Wave Inversion Technology Consortium

Wave Inversion Technology
established 1996 in Karlsruhe, Germany

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Institute of Geophysics
University of Hamburg

Hamburg, Germany

Universität Hamburg
DER FORSCHUNG | DER LEHRE | DER BILDUNG

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Preface

At the end of 2014, the Wave Inversion Technology Consortium looks back on eighteen years since its foundation. Eighteen years of WIT also mean eighteen years of financial support that provides an income for doctoral researchers, allows us to let students attend conferences, and provides resources we could otherwise not gain.

Your funding has greatly contributed not only to our research in seismic exploration but also to the education of the next generation of geophysicists. Since a substantial part of the work presented in this report was carried out by the WIT students in Brazil and Germany, we would like to share with you a few thoughts on the future Ph.D. education in Germany.

Traditionally, the German Ph.D. programme is research oriented, and to enter into this programme requires a master degree. There are no mandatory courses or lectures. The Ph.D. students are free to take courses in areas where they feel the need or desire for more in-depth knowledge or to broaden their view outside of their specific research topic.

This kind of research was driven by an intense relation between student and supervisor, therefore also sometimes called individual programme. This type of programme also offers a lot of freedom for the students to design their education in cooperation with their supervisors.

On the other hand, the so-called Bologna process has substantially changed the higher education in Germany over the last 15 years. B.Sc. and M.Sc. programmes were established. Because of too many external regulations, the B.Sc. programmes and sometimes even the M.Sc. programmes lack the flexibility and appear more like training than actual education. The strong emphasis on soft skills omits the necessity for a deeply-rooted foundation in, e.g., math and physics for students of natural science subjects.

There are new plans of European science administrators to establish the Ph.D. as the third level of higher education. These plans foresee so-called topic-oriented structural Ph.D. programmes with mandatory course work on the programme topic and soft skills. The supervision is performed by a panel comprising several professors and scientists.

Such programmes may have their virtues, however, in our view, to prescribe them as the primary recipe is a step in the wrong direction. Our results prove us right: Ph.D. research at WIT is and has always been topic oriented without being a formal structural programme.

In this report, you find the highlights of the WIT research in 2014 in terms of 23 papers, of which many were contributed by our promising students. The report covers a wide range of topics, beginning with but not restricted to a majority of papers on imaging. Articles on modelling and full wave form inversion complement the imaging research, and the report is rounded off with a variety of manuscripts dealing with other topics. All in all, we are proud to once again present an exciting account of our latest research.

The articles you find in the report are by no means the only good news of the year 2014. We are happy to share with you that Prof. Martin Tygel, team leader of WIT Campinas, has been elected as a member of the Brazilian Academy of Sciences. We congratulate Martin to this honour that expresses the recognition and appreciation of his lifetime achievements in science.

Other members of the WIT teams have also completed a significant step on their way to scientific renown: Tiago A. Coimbra, Eko Minarto, Sven Heider, and Martin Schäfer have successfully defended their Ph.D. in 2014, as well as Simone Butzer in January 2015. You will find some of their work not only in the report, but also on the accompanying CDROM and the WIT website.

As in previous years, WIT researchers have attended and presented their research at national and international conferences like the EAGE and SEG annual meetings and the International Workshop on Seismic Anisotropy (IWSA). A particular highlight was the EAGE workshop on multi-parameter stacking and processing that was organised amongst others by WIT members from the research teams as well as sponsors. In this workshop, thirteen contributions were received with high acclaim by 60 attendees and accompanied by spirited and inspiring discussions.

We close the preface by again thanking you for your continuing support. Without it, our work in the current form would not have been possible. On behalf of all WIT teams, researchers and students, we express our sincere appreciation and gratitude, and we are looking forward to continue our work in 2015.

Hamburg, 2015/23/02, Dirk Gajewski and Claudia Vanelle

Summary: WIT report 2014

IMAGING

Ahmed et al. apply a 3-D CRS workflow to data from a hard rock environment, where they emphasise the coherence-based seismic imaging approach. Their studies show that, in comparison to the actual stacks, coherence provides more information on the sub-surface, particularly on the geological structures.

