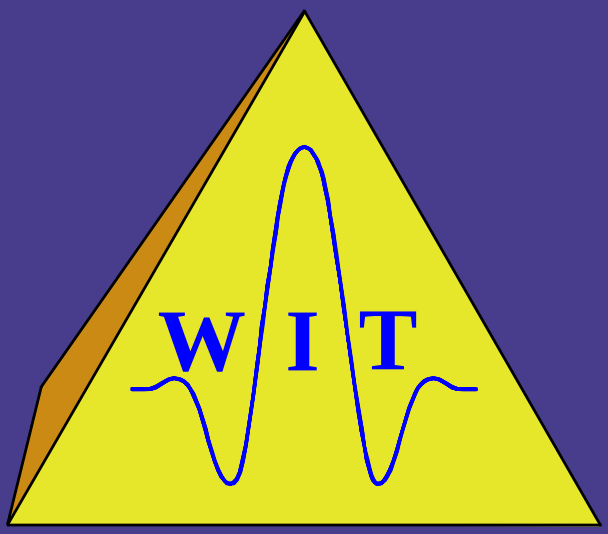
Wave Inversion Technology Consortium



Wave Inversion Technology
established 1997 in Karlsruhe, Germany

Annual Report No. 7
2003

Karlsruhe, 2004/02/15

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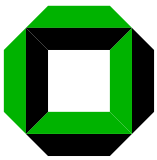


The EAGE Erasmus award 2003 (with honorary membership)
was presented to

Peter Hubral

In recognition of his many outstanding contributions to geophysics, including the introduction of image ray concepts, his work on true amplitude, on propagation in layered media and on reflection surfaces in conjunction with structural configurations, all of which have had far reaching consequences on the approach to imaging the Earth, and for his services to the Association.

Stavanger, 5 June 2003

Figure 1: On behalf of Prof. Peter Hubral, Dr. Jürgen Mann received the EAGE Erasmus award 2003 during the closing ceremony of the 65th EAGE Conference & Exhibition in Stavanger, Norway.

Contents

Preface

The Wave Inversion Technology (WIT) consortium has been successfully existing for 7 years now. During this time, many sophisticated seismic modeling, imaging, and inversion methods were developed, implemented, and tested by the research groups in Berlin, Campinas, Hamburg, and Karlsruhe. A new research group in Belém (Brazil) has now joined WIT working on very similar lines as the groups in Campinas and Karlsruhe. The activities of all WIT groups continue to converge to a—for the consortium very specific and successful—seismic workflow involving various methods like, e. g., 2D and 3D CRS stack, residual static corrections, isotropic and anisotropic true-amplitude modeling and imaging, tomographic inversion, characterization of rock properties, or passive monitoring.

We welcome TOTAL SA to the WIT consortium who took over the sponsorship from TOTAL E&P UK.

The successful work within the WIT consortium was once again noticed and honored in 2003 by the SEG at their annual international conference and exhibition in Dallas: Professor Shapiro and his co-authors received the renowned Best Paper Award: *Shapiro S.A., Rothert E., Rath V., and Rindschwentner J., 2002, Characterization of fluid transport properties of reservoirs using induced microseismicity. Geophysics, vol. 67, no. 1.*

Another paper has been denoted as a highlight in the AGU journal: *Rothert, E., Shapiro, S.A., Buske, S., and Bohnhoff, M., 2003, Mutual relationship between microseismicity and seismic reflectivity: Case study at the German Continental Deep Drilling Site (KTB). Geophys. Res. Lett., vol. 30, no. 17.*

Peter Hubral was invited to give a well-attended course on CRS Stack at the EAGE Education Days in London. He was also invited to give this presentation at the bi-annual meeting of the Brazilian Geophysical Society (SBGf) in Rio de Janeiro. Jürgen Mann was invited to give a special talk on the same subject at the EAGE/SEG summer workshop in Trieste, which was organized with the support of the WIT group.

