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GSH Journal

GEOPHYSICAL SOCIETY OF HOUSTON
Volume 12 • Number 1



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The Future of Open Source Earth Science
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Oct 2021..... Aug 16
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A Word from the Board

By Klaas Koster, President



In my previous Word from the Board, I wrote that I expected the days of working all day, every day, in an office are permanently behind us. That expectation has become reality for the company I work for. Since vaccinations have widely become available, all

employees are expected to work in the office from Tuesday to Thursday but can work from home on Monday and Friday. I have already experienced that being back with colleagues in the office has benefits, especially when it comes to building professional relationships. As soon as we were back in the office, I realized how few of my colleagues I had interacted with during the year at home. I simply never had the business need to schedule a video conference with them to address an issue or was not close enough to just call socially. The consequence of this lack of optional communication is that the quality of my relationships with colleagues has declined, or remained stagnant, and I made no new connections. That is not a good thing for getting something done when the need arises! We all know that it is much more likely that someone with whom you have a good rapport is going to do you a favor when you need one than someone who doesn't know you. And yes, like so many of us, I must often influence and persuade colleagues to get something done and cannot simply order them around!

How does all of this translate to our local professional societies in general and GSH specifically? GSH organized two post-vaccine events, a golf tournament and an icebreaker, and both were sold out. That shows us that many Houston-based geophysicists are keen to reconnect with their peers. GSH was successful in streaming nearly all technical meetings during the last year, as have most others, so there is no issue in getting professional content. But, like in the office, what is

missing is building personal connections. From the poll of geoscientists we ran a few months ago, we know that in-person events with time for people to connect are in demand – for instance, field trips and icebreakers rated highly. GSH will return to in-person events after the summer break to meet this demand, but we will also retain the ability to stream lectures where possible. We will trial a structured approach to help people build connections and start mini-mentoring sessions during our technical talks by perhaps pairing up early- and late-career geophysicists if they indicate that this is something they want to try.

While there is no doubt in my mind that there is a significant need for in-person technical and social events for geoscientists in the Houston area and therefore a solid future for many GSH activities, several of us on the GSH Board are convinced that there is a more efficient and cost effective way to do this than through a number of independent non-profit organizations. Besides GSH, SEG, EAGE, AAPG, HGS, SPWLA, SPE and others are all offering events for geoscientists in the Houston area. Consolidation is already happening between some of these; many of you have read that SEG and AAPG have committed to organizing their flagship Annual Meeting and Convention jointly for the coming five years. Furthermore, AAPG has started talks with SPE to explore merging. Similarly, the GSH Board has started discussing a proposal from SEG to operate as a Regional Office. Joining with SEG would give us access to a much-improved website and social media presence, an efficient online event registration system, and a much larger virtual audience for our authors and presenters. It would also do away with the need to run a separate member administration and most accounting, thus driving event costs down. Of course, a drawback might be that the GSH Board is no longer autonomous in this proposal – it would become an Advisory Board - and some degree of coordination with SEG would be required from event organizers. Watch this space to learn how these discussions progress! □

From the Other Side - Farewell FTOS

By L.C. (Lee) Lawyer



Look at that heading! That would make a 'grown man cry.' Don't you think? I have been the author of FTOS since about 1993. Ten each year yields a lot of writing in 28 years. I am not retiring from supporting the GSH. I like this local society. I like the closeness with

our membership. I write for a lot of friends and enjoy every word. Let's not change it.

Our organization is supported by a staff of two very capable people. We, the membership, burden them with a lot of work we ought to be doing ourselves. They don't mind. They are part of the GSH. The big and gutsy move of the GSH occurred when we parted from the HGS. Actually, the only connection was sharing office space and staff (2). It started us thinking that we could grow and prosper with a little effort. The oil and gas industry was healthy, and the service companies supported us with advertising and membership.

Since I have gone "historical," it is reasonable to show you a sample from the first FTOS column I wrote back in 1993, just after I retired from Chevron. The following is from number one.

Notice the heading for this column. I retired from Chevron on November 1, 1992, approximately ten months ago. It seems as if I have been out of the system much longer than that. I have gone from being a person whose every pronouncement was heeded, to a person who has difficulty getting his golfing partners (Kevin Barry, Bob Jones, and Jon Wisda) to listen when he gives them good advice on how to improve their play.

Clearly, I am on the other side. Mobil no longer looks at me as a competitor. Chevron no longer looks at me as an asset. Texaco no longer looks at me. Bob Graebner no longer takes me to lunch. I have to pay my own way to the SEG convention. My picture showed up in the First Break with a caption that said, "Olof Lundberg". I don't know Olof, but if he looks like his picture, I am truly sorry for him. A huge headline recently appeared in the San Francisco Examiner which read, "LAWYER TAKES VP POST AT CHEVRON". It was pretty exciting for a while but it turned out they meant a generic lawyer rather than a genetic one.

The name FTOS stayed with me the entire 28 years. It is not political. It means that I became a person on the "other side" of employment. Try and remember that. Otherwise, I take on the role of local cynic, always against something. Most of the columns were in the TLE (SEG), but writing for the GSH allows me to complain about the SEG (or praise it)!

The GSH had a rough ride during the pandemic. We are almost through with it, but we learned that "online" delivery of technical material was well received by the membership. We have lost a lot of members for one reason or another. **We, remaining members, should cajole all of their geophysical friends and acquaintances to come back into the fold. We need them. They will benefit.**

This is the end of regular monthly columns (FTOS). I have told our Editor that later I might have a strange urge to write another one. I don't guarantee that.

That's the future. But who knows?

Lee □

Apache

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Online presentation - Sept. 1, 2021 - 12:00pm-1:00pm CST

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Unconventional SIG

Fluid Discrimination Using De-trended Seismic Impedance

Xavier E. Refunjol, University of Houston

[Abstract and Bio](#)

Hybrid Event - Sept. 2, 2021 - 11:00am-12:00pm CST

Register



Technical Breakfast

Predicting Unconventional Reservoir Quality Using Rock Properties and Multicomponent Seismic Data: A Study in the Bakken Formation, North Dakota

Andrea Paris, PhD Candidate, University of Houston

[Abstract and Bio](#)

Online presentation - Sept. 8, 2021 - 7:00am-8:00am CST

Register



Data Science and Machine Learning SIG

The Future of Open Source Earth Science Data in the Cloud: @Earth

Kyle Jones, Amazon Web Services (AWS)

[Abstract and Bio](#)

Online presentation - Sept. 8, 2021 - 11:00am-12:00pm CST

Register



Data Processing & Acquisition SIG

Check <https://www.gshtx.org/> for the most up-to-date details!

Online presentation - Sept. 14, 2021 - 5:00pm-6:00pm CST

Register



Technical Lunch

Illuminating Fine Scale Geology and Creating Robust Seismic Attributes Using High Trace Density Seismic Data in the Midland Basin

Andrew Lewis, Fairfield Geotechnologies

[Abstract and Bio](#)

Hybrid Event - Sept. 15, 2021 - 11:00am-1:00pm CST

Register



Potential Fields SIG

Check <https://www.gshtx.org/> for the most up-to-date details!

