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GEOPHYSICAL SOCIETY OF HOUSTON
Volume 10 • Number 9

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High-resolution Distributed Acoustic Sensor Using Engineered Fiber for Hydraulic Fracture Monitoring and Optimization in Unconventional Completions – Page 23

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Preparing for a new seismic line.

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 Alvaro Chaveste, editor, at AlvaroChaveste@hotmail.com

GSH JOURNAL DEADLINES

Sept 2020.....	July 13
Oct 2020.....	Aug 17
Nov 2020.....	Sept 14

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Letter From The President

Geophysics in the Time of Coronavirus

By Craig J. Beasley, GSH President



Giving all due respect to Nobel Laureate Gabriel García Márquez, I don't intend to compete with his well-known novel of a similar title. Rather, I liked the provocative tone of the title: how could one possibly think of love amidst the horror of a cholera epidemic? Similarly, how can one be dabbling in

geophysics (actually data analysis) in the middle of what is said to be a global pandemic with the potential devastation of the 1918 influenza pandemic. More on this later, but for now, the answer is simple: I have no other choice. Your GSH officers have been forced to deal with the reality of managing GSH and its activities in the face of lock-downs, self-imposed quarantines, panic buying and a myriad of other issues imposed by the coronavirus outbreak. Believe me, it is not what any of us thought we had signed up for. Nevertheless, I expect that the Nobel Prize committee will find it difficult to choose between literature and mathematics for my prize. But, full disclosure, this is a work in progress as it is written in mid-April and things are sure to change as the virus and world's response to it evolve.

Being a long time Houston resident, the coronavirus event (so far) has had all the feel of a hurricane. Usually, the lead up to a tropical storm has three distinct phases. At the beginning, it is something far off that may or may not impact you. There is mild awareness and curiosity, but it is not high priority. As it comes closer, it comes on your radar screen (literally!) and one realizes that all the things experts are saying could actually happen. Prudent people begin to plan and prepare but don't take large measures as, after all, it may not hit. But they are ready to take action with their plan when it becomes necessary. The third phase is when it IS going to happen. The prepared start to execute their plan – the rest panic and do irrational things. Like hoarding toilet paper and bottled water. I can understand the first, but bottled water for a virus outbreak? Maybe it makes sense if you would

be so bummed at the prospect of having to drink tap water that you would break quarantine and go marauding for hidden stockpiles of Evian? Given the well-documented effect of such disasters on the birth rate nine months post-event, you'd think they might be hoarding other items, but I digress.

I like to think that GSH has responded in a calm, timely and reasonable manner. By mid-March, following advice from the CDC, we cancelled and/or postponed all in-person GSH events through mid-May. Major events such as the Spring Symposium, the GSH golf tournament and the Annual Meeting and Honors and Awards Banquet have been rescheduled in June, with the understanding that it is possible (some would say likely) that we will just be rescheduling again when June nears. So be it. Setting new dates ensures we have a venue if it is possible to hold events and, if not, there is no cost or risk to GSH in doing so – except our time. So, we will continue to take a wait-and-see approach but rest assured, we will be in time with any changes, which includes giving GSH members ample time to know of and respond to such changes.

I don't mean to minimize the impact of these disruptions on the GSH. Our time is important and we were already stretched to the limit in trying to respond to an already challenged industry. Before coronavirus, the board, volunteers and two staff (only two, can you believe what they accomplish?) had been working to provide more value to the members by expanding both social and technical events. We instituted a second



Letter From the President continued on page 5.

Sporting Clays event and held a new major technical event, the Fall Forum and welcomed two new SIGS this year. We were feeling good about these efforts and were planning how to make them better next year, along with expanded offerings to coincide with the SEG Annual Meeting, held in Houston this October. And then COVID-19 hit.

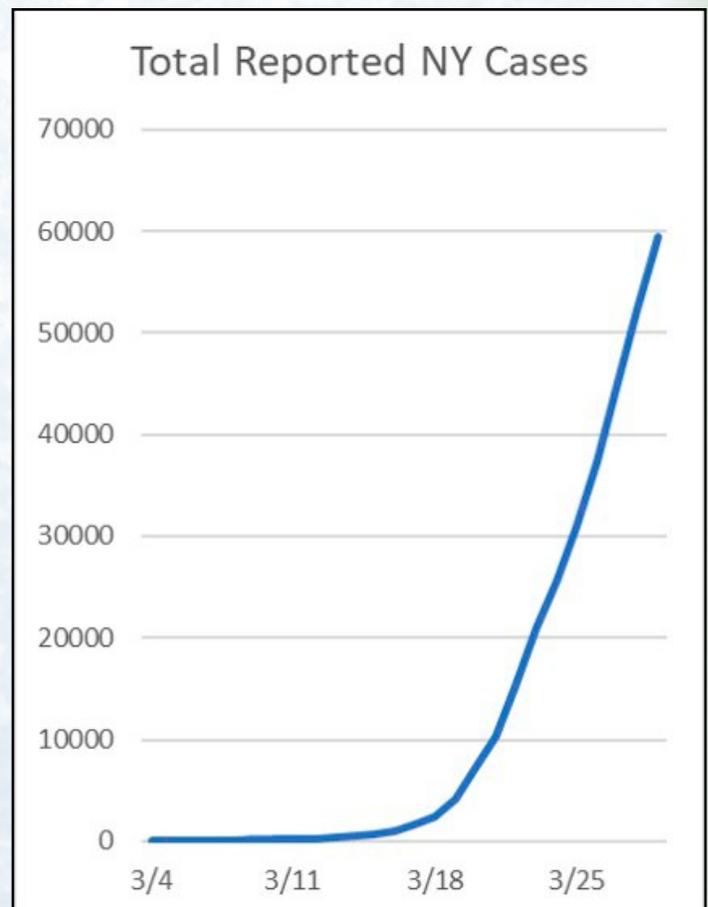
Actually, there is a fourth phase of disasters, which is what we have entered now: the disaster has hit, which is a time of uncertainty. Actions you take may be successful or not and there is always the issue of unintended consequences. For example, who predicted the hoarding of toilet paper in response to announcements that we would likely enter a phase of working from home and social distancing? Undoubtedly, this created the perfect environment to increase the spread. I am sure the lock down will show unintended consequences too. So, we at GSH are trying to think through what we are doing in response to these challenges. Our first thought was that maybe we could continue to hold events under the guidelines of the CDC, enforce social distancing, etc. However, we realized that our members might vote with their feet and we ran the financial risk of holding the event but nobody shows up. We began to prepare for possible cancellations and postponements by checking contracts for force majeure options, and compiling options, contingencies and cancellation/postponement issues. When the CDC made its announcement, we were ready to pull the trigger and immediately announced our actions. We will continue to be hopeful for a swift resolution but be prepared for a longer ordeal. Please watch for emails and visit gshtx.org for the latest GSH status messages.

Now for a little fun. As I have monitored the outbreak situation, I have watched the steady stream of numbers detailing new cases, deaths and so on. Geophysicists are naturally suspicious of any data (that is not their own). What I can say is that those numbers are practically meaningless in terms of what you would like to know: how deadly it is, how does it compare with other outbreaks, are we winning the war against the virus, when will it end, etc. Rather than continuing to shout my objections at the TV, I decided to take a positive approach: there must be something of value in the numbers, so what is it?

It's clear that we are somehow trying to model the outbreak so let's have a look. Let's assume a

contagious person infects r people a day. That means the number of new infections in a time period is rl where l is the number of contagious people at the beginning of the period. So the rate of change of infected people is rl , or writing it as a differential equation $l'(t) = rl(t)$. This simple analysis is where the exponential graphs come from. But, of course this can't be right, otherwise, infected populations would increase infinitely. We have confused "contagious people" with "infected people". In reality, people only are contagious for a time – they either get well or they die. And there is a more subtle issue: the probabilistic model of transmission assumes each carrier encounters a similar group of uninfected people at each time step. At some point, the population of those eligible for infection reduces due to immunity and death. And there are many other things we could model such as the fact that r may change over time. In fact, this last one is precisely what we are trying to do: decrease r over time. This is what they mean by "bending the curve" by social distancing.

To get a handle on this, let's assume we are at the beginning of an outbreak, as we are now, which



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means for this period, we can ignore the effects of immunity and death on the population that is at risk of infection. But we need to retain the other complexities. Assume people become infected and remain contagious for a fixed time period t_c . Then the number of contagious people at a given time $C(t)$ is the number contagious at the previous time step plus those newly infected less those who are no longer contagious. Writing this as a differential equation, we get $C'(t) = r(t)C(t) - r(t-t_c)C(t-t_c)$.

I won't go into it here, but this small change makes the problem more difficult to analyze in the classic sense of differential equations where one wishes to characterize existence and uniqueness of solutions in closed form. Simply adding the time delay has changed this to a delay differential equation (DDE) and it would not be too bad if r was a scalar, but in our case, we specifically want r to diminish over time – bend the curve!

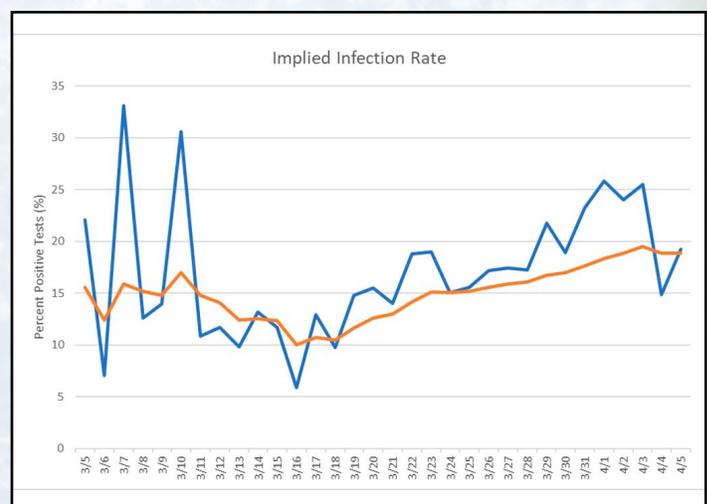
Now we have the equation that would govern an outbreak under these circumstances. Note that if we change our previous definition of $I(t)$ to be the number of newly infected people at time t , $I(t) = r(t)C(t)$. Wonderful! $I(t)$ is what the news gives us every day. We could begin with an initial condition, and use the equation for $C(t)$ above to model future times and arrive at an estimate for r . Except for one thing. We are not exactly given $I(t)$, we are given $I(t)$ restricted to the patients that were tested. Generally, these are sickest patients and, more problematic, the number of tests change with each time step.

Can we just assume that the tested group is representative of the entire population? That is what is implied by the media's use of these numbers. But this is exactly what we are trying to determine so we can't make this assumption. However, we can at least remove the variability of the number of tests. If we do that, maybe we can say something from the data. Here is a graph showing the "normalized infection rate" and the "cumulative infection rate".

The blue line shows the daily new positives normalized by the number of tests completed that day in the US. The red line shows the cumulative value of positives divided by total number of completed tests. The data are erratic early in the series, I suppose due to small

numbers of tests. Other than that, what can you say from this graph? One thing it shows is that, roughly, the number of positive coronavirus infections are between 10% and 25% of the total number of tests, which are performed on the sickest. It would be much lower for the full population. One thing that might disturb you is the apparent rise in the last few weeks towards 25%. That says only that the coronavirus cases are becoming a larger percentage of the total. Does this mean it is accelerating? Or could the others be slowing with warmer weather? In fact, a check of CDC data shows that at least influenza is decreasing during this period. But the last few days show a flattening, which is a good sign.

We still can't conclude much from the numbers given. In particular, the answers we want so desperately – are we winning, when can we go back to normal – are just not there. The last few days seem promising, but who knows at this point? By the time you read this, we will know much more. As I write this, the largest outbreak is in New York state and it dominates the numbers. However, there is a strong indication it is perhaps peaked, which is good news. But there are other potential hotspots which can rise if quarantine efforts are not effective. So, this problem may be like geophysics after all. People used to ask how long do you have to iterate migration or FWI. The answer is until you get tired or run out of money. That seems to be where we are heading with COVID-19. When we see the total number of active cases finally begin to decrease, we will know that, sometime in the past, we were successful in bending the curve. But it seems likely we will modify the lock-down before that. We just aren't made for that. Now, I'm going to go back to yell at the TV some more. □



A Word from the Board

By Phil Schearer, Second Vice President Elect



During the 2019 holidays, my son, a 3rd year TAMU student seeking a BS in Chemical Engineering was home. We shared some eye-opening conversations on energy, global warming/ climate change, electric and self-driving cars, mass transit and

millennial views on politics/current events and education.

I'll limit this column to some of the conversation we had on energy, but the others were equally engaging.

I noted since man figured out fire, fuel has evolved from the solid state (dung, wood, peat, coal) to the liquids state (oil and refined fossil fuel) and heading to the gas state (natural gas, hydrogen) and with the next generation of industrial scale technology, plasma, fusion etc. Inherent in each are issues. Solid fuels pollute. Witness the recent forest/grass fires in Australia, rain forest fires in the Amazon and annual burning of cropland in Indonesia/Malaysia (and even the swamps of Louisiana). The coal emissions in China are almost double those of the US currently. Liquids pollute too. The number of cars, trucks, airplanes, locomotives increases and with it are global increases in pollution and GHG, not to mention the additional need for roads, airports and infrastructure. We discussed wind, solar (renewable) and battery storage for a country wide grid. He dismissed that today's technology and physical limitations preclude us from generating enough wind and solar combined to wean us off fossil fuel power generation. The laws of physics don't allow for it. A friend mentioned a paper by Mark Mills entitled: The "New Energy Economy": An Exercise in Magical Thinking. I passed it on to him to read. Mills notes "with today's technology, \$1 million worth of utility scale solar panels will produce about 40 million kilowatt-hours (kWh) over a

30-year operating period. A similar metric is true for wind: \$1 million worth of modern wind turbine produces 55 million kWh over the same 30 years. Meanwhile, \$1 million worth of hardware for a shale rig will produce enough natural gas over 30 years to generate over 300 million kWh." We will not wean ourselves off fossil fuels anytime soon until there are alternatives for power generation—for industrial and transportation needs—or other uses: paint, fertilizers, cosmetics, tires, plastics and on and on. Reductions are certainly possible but a complete stop—not anytime soon. He contended just last week that wind, solar and nuclear could provide 100% of our energy needs—at a cost of trillions—and we'd better spend it than waste the planet.

At last month's IAGC Annual Conference Dr. Scott Tinker presented very similar comments on renewables versus fossil fuels. Check his presentation in the IAGC website at: <https://www.iagc.org/past-annual-conferences.html>.

Millennials want cars, (gas or electric), smartphones, portable devices, Bluetooth speakers/remote access devices (all with batteries), air-conditioned homes, schools and malls, cheap travel, internet, etc. The more experienced of us, used to ride our bike (or walk) to unairconditioned schools, shopping centers, record stores, playgrounds and friends' houses on weekends, didn't have portable electronic devices, X-box or devices that stayed on in power conservation mode. "Airconditioned Inside" meant something. Our individual carbon footprint was considerably smaller.

It's rarely mentioned that it takes 50-100 pounds of earth mined and processed to create 1 pound of battery material. That neither considers the fuel burned to excavate it nor the energy expended to manufacture a battery. Lithium Ion batteries too have a disposal problem. (Where the used Tesla battery graveyard?). Today there are estimated to be 3.5 billion cell phones in the world, 5.15 billion mobile devices and 9.4 billion mobile connections. Global population: 7.7 billion.

Word From the Board continued on page 8.

We agreed that nuclear power should be part of the solution, save the disposal problem. We can engineer nuclear power safety, environmentally smart and at a reasonable price by standardizing the design (works in France). After 3 Mile Island, Chernobyl and the Fukushima Daiichi disasters, public opinion won't sway anytime soon.

A lot is written in this column about the GSH finances and membership, industry recruitment and retention of employees, price of oil, exploration budgets—all down; and layoffs, consolidation, industry age— all up. It is all bad or depressing news; this is not unique to the GSH or the industry but across multiple industrial organizations.