It is evident that international cooperation and the exchange of ideas with sponsors are very important elements of WIT. We were pleased that Professor Norman Bleistein stayed for 6 months with the Karlsruhe group. We will try to continue our research in the same successful way and hope that our supporters will maintain confidence in us, our ideas and implementations for years to come. On behalf of all WIT colleagues I want to thank our sponsors for their support during the last seven years.

Peter Hubral

Summary: WIT report 2003

IMAGING

Perroud and Tygel introduce a new implementation of the normal-moveout (NMO) correction called Nonstretch NMO. The procedure automatically avoids the undesirable stretch effects that are present in conventional NMO. In this way, a significant range of large offsets, that would normally be muted in the case of conventional NMO, can be kept and used, leading to better stack and velocity determinations. Illustrative applications to synthetic and real datasets, obtained from high-resolution (HR) seismic and ground-penetrating radar (GPR) measurements are provided.

Garabito et al. review the CRS and Multifocus traveltime moveouts in the presence of strong topography. Simple examples designed to illustrate the accuracy of the traveltime expressions are provided.

Chira-Oliva et al. present a modified 2-D ZO CRS stacking operator in order to consider effects due to the smooth topography. By means of this new CRS formalism, they stack the land seismic data for obtaining a high resolution ZO seismic section, without applying static corrections. As by-products the 2-D ZO CRS stack method with smooth topography also provides accurate estimates of the CRS parameters.

Garabito et al. present a new algorithm of the Common Reflection Surface (CRS) method based on global (Simulated Annealing - SA) and local (Quasi-Newton - QN) optimizations to estimate the CRS parameters from multicoverage data. We have applied the proposed SA-QN optimization to the Marmousi dataset with very good results. These results indicate that the procedure is able to provide highly accurate CRS parameters and images in complex seismic data.

Majana et al. discuss three local optimization methods applied to refine the initial values for the attributes of the CRS method in 2D. The performance and accuracy of the methods are examined by means of illustrative synthetic and real data examples.

Mann and Duveneck present an event-consistent smoothing algorithm for the CRS wavefield attributes. Based on one of the wavefield attributes, namely the emergence angle of the normal ray, and the coherence measure associated with the CRS stacking operator, a combination of a median filter and averaging is applied. The attribute fluctuations due to noise as well as outliers to the pragmatic search strategy are strongly reduced in accordance to the theoretical background. All applications of the wavefield attributes, including the stack itself, benefit from this smoothing.

Koglin and Ewig briefly present how CRS atributes are used to obtain CRS moveout corrected CRS super gather which are necessary for the subsequent residual static correction. The theoretical background and a first real data example are discussed.

Gamboa et al. investigate the use of CRS attributes multiple identification and attenuation purposes. Various algorithms are proposed, together with synthetic examples that illustrate their application.

Alves et al. present a paper that is a computational exercise related to seismic multiple attenuation by combining two theories: the classical Wiener-Hopf-Levinson for prediction (WHLP), and the common-

reflection-surface (CRS) stack, here denoted as WHLP-CRS.

Bergler and Müller give a short overview on the current state of the 3-D CRS software developed at the University of Karlsruhe. Moreover, utility programs faciliating the choice of the 3-D CRS processing paramters are introduced.

Duveneck shows how kinematic wavefield attributes obtained from the application of the 3D CRS stack can be used in a tomographic inversion to determine a smooth 3D subsurface velocity model for depth imaging.

Kluever presents a tomographic inversion scheme which makes use of 2D finite-offset kinematic wavefield attributes to determine smooth, laterally inhomogeneous, isotropic subsurface velocity models.

Hertweck et al. present the concepts of a seismic reflection imaging workflow based on the Common-Reflection-Surface stack. The consecutive processing steps are outlined and demonstrated for a synthetic data example. The workflow includes the application of the CRS stack itself together with an automated time migration, a CRS-attribute-based tomographic inversion to estimate a smooth macro-velocity model, and pre-/poststack depth migration by means of the obtained model.

