November 2019

The Epicenter of Geophysical Excellence

GSH Journal

GEOPHYSICAL SOCIETY OF HOUSTON
Volume 10 • Number 3

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Rock Physics Bridge Towards Characterizing a GoM Jurassic Field – Page 16

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Photo courtesy of WesternGeco.

EDITOR'S NOTE

To ensure your information reaches the GSH members in a timely manner, please note the following deadlines and plan accordingly. Please submit your articles and any questions to Alvaro Chaveste, editor, at AlvaroChaveste@hotmail.com

GSH JOURNAL DEADLINES

Jan 2020.....Nov 8
Feb 2020.....Dec 13
Mar 2020.....Jan 10

GEOPHYSICAL SOCIETY OF HOUSTON ORGANIZATION CONTACTS

Karen Blakeman, Office Director • Kathy Sanvido, Webmaster/Membership Manager
14811 St. Mary's Lane, Suite 204, Houston, TX 77079 • Office Hours 8 a.m. - 5 p.m.
Phone: (281) 741-1624 • Fax: (281) 741-9364 • Email: office@gshtx.org • Website: http://www.gshtx.org

GSH Board of Directors = GSH Executive Committee + SEG Section Representatives

		Phone	Cell	Email
PRESIDENT	Craig Beasley		713-689-6818	cbeasley@slb.com
Sponsorship	J Haynie Stringer	281-491-2045	832-606-3993	hayniestringer47@yahoo.com
Doodlebugger Fund	Paul Schatz	713-975-7434	713-829-5254	Paul.Schatz@int.com
Editorial Board	Lee Lawyer	281-531-5347	713-628-3513	llawyer@prodigy.net
Historian	Art Ross	281-360-9331		artross@airmail.net
Office	Frank Dumanoir		713-594-2371	dumanoir@swbell.net
Outreach	Lisa Buckner		713-252-9665	outreach@gshtx.org
Scholarship Liaison	Jim Schuelke	713-296-6801		Jim.schuelke@apachecorp.com
PAST PRESIDENT	Dennis Yanchak	713-296-6109		Dennis.Yanchak@apachecorp.com
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PRESIDENT ELECT	Peter Duncan	713-395-2408	713-725-4806	pduncan@microseismic.com
GSH Membership	Chris Egger		361-658-5480	christopher.egger@tgs.com
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Diversity & Women's Networking	Nicola Maitland		281-507-6552	coronster@gmail.com
NextGen	Whitney Blanchard		713-380-7255	wcharris26@gmail.com
TECHNICAL EVENTS				
FIRST VICE PRESIDENT	Peter Wang	713-393-4013		pwang01@gmail.com
FIRST VICE PRESIDENT ELECT	Matt Blyth	281-285-6987	832-444-4206	mblyth@slb.com
Tech Luncheons	Peter Wang	713-393-4013		pwang01@gmail.com
Tech Breakfasts Northside	Peter Flaming		951-219-3499	pflaming@smu.edu
Tech Breakfasts Westside	Michael Obriain	713-689-6913	713-829-5238	obriain1@slb.com
	John Gilbert	713-689-7803	832-655-4197	JGilbert@exchange.slb.com
Continuing Education	Mike Graul	713-465-3181	713-248-3562	mgraul@texseis.com
Webinars	Haynie Stringer	281-491-2045	832-606-3993	hayniestringer47@yahoo.com
Spring Symposium	Peter Wang	713-393-4013		pwang01@gmail.com
Fall Forum	Scott Singleton		832-524-8382	Scott.Singleton@comcast.net
Geoscience Day	Haynie Stringer	281-491-2045	832-606-3993	hayniestringer47@yahoo.com
SEG DISC	Peter Wang	713-393-4013		pwang01@gmail.com
SPECIAL INTEREST GROUPS (SIGS)				
Data Processing and Acquisition	Caroline Wilkinson	713-689-7667	949-887-3394	cwilkinson2@slb.com
Microseismic & Unconventional	Scott Singleton		832-524-8382	Scott.Singleton@comcast.net
Potential Fields	Daniel Minguez	832-854-3249	626-818-2114	xdminguez@gmail.com
Rock Physics	Ellen Mallman		346-252-8462	Ellen.mallman@bp.com
Wavelets (U of H)	Matthew L Storey			matthewlstorey@gmail.com
SOCIAL / FUNDRAISING EVENTS				
SECOND VICE PRESIDENT	Kenneth Mohn	713-485-9696	713-485-9696	kwmohn123@gmail.com
SECOND VICE PRESIDENT ELECT	Phil Schearer	281-921-8047	281-948-9312	phil.schearer@shearwatergeo.com
Warm Up Shoot	Ryan Marshall	713-917-6772	713-962-9414	ryan.marshall@dawson3d.com
Icebreaker	Tony LaPierre	713-482-3845	281-733-5281	Tony.Lapierre@rpsgroup.com
Salt Water Fishing Tournament	Nathan Lenz		281-468-5459	nathaniel.lenz@tgs.com
Tennis Tournament	Russell Jones	832-295-8350		rjones@Seitel.com
Sporting Clays	Ryan Marshall	713-917-6772	713-962-9414	ryan.marshall@dawson3d.com
Golf Tournament	Wesley Tyrrell		713.485.9502	wesley.tyrrell@katalystdm.com
Annual Meeting & Awards Banquet	Katherine Pittman	281-615-3339		Katherine.pittman@enverus.com
SECRETARY	Jennifer Graf		972-795-8888	secretary@gshtx.org
TREASURER	Marie Clavaud	281-509-8450		marie.clavaud@pgs.com
Finance Committee	Gabriela Suarez		832-818-6832	suarezc2001@yahoo.com
COMMUNICATIONS				
EDITOR	Alvaro Chaveste		832-707-6505	Alvarochaveste@hotmail.com
Assistant Editor	Hailey Byers		832-494-7436	Hailey.Byers@Emerson.com
Assistant Editor	Ryan Egger		361-947-8650	Ryan.egger@emerson.com
Assistant Editor	Tom Trowbridge		832-282-5147	Tom.Trowbridge@emerson.com
Assistant Editor	(unassigned)			
Technical Article Coordinator	Scott Singleton		832-524-8382	Scott.Singleton@comcast.net
Publications	J Haynie Stringer	281-491-2045	832-606-3993	hayniestringer47@yahoo.com
Website	Paul Schatz	713-975-7434	713-829-5254	Paul.Schatz@int.com
Advertising Committee	(unassigned)			
Social Media Coordinator	Liza Yellott	713-881-2894	713-204-0998	lyellott@Seitel.com
SEG SECTION REPRESENTATIVES	Tommie Rape		713-829-5480	tommiedr@aol.com
	Maitri Erwin	713-380-4800	281-785-5814	maitri.erwin@gmail.com
	J Haynie Stringer	281-491-2045	832-606-3993	hayniestringer47@yahoo.com
	Dennis Yanchak	713-296-6109		Dennis.Yanchak@apachecorp.com
	Craig Beasley		713-689-6818	cbeasley@slb.com
	Peter Duncan	713-395-2408	713-725-4806	pduncan@microseismic.com
SEG ALTERNATE REPS	Mihai Popovici	281-945-0000		mihai@z-terra.com
	Mike Graul	713-465-3181	713-248-3562	mgraul@texseis.com
GEOSCIENCE CENTER	Bill Gafford	281-370-3264		geogaf@hal-pc.org
SPG-NA Rep.	Samarjit Chakraborty			chakraborty.samarjit@gmail.com
ECH liaison	Bill Gafford	281-370-3264		geogaf@hal-pc.org
HPAC	(unassigned)			

A Word from the Board

By Kenneth Mohn, 2nd Vice President (in charge of the fun stuff)

I am sitting in the empty restaurant of the Crockett Hotel after realizing I am a week past the deadline for submitting this note. I am in San Antonio attending the Society of Exploration Geophysicists (SEG) Annual Convention. The talks and exhibits were good. The general mood is optimistic and a lot of new technology and new applications to old technology was presented.

What a difference a day makes:

On Friday I was having a conversation with a colleague in the oil business about the status of the industry at $52-$54 oil. That evening the unfortunate news of the attack on Saudi Aramco facilities pushed oil prices up to $60-$62 per barrel. At the time of writing this, the price has dropped to $57/barrel. For most of us, our business' success or failure is fundamentally rooted in the price of our commodity and the efficient way we conduct our business.

I still remember the day that Joe Foster, CEO of Newfield Exploration Company, gave a presentation at a geoscience event (I can't remember which event). The title of Joe's talk was "It's the Margin ("stupid"). At the time, it was the late 1980s or early 1990s and a lot of US oil companies decided the Gulf of Mexico was the "Dead Sea" and that it was time to explore outside the Gulf of Mexico. I was working at TGS Geophysical Company at the time and we started shooting surveys in Trinidad and West Africa with success. Several of our clients had formed international divisions and were now working in West Africa and other regions outside North America. At the same time, Newfield was busy finding oil and gas success in the northern Gulf of Mexico.

Joe Foster opened my eyes during his talk when he pointed out that the margin for US oil companies in the Gulf of Mexico was much higher than the margin for discoveries made in international basins. In other words, you have to find a field that is almost twice the size of the same discovery in the Gulf of Mexico to make the same return on investment. Joe pointed out the economics and the importance of understanding that margin in a very clear and concise way. As a young geoscientist, I was impressed. I learned something. It made me look at the big picture, including client economics when developing projects. What a difference one day can make.

The Big Picture

Please don't expect me to know what the "big picture" is. I believe it's different for everyone. Just keep your eye out for it. For example, here's something I have my eye on.

People tell me, as Second VP of the GSH that I'm in charge of the "fun stuff." Fun stuff includes all of the social events, which are also fundraising events for the GSH, but does NOT include the technical talks, webinars, SIGS, educational activities, and all of the other technical and educational GSH activities.

I enjoy the fun stuff, as it's for the members and the benefit of our society (I also enjoy participating).

At times, I get credit for the success of this or that event, but it is really the Chairmen or Chairs of each event who do all of the work and make these events a success. In my GSH world, the big picture is the success of these events. The Chairmen make a hard job look easy. They are doing a great job.

These volunteer Chairs of each event should be recognized, as they do a lot of work. Please note the date of the events and plan to attend if you can. The events include:

- **Fall Warm Up Sporting Clays Tournament**
  (Held August 24th, 2019),
  Chairman: Ryan Marshall of Dawson

Word From the Board continued on page 5.

Dear GSH Journal readers,

Please feel free to contact us with any and all questions or suggestions that you may have. My email is listed below. Additional Organization Contacts can be found on page 3.

Sincerely,

Alvaro Chaveste, Editor, at AlvaroChaveste@hotmail.com

Word From the Board continued from page 4

- **Ice Breaker**
  (Held September 5th, 2019),
  Chairman: Tony LaPierre of RPS

- **Saltwater Fishing Tournament**
  (to be held on October 11th, 2019),
  Chairman: Nathan Lenz of TGS

- **Tennis Tournament**
  (to be held November 8th, 2019),
  Chairman: Russell Jones of Seitel

- **The 34th Annual Sporting Clays Tournament**
  (to be held in March 7th, 2020),
  Chairman: Ryan Marshall of Dawson

- **Golf Tournament**
  (to be held April 27th, 2020),
  Chairman: Wesley Tyrell of Katalyst

- **Honors & Awards Banquet**
  (May 7th, 2020), Chairman:
  Katt Pittman of Drillinginfo

I should also mention the hard work of Kathy Sanvido (GSH Website and Membership Manager) and Karen Blakeman (Office Director) who also work tirelessly on all of the events; as well as Phil Schearer, (Second VP Elect this year) who will take over this job next year and is also very involved.

The GSH events above are put together to provide a social gathering and fun activity for our members to network with colleagues and friends. These events are fun and a major source of funding for the GSH, which is a non-profit organization. Our goal with these events is to provide the members with a good environment to network off-campus.

We receive generous sponsorships from various companies and individuals. Our sponsors and I would like to see as many people as possible come out and attend at least one, if not all of our events. You don't have to be a scratch golfer or a good shot. The best value of membership is participation in both the technical and non-technical events. This helps to build our network and knowledge.

One constant in life is change. I would welcome any feedback or comments on current GSH events above or a suggestion of other new events that may be of interest to our members. How can we make it better? Thank you for your participation, sponsorship, and membership in the GSH. It is greatly appreciated.

We look forward to seeing you soon! □

From the Other Side

By Lee Lawyer

I am typing away in a hotel room in San Antonio. I am behind schedule. The SEG is having their Annual Meeting (convention). There are about 6000 registrants, plus or minus, which is down from the good old days but still healthy and vigorous. There are over 20 simultaneous technical presentations. Back in those 'good old days', we thought seven was too many. The exhibit floor was full of interesting displays.

Having patronized all of you for a whole paragraph, I now need to give you some unusual things I saw and some not so unusual. Most of you know that I have held several offices and received several honors. No brag, just fact. Mandy (staff) sent the Board officers a series of ribbons to attach to their convention badges. I had a friendly contest with Milo Backus to see which of us had the most ribbons. He always won but it was fun. This year no ribbons were sent. No one recognized me without my ribbons. Mandy (same staff person) suggested I get my ribbons in the registration area. She said, "Check the Ribbon Wall". And lo and behold, I found a lot of ribbons. Anyone could walk up and select a ribbon. Maurice Ewing award, Past President, Past President spouse, Life membership, and on and on. I could become anything I wished. I restrained myself and only selected five!

