AAPG Midcontinent Sectional 2023

“Finding New Oil and Gas, the Old-Fashioned Way”

Oklahoma City, OK

OCGS
OKLAHOMA CITY GEOLOGICAL SOCIETY

MID - CONTINENT SECTION
AAPG
1965

Chairman's Welcome

Wow, it is hard to believe the convention is already here! When we started this 28 months ago, we met with Tom Cronin and Terry Hollrah over lunch and decided to be Co-Chairs, we got their notes and set sail on a great adventure. We did not know each other, nor did we have any idea what we were getting into, but what a great partnership and friendship that materialized! We have met a great number of people and made some new friends. We certainly want to thank Tara Benda, Jamie Woolsey, and Kristi Ferguson for all the of their help and again salute the great job they did in Tulsa!

So here we are 28 months later and on behalf of the Midcontinent Section of the AAPG and the Oklahoma City Geological Society, it is our pleasure to welcome you to the 2023 Midcontinent Section Convention where we are "Finding New Oil and Gas the Old-Fashioned Way"! We hope that you will reconnect with old friends, make some new ones and take home some great ideas.

The heart of any convention revolves around the technical program, and our geological community has really put the time in to create a dynamic program. They have produced a wide variety of oral presentations, special sessions, panel discussions, field trips, and short courses. The technical program offers us an opportunity for the exchange of new ideas, the reconsideration of old ideas, and ways to stimulate our creativity. Per the theme of our convention, we will discuss how to be an independent, look at different plays, how to start a business, exploration ideas, some alternates and new ways to reinvent old concepts in modern terms. We hope to learn from the past with a better understanding of complex reservoirs and petroleum systems – integrating this knowledge base with the latest technologies to focus on making money in the future.

Geoscientists love to connect, share stories, and bounce around ideas. There will be plenty of opportunities to do this starting with the Ice Breaker Sunday night and at the All Alumni Social and DataLog+GeoVision after-party on Monday evening. Be sure to catch our luncheons where you can enjoy a Fire Side Chat with author Alex Epstein on Monday and Continental Founder Harold Hamm on Tuesday. And don't miss out book signings from each of these legends! The Exhibit Hall will be full of companies showing off their latest technology and new ideas. Be sure to stop by to see what all is going on and enjoy our core layouts while you're at it!

We really want to express our deepest appreciation to our Leadership Committee that has worked so hard the past couple of years making the whole convention come together for all of our enjoyment. They have been truly dedicated to making this a wonderful and meaningful experience. Thank you all, it has been a joy and a lot of fun working on this with all of you. Give them a pat on the back!

We also wish to thank all of our sponsors; they have come through in such a generous manner and helped us make this a very special experience. Thank you again to all!

Welcome to Oklahoma City and our new Convention Center. We are excited to have you here for the AAPG 2023 Midcontinent Sectional. Have a great time!

Best Regards,

Molly Turko and Steve Ladner

AAPG MCS 2023 Co-Chairs

Steve Ladner
Ladner Consulting

Molly Turko
Devon Energy

Thank You to our Sponsors

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RILEY PERMIAN

Impac EXPLORATION SERVICES

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Medina Exploration, Inc
Jerry Medina

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Steve Ladner

Mark Lester

Van Alstine Geosciences
James Van Alstine
Geophysical Consultant

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President's Welcome

Dear Attendees,

On behalf of the Oklahoma City Geological Society, I am pleased to welcome you to Oklahoma City and to our new $288 M 500,000 sq. foot Convention Center. The theme for this year's Midcontinent Sectional is "*Finding New Oil and Gas the Old-Fashioned Way*" and by attending, I hope you feel the energy around developing new resources in the middle of one of the world's most mature, oil and gas producing areas. So what is old-fashioned? It certainly isn't the plethora of statistical tools we employ, or the technology that enables drilling 2-plus mile laterals. I think you will find that Oklahoma City's "old-fashioned" is all about the determination, resilience, and especially the ingenuity that got us where we are and makes us who we are today. Indeed, the spirit and ingenuity that led to the first reflection seismograph at Belle Isle OKC in 1921 is still very evident in how we find and deliver new resources using today's technologies.

The program boasts field trips, short courses and social activities to go along with the exhibits, talks, and posters and if you have additional time you may wish to visit the First American's Museum, the Oklahoma History Center, the Oklahoma City National Memorial, or perhaps walk the 89'r Trail to learn more about Oklahoma City's rich, pioneering history.

Please enjoy yourself and thank you very much for attending and supporting our Society. Many additional thanks to our amazing Organizing Committee, and to our generous Volunteers, Sponsors, and Exhibitors.

Thank you!

Sincerely,

Lesley W. Evans

President, Oklahoma City Geological Society

OCGS

OKLAHOMA CITY GEOLOGICAL SOCIETY

Organizing Committee

Major Events

Nic Brissette

Audio/Visual

Garrett Powell
Galvanic Energy

Registration and Hospitality

Breanne Kennedy
Amplitude Consulting and Exploration

Rosie Gilbert
Continental Resources

Marketing & Media

Troy Johnson
Flint Hills Consulting, Inc

Michael Hale
Novo Oil & Gas

Technical Program

John Dodds
Chesapeake Energy

Hannah Morgan
Devon Energy

Sponsorships & Exhibitors

Steve Ladner
Ladner Consulting

Cat Campbell
Camino Resources

Joe Stone
Riley Permian

Judging

Steve Yeakley
Sand Sage Exploration LLC

Short Courses

Raleigh Blumstein
Mack Energy

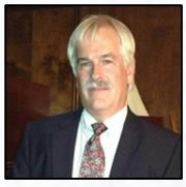
Chris Wiggers
Commissioners of the Land Office

Field Trips

Brian Bayliss
Devon Energy

Sloan Anderson
Devon Energy

Technical Leaders



Joel Alberts
Chalk Creek Production Co.

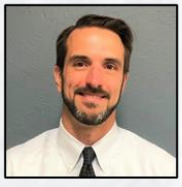
John Brett
Brett Exploration

Finance

Jason Currie
Point Bar Energy

Dick Howell
Columbine Corp.

Spouse & Guest Activities



Walt Kennedy
Red Bluff Resources

Kate Kennedy
Devon Energy

Poster Presentations

Shannon Dulin
University of Oklahoma

Tiffany Stephens
Duncan Oil Properties

Meeting Schedule

Friday October 6th

10:00am-5:00pm Historical Field Trip through the OKC Giant Oil Field: 100 years of Exploration & Development
5:30pm OKC Geological Society's Annual Shrimp Boil at the Oklahoma History Center

Saturday October 7th

7:30am-5:30pm Field Trip to the Arbuckle Mountains: A Basinward Transect of the Woodford Shale from the Lawrence Uplift to the Marietta Basin and Beyond
8:00am-4:00pm Short Courses

Sunday October 8th

10:00am-2:00pm OSU Sponsored Core Workshop: Revisiting and Re-assessing the Middle to Upper Mississippian in a Core Transect across the Anadarko Shelf
8:00am-4:00pm Short Courses
4:30pm-7:30pm Convention Kickoff with an Awards Ceremony (Room 302A-D) & Ice Breaker (Ballroom AB/Exhibition Hall)

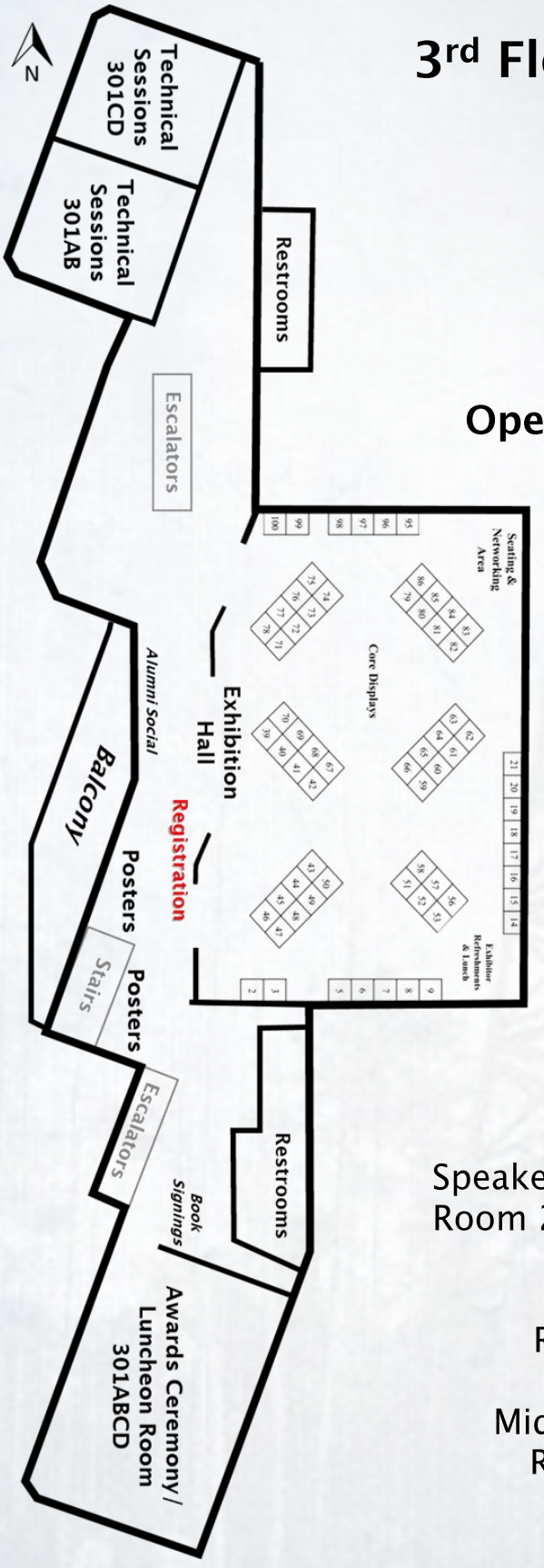
Monday October 9th

7:00am-8:00am Speakers/Volunteers (Breakfast Room 205AB)
8:00am-5:00pm Technical Presentations (Rooms 301AB & 301CD)
8:00am-5:00pm Posters (Lobby)
10:00am-11:30am Alex Epstein Book Signing (Outside Room 302A-D)
11:30am-1:00pm Luncheon with Keynote Alex Epstein (Room 302A-D)
4:00pm-5:00pm All Alumni Social (Lobby/Balcony Area)
5:00pm-7:00pm After-Party Sponsored by DataLog+GeoVision at the Historical Union Station in Scissortail Park (see Map)
8:00am-5:00pm Exhibition Hall Open (Ballroom AB)

Tuesday October 10th

7:00am-8:00am Speakers/Volunteers Breakfast (Breakfast Room 205AB)
8:00am-5:00pm Technical Presentations (Rooms 301AB & 301CD)
8:00am-5:00pm Posters (Lobby)
11:30am-1:00pm Luncheon with Keynote Harold Hamm (Room 302A-D)
1:00pm-2:00pm Harold Hamm Book Signing (Outside Room 302A-D)
8:00am-3:00pm Exhibition Hall Open (Ballroom AB)

Map



3rd Floor of the Convention Center

Technical Sessions
Rooms 301AB & 301CD

Poster Sessions
Lobby, across from Registration

Opening Session & Awards Ceremony
Room 301A–D

Monday Luncheon
Room 301A–D

Tuesday Luncheon
Room 301A–D

Book Signings
Outside Room 301A–D

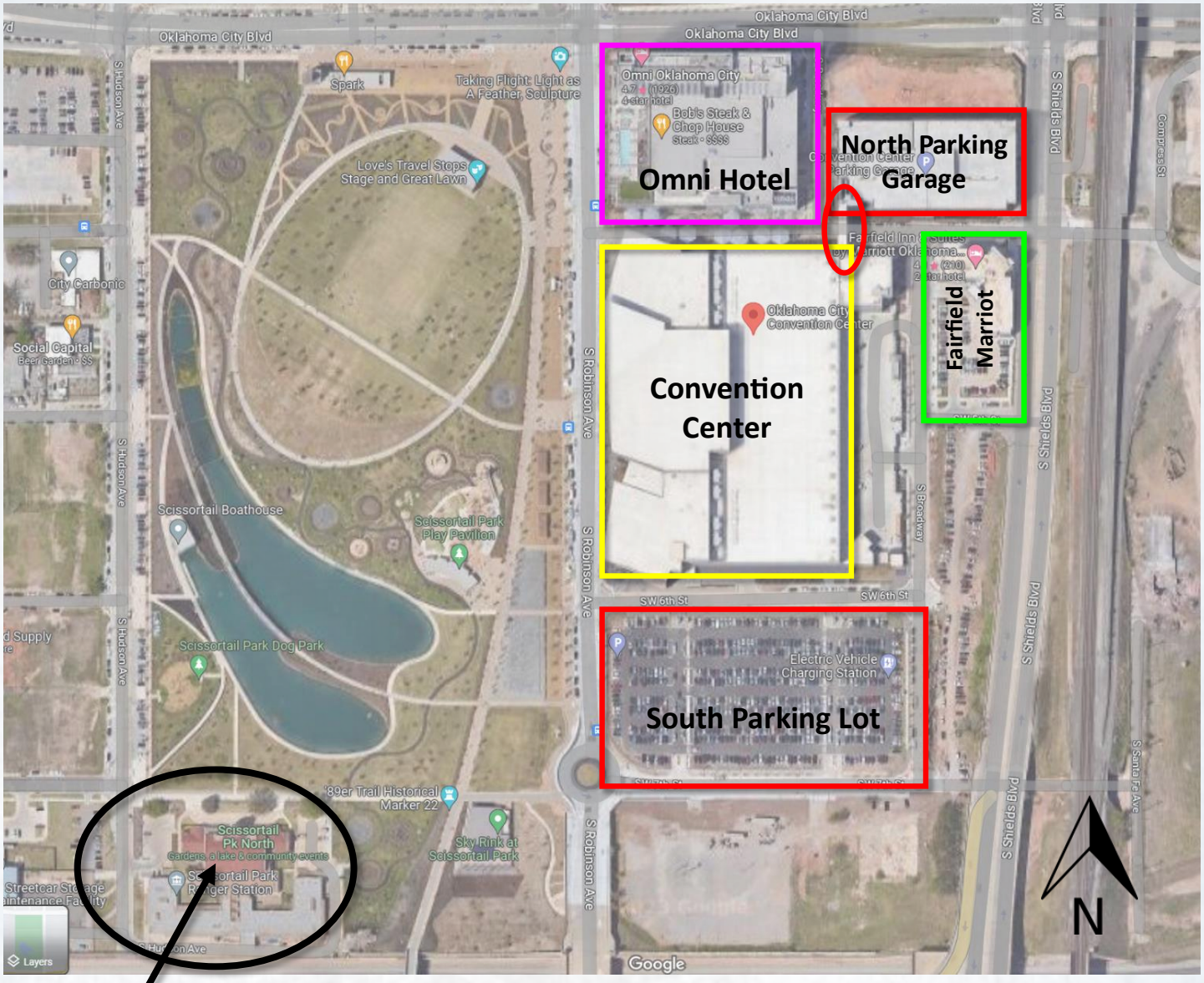
All Alumni Social
Lobby/Balcony Area

Events on the 2nd Floor
Speakers/Judges/Volunteers Breakfast 2nd Floor
Room 205AB, Monday & Tuesday, 7:00–8:00am

Judges Meeting 2nd Floor
Room 206A, Monday, 7:00–8:00am

Midcontinent Business Meeting 2nd Floor
Room 206A, Tuesday, 7:00–8:00am

Map



Historical Union Station Monday Evening After-Party from 5-7 sponsored by

DataLog + GeoVision

North Parking Garage
South Parking Lot

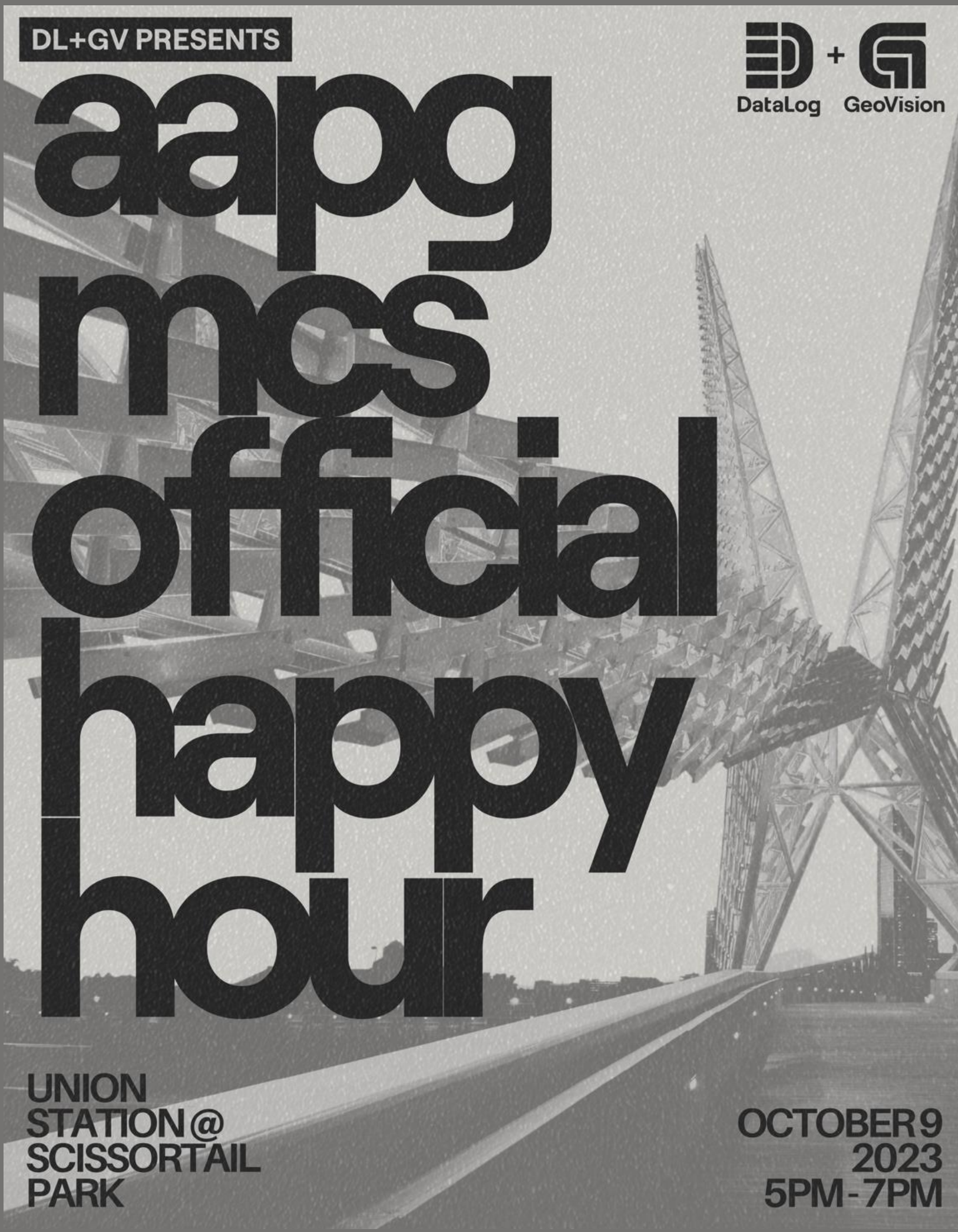
Convention Center

Omni Hotel

Fairfield/Marriot

Parking is estimated to be $10/daily or $2/hourly

Sky Bridge to the Convention Center


DL+GV PRESENTS
DataLog + GeoVision
aapg mcs official happy hour
UNION STATION @ SCISSORTAIL PARK
OCTOBER 9 2023
5PM - 7PM

Sunday Opening Session 4:30pm-5:30pm

Opening Remarks from Co-Chairs Steve Ladner & Molly Turko

Welcome Note from OCGS President Lesley Evans

Awards Ceremony-Jamie Woolsey, MCS President & Nathan Randolph, MCS VP

Movie Trailer: Miracle In East Texas

Video Vignette

Ice Breaker 5:30pm-7:30pm

Awards

A. I. Levorsen Memorial Award

The A. I. Levorsen Memorial Award is given in recognition for the “Best Technical Paper” at the AAPG Section meetings with particular emphasis on creative thinking toward new ideas in petroleum exploration.

The A. I. Levorsen Award for Best Paper goes to **Dr. Molly Turko**, for her paper on "The Birth and Tectonic Evolution of the Anadarko Super Basin".

Roger N. Planalp Memorial Award

The Roger N. Planalp Memorial Award is given in recognition for the “Best Poster” presentation at the AAPG Section meetings. The award is in honor of Roger N. Planalp, who passed away in 1986 while serving as the President of the Mid-Continent Section.

The Roger N. Planalp award for Best Poster goes to **Dr. Jim Puckette, Brandon Stukey**, and **Dr. Cory Godwin**, for their poster on "Conodont Constrained ages of Mississippian Carbonate-Siliciclastic Sequences, STACK Play, Oklahoma".

Certificate of Meritorious Service Award

The Mid-Continent Section Certificate of Meritorious Service Award is given to those individuals who have contributed their time, dedication, and volunteer services to the AAPG Mid-Continent Section.

Come to the Awards Ceremony to find out the Recipients

Awards Ceremony

Robey H. Clark Distinguished Service Award

The Robey H. Clark Memorial is the Mid-Continent's highest award. This award is given in recognition to those individuals who are unsurpassed in their dedication to the geological community, the petroleum industry, and are of the highest personal and professional integrity.

This year's Robey H. Clark Award winners are:

Come to the Awards Ceremony to find out the Recipients

It might just be a surprise!

Keynote Luncheons

Monday Luncheon

Featuring a Fireside Chat with

Alex Epstein

Best-selling Author and Champion for the Oil & Gas Industry

Moderators: Troy Johnson & Michael Hale

Alex Epstein is a philosopher and energy expert who argues that "human flourishing" should be the guiding principle of energy and environmental progress. He is the author of the new bestselling book *Fossil Future: Why Global Human Flourishing Requires More Oil, Coal, and Natural Gas—Not Less.* He is also the creator of EnergyTalkingPoints.com—a source of powerful, well-referenced talking points on energy, environmental, and climate issues. Widely recognized as a master of persuasion and debate on energy issues, Alex has spoken at dozens of Fortune 500 companies and dozens of prominent universities. He is also a highly sought-after consultant on messaging, working with dozens of major political offices on pro-energy, pro-freedom messaging.

Preceded by a Book Signing 10:00am-11:30am

Books will be for sale courtesy of Full Circle Bookstore

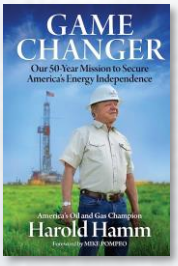
Tuesday Luncheon

Featuring a Fireside Chat with

Harold Hamm

Founder and Executive Chairman of Continental Resources

Moderator: Mark Oekerman



Harold Hamm established Continental Resources in 1967 at the age of 21. He built a grassroots startup into a Top 10 oil producer in the U.S. Lower 48. As a voice for America's oil and natural gas industry and as the leader of one of America's top E&P companies, he has helped to make America energy independent. Mr. Hamm also co-founded and serves as Chairman of the Domestic Energy Producers Alliance, which aims to preserve the millions of jobs and billions of dollars in economic activity and tax revenues generated by onshore drilling and production activities within the United States. Through his work with DEPA, Mr. Hamm is widely recognized as the man who led the charge to lift America's 40-year-old ban on U.S. crude oil exports.

Continental RESOURCES

Followed by a Book Signing 1:00pm-2:00pm

Books will be for sale courtesy of Full Circle Bookstore

All Alumni Social

When: Monday 4:00pm–5:00pm

Where: 3rd Floor Lobby/Balcony Area

Cash Bar or Drink tickets *may be* available at your alumni table

MEWBOURNE COLLEGE OF EARTH AND ENERGY
SCHOOL OF GEOSCIENCES
The UNIVERSITY of OKLAHOMA

BOONE PICKENS
SCHOOL OF GEOLOGY
College of Arts and Sciences

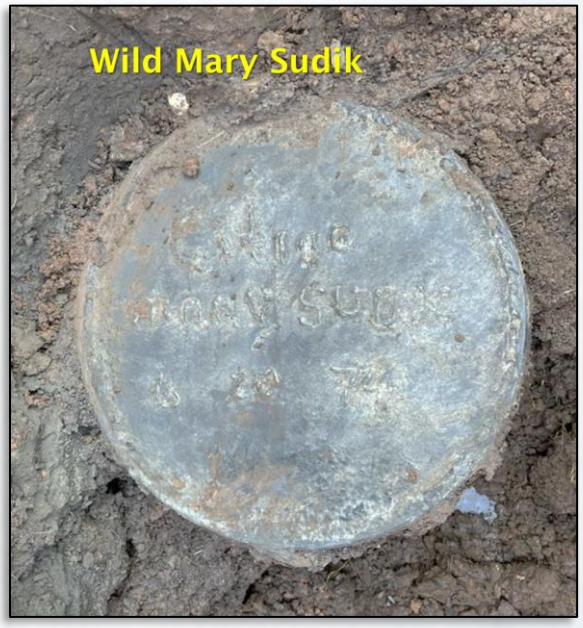
THE UNIVERSITY of TULSA
Department of Geosciences

WICHITA STATE UNIVERSITY

A Field Trip through the Oklahoma City Giant: 100 years of Exploration & Development

Field Trip Leaders: Jim Tull, Stephens & Johnson Operating Co. and Jordan Williams, Gulf Exploration LLC

Beneath downtown Oklahoma City lies one of the world's giant oilfields, discovered in 1928 and still active today with cumulative production in excess of 820 MMBO. This field trip will visit significant sites around the city to learn about the history, geology, and innovations in the Oklahoma City field that shaped the industry. This is a rare opportunity to learn about the field from geologists who are still drilling wells within it today, 100 years after the initial mapping of a surface anticline in Oklahoma City. Stops will span sites in southeast Oklahoma City such as the location of the Wild Mary Sudik, the grounds of the State Capital, and to the northern extent of Wilcox production near Quail Springs Mall. Many notable discoveries will be discussed, as well as a few dry holes. A type section of drill cuttings through the subsurface formations will also be examined. The trip will start and end at the Oklahoma History Center in time for participants to attend the OCGS Shrimp Boil at the same location.



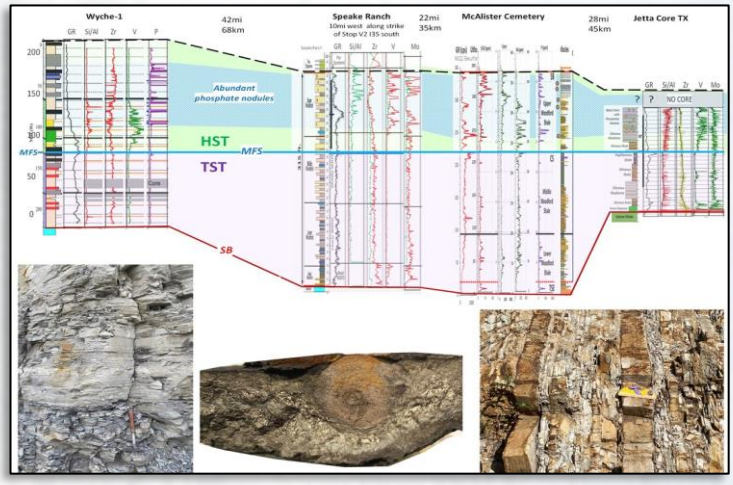
Friday October 6th
Time 10:00-5:00
Cost $75 (Students $25)

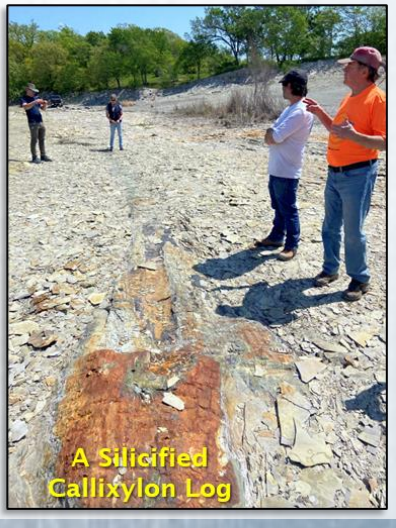
A Basinward Transect of the Woodford Shale from the Lawrence Uplift to the Marietta Basin and Beyond

Field Trip Leaders: David Hull & Andrew Cullen

Time 7:30-5:30, Cost $150 (Students $45)

This fieldtrip focuses on the Woodford Shale in south-central Oklahoma. We will make 5 to 6 stops selected from an extensive set of outcrops described in an accompanying guidebook that synthesizes decades of studies overseen by Brian Cardott, Paul Philp, Jim Puckette, and Roger Slatt. The stops represent a 100mi/162km progressive basinward transect from the Lawrence Uplift through the Arbuckle Mountains to the Criner Hills uplift in the Ardmore Basin. The lithostratigraphy observed in these outcrops will be placed within a well-defined regional sequence stratigraphic framework and key aspects of source rock richness and geomechanics will be discussed. The overarching theme of this trip is placing the Woodford petroleum system into the much larger framework of Late Devonian to Early Mississippian paleogeography and basin geometry as pertaining to controls on organic carbon and phosphate/REE sequestration. We will also examine outcrops across two major mass extinction boundaries (Frasnian-Famennian and Devonian-Carboniferous) and discuss the potential drivers behind those events.