Heilmann et al. present a recent application of a CRS-stack-based seismic imaging workflow to data acquired in the Oberrheingraben, Germany. The main objective of the presented exploration project was to image faults and fractures relevant for a planned geothermal power plant. The individual steps of the applied CRS-stack-based imaging workflow were 1) the CRS stack and attribute determination, 2) the determination of a smooth macrovelocity model by tomographic inversion using the CRS attributes, and 3) pre- and poststack depth migration using the obtained macrovelocity model.

Tessmer tests full-wave pre-stack reverse-time migration using different types of wave-equations with synthetic data sets. By varying parameters like migration velocities, different degrees of macro model smoothing and by adding noise to the synthetics he shows the stability of the method. In addition he shows a comparison between reverse-time migration and Kirchhoff depth migration for a synthetic data set of the Picrocol model, which indicates that imaging with reverse-time migration is superior.

Vanelle et al. explain how the traveltime-based strategy for true-amplitude migration can be extended to include later-arrivals. They introduce a method for locating discontinuities of the wavefronts, that can also be applied to detect caustics. Examples on the interpolation of later-arrival traveltimes demonstrate the technique.

Jäger et al. show how true-amplitude Kirchhoff migration can be performed for data recorded with an irregular acquisition geometry on a non-flat measurement surface. They deal with problems usually known as acquisition footprint in the literature.

Schleicher and Bagaini realize a Common-Shot Migration to Zero Offset (CS-MZO), which transforms a common-shot section into a zero-offset section, as a Kirchhoff-type stacking operation for 3D wave propagation in a 2D laterally inhomogeneous medium. By application of suitable weight functions, data amplitudes are preserved or transformed by replacing the geometrical-spreading factor of the input reflections by the correct one of the output zero-offset reflections. A numerical example validates the process and highlights the differences between amplitude preserving and true-amplitude CS-MZO.

Schleicher et al. study the finite-difference solution of the image-wave equation for depth remigration and possible applications. Grid dispersion and dissipation can only reduced to acceptable levels by the choice of very small grid intervals. First applications to inhomogeneous media point towards the method's potential of being useful as a tool for migration velocity analysis.

ROCK PHYSICS AND WAVES IN RANDOM MEDIA

Müller and Gurevich use the Bourret approximation in order to describe the coherent wavefield in 3-D randomly inhomogeneous poroelastic structures. This model allows to quantify attenuation and dispersion of seismic waves propagating in porous rocks with meso-scale inhomogeneities. For example, the important problem how seismic waves respond to partial rock saturation can be tackled by this approach.

Kravtsov et al. study the traveltime fluctuations of refracted waves in random elastic media in the framework of a geometrical optics approach. Covariance function of traveltime fluctuations is derived for the case of a constant gradient of the average wave velocity. The theoretical consideration is verified with the numerical modelling and the main statistical parameters -variance of refractive index, horizontal and vertical scales of inhomogeneities- are estimated.

Kaselow and Shapiro give a short introduction into the extension of the stress sensitivity approach to arbitrary anisotropic media under arbitrary load and show that there are rocks where the stress sensitivity is also able to explain the stress dependence of electrical resistivity.

Orlowsky et al. show the effects of parallel crack distributions on effective elastic properties. The numerical study is performed using the so-called rotated staggered finite-difference scheme.

Saenger et al. consider three different kinds of 3D isotropic fractured media with a different pore structure. They have numerically tested effective velocity predictions of the Gassmann equation and the Biot velocity relations.

Delépine et al. estimate for the Soultz geothermal reservoir two independant permeability values, a permeability tensor and a heterogeneous reconstruction of the hydraulic diffusivity. The results agree very well with independent *in-situ* and laboratory tests.

Rentsch et al. present a new approach for estimating the hydraulic parameters of rocks. This approach provides possibilities to characterize hydraulic properties on large spatial scales with high precision using probability considerations of fluid-induced micro earthquakes.

MODELING

Costa et al. show a fast raytracing in a piecewise homogeneous anisotropic medium in 3-D. The implementation is for a triclinic anisotropic medium.

