



*The Epicenter of
Geophysical Excellence*

January 2017

GSH Journal

GEOPHYSICAL SOCIETY OF HOUSTON
Volume 7 • Number 5



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Vibrator Operations in Alaska.

Photo Courtesy of WesternGeco.



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.

2016 GSH JOURNAL DEADLINES

Mar 2017	Jan 3
Apr 2017	Feb 2
May 2017	Mar 3

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A Word from the Board

Continuing Education in a Low-price Environment

By Lisa Buckner, 1st Vice President

Whether you are currently employed in the industry, or not, the GSH is here to help you keep up with technical advances and network with colleagues for a nominal fee or free. As your 1st VP, I've been working hard to invite good speakers to fill parts of the GSH calendar of over 80 technical events, some of which are free to attend. We offer a monthly technical luncheon at three locations, a monthly technical breakfast at two locations, a two-day Spring Symposium, five Special Interest Group (SIG) meetings (some of which meet monthly), periodic webinars and the SEG DISC. The SIG leaders invite their own speakers and the webinar committee arranges for their instructors. I've noticed several of our members have been attending almost all of the events and a number of new members have joined GSH.

Mark your calendars! Our premier event of the year, the Spring Symposium, is coming up in April. We will be honoring David Monk and Malcolm Lansley on April 12 & 13, 2017 at the Norris Conference Center. The working title for this year's theme is "Geophysical Acquisition: Advanced techniques revealing challenging targets". We've invited a world class group of speakers and allocated ample time for extended talk discussions, exhibit booth engaging and networking with colleagues. This will be a must not miss event for knowledge sharing and networking which does not require travel expenses for Houston area residents.

We've made a couple of adjustments to our technical events this year which we hope you agree are for the better. We moved our Thursday luncheon to Southwestern Energy which offered us a much lower catering cost and free parking. The other adjustment was moving the Downtown luncheon to the Hess Tower when the Petroleum Club of Houston could not accommodate our schedule.

The monthly technical luncheon schedule this year includes two CSEG Distinguished Lecturers, a SEG Distinguished and a SEG Honorary Lecturer and a variety of speakers from operators, service companies and academia. Sponsorship opportunities for individual luncheon events (Westside, Downtown, and Northside) are available with a vendor spotlight.

The technical breakfasts are also held monthly but at only two locations (Northside and Westside) with a variety of speakers from operators, service companies and academia. The Northside breakfast is hosted by Anadarko Petroleum with the catering generously sponsored by Lumina Reservoir Inc. on the first Tuesday of the month. The Westside breakfast is hosted by Schlumberger with the

catering sponsored by WesternGeco and others (sponsorships are still available) on the second Wednesday of the month. Both offer breakfast at 7:00 AM with the technical presentation from 7:30 AM– 8:30 AM. I encourage you to attend the one closest to your home or office as they are a great way to start your day. Please preregister at www.gshtx.org, so we can ensure we order enough breakfast for everyone.



**Lisa Buckner,
1st Vice
President**

The Special Interest Group (SIG) meetings have been very educational and enjoyable this year. You don't have to be a subject matter expert to learn something new and get something meaningful out of them. I've been going to some of the Rock Physics SIG meetings sponsored by CGG & Ikon Science and Data Processing & Acquisition SIG meetings sponsored by Schlumberger for years because they interest me and are conveniently held after work near my home. Apache generously sponsors both the venue and lunch for the Microseismic SIG. New this year, is the joint meeting of the GSH Geoscience Computing SIG and the Society of HPC Professionals which is a lunch and learn event held at and sponsored by Unique Digital Inc. All four of these SIGs meetings are free for GSH members and non-members to attend due to their generous sponsors. The Potential Fields SIG technical dinner meetings are held every other month at the Houston Engineering and Science Society (H.E.S.S.) Club. They charge a registration fee to cover their costs (sponsorships are available and encouraged). Parking is free, or free with validation, at all SIG meeting locations and light snacks are served at those that don't serve meals. Therefore, they are all quite cost effective for those on tight budgets.

The final technical event of the year will most likely be the 2017 SEG Distinguished Instructor Short Course (DISC) which had not been scheduled at the time of writing this article.

For your nominal annual membership fee, the GSH provides you access to a wide variety of opportunities to enhance your technical skills and network with colleagues. All of the technical events meet professional board continuing education requirements. Lastly, I would like to thank all of the technical speakers at the breakfasts, luncheons, SIG meetings, webinars, Spring Symposium and SEG DISC for stepping up to share their knowledge with the GSH family. Visit www.gshtx.org to view the calendar of upcoming events and register today!

**Watch for the
GSH 2017 Annual
Golf Tournament
information!**



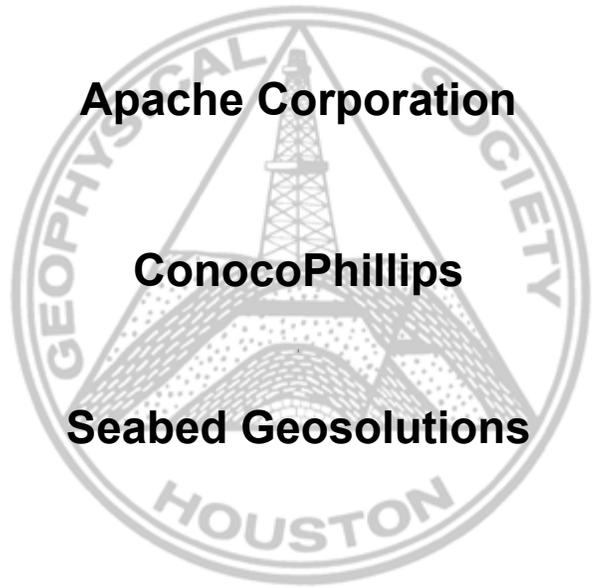
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Technical Events - See gshtx.org for more details on these events

TECH BREAKFASTS

The Total Solution to Near Surface Problem in Complex Exploration Areas

	Speaker(s):	Liansheng Liu, PanImaging Software Development Limited
Jan. 10, 2017	7:00 AM to 8:30 AM	Sponsored by Anadarko and Lumina Reservoir Inc.
Northside Breakfast	Location:	Anadarko Petroleum 1201 Lake Robbins Drive The Woodlands, TX 77380
Jan. 11, 2017	7:00 AM to 8:30 AM	Sponsored by Schlumberger, WesternGeco and PanImaging Software Development
Westside Breakfast	Location:	Schlumberger, Q-Auditorium 10001 Richmond Avenue Houston, TX 77042

DATA PROCESSING & ACQUISITION SIG

Signal Enhancement and Impedance Inversion for Highly Cyclically Stratified Sedimentation

Jan. 10, 2017	Speaker(s):	Dr. Chen Qi, Halliburton
	4:30 PM to 6:00 PM	Sponsored by Schlumberger
	Location:	Schlumberger, Q-Auditorium 10001 Richmond Avenue Houston, TX 77042

GEOSCIENCE COMPUTING SIG

HPC Systems - Not a Good Fit for Most IT Departments?

Jan 12, 2017	Speaker(s):	Bill Menger - President, Houston HPC Services, Inc. Deepak Khosla – Founder CEO, eXcellence in IS Solutions X-ISSS
	11:30 AM - 1:30 PM	Sponsored by The Society of HPC Professionals and UDI
	Location:	Unique Digital Inc. Conference Center 10595 Westoffice Dr. Houston, TX 77042

TECH LUNCHEONS

Getting More for Less: Frequent Low-cost Seismic Monitoring Solutions for Deepwater Fields

	Speaker(s):	Paul Hatchell, Shell and 2017 SEG Distinguished Lecturer
Jan. 17, 2017	11:00 AM to 1:00 PM	Sponsored by Data Direct Networks
Westside Luncheon	Location:	Norris Conference Center 816 Town & Country Blvd. Houston, TX 77024 (Free parking off Beltway-8 northbound feeder or Town & Country Blvd.)
Jan. 18, 2017	11:00 AM to 1:00 PM	Sponsored by Data Direct Networks
Downtown Luncheon	Location:	Petroleum Club of Houston 1201 Louisiana, 35th Floor (Total Building) Houston, TX 77002 (Valet parking entrance off Milam; UH & Rice students are encouraged to use Metro Rail)
Jan. 19, 2017	11:00 AM to 1:00 PM	Sponsored by Data Direct Networks
Northside Luncheon	Location:	Southwestern Energy Conference Center 10000 Energy Drive Spring, TX 77389 (Free Parking onsite)

POTENTIAL FIELDS SIG

The Tectonic Origin of the Bay of Bengal and Bangladesh: A Detective Story

Jan. 19, 2017	Speaker(s):	Manik Talwani, Schlumberger Chair of Advanced Studies and Research Emeritus and Research Professor of Earth Science, Rice University, Houston, Texas
	5:30 PM to 8:30 PM	
	Location:	HESS Club (Houston Engr. & Science Society) 5430 Westheimer Houston, TX 77056

Technical Breakfasts

The Total Solution to Near Surface Problem in Complex Exploration Areas

Register
for Tech Breakfast
Northside

Register
for Tech Breakfast
Westside

Speaker(s): Liansheng Liu,
PanImaging Software
Development Limited

Northside

Tuesday, January 10, 2017
7:00 – 8:30 a.m.

**Sponsored by Anadarko and
Lumina Reservoir Inc.**

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

Abstract:

In seismic imaging, static correction has been employed as the dominant method for solving the near surface problem in complex exploration areas. However, more precise subsurface seismic images, both in time as well as depth domain with high SNR, are required and demanded in prospect generating, especially in complex areas and unconventional explorations. Static corrections are simply not enough to meet the model-based imaging challenges. Here a total solution approach, based on high resolution near surface velocity model from first arrival tomography inversion, is proposed. Total solution is meant to cover all necessary compensations from field acquisition, processing and interpretation. Specially, Total solution consists of near surface absorption and attenuation compensations in addition to traditional static correction, which is critical due to the near surface severe signal absorption. In the data acquisition stage, it is proposed to take advantage of existing seismic data so that optimum survey parameters and shot hole depths can be designed for the low velocity layer, which will automatically ensure higher quality data. On the other hand, in the processing stage, in addition to applying "static" time shift corrections, the proposed solution uses first arrival signals to invert to a near surface velocity model and then applied to PSDM model building with great improvements. Lastly, in the interpretation stage, we have harmonized the near surface model with the deep reflection derived model so that the velocity mapping quality will be significantly improved. In general, our proposed total solution takes into account all corrections from elastic kinematical & dynamical aspects, from initial survey design to final interpretation cycle. Case studies demonstrating the above improvements will be presented and discussed.

Westside

Wednesday, January 11, 2017
7:00 – 8:30 a.m.

**Sponsored by Schlumberger,
WesternGeco
and
PanImaging
Software
Development**

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



**Liansheng
Liu**

Biography:

Liansheng obtained his BSc and MSc degrees in Geophysics from Chang'An University of China in 1990 and 1993. He started working at Geophysical Research Institute of BGP doing seismic data processing and R&D in 1993. He established PanImaging Software Development Limited in Beijing in 2004 and PanImaging Canada in 2014. Liansheng has been focusing on static correction and near surface problems since 1995. He proposed the approach of first arrival residual static correction in 1998 and built the static correction processing flow for complex exploration areas which is still widely applied in China. He was granted the National Science and Technology Progress Award by the Chinese government in 2003. In the past six years, Liansheng has been invited as the honourable lecturer by Sinopec to deliver talks concerning the leading technology and development of near surface

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Data Processing & Acquisition SIG

Signal Enhancement and Impedance Inversion for Highly Cyclically Stratified Sedimentation

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for Data Processing

Speaker(s): Dr. Chen Qi, Halliburton

Tuesday, January 10, 2017

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

5:00 p.m. Start of presentation

Abstract: In highly cyclic sedimentation with large impedance contrasts, such as coal beds, peg-leg multiples make seismic ties with primary-only synthetics difficult. Two ways are proposed to interpret the synthetic seismograms and seismic data: signal enhancement processing and impedance inversion.

Firstly, a processing technique based on time-varying matched filters is presented for removing the effects of peg-leg multiples in near-offset stack data. This method was tested on a synthetic seismic line based on well-log curves from a highly cyclic coal-bed area and the result demonstrated the efficiency of the method. Secondly, I demonstrated the limitation of conventional generalized linear inversion (GLI) for impedance estimation from seismograms with severe peg-leg multiples. High-frequency coda noise made conventional GLI unstable. Compared with the conventional GLI, which inverts for the

Sponsored by Schlumberger

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



Dr. Chen Qi

whole trace at once, my modified GLI method iteratively stages the inversion for acoustic impedance on post-stack seismic data from a low-frequency band to a frequency band as wide as the original source wavelet. The inversion at the low-frequency band inverts for the boundaries of the stratified sedimentation while the inversion at the high-frequency band inverts for the details within the bed boundaries.

Biography: Chen Qi received a B.S. (2011) in geophysics from the Chengdu University of Technology, and an M.S. (2013) and Ph.D. (2016) in applied geophysics from the University of Houston working on coal beds internal multiple interpretation and elimination advised by Fred Hilterman. He is currently working in Halliburton on the DAS project. His research interests include seismic modeling, impedance inversion and quantitative interpretation.

