October 2017

GSH Journal

GEOPHYSICAL SOCIETY OF HOUSTON
Volume 8 • Number 2

The Epicenter of Geophysical Excellence

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Deploying wireless seismic acquisition units in Kurdistan. Photo courtesy of Wireless Seismic.

EDITOR'S NOTE

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

GSH JOURNAL DEADLINES

Dec 2017	**Oct 10**
Jan 2018	**Nov 8**
Feb 2018	**Dec 8**

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A Word from the Board

Technology-Driving Society in An Oil Town

By Xianhuai Zhu, 1st Vice President

Geophysical Society of Houston (GSH) is the largest section of the SEG. It has about 2000 members working in the Greater Houston area today. Believe it or not, approximately more than 95% of the headquarters of US-based oil and service companies are in this oil town!

Associated with SEG, GSH has always been a technology-driving society for its members. Technical events include Luncheons, Breakfasts, Special Interest Groups (SIG) and Continuing Education (Webinars). Also, there is an annual Spring Symposium.

We are very excited to announce that five speakers have already confirmed for our monthly technical luncheons in Q4 2017 and Q1 2018, including the SEG Distinguished Lecture on "Simultaneous and coded seismic sources: Present and upcoming technologies" by Raymond Abma from BP in October, and the SEG Honorary Lecture on "How widespread is human-induced seismicity in the United States and Canada?" by Mirko van der Baan from the University of Alberta in December. The SEG DL and SEG HL will be presented at three locations: Downtown (Petroleum Club), Westside (Norris Center) and Northside (Southwestern Energy). Other luncheons will be mainly conducted in Downtown and Westside only. Sponsorship opportunities for individual luncheon events (Westside, Downtown, and Northside) are available with a vendor spotlight.

The technical breakfasts are also held monthly but at only two locations (Northside and Westside) with a variety of speakers from operators, service companies and academia. The Northside breakfast is hosted by Anadarko Petroleum with the catering generously sponsored by Lumina Reservoir Inc. on the first Tuesday of the month. The Westside breakfast is hosted by Schlumberger with the catering sponsored by WesternGeco and others (sponsorships are still available) on the second Wednesday of the month. Both offer breakfast at 7:00 AM with the technical presentation from 7:30 AM– 8:30 AM. I encourage you to attend the one closest to your home or office as they are a great way to start your day. Please preregister at www.gshtx.org, so we can ensure we order enough breakfast for everyone.

Xianhuai Zhu

The Special Interest Group (SIG) meetings have been very educational and enjoyable. You don't have to be a subject matter expert to learn something new and get something meaningful out of them. This year Maitri Erwin, GSH 1st VP Elect, is working with each SIG leaders for their events, including Data Processing and Acquisition SIG, Microseismic SIG, Potential Fields SIG and Rock Physics SIG. Due to the lack of support, we will not have Geoscience Computing SIG this year.

Continuing Education (Webinars) program has been very successful at GSH. In our October webinar, Enders Robinson and Sven Treitel are going to present entirely in Spanish, titled "Geophysical Signal Processing 101 (Procesamiento de Senales Geofisicas 101)"! With increased demand, we are inviting speakers to present in Mandarin Chinese and other languages at GSH webinars!

The Spring Symposium is a premier event for GSH. We will be honoring Dave Hale on April 4 & 5, 2018 at the Norris Conference Center. Based on the themes of "Interpretation Technology" in 2016 for honoring Alistair Brown and "Geophysical Acquisition" in 2017 for honoring Malcolm Lansley and Dave Monk, we have chosen "Seismic Imaging" as the theme in 2018 for Dave Hale. We've invited a world class group of speakers and allocated ample time for extended talk discussions, exhibit booth engaging and networking with colleagues. This will be a must not miss event for knowledge sharing and networking which does not require travel expenses for Houston area residents.

Finally, I would like to thank all the technical speakers at the Breakfasts, Luncheons, SIG meetings, webinars, Spring Symposium and SEG DISC for stepping up to share their knowledge with the GSH family. Also, we would like to thank our event sponsors! Please visit www.gshtx.org to view the calendar of upcoming events and register today!

Dear GSH Journal reader,

We would like to continue communicate with you by publishing your letters to the Editor in new issues of the Journal, however we received no correspondence for the month of October. As an Editor, I'm always very keen on hearing from our marvelous community about things they would like to change, keep the same or comment on. I encourage everyone to contact Editorial Board at editor@gshtx.org with any kind journal/community related matter whether it's a simple question/concern or a content that you would like to share with others.

Once becoming an Editor I've realized how great our community is. Being on the very edge of Oil and Gas industry each of us either constantly travels or dealing with outstanding situations daily. We are very open people who enjoy hearing and telling stories about our work, life and, most importantly, personalities. Editorial Board is always happy to receive and publish articles that are coming from our readers. We are one hundred percent sure that excellent content quality of the GSH Journal could be only achieved through a deep all-around involvement with the community which means that your personal contribution will be highly valued and appreciated.

Sincerely,

Dmitry Kulakov

Technical Breakfasts

VSP and DAS Data Noise Attenuation using Complex Wavelet Transform

Register for Tech Breakfast Northside

Register for Tech Breakfast Westside

Speaker(s): Zhou Yu, BP

Zhou Yu

Northside

Tuesday, October 3, 2017
7:00 – 8:30 a.m.

Sponsored by Anadarko Petroleum and Lumina Reservoir Inc.

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

Westside

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

Sponsored by Schlumberger and WesternGeco

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

Abstract:

Author is going to present newly developed iterative processing flow that uses a complex wavelet transform to perform noise attenuation and separation of up- and down-going waves in Vertical Seismic Profiles (VSP) data.It is also used to address the noise problem in Distributed Acoustic Sensing (DAS) data. The objective is to improve the signal-to-noise ratio without compromising the high frequency signal or data bandwidth. This approach is adaptive to the geometry of VSP and DAS data acquisitions, where the limited aperture poses a challenge to conventional methods because of the aliased energy and localized unwanted waves. Another advantage of the methodology is efficiency and ease of use since it asks for very few parameters in the localized representation of data in the complex wavelet transform domain. Significant time reductions were obtained in multiple field data processing projects when compared to processing times using the conventional Fourier transform based method. VSP and DAS field data are used to demonstrate the method's effectiveness and efficiency.

Biography:

Zhou received a B.S. (1983) in marine geophysics from Ocean University of China, an M.S.(1996) in geophysics from MIT, USA and a Ph.D. (2001) in geophysics from University Texas at Dallas, USA. Zhou joined BP in 2001 and has been working in BP's Advanced Seismic Imaging group in the Upstream Technology organization. Zhou's interests are innovative solutions to various signal process and analysis problems. They include Kirchhoff migration operator anti-aliasing, land data process, deconvolution, conditioning data for AVO analysis, ocean bottom seismic data process, inverse-Q process and seismic attribute estimation.

Technical Luncheons

Simultaneous and Coded Seismic Sources: Present and Upcoming Technologies

Register for Tech Lunch Westside

Register for Tech Lunch Downtown

Register for Tech Lunch Northside

Raymond Abma

Speaker(s): Raymond Abma, BP America, SEG Honorary Lecturer

Westside

Tuesday, October 17, 2017
11:00 a.m. – 1:00 p.m.

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

Northside

Thursday, October 19, 2017
11:00 a.m. – 1:00 p.m.

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

Downtown

Wednesday, October 18, 2017
11:00 a.m. – 1:00 p.m.

Location: Petroleum Club of Houston Total Building
1201 Louisiana St, Floor 35
Houston, TX 77002
($10 valet parking with discount – entrance is off of Milam Street)

Abstract:

Simultaneous source seismic surveys, using a method referred to as source blending, use more than one seismic source at a time. This technology is part of the progression of seismic surveys to obtain denser sampling and better seismic images. Simultaneous sourcing uses multiple seismic sources, producing seismic signals that overlap with the signals from the other seismic sources. This increases the efficiency of seismic exploration by decreasing the time between shots, significantly reducing the cost and time needed to acquire a seismic survey. The main challenge to the use of simultaneous sources is the separation of signals from the different sources. This separation is accomplished by using concepts from compressive sensing by way of sparse inversion, a method of getting the simplest answer to the inversion of a matrix equation. While this involves a significant computational expense, the decrease in the acquisition cost is even more substantial.

I will show examples of various BP simultaneous source seismic surveys and share some details about how they were acquired and processed. I will also cover some of the requirements for a successful simultaneous source survey and an analysis of the quality of the seismic data obtained.

Present simultaneous source surveys use the random activation of the shot times as a code to allow shot separation. I will provide some speculation about extending this coding to other possible coding methods. Among some other advantages, these new types of coded sources allow the extension of simultaneous source survey geometries to more general seismic survey types, in particular, towed-streamer acquisition.

Biography:

Ray Abma is a Senior Research Geophysicist in the Upstream Technology group in BP. He received a Ph.D. from Stanford University in 1995 was with the Stanford Exploration Project. His thesis was 'Least-squares separation of signal and noise using multidimensional filters'. He has worked for Western Geophysical, Shell, ARCO, and now BP. He has spent more than a decade developing simultaneous and coded seismic source technology. In 2012 Ray and his team won the BP Technology Award for the development of marine simultaneous source acquisition. Later in 2012 Ray and the simultaneous source team won the BP Helios award, the highest award within BP, for delivery of the Trinidad simultaneous source ocean-bottom cable survey. This was the first large scale marine simultaneous source survey, which was considered to be a spectacular success.

Ray's interests are seismic interpolation and regularization, multiple and noise attenuation, sparse inversion, coded source seismic acquisition, and simultaneous source acquisition. He is a member of SEG, EAGE, GSH, and SIAM.

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TENNIS TOURNAMENT

2017

November 17, 1-5pm

GEOPHYSICAL SOCIETY OF HOUSTON

Fee: $80

To sponsor or register,
visit us online @GSHTX.ORG
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Ivette Gonzalez: igonzalez@seitel.com
Kathy Sanvido: kathys@gshtx.org

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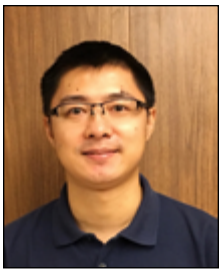
Data Processing & Acquisition SIG

Register for Data Processing

The First Multi-dimensional Internal-multiple-elimination Method: A New Toolbox Option for Removing Internal Multiples That Interfere With Primaries, Without Damaging the Primary, and Without any Knowledge of, and Need for, Subsurface Information

Chao Ma

Arthur B. Weglein



Yanglei Zou

Speaker(s): Yanglei Zou, Chao Ma, and Arthur B. Weglein, M-OSRP/Physics Dept./ UH

Sponsored by Schlumberger

Monday, October 9, 2017
4:30 p.m. Sign-in, Snacks, Social Time
5:00 p.m. Start of presentation

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

Abstract:

We begin with a brief overview of M-OSRP projects and their approach to identifying and addressing pressing and prioritized seismic challenges. Within that broad perspective we focus on the project that progresses and delivers new and necessary capability and effectiveness for the removal of multiples. In seismic exploration, migration and migration-inversion are the methods to locate and identify targets and hydrocarbon reservoirs. Only primaries are migrated and migration-inverted. And primaries come in two varieties: those that are recorded and those that are not recorded. There are circumstances where a recorded multiple can be used to provide an approximate image of an unrecorded primary, where the latter is a subevent of the recorded multiple. The removal and using of multiples are not adversarial positions and viewpoints, but rather are addressing different issues and circumstances, and represent different levels of ambition, capability and effectiveness, as options within the seismic processing toolbox.

However, only recorded primaries can provide specular and non-specular structural imaging (e.g., for curved reflectors and pinch-outs) and subsequent amplitude analysis using the most effective and interpretable imaging and inversion method, Stolt CIII migration. The new Stolt CIII migration for heterogeneous media is the first migration method that is equally effective at all frequencies at the target and reservoir, and provides resolution benefits and added value (at the target and reservoir) that is beyond the intrinsic resolution capability of RTM and all variants and extensions of RTM. Stolt CIII migration inputs recorded primaries. For a smooth velocity model and Stolt CIII migration, multiples will produce false images and artifacts; therefore, multiples must first be removed prior to migration and migration-inversion. Hence removing multiples remains a significant and important E&P objective, and obstacles to the effective removal of multiples are a prioritized and pressing challenge in many offshore and onshore plays.

This presentation will focus on certain serious obstacles and challenges to current multiple removal capability, and recent advances to address those challenges in removing internal-multiples. The Inverse-Scattering-Series (ISS) internal-multiple-attenuation algorithm (Araújo et al. (1994), Weglein et al. (1997) and Weglein et al. (2003)) has stand-alone capability since it is the only method that can predict all internal multiples with correct time and approximate amplitude without requiring any subsurface information. It makes none of the assumptions of other methods (e.g. stacking, FK filter, Radon transform, deconvolution and Feedback loop etc.) and is especially effective when the subsurface is complicated, complex and unknown. When internal multiples and primaries are isolated, the ISS internal multiple-attenuation algorithm is usually combined with an energy minimization adaptive subtraction to remove internal multiples. When internal multiples are proximal to and/or interfering

DP&A continued on page 10.

DP&A continued from page 9

with primaries or other events, the criteria of energy-minimization adaptive subtraction can fail. With interfering events, this failure of energy-minimization adaptive subtraction can lead to removing/damaging the target primary which is the worst possible outcome.

In this presentation, we provide the first multi-dimensional ISS internal-multiple-elimination algorithm that can predict both the correct time and the correct amplitude of internal multiples without any subsurface information. This is an important part of a three-pronged strategy proposed by (Weglein 2014). That provides an effective response to this challenge while retaining and adding to the strengths of the current ISS internal-multiple-attenuation algorithm. We provide this method as a new capability in the multiple-removal toolbox and a new option for circumstances when this type of capability is called for, indicated and necessary. 1-D and 2-D acoustic and elastic model data are used to examine, analyze and evaluate the new internal multiple removal capability. We will discuss open issues, significant remaining challenges and future plans.

