Wave Inversion Technology

Annual Report

1997

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Wave Inversion Technology

Annual Report No. 1

1997

Karlsruhe, February 16, 1998
with contributions
from the WIT Groups:

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http://www-gpi.physik.uni-karlsruhe.de/pub/wit/wit.html
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Preface

We are glad to put the first Annual Report of the WIT Consortium into your hands. We hope it will please you as we have made all attempts to be as professional in compiling this report as we have always been in our research. We are glad that in addition to the research contributions from Karlsruhe and Campinas (Brazil) the sponsors can now benefit from contributions from Hamburg University. This demonstrates that the WIT Consortium wants to operate globally, by attracting attractive researchers from wherever they are as long as they are attracted by the WIT philosophy. This is to attract attractive sponsors by providing them the most attractive geophysical research products.

Peter Hubral

Karlsruhe, February 16, 1998
## Working groups

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<th>Group:</th>
<th>Seismic Imaging and Inversion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group leaders:</td>
<td>Peter Hubral</td>
</tr>
<tr>
<td></td>
<td>(University of Karlsruhe, Karlsruhe, Germany)</td>
</tr>
<tr>
<td></td>
<td>Walter Soellner</td>
</tr>
<tr>
<td></td>
<td>João Carlos Ribeiro Cruz</td>
</tr>
<tr>
<td></td>
<td>(Federal University of Pará (UFPa), Belem/Brazil)</td>
</tr>
<tr>
<td></td>
<td>Martin Tygel</td>
</tr>
<tr>
<td></td>
<td>Jörg Schleicher</td>
</tr>
<tr>
<td></td>
<td>Lúcio Tunes Santos</td>
</tr>
<tr>
<td></td>
<td>(State University of Campinas (UNICAMP), Campinas/Brazil)</td>
</tr>
<tr>
<td>Ph.D. students:</td>
<td>Luiz Alfredo Montes Vides</td>
</tr>
<tr>
<td></td>
<td>Determination of Interval Velocities in 3D Inhomogeneous Media -administration of programs (group developments)</td>
</tr>
<tr>
<td></td>
<td>German Garabito Callapino</td>
</tr>
<tr>
<td></td>
<td>Zero Offset Imaging - responsible for FOCUS/Disco based processing</td>
</tr>
<tr>
<td></td>
<td>Isabel Cristina Tavares</td>
</tr>
<tr>
<td></td>
<td>Determination of the Characteristic Function of Hamilton from Reflection Seismograms</td>
</tr>
<tr>
<td></td>
<td>João Luís Martins (UNICAMP)</td>
</tr>
<tr>
<td></td>
<td>Migration and Demigration in 2.5 Dimensions</td>
</tr>
<tr>
<td></td>
<td>Maria Amélia Novais Schleicher (UNICAMP)</td>
</tr>
<tr>
<td></td>
<td>An Unified Born–Kirchhoff Approximation</td>
</tr>
<tr>
<td></td>
<td>Ricardo Biloti (UNICAMP)</td>
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<td>Multiparameter Inversion by Optimization</td>
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<td>Rodrigo Portugal (UNICAMP)</td>
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<td></td>
<td>The 2.5D Acoustic Wave Equation</td>
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<td></td>
<td>Carlos Piedrahítra (UNICAMP)</td>
</tr>
<tr>
<td></td>
<td>Multiparameter Velocity Analysis</td>
</tr>
<tr>
<td></td>
<td>Makky S. Jaya</td>
</tr>
<tr>
<td></td>
<td>Construction of migrated image scans by post-stack remigration</td>
</tr>
<tr>
<td></td>
<td>Thilo Müller</td>
</tr>
<tr>
<td></td>
<td>Developing the Common Reflection Stacking (CRS) method; Assisting Prof. Hubral in giving lectures; Supervising Master students;</td>
</tr>
</tbody>
</table>
Master students: Norcirio Pantoja Queiroz

