Welcome to the fourth *TCCS Newsletter*!

The Texas Consortium for Computational Seismology is a joint initiative of the Bureau of Economic Geology (BEG) and the Institute for Computational Engineering and Science (ICES) at The University of Texas at Austin. Its mission is to address the most important and challenging research problems in computational geophysics as experienced by the energy industry while educating the next generation of research geophysicists and computational scientists.

TCCS Sponsors

TCCS appreciates the support of its sponsors: BP, Chevron, CGG, ConocoPhillips, ExxonMobil, Saudi Aramco, Schlumberger, Shell, Statoil, and Total.

For sponsorship opportunities, please contact sergey.fomel@beg.utexas.edu.

Fall Meeting

The Fall 2013 Research Meeting of the Texas Consortium for Computational Seismology will take place in Austin, TX, on September 30 and October 1 and will be hosted by the Institute for Computational Engineering and Science in the O'Donnell Building for Applied Computational Engineering and Sciences (POB) on the University of Texas at Austin main campus.

Representatives of participating companies are invited to register for the meeting by following the link at http://www.beg.utexas.edu/tccs/

Presentations at SEG in Houston

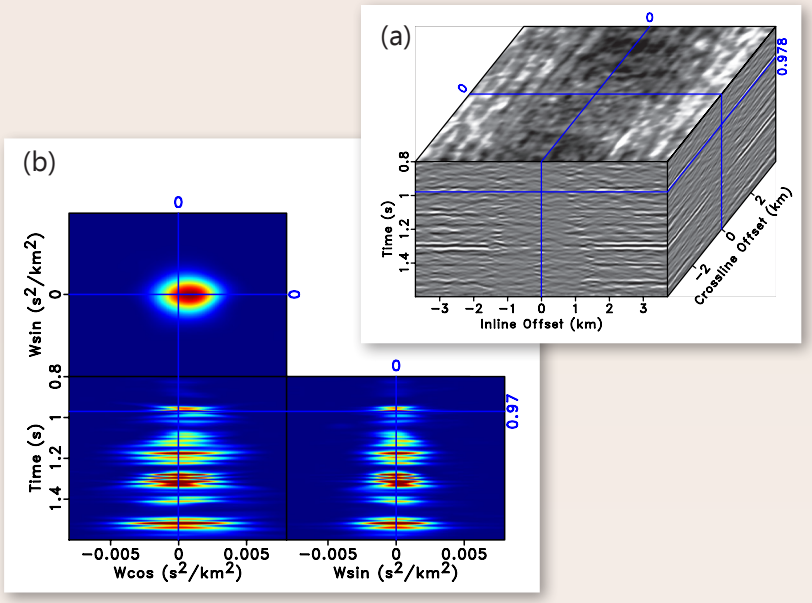
SEG Houston 2013

TCCS members and collaborators will make several presentations at the upcoming SEG 2013 Annual Meeting in Houston.