Core Workshop

Revisiting and Re-assessing the Middle to Upper Mississippian in a Core Transect across the Anadarko Shelf

Instructors: Dr. Buddy Price, Devon Energy; Dr. Jim Puckette, OSU, & Dr. Michael Grammar, OSU

Date/Time: Sunday October 8th, 10:00 am - 2:00 pm

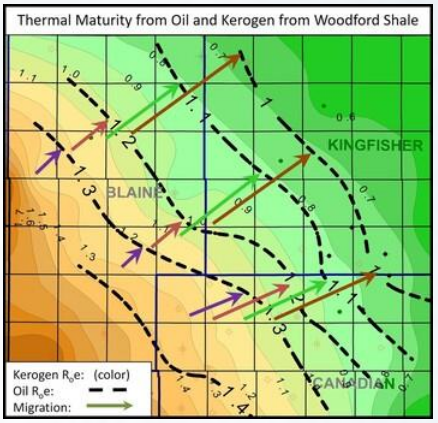
Cost: $45 (Students $15)

Course Description:

The Mississippian section in Oklahoma continues to be a hot topic for both oil and gas production and research on carbonate and mixed siliciclastic-carbonate depositional systems. This core workshop will focus on middle to upper Mississippian strata along a transect of public and proprietary cores across the Anadarko Shelf covering some of the primary horizontal drilling targets of the Meramec reservoirs in and around the STACK Play. Recent biostratigraphic interpretations from core and outcrop samples provide new insight for broad regional correlations as well as linkages between the presented wells. Within this framework, the walkthrough will highlight varying play concepts and controls on variations in porosity development at multiple timeframes in the Mississippian. The workshop will also focus on correlations and updates to the depositional interpretations for Meramec reservoirs in the STACK region in Kingfisher, Blaine, and Canadian Counties as well as correlations to downdip intervals in the Sycamore Limestone and Caney Shale in the SCOOP region.

Short Courses

Geochemistry as the Most Useful Tools for Evaluating and Developing Conventional and Unconventional Plays



Instructor: Dr. Wahid Rahman, Director of Geoscience and Laboratories, Impac Exploration, Inc., Houston, Texas

Date/Time: Sunday October 8th, 8:00 am-4:00 pm

Cost: $145 (Students $45)

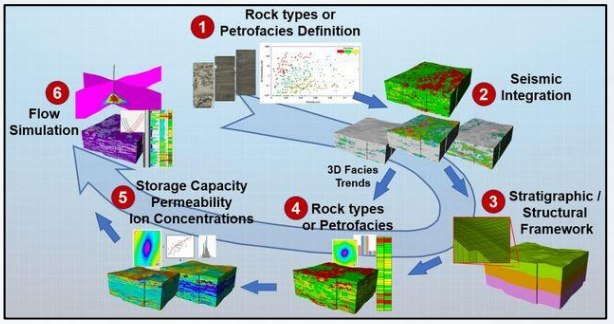
Course Description:

- The Geochemistry course will provide introduction and evolution of conventional and unconventional petroleum systems. The intent is to cover most of the geochemical methods: total organic carbon (TOC), organic facies (kerogen/maceral types), vitrinite reflectance/thermal maturity (Ro) and its equivalent (VRoE) from bitumen, pyrolysis data (Hydrogen index, Tmax,) and produced oil and gas.
- Geochemistry to understand level of organic maturation (LOM), prediction of hydrocarbon phase, API gravity, gas-to-oil ratio (GOR), condensate-to-gas ratio (CGR), production allocation (rock extracts-produced fluids) to identifying drainage volume (DRV).
- Geochemistry data to analyze and understand petroleum systems from molecular scale to basin scale through basin modeling.
- The course will also cover oil to oil, oil-gas, gas-gas, and oil to source rock correlations from source rock (e.g., TOC, SRA, Rock-Eval, Hawk pyrolysis) data to produced hydrocarbon (oil and gas) geochemistry data (GC, GCMS, GC-IRMS).
- There will be examples from different US onshore unconventional resource plays (e.g., Anadarko Basin) and conventional plays from published data.
- Course attendees will be able to learn the fundamentals and application of geochemistry to exploration, development, and production of oil and gas for both conventional and unconventional plays.

Instructor Bio: Dr. Wahid Rahman is currently working as the Director of Geoscience at Impac Exploration Services, Houston Texas. Dr. Rahman has previously worked as Sr Staff Scientist/Program Coordinator at TCEQ, Austin, Texas; as Director at Geoscience at GPR, Inc, Houston, Texas; as Chief Geochemist at Paladin Geological Services, Edmond, OK; as Geological Adviser at Ossidiana Energy, Denver, CO; as Geochemist-Petroleum Systems Analyst at Pioneer Natural Resources, and Devon Energy Corporation. Wahid has 20+ years of industry, academic, and research experience as Geochemist and he worked on most of the North American unconventional and conventional basins and many international basins. He has over 50 conference presentations, and peer reviewed journals (with more than 775 citations) in the field of geochemistry, environmental geochemistry, and geology. He received his Ph.D. in Organic Geochemistry from Southern Illinois University, Carbondale, IL; M.S. in Geology from Auburn University, Auburn, AL; M.S. and B.S. in Geology from University of Dhaka, Dhaka, Bangladesh.

Short Courses

From Rocks to Models: Geological Reservoir Characterization and Modeling



Instructor: Dr. Matthew J. Pranter, University of Oklahoma

Date/Time: Saturday October 7th, 8:00 am-4:00 pm

Cost: $145 (Students $45)

Course Description:

An introduction to the concepts and methods of geological reservoir characterization and 3-D reservoir modeling. Data integration to evaluate, map, model, and interpret subsurface geological characteristics and formation property heterogeneity. Methods can be applied to subsurface reservoirs and aquifers related to energy (oil, gas, geothermal, hydrogen), water, and CO 2 storage.

- Introduction to subsurface data analysis, modeling, and interpretation
- Sedimentology, stratigraphy, subsurface properties, flow units
- Subsurface data and their uses (e.g., core, well logs, 3D seismic, outcrops)
- Log-based rock types, well- and seismic-based correlations, basic geostatistics, and subsurface mapping
- Subsurface modeling concepts and methods: Stratigraphic and structural framework (3-D grid), well-log upscaling
- Facies modeling (sequential-indicator simulation, object-based, multiple-point)
- Petrophysical modeling (e.g., sequential-Gaussian simulation with co-located co-kriging, cloud transform)
- Static connectivity; rock, pore, and fluid volumes
- Case studies

Instructor Bio: Matthew J. Pranter is the Victor E. Monnett Endowed Chair in Energy Resources and Professor of Geosciences at the University of Oklahoma. He is also an affiliate faculty in the Mewbourne School of Petroleum and Geological Engineering. He was previously a geology professor at the University of Colorado Boulder and a senior research geologist with ExxonMobil Upstream Research Company and Conoco. He received a B.S. in geology from Oklahoma State University, B.S. in geological engineering from Colorado School of Mines, M.S. in geology from Baylor University, and Ph.D. in geology from the Colorado School of Mines. His research interests include petroleum geosciences, energy resources, reservoir characterization and modeling, and sedimentary geology. He has been an active member of AAPG since 1986, is a member of the AAPG Executive Committee, and serves as AAPG Editor.

Carbonate Play Development in Paleozoic Sequences of the Midcontinent Region: Influence of Physiographic Setting and Structural Controls

Instructor: Dr. Jeff Dravis, Dravis Geological Services, Houston, Texas

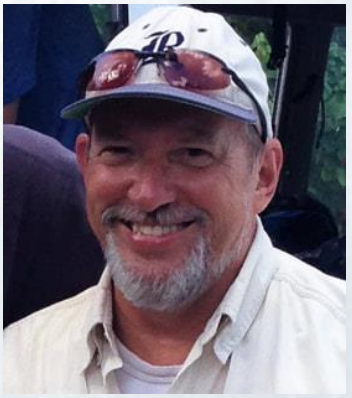
Date/Time: Saturday-Sunday October 7th-8th, 8:00 am-4:00 pm

Cost: $290 (Students $90)

Course Description:

Understanding the key controls on the distribution and geometry of carbonate plays is critical to enhanced exploration/exploitation in any basin. Further, delineating potential carbonate plays from seismic or wireline logs requires a very sound understanding of the depositional and diagenetic controls that create the reservoir facies, which must be considered within the context of geological age and physiographic setting. One should appreciate the environmental controls on carbonate facies development, and the potential pathways for diagenesis and porosity evolution. This short course reviews the key controls on carbonate facies occurrence and distribution, and demonstrates the strong influence of physiographic setting, both at the global and local scale. Because most Paleozoic carbonate reservoirs were developed within tropical or subtropical settings, paleotrade winds often influenced their occurrence and distribution. In addition, favorable limestone diagenesis or dolomitization controlled porosity and permeability evolution in these plays. Discerning the relative timing of secondary porosity development in these carbonates is key to exploiting regional porosity trends. This short course first discusses key aspects of carbonate diagenesis and porosity evolution for limestones and dolostones. It reviews existing depositional paradigms for carbonate platforms and ramps and introduces the newer paleotrade wind models and applications. This seminar culminates with a discussion of conventional and unconventional carbonate play types (occurrence, geometry and distribution) related both to geological age and local physiographic setting (platform versus ramp bottom topography). This discussion will be applied to specific Paleozoic play type examples from the Midcontinent area. In doing so, the role that deep-seated faulting often plays in carbonate diagenesis and development of reservoir quality, as well as hydrocarbon entrapment, will become apparent. The key take-aways from this seminar apply to other Paleozoic sequences elsewhere in the U.S., Canada and other basins worldwide. If you are working Mesozoic and younger carbonate successions, the guidelines from this seminar apply to them, as well.

Instructor Bio: Jeff Dravis is a consulting carbonate geologist primarily focused on helping discover oil and gas deposits, or enhancing their development once they are discovered. He also conducts numerous applied carbonate training seminars for industry every year. To date, Jeff has completed 199 technical projects worldwide, working on carbonate sequences ranging in age from Cambrian to upper Tertiary. He has presented 327 in-house and field seminars to industry, both on a public and private basis. This includes 73 industry and academic seminars on Caicos Platform in the southeastern Bahamas, as well as numerous ancient carbonate field seminars in west Texas and New Mexico. Jeff is an Adjunct Professor of Geology at Rice University and also teaches the carbonate geology segment of the University of Houston's Professional Master's Program in Petroleum Geology.



Prospecting and Being an Independent

Instructor: Lance Ruffel, Lance Ruffel Oil & Gas, LLC

Date/Time: Sunday October 8th, 9:00 am-3:00 pm

Cost: $145 (Students $45)

Course Description:

Have you ever wondered how geologists found oil and gas in the last fifty years, or started their own independent career? This course will try to answer this question. Successful methods and techniques will be shown. Take this course and find out how you, too, can prospect and be an independent.

- Introduction: "What does it mean to be an independent?"
- Goals: Discussion concerning areas of advancement such as consulting, establishing a company, government work, oil and gas, as well as other non-hydrocarbons potential.
- Developing prospects and projects: Specific examples and methods of using data. Researching and how to use the data available. Real examples of using old methods, solving problems with information, and finding solutions. This course will go into details of finding and using old data.
- I have an idea, now what?: This section will explain ways to make deals, promotes and how to sell a project.
- Handling disappointment: There will be dry holes and tough times. What can be done?
- Locating the resources: The most basic part of any project is locating resources. Examples will be shown and discussed, including the value of some overlooked resources and the problem with trusting some of the data that can be found online.
- Putting the deal together: Explaining how a landman can help and what does a landman do?

Equipment, buy right and know who you are buying from: Discussion on important but often overlooked parts of operating a well.

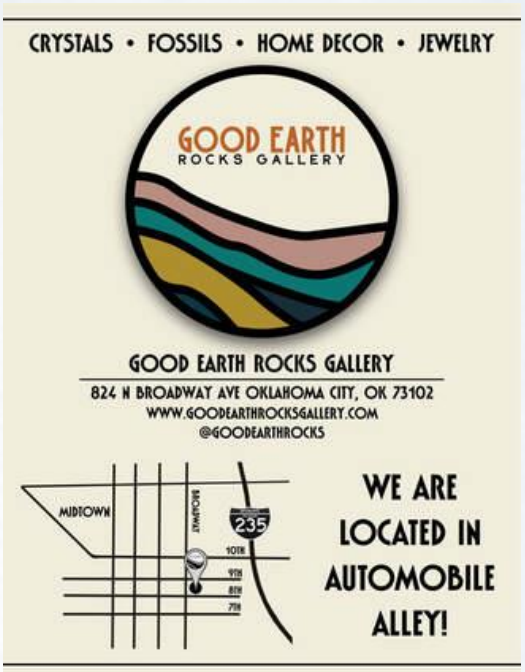
This course is for anyone who is considering being a consultant, independent prospector or is considering starting a company.

Instructor Bio: Lance Ruffel is a geologist and President at Lance Ruffel Oil & Gas, LLC in Oklahoma City. He started his business in 1983 and was previously with John A. Taylor Exploration as a geologist. Prior to that he completed his graduate work from the University of Oklahoma.

Spouse/Guest Activities

Monday, October 9th

Good Earth Rocks Gallery Open House
10:00am–1:00pm
Free of charge



Oklahoma River Boat Sunset Cruise
6:00pm – 7:30pm
Includes dinner on the water w/ cash bar
$65/person
Limited to 28 people **Cancelled**
Sign up Deadline is 9/18

Tuesday October 10th

Lunch at Vast
11:30am–12:30pm
$30.00
Sign up deadline is 10/6

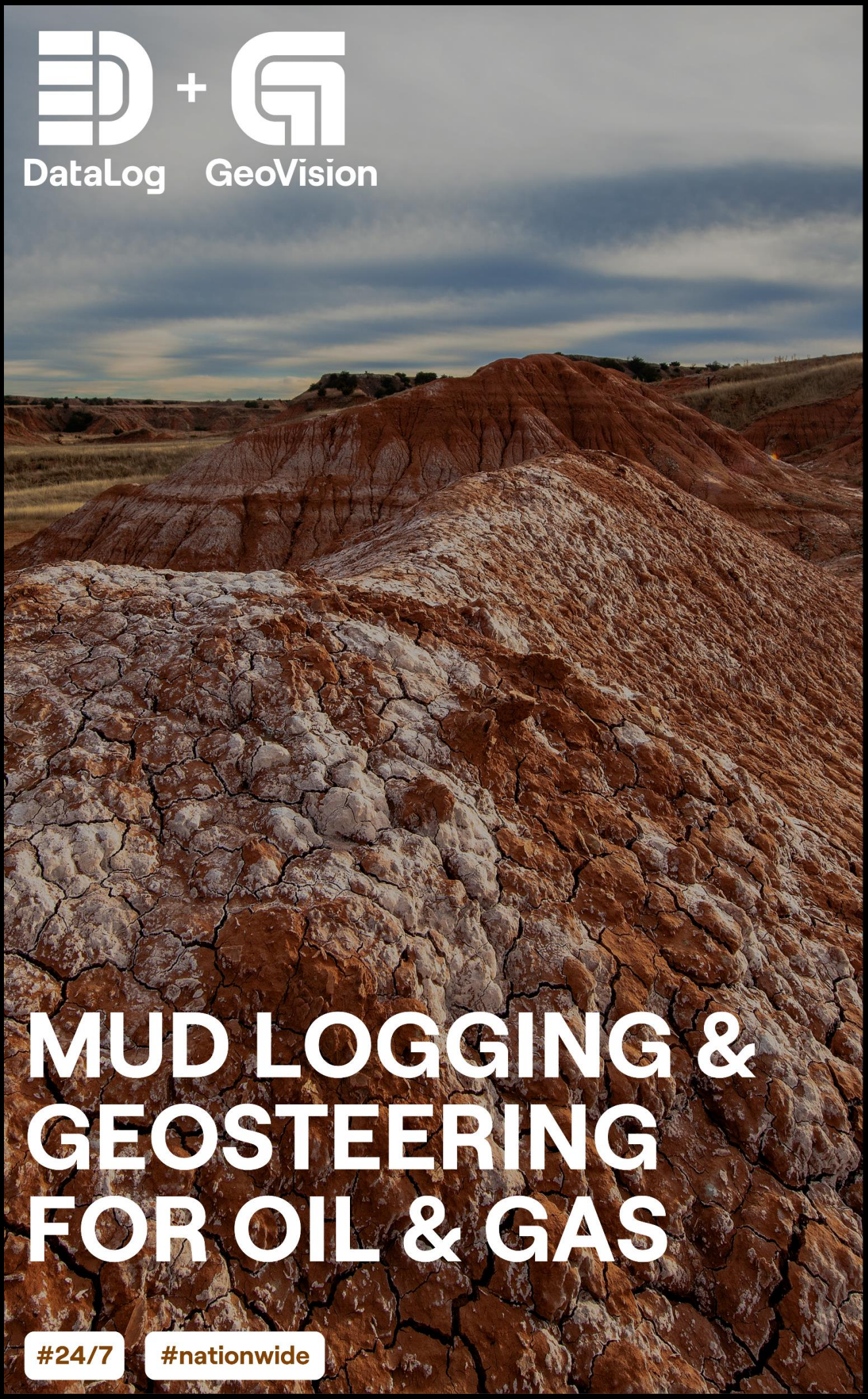
Additional Activities to Check Out

Myriad Gardens
OKC Museum of Art
OKC National Memorial & Museum
Bricktown

okcstreetcar.com

Each of these are within walking distance from the OKC Convention Center and the Omni Hotel or catch a Streetcar!

DataLog + GeoVision



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ADVANCED HYDROCARBON STRATIGRAPHY (AHS)

Untapped Value from Well Cuttings

for Pay identification and Reservoir characterization

RVStrat^{sm}- Rock Volatiles Stratigraphy

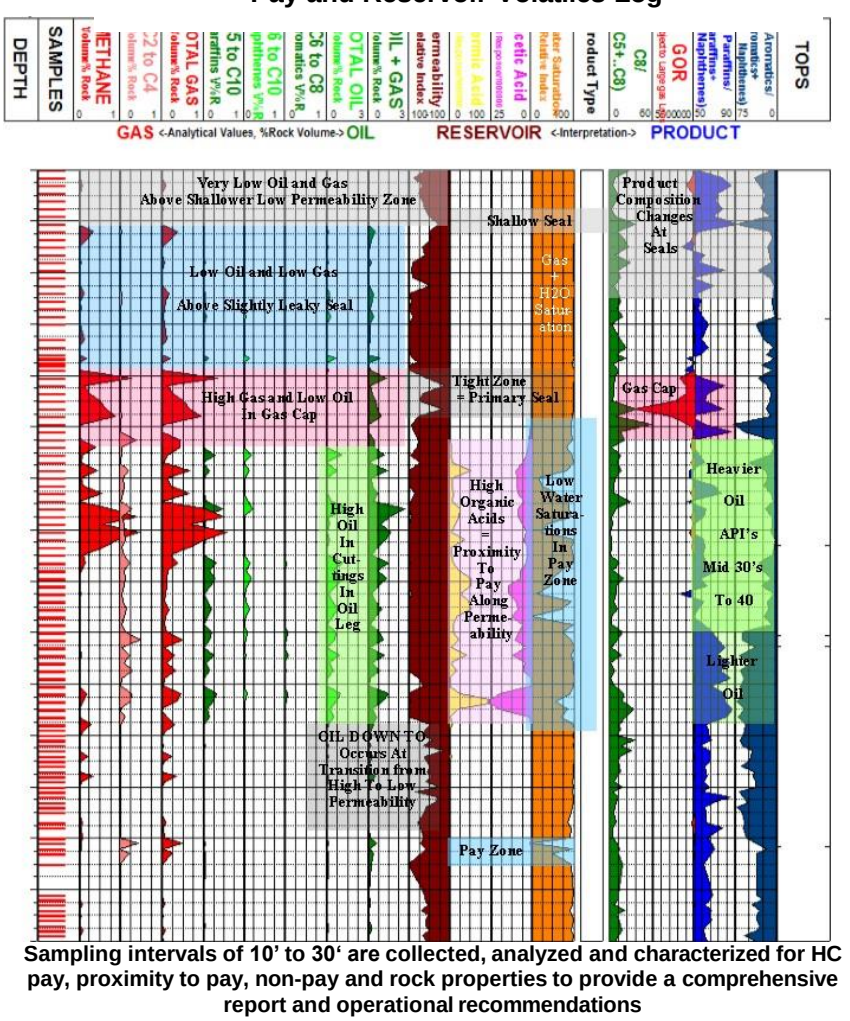
AHS technology provides **advanced volatiles well logs and innovative interpretation** from mass spectrometer analysis of **well cuttings, drilling muds and core samples**. Unconventional (pilots and laterals) and vertical conventional wells (old and new) can be analyzed; samples from oil based muds and PDC drilling bits can be analyzed and interpreted.

AHS has developed an independent predictive analysis and interpretation for:

- **Pay identification & HC characterization (C_1-C_{10}):**
  - Pay zones, proximity to Pay
  - Water contacts, fresh H_2O
  - HC migration history
  - Estimated ultimate recovery (EUR)
  - API predictions (oil vs gas)
- **Rock properties prediction:**
  - Properties logging:
    - Perm (k) trends
    - Wettability
    - Mechanical strength
  - Reservoir compartmentalization:
    - Fault identification
    - Fracture recognition
    - Seal(s) detection
- **Report development & consultation:**
  - Volatile well logs:
    - HC's and rock properties interpretation
  - Operational recommendations within Ops time constraints:
    - Pay and missed pay identification
    - Landing zones identification
    - Proximity to pay indicators
    - **Completion recommendations:**

      Subsurface stage by stage performance
  - Mapping: HC and rock properties

Pay and Reservoir Volatiles Log



Sampling intervals of 10' to 30' are collected, analyzed and characterized for HC pay, proximity to pay, non-pay and rock properties to provide a comprehensive report and operational recommendations

Advance **H**ydrocarbon **S**tratigraphy's low cost innovative patented technology is being utilized for production and exploration wells, conventional, unconventional and hybrid reservoirs in US domestic and international basins – and used in applications for geothermal, CCS site evaluation, and helium exploration.

Contact **AHS** for your **hydrocarbon characterization, rock property** predictions and expert **consultation**.

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Tulsa, OK 74107 USA
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at AAPG MidCon in OKC

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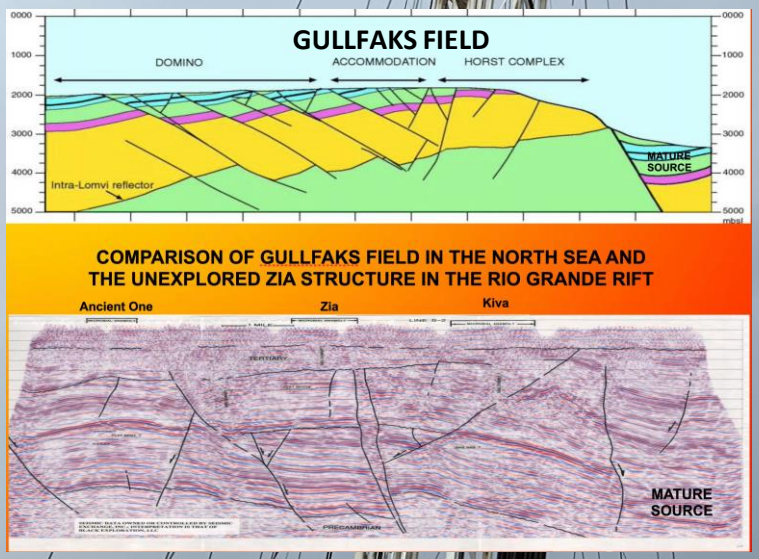
ASSAPH GUTOWSKY
KING OF THE WILDCATTERS
The true story of Assaph "Ace" Gutowsky, a Ukranian immigrant decended from royalty, and his journey to discover one of the greatest oil finds in Oklahoma history. After 28 failed attempts and against all odds, along with the rejections of 10 major oil companies, Gutowsky's unwavering persistence yielded one of the largest oil discovereies of the day, which contributed to the Allied Victory of WWII...
The West Edmond Oil Field!
Come visit our booth to learn more.

BLACK EXPLORATION LLC

Behold the Turtle…

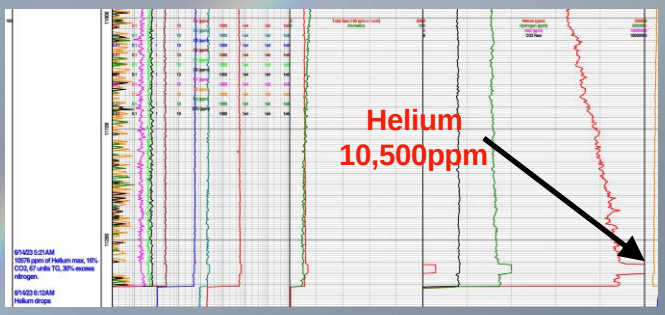
Bruce A Black, PhD
(505) 486-3808
koko16@earthlink.net

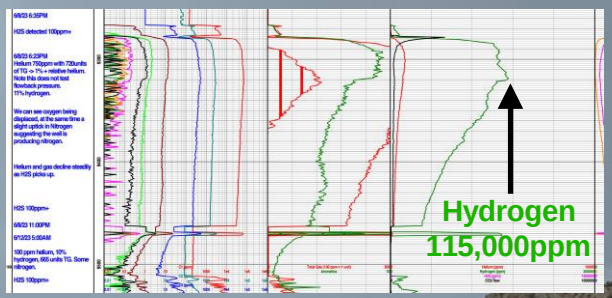
Bruce H Black
(505) 402-5900
brucehblack@icloud.com

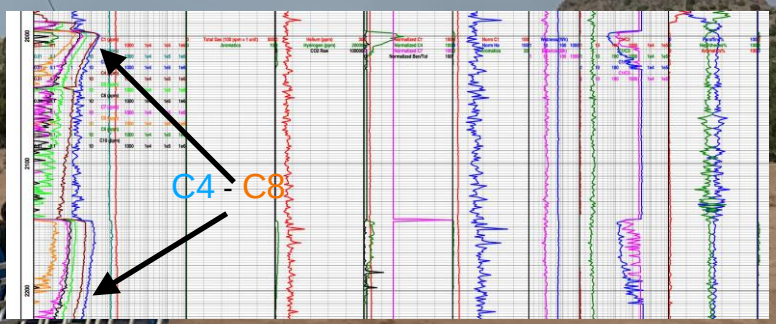


33,840 acres

Similar to Gullfaks Field, North Sea in Structure and Size (1.6 BBOE capacity)

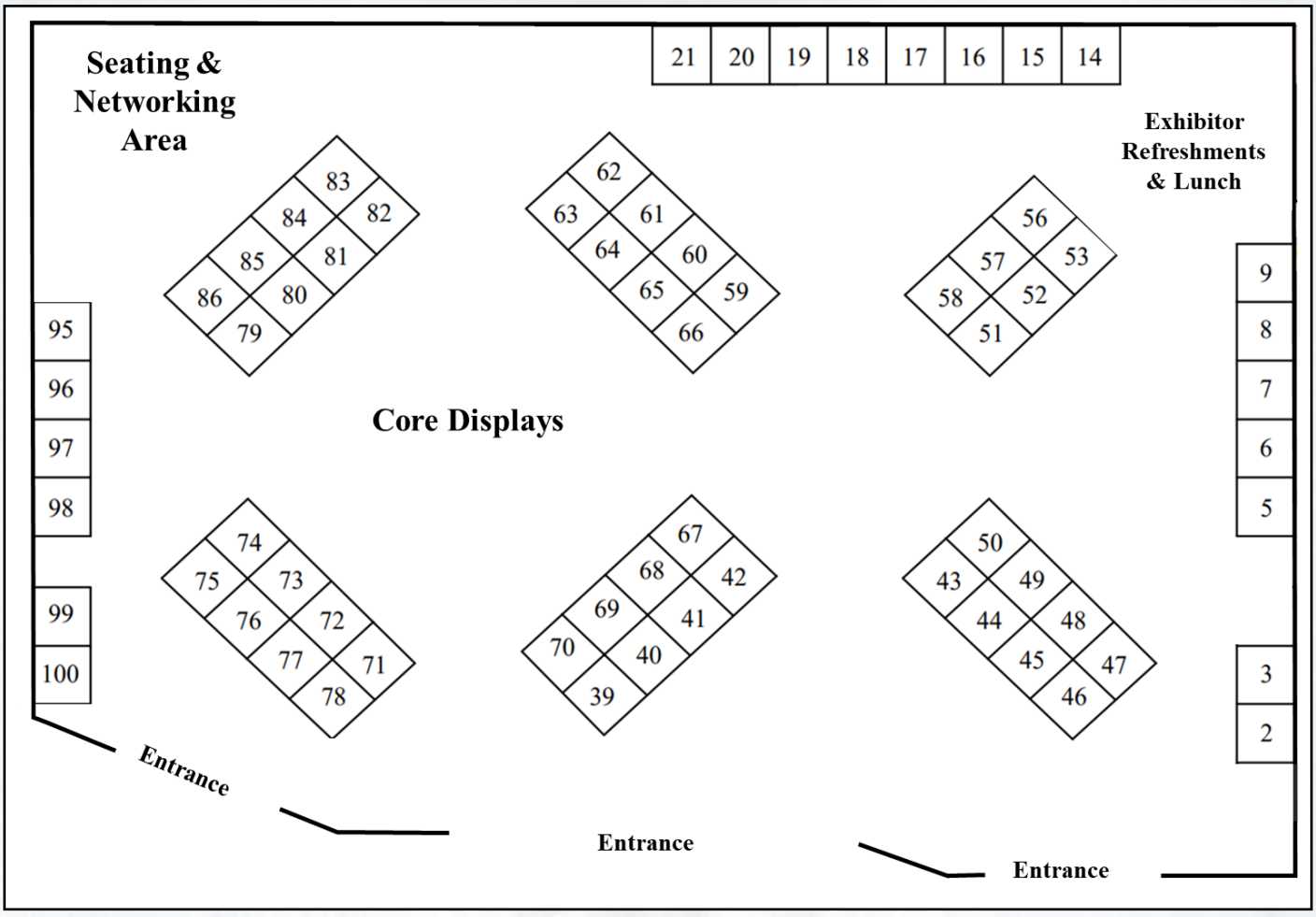






Booths 61 & 62

Exhibitor Floor Plan



Be sure to stop by the Core Displays featuring:

The Cherokee Shale courtesy of REVOLUTION RESOURCES

The Marchand Sand Courtesy of devon

The Woodford Shale Courtesy of Charter Oak Production Co., LLC
Oil & Gas Exploration and Production

Exhibitor Directory

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AHS Advanced Hydrocarbon Stratigraphy AdvancedHydrocarbon.com	Advanced Hydrocarbon Stratigraphy	73 & 74
BLACK EXPLORATION, LLC	Black Exploration	61 & 62
CANAMERA CORING	Canamera Coring	97
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GALVANICENERGY	Galvanic	70
GEOEDGES INC.	GeoEdges Inc	82 & 83
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Geolumina	GeoLumina	68
GEOMAP® COMPANY YOUR GUIDE TO THE SUBSURFACE	GeoMap Company	39 & 40
GEOMARK	GeoMark Research	78
Oklahoma City University Meinders School of Business	OCU Meinders School of Business	23

4cast is a cutting-edge platform designed for the efficient evaluation of oil and gas assets. With a data-integrated workflow, it equips operators, mineral buyers, and sellers with the tools they need for swift and precise valuations.