I thought I had run into the head of the National Rifle Association, Wayne LaPierre but, it was Tony LaPierre, a member of the GSH. The exhibit floor was awesome. I noticed a company named Seismos. I thought that was interesting. I asked how the company chose that name. After a blank stare, one suggested it might be Greek. I was happy to tell them that Seismos was a German Company that was formed back in the mid 1900's. It was formed by Ludger Mintrop who brought the first refraction seismic crews to the US and located a lot of Salt Domes in Texas and Louisiana. My good deed for the day.

The opening ceremonies involved a talk by the President of the SEG, Rob Stewart. It was a super talk, good slides and lots of data on the SEG. He was extoling Cecil Green and said he started GSI. WRONG! The GSI was started in 1930 by J. C. Karcher who was credited with the first use of reflection seismology back in the early twenties. Cecil Green was a party chief on one of the first GSI crews. He became the CEO of GSI when Karcher sold the company to a few of his employees in the 1940's. I probably was the only one in that big audience to note the error. Picky, picky, picky.

The finals of the Challenge Bowl occurred on Monday. Ten finalist teams representing worldwide participants vied for first place. A team from Argentina won and received $1,000. Second place got $500 and the third got $1. Peter Duncan is the founder of the Challenge Bowl. He conducts many of the preliminary matches. The GSH sponsors a preliminary round in Houston. The prize for winning the Houston round is a trip to the next SEG Annual Meeting with expenses. I am amazed that more student teams don't sign up. Think of the University of Houston, Rice, Texas A&M, University of Texas, University of Texas (San Antonio), and on and on.

The hotel I stayed at is beside the Convention Center. Each day I noticed a low black car parked on the way to the meeting. I (laughingly) suggested that it was a door prize. The funny name on the car was, "Lamborghini". Is that the way it is spelled? On Wednesday it disappeared. Sadness, but for my money I will take a Ferrari or a Bugatti any day (obviously kidding). I left San Antonio on Wednesday evening. The storm at Houston caused a 40-minute delay on the runway. Finally made the trip and experienced a very bumpy descent onto the Houston airport runway. I survived Harvey and now Imelda. □

Technical Luncheons

Practical Insights and Techniques in Seismic Velocity Estimation

Register for Tech Lunch Westside

Register for Tech Lunch Downtown

Register for Tech Lunch North

John T. Etgen

Speaker: John T. Etgen, Sr Advisor at BP

Westside

Tuesday, Nov. 19, 2019
11:00 a.m. – 1:00 p.m.

NEW LOCATION: Houston Marriott Energy Corridor
16011 Katy Freeway
Houston, TX 77094

Downtown

Wednesday, Nov. 20, 2019
11:00 a.m. – 1:00 p.m.

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

Northside

Thursday, Nov. 21, 2019
11:00 a.m. – 1:00 p.m.

Location: Repsol
2455 Technology Forest Blvd.
The Woodlands, TX 77381

** Please allow some extra time to sign in with security, and required escort to auditorium on 2nd floor.

Abstract:

The estimation of seismic wave speeds plays a critical role in seismic data processing. As we explore more complex and previously unexplorable provinces, accurate velocity models are of paramount importance, especially since we are demanding ever-higher quality images from seismic reflection data everywhere. I feel this topic is so important that everyone involved should understand the fundamentals of seismic velocity estimation and be able to recognize the limitations and pitfalls in practical applications.

Thus, this presentation is designed to give insight into how seismic velocity estimation really works, what you can resolve, and what you will have difficulty resolving. I will show you experiments that demonstrate the power and the limitations of tomographic approaches that rely on iterative prestack migration. During the presentation, you will learn concepts that might at first seem counter-intuitive; for example, lateral resolution of velocity anomalies can often be higher than vertical resolution. I will show you simple and effective ways of performing analysis and quality control during velocity model construction. Then, to conclude, we will discuss emerging and advanced methods for building velocity models in the most complex settings that are currently of industrial interest.

Biography:

John T. Etgen received a B.S. in geophysical engineering from the Colorado School of Mines in 1985 and a Ph.D. in geophysics from Stanford University in 1990. During his studies, he worked on a wide variety of topics in seismic imaging and data processing while learning from his mentors Jon Claerbout and Norm Bleistein; as well as many

Technical Lunch continued on page 8.

Technical Lunch continued from page 7.

talented colleagues and fellow students. His thesis studied new-at-the-time prestack-migration--driven tomographic techniques for velocity estimation. That experience taught him how truly difficult inverse problems really are. Leaving Stanford behind, he began his industrial career in late 1990 at the Amoco Production Research Company in Tulsa, Oklahoma. Unlike many new Ph.D.'s, he did not want to continue work on his thesis topic. Fortunately, once again, he had the opportunity to work on a wide variety of topics and learn from leading researchers such as Dan Whitmore, Rusty Alford, Kurt Marfurt, Ken Kelley, Sam Gray and many others. In 1999, Amoco merged with BP, and John moved to Houston. His role was Senior Scientist and then Senior Scientific Advisor for Seismic Imaging in BP. In 2008, he and Carl Regone were awarded the Virgil Kauffman medal for their work in wide-azimuth marine seismic. In late 2011, John was appointed Distinguished Advisor for Seismic Imaging in BP. John is currently Assistant Editor for the scientific journal Geophysics. He continues to work in the Upstream Technology organization at BP. □

Technical Breakfasts

Depth to the Top of Overpressure in the Deepwater Gulf of Mexico: Garden Banks, Green Canyon, Keathley Canyon, and Walker Ridge

Register for Tech Breakfast North

Register for Tech Breakfast West

Sharon Cornelius

Speaker: Sharon Cornelius,
Research Scientist Staff at University of Houston

Authors: Sharon Cornelius,
University of Houston;
and Peter A. Emmet,
Brazos Valley GeoServices Inc.

North

Tuesday, Nov. 5, 2019
7:00 – 8:30 a.m.

Sponsored by Oxy

Location: Oxy (formerly Anadarko Bldg.)
1201 Lake Robbins Drive
The Woodlands, TX 77380

West

Wednesday, Nov. 13, 2019
7:00 – 8:30 a.m.

Sponsored by Schlumberger and WesternGeco

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

Abstract:

For the Gulf of Mexico, overpressure is defined as the point below the seafloor at which the geopressure gradient reaches 0.70 psi/ft, or a 13.5 ppg drilling mud weight (Bebout et al., 1982 and Rabinovich, 2011). The geo-pressure gradient was calculated from 150 wells using the bottom-hole mud weights converted to psi and then subtracting the hydrostatic pressure of the water column. The depth at which the remaining sediment (pore) pressure would reach 0.70 psi/ft was then calculated using the geopressure gradient. There are twelve contributing factors to the formation of overpressure in the study area but the only one correlating over the whole region is water depth. Disequilibrium compaction is widespread due to high sedimentation rates during the Cenozoic; but numerically it does not contribute greatly. Other more significant contributors are hydrocarbon generation, smectite to illite transformation, and sandstone diagenesis. Location factors include seafloor topographic highs or lows, presence of salt bodies, salt movement, proximity to faults, geothermal gradients, and thickness of clastic lithological units.

Biography:

Sharon Cornelius began her career in the oil & gas industry in 1980 as a geophysical programmer at Exxon Production Research. From there, she went to Conoco as an exploration geophysicist working lease sales in the Gulf of Mexico. In 1992, she became a consultant in sequence stratigraphy for Landmark Graphics working under Dr. Peter Duncan in Caracas, Venezuela. After returning to Houston, she worked for Halliburton Energy

Technical Breakfast continued on page 10.

Technical Breakfast continued from page 9.

Services as Principal Technical Administrator in Global Well Construction (1999-2002). In 2007, Sharon became Operations Manager for Paradigm Geophysical at their corporate headquarters in Houston, TX. In the fall of 2009, she became a PhD student in Geophysics at the University of Houston working under Dr. John Castagna. While in school, she worked part-time as a Senior Consulting Advisor in Geophysics and Geology and has done projects for Korea National Oil Company (KNOC) in Calgary, Tiandi Energy in Beijing, OMV Petrom in Bucharest, and Pemex in Villahermosa.

She received a B.S. in Chemistry from the University of Houston and an M.S. in Physics from Rice University. While working for Exxon, she went back to Rice University for a PhD in Geology under Dr. Peter Vail in sequence stratigraphy, and now she has completed a PhD in Geophysics as of May 2017. □

"Cutting advertising to save money is like stopping a clock to save time."
- Henry Ford

GSH Media Kits

Microseismic SIG

Applications of Controlled Source Electromagnetic Methods for Fracture Monitoring

Register for Microseismic

Oscar Vasquez

Speaker: Oscar Vasquez, Deep Imaging

Authors: Mark S. Hickey, C. Santiago Trevino, Oscar Vasquez, Deep Imaging
Mark E. Everett, Department of Geology and Geophysics, Texas A&M University

Sponsored by MicroSeismic, Inc.

Location: MicroSeismic, Inc.
10777 Westheimer, Suite 110
Houston, TX 77042

Thursday, Nov. 7, 2019
11:30 a.m. - 1:00 p.m.

Abstract:

Land-based Controlled-Source Electromagnetics (CSEM) is currently used to monitor fluid injection during a hydraulic fracturing operation. The ability of a CSEM system to interact with a fluid filled fracture network at depth is aided by the highly conductive metal casing, as well as, percolation properties of the fracture network. However, differences in the frequency response and location of surface responses due to the injected fluid is a complex combination of the interaction of the fluid filled fracture network at depth with human infrastructure and natural geological structures in the subsurface. In this study, differences in these responses, as metal infrastructure and geological structures are added to the system, is investigated.

We start with a simple case of a single well with created fracture network in a half space and gradually increase the complexity of the system, ending with a model of layered, anisotropic and isotropic geology with multiple wells and different depths. We study how the signal strength at different frequencies changes on the surface. The secondary signal strength at different frequencies has larger responses depending on the depth, formation type, number of well casings, and other parameters associated with changes at depth due to the hydraulic fracturing process.

This is followed by a case study in the Anadarko basin. Electromagnetic data is generated and recorded by using surface transmitters and receivers where a baseline field is also recorded prior to fluid injection. Imaging is made possible by applying simple processing workflows to identify changes in reservoir conductivity in response to fluid and proppant placement. The case study shows EM frequencies migrating towards a fault in the formation during different hydraulic fracturing stages revealing the extent of the fracture network. An understanding of how these frequencies change with depth can help in isolating a target of interest in the subsurface.

Biography:

Oscar Vasquez is a geophysicist at Deep Imaging. He is part of the processing and imaging team where he is tasked with identifying frac hits, plug failures and other problems affecting well performance in unconventional environments.

He received his BSc from the Texas A&M University and his MSc from the Memorial University of Newfoundland where he acquired experience in collection, processing and interpretation of electromagnetic, seismic, and gravity data.

Oscar is exploring data science and machine learning applications for geophysical data; as well as integration of cloud computing to the company infrastructure. □

Data Processing & Acquisition SIG

Advanced Ray-based Modelling for Velocity Sensitivity Analysis and Use of Point-spread Functions for Fast-track PSDM Simulation

Register for Data Processing

Graham Johnson

Speaker: Graham Johnson,
President, Sound Seismic Solutions

Authors: G. Johnson, T. Kaschwich,
L. Zühlsdorff (NORSAR)

Sponsored by Schlumberger

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

Tuesday, Nov. 12, 2019
4:30 p.m. Sign-in, Snacks, Social Time
5:00 p.m. Start of presentation

Abstract:

The oil industry is looking for successively smaller and deeper reservoirs in more complex structures, which are more difficult to illuminate and image using seismic. This poses a challenge to seismic acquisition design and survey evaluation. Illumination mapping is the classic application of ray tracing, as the location of reflection points is known. However, advanced ray-based methods go far beyond the classic approaches. Kirchhoff modelling exploits Green's functions and thus models diffractions, generating synthetic gathers that allow for migration tests (i.e., PSDM simulation) while keeping the flexibility and efficiency of ray-based techniques. The computational effort typically is larger than for conventional ray tracing but still significantly less than expected for full wavefield modelling. A key application is the assessment of the sensitivity of the migrated image to velocity uncertainties. A complex structural model and initial velocity field can be used to generate the synthetic shot gathers, while a perturbed velocity field can be used to migrate the synthetic data, and the image compared with the original structural model to assess shifts in position.

Using Green's functions for generating so-called illumination vectors is an even more efficient process. Each illumination vector is representing a valid shot and receiver combination of the survey, and combining all given shots and receivers provides an illumination function dependent on survey, sub-surface model and illumination point. Converting illumination vectors into scattering wavenumbers and combining them with the amplitude spectrum of a given wavelet generates a specific 3D filter that integrates both illumination and resolution properties. The filter can be applied to a representative model volume around the illumination point, acting as a fast-track PSDM simulator directly from a reservoir model. The depth domain representation of the filter is a point-spread function that provides direct access to both vertical and lateral resolution. For the given purpose, the point-spread function is considered as a 3D convolution wavelet that is as efficient but much more realistic and accurate than 1D convolution wavelets, which often are still used when modelling results are required quickly.