GSH Premier Event

Education & Development for
Unemployed Professionals

**“How to prepare for the
future hiring environment,
from current industry
professionals.”**

**Limited Space
Pre-registration Required**

January 25th, 2017

Geoscience Center @ 1790 West Sam Houston Parkway North

4:00 – 6:00 pm

Please visit website for further details



Geoscience Computing SIG

HPC Systems - Not a Good Fit for Most IT Departments?

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Now meeting every month during lunch. A lunch will be served.

Speaker(s): Bill Menger - President, Houston HPC Services, Inc.
Deepak Khosla – Founder CEO, eXcellence in IS Solutions | X-ISS

Sponsored by The Society of HPC Professionals and UDI

Wednesday January 12, 2017
11:30 a.m. - 1:30 p.m.

Location: Unique Digital Inc.
Conference Center
10595 Westoffice Dr.
Houston, TX 77042
www.google.com/maps

Abstract:

Everyone one can agree, there are major differences between running a 5,000 head cattle ranch with only 2 customers versus tending a herd of 500 Alpaca sheep whose wool is destined for thousands of boutique customers. Each business has its own sets of challenges to be addressed.

IT staffs deal with thousands of users typically and only need to deploy a few dozen servers to manage them. HPC staffs typically deal with thousands of servers and usually only a dozen to hundreds of users having high-end workstations with specialty or home-grown software. The jobs for these two staffs are vastly different. Might it take a different organization with different skills to manage these very different scenarios? In this presentation, we will discuss the similarities and differences between the needs presented to HPC departments vs. those presented to IT departments. Our goal is for you to leave with at least one challenge for your IT or HPC computing departments to consider that will make your company stronger, more agile, better prepared for disaster, or better at meeting the needs of its user base.

Biography:

Bill holds BS degrees in Electrical Engineering and Geophysics from Texas A&M University (1977). Bill's engineering career included stops with the US Navy, Conoco, ION Global Geophysical, and currently Houston HPC Services. His experience spans HPC Software development to supervising a team of HPC admins and software developers. At ION, Bill managed a team of thirteen and a budget of \$20MM. Bill is co-founder, former board member, and past President of the Society of HPC Professionals. Bill and his wife Patty are A2 square dancers, parents of three boys, and have six grandchildren.

Deepak Khosla is the Founder and CEO of X-ISS and has over 25 years of managerial and development experience in technology and software industries. Prior to X-ISS, Deepak served as the President and Co-Founder of NetPartners. Previously, Deepak held a management position at ParaNet. Deepak began his career with Landmark Graphics leaving the company as a product manager. Deepak received a M.S. in Electrical Engineering from the University of Houston.



Technical Luncheons

Getting More for Less: Frequent Low-cost Seismic Monitoring Solutions for Deepwater Fields

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for Tech Lunch
Downtown

Register
for Tech Lunch
Northside

Speaker(s): Paul Hatchell, Shell and 2017
SEG Distinguished Lecturer

Sponsored by Data Direct Networks

Westside

Tuesday, January 17, 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

Wednesday, January 18, 2017

11:00 a.m. – 1:00 p.m.

Location: Petroleum Club of Houston
1201 Louisiana, 35th Floor (Total Building)
Houston TX 77002
(Valet parking entrance off
Milam; UH & Rice students are
encouraged to use Metro Rail)

Abstract: Time-lapse seismic reservoir surveillance is a proven technology for offshore environments. In the past two decades, we have seen this technology move from novel to necessary and enable us to monitor injection wells, water influx, compaction, undrained fault blocks, and bypassed reserves. Value is generated by influencing the management of our field operations and optimizing wells to reduce cost, accelerate production, and increase ultimate recovery.

Significant advances in technology are improving the quality of our data. Errors in acquisition repeats are nearly eliminated using permanently installed systems or dedicated ocean bottom nodes. We now routinely obtain surveys with such a high signal-to-noise ratio that we can observe production induced changes in the reservoir after months instead of years. This creates a demand for frequent seismic monitoring to better understand the dynamic behavior of our fields. Increasing the frequency of seismic monitoring will have a proportionate cost implication, and a challenge is how to design a monitoring program that maximizes the overall benefit to the field.

Reducing individual survey costs is important to enable frequent monitoring. Several techniques are considered for lowering these costs such as:

Northside

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**Paul
Hatchell**

- Reducing the number of shots and/or receivers to minimize offshore vessel time. This includes shooting targeted (i4D-style) surveys on a frequent basis in between full-field surveys that are acquired infrequently.
- Use of smaller source arrays towed by less-expensive vessels.
- Semi-permanent ocean-bottom nodes that can be left on the seafloor for multiple on-demand surveys.
- Time-lapse VSPs that use permanent distributed acoustic sensors (DAS) in well bores.
- High-resolution 4D surveys that monitor shallow reservoirs cost effectively using low-cost vessels towing arrays of short-streamer cables (e.g., P-cable).

There is no single solution that works for every field, and we need to understand the pros/cons of the various technologies to select the best option for a specific field. Some results of applying these techniques to deepwater fields will be discussed.

Biography: Paul Hatchell joined Shell in 1989 after receiving his PhD in theoretical physics from the University of Wisconsin. He began his career at Shell's Technology Center in Houston and worked on a variety of research topics including shear-wave logging, quantitative seismic amplitude analysis, and 3D AVO applications. Following a four-year oil and gas exploration assignment in Shell's New Orleans office, Paul returned to Shell's technology centers in Rijswijk and Houston where he is currently a member of the Areal Field Monitoring team and Shell's principal technical expert for 4D reservoir surveillance. His current activities include developing improved 4D seismic acquisition and interpretation techniques, seafloor deformation monitoring, and training the next generation of geoscientists.

Potential Fields SIG

The Tectonic Origin of the Bay of Bengal and Bangladesh: A Detective Story

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Speaker(s): Manik Talwani, Schlumberger Chair of Advanced Studies and Research Emeritus and Research Professor of Earth Science, Rice University, Houston, Texas

Location: HESS Club (Houston Engr. & Science Society)
5430 Westheimer
Houston, TX 77056



**Manik
Talwani**

Thursday, January 19, 2017

5:30 Registration / Cash Bar

6:30 Dinner Served

7:30 Presentation Begins

8:30 Adjourn

Abstract:

We are able to unambiguously decipher the tectonic origin of the Bay of Bengal, a puzzle which has not been satisfactorily solved in the past and are also able to shed new light on the buried 85°E Ridge. We do so by incorporating a number of disparate items into a unified solution. These items are the marine magnetic anomalies in the Western Basin of the Bay of Bengal, the Rajmahal and Sylhet traps and Deep Seismic Sounding lines in India, a prominent magnetic anomaly doublet and seismic Seaward Dipping Reflectors in Bangladesh, and a new precise gravity map of the Bay of Bengal. The 85°E Ridge divides the Bay of Bengal into a Western and an Eastern basin. We identify seafloor spreading magnetic anomalies ranging in age from 132 Ma (M10n) to 124 Ma (M2) in the Western Basin. These anomalies are "one sided", the conjugate anomalies lie in the Enderby Basin, off East Antarctica. The direction of spreading was approximately NW-SE, and the rate of spreading ranged from 4.2 to 3.0 cm/yr. With the arrival of the Kerguelen plume at around 118 Ma, sea floor spreading was reorganized and a new spreading axis opened at or close to the line joining the Rajmahal and Sylhet traps. The prominent magnetic anomaly doublet connecting the Rajmahal and Sylhet traps indicates that these traps are not individual eruptions, but rather, together, define the new line of opening. Spreading started at this line in an N-S direction as India moved northwards. The new oceanic crust, thus generated, underlies the Bangladesh and the Eastern Basin of the Bay of Bengal and is younger than 118 Ma. The western boundary of the new ocean floor is a transform boundary which was generated by the spreading axis jump. In part, it lies along the 85°E Ridge. A unique feature of the northern boundary of the new oceanic crust is that it lies on the continent, as opposed to all other ocean continent crustal boundaries in the world, which lie offshore.

Biography:

Dr. Talwani is the Schlumberger Chair of Advanced Studies and Research Emeritus and Research Professor of Earth Science at Rice University, Houston Texas. He earned a B.Sc. and M.Sc. in physics from Delhi University in 1951 and 1953 respectively, a Ph.D. in Geophysics from Columbia University in 1959 and an Honorary Ph.D. from Oslo University in 1981.

He has held various positions and appointments throughout his career notably as President and CEO, Integrated Ocean Drilling Program-Management International, 2004 – 2009 Schlumberger, Professor of Advanced Studies and Research, Rice University, 1985-2006, Director, Geotechnology Research Institute, Houston Advanced Research Center, 1985 – 1998, Chief Scientist, Gulf Research & Development Company, 1983-85, Director, Center for Marine Crustal Studies, Gulf Research & Development Company, 1981-1983, Director, Lamont-Doherty Geological Observatory, 1972-81, Professor of Geophysics, Columbia University, 1970-82, and Research Scientist, Senior Research Associate, and Associate Professor, Lamont-Doherty Geological Observatory of Columbia University, 1959-70.

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Geoscientists Without Jobs: A Guide to Surviving the Downturn

Part Five: Reciprocity, Altruism and the Search for Work

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

In a previous edition of this column, we discussed strategies for growing one's network. While it is necessary to expand one's network to prosper, maintaining the network is the more important and difficult task, especially if you wish to remain in good standing within it. There will come a time when you need your network (as any unemployed professional will tell you) more than it would appear to need you. When this turn comes, how your network responds can be boiled down to two basic moral principles: reciprocity and altruism. Most have an implicit understanding of these concepts, but taking the time to think about them explicitly in the context of the job seeker (whether a consultant of someone seeking full-time employment) is a useful exercise. You cannot control someone else's behavior or judgment, but you can model the behaviors you wish to see in your network and try to create positive feedback by doing so.

There will come a time when you need your network (as any unemployed professional will tell you) more than it would appear to need you.

Most geophysicists know the term reciprocity as it applies to seismic experiments, but the relevant usage here is from moral philosophy. In Western societies, we call it the "Golden Rule", and it is axiomatic that we should treat others the way we wish to be treated. We also expect people to help us when we are in need without apparent or immediate benefit to themselves. This is *altruism*.

I'm sure that each of us can cite numerous examples of fruitless efforts to make connections and manage our careers: emails and phone calls that never get answered, job interviews where you never hear from

them again, or that headhunter who mysteriously disappears after three phone calls. While we are not always treated as we wish to be treated by HR personnel, recruiters, hiring managers, potential clients, or even our friends and colleagues, the only choice we have is to act as though we are.

After setting up a website for my consulting business, I have received a steady stream of inquiries and résumés targeting non-existent vacancies. Because the percentage of people who respond to my own inquiries is always lower than I hope, I have empathy for anyone who makes the effort to contact me. I know too well what it's like to be on the other end of that conversation, and I know the effort to respond is minimal. Even if the response is not positive or encouraging, I always respond. If you don't take any other lessons from my columns, please take this one: any response is better than none. Your time is not more valuable than anyone else's.

Being altruistic as a job seeker is often a harder proposition because it can seem counter-intuitive. I've been approached about job opportunities where declining was the best course of action. In one case, I was asked if I could perform a task that was well outside of my particular skill set. Being a bit desperate for the work, I seriously considered how I could study up in my "spare" time (a laughable notion if you are trying to grow a consulting business) and fake my way through it. I quickly decided to decline the work and suggested another consultant who I knew was better qualified. One does not have to believe in karma to realize that my value in the network grows by acting altruistically in this regard: one person gets a better result, another person gets more work, and they both can point to me as the enabler of that. This benefit far outweighs the risk of reputation damage likely to occur by me attempting that work myself. I may not ever derive any further benefit from this interaction, but I would rather live in a world where such behavior might not be rewarded than to live in one that lacks a moral landscape.

In some fields (far outside the oil business), I have friends and family members who have built careers

Geoscientists Without Jobs continued on page 13.

Geoscientists Without Jobs continued from page 12.

by responding to job postings and never having known someone on the inside who could refer them to a hiring manager. The oil business does not work this way, so building a career in this business depends on your ability to grow and maintain a network of people with whom you can collaborate. I have no idea how long this downturn will last, but I recognize that when the time for growth and opportunity comes again, the first people to get phone calls will be those with whom someone else wants to work. If you can demonstrate your value to your network in the worst of times through reciprocity and altruism, you stand a good chance of getting one of those calls. Alternatively, you can view job searching as asymmetric warfare, but in my opinion, "The Hunger Games" should remain a work of fiction and not a model for how to succeed in business.

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Interesting Topics in Land Seismic Data Acquisition, Processing, and Inversion

Oz Yilmaz, PhD in Geophysics

Director of Anatolian Geophysical & CTO of GeoTomo LLC.