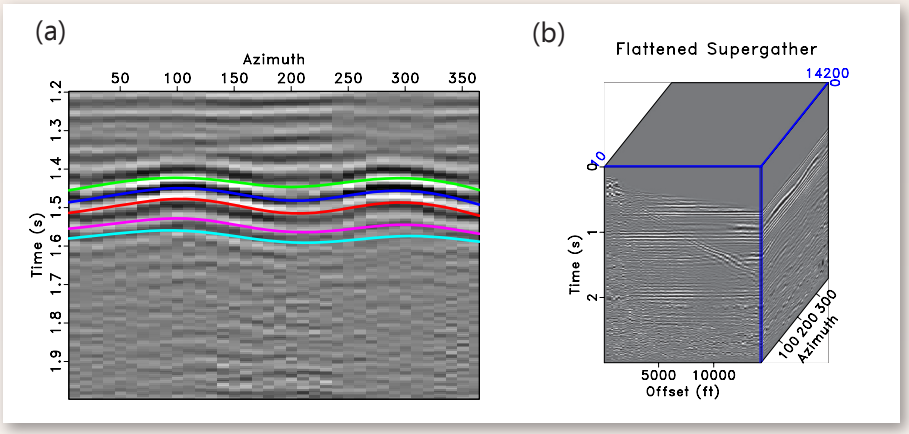
Monday, Sept. 23	4:00 pm	SPMI 1: Beam and Kirchhoff Migration	A. Klokov and S. Fomel	Seismic diffraction imaging, one migration dip at a time
	4:25 pm	SPMI 1: Beam and Kirchhoff Migration	S. Fomel	Wave-equation time migration
Tuesday, Sept. 24	9:40 am	SPMI P2: Diffraction Imaging and Fracture Detection	L. Decker, A. Klokov, and S. Fomel	Comparison of seismic diffraction imaging techniques: Plane wave destruction versus apex destruction
	10:00 am	TL E-P1: Watching Carbon Come and Go	R. Zhang, X. Song, S. Fomel, M. Sen, and S. Srinivasan	Time-lapse seismic registration and inversion for CO_2 sequestration study at Cranfield: Part II: Pre-stack analysis
	2:30 pm	ST P1: Traveltime and Wavefield	X. Yang, J. Lu, and S. Fomel	Seismic modeling using the frozen Gaussian approximation
Wednesday, Sept. 25	8:55 am	FWI 4: Elastic and Non-Linear Inversion	J. Cheng and S. Fomel	Fast algorithms for elastic-wave-mode separation and vector decomposition using low-rank approximation for anisotropic media
	9:40 am	INT E-P2: Attributes and Visualization	P. Karimi and S. Fomel	Computing volumetric-curvature attributes using predictive painting
	10:40 am	INT E-P2: Attributes and Visualization	P. Karimi and S. Fomel	Predictive coherency
	1:30 pm	SPIR 1: Compressive Sensing and Applications	P. Yang, J. Gao, and W. Chen	An iterative half thresholding method for seismic data interpolation
	4:25 pm	ACQ 3: Blending and Deblending	Y. Chen, S. Fomel, and J. Hu	Iterative deblending of simultaneous-source seismic data using shaping regularization
Thursday, Sept. 26	8:30 am	ANI 1: Fractures, Shale, Well-Log-Integration, and Case Studies	M. Far, J. Figueiredo, R. Stewart, and N. Dyaur	Measurements of anisotropy parameters with variable frequency and stress in synthetic fractured media
	8:30 am	SPMI 6: Advanced Migration Algorithms	T. Alkhalifah, Z. Wu, and S. Fomel	Exploring imaging capabilities of the extended prestack wavefield
	8:55 am	SVE 3: Tomography and More	J. Hu, S. Fomel, and L. Ying	A fast algorithm for 3D azimuthally anisotropic velocity scan
	9:20 am	SI 3: Case Studies	M. Far, B. Hardage, and D. Wagner	Inversion of elastic properties of fractured rocks from AVOAz data—Marcellus Shale example
	9:20 am	SPNA E-P2: Filtering	Y. Chen and J. Ma	Random noise attenuation by f-x empirical mode decomposition predictive filtering
	9:20 am	SVE 3: Tomography and More	S. Li and S. Fomel	A robust approach to time-to-depth conversion in the presence of lateral-velocity variations
	10:10 am	SM 4: Finite Differences	G. Fang, Q. Du, and S. Fomel	Seismic wave extrapolation on a staggered grid using low-rank decomposition and low-rank finite differences
	10:35 am	RP 5: Carbonate Models and Measurements	M. Far, J. Figueiredo, R. Stewart, and N. Dyaur	Fracture compliance measurements in synthetic fractured media
	10:35 am	SPMI 6: Advanced Migration Algorithms	J. Sun and S. Fomel	Low-rank one-step wave extrapolation
	11:40 am	FWI E-P1: Development and Applications	S. Li	Wave-equation migration velocity analysis by non-stationary focusing
	1:30 pm	W-10: Gathers for Modern Migration Algorithms	A. Klokov	Application of dip-angle gathers in diffraction imaging
Friday, Sept. 27	11:30 am	W-18: Advances in Computational Mathematics for Geophysicists	B. Engquist	Sweeping preconditioners
	12:00 pm	W-18: Advances in Computational Mathematics for Geophysicists	S. Fomel	Wave propagation using lowrank symbol approximation
	3:50 pm	W-15: Are We Able to Detect and Characterize Fractures?	M. Far	Fracture characterization in Marcellus shale using multicomponent seismic data

