

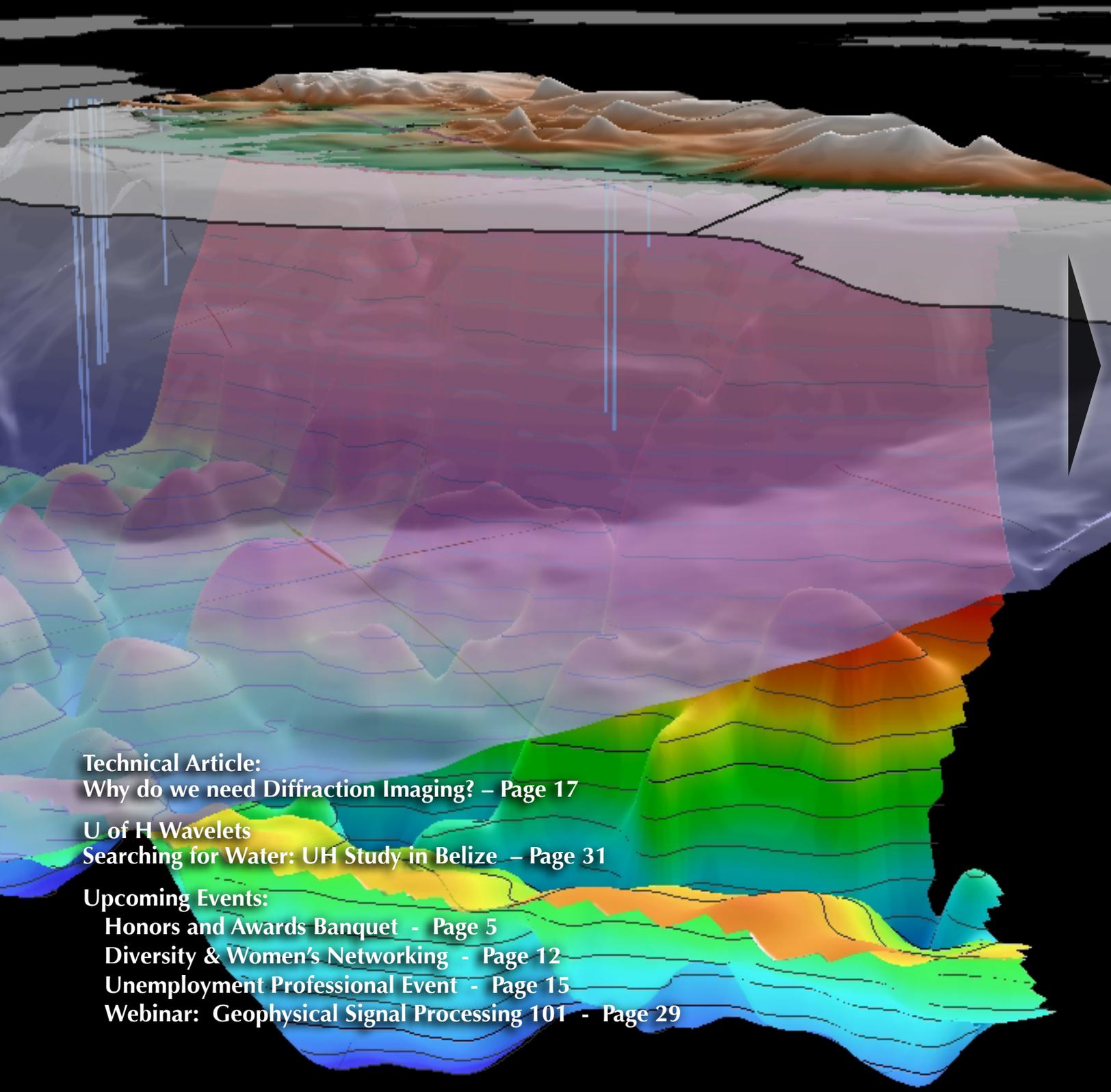
May 2017



*The Epicenter of
Geophysical Excellence*

GSH Journal

GEOPHYSICAL SOCIETY OF HOUSTON
Volume 7 • Number 9



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Why do we need Diffraction Imaging? – Page 17

U of H Wavelets
Searching for Water: UH Study in Belize – Page 31

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Potential fields modeling to constrain sediment thickness and basin architecture by mapping the depth of basement.

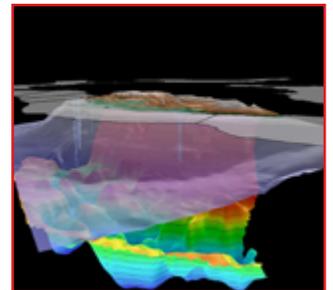


Image courtesy of CGG Multi-Physics.

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

Sept 2017	Jul 7
Oct 2017	Aug 9
Nov 2017	Sept 8

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Social at TopGolf - North	TBD		
Social at TopGolf - West	Duane Pankhurst	713-864-7700	713-444-7177
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Annual Meeting & Awards Banquet	Katherine Pittman	713-972-6206	
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A Word from the Board

GSH: A Solid Home

By Edith Miller, 2nd VP Elect

It is May and that means the GSH year is drawing to an end. We have elected new Board members, we have a few final events to look forward to and we are looking back on the year at the annual GSH Honors and Awards Banquet. We will also be closing the financial books by the end of June. I have had the pleasure to serve as your Treasurer this year, and quite a year it has been. A year of hope for a steady recovery of Oil & Gas and on the financial front, a year of budgets. In times of uncertainty, having a realistic budget is an important tool to avoid surprises and plan ahead. I am sure that many of you, just as I, have found yourselves involved in more detailed financial forecasting and planning in recent times than in oil boom times. And so it was for the GSH in response to our shifting environment. Uncertain times call for certain measures.

It may be easier to serve on a Board in a time of plenty, but it might be even more rewarding to successfully deal with a challenging environment. This year, the Board as a team, with GSH volunteers and staff, ensured that the GSH will continue to steadfastly fulfill its mission to promote the science and profession of geophysics and to foster fellowship and cooperation among all persons interested in geophysics. At the start of the year, all Board members did their part in the financial forecasting that informed the decisions necessary to maintain a healthy balance sheet and continue to serve you our members with excellence.

How, do you ask, can the GSH maintain financial health to serve its members well through oil lean times? The short answer is by the very hard work of volunteers and staff. More specifically, by managing our finances through ups and downs, not overspending in times of plenty, and keeping overhead limited so that we can adjust to a changing environment. Key to making this happen is volunteer work. We are a local society, which compared to global organizations such as SEG, AAPG and SPE is small enough to have a small staff, but we

are such an active local society that there is a lot of work to be done by volunteers. If you are an avid reader of this Journal you will realize how much work the volunteers do in terms of planning and running events, supporting the office, and many other activities, including the work involved in creating this Journal itself.



Edith Miller

The GSH forms a strong community of loyal members and contributors. We pursue sharing and promoting science and technology as well as camaraderie regardless of the oil price. As such we will always be hosting great technical and social events, again thanks to all the hard work of the volunteers and staff and thanks to your participation. The advantage of a local society is the opportunity to get together with fellow geophysics practitioners and enthusiasts, in good times as well as more challenging times. We do our best to adapt to our community's needs. In addition to all our classic events, you will have noticed several Diversity & Women's events throughout the year (everyone welcome!) as well as a Career Development Event for Unemployed Professionals which was hosted in January. And I believe we held a record number of Webinars this year, providing a convenient high-quality learning experience and expanding our Society's reach beyond the Houston metro area.

Our budget process served us well this year to help the GSH plan and adjust where needed and I remain optimistic about the years ahead. I do not have as long a history with the GSH as many of the other volunteers and members, but it has quickly become a home and it will remain one of my homes even when I may move to other corners of the world. Membership renewal is coming up; make the GSH one of your homes again, your home for local geophysics and beyond, and join your fellow GSH members at our 2017-2018 events.



Editor,

This is my first ever letter to the Editor. I am an Emeritus Member of the Geophysical Society of Houston. I have spent fifty-three years in the seismic business. I have semi-retired and now reside in East Texas.

I don't understand why I haven't been receiving my Journal. I sometimes don't get around to reading the Journal but it has been several months since I have received one. This is a very poor way to run an organization.

I would greatly appreciate if you would send me the missing copies. I have gone through my files and I believe the last one I received was in June, 2016.

Thanks,

Gorge Goshenheimer
Route 21, Box 14k
Thicket, Texas

Dear Mr. Goshenheimer,

Thank you for your inquiry. Because of the temporary downturn of the industry, it was decided to temporarily discontinue printing the Journal to be fiscally responsible due to the printed version and distribution costs. It is still available online at the GSH Website. (<http://www.gshtx.org>). The last printed copy was Sept 2016 as we always skip July and August. You seem to have missed five Journal issues. They are all available to you online. They are presented in pdf format for ease of handling. Thank you for your interest and your long service.

If you have other questions or concerns, don't hesitate contacting us. We can be reached at Office@gshtx.org.

Editor



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

Please join us as we honor our colleagues,
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



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

TECH BREAKFASTS

Revealing Overburden and Reservoir Complexity with High-Resolution FWI

		Speaker(s): Rongrong Lu, ExxonMobil Upstream Research Company
May 2, 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
May 10, 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

DATA PROCESSING & ACQUISITION SIG

Assessing Marine 3D Seismic Acquisition with Triple Source and Deep Tow Streamers

		Speaker(s): Speaker: Peter Aaron; Apache Corporation Co-authors: Grant Byerley and David Monk; Apache Corporation
May 9, 2017	4:30 PM to 6:00 PM	Sponsored by Schlumberger
		Location: Schlumberger, Q-Auditorium 10001 Richmond Avenue Houston, TX 77042

TECH LUNCHEONS

Wolfspar®, an “FWI-friendly” Ultra-low-frequency Marine Seismic Source

		Speaker(s): Joe Dellinger, BP America
May 16, 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.)
May 17, 2017	11:00 AM to 1:00 PM	
Downtown Luncheon		Location: Petroleum Club of Houston 1201 Louisiana, 35th Houston, TX 77004 (Valet parking onsite.)
May 18, 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)

POTENTIAL FIELDS SIG

Joint Inversion of Geophysical and Geologic Data Using Cross-gradient Analysis

May 18, 2017		Speaker(s): David Schwartz, Multi-Physics Imaging, CGG
	5:30 PM - 8:00 PM	
		Location: HESS Club (Houston Engr. & Science Society) 5430 Westheimer Houston, TX 77056

Technical Luncheons

Wolfspar®, an “FWI-friendly” Ultra-low-frequency Marine Seismic Source

Register
for Tech Lunch
Westside

Register
for Tech Lunch
Downtown

Register
for Tech Lunch
Northside

Speaker(s): Joe Dellinger, BP America

Westside

Tuesday, May 16, 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, May 17, 2017

11:00 a.m. – 1:00 p.m.

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

Abstract:

Over the past decade, BP designed, built, and field tested Wolfspar®, a full-scale, ultra-low-frequency seismic source capable of producing frequencies of 1.4 – 8 Hz. This was quite an ambitious project to undertake, and was the culmination of years of thinking differently about the challenge of seismic imaging in deep water under complex salt.

