Wave Inversion Technology Consortium

WIT

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NMO/DMO is good!
PreSTM is much better!
CFP is $(\text{much})^2$ better!
CRS is $(\text{much})^3$ better!

— Oz Yilmaz —
(SEG meeting 2001, San Antonio)

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Preface by Peter Hubral

5 years of Wave Inversion Technology (WIT) — a special event! This 5th annual report was compiled by the same WIT research groups in Campinas, Berlin, Hamburg and Karlsruhe with the same amount of researchers. This WIT report is placed into the hands of almost the same sponsors that we had when we started the consortium in 1997.

Through the support of our sponsors, many young, enthusiastic scientists were able to complete their M.Sc. and Ph.D. studies and present their research at international meetings and conventions. After all, that is really what WIT is all about. The idea is that the sponsor can tap a "unique human resource" by supporting young talents full of wit and bringing them close to industry-related research.

During the past five years, numerous international guest scientists have complemented our WIT-research. Among them were Sven Treitel, Enders Robinson, Boris Gelchinsky, Mikhail Popov and Lourenildo Leite, just to mention a few. Recently, the Hamburg group benefitted from the visit of Professor Boris Kashtan; the Berlin group hosted the Alexander von Humboldt-prizewinner Dr. Kravtsov. Both are renowned scientists from Russia. The Karlsruhe group is proud to have Professor Norman Bleistein (USA) as an Alexander von Humboldt-prizewinner join its current research activities.

Approximately 400 participants from all over the world have visited the "WIT-Workshop-Series" during the last 5 years. Special workshop issues appeared so far in Journal of Seismic Exploration and Journal of Applied Geophysics. A notable event in 2001 was the "2nd WIT Workshop on Seismic True Amplitudes" which took place in Karlsruhe and was organized jointly by the WIT groups of Martin Tygel and Peter Hubral. The event was again co-sponsored by the EAGE and SEG. A special workshop issue is scheduled to appear in 2002 in the Journal of Seismic Exploration.

For the years to come we hope to be able to keep the trust that our supporters have in our research and desire to be of help to you. On behalf of my WIT colleagues I want to thank our sponsors for their support during the past five years. We wish that you maintain your WIT as a never-ending source of creativity, happiness and well-being.

Summary: WIT report 2001

IMAGING

Höcht and **Bergler** present a traveltime formula that can be used to simulate a ZO volume by means of the CRS stack from multi-coverage reflection data acquired with a 3-D survey.

Bergler et al. describe how the recently developed 2-D finite-offset Common-Reflection-Surface (FO CRS) stack can be applied to multi-component seismic reflection data. They show that the data-derived wavefield attributes obtained from the FO CRS stack are of use to separate unconverted from converted primary reflections.

Chira and **Hubral** give a new analytic moveout formula for the CRS stack surface and a normal moveout velocity formula for a 2D curved measurement surface. These formulas are in fact valid for 3D media with a curved measurement surface. This new NMO velocity can be used to recover the interval velocities and the depths of reflectors with a generalized Dix-type inversion.

Grosfeld et al. propose a strategy to correct the CRS stacked section, as well as the CRS attributes, for the topographic effects.

Biloti et al. propose a method, based on the well-established Hubral and Krey algorithm, to obtain a velocity model from the CRS attributes. The major improvements are: a strategy to represent interfaces as optimized cubic splines and the possibility of the layer velocities be recovered as gradients in depth. Two synthetic examples are presented.

Koglin shows the effects of several smoothing methods applied to extracted CRS attributes. The smoothed CRS attributes are used for inversion purposes. A real data example shows the results of a subsequent depth migration.

Schleicher and **Santos** investigate the resolution of Kirchhoff depth migration in dependence on source-receiver offset and reflection angle. They find that, when the aperture is large enough, resolution after migration is a function of angle rather than offset. Thus, in principle, achievable resolution does not depend on reflector depth. In an AVO/AVA analysis of large-offset data, the angle dependence must be taken into account as it may lead to degraded amplitudes at larger angles.

Hertweck et al. investigate aperture effects in 2.5D Kirchhoff migration. They relate the terms of the Method of Stationary Phase, which mathematically describe the boundary effects, to simple geometrical situations. This provides a more physical and intuitive interpretation of the artifacts and helps to better understand methods to suppress them.

Santos et al. propose an approach called reflection impedance, which is based on constant ray parameter and a power relationship between density and S-wave velocity. This new method proved to be of better accuracy for angular impedance estimation and reflection coefficient recovery when compared with the elastic impedance approach.