February 28, March 1, 2, 3, 2017 10:00 am - 2:00 pm



Using the desktop in your own home or office find out what you need to know (or knew and forgot) about land seismic presented by a technological leader for the industry. Topics to be covered include:

Shot-receiver spatial sampling requirements in land seismic data acquisition, large-offset recording, swath-line recording, the meaning of the near-surface in exploration seismology, seismic wave velocities in the near-surface, factors that influence surface-wave propagation in the near-surface --- source depth, velocity contrast between the near-surface and the subsurface, thickness of the near-surface, near-surface geometry, near-surface velocities, near-surface heterogeneities, wave attenuation in the near-surface, surface topography, and recording geometry --- workflows and case studies for near-surface modeling by travelttime inversion and image-based near-surface modeling for statics corrections, workflow and case studies for subsurface imaging in areas with irregular topography, complex near-surface and complex subsurface.

Oz Yilmaz received his B.S. in Geology with Geophysics Option from the University of Missouri-Rolla in 1970, M.S. in Geophysics with research in rock physics and earthquake seismology from Stanford University in 1972, and after five years in the industry, a Ph.D. in Geophysics with research in exploration seismology from Stanford University in 1979. Aside from numerous publications on all aspects of seismic data analysis, Oz wrote three books published by SEG --- Seismic Data Processing (1987), Seismic Data Analysis (2001), and Engineering Seismology (2015).



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An Oklahoma Broadband Land Seismic Case History

By Mike Yates, Grant Byerley, Richard Eden, David Monk, and Simon Voisey, Apache Corporation

This is the second of two articles on broadband seismic data and its uses in hydrocarbon exploration and production. The first article (December GSHJ) focused on the basics of broadband acquisition and processing and how this impacts seismic interpretation. This month we show a case history of broadband seismic acquisition, processing and interpretation on an unconventional play in Oklahoma.

Summary

Apache Corporation started planning a broadband 3D seismic survey targeting the Woodford Shale in the South Central Oklahoma Oil Province (SCOOP) toward the end of 2014. Following 5 months of permitting, field operations started in late May of 2015 and concluded in early August 2015. We show that through the application of high-density acquisition, custom low-dwell vibroseis sweeps and a bandwidth preserving processing flow we were able to recover six octaves of usable seismic signal which could be used to generate an absolute inversion without the need for a seismic wavelet or low frequency model.

Introduction

The SCOOP is a liquids-rich play in southern Oklahoma, (Figure 1), containing the Woodford shale which is said to be one of the best shale reservoirs in the USA.

During planning the survey polygon changed several times to accommodate changes in acreage, eventually settling on 110 square miles. This encompassed nearly 4,000 surface owners and more than 70 mineral owners. Although the majority of the survey covered livestock pasture and arable lands producing hay, corn, and alfalfa, it also crossed into the city limits of Small-Town Oklahoma.

Apache had been gaining experience elsewhere with broadband methods and simultaneous sweeps and both were to be implemented to create a high-density, broadband, full azimuth 3D survey with the goal of creating a high quality inversion product to guide exploitation. We will show how the extended low-frequency bandwidth improved Apache's ability to invert for impedance.

Seismic Survey Design

Scouting of the area suggested that a vibroseis source could work well in this area, as the sandy soil and rolling topography looked to offer good drainage, and annual weather patterns suggested that late spring would be the ideal acquisition window. The most recent acquisition in the area had used a dynamite source, possibly to widen the weather-window for acquisition, but the costs associated with a dynamite source precluded the density sought on this project.



Figure 1: Oklahoma map showing SCOOP area. Base map by Bing.

Technical Article continued on page 15.

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

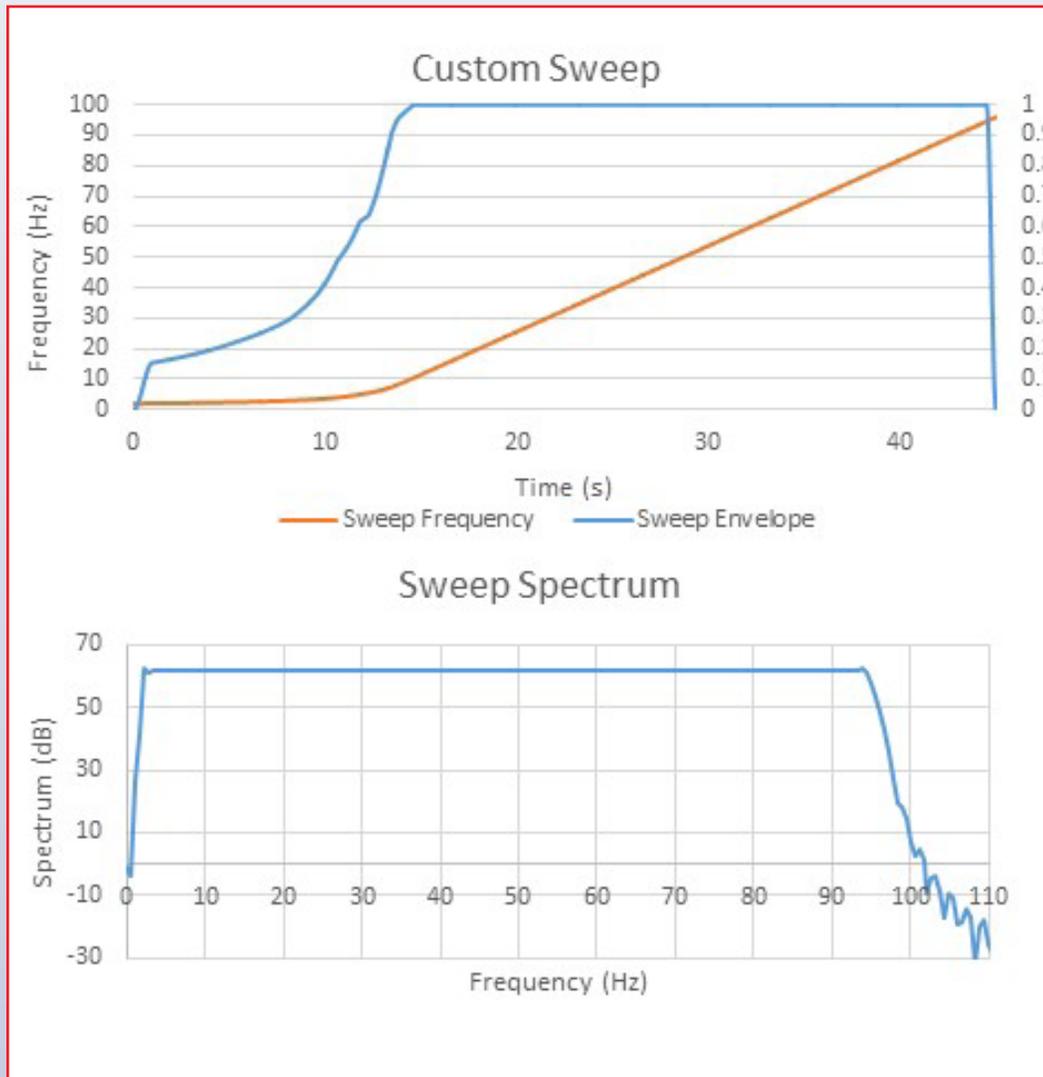
As our survey was to be merged with an adjacent dataset, we started out with a similar layout: equally-spaced, orthogonal lines. A series of adjustments were then made to optimize source productivity and maximize trace density to meet our objectives:

- 2 vibes per fleet allowed up to 5 fleets active
- More fleets increased efficiency with many small tracts
- Sweep length increased to compensate for fewer vibes
- Slip-sweep introduced to maintain productivity
- Source line interval reduced, source density increased

- Receiver line interval increased to boost layout speed
- Receiver point interval halved to boost receiver density
- Design fold was 4x adjacent dynamite survey fold

Custom Low-Dwell Vibroseis Sweep

To maximize the seismic bandwidth, the lowest effective start frequency was sought. Servo-hydraulic vibrator output is limited at low frequencies by reaction mass displacement limits (Bagaini, 2006); to overcome this limitation a custom low-dwell sweep was designed (Figure 2) and tested for effectiveness against a linear sweep with cosine tapers. The upper limit of the sweep was 96Hz.



From a start frequency of 2 Hz, the drive level and sweep rate remained low until the sweep entered the nominal frequency range of the vibrator, at which point the drive level increased to the selected level and the sweep rate increased to become linear. The result was an almost flat spectrum between the taper-points.

Slip Sweep Design

Due to the longer sweeps, slip sweep was implemented to maintain productivity (Rozemond, 1996). In this way, one fleet could start sweeping without waiting for the prior group's sweep to be completed. To minimize the risk of contaminating the seismic record with harmonics of the subsequent sweep, a conservative 30s slip time was used (Figure 3). This was supported by test data and subsequently production data.

Figure 2: Custom non-linear low-dwell sweep definition

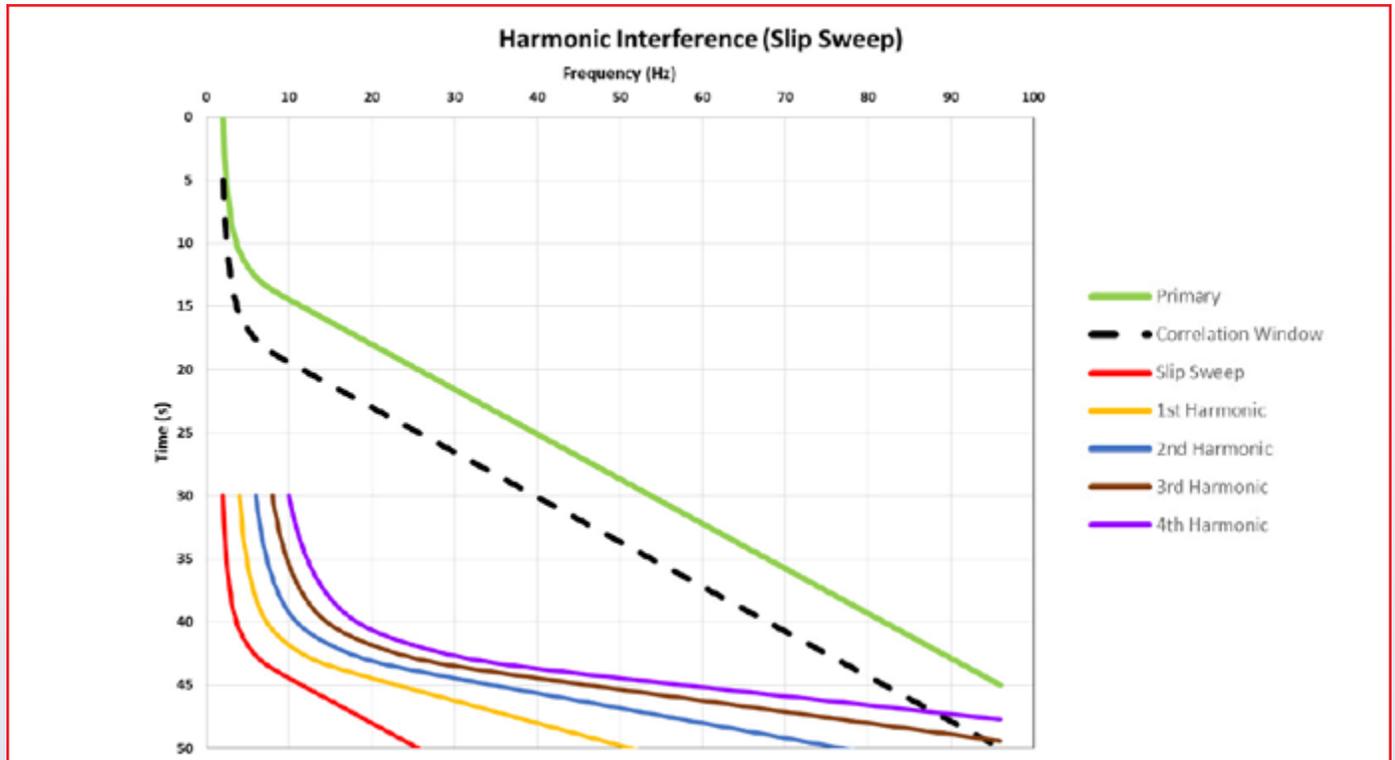


Figure 3: Harmonic Interference (45s sweep, 30s slip, 5s record)

Field Operations

Acquisition was originally scheduled to begin in May 2015, but the startup of field operations was delayed first for permits, following an expansion of the program, and then for weather. May 2015 went rapidly from being the wettest May on record, to the wettest month since records began. Weather stations close to the survey area experienced more than 3 times the average rainfall for the month.

The use of a self-contained nodal system, and specifying that all nodes must be buried below the surface, offered a number of advantages for this project. Deployment and retrieval were rapid, and in active agricultural areas, higher levels of activity (including crop cutting) did not damage nodes that were correctly deployed. However the crew did sustain some equipment damage following plowing and disking operations where prior notice was not given.

Urban Seismic Operations

The survey included four square miles within the city-limits of Small-Town Oklahoma which required special consideration for vibroseis operations. A dedicated peak-particle-velocity (PPV) study was performed on the outskirts of town to establish safety distances. Following this the urban vibrator points (VPs) were recorded in just

two days using a single vibrator set to reduced-force. In order to minimize the interference with the town's activities, the vibrator was escorted by personnel from the county sheriff's office at all times and the crew observed shorter work days.