Encyclopedias and the Dewey Decimal system are out, and Facebook/Instagram/Twitter are in for reference material. Real News versus Fake News. Fox versus CNN. SNOPEs versus FactCheck. We're blasted with more information from more outlets than ever and deciphering the truth is exhausting.

What I find most evident from our conversation is that millennials want solutions to a myriad of issues- both societal and economic- but are basing their answers and proposed solutions on erroneous or heavily biased premises.

The more experienced generation created the freedom enjoyed today (just count the worlds dead in Europe) and products and by-products that have led to a rapid increase in global quality of life. The subsequent generations are reaping the benefits and its problems. It is incumbent on them to learn how to manage it.

The Energy Industry has a woeful reputation at being environmentally responsible. As a collective group, GSH, SEG, EAGE, IAGC, and energy producers and countless others, we should start clarifying their premises so they can make informed decisions for their future and leave behind the "How Dare You" moments. □

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From the Other Side

By Lee Lawyer



In the past, I have mentioned the subject of global climate change. Over twenty years ago, I had a good run of comment from my readers on the subject of 'man-made global climate change'. There was some emotion involved in some of the exchanges.

Today the subject seems to be a political football, so to speak. I used the word, anthropomorphic (?) to keep the discussion moving. Leaving remediation of climate change behind, I decided to do a little review of the issue today. I dislike the use of the term, denier. That denigrates viewpoints I want to hear.

We are Earth physicists and geologists. We need data to make decisions. Where would one go to get the kind of data we need? I went to NOAA. There I found the Intergovernmental Panel of Climate Change (IPCC). These people have tons of data! They seem to have measured everything pertinent to climate change and then some. No one can doubt the acquired data. That is pure scientific methodology. Maybe one can question the climate models used to analyze the data and to forecast the future.

I have lifted much of what follows from the IPCC site. That organization is the most senior and authoritative body providing scientific advice to global policymakers. They have met in full session in 1990, 1995, 2001, and 2007. I believe, the term 'greenhouse effect' was coined in the first paper on the subject of climate change many years ago. Water vapor is the most abundant greenhouse gas, followed by carbon dioxide and other trace gases. The greenhouse effect is unquestionably real and helps to regulate the temperature of our planet. It is essential for life on Earth and is one of Earth's natural processes. The concern is how much human activities contribute to this natural process. "Without a natural greenhouse effect, the temperature of the Earth would be about zero degrees F (-18°C) instead of its present 57°F (14°C)."

Pre-industrial levels of carbon dioxide (before the start of the Industrial Revolution) were about 280 parts per million by volume (ppmv), and current levels are greater than 380 ppmv and increasing at a rate of 1.9 ppm yr⁻¹ since 2000. The global concentration of CO₂ in our atmosphere today far exceeds the natural range over the last 650,000 years, which ranged from 180 to 300 ppmv. The Sun drives our entire climate system. However, there are some variations in its output. I was keenly interested in those variations in the early '50s. There is an output variation with a cycle of about 11-12 years. That cycle is notable in short wave radio propagation and was ascribed to sunspots who have that cycle. Normally, my 50 Mhz radio could only reach receivers in a direct line. Back then I was told that this increase in sunspot activity allowed the e-layer in our atmosphere to ionize and cause the 50 Mhz signals to bounce back to the Earth giving me a range of thousands of miles rather than just a few miles. (Depending on the height of my antenna). We called that increased range, "Skip" which happened on an 11-12-year cycle.

Global surface temperatures have increased about 0.74°C (plus or minus 0.18°C) since the late-19th century, and the linear trend for the past 50 years of 0.13°C (plus or minus 0.03°C) per decade is nearly twice that for the past 100 years. The warming has not been globally uniform. Some areas (including parts of the southeastern U.S. and parts of the North Atlantic) have cooled slightly over the last century. Earth's position and orientation relative to the sun (our orbit) also varies slightly, thereby bringing us closer and further away from the sun in predictable cycles (called Milankovitch cycles). Variations in these cycles are probably the cause of Earth's ice-ages.

That is the data, but first we need to ask ourselves whether we can trust the scientists who have acquired the data and done the research. Can we believe a consensus of scientists in the same field who agree with the conclusions? I would say a resounding "YES!", but what are we going to do to mitigate the predicted results? Aye, there's the rub. Maybe we can use AI to decide when we should get serious. □

The GSH is here VIRTUALLY for you!

We have rescheduled several events to be ONLINE:



TECHNICAL EVENTS 11:00am

- o **Greg Hatch**, Ford Resources **May 6th**
- o **Xianhuai Zhu**, Forland Geophysical Services, **May 20th**

SIG EVENTS at regular times

- o **D P & A - Coerte Voories, III**, Gustavson Associates, **May 5th**
- o **ROCK PHYSICS – Joe Higginbotham**, Z-Terra, **May 13th**
- o **POTENTIAL FIELDS – Laura Hubner-Diaz**, Chevron, **May 21st**

We also have a stellar 4 half-day **WEBINAR – Dr. Leon Thomsen, May 11 – 14th**

The GSH policy concerning responsibly dealing with the COVID-19 pandemic is to follow guidelines and requirements of the CDC and other health authorities. As of Sunday, March 15, the CDC is recommending cancelling events with attendance of 50 or more people for the next 8 weeks.

As a result, the GSH is postponing or cancelling all in-person events through May 15, 2020. As recommendations may change frequently, please watch for email and check gshtx.org for up-to-date information.

GSH Board of Directors

12 March 2020

We welcome your continued participation at the GSH!



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Dear GSH Journal readers,

Please feel free to email us with any and all questions or suggestions.

Sincerely,
Alvaro Chaveste, Editor,
AlvaroChaveste@hotmail.com

Online Tech Event

“Wildcat” Exploration and a Major Gas Discovery in Guatemala

Register
for Online
Tech Event

Speakers: Greg Hatch, Geophysicist at Ford Resources

Tuesday, May 6, 2020

11:00 a.m. – 12:00 p.m.

Location: Online Presentation



Greg Hatch

Abstract:

In late 2014 of Mexico first allowed foreign investment into their petroleum resources that had been prohibited for the previous 75 years. This change in policy has resulted in significant oil and gas industry interest in Latin America, specifically Mexico’s Southeast or Sureste Basin.

The border between Mexico and Guatemala can be considered the southeastern edge of the Sureste basin. This area in Guatemala is the project area for this discussion.

The #2x exploration and discovery well was drilled in Ocultun block 1-2008 in 2012. The #4xst appraisal well was drilled in 2015. Designated as Ocultun field, production is 2,100 barrels oil equivalent per day (~850 barrels condensate per day and 7.0 million cubic feet gas per day). Additional development and exploration opportunities are currently under investigation with a planned drilling program to begin in 2020.

The methods used leading to discovery include: 1.) regional geologic analysis, 2.) well log review, 3.) acquisition and interpretation of 2D and 3D seismic data, 4.) synthetic seismogram generation, 5.) vertical seismic profile acquisition and interpretation, 6.) processing and interpretation of 3D seismic attributes, and 7.) acquisition and interpretation of potential field data that included gravity, aero-magnetic, and radiometric.

During this talk we will discuss the scientific techniques used and interpreted results that led to the discovery of what is likely a major gas field in the jungles of Guatemala.

Biography:

Greg Hatch was born on the northwest side of Chicago, Illinois and attended Northern Illinois University. A Bachelor of Science degree in Geology was earned and a Master of Science Degree with thesis titled, “An Automated Analysis of Refraction Data from Marine Seismic Reflection Data, Georges Bank, Massachusetts” (precursor to automated refraction statics seismic processing) was also completed.

Greg came to Texas with all the other “high tech kids” mostly from California, Illinois, and New York during an oil boom in 1983 for employment with Sun Oil in Dallas, Texas as an Associate Geophysicist. Leaving Dallas in 1995 his career continued to Houston with Union Oil of California, Cabot Oil and Gas, Noble Energy, El Paso, and Repsol. In 2011 he left Houston for the Hill Country of Texas, beginning a relationship with a small family owned oil and gas company, Ford Resources, in San Antonio, Texas.

His expertise lies in using geophysical techniques to understand the subsurface, then application of a geological model that fits the subsurface interpretation, next identifying anomalous zones that represent potential hydrocarbon deposits, and finally, making certain the identified opportunity is easily understood through presentation.

Greg considers himself a treasure hunter, although he is professionally referred to as a geophysicist. He has experience and success working sedimentary basins all over the planet in a search for hydrocarbons. □

Online Tech Event

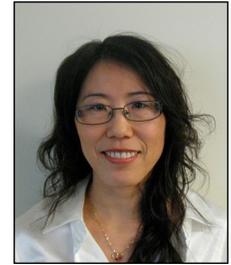
Integrated Turning-Ray and Reflection Tomography for Velocity Model Building in Foothills Areas

Register
for Online
Tech Event

Speakers: Xianhuai Zhu and Grace (Yan) Yan,
Forland Geophysical Services (FGS)



Xianhuai Zhu



Grace
(Yan) Yan

Tuesday, May 20, 2020
11:00 a.m. – 12:00 p.m.

Location: Online Presentation

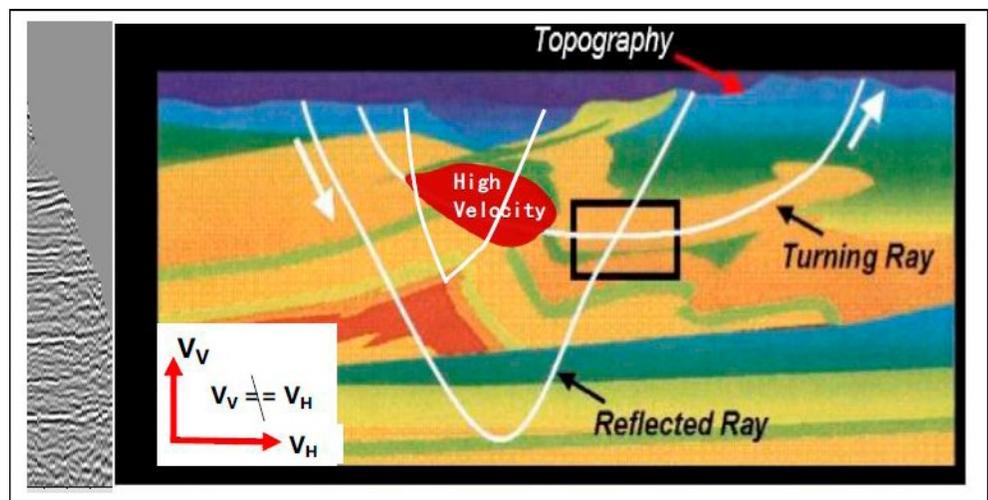
Abstract:

One of the challenges for land seismic exploration in foothills is estimating velocities. This is because of the complexity in both near-surface and subsurface structures. This talk shows a robust approach of velocity-model building for both shallow and deep sections, using joint or integrated turning-ray and reflection tomography. First, turning-ray tomography is performed to derive a near-surface velocity-depth model. Second, we combine the near-surface model with an initial subsurface model as the starting model for reflection tomography. During reflection tomography, both near-surface and subsurface velocity-depth models are jointly updated. This method is practical and efficient for velocity model building and prestack depth imaging in foothills regions.

The study area is located at Kelasu Thrust Belt between Tianshan Mountain to the North and the edge of Baicheng sag to the South. One of the objectives of this study is to understand why the previously drilled well (KS12) was dry. Because depth imaging is very sensitive to velocities, we

developed and applied joint turning-ray and reflection tomography to improve the accuracy of velocity-depth models at both shallow and deep sections in the study area. After TTI anisotropic prestack depth migration from topography, using velocities estimated from joint tomography, results have shown that the structural apex of the previously drilled dry hole is several hundreds of meters away from the newly imaged structural apex, suggesting that a new well location is to be considered.

In addition, this depth imaging project has helped an on-going drilling program (KS14) near well KS12.



Technical Breakfast continued on page 13.

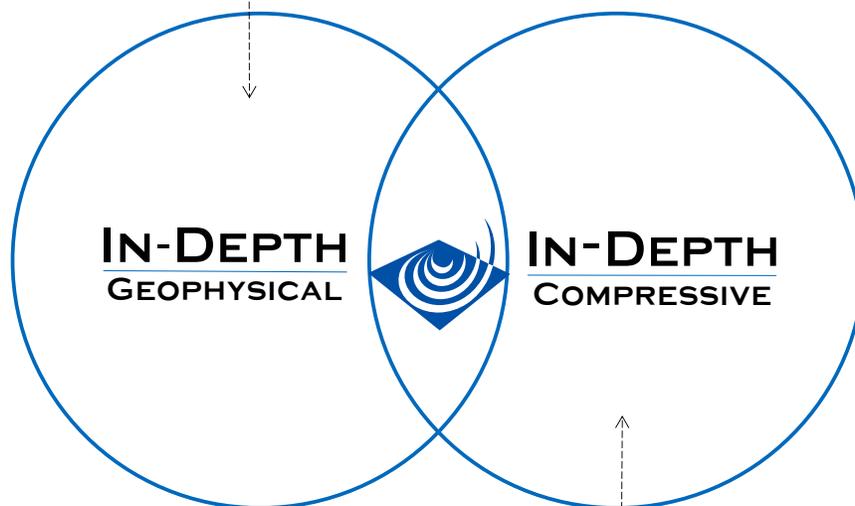
Biography:

Dr. Xianhuai Zhu received a B.S. in geophysics from the China University of Petroleum and a Ph.D. (1990) in geosciences from the University of Texas at Dallas. He has more than 30 years of experience in the oil and service company industry. He had been with Anadarko (formerly UPR), PGS, Fusion Petroleum Technology, and Conoco-Phillips. He started his career from the field in a seismic crew. From 1985 to 1986, he was a visiting scientist at Cornell University in Ithaca, USA. In 2016, he founded Forland Geophysical Services Company (FGS) in Houston, which deals with developing and applying advanced technologies for land, shallow-water, and OBN seismic data acquisition, imaging, and interpretation. From SEG, he received the Reginald Fessenden Award in 2012 for his pioneering work on turning-ray tomography and tomostatics, and the Life Membership Award in 2018. In 1999, he received the Best Paper Award on "Recent Advances of Multicomponent Processing."

He was the Director-at-Large for the SEG Board of Directors from 2014 through 2017 and the first vice president of the Geophysical Society of Houston (GSH) from 2017 through 2018.

Grace (Yan) Yan received a B.S. (1990) in geophysics from China University of Petroleum and an M.S. (2001) in geophysics from the University of Calgary. She has more than 25 years of experience in oil exploration, oil companies, and service companies. She worked at Xinjiang Petroleum Exploration Company for eight years, GXT Canada for five years, CGGVeritas as a senior geophysicist and team leader for six years, and ConocoPhillips as staff processing geophysicist for four years. Her specialties are pre-stack time and depth migration, tomographic velocity update integrating wells, horizon picking, and VVAZ/AVAZ processing. Currently, she is working at Forland Geophysical Services as the vice president of processing. □

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Data Processing & Acquisition SIG

A Model for Fluvial SAND Channel System Reservoir Delineation and Optimal Drill Location Selection Utilizing Post Stack Processing, Precise Amplitude Attribute Analysis and Stratal Domain Visualization and Interpretation

Register
for Data
Processing



**Coerte A
Voorhies**

Speaker: Coerte A Voorhies, III PG
Gustavson Associates, LLC
Geoscientist

Sponsored by Schlumberger

**Location: Online
Presentation**

Tuesday, May 5, 2020

5:00 p.m. - 6:00 p.m.

Abstract:

A model was created utilizing InsightEarth software to lower risk with selecting well locations for optimal reservoir stratigraphic, structural and production constraints. Results were used to delineate and create maps for a productive fluvial sand channel system in the Client's Kazakhstan project area and analogous to fluvial systems in other basins. Project data is provided by Gustavson Associates, LLC, Boulder, CO and consists of 350 square kilometers of 3D seismic. The production is from a fluvial sand system where the numerous channels conceal the continuity of the reservoir and contributed to drilling non-productive wells.