This study shows some examples how sharp lateral velocity variations in the overburden may affect imaging underneath if the migration velocity field is overly smooth. Point-spread functions are used for estimating both lateral and vertical resolution at target level and fast-track PSDM simulation in combination with illumination analysis

Data Processing & Acquisition continued on page 13.

Data Processing & Acquisition continued from page 12.

indicates illumination limitations due to overburden and survey setup.

Biography:

Graham Johnson has been a representative of NORSAR in North America and user of NORSAR's software since 1999. Working with NORSAR's service department, he has completed several illumination studies on various prospects mainly in the Gulf of Mexico. Using NORSAR software, he performed numerous studies for the SMAART II consortium in connection with their physical tank model.

Graham holds a Bachelor of Science degree in Physics from the University of Durham, UK, and Master of Science degree in Geophysics also from Durham. After graduating, he joined the research department at Seismograph Service Ltd in the UK where he developed and maintained signal processing and signature deconvolution software. After five years, he joined GECO as part of a team developing Marine Vibrators for commercial use. He continued with Schlumberger after the merger and worked with land and marine source development, as well as borehole geophysics and general geophysical support. Since 1999, he has been president of Sound Seismic Solutions and, in addition to his NORSAR activities, has continued his involvement in the development of Marine Vibrators and other geophysical projects. □

Potential Fields SIG

Crustal Structure of the Eastern Mediterranean Basin Based on Integrated Geological and Geophysical Data.

Register for Potential Fields

Mark B. Longacre

Speaker: Mark B. Longacre, MBL Inc.

Thursday, Nov, 21, 2019
5:30 p.m. - 8:00 p.m.

Sponsored by CGG

NEW LOCATION:

Location: The Black Lab Pub
4100 Montrose
Houston, TX 77006

Abstract:

This study, based on the integration of regional geology with gravity and magnetic modeling, has determined the crustal type, structure, and depth to Moho for the Eastern Mediterranean Basin. Three gravity models have been generated showing the different crustal types associated with the rifted Levant margin and oceanic crust. Further, there is strong evidence for translational / transpressional boundaries between the extended continental and oceanic crusts. Mapping the crustal thickness, crustal type, crustal boundaries, and depth to Moho is important to understanding the tectonic evolution of the basin and its impact on hydrocarbon generation.

Biography:

Mark Longacre has been a professional geophysicist for the past 38 years working exclusively as a gravity and magnetic specialist for the oil and gas exploration industry. He graduated from the University of Wisconsin – Milwaukee in 1978 with a BS degree in geology and then attended Purdue University where he graduated with an MS degree in Geophysics in 1981.

Mark started his career with Sohio Petroleum in San Francisco as a potential field geophysicist. In 1982 he was transferred to Dallas, where he earned an MBA degree in Technical Management from the University of Dallas and in 1985, he was transferred to Denver. Later that year he joined Aqua Terra International, a gravity and magnetic consulting firm, as Manager of US Operations.

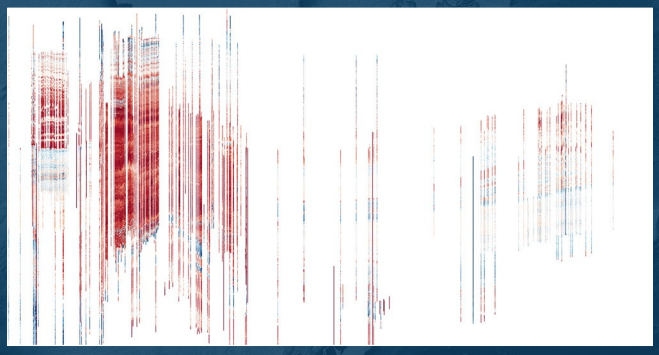
In 1991 Mark started MBL, Inc., a gravity and magnetics consulting company in Denver. MBL, Inc. specializes in the acquisition, processing, and integrated interpretation of gravity and magnetic data for the oil and gas exploration industry. In 1999, Mark opened a second office in London, England.

Over the past 28 years, he has traveled to over 60 countries doing a variety of specialized gravity and magnetic projects for the oil and gas exploration industry. □

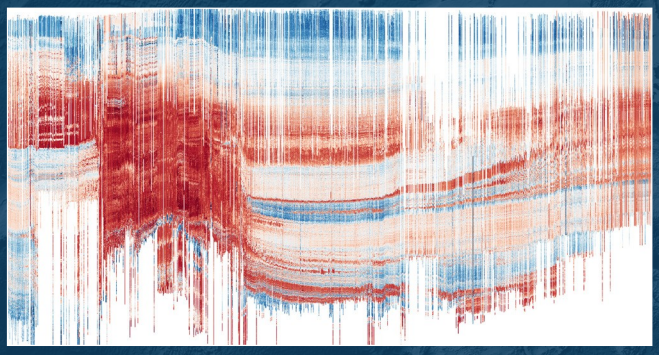
Machine Learning with the industry's largest data library

Access the world's richest analytics ready data set

ARLAS – Analytics Ready LAS uses machine learning algorithms to fill in gaps of log curves and calculate the curve response of missing log runs. ML models improve significantly with access to large amounts of training data and TGS has the largest commercial library from which to learn. Access more data with complete coverage from surface to TD to see the subsurface like never before.

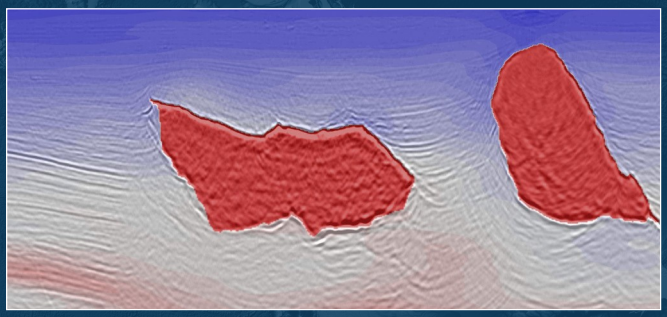


Commercially Available Sonic Curves

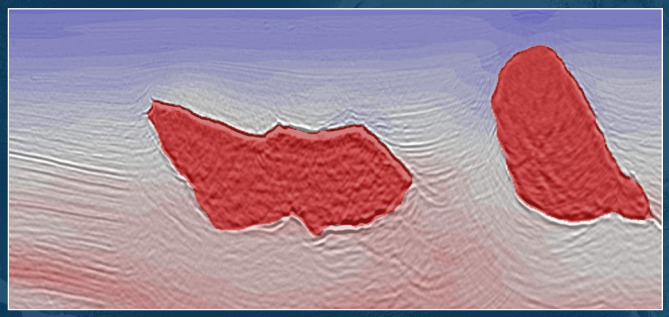


Predicted Sonic Curves

TGS has developed a modern analytics workflow, SaltNet, that proves to reduce cycle time by up to 80% when picking top and base of salt within a seismic dataset. With TGS' new predictive workflow, operators can automatically build salt models which can be efficiently integrated into the salt prediction process.



40 Gulf of Mexico Blocks – Hand Picked
Top of salt picked in 19 days
Base of salt picked in 11 days



40 Gulf of Mexico Blocks – Machine Picked
Top of salt picked in 3 days
Base of salt picked in 3 days

See the energy at TGS.com

TGS

Rock Physics Bridge Towards Characterizing a GoM Jurassic Field

Julio Hernández[1], Janet Ravelo[1], Henry Maldonado[1], John Mathewson[1], Cecilia Acevedo[2], Jaime Ríos[2], Madaín Moreno[2]. Francisco Lopez[2], Alan Alcalá[2], [1]Schlumberger, [2]PEMEX

Summary

The Carbonaceous Jurassic Kimmeridgian (JSK) interval has been studied in several Mexican basins, but in the northeast shallow-waters petroleum region of the Mexican Gulf of Mexico it is still an exploratory play. A rock physics modelling and multi-azimuthal seismic inversion approach allowed PEMEX to validate their JSK conceptual models. Herein, we focus on the application of a rock physics methodology to analyze the pore types that contribute to the total porosity of carbonate reservoir and to build synthetic shear velocity logs (Vs) which are essential in the seismic characterization process.

Introduction

In carbonate rocks, it is very important to know the pore type distribution to discriminate best storage facies. Conventional workflows to make porosity splitting into primary and secondary porosity are based in petrophysical procedures that are difficult to be outstretched to whole reservoir using seismic information. This work proposes to apply a rock physics method to estimate pore type concentration and estimate its distribution along the reservoir using seismic inversion and probability density functions to compute probabilistic litho-class volumes.

Seismic inversion and probability density functions require S-wave velocity (Vs) log but none of the wells inside the 90-km^2 study area (Well-T, Well-I, and Well-K) have shear sonic logs (DTS). Usually synthetic Vs logs are estimated from regressions or neural networks techniques which often do not represent all variables present in the rock such as porosity type, minerals and fluid content.

A rock physics approach based on works by Kuster and Tokzös (1974) and Key and Xu (2002) was used to estimate pore type concentration and synthetic Vs logs for the wells inside the study area.

Synthetic shear velocity logs were used to extract wavelets from partial stacks divided by incident and azimuthal angles, to build a low-frequency model, to provide quality control for multi-azimuthal seismic inversion results and, finally, to compute probabilistic litho-class volumes through the

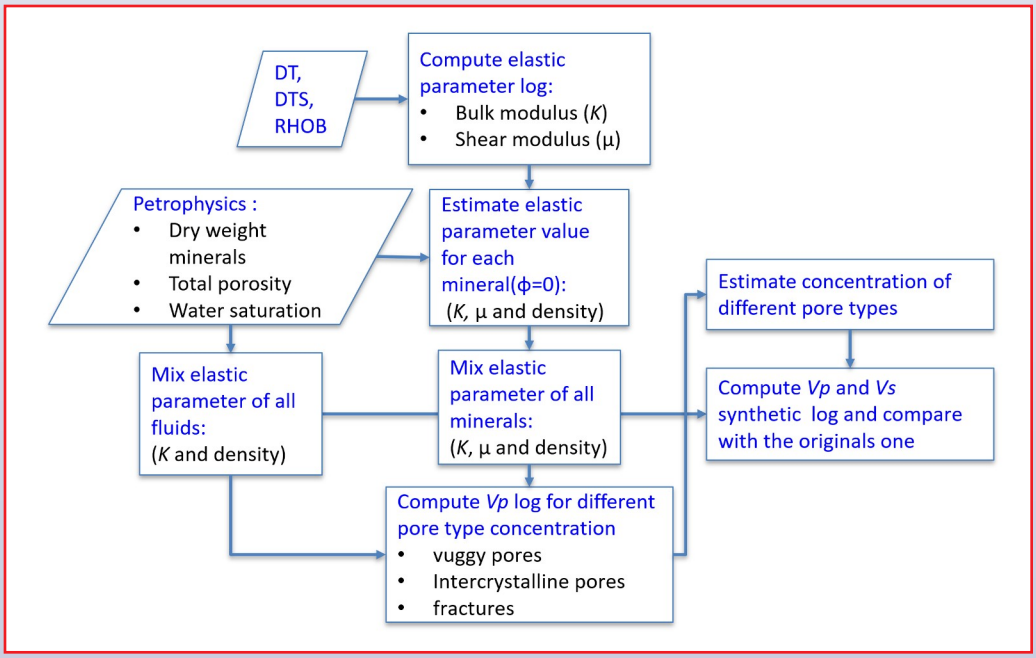


Figure 1: Workflow to estimate pore type concentration and synthetic Vs log.

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

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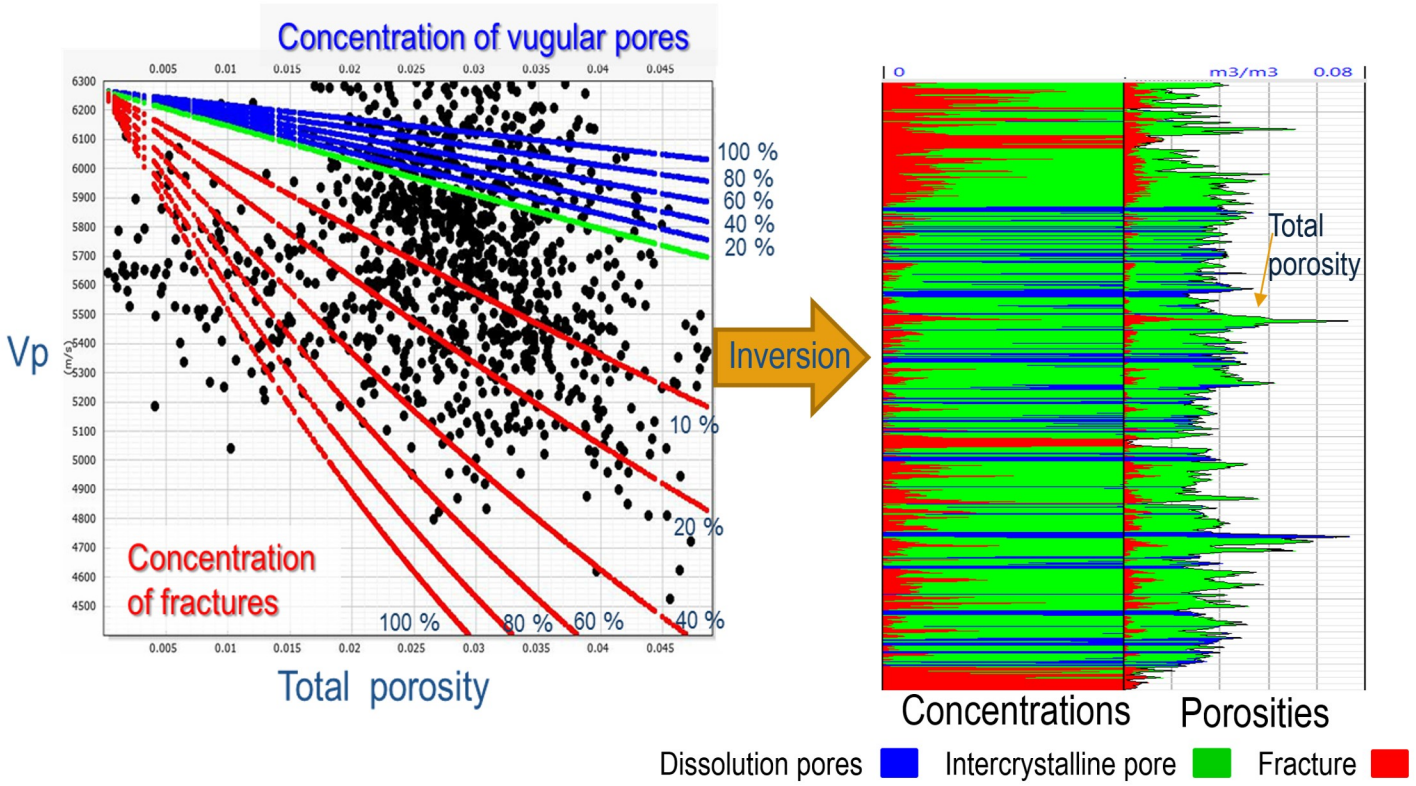

Figure 2: Crossplot of P-wave velocity versus total porosity with measured data and P-wave velocity models and estimated pore type concentration. Modified from Villaorduna et al. (2015).

combination of seismic inversion results and rock physics analysis.