First, we realized that our wide-azimuth seismic data have become good enough that they are no longer the primary impediment to imaging under complex salt. The limiting factor is now our velocity models. Our “Garden Banks” model study showed that in areas of complex salt, our velocity models likely include “interpretation busts”, where cubic kilometers of the velocity model may have salt where there should be sediment, or vice versa. These mistakes are very hard to identify and fix using any form of manual interpretation --- if that strategy worked, the problem would have been solved by now. Model studies showed that FWI can fix these problems, but requires seismic data with ultra-low frequencies (below 2 Hz) recorded at wide offsets (20-30 km) to do so. The problem then becomes, how can we get the required data at a reasonable cost? How do we design an entirely new acquisition strategy around velocity-model-building using FWI?

Northside

Sponsored by
Southwestern Energy

Thursday, May 18, 2017

11:00 a.m. – 1:00 p.m.

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



Joe Dellinger

Acquiring frequencies below 2 Hz at wide offsets introduces a whole new set of challenges. Marine seismic sources naturally roll off at low frequencies at about 18 dB / Octave, and below 2 Hz the natural microseismic background noise also rapidly increases, resulting in a very steep S/N “wall” to climb. It is very difficult to penetrate this noise wall. We need a source that increases the signal at low frequencies that does not also create undesirable additional high frequencies. Conventional broadband sources are not well suited to the challenge. These considerations drove us to controlled sources that could tailor their output to concentrate their power on just the required frequency range. Conventional marine vibrator designs optimized to produce 10-100 Hz are problematic to scale up to produce lower frequencies, however. To maintain a constant far-field amplitude, the volume of water to displace scales as inverse frequency cubed, so a 1 Hz source would need to displace 1000 times the volume of a 10 Hz source of the same design. The power required to move such a large volume of water using vibrator technologies can become impractically large. Our solution was an energy-efficient, resonating piston design. The engineering challenge of how to seal a 1.6-meter diameter piston moving back and forth over a range of motion of half a meter proved to be solvable. Field-testing the source under tow at 4 knots, recording into ocean-bottom sensors, we achieved an excellent signal-to-noise ratio in the deep water Gulf of Mexico at offsets of over 30 km and at frequencies as low as 1.6 Hz despite the significant ambient noise at these frequencies.

Now that a prototype source exists, the remaining problem is acquisition design. Streamers are noisy at low frequencies and don't easily accommodate the

Technical Luncheons continued on page 8.

necessary offsets and azimuths. This drives us to a low-noise nodal acquisition. Conventional node arrays spaced ~400 meters apart recording offsets out to 30 km or more at all azimuths would be quite expensive. The key is to realize that we are designing the survey to record low-frequencies for velocity-model-building, not for conventional imaging purposes. Sampling considerations allow us to consider a cost-efficient sparse 3D acquisition geometry, reminiscent of land acquisition strategies of the late 1990's, but performed at sea. We believe that by rethinking acquisition from end to end, we can meet the challenge of imaging in areas of deep water and complex salt.

Biography:

Joe Dellinger received a PhD in 1991 from Jon Claerbout's Stanford Exploration Project, then did a 3-year post-doc at the University of Hawai'i before joining Amoco's Tulsa Research Center in 1994. He moved to BP in Houston in 1999 and has worked there since. In his career, he has specialized in anisotropy, multi-component algorithms and processing, and most recently rethinking marine seismic acquisition. As part of that work, he has spent considerable time closely examining seismic data trying to understand

all the signals present in it. He calls this "Forensic data processing", which was the title and subject of his 2016 Spring SEG distinguished lecture series (41 talks in 11 countries in 3 months!). Since 2006 Joe has been the lead BP geophysicist supporting BP's "Wolfspar" project, with the goal to design, build, deploy and commercialize an ultra-low-frequency marine seismic source.

Joe was awarded SEG life membership in 2001 and honorary membership in 2016 for his services in helping the SEG to adapt to the internet age. Joe's hobbies include attending the Houston Symphony, photographing birds, recording frog calls in the swamps around Houston, and public outreach astronomy at the George Observatory. Asteroid "78392 Dellinger" was named in his honor.

Price List:		
	Pre-Registered	Late/Walk-Up
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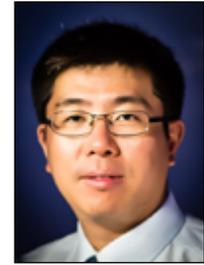
Technical Breakfasts

Revealing Overburden and Reservoir Complexity with High-Resolution FWI

Register
for Tech Breakfast
Northside

Register
for Tech Breakfast
Westside

Speaker(s): Rongrong Lu,
ExxonMobil Upstream
Research Company



Northside

Tuesday, May 2, 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

Westside

Wednesday, May 10, 2017
7:00 – 8:30 a.m.

Sponsored by Schlumberger and WesternGeco

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

Rongrong Lu

Abstract:

The use of acoustic FWI as a velocity model building tool has by now been well-documented in numerous publications. The vast majority of the published studies share two characteristics: (i) FWI is only using refracted arrivals and very low frequencies, typically less than 10 Hz; (ii) velocity models generated with FWI are only used to produce better migrations, but do not possess the resolution to be directly interpretable. We present here an FWI field data application, that differs from common practice in two substantial ways: (i) the input seismic data set is dominated by reflections, with no appreciable amounts of refracted energy; (ii) FWI products were generated with sufficient high-frequency bandwidth (40 Hz), to be directly interpretable. We found that FWI provided significant benefits for imaging and sub-surface interpretation. The FWI velocity model resolved the velocity complexity associated with shallow gas pockets, and enabled us to mitigate imaging distortions at the target intervals. In addition, FWI uncovered a scale of sub-surface information typically unavailable on standard migrated sections, in effect filling-in the low wave numbers that correspond to frequencies below the traditional seismic bandwidth.

Biography:

Rongrong Lu received his B.S. in Electrical Engineering (1999) and M.S. in Acoustics (2002) from Nanjing University, China. He then joined the MIT Earth Resources Lab as Presidential Fellow working with Prof. Nafi Toksöz and received the Ph.D in Geophysics in 2008. After graduation, he joined ExxonMobil and worked in various positions in the Upstream Research Company and the Exploration Company. Since 2015, he has been holding a position as Seismology supervisor in the Seismic Acquisition

and Imaging function. Rongrong has broad interest in practical geophysical solutions including seismic imaging, inversion, signal processing, etc. In his free time, he likes travel, reading, and photography.

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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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Data Processing & Acquisition SIG

Assessing Marine 3D Seismic Acquisition with Triple Source and Deep Tow Streamers

Speaker(s): Peter Aaron; Apache Corporation

Co-authors: Grant Byerley and David Monk;
Apache Corporation

Tuesday, May 9, 2017

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

5:00 p.m. Start of presentation

Abstract:

Over the last ten years both broadband and simultaneous source acquisition have played a major role in advancing the data quality and efficiency of 3D marine seismic surveys. This is made possible through the continued improvement of specialized processing techniques called "de-ghosting" and "de-blending". Prior to acquiring data offshore Suriname in 2016, two key design aspects were assessed which would have a significant impact on both the data quality and efficiency. The first was a triple source design allowing for greater efficiency at the expense of overlapping shot records and the second was to tow the streamers deeper leading to improved signal content and reduced exposure to weather downtime. This presentation shows how test datasets were used to compare current industry capabilities for "de-ghosting" and "de-blending" and to ultimately validate the new acquisition technology.

Biography:

Peter Aaron graduated with a B.Sc. in Physics from the University of Birmingham (2000) and a M.Sc. in Exploration Geophysics from the University of Leeds (2001). He joined Petroleum Geo-Services in 2001 and worked on the development and commercialization of seismic processing

Register
for Data Processing



Peter Aaron

Sponsored by Schlumberger

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

software including signal enhancement, multiple attenuation, and source separation and de-ghosting techniques before moving into an Area Geophysicist role in 2011. Since 2013, Peter has been employed with Apache Corporation and is currently a Staff Geophysicist in their E&P Technology Geophysics group where he oversees both land and marine external and in-house processing projects.

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Joint Inversion of Geophysical and Geologic Data Using Cross-gradient Analysis

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for Potential Fields

Speaker(s): David Schwartz,
Multi-Physics Imaging, CGG

Thursday, May 18, 2017

5:30 p.m. - 8:00 p.m.

Abstract:

A subsurface volume that can be reliably interpreted in terms of geologically-relevant attributes is a desirable objective for products from depth inversion workflows. Geophysical data are inherently inaccurate (noise, aliasing, etc.) and the inverse problem is commonly non-unique, so an implementation of some type of constraint is required to recover reasonable output models. We illustrate an implementation of cross-gradient inversion where surface geological information is included in the input data set, following on from the work done by Scholl et al. (2015 and 2016). The basic application covers the usual structural similarity objective – comparing the gradient fields of distinct property volumes derived from different geophysical domains – but a particular advantage comes when including gradients derived from surface or subsurface geology, or any ancillary property

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



David Schwartz

set, providing reference gradient control during single or joint domain inversions of geophysical data.

Biography:

David received his B.S. in Geophysical Engineering from the Colorado School of Mines in 1972. He began his career in the geophysical engineering world with Dames & Moore (Denver) and then Fugro (Long Beach). He moved into gravity and magnetics with EDCON (Denver), Fugro Gravity & Magnetic Services and CGG Multi-Physics (Houston), where he is currently Business Development Manager for North America. He did also make some forays into the seismic processing world with the Geodigit division of CGG (1976) and Geomage (2010-2013). David lives in Houston and has four daughters and thirteen grandchildren who live in a variety of places.



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5pm – 8pm

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How Things Have Changed:

GSH Newsletter June 1986 *By David W. Watts*

A historical review of the volatility of the price of oil was what I was in search of and what I found was something I wanted to share on how things have changed over the years but also have stayed the same. I do remember those days especially that one eventful day in summer of 1985 in which entire teams of geophysicists were laid off, the floors were empty of people, and any spot in the parking garage was available as every company car was returned and their leases cancelled. To me, that day was the worst day of my career and I will never forget it. I vividly remember the pagers of my co-workers going off near the noon lunch hour which foretold that they were being called up for an end to their jobs that day. A review shows that in May of 1980, the price of oil hit an all-time high of \$118.78 per barrel and by November of 1985, it had dropped to \$68.86 which was a drop of 42%. However, this wasn't the big drop. From that time in November 1985 to Mar of 1986, the price had plunged to \$22.95 which was another 38% for a total of 80% loss from its all-time high in 1980. Now, let us jump forward to our recent downturn. In June of 2008, the price of oil had hit a staggering \$155.78 and by Jan of 2009, it had dropped to \$48.16 which was a 69% drop in 7 months. The price steadily recovered a bit by June of 2014 at \$108.40 and then by Jan of 2016 had dropped to \$29.27 which was 63% drop in value.

