

April 2017



*The Epicenter of
Geophysical Excellence*

GSH Journal

GEOPHYSICAL SOCIETY OF HOUSTON

Volume 7 • Number 8

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Technical Article: Seismic Interpretation in
the Age of Big Data – Page 20

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Low environmental impact seismic data acquisition by Global Geophysical.

Photo courtesy of Global Geophysical.



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 David W. Watts, editor, at DWatts1@slb.com.

GSH JOURNAL DEADLINES

June 2017	Apr 7
Sept 2017	Jul 7
Oct 2017	Aug 10

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A Word from the Board

Connecting as a Community

By Kat Pittman, 2nd VP Elect

Do you like to chat over cocktails? Go fishing? Shoot sporting clays? Play golf on a sunny day while drinking a few beers? Are you a tennis pro, or have you ever thought about picking up a tennis racket for the first time? Believe it or not, you can enjoy all of your favorite hobbies or pick up some new ones with the Geophysical Society of Houston! As the current 2nd VP Elect and incoming 2nd VP for next year, my role is to oversee all social and networking events for the society. We have a lot of fantastic annual events to choose from every year: the Icebreaker, Sporting Clays Tournament, Saltwater Fishing Tournament, Tennis Tournament, Golf Tournament and our end-of-year bash, the Annual Honors and Awards Banquet. As a social person by nature, these have always been events that I enjoy. I have attended numerous events every year during my ten years with the society and I always enjoy meeting new people!

Getting out and networking with your peers is one of the best ways to stay up-to-date on what is happening in the industry and in the community. It is also a fantastic opportunity to market yourself in a relaxed environment, without the pressures of a typical professional event. The role of social outings is not only to network with your peers, but to connect with them as well. I work at a company with less than ten people, and it's still all too easy to simply pass them by in the hallways or in the kitchen. It's hard to carve time out of your day to have intentional conversation and connection. Setting aside the time to visit and socialize with your colleagues in the society does take a commitment, but remember, the latest developments in seismic acquisition or the benefits of advanced high resolution processing can be discussed as easily, if not more freely, on the golf course as they can in a conference room!

We live in the capital of the oil industry and have an amazing network right at our fingertips. Did you know that the Geophysical Society of Houston is the largest section of the SEG? We partner with the SEG for many of our technical events throughout the year, and I have made it one of my goals to strengthen the bond that we have with the SEG for social events as well. Houston will be hosting the SEG Annual Meeting in September 2017, which is a perfect opportunity to create a joint networking event surrounding the convention. Stay tuned for some exciting announcements about this event during the Annual Meeting! We are excited to show the SEG

body the hospitality that our society and our city have to offer.

As we have weathered this industry downturn together, our social events have continued to be a success. Some events have even come close to record attendance. We could not do what we do as a society without the continued and generous support of our sponsors, the tireless work of our volunteers and committee chairs, or the participation of our membership!



**Kat
Pittman**

The 2016-2017 GSH Board of Directors has watched all expenses closely and has had to make some hard decisions at times and I am proud to say that we have not only stuck to the 2nd VP budget to date, but have surpassed our expected profits. We have limited expenses whenever possible without increasing the cost of events for our members. The Icebreaker, our kick-off social event of the year, even remained free for members. Every dollar of profit goes right back into the society to help foster the community and facilitate the events that connect us all.

I want to personally thank the chair people that have made our social events this year such a success: Tony LaPierre - Icebreaker, Rick Trevino and Ryan Marshall - Sporting Clays Tournament, Bobby Perez - Saltwater Fishing Tournament, and Russell Jones - Tennis Tournament. Each of these event chairs watched every line item, solicited sponsorship in a very difficult year, and achieved higher profits than promised. They were a pleasure to work with and put in a lot of time and effort to make these events fun for all of us! It takes a great team to plan these events in a down market, but it takes an incredible team to continue to surpass expectations and gather such momentum and excitement for their respective events.

Though the role of networking and connecting with our colleagues evolves as the needs of the community changes, the importance of coming together and connecting never goes away. I hope to see many of you at our Golf Tournament in April, and please join in on our party at the end of the year, The Annual Honors and Awards Banquet! It is always a blast and is an opportunity to thank the people who contribute to both our society and our geophysical community as a whole.

Technical Events - See gshtx.org for more details on these events

TECH BREAKFASTS

Automatic Early Arrival Traveltime Tomography and Its Applications

	Speaker(s):	Jun Tang, WesternGeco, a division of Schlumberger
Apr. 4, 2017	7:00 AM to 8:30 AM	Sponsored by Anadarko Petroleum and Lumina Reservoir Inc.
Northside Breakfast	Location:	Anadarko Petroleum 1201 Lake Robbins Drive The Woodlands, TX 77380
April 19, 2017	7:00 AM to 8:30 AM	Sponsored by Schlumberger and WesternGeco
Westside Breakfast	Location:	Schlumberger, Q-Auditorium 10001 Richmond Avenue Houston, TX 77042

ROCK PHYSICS SIG

Correcting Lithology/Fluid Effects for Pore Pressure Analysis

April 5, 2017	Speaker(s):	Yaping Zhu, Statoil
	5:15 PM to 6:30 PM	Sponsored by CGG and Ikon Science
	Location:	CGG 10300 Town Park Dr. Houston, TX 77072

GEOSCIENCE COMPUTING SIG

1st: Technically We Don't Produce the Weather, We Predict It. 2nd: Introduction to the OpenPOWER Foundation.

April 11, 2017	Speaker(s):	Robert Berglund, IBM Weather Company Bryan Talik, IBM Director of OpenPOWER System Enablement and President of OpenPower Foundation
	11:30 AM - 1:30 PM	Sponsored by The Society of HPC Professionals and UDI
	Location:	IBM Houston Office 10777 Westheimer (5th floor 05-565C Grand Ballroom) Houston, TX 77042

DATA PROCESSING & ACQUISITION SIG

Compressive Seismic Imaging: A Year of Production

April 11, 2017	Speaker(s):	Chuck Mosher, ConocoPhillips
	4:30 PM to 5:00 PM	Sponsored by Schlumberger
	Location:	Schlumberger, Q-Auditorium 10001 Richmond Avenue Houston, TX 77042

TECH LUNCHEONS

Full Waveform Inversion With Steerable Variation Regularization

	Speaker(s):	Lingyun Qiu, PGS
April 18, 2017	11:00 AM to 1:00 PM	
Westside Luncheon	Location:	Norris Conference Center 816 Town & Country Blvd. Houston, TX 77024 (Free parking off Beltway-8 northbound feeder or Town & Country Blvd.)
April 19, 2017	11:00 AM to 1:00 PM	
Downtown Luncheon	Location:	Petroleum Club of Houston 1201 Louisiana, 35th Houston, TX 77004 (Valet parking onsite.)
April 20, 2017	11:00 AM to 1:00 PM	Sponsored by Southwestern Energy
Northside Luncheon	Location:	Southwestern Energy Conference Center 10000 Energy Drive Spring, TX 77389 (Free Parking onsite)

Technical Breakfasts

Automatic Early Arrival Traveltime Tomography and Its Applications

Speaker(s): Jun Tang, WesternGeco,
a division of Schlumberger.

Northside

Tuesday, April 4, 2017

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:

Recent advances in Seismic data acquisition have significantly improved our capability in imaging complex subsalt structures. These data also provide extremely valuable refractions energies, including diving wave, head wave and large angle reflections, for velocity inversion and anisotropy analysis. We have developed a method of macro velocity inversion that does not require explicit picking of either common image point gathers or first breaks. In this method, seismic data are first decomposed into Gaussian packets. Packets associated with early-arrival energies are selected and used as input to a tomography solver. The outputs of the solver are velocity and Thomsen's anisotropy parameters, or any of their combinations. Using information contained in the packets we can correctly model the early-arrival energies (first breaks and/or other refractions). The workflow is fully automatic and can be used in a batch processing environment with minimum human intervention. We have applied our method in two field dataset. The first field data example is for a shallow marine seismic data project. We are able to obtain a better shallow velocity model

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for Tech Breakfast
Northside

Register
for Tech Breakfast
Westside

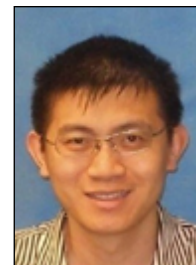
Westside

Wednesday, April 19, 2017

7:00 – 8:30 a.m.

**Sponsored by Schlumberger
and WesternGeco**

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



Jun Tang

using our method than a legacy approach. In the second field data example, we have applied our method on a deep water dataset from a dual coil acquisition, with full-azimuth and long-offset coverage. Our method can correctly model early-arrival energies recorded at long offsets and use them in the iterative inversion such that better estimation of velocities and anisotropy parameters in shallow sediments can be achieved. We have tested different starting models for the inversion and have been able to get very similar results suggesting that our method is not sensitive to accuracy of a starting model.

Biography:

Jun obtained his BSc degree in Physics from Peking University, China, in 2000 and his MSc degree in Electrical and Computer Engineering from Rice University in 2002. He started working as an Electrical Engineer at Freescale Semiconductor Inc. in 2002. He joined Nexus Geoscience Inc. in 2009 as a Research Geophysicist. He is currently a Senior Geophysicist working for Schlumberger. His interests include various topics in seismic velocity model building and imaging.



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Rock Physics SIG

Correcting Lithology/Fluid Effects for Pore Pressure Analysis

Register
for Rock Physics

Speaker(s): Yaping Zhu, Statoil

Wednesday, April 5, 2017

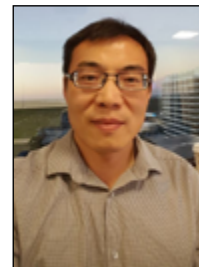
5:15 p.m. Refreshments

5:30 p.m. Presentation Begins

6:30 p.m. Adjourn

**Sponsored by CGG
& Ikon Science**

Location: CGG
10300 Town Park Dr.
Houston, TX 77072



Yaping Zhu

Abstract: Shale is the most abundant sedimentary rock, and commonly used methods for pore pressure analysis such as Eaton (1975) and Bowers (1995) methods often focus on rocks with high shale concentration, esp. pure shale. Real rocks, however, generally differ from pure shale in that they have varying lithology and fluid contents, such as sandy shale and shaly sand. To correct for the lithology and fluid effects on rock properties (e.g., velocity and resistivity), we suggest applying lithology and fluid substitutions based on rock physics relationship calibrated to well logs. This allows us construct the pseudo shales that are featured with 100% Vshale, 100% Sw (for water-wet rocks) and background shale porosity. The corrected logs (pseudo logs) can be used for pore pressure analysis. The work is further developed to a pseudo-LogR approach, where pseudo logs of sonic transit time and resistivity are overlain and properly scaled

for the background shale intervals, and differences in sonic and resistivity logs for pseudo shale intervals are correlated to pressure of the corresponding sandy shale and shaly sand intervals. Here we assumed that the rocks are non-source rocks. We use synthetic and real examples to demonstrate the concept.

Biography: Yaping Zhu graduated from Tsinghua University in Beijing, China in 2000 and received his PhD in Geophysics from Center for Wave Phenomena (CWP) at Colorado School of Mines in 2006. From 2006 to 2013, he worked for ExxonMobil Upstream Research Company as a research specialist and ExxonMobil Exploration Company as an exploration geophysicist. He currently works for Statoil on pore pressure and geophysical basin modeling projects.



GSH Annual

GOLF TOURNAMENT

Walden Country Club

on Lake Conroe

MONDAY, APRIL 17, 2017

Geoscience Computing SIG

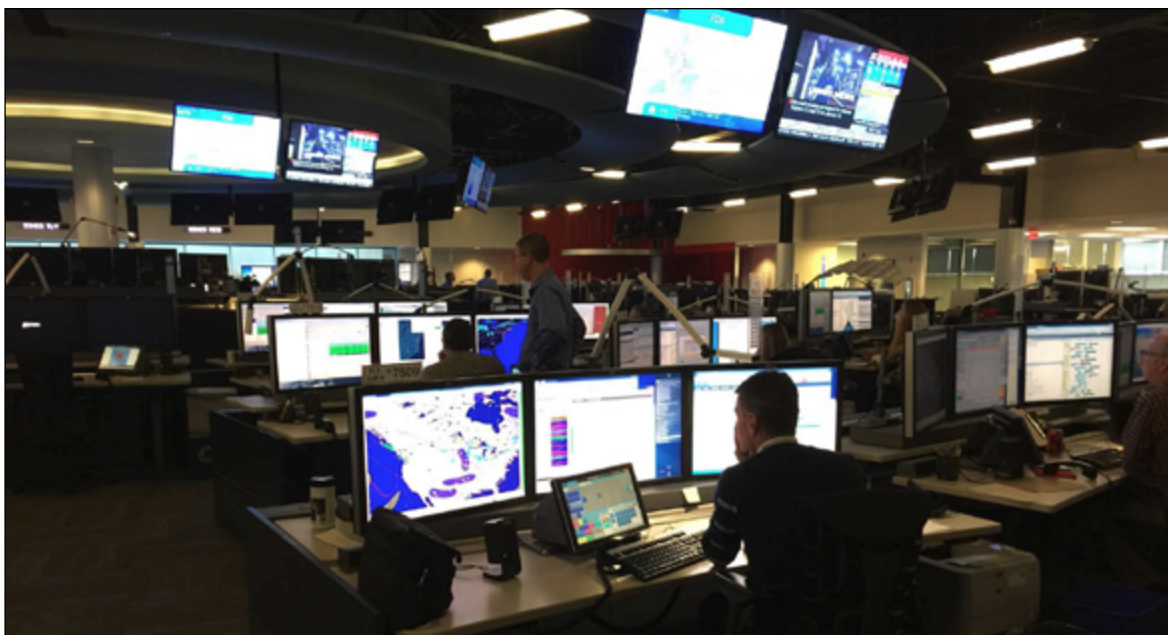
Thursday, April 11, 2017

11:30 a.m. - 1:30 p.m.

