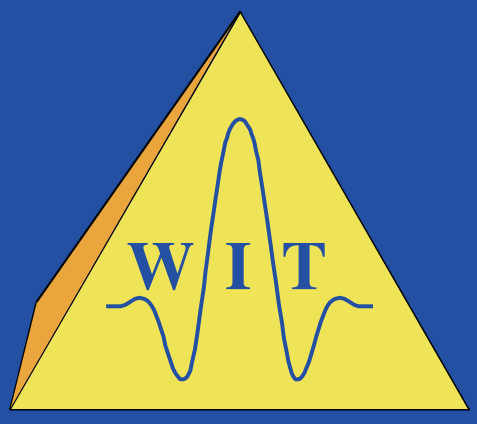
Wave Inversion Technology



Annual Report

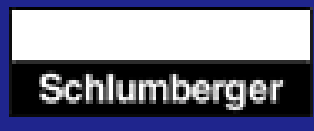
1999

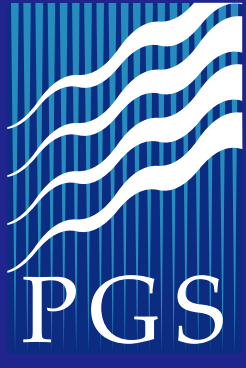
Research Personnel

A-B
Tim Bergmann
Ricardo Biloti
Stefan Buske
C-E
Radu Coman
Robert Essenreiter
F-G
Dirk Gajewski
Alexander Goertz
H-K
German Hoecht
PeterHubral
Martin Karrenbach
Axel Kaselow
L
L.B.W. Leite
Stefan Lüth
M
Joao L. Martins
Jürgen Mann
Patrick Mayer
Elive M. Menyoli
Thilo Müller

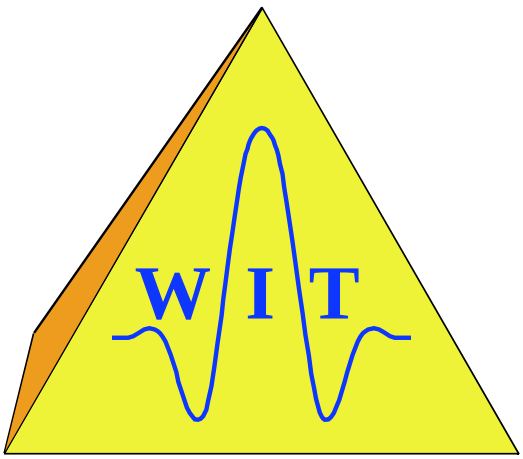
N-P
M. Amelia Novalis
Robert Patzig
Claudia Payne
Carlos Piedrahita
Melanie Pohl
Rodrigo Portugal
Q-R
Matthias Riede
S
Erik H. Saenger
Lucio Tunes Santos
Jörg Schleicher
Sergei Shapiro
Svetlana Soukina
T
Ekkehart Tessmer
Marc Tittgemeyer
Baerbel Traub
Martin Tygel
U-V
Claudia Vanelle
Kai-Uwe Vieth
W-Z
Friedemann Wenzel
Jörg Zaske
Yonghai Zhang

WIT Sponsors





Wave Inversion Technology



Annual Report No. 3

1999

Karlsruhe, February 29, 2000

with contributions
from the WIT Groups:

Geophysical Institute
Karlsruhe University
Hertzstr. 16
76187 Karlsruhe
Germany

Tel.: (+49) 721/608-4443
Fax: (+49) 721/71173
e-mail: peter.hubral@physik.uni-karlsruhe.de

Dept. of Applied Math.
IMECC - UNICAMP
C.P. 6065
13081-970 Campinas (SP)
Brazil

Tel.: (+55) 19/788-5984 or -5973
Fax: (+55) 19/289-5808
e-mail: tygel@ime.unicamp.br

Institute of Geophysics
Hamburg University
Bundesstr. 55
20146 Hamburg
Germany

Tel.: (+49) 40/4123-2975
Fax: (+49) 40/4123-5441
e-mail: gajewski@dkrz.de

Fachrichtung Geophysik
Freie Universität Berlin
Malteserstrasse 74 - 100
12249 Berlin
Germany

Tel.: (+49) 30/7792-839 or -830
Fax: (+49) 30/7758-056
shapiro@geophysik.fu-berlin.de

WIT Web Page:
http://www-gpi.physik.uni-karlsruhe.de/pub/wit/wit.html

Preface

The third WIT (Wave-Inversion-Technology) report gives a compilation of the 1999 WIT activities. The global WIT consortium with one group in Campinas (Brazil), one in Berlin, one in Hamburg and two in Karlsruhe continued to function effectively with slightly more sponsors and researchers than in the previous two years. The WIT research in Karlsruhe in 1999 was reinforced by three visiting professors (Dr. B. Sibiriakov (Novosibirsk), Dr. B. Gelchinsky (Tel Aviv) and Dr. E. A. Robinson (New York)). Also Dr. N. Bleistein (Colorado) was a visiting professor in Campinas.

As an attractive WIT contribution in addition to this third report, I like to mention the book "The Common Reflection Surface Stack Method", which appeared at the publishing house *Der Andere Verlag*. It is essentially a reproduction of the Ph.D. thesis of Dr. Thilo Müller, who received the Van Weelden Award at the 1999 EAGE Helsinki Meeting for his work.