OTHER TOPICS

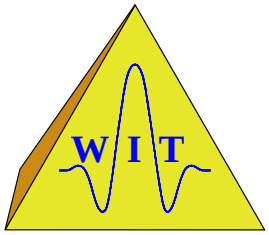
Buske and Kravtsov demonstrate the behaviour of divergence of the geometrical optics series when the conditions for its applicability are violated. Two analytical examples in elementary functions are presented: a shear wave propagation in 1D elastic media with exponentially changing parameters and 2D Gaussian beam diffraction in free space. These examples evidence that accounting for higher terms in GO power series leads to divergence and therefore becomes completely senseless beyond the boundaries of GO applicability.

Vanelle and Gajewski present expressions for sectorially best-fitting isotropic P- and S-velocities following from a generalisation of Fedorov's (1968) technique. Examples for media with polar (VTI) and triclinic symmetry confirm the superiority of the sectorial fit over the commonly used global fit by Fedorov.

Soukina et al. present a joint inversion of qP- and qS-waves in piecewise homogeneous weakly anisotropic media using a linear formalism for both qP- and qS-waves. If the observed qS-wave polarization vectors are introduced into the inversion, the tomographic relations for qS-waves can be linearized and are formally identical to those for qP-waves. The inversion procedure was tested using synthetic noise-free and noisy data obtained for a layered model.

Gomes et al. estimate the fractures orientation through multiazimuthal AVO analysis of qP and its converted waves. They assume the fractured medium behaves as an effective transversally isotropic (TI) medium.

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 fully integrated 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. In 2003, the Geoscience Center at the University of Pará, Belém, Brazil joined the WIT Consortium as an affiliated working group. 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. data-driven multicoverage zero-offset 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 modeling
8. modeling and imaging in anisotropic media

WIT PUBLIC RELATIONS COMMITTEE

Name	University	Area
Peter Hubral	Karlsruhe	WIT headquarter
Claudia Payne	Karlsruhe	WIT headquarter
Jürgen Mann	Karlsruhe	WIT headquarter & WIT report
Thomas Hertweck	Karlsruhe	WIT headquarter, WIT report & WIT CD-R
Ingo Koglin	Karlsruhe	WIT report & WIT CD-R
Christoph Jäger	Karlsruhe	WIT homepage manager
Axel Kaselow	Berlin	WIT homepage manager

STEERING COMMITTEES

Internal		External	
Name	University	Name	Sponsor
Dirk Gajewski	Hamburg	Paolo Marchetti	ENI
Thomas Hertweck	Karlsruhe	Buzz Davis	Landmark
Peter Hubral	Karlsruhe	Jurandyr Schmidt	Petrobras
Christoph Jäger	Karlsruhe	Paul Krajewski	Gaz de France
Axel Kaselow	Berlin	Leon Hu	Saudi Aramco
Jürgen Mann	Karlsruhe	Pierre-Alain Delaittre	Total
Claudia Payne	Karlsruhe	Henning Trappe	TEEC
Jörg Schleicher	Campinas	Alfonso Gonzalez	WesternGeco
Sergei Shapiro	Berlin		
Ekkehart Tessmer	Hamburg		
Martin Tygel	Campinas		

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 access to a 16 nodes (8 CPUs and 8 GB each) NEC SX-6 supercomputer at the German Computer Center for Climate Research (Deutsches Klimarechenzentrum, DKRZ) for numerically intensive calculations. Additional computer facilities consist of several SUN workstations and Linux PCs.

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.

The main computing facility at the Geophysics Graduation Program in Belém is the Seismic Processing Lab (ProSis). The hardware resources include: workstations (RS3600) from IBM and a SUN SparkStation 20, all networked to a local server SUN Enterprise-3500 with 2 processors; several networked Linux-PCs; for large-scale applications, a cluster of PCs with 20 dual-processor nodes. The proprietary software packages available for seismic applications are ProMAX, Disco-Focus, and Gocad.