**Sponsored by The Society of
HPC Professionals and UDI**

Register
for Geoscience Computing

Location: IBM Houston Office
(5th floor 05-565C
Grand Ballroom) at
10777 Westheimer
Houston, TX 77042
www.google.com/maps



Technically We Don't Produce the Weather, We Predict It

Speaker(s): Robert Berglund, from the IBM
Weather Company team

Abstract:

Robert Berglund, from the IBM Weather Company team, will share with the group the IBM Weather Company agenda for the plethora of data being collected around the world for all the various industry related needs. A focus will be on Oil & Gas industry Weather information and how that might pertain to Oil Field operations.

The Weather Company is an IBM subsidiary, including Weather Underground.

Introduction to the OpenPOWER Foundation

Speaker(s): Bryan Talik, IBM Director of
OpenPOWER System Enablement and
President of OpenPower Foundation.

Abstract:

Bryan Talik will share with the HPC Society the relevancy of the OpenPower Ecosystem for science and industry collaborative innovation. You can read about OpenPower Foundation at www.Openpowerfoundation.org. The OpenPOWER Foundation was founded in 2013 as an open technical membership organization that will enable data centers to rethink their approach to technology. Member companies are enabled to customize POWER CPU processors and system platforms for optimization and innovation for their business needs. These innovations include custom systems for large or warehouse scale data centers, workload acceleration through GPU, FPGA or advanced I/O, platform optimization for SW appliances, or advanced hardware technology exploitation.

Data Processing & Acquisition SIG

Compressive Seismic Imaging: A Year of Production

Register
for Data Processing

Speaker(s): Chuck Mosher, ConocoPhillips

Tuesday, April 11, 2017

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

5:00 p.m. Start of presentation

Sponsored by Schlumberger

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



**Chuck
Mosher**

Abstract:

Compressive sensing provides a new framework for sampling signals and wave-fields. This technology based on non-uniform sampling, sparsity, and optimization can increase sampling efficiency by a factor of two or more in each sampling direction. Seismic data are acquired in four spatial dimensions, so the efficiency gains can approach an order of magnitude. When combined with simultaneous shooting, the gains can be even larger. We refer to our framework for utilizing compressive sensing concepts in seismic acquisition, processing, and imaging as Compressive Seismic Imaging, or CSI. ConocoPhillips has recently completed a full year of production application of CSI to land, marine, and ocean bottom node surveys. All of these projects have achieved significant improvements in both acquisition efficiency and in data quality. Acquisition efficiency improvements achieved in production range from a factor of 4 to as high as 10. Significant improvements in spatial resolution were achieved as well. The acquired data have been used for imaging, AVO, and 4D analysis. Direct comparisons of these results have been made to both test data acquired specifically for comparison, and data from adjacent and overlapping surveys. In all cases, quality of the CSI data exceeds that of the comparison data.

Biography:

Chuck Mosher is currently a Senior Geoscience Fellow in the Technology and Subsurface organization at ConocoPhillips. He received his BS (1978), MS (1979), and PhD (1980) degrees from the University of Minnesota Department of Geology and Geophysics. Chuck began his career as a geophysicist with ARCO Oil and Gas Company beginning in 1980, where he held research and management positions in the Geophysical Research and Information Technology departments. From 2000 to 2003, Chuck worked for Chevron Technology Corporation as a research geophysicist. In 2003, Chuck joined ConocoPhillips

as a Geoscience Fellow in the Subsurface Technology organization. In his present position, Chuck is responsible for assuring the technical quality of research and technical service projects involving Geophysical Technology at ConocoPhillips. Chuck's areas of expertise include the design and execution of projects in seismic data acquisition, processing, and imaging. His current research interests include compressive sensing, seismic survey design, and seismic processing and imaging.

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Technical Luncheons

Full Waveform Inversion with Steerable Variation Regularization

Speaker(s): Lingyun Qiu, PGS

Westside

Tuesday, April 18, 2017

11:00 a.m. – 1:00 p.m.

Location: Norris Conference Center
816 Town & Country Blvd.
Houston, TX 77024
(Free parking off Beltway-8 northbound
feeder or Town & Country Blvd.)

Downtown

Tuesday, April 19, 2017

11:00 a.m. – 1:00 p.m.

Location: Petroleum Club of Houston
1201 Louisiana, 35th
Houston, TX 77004
(Valet parking onsite.)

Abstract:

We propose a new regularization scheme for Full Waveform Inversion (FWI). The new method makes use of a priori information on the spatial variability of the earth model to overcome the limitations of the inversion in the presence of high velocity contrast geobodies and cycle skipping. It comprises two additional regularization terms to the FWI objective function. The first term evaluates the L1 norm of total variation (TV) of the model, while the second term steers the solution based on local prior information of the model spatial variability. Both regularization terms can be made spatially variant to accommodate different geological features in the model, i.e. sediments (smooth changes), salt bodies (piecewise constant). Our procedure makes use of the split Bregman iterations, an effective algorithm for solving the L1 optimization problems. The result is a computationally efficient and accurate implementation. We show the potential of the method by using the BP 2004 and SEAM velocity benchmark model. In these examples, our regularization scheme allows the inversion to start from a simple velocity model and delivers a high-quality reconstruction of salt bodies.

Register
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Westside

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Northside

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Southwestern Energy**

Tuesday, April 20, 2017

11:00 a.m. – 1:00 p.m.

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



Lingyun Qiu

Biography:

Lingyun Qiu obtained his PhD in Mathematics from Purdue University in 2013. He spent two years as an industrial postdoc jointly in ExxonMobil Research & Engineering Company in New Jersey and the Institute for Mathematics and its Applications at the University of Minnesota. In 2015, he began his career at Petroleum Geo-Services in Houston and worked on a variety of research topics including regularization methods for linear and non-linear inverse problems, multi-parameter full waveform inversion and optimal-transport based objective function for inversion.



SEG ADVANCED MODELING

Visit our Booth at the Spring Symposium

Geoscientists Without Jobs: A Guide to Surviving the Downturn

Epilogue: To the Geoscientists with Jobs

By Paul E. Murray (paulm@fipgeophysical.com)

My layoff triggered a series of harrowing experiences, such as applying for unemployment benefits, borrowing money, forcing my spouse to reenter the workforce, and uprooting my family to move once again. I've learned a number of lessons about searching for work and life as a consultant that I've tried to pass along here. I hope that even if others did not find the warning signs from my path particularly useful, they at least appreciated knowing they're not alone on the journey.

Although the *Geoscientists without Jobs* columns were nominally written for the titular audience, my primary goal was to start conversations among us bearing the brunt of our first major downturn and those who've been here before. With that in mind, the final entry of this series is aimed specifically at my gainfully employed colleagues who continue to enjoy a paycheck, paid health insurance, and the knowledge someone considers you valuable enough to keep you on the payroll (for now).

My employed colleagues can be divided into three general categories. The first category is for those with whom I can freely converse. These are the people who answer the phone, who take the time to talk with me when I need, who share their advice, and in some cases, who have been able to guide me towards possible jobs and networking opportunities. For them, I am truly grateful. The most valuable lesson I have learned on this journey goes beyond the truism that stress does not build character, it reveals it; it also reveals the character of your friends.

The second group of employed colleagues is somewhat larger, and it is them I hope to convince to join that inner circle for one of their unemployed friends right now. For the most part, these people will speak to me, but only when no other option is available and decorum prevents them from fleeing the scene. I see these people at conferences and workshops around town. We'll chat for a minute, and some even suggest I call them or send an email next week because they might have something for me. Inevitably, they never return the phone calls or emails. Maybe they are embarrassed that lead didn't pan out and they don't want to break that news to me. Maybe they are uncomfortable being around

*The GSH membership owe a considerable amount of gratitude to the author of *Geoscientists without Jobs* series, Paul Murray. Over these past 8 months, Paul has written a series of articles to those who have lost their positions during this latest downturn and he*



Paul Murray

has enlightened all of us with his experiences and frustrations. I will be the first one to personally thank Paul for his contributions and hard work and I believe that the GSH and its members have been granted a very rare opportunity in seeing what it is like being one of the many who have lost so much during this downturn along with all the tribulations that go along with it.

It has been truly an honor to be able to host and publish his series and I wish Paul and all of you who have lost to be rewarded soon.

David Watts
GSH Editor

someone unemployed because it reveals their own stress and insecurities.

Don't get me wrong; the oil patch is not the easiest place to work right now. Humans have a fast AGC on their perceptions of anxiety, stress and difficulties, though. Or, as one of my friends likes to say, your biggest problem is your biggest problem. Working through this downturn is difficult, but it's a lot harder to do so with no steady income, mounting bills, and depending on others when you were formerly independent. Comparing their difficulties to that

Geoscientists Without Jobs continued on page 12.

of an out-of-work professional causes amplitude rebalancing that forces a sense of perspective that is often unwanted and uncomfortable. Rather than avoid contact, I would encourage you instead to consider how the "ring theory of grief" might allow you to cope with this and help out someone else.

In the ring theory of grief, counselors model a person dealing with any kind of traumatic loss at the center of a circle, and their friends surrounding them in concentric rings of increasing distance. The inner circle contains the closest confidants, and the outer ring the most casual acquaintances. Whatever your position in someone's circle, the rule of behavior should be, "comfort in, dump out" so as to avoid saying or doing the wrong thing. If you have friends suffering through a job loss, keep this model in mind. Complaints should be directed to outer circles, and comfort provided to anyone inside your particular ring. Whatever comfort you can provide is always appreciated, but complaints about the new TPS report cover sheets will be met with disdain by unemployed colleagues. Save that for an outer ring.

As an aside to my unemployed colleagues, here is the second most important lesson: My initial guesses

about who belonged in which ring were sometimes wrong. You, too, will find out who your true friends are. Remember them, but also be kind to those who aren't so accommodating. Like any trauma, those who haven't experienced it may simply not understand.

So, what is the third category, you ask? I'm both a scientist and an optimist at heart, so I acknowledge there is a sea of people out there I haven't met. Chances are I haven't met you, but you probably know someone out there suffering through the pain a job loss. Where do you stand in relation to them? If you haven't already done so, I challenge you to step outside your own comfort zone and serve as a confidant, friend, or just a friendly ear to one of your geoscientist friends without a job. When the downturn ends, you will need us once again, and we'll remember who were our friends when we needed them.

The author would like to thank the GSH and especially Editor David Watts for giving me the opportunity to write for you. Of course, I must also thank my friends on my inner circle, namely Bryan DeVault, Bob Hardage, Robert Fernihough and Samir Seth; without them, this journey would be much harder.



ANNOUNCING THE 2017
**GEOPHYSICAL SOCIETY OF HOUSTON
HONORS & AWARDS BANQUET**

Thursday, May 4th, 2017
Cocktails - 6:00 pm, Dinner - 7:15 pm

Lakeside Country Club
Grand Ball Room
100 Wilcrest Drive
Houston, TX 77042

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SEG and GSH Milestone Recipients,
and GSH Honorary and Life Members.

Spouses and guests are welcome.
Register online at www.gshtx.org.

