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HGS Bulletin

Houston Geological Society

SEPTEMBER 2023

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The Bulletin
Houston Geological Society

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In Every Issue

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About the Cover: Olivine websterite dike deformed in a shear zone that is part of the Dun Moutain Ophiolite Belt, Red Hills New Zealand.

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INSTRUCTIONS TO AUTHORS

Materials are due by the first of the month for consideration to appear in the next month's publication. Submissions should be emailed to editor@hgs.org. The Editor reserves the right to reject submissions or defer submissions for future editions.

Text should be submitted as a Word file. Figures or photos may be embedded in the document or submitted separately. The following image formats are accepted: tif, .jpg, .png, .psd, .pdf.

Feature submissions, e.g., Rock Record, should be approximately 600 words. Technical papers should be approximately 2000 words or less (excluding references).

HGS CELEBRATES 100 YEARS

Houston Petroleum Club

Saturday October 7

Join HGS Past Presidents and Board members to toast the Houston Geological Society's celebration of 100 years of service 1923-2023

The evening will include fine dining created by the chefs of the Petroleum Club, social hour bar service, commemorative items, and showing off the Special 100th Anniversary Bulletin issue (Chief Editor Craig Dingler). The evening hosts will be HGS President Paul Britt, Past Presidents Charles and Linda Sternbach (100th Anniversary Committee co-chairs), Dick Bishop, and Jeff Lund.

Featured HGS speakers will present a historical review over the past 25 years (1998-2023), slideshows, video reels, audience participation, laughter, and fun stories. There will be prizes and audience participation!

We look forward to a beautiful meal, a champagne toast, and a fabulous dessert! As the sun sets over downtown Houston, guests will glimpse the city at dusk out of the Petroleum Club windows and imagine the new chapters in the story of the Houston Geological Society.

Contact Jeff Lund for Sponsorship Oopportunities.

Corporate sponsors at the Gold (10K), Silver (5K), and Bronze (2K) include tickets to the event. Personal sponsorships at the Faithful Friends ($100), Benefactor ($500), and Founder ($1,000) levels include printing the sponsors in an honor roll in the HGS *Bulletin*.

HGS 100th Anniversary Gala Sponsorship Opportunities

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Please submit company logo (jpg) for recognition

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Paul Britt
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Welcome to the Centennial Year for the Houston Geological Society

This is the centennial year for the Houston Geological Society. It is truly an honor to serve as President in this celebratory year. This year's goal is to continue last year's progress toward a sustainable future for the Society while bringing back the events that have been successful in past years. Highlights of this year's plans are described below.

JOIN US FOR EVENTS!

The Centennial is being marked by a 100th Gala on Saturday, October 7th, and by a special issue of the *Bulletin* documenting the Society's history. *The Gala will be a grand event*, open to all, and details are available elsewhere in this issue. I look forward to seeing many of you there.

We have a full slate of General Dinners and Lunches lined up due to the efforts of our Vice President, Linda Sternbach, beginning with the September dinner meeting on Monday, September 11th. We are bringing back the General Lunches with the first on Wednesday, September 27th, downtown at the Petroleum Club. The Environmental and Engineering Meeting is on the second Wednesday of every month, in September it is the 13th. The North American and International Dinners are still in planning, so watch for more details to be shared soon.

This year's goal is to continue last year's progress toward a sustainable future for the Society

Mark your calendars for these other upcoming events:

- ***The Student Expo*** on September 18th and 19th is expected to have a sell-out crowd. Extra special thanks to our sponsors of this event.
- ***The GESGB-HGS Africa Conference*** will be held on September 20th and 21st in London.
- ***Centennial Gala*** will be held on October 7th.
- ***Golf Tournament*** will be held on Monday, October 16th
- ***Continuing Education*** Virtual short course on Reservoir Volumes using PVT is scheduled for Friday, October 20th.
- Saturday, December 9th is the return of the ***Sporting Clays Shoot*** after a several year hiatus.
- Submit your favorite geological photos or art work to the ***"Geology is Beautiful" art contest,*** winners to be featured on the *Bulletin* cover, the Website, and/or at HGS meetings and events throughout the year. The contest ends December 1st, so don't wait! See page 23 for contest details.
- In planning is the ever-popular ***Guest Night***, so watch for future developments, as is a conference on Geothermal in Texas. For all of these, see the calendar for details, and read the *Bulletin* for developments.

BECOME A SPONSOR!

Our sponsors, both companies and members, make many of our events possible. Beginning with this *Bulletin*, we are acknowledging sponsors from the individual member and up. In addition, we are revising the advertising rates for the *Bulletin* and Website, and we are offering a sale on business card ads in the *Bulletin*. For the HGS' 100th year you can get a business card add for $100 that includes publication in 10 issues. *I encourage everyone to run their business card, because these ads get attention.* New ad rates for everything else will be available by the October *Bulletin*.

EXCITING UPDATES TO THE BULLETIN!

We are instituting a new process to make getting your *Bulletin* easier. The email notice that you receive for this issue included a one-click button that takes you straight to the *Bulletin* without having to log into your account, and another click downloads it.

When I need to do a literature search for a new project or field, more often than not, I find an article from a local society bulletin. *The Editor and I would like to see the HGS Bulletin be a go-to reference for technical content in Southeast Texas.* In order to achieve that, we are seeking technical articles, but especially type field descriptions, type logs or type stratigraphic columns at the field level that we can publish. Many of you have either a type section or type log of fields that you have worked or are working, and I would ask that you consider publishing those. These are often a one-page item, not an in-depth article, and are generally **From the President** *continued on page 7*

From the President continued from page 6

not proprietary. For the non-petroleum geologists, what about a shallow or near surface stratigraphic column by location, surface geology of the Houston area, groundwater studies, or other articles of geological interest. Consider this a call from your President for technical articles and content.

OTHER IMPORTANT ISSUES THIS YEAR

The HGS office lease is up later this year, and we are reviewing the options. In consideration is taking it virtual, a logical option given the large geographic Houston area. Not having a physical office could result in savings of over $30,000 per year. There are numerous items including furniture in the office that may come up for sale to members. A committee has been convened to review the options.

A CALL FOR VOLUNTEERS.

The Society runs on volunteer efforts, and as can be seen in the committee list at the beginning of this Bulletin, there are some vacancies, and every committee can also use help, so please consider what interests you and contact the committee chair of your interest, the office, or me if interested.

In closing, *it is truly an honor to be President in the Centennial year*. Having served as the AAPG President in their centennial year, the significance is not lost on me. We are looking forward to an exciting and dynamic year for the Society, and a return to normalcy, made better by everyone's participation. I look forward to seeing all of you at the next HGS event!

2023-2024 Houston Geological Society Sponsors

The Houston Geological Society would like to thank and recognize the sponsors and contributors for their generous and continuing support of the HGS.

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[1]*Includes Gala Contribution* [2]*Includes Student Expo*

Caroline Wachtman
editor@hgs.org

Who are HGS Members?

This is one of the first questions I explored since commencing my term as Editor of the HGS *Bulletin*. I am interested to learn about members' interests, so that the society can better adapt to meet the needs of current and future members. I am approaching editorship as a scientist: asking a question and collecting data.

First, I consulted the HGS member database. Although many members do not update their profiles on a routine basis, the database serves as a starting point for better understanding information such as role and company type, location and years of membership. In addition, I have interviewed both long-serving members and recently-joined members to get their direct feedback. I share some of their stories in this edition and will also continue to highlight member profiles in future editions of the *Bulletin*, too.

WHAT I HAVE LEARNED FROM THE MEMBERSHIP DATABASE

Over 70% of HGS members are located in Harris County. Members are dispersed throughout the ~1700 square miles of the county, however, the highest concentration of membership addresses is in zip codes along the I-10 corridor between the Heights and Cinco Ranch **Figure 1**. Each of the 20 zip codes in this area has ~30-60 members. One zip code in the Woodlands has a similarly high concentration of membership addresses. Nearly 70 other zip codes spread throughout the county each contain 10-30 membership addresses.

Figure 2 shows that the majority, nearly 40%, of HGS members work as independent contractors or consultants. Many of these members have eponymously named LLCs and many appear to be serving oil and gas clients. Nearly 30% of members work for Exploration & Production (E&P) companies in the Oil & Gas (O&G) sector. Of those E&P employees, 15% work for smaller-sized companies, such as Red Willow Production, Walter Oil & Gas and Southwestern Petroleum. 11% work for mid-sized and Majors, such as Oxy, Chevron and ExxonMobil.

Students and professors comprise 13% of the members, and 11% are retired. Members working for environmental geology companies, government agencies and other groups make up the remaining 11% of the membership.

WHAT I HAVE LEARNED FROM TALKING TO MEMBERS

I have recently conducted over 12 hours of interviews with geologists, including members who joined the society as early as 1967. A few themes have emerged. First, members attribute value to the professional networking and **From the Editor** *continued on page 10*

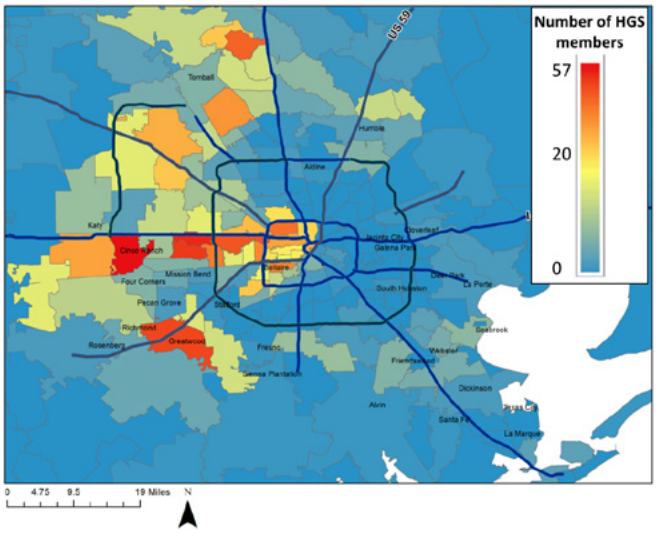

Figure 1. *Map of Harris County showing number of HGS members per zip code. Location data is from HGS member profiles.*

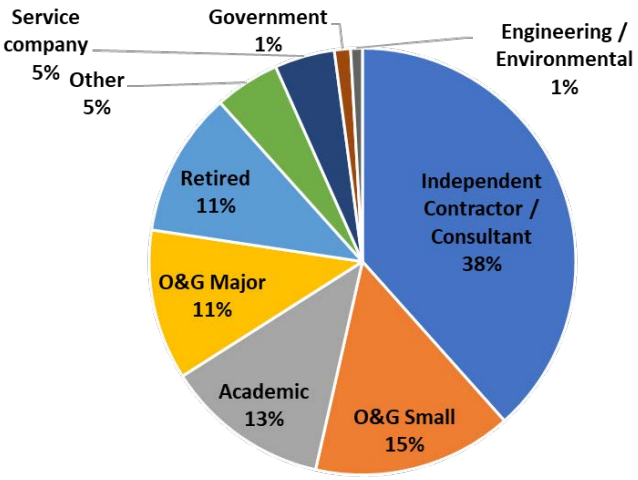

Figure 2. Pie chart showing the distribution of employment types for ~1800 HGS members, as recorded on their HGS member profiles.

From the Editor continued from page 9

friendships that they have developed through HGS. Members have leveraged those connections to get jobs or investors. Second, members choose to get involved in HGS in different ways. Some, but not many, have served on committees or held Board roles. Others have chosen to focus more on attending social events.

The third insight is that members are concerned that junior geologists are not developing strong a technical skill base. Interviewees attribute the lack of skill set to over-reliance on technology and exclusive exposure to unconventional resource production. Interestingly, even interviewees not working in oil and gas cite the shale boom as contributing to a lack of technical skills. Furthermore, multiple members highlight the concern that many university programs have moved away from a traditional hydrocarbon exploration curriculum, and that many students do not see a future in oil and gas.

Finally, the members I have talked to love their science and their profession. This is evidenced by their desire to stay in an industry that has caused them challenges including multiple layoffs and multiple relocations. They have adapted to the challenges by leveraging skills they acquired adject to their geology technical work: business acumen, negotiation and influence, communication, managing multi-disciplinary projects, and prioritization among multiple competing projects.

FOR THE NEXT STEP

To build on the insights from the membership database and interviews with members, I propose a short survey to capture a broader population of members and non-members. You can find the link to the survey by using the QR code in this letter: if reading electronically click the QR code; hover the camera of your phone over the QR code and click the link; or by clicking the link in the weekly newsletter sent from the HGS office. Responses will be collected through October 1, 2023.

Please share your thoughts on the HGS by filling out the survey at this link: https://forms.gle/sjZb6HqrkGdyLENY8, or by accessing the QR code

About the Editor: Caroline has extensive experience managing and executing complex subsurface projects and has explored, developed and produced resources worldwide. She spent 15 years with ExxonMobil, where she led multiple cross-functional teams identifying and evaluating resources throughout West Africa, the Caribbean and Caspian regions. In 2021, she explored roles at small start-up companies and then pivoted to Carbon Capture, Utilization and Sequestration (CCUS) with Oxy. She recently became a Professional Geologist licensed in Texas. In addition to volunteering with the HGS and AAPG, Caroline is an active Girl Scout Troop leader for her two young daughters and 20 of their friends.

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HGS MEMBER SURVEY

We want to hear from you!

Please fill out the short survey linked below to tell us about how the HGS can work for you. Your input is vital to making the HGS an even better society.

Please respond by October 1, 2023.
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- Geologic carbon storage on the Gulf Coast (BEG GCCC)
- Critical metals (and Lithium) exploration value chain
- Session hosted by the Energy Mineral Division (AAPG)
- East Texas petroleum exploration
- University-Industry collaboration, hydrology, geothermal, "The Business of Petroleum", and many others!

