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

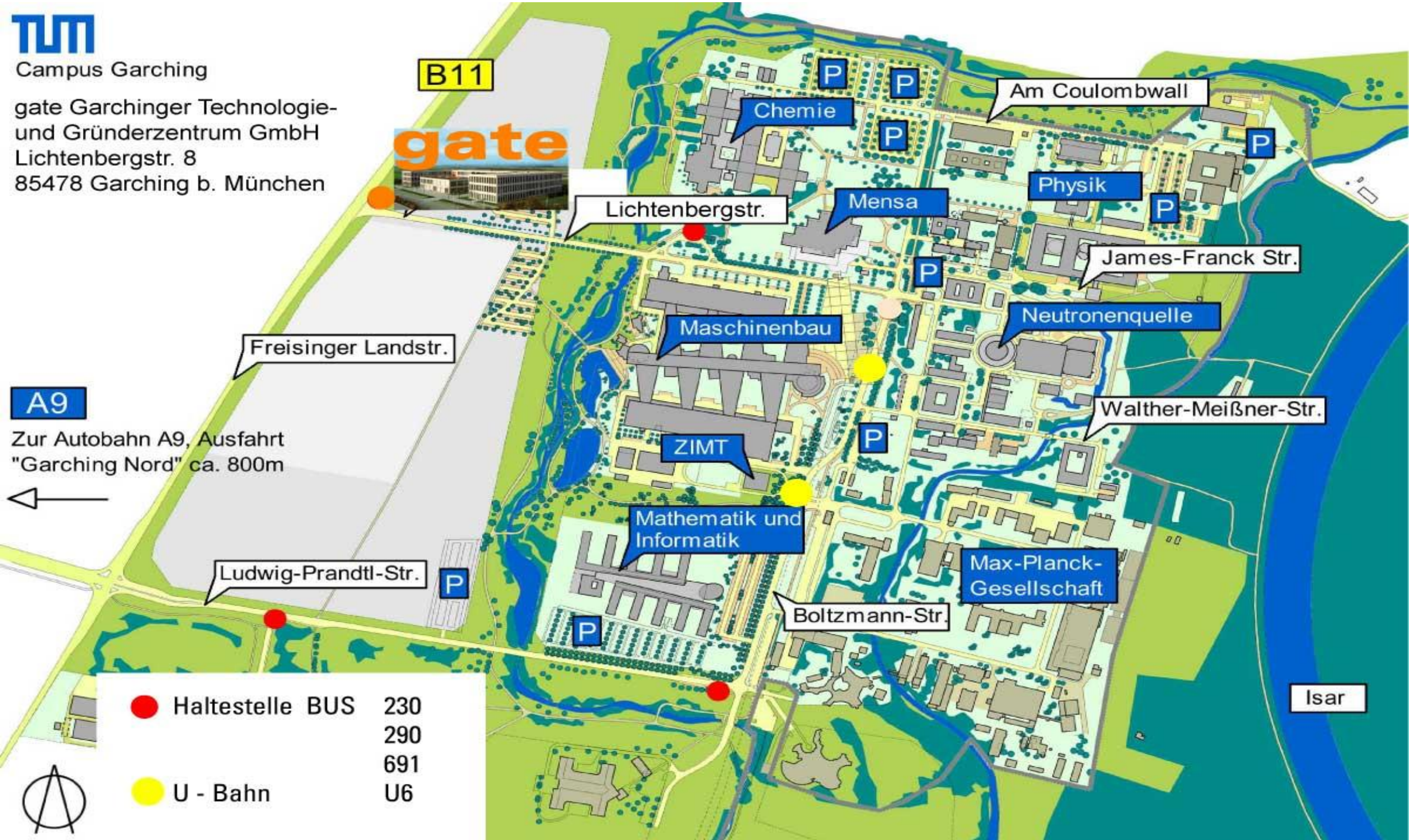
COURSE FEES: 2950 Euro + VAT (19%) (The VAT Tax is 100% refunded by the German Ministry of Finances)

REGISTRATION DEADLINE :

ONLINE REGISTRATION: www.GeoNeurale.com

gate 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

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

PART 4

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

Alford Rotation Is..