True Amplitude Time Migration without Knowledge of Velocities

German Höcht

Imaging with the Common Reflection Point and the Common Reflection Surface Stack

Rainer Jäger

Title of the thesis not yet known

Jürgen Mann

Derivation and Implementation of the Image Wave Theory and its Application to Seismic Data

Group: Analysis and Modeling of Complex Structures
Group leader: Martin Karrenbach

scientific leadership, development of modeling and analysis methods

Ph.D. student: Joerg Mueller

Finite difference modeling in fault zones and complex structure 3D Model building in GOCAD

(Skills: Fortran90, SEPlib, Matlab)

Research Geophysicist: Maren Scheidhauer

Testing of processing algorithms for nonconventional surveys (Processing Packages: FOCUS, SEPlib, SU, GMT)

Research Student: Baerbel Traub

3D Asymptotic Raytracing with a Wave Front Construction Method

(Skills: SEPlib, Moser’s recursive raytracing)

Research Student: Kai-Uwe Vieth

Pre-stack processing of nonconventional seismic surveys

(Skills: Fortran, FOCUS, SEPlib, SU, GMT)

Group: Multiple Reflection Identification and Suppression
Group leader: Martin Karrenbach

scientific leadership

Ph.D. student: Robert Essenreiter

Development of multiple identification and suppression techniques on the basis of neural networks

Master students: Susanne Laux
Selective and full wave form modeling with the reflectivity method for testing of deconvolution techniques
(Skills: SEPlib, Reflectivity Modeling)
Albrecht Haeussermann

Application of neural network multiple suppression on real data

Research students: Robert Mauch

Coherency analysis of seismic data (Skills: SEPLIB, Fortran90)

Ingo Koglin

Computation and analysis of seismic attributes
(Skills: SEPLIB, Fortran90)

Group: Geophysical Characterization of Reservoirs and Stochastic Structures
Group leader: Sergei A. Shapiro

Scientific leadership

Ph.D. students: Andreas Kirchner, Karlsruhe

Stochastic characterization of reservoir properties. Characterization of fault zones in non-destructive testing. Management and administration

Tobias Mueller, Karlsruhe

Statistical wavefield analysis and further development of Rytov Approximation. Wave propagation in poroelastic media

Kai-Uwe Vieth, Karlsruhe

Application and development of imaging and inversion techniques. Non-destructive localization of macroscopic cracks in fibre reinforced composite materials

Erik Saenger, Karlsruhe

Simulation of the Propagation of elastic waves through inhomogeneous media. Application of parallel computing devices

Pascal Audigane, Nancy/France

3D inversion and modeling of permeability tensor

Affiliation: CRPG-CNRS, Nancy, France

Master student: Stephan Bojinski, Karlsruhe

Seismic Characterization of fractured composite media by statistical wavefield analysis, thesis to be finished soon.
Group: **Elastic Wavefield Modeling**

Group leader: Friedemann Wenzel

Ph.D. students:
- Linus Pasasa
  - *High-resolution seismic imaging in waste disposal sites*
- Melanie Pohl
  - *Modelling of anisotropic features in the earth's crust*

Master student: Mechita Schmidt-Aursch
- *FD-modelling of the elastic wavefields generated by realistic sources*

---

Group: **Applied Geophysics Group (AGG), Hamburg**

Group leader: Dirk Gajewski

Research associates:
- Norman Ettrich
- Ekkehart Tessmer

Ph.D. students:
- Joachim Falk
- Andree Leidenfrost

Master students:
- Thorsten Graf
- Olgierd Koslowski

Other students:
- Carsten Falck
- Maximilian Krueger
- Sebastian Barth
  - (Skills: Seismic Unix (SU), GeoDepth)
## Software List

The authors are responsible for their programs and the copyright and ownership remains with the author. Sponsors of WIT can use those programs for all internal purposes. No warranty or suitability for any particular purpose is given, neither expressly nor implied. For access to the software contact the authors at the email addresses given below and arrange transfer modalities (installation) with them directly. The sponsor has to cover possible costs for the transfer.