Abstract Submissions: Abstract submission closes December 15, 2023. Visit **geogulf2024.org** to learn more about were to submit abstracts, guidelines, and attending **GeoGulf2024.**

Immerse Yourself in the Evolution of Geological Science

We Are The HGS

Bradley Broekstra HGS member since 2002

"I've always loved my job," say Bradley Broekstra, who started his geology career in 1972 interpreting paper seismic lines and making paper prospect maps. He has held numerous roles since then, both as an independent and for small exploration and production companies. Broekstra recalls that his favorite role was with Midstates Petroleum, where he started as one of five founding members in 2005, and helped take the company public in 2012. Broekstra didn't stop there; he has continued to be an oil-finder and is now a Principal at Sentinel Petroleum.

Looking back over his 50+ year career, Broekstra recounts that the biggest challenges he faced have been from technology changes. He explains that the learning curve of going from paper to workstation wasn't easy. Recently, he lost over a decade of work products as a result of a cybersecurity breech.

Today, Broekstra is concerned about the lack of prospect-generation experience for many new geologists. "Guys and gals coming into geology today are geosteerers. They don't know how to make a map," he says. Broekstra's advice to new geologists is to learn how to look for new ideas and to be opportunity-finders. "New ideas in old areas with new technology" is what has made Broekstra successful and what he says will help the next generation be successful, too. ■

Jeff Martin HGS member since 2002

A strong foundation in fundamental geology skills is one of the key strengths that has benefitted Jeff Martin throughout his 40+ year career. He started mudlogging while an undergraduate, which helped him secure his first full time role at Gulf Oil in 1980. Over the next decade of tumultuous oil price, Martin leveraged his geology skills, and pivoted to selling geologic data and products in the early 1990s. Since then, he has held sales roles for companies marketing geologic reports, gravity and magnetic data, petrophysical software, micro-scale core imaging services, and seismic processing products.

In each of his role pivots, Martin has relied on his ability to think like a geologic integrator and his ability to "listen to what keeps the customer up at night." Martin says of customers, "If I can address their challenges they will have success, and if they have success they will keep coming back." In addition, Martin says that geologists are trained to tailor their message to different audiences because they are often the connectors and communicators at companies. He has utilized this skill set throughout his career to connect with technical contributors and managers.

In recent years, Martin has been invited to speak and mentor at his alma mater, Western Michigan University, and highlight his diverse career path in geology. He notes that many of today's students are focused on learning the technology, but need to improve their understanding of geologic principles. "Spend time with the rocks," advises Martin to students and recent graduates.

Martin enjoys participating in the HGS because it allows him to keep in touch with former colleagues, learn from a new generation, and build networks. He is a frequent attendee at social gatherings such as the Annual Crawfish Boil and at dinner meetings. Martin says, "I've always had the gift of gab," and he loves to connect with people. ■

Matt Jurik HGS member since 2021

Diversity in career experiences is one of the keys to success for Matt Jurik, a geology team leader for the Thunderhorse North field at BP. Jurik began his career hand-correlating logs and coloring maps for his father, an independent E&P in New Orleans in the late 1990's.

Shortly thereafter, Exxon offered him a technician role and supported his Master's degree thesis work that involved evaluating ash beds around Green Canyon 18 field in the Gulf of Mexico. Jurik went on to have a 23-year career at ExxonMobil, working across the upstream value chain in strategic planning, exploration, well execution and field development projects. He held assignments working onshore and offshore Gulf of Mexico, Angola Block 15, and spent nearly 5 years as an expatriate working development projects in St. Johns, Newfoundland.

"Don't get pigeonholed, and always be learning new skills," says Jurik of the career advice that has carried him through multiple industry downturns and now to his current role at BP. Additionally, Jurik highlights the importance of networking in surviving the oil and gas business. Expanding his network was the impetus for joining the HGS in 2021. Jurik explains that **We Are The HGS** *continued on page 14*

Pivot Profile: Lee Vaughan on the Intersection of Geology, Programming, and Authorship

By Caroline Wachtman

"80% of success is showing up," says Lee Vaughan, a Houston-area geologist and successful author who literally wrote the book on Python programming applications for science and engineering. Vaughan has done far more than "show up" by becoming a self-taught Python programming expert, who continues to learn and grow his skills six years into retirement following a 31-year career as a geoscientist and geologic modeler at ExxonMobil.

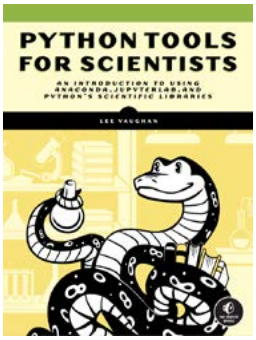
Vaughan began his pivot to programming nearly 10 years ago when he was responsible for evaluating and creating proprietary reservoir modeling software. "I bought a book from Barnes and Nobel on my way home from work, sat on the couch, and figured it out," says Vaughan of his self-taught path to learning Python. He quickly realized that there were few scripting resources for geoscientists and engineers beyond the "absolute beginner" books, so he wrote his own instructional book that was published in 2018. This book was followed by two more instructional books that offer scientists a toolkit on how to apply Python to their technical questions.

According to Vaughan, Python is the premier language for science and engineering and can be applied to clean and analyze large and complex datasets, create animated maps, and plot well logs among other uses. Despite these advantages, few geoscientists know how to use Python, says Vaughan. He encourages new users that Python is easy to learn, and that users can make progress at their own pace.

"Programming is 90% problem-solving," says Vaughan. And geology is all about solving problems by asking questions and testing hypotheses. Just like it is important to think through multiple scenarios and test hypotheses when planning a well or building a geologic model, it is critical to test hypotheses when scripting. One technique is to use "linters," programs that help the scripter find errors and apply best practices to their code.

Programming is 90% problem-solving

ChatGPT and other AI tools have introduced new benefits and challenges to scripting. For example, users can quickly generate code using ChatGPT. However, only a trained scientist and/or programmer can determine whether the code is correct and appropriate for the problem being solved.



You can find Vaughan's books in bookstores and online at Amazon.com. His latest book, *Python Tools for Scientists*, is designed as a starter kit for anyone interested in learning Python. He also publishes instructional articles online at https://medium.com/@lee_vaughan. ■

Pivot Profile is an occasional series that highlights geoscientists who have applied their geology skills to interesting career applications. Are you interested to learn more about unique geology-inspired careers or do you have a suggestion of someone to profile? Contact me at editor@hgs.org.

We Are The HGS *continued from page 13*

networking happens internally at large companies, but that should not deter workers from also seeking external networking. "Maintain an external network," says Jurik, "because no job is forever."

Jurik offers insight into the challenges and opportunities for attracting and retaining members, including location and content. In recent years, companies in Houston have moved out of downtown into isolated suburban campuses, making it more difficult to meet in-person. Additionally, larger companies have their own internal training programs, making it unnecessary to seek out society short courses. Jurik contends "it will take management support" to recruit significant numbers of new members and keep them active. ■

We Are The HGS is a series that highlights the careers and contributions of HGS members with the intention of building community. Would you like to be featured in We Are The HGS? Send a note to editor@hgs.org

The Rock Record

Dunite and Cold Oatmeal: Learning a Tough Lesson about Inclusion on South Island, New Zealand

By Caroline Wachtman

As I jumped down from the helicopter onto the barren, rocky ground I was feeling invincible. I was a second year Master's Student at the University of Wisconsin-Madison and had just arrived in New Zealand to conduct a two-month long field work campaign to map and sample dunite in the Red Hills Mountains that are located in the northern part of the South Island. I was testing a hypothesis that the olivine grains in mantle rocks kept a record of deformation events and that was preserved in the grain's lattice preferred orientation.

The terrain was otherworldly (where Lord of the Rings was filmed). Few plants grow on mantle rocks like dunite, pyroxenite and serpentenite because of the chemical composition of the rocks. Almost no wildlife existed, except for wetas, 6-in long cricket-type insects. And it was remote. The field site was about 20 km from the nearest road, which made helicopter transport essential. We would get one trip in and one trip out. On that clear, sunny, windy day, I watched the helicopter fly off and looked around. I had my field assistant, a satellite phone, my rock hammer, my backpack, and a plastic tub of food to last for about eight weeks.

The planning for this trip had started months earlier as I formed a data collection plan, gathered maps and literature. A friend from undergraduate school joined me as a field assistant. He was another Master's student and an experienced fieldworker. We both knew that the project budget allowed for little more than oatmeal and instant soup every day. To stretch our budget as far as possible, I had planned a detailed list of all the supplies we would need to take with us for the two-month field season. After nearly 28 hours of travel we arrived in Nelson, New Zealand on a warm, sunny January morning. We headed to the grocery store to buy the items on my list and prepared for our helicopter transport to the field. We were ready.

When jumped down from the helicopter and stepped out onto the barren mountain ridge. We quickly started to make camp by setting up our tent and kitchen area. As I unpacked our plastic tub of supplies, my heart plummeted to my stomach and feelings of embarrassment, frustration, and fear swept over me. I had not packed any fuel for the stove! There were no natural fuel sources to start a campfire. We were facing the demoralizing prospect of eating cold oatmeal and cold soup for the next two months. I double checked my detailed list and realized that stove fuel was…absent.

Caroline in the Red Hills of South Island, New Zealand upon realizing she did not pack fuel for the stove.

In the moments that followed, I realized that I had not included my field assistant or anyone else on the trip planning process. I had planned it alone, and I had planned it poorly. Had others reviewed my grocery list, someone would likely have noticed that fuel was missing. I could have potentially prevented this gastronomically displeasing, and possibly life-threatening scenario had I been more inclusive.

The lesson that I learned that morning in New Zealand has directly impacted the way I approach interacting with teams.

In the years that followed, I've gone on to lead multi-disciplinary teams solving world-wide subsurface technical problems. The lesson that I learned that morning in New Zealand has directly impacted the way I approach interacting with those teams. I try my best to be inclusive in the planning process so that the execution of the plan is more efficient and effective. I don't want myself or my colleagues to be stuck on the side of a mountain eating cold oatmeal ever again! ■

If you are interested in reading more about mantle overprinting, you can check out these papers from the author, Caroline (Webber) Wachtman:

Webber, C.E., Newman, J., Holyoke, C., Little, T., Tikoff, B., 2010, Fabric development in cm-scale shear zones in ultramafic rocks, Red Hills, New Zealand: Tectonophysics, v. 489, p. 55-75.

Webber, C.E., Little, T., Newman, J., Tikoff, B., 2008, Fabric Superposition in Upper Mantle Peridotite, Red Hills, New Zealand: Journal of Structural Geology, v. 30, p. 1412 – 1428.

The Rock Record is an occasional series that spotlights interesting lessons learned from rocks. Do you have a story to tell about a life lesson you've learned from your rock collection? Tell us about it at editor@hgs.org.

Strong Easterly Trade Wind Models of Carbonate Deposition from Caicos Platform (Southeastern Bahamas): Application to the Cretaceous Golden Lane-Poza Rica Pools In Mexico

By Jeffrey J. Dravis PhD – Consultant: Dravis Geological Services/Dravis Interests, Inc.
Adjunct Professor, Rice University and University of Houston, Houston, Texas

ABSTRACT

Carbonate sedimentation on the windy Caicos Platform in the southeastern Bahamas, dominated by persistently strong easterly trade winds, yields several depositional models that expand the potential for subsurface carbonate exploration (Dravis and Wanless, 2017). These models predict high-energy facies (isolated reefs; oolitic and/or skeletal-oolitic grainstones) in platform-interior settings previous ignored, based on northern Bahamian models ingrained in published literature for decades. Further, strong easterly trade winds can promote leeward platform-margin reef deposition and shed much more carbonate sand off these margins, creating onlapping wedges of grainstones with excellent reservoir potential. Caicos Platform trade wind models have direct application to most Phanerozoic subsurface shallow-marine carbonate settings that existed between 5- and 22-degrees latitude, north or south of their age-equivalent equator.

The giant Middle Cretaceous interrelated Golden Lane and Poza Rica oil pools in Mexico are dominated by molluscan (rudist)-derived sediments but their occurrence never made sense when viewed through the prism of the northern Bahamian depositional models. Those models do not explain why these coalesced rudist reefs developed along the leeward (western) platform margin of Golden Lane Atoll and further, why oolitic sands coexisted with them. In addition, these models never explained the prolific shedding of reef-derived skeletal grainstones off that margin that created an impressively thick (up to ~500 meters), onlapping wedge that is now Poza Pica Field.

The strong trade wind models from Caicos Platform better explain the interrelationship between Golden Lane and Poza Rica fields. During the middle Cretaceous, Golden Lane Atoll was an isolated carbonate platform in the western ancestral Gulf of Mexico basin, situated in a tropical belt 10-15 degrees north of the paleoequator. That setting produced strong easterly paleotrade winds. Local wind-wave agitation by those winds promoted leeward margin rudist reef development but also converted the finer-grained skeletal grainstones of the back-reef flat to oolitic sands. And, as on Caicos Platform today, strong trade wind-wave agitation persistently shed rudist grainstones over the leeward platform margin, aided by major storm activity. The result was the thick onlapping grainstone wedge from which Poza Rica Field produces still today.

