April 2021

GSH Journal

GEOPHYSICAL SOCIETY OF HOUSTON
Volume 11 • Number 8

The Epicenter of Geophysical Excellence

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LOOK INSIDE

On The Cover.

Global Geophysical surveying pasture land.

Photo courtesy of Global Geophysical.

EDITOR'S NOTE

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

GSH JOURNAL DEADLINES

Jun 2021	**Apr 12**
Sept 2021	**Jul 13**
Oct 2021	**Aug 17**

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A Word from the Board

By Katja Akentieva, Second Vice President Elect

Necessity is the mother of invention.

I have always loved this quote and it has never been more relevant than it is today.

As we all continue to navigate the daily challenges and consequences of the Covid pandemic we are also, as an industry, grappling with fundamental change in the energy sector, the rise in renewables and transition toward a lower carbon future. And of course, on top of this, some of us continue to deal with the aftermath of the recent deadly arctic storm that hit the southern US.

As a wife and mother, the safety and wellbeing of my family is my top priority, what seemed so alien a year ago, face masks and social distancing, has become our new norm. As a professional who has recently been given the responsibility to start and develop a new business, TGS New Energy Solutions, I am excited about adding new energy into the mix. As an energy consumer in Texas, I am looking for answers and reassurance of the future stability of our energy supply and wondering what steps we can take personally to ensure this.

Each of these changes to me, my family and my profession, has necessitated invention. Whether it be a vaccine for Covid, a new way of applying my company's core strengths to capturing renewable energy data or recognizing that pool water and a bucket are a great solution in the absence of mains water.

More broadly we are all adapting to the challenges we face, the innovation and invention that will be bought to bear as a result of this I believe will be of benefit to us all in the future.

The response of the medical sector to Covid has been, in my opinion, simply astonishing. The individual commitment of practitioners and carers across the industry has been incredible and the speed and effectiveness of vaccine development and deployment outstanding.

Beyond the vaccine, while people were looking for ways to adapt to lock downs and social distancing, some of the most creative solutions came from the world of robotics! Robots were enlisted to deliver food in different parts of the world including some University Campuses here in Texas. Some were used to patrol parks and remind people of social distancing.

What about our industry? Of course, there are many, we are an inventive bunch! In the geothermal arena the good folks from Calgary behind the Eavor loop are gaining a lot of attention, and rightly so. What a great idea, let's hope it can be scaled up and prove efficient. Closer to home for the GSH, there has been exciting developments. Texas leads the nation in oil and gas production in the Permian Basin where CO2 can be utilized for enhanced oil recovery, this is one good reason for Texas to invest in carbon capture technologies. Our region is also rich in underground storage opportunities because we have salt domes and saline aquifers to hold significant volumes of CO2. We all know how critical it is to have comprehensive subsurface knowledge in order to screen for new storage opportunities and to mitigate the risks. This means geophysics is expanding its applications, which represents opportunity.

Finally, and most importantly, how about the health of our geophysical society as a whole? It has probably been the most challenging year in the history of our industry. Consequently, the need for a strong, local, geophysical community is amplified at a time like this. It is necessary therefore to be inventive, to find new and modern ways to fuel our organization, with new ideas, new events, new subject matter to engage our evolving and diverse geophysical society.

I would personally like to wish you all the very best as we move forward. □

From the Other Side

By Lee Lawyer

I got started last month (FTOS March 2021) on my origin(s). I was hired by Standard Oil Company of Texas (Chevron) and sent to a Chevron seismic crew, Party #5 for a three-year tour. Essentially, this was a training assignment. I learned a lot. We sent a report to Headquarters every week. The report consisted of three or four contour maps. Paper records of each shot were brought to a crew field office and were usually washed and hung over a bathtub to dry. A header was placed on each record, which contained acquisition details, such as line number and shot ID. Up hole information was included. A series of 10 millisecond timing lines was printed along with the seismic traces. A geophone was placed near the shot hole and was recorded with the other data. The timing lines are adjusted to the nearest timing line by the up-hole data. We recorded 24 stations for each shot. Normally the shot is placed at the center of the layout, i.e., between station 12 and 13. Thus the technique was called "split spread". Today's jargon calls that 'single fold', since the next shot is located a half spread ahead. This yields 'continuous" coverage of the subsurface (almost). The reflected events are picked (across the 24 wiggle traces) and timed at stations 1, 12-13 and 24. Therefore, the times on trace 1 and trace 24 are used to measure the dip of the picked events. "Picked" is an interesting term used universally on seismic crews. It means selected and timed.

I don't want to get into details of seismic acquisition in the '50s. They were simple, single fold techniques. No reproducible recording so no data processing. All data was analog and Interpreted in the field. When tape recording came along (still analog), there were no more second shots, but we still used a paper play-back record to interpret the data. (pick)

Near the end of my three-year stint, I was assigned the supervision of seven gravity crews scattered across New Mexico, Texas, and Oklahoma. I scheduled trips to each crew and reported results each Friday in Houston. That required a lot of travel. My base was in Palestine, Texas (that's Palesteen) with one of the seven crews. My wife and two children made the best of it and so did I. The recorded gravity data plus elevation and location were used to calculate Bouguer data which was mapped and roughly interpreted.

I did not know much about seismic data acquisition and interpretation. I knew less about Gravity data. Therefore, my first assignment after the field work was in the Gravity Section, based in Houston. There was a lot of smoothing functions and modelling. My tenure there was one year. The next move was to a Division office in Amarillo. We sold the trailer and let SOTEX pay for our moving expenses. During my first week in the office, I attended an exploration meeting. The head geophysicist explained that one needed to shift the gravity data because of the nearby shallow granite. Oops! That is for magnetic data, not gravity. Our principal area was the Anadarko Basin IN TEXAS. The Oklahoma portion was handled by the Division in Oklahoma City. I cannot recall any communication between the two Divisions. Our Division Manager was an alcoholic who spent very little time in the office. When he did show up, the District leaders would meet with him in the Motel he used as an office. He did not last long. Lots of work. We discovered and drilled the deepest productive well in the world. (I think) It was below 30,000 feet! All gas, out of the Ellenberger. I did the interpretation on that find as well as a 20 MMBL oil discovery. I think I have told you this before, but the only data we had was "trade" data! We traded with other oil companies for old paper recordings and mapped from those. Eventually, SOTEX shot two lines across the two discoveries. Did not help much. We stayed on the high plains for about six years. Palo Duro Canyon, Jack Rabbits, and Wind, continuous wind, and other scenic things.

Maybe next month, I will reveal my next move! Clue: the prodigal son. □

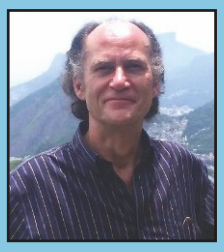
A Live Webinar!

Velocities, Imaging, and Waveform Inversion

The Evolution of Characterising the Earth's Subsurface

Featuring Dr. Ian F. Jones - ION Geophysical

April 12 - 15, 2021 9:00 am – 1:00 pm Houston Time



The course is designed for practising geoscientists and geoscience students who desire a better understanding of the principles and limitations of both current and emerging technologies involved in subsurface parameter estimation and imaging. The material is designed to help readers better understand how contemporary velocity estimation methods work, and what approximations are involved in obtaining computationally tractable solutions. The evolution of the industry's approaches to building earth models with ray tomography and full waveform inversion is covered, as are some of the emerging possibilities for replacing imaging techniques with direct subsurface parameter inversion methods. The approach will be mostly non-mathematical, concentrating on an intuitive understanding of the principles, demonstrating them via case histories.

This **16 hour course** can be taken in the comfort of **your office** or even **your own home**. It works on **PC's, iPads, iPhones**, or even two tin cans with a taut string (not recommended). **No travel costs**. **The Course Fee: $390!** With major discounts for Groups and Students. 1.6 CEU's are awarded.

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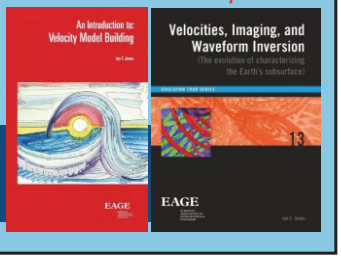


Register now at: gshtx.org and seg.org

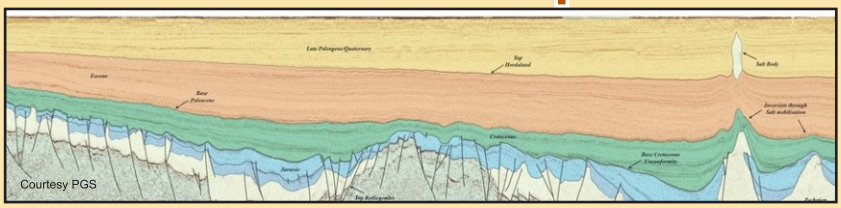
All sessions are recorded and available on-demand to attendees.

A Live Webinar

Sponsored Jointly by the SEG and GSH

SEG SOCIETY OF EXPLORATION GEOPHYSICISTS

Basic Seismic Interpretation



Four Half-days (9 AM - 1 PM Houston Time) May 25-28, 2021

Presented by

Don Herron & Bob Wegner

The course consists of lectures on fundamental topics including basics of seismic exploration, seismic response, velocity, resolution, seismic migration, seismic correlation and mapping techniques, and quantified interpretation. Lectures are supported by hands-on exercises, and the second half of the course includes several practical correlation and mapping exercises and projects.

This **16 hour course** can be taken in the comfort of **your office** or even **your own home**. It works on **PC's, iPads, iPhones**, or even two tin cans with a taut string (not recommended). **No travel costs**. **The Course Fee: $390!** With major discounts for Groups and Students. 1.6 CEU's are awarded.