The American Association of Petroleum Geologists (AAPG) is one of the world's largest professional geological societies. AAPG works to advance the science of geology, especially as it relates to petroleum, natural gas, other subsurface fluids, and mineral resources; to promote the technology of exploring for, finding, and producing these materials in an economically and environmentally sound manner; and to advance the professional well-being of its members. AAPG was founded in 1917 and is headquartered in Tulsa, Oklahoma; currently almost one-third of members live outside the United States.

Advanced Hydrocarbon Stratigraphy (AHS) provides a unique perspective on the subsurface via the direct analysis of subsurface fluids entrained in cuttings or core rock samples whether they are decades old unpreserved legacy materials or hermetically sealed fresh at the wellsite. 40+ volatile compounds are directly measured on a custom built and patented cryo-trap mass spectrometer system developed in house by AHS at its lab in Tulsa, OK. From serving clients in unconventional and conventional oil and gas, geothermal, helium, carbon capture, and hydrogen; if you want to understand what fluids are in the subsurface, if they have migrated, been impacted by offset production or neighboring geological features, and/or how they interact with the rocks around them then our unique Rock Volatiles Stratigraphy technology and award winning technical team will tell you more than you could imagine to help you answer your subsurface questions quickly and effectively.

Black Exploration, LLC specializes in true Frontier Exploration. It is actively exploring for new oil and gas fields, as well as helium and hydrogen in high potential, lightly explored sub-basins of the Rio Grande Rift in New Mexico.

Canamera Coring is the leader in conventional and specialty coring services within North America. Our focus is to deliver innovative, cost effective, and practical coring solutions paired with renowned customer service.

We are driven to be the best geological well-site service company in the country. Our professional well-site geologists utilize a massive team of resources and tools to provide the best in class and integrated formation evaluation services in the industry. We consistently strive to maximize our customer's return on investment by delivering the most detailed subsurface geological data in any area. We promote a culture of integrity, dedication, quality, collaboration and safety.

The primary purpose of the CLO is to administer the school land trust funds for the production of income for the support and maintenance of the common schools and the schools of higher education.

Experts in subsurface navigation and home of GeoFLEX® - geologic horsepower, on demand. We can be your complete geological team or augment specific needs to support your operations.

DataLog provides reliable mud logging services, accessible day or night, for operations geologists. GeoVision specializes in precise geosteering, offering valuable insights and a fresh perspective to oil companies. Together, we deliver comprehensive expertise for successful oil and gas operations. FIELD TESTED. FUN-LOVING.

Based in Oklahoma City, DB Beading is driven by the visions of creative artists Debra Wilson and Betty Hollrah. Both concierge designers are sharing their passion by making one-of-a-kind jewelry for individuals plus the teaching of private and group classes. These master artists are skilled in Kumihimo, peyote stitching, brick stitching, loom weaving, stringing, wire wrapping and knotting.

Diversified partners with clients to lower finding and development costs, decrease the risk profile, increase reserves, and to improve capital efficiencies and returns on investment. We are on the cutting edge of innovation in the fields of robotics and automated sample collection, including quantitative measurements using robotics and AI data-driven solutions. Our technologies provide high-resolution and compositional analysis to assist our clients' operational activities with more safety, less risk, and increased certainty.

Field Geo Services Inc. is a full service geology company that provides multiple and layered levels of subsurface and wellsite analysis. Our specialties include traditional manned mudlogging, technical geosteering services, advanced geochemical mudlogging and subsurface geochemical modeling and analysis. We have the capability to perform all levels of evaluation of your basin or subsurface geology. From laboratory based x-ray diffraction to onsite rock physics evaluation using x-ray fluorescence, our blend of field-based techniques integrating geochemical data increases drilling efficiencies, completions, and increases the velocity of understanding of your project goals.

Galvanic Energy is a privately held geoscience-driven exploration company with expertise in reservoir characterization and mineral acquisition. Employing innovative, proprietary discovery methods, Galvanic seeks to identify safe, affordable and sustainable lithium resources within continental U.S. brine reservoirs.

GeoEdges Inc. creates and licenses its proprietary, digital, subsurface, geological map layers to the petroleum industry and to other energy-related companies. We have the best subsurface geological maps available for all of the United States, Canada, Mexico, and beyond. Not just for the topical energy plays, but for all the plays … all the basins … and all the productive zones. Come and see us at the show!

The Geologist Wives Association was founded in 1947 and proudly supports the geologic community.

NVZN AI for the Digital Subsurface. Your interpretation assistant that structures and analyzes data. Unlocking insight and orchestrating work.

Geomap is the leading supplier of interpretive geologic maps to the energy industry, from detailed subsurface structure and stratigraphy, to regional depictions reflecting production and activity. Data used to create and update these maps and map services, covering most domestic conventional and resource plays, is available to clients in Geomap's Data Center in Plano, Texas.

GeoMark Research, Providing quality geochemical data and knowledge, from a source you can trust. Science, done right.

Exhibitor Directory

Good Earth Rocks Gallery	6 & 7	Good Earth Rocks Gallery in Oklahoma City's Automobile Alley is Oklahoma's premier store for all jewelry, fossils, gems, minerals, crystals, and more!
GVERSE Geographix	59 & 60	GVERSE GeoGraphix was founded in Denver, Colorado to build the world's first geoscience software on Windows. GVERSE GeoGraphix is the latest evolution in G&G software that delivers advanced geological and geophysical interpretation at an exceptional price. The latest release includes cutting-edge features and tight integration in geomodeling and geophysics, fast reservoir characterization, and a laser-like focus on the core workflows geoscientists use every day.
Impac Exploration Services LLC	99 & 100	Your client focused and Data driven provider for surface logging, geo steering, drilling and completions optimization and oil field laboratory needs.
Kansas Geological Society	18	The Kansas Geological Society is composed of geological professionals from across the country. The Society hosts many educational lectures and social functions and maintains an impressive paper and digital library of Kansas geological data.
Lumina	86	Lumina Geophysical develops technologies and software for seismic processing and seismic analysis and conducts geosciences studies that vary from 2D/3D survey design, time and depth seismic processing, geophysical analysis, rock physics and petrophysical analysis, regional interpretation studies, seismic inversion, AVO analysis and reservoir characterization, combining expertise with the latest computer technology, the company has earned international recognition for its new developments in high resolution reservoir characterization and quantitative interpretation.
MCWL Palladian	64 & 65	MCWL is an established service company with a fresh and innovative foothold in the future. Services include muddloging, geosteerin, and wellsite geochemistry.
Mid-Continent Exploration Group	98	The Mid-Continent Exploration Group is a consortium of independent Geoscientists specializing in prospect generation, petroleum consulting, behind pipe evaluation, seismic analysis, and play appraisal. For more information on available prospects and consulting opportunities, please visit MIDCONXGROUP.COM.
Mid-Continent Geological Library	66	#1 data source for all your geological needs in Oklahoma & Texas Districts 9 & 10 with permanent ownership of downloaded documents.
Minerally	14 & 15	Minerally is a small family business that provides high quality minerals and fossils. Follow us on Facebook to find us at an event near you.
Neuralog	71	Neuralog remains the leader in data capture, conversion, and rapid analysis. Our log scanners and printers are used worldwide by independents and large companies. Automated digitizing, curve calculations, volumetrics, and quick correlations make geological interpretation fast and easy. Subscriptions, leases, and permanent installations are available.
NodalSeismic	19	NodalSeismic is a full-service seismic acquisition company founded in 2010. Since then, the company has been involved in O&G, CO2/gas storage, geothermal and mining projects providing 2,3,4D seismic data acquisition services. We also can provide Project Management, Survey Design, Permitting, Field Survey, Seismic Acquisition and Seismic Data Processing through one of our JV Partners.
NuTech	8	The pioneers of reservoir intelligence, today we form a multidisciplined team of professionals who have analyzed both core and logs of nearly every prospective and producing basin in the world. We have modeled the most prolific American unconventional reservoirs from a 3D geological model to optimized fracture treatments to field development plans.
OCGS	17	The Oklahoma City Geological Society strives to advance the Geological Sciences and the profession of geology while establishing standards of education, experience, and professional conduct in the practice of Geology. We provide professional educational opportunities including luncheons and short courses along with networking and social activities. The OCGS also provide mentorships and scholarships for students. Learn more at www.OCGS.org
Oklahoma Geological Foundation	51 & 58	The mission of the Oklahoma Geological Foundation is to implement a model of excellence in Earth science education. With the help and support offered through the foundation, we work with students, teachers, and community members to make Earth science education a priority.
Oklahoma Geological Survey	96	The Oklahoma Geological Survey is a state agency for research and public service located on the Norman Campus of The University of Oklahoma and affiliated with the OU Mewbourne College of Earth and Energy. The Survey is chartered in the Oklahoma Constitution and is charged with investigating the state's land, water, mineral, and energy resources, and disseminating the results of those investigations to promote the wise use of Oklahoma's natural resources consistent with sound environmental practices.
Oklahoma State University	52	The Boone Pickens School of Geology (BPSoG) at Oklahoma State University School is housed in the Noble Research Center, a 35,000 sq. ft research and teaching facility in Stillwater, Oklahoma. BPSoG is led by twenty-two faculty dedicated to providing the highest quality education and offering interdisciplinary research in sedimentology/ (bio)stratigraphy, structural geology and tectonics, geophysics, paleontology, hydrogeology, remote sensing, geochemistry, and geological engineering.
OSU Geology Student Organizations	53	OSU geology student organizations including AAPG, SEG, GGAS, AIPF, OSUGS, & AWG
OU SEG Student Chapter	56	SEG student chapters empower students to participate and spearhead projects that will address issues, challenges, and opportunities related to the SEG's mission of promoting the science of geophysics. We currently have approximately 50 students (from both geology and geophysics) within the School of Geosciences who are actively engaged in our SEG student chapter with active participation in most of our events. Our chapter is committed to helping our students while carrying this momentum into the coming semester.
Pinson Well Logging	77	Established in 1985, Pinson Well Logging is a family owned and operated company. At Pinson Well Logging, we take pride in the relationships we have established with our clients in the oil and gas industry. We provide comprehensive geological services to enable optimal drilling placement to maximizes performance and minimizes risk.

Exhibitor Directory

Raptor Consulting Inc.	67	Raptor provides professional, high quality well site geology and geosteering services throughout the Untied States. Services include mud logging, geosteering, data analystics, remote air monitoring, and safety training.
Rare Earth Mercantile	84 & 85	Founded in Oklahoma City, Rare Earth Mercantile offers a wide selection of curated natural home décor sourced from around the globe. These timeless treasures include fossils from Madagascar and Morocco, Indonesian Petrified Wood, Brazilian Agate, Mexican Onyx, one-of-a-kind natural stone jewelry and more. Shop with us online at www.rareearthmercantile.com.
RevoChem, LLC	45	RevoChem provides reservoir characterization and monitoring by analyzing geochemical fingerprints from cuttings and produced oils to quantify drainage frac height, production allocation, and well communication to optimize field development, improve reservoir prediction, and EOR. We have characterized and monitored nearly 5,000 wells around the world.
ROGii	50	Founded in 2013 in Houston, Texas, ROGII provides upstream oil and gas operators with world-class software solutions for real-time analysis, data automation, and operational efficiency for geology, drilling, and completions teams to use on a customized cloud-based platform. With over 400 clients worldwide and over 35,000 wells drilled with our solutions, we have a proven track record in more than 15 countries in a wide variety of plays, including tight shales, carbonates, CBM/CSG, fluvial systems, heavy oil, and many more. ROGII is committed to providing an innovative and customizable suite of applications that allow multidisciplinary teams to create the exact software platform they need as oil and gas continue to evolve.
Sabata Energy Consultants	69	Sabata Energy Consultants is your one-stop shop for subsurface data and data services. Our database covers 40 US states and 5 Canadian provinces. Check out our online directory to find oil & gas faster!
Silverthorne Seismic LLC	49	Enhance your exploration projects with Silverthorne Seismic. We've got you covered from Exclusive Seismic Brokerage, 2D and 3D Acquisition Design and Management, Data Forensics, Data Management & Digital Data Storage.
SIPES	3	Society for Independent Professional Earth Scientists. SIPES strives to be the pre-eminent organization for furthering the professional and business interests of independent practitioners of the earth sciences.
Stratagraph Inc	72	Stratagraph is a pioneer in the mud logging industry. Provided services include mudlogging and gas detection, geosteering, geochemistry, completion and production chemicals, Wellbore Placement, and unmanned gas detection. Since 1961, Stratagraph has been providing quality, reliable and accurate data services throughout the Gulf of Mexico, across North America, and overseas. This organization is also proud of its immense experience throughout Texas and the many basins throughout North America.Stratagraph delivers outstanding service with industry-leading FID gas detection and efficient data acquisition services. Stratagraph offers numerous geological services including Geosteering, Mass Spec, FID, XRF analysis, cutting analysis, and much more.
Stratum Reservoir	80	Stratum Reservoir is an industry leader in rock, fluid, and stable isotope analysis for the energy, mining, and agricultural industries. Our network of laboratories around the world, produces high precision analytical data that our global team of subject matter experts use to deliver scientific insights that enable our customers to gain a thorough understanding of their resources
TGS	44	TGS provides scientific data and intelligence to companies active in the energy sector. In addition to a global, extensive and diverse energy data library, TGS offers specialized services such as advanced processing and analytics alongside cloud-based data applications and solutions.
The Great Gutowsky	20 & 21	"King of the Wildcatters", Assaph "Ace" Gutowsky discovered The West Edmond Oil Fields in 1943. His amazing journey began as a young Ukrainian immigrant and became an American "Hero on the Home Front" helping allies win WWII. This powerful story is told by his granddaughter, Kim Gutowsky van der Wal.
Tricon Geophysics, Inc.	57	Tricon Geophysics, Inc. is a full service seismic land and marine processing company with data centers in Houston and Denver. Services include time and depth imaging, fracture analysis, pre-stack inversion, rock property prediction, AVO, petrophysical analysis, pore pressure estimation.
Tulsa Geological Society	16	The Tulsa Geological Society (TGS) is a non-profit organization of geologists and other geoscientists that share a common interest in geology. Our purpose is to educate and disseminate knowledge of and interest in the science of geology and related earth sciences, to promote the study and practice of earth sciences as a profession, and to promote the advancement of earth sciences in all phases.
University of Oklahoma	75	The School of Geosciences at the University of Oklahoma is a premier program where faculty, staff, and students work in a diverse range of geoscience fields related to Earth, energy, and the environment. We provide innovative educational and research experiences for the next generation of scientists. Society needs us – geoscientists in a variety of fields are critical as we work to provide natural resources for society, to address fundamental Earth sciences questions, and to solve some of the world's most important challenges.
University of Tulsa	76	TU's Department of Geosciences offers unparalleled academic and research opportunities for students interested in geology, geophysics, environmental geology and biogeosciences. Traditionally, our geosciences program focuses on sedimentary geology and petroleum geophysics. Other department strengths include sedimentology, structural geology, geochemistry, organic geochemistry, petroleum geology, Earth surface processes and igneous petrology.
US Coring	81	The worlds only proactive jam mitigation technology + full closure coring platform. Paired with our patented fluid invasion deflectors and long run coring capabilities, our customer service is unmatched. CCUS, conventional or unconventional, we deliver high quality core!
Wireline Logging Solutions	79	Wireline Logging Solutions provides Open-Hole Logging with the Compact Slim Tools, and Specialty Cased-Hole Services, including Pulse Neutron logging, Compensated Neutron, Multi-Arm Calipers, and Magnetic Thickness Tools; throughout the Permian.WE ARE WIRELINE!
Core Lab	25	

Monday Morning Room 301AB

How to be an Independent
Moderated by David Sanger & Jim Bedford

8-8:05 *Intro*

8:05-8:35 **Options for an Independent**
Suzanne M. Rogers

8:35-9:05 **The Independent Geologist - When Preparation Meets Opportunity**
Michael W. Smith

9:05-9:35 **To Be or Not to Be an Independent**
Kristie Ferguson

9:35-10:00 *Break*

10:00-10:30 **Open-Source Mapping Software for Independent Geoscientists**
John McLeod

10:30-11:00 **Geology on the other side of the rock: Life as an "environmental" geologist**
Kathy Lippert

11:00-11:30 **Theory, Application, Discovery: From OGCS Talk to Drilling to Production!**
John Brett, Ted Beaumont*

Monday Morning Room 301CD

Geology and Geophysics of the Midcontinent: The Anadarko Basin-Part 1
Moderated by Will Shaffer & Abidin Caf

8-8:05 *Intro*

8:05-8:35 **Finding New Oil the Old-Fashioned Way - An Update on New Developments in Old Areas and Old Concepts Being Applied to New Places**
Bryan Bottoms

8:35-9:05 **Integration of Microseismic and Geochemical Profiling to Understand Effective Drainage Height**
Shawn Maxwell, R. Brito, G. Ritter, J. Sinclair, A. Leavitt, F. Liu and J. Bachleda*

9:05-9:35 **Comparison and Re-assessment of Middle-Late Mississippian Strata Across North America**
Buddy Price

9:35-10:00 *Break*

10:00-10:30 **The Red Fork Delta Revisited**
Rick Fritz, Chris Johnson, & Mike Kuykendall*

10:30-11:00 **Paradise Machine Learning Technology - Understanding the Sub-surface in Detail**
Deborah Sacrey

11:00-11:30 **Seismic-constrained reservoir modeling and simulation for CO2 sequestration potential of the Arbuckle Group: Wellington Field, Kansas**
Abidin Caf

Monday Afternoon Room 301AB

Emerging Energy and Resources of the Midcontinent
Moderated by Garrett Powell & Tyler Gruenbacher

1:10–1:15 *Intro*

1:15–1:45 **Identifying Value Elements in Oilfield Brines**
Brent Wilson

1:45–2:15 **Oklahoma Geological Survey & The Energy Transition**
Nicholas Hayman

2:15–2:45 **Chasing Lithium: Oil Field Brine and Petroleum Correlations Across Southeastern Oklahoma**
Catherine Donohe, Adam Turner, & Alex Zumberge*

2:45–3:10 *Break*

3:10–3:40 ***NEW*** **Super-giants, Giants and the Mid-Con**
Richard Bishop & Charles Sternbach*

3:40–4:10 **Future Prospects of Helium Exploration in Oklahoma with Legacy Samples, Modern Insights**
Christopher M. Smith. Timothy M. Smith, Patrick S. Gordon, & Michael P. Smith*

Special Session from our

Emerging Energy Sponsor

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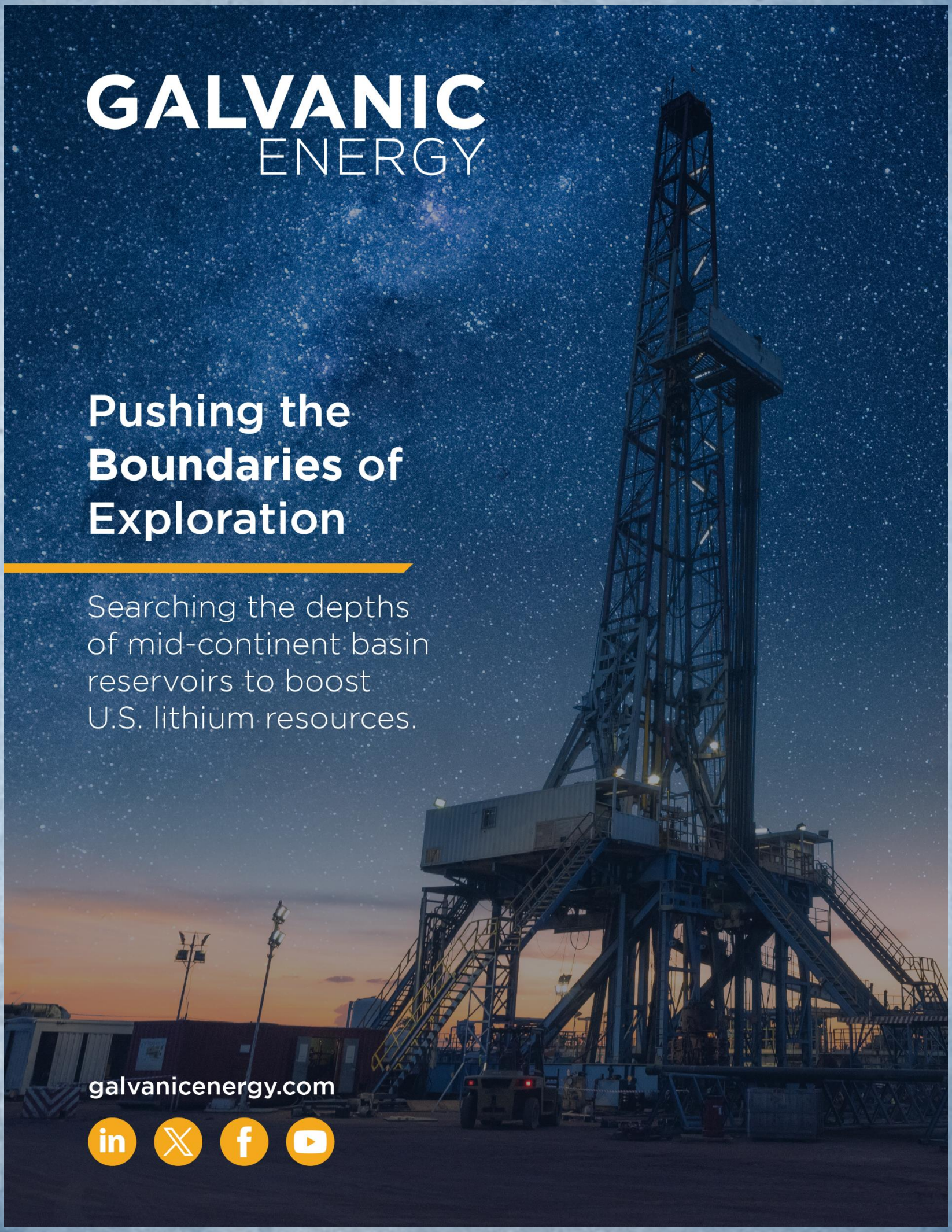
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Monday Afternoon Room 301CD

Geology and Geophysics of the Midcontinent: Kansas and Arkoma
Moderated by Troy Johnson & Jason Currie

1:10–1:15 *Intro*

1:15–1:45 **Demonstrating the Utility of CO2 Entrained in Legacy Drill Cuttings as a Proxy for Pressure Compared to Drill Stem Tests Measurements in Oil Fields from Kearny County Kansas**
Christopher M. Smith, Timothy M. Smith, Patrick S. Gordon, Michael P. Smith, & Franek Hasiuk*

1:45–2:15 **Breaking Bad – Ordovician Source Rocks: the Primary Origin of Pre-Pennsylvanian, Produced Oils in South Central, Kansas**
Brian W. Wilhite & Tim Ruble*

2:15–2:30 *Break*

Special Panel Session

The A-Team: Dealing with Careers, Challenges, and the State of the Industry

Monday from 2:30pm–4:00pm in Room 301CD

Featuring Mark Oekerman, Caroline O'Keefe, Aubrey Humbolt, Herb Martin, Mark Lester, & John Brett

Moderated by Lanny Holman & Cat Campbell

Join our special session where a diversity of seasoned experts will answer questions on their careers including the path they took, the challenges they faced, how they overcame them, and the challenges they see facing today's geoscientists. We'll also ask them their advice on staying above the competition, what they think the future looks like for the oil and gas industry, and any advice they have on networking and building industry relationships. We hope you'll stop by to join in on the Q&A session and take advantage of a great opportunity to hear from these smart folks!

The A-Team

Mark Oekerman: Mark is a third-generation petroleum industry professional who has a deep passion for subsurface exploration. During his 15+ years of petroleum exploration, development and leadership experience, Mark has been fortunate to work alongside industry leading PetroTechnical and leadership professionals during his tenures at Chesapeake Energy, American Energy Partners, and Continental Resources. In Mark's current role as Exploration Director at Continental Resources, he oversees the geoscience teams who develop and explore the Anadarko Basin & Williston Basin.

John Brett: John began his career in oil and gas for Leeman Energy Corporation in 1984 in OKC. He was later employed by Carl E. Gungoll Exploration for 4 years as a prospecting geologist. In 1994 he formed Brett Exploration, LLC to provide geological and geophysical consulting services as well as prospect generation and marketing. From 1999-2015 he was on retainer with Raydon Exploration, Inc. focusing on oil and gas exploration and development primarily in the Midcontinent. In January of 2016, he began Jasper Energy, LLC to explore and develop the Midcontinent. He previously served as the president of the OCGS and is currently the secretary for the AAPG MCS. He also served as a director of the Boone Pickens School of Geology Alumni Advisory Committee at OSU (GO POKES).

Aubrey Humbolt: In her 15+ years with Devon Energy, Aubrey has been fortunate to work alongside many influential mentors and has held numerous, diverse roles including, multi-basin asset geologist, JV and A&D project coordinator, geoscience manager, corporate performance and budget manager, and Mid-Continent asset manager. In her current role as the Delaware East Asset Director, Aubrey leads multiple interdisciplinary teams in the responsible discovery, development, and production of hydrocarbon resources in the eastern Delaware Basin. A lifelong lover of the natural sciences, Aubrey has a passion for promoting STEM education and mentoring.

Herb Martin: Herb retired in 2017 after 35 years of prospecting and management in exploration, exploitation, and production roles for an integrated oil and gas E & P company. He focused on prospect evaluation, development, prioritization and presentation. Herb worked all over the world, with a focus on U.S. Gulf Coast, International (especially Far East basins) & Permian projects. Herb served in upper management at Devon Energy where his primary responsibilities included generation and evaluation of exploration opportunities, application of technology solutions, and cross-disciplinary integration solving the unique challenges in Resource plays.

Mark Lester: Mark spent his entire career in oil & gas exploration and managed the Geoscience Department at Chesapeake Energy Corp. from 1989 till his retirement in 2010. He continued working as a consultant in the oil and gas industry for several years and now manages investments for two family LLCs. Over the years Mark has been involved with several philanthropic Boards, including the Oklahoma School of Science and Math, the Oklahoma Arts Institute, deadCenter Film, and the Oklahoma Geological Foundation. Mark also served on Purdue University's Department of Earth, Atmospheric, and Planetary Sciences Advisory Board and Purdue's College of Science Dean's Advisory Board.

Caroline O'Keefe Bork: Caroline is currently the Head of Permian Geoscience at BP in Denver, Colorado. She leads a great team of geoscientists and engineers through their exploration and development program. Prior to BP Caroline spent several years in Oklahoma City working for Chesapeake Energy in their Midcontinent Business Unit. She is a proud graduate of the University of Arkansas, Go Hogs!

Tuesday Morning Room 301AB

The Business Side of Oil and Gas

Moderated by Joe Stone & Karelia La Marca

8–8:05 Intro

8:05–8:35 **Let's Make A Deal!!! – Starting and Funding an E&P**
Joe Brevetti

8:35–9:05 **"Onward and Upward" Entity Structure for the Self-Employed and Basic Agreements**
Brett Sanger

9:05–9:35 **A Day in the Life of a Branch Board Director**
Walt Duncan

9:35–10:00 *Break*

10:00–10:30 **Using Data, Facts, and Science to have a Rational Conversation about the Environment, Global Warming, Population Growth, and the Importance of Oil and Natural Gas in our Domestic and Global Economies**
Steven C. Agee, Ph.D.

10:30–11:00 **Beyond Science and Technology, How Business and Regulations Impact Geology**
Dana L. Murphy

11:00–11:30 **Improved Diagnostic Insight through Near-Wellbore Measurements: Advancing Completions Understanding**
Kevin Wutherich

Tuesday Morning Room 301CD

Geology and Geophysics of the Midcontinent: The Anadarko Basin–Part 2

Moderated by Cole Mount & Chris Wiggers

8–8:05 Intro

8:05–8:35 **Rethinking the Woodford Petroleum System of Oklahoma**
John McLeod

8:35–9:05 **Geochemistry for unconventional petroleum exploration and development: A Case study from Anadarko Basin, Oklahoma, USA**
Wahid Rahman, Ph.D.

9:05–9:35 **Woodford Core-Log Facies Model tied to Sequence Stratigraphy and Applied to Full-field Development in STACK and SCOOP**
Richard Brito, Guanghua Xue, Cameron Cross, Cindy Guenard, John Sinclair, & Aaron Leavitt*

9:35–10:00 *Break*

10:00–10:30 **Insights from Rock Volatiles Stratigraphy from the Woodford in the Anadarko Basin**
Christopher M. Smith, Richard Brito*, John Sinclair, Aaron Leavitt, Timothy Smith, Patrick Gordon, and Michael Smith*

Tuesday Morning Room 301CD – Cont.