Online presentation - Sept. 16, 2021 - 4:00pm-5:00pm CST

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2021 GSH ICEBREAKER

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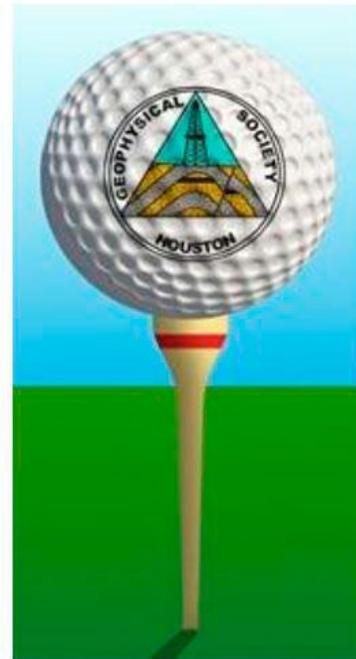


Guided Boats,
Cash Pots,
Trophies

October 8, 2021
Harborwalk,
Hitchcock, Texas



SAVE-the-DATE!
**1st Annual GSH
FALL Golf Tournament**



November 8th, 2021

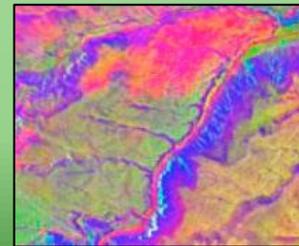
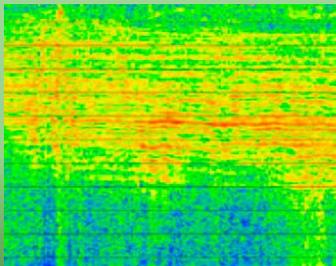


GSH Gets Down to Business

a business-oriented online series

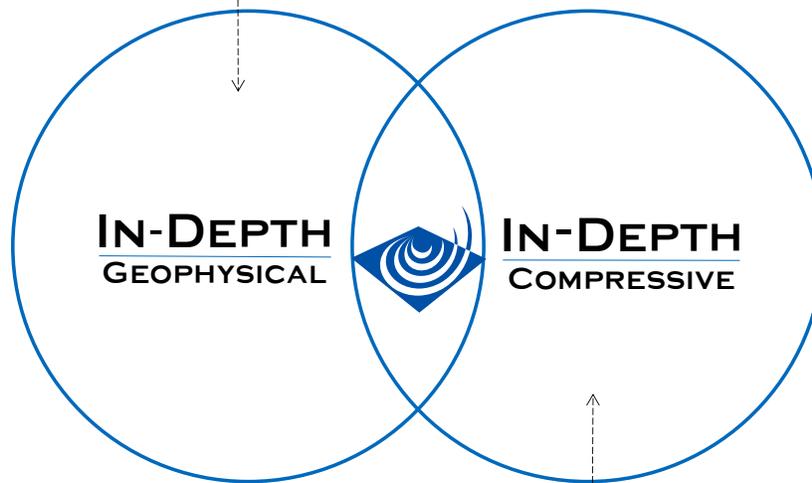
The traditional technical marketing meeting, whether it is a proprietary client in-house event or a booth presentation at a convention, is evolving. The GSH has an online commercial presentation series where companies are able to deliver information on their latest products and services to GSH members and friends! Key features are:

- * A vendor offers their commercial presentation as an online event through GSH.
- * The event is announced, promoted and managed by GSH; attendance is free.
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- * After the presentation, there will be an interactive Q&A session.
- * This is an excellent opportunity to present your product or service to a broad group of GSH members and associates.



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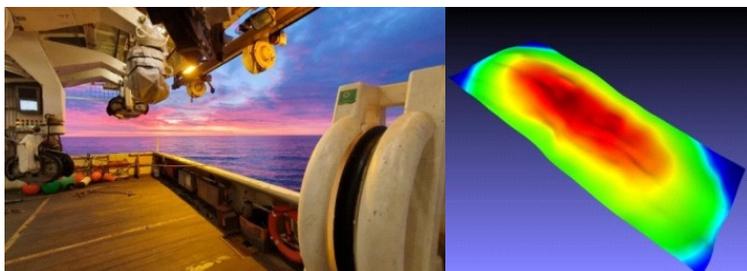
Mon. 30th August 2021
9:00 am to 1:00 pm (CST)

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

Speakers include John Brittan, Christof Stork, Mark Meier, Dave Monk, Malcolm Lansley, Chris Rudling, Andreas Laake, & Ray Abma

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

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2021

GSH FALL FORUM

Carbon Capture, Utilization & Storage (CCUS)

The Path to a Zero Carbon Future

October 25–26, 2021

For Registration, Sponsorship & Booth info, call the GSH @ 281-741-1624 or visit gshtx.org

Climate Change, the Energy Industry, and the Role of Carbon Capture Utilization and Storage

Ali Tura*, Yanrui Ning, Yesser Haj Nasser, Colorado School of Mines

Summary

This paper discusses several key topics related to Carbon Capture Utilization and Storage (CCUS). First, we discuss the forces requiring global carbon reduction. Then we discuss the energy transition and the key role of CCUS. Finally, we discuss the economics of different carbon capture and sequestration options and show why enhanced oil recovery related sequestration can be an optimal solution. We show that this potentially can form the best path for the energy industry and a reasonably well posed problem for geological and geophysical long-term storage and monitoring. Finally, we discuss the potential of CO₂ for enhanced oil recovery (EOR) in unconventional resources.

Introduction

CO₂ molecules have been released into the atmosphere during most of the industrial revolution and earlier. So why is there such an urgency at this time? We discuss two key reasons: public opinion and technological changes. As a result of this emerging urgency, the oil and gas industry has started to respond. However, perhaps the most cost-efficient solution that can both increase production and sequester CO₂ has not yet emerged in a substantive manner. Many power companies are choosing to close down their facilities since either they are not aware or have not considered other options. Further, incentives and regulations are poorly understood. In this paper we discuss these topics and show a way forward that can be a positive outcome for the power companies (coal, natural gas) and oil and gas companies through collaboration.

The Current CO₂ Issue and Relevant Forces

The relationship between historic CO₂ in the atmosphere and warming of the planet is nearly linearly correlated. Using this approximation, to obtain a 2-degree C rise in global temperatures we would need to release 3,700 giga-tons (Gt) of CO₂ into the atmosphere. Given the current trend of CO₂ release and with no changes, that would occur in approximately 2038. To put this in context, during the last glacial maximum global temperatures were

6-degree C cooler versus 20th century averages. EPA (Environmental Protection Agency) compiled scientific studies indicating that 'extreme weather events such as heat waves and large storms are likely to become more frequent as a result of change in global temperatures' (EPA.gov). In recent years, some of these changes are having a direct impact on population. As a result, public opinion and related policy changes are one force that is gaining momentum. Examples of this are the European Green Deal, limiting energy and transportation sector emissions, government and state policies such as 45Q carbon credits, clean fuel incentives, and cap-and-trade (California and a group of 11 North-Eastern US states). The second force causing change can be summarized as technology. Since 2009, cost of energy from solar has gone from \$350 per megawatt hour to around \$50 per megawatt hour. At \$50 per megawatt hour, solar is half the cost of nuclear and coal and about the same cost as gas and wind. Clearly these costs rise if solar is used at night since it requires vast storage facilities; thus, it becomes less competitive.

Carbon Capture Utilization and Storage (CCUS)

As a result of these relevant forces, the oil and gas industry has started to transition. Detailed plans have been provided by many operators and in the end they are focused on two key areas: a) reduce carbon intensity and b) expand into non-hydrocarbon energy. In this paper we focus on item a) reduce carbon intensity. According to the IEA (International Energy Agency) Energy Technology Perspectives 2020 Report, 'CCUS is the only group of technologies that contributes both to reducing emissions in key sectors directly and to removing CO₂ to balance emissions that cannot be avoided'. For reference, CCUS involves the capture of CO₂ at the generating facility (for example a coal-based power plant), then transportation to a utilization or storage location. Storage is usually in oil and gas reservoirs (depleted or for EOR), deep saline aquifers, coal beds, and salt beds, which all require geological and geophysical characterization and monitoring. Further, the IEA report shows a significant recent increase in CO₂ capture volumes and an increase in the number of facilities engaged in CCUS. Clearly the government and state tax, clean fuel,

Technical Article continued on page 12.