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 implementation of the CRS stack for finite offset and the 3D CRS stack. He is a member of DGG, EAGE, and SEG.

Ricardo Biloti received his BSc (1995), MSc (1998) as well as PhD (2001) in Applied Mathematics from the State University of Campinas (UNICAMP), Brazil. Since May 2002, he has been working for Federal University of Paraná (UFPR), Brazil, as an Adjoint Professor at the Department of Mathematics. Nevertheless he is still a collaborator of the Campinas Group. His research areas are multiparametric imaging methods, like CRS for instance. He has been working on estimating kinematic traveltime attributes and on inverting them to construct velocity models. He is also interested in Numerical Analysis, Numerical Linear Algebra, and Fractals. He is a member of SBMAC, 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 EAGE.

Klaus Mairan Laurido do Carmo received his BSc (2001) in Mathematics from the Federal University of Pará (Brazil). Presently, he is finishing his master's thesis entitled "Global Optimization methods applied in the search of the 2-D CRS stack parameters" at Federal University of Pará. His research interest is Applied Mathematics.

Pedro Chira-Oliva received his MSc in 2000 and PhD in 2003 from Federal University of Pará (Brazil), both in Geophysics. His research interests are macro-model independent imaging methods, seismic image wave methods and 3D modeling. He is a member of SBGf and SEG.

Jessé Carvalho Costa received his diploma in Physics in 1983 from the Physics Department, Federal University of Pará (UFPA) and a Doctor degree in Geophysics in 1993 from the Geophysics Department at the same University. He was a Summer Student at Schlumberger Cambridge Research in 1991 and 1992. He spent 1994 and 1995 as a post-doc in the Stanford Tomography Project at Stanford University. He held a faculty position the Physics Department at UFPA from 1989 to 2003. Currently his is Associate Professor in the Geophysics Department, UFPA. His fields of interest include seismic anisotropy, traveltime tomography and seismic modeling.

João Carlos Ribeiro Cruz received a BSc (1986) in geology, a MSc (1989), and a PhD (1994) in geophysics from the Federal University of Pará (UFPA), Brazil. From 1991 to 1993 he was with the reflection seismic research group of the University of Karlsruhe, Germany, while developing his PhD thesis. Since 1996 he has been full professor at the geophysical department of the UFPA. His current research interests include velocity estimation, seismic imaging, and application of inverse theory to seismic problems. He is a member of SEG, EAGE, and SBGF. Actually, he is the Director of the National Department of the Mineral Production of the Pará Province.

Eric Duveneck received his diploma in Geophysics from the University of Kiel, Germany, in 2000. Since March 2001 he has been a PhD student at the Geophysical Institute, Karlsruhe University. His research interests include seismic imaging and velocity model determination. He is a member of SEG and EAGE.

Jaime Fernandes Eiras received his diploma in geology in 1975 from the Pará University, Brazil. He joined Petrobrás in 1976, where he worked as a wellsite geologist until 1983, and as an exploration geologist until 2001. Since March 2002, he has been a visiting professor at the Geophysics Department of the ParÚniversity. As a basin interpreter, he has studied many of Brazil's offshore and onshore areas, such as Atlantic-type, paleozoic, rift, and multicyclic basins. His fields of interest are structural, stratigraphic, and seismic interpretation, especially seismic stratigraphy. He is a member of the Brazilian Geological Society.

Erik Ewig received his diploma in Geophysics in August 2003 from Karlsruhe University, Germany. His thesis dealt with residual static corrections by means of CRS attributes. He is a member of EAGE and SEG.

Carlos A.S. Ferreira received a BSc (1996) and a MSc (2000), both in physics, at Federal University of Pará. From 1997 to 2001, he spent some time studying geology, where he had the opportunity of working with some geophysical methods, such as vertical electric sounding and well logging, both as a geology graduate student. Presently, he is working towards his PhD in geophysics at Federal University of Pará, where the main topic of his thesis is prestack depth migration using Gaussian beams. His main research interests are quantum description via Ermakov invariants (in physics) and all forward and inverse seismic imaging techniques. He is member of SEG, SBPC and SBGf.