<table>
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<th>Program Name</th>
<th>Program Description</th>
<th>Language</th>
<th>Software Package Requirements</th>
<th>Interactive</th>
<th>Author</th>
<th>E-mail</th>
</tr>
</thead>
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<tr>
<td>Remnew</td>
<td>3D finite difference post-stack time and depth remigration based on seismic image wave theory</td>
<td>Fortran90</td>
<td>SEPlib</td>
<td>no</td>
<td>Juergen Mann</td>
<td><a href="mailto:jmann@gpirs1.physik.uni-karlsruhe.de">jmann@gpirs1.physik.uni-karlsruhe.de</a></td>
</tr>
<tr>
<td>MZO90</td>
<td>Finite difference migration to zero-offset and finite difference dip moveout based on seismic image wave theory</td>
<td>Fortran90</td>
<td>SEPlib</td>
<td>no</td>
<td>Juergen Mann</td>
<td><a href="mailto:jmann@gpirs1.physik.uni-karlsruhe.de">jmann@gpirs1.physik.uni-karlsruhe.de</a></td>
</tr>
<tr>
<td>Illu</td>
<td>Performs the so called Common Reflection Surface Stack, searching the three stacking parameters at the same time.</td>
<td>Fortran 90</td>
<td>SEPlib</td>
<td>no</td>
<td>Thilo Mueller</td>
<td><a href="mailto:Thilo.Mueller@phys.uni-karlsruhe.de">Thilo.Mueller@phys.uni-karlsruhe.de</a></td>
</tr>
</tbody>
</table>
Program Name: Illu2
Program Description: Performs the so called Common Reflection Surface Stack, searching the three stacking parameters in 2 search steps. Therefore it is faster, but not as accurate as Illu.
Language: Fortran 90
Software Package Requirements: SEPlib
Interactive: no
Author: Thilo Mueller
E-mail: Thilo.Mueller@phys.uni-karlsruhe.de

Program Name: AKU2D
Program Description: 2D finite-difference wave equation modeling of acoustic waves, 6th/10th order approximation in space, 2nd/4th order approximation in time, absorbing boundaries, free surface
Language: Fortran 77
Software Package Requirements: none
Interactive: no
Author: Joachim Falk, University of Hamburg
E-mail: falk@dkrz.de, gajewski@dkrz.de

Program Name: ELA2D
Program Description: 2D finite-difference wave equation modeling of seismic waves (P-SV), 6th order approximation in space on staggered grids, 2nd/4th order approximation in time, absorbing boundaries, free surface
Language: Fortran 77
Software Package Requirements: none
Interactive: no
Author: Joachim Falk, University of Hamburg
E-mail: falk@dkrz.de, gajewski@dkrz.de

Program Name: GRIMFIDI
Program Description: 2D finite-difference wave equation modeling of seismic waves (P-SV), 6th order approximation in space on staggered grids, 2nd/4th order approximation in time, adjustable grid spacing by grid refinement technique, absorbing boundaries, free surface, manual available

Language: Fortran 77
Software Package Requirements: none
Interactive: no
Author: Joachim Falk, University of Hamburg
E-mail: falk@dkrz.de, gajewski@dkrz.de

Program Name: PWC-Stack
Program Description: velocity independent stacking approach
Language: Fortran
Software Package Requirements: DISCO/Focus
Interactive: No
Author: W. Soellner and G. Garabito Callapino
E-mail: soellner@marajo.ufpa.br

Program Name: Fdmod
Program Description: Finite Difference Modeling Package (time domain, optimized derivative coeff., elastic, viscoelastic, anisotropic, free surface, absorbing, topography)
Language: Fortran90 (HPF)
Software Package Requirements: SEPlib
Interactive: No
Author: M. Karrenbach
E-mail: martin.karrenbach@physik.uni-karlsruhe.de

Program Name: sepref
Program Description: Reflectivity Modeling (isotropic, wave field selection)
Language: Fortran77
Software Package Requirements: SEPlib
Interactive: No
Author: S. Laux
E-mail: martin.karrenbach@physik.uni-karlsruhe.de

Program Name: CHANT
Program Description: 2D elastic pseudospectral Fourier-Chebyshev fullwave modeling with free surface boundary conditions and surface topography. 4th order Taylor expansion in time.

