December 2016

GSH Journal

GEOPHYSICAL SOCIETY OF HOUSTON
Volume 7 • Number 4

The Epicenter of Geophysical Excellence

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LOOK INSIDE

On The Cover...

Global Geophysical land operations as summer turns to fall.

Photo courtesy of Global Geophysical.

EDITOR'S NOTE

To ensure your information reaches the GSH members in a timely manner, please note the following deadlines and plan accordingly. Please submit your articles and any questions to David W. Watts, editor, at DWatts1@slb.com.

2016 GSH JOURNAL DEADLINES

Feb 2017	Dec 3
Mar 2017	Jan 3
Apr 2017	Feb 2

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A Word from the Board

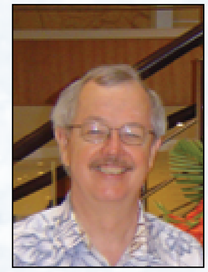
Times They Are a Changin'

By Tommie Rape, President Elect

As I contemplated what to share with you in this column, I thought a lot about the Geophysical Society of Houston (GSH) and what it has meant to me. Reflecting on my current position as President Elect my thoughts centered on two aspects - (1) what I hope to achieve for the GSH during my tenure, and (2) a small amount of intimidation at the rich company of current and past officers of this extraordinary organization. Discussion on that first item can wait, but I want to expound a little on that second issue.

Like most of you I entered the GSH with no intent to get heavily involved in it. I just thought that it was a bargain in the opportunities it provided for me to increase my awareness and understanding of the many relevant current technical issues in geophysics. It bears repeating that the GSH offers more than 80 technical events a year with presentations by many of the current leading geophysicists in the world. For many years, I continued in that mode of attending a few GSH events a year where talks of interest and my work schedule intersected. And my limited involvement in the GSH still paid off with the technical education it provided.

During those years, I had friends and knew others that became much more heavily involved with the GSH in various leadership roles. I admired what they were doing and often thought about following their lead, but I just was not sure that my interest or available time was sufficient for my stepping up. But then the GSH Editor, Raj Shrestha, for whom I owe a debt of gratitude, asked me to be an Assistant Editor and help him out. That experience was very fulfilling, and besides sharpening my editing skills, provided me with the opportunity to see a little closer the inner workings and the leadership of the GSH. That led to two years of my being in the Editor role, working on several committees, and then my more recent entrance into the President Elect position.



Tommie Rape, President Elect

I recently looked at the list of past leaders of the GSH, which will soon be posted on the GSH website, and this is where the intimidation factor arose. I was taken aback at the amazing list of GSH past officers, which included many of the most well know geophysicists in the world. Now many of these past officers were similar to me in being the more common garden variety of lesser known geophysicists (though still being very technically proficient and accomplished). And that is a compliment, because I include myself in that category. But they all, through good and bad times, stepped up to build the GSH into the largest and BEST Section within the SEG.

Though normally a confident person, I still desperately want to live up to the example shown by the many great past leaders. I greatly admire many of these people who, beyond holding officer positions, still continue to step up to help the GSH in many important roles. I have to raise a shout-out for many of these people: Lee Lawyer, Haynie Stringer, Mike Graul, Scott Singleton, Bill Gafford, Dave Agarwal, and Frank Dumanoir. Now I assumed a leadership role initially because someone asked me to. But I have an extra bit of admiration for those who stepped up on their own and volunteered to help the GSH in various tasks, and then eventually stepped into higher and higher roles of responsibility, including officer positions. I hope you do not wait as long as I did before experiencing the fulfillment of working with the GSH; so step up and volunteer in an area of your interest.

Continuing with the historical perspective, if you are like me and enjoy the subject of history, check out the list of past officers on our website. Also check out the GSH History:

Board of Directors Announcement

The Geophysical Society of Houston has had a change to our Board of Directors. Lee Bell has resigned from his role of First Vice President Elect and Neda Bundalo has resigned from her role as Secretary. In accordance with our bylaws, the Geophysical Society Board of Directors has unanimously voted to fill these vacant positions of First Vice President Elect and Secretary with Xianhuai Zhu and Nicola Maitland respectively. Please join us in welcoming Zhu and Nicola to the Board of Directors of your GSH.

Word from the Board continued on page 5.

Word from the Board continued from page 4.

https://www.gshtx.org/Public/About_GSH/History/public/About_GSH/History.aspx?hkey=6807ac65-9f09-4d71-b51f-baad854a6dd3

The GSH was formed in 1947 as the Houston Section of the Society of Exploration Geophysicists. Ten years later the name was changed to its current name. You will find interesting the many elements of growth and development of this organization, including the key founders, the growth in membership, the meeting locations, the growth of the Special Interest Groups (SIGs), the foundation and development of the Geoscience Center, etc.

"Times they are a-changin' ", and the industry is going through some tough times. But the GSH will continue to offer you opportunities - opportunities for self-improvement and opportunities for you to help others improve themselves. And though I may feel somewhat intimidated, I feel honored to fill one of these leadership positions and look forward to fulfilling the duties (and even doing a little more than that) in working with the other officers and GSH staff in keeping the GSH the best professional organization that it can be.

We appreciate our Corporate Members

Apache Corporation

ConocoPhillips

Seabed Geosolutions

For more information about becoming a Corporate Member, please contact the GSH office at 281-741-1624, or office@gshtx.org.

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

MICROSEISMIC SIG		
Case Examples, QC and Interpretations of Waveform-Based Moment Tensor Solutions		
Dec. 1, 2016	**Speaker(s):**	Alexander Droujinine, Shell
	11:30 AM to 1:00 PM	Sponsored by Apache Corporation
	Location:	Apache Corporation 2000 Post Oak Blvd. #100 Houston, TX 77056
DATA PROCESSING & ACQUISITION SIG		
Linking Seismic Imaging and Inversion: SEAM I Case Study		
Dec. 6, 2016	**Speaker(s):**	Konstantin Osypov, Chevron
	4:30 PM to 6:00 PM	Sponsored by Schlumberger
	Location:	Schlumberger, Q-Auditorium 10001 Richmond Avenue Houston, TX 77042
TECH BREAKFASTS		
Improving Tight Reservoir Definition Using Seismic Object Detection Within the Woodford Formation		
	Speaker(s):	Christopher P. Ross, PhD, Cross Quantitative Interpretation, LP
Dec. 6, 2016	***7:00 AM to 8:30 AM***	Sponsored by Anadarko and Lumina
Northside Breakfast	**Location:**	Anadarko Petroleum 1201 Lake Robbins Drive The Woodlands, TX 77380
Dec. 7, 2016	***7:00 AM to 8:30 AM***	Sponsored by Schlumberger
Westside Breakfast	**Location:**	Schlumberger, Q-Auditorium 10001 Richmond Avenue Houston, TX 77042
GEOSCIENCE COMPUTING SIG		
Annual HPC Market Update: The Good; The Bad & The Ugly		
Dec. 7, 2016	**Speaker(s):**	Addison Snell, CEO, Intersect360 Research
	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
ROCK PHYSICS SIG		
Seismic Wave Attenuation and Dispersion in Saturated Rocks		
Dec. 7, 2016	**Speaker(s):**	Professor Nicola Tisato, UT-Austin
	5:15 PM - 6:30 PM	Sponsored by CGG & Ikon Science
	Location:	CGG 10300 Town Park Dr. Houston, TX 77072
TECH LUNCHEONS		
Integrating Geological, Petrophysical and Seismic Rock Property Data to Identify Prospective Areas and High-grade Locations		
	Speaker(s):	Paola Fonseca, CGG GeoConsulting
Dec. 13, 2016	***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.)
Dec. 14, 2016	***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)
Dec. 15, 2016	***11:00 AM to 1:0 0 PM***	Sponsored by Data Direct Networks
Northside Luncheon	New Location **Location:**	Southwestern Energy Conference Center 10000 Energy Drive Spring, TX 77389 (Free Parking onsite)

Microseismic SIG

Case Examples, QC and Interpretations of Waveform-Based Moment Tensor Solutions

Register for Microseismic

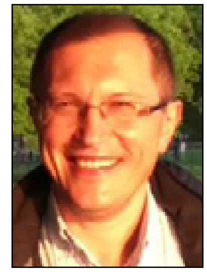
Speaker(s): *Alexander Droujinine, Shell*

Thursday, December 1, 2016
11:30 a.m. - 1:00 p.m.

Sponsored by Apache Corporation

Location: Apache Corporation
2000 Post Oak Blvd. #100
Houston, TX 770562

Abstract: The primary tool for understanding the heterogeneity of reservoirs and the complexity of fracture networks has been microseismic monitoring. It is known that source mechanisms (double-couple or full moment tensors) provide the means to estimate subsurface elastic properties linked to geological, geomechanical and in situ stress conditions. The waveform-based moment tensor inversion method presented here provides both focal mechanisms and tensile failure parameters obtained from full moment tensors. The method has been validated to help optimize the multi-stage hydraulic fracture stimulation (North America) and to monitor the induced seismic activity in a depleting gas reservoir (Oman). *More information is available online - www.gshtx.org.*



Alexander Droujinine

Biography: Alexander works in the Shell Projects & Technology team (Rijswijk, The Netherlands) as a senior geophysicist. In the recent years his main focus has been on passive seismic monitoring worldwide. Alexander joined Shell in 2006, after several years of service (as a geophysicist) for the British Geological Survey in Edinburgh, UK. He holds a PhD in geophysics from the Russian Academy of Sciences (1990).

Data Processing & Acquisition SIG

Linking Seismic Imaging and Inversion: SEAM I Case Study

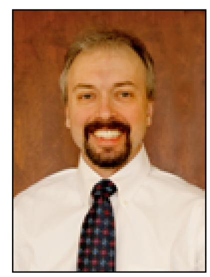
Register for Data Processing

Speaker(s): Konstantin Osypov, Chevron

Tuesday, December 6, 2016
4:30 p.m. Sign-in, Snacks, Social Time
5:00 p.m. Start of presentation

Sponsored by Schlumberger

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



Konstantin Osypov

Abstract: Seismic image and its attributes are essential in conditioning reservoir models. However, image resolution is limited and commonly not high enough to extract complex 3D facies geometries. While elastic full-waveform inversion in the full frequency band is gradually emerging, current industry practices still rely on a separation between imaging and inversion. This talk discusses the workflows combining imaging and inversion and the limitations of the approximations used. In particular, a common seismic inversion workflow relies on depth-to-time stretch of a depth image using an acoustic approximation (prestack or poststack) and 1-D convolutional model in time domain. This approximation is insufficient for complex 3D stratigraphy and strong multi-scale velocity heterogeneities. Furthermore, quantitative inversion requires accurate amplitude treatment in processing and "true amplitude" migration with illumination compensation not only for AVA/AVO purposes but even for poststack inversion and stratigraphic interpretation. 3D deconvolution/inversion in depth domain using point-spread functions (PSF) is an alternative emerging approach. The case study of acoustic and elastic SEAM I synthetic compares application of 1D and 3D deconvolution/inversion methods applied to RTM and Gaussian Beam images. Since SEAM elastic synthetic is a good approximation of a seismic experiment in the real Earth, the study reveals some insights on seismic resolution and pushes the envelope for enhancing extraction of reservoir models from the image.

Biography: Konstantin Osypov received his Ph.D. in geophysics from St. Petersburg University, Russia, in 1992. After working as a postdoc at the University of Uppsala, Sweden, and the Colorado School of Mines, he joined Western Geophysical R&D in Denver as a Senior Research Geophysicist in 1997. He has since held several positions with Schlumberger and WesternGeco in Moscow and Houston. His last assignment in Houston was Research Manager for Earth Model Building Technologies. He joined Chevron in Houston in 2014 and currently he is Project Manager, Interpretive Imaging Strategic Research.

Technical Breakfasts

Register for Tech Breakfast Northside

Register for Tech Breakfast Westside

Improving Tight Reservoir Definition Using Seismic Object Detection Within the Woodford Formation

Speaker(s): Christopher P. Ross, PhD
Cross Quantitative Interpretation, LP
cross@crossqi.com

Christopher P. Ross, PhD

Northside

Tuesday, December 6, 2016
7:00 – 8:30 a.m.

Sponsored by Anadarko and Lumina

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

Westside

Wednesday, December 7, 2016
7:00 – 8:30 a.m.

Sponsored by Schlumberger

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

Abstract:

Accurate evaluation of reservoir thickness and extent is crucial for drilling risk and economic development decisions. Often, this can be performed using available well logs integrated with high resolution 3D seismic data. Typically, acoustic impedance inversions are computed to mitigate wavelet effects and to better define the reservoir units directly, allowing a more straightforward interpretation of reservoir thickness, porosity and extent in terms of the sonic-density parameters. However, with thinner, tighter, more challenging geologies, the single attribute interpretation of acoustic impedance per se may not be refined sufficiently for unresolved seismic reservoirs with spatially varying lithologic properties. More progressive techniques such as seismic object detection involve multiple attributes, including prestack simultaneous inversion volumes and regularly better identify potential reservoirs, their extent and thickness, by classifying the interval geologies into seismic facies.

Seismic object detection is used to identify and define the silt and shale members of the Woodford Formation and the bounding Mississippian and Devonian carbonates of the Midland Basin in West Texas. The Woodford Silt is the reservoir of interest which is seismically-thin and has porosity ranges of 1% to 8% that varies laterally across the 110 square mile study area. Identifying carbonate, shale and silt seismic facies through multi-attribute object detection techniques facilitates better interpretation of the variable porosity silt deposits, and better differentiation from the underlying lower-impedance shale. Object class and relative probabilities of each facies are incorporated into the interpretation process to better assess the tight reservoir definition.

Biography:

Dr. Christopher P. Ross is currently president of Cross Quantitative Interpretation, LP, a quantitative interpretation consulting service company based in Santa Fe, New Mexico with clients in the United States and abroad. As an applied geophysicist by training, he specializes in technology-driven applications to help mitigate risk and improve drilling decisions for exploration and development projects. His focus areas are, but not limited to: seismic attributes; VSP; AVO modeling and analysis; simultaneous prestack inversion; multi-attribute (neural network) inversions; seismic overpressure analysis; and geostatistical projects.