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).

German Garabito received his BSc (1986) in Geology from University Tomás Frias (UTF), Bolivia, his MSc in 1997 and PhD in 2001 both in Geophysics from the Federal University of Pará (UFPA), Brazil. Since 2002 he has been full professor at the geophysical department of UFPA. His research interests are data-driven seismic imaging methods such as the Common-Refection-Surface (CRS) method and velocity model inversion. He is a member of SEG, EAGE and SBGF.

Ellen de Nazaré Souza Gomes received her diploma in Mathematics in 1990 from University of Amazônia. She received her Master degree in Applied Mathematics in 1999 from the Mathematics Departament, Federal University of Pará. In 2003, she received her Doctor degree in Geophysics from Geophysics Department at the same University. Her fields of interest are anisotropy and seismic modeling. She has been professor at the Federal University of Pará since 1997.

Zeno Heilmann received his diploma in Geophysics from the University of Karlsruhe (TH) in October 2002. Since November 2002 he has been a research associate at the Geophysical Institute, Karlsruhe University. Currently he works on the development of the common-reflection-surface (CRS) stack, focusing on the influence of the top surface topography.

Thomas Hertweck received his diploma in Geophysics in May 2000 from Karlsruhe University, Germany, where he passed the exams with distinction. His thesis dealt with true-amplitude migration, demigration, and modeling by demigration. Since August 2000, he has been a research associate, computer system administrator, mentor, and teaching assistant at the Geophysical Institute, Karlsruhe University. He is part of the WIT headquarter and responsible for the WIT report and the WIT software CD. His fields of interest

are numerical analyses, development of seismic software (especially on Linux systems and parallel shared-memory machines), seismic ray theory, and seismic (true-amplitude) imaging. Currently, he focuses on the implementation of true-amplitude migration software in the context of a data-driven seismic imaging workflow based on the common-reflection-surface stack and the application on real data. He is a member of EAGE and 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, the SEG's Reginald Fessenden Award in 1979, and the EAGE's Erasmus Award in 2003. He is a regular member of DGG and an honorary member of the EAEG/EAGE 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.

Christoph Jäger received his diploma (with distinction) in Geophysics in February 2002 from Karlsruhe University. His thesis was about true-amplitude (de)migration and its implementation. Since March 2002, he has been a research associate at the Geophysical Institute in Karlsruhe. He is currently working on the efficient implementation and the application of true-amplitude (de)migration software. Christoph is also responsible for the maintenance of the WIT homepage. He is a member of EAGE and SEG.

Florian Karpfinger is a diploma student. Presently, he is working at the reservoir characterization group at the Free University Berlin. He is a member of the SEG, DGG, and EAGE.

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 interests are ray method and migration in anisotropic media. She is a member of EAGE.

Axel Kaselow received his diploma (M.Sc. equivalent) in Geology from Karlsruhe University in April 1999. Since then, he has been a research associate at the Geophysical Institute, Karlsruhe University, and became a member of WIT's internal steering committee. In January 2002 he joined WIT's rock physics group in Berlin. His research interests are 4D modeling and rock physics, and the development of rock physical software. He is currently working on seismic properties of porous and fractured rocks under stress, especially on the dependence of seismic velocities on pore fluid pressure. He is a member of the SEG and EAGE.

Tilman Klüver is currently writing his diploma thesis at the Geophysical Institute, Karlsruhe University. He works on tomographic inversion schemes using CRS attributes to determine smooth macrovelocity models for depth imaging.

Ingo Koglin received his diploma in geophysics in 2002 from Karlsruhe University. Since 2002 he has been a research associate at Karlsruhe University. His research interests include preparation and application of seismic wavefield attributes obtained by the CRS stack. He uses the attributes for inversion and to improve imaging. A second field of interest is the improvement of the CRS stack by means of residual static correction. He is a member of EAGE and SEG.