Method

Figure 1 shows the general workflow used to estimate pore type concentrations and synthetic Vs logs in order to characterize the best storage facies in JSK Reservoir. The workflow begins with computing the bulk and shear modulus logs in nearby wells (C and K') having shear log information. Elastic parameter values for each mineral were estimated from elastic parameters (K, μ) versus total porosity cross plots with the dry weights of minerals plotted in colors *(Figure 3)*. Elastic parameters for each mineral were mixed using the Voigt-Reuss-Hill rule of mixing (Hill, 1952).

This rock physics approach considers mineral type contribution, saturating fluids, and total porosity to predict bulk modulus (K) and shear modulus (μ) response in dry rock for different pore types, and, using the Gassmann equation (Gassmann,1951), the fluid saturated bulk modulus (K_{sat}) is computed.

The methodology of Key and Xu (2002) was used to estimate bulk moduli of the observed dry frame and Gassmann´s equation to compute effective bulk moduli for different pore type concentrations. First, we compute P-wave velocity model for a rock with intercrystalline porosity, then we compute P-wave velocity models adding fractions of porosity related to fractures or dissolution/vugular pores. *Figure 2* shows the results of these computations in a velocity-versus-total porosity cross plot. P-wave velocity (Vp) models for a water-bearing limestone with different concentrations of fractures are shown with red lines and vugular/dissolution pores with blue lines; the green line belongs to a P-wave velocity model for the same rock with intercrystalline porosity. Measured well log data (black dots) are also in the cross plot. From the measured P-wave velocity log and velocity models for different pore types concentration, we can estimate the concentration of each pore type

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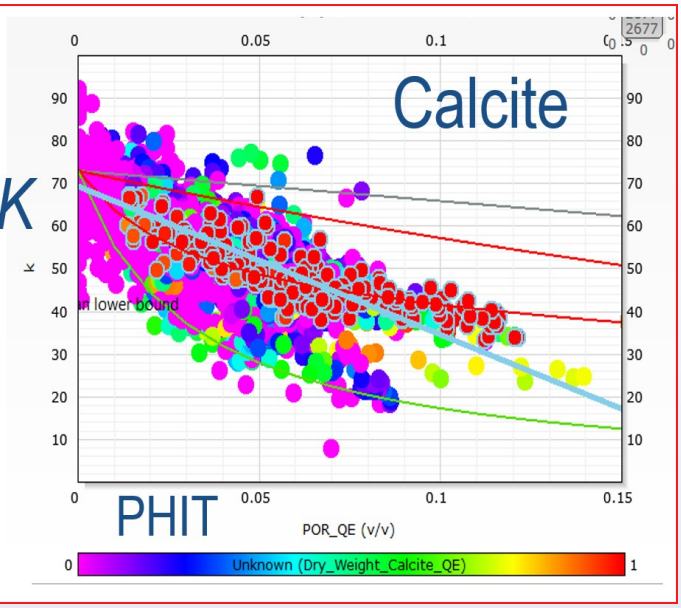

Figure 3: Cross plot of bulk modulus calculated from well logs versus total porosity with dry weight calcite volume plotted in color scale.

making up the total porosity. These concentration curves range from 0 to 1. The estimated pore type concentration curves are used to estimate synthetic P- and S-velocity logs applying the same methodology and parameters that were used to compute P-wave velocity models for different pore type concentrations.

The synthetic P-wave velocity log always has similar values to the measured logs because the pore type concentration curve used to estimate the synthetic P-wave velocity log is calculated using the same measured P-wave velocity log. The synthetic S-wave velocity log, conversely, can be different than the measured S-wave velocity log if the dry weight minerals, fluid saturation, elastic parameters for each mineral or total porosity curve are not properly estimated.

Example

A seismic reservoir characterization study was carried out in a Gulf of Mexico (GoM) Jurassic field through processes such as multi-azimuthal seismic inversion and probabilistic litho-class volumes generation. These processes require shear velocity log data, but none of the three wells in the study area has this log available.

The workflow shown in *Figure 1* was applied to estimate pore type concentration and synthetic Vs logs for the nearby wells. This workflow started with estimating the elastic parameter (density, bulk, and shear modulus) values for each mineral. *Figure 3* shows this process in a bulk modulus (computed from well logs) versus total porosity (PHIT) cross plot with dry weight calcite volume plotted in color. High values of calcite volume are selected so that only these selected points are used for regression estimation to obtain the elastic parameter value at zero porosity.

Once the elastic parameters for all minerals were estimated, we mixed them using the dry weight curve for each mineral by means of a Voigt-Reuss-Hill average to derive the elastic parameters of the rock matrix. *Figure 4* shows the dry weight of the minerals and the elastic parameters computed for the rock matrix for Well-K. Bulk modulus and fluid density were computed by means of saturation curves and Reuss rule of mixing.

P-wave velocity models were generated for different pore type concentrations in the offset wells (C and K'). Cross plots *(Figure 5)* of measured P-wave velocity (black dots) versus total porosity

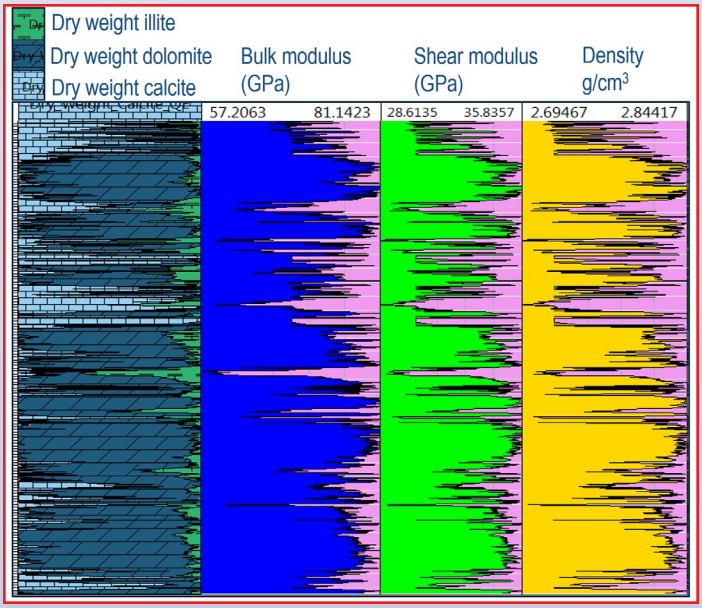

Figure 4: Dry weight of the minerals and the elastic parameters computed for the rock matrix for Well-K.

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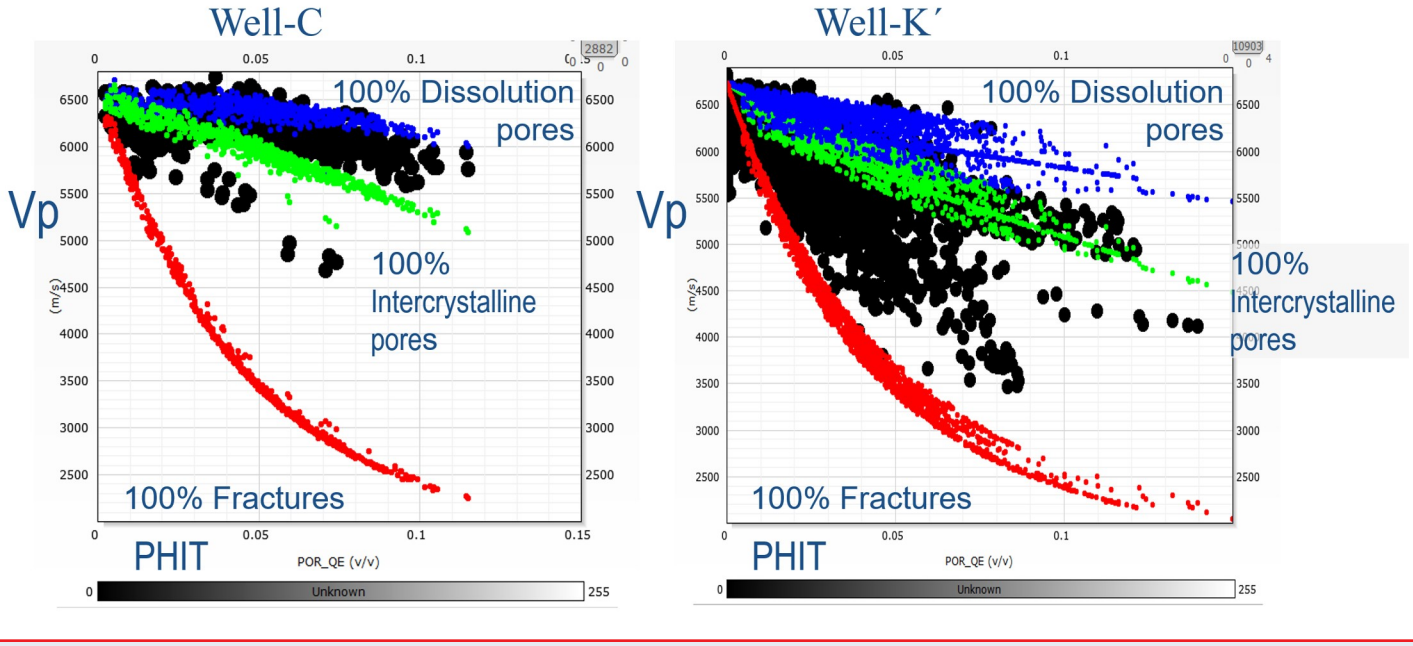

Figure 5: Cross plots showing P-wave velocity versus total porosity of measured data (black dots) and models for different pore types for Wells C and K′.

with data from these wells show that most of the points in Well-C are above the velocity model for intercrystalline pores, which suggests that total porosity for this interval is made up of dissolution pores and intercrystalline pores. On the other hand, the cross plot of P-wave velocity versus total porosity for Well-K′ shows that most of the measured data are below the velocity model for intercrystalline pores, which suggest that porosity in this well comes from fractures and intercrystalline pores.

For each well, Vp models were developed for different stiff pores (dissolution pores) and fracture concentrations, and then we can obtain pore type concentration curves. These concentration curves vary from 0 to 1, with the remaining porous space belonging to the intercrystalline porosity concentration. *Figure 6* shows pore type concentration present in the K′-well. Once these concentration logs are estimated, we derived synthetic Vp and Vs logs and compare them with the measured ones.

Following the same methodology and using elastic parameter for each mineral estimated in the offset

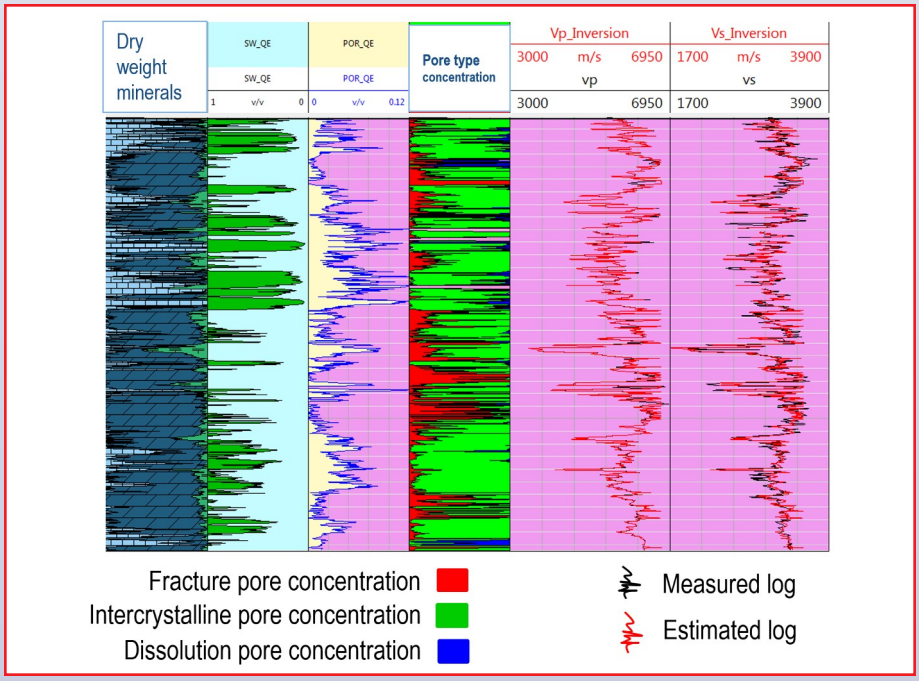

Figure 6: Pore type concentration in Well-K synthetic Vp and Vs logs.