Chris began his career as a geophysicist with Amoco Production Company, and has worked for various oil and gas companies and contractors as a special projects geophysicist, and as a manager of technical groups. He earned a PhD in Geophysics from Georgia Institute of Technology in 1992, a MS in Applied Physics in 1984 from University of New Orleans, and a BS in Geophysics from Virginia Polytechnic Institute in 1982. He is a patent holder, has published a large number of cited technical papers on AVO, and has received awards for presentations on similar topics. Chris is an active member of AAPG, AGU, EAEG, and SEG, and is a Texas Board Certified Geophysicist.

Chris resides in Santa Fe, New Mexico with his wife Ann and their dogs, and enjoys biking, hiking, skiing and the great climate of the nearby Sangre de Cristo and Jemez Mountains.

Geoscience Computing SIG

Annual HPC Market Update: The Good; The Bad & The Ugly

Register
for Geoscience Computing

The Geoscience Computing - Special Interest Group (SIG).

This SIG was established with the goal to be ***a vendor neutral, user centric.*** The benefits that will be derived by the members will come from the two-way communications provided through open forum meetings that will bring the geophysicists support community together to share technology, user experiences and maintain dialogs among its membership.

Meetings will address the areas of interest that have been defined by the high performance & supercomputing community and will be conducted in a round table discussion format.

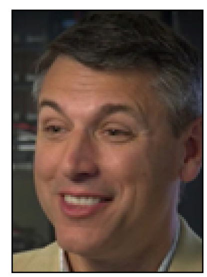
Technical presentations NOT SALES!!!

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

Speaker(s): Addison Snell, CEO, Intersect360 Research

Wednesday December 7, 2016
11:30 a.m. - 1:30 p.m.

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



Addison Snell

Sponsored by The Society of HPC Professionals and UDI

Abstract:

Intersect360 Research covers the changing market dynamics of users, technologies, and vendors in the Intersect360 Research HPC market advisory service. The end-user research that forms the foundation of the market advisory service leverages our exclusive HPC500 user organization, which incorporates both high performance technical computing (HPTC) and high performance business computing (HPBC) use cases worldwide, to provide a comprehensive view of the complete HPC industry.

Biography:

Addison Snell is the CEO of Intersect360 Research and a veteran of the High Performance Computing industry. He launched the company in 2007 as Tabor Research, a division of Tabor Communications, and served as that company's VP/GM until he and his partner, Christopher Willard, Ph.D., acquired Tabor Research in 2009. During his tenure, Addison has established Intersect360 Research as a premier source of market information, analysis, and consulting. He was named one of 2010's "People to Watch" by HPCwire.

Addison was previously an HPC industry analyst for IDC, where he was well-known among industry stakeholders. Prior to IDC, he gained recognition as a marketing leader and spokesperson for SGI's supercomputing products and strategy. Addison holds a master's degree from the Kellogg School of Management at Northwestern University and a bachelor's degree from the University of Pennsylvania.

Rock Physics SIG

Seismic Wave Attenuation and Dispersion in Saturated Rocks

Register
for Rock Physics

Speaker(s): Prof. Nicola Tisato, UT-Austin

Wednesday, December 7, 2016
5:15 p.m. Refreshments
5:30 p.m. Presentation Begins
6:30 p.m. Adjourn

Sponsored by CGG & Ikon Science

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

Prof. Nicola Tisato

Abstract:

Geophysical methods allow exploring the subsurface and rely on physical properties of rocks and their saturating phases. In the case of seismic tomography, the knowledge of rheology is pivotal to infer the structure and the content of subsurface domains. Nonetheless, very often geophysicists treat geo-material as purely elastic overlooking at the role of attenuation in absorbing seismic energy. During the presentation I will introduce anelasticity in saturated rocks and how fluids can produce frequency dependent attenuation and dispersion. Focusing on sandstones saturated with different portions of gas and liquids, I will present laboratory experiments performed to investigate wave-induced-fluid-flow and wave-induced-gas-exsolution-dissolution and how these attenuation mechanisms could be modelled revealing details about subsurface saturation. The present work aims at improving the imaging of subsurface to reveal, for instance, the formation of gas bubbles in oil and gas reservoirs.

Biography:

Nicola Tisato is an Assistant Professor in the Department of Geological Sciences - Jackson School of Geosciences - The University of Texas at Austin. His research focuses on the study of physical and mechanical properties of geo materials at pressure and temperature which are relevant for subsurface reservoirs. He especially uses the sub resonance method to understand visco elasticity in sediments saturated with multiphase fluids. Lately, he has paired the sub resonance method (i.e. a high pressure vessel) and the CT scanning method to measure viscoelastic properties of partially saturated sandstones and observe fluid distribution in the tested sample. Such a combination allows gaining insight into wave induced fluid flow and wave induced gas exsolution dissolution, which are important seismic wave attenuation mechanisms.

From the GSH Editorial Staff

May the New Year bring you happiness and prosperity!

Technical Luncheons

Register for Tech Lunch Westside | Register for Tech Lunch Downtown | Register for Tech Lunch Northside

Integrating Geological, Petrophysical and Seismic Rock Property Data to Identify Prospective Areas and High-grade Locations

Speaker(s): Paola Fonseca, CGG GeoConsulting
paola.fonseca@cgg.com

Sponsored by Data Direct Networks

Paola Fonseca

Westside

Tuesday, December 13, 2016
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, December 14, 2016
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)

Northside

Thursday, December 15, 2016
11:00 a.m. – 1:00 p.m.

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

Abstract:

New technologies in seismic acquisition, processing and reservoir characterization are allowing for a better understanding of hydrocarbon reservoirs. The ability to implement this complete technological value chain allows us to tackle the most complex exploration and development projects.

The focus of this study was a shallow water carbonate reservoir located in the southern Gulf of Mexico. The main objective was to identify areas associated with the presence of fractures and/or good porosity (often vuggy) to help delineate the areas with the greatest potential for hydrocarbon production within the carbonate reservoir. The characterization effort posed a significant challenge due to the many processes that have affected the reservoir's formation. Compaction, diagenesis, fracturing, dissolution, compressional and extensional processes, salt tectonics, among others have affected the reservoir to varying degrees, making for a very complicated geological environment, requiring optimal data for its analysis.

At the end of the process, we were able to high-grade prospective areas using lithology and porosity estimates from the integration of geologic and seismic data as well as fracture information derived from the azimuthal inversion process.

Biography:

Paola is a graduate of the Universidad de America in Colombia where she earned her Bachelor of Science in Petroleum Engineering in 2002. She has more than twelve years of experience as a petrophysicist working in both conventional and unconventional reservoirs. She began her career with Ecopetrol – ICP where she was responsible for the petrophysical evaluation of mature fields. Her work included the ongoing review, updates and improvements of the petrophysical model for the Llanito Field in the Basin through the Magdalena Valley and also work in the Piedmont Basin.

In 2007, she joined CGG in Ciudad del Carmen, Mexico where she worked on Cantarell Field projects, gaining a wide experience in the petrophysical characterization of naturally fractured reservoirs.

In 2012, Paola was transferred to the CGG Houston office to provide petrophysical interpretation and rock physics modelling expertise for inversion projects, gaining extensive experience working the unconventional plays in North America for seismic projects and regional integrated geological studies.

She has presented papers on the Porosity Discretization in Sihil (part of the Cantarell Field) in the Petroleum Congresses in both Mexico and Colombia, and also at the EAGE 2010 in Barcelona, Spain. She has authored and co-authored several papers and published a paper in the EAGE First Break.

Geoscientists Without Jobs: A Guide to Surviving the Downturn

Part Four: Virtual Networking and Social Media

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

In the previous installment, I wrote about the importance of real-life networking for geoscientists. Our jobs require multidisciplinary competence, so few managers are willing to hire experienced professionals without direct knowledge of their abilities. The best path to a job is through a trusted network, and the Internet is now our primary form of communication. Social media is a great way to raise your visibility in the community, but social media can be both used and abused in the quest for self-promotion.

Sites such as LinkedIn, Twitter and Facebook have utility, but they can become virtual Skinner boxes. They condition you to repeat behaviors by rewarding the pleasure centers of your brain; instead of food pellets, they give out "likes", re-tweets, profile views and endorsements. If you're on the job hunt, this may not be the best use of time. My favored strategy is to contribute only when it has both positive value and a low probability of reflecting poorly on me. The lessons learned are divided into positive (i.e., good uses of time), negative (so don't do them), or both simultaneously.

Things Positive

For me, social media's best use is maintaining connections to my real-world network of classmates and colleagues scattered across the globe. With the exception of chance meetings at conferences, I would lose touch with most were it not for the Internet. Some friends have directed me towards job prospects, offered advice, arranged introductions, and even referred me for consulting contracts. For such efforts I am truly grateful, and I reciprocate in whatever ways I am able.

If I'm looking for technical discussions and expertise, I spend time in places like Stack Exchange. The model here is egalitarian, whereby people pose questions to a community of experts, anyone can answer, and then peer review determines which answers rise to the top. Status and visibility are based purely on the value of your contributions to the community. If you have knowledge and experience, this is a great way to demonstrate it.

If you are willing to put in the time and learn the tools, social media sites provide ways to connect with people, do background research on companies and personnel, and showcase your knowledge and skills.

Things Negative

By contrast, you can easily spend your social media time in worse ways. Just because you can do something online, it doesn't mean you should. Activities to avoid include:

—Commenting on everything to boost your activity ranking. This only demonstrates you can game the system. The same can be said of endorsing people for skills without basis.

—Posting your political views (unless you are a career politician). You are guaranteed to alienate many potential clients, employers and co-workers.

—Commenting on anyone's appearance. No matter how you intend this, you will be seen as a cretin.

—Posting or commenting on irrelevant fluff. When Selena Gomez's Instagram was trending in the oil and gas groups this summer (yes, this actually happened), it made me weep for the

The best path to a job is through a trusted network, and the Internet is now our primary form of communication.

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future of humanity, and a small part of me wished for a giant asteroid impact.

Things Indeterminate

Some lessons are simultaneously positive and negative. After posting columns like these online, I receive comments and emails from people in similar situations for whom these ideas resonate; this is encouraging. Other comments are horror stories about people who lost everything, who have no hope, and suffer debilitating bouts of depression resulting from job loss. I can only hope to offer encouragement, but secretly fear this same abyss. After setting up a consulting website, I began receiving résumés, which is both flattering and heartbreaking. I always respond and try to point applicants in a more useful direction.

A final caveat should be made about interacting with professional contacts on sites where one typically interacts with friends and family (like Facebook); this is a double-edge sword. You may learn something that helps you connect to a colleague, or you may want to bathe in Lysol after peering inside their stream-of-consciousness. The risk one takes here is to completely alter your working relationships.

Conclusion

I'm old enough that I still view a computer as primarily a number-crunching device, so I marvel at how the device that once alienated me from society as a computer nerd is now the thing that connects everyone in a hyper-Darwinian social network. Social media is a tool, and like all tools with sharp edges, you must handle it with care. It is a particularly sharp tool when one considers how our digital footprints remain fossilized online for all to examine for eternity. Even if you're not looking for a job right now, your record is there for all future employers. Proceed with caution, and do your best to create value and increase the signal level rather than contribute to the noise.

What Does "BroadBand" Mean to an Interpreter

By David Monk, Grant Byerley, Apache Corporation

This is the first of two articles on broadband seismic data and its uses in hydrocarbon exploration and production. This article focuses on the basics of broadband acquisition and processing and how this impacts seismic interpretation. Next month we will follow up with a case history of broadband seismic acquisition, processing and interpretation on an unconventional play in Oklahoma.

Summary

The development of so called "Broadband" data has fundamentally changed the information content of seismic volumes and helped the interpreter get closer to the goal of direct determination of commercially producible hydrocarbons from seismic data. However, "Broadband" comes in many different varieties, and not all are equal. It is important to understand how the bandwidth of data is achieved and what limits the usefulness of Broadband data. In this paper we review some of the basics of Broadband acquisition and processing, and uncover some of the fallacies and truths about resolution in seismic interpretation.

Introduction

What does "Broadband" really mean? Ten years ago the emphasis on increasing bandwidth of seismic data was to improve the high frequency component of the spectrum. There were many methodologies proposed for processing seismic data that were aimed at recovering, or generating frequencies which were lost due to absorption, inter-bedding or simply not generated at the source. It's interesting to note that most of the emphasis at this point was on processing methodologies, and not on acquisition.

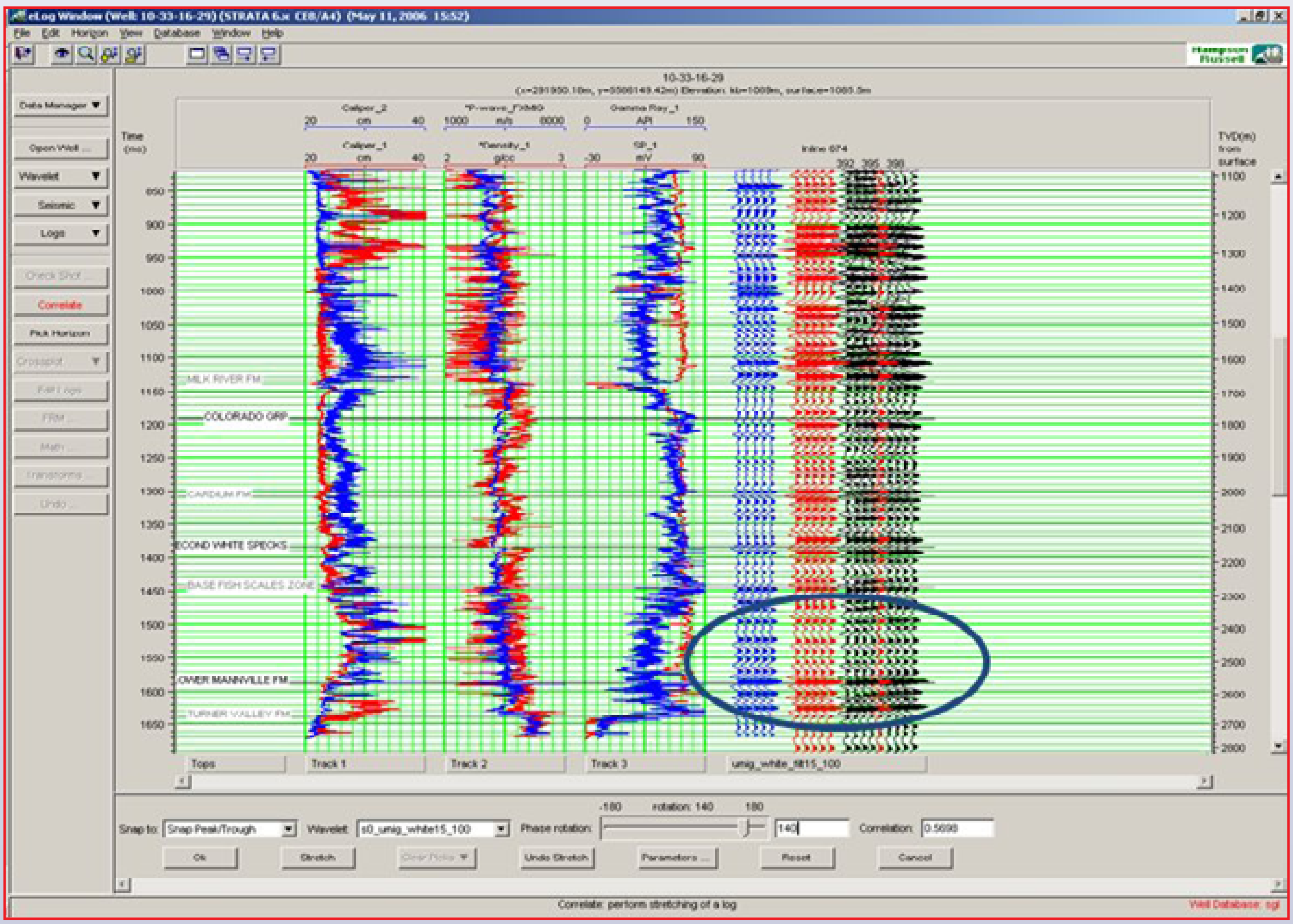

Figure 1: Well tie to convention and bandwidth enhanced seismic. Blue traces are repeated well synthetic, Red traces are repeated seismic traces from the set of seismic traces shown in black. Note the well tie in the zone of interest highlighted.