The link below provides relevant references for this presentation.

http://www.mosrp.uh.edu/news/annual-meeting-2017

Biography:

Yanglei Zou received a B.S. in physics from University of Science and Technology of China. He is currently a PhD student in seismic physics at the University of Houston, advised by Prof. Arthur B. Weglein. His research topics include: developing more effective methods for multiple removal and resolution comparisons between Reverse Time Migration (RTM) and the first migration method that is equally effective at all frequencies at the target. Yanglei Zou and colleagues proposed the first multi-dimensional ISS internal-multiple-elimination method that can predict both the correct time and amplitude of all first-order internal multiples. That provides the capability to remove internal multiples that interfere with primaries, without subsurface information, and without damaging the primary. This elimination method is more effective and more compute intensive than the current most capable internal-multiple removal method today used in industry (ISS internal-multiple attenuation plus adaptive subtraction). It is a new internal-multiple removal toolbox option for circumstances when this kind of capability is especially needed.

Yanglei and his colleagues (Qiang Fu) demonstrated that all current migration methods make high frequency approximations, and that the new Stolt CIII migration had resolution benefit beyond RTM for the wedge model.

Chao Ma received a B.S. (2010) in Geophysics from China University of Petroleum (East China), and a Ph.D. (2016) in Physics from University of Houston. Currently he is a post-doctoral fellow at Mission-Oriented Seismic Research Program (M-OSRP) at University of Houston. His Ph.D. thesis focuses on extending the capability of the ISS internal multiple attenuator to allow both primaries and internal multiples as subevents, by including higher-order terms in the ISS that can accommodate and benefit from all events in the recorded data. The extended algorithm retains the unique advantage of the original algorithm (i.e. predicting internal multiples without any subsurface information) and it is more accurate in predicting internal multiples when there are many internal multiple generators in complex on-shore and off-shore plays. Chao Ma had several successful internships at Schlumberger and at PGS. Chao Ma worked on multiple removal research projects at Schlumberger and among the topics he progressed at PGS was the use of multiples to enhance imaging, providing an approximate image of an unrecorded primary.

This past year, Chao Ma helped reformulate the ISS direct depth imaging without a velocity model, as a migration operation, taking an important step from the Kristin field data viability demonstration, towards a tool box option.

Arthur B. Weglein received his PhD in physics from the City University of New York and then spent two years as a Robert Welsh Postdoctoral Fellow at the University of Texas at Dallas. He entered seismic petroleum research in 1978, first at Cities Service Oil Company Research Laboratory in Tulsa (1978-81) and Sohio Petroleum Company Research Laboratory in Dallas (1981-85). Weglein spent the next 15 years as a member of ARCO's research staff. He spent a sabbatical year (1989-90) as visiting professor at the Federal University of Bahia, in Brazil, and three years (1990-94) as scientific advisor at Schlumberger Cambridge Research in Cambridge, England. In 2000, Weglein joined the University of Houston as the Robert Sheriff Chair in Geophysics . In 2002, Weglein was promoted to a University-wide chair, the Hugh Roy and Lillie Cranz Cullen Distinguished University Chair in Physics, with a joint professorship in the Department of Physics and the Department of Earth and Atmospheric Sciences. Weglein was the SEG Distinguished Lecturer in 2003, in 2008 he received the CCNY Townsend Harris Medal, and in 2010 the SEG Reginald Fessenden Award for contributions to seismic exploration. In 2016, Weglein was awarded the SEG's highest honor, the Maurice Ewing Medal.

Procesamiento de Señales Geofísicas 101

Enders A. Robinson & Sven Treitel

Dos de los más reconocidos y condecorados Doctores en Geofísica del MIT, quienes han colaborado por décadas en libros, artículos, y presentaciones, serán los anfitriones de este seminario web en vivo.

en Español

Seminario web en vivo

3-6 de Octubre, 2017

Cuatro medios días 8:00 am - 12:00 pm Hora Central (USA)

Este es un curso diseñado para aquellas personas que son nuevas en el campo de procesamiento de señales geofísicas, o para aquellos que han olvidado lo que han aprendido anteriormente acerca de este tema. Comenzaremos con una discusión del método sísmico, cubriendo el movimiento de las ondas sísmicas, migración sísmica, inversión de la forma de onda completa (FWI) y visualización. El éxito de la migración y de la inversión de la forma de onda completa (FWI) dependen en nuestra habilidad de preprocesar los datos de campo de tal manera que estén libres de eventos que degradan el resultado final, como por ejemplo diferentes tipos de ruidos sísmicos. Nosotros por lo tanto introducimos herramientas elementales de procesamiento de señales como convolución y correlación, junto con explicaciones básicas de como calcularlas. A continuación seguiremos con el estudio del diseño de filtros digitales, sus inversas y sus problemas de estabilidad. Finalmente trataremos con filtros digitales óptimos y como son usados para resolver múltiples problemas prácticos.

Te perdiste parte de las sesiones? No hay problema. Todas las sesiones son grabadas y disponibles para los usuarios registrados.

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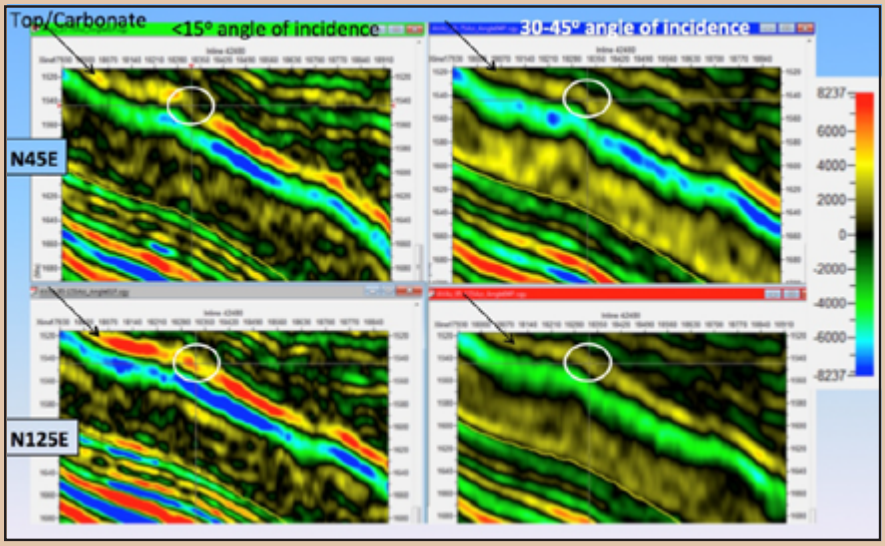

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Prestack Seismic Inversion in Anisotropic Unconventional Shale Plays

By Jinming Zhu, Mike Lovell, Chesapeake Energy Corporation;*
Chuck Skidmore, Flamingo Seismic Solutions

Summary

Seismic inversion can provide critical data points for reservoir description and field development but has historically not taken into account of the anisotropic effect on AVO curves of reflections. The strong anisotropy present in shales pose a significant challenge to the effectiveness and accuracy of the established inversion practices when elastic inversion is deployed for the purpose of describing the shale reservoirs and development. From the similarity of the forms and components of the reflection coefficient expression for VTI media to that of the traditional isotropic reflection coefficient, one can simulate the VTI reflection amplitude in terms of effective elastic parameters (Roberts et al. 2004). With the knowledge of anisotropic Thomsen parameters, the traditional simplified Zoeppritz equation could be deployed for inversion by simply modifying the observed angle reflectivity in VTI media with a combination of angle modulated contrasts of the Thomsen parameters. We adapt the recorded seismic amplitude to honor the isotropic formula. We use synthetic data with realistic Thomsen parameters obtained from core and petrophysical analysis. The elastic properties from inversion on the synthetic VTI data is very close to those from the isotropic gather. This essentially validates the effectiveness of this treatment. The inversion on a Utica case produces high resolution elastic properties of P impedance, S impedance and density which match the well logs with high accuracy.

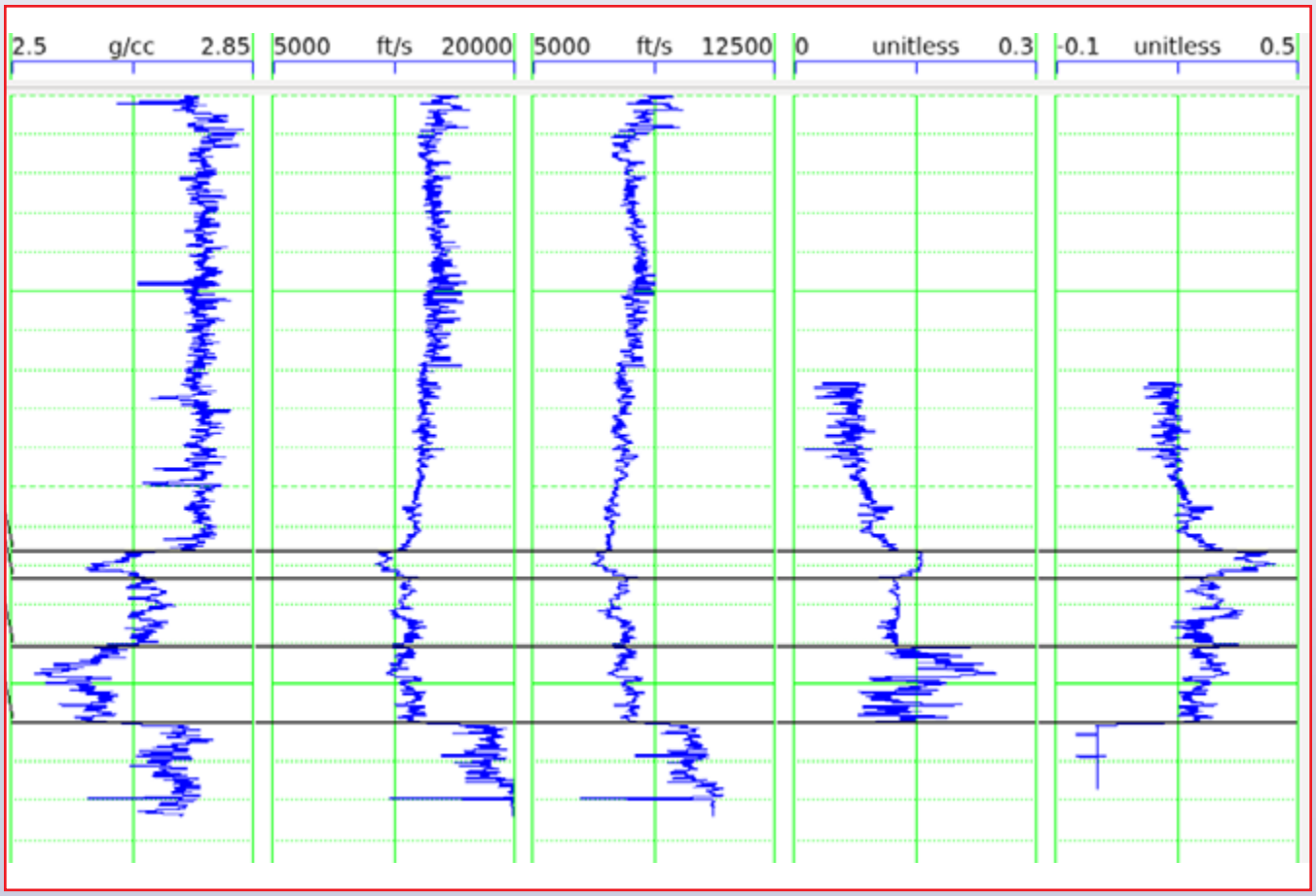

Figure 1: Log curves from well AA in Utica. From left to rght are density, P sonic, S sonic, Thomsen δ and ε respectively.

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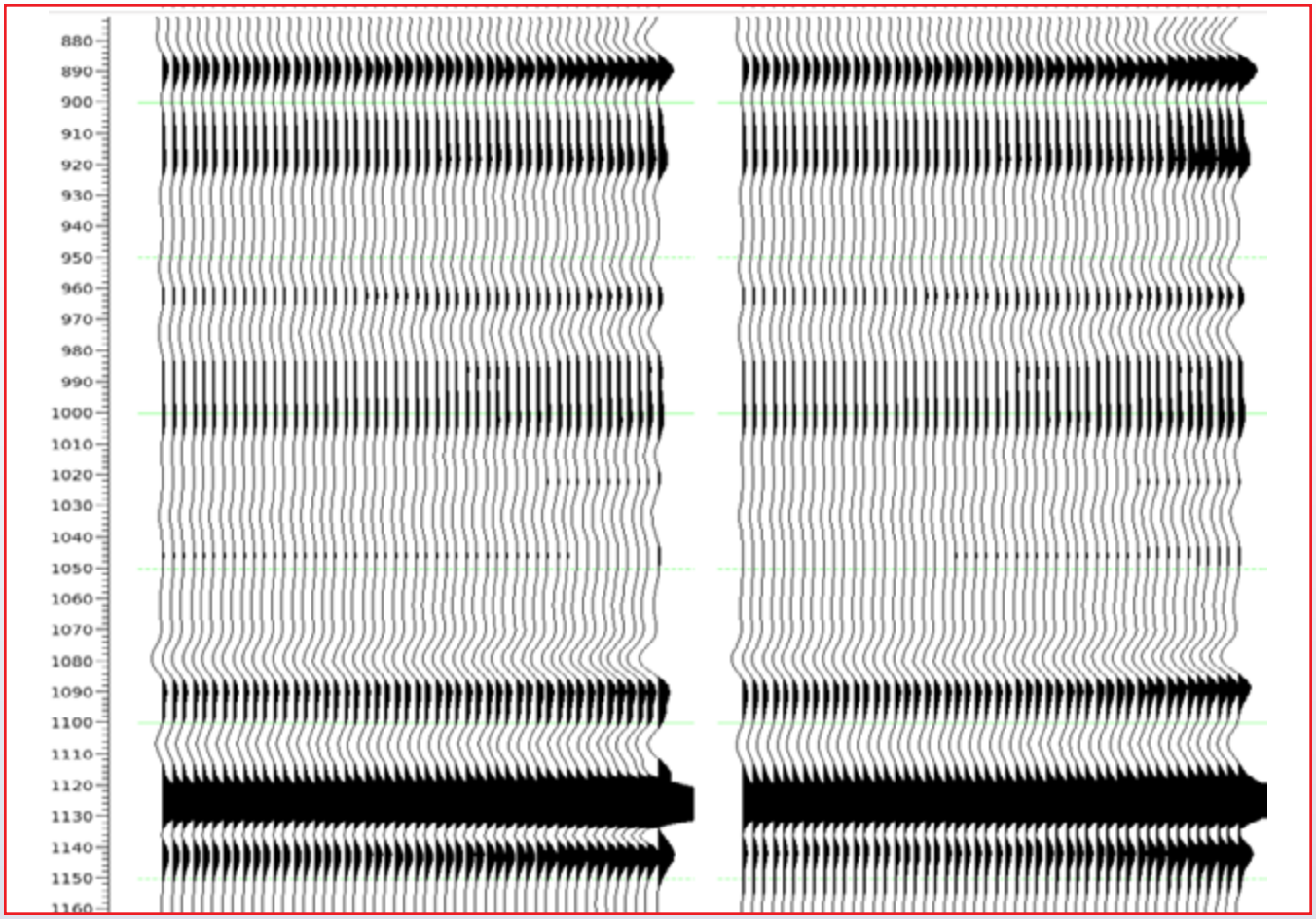

Figure 2: Synthetic angle gathers modeled from the logs in Figure 1. The gathers cover incident angles from 0 to 50 degrees. The isotropic gather is shown in left while the VTI gather is shown in right. Differences can be noticed in the high angles in later arrival times of the gathers.

