June 2018

GSH Journal

GEOPHYSICAL SOCIETY OF HOUSTON
Volume 8 • Number 10

The Epicenter of Geophysical Excellence

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Photo 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 Dmitry Kulakov, editor, at dkulakov@slb.com

GSH JOURNAL DEADLINES

Sept 2018 ..... **July 13**
Oct 2018 ..... **Aug 16**
Nov 2018 ..... **Sept 13**

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A Word from the Board

"Proud to be a Geophysicist"

by Tommie Rape, President

As we approach the end of another administrative year for the GSH, we naturally reflect back on the highs and lows of our organization. So, I will do my part and summarize these highlights. But, first, instead of encouraging our readers to join the GSH and become more active, I want to expound on why I feel so blessed and lucky to have experienced the past year in the GSH. I want to tell you what I have gotten out of the last year.

- First, I feel a sense of accomplishment for doing my small part in helping the GSH provide another year of service for thousands of geophysicists. Many have expressed their appreciation for the technical education and many other opportunities provided by the GSH; my pride in our profession contributes to my desire to support the GSH in its efforts to maintain the highest quality of geophysics.

- My participation in many GSH social and technical activities has provided extensive networking opportunities. I have extended my existing professional connections and made new connections in my main areas of technical expertise. I have also made connections that I can rely on should I expand into new technical areas. These connections go both ways; I can call them when I need some work done, and they can call me when they need some work done.

- Working in the GSH not only helps in making professional connections, I have developed new friendships. Working closely with people with similar interests, e.g. GSH and obviously geophysics, provides opportunities to develop those friendships and the opportunity to find other mutual interests.

- I have attended GSH events and have received GSH newsletters for many years, but I still had only scant knowledge how things worked within the organization. But while serving on the Board of Directors as Editor for two years, I learned so much about the GSH. I learned how the GSH planned and arranged events, how the GSH funded events, and naturally I learned much about publishing and editing a publication. Then serving as President, I surprisingly learned so much more about how a large volunteer organization runs, including 501c implications. Not only did I find out how the organization runs, but also who runs the organization. I found out about so many people involved with the GSH.

Tommie Rape

- Though not exclusively during the last year, I have learned how to do new things while serving the GSH. I already mentioned learning much about editing and publishing a sophisticated publication. I also learned much about how a website works and is organized. Though still a novice at editing a website compared to others like Paul Schatz and Kathy Sanvido, I did enjoy modifying our website. Hopefully none of you were aware of the time when I accidentally shut down our website for a few hours.

- I am certainly not among the most magnanimous people in the world, much less within the GSH. But I gained such a feeling of satisfaction while working for the GSH, by helping others. Besides providing technical presentations/ education to the geophysical population, individuals reach out to us for assistance, and we do what little things we can to help them. Also, in these difficult times we have conducted forums for Education & Career Development for Unemployed Professionals. Our Outreach program, led by Lisa Buckner, does a tremendous job in promoting STEM education for our area's youth. I feel a tremendous sense of pride for the work of the GSH in helping others.

- Like most GSH members, my attendance at technical events is concentrated on events related to my general area of technical expertise. Yet I have expanded my technical horizons by attending events with presentations beyond this area of expertise. Though I certainly have no expertise in these new areas, being aware of the general principles benefits my technical prowess.

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A Word From the Board continued from page 4

- Even with all the highlights noted above, one of the most positive things about the last year is the wonderful time that I have had. I have enjoyed participating in all aspects of GSH activities. I think we all can appreciate any job that is so much fun!

The GSH has certainly had an eventful year. Of course, the most consequential event of the past year was Hurricane Harvey. The GSH office was closed for over two weeks due to flooding in and around our office building. The elevator in the office building was out of order for almost ten months. Due to flooding and general chaos in the city, we had to cancel two events and reschedule two other events. This could have been much worse if the hurricane had occurred another time. Then, of course, the hurricane put into doubt whether the SEG Convention could occur. But thanks to many local geophysicists, the convention was a huge success. In conjunction with the SEG and the convention, our Icebreaker at St. Arnold's Brewery was also a big success. We will do that again. The GSH had another very successful year of technical and social events. The Symposium, honoring Dave Hale, and six webinars were certainly highlights according to the very positive feedback. We have continued our new efforts to aid some of the unfortunate unemployed geophysicists in the area. We are currently looking at new ways to further this assistance. The GSH is also looking at new ways to connect with the many young professional geophysicists in the area who are not currently affiliated with our professional society. In these difficult times for our industry, not everything was positive, of course. Financially we are having to be cautious, but we have not eliminated any functions to save money. We have lost some membership, but other local technical societies have remarked that they wished they were doing as well as the GSH.

Bottom line, we have had another very successful year at the GSH. And we have only been able to be so successful thanks to the numerous volunteers who have contributed their time, money, and care to our society. I want to offer some sincere thanks to some of these stalwarts of the GSH. First, I want to give a special thanks to Karen Blakeman and Kathy Sanvido, who maintain our office and the day to day running of our organization. Though they are paid staff, they perform way beyond the call of duty due to their love and dedication to the GSH. Naturally we all owe an immense debt of gratitude to my fellow officers of the GSH. They have all stepped up in support of me and you, and their enormous dedication keeps this organization functioning. I want to give a special thanks to the many speakers who have made presentations at our numerous technical events. Without the high quality of these presentations, there would be little interest and participation in the backbone objectives of our society. Of course, I appreciate so much the financial contributors to our Society. Without these contributions from both corporate sponsors and individual contributors, we would not be able to provide the technical enlightenment or fun social activities through which most of you know the GSH. I also would like to thank the many participants that attend our social and technical events. We hold these events for you, but you do not have to come; it is your active participation that makes all these efforts worthwhile. But most of all, I want to thank the many volunteers that make the GSH deliverables available to the geophysicists of our community. These volunteers include our officers and staff, but there are many others that step forward (or work in the background) to help make everything happen. We are a volunteer organization that is successful only because there are people that are willing to give their time and effort for others. Thank you to you all.

Thank you for a wonderful year!!! May next year be even greater!!!

Looking for more ways to participate in the Geophysical Society of Houston?

Consider how you can make a difference by volunteering at one of our events!

Contact Nicola Maitland to learn more about this excellent networking opportunity:

nmaitland@resolvegeo.com - 713-972-6209

Dear GSH Journal reader,

Please, feel free to contact any of us with any and all questions or suggestions that you can come up with.

editor@gshtx.org

Sincerely,

Dmitry Kulakov, Editor

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From the Other Side

By Lee Lawyer

If you didn't get to attend the Spring Symposium this year, you missed a real treat. But what makes this any better than last year's Spring Symposium, you ask? Good question. I thought last year's symposium was great also. Last year we had a topic that was distinct from other forums. It was Acquisition. As I recall, I said to myself, "Oh hum" what's new with Acquisition. I had a lot to learn.

This year the topic was, "Sharper Imaging: Case studies highlighting advances in seismic acquisition and processing that impact drilling decisions on and offshore." Oh hum, I thought. Here is a long title that covers the entire field of Applied Geophysics. (I will discuss the reason for the capitalized word, Applied.) I had a lot to learn. Last year we had two honorees. Dave Monk and Malcolm Lansley. Interestingly, both presented papers on Acquisition. This year we had Dave Hale, lately from Colorado School of Mines. Dave didn't present a technical paper but he delivered a great acceptance speech. He is walking the Continental Divide Trail (Hiking, that is.). I will keep track of him and keep you informed of his progress. (He is a former Chevron.)

A similarity between the two symposia is the Challenge Bowl. Oh hum, I thought. I won't know the answer to any of the questions. I was accurate with that prediction. My brain does not work fast enough to come up with the right answer in the allotted time. Give me a day or two, no big deal. Peter Duncan started Challenge Bowl several years ago. It is a competitive question and answer program, structured so that the winning team gets a free trip to the next SEG Annual Meeting where the final Challenge Bowl of the fiscal year is held. This year it is a trip to Anaheim California. Would you believe me if I told you that we had some difficulty encouraging student participation? No team from UT, TAMU, or Rice. Are the students aware of the first prize? An all paid trip to the next SEG Annual Meeting? Beyond belief. I blame the faculty at these Universities for not promoting the competition.

We have a unique style for the symposium, which was initiated by Phil Schultz several years ago. The speakers are invited. The length of a presentation is one hour. The presenters limit the presentation to about 30 minutes or so, leaving a lot of time for questions and answers. Often the Q&A is more interesting than the presentation.

I always cringe at the term "Applied" geophysicist. It is not new. It has been around for 20 years or more. I can see no reason to modify or denigrate a geophysicist. Surely, no other professional Society does that. I was there when it was decided to hang that adjective around our necks. I would wager a large some of money that there is not one geophysicist who answers the question, "What do you do?" with, "I am an APPLIED geophysicist", implying that there are "real" geophysicists out there somewhere. We don't know how to be a geophysicist. All we do is apply someone else's ideas and techniques. Bah! He just applies technology and on and on. I hope the GSH realizes the basic technology involved and refuses to limit us to "applied" geophysicists. Some of us acquire data. Some of us process data. Some of us convert data into geologically meaningful information. Some of us do all of that. Some of us acquire PhDs from Stanford (Dave Hale). Of course, we apply our knowledge and skills to the objective we are seeking. You think I am too emotional about this subject? What difference does it make? I guess AGU members should be called, "Unapplied geophysicists".

Thanks for reading this far. The GSH is always looking for new and better ways to serve the membership. That sounds sort of funny. We, the membership, are the GSH. The SEG CALLS THEMSELVES "A MEMBER DRIVEN SOCIETY". The GSH *IS a* member driven society. We have two staff positions and they do a great job but all of the other stuff is done by members. I have written FTOS for over 24 years. Multiply that by 12 to get the number of columns. I know, some are better than others. But that is because you didn't drop me a note. Any comment is a good comment. I may use an anecdote or story about doodlebuggers. The SEG is "rebuilding itself". They are global. They say that there are more members outside of the US than inside. The GSH is local. It is a group that has banded together to exchange ideas through meetings and publications. We have no aspirations toward expansion into other areas (Sugarland could be our next target). Our financials are good (sort of). We are happy.