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The hope for the interpreter was that increased bandwidth would lead to increased resolution, and the ability to determine the presence of thin or thinner beds.

There is no doubt that processing methods exist where the output has a much higher bandwidth than the input. However, it's not always clear that additional information has been added for interpretation. One could achieve a high frequency result by picking reflection events in the seismic as a series of spikes and then convolving a new wavelet with higher bandwidth onto the resultant spike series.

Despite the obvious difficulty in trying to generate signal with frequencies that were absent or significantly attenuated at the input stage, it is clear that some methods do have the potential to improve the high frequency content of data.

From the interpreter's viewpoint, a healthy skeptic will always revert to checking the correlation of data with a well synthetic. An example of successful bandwidth extension for high frequencies is shown in *Figure 1* which shows the well tie to aconventional seismic result and the tie to a bandwidth broadened result, with a new synthetic and higher frequency wavelet. In this case, it is clear that additional "events" in the seismic tie with the synthetic, and broader band data has potentially helped the interpretation.

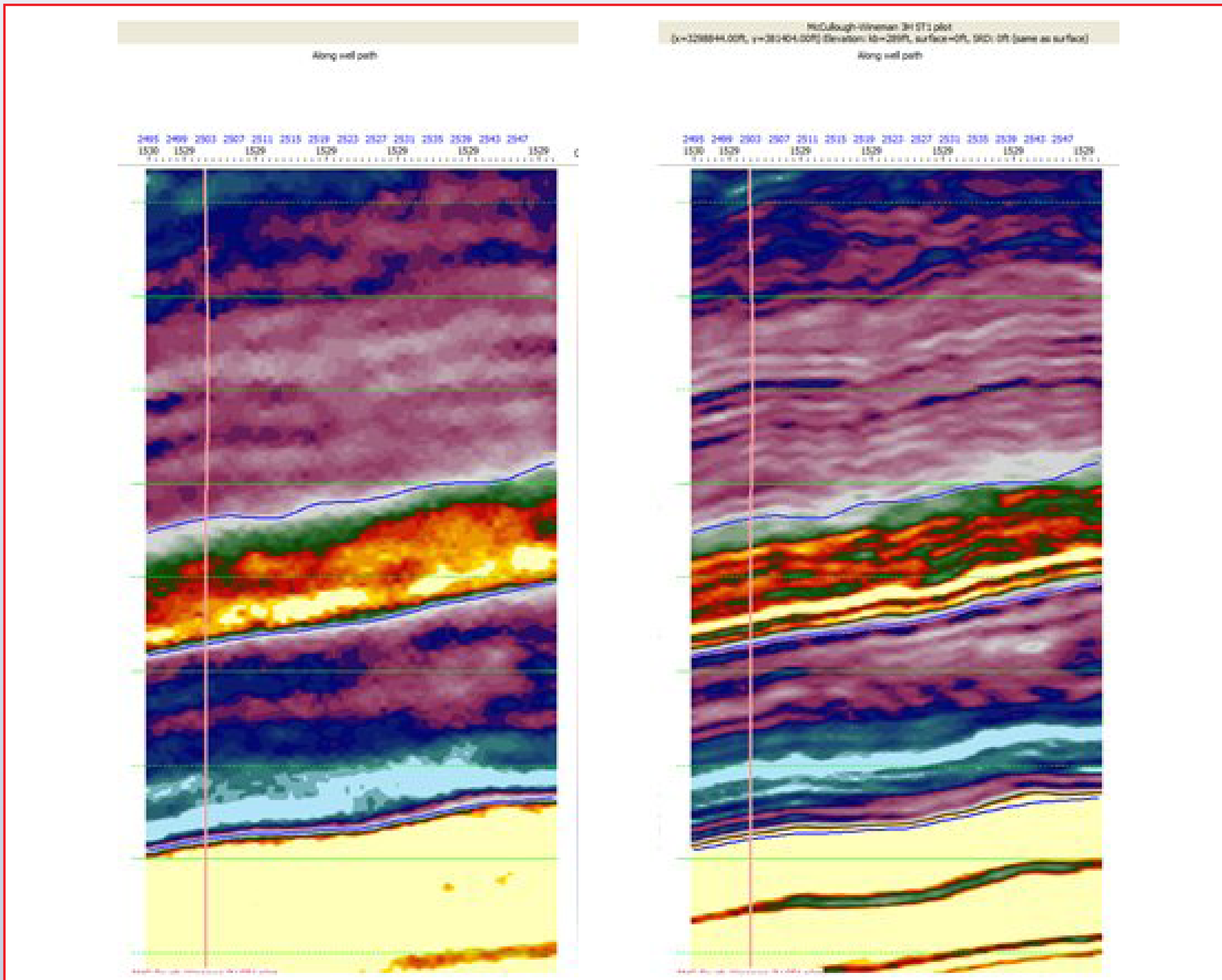

Figure 2: Example of inversion result obtained from conventional data (left), and bandwidth broadened (high frequency) on the right.

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Figure 2, shows the result of an inversion to rock property (in this case P impedance) from conventionally processed data on the left, and from bandwidth broadened data on the right. More detail of the thin beds are obvious in the result from the data where higher frequencies have been enhanced, and the well tie (not shown) is also improved.

Broadband Today

However, during the last 5 years "Broadband" data has come to mean something different. Rather than trying to recover the higher frequencies in the seismic, the emphasis has been on recovery of low frequencies. While lower frequencies are typically less attenuated as they travel though the earth, they may be difficult to generate in a land environment, and are naturally cancelled in a typical marine acquisition situation. It is useful to understand why the emphasis has changed before reviewing how the additional low frequencies from today's Broadband seismic have aided interpretation.

The benefits of lower frequency data

While a higher bandwidth can help resolve thin beds, and the boundaries associated with changes in the subsurface layers, it is the lower frequencies that allow the interpreter to start to get a better quantitative understanding of the subsurface geology and the rock properties. Consider the upper illustration in *Figure 3*. This shows a seismic trace generated using a "full bandwidth" wavelet (a spike), in response to a single layer in the subsurface. The right side of the figure illustrates the relative acoustic impedance that would be derived from this seismic trace (in this case by simple integration of the seismic), and it perfectly represents the model.

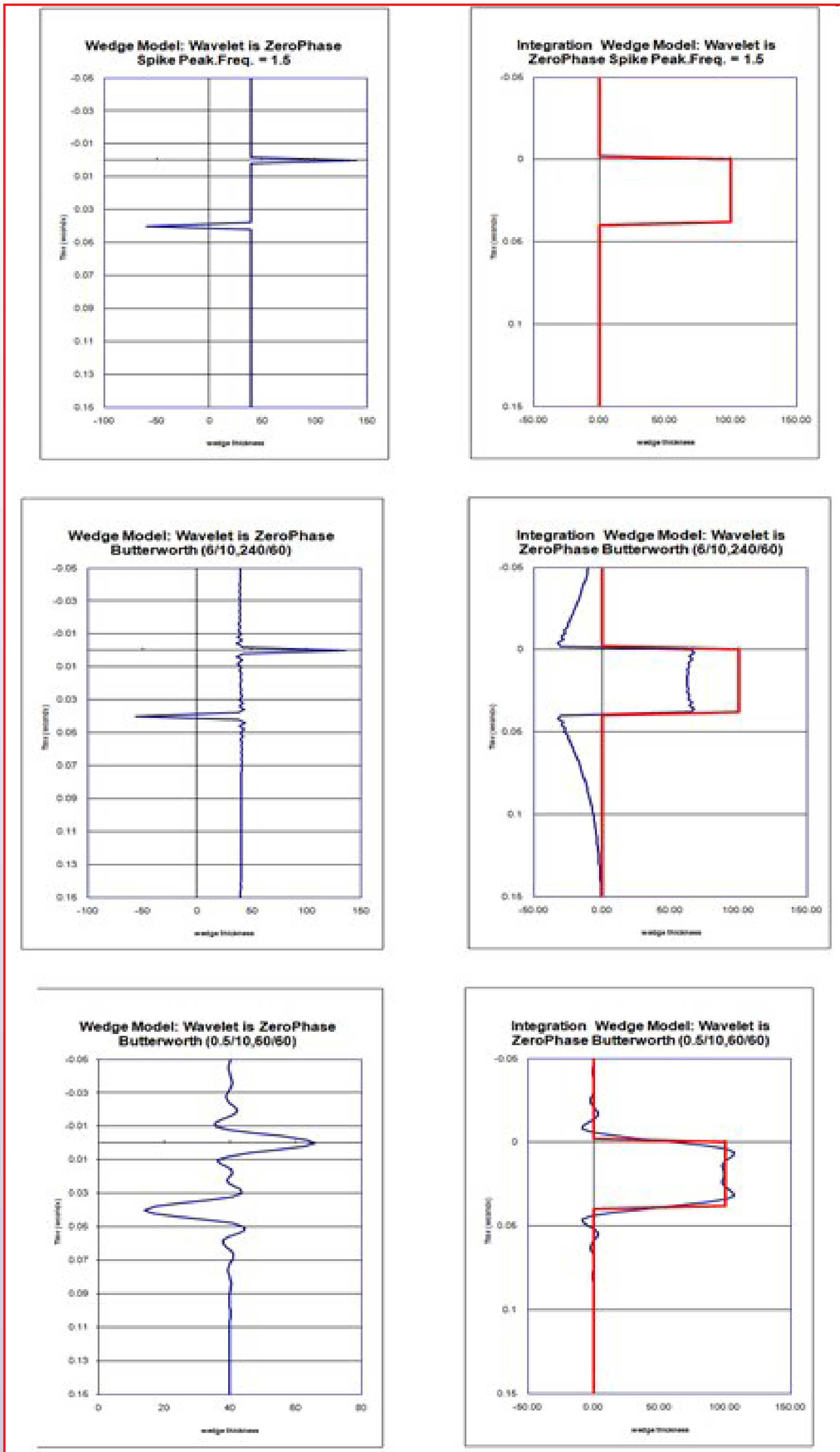

Figure 3: Inversion of seismic for a simple, single layer. Top: Broadband wavelet; Middle High frequency wavelet; Bottom, Low frequency wavelet.

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The second pair of figures illustrate the result when the wavelet is deficient in low frequencies. The seismic trace looks to be almost equivalent to the perfect result, but the inversion is not. While the boundaries of the layer are readily identifiable, the inversion has produced the poor estimate of acoustic impedance in the model layer. A fundamental problem for quantitative interpretation of rock properties. A real data example illustrating exactly this phenomena is shown later in *Figure 7*. Now consider the result when the wavelet is deficient in high frequency content which is shown at the bottom of *Figure 3*. While the boundaries of the layer are less accurately indicated, the value of acoustic impedance in the layer is now much closer to the correct value. It is the low frequencies that are critical for accurate determination of the acoustic impedance in this model. This example demonstrates the importance of having good low-end bandwidth to reduce the influence low frequency models often have in the inversion process. The savy interpreter who understands the uplift from this increased bandwidth will often forego the timely inversion process and interpret on simple integrated trace volumes for this reason.

The problem in a Marine Environment

Marine acquisition is fundamentally constrained in that the data is acquired below the water surface. This water/air interface acts as an almost perfect reflector and reflects upward travelling energy from the source back down, and also reflects energy that has passed the receiver as it returns from the subsurface. In both cases the result is that some components of the seismic bandwidth are enhanced, and some are attenuated. However, regardless of the depth of source and receiver, there is always a "notch" in the spectrum at zero Hz, and the lowest frequencies are attenuated at both the source and receiver ends of the raypath by this surface "ghost".