Bakhtiari Rad et al. suggest a CRS-based workflow for the generation of prestack diffraction-only gathers. The method applies prestack data enhancement by partial stacking after performing a separation of reflected and diffracted events. Results for the complex Sigsbee 2A data as well as for field data not only confirm the applicability of the method, they also demonstrate the potential for time migration velocity analysis using diffraction-only data.

Bauer et al. introduce a straightforward decomposition principle for diffractions, which establishes a direct connection between zero-offset and common-offset information. This allows the ZO-based prediction of common-offset diffraction wavefield attributes. By fitting traveltimes they show that each common-offset diffraction operator may be decomposed into two independent zero-offset operators. Application to simple waveform data reveals the potential of the new method to reliably image diffractions in the common-offset domain.

Bauer et al. apply the previously introduced decomposition principle for diffractions to complex synthetic and marine field data. Combining the stability of zero-offset processing with the improved illumination in the common-offset configuration, the promising results reveal the potential of the new method to reliably enhance diffractions and attenuate reflections in pre-stack data and thus motivate a reliable pre-stack diffraction separation. High quality common-offset diffraction attributes favor the development of a diffraction-stereotomography.

Bobsin et al. derive a prestack time migration operator based on the i-CRS operator. The required time migration velocities are determined as a byproduct of the preceding i-CRS stack. The application to synthetic and field data leads to the promising conclusion that complex features like faults and diffractions are well resolved, as are the reflections.

Gonzalez et al. develop a practical approach to construct velocity models in the time and depth domains using seismic diffractions. This methodology applies plane wave destruction (PWD) filters jointly with the residual diffraction moveout (RDM) method. Its only requirements are the presence of identifiable diffraction events after filtering out the reflection events and an arbitrary initial velocity model as input. We compare post-stack migrated images (in the time and depth domains) with images migrated with models obtained from conventional seismic processing. In both cases, we used post-stack Kirchhoff migration. Beyond the need to identify and select the diffraction events in the post-stack migrated sections in the depth domain, the method has a very low computational cost. The processing time to reach an acceptable velocity model was 75% less as compared with conventional processing.

Santos et al. improve on the derivation of remigration-trajectory velocity analysis presented last year. Moreover, they present a detailed algorithm of the method and carry out additional numerical tests on synthetic datasets from three gradient models and the Marmousoft data. These tests demonstrate the feasibility of the method in more realistic situations with strong velocity variations in different directions.

Santos et al. develop a 3D depth-velocity model building based on 3D gravity inversion. Their method consists in determine the density distribution of specific bodies (targets), and replace them by coherent velocity values. This initial velocity model can be used together with migration velocity analysis tools, which in turn, can provide sufficient information to updated the initial geometric parameters for a recent gravity inversion. The main advantage of their technique is that it provide a iterative and robust algorithm that does not require the solution of an equation system. This joint processing and interpretation shows to be a fast alternative to improve the knowledge of complex structures like salt structures and sub-salt sediments.

Schwarz et al. revisit the concept of auxiliary media and provide a unified view on presently used stacking techniques. By introducing the inverse transformation from the optical to the effective domain, the authors emphasize that all higher order stacking operators, like the multifocusing approximation or the hyperbolic common-reflection surface, have two different *faces*. Synthetic examples indicate that these transformations not only contribute to unification, but that they also, i. e., when used in combination, provide unique opportunities for wavefield characterization and passive source time inversion.

Valente et al. present a strategy for time-to-depth conversion and velocity estimation based only on image-wavefront propagation. In particular, it makes use of a geometric manipulation to directly compute both the velocity field and the traveltime, avoiding a previous ray-tracing step. Moreover, it requires only the knowledge of the image-wavefront of the previous time step. It robustness is proved with its application on a simple synthetic example and on the Marmousi model. The quality of the results are evaluated by depth migrated images from the Marmousi data set with the extracted velocity models.