Rock Physics SIG

Deciphering the Electrical Conductivity of Inorganic Shale

Register for Rock Physics

Speaker(s) James T. Krushin, Consulting Geologist

Sponsored by CGG & Ikon Science

Wednesday, June 6, 2018
5:15 p.m. Refreshments
5:30 p.m. Presentation Begins
6:30 p.m. Adjourn

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

James T. Krushin

Abstract:

About 70% of a sedimentary basin is composed of shale. The term "shale" is used here as a general classification of predominately fine-grained clastic rocks, without regards to laminations, fissility, or anisotropy. Unlike the many recent resource investigations of organic shales, the electrical properties of inorganic shale are rarely studied. One important, commonly used, industry application of inorganic shale electrical resistivity (i.e., inverse of conductivity) is to infer compaction and pore pressure. Typical petrophysical parameters controlling bulk rock electrical conductivity (Co) of clay-rich rocks are porosity, formation factor, pore water conductivity (Cw), and bulk cation exchange capacity (CEC). The porosity variable must be integrated onto a compaction model. These parameters should be accounted for when utilizing resistivity logs for shale compaction and pore pressure interpretation. Because of the inherent low permeability and swelling nature of shale, measuring bulk electrical conductivity with variable brines and maintaining constant porosity is extremely difficult and impractical. A petrophysical reinterpretation of published soil lab-studies are used as a surrogate for shale bulk conductivity response with different brine salinity. These studies show pure clay and sand/clay mixtures saturated with various brines and water contents, i.e., saturated porosity. For each sample, they measured the resulting electrical conductivity. A typical shaly sand response would show bulk conductivity (Co) increasing as the saturating brine conductivity (Cw) increases. In stark contrast to the typical shaly sand response, the soil data, here treated as shale, show no change in Co, as the saturating solution is varied from 800 to 8,000 ppm NaCl. An additional published study suggests these brines are representative of bulk water in natural shale. This constant Co, with varying Cw, is attributed to the electrical buffering effect of the exchangeable cations (CEC) in the shale. As the saturating brine salinity increases, more of the exchangeable cations migrate from the more mobile diffuse layer to the electrically less mobile Stern layer and vice versa. The net effect is a constant Co. These results are integrated with a thermodynamic-based shale compaction pore pressure model, which accounts for effective stress, temperature, and variable shale lithologies. This study increases shale compaction understanding and therefore aids with basin modeling, pore pressure and seismic interpretation, and increasing drilling safety and efficiency.

Biography:

Jim Krushin is a consulting geologist/petrophysicist with 35 years of experience working both domestically and internationally in the spectrum of single-well petrophysical interpretations, integrated field studies, and company appraisals. Prior to working as a consultant, Jim worked at the extinct Gulf Research and Development, Harmarville, PA and Amoco Production Company in Tulsa, OK, and Houston, TX in exploration/development and research. His interests include quantifying reservoir and seals' petrophysical properties by combining core data with well logs. Recently, he developed a thermodynamically-based shale compaction/pore pressure model by utilizing water sorption isotherms. He continues to unravel some of the mysteries of inorganic shale by applying oil and gas petrophysical techniques to engineering studies of soils and clays.

Jim has both a BS and MS degrees in geology from the University of Pittsburgh and also is a graduate of Amoco's yearlong Petrophysics Training Class, where his interest in the petrophysical properties of shale was piqued.

Microseismic SIG

New Look at Old Data: Considering The Effects of Mechanical Stratigraphy On Future Treatment Design

Register for Microseismic

René Mott

Orlando Teran

Speaker(s): René Mott, Sr. Geophysical Advisor, Enervest Operating, LLC
Orlando Teran, PhD, Sr. Structural Geologist, MicroSeismic, Inc.

Thursday, June 7, 2018
11:30 a.m. - 1:00 p.m.

Presented by Enervest Operating, LLC and MicroSeismic, Inc.

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

Abstract:

Mechanical rock layers above and below reservoirs can have a difference on reservoir performance. In this study, we reevaluate a microseismic dataset from a pad of lower Barnett wells in northern Ft. Worth basin. The re-look objectives were to understand the mechanical conditions that favored out-of-zone growth using microseismic fracture plane solutions.

Biographies:

René Mott,
Sr. Geophysical Advisor, Enervest Operating, LLC

Rene' Mott received her B.S. (1982) in Geophysics, and a Masters (1996) in Sedimentology from University of Texas at Dallas.

In 2011, she joined EnerVest, Ltd, as Senior Geophysical Advisor where she is working on onshore exploiting oil and gas fields with an integrated team of Geologist, Petrophysicist and Engineers.

Her areas of interest include structural and stratigraphic interpretations with attention to fully exploiting the waveform for attributes and rock properties to discover or increase production.

She has published publications on topics from visualization, interpretation workflow, risk reduction, seismic attributes, azimuthal, 5D interpolation and reservoir characterization. She is an active member of SEG, AAPG and local geoscience chapters, HGS and GSH, in Houston, Texas.

Orlando Teran, PhD,
Sr. Structural Geologist, MicroSeismic, Inc.

Orlando is currently responsible for the completion geomechanics analyses using microseismic data at MicroSeismic, Inc. He started at MicroSeismic in the fall of 2014 where he was first trained in seismic processing. Before joining MicroSeismic, Orlando pursued a graduate degree in geology in Baja California, where he lived on the beach and studied active faults and a modern earthquake rupture.

Orlando has a Ph.D. in Geology from CICESE in Ensenada, Baja California, Mexico, and a BA in Geology from Western State Colorado University in Gunnison, Colorado.

He has co-authored articles published in Science and Nature based on his contributions to advancing the understanding of earthquake ruptures.

Awards Banquet 2018

In Honor of Joe Dellinger

In Honor of Amy Rhodes

Honors and Awards continued on page 11.

Honors and Awards continued from page 10.

Honors and Awards Banquet 2017 - 2018

Thank you everyone who attended the Geophysical Society of Houston's Annual Honors and Awards Banquet. It was a wonderful evening celebrating the heroes who have made significant contributions to our Houston-based community and the geophysical community as a whole. This elegant evening was made possible by the following generous sponsors: BP and Seitel as Titanium Sponsors, ConocoPhillips as a Platinum Sponsor, Resolve GeoSciences, Inc. as a Silver Sponsor, and Actus Veritas Geoscience, Bill Barkhouse and Lee Lawyer as Bronze Sponsors.

Almost one hundred attendees were present to honor their colleagues or to be honored at Hotel Sorella in City Centre. The evening unfolded with cocktails (courtesy of Seitel), followed by a seated dinner and a presentation by SEG President-Elect Rob Stewart on the state of the SEG. Tommie Rape, outgoing president of the GSH presented a recap of the significant highlights and lowlights of the last year.

Nancy House, current SEG President, presented the SEG Awards to 25, 50 and 60 Year Honorees. Tommie Rape then presented 25, 50 and 60 Year certificates to the long-term GSH members. The GSH Honorary Membership Awards were then announced; Honorary Memberships are awarded to an individual who has made a distinguished contribution to the geophysical profession. Nominations for this award require unanimous approval of the Board of Directors of the GSH. Both Katya Casey and Joe Dellinger were in attendance to receive this honor.

Honors and Awards continued on page 12.

Honors and Awards continued from page 11.

Honors and Awards Banquet 2017 - 2018

Life Membership is awarded to individuals who have performed exceptionally meritorious service to the GSH. These awards also require unanimous approval of the Board of Directors of the GSH. Glenn Bear was in attendance to receive his Life Membership Award, and though Amy Rhodes was unable to attend, she was recognized for her contribution as President of the GSH in 2016-2017.

Tommie Rape gave out Presidential Awards to Scott Petty Jr., Dick Baile, and Lee Lawyer; these three individuals stepped up during difficult financial times to provide a substantial monetary contribution to the Geoscience Center, along with an incentive to encourage other contributions through the Geoscience Center Challenge.

To close out the evening, the outgoing Board of Directors was honored for their service and presented with a plaque commemorating their long service to the GSH. The following members of the outgoing board were felicitated: President: Tommie Rape, First Vice President: Xianhuai Zhu, Second Vice President: Katherine Pittman, Secretary: Lillian Comegys, Treasurer: Katie Baker, Editor: Dmitry Kulakov. The incoming board were introduced to the attendees: President-Elect: Craig Beasley, First Vice President-Elect: Peter Wang, Second Vice President-Elect: Kenneth Mohn, Treasurer: Gabriela Suarez, Secretary: Sara Davis, Editor: Dmitry Kulakov.

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Honors and Awards continued from page 12.

Congratulations to our Honorary Membership Awardees
Honors & Awards Banquet 2018

2018 Honorary Membership Awardee Katya Casey

Katya Casey holds a Master of Science degree in Geophysics from the University of Houston. Katya started her career with the Russian Academy of Sciences in Moscow and continued it in the United States where she worked for Amoco Petroleum, Vastar Resources, BHP Billiton, Apache and Murphy Oil companies. Currently she is one of three managing directors at Actus Veritas Geoscience, LLC

She developed and applied a new method of iterative interpretation of geophysical and regional sub-surface data with plate tectonics reconstructions and integrating results into petroleum systems analysis.

She is known in the petroleum industry for designing and implementing multiple geoscience technologies and innovations including an early adoption of ArcGIS into oil and gas exploration workflows.

She is adept at project definition and optimization of team dynamics. She provides mentorship and develops early career geoscientists and colleagues through publications, training, teaching, and industry forum presentations.

Katya is a respected technical speaker. She has coauthored papers and presented at multiple industry conferences and workshops. In 2008 she received an award in "Leadership in Technology" from the Association of Women in Computing.

2018 Honorary Membership Awardee Joe Dellinger

Joe Dellinger was born in the SEG home town of Tulsa, Oklahoma, and learned to ride a bicycle practicing in the Amoco Tulsa Research Center parking lot. Joe's father Tom Dellinger led a research group at the Mobil Field Research Lab in the 1970's-1980's, which coined the term "Extended Reach Drilling" to describe to management what it was they were doing.

With this background, it is not surprising that Joe majored in Geophysics at Texas A&M. He received a PhD in 1991 from Jon Claerbout's Stanford Exploration Project. He then did a 3-year post-doc at the University of Hawaii before joining Amoco in Tulsa in 1994. He moved to BP in Houston in 1999 and has worked there since.