Marine solutions

Marine acquisition offers the potential to reduce the impact of the surface ghost in several ways. While there are a plethora of commercial offerings, these can be described generically as:

- Deployment of streamers at two different depths. This yields the potential to distinguish the up-going energy from the down-going energy at each point along the streamer. *Figure 4* shows the ghost notches present on streamers with different deployment depths. Note how the notches in the spectrum vary, and can potentially be "filled in" by use of streamers at two different

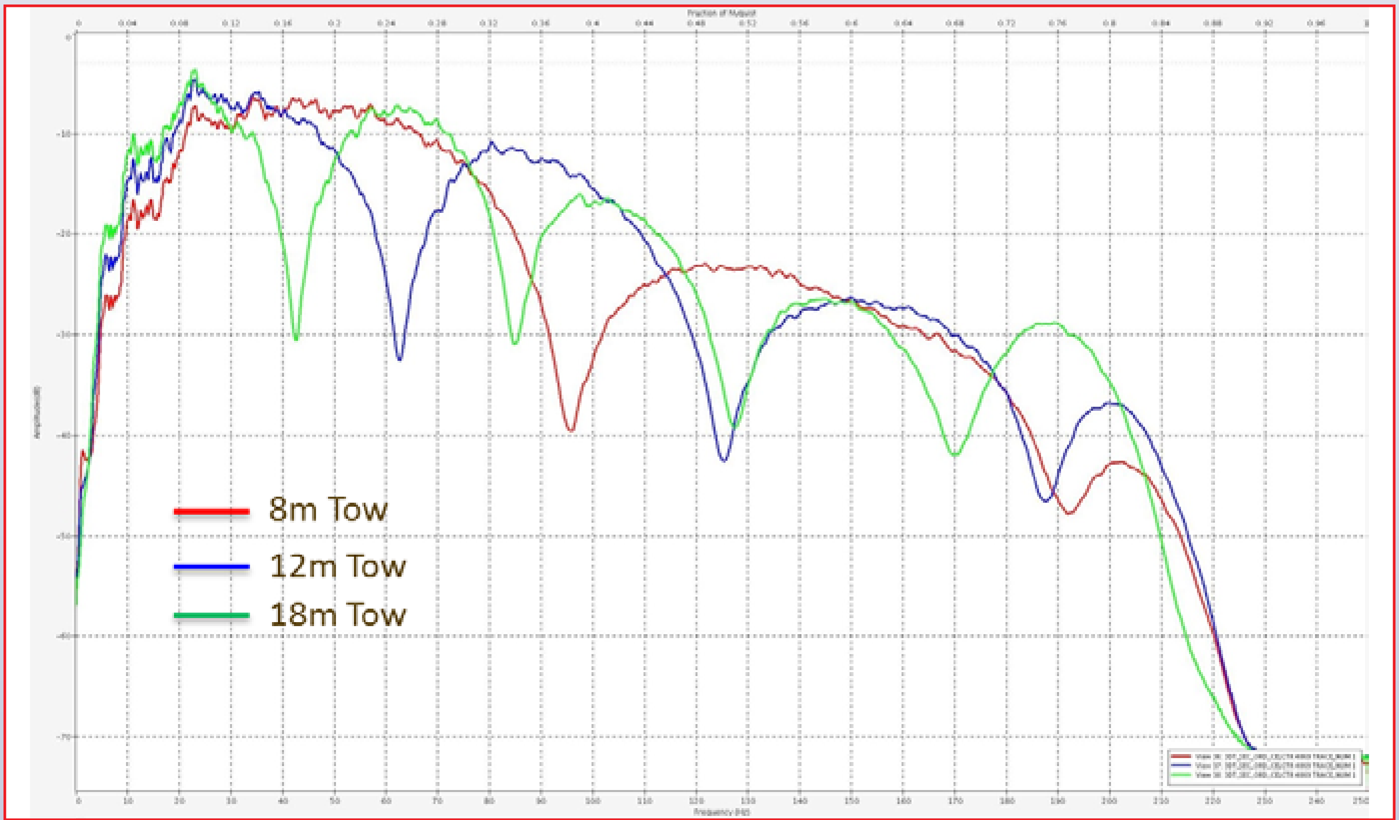

Figure 4: Spectral analysis of stacked marine seismic data recorded with 8m (red), 12m (blue) and 18m (green) streamer deployment.

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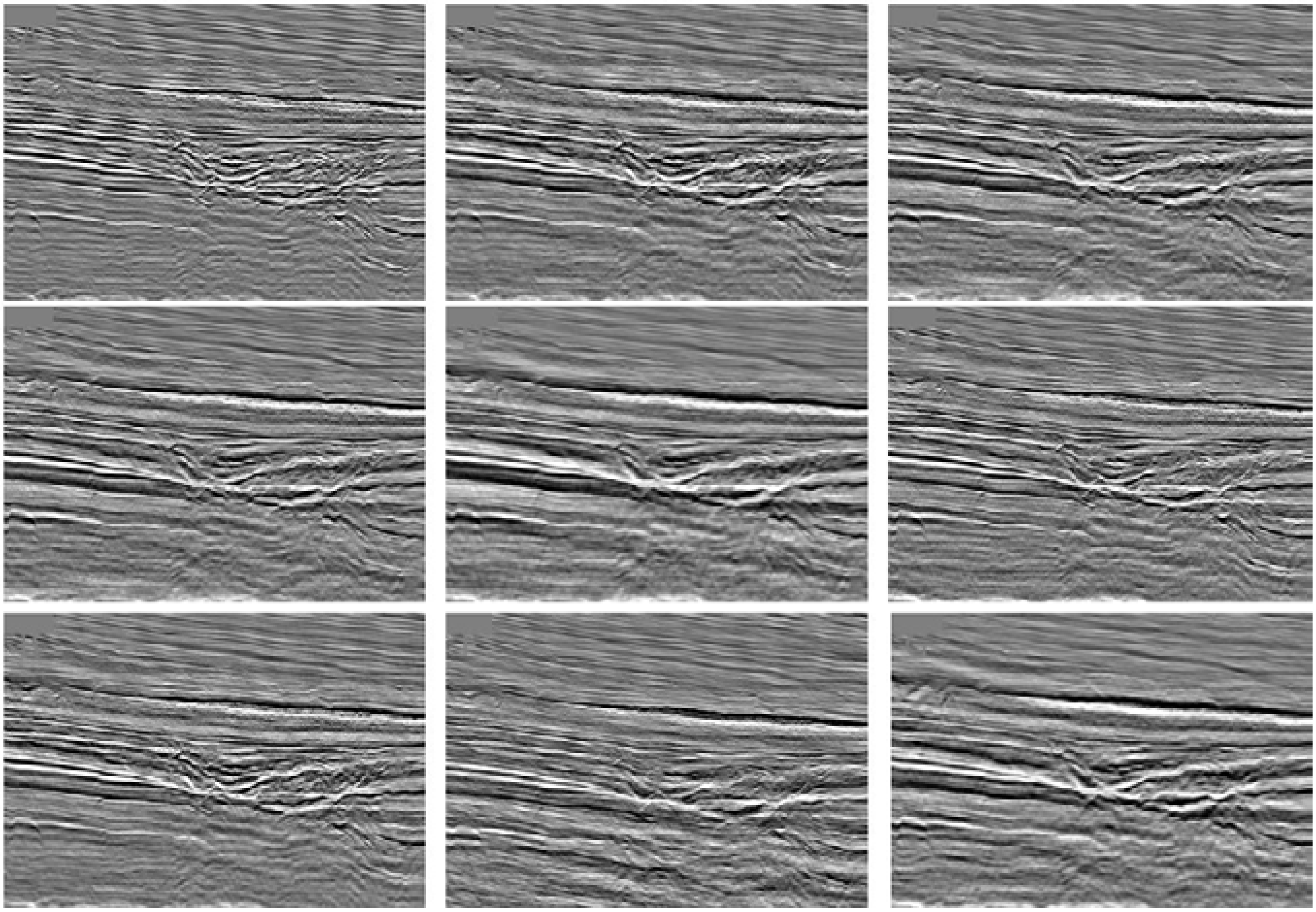

Figure 5: Examples of "Broadband" data. Section on the top left is conventionally acquired and processed seismic. Other sections are a variety of acquisition and processing methods designed to deliver "Broadband" results.

depths. The notch at zero Hz, is reduced by using the deepest streamer deployment to allow recovery of data as close to DC as possible.

- The obvious extension of two streamers at different depths is deployment of a single streamer with depth variations along the streamer. Such "slant" streamer deployments do not permit wavefield separation given only data from a single offset, but by examining all offsets it is possible to distinguish the up and down going energy through the variation of effective ghost notch. Often referred to as "notch diversity".

- Deployment of a streamer which contains both pressure and velocity sensors. Since the detectors can be arranged so that the up-going energy is in phase, the down-going ghost will be 180 degrees out of phase, and separation is therefore possible.

- Deployment of a streamer that not only contains pressure and velocity sensors, but also horizontal pressure gradient sensors, which potentially allow a more complete understanding of the wavefield, and offer the potential to go beyond simple 2D deghosting.

There are less options for "deghosting" the source end of the raypath. Dual depth sources have been used, and on rare occasions the potential for a surface deployment of the source has been considered. The advent of new marine acquisition methods which lead to deghosted data and improved bandwidth has driven a re-examination in the industry as to whether conventionally acquired marine streamer data can be processed and deghosted. The number of processing methods proposed and offered for performing deghosting has far exceeded the number of acquisition methods, and while it is relatively easy to "flatten" the spectrum of a seismic trace, it's not always clear that this is the same as removing the ghost and adding signal content where previously there was none. A detailed description of individual processing methods is beyond the scope of this paper, but it is sufficient to

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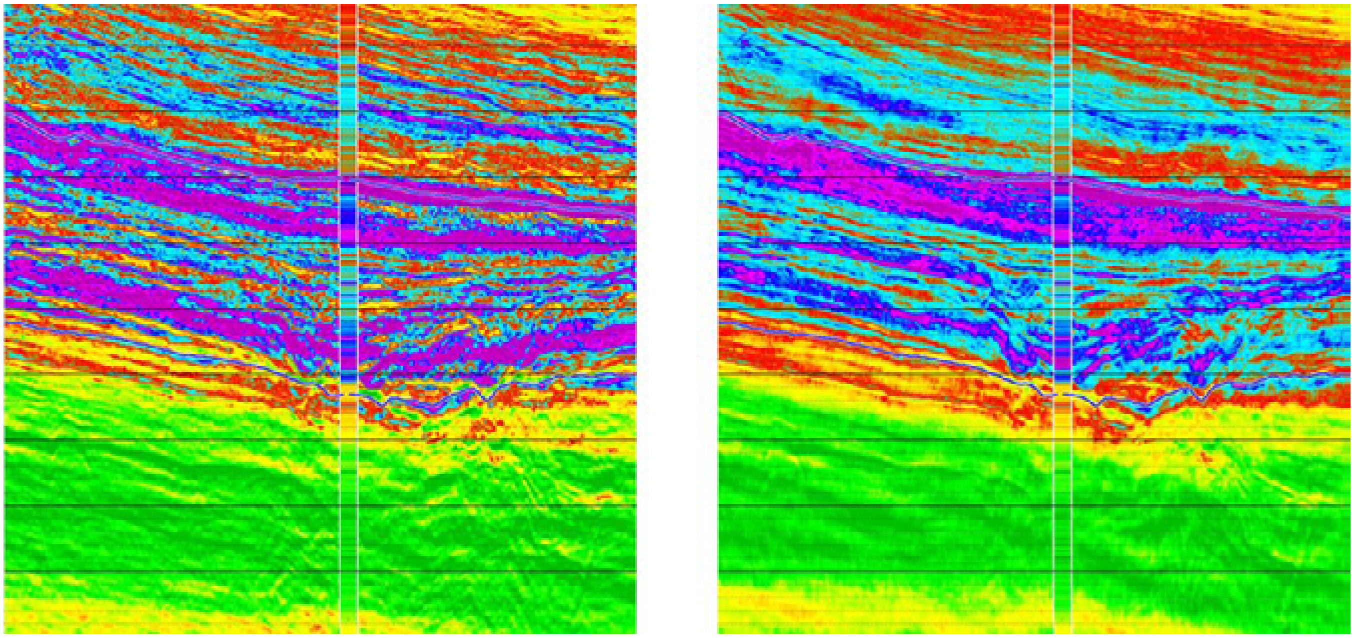

Figure 6: Inversion comparison tied to well data. Left: Conventionally acquired and processed data. Right: Broadband result from method resulting in stable, narrow, low side lobe wavelet.

say that the reader can easily find dozens of methods which claim to deghost seismic data.

The interpreter's dilemma

Given the enormous number of potential methods to achieve Broadband data in a marine environment, the interpreter may be faced with a variety of results, and must try to evaluate which is actually the best representation of the subsurface. *Figure 5* illustrates the problem. The section on the top right is from a conventionally acquired and processed data volume. The other sections are all "BroadBand" results generated by a variety of contractors using different acquisition and processing methods. For this particular test, this is a subset of close to 40 data volumes. Clearly a visual evaluation of the data is inadequate to assess which of these data sets is a best representation of the earth. There are at least two possible ways to evaluate these datasets, and once again, both rely on having "hard" data from a well. The first is to simply examine the implied wavelets on each data volume through well ties to see which has the most compact wavelet with the highest peak to side lobe ratio , but a better option is to invert the data to a known/measured rock property and see which gives the best tie to well control.

In this case the inversion to rock properties for some of the data shown in *Figure 5* is shown in *Figure 6*. The inversion result on the left is from the conventional data, and the result on the right is from one of the Broadband data volumes. In both cases, the same well data is displayed and tied in the center of the figures. The improvement in tie to the well data is significant, and interpretation is likely to be far more quantitatively accurate.

Data evolution example through Broadband processing

As a real example of the improvement that is possible only through modern "Broadband" processing of marine seismic data, *Figure 7* illustrates data from the Forties field in the North sea processed through various methodologies and subsequently inverted to sand/shale lithology volumes (all band limited with no influence from low frequency models). All the data is modern acquisition using a "Q" marine system, but does not involve a field technique to deghost the data. The results are therefore indicative of improvement through processing and not acquisition. The top section is processed conventionally using colored inversion. Note in particular the tie to wells (GR logs shown), and how this volume stuggles to accurately show the thicker Forties sands deeper in the section. The middle section uses a processing scheme directed at improving the low frequency content of the data. Note now that it is not just the top reservoir that is defined, but the thicker Forties channel sands become resolvable. Finally in the bottom section, processing has additionally used a deghosting technique to remove the receiver ghost. Note how the more complex stratigraphy of the stacked channel sands defining the Forties reservoir are better resolved.