Vanelle et al. suggest an intuitive parametrisation for the CRS offset case. They introduce a new method to obtain the finite offset CRS attributes by extrapolation from either zero offset or another finite offset. These attributes can be used, e.g., as initial values for a global optimisation. Another important application is their incorporation into the partial stacking algorithm for pre-stack data enhancement. That technique currently requires a search for the zero-offset parameters that best describe the traveltime at a given offset, which is not only tedious and potentially non-unique, but also leads to a lower degree of accuracy than the use of the corresponding offset parameters. With the new method, the latter parameters are available. The resulting expressions are exact for planar reflectors. Generic examples with curved reflectors show that the offset parameters can be predicted with good accuracy.

Walda and Gajewski recognize that most current implementations of the CRS operator suffer from the occurrence of conflicting dip situations in the acquired data. To address this properly we apply the idea of the CDS to the i-CRS operator and show, that conflicting dips can be resolved well in multi-parameter processing. The results are promising and reveal a lot of potential for further applications. This is shown by a diffraction separation technique applied to field data obtained in the Levantine Basin.

Yang et al. suggest a partial time migration method for subsalt imaging. It combines the robustness of time migration with the data enhancement properties of multi-parameter stacking. The presented method is based on the generation of partially time-migrated gathers, i.e., prestack data in the common scatterpoint (CSP) domain, that are used as input for a subsequent multi-parameter stacking procedure. The results are kinematically equivalent to conventional prestack time migration results, but lead to better image quality because of the inherent prestack data enhancement capability. The application to a complex synthetic data set as well as to field data demonstrates a considerable improvement, not only in faults and salt boundaries, but also in the subsalt region.

MODELING

Bohlen and Wittkamp investigate the implementation of the multi-step Adams-Bashforth method to increase the temporal accuracy in FDTD seismic modelling. They show that the global accuracy of FDTD seismic modelling can be easily increased up to fourth order without significant additional computational costs. The price to pay is an moderate increase of the memory requirement which is feasible on modern parallel High-Performance computers.

FULL WAVEFORM INVERSION

Shigapov et al. investigate multiparameter viscoacoustic full waveform inversion. Sequential and parallel inversion strategies are applied to inverse problems with both spatially correlated and uncorrelated models. Results are shown for a simple 1D medium as well as the Marmousi model.

OTHER TOPICS

Behzadi et al. present a passive seismic imaging method based on moveout correction and cross-correlation stacking. The method takes into account and countermands effects due to geometrical spreading and reduces the impact of the acquisition footprint. Application to synthetic and field data examples demonstrates the performance of the method and shows that it succeeds in a reliable localisation not only for impulsive sources but also for microtremors.

Coimbra et al. propose a Kirchhoff-type, time migration algorithm that is optimal in two respects. First, the summation is performed along the common-reflection-point (CRP) curve (as opposed to the conventional diffraction-time hyperbola). Second, a small aperture, associated to the projected Fresnel zone (PFZ), is employed that is able to restrict the summation to that part of the CRP curve where constructive interference occurs. First real-data examples confirm that the technique has a good potential for high-quality, time migration imaging.

Faccipieri et al. investigate the use of different apertures tailored for reflection and diffraction enhancement events. The use of SSR moveouts with small apertures in midpoint, produced comparable results as the ones of conventional CRS with full-parameter reflection moveouts. In both cases, reflections are enhanced and diffractions attenuated. However, using the DSR moveout with large midpoint apertures produced stacked sections in which diffractions are enhanced and reflections attenuated. The quantification of small and large apertures was defined using an approximation of the PFZ for optimal overall imaging.

Gelius and Tygel propose a generalized higher-order screen propagator to be used in modelling and migration in the frequency-wavenumber domain. The new formulation is compared with other known screen propagators and its superior behaviour is demonstrated.

Schleicher and Costa discuss the pseudo-S wave in VTI media and show how their occurrence can be avoided. A Padé approximation with slightly unconventional numbers for the Padé coefficients led to the best approximation. An implementation of a low-rank approximation to this equation demonstrated that is can provide high-accuracy wavefields even in strongly anisotropic inhomogeneous media.