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

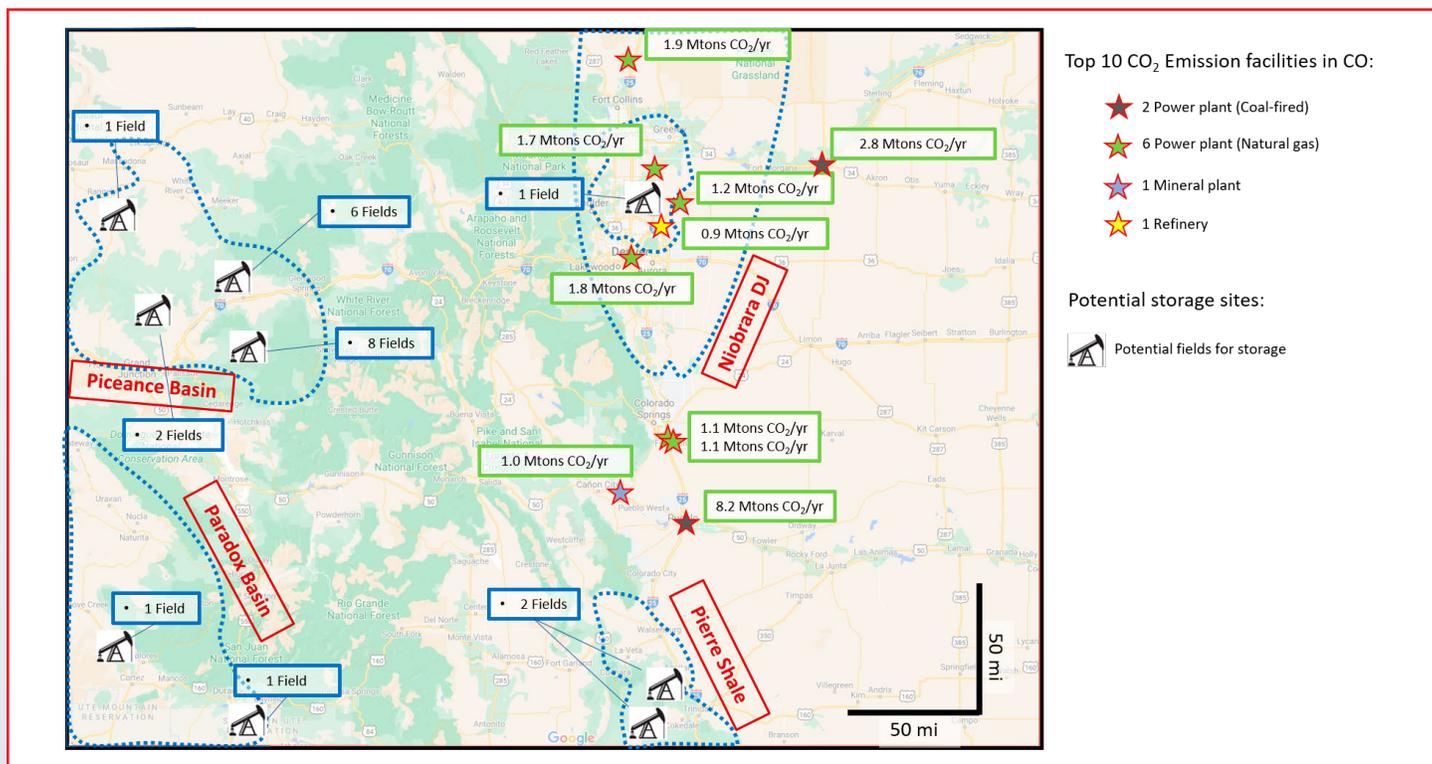


Figure 1: 10 largest CO2 sources for the state of Colorado (stars and green boxes), oil and gas basins (red boxes with blue dashed lines), and oil fields for sequestration (blue boxes with jack pump).

and cap-and-trade incentives and policies are helping the growth of CCUS projects.

Economics of CCUS – A Win-Win Scenario

In our research, as part of a Department of Energy (DOE) project, the first thing was to study the economics of CCUS projects to understand what is the most profitable way forward in this new industry. We have studied capture costs from coal-fired power plants (C-PC), natural gas combined cycle plants (C-NGCC), and extraction from underground natural sources (C-NS). From this we see that NGCC is most expensive, followed by PC, and NS being cheapest. This is likely why CO2 is extracted from the subsurface in Colorado and sent to Texas for EOR purposes. Next, we studied transportation costs. It turns out that the cost to build capture facilities is substantially more expensive than transportation costs by at least an order of magnitude. Finally, we studied storage costs for EOR (S-EOR) and saline aquifer (S-SA). Once again, the storage (and monitoring) costs are significantly less than capture costs. In fact, CO2 capture represents more than 78% of the total CCUS costs. When we sum these costs and deduct 45Q tax credits and any revenue (for example from

additional production from EOR operations) we find that on average, C-PC with S-EOR and C-NS with S-EOR create a positive gain. This is an important result that implies that, through collaboration of power and oil companies, we can not only sequester CO2, but also produce more resources and increase profit margins!

Example of CCUS Projects - Colorado

We show an example of several potential projects that have components of capture, transportation and storage from the state of Colorado as part of the DOE project. Figure 1 shows the 10 largest CO2 output sources in Colorado indicated with stars; 2 PC, 6 NGCC, 1 mineral plant and 1 refinery. The CO2 volumes for each source are given in the green boxes. We note that several PC's that are closing in the near future are excluded from this analysis. Several oil and gas field basins and fields to sequester the CO2 are also indicated. A collaborative effort between the power and oil companies can lead to a large array of CCUS projects with an EOR component. Transportation pipeline options from source to sequestration points are not indicated here since their design involves many factors (such as land ownership and optimal length).

