HGS Bulletin
Houston Geological Society
Volume 63, Number 2
October 2020

No Ammonites? No Problem! How Paleocene Trace Fossils in Wyoming Complicate Sediment Routing Histories for the Wilcox

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HGS Executive Office Director	Andrea Peoples	713-463-9476	andrea@hgs.org
HGS Admin. Assistant/Web Content Manager	Alyssa Cushing	713-463-9476	acushing@hgs.org

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In Every Issue

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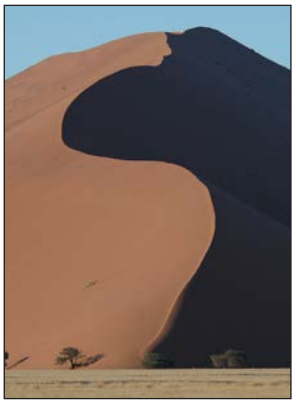
Technical Meetings

Other Features



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About the Cover: A mid-Paleocene, incised valley fill complex of the basal Hanna Formation in Wyoming's Carbon Basin is a remnant of the regional sediment fairway to the Gulf Coast Wilcox Group. The sandy valley complex incises earlier Paleocene lagoonal and coastal plain carbonaceous shales of the Ferris Formation. Photo supplied by Anton Wroblewski.

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The Calvert Memorial Fund *is a scholarship program for U.S. students enrolled in earth science graduate programs in our region. It is managed by a 5 member HGS board of trustees that provides annual support for* **graduate** *studies.*

The HGS Foundation Fund *is a scholarship program designed specifically for* **undergraduate** *geoscience students from area universities.*

Jim Tucker
president@hgs.org

October is a Busy Month

This will be a busy month for your society. We started the activity year in September will a full slate of remote technical meetings. Our Field Trip Friday and Continuing Education programs during the summer allowed us to become familiar with how to execute remote presentations and large meetings. We had some experience with Zoom meetings for the Board and some committee meetings, but not for presentations, so it has been a learning experience, and will continue to be.

Every other year in the autumn, we host the Africa Conference, in alternate years with the Petroleum Exploration Society of Great Britain (PESGB). This event has drawn several hundred attendees in some past years for the in-person events, and has developed over almost two decades of HGS involvement into the premier geoscience event covering the entire African continent. This year it will definitely look differently, although the solid technical content will be there. Several months ago we decided to be virtual, and since often attendees will travel from the Eastern Hemisphere to attend, will have presentations five Thursday mornings (Houston time) so the event may have attendees from several time zones east of Houston, later in their afternoon. We are able to offer this content-rich event at an attractive price, for all five sessions or by individual sessions. If you are interested in the region, check the conference program on HGS website for talks of possible interest.

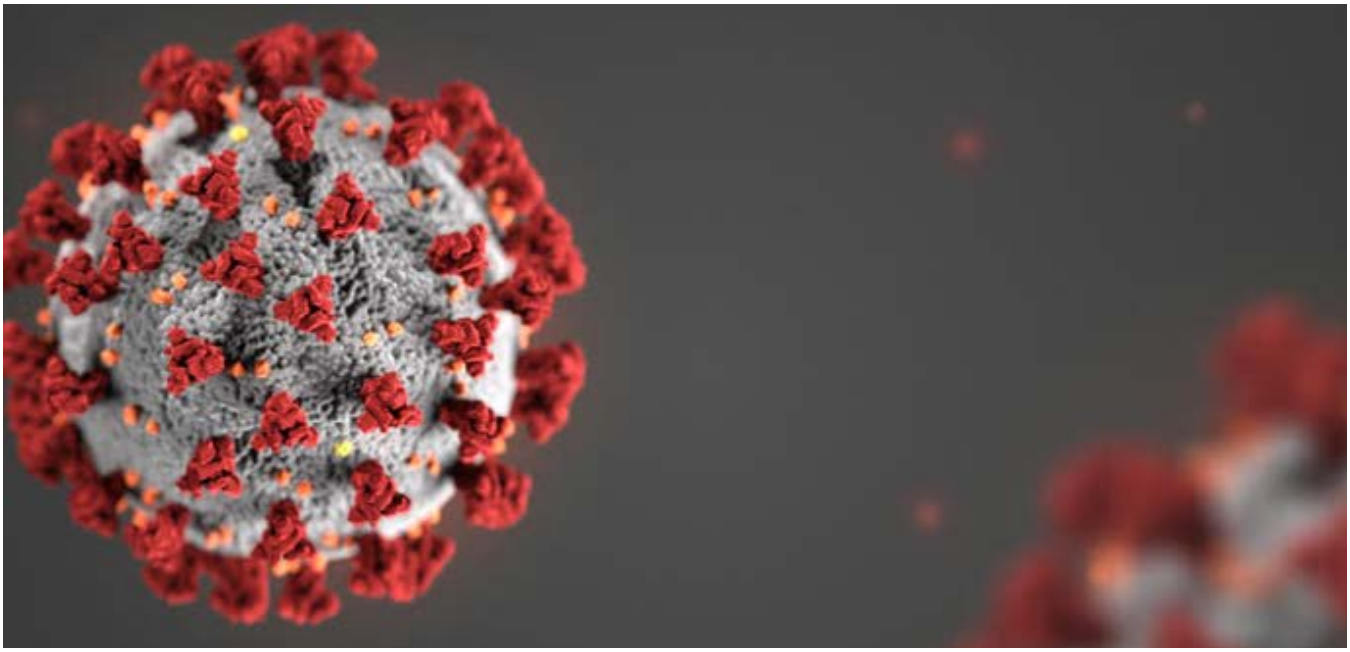
October begins with the AAPG ACE annual meeting, the GCAGS annual GeoGulf meeting, and the SPE-GCS mid career Hiring Event, so many of us have a busy week in store, in addition to the Africa Conference.