The WIT consortium also organized on February 14-16, 1999 the EAGE/SEG sponsored "Karlsruhe Workshop on Macro-Model-Independent Reflection Imaging" for which now a Special Proceedings Issue with 11 contributions has appeared in the Journal of Applied Geophysics.

Finally, the WIT consortium member Dr. S. A. Shapiro organized the EAGE/SEG sponsored workshop "Seismic Signatures of Fluid Transport" from February 27-29, 2000 at Berlin.

Peter Hubral

Karlsruhe, February 29, 2000

TABLE OF CONTENTS

Other Topics

Appendix

Wave Inversion Technology, Report No. 3, pages 1-4

Reviews: WIT Report 1999

Responsible for compilation and layout: E. H. Saenger & M. Riede [1]

Imaging

Tygel et al. propose a new asymptotic inverse to the forward Kirchhoff-Helmholtz integral. Analogous to the forward integral, the new inverse consists of a summation along the reflection traveltime surface of the reflector. A simple numerical example shows how this can be used for migration.

Tygel et al. show that the methods of true-amplitude PreSDM and MZO can be used to perform an AVO/AVA analysis. By means of a simple but illustrative example, they discuss the advantages and disadvantages of both methods.

Cruz et al. present a sensibility analysis of the functional that simulates the observed data with respect to the searched-for wavefront parameters. The most important result is the very high sensibility of the multifocusing traveltime on relation to B_0 and K_{NIP}. The K_N parameter presents a strong ambiguity and is poorly determined during the optimization procedure.

Majer et al. present an inversion method which make use of data-derivated kinematic wavefield attributes to determine a 2 D macro-velocity model. This attributes are provided by the CRS Stack method. By means of geometrical optics primary reflection events of a zero-offset section with the associated wavefield attributes determine reflection points of interfaces in the subsurface. The interfaces are constructed layer by layer with interpolating spline functions. First appliacations of the algorithm are shown for two synthetic examples.

Rock Physics and Waves in Random Media

Shapiro proposes an extension of the SBRS approach to estimation of permeability tensors to the case of 3-D heterogeneous structures. The approach is based on a geometrical optic approximation for triggering fronts and provides a possibility at least semi qualitatively characterize hydraulically heterogeneous media using microseismic data.

[1] **email:** Erik.Saenger@phys.uni-karlsruhe.de & Matthias.Riede@gpi.uni-karlsruhe.de

Müller and **Shapiro** extended the O'Doherty-Anstey approach for primary arrivals to the case of statistically isotropic randomly heterogeneous media. They are able to predict the seismic pulse evolution in typical realizations of seismograms in the range of week wavefield fluctuations. This makes possible a Green's function construction taking into account effects of isotropic random heterogeneity.

Saenger and **Shapiro** propose to model the effective velocities of fractured media using the rotated staggered finite difference grid. In contrast to the standard staggered grid the rotated one does not have instability problems by modeling wave-difraction effects in media with fractures. Thus, such a numerical modeling can be considered as an efficient and well controlled computer experiment. Therefore, it is a promising tool for a study of elastic properties of dry rock skeletons. In this paper the importance of the critical porosity concept is demonstrated for the case of intersecting fractures.

Modeling

Portugal et al. describe of 3-D wave propagation in a 2-D medium (2.5-D situation) by means of a simple 2.5-D wave equation. A comparison to alternative approximations in homogeneous and vertical-gradient media shows that the accuracy of a previously suggested approximate 2.5-D wave equation (Liner's equation) depends on how well the rms velocity can be approximated by a constant velocity.

Schleicher et al. introduce the Kirchhoff-Helmholtz modeling integral to general anisotropic elastic media, using the natural extension of the Kirchhoff approximation of the scattered wavefield and its normal derivative for that media. After its asymptotic evaluation, the anisotropic Kirchhoff-Helmholtz integral reduces to the zero-order ray theory approximation of the reflected response from the interface.

Schleicher et al. generalize the decomposition formula for the geometrical-spreading factor to anisotropic media in terms of second-order mixed derivatives of the traveltime as well as group and phase angles at the reflection point.

Coman and **Gajewski** present a hybrid method for computing multi-arrival traveltimes in 3-D weakly smoothed media. The method is based on the computation of first-arrival traveltimes with a finite-difference eikonal solver and the computation of later arrivals with the wavefront construction method (WFCM). The detection and bounding of regions where later arrivals occur is done automatically. The hybrid method is faster than WFCM.

Menyoli and **Gajewski** used the first order perturbation principle to simultaneously compute P- and S-wave traveltimes in a 2D model. It is demonstrated on a constant gradient velocity model with a parabolic lens at the centre. This perturbation method is useful for a simultaneous kinematic Kirchhoff migration of converted waves with slightly different macro models.

Vanelle et al. introduce a new representation of the ray propagator valid in an arbitrary 3-D coordinate system. Its relation to the Bortfeld and Cerveny formulations is explained. Applications like traveltime interpolation and the computation of geometrical spreading demonstrate the versatility of the method.

Bergmann and **Gajewski** present their first results on developing a finite-difference (FD) formulation for the simulation of non-linear elastic waves. The results show that conventional FD approaches applied for linear problems may not extended to the non-linear case. For this reason, the authors show a new algorithm and make related important aspects in terms of physics and computation evident.

By combining fast marching level set methods with full wave form modeling **Karrenbach** takes advantage of numerical properties of both methods. He is able to reduce the computational expense associated with full wave form finite difference methods by decomposing the computational domain dynamically into subdomains. The size and shape of these subdomains is derived from the shape of the wave front given by an asymptotic Eikonal solution.