10:30–11:00 **Applications of Organic Geochemistry to Modeling Hydrocarbon Charge Events in Source-Adjacent Reservoirs: STACK Case Study**
Carl Symcox, R. Paul Philp*

11:00–11:30 **A Statistical Look at the Drainage Behavior of Unconventional Wells in the SCOOP and STACK Plays with Case Studies**
David Duarte, Shuangyu Ge, Richard Brito, Geoff Ritter, John Sinclair, Aaron Leavitt, Jana Bachleda, & Faye Liu*

Tuesday Afternoon Room 301AB

Geology and Geophysics of the Midcontinent: Regional/General

Moderated by Hannah Morgan & David Lubo-Robles

1:10–1:15 Intro

1:15–1:45 **Hydraulic-fracture triggered earthquakes in Oklahoma, 2013 to present**
Jake Walter, Paul Ogwari, & Nick Hayman*

1:45–2:15 **Geochemical and Mineralogical Characterization of Hydrothermally Altered Spavinaw Granite**
Alexander Cordero & Brett M. Carpenter*

2:15–2:45 **Oklahoma's Intraplate Earthquakes: Insights from Pawnee 3D seismic**
Priyank Jaiswal, PhD, B. Springman, J. Walter, H. Daigle, S. Verma, & J.M. Gregg*

2:45–3:10 *Break*

3:10–3:40 **Estimating Recovery by Quantifying Mobile Oil and Geochemically Allocating Production in Unconventional Reservoirs**
Jennifer J. Adams, Tim Ruble, Matt Flannery & Mark A. McCaffrey*

3:40–4:10 **Improved Seismic Reservoir Characterization with Interbed Multiple Suppression**
Gabriel Gil & Jeff Martin*

4:10–4:40 **Tying local structure to regional deformation history: Integrating core data with published fault maps reveals the timeline of deformation within the Southern Oklahoma Aulacogen**
Jamie M. Bowie, Brett M. Carpenter, & Michael J. Soreghan*

Tuesday Afternoon Room 301CD

Discovery Thinking

Moderated by Cam Thompson & John Dodds

1:10–1:15 Intro

1:15–1:45 **History of the First Seismic Reflection Experiment and Interpretation of a Modern 2D Line Located Near the Original Experiment**
Jan Dodson

1:45–2:15 **The Horizontal Redevelopment of the Abandoned Pendleton Fractured Chalk Field**
Julie Garvin

2:15–2:45 **Visualizing Uncertainty & Risk to Reduce Bias and Improve Decision Making: My Favorite Diagrams**
Andrew Cullen

2:45–3:10 *Break*

3:10–3:40 **Helium Exploration in the Rio Grande Rift**
Bruce A. Black, and Bruce H. (Buz) Black

3:40–4:10 **Uncertainty Assessment in Unsupervised Machine Learning Methods for Deepwater Channel Seismic Facies**
Karelia La Marca, Heather Bedle , Lisa Stright, & Kurt Marfurt*

4:10–4:40 **Seismic Identification of Carbonate Reservoir Sweet Spots using Unsupervised Machine Learning: A Case Study from Brazil Deep Water Aptian Pre-Salt Data**
Marcus Maas, Marcus Vinicius Rodrigues Maas, Heather Bedle, Marcilio Castro de Matos*

Poster Presentations

Poster Presentations–Alphabetical Order

Poster #	
18	**A comparison of unsupervised ML algorithms for channel seismic facies in the Taranaki Basin** *April Moreno-Ward, Karelia La Marca, & Heather Bedle*
14	**Application of Seismic Inversion Techniques for Reservoir Characterization in the Anadarko Basin, Oklahoma** *Sreejesh V. Sreedhar, Camalia C. Knapp, & James H. Knapp*
19	**Assessment of Spectral Attributes in Identifying Gas Hydrates in Seismic Data from the Pegasus Basin, Offshore New Zealand** *Emily Jackson, Heather Bedle, & Thang Ha*
17	**Capabilities and limitations of unsupervised clustering techniques for seismic facies classification in a merged seismic cube** *Pamela Blanco Dufau & Heather Bedle*
9	**Carboniferous Hydrocarbons Plays in the Western Pomerania, Poland** *Przemyslaw Karcz, Grzegorz J. Nowak, Aleksandra Kozlowska, Marta Kuberska, & Barbara Massalska*
5	**Comparisons of Grain Size Distributions from Jezero Crater Delta Front to Deltas on Earth** *Cailin Stauffer, Ryan Cramer, Chloe Wild, & Aaron Ball*
8	**Crustal Shears and Future High-Resolution 3D Seismic-Based Exploration for Large Oil and Gas Fields in Central Oklahoma from A Globalist View** *Thomas E. Moon & Steven L. Getz*
11	**Fault Zone Characterization using Earthquakes in Quinton Oklahoma** *Paul Ogwari, Jacob I. Walter, Isaac Woelfel, Andrew Thiel, Fernando Ferrer, & Xiaowei Chen*
2	**High-resolution sequence stratigraphy of fine-grained turbidite deposits, Leonardian Bone Spring Formation, Delaware Basin** *Rui Zhai*
13	**Impact of hydrothermal fluid flow on the Anadarko Basin petroleum system as revealed by the Pan Am Barnes D-2 Core** *Andrew Hollenbach, Robert Goldstein, Sahar Mohammadi, Andreas Möller*
7	**Impact of tectonic stress and hydrostatic pressure on the giant field of Hassi Messaoud, Algeria** *Lonnie G. Kennedy*
15	**Investigating the Sensitivity of Seismic Attributes in Seismic Facies Identification Using a Supervised ML Technique** *Emuobosa Patience Ojoboh, Heather Bedle, and Brett M. Carpenter*
4	**Petrophysical Considerations for Rare Earth Element and Critical Mineral Evaluation in Midcontinent Pennsylvanian Strata** *Ibukun Bode, Stephan Oborny, Franek Hasiuk, & Matt Joeckel*
3	**Preliminary assessment of the phosphate and rare earth element potential in the Upper Woodford Shale on the Lawrence Uplift, Ada OK** *Andrew Cullen & David Hull*

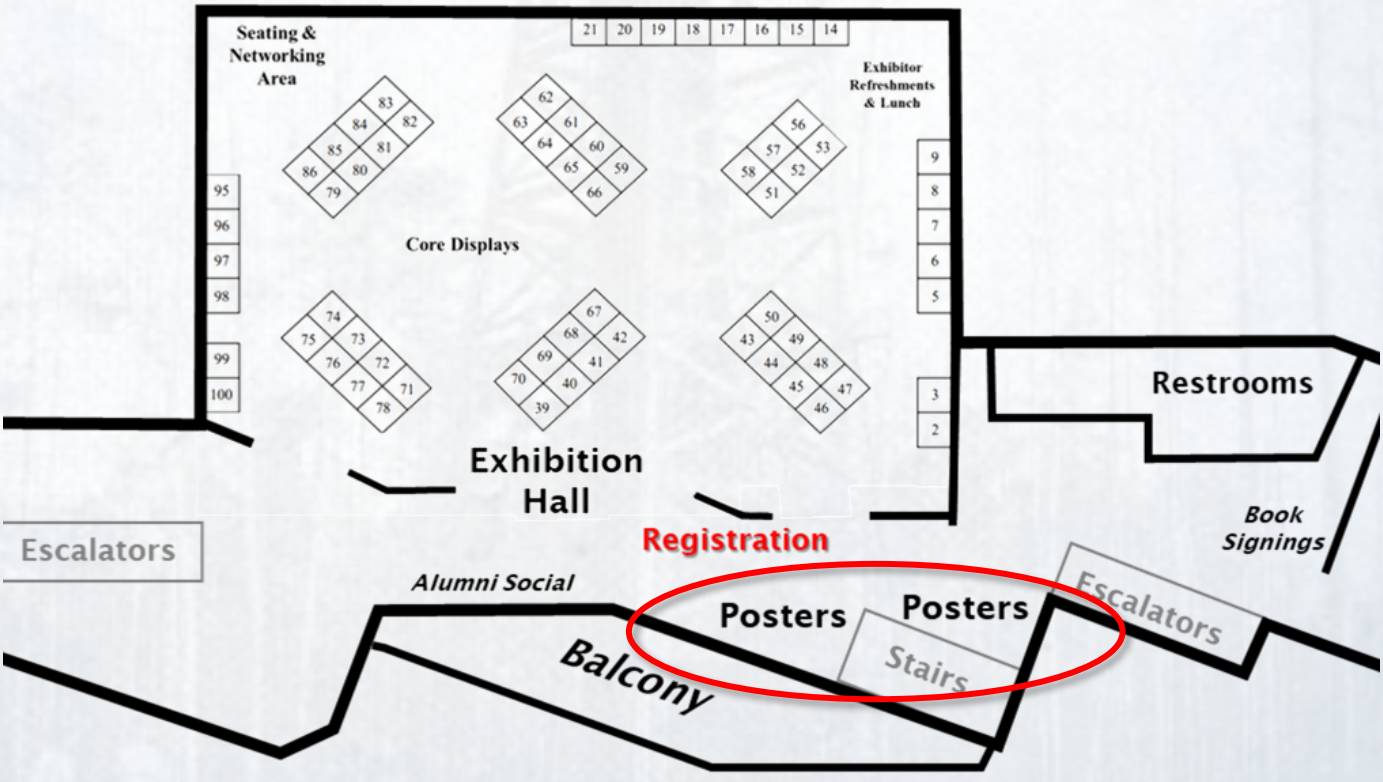
Poster Sessions

Poster Presentations–Alphabetical Order

Poster #	
12	**Revealing the hidden faults of the Oklahoma basement through unsupervised machine learning and integration with earthquake data** *Diana Katerine Salazar Florez, Heather Bedle, & Brett Carpenter*
1	**Statewide assessment of CO2 storage capacity for the Cambrian–Ordovician Arbuckle Group and selected Ordovician formations, Oklahoma** *Anna Turnini & Matthew Pranter*
10	**The Economic Impact of Saltwater Disposal Performance: Observations of Clay Type and Distribution in an Underperforming SWD** *Benjamin L. Howard & Joe Bauman*
16	**Thin Layer Effects on Horizon Attributes: Beyond Amplitude Tuning** *Muhammed Jallow & Abdelmoneam Raef*
6	**Unconventional Reservoir Characterization of the Newly Explored Caney Shale, Southern Oklahoma** *Izabelle Buentello, Michael Grammer, & Yulun Wang*

All posters will be on display in the Lobby, across from Registration both Monday & Tuesday

We ask presenters to be by their posters from 9:00–10:00am & 2:30–3:30pm



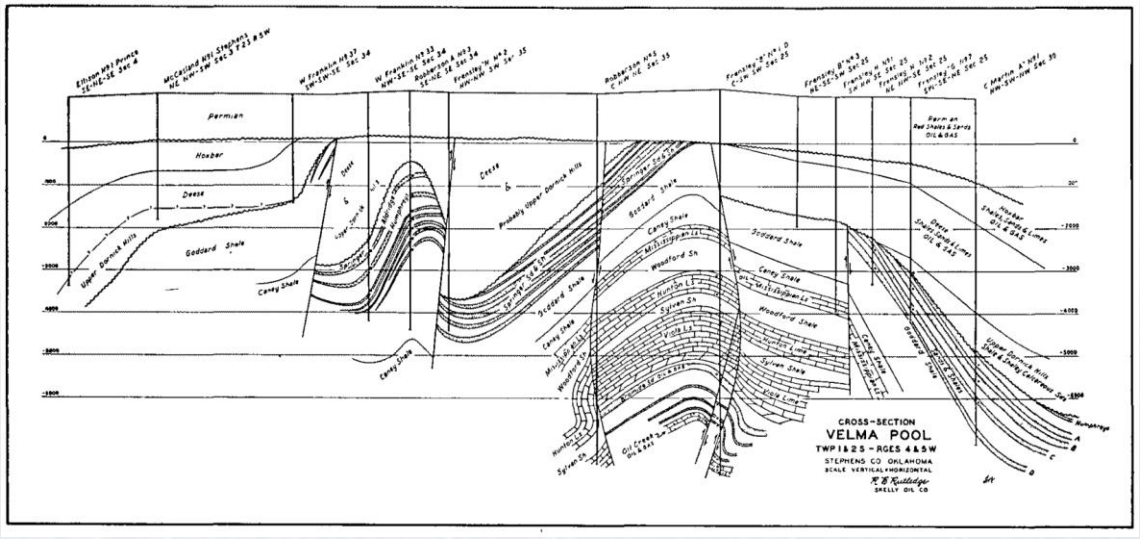
Oil Field History: Sho-Vel-Tum Oil Field

Year Discovered: 1905
Discovered by: H.B. Goodrich
Producing discovery horizon: Sands at 860'
First production amount: 6 million cubic feet of gas per day
Historic Production #'s: Over 46 million barrels were produced in 1953
Total Production to Date: >740 Million Barrels
Producing horizons: Permian Pontotoc Group, Pennsylvanian Hoxbar, Deese, & Dornick Hills-Springer Groups, Mississippian Sycamore, & the Ordovician Simpson
Trap: Structural Anticlines & Stratigraphic Traps
Fun Facts: Sholom Alechem is Hebrew for 'Peace be with you,'

Sho-Vel-Tum (named in 1956 by the DOE) is an acronym for three of the older and larger producing structures within the giant field including the Velma, Sholem Alechem, and Tatums Fields. However, there are actually 31 smaller oil and gas fields within the giant. As production grew in these smaller fields they eventually began to overlap resulting "Sho-Vel-Tum" as we see it today.

Back in 1903, H.B. Goodrich came to Ardmore as a geologist for the Santa Fe Railway and worked out the geology near the Wheeler oil seep. His company, the Coline Oil Company, finally completed its discovery well in October of 1905 at a total depth of 860 feet. Initial production was 6 million cubic feet of gas, with oil production coming on a year later just below the gas. The Wheeler Field, was the first in the conglomeration of Sho-Vel-Tum.

The Velma Field was discovered in July of 1917 by Texas Company after they drilled (and shot) a well at 472 feet that produced 10 barrels from a Permian sand. Sholem Alechem was discovered in December of 1923 by Humble Oil and Refining Company's Jennings #1 where production came from a sand in the Deese. Production was entirely from lenticular sandstones in the Hoxbar and Deese formations until August 1947, when production from sandstones in the Springer formation were discovered on the north flank of the field by the Stanolind Sims #1. The Tatums discovery well was completed January 14th 1927 by the Magnolia Petroleum Company. It was the Pollock #1 with an initial production of 25 barrels. In 1933 the Carter Oil Company drilled a well that had 482 bbls/day from a sand at 2,750 making it the first big producer.



Rutledge, 1954

Oil Field History: Oklahoma City Field

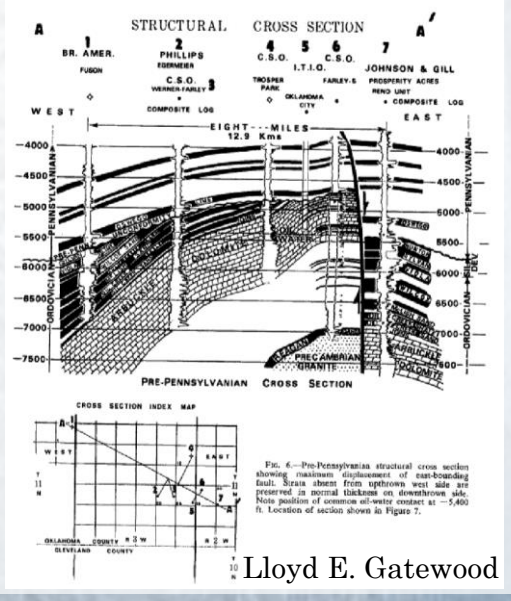
Year Discovered: 1928
Discovered by: Indian Territory Illuminating Oil Company
First Well Name: Oklahoma City #1
Producing discovery horizon: Arbuckle Limestone at 6,624'
First production amount: 6,000 bbl/day
Historic Production #'s: By 1969 more than 735 million barrels of oil and more than 2 trillion cubic feet of gas had been produced
Producing horizons: Cambro-Ordovician Arbuckle as well as the Ordovician Oil Creek sandstone and Simpson "Wilcox" sandstone
Trap: Structural Faulted Anticline
Fun Facts: The OKC Oil Field helped keep Oklahoma's economy stable during the Great Depression.

The region around Oklahoma City had been subject to oil exploration for decades prior to December 4, 1928, when the Oklahoma City #1 was completed south of the city limits. This discovery opened the Oklahoma City Field, which progressed so rapidly that by May 1930, it entered the city limits of Oklahoma City.

Early in 1930 the Oklahoma City Council passed an ordinance limiting drilling to one well per city block and restricting activity to specifically designated sections of the city. Legal challenges and flagrant law violations led to chaos, followed by several instances of martial law being declared. In 1933, House Bill Number 481 finally passed, imposing limitations on all oil produced in Oklahoma and bringing oil production under some sort of control.

One of the most spectacular incidents in Oklahoma oil field development occurred when the Mary Sudik Number One, on the south side of Oklahoma City, came in on March 26, 1930. The drilling crew lost control of the well, and it sprayed oil across the countryside for as far as ten miles away until the rig was capped on April 6. The "Wild Mary Sudik," as the well came to be called, was probably the most spectacular well blowout in the state. Peak annual production from 1933 through 1937 within the field ranged from fifty-one million to sixty-seven million barrels with strong production continuing until well after World War II ended.
-Oklahoma Historical Society

Oklahoma Historical Society



Lloyd E. Gatewood

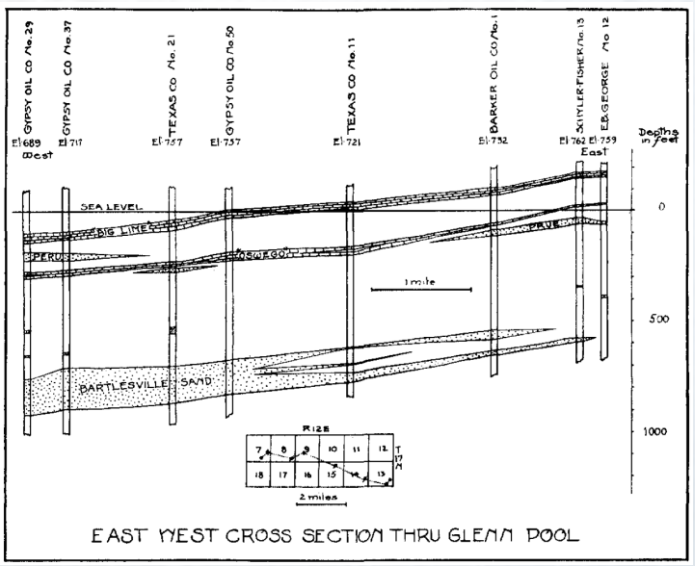
Oil Field History: Glenn Pool Field

Year Discovered: 1905
Discovered by: Robert Galbreath
First Well Name: Ida E. Glenn #1
Producing discovery horizon: Bartlesville sand at 1,481'
First production amount: 75-85 bbl/day
Historic Production #'s: 43,520,000 barrels in 1907
Total Production to Date: >340 Million Barrels
Producing horizons: Pennsylvanian Bartlesville sandstone and Ordovician Wilcox sandstone
Trap: Stratigraphic pinch out
Fun Facts: Glenn Pool's production propelled Oklahoma into the nation's leading oil producer, a distinction held until 1928 where Tulsa was known as the "Oil Capital of the World".

Robert Galbreath began looking for other oil prospects in the summer of 1901. In July he located a likely location on the Ida E. Glenn farm, about twelve miles south of Tulsa, but delayed leasing until legal restrictions on Indian allotments had eased. He and Frank Chesley spudded the Ida E. Glenn #1 in autumn of 1905. The well was drilled in the utmost secrecy in an effort to avoid the type of chaos that had followed the Red Fork discovery a few years earlier. Unfortunately, several oilmen were operating in the area at the same time, and their activity, coupled with federal government regulations requiring drilling on Indian allotments within ninety days of signing a lease, soon created the first gigantic oil boom in Oklahoma history.

A number of prominent oil figures, including Harry Ford Sinclair, who later founded the Sinclair Oil and Refining Company, and J. Paul Getty of Getty Oil Company fame, received their initial start during the Glenn Pool boom. Oklahoma Natural Gas Company was founded and in 1907 built a pipeline from the Glenn Pool to provide gas service to Oklahoma City.
-Oklahoma Historical Society

Oklahoma Historical Society

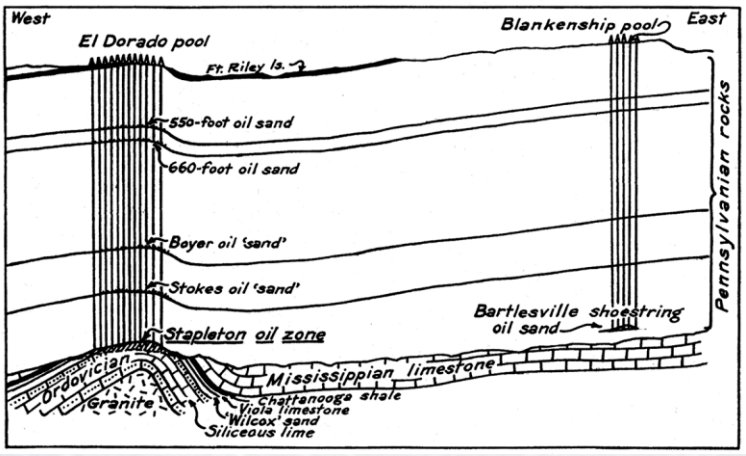


Wilson, 1929

Oil Field History:
El Dorado Oil Field

Year Discovered: 1915
Discovered by: Wichita Natural Gas Company (now the Empire Gas and Fuel Company)
First Well Name: Stapleton #1
Producing discovery horizon: Ordovician Viola known as the "Stapleton Zone"
First production amount: 95 bbl/day from 600' before being deepened to 2,500' where it increased to 110 bbl/day
Historic Production #'s: The El Dorado oilfield produced 29-36 million barrels a day, equating to 64% of Kansas output and up to 9% of the national output during WWI
Total Production to Date: >300 Million Barrels
Producing horizons: Shallow Permian age sands that are gently folded over the deeper structure, the Viola, & St. Peter
Trap: Structural Anticlines
Fun Facts: In 1912, El Dorado had the first woman bailiff in Kansas and the US, Eva Rider. Mrs. Rider assembled the first women's jury of Kansas, which was composed entirely of El Dorado women.

Pioneers named El Dorado, Kansas, in 1857 for the beauty of the site and the promise of future riches but not until 58 years later was black gold discovered when the Stapleton No. 1 oil well came in on October 5, 1915. El Dorado's leaders were envious when nearby towns found huge gas fields and thrived. John Donley, an El Dorado barber, had tried to find either gas or oil in 1878 at a nearby site selected by a spiritualist. He staked out a townsite and drilled 200 feet before running out of money. Wells in 1879 and 1882 produced only brine. In June, 1914, chafed over discovery of oil in nearby Augusta, El Dorado city fathers contracted with Erasmus Haworth, soon to retire from his position as State Geologist, to perform a geological study of the area. His field work outlined the El Dorado Anticline, which unsuccessfully was drilled first in August, 1915. On abandonment, the Wichita Natural Gas Company purchased the lease and drilled the Stapleton No. 1 oil well. More success followed and by 1918, the El Dorado produced 29 million barrels, almost 9% of the nation's oil. Earlier giant fields had hurt the price of crude oil but the El Dorado came in as both World War I and the rapid popularization of motor transport made a market for both light and heavy ends of the refinery stream. In late 1995, the El Dorado Field produced its 300 millionth barrel of oil. -USGS



Reeves, 1929

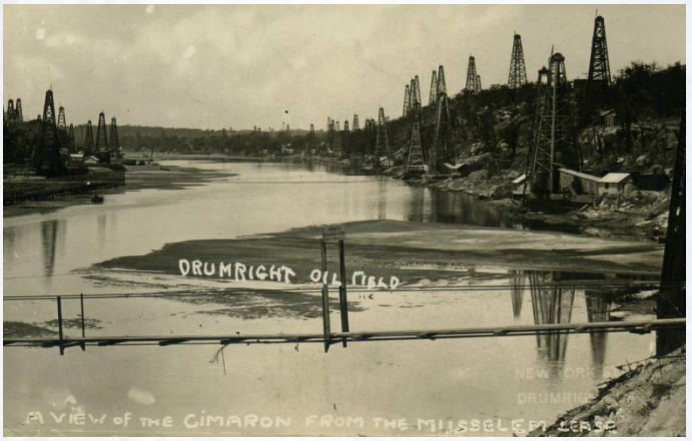
Kansas Historical Society

Oil Field History: Cushing Oil Field

Year Discovered: 1912
Discovered by: Thomas B. Slick and C. B. Shaffer
First Well Name: Wheeler #1
Producing discovery horizon: Wheeler sand at 2,347'
First production amount: 400 bbl/day
Historic Production #'s: 236 million barrels were produced by 1919
Total Production to Date: >250 Million Barrels
Producing horizons: Pennsylvanian Layton, Jones, Wheeler, Prue, Skinner, Red Fork, and Bartlesville sands as well as the Ordovician Wilcox sandstone
Trap: Structural Anticlines
Fun Facts: Cushing is now a major trading hub for crude oil.

This field, often called the Cushing-Drumright Field, is about twelve miles east of Cushing and one mile north of present Drumright. After the discovery well was drilled, Slick managed to keep it a secret for almost two weeks while he and his partner leased as much of the surrounding property as possible. When word of the discovery leaked out, an oil boom erupted with the town of Cushing as its supply center. In November of 1913, the Prairie Oil and Gas Company brought in a massive producer from the Bartlesville sand at a depth of 2,600'. And in January of 1915, yet another prolific pay horizon was discovered in the northern part of the field. Daily field production peaked in May of 1915 when 3,090 wells produced 310,000 barrels of oil.

By the end of 1919 the Cushing-Drumright Field had produced 236 million barrels of oil since its discovery. In that same year the field produced 17 percent of all the oil produced in the nation. Additionally, almost fifty refineries and ten natural gasoline (casinghead gas) plants were built in the area of the field, and numerous pipelines made marketing Oklahoma oil much easier than in the past. Moreover, Oklahoma became the focus of national oil production just at the beginning of World War I when a huge quantity of petroleum was needed. -Oklahoma Historical Society



Digital Prairie Ok

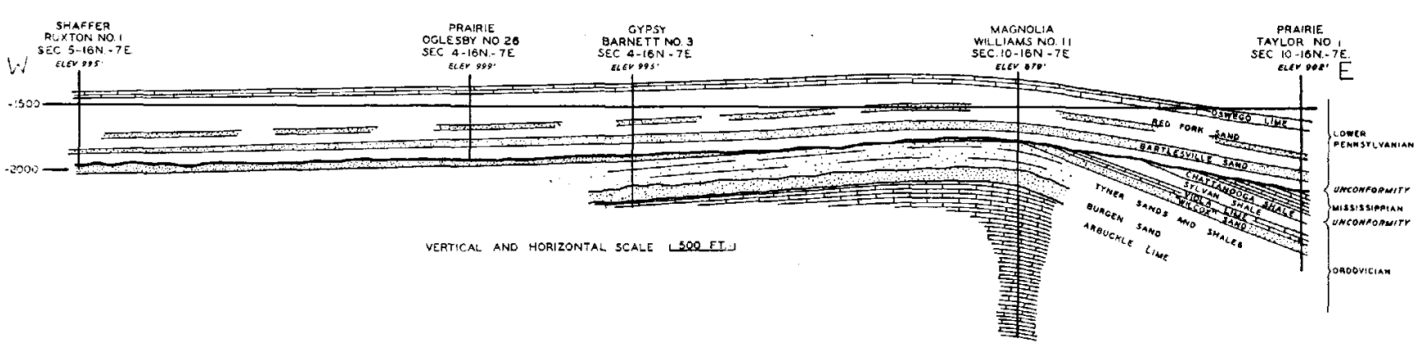


FIG. 6.—West-east cross section, *C–C* (Fig. 3), through the north part of T. 16 N., R. 7 E.