The Fast-Slow Dealy

Seismically-Detected Fractures

Principal Sections showing Split-Shear

The Slow-Mode Amplitudes are Variable

Slow-Mode Zones Correspond to Fravtures 1,2,3

These Fast-Slow Differences are Magnified 1,2

The previous Derivation does not work

if the Azimuth of Ansotropy changes..

Time Lapse

The Argument for Sensing..

The Stress-Cracks-Anisotropy Connection 1,2

Time-Lapse Changes in Shear-Wave Splitting 1,2,3

Chages 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

BIOGRAPHY

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.

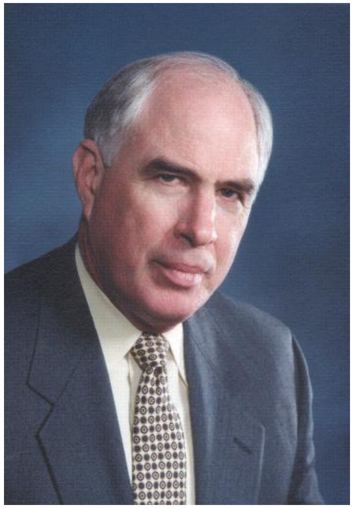
Following the change of its mission in 1994, he joined Amoco's worldwide exploration department in Houston.

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
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B. S. Geophysics, 1964, California Institute of Technology

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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, γ_{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

(1969-1970) Chargé de Recherche

Selected Publications

Xia, G., L. Thomsen, and O. Barkved, Fracture Detection from Seismic P-wave azimuthal AVO analysis – application to Valhall LoFS data, Europ. Assoc. Geosci. Engrs. Conv. Expnd. Absts., 68, 2006.

Thomsen, L, and J. Dellinger, On shear-wave triplication in polar-anisotropic media, J. appl. Geoph., 54, 289-296, 2003.

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

Gretener, P. and L. Thomsen, AVO and Poisson's Ratio, Geophysics: The Leading Edge of Exploration, 22(1), 70-72, 2003.

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

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Thomsen, L., Elastic Anisotropy due to Aligned Cracks in Porous Rock, Geoph. Prospg., 43, 805-829, 1995.

Scott, D., and L. Thomsen, A Global Algorithm for Pore Pressure Prediction, Europ. Assoc. Expl. Geoph. Expnd. Absts., 55, 1993.

Tsvankin, I. and L. Thomsen, Nonhyperbolic Moveout in Transversely Isotropic Media, Soc. Expl. Geoph. Conv. Expnd. Absts., 62,1992.

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Lynn, H. B. and L. Thomsen, Reflection Shear-Wave Data Collected near the Principal Axes of Azimuthal Anisotropy, Geophysics, 55(2), 147, 1990.

Thomsen, L., Reflection Seismology in Azimuthally Anisotropic Media, Geophysics, 53(3), 304-313, 1988.

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Thomsen, L., Biot-Consistent Elastic Moduli of Porous Rocks: Low Frequency Limit, Geophysics, 50(12), 2797-2807, 1985.

Thomsen, L., and M. Joggerst, Oil and Gas in Offshore Tracts: Bias in Estimates of Reserves, Mathematical Geology, 17(4), 353-365, 1985.

Thomsen, L, 129Xe on the Outgassing of the Atmosphere, J. Geoph. Res., 85(B8), 4374-4378,1980.

Thomsen, L, Theoretical Foundations of Equations of State for the Terrestrial Planets, Ann. Rev. Earth Planet. Sci., 5, 491-513, 1977.

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 ".

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 cancellation 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 annullment (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.

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:

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Email:

SIGNATURE: ______________________________

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TRAINING LOCATION – RESEARCH CENTER

http://www.geoneurale.com/documents/GATE-Y7.pdf

GATE GARCHING

http://www.geoneurale.com/documents/GATE-Y6.pdf

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

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A school of Geosciences in the alpine region