All Sessions are recorded for future viewing if you miss a session

Visit gshtx.org, Events Tab to register and see expanded Course and Presenter Information

A Live Webinar

Sponsored Jointly by the SEG and GSH

PRACTICAL SEISMIC PETROPHYSICS: THE EFFECTIVE USE OF LOG DATA FOR SEISMIC ANALYSIS

Now available for ON DEMAND viewing

Originally presented live on March 23-26, 2021

*Includes a 2-3 hour primer on sonic and density logs presented by **Matthew Blyth**, Schlumberger Well Construction.*

Presented by
Tad Smith, PhD, Geology

This class will focus on the important role of "seismic petrophysics" in the quest to extract additional information from subtle seismic responses. Some of the topics covered will include important background information, relevant aspects of petrophysical interpretation, various aspects of log editing, and the basics of elasticity and rock physics. We will spend considerable time discussing some common pitfalls associated with the "workhorses" of rock physics, including invasion corrections, problems associated with shear velocity estimation, and some of the challenges and pitfalls associated with Gassmann fluid substitution. It is important to recognize that log data should not simply be recomputed to fit prior expectations as defined by a rock physics model. Instead, rock physics models should be used as templates, which allow the interpreter to better understand the underlying physics of observed log responses and how they are governed by local petrophysical properties. Case studies and hands-on exercises will be used to reinforce critical concepts.

This **16 hour course** can be taken in the comfort of **your office** or even **your own home**. It works on **PC's, iPads, iPhones**, or even two tin cans with a taut string (not recommended). **No travel costs**. **The Course Fee: $390!** With major discounts for Groups and Students. 1.6 CEU's are awarded.

All webinars are recorded in case you miss a session or in case you'd prefer to watch the webinar on your own schedule and pace. They will be available *On Demand* to all registered.

Extended Viewing Time

Due to the Covid times we are experiencing and based on input from several past webinar participants, the recordings for this webinar will remain accessible and available for ON DEMAND viewing for an extended period after conclusion of the live webinar. By registering for the webinar before, during, or after the live presentation, you will be granted access to the recordings to view according to your own schedule.

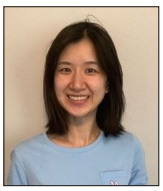
Visit gshtx.org, Events Tab to register and see expanded Course and Presenter Information

GSH Technical Events

Unconventional SIG

New Life for Old Wells: Oil and Gas Data for Geothermal Prospecting
James Keay, New Energy Solutions Team, TGS
Co-Author: Cian O'Reilly, TGS
Abstract and Bio
Online presentation - April 1, 2021 - 12:00pm-1:00pm CST

Register



Rock Physics SIG

Facies Characterization Using Probabilistic Rock-Physics Templates and Semi-Supervised Machine Learning
Wei Xie, University of Texas at Austin, PhD. Student in Geophysics
Abstract and Bio
Online presentation - April 7, 2021 - 12:00pm-1:00pm CST

Register

Data Processing & Acquisition SIG

TBA
Speaker
Abstract and Bio
Online presentation - April 13, 2021 - 5:00pm-6:00pm CST

Register

Technical Breakfast

TBA
Speaker
Abstract and Bio
Online presentation - April 14, 2021 - 7:00am-8:00am CST

Register

Data Science and Machine Learning SIG

The Oil Industry Needs A Makeover
Ryan Dawson, Founder and CEO at Corva
Abstract and Bio
Online presentation - April 14, 2021 - 11:00am-12:00pm CST

Register

NextGen: Under a Different Rock

Bridges Over Troubled Waters: Assessing, Communicating and Reducing the Risk of Seismic and Tsunami Hazards in Indonesia
Ron Harris, Professor of Geological Sciences at BYU, Geophysicists Without Borders
Abstract and Bio
Online presentation - April 15, 2021 - 6:00pm-7:00pm CST

Register

GSH Gets Down to Business

Geophysics by Seisware - Back to Basics
Marko Gauk, SeisWare International
Abstract and Bio
Online presentation - April 20, 2021 - 12:00pm-1:00pm CST

Register

Technical Lunch

Fiber Optic Strain Monitoring of Hydraulic Stimulation: From Modeling to Inversion
Zhishuai Zhang, Chevron
Abstract and Bio
Online presentation - April 21, 2021 - ?:00am-12:00pm CST

Register

GSH Annual Golf Tournament 2021

The Woodlands Country Club Tournament Course has been chosen to host this year's Geophysical Society of Houston's Annual Tournament. Winding through the village of Grogan's Mill, the overall design of the Tournament Course promotes the feeling of tranquility, with well-integrated ponds, lakes, natural trees, and pristine landscaping. The Tournament Course serves as host to The Insperity Invitational which will be taking place 2 weeks after our event ensuring that the golf course will be in pristine shape.

$200 GOLFER OR $800 PER TEAM

Please register online at www.gshtx.org

Space is limited to 120 players

Sponsorships are still available

For more information contact Wesley Tyrrell:

{e} wes@tyrrelldataservices.com {c} 713.205.3546

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For information about Annual Sponsorship go to: gshtx.org

2021 GSH-SEG ONLINE SPRING SYMPOSIUM

DATA SCIENCE AND GEOPHYSICS: HOW MACHINE LEARNING AND AI WILL CHANGE OUR INDUSTRY

April 27th-28th 2021

JOIN US FOR AN EXCITING AND INTERACTIVE SYMPOSIUM ON HOW DATA SCIENCE WILL DRIVE THE FUTURE OF GEOPHYSICS.

SPEAKERS INCLUDE:

Aria Abubakar, *Schlumberger* | Satinder Chopra, *SamiGeo* | Jon Downton, *CGG* | Yuting Duan, *Shell* | Hugo Garcia, *Geoteric* | Wenyi Hu, *AGT & U of H* | Elive Menyoli, *Emerson* | Tom Smith, *Geophysical Insights*

THIS TWO DAY EVENT WILL ALSO FEATURE:

- **The SEG Regional Student Challenge Bowl live event**
- **A special presentation of the Geophysics In The Cloud Machine Learning Competition results!**

WWW.GSHTX.ORG

MEET THE CANDIDATES

A Note From the President

Dear Fellow GSH Members,

An important event in the life of the GSH occurs every year around this time. That event is when you get to nominate and elect the future officers of the society. It is your chance to help steer the GSH in the direction you think most appropriate. The difficulties this year notwithstanding, the election will go forward as usual. The Nominating Committee is pleased to submit the following slate of candidates for your consideration. Each candidate has expressed a sincere commitment to guiding the GSH to a successful future. I trust you will give careful consideration as you make your selection in the elections which will take place next month. I should add that our bylaws allow GSH active members to submit write-in candidates for any office as well. **Nominations will close as of April 15.** Check the bylaws for specific guidelines."

Peter M. Duncan

Peter Eick

(In-Depth Compressive Seismic)

GSH Candidate for
President-Elect
2021-2022

Peter Eick received an M.S. in Geophysics from the University of Utah in 1989, and a B.S. in Geology from Michigan Technological University in 1987. He joined Conoco in 1990 and worked as an explorer in Alaska and Lower-48 Business Units. He switched from explorer to seismic acquisition coordinator early in his career for Conoco and later ConocoPhillips. He has designed and acquired borehole, marine

Peter Eick Biography continued on page 14.

Kenneth Mohn

(Mohn and Associates)

GSH Candidate for
President-Elect
2021-2022

Kenneth Mohn is owner of Mohn and Associates, a Houston based service company working with clients and partners focused on multi-client and proprietary 2D and 3D projects, exploration projects, as well as time and depth processing projects.

After graduating with a Bachelor and Master of Science degree in Geology from Stephen F. Austin State University, Kenneth started working in the seismic industry in 1987 with

Kenneth Mohn Biography continued on page 14.

Katie Fry

(Oxy)

GSH Candidate for
Editor
2021-2022

Katie Fry entered the geoscience industry at the ripe age of four after experiencing the Northridge earthquake. Years of collecting rocks, plotting earthquake epicenters from USGS public data, and celebrating birthdays at the Natural History Museum led to an undergraduate Bachelor of Science from the University of California at Santa Barbara (2012), one year abroad at the University of Glasgow

Katie Fry Biography continued on page 16.

Dmitry Kulakov

(Schlumberger)

GSH Candidate for
1st VP-Elect
2021-2022

Dmitry has 11 years of experience in the Oil and Gas industry. He received a BS degree in Exploration Geophysics from Gubkin Russian State University of Oil and Gas in 2009. In 2011, he graduated from the dual-diploma Reservoir Geoscience and Engineering program holding a MS degree in Geoscience from IFP-School (Paris, France) and MS degree in Reservoir Engineering from Gubkin University (Moscow,

Dmitry Kulakov Biography continued on page 14.

Simon Voisey

(Apache Corporation)

GSH Candidate for
1st VP-Elect
2021-2022

Simon Voisey is a staff geophysicist specializing in quantitative interpretation (QI) at Apache Corporation based in Houston with 16 years of industry experience. He holds an MSc in Petroleum Geoscience from the University of Aberdeen and a BSc in Geophysics from University College London.

He has played active roles in both the SEG and GSH. Currently, Simon serves on the 2021 GSH spring

Simon Voisey Biography continued on page 15.

MEET THE CANDIDATES

Tony LaPierre
(RPS)

GSH Candidate for
2nd VP-Elect
2021-2022

Tony LaPierre is the Technical Director of seismic operations and site investigations at RPS, in Houston. Tony has degrees in Geology BSc (Hons) and Civil Engineering MASc. He has 35 years of geophysical industry experience, including 24 years with RPS. Tony's responsibility at RPS covers seismic and site investigation consultancy services worldwide. His core area of expertise is providing

Tony LaPierre Biography continued on page 16.

Scott Sutherland
(CGG)

GSH Candidate for
2nd VP-Elect
2021-2022

Scott Sutherland is a senior sales manager in the multi-client/new ventures group at CGG. With 24 years of experience in onshore/offshore processing for operators and service companies. He holds a B.Sc. in Applied Geology from Kingston University in the UK, and is a member of Geophysical Societies in Houston, Dallas, Oklahoma City and Pittsburgh.

Scott Sutherland Biography continued on page 15.

Jeni Masi
(Geoex-MCG)

GSH Candidate for
Secretary
2021-2022

Jeni is originally from Venezuela and currently based in Houston. She is currently the Chief Geoscientist at Geoex-MCG, responsible for the generation of leads on frontier basins globally and planning of seismic surveys. She received her bachelor's degree in Geophysical Engineering from the Simon Bolivar University in Venezuela, and her PhD in Earth Science with focus in Global seismology from

Jeni Masi Biography continued on page 15.

