Seismology of Azimuthally Anisotropic Media and Seismic Fracture Characterization, by Ilya Tsvankin and Vladimir Grechka, ISBN 9781560802280, SEG, Geophysical References Series no. 17, 2011, 480 pp., US $99, ($79 member).

Two distinguished geophysicists, Ilya Tsvankin (a recipient of SEG's Virgil Kauffman Gold Medal) and Vladimir Grechka (a J.C. Karcher awardee), share their vast expertise in anisotropy parameter estimation and fracture characterization in Volume 17 of SEG's Geophysical Reference Series, *Seismology of Azimuthally Anisotropic Media and Seismic Fracture Characterization*. Together the authors developed much of the underlying theory during their time with the A(nisotropy)-team at the Colorado School of Mines (CSM). Earlier in their careers, both authors were employed at leading geophysical research institutions in Russia. Vladimir Grechka is now a senior geophysicist with Shell, while Ilya Tsvankin is a coleader at the Center for Wave Phenomena at CSM. Both provide ongoing contributions to influential research publications on seismic anisotropy and together teach a two-day SEG continuing education class on seismic anisotropy.

Seismic wave velocity can change as a function of propagation direction at a given position inside fractured or periodically layered rock formations, a phenomenon that is called seismic anisotropy. The goal of this book is to analyze deviation from normal "isotropic" behavior and relate it to fracture parameters that are important for cost-effective development of reservoirs. Correcting conventional seismic processing for anisotropic distortions and extracting sensitive information from seismic signatures recorded in anisotropic media have been academic goals for many years. However, the underlying wave-propagation theory is complex and the inversion for anisotropic parameters, until recently, has been considered impractical by many in the industry. This picture is now rapidly changing with the success of unconventional resource plays due to improvements in seismic acquisition, computational power and cross-disciplinary data integration. In other words, seismic anisotropy is a hot topic so the arrival of this publication could not be better timed.

In spite of the enticing topic, before pulling out your credit card and ordering, be aware that this publication is written for an advanced audience. Seismic anisotropy is a complex topic that requires intricate workflows, a thorough understanding of wave propagation, and an appreciation of nonuniqueness in multiparameter inversion. Given these factors, this is not a text for the novice. If terms such as Christoffel equation, group velocity, and compliance tensors are unfamiliar, you may want to first familiarize yourself with more introductory texts, such as Tsvankin's 2001 monograph *Seismic Signatures and Analysis of Reflection Data in Anisotropic Media*.

At first glance, *Seismology of Azimuthally Anisotropic Media and Seismic Fracture Characterization* appears to be a mere collection of Geophysics papers. In particular, do not expect an accommodating and easy-going, textbook-style handholding by the authors. The material is tough, mathematically challenging and often interwoven with references to other publications. Despite these factors, what makes this worthwhile reading are its unique, broad, and competent insights into how to reliably extract, constrain, and combine essential expressions of seismic anisotropy introduced by fracturing or periodic sedimentation.

Overall, the book is highly structured with hierarchical descriptions of wide-azimuth data processing and inversion technologies, starting with conventional normal-moveout analysis of seismic reflection gathers. It is quite remarkable that despite a complex subsurface structure composed of anisotropic layers, for all practical purposes, the normal-moveout velocity changes in a simple, elliptical manner. As shown in Chapter 2, the semi-axes of this ellipse can be extracted by careful processing and may be inverted for layer-specific interval ellipses using a generalized Dix equation. Finally, after separating out the influence of lateral heterogeneities, this anisotropy-induced ellipticity can be used to estimate spatially varying fracture orientations. A field data example from Wyoming is full of practical advice and highlights the sensitivity of the produced fracture maps to careful smoothing and data conditioning.

In Chapter 3, the authors address the kinematics of reflections recorded at large offsets. As shown on normal-moveout corrected gathers, long-spread reflection events for horizontal reflectors in fractured media can change with azimuth. An exact analytic description shows that this azimuthal variation is of a more complex nature than the previously discussed simple elliptical normal-moveout response. A generalization of the inversion algorithm used for VTI media allows inverting for effective anellipticity parameters as demonstrated on wide-azimuth data from the Weyburn Field in Canada.

Chapters 4–6 describe multicomponent seismic technologies, including the "PP+PS=SS" method that constructs pseudoshear data that are kinematically equivalent to pure shear primary reflections. This clever approach overcomes the intrinsic problems of poor shear data quality on land (or its absence in marine acquisition) by more easily exploiting mode-converted energy. Thus augmenting P-wave data with shear-wave information helps to estimate and constrain anisotropic parameter sets (as demonstrated for two field data examples from the Gulf of Mexico and the North Sea).

Although the book primarily focuses on reflection data, Chapter 7 provides a quick introduction on vertical seismic profiling methodologies and highlights their potential to obtain the complete stiffness tensor at receiver locations. In several data examples, VSP surveys produce well-resolved parameters that provide information about lithology and fracturing.

Over the last ten years, azimuthal amplitude versus offset analysis (AVO with azimuth or AVAZ) has proven to be a robust and essential technique to characterize fractured reservoirs due to the high sensitivity of the reflection coefficient to pertinent anisotropic parameters and the high resolution of the method. The fundamentals of AVAZ and two more recent technologies (seismic critical angle reflectometry and attenuation anisotropy) are introduced in Chapter 8.

Chapter 9 links the observed anisotropy parameters to characteristics of fracture systems by reviewing two popular effective media theories. In particular, it is shown that Schoenberg's (1980) linear-slip formalism is more accurate than Hudson's (1980) theory. A second important observation is that multiple fracture sets in an isotropic matrix rock produce orthorhombic symmetry, although with fewer parameters as expected for this symmetry system. This final chapter also relates AVAZ gradient variations to crack density and crack filling, highlighting important differences in reflection response between dry and fluid-filled fracture systems.

In summary, *Seismology of Azimuthally Anisotropic Media and Seismic Fracture Characterization* is a leading-edge publication and reference book in the field of seismic anisotropy parameter estimation. It condenses a decade of research by some of the brightest minds in this field and, consequently, is not an easy read. The publication is best described as a well-organized and decorated compilation of GEOPHYSICS papers covering normal- and nonhyperbolic moveout inversion, prestack amplitude variations, VSP, and converted-wave data processing of wide-azimuth data. An impressive number of fracture-characterization field data examples demonstrate the proposed inversion workflows and adds credibility to the main text. Missing topics include shear-wave rotation methods, migration velocity analysis and full waveform inversion. The text is excellently written, scientifically rigorous and nicely decouples the discussion of physical observations from the more involved mathematical derivations. It is a suggested buy for geophysical researchers and the curious practitioner who wants to gain a strong foundation of the science underlying current and emerging fracture detection algorithms.

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