Recording Statistics

Layout/shoot/pickup operations functioned without significant interference from each other. Average daily layout was over 1,000 stations, and average daily recording production was over 750 VPs (or roughly 4.5 square miles of surface) shot per day. The vibrators worked for 20 days in a 30-day period to cover the 110 square miles, with 8 recording days lost to weather and 2 waiting on spread. No recordable incidents were reported.

The implementation of slip sweep resulted in nearly 50% of sweeps starting with a slip time of 30s from the previous sweep start. This translates into over 40 hours of production time saved during 20 days of vibrator operations.

Processing and Imaging

Until recently, domestic vibroseis surveys would skip the first 2-3 octaves of bandwidth and start sweeping at 6-8 Hz. This limitation was imposed by a combination of issues

Technical Article continued on page 17.



Figure 4: Typical field conditions

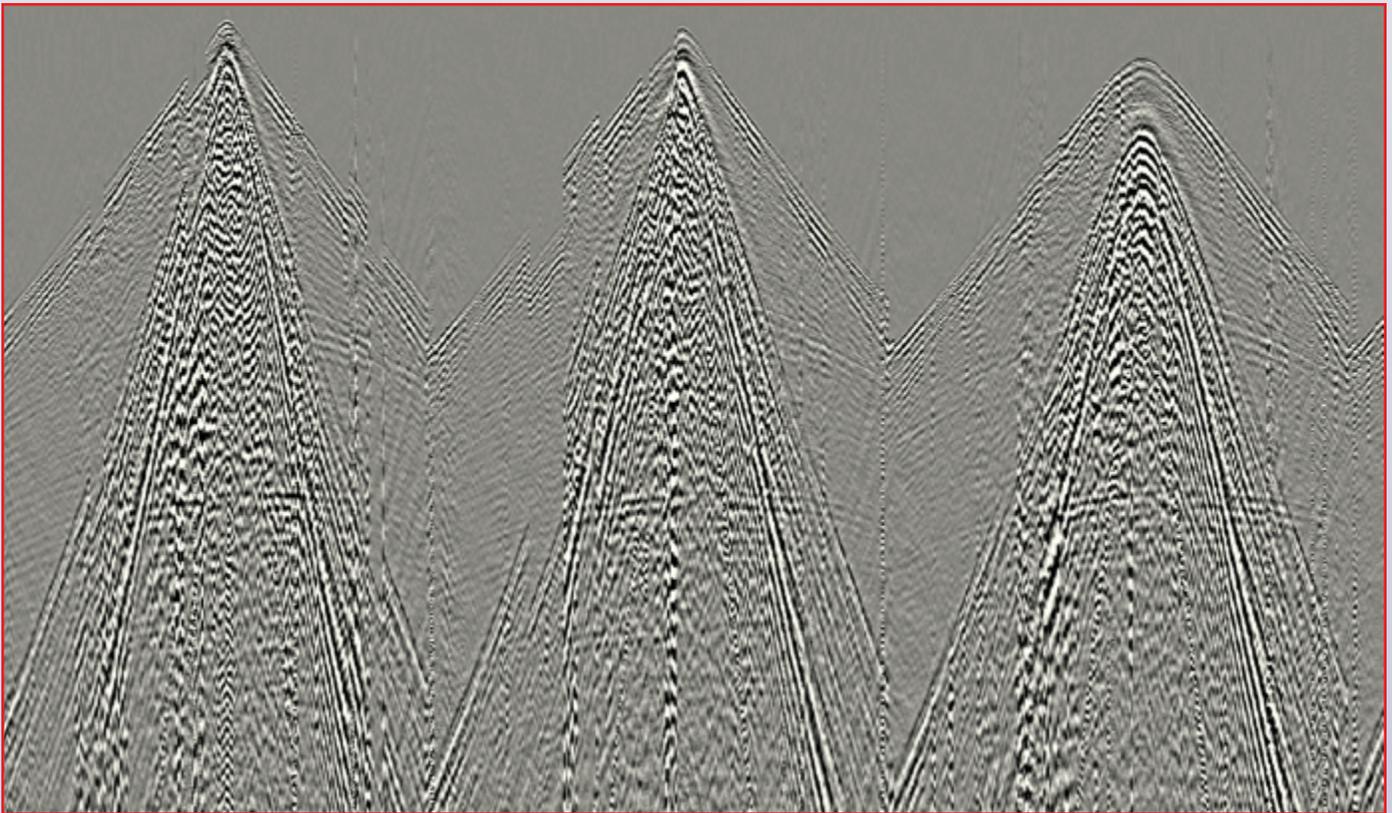


Figure 5: Example of raw shot records showing clean, well sampled noise trains which can be removed with conventional noise attenuation techniques

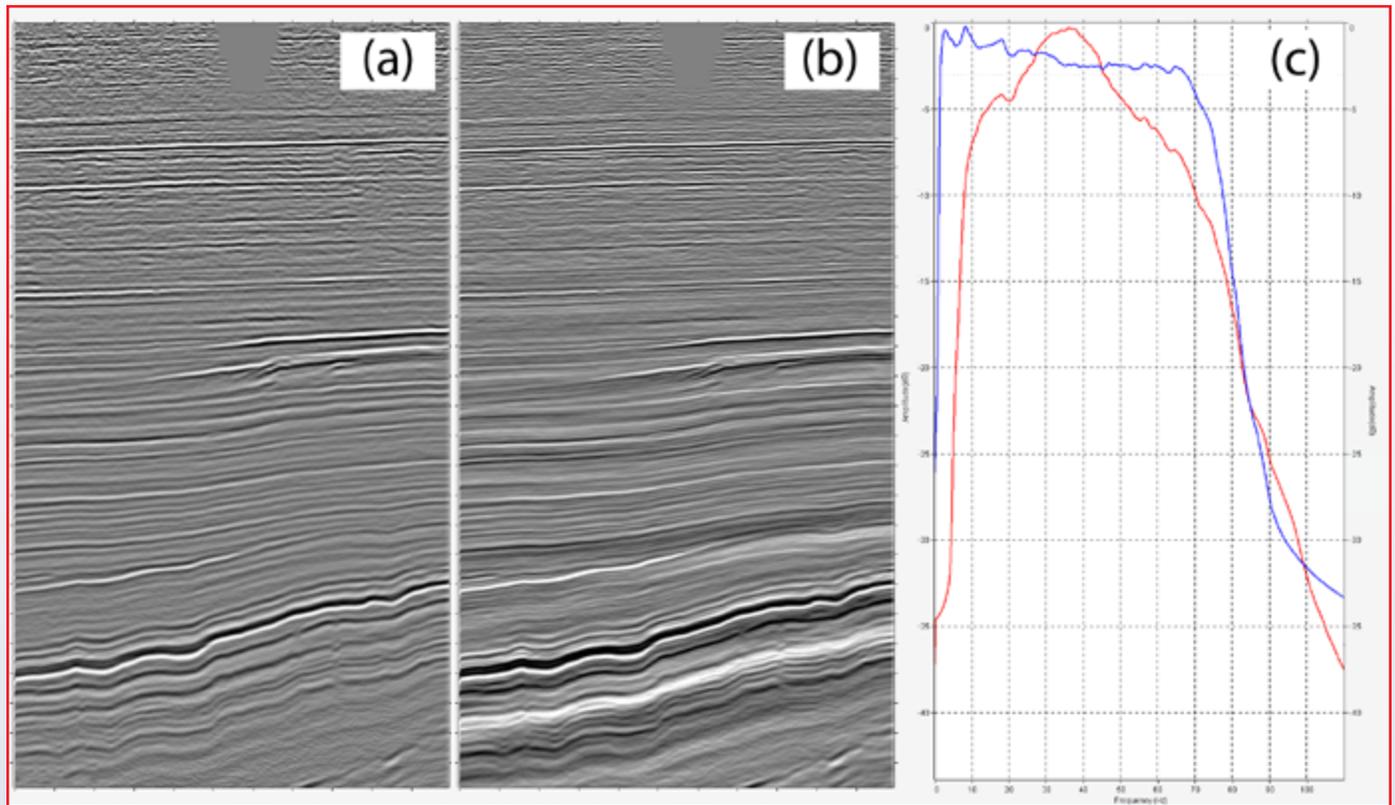


Figure 6: Stack sections before (a) and after (b) post migration shaping, and (c) Amplitude spectra before (red) and after (blue) shaping to enhance the broadband character of the data. In this example we were able to achieve a flat response from 2-65Hz at the target interval.

including source limitations, coherent noise, sampling and near surface effects (Denis et al., 2013). However had we been able to do this it would have been difficult to remove usable signal from the low-velocity surface waves which would have been aliased due to the low channel counts imposed by legacy recording systems. Although workarounds could have been possible, they might not have made economic sense.

As acquisition hardware and design changes, so must processing flows. In order to maximize the benefits of the low dwell sweep, care was taken during the processing sequence to both preserve and enhance the low frequencies. This was achieved in part by generating amplitude spectra and QC displays of octave filter panels to ensure coherent, low frequency signal was preserved.

We recorded the data using standard 10Hz analogue geophones. It has been shown that although these phones exhibit a 12 dB/octave roll off below their natural frequency, they are capable of recording up to 2 octaves below this (Maxwell et al., 2011). To correct for this effect an inverse filter was derived to flatten the low frequency response down to 2Hz; this boosted both coherent signal and low velocity surface noise. Fortunately we were able to record un-aliased noise thanks to a combination of dense

shot and receiver sampling and cooperative near surface conditions making noise attenuation a straightforward step. Whilst on the topic of geophones it's worth noting that in addition to amplitude decay, a standard geophone will also introduce a rapid, frequency variant phase rotation of approximately 90 degrees between 2-10Hz (most manufacturers publish the numbers for their specific geophones). Although it's possible to correct for phase and amplitude effects with a single inverse filter, we went with the assumption that spiking decon would correct for the phase component. Regardless, understanding and correcting for phase effects at these low frequencies will be an important part of any broadband experiment if the end goal is to use the data for quantitative interpretation. This includes phase effects introduced by the geophone, recording system, near surface and attenuation, amongst other things.

After correcting for the geophone we ran a pass of "throw away" denoise, pre-deconvolution. Combined with the geophone response this helps ensure the input to deconvolution is noise free and broadband: two of the three pre-requisites of spiking decon. In hindsight we realized we could have included a Q-compensation to further broaden the spectrum and prevent spiking decon from boosting high frequency noise deeper in the section,

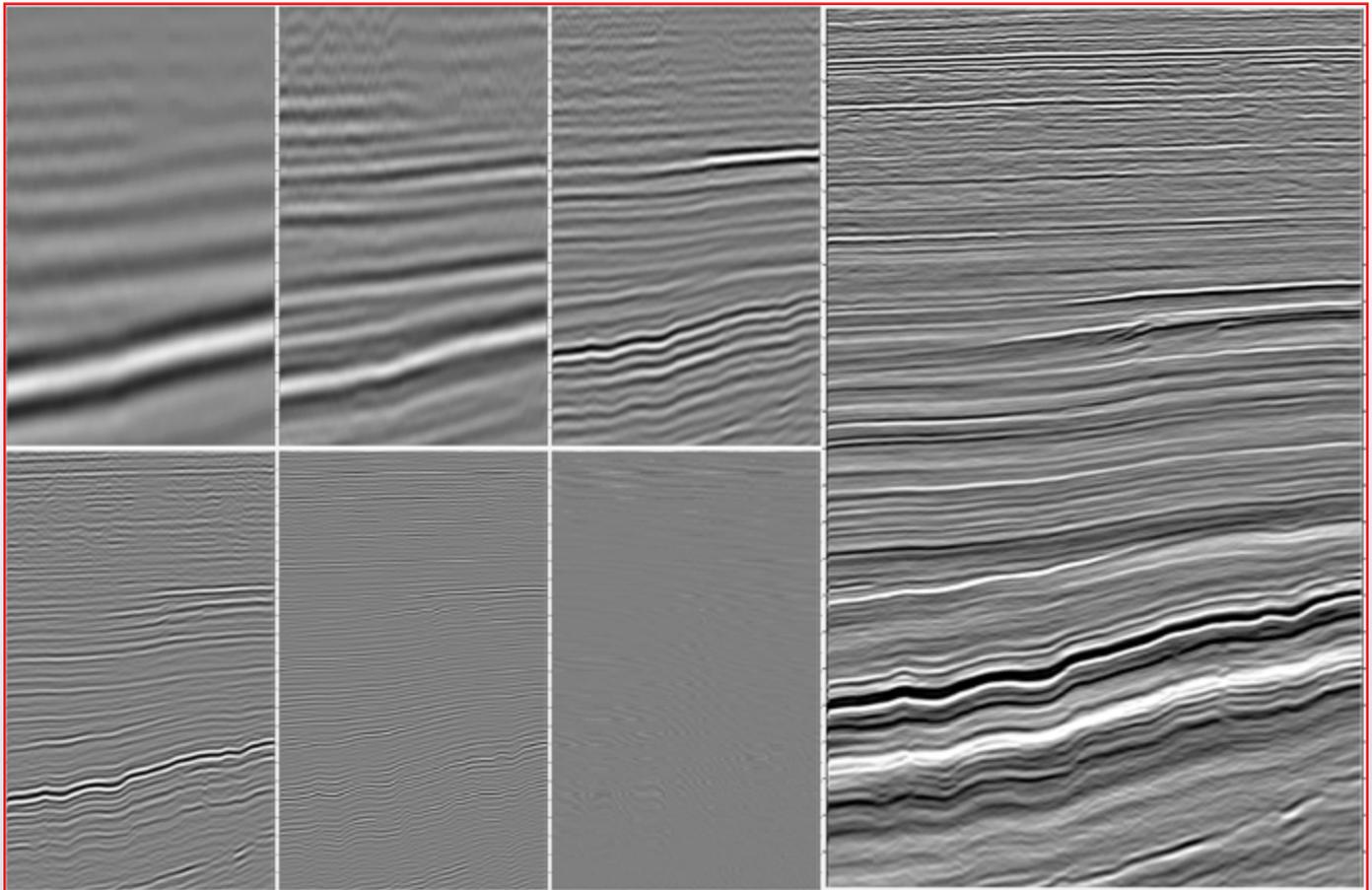


Figure 7: Filter panels showing that we successfully recovered six octaves of usable data to create a broadband dataset

as is often observed. Instead an amplitude only Q was included as part of the post migration processing sequence to temporally whiten the spectrum. When designing the decon operators, the impact of the lower frequencies on operator length should also be considered. We applied the decon operators to the pre-denoise data, then tackled the remaining noise with conventional, cascaded noise attenuation techniques. Other than careful and regular QC of the low frequencies present in the data, the rest of the pre-migration processing sequence could be considered "industry standard".