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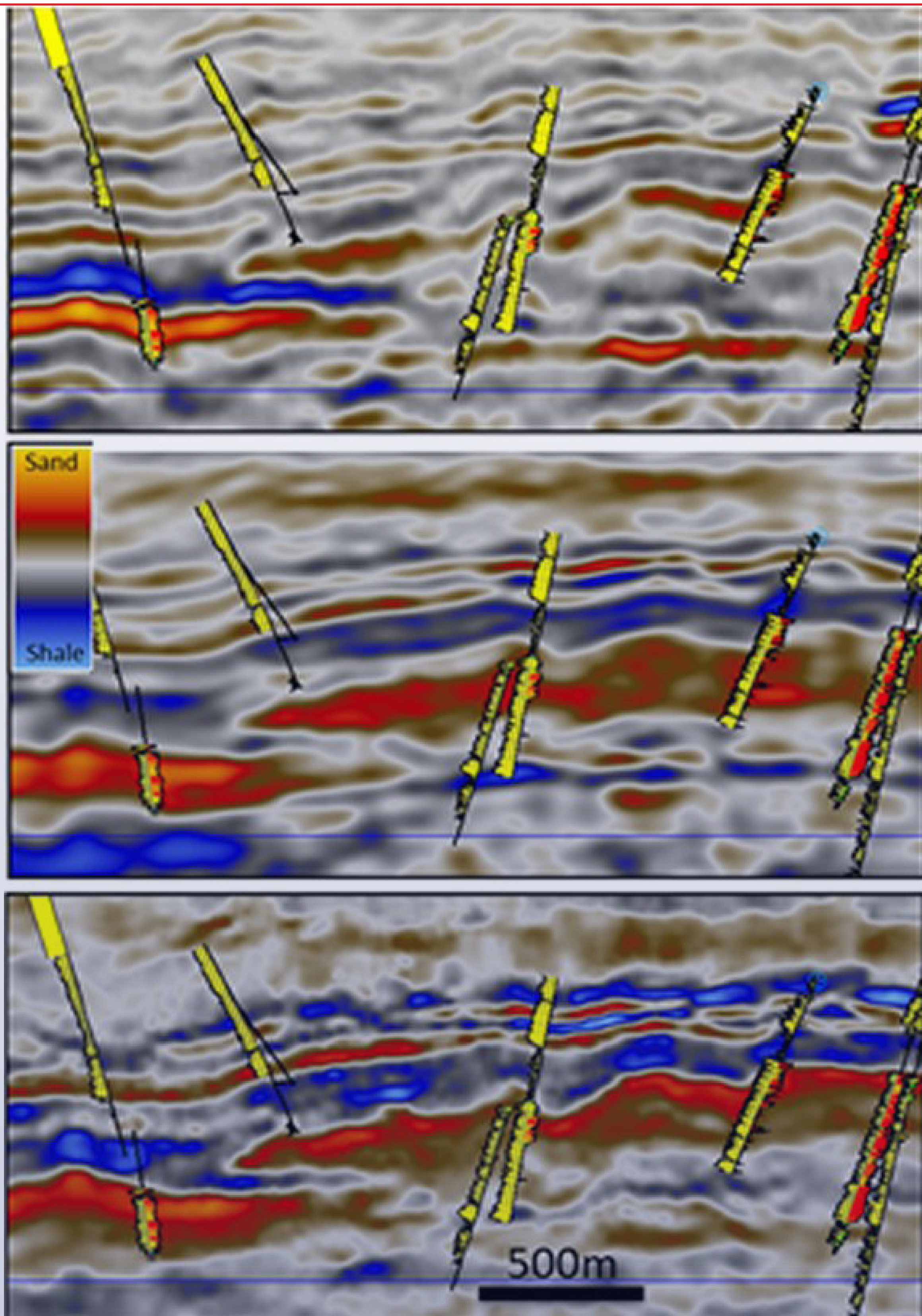

Figure 7: Interpretation uplift in band-limited inverted lithology data from broadband processing. Top: Conventional processing. Middle; Improved wavelet stability and focus on low frequency. Bottom: Processing includes streamer deghosting.

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The interpretation benefits of Broadband processing in this case helped de-risk over 20 new successful infill wells at Forties since the broadband lithology volume was first generated in 2014.

Land Seismic

In a review paper such as this it is impossible to cover all the aspects of acquisition and processing in both land and marine environments. Dens et.al. 2013 ask the question of whether land broadband seismic can be as good as marine broadband, and rightly conclude that the issues are both different, and similar, in that source, receiver and survey design all play a role. Buried dynamite generates a source ghost, albeit typically not as strong as a marine ghost, and until recently Vibroseis sweeps were constrained to start at 6Hz or higher due to the mechanical limitations of the device. New vibrators, and control systems (see for example Wei and Phillips 2012) have pushed this limit close to (and some would claim even below) 1Hz.

In the past the industry has perhaps not paid enough attention to the response of detectors at very low frequency and it has been suggested (Chiu et.al 2012) that if properly processed, data from a typical 10Hz geophone can be made to match that of a 2Hz phone down to very low frequencies. Suggesting perhaps that we do not need new instrumentation, we simply need to take more care of how we process data. *Figure 8* shows a land data example where conventional statistical deconvolution has been performed, with and without deterministic correction of the geophone response before the deconvolution. What looks like noise at frequencies below 6Hz without correction for the geophone response, now looks like signal.

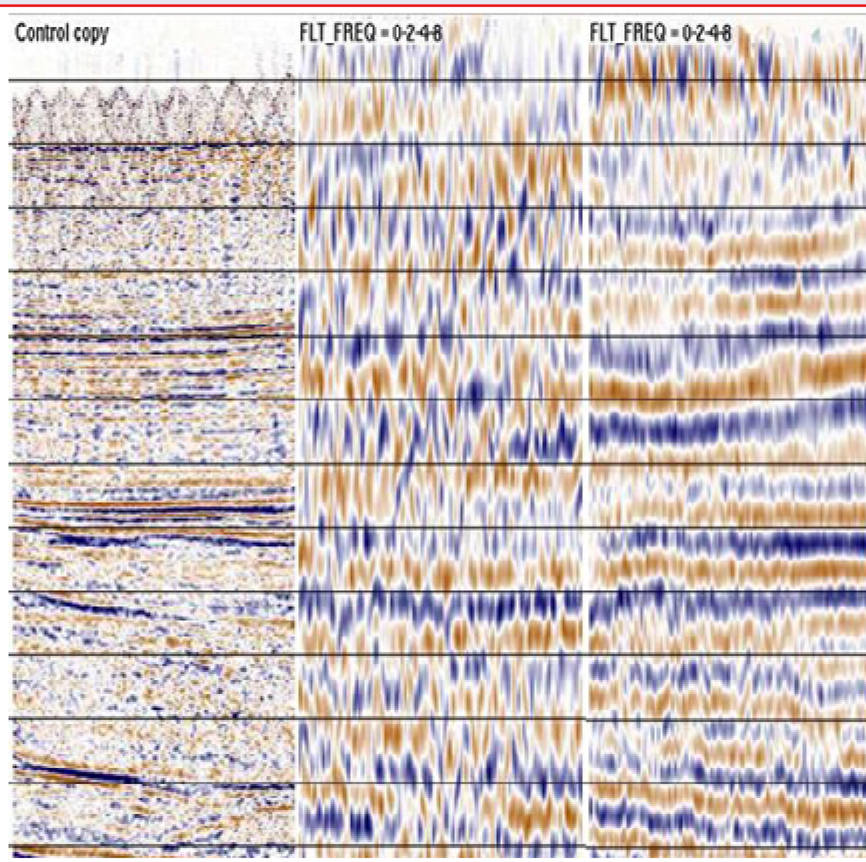


Figure 8: Stack data: Left: full bandwidth input, Middle 1-6Hz bandpass after deconvolution; Right 1-6Hz with receiver response correction prior to deconvolution.

Conclusions

Through the continued development of Broadband data we are getting closer to the interpreters goal of obtaining quantitative measures of commercially producible hydrocarbons from seismic data. Development of techniques for acquiring and processing this type of data continues to evolve, and this paper has deliberately avoided making comparisons between different methodologies.

All the new acquisition techniques suggested here have merit, and while some processing techniques are better than others, it is almost impossible to keep up with the day to day developments of new methods of processing to achieve Broadband results. The reader is only to look at the other papers presented at meetings this year (and I suspect also at this meeting) to see that developments continue.

Acknowledgements

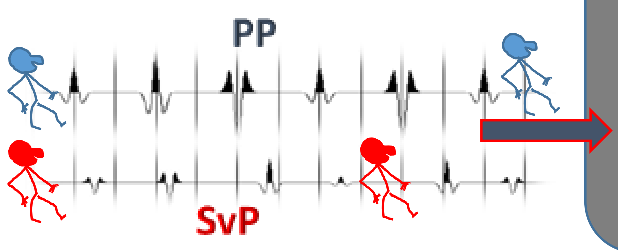
Many companies have contributed to this review, but I would like to recognize the contributions of current and previous colleagues at Apache in Australia, USA, and UK.

http://dx.doi.org/10.1190/segam2016-13862744.1

Tutorial Nuggets
By Mike Graul

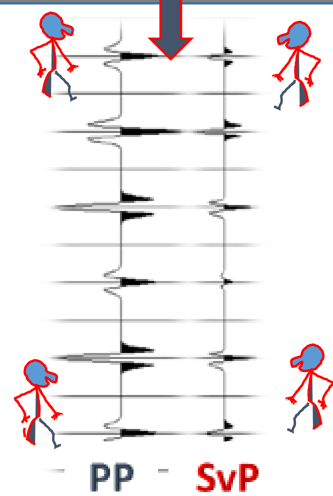
Converted Wave Exploration

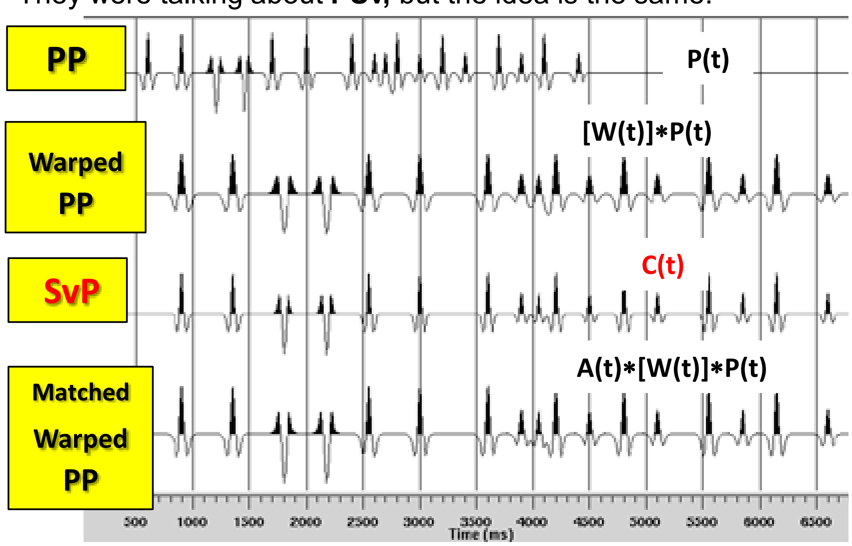
(Continued from the Late Tertiary)



While the short cut to effective registration of **PP** and **SvP** reflections is through PSDMigration, there is a need to consider the intermediate processing step of **PSTM** and the proper time alignment (registration) of common interface reflections which have traveled at different **velocities**, along different **paths**, but ended up at a common image point (**CIP**).

In the time domain, it's necessary to **"warp"** the time scale of one mode to match the reflection time of the other. This concept was published by Sergey **Fomel** and the **Warpers** (Mike **DeAngelo,** Milo **Backus**, Paul **Murray**, and, of course, the Chief Convert, Bob **Hardage**). They were talking about **PSv,** but the idea is the same.





The original **PP** stack is time-warped to match the equivalent depths in converted wave time. The operator depends on the ratio, $\gamma = \frac{Vp}{Vs}$, which will generally vary with depth. For clarity, The Guru has rendered it constant at **2.** This reduces the warping function to **Tsp = (3/2)Tpp**. The stretching of **P(t)** trace results in a stretched wavelet with a narrowed frequency spectrum. This will be compensated by a filter, **a(t)**, which acts in the capacity of a **match filter**. The whole process is accomplished by an iterative **LSE** approach. In real life, the **P(t)** and **C(t)** waveforms will probably differ significantly, in comparison to those than shown here, in both amplitude and polarity. All this will be handled after the holidays, in 2017. In the meantime, enjoy yourself doing Nugget puzzles such as those on the next page.

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Tutorial Nuggets

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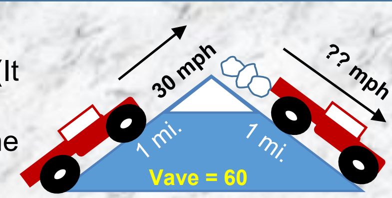
November's Impossibly Probable and Probably Impossible

ΔZ	Vint
1000 ft	2000 ft/s
1000 ft	3000 ft/s
1000 ft	4000 ft/s
1000 ft	6000 ft/s

In the model at the right, **what is the average velocity, Vave**, for the vertical reflection off the bottom layer? In other words, the average of the four given velocities traveling the same distance at each, respectively. Pretty obvious, eh?

This little puzzle is a kissing cousin of the old childhood teaser about a trip up and back down the other side of **Piker's Peak** (a parsimonious version of the famous Colorado mountain). From ground level to the Peak, the distance is precisely **1 mile**. From peak to ground level on the other side, it is the same. You're driving a 1999 Ford 150 and can manage a swift **30 mph** on the steep trip up.

The problem: **How fast** must you travel **down** the mountain in order to **average 60 mph?** (Tighten your seatbelt). Let's kick it around next month.



<u>Kick around time</u>. Let's look at the childhood teaser first. (It will make the answer to the first question easier to swallow.) The natural temptation is to answer **90 mph** going down the peak in order to **average 60**. **(30+90)/2 = 60**. Simple, eh?

Not **so fast** my friends. As you know, **60 mph** is equivalent to **1 mile per minute**. This means that for a **Vave = 60 mph**, the **2 mile** mountain trip must be completed in **2 minutes**, but wait a minute! [Excuse The Guru] You already **used 2 minutes** going up the mountain at **30 mph (1/2 mile per minute).** That leaves you **no time** to complete the second mile, which corresponds, roughly, to **Vdown ≈ ∝** (a rather zooming speed).