Vefagh et al. introduce an approach for multiple attenuation, which is applicable to any type of multiple reflection including internal multiples. It includes picking zero-offset traveltimes in a stacked section, which are then used to predict the pre-stack multiples with the help of the stacking velocity. This method performs stable for dipping reflectors and far offsets. Furthermore, it does not require high computational effort. Both synthetic and field data examples illustrate the potential of the method.

Walda and Gajewski suggest the use of a genetic algorithm for the global optimization in the CRS context. The CRS operator improves the signal to noise ratio significantly due to the consideration of neighboring midpoints as well as the offset. The determination of the required attributes for the CRS operator is often done by the pragmatic approach to get initial values that are refined by a local optimization. This approach has limitations. Therefore we propose to use a genetic algorithm based optimization and show that the stack and especially the determined attributes are significantly improved.

Witte et al. investigate the properties of the semblance function in the two-dimensional CRS stack and propose a modified version of the conjugate direction method for its optimization. Instead of relying on initial guesses from the pragmatic approach, an initial starting guess for the final local optimization is obtained by coarsely sampling the objective function along a one-dimensional direction.

The Wave Inversion Technology (WIT) Consortium

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The Wave Inversion Technology Consortium (WIT) was established in 1996 and is organized by the Institute of Geophysics of the University of Hamburg. It consists of three integrated working groups, one at the University of Hamburg and two at other universities, being the Mathematical Geophysics Group at Campinas University (UNICAMP), Brazil, and the Geophysical Institute of the Karlsruhe University. In 2003, members of the Geophysical Department at the Federal University of Pará, Belém, Brazil, have joined WIT as an affiliate working group. In 2007, NORSAR joined WIT as research affiliate. In 2010, Fraunhofer ITWM joined WIT as research affiliate.

The WIT Consortium offers the following services to its sponsors:

a.) research as described below;

b.) deliverables;

c.) technology transfer and training.

The ultimate goal of the WIT Consortium is a most accurate and efficient target-oriented seismic modelling, imaging, and inversion using elastic and acoustic methods. Within this scientific context it is our aim to educate the next generations of exploration geophysicists.

Exploration and reservoir seismics aims at the delineation of geological structures that constrain and confine reservoirs. It involves true-amplitude imaging and the extrapolation of the coarse structural features of logs into space. The goals on seismic resolution are constantly increasing which requires a complementary use of kinematic and wave equation based techniques in the processing work flow. At WIT we use a cascaded system of kinematic and full wave form model building and imaging techniques. Since our data and inversions are never perfect it is the challenge to find those techniques which produce the best images for erroneous velocities and faulty wave forms.

RESEARCH TOPICS

The WIT consortium has the following main research directions, which aim at characterizing structural and stratigraphic subsurface properties. Some of the topics are studied by more than one team, applying different approaches. The WIT research is divided into five subgroups:

Processing and Imaging

The Common Reflection Surface (CRS) concept plays a key role in the WIT research on processing and imaging. The WIT hyperbolic CRS and non-hyperbolic i-CRS stacking operators are based on this concept and represent the backbone of many research topics.

- global (ZO CRS) vs. local (CO CRS) approximations
- estimation of CO CRS attributes from ZO attributes
- amplitude-friendly CRS processing
- improved conflicting dip processing
- 3-D i-CRS operator
- wavefield decomposition using stacking attributes (multiples, reflections, diffractions)
- utilizing super resolution
- pre-stack diffraction/reflection separation
- 5-D CRS and i-CRS interpolation and pre-stack data enhancement
- improved coherence measures (MUSIC, cross-correlation, analytical trace, etc.)
- optimization of multi-dimensional coherence analysis
- data driven isotropic and anisotropic time migration
- wavefield decomposition and filtering in the CSP domain
- inverse CSP mapping
- CRS and diffraction processing of 3-D hard rock data
- angle domain migration
- beam migration
- image wave re-migration
- migrated-domain CRS methods

Model Building

Most of our model building approaches also exploit the CRS concept, which may be applied in the data or time migrated domain.

- diffraction focusing velocity analysis
- diffraction stereotomography
- passive seismic data velocity model update
- CRS based time to depth conversion
- tomographic inversion of stacking attributes

Full Waveform Inversion

Research on Full Waveform Inversion (FWI) is moving toward applications to marine reflection seismic data and near surface seismic data (surface waves) and three-component Vibroseis data acquired in crystalline rocks.