Introduction

Seismic inversion generates quantitative rock properties such as acoustic impedance (AI) from reflection seismic data, which only measures the acoustic impedance contrast across interfaces. With the wavelet effects removed from the seismic, inversion results can provide much higher resolution of the subsurface than the seismic reflectivity itself. The original work of Lindseth (1979) demonstrates many advantages of inverted rock properties, AI or velocity, in identification of facies, porosity among other things.

Elastic inversion simultaneously solves for elastic properties of P impedance, S impedance and density, from the prestack seismic angle gathers. The combination of these rock properties provides superior power to describe lithology and reservoirs more effectively than AI or sonic log alone (Lindseth, 1979).

However, the success of prestack seismic inversion depends on several key factors: the validity of the reflection coefficient relationship adopted in the inversion, the quality of preprocessed seismic gathers with relative amplitude preservation, the accuracy of the wavelets estimated from the seismic gathers, and the availability of reliable low frequency (LF) elastic models. We build the initial LF models for P velocity α, P impedance Ip, density ρ, S impedance Is, sequentially from seismic driven velocities primarily through multi-attribute linear regression networks.

Approximations to the isotropic Zoeppritz equation are developed for more insightful understanding of the effects of different elastic properties on the reflection amplitude at different incident angles, such as Aki and Richards (1980). The simplified relationship is fundamental to invert for rock properties, Ip, Is and ρ, from the seismic reflection amplitudes. The inversion based on such relationships works brilliantly in the isotropic case, but is challenged when anisotropy is present.

Anisotropy has been known and well documented (Thomsen, 1986), but not well incorporated in seismic data processing and interpretation, primarily due to the limited accuracy in its measurement. Its effects on both

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travel time and seismic amplitudes can be significant, especially when wide azimuth long offset data is acquired. The recent advance in acquiring advanced 3D seismic data with long offset and rich azimuth, has made the accurate estimation of anisotropy possible, leading to significant improvement in seismic processing, subsurface imaging and well tying (Alkhalifah and Larner, 1994; Zhu et al., 2012).

Roberts et al. (2004) observed the anisotropic effects on inversion using a long offset 3D seismic data set when they aimed for density to discriminate gas saturation in an offshore Egypt gas field. They elegantly combined the effects of the Thomsen anisotropic parameters, δ and ε, into the effective elastic parameters of P wave velocity α, S wave velocity β and density ρ, such that the simplified isotropic Zoeppritz equation with the effective values of α, β and ρ accurately approximates the AVO curves of the anisotropic case. This way they used the same isotropic Zoeppritz equation approximation to invert for the effective elastic properties which can then be converted back to the standard elastic properties by removing the effects of the Thomsen parameters. Ferla et al. (2014) used the same approach to perform inversion for reservoir description and characterization of a deep water turbiditic reservoir encased by shale.

Methodology

The P-P reflection coefficient at the interface of two VTI media can be expressed with the following approximation (Ruger, 1997):

$$R_P^{VTI}(\theta) = R_{P0} + \left(G_{iso} + \frac{\Delta\delta}{2}\right)\sin^2\theta + \left(C_{iso} + \frac{\Delta\varepsilon}{2}\right)\sin^2\theta\tan^2\theta \quad (1)$$

where,

$$R_{P0} = \frac{1}{2}\left(\frac{\Delta\alpha}{\bar{\alpha}} + \frac{\Delta\rho}{\bar{\rho}}\right), \quad (2)$$

$$G_{iso} = \frac{1}{2}\frac{\Delta\alpha}{\bar{\alpha}} - 2\left(\frac{\bar{\beta}}{\bar{\alpha}}\right)^2\left(2\frac{\Delta\beta}{\bar{\beta}} + \frac{\Delta\rho}{\bar{\rho}}\right), \quad (3)$$

$$C_{iso} = \frac{1}{2}\frac{\Delta\alpha}{\bar{\alpha}}. \quad (4)$$

θ denotes the incident phase angle, α and β are the vertical P and S wave velocities; Δ denotes the difference of properties across the boundary where subscripts 1 and 2 refer to the upper and lower layer respectively, while the overbar denotes the average of the properties across the boundary. R_{P0} is the vertical incident reflection coefficient, i.e., the intercept, G_{iso} is the isotropic gradient, and C_{iso} is essentially the curvature of the isotropic AVO curve.

This equation has the same elegant form as the isotropic reflection coefficient, consisting of 3 terms, the vertical reflectivity, the near angle contribution in terms of

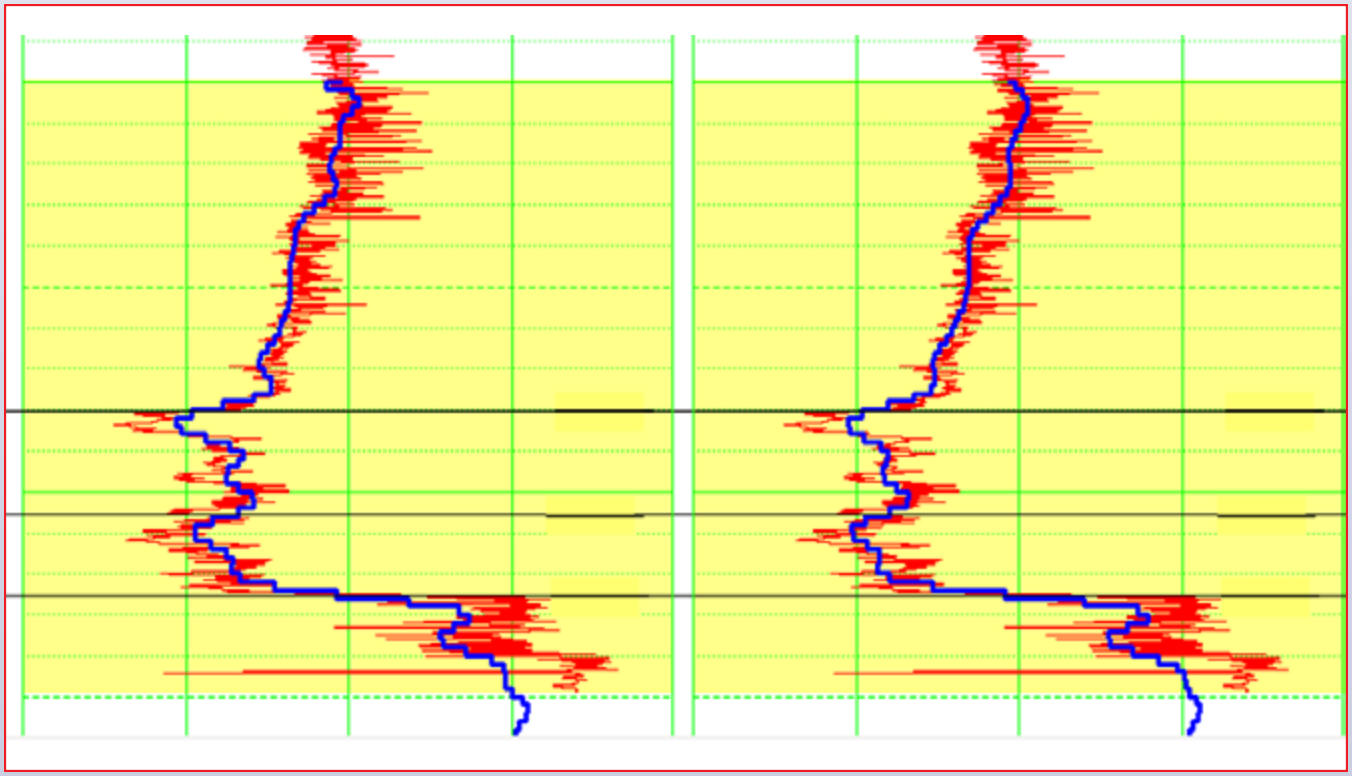

Figure 3: Inverted P impedance from the synthetic gathers shown in Figure 2. Right is from the isotropic gather, while the Left is from the VTI gather. The red colored curve is acoustic impedance log; the blue colored is inversion result.

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$\sin^2\theta$, and the far angle contribution governed by $\sin^2\theta \tan^2\theta$ (Wiggins et al., 1983). The anisotropic effects only contribute to the near and far angles, in terms of the contrast of the Thomsen parameters, $\Delta\delta$ and $\Delta\varepsilon$. In moveout analysis, it is well known that δ and ε contribute to the near angle and far angle moveouts respectively. Equation (1) indicates that the Thomsen parameter contrasts, $\Delta\delta$ and $\Delta\varepsilon$, affect the near and far angle reflection coefficients respectively. In the special case of identical Thomsen parameters δ and ε across the boundary, $\delta_1 = \delta_2$, $\varepsilon_1 = \varepsilon_2$, the reflection coefficient degrades to the isotropic case, as if there were no anisotropy present in the media across the boundary. Nevertheless, the anisotropic effect on the travel time persists.

If we know the Thomsen parameters δ and ε, the VTI AVO equation (1) can directly be solved for the elastic properties α, β and ρ.

Roberts et al. (2004) take advantage of the exact similarity between the formulas for the VTI reflection equation and the isotropic one. They construct effective isotropic parameters which enable them to perform inversion as if it were just for isotropic media. Thus, they use the VTI incorporated isotropic AVA approximations to model the seismic amplitudes at different angles.

Alternatively, equation (1) can be rewritten as,

$$R_P^{VTI}(\theta) - \frac{\Delta\delta}{2}\sin^2\theta - \frac{\Delta\varepsilon}{2}\sin^2\theta \tan^2\theta = R_{P0} + G_{iso}\sin^2\theta + C_{iso}\sin^2\theta \tan^2\theta \qquad (5)$$

The right side of equation (5) is exactly the reflection coefficient for isotropic media. Thus, after subtracting the observed angle reflectivity in the VTI media by half $\Delta\delta$ modulated by $\sin^2\theta$ and half $\Delta\varepsilon$ modulated by $\sin^2\theta \tan^2\theta$, as shown in the left side of equation (5), the resultant angle reflection will be just the effects of the isotropic media, and can thus be solved with the established traditional isotropic inversion.

This would be a really elegant treatment. What would make such a treatment difficult to work in practice is the requirement to know the anisotropic parameters across the boundary. In fact, the anisotropic Thomsen parameters are generally much less accessible than the properties of velocities and density.