Kaselow et al. model changes in p-wave and s-wave velocity in reservoir rocks that are due to changes in porosity and fluid content. They present a technique that computes the seismic wave response from a reservoir, whose shape and constitution changes over time, allowing to conduct feasibility studies in realistic reservoirs in order to optimally control production.

The paper by **Karrenbach** describes the importance of full wave form modeling techniques in time-lapse studies, where preliminary time-lapse tests are computed numerically in an elastic 3D SEG/EAGE salt model. Recent activities of the SEG 3D modeling committee show that, while 3D full wave forms studies are indeed much desired, their computational expense has been prohibitively high up to now. However, new advances in numerical algorithms and cheap high-performance hardware computer hardware might allow realistic studies in the near future on a routine basis.

To reduce the computational burden in 3D full wave form modeling **Pohl et al.** suggest the use of optimal gridding procedures for certain characteristic seismic reservoir geometries. The grid is adapted to the major layering features of the reservoir and uses a spectral method to compute derivatives and produces accurate and artifact-free numerical solutions. A 2D modeling example attempts to grid a salt dome structure optimally, such that some of the major grid contours follow the overburden layers as well as the salt dome interfaces.

Other Topics

Birgin et al. introduce a new optimization algorithm to directly extract the Common Reflecting Surface (CRS) parameters out of coherency analyses applied to multicover-

age data. Numerical results obtained in sunthetic examples confirm the good perfoemance of the method, both in accuracy and computational effort.

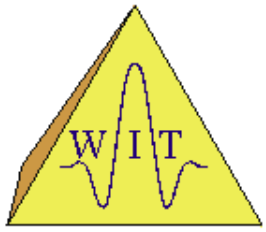
Ettrich et al. present simple relations to compute the best fitting ellipsoid for an arbitrary anisotropic medium. The fit can be applied globally or locally, e.g., in a cone of interest for vertically propagating waves. This model can serve as a background medium to compute wave field properties in arbitrary anisotropic media using perturbation techniques. It provides improved results when compared with the best fitting isotropic background medium particularly if strong P-wave anisotropy is present (e.g., shales).

The report of **Leite** and **da Rocha** deals with the application of Kalman's method to the deconvolution of the source wavelet as a time varying pulse that serves to model the inelasticity of the medium. The wave propagation is given by the Goupillaud solution. We demonstrate the necessity for applying a low-pass equalization to compensate for the amplification of the high frequency content of the data when submitted to deconvolution.

The report by **Mauch** compares various coherency measures analytically as well as by numerical examples. A common notation allows easy comparison of different coherency definitions. Synthetic as well as real data examples are used to contrast the performance of different coherency criteria.

Wave Inversion Technology, Report No. 3, pages 253-260

The Wave Inversion Technology Consortium



The Wave Inversion Technology Consortium

The Wave Inversion Technology Consortium (WIT) was established in 1997 and is organized by the Geophysical Institute of the Karlsruhe University. It consists of five working groups, two at Karlsruhe University and three at other universities, being the Mathematical Geophysics Group at Campinas University (UNICAMP), Brazil, the Seismics/Seismology Group at the Free University (FU) Berlin and the Applied Geophysics Group (AGG) of the University of Hamburg.The WIT Comsortium offers the following services to its sponsors.

- Research as described in the topic "Research aims" below
- Deliverables.
- Technology transfer / training.

Research aims

The ultimate goal of the WIT Consortium is a most accurate and efficient target-oriented seismic modeling imaging and inversion using elastic and acoustic methods.

Traditionally, exploration and reservoir seismics aims at the delineation of geological structures that constrain and confine reservoirs. It involves true-amplitude imaging and the extrapolation of the coarse structural features of logs into space. Today an understanding is emerging on how sub-wavelength features such as small-scale disorder, porosity, permeability, fluid saturation etc. influence elastic wave propagation and how these properties can be recovered in the sense of true-amplitude imaging, inversion and effective media.

The WIT consortium has the following main research directions, which aim at characterizing structural and stratigraphic subsurface characteristics and extrapolating fine grained properties of targets:

1.
    - Macromodel-independent multicoverage zero-offset simulations.

- Macromodel determination.

2.
   - Seismic image and configuration transformations. (Data mappings)
   - True-amplitude imaging, migration and inversion.

3.
   - Seismic and acoustic methods in porous media.
   - Passive monitoring of fluid injection.

4.
   - Fast and accurate seismic forward modeling
   - Modeling and imaging in anisotropic media

Steering committee

Internal steering committee:

- Dirk Gajewski
- Peter Hubral
- Martin Karrenbach
- Andreas Kirchner
- Claudia Payne
- Matthias Riede
- Erik Saenger
- Jörg Schleicher
- Sergei Shapiro
- Ekkehart Tessmer
- Martin Tygel
- Kai-Uwe Vieth
- Friedemann Wenzel

External steering committee (company representatives):

- Paolo Marchetti, AGIP
- Heinz-Jürgen Brink, BEB
- Josef Paffenholz, BHP
- Glyn M. Jones, Chevron
- Claude Lafond, Elf
- Ralf Ferber, Geco Prakla
- Andreas Rüger, Landmark
- David L. Hinkley, Mobil
- Martin Widmaier, PGS Seres
- Paul Krajewski, Preussag
- Christian Henke, RWE-DEA
- Norman Ettrich, Statoil

