

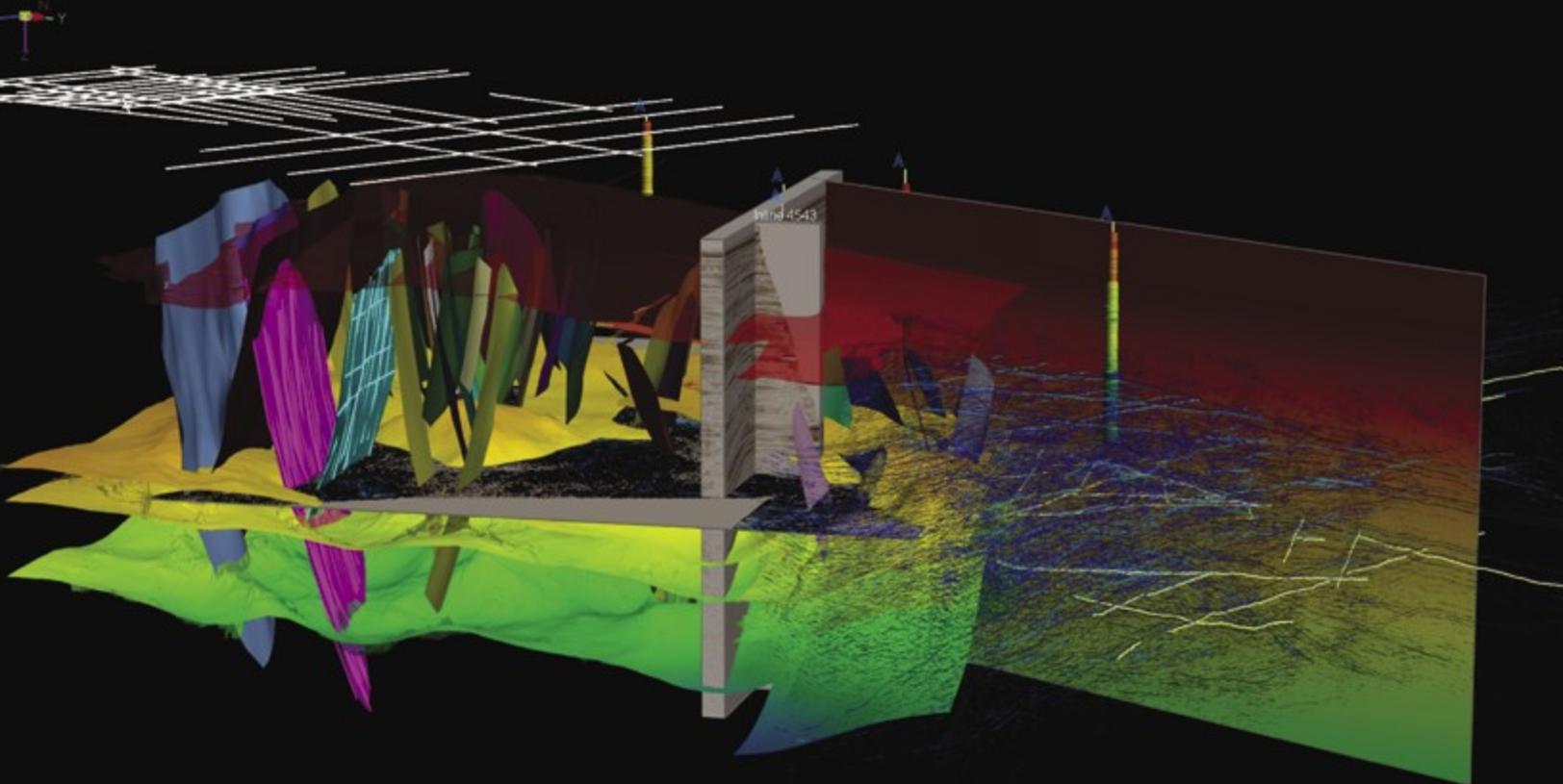
October 2018



*The Epicenter of
Geophysical Excellence*

GSH Journal

GEOPHYSICAL SOCIETY OF HOUSTON
Volume 9 • Number 2



Technical Article:
**Velocity Model Building Challenges and Solutions for Seabed-
and Paleo-canyons: A Case Study in Campos Basin, Brazil – Page 14**

**Recognizing Outstanding
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Eritrea – What Happened To Thee? Part 2 – Massawa – Page 39

**Diversity and Women's
Networking event: Wrap-up – Page 21**

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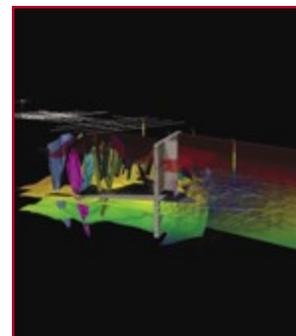
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Regional subsurface perspective in a multi-survey interpretation canvas. Data courtesy of AWE Limited. Image courtesy of Paradigm.



EDITOR'S NOTE

To ensure your information reaches the GSH members in a timely manner, please note the following deadlines and plan accordingly. Please submit your articles and any questions to Dmitry Kulakov, editor, at dkulakov@slb.com

GSH JOURNAL DEADLINES

Jan 2019..... Nov 9
Feb 2019..... Dec 14
Mar 2019..... Jan 11

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A Word from the Board

Strength and Growth for Now and Tomorrow

By Maitri Erwin, First Vice President

It's another exciting year for the Geophysical Society of Houston! Our community innovates and thrives inside continuing uncertainty, which only shows an unparalleled dedication to our chosen profession. As GSH First Vice President this year, it is my honor to select and host technical talks of the highest quality, but more crucially, ones that showcase the importance of the geophysicist in this wide-ranging and challenging energy ecosystem. It is a high level of awareness and agility that will help geophysics and our Society continue to meet high standards and remain ever future-facing.

Expanding on the above, the objective for technical talks this year is to make them more dynamic and inclusive – this is achieved by bringing in talks on case studies, integrated projects and applications of geophysical techniques to detection/recovery/decision-making, instead of simply techniques, given by a diverse set of professionals. In this manner, we promote geophysicists not just as technical specialists, but as who we really are – varied and vital members of the energy exploration-production business chain, innovation machine, education system, and beyond.

By the time this Word from the Board is published, GSH will have hosted fine technical talks, including integrating pre-stack seismic and controlled-source electromagnetics for residual hydrocarbon detection by Pedro Alvarez, and the value of human capital in exploration workflows that now include big data, analytics and machine learning by Katya Casey, experienced explorer and 2018 GSH Honorary Membership Awardee. In conjunction with the SEG Emerging Professionals International Committee and the SEG Women's Network, we will also have hosted our annual Diversity and Women's Network event on September 11th. The event included a learning component on building one's professional brand through introspection and conversation, along with time for networking and connection.

The spirit of goodwill and geo-collaboration continues, GSH will participate along with the Houston Geological Society in a joint dinner on October 8th, in which West Africa explorer and technical advisor Igor Effimoff will speak on the emerging hydrocarbon province in Offshore Senegal. If you plan to attend the SEG Annual Meeting in Anaheim, please attend talks by your fellow society members! We are now actively soliciting

high-quality speakers for Spring 2019 breakfast and lunch events. Please send your abstracts to 1st_vice_president@gshtx.org

Lastly, I encourage you to be an active member of the geophysical community of Houston by participating in the GSH and making this Society yours. Like me, I know you support inclusion and diversity in our profession as well as the continued growth and relevance of GSH. Strength, resilience and growth can only come through continuous effort, struggle, and contribution, and by many not just a few, but it's worth it. To this end, please assist in creating and hosting events, actively volunteer to manage or evolve existing activities, run for elected office, encourage others to get onboard, and join us in building the positive change you want to see!



Maitri Erwin



Looking for more ways to participate in the Geophysical Society of Houston?

Consider how you can make a difference by volunteering at one of our events!

Contact Nicola Maitland to learn more about this excellent networking opportunity:
nmaitland@resolvegeo.com - 713-972-6209





Dear GSH Journal reader,
Please, feel free to contact any of us with any and all questions or suggestions that you can come up with.

editor@gshtx.org

Sincerely,

Dmitry Kulakov, Editor



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From the Other Side

By Lee Lawyer



As you read this column, I will be very close to the completion of my three-year term in office with the SEG Board of Directors. At the end of the Annual Meeting in Anaheim my tour is over. For those of you who have not avidly followed my involvement with the SEG, I am the

Chair of the Council. With that title comes automatic membership on the Board of the SEG.

The Council of the SEG is part of the SEG governance. Eight or so years ago, the Council was the 'ruling body' of the SEG. The Executive Committee was an integral part of the Council. (President, President E, Past President, two vice presidents, a Treasurer, and the Editor) But things change. The Board was enlarged from seven to fourteen members. Today, the SEG Board is the 'ruling body'.

The Council is made up of delegates from Sections and Associated Societies (SAS) plus two District Representatives for each of the twelve Districts. Changes in the bylaws and dues changes must be approved by the Council. In August, the Council was asked to approve a \$25 increase in dues. Since I am writing this before the vote was taken, I have no idea how that turned out. I know the AAPG increased their dues about the same amount.

I have had excitement now and then on the Board. We discussed and discussed and discussed the advisability of setting up an SEG Certification program for "Applied Geophysicists". (Have I told you I don't like 'applied' in front of 'geophysicist'?). At one time we (the Board) agreed to proceed if and only if sufficient funds were donated to cover all expenses. Then the downturn hit and it was difficult to solicit funds from anywhere or anyone. I am still not sure how successful certification would have been even if it had been funded.

In my first year, there was an initiative to remove requirements for Active Membership. We would become similar to the SPE where paying one's

dues is the only requirement for membership. That would do away with the Associate Member category and any need for experience. The Council soundly rejected those changes but the idea is still around. In my second year, the direction was to "Rebuild the SEG", whatever that meant. All of Committee Chairs were asked to report their purpose, progress and future plans. There are a lot of committees! Organizational planning went forward. Membership steadily declined. Revenue from Advertising was greatly reduced as was attendance at the Annual Meetings. The Tulsa staff was greatly reduced. Financial disaster was around the corner.

The idea of 'Rebuild the SEG' has continued in my Third Year. We set up "Portfolios", to identify and activate opportunities and create a business environment. Each Portfolio contained a number of the appropriate Committees. Each Portfolio is headed by a Staff person and a Member. A member of the Board is assigned as liaison to each Portfolio. Each Portfolio was asked to work up a formal business plan for the next five years. In spite of a recommendation of the Bylaws Chair, a decision was made that the formation of Portfolios doesn't require a change in the Bylaws, ergo no Council vote was needed.

There is one more 'excitement' for my third year. A few years ago, the SEG built a second office building on its Tulsa site. The SEG owns two buildings and occupies one floor in the original one. It seems that we failed to consider the early "cash flow" this caused. There are big upfront costs of getting the new building leased. We had borrowed money and are currently paying off the note. Most real-estate investments are either 'flipped' when the market is right or the note is refinanced and we wait for a more auspicious time. A portion of the Board would sell the buildings and land immediately, regardless of the timing. I feel that that is not the way. Investing high and selling low doesn't seem right for some (\$\$) reason. The arguments in favor of the early sale include, "What is the SEG doing in the real-estate business???. We should be processing seismic data not sweeping floors". And so it goes.