In his career he has specialized in Anisotropy, multi-component algorithms and processing, and most recently "looking for useful information in data that would normally be ignored", which he calls "Forensic data processing". This was the subject of Joe's Spring 2016 SEG Distinguished Lecture. (If you missed it, the complete talk is available for free on the SEG website.) Examples include studying the 2006 "Green Canyon" earthquake, investigating how the Valhall Ocean-bottom-cable array might be used between seismic surveys, and characterizing sources and noise in deep water ocean-bottom Gulf of Mexico data. All of this was excellent preparation for his main work of the last few years, redesigning seismic acquisition for the purpose of velocity-model building in areas of complex geology using FWI.

Joe was awarded life membership in the SEG in 2001 for his services in helping the SEG to successfully adapt to the internet age, and honorary membership in 2016 for continuing to serve the SEG after 2001. Joe's hobbies include attending the Houston Symphony, photographing birds, recording frog calls in the swamps around Houston, and astronomy at the George Observatory. Asteroid "78392 Dellinger" was named in his honor.

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Congratulations to our Life Membership Awardees
Honors & Awards Banquet 2018

2018 Life Membership Awardee Amy Rhondes

Amy Rhodes received a B.S. in Geophysical Engineering and a M.S. in Geophysics from Colorado School of Mines. She completed her thesis research in rock physics under Dr. Mike Batzle on the chemical and acoustic properties of heavy oil. Upon graduation, she relocated to Anchorage, Alaska to work as a geophysicist for ConocoPhillips.

Since joining ConocoPhillips in 2006, Amy has been blessed to work in a variety of roles including seismic analysis and modeling, Alaska North Slope development and operations, and DWGOM exploration. In her last position, she transitioned from geophysics to a development supervisor role in the Permian Basin in Texas. In her current role, she is a development supervisor for the Kuparuk Satellite fields on the North Slope of Alaska.

In addition to her technical work, she is involved in ConocoPhillips University Relations as a University Partner at Colorado School of Mines and sits on the ConocoPhillips Geoscience Intern and New Hire Decision Panel. She is passionate about STEM outreach and developing diverse talent in geophysics. She served on the Board of Directors for the Geophysical Society of Houston as Treasurer in 2014-15, Finance Committee Chair in 2015-16, President in 2016-17 and she currently serves as Past President.

During her time on the GSH Board of Directors, she worked with the Finance Committee to improve annual budget processes and financial tracking tools. She was also proud to champion new events aimed at increasing the diversity of the members who actively participate in the society's events. The inaugural GSH Diversity and Women's Networking Event was held in May of 2016 with a distinguished panel speaking about professional career development. During her presidency, the society offered two Diversity and Women's Networking Events in November of 2016 and May 2017. She has encouraged diverse candidates to run for positions on the Board of Directors and has been an outspoken advocate for professional recognition of diverse candidates by our society.

2018 Life Membership Awardee Glenn Bear

Glenn Bear has a BS in Geology (Bowling Green State University, 1989), an MS in Geophysics (Indiana University, 1992) and a PhD in Geophysics (Indiana University, 1997). While in graduate school, he worked for BP, Chevron, and Mobil before settling in at Exxon Production Research in 1997. From 1997 to 2002, he worked on imaging and illumination issues around salt bodies. In 2002, he transferred to ExxonMobil Exploration Company to develop subsalt prospects. In 2003, he transferred to the Upstream Research Company and focused on commercializing internally-developed technologies. In 2007, he became the Team Leader responsible for applying ExxonMobil's controlled-source electromagnetic technologies around the world, and transferred back to ExxonMobil Exploration Company to continue this work in 2010. In 2011, he became the Geophysical Advisor responsible for ExxonMobil's seismic data acquisition and processing technologies, both internal and external. In 2014, took on the role of Skill Area Coordinator for ExxonMobil's seismic data processors deployed around the world. Earlier this year, he moved back to the research company and is now the supervisor for a group developing and applying time-lapse seismic methods.

Glenn is a 28-year member of SEG, having been enticed to join by the promise of available scholarships for geophysics students. He is a volunteer instructor for the Student Education Program, and an SEG Foundation Sustaining Trustee Associate. He is also an active member of the CSEG, EAGE, the Houston Geological Society (HGS) and the Geophysical Society of Houston (GSH). Glenn's long service to the GSH includes serving as editor of the GSH newsletter, 1st Vice President, and President.

When not working for ExxonMobil or volunteering for the SEG and the GSH, Glenn spends his time volunteering with the Boys Scouts of America, building homes with Habitat for Humanity, and singing with several choirs. He and his wife Lorie (also a geophysicist), have two sons that both appear determined to defect from geophysics and become engineers or economists or anything that doesn't involve rocks.

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Announcing the GSH 2018 - 2019 New Officers

President Elect
Craig Beasley

1st VP Elect
Peter Wang

2nd VP Elect
Kenneth Mohn

Treasurer
Gabriela Suarez

Secretary
Sara Davis

Editor
Dmitry Kulakov

Congratulations to our newly elected Officers!

President's Award Winners

Our honorees have exhibited outstanding generosity by funding matching donations to the GSH Geoscience Center from the GSH population.

Scott Petty Jr.

Dick Baile

Lee Lawyer

25 Year GSH Honorees

Lynn Boone
Timothy Brickner
E. Marie Henry
Doug McCowan
Steven Peterson
Don Robinson
Kathy Roldan
Gene Womack

50 Year GSH Honorees

Wilburn Albers
Sharon Macha
Louis Schneider
James Sherar

60 Year GSH Honorees

James Grigsby

Models for Seismic Imaging – A Discussion

Norman S. Neidell

In the real world, the laws of physics govern the behavior of events and processes, and our understanding of these laws is always incomplete, at least in certain or some aspects. Hence we build models of those events or processes nevertheless, to embody what understanding we do have. While our models can successfully and even accurately predict behavior to a degree, we basically understand that they are not all inclusive nor perfect in their operation. If we mistakenly believe that a model truly represents reality in all aspects, and use it to guide information capture and various processes and procedures, we can often unnecessarily limit progress toward some of our desired goals. Some such objectives may even be deemed unattainable. Yet when alternate models can help us accomplish such goals, confusion and even hostility may be encountered. This is precisely the case with the imaging of exploration seismic data.

We shall see that currently, there are three differing models most used which underlie the imaging of exploration seismic data for practical use. Each of them has different advantages, equipping each to address some facets of the physical reality. For example, we mainly use the particular and common seismic method to image in sedimentary basins, where we hope to find trapped accumulations of hydrocarbons. These environments are generally layered consisting of sequences of differing rocks with depth and some additional variations or "structural" complexity. The boundaries of these rocks separate differences in acoustic properties, and hence are expected to produce what we call reflections.

If we have a source and receiver on the surface, and we receive and record what we call a reflection, then according to a layered earth model of the subsurface we have to have a reflector at an appropriate depth below. This is the model at this time most commonly used for imaging exploration seismic data. Reflectors are a feature of our usually selected layered model. A companion idea is that our source has a signature acoustic waveform (wavelet) which is related to the character of the recorded reflection, and we then further worry about the character and travel of this waveform, which constitutes yet another imposed model.

From such usual thinking, for any particular source-receiver pair, we believe that there is one particular region on each reflector contributing more energy than anywhere else on it. This is of course true. For each source-receiver pair, we credit a different region as giving rise to the reflection, unless they include a common point of symmetry (to some approximation as in CDP or common reflection point trace collections). All these high energy regions collectively define the reflector according to our model. The presumed waveform also defines the reflection character and the resolution by which we describe the reflection.

The result of such thinking has been positive and quite profound, producing excellent results enabling many economic discoveries of hydrocarbons. Accompanying these contributions have been some related limiting conditions, based on an over-reliance this model. First, the image itself as produced is not actually of the subsurface, but of reflections from the subsurface limited in frequency, from which the subsurface must be interpreted.

Next, we would be led not expect any benefit from imaging at subsurface locations other than those relating to the survey sampling design, since we are trying to use only and all reflector elements having the highest energy contributions. Also, owing to the waveform and Nyquist limits, we believe there would likely be little benefit in terms of resolution for finer time sampling, particularly at greater depths, since higher frequencies are preferentially lost owing to propagation effects. Such considerations related to the layered-earth model are usually not explicitly recognized or stated.

Figures 1A and 1B show a 2D model earth having one well-defined reflection point or diffractor. On the surface are one source and two receivers. In one instance we use raypaths to define where the reflection and diffraction originate. For the second view, following with Huygens's ideas we introduce a wavefield from the source and bounce it off the point reflector, and it too has an effect on both receivers, but also everywhere. This again is a model, but perhaps closer in approximation to the physics involved. The returning wavefield would be seen everywhere at the surface.

By starting with more realistic physics, but taking a different view, when we inject wavefield energy into a subsurface volume of earth-like materials, whatever its form (initially unknown), we expect wavefield illumination over time to reach everywhere within such a volume. Consequently,

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

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Figure 1a: Single diffraction point model, ray theory view with emphasis on reflections

Figure 1b: Single diffraction point model, wave theory view. Diffraction wavefield returns everywhere. Amplitudes and time vary but weaker returns are greater in number.

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we expect some energy to return from everywhere – not all contributions of equal strength of course, but nevertheless in very great number. If we use a representation of the subsurface as point reflectors (also called point diffractions), having amplitudes scaled as relative reflectivity, a "reflector" as described by the previous Figure using rays, under this point-based imaging approach would appear as a contiguous grouping of strong returns, and look much like a reflector on a normally processed seismic section. However, this is not an image of a wavefield for interpretation of the subsurface, including a wavelet, but rather an image of relative reflectivity of the subsurface medium itself. Such image can be better defined, since it draws more widely on the captured wavefield information content, and does not include the limitations of propagating wavelet.

Before we go further with comparing results, it is important to better understand the character of reflections from geologic boundaries. This is addressed in very general terms by *Figures 2A*, *B and C*. There are three conditions illustrated, taking these largely from the work of Neidell (1993). For some boundaries related to sea level changes, the geologic time lines and the changes of lithology do not coincide. Such boundaries have higher depositional energy with both some vertical grading of rock materials and also variations over the Fresnel zone from which the reflection is derived. Such deposition typically consists of coarser grains, good porosity and good reservoir possibilities. These circumstances described many of our industry's prized objectives for many years. Such reflectors having this nature, and as a practical matter, have a time frequency description for coherent components which rarely goes beyond 60 -90 Hz.