WIT public relations committee

Peter Hubral	
Claudia Payne	
Erik Saenger	*WIT Report and WIT Meeting Organization* *Contact to other WIT groups*
Matthias Riede	*WIT Report and WIT Meeting Organization* *Contact to other WIT groups*
Andreas Kirchner	*WIT Homepage Manager*
Jörg Zaske	*WIT Seminar Organizer*
Jürgen Mann	*WIT Poster Organizer*
Kai-Uwe Vieth	*WIT Poster Organizer*

Research groups

Research Group Karlsruhe (Hubral)

Macro-Model Independent Reflection Imaging

Group leader:

Peter Hubral

Visting Professors:

E. A. Robinson	*Teaching and developping new methods of deconvolution and inversion for the removal of multiple reflections and integrating the results with seismic imaging technology*
L.W.B. Leite	*Seismic wave propagation in thin layers for deconvolution and inversion problems*

Ph.D.students:

German Garabito Callapino	*Zero Offset Imaging - responsible for FOCUS/Disco based processing*
German Höcht	*Imaging with the 3-D CRS Stack*
Jürgen Mann	*Implementation of the CRS stack and its application to real seismic data*
Matthias Riede	*Modeling by Demigration*
Kai-Uwe Vieth	*Application and development of imaging and inversion techniques. Non-destructive localization of macroscopic cracks in fibre-reinforced composite materials*
Jörg Zaske	*Prediction and attenuation of multiples using wave-front characteristics of primary reflections*
Yonghai Zhang	*3D-True Amplitude Imaging*

Master students:

Thomas Hertweck	*Modeling by Demigration*
Patrick Majer	*Macro-model determination*

Research students:

Ingo Koglin	*Wave-field attribute determination*
Stephen Bergler	*Wave-field attribute inversion*

Research Group Karlsruhe (Wenzel)

Full Wave Form Modeling and Imaging with Fast Marching Schemes

Group leaders:

Martin Karrenbach
Friedemann Wenzel

Ph.D.students:

Alexander Görtz	*3D velocity model building using GOCAD and 3D Finite Difference seismic modeling in complex fault zones*
Axel Kaselow	*Finite difference modeling of wave propagation in fluid-saturated porous media and fluid flow modeling at complex fault zones.*
Melanie Pohl	*Modelling of anisotropic features in the earth's crust and development of Finite Difference methods on irregular grids*
Robert Essenreiter	*Development of multiple identification and suppression techniques on the basis of neural networks*

Master students:

Robert Mauch	*Coherency analysis of seismic data (Skills: SEPLIB, Fortran90)*
Bärbel Traub	*3D Asymptotic Raytracing with a Wave Front Construction Method (Skills: SEPlib, Moser's recursive raytracing)*

Research Group Hamburg (Gajewski)

Applied Geophysics Group (AGG)

Group leader:

Dirk Gajewski	*High frequency asymptotics for imaging and modeling*
Research associates:	
Tim Bergmann	*Effects of nonlinear elastic behaviour on wave propagation.*
Ekkehart Tessmer	*Full wave form modeling.*
Ph.D. students:	
Radu Coman	*Hybrid method for travel time computation in 3D complex media*
Elive Menyoli	*Prestack depth migration of converted waves*
Svetlana Soukina	*Material parameter determination in anisotropic media*
Claudia Vanelle	*Model independent time processing*
Master students:	
Sebastian Barth	*Processing and migration of wide angle observations*
Christian Herold	*Processing of long spread reflection seismic data*
Tina Kaschwich	*3D Wave front construction*
Maximilian Krüger	*AVO modeling*

Research Group Campinas (Tygel)

Modeling by Demigration, Kirchhoff Migration, Traveltime Inversion, Configuration Transforms,Kirchhoff Modeling, AVO/A Analysis, CRS Stack,2.5-D Wave Propagation

Group leaders:

Lúcio Tunes Santos
Jörg Schleicher,
Martin Tygel,

Visting Professors:	
Norman Bleistein	*Teaching and developing seismic reflector mapping methods*
Ph.D.Students:	
Ricardo Biloti	*Multiparameter Velocity Analysis*

João Luis Martins	*Migration and Demigration in 2.5 Dimensions*
Rodrigo Portugal	*Configuration Transforms in 2.5D*
Carlos Piedrahita	*Seismic Ray Tracing in Blocked Media*
Matthias Riede	*Modeling by Demigration*
Maria Amélia Novais Schleicher	*Modeling of Reflections and Diffractions by a unified Born-Kirchhoff approximation.*

Master Sudents:

Sérgio da Silva Araújo	*CRS Processing*
Valéria Grosfeld	
Claudio Guerra	*Kirchhoff-type multiple elimination.*
Angela Maria Vasquez	*True-amplitude MZO*

Research Students:

Vanessa Giuriati

Thomas Hertweck

Marina Magalhães

Guliana Nascimento

Research Group Berlin/Karlsruhe (Shapiro)

Permeability, Seismic Inversion,
Random Media Wave Propagation

Group leader:

Sergei A. Shapiro

Research associates:

Stefan Buske	*Seismic modeling and inversion, deep seismic sounding and parallel programming*

Ph.D.Students:

Pascal Audigane	*3D inversion and modeling of permeability tensor. Affiliation: CRPG-CNRS, Nancy, France*.
Andreas Kirchner	*Efficient forward modeling with Born Approximation*