Technical Luncheons

Water Avoidance, Landing, and Sweetspotting Solutions

for the Permian Basin: The Role of Surface Seismic

Register
for Tech Lunch
Westside

Register
for Tech Lunch
Downtown

Register
for Tech Lunch
North

Speaker(s): David Paddock¹, Dianna Shelander², Sagnik Dasgupta¹, David Ng³, Andy Walz¹, Carol Boyd¹, and Vasudhavan Sudhakar¹

¹WesternGeco, 10001 Richmond Avenue, Houston, TX 77042

²WesternGeco, (retired), ³Consultant



David Paddock

Westside

Tuesday, Oct. 23, 2018

11:00 a.m. – 1:00 p.m.

Location: Norris Conference Center (City Centre)
816 Town & Country Blvd.
Houston, TX 77024
(Free parking garage)

Downtown

Wednesday, Oct. 25, 2018

11:00 a.m. – 1:00 p.m.

Location: Petroleum Club of Houston
1201 Louisiana St, Floor 35
Houston, TX 77002
(Valet parking onsite)

Abstract:

Twenty-two Delaware Basin Wolfcamp “A” lateral wells within the area of Reeves County with the highest lease cost were examined for profitability. Their seismic attributes were examined for associated causality. A B30 (best 30 days of production) cutoff of 15,000 barrels was determined and used as a breakeven metric. Only ten of the 22 wells passed that hurdle.

Poor wells were found to be afflicted by one or more of the following: landing 200 feet or more too low, fracking into poor reservoir, and/or producing excessive water associated with faulting either above or below the Wolfcamp “A” target stratigraphic level. Use of the seismic data would mitigate the risk of landing too low to hydraulically fracture up into the reservoir. Seismic data could also be used to predict the adequacy of reservoir quality. Finally, surface seismic data could be used to detect the risk of faults that can bring water from either above or below the lateral. The use of seismic data was found to be a crucial tool for ensuring economic success in the Wolfcamp play.

Northside

Thursday, Oct. 24, 2018

11:00 a.m. – 1:00 p.m.

Location: Southwestern Energy Conference Center
10000 Energy Drive
Spring, TX 77389
(Free Parking onsite)

Biography:

David Paddock is a scientific advisor in WesternGeco’s North American Onshore Multiclient Exploration team. He has consulted on dozens of unconventional development projects throughout North America as well as in South America, Europe, the Middle East, and North Africa. A baby boomer, Dave has only had two employers, ARCo for 18 years and now Schlumberger for 17 years in their Consulting and Geophysical product lines. Dave has won Best Speaker Award at AAPG’s Southwest Section meeting, has had talks selected for SEG’s Best of AAPG session, and has two silver medals and two bronze medals from Schlumberger’s Performed by Schlumberger program (an internal project success recognition program). He holds an MBA from the University of Louisiana at Lafayette and both a Masters degree in geology and a Bachelor of Science degree in Mathematics from Michigan State University. He is recognized by industry as the leading expert in Ant Tracking, a detailed seismic fault identification application widely utilized, particularly in the development of unconventional resources.

Technical Breakfasts

Salt Dissolution: Implications for Exploration and Seismic Imaging

Register
for Tech Breakfast
North

Register
for Tech Breakfast
West

Speaker(s): Clara Rodriguez, Senior Exploration Geologist, WesternGeco, Schlumberger, US

Co-author: Professor Christopher A-L Jackson. Imperial College London, UK.



Clara Rodriguez

North

Tuesday, Oct. 2, 2018
7:00 – 8:30 a.m.

Sponsored by Anadarko Petroleum and Lumina Reservoir Inc.

Location: Anadarko Petroleum
1201 Lake Robbins Drive
The Woodlands, TX 77380

Abstract:

Dissolution of salt structures can result in: (i) the development of salt karst features, such as sinkholes and residual mounds; (ii) discordant geometrical relationships between remaining salt and overburden, (iii) the formation of a residual caprock (i.e., less-soluble residual evaporites and carbonates at the crest and the flanks of dissolved salt structures); (iv) deformation within the overburden (i.e., from local disruption of conformable strata, rotation with apparent downlaps to highly chaotic); and (v) the formation of diapiric solution breccias composed by less-soluble residual evaporites and collapsed overburden.

Despite its occurrence in worldwide salt basins and its significant impact on resource exploitation, surprisingly few studies have used 3D seismic reflection data to investigate the processes and products of salt dissolution. Characterizing salt karst, caprocks and related overburden deformation has a range of important implications for exploration and seismic imaging. First, the caprock has the potential to become reservoir rocks and a source of economic minerals. Salt karst and related faulting generate local accommodation,

West

Wednesday, Oct. 3, 2018
7:00 – 8:30 a.m.

Sponsored by Schlumberger and WesternGeco

Location: Schlumberger
Q Auditorium
10001 Richmond Ave.
Houston, TX 77042

potentially promoting hydrocarbon reservoir deposition and trap development in the supra-salt. In addition, the formation of mega-pores and diagenetic alterations leading to caprock formation negatively impact the sealing properties of the salt and its overburden and increase drilling risks. Hydrocarbon exploration and production entails accurate seismic imaging of salt structures and the complex geometries associated to flanking strata and distorted overburden. Therefore, a suitable seismic velocity analysis and model are required in areas where salt karst, caprock stratigraphic heterogeneities and highly deformed intrasalt lithology are evident and unknown.

The aims of this talk are to integrate 3D seismic reflection and borehole data to: (i) illustrate salt karst and caprock and its impact on the overburden in the Santos Basin, offshore Brazil and the Gulf of Mexico, and (ii) discuss the implications of salt dissolution for exploration and seismic imaging in salt basins.

Biography:

Dr. Clara Rodriguez is a Geoscientist with 16 years' work experience in seismic interpretation of sedimentary basins, reservoir characterization and

Technical Article continued on page 10.

Technical Breakfast continued from page 9.

seismic data management. She obtained a PhD in Geology (2017) and a MSc. In Petroleum Geoscience (2007) from the Imperial College London in the United Kingdom.

Her experience while working for Schlumberger and during her degrees involves projects in worldwide sedimentary basins of the Gulf of Mexico, Brazil, Venezuela, Trinidad and Tobago, Norway, United Kingdom, Algeria, Angola, Ghana, Gambia, Namibia and Tanzania. During her PhD research at the Imperial College London, she investigated intrasalt stratigraphy, salt tectonics controls on deepwater sedimentation and the impact and significance of submarine salt dissolution.

Dr. Rodriguez is an author and coauthor in publications in the AAPG Bulletin, Geosphere, Geology and the Journal of Structural Geology. She has also continuously presented her work in worldwide conferences like the EAGE, AAPG ACE, AAPG ICE, University of Texas AGL, BSRG, PESGB, NAPE and Schlumberger WesternGeco Regional Geophysical Conference.



SAVE THE DATE!

HGS - GSH JOINT SOCIETY DINNER

**SNE and FAN Discoveries
Offshore Senegal are World Class
and Herald a Major New
Hydrocarbon Province**
by
Igor Effimoff

**OCTOBER 8TH, 2018
PETROLEUM CLUB OF HOUSTON**

GEOPHYSICAL SOCIETY OF HOUSTON

**November 16, 12-5pm
2018**



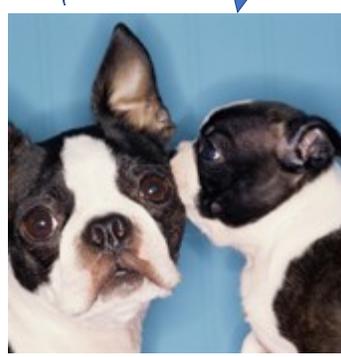
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GSH Media Kits

Data Processing & Acquisition SIG

5D Compressive Sensing Conditioning for Improved Dual Coil Model Building and Imaging

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for Data
Processing

Speaker(s): Will Sanger,
Geosolutions Geophysicist,
WesternGeco

Co-authors: Alexander Zarkhidze, Massimiliano
Vassallo, Hazem Ahmed and Paul
Vascik, all with WesternGeco

Sponsored by
Schlumberger

Location: Schlumberger
Q Auditorium
10001 Richmond Ave.
Houston, TX 77042



Will Sanger

Tuesday, Oct. 2, 2018

4:30 p.m. Sign-in, Snacks, Social Time

5:00 p.m. Start of presentation

Abstract:

Complex imaging environments such as the subsalt Gulf of Mexico often present illumination challenges that are best met with full-azimuth (FAZ) acquisition patterns. To achieve the full imaging benefits promised by FAZ, data should be recorded with sufficient density in four spatial dimensions (2D midpoint, offset, and azimuth, for example) to avoid undersampling artifacts. Traditionally, the Shannon-Nyquist criterion of two samples per wavelength has been used to measure whether a survey geometry is “well sampled”. However, by this measure, nearly all economically feasible survey geometries are undersampled in one or more dimensions, and full-azimuth geometries are especially challenged in this tradeoff because they record a larger range of the wavefield.

Fortunately, compressive sensing (CS) offers a way to image the subsurface with fewer samples than Shannon-Nyquist. CS theory demonstrates that in certain conditions a signal can be measured correctly by sampling fewer and coarser samples than required by the traditional sampling theorem—these conditions are that (1) the sampling grid is randomized and (2) the signal can be sparsely represented in a transform domain.

Dual coil shooting, a method of marine streamer acquisition through circular towing patterns, is designed to randomize the sampling locations, satisfying the first requirement of CS. A new workflow, 5D compressive sensing conditioning (CSC), satisfies the second requirement by representing the signal in a sparse transform domain.

The 5D CSC workflow promotes the coherent low-to-mid frequency information in dual coil recording in a transform domain while explicitly reducing the random noise. We see benefits to model building and far-offset imaging in subsalt Gulf of Mexico through application of 5D CSC.

Biography:

Will Sanger works as a Geosolutions Geophysicist for WesternGeco, where he started in 2012. After performing testing and production for several large multient projects, his main focus the last two years has been to implement new workflows, mainly to improve time processing of dual coil data. Will is interested in connecting geophysical domain knowledge with the areas of machine learning, user interface, and data visualization. He holds a B.Sc. in Geophysics from the University of Tulsa.

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We will hold the event in the late fall of 2018 if sufficient interest and support from companies and individuals exist. Please let us know if you would support/sponsor or attend the event by

GSH / HGS 18th ANNUAL SALTWATER TOURNAMENT

- Friday, October 12, 2018 -

TopWater Grill Marina, 815 Avenue O, San Leon, TX
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We are looking forward to a big event this fall and we encourage full family participation!

Galveston Bay Complex Division

Trophies will be awarded for the heaviest individual Redfish (Non-Tagged), Speckled Trout, and Flounder. Trophies will also be awarded for the heaviest individual Stringer - 1 Redfish, 3 Speckled Trout, and 1 Flounder.

