GeoNeurale

Announce

Leon Thomsen

SEISMIC ANISOTROPY in EXPLORATION and EXPLOITATION

Munich
SEISMIC ANISOTROPY in EXPLORATION and EXPLOITATION

( NEW ENLARGED PROGRAM )

MUNICH

at the

GATE – Garchinger Technologie und Gründerzentrum

3 DAYS COURSE
INSTRUCTOR:  Dr. Leon Thomsen
LEVEL:    Advanced
This is an excellent opportunity for all geophysicists to learn how a fundamental property of rocks impacts all our data and how to deal with it.

AUDIENCE:  Geophysicists, Seismic Processors, Petrophysicists, Explorationists

COURSE FEES:  2950 Euro + VAT (19%) (The VAT Tax is 100% refunded by the German Ministry of Finances)

REGISTRATION DEADLINE :

ONLINE REGISTRATION:  www.GeoNeurale.com
GeoNeurale Office and Training Location
at the Munich-Garching Research Center
SEISMIC ANISOTROPY in EXPLORATION and EXPLOITATION

PROGRAM

Course Description
All rock masses are seismically anisotropic, but we generally ignore this in our seismic acquisition, processing, and interpretation. The anisotropy nonetheless does affect our data, in ways that limit the effectiveness with which we can use it, so long as we ignore it. In this short course, we will understand why this inconsistency between reality and practice has been so successful in the past, and why it will be less successful in the future, as we acquire better seismic data (especially including vector seismic data), and correspondingly higher expectations of it. We will further understand how we can modify our practice so as to more fully realize the potential inherent in our data, through algorithms, which recognize the fact of seismic anisotropy.

Who should attend?
This is an excellent opportunity for all geophysicists to learn how a fundamental property of rocks impacts all our data and how to deal with it.
PROGRAM

1. Physical principles (Day 1, morning)
2. P-waves: imaging (Day 1, afternoon)
3. P-waves: characterization (Day 2, morning)
4. S-waves: (Day 2, afternoon)
5. C-waves: (Day 2, afternoon)

Epilogue: (Day 2, afternoon)
SEISMIC ANISOTROPY in EXPLORATION and EXPLOITATION

Detailed Program

INTRODUCTION

Course Outline
Support Materials
End Presentation

PART 1

Definition
Physical Principles
Most Sediments are Not
Most Sediments Are
Inhomogeneities
Massive Shales
Small Scale
Mother Nature
Core Expand
Different Fabrics
Physical Anisotropy of all types
Electrical Anisotropy (1)
Electrical Anisotropy (2)
Electrical Anisotropy (3)
Anisotropy as a Function of Scale
Consider Vertical and Horizontal Elasticity and Symmetry
The Role of Ekastic Tensor 1,2,3
Hooke’s Law
Symmetry of the Medium
How bad could it be 1,2,3,4,5,6
In the survey coordinate system
Polar Anisotropy
Solution
The Velocity of Plane Waves
A careful Inspection
The exact Velocity of Plane Waves
Weak polar Anisotropy 1,2,3,4
AP Wave front 1,2,3,4
P Slownesses ia a WA-VSP
Alternative Formulations
Example
Card Tricks
Comparison of P -Anisotropies
Azimuthal Anisotropy
Azimutal Variation 1,2
The Power of Notation
End of Presentation
PART 2

Canonical Anisotropic Reflection Problem
Ray Greater than Wavefront 1,2
Thin Layer
Thin Isotropic Layers
Thin Anisotropic Layers 1,2
NM Stacks
Anisotropic Movement Velocity
Taylor Series Coefficients
Yields the Moveout Velocity
Short Spread 1,2
Reflection Problem 1,2,3
Fuggy Images
Hyperbolic Moveout Analysis 1,2
A Single Polar-Anisotropic Layer 1,2,3
Hockey Stricts Straightened
Anisotropic DMO
The DMO Operator 1,2
Isotropic and Anisotropic 1,2
Various Constant Velocities
Beds and Faults
Anisotropic Time Migration
Two Problems
Imaging Errors
Benefit of Anisotropic Time Migration
Anisotropic Depth Migration
A Synthetic Anisotropic Model
Anisotropic Depth Migration 1,2,3,4
Determining the Parameters
2-Parameters Semblance Plots 1,2,3
NMO Velocity
Slowness Ellipses
Azimuthal Variation of Moveout Velocity 1,2
Parameter Semblance Plots
Gathers are not flat
Determined from Residual Moveout
The total Slowness
Azimuthal Anisotropy
Some beds dip
Elasticity Tensor 1,2
Scattering Problems
Dipping Anisotropy 1,2
Expensive Mis-Imaging 1,2
Isotropic Mislocate the Faults
Correctly Images the Fault
Orthorhombic Anisotropy
3-D Geometry 1,2
Anisotropy fro Real Formations 1,2
9 Equations 9 Unknowns
For all Directions
End of Presentation
PART 3