For this problem, the **average of 30 and ∝ is 60 m**ph. Life's not fair. Note that if you went up at 45 mph, then coming down at 90 would average 60 mph

Now we can attack the first part of November's problem which, incidentally, has practical significance for geophysicists (a large part of our reading public – now numbered at 5). The thing to keep in mind is the simple definition of average velocity:

$$V_{ave}(Z) = \frac{Z}{T} = \frac{\text{Total Distance}}{\text{Total Time}}$$

Note that **Vave(Z) = Vave(T),** just in case there was any question. For a mixture of velocities, there is a temptation to simply average them: **(V1 +V2 + V3 +V4)/4 = Vave.** For the problem above that would yield **Vave = 3750 ft/s**. While that looks sensible, does it meet the definition of average velocity? And perhaps more importantly, can the answer be used in the most fundamental of geophysical equations, **Z = (Vave)·(T/2)?** Unfortunately the answer is **NO** on both counts. Notice there is no hint of time in this calculation. This same problem arises when well meaning processors try to smooth (a running average) velocities in time or depth. Let's see how the averaging should be done.

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Tutorial Nuggets

Tutorial Nuggets continued from page 23.

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

Above, we have augmented our original table with 3 new columns: Total Time (**T**), Depth to the bottom of each layer (**Z**), and resulting average velocity, **Vave(Z).** Note the depth error that would result if one (not you, certainly) were to use the impulsively risky **Vave = 3750 ft/s** from the seemingly obvious calculation done by so many of our fellow travelers.

3750 · (2.500/2) = **4687.5 ft vs 3200** · (2.500/2) = **4000 ft**

Some people might consider an **error of 688 ft** at a depth of **4000 ft** fairly sizable.

Given **Vint(k)** and T_K, where Δt_K is the interval time in the Kth layer (**K = 1,2, …,N**) and T_K is the total time to the bottom of the Kth layer, one (you) may compute average velocity, **Vave(T_N)**, by using the following:

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

Note the distinction between the mindless averaging of velocities and the correct method (above), is that the latter is a **weighted average** which takes into consideration the amount of time, Δt_K, spent at each velocity, **Vint(k)** in computing the average. Note also that Δt_K may be **one-way or two-way time** as the factors of **2** are obliterated by an **M.A.D.** Agreement.

December - January Puzzle Nugget: While we're at it, let's put the ever-popular **Vrms** into the mix. For this purpose, **add your own column** to those given showing the **Vrms(T_K)** at each reflection time. In case it has slipped away over the holidays, the "rms" is **R**oot **M**ean **S**quared, which, in turn, suggests you find the **mean** (average) of the **squared velocity** and then put it back into the proper units of **feet/second** by taking the **Square root.**

Questions: **How is Vrms used? Why is it used?** Is it **accurate for this purpose?** Can it be use it for **depth conversion? Depth Migration?**

Merry Christmas!

A Conversation With ...

Bob Wegner *By Lee Lawyer*

Actually the story below was not part of a discussion with Bob. It was a result of many discussions trying to get him to write something down. In this story, he is with a Lamont research vessel called the RV VEMA, but the real story is the incredible amount of hard data that was obtained by that Institution and the cost of some of that data. Lamont had a marine seismic program in which dynamite was the source. The dynamite was fused and thrown off of the shooting boat. Long story shortened, one of the charges detonated while still aboard, killing a Lamont research associate. As a result, Maurice Ewing asked one of the technicians to come up with a non-explosive source. The air gun that is widely used today is the result. I worked in the Gulf of Mexico many, many years ago. We used marine velocity spreads acquired by a Lamont research boat. Ewing, et al, also acquired many drop core samples showing that sea floor spreading hypothesis was a reality. And on and on. Think of a sail boat with three masts and no sails. Think of the roll that would cause. I would have taken a chainsaw to all three masts had I taken the trip! But let's get Bob's version even though it was written several decades after the facts. (Lee Lawyer)

My career in geophysics began after college. But my story begins in high school after my college guidance counsellor told me "I was not college material". Consequently, I attended a trade school to become an electronics technician before realizing my grades suggested college might be a possibility. With perseverance, I managed a degree in Geology, 5 ½ years after high school. Incredibly, only as a college senior year did I realize an undergraduate degree in Geology would do little to secure a job in my home town of Manhattan, New York where outcrops are noticeably scarce. It seemed a Master's degree in geology was necessary, but how was I to fill the time gap between a January college graduation and a September grad school enrollment?

Fortunately, my sedimentology professor told me about Columbia University's Lamont Geological Observatory and their need for qualified people to sail on oceanographic research vessels. In the early 60's, concepts of plate tectonics and seafloor spreading were taking hold, but there were many unanswered questions, lingering academic resistance, and a clear need for more data. More information about mid-ocean ridges, their geographic location, the distribution of heat flow and the intriguing symmetric pairing of magnetic anomalies and rock ages along mid-ocean ridge flanks. In my last semester of college, I spent Saturdays at Lamont's campus in Palisades N.Y., working with Dennis Hayes, learning to be a deep-sea sediment-core describer, responsible for recording the physical characteristics of deep sea cores: literally digging for nature's secrets, looking for clues supporting continental plate movement.

My cruise would be on the RV VEMA, a 200 foot, three-masted schooner with masts no longer used to sail as a luxury yacht, but still attached to a now refurbished research vessel.

Unfortunately, masts without sails ensure a higher center of mass making calm-water sailing an experience of continual rolling and rough-weather sailing a major cause of motion sickness … I subsequently vomited in all the major ocean basins of the world.

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VEMA would embark on its 24th ocean cruise, a circumnavigation of the globe lasting 11 months. I remember she was equipped with an airgun seismic recording system, fathometer, gravimeter, magnetometer, thermometers, instrumentation to monitor water turbidity, and of course a piston corer to sample the seabed's top 30+ feet … making all the necessary measurements to reveal nature's secrets regarding drifting continents.

VEMA was the first non-military U.S. vessel to have satellite navigation. When on watch in the aft scientific lab, the special navigation receiver would emit a Doppler-like transmission signal that required a manual tuning adjustment to lock in the satellite signal and thereby, receive location coordinates. Location accuracy had an uncertainty equal to the ship's length. Often, I delighted in walking to the bridge, handing the first mate our position using numbers having far more digits than accustomed and smiling wistfully as a landlubber having no clue about seamanship. The first mate's tolerance was impressive.

In January 1967, our journey began. Joe Worzel was chief scientist on this first leg of our cruise. A typical cruise segment lasted 30 days at sea with 3 days in port. Joe assembled the science crew in the aft lab for an informal introduction to the work ahead as we travelled down the Hudson River heading for Atlantic open water. We had challenging objectives for collecting new data which could be used to fuel the scientific revolution that was blowing in the wind. Until now, mankind looked at a globe implicitly accepting continent locations were fixed, never moving. Now that paradigm was changing as we came to understand the earth's surface was in constant motion.

My job was defined by Maurice Ewing years ago, he wanted a deep-sea core taken every day we were at sea.

Taking a core required the ship to stop engines and drift with the current, lower a core barrel mechanism over the side, which is tethered by a thick cable to a winch having a large wire spool located amidships. The winch operator lowered the coring device to the sea floor, some thousands of feet below, and when nearing the sea bottom the winch slowed and relied on a tripping mechanism dangling 10 feet below the tip of the core barrel to trigger a free fall of the corer to its final decent.

The several-hundred-pound weight atop the core barrel ensured adequate sediment penetration. After several hours of cable rewinding, similar to a fishing reel, the core barrel landed on the ships' deck. Another cable system used a piston to extrude the 2 ½ inch diameter sediment core into long trays for analysis and storage.

Core description included plankton sampling for age estimation, penetrometer measurements for density, and color coding for sediment layering. Occasionally, I preserved a portion of the core at the water-sediment interface for the Navy. These samples were stored in a "special", small refrigerator… and one can only imagine their purpose … possible submarine detection below the thermocline. On one occasion, we cored the crest of the East Pacific Rise and reconfirmed sediment absence at spreading centers. We retrieved an empty core barrel, oddly bent in the letter "J" when attempting penetration of rigid basalt. I especially remember coring the Marianna Trench at a depth of 36,000 ft. The extreme cable length was fabricated from several wire spools stored below deck and linked together following a circuitous path of pulleys winding along hallways before reaching the winch. The winching operation lasted many, many hours. In the end, I was completely fascinated by the core's multitude of thin layers and color variation that I spent extensive time recording each layer thickness and color variation. After finishing a very long day I retired, exhausted, to a remarkably comfortable bunk.

The next morning, I eagerly awoke to revisit this special core, and to my great surprise the layering disappeared…this most beautiful stratigraphy had apparently oxidized and now appeared as a single layer, colored an unremarkable dark brown. During those long, monotonous hours of cable winching, I pondered the uniqueness of this event. In commemoration, I wrote my name on a porcelain coffee mug and pitched it overboard. Today, I still romantically believe my name is enshrined at the bottom of Challenger Deep.

I had a change in job description when we docked at Subic Bay, Philippian Islands, where we loaded two tons of TNT from the US Naval Station. These were the last

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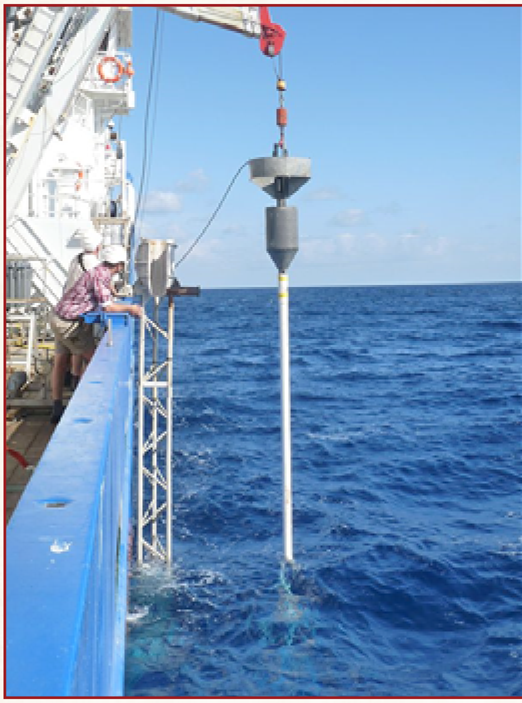

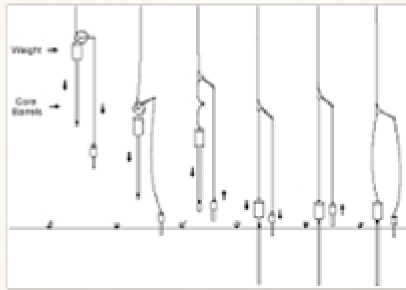

satchel charges used by our Marines during WWII to liberate the Pacific Islands, and they were a donation from the Navy for academic research. The wooden packing crates had epitaphs written by our soldiers commenting on the demise of our enemies. In the South China Sea, we rendezvoused with a counterpart Japanese research vessel to do a crustal refraction survey. Now the satchel charges were being shared with the Japanese in a new and beneficial way. How thick and deformed was the crustal plate and what were the implications for plate tectonics?

A two-boat refraction survey required a shooting boat to sail away from a recording boat, explosive charges of increasing size allowed arrivals to be recorded at increasingly greater distance. The size of the survey's last shot was impressive, assembled by binding many satchel charges together into a modest, refrigerator-size brick. The detonation was a cascade of events, beginning with my lighting a fuse which ignited a blasting cap, which in turn ignited plastic explosive, which finally ignited primacord that connected the "bricks of TNT" nestled inside each satchel. I can still see this assembled explosive: forty-plus satchel charges that I banded together with three redundant fuse assemblages. As I and another expendable young scientist lit the fuses on the fantail of the VEMA that day, we put our shoulders to the "refrigerator" as we pushed it overboard. Just then - wait for it - a rogue wave fortuitously rocked the boat and the assemblage pirouetted back on the deck. In apparent slow motion, we gasped looking wide-eyed at one another, then frantically lifted the seemingly featherweight bundle off the deck and into the sea. The timed, deep-depth explosion detonated so shallow that the water splash was a much more remarkable eruption than expected. Needless to say the Japanese did not record those weak arrivals, and we had to suffer acrimonious comments from our former bunkmates. Fortunately, the large store of satchel charges on the boat remained unharmed.

It should be noted that long ocean voyages were accompanied by significant periods of boredom as the routine of daily life settled into monotony...this was more so for the tasks done by the operations crew, all Canadians, steeped in a heritage of seamanship. One significant and boredom-breaking highlight of the cruise was the sumptuous meal served on the fantail every Sunday afternoon. Here an ice cream dessert was offered. This frozen delight was made most appealing when stationed in the Pacific, near the equator for long weeks, on a ship without air conditioning. The revered ice cream was stored in a refrigerator below deck at a prominent intersection of major hallways, and we all marveled at its content when passing. It was secured like Fort Knox, several thick steel bars wrapped completely around the door, large hinges on one side and numerous padlocks on the other side. For months, I marveled daily at the deliciousness contained within.

After completing a late-night watch several months into the cruise, I first noticed that the hinges were attached with seemingly simple flat-head screws. No, it couldn't be that easy to undo these screws and open the door using the far-side padlocks as hinges… these screws must be welded inside. As scientists, we are familiar with hypothesis testing, so I slipped into the tool shed and retrieved the requisite screwdriver. Removal of the screws was easy and the door opened effortlessly. Similar to what Howard Carter must have experienced when first opening King Tut's tomb, I experienced a blinding flash of ecstasy, then I grabbed the smallest container of chocolate ice cream, a 5 gallon tub, and quickly restored the door. I entered my cabin and fellow bunkmate Larry and I finished an impressive amount of ice cream before tossing the now partially-melted remains, container, utensils and napkins overboard leaving no forensic trace of ill-gotten goods.

Early the next morning there was a sharp knocking on everyone's cabin door, and the entire scientific crew

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mustered topside, toes planted on a hastily drawn chalk line scratched onto the deck. Having a passing friendship with the first mate, who watched us like a hawk for aberrant behavior, I whispered to him what was happening. He whispered back, apparently one of the mess boys opened the coveted refrigerator and tallied one less ice cream tub than expected. This observation was quickly passed up the chain of command, and the captain deduced none of his operations crew would be involved; hence, let's begin questioning the likely suspects. The science crewmembers waited patiently as each was summoned into the captain's office for interrogation. Some stayed longer than others and we soon recognized those were not his favorites. My brief and apparently convincing denial of any suspicious activity allowed a quick return to work. The ship was abuzz with speculation, and monotony was a thing of the past. However, after one week life slowly returned to normal. Recognizing my responsibility to minimize boredom, I stepped up, and another tub of chocolate ice cream vanished. Knowing that Larry and I could not finish the tub, I invited another mate from the next cabin to join us. First sworn to secrecy, he giddily joined us. Unfortunately, we again could not finish off the tub and our newest cohort offered to dispose of all evidence.