The several technical presentations in September went well, and we have the techniques set for conducting these talks remotely, including a question and answer period after the talks. We do not anticipate any in-person events through the remainder of 2020, and hope that we can resume meetings safely sometime next year. But we will not have in-person meetings until we are sure that we can do it safely. Unfortunately, that goes for our several social events throughout the year, which by their nature, involve socializing. We are thinking of ways to have safe sessions, but they will not be before sometime in the Spring of 2021. We are planning for one continuing education program in the first quarter or 2021, and we are planning on it being virtual, although there is plenty of time for it to change to in-person, if conditions allow. And although it is fully-subscribed, with a waiting list, the biennial Grand Canyon Raft Trip, moved from last June to next June, we all hope it can go as planned. If you have not been on this trip, ask anyone who has been on it, and they will convince you it is a trip you have to take at least once.

October begins with the AAPG ACE annual meeting, the GCAGS annual GeoGulf meeting, and the SPE-GCS mid career Hiring Event, so many of us have a busy week in store, in addition to the Africa Conference. Plenty of opportunities for professional development, and hopefully, some (remote) socializing with colleagues.

So, your society is off to a good start this challenging year. Last month I mentioned my effort to call at least one colleague I have not kept up with each day. It's a good week if I talk to one or two, but we enjoy catching up, and it's good to maintain my network. Try it and I'll bet it brightens up your day. ■

Be safe and volunteer for something this month.
Jim Tucker



Coronavirus (COVID-19) Policy Statement: Updated Monday, September 28, 2020

Because of the ongoing coronavirus (COVID-19) situation, all in-person HGS events through the end of 2020 are cancelled/postponed or will be substituted by online events. Please check the HGS website on a regular basis for all HGS online event opportunities.

The HGS Board will continue to monitor the situation and determine whether to extend the cancellation or postponement of HGS in-person events as we enter the New Year.

Please monitor hgs.org and your email for further communication concerning HGS events.

For more information about how you can help to prevent the illness, visit the CDC website: https://www.cdc.gov/.

2020-2021 HGS Board

Ceri Davies
editor@hgs.org

There's No Place Like the Field

Hello rock friends, The featured talk this month is titled *No Ammonites? No Problem! How Paleocene Trace Fossils in Wyoming Complicate Sediment Routing Histories for the Wilcox.* The talk will be presented on Wednesday 28th October by Anton Wroblewski, a great geologist who I was lucky enough to accompany in the field a few summers ago.

For the most part, field trips play a major role in why we all pursue geology with a passion – being able to work outdoors, travel to new and interesting places or maybe revisiting a place for the tenth time and still discovering something new.