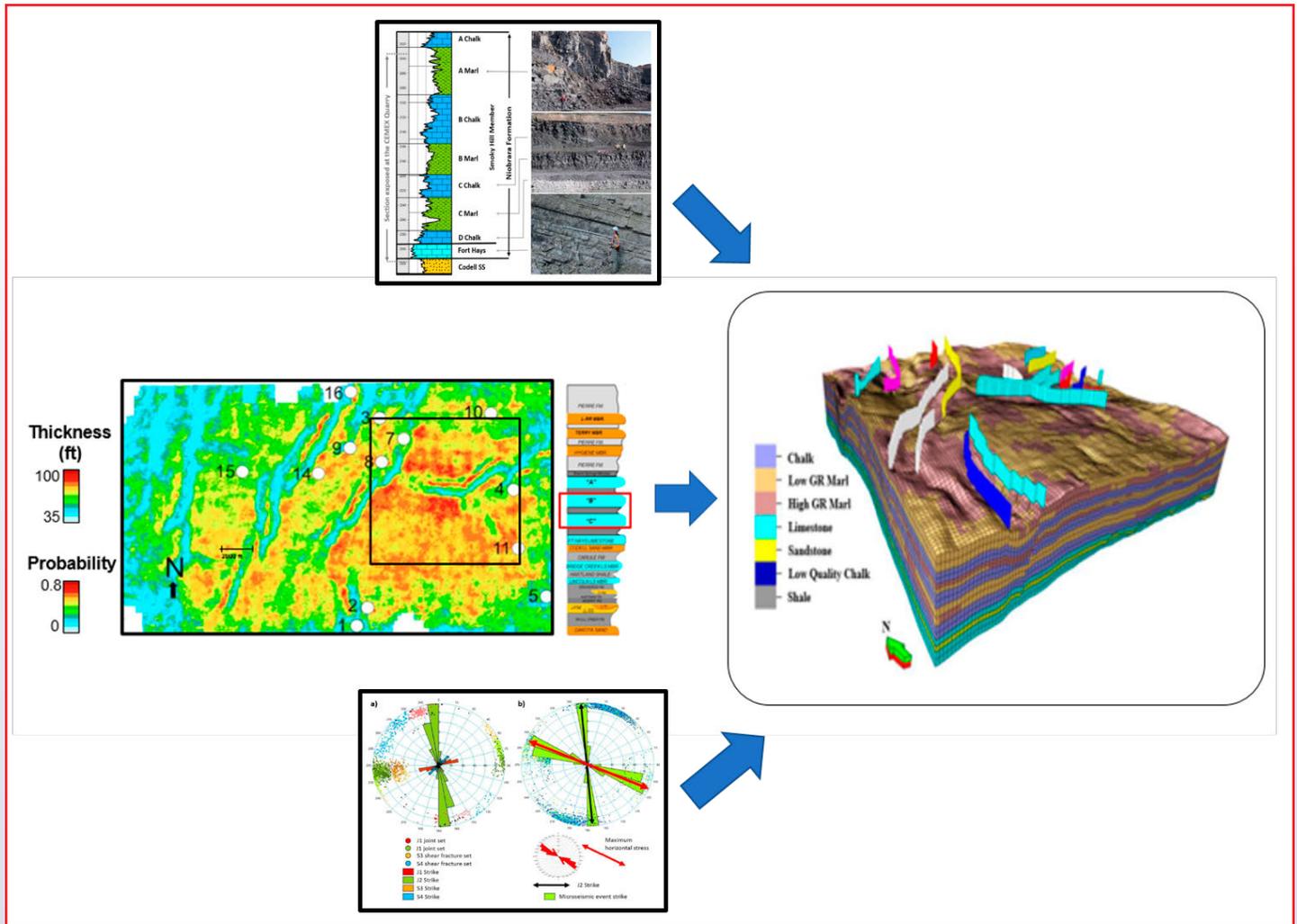


Figure 2: Discrete Fracture Network (DFN) static model for the Wattenberg Field, Colorado integrating outcrop, well log, seismic data (Grechishnikova, 2017).

CCUS Subsurface Technology

The use of CO₂ for EOR purposes in conventional reservoirs has been executed and studied for some time (Davis et al., 2019). From these studies it is well known that given appropriate reservoir conditions, seismic methods can be used for monitoring CO₂ spatially and in depth, given the seismic resolution. This can impact both optimal injection and production design, as well as monitoring any propagation to the surface or breach of the seal(s).

More recently attention has turned to EOR in unconventional reservoirs (UR) via gas re-injection. This has been shown to be successful in increasing production in unconventional plays in the Eagle Ford (Hoffman, 2018) and is now being applied in different basins in the

US. One yet unanswered research question is if CO₂ injection for EOR in UR can be successful and if seismic methods can detect the time-lapse changes.

EOR in Unconventional Reservoirs (UR):

To study EOR in UR we created a dynamic reservoir simulation model as follows:

- Build a Discrete Fracture Network (DFN) static (geological) model using outcrop data, well log fracture data, well log property data, and seismic data as in *Figure 2*.
- Incorporate 3D Hydraulic Fractures (HF) through geomechanical modeling using mechanical and completion properties (Alfataierge, 2017).

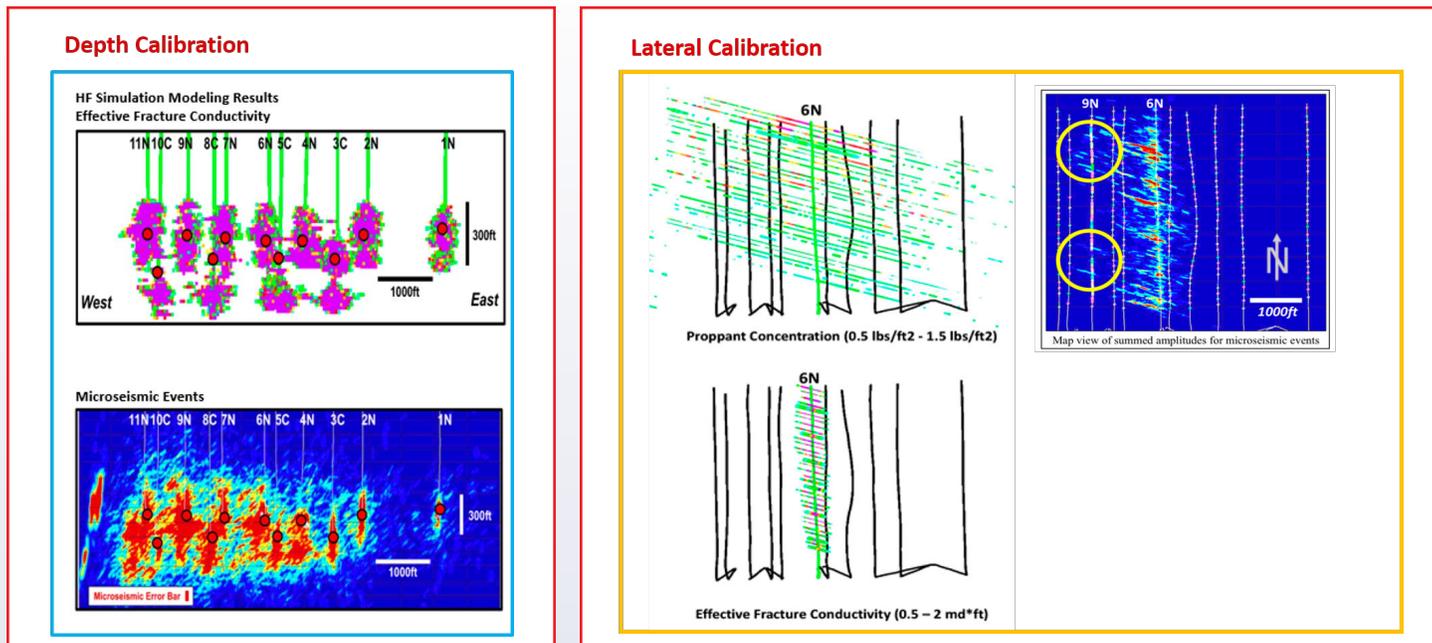


Figure 3: Lateral and depth calibration of hydraulic fractures from geomechanical model with microseismic data (Alfataiege, 2017).

- Calibrate the HF model using microseismic data in depth and laterally (Figure 3). Notice that the fractures propagate a substantial distance as seen in microseismic data but produce from a limited region around the well with proppant as pressure drops.
- Incorporate the HF's in the static model and history match the dynamic model.

The history matched dynamic simulation model is used to predict increased recovery from EOR operations. In Figure 4, we show the increased recovery from 6-months of 1 MMscf/day gas re-injection, followed by 6-months of shut in of 3 wells converted to injectors. This particular design shows 13% additional production even though 3 wells are taken out of production to be used for injection (Figure 4). Using this calibrated dynamic model, we study CO₂ injection vs. gas re-injection as well. (submitted to SPE Journal, 2021).