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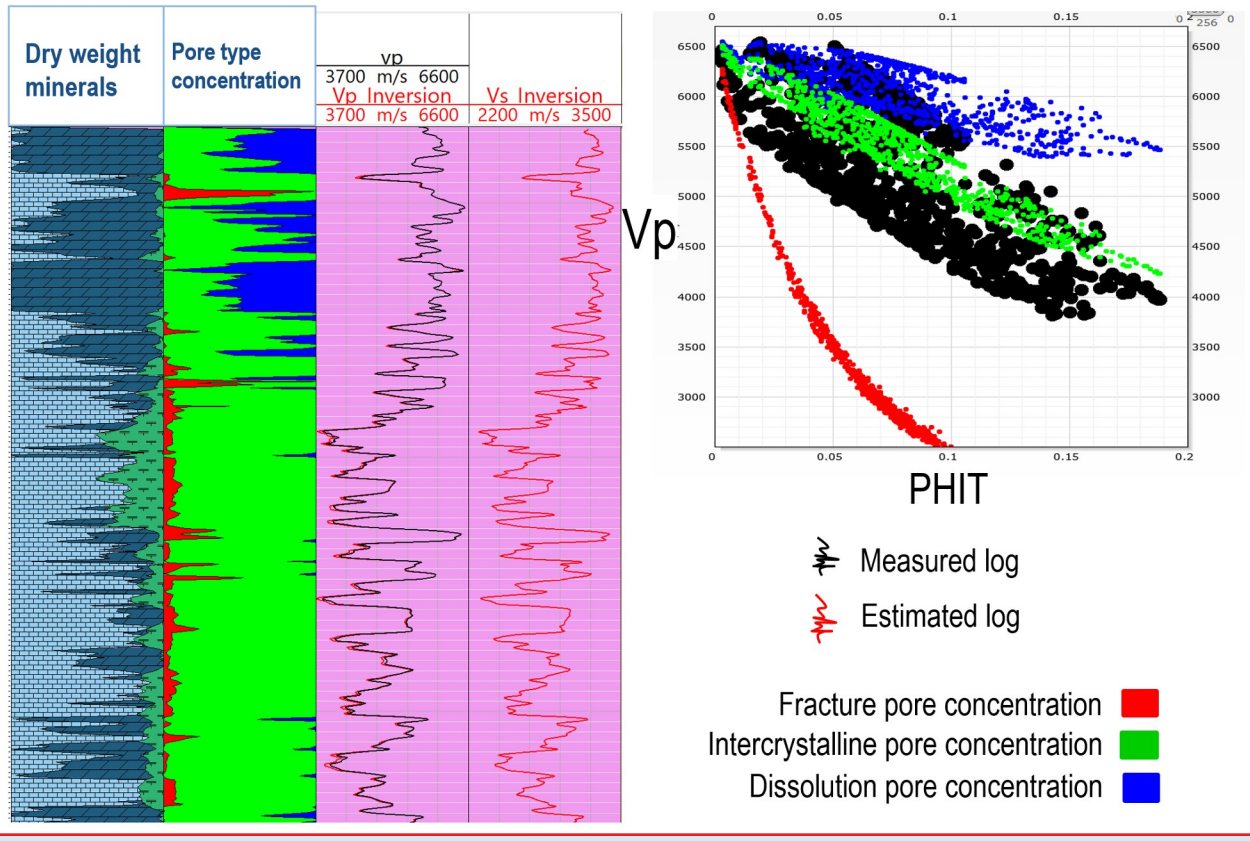

Figure 7: Cross plot of P wave velocity versus total porosity for Well-I, with pore type concentration and synthetic Vp and Vs logs.

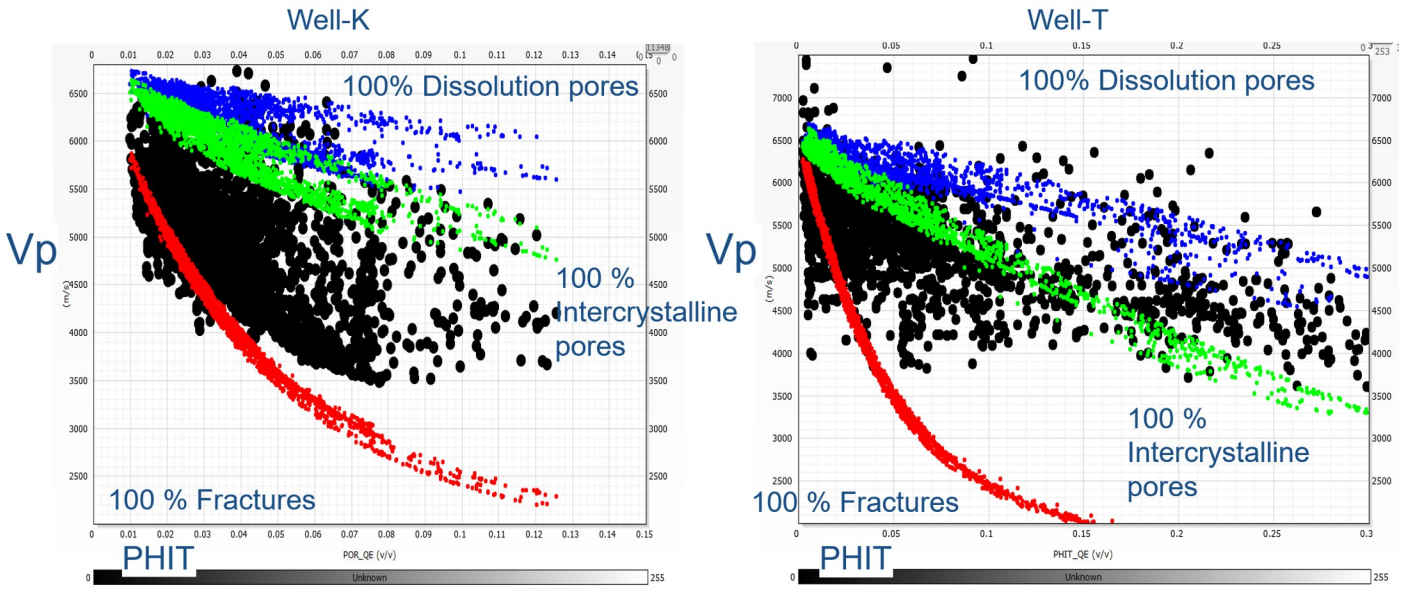

Figure 8: Cross plots of P-wave velocity versus total measured data porosity (black dots) and models for different pore types for Wells T and K.

Technical Article continued on page 21.

Technical Article continued from page 20.

wells, a pore type concentration was estimated for every well inside the study area; using this pore type concentration, the synthetic shear velocity log was estimated.

The cross plot of P wave velocity versus total porosity for Well-I in *Figure 7* shows that most of the measured data is close to the P-wave velocity model for intercrystalline pores. The pore type concentration track shows that most of the interval has intercrystalline porosity and fractures. Dissolution porosity found in the upper part, is possibly related to an oolitic bank. *Figure 7* also shows synthetic Vp and Vs logs.

Figure 8 shows P-wave velocity versus total porosity cross plots of measured data and modeled data for different pore types of Wells T and K. In Well-T, we can observe two trends of the Vp-porosity relationship; for porosities lower than 15%, most of the data are below the P-wave velocity model of intercrystalline pores, and, at porosities higher than 15%, most of the measured data (black dots) are found above the P-wave velocity model of intercrystalline pores, which suggests that dissolution pores are increasing the total porosity.

In Well-K, most of the measured data are found below the P-wave velocity model of intercrystalline pores, which suggests that total porosity mainly coming from intercrystalline pores and fractures.

From these pore type concentration logs, synthetic Vs logs were generated for Wells K and T. These synthetic well logs were used to perform multi-azimuthal seismic inversion. Elastic property volumes (acoustic impedance, density, slow and fast shear impedance, and fast shear impedance azimuth) were estimated using Kirchhoff prestack depth migration data converted to time. *Figure 9* shows a quality control of multi-azimuthal seismic inversion.

Integrating rock physics and seismic attributes to predict pore type, lithology, and storage capacity was carried out through selecting attributes, which allowed us to establish the best correlation with the properties that we plan to predict in terms of 3D distribution. Using offset well logs data, we built probability density functions and apply on inversion results to estimate lithoclasses and probabilistic volumes of predominant minerals, best storage facies, and predominant pore type distributions. Knowing the pore type concentrations that make up the total porosity is important to identify facies in the reservoir that could have the best storage capacity (dissolution pores). *Figure 10* shows the probability density functions for shale and predominant pore type distribution in carbonates.

Figure 11 shows the shale and predominant pore type distribution in carbonates.

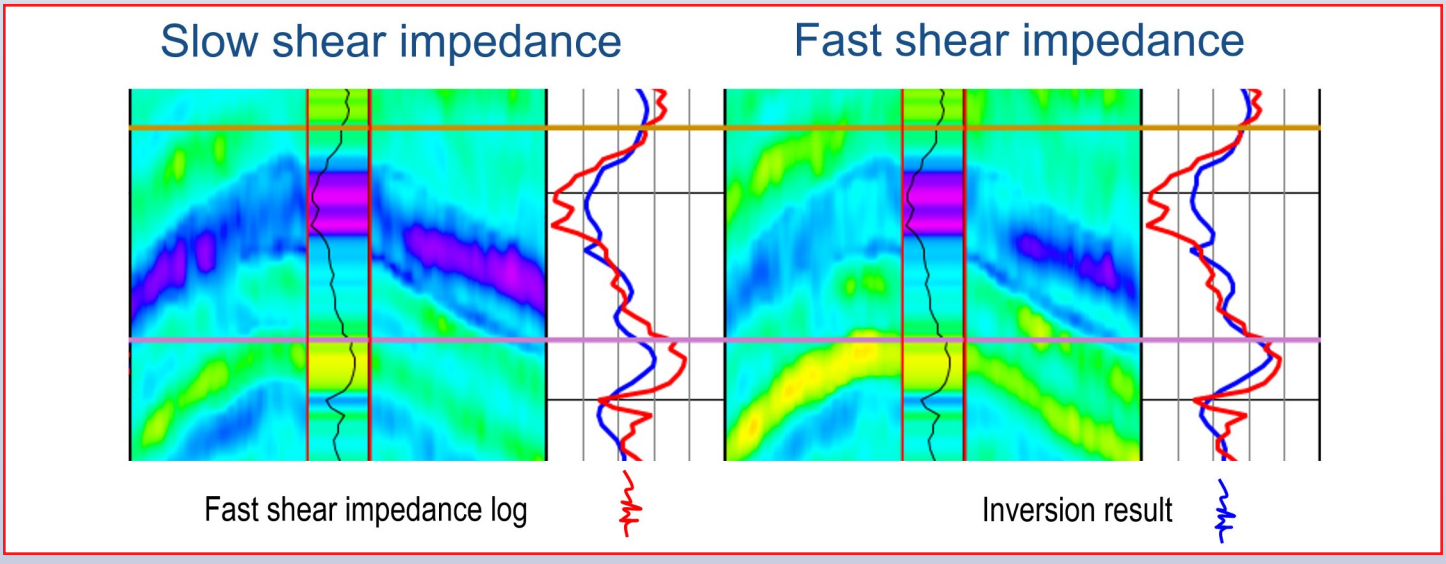

Figure 9: Quality control of multi-azimuthal seismic inversion.