For more information, contact Kat Pittman at
281-615-3339 or kpittman@resolvegeo.com



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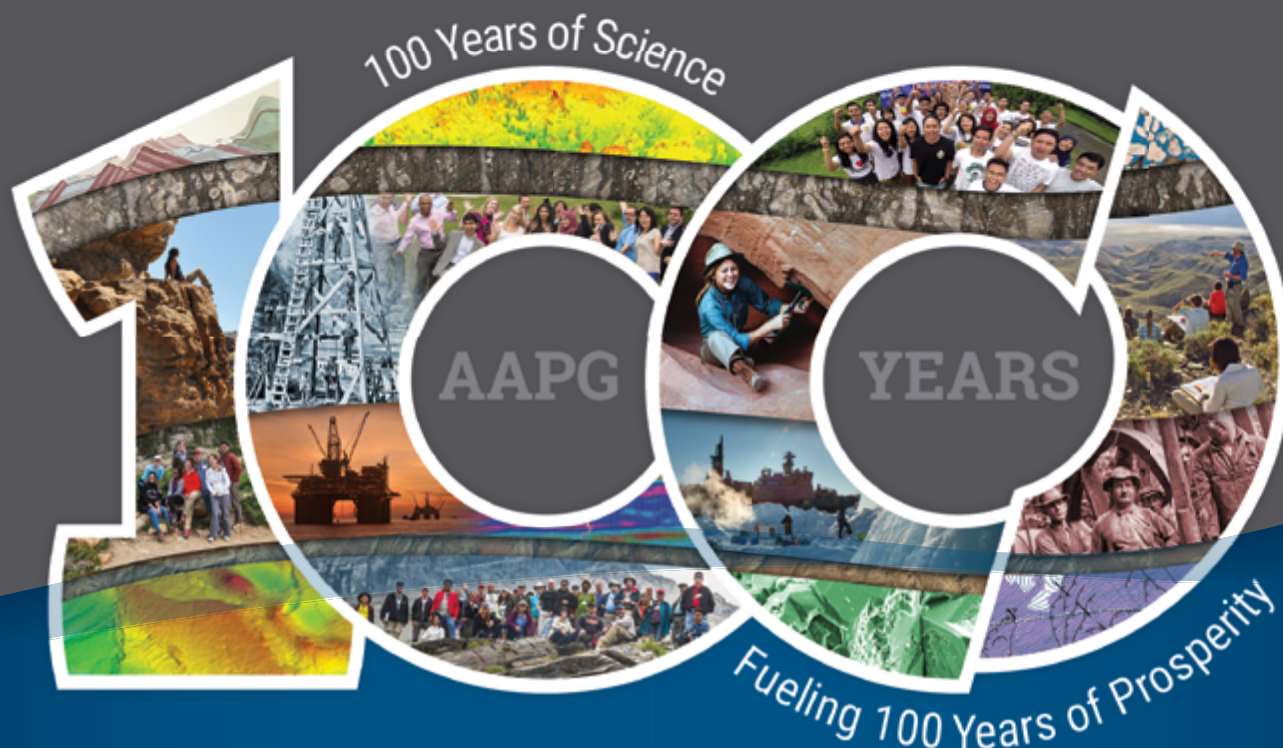
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How Things Have Changed: GSH Newsletter Evolution into Journal – 1967 to 2017

By David W. Watts

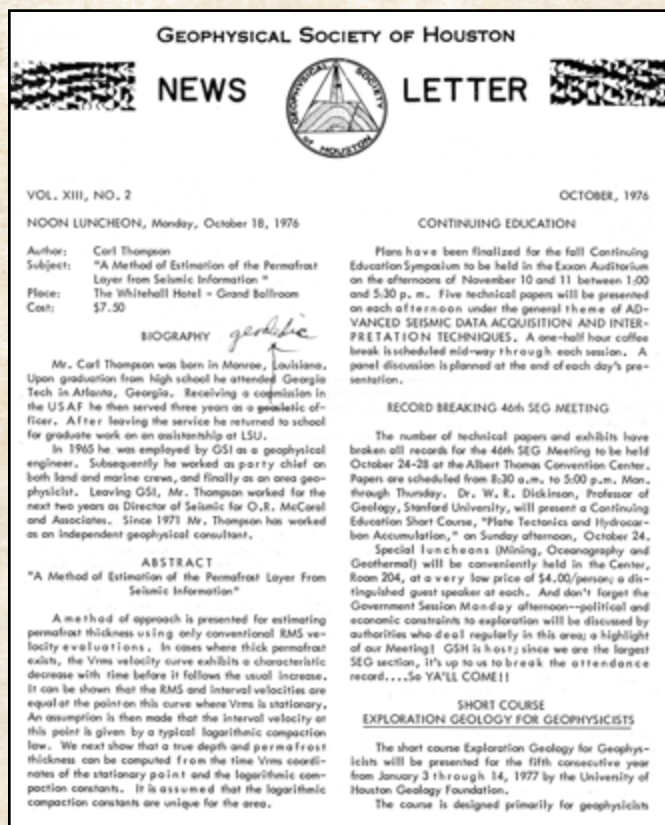
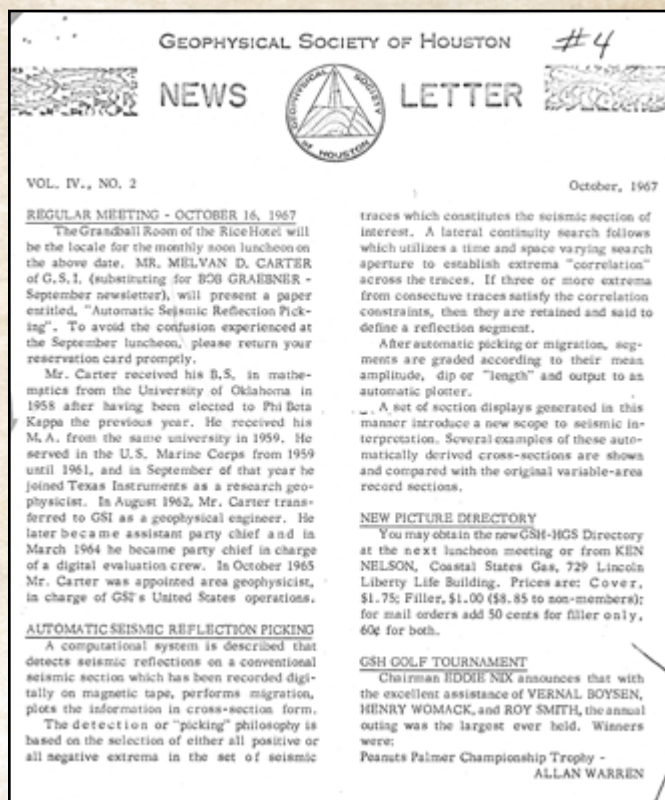
The beginnings of the Geophysical Society of Houston goes back to 1947 when Walter J. Osterhoudt was named as temporary chairman of a Constitutional Committee and Dr. E. E. Rosaire was made chairman of a Nominating Committee. On November 20, 1947, 108 geophysicists met in the Houston Engineers Club to form what was then called the Houston Section of the Society of Exploration Geophysicists (the name was not changed to the Geophysical Society of Houston until about ten years later). In the early days, information of the happenings of the GSH was provided via a newsletter which ultimately transformed itself into the current journal which we have today. In performing research on the newsletter/journal, I was able to find the earliest copy that the GSH/Geoscience Center had available was dated October of 1967 (online archives of the newsletter only go to 1996). The October 1967 edition states that it is Vol. IV., No. 2. Therefore, in going back, we can surmise that the earliest documented newsletter would have been in August of 1964. The GSH did not have any record or documentation prior to this October 1967 document and none of our Living Legends had any records to share. However, I wanted to present a historical overview to showcase how the GSH Newsletter evolved into our online Journal that you as members read and have access too.

The October 1967 GSH Newsletter was a 7 x 8.5 inch two page newsletter which was mailed to its members and had updates on:


- Monthly meeting
- Technical talk
- Announcement of the picture dictionary
- Golf tournament results announcement
- SEG 37th annual meeting announcement
- Member updates
- Financial donation list for the "social fund"

It was interesting in that back in 1967, the newsletter had information/announcements that we still have today.

In October 1976, the newsletter was still a 7 x 8.5 inch 4 total pages of printed material, (2 pages front and back) mailed periodical. However, the newsletter started to give abstracts and biographies of the monthly technical meeting speaker as we do today with all of our SIG meetings. The 1976 newsletter had a section on Continuing Education which has transformed itself into Mike Graul's Nuggets article. It was noted that the 46th annual SEG convention was a record breaker and the October 1976 newsletter described several courses at the convention as well as at the University of Houston for the members to increase



How Things Have Changed continued on page 15.



GEOPHYSICAL SOCIETY OF HOUSTON

NEWS LETTER

VOL. XXIII, NO. 2 October, 1986

NOON LUNCHEON

Monday, October 20, 1986

Place: Strouffer's Hotel, Greenway Plaza

Speaker: Norman S. Neidel

Topic: "Stratigraphic Visibility"
A Forefront for Cost Effective Seismic Exploration

Time: Cash Bar 11:30 A.M. to 12 noon

Cost: \$12.50 (Students half price)

PHONE RESERVATIONS BY NAME
Call 771-8330 by Thursday, October 16. Give your name when making your reservation(s). Persons with reservations will have priority in seating for the dinner, and others will be seated according to a standby list. (Please note reduction in price.)

STRATIGRAPHIC VISIBILITY

A Forefront for Cost Effective Seismic Exploration

Declining exploratory and exploitation drilling success from the consistent performance prior to 1985 strongly indicates that cost savings by "starting" on technology is false economy. In the face of low oil and gas prices, effective seismic exploration requires not only cost reduction, but increased success rates as well. At the forefront must be proven high technology methods which entail only modest incremental cost to develop prospects and plays by validating leads and geologic concepts.

Stratigraphic changes in the subsurface hold the key to most of the discoveries yet to be made. Conventional seismic processing and displays cannot image most such information even though it may be present in the basic field data. Closely spaced moveout velocities in conjunction with enhanced dynamic range color displays are necessary to see such information. We cannot interpret what we cannot see no matter how "sharp" our skills.

Wavelet processing, improved velocity analyses and repeated statics computations are part of the basic data conditioning, as is trace inversion by integration. Clear advantages are offered by viewing the enhanced dynamic range displays scaled as approximate interval velocities to that velocity and geometry can act in intuitive concert. Velocity information from both moveout and amplitudes, along with mapping of anomalies, sequences boundaries and facies changes further qualify opportunities.

Visibility of stratigraphic information components is an essential prerequisite for developing cost effective quality drill sites and taking full advantage of all other advancements and procedures. In particular, prestack processes, enhanced imaging, 3-D surveys, VSP and other such tools benefit substantially from improved data conditioning and displays. Shallow carbonates, channel systems, growth fault related traps and new salt geometries, are amongst the case studies we can show to illustrate the importance of these considerations. The economic consequences follow naturally from the added interpretive insights. We cannot lose sight of the value of information in the present exploration climate, and the fundamental role which new high technology methods can play in restoring our ability to find reserves.

Continued on Page 2

NOON LUNCHEON SCHEDULE

October* Monday, October 20, 1986

November Monday, November 17, 1986

January Monday, January 19, 1987

February** Tuesday, February 17, 1987

March Monday, March 9, 1987

April Monday, April 20, 1987

*GSH HGS Joint Dinner Meeting

**Note: Tuesday Meeting

GEOPHYSICAL AUXILIARY

Bridge Luncheon

The Fall Bridge Luncheon will be held at the Holiday Inn CROWN PLAZA PARK 15, 14700 Park Row, (Interstate 30 & Hwy 61) from 10:00 AM - 2:00 PM on Monday, October 20, 1986. Reservation deadline is October 13th. Cost: \$10.00 per person. Mail checks to Sybil Petersen - 3638 Robinson Road, Missouri City, Texas 77059 or call 437-0690.


Special Thanks To "Mac" McKinney....

for the article entitled "What To Do When The Bottom Drops Out" carried in the June 1986 GSH Newsletter.

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For Inside



Geophysical Society of Houston

VOL. 32, NO. 2 NEWSLETTER OCTOBER 1996

Use of Wireline Measurements in Surface Seismic AVO and Anisotropy Studies

Chenela, Willem Schlumberger Wireline and Testing Houston, Texas
Armstrong, Phil. Geo-Physis, Galloway, England

Introduction

In the past few years there has been a significant range in advanced processing and interpretation techniques used in surface seismic. One example is a technique for line tuning (DMO) to take anisotropy (TTV) into account. (Alkhalifah, 1995). The authors showed that application of anisotropic DMO resulted in considerably better alignment of reflections from horizontal and dipping reflectors. Other recent work has highlighted a petrophysical approach to AVO interpretation using crossplots of gather attributes to analyze lithology and fluid content. (Bilman, 1995). Others have used anisotropic AVO to map productive trends associated with fracturing. (Kendall, 1995).

Parallel to these advancements in surface seismic techniques have been complementary advances in wireline logging. For instance, a technique has been developed for in-situ measurement of the four coefficients necessary to completely describe a transversely isotropic zone (TTV). Of course this description of the anisotropic medium can be simplified to give Thomsen's parameters ϵ and σ , or the anisotropy coefficient η , for input to anisotropic forward modeling, migration, or DMO programs.