Figure 1. *Map of Golden Lane Platform ("Atoll') showing the Golden Lane Field comprised of a string of small, purple-colored oil fields that exist along its western (leeward) margin. The platform developed over an offshore granitic basement high surrounded by basinal waters. Poza Rica Field is the largest field comprised of allochthonous skeletal (mostly rudist) grainstones that were shed from the Golden Lane rudist reef complexes into the deeper basin. These grainstones constitute most of the Tamabra Formation.*

INTRODUCTION

Golden Lane and Poza Rica fields occur along the western margin of the Golden Lane Platform in eastern Mexico (**Fig. 1**), are Middle Cretaceous (Albian) in age, and both contain more than 2 BBOIP (Salas, 1949; Barnetche and Illing, 1956; Viniegra-O and Castillo-Tejero, 1970; Coogan, et al., 1972; Viniegra-O, 1981; Enos, 1983 and 1985; Cook, 1979; and Janson, et al., 2011).

These two pools are inextricably linked depositionally because the Golden Lane Field Trend is the source of most of the allochthonous shallow-marine, rudist reef-derived sediments that comprise Poza Rica field. The occurrence of these oil pools on the leeward side of Golden Lane Platform ("Atoll"), **Technical Article** *continued on page 17*

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however, would have never been predicted based on northern Bahamian, subtropical depositional models ingrained in the literature (see Scholle, et al., 1983; Harris, et al., 2015). However, newer depositional models from the tropical and much windier Caicos Platform in the southeastern Bahamas better explains this depositional linkage (Dravis and Wanless, 2017).

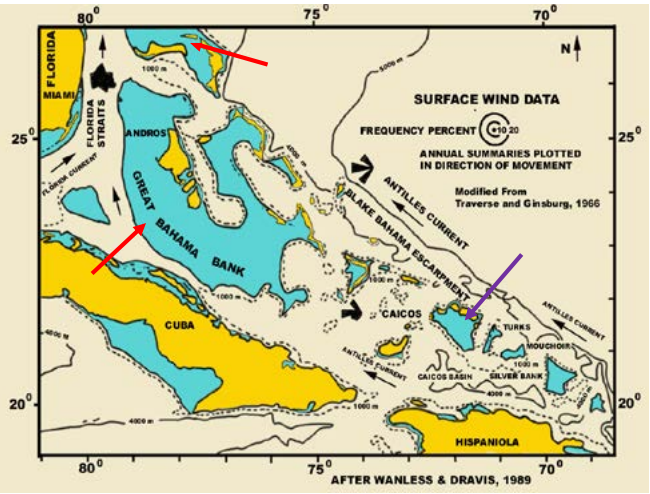

Figure 2. *Map of the Bahamas Platform Complex showing the location of the larger northern Bahamian carbonate platforms (red arrows) and the smaller Caicos Platform (purple arrow). Caicos Platform is located in the tropics and is influenced by strong easterly trade winds; northern Bahamian platforms are subtropical and subjected to gentle easterly trade winds.*

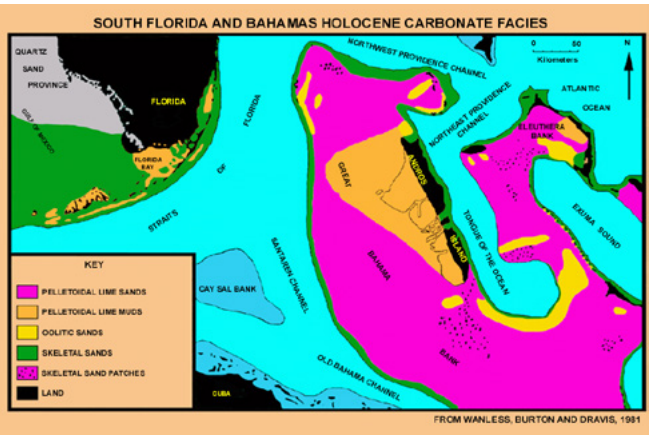

Figure 3. *Map of Great Bahama Bank showing it today dominated by low-energy, burrowed, micritic sedimentary environments, namely, "pelletoidal" lime sands (preserved as hardened peloidal wackestones to packstones) and "pelletoidal" lime muds" (preserved as soft peloidal wackestones). Platform margin reefs are confined to eastern margins that are influenced by oceanic swells. Narrow belts of oolitic sand dominated the western (leeward) margin. This model changes slightly at the southern and northern ends of Tongue of the Ocean (Harris, 1979) or at the northern end of Exuma Sound on Eleuthera Bank (Dravis, 1979) because of increased tidal current velocities associated with these deep-water embayments. Weak cross-bank currents set up by the gentle easterly trade winds only shed lime mud and silt-sized sediments from the top of the platform to the west, producing thick onlapping wedges of micritic sediment along the western (leeward) margin of Great Bahama Bank (Wilber et al., 1990).*

OLDER NORTHERN BAHAMIAN DEPOSITIONAL MODELS

The well-studied northern Bahamian platforms like Great Bahama Bank occur at a latitude between 23 and 26 degrees north, placing it in a subtropical setting dominated by oceanic processes (swells or tidal currents) and influenced by gentle easterly trade winds (**Fig. 2**; Traverse and Ginsburg, 1966; Wanless, et al., 1981 Reijmer, et al., 2009; Harris, et al., 2015).

On Great Bahama Bank, linear reefs only occur along its eastern platform margins exposed to open-ocean swells. Behind these reefs, the finer-grained skeletal debris is never converted to oolitic sand (Perkins, 1986; the so-called "default principle" in carbonate sedimentation). Along its more protected western (leeward) platform margins, daily tidal currents influence carbonate sedimentation but only generate narrow, actively-agitated oolitic sand belts usually a few kilometers across oriented parallel to these margins (**Fig. 3**; Purdy, 1963 a,b; Wanless et al., 1981). The gentle easterly trade winds produce weak cross-bank currents that only shed mud- and silt-sized carbonate material from the platform-interior that is dominated by micritic-peloidal sands and muds. The resultant highstand wedges that onlap the leeward (western) margin of Great Bahama Bank are mud-dominated and exhibit poor reservoir potential (Wilber et al., 1990). Linear or isolated reefs on leeward margins are absent or poorly developed due to persistent off-bank sediment stress (Hine and Neuman, 1977).

Neither the leeward margin rudist reef complexes of Golden Lane Field nor the thick onlapping rudist grainstone wedge of Poza Rica field would have ever been **Technical Article** *continued on page 18*

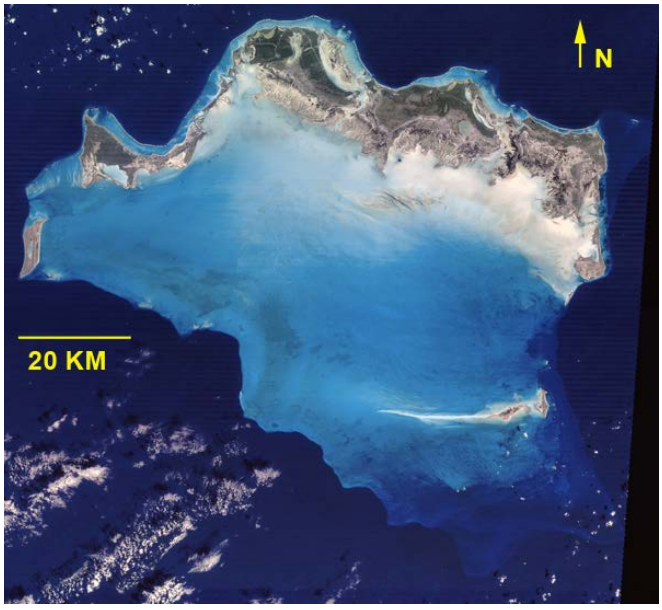

Figure 4. *Satellite photograph of Caicos Platform in the southeastern Bahamas, surrounded by dark-blue oceanic waters 2000 m in depth, or deeper. Most of Caicos Platform itself is well less than 10 m deep; lighter blue areas are less than 2-3 meters deep. Larger islands along its rim are Pleistocene in age. The open Atlantic Ocean is to the north of the platform. Compare to* **Figure 5**.

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predicted based on the Holocene shallow-marine sedimentary processes and products observed on Great Bahama Bank.

NEWER CAICOS PLATFORM DEPOSITIONAL MODELS

Caicos Platform is the southernmost Bahamian platform with exposed islands (**Figs. 2, 4**).

It occurs at a latitude between 21 and 22 degrees north of the equator, placing it in a tropical setting influenced by strong easterly trade winds (Dravis and Wanless, 2017). Tidal currents have little influence of carbonate deposition; instead, strong trade winds that blow persistently out of the eastern quadrant (NE, E and SE components) dominate shallow-marine carbonate deposition on this platform.

As a result, Caicos Platform is a carbonate sand-dominated platform where oolitic sands are present not only along its margins but well into its interior (**Fig. 5**). These oolitic sands occur as linear subtidal sand shoals oriented parallel to the prevailing trade winds or occur as widespread subtidal sheets in deeper-water (up to 7-8 meters), platform-interior settings. Wherever preexisting islands face into these easterly trade winds, shoreline-parallel oolitic sands form perpendicular to these winds and quickly prograde into them. All Caicos Platform ooids form in response to persistent trade wind-wave agitation; tidal currents play no role in their formation.

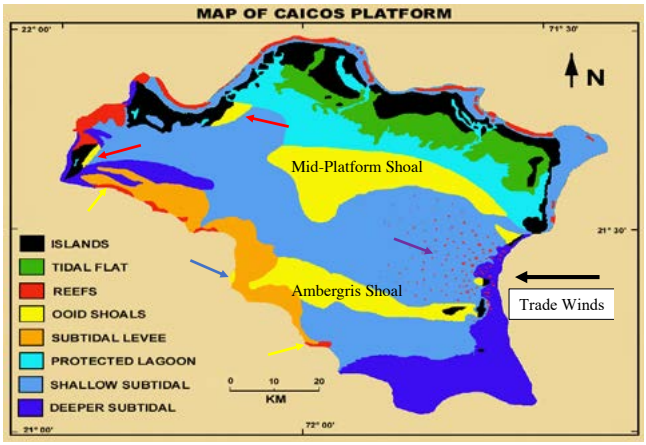

Figure 5. *Physiographic map of Caicos Platform showing the prominent yellow oolitic sand bodies on the platform. Subtidal ooid sand shoals (Ambergris and Mid-Platform Shoal) line up parallel to the strong easterly trade winds, but smaller ooid sand bodies (red arrows) developed adjacent to older Pleistocene islands (colored black) are shoreline parallel but oriented perpendicular to the strong easterly trade winds. These strong trade winds also strip finer-grained carbonate mud and silt from the platform interior and move it off the leeward margin, like in the northern Bahamas. But these trade winds also gradually move carbonate sand, including ooids, to the leeward margins. There, these sands are either shed off the edge of the margin, like at West Spit (blue arrow), or are thrown back by hurricanes to form broad "subtidal levees" just in from the margin (orange-colored areas). Isolated patch reefs (red dots ; purple arrow) also occur over 40 kilometers inboard from the eastern platform margin, in waters as deep as 10-12 meters. Skeletal sands shed from these reefs are currently being converted to oolitic sands by wind-wave agitation. Along the leeward margin of Caicos Platform (yellow arrows), wherever parts of the platform jut out into the prevailing trade winds, isolated linear platform margin reefs up to a few kilometers in length have developed and are capped by reef flats (see* **Figure 6***). Their finer-grained, back-reef skeletal sands also are being transformed into oolitic sands by the persistent strong easterly trade wind agitation. Therefore, on Caicos Platform, in stark contrast to the northern Bahamas, coeval oolitic sands do occur behind platform-margin reefs.*

Strong trade wind-wave agitation also promotes isolated and coalesced patch reef development in the interior of Caicos Platform, up to over 40 kilometers inboard of the eastern platform margin, and in waters as deep as 10-12 meters (**Fig. 5**). Skeletal sands shed from these reefs are transformed to oolitic sands by the same wind-wave agitation. Along the leeward margin of Caicos Platform, wherever parts of the platform jut out into the prevailing trade winds, isolated linear platform margin reefs up to a few kilometers in length have developed and are capped by reef flats. The finer-grained, back-reef skeletal sands are being converted to oolitic sands by the persistent easterly trade wind agitation (**Fig. 6**). Therefore, on Caicos Platform, in contrast to the northern Bahamas, coeval oolitic sands do occur behind platform-margin reefs.

Finally, in concert with hurricanes, strong trade winds persistently shed not only mud- and silt-sized carbonate sediments from the interior of Caicos Platform but also push oolitic sands to the edge of its leeward platform margin. Many of these sands cascade over the platform margin due to strong wind-wave agitation, producing onlapping wedges

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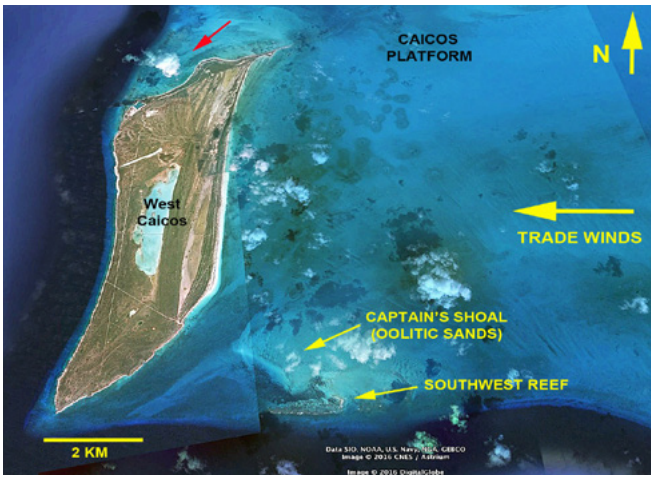

Figure 6. *Google Earth image of the southwestern part of Caicos Platform showing development of an isolated, leeward platform-margin reef called Southwest Reef. This reef exists because the platform margin curves around and catches the influence of the strong southeasterly trade winds. The storm-generated, finer-grained, back-reef skeletal sands at Captain's Shoal are persistently agitated by the trade winds, converting them to oolitic sands. Here, ooids and reefs coexist in the same environment, a relationship not seen in the northern Bahamas. Oolitic sands also are forming off the northwest side of West Caicos Island in close association with small patch reefs (red arrow), in response to persistent agitation from oceanic swells and trade winds.*

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likely dominated by oolitic sands with excellent reservoir potential (Dravis and Wanless, 2017).