Galveston Offshore Division

Trophies will be awarded for the heaviest individual Ling, King Mackerel, and Mahi-mahi



REGISTRATION OPTIONS

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Velocity Model Building Challenges and Solutions for Seabed- and Paleo-canyons: A Case Study in Campos Basin, Brazil

Kai Zhang, Javier Subia, Chevron; Chanjuan Sun, Hao Shen, Nuree Han, CCG

Summary

The Campos Basin, offshore Brazil, features complex shallow geology in the forms of pronounced seabed canyons and paleo-canyons. The rapid variations in the velocity field due to these complex shallow geologic features can be difficult for ray-based tomography techniques to resolve, resulting in distorted images in the deeper section. Full waveform inversion (FWI) is able to utilize the recorded diving-wave energy to resolve the high-resolution velocity model in these geologically complex areas. Additionally, dip-constrained non-linear slope tomography introduces dip constraints to ray-based residual move-out tomography and is able to capture small-scale velocity anomalies associated with these shallow heterogeneities. A combined workflow of FWI and dip-constrained tomography enabled Chevron to build accurate and detailed velocity models in the Campos Basin, resulting in fewer seismic image distortions. We demonstrate the method using a Campos Basin, Brazil narrow-azimuth streamer dataset.

Introduction

It has been long noticed that submarine canyons incised into the continental slope water bottom present significant challenges in seismic imaging and interpretation for oil and gas exploration. Such complex seafloor bathymetry can distort seismic wavefronts and amplitudes, making it difficult to estimate accurate velocity models and construct real geologic reflectivity images, and therefore negatively impacts the results of the derived interpretation. In time processing, it was suggested to use wave-equation datuming (Berryhill, 1986) or time-variant statics (Dent, 1983) to reduce the “pull up” or “push down” effects. Such approaches do not solve the velocity problem but instead provide horizons which are perceived as true geology. Debenham and Westlake (2013) compared pre-stack time migration (PSTM) and pre-stack depth migration (PSDM) workflows with a 2D line study and demonstrated that image distortions and amplitude dim zones cannot be fixed by a static-correction method, while PSDM image with careful

depth model building workflow shows obvious uplift. The practice of 3D depth imaging in the Campos Basin has taught us a couple of things. First, initial velocity models that honor shallow geologic features are very helpful and sometimes critical for tomography to converge quickly to reasonable final models. Birdus (2009) proposed the use of geo-mechanical methods to build initial seabed-canyon models. Arnaud et al. (2008) built an initial model with 1D inversion of a picked sub-channel horizon to a reference horizon. The second thing experience has taught us is that high-resolution (HR) model building techniques are important to capture the velocity variation associated with the narrow canyon widths – typically narrower than the acquisition streamer length. Thus far, techniques for implementing or improving ray-based tomography have dominated discussions of velocity model-building strategy for submarine canyons; analysis relies heavily on the quality and density of the residual moveout (RMO) picks to build accurate high-resolutions models (Fruehn et al., 2015). In addition, different techniques such as pick weighting and layer constraints (Sun et al., 2011; Chen and Shen, 2012; Chen and Hu, 2014), reference horizons and offset-consistent dip constraints (Graham and Richard, 2009, Guillaume et al., 2013, Chen and Hu 2014), have been explored to help invert good models.

However, ray-based analysis has been hindered not only by the lack of sufficient offsets for picking shallow events, but also by the complex ray paths generated by steep canyon walls. Deeks and Lumley (2015) pointed out that multiple paths of prism waves are usually generated by the canyons, even at short offsets. Prism wave energy becomes stronger in narrow and deep canyons and creates shadow events in stacked images and CDP gathers (Deeks and Lumley, 2015; Debenham and Westlake, 2014). Confidence in picking proper RMO and geological events is low in the presence of prism waves. Furthermore, multi-path energy cannot be properly handled by single-path residual curvature analysis (RCA) and migration algorithms like Kirchhoff migration, which are typically used in this case.

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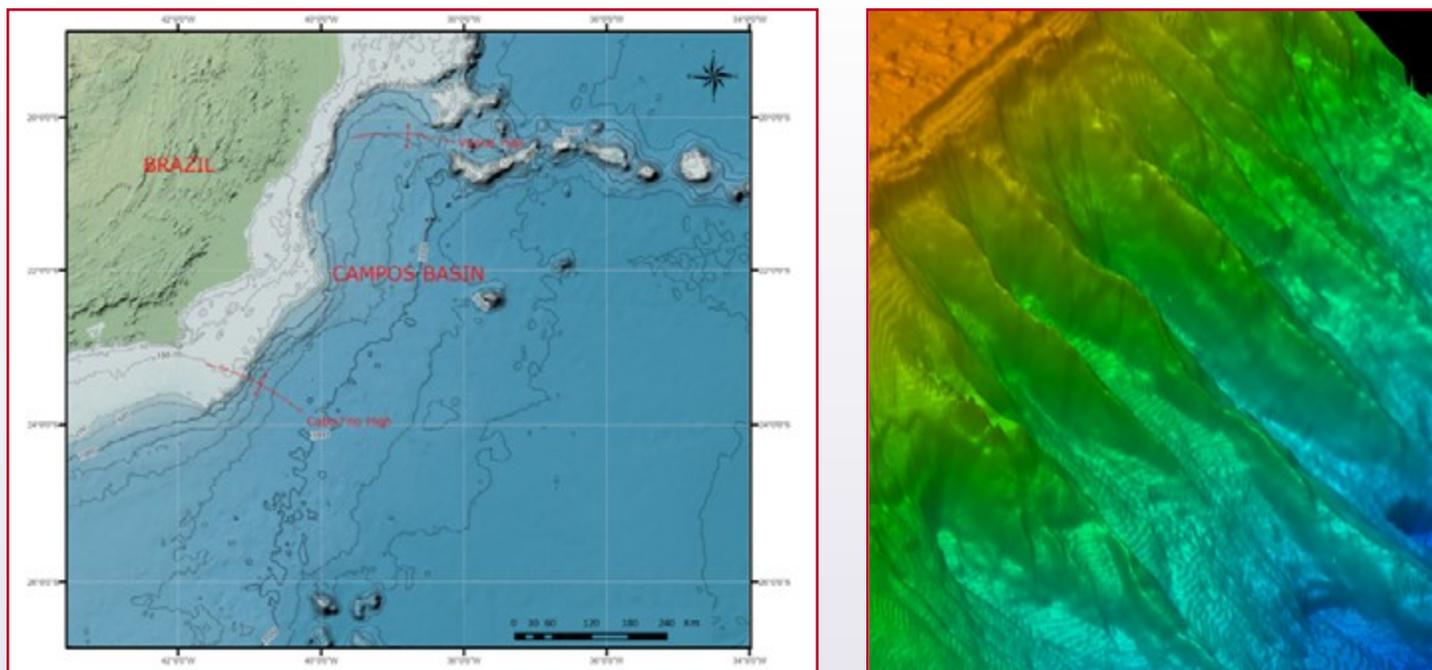


Figure 1 Campos Basin Location Map and water bottom map of the study area.

FWI provides a different way to tackle the problem. It uses the wave equation to produce high-resolution velocity models by directly comparing modeled data to the real seismic records. It handles complex ray paths naturally and doesn't rely on a priori geology assumptions or RMO picking. FWI was applied in this Campos Basin case study, followed by a ray-based model building workflow with dip-constrained non-linear slope tomography (Guillaume et al., 2013). The result shows improvement in the sub-canyon image and satisfying quality in both the data and gather domains.

Study area and workflow

The study area is situated in the Campos Basin, offshore Brazil. Water depths range from 150m to 1,500m. The typical rugose seafloor in the area is presented in *Figure 1*, where canyons carve about 300m into the continental slope.

The first 3D narrow azimuth streamer data (NAZ) acquisition in this area was acquired and processed with conventional ray-based tomography model building workflow for PSDM in 2008. Imaging suffers from structure distortions below seabed-canyons down to the Cretaceous at around 3 km depth. In 2010, a new 3D NAZ streamer survey was acquired. These data were processed in 2011-2012 using a workflow of layer-constrained HR tomography with structurally-guided weighting. Details of the workflow can be found

in Chen and Shen (2012). Compared to the original imaging, the 2012 workflow was able to greatly reduced sub-canyon image distortions. However, with this method, a lot of labor-intensive effort and attention was required during each of the tomography iteration to evaluate stack image in order to identify potential non-geologic artifacts in velocity model. Despite the good effort in the 2011-2012 work, there were still residual image distortions in the deeper part of section because velocity anomalies in the shallow overburden were not fully resolved., as proved by well data.

Due to FWI's ability to provide high resolution velocity model in the shallow overburden, it is designed to be the main part of a 2015 re-imaging effort to update the velocity model using the 2010 NAZ dataset. We utilized an acoustic, finite difference time domain FWI for the study (Ratcliffe et. al, 2011). The velocity update is primarily driven by refraction energy. The smoothed 2012 model served as input model for the 2015 FWI. 48 iterations of FWI were run from 5 to 10Hz in order to minimize the misfit of phase between synthetic shot gathers and real shot gathers. After reaching a good match in the data domain, Kirchhoff PSDM (KPSDM) was run to evaluate the FWI updated model in the image and gather domains. As shown in the next section, most of the non-geological structural undulations were removed from the stack, but some small residuals remained. Additional iterations of dip-constrained non-linear tomography were then applied..

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RMO and dip fields on near, middle, and far stacks were picked for dip-constrained tomography. A model was derived to flatten the gathers as well as minimize the difference between offset dependent dips and a reference dip. This final model healed all residual non-geological post-FWI structural undulations.

Results and analysis

Since FWI attempts to match modeled and recorded shots, we performed data domain QC first to validate the FWI update. Near/mid/far channels are evaluated in *Figure 2*. The top panel is modeled data with the initial model; the middle panel is modeled data with the FWI updated model, and the bottom panel shows the recorded field data. The initial model provides good

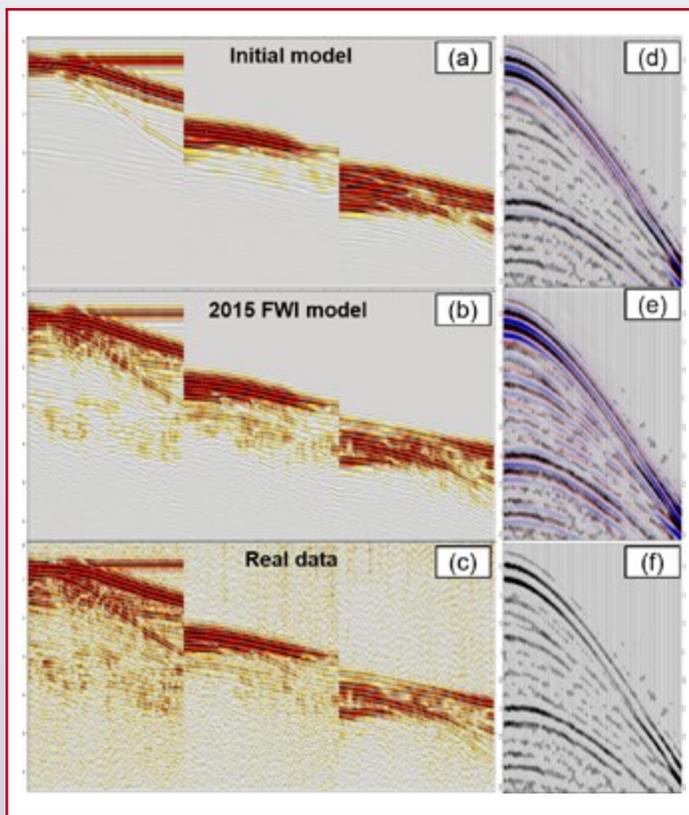


Figure 2 On the left, near/mid/far channels (a) modeled with initial smooth model (b) modeled with FWI update model and (c) recorded. On the right, recorded shot is presented with wiggles and modeled shot is overlaid with positive amplitude in red and negative amplitude in blue. Better blue to trough and red to peak alignment indicates better matching between the modeled and recorded shots. (d) Modeled shot with initial model is overlaid on recorded shot gather; (e) Modeled shot with FWI model is overlaid on recorded shot gather; (f) Recorded shot gather

match for near water-bottom events, but poor match for deeper events. Better match with the real data is seen after the FWI update which indicates that it worked as expected.

