Seismic signatures and analysis of reflection data in anisotropic media, (Handbook of Geophysical Exploration 29) by Ilya Tsvankin. ISBN 0-08-043649-8. Pergamon Press (Elsevier Science), 2001. 454 pp. $156.50

This book has been long-awaited in the seismic exploration community. Anisotropy is now in the mainstream of seismic processing, and one can hardly find a session at SEG meetings at which anisotropy is not mentioned. With the increasing popularity of multicomponent seismic, more and more geophysicists face the problem of imaging the subsurface in anisotropic environments. Yet, we had no book covering both anisotropic theory and practical methods of estimating anisotropy from seismic data in a uniform and consistent way. The difficulties in applying anisotropic inversion and processing are exacerbated by the fact that this complicated area is still under development (especially for converted waves), with a steady stream of newly published papers presenting controversial conclusions. Anisotropy often manifests itself in subtle ways, and improper treatment can go unnoticed at the processing stage but eventually cause disastrous consequences when the results of seismic interpretation are used in reservoir characterization and in making drilling decisions.

Ilya Tsvankin is a world-recognized expert in this field, who, with Vladimir Grechka, has spearheaded much recent progress in anisotropic parameter estimation and processing. Tsvankin is known for an extremely thorough approach regarding practical applications; he is concerned not just about the theoretical solution to a problem, but also about the whole multitude of issues related to its implementation. That is why each problem in the book is subject to a careful error analysis using synthetic data. Unfortunately, this crucial step is sometimes omitted by geophysicists working in service and oil companies. The book contains several striking examples that demonstrate how theoretically attractive parameter estimation schemes may completely fail due to the large uncertainty in the inverted anisotropic parameters. We have seen many published papers whose authors could not recognize the pitfalls of applying new algorithms without proper uncertainty estimates.

The book provides background information about anisotropic wave propagation and discusses modeling, inversion, and processing of seismic reflection data in the presence of anisotropy. Particular attention is given to reflection moveout and other signatures of *P*-waves and converted *PS*-waves in layered transversely isotropic media with a vertical (VTI) and tilted axis of symmetry. The detailed description of velocity analysis and imaging for VTI media includes efficient methods of *P*-wave time-domain processing, and joint depth-domain inversion of *P* and *PS* data that yields the velocity model for anisotropic depth migration. Field-data examples illustrate improvements in imaging achieved by anisotropic dip-moveout and migration algorithms, and the possibility of using estimated anisotropic parameters in lithology discrimination. The chapter devoted to the anisotropic Green's function and AVO analysis introduces simple approximations for reflection coefficients and AVO propagation phenomena.

The most valuable features of the book are:

- it is the first comprehensive description of reflection seismic signatures and processing methods in anisotropic media.
- it identifies the key parameters for time and depth imaging in transversely isotropic media and describes practical methodologies for estimating them from seismic data.
- it provides a thorough discussion of the important issues of uniqueness and stability of seismic velocity analysis in the presence of anisotropy.
- it includes a complete description of anisotropic imaging methods, from the theoretical background to algorithms to implementation issues.

The only drawback is a relatively high price; however, after owning this book for some time, I feel that the expense was more than justified. Whenever I need to work on an anisotropic algorithm or understand the underlying theory, this book saves a lot of time and effort that would have been spent on digging out dozens of old and modern papers containing contradictory notations and results. This fact, together with very clear language and concise style, should make it useful for both graduate students and geophysicists working in research, exploration and development.

—Andrey Bakulin
Cambridge, England

Tsvankin's book describes theory for anisotropic wave propagation and practical implications for modeling inversion and data processing.

Chapter 1 provides background information on the reasons for anisotropy including intrinsic rock properties, sedimentary layering, and fractures. The equations of motion for anisotropic media are derived and the elastic constants are related to Thomsen's parameters (ε, δ) which supply general models for TI (transversely isotropic), HTI (horizontally transversely isotropic), and orthorhombic media.

Tsvankin describes the effect of anisotropy on AVO in Chapter 2. It is shown that anisotropy can cause nongeometric effects which do not exist in isotropic media. Reflection coefficient expressions that are complicated enough in isotropic media become even more complicated in the presence of anisotropy.

Chapters 3-7 deal with NMO and velocity analysis in anisotropic media, stating that seismic NMO effects produce the most reliable velocity estimates. It is shown that isotropic NMO can lead to mis-stacking when a medium is anisotropic. Nevertheless, Tsvankin shows how one can make corrections to velocity analysis to correct for anisotropy, by developing an anisotropic version of Dix's equation. A parameter η (related to the difference of Thomsen parameter) is introduced to simplify the anisotropic velocity analysis. Tsvankin also describes anisotropic velocity analysis for mode-converted *PS* waves, with the understanding that anisotropic effects may be bigger for these waves than for *P*-wave reflections. In velocity analysis, it is stated that η (the Tsvankin anellipticity parameter) and the normal moveout velocity are the most important parameters.

Finally, the implications of anisotropy on time and depth migration are analyzed. The book effectively gives anisotropic procedures for DMO analysis prior to migration for dipping reflectors. In industry today, it turns out that anisotropic parameters are also used in prestack migration, which is a more general procedure than DMO methods.

This book contains an excellent

compendium of topics on seismic anisotropy. It clearly explains the complexities while offering tractable solutions. However, excellence does not imply perfection and there are a few items that could be emphasized more. Anisotropic prestack depth migration now plays a big role in correctly imaging lateral reflectors. Core measurements, refraction surveys, and VSP data could provide important information about anisotropic parameters: This should also be mentioned.

Overall, Tsvankin has done an excellent job. Although the book's price may be prohibitive for students, it would be very worthwhile for geophysicists who are wrestling with anisotropy problems in their exploration plays.

—Larry Lines
Calgary, Alberta, Canada