GOLDEN LANE AND POZA RICA FIELDS, MEXICO

In Mexico, Golden Lane Field (2.2 BBOIP) and Poza Rica Field (2.7 BBOIP) were situated in a tropical setting 10-15 degrees north of the paleoequator during Middle Cretaceous (Albian) time (**Fig. 7**). Golden Lane produces from a series of rudist reef complexes developed along the western (leeward) margin of Golden Lane Atoll (Figs. 1 and 8; Enos, 1985). Nearby, Poza Rica Field produces from a thick wedge (up to over 500 meters) of rudist grainstones onlapping the western margin of the Golden Lane Atoll; these grainstones were clearly sourced from the Golden Lane platform margin reefs (Salas, 1949; Viniegra-O, 1981; Enos, 1983; 1985).

An offshore granitic basement high, surrounded by relatively deeper-marine waters, served as the paleotopographic high that initiated development of Golden Lane Atoll (Enos, 1983). Rudist reef complexes developed around the periphery of this feature, including the eastern margin, but later structural movement and upward tilting to the northwest confined hydrocarbon production mainly to the western margin of this atoll structure. As noted earlier, paleogeographic reconstruction indicates that the Golden Lane Atoll was located 10-15 degrees north of the paleoequator during Middle Cretaceous time, in the heart of the strong easterly paleotrade wind belt (**Fig. 7**; Hofling and Scott, 2002). This climatic setting implied that the western margin was a leeward margin. Based on the northern Bahamian models discussed earlier, a leeward platform margin is a poor location for robust reef development not only because it faced away from the oceanic swells of the open ancestral Gulf of Mexico, but because of the high probability of being stressed (smothered) by off-bank sediments shed from the micritic interior of the Golden Lane Atoll by the strong easterly paleotrade winds.

The strong easterly trade wind models developed on Caicos Platform best explain the juxtaposition of these two major reservoirs. The Golden Lane rudist reefs thrived along the leeward margin of this atoll for two reasons. First, persistent wind-wave agitation on the platform, promoted by the strong easterly paleotrade winds, enhanced water agitation and development of rudist reefs on the western (leeward) side of the atoll (one application of the Caicos Platform models; **Fig. 9**). Second, the platform interior ("lagoon" in **Figure 9**) was sufficiently deep to inhibit off-bank sediment stress, a relationship later supported by newer seismic data collected by Pemex (C. Kerans, 2004, personal communication). Major storms initially broke down the rudist reef complexes to generate rudist grainstone debris; persistent wind-wave agitation by strong easterly paleotrade winds likely moved this debris east to west, including shedding this debris off the leeward margin into the basin, just as it does today on Caicos Platform (Dravis and Wanless, 2017). The result was Poza Rica field, a prominent onlapping wedge of molluscan (rudist) grainstone over 500 meters thick adjacent to the Golden Lane Platform but thinning to a feather's edge about 8 kilometers from the leeward platform margin (Enos, 1983). Because of later Tertiary-age structural tilting to the northwest, this oil pool exhibits porosity pinchout into the adjacent basinal limestones, creating a classical combination structural-stratigraphic trap.

The key independent observation that proves the predominant influence of strong easterly paleotrade winds on pool development is the conversion of back-reef skeletal (rudist) sands, derived from rudist reefs along the western margin, to ooids (Coogan, et al., 1972; **Fig. 9**). As discussed earlier, this mixture of reefal debris and ooids is inconsistent with the northern Bahamian depositional models, but is observed on Caicos Platform today (**Figs. 5** and **6**). Like Caicos Platform today, the strong paleotrade winds operative during Golden Lane deposition would have persistently shed rudist grainstones from these leeward margin reef complexes, augmented, of course, by episodic hurricanes, thus better explaining the development of a thick wedge of onlapping rudist-derived skeletal grainstones that now defines Poza Rica Field.

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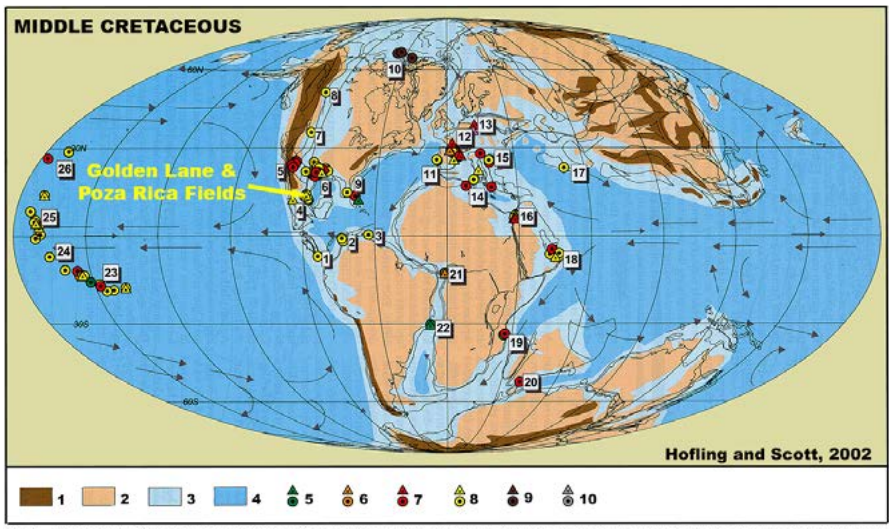

Fig. 6. - Global distribution of biota in buildups of "Albian" time slice 24, late Aptian to middle Cenomanian. Ocean surface currents were derived from the plate tectonic configuration. Circles refer to late Aptian-Albian reefs; triangles indicate Cenomanian age. Key to symbols: 1 = mountains, 2 = land, 3 = shelf, 4 = deep water, 5 = microbes, 6 = algae, 7 = stromatoporoids, 8 = siliceous sponges, 9 = corals, 10 = bivalves, 11 = serpulids, 12 = indeterminate. Locality index (rectangles): 1, Puerto Rico; 2, Venezuela; 3, Trinidad; 4, southern and eastern Mexico; 5, northwestern Mexico and Arizona, U.S.A.; 6, Texas and Louisiana, U.S.A.; 7, Wyoming, U.S.A.; 8, British Columbia, Canada; 9, Florida, U.S.A. and Bahamas; 10, Nunavut, Canada; 11, Portugal; 12, northern Spain and southern France; 13, central Germany; 14, Algeria, southern Italy and Greece; 15, southern Bavaria, Germany, to Hungary; 16, Israel; 17, Iran; 18, United Arab Emirates and Oman; 19, Tanzania; 20, Southern India; 21, Nigeria; 22, off Brazil; 23, Mid-Pacific mountain guyots; 24, Wake Group Guyots; 25, Japanese Seamounts; 26, Japan (paleoposition hypothetical). Map provided by Wolfgang Kiessling.

Figure 7. *Paleogeographic map for the Middle Cretaceous showing the location of the interrelated Golden Lane and Poza Rica oil fields in Mexico. The ocean surface currents on this map effectively reflect the prevailing trade winds. These oil pools were situated between 10-15 degrees north of the paleoequator, implying they were influenced by strong easterly paleotrade winds.*

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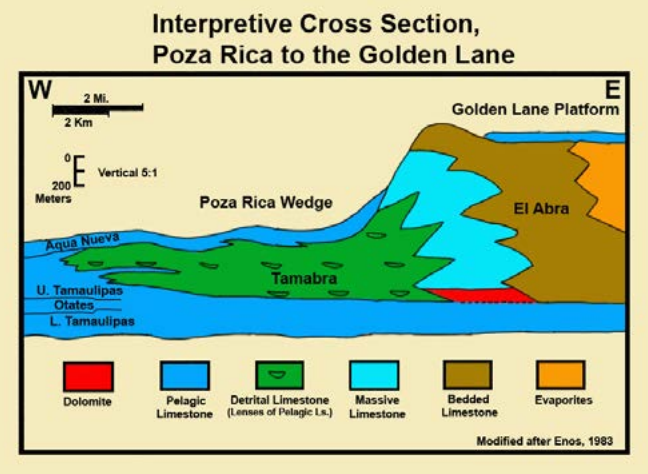

Figure 8. *Cross section of depositional lithologies across the western (leeward) margin of Golden Lane Atoll (Enos, 1983). The oil-productive, massive El Abra limestones (light blue color) are rudist reef complexes, modified by subaerial karst processes. The onlapping green-colored Tamabra limestone wedge, over 500 meters thick along the margin of Golden Lane Platform, is comprised of rudist grainstones that are the principal reservoir facies of Poza Rica field. These grainstones were preferentially shed from this leeward margin into the deeper basin, where they were admixed with lenses of basinal pelagic sediments. This style of shedding is consistent with the process seen today off Caicos Platform, in the present-day strong easterly trade wind belt.*

Cook (1979; **Fig. 9**) implied symmetrical shedding from both sides of the Golden Lane Atoll. But it is clear that leeward margins are the preferred settings for shedding greater amounts of carbonate sediment into the basin during highstands of sea level (Muir, et al., 1985; Eberli and Ginsburg; 1987; Wilber, et al., 1990; Wendte, et al., 1992). The textures of these allochthonous sediments are controlled by the strength of the easterly paleotrade winds, modified by ephemeral hurricane activity.

Exploration for carbonate plays within basins situated in tropical/subtropical settings, including Paleozoic basins in the Mid-Continent area, must assess what the relative strength of associated easterly paleotrade winds was and the orientation of their platform margins with respect to those winds (windward versus leeward). That assessment helps predict the direction of preferential shedding of sediments off the platform margin and interior and whether the resultant onlapping wedges were grainstone-rich or micritic. Persistent, strong easterly paleotrade winds also increase the potential for oolitic grainstones and isolated reefs to develop much further inboard on ancient carbonate platform interiors than the northern Bahamian depositional models predict.

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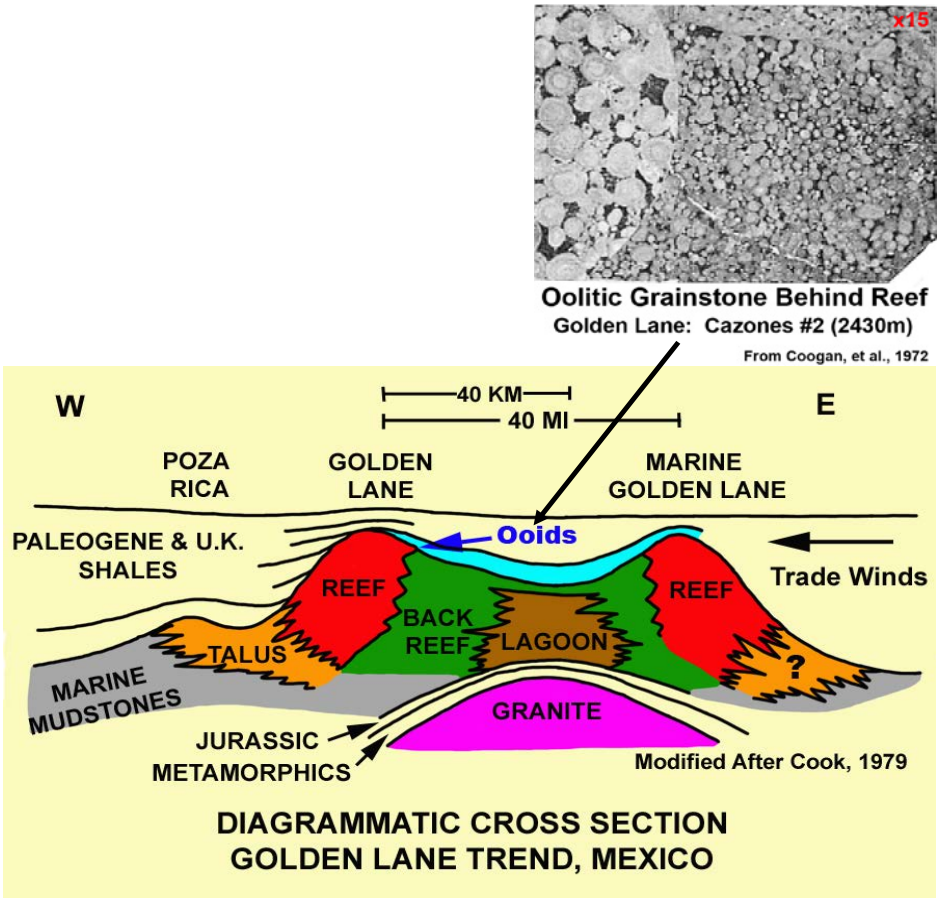

Figure 9. *Highly schematic diagram showing the generalized facies relationships across the Golden Lane Trend. Production at Golden Lane field occurs from the rudist reefs complexes along the western edge, in part developed because of agitation provided by the stronger easterly paleotrade winds, and because the deeper lagoon to the east inhibited off-bank transport of sediments. The presence of ooids with the back-reef grainstones (Coogan, et al., 1972) confirms the trade wind influence (again, reefs and ooids coexist). Golden Lane field later was modified by karstification. Poza Rica Field produces from talus shed off the western margin, again mostly driven by the stronger trade winds moving reef-derived rudist sands off the leeward margin. Windward-facing reefs ("Marine Golden Lane"), developed along the eastern platform margin that faced the open ocean, should not shed much material into the adjacent basin The question mark on this diagram was not placed there by Cook (1979) but by this author, as isolated complexes do not exhibit symmetrical shedding effects, a relationship well documented in other basins (Muir, et al., 1985; Eberli and Ginsburg, 1987; Wendte, et al., 1992). The light blue unit on top of Golden Lane represents younger pelagic limestones.*

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Educational Outreach Spotlight: Bones in Schools

By Letha Slagle

The HGS Bones in Schools Program provides students with hands on experiences handling real Pleistocene fossils and experiencing the Gulf Coast Ice Age Prairie. Since the program began, many local schools have taken advantage of this opportunity, and have received samples and a framed poster to illustrate ancient times and stimulate interest in geology, ecology and paleontology.