In contrast to the conceptual treatment above, we propose to shape the seismic amplitudes along angles such that the AVA curves from the conditioned angle gathers would fit a theoretical isotropic AVO relationship. The anisotropic effects on velocity and thus travel time have to be properly taken care of separately as described by

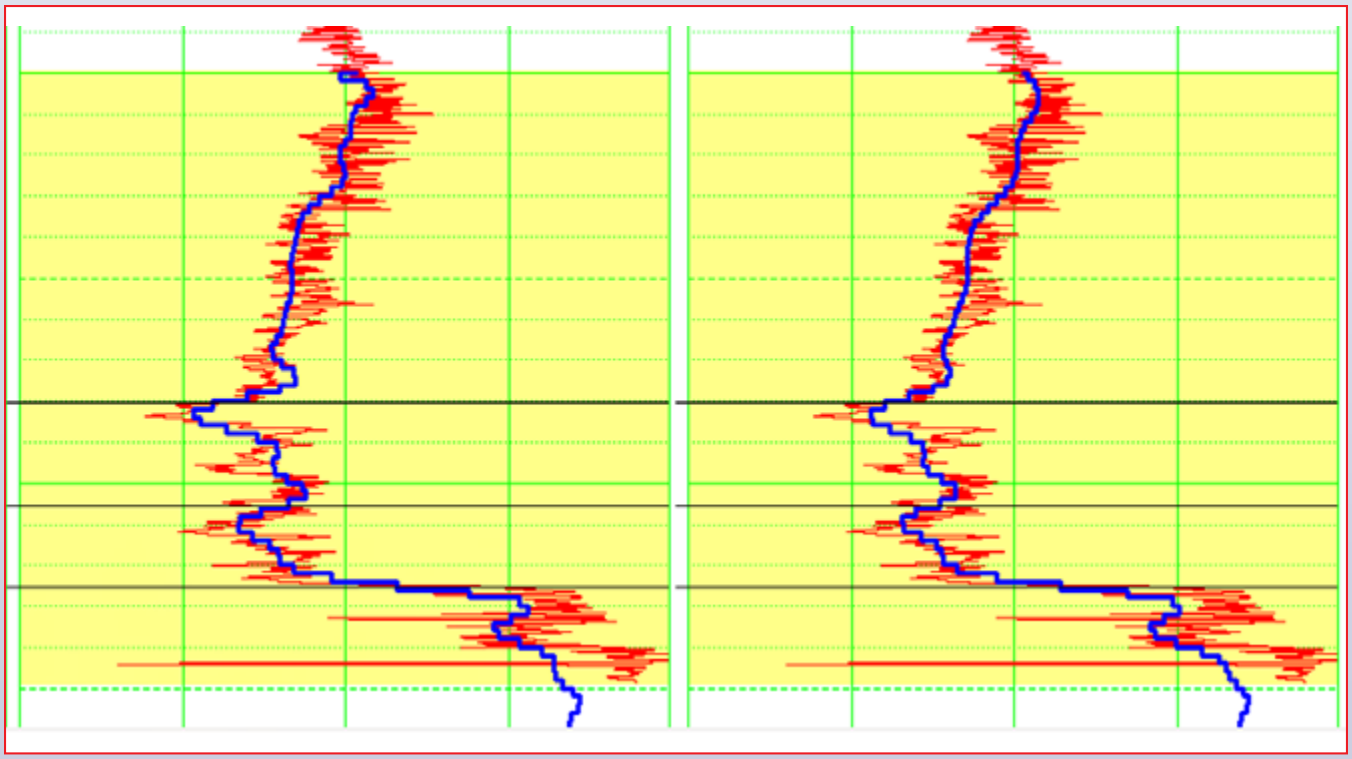

Figure 4: Inverted S impedance from the synthetic gathers shown in Figure 2. Right is from the isotropic gather, while the Left is from the VTI gather. The red colored curve is shear impedance log; the blue colored is inversion result.

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Ferla et al. (2014) such that wells tie and wavelets are free of such anisotropic effects. The resultant conditioned angle reflection amplitudes can thus be inverted with the traditional isotropic equation without the knowledge of the anisotropic parameters.

To demonstrate the effects of the proposed treatment on inversion in the shale plays, we take a set of logs from a true vertical well. The well has already gone through a comprehensive rock mechanics measurements and petrophysical modeling studies, with Thomsen anisotropic parameters of δ, ε, and γ available. Very strong values of δ and ε are observed for the interval of top Utica shale. For example, the ε value as high as 40% is observed. *Figure 1* shows the set of P sonic, S sonic, density, and the Thomsen parameters δ and ε.

We first simulate an angle gather from the isotropic parameters only using a synthetic wavelet with frequencies up to $80Hz$. *Figure 2* shows the isotropic synthetic gather at the left panel. A standard prestack seismic inversion is performed on this isotropic gather using the exact seismic wavelet. The inverted Ip, Is and density are shown in blue curves in the right panels of *Figures 3, 4 and 5* respectively. The red curves are the corresponding logs. The inversion recovers the elastic properties very nicely, as expected.

We then construct a synthetic angle gather with eq. (1) by incorporating the Thomsen anisotropic parameters. The VTI angle gather is shown in the right panel of *Figure 2*. We perform prestack seismic inversion with the exact wavelet used in the synthetics to directly invert for the elastic properties of Ip, Is and density on the synthetic VTI gather. The results are shown in the left panels of *Figure 3, 4 and 5* respectively. The inverted curves are in blue while the actual logs are in red. The inversion results are amazingly close to the logs. You would not be able to see the difference of the VTI data inverted results from those of isotropic gather based inversion without a close examination. *Figure 6* shows the two inverted shear impedance versions together with the same scale, from the VTI and isotropic gathers respectively. In the target interval, they are very close to one another with some small differences in the upper middle section.

This exercise clearly demonstrates that the proposed treatment can effectively take into account of the anisotropic effects on seismic such that elastic properties are truthfully recovered from the prestack seismic data.

Applications to the Utica

The 3D seismic data was acquired in a brick template during 2012-2013. It uses 20 receiver lines with 880 ft line spacing. The receiver spacing is 220 ft. Shot interval is 220 ft with shot line spacing of 1320 ft. The acquisition bin size is thus 110ft by 110ft. The nominal fold is 130 while the maximum offset is over 19000 ft. Figure 7 shows the rose diagram of this 3D seismic. It clearly shows that the data is full azimuth for up to 8360 offset. The target depth of the reservoir in the field is around 7000-9000 ft. Thus there is generally full azimuth

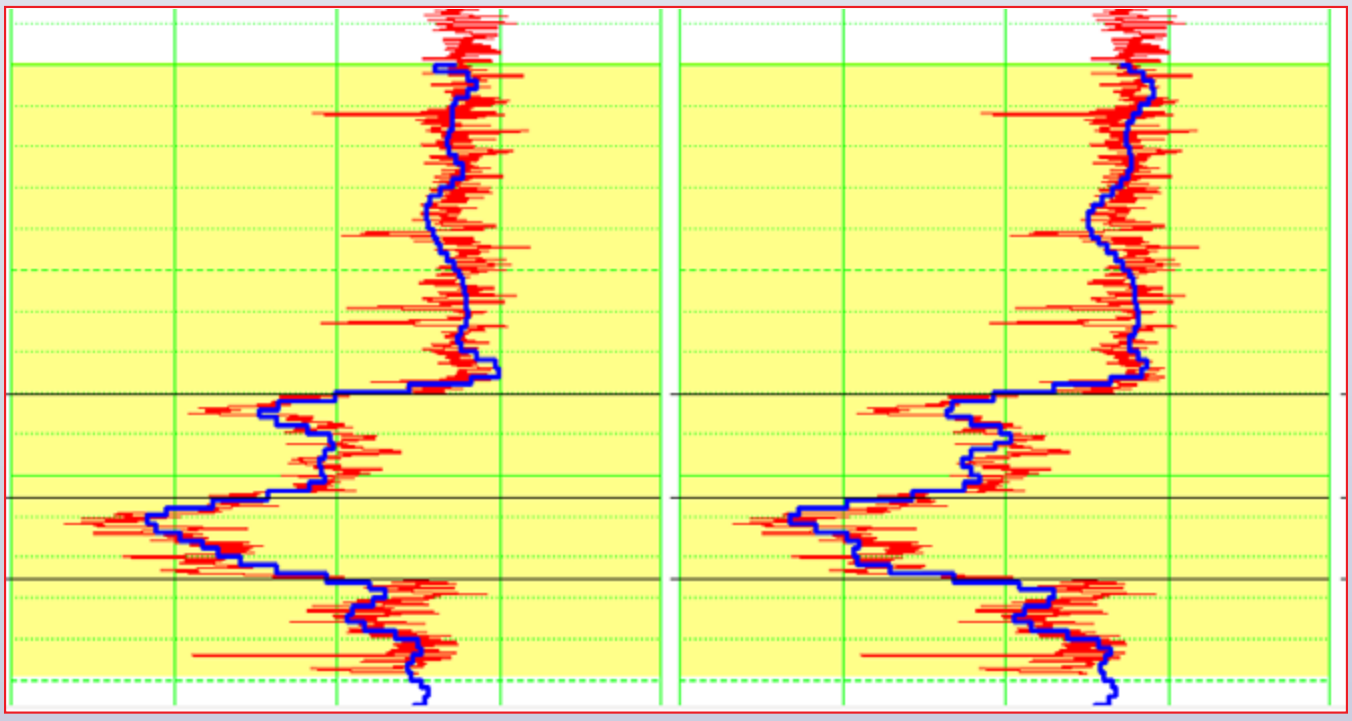

Figure 5: Inverted density from the synthetic gathers shown in Figure 2. Right is from the isotropic gather, while the Left is from the VTI gather. The red colored curve is density log; the blue colored is inversion result.

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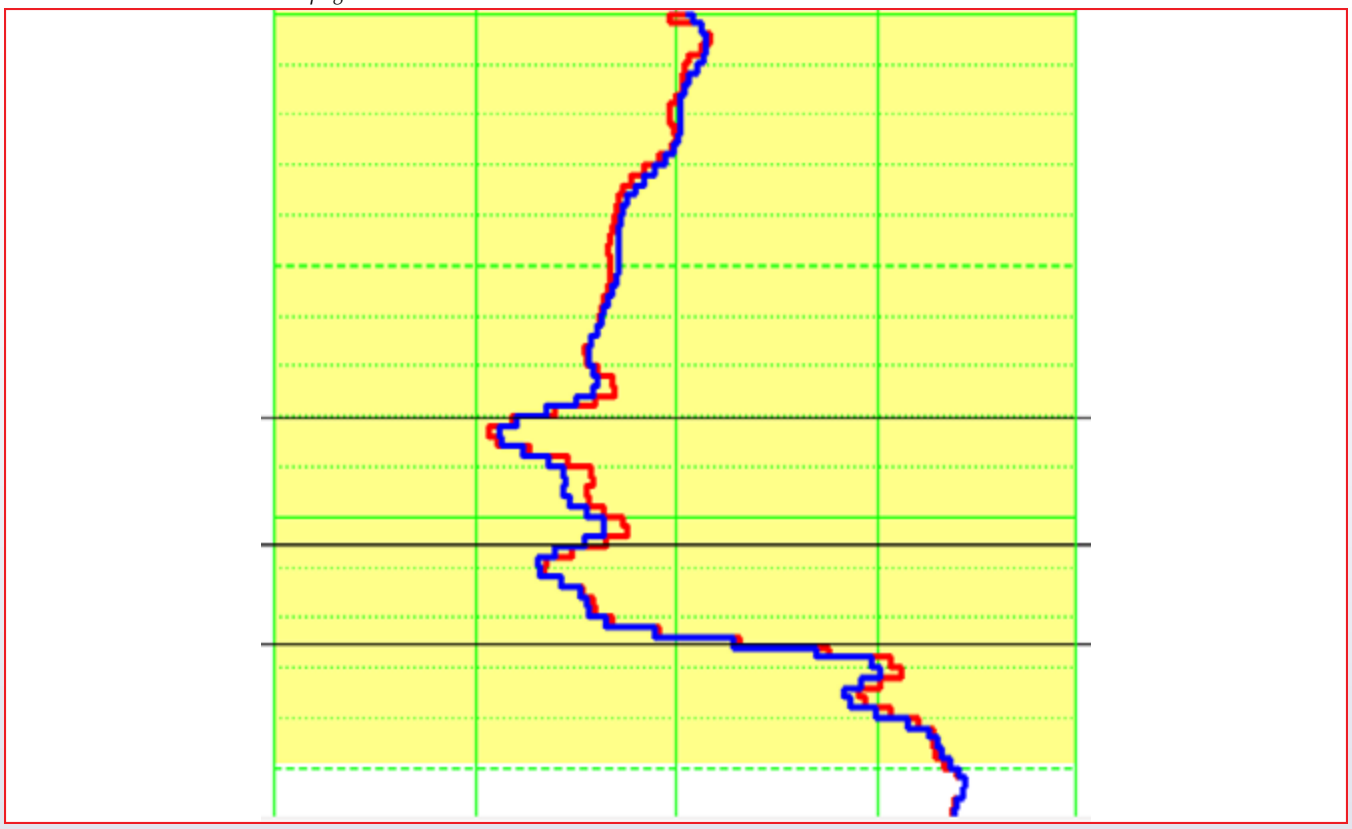

Figure 6: Inverted shear impedances from the synthetic gathers. The blue curve is inverted from the isotropic synthetic gather; the red curve is inverted from the VTI gather.

coverage up to the offset, with offset depth ratio of 1. This offset-azimuth property makes reliable fracture related azimuth analysis possible for the 3D seismic survey.

The seismic data is generally good in quality. In the target zone we have some quality reflections even in the 60-80*Hz* frequency range. However, it is also apparent that there is a significant loss or missing of the low frequencies as is common in land acquisition when 10Hz geophones are deployed for the acquisition

During the data conditioning, before the prestack inversion, we have exercised extra effort in recovering the low frequencies. The data was carefully reviewed that no dramatic low cut filter was applied to the data to limit the recovery of the intended low frequencies from the 10Hz geophones (Zhang et al., 2012). We were able to recover frequencies as low as 4-5*Hz*. This essentially lowers the lower end of the frequency by approximately 2 octaves. Without the need to boost the high frequency end, this low frequency recovery itself boosted the frequency bandwidth,

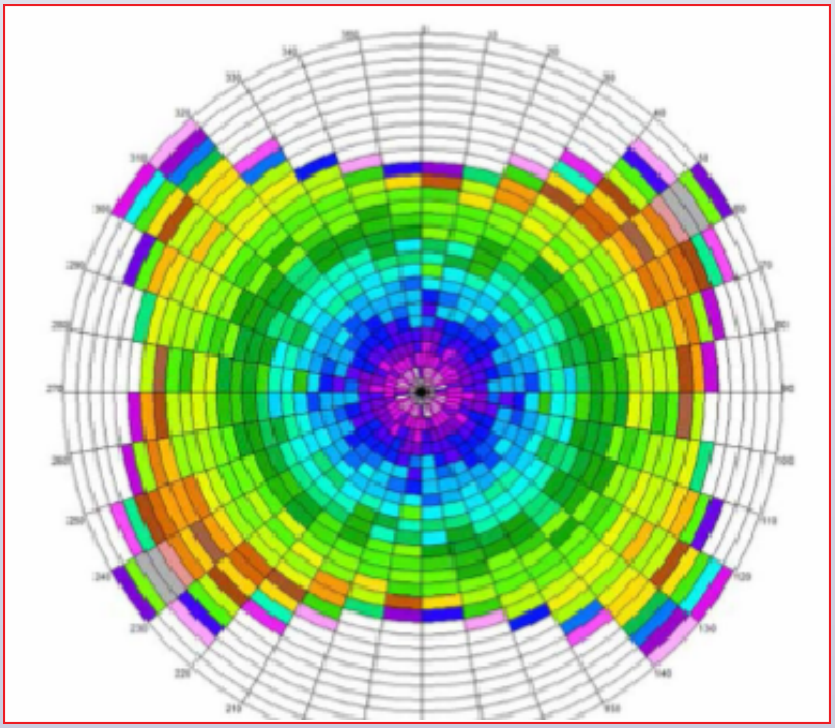

Figure 7: Rose diagram of the 3D seismic data. The data is full azimuth for offsets up to 8360 ft.

