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GSH Journal

GEOPHYSICAL SOCIETY OF HOUSTON
Volume 10 • Number 6

GEOPHYSICAL SOCIETY HOUSTON

The Epicenter of Geophysical Excellence

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On The Cover...

Organizing equipment for a new seismic acquisition operation.

Image courtesy of Geospace Technologies.

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

Apr 2020	Feb 7
May 2020	Mar 13
June 2020	Apr 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
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Editorial Board	Lee Lawyer	281-531-5347	713-628-3513	llawyer@prodigy.net
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Tech Breakfasts Westside	Michael Obriain	713-689-6913	713-829-5238	obriain1@slb.com
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SEG DISC	Peter Wang	713-393-4013		pwang01@gmail.com
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Microseismic & Unconventional	Scott Singleton		832-524-8382	Scott.Singleton@comcast.net
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Rock Physics	Ellen Mallman		346-252-8462	Ellen.mallman@bp.com
Wavelets (U of H)	Matthew L Storey			matthewlstorey@gmail.com
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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
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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
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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	Courtney Anzalone		713-689-5741	canzalone@slb.com
Assistant Editor	Hailey Byers		832-494-7436	Hailey.Byers@Emerson.com
Assistant Editor	Kara Detro		713-689-6226	kdetro@slb.com
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
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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	Rose Marie Geetan	281-366-6614		Rosemarie.Geetan@bp.scom
HPAC	(unassigned)			

A Word from the Board

By Marie Clavaud, Treasurer

There is no denying that the past years have been troubled times for our industry, and we are all looking forward to a bright future. However, the future depends on our ability to attract students to our industry, as well as ensuring that young and talented professionals entering the industry remain with us.

Current petroleum and geoscience programs in universities are not as attractive as other STEM programs and graduates don't always pursue geosciences once out of university. The exciting world of Data Science is taking great talents away from Oil & Gas, not to forget the rise of consciousness about governance and environmental issues related to our industry: these are some of the real challenges that we are facing to attract and keep talents.

In this context, the role of the Geophysical Society of Houston (GSH) is essential. It is a stalwart for the geophysical community, and via its activities, it continues to bring together our members and non-members. The numerous social and technical events (over a hundred annually!) are well attended and have helped many of us who have lost their jobs in making essential connections. The Geoscience Center is an extraordinary resource to tell the rich history of our industry and the Outreach Committee, and its amazing volunteers, are doing a formidable job inspiring young students to enter the industry. Their work is vital to renewing our aging workforce.

The newly formed NextGen committee is a dynamic group of young professionals that we all need to support. It is exciting to hear about all their ideas. I am looking forward to seeing its members take a more prominent role in the Society. Our industry is changing, and it needs to embrace the diversity of thought coming from this new generation to stay relevant and attractive.

This is only a glimpse of what the GSH does to help our community thrive. The value proposition of the GSH is clear. We all have a role to play to promote and inspire the new generation.

I am the treasurer and probably you have already guessed where I'm going. The continued support of the community is critical for the future of the GSH. Support helps in continuing GSH's role in keeping our buoyant community attractive. From annual or event-based sponsorship, membership, registrations to our many events, fundraising for the Geoscience Center, to volunteering; there are many ways to help GSH continue to thrive and play an essential role in renewing our workforce. □

Dear GSH Journal readers,

Please feel free to contact us with any and all questions or suggestions that you may have. Contact me at the email address listed below.

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

From the Other Side

By Lee Lawyer

I seem to be getting items from the AAPG Explorer these days. Why is that? The item in question is called, "Historical Highlights" in the December Explorer. The subject was the discovery of Chicxulub. The author is Glen Penfield. Glen has been a magnetic guy as well as many other things. The article is written in the first person and speaks of his very interesting life and career. He focuses on a large magnetic anomaly named Chicxulub after a small town nearby. He throws in a few technical notes including the contour interval for a magnetic map. It was 50 nT, which may be in nanoteslas. Back in the '50s, I was in a G&M section of Standard Oil Company of Texas. Didn't we use Gauss (Gausses?) for contour intervals?

Glen was rejected a lot for his idea that Chicxulub was an impact crater rather than a volcano. His analyses proceeded the work by Alverez and others on the Iridium layer at the Cretaceous boundary, meaning that Chicxulub was known to be an impact crater before we needed it to kill off the dinosaurs, etc. A similar discussion on 'volcano versus impact' happened on the northern limb of the Anadarko Basin in Oklahoma. It was older than Chicxulub and Permian age in age. Fortunately, a seismic survey and well information solved that puzzle. The Anadarko crater was caused by an impact. I don't think anyone has suggested that it was responsible for the Permian massive die-off. Too small.

Arguments (friendly) about field observations are numerous. Remember the chap who said Africa and South America fit together across the Atlantic? Anyone could see the similarity of the edges of the two continents. Alfred Wegener proposed Continental Drift in the early 1900s but he had no mechanism available to move continents around. The idea lingered on the edge of discovery. Along came Harry Hess who suggested that the continents didn't need to plow through the ocean floor. Instead, they passively floated while the ocean floor moved. Wow! Listen to the discussions about that. I was in Amarillo when a speaker showed fossils of plants with large leaves located way up in Canada. A question was asked of him, "How can tropical plants live at that latitude", thinking to catch an error. The speaker sarcastically answered, "They can't. They moved there after fossilization." A lot of groans and big eyes. We came around after he stated that Maurice Ewing proved it with his present-day ocean-bottom core sampling.

Later came the discovery of magnetic stripes that were symmetric across a spreading center. That may have been offshore Washington and Oregon, or perhaps it was first noted at the mid-Atlantic ridge.

I like recalling some of these discoveries that spawned controversy. The old discoveries shouldn't count since we didn't have the geology or physics figured out. People would naturedly be skeptical of marine fossils found high in the mountains or that mankind (and life) evolved from lower species. The best (?) controversies are between knowledgeable people with scientific backgrounds. Global Warming caused by "Greenhouse gases" was and still is a little difficult for many to swallow.

There was a PhD candidate in Germany who collected data to show that he could generate man-made earthquakes. In early 1900, he erected a tall derrick, hoisted a large iron ball to the top and dropped it while recording devices were operating below. He generated small earthquakes, but more importantly he recorded them on things called "seismographs". His name was Ludger Mintrop.

There are still a lot of people who are skeptical of "man-made" global warming. I know the globe is warming. I know we are putting "Greenhouse Gas" in the atmosphere, which undoubtedly contributes to warming. What we need to do and how soon we need to do it is what's problematic. Shut down oil companies? Tough statement.

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From the Other Side continued from page 5

Levy a carbon tax to discourage the use of hydrocarbons? Undoubtedly this would result in double or triple the price of gas, natural or fuel.

Two of the past Presidents of the GSH left us in 2019, Bob Tatham in October and Dave Agarwal back in January. Both came as sort of a shock to me since I knew them well. There is a Memorial for Bob in the December TLE, written by Dan Ebrom. Bob and I have something in common: I was the first President-Elect of the SEG and Bob was the first President-Elect of the GSH. Before that, the Past President remained on the respective Board for an extra year. Both Bob and Dave stayed connected to their professional organizations after retirement. Dave served as Chair of the GSH office committee for many years. Bob retired from the University of Texas in 2014 but like Dave, he stayed connected to the University as Professor Emeritus. □

Technical Luncheons

Register for Tech Lunch Westside

Register for Tech Lunch Downtown

Register for Tech Lunch North

2020 1Q/2Q Distinguished Lecturer

Automating Seismic Data Analysis and Interpretation

Sergey Fomel

Speaker: Sergey Fomel
Wallace E. Pratt Professor of Geophysics
The University of Texas at Austin
Director of the Texas Consortium for Computational Seismology (TCCS)

Westside

Tuesday, Feb. 18, 2020
11:00 a.m. – 1:00 p.m.

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

Downtown

Wednesday, Feb. 19, 2020
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, Feb. 20, 2020
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:

Recent developments in artificial intelligence and machine learning have enabled us to automate different tasks in data analysis. I will discuss the quest for automation by tracking the development of automatic picking algorithms all the way from velocity picking in seismic processing to horizon picking in seismic interpretation. We will search for the limits of automation to discover the distinguishing qualities that separate human geophysicists from machines.

The automatic picking algorithm follows the analogy between picking trajectories in images with variable intensities and tracking seismic rays in the subsurface with variable velocities. Picking trajectories from local similarity panels generated from time shifts provide an effective means for measuring local shifts between images. In addition, it provides practical application in time-lapse and multi-component image registration, matching seismic with well logs, and data compression using the seislet transform. In seismic interpretation, automatic picking also provides the ability to track fault surfaces, salt boundaries, and other geologic features.

The power of automatic picking is further enhanced by novel deep learning algorithms. The deep learning approach can use a convolutional neural network that is trained on synthetically generated images to detect geologic features in real images with unmatched efficiency and accuracy. The lessons to learn from these developments

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include not only the potential for automation harvested through artificial neural networks and modern computing resources but also the potential for human ingenuity harvested through professional networks.

Biography:

Sergey Fomel is Wallace E. Pratt Professor of Geophysics at The University of Texas at Austin and the director of the Texas Consortium for Computational Seismology (TCCS). He received a PhD in geophysics from Stanford University in 2001. For his contributions to exploration geophysics, Sergey has been recognized with several professional awards, including SEG's J. Clarence Karcher Award in 2001 and the EAGE Conrad Schlumberger Award in 2011. He has served SEG in different roles, most recently as the Vice President, Publications. Sergey devotes part of his time to developing "Madagascar," an open-source software package for geophysical data analysis. □

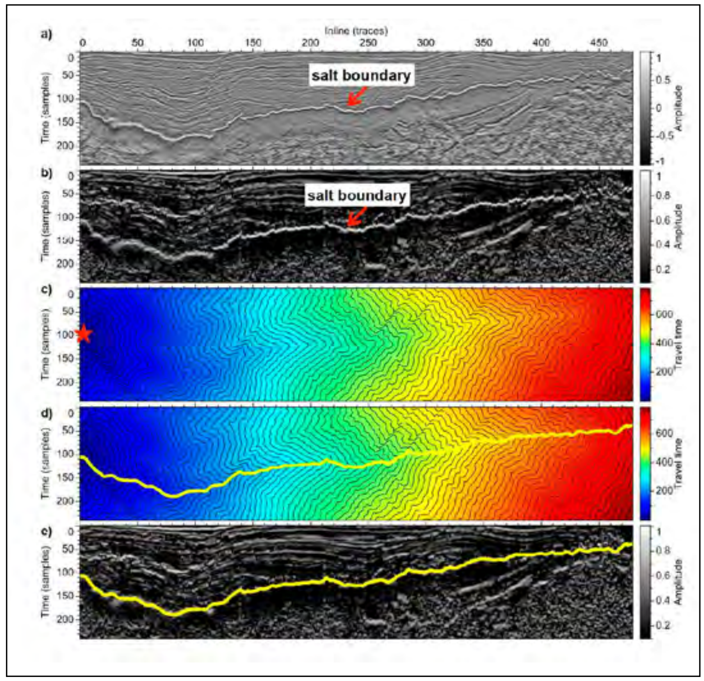

Figure from X. Wu, S. Fomel, and M. Hudec, 2018, Fast salt boundary interpretation with optimal path picking: https://doi.org/10.1190/geo2017-0481.1

Technical Breakfasts

Unlocking Gas Reserves in Bypassed Stratigraphic Traps in a Deep-water Brownfield using Prestack Seismic Inversion, Offshore West Nile Delta, Egypt

Register for Tech Breakfast North

Register for Tech Breakfast West

Dr. Hamed El-Mowafy

Speaker: Dr. Hamed El-Mowafy
Senior Geoscientist Consultant
NeuEra GeoServices

North

Tuesday, Feb. 4, 2020
7:00 – 8:30 a.m.

Sponsored by Oxy

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

West

Wednesday, Feb. 12, 2020
7:00 – 8:30 a.m.