Post-migration some frequency smoothing was required on the lower octaves to remove residual noise before applying an amplitude only Q-compensation. As a final step the amplitude spectra of the data over the target zone were shaped to a spike to enhance the broadband seismic character. *Figure 6* shows the data before and after shaping, and the associated change in amplitude spectrum as a result. In total we were able to preserve six octaves in the final processed image (*Figure 7*) leading to a full, broadband dataset suitable for input to reservoir studies.

P-Impedance (post-stack) Seismic Inversion

A low frequency initial model is required for generating an absolute amplitude seismic inversion for two reasons (Russell, 1991):

- To create a geological starting model that the seismic inversion operation perturbs from.
- To provide the low frequency component to the seismic inversion that is missing from the band limited input seismic.

In this example we took advantage of the additional two octaves of low frequency energy in the seismic to replace the low frequency model and obtain an absolute amplitude seismic inversion using a pseudo inversion technique which employs the integration of the seismic trace (Hall, 2009).

The integration of the seismic trace is achieved by simply summing samples down the seismic trace. The technique is considered a pseudo inversion because the sample

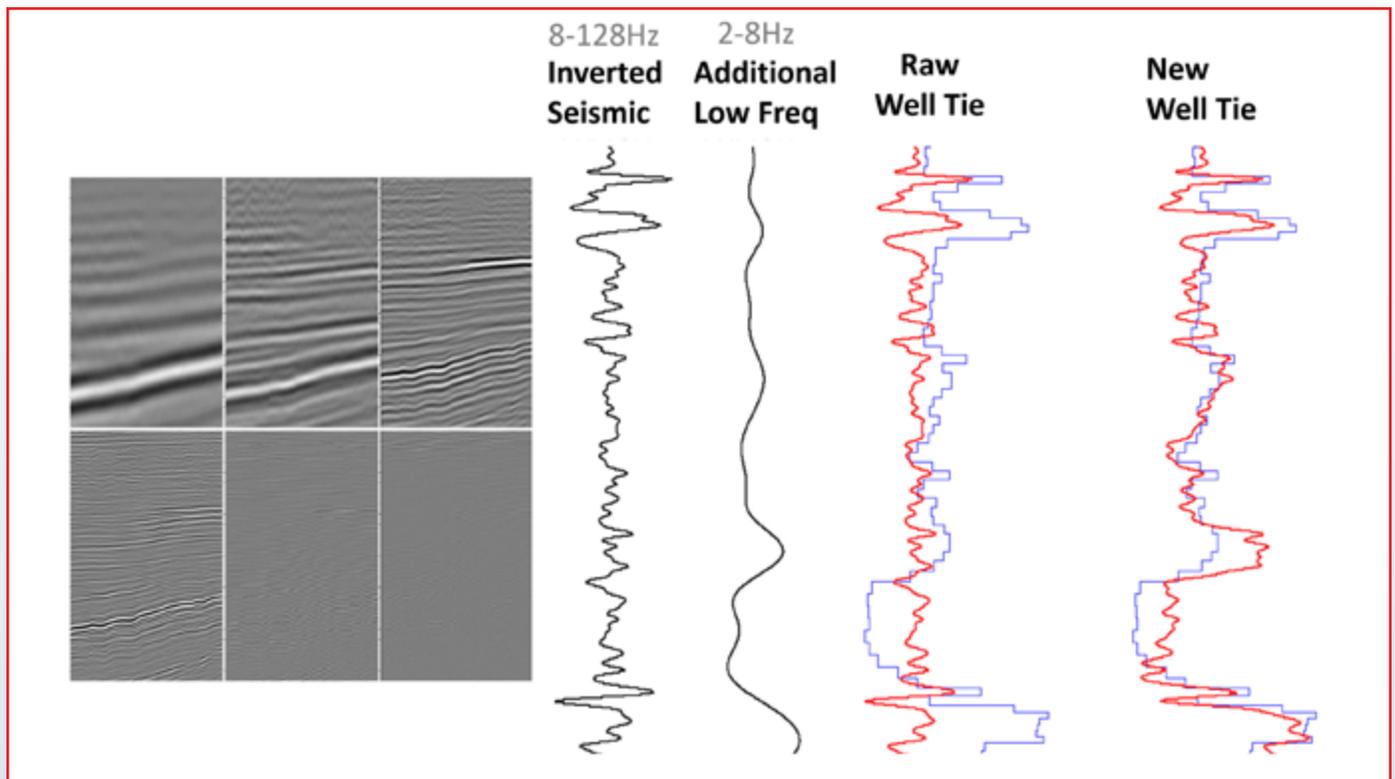


Figure 8: Track 1: Integration of the 8-128Hz seismic trace. Track 2: Integration of the 2-8Hz seismic trace. Track 3: [RED: Linear transform targeting P-impedance using Track 1 only] [BLUE: Blocked P-impedance log] Track 4: [RED: Multi-attribute linear transform targeting P-impedance using both Track 1 and Track 2] [BLUE: Blocked P-impedance log]

values derived directly from the seismic data are not true impedance and the resulting inversion is implicitly bandlimited to the input seismic.

To convert our pseudo inversion to an absolute amplitude P impedance inversion we used a multi-attribute linear transformation (Hampson, 2001). *Figure 8* shows our prediction of P impedance purely based on the integrated seismic trace. We split the broadband seismic into two frequency ranges: (i) 2-8 Hz and (ii) 8-128 Hz to demonstrate the benefit the additional two octaves of information bring to the inversion. Each frequency band was then integrated separately and the results are shown in *Figure 8*. This shows how the superposition of the low frequency trend with the high frequency information is able to match the well's P-impedance after scaling the pseudo impedance values using multi-attribute linear prediction. Therefore employing low frequencies have a better prediction of P impedance (*track 4*) compared to a standard (non-broadband) seismic data set (*track 3*). In addition this seismic inversion (*track 4*) does not include a low frequency initial model and is purely based on the seismic.

Conclusions

Through tuning survey geometry and parameters the project was acquired on-time and under budget, minimizing exposure to further weather events and minimizing the time equipment was deployed. We were able to successfully acquire, process and image a broadband dataset; the low frequency component of the dataset allowing the prediction of P-impedance without the need for a prior model.

Acknowledgements

The authors would like to thank their colleagues at Apache Corporation for permission to publish and present this case-history, and contractors McDonald Land Services, Pathfinder, Verif-I Ltd, EPI, and Geokinetics USA for each of their parts in making this project a success.

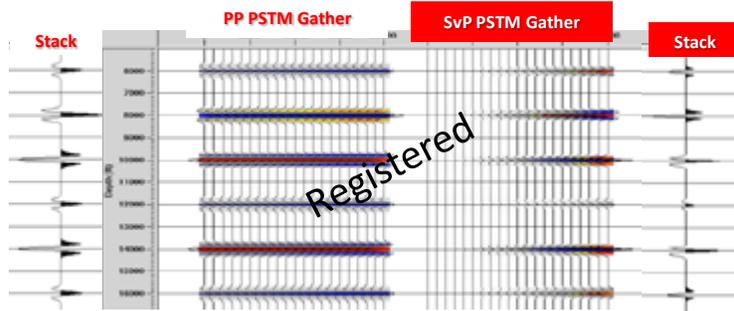
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GSH Morals Squad Reveals Guru Implicated in Markov Chain Migration Scandal

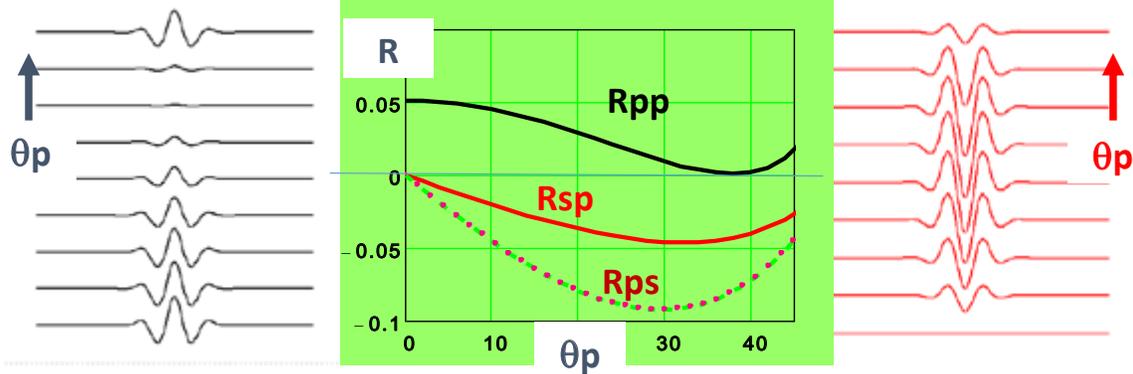
Details and angry denials at 10. But first let's return to our current studies and some exciting innovative, and disruptive applications of the **Sv-P waves** that are lurking in your **regular data** as we speak (just a friendly reminder that the Sv-P wave, like the Moon, is FREE!).

Now that we have the **PP** and **SvP** waves **registered in depth** (convertible to time using **Vp**, if desirable), we can proceed with an **AVO** analysis (with all anisotropic principles honored in case the Anisotropic Division of the Morals Squad is watching).



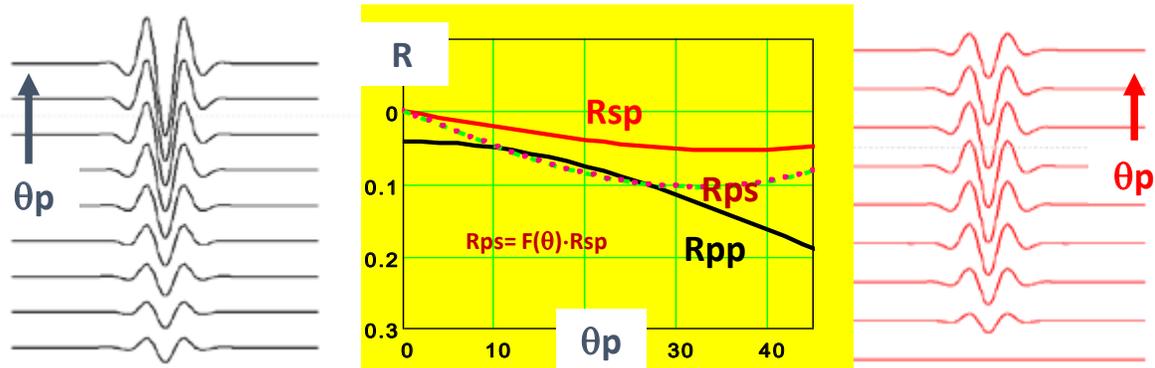
The Brine SS R_{pp} has a mild gradient and $R_{pp} \geq 0$

Shale: $\alpha_1 = 8443$ $\beta_1 = 3714$ $\rho_1 = 2.38$ $\sigma_1 = 0.38$
Brine SS: $\alpha_2 = 10070$ $\beta_2 = 5286$ $\rho_2 = 2.21$ $\sigma_2 = 0.31$



The Gas SS $R_{pp} \leq 0$ with negative gradient. The R_{sp} remains about constant since μ is unaffected by gas.