Polar Anisotropy
Lithology from Velocity Ratio
Laboratory Data on Dry Shales
Estimation of Lithology
N-Estimation of Lithology
Pore Pressure Prediction
Amplitudes
Angle-Dependent Effects
Linearized Isotropic Half-Space
Quantitative AVO 1,2,3
Wavefront Angle
Qualitative AVO 4
Crossplot 1,2,3
Azimuthal Variation of Velocity
Stacking Velocity
Anomalies from coherent zones
Zone of High Anisotropy
Clair: World Largest Uneconomic Field
Multi-Azimuth
P-Wave and S-Wave Velocity Analysis
2D Surface Seismic Lines
Apparent Velocity Correlated with Production 1,2
Azimuthal AVO: Fracture Detection
Amplitude Variations in Transmission
Two-Term Anisotropic P-AVO 1,2
Azimuthal Variation 1,2
Azimuthal Variation of P-AVO
Anomalies from Coherent Patterns
Stress and Fractures
Shear Fractures
Tensile Vertical Joints
Some Fractures are Sealed
Regional Orthogonal Extensive Fractures
All three Stress Eigenvectors
Confirmation of Theory for Dry Rocks 1,2,3
Theoretical Effects of Saturated Cracks
Effect of Cracks in an Impermeable Medium 1,2,3,4
Effect of Cracks in a Permeable Medium 1,2,3
Theoretical Effect of Saturated Cracks in Sandstone
Confirmation of Theory for Saturated Rocks
Crack-Induced Anisotropy
Orthogonal Canyons
Orthogonal Jointing
Long Cracks
End Presentation
Isotropic Shear Waves
The Theory Behind
Inline and Crossline Polarizations
Polar Anisotropy 1,2
Weak Polar Anisotropy
Card Tricks: Polar Anisotropy
Horizontal Propagation
Cusps and Triplications
Wavefront-Velocity
Ray-Velocity
Strong Anisotropy
This complicated Behaviour occurs only if.. 
But this can be simplified to 1,2 
The approximation is good
VSP’s
Polar Anisotropy in an Offset VSP Survey
Schematic Illustration of S-ave Anisotropy 1,2
Afford Rotation
Devil’s Elbow Pennsylvania
Principal Modes Propagate down
As Recorded on Receivers 1,2
The Spike-Seismogram Vector: Crossline Source
The Spike-Seismogram Vector: Inline Source
2cx2c Data Matrix 1,2,3,4
Principal coordinate System
Afford Rotation Is..
The Fast-Slow Delay
Seismically-Detected Fractures
Principal Sections showing Split-Shear
The Slow-Mode Amplitudes are Variable
Slow-Mode Zones Correspond to Fractures 1,2,3
These Fast-Slow Differences are Magnified 1,2
The previous Derivation does not work
if the Azimuth of Anisotropy changes..

Time Lapse
The Argument for Sensing..
The Stress-Cracks-Anisotropy Connection 1,2
Time-Lapse Changes in Shear-Wave Splitting 1,2,3
Changes in Overburden Shear-Wave Splitting 4
VSP’s
An Example of Coarse-Layer Variation
Crossed Dipole Sonic Data
Conventional Logging uses a Monopole Source
In a slow S-Formation
The Crossed-Dipole Tool
Crossed-Dipole Log
End of Presentation
PART 5

C-Wave Basics
Isotropic Waves at a Plane Interface
C-Waves in ocean bottom Seismic 1,2,3
The canonical C-Wave Problem
Homogeneous and Isotropic Case 1,2,3
Velocity
The partially Realistic C-Wave Problem
C-Wave Moveout Velocity 1,2,3
Non-Hyperbolic Movement
The more Realistic C-Wave Problem
C-Wave Nonhyperbolic Moveout 1,2
Diodic Movement
Asymmetric Inline CMP
If you Pick the Slow Mode you Get..
The Gather was Centered about a Point
Common conversion Point Gathers
The minimally realistic C-Wave problem 1,2,3
An approximate computation
The Effective Velocity Ratio 1,2
An Approximate Computation
Anisotropic Prestack Depth Migration
C-Wave 2d Section at Valhall 1
Conventional P-Wave
The Moveout Ellipse for C-Waves is Off-Center 1
C-Wave 2d Section at Valhall 2
The Moveout Ellipse for C-Waves is Off-Center 2
Valhall: DMO/Post Stack Time Migration 1,2
Anisotropic Prestack Depth Migration
Valhall: Anisotropic Pre-Stack C-Wave
Anisotropy Required to focus Image
Amplitudes
Linearized Anisotropic Half-Space 1,2
The Anisotropy combined with Shear
A C-Wave Split-Spread Gather
Such Data must be Described
Vector Infidelity
Azimuthal Anisotropy 1,2,3
Alignment of Split C-Waves
Quotation
Acknowledgements
End Presentation