KPSDM results with the initial model and the FWI updated model are shown in *Figure 3 (a) and (b)*. The “pull-up” and “push-down” structure associated with the canyon shape is clearly observed in the initial model image from ~1,400m to ~3,000m. FWI model fixes the “pull-up” indicated by the arrows, however some short wavelength undulations still remain. There are multiple explanations why FWI could not fully resolve the canyon related velocity issues. First, the strong feathering of the NAZ acquisition resulting in non-uniform source-receiver patterns could be an issue. Second, no usable signal could be extracted below 5Hz from the NAZ data while lower frequencies are usually important for FWI to avoid cycle skipping. Third, the acquisition direction, which is parallel to the canyon direction (dip to structure), may also play a role in preventing FWI from resolving a perfect model. Besides the data limitations, the FWI algorithm can also suffer from possible anisotropy and density leakage. In order to

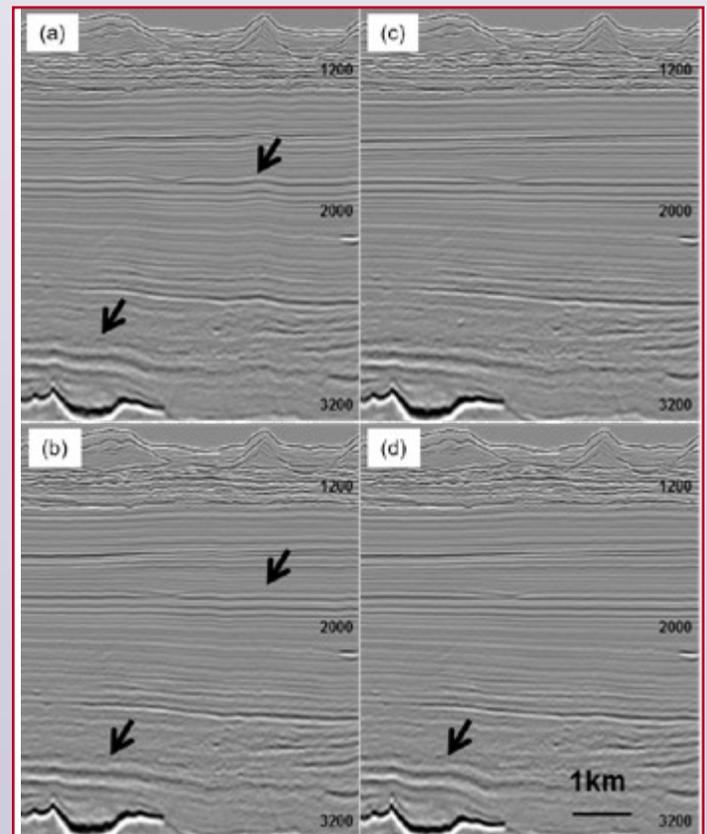


Figure 3 Kirchhoff PSDM stacks for (a) initial model (b) FWI update model (c) 2015 final model (d) 2012 final model.

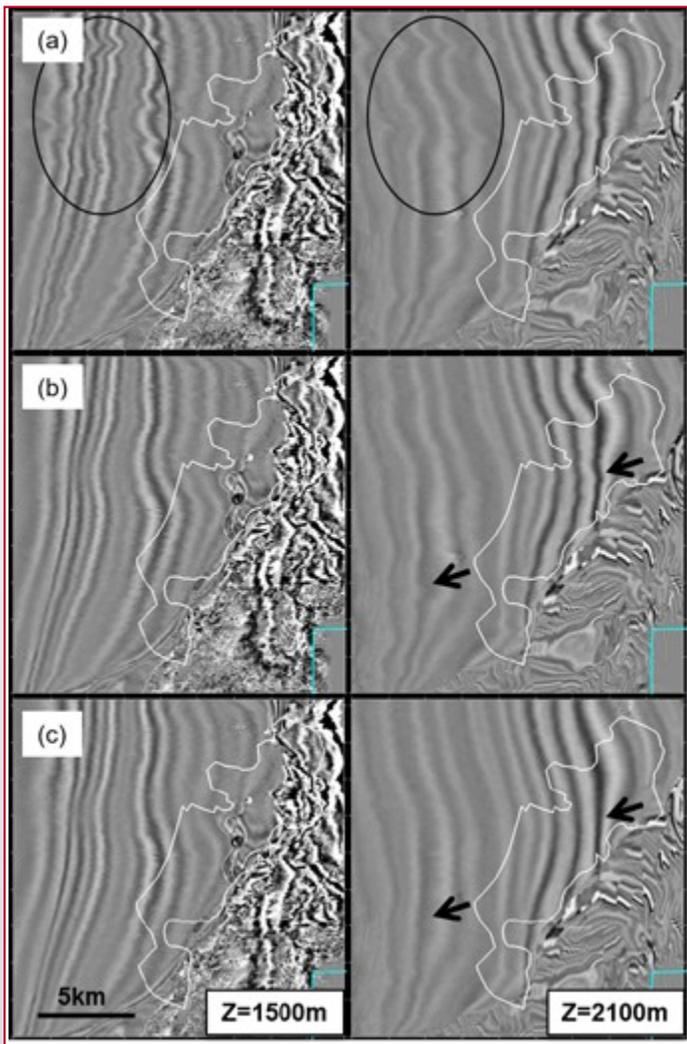


Figure 4 Depth slice at 1,500m (left) and 2,100m (right) for (a) initial model (b) 2012 final model and (c) 2015 final model

completely fix the image distortions in deeper section, subsequent ray-based tomography is applied. Dip fields are picked on the stack and reference structural dips are created by smoothing out these small undulations. After dip-constrained tomography, the 2015 final model was obtained. Figure 3 (c) is KPSDM QC of the 2015 model. It shows smooth sediment layers in the entire section. For a fair comparison, a KPSDM stack using the 2012 final model was generated, as shown in Figure 3 (d). The 2012 model also shows a good match at shallow depths. However, in the deeper section, a mild residual can be seen below 2,600m. From depth slice QC displays, this observation is even more apparent. Figure 4 compares depth slice images at 1,500m and 2,100m for the initial, the 2012 and the 2015 final models. In the initial model image, jitters caused by the seafloor canyons

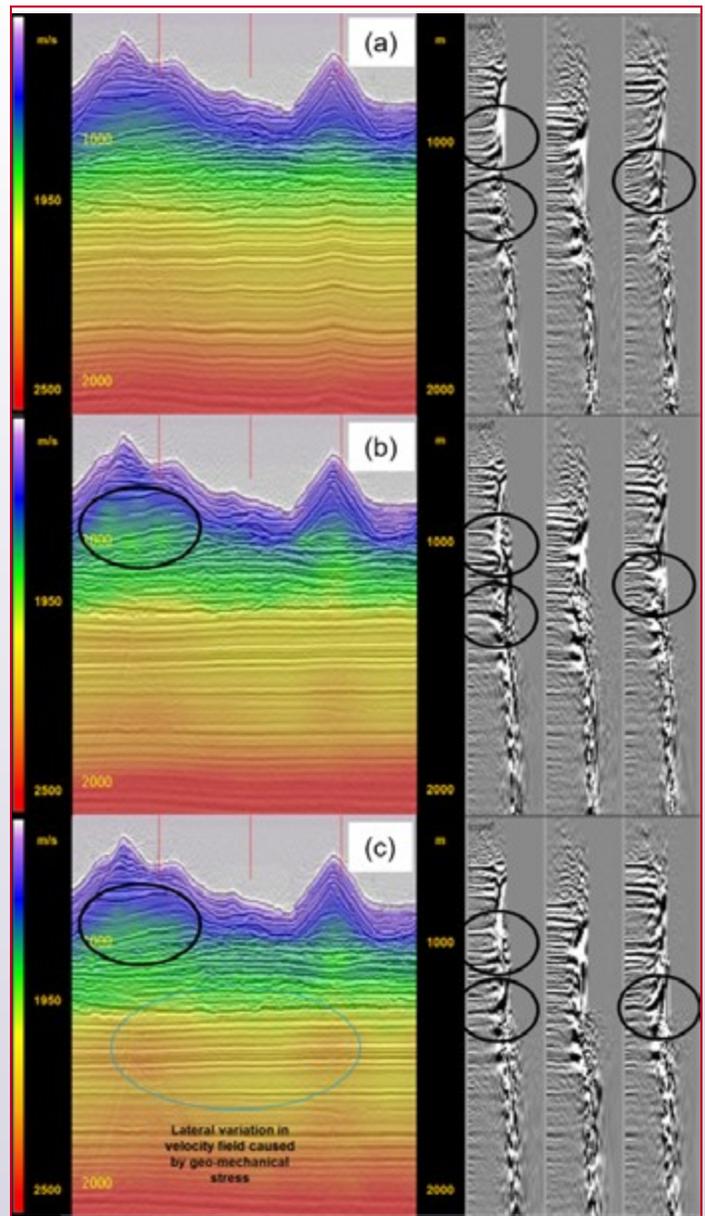


Figure 5 Model overlaid on PSDM stack for (a) initial model (b) 2012 final model and (c) 2015 final model. Gathers at the selected location are shown on the right side.

exist everywhere and become milder at deeper depth. The 2012 image did a good job at reducing most of the distortions but some small residuals can still be seen on the 2,100m depth slice. In the 2015 image, all sediment contours are smooth without distortion.

Gather domain QC display provide additional support for the 2015 model. Figure 5 presents the three models overlaid on their corresponding KPSDM stack with CIG gathers on the right side. The initial model is a smoothed velocity field without any lateral changes. The

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gathers show quite large RMO. Far offsets (~2,000m) quickly stretch out or disappear in this area, which is not ideal for ray-based tomography. The speed up and slow down associated with canyon flanks and valleys are captured in the 2012 and 2015 final models. The latter puts a smoother velocity inside canyon flanks (black circle) and a stronger velocity variation around 1,500m. The oscillating velocities healed the imaging undulations and minimized gather RMO. The 2015 final image provided a higher level of confidence in the interpretation results. The image depthing accuracy was proven by a well drilled shortly after the processing. Other products based on the seismic data, like seismic inversion, were also greatly improved, showing better continuity and a better match with well data. By resolving the effects of seabed canyons, the uncertainty on the placement of horizontal wells in thin and low dip-angle reservoirs in the field was reduced.