I was lucky enough to attend a University that fully embraced the concept that the best geologists are the ones who have seen the most rocks. My Easter and Summer breaks were spent all across Europe – from the previously discussed Pembrokeshire coastline, the iconic limestone ridges of the Cantabrian mountains through to the metamorphic basement of the Swiss Alps. Aside from the geology, one of the most endearing memories of this time was a particularly fresh Alpine snowfall that required hours of shoveling to make way for our camp that evening.

Whilst nothing can beat time in the field, this summer, the Houston Geological Society, led by Linda Sternbach, provided a series of Field Trip Friday webinars – taking us back to a time when we could enjoy the wonders of geology first hand. One of these webinars was an excellent virtual float along the Colorado River through the Grand Canyon as Linda presented her experience from a recent HGS Grand Canyon Raft Trip.

With company budgets at a premium and field trips falling further down the priority list, we're looking to our members to suggest trips or locations they would like to visit when the world opens up once more – if you have any outcrops that you would like to explore with like-minded individuals, please do get in touch and we will present the idea to our members.

This leads me onto one of my favorite places in the US for fieldwork – the Powder River Basin of Wyoming. The flanks of the basin provide wonderful exposure of the remnants of the Western Interior Seaway, manipulated by subsequent tectonic events where the sandstone packages now present themselves as a series of ridges northwards out of Casper along I-25. This weekend, I head to a southern exposure of the seaway, visiting the Grayson Formation in Waco to explore the late Cretaceous as preserved in Texas. ■

Making friends with the locals. Snake Ridge, Angostura Reservoir, South Dakota.

With best wishes,
Ceri

The Wall Creek Members of the Frontier Formation, Western flank of the Powder River Basin, Wyoming.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OCTOBER 1, 2020

SESSION 1 : AFRICA OVERVIEW & ACTIVITY

CHAIRS: MIKE LAKIN, MATT TYRRELL

ALL TIMES ARE IN CENTRAL STANDARD TIME (CST)

8:00AM - 8:05AM
WELCOME & OPENING REMARKS

8:05AM - 8:20AM
THE TRUE COST OF EXPLORATION IN AFRICA OVER THE PAST DECADE
KEITH MYERS, WESTWOOD ENERGY

8:20AM - 8:30AM
THE LANDSCAPE OF ACQUISITION & DIVERSITURES
MIKE LAKIN, ENVOI

8:30AM - 8:35AM
BRIEF INTERMISSION

FARMOUT FINANCE FORUM

8:35AM - 9:45AM
FIVE MINUTE FARMOUT DEALS
VARIOUS ENERGY COMPANIES

9:45AM - 9:55AM
FINDING FINANCE FOR YOUR ENERGY ASSET IN 2020
TBC

9:55AM - 10:00AM
CLOSING REMARKS

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PROGRAM

OCTOBER 8, 2020

SESSION 2: AFRICA & ITS CONJUGATE MARGINS

CHAIRS: BILL DICKSON, HELEN DORAN

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8:00AM - 8:05AM
WELCOME & OPENING REMARKS

8:05 AM - 8:25AM
RIFTING & BREAKUP IN THE SOUTH ATLANTIC
PAUL BELLINGHAM, ION GEOPHYSICAL

8:25 AM - 8:45AM
THE GUINEA-DEMERARA VOLCANIC CONJUGATE MARGINS
MARCUS ZINECKER, UNIVERSITY OF HOUSTON

8:45 AM - 8:50AM
POSTER: APPLICATION OF NON-TRADITIONAL BIOMARKERS TO THE EQUATORIAL ATLANTIC MARGIN
CATIE DONOHUE, GEOMARK RESEARCH

8:50 AM - 8:55AM
POSTER: A NEW METHOD USING MARINE SATELLITE GRAVITY DATA
MARCO URDANETA, UNIVERSITY OF HOUSTON

8:55 AM - 9:00AM
POSTER: UNDERSTANDING THE SUB-SALT RIFTING HISTORY OF THE SOUTH GABON BASIN
SEAN ROMITO, UNIVERSITY OF HOUSTON

9:00 AM - 9:05AM
POSTER: SYNTHESIS OF CRUSTAL STRUCTURE & HYDROCARBON POTENTIAL
HUALING ZHANG, UNIVERSITY OF HOUSTON

9:05 AM - 9:15AM
POSTER Q&A

9:15AM - 9:35AM
A SIDEWAYS LOOK AT SYN-RIFT PROSPECTIVITY ON TRANSFORM MARGINS
GAVIN ELLIOT, NEW AGE (AFRICAN GLOBAL ENERGY) LIMITED

9:35AM - 9:55AM
GEOCHEMICAL CLASSIFICATION OF 1500 CRUDE OILS
CRAIG SCHIEFELBEIN, GEOCHEMICAL SOLUTIONS INT., INC.