Research Highlights

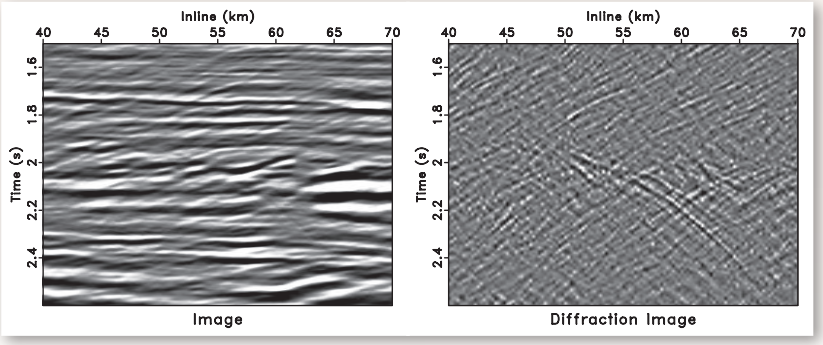
Jingwei Hu has developed a fast algorithm for 3D azimuthally anisotropic velocity scans by extending the butterfly algorithm for hyperbolic Radon transform. A subset of the McElroy dataset from West Texas was formed in a supergather (a). Though the data have been isotropically NMO corrected, we see some nonzero values of anisotropic parameters on the semblance plot (b); obtaining these data with the fast algorithm took only 45 seconds. By contrast, direct computation in the same situation would have required approximately 30 hours.



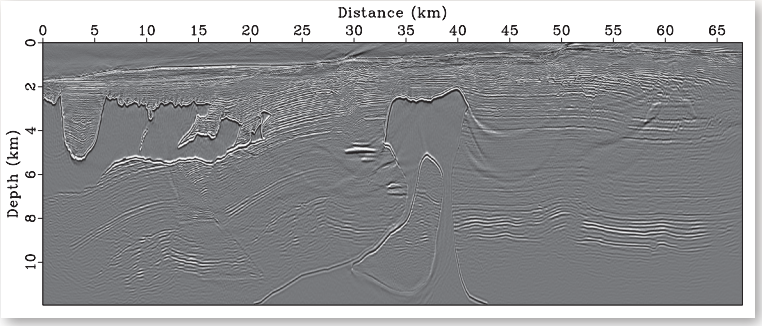
Mehdi E. Far is developing new methods for realistic anisotropic velocity model building using inversion of reflection amplitudes and reflection moveouts. Mehdi is using predictive painting to automatically identify reflections and use them for inversion. The figure shows a common-offset section from Marcellus shale data with azimuthal variation in traveltimes and amplitudes. Using predictive painting, CMP gathers can be flattened automatically enabling extraction of amplitude and moveout information.



Luke Decker has been working with Alexander Klokov and Sergey Fomel to develop a new method of seismic diffraction imaging that is able to successfully extract diffraction events in regimes where data-domain plane-wave destruction's requirement of continuously variable reflection event slope is violated by selecting diffractions in the partial image domain. This figure shows an example diffraction image using the new method on the Viking Graben dataset.



Using lowrank decomposition, **Gang Fang**, a visiting Ph.D. student from China, developed two new seismic wave extrapolation methods on a staggered grid: a staggered-grid lowrank (SGL) method and a staggered-grid lowrank finite difference (SGLFD) method. The figure depicts the result using the SGLFD method for RTM in a BP2004 model exhibiting strong velocity and density contrasts.



Madagascar Working Workshop

Several TCCS members participated in the First Madagascar Working Workshop, which took place in Austin on July 25-27 and attracted 25 participants from 9 different organizations. The participants divided into 10 teams of 2-3 people by pairing experienced Madagascar developers with novice users. Each team worked on a small project, updating either reproducible papers or entries in the migration gallery.

Graduate Portfolio in Computational Geosciences

The University of Texas at Austin is starting a Graduate Portfolio Program in Computational Geosciences. Portfolio programs are opportunities for students to obtain credentials in a cross-disciplinary academic area of inquiry while completing the requirements for a master's or doctor's degree in a particular discipline.

The Computational Geosciences Graduate Portfolio Program requires the completion of five courses with a grade of at least B. Moreover, each student's portfolio must include courses from at least two departments outside the student's home department. The five courses are as follows:

- SSC 394 Scientific and Technical Computing.
- At least two computational geosciences courses, such as GEO 384W Seismic Imaging or GEO 391 Multidimensional Data Analysis.
- At least two "methods" courses, such as SSC 394C Parallel Computing, CSE 383C Numerical Analysis: Linear Algebra, or CSE 383L Numerical Analysis: Differential Equations.

In addition, students in the portfolio program are expected to deliver a seminar in the computational geosciences seminar series describing their research and how it integrates the different areas of computational geosciences.