Stefan Lüth	*Refraction seismic data interpretation, seismic processing and integration of geophysical and geodynamic data.*
Tobias Müller	*Green Functions in statistically isotropic random media. Poroelasticity.*
Robert Patzig	*Application of CRS stacking to seismic profiles from the northern Chilean coast.*
Erik Saenger	*Simulation of elastic wave propagtion through heterogeneous and fractured media. Application of parallel computing devices.*
Kai-Uwe Vieth	*Application and development of imaging and inversion techniques. Non-destructive localization of macroscopic cracks in fibre reinforced composite materials.*
Master students:	
Jan Rindschwentner	*In-situ estimation of the permeability tensor using hydraulically induced seismicity*

Computer facilities

In Karlsruhe, the research project uses computer facilities that consist of mainly Hewlett-Packard and Silicon Graphics workstations, and Linux PCs. These are networked with a local computer server, a multi-processor SGI PowerChallenge. For large-scale computational tasks a 256-node IBM SP-2 is available on Campus. Additionally, we have access via ATM networks to the nearby German National Supercomputer Center with primarily a 512-node Cray T3e and NEC SX-4.

The Hamburg group has direct access to the German Computer Center for Climate Research (Deutsches Klimarechenzentrum, DKRZ). A Cray 916 and a Cray T3D (128 processors) are used for computationally intensive tasks.

The Geophysical Department of the Free University of Berlin (Fachrichtung Geophysik, Freie Universität Berlin) has excellent computer facilities based on SUN- and DEC-ALPHA workstations and Linux-PCs. It has access to the parallel supercomputer CRAY-T3M (256 processors) of ZIB, Berlin.

List of WIT Sponsors

BEB Erdgas und Erdl GmbH
Postfach 51 03 60
D-30633 Hannover
Contact: Dr. Heinz Jürgen Brink
Tel. 49-511-641-2275
Fax: 49-511-641-1020
email: Heinz-Juergen.Brink@beb.de

BHP Petroleum
1360 Post Oak Blvd.,Ste. 500
Houston, TX 77056-3020
USA
Contact: Dr. Josef Paffenholz
Tel. 1-713-465362
Fax. 1-713-9618400
email: Paffenholz.Josef@bhp.com.au

Chevron Petroleum Technology Co.
6001 Bollinger Canyon Rd
San Ramon, CA 94583
USA
Contact: Dr. Glyn M. Jones
Tel. 1-925 842-6499
Fax: 1-925 842-2076
email: gmjo@chevron.com

Elf Exploration UK plc
30 Buckingham Gate
London SW1E 6NN
UK
Contact: Mr. Alan Burns
Tel. +44 171 963 5005
Fax. +44 171 963 5061
email: Alan.Burns@elfgrc.co.uk

ENI S.p.A. AGIP Division
Geological and Geophysical Research &
Development Departement
Via Emilia 1
20097 San Donato Milanese MI
Italy
Contact: Mr. Serafino Gemelli
Tel. 39-02-520 63441
Fax: 39-02-520 63741
email: serafino.gemelli@agip.it

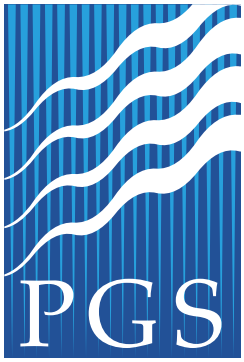
Exxon Mobil Corp.
P.O. Box 650232
Dallas, TX 75265-0232
USA
Contact: Mr. David L. Hinkley
Tel: 1-214-951-2839
Fax: 1-214-951-2098
email: dave_hinkley@email.mobil.com

Geco Prakla UK Ltd.
Schlumberger House,
Buckingham Gate
Gatwick Airport
Gatwick, West Sussex RH6 0NZ
UK
Contact: Dr. Ralf Ferber
Tel: 44-1293-556802
Fax: 44-1293-556800
email: ferber@gatwick.geco-prakla.slb.com

Landmark Graphics Corp.
7409 S. Alton Court, Ste.100
Englewood, CO 80112
USA
Contact: Mr. Burke Angstman
Tel: 1-303-7798080
Fax: 1-303-7960807
email: BAngstman@lgc.com

Preussag Energie GmbH
Waldstr. 39
D-49808 Lingen
Contact: Mr. Paul Krajewski
Tel: 49-591-612-381
Fax: 49-591-6127000
email: P.Krajewski@preussagenergie.com

PGS Seres AS
P.O. Box 354
Strandveien 4
1326 Lysaker
Norway
Contact: Dr. Martin Widmaier
Tel. 47-67514511
Fax: 47-67526640
email: martin.widmaier@oslo.pgs.com



RWE-DEA AG für Mineralöl und Chemie
Postfach 600449
D-22204 Hamburg
Contact: Dr. Christian Henke
Tel: 49-40-6375-2739
Fax: 49-40-6375-3384
email: Christian.Henke@rwedea.de

Statoil F&R, Datakral
Arkitekt Ebbels vei 10
7005 Trondheim
Norway
Contact: Dr. Norman Ettrich
Tel. 47-7358341
Fax: 47-73584325
email: NEt@statoil.com

Research Personnel

Tim Bergmann received his MSc (1995) in geophysics from the University of Kiel, Germany, and a PhD (1998) from the Earth Science Department of the Swiss Federal Institute of Technology (ETH) in Zuerich, Switzerland. Currently, he is a research associate at the Institute of Geophysics at the University of Hamburg. His research interests include seismic and GPR theory, wave propagation, and numerical methods. He is a member of AGU, EAGE, EEGS-ES, DGG, SIAM, and SEG.