Weirich, 1928

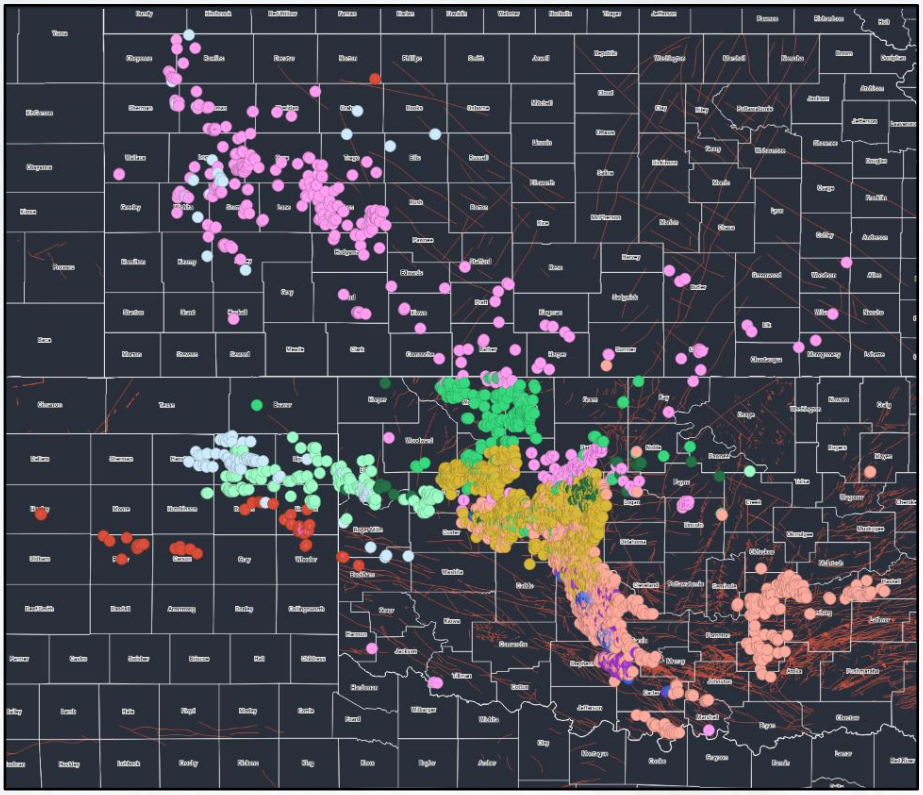
Midcontinent Oil History Quiz

1. **What is the deepest well in Oklahoma?**
2. **What was Oklahoma's first oil company?**
3. **When was the first oil well drilled in Oklahoma?**
4. **When was the first "commercial" oil well drilled in Oklahoma?**
5. **How much crude oil and natural gas does Oklahoma have in reserves?**
6. **When was the first commercial oil well drilled in Kansas?**
7. **Where was the famous 1903 gas well drilled in Kansas containing significant amounts of Helium, known as "the gas that wouldn't burn"?**
8. **What are some of the famous fields in the Midcontinent that contain the largest reserves of Helium in the US?**

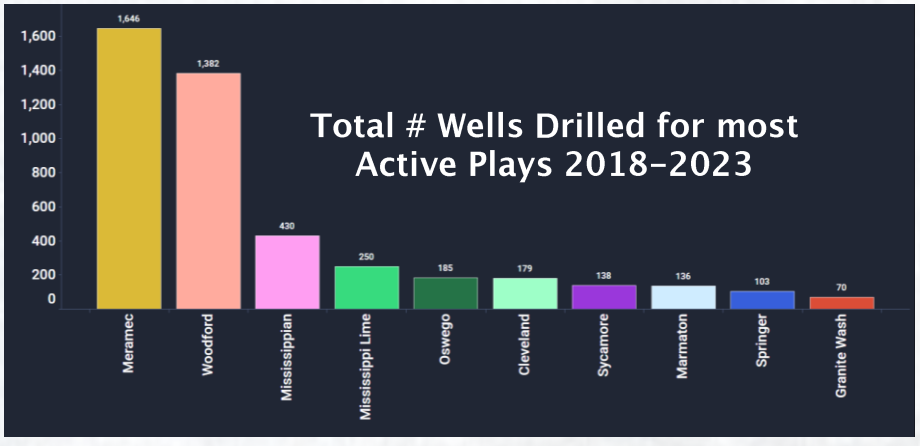
1. ***The 1974 Bertha Rogers No. 1 well in Washita County, a 31,441 foot dry hole in the Anadarko Basin***
2. ***Chickasaw Oil Company, organized in 1872 and encouraged individual citizens to develop natural resources.***
3. ***In1889, a wildcatter named Edward Byrd secured mineral leases from the Cherokee Nation. He drilled his first well near present-day Chelsea in 1890, and found oil at a depth of only 36 feet. His well produced about a half a barrel a day but his efforts were hampered severely by government regulation, inadequate transportation facilities and the lack of a readily accessible market. His Chelsea well is still celebrated as Oklahoma's first oil well.***
4. ***After securing rights to explore in the Cherokee Nation, a small group of businessmen drilled on the west bank of the Caney River and found oil on March 25, 1897, at a depth of about 1,300 feet. A few weeks later, Bartlesville residents gathered at the site to watch the "shooting" of the Nellie Johnstone No. 1, the future state of Oklahoma's first commercial oil well, sometimes known as the "Bartlesville Gusher".***
5. ***1.47 billion barrels & 35.5 trillion cu ft***
6. ***About 110 miles southwest of Paola, on November 28, 1892, after 22 days of difficult drilling, the Norman No. 1 well found oil at Neodesha. The first commercial oil well in Kansas was completed in a garden plot belonging to T.J. Norman, a local blacksmith. William Mills made the discovery along the banks of the Verdigris River. Since he had been drilling for natural gas (near natural oil seeps) he temporarily capped the well, which was about 830 feet deep.***
7. ***Dexter, KS. The entire town gathered at the well as the mayor made a speech proclaiming the wonders the well would bring. He then ordered a burning bale of hay to be placed in the well. Instead of the gas catching flame, as all expected, the fire on the bale was put out. This process was repeated several times, but always the flames would be extinguished. Dexter's dreams of becoming an industrial metropolis were blown out with them.***
8. ***The Hugoton field, the Panhandle field in Texas, the Greenwood field in Kansas, and the Keyes field in Oklahoma. These contains unusually high concentrations of helium, from 0.3% to 1.9%***

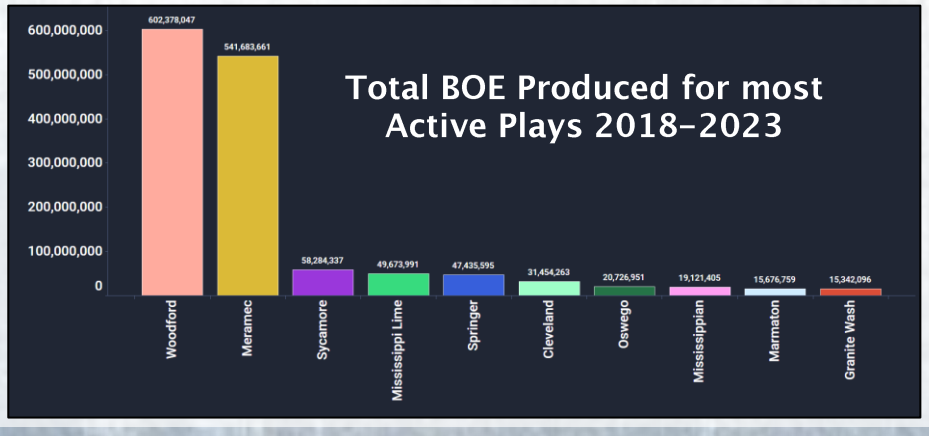
Recent Activity

Most Active Midcon Plays 2018-2023



- Cleveland
- Granite Wash
- Marmaton
- Meramec
- Mississippi Lime
- Mississippian
- Oswego
- Springer
- Sycamore
- Woodford





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Monday	Room 301AB

How to be and Independent (David Sanger, Jim Bedford)

8:05–8:35 **Options for an Independent**

Suzanne M. Rogers

As a geologist progresses through her career, new options appear that are more than just drilling a well. There is the usual prospecting on your own, but also consulting for clients, evaluations of drilling deals for clients, royalty and mineral appraisals for attorneys and others, buying production and minerals, and being an expert witness. Each of these areas will be discussed with information as to how give yourself some protection for your idea as well as how to do the necessary calculations to handle each and buying at a good price. Copies of sample documents discussed will be available.

8:35–9:05 **The Independent Geologist – When Preparation Meets Opportunity**

Michael W. Smith

The Independent Geologist must embrace the importance of independence and self-reliance. A successful and effective Independent should possess qualities such as collecting and analyzing data, organizing and filtering information, understanding the local industry, and being adaptable yet committed to their work. It can indeed be a challenging but rewarding journey for those who choose to pursue their future as an Independent Geologist.

9:05–9:35 **To Be or Not to Be an Independent**

Kristie Ferguson

The timing is never right, and your experience level is never appropriate to take the leap and “hang out your shingle”, “hit the pavement”, “jump off the ledge”, or however you may refer to becoming an independent. The truth is most become independent not by choice. This not by choice may be the best thing in the world along with the scariest thing to ever happen all at once. Timing, funding, paths, obstacles, skills, networks, good times, bad times, really bad times, constant learnings, and continual redefining yourself will be just a bit of what is discussed. This talk will address the basic questions and go into the realisms of what life can be like on the outside.

10:00–10:30 **Open-Source Mapping Software for Independent Geoscientists**

John McLeod

Mapping software is the cornerstone of modern exploration and production analysis. Mapping, including the gridding and contouring of well data, georeferencing raster images, and linking map elements to external programs, is a basic requirement for most geoscientists. It does not, however, necessitate investment in expensive commercial software. If you primarily develop and promote vertical drilling prospects, for example, open-source geographic information system (GIS) software can manage these essential tasks. Open-source GIS can also perform useful tasks that are not included in some commercial industry software. A downside of committing to a new mapping platform is the time and effort involved in learning a new complex program that is a toolkit rather than an industry-specific platform. In addition, some geoscientists may have only a cursory knowledge of computer mapping from their salaried careers, as they were provided technical assistants to create projects, load data and even do gridding and data analysis. Others will elect to purchase expensive licenses for their old software so as not to have a steep and time-consuming learning curve. Like commercial software, the utility of a core mapping program and its plugin extensions can be enhanced by linking map elements to external programs to manage specialized tasks, such as geosteering, seismic interpretation, petrophysics, cross-section construction and 3D visualization. Linking can also provide an easy path from map elements to well documents, research papers, images and website URLs that will facilitate a comprehensive project containing all data types in an area of interest.

Abstracts in Chronological Order

Monday	Room 301AB

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10:30–11:00 **Geology on the other side of the rock: Life as an "environmental" geologist**

Kathy Lippert

Reservoir Characterization for the Environmental Geologist is a different scale than in Oil and Gas Exploration. As an example, the rock with porosity is an aquifer, not a reservoir. A Site Characterization Model is the equivalent to reservoir characterization; our SCM is used to develop a remedial plan for the identified contaminants. Our job is to clean the earth up.

11:00–11:30 **Theory, Application, Discovery: From OGCS Talk to Drilling to Production!**

John Brett, Ted Beaumont*

Where is your next exploration or development idea coming from? Why not the next OCGS technical presentation? That is exactly where the technical methods came from that took a tired, uneconomic prospect to a profitable venture. An OCGS luncheon meeting unexpectedly unlocked a way to calculate the potential oil column of a low perm Lansing reservoir in the Hugoton Embayment, resulting in the patience to drill "one more well". Ted Beaumont's presentation in 2004 explained how capillary pressures and buoyancy pressure are related, and even measurable. This presentation will show the field development history and the impact of the application on developing additional reserves. From now on, I always try to take away some nugget from any talk I attend- you should too. It might just pay dividends!

Monday	Room 301CD
	Geology and Geophysics of the Midcontinent: The Anadarko Basin-Part 1 (Will Shaffer, Abidin Caf)

8:05–8:35 **Finding New Oil the Old Fashioned Way – An Update on New Developments in Old Areas and Old Concepts Being Applied to New Places**

Bryan Bottoms

The Mid-Continent has seen a resurgence of development in mature producing areas. Whether it be from new benches being delineated, or from old concepts being applied to new areas, the Mid-Continent continues to offer new opportunities. Plays such as the Red Fork, Cherokee, and Oswego may be limited in areal extent or repeatability when compared to plays in other basins, but successful operators have leveraged geologic knowledge to underpin their innovation and success within these developments. Similarly, old plays such as the Tonkawa & Caney, and mature areas like Sho-Vel-Tum have seen operators pair legacy play concepts with technological advances to create successful outcomes. As the Mid-Continent has recently been overlooked due to the maturity of its development and geologic complexity, investors and operators with a geologic acumen can benefit from a lower cost of entry compared to elsewhere in the Lower 48. Additionally, these same concepts being applied in the Mid-Continent, are being applied elsewhere in places like the Permian and beyond. This talk will discuss interesting developments and similarities between new plays in the Mid-Continent and elsewhere in the Lower 48.

8:35–9:05 **Integration of Microseismic and Geochemical Profiling to Understand Effective Drainage Height**

Shawn Maxwell, R. Brito, G. Ritter, J. Sinclair, A. Leavitt, F. Liu and J. Bachleda*

This study integrates microseismic hydraulic fracture mapping with geochemical production profiling to understand the interaction between mechanical stratigraphy, fracture geometry, and effective drainage for wells landed in different benches of the STACK play in Oklahoma. Microseismic monitoring was used to map the extents of the hydraulic fracture system contacted during stimulation, while high resolution geochemical analysis or 'fingerprinting' was used to assess how different formations in the reservoir were draining. Microseismicity showed that hydraulic fracture growth from an Upper Meramec well rapidly cover the entire Meramec interval with some growth downward into the Woodford. Conversely, microseismicity initiating from a Woodford well clustered in that layer and grew upward into the Lower Meramec with time. Geochemical profiling closely matched the microseismic depth distributions for the associated well landing zones. Similar to the microseismic hydraulic heights from both Upper and Lower Meramec wells consistently produced from the entire Meramec, with additional recovery from the Woodford. Woodford landed wells produced Woodford oil with some production also coming from the Lower Meramec, also consistent with the microseismic depths. These production profiling trends were found to be very consistent across multiple sets of wells drilled into the same target formations. Integrating mapping of hydraulic fracture growth with geochemical assessment of the effective drainage within the hydraulically contacted zones provides unique insights into the reservoir contact and drainage. Understanding the mechanical stratigraphic controls on hydraulic fracture height growth relative to the reservoir drainage is key to informed decisions on wine-rack configurations for optimal reservoir drainage.

9:05–9:35 **Comparison and Re-assessment of Middle-Late Mississippian Strata Across North America**

Buddy Price

The Mississippian subsystem of North America houses multiple historic and current hydrocarbon reservoir objectives representing both conventional and unconventional targets. Most major onshore United States basins contain some level of productivity from Mississippian-age intervals. A majority of the Mississippian strata accumulated across North America during periods with greenhouse conditions, generally low amplitude sea-level fluctuations, and minimal syndepositional tectonism, imparting low levels of heterogeneity in the system. However, even with minimal influence from allogenic depositional drivers, discussions still exist in terms of depositional environment and processes driving sediment accumulations. Specifically, recent debates focus on middle to upper Mississippian siliciclastic-rich intervals through the Anadarko Basin in Oklahoma represented by the informally termed "Meramec" unit in the STACK play and the siliciclastic-rich Sycamore "Limestone". The arguments appear to be due to a historical lack of biostratigraphic data in key studied regions, regional inconsistencies of formation names, the use of formation designations as correlative time intervals, lack of incorporation of craton-wide studies when assessing the system, use of incorrect paleogeographic reconstructions for certain ages of the Mississippian, use of carbonate depositional environment terminology for siliciclastic systems, and the proliferation of 1-dimensional core studies and/or localized 3-dimensional studies driving interpretations of the entire system. This study aims to address some of these issues within middle to upper Mississippian strata across the United States equivalent in age to the debated siliciclastic-rich sections in Oklahoma. As the interval houses reservoir potential in the Anadarko Basin and likely other regions across the U.S., accurate characterization of depositional environment and paleogeographic reconstruction should aid in understanding facies architecture, stratal geometries, and sequence stratigraphic implications across the North American craton.

10:00-10:30 **The Red Fork Delta Revisited**

Rick Fritz, Chris Johnson, & Mike Kuykendall*

In 1985, Masera Corporation geoscientists started a project to map the Middle Pennsylvanian Red Fork sandstone-shale complex across Oklahoma. Up to that time, the Red Fork was like the example of multiple scientists wearing blindfolds and trying to describe an elephant. Many workers had described different parts of the delta, but a comprehensive map was not available—primarily due to the sheer size of the complex. To understand the geometry of this large deposit. 33,000 logs were correlated across Oklahoma. Regional correlation showed the Red Fork sandstone had formed as the result of progradation across eastern Kansas and most of Oklahoma. With this understanding, new sequence stratigraphic methods were used to divide the Red Fork into at least three prograding sequences. In addition, each sand body was given a depositional indicator based on core and log response (this proved to be the key to mapping). Core descriptions were derived from various master's theses combined with core donated from companies working the Red Fork. The Red Fork is one of several transgressive-regressive sequences (cyclothems) developed within the Desmoinesian Cherokee Group. Sea level changes, together with varying subsidence, were dominant factors controlling the general stratigraphic (correlative) characteristics of the Red Fork interval. Progradation was episodic, with sand deposition in the more active part of the basin during lower sea level stands and valley-fill deposition in the more stable areas during sea level rises. A map of Red Fork sand trends reveals an alluvial-deltaic complex covering most of Oklahoma. The Red Fork consists primarily of alluvial-valley and plain (fluvial) bodies in the northernmost part of northeastern Oklahoma, alluvial-deltaic bodies in most of the remaining parts of the shelf area, valley fill and marine bar deposits in the mid-shelf areas, and off-shelf submarine-fan and slope basinal-floor complexes within the deeper part of the Anadarko basin. Determination of reservoir trend and genesis requires integration of rock and log data. Logs need to be calibrated to cores in order to estimate depositional environments accurately and to make a reasonable assessment of diagenetic overprints. Red Fork reservoirs are charged with oil and gas from both Devonian and Carboniferous source rocks. Much of the oil and gas has been trapped in stratigraphic traps, and a significant amount of oil is in channel sandstones with trends at high angles to the structural grain. In some areas, secondary clay, in particular chloritic clay, has resulted in microporosity, high water saturation, and correspondingly low resistivities in oil reserves. The Red Fork sandstone and the surrounding Cherokee Group sands and shales form a system of complex, hydrocarbon saturated reservoirs. As a result, there is opportunity for multiple resource plays using unconventional drilling and frac'ing methods.

10:30-11:00 **Paradise Machine Learning Technology – Understanding the Sub-surface in Detail**

Deborah Sacrey

Multi-attribute machine learning using SOM (which is an unsupervised learning process) can be shown to reveal details in the data not previously identified and which can be interpreted to be lithologic in nature. The detail comes with the statistical analysis of the data based on information from each sample at each trace in the data. The result of this sample-based statistical analysis is that one can interpret thin-bed resolution well below conventional wavelet tuning. This in turn, helps with highly accurate reservoir prediction when one ties the information to existing production or in the estimation of new reserves in exploration plays. This presentation will be showing a project, commissioned by TGS, to study the ability of machine learning to see "sweet spots" in unconventional resources. The target area was in Blaine and Kingfisher Counties, Oklahoma, and the study formation was the Mississippian-age Meramec Formation. Wells used for calibration were straight holes as opposed to horizontal wells, due to the variation of completion techniques. TGS supplied the seismic data and various support volumes, including Inversion volumes for use in the analysis. They also supplied all the well information including digital logs and testing/production information. Synthetics were created on key wells to better tie the neural information to exact points in completion. The results support the ability to identify higher porosity and resistive beds within the Meramec Formation, which results in better performance in production. Additional work was done in calculating and predicting the production using geobody volumes created from the cluster data.

11:00–11:30 **Seismic-constrained reservoir modeling and simulation for CO2 sequestration potential of the Arbuckle Group: Wellington Field, Kansas**

Abidin Caf

In this study, we integrated seismic elastic property and amplitude information with well log and core data for a seismic-constrained modeling and simulation workflow. The aim is to model the CO2 storage potential and long-term CO2 plume behavior of the Arbuckle Group at Wellington Field, Kansas.
We first defined three petrophysically constrained rock types (petrofacies) from core-derived porosity and permeability measurements using the flow-zone indicator (FZI) approach. Then, using the artificial neural network (ANN), we classified these petrofacies in non-cored intervals and a well. We observed that petrofacies 1 corresponds to medium and coarse-grained dolomitic packstone, wackestone, and dolomitic breccia with up to 8% porosity and Darcy-scale permeability values. Whereas petrofacies 2 and 3 correspond to argillaceous and fine-grained micritic dolomites and dolomitic mudstones with lower permeability values for a given porosity, with respect to petrofacies 1. Using the common reflection-point gathers, we performed pre-stack simultaneous inversion and calculated various amplitude-versus-offset (AVO) attribute volumes. We used these elastic properties and AVO attribute volumes as input for estimating supervised seismic-scale 3D petrofacies and petrofacies probability volumes using the Random Forest algorithm.
To further address the spatial variability of petrofacies and corresponding petrophysical properties, we used the 3D petrofacies and petrophysical-property trends with well log and core data and generated 3-D seismic-constrained petrofacies, porosity, and permeability models of the Arbuckle Group via geostatistical modeling. Seismic-constrained models reveal the lateral and stratigraphic heterogeneity of petrofacies, porosity, and permeability. Low permeability petrofacies of the middle Arbuckle interval act as baffles and barriers to fluid flow. Relatively higher porosity and permeability petrofacies in both the lower and upper Arbuckle are candidate injection zones. We calculated the theoretical CO2 storage capacity using the DOE- NETL equation for saline aquifers. The theoretical CO2 storage capacity for the study area is estimated between 0.95, 5.41, and 22.5 Mt for low-, mean-, and high-case scenarios. Using these static models, we performed dynamic CO2 injection simulations to evaluate the subsurface behavior of a theoretical CO2 plume for long-term carbon-storage potential. Dynamic simulation results show the CO2 plume is dispersing laterally and contained within the injection zone during both injection and post-injection periods. The integrated workflow allows us to integrate seismic information with well-log and core data through supervised machine learning algorithms to further constrain the geostatistical models. Compared to the previous studies, this workflow differs significantly and produces 3D reservoir models that represent the stratigraphic variability of subsurface properties in greater detail; thus, further reducing the subsurface uncertainty in the study area.

Time	Room 301AB
	Emerging Energy and Resources of the Midcontinent (Garrett Powell, Tyler Gruenbacher)
1:15–1:45	**Identifying Value Elements in Oilfield Brines** *Brent Wilson* To maintain profitability, energy companies often undertake a systematic process of evaluating costs and efficiencies. This endeavor can prove especially beneficial during periods of declining oil and gas prices or inflation, resulting in higher service and materials costs. Though this exercise often leads to economic improvements, the law of diminishing returns can become a limiting factor. At some point, companies squeeze every ounce of value from their operations. Or do they? In addition to increasing revenue margins through reductions in operating costs, energy companies may also want to consider value creation through new revenue streams when feasible. For example, the industry produces a significant amount of saltwater as a byproduct of oil and gas production. Regarded as waste, the saltwater is eventually pumped back into the earth via disposal wells. While much effort has been placed on water capture and recycling in recent years, most operators reinject waste fluids without analyzing the full chemical content of these brines, which can contain other extractable commodities. It has been correctly stated that seawater contains gold. Measured in parts per trillion, the concentration is extremely low, making it economically infeasible to capture due to current gold prices and production costs. Alternatively, there are other elements (some more valuable than gold) found in meaningful concentrations within oilfield brines. In fact, the economics are sometimes favorable enough to produce these elements as standalone products. Because these elements often go undetected, operators miss out on potential value streams associated with their wells. In 2018, Galvanic Energy was founded on the premise that critical minerals such as lithium, cobalt and nickel are required for the rapidly growing electric vehicle (EV) and energy storage sectors, and demand was significantly outpacing supply. After researching potential domestic resources, Galvanic eventually focused on the Smackover Formation in southern Arkansas. Historically known for its bromine-rich brine, the company found it was also elevated in lithium and other value elements. Given lithium is the key ingredient in the lithium-ion batteries used in electric vehicles, electronics and power tools, the Smackover became Galvanic's primary target. After successfully delineating, leasing and testing a 120,000-acre prospect, Galvanic sold the project to a major oil and gas company and is now exploring new prospect opportunities. While lithium remains the company's primary focus, it is also evaluating other critical elements of interest. Although the Galvanic team got its start in the oil and gas industry, its story illustrates how geologists, landmen and other industry professionals can pivot their careers when new opportunities arise without abandoning core competencies and skillsets developed in the oil and gas sector. This presentation will provide an overview of some of the elements already being produced from oilfield brines, critical minerals that will be required in the future, extraction technology insights, and key takeaways from Galvanic's lithium exploration venture.
1:45–2:15	**Oklahoma Geological Survey & The Energy Transition** *Nicholas Hayman* The Oklahoma Geological Survey (OGS) houses much of the state's geologic core and data, operates a public seismic network, and strives to keep the public and scientific communities informed of the latest science about energy and the environment. The OGS currently is navigating the dual mission of supporting the oil-and-gas industry of Oklahoma, while also preparing Oklahoma for the energy transition toward net-zero carbon-dioxide emissions. The two sides of this "energy mission" interact in surprising ways. For example, geological carbon sequestration both relies on our understanding of reservoirs traditionally targeted for disposal of fluids produced by oil-and-gas production. Moreover, carbon sequestration will likely be paired primarily with large fossil-fuel power plants to offset emissions. Future use of hydrogen is planned as a cleaner-burning fuel that can potentially be produced with lower greenhouse gas emissions than natural gas alone. Geothermal energy is surprisingly available even away from active anomalies. Lastly, the raw materials for much of this energy transition – including a stronger dependence on battery storage – is leading to a reassessment of the domestic mineral resources, which stem both from hard-rock mineral deposits and waste-streams from hydrocarbon fuels. The geological approach to this energy transition is well-defined, but requires elimination of zero-sum thinking and increase in local enthusiasm to succeed.

2:15–2:45 **Chasing Lithium: Oil Field Brine and Petroleum Correlations Across Southeastern Oklahoma**

Catherine Donohe, Adam Turner, & Alex Zumberge*

Operators with existing positions in southeastern Oklahoma are familiar with the world class performance of the Woodford source rock and the additional opportunities being identified within the Caney formation. However, shareholders are increasingly looking to see energy companies provide opportunities beyond petroleum resources. Lithium and other mineral components of oilfield produced waters have been recognized as a potential revenue opportunity that helps diversify operator portfolios while complimenting the primary hydrocarbon operation. Here, we examine trends that relate produced water chemistry, with a focus on lithium, to petroleum system trends such as maturity and migration pathways to characterize the current natural resources of the southeastern Oklahoma area.
The study area covers the production areas from the eastern Anadarko, Ardmore and Cherokee Basins as well as the Seminole Uplift and includes the eastern portion of Grady County along with Cleveland, McClain, Garvin, Murray, Pottawatomie and Carter Counties. The data set that will be shown consists of over 1,900 produced water samples, 9,500 Woodford and Caney source rock samples, and 150 oil samples. These samples were cleaned and reviewed for basic data quality and consistency and integrated into a simple basin model to describe the present day structural and thermal trends of the study area. The data was then compared to known Lithium and petroleum workflows such as correlations with TDS (total dissolved solids), maturity (based on pyrolysis Tmax), and oil migration trends (based on geochemical interpretations completed previously to this study).
This work provides a basic ranking order for the studied areas based on measured Lithium ranges and potential in produced oilfield brines. Results will show that of the areas studied, the Ardmore Basin shows the best potential for Lithium brine exploration. While parts of the Anadarko basin show similar mineral concentrations, correlations with Lithium are independent of some previously assumed trends such as TDS. Maturity relationships with the Woodford source rock proved to be inconclusive over the area, as many of the high lithium potential regions are structural complex and the measured chemistry of migrated fluids are independent of maximum maturity. This work represents an easily adopted workflow for evaluating brine potential in areas in the context of petroleum systems, allowing current operators to leverage previous learnings into new resource exploration.

3:10–3:40 **Vintage Value: Unconventional Exploration of Overburden and Salt Structures' Impact on the Hugoton's Hydrocarbon-Helium Gas System**

Matthew Fox, Wahid Rahman*

The Hugoton and Panhandle Gas Fields' and their satellite extensions', in short "The Hugoton", produce low BTU (850-1050) dry gas enriched with economic helium concentrations (0.25 – 2.5%) predominantly from the shallow Permian reservoirs that extend across Southwest Kansas and further southward into the panhandles of Oklahoma and Texas (Hemsell, 1939; Rascoe, 1968; Pippin et al., 1970; Caldwell, 1991; Sorenson, 2005; Dubois et al., 2006). The Hugoton was originally discovered in Seward County, Kansas during December of 1922, but it wasn't until May of 1927 that the Hugoton Field was truly identified and subsequently became important (Hemsell 1939; Pippin et al., 1970). Since the 1922 discovery well, the Hugoton has produced somewhere between 50-70 TCF of natural gas commingled with crude helium volumes totaling 120 BCF (Foster et al., 2022; Peterson et al., 2022; Fox et al., 2023a; Fox et al., 2023b). This volume was achieved with 18,000 field development wells. Today, the Hugoton continues to capture roughly 1.2 BCF of helium annually (20 – 25% of global production) from 300-500 BCF of gross commercial natural gas, per year. The objectives of this paper are to observe the Hugoton's regional overburden variability; define the Hugoton's salt seal's timing; and to demonstrate how salt structures played a role in helium gas migration and accumulation in different reservoirs in and around the Hugoton. Along the western margin of the Hugoton, a few satellite fields are proven to produce higher helium concentrations than its main trend (Fox et al., 2023a; Fox et al., 2023b). Like the Hugoton, these satellite fields produce gas from Wolfcampian Chase Group reservoirs at shallow depths of 3,000 feet or less. The regional overburden interplay between a thousand feet of Permian layered evaporites and their roof of marginal Mesozoic Interior Seaway coupled to the Hugoton's distal tectonic uplift history from Laramide Orogeny and Front Range Thrust, created a series of salt tectonic expulsion rollover evacuation structures that provided gas migration pathways responsible for charging and

compartmentalizing the satellite fields' reservoirs. The salt tectonic analysis is the result of detailed salt interval mapping across 15,000 wells in Kansas's Southwest 15 counties.
The 15 counties in the regional study include the 8 counties that define the Hugoton Field's corridor, as well as their neighboring counties to capture the full extent of the mapped salt basin. The regional salt tectonic structures' coeval timing with the post Laramide migratory gas front (Sorenson, 2005), indicate the salt structures provided fluid migration pathways to the satellite fields' reservoirs and the salt feeder's eventual structural collapse provided the subregional gas system's seal. The Hugoton's satellite fields show how overburden thickness and the salt seal integrity play a critical factor in controlling the underlying distribution of pre-salt reservoir fluids and the geologic conditions constraining where the reservoir fluids can be most economically produced today.