Conclusions

A model building workflow of combined FWI and ray-based dip-constrained tomography to solve for an

accurate model in complex geology settings of seabed-canyons has been developed. FWI has an advantage over conventional ray-based tomography which can break down without good picks and cannot handle multi-pathing. Although with this NAZ data, FWI alone did not fully resolve the problem, it fixes large image distortions and provides a better starting point for a ray-based tomographic update. Dip-constrained tomography further resolves the residual undulations using RMO and offset dependent dips. It has been shown that this workflow is effective at automatically resolving image distortions down to target level without manually pre-setting layers or regions for tomographic update. With the proposed workflow, a high-resolution model that is geologically conformable and geomechanically meaningful was efficiently generated.

Acknowledgements

The authors thank Chevron and CGG for their support for this project. We would also like to specifically recognize Chris Manuel and Vanessa Brown, both of Chevron, for their invaluable assistance.

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GSH Outreach

Committee Activities By Lisa Buckner, outreach@gshtx.org

Earth Science Week, Oct. 14-20, 2018

Since October 1998, the American Geosciences Institute has organized this national and international event to help the public gain a better understanding and appreciation for the Earth Sciences and to encourage stewardship of the Earth. This year's **Earth Science Week will be held from October 14-20, 2018** and will celebrate the theme "Earth as Inspiration." This year's event, the 21st annual Earth Science Week celebration, will emphasize artistic expression as a unique, powerful opportunity for geoscience education and understanding in the 21st century.

Earth Science Week 2018 learning resources and activities will engage young people and others in exploring the relationship between the arts and the Earth systems. The coming year's theme will promote public understanding and stewardship of the planet, especially in terms of the ways art relates to geoscience principles and issues as diverse as energy, climate change, the environment, natural disasters, technology, industry, agriculture, recreation, and the economy.

.....

You can help by volunteering at the GSH booth at one of the events here in Houston or visiting your child's school. If you can't volunteer, I encourage you to bring the children in your life to one of the events and enjoy a fun day of learning.

Earth Science Celebration Saturday, Oct. 13 (11:00 AM – 3:00 PM) at HMNS

For more information about the HGS Earth Science Week events in Houston, go to <https://www.hgs.org/earth-science-outreach>

Energy Day Festival Saturday, Oct. 20 (11:00 AM – 4:00 PM) at Sam Houston Park (FREE)

More information about Energy Day can be found at <https://energydayfestival.org/houston/>

For information about volunteering at the GSH outreach hands-on activity booth at the Earth Science Celebration or Energy Day events contact Lisa Buckner (outreach@gshtx.org).

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Show your pride at industry conferences and outreach events. Pick-up your FREE "I'm a Geoscientist" lapel pin at a GSH meeting. The SEG is a member society of AGI.

<https://www.americangeosciences.org/im-a-geoscientist>



Are you interested in volunteering? Do you know of a school that has a career day seeking speakers or a career fair at which GSH might be able to host an exhibit booth? Or have you been invited to give a classroom presentation at your child's school? We can work together to bring awareness to the students & their educators of the many rewarding and fun careers in the geosciences. Please contact Lisa Buckner at outreach@gshtx.org.

HGS Golf Tournament

Monday – October 22nd, 2018

Format: 4-Man Scramble



Come join us for golf, food, friends and fun at the annual HGS Golf Tournament at our new location, *Sterling Country Club and Houston National Golf Club* (www.sccathn.com). There will be prizes awarded for closest to the pin and long drive, putting games before we start, as well as many great door prizes for participants.

Entry Fee: \$175.00/Golfer or \$700.00/Team.

Early Bird Special: Sign up before September 25th to receive a **discount** of \$25.00/Golfer or \$100/Team.

Entry Deadline: October 17th.

Individual entries will be grouped with other individual golfers to make a foursome. Entries are limited to and will be accepted on a first-in basis.

SCHEDULE OF EVENTS

8:00 – 9:45 a.m. Registration, free use of driving range and mini games, breakfast provided

10:00 a.m. Shotgun start

3:00 p.m. Cash bar, open buffet

3:30 p.m. Door prizes and awards presentation

Companies or individuals interested in sponsoring the event should contact Elliot Wall at 713-328-2674 or elliott.wall@corelab.com. Sponsorship deadline is September 30th.

REGISTRATION OPTIONS

- Online: www.hgs.org/golftournament
- Email: office@hgs.org
- Fax: (281) 679-5504
- Mail: Houston Geological Society, 14811 St. Mary’s Lane, Suite 250, Houston, TX 77079

If paying by check, please make check payable to HGS Entertainment Fund.

Team Captain _____ Phone _____ Amount Enclosed _____

Company _____ Email _____

Credit card # _____ Billing Address _____

Expiration Date _____ Security Code _____

	Foursome Members	Company	Phone	Email
<i>(Please Print)</i>				
1.	_____	_____	_____	_____
2.	_____	_____	_____	_____
3.	_____	_____	_____	_____
4.	_____	_____	_____	_____

*Please provide email addresses for **all team members**, as all communications will be done via email.*



Diversity & Women's Networking Event Sept. 11th Great Success!

The GSH, SEG Women's Network and SEG EPIC cohosted a Diversity & Women's Networking event on Tuesday, September 11. It was the first event, but not the last, in which I joined in the coordination effort. My co-organizers were Mairi Erwin, Nicola Maitland, and Elena Dutcher. This was an eye-opening experience to me in several different ways, the most important aspect being just how much effort goes into the process of building a successful event for the organization as well as the participants.

The organizers first met to discuss strategy in June. We used SEG's connection to Lincoln Leaders to commit them for a talk on professional branding, and we negotiated with Sable Gate Winery for the location, food, beverage (and some take-away prizes). Then came the hard part, emailing everyone we knew to get sponsors for a successful event. Several people and companies came through and made generous donations. Our table sponsors were Lorie and Glenn Bear. The support sponsor was Resolve Geosciences and Weir Consulting. The media sponsors were Fairfield Geotechnologies, Mairi and Derick Erwin, and TEEC Solutions. Additionally, other companies and the organizers made donations for a raffle contest totaling \$1,000 in value that the event registrants participated in to raise money for the GSH's scholarship fund.

The event was a huge success. We had 60 attendees, and the speaker, Carla Arimont Lincoln, was able to give an insightful talk on the different components of branding yourself while artfully comparing the process to wine-making. Her message was simple: present yourself in a clear, streamlined way; be truthful about who you are (and own it); and focus more on the purpose behind your actions instead of generic goals. Carla filled her discussion with humor, and asked us to not focus on talking at potential employers, but establishing a connection with them.

The wine and cheese spread was excellent, the message was entertaining and thought-provoking, and the conversation among the women and men gathered was lively. However, none of it would have been possible for the GSH staff who donated their time to working the event and the volunteers who helped at the raffle table, set everything up, and took the pictures below for us to share our memories. Thank you so much to Karen Blakeman, Kathy Sanvido, Jennifer Graf, Kathy Roldan & Becky Olsen. And, as always, thank you to the GSH members who came out to support our organization and each other. We look forward to seeing you at the next event!

By Lillian Comegys



Continued on page 22.

Building your Professional Brand



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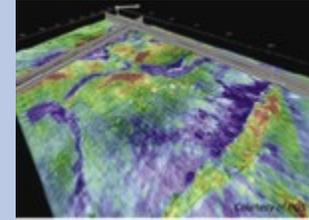
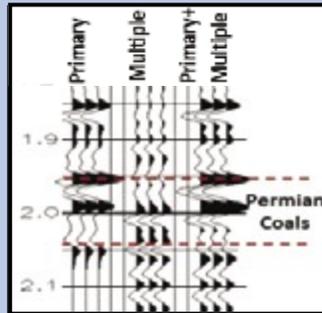
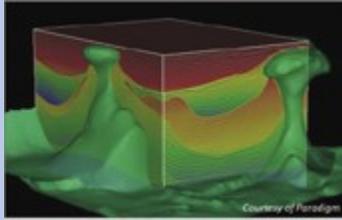


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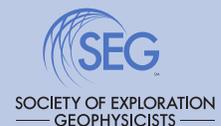
Title

Presenter

Seismic Modeling, Migration, and Inversion	Bee Bednar
Beyond AVO to Quantitative Inversion Interpretation QII	Bill Goodway
Affordable S-Wave Reflection Seismology	Bob A. Hardage
Simplifying and Lowering the Cost of S-Wave Reflection Seismology	Bob Hardage
Basic Seismic Interpretation	Don Herron & Bob Wegner
Basics and UPDATES on Anisotropy: Azimuthal P-P for better Imaging, Fractures & Stress Analysis Acquisition, Processing & Interpretation	Dr. Heloise Lynn
Geophysical Signal Processing 101	Enders A. Robinson & Sven Treitel
Seismic Amplitude 20/20: An Update and Forecast	Fred Hilterman & Mike Graul
Applied Azimuthal Anisotropy-Azimuthal 3D P-P Seismic: Why Bother?	Dr. Heloise Lynn
Understanding Seismic Anisotropy in Exploration and Exploitation	Leon Thomsen
An Introduction to Borehole Acoustics	Matthew Blyth
Topics in Land Seismic Data Acquisition, Processing, and Inversion	Oz Yilmaz
Everything You Always Wanted to Know about Microseismic Monitoring	Peter Duncan
Full-Wave Seismic Exploration: Acquisition, Analysis, & Applications	Rob Stewart
Introduction to Applied Depth Imaging	Ruben D. Martinez
The Interpreter's Guide to Depth Imaging	Scott MacKay



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Machine Learning Essentials for Seismic Interpretation

A LIVE WEBINAR

30 October — 2 November 2018 | 10:00am — 2:00pm



DR. TOM SMITH
President & CEO
Geophysical Insights

This webinar will address the following questions:

- What is machine learning and how does it apply to seismic exploration and unconventional resource development?
- What is the difference between supervised and unsupervised machine learning?
- When is an analysis statistical and when is it machine learning?
- What is attribute space and what is the mathematical foundation of this technology?
- How do you know if the results are any good?
- What are some case histories that illustrate machine learning principals?
- What are some practical tips?

Each of these topics will include one or more examples and simple exercises to illustrate a principal where appropriate.