Oliver Krüger received his diploma in geophysics in 2002 from Freie Universität Berlin and is currently a PhD student at Freie Universität Berlin. His research interests focus on finite difference modeling, imaging and property prediction of fractured materials.

L.W.B. Leite is a 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.

Rômulo Correa Lima received his diploma in geophysics in 2002 from Geophysical Department of the Federal University of Pará, Brazil, with a thesis on Seismic Migration. In 2002 and 2003, he was a researcher in the seismic group of that university. Currently he is working on 3D modeling.

Stefan Lüth received his diploma in geophysics from the Technical University Clausthal in August 1996. His thesis was on numerical and methodical investigations on diving wave tomography. He then moved to Free University Berlin in order to work on a PhD project within the SFB 267 (Deformation Processes in the Andes). He processed and interpreted Wide-Angle and Seismic Refraction Data from the Andes. He defended his thesis at the FU Berlin in February 2000. Currently, he is a post-doc researcher working on imaging three-component seismic recordings along a tunnel or a VSP-configuration using 3D prestack migration. He is a member of DGG, AGU, and EAGE.

Jürgen Mann received his diploma in geophysics in 1998 from the Faculty of Physics, Karlsruhe University, with a thesis on Seismic Image Waves. In 2002, he received a doctorate in natural sciences (with distinction), again from the Faculty of Physics in Karlsruhe, with a thesis on the Common-Reflection-Surface Stack method. Since 1998 he has been a research associate at Karlsruhe University, since 2001 he is assistant to Prof. Peter Hubral. His fields of interest are seismic reflection imaging methods, especially data-driven approaches based on kinematic wavefield attributes. He is member of the EAGE and the SEG.

Alex Müller received his diploma in geophysics in December 2003 from Karlsruhe University, Germany. His thesis dealt with the implementation of the 3D CRS stack. He will continue his work as a PhD student.

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M. Amélia Novais received her M.Sc. in Mathematics from the Brazilian Institute of Pure and Applied Mathematics (IMPA) in 1993 and her PhD in Applied Mathematics from State University of Campinas (Unicamp) in 1998. Since 1996, she has been a professor for Mathematics at the Federal University of Sao Carlos (UFSCar), Brasil. She has joined Unicamp in April 2002. Her research interests focus on partial differential equations and include seismic forward imaging. In particular, she works with finite differences to obtain the solution of the acoustic and elastic wave equation, as well as with the Born and Kirchhoff approximations. Presently, she also studies image-wave equations. She is a member of SEG, EAGE, SBGf, SBMAC, and SBM.

Miltiadis Parotidis received his diploma in geodesy and geophysics (Diplom-Ingenieur) in January 1997, and his PhD (Doctor techn.) in June 2001, both from the Vienna University of Technology, Austria. Since November 2002 he has been a post-doc researcher at the Geophysics Department of the Freie Universität Berlin. His main research interests are hydraulic characterization of reservoirs, triggered seismicity by fluid injections, earthquake triggering mechanisms and signatures. He is a member of AGU, DGG, EAGE, EGU, and SEG.

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 since 1990. She is in charge of all WIT administrative tasks, including advertising, arranging meetings, etc. Email: Claudia.Payne@gpi.uka.de; phone: +49-721-608-4443, fax: +49-721-71173

Rodrigo Portugal received his B.Sc. (1995), M.Sc. (1998), and PhD (2002) in Applied Mathematics from the State University of Campinas (UNICAMP), Brasil. In his thesis he studied wavefront construction in the 2.5D situation and its application to the four Kirchhoff operations, namely: modeling, migration, demigration and demodeling. Currently he is an associate researcher of the Department of Geology and Natural Resources (DGRN) at UNICAMP. His research interests include wavefront propagation, numerical analysis, seismic imaging and inversion.