Language: Fortran 77
Software Package Requirements: none
Interactive: no
Author: Thomas Ruedas, University of Hamburg
E-mail: ruedas@dkrz.de

Program Name: CT3D
Program Description: 3D elastic pseudospectral Fourier-Chebyshev fullwave modeling with free surface boundary conditions. 4th order Taylor expansion in time.

Language: Fortran 77
Software Package Requirements: none
Interactive: no
Author: Ekkehart Tessmer, University of Hamburg
E-mail: ekkehart.tessmer@dkrz.de, gajewski@dkrz.de

Program Name: CT3DTOPO
Program Description: 3D elastic pseudospectral Fourier-Chebyshev fullwave modeling with free surface boundary conditions and surface topography. 4th order Taylor expansion in time.

Language: Fortran 77
Software Package Requirements: none
Interactive: no
Author: Ekkehart Tessmer, University of Hamburg
E-mail: ekkehart.tessmer@dkrz.de, gajewski@dkrz.de

Program Name: CT3DANX
Program Description: 3D fully anisotropic elastic pseudospectral Fourier-Chebyshev fullwave modeling with free surface boundary conditions. 4th order Taylor expansion in time.

Language: Fortran 77
Software Package Requirements: none
Interactive: no
Author: Ekkehart Tessmer, University of Hamburg
E-mail: ekkehart.tessmer@dkrz.de, gajewski@dkrz.de
<table>
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<tr>
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<th>Author</th>
<th>E-mail</th>
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<tr>
<td>vid2d</td>
<td>2D finite-difference eikonal solver, expanding squares</td>
<td>Fortran 77</td>
<td>no</td>
<td>Norman Ettrich, University of Hamburg</td>
<td><a href="mailto:ettrich@dkrz.de">ettrich@dkrz.de</a></td>
</tr>
<tr>
<td>fdpert2d</td>
<td>2D finite-difference eikonal solver, first-order perturbation method included, simultaneous traveltime computation for several isotropic models, traveltime computation for anisotropic models</td>
<td>Fortran 77</td>
<td>no</td>
<td>Norman Ettrich, University of Hamburg</td>
<td><a href="mailto:ettrich@dkrz.de">ettrich@dkrz.de</a></td>
</tr>
<tr>
<td>qin3d</td>
<td>3D finite-difference eikonal solver, wavefront expansion</td>
<td>Fortran 77</td>
<td>no</td>
<td>Norman Ettrich, University of Hamburg</td>
<td><a href="mailto:ettrich@dkrz.de">ettrich@dkrz.de</a></td>
</tr>
<tr>
<td>wfc2d</td>
<td>2D wavefront construction, multivalued travel-times, amplitudes, phases, take-off angles</td>
<td>Fortran 77</td>
<td>no</td>
<td>Norman Ettrich, University of Hamburg</td>
<td><a href="mailto:ettrich@dkrz.de">ettrich@dkrz.de</a></td>
</tr>
<tr>
<td>polfd</td>
<td></td>
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</tbody>
</table>
Program Description: 2D FD eikonal solver in polar coordinates. Takes a velocity field on a rectangular grid as input and gives the computed travel times on an also rectangular grid.

Language: Fortran 77
Software Package Requirements: none
Interactive: no
Author: Andree Leidenfrost, University of Hamburg
E-mail: leidenfrost@dkrz.de
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Research Personnel

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.