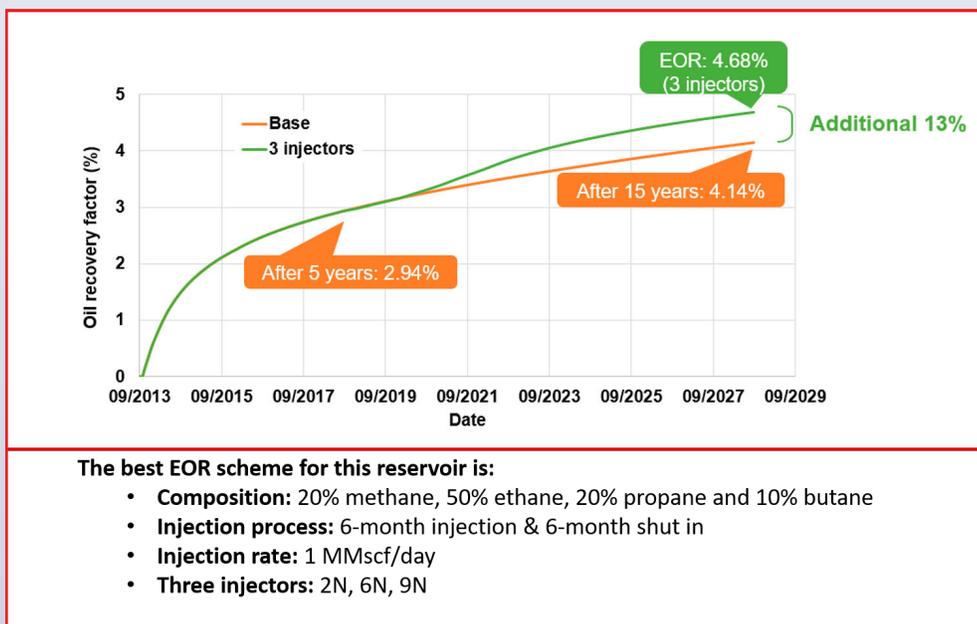


Figure 4: Calibrated simulation model showing increase in oil production via gas injection EOR (Ning, 2017).

Can time-lapse seismic detect changes in UR:

Baseline and monitor 9-component seismic surveys were acquired over the Wattenberg field pre-production and after 2 years of production. During this time, as confirmed by the drop in reservoir pressures and dynamic simulation

model, gas has come out of solution. Following pre-stack seismic inversion, the baseline and monitor data are compared in *Figure 5*. In this figure we can see the extended data points in the monitor data circled in red (low lambda-rho and low mu-rho). This clear slow-down signal is coming from the Niobrara and Codell reservoir depths where the producing wells are located. In *Figure 6*, we see the time-lapse change between the baseline and monitor data. A clear slowdown signal from the producing reservoir, indicating open fractures and gas, can be seen in the green circle. This is also confirmed by a linear correlation between the summed 4D signal along the wells and amount of gas that well has produced during two years of production, as shown in *Figure 7*. The more gas produced, the larger the 4D signal along the well. Finally, when we look at time-lapse time-shifts across the reservoir, we can see a clear slow-down signal as shown in *Figure 8*. This slowdown correlates with both well pads that have dropped under bubble point with gas coming out of solution. These results show that qualitatively a gas vs. oil contrast can be seen in unconventional reservoirs. This is a preliminary indication that under the right circumstances CO₂ injection into an unconventional reservoir has the potential to be observed from time-lapse seismic data.

Discussion on Geological CO₂ Sequestration

CO₂ injection into conventional reservoirs for EOR has been studied for some time. However, CO₂ sequestration into unconventional reservoirs still has many research topics open to study. For unconventional reservoirs, we are still in the early phases of understanding CO₂ injection for EOR. There are many reservoir engineering questions that will need to be answered to show the utility and economic value. There are also many geophysical questions related

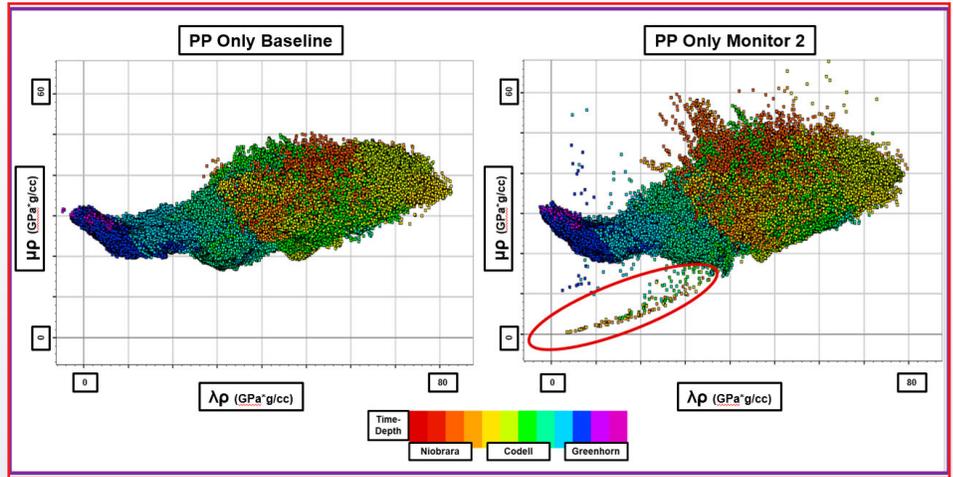


Figure 5: Time-lapse changes from pre-stack inversion. Baseline inversion (left), monitor inversion (right) after 2 years of production and gas out of solution. Points in red circle indicate regions in reservoir of slowdown (Copley, 2018).

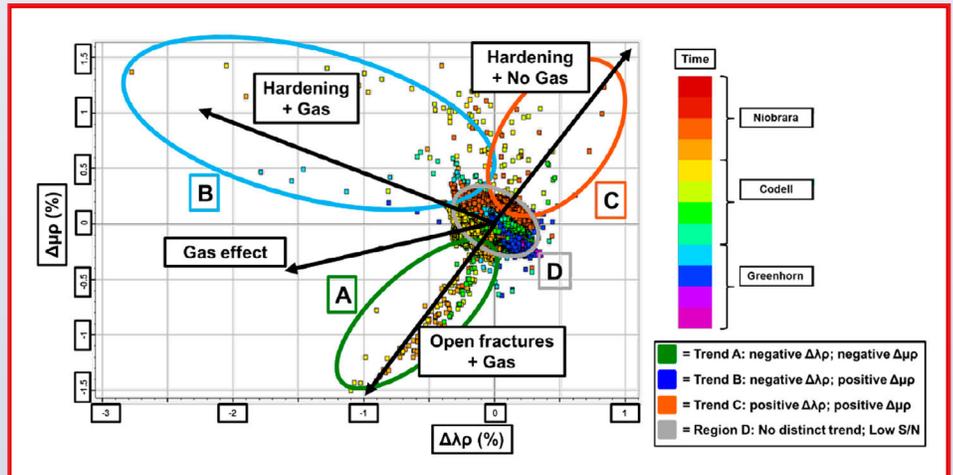


Figure 6: Difference between baseline and monitor data showing slow-down region in green circle indicating gas filled open fractures (Copley, 2018)

to the ability to monitor CO₂ injection into unconventional reservoirs. Research topics related to CO₂ sequestration are: vertical resolution of saturation changes, pressure build up, seal or fault breach, microseismic activity and characteristics, dissolution, and mineralization, amongst others.