Another new technique involves using multi-offset VSP data to calibrate the AVO processing of the surface seismic. Techniques for offset balancing (Bloss, 1995) have already been presented as an attempt to quantify the relationship between the offset response of seismic reflections and the corresponding theoretical predictions. Multi-offset VSP data can be used to measure directly the AVO response of the formation at one CDP point. This can act as a calibration point to test both the AVO processing of the surface seismic and the forward modeled gathers used to understand the AVO response.

There have also been advances in wireline acoustic logging allowing one to record continuous compressional and shear waveforms in essentially any formation. These inputs are essential for proper AVO modeling.

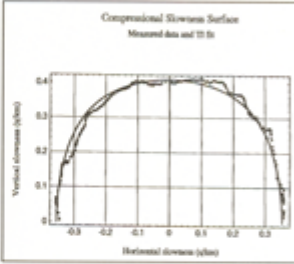


Figure 1
Anisotropy

In the past, oilfield theory and practice assumed that seismic waves traveled equally fast in all directions. More recently, there has been a considerable emphasis in understanding the effects of elastic anisotropy on the seismic response (AVO, NMO, etc.). Often this anisotropy is associated with a spatial ordering of grains and/or bedding planes. In many cases, velocity does not vary horizontally but may vary vertically and the horizontal velocity is typically faster than the vertical velocity. Such a material is called transversely isotropic with a vertical axis of symmetry (TTV). For seismic waves traveling in a plane, the TTV medium can be fully characterized by the four elastic moduli, $\epsilon_{11}, \epsilon_{33}, \epsilon_{12}, \epsilon_{13}$.


Continued on Page 7

their knowledge spectrum. In 1976, the GSH sponsored two awards at the El Campo Science and Engineering Fair which obviously was the early happenings of the GSH Outreach which has been led and promoted so well over the years most recently by Lisa Buckner and her volunteers.

In October of 1986, the Newsletter had evolved into a standard 8.5x11 eight page mailed periodical (4 printed pages front and back). While still having a single monthly technical luncheon meetings, it was interesting that you could now make reservations to attend by calling on the phone. This Newsletter had all kinds of new announcements:

- from the Geophysical Auxiliary
- a calendar of events
- an announcement of the Potential Fields Group
- Employment help
- Request for volunteers
- 56th SEG meeting in the Astrohall and Astroarena (who of you remember those names?)
- Sporting Clays announcement of results
- Golf tournament announcement (only \$55.00 per person – what a deal that was)
- Tennis tournament announcement

How Things Have Changed continued on page 16.



Geophysical Society of Houston

VOL. 41, NO. 2 NEWSLETTER OCTOBER 2006

Technical Luncheon

Date: October 17, 2006
Time: 11:30 a.m.
Location: Omni Palace (Salon B)
12121 Westheimer Rd.
Houston, TX
(see map on page 6)

Topic: "Earth Transmission Effects: Motivation and Challenges"
by: Fred Herkenhoff
Richard Alford
Dennis Bones
Harry Martin
Joe Stefani
Chenela, San Ramon, California

Speaker: Fred Herkenhoff

Abstract: Walkway VSP observations of transmitted waves indicate that earth transmission filters may introduce amplitude and phase complexity into the propagating wavelet that are not usually

Technical Luncheon continued on page 6

Technical Breakfast

Date: October 11, 2006
Time: 7:00 a.m.
Location: Fugo
6100 Hillcroft, Suite 100
Houston, TX 77274
Please RSVP by contacting
Liz Irie at Fugo
713-369-5863
lirie@fugo.com

Topic: Variable Hydrocarbon Indicators Identified On 3D Seismic Data Amongst The Subtle Stratigraphic Features And Complex Structures Of Cape Three Points Deep, Offshore Ghana
by: Karlene Coterill
Charlotte Miller
Bob Schaefer
Gabor Tari
Venco Energy Co.

Speaker: Karlene Coterill

Abstract: The Cape Three Points Deep Area is located at the southwestern border of

Technical Breakfast continued on page 26

President's Column

by George Marion, Pres-Elect

All This And Money Too!

Last month Kathy Hardy set the theme by writing "You people have got to get out and have some fun...". Continuing that thought, an excellent opportunity for fun presented itself in the form of the SEG Annual Meeting & Exposition in New Orleans October 1-6 (hopefully you are already in N.O. by the time you read this).

Maybe your idea of fun is getting value for your investment. Then consider that those of us with a PG license will need Continuing Education Professional Development Hours (CE PDH) to renew the license beginning 9/1/2006 (yep, it has already begun). GSH can help. Our technical meetings count towards the CE PDH. Not only will you enjoy a social visit with your professional comrades, but also acquire CE PDH credits from the Technical Luncheon, SEG meetings, Technical Breakfast, DISC, or Spring Symposium. That's added value for your membership.

The Texas Board of Professional Geoscientists site <http://www.tbpgeoscientists.org/>

President's Column continued on page 9

Join us at SEG in New Orleans

October 1-6, 2006

<http://www.seg.org/2006/abstracts.asp>

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October 1996 brought further changes. While still officially defined as the 'Newsletter', it had evolved into a 12 page periodical of six printed front and back pages. The front page had a "table of contents" for easy reference as well as the inside first page containing the leadership page which is now within every journal publication. In 1996, the Newsletter had

- Editor's Notes (precursor to our Word from the Board)
- Technical Breakfast and Luncheon meetings (multiple technical meetings each month)
- Interactive Workstation SIG meeting (this was in the days that workstations were new to the community)
- New SIG teams of
 - o Seismic Processing
 - o Reservoir Geophysics
 - o Environmental Applications
- GSH Employment Referrals
- Monthly Technical article in full with abstract, topic, images, conclusions, and references (this is now Scott Singleton's expertise)
- 66th SEG International Exposition and Annual Meeting in Denver

- Images of the GSH Fall Ice Breaker and Awards Ceremony (Be watching for our Honors and Awards Banquet as led by Kat Pittman, 2nd Vp Elect)

The October 2006 Newsletter was a 20 page periodical of 10 front and back printed pages and it had the beginnings of color borders around certain sections and a glossy paper finish. The President's Column was on the front as well as the schedules for that month's technical luncheons and breakfast meetings. There was an article concerning the "Museum and History" which our Bill Gafford and team now support. Two of the interesting new features consist of a President's Luncheon article and photos as well as a significant level of advertising. Many different companies are now advertising to support themselves and in supporting the Newsletter:

- Fugro (now part of CGG)
- Fairfield
- Dawson
- WesternGeco
- TGS
- And many, many individual business card advertisers

By October 2016, we had evolved into the Journal that you currently receive (the first Journal as we know it today was in September 2010 as Volume 1, Number 1). In 2016, the biggest evolution was not in the size of the periodical, 41 actual pages, but the fact that it was completely electronic and fully linked to everything on the internet and the October 2016 edition was the very first to be an online publication. The 2016 edition is now interactive and portable so you could access it anywhere, anytime. Just log in and click and read away. In 2016, we had some new articles and features over the 2006 edition:

- A Conversation with... (interview conducted by Lee Lawyer)
- Nuggets (Continuing education by Mike Graul)
- Webinars for continuing education in association with the SEG
- Saltwater Fishing tournament
- Women's Networking Event (hosted by Amy Rhodes, Sofia Campbell, Rita Creasy-Reed, and many others)
- GSH Scholarship Recipients
- Geoscience Computing SIG
- Geoscientists without Jobs (by Paul Murray)
- UH Wavelets article (strengthening ties to young students)
- Doodlebugger Diary (stories from our Living Legends)



How Things Have Changed continued from page 16.

Over the years, the evolution from the earliest Newsletter and the current Journal has been continuous. The publication has evolved from the very basics mailed via the US Postal Service to an electronic version which is e-mailed to you from the GSH office staff. From one to two events a month in 1967 to upwards of 13 events per month in 2017, you can see the continuity, evolution and increase in events, articles, features, and announcements which make up the GSH that we have today. In performing this research, I have to wonder if the originators of the GSH and the Newsletter from 1967 would have ever thought that our Journal would be in the state that it is today. Probably not. I can imagine though that if they were to see everything today with all the technical and social activities that are organized and held for the members every month that they would indeed be proud. I know that I am. However, I must point out that the successful evolution of the Newsletter into the current Journal goes to all those who have gone before in building the GSH and Journal to what it is today. As my term of editor comes to a close in a few months, I see that the future volunteers will keep our publication and the GSH as a whole growing and moving forward. I will be looking forward to reading the Journal in 2026.

Employers Matching and Gifting Programs

Please consider supporting the G S H through your Company Matching or Gifting Program. Volunteer hours are often rewarded with an Outreach Grant / Gift to the organization. Check with your employer now.

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7:00 am – 1:00pm

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**GSH Office ▸ (281) 741-1624
karen@gshtx.com**

Register NOW on-line @ the www.gshtx.org events calendar

2017 GSH - SEG Spring Symposium & Exhibition April 12 - 13 Norris Conference Center - CityCentre

Geophysical Acquisition: Advanced techniques revealing challenging targets

General Chairman – Lisa Buckner Technical Program Chairman – Tad Smith

Speakers & Topics include:

Nikki Martin, IAGC – Political Landscape
Malcolm Lansley - Historical Context
John Etgen, BP – Needs of the Interpreter
Sarah Cooke, CVX – Marine Technology case study
Chengbo Li, ConocoPhillips - CSI (compressive sensing)
Eivind Fromyr, PGS - Multisource/Multicomponent
Nick Moldoveanu, SLB - Point Source/Point Receiver
John Archer, GOK - Dispersive Source Acquisition
Shuki Ronen, LISS – Low Impact Seismic Sources
John Wei, INOVA, Low Frequency Land Sources
Dave Monk, Apache – Future Directions
*** Dedicated Vendor Hour ***

*Exhibit Booths
Available!*

*Wed. Evening
Networking
Reception*

*SEG Student
Gulf Coast
Challenge Bowl
Lunch Wed.*



Honoring :
Malcolm Lansley & Dave Monk
Honoree Roast & Toast over Lunch on Thursday, April 13th

Go to
**[www.gshtx.org/
symposium2017](http://www.gshtx.org/symposium2017)**
*To register, sponsor and
find out more!*



Carbonate Essentials

Christopher L. Liner, PhD

Former SEG President

Storm Endowed Chair of Petroleum Geology

University of Arkansas



A Live Webinar

April 25 & 26, 2017

8:30 am - 11:30 am Central Time (USA)

This course is an overview of carbonates from geology to seismic interpretation, with particular emphasis on karst topography and seismic expression thereof. Carbonate reservoirs represent the majority of worldwide petroleum reserves, including emerging unconventional reservoirs. Unlike clastics, carbonate mineralogy is relatively simple, while complexity arises from depositional environment lateral variability, pore structure, diagenesis and dissolution. These factors influence bulk rock properties and, in turn, seismic response. The course offers a broad overview of carbonate geology and properties that are mappable on a seismic scale as potential hydrocarbon reservoirs. To illustrate key concepts, field sites and case histories are presented from global locations.

Session 1: Geology
Session 2: Rock Physics
Session 3: Wireline

Session 4: Seismic 101
Session 5: Horizons
Session 6: Attributes

Miss part of the sessions? Never fear. All sessions are recorded and available for later viewing by registered users.

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Major discounts available for groups and students
All sessions are available on demand to attendees.

Register now at: gshtx.org and seg.org

Seismic Interpretation in the Age of Big Data

By Rocky Roden, Geophysical Insights

Summary

Interpretation of seismic reflection data routinely involves powerful multiple-central-processing-unit computers, advanced visualization techniques, and generation of numerous seismic data types and attributes. All of this information, i.e. "Big Data", indicates that seismic interpretation has entered the age of data deluge, where the amount of data has outgrown the capabilities to efficiently and effectively be analyzed. Machine learning has evolved to handle Big Data. This incorporates the use of computer algorithms that iteratively learn from the data and independently adapt to produce reliable, repeatable results. Principal component analysis (PCA) and self-organizing maps (SOM) are components of unsupervised machine learning methods that have evolved to help interpreters sift through enormous amounts of data and gain a better understanding of the geology. Employing these approaches and visualizing SOM results utilizing 2D color maps reveal geologic features not previously identified or easily interpreted from the seismic data.

Introduction

The object of seismic interpretation is to extract all the geological information possible from the data as it relates to structure, stratigraphy, rock properties, and perhaps reservoir fluid changes in space and time (Liner, 1999). Today's interpretation environment involves enormous amounts of data generated in and for workstations. Regional 3D surveys with numerous processing versions, seismic gathers, large populations of wells and associated data, and dozens if not hundreds of seismic attributes in time and depth routinely produce quantities of data in the terabytes. This Big Data deluge poses issues for interpreters attempting to make accurate and efficient evaluations.