Norman Ettrich received his Diploma (1993) in geophysics from the Technical University of Clausthal and a PhD (1997) in geophysics from the University of Hamburg. Since 1996, he has been a research assistant at the University of Hamburg. His interests are ray tracing and seismic migration/inversion. He received EAEG’s Van Weelden Award in 1995. He is a member of EAGE.

Joachim Falk received his Diploma (1994) in geophysics from the University of Hamburg. Since 1994 he has been a research associate at the University of Hamburg. He is working on the development of finite difference algorithms using adapted grids for the numerical modeling of acoustic, seismic and electro-magnetic wave propagation problems in complex media. He is a member of the EAGE.

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 asymptotics, seismic modeling, and processing of seismic data from isotropic and anisotropic media. Together with Ivan Psenck, 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).
Norbert Gold is dealing with the propagation of elastic waves in 2-D and 3-D random media and with finite difference modelling on parallel computers.

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 is a member of DGG, EAEG and 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.

Makky S. Jaya is working on image animation, i.e., he is trying to solve the problem of obtaining seismic images for a continuous set of parameters using image-wave equations and their solutions.

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.

Andree Leidenfrost received his Diploma (1995) in geophysics from the University of Hamburg. Since 1995 he has been a research associate at the University of Hamburg. His interests are
travel time computation and seismic migration. He is a member of EAGE.

**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.

**Tijmen Jan Moser** received his Ph.D. in Geophysics from the University of Utrecht in 1992, on a thesis concerned with the shortest path calculation of seismic ray paths. Thereafter, he held research positions at Amoco (Tulsa, summer 1992), IFP (Paris, 1992-1993), IPG (Paris, 1993-1994), ISEP/Norsk Hydro (Bergen, 1995-1996). He was an Alexander-von-Humboldt fellow at the Geophysical Institute in Karlsruhe (1996-1997). He is currently a consultant at Nork Hydro (Bergen). His main research interests include applied mathematics, computational seismology, and ray-based imaging. He is a member of SEG, EAGE and MAA. His main area of interest is ray-based imaging. As such, he is involved in developing cost- and memory-effective techniques for wavefront construction, in 2D and 3D smooth and non-smooth media. These techniques have found applications in forward modeling and VSP in complicated structures. Also, he is interested in applications in true-amplitude imaging in presence of realistic, possibly non-smooth, macro-velocity models.

**Thilo Müller** is working on imaging techniques. He is particularly involved in the so called CRS (Common Reflection Surface) Stack Technique. This is an imaging process that stacks data along the optimum stacking surface, using much more traces than standard techniques and needing no velocity information.

**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.

**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.
Thomas Ruedas began studying geophysics at Hamburg university in 1991 and received his Diploma in 1997.

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 Sao 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.
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. Since 1991 he has been a senior research scientist at the Geophysical Institute of Karlsruhe University, Germany, the first two years as an Alexander von Humboldt fellow. From January to August 1997, he was a Heisenberg associate-research professor in Karlsruhe. Since September 1997, he has been a full professor in Applied Geophysics at the Nancy School of Geology, France, where he is cooperating with GOCAD consortium. His interests include exploration seismology, rock physics, and forward and inverse scattering problems. He is a member of SEG, EAGE, AGU, and DGG.

Walter Söllner received a diploma (1983) in geophysics from Clausthal Technical University and his Ph.D. (1990) in geophysics from Clausthal Technical University. Since 1995, he has been a visiting professor in applied seismics at the Federal University of Para (UFPa), Brazil. From 1989 until 1994 he worked as research scientist at the Geophysical Institute at Karlsruhe University. His research interests are seismic processing, imaging and inversion. He is a member of SEG and SBGf.

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.

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.

Wolfgang Velten deals with the development of ray tracing algorithms in 3D blocked media with triangulated surfaces.

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.
Ulrich Werner is working on an expansion of the generalized O’Doherty/Anstey theory that, in addition to the frequency-dependent anisotropy due to thin multilayering, also takes frequency-independent intrinsic anisotropy of each layer into account.