3:40–4:10 **Future Prospects of Helium Exploration in Oklahoma with Legacy Samples, Modern Insights**

Christopher M. Smith. Timothy M. Smith, Patrick S. Gordon, & Michael P. Smith*

Helium has previously been listed as a critical mineral by the United States government and represents an important feedstock for critical industries and applications including aerospace, medical imaging devices, and specialty welding applications. The US has a well-developed helium infrastructure and historically good data collection which enabled it to become a predominate producer of helium; much initially based in the Oklahoma and Texas panhandles and Kansas. A major producing field and location of key infrastructure is Keyes Field in Cimarron County, Oklahoma. Wells that identified helium (≥2%) were drilled in the 1950s with off and on helium production for the next several decades. Advanced Hydrocarbon Stratigraphy (AHS) partnered with the Oklahoma Geological Survey to examine cores from the Keyes Field early in its life cycle and after over a decade of production. AHS significantly improved its Rock Volatiles Stratigraphy (RVS) technology to measure sub-nanomole quantities of helium from rock samples. This study, to our knowledge, was the first quantitative measurements of helium from core samples being several decades old; 69 years at time of analysis. These data are likely from the pores of the rock samples, not fluid inclusions; core from a well offset to a producing well drilled 10+ years prior shows fractionation signatures from gas production and correspondingly low helium. Examining multiple cores with available helium and production data in the well or from offset wells across different time horizons in the field allows for an appreciation of how this conventional helium enriched natural gas field, which is still produced for its helium today, has been drained. While the number of cores in this study are limited, such an approach on a wider scale may enable targeted drilling and continued development of the Keyes dome and other conventional helium brown fields. Additional key observations are the ability to identify low water content by RVS measurements and helium can be best preserved in "tighter" rock of poorer reservoir quality. This presents a usable workflow for RVS studies utilizing legacy samples - identifying enhanced helium responses in/below sealing features with low water content in the reservoir below the seal. Utilizing legacy materials from state surveys in Oklahoma, Kansas, and Texas has important implications for continued use of the existing helium infrastructure as fields mature and presents an important tool for future helium exploration.

Monday	Room 301CD
	Geology and Geophysics of the Midcontinent: Kansas and Arkoma (Troy Johnson, Jason Currie)

1:15–1:45 **Demonstrating the Utility of CO2 Entrained in Legacy Drill Cuttings as a Proxy for Pressure Compared to Drill Stem Tests Measurements in Oil Fields from Kearny County Kansas**

Christopher M. Smith, Timothy M. Smith, Patrick S. Gordon, Michael P. Smith, & Franek Hasiuk*

Prior work on the solubility of CO2 in water and oil phases for a variety of subsurface applications including enhanced oil recovery (EOR) and saline aquifer CO2 injection, better known as carbon capture and sequestration (CCS), has established that the pressure in the subsurface exerts a strong control over this solubility. Direct measurements of CO2 in fresh and legacy cuttings by the rock volatiles stratigraphy (RVS) methodology has established a relationship between the quantity of CO2 present, knowledge of pressure regimes in a given wellbore, well performance issues directly linked to subsurface pressure, and/or past activities in the subsurface that would have led to pressure loss. Herein, for the first time we compare direct measurements of CO2 and other associated entrained volatile compounds measured by RVS in unpreserved cuttings (Patterson and Hartland fields in Kearny County, Kansas) to pressure measurements taken in the same zones in either the same or directly offset wellbores. RVS is a novel technique that directly measures 40+ different volatile small molecule compounds contained in fresh and legacy rock samples under various vacuum extraction conditions developed by Advanced Hydrocarbon Stratigraphy (AHS). Working in partnership with the Kansas Geological Survey (KGS), RVS was previously utilized on fresh cuttings from CarbonSAFE Phase II wells drilled by KGS in 2020 at the study area to compare the CO2 measured in the cuttings to a regional baseline in order to establish if there was any past history of potential CO2 loss at the Patterson CarbonSAFE site. Of particular interest were subsequent comparisons between these data and data from legacy cuttings, especially the 1941 Patterson field discovery well. In comparing the Morrow Sand, under production for 79 years between the 1941 and 2020, Patterson wells showed a significant reduction in CO2 while in the deeper carbonates (e.g., Arbuckle Group that are a potential CCS injection target) there is no significant difference in the amount of CO2 present between the cuttings from the two wells. When examining the pressure data vs. the ratio of easily extracted CO2-to-water from the RVS data between these wells a fairly linear relationship is obtained. These relationships in addition to other factors that impact the concentration of CO2 in the subsurface (e.g., temperature, salinity, acidity, etc.) will be examined have been compared to pressure data. Beyond demonstrating the linkage between CO2 and pressure, this study may provide new insight into the controls on CO2 solubility in a subsurface aqueous phase and provide a new method of assessing subsurface pressure using existing rock samples collected from the drilling process. It also suggests that valuable information about seal integrity of potential CO2 storage reservoirs can be derived from cuttings rather than requiring expensive coring.

1:45–2:15 **Breaking Bad – Ordovician Source Rocks: the Primary Origin of Pre-Pennsylvanian, Produced Oils in South Central, Kansas**

Brian W. Wilhite & Tim Ruble*

Produced oil samples from nineteen wells along the western edge of the Sedgwick Embayment (Barber Co.) and across the Pratt Anticline (Comanche Co.) in south-central Kansas were analyzed by gas chromatography (GC) to determine their origin. Producing reservoirs sampled included the Ordovician Viola and Simpson Groups, the Devonian Woodford Shale, and the Mississippian Osage, Cowley, and Warsaw Formations. Geochemical parameters, particularly C7 hydrocarbon data, strongly suggest that the majority of these produced oils originated from an Ordovician-aged source. This study dispels the long-held theory of the Woodford Shale being the main source rock for south-central Kansas and therefore, contributes to the ever-evolving knowledge of petroleum systems within the Midcontinent. Sixteen of the nineteen sampled oils were characterized to be Ordovician-derived, either Assemblage A or Assemblage B. Assemblage A oils have a distinctive GC fingerprint indicating a high contribution of G. Prisca algal organic matter, high maturity and gravity (average 37o API), and are correlated with a possible Simpson and/or Lower Viola source (Champlainian-Blackriverian(?)). Reservoir fluids in the study area with an Assemblage A signature include the Simpson and Viola, as well as the Woodford. Ordovician Assemblage B oils are of lesser maturity and gravity (average 23o API), and indicate a possible Middle-Upper Viola and/or Maquoketa (Sylvan) source (Cincinnatian-Richmondian(?)). Reservoirs producing Assemblage B oils were restricted to the Mississippian Cowley and Osage Formations. The three remaining oil samples originated from a unique source that appears to be slightly enriched in terrigenous organic material and indicates a Pennsylvanian marine shale source (average 34o API). These oils were produced from the Mississippian Warsaw Formation, west of the Pratt Anticline, towards the Hugoton Embayment, demonstrating structural segregation in hydrocarbon sources. Two of the Mississippian Assemblage B oils, and all three of the Pennsylvanian sourced oils, hinted at a potential mixing with Woodford sourced oil, but the data were not unequivocal. Based on the green oxic shales in the Simpson and the gray shales in the Maquoketa, both of which are organically lean, and the thermal immaturity of the Woodford Shale, the produced oils are interpreted to have not been sourced in-situ or locally. Instead, these oils were likely generated in the deep Anadarko Basin and emplaced after long-distance migration.
Fluid inclusions and pyrobitumen samples from the Bartholow core provide insights on Ordovician oil migration into south-central Kansas. Documented pyrobitumen, trapped in the base of the Woodford Shale, indicates Ordovician-derived oil migrated into Kansas beginning as early as Late Devonian – during Woodford deposition. Petroleum fluid inclusions from both the Woodford and the upper Viola occur at homogenization temperatures of 90oC, suggesting Ordovician charging and entrapment continued into the Cretaceous, during maximum burial. In the modern world of exploration where source rocks that once charged 'traditional' conventional reservoirs are now major play objectives, understanding the origin, genesis, timing, and migration pathways, is crucial in the quest to find and discover new reserves.

Tuesday	Room 301AB

The Business Side of Oil and Gas (Joe Stone, Karelia La Marca)

8:05–8:35 **Let's Make A Deal!!! – Starting and Funding an E&P**

Joe Brevetti

This presentation details the process involved in starting and funding an E&P company. Steps outlined include the business plan, raising money, and the variety of deal structures including potential pitfalls. Also covered are various requirements to becoming an operator, suggested pathways, some "Rules of Thumb" and available resources.

8:35–9:05 **"Onward and Upward" Entity Structure for the Self-Employed and Basic Agreements**

Brett Sanger

This presentation will discuss the basic start up entity types and topics, as well as common business structures for self-employed individuals including common agreements utilized in the oil and gas industry.

9:05–9:35 **A Day in the Life of a Branch Board Director**

Walt Duncan

Walt Duncan is President of Duncan Oil Properties, Inc. headquartered in Oklahoma City. Mr. Duncan has also served on the Oklahoma City Branch of the Kansas City Federal Reserve Bank for the past five years. In his role as a Branch Board member, he reports on the status of the energy sector within the Kansas City Federal Reserve Bank's District (District 10). District 10 encompasses western Missouri, Oklahoma, Kansas, Nebraska, Wyoming, Colorado, and Northern New Mexico. Mr. Duncan will briefly discuss the history of the Federal Reserve systems whose formation was the result of Oklahoma senator Robert Latham Owen's legislation which created the Federal Reserve System in 1913. Mr. Duncan will then discuss the structure and leadership of the Federal Reserve system. The Federal Reserve is charged with a dual mandate of full employment and stable prices by congress. The historic tools that are available to influence these mandates are blunt and affect different industries in different ways. The addition of recent tools that have been used to avoid the economic crises of the "Great Recession of 2009" and the impact of COVID will be reviewed. In understanding the total impact on the economy, it is important to understand the interaction between government stimulus and the role the Federal Reserve plays in controlling monetary policy and more specifically, to first, attempt to support the economy and employment during COVID and then to control inflation that resulted from both post-COVID economic conditions and the War in Ukraine. Finally, Mr. Duncan will provide an example of the information he provides at the Branch level (including oil and gas industry information) and how the Federal Reserve systems collects this information and uses it to make monetary decisions.

10:00–10:30 **Using Data, Facts, and Science to have a Rational Conversation about the Environment, Global Warming, Population Growth, and the Importance of Oil and Natural Gas in our Domestic and Global Economies**

Steven C. Agee, Ph.D.

The focus of this talk will be on the increasingly sharp attacks on the oil and gas industry by the environmental lobby – with a presentation of data and facts about the critical nature of oil and natural gas in both our domestic and global economies. Those of us from the oil and gas industry know about the importance, but many people outside the industry are simply ignorant of the data and facts that show that nearly 80% of our domestic and worldwide consumption of energy comes from hydrocarbons (oil, natural gas, and coal). Coal has been declining in use in the United States but not in other growing regions in the world – like SE Asia and Africa. With population growth occurring mostly in SE Asia and Africa, we need to understand their needs for energy supplies and security, so it is important to examine the overall global demand for energy – and where that energy will come from, and what sectors will be using it.

We will look at data and facts to demonstrate the importance of oil and natural gas in terms of running our economic engine, both domestically and globally, and how this need for energy resources will only be growing over the coming decades. We'll look at data and graphics about how slowly energy transitions take – typically decades and not just years, and you will leave with materials, data, facts, and graphics that you can use when you have discussions with members of the environmental community about climate change.

10:30–11:00 **Beyond Science and Technology, How Business and Regulations Impact Geology**

Dana L. Murphy

While technology has significantly changed how many geologists perform their work, ongoing changes in the business and regulation of oil and gas continue to have their impacts as well. Adaptability seems a key word for the geologist of today and tomorrow. Keeping apprised of changes is now a necessity. Among recent changes: The Corporate Transparency Act which is estimated to affect over 32 million small businesses now being required to file annually with the U.S. Treasury Department; the federal Infrastructure grant of funds for the plugging of orphaned wells in Oklahoma and other states; the digital transformation of the Oklahoma Corporation Commission; ongoing impacts to well completions and water disposal; the ever-growing pressure over the use of fossil fuels; and ongoing recovery from the effect of the pandemic on supply chains and work force.

11:00-11:30 **Improved Diagnostic Insight through Near-Wellbore Measurements: Advancing Completions Understanding**

Kevin Wutherich

Fracture diagnostics play a vital role in comprehending and optimizing completions designs, utilizing a range of tools from pumping pressures to fiber optics. While these diagnostic tools are continually advancing in terms of their quantity and quality, the information they provide is often complex and elusive. For instance, why do some perforations exhibit higher productivity within a stage compared to others? Or why are frac hits observed in certain stages but not in others? The underlying reason lies in the inherent heterogeneity of the reservoir, encompassing factors such as formation characteristics, perforation techniques, pumping parameters, as well as drilling and cementing practices. Variations exist not only between different stages and clusters but even within individual feet, rendering each stage unique and affecting the diagnostic response. Consequently, an important question arises: "If we are unable to quantify the impact of these factors on diagnostic response, how can we accurately interpret the results?" This presentation will emphasize the inclusion of near-wellbore rock properties as a fundamental component of almost any diagnostic service, offering a significant enhancement in the understanding of completions. By examining various instances where near-wellbore properties, such as rock strength and the presence of pre-existing fractures, have provided valuable context to pumping data, surface seismic analysis, microseismic monitoring, RA tracers, fiber optics, and image logs, the talk will illustrate their critical role. Additionally, a framework for utilizing near-wellbore properties in the development of a robust completions test plan will be discussed. Through this comprehensive approach, diagnostic insights can be substantially improved while incurring minimal additional costs.

Tuesday	Room 301CD

Geology and Geophysics of the Midcontinent: The Anadarko Basin-Part 2 (Cole Mount, Chris Wiggers)

8:05-8:35 **Rethinking the Woodford Petroleum System of Oklahoma**

John McLeod

The generation, expulsion and migration of hydrocarbons in a basin is broadly a product of thermal maturation of organic matter and geologic history. Mapping of normalized maturity data can represent the geometry of a basin during the first (and sometimes most important) phase of petroleum system formation. It is unusual for thermal maturity and modern structure to be perfectly concordant – the kitchen is the ancestral thermal basin and modern structure is the cumulative tectonic basin. Deformation can cause profound movement of previously trapped hydrocarbons as well as reactivate older/basement structure to allow penetration of hydrothermal fluids. Most produced oils in Oklahoma have been typed to a Woodford source, despite an abundance of other mature Carboniferous source rocks. Two major depocenters, the Anadarko and Arkoma Basins, were historically postulated as the principal Woodford “kitchens”. Expulsion and long-distance migration were thought to be largely normal to modern structural gradient that was caused by plate collision during the formation of the supercontinent Pangea during the Pennsylvanian. The normalized regional vitrinite reflectance maturity data of Brian Cardott (Oklahoma Geological Survey) affords an unusual opportunity to analyze postulated Woodford petroleum migration vectors as represented by its basin geometry at the time of maximum source rock maturity. The analysis suggests five major Oklahoma kitchens: Anadarko Basin, Ardmore Basin, Marietta Basin, Arkoma-Ouachita Basin and the Osage-Cherokee Thermal Anomaly. This latter lesser-known feature is a likely source of the prolific shallow Pennsylvanian Bartlesville sand oil fields in northeast Oklahoma. Major tectonic features, including the structural basins, the Nemaha Ridge, the Ozark Uplift, and associated basement faults had a profound later effect on the occurrence and distribution of Woodford-sourced hydrocarbon accumulations and losses in Oklahoma.

8:35–9:05 **Geochemistry for unconventional petroleum exploration and development: A Case study from Anadarko Basin, Oklahoma, USA**

Wahid Rahman

It is hypothesized that oil and gas migrate in an up-dip direction, but the extent of hydrocarbon migration has not been very well documented in many petroleum basins around the world. This study provides some new insights and an overview from US unconventional perspectives through produced oil geochemistry to forecast the extent of self-sourced petroleum, its migration, areal extent, hydrocarbon phase behavior and key reservoir engineering properties evaluations for reservoir geochemistry-based exploration, which leads to proper field development and economic production of oil and gas. Source rock maturity produced oil and gas molecular chemistry, biomarker ratios, and carbon isotopes were analyzed and compared to better understand migration and self-sourcing in the study area (e.g., Anadarko Basin). In this paper, major emphasis is given to the Woodford Shale, Anadarko Basin, Oklahoma, USA, which is one of the most prolific unconventional petroleum source rocks/reservoirs in the United States. Within the study area, the petroleum produced from this reservoir is self-sourced with a significant component having migrated in from deeper in the basin.
This geochemical work was performed on well cuttings, cores and oils extracted from source rocks, as well as produced oils and gases from the targeted reservoirs. Sampled Woodford organic-rich shales contain very little vitrinite; however, they contain abundant solid bitumen. Thermal maturity data from solid bitumen were converted to a vitrinite reflectance equivalent (Jacob, 1989) and compared with pyrolysis data (e.g., Tmax and Hydrogen Index (HI)). Both methods were found to be in excellent agreement. Source rock maturities vary across the area of study from early oil (~0.70 % Ro) to gas windows (~>1.35 % Ro) and approximately follow the present-day structural depth of the Woodford source rock.
Produced oil and gas geochemistry data (molecular fingerprints, isoprenoid distributions, saturate and aromatic carbon isotopes, biomarker ratios and gas carbon isotopes) from several wells suggest a common Woodford source; however, the oil maturities (e.g., Ro equivalent from biomarkers) are significantly higher than the Woodford source rock in many locations. Furthermore, the predicted GOR (gas-to-oil ratio) values from the same oil chemistry data are well matched with the produced GOR and estimated GOR from the recombined fluid samples. These findings support the interpretation (Rahman, 2021, Rahman, 2019; Peryum et al., 2018; Peryum et al., 2017; Rahman et al., 2017a; 2017b) that production from several Woodford wells includes migrated hydrocarbons from a deeper source. This study highlights many important ways in which geochemistry can be used to better evaluate unconventional reservoirs: 1) by identifying the existence and extent of hydrocarbon migration, 2) by predicting and understanding the quality and type of petroleum fluids stored in tight, unconventional source rocks, and 3) by explaining high GOR anomalies as the result of multiple charging episodes in certain areas in tight reservoirs (e.g., Meramec). The approaches described in this paper can be utilized to predict, understand, and more accurately classify unconventional reservoirs all over the world.

9:05–9:35 **Woodford Core-Log Facies Model tied to Sequence Stratigraphy and Applied to Full-field Development in STACK and SCOOP**

Richard Brito, Guanghua Xue, Cameron Cross, Cindy Guenard, John Sinclair, & Aaron Leavitt*

The Ovintiv Woodford model integrates the Woodford Shale rock data from cores and outcrops with well logs in the STACK and SCOOP development areas of the Anadarko Basin. The goal was to create a facies model that best reflects the key characteristics of the Woodford that impact drilling, completions, and production performance.
The first step in our process was to define core facies combining fabric descriptions from thin sections, organic matter content from TOC data, elemental and mineralogical composition from XRF, and XRD data. These core facies are the foundation of the Woodford stratigraphic framework and include several cores both in southern and northern Oklahoma. Furthermore, this interpretation was aided by previous work done by The University of Oklahoma on Woodford Shale outcrops that provided additional insight on the lateral variations of facies. During the facies classification, we emphasized the additional depositional characteristics of the Woodford Shale, like interaction of biogenic and detrital quartz in the formation and the presence of bed-bounded fractures and phosphate nodules.

In parallel and independently, we generated an electrofacies framework using triple combo log data available basin-wide and running hierarchical cluster analyses (HCA). We had to address issues with log quality, the need of log normalization, and the limitation of using gamma ray logs due to very high gamma ray API units in the formation missing during the printing or digitizing of raster logs. During the HCA, we tried different numbers of clusters to evaluate them against the core facies. We made use of well log ternary plots to observe distribution and constellation plots to compare with each facies identified in core. This iterative process allowed us to unify and refine one consistent model from the depositional and reservoir quality perspective by honoring the rock data.
The resulting Woodford Shale model comprises seven major facies: Green Claystone, Argillaceous Shale, Siliceous Claystone, Argillaceous Siliceous Shale, Organic-Rich Siliceous Shale, Siliceous "detrital" shale, siliceous Mudstone, and Chert. Each facies has distinct properties and rock fabrics, but also can be identified on a combination of log responses. We checked every thin section and sample with data on each core to their generated rock facies to evaluate fidelity. After rock-to-log facies validation, we generated a 3D facies model across the basin focusing on carrying the original rock properties through the upscaling process by using a weighted cell definition. This model strongly supports our current sequence stratigraphic framework for the Woodford Shale in Oklahoma allowing us to assess the lateral and vertical distribution of reservoir quality, improve our drilling execution, and better predict well performance in our current operations. Included in this work are several examples of how we have applied this facies model before, during and after drilling Woodford wells and the impact they have generated in improved drilling times and other efficiencies.

10:00-10:30 **Insights from Rock Volatiles Stratigraphy from the Woodford in the Anadarko Basin**

Christopher M. Smith, Richard Brito*, John Sinclair, Aaron Leavitt, Timothy Smith, Patrick Gordon, and Michael Smith*

In 2019 and 2020, eight cores from across the Anadarko basin in Oklahoma were analyzed using rock volatiles stratigraphy (RVS). These were legacy Newfield cores that were acquired from 2013 to 2015. RVS is based on a novel cryotrap mass spectrometry system developed by Advanced Hydrocarbon Stratigraphy which allows for the direct measurement of 40+ entrained volatile compounds in rock samples including those that can be several decades old and unpreserved. Analyzed volatiles include the C1-10 HCs, water, organic and inorganic acids, and a variety of sulfides. In addition to collecting these volatile compounds, mechanical strength measurements are also estimated by crushing the rock sample. These analyses provided important insights into water and hydrocarbon content, hydrocarbon composition, the petroleum system, and rock properties from the Mississippian Chester, Meramec and Osage as well as the Devonian Woodford and Hunton Formations. A study examining some of the key findings from the Mississippian section of these cores was published in 2021 at URTEC (see URTEC 2021 Paper # 5571) – herein we present a subsequent study examining the key trends present in the Devonian Woodford and Hunton intervals.

Main findings include the apparent beginning of expulsion overcoming generation of liquid hydrocarbons around 10300 ft, the generation and expulsion processes having important influences on the hydrocarbon composition of the liquids present and retained in the Woodford, and a systematic relationship between the loss of easily removable "macro" water with the generation of HC liquids. The expulsion is either started once the Woodford enters the gas condensate window or RVS data are responding to a second pulse of migration from depth. In addition to the process of generation and expulsion having significant controls over the composition of the measured liquid hydrocarbons, other effects correlated to burial depth, such as the upper Woodford have increasing mechanical strength with depth while other subunits with high organic content remain unaffected, and a general decrease in compounds like sulfides, will be discussed. Furthermore, a general trend of water loss with depth allows for an appreciation of the petroleum system in the Anadarko basin and the Woodford source rock. From small pieces of rock and the volatile matter trapped in the rock, one can see the story of Woodford burial, hydrocarbon generation and migration begin to unravel.

10:30–11:00 **Applications of Organic Geochemistry to Modeling Hydrocarbon Charge Events in Source-Adjacent Reservoirs: STACK Case Study**

Carl Symcox, R. Paul Philp*

This project documents a large dataset of 172 produced oils and 59 core plugs from the across thirteen counties of the STACK and SCOOP petroleum systems with respect to their maturity and composition. Studied intervals include the Woodford Shale, the Mississippian Group, and the Springer Group of the Anadarko Basin, Oklahoma. Oil maturity versus reservoir depth shows that STACK produced oils are equivalent in maturity to SCOOP oils produced approximately 3,000 ft deeper. Furthermore, separate correlations were observed for oil maturity (Rc%) and initial producing gas-oil ratios (IP GOR) between overpressured and normally pressured wells. Normally pressured wells exhibited IP GOR upwards of an order of magnitude higher than overpressured wells at any given Rc%, possibly due to mixing with methane sourced from deeper in the basin. Third, residual oil extracted from the Meramec and Osage core within the overpressured portion of the basin show that the oil is heterogeneous and not well-mixed within a vertical profile. The maturity of the fluid was found to be inversely proportional to the amount of extractable organic matter (EOM) per gram of rock, believed to be an approximation for porosity in an oil saturated reservoir. This may provide a quick and effective way to predict reservoir quality and gain new insight into its charge history.

11:00–11:30 **A Statistical Look at the Drainage Behavior of Unconventional Wells in the SCOOP and STACK Plays with Case Studies**

David Duarte, Shuangyu Ge, Richard Brito, Geoff Ritter, John Sinclair, Aaron Leavitt, Jana Bachleda, & Faye Liu*

Understanding drainage behaviors, such as drainage fracture height (DFH), zonal contribution, and temporal variations, is essential for evaluating well performance. This study analyzes drainage data from 369 monitored wells in the Anadarko Basin's STACK and SCOOP Plays, derived from a geochemistry-based model that correlates produced oils to their contributing intervals. Special attention was paid to Woodford and Caney in the SCOOP play, and the Woodford and Meramec in the STACK.

A key parameter characterizing drainage behavior is the P80 Drainage Frac Height (DFH), representing the range of fracture height that continuously contributes to 80% of production. The STACK and SCOOP Plays exhibit contrasting patterns in P80 DFH behavior. The STACK Play demonstrates a larger median P80 DFH of 235', with a wide range of 162' from the 5th percentile (175') to the 95th percentile (337'). Conversely, the SCOOP Play shows a median P80 DFH of 160', with 90% of P80 DFH falling within a narrower range of 48' (from 138' to 186'). Furthermore, the P80 DFH of wells targeting different intervals in the STACK and SCOOP Plays display distinct patterns. In the STACK Play, wells targeting the Upper Meramec and Lower Meramec intervals exhibit larger medians (268' and 239', respectively) and wider ranges (varying between 5th to 95th percentile) of 100' and 118', respectively. This variability may be attributed to geological complexity, natural fractures, diverse targets within sub-formations, and varying completion styles. Conversely, wells targeting the Woodford interval in the STACK Play have smaller P80 DFH medians (210') with narrower ranges (69'), possibly due to the richness of the Woodford interval and/or geomechanical properties constraining fracture growth. In contrast, the SCOOP Play displays different patterns, where wells targeting the Lower Caney and Upper Woodford intervals have similar P80 DFH medians (162' and 158', respectively) and comparable P80 DFH 90% ranges (27' and 50'). These observations significantly differ from the drainage heights observed in the STACK Play.

Additionally, zonal contributions vary between the STACK and SCOOP Plays, even for wells landed in equivalent intervals. Woodford-landed wells in the STACK show approximately 70% contribution from outside the Woodford interval (e.g., Meramec, Osage, and Hunton formations), while Woodford-landed wells in the SCOOP exhibit an average contribution of only ~45% from outside the Woodford interval (e.g., Caney formation).Despite the limitations of observations from 369 monitored wells, these findings provide valuable data points for future studies in the Anadarko Basin, facilitating more effective and economically viable development of the plays.

Tuesday	Room 301AB

Geology and Geophysics of the Midcontinent: Regional/General (Hannah Morgan, David Lubo-Robles)

1:15-1:45 **Hydraulic-fracture triggered earthquakes in Oklahoma, 2013 to present**

Jake Walter, Paul Ogwari, & Nick Hayman*

The Oklahoma Geological Survey (OGS) has studied seismicity throughout the state since the survey was chartered during statehood. In modern times, we monitor with permanent and temporary seismometers operated by OGS and other agencies and report out earthquake information within seconds of those events. Over the last decade, Oklahoma experienced an unprecedented increase in seismicity that peaked in 2015 when there were ~900 M3.0+ earthquakes, compared to a tectonic background rate of just 2-3 M3.0+ earthquakes per year prior to 2009. While most public and regulatory attention has historically been focused on wastewater disposal into the Ordovician-age Arbuckle Group as a causal mechanism, in the last few years hydraulic fracturing (HF) triggers most of the induced seismicity in the state. We will report on our recent efforts to categorize HF-triggered seismicity, over the last decade, through statistical analysis. During the last decade, almost 15% of HF completions are correlated with the occurrence of an earthquake and about 2% of all HF completions produced an earthquake that was reported to be felt by a human. In addition to this broad analysis, we will show several case studies that demonstrate the effectiveness of the Oklahoma Corporation Commission's stoplight protocol. Finally, we will describe an anomalous case of a M3.2 HF-triggered earthquake that led to reports of light damage in southern Canadian County. Our findings have important implications for regulatory and corporate oversight of safe HF well completions.

1:45–2:15

Geochemical and Mineralogical Characterization of Hydrothermally Altered Spavinaw Granite

Alexander Cordero & Brett M. Carpenter*

The state of Oklahoma experienced a surge in felt seismic events between 2016 and 2019, primarily attributed to anthropogenic activities mainly involving wastewater injection. Notable seismic events include the M5.7 Prague earthquake in 2011, the M5.8 Pawnee earthquake in 2016, and the M5.0 Cushing earthquake in 2016. The Cushing earthquake was especially notable as it raised concerns about its impact on critical infrastructure due to its proximity to oil storage facilities. This study focuses on analyses of rock samples from the Spavinaw Granite Group in the Oklahoma basement, which is known for its susceptibility to seismic reactivation. The samples for this study consist of three samples housed by the Oklahoma Geological Survey's Oklahoma Petroleum Center (OPIC) that were extracted from the AMAX SP-1 well, within a depth interval in MD between 1,745-1,809ft. The cores show different degrees of mineral alteration and were classified as: highly altered (sample A), moderately altered (sample B) and fresh-slightly altered (sample C). Mineral recognition in the three samples studied was carried out by X-ray diffraction (XRD) and Scanning Electron Microscopy (SEM) analysis. Due to the presence of clay minerals, ethylene glycol and heat treatments were applied during the XRD tests to validate or discard the mineral assemblages. The results reveal that the rocks contain a variety of minerals, including illite, chlorite, kaolinite, pyrite, quartz, aragonite, and others. The presence of these minerals indicates different hydrothermal alteration processes and compositions of the fluids involved. The analysis suggests the occurrence of multiple hydrothermal events, with acidic and intermediate-alkaline compositions. The mineral assemblages and temperature ranges derived from the analysis further support these conclusions. The presence of clay minerals, especially in sample A, would be expected to significantly affect its mechanical behavior. Clay minerals are known to weaken faults and modify parameters such as the friction coefficient, permeability, strength, and hardening rate. The high content of illite and chlorite in sample A suggests propylitic alteration, while the presence of kaolinite, and illite in sample B indicates intermediate argillitization. The alteration processes and mineral assemblages observed in the samples highlight the importance of considering clay minerals in understanding crust/fault behavior. The study also emphasizes the role of fractures as conduits for fluid flow and mineral precipitation. The proximity of sample A to fractures suggests a higher degree of alteration due to a longer exposure to hydrothermal fluids. The findings indicate that the hydrothermal fluids responsible for the alteration could have originated from deeper sources enriched with potassium or could have undergone ion exchange within low-permeability fractures. Overall, the extensive hydrothermal alteration observed in the Oklahoma basement raises concerns about the stability of fault zones at shallower depths. The presence of clay minerals and the heterogeneity of alterations suggest seismically unstable materials would be expected within fault zones. Understanding the mineralogical and geochemical changes in the basement rocks provides valuable insights into the thermo-tectonic history of the basement and can contribute to improved seismic hazard assessments in the region.