Still other reflectors we record have other properties. Low energy Shale developments, pelagic Carbonates, and others have sharper, well-defined boundaries. These may require their coherent elements be described using hundreds of Hertz. If we limited our effective seismic frequency range to perhaps 125 Hz, these could be described inadequately and only in gross general terms. This category we now see embodies also, many of our currently prized unconventional reservoirs.

As a last consideration related to reflectors we note an example of a thinning, but everywhere well-defined boundary which changes greatly, but within the spatial dimension of the Fresnel zone. Any single well penetration would indicate a sharp boundary, but the seismic expression owing to the Fresnel zone averaging would suggest a gradational change characterized by lower frequencies. We see here that the spatial scale of variation can strongly affect frequency properties as observed for the seismic time signature.

Returning now to our point diffractor model, the model data no longer includes only contributions from points from which we expect reflective returns,

Figure 2a: Geologic model 1. Transgressive shoreline with rising sea level showing development of sand unit A. (Reproduced from Neidell, 1993)

Figure 2b: Geologic model 2. Marine carbonate deposition with rising sea level. (Reproduced from Neidell, 1993)

Figure 2c: Hypothetical productive sand body with electric logs. Curves to right show acoustic impedance signature and effective seismic signature at well B when distance D is smaller than Fresnal zone diameter. (Reproduced from Neidell, 1993)

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but all points. We then have many more of such imaging points than our layered earth model would have us consider. Since we are directly imaging relative reflectivity, there is no need for a wavelet as would be the case for usual reflection imaging. Without a wavelet and choosing point reflectors more closely spaced in time, limitations, as imposed by Nyquist sampling, are relaxed and much higher frequencies as necessary to describe some boundaries in the subsurface can be well represented.

Hence a subsurface image unlike a wavefield image from the layered model has frequency and wavenumbers as determined by the character of the subsurface boundaries, and not by acquisition sampling or Nyquist limits. Providing adequate image sampling locations permits recovery of frequencies and spatial resolution as needed having great detail (as for example in the hundreds of hertz), but only where they are present, and with some spatial continuity. (See Neidell work on Undersampling our Seismic Images, 2018).

Since the procedure described is actually imaging the subsurface directly in terms of relative reflectivity, the specifics of the wavefield illumination nature are of lesser importance. So long as the illumination is approximately constant, the reflectivity would be seen in relative terms from point to point. Acquired seismic data from a survey becomes a "wavefield capture", and the image volume is considered to consist of point reflectors or voxels. The paramount issues now are: What are the dimensions of an appropriate voxel or point reflector? And, How many of such elements should there be? The answer lies with the information content of the acquired data, signal/noise considerations and total amount of the data.

Dr. Elmer Eisner (1998) in a publication related to these imaging ideas proposed a simple answer. According to his reasoning, if we would have in an acquired data set 10 million data samples, and we ask only 100,000 image points in our image volume, the 100 to 1 ratio suggests that our image samples would be quite reliably determined. However, looking at an alternate and more restrictive model, we may be defining only 10,000 image points, offering only a coarser and less detailed view of the same volume.

Using point diffractors, the images obtained from standard seismic data sets can have many more samples as compared to images developed from standard processing using ideas about a layered earth and a wavelet. Counting increased sampling in both spatial coordinates and time, the number of well-determined samples may reasonably be from 8 to 64 times greater than normally obtained. This specific number becomes a processor and, or interpreter choice, depending also on the computing costs. The additional image points represent valid information not from a wavefield image derived from reflection points as favored by conventional imaging, but rather a subsurface image, with data points aggregated with fidelity from a very large number of diffractive contributions, using, of course, an appropriate imaging procedure.

As for reliability, at the denser imaging sampling levels, as noted, the answer rests with the data information content, noise levels, survey multiplicity, etc. For virtually all competent surveys, however, sampling increases of from 8 to 16-fold can usually be routinely obtained. A new reasonable standard now appears to be 1 ms time samples, and spatial bins of ¼ or 1/8 the current standard.

The point reflector subsurface model and relative reflectivity image as described above was introduced by Neidell (1997) with supporting commentaries provided by Dr. Eisner as noted, and also Professor Enders Robinson (1998). Professor Robinson noted that since the concepts of Holography also view imaging as a superposition of point reflectors, the analogous seismic imaging method can also be referred to as Holographic. Optical holography however used analog procedures as a practical matter, since a digital implementation (as for the seismic case) would need nanosecond sampling, and introduce prohibitive requirements for hardware performance and digital computing.

Owing to the relaxation of both survey and Nyquist constraints associated with using the point

Figure 3: Seismic expression of Reinecke Field. Legacy imaging (right) and HPR imaging (left) of available 3D data. Composite inversion is needed to see cyclic deposition. (Reproduced from Neidell and Charuk, 2018)

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diffraction model, it may also be appropriately called Highest Possible Resolution or HPR Imaging. We should emphasize again, that the usual constraints imposed by acquisition geometry have been removed, as has the importance of a waveform, Nyquist limits, aliasing, and other such limiting criteria, which had to be introduced only in consideration of the layered earth reflectivity model.

Figure 3 compares a conventional image and an HPR image formed from the same data acquisition, but the HPR image includes 4 times as many time samples and twice as many traces – 8 times as much data. The feature indicated is the Reinecke Reef Field (Bordon County, Texas) discovered initially using standard methods many years ago.

Hence, the layered reflective view is not only undersampled but does not use all the available information in the original seismic survey. It calls only fewer source-receiver pairs (having larger contributions) related to specific geometries. It does not use the full energy and information content available in the recorded wavefield, as does the HPR method. Hence we have for HPR superior imaging both in terms of energy and signal/noise, because the full wavefield is involved for every image point, of which there are a very great number. The nature of the images obtained as previously noted have some similarity, but also noteworthy differences.

The high energy form of the reef top has likeness and would not be overlooked in either image. Hence this accounts for early discovery using older exploration methods. Yet the lower energy cyclic deposition of the basic reef structure cannot be discerned from the wavefield image. While the detail presented by the Holographic image suggests more information, the standard data presentation as employed is not particularly effective. This issue must be addressed further.

Another matter of interest, the Kirchhoff Migration routinely used in standard imaging (and also for correctly positioning events) has computational similarity to the diffraction imaging. However, it is only applied at selective locations as discussed, and often includes elements which preserve the hypothetical waveform, further introducing unnecessary resolution limitations. Hence the standard imaging is, in fact, correct, but indirect in producing a wavefield image (rather than relative reflectivity), nor does not it fully embody the available data information content.

HPR or Holographic seismic imaging is so rich in extended information content that standard displays cannot fully represent it. Newer displays using color and concepts involving Extended Visual Dynamic Range (EVDR), or some equivalent capabilities are needed. These have been described and documented with many examples elsewhere in the literature (see References).

Figure 4 shows details of the Reinecke Reef using such an EVDR display, and how they may be related to cyclic sea level changes determined from geologic data (see Neidell, 2018). The color plot is a Composite Inversion including a low frequency velocity trend derived from detailed high resolution velocity information. Adjacent color changes indicate 400 ft/s steps in velocity. Pink and green denote the porous Reef Carbonates. The basal Carbonate below showing colors of red and mustard has very high velocities reaching 22,000 ft/s. Detrital material surrounding the Reef is a higher velocity Clastic, but with velocities about 2000 ft/s less than the Reef Carbonates.

It is interesting to point out that neither of the subsurface models (layered reflectivity or point reflectors) as just described, can image non-reflectors such as near vertical faults or fractures, which of course do have seismic expression. For both methods, the presence and nature of faulting, for example, must be interpreted as discontinuities of otherwise continuous formations.

There is yet another method of modeling the subsurface having specific application to imaging of such features. This is called diffraction imaging. These diffractions unlike the point reflectors previously introduced are edge diffractions. They do not have radial symmetry but vary greatly with direction. In order for effective diffraction imaging of this type, all reflections are typically removed. The goal is to represent only the discontinuities which describe faults as planes or curved surfaces usually standing close to vertical. A short exposition of why we need diffraction imaging was offered by Neidell (2017).

Many of the most astute industry technical leaders are addressing this application, and some effective commercial products are presently available. As noted at the start of this discussion, we are seeing here a model which relates only to a special class of subsurface features, which we wish to see and clarify with greater fidelity. Hence, we should not lose sight of underlying models noting, in particular, their advantages and limitations. We should be cautious however in how we view them though, as over-reliance can unintentionally limit both our understanding and future progress.

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Core Logs from Reineke Field treated the reef as continuous unit with varying lithology. The HPR derived composite inversion image Clearly shows at least 5 cycles of reef deposition.

Figure 4: Reinecke Field montage, Borden County, Texas. Upper Left: Early concept of stratigraphy from well information. Lower Left: Cyclic deposition seen from composite inversion and correlated with geologically defined sea level cycles (seen on sea level curve on right). (Reproduced from Neidell and Charuk, 2018)

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Permalink: https://doi.org/10.1190/segam2017-17632715.1

GSH Outreach

Committee Activities *By Lisa Buckner*

On Saturday, April 14th, Mac Hooton, Patricia Henderson, Liqin Sang, and I hosted a career exhibit booth at the annual **Scout Fair at NRG Arena**. There were 69 booths visited by Boy Scouts and Girls Scouts of all ages, their troop leaders and their families. At least 10,000 people attended the event. The younger children played the Drilling for Oil game. Some remembered playing it at one of the events at the Houston Museum of Natural Science. We explained geophysics to the older students using a coiled toy spring to demo wave motion and an interpreted seismic section. We also had crude oil samples, one black and the other orange (sulfur). Mac brought some rock hand samples to pick up and examine with the geophone connected to his phone to display waves like an oscilloscope. People were also attracted to our booth by the light animated seismic acquisition survey poster which we explained to them along with a cut-away geophone. We distributed "Earth is Calling … will you answer?" brochures and 750 GSH coiled toy springs. Our booth experienced a non-stop stream of visitors from 9:45 AM – 3:00 PM. If you are interested in volunteering at this event **next year, mark your calendar for April 6, 2019**.