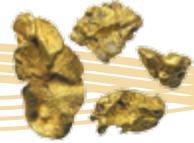
Shale: $\alpha_1 = 8443$ $\beta_1 = 3714$ $\rho_1 = 2.38$ $\sigma_1 = 0.38$
Gas SS: $\alpha_2 = 8884$ $\beta_2 = 5496$ $\rho_2 = 2.08$ $\sigma_2 = 0.19$



Tutorial Nuggets continued on page 22.

Tutorial Nuggets

Tutorial Nuggets continued from page 21.



The December-January Nugget Puzzle

This month's puzzle was designed to be an extension of December's in which we investigated a common error in estimating average velocity.

$$V_{ave}(T_N) = \frac{\sum_{k=1}^{k=N} V_k * \Delta t_K}{\sum_{k=1}^{k=N} \Delta t_K} = \frac{Z_N}{T_N}$$

We were forced to recall that **Vave**(T_N), the average velocity to a time T_N or depth Z_N was given by Z_N / T_N , which may be regarded as a weighted average in which each component

velocity, V_k , is weighted by the time spent at it, ΔT_k . The product is really the thickness in each layer, $\Delta Z_k = V_k \cdot \Delta T_k$, which sums to Z_N .

The increasingly bored reader was then asked to define a thing called **Vrms** and, more importantly, give us a reason for its existence (if any). The **Vrms** (in its squared form) is defined by the equation above. As you can plainly see, it, like the **Vave**, is a weighted average of the squared interval velocities, $V^2 K$. The weighted product could also be viewed as the V_k weighted by the thickness, ΔZ_k , of the K th layer:

$$Vrms^2(T_N) = \frac{\sum_{k=1}^{k=N} V_k^2 * \Delta T_K}{\sum_{k=1}^{k=N} \Delta T_K}$$

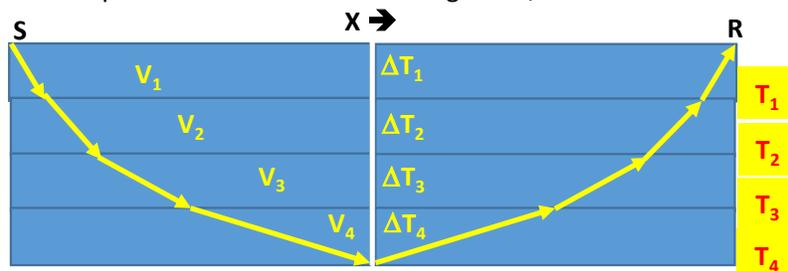
$$V_k^2 \cdot \Delta T_k = V_k \cdot (V_k \cdot \Delta T_k) = V_k \cdot Z_k$$

Our table from December has now been augmented to include **Vrms**(T_N), the square root of **Vrms**²(T_N). OK, so what's the point of having this strange animal in the mix?

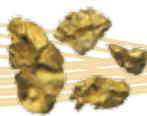
ΔZ	Vint	ΔT	T	Z	Vave(Z)	Vrms(T)
1000 ft	2000 ft/s	1.000 s	1.000 s	1000 ft	2000 ft/s	2000 ft/s
1000 ft	3000 ft/s	0.667 s	1.667 s	2000 ft	2400 ft/s	2449 ft/s
1000 ft	4000 ft/s	0.500 s	2.167 s	3000 ft	2769 ft/s	2882 ft/s
1000 ft	6000 ft/s	0.333 s	2.500 s	4000 ft	3200 ft/s	3464 ft/s

Well, it turns out that like so many things in the geophysical world, **Vrms** happens. In its case, there are two prominent instances: **NMO** description and Pre-Stack Time Migration, **PSTM**. Both can be understood, in a vague mystical way, from a casual study of the ray diagram at the right.

If only the earth were made of One Homogeneous Layer, with but one velocity, V , then it would be possible to describe the ray path of reflected waves and consequent times of arrival with S-R offset distances, X , in a very simple manner:



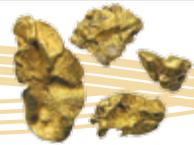
$$T_x^2 = T_0^2 + X^2/V^2$$



Tutorial Nuggets continued on page 23.

Tutorial Nuggets

Tutorial Nuggets continued from page 22.



This equation is the long-treasured description of the **NMO** curve as a **hyperbola**. But wait a minute, there are some problems here.



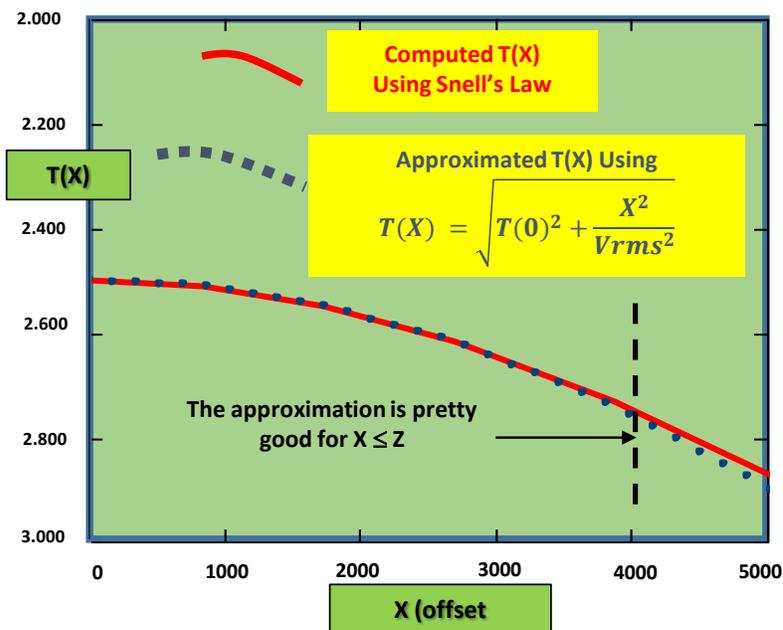
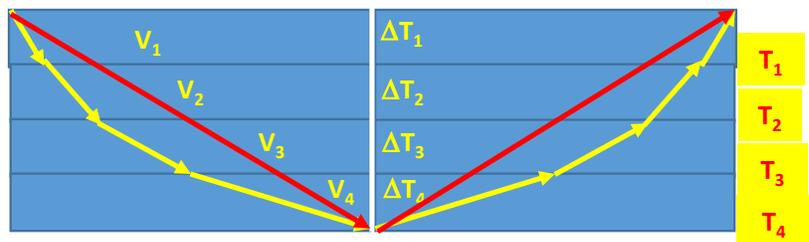
In the real world there are lots of layers with different velocities!

Yes, and that means Sam Snell gets in the act!

These are astute observations, Junior Geophysicists. Further more, nobody gives us the layer velocities, V_k , or the angles from which we may compute, using Snell's Law, ray lengths and consequent times. The hyperbolic equation, so nifty for describing time as a function of offset and known velocity, has dissolved into a fantasy miasma. Or has it? Geophysicists are a tenacious bunch, and will use simple equations when ever possible (or impossible).

Thanks to **Tury Taner** and his cohorts (including serious series people like Brook Taylor), it was demonstrated that the trusted hyperbolic equation approximates the NMO times very closely where offset is less than depth at T_0 by cutting off the infinite Taylor series to a couple of terms (major saving in writing time), Tury was able to express the travel time curve to a close approximation with the hyperbolic expression:

$$T(X) = \sqrt{T(0)^2 + \frac{X^2}{V_{rms}^2}}$$



The trick, as you have probably noticed, is the use of **V_{rms}** at **$T(0)$** . The use of a single velocity implies that we have replaced all the bending and individual V_k with a single straight path (the red lines in the ray diagram above). The velocity along this path is **$V_{rms}(T_0)$** . It yields times very close to the real times along the bent rays.

The diagram at the left shows the computed vs the approximated hyperbolic fit.

A lingering question: Where did we get **$V_{rms}(T_0)$** ?

HAPPY NEW YEAR! NEW MATERIAL AND DERANGED PUZZLES IN 2017



GSH Outreach

Committee Activities - By Lisa Buckner and David Tett

We participated in two events in celebration of Earth Science Week (ESW) which is sponsored by the American Geological Institute and its Member Societies (including SEG) on behalf of the geosciences community. It is celebrated annually during the second week of October and the 2016 theme was "Our Shared Geoheritage".

Saturday, October 8 was the 13th Annual Earth Science Week Celebration at the Houston Museum of Natural Science organized by our friends & colleagues, the Houston Geological Society. The festival consisted of volunteer demonstration stations with 8 hands-on activities. The GSH hosted a hands-on activities exhibit booth. It included the geophone and laptop oscilloscope emulation, our Ocean Drilling Activity and the animated shot diagram. We gave away approximately 200 GSH logo plastic coiled toy springs. A huge "Thank You" goes out to our tireless volunteers: Whitney Blanchard, Luan Nguyen, Laura Carter and Stephanie Nwoko.



Laura Carter and Whitney Blanchard

360 GSH logo plastic coiled toy springs. A huge "Thank You" goes out to our volunteers: James Colwell, Stephen Adeniran and Chinaemerem Kanu.



James Colwell and Chinaemerem Kanu

Saturday, October 15 was the 6th annual Consumer Energy Alliance "Energy Day". This family-friendly free downtown festival was held in partnership with the City of Houston in Sam Houston Park. It is intended to educate K-12 students and the general public about all forms of energy. An estimated 22,000 people attended and were educated by 50+ interactive exhibits highlighting a wide range of energy sources and technologies that help shape our everyday lives and the Houston economy. Please visit the Energy Day website at <http://energydayfestival.org/> for more information. The GSH had a tented booth with the Ocean Drilling Activity, an ION interpreted Gulf of Mexico section, P & S wave motion demo using a large colorful coiled toy spring and the animated shot diagram. We gave away approximately



Laura Carter

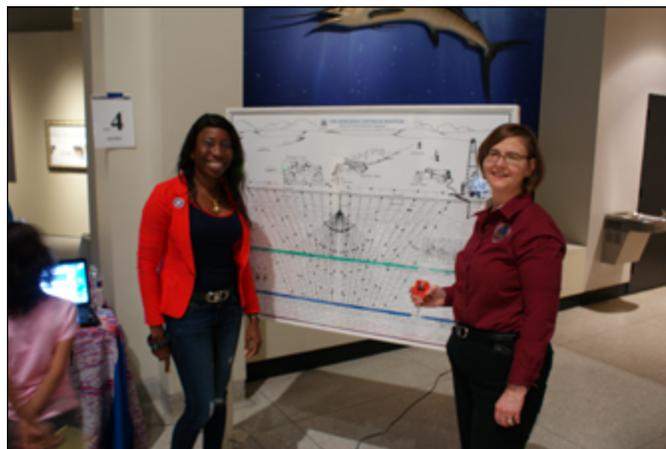
GSH Outreach continued on page 25.



Luan Nguyen explains a geophone

an "Earth is Calling ... Will You Answer?" brochure, and a list of geoscience websites.

The high school students were especially inquisitive about geoscience and the oil and gas industry; though our efforts, some students may have been convinced to consider a course of study in geoscience, and everyone came away knowing more about the search for oil and gas. The most memorable element of the Expo was the drone flying around the atrium of the HCC building, operated by the Texas Society of Professional Surveyors. Among the other exhibitors and presenters were the Society of Petroleum Engineers, Schlumberger, CITGO, Occidental Petroleum, Dow Chemical, PBK Architects, Johnson Controls, Skanska



Stephanie Nwoko and Lisa Buckner

USA, Memorial Hermann, KPRC meteorologists, City of Houston Public Works, and about 15 Texas universities. Hats off to the HCC staff, who did a great job of organizing this event.

Volunteers are needed. If you are interested in educating teachers, children or the general public about geoscience, please visit our [Outreach](#) webpage for a list of upcoming events from which you can choose and instructions for how to get involved. There are several events in January & February.

Come play with us and help inspire the next generation of geoscientists!.

Mystery Item

This is a geophysical item...



Do you know what it is?

This month's answer on page 39.

Earth Science Day

University of Houston SEG Wavelets Teach Community About Geophysics

By Walter Reed



Graduate Students from the University of Houston posing during the Earth Science Day with the GPR system. Image was created with LIDAR demonstration.

On Saturday, October 8th, at the Houston Museum of Natural Science, the University of Houston's Society of Exploration Geophysicist chapter, the SEG Wavelets, had the opportunity to help demonstrate several geophysical techniques during the annual Earth Science Week. This annual event has been celebrated every year across the country since 1998 when the American Geosciences Institute first organized the event. The theme for this year's event centered on "Our Shared Geoheritage" which focused in on the world's natural landforms and resources that we now collectively manage and conserve as a society.

The SEG Wavelets brought along several intriguing and hands on demonstrations for the community to see. Three different demonstrations were provided including GPR, LIDAR & GPS, and a robotic geophone. Kids and families were able to use a small portable GPR unit that resembled the shape of a push mower to immediately "see" what was beneath them. A small route inside the museum was set up where individuals could see when the GPR crossed over objects such as barbwire or electrical wiring. The LIDAR & GPS were also very fascinating to kids and family as they were able to learn how lasers can be used for mapping and creating 3D images of the surrounding environment. What kid isn't fascinated with lasers?