Rene' Mott
(Enervest, Ltd)

GSH Candidate for
Treasurer-Elect
2021-2022

Rene' Mott received her B.S. (1982) in Geophysics, and a Masters (1996) in Sedimentology from University of Texas at Dallas. Her career started at Unocal Houston in the Gulf of Mexico in interpretation for Federal OCS lease sales. Her current position at Enervest, Ltd, as Senior Geophysical Advisor is working on onshore exploiting oil and gas fields with an integrated team of Geologists, Petrophysicists

Rene' Mott Biography continued on page 16.

Jameson White
(IAGC)

GSH Candidate for
Treasurer-Elect
2021-2022

Jameson White is the Director of Member & Industry Relations with the International Association of Geophysical Contractors (IAGC). As the Member & Industry Relations Director, Jameson is responsible for managing the integration of the IAGC's membership, committee and workgroup structure, and strategy. His duties encompass overseeing the development and updating of industry best

Jameson White Biography continued on page 16.

Caroline Wilkinson
(WesternGeco)

GSH Candidate for
Secretary
2021-2022

Caroline Wilkinson joined WesternGeco in 2011 and has held many positions within the organization; spending the first six years of her career as a project geophysicist before moving into a technical sales role in 2017. In 2019 she joined the WesternGeco HQ team as the Sales Performance Manager, supporting the global sales team and leading special projects.

Caroline Wilkinson Biography continued on page 15.

Peter Eick Biography continued from page 12.

and land 3D and 2D seismic surveys worldwide. In the process of providing on site acquisitions support, he has collected seismic data on every continent, except Antarctica, and many of the world's oceans. He progressed to be a Principal Acquisitions Geophysicist for ConocoPhillips, and he has over 50 publications and is the named inventor on 68 US patents. He left ConocoPhillips in 2015 and started Serenity Geophysical Consultants allowing him to focus more heavily on developing shear wave, impulsive sourced and high-resolution seismic exploration projects. In 2017, he joined In-Depth Compressive Seismic as CCO and is managing the application of compressive seismic acquisition and processing projects worldwide for their clients.

Mr. Eick is a licensed Professional Geophysicist (#16). He is a Continuing Education Instructor for over 20 years with the SEG, and an active member of the SEG for nearly 3 decades. His activities at the SEG run the gamut from reviewing papers, to chairing sessions for the annual meeting, and participating in the Continuing Education program. He was the Treasurer for the GSH previously and a GSH member since 1999. He also participates in the AAPG. He is an Eagle scout, active photographer and spends his spare time repairing cars and rockhounding for fun. His favorite rock types are the ultramafic, and he continues his search for the perfect spinifex textured komatiite sample. □

Kenneth Mohn Biography continued from page 12.

TGS Geophysical Company. In 2003, Kenneth joined Fugro as Vice President of the multi-client Group for North Central and South America. This group developed several seismic surveys and interpretation studies in the Gulf of Mexico, Central and South America. When the group was sold to CGG in 2012, he joined Multiclient Geophysical (MCG) in 2013 as Managing Director and Vice President for the Americas. Since 2019, Kenneth started Mohn and Associates and has been working on projects and consulting for various companies on multi-client and proprietary projects.

Kenneth has served as 2nd Vice President of the Geophysical Society and has been the Chairman of the Sporting Clays committee several times during his career. He currently works on the "GSH Gets Down to Business" inviting companies to make commercial presentations on the GSH website to help raise revenue.

Kenneth believes there are basic needs that the GSH can serve for its members. These include Quality Technical material, Professional Network interaction through technical meetings and social programs, and Education for the Members and the Community. As a Member of the GSH, he believes it is our responsibility to participate and, when possible, contribute time to the Society.

In his free time Kenneth likes to spend time with the family as well as just about anything outdoors; hunting, freshwater and saltwater fishing, searching for fossils and occasional bad golf. □

Dmitry Kulakov Biography continued from page 12.

Russia). He is an active member of SEG, EAGE and GSH.

During his studies, Dmitry actively participated in university student science society, presented his works on student conferences and as a team member presented Gubkin University in AAPG IBA competition in 2011. For his contribution to the University, he received an honors scholarship in 2009.

Dmitry took several part time and summer positions during his study that exposed him to various activities such as offshore engineering seismic processing on Sakhalin Island with ROMONA, VSP R&E in Schlumberger Moscow Research, microseismic and reservoir data integration in Total E&P (Pau, France), and logistics database design and support in Total E&P Moscow.

After graduation in 2011 Dmitry joined WesternGeco (Schlumberger) in Houston Texas, where he is currently holds the position of Senior Earth Modeling Geoscientist. He supports production teams globally with his experience in velocity model building using all up to date technologies such as Full Waveform Inversion, Seismic Guided Drilling, Localized Seismic Imaging, Seismic Tomography and Rock Physics Guided Migrations. He also developed and currently manages internal FWI training program in Schlumberger and authored several abstracts for SEG. Dmitry started actively volunteering in the GSH in 2017, first in a role of GSH Journal assistant editor. He was the Editor for the GSH Journal for 2017 and 2018.

Dmitry Kulakov Biography continued on page 15.

Simon Voisey Biography continued from page 12.

symposium planning committee. A previous position was technical co-chair for the 2019 GSH spring symposium honoring Dan Hampson and Brian Russell. At the SEG, he is a member of the DISC technical committee and reviews expanded abstracts for the SEG conference. In 2019, he chaired the AVO and Seismic Inversion (AVOSI) technical sessions program at the SEG conference.

Simon started his geophysical career at Scott Pickford in 2004 as a technical assistant (TA). In 2005, he joined Hampson-Russell software working on the technical support desk, plus presenting public and private workshops. In 2009, he moved to Houston to the Hampson-Russell services group, conducting seismic attribute projects for various oil companies. In 2014, Simon joined Apache Corporation and currently works in their Applied Geoscience Technology (AGT) group. At Apache, he has carried out seismic attribute analysis for all their main assets, focusing on Egypt over the last four years. Recent work has also included the North Sea.

In Simon's free time, he is a keen hiker and has trekked many of America's National Parks. He is a season ticket holder for both the Houston Dynamo soccer team and Houston Saber Cats rugby team. □

Dmitry Kulakov Biography continued from page 14.

In his free time Dmitry enjoys life in Houston with his wife and son. He is keen on reading, photography, playing competitive paintball across Texas and snowboarding. □

Caroline Wilkinson Biography continued from page 13.

Outside of her responsibilities at WesternGeco, Caroline has been a member of the Geophysical Society of Houston since 2018 and assumed the role of Data Processing & Acquisition SIG Leader in 2019. She has been an active member of the Society of Exploration Geophysicists since 2017 and volunteered as a non-voting member of the SEG Strategy & Planning Committee under Maurice Nessim in 2020.

Beyond the energy industry, Caroline volunteers her time and skills to the Houston Area Women's Center, Kids' Meals, and other local Houston-based nonprofits. And on a personal note, she has enjoyed spending her pandemic days going for long walks in the neighborhood, baking quiche, and strong-arming her friends into philosophical discussions via Zoom.

Caroline has a BSc in Geophysics from Boston College and graduated in 2010. A program so small she was the only undergraduate geophysics major in her graduating class. □

Jeni Masi Biography continued from page 13.

Rice University. After she finished her Ph.D. studies and prior to her current role, she joined BP America Inc. and Osprey Petroleum as a Geophysicist where she identified and evaluated lease opportunities, supported current operations, and aided the design of new wells. Jeni previously served as President and Vice-President of the Association for Women in Science Gulf Coast Houston Chapter. In her spare time, she enjoys dancing, long distance running, cooking and spending time with friends and family. □

Scott Sutherland Biography continued from page 13.

His career started on seismic vessels with Horizon Exploration, processing 2D and 3D seismic data from the North Sea to the South Atlantic. After moving from a boat to a cubicle with Western Geophysical in Isleworth, Scott joined CGG and was transferred to Houston where he continued to work on imaging of marine 3D surveys. Over the next several years, Scott moved into Land processing, eventually switching to Land exclusively in 2008. In 2013, Scott was given the opportunity to join Devon Energy and moved to Oklahoma City where he joined Devon's Reservoir Technology Optimization group. Scott continued to manage 3D seismic processing efforts for Devon but was also tasked with evaluating new and existing technologies and maximizing the impact of geophysical work programs. In the course of this endeavor, Scott authored and co-authored several papers and presentations.

Scott recently took over as chairman of the sporting clays committee and looks forward to being more involved with the GSH now that he is back in Houston. He hopes to explore new social networking events and venues on behalf of the GSH in an effort to boost membership and bring geoscientists back together after the isolation the pandemic has caused.

Scott is passionate about the role of geophysics in exploration and production programs and supporting the geophysical community - particularly during these uncertain times. □

Katie Fry Biography continued from page 12.

(2010-2011; because he/she/they who sees the most rocks wins), and a Master of Science at the University of Texas at Austin (2015).

While Katie prides herself as a petrographer that has dabbled in igneous, metamorphic, and sedimentary rocks, she has established herself as an upstream petroleum geologist with experience in unconventional reservoir characterization; new play exploration; conventional water flood and CO2 enhanced oil recovery; and long-term field development strategy and planning. Along with her standard geologic duties, Katie has been active in professional organizations as a member of the AAPG Student Expo Committee, a trivia writer for the Houston Geological Society's NeoGeos, and a volunteer at the Houston Museum of Natural Sciences.

On a less geological note, Katie is an animal-lover and active member in the rescue community in Houston. She is a classically trained singer that has performed with the Houston Symphony and Mercury Houston. Katie also likes to garden, ferment cider, and paint CMYK rainbow color gradients on treated wood in her spare time. □

Jameson White Biography continued from page 13.

practices and standards, including health, safety, and environment (HSE) guidance; model contracts; statements of principles; and managing IAGC member-dependent efficiency initiatives.