While the oil bust of 1985-1986 had several similarities from the current downturn from 2016-2016, my research at the GSH Geoscience center indicated that the October 1986 Newsletter had a thank you to "Mac" McKinney for his article entitled 'What to Do When The Bottom Drops Out' written for the GSH June 1986 newsletter. Intrigued, I pulled out the June 1986 Newsletter from

the archives and read the article. In it, the author is pushing the attendees at an unemployment forum hosted by the HGS and GSH to be strong in times of adversity from the mid 80's. Similarly to the times of 1986, our current GSH team has just completed a similar forum to assist our colleagues. We also have a second forum in the works in the month of May and have also sponsored SPE on their Upstream Oil and Gas Professionals Hiring Event which occurred in March.

Over the past 31 years since this article was written, the world has changed quite a bit. While the message is still the same: be strong and strive to get up from being knocked down, our most recent contributors in 2016-2017: Paul Murray, George Laguros and Sofia Campbell also have guided us with their motivation, experiences, compassion, and knowledge in the fact that the 21st century is very different from the 20th century. The 21st century current focus is on diversity, networking, personal development, and strategies for determining what is critically important for potential employers.

The following article was written for the June 1986 GSH Newsletter and when you read it, please think of how the times have changed. Here is the article in its entirety as originally presented:

'What to Do When The Bottom Drops Out'

On Friday, March 7, 1986, 110 people spent five hours listening to a panel of experts discuss job opportunities in the oil industry. The seminar was first class. The speakers were well prepared and made excellent, professional presentations. I was asked to print in the Bulletin my opening remarks to the gathering, which are as follows:

How Things Have Changed continued on page 14.

Ladies and Gentlemen:

You are unemployed or underemployed because of the situations in the oil industry and not due to any fault of your own. I want you to remember, however, a winner can be knocked down a dozen times but only a loser stays down. Thomas Edison failed hundreds of times when he tried to invent the light bulb, but he never quit.

Losers block out awareness of winning alternatives. Haven't you heard people complain that they never meet anyone that can help them find a job, and when you suggest that they get active in the geological society or the geophysical society they say, "Oh, I couldn't do that."

I've been reading a lot of psychology books lately and I'll share with you some of the concepts I found. An amazing concept of psychology to me is how I think others think of me. What I expect others to see in me rests on what I think of myself. If I think of myself as a loser, I come across to others as a loser without even trying. Just like a neon sign I flash "loser" in my tone of voice, physical gestures, facial expression, clothes, the condition of my hair, my fingernail and everything. I've seen people at job interviews who hung their heads, were afraid to speak up, who wore inappropriate clothing, had unkept hair and dirty nails. They're losers. However, if I view myself as a winner, I am recognized as one and related to accordingly. So we can expect to be treated the way we've set ourselves up to be treated. In Shakespeare's Julius Ceaser, Casius says, "The fault, dear Brutus, lies not in the stars but in ourselves----."

Negativism can be spotted in interviews. Things to be careful of include:

1. Gestures, Handshake
2. Directness
3. Eye Contact
4. Neatness
5. Dress
6. Negative indicators, e.g. bitten nails, missing buttons, spots on tie, runs in hose, etc.

Positive applicant have the following traits:

1. Ask clear questions
2. Find out about the company ahead of time
3. Punctual (so important)
4. Express interest in the job

When you're out of work there is a tendency to be depressed, sleep late, and have a hard time getting up in the morning. Avoid depression by getting up immediately in the morning and look for a job. Keep active!

I've heard that there are between 1,000 and 2,000 geologists looking for a job here in Houston. You people in this room are in the top 5 or 10% of all these geologists because you are here doing something positive with your lives. You're not at home watching the boob-tube. You're trying to learn something to better yourselves and that makes you winners.

In Napoleon Hill's book, "Think and Grow Rich", there's a poem that ends, "The one who wins the race is the one who thinks he can." So keep thinking positively! Remember, everyone loves a winner!

"Mac" McKinney

How Things Have Changed continued from page 14.

When I read this article, I think back of a time that is very different than today: a time in which the “good ole boys” ruled the day. Today, diversity is the name of the game. How different was the mid 1980’s from today? I would say very different.

The oil industry learned a lot from the big downturn of the mid-80s and hasn’t repeated the same mistakes from 31 years ago. We are slowly recovering and while it has been hard, we are moving forward.

The GSH is hosting our second unemployment forum to continue our efforts to assist our members with the main message being that the GSH is at your service in good times and tough times.

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Why do we need Diffraction Imaging?

By N. S. Neidell

Summary –

The oil and gas industry has made remarkable progress in imaging subsurface reflections using seismic data. They extract even further information from such data via attribute computations and auxiliary analyses, for example, AVO (Amplitude Variation with Offset) methods. In the face of such accomplishments, why would we need any other methods for imaging seismic data?

Seismic data processing is actually only reflection seismic data processing. The real problem lies with contributions from non-reflectors. Signatures of such features in the subsurface are imbedded and are integral to all acquired seismic data. CDP-based methods and reflection imaging are not capable of treating such contributions correctly. Different technology is required. So, what are features that do not reflect? Are they of importance? In fact, such applications range from fracture detection in unconventional reservoirs, seismic rock property determinations, defining upwelling salt bodies, AVO studies, and of course depth imaging. We are talking about a problem that goes beyond those we currently understand well such as resolution limits, etc. Our goal is not to discard CDP seismic imaging technology, but to augment it, and ultimately increase its potency.

Introductory Discussion –

A fairly recent paper by a technical expert at a super-major oil company (P.J. Hatchell, Geophysics, 2000) discussed interference with seismic imaging and AVO character imparted by large-scale and near vertical faults in the offshore. He called such interference “whispers” and was able to replicate elements of such effects by careful analysis of transmission effects. His conclusions address the problem only for two specific cases, but offers no general guidelines or characterization of the underlying problem. No mention is made of diffraction contributions. Therefore, we must address diffractions as a first order of business.

Perhaps the simplest approach might be to process a

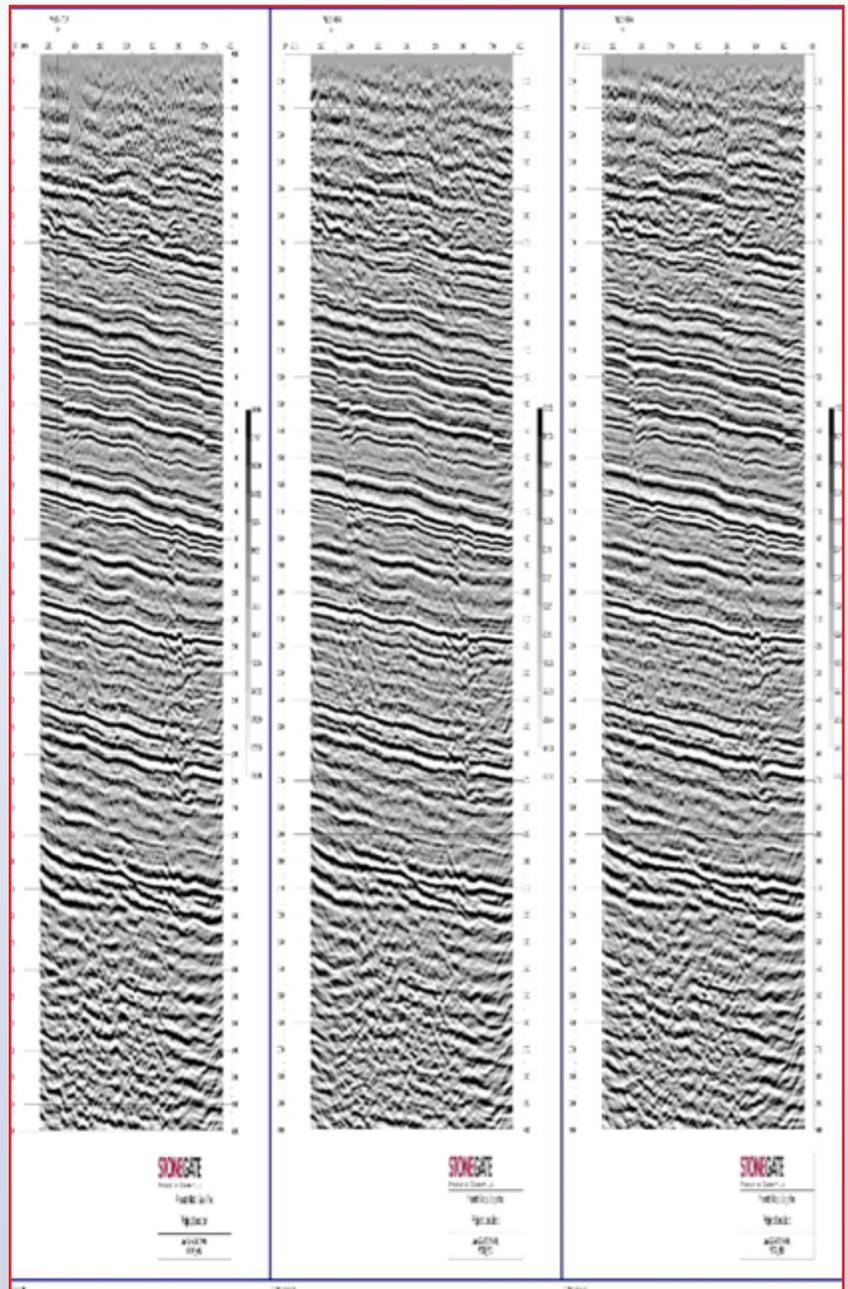


Figure 1:

split spread acquired seismic line as would be routinely done using all the sources, but then to reprocess it again (independently in each case) using only sources first in one direction with respect to the receivers, and then using only sources in the other direction. We could then study differences as we might observe and consider their meaning. Portions of these three results are shown in Figure 1. Even in the shallow section (around 1 sec in two-

Technical Article continued on page 18.

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

way reflection time and just below), the positioning and appearance of the faulting is different. Using the posted well as a reference we see positioning differences, some of which approach 1000 ft. Faults, especially of high-angle will be interpreted unreliably using CDP imaged data. We also understand that many current 2D seismic acquisitions are performed using sources mainly on one side of the receivers. The issue of direction for 3D surveys is an even more complex matter as we shall see.

Figure 2 (after Trorey) shows a strong edge diffraction signature. In **Figure 3**, this model is expanded to a third dimension by simply extending the same cross-section horizontally. We see quite clearly that the diffraction changes its shape if viewed from another direction.

Collapsing the edge of the diffraction via a migration-type operation would in fact require a radially varying velocity. Of course, the reflections in the data should require no similarly varying treatment. CDP imaging can make no similarly varying treatment. CDP imaging makes no allowance for such a dichotomy.

The Main Pass 73 Field case study performed by Ammar, Saunders, Henry, and Wilkinson, all of Energy XXI, and Frismanis, Bradshaw, Codd, and Kessler of Seismic City addressed this well-established producing field (SEG Abstract, New Orleans 2015), also with a new 3D seismic survey in hand. Reprocessing was felt to be in order, but did not appear to address underlying inconsistencies also suggested by the well control.