- development of robust preprocessing of seismic data for FWI
- multi-parameter FWI
- source wavelet inversion
- accurate methods for geometrical spreading correction
- implementation of 3-D acoustic/elastic/viscoelastic FWI on HPC machines
- FWI in viscoelastic media
- optimization of Finite-Difference forward solvers used in FWI with respect to MPI communication, higher order time integration, variable spatial discretization and smooth free surface topography
- application of pseudo spectral methods in FWI

Modeling and RTM

In modeling and RTM we use FD, FE, and pseudo spectral approaches. Optimizations of the computational effort is highest on the agenda.

- 2-D and 3-D RTM for VTI and TTI media (spectral methods)
- 2-D and 3-D acoustic and elastic RTM (FD methods)
- finite element (FE) elastic wavefield modeling
- computational optimizations of FD and spectral method approaches for acoustic, elastic, and anisotropic media, including benchmarking
- improved one-way wave equation
- reflection impedance description of reflection coefficients
- tuning effects in AVO and AVA

Passive Seismics

Passive seismic signals as a diffraction event provide the link to reflection seismics. Located diffractions or micro-earthquakes provide natural Green's functions for reflection imaging.

- optimization of model domain stacking and time domain localization approaches
- high resolution full waveform relative event localization
- microtremor localization
- interferometric re-localization
- development of fast time-domain localization technique
- localization uncertainties (apertures, velocities, bandwidth, acquisition footprint)
- real time processing methodology

WIT STEERING COMMITTEES

Internal Steering Committee

Name	WIT team
Thomas Bohlen	Karlsruhe
Norman Ettrich	ITWM
Dirk Gajewski	Hamburg
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Shinichi Itoh	Hanshin Consultants
Dan Grygier	Landmark Graphics Corporation
Jan Erik Lie	Lundin
Rune Øverås, Jon Sandvik	PSS-Geo
Henning Trappe	TEEC

COMPUTING FACILITIES

The Hamburg group has access to a 264 nodes (16 dual core CPUs, 8448 cores in total) IBM p575 "Power6" cluster at the German Computer Center for Climate Research (Deutsches Klimarechenzentrum, DKRZ) for numerically intensive calculations. It is equipped with 20 TeraByte of memory and its performance per core is 18.8 GigaFlops. There is also access to an IBM Linux cluster (Intel XEON). A SUN Fire X4600 (8 dual core Opteron, 32 GB) is exclusively available for the group's computing demands. Additional computer facilities consist of several Linux workstations and Linux PCs. Furthermore, the group has exclusive access to a Maxeler MaxWorkstation with a 24 GB memory MAX3 acceleration card which is FPGA based.

The research activities of the Campinas Group are carried out in the Computational Geophysics Laboratory. The Lab has 15 Linux PC workstations connected by a dedicated high-speed network, suitable for parallel processing. Educational grants provide seismic packages from leading companies such as Landmark and Paradigm. Besides State Government funds, substantial support both for equipment and also scholarships are provided by the Brazilian Oil Company Petrobras. An extension of the Lab with substantial increase of computer power and space in the new facilities of the Center of Petroleum Studies went fully operational in 2012. The new Lab extension counts on another 30 Linux PC workstations that rely on resources shared by a high-performance server and provide access to a 3Tflops cluster with 2TB RAM. The LGC also has remote access to the computing facilities of the Petrobras Research Center in Rio de Janeiro.