Sponsored by Schlumberger and WesternGeco

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

Abstract:

The Nile Delta and its offshore area is rapidly emerging as a major gas province in the Mediterranean region. Offshore exploration using high-quality 3D seismic data helped in achieving significant discoverers in the last two decades. The giant Zohr discovery made in 2015 by the Italian oil company ENI offshore Egypt and the Glaucus discovery made by ExxonMobil offshore Cyprus in 2019 is proof of the significant remaining yet to be found hydrocarbon potential of the East Mediterranean Basin.

Deepwater channel systems and turbidite plays have been the primary focus of hydrocarbon exploration and development. The prolific Pliocene slope turbidite canyon-channels of offshore Egypt are restricted to the Nile Delta cone. Scarab field is one of at least nine deepwater Pliocene slope canyon-channel systems in the WDDM concession that was found in the expansive slope setting during the progradation period of the El-Wastani Formation (El-Mowafy et al., 2019).

This study is focused on characterizing bypassed subtle stratigraphic traps encountered in the upper Pliocene El-Wastani Formation of the Scarab gas brownfield (El-Mowafy et al., 2019). These bypassed traps are important architectural elements of the submarine deepwater slope turbidite channel systems.

Simultaneous seismic inversion was applied over the Scarab field with the purpose of evaluating the hydrocarbon potential of newly identified

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stratigraphic traps. Using the inverted impedance and Vp/Vs volumes with FMI facies logs, Bayesian facies classification was applied to separate thin- and thick-bedded gas-sand facies from shale. Facies classification was focused on two prospective bypassed stratigraphic traps: the Upper Scarab Channel Remnant Levees (RML and RSL) and the Lower Scarab Channel Lateral Accretion Packages (LAPs). A development well location is proposed to validate the interpreted gas-sand reservoirs in the shallower RML and the deeper LAPs stratigraphic traps. The results suggest that application of the seismic inversion and facies classification led to reliable inferences, which will likely have a positive impact on field development, potential reserves growth, and consequently boosting gas production.

Biography:

Dr. Hamed El-Mowafy received a Bachelor of Science in geology and a Master of Science in petroleum geology from Al-Azhar University in Cairo, Egypt, and a Ph.D. in geosciences from the University of Tulsa, Oklahoma. Currently he is a Senior Geoscientist Consultant with NeuEra GeoServices based in Houston, where he conducted several projects in multiple sedimentary basins around the world, mainly East Mediterranean, Atlantic margins and the Gulf of Mexico basins.

He Spent 12 years with Apache Corporation in Houston and Apache Egypt where he participated in multiple oil and gas discoveries and created multiple drillable prospects in Egypt and US. He shas extensive experience in various areas of petroleum exploration and production.

His professional interests include seismic and sequence stratigraphy, interpretation of seismic data, and reservoir characterization. □

Unconventional SIG

Register for Unconventional

Application of Geostatistical Seismic Inversion in the Meramec Formation STACK Play of the Anadarko Basin

Bertrand Six

Speaker(s): Bertrand Six
Regional Technical Manager
Reservoir Characterization Group, CGG

Thursday, Feb. 6, 2020
11:30 a.m. - 1:00 p.m.

Sponsored by TGS

Location: TGS
10451 Clay Rd.
Houston, TX 77041

Abstract:

This study focuses on characterizing the Meramec Formation, located within the STACK play in the Anadarko Basin area, Oklahoma. Geologically, the Meramec interval shows a strong shift in depositional styles across the Anadarko Basin, resulting in a change from a carbonate system to a siliciclastic system. Understanding the stratigraphy and facies changes is an important factor to characterize horizontal and lateral changes between carbonate and siliciclastic intervals. The carbonates of the Mississippian are often susceptible to diagenetic alteration, resulting in high variability of porosity values laterally across the area, making correlation attempts in the area challenging throughout the Meramec formation.

A high-end multi-client seismic survey combined with a geostatistical inversion approach was used to build detailed facies models and accurately predict porosity variation. Ranking of the geostatistical model based on an objective criterion identified three model scenarios of P10, P50, and P90 that helped to measure the rock quality uncertainty and de-risk drilling in the section of interest.

Biography:

Bertrand is currently the Regional Technical Manager in the Reservoir Characterization Group of CGG in Houston. He develops new workflows using Machine Learning, Rock Physics and Petrophysics in both, conventional and unconventional plays.

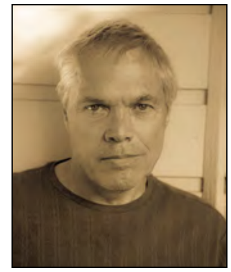
Bertrand has held several positions at CGG in Europe, the Middle East and North America. He has worked on various integrated projects, including exploration in the Berkine Basin (Algeria) and 4D reservoir monitoring in the Middle East and West Africa (Removable and PRM systems). During his six years in the Middle East, he worked closely with processors to develop integrated workflows to improve PSDM imaging using petrophysics, rock physics and regional geology as well as detailed seismic attribute interpretation for strike-slip fault identification in carbonate reservoirs.

He holds a Master of Science in Geology from LaSalle Institute, France and a Master of Science in Petroleum Geoscience from Imperial College London. □

Data Processing & Acquisition SIG

A Survey of Near-Surface Issues in the Permian Basin

Register for Data Processing



Chuck Diggins

Speaker: Charles F Diggins III
Principal Geophysicist at
DownUnder Geosolutions (DUG).

Tuesday, Feb. 11, 2020
4:30 p.m. Sign-in, Snacks, Social Time
5:00 p.m. Start of presentation

Sponsored by Schlumberger

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

Abstract:

The Permian Basin is notorious for its statics problems. Near-surface complexity includes karsting, near-surface inversions, refractor shingling and refractor anisotropy. Such complexity makes the estimation of refraction statics a challenging problem. This presentation provides a collection of several 3D surveys from the Delaware and Midland Basins, discusses the challenges each presented, and shows the strategy that was finally taken to resolve the statics problems.

Each dataset required very different and sometimes radical approaches.

The paper discusses the concepts of refractor-driven versus first-break driven refraction statics, directional refractor behavior, and tying upholes to refraction solutions. It presents an example of delay-time prediction used to pick "impossible" first breaks. Delay-time versus tomographic solutions are discussed, including the strategies for refractor model construction.

Biography:

Chuck Diggins has BAs from Penn State in Anthropology and Spanish. He did his graduate work at University of Delaware in Marine Geophysics.

Chuck began his career as Research Geophysicist with Western Geophysical in 1978, where he served as Technical Coordinator for Statics Worldwide from 1983 to 1991. He developed the EGRM, and the 2D/3D Reflection and Refraction MISER Software. Since then he has focused on development, training and services associated with reflection and refraction statics software at companies such as Green Mountain, Maverick, PGS, Renegade and XtremeGeo.

He has taught classes in 30 countries, consulted on statics issues worldwide, and provided statics services for both oil and geophysical companies. He has also chaired several SEG technical sessions and workshops. He recently served as Center Manager for Sterling Seismic Services' Houston office. In 2015, Chuck and wife Yvonne Diggins created Statics Rocks, LLC, dedicated to all things statics: services, consulting, teaching, programming, etc.

In 2017, Chuck joined DownUnder Geosolutions (DUG) as Principal Geophysicist. At DUG Chuck is involved in refraction statics on all land 3D projects. Chuck especially appreciates the challenge of working on "impossible" refraction statics problems.

Chuck lives in Louisville, Colorado and enjoys biking and photography. □

Rock Physics SIG

Rock Physics of Glaciers and Ice Sheets

Register for Rock Physics

Speaker(s): Colin M. Sayers
Schlumberger

Wednesday, Feb. 12, 2020
5:15 p.m. Refreshments
5:30 p.m. Presentation Begins
6:30 p.m. Adjourn

Sponsored by NER, CGG and Ikon Science

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

Colin M. Sayers

Abstract:

Glaciers and ice sheets are composed mainly of polycrystalline ice. Individual ice crystals have hexagonal crystallographic symmetry. The elastic stiffness tensor of a crystal with hexagonal symmetry is transversely isotropic with the axis of rotational symmetry (c-axis) perpendicular to the basal plane. Shear deformation on basal planes resulting from an applied shear stress in ice crystals is much easier than on other planes. Individual ice crystals in polycrystalline ice rotate, therefore, in the presence of stress anisotropy. This leads to a preferred orientation of ice crystals, and this is important to understand and model the behavior of ice sheets under stress. Analysis of elastic wave anisotropy allows obtaining information on the crystal orientation distribution function without the requirement of assuming a particular idealized fabric. This approach enables determining more complete information on the orientation distribution function from ultrasonic, sonic, and seismic data. Applying the method to ultrasonic velocity measurements on samples from the Dye 3, Greenland, deep ice core shows that a description of the ice fabric in terms of a second-rank fabric tensor is insufficient to describe the elastic anisotropy of polycrystalline ice.

Grain boundaries in polycrystalline ice influence various mechanical phenomena such as creep, yield, and fracture. Above -10° C, large changes in grain boundary mobility have been reported that were suggested as being due to grain boundary melting that involves a zone with liquid-like structure at the grain boundaries. This may play a role in the mechanical behavior of ice sheets because temperatures at the base may exceed the melting point, even though near-surface temperatures are typically below -20° C. Measured elastic stiffnesses of ice polycrystals decrease with increasing temperature due to a decrease in grain boundary stiffness. Grain boundaries are represented as imperfectly bonded interfaces, across which traction is continuous, but displacement may be discontinuous. Application to resonant ultrasound spectroscopy measurements on ice polycrystals enables determining the ratio of the normal to shear compliance of the grain boundaries, which are found to be more compliant in shear than in compression. This ratio is small at low temperatures, but increases as temperature increases, implying that the normal compliance increases relative to the shear compliance as temperature increases.

Biography

Colin Sayers is a Scientific Advisor in the Schlumberger Seismics for Unconventionals Group in Houston. He entered the oil industry to join Shell's Exploration and Production Laboratory in Rijswijk, The Netherlands in 1986, and moved to Schlumberger in 1991.

His technical interests include rock physics, exploration seismology, reservoir geomechanics, seismic reservoir characterization, unconventional and fractured reservoirs, seismic anisotropy,

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borehole/seismic integration, stress-dependent acoustics, and advanced sonic logging.

He is a member of the AGU, EAGE, GSH, HGS, SEG, and SPE, a member of the Research Committee of the SEG, and has served on the editorial boards of the International Journal of Rock Mechanics and Mining Science, Geophysical Prospecting, and The Leading Edge. He has a B.A. in Physics from the University of Lancaster, U. K., a D.I.C. in Mathematical Physics and a Ph.D. in Physics from Imperial College, London, U. K.

In 2010 he presented the SEG/EAGE Distinguished Instructor Short Course "Geophysics under stress: Geomechanical applications of seismic and borehole acoustic waves" and was chair of the editorial board of The Leading Edge. In 2013 he was awarded Honorary Membership of the Geophysical Society of Houston "In Recognition and Appreciation of Distinguished Contributions to the Geophysical Profession". He received the award for best paper in The Leading Edge in 2013. □

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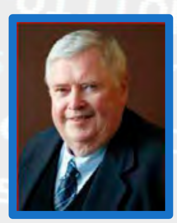

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Item of Interest

In 1269, Petrus Pereginus wrote the first treatise on the compass, a geophysical instrument, giving a description of an azimuth and a graduated circle of 360 degrees.

Seismic Expression of Salado Formation Gas Pockets in the Midland Basin

Kevin Woller, Robert Meek# * Consultant # Meek Geophysical Consulting, LLC*

** # Formerly Pioneer Natural Resources USA, Inc.*

Summary

Gas pockets within the Salado Formation in the Midland Basin have an amplitude expression on seismic data. The largest of these anomalies can be mapped and avoided. The smaller ones may require higher resolution seismic than normally used for exploration and development.

Introduction

There has been anecdotal information about nitrogen-filled gas pockets within the Salado Formation in the Midland Basin, Texas, USA for years. Winters (2014) indicated that they could be seen on seismic data. We examined one of our newer 3D survey data sets near Winters study area and found high amplitude events within the Salado interval.

Further study of our seismic library revealed many more high amplitude anomalies within the Salado level, but they were not everywhere within our data coverage. Only the largest ones could be seen on older vintage data. These anomalies range in size, shape, amplitude, reflection time and depth, but all are in the Salado Formation.