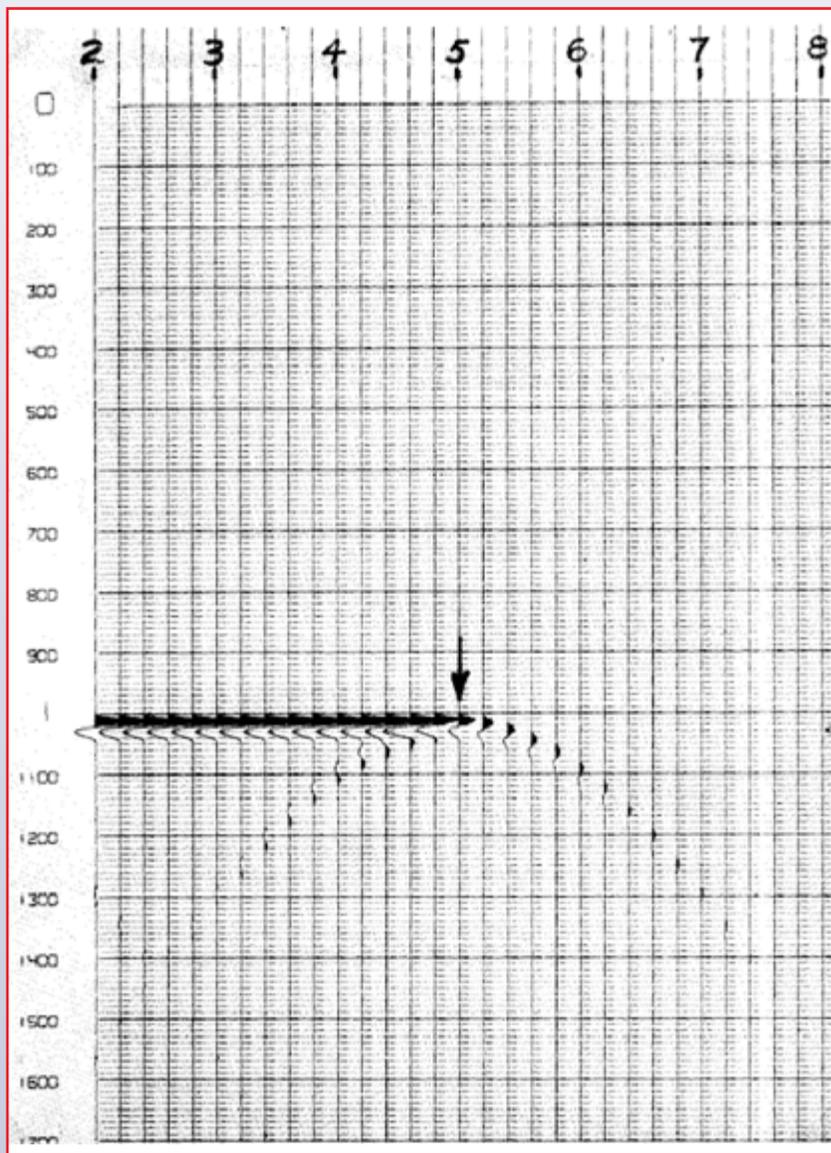


Figure 2:

Figure 4 shows the old salt model as a transparent blue overlay with the new Salt model under it. An approach using model studies and incorporation of model-based seismic data with processing and well correlations, was undertaken. One of the complex models employed in the procedure is also shown in **Figure 5**. This insight and understanding could not have been attained by processing alone, but only with the incorporation of an interactive forward modeling procedure. The recently drilled Ashton well (in red – drilled in 2011) encountered hydrocarbons at each black dot shown in the Figure. Some of these Sands lie within the previously interpreted Salt column.

Of course we are at quite a large scale here, yet we see the inability of CDP-based imaging (processing) to perform as we might have thought it should. Let us now go to the other end of the size scale, and consider a fractured unconventional Carbonate reservoir. The objectives were to understand the fracture system, and further estimate rock parameters from the seismic data. One such work was presented by Heloise Lynn at the 22nd Annual RMAG and DGS 3D Seismic Symposium, March 3, 2016. Dr. Lynn assumes that the seismic amplitudes representing reflections from a Carbonate unit which happens to be fractured may be treated according to usual procedures by appealing to anisotropy. Unexpected amplitude variations within the AVO gathers must also be explained. This leads Dr. Lynn to consider the orientation of the fractures, rock properties in detail, and

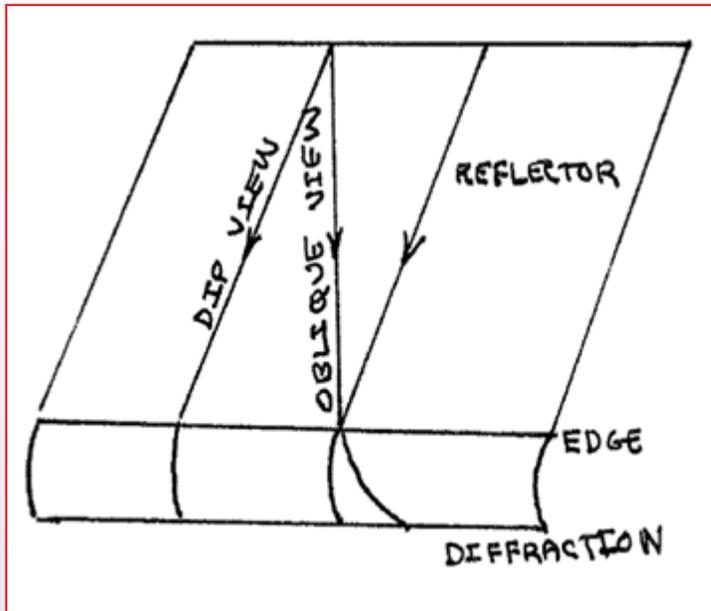


Figure 3:

the refinements of shear wave propagation and splitting within her presumed model.

The physics that she follows is extraordinarily complex and assumes that the data represents quite normal reflectors. The contributions of the vertically standing fractures however are diffractive and distinct from the reflecting horizons. They introduce the peculiar behavior within the AVO gathers, and the resulting imaged amplitudes as well. Unless a more appropriate underlying model including diffraction effects is considered, the rock physics determinations are most unreliable.

It should then become clear that some technique for using the seismic data to correctly image diffractions would be of great benefit to augment the imaging attained using standard CDP methods. We have seen via one example of the Salt column where modeling and well control were effectively used to address the problem. The complexity of such "custom" treatments is daunting. A diffraction imaging method while not simple, offers a more routine procedure, for addressing many of the issues described.

Conclusions -

As a first consideration, non-reflectors of all size matter. Whatever the scale, fractures to salt columns, the significance of non-reflectors in terms of hydrocarbon production can be quite pronounced. They cannot be properly addressed by standard CDP reflection seismic imaging.

In this text we have addressed diffractions as introduced from a 2D seismic reprocessing effort, from Trorey via

the literature, and specific wave equation seismic model studies. We have cited the fairly recent findings of Hatchell and his most detailed analysis, but also his failure to see a more complete picture – including seismic signatures of non-reflectors. We noted the efforts of David Kessler and his Energy XXI coauthors who moved beyond traditional seismic processing to include modeling, in order to understand the structure of a mainly hollow vertical Salt column. They were rewarded with large commercial returns in a "text-book" example of good practice.

We cited also an AVO directional study over known fractures in an unconventional Carbonate reservoir context, where failure to recognize non-reflecting seismic contributions and their properties masked fundamental problems leading to questionable physical determinations of rock properties.

Correcting CDP imaging for non-reflection signatures can be addressed specifically application by application.

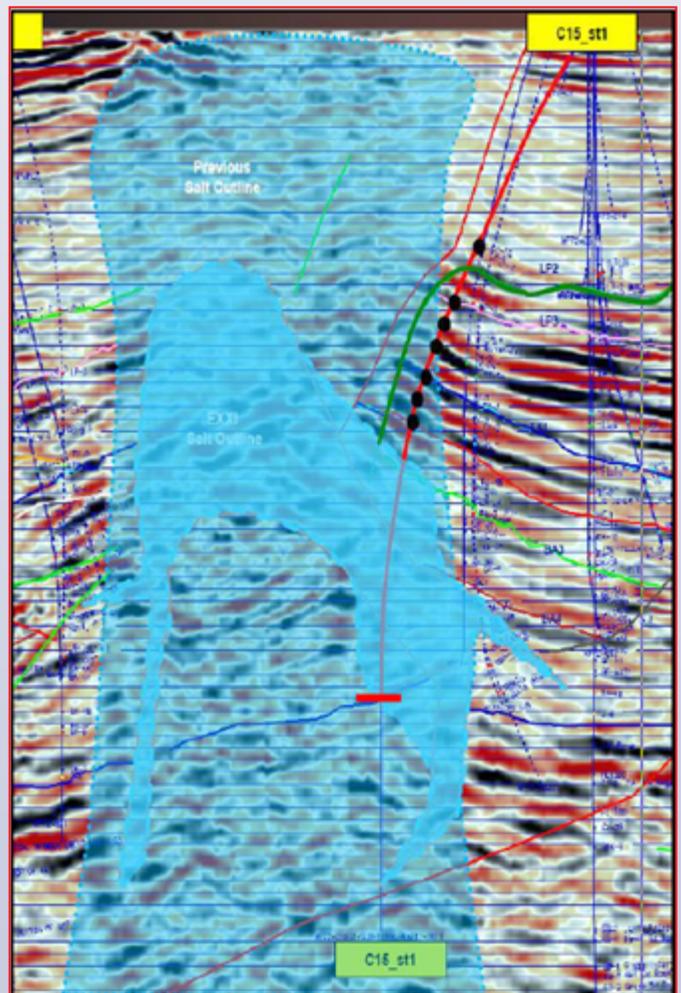


Figure 4:

Diffraction Imaging may provide a good starting point in many cases. It is humbling to have failed to recognize such a basic deficiency. A good place to start, however, would be with a thanks those individuals expressing discomfort with certain results as obtained using CDP seismic imaging. After that, we can make some general statements which characterize the problems we face inherent in using CDP imaging as currently practiced.

Non-reflectors of any size contribute their seismic signatures to the reflection seismic data. These non-reflecting contributions have directional dependence and diminish the validity and utility of legitimate reflection seismic amplitudes both for interpretation and analytical studies. Unfortunately, the role or importance of these effects when and if they are present is initially not known. Such contributions are further directionally "homogenized" or averaged by the CDP process, thus further compounding errors, and increasing the underlying uncertainty. Such effects when present can call into question: results of depth imaging, complex salt imaging studies, AVO investigations, effectiveness and geometries of traps and seals, seismic rock property determinations, correlations with well information, and diffraction imaging studies used to obtain high resolution, just to name a few.

Severity of the errors of each instance are not known in advance. Clearly, we are addressing a matter of some consequence concerning the routine use and unquestioning acceptance of CDP imaging of seismic data. Diffraction Imaging may help us better understand the subsurface as it truly exists.