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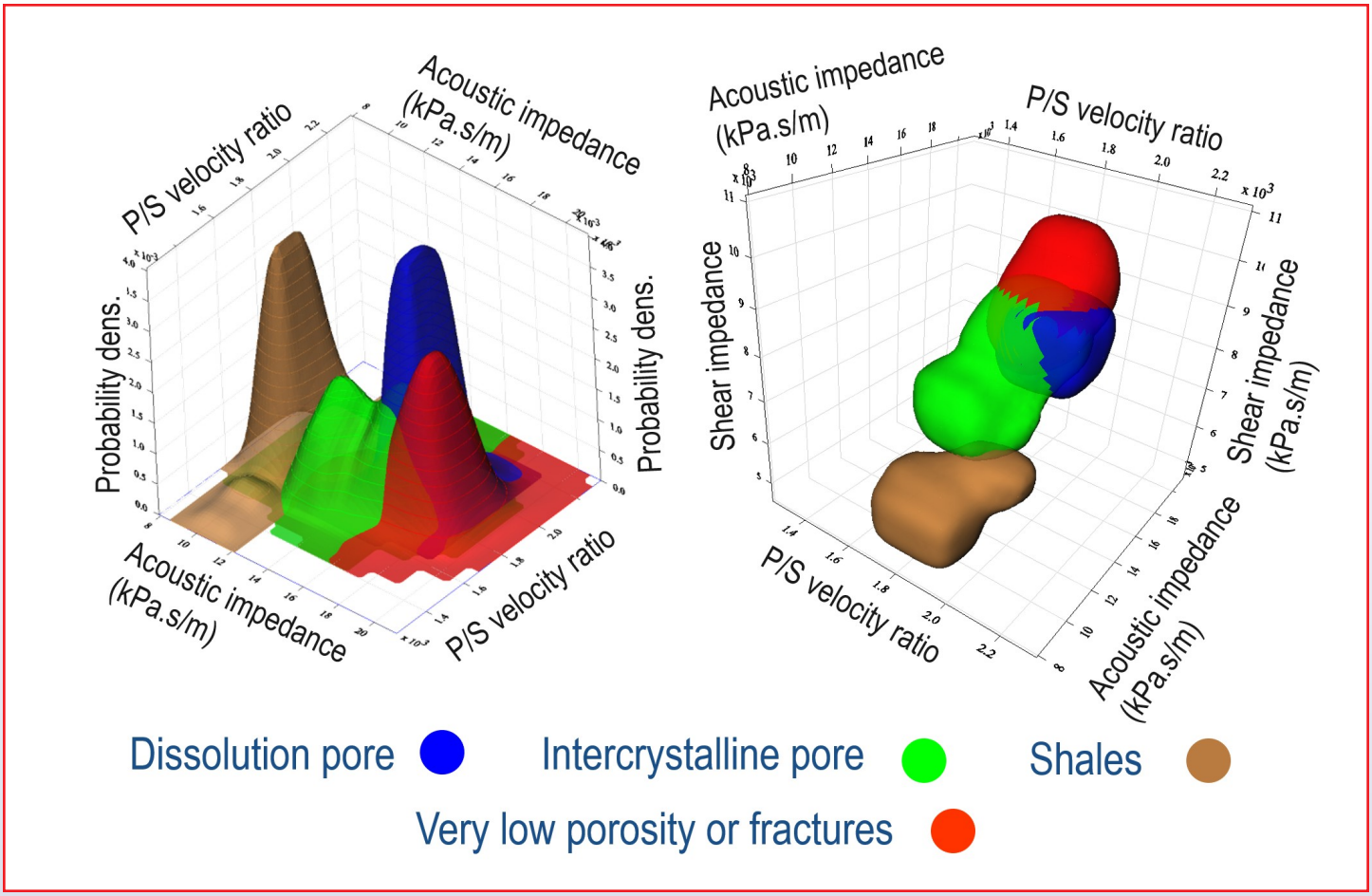

Figure 10: Probability density functions for shale and predominant pore type distribution in carbonates.

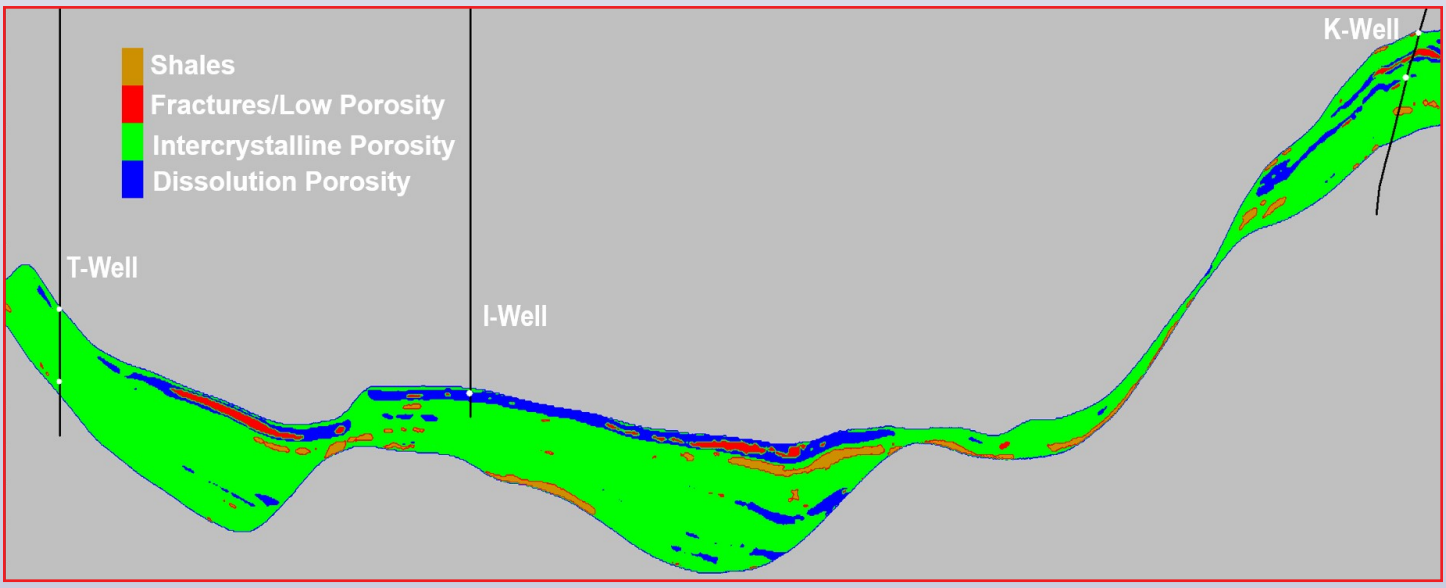

Figure 11: Shale and predominant pore type distribution in carbonates.

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Technical Article continued from page 22.

Conclusions

A rock physics approach based on the works of Kuster and Tokzös (1974) and Key and Xu (2002) allowed us to characterize a GoM Jurassic field through estimating the pore type concentration and synthetic Vs logs.

Inversion results show good agreement with the synthetic shear impedance log estimated using the described methodology.

Wells inside the study area exhibit different pore types. Well-I has intercrystalline pores in most of the JSK interval except for the upper part where it has dissolution pores, while well-K has intercrystalline pores and fractures. The pore types distribution inside the study area was obtained by means of probabilistic generation of litho-class volumes.

Acknowledgments

We thank the PEMEX petrophysical team for their support and constant feedback. □

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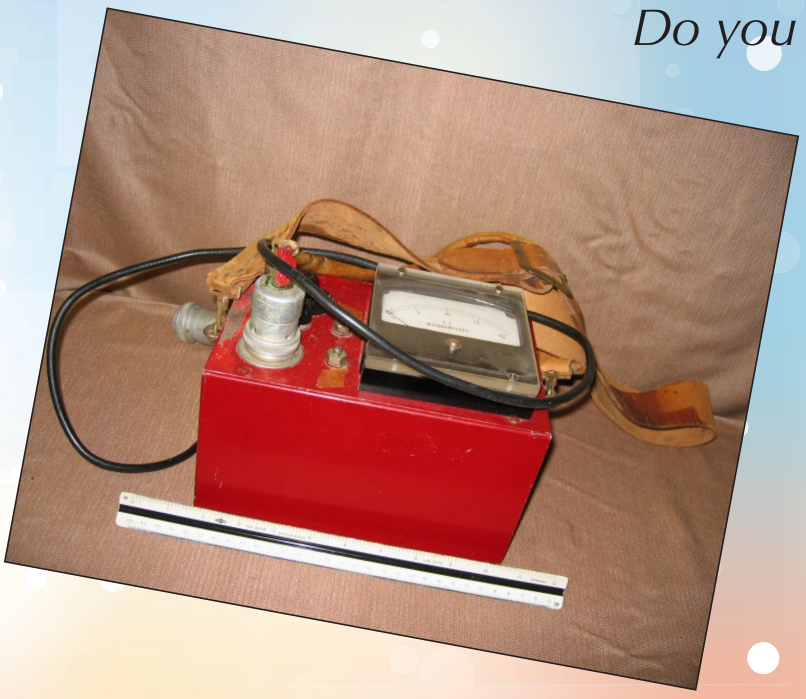
Permalink: https://doi.org/10.1190/segam2018-2997784.1

Mystery Item

This is a geophysical item...

Do you know what it is?



This month's answer on page 31

GSH Outreach

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

Fall has been very busy for the GSH Outreach volunteers with six events. More information and photos from all events will be included in a later issue. **Earth Science Week (ESW)**, celebrated annually during the second week of October, is sponsored by the American Geological Institute and it's Member Societies (including SEG) on behalf of the geosciences community. The 2019 ESW theme is *"Geoscience is for Everyone"*.

The first event was **STEM/Nova Day at the Houston Museum of Natural Science** on Saturday, September 21. This was the third time we participated in this event organized for Cub Scouts, Boy Scouts, Girl Scouts, as well as Houston Museum of Natural Science (HMNS) visitors. They "drilled for oil" and learned about the importance of math and science in finding and developing oil and gas resources to power the world. Special thanks to Huw James for volunteering alongside me.

2019 STEM Nova Day - Boy Scout looking at rocks

2019 STEM Nova Day - Girl drilling for oil

The second event was **The Educator Event** held on the evening of Friday, October 4 at HMNS. I taught two 30 minutes hands-on activity teacher workshops with the assistance of Huw James. One was the "Cupcake Coring" and geology model building activity for grades K-5. The other was the "Exploring for Petroleum using Geophysics" activity for grades 6-12.

The following day, Saturday, October 5, was the first **HGS-GSH Family & Friends Fall Fun Day in The Woodlands**. We brought out our hands-on activities for the children and grandchildren of HGS and GSH members to enjoy and learn about what their family members do. The GSH Geoscience Center also brought out some interesting artifacts for everyone to learn about the history of our tools.

Two simultaneous events were held on Saturday, October 12. **The 16th Annual Earth Science Celebration at HMNS**, organized by our HGS friends & colleagues. The passport collection event consisted of volunteer demonstration stations with hands-on activities from area earth science related professional societies including GSH and the UH SEG Wavelets. The other event was the **Reach for the Stars! STEM Festival** for middle school girls held at Rice University. GSH had an outdoor exhibit booth as part of the street fair in the engineering quad.

The sixth event held on Saturday, October 19 was the **9th Annual Energy Day Festival presented by Consumer Energy Alliance**. This admission free, family-friendly downtown festival was held in partnership with the City of Houston at Sam Houston Park. It was intended to educate K-12 students and the general public about all forms of energy. Please visit the Energy Day website at http://energydayfestival.org/ for photos, videos and more information. The GSH had a tented booth with several activities.

If you are interested in volunteering for any future outreach events, please contact Lisa Buckner at outreach@gshtx.org.

U of H Wavelets

SEG Wavelets Kicks Off the 2019 Fall Semester with Seminars and Socials!

By Zhongmin Tao

On August 20th, SEG Wavelets in conjunction with AAPG Wildcatters and GeoSociety, hosted a resume workshop for all undergraduates and graduates in the Earth and Atmospheric Sciences (EAS) department. Catherine Graber, who has 15 years of experience in labor/employment & regulatory law, and Judy Schulenberg, who has over 30 years of experience in all aspects of exploration and development in conventional & unconventional plays, were invited to present their tips for creating resumes geared towards the energy industry. These two special guest speakers were also joined by members of the University Career Services to help give advice and provide one-on-one reviews. Overall, this workshop provided last minute preparations to develop a running start for students seeking job opportunities amidst the beginning of recruiting season.

To celebrate the start of the semester, SEG Wavelets in conjunction with AAPG Wildcatters and GeoSociety, hosted a happy hour at The Den Campus Bar at UH on August 23rd. Students were able to learn about upcoming events for each society while relaxing with their friends and members.

After a successful first week, SEG Wavelets in conjunction with AAPG Wildcatters, hosted an Internship Panel on September 3rd to further help students prepare for recruiting season. Six graduate students who did internships this summer were invited to give presentations that covered different aspects of their experience ranging from the interview process/ questions all the way to final presentations and overall experience. This event aimed to help students gain a better understanding of the internship experience and better prepare them for the upcoming Energy Career Fair at UH and for interviews. □

Students were queuing up at the resume workshop to have their resumes reviewed.

Students listen on as the first speaker describes an internship experience at TGS.

2019-2020 GSH ICEBREAKER

The Beer Hall at the St Arnold Brewery was the scene of the first social event of the GSH 2019-2020 season. The staff of the GSH, Karen Blakeman and Karen Sanvido, and GSH volunteers ensured the evening was a success. To the 125 attendees thank you for your commitment to the GSH. The photos are all courtesy of GSH member Tammy Price. Thanks to the event sponsors (Shearwater, ACTeQ and RPS) for taking part in this collaborative marketing event and helping the GSH kick off the season in style.

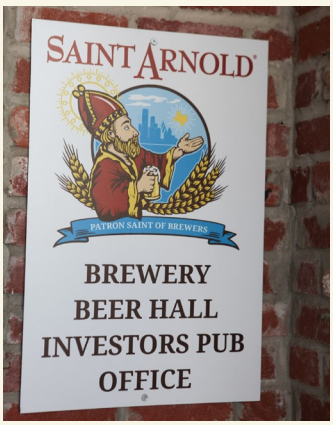


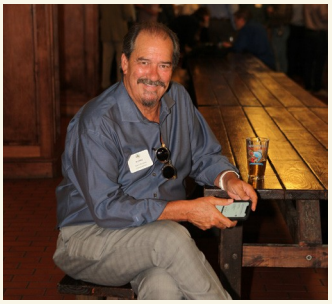



Icebreaker continued on page 28.