This presentation will document the nature of the anomalies on seismic data and offer a possible explanation for their origin.

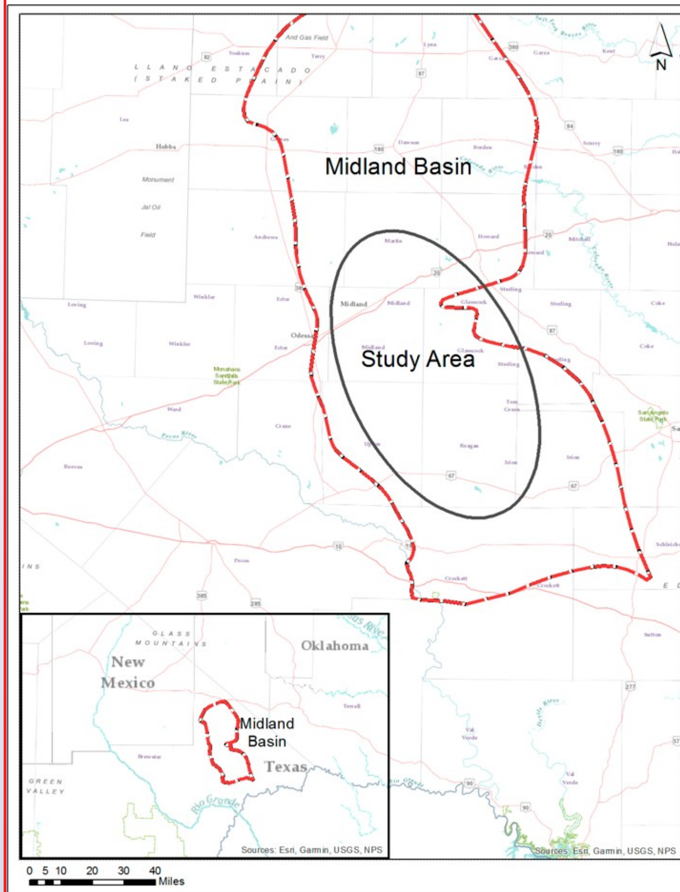

Figure 1: Study Area in the Midland Basin of the Permian Basin, Texas.

Background

Shallow gas pockets expressed on seismic have been a subject and focus for geophysicists for many years. The most typical such scenario has been to look for shallow high amplitudes that could be methane pockets, typically along a fault. The fault would be the conduit for methane generated at depth to travel upward and collect within a reservoir adjoining the fault. These gas pockets should be avoided, as they can cause problems with drilling wells by changing the density of the drilling fluids and/or pushing the drilling fluids up out of the hole.

Often these gas pockets would be too thin or shallow to be seen on conventional seismic surveys aimed at deeper exploration or production targets. Consequently, companies would commission high-resolution site surveys over a drilling area to find and avoid these gas pockets.

The gas pockets in the Midland Basin are reported to be nitrogen in isolated pockets not associated with faults or any other deep-seated conduits. They occur at different stratigraphic levels within the Salado Formation, from the top to the bottom.

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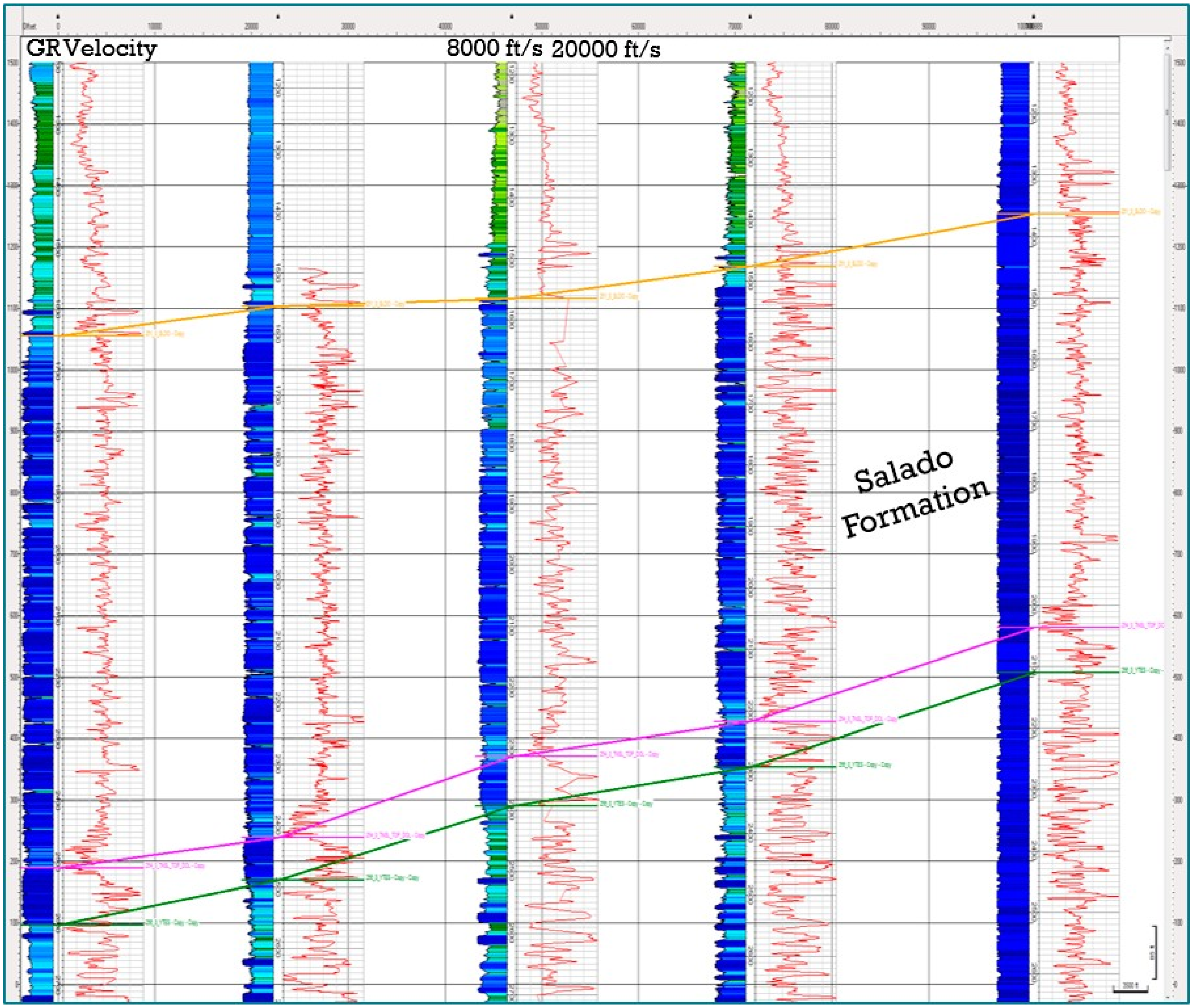

Figure 2: Velocity Cross-section of the Salado Formation.

The Salado Formation

Hovorka (2000) wrote the most comprehensive description of the origin and nature of the Salado Formation. Within our study area *(Figure 1)* the Salado ranges from 550-1250 feet thick (165–380 m). The formation is composed of layers of halite, anhydrite, dolomite and siltstones with some shale laminations. In some areas people circulate water to mine the salt from the Salado and then use the resulting cavity for storing fluids. It is possible some of these man-made caverns could be seen on current seismic surveys, but they are not always easy to locate.

The type logs in Hovorka's paper provided a good framework to use in picking the Salado on our well log data base. In addition, the various cycles described by Johnson (1993) were picked and mapped within our study area by an intern.

Well logs

Figure 2 shows velocity logs computed from sonic tool measurements near one of the amplitude anomalies. We can see that there are variations in thickness and velocity within the Salado Formation, but the average interval velocity is about 14,000 ft/s (~4250 m/s). Density ranges between that of

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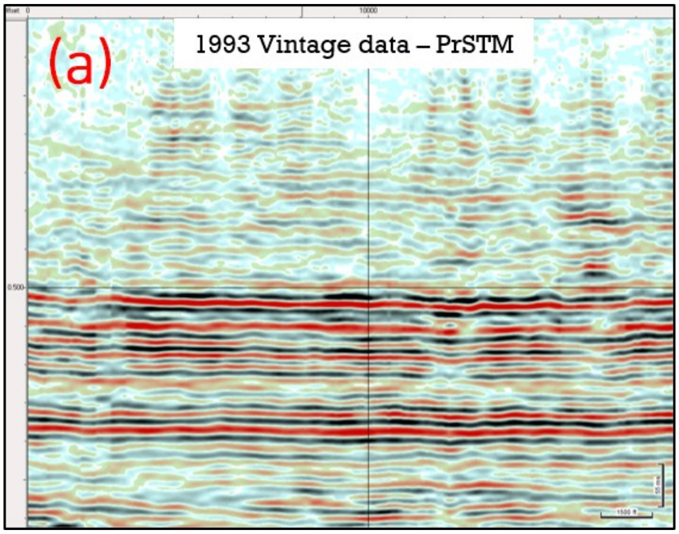

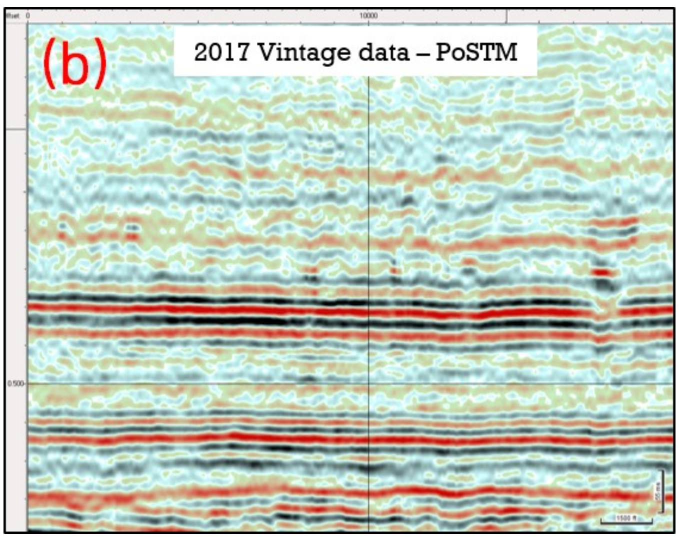

Figure 3: Seismic vintage comparison of 1993 (a) and 2017 (b) seismic data sets.

halite (~2.16 g/cc) to that of anhydrite (~2.97 g/cc). Density logs (not shown) indicated that the formation is mostly halite in composition.

Expression on seismic

Figure 3b is an arbitrary line using modern data that connects some amplitude anomalies in the Salado Formation. Some of these anomalies occur at similar depths or stratigraphic levels near the base of the Salado Formation, but others are at a higher level. We can see high amplitudes, and for the larger amplitude anomalies we can see an effect on the underlying reflectors. *Figure 3a* is from a reprocessed 1990s vintage seismic survey. We can see the largest anomaly on the right, but none of the other ones are visible on the modern survey.

Figure 4 is detailed view of a large anomaly in another area. This anomaly appears to be about 1000 feet wide in the displayed direction. The polarity of the display is a black peak = an increase in acoustic impedance according to calibrations. Thus, the anomaly is mainly expressed as a large trough event with large trailing peak. The dominant frequency of the data at this level is about 58 Hz, so the tuning thickness would be about 60 ft. (18.3 m). In this zoomed view we can more easily see the effects of the anomalies on the underlying reflectors. There appears to be a diminishment of amplitude, and either a time delay or push-down or phase distortions or interferences that look like some slight down-warping.

Seismic interpretation methods

Since the anomalies have higher than background amplitudes, the first pass in finding them was to compute RMS amplitudes over a window within the Salado formation. This was done by referencing the calculation window to the underlying Yates horizon, such as minus 30 to minus 90 milliseconds above the Yates horizon. The size of the window varied depending on the thickness of the zone over which anomalies were seen in an examination of the data. A map display of the RMS amplitude would show circular or lenticular features with values higher than their surroundings, and a polygon was digitized over the higher amplitude areas. Some areas had more high amplitude anomalies than others.