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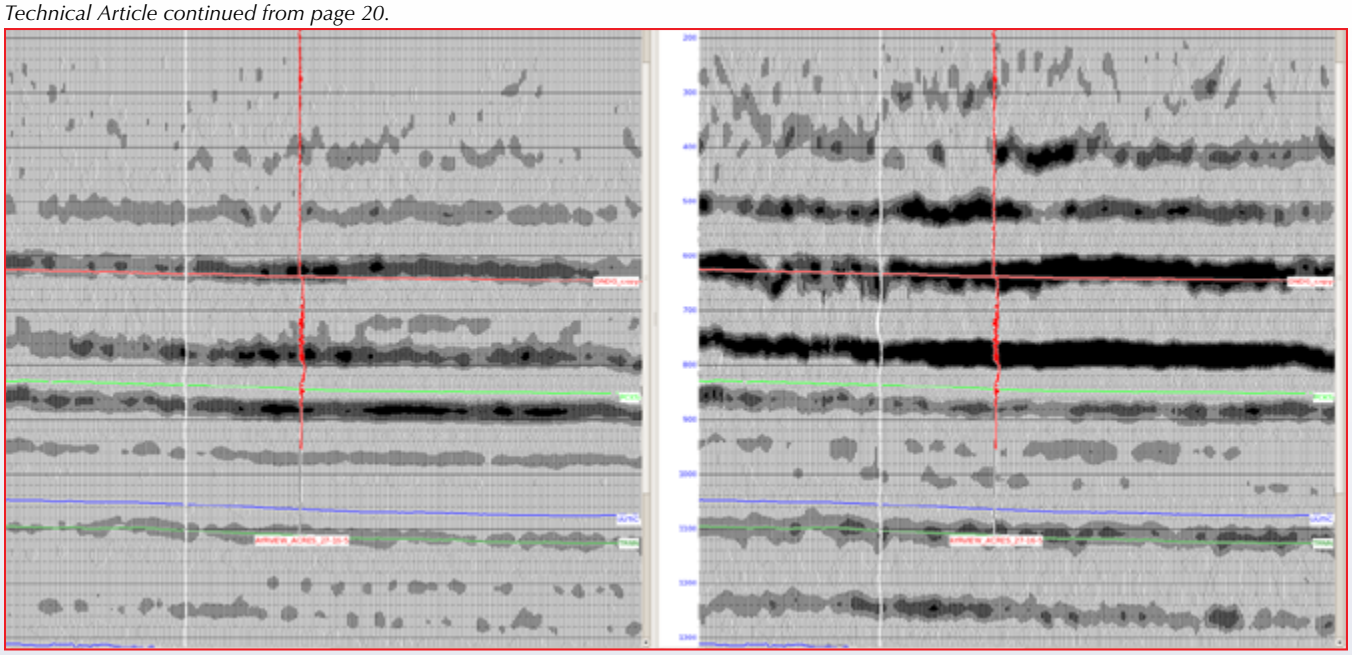

Figure 8: Low frequency comparison of the data before (left) and after conditioning (right). Significant low frequency data are recovered.

thus improving the resolution significantly. *Figure 8* shows a comparison of the low frequency components of the data (high cut at 10-15Hz) before and after the low frequency compensation.

With the seismic data properly conditioned, we were able to further enhance S/N, and zero-phase the seismic data. We were able to extract reliable wavelets, all practically zero-phased, consistently across angles.

We built low frequency (LF) elastic models from seismic velocities and seismic amplitudes. In unconventional resource plays we often have lots of wells with dipole sonic and density logs. This is really an advantage in shale plays, but it demands a lot of intense petrophysical work, as we found some of these dipole sonic logs had not been reviewed and edited for years after acquisition. We used carefully picked seismic velocities and the seismic amplitude attributes to build low frequency models for velocity, acoustic impedance, density, and shear impedance in sequence. This was achieved through training multi-attribute linear regression networks to predict log properties. These LF models all have a roll off frequency of 10Hz at the high end, essentially complementing the seismic data frequencies in the low end.

Prestack elastic inversion was performed on the conditioned seismic angle gathers with the seismic driven LF elastic models. The amplitudes along angles were conditioned to be conformable to the isotropic Zoeppritz equation as described in the previous section. For the target Utica shale interval, we were able to invert for angles over 45 degrees.

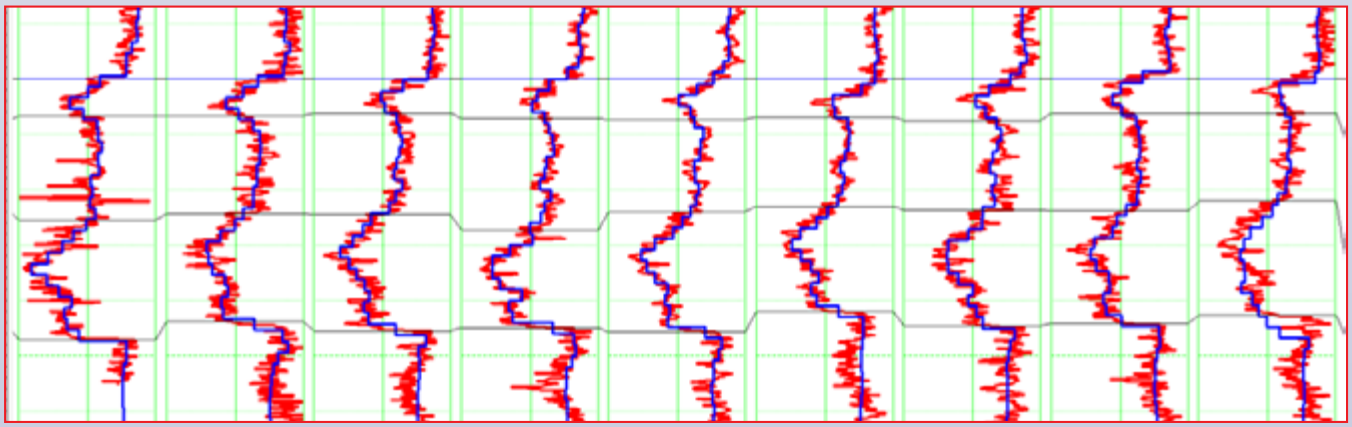

Figure 9: Final density through wells. The well at far right is a blind well. Prestack seismic inversion generates very high resolution density property closely matching the density logs.

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Figure 9 shows the final density property from this prestack inversion work. The far right curve is from a blind well. One can easily see that the inverted density very closely matches the logs at all the well locations including the blind well. This is really encouraging, as it is not that common to recover the density with such a high accuracy and resolution.

Such high quality is not just unique to the inverted density property, it is also present in the inverted P-impedance and S-impedance. *Figure 10* shows an arbitrary line of the inverted S-impedance. There are a few critical wells in this line including blind wells. The inserted far right well is nevertheless found to have issues with the S wave sonic, thus the S-impedance is unreliable. The inserted well at the center of the line is a blind well. Even with much fewer S wave sonic logs available relative to the P wave sonic and density logs, the final inversion reliably estimates the S-impedance with resolution and accuracy in the target zone of the project which is between the 2 horizons posted in the section.

Conclusions

Anisotropy is naturally present in shale, and its effects are often significant on both the travel time and amplitudes. Ignoring its effects will negatively affect the accuracy of seismic imaging and inversion. We present a workflow to address the effects of anisotropy on prestack seismic inversion by processing the seismic gathers such that the amplitude versus angle on such conditioned gathers can still be described by the isotropic Zoeppritz relationship. Synthetic VTI angle gathers, using Thomsen parameters from the Utica play, produces very similar elastic properties of P impedance, S impedance and density compared to the inversion results from synthetic isotropic gathers. Prestack inversion on the 3D seismic gathers for the Utica case generates high resolution elastic properties. These inverted properties are consistent across the area, matching well to the existing logs. These high quality, inversion based rock properties are being effectively incorporated into reservoir description and field development plans.

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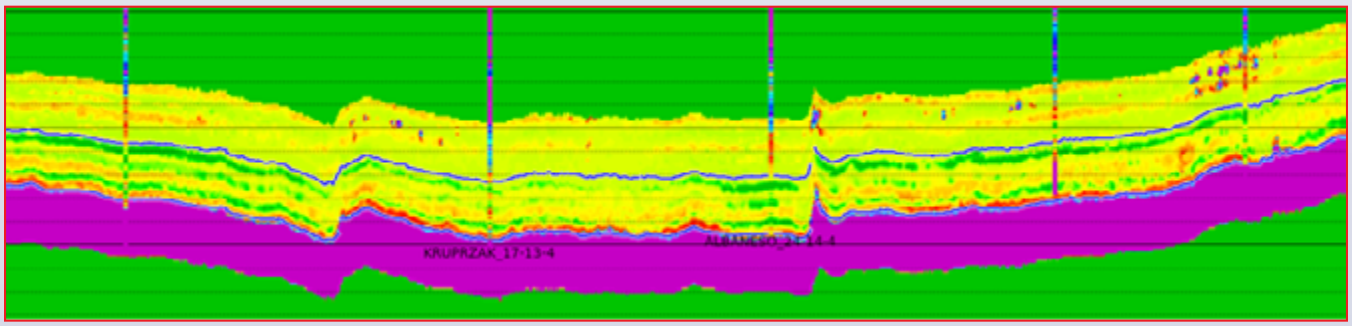

Figure 10: Final S-impedance from prestack seismic inversion. This arbitrary line passes through a few wells including a couple blind wells. The far right well is having issues with the S wave sonic, thus the S-impedance is incorrect. The inversion focus is between the 2 posted horizons.

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U of H Wavelets

Exploring for Water Using Resistivity Methods at the UH 2017 Geophysics Field Camp

By Abigail M. Ross, Jingjing Zong, Robert R. Stewart, and Bob Wiley

Fresh water is becoming a greater key resource as populations and infrastructure expand. Consequently, finding water is increasing in importance. This, in turn, mandates further application of geophysical methods and education in groundwater exploration. In May 2017, over 50 undergraduate geophysics students from across the southern U.S and 15 faculty and assistants participated in the 9th annual University of Houston (UH) Geophysics Field Camp, mobilized out of Galveston, Texas. The newest addition to the repertoire of geophysical skills taught to students in this 9-day intensive course was electrical resistivity tomography, using the Supersting R8 generously loaned to us by Advanced Geoscience, Inc. (AGI). Each day a group of 10 surveyed a coastal prairie field at the former Camp Wallace - now hosting UH's La Marque Geophysical Observatory (LGO). Previous work at the "shell" field, so-called because of the oyster shells distributed across its surface half a century ago, included a 560 ft x 160 ft electrical resistivity tomography (ERT) survey completed in February 2017 and a shallow test well completed in late April (Figure 1). A 56-electrode cable is consistently used among surveys with a custom, merged command file which utilizes the best features of the strong gradient and dipole-dipole arrays (Figure 2). Students learned the principles and practice of ERT surveying (Figure 3) from start to finish.

Figure 1. Map layout of the two ERT surveys and associated test well at the La Marque facility's "shell" field.

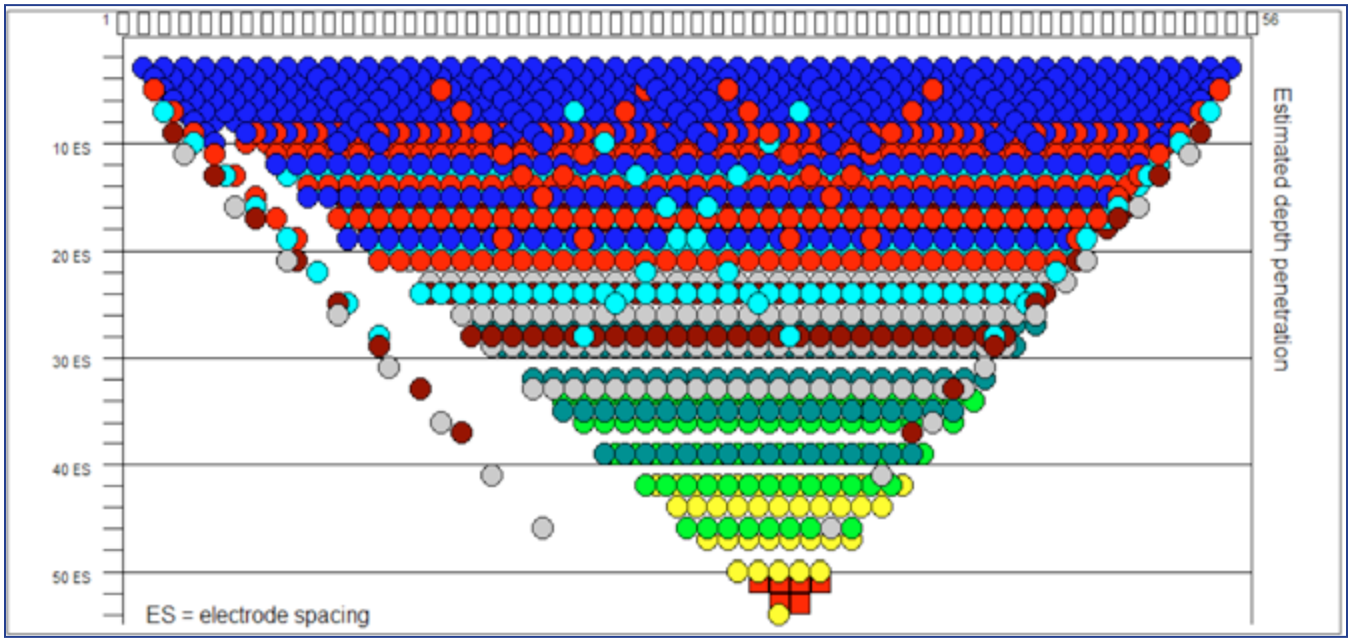


Figure 2. Electrical resistivity survey geometry including hypothetical survey points given the linear combination of strong gradient and dipole-dipole arrays.