This month, Letha Slagle had the opportunity to visit the Houston Audubon Society (HAS) Summer camp, where 7-10 year olds were "making fossils" with camp instructors Amber Leung and Shelby Fletcher. A short presentation was given on Ice Age Ecology, and how mammals adapted to their environment through their teeth and other features. HAS camps are held at the Edith L. Moore Sanctuary and the Raptor and Education Center. They were pleased to receive and hold a few fossils for future classes, including a mammoth tooth.

We have teaching materials available for classes of all ages so if you are interested in bringing this program to an educational facility near you, please reach out to HGS Education Committee Chair Phil Caggiano or the HGS office. If you are interested in seeing more information about the HAS and their sanctuaries and programs, visit the website at houstonaudubon.org ■

HGS Sponsors Summer Interns at Houston Museum of Natural Science

By Dorene West

The HGS supported two local students this summer who participated in the Plant Astronomy Internship program at the Houston Museum of Natural Science (HMNS) this summer. Students engaged in an ongoing research project to evaluate the possibility of growing food on Mars and Earth's Moon. The research involved determining what the soil and atmosphere compositions are/will be, and what can to be done to help plants grow in these environments.

The HMNS summer internship program hosts students in grades 9-12 who won their divisions in the Science and Engineering Fair of Houston (SEFH). HGS members can learn more about the research these students conducted by visiting a display case in the Astronomy department that is located in the basement of the HMNS. ■

Left to right: Vedant Sharma (HGS sponsored intern), Dorene West, Abirami Balachandran (HGS sponsored intern). Vendant attends Awty International and Abirami attends St. John's School.

HGS Bulletin Art Contest
Geology is Beautiful 2023

Geology is beautiful! The Houston Geological Society invites you to submit your original photo or original artwork to the 2023 HGS *Bulletin* Art Contest for an opportunity to have your work featured on the cover of the HGS *Bulletin*, on the HGS website, and at selected HGS meetings.

KEY DETAILS

- Must be original photos or original artwork
- Include a title and a short description of the image (100-500 words)
- Open to HGS members and non-members
- Enter your submission by email to editor@hgs.org; use one of these formats: jpeg, jpg, png, pdf; portrait orientation is preferred
- Submissions accepted September 1, 2023 – December 1, 2023. Contest closes on midnight Central Standard Time.
- Maximum of one entry per person per category

➛ **Categories**

(1) Geologically interesting landscapes
(2) Rocks up-close and personal
(3) Energy

CONTEST RULES

- Submissions should be the original work of the submitter. No third party may own or control any materials the photo/art contains, and the photo/art must not infringe upon the trademark, copyright, moral rights, intellectual rights, or rights of privacy of any entity or person.
- Photos must be in its original state and cannot be altered in any way, including but not limited to removing, adding, reversing, or distorting subjects within the frame.
- No AI generated images.
- The following digital formats are accepted: jpeg, jpg, png, pdf. Digital files will not be returned to the submitter.
- Submissions should exclude images of people, unless the person is being used for scale and the person submits written permission for their image to be included in the contest.
- Entries will not be accepted unless submitted via the official contest channel. Entries not submitted through the proper channel will be deleted.
- By entering the contest, entrants agree that photos/art submitted can be used by the HGS for the *Bulletin*, website, on social media, or at meetings.
- The HGS Board reserves the right to change the category of the submission, if the submission does not appropriately match the category as submitted.
- Entries will be judged by the HGS board. All decisions are final.
- The HGS Board reserves the right to disqualify any entry that is deemed inappropriate or does not conform to stated contest rules.
- Violators will be removed from the contest, stripped of any prize(s), and banned from entering future contests.

Link to submission form: https://forms.gle/3uZ1ZFV1SCr9wirq6

Or Scan the QR Code

MEMBER SUPPLIED PHOTOS FEATURED ON PAST BULLETIN COVERS

2023 HGS Grand Canyon Field Trip

By Ross Harrison and Maddie Reid

Grand Canyon 2023 trip participants

Houston Geological Society hosted the Semi-Annual Grand Canyon Field Trip from May 31st to June 8th of 2023. This year's trip, co-led by Mattie Reid and Ross Harrison, was a resounding success on multiple fronts. Each experience in the Grand Canyon is unique and special, not only for the amazement of our physical world and its wonders, but also due to the delightful, interesting people who made their own individual contributions to the experience.

Trip participants ranged in age from 14 to 81 and included a mix of geology afficionados holding PhDs and those with no formal geology education. Of the 28 total attendees, there were two father-son pairs, multiple sibilings, and several sets of husbands and wives. Each of these individuals drew upon their life (and geologic) experience to enhance the awe-inspiring journey. The presence of structural geologists, sedimentologists, basin modelers, geochemists, geophysicists, sequence stratigraphers, and petrophysicists on the trip made this a profoundly special educational experience.

In addition to the roaring rapids of the Colorado and steep side-canyon hikes, this group observed: modern ripple sets and giant standing waves, quaternary mass transport deposits, lava slides, Permian-aged reptile tracks, well-preserved in-situ Cambrian trilobite tracks, and beautiful pre-Cambrian stromatolites. The group identified "the Greatest Angular Unconformity" that represents approximately 1.2 to 1.5 billion years in missing time, where the Cambrian Tonto Group (Tapeats Sandstone Formation) can be observed overlying the faulted and tilted Early Proterozoic Vishnu Schist formation. In addition to the "geologic attractions" and awe-inspiring views, the group observed several anthropologic wonders, including ~1100-year-old granaries (particularly steep hike but with rewarding views) and ancestral-Puebloan pictographs.

HGS traveled with Hatch River Expeditions, a commercial trip operator founded by Bus Hatch that began operating in the Grand Canyon 1934. Hatch safely led the HGS group for ~186 miles of the Colorado River. The trip guides, Kelsey and Eric, have nearly 40 years of experience on the river between the two of them. Along with the "swamper" (guide's assistant), Jackson, the crew kept the HGS group safe, entertained, well-fed, and continuously educated. The workday on the river and its banks never ends, and it was clear the guides felt a personal calling to their occupation and to the Canyon—the success of our trip rested on their shoulders, and they did not disappoint.

In addition to everything listed above, one of the most rewarding factors of this trip was the presence of a local Houstonian and Texas A&M undergraduate geology student. It was a joy to see this student's eyes saturated and mind permeated with the knowledge of what the Grand Canyon offers. For future trips, HGS (or any individual/organization reading this article) is encouraged to establish a scholarship fund to support undergraduate students attending the trip. ■

Acknowledgements:
We would like to thank Steve Earle and Dave Lazor for imparting their knowledge of the Canyon on us, HGS for entrusting the experience of this trip with us, Hatch for their phenomenal work, and most of all each participant of this year's trip for everything they contributed.

Monday, September 11, 2023

5:30 – 9:00 p.m.

HGS Members/Emeritus/Honorary Life $65
Students $25 • Non-Members & Walkups $75
Norris Conference Center, Citycentre
816 Town and Country Blvd #210 • Houston, TX 77024
https://www.hgs.org/civicrm/event/info?id=2468
Event Contact: Linda Sternbach • linda.sternbach@gmail.com

Richard A. Sears
(retired Shell Vice President), currently Adjunct Professor at Stanford University

The Economics of Deepwater; Myths and Realities Through the Decades

IS DEEPWATER EXPLORATION SPECIAL?

(Spoiler Alert: Yes and No) Deepwater oil and gas has been around for decades. More than fifteen if we start counting at the first production from deepwater reservoirs. Somewhat less, five or six, if the starting point is the first targeted exploration drilling beyond the shelf edge. Whatever your definition, there must be something attractive about deepwater for it to have this longevity. Given that deepwater is being sustained largely by commercial oil and gas companies, that attractiveness must be anchored by fundamentally favorable economics. Not a particularly surprising conclusion. Through an examination of deepwater over the last several decades we can learn a lot about deepwater itself, as well as the broader business of exploration.

Good fields and good projects are good, over a wide price range.
Price is not an existential threat for well-run companies.
Deepwater projects, done right, are good projects.
Technology is the enabler and the great multiplier.
It's the oil business and few things on the planet are more profitable than a properly developed, producing oil field!

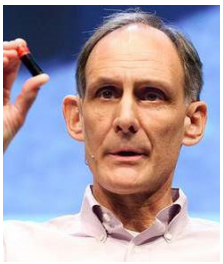
Headlines over the years such as "There is No Reservoir or Active Petroleum System in Deepwater" (1970's) to "It's a Gulf of Mexico Thing" (1990's) to "Deepwater Exploration; Is the Deepwater Dead and Buried?" (2000's) have been interspersed with a steady stream of announcements of deepwater discoveries and project sanctions globally, along with a different set of headlines over the last decade such as "Deepwater Discoveries Down But Not Out", "Do Call it a Deepwater Comeback" and "Oil Majors' Focus on Deepwater Pays Off". More telling was the recognition just three years ago that "Global Deepwater Production Hits 10 million BOE/D" and late last year "Deepwater Production Set for Steady Growth" and that "Global Production Should Climb to 17 million BOE/d by 2030". Most recently that from 2022 through 2025, over $200 billion in capital spending is expected to be allocated to deepwater projects.

These messages, taken together are not the ramblings of a schizophrenic industry but instead make perfect sense in a play where new discoveries and projects require new geologic thinking and production technology. This lecture will look at the economic perceptions and realities that have brought us to where we are today, and just as importantly, to where the deepwater is going in the future.

Today, most everybody is saying:

- Deepwater is the cheapest and greenest source of supply
- Deepwater production set for continued growth

BIOGRAPHICAL SKETCH



Rich Sears says he is *Gamechanger* on his LinkedIn profile

Current Activity

- Consulting and communications on energy, energy sources and supply, and evolving energy systems.
- Stanford University Professor of Practice since February 2012
- Visiting Scientist at Massachusetts Institute of Technology 2013

Industry Experience

- Vice President Royal Dutch Shell 1998-2005, External Research Coordinator at Shell till 2009
- Head of Shell Exploration in the UK 1992-1995
- Exploration Manager at Shell US 1989-1991
- BS and MS Geophysics and Physics, Stanford University 1976

Wednesday, September 27, 2023

11:15 a.m. – 1:00 p.m.

HGS Members (pre-registered) $50 • Emeritus/Life/Honorary $40
Students $20 • Non-Members & Walkups $60
Petroleum Club of Houston
1201 Louisiana St 35th floor Houston TX
https://www.hgs.org/civicrm/event/info?id=2481
Event Contact: Linda Sternbach • linda.sternbach@gmail.com

HGS General Luncheon Meeting

Joint Presentation
***Christine Griffith**, Texas A&M University*
***Art Donovan**, Texas A&M University*

Regional Sequence Stratigraphy, Biostratigraphy, Facies, and Depositional Environments of the Upper Cretaceous Austin Chalk in South and Central Texas

Christine Griffith, James Pospichal, Eric de Kaenel, Michael Pope, and Arthur Donovan

INTRODUCTION

The Upper Cretaceous Austin Chalk is a major hydrocarbon reservoir, with active exploration and development across Texas. It occurs in an extensive outcrop belt across Texas and Mexico and in tens of thousands of wells (**Fig. 1**). This regional stratigraphic study focuses on south and central Texas, where Austin Chalk thicknesses vary from <100-1000' (30-300 m). Correlation is difficult due to significant thinning across the San Marcos Arch and toward the outcrop belt. Persistent markers in the basins pinch out and look different on either side of the arch. Different stratigraphic nomenclature was developed in Pearsall field (Ewing, 2013) west of the arch, Giddings Field (Maranto, 2017) east of the arch, and in the outcrop (Young, 1985). Previous workers (Durham, 1957; Jiang, 1989; Young, 1985) recognized an angular unconformity within the Austin Chalk in outcrops from Austin to San Antonio, based on lithostratigraphic, macrofossil, and nannofossil criteria. A sequence stratigraphic framework (Cooper et al., 2020), developed from San Antonio outcrops recognized this same unconformity in the shallow subsurface toward Austin. The goal of this study was to cross the "Great San Marcos Divide", identify Austin Chalk sequences, and place facies in a sequence stratigraphic framework to aid future hydrocarbon development.