In the end, it appeared best to scan through each survey line-by-line to find amplitude zones higher than their surroundings. This is because the data is not fully balanced, and a high amplitude in one area might not stand out when the full amplitude range is calculated for an entire survey. Going line-by-line, and looking for isolated high amplitudes in the Salado, qualifying the amplitude with a cross-line or an arbitrary line, and then generating a time slice through the suspected anomaly is the current procedure to make sure we don't overlook any of the smaller anomalies.

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Seismic modeling and inversion

One-dimensional convolutional models assuming a decrease in velocity to about 7500 ft/s within the gas pockets indicate we cannot detect or resolve a thin zone 25 feet or less in thickness. In addition, our spatial sampling of 82.5 feet (25 m) bins might miss a smaller pocket.

We performed post-stack acoustic impedance inversion on a small 3D volume over one of the larger anomalies. This 3D volume has higher shallow fold than most as it was an experimental survey. The acoustic impedance (AI) over the anomaly is estimated at 8300-11,000 ft/s*g/cc, which is much lower than the background AI in the Salado Formation in this area of about 27,000-32,000 ft/s*g/cc, which fits with the general properties of halite with a velocity of about +/- 14,000 ft/s and a density of +/- 2.1 g/cc. The estimated thickness from the AI inversion was about 45 feet through the lowest impedance zone. Since this is impedance inversion, we can only guess at the ranges of velocities and densities. We hope to improve our estimates through elastic inversion if the gathers are sufficient to do this kind of inversion at these depths and offsets.

We are pursuing ray trace modeling and pre-stack inversion over an anomaly.

Data processing considerations

Much of our interpretation of the Salado amplitude anomalies has been on post-stack time migrated data generated as a fast-track volume to our final pre-stack time migrated data. This is because we noticed that some of the weaker or smaller anomalies noted on the fast-track volumes were sometimes missing on our final pre-stack time migrated data. We theorize that some of our noise removal processes applied during the processing flows for our pre-stack migrated data may be attenuating these isolated high amplitude events. We have started generating a post-stack time migrated volume with the benefits of improved signal processing and velocity analysis, but without some of the noise reduction steps to provide a better interpretation tool than the fast track volumes, which often have limited signal enhancement or velocity analysis.

Most of the shallow amplitude anomalies are not detectable on our 1990s vintage 3D data, even when reprocessed with modern pre-stack time migration methods. This is shown in *Figures 3a and 3b* where we compare pre-stack time migrated 1993 vintage data to 2017 vintage post-stack time migrated data. The best version of the 1993 data is shown, which in this case is the final pre-stack time migrated data. The largest anomaly on the right side of the displays was seen and mapped on the 1993 reprocessed data, but the others were not.

We examined stacked data before post-stack migration to see if diffractions might indicate the anomalies, but diffractions are not apparent. In *Figures 5a and 5b* we show an arbitrary line through several anomalies on stacked and post-stack migrated data. The anomalies are clearly discernible on the post-stack migrated data, but the diffraction energy is not apparent on the stacked data. It may be so steep and/or weak that it is hidden in the reflections under the source of the diffractions.

We have not yet tried diffraction imaging specifically on this zone. This may be difficult due to limited offsets at the Salado level.

Observations

Some of the larger amplitude anomalies have an associated amplitude change and time sag at the Yates reflector level underneath them. This suggests that the anomalies have a lower velocity and a possible attenuation effect on waves passing through them. This supports the idea that the amplitude anomalies are significantly lower velocity than the surround rocks. Some of the smaller and weaker anomalies do not have a time sag, suggesting they are not big enough to affect the underlying reflections.

Some of the anomalies are on linear patterns, but most are not. Anomalies that lie on linear patterns suggest there may be local faults or cracks that were conduits for underlying fluids to circulate and dissolve evaporites. Sometimes multiple anomalies occur along a stratigraphic level, suggesting a lateral conduit for fluid flow and dissolution.

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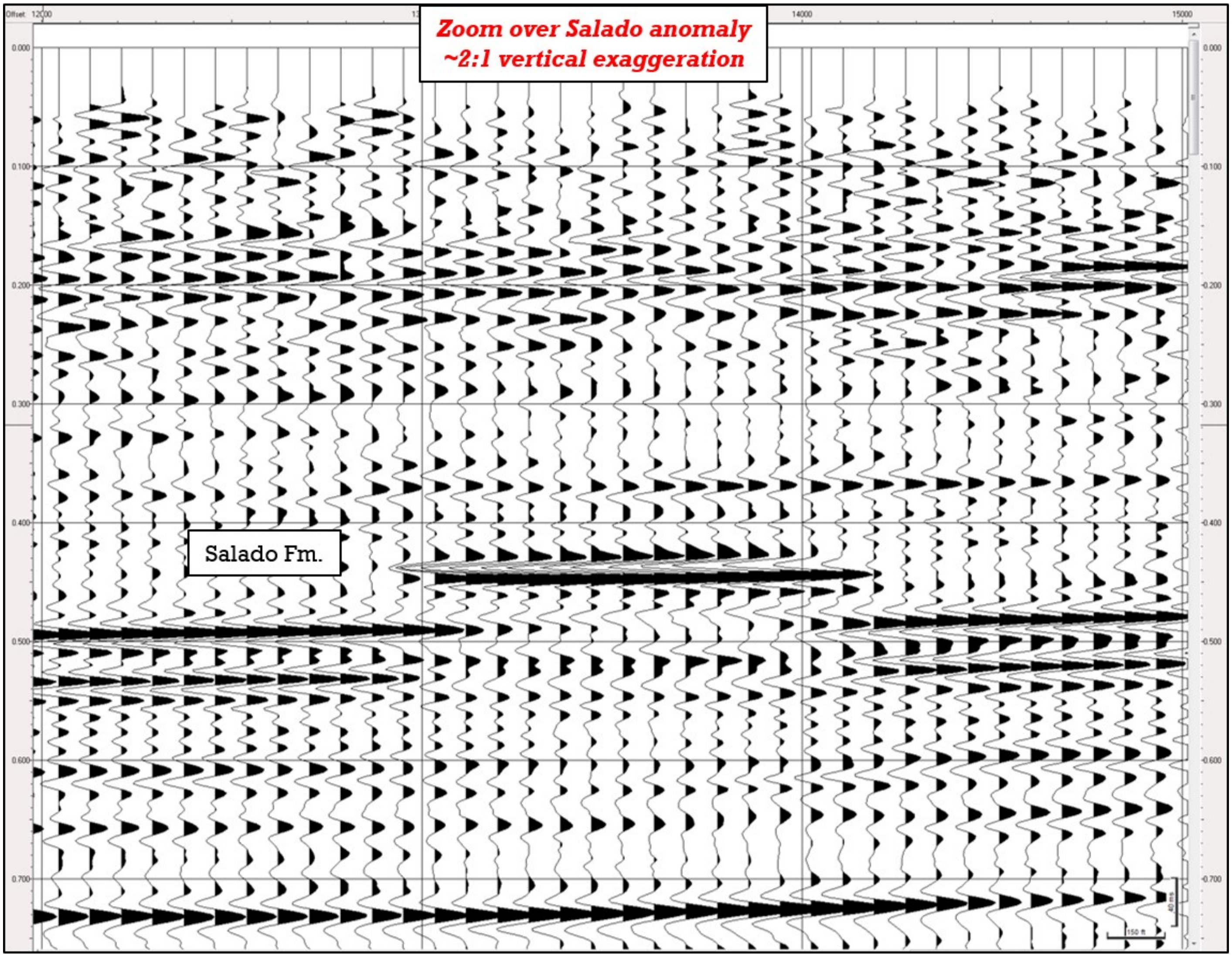

Figure 4: Example Anomaly in the Salado Formation and shadow zone beneath it.

Origin

There are three components to understanding the gas pockets in the Salado formation in the Midland Basin. They are:

- Formation of the void or pore space in the Salado formation,
- Generation or migration of nitrogen into the void, and
- Pressurizing the nitrogen.

Within the controls of our well logs, we don't see rapid thinning or thickening one might associate with karstic dissolution or internal flow of the halite members of the formation. Our shallow seismic imaging is somewhat limited, but where it is good, we don't see shapes commonly associated with salt karst environments. If we had a salt karst environment, then there would normally be an increase in the number of voids and consequently anomalies at the exposure surface, and one would typically see an expression of the hole going down from the exposure surface to the bottom of the cave or cave collapse feature. This type of circular feature is very common in the Ellenburger formation in the

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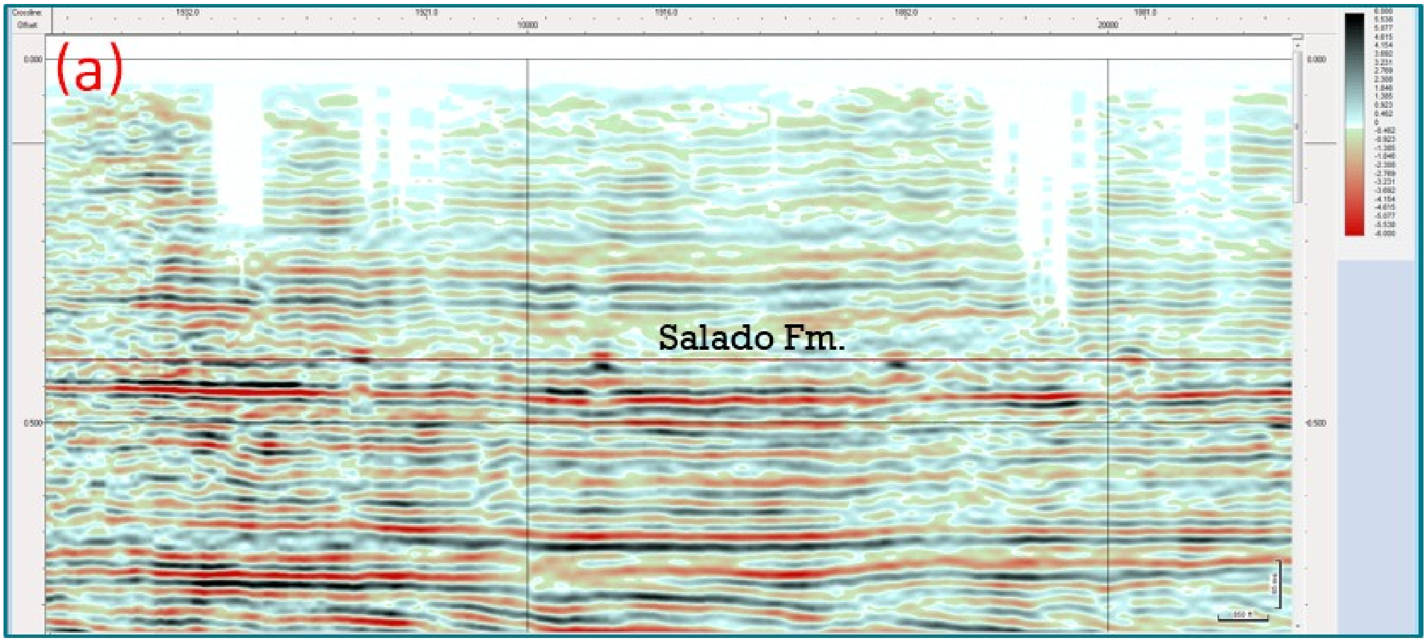
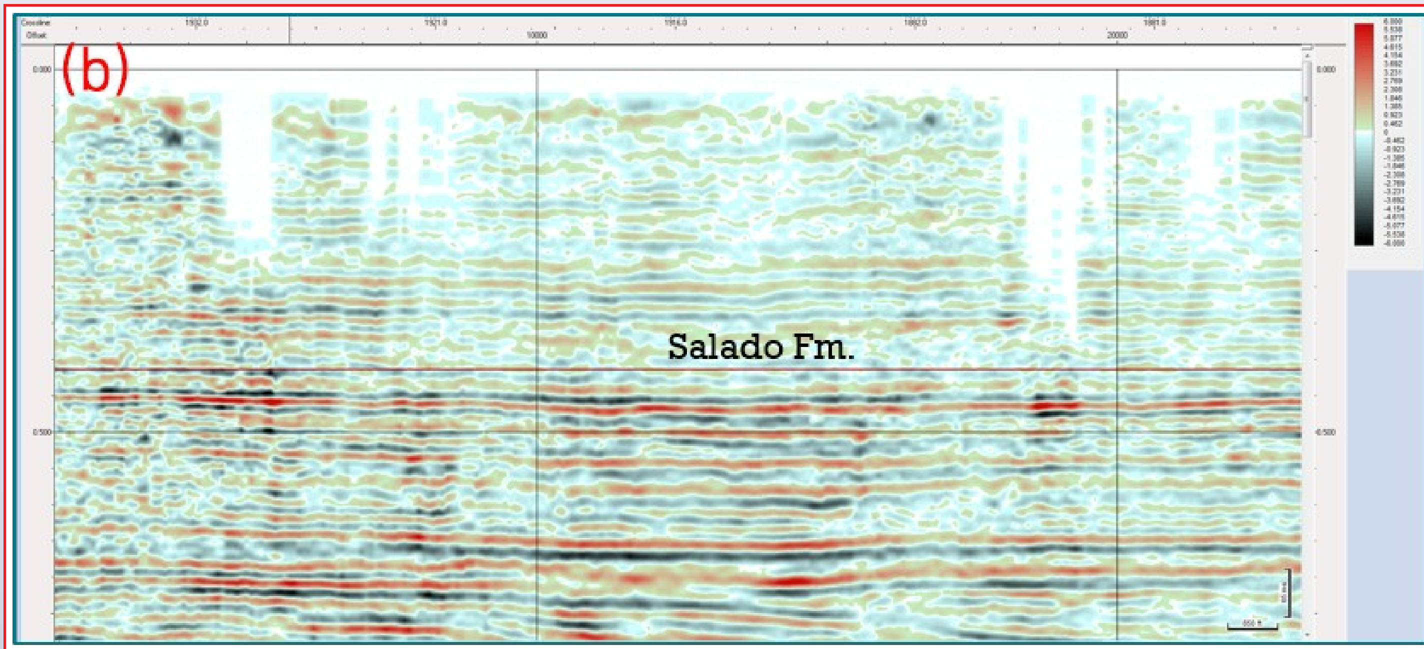