EXERCISES
Leon Thomsen

Leon Thomsen holds degrees in geophysics from Caltech (B.S. 1964) and Columbia (Ph.D. 1969).

His academic career began with post-doctoral appointments at CNRS in Paris, and at Caltech, followed by faculty appointments at the State University of New York in Binghamton (1972-80).

Thomsen’s industrial career began with 14 years at Amoco, at its famous Tulsa Research Center.

Following the change of its mission in 1994, he joined Amoco’s worldwide exploration department in Houston.

Following the recent merger, he serves in BP Amoco’s Upstream Technology Group in Houston, as Principal Geophysicist.

For his work in seismic anisotropy, Thomsen was given the Fessenden Award in 1994 by the SEG.

He served as the SEG Distinguished Lecturer in 1997, and was Chairman of the Research Committee in 1998-2000.

He and his colleagues received the EAGE’s Best Paper Award in 1997 for their converted-wave analysis at Valhall. Thomsen was given Honorary Membership in the GSH in 1998.
Leon Thomsen  
Research Professor of Geophysics  
Ph. D Geophysics, 1969, Columbia University  
B. S. Geophysics, 1964, California Institute of Technology

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University of Houston  
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Research Interests
During 28 years at Amoco, BP-Amoco, and BP, Thomsen lead the exploration community in four major paradigm-shifts in seismic exploration:

- Seismic polar anisotropy (His 1986 paper establishing key concepts is the most-frequently cited paper in the history of Geophysics.)
- Seismic azimuthal anisotropy (He discovered the phenomenon in 1980; his 2006 paper establishes that the P-wave seismic signature corresponds to real subsurface fracture patterns.)
- Converted-wave seismic (His 1999 paper established numerous key concepts, such as C-waves, $\gamma_{\text{eff}}$, diodic velocity, vector fidelity, vector reciprocity, and event registration.)
- Electromagnetic imaging, seismic style (with KMS personnel)

This work was realized in 60 refereed papers, 2 books, 16 patents (plus 3 others in process), and many presentations and interviews. He retired from BP in 2008, as Principal Geophysicist and Senior Advisor.

Awards
Thomsen is a Foreign Member of the Russian Academy of Natural Sciences, and holder of their Kapitsa Medal. He is an Honorary Member of the European Association of Geoscientists and Engineers, and also of the Geophysical Society of Houston. He holds a Fessenden Award (1993) from the SEG, and numerous best-paper awards from various societies.

Service
Leon served the worldwide Society of Exploration Geophysics as President in 2006-07; in this role he was the de facto head of the international profession of applied geophysics. Prior to that, he held several elected SEG positions, and chaired several important committees. He also served as SEG/EAGE Distinguished Instructor (2002) and SEG Distinguished Lecturer (1997). He serves on the Advisory Boards to the Director, Lamont-Doherty Geological Observatory, and to the Dean of Natural Sciences and Mathematics, University of Houston. He served on the Advisory Board to the Associate Director for Geosciences, National Science Foundation.
Experience

University of Houston
(2008-) Research Professor of Geophysics

Delta Geophysics:
(2008-) Chief Scientist

KMS Technologies:
(2008-) Executive Advisor

Lawrence Berkley National Laboratory
(2008-) Visiting Scientist

Amoco -> BP
(1980-2008) Senior Research Scientist -> Principal Geophysicst

State University of New York, Binghamton
(1977-1980) Associate Professor of Geophysics (with academic tenure)
(1972-1977) Assistant Professor of Geophysics

NASA Goddard Space Flight Center
(1979) Visiting Research Fellow (sabbatical leave from SUNY)

Australian National University
(1978) Visiting Research Fellow (sabbatical leave from SUNY)

International Business Machines
(1970-71) Consultant

California Institute of Technology
(1970-71) Research Fellow

Centre Nationale de la Recherche Scientifique
Selected Publications


Thomsen, L., Converted-Wave Reflection Seismology over inhomogeneous, anisotropic media, Geophysics, 64(3), 678-690, 1999.