Acquisition footprint and random noise were eliminated from original data to condition the seismic volume. Accurate dip-guided amplitude attributes were generated from the conditioned volume. The stratal domain transform process was used to convert the conditioned time and attribute volumes into paleo-surface stratal volumes. The objective was to obtain an accurate structural and stratigraphic interpretation of the productive "D" sand. Structural relationships were corrected in the time domain volume and the new stratal domain volume yielded horizontal events (stratal slices) that imaged the intricate fluvial systems to represent the depositional environment of the reservoir.

Stratal domain volume results and structural analysis indicate that the reservoir and associated complex faulted structure of a previously selected well location were not ideal. The new reservoir interpretation provided the required risk analysis to recommend the selection of an alternate well location.

By utilizing volume conditioning (acquisition footprint removal), attribute analysis and stratal domain visualization and interpretation, a model was created to accurately map the recognizable morphologies of fluvial sand channel systems to provide precise reservoir delineation and optimal well location selection for the Client's project and project development in analogous geographic locations.

Biography:

Coerte is a geophysical and geological interpreter with over thirty years of international and domestic experience. Coerte is an expert user of the CGG InsightEarth® 3D Visualization, Processing and Interpretation Software Technology (CGG: InsightEarth) and is currently providing InsightEarth® consulting services for Gustavson Associates, Boulder CO (Gustavson – Oil Gas and Mining Consultants Colorado USA). He holds a Master of Science (M.S.) in Geology from the University of Louisiana – Lafayette. He is a SIPES member, GSH member and is a professional geoscientist in Texas. □

Rock Physics SIG

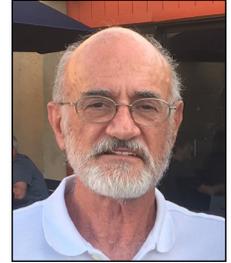
Shale Crush Point

Register
for Rock
Physics

Speaker: Joseph H. Higginbotham
Z-Terra inc.

Wednesday, May 13, 2020
5:30pm Presentation Begins
6:30pm Adjourn

Location: Online Presentation



**Joseph H.
Higginbotham**

Abstract:

A rock physics model that involves combining Gassmann's equations with Nur's critical porosity model. This theory leads to a hyperbolic relation between V_p and V_s with coefficients that are constant for a given mineral as porosity changes. Similarly it leads to another relation between rock bulk density and V_p . The hyperbolic relation between V_p and V_s matches up quite well with measurements that have been reported for sandstone, limestone, and shale. There is a problem with shale because measurements by Mondol et al. (2008, TLE) don't seem to follow Nur's model which would suggest that the theory should not work for shale. However, if the shale data is assumed to have a "crush point" where the overburden stress causes a quick change in strain instead of a gradual change, then the data of Mondol et al. will support Nur's model and the full theory seems to apply to shales.

Biography:

Joseph (Joe) H. Higginbotham received his MS and PhD in physics from the University of Toledo, Toledo Ohio – his thesis work was published in the Journal of Physics B, and in Physical Review. He took a job in aerospace shortly afterward working on navigation software for the space shuttle and studying the non-linear response of accelerometers. Joe also designed vibration simulation software, using scaled integer math, that could be run inside fighter aircraft navigation computers to allow tests of installed navigation software.

In late 1979 Joe took a position with Texaco in the Exploration and Production Technology Department where he worked on wave equation imaging software. Joe was the first to do imaging in a tilted coordinate system – Texaco did not allow publication until 1985. He designed a processing system, SEISPAK, that was used by the Texaco R&D staff through the 1980's and 90's for development and testing of seismic data processing software.

After Texaco and Chevron merged Joe continued to use SEISPAK to support his research and to do survey simulation for Chevron. Joe retired from Chevron in August of 2006 with a license from Chevron to use SEISPAK, which supports automatic parallel processing, freely within the industry. He worked briefly for 3D Geo and in June of 2007 Joe founded Wave Imaging Technology Inc. Joe was joined at Wave Imaging by Morgan Brown in October and together they ran the company for over six years providing quality depth imaging and seismic simulation services, in the SEISPAK system, to large and small companies around the world.

In October of 2013, Wave Imaging Technology was sold to GEOCENTER which later became SEIMAX. Joe worked at SEIMAX until mid spring of 2018 when he left SEIMAX to take his current position as Chief Technical Advisor at Z-Terra. Joe became interested in rock physics through the development of software for seismic amplitude analysis. □

Potential Fields SIG

A Crustal Investigation of the Gulf of Mexico: Using Voxet-based Gravity Inversion to Model Radiogenic Crust

Speaker: Laura Huebner-Diaz
Chevron Energy Technology Company.

Co-Author: Elizabeth Johnson
Chevron Energy Technology

Thursday, May 21, 2020
5:30 p.m. - 8:00 p.m.

Abstract:

Crustal architecture is a fundamental input to basin analysis on attenuated continental margins. Estimates of crustal thickness and composition from seismic refraction data provide constraints on crustal architecture but are sparsely distributed in the Gulf of Mexico. Modeling of global refraction-based crustal layers, which utilize Vp-Density relationships for density of crustal layers, often leave significant long wavelength gravity residuals. To create a crustal architecture model that is consistent with both seismic refraction and gravity we have performed a seismic-constrained voxet-based 3D inversion of the crustal density using Seequent's VOXI software. Allowing crustal density to vary vertically and laterally within density bounds, we have created a crustal architecture from which we can extract radiogenic crustal isopachs and better estimate radiogenic contributions to heat flow. The results from voxet-based gravity inversion compare favorably with those obtained from a more traditional density-constrained layered inversion.

Biography:

Laura Huebner-Diaz is a potential fields geophysicist at Chevron Energy Technology Company. She has a BS degree in geoscience from the University of Arizona and a MS degree in geophysics from the University of Nevada, Reno. Laura has experience in applying potential fields for oil

Register
for Potential
Fields



**Laura
Huebner-
Diaz**

Sponsored by Seequent

**Location: Live & Online
Presentation**

Location: Churrascos
2055 Westheimer Rd.
Houston, TX 77098

and gas, geothermal, and mineral exploration. Having lived in Houston for the past 7 years, she has reluctantly gotten used to flat-lands, but is always excited to explore mountains and basins whenever she can. □



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GSH COVID-19 Policy

The GSH is here for you! How are we adjusting to the COVID-19? The GSH Board of Directors has issued an official statement, available on the Home page of the Website, and the President will update as necessary. Please check the website regularly. Currently the official statement is:

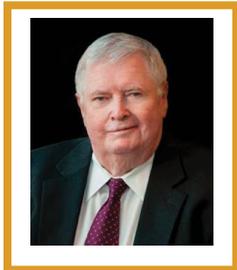
The GSH policy concerning responsibly dealing with the COVID-19 pandemic is to follow guidelines and requirements of the CDC and other health authorities. As of Sunday, March 15, the CDC is recommending cancelling events with attendance of 50 or more people for the next 8 weeks.

As a result, the GSH is postponing or cancelling all in-person events through May 15, 2020. As recommendations may change frequently, please watch for email and check gshtx.org for up-to-date information.

GSH Board of Directors

12 March 2020

We have tentatively rescheduled several major events:



• **SPRING SYMPOSIUM**

- Rescheduled Date: **June 16th & 17th**
- Pre-registrations are still current for the new dates
- Registration is open
- Some adjustments in presenters are currently in the works
- The Challenge Bowl will not be included and potentially will be part of our September icebreaker



• **GOLF TOURNAMENT**

- Rescheduled Date: **June 15th**
- Rescheduled Time: Shotgun Start at 8:30 AM
- Pre-registrations are still current for the new dates
- Registration is open



• **ANNUAL MEETING and HONORS & AWARDS**

- Rescheduled Date: **June 25th**
- Registration is now open

We welcome your continued participation at the GSH!



Please register online at
www.gshtx.org

GSH Annual Golf
Tournament 2020

MONDAY | **8:30 AM***
JUNE 15 | **SHOTGUN START**

The Woodlands Country Club Palmer Course
Space is limited to 216 players • Sponsorships are still available

* Please note the new date and earlier start time

\$200
GOLFER **OR** **\$800 PER**
TEAM

For more information contact Wesley Tyrrell
{e} wesley.tyrrell@katalystdm.com
{c} 713.485.9502

Join us for our end of the year party!
The Geophysical Society of Houston's Annual Meeting and

Honors and Awards Banquet

Thursday, June 25, 2020
Norris Conference Center
Magnolia Room

Cocktails | 6:00 pm
Dinner | 7:15 pm

Spouses and guests welcome.



2020 GSH-SEG
Spring Symposium and Expo



HOW GEOPHYSICIST-MACHINE COLLABORATION IS CHANGING OUR INDUSTRY

JUNE 16-17, 2020

NORRIS CONFERENCE CENTER, HOUSTON TX

RESCHEDULED

Actual case studies that highlight the applications of new technologies to solve Geophysical and E&P problems

- Tom Smith, GEOPHYSICAL INSIGHTS, **Multi-attribute machine learning improves thin bed resolution**
- Mike Li, CHEVRON, **Using Meta Learning to Build Adaptive AI Model for Oil and Gas Exploration**
- Wenyi Hu, AGT & UH, **Progressive transfer learning for low frequency prediction in FWI**
- Long Jin, SHELL, **Scalable seismic attributes computation framework in the age of deep learning and big data**
- Satinder Chopra, TGS, **Some machine learning applications for seismic facies classification**
- Hugo Garcia, GEOTERIC, **Automated Fault Detection from 3D Seismic Using Artificial Intelligence**
- Aria Abubakar, SCHLUMBERGER, **Machine Learning for Geoscience Applications**
- Elive Menyoli, EMERSON, **Wavefield separation via principle component analysis and deep learning in the local angle domain**
- Christopher P. Ross, CROSS QI, **Predicting production metrics for unconventional shale reservoirs**
- Chengbo Li, CONOCOPHILLIPS, **Hybrid learning-based framework for seismic denoising**
- Wen Hu, FORLAND, **Seismic Denoising using Structure-Aware Stacked Denoising Autoencoder Networks**
- Philip Neri, ENERGISTICS, **Standards for Knowledge Metadata are Crucial to Upstream Digital Transformation**
- Tammy Weir, WEIR CONSULTING, **Can I move my data to the Cloud?**
- Keith Gray, BP, **High Performance Computing at BP**

Great opportunities for knowledge sharing and networking

Sponsorships and Exhibit booths available

SEG Student Challenge Bowl competition

Tuesday evening - Reception

Wednesday - Banquet roasting and toasting Mike Graul



2020 Honoree Mike Graul

For sponsorship and booth details, call the GSH at
281-741-1624 or visit gshtx.org/symposium2020

Professional Society Response to Coronavirus Pandemic

By Scott Singleton

To say the situation in the O&G industry right now is 'in flux' might be considered by some to be a flagrant understatement. A more frank assessment might be one of an unmitigated disaster that is quickly unfolding as oil prices have crashed into the low \$20's (and below) due to an oil production war between Russia and Saudi Arabia, with US shale fields caught in the middle with extraction costs significantly above those of the two protagonists mentioned above. And on top of that is the steadily worsening health crisis in the form of a novel coronavirus (COVID-19) that is in the process of infiltrating all corners of the globe, bringing the world's leading economies to a screeching halt as we shelter in place to keep from all getting infected at once and overwhelming the health care system.

The growing realization in our industry as well as the population at large is that life as we knew it has changed forever. We are all in the process of trying to figure out what that brave new world might look like. The GSH would like to assist you in keeping up with the current trends in the industry. As such, we present a review of actions various professional societies have taken in response to the coronavirus pandemic to ensure their operations are in line with CDC and WHO guidelines.

SEG

The SEG office in Tulsa went to remote operations on March 16. Staff and the Board have been in constant contact either via online message boards, email or Zoom meetings. On March 19, SEG sent out an email to members stating actions that have been taken with regards to their normally scheduled events. The second paragraph of this email states:

"A key to achieving this is protecting the wellbeing of our staff as it works on your behalf. SEG's global offices in Tulsa, Houston, Dubai, Beijing, and Kuala Lumpur are operating fully remotely, and all staff members are connected and available to serve our members and other constituents. Enhancing our social distancing through remote working is one of the most effective approaches we can implement without significant disruption to our operations."

The first action taken was to cancel all events through mid-May. This includes the SEG-GSH Education Week (24-27 March), SAGEEP (Denver, March 29 – April 2), Denver URTEC Workshop (April 16). Calgary's GeoConvention 2020, initially set for May 11-13, was postponed to August 31-Sept 2. By late April, all events through mid-

June had fallen to the same fate (<https://seg.org/Events/Events-Calendar>).

This forced the SEG to work quickly to move its well-known HL and DL lectures to a virtual format which is free to anyone. This effort has been very successful as can be seen by the results of these lectures through late April:

- Regional to reservoir stress-induced seismic azimuthal anisotropy – Lisa Gavin HL
- 25 Feb & 3 Mar: 326 registered; 191 attendees from 17 countries
- Deep learning for seismic processing and interpretation – Xinming Wu HL
- 14 Apr: 1951 registered; 1559 attended from 45 countries
- 16 Apr: 1052 registered; 788 attended from 45 countries
- Generalized sampling and gradiometry: Changing the rules of the information game – Johan Robertsson HL
- 20 Apr: 628 registered; 543 attended from 42 countries
- Automating seismic data analysis and interpretation – Sergey Fomel DL
- 22 Apr: 1089 registered; 709 attended from 45 countries

Anticipating that this situation will continue for some time, the SEG has set up a webpage listing all the free online events as they become available (<https://seg.org/Events/SEG-Live/>). Being a co-sponsor of Energy in Data, SEG also lists a series of webinars sponsored by that group (<https://energyindata.org/Webinars/>).

Preparations for the SEG Annual Meeting (Houston, Oct 11-16) are continuing as normal with the expectation that we will be able to hold this event in the fall. However, simultaneously preparations are underway to enable virtual capability, which is a common theme among all the major conferences during this time of uncertainty. The Annual Meeting organizing committee is very concerned about the possibility of dramatically reduced attendance due to the progressive collapse of the oil industry. This could have significant impact on SEG finances.

OTC

This event was scheduled for May 4-7 but it soon became evident that by May things would not yet be

Professional Societies Responses continued on page 21.

back to normal so the organizers (SEG, SPE, AAPG) initially postponed the event until the third quarter. But when they were able to declare force majeure, which happened when the city of Houston issued stay-at-home orders through the end of April, the organizing committee cancelled the conference. This was a tremendous financial hit to the three organizing sponsor societies.

URTeC

Preparations for this year's URTeC conference (Austin, July 20-22) are continuing with the expectation that stay-at-home orders will be lifted by June. The organizing committee (SEG, SPE, AAPG) is monitoring the situation and at the time of this writing (late April) the conference is still planned to occur. However, as with all other conferences, virtual attendance capabilities are being explored with the expectation that many potential attendees might prefer to see the conference while not having to physically be present.

AAPG

AAPG is in a similar situation as was just described for SEG. All events between mid-March and the end of June have either been postponed or cancelled (<https://www.aapg.org/events/calendar>). However, at this writing (late April) they are insisting they will still be holding their main convention (ACE) in Houston on June 7-10. They have a statement to this effect on the homepage of their website (<https://www.aapg.org/>) but the statement in their emails to members is more direct:

"AAPG continues to monitor the global spread of COVID-19 and the reports from international and national health authorities, including the World Health Organization and Centers for Disease Control and Prevention, to guide our decision-making. Based on ongoing evaluation, close coordination with the City of Houston, and our understanding of current advisories, AAPG's Annual Convention and Exhibition (ACE) is scheduled to take place as planned, 7-10 June, in Houston.

As the global community confronts this challenge, the health and safety of our members, customers, and employees remains our primary concern. With many of the current declarations and advisories in effect through April, we will provide additional updates on 1 May or sooner as warranted."

Translating this into common English, what they are saying is they cannot declare force majeure at this time because the City of Houston only has stay-at-home orders from March 24 to April 30. However, on April 22 the City of Houston issued mandatory mask order from April 27 to

May 26, which may be an indication that an extension of the stay-at-home order might be issued. Until such a time, expect the ACE event to be in limbo.