Multi-attribute machine learning approaches have proven to resolve two major issues seismic interpreters face today: 1) the big data issue of too much information to effectively interpret and 2) the fact that humans cannot understand the relationships of numerous types of data all at once. Seismic attributes reveal features, relationships, and patterns in the seismic data that otherwise might not be noticed (Chopra and Marfurt, 2007). A seismic attribute is any measurable property of seismic data, such as amplitude, dip, phase, frequency, and polarity and can be measured at one instant in time/depth over

a time/depth window, on a single trace, on a set of traces, or on a surface interpreted from the seismic data (Schlumberger Oil Field Dictionary). Machine learning methods, PCA and SOM, provide multi-attribute analyses that have proven to be excellent techniques in the seismic interpretation workflow to attack big data.

Principal Component Analysis

A critical step in a seismic multi-attribute analysis is to determine which seismic attributes are important. Interpreters familiar with seismic attributes and what they reveal in their geologic setting may select a group of attributes and run a SOM. If it is unclear which attributes to select, a principal component analysis (PCA) may be beneficial beforehand. PCA is a linear mathematical technique to reduce a large set of variables (seismic attributes) to a small set that still contains most of the variation of independent information in the large set. In other words, help determine the most meaningful seismic attributes.

Figure 1 displays a PCA analysis from a 3D survey where 18 instantaneous attributes were input over a 170 ms window encompassing a reservoir of interest. Each bar in **Figure 1a** denotes the highest eigenvalue on the inlines in this survey. An eigenvalue is the value showing how much variance there is in its associated eigenvector and an eigenvector is the direction showing a principal spread in the data. The bars in red in **Figure 1a** denote the inlines that cover the areal extent of the geologic feature of interest and the average of their eigenvalues are displayed in **Figure 1b and 1c**. **Figure 1b** shows the principal components from the selected inlines over the zone of interest with the highest eigenvalue (first principal component) indicating the seismic attributes contributing to this largest variation in the data. The percentage contribution of each attribute to the first principal component is designated. The top five seismic attributes represent 63% of the variance of all the attributes employed. These five attributes will be employed in a SOM analysis and the results will be shown in the case study. **Figure 1c** displays the percentage contribution of the attributes for the second principal component. The top four attributes contribute 70% to the second principal component. PCA determines the variance of the data with principal components, but it is up to the interpreter to determine and evaluate how this relates to geology. In this case both the highest contributing attributes in **Figure 1b and 1c** will be run in SOM analyses A and B, respectively, for the case study.

Technical Article continued on page 21.

For Information Regarding Technical Article Submissions, Contact GSHJ Coordinator Scott Singleton (Scott.Singleton@comcast.net)

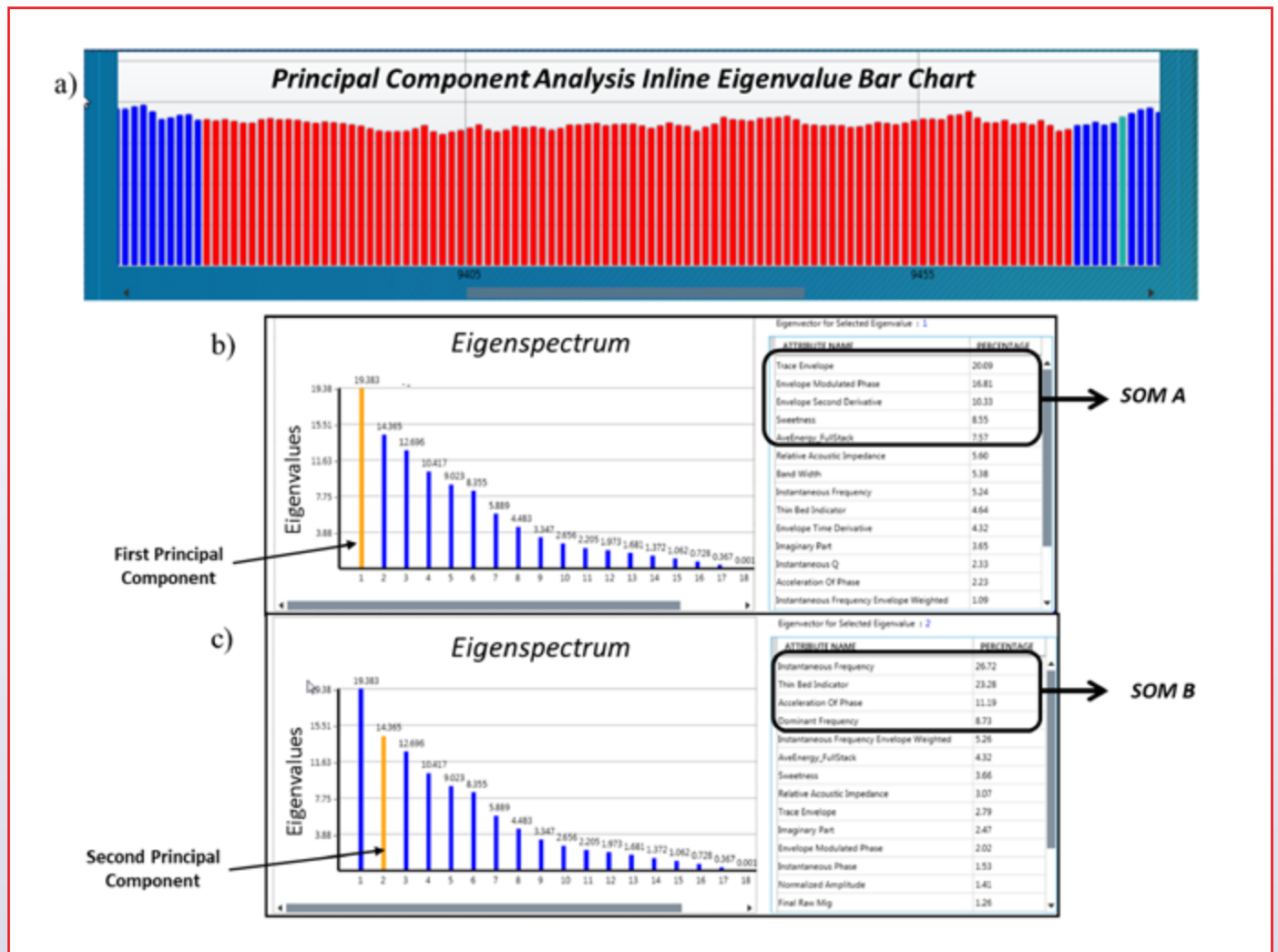


Figure 1: Results from PCA using 18 instantaneous seismic attributes: (a) bar chart with each bar denoting the highest eigenvalue for its associated inline over the displayed portion of the seismic 3D volume. The red bars specifically represent the highest eigenvalues on the inlines over the field, (b) average of eigenvalues over the field (red) with the first principal component in orange and associated seismic attribute contributions to the right, and (c) second principal component over the field with the seismic attribute contributions to the right. The top five attributes in panel (b) were run in SOM A, and the top four attributes in panel (c) were run in SOM B. Modified from Roden et al., 2015.

Self-Organizing Maps

Once a geologic problem is identified and a set of attributes has been selected (PCA), the next level of interpretation requires pattern recognition and classification of often subtle information embedded in the seismic attributes. Taking advantage of today's computing technology, visualization techniques, and understanding of appropriate parameters, self-organizing maps (SOMs) efficiently distills multiple seismic attributes into classification and probability volumes (Smith and Taner, 2010). Developed by Kohonen in 1982 (Kohonen, 2001), SOM is a powerful non-linear cluster analysis and pattern recognition

approach that helps interpreters identify patterns in their data that can relate to desired geologic characteristics.

The samples for each seismic attribute in a 3D survey are placed in attribute space where they are normalized or standardized. Also in attribute space are neurons, which are points in space that start at random locations and train from the attribute data and mathematically hunt for natural clusters of information in the seismic data. After the SOM analysis each neuron will have identified a natural cluster as a pattern in the data.

To interpret the SOM results, each neuron is displayed in a 2D color map. Highlighting a neuron or combination

Technical Article continued on page 22.

of neurons in a 2D color map identifies their associated natural clusters or patterns in the survey because each seismic attribute data point retains its physical location in the 3D survey. The identification of these patterns in the data enables interpreters to define geology not easily interpreted from conventional seismic amplitude displays alone. These visual cues are facilitated by an interactive workstation environment.

Case Study

This case study is located offshore Gulf of Mexico in a Class 3 AVO geologic setting (Rutherford and Williams, 1989). There are two successful wells drilled on the upthrown side of an east-west trending normal fault and into an amplitude anomaly identified on the available 3D seismic data. The goal of this multi-attribute analysis is to more clearly identify possible DHI characteristics such as flat spots (hydrocarbon contacts) and attenuation effects. Before the two successful wells found about 100 feet of pay each in this field, 7 dry holes were drilled in this area on amplitude anomalies

indicating amplitudes alone are not definitive of the presence of hydrocarbons.

As described previously, 18 instantaneous seismic attributes were run in a PCA analysis with the first principal component identifying five prominent attributes and the second principal component identifying four different and prominent attributes (Figure 1). These two sets of attributes were run in SOM analyses A and B. **Figure 2** displays the SOM A results with a 5 X 5 matrix of neurons (25) from a north-south line through the field. In **Figure 2a**, the 2D color map associated with the SOM classification results indicates all 25 neurons are displayed and **Figure 2b** shows results with four interpreted neurons highlighted. Based on the location of the hydrocarbons determined from well control, it is interpreted from the SOM results that attenuation in the reservoir is very pronounced with this evaluation. The apparent absorption banding in the reservoir above the known hydrocarbon contacts in the field correlates with the relative low-frequency broad

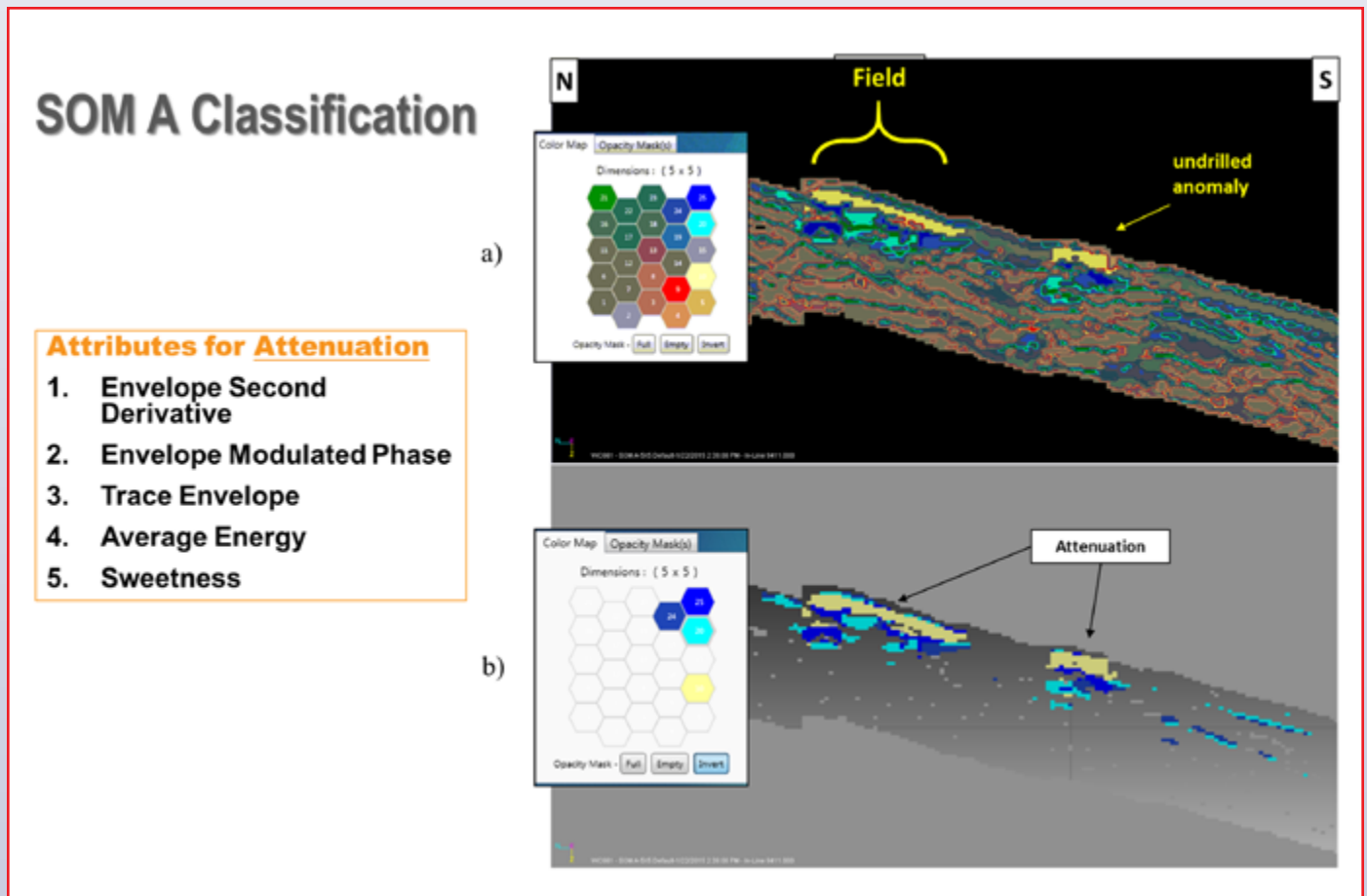


Figure 2: SOM A results on a north-south inline through the field: (a) SOM results with associated 5 X 5 color map displaying all 25 neurons, and (b) SOM results with four neurons selected that isolate interpreted attenuation effects. Modified from Roden et al., 2015.