Ricardo Biloti received his B.Sc.(1995) and M.Sc. (1998) in Applied Mathematics from the State University of Campinas (UNICAMP), Brazil, where he is a PhD student since 1998. In his PhD thesis he has been developing a macro-model velocity independent inversion method. He has worked with CRS (Common Reflection Surface) type methods and developed a technique to estimate some seismic attributes without the knowledge of macro-model velocity. He is also interested in fractals. He is a member of SIAM and SEG.

Stefan Buske received his diploma in geophysics (1994) from Frankfurt University. From 1994 until 1998, he worked as research associate at Frankfurt University, and from 1998 until 1999 he was with Ensign Geophysics Ltd. (Depth Imaging Department) in London. Since 1999 he is a university staff member at the Free University of Berlin. His research interests include seismic modeling and inversion, deep seismic sounding and parallel programming. He is a member of DGG and EAG

Radu Coman received his Diploma (1995) in geophysics from the University of Bucharest. From 1995 until 1996, he worked as research assistant at Geoecomar Bucharest and also specialized in geology at the University of Bucharest. After this, he spent two years at the Westfälische Wilhelms-Universität Münster. Since 1999 he is a Ph.D. student at the University of Hamburg. His interests are travel time computation.

Robert Essenreiter received his M.Sc. in Geophysics from the University of Karlsruhe, Germany, in August 1996. His master thesis was on Geophysical Deconvolution and Inversion with Neural Networks. Currently he is a Ph.D. Student at the Geophysical Institute, University of Karlsruhe, Germany. His research interests include signal processing and artificial intelligence. In his current project he is working on a new approach for multiple attenuation using neural networks.

Dirk Gajewski received a diploma in geophysics in 1981 from Clausthal Technical University and a PhD from Karlsruhe University in 1987. Since 1993, he has been associate Professor (Applied Geophysics) at Hamburg University. After his PhD, he spent two years at Stanford University and at the Center for Computational Seismology at the Lawrence Berkeley Lab in Berkeley, California. From 1990 until 1992, he worked as an assistant professor at Clausthal Technical University. His research interests include high-frequency assymptotics, seismic modeling, and processing of seismic data from isotropic and anisotropic media. Together with Ivan Psencík, he developed the ANRAY program package. He is a member of AGU, DGG, EAGE, and SEG, and serves as an Associate Editor for Geophysical Prospecting (section anisotropy).

Alexander Goertz received his diploma in geophysics in 1998 from Karlsruhe University. Since 1998 he is a research associate with Karlsruhe University. His research interests include 4D modeling of geophysical systems with finite differences, imaging of complex fault zone structures and seismic sounding of lithospheric heterogeneities.

German Höcht received his diploma in geophysics in 1998 from Karlsruhe University. Since 1998 he has been a research associate at Karlsruhe University. His interests are macro velocity model independent imaging methods. He is member of the SEG.

Peter Hubral received an M.Sc. in 1967 in geophysics from Clausthal Technical University and a Ph.D. in 1969 from Imperial College, London University. Since 1986, he has been a full Professor of Applied Geophysics at Karlsruhe University specialising in Seismic Wave Field Inversion. During 1970-73 he was with Burmah Oil of Australia and from 1974 to 1985 he was with the German Geological Survey in Hannover. He was a consultant in 1979 with AMOCO Research and, during 1983-1984, a PETROBRAS-sponsored visiting professor in the PPPG project at the Universidade Federal da Bahia in Brazil. In 1995-1996 he was an ELF- and IFP sponsored visiting professor at the University of Pau, France. He received EAEG's Conrad Schlumberger Award in 1978 and SEG's Reginald Fessenden Award in 1979. He received the first Foreign Geophysicist Award of the Brazilian Geophysical Society in 1999. He is a member of DGG, EAEG and an honorary member of the SEG. Peter Hubral is involved in most of WIT's activities, in particular those including research on image resolution, image refinement, image attributes, multiple suppression, incoherent noise suppression, true-amplitude imaging, interpretative processing, and image animation.

Martin Karrenbach received his ”Vordiplom” in physics in 1985 from the University of Karlsruhe, West Germany, and his M.S. in geophysics from the University of Houston in 1988. He was with SEP from September 1988 through February 1995 when he received his Ph.D. in geophysics from Stanford University. He had summer employment with Siemens, BEB, Cogniseis and most recently with Chevron Oilfield Research Co. He is currently an Assistant Professor at Karlsruhe University, Germany. He is a member of the AGU and SEG.

Axel Kaselow received his diploma in Geology focused on Hydrogelogy from the University of Karlsruhe in 1999. Since April 1999 he is a research associate at Karlsruhe University. Currently, he focuses on finite difference modeling of wave propagation in fluid-saturated porous media and fluid flow modeling at complex fault zones. He is a member of AGU.

L.W.B. Leite Professor of Geophysics at the Graduate Course in Geophysics, and member of the Department of Geophysics of the Federal University of Pará (Belem,Brazil). His main emphasis at the present time is seismic wave propagation in thin layers for deconvolution and inversion problems.

Stefan Lüth received his Diploma in geophysisics from the Technische Universität Clausthal in August 1996. His thesis was on numerical and methodical investigations on diving wave tomography. He is currently working as a Ph.D student at the Freie Universität Berlin. His research interests include refraction seismic data interpretation, seismic processing and integration of geophysical and geodynamic data.

Joao L. Martins is occupied with the development of fast and efficient Kirchhoff-type true-amplitude imaging methods for several different simpler types of media.