Conclusions

There are multiple forces that will change the energy mix of the future. The key forces we see at this time are public opinion that impacts policy and technological changes that impacts price. This transition could be

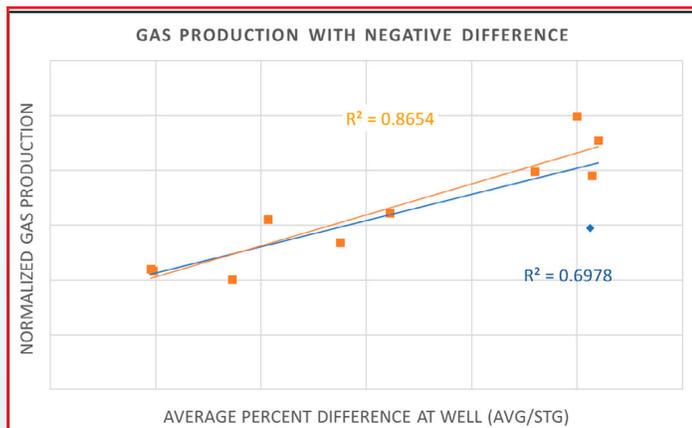


Figure 7: Changes in time-lapse signal between pre-production and two year of production summed along each well (horizontal axis) and gas production from each of the 10 wells during the two years. The larger gas producing wells show larger time-lapse changes (Copley, 2018).

rapid and will impact power and oil company operations. CCUS is expected to be a large component of the future that can make hydrocarbons clean energy. Further, CCUS can be profitable, given government and state incentives of the oil and gas industry. Subsurface engineering and geoscience understanding of CO2 EOR and sequestration are key areas of research. In this paper we show leading indications that CO2 EOR in unconventional reservoirs is also a new research area for both reservoir engineering and geosciences. Further, various new cost-efficient monitoring technologies are a necessity. It is expected that technological developments will play a large role in

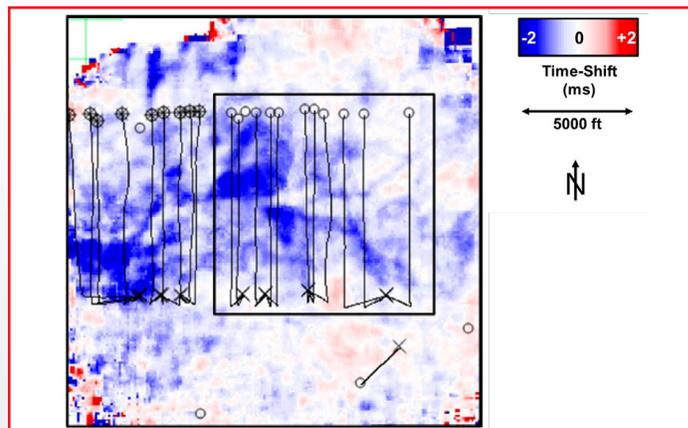


Figure 8: Time-lapse time-shifts from the 40-50o angle range show slowdown due to gas out of solution around wells in the pad with black box. Slowdown signal to the left of the black box was noticed, and the operator confirmed later on the existence of those additional producing wells that started production 3 months earlier (Copley, 2018).

determining both the energy mix of the future and optimal CCUS implementation programs.

Acknowledgements

The authors would like to thank sponsors of the Reservoir Characterization Project (RCP) at Colorado School of Mines and the Department of Energy for support for parts of this work. We also thank Anadarko (now Oxy) for the Wattenberg project, and Ahmed Alfataierge, Matt Copley, and Alena Grechishnikova for their contributions to the Wattenberg project. □

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Permalink: Please contact Scott Singleton (Scott.Singleton@comcast.net)

Mystery Item

This is a geophysical item...

Do you know what it is?



This month's answer on page 22.

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Geoscience Center

The History of Geophysics By Bill Gafford

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

Our **Living Legends Doodlebugger social event** held on **August 11** was well attended. These events are open to everyone and provide a time to visit with old friends and share tales of the oil patch as well as experiences after retirement. Retired or nearly retired doodlebuggers, and their spouses are invited, as well as anyone who is interested in visiting our Geoscience Center.

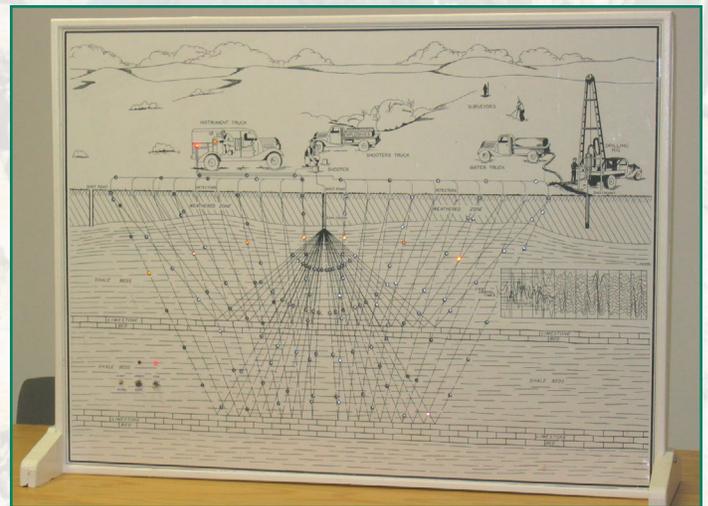
This is a chance to visit with some of the Legends in our industry, and see some of our more interesting geoscience artifacts and some of the Mystery Items that have been featured in the GSH Journals. We have these free events quarterly, and no reservation is needed. Parking is free. Light snacks, coffee, soft drinks, and water are provided. The **next event** will be on **November 10, 2021**.

VOLUNTEERS

Volunteers are always needed to help **research** some of our older instruments and artifacts and **organize** our storage shelves. We currently need help to **prepare a 1980's GUS recording system for display**. It is partially refurbished, and we need help with signage and finishing up with some cleaning.

Also, for many years an electronic animated seismic diagram board, (shown in the picture with this article) has been used at the Geoscience Center and by the GSH Outreach committee at school career days and many other educational events. A newer and smaller electronic seismic diagram board, that will be more portable, is also under construction and partially completed. **Anyone with some experience with electronic devices and construction** who would be willing to help complete this newer version would be very welcome.

We are also always interested in finding new locations where some items from our museum collection can be put on display and help educate the public. This could be in company offices or educational facilities.



Electronic animated seismic diagram board

We continue to receive donations of books and periodicals for our Bob Sheriff Library and have duplicates of many books and periodicals that are Free for visitors. These include textbooks, training manuals, workshop notes, and a variety of geoscience related SEG and AAPG publications. If you are interested in a particular geoscience specialty or want to expand your general knowledge, we probably have educational publications that will fit your need in our library. Items in our permanent Library Collection are also available to be checked out. □

The Geoscience Center has been mostly closed due to the Covid-19 restrictions with only a few volunteers at a time, but we are slowly opening again. Usually there is someone available on Wednesday mornings from 9:00 until noon or by appointment, and visitors are always welcome. Please contact me at: geogaf@hal-pc.org or by phone at: 281-370-3264 for more information.



Displaced

An Empathetic Guru Continues His Philanthropic Nugget Crusade



Hungry



Flicked

If you've been "flicked" or otherwise **displaced** from your cozy job in geophysics at *Loyalty Oil & Gas* or maybe if you know someone who **used to work** for a **geophysical "service"** company, or perhaps you qualify as an **unemployed Millennial** with an MS in Geophysics and no job in exploration, you are the guys that the ever-sympathetic Guru is targeting with his up coming series.