Raw post-stack time migration



Raw stack

Figure 5: Migrated (a) vs. raw stack (b) data sections

Midland Basin and elsewhere. We see circular features, but they are limited in time and depth and don't cut down into lower layers. Consequently, we don't think the gas pockets are related to a salt karst environment.

A second explanation would be for lower salinity water to be conveyed to the Salado formation. Salt dissolution would result, and the high salinity water could continue down-dip, leaving void space behind. Many of the larger anomalies do occur

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near the base of the Salado, near the Yates and Tansill formations, so these formations could be the source of the lower salinity water.

Nitrogen is not a common gas to encounter in the subsurface. Nitrogen is not associated with typical hydrocarbon generation and accumulation. It is not associated with deep igneous intrusives.

Brown (2017) developed several theories addressing how nitrogen can be generated in low thermal maturity areas that have clays containing ammonium. The key to this type of nitrogen release is to have an influx of lower salinity fluid to mix or interact the shales. A low salinity fluid influx could at the same time dissolve out halite and create voids for the nitrogen to fill. Additional overburden could also add pressure to the void space as evaporates have higher mobility than clastic or carbonate rocks.

We used a surface elevation and regional depth grid of the Yates formation to estimate how deep below the surface the Yates formation subcrops. To the east of the study location the Yates is only a few hundred feet below the surface, providing opportunity for freshwater influx.

Conclusions

Amplitude anomalies within the Salado Formation in the Midland Basin are probably nitrogen gas pockets. Modern 3D seismic recording methods allow us to see amplitude anomalies related to the gas pockets in the Salado Formation that were previously undetectable due to low fold and offset coverage. Some gas pockets are still unresolvable with current seismic recording and imaging due to lack of fold and offsets due to source/receiver spacing and density, as well as obstacles that prevent placing receiver and source points, such as tank farms, buildings and other cultural obstructions. Noise cancellation methods may reduce or attenuate some amplitude anomalies.

Acknowledgements

Glenn Winters (formerly with Fasken Oil and Ranch, Ltd.) was the first one to bring the Salado anomalies to our attention. Jeremy McDowell interpreted internal Salado formation tops during his internship at Pioneer. Pioneer management provided the time and resources to study this phenomenon. □

References

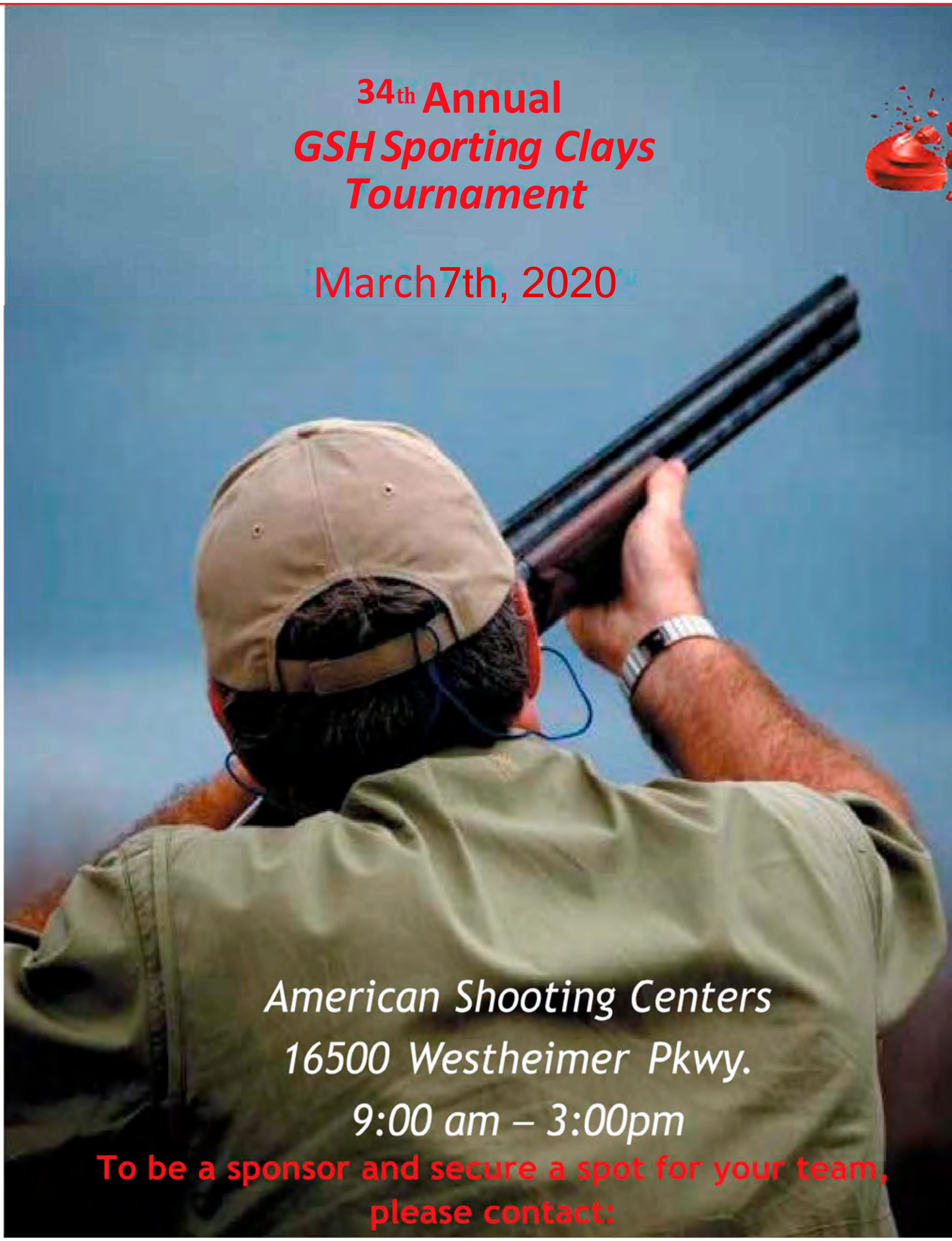
Brown, A. A., 2017, Possible origins for low thermal maturity, high-nitrogen natural gases: Search and Discovery Article #42065, http://www.searchanddiscovery.com/pdfz/documents/2017/42065brown/ndx_brown.pdf.html.

Hovorka, S. D., and N., Robin, 2000, Characterization of Bedded Salt for Storage Salt Caverns– A Case Study from the Midland Basin, Texas: Texas; Bureau of Economic Geology publication, doi: https://doi.org/10.2172/756545.

Johnson, K. S., 1993, Dissolution of Permian Salado salt during Salado time in the Wink Area, Winkler County, Texas: in D.W. Love, J.W. Hawley, B. S. Kues, G. S. Austin, S. G. Lucas, eds., Carlsbad Region (New Mexico and West Texas): New Mexico Geological Society 44th Annual Fall Field Conference Guidebook, 211–218.

Winters, G., 2014, Obstacles and Pitfalls of the Everyday Interpreter, the Role of Geophysics in Resource Plays: Presented at Dallas Geophysical Society meeting.

Permalink: https://doi.org/10.1190/segam2019-3214795.1



Ryan Marshall ▸ (713) 962-9414 ryan.marshall@dawson3d.com

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GSH Outreach

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

UPCOMING EVENTS – Volunteers Needed

Monday, February 10, 2020
Bellville Engineering Science Technology Booster Club

The Bellville Engineering Science Technology Booster Club will be hosting their annual Family Science Night on Monday, February 10, 2020 from 6:30 pm – 8:00 pm. These students and their family members are really interested in the oil and gas business because there are active seismic crews and wells being drilled in their community.

Saturday, February 15, 2020
Girls Exploring Math and Science (GEMS)

GSH will host a Community Booth at the Girls Exploring Math and Science (GEMS) event for Girl Scouts on Saturday, February 15 at the Houston Museum of Natural Science. Four volunteers are needed from 7:30 AM – 1:30 PM to setup, teardown and staff the booth. Benefits include admission to the museum until it closes at 5 pm, snacks during the event, the chance to make new friends while networking with colleagues, and have a lot of fun educating Girl Scouts and the general public!

Saturday, February 15, 2020
Science and Engineering Fair of Houston (SEFH)

The Science and Engineering Fair of Houston (SEFH) needs you to volunteer. At least six GSH volunteer Special Awards Judges will be needed on Saturday, February 15 from 11:30 AM – 4:15 PM (lunch is included) at the George R. Brown Convention Center Hall E to select winners for GSH Awards. We work in teams and no previous judging experience is necessary. Contact the GSH Lead Judge Gokay Bozkurt to volunteer at gbozkurt2002@yahoo.com. The SEFH is also in need of 500 Place Award Judges (see flyer). Information regarding both types of judging can be found at http://www.sefhouston.org. Science fairs are not only important for our students to learn more about Science, Technology, Engineering and Math (STEM) but also for Houston's future.

Friday, February 21, 2020
Ridgemont Elementary School (FBISD)

Ridgemont Elementary School (FBISD) will be hosting a Career Day Expo on Friday, February 21. Two volunteers are needed from 8:30 am – 11:00 am to host the GSH booth.

April 4, 2020
Scout Fair

Six or more volunteers are needed on April 4, 2020 to host the GSH booth at Scout Fair. Thousands of scouts attend this event, and we give away 600 - 900 GSH logo coiled toy springs. This admission-free event will be held at NRG Area from 10 AM – 3 PM. If you are available, please contact me to volunteer for lots of fun!