The last demonstration probably caught the most attention due to its unique look resembling a spider or other insect. The geophone robot contained six geophones that act as the robot's legs. The robot has the ability to walk around and use each geophone to record data about incoming

seismic waves. Kids and families were able to see the recording of seismic waves that were displayed on a tablet. Viewers were shown how different waves were produced depending on where the source wave was created on the table. This was used in order to teach viewers about the concept of anisotropy and how the table is not the same throughout.

Overall the families and kids that came out had a great time learning about our Earth, ways to take care of it, and how we can better understand it. As the event ended, the graduate students from the University of Houston gathered for a professional photo from our own LIDAR. Special thanks to the Houston Geological Society for inviting us to participate in this event.



Robot geophone used to demonstrate recording of seismic waves

A Mammoth in our Midst: Using Ground Penetrating Radar (GPR) for Paleontological Prospecting

By Clark Sturdevant and Robert R. Stewart

Some ten thousand years ago and before, Texas was home to large Pleistocene megafauna including the Columbian Mammoth. (A relative of the Asian elephant) Perhaps due to climate changes at the end of the Great Ice Age or human hunting, these large mammals became extinct. However, with the recent urban development and activities on Houston's west side, there have been a host of paleontological discoveries bringing, at least, the bones back to light. Along a quiet tributary of Cypress Creek in Harris County, one such site has been known through local lore for some years. Previous discoveries at the location (Figure 1) include a partially intact Columbian Mammoth (Molly) as well as hundreds of teeth and scattered remains of a wide variety of Pleistocene fauna including a crocodylian, a large turtle, and two species of horse, bison, Mammuthus, Cuvieronius, Eremotherium, Camelops, and Paleolama¹.



Figure 1: Excavation site, near a bend in Cypress Creek, of the Columbian Mammoth "Molly".

Recently, a volunteer team including geoscientists from the University of Houston (Figure 2) and the University of Texas began renewed excavations at the site. As excavations began, the team observed two separate fossil rich zones. Ground penetrating radar (GPR) surveys were undertaken to better understand the geologic context for the site as well as performing a non-invasive analysis of the prospect in the immediate vicinity for further fossil material.

A survey grid 2.5 m x 7 m was laid out beside an active excavation. A 250 MHz PulseEKKO system was employed

to complete the initial survey at a line spacing of X=25 cm and Y=50 cm (Figure 3). The same survey was then conducted again using a PulseEKKO 1 GHz system with spacing of x=10 cm and y=10 cm. The data were processed using EKKO Mapper and EKKO View Deluxe software packages. Three-D volumes were produced and sliced at 12.5 cm depth intervals. We found that the 1 GHz system did not have sufficient penetration under the conditions present at the site; however, the 250 MHz data were quite good.

Once the GPR surveys were completed, a 1.5 m x 1 m section of the survey site was excavated in 12.5 cm vertical slices to provide "ground truth" to the 3D volume and



Figure 2: Surveying team members from the University of Houston with the 250 MHz GPR system.

U of H AGL continued on page 28.



Figure 3: UH survey team collects data at the excavation site.

depth slices. A prominent sand over clay interface was found which compared convincingly to a strong reflection in the 3D volume (Figure 4). This increased our confidence in the processing, modeling, and interpretation of the GPR data. The topography of the excavated clay interface was found to fit very closely with the reflector noted above in the .275 m depth slice.

Upon excavation (guided by the GPR data) of the survey area, the marked reflector located at $x=2.75$ m and $y=0.6$ m indicated an anomaly (just over 1 m beneath the surface) which led to the discovery of a large (~12ft), intact mammoth tusk. We are very excited about the mammoth excavation and the role that GPR had in its discovery and delineation. Future plans for the project include surveys along the creek to continue site development and targeted excavations.

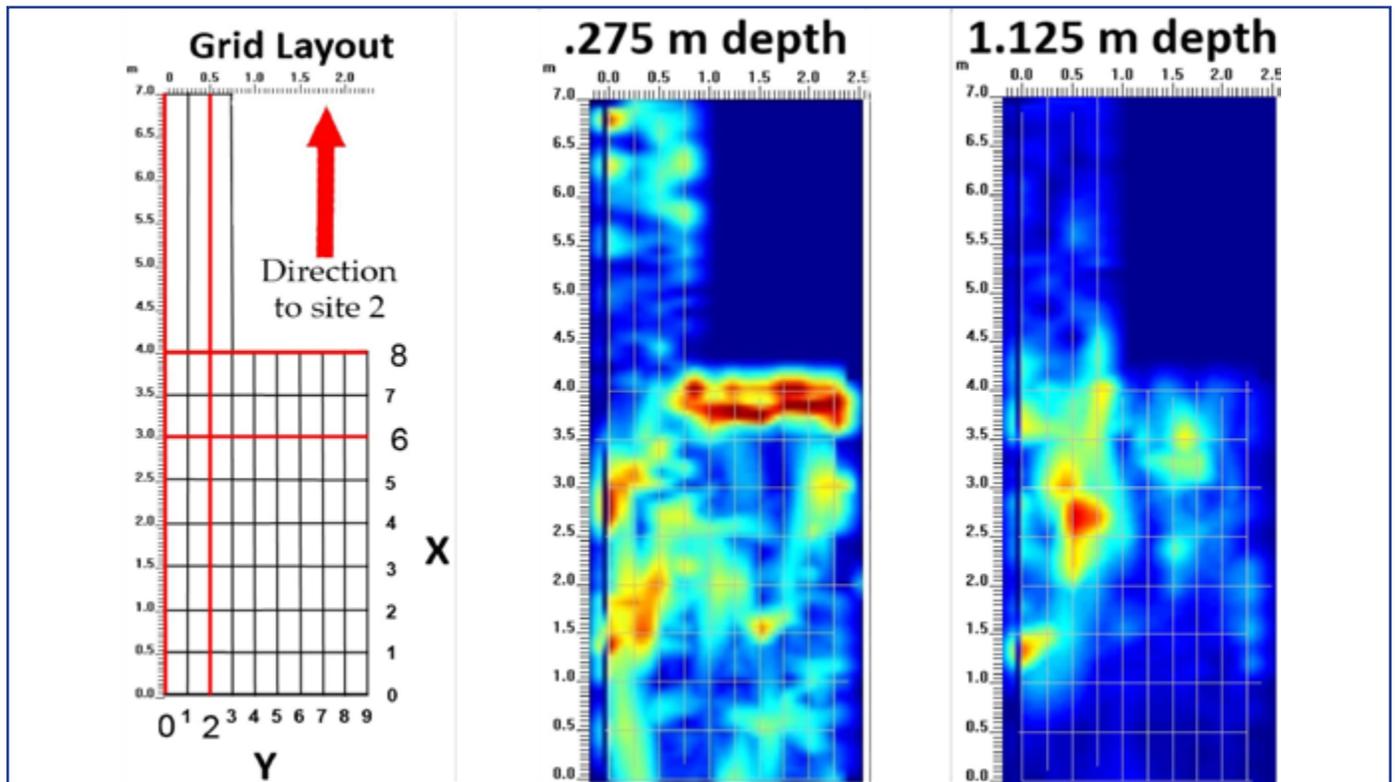


Figure 4: GPR grid layout (left). A depth slice (middle) at 0.275 m is interpreted as showing a strong sand/clay interface. The depth slice at 1.125 m reveals a strong anomaly that led to the discovery of a second mammoth tusk.

¹Lundelius, Jr., et al., 2013, *The first occurrence of a toxodont (Mammalia, Notoungulata) in the United States*, *Journal of Vertebrate Paleontology* 33(1):229–232.

GSH Members Honored by SEG

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GSH Jan 2017
Christine Krohn
Lifetime Achievement

Christine Krohn is awarded Life Membership in honor of her many years of service on the SEG Research Committee and for being a thoughtful and energetic force on the SEG Board of Directors for three years.

By Partha Routh

Christine (Chris) Krohn obtained her BS in physics from Emory University and PhD in experimental solidstate physics from the University of Texas at Austin as a National Science Foundation Fellow. Soon after graduate school, she transitioned from experimental physics to geophysics, and joined ExxonMobil Upstream Research Company (formerly Exxon Production Research) in 1979, where she carried out many assignments until her retirement in 2016.

Chris is a recognized expert in multiple geophysical methods with significant contribution in the area of seismic acquisition and design. It is most appropriate for SEG to recognize Chris with Life Membership for

Christine Krohn continued on page 30.



GSH Jan 2017
Edith J. Miller
Lifetime Achievement

Edith Miller exhibited great leadership, judgment, and dedication during her three years on the SEG Board of Directors. She is a deserving recipient of Life Membership.

By Maria Angella Capello, Eva Sprunt, and Don Steeples

Edith van Veldhuizen Miller is a wonderful role model for how a young member can have a large impact on SEG in the first 10 years of a career. Edith received a master's degree in applied physics in 2002, and a PhD cum laude in geophysics in 2006 from Delft University of Technology (as Edith van Veldhuizen), where she was a member of the Delphi consortium. She has been published in GEOPHYSICS and presented numerous papers at SEG and EAGE conventions. She joined SEG as a student in 2002 when she began her geophysical studies.

She has 10 years of industry experience and has worked on oil and gas assets worldwide, including deepwater

Edith J. Miller continued on page 30.

GSH / SEG Awards 2016

Jim Gaiser (Emeritus) - SEG Distinguished Instructor 2016
Joe Dellinger (Active) - SEG Distinguished Instructor Spring 2016

Edith Miller (Active) - SEG Life membership
Christine Krohn (Honorary) - SEG Life Membership

Giannan Wang (Student) and Rob Stewart (Honorary)

Christine Krohn from page 29.

her exceptional volunteer services and contributions to the geophysical profession. Chris has served SEG by striving to empower broad participation by all of its members. As a director at large on the SEG Board, Chris proposed a new mission statement focused, not just on the science and technology, but also on the greater geophysical community - the people of geophysics. As part of her efforts, a young professional committee was initiated and several items related to the strategic priority of "Connecting and inspiring early-career and global geophysicists" were approved. She also was instrumental in forming the new Continuing Innovation Portfolio (CIP) Committee with the mission of ranking a portfolio of competing proposed new SEG programs and making recommendations to the Board during budgeting and planning.

She continues to significantly support workshop activities and the SEG Global Events Operations Department, where she helped to develop a set of guidelines for workshop organization committees that will facilitate workshop organization by more groups, from more places, and for broader audiences. Previous to her election to the SEG Board, Chris served as chair and vice chair of the SEG Research Committee. During her two-year tenure as chair, the Research Committee organized six summer research workshops and 20 post-convention workshops, recruited students, and started new initiatives such as hot topics identification and interest groups. She herself has organized more than three summer research workshops including one in Turkey and more than five post-convention workshops, including the first one organized by and for the students.

As chair of the SEG Research Committee, she led it to involve more students, refocus workshops, and develop new initiatives and interest groups. Chris also has made extensive technical contributions in a number of different areas. She is a recognized expert in acquisition (simultaneous sourcing, vibroseis, and geophone ground coupling), near-surface geophysics (surface waves, first-arrival tomography), borehole geophysics (cross well, 3D VSP), and rock physics. Her more than 35-year geophysics career at ExxonMobil is reflected in more than 16 journal articles, 25 convention presentations, and 18 patent applications. It is inspiring to see that Chris' volunteerism to professional societies is now recognized by her well-deserved SEG Life Membership Award.

Edith J. Miller from page 29.

Gulf of Mexico and the Australian North West Shelf. Her areas of expertise include seismic processing and imaging, seismic acquisition technologies (offshore and onshore), and earth modeling. She has worked for Chevron since 2006 in exploration, R&D, and technical services roles in the United States and

Australia. Currently, she works in Houston as a project manager and specialist in seismic-imaging technology deployment.

Right at the beginning of her career, Edith began taking on leadership roles in SEG. From 2006 to 2012, she was a special editor on the GEOPHYSICS Editorial Board; from 2007 to 2011, she was a peer reviewer of technical papers for GEOPHYSICS; and from 2008 to 2013, she was a peer reviewer of conference abstracts for the SEG Annual Meeting.

With a passion for membership matters and strengthening the inclusiveness of the SEG community, the scope of Edith's engagement soon expanded. She served as chair of the Continuing Education Committee from 2010 to 2012. In 2010, Edith served on Women's Network Task Force and became a founding member of the Women's Network Committee (WNC) when it was created in 2011, including serving as the committee's board liaison after she was elected to the SEG Board of Directors. She led the WNC initiative to create the Outstanding Educator's Award, authoring the successful proposal.

Tom Agnew, SEG associate executive director, programs, shared his experience of working with Edith. "I cannot say enough good things Edith. Not only was she a strong leader, but she was a pleasure to work with. I know she made my job more fun, but she also blended new ideas in to the committee while at the same time respecting members who had served for many years."

In particular, Tom shared that in her two years as chair of the Continuing Education Committee beginning in 2010, "Edith was able to infuse the committee with a richer diversity of members, including early career. At the same time, she worked with seasoned professionals to streamline SEG procedures for course selection and other issues, bringing in new courses to the SEG curriculum that helped SEG set attendance records for the Society at continuing education events. Edith handled all of her duties with professionalism and tenaciousness, helping create an excitement about the professional development of SEG members."