Jameson began his career working as a geophysical trainee with Quantum in 2006, then Geokinetics upon graduation from the State University of New York at Oswego in 2008. In 2011 he took on new responsibilities as the Worldwide Asset Manager, responsible for the accurate inventory, tracking and maintenance of company's fixed asset system consisting of over $400 Million in company assets distributed over 25 countries. Jameson returned to fieldwork with Global Geophysical as a Party Manager in 2013 and in 2015 became the Business Development Manager for the Alaska office. In 2017, Jameson joined the IAGC in the Government & Regulatory Affairs department and in 2019 promoted to lead the Member & Industry Relations group.

Outside of work, Jameson enjoys playing hockey, golf, and spending time outdoors. □

Rene' Mott Biography continued from page 13.

and Engineers characterizing reservoirs.

Her professional areas of interest are Seismic Interpretation and Big Data Analytics. She enjoys the challenge of complex structural and stratigraphic areas, exploiting the waveform for attributes and rock properties to discover new or increased production. She strives to incorporate other data from wells, logs, image logs, thin section, microseismic data, and completions with seismic data into Big Data Analytics for prediction of reservoir character or production.

She has many publications on topics from Visualization, Interpretation Workflow, Risk Reduction, Seismic Attributes, Azimuthal processing, 5D Interpolation and Reservoir Characterization.

She is an active member of SEG, AAPG and local geoscience chapters, HGS and GSH, in Houston, Texas. □

Tony LaPierre Biography continued from page 13.

teams of technical experts to project manage and supervise geophysical and geotechnical projects. He manages a team that has worked on some of the world's largest and most complex exploration seismic and geotechnical projects. Tony's ability to understand what is required in the field is based on his extensive experience offshore on marine seismic and seabed studies. Tony is an experienced presenter having delivered papers at geophysical and geological conferences in Cairo, Copenhagen, Dublin, Halifax, Houston, and Moscow. Tony has been a member of the GSH for a decade and has played a key role in the GSH annual kickoff events pre-pandemic restrictions. Tony welcomes the opportunity to help the GSH as it adapts to the current and evolving business climate and asks for your vote as 2nd VP elect to make this possible. □

Mystery Item

This is a geophysical item...

Do you know what it is?

This month's answer on page 32.

How Geophysics Can Help the Geothermal Industry

Erika Gasperikova, Lawrence Berkeley National Laboratory and William Cumming, Cumming Geoscience

Summary

Geothermal energy resources are sustainable if the rates of energy extraction and recharge are balanced, and renewable over 100s of years if not. Electric power generation and district heating have been supported commercially by producing hot water from permeable geothermal reservoirs at 200 to 4000 m depth from 200 to 380°C magmatically heated systems for 100 years, from 80 to 220°C deep-circulation fault-hosted systems for 40 years, and from 100 to 150°C deep sedimentary systems for 20 years. Research is ongoing to develop power from >380°C supercritical magmatic systems and from enhanced geothermal systems (EGS) created in low permeability hot rocks that are found within drillable depths worldwide.

The geophysical applications that are relevant to geothermal exploration and development depend on the geoscience and practical context. Magnetotelluric (MT) surveys are the default exploration method for imaging the low resistivity impermeable smectite clay that caps almost all volcano-hosted reservoirs. MT is typically more effective than reflection seismic for imaging shale caps of geothermal reservoirs hosted in sediments. Less reliably, MT supplements microseismic monitoring of shallow magma that can limit rift-hosted geothermal reservoirs. Transient electromagnetic, gravity and magnetic surveys are sometimes relevant in narrower contexts. For deep sedimentary geothermal targets, high quality 3D seismic reflection survey is essential for targeting wells on permeable, water saturated rock. Well logs are important in modeling the petrophysics of potential permeable zones. After a >230°C field is developed, repeat microgravity surveys are used to monitor boiling and phase change. Subsidence surveys, where feasible using InSar, support the repeat microgravity and help characterize reservoir pressure and temperature changes. Because injecting cold water into very hot rock induces microseismic events, seismic monitoring arrays are routinely installed to track injection, characterize the structural compartments of reservoirs, and predict the depth to the base of the permeable reservoir. Microseismic monitoring surveys are also crucial to understanding the dimensions and properties of both EGS and supercritical systems. New geophysical technology of particular relevance to the geothermal industry includes 3D joint inversion, greater integration with well logs, improved characterization of uncertainty in 3D inversions, and adapting geophysical methods to higher risk geothermal prospects less analogous to the archetypes for which the current methods have proven most useful.

Introduction

The relevance of specific geophysics methods varies depending on the geothermal resource type and the wide range of geological settings in which they are found. Geothermal systems can be divided into convection- and conduction-dominated plays, with almost all commercial geothermal development currently in the convection-dominated category. The nature of the heat source, the tectonic setting, the thermodynamic state, and the formation types add further subcategories to convection-dominated plays; for example, magmatic versus non-magmatic types or focused (fault-hosted) versus distributed permeability types. Conduction-dominated plays are further divided according to their dominant permeability control: lithofacies, fractures, or a combination of both.

The typical criteria used to explore for convection-dominated commercially viable geothermal systems are temperature, chemically benign water and sufficient permeability. Based on analogies to numerous developed fields, exploration strategies for undrilled convection-dominated systems focus on integrating surface geology, geochemistry and geophysics in conceptual models consistent with thermodynamic constraints on upflow and outflow. In conduction-dominated plays, the focus is on mapping subtle subsurface rock properties, primarily using 3D reflection seismic data, to locate zones that likely have high productivity despite the lack of natural convective flow.

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Exploration Geophysics for Geothermal Reservoirs

Geophysical methods are applied to geothermal exploration in the context of other geoscience data, including: 1) well temperature, production and formation data, if they exist; 2) gas and water geochemistry and temperature of fumaroles, springs and water wells, if those features exist; and 3) geology surveys, including structural, formation and alteration mapping. Specific survey types and designs will also depend on access limitations, noise sources, costs, and, most importantly, the likelihood that the data will significantly reduce uncertainty in the current resource conceptual model. Based on these criteria, particular geophysical methods become associated with specific play types. For example, MT is the default geophysical method for exploring volcano-hosted reservoirs where the base of the low resistivity clay cap is likely to be deeper than other resistivity methods can detect. However, a 3D reflection seismic survey would be far more relevant to the detection of a permeable zone associated with karsted carbonate rocks in a pinnacle reef at 4 km depth.

To identify prospects for more focused investment in geophysics, the geothermal industry has focused on integrating regional geochemistry, geology, hydrology, and temperature data from wells drilled for non-geothermal purposes. However, since 2014, researchers have been investigating whether prospects could be more reliably identified if the geology and geochemistry data were supplemented by regional geophysics in play-fairway studies, including airborne magnetic and widely-spaced surface geophysical surveys like gravity and MT (Garchar et al., 2016).

The geophysical survey types that are most commonly used in geothermal exploration, roughly ordered by prevalence, include; magnetotelluric (MT), transient electromagnetic (TEM), controlled source audio-magnetotelluric (CSAMT), vertical electrical sounding (VES), gravity, magnetic, 2D/3D reflection seismic and passive seismicity monitoring.

MT is the default resistivity method in geothermal contexts because of its greater practical depth of investigation than other resistivity detection methods (Muñoz, 2014; Gasperikova et al., 2015). Many researchers interpret relatively low resistivity patterns derived from MT in terms of fracture porosity, matrix porosity, water saturation, salinity and fluid movement. However, detecting low resistivity deeper than several kilometers in rift areas raises the concern that it may be shallow magma. Deep low resistivity in Paleozoic metamorphic rocks is likely to be due to graphitic schist (Kuyumcu et al., 2011). In any case, the focus of most geothermal industry interpretations of MT resistivity is on lower risk interpretations that can be validated by well logs,

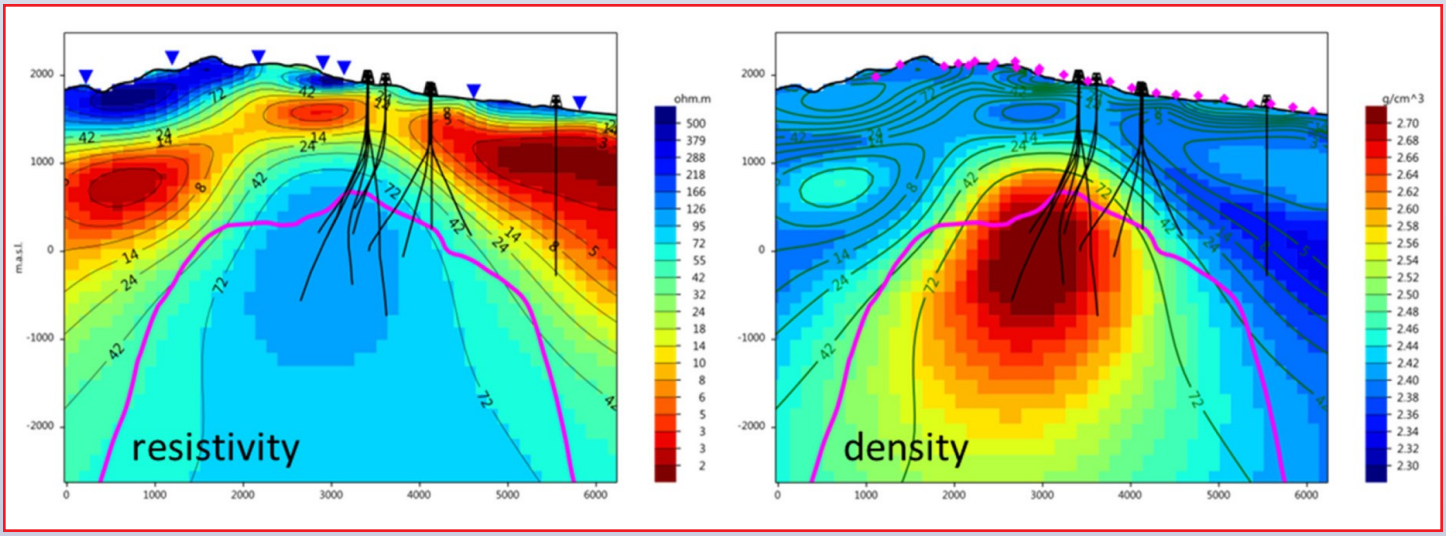

Figure 1: MT and gravity 3D joint cross-gradient inversions completed by CGG for resistivity and density with the Darajat Geothermal Field boundary outlined. (From Soyer et al., 2017)

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typically emphasizing low resistivity clay and zeolite zones shallower than 3 km that act as aquicludes, capping buoyant thermal flow, flooring cold water zones, and therefore acting as the container of the exploitable geothermal resource. In *Figure 1*, the low resistivity (<14 ohm-m) smectite clay cap of the Darajat Field is shown in red tones and the high resistivity (>40 ohm-m) propylitic alteration of the >240°C reservoir is blue. The density model at right shows that the hydrated clay of the smectite cap is lower density (<2400 kg/m3) whereas the propylitic alteration of the >240°C reservoir is higher density (>2400 kg/m3). Arguably, the main contribution of gravity in most 3D MT inversions of geothermal fields is to reduce resistivity inversion artifacts due to noisy MT data.