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

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U of H Wavelets - Geoscience Article

On The Rock Physics Basis For Seismic Hydrocarbon Detection

By Lian Jiang and John P. Castagna, Department of Earth and Atmospheric Sciences, University of Houston

Note from the Editor: In this month's U of H wavelets' technical article Jiang and Castagna go over the rock physics basis for seismic hydrocarbon detection. They come up with a method to determine an empirically optimized parameter for fluid discrimination. Their work concurs with Woodway's Lambda*Rho (λρ) and Russel's 'c' parameter. For the complete article follow the link: https://doi.org/10.1190/geo2018-0801.1

One of the primary fluid indicators for direct hydrocarbon detection using seismic amplitude anomalies is the difference between saturated-rock P-wave impedance and the rock-frame impedance. This can be expressed in terms of the difference between the observed P-wave impedance squared and a multiplier times the square of the observed S-wave impedance. This multiplier is a fluid discrimination parameter that laboratory and log measurements suggest varies over a wide range. Theoretically, this parameter is simply related to the ratio of frame bulk and shear moduli and the ratio of densities between the frame and fluid-saturated rock. In practice, empirical determination of the fluid discrimination parameter may be required for a given locality. Given enough data for calibration, the parameter can be adjusted to best distinguish hydrocarbon-saturated targets from brine-saturated rocks. Using an empirically optimized fluid discrimination parameter has a greater impact on hydrocarbon detection success rate in the oil cases studied than for gas reservoirs, for which there is more latitude. Application to a wide variety of well log and laboratory measurements suggests that the empirically optimized parameter may differ from direct theoretical calculations made using Gassmann's equations. Combining laboratory and log measurements for sandstones having a broad range of frame moduli, varying from poorly consolidated to highly lithified, reveals a simple linear empirical relationship between the optimized fluid discrimination parameter and the squared velocity ratio of brine-saturated sandstones.

Goodway et al. (1997) conceptually argued for "lambda-rho", λρ, as an optimal hydrocarbon indicator. However, he did not prove why λρ can increase the sensitivity of identifying fluids theoretically. In fact, as will be shown, λρ does not eliminate the effect of porosity and lithology completely. Russell et al. (2003) derived c from Gassmann's equations by taking the fluid effect to be related to the change in bulk modulus due to fluids (ΔK) as provided by Gassmann theory. However, the Russell et al., (2003) analysis is incomplete, as they only account for the fluid modulus contribution to the fluid effect. The density contribution of fluids to the impedance contrast can be significant in porous rocks with light hydrocarbons and cannot be always neglected. Setting F equal to the squared impedance change of the bulk rock (Z_P) from that of the rock frame (Z_P^{frame}) gives the full fluid effect. For hydrocarbon detection, given enough well log information and constraints, c can be estimated from extracted moduli using Gassmann's equations for moduli and the mass balance equation for densities. However, frequently, such information is not available. In those circumstances, a purely empirical approach can be employed by asking the question: what value of c in an area will lead to the

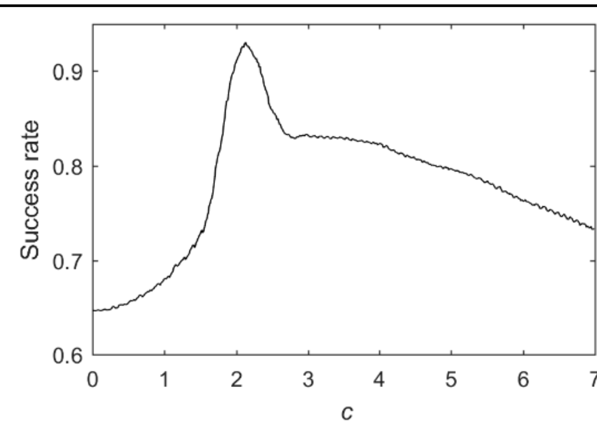

Figure 1. (a): (a) Success rate in distinguishing gas and brine sands from all the datasets versus hypothetical fluid identification parameters, c.

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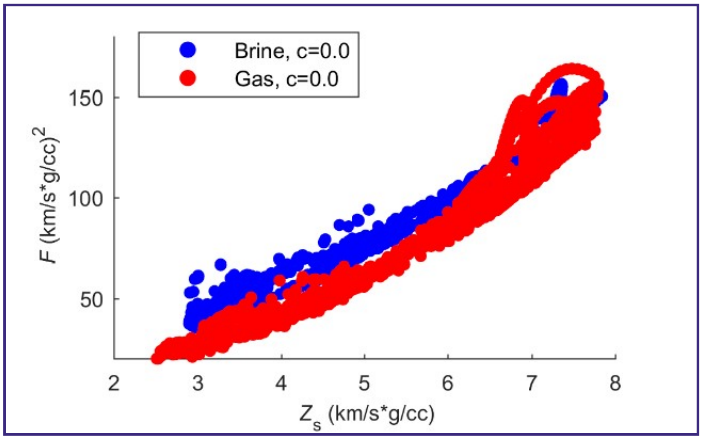

Figure 1b

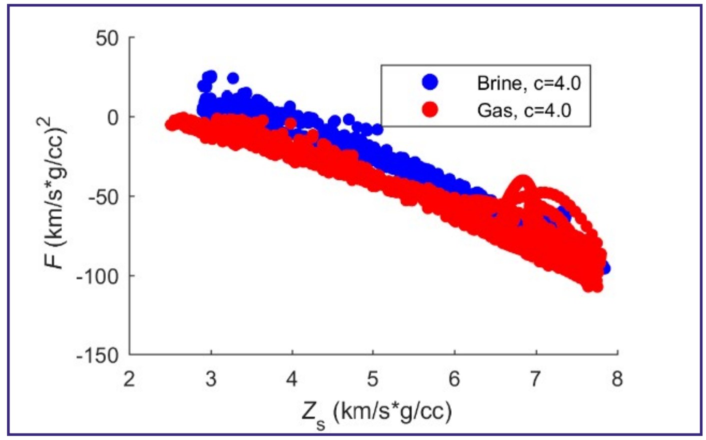

Figure 1c

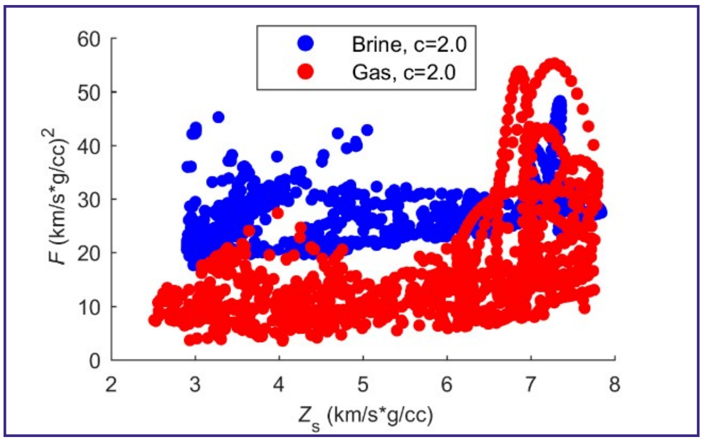

Figure 1d

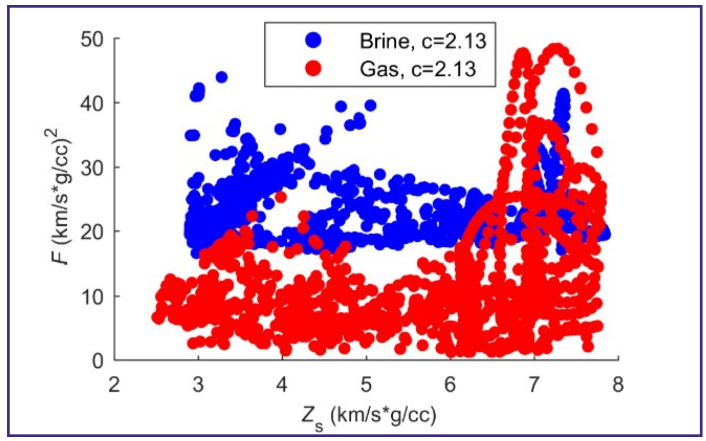

Figure 1e

Figures 1. (b to e): Crossplots of the fluid indicator, F, versus shear-wave impedance with different assumed values of c. In (b) c = 0; (c) c = 4.0; (d) c = 2.0; (e) c = 2.13. c is found by iteration to be the best discriminator for these data. The highest success rate is 0.93, and the threshold is 18.0. Fluid subsitution and hydrocarbon detection are unreliable at high shear-wave impedances as these rocks are likely to be low porosity and relatively incompressible.

best hydrocarbon detection rate? By best we mean here the smallest sum of false positives and false negatives. Given enough drilling results, this is a simple matter of defining the sum of false predictions as a penalty function and optimizing for the c value that gives the smallest penalty. Fortunately, we can test the concept without requiring drilling results.

Figure 1 shows the optimized c obtained by combining all the cited laboratory and log measurements we have investigated. The optimal value for this wide range of data is 2.13; essentially half-way between Goodway's assumed value of 2.0, and Russell's derived value of 2.25, thereby empirically validating their conclusions. Ability to discriminate brine and gas can be poor at high shear-wave impedance due to small fluid effects. Modifying c to best match these data would not be worthwhile if these rocks are not amenable to direct hydrocarbon indication. However, we have shown for specific datasets, that c can vary over a wide range, with values over 3 obtained in some offshore wells. We are interested in knowing if the data itself will allow us to make better estimates of

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Wavelets continued from page 28.

c in localities where there is the potential to improve success rates from those obtained using a “global” average value.

To investigate the dependence of c on rock properties, we broke the entire dataset up into ranges of rock properties, and separately optimized for c in each subset range. *Figure 2* shows that there is a well-defined linear relationship between optimized c and the average brine-sand squared velocity ratio. The correlation coefficient is 0.98. Thus, given measured or estimated VP/VS for brine-saturated sandstones in a given area, a reasonable estimate of c can be made. This ratio can usually be estimated to first order using global empirical trends. Thus, rather than using a global average a priori c, it should be possible to make a better estimate as a function of depth in specific basins. From the examples investigated here, we expect higher values for c, and better success rates, in young, porous, poorly-lithified reservoir rocks. By optimizing c for a given dataset, we find the best improvement in success rate over a globally assumed value of 2 to be about 8 percentage points for gas detection. Similarly, the best improvement in success rate compared to that using c = 2.25 is about 4 percentage points for gas detection. Furthermore, although the optimized c is very high in the Gulf of Mexico, the improvement in success compared to assuming a low value for c of 2 or 2.25 is only marginal; the gas effect is so strong in these examples that even a very wrong value for c works reasonably well. The improvement in success is better in the fluid-substituted-to-oil offshore Gulf of Mexico well; presumably because more precision is needed to distinguish oil from brine. For gas-sandstones, low values for c will work reasonably well, even if a higher value for c can maximize the success rate by a small percentage. For oil sands, however, more precision may be needed, and local optimization for c may be desirable, with maximum improvement in success rate of almost 20 percentage points obtained.

In this work we analyze the effect of changing fluids in porous rocks and argue for a fluid indicator based on the compressional-wave impedance change between the rock frame and the fluid-filled rock. We concur with prior work suggesting that the difference between the compressional-wave squared impedance and a multiplier times the squared shear-

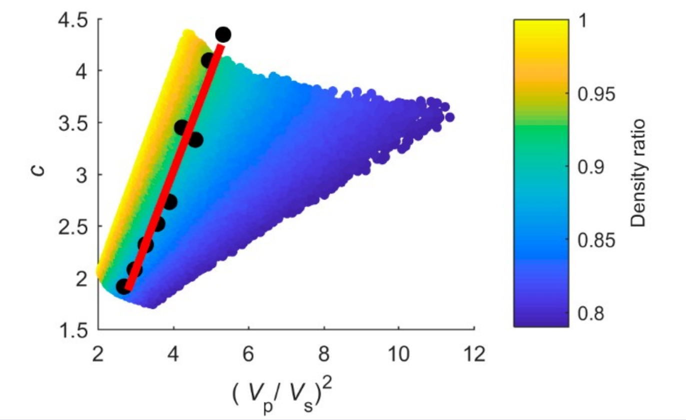

Figure 2. Crossplot between c and average (VP/VS)2 of brine sandstones. The black points are optimized c values determined with the following procedure: we first gather all the datasets we have used in this paper, then split them into small sub-datasets within small ranges of brine sand VP/VS, and finally optimize c for each velocity ratio range. The red solid line is the linear regression fit on black scatter points. The colored points are theoretical numerical simulation results based on the Gassmann equations.

wave impedance can be a hydrocarbon indicator, however, we formulate that difference relative to the impedance of the rock frame. We refer to the multiplier as a fluid discrimination parameter.