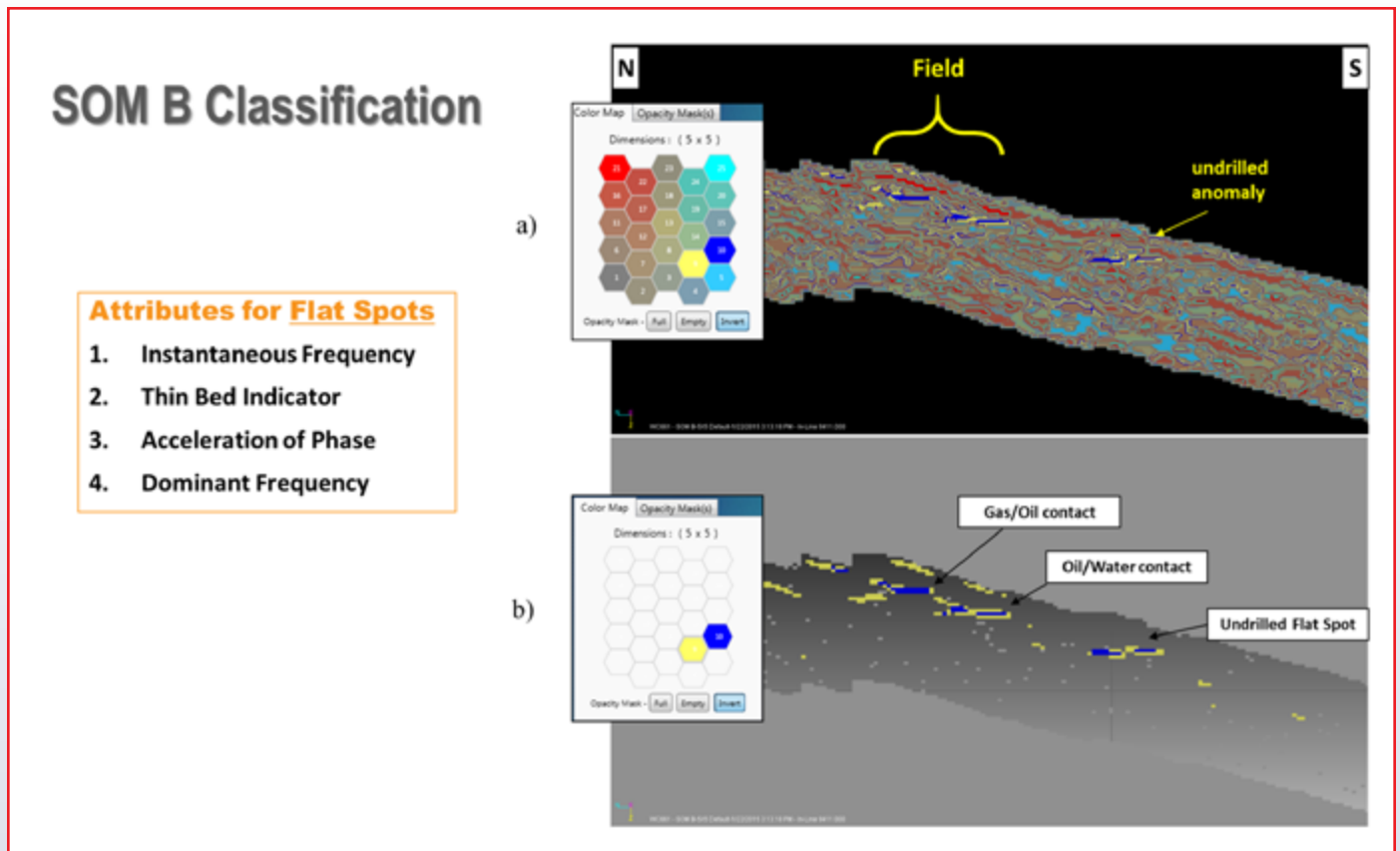


Figure 3: SOM B results on the same inline as Figure 2: (a) SOM results with associated 5 X 5 color map, and (b) SOM results with color map showing two neurons that highlight flat spots in the data. Modified from Roden et al., 2015.

variation in the seismic signal often associate with attenuation effects. Downdip of the field is another undrilled anomaly that also reveals apparent attenuation effects. **Figure 3** displays the results from SOM B and incorporates a different set of seismic attributes than SOM A (see **Figure 1**). With a 5 X 5 neuron matrix, **Figure 3** shows the classification results on the same north-south line as **Figure 2** and clearly identifies several hydrocarbon contacts in the form of flat spots. These hydrocarbon contacts in the field are confirmed by well control. **Figure 3a** defines three apparent flat spots and **Figure 3b** display these features with two neurons. The gas/oil and oil/water contacts in the field were very difficult to see on the original seismic data, but are well defined and mappable from this SOM analysis. Downdip of the field is another apparent flat spot event that is undrilled and is similar to the flat spots identified in the field. Based on SOM evaluations A and B in the field that reveal similar known attenuation and flat spot results, respectively, there is a high probability this undrilled feature contains hydrocarbons.

Conclusions

Seismic attributes aid interpreters in identifying geologic features, which are not clearly understood in the original data. However, the enormous amount of information generated from seismic attributes (big data) and the difficulty in understanding how these attributes when combined define geology, requires another approach in the interpretation workflow. **Figure 4** illustrates the interpretation workflow described in this paper that employs machine learning to address big data and improve evaluations. An interpreter must first determine the geologic problem to be resolved. Is the goal to identify facies, porosity, depositional environments, stratigraphy, fractures, etc.? Depending on the interpretation goals, the appropriate seismic attributes can then be determined from PCA or from experience in the area of interest. At this point SOM evaluations can be run with different combinations of attributes and neuron counts. It is important to understand that the higher the neuron count the more detail in the analysis. After the SOM analyses, the results are interpreted with 2D color maps to isolate neurons or neuron groups to identify the geologic

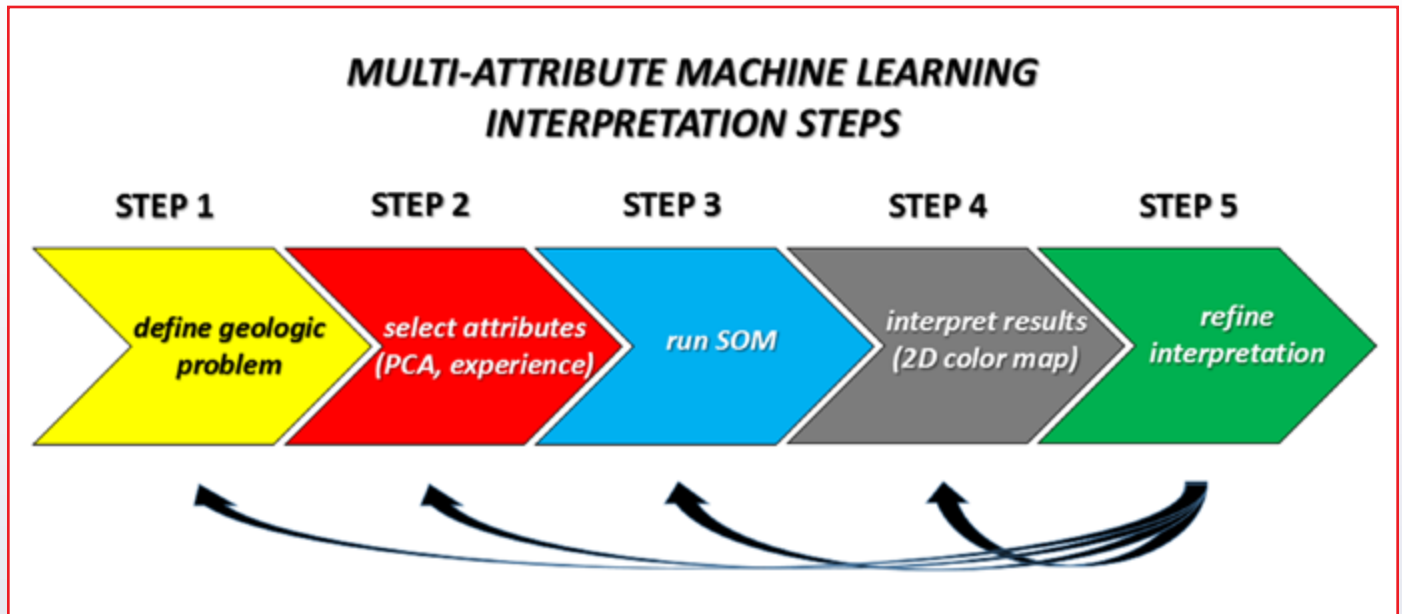


Figure 4: Interpretation steps employing machine learning (PCA and SOM).

features of interest. The interpretations can then be refined with different attribute combinations, neuron counts, and re-evaluation of the most meaningful neurons for specific geologic features with different 2D color maps.

The application of PCA and SOM have proven to identify geologic patterns not seen previously in the seismic data, but it can also increase or decrease confidence in already interpreted features. In other words, this multi-attribute approach provides a methodology to not

only address big data issues, but also produce a more accurate risk assessment of a geoscientist's interpretation. This technology may represent the next generation of advanced interpretation.

Acknowledgments

The author would like to thank the staff of Geophysical Insights for the development of this technology. Thanks also to Tom Smith for review of the paper and for thoughtful feedback.

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<http://dx.doi.org/10.1190/segam2016-13960154.1>

GSH Outreach

Committee Activities - *By Lisa Buckner*

On Saturday, January 21, GSH Outreach volunteer Fareen Elias and I manned the GSH booth at The Educator Event @HMNS. He spoke with hundreds of K-12 educators from all around the Houston region about the GSH Outreach Program and how we can help them expose their students to geophysics. The teachers picked up my GSH Outreach business card and flyer listing the types of events in which we can participate. Burbank MS (HISD) and Hargrave HS (Huffman) contacted me to invite us to their school career days. While the teachers were attending workshops at The Educator Event, we spoke to Houston Museum of Science visitors, kids played the Drilling for Oil game and we gave them GSH coiled toy springs. Thanks again to Fareen for helping.

The GSH was invited back for the 9th Annual First Colony Middle School Career Day in Sugar Land on Thursday, January 26 to host a career exhibit booth. GSH Outreach volunteers, Ken Green, Randy Keller, Mac Hooton and I educated the 8th grade students about geophysical careers in the oil & gas industry, educational requirements and starting salaries. Interested students picked up the "Earth is Calling ... will you answer?" brochure (<http://www.beageo.com>). Several students told us that one of their parents worked for one of the major oil companies as a geologist or geophysicist. We used the seismic

survey poster animated with lights to explain seismic data acquisition. Next, we explained how the geophone works using a cutaway geophone. Then we explained seismic data processing and interpretation. Afterwards, we gave 244 GSH logo coiled toy springs to those who watched us demonstrate P-wave and S-wave motion and/or listened to our presentation. Thanks again to GSH Museum Committee members Gene Womack and Rhys Evans who framed & wired the animated poster. It's a great draw for our booth.

Thursday evening, January 26, Cory Hoelting and I hosted the GSH booth at the Morales Elementary School Science Night in Pasadena. The event was scheduled after their school science fair awards ceremony and was very well attended by the very curious students and their families. At our booth, the students played the Drilling for Oil (black shoe polish) game with a pencil in the Gulf of Mexico (plastic box filled with cat litter). They had to avoid drilling near the coral reef (Nemo's home) and archeological site (pirate ship). About half of them drilled dry holes but they all had fun trying. Cory had the students bang on the table and watch the wave on a laptop screen (oscilloscope emulation). He also explained sound wave motion using the colorful coiled toy spring. We gave away 122 green plastic GSH logo coiled toy springs to students.

Upcoming Outreach Events Where You Can Volunteer

April 22, 2017

(10:00 AM – 2:00 PM)

HISD When I Grow Up Career Expo at HISD Administration Building

May 6, 2017

(10:00 AM – 3:00 PM)

Scout Fair at Minute Maid Park (over 1000 Scouts)

Do you know of a school that has a career day seeking speakers, career fair or science night at which GSH might be able to host an exhibit booth? We can work together to bring awareness to the students of the many high paying and fun careers in the geosciences.