Wavelets continued on page 24.

Wavelets continued from page 23.

Figure 3. Field Camp students at the survey site, with teaching assistant J. Zong, reviewing the fundamentals of electrical resistivity tomography (ERT) before beginning the surveys with the Supersting resistivity system.

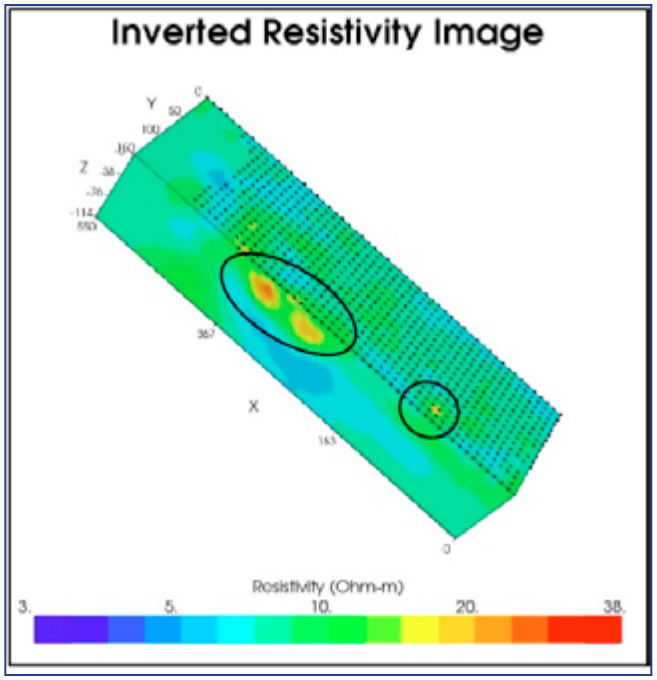


Figure 4. Merged inverted 3D resistivity from the February 2017 survey. Highlighted areas indicate zones of interest.

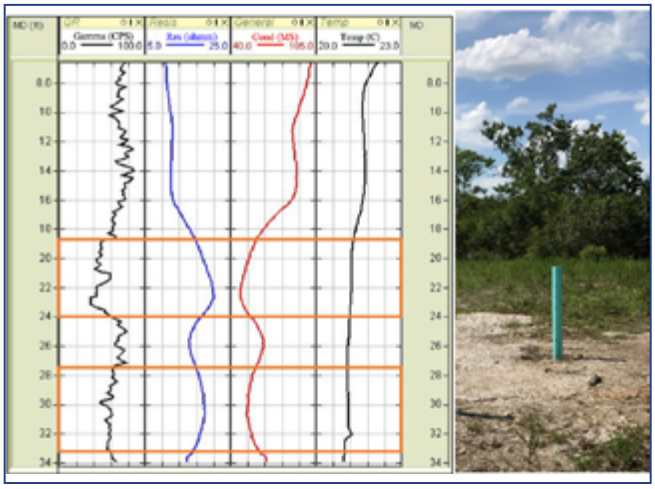


Figure 5. Test well logging results including gamma-ray, resistivity, conductivity, and temperature measurements. Lithology interface picks are highlighted. Photo of the test well (right).

Results from the February survey were interpreted as showing a fluvial channel of freshwater-saturated sands at around a 35 ft depth. The quasi-3D geometry along with the optimized electrical survey array indicated several high-resistivity zones of interest (Figure 4). This led us to drill a test well into the anomaly to evaluate our interpretation of a fresh-water saturated sand. Cuttings from the well indicated sand layers from 20 ft to 40 ft depths. Subsequent logging showed a gamma ray low and resistivity high (Figure 5) in this interval which we interpret as the same fresh-water saturated sands.

These results were consistent with those from other previously drilled wells at the site (Figure 6).

Water from the "shell" field well and well MW3, from the hydrogeological well field about 3300 ft away, were

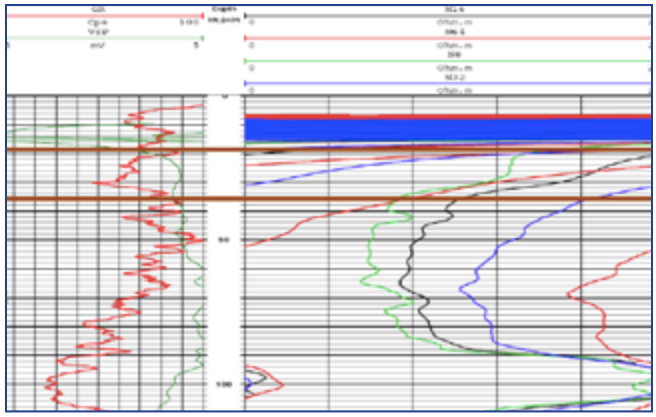


Figure 6. Well logs from top 100 ft of nearby observation well at LGO. We interpret low gamma ray and high resistivity intervals as water-saturated sands. Zones of interest and correlation are highlighted.

Wavelets continued on page 25.

Wavelets continued from page 24.

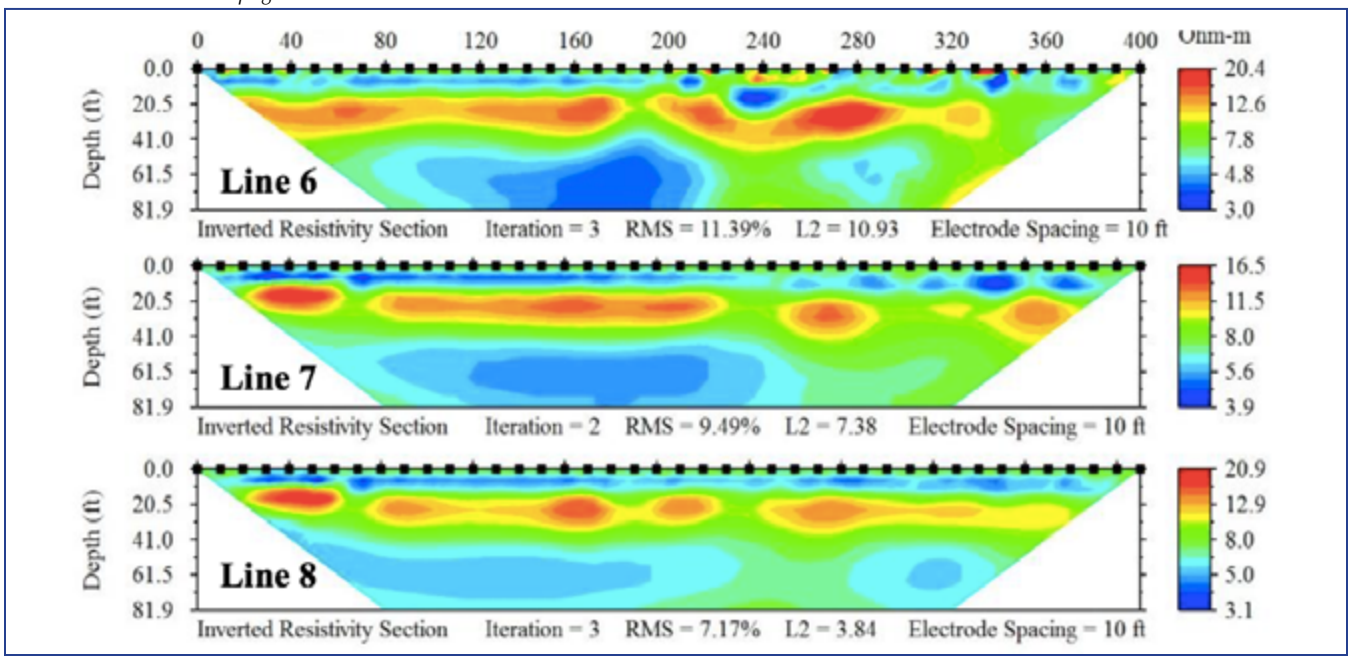


Figure 7. Inverted 2D sections from May 2017 surveys. Zones of interest are consistent with February 2017 survey and test well logging results.

tested soon after drilling was completed (See Capuano, R.M & Jan, R.Z, 1996 for more information about the hydrogeological well field at LGO). The new well water had an electrical conductivity of 813 µS/cm and a total dissolved solids (TDS) measurement of 520 ppm. Water from MW3 measured 1300 µS/cm and 851 ppm. For comparison, tap water from the lab building at LGO measured 210 µS/cm and 134 ppm. The TDS values from drilled wells were likely contaminated with drilling mud and sediments, but could be flowed to test the formation waters.

New survey lines, using the same surveying parameters as in February, were acquired during the UH Geophysics Field Camp in May 2017 and yielded similar anomalies at about 20 ft and 35 ft. Added survey lines stretched the initial survey area to 560 ft by 240 ft and give a glimpse into the time-variant relationship of shallow subsurface earth materials and electrical resistivity. Results initially indicated that the subsurface was too dry to effectively measure the resistivity and RMS error values were well above acceptable values. However, after a rainstorm, where about 3.5 inches of rain fell on the surface, contact resistances returned to normal and results from re-surveying of the original lines revealed a continuation of the 35 ft sand (Figure 7).

On the final days of the Field Camp surveying, perpendicular survey lines were recorded and confirmed the lateral location of the sand channel, matching the vertical field lines and the original 3D volume from February. Cross-line surveys (Figure 8) imaged the sand body located in the eastern section of the field, but also a second body located on the western edge. These results matched initial findings from the 3D volume where a smaller but still higher than background resistivity body dominated the zone.

We are excited about the potential to further develop resistivity tomography methods, applications, and future Field Camp instruction. A big thank you to everyone who has helped with this project, especially those at Advanced Geosciences Inc.: Drs. Markus Lagmanson and Hector Hinojosa and Jason Greenwood, the Allied Geophysics Lab, and UH's Department of Earth and Atmospheric Sciences for their continued support of Geophysics Field Camp.

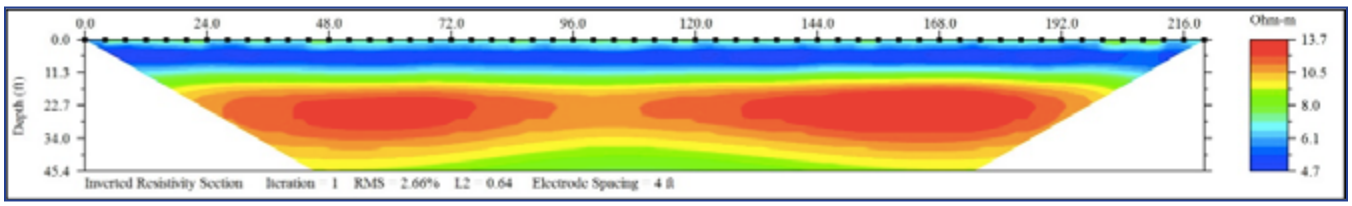


Figure 8. Inverted 2D sections from the May 2017 survey in the East-West direction

GSH Education and Development for Unemployed Professionals

By Whitney H. Blanchard, Chair

Geoscientists from all over Houston are enjoying this newest GSH event series. The objective of this event series is to help our members gain both technical and personal knowledge in preparation for upcoming career opportunities.

What makes these events most interesting is the widespread background of our speakers. Presenters include those working for large corporations in industry, conducting independent consulting work, managing their own business, and teaching in academia.

At one of our latest events Robert Stewart, from the University of Houston, presented current research being conducted at UH and described what programs are currently available for those seeking to further their education. This event also included Paul Murray, who has written a series of articles in the GSH Journal entitled *"Geoscientists without Jobs: A Guide to Surviving the Downturn."* His talk focused on his perspective of job searching and consulting, with an emphasis on networking. Attendees found both talks incredibly helpful, and were excited to learn and network at the Geoscience Center (where this event series is held).

GSH plans on continuing this event series for the foreseeable future, and has upcoming events scheduled for November.

GSH Outreach

Committee Activities *By Lisa Buckner*

20th annual Earth Science Week, Oct. 8-14, 2017

Since October 1998, the American Geosciences Institute has organized this national and international event to help the public gain a better understanding and appreciation for the Earth Sciences and to encourage stewardship of the Earth. This year's Earth Science Week will be held from October 8-14, 2017 and will be dedicated to the theme "Earth and Human Activity." This year's event, the 20th annual Earth Science Week celebration, promotes awareness of what geoscience tells us about human interaction with the planet's natural systems and processes.

Earth Science Week 2017 learning resources and activities are engaging young people and others in exploring the relationship between human activity and the geosphere (earth), hydrosphere (water), atmosphere (air), and biosphere (life). This year's theme promotes public understanding and stewardship the planet, especially in terms of the ways people affect and are affected by these Earth systems.

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

Earth Science Celebration - Saturday, Oct. 14 (11:00 AM – 3:00 PM) at HMNS

Energy Day - Saturday, Oct. 21 (11:00 AM – 4:00 PM) at Sam Houston Park (FREE)

For more information about the HGS Earth Science Week events in Houston, go to https://www.hgs.org/civicrm/event/info?id=1925.

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

Show your pride at industry conferences and outreach events. Pick-up your FREE "I'm a Geoscientist" lapel pin at a GSH meeting or order a free one from the American Geosciences Institute (AGI). The SEG is a member society of AGI.
http://www.americangeosciences.org//be-a-part

Are you interested in volunteering?