The very next morning we were once again summoned to the now familiar chalk line. Remarkably, the captain could now be heard loudly shouting questions of interrogation, with four–letter words sprinkled into the conversation. Once again I asked the first mate what happened. He replied, another ice cream theft, but this time it was much more egregious. As the crew awoke this morning, all noticed an odd trail of chocolate ice cream staining the floor. In following the chocolate trail, one end started at the ice cream refrigerator and then snaked throughout the ship, above and below deck, finally ending at the captain's stateroom door. The implication of who stole the ice cream became quite clear to everyone!

In retrospect, Larry and I realized our cohort and the captain were always at odds, and I guess the temptation to alternately dispose of the ice cream proved too compelling. I never told anyone how the ice cream was liberated, and after this experience it never happened again. After rumoring subsided, it was my pleasure to experience the slow return to boredom.

It seems to me that they made a movie out of this ice cream theft on a boat. Wasn't Bogart the Captain in the movie version? Or was it the one with Henry Fonda? (LL)

When the ship birthed in Townsville, Australia, I again reminded the captain of my planned return to the States and the start of my graduate studies. Apparently the captain had other plans. The next morning, the first mate asked me to visit the captain in his stateroom. There he introduced me to the chief constable of the Townsville police department. The constable inquired if I had an exit visa…apparently one could not just walk off the ship onto foreign soil without permission. Failing to produce the requisite document, I was dutifully informed that I would be jailed several days waiting for an exit visa. Notably, the jail was small forcing me to share a cell with either a convicted murderer or a known rapist. My decision to either stay on board or depart focused mainly on the unfortunate time I had already lost to education, beginning with the debilitating advice of my high school guidance counselor and then the circuitous 5 ½ year path to a college degree … I didn't want to lose more time. Upon reaching a decision, I stared at them exclaiming "I choose to leave the VEMA, what real harm would there be in waiting for the exit visa". Firstly, they both started incredulously at me and then slowly turned towards each other mouths agape. The captain jumped up from his chair, arms flailing and shouted for me to leave. Several hours later the first mate knocked on my cabin door, handed me a plane ticket, said tomorrow at 6 am a taxi parked at the dock would take me to the airport and I was not to mention this departure to anyone.

My flight from Townsville to Sydney had a 6-hour layover before heading to the United States. I exited the airport and asked a taxi driver for a downtown Sydney tour in which we had a marvelous time. As the tour ended, the cabbie said he needed to place a bet on a horse. His previous fare gave him a valuable tip on picking the winner. He asked if I wanted to accompany him. "Of course" I replied, and we set off for his neighborhood bar where he could place an illegal bet. Just as we entered the bar, the race started preventing him from placing a bet and the horse won. Dejected, he sat at a table, ordered us beers and studied the jockey/horse factsheet for the next race. After pondering the choices, he slowly turned and asked me to pick the winner having narrowed down the selection to two horses. Never having bet on horses much less doing so in Sydney, I felt unencumbered to make a meaningful choice based on factual information graciously offered. Having made my choice, we both placed the minimum bet with the attendant bookie, and - wait for it – the horse won.

The cabbie cheerily purchased more beer and narrowed the choices for the next race before seeking my decision. This time we bet more… and again the horse won. While pondering the next race, practically everyone in the bar surrounded our table, and after my selection the bookie became very busy. OK… the horse won. Now for the final race of the day, even before any horses were discussed, patrons were phoning friends to come-on-down to the bar. The larger crowd surrounded our table quietly waiting for my "final answer" and once given, the grousing bookie had his hands full trying to cover all the frantic bets being

Interview continued on page 29.

Interview continued from page 28.

made. Guess what… we won again!!!! Now beer was really flowing, friendships were made, and I learned about "shouts" when buying Aussies beer. Regrettably, the cabbie looked at his watch and said it was time to go. As we drove to the airport, he confessed that he had been losing money to that bookie over the past several months. His wife was becoming suspicious about the claimed poor tips excuse used to cover gambling losses. Clearly, that would not be the case tonight! Then he inquired if I would like to be his guest and stay at his house, tomorrow there would be dog races to consider. I smiled, thanked him, and said I really needed to get back to the States where there is a Master's Degree waiting for me.

Getting back to the VEMA trip, I was interested in how they acquired any Gravity data. There is an Etvos effect, which is the response of the gravity meter to movement. It must be mitigated somehow to get useable information from a gravity meter. I asked Bob and supplied the explanation. (LL)

The gravimeter was located near the "center" of the ship, in a dedicated room. It was mounted on a gimbaled, 3-axis gyroscopically controlled table to allow it to remain horizontal and independent of the ship's rolling motion. One day during a typhoon in the South Pacific Ocean, I visited the gravimeter. It was moving wildly, doing corkscrews with it gyroscopic motors whirring endlessly. It took a moment to realize that the gravimeter was actually level, and I was whirling around the machine. The next day into that typhoon, when seasickness gradually took hold of mind and body, I had to fight the desire to revisit that room and jump on the gravimeter for a moment's respite.

I leave out stuff that Worzel and Ewing were responsible for. I keep thinking of new ones. How about the layer in the ocean that affected communications and allowed subs to hide under? (LL)

As you know, Worzel was a gravity guy, and our stop at Midway Island allowed Joe to accept a dinner invitation from a Navy submarine captain for a meal aboard the ship. I would have loved to be invited and listen to the stories recalled that evening going back to the end of WWII. I got to know Joe pretty well, he was chief scientist for several cruise segments. He and Doc Ewing constituted the fabric of Lamont during that incredible revolution in earth science. Hard to realize, I was so fortunate to be a hitchhiker.

Bob went on to acquire a PhD and had a long career with Exxon. He is a past President of the GSH and resides in Houston, Texas.

Mystery Item

This is a geophysical item…

Do you know what it is?

This month's answer on page 34.

2016 Saltwater Fishing Tournament

The 16th Annual Saltwater Fishing Tournament had sunny skies, cool breezes, gorgeous water and that salty smell that is perfect for anglers and their families. Everyone enjoyed the day. Some fishermen caught fish too large and had to let them go others didn't have many bites and those that got it just right came home the winners.

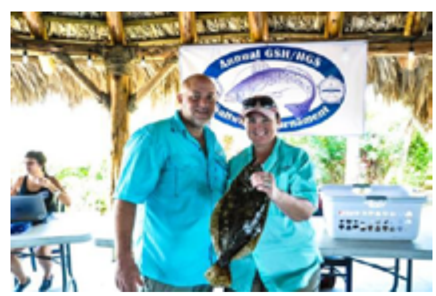
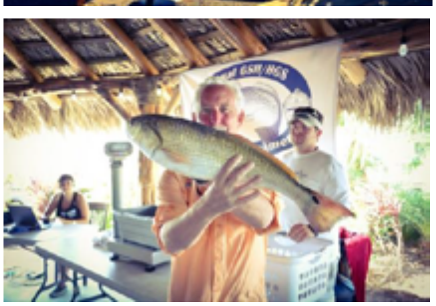
After weighing-in, everyone enjoyed the seafood meal at the Topwater Grill. Bobby Perez and his seasoned team passed out Trophies and, of course, lots of Door Prizes. All of this was only possible with the support of our generous Sponsors!

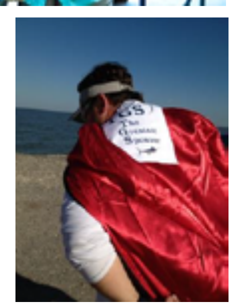
See you all next year on Friday, 6 October 2017!

Tournament Winners

HEAVIEST TROUT		
1st Place	Sheridan Elias	2 lb. 9 oz.
2nd Place	Jake Marson	2 lb. 7 oz.
3rd Place	Keith Peoples	1 lb. 7 oz.
HEAVIEST REDFISH		
1st Place	Bill Sanstrom	6 lb. 4 oz.
2nd Place	Ron Casso	5 lb. 2 oz.
3rd Place	Keith Peoples	3 lb. 5 oz.
HEAVIEST FLOUNDER		
1st Place	Andrea Peoples	2 lb. 2 oz.
HEAVIEST STRINGER		
1st Place	Randy Appleby	10 lb. 7 oz.
2nd Place	Brian Elias	10 lb. 3 oz.
3rd Place	Richard Barren	6 lb. 4 oz.



Photos courtesy of Ryan Egger. For more pics, go to our Facebook page or contact Bobby, (rperez@seimaxtech.com)

GPR: Probing for Accuracy

by Somaria Sammy and Robert R Stewart

Figure 1: Map of survey area showing elevation data positions (dots) and GPR survey grid area (pink rectangle), UH Coastal Center La Marque, TX. (Map Source: Google Earth.)

The culvert bridges at the UH Coastal Center in La Marque, Texas provide the perfect locations for Ground Penetrating Radar (GPR) surveying. GPR is a nondestructive technique for imaging the shallow subsurface. High frequency radio waves are transmitted into the ground and reflect off of subsurface structures and buried objects.

At the coastal center, the flat stratigraphy, sandy soil and exposed culverts under the bridges create textbook GPR responses. In 2013 and 2014, Dr. Azie Aziz conducted the first 3-D GPR surveys over the north bridge as part of her Ph.D. research. On July 22, 2016, Dr. Robert Stewart, Li Chang, Michael McClimans, Carl Buist, and Somaria Sammy of the Allied Geophysical Lab (AGL) at UH returned to the Coastal Center to conduct a follow-up survey. The aim was to practice using GPR equipment, compare results with Dr. Aziz's earlier work, and investigate the accuracy of depths determined by GPR data. The visit also provided an opportunity to practice flying and acquiring pictures with AGL's new drone.

At the Coastal Center, there are four culvert bridges oriented roughly east to west. The fill material over the culverts consists of gravel and shells. The bridge selected for our survey was the third bridge from the north. Dr. Aziz's survey was conducted on the north bridge (Aziz, 2016) and the surface of the second bridge was potholed. To minimize surface clutter in the data, the third bridge was selected, as its surface was smoother.

Work began around 11 am and was completed by 2pm. The high that day was 92F, the average humidity was 74% and there had been 0.05" of rain in the previous 48 hours. We used measuring tapes and spray paint to mark the outline of a 5m by 30m survey grid. We used the 3-4-5 right triangle method to make 90° corners and were delighted to find that the grid was within 11cm of being rectangular. Staining our fingertips orange and yellow with spray paint, we marked 0.5 m spaced dashes along the perimeter as a guide for the survey lines. 11 lines were collected transverse to the culverts (east-west) and 61 lines parallel to the culverts (north-south). Elevation data was also collected at various points around the survey area. The elevation points and the GPR survey area are shown in figure 1. The Noggin Plus 250 MHz GPR System and the Leica Total Station were used.

The results of this survey closely match Dr. Aziz's findings (Aziz, 2016) (refer to figure 3). The velocity of the material overlying the culverts was found to be 0.08m/ns. After migration, the shapes of the diffractions are close to the shape of the culvert tops (refer to figure 4). In order to determine the accuracy of the GPR depths observed, the recorded GPR depths of the tops of culverts 2 and 4 along one line was compared to the expected depths of the tops of the culverts. Initial analysis shows that the processed GPR data give depths with an error of 4%.

U of H AGL continued on page 32.

U of H AGL continued from page 31.

Figure 2: Michael McClimans hooking up the digital video logger (DVL) to the battery.

Total station data were collected along the top of culverts 2 and 4. Culvert 2 was found to be dipping to the North with a 2.3mm/m slope. Culvert 4 was found to be dipping to the South with a slope of 2.9mm/m. The GPR X-5 line runs perpendicularly over the culverts and total station surface elevation was recorded close to the point where the GPR line crosses over the culverts. The expected depths of the tops of the culverts was calculated for the point where the X-5 line crosses over the culvert using the slope of the culvert and the surface elevation of the road at that point.

Based on initial calculations, the expected depth of the top of culvert 2 is 44.67cm along line X-5. The processed GPR data show a depth of 46.60cm. This gives a difference of 1.93 cm, a 4% error. The expected depth of the top of culvert 4 is 34.65cm. The processed GPR data show a depth of 36.20cm giving a difference of 1.55 cm and an error of 4%.

While this initial error value is encouraging, more detailed calculations need to be performed to increase the accuracy of this error estimate. Further study should focus on the accuracy of the culvert slope calculations, the corrugated surface height variations of the culverts, and testing the depth measurements at more points.

Acknowledgments: Thank you to Li Chang, Michael McClimans, and Carl Buist for sweating in the field with us and conducting the survey. Special thanks to Azie Aziz for patiently teaching Somaria how to plan the survey and process the data.