It is now abundantly clear that this **downturn** may never experience the **recovery** that accompanied the crises of yesteryear. *The Fossil Fuel Must Go* crowd looks to prevail over us fossils who made a living looking for it.



The Home Office

Survivors will have to **adapt**. How? Understand and respond to **new geophysical applications** and technology. One of the hot applications that will grow jobs for geophysicists is carbon capture and sequestration (**CCS**). This is very much like looking for reservoirs from which to extract oil and gas, but in **reverse**, as now we want to hide away the villainous by product of fossil fuels, **CO₂**. We also want to be sure it doesn't leak out to infest the air, poison trees, cause global warming, hives, subduction, earthquakes, and corns.

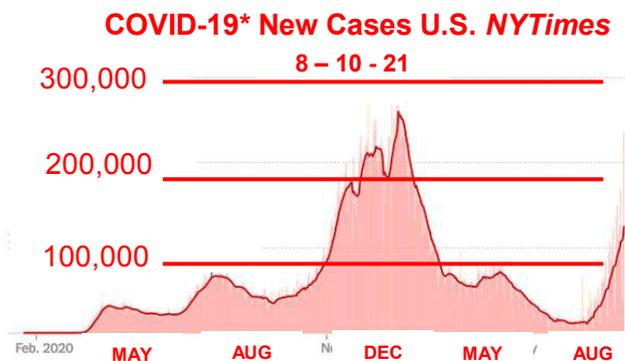


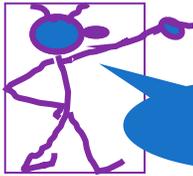
Serviced

The technology of **CCS** and **hydrogen** storage will be discussed by the eager-to-help Guru, but in the meantime, he is most interested in providing a necessary **foundation** for the associated **technology** which includes the ever popular, but little understood topics of **AI** (artificial intelligence) and **ML** (machine learning). With applications in virtually every field of geophysical endeavor, this subject is dependent on a good understanding of **Probability and Statistics**. That is why the Guru is continuing his series on **Stein and Bayes** for your amusement.

Update on Herd Immunity and Breakthrough infections (of the Vaccinated)

From the current **surge** (wave) in new cases, you might think the Guru's take on **Herd Immunity** (June *Nuggets*) was destroyed, but you would be **wrong**. We were OK with the original COVID-19, but the **Delta Variant** added a new factor creating a much more **contagious** disease (100,000) new cases/day as of **8-10-21** – last seen in **February 2021**). Most **Hospitalizations** are among the **unvaccinated (99%)**, showing the Vaxed are well protected from **serious** consequences of the "**Breakthrough Infections**" of the vaxed. **Get vaccinated..**

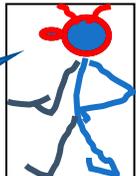




Sounds Heavy

Stein, Bayes, Statistics, & Our Future

Just Dense



We're very limited in space here (a form of censorship by the Editorial

Board), but we will prevail with **epiphanic insight** using Nuggetorial parables, graphics, Great Truths, and the **PBF** deemed essential by Gen. **Jack Ripper** of **Dr. Strangelove** fame.

Stein and **Bayes** never met, separated only by time (**150 years** or so), but they surely would have appreciated each other's' contribution to **statistics**. The best reference to what can be some dark and heavy **notation** and **derivation** is anything written by **Brad Efron** (and often with Carl **Morris**, his grad student at **Stanford**). Here, we'll deal with **Stein Lite**.

Stein's Paradox - a rule for **estimation** or **prediction** of many things at once (**multivariants**) can be closely approximated from a **Bayes estimator** of the same kind. Stein's (**JSE**, with the **J** honoring his colleague, **James**) was not derived from Bayes (**BYE**), but it has been shown by Efron and Robbins that **JSE** \approx **BYE**. More on this later. Both have a lower **Risk** of error than the Traditional and Treasured **MLE** (maximum likelihood estimator which is nothing more than using the prior probability to predict the future (which failed so miserably in the *Monty Hall* problem we have discussed at length. As you know from these *Nuggets of Truth*, Bayes uses posterior stats

to estimate, for example, the batting average (**BA**) of a group of players at the end of the season, from sampling done after only, say, **45** at bats (**AB**). This was the problem we used to kick off this **Stein** topic in **May 2021**.

The **frequentists** have held for at least **150** years, that the best estimate of the subsequent 350 +/- **ABs** would produce as a **BA** for, say, **Robinson**, is given by **.378**, as he batted after **45 ABs**, the **MLE**). **Bayes**, and later, **Stein**, knew better, both using what amounts to a **shrink factor** that produces a uniformly better estimate of the future by compressing toward the Grand Average, (**.265**).

The curious thing, for the theme of these *Nuggets*, is that while **Bayes** is respected und widely used in all sorts of industrial applications from medicine to space travel to **geophysics**, the

	Player, Pi	BA (45)	MLE	True BA	J-S
i	Name	hits/AB	$\hat{\mu}$	μ_i	$\hat{\mu}$
1	Clemente	18/45	.400	.346	.294
	F Robinson	17/45	.378	.298	.289
	F Howard	16/45	.356	.276	.285
	Johnstone	15/45	.333	.222	.280
5	Berry	14/45	.311	.273	.275
	Spencer	14/45	.311	.270	.275
	Kessinger	13/45	.289	.263	.270
	L Alvarado	12/45	.267	.210	.266
	Santo	11/45	.244	.269	.261
10	Swoboda	11/45	.244	.230	.261
	Unser	10/45	.222	.264	.256
	Williams	10/45	.222	.256	.256
	Scott	10/45	.222	.303	.256
	Petrocelli	10/45	.222	.264	.256
15	E Rodriguez	10/45	.222	.226	.256
	Campaneris	9/45	.200	.286	.252
	Munson	8/45	.178	.316	.247
18	Alvis	7/45	.156	.200	.242
	Grand Average		.265	.265	.265





latter, **geophysics**, seems to have largely overlooked the **Stein estimation** process for so many of its statistical **applications** in **ML-AI**, **inversions**, **reservoir characterization**, and **salary prediction** – thus increasing the **Risk** in all **Predictions** made from the **available data**. We'll discuss the details of **JSE** in **October** along with specifics of the **Risk analysis** from the **MLB BA** example (previous page). Study up and **tighten** your math **seat belt** for the **GSHJ**.

The Impossibly Probable & The Probably Impossible

From June: An unwoke, gender-conscious village (Biasville, AL) follows a strange custom. They have babies only to have a **boy**. Whenever a boy is born in a family, they **stop** having babies and whenever a **girl** is born, they have a **baby** again and again until a **boy** is born.

The **probability** of having a boy is same as the probability of having a girl, $P(B) = P(G) = 0.5$. What will be the **proportion of boys to girls** in the village after some time?



Typical Village Class Picture

Solution (plausible rationale)

Clearly (?), This could go either way – **and just might** (as the *Old Coach* used to say). If the recent snapshot of **Biasville High** is representative, the women folk dominate (surprise, surprise). But let's take a bold **objective** look at the situation.

After the **first** round of **pregnancies and deliveries**, we may expect (in the statistical sense) an **equal** number of **female** and **male** births, if you can accept the **binary** model of **gender** choices. Assuming, without loss of generality, that each round of births uses up **half** the **eligible couples** (those that haven't given birth to boys, N_c), then the second round of births will produce $(1/2)(1/2) N_c = (1/4) N_c$, an equal number of boys and girls. This **1:1 ratio** of expected births continues until the last couple produces. The last round, with only one couple, is where things get sticky. We'll have to accept the consequences of the vicissitudes which might produce **1 extra boy** or (gasp) a bunch of excess girls (if such a thing is possible – even in **Biasville!**).