Vanelle and **Gajewski** show how the optimum migration aperture can be determined from traveltimes. They illustrate their method with examples and give estimates of possible savings in computational time.

Vanelle and **Gajewski** show how their technique of traveltime-based true-amplitude migration can be extended to converted waves. They illustrate their method with an example.

Buske et al. present a method for taking into account the amplitude losses due to scattering in a statistically heterogeneous overburden during migration. The scheme is implemented as an additional weighting term within the Kirchhoff integral formulation. The applicability is demonstrated with the help of a synthetic deep seismic data set.

Jäger et al. show that the CRS Stack is a powerful tool to gain a clear image of the subsurface by comparing results with NMO/DMO/Stack. Furthermore, they present an application of cascading true-amplitude Kirchhoff migration and demigration, namely trace interpolation for a real data example.

Hertweck et al. give a short introduction to modeling by demigration. They show an application of this method by means of simulating reservoir monitoring (time-lapse seismics). Seismograms for different stages of production are simulated and changes in the reservoir are quantitatively recovered.

ROCK PHYSICS AND WAVES IN RANDOM MEDIA

Shapiro uses the theory of poroelasticity to analyze stress dependences of seismic velocities. He shows that elastic properties of saturated rocks and their porosity depend mainly on the differential stress. Separating the porosity into compliant and stiff parts he derives equations which approximate well laboratory observations of seismic velocities under changing stresses.

Kravtsov et al. provide a detailed analysis of the statistical properties of seismic reflection traveltimes in randomly inhomogeneous media in order to characterize the inhomogeneities of the reflector overburden.

Sick et al. propose a method to correct transmission losses due to scattering attenuation. They show, by means of two examples, that the implementation of this procedure on synthetic data yields more reliable estimates of reflection coefficients.

Müller et al. present a scattering attenuation model based on the statistical wave propagation theory in random media. They present formulas to quantify scattering attenuation in complex geological regions using simple statistical estimates from well-log data. To verify the theory they perform numerical simulations of seismic wave propagation in 2-D random media using a finite-difference solution of the elastodynamic wave equation and find a good agreement between theoretical and numerical Q estimates.

Saenger et al. present the latest results of wave propagation in fractured media using the rotated staggered finite-difference grid. Viscoelastic wave propagation, a numerical accuracy consideration and a large-scale 3D FD simulation are shown.

Rothert et al. show the application of the SBRC approach to characterize reservoirs in terms of hydraulic diffusivity or permeability in 3D on large spatial scales. Recently, methods were developed using the spatio-temporal evolution of fluid-induced microseismicity for reconstructing rock properties in heterogeneous, anisotropic, fluid-saturated media. For the first time, case studies on data from sedimentary environments are shown as well as numerical verifications of the approach.

MODELING

Coman and **Gajewski** propose an efficient wavefront-oriented ray-tracing technique for the computation of multivalued traveltimes in a smooth 2D velocity model. The technique starts with few rays, which are propagated stepwise through the model, and inserts new rays if certain criteria are satisfied. The authors suggest new approaches for the insertion of rays and for the estimation of traveltimes at gridpoints. They also analyze the influence of the input parameters which control the wavefront and ray densities on the accuracy of the proposed technique.

Novais and **Santos** show how a finite difference scheme can be adapted to the 2.5-D situation. The full 3-D FD scheme can be reduced to a repeated 2-D FD scheme by applying the Fourier transform with respect to the out-of-plane coordinate to the 3-D wave equation and using the medium symmetry.

Soukina and **Gajewski** use the finite-difference perturbation method for traveltime computation in 3-D arbitrary anisotropic media.

Portugal shows how the Smirnov's lemma can be applied in ray theory. It can be used to establish the connection between the traveltime and the amplitude along a ray, transforming the transport equation into an ordinary differential equation, which is simply solved.

OTHER TOPICS

Gajewski and **Vanelle** introduce an extension of the well-known $T^2 - X^2$ method to 3-D heterogeneous media. They give an example of traveltime interpolation as one of the possible applications of their method.

The Wave Inversion Technology (WIT) Consortium

The Wave Inversion Technology (WIT) Consortium was established in 1997 and is organized by the Geophysical Institute, Karlsruhe University, Germany. It consists of four working groups, one 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) in Berlin, Germany, and the Applied Geophysics Group (AGG) of the Hamburg University, Germany. The WIT Consortium offers the following services to its sponsors: a) Research as described in the topic "Research aims" below; b) Deliverables; c) Technology transfer and 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 acustic 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 onto 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 and finite offset simulations.
2. Macromodel determination.
3. Seismic image and configuration transformations (data mapping).
4. True-amplitude imaging, migration, and inversion.
5. Seismic and acoustic methods in porous media.