Thomsen, L, I. Tsvankin, and M. Mueller, Layer-Stripping of Azimuthal Anisotropy from Reflection Shear-wave data, Geophysics, 64(4),1126-1138, 1999b.

Thomsen, L., Poisson was not a Rock Physicist, Either!, Geophysics: The Leading Edge of Exploration, 15(7), 852-855, 1996.


Registration Details

• Course fee: 2950 Euro + VAT (19%)
• Registration deadline:

Payment and Registration
Tuition fees are due and payable in Euro upon enrollment in the course by bank transfer to the bank account given below unless another payment form is agreed.

Unless otherwise indicated, the payment should be received before the date specified in the invoice as payment term to make the enrollment effective.

To register to the course please fill in the registration form and fax or email it along with the confirmation of your bank transfer to:
GeoNeurale
Lichtenbergstrasse 8
85748 Munich-Garching
T +49 89 8969 1118
F +49 89 8969 1117

ONLINE REGISTRATION: www.GeoNeurale.com

Bank Information: Genossenschaftsbank EG Muenchen
Bank Account N. 519618 BIC – Code : GENODEF 1M07
BLZ 701 694 64 IBAN : DE19 7016 9464 0000 5196 18

Please indicate your name and the purpose: “SEISMIC ANISOTROPY in EXPLORATION and EXPLOITATION”.

www.GeoNeurale.com
Provisions

Tuition fees are due and payable in Euro upon enrollment in the course. Unless otherwise indicated, fees do not include student travel costs and living expenses.

Payments are also accepted via personal or company check, traveler's check, credit card, and Company Purchase Orders.

Cancellations by Participant:

All cancellations are subject to a 100 Euro non-refundable cancellation fee.

Cancellation have to be notified to our office, at least 30 days prior to the course start date to receive a refund (less the 100 Euro cancellation fee).

If the participants are unable to cancel prior to the 32 days notification date, they may substitute another person at their place in a course by notifying us prior to the course start date.

Course Cancellations:

GeoNeurale reserves the right to cancel the courses if necessary. The decision to cancel a course is made at least two weeks prior to the course start date. If a course is cancelled, the participant will receive a full reimbursement of the tuition fees (but not of the plane ticket or hotel expenses or any other costs), or will be enrolled in another course upon his decision (the cost of the original course will be applied to the cost of the replacement course).

GeoNeurale can not be responsible for any penalties incurred for cancellation or change of airline or hotel reservations.

Refunds:

GeoNeurale will promptly remit all refunds of tuition fees due to cancellations or annulment (less any appropriate non-refundable cancellation fee) within 30 days of the course cancellation.

Force Majeure:

GeoNeurale can not be responsible for cancellations due to "force majeure" events: airplane or airport strikes, emergency situations, natural catastrophes and all situations and incidents independent or outside the human control that can delay or cancel the course. In case of such events related cancellations the course tuition fees will be refunded to the client.

GeoNeurale is not responsible for any delay or absence caused by the training instructor or training instructor company for reasons which are independent or out of the control of GeoNeurale's decisions.

AGREEMENT: Upon enrollment all parts accept the above mentioned provisions. The above specified provisions shall regulate the agreement between GeoNeurale and the participant and the participant company and will enter into force upon enrollment.

www.GeoNeurale.com
REGISTRATION FORM
Please fill out this form and Fax to +49 89 8969 1117
or Email to Courses@GeoNeurale.com

SEISMIC ANISOTROPY in EXPLORATION and EXPLOITATION
Munich, _________________
Course Fee: 2950 Euro + VAT (19%) (The VAT Tax is 100% refunded by the German Ministry of Finances)

Name:

Company:

Address:

Job Title:

Phone:

Fax:

Email:

SIGNATURE: ________________________________ www.GeoNeurale.com
INFORMATIONS, HOTELS, MAPS, LINKS

TRAINING LOCATION – RESEARCH CENTER

GATE GARCHING

MAP MUNICH-GARCHING
http://www.muenchen.city-map.de/city/db/130208000001/14269/Garching.html

MUNICH INFO and MAP MUNICH CENTRAL
http://www.muenchen.de/home/60093/Homepage.html

MAP MUNICH UNDERGROUND
http://www.mvv-muenchen.de/web4archiv/objects/download/3/netz1207englisch.pdf

HOTELS NEAR GeoNeurale

BAVARIA INFO
A school of Geosciences in the alpine region