As a member of the SEG Board of Directors from 2012-2015, Edith took on some of the most demanding and time-consuming roles. She served for three years on the Audit Committee, including as the chair.

Although Edith is only 10 years into her career, there isn't room to list all of her service to SEG. She continues as a member of both the Bylaws and Membership Committees. Also, Edith is the 2016-2017 Treasurer on the Geophysical Society of Houston (GSH) Board of Directors. As a shining young superstar, Edith is an incredible example of how someone can have a big impact early in her career.

Geoscience Center News

By Bill Gafford

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

Would you like to learn more about some of our mystery items, or about how some of the early exploration instruments worked, or what some prospect maps looked like in the 1920's? Then come visit the Geoscience Center on a Wednesday morning. We need some new volunteers to help with some of our projects, and visitors are always welcome too and we seem to always have some new "old" items for discussion. A picture from our November Living Legends Doodlebugger social event is shown below where some stories are being told and some current events are being discussed. The next such event will be on February 9, 2017.



Our collection of company hats has expanded thanks to a donation of an interesting collection from Gary Crews. Although there are some duplicates, most of the hats are new to our collection, and some have an international flavor. They are being added to our display, which is on loading poles. We also recently received some vintage photos of early exploration. These photos are helpful in identifying some of our older instruments without any identification or documentation.

We recently received a donation of a print of a very interesting painting. It is called the Panorama of



Petroleum, and the original mural was 56 feet wide and 13 feet tall, and was installed in the Smithsonian Institution Hall of Petroleum in 1967. The mural is a portrayal of the operations and equipment of the petroleum industry in 1966. Twenty six of the forty-four individuals depicted in the mural are shown in their jobs at the beginning of their careers, and they are identified at the bottom of the picture, which is shown below. The mural was painted by Delbert Jackson, who was a Staff Illustrator at Pan American Petroleum in Tulsa at the time and worked on the project for two years. In 1998, the mural was relocated to the Tulsa airport, where it can be seen today.

We had a very good response to the Dick Baile Challenge to raise funds for the continued operation of the Geoscience Center but we are still accepting donations, which can be sent to the GSH office at 14811 St. Mary's Lane, Suite 204, Houston, TX, 77079, with a note that the donation is for the Geoscience Center Challenge.

We hosted the November GSH Board of Directors meeting at the Geoscience Center and used our long tables which worked well for this kind of meeting. Your BoD is shown at work in a picture below.



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

We want to thank Dick Baile for initiating the Geoscience Center Challenge; Scott Petty, Jr. for a very generous contribution; and for all the other individuals who have supported this project.

Alchemy of Success - A GSH Women's Diversity & SEG Women's Network Committee Event

By Rita Creasy-Reed

Although we all gathered to learn more about becoming a diamond produced by this industries heat and pressure, the room had a great vibe with no pressure. With over 105 attendees from various geoscience backgrounds, people were connecting and recounting the ideas and vision shared from our speakers. Geoscience and the people in geoscience careers make a difference in the future of energy development. Be proud of what you do.

Locally

The *Local GSH Women Diversity Vision* was delivered by GSH President, Amy Rhodes.

Amy reminded us of studies that were cited in the WSJ highlighting that women CEO's are successful at handling difficult tasks and pressure and can pull companies through challenges. The alchemy of success does include intense heat that forces changes in a person, but the end result is thriving. What women have accomplished in our industry does matter and some of those women were sitting amongst us. Joining a local chapter will keep you connected to women and men that are thriving and can help our industry grow into the next phase. The work that we all do to advance our industry matters and volunteering matters too. Amy encouraged men and women to look for opportunities to serve locally or globally.

The *Local and Global SEG Women's Network Committee Vision* was delivered by Committee Chair, Maitri Erwin. Maitri's vision is to act locally, think globally. She has a passion to inspire and encourage the next generation of leaders and students in the field of geophysics. She delivered her action plan to the local audience and had recently delivered that same vision and action plan at the SEG in Dallas in October. Expanding your networks outside of our industry will help grow your understanding not only professionally, but personally as well. By networking widely and volunteering, you will find opportunities that would have gone untapped.

Globally

The *Global SEG Vision* was delivered by President-Elect, Nancy House. Nancy echoed the act locally, think globally mantra but expanded the idea to mentorship and sponsorship. A mentor talks with

you. A sponsor talks about you and shapes our next leaders.

Alchemy has four stages, and for this next generation, getting through the adapting and breakthrough phases will navigate these phases competitively and creatively if the more experienced leaders take time to invest in sponsorship. Encouraging women to become and remain geophysicists helps to drive diversity within the profession. Nancy wants to increase the voice of a growing membership demographic and convert female student members into professional SEG members. Having female early career members in volunteer and leadership roles will shape the society for the future.

Escaping the sticky middle and how to do it. Acquiring a sponsor will help women escape the sticky middle where they become your advocates for the next promotion and connects you to new career opportunities.

SEG participation benefits advancing exploration geophysics with

- * Technical excellence
- * Communication skills
- * Emotional intelligence
- * Innovative spirit
- * Futuristic vision

SO the best way to predict the future is to create it. Act locally, think globally.

Global Energy: Where Do I Turn? was delivered by Dr. Scott W. Tinker, Director of Bureau of Economic Geology.

Fossil fuel demand will continue until the introduction of more *secure* energy options are available. More secure meaning sources that are affordable, available, reliable, and environmentally sustainable. Because fossil fuels are reasonably secure, they represent 85% of the global energy mix today.

The convergence of ideas and technology has created a commercial environment in which unconventional reservoirs could supply oil and natural gas to North America for 50 years or more.

Geoscientist play an important role in the future

Alchemy of Success continued on page 33.

Alchemy of Success continued from page 32.

of energy development. With new and emerging technologies coming to the forefront, we are valuable contributors not only in shale research, but also areas including: geothermal, uranium mining, and rare earth-element mining. Input from geoscientists is also needed when researching the placement of wind turbines onshore and off-shore, as well as when studying soil science and hydrology for biofuels. Our industry, although undergoing adapting and breakthrough technologies, will continue to thrive.

A sincere thanks goes out to our sponsors for this successful event: Conoco-Phillips, Apache, SEG



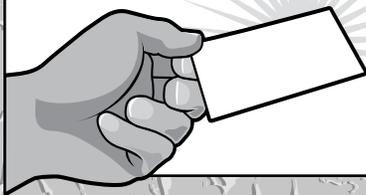
Women's Network Committee, Lori & Glenn Bear, and PGS.

Thank you to the planning committee that listened to our membership and designed a relevant program to keep us informed of the ever-evolving landscape. The planning committee members were: Sofia Campbell, Amy Rhodes, Nicola Maitland, Maitri Erwin, and Rita Creasy-Reed.

Alchemy of Success continued on page 34.







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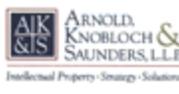
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Doodlebugger Diary

The Odyssey of a Doodlebugger

(The life and times of Ed Lengel) Part 1 of 4

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

Prologue

This obscure Tome is a recollection of my times, travels and various escapades as I can recall them. The more I write, the more I remember, so this may never be complete. Most of the people involved have passed on but we remember them in these collections of stories that are meant for the reader's amusement. The travel is not necessarily chronological but I tried to keep it in an alphanumeric order, sorted by country but trying to sort by year proved impossible.

This document is a semi-biography that is supposed to recall a group of events that make up my life. They are memoirs of my history as close as I can remember them. Unfortunately, I can't remember all the events, but as I write this, more memories come to me. I have read an article that states memories are altered every time they are recalled. I can only hope that this narrative is very close to the truth. In some cases this is a travelogue, and in others, a collection of anecdotes or just thoughts from my perspective of countries and events. Many of my visits were unremarkable with no good anecdotes. (Or none that I can remember right now) but I have written something about contacts or geography in those cases. I don't profess to be a wordsmith nor is my narrative particularly articulate or eloquent. Many recollections would be understandable to "Doodlebuggers" only because of their technical jargon. This appears to be a constant group of events but this took place over 50 years of history. It just looks like continuous ramblings and escapades of a slightly deranged person. A complete listing of countries visited is at the end of this "Chronical". It encompasses 102 countries visited, 84 countries I have done business in and 6 countries I have lived in. I have attempted to give the present country names to the old names I knew, (in brackets). Also, I have included all the companies I have worked for, several of them more than once. I was an Instrument Supervisor with Ray Geophysical (Geosource) so visiting many countries was for trouble shooting and repair only.

Unfortunately, I didn't take many pictures of my international travels, or have any from my Canadian days. I never saw a reason for pictures because I moved a lot. I tended not to have anything personal to hold me back. That, and not having any close relatives or heirs kept me from keeping much.

There is an Epilogue at the end of this chronical which explains some of what I turned out to be.

Episode 1: The Beginning

I started by working for the Dept. of Highways during the summer months. I rose to Surveyor after being a Chainman, Rodman, and Area Office Manager. I had quit University because I needed to earn money. For a while I lived on Kraft dinners which I could get by cashing in pop bottles I scrounged at 2 cents a bottle (10 bottles bought the box KD). During this period, I was an Outrider at the Chuck-Wagon races at the Calgary Stampede. I only rode one race and then quit because it scared the crap out of me. My job was to hold the leaders of the lead horses and turn them around the first barrel. This got me in as a 'Cowboy' with the "Tack Room Groupies".

I tried stock car racing in the various small towns. I worked with the Dept. of Highways. I raced a 34 Ford with a flat head V8 on a ¼ mile track with limited success. I was driving a 59 Chev convertible, pulling the stock car with a 5 foot stuffed Bugs Bunny in the front seat and my guitar in the back. This was a real "Babe Magnet" in the small towns. I was successful in dating but I got beat up a lot by local farm boys for stealing their girlfriends.

There was a mental hospital in a town called Ponoka. It had lots of women in residence. We would get a bunch of the women and go to my rented house to party. I usually had a few gallons of wine or gin brewing in the bathtub. We had a mouse in the house and it was killed with a broom by one of the guests. We held a trial in the local bar for murdering the mouse (I was the prosecutor). He was found guilty, and we hanged him (the broom) from a ceiling fan. Apparently the rope was a little tight and he spent a few seconds dangling!

Later, I left the bar and was so drunk that I was driving down the sidewalk by the pool hall when the RCMP came beside me and told me to stop. I bailed out of the car with two cases of beer not realizing I was doing about 30 mph. My car continued on and hit a telephone pole. I woke up in jail. The bar got a group together and made my bail. Thank God drunk driving etc. was not a serious crime back then. I got out with a warning and a \$79.00 fine. My car (a 57 Meteor) needed repair at a body shop.

Doodlebugger continued on page 39.

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

As I travelled from town to town, I finally realized "I had better grow up" hence my transition to oil exploration. Growing up didn't seem to be important at the age of twenty. I got married and inherited a delightful step daughter, which I treated as my own. My wife died a year after the wedding. During my marriage, and afterwards, I worked at Pan American Oil as a Playback Operator (Computer Operator), then went to a university for 3 hours, and then drove a taxi cab for a 4 hour shift. A very busy, tough time.

After my wife died, I decided I had enough of selfish people and their tendencies of interfering with me and my step daughter's lives. I searched within the Oil Industry and found that Oil Field Exploration, or "Doodle Bugging" was just what I wanted. After a few years in Canada and the Arctic, the world beckoned. I heeded the call, and went on to an interesting life. I have had "A Good Kick at the Cat" as they say when describing the account of one's life.

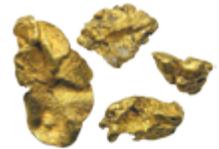
Mystery Item

The Mystery Item for the January GSHJ is a single trace camera used for seismic refraction work in 1929.

Mystery Item on page 25.

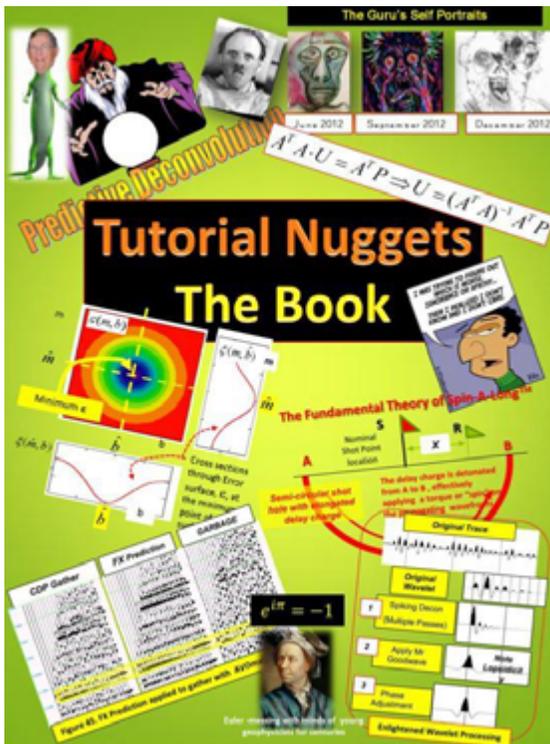


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