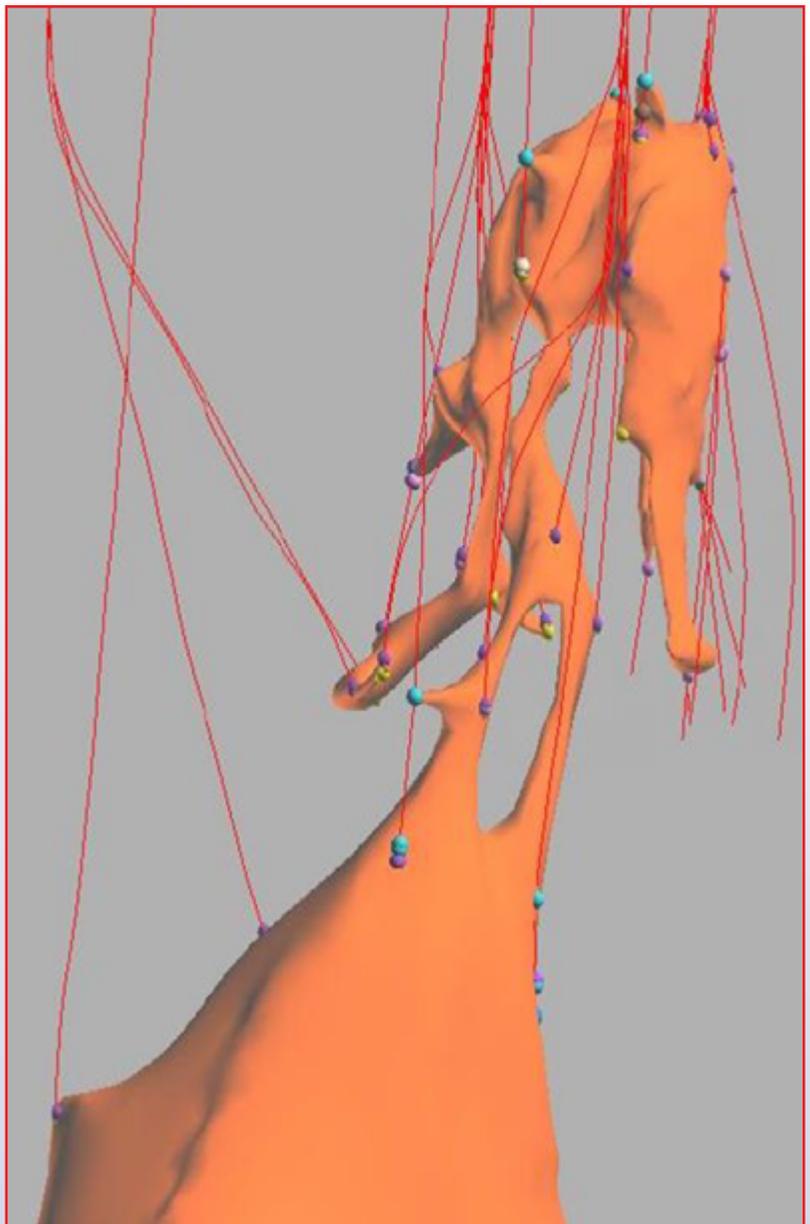


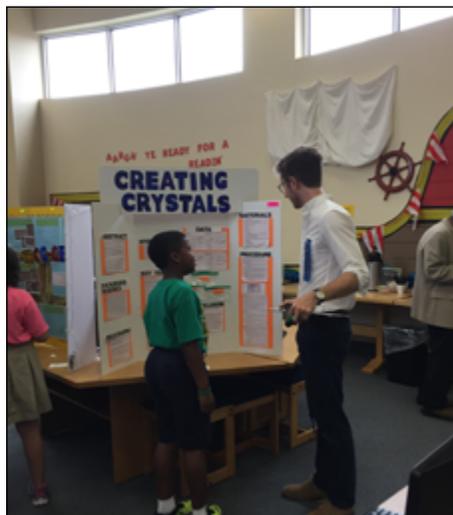
Figure 5:

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GSH Outreach

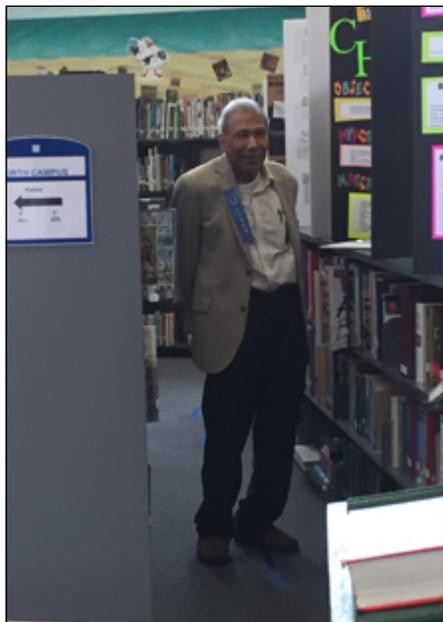
Committee Activities - By Lisa Buckner



In the Burbank Middle School HISD Career Day letter to volunteer speakers, David Knittle, Principal wrote:

"Many of our students are unaware of the career opportunities available to them, and this is a fantastic way to provide them with firsthand knowledge of potential career paths. This is also a great way for you to get involved and make an impact on the students' futures."

Many thanks go to Jeff Allen, son of Jim Allen, who stepped up to give three classroom presentations about his career as a geologist in his father's place upon short notice on Wednesday, February 15. Students were given a GSH logo coiled toy spring and an "Earth is calling ... will you answer?" brochure.



On Saturday, February 18, GSH and Association for Women Geoscientists (AWG) collaborated to host a booth at the Girls Exploring Math and Science (GEMS) event for Girl Scouts at the Houston Museum of Natural Science. Approximately 1400 girls attended. This was the first year for either organization to participate in this event and it is so popular that we had to apply to be exhibitors. SPE and Oxy also exhibited. I invited the three AWG volunteers (Amalia Doebbert, Luisa Aebersold and Kelsi Ustipak) to bring some items to share with the girls. They brought three samples of different colored sands from the beaches of Hawaii, some

rock samples from Minnesota and other places, a few hand lenses and a Brunton compass. The girl scouts really enjoyed looking at the samples with the hand lenses. The jumbo colorful coiled toy spring drew a lot of attention to our booth as well as the oil samples and interpreted seismic section. Visitors were given an "Earth is calling ... will you answer?" brochure. The exhibit booth volunteers were asked to judge student science projects during their break from manning the booth. TD, the Super Bowl LI mascot, was roaming around the event posing for photos with fans and distributing small Super Bowl LI footballs.

Outreach continued on page 22.



GSH outreach volunteers participated in two events on Saturday, February 25: EYH and SEFH (see article by Gokay Bozkurt). Lisa Vinson Neelen and Laura Younker facilitated two of the many classroom hands-on activity workshops for 38 of the 450 middle school girls from all around Houston at the AAUW Expanding Your Horizons in Science and Mathematics (EYH) event. Working in small teams, the girls filled paperboard shoe boxes with layers of sand and gravel and hid a small balloon pre-filled with water dyed black "oil reservoir". They traded their box with another team. They then conducted a seismic survey to find the "oil reservoir" by tapping the box lid with their hands (source), listening with their ears (receivers) and processing with their brains. They used a bamboo skewer to "drill for oil". Lisa Vinson Neelen wrote after the event "I think the girls had a lot of fun and feel like there were some ah-ha moments for some of them. Others just like to play in the sand." Girls were given a GSH logo coiled toy spring and an "Earth is calling ... will you answer?" brochure to take home.

On Friday, March 10, GSH outreach volunteers helped judge 23 science fair projects at Fort Bend Christian Academy.

GSH volunteer Stephan Gelinsky wrote:

"The event was fun, well organized. The kids were 3rd and 4th graders and even those who initially were a bit shy quickly warmed up once talking about their projects with us. There were 29 projects on display, many of them focused on exploring unexpected properties of objects around us – for examples fruits as batteries, plastic or yogurt from milk. I especially liked those experiments that tested the perception that high product price equals higher product quality: Whether the sealing capacity of ziplock bags or the amount of residual un-popped popcorn – there is no simple, universal correlation between price and quality!"

GSH volunteer Karl Schleicher wrote:

"The science fair at third and fourth grade students at Fort Bend Christian Academy was organized by Rebecca Morgan. Judging was well organized. Ms Morgan sent me an email about two weeks before fair day that explained the location, time, and included a copy of the evaluation rubric. Judging was well organized. I believe there were six judges. Each judge evaluated one aspect of posters to provide more consistent judging. We met at 7:45 AM for a brief orientation and started judging at 8AM. I evaluated the abstract, a school staff member evaluated the bibliography, and other volunteers evaluated board layout, data tables and graphs, and other poster aspects. At 9 am students started to arrive for three minute interviews. Judging was completed by about 10:30.

Participation was optional and there were about 25 posters. Some students were participating for the first time while others were involved last year. There was a range of skills. My favorite was an experiment to measure strength of reaction when you drop Mentos (a candy) in soda. The poster tested several soft drinks. The reaction of six Mentos in two liters of Coke will erupt to six feet!"

The Elementary School Science Specialist, Rebecca Morgan, who organized the science fair wrote:

"Your members were such an asset. They were kind, knowledgeable, thorough and gave a fantastic testament to our students as to what a scientist looks like and what they may aspire to be when they grow."

Thank you to the GSH Outreach volunteers: Stephan Gelinsky, Karl Schleicher, Eric Barefoot, Ashok Ghosh, Mac Hooton and Larkin Spires.

The annual Scout Fair is Saturday, May 6. It has moved this year to Minute Maid Park. We typically give away 900 GSH logo coiled toy springs. Approximately 10,000 scouts attend the daylong event.

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.

GSH Outreach

58th Annual Science and Engineering Fair of Houston

by Gokay Bozkurt



GSH President Amy Rhodes and Lead Judge Gokay Bozkurt with the award recipients.
Photo Courtesy: Tuhin Dey, SEFH, University of Houston.

March 2017

The Geophysical Society of Houston (GSH) participates in a number of community outreach projects throughout the year. We actively engage with K-12 students in a variety of venues around Houston to foster an interest in math and science among these brilliant minds, while fueling their curiosity towards geological and geophysical concepts.

One of these venues is the Science and Engineering Fair of Houston (SEFH). It is the largest fair of its type in Texas, and one of the largest in the world. SEFH serves as the regional fair for all public, private, charter and home school Junior and High School students in Harris County and 22 surrounding counties throughout Southeast Texas. GSH proudly supported this event as a Special Awarding Agency alongside with 48 other organizations and professional societies in Houston.

This year SEFH convened for the 58th time hosted by the University of Houston at their Main Campus Athletic/Alumni Center. SEFH drew a total of 775 project entries in 16 categories with 920 student participants (512 female and 408 male) showcasing their research work. There were 436 Middle School and 484 High School exhibitors.

On February 25th, seven GSH volunteer judges high-graded and reviewed projects deemed relevant to our professional interests and selected a winner and a runner-up for the Junior (grades 7 & 8), Ninth Grade, and Senior (grades 10-12) divisions. The GSH judging committee is proud to announce Special Award recipients and the titles of their research work:

Outreach continued on page 24.