The local facilities of the WIT group in Karlsruhe mainly consist in about 30 clustered quad-core Linux workstations. For large-scale computational tasks, a Hewlett-Packard XC3000 (HC3) Linux cluster and is available on campus. It hosts about 300 nodes with two quad cores each. The total nominal peak performance is 27 Teraflops, the total main memory 10 Terabyte. About 300 Terabyte disk space are available via a Lustre file system and an InfiniBand interconnect. Sharing the same file system, the WIT group in Karlsruhe co-funded and has exclusive access to the SCC Institutscluster 2 (IC2) which is a distributed memory parallel computer with 400 16-way compute nodes where each node has two Intel Xeon Octa-Core sockets with Sandy Bridge architecture, 2.6 GHz frequency and 64 GB local memory. The total nominal peak performance is 132 Teraflops, the total main memory 28.3 Terabyte. In addition, the WIT group in Karlsruhe has access to the computing facilities of the state-owned bwGRiD consisting of a total of 101 IBM blades centers distributed over seven universities in Baden-Württemberg. Furthermore, successful project proposals at the Jülich Supercomputing Centre (JSC) and the High Performance Computing Center Stuttgart (HLRS) has granted access and a large volume of computing hours for the Juropa Clustercomputer and the Cray Hermit Supercomputer. The Juropa super computer consists of 8640 cores total, 52 Terabyte main memory with a peak performance of 101 TeraïňĆops, while the Hermit cluster computer consists of 3552 cores total, about 150 Terabyte main memory and with a peak performance of 1.045 Petaflops. Both super computers will be used for large scale forward simulation and full waveform tomographies.

The main computing facility at the Geophysics Graduation Program in Belém is the Seismic Processing Lab (ProSis). The hardware resources include: several networked Linux-PCs and for large-scale applications, a cluster of PCs with 15 dual-processor nodes with Tesla GPGPU cards in 8 nodes. The proprietary software packages available for seismic applications are ProMAX and MATLAB.

Fraunhofer ITWM builds up new compute clusters early 2014. The largest machine consists of 192 dual Intel Xeon E5-2670 ("Sandy Bridge") (i.e. 16 CPU cores per node) with 64 GB RAMeach, 300 GB HDD, 2x Gigabit Ethernet and FDR Infiniband interconnect. In total, 3072 CPU cores, 12 TB main memory, and 57 TB disk space. Estimated peak performance is 56 TFlops. In addition, 4 quad Intel Xeon E5-4650L ("Sandy Bridge") (i.e. 32 CPU cores per node) with 256 GB RAM, 2x 500 GB HDD will be available. The storage system consists of 12 storage servers, connected via FDR Infiniband an 10 Gigabit Ethernet with a total capacity of 200 TB via the Fraunhofer file system. In addition, the HPC department of ITWM runs a cluster with 92 compute nodes, among them 60 Intel Xeon E5-2680 IvyBridge nodes.

Disk capacity will be 270 TBytes.

WIT research personnel

Ivan Abakumov received his MSc from St. Petersburg University in 2013. He is now a PhD student in the University of Hamburg. His research interests are time imaging, converted waves, time-lapse seismic, full waveform inversion, geophysical data processing and computer programming. Ivan is a student member of EAGE, SGE and SPE.

Peter Adetokunbo received a B.Tech. in Applied Geophysics from the Federal University of Technology, Akure, Nigeria in 2007 and is currently a M.Sc. student in Geophysics at Earth Science Department, King Fahd University of Petroleum and Minerals, Saudi Arabia. His research interests focus on frequency dependent seismic attenuation, seismic imaging and interpretation. He is a member of SEG, SPE and IAH.

Niklas Ahlrichs is a M.Sc. student in geophysics at the University of Hamburg. His research interests focus on conflicting dips, diffractions and CRS.

Khawar Ashfaq Ahmed received a B.Sc. from the University of the Punjab in Lahore, Pakistan, in 2005. He received a M.Sc. in Geophysics in 2007 and a M.Phil. in Geophysics in 2009, both from the Quaid-i-Azam University in Islamabad, Pakistan, where he also worked for three years as teaching and research associate in the Department of Earth Sciences. Since 2010, he is enrolled at the University of Hamburg as a Ph.D. student in Geophysics. His recent work is 3D seismic processing with hybrid approach and diffraction mapping. His current research work is on seismic imaging in 3D Schneeberg data (crystalline environment).