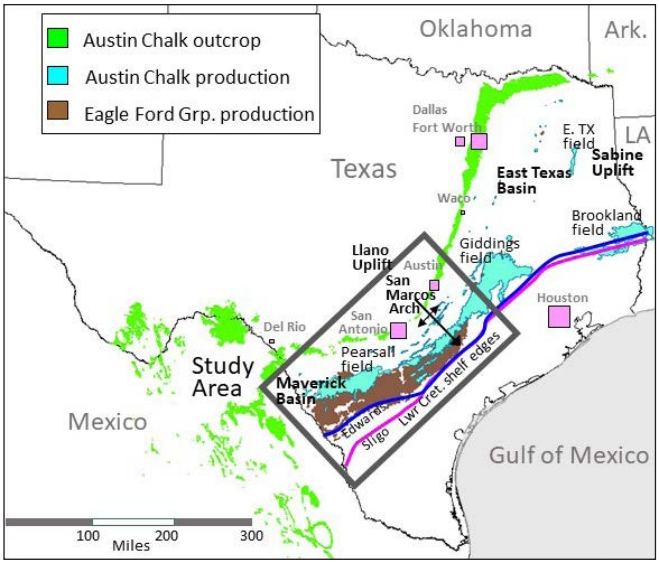


Figure 1. *Index map*

RESULTS

Facies and Correlation Markers

Although dominated by fine-grained pelagic nannofossils, the lithology, sedimentary structures, and biota in the Austin Chalk vary laterally and vertically (Dravis, 1980; Loucks et al., 2020), indicating different water depths, oxygen, nutrients, and currents. The Austin Chalk is similar to other formations in the Gulf Coast, deposited on a gentle slope, dipping toward the Gulf of Mexico. Updip facies are light-colored, with diverse macrofossils like oysters and echinoids, and diverse burrowers, indicating deposition in fully oxygenated water. Downdip facies have fewer and less diverse (mainly horizontal) burrowers or are laminated, indicating deposition in a dysoxic middle ramp to intermittently anoxic outer ramp setting. Darker colors are due to admixed argillaceous material, disseminated pyrite, and organic matter (~2%).

Depositional surfaces, like hardgrounds and firm grounds with Glossifungites facies, occur at sequence boundaries. Glauconitic and phosphatic skeletal packstone beds, with bored lithoclasts, are interpreted as transgressive lags above sequence boundaries. Glauconitic-rich beds are associated with biostratigraphic hiatuses (next section), have a widely correlatable medium GR and low resistivity log signature and overlie angularly truncated beds.

Other log markers, such as volcanic ash from distant arc volcanoes or local Texas tuff cones and organic-rich marker beds, indicate deposition in quiet water. Organic-rich 'C' and 'D' marker beds in the Maverick Basin in south Texas are interpreted as maximum flooding surfaces, deposited in a widespread oxygen minimum zone across a range of paleowater depths.

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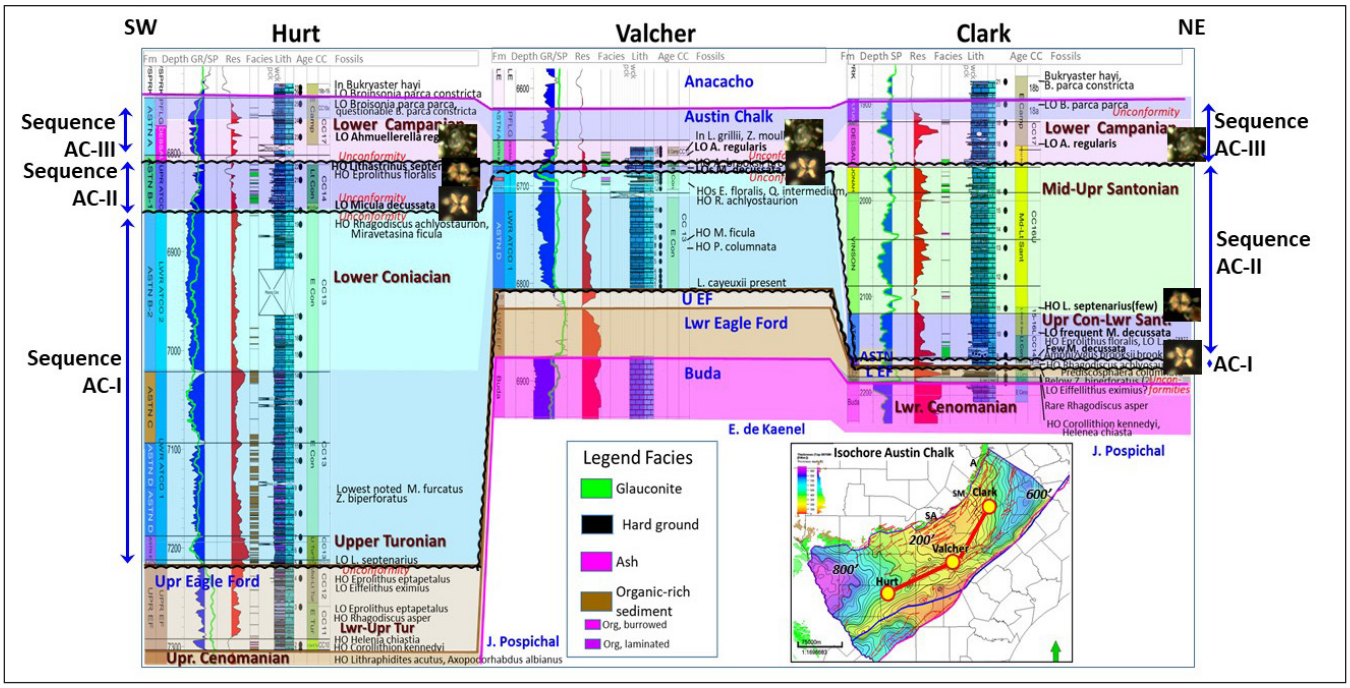

Figure 2. *Biostratigraphy and sequence boundaries in three key wells*

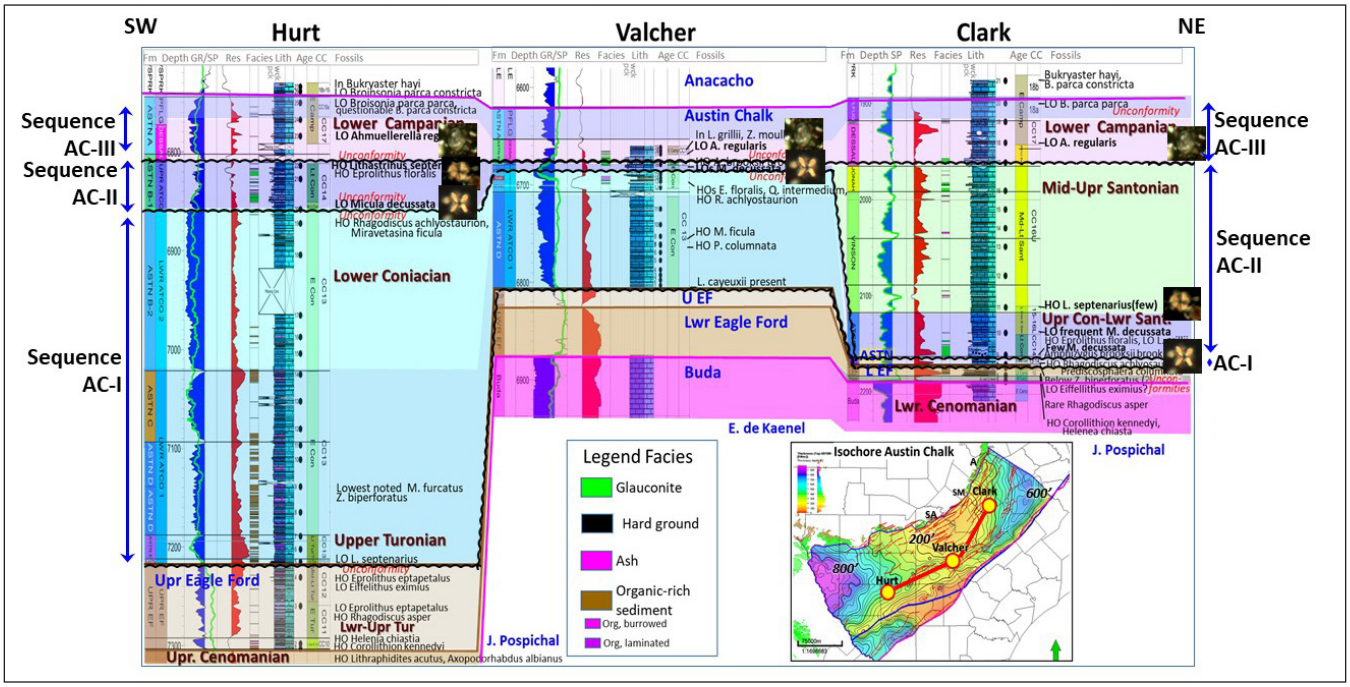

Figure 3. *Strike cross section with stratigraphic nomenclature*

Nannofossil Biostratigraphy

The sequence stratigraphy is based on new nannofossil biostratigraphy from cores of three wells: the Getty Lloyd Hurt (4228330305) on the west flank of the San Marcos Arch, the Shefts Sallie Clark (4205501852) on the east flank (analyses from James Pospichal) and the Tesoro Valcher (4249330230) on the axis of the arch (from Eric de Kaenel). Three nannofossils are particularly important in recognizing the stratigraphic sequences in these wells: the LO (lowest occurrence) of Micula decussata (base Middle Coniacian), the HO (highest occurrence) of Lithastrinus septenarius (base Middle Santonian), and the LO of Ahmuellerella regularis (base Campanian). These three fossils distinguish biostratigraphic hiatuses (and associated glauconitic-rich beds) that define three unconformity-bound composite stratigraphic sequences in the Austin Chalk. (**Fig 2**). The first sequence, AC–I (Upper Turonian to Middle Coniacian) is best developed in the Getty Lloyd Hurt well. The AC-1 is truncated toward the east and is unconformably overlain **General Luncheon Meeting** *continued on page 28*

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by sequence AC–II (Upper Coniacian to Upper Santonian), which is best developed in the Shefts Sallie Clark well. Sequence AC–II is truncated over the San Marcos Arch and in the west and is unconformably overlain by the third sequence, AC–III (Upper Santonian-Lower Campanian).

Cross Sections

Sequence boundaries from nannofossil biostratigraphy were correlated into glauconitic-rich beds and hard grounds described in multiple cores (e.g. Dravis, 1980; Loucks and Reed, 2022). Correlations were extended across the study area based on consistent log character of glauconitic beds above and angular truncation below sequence boundaries. A strike cross-section (**Fig. 3**) ties the nomenclature from the outcrop into the major Austin Chalk petroleum fields on either side of the San Marcos Arch. The cross section shows that the log markers on either side of the arch are largely of different ages, and that much of the Austin Chalk in south Texas is older than in central Texas. The San Marcos Arch was tectonically active during Austin Chalk deposition. The axis of the San Marcos Arch moved from the eastern study area, to west of San Antonio, to an intermediate position in successive sequences of the Austin Chalk. Sequence AC–I (Upper Turonian to Middle Coniacian) is almost completely eroded in central Texas but is very thick in south Texas. The axis of uplift shifted westward during sequence AC–II (Late Coniacian to Late Santonian), with erosion in the center and on the west side of the arch and thick sediment accumulation in central Texas. The axis of the San Marcos Arch moved to an intermediate position during the sequence AC–III (Late Santonian to Early Campanian), with more sediment accumulation toward the east.

The Austin Chalk thins toward the relict Edwards shelf edge from a maximum thickness in the Maverick Basin (index map in **Figures 2** and **3**), due to either (1) subsidence in the Maverick Basin and uplift at the relict shelf edge, or (2) subsidence toward the Gulf of Mexico and formation of a depositional ramp. The second model is favored, based sediment architecture and facies above and within the Austin Chalk. The overlying Anacacho Formation thickens downdip toward the relict Edwards shelf margin as the Austin Chalk thins, indicating greater subsidence and accommodation space toward the south. The 'C' and 'D' correlation markers in the Austin Chalk have a sigmoidal offlapping geometry downdip toward the relict Edwards shelf edge (Ewing, 2013). Vertical facies (Getty Lloyd Hurt core) become more fully oxygenated up section. ramp formation is attributed to greater coccolith productivity updip and/or stronger bottom currents downdip. ■

ACKNOWLEDGMENTS

I am grateful to John Cooper and Alexis Godet at University of Texas San Antonio for sharing the Tesoro Valcher nannofossil biostratigraphy; for help from Texas A&M University students: Eric Peavey, Molly McCreary, Samantha MacKenzie, and John Sarao; data from DrillingInfo, and S&P Global–IHS Markit; software from Schlumberger Petrel and EasyCore; and financial support from AAPG, GCAGS, and the TAMU Berg-Hughes Center.

BIOGRAPHICAL SKETCH

Christine Griffith worked as a petroleum geologist and subsurface coordinator for Shell Oil, on exploration and development projects in onshore and offshore United States, Nigeria, and Brazil. After retirement, she continued her geological education at Texas A&M University, where she teaches an online class in petroleum geology. She received her Ph.D. in 2023, with a dissertation on the regional sequence stratigraphy of the Upper Cretaceous Austin Chalk in south and central Texas. Her previous degrees were a BS in Geology from the University of Illinois, and a MS in Geology from the University of Wisconsin. She is longtime member of AAPG and served as a member of House of Delegates for 6 years in the 2000's. She is a member of the Houston Geological Society, South Texas Geological Society, and a licensed professional geologist in Texas.

Christine's interest in the Austin Chalk was sparked by years of hearing about activity in the trend. She could see that that stratigraphic nomenclature differed in the subsurface across the San Marcos arch and between the subsurface and outcrop, andno one had published a stratigraphic synthesis of this important reservoir, even as new exploration and development activity was ramping up. The starting hypothesis was the stratigraphic complexity was due to an unconformity, and that this unconformity could be collaborated with nannofossils. Previous workers had showed the presence of an internal unconformity in the Austin Chalk outcrop, based on lithostratigraphic, macrofossil, and nannofossil criteria. Christine would like to acknowledge the nannofossil biostratigraphic analyses by James Pospichal and Eric de Kaenel on three Austin Chalk cores across the San Marcos Arch, which provide the underpinning of this stratigraphic synthesis.