SPE

SPE has a page on their website devoted exclusively to SPE's response to the pandemic (<https://www.spe.org/en/about/response/>). I commend them for devoting this amount of effort to directly address the dilemma we are all in. This page concisely lists all events by continent with a link to the event and giving a new date or saying that it is still TBD. I also particularly like their emphasis on networking and maintaining contact with each other in these tough times. The statement on their response page regarding this is as follows:

"We understand the uncertainty facing our members and want you to know that we are doing what we can to adapt to current conditions. We are exploring online options for many programs. We recognize that networking is a very important part of SPE. While many people are working from home, we encourage you to remain part of the valued SPE community. Use SPE Connect to stay in touch with colleagues."

Their annual conference is in October (5-7) in Denver so is unaffected at this time (similar to SEG's).

EAGE

EAGE is a study in contrasts. From the beginning of this crisis until the time of this writing they have not listed any events as cancelled or postponed in Europe or Russia (<https://events.eage.org/>). However, they are sending out a steady stream of emails promoting connection among members, much like SPE. Their weekly newsletters are often a list of things that can be done online and in collaboration with other EAGE members, with an emphasis on online learning opportunities. These efforts are definitely commendable and show sensitivity to the plight of all professionals in this trying time.

Regarding their annual conference (Amsterdam, June 8-11), they held out until 3/24 before pulling the plug on it. Their statement on this is as follows:

"In view of the continuing COVID-19 pandemic, EAGE is announcing today the postponement of the 82nd EAGE Annual Conference and Exhibition scheduled for 8-11 June in Amsterdam. We are now going to hold the event at the same venue (RAI Exhibition Centre, Amsterdam) in the week of 6 December 2020. We are confident that intending visitors, exhibitors and sponsors will understand the reasons for this decision and sincerely hope all those involved will be able to join us in December." □



A GSH/SEG Web Symposium

Marine 3D seismic survey design For modern acquisition and processing

A wide range of technologies are available for marine seismic surveys. Attendees at this symposium will interact with key industry thought leaders and learn how the latest developments in streamer and seabed acquisition and processing technology are driving advanced survey design.

Wed. 24th June 2020
9:00 am to 1:00 pm (CST)

Registration	
General public	\$125
GSH/SEG Members	\$ 90
Students	\$ 25

Who should attend ? : Geoscientists, technical managers and field operation specialists seeking to remain current with the latest technology developments..

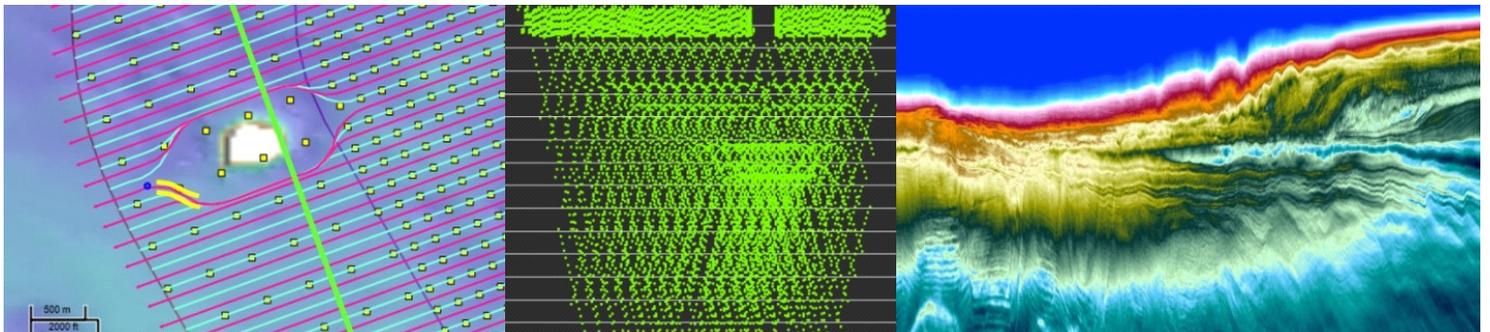


Speakers include global thought leaders such as Joe Dellinger (BP), Rune TENGHAMN (PGS), Gary Hampson (Down Under Geophysical), Joachim Blanch (BHP), Jiawei Mei (CGG) and John Young (DHI Water and Environment).

This informal and interactive event will also feature presentations by co-chairpersons Dave Monk (Past President of SEG) and Malcolm Lansley (Consulting Geophysicist)

Visit gshtx.org, Events Tab to register and see full presenter information (when available)

Event sponsors



Images (Clockwise from top left) courtesy of AGS, CGG, DUG, Polarcus and ACTeQ

High-resolution Distributed Acoustic Sensor Using Engineered Fiber for Hydraulic Fracture Monitoring and Optimization in Unconventional Completions

Peter Richter, Tom Parker, Craig Woerpel, Wenxia Wu, Rogelio Rufino
and Mahmoud Farhadiroushan, Silixa LLC

Summary

We present the benefits of an advanced high-resolution Distributed Acoustic Sensor that utilizes the new generation of engineered optical fibers for hydraulic fracture monitoring and optimisation in unconventional completions. We have also developed a retrievable engineered wireline fiber optic cable that can be economically deployed for crosswell strain measurement and identification of frac hits, microseismic monitoring, and time-lapse Vertical Seismic Profiling (VSP) acquisition with unprecedented data quality.

Introduction

Monitoring the fracture geometry and estimating stimulated rock volume (SRV) is the goal for a better understanding of how wells and completions interact with each other.

The Distributed Acoustic Sensor (DAS) and Distributed Temperature Sensor (DTS) are used for multiple measurements along the entire wellbore. During the hydraulic fracturing treatment, the acoustic energy distribution and temperature profiling are recorded in real-time to analyse the fluid allocations per cluster.

The utilization of distributed fiber measurements has been increasing over the past few years. By installing a permanent fiber cable on the outside of a casing string, measurements along the entire wellbore can be achieved. However, the requirements for the cable orientation and directional perforation adds additional complexity and costs for the installation of the fiber and, therefore, limits the number of wells that can be instrumented with fiber and monitored simultaneously.

The high-resolution Distributed Acoustic Sensor system (called Carina) utilizes a new generation of engineered optical fibers (called Constellation fibers) and offers 100x (20dB) improved sensitivity compared to that of standard fibers.

The improved sensitivity has also led to the development of a retrievable wireline cable with engineered fiber that can be economically deployed in offset wells to provide addition measurements axes simultaneously with the data acquired on the permanently installed fibers with unprecedented data quality. The combined data provides a wide volume coverage for fracture monitoring and completion diagnostics.

High-resolution DAS with engineered fiber

The existing DAS systems utilize standard single mode fiber (Parker T. et al. 2014). However, a transformative improvement in the measurement sensitivity has been achieved by advancing the state of the DAS optoelectronics interrogator architecture, together with the introduction of next generation engineered fiber. This fiber is engineered with bright scatter centres along its length to capture and reflect more light back to the interrogator, as indicated in *Figure 1*. This is

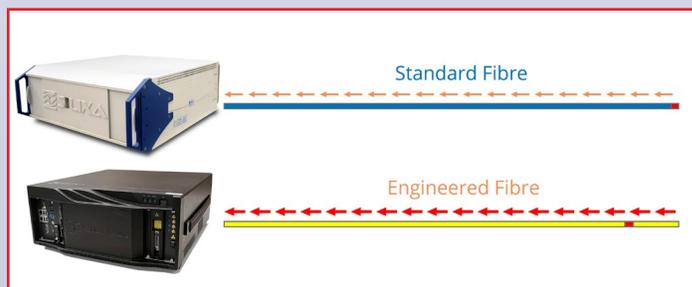


Figure 1. The DAS system using standard and engineered sensing fiber

Technical Article continued on page 24.

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

achieved without introducing significant loss to the forward propagating laser pulses.

The DAS noise performance with engineered fiber is 100x (20dB) lower compared to that when using standard fiber. The DAS performance is comparable to that of geophones around 10Hz but can far exceed the response of geophones in the range below 1Hz. The highly sensitive low-frequency strain measurement provides valuable data for monitoring the crosswell poroelastic build up within the reservoir and the detection of frac hits in the offset well.

The high sensitivity and wide dynamic range of the engineered fiber with its broadband and wide-aperture response can provide unprecedented data quality for both the permanently installed and intervention cables for fracture monitoring and completion diagnostics in multiple wells.

Field deployment

Figure 2 shows the fiber field deployment setup in unconventional multiple wells. Two of the wells have a permanent engineered fiber cable cemented behind the casing. In complex projects, it is recognized that acquiring additional data between the wells can be valuable in understanding the crosswell interference. This was achieved using a new engineered intervention wireline cable pumped down in to an already completed well. The wireline cable also has a mono-conductor for being tracted downhole.



Figure 2. Multiple well monitoring using permanent and intervention engineered sensing cables. Intervention engineered fiber cable provides a new accessible dimension for crosswell monitoring

With the introduction of the wireline intervention cable, we have added flexibility in designing the fracture monitoring program. By utilizing a retrievable cable, we can now eliminate drilling risks associated with the permanent fiber installation behind the casing and also reduce the overall cost.

The high data recorded both on the permanent and intervention cables can be combined and fed into the completion design in near real time in order to optimize the operations on the current well pad and for future development plans.

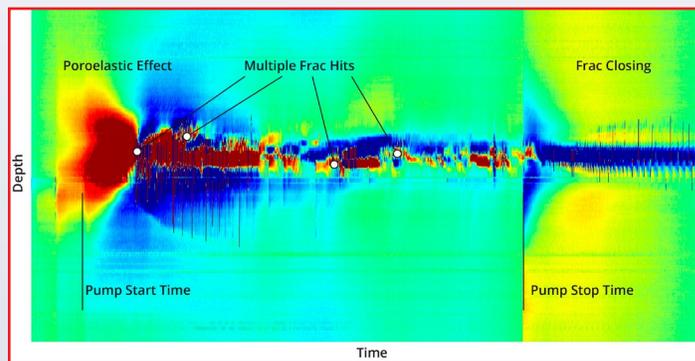


Figure 3. Colour map of the crosswell strain at depth versus time (600m wide over few hours)

Monitoring the crosswell strain and the build-up of poroelastic effect

The crosswell strain data, shown in Figure 3, was acquired on the wireline intervention cable utilizing the engineered fiber. As indicated, we can easily identify critical strain effects and treatment processes including pump start time, poroelastic effect, frac hits, pump stop time, and fracture closure in such a intervention deployment with unprecedented clarity. This new data allows completion engineers to map the depth, azimuth and speed of the fractures and feed that information back into the fracture models to validate and optimize the designs for the next operation.

To further validate the intervention response, the wireline cable was pumped down in the same well that has been instrumented with a permanent fiber behind the casing. As it can be seen in Figure 4, we can observe a strong similarity in the response of the both cables.

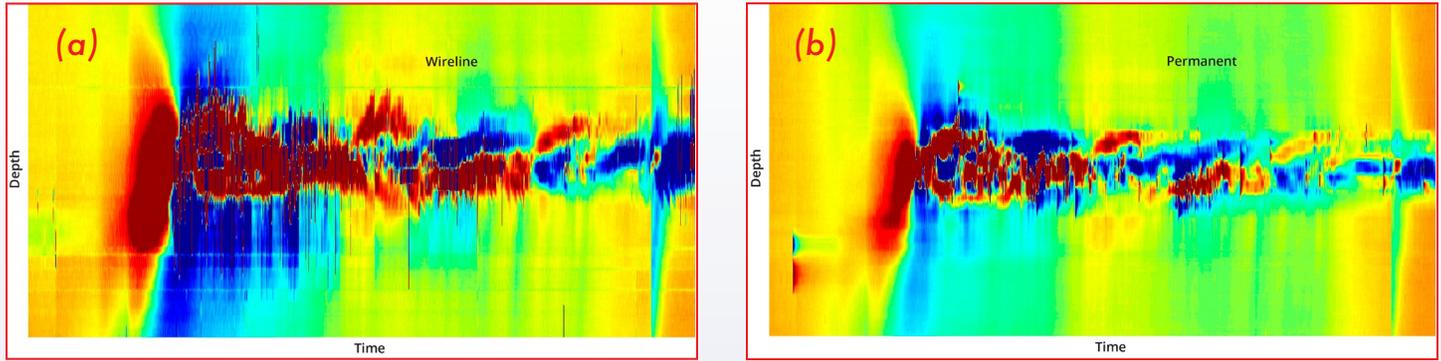


Figure 4. (a) Low-frequency strain data on the wireline intervention cable compared to (b) the permanently installed cable cemented behind the casing in the same well (300m wide over few hours)

The results indicate that there is a sufficient frictional coupling between the wireline cable and the inside wall of the casing. In addition, we can see the strain rate (in the order of tens of nano-strain per second) exerted on to the outside of the cable is transferred to the fiber inside the cable in both cases.

Distributed temperature data was also recorded along both cables with a fine resolution down to 0.01oC. The results confirmed that the low-frequency strain data are not affected by any observable temperature changes during this time interval.

Multiple frac hits can be observed following the tensional and compressional strain building up due to the poroelastic effects as the fluid is pumped into the reservoir.

Frac hits identification

As discussed previously, the engineered fiber deployed on wireline enabled us to acquire high quality distributed data between the wells. As shown in *Figure 5*, by simultaneous recording along three cables, each in a different well, we were able to map the fracture azimuth propagation through

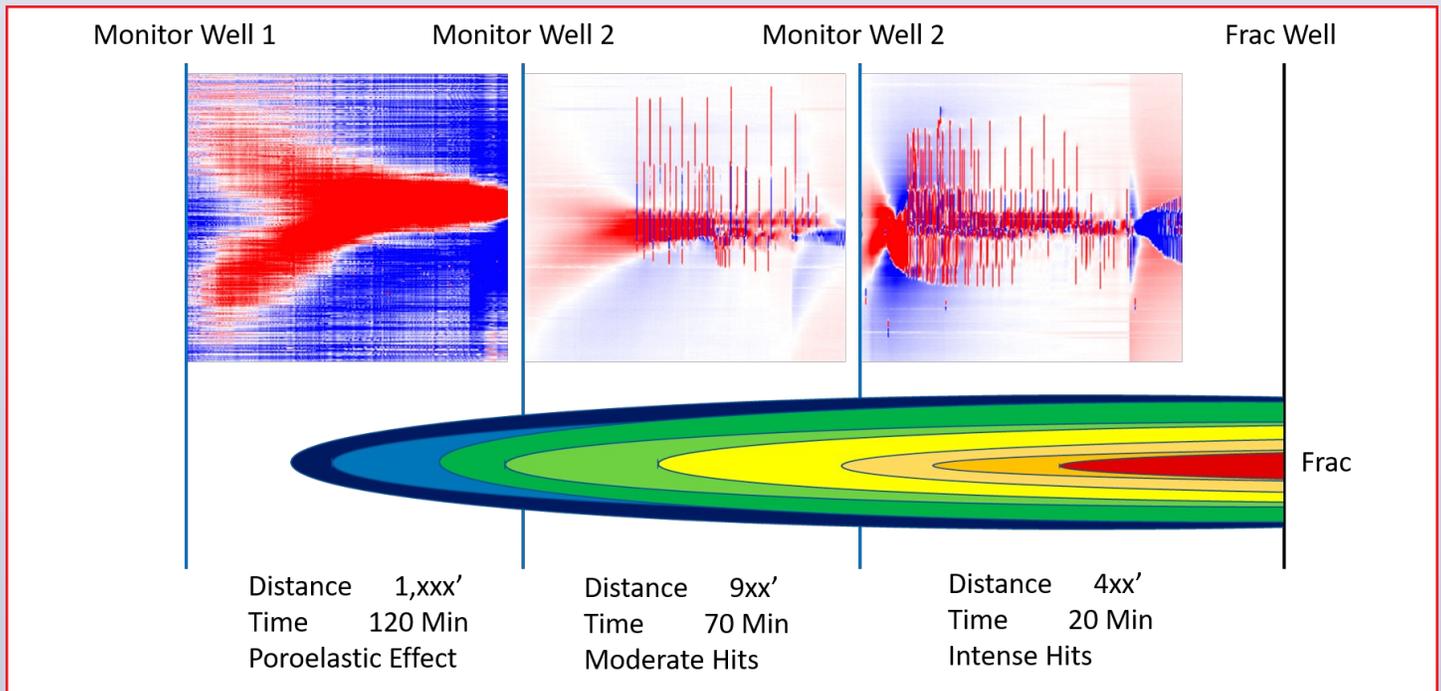


Figure 5. Monitoring the poroelastic effect and frac hits passing through three fiber locations