In the next issue, I'll report about the **Reach for the Stars! STEM Festival at Rice University**, **Roberts Road Elementary Science Night**, and two school career day events.

Enjoy the summer. I may be educating middle school students about geoscience careers at **San Jacinto College EnergyVenture Camps.** I will need volunteers to help at the **Earth Science Week event at the Houston Museum of Natural Science** on **Saturday, October 13, 2018** and **Energy Day** the following **Saturday, October 20, 2018 at Sam Houston Park (downtown)**. I will need to delegate more outreach event organization to others. Let me know if you are interested in developing some leadership skills.

Do you know of a school that has a career day seeking speakers, career fair or science night at which GSH might be able to host an exhibit booth? If so, please contact Lisa Buckner at lbuckner@hess.com and we can work together to bring awareness to the students of the many high paying and fun careers in the geosciences.

2018 Annual GSH Golf Tournament

By Wesley Tyrrell

On Monday, April 16, 2018, a total of 38 teams participated in the Geophysical Society of Houston Golf Tournament held at the Woodlands Country Club Palmer.

The day commenced with a **putting contest sponsored by TGS and won by Max Cunningham**. The 12 p.m. shotgun start began the 27 holes of golf which included contests along the way and **team photos by Resolve Geosciences**. Players had a chance to win a trip to the Fiesta Bowl with a Hole in One from Dixon Golf. Unfortunately nobody was able to win the trip but we did have a **Hole in One by** one of our sponsors, **Galen Treadgold with GeoInteriors**. Congratulations on the ace! We also had **Adam Majeski** not only **winning a long drive contest** but **also grabbing a closest to the pin. Other closest to the pin and long drive winners included Tom McEntire, Scott Layne and Trey Barnes.** Taking home the **Steve Tyrrell Memorial Trophy** with an impressive score of 54 **was the group of Matt Malouf, John Hull, Steve Lichlyter and Justin Vandenbrink.** Our **1st place Net team** was **the group of Daniel Baker, Dearl Benson, Neil Barrett and Conlee Eiker.** I imagine quite a few putts found the back of the cup between these groups, congratulations! The night concluded with dinner, an awards ceremony and lots of door prizes to go around.

The Geophysical Society of Houston would like to thank our **two tournament sponsors, Seitel and Dynamic Technologies**. These two sponsors are the main reason why we were able to enjoy such a great venue this year. We truly appreciate the continued support.

Special thanks to all of our **additional sponsors: TGS, Weir Consulting, Dawson Geophysical, Geospace Technologies, Katalyst Data Management, Oildex, Orica, Tricon, GeoInteriors, Cypress Lakes Golf Course, Precision Golf Academy, Beltway Seismic, Polaris E&P Services and Resolve GeoSciences.**

We also want to thank all of our volunteers this year. You did a wonderful job and the tournament couldn't have run any smoother. **Volunteers** included **Kat Pittman and Nicola Maitland from Resolve, Liza Yellott and Eve Gonzalez from Seitel, Gene Sparkman from Lumina Solutions, Bobby Perez from SEIMAX, Kathy Sanvido from GSH and Michael Zdenek from TGS.**

It was an honor to be a part of this special event and special thanks goes to Denise Dorsey for all of the help that she gave me along the way. I look forward to working very hard for next year's tournament and I hope to see you all out there.

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Golf Tournament continued from page 23.

2018 Annual GSH Golf Tournament

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PRECISION GOLF ACADEMY

Tutorial Nuggets

By Mike Graul

The Saga Continues

REFINING

Hope is alive and well

Golly Moses, what's he done with the language now!?!

It's called "Inverting English"

On our last visit together, we discussed the sad state and practicalities of **Inversion**. Prominent among the woes was the fact that there are too many unknowns (**impedances** in our case) for the number of observations (data points), which in this application are **reflection coefficients**).

$\rho_0 = 2.24$	$V_0 = 9000$	$Z_0 = 20160$	
$\rho_1 = 2.30$	$V_1 = 10000$	$Z_1 = 23000$	$R_0 = 0.066$
$\rho_2 = 2.271$	$V_2 = 9500$	$Z_2 = 21570$	$R_1 = -0.032$
$\rho_3 = 2.175$	$V_3 = 8000$	$Z_3 = 17400$	$R_2 = -0.107$
$\rho_4 = 2.119$	$V_4 = 7200$	$Z_4 = 15250$	$R_3 = -0.066$
$\rho_5 = 2.208$	$V_5 = 8500$	$Z_5 = 18770$	$R_4 = 0.103$

At the left is the model we concocted to illustrate the problems and solutions with inversion. Painful as you might find it, it will be useful to put information into **matrix form** to better understand the underlying principles and solutions. Recall that the *Tutorial Nuggets* provided a simplified guide to MatriSeis back in June 2013 continuing well into 2014.

We'll use the forward modeling for reflectivity, as shown at the right, expressed as a matrix multiplication to establish exactly what must be solved for determining Impedance.

$$R_{N+1} = \frac{Z_{N+1} - Z_N}{Z_{N+1} + Z_N}$$

Before we launch into this murky moonscape, let's consider how you would express $\mathbf{R_{N+1}}$ as a linear expression in **Z** values. Clue: not with these values, and not with the defining equation for $\mathbf{R_{N+1}}$. The problem is that the yellow box contains a division, and while simple enough, limits our ability to write an invertible matrix expression. We need the **all-forgiving Approximation Man.**

Example

$\rho_1 = 2.30$	$V_1 = 8500$
$\rho_2 = 2.50$	$V_2 = 9500$

$$R_{n+1} = \frac{Z_{n+1} - Z_n}{Z_{n+1} + Z_n} = .097$$

The Real Thing

$$R_{n+1} \approx .5\ln(Z_{n+1}) - .5\ln(Z_n) = .097$$

This **approximation** will allow us to write a linear equation relating Reflectivity and Impedance in **Matri-Speak**, and, in turn, write the inversion equation for impedance in terms of reflectivity.

Tutorial Nuggets continued on page 26.

Tutorial Nuggets continued from page 25.

Definitions for Example **Gm = d**: $m_n = 0.5 \cdot \ln(Z_n)$; $d_n = R_n$

$$\underset{G}{\begin{pmatrix} -1 & 1 & 0 & 0 & 0 & 0 \\ 0 & -1 & 1 & 0 & 0 & 0 \\ 0 & 0 & -1 & 1 & 0 & 0 \\ 0 & 0 & 0 & -1 & 1 & 0 \\ 0 & 0 & 0 & 0 & -1 & 1 \end{pmatrix}} \bullet \underset{m}{\begin{pmatrix} 4.956 \\ 5.022 \\ 4.99 \\ 4.882 \\ 4.816 \\ 4.92 \end{pmatrix}} = \underset{d}{\begin{pmatrix} 0.066 \\ -0.032 \\ -0.107 \\ -0.066 \\ 0.103 \end{pmatrix}}$$

In **forward** modeling (synthetic) we know **m**. For **inversion**, we know **d** and must find **m.**

$$m = G^{-1} \cdot d$$

The trouble here is that **G** is not square, and has no inverse. This means there are an infinite number **of impedances** that will produce the same **reflectivity.** How about a Least Squared Error (**LSE**) approach by creating the Normal Equations?

$$m = (G^T G)^{-1} \cdot G^T d$$

Seemed like a good idea, but alas, the $G^T G$ matrix, while square, is singular, again meaning totally ambiguous solutions and lots of them. This comes about because any sequence of impedances can be multiplied by a **scalar** and yield the same set of reflection coefficients. Give it a try. **WAIT-A-MINUTE!!** An idea is being born in the Gurraic Brain: not all of those **Z** sets make any sense! We know the **ρV** product won't be less than **5000** (g/cm3)(feet/s) as in water, and is unlikely to exceed **90000** even in a metallic world. As a matter of fact, if there are any near by wells or even some sensible estimates of lithology in the area, we can reduce the possibilities considerably! How, you ask? Easily. Just add a Constraint Equation that limits the range of impedances to something realistic – like the ballpark average of neighborhood **Z.**

$$\underset{Ga}{\begin{pmatrix} -1 & 1 & 0 & 0 & 0 & 0 \\ 0 & -1 & 1 & 0 & 0 & 0 \\ 0 & 0 & -1 & 1 & 0 & 0 \\ 0 & 0 & 0 & -1 & 1 & 0 \\ 0 & 0 & 0 & 0 & -1 & 1 \\ 0.167 & 0.167 & 0.167 & 0.167 & 0.167 & 0.167 \end{pmatrix}} \bullet \underset{m}{\begin{pmatrix} 0.5 \cdot \ln(Z_0) \\ 0.5 \cdot \ln(Z_1) \\ 0.5 \cdot \ln(Z_2) \\ 0.5 \cdot \ln(Z_3) \\ 0.5 \cdot \ln(Z_4) \\ 0.5 \cdot \ln(Z_5) \end{pmatrix}} = \underset{da}{\begin{pmatrix} 0.066 \\ -0.032 \\ -0.107 \\ -0.066 \\ 0.104 \\ 4.931 \end{pmatrix}}$$

The "**a**" means the original matrix has been augmented. The bottom row on **G** and **d** have been added to represent **adding** and **weighting** the **(.5)ln(Z)** values to equal a reasonable **Z-average.**

Solving either $m = (Ga^T \cdot Ga)^{-1} Ga^T \cdot da$ or $m = Ga^{-1} \cdot da$, we get the same answer, and a reasonable one. Given in transpose form (space saving) at the right.

m^T = [20160, 23000, 21570, 17400, 15250, 18770]

Do you wonder if this is how it's done by the Big Boys? Nope. There's a more robust method that will be revealed after your summer Hiatus

Tutorial Nuggets continued on page 27.

Tutorial Nuggets

Tutorial Nuggets continued from page 26.

Last Month's Puzzle

Shifty Stringer is a well known Houston gambler believed to use a dishonest coin or two to pad his pension. Most of the losers are geophysicists with a misguided sense of trust and probability. Your problem is to propose a game that will give you and Shifty a **50-50** chance of winning regardless of how the die has been loaded, that is how lop-sided the probability of heads vs tails. You are not restricted to a single flip. This little probability gem was first suggested by John Von Neumann, a master mathematician and top expert in game theory.