We find that the fluid discrimination parameter varies for different datasets; with it tending to be low in well-lithified laboratory samples and high for acoustic log data in poorly-lithified offshore reservoir sandstones. A global optimization for this parameter yields a value of 2.13 which is consistent with prior work. We find an optimized value of over 3 for well logs acquired offshore China and in the Gulf of Mexico. We find this difference in the parameter to have only a small effect on the success rate for the case of gas prospects, as the fluid effect is so large in soft rocks that there is wide latitude in selecting the parameter. However, for oil prospects, more precision may be desired and local calibration of the fluid discrimination parameter may be needed. Towards this end, we find a simple linear relationship between the optimized fluid discrimination parameter and the squared velocity ratio of the fully brine-saturated rock. □

Mystery Item

This is a geophysical item...

Do you know what it is?

This month's answer on page 37.

SEG-GSH 2020 HOUSTON EDUCATION WEEK

24–27 MARCH 2020, HOUSTON, TX

CHRISTOPHER ZAHM | MRINAL SEN | SIDDHARTH MISRA | REINALDO MICHELANA | JAMES GILMAN

LUNCH INCLUDED

U of H Wavelets

SEG Wavelets Hosts SEG Distinguished Lecturer and Cohosts Annual 2019 Holiday Party *By Zhongmin Tao*

Figure 1. John Etgen presenting to students.

In middle November 2019, SEG Wavelets invited Chris Hartley from Gyrodata to speak on "Downhole Survey Technology". We were excited to invite such an experienced wellbore placement advisor to talk about drilling to students. He provided a unique overview/historical timeline of downhole survey tools including MEMS memory and solid-state gyro instruments. Students really enjoyed learning about the history of mwd (measuring while drilling) tools and the influence of Earth's gravity, magnetic field, and rotation on surveying instruments.

On November 18th we hosted BP for a great talk. It focused on

Figure 2. A photo featuring participants in the annual ugly sweater contest.

Wavelets continued on page 32.

Wavelets continued from page 31.

practical insights into seismic velocity estimation; how it works, what can be resolved, and what will be difficult resolving. We invited John Etgen who is SEG's 2019 3Q/4Q Distinguished Lecturer to give this talk as part of SEG's 2019 3Q/4Q Distinguished Lecture series! John Etgen provided us with 2-hours of lecture and discussion as we learned about effective analysis and QC of velocity model building in both, simple and complex geologic settings. We also learned about instances in which lateral velocity resolution is higher than vertical velocity resolution.

At the beginning of December, SEG Wavelets, AAPG Wildcatters, Geosociety at The University of Houston, and the UH EAS Graduate Student Committee held our annual holiday party to celebrate the end of spring semester! Students took festive pictures with their friends using the Christmas photo booth over there. □


Earth & Atmospheric sciences
UNIVERSITY of HOUSTON
COLLEGE of NATURAL SCIENCES & MATHEMATICS
NASA
Jet Propulsion Laboratory
California Institute of Technology
26th Annual Milton B. Dobrin Lecture
Title: Seismic Exploration on Mars
Speaker: Bruce Banerdt
Principal Investigator, NASA's Insight mission to Mars,
Jet Propulsion Laboratory, Pasadena, CA
Date: February 12th, 2020
Time: 5:00-8:00pm
Location: Alumni Center,
O'Quinn Great Hall,
3204 Cullen Blvd,
Houston, TX 77204
Admission is free. Please RSVP here.
5:00pm: Poster Session & Happy hour
6:30pm: Lecture
Co-sponored by GSH
Photo credit: Le Point Sciences

GSH GEOSCIENCE CENTER
CHALLENGE

Match donations by Scott Petty. Jr., Lee Lawyer, Tom Smith, and Dick Baile

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GEOSCIENCE CENTER 2019 – 2020 CHALLENGE

Challengers: **Dick Baile, Lee Lawyer, Scott Petty, Jr., Tom Smith**

Matching: Gary Hoover, Robert Wyckoff, Craig Beasley, Bruce Blake, Frank Dumanoir, Bill Gafford, Karl Schleicher, Kenneth Mohn, Tommie Rape, Lisa Buckner, Marie-Helene Clavaud, Peter Duncan, Abhijit Gangopadhyay, Randy Keller, James Medlin, Barry Rava, Liza Nell Yellott, Carlos Cabarcas, Helen Delome, Jennifer Graf, Louis Hebert, Paul Schatz, Gene Sparkman, Harold Yarger & Gene Womack

Donations support Programs and Activities of the GSH Geoscience Center including:
Artifact cataloging and storage, Loans to Universities for display, Bob Sheriff Library,
Instruction space and the Living Legends Doodlebugger Social Gathering.
The GSH is a 501(c)3.

Join us at the Geoscience Center for:

Geoscience Center

The History of Geophysics By Bill Gafford

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

Bob Sheriff Library
books and reference material

Bob Sheriff Library
periodicals and training manuals

Our next **Living Legends Doodlebugger Social Event** will be on **Wednesday, February 12**. We will have a few newly donated "old" items on display as well as some other artifacts available for discussion, which will hopefully trigger stories from the oil patch. If you have not been to one of these quarterly events at the Geoscience Center, put this on your calendar. There is no cost or registration needed. There will be light snacks as well as coffee, water, and soft drinks. It is a good time to share petroleum industry experiences , travel stories, and to see some of the geoscience artifacts that were used in the early days of exploration, or some of the Mystery Items that have appeared in the GSH Journal.

We are also continuing to add to our Bob Sheriff Library. As the library collection has grown, we have rearranged the space in the Geoscience Center so that the periodicals, training manuals and seminar workbooks are now located in a separate area, while books and reference materials are located in the original library room. We are also adding to the digital files, which include DVD's and CD's. This area also includes many SEG and AAPG publications and a bookcase of duplicates that are available to visitors for Free. The items in the library collection are available to be checked out. Pictures of a portion of the library collection are included with this article.

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.

Geoscience Center continued on page 37.

Geoscience Center continued from page 36.

One of our continuing projects is nearing completion. Many of you may have seen our electronic seismic chart, which illustrates the geometry of seismic energy on a wall chart with flashing lights indicating seismic travel paths. This chart has been used by our outreach committee for several years to educate students and interest them in a geoscience career.

The chart is rather large and somewhat difficult to transport so we decided to make a smaller version that would be more portable. Karl Schleicher and Gene Womack agreed to undertake the project. Gene built the chart and frame, and Karl is nearly finished wiring the electronic components.

There will be more information on this project in the future. □

The Mystery Item
on page 30
is a
Communication unit
from about the 1950's.
It was used to
communicate down
the seismic line
by hooking into
master cable.

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

Honors and Awards Banquet

Thursday, May 7, 2020
Norris Conference Center
Magnolia Room

Cocktails | 6:00 pm
Dinner | 7:15 pm
Spouses and guests welcome.

2019-2020 GSH Scholarships

By: Jim Schuelke

The GSH offers two scholarships as part of our continuing effort to support young professionals. They are the **Carlton-Farren Scholarship** and the **Hugh Hardy Scholarship** for worthy college students in the field of geoscience. Both funds are administered by the SEG and funded by the GSH. The funding for these programs increases and decreases depending on our finances and the amount of donations received. The goal is to build the funds to be self-sustaining. The scholarship endowments were named in honor of outstanding individuals in the GSH.

The 2019-2020 GSH/Hugh Hardy scholarship awardee is Alexander D'Marco Garcia, a Master's in Geophysics student at the University of Texas at El Paso. The 2019-2020 GSH/Carlton-Farren scholarship awardee is Bhavya Merchant a senior in the Geophysics and Computer Science programs at the University of Houston.

I think the best way to highlight the impact of this educational support is through the student's letters of appreciation to the GSH and SEG for their scholarships.

Alexander D'Marco Garcia

GSH/Hugh Hardy scholarship awardee

I was very happy and appreciative to learn that I was selected as the recipient of your scholarship. As one of this year's recipients, I am grateful for the opportunities this award will provide me. I rely heavily on financial aid, grants and student loans to help finance my education. Receiving this scholarship will help reduce my financial burdens and provide assistance for me as I continue pursuing my education.

I am a Geophysics major at the University of Texas at El Paso (UTEP) with an emphasis in shallow subsurface geophysics utilizing seismic, gravity and magnetics. I am currently a graduate student, and plan to graduate in the Spring of 2020. As a current Pathway's Intern at NASA's Kennedy Space Center, I plan to convert into a full-time employee upon graduating from UTEP. Thanks to you, I am one step closer to that goal.

By being awarded this scholarship, you have lightened my financial burden which allows me to focus more on the most important aspect of school, learning. Your generosity has inspired me to help others and give back to the community. I hope one day I will be able to help students achieve their goals just as you have helped me.

Sincerely,
Alexander D'Marco Garcia

Bhavya Merchant

GSH/Carlton-Farren scholarship awardee

Thank you for your generosity in funding an SEG Scholarship. I am sincerely honored to be a recipient of this award.

I graduated from Riverside High School in Greer, South Carolina in May 2016. This fall, I will start my fourth and final undergraduate year at the University of Houston. I am pursuing three separate B.S. degrees in Geophysics, Computer Science, and Mathematics. My goal is to complete an M.S. or a Ph.D. before beginning a career in the energy industry.

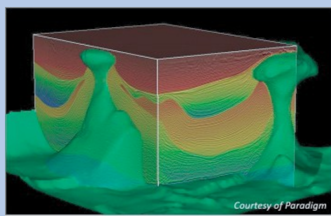
I look forward to many opportunities I will encounter in my senior year, specifically as I work towards completing a senior honors thesis. My thesis is on using machine learning techniques to identify and classify objects in hyperspectral images. Like last year, I know my professors and the GSH/SEG will continue to help and support me as I work towards becoming a geophysicist. Thank you for giving me this opportunity to help me achieve my goals.

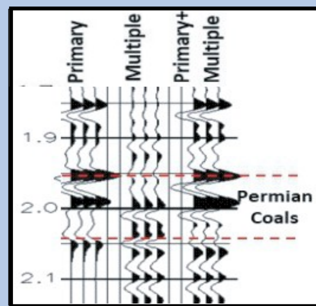
Sincerely,
Bhavya Merchant

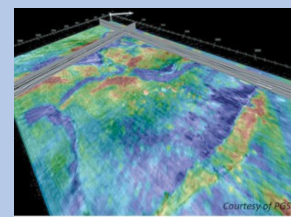
The GSH appreciates the support provided by our members and the companies that sponsor our social events, which fund this scholarship effort. If you would like to add your donation to this fine effort, please call the GSH office at (281)-741-1624.

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
• Everything You 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

GEOPHYSICAL SOCIETY HOUSTON

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SEG
SOCIETY OF EXPLORATION GEOPHYSICISTS

HGS Scholarship Night 2020

Special Speaker: Jessica Watkins, NASA Astronaut Candidate

Jessica Watkins has been selected by NASA to join the 2017 Astronaut Candidate Class. She reported for duty in August 2017. The Colorado native earned a Bachelor's degree in Geological & Environmental Sciences at Stanford University, & a Doctorate in Geology from the University of California, Los Angeles (UCLA). Watkins has worked at NASA's Ames Research Center & NASA's Jet Propulsion Laboratory & was a collaborator on the Mars Science Laboratory rover, Curiosity.

Watkins was born in Gaithersburg, Maryland, but considers Lafayette, Colorado her hometown. Her parents, Michael & Carolyn Watkins, still live there. In college, she was a member of Stanford Women's Rugby as well as the USA Rugby Women's Sevens National Team. During her postdoc, she served as a volunteer assistant coach for the Caltech Women's Basketball team. She also enjoys soccer, rock climbing, skiing, & creative writing.

During undergraduate internships at NASA's Ames Research Center, Watkins conducted research supporting the Phoenix Mars Lander mission & prototype Mars drill testing. She also served as chief geologist for NASA Spaceward Bound Crew 86 at the Mars Desert Research Station in 2009. As a graduate student, Watkins participated in several internships at NASA's Jet Propulsion Laboratory (JPL), including analysis of near-earth asteroids discovered by the NEOWISE mission in 2011, tactical & strategic planning for the Curiosity mission in 2013, & system design testing for the upcoming Mars 2020 & Mars Sample Return missions the following year. In addition, she served as a science operations team member for a Desert Research & Technology Studies (Desert RATS) analog mission at NASA's Johnson Space Center in 2011 & participated in the NASA Planetary Science Summer School at JPL in 2016. Watkins reported for duty in August 2017 to begin two years of training as an Astronaut Candidate. Upon completion, she will be assigned technical duties in the Astronaut Office while she awaits a flight assignment.