Gravity is often too ambiguous to reliably interpret without support from other data, particularly in heterogeneous volcanic rocks. For example, as shown in *Figure 1*, ambiguity in volcanics can often be reduced in a joint inversion (or joint interpretation) with MT data (Soyer et al., 2017). In relatively uniform sedimentary basins or in zones with massive uniform volcanic rocks, the geometry of underlying high density, high temperature alteration and/or crystalline rocks can often be inferred from gravity data if it is supported by MT data.

Magnetic data are less commonly effective in volcanic geothermal settings than gravity data, although a joint gravity and magnetic interpretation at the Salton Sea was particularly successful (Griscom and Muffler, 1971). The destruction of magnetite by sulfate water demagnetizes volcanic rocks near fumaroles, so magnetic maps can provide a constraint on shallow sulfate alteration before resistivity data can more reliably image this alteration. Although structures are commonly inferred from high pass filtered (derivative and gradient) gravity and magnetic data, these features tend to be much less reliable than ground mapping of structure (Hinz et al., 2016).

According to geothermal best practice, geophysical data sets should be integrated with other geoscience data in a conceptual resource model consistent with thermodynamic constraints in order to target wells and assess resource capacity (Cumming, 2016). A resource conceptual model is initially developed based on surface geology and analogies to fields in similar settings, and it is updated as new data become available. The geochemistry, alteration and structural geology data identify likely temperatures and basic flow elements while the low resistivity clay cap imaged using MT constrains the upflow and buoyant outflow shape of the resource. Stabilized well temperature and pressure data are decisive for defining the conceptual model and so are given the greatest attention, while the overall model is adjusted to the cuttings geology, alteration and any production geochemistry.

In high temperature geothermal wells, borehole image logs are commonly run but wireline geophysical logs are less utilized, an industry shortcoming attributed partly to the high borehole temperature and partly due to the very large effective "pay" thickness of geothermal reservoirs. The use of pre-perforated liners removes the need to use wireline well logs to identify pay zones for perforation after casing is set. Nonetheless, field models might be improved if well log data were more routinely utilized (DiPippo, 2016).

After the initial wells are drilled, converting the conceptual models to 3D digital models is often worthwhile. The 3D joint resistivity and density patterns (from MT and gravity), earthquake locations, velocity tomography, and reflection seismic impedance are most effectively interpreted in the context of the isotherm model using 3D tools. The conceptual model elements, particularly the natural state isotherm interpretation, are the starting point for the numerical reservoir simulation models used to forecast the performance of the geothermal reservoir under various production scenarios, a required step for any power plant investment commitment.

MT and Geothermal Conceptual Models

Although anomaly hunting is still common within the geothermal industry, the application of geophysics to geothermal resource exploration and development is more effective when it is directed at constraining an integrated resource conceptual model. A conceptual model approach promotes the interpretation of geophysics in the context of all available geoscience information (DiPippo, 2016).

A conceptual model approach is particularly advantageous because it highlights inconsistencies

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as the lower risk prospects are explored and the remaining prospects become a poorer fit for the exploration assumptions. As shown in *Figure 2*, in high temperature volcano-hosted geothermal systems, the conceptual integration of the geochemistry of fumaroles and springs with hydrology, geology and the 3D MT image of the low resistivity smectite clay cap often decisively characterizes the upflow and outflow geometry of the reservoir needed to target wells and assess capacity (Cumming, 2016). The relative importance of surface geochemistry is lower in the case of deep-circulation geothermal systems without hot springs so structural geology and alteration mapping is typically integrated with MT resistivity imaging of sedimentary clay aquicludes to build resource conceptual models of upflow and outflow (Cumming, 2009). As these types of geothermal targets are explored, the remaining prospects have become more challenging to target. For example, a large proportion of unexplored volcano-hosted prospects are on the flanks of vapor-core volcanic vents (Hochstein and Sudarman, 2015) or in structural zones where permeability is very focused at ideally stressed faults (Hinz et al., 2016). Both require higher resolution in structurally more complex areas, placing more demands on the MT 3D inversions and highlighting the need to better characterize the uncertainty of the inversions.

Reflection Seismic for Deep Sedimentary Targets

Very permeable karsted pinnacle reefs of the Malm formation in Bavaria could be relatively easily imaged at over 3300 m depth using 3D reflection seismic to produce >120°C water (Buness et al., 2010). However, as the pinnacles were explored, the more subtle permeability associated with open fractures that may or may not be associated with karst has proven to be a riskier target for 3D seismic stratigraphic modeling and attribute analyses.

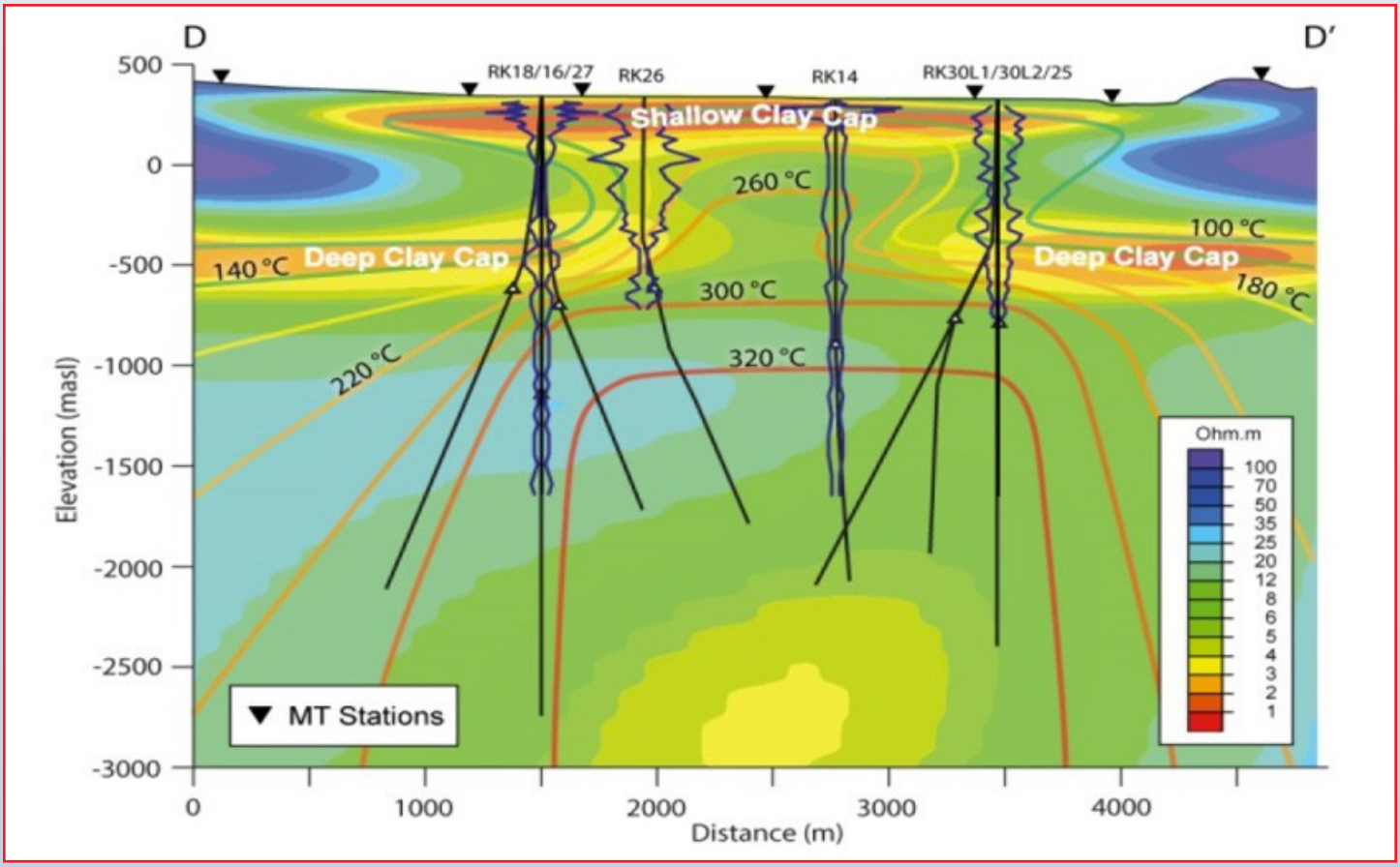

Figure 2: Rotokawa Geothermal Field MT resistivity cross-section with natural state temperature and smectite content (Methylene Blue, %) logs shown in blue along well tracks. (From Sewell et al., 2015)