Shifty Stringer

Answer: Let's say Shifty's coin has been fixed by a coating of transparent Densi-lux on the Tails side. This heavy coating of invisible juice causes the coin to land on that face with a probability of 2/3. in this manner, the probability of Heads appearing on any given flip is P(H) = 2/3. (in his other pocket Shifty has a similar coin, but with Densi-lux on the Heads face.)

Your proposed game is this; on any two successive flips of the dishonest coin, one of you bets it will be H and T, the other bettor wagers it will T and H. What happens if on 2 successive flips you get H, H (or T, T)? Simply re-flip 2 times until they are H-T or T-H to determine a winner. Why is this a fair bet? Because the probabilities of H-T is the same as T-H. On 2 successive independent flips the possibilities where there is a change (about 44% of the time) are P(H,T) = P(H)P(T) = (2/3)(1/3) = 2/9 = P(T)P(H) =(1/3)(2/3) = 2/9.

The Summer Puzzle

3D Visualization

Top

Front

This brain teaser was used as a one question final exam for architectural students. The "Top" and "Front" views of a solid object are faithful to the rules of mechanical drawing, that is, an **edge** is shown as **a solid line,** and a **hidden edge** (internal or on the back surface) is shown as a **dashed line.**

Side View

Your assignment, due for the September GSH Journal, is to sketch the **side view** of this object.

Is your answer unique?

GEOSCIENCE CENTER

2017 – 2018 CHALLENGE

Challengers: Dick Baile, Lee Lawyer, Scott Petty, Jr.

Matching: John & Amy Aubrey, Frank Dumanoir, Dave Agarwal, Michael Forrest, Cheryl Mifflin, Michael Abrams, Bruce Blake, Martin Stupel, Raymond Abma, Bill Barkhouse, Kevin Bishop, Lisa Buckner, Emile Bussemey, Jerry Coggins, Sidney Conger, Peter Duncan, D W Frye, Kathy Hardy, Bob Johnson, Jim Medlin, Tommie Rape, Art Ross, John Sherwood, J. Haynie Stringer, Robert Wyckoff, Neil and Sharon Zimmerman, Bill Albers, John Bain, Ralph Baird, Karen Blakeman, Brian & Julie Burgess, James Farmer, Alan Foley, Taylor Galloway, Ashok Ghosh, Mike Graul, Ken Green, Pramod Kumar, Tony LaPierre, William Little, Dr. Walter Lynn, Robert Neese, George Parker, Paul Schatz, Michael Schoenberger, Don Singleton, Dave Smith, Zachery Van Ornam

Thank you!

Thanks to you, the Challenge has been met!

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 Living Legends. The GSH is a 501(c)3

Mystery Item

This is a geophysical item...

Do you know what it is?

This month's answer on page 33.

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SHEARWATER REVEAL

A Conversation With...

Ken Tubman

by Azie Sophia Aziz

I recently had the opportunity to interview Ken Tubman, vice president of Subsurface at ConocoPhillips, at the company's headquarters in Houston, Texas. We discussed his career, industry trends and the skills geophysicists need for the future.

Ken earned a Bachelor of Science in physics from the University of Massachusetts and a Ph.D. in geophysics from the Massachusetts Institute of Technology (MIT). Throughout his career, he has held various leadership roles in technology and other organizations, developing and applying innovative technical solutions to business problems.

In his current role, he is responsible for the central groups for geophysics, geology, reservoir engineering and petrophysics. The groups' focus is to develop and implement innovative solutions in the subsurface domain.

How did you end up working in the oil and gas industry?

Solving technical challenges with real business impacts has always appealed to me, and this industry has a lot of challenges. When I started my Ph.D. at MIT, I had not thought about working in oil and gas. My advisor actually pushed me to try a project modeling acoustic logging tools, which led me to doing summer jobs with oil companies. I really enjoyed getting to go to the field and trying different tools.

The breadth of challenges and opportunities in the industry is also very motivating. We can't see very far down the wells we drill, so I was really interested in exploring new types of measurements to determine the characteristics of the formations and get more insights on the conditions of the rocks, the borehole and the entire reservoir. Then, seeing my results being put to practical use as the field was being developed was also very motivating.

What are the hottest trends in upstream oil and gas technology?

First, I would say data analytics and machine learning. We are currently undergoing a technological revolution as great or greater than the move from paper to computers. When that transition began, computers allowed us to do the same tasks, with the same approaches, but much faster. Eventually, computers allowed us do things we couldn't imagine before. Similarly, data analytics and machine learning are at the beginning stages of creating this type of impact in our industry. They enable us to find ways to gain efficiency and look at more data. These new tools also let us assemble data from different disciplines and analyze them together in ways not possible before. I believe we will soon make enormous leaps to capabilities we can't even imagine right now.

I envision a situation where our machine learning capabilities augment our human creativity. Once the machines can reliably reproduce the more repetitive and predictable aspects of work, we are free to focus our human attention on the next

Interview continued on page 31.

Interview continued from page 30.

steps and add our insights and expertise. I recently heard a presentation on cancer radiology error rates by Daniela Rus, a professor at MIT and director of MIT's Computer Science and Artificial Intelligence Laboratory (CSAIL), that really resonated with me. This seems a reasonable analogy to some of our problems as geoscientists: imaging and understanding the nature of bodies we can't see. She stated that human cancer radiologists have an error rate of 3.5%. Machine learning algorithms have an error rate of 7.5%, but combined – human and computer – the error rate drops to 0.5%. That's a tremendous improvement by using the machine algorithms to augment the human abilities. I think we will see something like this in our industry. The algorithms will highlight possibilities from a great breadth and volume of data, and our interpreters will be able add their physics expertise and experience to gain new insights. It's the combination that will lead to great advances.

The other trend developing at the same time is the rise of unconventional resources. The large number of available wells gives us a lot more data, and the nature of the development allows us to improve continuously. We will be drilling for years, so the lessons from current wells and pilots will impact thousands of future wells. What's happening in the U.S. and how much unconventional oil and gas is being produced is incredible. I think unconventional reservoirs will continue to play a big role in the market. Our Lower 48 business unit is doing an amazing job pulling all the data together, making it available for everybody to use and extracting new insights to dramatically reduce drilling time, increase production uptime and maximize per-well recovery of oil and gas.

What is the demand profile for the future geophysicists, and what skills will they need?

Geophysicists have a big opportunity in the industry now and in the future. Their mathematical and analytical skills will be key in proving value in new development areas, as well as augmented characterization and modeling. Future geophysicists need to be open to new technologies, willing to learn them and apply them with their domain of expertise. We may see a pick-up in offshore developments, where imaging was a key technology, but much of the industry capital will be invested in onshore.

Interview continued on page 32.

Interview continued from page 31.

As John Castagna pointed out in his interview in the April edition of GSH Journal, demonstrating value is a high priority. That's going to come through a focus on the business impact and creative views of what information can be extracted from the data and how it can be extracted. Taking the same established procedures and applying them to unconventional resources is likely not going to be enough. Like I mentioned earlier when I was discussing machine learning, the combination of human creativity and machines is what will be key.

While we think of technical skills in terms of geology, physics, math, etc., there are also hard business skills. How does the company make money? How does our work impact that? What decisions can be influenced with our work? These are key questions we need to keep in mind as we evaluate challenges to tackle and projects to take on. Having a strong financial acumen and understanding the business impacts of your work helps you further demonstrate value.

Along with strong technical skills, I cannot stress enough the importance of non-technical skills as well. Obviously, flexibility and adaptability are key in today's fast-changing environment. Companies' focus of activity has changed, portfolios have changed, and technology is certainly changing rapidly. Additionally, collaboration and integration are also important. People bring different perspectives and experiences to their work; we need to harness these better. To solve problems more efficiently and innovatively, we need to work together, with all types of people and disciplines.

Due to this, I am a strong believer in understanding personality styles, and learning not just about your own style but also understanding others and how they react to different situations. I actively try to collaborate with people who have opposite styles from me to help fill in my blind spots. Being able to look at a situation through another perspective can help build stronger relationships and yield better results. Of course, it's a challenge to truly see with different perspectives, which is why it so important to have different styles and backgrounds on teams. Diversity, not just based on visible traits but also invisible traits like personality style, has been shown to dramatically increase the creativity of teams.

What's next in the future of geophysics in your organization?

We're focused on accelerating the pace of innovation. We have some top-notch engineers and geoscientists who are developing cutting-edge technology solutions, like compressive seismic imaging, which allows us to collect better data at a reduced cost.

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***Career Days**
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***Young Women Energized**

Contact Lisa Buckner at: lbuckner@hess.com

To support OUTREACH:
https://my.reason2race.com/cause/gsh

Employers Matching and Gifting Programs

Please consider supporting the GSH through your Company Matching or Gifting Program. Volunteer hours are often rewarded with an Outreach Grant / Gift to the organization. Check with your employer now.

The Geophysical Society of Houston is a 501(c)3.

Mystery Item

The Mystery Item on page 29 is a **Magna Disc from 1956**, used for recording seismic data.

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U of H Wavelets

Spring 2018 distinguished lecturer, Dr. William Symes

by Monica Guerrero

The University of Houston's SEG student chapter, The Wavelets, hosted the 2018 spring distinguished lecturer, Dr. William Symes from Rice University on March 19, 2018. Dr. Symes discussed the two variants of reverse time migration directed at enhancing the significance of image amplitudes. The talk primarily focused on the applications of true amplitude migration, and Least Square Migration (LSM). Applications discussed: shaper imaging/angle-dependent reflectivity, accelerated LSM, Fast LSM angle-dependent reflectivity, irregular sampling/missing data, accelerated full waveform inversion, and velocity estimation.

Figure 1 Distinguished lecturer, Dr. William Symes

Figure 2 Q & A session with Dr. Symes following talk.

Professors and students, both graduates and undergraduates, attended the lecture, which began by a quick introduction by The Wavelets host, Matt Sexton. The hour-long talk was followed by a 15-minute Q & A session, where many students asked questions.

The SEG Wavelets host at least one speaker per month, for members, faculty, graduate and undergraduate students. They select the speaker such that his/her lecture provides information to the audience that helps broaden their understanding of current research topics and engage the audience in thinking about solutions for common problems faced in the industry. The Wavelets were honored to have Dr. Symes accept their invitation to speak at the University of Houston, and are thankful for Mr. Sexton for coordinating the event.