Operation

- Supervised and Unsupervised Learning
- MLP; CNN; FCN; k-means; SOM
- Attribute space
- Classification

Practice

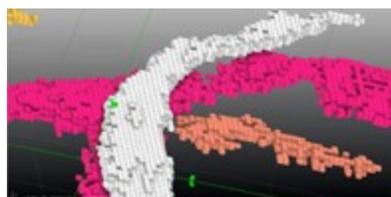
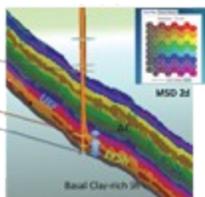
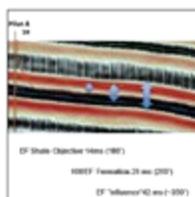
- Geobodies
- Geobody Classification
- Below-Tuning
- Fluid Contacts
- Geobody Seismic Facies
- Making Predictions

Foundation

- Seismic Processing for Machine Learning
- Attribute Selection List Objectives
- Principal Component Analysis

Prediction

- The Best Well
- The Best Seismic Processing
- Over-Fitting
- Cross-Validation
- Who Makes the Best Predictions?



Dr. Tom Smith, the founder of Seismic Micro-Technology (SMT) and creator of the KINGDOM Software Suite, is the President and CEO of Geophysical Insights (geoinsights.com), where he leads a team of geophysicists, geologists and computer scientists in developing machine learning technologies for interpretation. Dr. Tom Smith received a BS and MS degree in Geology from Iowa State University, and a Ph.D in Geophysics from the University of Houston. Over a 50-year career, Dr. Smith has been recognized numerous times for his accomplishments in pioneering the science of geophysics. The Society of Exploration Geologists (SEG) recognized Dr. Smith's work with the SEG Enterprise Award in 2000, and in 2010, the Geophysical Society of Houston (GSH) awarded him an Honorary Membership. Iowa State University (ISU) recognized Dr. Smith's accomplished career with the Distinguished Alumnus Lecturer Award in 1996, the Citation of Merit for National and International Recognition in 2002, and the highest alumni honor in 2015, the Distinguished Alumni Award. The University of Houston College of Natural Sciences and Mathematics recognized Dr. Smith with the 2017 Distinguished Alumni Award.

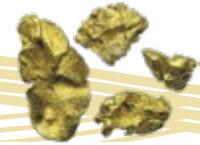
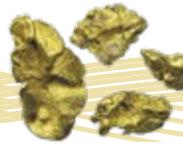
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The Guru Under Attack by The Untutored



Get to the Point !

A flurry of angry Twitters replied with language too colorful to quote here.

Threats of impeachment and pay stoppage were met with yawns and the rather compelling argument that the **Guru**, like so many GSH worker bees, is an Unpaid, Volunteer. The All Merciful Guru forgives all and will continue his Learned Discussion of

Inversion: The Story So Far ...

To this point, our experience with the process of turning **wiggles** into **rock properties** has been restricted to what is commonly called Acoustic Impedance (**AI**): $Ip(t) = Vp(t) \cdot \rho(t)$. The inversion process is established by first considering the **forward model** for obtaining reflectivity from impedance contrasts expressed using linear approximations. The **inversion** turns the process around and solves for **impedance from reflectivity**.

Forward Model

$$R_{n+1} \approx .5 \text{Ln}(Z_{n+1}) - .5 \text{Ln}(Z_n)$$

In Matrix Terms

$$R = D \cdot L$$

D is a **differencing** operator computing the contrast in **Ln**.

Inversion

(Matrix Terms)

$$L = D^{-1} \cdot R$$

Problems with **D⁻¹** are solved by **constraint** equations .

Z_n and Z_{n+1} are respective values of layer **impedance**. They are expressed in logarithmic terms (Ln) for **linearization** of the equations.

This inversion was extracted from **post-stack** data using assumptions of relatively small contrasts of velocity and density and a very small angle of **P-wave** incidence ($\theta \approx 0^\circ$). Before we move on, we should admit that an important piece of the forward model has been ignored, namely, the wavelet, **W(t)**, which is convolved with the reflectivity, **R(t)**, to produce the seismic trace, **S(t)**. $S(t) = W(t) * R(t)$. This augmented model can be written using the matrix notation from above: $S = W \cdot R$. We may then re-express the forward model as $S = [W \cdot D] \cdot L$.

Inversion

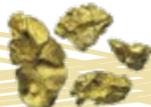
(Matrix Terms)

$$L = [WD]^{-1} \cdot S$$

Note that the introduction of the **seismic sampled trace now** requires a value for the impedance at each corresponding sample time, rather than at major reflection times as our earlier cartoon model of reflectivity. This gives rise to an enormous increase in the **size** of the matrices and their corresponding inverses. This problem requires alternative numerical



Whither Go Us?





procedures for a stable solution in a reasonable time. Earlier we discussed **iterative** methods such as the **Conjugate Gradient** in which we initiate the process with a guess and update at each step to finally converge to acceptable solution. We'll save the applications of inversion until we complete the next little improvement in the process. This leads us to -

Inversion: The Story Expands ...

Not to be greedy, but the next step is to mine even more **rock properties** from **Pre-Stack** data through the inversion of **AVO angle stacks**. The initial product may be called **Elastic Inversion (EI)** since we now include **Shear** information gleaned from the **AVO** response at reflecting boundaries of incident **P waves** at various angles of incidence, θ . For this purpose, we use a few mathematical tricks (as we did for Post-Stack inversion to obtain **Ip**) to estimate **Is** = **Vs**· **ρ** , the Shear Impedance. The search for shear data increases the magnitude of the problem considerably. The next step will add even further to our technical agenda and dilemma.

Further down the road, we will use direct measurement of converted waves (**S to P**) which are buried in your legacy **P-wave** data. (Refer to previous issues of *The GSH Journal* for **Nugget Tutorial** discussions of the these **S-P** converted waves). All will be revealed in **November**.



The October Puzzle: 3 Guys Share 8 loaves of Bread.

Normally around the lunch table at the **GSH International Headquarters**, the **Past Presidents** get Free Lunch. This year, however, in an austerity move, every 3rd Thursday of each month has been designated as a Buy-Your-Own-Lunch. Even the most recent PP's agree to the sacrifice (after much debate, hand-wringing, soul-searching, and whining).

Tommie and **Paul** bring **5** and **3 loaves**, of freshly baked bread, respectively. **Glenn** suggests they share the loaves for lunch and he will pay cash for his share.

They eat equal amounts and **Glenn flops \$8** on the table. The other two agree that's fair.

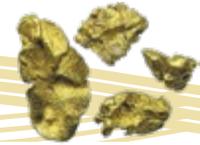
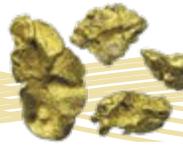
Then the fun begins: How to **split the money from Glenn**. After much haranguing and expletive laden screaming, it was decided to bring in a judge to make the decision. There was *only one* choice: **Lee-The-Lawyer**. How did he rule? You may assume that Lee is infinitely fair and most wise.

The October Solution

The Wise and Good **Lawyer**, immediately foresaw trouble when mere mortals and/or geophysicists were left to decide such weighty matters.

This proved to be the case when the Crafty-but-Innocent **Paul** suggested that since **Tommie** donated **5** loaves and he, **Paul**, put in **3**, **Tommie** should get **\$5** and he, **Paul**, should get **\$3**. **Tommie**, rumored to be a recent and rare survivor of the dreaded **FEFF**, and therefore somewhat brain diminished, said, "Uh, OK, I guess."
[continued next page]





At this point, **Lee-The-Lawyer** stepped in to say, “**Tommie**, you’re being bamboozled. You should get **\$7**, and the crafty-but-innocent **Paul** should get **\$1**. And here’s why.” Lee pointed to the lower left corner the GSH White Board where all Membership Figures, Election Statistics, Staff and Executive Salaries, Calendar Events, and other Notable Things were carefully written and permanently stored using erasable red and blue markers. There, the arithmetic of **Loaves and Cash Splitting** were documented.

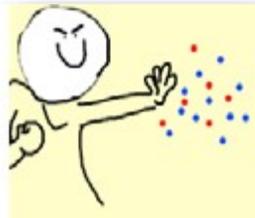
8 loaves, 3 Guys (T, P, and G). Each ate 8/3 Loaves
Tommie donates 5 L = 15/3; 15/3 – 8/3 = 7/3 → Glenn
Paul donates 3 L = 9/3; 9/3 – 8/3 = 1/3 → Glenn
Ratio of Tommie’s Contribution to Paul’s for Glenn = 7:1

Lee reasons Tommie gave bread in the ratio **7:1**, and therefore should be compensated at the same ratio, **\$7 to \$1**.

The November Puzzle

Down at The GSH Intellectual Bar & Grill Game Room, **Craig Beasley**, freshly minted GSH

President –Elect, was holding forth and **2 bags of marbles**. The **Seismic Hardliners**, a wizened and motley group, were enthralled as **Craig** pointed to the bags and challenged the puzzled but eager fan base, “These two bags contain **18 marbles**, some blue and some red. If one marble is selected at random from each bag, the **odds*** against getting **2 Red Marbles** are **11 to 5**. The **Beasley Cup** (broken handle, fungus growth in the cracked rim) goes to **he** or she who can tell me the **Odds against getting two Blue Marbles, one from each bag.**”



“**Not so fast, Swifty!** I didn’t just fall off the **SEG** Turnip Truck. You didn’t even tell us how many marbles are in each bag,” declared Aged Resident Curmudgeon, **Lee Lawyer**.

“**Nor will I,**” said the erstwhile **SEG** president, “but I will tell you this: there is but one answer to my question, and even you should be able to discover it. A dejected **Lee** sought solace in the bar’s only bottle of E & J

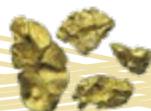
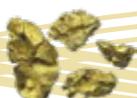
Domestic Cognac (lonely on the top self, with only MD 20/20 for company), and solicited help from **The GSH Brain Trust**, and while most of its members were well past their use-by dates, they would, nevertheless, ferociously attack any brain teaser put in front of them – especially if the coveted **Beasley Cup** was the prize.

If you are a card-carrying Member of the **GSH**, or even a Fellow Traveler, you are eligible to assist the **GBT** by submitting your solution to the **GSH Keeper of Cup, Karen Blakeman**.



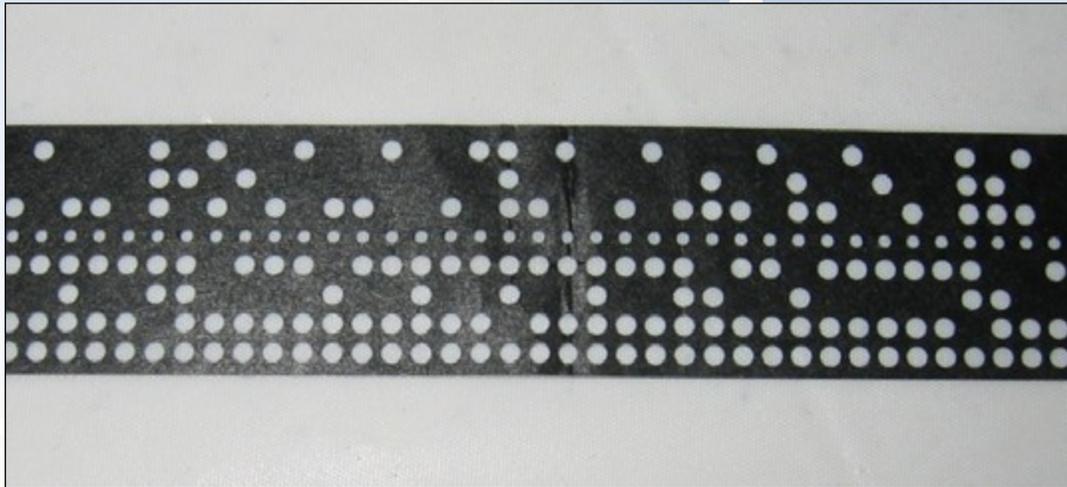
Deadline for Submittal:
October 31, 2020.