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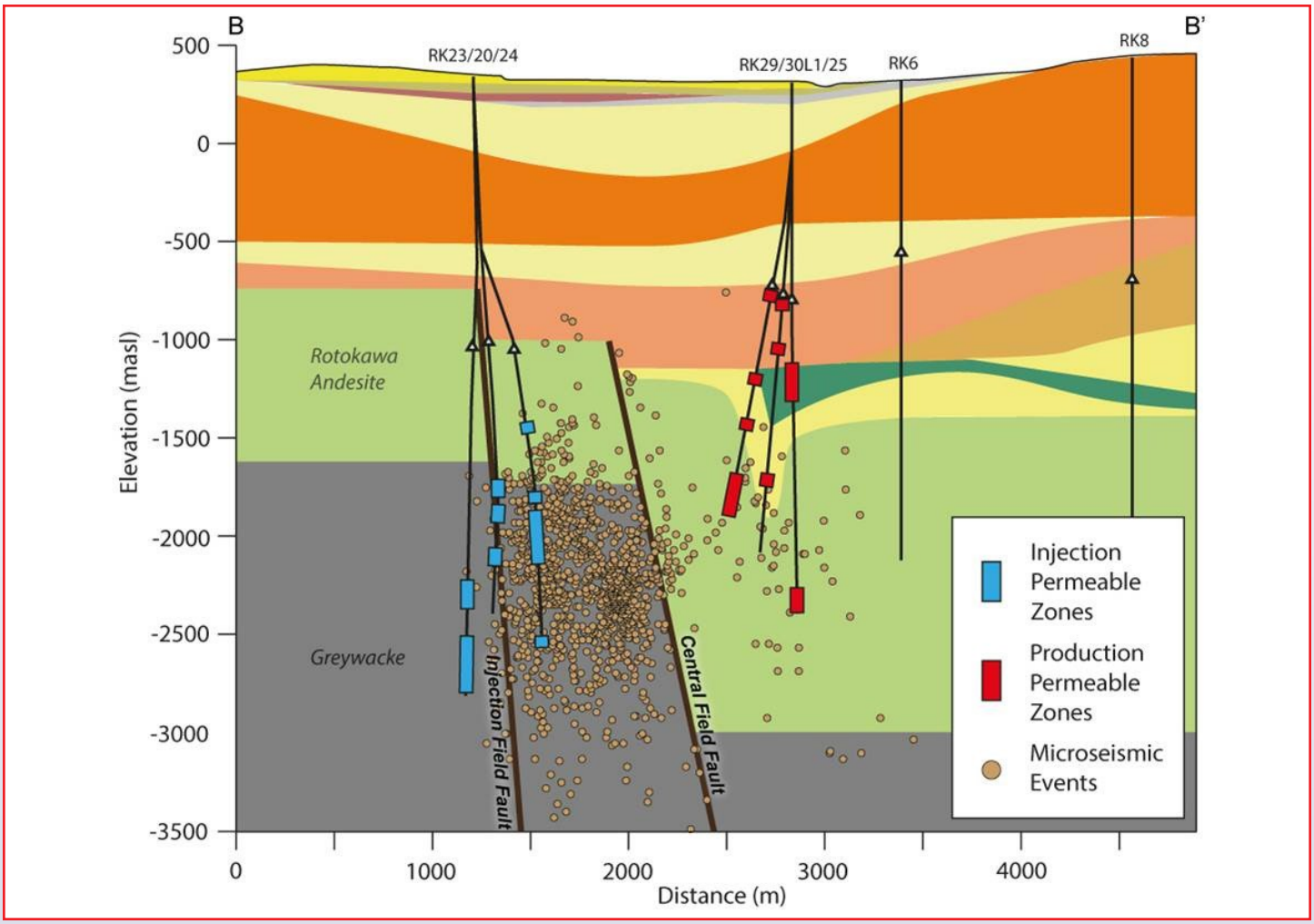

Figure 3: Microseismic events at Rotokawa Geothermal Field showing events related to cold injection water moving toward the pressure low related to production and stopping at the Central Fault Zone. (From Sewell et al., 2015)

In the Otway Basin of South Australia, the Salamander-1 well was targeted based on 3D seismic to penetrate a porous zone of the Pretty Hill Sandstone at >130°C at 3000 to 4000 m depth, over 500 m downdip from a gas well 5 km away (Hand et al., 2015). The well confirmed the seismic prediction of high porosity to great depth and elevated temperature. However, differences in diagenesis in the water saturated part of the sandstone targeted by the well in comparison to the same zone in the nearby gas wells was probably important to the permeability of the gas wells. Moreover, although the porosity had been preserved by clay cementing of the sands, the migration of chlorite and kaolinite fines when water moved through the formation made it impossible to produce the well at a high rate.

Further deep sedimentary assessments worldwide are focusing on supplementing the 3D seismic with a petrophysical model more favorable to success.

Geophysical Monitoring of Developed Fields

Repeat microgravity surveys detect changes in steam/gas saturation in the rock pore space due to reservoir boiling under production or condensation due to cooling under injection (Allis and Hunt, 1986). Most boiling occurs near the apex of a reservoir where it is near the boiling point, the typical location for development of a steam cap. Atkinson and Pedersen (1988) report a simulation of the Bulalo Field where the gravity change computed for the gravity stations from the fluid

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density change simulated in a numerical reservoir simulation model indicated that the reservoir was significantly larger than initially modeled. This supported the eventual expansion of generation from 330 to 458 MW.

Monitoring of small seismic events has been a routine application in geothermal developments that use deep injection into hot rock. Most publications on seismic monitoring of geothermal fields focus on imaging rock properties, commonly tomographic imaging of P- and S-wave seismic velocities. Because of resolution issues, this has seldom been directly used in making resource decisions, although the information is important to the velocity model for observed seismic events and is steadily improving. The most decisive analyses of seismic monitoring data that have affected resource decisions have involved careful correlation of production and injection rates, pressure and temperature, and permeable zones with respect to 4D visualization of the location and timing of the seismic events, supporting important injection management decisions (Sewell et al., 2015). For example, at the Rotokawa Geothermal Field, microseismic events (MEQs) induced mainly by injection cooling show that the cool injection water is pulled to the pressure low at the production wells but does not impact the productions wells because it is diverted by the Central Field Fault *(Figure 3)*.

Geophysics and EGS

Seismic monitoring is an essential tool for defining EGS reservoirs and managing related hazards and nuisance issues have been addressed by a formal standard (Majer et al., 2012). An enhanced geothermal system (EGS) (also called a hot dry rock system) has heat but lacks porosity and permeability and, as a result also typically lacks a working fluid to extract heat from the system. These systems typically include low permeability crystalline basement, low permeability very hot volcanics or tight sedimentary rocks at depths greater than 3 km. Because such systems are found at drillable depths worldwide, the potential resource is large if the thermal energy stored in hot rock can be extracted economically (MIT, 2006). Rock fracturing or the stimulation required to create man-made reservoirs typically results in shear failure, especially in zones of high in situ stresses. These are manifested as MEQs that can be detected using seismometers deployed either at the surface or in downhole locations. Such MEQs are essential to mapping the induced fractures and flow paths within the reservoir in space and time (e.g., Baisch and Vörös, 2010). However, development of the very large EGS resource base may be conditioned by adequate prediction and management of the risk of induced seismicity at EGS projects.

Conclusions

As geothermal exploration extends to resources that do not fit earlier archetypes, targets become more risky and the demands placed on geophysical methods increase. MT is the standard method used in conventional geothermal exploration and it continues to meet most needs, albeit with increasing requirements for resolving a 3D conductor 100s of meters across and over 1000 m deep in the presence of increasing power line noise worldwide.

Unlike Oil and Gas, reflection seismic is not widely used in geothermal exploration, except for deep sedimentary prospects where 3D seismic is mandatory and the resource viability requires improved constraints on petrophysical models. Although chaotic geology, rugged topography, high near-surface velocity contrasts, shallow gas-charged smectite clay, and other issues have made 3D reflection seismic data too risky and expensive to acquire over volcano-hosted geothermal systems, 3D reflection seismic is essential to the exploration of deep sedimentary geothermal systems.

Gravity and magnetic surveys remain locally valuable methods and joint inversion of gravity and MT are becoming routine. Repeat microgravity and subsidence monitoring are established standard applications for high temperature systems that are likely to experience reservoir boiling and reduction of bulk density related due to the creation of zones of higher steam saturation under production.

Microseismic monitoring is a standard application for monitoring injection in conventional geothermal reservoirs and for understanding the geometry of a reservoir created in an EGS experiment. Basic needs have been met but improved velocity tomography, moment tensors, and similar analyses remain under development. □

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GSH Movie Time

Now Showing
Wheels on the Arctic*

When you hear someone say “Arctic Islands” you may think of northern lights, polar bears, or icebergs. For GSI crew members hearing “Arctic Islands” brought to mind ice that is sharp enough to tear a tire like a hot knife through butter, lousy traction in loose snow on diamond-hard ice, changing busted axles or replacing tires - hugh tires deflated by the minus 50° Fahrenheit temperature - or about the dogs that crews keep around to warn about the proximity of dangerous polar bears.

Take a look at one operation on ice, 200 miles NW of Resolute, where a single string camp is towed by a Caterpillar and a fully articulated TT200 6x6 drive unit. The camp is a foldout camp featuring trailer units that expand out to increase the living space by a factor of 3 and enable easy transport by Hercules aircraft. The crew was supported from Calgary, 1800 miles from Resolute.

Click on red ticket to view movie

* GSI vintage videos courtesy of Schlumberger – WesternGeco

GSH Outreach

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

The 2021 Science and Engineering Fair of Houston was held virtually February 18 – 27. This year, the sixth grade was added to the Junior Division. The GSH Special Awarding Agency Team consisted of five to seven volunteers. We selected and judged projects related to geophysics in the Junior (grades 6-8) and Senior (grades 9-12) Divisions. A first and second place winner were chosen in each division. Details will be included in the June issue of the GSH Journal.

A teacher at the Thompsonville Christian School in Georgia invited the GSH Geoscience Museum to give a live Zoom classroom presentation to her school in lieu of a field trip.

> *"My students will soon be learning some geoscience topics and we are wondering if the Geoscience Museum currently offers or would consider offering a virtual program similar to the classroom presentations you would normally present to a live audience. Our presenters in the past have typically presented for 30-45 minutes with a Q&A session at the end.*
>
> *My classroom currently serves grades K-4, while grades 5-8 would likely join us for virtual programs."*

Bill Gafford forwarded the invitation to me and I forwarded it to the Outreach volunteers. Four people volunteered to give the presentation. I provided the lucky presenter with an example PowerPoint presentation suitable for elementary school and they worked with the teacher to set a date and time.