FEBRUARY 10, 2020 | NORRIS CONFERENCE CENTER

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Doodlebugger Diary

A Day in the Life and Times of the M/V Polar Prince – Gulf of St. Lawrence, Summer 1982

By Eric Hann, GSI, 1982, Photos by Bill Duffy, Offshore Navigation (Canada) Ltd., 1982, Recounted by Scott Singleton

The Doodlebugger Diary recounts the experiences of geophysicists during their working lives. During the last two years I've been recounting my own experiences but last June I shifted to publishing three episodes of SEG Past-President Nancy House's experience in the Peruvian jungles. Last fall I started reprinting a series of early 1980's articles from the GSI Shotpoints. These newsletters are among many archived GSI publications maintained by Bill Boettcher at http://gsinet.us/.

All people have certain goals they must achieve before they can truly say they have lived life to its fullest. One of these might be to live and work on the biggest and newest member of the elite GSI fleet, the M/V Polar Prince.

But, like everything else in the world, this life has its ups and downs, especially at sea. After engineering tests on the Grand Banks of Newfoundland, it was time to put our multiplex streamer system to work on its first client job. The vessel was equipped with a new prototype multiplex (MUX) 240-trace streamer and corresponding prototype instruments. Also complementing our MUX system was an

Fig 1: M/V Polar Prince entering St. Johns, Newfoundland, harbor.

Doodlebugger continued on page 46.

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 45.

Fig 2: Al Stroud and Eric Hahn at the multiplex terminal in the doghouse.

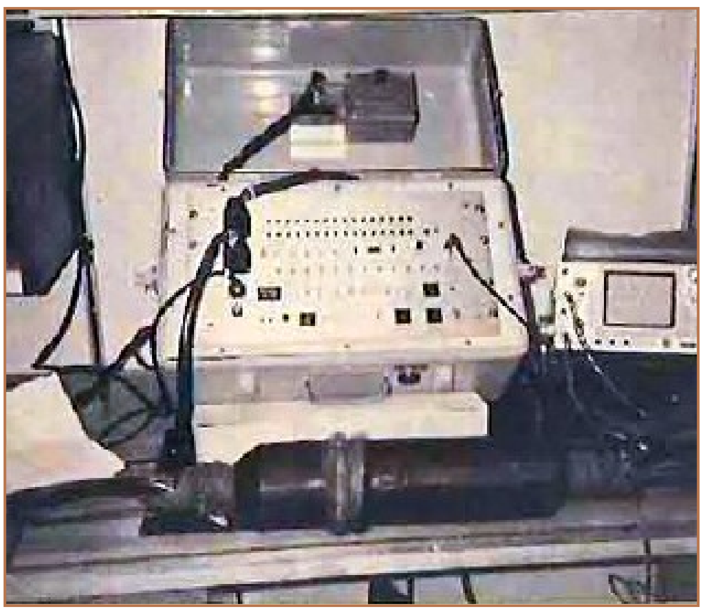


Fig 3: Test unit for the streamer electronics modules (SEMs).

STS III streamer tracking system and new TIGER 11 airgun controller system.

The Polar Prince departed Sydney, Nova Scotia, on June 12 enroute to its first client job in the Gulf of St. Lawrence. The first stage of the prospect was in the mouth of the St. Lawrence Seaway and stage two was off Anticosti Island which is located in the middle of the Gulf.

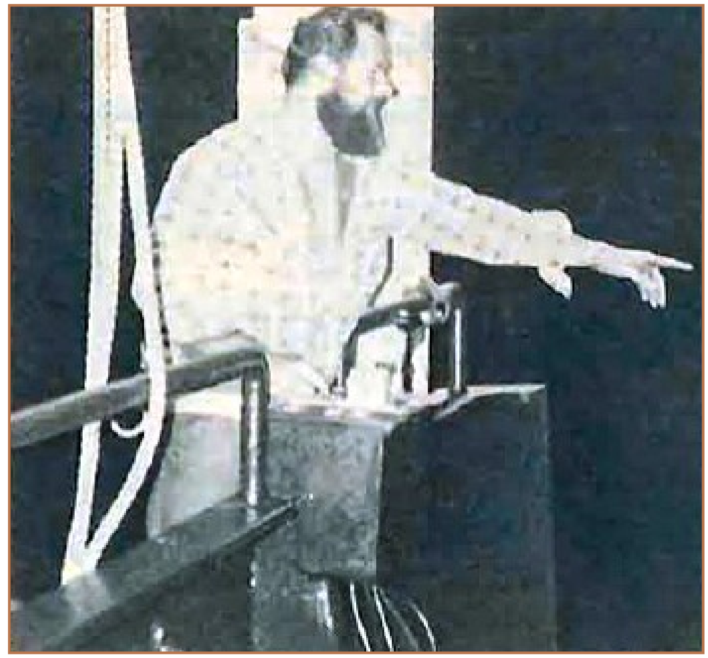


Fig 4: Ralph Hodge at the cable reel controls guiding recovery of the streamer.

Initially, numerous problems were encountered which severely hampered the vessel in becoming production-oriented. We had to make two port calls at Sept Isles and Gaspe Bay in Quebec to pick up spares, and when we were not in port waiting for parts, we were at sea waiting for a helicopter to furnish us with the spares. The ports in Quebec benefited greatly with an increase in beer sales and our onboard crew adapted to the frequent visits by becoming bilinguals.

Aboard the vessel we got what we referred to as the "MUX Blues Syndrome." During August our problems became less frequent due to several factors that we feel contributed greatly to our final success:

1. Our field service representative for the Canadian operation, Mike Landua, rode the vessel for two weeks and discovered various problems causing instrument downtime.

2. A decision was made to reconfigure the streamer from 240 traces to 168, which alleviated the majority of the streamer-related problems.

Doodlebugger continued on page 47

Doodlebugger continued from page 46.

Fig 5: Bill MacInnis, Scott Brennan and Jim Manclark change out the airgun array on one of the gun strings.

Fig 6: Pat Tesi works with the slip ring using a repeater (an instrument used to diagnose streamer trace problems). The slip ring is where the streamer electronics were paired with the shipboard electronics.

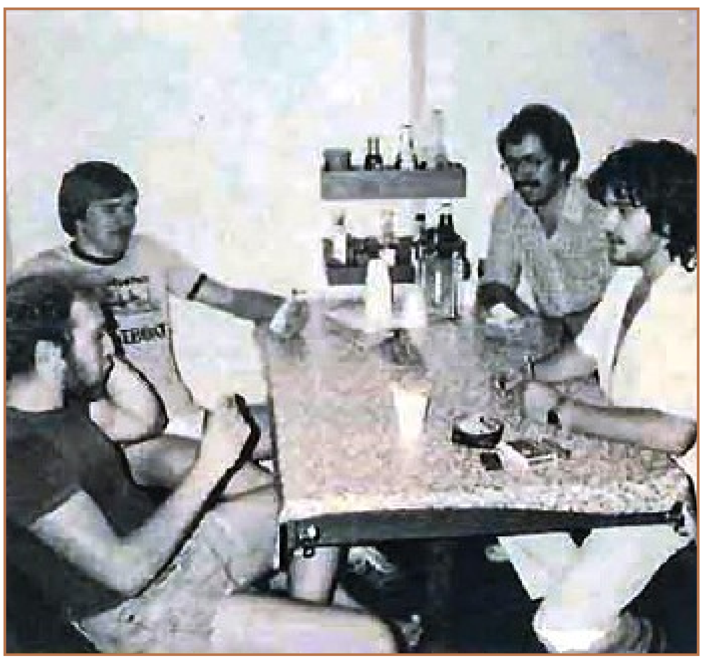
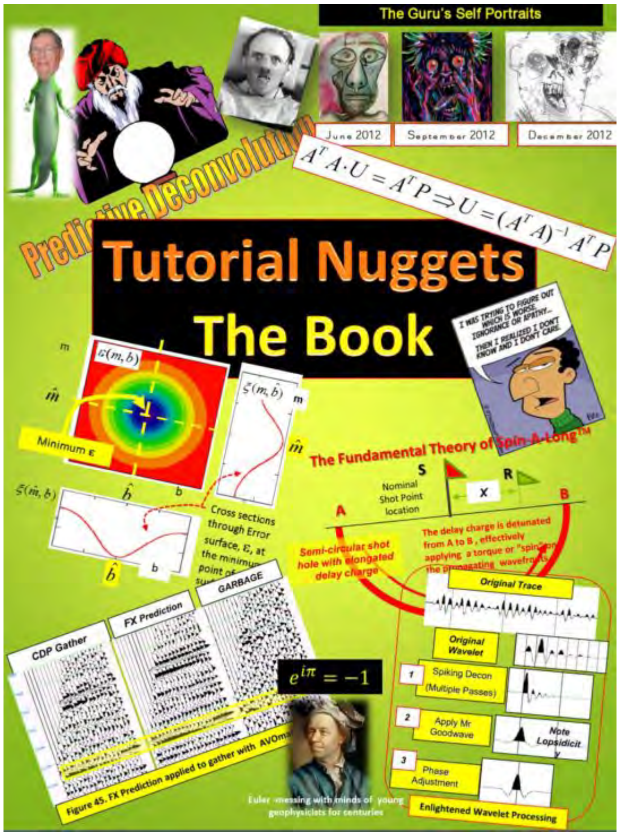


Fig 7: Les Noel, Terry Peach, Tony Richardson and Craig Rickert at the nightly cribbage game. Note that this was before the ubiquitous presence of satellite communications, meaning the crew had to (gasp!) entertain themselves while onboard the vessel.

3. Dallas Engineering provided us with valuable information when we were experiencing general problems with onboard electronics. The MARISAT was our link with Dallas which gave us access to an abundance of knowledge.

With these factors in consideration, the on board crew was virtually cured of the "MUX blues" and real production began. From Aug. 16 to Sept. 15 the Polar Prince tallied over 3100 km and on several days broke the 200-km barrier. Upon completing the first client job in late September our MUX-experienced crew reluctantly derigged the multiplex system and hoped for its success on its next job on the M/V Karunda.

We would like to thank everyone who was involved in the mobilization of the Polar Prince and in all the production stages along the way. □



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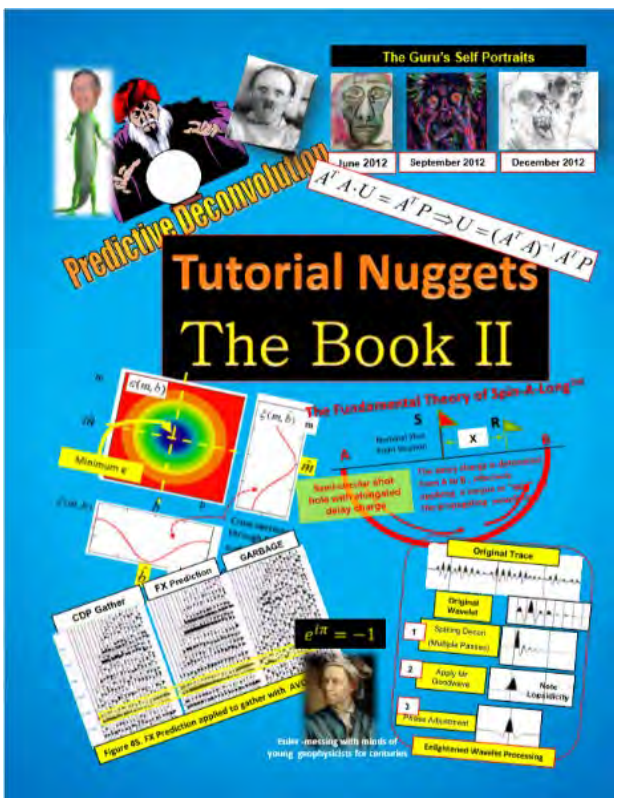

Tutorial Nuggets The Book II

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