* **Odds** are slightly different than **Probability**. **Odds** are expressed as the ratio of the number of ways to get **2 Reds** to the ways of **NOT 2 Reds**
Example: Coin Flip for Heads.
 $P(H) = \frac{1}{2}$.
Odds of H = 1:1.



Mystery Item

This is a geophysical item...



Do you know what it is?

This month's answer on page 34.



GSH OUTREACH is looking for volunteers for:

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Recognizing Outstanding GSH Volunteers...

Lee Lawyer

by Tommie Rape

The many social and technical opportunities offered by the Geophysical Society of Houston (GSH) for the geophysical profession of Houston and beyond are due largely to many dedicated volunteers. The GSH wants to recognize some of these dedicated volunteers and will do so through this series of articles where we will present a monthly selected volunteer and provide our readers with some of the volunteer's professional and volunteer background. Hopefully this will increase our readers' appreciation of these volunteers and maybe encourage them to join the GSH volunteer ranks where they can partake of the many benefits that this work provides. --- Tommie Rape

Lee Lawyer was born in Kansas, but his family moved around considerably, since his father worked for a pipeline company. Lee's early introduction to the petroleum industry was largely centered in Oklahoma. He followed this up with his entry to the University of Oklahoma, where he began studies in petroleum engineering but soon switched to geological engineering. These studies were interrupted, when he was drafted into the military during the Korean War. He entered the army as a private, but was later selected for Officer Candidate School. Upon completion of officer school he became a 2nd Lieutenant in the Army Corp of Engineers. Thus, began Lee's leadership training while he served in France during the war. Upon completion of his service, he returned to Oklahoma where he completed his geological engineering degree in 1954.

Having several job offers, Lee took the offer to be a geophysicist because he was not sure what a geophysicist did. (Note: this will not be the last time Lee makes a sarcastic remark.) He went to work for Standard Oil Company of Texas (SOTEX). Initially, he was a junior bird dog (Client Representative) on company seismic crews and other contract crews. Not only was Lee a representative on seismic crews, but he also was the client representative on seven contract gravity crews. In total, he moved 30 times in three years. Lee then spent several years prospecting as a seismic interpreter. Lee says he enjoyed that job more than all the others because of the hands-on-data nature of the work. SOTEX became Chevron in 1961 and Lee spent many years moving between cities



such as Houston, Amarillo, Oklahoma City, Denver, and San Francisco, while progressing through the organization as Division Geophysicist, Vice President, and finally, Chief Geophysicist of the Chevron Corporation from which he retired in 1992.

Lee began an extensive volunteer service with the SEG in 1967 when he was on the Arrangements Committee for the SEG Annual Meeting in Oklahoma City. He was the Chair of the Arrangements Committee for the 1975 Annual Meeting. He was the General Chair of the 1978 Annual Meeting in San Francisco. In 2005, Lee was the Chairman of SEG's 75th Anniversary Committee. His service with the SEG did not end there as he has also served in elected positions. Lee was the Second Vice President in 1980-81. He was the SEG's first President-Elect in 1986-87 and then served as President 1987-88. During his Presidency he helped the SEG withstand the major industry downturn. Lee has also served as a GSH Representative on the SEG Council for a number of years and is currently finishing a three-year term as Chair of the Council.

Volunteers continued on page 30.



With all of Lee's service to the SEG, it is hard to believe that he had time for the GSH. His activity with the GSH certainly rose after his retirement from Chevron in 1992. Lee has served on a number of committees over the years, including the Symposium, Financial, Nominations, and Teller Committees, etc. In 2001-02, he was an assistant to the Editor of the GSH Newsletter. He was elected to Editor the following year. Recognizing the depth of the editorship position, the GSH asked Lee if he would be Editor a second year; he agreed and was re-elected, serving in the position 2002-04.

Lee was instrumental in forming the GSH Journal, which began publication in 2010. For a number of years, he has served as chair of the Editorial Committee. The Journal is noted for the Doodlebugger Diary, A Conversation With, and the Tutorial Nuggets. Lee's writing skills are renowned. He has written the very popular series, "From the Other Side" (FTOS), in the SEG's The Leading Edge for about 24 years (288 columns). In the past year this series has moved from The Leading Edge to the GSH Journal. So, check out the FTOS series in the Journal, and partake of Lee's wit and foresight.

Lee is also the Chair of the Advisory Committee for the GSH. Herein lies perhaps the greatest benefit that Lee provides the GSH; in an organization where

the leadership changes from year to year, Lee provides GSH experience covering many years and provides sound and insightful advice to the leadership of the GSH. Lee has been involved in volunteering for the GSH for over 25 years now. He also has made many financial contributions to the GSH over the years, often in support of the Geoscience Center and students who participate in GSH activities.

Lee not only volunteers for the GSH, but is probably the most active participant in GSH activities. He attends many technical events and is grateful for the technical knowledge that is shared. This





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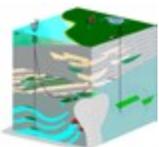
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shared knowledge helps keep him abreast of the technical changes occurring in our technical profession. Needless to say, he also enjoys the social events. You will often find him in the middle of spirited discussions at these events. He also feeds his competitive spirit by playing in the golf and tennis tournaments. Lee and Haynie Stringer (another strong volunteer for the GSH) show up at the GSH office periodically for "Taco-Fest" to show the staff our appreciation for their efforts.

When asked why he volunteers for the GSH, he says that he is "paying it back". Younger members can "pay it forward". Lee is proud of what he has contributed to our geophysical profession and very grateful for all that the profession has given to him. He highly encourages all geophysicists to get involved with the GSH. If you are interested in volunteering for the GSH, contact officers, committee chairs, Kathy or Karen in the office, or anyone else that you might know that is involved in the GSH. Volunteering will also add to your professional contacts and make you a more integral part of "the brotherhood of geoscientists".

In recognition of a lifetime of contributing time and effort to the SEG and GSH, Lee has received numerous awards. The SEG has awarded Lee with a Special Commendation Award, the SEG Presidential Award, and SEG Honorary Membership. The GSH has awarded Lee with Lifetime Membership and twice he was presented the GSH Presidential Award. Please join us in recognizing Lee for all his efforts for the GSH, and the next time you see him, personally thank him for all that he has done for the GSH.

U of H Wavelets

SEG Wavelets host Workshop for Python and Julia

by Jackson Zerr and Matthew Sexton



Participants of this year's Working Workshop

In early August, the SEG wavelets hosted a workshop led by Karl Schleicher of the Bureau of Economic Geology. Participants worked together to create software, which solved a given geophysical problem. Attendees from different universities and industries were split up into multiple small groups. Within their group, they were tasked to use Julia and Python computer languages to create software that solved a given challenge.

Historically, Python and Julia are used for selected seismic processing. The lack of software produced for geophysical application motivated Schleicher to host the working workshop and teach the languages' diversity and application. By leading this workshop, Schleicher hopes to create software, which reads geophysical data, interface to legacy processing systems, and implement common algorithms.

Throughout the several day workshop, groups would report on their progress. By collaborating with one another, groups were able to polish and better utilize their results. The workshop ended with each group sharing their results in a short lighting talk. Ultimately, this workshop was a great opportunity to learn new skills, brainstorm ideas, and build a stronger professional network.



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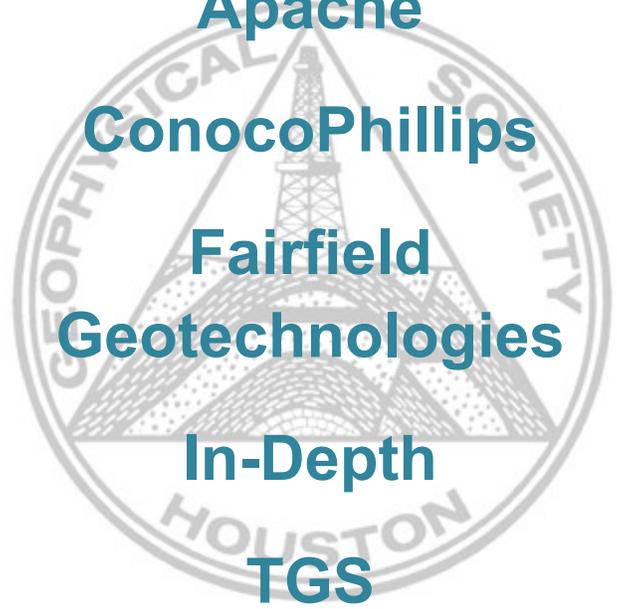
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? ? The Mystery Item on page 28 is a Paper punch tape, used for input to computers in the 1950's and 1960's. ? ?



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Geoscience Center News

By Bill Gafford

1790 W. Sam Houston Pkwy. N. (Right on Shadow Wood)



We recently received a nice donation from WesternGeco for our Museum Collection. It is a model of the Western Regent seismic boat, which was built in 1993. This will add to our marine seismic items and is on display at the Geoscience Center underneath a map of the Gulf of Mexico, as shown in the picture below. They also donated some geophones and we hope to receive a few more items. We also received a large number of Journals from Fred Hilterman. The donation included copies of "The Leading Edge", EAGE "First Break", EAGE "Geophysical Prospecting", and "The AAPG Bulletin". We have some copies of all of these journals, but Fred's donation will fill some large gaps. We will have many duplicate copies and they will be added to the AAPG Publication Pipeline project. The mission of the AAPG Publication Pipeline Committee is to improve geoscience education by providing used geoscience books and periodicals at no cost to overseas university libraries and other libraries that need them.

Our next Living Legends Doodlebugger social event will be on Thursday morning, November 8 th. Although these quarterly events were started for retired or nearly retired people, anyone is welcome and we usually have some visitors who enjoy seeing the items we have on display as well as some of our previous mystery items from the GSH Journal.

We still need some volunteers who could help with various projects such as organizing some of our artifacts and researching how they were used in the earlier days of exploration. There is also a need for creating some display signs to accompany some of the items we have on display. Please contact me if you might have a few hours to volunteer on a Wednesday morning.

Visitors are welcome at the Geoscience Center on Wednesday mornings from 9:00 until noon or by appointment. Please contact me at geogaf@hal-pc.org or at 281-370-3264 for more information.