6. Passive monitoring of fluid injection.
7. Fast and accurate seismic forward moelding.
8. Modeling and imaging in anisotropic media.

COMPUTING FACILITIES

In Karlsruhe, the research project uses computer facilities that consist of mainly Hewlett-Packard (HP), Silicon Graphics (SGI), and Linux workstations. These are networked with a local compute server, a SGI Origin 3200 (6 processors, 4GB shared memory). For large-scale computational tasks, an IBM RS/6000 SP-SMP (256 nodes + 52 nodes) and a Fujitsu VPP 5000 are available on campus. If there is still a request for more computing power, a Cray T3e (512 nodes), a NEC SX-4/32, and a Hitachi SR8000 (16 nodes) can be used via ATM networks at the nearby German National Supercomputing Center (HLRS) in Stuttgart.

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 proc.) are used for computationally intensive tasks.

The Geophysical Department of the Free University of Berlin has excellent computer facilities based on Sun- and DEC-Alpha workstations and Linux PCs. Moreover, there exists access to the parallel supercomputer Cray T3m (256 proc.) of ZIB, Berlin.

The research activities of the Campinas Group are carried out in the Mathematical Geophysics Laboratory. The Lab has many PC Linux workstations and Sun Ultra 60/80 workstations connected by a dedicated network, suitable for parallel processing. For large-scale applications, the Lab has full access to the National Center for High Performance Computing of São Paulo, that maintains, among other machines, an IBM RS/6000 9076-308 SP (43 nodes) with 120GB of RAM. Also available are seismic processing software packages from Paradigm and CGG.

WIT PUBLIC RELATIONS COMMITTEE

Name	University	Area
Peter Hubral	Karlsruhe	WIT headquarter
Claudia Payne	Karlsruhe	WIT headquarter
Steffen Bergler	Karlsruhe	WIT report
Thomas Hertweck	Karlsruhe	WIT report
Axel Kaselow	Karlsruhe	WIT homepage manager
Christoph Jäger	Karlsruhe	WIT homepage manager
Yonghai Zhang	Karlsruhe	WIT seminar organizer
Jürgen Mann	Karlsruhe	WIT poster organizer

STEERING COMMITTEES

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Steffen Bergler	Karlsruhe	Jürgen Meister	BEB
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Ekkehart Tessmer	Hamburg	Paul Williamson	TotalFinaElf
Martin Tygel	Campinas	Henning Trappe	TEEC

WIT research personnel

Steffen Bergler received his diploma in geophysics from Karlsruhe University in February 2001. Currently, he is working as a research associate at Karlsruhe University on the the implementation of the CRS stack for finite offset and the 3D CRS stack. He is a member of DGG, EAGE, and SEG.

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 staff member 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, ISC, 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 has been 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 has been 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, EAGE, and SEG.

Pedro Chira-Oliva obtained a master degree of Geophysics in Seismic Methods from Federal University of Pará (Belem, Brazil). He started his PhD studies at the Geophysical Institute, Karlsruhe University. Currently, he is working on 3D CRS stack. His interests are macro velocity model independent imaging and seismic image wave methods.

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 traveltime computation and Kirchhoff migration. He is a member of EAGE and SEG.

Erik Ewig is a graduate student. He is planning to start his diploma thesis in April 2002. The topic of the thesis will cover the use of CRS attributes for AVO analysis.

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 Psencîk, 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 has been 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.

Zeno Heilmann is currently writing his diploma thesis at the Geophysical Institute, Karlsruhe University. He works on the application of the CRS stack, especially with respect to the topography of the measurement surface.

Thomas Hertweck received his diploma in Geophysics in May 2000 from Karlsruhe University, Germany, where he passed the exams with distinction. Since August 2000, he has been a research associate and teaching assistant at the Geophysical Institute, Karlsruhe University. His fields of interest are numerical analyses, development of seismic software (especially on Linux PCs and multi-processor shared memory systems), seismic ray theory, and seismic true-amplitude imaging. Currently, he focuses on an implementation of true-amplitude (de)migration software and applications of the Unified Approach Theory. He is a member of EAGE and SEG.

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 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.