Bill Gafford also forwarded an inquiry from an SEG member looking for the former SEG Youth Education Committee K-12 tutorial PowerPoint presentations that were posted on the old SEG website. He has a friend that helps teach science to his home-school age grandkids. He asked the SEG member if he could tell them about his profession and thought showing something with illustrations would be of help more than just talking. There was an intention to post the presentations on the SEG WiKi, but they are not there yet. I forwarded the presentations to them that I had downloaded from the old site before it went down.

The Scout Fair @NRG Arena (over 10,000 Scouts), which occurs annually in April, was canceled due to COVID-19.

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 give a virtual presentation?

If so, please contact Lisa Buckner at outreach@gshtx.org. and we can work together to bring awareness of geophysics to the students. □

U of H Wavelets

University of Houston Sheriff Lecture Student Poster Competition

By Joe McNease

With the spring semester fully, the SEG Wavelets have had many new and exciting events to host. On January 29th, the SEG wavelets, along with the AAPG Wildcatters, EAS Graduate Student Committee, and UH Geosociety, hosted a student organization welcome back event. The night consisted of students and professors competing in trivia, a geophoto contest, and a chance to win the welcome back raffle. On February 18th, Dr. Mel Best gave his lecture, *'Geophysical Applications in Mineral Resources'*, as part of the continuing 'Under a Different Rock Series' lectures by NextGen Geophysical Society of Houston. Dr. Best has more than 30 years of exploration geophysics experience, working in both industry and government roles. To stay up to date and register for future *'Under a Different Rock Series'* lectures you can go to the GSH homepage here.

The Geoscience Trivia Night originally planned for January 28th has been postponed, but we are working hard to establish a new date for the event, which will subsequently be posted on all our social media accounts linked below. The UH EAS Structure and Tectonics Seminar is an ongoing series of informal research presentations on structure, tectonic, and petroleum topics that we encourage anyone with an interest in geoscience to attend. The seminar features graduate and undergraduate research presentations with a Q & A session that helps the students to refine their ideas. Additionally, the seminar is a great way to make new connections with faculty and students that share a love of geoscience. These presentations are held every Friday from 10:00 a.m. to 12:00 p.m., and we hope to see you there!

To keep up with the SEG Wavelets, follow our social media profiles on LinkedIn, Facebook, Instagram, and Youtube. Also, you can join SEG at the local level with the Wavelets and the national level by following the instructions on our site! □.

Bayes' Last Stand ... Fade to Gray

As we move into new fields of **probability and statistics**, let's clean up some hanging issues, the first of these would be the Puzzle for April in which the fate of **Bobby Pure**, the disgraced Astro's slugger, batting **.437** with over 5 years, who was accused by the **MLB** of **steroid use,** having tested **positive.** The test, it was claimed, was essentially **"fool proof"** having a **95% accuracy** rate, meaning that if Bobby were injecting steroids, he would test **positive (T+) 95%** of the time. This sure-fire statistic plus the **false positive rate of 5%** are more than enough to convince the **MLB** to suspend Bobby from the game

MLB Executive

Surprisingly, Astro execs supported the suspension fully. Some think it is related to the **new contract** being negotiated with Bobby Pure for 7 years at a total of **$280 Million**.

Bobby lamented the decision, saying, "All I ever wanted was to play ball. I never took no drugs of any kind!" Is **95% probability** a true assessment of the likelihood that Bobby **used the performance enhancing drugs?**


Astro Executive

Maybe **not**, what we need to know is the **probability or rate** at which major leaguers take such drugs. That rate or probability is **.05**, meaning of some 700 players on the MLB rosters, 35 is the expected number of cheaters. Now we have what we need to help the **MLB** and **Astros** understand the real likelihood Bobby is among them. **H**, below, is the **Hypothesis** that Bobby takes drugs.

P(T+ | H) = .95 (True Positive) .....P(T+ | NotH) = .05 (False Positive)
P(T- | NotH) = .95 (True Negative) .....P(T- | H) .05 (False Negative)
P(H) = 0.05 (Use of steroids by MLB players)
Determine P(H | T+) probability that Bobby is really using Steroids

Bayes sayeth: $$P(H|T+) = \frac{P(T+|H)P(H)}{P(T+)} = \frac{(.95)(.05)}{(.95)(05).+(05)(.95)} = 0.5 = 50\%$$

Not exactly overwhelming evidence of innocence , but it beats **95% of guilt** and it was enough to convince the MLB to **hold off on suspension** without further evidence.

P(T+|H) + P(T+| NotH)
All the ways of testing positive

The one remaining **Bayesian issue** is that of the **Monty Hall problem** - the one which got **Marilyn Vos Savant** in such trouble with overzealous and uninformed Frequentists in the ranks of academia. Recall the essence of the problem is to select a door behind which is a valuable car - **$500K Roll Royce Phantom**. There are 3 doors (behind **2 are goats**). The probability that the car is behind any one is simply **1/3**. You choose **door A** . Monty shows you behind **door B**

Tutorial Nuggets continued on page 29.

Tutorial Nuggets continued from page 28.

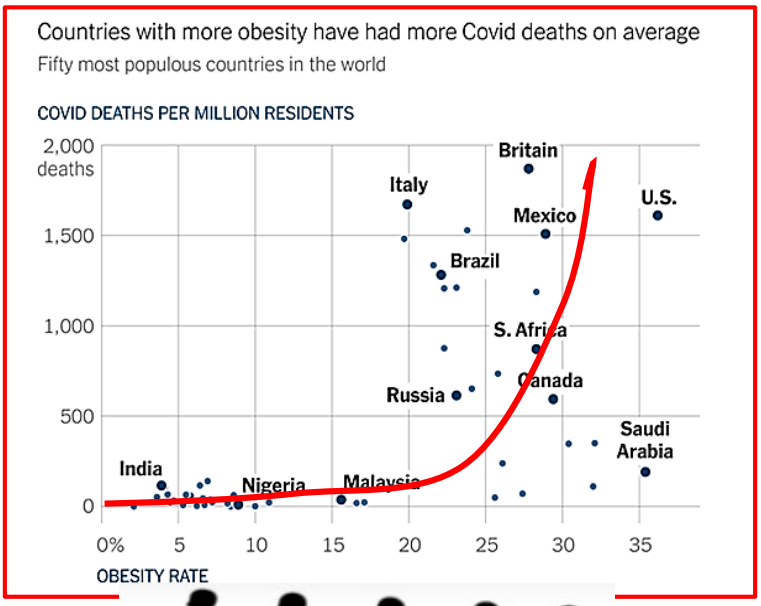
is a **goat**. This is game changing information to assist you answering the next question**: would you like to switch your first choice from door A to door C** (given you now know it's not behind door **B**). At first glance it seems as if there is equal probability for **A** and **C**: **P(Car@A) = P(Car@C) =** ½. But is it? Since we have new information since your pick od A, let's pose the problem as **Bayesian.**

Here we calculate the **P(C| openB),** which gives us the probability of the car being behind **door C** given that Monty exposed the **goat behind door B**. What you need, to fill in the blanks correctly, is to consider why he chose door **B** knowing both what you selected (**A**) and what's behind (**C**): the **Phantom?** This is your **Probably Impossible and Possibly Improbable Puzzle for May 2021. Good Luck.**

$$P(C|openB) = \frac{P(openB|C)P(C)}{P(openB)}$$

Cause and Effect ?

Every now and then, the Guru likes to inject **new life** into these learned discussions:



BMI	18-25	>25	>30	>35	>40
	Normal	Over-weight	Obese	Extremely obese	Morbidly obese

The diagram, at the left, appeared recently in the esteemed ***Journal of Health and Environmental Science***. The values of COVID death rate (deaths per million residents) vs the percentage of obese residents. Obesity at various levels by **BMI** (body mass index) = (703) x [weight (lbs.) / height^2 (in^2)]. **For example**, if a male weighs **200 lbs**. and is **5'10"**, he has a **BMI = 28.7**, which puts him above overweight, but less than fully "obese". (See the graphic below the chart.)

Some innocent, but untutored "scientists", might find this exponential relationship (red curve) compelling evidence that the main cause of death and other nasty consequences of COVID is **obesity.** Grabbing their ever-ready pitch forks, the fat offenders, are rounded up, notwithstanding the fact that they are the **victims** as well as the **perpetrators.** **What is wrong with this analysis?**

Tutorial Nuggets continued on page 30.

Tutorial Nuggets continued from page 29.

What Went Wrong ? Step in The SEG ...

The Research and Deep Investigation Committee **(RDI)**, at our favorite Society, dedicated to the best interests of Exploration Geophysicists, has revealed *The Occult Study of Climate Change and Its Impact On the Earth – as we know it"* and it's Not Good.

Returning, briefly, to the issue raised at the bottom of the previous page, it was immediately recognized by the **RDI** as the same paradox that has misled geophysicists for decades, namely the belief that velocity is directly related to density, i.e., the greater the density, the faster the velocity. Gardner, Gardner, Gregory, and Gardner exposed us to the concept in their 1974 seminal paper. Below are two equations, derived empirically from sonic and logs:

$$\rho = .23Vp^{0.25}$$

$$Vp = 357\rho^{4}$$

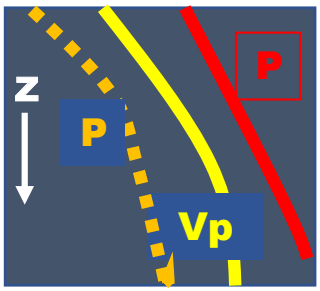
Where ρ is in g/cm³
Vp is in ft/s

These equations are often used to estimate density or velocity if either sonic or density logs are missing. For this purpose or modelling, they work acceptably well (perfect being the enemy of good enough). Strangely however, this empirical relation showing a direct correspondence between Vp and ρ, is not a **physical** relationship which shows, from solid physical principles, that the two are **inversely related:**

$$Vp = \sqrt{\frac{K + \frac{4}{3}\mu}{\rho}}$$

K = Bulk modulus
μ = Shear modulus

This cozy **Great Truth** (left) then raises the same issue confronting us with **deaths** related to **BMI**: How can they be correlated if not physically related? The answer is essentially the same as for **Vp and ρ.**



Both **Vp** and ρ increase with increasing **pressure (P)** or stress which itself increases with depth (**Z**) due to the increasing weight of the overlying rocks (**overburden**). See precise graphical evidence at the left. In the case of disease, death, and BMI, it has been determined by the **SEG RDI** committee that these parameters are very likely ("high probability") in response to the **proven** rate of **climate change** caused by the **abundant overuse of fossil fuels**, in particular the emissions of **CO_2** and its **dire consequences**. (Details to be discussed later.)