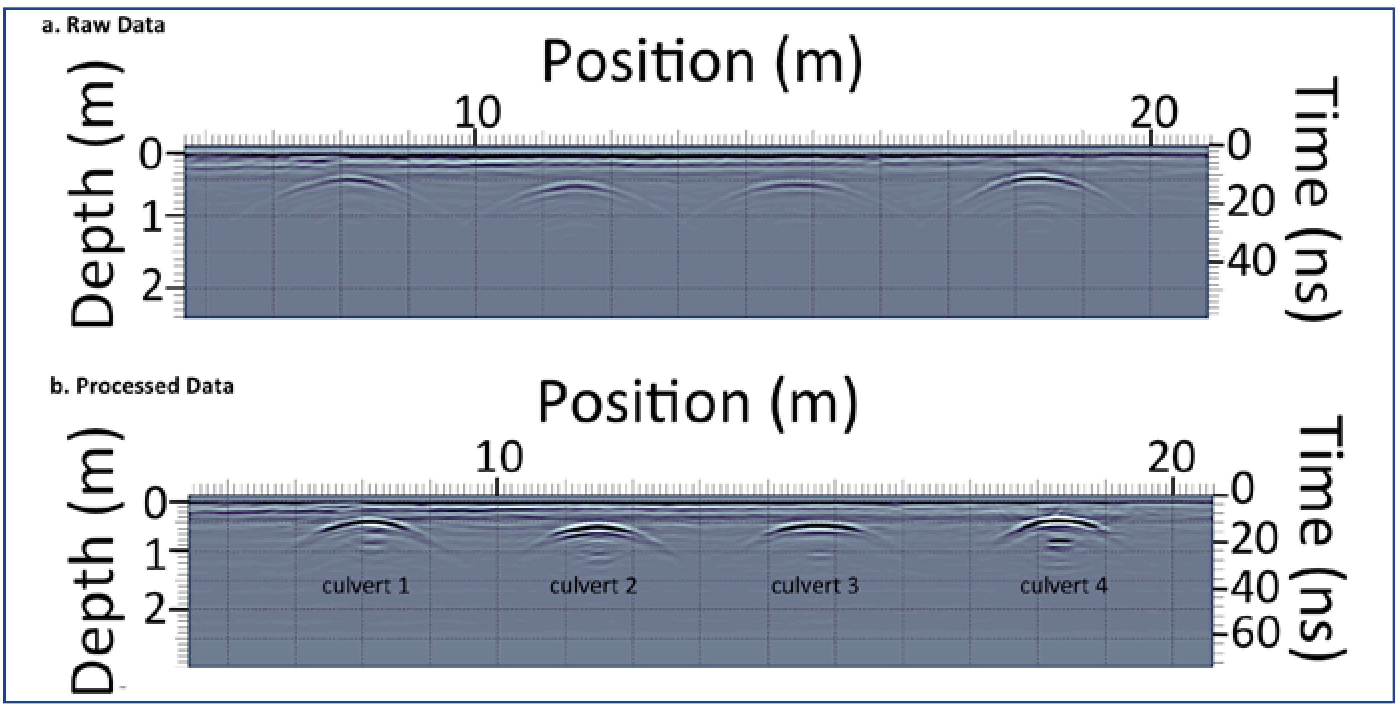
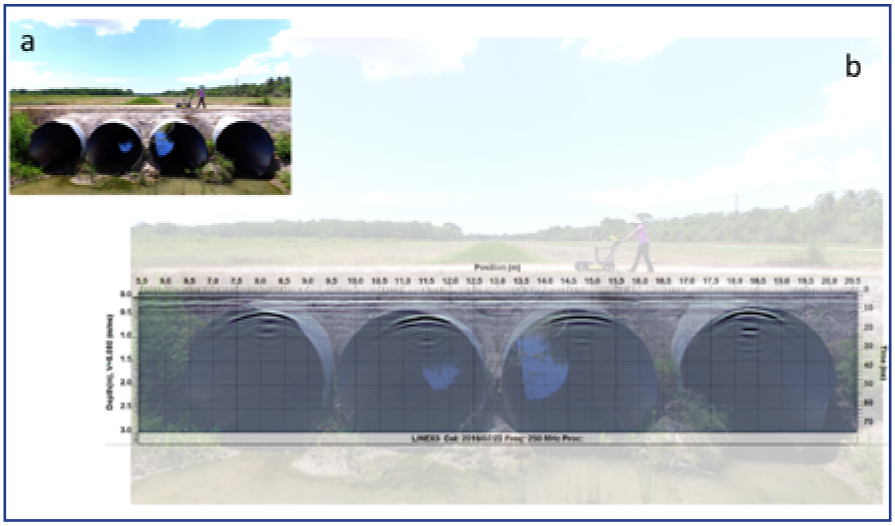


Figure 3: a. GPR center transverse line (X-5 line) raw data, b. Data after dewow, SEC gain, deconvolution, and migration.

U of H AGL continued on page 33.

U of H AGL continued from page 32.



Reference: Aziz, A.S., 2016, 3D ground-penetrating radar (GPR) investigations of buried culverts, historical graves, and a sandstone reservoir analog: Ph.D. thesis, University of Houston.

Figure 4:a. Somaria Sammy operating Noggin Plus 250MHz GPR antenna, b. Overlay of culvert photograph and image of processed GPR data after Aziz, 2016. (Photo acquired via drone courtesy of Dr. Robert Stewart.)

Wavelets

Reflections on the SEG Wavelets Summer Internship Talk

By Claire Ong

On September 16th of this year, SEG Wavelets, AAPG Wildcatters, and the UH student chapter of GeoSociety hosted a Summer Internship Talk Event. Five current graduate students at the University of Houston were invited to give a few tips on what companies are looking for in an internship candidate and to speak about the details of their internships, such as what the interview process entailed. The five companies that were spoken about were Kosmos Energy, Halliburton, Air Products and Chemicals, Inc., Chevron, and Shell.

An array of tips

All of the presenters had interned in different departments and gave advice regarding their individual experienced fields. For example, a Geology Ph.D. student, Proma Bhattacharyya, interned as a GIS analyst and her tip for those who want to be in the same field was to know the programming language Python. While there were specific tips such as Proma's, there were also general tips. Another geology Ph.D. student, Naila Dowla stated, *"If you're going to work with a small company, you have to know your field in and out."* Overall the tips of the presenters gave a useful insight into what kind of skills are needed depending on your desired field or just into the main skills and abilities that companies would find appealing.

"You have to be able to explain what you are trying to do to someone who does not know anything about your field." -Yuribia Munoz, 5th year PH.D. student

What are interviewers looking for?

Although there were five companies spoken about and all five companies had different interviewing processes, such as multiple stages or including a video call interview, a majority of them seemed to have one thing in common for the interview process: asking behavioral questions. These companies, and perhaps most other companies, want to know if a prospective intern or employee can work well in a team or how they will respond in pressured situations. Rather than only preparing for skill-based questions, students, and prospective employees in general, should also equally practice answering questions such as "Tell us about an event in your life in which things did not go to plan and what you did in response".

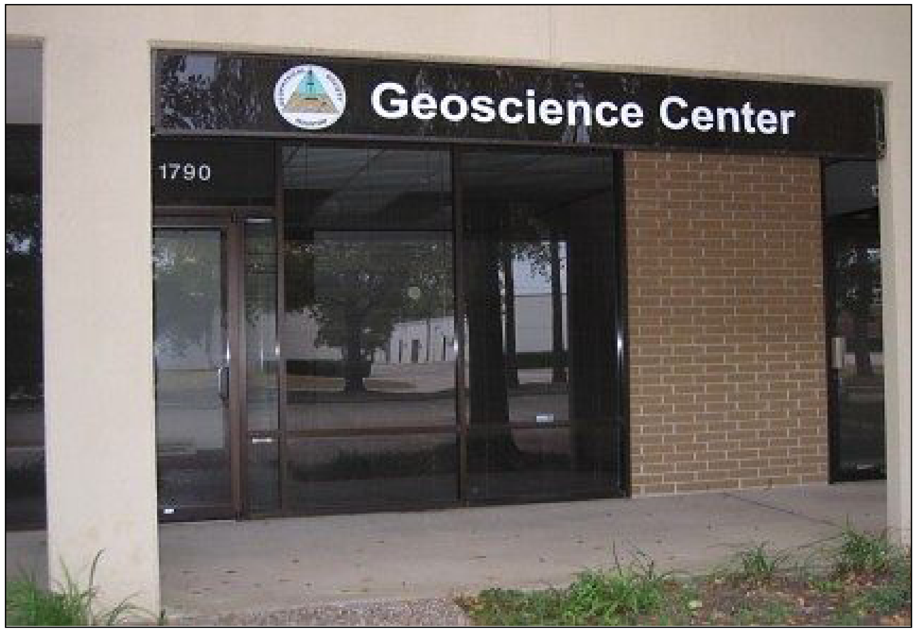
Final reflections

From tips on which skills should be acquired depending on the field to general tips on companies to tips on how to practice interviewing, the students who attended this event left with a better understanding in how to better prepare for a much desired intern position. SEG Wavelets is very thankful for those who agreed to talk about their summer internships during this event and is planning for more useful events in the future.

Geoscience Center News

By Bill Gafford

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



We have renewed our lease on the Geoscience Center space for 2 more years, and are continuing to add a few more displays of some of our more interesting artifacts. We also continue to receive donations of vintage geoscience instruments, books, and other materials. Volunteers are needed to help with updating our inventory, researching the history of some of the more unusual instruments from the 1930's and 1940's, and creating informational signs for some of our displays. Some of this work could be done from home by using some of our older periodicals, text books, company manuals, and workbooks. If you are interested in helping with any of these projects please contact me or come by for a visit one Wednesday morning. Also, our collections of "Geophysics", "TLE", and GSH Newsletters are missing some issues, so we would welcome donations of these items, especially any GSH Newsletters from the 1960's.

There is a new opportunity to support the GSH Geoscience Center. Longtime GSH and SEG member Dick Baile has offered to donate $5000 to the Geoscience Center if that amount is raised from individuals during the rest of this year. Donors will be recognized in our "Friends of the Geoscience Center" listing near our entrance.Financial support will continue to be solicited from companies. The GSH is a 501 (C) 3 organization.Donations 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.

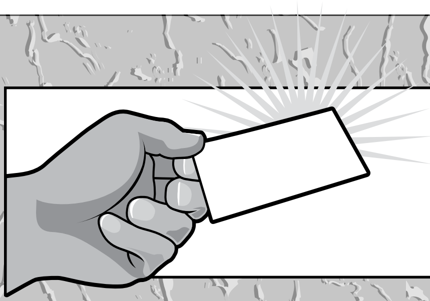
Another successful Living legends Doodlebugger social event was held at the Geoscience Center on Thursday November 10. As usual, we had some first time visitors and there were many conversations about some of our newer displays. The next Doodlebugger event will be on Thursday, February 9, 2017. All are welcome so please plan to attend. We also hosted the November GSH Board of Directors meeting on Friday, November 11, and this gave those who hadn't been there before a chance to visit the Geoscience Center.

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.

Mystery Item

The Mystery Item for the December GSHJ is a model of a broomstick primacord charge used in the 1960's

Mystery Item on page 26.



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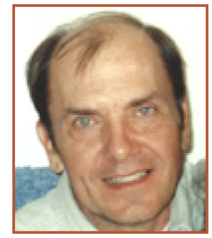
Doodlebugger Diary

A Heliportable Operation in the Rockies

By Matt Mikulich

The GSH would like to extend our deepest condolences to the family of Matt Mikulich who just provided this Doodlebugger Diary article for our Journal publication. Matt retired from Chevron as Chief Geophysicist a few years ago and had been fighting and winning a battle with an invasive cancer recently. Unfortunately, he lost that battle on Wednesday, October 19, 2016. For all of you who will read this article, we owe him a sense of gratitude for sharing his past experiences with us. Please honor and remember his passing by reading and imagining what his past experience must have been like.



The following story is about a land acquisition survey in northwest Wyoming. For those of you who have been in the region, the beauty is just incredible and one might just think that searching for and finding hydrocarbons in such beauty should not be permitted. Matt describes a harrowing time shooting the seismic line, flight from the lightning and thunderstorm and the experience that will forever be remembered. Maybe the end of the story was a sign that we shouldn't be treading in such a region. If you have a story to tell, please email Lee Lawyer, llawyer@prodigy.net or David Watts, editor@gshtx.org, or dwatts1@slb.com, and we will get your story in print and shared with our community. I am sure everyone would like to hear it.

It was 1986; I was Northern Region Chief Geophysicist for Chevron based in Denver, CO. The exploration teams had been pursuing follow-up targets northward from Evanston along the West Wyoming Thrust Belt province towards Jackson, and had turned up interesting leads. As the focus area expanded northward, the topography also changes with quick elevation rises. The Wyoming Range becomes the dominant surface expression of the thrusting and reaches over 9,000 ft in that range south of Jackson and west of Bondurant, WY.

We had little data to go on, and so a summer of seismic recording was planned. With the difficult topography, a helicopter assisted operation was decided; it would be slow, and costly. We needed good weather in an area known for mid-day thunder and lightning storms. The crew would be exposed to deadly lightning and need to be quickly brought back to safe lower elevation when threatened. Helicopters are very costly to operate, and were needed almost on a standby basis. With overthrust carbonate rocks on the surface and rapid elevation changes on west trending lines, we were shooting perpendicular to the strike of the thrusting in the direction of maximum topographic change. Surely this is not the kind of geology a 2D seismic survey is planned to delineate. But we needed some confirmation of the subsurface; this would be it for now.

It was a daring plan and interesting to observe how we'd go about the operation. Our Corporation Chief Geophysicist was Lee Lawyer whose office was in Houston, TX. Now where he might be willing to go for few days to get out of the Houston summer heat? Maybe I could entice him to come to northwestern Wyoming for a field visit, do you think? He came. Lee, the division geophysicist Steve Doherty, and myself flew to Jackson from Denver. It was to be just a couple of days.

In early morning we drove to the crew mobilization point near Bondurant to meet the party chief and get an update on the status of the operation. A helicopter arrived by 9:00am to lift us to a high point along one of the lines that was being worked. He dropped us on a sharp perch where we tried to survey the line struggling for footing on the steep slope. It was very difficult topography and hard to see anything really except cables and phones strung out as the topography dropped away from us on all sides. Our energy source was to be poulter shooting; the surface was all consolidated rock impossible to drill with light drills. This is not the thing you really want to use for a source; we knew the records would have high air blast, but we hoped by the magic of CDP we could salvage some signal from what was certain to be noisy records.

Shortly after noon we saw large thunderclouds quickly building to the west and moving rapidly towards our position. The helicopter screamed back in return for us and with haste we all hopped back on. But the tempest had already arrived. As we lifted off we ran into a heavy hail squall that rattled off the plastic canopy

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

DoodlebuggerL continued from page 38.

in a deafening racket. The pilot lifted but visibility dropped dramatically, and decided he needed to find safe air and a place to set down quickly. There was lighting all around us too. It was a little scary; if you are not a little scared every time you jump into a helicopter, there is something wrong with you. The pilot knew the area and spiraled us down to a flat spot on a sand bar in the middle of a small creek bed. We stayed there for a short time with the engine idling until the hailstorm went past. After 30 minutes he lifted off and took us back to the crew staging area. I'm not sure how the regular crew got to safety, but we had employed some real experienced rock climbers on the crew, and there was another helicopter looking after them. I don't remember if we had lunch that day; I think we didn't. I don't like to miss lunch.

In the end we recorded 4 lines I think, maybe 8 to 10 miles long each. You know, I don't remember seeing any of that data after processing. Maybe there wasn't anything to see at all; Steve never told me. We were never able to firm a drillable prospect in that area either, nor secure a well permit. I'm sure there is a beautiful hanging wall or footwall fold down there full of oil, but I sure don't know what it looks like. That night we did have a cold beer and a nice dinner at the Wort Hotel in Jackson. Was it Steve who told us at dinner that our pilot was a Vietnam Vet with one eye, or did I dream that?