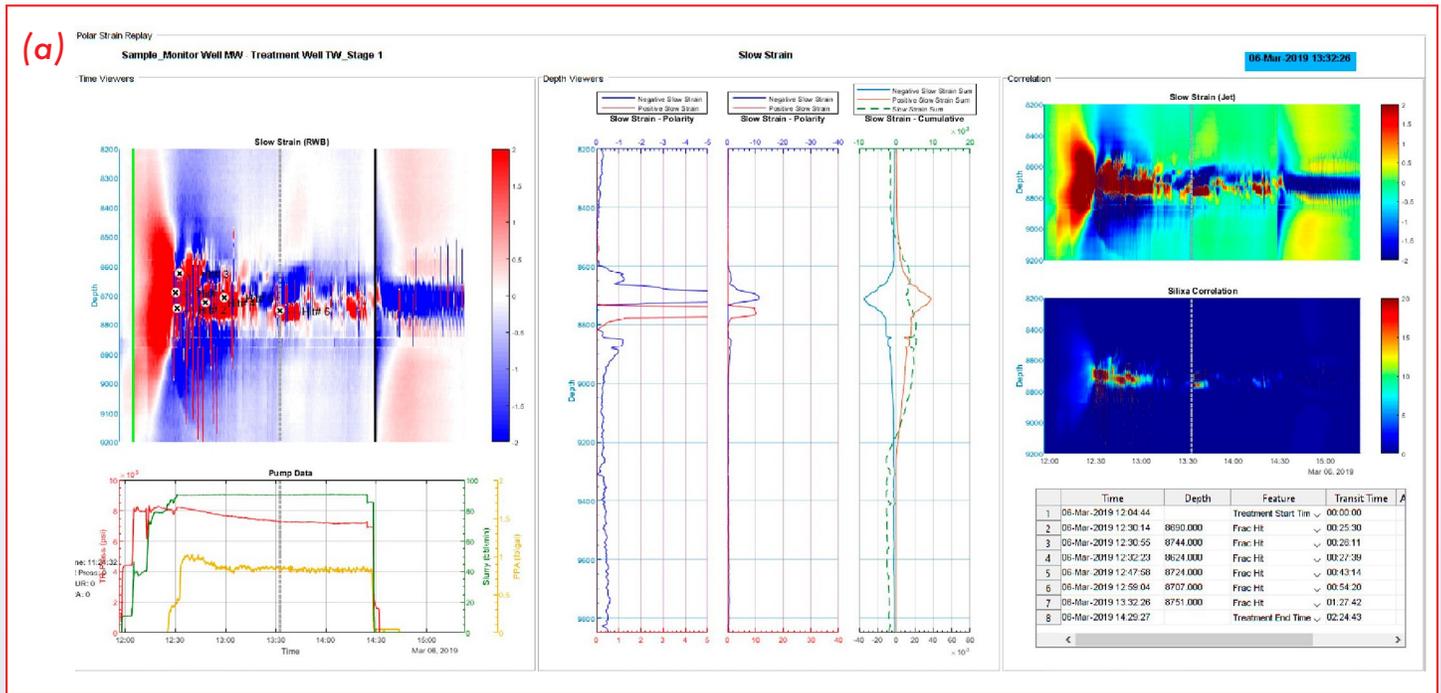


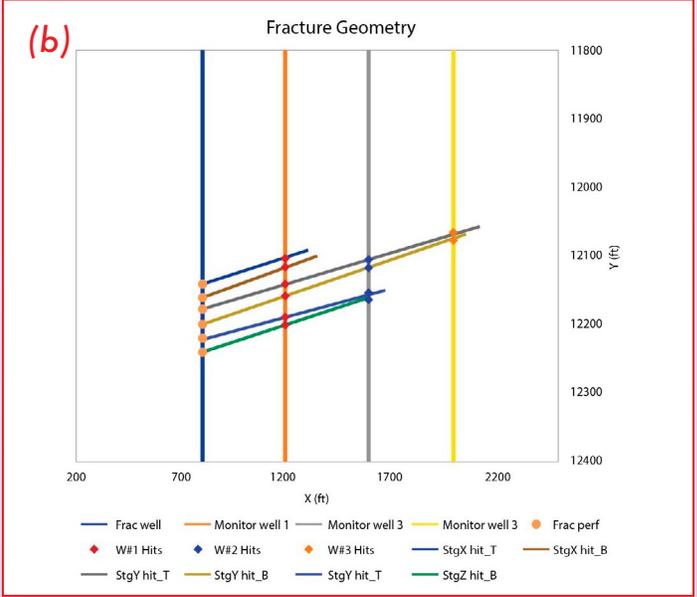
Figure 6. (a) Interactive strain data processing and (b) identifying the frac hits in real time

the formation and as passing through each fiber location. For illustrative purposes, an example of a fracture half-length is also displayed (Viegas G. et al. 2018). We can see that the wells closer to the frac well have a higher intensity of strain events and the farthest well does not actually experience a frac hit.

Figure 6 shows the strain data was processed and the frac hits were identified in real time at the wellsite, including the direction and the magnitude, and the information was immediately fed back interactively into the completion designs plan.

Microseismic

The objective in hydraulic fracture monitoring (HFM) is to map the treated volume’s height, length, width and azimuth. We assume this volume is closely approximated by a microseismic cloud of event locations or hypocenters. Until recently, only geophones had sufficient signal-to-noise quality to detect and locate a sufficient number of events hypocenters to map the fracture. Due to recent advances in optical fiber engineering a single fiber can collect data comparable to over 5000 Z-component geophones.



If only one monitor well is available, only the origin time, measured depth and distance from the fiber can be determined for each event. Plotting event time and measured depth on a strain waterfall shows strong correlation between strain and microseismicity, enhancing support for both. While an array in a single horizontal or vertical monitor well is not able to fully locate micro seismic events, two or more such arrays certainly can. Colocation finds the hypocenter which best fits arrival times at all monitor wells simultaneously. Therefore, colocation by two or more monitor wells is highly recommended.

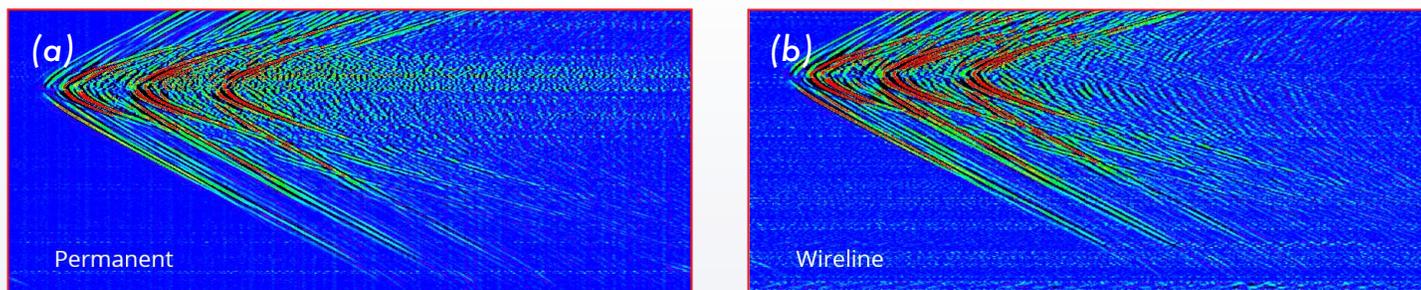


Figure 7. Comparison of the field microseismic event detection on (a) the permanent and (b) wireline engineered fiber

Downhole geophones are three-component instruments, measuring ground motion in X, Y and Z directions. This polarization helps constrain the source direction but is more difficult to measure and predict than simple arrival times. Refraction at stratigraphic boundaries and SH and SV shear wave interference complicate this problem. A fiber optic array in two or more wells requires only arrival times for hypocenter determination, negating the need for polarization modelling and measurements.

The initial impetus for live hydraulic fracture mapping was to enable modification of the treatment on the fly. For example, stopping a stage that is growing into a water bearing zone or continuing a frac that had not achieved desired length. Such incidents have indeed happened, but more commonly the value of live HFM is simply quality control. The operator can be assured that good valid fracture diagnostics are being recorded for each stage. Today critical fracture parameters such as clusters per stage and cluster and stage spacing can be tested and optimized for later stages of the same job.

Experience with geophones shows that data quality is dependent on the degree of coupling between the phones and the surrounding rock. Magnets, bow springs, and even strong locking arms do not provide ideal coupling because of the high mass of the recording tool and the very limited area of contact with the casing, typically only three points.

An engineered fiber laying inside a typical horizontal well contacts the casing over 5 km or more and is much lighter per meter of well than a downhole geophone recording

tool. Direct comparisons have shown that this coupling enables data quality similar to fiber permanently installed in the cement outside the casing.

Both P and S arrivals from a microseismic event can be seen over the entire cable length as shown in *Figure 7*. With the sensitivity of the measurement, we can see events in the vertical section as well as the horizontal, allowing for better location by taking in to account the wellbore trajectory.

It is worth noting that fiber optic HFM has:

- No moving parts to wear out,
- No downhole electronics to fail (particularly in high temperatures),
- It can be pumped down thanks to the low weight, and
- No polarization processing required.

Time-lapse Vertical Seismic Profiling (VSP)

An important aspect of time-lapse VSP is the effort to characterize the changes in the reservoir. In this case we recorded changes during frac activities, with VSP data acquired after each frac stage during the course of the project. Using this technology, the effectiveness of the frac design and ultimately the return on investment for the pad, can be continuously improved.

The recent improvements in DAS measurements utilizing the engineered fiber means that we now can collect high quality VSP data in between stages without interfering with the

overall operations. **Figure 8** shows a comparison of same stage measured with permanent cable vs. intervention wireline cable. In addition, high quality microseismic events can be correlated with 4D-VSP effects to help understand fracture complexity.

By having the improved sensitivity and broader bandwidth of the new engineered DAS system, we can now easily measure the changes at the reservoir before and after stages on the neighboring wells to understand fracture half lengths and frac hits on a well (Byerley G. et al. 2018). This is achieved with a large antenna that could cover the entire well with few vibroseis sweeps. In addition, we can measure accurately time-depth pairs and velocities along the borehole and changes in velocity due to fracking activity. The ability of having multiple cables on a project allows for better understanding of dynamic changes in the reservoir.

Conclusion

The next generation of DAS system utilizing the engineered fiber offers 100x improvement in sensitivity compared to standard fiber and provides unprecedented data quality both on permanent and wireline intervention cables.

The intervention wireline cable can be economically deployed to provide additional accessible measurement axes for crosswell strain identification on frac hits, microseismic monitoring, and time-lapse

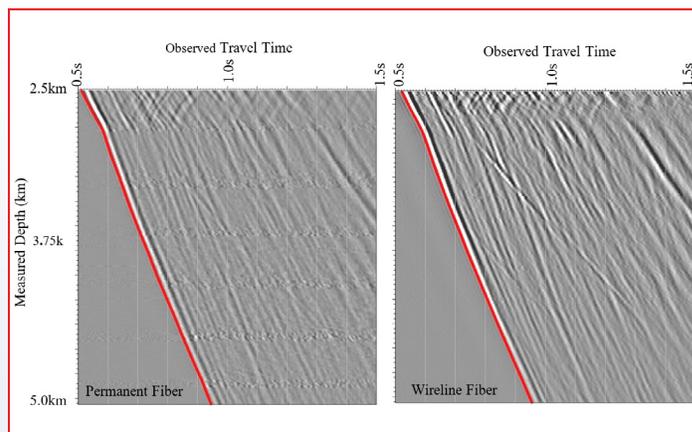


Figure 8. Permanent installed fiber (left) vs Wireline Intervention cable fiber (right) VSP acquired during the same stage with same source location.

Vertical Seismic Profiling (VSP) acquisition. The wireline data can be combined with the permanently installed fibers to provide a wide volume coverage for fracture monitoring and completion diagnostics in near real-time.

Acknowledgements

We would like to thank all our collaborators for sharing their experiences with us, their contributions and their permission for the use of data. We would like also to thank our colleagues for their dedicated work and contributions, in particular Craig Milne, Arran Gillies and Sergey Shatalin for their expertise in developing the engineered intervention wireline services. □

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Viegas G., Urbancic T. and Thompson J. [2018], "Utilizing microseismicity to define stimulated surface area and effective permeability", First Break, pp. 66 -74, Vol. 36.

Permalink: <https://doi.org/10.1190/segam2019-3215860.1>

GSH Movie Time

Now Showing

Function 1 - The History of GSI*

Geophysical Services Incorporated (GSI) was a pioneer in the development of the seismic reflection method. This movie, produced in the mid-1980s, starts in 1917 when young John Clarence Karcher develops the equation to estimate depth to a formation using the formation's velocity and seismic wave's travel time. Learn about the progression of the development of the reflection method; as well as the transformation that Geological Engineering, John Karcher's initial company, had through time up to the creation of Texas Instruments and its subsidiary, GSI.

Function 2 – Streamer Techniques**

This clip, by Shearwater GeoServices, showcases modern marine streamer technology. The industry has come long ways in both, land and marine acquisition since John C. Karcher produced the idea of the seismic reflection method.

* GSI vintage videos courtesy of Schlumberger – WesternGeco

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Apache

EXPLORING WHAT'S POSSIBLE



Perversion of Inversion

It has come to the attention of The Guru – a rare occurrence - that his readership was unsatisfied with the way they were left hanging and gasping for more inversion **tutorials** (heavy emphasis on the latter). That was over a year ago, and in recognition of the average reader's half-life of retention, The Guru has consented to an abbreviated Redux in his incomparable and incomprehensible tutorial manner.

This Cocktail of Great Thoughts of the Guru will be served with a couple of new twists, one of which is the implementation of the highly touted and strongly advised Azimuthal AVO (**AzAVO**).

Among the Touters, **Heloise Lynn** and **Leon Thomsen**, both of whom have presented Webinars* for the GSH-SEG distance learning program.

A New Twist



Azimuthal AVO



Leon

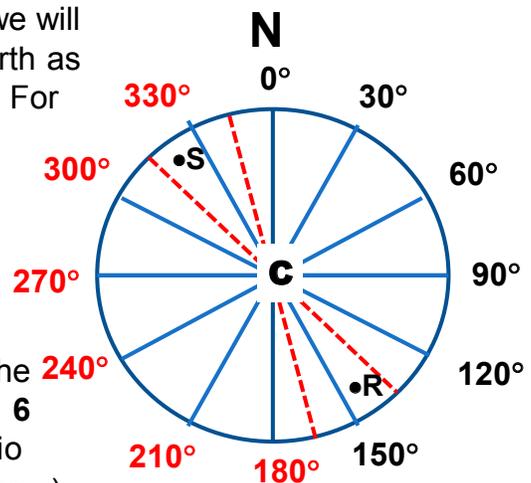
Those who continue to use old fashioned AVO without measuring azimuthal dependence are doomed to a Geophysical Life of Emptiness, one full of Pondering without Knowledge



Heloise

Harsh and bitter as these words may be, they ring of truth, azimuth does matter. Why? Because the world is full of anisotropic rocks, which means a measurement of reflection amplitude, for example, in one direction (source to receiver azimuth) may well not be the same when viewed from another **S-R** direction – even if the offset and reflection points are identical.