Jürgen Mann received his diploma in geophysics in 1998 from Karlsruhe University. Since 1998 he has been a research associate at Karlsruhe University. His fields of interest are seismic image wave methods and macro velocity model independent imaging methods. He is member of the EAGE and the SEG.

Patrick Mayer deals with different inversion methods of the wave field attributes received from the CRS stack using cubic splines interpolation for constructing the interfaces of the macro velocity model. He is a member of the SEG.

Elive M. Menyoli received his diploma in Physics with specialization in Geophysics in 1998 at the University of Goettingen. From April 1998 until November 1998, he was with the German Geological Survey in Hannover. Since December 1998 he is a Ph.D. student at the University of Hamburg. His research interest is in Kirchhoff migration of P-SV converted waves.

Thilo Müller received his diploma (1996) in geophysics from Karlsruhe University. Since then he is working as a research scientist on imaging techniques. He is particularly involved in the development of the Common Reflection Surface (CRS) Stacking Method. This is an imaging process that does not need any explicit knowledge of the velocity field and uses stacking surfaces that match the reflection response better than the ones of conventional methods.

Robert Patzig received his diploma in geophysics from Braunschweig. In the dipoma thesis he developed a digital filter for the detection of the Stoneley-wave (borehole seismics) by combination of a predictionfilter and the envelope of the wave. 1999 he received his Ph.D. for ”Local earthquake tomography in the region of Antofagasta (Chile)”. His actual research interest is the application of CRS stacking to seismic profiles from the northern Chilean coast.

M. Amélia Novais investigates the different aspects of Born and Kirchhoff forward modeling schemes, in particular with respect to amplitudes. She is also working on a combined scheme that incorporates the advantages of both methods.

Claudia Payne has been Peter Hubral's secretary for 9 years. She is in charge of all WIT administrative tasks, including advertising, arranging meetings, etc.

Carlos Piedrahita received a B.Sc. in mathematics from UNAL of Colombia,and the M.Sc. in mathematics from SUNY at Buffalo in 1986. Has worked in the laboratory of geophysics and the material science group of ICP,the research group of ECOPETROL since 1988. Currently is working toward his Phd at the State University of Campinas, Brasil. His thesis subject is ray tracing using continuation procedures trying to extend these methods to complex structures. His interests are in numerical methods and continuum mechanics.

Melanie Pohl is dealing with wave propagation in generally anisotropic 3D media. She is applying these schemes in lower crustal structure studies and in reservoir simulations.

Rodrigo Portugal received his B.Sc. (1995) and M.Sc. (1998) in Applied Mathematics from the State University of Campinas (UNICAMP), Brazil, where he is a PhD student since 1998. In his PhD thesis he is currently working on employing wave front construction based ray tracing in 2.5D migration, demigration, and other image transformations. His research interests are in numerical analysis, modeling, and imaging. He is a member of SEG.

Matthias Riede received his M.Sc. in Geophysics from the University of Karlsruhe, Germany, in 1997. Currently he is a Ph.D. Student at the Geophysical Institute, University of Karlsruhe, Germany. His research interests include signal processing, seismic imaging and modeling.

Erik H. Saenger received his diploma in Physics in 1998 from the University of Karlsruhe in March 1998. Since April 1998 he has been a Ph.D. student at the Geophysical Institute at Karlsruhe University. Currently, he focuses on Finite Difference modeling of fractured materials. He is member of the SEG and EAGE.

Lúcio Tunes Santos received his BS (1982) and MS (1985) in Applied Mathematics from the State University of Campinas (UNICAMP), Brazil. In 1991 he earned his Ph.D. in Electrical Engineering also from UNICAMP. From 1985 to 1988 he was employed as a Teaching Assistant at the University of São Paulo (USP). Since 1988 he has been working for UNICAMP, first as a Teaching Assistant and since 1991 as an Assistant Professor. Between August 1994 and August 1995, he visited Rice University as a postdoc researcher. His professional interests

include seismic modeling and imaging as well as nonlinear optimization. He is a member of SIAM and SBMAC (Brazilian Society of Applied Mathematics). His main areas of research are seismic modeling and true-amplitude imaging. He's also interested in nonlinear optimization algorithms and fractals. His present activities include MZO for variable velocity and modeling by demigration. Moreover, he's also working on exact penalty methods in nonlinear programming.

Jörg Schleicher received his ”Diplom” (MSc equivalent) in Physics in 1990 and his ”Dr. rer. nat.” (Ph.D. equivalent) in Geophysics in 1993 from Karlsruhe University, Germany. After employment as a research fellow at the Geophysical Institute from February 1990 to September 1995, he became a visiting scientist at the Institute for Mathematics, Statistics, and Scientific Computing of the State University of Campinas (IMECC / UNICAMP), Brazil, with a joint grant from the Brazilian National Council for Scientific and Technological Development (CNPq) and Alexander von Humboldt foundation. Since October 1996, he has been employed as an Associate Professor for Applied Mathematics at IMECC / UNICAMP. His research interests include almost all forward and inverse seismic methods. He is a member of SEG, EAGE, DGG, SBGf, and SBMAC. His main areas of research include true-amplitude imaging and ray tracing. He's also interested in any kind of seismic modeling or imaging theories and algorithms. His present activities include research on how to control amplitudes in different kinds of seismic imaging methods and on how to efficiently perform the true-amplitude imaging. Moreover, part of his research is directed towards the extraction of more useful image attributes from seismic data. In 1998, he received SEG's J. Clarence Karcher Award.