Do you know of a school that has a career day seeking speakers or a career fair at which GSH might be able to host an exhibit booth?

Or have you been invited to give a classroom presentation at your child's school?

We can work together to bring awareness to the students & their educators of the many rewarding and fun careers in the geosciences. Please contact Lisa Buckner at lbuckner@hess.com or 713-496-4256.

Outreach continued on page 28.

Outreach continued from page 27.

K-12 Outreach Volunteers Needed

Tuesday, October 10, 2017 5:00 PM – 9:00 PM

Needed - Energy industry female role models (technical & non-technical), Women's Energy Network (WEN) membership is required to volunteer to talk to small groups of high school juniors and seniors. Box dinner provided.

Young Women Energized at Houston Baptist University

https://www.womensenergynetwork.org/houston/community-initiatives/young-women-energized/

Earth Science Week 2017 Theme: "Earth and Human Activity"

Please help GSH educate children & families about geophysics and geology through fun and easy hands-on activities at our exhibit booths.

Easy instructions and lunch will be provided for all volunteers.

Saturday, October 14, 2017 11:00 AM – 3:00 PM

Earth Science Celebration at Houston Museum of Natural Science

http://www.hmns.org or http://www.hgs.org

Saturday, October 21, 2017 11:00 AM – 4:00 PM

Energy Day Festival at Sam Houston Park (downtown)

http://energydayfestival.org/houston

Contact Lisa Buckner at lbuckner@hess.com or 713-496-4256 to volunteer at any event.

Come play with us!

HPAC Auxiliary News

The Houston Petroleum Auxiliary Council

By Louise Andrews, GSH - HPAC Liaison

The HPAC is celebrating 10 years since merging with Geological, Landmen and Petroleum Engineering Auxiliaries.

Board: President Donna Parrish, V P Shirley Gordon, 2nd VP Wanda Shaw, Treasurer Jacqueline Yee, Secretary Susan Graul, Technology Georgeann Massell, Liaison Louise Andrews, Editor Bernadette Clark, Past Pres Bernadine Billiard

Mystery Item

This is a geophysical item...

Do you know what it is?

This month's answer on page 35.

Geoscience Center News

By Bill Gafford

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

We hosted another successful Living Legends Doodlebugger social event on August 10. There were a few new attendees as well as some of our regular guests. Some of the attendees are pictured below entertaining each other with stories of the oil patch and they also enjoyed seeing some of the items we were preparing for display at our booth at the September SEG Annual Meeting. These quarterly Doodlebugger events are free and don't require registration, but don't wait until the next one to come by for a visit. We are open on Wednesday mornings.

The Lafayette Louisiana Science Museum and the University of Louisiana-Lafayette are preparing an exhibit on petroleum industry history. The exhibit will open in late October and one of our torsion balances is on loan to them. Thanks to Fernando Ziegler for seeing that the torsion balance was delivered and assembled. We are also supplying supporting information to explain the role that torsion balances played in early Gulf Coast petroleum exploration.

Our "Bob Sheriff Library" now includes over 1000 books as well as many seminar workbooks and a growing collection of geoscience periodicals. Most of these may be checked out and we encourage the GSH membership to take advantage of this resource. We also have a variety of company publications and reports that help explain the development of some of our instruments in our inventory.

Volunteers are still needed to help with various projects which can include researching information on some our unusual artifacts to creating informational signs to add to our displays at the Geoscience Center and other display locations. We also welcome financial support from individuals or companies.

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

An Interpretive Seismic Attribute: *How Sweet it is*

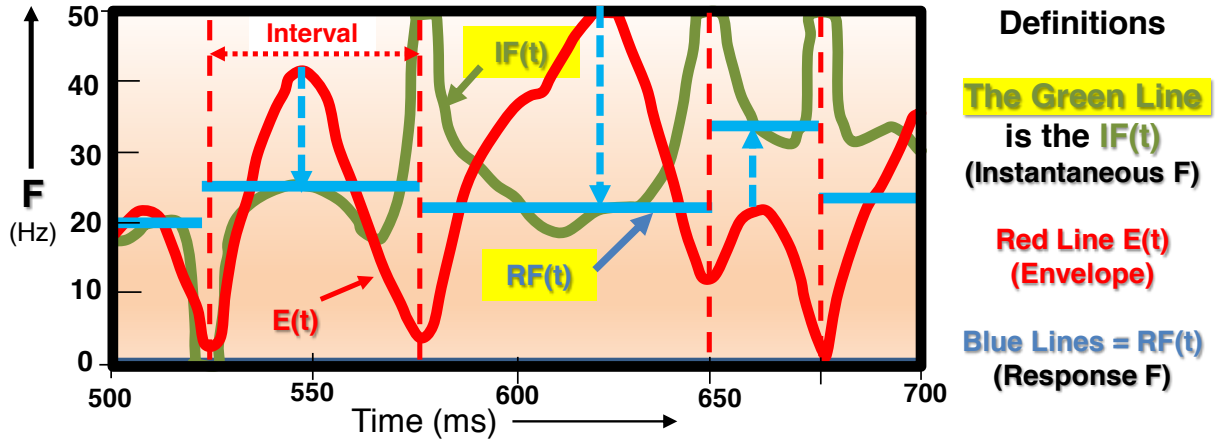
One of the joyful things about the Vector Trace Attributes is the variety of ways they can be combined, manipulated, and mutilated to serve the purposes of the ever-inventive Interpreter.

Today's discussion features the Interpretive Attribute known as "Sweetness" – an indicator of Good Things To Come.

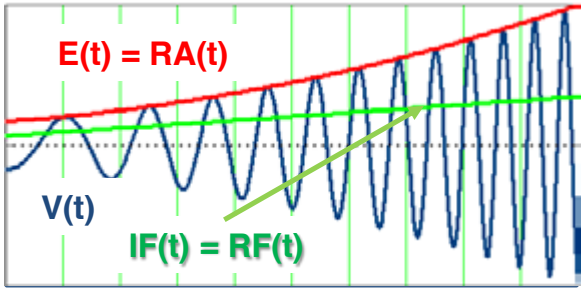
First, a few basic secondary attributes with which the lay attributer may not be familiar.

- **Response** Attributes. Example: **RF(t)**, the attribute values of **IF(t)**, at the **Peak of the envelope**, constant over an **interval** defined by the successive **minima** of the envelope, **E(t)**.
- **Response Amplitude** is the value of the **envelope** peak, held constant over the **interval** between minima.

The sketch, below illustrates these new kids on the block.



At the right is a **Vibroseis sweep**, **V(t)**, nominally designated an **upsweep**, with a **linear increase in frequency**, **f(t)**, but an exponential increase in gain, **E(t)**. In this case, both the Response Amplitude and the Response Frequency are the same as their Instantaneous counterparts. Somebody suggested this would clarify the descriptions of Response functions. Maybe not.



Oh, it's all so wonderful, Mr Guru! What can be done with it to find Grease?

A Pithy Question, Oh weary travelers on the Yellow Brick Road. Turn the page, now!

Tutorial Nuggets continued on page 32.

Tutorial Nuggets continued from page 31.

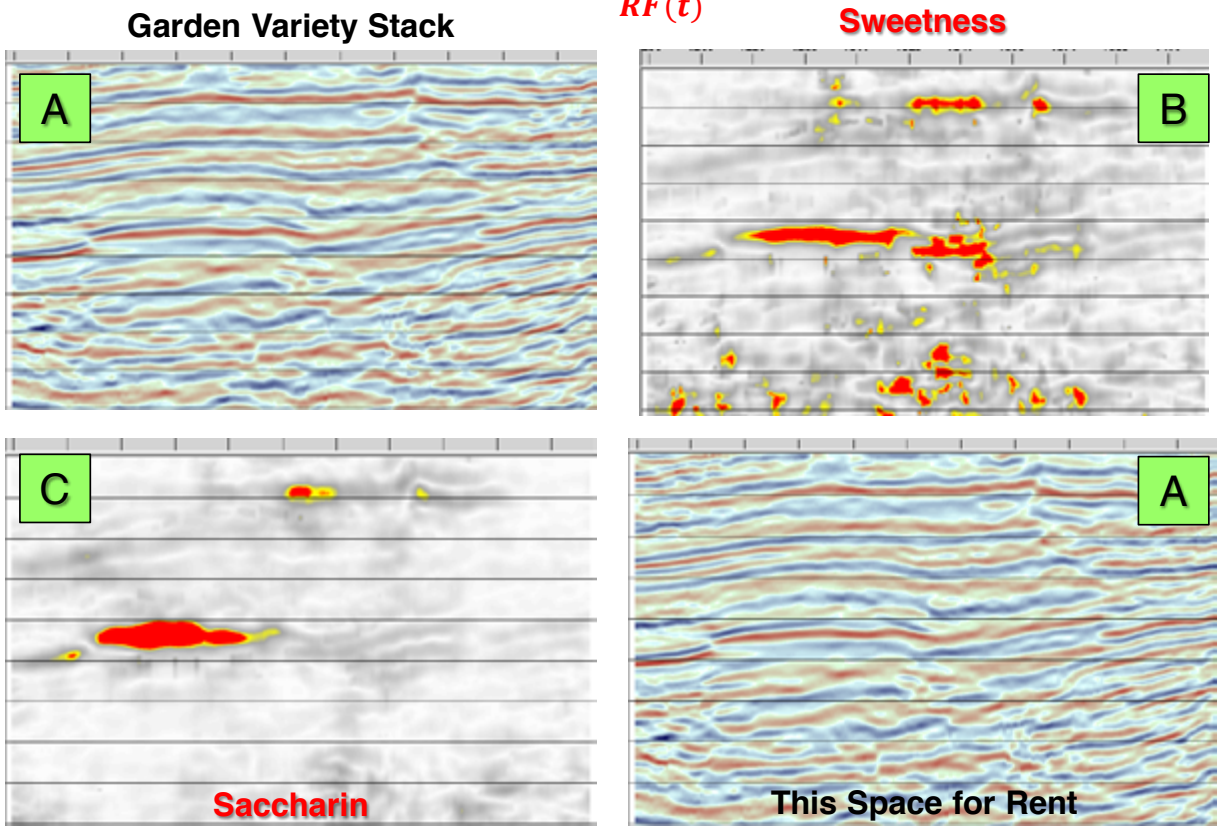
The Page with Answers to Pithy Questions

Some attributes have been known to rise up in righteous anger and demand to be recognized as legitimate **DHI**s. One such member of this patriotic class is the Instantaneous Frequency, **IF(t)**. A spokesman for **23 Hertz**, one of the original "Instants", said, "It has been well known in this community, that gas sand reservoirs cause not only a **Bright Spots** - Super Star DHIs, worshiped by all, but lesser known phenomenon as well. Among them, reduction in in high frequency content, along with diminished **Q** and a host of other tell-tale effects longing for a role in finding fuel for the masses.

Their Day Has come

Sweetness to the rescue. In earlier times (the 2nd Millennial Gay 90's) **Radovich and Oliveros** ('97 and '98) with subsequent tweaks by **Barnes**, defined this attribute, whose name says a lot, to be Response Amplitude divided by Response Frequency (discussed recently in these pages):

$$S(t) = \frac{RA(t)}{RF(t)}$$



[A] The GV PSTM Stacked section on InLine 4567; **[B]** The **Sweetness** Attribute: Clues about where to find the Goodies; **[C]** **Saccharin** (see below); **[A]** (again) Loves publicity, will fill gaps.

Saccharin is a **Guru**-invented attribute which utilizes special **AVO attributes** to make the Sweetness more **discriminating** and **obvious** to the weekend oil finder. More later.

Tutorial Nuggets continued on page 33.

Tutorial Nuggets

Tutorial Nuggets continued from page 32.

In September we proposed a Piece-Of-Cake question to start a New Nugget Season on a successful note. It appeared as given below:

Something Easy for the **Fall Opening Puzzle**: Bob can pick velocities in **100 mi² in 4 days**. Fred does the same job in 2 days. How long will it take Bob **and** Fred to do 200 mi²?

The **answer** (SPOILER ALERT !!!) is somewhat similar to the velocity averaging problems we faced last Spring. In this case, get the **rates** of picking velocities (in area per day) and write a simple expression for Total square mileage of velocity picking per day (both Fred and Bob working butts off). Then compute the **Total Time** = Area / (Mileage / day). Numbers below.

Rates: **(Bob) b = 25 mi²/day (Fred) f = 50 mi²/day**

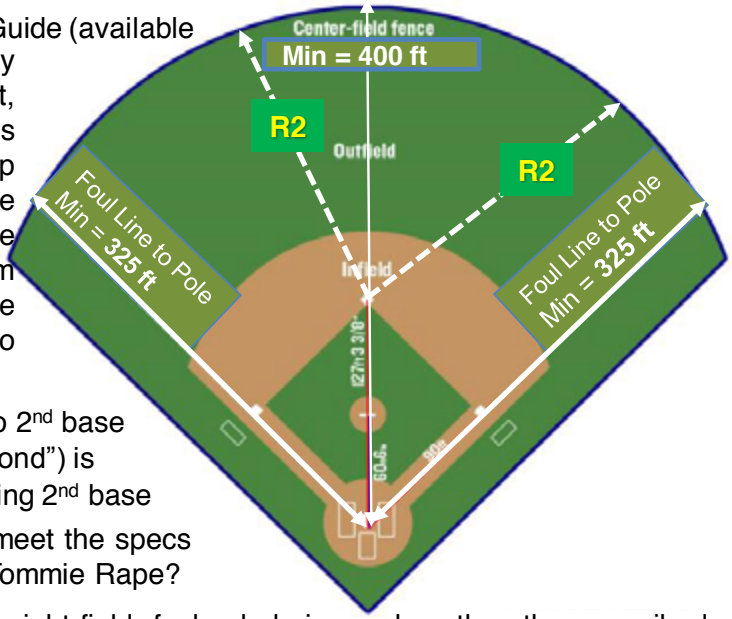
Working together: **(Bob and Fred) (b+f) = 75 mi²/day**

Total time: **(200 mi²) / (75 mi²/day) = 2.6667 days** ($2\frac{2}{3}\ days$)

[Caution: Bob and Fred should be encouraged to cross check each other's work to be sure the velocities tie seamlessly and smoothly across the full area.]