The diagram at right will assist us in defining azimuth as we will use it here. The GSH International Convention shows **North** as corresponding to **0° azimuth**, with **E** being **90°** clockwise. For geophysical purposes, this pie chart will be divided into **6 sectors**, each of width **30°** and labelled at center points **0, 30, 60, 90, 120, and 150°**. Note that the **reciprocity** principle is invoked to negate the necessity of distinguishing 180° from 0° or 150° from 330° since any source-receiver pair with a reflection point at **C**, (**CDP**) will fall in the **same sector** with the same offset if the roles of **S** and **R** are interchanged or reversed. Handy. **6** sectors appear to be a nice compromise between **S/N** ratio and **precision** of the azimuth. (**Precision without Accuracy.**)



* Don't miss Leon's upcoming Webinar "**Modern Seismic Reservoir Characterization**" Presented **May 11 – 14, 2020** in Four Half-Day Segments GSH Web Site gshtx.org

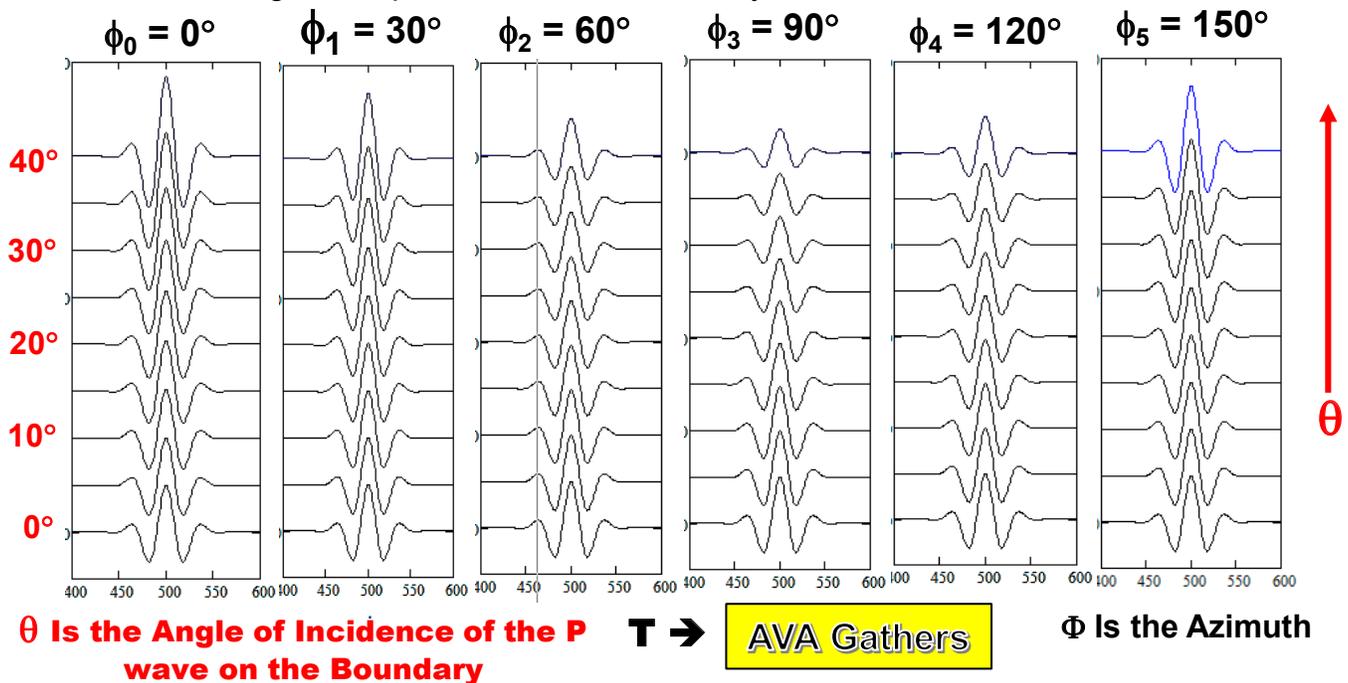


Tutorial Nuggets continued on page 31.



We'll demonstrate the need for Azimuthal consideration in processing AVO data with a simple example drawn from a model created by **Andreas Ruger**, who knows some stuff. The data shown in this cartoon are normal **PP** reflections, regular blue-collar reflection data. Below is a suite of **AVA gathers** where the 2nd "A" is the incidence angle, θ , converted to angle from offset, after **PSTM**. There are **6 AVA gathers**, one for each of the **6 sector angles**, Φ , each of which has **9 θ angles** ranging from **0°** (normal incidence) to **40°**.

Note that while the amplitudes are the same at $\theta = 0^\circ$, as they should be with no mode conversion. However the amplitudes undergo major variations with increasing θ and Φ . Note the Amplitude **increases** at $\Phi = 0^\circ$, while it **decreases** at $\Phi = 90^\circ$. This has been caused by certain anisotropic parameters we'll be discussing next time. The point here is that the **Gradient**, which measures the change of amplitude with θ , is also very sensitive to azimuth, Φ .



When we continue in June, we'll look at azimuthal comparisons of **gradient traces** (an **AVA attribute**) and see why there's such a monumental variation among the gathers. See you then

Improbably Possible and Impossibly Probable

Mercy being the virtue of the day, the Guru has selected a **simple puzzle** you may ponder before our June pursuit of Truth and Justice in Geophysics.

Lee Lawyer and 3 cronies are about to play golf and want to play as partners. **Crony Craig** suggests taking a ball (they all use different brands) from each and then randomly selecting **2** to be partners. **Haynie** says they only need **3** balls not all **4**, and randomly select **2** from that collection to achieve an equally probable outcome.

Is Haynie right? He does have a track record of bright solutions, but nobody is always right.





Improbably Possible and Impossibly Probable

April Puzzle: Candle A is 1 inch longer than Candle B. Candle A was lit at 3 PM, and Candle B began burning at 5 PM. At 9 PM, they are the same lengths. Candle A burns out at 11 PM, while Candle B self-extinguishes at 10:30 PM.

Clearly, they burn at different rates, probably due to different diameters and wax quality (one of the candles consisting of basically human ear wax, the other, Sperm Whale wax and traditional Beeswax).

What are the original lengths of the candles? Send your answers to the GSH with supporting evidence and a sizable donation for Craig's Cause (preferably in cash).

Apparently, this was not the piece-of-cake puzzle we had hoped for as a kick-start for 2020. The one submitted answer (with no donation) was wrong but used an interesting geophysical analogy approach with candle burning rates simulating seismic velocity.

The Guradic staff has suggested we provide a bare-bones answer and with the clues above, inspire latent puzzlers to join the fray. Bare bones below.



You should be able to determine, from the clues, that the burn rates for candles A and B are, respectively, $R_A = 1.5 \text{ in/hr}$ and $R_B = 2 \text{ in/hr}$. That information combined with the total burn time of A and B yields the following: the lengths (L) of the candles must have been $L_A = 11$, $L_B = 12$. Check those answers.



Bonus Puzzle: The jar has 1692 coins (N_q quarters, N_d dimes, N_k nickels, and N_p pennies). They add up to a value of \$100.54. How many of each kind of coin are there? [NB: There are numerous solutions.]

At first glance, you'd probably be happy to find one solution of the "numerous" collection. The trick here is to find other constraints besides the obvious two:, expressed as equations:

(1) $N_q + N_d + N_k + N_p = 1692$ and (2) $(.25)N_q + (.10)N_d + (.05)N_k + (.01)N_p = \100.54

Additional constraints don't lend themselves to equational format. They include such logical statements as no fractional numbers ($N_d \neq .45$); N_p must contain the 4 cents, and the fuzzy notion that the N_d , N_k , and N_p must dominate the N_q , or you'll never get to 1692. These are logical issues that very often accompany problems with nonunique solutions – like so many geophysical issues. This may become the domain of operation for Machine Learning and Artificial intelligence – upcoming topics in your monthly *Tutorial Nuggets*.

Brain Learning, the DIY of dessert island puzzle solving, leads us to the conclusion that $N_q = 68$, $N_d = 522$, $N_k = 508$, $N_p = 594$. Also (in the same sequence), (69, 518, 511, 594); (70, 506, 532, 584), and (70, 514, 514, 594). Let's get back together in June.





Leon Thomsen Webs Again



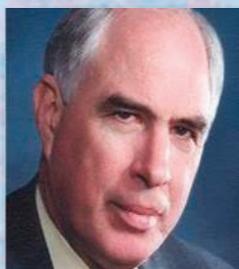
A Live Webinar Jointly Sponsored by GSH and SEG

“Modern Seismic Reservoir Characterization”

May 11 – 14, 2020 in Four Half-Day Segments

Presented By Leon Thomsen

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Geophysics



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This 16-hour course summarizes the state-of-the-art of seismic reservoir characterization, using anisotropic seismic rock physics.

Yes, there will be **Anisotropy** and much, much more ...

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Geomechanics ... Fluids ...Pore pressure...Anisotropic AVO...

Cracks...Permeability ... plus numerous classroom exercises

Classical reservoir characterization typically assumes that the reservoir is elastically and hydraulically isotropic and is adequately analyzed using core and/or log data. However, **most real reservoirs are elastically and hydraulically anisotropic, and spatially heterogeneous** (on many scales), so that core and/or log data are not representative of the larger reservoir volume. This applies to both conventional and unconventional reservoirs. Hence, the best means to physically characterize most real reservoirs, throughout their volume, uses *seismic* data, acquired and interpreted anisotropically. Azimuthal processing is the new standard.

Register Now: GSH Web Site gshtx.org

Not available that week?
The Webinar will be
recorded and available to
all registrants.

GSH Outreach

Committee Activities *By Lisa Buckner, outreach@gshtx.org*



Bellville - Anna Leslie talking to girl



Bellville - Lisa Buckner explaining geophone



Bellville - Anna Leslie talking to a boy

The annual **Bellville Engineering Science Technology Booster Club Family Science Night** was held on **Monday, February 10**. Anna Leslie and I made the drive to Bellville to host the GSH table. Students enjoyed playing the Drilling for Oil Game. It was a great event especially with students and families who are familiar with seismic survey and drill crews working on their properties. Two fathers who work in oil & gas, one a geophysicist, visited our table with their children. We gave away 82 GSH logo coiled toy springs and the "Earth is calling ... will you answer?" brochure to students.



Bellville - Geophysicist father and boys



GEMS - Mac Hooton

The **Girls Exploring Math and Science (GEMS)** was held at the Houston Museum of Natural Science on **Saturday, February 15, 2020**. The event is organized for Girl Scouts and the general public and was attended by over 2,250 museum visitors. The GSH geophysics booth was manned by volunteers. Mac Hooton and I gave away 153 coiled toy springs. I also judged science fair type student projects created by the girl scouts. The third place winners were 'Robotics is "Out of this World!"' The Jersey Village robotics team created a fully functional robot to accomplish certain tasks such as taking in cargo (a large rubber ball) and sending that cargo off into space (shooting the ball out). These girls were able to control, manipulate, and maintain the robot. In second place, we had the Tanglewood Middle School team "Save the Avocados!" They saw a global problem regarding water scarcity and sought to find a solution. They had noticed how the topography of Chile had affected water resource distribution and how that can harm farmers and specifically the avocado crop. They created a fully functional diorama to model their proposed solution, and did a wonderful job seeking to help global issues! And finally, our first place group was "Kits 2 Kids!" The group led by Ashley created 7 STEM-based craft kits to increase student and public interest in STEM. She has donated these kits to schools, hospitals and more in her mission to showcase STEM in a new and exciting way! It was a very inspiring message, and her activities were also fun for our visitors of all ages!

Outreach continued on page 35.



Ridgemont ES Career Expo - Huw James

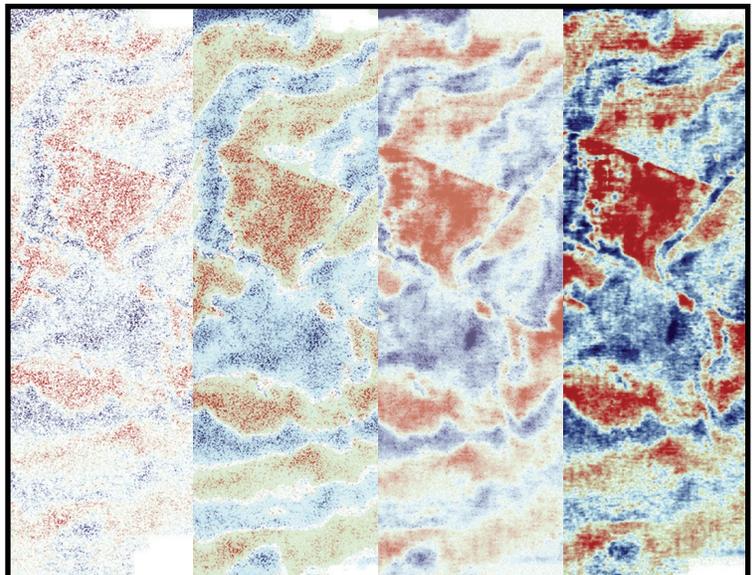
Gokay Bozkurt led the GSH Special Awards judging team at the **Science Engineering Fair of Houston (SEFH)** on **Saturday, February 15**. They selected first and second place winners in the Senior and Junior high school divisions.

On **24th February**, Huw James, GSH Outreach volunteer, attended **Career Day at Ridgemont Elementary School** of the Fort Bend ISD for 3 hours. There were 15 tables for presenters and 295 total students from the second through fifth grades. The students were led around the tables in groups of about 6 to 8. We did not have any of the usual games but showed logs, seismic data and many pictures of seismic acquisition, computers and interpretation from books. The children asked lots of questions and appeared to be engaged in the subject.

UPCOMING EVENTS – Cancelled

Outreach career day and science night events in March and April were cancelled by the school districts, as well as Scout Fair by the Sam Houston Area Council, due to the novel Coronavirus (COVID-19) pandemic for the health and safety of everyone in the community.

Do you want to be added to the GSH Outreach Volunteers email distribution list or know of a school that has a career day, career fair or science night at which GSH might be able to host an exhibit booth? If so, please contact Lisa Buckner at outreach@gshtx.org and we can work together to bring awareness of geophysics and geology to the students. □



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Dr. Fomel presenting to the audience

In February, SEG wavelets invited Dr. Sergey Fomel, SEG's 2020 1Q/2Q Distinguished Lecturer, to give his talk on "Automating Seismic Data Analysis and Interpretation"! He focused on the application of artificial intelligence and machine learning on geophysical data analysis such as automated velocity picking in seismic processing and horizon picking in seismic interpretation. Many faculty members and students came to hear about

the revolutionary work done by Dr. Fomel with the use of machine learning and CNN's applied to exploration geophysics. The audience was able to see workflows that involved training the data and automated seismic interpretations of complex fault systems. The crowd was fascinated by Dr. Fomel's presentation; they stuck around 30 minutes after the presentation to ask questions and to meet with Dr. Fomel! □

19th Annual Saltwater Fishing Tournament Recap



Friday,
11 October 2019
San Leon, Texas



Thanks to everyone who made it out to the 19th Annual Saltwater Fishing Tournament. Although we had a front coming in, that didn't hold anyone back from having a great time and catching a good amount of fish before weigh-in.

The GSH awarded Trophies, Cash Prizes and Door prizes to the teams and individuals who participated.

We hope to see you in 2020!



The front came through



Then passed on by!

Fishing Tournament continued on page 38.

TEAM TOURNAMENT WINNERS

Place	Team	Captain
-------	------	---------

HEAVIEST TROUT

1st	Bad Apples	Neil Appleby
-----	------------	--------------

HEAVIEST REDFISH

1st	Driftkings	Nathan Lenz
-----	------------	-------------

HEAVIEST FLOUNDER

No individual Flounder entries

Place	Individual	Team
-------	------------	------

HEAVIEST STRINGER

1st	Neil Appleby	Bad Apples
-----	--------------	------------

2nd	Nathan Lenz	Driftkings
-----	-------------	------------

3rd	Mike Naughton	Geofishest
-----	---------------	------------



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Photos courtesy of Ryan Egger. For more pics, go to our Facebook page or contact Nathan, nathaniel.lenz@tgs.com

Mystery Item

This is a geophysical item...

Do you know what it is?



This month's answer on page 42.