Junior Division

1st Place:

Victor Markhasin

"Measuring induced seismic activity with a homemade seismograph"

2nd Place:

Karen Pan

"Ocean Tides"

Ninth Grade Division

1st Place:

Priyanka George, Maha Chishtey
and Muskan Effendi

"The Colors of the Sun"

2nd Place:

Emma Mroz

"Transit Photometry and Spectroscopy of Tabby's Star"

Senior Division

1st Place:

Irineo Sanchez

"Ultrasonic Map Creator"

2nd Place:

Alexandra Tan

"Electromagnetoception in Planaria"

SEFH was concluded with an awards ceremony on the evening of Tuesday, February 28th where students, teachers and parents gathered at the UH Cullen Performance Hall and eagerly waited to hear their names called as winners. GSH President Amy Rhodes attended the ceremonies and personally handed the Special Awards to our 1st and 2nd place division winners. Students were very appreciative of their Best Buy gift cards (\$50 for 1st place and \$25 for runner-up) and their Certificates of Merit. A group picture was taken with the awardees who were present at the ceremony.

I would like to extend my appreciation to all the dedicated members of GSH who participated and generously volunteered their time for the successful representation of our society at the SEFH, in particular Lisa Buckner and Sue Pritchett for their support and guidance.

This year's GSH Special Awards Judges were: Gokay Bozkurt (Lead), Sireesh Dadi, Obinna Kanu, Peter Lanzarone, Xiang Lin, Syed Mehdi and Emmanuel Ubaha.

Thank you very much!

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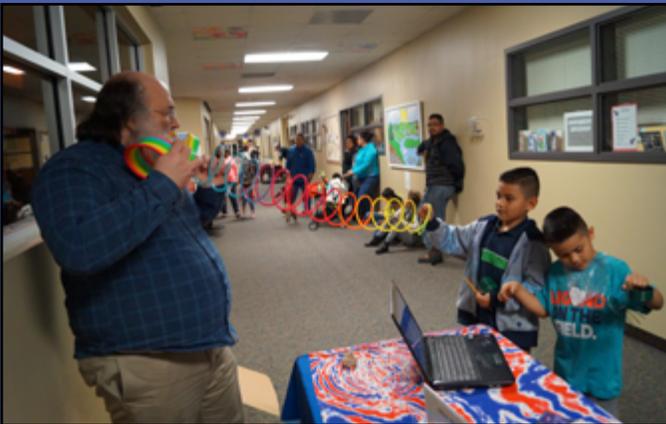
HMNS Educator Event, 9th Annual First Colony Middle School Career Day, Morales Elementary School Science Night



Fareen Elias at The Educator Event at the Houston Museum of Natural Science



Randy Keller and Mac Hoonton at the 9th Annual First Colony Middle School Career Day



Cory Hoelting Slinky Demo with two boys at Morales Elementary School Science Night



Boy strikes oil at Morales Elementary School Science Night

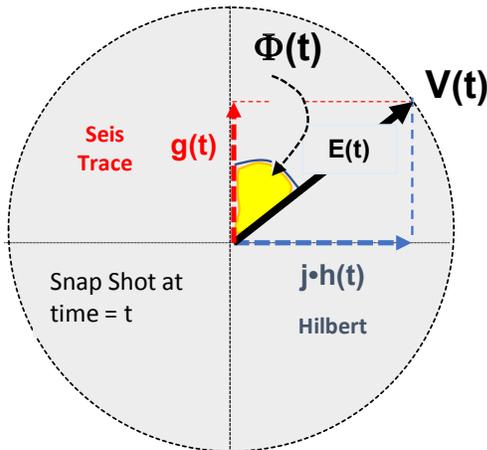


Cory Hoelting Slinky with girls at Morales Elementary School Science Night



Learning to Live with Attributes of the Vector Trace

The first thing to appreciate is that attributes, like plants, animals, and people, have feelings and attitudes. We have already looked at the Alpha Attribute, **the envelope, $E(t)$** , and we'll now shine the light of fame onto **Instantaneous Phase, $\Phi(t)$** .



One must be careful not to confuse this guy, $\Phi(t)$ *instantaneous phase* with what is called the *wavelet phase, $\theta(f)$* . The latter is a characteristic of a simple wavelet (smooth symmetric envelope), which expresses a **constant phase** for all frequencies in the wavelet. This phase is referred to as a “phase rotation”. The confusion irks the snot out of $\Phi(t)$ because he is continuously changing as the vector, $V(t)$, spins around the time line with changing length, $E(t)$, and pointing angle.

There is a connection between the two, and that will be revealed in due time by the Guru.

Combining the geometry, depicted above, with the concept of the complex or vector trace, $V(t)$, we may express the trace we see, $g(t)$, and his occult reclusive cousin, $h(t)$, in a graphical manner that can't miss as an insightful epiphany.

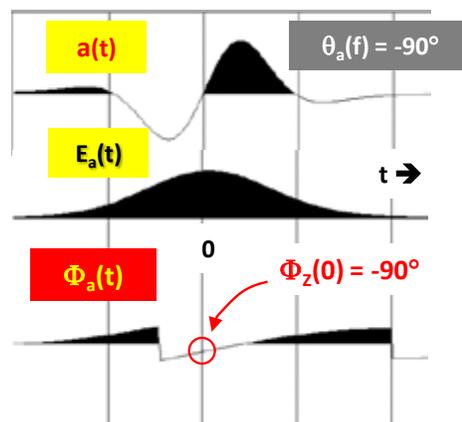
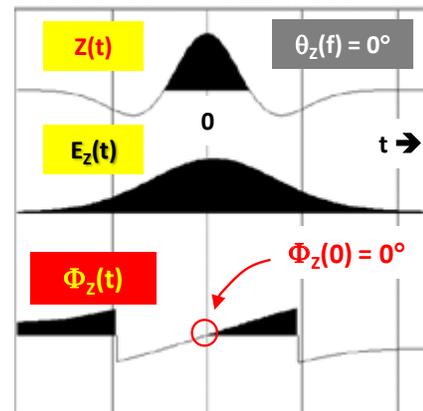
$$\begin{aligned} V(t) &= g(t) + j \cdot h(t) \\ g(t) &= E(t) \cos[\Phi(t)] \\ h(t) &= E(t) \sin[\Phi(t)] \end{aligned}$$

The first equation suggests a vector addition, which is apt, since it is. The second connects the temperamental I-phase with the robust envelope to produce $g(t)$, the trace we see, know, and love. The 3rd expression relates the envelope and $\Phi(t)$ to the unseen, but highly regarded, Hilbert Transform, $h(t)$.

At the right we see two wavelets, $z(t)$ and $a(t)$. The first is “zero phase”, $\theta_z(f) = 0^\circ$, while the second, in the lower panel, $a(t)$, is anti-symmetric, and as such, has a wavelet phase of $\theta_a(f) = -90^\circ$.

Envelopes: $E_z(t) = E_a(t)$. This is always the case for a phase-rotated wavelets compared to the original, even though $\theta(f)$ is not constant (e.g., Min-Phase).

Wavelets Envelopes I-Phases

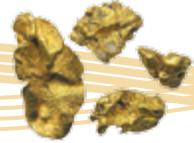


Tutorial Nuggets continued on page 27.

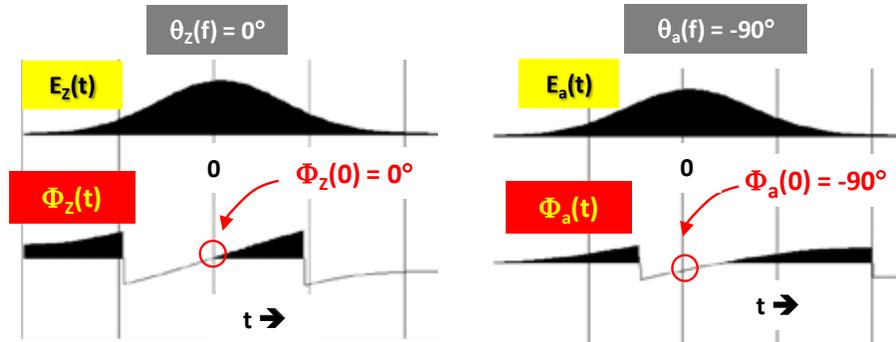


Tutorial Nuggets

Tutorial Nuggets continued from page 26.



In the special but not unusual case of constant wavelet phase, $\theta(f) = k \pm \epsilon$, where ϵ = an itsy bitsy (a small deviation from perfect), there is an interesting, if useful, relationship between the wavelet phase, $\theta(f)$, and the I-Phase, $\Phi(t)$, at the envelope peak, which for simplicity we'll say occurs at $t = 0$.



The extract, from the figure on the previous page, illustrates the principle that the I-Phase at the envelope peak yields a good estimate of the constant wavelet phase, $\theta(f)$. If you were in the business of phase correcting the wavelet to zero, this would be handy information to have.

At the right, we test the notion from the previous page that,

$$g(t) = E(t)\cos[\Phi(t)].$$

and surprisingly, it works. A comparison of the upper input trace, $g(t)$, and the derived trace, $E(t)\cos[\Phi(t)]$, puts it beyond the grasp of the skeptics.

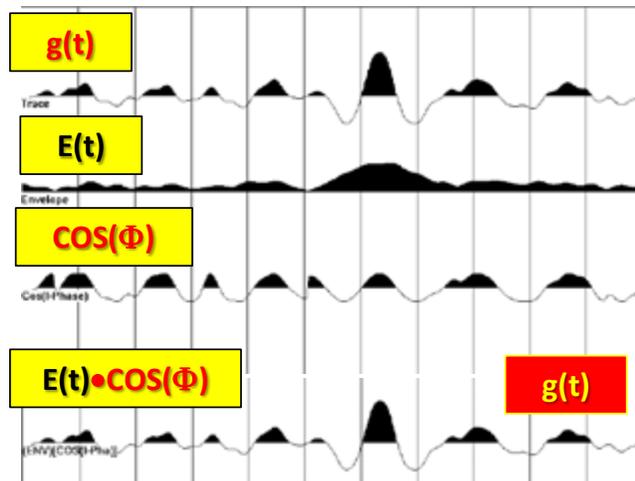
So far we have looked at instantaneous attributes describing reflection strength, $E(t)$, and phase, $\Phi(t)$. A natural companion to these two would be *Instantaneous Frequency*, which we'll call $f(t)$. This guy will measure how fast the spinning vector, $V(t)$, is rotating or changing angle, $\Phi(t)$, as it moves down the time line. Clearly this calls for a derivative, which was born for this purpose.

$$\frac{d\Phi(t)}{dt} = \omega(t) = 2\pi f(t) = 360f(t)$$

The results on the right side are angular velocity in units of radians per second or degrees per second. To obtain $f(t)$ Hz, we normalize by 2π ($360^\circ F$).

I-Frequency:

$$\frac{1}{2\pi} \frac{d\Phi(t)}{dt} = f(t)$$



At this point, The Guru knows that many of you are wondering what is this mathematical miasma is all about.



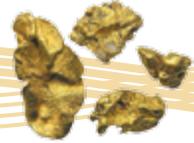
GSH Political Action Committee for the Merciful Impeachment of The Guru

Mr Guru, what is this mathematical miasma all about?

Thanks for asking, little radicals. All or at least most will be revealed next month – if I'm still in office.



Tutorial Nuggets continued on page 28.