If you are interested in joining the Outreach Committee or volunteer at any event, please contact Lisa Buckner at lbuckner@hess.com or 713-496-4256.

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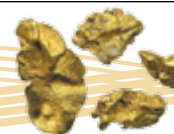
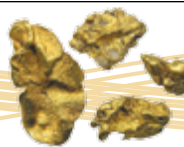
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The Nugatory Treatment of Seismic Attributes

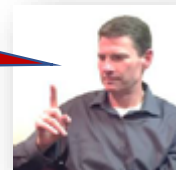
(They Deserve Better)

During our last visit we discussed the envelope, $e(t)$, or “Reflection Strength”, of the seismic trace. The Guru and the **Enlightened** (his followers) consider the envelope to be of great importance in the seismic game if, for no other reason, than its significance in defining what is called “**Resolution**”.



I give them up every New Years Day!

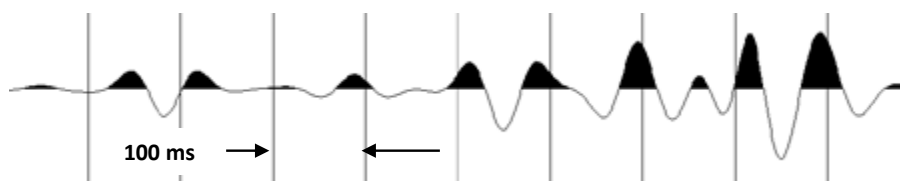
Not that Resolution, Oh Long-Haired Stick Person of Modified Mentality



Guru Spokesman

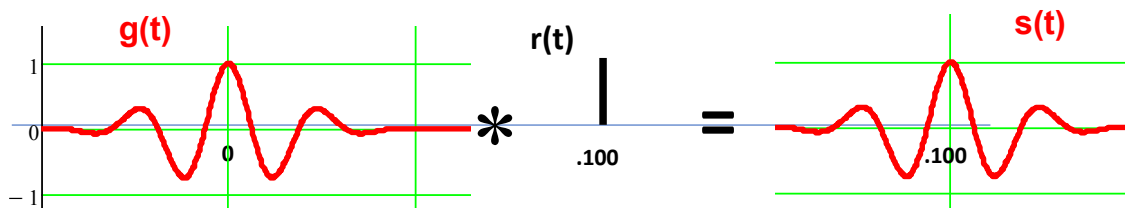
The Resolution of which we speak is the ability to **distinguish individual reflections** from among a host of others.

Resolution also implies closely estimated times and amplitudes (at the very least, polarity)

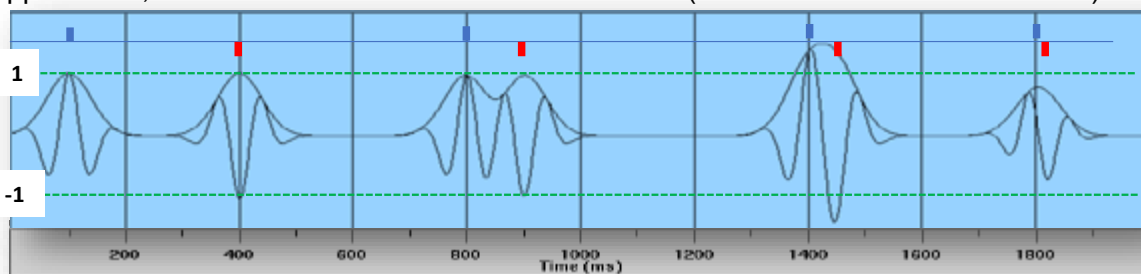


How many reflections, with amplitude and travel time, can you see?

Let's use a simple version of our model of the seismic trace: $s(t) = g(t) * r(t)$. Below, the reflectivity is a single reflection. Even the most unseasoned could resolve this case.



We'll expand this model to **2 reflections** and that should be enough to see when and how resolution is lost, and how it is **quantitatively measured** using the envelope. Once appreciated, the solution to lost resolution can be ours (or at least borrowed for a while).



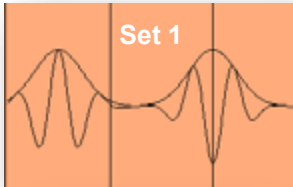
In the above diagram, there are **4 sets of 2 reflections**: [1, -1], separated respectively by $\Delta T = 300$ ms, 100 ms, 50 ms, and 10 ms. The first set are clearly resolved. The second set ($\Delta T = 100$ ms) are resolved, but only barely. **Set 3** has lost amplitude and some timing resolution and the **4th set has obviously lost amplitude and time resolution** – even at this scale. Notice that in both sets of lost resolution, the **envelopes** of the two reflections have blended into **one**.



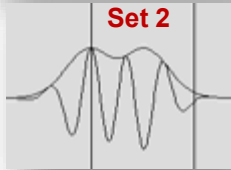
Tutorial Nuggets continued on page 28.

Tutorial Nuggets

Tutorial Nuggets continued from page 27.

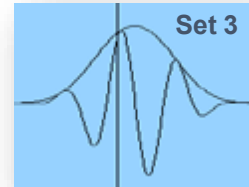


Resolution may be related to $e(t)$ in a simple way: If the individual reflections are separated so that they exhibit distinguishable peaks of their envelopes, they are reasonably resolved. **Set 1** is almost perfectly resolved. **Set 2** is resolved ($e(t)$ peaks visible), but the envelopes are about to lose separate identities.



Set 3 ($\Delta T = .050$ s) shows the envelopes have amalgamated into one, exhibiting but one peak. At what point does the critical amalgamation occur?

Answer: When the $\frac{1}{2}$ amplitude width of the $e(t)$ is greater than the ΔT separating the reflections.

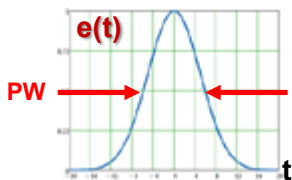


Rules of Thumb and Definitions: Pulse (wavelet) Width = $PW \approx \text{Width at } \frac{1}{2}e(0)$

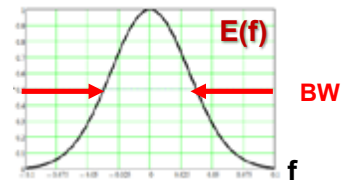
(1) For Resolution: $PW < \Delta T$

$\Delta T = \text{Time separation of 2 reflections}$

$BW = \text{Bandwidth (Hz)} \approx 1/PW$



The transform of the Bell-Shaped $e(t)$ is a Bell-Shaped curve in the frequency domain, $E(f)$. $PW \approx 1/BW$



(2) For Resolution: $BW > 1/\Delta T$

To resolve the top and bottom of a **100 ft sand**, $V_{int} = 10000$: $PW < .02$ s, $BW > 50$ Hz.

Puzzle Time

In the **March Nuggets**, we asked the readers an abnormally easy question: A fish (Wanda) weighs 10 pound plus $\frac{1}{2}$ her weight. How much does Wanda weigh?

From a 7th grade Algebra: $W = 10 + \frac{1}{2} W \rightarrow W = 20$ lb.

(The Guru said it would be easy.)



Wanda

For April, we'll challenge the gifted readers with 2 puzzles, one a logic question, the other a baseball problem – always popular.

(1) As you know, the **GSH** has a Geophysical Certification Program that is considered the International Standard. A recent test, given to 3 applicants, (Amy, Bill, and Chuck) had the embarrassing result that only two passed. When asked about this abnormal result each made a statement:

Amy: I passed the test. Bill passed the test.

Bill: Amy passed the test. Chuck failed the test.

Chuck: Amy failed the test. I passed the test



One of the 3 students made **2 true** statements. Another one made **1 false and 1 true** statement. **The 3rd made 2 false statements. Who failed the test?**



K.K. Casey

(2) K.K. Casey (remember him?) uses only 27 pitches for a No Hitter Shutout. How many **strikeouts** did Old K.K. register?



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News

In the last several years, our industry has undergone major changes technically, politically, and morally. For the most part, our journals and newsletters have maintained a steadfast silence on any subject that was deemed controversial.

This traditional approach has led to consequences never anticipated when such timid policies were adopted years ago.

In many instances, the public perceives oil industry geoscientists (generally lumped under the category of “geologists”) as being complicit in the damaging policies of our major employers.

Even within our ranks, there is growing distrust of the very technology that has been our life-blood for over 80 years. What many editors see as encouragement to young authors to publish their fresh ideas, many others see as danger to the integrity of peer-reviewed geophysical technology.

The intention of this addition to the *GSH Journal* is to bring an unbiased look at news of the industry as well as an honest review of the latest technology.

Some of what we publish here will not be popular with everyone. As a consequence, authors names will not be used as a byline nor disclosed in any manner. It is not our purpose to force our opinions on any member of this society, but we must, at this critical junction, speak out. We invite you to share your view point with us and the geophysical world.

Facts

Climate Change

One of the most controversial issues of our time is the matter of climate change, specifically anthropogenic climate change, currently characterized by global warming.

The issue: is it truly anthropogenic? Can man really have a major effect on the earth's climate? Yes, it is true, and the science is in to prove it. The Intergovernmental Panel on Climate Change (IPCC) and the National Oceanic and Atmospheric Administration (NOAA) have published irrefutable evidence.



Scientists and prominent citizens from all walks of life, who care about the earth on which we exist,

have urged us to throw off the shackles of industrial bias and join world forces in reining in the indiscriminate pollution of the earth's atmosphere and the global warming it causes.

Geophysicists are increasing becoming grouped with other less technically oriented members of society as “Deniers”. It is time our members took a stand with the world of science and admit the factitious nature of Global Warming and Climate change in general.

Editors Note: The articles which appear on these pages are not necessarily shared by the Editorial Board or the Board of Directors of the GSH.

A Live Webinar

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Enders A. Robinson & Sven Treitel

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Geoscience Center News

By Bill Gafford

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



Our year started with a good bit of activity at the Geoscience Center. We continue to receive donations of books and periodicals which are used to add to our growing collection. When we receive materials that are duplicates to what we already have, or are not geoscience related, we put them aside and are donating them to a program operated by the HGS and the AAPG called the Publications Pipeline. Under this program, the books are shipped to foreign universities to aid in geoscience education. We were recently able to provide about 20 boxes of books that are going to the University of Lubumbashi in the Democratic Republic of the Congo. Until our duplicates are donated to this program, they are also available to anyone who wants to add them to their personal library.

We were pleased to host the very successful GSH "Education and Development for Unemployed Professionals" seminar on January 25 at the Geoscience Center. The attendees enjoyed looking over some of our displays and artifacts and a few mentioned that they plan to come back and spend more time learning about some of the older instruments in our collection. A more complete description of this event is located elsewhere in this month's Journal.

Another successful Living Legends Doodlebugger social event was held on February 9. We had some new visitors as well as many familiar faces. They enjoyed seeing some of our newer additions, including our expanded library and periodicals area. We also received some information on some of our older instruments that we can use when preparing signs describing the items. Two pictures of the event are included below.



If you would like to visit the Geoscience Center, and see some of the Mystery Items from the GSH Journal, see some of the items previously mentioned in the Geoscience Center News, or volunteer to help with some of our projects, please contact me at geogaf@hal-pc.org or at 281-370-3264.

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Unconventional – In both resource and technology!

By Nick McDaniel and Robert R. Stewart

"Drill for oil? You mean drill into the ground to try and find oil? You're crazy."

While the prospect of drilling for oil is no longer absurd, the task of finding and producing oil remains challenging. Fortunately, many decades of innovation have resulted in exploration technologies that greatly reduce the risk associated with drilling oil wells. Recently, a geophysical crew from the Allied Geophysical Lab (AGL) at the University of Houston was able to see this innovation in progress. In early January of this year, the AGL group (Figure 1) traveled to West Texas to participate in a 3D seismic acquisition program undertaken by Apache Corporation and Geokinetics Inc.

This particular seismic survey was implemented using drone photography and surveying (Figure 2),



Figure 1



Figure 2



Figure 3

a number of different vibroseis sweeps and various vibrator move-ups patterns to minimize elapse time (Figure 3). On the receiver side, there were combinations of up to 7 different co-located nodal



Figure 4

AGL Lab continued on page 34.

AGL Lab continued from page 33.

and wired sensors (Figure 4) including Geospace GSR nodes with three- component geophones and Texan nodes with low-frequency geophones provided by UH's Department of Earth and Atmospheric Sciences. The acquisition was performed by continuous 24-hour acquisition. From this combination of various source sweeps, receiver types, and geometries we hope to develop an optimized survey design to achieve the most time- and cost-effective surveys while improving data quality.