Sergei Shapiro received his M.Sc. in 1982 from Moscow University and the Ph.D. in 1987 from All Union Research Institute of Geoinformsystem (AURIG) in Moscow, both in Geophysics. During 1982-90 he worked for AURIG as a research geophysicist. In 1991-1997 he was a senior research scientist at the Geophysical Institute of Karlsruhe University, Germany.

The first two years of this time he was an Alexander von Humboldt fellow. From January to August 1997, he was a Heisenberg associate-research professor. Since September 1997 till January 1999, he was a full professor in Applied Geophysics at the Nancy School of Geology, France, where he was cooperating with GOCAD consortium. Since February 1999 he has been a full professor of Geophysics at the Free University of Berlin, where he leads a research group in Seismology. His interests include exploration seismology, rock physics, and forward and inverse scattering problems. He is a member of SEG, EAGE, AGU, and DGG.

Svetlana Soukina received her diploma in geophysics in 1995 from St. Peterburg State University, Russia. Until 1999 she was a research scientist in the Institute of Physics at St. Petersburg State University. Since 1999 she is a Ph.D. student at the University of Hamburg. Her research interest is the computation of traveltimes in anisotropic media.

Ekkehart Tessmer received an MSc in 1983 in geophysics from Hamburg University and a PhD in 1990 from Hamburg university. Since 1990, he has been senior research scientist at the Institute of Geophysics at Hamburg university. Since 1994, he has a university staff position. His research interests include exploration seismology, seismic and electromagnetic wave propagation simulation, and migration. He is a member of DGG, EAGE, and SEG.

Marc Tittgemeyer is focussing on elastic wave propagation through random media. In particular he's interested in an explanation for prominent seismic refraction phases being efficiently propagated most likely within a sub-Moho waveguide.

Baerbel Traub is dealing with calculation of traveltimes and Greens functions in 3 dimensions. Her research interests include implementation and processing of large geophysical algorithms on massively parallel computers.

Martin Tygel received his BSc in physics from Rio de Janeiro State University in 1969, his M.Sc. in 1976 and Ph.D. in 1979 from Stanford University, both in Mathematics. He was a visiting professor at the Federal University of Bahia (PPPG/UFBa), Brazil, from 1981 to 1983 and at the Geophysical Institute of Karlsruhe University, Germany, in 1990. In 1984, he joined Campinas State University (UNICAMP) as an associate professor and since 1992 as a full professor in Applied Mathematics. Professor Tygel has been an Alexander von Humboldt fellow from 1985 to 1987. In that period, he conducted research at the German Geological Survey (BGR) in Hannover. Since 1995, he has been president of the Brazilian Society of Applied Mathematics (SBMAC). His research interests are in seismic wave propagation and processing, including imaging, migration and inversion. He is a member of SEG, SBGf, and SBMAC. His research combines wave propagation and seismic processing. This includes the development of imaging, migration and inversion algorithms, that possess a sound wave theoretical basis and can as well be applied to practical problems. His recent publications have been in the study of amplitude aspects of seismic data, namely true-amplitude depth migration and migration to zero offset (MZO). He is also working in kinematical imaging by stacking multi-coverage data, as for example by the common reflection element (CRE) method.

Claudia Vanelle received her diploma in physics in 1997 at the University of Hamburg. Since 1997 she has been a research associate at the University of Hamburg; since 1998 at the Institute for Geophysics. Her scientific interests focus upon seismic traveltimes. She is a member of EAGE and SEG.

Kai-Uwe Vieth received his diploma in Geophysics in 1998 from the University of Karlsruhe in March 1998. Since April 1998 he has been a Ph.D. student at the Geophysical Institute at Karlsruhe University. Currently, he focuses on imaging cracks / reflections in heterogeneous media and on new applications using the CRS stack. He is member of the EAGE.

Friedemann Wenzel received a Ph.D. in geophysics from Karlsruhe University in 1985. Until 1988 he worked as research

scientist in Karlsruhe and at Columbia University (U.S.), until 1990 as Associate Professor in Karlsruhe, until 1992 as Principal Research Scientist of CSIRO Division of Exploration Geosciences in Sydney (Australia), until 1994 as Director of the department 'Structure of the Earth' at GeoForschungs Zentrum Potsdam, and Professor of Geophysics at Potsdam University, since 1994 as Professor at the Geophysical Institute, Karlsruhe University. He is currently head of the Collaborative Research Center 461 (Sonderforschungsbereich) 'Strong Earthquakes - A Challenge for Geosciences and Civil Engineering' at Karlsruhe University. His research interests are in seismology, modeling of wave propagation, and seismic hazard assessment. He is a member of AGU, SEG, EGS, EUG, and SSA.

Jörg Zaske received his M.Sc. in Geophysics from the University of Karlsruhe, Germany, in September 1997. His master thesis was on in-situ estimation of poroelastic aquifer properties using earth tide induced water level fluctuations in boreholes. Currently he is a Ph.D. Student at the Geophysical Institute, University of Karlsruhe, Germany. In his current project he is working on a new approach for multiple attenuation using wavefront characteristics of primary reflections.

Yonghai Zhang received the Master Degree of Science in Theoretical Physics from Lanzhou University in P.R.China in June 1991 . Untill the October 1993 he worked as teaching assistant in Physics Department of Lanzhou University and, until September 1999 he worked as lecturer. He is now a Ph.D student at the Geophysial Institute at Karlsruhe University where he works on true-amplitude imaging.