9:55AM - 10:00AM
CLOSING REMARKS

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OCTOBER 15, 2020

SESSION 3: WEST AFRICA EXPLORATION

CHAIRS: PAUL BELLINGHAM, PAUL HARYOTT

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8:00AM - 8:05AM
WELCOME & OPENING REMARKS

8:05AM - 8:20AM
EXPLORATION POTENTIAL IN THE FRONTIER OFFSHORE NAMIBE BASIN, ANGOLA
NEIL HURST, ION GEOPHYSICAL

8:20AM - 8:35AM
REVEALING THE UNDEREXPLORED POTENTIAL OF THE KWANZA SHELF AREA, OFFSHORE ANGOLA
AVRIL BURRELL, PGS

8:35AM - 8:50AM
THE NEXT PHASE OF EXPLORATION IN THE ONSHORE KWANZA BASIN
MATT TYRRELL, ENVOI

8:50AM - 8:57AM
POSTER: SEISMIC STRATIGRAPHY & BURIAL HISTORY FOR SOURCE & RESERVOIR PREDICTION IN THE NORTHERN LUDERITZ
REGINALDA JOSEPH, UNIVERSITY OF NAMIBIA

8:57AM - 9:04AM
POSTER: STRUCTURAL EVOLUTION & BURIAL HISTORY OF THE DOLPHIN GRABEN/NORTHERN WALVIS BASIN, OFFSHORE NAMIBIA
FRIEDA KAHEWA-KETU THOMAS, UNIVERSITY OF NAMIBIA

9:04AM - 9:20AM
KAROO-RELATED BASIN-FORMING FAULT SYSTEMS OF NORTHERN NAMIBIA
JAMES GRANATH, GRANATH & ASSOCIATES CONSULTING GEOLOGY

9:20AM - 9:30AM
Q&A ON ANGOLA AND NAMIBIA

9:30AM - 9:45AM
BIO-PETROGRAPHICAL CHARACTERISTICS OF THE KALAMBAINA FORMATION
NUHU OBAJE, NIGERIAN NATIONAL PETROLEUM

9:45AM - 9:52AM
POSTER: SIGNIFICANCE OF FAULT ZONES & API-GRAVITIES ON BIODEGRATION OF CRUDE OILS
ANTHONY MADU, MICHAEL OPKARA UNIVERSITY OF AGRICULTURE

9:52AM - 9:58AM
Q&A ON NIGERIA

9:58AM - 10:00AM
CLOSING REMARKS

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OCTOBER 22, 2020

SESSION 4: SOUTH & EAST AFRICA EXPLORATION

CHAIRS: KEVIN DALE, SAM WALKER

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8:00AM - 8:05AM
WELCOME & OPENING REMARKS

8:05AM - 8:25AM
SOURCE ROCK INSIGHTS FROM A BASIN ANALYSIS WORKFLOW
KARYNA RODRIGUEZ, SEARCHER

8:30AM - 8:50AM
BRULPADDA & SEA LION: COMPARISON OF CONJUGATE DISCOVERIES
JOHN DRIBUS, DRIBUS GEOLOGIC CONSULTING, LLC

9:00AM - 9:20AM
TWO CASES OF DOUBLE SALOON DOOR TECTONICS IN AFRICA
KEITH MARTIN, INDEPENDENT CONSULTANT

9:25AM - 9:45AM
A KINEMATIC MODEL OF THE BIERA HIGH
JAVIER MARTIN, CGG

9:55AM - 10:02AM
POSTER: DEVELOPMENT OF LATE JURASSIC-EARLY PALEOGENE & NEOGENE-QUATERNARY RIFTS
LUELSEGED EMISHAW, OKLAHOMA STATE UNIVERSITY

10:05AM - 10:25AM
PETROLEUM PLAYS & PETROLEUM SYSTEMS MODELING OF THE LAMU BASIN IN KENYA
GODFRED OSUKUKU, NATIONAL OIL CORPORATION OF KENYA