Christoph Jäger has been a research assistant at the Geophysical Institute, Karlsruhe University since 1999. He just finished his diploma thesis where he focused on practical aspects of true-amplitude seismic imaging and an implementation of Kirchhoff true-amplitude migration and demigration. He will continue his work as a Ph.D. student at Karlsruhe University.

Tina Kaschwich received her diploma in 2000 in geophysics from Hamburg University. Since 2001 she has been a Ph.D. student at the University of Hamburg. Her research interest is the computation of traveltimes in anisotropic media. She is a member of EAGE.

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 rock physics and finite difference modeling of wave propagation in fluid-saturated fissured porous media. He is a member of AGU and SEG.

Ingo Koglin is a diploma student. His thesis focuses on the preparation and application of seismic wave field attributes obtained by the CRS stack. He uses the attributes for inversion and to improve imaging.

Oliver Krüger is a diploma student. Presently, he is working in the modeling group at the Freie Universität Berlin. His thesis is about accuracy of numerical modeling methods.

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 Lueth received his Diploma in geophysics from the TU Clausthal in August 1996. His thesis was on numerical and methodical investigations on diving wave tomography. In 2000 he received his Ph.D. from the FU Berlin. His research interests include refraction seismic data interpretation, seismic processing and integration of geophysical and geodynamic data.

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.

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

Alex Müller is a graduate student currently working on the implementation of the 3D CRS stack. His main task is the development of efficient search strategies for the eight-parameter moveout surface used in the 3D CRS stack.

Tobias M. Müller received a diploma in geophysics in 1998 from Karlsruhe University and his Ph.D. in 2001 from Freie Universität Berlin. His research interests include the theoretical and numerical description of seismic wave fields in randomly inhomogeneous (poro-)elastic media.

M. Amélia Novais received her M.Sc. in Mathematics from the Brazilian Institute of Pure and Applied Mathematics (IMPA) in 1993 and her Ph.D. in Applied Mathematics from State University of Campinas (Unicamp) in 1998. At the present date, she is a professor for Mathematics at the Federal University of Sao Carlos (UFSCar), Brazil. She will join Unicamp in the first months of 2002. Her research interests include seismic forward modeling, in particular finite-difference schemes and the common and different aspects of Born and Kirchhoff modeling. She is a member of SEG, SBGf, SBMAC, and SBM.

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 prediction filter and the envelope of the wave. 1999 he received his Ph.D. for "Local earthquake tomography in the region of Antofagasta (Chile)". Next he applied CRS stacking to a seismic profile from the northern Chilean coast. His actual research interest is localizing acoustic emissions with respect to the influence of seismic anisotropy and poor recording conditions (i.e., only on string of receivers in a single borehole).

Claudia Payne has been Peter Hubral's secretary for 11 years. She is in charge of all WIT administrative tasks, including advertising, arranging meetings, etc. Phone: ++49-(0)721-608-4443, email: Claudia.Payne@gpi.uni-karlsruhe.de

Carlos Piedrahita received a B.Sc. in mathematics from UNAL of Colombia, and the M.Sc. in mathematics from SUNY at Buffalo in 1986. He has worked in the laboratory of geophysics and the material science group of ICP, the research group of ECOPETROL since 1988. Currently he is working toward his Ph.D. 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.

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 wavefront 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 finishes his Ph.D. at the Geophysical Institute, University of Karlsruhe, Germany. His research interests include signal processing, seismic imaging, and modeling.

Jan Rindschwentner is a diploma student. Presently, he is working in the reservoir characterization group at the Freie Universität Berlin. His thesis deals with estimating the global permeability tensor.

Elmar Rothert received his diploma in Geophysics in 1999 from the University of Göttingen. In his diploma thesis he studied the scattering of teleseismic waves at small-scale heterogeneities in the crust and lithosphere below the seismic receiver array GRF in Germany. Since January 2000 he has been a Ph.D. student of Prof. Shapiro at the Freie Universität Berlin. Currently, he focuses on the reconstruction of permeability in heterogeneous, anisotropic, fluid-saturated media from induced microseismicity. He is a member of AGU, EAGE, and SEG.

Erik H. Saenger received his diploma in Physics in March 1998 and his Ph.D. in Geophysics in November 2000 from Karlsruhe University. Currently, he is working at FU Berlin where 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 Ph.D. 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. 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 resolution and aperture effects of Kirchhoff migration. 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. He is a member of SEG, EAGE, DGG, SBGf, and SBMAC.

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.

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Sebastian Sperlich is a diploma student. Presently, he is working in the reservoir characterization group at the Freie Universität Berlin. His thesis deals with induced microseismicity.

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.

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.

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