Denis Anikiev received his MSc in geophysics in 2011 from Saint Petersburg State University, Russia, with a thesis "Methods of dynamic inverse problem for horizontally homogeneous media". He participated in an exchange program with Hamburg University in 2006-2009 during his work on the BSc thesis "Localization of Seismic Events by Diffraction Stacking". Since 2011 he is a Ph.D. student at Earth Physics Department in Saint Petersburg State University. The preliminary title of his Ph.D. thesis is 'Reverse-time migration in isotropic elastic media'. His present research interests include elastic reverse-time migration, full waveform inversion, localization of seismic events, localization of microtremors, dynamic inverse problems for acoustic layered media. He is a student member of SEG, EAGE, SPE.

Parsa Bakhtiari Rad received a B.Sc. in Mine Exploration Engineering from the Islamic Azad University, Iran, in 2005 and received a M.Sc. in Exploration Seismology in 2008 from the same university with a thesis title "Application of Karhunen-Loeve Filter in Multiple Attenuation Camparison with Radon Transform on Seismic Reflection Data". He also worked for almost three years as a Data Analyst in 2D/3D seismic data processing center of OEOC-CGG companies in Tehran and as a geophysicist in data acquisition fields for geophysical section of National Iranian Oil Company(NIOC) as well. In 2012, he enrolled at the University of Hamburg as a Ph.D. student in Geophysics. His main research interest is processing and imaging of seismic diffractions.

Alexander Bauer received an M.Sc. in Geophysics from Hamburg University in 2014 and is currently a PhD student in the Hamburg WIT group. His research interests focus on imaging and processing of seismic diffractions.

Mehrnoosh Behzadi has received her B.Sc. in physics (2004) and M.Sc. in seismology (2009) from Islamic Azad University of Tehran, Iran. Since 2011, she is a Ph.D. student in the Hamburg WIT group. Her research interests include passive seismics, site effects, and microseismicity. She is a member of EAGE.

Ricardo Biloti received his B.Sc.(1995), M.Sc. (1998) as well as Ph.D. (2001) in Applied Mathematics from the State University of Campinas (UNICAMP), Brazil. He worked at Federal University of Paraná (UFPR), Brazil, as an Adjoint Professor, at the Department of Mathematics, from May 2002 to September 2005, when he joined Unicamp as an Assistant Professor. He has been a collaborator of the Campinas Group since his Ph.D. 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 (Brazilian Society of Applied Mathematics), SIAM and SEG.

Martina Bobsin is a Ph.D. student at the University of Hamburg. Her research interests focus on time migration and demigration. She received her M.Sc. (2014) and B.Sc. (2012) in geophysics at the University of Hamburg. Topics of her work were the application of multiparameter stacking operators.

Thomas Bohlen received a Diploma of Geophysics (1994) and a Ph.D. (1998) from the University of Kiel, Germany. From 2006 to 2009 he has been Professor of Geophysics at the Institute of Geophysics at the Technical University Freiberg where he has been the head of the seismics and seismology working groups. Since 2009, he is Professor of Geophysics at the Geophysical Institute of the Karlsruhe Institute of Technology. He is the head of the applied geophysics group. His research interests and experience include: seismic modelling, full waveform inversion, surface wave inversion and tomography, reflection seismic imaging. He is a member of SEG, EAGE, AGU, ASA, and DGG (member of the executive board).

Alexandre William Camargo received his BS (2011) in Applied Mathematics from the State University of Campinas (UNICAMP), Brazil. He is currently about to finish the Master Science in Applied Mathematics in the same university. His professional interests include seismic modeling and numerical methods for differential equations. He is member of SEG (Society of Exploration Geophysicists).

Pedro Chira Oliva, received his diploma in Geological Engineering (UNI-Peru/1996). He received his MSc., in 1997 and PhD., in 2003, both in Geophysics, from Federal University of Pará (UFPA/Brazil). He took part of the scientific research project "3D Zero-Offset Common-Reflection-Surface (CRS) stacking" (2000-2002) sponsored by Oil Company ENI (AGIP Division - Italy) and the University of Karlsruhe (Germany). Currently he is full Professor at the Institute of Coastal Studies (IECOS) of UFPA. His research interests include seismic stacking and seismic modeling. He is member of GOCAD consortium (France) and SBGf.

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