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Unraveling the "Eaglebine": A Sequence Stratigraphic Framework for the Eagle Ford Group in the East Texas Basin

A.D. Donovan, P. Johnson, S. R. Gifford, M.J. Meyer, S. Dangtran, L. Evans, and M. Pope

Geochemical data indicates that the "Eaglebine Resistivity Zone" in the Southern East Texas Basin (SETB) is a Ca- and TOC-enriched mudstone. Previous researchers had assigned and interpreted this unit as either the: 1) basal Pepper Shale, coeval to the Woodbine Freestone Delta; or 2) Maness Shale of the Washita Group, which predates the Woodbine Group. Along the outcrop belt to the northwest, similar mudstones occur at the base of the Eagle Ford Group and overlie Al-rich and TOC/Ca-poor mudstones of the Woodbine Group.

In order to resolve this juxtaposition in the facies succession between the outcrop belt and subsurface of the SETB, a detailed sequence stratigraphic study, including a grid of well-log cross sections, as well as geochemical data from key cored wells, was constructed. This sequence stratigraphic analysis indicates that: 1) a major regional unconformity separates the Woodbine from the Eagle Ford Groups across the study area, 2) the " Eaglebine Resistivity zone" in the SETB overlies this unconformity and correlates to the Middle to Late Cenomanian Lower Eagle Ford Formation along the outcrop belt to the west; and 3) the classic "top resistivity marker" overlies a sequence boundary. which defines the base of the Upper Eagle Ford Formation. Across the study area, Lower Eagle Ford Ca- and TOC-enriched mudstones, unconformably overlie Al-rich, TOC-/Ca-poor, low-resistivity mudstones of the Pepper Shale (Woodbine Group/Freestone Delta), and are overlain unconformably by the Al-rich, TOC-/Ca-poor Lower Member of the Upper Eagle Ford Formation (Harris Delta). Based on sequence stratigraphic analysis it is now clear that the bulk of the "Eaglebine" in the SETB, is actually the Eagle Ford Group. ■

BIOGRAPHICAL SKETCH

Dr. Art Donovan is a globally recognized expert in the fields of sequence stratigraphy, siliciclastic depositional systems, and unconventional reservoirs. Art has over 35 years of experience in the oil and gas industry, where his efforts focused on understanding reservoir distributions and architectures, as well as exploring for oil and gas, in basins around the world, for both ExxonMobil and BP. During his time at BP, Art was the Sed/Strat Discipline Lead; served as a member of BP's Global Exploration Technical Assurance Team; and worked as the Senior Technical Advisor for BP's Onshore Exploration efforts in North America, as well as, led BP's outcrop research efforts on unconventional reservoirs. Art retired from BP in 2016, and since that time has worked as a full-time faculty member in the Department of Geology and Geophysics, at Texas A&M, where he teaches, advises numerous graduate students, as well as conducts research with his students on conventional and unconventional reservoirs in Texas, as well as across North America.

The Houston Geological Society

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September 2023

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
RESERVATIONS The HGS prefers that you make your reservations online through the HGS website at WWW.HGS.ORG. If you have no internet access, you can e-mail OFFICE@HGS.ORG, or call the office at 713-463-9476. **Reservations for HGS meetings must be made or cancelled by the date shown on the HGS website calendar, normally that is 24 hours before hand or on the last business day before the event**. If you make your reservation on the website or by email, an email confirmation will be sent to you. If you do not receive a confirmation, contact the HGS office at OFFICE@HGS.ORG. Once the meals are ordered and name tags and lists are prepared, no more reservations can be added even if they are sent. **No-shows will be billed.**					1	2 Make your reservations online at hgs.org
3	4 **Labor Day HGS Office Closed**	5	6 **HGS Luncheon Meeting** *Austin Chalk and Eaglebine* *Page 25* *https://www.hgs.org/civicrm/event/info?id=2481*	7	8	9
10	11 **HGS General Dinner Meeting** *Deepwater Business Richard A. Sears* *Page 26* *https://www.hgs.org/civicrm/event/info?id=2468*	12	13 **HGS E&E Dinner Meeting** *TBA*	14	15	16
17	18 **HGS Student Expo** *https://www.hgs.org/civicrm/event/info?id=2461*	19	20 **PESGB-HGS Africa Conference**	21	22	23
24	25	26	27	28	29	30

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Industry Spotlight from Wood Mackenzie
Trends in Exploration Spend

By Julie Wilson, Research Director for Global Exploration at Wood Mackenzie

Source: Wood Mackenzie. Spend is in real 2023 terms

Exploration spend over the next five years will rise from pandemic lows as explorers become bolder. Most of the big spenders remain keen on wildcatting. The NOCs and Majors will play an increasingly dominant role in the exploration sector. Majors are committed to high-impact wildcatting as a way to build new hubs that will offset legacy decline—with better economic and ESG metrics. NOCs' spend will increase mostly in domestic basins to counter energy security concerns. Non-IOCs such as conglomerates and privates will continue to be important in countries that are generally less accessible, or less attractive, to IOCs.

The biggest growth will be in deepwater areas of the African Atlantic Margin and the Eastern Mediterranean, although the emergence of new basins and plays could shift this emphasis.

The business case for exploration is robust, supported by numerous tailwinds. Attractive economics and a need to add more advantaged resources to company portfolios are facilitated by strong upstream sector financials and a renewed license to operate. The emergence of hot new frontiers such as Namibia's Orange sub-basin creates excitement and confidence in the sector. Increased seismic acquisition activity points to future growth in drilling.

Wood Mackenzie's annual "Future of Exploration Survey", in which we take the pulse of the exploration sector, clearly supported increased spending. Most respondents indicated a higher number of wells and an increased budget in 2023 compared to 2022. Portfolio renewal is back on the agenda, in recognition of exploration's place in an accepted longer energy transition. Shorter-cycle opportunities continue to be emphasized. That said, the most important metric for demonstrating exploration performance was value creation, suggesting high-impact exploration is firmly in play.

Despite the tailwinds, constraints on exploration spend remain – and these will put a ceiling on how far the recovery will go. Years of portfolio concentration have led to a shortage of high-quality prospects—especially ones that meet stricter ESG standards. When asked about challenges for their company, explorers in our Survey ranked "limited prospect inventory" as the top challenge.

The business case for exploration is robust, supported by numerous tailwinds.

A diminished corporate landscape and staff reductions following years of consolidation have left the sector short of talent. This was the third most significant challenge in our Survey. Supply chain issues and inflation fears also play a part in constraining exploration spend.

But the biggest constraint of all is the mantra of executives everywhere: capital discipline. Lack of budget was the second largest challenge in our Survey. And it was the second most important metric in demonstrating exploration performance. While capital discipline supports exploration's ability to create value, it should not be so tight that it stifles the creativity of oil and gas finders. ■

The Houston Geological Society Continuing Education Committee Presents

Applied Understanding for Geoscientists of How Engineers Calculate Reservoir Oil and Gas Volumes Using PVT

Ronald (Ron) L. Lang, P.E.

Thursday, October 20, 2023
Virtual Event via Zoom • 8:00 am – 1:00 pm
https://www.hgs.org/civicrm/event/info?id=246
Attendees will receive a Certificate of Continuing Education for 4 PDH

COURSE DESCRIPTION

Learn to apply the fundamental principles of PVT beginning at the well site and progressing through the lab to the PVT report and its application in estimating oil and gas volumes.

PRICING

$200 for HGS Members
$100.00 Student/Emeritus
$400 Non-Members or
Non-Members can submit an application and pay their dues before registering to get the member price. Please call the HGS office at 713-463-9476 to be registered only AFTER your application and dues are submitted.

SUMMARY

This practical course will provide students with a working knowledge of Pressure Volume Temperature (PVT) and an understanding of Equation of State (EOS) and its application, following a path from field sampling to the lab and on to the examination of common practices and analyses used in classical and simulated reservoir engineering.

Objectives

- Understand the field separation processes and sampling procedures
- Learn how to select the method of sampling at the well site
- Learn how the PVT lab validates samples and conducts experiments
- Determine which PVT experiments to perform on your samples
- Identify the six reservoir fluid types and their phase behavior
- Learn to read PVT lab reports for DLE, CCE, CVD, and Separator Tests
- Construct black oil PVT tables for volumetrics and simulation models

INTRODUCTION

As a Geoscientist it is useful to understand how your team Reservoir Engineer calculates reserves. You might ask what is Applied Understanding of PVT? It means that you don't need to be an expert in PVT to immediately and effectively apply its fundamental principals in estimating oil and gas volumes at various temperatures and pressures. By the end of this course, you will understand phase behavior in the context of reservoir fluid types and the effect of PVT (pressure-volume-temperature) changes for a characterized fluid (a defined multi-component oil and gas system). You will be equipped to apply your knowledge in the field during sampling and in discussions with the lab, and confidently use the reported results to construct PVT tables. You will also learn how to construct PVT tables using correlations built into Excel. The applied understanding of the fundamental principals is a must for petroleum engineers, especially for reservoir engineers who need to effectively estimate reservoir oil and gas volumes at reservoir temperature and pressure during depletion and enhanced oil recovery (EOR). It is valuable for Reservoir Geoscientists to have an understanding of these principals.

Continuing Education *continued on page 34*

Date: May 24, 2023 • 8:00am – 1:00pm • Virtual Event via Zoom.
Registration will close Wednesday October 19, 2023 at 4 pm. Meeting links will be sent at this time to the "Primary" email listed on your HGS account
Please make your reservations on-line https://www.hgs.org/civicrm/event/info?id=2488
For more information about this event, contact HGS Office 713-463-9476 • office@hgs.org

Continuing Education continued from page 33

HGS Short Course: Applied Understanding for Geoscientists of How Engineers Calculate Reservoir Oil and Gas Volumes using PVT
Date: October 20, 2023 • 8:00am – 1:00pm • Virtual Event via Zoom.
Registration will close Wednesday October 19, 2023 at 4 pm. Meeting links will be sent at this time to the "Primary" email listed on your HGS account
Please make your reservations on-line https://www.hgs.org/civicrm/event/info?id=2488
For more information about this event, contact HGS Office 713-463-9476 • office@hgs.org

COURSE OUTLINE

Volumetrics and Correlations

- Oil and Gas Volumetric Equations
- Oil Correlations for Rs Pb Bo
- Gas Correlations for Z and Bg
- Oil and Gas Behavior Animations
- Oil and Gas Correlation Spreadsheets

Field Separation and Sampling

- Surface Separation of Oil and Gas
- Sampling Separator Oil and Gas

Material Balance of Fluids

- A Day in the Life of a Mole

PVT Lab and Surface Samples

- PVT Lab Surface Sample Workflow
- PVT Lab Sample Validation
- PVT Lab Compositions
- PVT Lab Gas Plant Liquids

PVT Lab Experiments

- Six Reservoir Fluid Types
- Methods and Analyses
- Physical Recombination
- CCE Experiment
- CVD Experiment
- DLE Experiment with Correction to Surface Conditions
- Example PVT Tables

BIOGRAPHICAL SKETCH

Ronald (Ron) L. Lang, P.E. has over 40 years of experience in reservoir engineering, including classical and simulation applications. He is actively involved as a consultant in domestic and international studies requiring application of PVT equation of state (EOS) principles. He participates in association with geoscience teams in field development strategies including primary, secondary, and enhanced oil recovery (EOR) projects. Mr. Lang is a regular guest speaker for the SPE International Continued Education Accelerated Learning Tutorials relating to PVT and EOS.

Mr. Lang received a BSc degree in Petroleum Engineering in 1974 from Texas Tech University. His career began with Amoco Production Company in Houston and transitioned to consulting firms engaged in exploration and development; acquisition and divestment transaction advisory; and petroleum engineering technical evaluations. He is a licensed professional engineer in the state of Texas.

As an experienced simulation engineer, Mr. Lang learned the importance of correctly applying PVT (EOS) to properly characterize reservoir fluids and accurately predict fluid behavior and its impact on reservoir oil and gas volumes and performance. He has studied under the guidance of leading experts in this field in the oil and gas industry. Mr. Lang had a supporting technical role during the litigation of the Deepwater Horizon Macondo oil spill. In the development of conventional and unconventional oil and gas resources, it is crucial for engineers to understand the differences among the various classes of reservoir fluids. In particular, reserves and their value can be lost rapidly if engineers do not properly identify near-critical fluids, and their behavior, such as in the volatile oils and retrograde gases. ■

WORD BRECCIA – A GEOLOGY WORD JUMBLE

Unscramble the words below and rearrange the circled letters to find the answer to the clue.