Icebreaker continued from page 27.

2019-2020 GSH ICEBREAKER





Geoscience Center

The History of Geophysics *By Bill Gafford*

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

The main mission of the GSH Museum and Geoscience Center Committee is to preserve the geophysical artifacts in the Museum Collection and to educate the public about the history and use of these artifacts. We try to accomplish these goals by maintaining displays of the equipment in locations that are secure but available to the public.

We also try to include informational signs with the displays that explain the purpose of the item on display and its approximate period of use. In previous months I have shared several of the display locations around Houston and included pictures of the displays. Some donated items have included a history of the item and possibly a manual for its use; however many of these do not have such information. **I know there are many experienced geoscientists in our community with a background in instrumentation, field recording, surveying, and interpretation that could help identify some of our artifacts and explain how they were used.** We have many individual components for recording and playback systems of different vintages and manufacturers, and a variety of early interpretation tools. We would like to have these items arranged appropriately with the proper descriptions. Some of these have been included as Mystery Items in each month's Journal. We have pictures of a majority of the inventory items, but a hands-on inspection is usually best for proper identification. If anyone is interested in sharing their knowledge and helping with our projects we can arrange a time at the Geoscience Center for a brief tour to review some of the more interesting items.

Picture from past Living Legends event.

Picture from past Living Legends event.

Help Wanted
Seeking Experienced Geoscientists to Help Identify Some of Our Artifacts

Geoscience Center continued on page 31.

Geoscience Center continued from page 30

Picture from past Living Legends event.

Our next **Living Legends Doodlebugger social event** will be held on **Wednesday, November 13**. These events are open to everyone and provide a time to visit with some of the Legends in our industry and see some of our more interesting geoscience artifacts. No registration is required, and light snacks, coffee, soft drinks, and water will be provided. Pictures from past Living Legends events are included with this article.

The books, technical reports, training manuals, geoscience-related periodicals, and SEG and AAPG continuing education publications in our Bob Sheriff Library are available for research or can be checked out. □

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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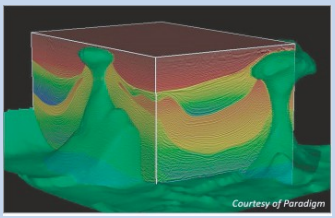
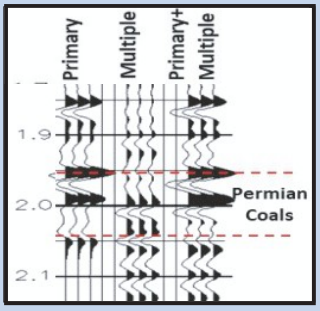
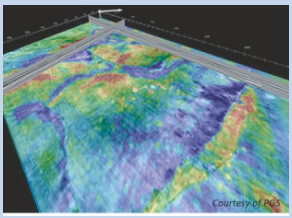
The Mystery Item
on page 24
is a
Beta type
Geiger Counter
from around 1950.

The GSH - SEG Webinar Series is Online

Access the recordings of these webinars originally presented live from the convenience of your home or office and according to your own schedule.







Title	Presenter
Seismic Modeling, Migration, and Inversion	Bee Bednar
Beyond AVO to Quantitative Inversion Interpretation QII	Bill Goodway
Affordable S-Wave Reflection Seismology	Bob Hardage
Simplifying and Lowering the Cost of S-Wave Reflection Seismology	Bob Hardage
Carbonate Essentials	Chris Liner
Basic Seismic Interpretation	Don Herron & Bob Wegner
Basics and UPDATES on Anisotropy: Azimuthal P-P for better Imaging, Fractures & Stress Analysis Acquisition, Processing & Interpretation	Dr. Heloise Lynn
Geophysical Signal Processing 101	Enders A. Robinson & Sven Treitel
Seismic Amplitude 20/20: An Update and Forecast	Fred Hilterman & Mike Graul
Extracting Geology from Seismic Data	Fred Schroeder
Applied Azimuthal Anisotropy-Azimuthal 3D P-P Seismic: Why Bother?	Dr. Heloise Lynn
Understanding Seismic Anisotropy in Exploration and Exploitation	Leon Thomsen
An Introduction to Borehole Acoustics	Matthew Blyth
Topics in Land Seismic Data Acquisition, Processing, and Inversion	Oz Yilmaz
EverythingYou Always Wanted to Know about Microseismic Monitoring	Peter Duncan
Full-Wave Seismic Exploration: Acquisition, Analysis, & Applications	Rob Stewart
Introduction to Applied Depth Imaging	Ruben D. Martinez
The Interpreter's Guide to Depth Imaging	Scott MacKay
Machine Learning Essentials for Seismic Interpretation	Tom Smith

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A Conversation With... *Jim Gaiser*

By Alvaro Chaveste

Dr James Gaiser is a Principal Research Advisor for Gaiser Geophysical Consulting and holds a PhD in geophysics from the University of Texas at Dallas. Apart from consulting, he participates with the SEG as an instructor and in their Research Committee. Jim is regarded as a leading expert in S-wave technology and, in this conversation (part one of two), he talks about his professional life and gives advice to younger generations of geophysicists.

Alvaro: Thanks for accepting the interview, Jim. You are recognized as a leading expert in S-wave technology. Can you tell us how did you get where you are? Did you have an epiphany moment when you realized what you wanted to do for a career, or did you discover that along the way as you tried new things?

Jim: Thank you Alvaro. I am happy to talk to you. It's an honor to be interviewed for the GSH readership.

I have spent most of my career in S-wave research. But I think it was a gradual process rather than an epiphany. My interest in S-waves began at ARCO while in the processing group, analyzing horizontal vibrator data for the research department. This was in the late '70s when our industry was eagerly investigating the value of S-waves mainly for lithology discrimination and bright-spot validation. Later, in the early '80s, I moved to the VSP (Vertical Seismic Profiling) research group where I worked primarily with P-waves. We (Jim DiSiena, Jim Fix, and Jim Davis; you had to be named Jim to work in that group, ☺) noticed the ubiquitous presence of S-waves on all surveys.

The industry at the time was at somewhat of a high point and prospects for VSP and S-waves were great.

At the same time, I was getting my PhD at UTD (the University of Texas at Dallas) with ARCO's support. My studies focused on P-wave anisotropy using VSP, but I learned quickly the importance of S-wave coupling with P-waves. S-wave anisotropy could be inferred from P-wave travel times! I thoroughly enjoyed those years at ARCO and studies at UTD in the 80s.

Jim Gaiser

It was after that, in the 90s, that I enthusiastically joined the converted-wave (PS-wave) revolution along with others in the field like Rob Stewart.

Alvaro. I know that you have had a busy schedule, including an anniversary, writing a paper, preparing the workshop you gave at the SEG and this interview. Can you expand on your latest activities?

Jim: Yes, my wife Kathy and I just celebrated our 50th anniversary. Our sons gave us a wonderful party, attended by lots of family and friends. Also, I've been very fortunate to be able to do some consulting with my DBA, "Gaiser Geophysical Consulting", in addition to the other things you mentioned. My interest in geophysics did not end with my retirement and it seems I am busier than ever.☺

Also, I still enjoy my activities with the SEG Research Committee in organizing workshops. This year we had a workshop highlighting joint imaging and inversion with P-waves and shear waves.

Interview continued on page 36.

Interview continued from page 35.

It emphasized advancements in using recorded shear wave data with P-waves for elastic model building, migration, and interpretation. This could be the beginning of our industry recognizing that shear waves will be a part of big data and machine learning for petrophysical analysis.

Early this year, I decided to write a peer-reviewed paper on my recent work with shear-wave radiation from vertical sources for modeling SP-waves in anisotropic media. Such efforts are always a lot of work – on the order of months. And since I am retired now, I don't have the kind of support one gets from an employer. Anyway, I've thoroughly enjoyed the process and working with the reviewers who made many helpful and constructive improvements. It's going to be published in an upcoming Special Issue of Geophysical Prospecting on Advancements in Anisotropy, Volume 67, and Issue 9. These are papers from the 18th International Workshop on Seismic Anisotropy that I attended in Israel last year.

Alvaro: All that sounds like a lot of work. Could you give the younger readers some insight on how to have a good work/life balance and how to be steady and motivated at a time when the industry is at a low point?

Jim: Wow, that can be a challenge at times in our industry, which has a fair amount of up and downsizing. Interestingly, you use the term "balance", because that is an important philosophy in my life. It should be practiced in every aspect of life.

In this instance, it is good to separate school and work, particularly while raising a family –finish school first and then focus on work. That's the normal way it is done, but in a way, this is out of balance.

On the other hand, having the support of ARCO for my PhD while working was very advantageous. UTD was an excellent school and ARCO was at the forefront of shear wave and VSP research. However, the downside was that it took me nearly 10 years to finish my PhD – too long!

I was fortunate because I had the tremendous support from my wife Kathy. She's a hard worker too and was very involved in raising the kids through school. She made it much easier for me in both the good and bad times.

So besides self-motivation, a big motivating factor is support from family, friends, and colleagues. It's a balance.

Alvaro: You have had many accomplishments. If you had to pick one thing that you would want to be known for, what would that be? Is there anything that most people don't know about you?

Jim: That's a hard one to answer. It's like the question my wife asks: "if you had to pick one food to eat for the rest of your life, what would it be?" I don't have an answer because of the "balance" thing. ☺

In hindsight, I am most proud of the method I developed for my PhD thesis; determining velocities and seismic anisotropy in a single well with walk-away VSP data. It estimates the phase slowness vector and polarization directions. Since then, many others far smarter than I have made significant improvements and perfected the technique.

One method that I thought was pretty clever was getting around Amoco's patents for S-wave splitting analysis and processing. I applied it to PS-waves, which they hadn't considered. This is the 4C (four-component) Alford rotation and layer stripping technique developed by Rusty Alford for pure-mode SS-waves. Although my discovery served a purpose at the time, it hasn't stood the test of time. There are better 2C methods to handle S-wave splitting that most contractors use today. Anyway, that›s the nature of research.

From a general point of view, I would like to be known as a major contributor to promoting S-wave awareness. This focuses on educating explorationists on the anisotropy that is most important for extracting petrophysical properties. S-waves are so complex, compared to P-waves, that it is easy to get lost in all the details. For educators, it's easy to baffle people with complicated details. I try not to do that and would rather emphasize the shear wavefield properties that provide useful S-wave images.

Interview continued on page 37.

Interview continued from page 36.

This includes informing our exploration geophysicists on how to incorporate S-waves in with our P-wave business.

Alvaro: You are a specialized scientist in a field considered intellectually challenging to many. Can you tell us how does this stack up against the job of raising a family and, particularly, being a dad?

Jim: Maybe I am beyond this point, Alvaro, because I am a retired consultant, and now a grandpa! ☺

It has been tremendously challenging, rewarding and fun doing both. I have thoroughly enjoyed all these years in S-wave research and still find time to keep up with new research. I also take a lot of time to spend with my family.

Although mistakes are not all that great (and I have made a few) they end up being a learning experience to obtain greater insight. If you aren't making mistakes you aren't trying new things. As I mentioned earlier, try to keep everything in "balance". Don't neglect the family at the expense of too much work and vice versa. I consider both to be equally important achievements.

Alvaro: Lastly, do you have any advice for college students, grad students, or young industry folks that you wish you had known at those respective times in your life?

Jim: Yes, just follow your technical interests and pursue the appropriate education for those goals. There are plenty of opportunities in our industry, but if you are interested in pursuing S-wave exploration applications, look for a company that is using them and has a good track record. If you are interested in S-wave technology you may have to go into research, but even then, most companies do not have well-dedicated research programs. Interest in S-waves unfortunately comes and goes with the "price of oil".