*“Cutting advertising to save money
is like stopping a clock to save time.”
- Henry Ford*

GSH Media Kits

Item Of Interest

John Michell invented the first torsion balance in 1777. The second one was designed by Charles Augustin de Coulomb in 1786. In 1921, Rycade Petroleum under the direction of Everette Lee DeGolyer, brought two Eotvos Torsion Balances to North America one of which was used to discover Nash Dome in 1924, the first discovery using a geophysical method.

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Geoscience Center

The History of Geophysics By Bill Gafford

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



Our collection of caps shown at SEG75

The date of our next Living Legends Doodlebugger social event at the Geoscience Center will be sometime later this summer and there will be a reminder before the event. Everyone will be welcome, and the event is free, no registration is required. This will be a chance to visit with some of the legends of our industry and see some of the unique geoscience artifacts in our museum collection. We continue to receive donations of various items and instruments from the past as well as books and periodicals so there is always something new, even if you have visited the Geoscience Center before.

In addition to the historical geophysical and geological instruments used in field recording, processing, or interpretation that we have in our museum collection, we have collected a variety of other items that illustrate the history of our industry.

One of these is our collection of coffee mugs from large and small oil companies and contractors,



Our collection of company coffee mugs

Geoscience Center continued on page 42.



Collection of SEG Annual Meeting pins

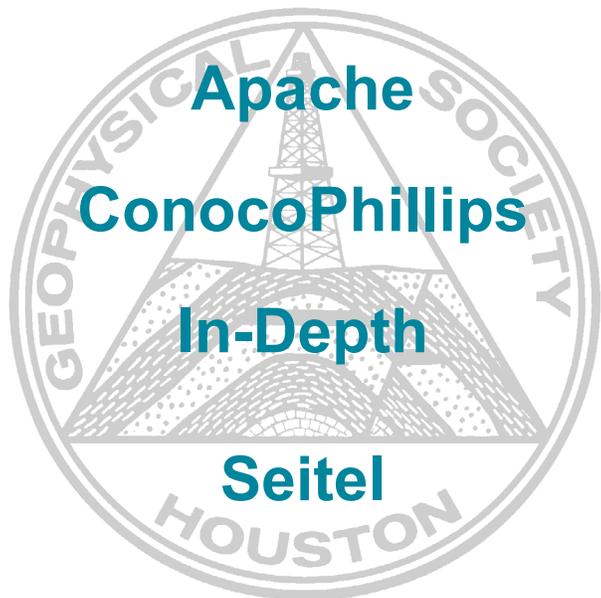
including companies that no longer exist, either through mergers or acquisitions. A picture of our coffee mug display is included with this article.

Another interesting collection is of caps from a large variety of companies, both American and foreign. We have used these at many SEG Annual Meetings with our display of items from our museum collection. We have over 370 caps currently, with many of them on display at the Geoscience Center. In 2005 we displayed some of the caps at the entrance to our booth at SEG75. These caps are shown, attached to dynamite loading poles, with this article as well.

One of our smaller displays is of SEG Annual Meeting pins which are shown in a shadow box here. □

The Geoscience Center is open on Wednesday mornings from 9:00 am to 12:00 pm or by appointment, and visitors are always welcome. Please contact me at: geogaf@hal-pc.org or by phone at: 281-370-3264 for more information.

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The Mystery Item
on [page 39](#)
is a
**Marine gimballed
geophone from 1954.
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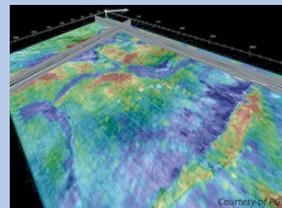
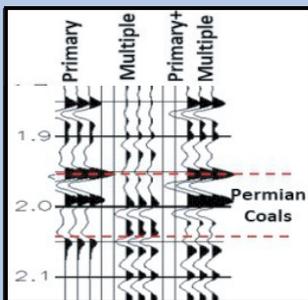
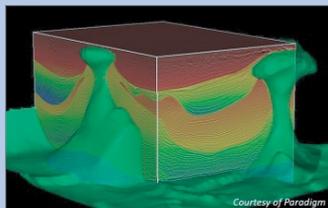
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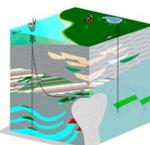
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HGS-PESGB Africa Conference 2020 Africa and its Conjugate Margins – New Ideas, Plays, and Innovation

The recent global events have had a great impact on exploration in Africa in 2020 and onward. Change in commodity prices has resulted in many planned projects being uneconomic for the foreseeable future. However, the global economic and health crisis can also create many new opportunities for ideas and concepts as everything is being evaluated and common practice is reviewed with a new perspective.

The theme for the 2020 Africa Conference is no exception. The Technical Committee is focused on what can be done differently. Given the global changes in the Oil and Gas Industry the focus for the HGS-PESGB Africa Conference will change. It will focus on areas where commercial projects will be most likely to be pursued and what analogue areas could have a similar path forward. As a result, the 2020 Africa Conference Themes will include the Conjugate Margin to expand the reach and thoughts on exploration for the next decade.

The conference will still seek to cover

1. Ideas that should be tested?
2. What has industry learned that should guide us toward new ways of thinking about exploration and development in Africa and its Conjugate Margins?
3. What technology(s) can help unlock additional reserves in existing basins and help find new resources in unexplored areas?
4. How governments can attract and promote investment in new and existing areas.

Technical Session Themes

1. Offshore Africa and its Conjugate Margins – New Ideas in an Old Area, Old Ideas in a New Area
 - Known Plays to be Tested in New Areas
 - Mapping Known Plays Across Multiple Basins
2. Applications of New Technology
 - Adding Reserves in Existing Basins
 - Reducing Cycle Time and Costs in Exploration
 - Integration of Multiple Technologies to Unlock Future Potential
3. North Africa Focus – New Areas and Ideas – Central Atlantic and Mediterranean Margins
 - Frontier Exploration Plays
 - New Exploration Plays in Under-explored Areas
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Doodlebugger Diary

Western Vessels Conduct Shallow Water Operation Aided by Small Craft in the Egyptian Red Sea

Story and Photos by Jeff Marcinak, Western Geophysical, 1978;
originally published in the 1978 Winter Western Profile
Recounted by Scott Singleton

The Doodlebugger Diary recounts the experiences of geophysicists during their working lives. I've published extensively on my own experiences and encourage those of you with experiences of your own to also contribute. Your fellow industry professionals would love to hear your stories.

Last fall I started reprinting a series of early 1980's articles from the GSI Shotpoints that can be found at <http://gsinet.us/>. In March I shifted to reprints of archived Western Geophysical Profile articles. These can be found at <https://seg.org/Publications/Journals/Western-Profile>.

Editor's Prolog: I usually comment about the historical and cultural events of the time being recounted in this month's article, but the author, a field service engineer on the Western Beach, was apparently very well versed in his ancient history as well as his knowledge of marine operations and thus no additional dialog is needed. I enjoyed reading this account of how things were in a past time. I actually wrote about a similar adventure I had off of Eritrea in 1998 in a 2018 Doodlebugger Diary segment. I hope everyone enjoys this account just as I did.

The Red Sea in 1978

EGYPT'S RED SEA COAST was the home of shallow water crew Party 181 for the winter and spring of 1978. Returning for the second year to continue work near the Egyptian port of Hurgada, the Western Beach and her flotilla of small craft were joined this season by the Western Geophysical I, providing logistics support.

Situated on the northeast corner of Africa in an arid climate zone, the majority of the Egyptian population is concentrated along the fertile flood



Figure 1: Moored in five fathoms of crystal clear water on a calm day, the Western Geophysical I and the Western Beach transfer supplies.

plain of the Nile River and on the rich soil of the Nile Delta, which spreads northwards from Cairo some 170 kilometers to the Mediterranean Coast. The agrarian methods and life style pursued by most of the inhabitants have changed surprisingly little over the past several thousand years except that the river below Aswan no longer floods and the use of fertilizer is becoming increasingly important.

On the western edge of the delta, in an area known for its wide, sandy beaches, lies the port of Alexandria, Egypt's second largest city, a metropolis that is strongly influenced by Mediterranean rather than Arabic life styles. King Farouk's summer estate and palace, now a museum, is located near the city, which has spread high-rise apartments for summertime visitors along the coast from the original harbor site that was founded by Alexander the Great in 332 B.C. Once the center of Hellenistic culture and scientific achievement, as well as the site of the huge Pharos, or lighthouse, that was one of the

Doodlebugger continued on page 51.

If you would like to add stories to the Doodlebugger Diary, send them to: Scott Singleton at scott.singleton@comcast.net
or mail them to Box 441449, Houston, TX 77244-1449



Figure 2: Field Supervisor Dave Durham (left) and Helper Paul Best are working with Party 181 on the Western Beach offshore Egypt in the Red Sea as they cut ropes to specific lengths for the navigation buoys.

seven wonders of the ancient world, Alexandria began its decline as the entire region of Egypt came under Roman control with the defeat of Mark Antony by Octavian (later known as the Roman Emperor Augustus) in 31 B.C. The subsequent suicide of Antony's cunning and beautiful lover Queen Cleopatra, who was also the wife and sister of Emperor Ptolemy XIII, as well as the former lover of Julius Caesar, solved any remaining question of Egyptian control of Egypt. As a result of various seizures and riots over the following several hundred years, the glories of ancient Alexandria have largely been destroyed.

Up the Nile River to the south lies the sprawling and dusty conglomeration of seven million people that is Cairo, the capital of Egypt and home of Western's Middle East land and marine operations. Misr El Kahira, the official Arabic name for the city, has been undergoing large scale development since 1952. The innumerable construction activities only add to the noise and

confusion of streets that are congested with modern traffic, as well as with overcrowded electric trolleys and slow moving donkey carts. Pedestrians dressed in traditional Moslem robes, as well as in western styles, overflow the sidewalks and occasionally are joined by small herds of goats or sheep that are being driven to market by their masters. The older sections of the city have retained a more historic flavor amid the grime of the centuries.

The earliest section of the present urbanization dates back to 30 B.C. when Octavian, with somewhat excessive expectations, built a fortress near the Nile and named it "Babylon of Egypt." Other sections of the city were established by various conquering factions during the chaotic history of Misr El Kahira's current millennium.

Dominating the Mokattam Hills east of the Nile is the Citadel, a medieval fortress built about 1175 A.D. by the Sultan Saladin, a military officer and soldier of fortune who united Egypt and Syria against the Islamic Turks and the Christian Crusaders, who were themselves fighting for control of the "Holy Land." With the later invention of the cannon, the Citadel was rendered vulnerable to barrage from higher hills nearby. Below the walls of the fortress the skyline of the old city is marked by the graceful domes and towering minarets of the many Islamic mosques, some of which represent outstanding achievements in Arab architecture and Moslem art between the 10th and 18th Centuries.

WG's View of Pyramids

Western's Middle Eastern office for land and marine operations is located a block from the Nile River in Garden City, a section of Cairo formerly known for its stately, 19th Century mansions and formal gardens but now being engulfed by high-rise apartments and office buildings.

Within view of Western's warehouse, on the extremity of the city near the escarpment that marks the edge of the Nile flood plain, stand the three great pyramids of Giza, Cheops, Chephren, and Mycerinus. The ancient Egyptian name of the largest is translated as "Cheops belongs to the horizon"; and indeed the massive structure, at a height of about 137 meters (originally 147

meters), appears to loom out of the vastness of the desert closer than it actually is. Most of these tombs were plundered in antiquity; the movable stone at the entrance to Cheops' tomb was even known to writers of the early Christian era. As recently as 1925, however, the discovery of a hidden chamber untouched by thieves yielded part of the opulent grave furnishings of Queen Hetepheres, mother of Cheops.

Herodotus, who visited the area about 450 B.C., some 2,000 years after completion of the pyramids, remarked that local legends claimed that it took 100,000 men, laboring in three-month shifts, 10 years to build a causeway for moving the stone and another 20 years to build the Great Pyramid. The more than 6 million tons of stone that was hauled from quarries across the Nile for the Cheops pyramid alone was absolutely required for a place of communion between the worldly and the divine, for it is through the mechanism of the pyramid that the Pharaoh's soul ascends to join his fathers, the gods. The rest of the population was, of necessity, left behind. They were needed to build the rest of the 22 major pyramids that the Memphite rulers constructed in a 30 kilometer stretch along the Nile. This was the earliest high flourishing of Egyptian civilization, which commenced about 2686 B.C. and maintained continuity for 550 years.

Egyptian Civilizations

Egypt then entered the first intermediate period, during which the country underwent an anarchic division into smaller feudal states. The next flowering of Egyptian civilization, the Middle Kingdom, occurred about 2050 B.C. when Mentuhotep II reunited the country. Now that Upper Egypt was in control, the seat of government and religion was established at Thebes. The city of the god Amun is near present Luxor, about 675 kilometers south of Cairo. Although the Memphite god Ptah was returned to the minor league of local deities, Memphis, seat of the Old Kingdom, retained its importance as a strategic gateway to Upper Egypt, as a commercial center, and as the site of one of the Pharaoh's harems. Egypt extended her influence south, opened trade routes to the Red Sea and beyond, and worked the mines of the eastern desert. The culmination of the Middle Kingdom with the XII

Dynasty was one of the most brilliant periods of Egyptian achievements and produced a wealth of art and literary works that have survived to modern times.

After another divisive decline, Egyptian civilization bounced back again with the renascent New Kingdom. Not only was the older monotheistic solar deity Ra forced to share the limelight with Amun as an entity within the person "Amun Ra, king of gods," but, perhaps reflecting the nepotistic inclination of his creators, Amun's family, Mut and Khons, also powerful gods, assumed more importance nationally. These expansionist times experienced a lull during the prosperous reign of Queen Hatshepsut, who ruled as Pharaoh to the extent of even dressing like a man and who suffered the not uncommon fate of attempted history revision as her name and face were chiseled



Figure 3: Helper Gamal Abu Kasem is tossing Norwegian buoys at 50 meter intervals while next to him Helper Kelly Moffitt is ready to drop the concrete anchor when exactly on Party 181's shot point. Seaman Ray King is manning the helm as the Western Beach's navigator, Dick Wendt, plots the location of the boat.



Figure 4: As the Western Beach moves to the north end of the prospect in the Red Sea, Captain Jock Lowman is at the wheel while Captain Derrick Rutherford is scanning the waters ahead of the ship for reefs and Coordinator W. J. McTernan checks the charts.



Figure 5: The three great Egyptian pyramids of Giza – Cheops, Chephren, and Mycerinus – are in plain view from Western's warehouse in Cairo.

from all of her monuments by her bitter nephew and stepson, Tuthmosis III.

An attempt was made by Amenophis IV and his beautiful wife, Nefertiti, to discredit Amun, master of the gods, in favor of Ra. These changes, made by Pharaonic declaration and thus law, were not just a return to older deities; but, ironically enough, a mystical belief in truth formed the basis for sweeping new interpretations of godly powers. Amenophis IV's successor, Tutankhamun, renewed the old, polytheistic faith based around Amun and returned the capital to Thebes. Although Tutankhamun met an early demise at about age 18, his tomb, discovered intact in the Valley of Kings, yielded a fantastic array of grave furnishings.

During this era Ramesses II dominated large parts of Asia and Africa and built many colossal structures, which, although lacking the fine, artistic quality of the past, were achievements on a grandiose scale. The most imposing is the gigantic temple at Abu Simbel, dedicated not only to several of the gods but, in a characteristic display of royal humility, dedicated also to himself. Today Ramesses enjoys climate controlled accommodations under glass in the Egyptian Museum and is in an excellent state of preservation as he gives visitors the same solemn expression that he has worn for the past 3,280 years.

Thebes underwent considerable development during this time and must have been quite a place back in 1300 B.C. Homer describes it in the Iliad as a city "where the houses were full of treasures, a city with a hundred gates, from every one of which 200 warriors rode out with their horses and chariots." The soldiers may have been on their way to the mines of the eastern desert, which were worked by slave labor in ancient Egyptian, as well as in Roman times. The eight- or nine-day journey across the desert and through the mountains to the Red Sea Coast left the Nile Valley some 50 kilometers upstream from Thebes. A traveler making this trip in modern times would find that little has changed until he reaches the sea not far from present-day Hurgada, where he would encounter the small craft of Party 181 zooming up and down a line of pink buoys that stretch to the horizon across the dark blue depths and over the iridescent turquoise shallows.