Papers accepted and published 2012–2013

Accepted

B. Engquist, B. Froese, and R. Tsai, 2013, Fast sweeping methods for hyperbolic systems of conservation laws at steady state: Journal of Computational Physics, accepted.

S. Fomel, 2013, Seismic data decomposition into spectral components using regularized nonstationary autoregression: Geophysics, accepted.

J. Hu and S. Jin, 2013, On the quasi-random choice method for the Liouville equation of geometrical optics with discontinuous wave speed: Journal of Computational Mathematics, accepted.

J. Hu and L. Ying, 2013, A fast algorithm for the energy space boson Boltzmann collision operator: Mathematics of Computation, accepted.

A. Klokov and S. Fomel, 2013, Selecting an optimal aperture in Kirchhoff migration using dip-angle images: Geophysics, accepted.

S. Li, A. Vladimirsky, and S. Fomel, 2013, First-break traveltime tomography with the double-square-root eikonal equation: Geophysics, accepted.

R. Zhang, X. Song, S. Fomel, M. K. Sen, and S. Srinivasan, 2013, Time-lapse seismic data registration and inversion at Cranfield: Geophysics, accepted.

Published 2013

G. Ariel, B. Engquist, S. Kim, Y. Lee, and R. Tsai, 2013, A multiscale method for highly oscillatory dynamical systems using a Poincaré map type technique: Journal of Scientific Computing, v. 54, 247-268.

Y. Cai, S. Fomel, and H. Zeng, 2013, Automated spectral recomposition with application in stratigraphic interpretation: Interpretation, v. 1, SA109-SA116.

Z. Chen, S. Fomel, and W. Lu, 2013, Omnidirectional plane-wave destruction: Geophysics, v. 78, V171-V179.

Z. Chen, S. Fomel, and W. Lu, 2013, Accelerated plane-wave destruction: Geophysics, v. 78, V1–V9.

J. Chu, B. Engquist, M. Prodanovic, and R. Tsai, 2013, A multiscale method coupling network and continuum models in porous media II: single- and two-phase flows: Advances in Applied Mathematics, Modeling, and Computational Science, v. 66, 161-185.

B. Engquist and L. Ying, 2013, A fast algorithm for reiterated homogenization: Communications in Mathematical Sciences, v. 11, 635-649.

M. Far, L. Thomsen, and C. Sayers, 2013, Seismic characterization of reservoirs with asymmetric fractures: Geophysics, v. 78, N1-N10.

M. Far, C. Sayers, L. Thomsen, D. Han, and J. Castagna, 2013, Seismic characterization of naturally fractured reservoirs using amplitude versus offset and azimuth: Geophysical Prospecting, v. 61, 427-447.

S. Fomel, L. Ying, and X. Song, 2013, Seismic wave extrapolation using lowrank symbol approximation: Geophysical Prospecting, v. 61, 526–536.

S. Fomel and R. Kazinnik, 2013, Nonhyperbolic common reflection surface: Geophysical Prospecting, v. 61, 21-27.

J. Hu, S. Fomel, L. Demanet, and L. Ying, 2013, A fast butterfly algorithm for the hyperbolic Radon transform: Geophysics, v. 78, U41-U51.

S. Li and S. Fomel, 2013, Kirchhoff migration using eikonal-based computation of traveltime source-derivatives: Geophysics, v. 78, S211-S219.

Y. Liu and S. Fomel, 2013, Seismic data analysis using local time-frequency transform: Geophysical Prospecting, v. 61, 516–525.

J. Poulson, B. Engquist, S. Li, and L. Ying, 2013, A parallel sweeping preconditioner for high frequency heterogeneous 3D Helmholtz equations: SIAM Journal on Scientific Computing, v. 35, C194-C212.

J. Poulson, B. Marker, R. A. van de Geijn, J. R. Hammond, and N. A. Romero, 2012, Elemental: a new framework for distributed memory dense matrix computations, ACM Transactions on Mathematical Software, v. 39, 13:1-13:24.

C. Saragiotis, T. Alkhalifah, and S. Fomel, 2013, Automatic traveltime picking using instantaneous traveltime: Geophysics, v. 78, T53–T58.

X. Song, S. Fomel, and L. Ying, 2013, Lowrank finite-differences and lowrank Fourier finite-differences for seismic wave extrapolation: Geophysical Journal International, v. 193, 960-969.