More of the Possibly Improbable & Improbably Possible

(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?**

Answer: A reasonable approach when dealing with liars and cheats is to do a little supposin', and see which assumed failure answer satisfies the conditions stated above.

Statement by	If Amy Failed	If Bill Failed	If Chuck Failed
AMY	1 F & 1 T	1 T & 1 F	2 T
BILL	2 F	1 T & 1 F	2 T
CHUCK	2T	1 F & 1 T	2 F

The table tells the tale. It must have been Amy who flunked since only this assumption satisfies the conditions of 2 False, 2 True, and 1 False, 1 True from the 3 students.



K.K. Casey

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

As you have, no doubt, already figured out: Zero, None, Nada strikeouts. (27 pitches is one per batter in a 9 inning game).

For you to ponder until our next encounter:

An old brain teaser asks, "If you walk a mile south, then a mile east, followed by a mile north, end up where you started, and shoot a bear; what color is the bear?" Did you ever wonder why it was necessary to have a bear in the problem? Just to be cute, maybe? Or is there a more profound meaning, such as uniqueness? **Incidentally, for the stated problem, where did you start?**

Consider the PETA version of the Puzzle: Same path distances and directions (1mile S, 1 mile E, 1 mile N, end up at starting point), you meet and make friends with a walking bird. What color is the bird? **Does the bird or its color make the answer unique?**

The GSH Geographical Survey and Odd Facts Team has been dispatched to determine the answer. Can you beat them to it? **If it's not unique, name a few points on the earth where this could happen, so as to prove its non-uniqueness.** Good luck, and don't get lost.



Geophysical Signal Processing 101

Enders A. Robinson & Sven Treitel

Two of the geophysical industry's most recognized and decorated MIT Ph.D's in geophysics who have collaborated for decades on books, papers, and presentations host this live webinar.



A Live Webinar

May 23 - 26, 2017

Four Half-Days 8:00 am - 12:00 pm Central Time (USA)

This is a course for those new to geophysical signal processing, or who have forgotten what they learned about it. We start with an explanatory discussion of the seismic method, covering seismic wave motion, seismic migration, full waveform inversion (FWI) and visualization. The successful performance of migration and FWI depends on our ability to preprocess the field data so that it is as free as possible from performance-degrading events, namely the various kinds of noise. We therefore introduce elementary signal processing tools such as convolution and correlation, along with the basic means to compute them. We follow up with a study of the design of digital filters, their inverses, and their stability issues. Finally we deal with optimal digital filters, and how they are used to solve various practical problems. Throughout the course we illustrate concepts with simple examples, and invite listeners to solve small illustrative "pencil and paper" problems after (or even during) the lectures.

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Geoscience Center News

By Bill Gafford

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

Our next Living Legends Doodlebugger social event is on Thursday morning, May 11. The event is open to all who are interested in seeing some of our collection of geophysical and geoscience instruments from the early days of oil and gas exploration, or just visiting with some of the people who have experienced the ups and downs of our industry. No reservation is needed and light snacks, coffee, soft drinks, and water will be provided. You may come by for a short visit or stay for the whole morning.

In March, we were able to loan some of our museum items to the AAPG Preservation of Geoscience Data Committee for a display they were preparing for the recent AAPG convention here in Houston. The display included examples of early recording and storage media used in seismic and well logging. I have also been in discussions with representatives from Lone Star College-University Park about placing a display of some of our museum items in a new Energy and Manufacturing Institute building on their campus in northwest Houston. They have

an existing display of drilling and production equipment which is used in some of their educational curriculum and we hope to add some items from exploration as well. We would like to have more of our collection of historical geoscience items in displays available for public viewing and education. Please let me know if your company might be interested.

Our collection of industry caps and coffee mugs continues to grow and we also have started a collection of company lapel pins or buttons. Any donations of items such as these will be appreciated. We also need some issues of "The Leading Edge" and "Geophysics" to add to our collection of these periodicals.

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.

Mystery Item

This is a geophysical item...

Do you know what it is?



This month's answer on page 38.

U of H Wavelets

Searching for Water: UH Study in Belize

By Jacob Miller, Dr. Robert Wiley



When picturing Belize, most people imagine vast stretches of sandy beaches and resorts; however, much of the country is comprised of impoverished villages lacking basic necessities such as water. In January 2017, a group of University of Houston faculty and students including Dr. Robert Wiley, Fiona Gunawan, Jacob Miller, Kasey Mahaney, and Logan Anderson went to Belize to put classroom knowledge into practice. For almost two weeks, this group traveled to different villages around the country gathering resistivity and seismic data in the hopes of finding water. This data will then be processed to determine the best potential spots to drill new wells for the villages. In conjunction with the organization *Living Water*, this information will be used to drill future wells for villages throughout Belize.

Most of the villages we visited in Belize have two sources of water: a hand-dug well or a nearby river. Image 1 is an example of what a hand-dug well looks in these villages. Often these wells are only a few feet deep and near outhouses or livestock pens. With these sources of water being exposed to sources of contamination, it is not uncommon for the villagers to experience illnesses caused by the water. There are also villages in Belize that can only gather water from their wells during the wet season. When the wet season is over, they are forced to go to nearby villages or turn back to compromised water sources.



For the villages of San Roman Stann Creek, San Roman Orange Walk, Crique Jute, and Santa Familia we used a few different techniques to survey for potential well locations. These techniques included resistivity measurements and gathering 2-D seismic data. Image 2 shows an example of the team preparing to do a resistivity survey in San Roman. The type of survey that was used depended upon local geology and safety factors of the surrounding environment. The data is currently being processed at the University of Houston by the attending students and faculty, and the Allied Geophysical Laboratory. Once the data has been processed, the results will be passed on to the government of Belize and *Living Water* to determine future steps towards drilling new wells. Current data for Crique Jute has shown two low resistivity layers that are promising to contain water. We hope that the information we collected throughout the week will lead to a new and safer water supply for these villages.

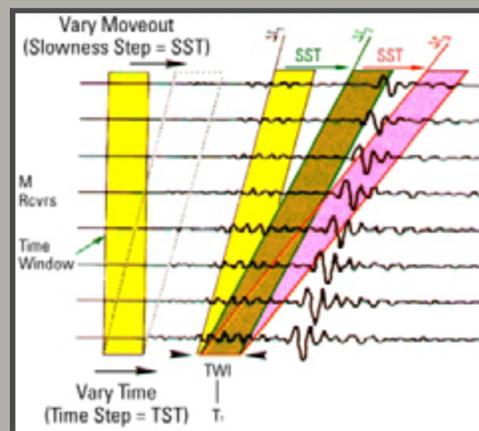
A Live Webinar

An Introduction to Borehole Acoustics - Theory, Measurement, Processing and Applications

Matthew Blyth

LWD Geophysics, Acoustics & Geomechanics Domain Head

Schlumberger Drilling and Measurements



July 25-28, 2017

10:00 am - 2:00 pm Central Time (USA)

This course is intended to provide an overview of the physics of common borehole acoustic modes, the challenges and techniques of their measurement, processing and quality control along with the applications of the answers across a wide range of problems from input to seismic and petrophysical models through to understanding rock mechanics and stress. It will also cover the history of borehole acoustic logging and an overview of modern tool design, both logging-while-drilling and wireline, including the unique concerns of each type of tool. This course will build from first principles and is applicable to all those with an interest in borehole acoustic measurements and their applications or who commonly incorporate this kind of data into their daily work.



Since joining Schlumberger in 1997 Matthew has filled a variety of roles, all within the field of logging while drilling. He is currently involved in the long term technical development plan for LWD acoustic and seismic technology and their applications within Schlumberger. He has authored and coauthored multiple papers on LWD technology and its uses. A graduate in 1996 from Cambridge University with a Bachelors and a Masters in Engineering, he is a member of the SPWLA, SPE, SEG and ASA and has served as both a VP and as President of the Houston SPWLA chapter. He is currently the secretary of the SPWLA Sonic SIG and is a 2016/2017 SPWLA Distinguished Speaker.

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



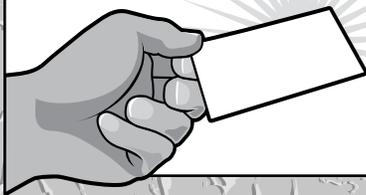
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Doodlebugger Diary

New Guy on the North Slope

Reporter Mike Roberts

This Doodlebugger story is a compilation of crew members from an old Western Geophysical Alaskan land crew on the North Slope of Alaska from 1989 and was first published in the Western Profile in the Winter 1990 publication. As young geophysicist at that time, I recalled how exciting the experience of a field crew must have been especially when I was just an office team member. The reporter of the story, Mike Roberts, supplied this story from the newly hired crew members for the crew and for me was something that I enjoyed reading over and over. For those who might like to read other publications from the Western Profile magazine, they are archived and accessible via an online link: <http://seg.org/Publications/Journals/Western-Profile>. 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 or at editor@gshtx.org.

Editor's Note: Newcomers to Western crews are greeted by experiences as vast and different as the myriad geographic operating locations. Signing up on a Western crew can place you anywhere from the frigid Arctic, to the smoldering desert heat of the Middle East, to the suffocating tropics. The following story, submitted by an Alaskan crew, is a compilation of crew members' first encounters on Western Parties 711 and 794. Welcome to an Alaskan land crew!

"The pilot has begun his gradual descent into Deadhorse. Please return your seats and tray tables to their full, upright positions. The current weather in Deadhorse is - 31°F with 10 mph northeast winds. We should be landing at 10:20 a.m."

At the announcement, I look out of the plane window at strobe lights flashing in the darkness. It doesn't look any colder to me than when I left Anchorage this morning, but I'll take their word for it. Now I began to wonder what I was getting into when I applied for a job with Western Geophysical two days ago. The flight attendant was right about the cold and wind. No covered gateway here! I should have kept my gloves and cap out of my baggage.

I pick up my bags in the terminal and wait for a person who doesn't know me. A young man in grease-covered coveralls approaches and asks if I work for Western. (It must have been the "lost" look on my face that gave me away.) Since I just started this job two days ago, I nod my head with some hesitation.

The young man drives me about one block away to a one-level structure with a bunch of antennas on top. We pass several trucks parked in the dark with their engines running and walk through the front door of the building. I'm told to grab a plate of food for lunch. Hey, this isn't so bad! Nice and warm inside, lots of good food, a telephone, television, and it's only a stone's throw away from the airport if I ever get tired of this place before I earn my one week break four weeks from now. I hear "OK, time to go". Huh? "Time to go out to your crew". Oh well, maybe the next place will be even nicer.

We drive on a road that is built up several feet higher than the surrounding flat terrain called tundra. I'm told the tundra is like a grassy marsh in the summer months, so roads and buildings have to be built up on gravel pads. The layers of gravel also serve as insulation between any source of heat on the surface and the permafrost (permanently frozen ground).

After travelling a short distance, we stop at a security checkpoint where we must identify ourselves, our company, and our destination. We pass many huge buildings along the way. Some appear to be where Oil Company employees live, others look like power generating plants, oil drilling rigs, and pumping facilities. All of them are illuminated by bright lights, and multiple pipelines zigzag all over the place. Large trucks are hauling oilfield equipment.