Thanks for this Jim. It has been fun. I have some practical questions regarding S-wave technology that we'd address in the second part of this conversation – to appear in the December edition of the GSH Journal. □

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Doodlebugger Diary

GSI Land Parties 1610, 1625 Cope With Desert Floods in Oman

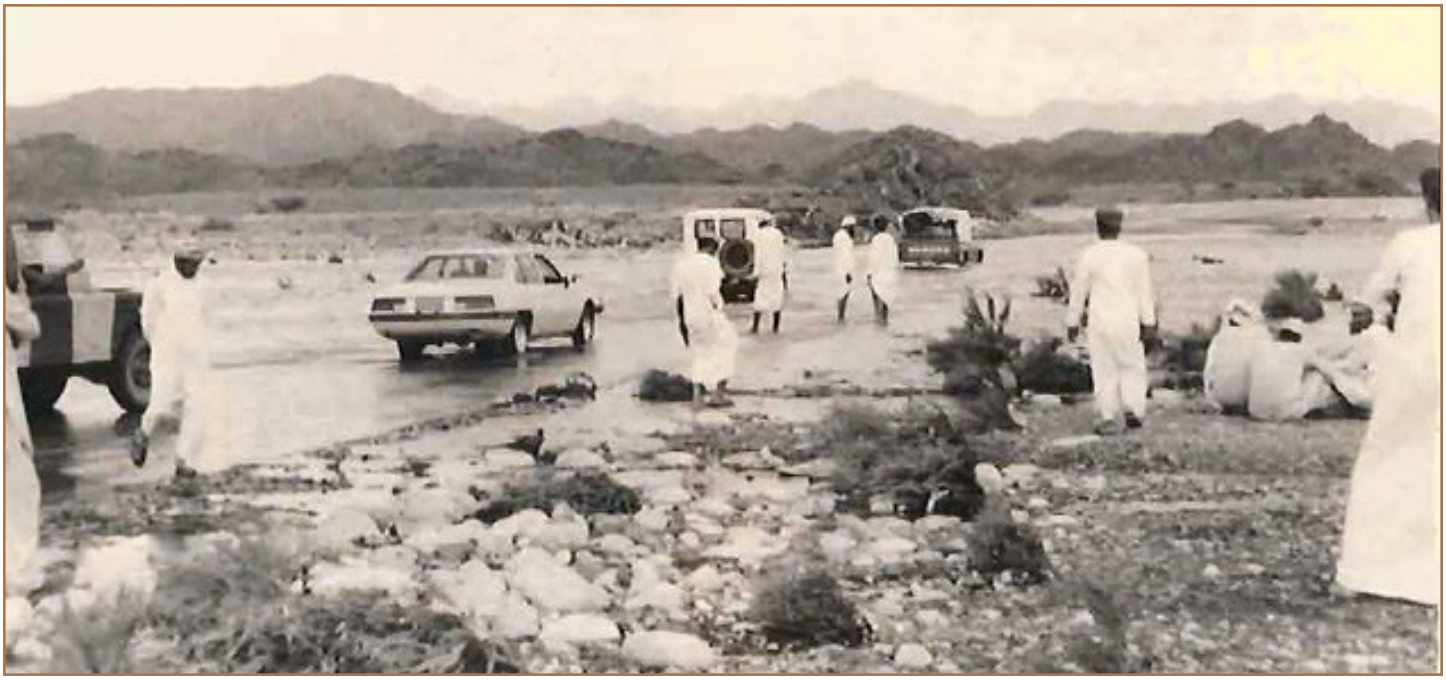
By Norm Harding

The Doodlebugger Diary recounts the experiences of geophysicists during their working lives. This month is an article from the GSI Shotpoints which is one of many archived GSI publications maintained by Bill Boettcher at http://gsinet.us/. This article comes from Vol. 2 #6, published in June 1982. Towards the end of the article the author identifies himself as an older gravity technician who's going out on a rotation to these two crews in the spring of 1982. I'll be extracting more interesting stories from these old GSI publications in future issues of the GSHJ.

I arrived in Oman at the end of March 1982, when heavy rains still poured down, which is as unusual as late spring snows in the United States. The water roared down the normally dry wadies (normally dry creek or river bed) and across the highways leading to Parties 1610 and 1625, which I had come to train gravity men.

The roads to 1610 were impassible, so my driver and I headed toward Nizwa with hopes that we could get as far as the drill rig and then go on to Party 1625's camp. Mountains rose along the highway to 7000 feet and the terrain reminded me of the Chisos Mountains in Big Bend National Park in my home state of Texas.

The technique used by my driver to judge if a wadi was passible or not was effective, if simple. He waited until a vehicle smaller than our Toyota four-wheel drive Land Cruiser had crossed safely, then went across.



Flooded highway, March 1982

Doodlebugger continued on page 40.

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

Doodlebugger continued from page 39.

Recording truck with DFS-V and FT-1. John Campbell-Smith, 1625's instrument engineer, sitting and client representative standing.

A stalled truck blocked one crossing holding up about 20 vehicles on each side of the wadi. After the driver of the stranded vehicle conferred with the GSI driver, we drove down, hooked a cable to the truck and pulled it out. Since that left us at the head of the line, we nipped on across and went on our way.

South of Nizwa, we came to a wadi with 40 vehicles stranded on each side. As we watched, a large transport truck tried to cross and was shoved off the road by the rushing water. We decided to call it a day and drove back to the Nizwa Hotel, a completely modern place with air conditioning, a swimming pool and a nice flower garden built a few years ago to serve oil drillers.

The next day, the water had receded and we were able to cross the wadi. We drove the last hour to 1625 in the midst of a raging dust storm.

Hank Lee, assistant party manager, assigned me a place to sleep and located a driver familiar with the area. Hank said the two wadies between 1625 and 1610 were still too high to cross and it would be a week or so before we could get through.

During a camp move a few weeks before my arrival, Hank had been caught between the two wadies when the first flash floods inundated them. A check of the debris around the flooded wadies showed that the water depth in the middle of the wadi was probably on the order of 6 to 10 feet. The normal water level is on the order of inches or the wadi is dry. When the crew could not cross the wadies, they stayed with local sheiks, and enjoyed their hospitality. Hank can speak some Arabic, so he was able to understand a good share of the conversations.

Party 1625's surveyor, Joe Gibbs, provided me with a sketch of the surveyed lines, and the driver and I started our gravity metering. The area is relatively flat with low gravel hills, meandering wadies with low bushes and some almost black desert pavement. Desert pavement is gravel that has been uncovered by blowing winds. Some of the wadies have a green sheen caused by grass growing as a result of the rains.

Indigenous wildlife consists of numerous large lizards that burrow underground, wild burros, a large variety (but few numbers) of birds, an occasional gazelle, a few rabbits, and lots of camels that were let loose when the natives turned to Toyotas.

March and April are still in the "cool" season so the daytime temperature did not exceed 110° F in the shade. Actually that is warm enough for grandfatherly types like myself. Air-conditioned offices, dining rooms and sleeping trailers were a welcome relief.

Party 1625 is using tracked vibrators, TK-2s, and MOL trucks for the heavy equipment, and Toyota pickups for the survey. A Mayhew 1000 is used for uphole surveys.

The would-be gravity trainee, Tony Carlisle, arrived on the crew in time to learn that one of the surveyors did not return from time off, so he was drafted to relieve Joe Gibbs so Joe could take leave. So I took my meter and notes and trundled off to Party

Doodlebugger continued on page 41.

Doodlebugger continued from page 40.

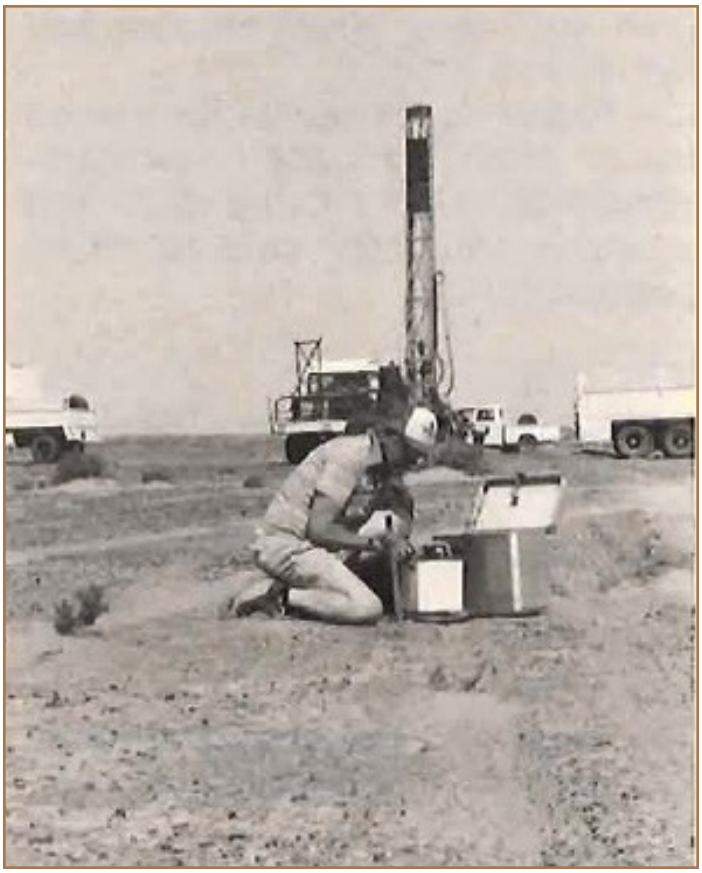
Hank Lee, fourth from the left, helps local sheik from flooded wadi. Hank was stranded nearby with Party 1625 when rains flooded wadi in March.

1610 to catch up with the metering of seismic stations in their area. The wadi was down to about 6 to 12 inches and could be easily crossed providing you picked the right spot and had four-wheel-drive. A local sheik had a problem with his two-wheel-drive, and Hank Lee and our drivers helped push him out while I stood on dry ground and took pictures. (I keep telling people we granddads have a few privileges.)

Party 1610 was near the flooded wadis, so they were able to take a cool swim in the evening after work. That and watching scorpion-camel spider fights pretty well covered the amusement opportunities.

Gravity people are sort of a rarity on seismic crews, and we get kidded a lot. The standard joke was along the Aggie line and went like this: If you add a 30-year gravity man to a seismic crews, you may have doubled the average working years but you cut the average intelligence in half!

While on Party 1610, I heard that GSI had hired a new gravity man who was waiting to be trained in Dallas, so I headed for Muscat to catch a plane back home to train Dale Grant on plotting profiles, the TI-59 and TI 770 before he hopped on a plane bound for Oman. Lucky man. □



Norm Harding at gravity meter. Party 1625's Mayhew drill is in the background.

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- Conventional hydrocarbon plays
- Unconventional hydrocarbon plays (e.g., Neuquén Basin of Argentina)
- Oil and gas exploration in South American Pre-Andean rift basins
- Geological and geophysical exploration in South American Pre-Andean rift basins
- The role of remote-sensing in oil and Gas exploration in South America

Oil Systems of the region and the challenges in the production

- Techniques and methodologies applied in Latin America for the oil and gas production (drilling systems)
- Carbon Capture and Storage (CCS) case in Brazil and Argentine
- Hydraulic Fracturing
- Geophysics applied in the oil and gas production
- EOR/ IOR

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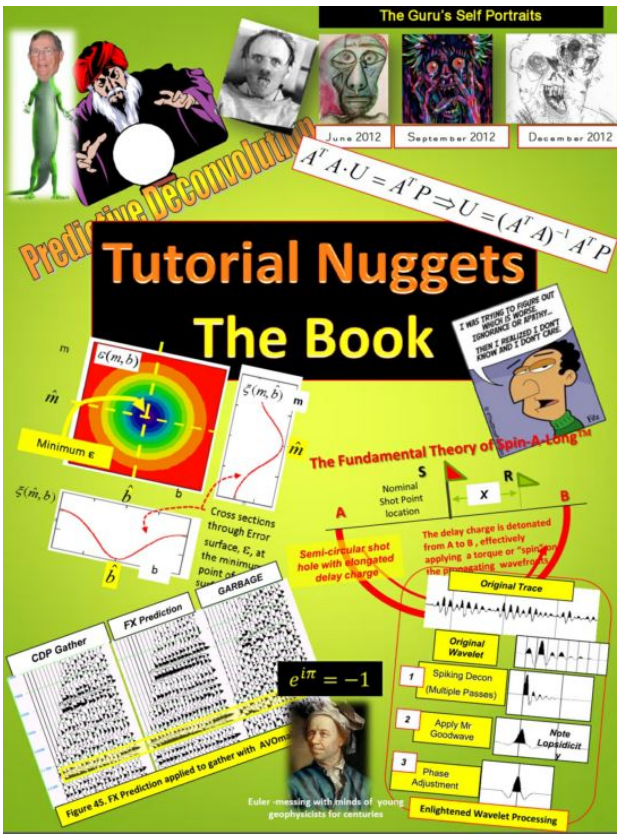

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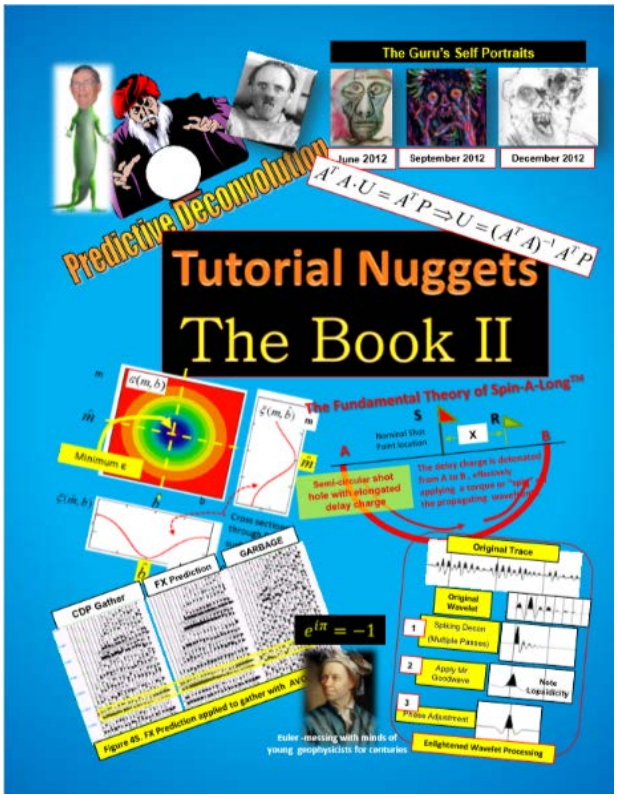

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