Shallow-Water Operations

The Hurgada area is sheltered from the main swells and rollers that move south out of the Gulf of Suez past the tip of the Sinai Peninsula and into the wider Red Sea by complex patterns of islands and coral reefs. Party 181's prospect lay on a large fault block that has not subsided as deep as the main rift of the Gulf of Suez. A complex

area crisscrossed by minor faults such as this makes drilling site location very crucial. Shallow water areas, neglected in the past, are becoming increasingly important in the difficult search for oil.

On the Western Beach the usual work day started with a hearty breakfast for some and, for those who preferred just coffee near the end of the meal hour, "Rip's" morning room service kept everyone aware of the time and weather conditions at frequent intervals. Soon the decks came to life in the sometimes misty, early morning twilight as the 24-foot aluminum jet boats were checked over and warmed up by Seamen Ray King and Thomas Tong. Others loaded the rubber Zodiac boats with hydrophones and transmitter buoys and were soon off across the waters through the cool, early morning air to lay out the line. Meanwhile, the transmitter buoys, which must be recharged every night, were connected to the hydrophone leaders and were secured to the Norwegian marker buoys placed by the navigation crew. The two shooting Zodiacs were made ready for work, the radio controlled shooting backpack was lashed in place, and the Primacord and other items were stowed securely.

Soon the entire spread had been laid out, and a noise measurement could be made. Choppy seas, nearby ships, and surf breaking over shallow reefs or crashing against rocky island cliffs all contributed to the noise level, which was usually at an acceptable low unless violent weather struck. In such a case work would be suspended anyway due to the difficulty and danger of working in heavy seas in such small craft. Other unavoidable downtime occurred when the VHF radios that were used for crew communication as well as for data transmission were rendered useless by the occasional large sandstorm that blew into our offshore area.

The shooting boats usually worked at opposite ends of the spread, moving up in the same direction as they alternately laid out a length of Primacord and shot it. As one boat would "make her run," the other would retrieve the shooting buoy and set up for the next shot. A safe, efficient shooting crew, such as Party 181's, must master subtle skills. The shooter must be able to tie off the cap quickly and securely under difficult conditions.



Figure 6: These three pieces of equipment – a rubber Zodiac boat, a jet boat, and a drill buggy – all belong to marine Party 181 and worked together during a land tie at low tide in the Red Sea.

The driver must be able to judge the drift of the Primacord as well as that of his own craft for precise placement. The size and shape of the waves not only affects visibility but sometimes makes it possible to run down the line rapidly by "surfing." On the return trip, however, running into head seas, the crew often enjoyed a bone-jarring roller coaster ride. Especially happy about the crisp, breezy January mornings were our shooter, Mark Maynard, and his incorrigible crew of pyrotechnical daredevils, Johnny Khoo, Karun T. Karunanithi, and Mark Parent. Calm days were welcomed by everyone since it was then that daily production records from the last calm period were usually surpassed.

During winter the chilly air, stiff breeze, and choppy seas made yellow slickers and full wet suits the usual dress of the day; but as spring approached with warmer days, these were gradually discarded in favor of T-shirts and shorts. With some of the French commercial divers the au nature/ look was de rigueur for an overall tan. With the approach of summer the calm days between the just-as-frequent windstorms turned into stifling days of oppressive heat, with the nearby coastal mountains obscured in dust and haze. The temperate Red Sea waters had a moderating effect on our immediate environment, but the time of year was fast approaching when inland temperatures would easily rise to 115° F.

Not every calm day stayed that way, however; choppy seas would occasionally build up rapidly as the sun rose higher in the sky. The position of the moon was critical as well since the tidal currents that flowed through channels between the numerous reefs and islands in the area affected surface conditions. The seas were highest during the full and new moons and peaked about an hour later each day as the moon changed phase. Tidal information was sometimes important to the Western Beach coordinator, W. J. McTeman, when planning the work day if very shallow areas were involved. A reef that is awash at low tide not only creates wasteful air blasts but also can cause access problems; detours of several miles occasionally had to be made by the small boats.

By Sea and Land

The Zodiac line boats were used to roll the spread forward as in any other seismic operation, with



Figure 8: Gun Mechanic John Bodor is steering the air-gun barge away from its Red Sea anchorage into heavier seas at the start of a day's work offshore Egypt on the Western Beach. Ready to do their jobs are the Party 181 helpers, Emanuel Grima (from left), Johnny Khoo, and John Hulme.



Figure 7: The Party 181 air-gun barge is a fairly seaworthy rig for the weight it carries. The barge is a product of nearly a month of hectic cutting, welding, fitting, and rigging by some of the Beach's crew.

the added complication that water depth variation has on the type of hydrophone array required. When not making a "powder run," Party 181 's assistant coordinator, Richard Brown, and the supply jet boat could often be found providing the line crew with suspended arrays for deep water, sandbagged phones for the shallows, special gimbal phones for the reefs, or flyers of geophones for crossing islands and for completing land ties. Helpers Peter Carabolt and the late Gordon Low needed considerable deck space near the shooting shack for the piles of the various hydrophones and stacks of coiled leaders on which they performed maintenance.

Lines that went into shore or across islands gave Party 181 crew members a chance to investigate the desolate, desert beaches and the guano-covered coral cliffs in the area. Besides the gulls an occasional bird of prey would sometimes have a nest on these barren outcrops. Islands were found that had small isolated coves, some with sandy beaches and crystal clear, blue-green waters. When in the northern section of the prospect, convoys of ships leaving or heading to the Suez Canal could often be seen silently stretched from one end of the eastern horizon to the other against the backdrop of the mountainous Sinai Peninsula, some 30 kilometers distant.

When not out at sea, the navigation crew could usually be found on the back deck of the Western Beach sorting ropes of specific lengths to be used on the appropriate buoys. Water depth, measured by a fathometer, could change quite drastically between adjacent shot points as the reef rose vertically from a sandy bottom or as the bottom itself steeply dropped several hundred feet across an underwater escarpment. Natural forces would conspire against Party 181 on occasion as in the case when large swells and choppy seas combined with 10 knot tidal currents between nearby islands to roll our concrete buoy weights downhill into marine canyons, changing the once straight line into a gigantic graceful arc.

Unappreciative of nature's artistic handwork was our navigator, Dick Wendt, who, along with his cutthroat crew of brawny brigands, Alan Balmer, Tom Farrell, Gamal Abu Kasem, and Kelly Moffitt, was faced with the arduous task of fixing the line in rough conditions only to turn around and watch 3 kilometers of buoys again "walk" away from their proper positions.

Party 181's air-gun barge was constructed on the beach at Gemsa in good time with maximum effort from everyone on the crew. A sculpture of pontoons and steel beams took form under the acetylene torch of Gun Mechanic John Bodor, whose welding and boiler-making skills produced a rugged craft. The four air guns were controlled by Western's AGI control system that was installed by Instrument Supervisor Mike Hardesty.

Trouble struck one stormy morning. The Western Beach was anchored on the leeward side of a horseshoe-shaped reef, inside the curve, while the air-gun barge was moored closer to the reef in shallower water. On the heliport for Zodiac boat repairs, several of the crew were surprised to see the barge heading south about 50 yards off the starboard beam with nobody onboard. Thus our own ghost ship, a clumsy craft built of iron, bathed in grease and swathed in bulldog tape,

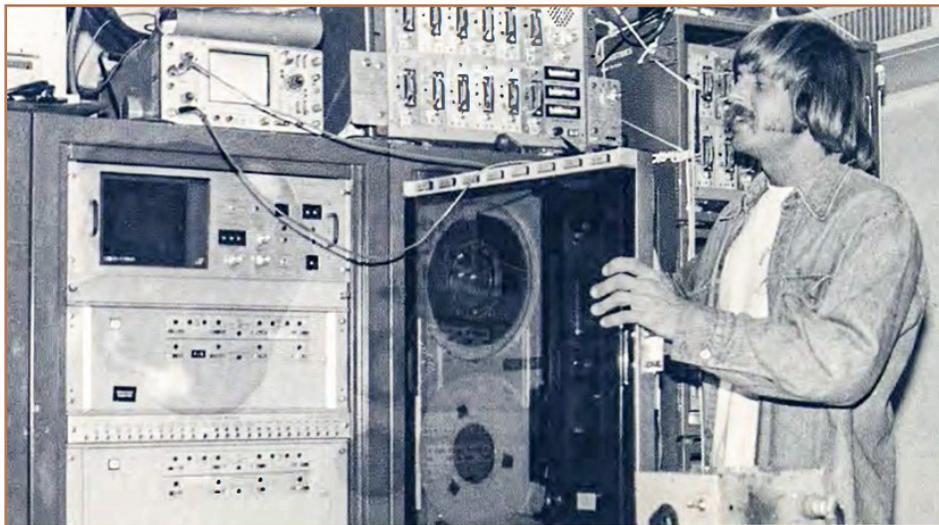


Figure 9: Field Service Engineer (and this article's reporter and photographer) Jeff Marcinak, who is on the Western Beach working with Party 181, is performing radical surgery on an unruly magnetic tape unit.

was heading captainless towards the Hurgada channel that leads out into the heavily traveled shipping lanes of the unpredictable Red Sea – that is, if the Egyptian navy did not intercept her first for moving without authorization! The crew quickly sprang into action. Before one of the jet boats could be untied from the stern of the mother vessel, the Zodiac boats, in turn tied to the jet boats and trailing behind them, had to be passed forward. It was not an easy chore in 8-foot seas and 45-knot winds. The never-named barge, rapidly heading for the horizon, was some distance away when reached by the men in the jet boat. The 353-horsepower diesel engine started on the first crank, and soon the barge was battering through heavy head seas on her way back home. The headaches were only beginning for the ship crew, however, who had to contend with the cumbersome vessel that was tied into the line of boats that trailed from the stern. It was not until the weather had calmed that it was possible to anchor the iron beast securely to the reef again.

Several commercial divers were used by Party 181 to recover hydrophones that would sometimes become stuck or whose leaders would get tangled in the irregular coral formations. Diving on the prolific reefs of the Red Sea was always an interesting experience both for the divers and

for those Westerners who occasionally joined them. The quiet beauty of this underwater world, however, was not without certain dangers.

Seagoing Creatures

Lurking in the nooks and crannies of the reef lives the lion fish, an impressive creature whose many barbed, spine-like fins protruding from his body like a mane contain a chemical that causes irritation and local paralysis when touched. Another animal with a similar defensive mechanism is the sand cone, a spiral-shelled snail whose single barb is easily avoided. Perhaps the most deadly is the sea snake, a small, yellow reptile whose powerful venom quickly attacks the nervous system. And even the safe-looking sand bars can conceal stingrays whose barbed tails are capable of inflicting serious cuts. Another good reason for wearing shoes in the shallow areas is the stone fish, which finds camouflage among the rocks an easy task thanks to its rough, toad-like skin. It is also appropriately called the one-minute fish; the fast-acting venom from one of its dorsal barbs brings certain death to anyone unfortunate enough to step on it.

On calm days when the sea's surface was smooth, the bottom up to 40 or 50 feet deep was clearly visible. It was in these more shallow areas that packs of sharks could sometimes be seen roaming about large clumps of coral that scatter the sandy seafloor. Although the majority of these predators are around three to five feet in length, sharks that swim toward the surface from a bottom of uncertain depth sometimes seem to grow rapidly bigger. The largest caught was a 12-foot white shark. Hooked and killed by local fishermen who were netting fish near our line one day, the beast's massive jaws provided souvenir teeth for some of our crew. Manta rays, turtles, and many-colored reef fish could often be seen hurriedly swimming away as Party 181's noisy, small craft invaded the privacy of this ichthyological paradise. An occasional group

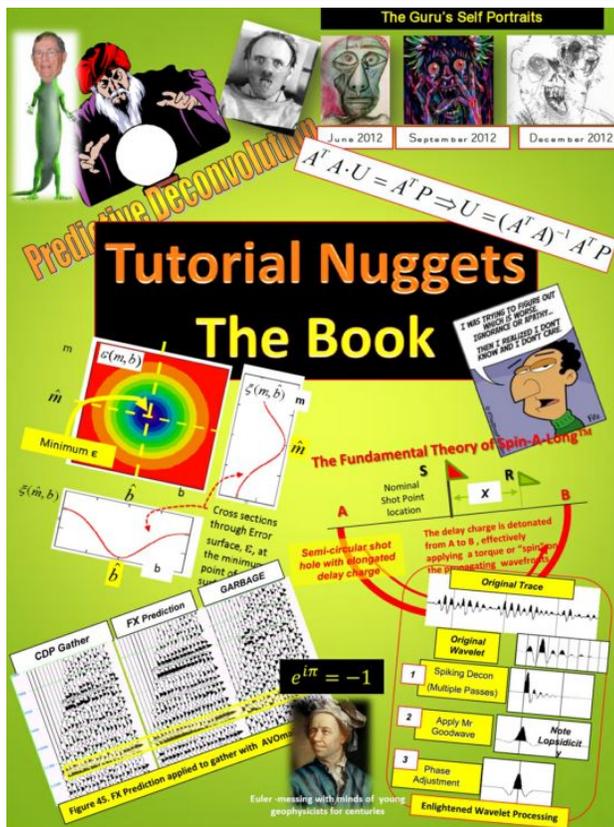
of porpoise followed and rode the bow wake as the ship sped ahead.

End of Survey

It was a boatload of happy doodlebuggers who headed back to Gemsa at the completion of the job. Just after the final line was finished, gale force winds blew up for the next several days, but malish, as they say in the Middle East; at that point the weather did not matter. After a robust dockside party with plenty of refreshments, the derigging was begun. The crew labored on this for a few days, always happy to be onshore and close by civilization, or at least the bars that came with civilization. But I'll have you know that not just any fine establishment serving suds would do for our discerning doodlebuggers. Despite the new hotel just down the road in Hurgada, the men of Party 181 generally preferred the 'distinguished' atmosphere of the lounge at the Gemsa Arms. This watering hole quickly became the go-to place where you would find crew members any time they weren't working on their own areas of responsibility on the boat. It was with many tears that upon the day when the crew's operations and tear-down was finally totally complete, we bid farewell to the Gemsa Arms and to the Egyptian Red Sea. □



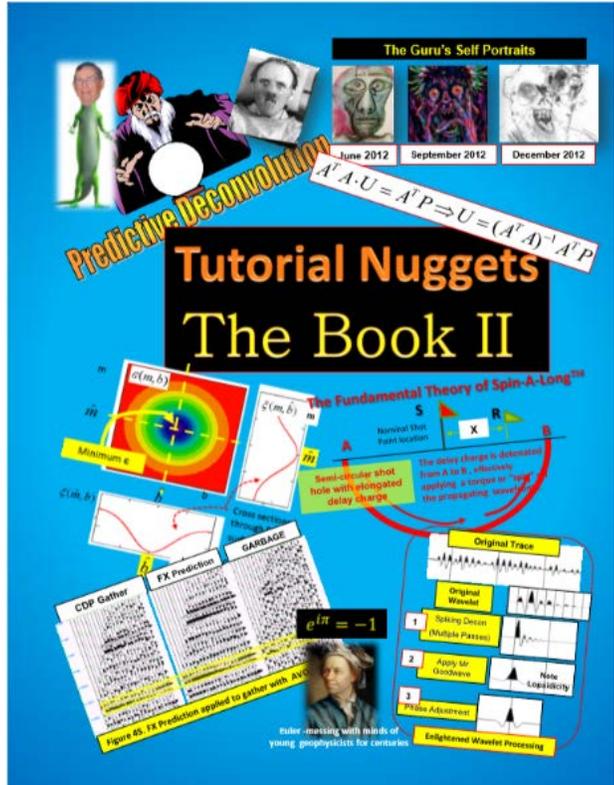
Figure 10: Local Red Sea fishermen bring in a four-foot shark on their line.



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