A Puzzle for October

A line of **100** passengers is waiting to board a plane. They each hold a ticket for one of the **100** seats on that flight. For convenience: the **n**th person holds seat **n**.



Snapshot at front of queue of 99 solid, obedient citizens and 1 Nut Case (ID-ed)

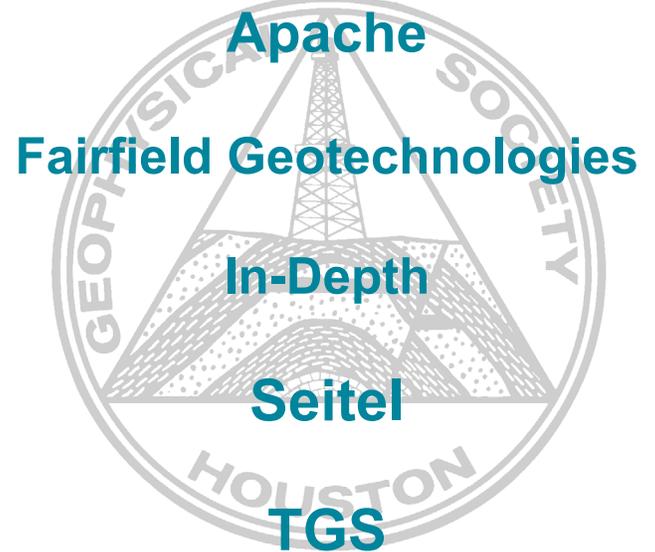
No.1 in line, an operative for the Greta Green Guys (**GGG**), demonstrates his utter **disdain** for the use of jet fuel – read “fossil” - to power the plane and instead of taking **seat # 1**, grabs another seat to create confusion and chaos. Assuming the other passengers behave, and if their seat is occupied, grab an **empty seat elsewhere** (at random) When does the first displacement occur? When does the displacement process end? And the **main question:** What is the **probability passenger 100 will sit in seat #100?**

Disclaimer: The views and opinions expressed in this article are those of the author and do not necessarily reflect the position of the editor.



The Mystery Item
on [page 17](#)
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GSH MEDIA KITS

Item Of Interest

In 1925, Everette DeGolyer formed the Geophysical Research Corporation with himself as President and John Clarence Karcher as Vice President. The following year, the GRC fielded an electrical refraction seismograph. □



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GSH Outreach

Committee Activities By Lisa Buckner, outreach@gshtx.org



GSH volunteers hosted a booth at the first in-person outreach event since the COVID-19 pandemic lockdown. The **Reach for the Stars STEM Festival** for middle school girls was held outdoors at Rice University on **Saturday, April 17, 2021**. All adult volunteers were required to wear masks and be fully vaccinated. Thank you to the brave GSH Outreach volunteers: Huw James and Katya Casey.

The event was scaled down to 200 girls split into 50 per shift, as opposed to 1,000 girls total in previous years. Huw said, *"It was pretty cool in the morning but the sun (our star) came out during the lunch period. Katya brought some pearl necklaces, rock samples, and jewelry which she used to get the students to think." Which are natural pearls and which are cultured pearls? Why are they different? Which do you like better? "This was very successful."* They demonstrated wave motion using a large rainbow coiled toy spring, showed some example log data, a rock sample of salt and some core samples, and gave away 59 GSH logoed coiled toy springs.

"The students were very refreshing and friendly, as usual. Both Katya and I enjoyed our visit. Our booth became busy as the sessions ended." Katya said, *"the parents seem to enjoy our little stories and exploratory questions just as much as their children."* Rice Professor Kirsten Siebach gave the keynote address about the Mars Perseverance Rover. Watch the [YouTube video](#) with narrated photos from the event and see if you can spot Huw James talking to some students.



Upcoming Outreach Event(s)

Held on Saturdays where you can volunteer (contact Lisa Buckner at outreach@gshtx.org) or bring children to have fun while learning:

**October 16, 2021
(11:00 AM - 3:00 PM)
Energy Day Festival at Sam Houston Park**



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 outreach@gshtx.org and we can work together to bring awareness to the students of the wide variety of careers in the geosciences. □



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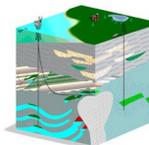


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Doodlebugger Diary

Cold Again

By Les Denham

The Doodlebugger Diary recounts the experiences of geophysicists during their working lives. This month we have the first of a number of occasional contributions by Les Denham, author of the 2020 book 'Blizzards and Broken Grousers', published by SEG. This book is the recounting of Les' experiences during the Antarctic field operations in 1970-71. His crew's objective was to document ice thickness using radar, gravity and magnetometer data. Les now devotes a lot of his time helping Bill Gafford document the huge amount of material at the GSH Geoscience Center, including getting that data incorporated into the SEG Wiki.

If our readers have stories of their early careers they would like to share, please send them my way. I'll be happy to print them in this segment.

You'd think that having spent a year in Antarctica, I'd have no problems with a minor Texas cold snap such as happened in January of this year.

You'd be wrong.

To start with, I've lost, mislaid, or worn out most of my Antarctic clothing over the last fifty years. I do have a couple of wool shirts still, though they seem to have shrunk over the years, and at least two pairs of Norwegian socks like I had in Antarctica. The socks may be ones I bought in Denmark when I lived there, though they are the same as we were issued for Antarctica. I wore one of the pairs of socks, and one of the shirts last week when we had no power.

Those nights in January when we had no power and a hard freeze were times I could have used a sleeping bag like those we used in the field on Law Dome. Actually, we used two at a time, one inside the other.

We didn't have polar sleeping bags, but we did sleep fully dressed as we did in Antarctica. Having no water for nearly a week was a little like living in the field in Antarctica. In 1970, all the water we had came from melting snow. During the freeze in Houston all our water came in small plastic bottles, and we only had about thirty of them to last three of us until the water came back on.

There were other times during the freeze which reminded me of my year in Antarctica. Our only heating for a couple of days last week was a gas fire heating artificial ceramic logs, a fair substitute for the folding kerosene stove we use a lot of the time in the field in Antarctica. I cooked oatmeal the same way: one cup of oatmeal and two cups of water in a pot, put it on the fire and stir it until you feel it thicken.

In March 1970, we had a very memorable pot of oatmeal. It was one of those days when the weather was too bad for us to work. None of us were properly awake, but Roger volunteered to cook the oatmeal for breakfast. Temperature outside was around -35C, and temperature inside the Nodwell which was both our transport and our living quarters (Figure 1) was around freezing. Roger sat on a box next to the engine cover which served as our table, and stirred the pot.

After twenty minutes, he looked up and addressed the three of us.

"There's something wrong with the porridge. It's not thickening."

I looked into the pot. "Show me the oats package," I said.

He handed me a cylindrical container with the familiar red and white Uncle Tobys Oats label. I shook a few white flakes into my hand.

Doodlebugger continued on page 32.

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

“We need to tell Singo to label it more clearly when he puts dehydrated potato in an oats can.” Singo was John Singleton, the cook at Casey who had packed our provisions for the field trip.

I threw the watery mashed potato out into the snow, and we restarted breakfast using real oats.

This happened less than two weeks into our first field trip. As the year progressed we had fewer of these little mishaps.

In the same way, let’s hope we don’t have any more system-wide power failures in Texas or I might get serious about building back up my supply of Antarctic clothing. □



Figure 1: 1969 Nodwell FN160 Crawler Carrier flextrack all terrain vehicle.