The **October Puzzle** honors *The Boys of October* with a **Geometric Baseball Problem**. This one doesn't have any baffling logic, but will help keep you and **Nick Pythagoras** on speaking terms.

Following the MLB Official Dimensioning Guide (available at GSH International Headquarters), Dmitry Kulakov, world renown geophysicist, editorial genius, and part-time grounds keeper for the Houston Astros, came up with a blinding brainstorm to build the outfield fence on the arc of a semi circle whose radius, **R2**, was the distance from **2nd base** to center field honoring the minimum distance from home plate to straight away center of **400 feet**.



Given that the distance from home plate to 2nd base is the diagonal of a 90 ft square (the "diamond") is some **127.28 ft**, will Dmitry's dream of having 2nd base the center of symmetric baseball utopia, meet the specs imposed by the Baseball Czar (2017-18) Tommie Rape?

Tommie is especially concerned about the right field foul pole being no less than the prescribed **325 ft from Home.** Does Tommie worry too much?

Doodlebugger Diary

Kareem and Wilt's Great Adventure

(weekend of June 25th, 1988) *By Steve Foster*

Marc Croes sent me this very interesting and entertaining item a few months ago. He specifically aimed at the Doodlebugger Diary. I re-read it and can see myself in this same situation (for some reason). We had two prominent geophysicists get on the wrong train in Eastern Europe and instead of returning to the EAEG meeting they spent a day or so much farther east than they wished. Lee Lawyer

If you have an item for the Doodlebugger Diary, send it to llawyer@prodigy.net or to editor@GSH.org

Geologist Dr. Perry Wigley and I (geophysicist) worked for the long-gone Texas Eastern Company in Jakarta with elderly Indonesian geologist Dr Udin Adinegoro. Pak* Udin was an emeritus professor of geology at a university in Jakarta who worked for us part-time. He also was a good friend to Perry and I and spoke fluent English. This was important to us, as I spoke a little Bahasa (Indonesian), and Perry spoke none. One time, Udin kindly invited Perry and I to visit his undergraduate field camp in the mountains of eastern Java at a place called Karamsambung. Udin and a couple of his fellow professors would be there along with roughly 40 students. Perry and I jumped at the opportunity to get out of the city for a few days.

For transportation, we were to take a train from Jakarta to Karamsambung, where Udin would meet us with a car and take us to the camp. One of the Texas Eastern drivers was assigned to go to the train station, wait in the long lines, and buy us a pair of first class tickets. We met the driver at the train station, he gave us our tickets and our adventure began.

We are standing in a packed train station in Jakarta, and I commented to Perry how I could read all the signs and figure out exactly where we were supposed to go. "What organization" I commented. Perry said "You can read all the signs because we are 6" taller than everyone else in the building!". He was right! I said "I feel like Kareem Abdul Jabbar", and the nickname stuck for the rest of the trip. I became Kareem Croes, and Perry was Wilt Wigley.

We jump on the train, find our assigned first class seats, and off we go. The train ride was interesting. We were the only Anglos on the train. There was a lot of foot traffic by our seats, and after a while we figured out we had become something of a tourist attraction for the Indonesian passengers. We took a chance and ate a meal (fried rice topped with a fried egg) served by a porter on chipped china. We had been warned not to use the silverware (or china) on the train, so we ate with our fingers. No wonder the Indonesians kept walking by! They wanted to see what the crazy Anglos were going to do next!

We had asked a porter to tell us when we got to Karamsambung, and we knew we should get there around 11:00PM. At the appointed time, I found the porter and he pointed out the Karamsambung train station as we whizzed past. We were on an express train. It didn't stop at Karamsambung. OOPS!! As we flew by, I could see our ride parked at the train station with its lights on, the engine running, and some students kicking around a soccer ball. I doubt they saw our shocked faces through the grimy train windows.

About an hour later, and maybe 30 miles down the road, we get off at the next stop. I don't remember the name of the town. It's 1:00AM and Perry and I are standing on the platform (the station was closed and locked) with no clue what to do. We decide the best course of action would be to try and get back to the Karamsambung train station, where hopefully our ride would still be waiting. The only others around are a handful of rough looking local men. I approach the men and tell them we need a taxi. The conversation probably went something like this:

Kareem (in Bahasa): Doorknob fruitcake smelling taxi?

Local (in Bahasa): What the heck are you talking about?

Wilt: (in English): What did he say?

Kareem (in English): I think he is going to get us a taxi.

After 30 minutes of arm waving and pigeon Bahasa, we figured out the men were NOT muggers or derelicts, they were pedicab drivers looking for fares! Pedicabs are bicycle powered buggies. They look like an open, horse-drawn carriage, except there's a guy pedaling a bicycle replacing the horse. They were a popular, inexpensive form of transportation in rural Indonesia. Now, we couldn't take a pedicab 30 miles to Karamsambung, but the drivers convinced us to get in 2 of their cabs so they could take us to a car. We negotiated a 1000 Rupiah fare (60 cents) for the rides, and then some serious squabbling broke out.

Doddlebugger continued on page 35.

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

Doodlebugger continued from page 34.

After a few minutes, I figured out they were arguing over who had to haul Wilt (Perry)! At the time, I was skinny and Perry was heavy. Both drivers wanted to take me! When I told Perry, what was happening, he cracked me up when he "I don't blame them. Hell! If I gain 20 more pounds I will be eligible to be King of Somoa!" I think my hysterical laughter scared the Indonesians.

Finally, we climb in the pedicabs and rumble off. All the other empty pedicabs followed us, as the other drivers wanted to see what happened. Once again we had become the local entertainment. Needless to say, we didn't understand all this. We thought there was a good chance we would be taken to the woods and robbed. As it turned out that didn't happen. We were taken a few blocks to a large house. One of the pedicab drivers beat on the door until the owner came out. He introduced us to the owner, and collected his 60 cents with a HUGE smile on his face. From his smile I guessed we had paid him double or triple his normal fare.

The house owner OWNED A CAR!! And he was willing to drive us to Karamsambung for a reasonable fare (to us) of $30. He goes inside, gets dressed, opens the driveway gate and rolls out in his "car". It's an ancient Kijang (Indonesian made) van. It looks like a miniature old VW hippie bus. One of the doors is missing. Most of the windows are gone. The stuffing is gone from the seats. The headlights don't work. I think you get the picture.

It's now around 3:00AM. We have no choice. We hop in the van and off we go! The driver is a wild man. He drives like he is trying to throw us from the van (no seat belts) through the missing door. He roars up and down hills in the center of one-lane dirt roads at 30 mph with no headlights. Every time he slows a bit, our dust trail catches up to us and fills the van with choking dust. Perry and I are truly scared. If another vehicle had come in the opposite direction there would have been no way to avoid a head-on collision. Around 4:30AM, we safely arrive at the Karamsambung train station. The station is empty, except for the always present collection of pedicab drivers. Once again, my broken Bahasa came in handy. The pedicab drivers tell us that our ride had been there for a few hours, but they had given up and gone back to the field camp around 2:00AM. Wait!! The pedicab drivers knew how to get to the field camp!! After additional negotiations, another $25 will get our luxurious van to take us to the field camp, and includes the price of a ride-along pedicab guide who would direct us to the place.

The field camp is on top of a mountain. The van doesn't have much power. The 10 mile ride takes an hour. We had to get out and push more than once. We arrive safely at the field camp at 6:00AM just in time for breakfast. Pak Udin was very relieved to see us. The whole trip had been his idea, and he was sure to get in trouble if something bad had befallen us.

Needless to say, our arrival causes a sensation. We say hello, take cold showers and climb into bed. The students got bits of our story from Udin during the day, and by evening they are bursting with questions about our adventure. We held a "press conference" with the students (Udin translated) and told our story. Our sense of humor about our long night endeared us to the students. They laughed their asses off at our story, and we got an extended ovation.

The rest of our stay was pleasant. The mountains were beautiful. The geology was interesting. The hard-working students adored us and we admired their intelligence and dedication. The students continually grilled us on life in America. Many of them had studied English so communication was difficult, but possible. I remember their amazement when I said there was little homelessness in America (tens of millions of Indonesians are homeless) and that in America many of the poor had televisions. At the time, TV's were a luxury in Indonesia, and TV's were quite scarce in the rural areas. By the time we left, I am sure every one of the students had resolved to move to the U.S. at the first opportunity.

The trip home was uneventful. We got on the right train!

My dear friend Perry Wigley went on to become Chairman of the Geology Department at the University of Nebraska and Director of the Nebraska State Geological Survey. Perry passed away in 2004 from complications after a back surgery gone bad. I miss him dearly. R.I.P. Perry.

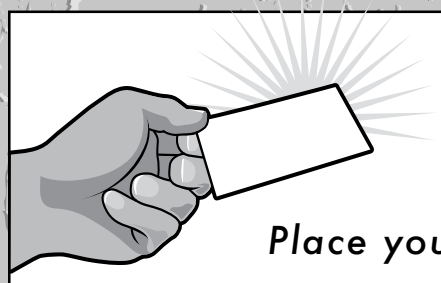
*Pak – Indonesian for "Uncle". Used as a term of respect among friends.

P.S. I was able to google the exact weekend because on Saturday night the students all gathered around a tiny TV to watch Holland beat Russia 2-0 in the UEFA Cup Finals. Indonesia was a former Dutch colony, and I was surprised to learn the students were rabid fans of the Dutch team. It turns out most of them were from middle and upper class families that prospered during the colonial era. Some of them, including Pak Udin, spoke Dutch!

Mystery Item

The Mystery Item for the October GSHJ is a VHS radio antenna that was used on a Vibroseis unit.

Mystery Item on page 29.



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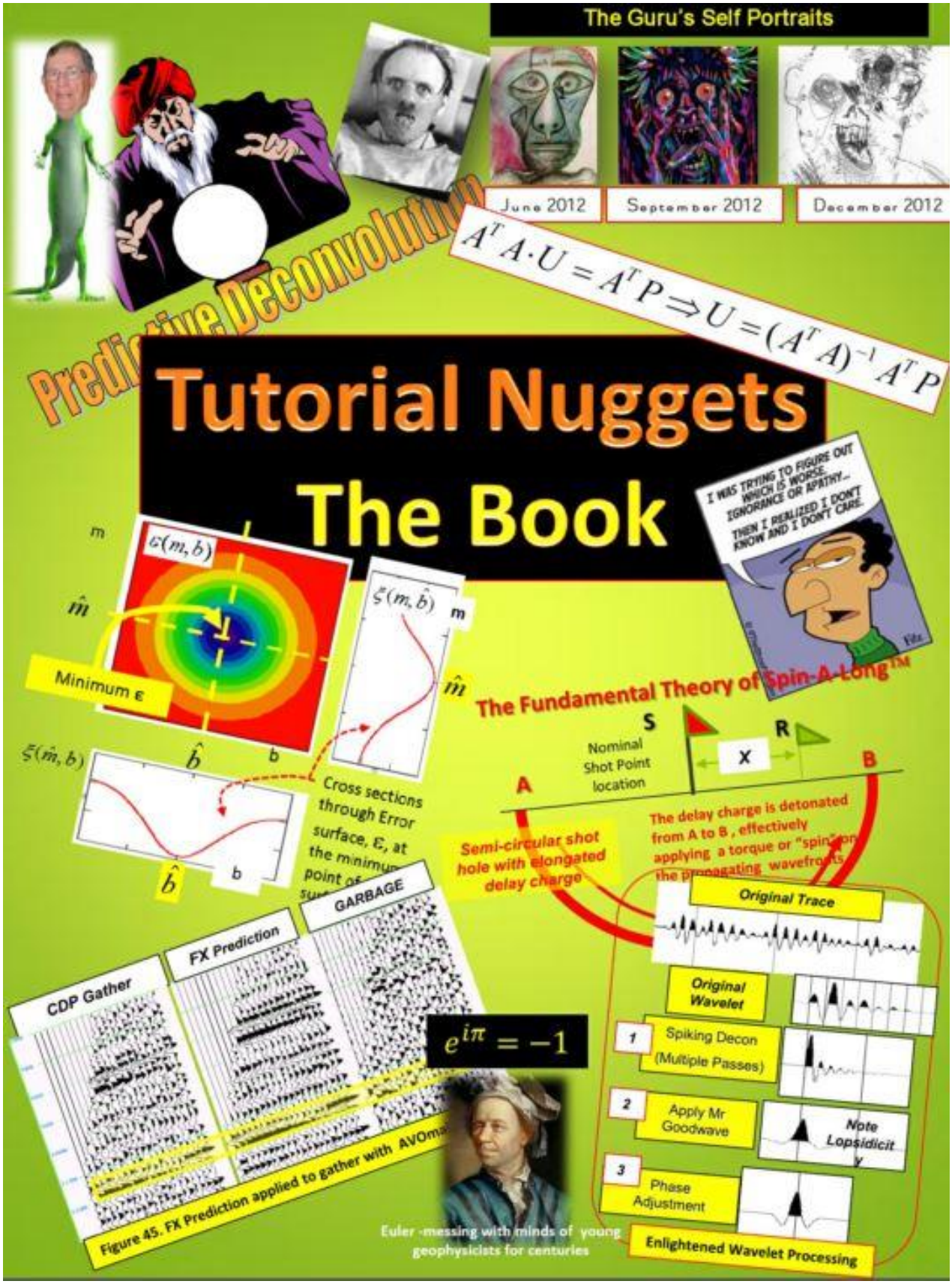

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