This finding corresponds almost exactly with that of the **Health and Environment** journal as well as that of dozens of **professional societies** including the AGU, AAPG, EAGE, CSEG, DNC, G&KI, et alia. The **SEG** has justifiably joined with them as revealed by their policy statement recently published in ***TLE.***

The SEG Council meets on Wednesday, **April 7**, to discuss and approve the **Bylaws Amendment** allowing the move of SEG HQ to **Houston**. It may also discuss the proposed change in the society's **name change** from Society of **Exploration** Geophysicists to the now more appropriate Society of **Environmental** Geophysicists. A name behind which we can all gather and support. Let the **SEG** know your hearty support of opposing use of **fossil fuels**.

The Mystery Item on page 17 is a **Radio Transceiver from 1936 donated by Sun Oil.**

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For more information about becoming a Corporate Member, go to GSHTX.org

Bright Spots in 2021

NextGen Industry Night

By Anthony Moraes, NextGen Committee Member

If there was one thing positive to come of 2021, it was the ability to virtually connect with others across the world. NextGen, a subgroup of the GSH for early career Geophysicists, decided to take advantage of this by engaging college students through a virtual "Industry Night." The first Industry Night was hosted by Tony Moraes (ExxonMobil) and Peter Lanzarone (BP) for the University of Georgia Geology Department, our alumni institution. The motivation behind the Industry Night event is to engage with students who attend schools that generally have an underrepresented recruiting presence within the energy industry.

The Industry Night consisted of three parts: an elevator pitch feedback session, Q&A, and interactive seismic interpretation tutorial. A key part of the job search is communicating your background and skills in a clear and concise manner, otherwise known as the elevator pitch. The students shared their excellent elevator pitches and received feedback on tailoring the pitches to E&P professionals for future recruiting events. After the elevator pitches, the students asked questions about careers in the energy industry. Finally, Moraes and Lanzarone utilized the full potential of Zoom to create an interactive interpretation session. Using a few publicly available seismic images from the Gulf of Mexico to the Santos Basin and offshore Angola, students used the whiteboard feature to make their very first seismic interpretations. These soon-to-be professional geoscientists are sure to bring a bright future for the energy industry! □.

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

GSH Media Kits

Item Of Interest

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

HGS SHRIMP PEEL & CRAWFISH BOIL

FRIDAY, MAY 21, 2021
12:00PM – 6:00PM
BEAR CREEK PIONEERS PARK, PAVILION 6
3535 WAR MEMORIAL ST. HOUSTON, TX 77084
Pavilion #6 is located off Bear Creek Dr.

BOILED SHRIMP
CAJUN CRAWFISH
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BEER & BEVERAGES
DJ MUSIC

Member reunion & celebration at our first in-person event in over a year!

HGS Members $30
Non-Members $35
Walk-Ups $45

Sponsorship Opportunities

Shrimp Sponsor $1,500 – 5 complimentary tickets
Crawfish Sponsor $1,500 – 5 complimentary tickets
Beer & Beverage Sponsor $1,000 – 4 complimentary tickets
Music Sponsor $1,000 – 4 complimentary tickets
Platinum Corporate Sponsor $1,000 – 4 complimentary tickets
Gold Corporate Sponsor $750 – 3 complimentary tickets
Silver Corporate Sponsor $500 – 2 complimentary tickets
Bronze Corporate Sponsor $250 – 1 complimentary ticket

For sponsorships, please call Andrea Peoples at the HGS Office at 713-463-9476 or email *office@hgs.org.*

Register online at www.hgs.org

Doodlebugger Diary

Black Magic in Geophysical Prospecting, Part 1

By L. W. Blau, Geophysics Department, Humble Oil & Refining Company

The Doodlebugger Diary recounts the experiences of geophysicists during their working lives. This month I am building on our January Doodlebugger Diary by Dan Plazak that discussed the early history of the term 'doodle-bugs'. This was followed up in March by Gene Sparkman's recounting of his early experiences with doodle-bugs. In this issue I have started a 3-part series that reprints the very first article published in Geophysics in 1936. I found this article very enlightening, and very lengthy, giving some indication of the import of the topic. It is apparent that quack science was a serious issue in our profession's early days. Recent history demonstrates that science is still under attack so we all must continue to defend the honor and objectivity of the scientific method.

If you have any similar stories you would like to share, please send them my way. I'll be happy to print them in this segment.

Reprinted from Blau, L.W, 1936, Black magic in geophysical prospecting: Geophysics, 1, 1-8, doi: 10.1190/1.1437076

PREFACE TO THIS REPRINT FROM THE SEG DIRECTOR OF PUBLICATIONS: *The Society of Exploration Geophysicists (SEG) and the Geophysical Society of Houston (GSH) share a commitment to using and promoting inclusive language — avoiding expressions that express, imply, or reflect, consciously or otherwise, ideas that are racist, sexist, or otherwise biased, prejudiced, or denigrating to any particular group. This commitment came into play when the editors of the GSH Journal requested permission from SEG to reprint the first article ever published in Geophysics for the purpose of reflecting on the work's technical contribution to our profession. SEG extended such permission and is joining GSH to use the occasion of this reprint to acknowledge the racial and religious insensitivity of the 1936 article's title — "Black magic in geophysical prospecting" — and to affirm our intention to minimize the use of such expressions, once offered without attention to or awareness of their marginalizing effect, in either organization's current and future publications or any other communications. The article was an essential contribution when first published, shedding light on specious methods and calling for higher standards of geophysical practice based on sound science. Despite containing exclusionary language, it endures as a cornerstone of modern applied geophysics.*

EDITOR'S NOTE FROM THE ORIGINAL 1936 PUBLICATION: The term "doodle-bug" is coming more and more to mean proposed methods of geophysical prospecting that are neither based upon scientific fact nor upon known or proven properties of oil, minerals and geologic formations. The geophysicist is often consulted concerning the reliability of such a proposed method, and his task then is to explain scientifically just why the proposed method fails and is unsuitable for the intended purpose.

Because such an explanation may often require a time consuming investigation, the geophysicist may be forced to spend more time on such an investigation than is justified. It is important then that as many as possible of these "new" methods be presented to the membership in order to prevent duplication of these investigations.

Dr. Blau's paper, "Black Magic in Geophysical Prospecting," initiates this department, and it is

Doodlebugger continued on page 38.

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

Doodlebugger continued from page 37.

hoped that the seriousness of the subject will be kept in mind while the reader enjoys the humor in Dr. Blau's paper. Additional papers on doodle-bugs are earnestly requested and the membership is urged to send in a description of any new doodle-bug that is brought to their attention, together with the details of their investigation and their conclusions.

The rapid growth of the oil industry, and the high profits derived by the more fortunate land and royalty owners from the oil which is often found by drilling on hitherto relatively worthless land, have so preyed on the imagination of some would-be inventors and miracle men, that hardly a month passes without news of the invention of a purportedly reliable oil finder. Fantastic claims are usually made for these devices and methods; thus, it is claimed to be possible to predict the gravity, quantity of oil, thickness of the oil sand or sands and their depths, as well as the presence and quantity of such useful minerals as salt, sulphur, and potash. It is supposed that in other parts of the country the same devices would be equally useful in prospecting for gold, silver and other metals.

It is characteristic of these inventors that they stress emphatically the fact that they have never studied any exact science. The assumption seems to be that all the really great inventions are made by people who know nothing about the subject and that training in the exact sciences tends to build up complexes as well as beliefs that certain things cannot be done; it is the function of these relatively innocent and untrained inventors to make those inventions which the scientists refuse to tackle. Another great talking point is that they have worked on the invention for many years, rarely fewer than ten and often seventeen to twenty, the number depending somewhat on the age of the inventor. A third point which is generally emphasized is that the invention has been submitted to great university scientists who were, however, unable to understand it. This inability to comprehend is undoubtedly due to the complexes mentioned above. These scientists are in the majority of cases alleged to be personal friends of the inventors and Nobel Laureates would probably be painfully surprised and astonished if they realized how many inventor-friends they have.

It is further characteristic of the devices that, whatever quantity may be read, the reading is generally high on oil or gas fields. In the case of devices which indicate direction, there is nearly always something which points toward the oil field. The assumption seems to be that a device giving a reading of 10 on an oil field and 200 off the field would be harder to sell than one giving a high reading on the field; by the same reasoning an apparatus pointing away from the oil deposit would not be desirable.

There are, roughly, five different principles which seem to be most useful in the design of oil finders:

- First, oil, gas, sulphur, even lime and granite, emit corpuscular radiations which can be observed by means of instruments at the surface of the earth.

- Second, the minerals which it is desired to find radiate vibrations which react upon the observer and enable him to locate them.

- Third, substances do not attract according to Newton's law, that is the force of attraction is not proportional to the product of the masses and inversely to the square of the distance; the force of attraction is alleged to vary with the chemical constitution of the substances and there appear to be grave doubts also to the effect that the exponent in the denominator is much, very much indeed, too large.

- Fourth, oil and gas send out electromagnetic waves which can be received with a sufficiently sensitive and properly tuned radio receiver.

- Fifth, organic substances exhibit sexual characteristics; sex, being one of the stronger emotions, can therefore be very profitably exploited in oil prospecting if the proper technique is employed.

Next Month: Black Magic in Geophysical Prospecting, Part 2 □