X. Song and T. Alkhalifah, 2013, Modeling of pseudo-acoustic P-waves in orthorhombic media with lowrank approximation: Geophysics, v. 78, C33-C40.

Published 2012

A. Abdulle, E. Weinan, B. Engquist, and E. Vanden-Eijnden, 2012, The heterogeneous multiscale method: Acta Numerica, v. 21, 1-87.

G. Ariel, B. Engquist, and Y.-H. R. Tsai, 2012, Oscillatory Systems with Three Separated Time Scales: Analysis and Computation: Numerical Analysis of Multiscale Problems (Lecture Notes in Computational Science and Engineering), v. 82, 23-45.

L. Demanet, M. Ferrara, N. Maxwell, J. Poulson, and L. Ying, 2012, A butterfly algorithm for synthetic aperture radar imaging: SIAM Journal on Imaging Sciences, v. 5, 203-243.

L. Demanet and L. Ying, 2012, Fast wave computation via Fourier integral operators: Mathematics of Computation, v. 81, 1455-1486.

B. Engquist, H. Holst, and O. Runborg, 2012, Multiscale Methods for Wave Propagation in Heterogeneous Media Over Long Time: Numerical Analysis of Multiscale Problems (Lecture Notes in Computational Science and Engineering), v, 82, 167-186.

B. Engquist and L. Ying, 2012, Fast algorithms for high frequency wave propagation: Numerical Analysis of Multiscale Problems (Lecture Notes in Computational Science and Engineering), v. 83, 127-161.

B. Engquist, J. Häggblad and O. Runborg, 2012, On energy preserving consistent boundary conditions for the Yee scheme in 2D: BIT Numerical Mathematics, v. 52, 615-637.

J. Häggblad and B. Engquist, 2012, Consistent modeling of boundaries in acoustic finite-difference time-domain simulations: Journal of Acoustical Society of America, v. 132, 1303-1310.

J. Hu and L. Ying, 2012, A fast spectral algorithm for the quantum Boltzmann collision operator: Communications in Mathematical Sciences, v. 10, 989-999.

A. Klokov and S. Fomel, 2012, Separation and imaging of seismic diffractions using migrated dip-angle gathers: Geophysics, v. 77, S131-S143.

L. Lin, J. Lu, L. Ying, W. E, 2012, Adaptive local basis set for Kohn–Sham density functional theory in a discontinuous Galerkin framework I: Total energy calculation: Journal of Computational Physics, v. 231, 2140–2154.

L. Lin, C. Yang, J. Lu, L. Ying, and W. E, 2012, A Fast Parallel Algorithm for Selected Inversion of Structured Sparse Matrices with Application to 2D Electronic Structure Calculations: SIAM Journal on Scientific Computing, v. 33, 1329-1351.

P. Schmitz and L. Ying, 2012, A fast direct solver for elliptic problems on general meshes in 2D, Journal of Computational Physics, v. 231, 1314–1338.

A. Stovas and S. Fomel, 2012, Shifted hyperbola moveout approximation revisited: Geophysical Prospecting, v. 60, 395–399.

A. Stovas and S. Fomel, 2012, Generalized non-elliptic approximation in tau-p domain: Geophysics, v. 77, U23–U30.

N. M. Tanushev, Y.-H. R. Tsai, and B. Engquist, 2012, A Coupled Finite Difference – Gaussian Beam Method for High Frequency Wave Propagation: Numerical Analysis of Multiscale Problems (Lecture Notes in Computational Science and Engineering), v. 82, 401-420.

P. Tsuji, B. Engquist, and L. Ying, 2012, A sweeping preconditioner for time-harmonic Maxwell's equations with finite elements: Journal of Computational Physics, v. 231, 3770–3783.

P. Tsuji and L. Ying, 2012, A sweeping preconditioner for Yee's finite difference approximation of time-harmonic Maxwell's equations: Frontiers of Mathematics in China, v. 7, 347-363.