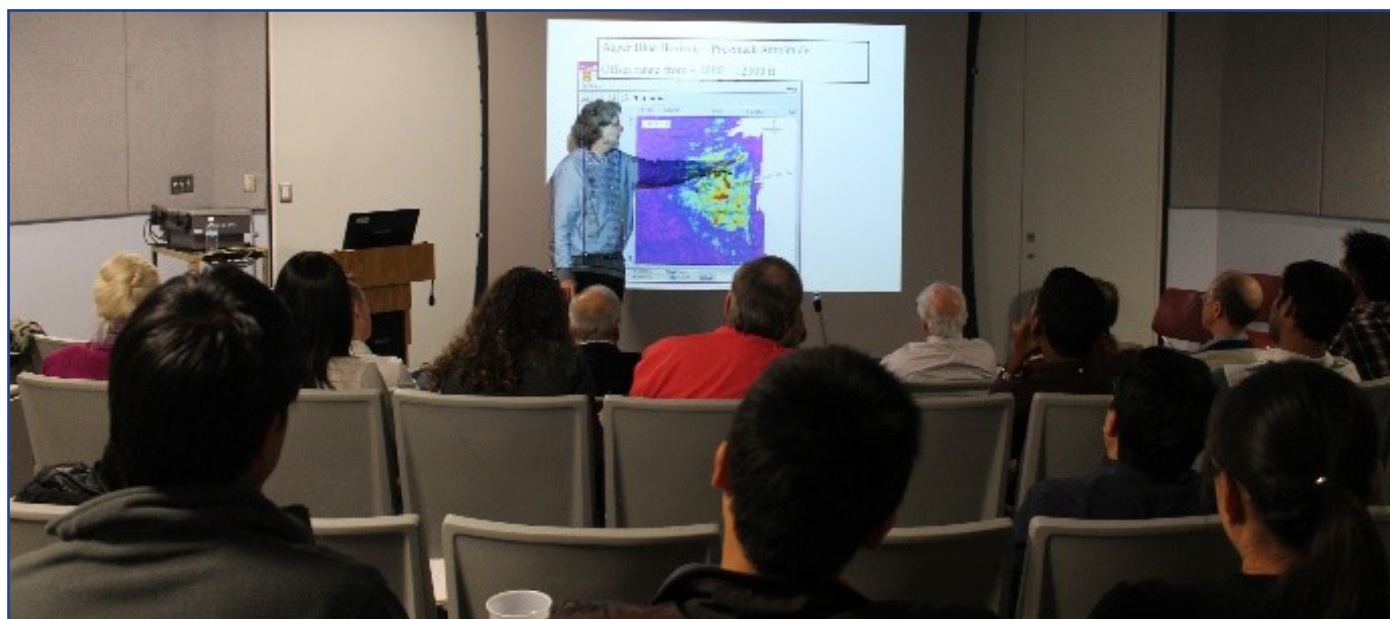
The survey was successfully completed and data are currently undergoing processing. There is quite a lot of excitement in analyzing how these new and forward-looking techniques (drones, nodes, 24-hour operation, variable sweeps and move-ups) can help with the discovery and recovery of unconventional resources.

We are most appreciative to Apache, Geokinetics, and Geospace for their commitment to advancing geophysics and their encouragement of research and educational collaborations.

U of H Wavelets

Reflection On a Lecture by Dr. Paul Hatchell

By Claire Ong



SEG's student chapter at the University of Houston, Wavelets, invited Dr. Paul Hatchell to be a guest speaker on January 20th, 2017. Dr. Paul Hatchell is currently Shell's principal 4D reservoir surveillance technical expert and a member of Shell's Areal Field Monitoring team in Houston. He is also a distinguished lecturer for SEG.

Dr. Hatchell's lecture was entitled "Seismic amplitude fidelity and its impact on 3D and 4D seismic interpretation". It began with an interactive exercise of questions that peaked the audience's attention toward the correct answer that would be revealed throughout the presentation. Other interactive exercises displayed were utilized to reiterate and confirm the information that had just been covered. These exercises succeeded in both capturing and

stimulating the minds of the audience. The lecture also included a multitude of graphs and figures that made it possible for undergraduates as well as the majority of graduate students, professionals, and faculty to better absorb and understand the presented information and its correlations.

SEG Wavelets organizes at least one guest lecture per month with the goal of spreading and stimulating knowledge. Anyone that is interested in the topics or is perhaps interested in the geoscience field is welcome to come. Although the lectures can be composed of technical terms, there are presentations such as Dr. Hatchell's that are both informational and easy to understand whether you are a professional with years of experience or an undergraduate student with solely a strong interest and hunger for knowledge.

GSH Premier Event: From Career Directions & Progressions *Education & Development for Unemployed Professionals*

By Whitney H. Blanchard, Chair

As current industry prices are slowly but surely on the rise, so are geoscience job openings. But with these new positions appearing, the competition is vast and fierce. To help our members better prepare for upcoming interviews, job fairs, and career events, GSH hosted its first ever event focused on developing unemployed professionals.

Everyone was welcome to attend the event, hosted on January 25th, 2017. However, the target audiences were those looking to gain knowledge in geotechnical and personal development for upcoming career opportunities. This event was hosted at the GSH Geoscience Center at 1790 W. Sam Houston Parkway North, in northwest Houston. Several members were impressed with the venue, and excited to see the wealth of knowledge and history the GSH has to offer at this location.



Guest speakers for this event included Sofia Campbell, Energy Professional Search and George Laguros from Marathon Oil. Each speaker discussed critical issues geophysicists currently face when trying to re-enter the industry workforce.

The first talk, presented by George Laguros, focused on geophysical technical aspects that individuals can improve while unemployed. Specifically, he provided information on several free software interpretation packages, free classes offered by various companies for both geophysical and petrophysical work, and other events held by similar non-profit organizations for personal development and improvement.

The second speaker of the evening was Sofia Campbell. Her talk focused on the "Signal-to-Noise Ratio" of an individual's career. The content presented provided simple and effective ways for individuals to develop strategies for determining what is critically important for potential employers. An extended version of Sofia's presentation can be found in the February issue of the GSH journal, pages 15 – 18.



Overall, the feedback provided by the attendees was positive and members were thankful to the GSH

Career Directions & Progressions continued on page 36.



for holding the event. In comments received from guests, they were appreciative for the opportunity to network both before and after the event, listen to the topics and materials presented, and learn more about what GSH has to offer in terms of volunteering opportunities, events, and the Geoscience Center.

We appreciate the sponsorship of Marathon Oil for this event and ask that members stay tuned for GSH's next professional unemployment event which will be occurring soon.



GSH Unemployed Professional Event



*SAVE THE DATE
May 17th, 2017*



Welcome 2016-2017 New Members

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Andrew Erich	ConocoPhillips	Kelly Jacobi	Schlumberger
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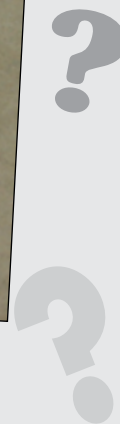
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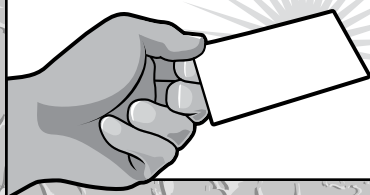
This is a geophysical item...



Do you know what it is?



This month's answer on page 43.



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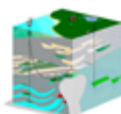
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Doodlebugger Diary

The Odyssey of a Doodlebugger

(The life and times of Ed Lengel) Part 4 of 4

As told to Lee Lawyer (Serialized to prevent total fatigue)

PRE "DOODLEBUGGER" DAYS: Employment:

This Doodlebugger story is part 4 of 4 from Ed Lingell and concludes his story. I had the privilege of meeting Ed recently at the Geoscience Center while doing some research for articles and he looks virtually the same today as in the photo, well maybe just a little bit grey. We thank Ed and all those contributors for their interesting stories. We are always welcoming others to use the Diary to tell us of their start in the industry or of some anecdote that happened along the way. Email to Lee Lawyer, llawyer@prodigy.net or David Watts, dwatts1@slb.com.

Episode 4: Wind Noise and Ice

Back in Alberta, we were working in a small town called Cochrane. The wind during the day was real bad, about 35mph. We couldn't work because of the wind noise, even though the geophones were buried. We decided to work at night which was not a good idea because we were in the bar until 11:00PM and went to work at 12:00AM. (Can you imagine the results yet?) The recorder was located near a place called Nordegg up in the mountains. In those days, we transmitted the sweep to the vibrators from the recorder so the radio was on transmit for 13 seconds until you hit "End of Record". (DFS-III/Sum-It). The Vibrator Operators would then "Pad Up" and move up 110ft. The Party Manager was asleep in his car and the Sr. Observer was asleep in the cab of the recorder and I fell asleep in the recorder too. When the Vibrator Operators heard the radio hadn't been turned off, and they couldn't hear the sweep carrier, they knew I had fallen asleep. They pressured their units down and went to sleep as well! When I woke up, the radio had been burned out for being on transmit all night. I woke everyone up and tried on a few excuses but none worked.

On a job on Great Bear Lake we had a Party Manager from Olympic Geophysical. He was an



Australian who hadn't been on a cold weather crew before. We needed fresh water and normally used a snow-melter but the Party Manager decided to drill a hole in the ice for water. He didn't realize that the pressure of our camp on the lake ice would push water up the hole. It was 45° below zero (Fahrenheit) and in the morning the whole camp was frozen in two feet of ice. The Party Manager decided to free the camp trailers and vehicles (on tracks) by using explosives. He used too much and ended up blowing the tracks off several vehicles. It took us 2 days to hack the camp out of the ice. We went on to Great Slave Lake with more success. When it was too cold, our twin Otter was routinely started by pulling a strap wrapped around the prop. Much later, I met the same Party Manager again in Ethiopia of all places.

Doodlebugger continued on page 43.

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

Doodlebugger continued from page 42.

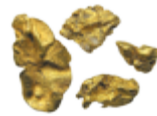
My travels have taken me to the Beaufort Sea, King Christian, Ellef Ringuss Island, Baffin Island, Banks Island, Dawson City, the Yukon, Victoria Island, and even the United States bases of Resolute and Alert on the Arctic Circle. This included several trips to Northwest Territories, White Horse, and Yellowknife, as well as a good portion of the Alaska Highway.

During my last days at Canwest, (before going to Ethiopia), I was working a job on Pointed Mountain, British Columbia in the spring. I was the Observer and the lines were very steep or full of mud. We had a D-8 Caterpillar to tow the vehicles. On one hill, I decided not to wait for the Cat, and took the recording truck straight up the hill. About three-fourths of the way up, I spun out so I decided to dig a hole by spinning my wheels and wait for the Cat. While I was spinning the wheels, I broke a cross link on the tire chains and the broken piece proceeded to cut the break line. When I went for the brake, the pedal went to the floor... no brakes! I popped the clutch and exploded the clutch plate! I had to stop the truck because there was a 300

foot drop on one side and a sheer cliff on the other. As I began to careen backwards down the hill, I cranked the wheel hard to wedge the truck against the hill. The truck rolled onto its side. There were 11 drills still at the top of the hill and could not get out because they couldn't get past me. The Drills were waiting and had to get out immediately because the spring road ban started the next day and it was over a half day to drive out. The Cat had to come back and winch the Recording truck upright. The mechanics repaired the clutch and I got out about midnight (with the drills). Needless to say, everyone was mad at me. I had to be at the airport the next morning to head for London, England to sign up with Ray Geophysical for assignment in Ethiopia. A further development to the recorder roll over, was that when the recorder was on its side, all the battery acid from the eight Cat batteries which powered the recorder, dripped into the DFS-III/Sum-It recording system. No matter how much they cleaned the bays, the instruments kept shorting out for years! Clarence Flowers, who was with Olympic at the time, never forgave me. He wouldn't even talk to me for several years.

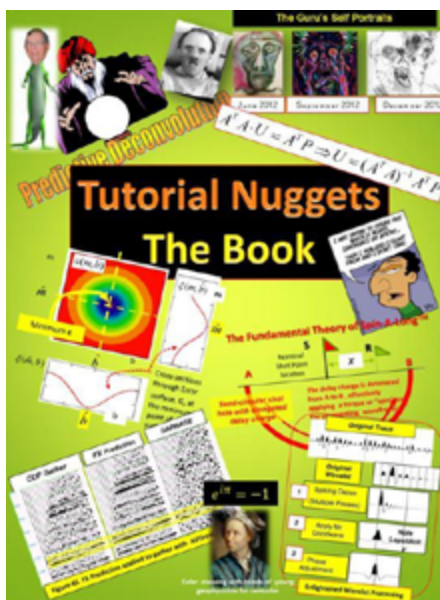


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Mystery Item

The Mystery Item for the April GSHJ is a survey tape used to measure distances.

Mystery Item on page 38.