2:15–2:45

Oklahoma's Intraplate Earthquakes: Insights from Pawnee 3D seismic

Priyank Jaiswal, B. Springman, J. Walter, H. Daigle, S. Verma, & J.M. Gregg*

Since 2011, the state of Oklahoma experienced an unprecedented earthquake swarm of which the Mw 5.8 event near Pawnee, Oklahoma, on September 3rd, 2016, was the largest. Here, using a high-quality 3D seismic volume from the Pawnee area, containing 1200+ hypocenters including the 5.8 Mw event, we show for the first time the relation between hypocenters and basement stratigraphy inspiring new realizations. First, there is an abundance of coherent reflectors in the basement, suggesting that the Precambrian in Pawnee is not a solid crystalline unit but a rather a stratigraphically complex and compartmentalized rock assemblage with enough impedance contrast to produce coherent reflections. Second, at least three strong reflectors, one inclined and two bounding sub-horizontals extend through significant distances within the volume. Such reflectors, regardless of their geological nature, e.g., slip-surface, shear-zone, dikes, etc., have a high probability of being planes of weakness. The Mw 5.8 event hypocenter at 19,200 ft lies immediately beneath the inclined reflector. Third, and possibly the most interesting, is that over 90% of the hypocenters are located within the sub-horizontal stratigraphy at least 1000ft or more away from the weakness planes. This begs the question of how and why, unlike at the plate boundaries, intraplate earthquakes in Oklahoma would originate at relatively intact locations when weaker zones are present in the neighborhood. We postulate that it is not the fluids penetrating the basement from the overlying sedimentary section that induces Oklahoma intraplate earthquakes but rather fluids that are seeping out of the basement into the overlying sedimentary section. The fluid seepage could be purely tectonic-driven, but wastewater injection can also enable it.

3:10–3:40 **Estimating Recovery by Quantifying Mobile Oil and Geochemically Allocating Production in Unconventional Reservoirs**

Jennifer J. Adams, Tim Ruble, Matt Flannery & Mark A. McCaffrey*

Due to highly variable well performance, unconventional reservoir (UR) field development relies heavily on production monitoring to predict total recovery, assess well interference, delineate drained rock volume, and diagnose mechanical issues. Completion design and well spacing decisions depend on accurate recovery estimates from reservoir models and can be limited by non-uniqueness in the history matching. Geochemical production allocation can greatly improve operator's understanding of well performance when integrated with reservoir characterization and in-reservoir P/T monitoring.

There are several long-standing challenges in the characterization of UR fluid flow: (i) collecting reservoir samples representative of mobile oil, (ii) accounting for production fractionation over the life of a well, and (iii) determining recoverable OOIP from contributing zones. Although many metrics and correlations are commonly used, ultimate recovery requires accurate quantification of production.

We have developed a rapid method for quantifying mobile and total oil saturations from WBM-collected, tight cuttings and sidewall core samples using low temperature hydrous pyrolysis (EZ-LTHP). These mobile oils commonly include even gasoline range compounds, which are the dominant compounds of produced liquids in most mid-continent UR fields, making them representative end-members for geochemical production allocation studies.

Here, we present quantified mobile oil recovery estimates based on integrated geochemical allocation studies from the Permian and Anadarko basins. A comparison of LTHP mobile oil to other estimates from popular extraction technologies shows bias in the solvent-based and vaporizable oil saturations. This difference means that the LTHP mobile oil generates more representative end-members for determining drained rock volume, production rates by zone, and well-interference. For example, the new method (EZ-LTHP) found that relatively organic-rich rocks contained higher total oil and mobile oil, but a lower ratio of mobile/total oil, than do higher permeability, non-source intervals, which likely contain more mobile migrated oil charge. By contrast, solvent extraction and vaporization volumes were very similar to log-derived values which are known to overestimate mobile oil in kerogen-rich intervals by incorrectly including kerogen-bound immobile oil.

In a Midland basin, multi-well-pad, time-lapse study, EZ-LTHP oil end members demonstrated that most of the wells are producing dominantly from their landing zone. The exception was for wells landed near the "non-target" Dean Formation or Lower Spraberry Sand, which contributes significantly to the production stream. These legacy wells are not exclusively producing from their intended landing zone, as shown by the allocation results derived from EZ-LTHP end member oils with pseudo end member oils. Accurate estimation of out of zone contributions therefore requires cuttings/core-based geochemical allocation. A subset of these wells requires additional consideration of production fractionation.

EUR estimates, and production forecasts by zone, are more accurate when calibrated to the mobile oil fraction, rather than total saturation. EZ-LTHP provides this step-change by quantifying that mobile oil fraction in WBM cuttings, when paired with reservoir volumetrics,
allows for better reservoir model calibration and field management.

3:40–4:10 **Improved Seismic Reservoir Characterization with Interbed Multiple Suppression**

Gabriel Gil & Jeff Martin*

Interbed multiples makes it difficult to correlate the seismic to wells, resulting in incorrect interpretation and mapping of seismic events thought to be associated to reservoir responses. They are a known source of seismic noise that, when interfering with primary events, often result in subtle, but significant, time delays and phase rotations of the seismic response. This effect is more dramatic in seismically dim reservoir levels. The strength and amount of interbed multiples depends on the elastic properties contrast between layers and their thickness relative to the wavelength of the seismic waves. Additionally, they are not limited to shallow layers, but instead occur all along the vertical column. Typically, they can vary laterally depending on the local geology, and are often present in all offsets with similar moveouts as primary events, making them hard to detect and eliminate. The workflow presented shows a model-based approach to predict and suppress the presence of interbed multiples from migrated pre-stack data using an adaptive subtraction method. This workflow was applied on a datasets in the Midland and Anadarko basins. These steps plus elastic properties estimation show an improvement in the seismic image achieved by removing interbed multiple interference.

4:10–4:40 **Tying local structure to regional deformation history: Integrating core data with published fault maps reveals the timeline of deformation within the Southern Oklahoma Aulacogen**

Jamie M. Bowie, Brett M. Carpenter, & Michael J. Soreghan*

Although the Paleozoic tectonic history within southern Oklahoma is understood in a broad sense, the nuances relating to the deformation mechanics and timing continue to be a source of interesting research and academic debate. The complex structural relationships observed in this region today are a result of the multi-phase geologic history and tectonic modification of inherited structural features. These features originated from Cambrian Iapetian rifting of the southern margin of Laurentia and the continental collision of the Ouachita-Marathon Orogeny. Studying basement deformation and structures on a local scale provides important information for resource exploitation and information regarding the geologic history of a region. Fractures and fault rocks from a nearly vertical fault zone are described from Beckham County, Oklahoma. This structural study integrates lithologic and structural observations from a previously undescribed fifteen-foot basement core with geochronological data and published fault maps, to constrain the relative timing of deformation within this uplifted region of the Southern Oklahoma Aulacogen (SOA). Based on the relative composition and macro-scale characteristics, the upper and lower portions of the core are interpreted as a felsic or intermediate lithotype, with a mafic interval present through the center. Fracture intensity is highest in the upper core within close proximity to the two juxtaposed lithologies. Fracture orientations measured indicate that both the upper and lower felsic zones contain dominant sets of vertical and moderately dipping fractures (~45°), however, the upper zone also contained an additional set of approximately horizontal fractures. Previously conducted Potassium-Argon geochronological analysis revealed that the felsic lithology of the lower core is approximately 591 (± 28) MY and the mafic lithology dates 494 (± 21) MY. Based on geochronological dates and cross-cutting relationships within the core and study area, we conclude that at least three tectonic phases are chronicled; these phases span the millions of years from Cambrian rift tectonics (extensional) to Pennsylvanian wrench tectonics (transpressional). During the late Cambrian to early Ordovician (~515-473 MY), a fine-grained mafic lithology intruded into the Pre-Cambrian basement (591 (± 28) MY). After dike emplacement, regional tectonics resulted in the formation of linear fractures which cut both lithologic units and are likely related to extensional stresses during rift-related extension. Concurrently or subsequently, the fault zone experienced slip which we constrain to have a maximum age of 515 MY (mid-Cambrian) and a minimum age of 320 MY (early Pennsylvanian). Veins cross-cutting the fault zone are post-faulting deformation interpreted to represent extensional stresses experienced within a transfer zone associated with left-lateral strike-slip faulting during late-Pennsylvanian transpression. In summary, these structural features indicate that this region of the Southern Oklahoma Aulacogen experienced extensional tectonic stresses before and after fault movement.

Tuesday	Room 301CD
	Discovery Thinking (Cam Thompson, John Dodds)

1:15–1:45 **History of the first Seismic Reflection Experiment and Interpretation of a modern 2D Line Located Near the Original Experiment**

Jan Dodson

The Centennial celebration for the First Seismic Reflection Experiment was held (belatedly) April 12–14, 2023 in Oklahoma City, OK. The technical program included historical reviews of J. Clarence Karcher's experiments in the summer of 1921. However, the five years before that summer, including graduate studies, military service, and a 3 week stint at the Thomas Edison Laboratory laid the foundation for those first Seismic Reflection experiments. An overview of those years provides an introduction to a modern seismic line designed to parallel Karcher's first experiment. Figure 1 is a screen capture from Karcher's autobiography published in The Leading Edge, November 1987.

In June, 2011, a celebration of the 90th anniversary of the first Seismic Reflection Experiment was held at Belle Isle Library, Oklahoma City, OK, USA. Events leading up to the celebration included the acquisition of a 2D seismic line to reproduce that first seismic reflection experiment. Dawson Geophysical Company provided funding, equipment, and processing for the 2D line. The line was located along the service road parallel to Northwest Expressway; it was 1300 ft. long.

Belle Isle library is located in the SE SW Section 7, Township 12 North, Range 3 West. The nearest oil or gas well is in Section 8, Township 12 North, Range 3 West. Jones and Pellow Oil Company completed the Belle Isle #8-1 in October, 1980 at a depth of 8099 ft. In order to interpret the seismic line, the location of the Belle Isle well was projected to the center of the Karcher 2D line, a distance of approximately 1.5 miles (figure 2).

Because no sonic logs are available for any wells within several miles of the Karcher line, a pseudo-sonic log was calculated from the resistivity log from the Belle Isle #8-1 well. Modern acquisition parameters and processing techniques produced a high quality survey that allows mapping of several hydrocarbon bearing subsurface geological formations. Oil and gas zones that are targets for drilling include: Pennsylvanian sandstones, Ordovician Viola Limestone, and Late Cambrian Arbuckle group. These formations are represented by clear reflection in the seismic profile. Figure three illustrates the time-depth relationship between subsurface formation tops and the seismic data.

1:45–2:15 **The Horizontal Redevelopment of the Abandoned Pendleton Fractured Chalk Field**

Julie Garvin

Pendleton field was discovered in 1958 and developed with vertical wells until the late 1960's when it was largely abandoned. The primary reservoir is the highly fractured Upper Cretaceous Saratoga Chalk, with additional production from the Marlbrook Marl and Annona Chalks, at depths of 3,000–4,500' TVD. The field lies on the southern plunge of the Sabine Uplift, and covers over 75,000 acres. Cumulative production at abandonment was over 40 MMBO of high gravity (40–55 API) crude from over 1500 vertical wells. Oryx (1991) and EOG (2006) drilled several horizontal wells on the northern edge of the field with only modest success. In 2018, Roxanna Oil began acquiring acreage in the core of the field based on our analysis that horizontal wells could access large remaining reserves from new, undrained fractures. To date, Roxanna and partners have drilled 4 horizontal wells, one vertical well, with two wells currently producing. IP rates were up to 600 BOPD from unstimulated 3,500' lateral wellbores. Cumulative production from the two wells is over 200,000 BO. Plans are to begin development drilling in the 4th Q 2023, and expect to drill 2–3 horizontal wells, and one SWD per year. Replicating the success of the initial two wells during the development phase will require applying key lessons learned from drilling and completion results, and continued cost efficiencies.

2:15–2:45 **Visualizing Uncertainty & Risk to Reduce Bias and Improve Decision Making: My Favorite Diagrams**

Andrew Cullen

All individuals and businesses make numerous decisions daily. The energy business is no exception. Most of us use mental short cuts, heuristics, to cope with the volume and rate of decisions- hardly aware of making these decisions because our intuitive minds fill in knowledge gaps to construct a coherent narrative aligned with prior experiences, a form of the confirmational bias heuristic; the Past is the Key to the Present is the converse of the Doctrine of Uniformitarianism. While this heuristic can ease the burden of overthinking a decision, it leads to bias in decision making that is commonly compounded by the affect heuristic that introduces motivational bias in which managers/teams favor their own projects over the projects of others, e.g., propose a downspacing in Oklahoma, build leasehold the Williston Basin, join a wildcat in the GOM, expand pipeline capacity in Texas, sell assets in Ohio, or buy a stake in a Nebraska wind farm. When deciding which projects to fund and how capital will be apportioned between them in building a portfolio, it is imperative that decision makers trust that each project has been evaluated with a consistent methodology to reduces bias within a portfolio.

After covering some of the common heuristics & traps that often cloud decision making, this talk presents several methods and diagrams that help visualize the assessment of risk & uncertainty. By reducing bias and improving our ability to communicate probabilistically these methods can help reduce the frequency and magnitude of poor decisions. Equally important these tools provide a framework to understand behaviors influencing decisions. My favorite three diagrams are 1) the Maastricht Template (Shell), 2) the Fourfold Pattern (Kahneman & Tversky), and 3) the Truth–Lie–Ignorance Ternary (Cullen). The breadth and utility of these diagrams will be examined using examples from bid round evaluations, an equity determination, brokered sales packages, reserves write-downs, and whether to take a vacation cruise. Whether buying a house, trading equities, funding a movie production, or taking a vacation, sustained success and happiness favors those who make decisions with an unbiased balanced vision.

3:10–3:40 **Helium Exploration in the Rio Grande Rift**

Bruce A. Black and Bruce H. (Buz) Black*

Black Exploration, LLC drilled a wildcat oil and gas test on a large structure on the Zia Pueblo in early 2023. The primary objectives were oil and gas. However, helium potential was also recognized as a possible secondary objective. This large structure sits adjacent to some of the largest reported air corrected mantle He and CO2 degassing carbonic and geothermal springs in the Rocky Mountain region. The prospect overlies a classic Synthetic Overlapping Transfer Zone between the northern Albuquerque Basin and the southern Espanola Basin in the Rio Grande rift in Northern New Mexico. Recognition of possible deep crustal and upper mantel faulting as well as surface geologic mapping, gravity, seismic and geo-microbial techniques helped delineated the prospect. A possible explanation for why high mantle derived helium is concentrated in this area is the intersection of the ancient Jemez Lineament and the more recent Rio Grande rift. This wildcat has now discovered helium and white hydrogen in the Abo formation. If economically productive the well may be the first helium /white hydrogen discovery in the Rio Grande Rift. This could open the rift and its sub basins into a large new oil, gas and helium /hydrogen producing province.

3:40–4:10 **Uncertainty Assessment in Unsupervised Machine Learning Methods for Deepwater Channel Seismic Facies**

Karelia La Marca, Heather Bedle , Lisa Stright, & Kurt Marfurt*

Machine learning (ML) techniques in seismic reflection data have increased popularity in the last years. Supervised ML methods allow training models to obtain the desired output using labeled or interpreted datasets. In contrast, unsupervised ML methods generally form clusters or groups of data points that keep a relation among them. However, for the latter, the interpretation of such clusters relies on the geoscientist's expertise and their in-context interpretation, especially when well-log or hard data is unavailable. Additionally, no methods for testing the error associated with the facies clustering have been reported. Therefore, there is a need and motivation to find robust and reliable unsupervised methods to characterize seismic facies. For that, we need to test the uncertainty associated with these predictions.

This study uses synthetic reflection data built upon an actual deepwater outcrop model to demonstrate how two unsupervised methods can cluster deepwater channel-related seismic facies and determine how much error there is in such facies grouping. Self-Organizing Maps and Generative Topographic Maps (GTM) are unsupervised ML methods that map an initial array of data points from a lower dimensional latent space onto a similar dimensional non-Euclidean curved surface as vectors that can then be interpreted as clusters that may have geological meaning. In order to apply SOM and GTM, a suite of input seismic attributes is required. In this case, an empirical analysis allowed us to define six input seismic attributes: RMS amplitude, instantaneous envelope, peak magnitude, and frequencies of 20Hz, 40Hz, and 55Hz in spectral decomposition form. Geobodies were interpreted and assigned to each cluster formed. Error in facies clustering was then determined by comparing the actual 3D model against the facies grouped by the SOM and GTM methods in a voxel-by-voxel fashion quantifying the error and determining metrics such as F1 score and accuracy after the generation of correlation matrices. Results show that: 1) GTM and SOM methods have similar performance; however, a clustering of 81 slightly reflected better metrics. 2) Error between clusters formed vs. actual model is approx. 2 % for the predominant facies (background shale) and very high for other individual channel related facies which suggests that channel clusters formed represent more than one facies combined. 3) The resolution of the dataset and imbalanced data (predominance of one facies over the others) influences the seismic facies predictability resulting in the non-uniqueness of clusters generated. 4) Synthetic seismic data allows us to gain valuable insights through experimentation with different unsupervised ML techniques. 5) Uncertainty assessment in unsupervised ML methods is paramount since critical economic decisions are based on reservoir interpretation, modeling, and associated volumetrics.

4:10–4:40 **Seismic identification of carbonate reservoir sweet spots using unsupervised machine learning: A case study from Brazil deep water Aptian pre-salt data**

Marcus Maas, Marcus Vinicius Rodrigues Maas, Heather Bedle, Marcilio Castro de Matos*

The pre-salt high-yield carbonate reservoirs of Brazil are responsible for about 75% of national oil production. Still, seventeen years since its discovery, detailed seismic characterization of these reservoirs remains challenging, with producing and nonproducing lithologies often exhibiting the same amplitude response. Those reservoirs are complex, composed of high productivity lacustrine carbonates (stromatolites and grainstones), mixed with non-producing mudstones, clays, and igneous intrusions. To address this heterogeneity, we evaluate unsupervised machine learning clustering techniques including Self Organizing Maps (SOM), Generative Topographic Maps (GTM), and K-means and apply them to a suite of instantaneous, geometric, interval velocity, and AVO seismic attributes. We use both static and dynamic reservoir data from 13 wells at the Mero field that penetrated lacustrine carbonates from Barra Velha formation to validate the accuracy of our unsupervised learning models. These wells are excellent blind tests as they were not used for any algorithm training. In this pioneer work, the first done using machine learning in the Mero field, we find that SOM, GTM, and K-means models provide clusters that can be linked to sweet spots associated with fracturing, karstification, and hydrothermal alteration. Additionally, clusters related to sill intrusions, platform facies and distal fine grained nonreservoirs were identified. The results can be extrapolated to the adjacent Central Libra Area (still in exploration phase), where we have identified the same clusters of the sweet spots reservoirs in Mero Field and, thus, they can be considered as future targets. For accuracy assessment, the same attribute combination SOM clustering was performed in another Petrobras' pre-salt confidential dataset and the results were satisfactory. So, for exploration projects optimization purposes, the new proposed workflows can also be applied to other areas with geological similarity to the Mero Field.

Poster Abstracts in Alphabetical Order

18 **A comparison of unsupervised ML algorithms for channel seismic facies in the Taranaki Basin**

April Moreno-Ward, Karelia La Marca, & Heather Bedle

The Mid-Continent has seen a resurgence of development in mature producing areas. Whether it be from new benches being delineated, or from old concepts being applied to new areas, the Mid-Continent continues to offer new opportunities. Plays such as the Red Fork, Cherokee, and Oswego may be limited in areal extent or repeatability when compared to plays in other basins, but successful operators have leveraged geologic knowledge to underpin their innovation and success within these developments. Similarly, old plays such as the Tonkawa & Caney, and mature areas like Sho-Vel-Tum have seen operators pair legacy play concepts with technological advances to create successful outcomes. As the Mid-Continent has recently been overlooked due to the maturity of its development and geologic complexity, investors and operators with a geologic acumen can benefit from a lower cost of entry compared to elsewhere in the Lower 48. Additionally, these same concepts being applied in the Mid-Continent, are being applied elsewhere in places like the Permian and beyond. This talk will discuss interesting developments and similarities between new plays in the Mid-Continent and elsewhere in the Lower 48.

14 **Application of Seismic Inversion Techniques for Reservoir Characterization in the Anadarko Basin, Oklahoma**

Sreejesh V. Sreedhar, Camalia C. Knapp, & James H. Knapp

Seismic inversion techniques are widely used for reservoir characterization. The present study focuses on seismic inversion techniques used to characterize reservoir formations in the Anadarko basin. Deterministic and stochastic inversion techniques are utilized to create a high-resolution reservoir model. The heterogeneities in the properties of the reservoir rocks can be inferred from the study. The seismic inversion explains the reservoir formation in terms of elastic properties and further reservoir properties like porosity volumes can be generated. The workflow involves and integrated interpretation of seismic and well data sets. Conditioning of the well logs, wavelet extraction, seismic to well tie, generating surfaces are some of the prerequisites for the inversion. A low frequency model, built from the acoustic impedance calculated from well logs, is used for deterministic inversion of post stack seismic data. A 3D structural model is built from the mapped surfaces for reservoir tops. Very fine layering is used in the structural model to create a high resolution model. The stochastic inversion technique requires a prior model for the inversion process. Acoustic impedance from wells are populated in the 3D grid and co-krigged with P-impedance volume generated from the deterministic inversion. This gives more control on the area away from wells. The model thus generated acts as a prior model for the stochastic inversion. Higher frequency information is obtained through statistical techniques. Variogram analysis of the well data provide high frequency information. This allows the stochastic inversion to predict multiple realizations of acoustic impedance. The output from the inversion is used to generate effective porosity volumes. The regression relation between the acoustic impedance and porosity from well logs aids in the calculation of the porosity volumes. This study provides valuable information in quantifying the pore volume for the reservoir formations in the Anadarko basin.

19 **Assessment of Spectral Attributes in Identifying Gas Hydrates in Seismic Data from the Pegasus Basin, Offshore New Zealand**

Emily Jackson, Heather Bedle, & Thang Ha

Gas hydrates are formed in the subsurface along shallow ocean basins or in permafrost settings, and are commonly identified in the seismic data by the bottom-simulating reflector (BSR). Various methods have been employed in the past to measure gas hydrates from lab analyses, well log, or velocity data, but few studies have demonstrated methods to identify gas hydrates in seismic data when the BSR is sparse or lacking. One approach is to measure the expected attenuation, or the reduction in the seismic waveform, caused by hydrates in the gas hydrate stability zone (GHSZ). This study proposes the application of two statistical attributes—skewness and kurtosis—that measure the asymmetry of the seismic amplitude spectrum in order to quantify the attenuation responses throughout the GHSZ. Although the study area does not contain well log data, there are numerous studies that confirm hydrates exist throughout the Pegasus Basin. These attributes, in addition to other instantaneous and amplitude-related attributes, demonstrate that frequency-related variations are the major contributors to attenuation response, rather than seismic amplitude or geology effects. The spectral attribute results show that strong positive skewness and kurtosis variations above the high amplitude BSR is likely due to attenuation through an interval of hydrates. Negative skewness and kurtosis may correspond to an interval that does not contain hydrates, therefore suggesting that the GHSZ in the Pegasus Basin consists of discontinuous intervals of hydrates, rather than one continuous layer from ocean bottom to BSR. Another zone of strong positive skewness and kurtosis variations occurs directly below the ocean bottom toward the northeast slope of the Hikurangi Channel, and this area may be due to biogenic hydrate accumulation directly below the ocean bottom.

17 **Capabilities and limitations of unsupervised clustering techniques for seismic facies classification in a merged seismic cube**

Pamela Blanco Dufau & Heather Bedle

Effectively managing large quantities of data is of paramount importance in the energy sector, especially for geoscientists handling extensive seismic datasets resulting from the merging of seismic cubes. In this context, machine learning techniques have emerged as indispensable tools for analyzing geologic features and facilitating the rapid interpretation of massive datasets. Among these techniques, unsupervised clustering algorithms have gained popularity among geoscientists due to their ability to assess multiple seismic attributes simultaneously. However, the quality evaluation of input seismic data becomes crucial prior to applying any machine learning technique, particularly when dealing with vast megamerge datasets.

The merging process of seismic cubes demands careful attention during processing, as legacy cubes are typically acquired at different times with varying technologies, acquisition geometries, and targets. Consequently, these diverse parameters lead to distinct seismic expressions of geologic interfaces, posing challenges when used as inputs for machine learning. This presentation delves into the exploration of unsupervised clustering capabilities and limitations in a megamerge dataset affected by processing issues and footprint presence in the western Gulf of Mexico.

The unsupervised clustering algorithm employed in this study is K-means. The technique is applied to a specific portion of the seismic cube, with the number of clusters for seismic facies varying to assess its impact on the output cubes. Additionally, the study investigates the influence of dimensionality reduction on the clustering results. The interpretation of the findings indicates that machine learning techniques can still facilitate the identification of geological patterns, even in the presence of a megamerge seismic cube exhibiting varying seismic expressions due to reprocessing issues and low signal-to-noise ratio (SNR) caused by footprints. This research highlights the potential of unsupervised clustering as a valuable approach in the analysis of complex seismic datasets, offering insights into the effective utilization of machine learning for geoscientific applications in the energy sector.

9 **Carboniferous Hydrocarbons Plays in the Western Pomerania, Poland**

Przemyslaw Karcz, Grzegorz J. Nowak, Aleksandra Kozlowska, Marta Kuberska, & Barbara Massalska

Western Pomerania of Poland is an area associated with deposits of oil and gas, which have their source in the Permian source rocks. About 200 deep (up to 3.000 m deep) boreholes have been drilled in this area with the Permian at the bottom. Seven gas and four oil deposits associated with Permian source rocks have been discovered. There are geological indications that in the area of Western Pomerania also Carboniferous rocks may be source rocks for hydrocarbons. For this reason, a research project was undertaken at the Polish Geological Institute-NRI to determine whether these rocks are source rocks for hydrocarbons. The occurrence of Carboniferous limestones and claystones enriched in organic matter together with the thermal maturity of the oil window seem to confirm the fact that some hydrocarbon deposits in the area may also be fed from Carboniferous source rocks.

In the area of Western Pomerania, about 70 deep boreholes (up to 5.000 m deep) were drilled with Carboniferous bottom. Of these, 14 were selected for detailed study, which had to have a core in the stratigraphic range of the Carboniferous. The selected cores have been profiled and sampled. The collected rock samples were the object of integrated palinostratigraphic, geochemical and petrographic tests. Petrology studies of organic matter were also carried out. Moreover, logs of geophysical curves were subjected to a detailed analysis.

Geophysical survey results revealed positive anomalies of gamma curves in Carboniferous intervals. These anomalies are related to the increased content of organic carbon which in places reaches 5% by weight. Organic geochemistry results suggest oil thermal maturity of types II and III kerogen. Organic petrology studies have shown the presence of both humic (vitrinite and inertinite) and bituminous (mainly alginite and bituminite) types organic matter. Vitrinite reflectance corresponds to the main oil window zone. Palinostratigraphic studies confirmed the Carboniferous age of the examined rock samples.

Preliminary results confirm that selected Carboniferous calcareous claystones and organodetrital limestones can be hydrocarbon source rocks. Thermal maturity in range of low-temperature thermocatalytic alterations also suggests that the studied rocks may be a source of oil. The petroleum potential of selected Carboniferous rocks oscillates in a wide range from low to high values.

5 **Comparisons of Grain Size Distributions from Jezero Crater Delta Front to Deltas on Earth**

Andrew Hollenbach, Robert Goldstein, Sahar Mohammadi, Andreas Möller

The Pan Am Barnes D-2 core was retrieved from the basin-shelf margin of the Midcontinent's Anadarko Basin. Petrography, fluid inclusion microthermometry, burial history, and U-Pb dating reveal that hydrothermal fluid flow was altering rocks before significant burial and petroleum migration. Recognizing hydrothermal fluid flow's impact on the petroleum system is critical because it diagenetically alters fluid migration pathways (and reservoirs), drags oil and gas along flow pathways, and can mature source rock above expected burial temperatures.

In one example, a calcite cement from Mississippian strata precipitated in the mold of an anhydrite nodule after silicification and stylolitization. This calcite has primary aqueous two-phase fluid inclusion assemblages that homogenize between 113°C and 115°C, and yields a U-Pb date of 318 ± 18 Ma. Using a fine-tuned burial history, the temperature is 72°C warmer than the ambient burial temperature at 318 Ma. This is evidence for hydrothermal fluid flow at 318 ± 18 Ma. This Mississippian-Pennsylvanian timing is consistent with other records of hydrothermal fluid flow from Midcontinent Mississippian rocks. These data suggest that warm fluids were driven by the hydraulic head associated with the topographic high of the Ouachita and Ancestral Rocky Mountains, and they migrated advectively out of the foredeep and towards the shelf.