The wind blows snow through the headlight beams that are making a feeble attempt to pierce the Arctic darkness. What a weird place this is! The crew cab pickup goes down an embankment off the gravel road and is now on a road with a different surface. I don't see any more gravel or blades of grass sticking up through the snow. It turns out that we're driving on a road that's been plowed over the frozen Beaufort Sea - we're actually driving on the frozen ocean! I hope it's nice and solid.

On the horizon is a bright light coming from the crew's camp. I've noticed it for a while, but it never seems to get any closer. We finally pull into camp at 1 p.m. The sky is dimly lit by the glow of the sun below the horizon. Nobody at this latitude sees the sun from early November until the last week of January.

The camp is composed of orange-painted trailers hooked together in parallel strings. Some bulldozers are pushing snow around, and the air is filled with the droning of diesel generators. A couple of people start unloading boxes from

Doodlebugger continued on page 37.

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 36.

the truck I rode up in, but they're so bundled up, I can't see anything except their eyes and noses. I unload my duffle bag from the truck bed and find that the handles are stiff. Boy, is it cold! I've never been in temperatures like this before.

"Hey, you!" a man standing inside an open door marked "office" shouts and then waves me inside. He tells me that he's the party manager. This doesn't look like it's going to be a party to me! The party manager gives me a safety orientation, telling me the do's and don'ts, assigns me a bunk, then tells me to go to the diner to pack another lunch, and to be ready to go to the line in 30 minutes. Line? What's a line?

A cheerful guy in a white uniform (must be the cook) points out where everything is in the lunch-packing area. It must have been that "lost" look again. I open up a large brown bag and throw in a few sodas, apple juice, orange juice, two sandwiches, mixed nuts, potato chips, two candy bars, peanut butter crackers, an apple, and some leftover chicken. With this 10-pound lunch under one arm and a small duffle bag of extra clothing in the other, I return to the office for my ride to the "line".

Another man in torn, insulated coveralls and a bearded face tells me to climb into a huge, funny-looking, orange truck. The first step is about three feet off the ground, and the bottom of the door is five feet off the ground. It takes me awhile to find the handles and figure out how to climb up. I hear my long underwear rip at a seam as I take that first huge step up.

I'm relieved to find that the truck cab is warm enough to unzip my coveralls and pull off my wool facemask, but it's still cold enough for my breath to form vapor. I guess everything is relative. The vehicle moves slowly and methodically over the featureless snow covered sea ice, rocking back and forth at every bump. This thing won't win any races, but its giant tires keep it from getting stuck.

The already-dim sky is fading to dark in the mid-afternoon and I see a small set of bright lights up ahead that turn out to be more huge, orange trucks, only they have cages on the back that are filled with cable. I get out, and the "taxi" pulls away under the roar of its diesel engine and a long, thick plume of steam trailing from the exhaust pipes. It suddenly feels very lonely out here in the middle of nowhere.

"Throw your stuff in this truck and come with me," a voice tells me. "This is a flyer pin. These are geophones. Take a geophone off the flyer pin, drop it on the ground, and stomp it into the snow. Keep them straight, level, spaced equally, and down into the snow so that they're out of the wind. The last phone should end up right here, then you connect to the main cable and the other flyer like this. If you have any questions, just ask."

Sounds easy enough. I plant the first set of phones too close together. I drop the second set and end up with a tangled mess. This stuff is getting heavy.

"Hey, you! Get back here and fix this!" I look back to see a big guy waving his arms around. "You dragged all these phones. Those two over there are upside down and you connected this one wrong!" - I'm glad to be wearing a face mask to hide my embarrassment.

When all the phones have been stomped down, three other guys and I pack into the cable truck where we find relief from the cold and wind. All of the riders pull off their gloves and facemasks, exposing their faces to me for the first time. Simultaneously, they all grab a paper towel, wipe off the icicles built up on their moustaches and eyelashes, pull out a juice, guzzle it down, and follow it with a bag of chips or candy, and then another juice.

The truck starts moving to "I don't know where." The windows become all fogged up from everyone's breathing except where the fans blow directly. This moisture has built up into thick layers of frost that make it nearly impossible to see out the side windows. I scrape the glass with my fingernails, but it frosts back up in less than a minute.

Since we laid out all of our cable and flyers, it's now time to drive somewhere to pick up cables and flyers so that we can lay them back down again somewhere else. We pick it up again, and again, and again. I suggest that we never pick it up at all, that we just tie one end to the truck and tow the whole thing over to where we want it. This idea earned a big laugh from everyone!

I'm impressed by how warm my hands stay inside a simple pair of cotton work gloves over a thin pair of wool gloves. The cotton gloves get moist from the snow, ice, and the body heat. This moisture freezes the cotton glove into a hard object, only flexible at the joints while the wool glove stays dry and the hands stay warm.

Our driver stops the truck and tells two of us to get out, after which he drives further down the line. I'm told to simply grab a flyer pin and start stringing the little loops attached along the cable onto the pin. I like this - it's a methodical task. Except I find that some of the cable is hard to pull out of the snow. Practically every geophone must be kicked five to 10 times to get it loose. This cable has been lying here for more than a day, and the constant wind has buried everything in hard-packed snow. When a geophone does come loose, it always has a big clod of packed snow stuck to it that has to be knocked off.

Now it's so dark that I can't see what I'm doing without standing near the bright lights of one of the trucks. So battery-powered headlamps are passed out to everyone; no shutting down because of darkness up here!

Doodlebugger continued on page 38.

Doodlebugger continued from page 37.

As the evening progresses, a mild breeze picks up. It's probably only 5 mph, but is enough to make facing into it a miserable experience. I thought I was well dressed, but I had neglected the space between my eyes that is now feeling painful. I hope it's not freezing!

Speaking of freezing, this metal flyer pin seems to be sucking the warmth right through my glove. The problem is solved by putting a mitten over my gloves. It just goes to show you, there's no such thing as bad weather in Alaska, just bad clothing!

It's after 10 p.m. and it feels good to think I finally have this "juggy thing" down now. I feel even better when the party manager calls everybody back into camp. I'm used to going to bed at this time after watching the late news, but tonight I'm dead tired and in the middle of nowhere, 800 miles from home. The approaching lights of camp offer some degree of comfort.

Upon returning to camp, the truck must be refueled, cleaned, and inspected. Then it's time for the highlight of the day - dinner! I can't decide between the steak, shrimp, or pork chops, so I take all three plus several vegetables, various salads, and a roll. No offense to my mother, but this is the best cooking I've had since Thanksgiving. I only wish my plate were bigger!

The delicious feast helped me forget all the work I did earlier today, but I'm rudely reminded when my stiff muscles keep me from reaching my back while in the shower. Some shower water seeps into my mouth and it tastes awful! I later learn that the shower, sink, and laundry water is made from melted snow. I guess I'll get used to it. All I care about right now is getting some sleep, so I don't bother to dry my hair. During the short, 50-yard walk from the shower trailer to my room, my hair freezes!

I turn the lights on to see my three roommates already asleep despite the drone of diesel generators and the melody of snores. My noisy entrance doesn't even phase them.

STOMP - STOMP - CLICK. I jolt upright in my bed wondering where I am. The dark room fills with invisible cold and I see the face of the cook staring back at me from the doorway. "Six o'clock, rock and roll", then he slams the door. Here we go again...

Mystery Item

The Mystery Item for the May GSHJ is a Worden Gravity Meter from 1950.

Mystery Item on page 30.



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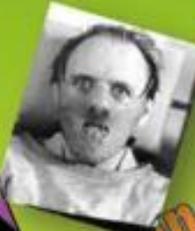
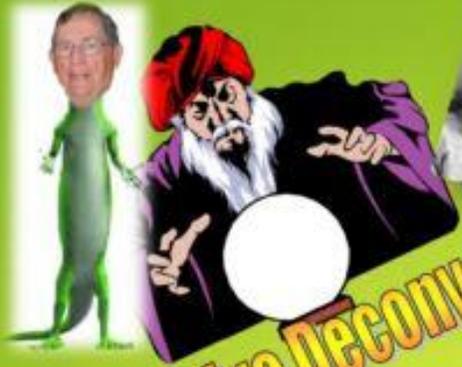
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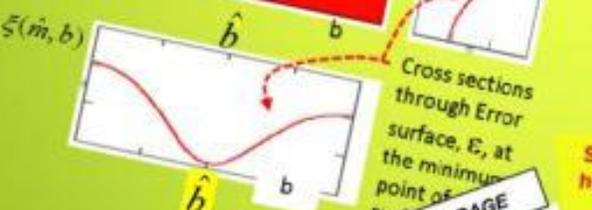
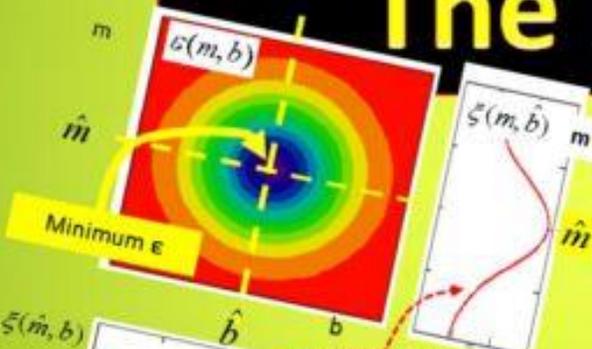
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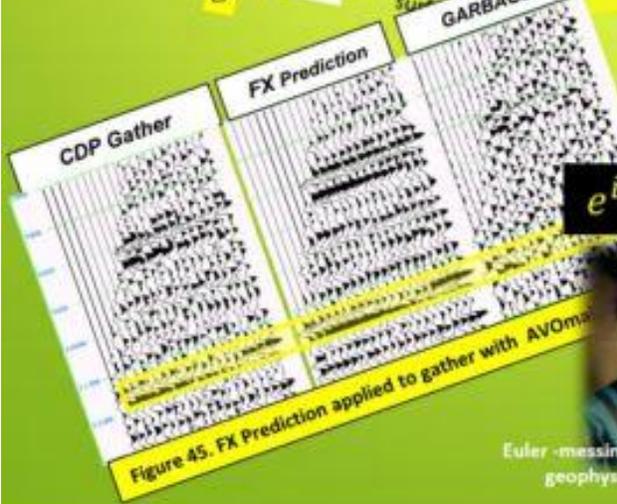
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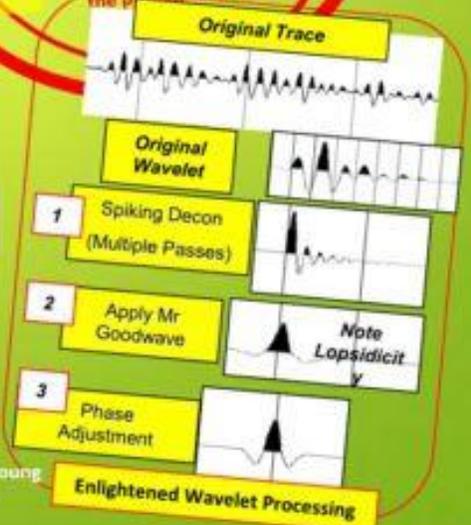
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