TOPHNY	_ _ _ O O _
YERGNE	O _ _ O _ _
NILAOE	_ _ O _ O _
SCIMIES	_ O _ _ O _ _
VARYTIG	O _ _ _ _ O _

A hot area for geoscience jobs: _ _ _ _ _ _ _ _ _ _

Renew Your HGS Membership

HGS.ORG

HGS ANNUAL
GOLF TOURNAMENT
16 OCTOBER 2023 | STERLING COUNTRY CLUB

SPONSORSHIP FORM

Sponsorship deadline: October 9, 2023

Title Sponsorship $2,250
- Sponsor LOGO signs on courses
- Company LOGO prominently displayed on sponsor recognition board at registration and awards banquet
- Company LOGO displayed on driving range and practice putting green signs
- Company LOGO displayed on beverage carts
- Set up on 2 holes (Meet & Greet, Swag and Food)
- Tournament entry for one team (4 people)

Beverage Sponsorship $2,000
- (All beverages must be purchased from the Club)
- Sponsor LOGO on HGS website and social media
- Company LOGO prominently displayed on sponsor recognition board at registration and awards banquet
- Company LOGO displayed on beverage carts
- Set up on 2 holes (Meet & Greet, Swag and Food)
- Tournament entry for one team (4 people)

Lunch Sponsorship $2,000
- Can BBQ onsite, bring in caterer, or have HGS pick the food
- Sponsor LOGO on HGS website and social media
- Company LOGO prominently displayed on sponsor recognition board at registration and awards banquet
- Set up on 2 holes (Meet & Greet, Swag and Food)
- Tournament entry for one team (4 people)

Breakfast Sponsorship $500
- Breakfast Tacos
- Sponsor LOGO on HGS website and social media
- Company LOGO prominently displayed on sponsor recognition board at registration and awards banquet
- Set up on 1 holes (Meet & Greet, Swag and Food)
- 1 complimentary Registration

Nicklaus Sponsorship $1,000
- Sponsor LOGO signs on courses
- Company LOGO prominently displayed on sponsor recognition board at registration and awards banquet
- Company LOGO displayed on driving range and practice putting green signs
- Set up on 1 hole (Meet & Greet, Swag and Food)
- 2 Complimentary Registrations

Hogan Sponsorship $500
- Sponsor LOGO signs on courses
- Company LOGO displayed on sponsor recognition board at registration and awards banquet
- Set up on 1 hole (Meet & Greet, Swag and Food)
- 1 complimentary Registration

Trevino Sponsorship $250
- Sponsor LOGO signs on courses.
- Company NAME displayed on sponsor recognition board at registration and awards banquet
- No Complimentary Registration

Individual Sponsorship $150
- Sponsor LOGO on HGS website
- Company NAME displayed on sponsor recognition board at registration and awards banquet
- No Complimentary Registration

Raffle Swag Prize Sponsorships
- Par Sponsor **$250**
- Birdie Sponsor **$500**
- Eagle Sponsor **$700**

Please submit company logo with form and payment. Payment by credit card or check.
Please make checks payable to *Houston Geological Society*. Email form to office@hgs.org.

Company Name: _____

Sponsorship Type: _____ Amount Enclosed: _____

Contact Name: _____

Billing Address: _____

Phone: _____ Email: _____

Card Number: _____Expiration Date: _____ CVC: _____

HOUSTON GELOGICAL SOCIETY | 713-463-9476
14811 ST. MARY'S LANE, STE. 250 | HOUSTON, TX 77079

HGS ANNUAL
GOLF TOURNAMENT
16 OCTOBER 2023 | STERLING COUNTRY CLUB

SPECIALTY SWAG SPONSORSHIP FORM

Sponsorship deadline: October 2, 2023

Gift Bag Tote Sponsor $1,000 - 1 available

- Sponsor logo on white gift bag tote giveaways
- Sponsor logo prominently displayed on sponsor recognition board at registration and awards banquet
- Sponsor logo displayed on HGS website and social media

Divot Tools Sponsor $750 - 1 available

- Sponsor logo on metal divot tool giveaways
- Sponsor logo prominently displayed on sponsor recognition board at registration and awards banquet
- Sponsor logo displayed on HGS website and social media

Golf Ball Sponsor $700

- Sponsor logo on golf ball giveaways
- Sponsor logo prominently displayed on sponsor recognition board at registration and awards banquet
- Sponsor logo displayed on HGS website and social media

Tee Sponsor $500

- Sponsor logo on bamboo tee giveaways
- Sponsor logo prominently displayed on sponsor recognition board at registration and awards banquet
- Sponsor logo displayed on HGS website and social media

Please submit company logo with form and payment. Payment by credit card or check.
Please make checks payable to *Houston Geological Society*. Email form to office@hgs.org.

Company Name: _____

Sponsorship Type: _____ Amount Enclosed: _____

Contact Name: _____

Billing Address: _____

Phone: _____ Email: _____

Card Number: _____Expiration Date: _____ CVC: _____

HOUSTON GELOGICAL SOCIETY | 713-463-9476
14811 ST. MARY'S LANE, STE. 250 | HOUSTON, TX 77079

HGS ANNUAL
GOLF TOURNAMENT
16 OCTOBER 2023 | STERLING COUNTRY CLUB

TEAM APPLICATION

Early Bird Deadline: October 9, 2023

Entry Deadline: October 12, 2023

Come join us for golf, food, friends, and fun at the annual HGS Golf Tournament at Sterling Country Club and Houston National Golf Club (www.sccathn.com). There will be prizes awarded for closest to the pin and long drive, putting games before we start, as well as many great door prizes for participants.

Entry Fee: $175.00/Golfer or $700.00/Team.
Early Bird Special (Through October 9th): $150.00/golfer or $600.00/team
Entry Deadline: October 12th.

Individual entries will be grouped with other individual golfers to make a foursome. Entries are limited to and will be accepted on a first-in basis.

Schedule of Events

8:00am - 9:45am Registration, free use of driving range and mini games
10:00am Shotgun start
3:00pm Cash bar, open buffet
3:30pm Door prizes and awards presentation

Companies or individuals interested in sponsoring the event should contact the HGS Office at office@hgs.org or 713-463-9476. If paying by check, please make check payable to HGS or Houston Geological Society. Sponsorship deadline is October 9th.

Team Captain: _____ Phone:_____ Amount Enclosed:_____

Company: _____ Email: _____

Card Number: _____ Exp. Date:_____ CVC:_____

Billing Address: _____

Foursome Members	Company	Phone	Email
1. _____	_____	_____	_____
2. _____	_____	_____	_____
3. _____	_____	_____	_____
4. _____	_____	_____	_____

Please print and provide email addresses for ALL team members, as all communications will be done via email.

FIRST ANNUAL HGS SPORTING CLAYS SHOOT

HGS 100TH YEAR ANNIVERSARY

SATURDAY DECEMBER 09, 2023
WESTSIDE SPORTING GROUNDS
10120 PATTISON RD., KATY, TX 77493

$800/4 person Team
$200 / Individual
Includes 4-man cart, 12 & 20ga ammo
Gun Rentals are available from the venue

Gun Raffels, Door Prizes, Lunch,
Drinks & MULLIGANS for purchase

Sponsorship Opportunities Available!

Register
your team now!

Registration & Sponsorship Info: www.hgs.org
or call 713-463-9476

First Annual HGS Sporting Clays SHOOT
HGS 100 YEAR ANNIVERSARY

Saturday, December 9, 2023
Westside Sporting Grounds
10120 Pattison Rd., Katy, TX 77493

Individual and Team Entry Form

This is a 100-target event, a 4-man cart per team and ammo are provided, **participants must provide eye and ear protection.** Westside Sporting Grounds and National Sporting Clay Association safety rules will be in effect. Door prizes and raffle tickets will be awarded by blind drawing after the conclusion of shooting. You must purchase tickets for the drawing, and you must be present at the time of the drawing to win. Lunch will be provided from 11:30 until 1:30. Refreshments will be available throughout the day. **Non-shooting guests are welcome to enjoy lunch and refreshments at a cost of $25 per guest.**

We are limited to 120 shooters on 1 course. Entry fee is $200.00 per shooter for registrations received by MONDAY, DECEMBER 1st. After 12/1/23 REGISTRATION IS CLOSED. Individual shooters will be squadded with a team ***Register early it will fill up fast!!***

For more information, contact: Andrea Peoples at (713) 463-9476 or office@hgs.org
For directions to the club, visit www.wsgclays.com

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ONLINE REGISTRATION INFORMATION AT: https://www.hgs.org/civicrm/event/info?id=2078

To pay by check, mail this form with a check made out to HGS to:
Houston Geological Society, 14811 St. Mary's Lane, Ste. 250, Houston, TX 77079

To pay by credit card, please call the HGS office: (713) 463-9476.

Name: _____ Company: _____

Email: _____ Phone: _____

CC#: _____ Exp:_____ CVC: _____

Ammo: (circle one) 12 gauge 20 gauge

Entry Fees: $ _____ + Guest Fees: $_____ + Sponsor Contribution: $ _____ = Total: $_____

If you wish to register as a squad, please return forms for all squad members together.

ALL SHOOTERS WILL BE REQUIRED TO SIGN A WAIVER OF RESPONSIBILTY BEFORE THEY WILL BE ALLOWED TO SHOOT!

Team Member Name	Email Address	Phone	Ammo Guage
1._____	_____	_____	_____
2._____	_____	_____	_____
3._____	_____	_____	_____
4._____	_____	_____	_____

First Annual HGS Sporting Clays SHOOT

HGS 100 YEAR ANNIVERSARY

Saturday, December 9, 2023
Westside Sporting Grounds
10120 Pattison Rd., Katy, TX 77493

Name: _____ Company: _____

Email: _____ Phone: _____

Sponsorship Level: _____ Amount: _____

Credit card # _____ Exp. Date: _____

Corporate Sponsor - $2,500

This will include one 4-man shooting team with carts and ammo. Your company logo will be recognized as a Corporate sponsor and be displayed on the website, printed banner, sponsor board and promotional items.

Hat Sponsor - $1,500

This will include one 4-man shooting team with carts and ammo. Your company logo will be recognized as the Hat sponsor and be displayed on the hat, website, printed banner, sponsor board.

Lunch Sponsor - $1,500

This will include one 4-man shooting team with ammo. Your company logo will be recognized as a Lunch sponsor and be displayed on the website, printed banner.

First Annual HGS Sporting Clays SHOOT
HGS 100 YEAR ANNIVERSARY

Beverage Sponsor - $750

This will include two team member registration with ammo. Pay for two more team registrations and get the cart with your package. Your company logo will be recognized as a beverage sponsor and will be displayed on the website, printed banner.

Breakfast Sponsor - $750

This will include two team member registrations with ammo. Pay for two more team registrations and get the cart with your package. Your company logo will be recognized as a breakfast sponsor and will be displayed on the website, printed banner.

Station Sponsor - $500

Company Logo will be displayed at assigned station, website and printed banner. You will be allowed to set up a tent at your sponsored station(s). You can either cook or provide snacks and non-alcoholic drinks to the participants.

Door Prize / Raffle Sponsor - $500

Company Logo will be displayed on website and printed banner.

Individual Sponsor - $250

Company Logo will be displayed on website and printed banner.

To pay by credit card, please complete the form and return to office@hgs.org or call 713-463-9476
To pay by check, mail this form with a check made out to HGS to:
Houston Geological Society, 14811 St. Mary's Lane, Ste. 250, Houston, TX 77079

HGS Membership Application

Houston Geological Society
14811 St Mary's Lane Suite 250 Houston
TX 77079
Phone: (713) 463-9476
Email: office@hgs.org

Active Membership

In order to qualify for Active Membership you must have a degree in geology or an allied geoscience from an accredited college or university or, have a degree in science or engineering from an accredited college or university and have been engaged in the professional study or practice of earth science for at least 5 years. Active Members shall be entitled to vote, stand for election, and serve as an officer in the Society. Active Members pay $36.00 in dues.

Associate Membership

Associate Members do not have a degree in geology or allied geoscience, but are engaged in the application of the earth sciences. Associate Members are not entitled to vote, stand for elections or serve as an officer in the Society. Associate Members pay $36.00 in dues.

Student Membership

Student membership is for full-time students enrolled in geology or an allied geoscience. Student Members are not entitled to vote, stand for elections or serve as an officer in the Society. Student Member dues are currently waived (free) but applications must be filled out to its entirety. Student applicants must provide University Dean or Advisor Name to be approved for membership.

Membership Benefits

Digital HGS Bulletin

The HGS Bulletin is a high-quality journal digitally published monthly by the HGS (with the exception of July and August). The journal provides feature articles, meeting abstracts, and information about upcoming and past events. As a member of the HGS, you'll receive a digital copy of the journal on the HGS website. Membership also comes with access to the online archives,with records dating back to 1958.

Discount prices for meetings and short courses

Throughout the year, the various committees of the HGS organize lunch/dinner meetings centered around technical topics of interest to the diverse membership of the organization. An average of 6 meetings a month is common for the HGS (with the exception of July and August). Short courses on a variety of topics are also planned throughout the year by the Continuing Education Committee. These meetings and courses are fantastic opportunities to keep up with technology, network, and expand your education beyond your own specialty. Prices for these events fluctuate depending on the venue and type of event; however, with membership in the HGS you ensure you will always have the opportunity to get the lowest registration fee available.

Networking

The HGS is a dynamic organization, with a membership diverse in experience, education, and career specialties. As the largest local geological society, the HGS offers unprecedented opportunities to network and grow within the Gulf Coast geological community.

Please fill out this application in its entirety to expedite the approval process to become an Active/Associate member of Houston Geological Society.

Full Name _____ Type *(Choose one)*: Active Associate Student

Current Email *(for digital Bulletin & email newsletter)*_____

Phone _____

Preferred Address for HGS mail_____

This is my home address _____ business address _____

Employer *(required)*_____ Job Title *(required)*_____ Will you volunteer? ____ (Y/N) Committee choice: _____

Annual dues Active & Assoc. for the one year *(July 1st-June 30th)* **$36.00**_____

Student **$0.00**_____

OPTIONAL Scholarship Contributions- Calvert/HGS Foundation-Undergraduate **$5.00**_____

Total remittance_____

Payment:

Check #_____

Credit card: V MC AE Discover

Credit Card#_____

CVV code (req'd): _____ Expiration: _____ (mm/yy)

Signature: _____ Date: _____

To the Executive Board: I hereby apply for membership in the Houston Geological Society and pledge to abide by its Constitution & Bylaws.

Company*(required, mark 'in transition' if unemployed)*_____

Company Address _____

City *(Work)* _____ **State** *(Work)* _____ **Postal Code** *(Work)* _____

School *(required)*_____

Major *(required)*_____ **Degree** *(required)*_____

Year Graduated _____

School *(optional)*_____

Major *(optional)*_____ **Degree** *(optional)*_____

Year Graduated _____

Years Work Experience *(required)*_____

Please submit a brief statement regarding your work experience in the practice or application of earth science or an allied science.

AAPG Member Number _____ OR

HGS Sponsor's Name _____

Signature: _____ **Date:**_____