Petrography in plane-polarized and ultraviolet (UV) light reveals that the porosity of the Pan Am Barnes D-2 core Mississippian rocks was enhanced episodically during structural deformation. After fracturing, dissolution enhances porosity, and then precipitation of mineral or bitumen reduces it. In one example, a fracture is filled with calcite exhibiting a cataclastic texture, indicating active deformation during the calcite precipitation. We obtained a new LA-ICP-MS U-Pb date of 302 ± 14 Ma from this calcite suggesting that active deformation was occurring in the area around the time of hydrothermal fluid flow, and the topographic high of the Ouachita and Ancestral Rocky Mountains. In yet another example, later in the paragenesis, calcite precipitated in a popped-open stylolite. In this late stage of the paragenesis, oil migration (and bitumen) is closely associated with fracturing. If the long-lived system of hydrothermal fluid flow was valved episodically by structural events, such as these, then long-term hydrothermal fluid migration could be represented by many pulses of fluid flow.

This prolonged period of hydrothermal fluid flow, the consequence of the enduring topographic highs of the Ouachita and Ancestral Rocky Mountains, would have impacted the petroleum system along the conduits of fluid flow. This impact would be most intense near the intersection of stratigraphically controlled aquifers and structural damage. Regionally, the alteration would be confined to rocks nearest the advective aquifer (e.g. below Pennsylvanian shales), but in fault damage zones the alteration would track vertically across section. In this

8 **Crustal Shears and Future High-Resolution 3D Seismic-Based Exploration for Large Oil and Gas Fields in Central Oklahoma from A Globalist View**

Thomas E. Moon & Steven L. Getz

The deep-seated strike-slip movements along the sub-parallel "North-South" fault systems are observed in Oklahoma north from the Ouachita, Arbuckle, and Wichita Uplifts to Central Kansas and beyond. (See Figures.) These tectonic movements define the play concepts in our main focal areas wherein prolific structural and stratigraphic accumulations of billions of barrels of Paleozoic oil have been proven. Early giant oil fields (Such as: Seminole, Bowlegs, Cromwell, etc.) were discovered from surface geologic mapping, and even the "smell of oil in the creek," or simply the wildcatter on the next hill.

Large oilfields could lie within and below the existing known shallow (5000 ft. and less) old producers. Exploration and development locations are seen within the massive geologic and production history in the areas of interest. Published surface maps in conjunction with high-resolution digital terrain satellite, shuttle and aircraft data (LIDAR) gives resolution not seen without combining these datasets. The published oil well and the inexpensive commercial well database information are useful only if accurately located.

The complexity of the shear fault zones, and their related secondary and tertiary generated fault systems cannot be adequately imaged without present state-of- the-art high resolution 3D seismic. (See Figures.)

Very closely spaced high-frequency seismic data can now be obtained cheaper than past good land surveys by using the best equipment and low-cost energy sources, when combined with the most efficient field layout designs and operations. Best practice methods and equipment will be suggested. (See Photos.)

The main purpose of this very brief poster session is to explain how to obtain and combine all of these major data sets in order to reduce exploration and/or exploitation risk. Drilling plans can be developed using these maps.

11 **Fault Zone Characterization using Earthquakes in Quinton Oklahoma**

Paul Ogwari, Jacob I. Walter, Isaac Woelfel, Andrew Thiel, Fernando Ferrer, & Xiaowei Chen

Over the last several years, we have recorded 1300 earthquakes ML 0.2-3.7 over the time period, near Quinton, OK. The seismic activity temporally coincides with the both the injection of wastewater from a single disposal well and adjacent hydraulic fracturing activity. The catalog locations suggest seismicity occurs around two parallel NE striking faults. However, due to the sparse regional seismic network in the area with poor azimuthal coverage, the seismicity hypocenters are poorly constrained for them to map onto the seismogenic faults or provide a conclusive spatiotemporal occurrence pattern. We re-analyze the seismicity by augmenting the regional broadband sensor network, operated by the Oklahoma Geological Survey, with two seismic arrays each composed of 15 3-component nodes recording for 35 days to assist in constraining the hypocenters, then relocate 1,300 earthquakes of magnitude ML0.2-3.7 using a double-difference scheme and a local 1D velocity model to unravel the seismicity patterns, delineate the seismogenic faults and perform source characterization. Our analysis shows a surface projection of three main fault segments, oriented in a NW direction as three clusters of earthquakes that linearly align to form an apparent NE striking fault zone. The spatiotemporal evaluation of seismicity indicate seismicity begins at the central fault segment that underlies the lateral positioning of the hydraulic fracturing wells and begins in a period when both hydraulic fracturing and waste fluid disposal activities occurred concurrently. Upon suspension of hydraulic fracturing activities, the seismicity then expands to the SW fault segment and later extends to the NE fault segment. Two earthquake swarm in the later period of the waste fluid disposal occur on the NE and SW fault segments respectively, reversing the spatial migration of seismicity with respect to the beginning of the sequence and coinciding with a period of reduced injection rates. The strike of the three faults is in the NW direction and dip to the SW direction at ~60o. The faults cut through the sedimentary layers above the Arbuckle and extend into the basement. The moment tensor solutions for the M>3 earthquakes indicate an oblique reverse fault movement on the NW striking faults. The fault slip is consistent with the regional stress orientation.

2 **High-resolution sequence stratigraphy of fine-grained turbidite deposits, Leonardian Bone Spring Formation, Delaware Basin**

Rui Zhai

The Leonardian Bone Spring siltstones on the northwest shelf of the Delaware Basin of west Texas and southeast New Mexico are associated with a fine-grained, sand-rich turbidite system. The Bone Spring is a heterolithic stratigraphic interval that is up to 1200 m (~4000 ft) thick and is mainly comprised of seven alternating carbonate and siliciclastic units that were deposited on the slope to basin floor. The second Bone Spring unit is currently one of the most important hydrocarbon pay zones of the Bone Spring play. Reservoir heterogeneity complicates horizontal-well placement and limits the efficient exploitation of the reservoirs. Consequently, to optimize production of prolific stacked pay zones, detailed analysis of Bone Spring stratigraphic variability and reservoir quality is warranted.

To delineate the second Bone Spring sequence stratigraphy, 530 km2 (204 mi2) of high-resolution 3-D seismic data, seismic attributes, and log data for 60 wells were analyzed. This study explores siltstones of the second Bone Spring Formation, which is dominated by a succession of deep-water, low-density turbidites. The second Bone Spring siltstone interval can be stratigraphically divided into three depositional units, consisting of a short-term transgressive carbonate zone bounded above and below by regressive siltstones. The average thickness of the upper and lower siltstone intervals is approximately 30 m (98 ft) and 50 m (164 ft), respectively. The lower and upper siltstones contain at least 4 and 3 siltstone cycles, respectively, and the thickness of each cycle is highly variable (mean thickness = 10 m; ~33 ft). Seismic geometric and frequency attributes and acoustic impedance illustrate the incised channels on the upper slope and distributary channel complexes on the distal slope. These sinuous distributary channels exhibit a nested geometry. The lateral dimension of channel complexes ranges from 10 m (~33 ft) to 120 m (~394 ft) and most channel complexes are <30 m (~98 ft) wide. Distributary channel complexes grade into sheet-sandstone complexes that are >300 m (~984 ft) thick. Distributary channel complexes grade vertically and laterally into sheet sandstone lobes in response to relative changes in sea level. This study reveals that the second Bone Spring Formation siltstones represents lowstand deposits that are sourced from multiple areas of the adjacent northwestern shelf. The stratigraphic characteristics of the upper and lower siltstones are important for horizontal-well design and to better understand the spatial variability of the Bone Spring Formation reservoirs across the Delaware Basin.

13 **Impact of tectonic stress and hydrostatic pressure on the giant field of Hassi Messaoud, Algeria**

Lonnie G. Kennedy

Hassi Messaoud (HMD) is a giant oilfield (40 x 40 km) discovered in 1956 and has been under development ever since. It is in the Sahara 800 Km south of Algiers, Algeria. The field is a modestly faulted anisotropic anticline (NE-SW). HMD is on the North African plate where σH > σV > σh (strike-slip) with σH oriented NW-SE. The major faults trend NE-SW, perpendicular to σH and were formed in a preceding stress system. Full-hole cores were taken for nearly every vertical well then analyzed for permeability (K), porosity (φ) and water saturation (Sw) from plugs taken every 20 cm.

HMD is over-pressured (0.607 psi/ft) which likely arises from artesian conditions. HMD is in a basin at -10900 ft (3300 m) but the reservoir crops out on the surface at +2950 ft (+900 m) in the Hogar Mountains, hundreds of Km south. Given the weight of salt water 0.105 bars/m * Δh (4,200 m) = 462 bars (6,700 psi) the original reservoir pressure (Po).

The reservoir is comprised of ~250 m of Cambrian-Ordovician quartz sands eroded to ~60 m in the center of the field (Hercynian orogeny). The reservoir is transgressive from alluvial fans to shallow marine. There are lithologic variations in vertical section but the strata are homogeneous laterally. So, it is surprising that permeability ranges from .001 – 1,000 mD impacting production.

About 440 wells were fracture stimulated with DFIT test to measure σh. Astonishingly, DFIT σh ranges from 5,150 – 12,300 psi. Given Po = 6,700 psi this infers low stress regions likely auto-fracked while the high stress regions challenge equipment to hydraulically fracture the rock at all.

Sigma h is often estimated using a bilateral constraint equation where σh is a largely a function of σV. There is little structural change across HMD nor much variation in poro-elastic properties. There is little correlation between σV and σh but there is a good correlation between σH and σh. This makes sense as the stress system is strike-slip. Mapping and 3D modeling of DFIT σh values shows low σh in faulted regions and antiformal areas with the inverse conditions for high σh.

In sandstone with pore water, stress imparts chemical energy causing Si dissolution at grain contact points then reprecipitation as pore lining (chemical compaction). High stress portions of HMD experience greater silica cementation, significantly degrading permeability sometimes with nominal changes in porosity. Strong σH is NW-SE so the resulting strain (folding and fault reactivation) is oriented perpendicular NE-SW as observed.

An empirical equation was developed years ago for HMD to estimate σh:

σh=11.837-40.687*Ø-9.035*Vsh+5.899*Sw

7 **Impact of hydrothermal fluid flow on the Anadarko Basin petroleum system as revealed by the Pan Am Barnes D-2 Core**

Andrew Hollenbach, Robert Goldstein, Sahar Mohammadi, Andreas Möller

The Pan Am Barnes D-2 core was retrieved from the basin-shelf margin of the Midcontinent's Anadarko Basin. Petrography, fluid inclusion microthermometry, burial history, and U-Pb dating reveal that hydrothermal fluid flow was altering rocks before significant burial and petroleum migration. Recognizing hydrothermal fluid flow's impact on the petroleum system is critical because it diagenetically alters fluid migration pathways (and reservoirs), drags oil and gas along flow pathways, and can mature source rock above expected burial temperatures.

In one example, a calcite cement from Mississippian strata precipitated in the mold of an anhydrite nodule after silicification and stylolitization. This calcite has primary aqueous two-phase fluid inclusion assemblages that homogenize between 113°C and 115°C, and yields a U-Pb date of 318 ± 18 Ma. Using a fine-tuned burial history, the temperature is 72°C warmer than the ambient burial temperature at 318 Ma. This is evidence for hydrothermal fluid flow at 318 ± 18 Ma. This Mississippian-Pennsylvanian timing is consistent with other records of hydrothermal fluid flow from Midcontinent Mississippian rocks. These data suggest that warm fluids were driven by the hydraulic head associated with the topographic high of the Ouachita and Ancestral Rocky Mountains, and they migrated advectively out of the foredeep and towards the shelf.

Petrography in plane-polarized and ultraviolet (UV) light reveals that the porosity of the Pan Am Barnes D-2 core Mississippian rocks was enhanced episodically during structural deformation. After fracturing, dissolution enhances porosity, and then precipitation of mineral or bitumen reduces it. In one example, a fracture is filled with calcite exhibiting a cataclastic texture, indicating active deformation during the calcite precipitation. We obtained a new LA-ICP-MS U-Pb date of 302 ± 14 Ma from this calcite suggesting that active deformation was occurring in the area around the time of hydrothermal fluid flow, and the topographic high of the Ouachita and Ancestral Rocky Mountains. In yet another example, later in the paragenesis, calcite precipitated in a popped-open stylolite. In this late stage of the paragenesis, oil migration (and bitumen) is closely associated with fracturing. If the long-lived system of hydrothermal fluid flow was valved episodically by structural events, such as these, then long-term hydrothermal fluid migration could be represented by many pulses of fluid flow.

This prolonged period of hydrothermal fluid flow, the consequence of the enduring topographic highs of the Ouachita and Ancestral Rocky Mountains, would have impacted the petroleum system along the conduits of fluid flow. This impact would be most intense near the intersection of stratigraphically controlled aquifers and structural damage. Regionally, the alteration would be confined to rocks nearest the advective aquifer (e.g. below Pennsylvanian shales), but in fault damage zones the alteration would track vertically across section. In this

15 **Investigating the Sensitivity of Seismic Attributes in Seismic Facies Identification Using a Supervised ML Technique**

Emuobosa Patience Ojoboh, Heather Bedle, and Brett M. Carpenter

Seismic reflection has been the primary method of subsurface exploration for over a century, as its high-precision imaging of the earth beneath our feet has been instrumental in supporting the oil and gas, geothermal, and environmental engineering industries. The understanding of subsurface structures from seismic data has been greatly enhanced by the increased use of machine learning, which allows for the quick and accurate identification of geologic structures in seismic images. Historically, seismic data interpretation has been subjective, resulting in a high likelihood of misinterpreting precise details of facies and their corresponding types. Recently, machine learning methods have been implemented in the identification of different types of facies, however, these methodologies are limited to identifying facies from different rock types. In this study, we start by replicating previous findings by utilizing a different seismic volume, with the ultimate goal of being able to identify similar rock types with different seismic facies. A tree-based machine learning model was developed using the random forest algorithm to classify different seismic facies with different rock types (volcanic rock and conformable sediments) and further interpret the sensitivity of seismic attributes to facies identification using Shapely Additive Explanations (SHAP). For this study, six seismic attributes were selected as inputs based on the results of a previous study, which indicated that they had high sensitivity in recognizing chaotic and high-amplitude reflectors, as well as those exhibiting semi-continuous to semi-chaotic amplitudes, which is characteristic of the facies in the target area. The chosen input attributes were peak magnitude, dip magnitude, coherency (energy ratio), peak frequency, GLCM homogeneity, and GLCM entropy. Publicly accessible, time migrated, and SEG negative polarity 3D Seismic Kora data (Kora3D) from the New Zealand Petroleum & Minerals website was utilized for this study. Preliminary results indicate that the seismic attributes used in this study have a high level of accuracy, approximately 85%, in distinguishing between seismic facies of different rock types. It was also observed that the peak magnitude and dip magnitude summed to significantly identify the different facies with a percentage importance of 80% when using SHAP while the GLCM attributes have little or no influence on the identification of seismic facies with different rock types. This study underscores the importance of understanding the inner workings of machine learning models and the influence of the input features in order to explain predictions. The findings from this study further illustrate the advantage of leveraging machine learning methodologies in improving seismic interpretation with minimal mismatch compared to the conventional subjective approach.

4 **Petrophysical Considerations for Rare Earth Element and Critical Mineral Evaluation in Midcontinent Pennsylvanian Strata**

Ibukun Bode, Stephan Oborny, Franek Hasiuk, & Matt Joeckel

Targeted exploration for critical minerals and rare earth elements (REE) in shale and coal beds in the midcontinent region can be done by leveraging oil and gas data and established formation evaluation techniques. This opportunity includes the use of electron capture spectroscopy (ECS) geochemical logging tools that provide rapid measurements of major minerals and trace elements. Here, we utilize multimineral modeling to examine possible correlations between ECS-measured Gadolinium (Gd) and other REEs in the Pennsylvanian section of the Cherokee Forest City Basin. Geochemical logging tools directly measure Gd due to its high microscopic capture cross section (CU) that allows for detection at concentrations as low as 0.0005 weight percent. Resistivity, density, spectral gamma, and elemental logs was integrated for continuous lithology interpretation. Photoelectric factor (PE), density, and neutron logs provided TOC and kerogen estimates for thin-bed coal flags. Results show a consistent relationship between elevated Gd concentrations and high thorium, iron, and density log response. Our ongoing work aims to establish strong correlations between log-measured Gd and lab-assessed REE concentrations from geochemical assays of cutting and core samples. Forward modeling techniques will also allow for predicting the presence of specific REEs from log Gd data. The outcomes so far highlight the untapped potential of reservoir characterization applications for mineral resource exploration. The proximal stratigraphic relationships between the formations of interest and regional oil and gas reservoirs also provide preexisting subsurface data, which are otherwise unavailable in other regions.

Poster Abstracts in Alphabetical Order

3 **Preliminary assessment of the phosphate and rare earth element potential in the Upper Woodford Shale on the Lawrence Uplift, Ada OK**

Andrew Cullen & David Hull

Apatite-dominated phosphate nodules and phosphorite beds in the Upper Woodford Shale occur at or near the Devonian-Carboniferous boundary over an area of more than 19,000mi2 / 40,000km2 and represent a potential source of phosphate and rare elements. Phosphate is a key ingredient in fertilizer and REEs such as neodymium (Nd) and dysprosium (Dy) that are critical for manufacturing high-strength magnets, substitute into the apatite crystal structure. The Devono-Mississippian Woodford Shale of Oklahoma is principally known as a world-class siliceous marine petroleum source rock suitable for exploitation as an "unconventional" reservoir, but the Woodford Shale also represents a potential resource for elements critical in the drive to decarbonize the US and global economy.

ICP-MS analyses of Woodford phosphate samples collected along a 150 km dip transect from the Lawrence uplift near Ada through the Arbuckle Mountains to the Criner Hills in the Ardmore Basin demonstrate that the Lawrence Uplift is strongly enriched in REEs relative to the other parts of the Woodford system. Lawrence uplift phosphates average (n=10) 249ppm Nd and 47ppm Dy and Woodford phosphate nodules average 33 wt.% P2O5 (Siy, 1988). Analysis of the quarry wall and a behind the outcrop core at the Wyche Shale Pit establish the Upper Woodford has a 60ft/18m interval containing about 5% phosphate nodules and phosphorite thin beds. Oher shallow cored wells and quarries on the Lawrence uplift show this is consistent an extensive feature.

The density contrast between the organic rich shale-host (2.4gm/cc) of the phosphate nodules (apatite 3.2gm/cc) should be sufficient for good recovery (~80%) using crushing and gravity separation methods. Recovery of REE by acid digestion commonly exceeds 90%. Assuming total recovery of 70% average thickness of 60ft with 5% nodules, average Nd, Dy & P2O5 concentrations, and respective current commodity prices we estimate there is around $750,000,000/mi2 of in-situ value in the Upper Woodford Shale phosphates on the Lawrence Uplift. Structural relief is low, the overburden is thin, and there is already an active shale mine, the Wyche Shale Pit with phosphate nodules exposed in the quarry walls. The favorable combination of these parameters suggests the need for a more rigorous commercial evaluation of the Woodford Shale's phosphate and REE potential on the Lawrence Uplift.

12 **Revealing the hidden faults of the Oklahoma basement through unsupervised machine learning and integration with earthquake data**

Diana Katerine Salazar Florez, Heather Bedle, & Brett Carpenter

The significant seismicity Oklahoma experienced in the past 15 years has made clear the importance of recognizing previously unmapped basement-rooted faults. The cause of this seismicity is associated with wastewater injection into the Arbuckle Group that overlies the basement rocks, bringing up the hypothesis that there is a structural connection between the overlying sedimentary strata and the Precambrian basement. Different studies have been conducted recently to try to understand and map these faults. There has been a great effort to increase the density of the seismometer network, improve the Oklahoma earthquake catalog, and enhance the tools to process the data to georeferencing the epicenters. Therefore, most of these studies have focused on earthquake data, while others have focused on core data and multi-attribute analysis using seismic reflection data. Neither of these studies has applied machine learning techniques for basement fault identification using seismic data.

In this study, we tested conventional and novel geometric seismic attributes, such as broadband and multispectral coherence, most-positive and most-negative principal curvature, and total aberrancy azimuth and magnitude, as well as their integration using unsupervised machine learning methods, such as self-organizing maps and generative topographic mapping. The seismic dataset used is located in Pawnee County, in northcentral Oklahoma, where a clear fault at basement depth was previously identified through earthquake data, and where an intrabasement reflector was also identified. Our approach focused on the correlation of surface extractions of the attributes and machine learning results from the top of the Arbuckle and the intrabasement reflector interval, and the geological reasoning was that lineaments constantly seen at such different intervals could be inferred to be structurally related rather than stratigraphically related.

Different lineaments were identified using the different geometric seismic attributes implemented, however, only their integration using unsupervised machine learning methods permit the identification of the previously detected earthquake fault as well as facilitate the visualization of other lineaments that could be potential basement-rooted faults. Some of these faults have strikes favorable for reactivation under the current stress state in Oklahoma, restating the importance of their mapping and reporting. Overall, the integration of different geometric attributes through unsupervised machine learning methods showed to be a successful approach for identifying and mapping previously unseen basement-rooted faults in Oklahoma. This approach could be further applied to other seismic datasets in the state to improve the understanding of basements faults in Oklahoma.

1 **Statewide assessment of CO2 storage capacity for the Cambrian-Ordovician Arbuckle Group and selected Ordovician formations, Oklahoma**

Anna Turnini & Matthew Pranter

In this study, we evaluate the CO2 storage capacity (Gt) for selected Ordovician reservoirs and the Cambrian-Ordovician Arbuckle Group for the State of Oklahoma (study area =43,920 mi²; 113,750 km2). While there have been regional assessments of CO2 storage capacity by the USGS that group the entire Paleozoic interval into one reservoir, there have not been assessments for individual reservoirs in Oklahoma. The Ordovician reservoirs include the Viola, Bromide, Tulip Creek, McLish, Oil Creek, and Joins. The CO2 storage capacity (Gt) was also determined for the top Arbuckle Group to basement.

A well-constrained regional 3-D structural model (stratigraphic and structural framework; 3-D model grid) for the Ordovician was built using >42,000 well-derived formation tops and 330 wells each with a modern suite of digital well logs containing Gamma Ray (GR), Density (RHOB), Neutron Porosity (NPHI), and Photoelectric Effect (PE) across the entire Ordovician section. The 3-D structural model for the Arbuckle Group was constructed using 6,500 well-derived formation tops and 93 wells with modern digital logs and full penetrations to basement. Using deterministic petrophysical methods, mineralogy curves (e.g. quartz, calcite, clay percentages) and lithology logs were generated for both intervals. 3-D lithology models consisting of limestone, dolostone, sandstone, and shale were created that were constrained to the Ordovician and Arbuckle 3-D stratigraphic and structural framework and lithology logs. For each interval, 3-D porosity models and pore-volume estimates were generated that are constrained to the 3-D lithology models and total porosity logs derived from neutron and density porosity. Using estimated geothermal gradient trend for Oklahoma, a 3-D temperature model was derived which was used to generate CO2 density. The mass of CO2 (kg) and CO2 storage capacity (Gt) for each interval was determined using the U.S. Department of Energy, National Energy Technology Laboratory (DOE-NETL) methods for saline reservoirs and a range of CO2 storage efficiency factors by rock type.

The Ordovician interval ranges in thickness from 0 to 2,100 ft (0 to 640 m) with an average thickness of 700 ft (213 m). The sandstones in interval exhibit porosity values up to 20% but typically range from 8-18%. The Arbuckle thickness ranges from 100 to 3,000 ft (30 to 914 m), with an average thickness of 1,730 ft (527 m). The Arbuckle commonly consists of predominantly dolostone with consistent porosity ranging between 6-10%. Results show that for the Ordovician interval CO2 storage capacity varies significantly both stratigraphically and

laterally across Oklahoma and ranges from approximately 45 Gt, 72 Gt, and 111 Gt depending on saline efficiency ranges (P10, P50 and P90, respectively). The interval comprising the Bromide, Tulip Creek, McLish, and Oil Creek, with 7% average porosity, has the highest CO2 storage capacity at 19 Gt, 36 Gt, or and Gt. The Viola (3% average porosity) storage capacity is 16 Gt, 24 Gt, and 33 Gt, and the Bromide (7% average porosity) storage capacity is 9 Gt, 11 Gt, or 15Gt (for P10, P50 and P90, respectively). Results illustrate that the Arbuckle Group P10, P50, and P90 CO2 storage capacity values are approximately 197 Gt, 265 Gt, and 346 Gt. Dolostone is the main reservoir rock within the Arbuckle Group and could store 183 Gt, 241 Gt, and 305 Gt of CO2, which equates to 93%, 90%, and 88% of the total Arbuckle Group storage capacity; the remaining CO2 storage capacity is associated with limestone and sandstone.

Significance
The U.S. Environmental Protection Agency estimates that in 2020 4,715 Gt of CO2 were emitted in the United States alone. According to the US DOE-NETL methods, for the State of Oklahoma, for the selected Ordovician reservoirs and the Arbuckle Group, the total CO2 storage capacity ranges from 242 – 457 Gt and will likely play a part in a decarbonized future.

10 **The Economic Impact of Saltwater Disposal Performance: Observations of Clay Type and Distribution in an Underperforming SWD**

Benjamin L. Howard & Joe Bauman
Saltwater disposal wells (SWDs) are a critical component of unconventional plays where water-oil ratios may exceed 2:1. Depending on producer working interest, volume of produced water, and injection performance SWDs may generate income for the SWD operator that may either provide another revenue stream or enable drilling in more marginal oil-productive areas—or, in the case of SWD underperformance, may degrade a project's economics. Injection performance may be the most difficult factor to predict, and the most limiting factor, in determining economic success.
In this study, we present an example of an SWD that has underperformed relative to expectations and illustrate the economic impact of such underperformance. Using core and NMR logs from an analog well, we illustrate how comparing wireline log motifs may be utilized to inform on mineralogy and permeability where no direct data is available and demonstrate that permeabilities may be as high as 2 orders of magnitude greater than what has been modeled for this SWD using performance data (nodal analysis). Potential causes of underperformance may be clay type and distribution, formation damage associated with drilling muds, and offset SWD interference; here we limit our discussion to the role of clay type and distribution.

16 **Thin Layer Effects on Horizon Attributes: Beyond Amplitude Tuning**
Muhammed Jallow & Abdelmoneam Raef
3D seismic data has revolutionized the oil and gas industry by providing vital insights into the stratigraphy, geologic structures, and sedimentology of sedimentary basins worldwide. However, accurately identifying prospects, delineating hydrocarbon reservoirs, and understanding their properties rely on the quality and resolution of the seismic data. The increase or decrease of seismic attributes, caused by thin-layers tuning "geometrical effect" interference between adjacent reflectors of geological layers, adversely impacts the utility of seismic attributes in reservoir characterization. Thus, distinguishing seismic attributes anomalies diagnostic of petrophysical properties from geometric effects poses significant challenges and uncertainties.
Several studies in seismic data tuning correction often focus on amplitude attribute correction. However, reservoir geometry can also affect other seismic attributes, such as phase and frequency, and may require tuning correction. Hence, there is a need for more integrated approaches that correct for multiple attributes simultaneously. This study presents an effective data-driven method to isolate and remove thickness (tuning) effects on seismic horizon attributes, such as the thickness-related variations in horizon instantaneous frequency and amplitude attributes.
This study employs three methods, statistical and deterministic approach, wedge model approach, and machine learning, to correct various seismic attributes and compare the results.
CO2 sequestration also causes reservoir seismic time-thickness changes and affects the seismic response due to the mixing with and displacement of hydrocarbon oil, changes in subsurface pressure, and fluid distribution. The response of thin layer effects on seismic attributes offers enormous potential in monitoring CO2 sequestration and enhanced oil recovery programs.

6 **Unconventional Reservoir Characterization of the Newly Explored Caney Shale, Southern Oklahoma**
Izabelle Buentello, Michael Grammer, & Yulun Wang
The Mississippian Caney Shale of the Ardmore Basin, southern Oklahoma, has recently been targeted as an unconventional hydrocarbon reservoir. Due to the limited industry experience with this play and the overall limited information of the Caney Shale as a viable unconventional target, we are evaluating and characterizing potential reservoir quality by quantifying the pore system architecture (e.g., pore type, size, shape) within a core-based stratigraphic and depositional environment framework. Porosity and pore system architecture are critical in evaluating reservoir potential, particularly the tie between pore types and resulting permeability.
Detailed core analysis was used to identify facies types and their tie with pore system architecture. A variety of mixed carbonate-siliciclastic facies types were identified, including low energy mudstones and siltstones, and carbonate intervals that are interpreted as higher energy event deposition (turbidites, debris flow deposits, contour currents, hybrid events) within the low energy background sedimentation on a slope to ramp system. Preliminary findings utilizing a scanning electron microscope (FE/SEM) demonstrate a variety of nanometer- to micrometer-sized pore types, including organic matter pores, a variety of intraparticle, intercrystalline, and interparticle pores, as well as intraparticle/intercrystalline pores within clay. Digital image analysis was used to quantify two-dimensional pore geometrical parameters (size and shape, etc.). Because it is a mixed carbonate and siliciclastic system, we are integrating laboratory measured sonic velocity to further predict the statistical relationship between acoustic response and poroperm trends in these small complex pore systems. The main facies groups have similar pore types, but variabilities are seen in the pore geometrical data, as well as acoustic response related to total porosity and permeability. These observations suggest variable pore system architecture relates to the resultant petrophysical response in the different facies, as well as the potential of estimating reservoir quality using pore geometrical data combined with sonic velocity. These results suggest that consideration of the variable depositional distribution patterns and relating pore architecture as well as tying sonic velocity relationships to relative permeability and reservoir quality of these facies can be valuable for quantifying porosity and permeability, and characterizing reservoir heterogeneity at multiple scales.

Notes


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