Figure 3 Group photo of Dr. Symes and lecture attendees.

Recognizing Outstanding GSH Volunteers...

Bill Gafford

by Tommie Rape

The many social and technical opportunities offered by the Geophysical Society of Houston (GSH) for the geophysical professionals of Houston and beyond are due largely to many dedicated volunteers. The GSH wants to recognize some of these dedicated volunteers and will do so through this series of articles where we will present a volunteer and provide our readers with some of the volunteer's professional and volunteer background. Hopefully this will increase our readers' appreciation of these volunteers and maybe encourage them to join the GSH volunteer ranks where they can partake of the many benefits that this work provides. --- Tommie Rape

Bill Gafford was born and raised in Water Valley, Mississippi. Bill met his wife Carol in high school, who he then dated through high school and college. They have now been married 50 years and have two daughters and four grandchildren, whom they spend considerable time visiting each year. After earning a B.Sc. in mathematics from the University of Mississippi, he went to work for Amoco in New Orleans. After spending a few years processing seismic data, Bill spent the next 12 years interpreting seismic data from Louisiana and the Gulf of Mexico for exploration and development purposes. The next six years, Bill supervised Regional Geophysical Field Operations for land and marine operations in the Gulf of Mexico area. Then, back to his first love, Bill did 2D and 3D seismic interpretation for the next 11 years, again specializing in the Gulf of Mexico region. During that period, Bill and his family moved to Houston in 1989.

After Amoco merged with BP, Bill spent the remainder of his career as a geohazards specialist. He coordinated work of various international and domestic contractors in the acquisition and preparation of marine geohazard surveys. Bill prepared geohazard and shallow water flow risk analysis reports for exploration, appraisal, and development drilling locations in shallow water and deep water areas. Bill retired from BP Amoco in 2002 after 35 years of petroleum work. He then did some consulting work for a couple of years.

Bill's professional volunteer efforts began while he was working in New Orleans. As a member of the Southeastern Geophysical Society (SGS), he served as Treasurer in 1977 and as President in 1981. He also served as Section Representative for several years. In 1987, Bill served as the Arrangements Chairman for the SEG Convention in New Orleans. After moving to Houston in 1989, Bill joined the Geophysical Society of Houston (GSH), which quickly began to benefit from Bill's magnanimous attitude when he was recruited to work on the Museum Committee by then Chairman, Bill Gilchrist. Though he has helped the GSH in many different capacities over the years, it is the Museum Committee that has proven to be one of Bill's greatest passions, and it is through the Museum Committee that the GSH has benefitted most from Bill Gafford.

Through the years, the GSH has received a large amount of geophysical and petroleum industry artifacts but never had a location or facility in which to display all of them. Consequently, portions of the historic artifacts have been stored or displayed in a variety of locations over three states. Tom Fulton (the chair of the Museum Committee prior to Bill) and Bill talked about trying to organize a museum and storage

Volunteers continued on page 36.

Volunteers continued from page 35.

facility in which to display and restore all of the artifacts. They applied for a grant from the SEG Foundation in 2007 for funds to help start a GSH Museum. A year or two later, the GSH received $7,000 from the SEG, and it was placed in a GSH bank account earmarked for the Museum until additional funds were raised. Described as a "man of action rather than a man of words", Bill exerted this attribute and continued raising funds for the Museum. He also conducted a search of properties for the right combination of space, location, and cost. Additional funding was provided by many companies, who are recognized at the Geoscience Center entrance, and the current location was prepared. The historic artifacts were brought from their many locations to form the GSH Geoscience Center in 2012. SEI was another major aid in moving equipment and providing furniture for the new Center.

The Geoscience Center is always looking for volunteers to help with the museum and to socialize while doing so. If you would like to test out this volunteering phenomenon, drop by the Center and talk to Bill about it.

The Geoscience Center is a tremendous asset to the GSH outreach program. It provides space for organizing, refurbishing, and preparing artifacts for display. The Center also has an extensive technical library, including over 1,000 books, other periodicals, and materials donated by Dr. Bob Sheriff and many others. It also has a meeting area that has been used for meetings, presentations, social functions, and educational seminars or workshops. The GSH hosts a quarterly "Living Legends Doodlebugger Social Event" at the Geoscience Center where geophysical "legends" meet and share experiences and their views of the modern petroleum era. The Geoscience Center is open every Wednesday morning where anyone can drop by to experience the history on display and network with Bill and others. You can also help them try to figure out what some of the older equipment does; so show

Volunteers continued on page 37.

Volunteers continued from page 36.

up with your investigator cap on. The GSH Outreach Program utilizes the contents and space for many of its greater than 25 outreach events. You can learn more about the GSH Geoscience Center by checking out the GSH website:

https://www.gshtx.org/Public/Outreach/Geoscience_Center_Museum/public/Outreach/Geoscience_Center_Museum.aspx?hkey=fc604547-22a6-4e65-98f7-115ac58d7103

The Geoscience Center is always looking for volunteers to help with the museum and to socialize while doing so. If you would like to test out this volunteering phenomenon, drop by the Center and talk to Bill about it.

Bill and others have also taken the opportunity to share a number of the Center's artifacts by displaying them in a booth at numerous SEG Conventions in Houston. Many attendees at the Convention, both young and old, stop by these booths to partake of the history of geophysics. These booths have also proven to be a popular meeting place for many people.

Bill's contributions to the GSH certainly were not limited to his work with the Geoscience Center. Bill has been one of the leaders of the GSH for many years; he served as one of our Section Representatives for several years, 1st Vice President in 1993-94 and President in 1997-98. However, Bill's efforts for the GSH certainly did not end when these leadership positions were finished.

Bill was a major contributor to the Geoscience Day co-sponsored by the GSH and HGS. Geoscience Day was a one-day program that started in 2007 and was designed for geoscientists that were early in their careers. This very popular program provided a broad overview of the upstream petroleum industry and helped many young professionals learn and appreciate how their efforts fit into the bigger picture. Some of the revenue from this event has been used to help fund the Geoscience Center. Bill also helped lead the Interpretation SIG and the Environmental (or Near Surface) SIG.

Another major focus of Bill's volunteer efforts is in helping the children of our community; Bill is the GSH Liaison with the ECH (Engineering, Science, and Technology Council of Houston), which promotes math and science education for our youth. It is impossible to give Bill adequate recognition for all his efforts, but Bill has been awarded a Lifetime Membership in the GSH for "exceptionally meritorious service" and has twice been awarded the Presidential Award for outstanding service. The GSH received an award from the ECH for his and Lisa Buckner's efforts toward youth education.

As can be expected from a person so giving of their time, the GSH is not the only organization that benefits from Bill's efforts. Bill has volunteered for many years for his local school district on their bond steering committees and the Community Leadership Committee, which is a citizen's group that supports public education and communicates with their friends about issues that affect the school district. Bill has also been a lay leader and the Finance Chair for his church. The church provides the opportunity for another of Bill's passions through his participation in the stained-glass ministry. Bill very much enjoys creating stained-glass art and sharing it with many people.

Bill is one of those individuals from which many people benefit by his association. The GSH is very lucky to have people like Bill that are so willing to contribute their efforts for others. Bill gives much credit to his father in helping develop Bill's love of volunteering. His father told Bill not to be just a joiner, but to be active in whatever he is involved in. More of us should listen to this sage advice. At a young age, Bill became very active in scouting and church activities, both activities which further developed his love in working with and for the benefit of others. Bill says that he gets much satisfaction in "giving back". He enjoys meeting and networking with the many people he meets through these volunteering efforts; he has made many lasting friends through these efforts. Bill said that his volunteering also benefitted his professional position by adding important contacts and increasing his technical knowledge. Bill described to me how other people can reap many of these same benefits in volunteering, including becoming part of a close knit community of friends with similar interests. All we have to do is follow our interests, and look for those opportunities to work with and serve others through volunteering.

Bill says that he also is greatly entertained by the many different types of people that visit the Geoscience Center. Why don't you stop by there and entertain Bill and yourself with a view of some of the history of geophysics.

Geoscience Center News

By Bill Gafford

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

Picture 1: Evolution of recording media

Picture 2: Geophones of various age

One of our missions at the Geoscience Center is to preserve the equipment and documents from the early days of geophysical exploration and use these items to educate the younger generation and the public about how innovation and technology have changed the methods of exploration. One of the ways this can be shown is by comparing the use of blast phones and early mechanical detectors to measure distances with current electronic and GPS survey instruments. Of course there were also many developments of survey instruments along the way and we are fortunate to have some of these in our museum collection. The advancement from single trace seismic recording on paper records to multiple trace, reproducible records, to analog, and then digital recording, is another area where examples of these changes can be illustrated with items from our inventory. We have a wall display showing the various recording media that have been used from paper records to the digital era. **(Picture 1)**. Of course, along the way there were similar advancements in other seismic instruments such as amplifiers, geophones, cameras, filters, etc. Our inventory includes many of these items, some made by companies such as Petty Geophysical Company, Geophysical Research Corporation, Geophysical Machine Works, or by oil company research departments such as Humble, Shell, Sun Oil, or Stanolind. Many of these "shop made" instruments were not marketed and there is not much documentation for them so it has been difficult to match them with other instruments in a recording system and to date them. Our large collection of geophones can probably best demonstrate the evolution of materials, shape, size, and design in the industry over the years. The variety of geophones reflects the need to accommodate land, marsh, and shallow water environments as well as the constantly increasing number of recording channels. A sample of some various geophones from over the years is shown in **Picture 2.**

There were also advancements in potential fields recording instruments, as shown by comparing a torsion balance used in the 1920's **(Picture 3)**

Picture 3: Torsion balance from 1920's

Geoscience Center News continued on page 39.

Geoscience Center News continued from page 38.

Picture 4: Gravity meter from 1950's

with a gravity meter from the 1950's **(Picture 4)**. As developments with these instruments continued, computers and software programs have enabled geoscientists to create regional and more detailed studies incorporating seismic data for a more complete image of the subsurface.

Our latest Living Legends Doodlebugger social event was held on Thursday, May 10. These quarterly events attract some of our emeritus members and enable them and other visitors a chance to see some of the interesting items in our museum collection and it is also a time for visiting with other oil patch veterans and keep up with the latest industry news. We usually have some first time visitors also who enjoy seeing instruments and equipment that they have never had the chance to see before.