L. Ying, 2012, A pedestrian introduction to fast multipole methods: Science China Mathematics, v. 55, 1043-1051.

TCCS Staff

The TCCS group consists of people from eight different countries who have come together to move science forward. Our research staff includes principal investigators, postdocs, Ph.D. students, M.S. students, B.S. honors students, a research associate and a senior research fellow:

Lubna Barghouty (B.S. Honors)
Yangkang Chen (Ph.D. 2nd year)
Luke Decker (M.S. 2nd year)
Björn Engquist (PI)
Mehdi Far (Postdoc)
Sergey Fomel (PI)
Shaunak Ghosh (M.S. 3rd year)
Jingwei Hu (Postdoc)
Parvaneh Karimi (Ph.D. 4th year)
Alexander Klokov (Research Associate)
Siwei Li (Ph.D. 5th year)
Karl Schleicher (Senior Research Fellow)
Yanadet Sripanich (Ph.D. 1st year)
Junzhe Sun (Ph.D. 2nd year)
Ryan Swindeman (M.S. 1st year)
Zhiguang Xue (Ph.D. 1st year)
Hejun Zhu (Postdoc)

For more information, see http://www.beg.utexas.edu/tccs/staff.php

Promotions

Alexander Klokov was promoted from postdoc to a permanent position of a research associate. As part of his promotion package, Alexander received funding from the Jackson School of Geosciences for a new high-performance computer cluster. The cluster has a 12-core head node with E5-2640 processor and 32 12-core compute nodes with E5-2420 processors and 64 GB memory connected by an InfiniBand switch.

After graduating with highest honors from UT Austin and receiving two bachelor of science degrees in geophysics and mathematical sciences, **Yanadet Sripanich** continues with TCCS as a Ph.D. student.

New faces

Ryan Swindeman received a B.S. in physics with a minor in mathematics from the University of Illinois at Urbana-Champaign. There his research and thesis comprised a condensed-matter physics and geophysics crossover project concerned with earthquake statistics and a mean-field model; his advisor was Dr. Karin Dahmen. Ryan enrolled at the University of Texas at Austin in fall 2013 and is pursuing a M.S. in geophysics. After graduation, he hopes to find a position in the oil industry.

Zhiguang Xue earned a bachelor's degree in exploration geophysics from China University of Petroleum (East China) in 2012. Before being admitted to the University of Texas at Austin in fall 2013, he worked with Professor Zhenchun Li on seismic data processing and imaging based on inversion. Zhiguang is currently a Ph.D. student in the Bureau of Economic Geology, working with Sergey Fomel. He chose TCCS for his advanced studies because of its outstanding geophysicists and excellent students, and he looks forward to his studies at this young, creative place.

Pengliang Yang is a visiting Ph.D. student in the Bureau of Economic Geology. He received his bachelor's degree in 2009 from Nanjing University of Aeronautics and Astronautics and is currently pursuing a Ph.D. at Xi'an Jiaotong University. Previously, he worked on sparsity-based seismic data reconstruction using the theory of compressed sensing. His current research is mainly on reverse time migration and sparse inversion, and at TCCS he will study seismic imaging and inversion.

Hejun Zhu is a Dean's distinguished postdoctoral fellow at the Jackson School of Geosciences, UT Austin. He earned a bachelor's degree in geology from Sun Yat-sen University in 2005, a master's degree in geophysics from Peking University in 2008, and a Ph.D in geophysics from Princeton University in 2013. His research focuses on solving seismic forward and inversion problems. His master's thesis concerned simulating seismic wave propagation in 3D Earth models by finite difference methods, while his Ph.D. thesis used adjoint methods of imaging the crust and upper mantle beneath Europe and the North Atlantic.

Testimonials

Gang Fang
(Visiting Ph.D. student from China University of Petroleum, 2012–2013)
"I have greatly enjoyed doing research at TCCS. Here, outstanding scientists from geophysics and applied mathematics as well as creative and diligent students are working together to figure out the most challenging issues in seismic exploration. The talented staff, the philosophy of reproducible research, the rich interplay between industrial and academic interests and easy access to the computer resources of TACC make TCCS one of the best research groups in the world. TCCS gave me a memorable and wonderful experience."

Yihua Cai
(M.S. 2012, currently at Shell)
"Being a top-level research group, TCCS integrates the best resources you can think of: leading academic scientists, experienced geophysicists with strong industry backgrounds, talented graduate students, collaboration with researchers in the industry, and tight connections to prestigious research institutes, i.e. the Bureau of Economic Geology and the Jackson School of Geosciences. Each published TCCS research result is easily accessed and reproducible with scripts and codes in the public domain, which allows interested researchers to reproduce and compile the results into their own platforms. TCCSers expand their research horizons with the same in-depth effort. Their research covers each topic in exploration geophysics study, from imaging to attributes analysis, signal processing to quantitative interpretation."