x, ϵ, and δ can be determined from reflection data. Application of VTI processing to data from TTI media may lead to misfocusing of reflectors and errors in parameter estimation, even when the tilt of the symmetry axis is moderate.

References

Behera, L., and I. Tsvankin, 2009. Migration velocity analysis for tilted transversely isotropic media, *Geophysical Prospecting*, **57**, 13-26.

Sarkar, D., and I. Tsvankin, 2004. Migration velocity analysis in factorized VTI media, *Geophysics*, **69**, 708-718.

Sarkar,D., and I.Tsvankin, 2006. Anisotropic migration velocity analysis: Application to a data set from West Africa, *Geophysical Prospecting*, **54**, 575-587.

Tsvankin, I., 2005. Seismic signatures and analysis of reflection data in anisotropic media, 2nd edition: Elsevier Science.