We have many items from our museum collection on display at various locations in Houston or in Austin and we are interested in other possible locations. Please contact me if your company might be interested in hosting a display of some of our geoscience artifacts. The inventory can be viewed on the GSH website under the Outreach tab, then Geoscience Center and Museum. There are pictures and a brief description of most of the items in our collection.

Visitors are welcome at the Geoscience Center on Wednesday mornings from 9:00 until noon or by appointment. Volunteers are also needed to help with some of our ongoing projects so if you have a little time come visit us. Please contact me at geogaf@hal-pc.org or at 281-370-3264 for more information.

Annual GSH/HGS Saltwater Tournament

18th ANNUAL SALTWATER TOURNAMENT

Friday, October 5, 2018
TopWater Grill Marina
815 Avenue O, San Leon, TX

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Doodlebugger Diary

Shipwrecked in the South China Sea
Part 5: Our Final Survey Vessel Replacement – The Kan Cha 3, a Chinese Navy Intelligence Vessel

By Scott Singleton

Doodlebugger Diary are the experiences of geophysicists during their working lives. Usually these are not recent events, but more recent ones are just as welcome. Think back to an earlier time when you were on a seismic crew, operating a magnetometer survey, gravity stations, or whatever. I included one that involved a data processing center. Seriously consider contributing a story or two. Scott Singleton recalls a few interesting stories. We are going to run them over several issues of the Journal. Scott is a past President of the GSH and still very active in professional affairs. I know you will enjoy his adventures as a truly certified doodlebugger. Lee Lawyer

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

At this point we had managed to complete all of the surveying between the Yacheng 13 field and the condensate processing site on Hainan Island, thanks to the erstwhile gambling boat, Huang May, and the humble fishing boat, Lingshiu. We were well known around town and had several local bars that considered us 'theirs'. To earn our patronage they would take us to their preferred money changers which allowed us to get the underground, or 'actual' exchange rate of at least twice the Yuan we could get at the 'official' government money exchange, and which we would gladly spend at their establishment. As you can imagine, there was quite the competition. We were having the time of our lives. Sort of like the WWII movies of being shipwrecked on the tropical island and forgetting who you really were and what you were doing that got you on that island in the first place. And don't forget that the Russian dancers from Khabarovsk were still doing their gigs on Hainan Island and elsewhere in the Guangdong Provence, but always seeming to come back to Sanya for some reason....

However, the wheels of power continued to churn higher up the food chain. No sooner did we

Figure 1: The Kan Cha 3, a Chinese navy intelligence gathering vessel.

Doodlebugger continued on page 44.

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

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Figure 2: The bow crane on the Kan Cha 3 being used to deploy one of our seafloor instruments.

finish the remainder of our 'rock' surveying on the Lingshiu that we heard a vessel would be docking in Sanya that we were to mob our gear onto. This vessel would take us along the pipeline route back to Hong Kong. We were overjoyed at this news because we had completely struck out trying to get a vessel that would both agree to do this and also be capable of doing it (we had pretty stringent requirements for our survey gear to be able to operate successfully).

So when the appointed day arrived, we all went to the dock to inspect this vessel, named the Kan Cha 3. At first glance it was quite impressive *(Figure 1)*. A long sleek hull, painted entirely white, sharp bow, crane on the foredeck, a very long stern deck which, upon inspection, had rails leading from a large hanger to the stern, obviously for deployment of something quite large. We were allowed in the hanger and, as you might well expect, it was completely empty, leaving us to guess what vessel or object was housed in this cavernous hanger (we later found out it was a submersible, but that we deduced from the very start). As we continued our tour we noted two interesting things – (1) we were not permitted to enter large portions of the vessel, and (2) there was

Figure 3: Our instrument room, such as it was, aboard the Kan Cha 3. I appear to be intently paying attention to the data being recorded as I catch a snooze. And, yes, that is a cigarette in the detached hand in the lower right corner.

always a Chinese naval officer and a plain-clothes government handler accompanying us wherever we went. We exchanged sideways glances at each other as things progressed. Soon we were pushing the Chinese handlers, asking if we could go here or

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there or anywhere that had a door and what each room or part of the vessel was for. Most of the time we were blown off – 'that is restricted access', 'that is not for you to know', 'that is for running the ship, and you don't need to know about it'.

Yes, folks, it had become patently obvious that we had been assigned a Chinese naval intelligence ship to act as an oil exploration survey vessel. The irony of this was not lost on any of us. These two types of activities are usually mutually exclusive. One will ultimately be overtaken and co-opted by the other. And since we were 'guests' aboard this vessel, we had no delusions as to who the boss was and whose objectives would carry precedence. But did you suspect that we would let that get in our way? Do I need to remind you, my little Obi-Wan, that our shipwrecked crew consisted mainly of Kiwis and Aussies? Let the games begin.

With the exception of the fact that most of the ship was off-limits to us, the survey expedition began fairly innocuously. They let us use their bow crane to deploy larger equipment *(Figure 2)* and their stern to tie everything off on. The big question facing us is where we could effectively establish our instrument room. We evaluated using their humongous (now empty) hangar but decided against it because it was like a cavern. So that left us with a relatively miniscule oblong room to cram everything *(Figure 3)*, despite the fact this was a huge ship. They did give us an officer's mess room for meals which was nice *(Figure 4)* and they served us the traditional Western version of Chinese food (like for instance the fact there was meat and fresh vegetables in every meal).

Surveying was relatively uneventful with the exception of the eastern side of Hainan Island where there was a long stretch of rocky seafloor that we had to finish finding a path through (we had started this task on the way down from Hong Kong, see Part 1 of this series). But after we finished the rocky section, life became quite routine and a bit boring for our small band of doodlebuggers. But not for long.

One day some of the guys had something quite exciting they wanted to share. In the overnight shift they had taken to cruising the boat to see what they could find (remember – it was mostly off-limits, which is an engraved invitation for us to find out why it was off-limits). They had found all sorts of stuff worthy of gossip. But the thing that took the prize, hands down, was RATS! The story goes like this – in the main galley area the cooks would cut up veggies for the next day and mix up dough for rice balls and then set it out to rise overnight.

Figure 4: Our mess hall on the Kan Cha 3, which normally was an officer's mess.

Figure 5: The infamous Rat Incident. A rat scampers quickly across the floor of the galley as I catch him in mid-stride and in very low light. On the left is a large mass of rice flour rising under a bowl

But there was a minor problem with this – if they left things unprotected the ship's rats would come out after everyone went to bed and eat it all. So to prevent this from happening they would sweep up the scraps that were merely thrown on the floor (yes, this was the traditional way the Chinese prepared food as well as ate it; you could tell by a pile of bones and scraps on the floor besides each table in the galley). These scraps would be left in a pile in the middle of the floor for the rats to feast on. That way the other food would be hopefully be left alone.

So immediately a plan was hatched whereby an early morning raid would be launched while the

Doodlebugger continued on page 46.

Doodlebugger continued from page 45.

Figure 6: Chinese naval boats docked at their base in Southern China. This is the picture that nearly caused an international incident and got me thrown in jail as an American spy.

boat was asleep whose primary goal would be to check out the rats. Several of us had cameras and we came prepared to document our exploits. But these rats were not stupid. If we made entirely too much noise and they would scatter. We had to get into position and hold it for lengths of time so they would come out and begin feasting again *(Figure 5)*. Our missions were so successful that more of our guys would get up in the early morning hours to accompany us just so they could witness this with their own eyes. We had a blast and carried out our early morning raids for at least a week. But all good things must eventually come to an end and one night one of the Chinese crew happened to see our raiding party. We knew we had been outed. Sure enough the next night there were no more piles of food on the floor overnight and there was a crew posted on watch. Damn! But we had a jolly good time while it lasted.

The next incident was very nearly the start of WWIII. My usual routine while aboard a vessel was to work the night shift and when I got off I would eat lunch, exercise however I could (on some vessels I actually ran laps), and then if the weather was warm I would lay out on the top deck and sunbathe (yes, in the 90's it was actually permissible to sunbathe). Well, at some point in our journey northward we passed the naval facility that was the Kan Cha 3's home base so ÷÷÷÷÷÷they took a detour from surveying and went into their base. So I was up on the top deck enjoying the view, of course with my camera to record everything for posterity. Well, after the now famous 'Rat Incident' they pretty much had someone shadowing us everywhere on the boat, so I saw the guy pop his head above deck and see me with a camera as we sailed into their base. He promptly popped back down in a flash and I just hung out waiting for the inevitable. A few minutes later our company handler (a really nice guy, a young oil company geologist with whom we had all sorts of great conversations) came out on the top deck and walked over to me and said that it wasn't too advisable for me to be on the top deck taking pictures of their naval base and that they thought I was spying and that I was probably in lots of trouble.

So I followed him down to a large hallway behind their bridge where we were met by a bevy of naval officers who were not very happy. There was lots of yelling and screaming back and forth. The commotion alerted our crew that 'the American' was in trouble and they all came up to stand by me. It was us on one side, them on the other side and our company handler in the middle translating. We were yelling at them that this was my camera, it was staying with me, and they would need to take it over our dead bodies and, after translation, I'm sure they were yelling back that they would be glad to do just that. This went on for a very long time and evolved into a Mexican standoff. We thought they would merely arrest us and forcibly take the camera but after a while it became evident our handler convinced them that if they did that there would be an international incident and that they probably wouldn't get paid. After an interminably long time they grudgingly let us go. As we were walking away my handler told me that it would be highly advisable for me to hide my camera and not take it out for the remainder of the trip.

Figure 6 is the incriminating evidence that proves in 1992 I actually was a spy for the US military.

Epilog: Fortunately it was only a week or so more before we arrived at Hong Kong, completed the survey, and demobed the vessel under the glaring watch of Chinese naval officers. We didn't do a whole lot during that time, being satisfied that we accomplished what we had set out to do, not only on the Kan Cha 3 but also on the Huang May, the Lingshiu, and the ill-fated Nanhai 501. It was a long and grueling 3 months but the important thing was we survived, succeeded in finishing a 780 km pipeline survey, met a lot of really nice people along the way, and have a lot of great memories that will last a lifetime.

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