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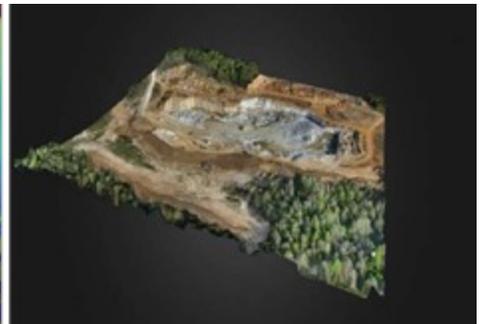
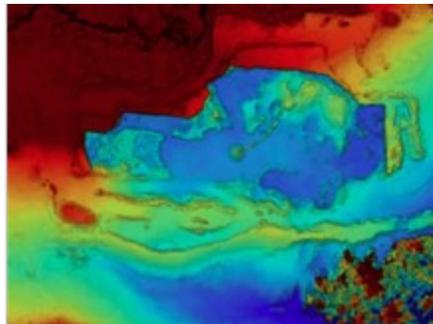
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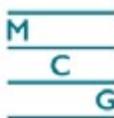
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Doodlebugger Diary

Eritrea – What Happened To Thee? Part 2 – Massawa

By Scott Singleton

This Doodlebugger Diary is the second in a series by Scott Singleton. The first told the story of a shipwreck in the South China Seas. If you missed it, I strongly recommend that you go back and start Episode one in the February 2018 GSHJ. There are four episodes that follow that first one. The second series starts in the September 2018 GSHJ and is set in Ethiopia and Eritrea in East Africa. This is Episode two.

The Doodlebugger Diary are the experiences of geophysicists during their working lives. Usually, these are not recent events, but more recent ones are just as welcome. Think back to an earlier time when you

were on a seismic crew, operating a magnetometer survey, gravity stations, or whatever. I included one that involved a data processing center. Seriously consider contributing a story or two. Contact me at llawyer@prodigy.net or our Editor at editor@gshtx.org. ~Lee Lawyer

The drive from Asmara to Massawa was very long and as we made it off the mountainous plateau we progressed from mild temperatures to extremely hot and dry. We passed foothills that were extensively terraced (*Figure 1*) which gave away to desert and Bedouin encampments (*Figure 2*).



Figure 1: Terraced foothills on the road from Asmara to Massawa.

Doodlebugger continued on page 40.

If you would like to add stories to the Doodlebugger Diary, send them to: Lee Lawyer at llawyer@prodigy.net or mail them to Box 441449, Houston, TX 77244-1449



Figure 2: A Bedouin semi-permanent encampment on the lowlands outside of Massawa.



Figure 3: A Mosque showing a direct hit by an aerial bomb. The story we were given was that a cowardly Ethiopian pilot in a Russian MIG flew in from Asmara, swooped down, dropped a bomb on the mosque, and flew away really quickly so he wouldn't get shot at.

But we were scarcely prepared for Massawa. We entered a town that made no attempt to hide the horror that it had been through for 30 years. Prominently displayed was a bombed out mosque (Figure 3), presidential mansion (Figure 4), and the remains of what was once the main port of entry

for Eritrea (Figure 5). We were met by a high-level oil ministry official who was all smiles. He immediately took us to the main highway roundabout at the start of the town and showed us the monument they had placed there. It was three tanks carefully arranged with the center one being up on a pedestal and the

Doodlebugger continued on page 41.



Figure 4: A presidential palace in Massawa that, from the looks of things, was the scene of some battles.

other two flanking it on the ground. They were pointed towards Asmara from where we had just come. He then told us their story. They were captured Ethiopian tanks (as was all the other military hardware the Eritreans used in the war) and were the first three tanks to break the Ethiopian front lines and charge into Massawa, which led to its capture by the Eritrean rebels. This was apparently the turning point in the war due to Massawa's importance as a port of entry (the

same strategy is currently playing out in Yemen across the Red Sea from Eritrea).

The town itself was a mixture of war-scarred buildings with bullet holes (Figure 6) to nicely-maintained buildings that revealed their Italian roots (Figure 7). During the course of our survey we were in this town quite a bit and found its inhabitants very friendly and excited that we were there trying to help them better their lives. We never had any issues walking around day or night, nor did we ever feel threatened no matter where we were. It was here that I fell in love with the Ethiopian cuisine of spicy meat curries called 'wat' (usually made with red pepper) that are served with 'injera', which is a thin, soft sourdough flatbread served rolled up. Pieces of injera are torn off, held between index finger and thumb and used to grasp a bit of wat to eat (there is no silverware in this society). It is quite messy and very good.



Figure 5: Two coastal freighters that were sunk while sitting at the dock in Massawa. They obviously had been there for some time before we arrived.

So after gear and crew were mobilized and we

Doodlebugger continued on page 42.



Figure 6: An entryway to a market square that had taken some damage during the war. This part of town didn't have a lot of activity while we were there. Wandering down side streets in this area revealed lots of bullet holes so the assumption was that it saw street fighting during the liberation.

went through pre-trip instrument checks, we set off. We had a list of sites to visit and proceeded from one to the next (Figure 8). The seafloor was very interesting in this area of the Red Sea because reefs and carbonate hardground occurred in random patches scattered through the region. Our hi-res instruments would penetrate in one area of soft seafloor and then be totally blocked in an adjacent area. In these hardground areas we resorted to piston coring to get a handle on what was down there. We brought up a lot of interesting shells in those core barrels.

During the month or two of our survey I was busy most of the time reviewing data and making interpretations. One of the things I needed to get a handle on was a hazy, diffuse reflection buried beneath some but not all of the hardground patches. This type of signature is typically produced by one of two possible sources – natural gas plumes or carbonate facies changes into a harder, denser matrix. I tried many times to get a piston core deep enough to sample this reflector but was unable. The piston core didn't have enough power



Figure 7: A part of town that appeared unscathed by fighting. This area had lots of businesses that were open. In fact, the white plastic chairs were in front of one of our favorite café bars. People often sat outside because it was hot and stuffy inside.

to penetrate through the hardground. It would take a subsequent visit by a shallow drilling rig to get a core of sufficient length. But nonetheless, because I knew a natural gas blowout had occurred in one of the exploratory wells in this area I could take no chances. I mapped the diffuse reflector wherever it was found, adding hi-res traverses until I was satisfied I knew its character and extent. It was fun and I was having the time of my life playing the wild frontier wildcatter. Eventually we mapped and sampled each of the original sites plus several more that I delineated. I called the survey to a close full of optimism that Anadarko would get some good prospects out of our work.

So we docked the boat, demobed the equipment, and drove back to Asmara for some of the best Ethiopian meals I've ever had. I of course came back to the US with as many local items as I could carry, which was my normal modus operandi in foreign sites I visited. For Asmara it was several big bags of freshly roasted Ethiopian Yirgacheffe coffee beans. (The coffee in this part of the world is Robusta rather than Arabica which is the more common variety in the US. It has more of a 'robust' flavor but is considered by some to be more earthy and harsh).

But all was not well in the end – on the flight back the plane landed in Addis Ababa to refuel and, being in business class, I thought it might be OK to eat my first salad since leaving the US. Wrong. I should have

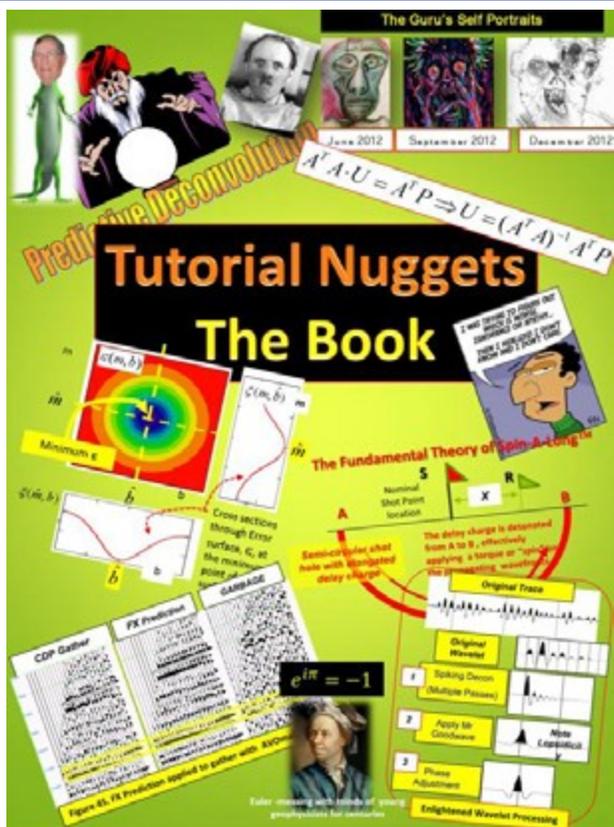
known better – the rules of foreign travel are to never eat anything that isn't cooked or peeled. So the middle of my first night home was spent in close proximity to the toilet. My wife told me later I sounded like I would die. I certainly felt like it too.

Epilog: After Anadarko mobbed a shallow drilling rig and took deeper cores they found that the hi-res signatures I mapped were all carbonate hardgrounds rather than shallow gas deposits. I am not sure if they drilled any exploratory wells but I heard that within a year or two after our departure they let the lease expire and left the country. This is when the border war with Ethiopia started and Eritrea's President-for-life Isaias Afwerki clamped down on political and cultural freedoms, turning Eritrea into a repressive, walled-off country. This is a country that has had a one-party political system, no press freedoms, one of the worst human rights records in the world, has been under a UN-sponsored arms embargo since 2009, and is one of the sources of migrant refugees trying to get into Europe. See their Facebook page 'PEN Eritrea', hosted by PEN International and devoted to freedom of expression.

I am very saddened to see this happen to what once was a proud people. My hope is that the thaw in relations with Ethiopia results in a re-establishment of cross-border ties between these two countries and that Eritrea once again is able to flourish.



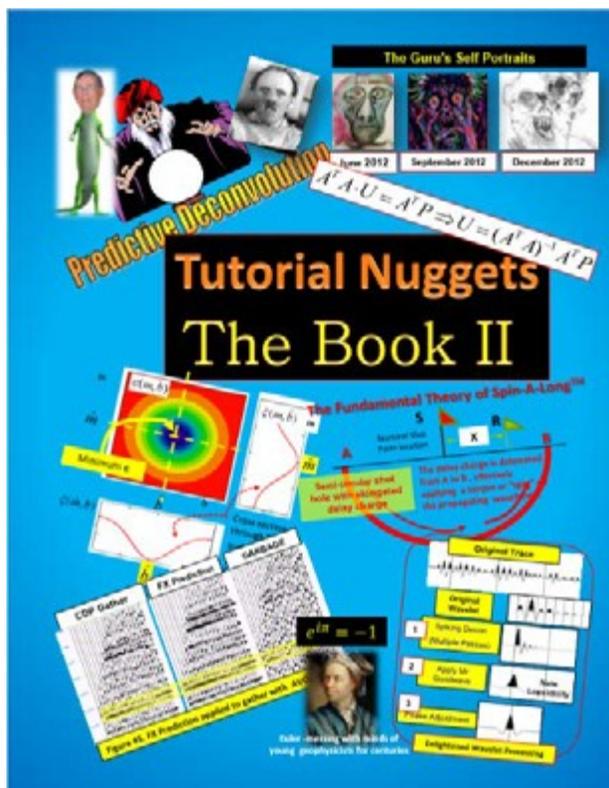
Figure 8: Deploying our gear at another site with our tender vessel keeping close track of things.



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