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Jörg Schleicher received a BSc (1985) in physics, an MSc (1990) in physics, and a PhD (1993) in geophysics from Karlsruhe University (KU), Germany. From 1990 to 1995, he was employed as a research fellow at KU's Geophysical Institute. From September 1995 to September 1996, he was a visiting scientist at the Institute for Mathematics, Statistics, and Scientific Computing of State University of Campinas (IMECC/UNICAMP) in Brazil with joint grants from the Brazilian Research Council CNPq and Alexander von Humboldt foundation. Since October 1996, he has been employed as an Associate Professor for Applied Mathematics at IMECC/UNICAMP. In 1998, he received SEG's J. Clarence Karcher Award. His research interests include all forward and inverse seismic methods, in particular Kirchhoff modeling and imaging, amplitude-preserving imaging methods, ray tracing, and model-independent stacking. He is a member of SEG, EAGE, DGG, SBGf, and SBMAC.

Uwe Schlifkowitz has just finished his diploma thesis at the Geophysical Institute, Karlsruhe University. His thesis dealt with the improvement of the Common-Reflection-Surface (CRS) stack method by developing a formula for an approximate time migration in the common-offset CRS stack.

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.

Christof Sick is a Ph.D. student and research associate at the Freie Universität Berlin. Presently, he is working in the random media group and the SFB267. His diploma thesis was about the analysis and modeling of the dynamics of spatio-temporal signals.

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

Miriam Spinner received her diploma in geophysics in December 2003 from Karlsruhe University, Germany. Her thesis dealt with an extension of true-amplitude (TA) Kirchhoff migration to handle data acquired on a measurement surface with topographic variations. She will continue her work as a PhD student at the Geophysical Institute in Karlsruhe. At the moment she studies the calculation of TA weights from traveltimes only in cooperation with the Hamburg WIT group.

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 B.Sc. 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. From 1995 to 1999, he was the president of the Brazilian Society of Applied Mathematics (SBMAC). In 2002, he received EAGE's Conrad Schlumberger Award. Prof. Tygel's research interests are in seismic processing, imaging and inversion. Emphasis is aimed on methods and algorithms that have a sound wave-theoretical basis and also find significant practical application. These include, for example, the unified approach of seismic reflection imaging (problem-specific combinations of true-amplitude migration and demigration) and, more recently, data-driven seismic imaging approaches such as the Common Refection Surface (CRS) method. Prof. Tygel is a member of SEG, EAGE, SBGf, and SBMAC.

Claudia Vanelle received her diploma in physics in 1997 and her Ph.D. in 2002, both from the University of Hamburg. Since 1997 she has been a research associate at the University of Hamburg and since 1998 at the Institute of Geophysics in Hamburg. In 2002 the Shell She-Study-Award was bestowed upon her in

appreciation of her Ph.D. thesis. Her scientific interests focus on true-amplitude migration and anisotropy. She is a member of EAGE and SEG.

Markus von Steht is currently working on his diploma thesis at the Geophysical Institute, University of Karlsruhe. His field of study focuses on the handling of rugged topography in the CRS stack and the application to synthetic and real data. He is a member of the SEG.

Mi-Kyung Yoon receeived her diploma from the TU/FU Berlin in 2001. Since 2001 she has been working as a Ph.D. student within the imaging group of the FU Berlin on imaging in random media. She is member of DGG, EAGE, and AGU.

Paola Chávez Zander is currently writing her diploma thesis at the Geophysical Institute, Karlsruhe University. Her thesis deals with the CRS stack, the velocity model determination from CRS attributes, and pre- and poststack migration. In particular, she is going to test the combination of the available imaging tools on several real datasets.

Yonghai Zhang received the Master Degree of Science in Theoretical Physics from Lanzhou University in P.R.China in June 1991. Until October 1993, he had been working as teaching assistant in the Physics Department of Lanzhou University. From November 1993 until September 1999, he had been working as lecturer. In May 2002, he received with his co-authors the EAGE “Eötvös Loránd Award” for the best paper published in Geophysical Prospecting in 2001. In 2003, he received a Ph.D. from Karlsruhe University. He is a member of EAGE and SEG.

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