10:30AM
CLOSING REMARKS

EACH PRESENTATION WILL BE FOLLOWED BY A FIVE-MINUTE Q&A

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OCTOBER 29, 2020

SESSION 5: NORTHWEST AFRICA

CHAIRS: BRIAN HORN, BEN SAYERS

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8:00AM - 8:05AM
WELCOME & OPENING REMARKS

8:05AM - 8:20AM
THE COMPLEX THERMO-TECTONIC STATE OF NORTH AFRICA
DUNCAN MACGREGOR, MACGEOLOGY LTD

8:25AM - 8:40AM
THE CALLOVIAN TRANSGRESSION ON THE ATLANTIC COAST OF MOROCCO
AUDE DUVAL-ARNOLD, UNIVERSITY OF MANCHESTER

8:45AM - 8:50AM
POSTER: APPLICATION OF BOREHOLE DEPTH IMAGING & SEISMIC REFLECTION TECHNIQUES IN RESERVOIR DELINEATION
MOHAMED A. EL-DAKKAK, EL HAMRA OIL COMPANY

8:55AM - 9:05AM
POSTER: APPLICATIONS OF NEW TECHNOLOGY - ALGERIA SEISMIC DATA
SAID GACI, SONATRACH-ALGERIAN PETROLEUM INSTITUTE (IAP)

9:05AM - 9:20AM
MEGA-REGIONAL POTENTIAL FIELDS AND SEISMIC REFLECTION STUDY
BENJAMIN MILLER, UNIVERSITY OF HOUSTON

9:25AM - 9:40AM
WHAT LURKS BENEATH TD?
ROBERT FOX, CHARIOT OIL & GAS

9:45AM - 10:00AM
MESOZOIC TO RECENT TECTONOSTRATIGRAPHY, PALEOGEOGRAPHY, AND HYDROCARBON PROSPECTIVITY OF THE GUINEA PLATEAU
MARCUS ZINECKER, UNIVERSITY OF HOUSTON

10:00AM
CLOSING REMARKS

EACH PRESENTATION WILL BE FOLLOWED BY A FIVE-MINUTE Q&A


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WHY SHOULD YOU ATTEND?

The HGS (Houston Geological Society) and EAGE (European Association of Geoscientists and Engineers) will host for the second time the Latin American conference that will take place in a fully virtual format, between the 1st and the 3rd of December 2020. On this occasion, the HGS/EAGE will bring an integral and exceptionally enriched conference on Latin America.

Since the last two decades, the Latin American region has faced continuous development in energy resources, which has opened to increased investment. In recent years, the oil and gas industry has significantly increased exploration and production activities in the southern Caribbean margin, the Andean foreland, Guyana-Suriname offshore, deep-water Brazil, Argentina and Uruguay offshore, unconventional exploration in Argentina and Colombia, and the opening of exploration areas on the Pacific margin of South America. All this makes the second HGS/EAGE Conference on Latin America a perfect setting to keep up with the latest in Petroleum Geoscience for Conventional and Unconventional E&P, Natural Resources and Ore Geology, Machine learning present and future role in exploration, Seismic Imaging in E&P, that in overall, contribute to open to constructive dialogues on energy integration and prosperity of the region.

The Technical Committee has prepared a flagship event that includes special sessions on the Caribbean Offshore and the Special Session on Venezuela "*Venezuela's Upstream to Downstream - Past, Present and Future*", oral presentations, and poster sessions that will be widely attended by academic and industry participants from the USA, Europe and Latin America.

We look forward to seeing you at the second Latin American conference hosted by the HGS/EAGE!

CONFERENCE TOPICS

The deadline for abstract submission is 21st September 2020. Please submit abstracts on the following topics:

The Geology of Latin America
- Latest insights from Mexico, the Caribbean, Central and South America.
- Conjugate Margins: cutting-edge ideas from geology and geophysics.

Seismic Imaging in E&P
- State-of-the-art methods
- Acquisition and interpretation success stories
- Challenges
- Regional insights

Applications of non-seismic Geophysical Methods
- Potential Fields: Gravity and Magnetics
- Multibeam and seabed coring
- Sea surface oil slick evaluation

Petroleum Geoscience for Conventional and Unconventional E&P
- New fields
- Key reservoirs and source rocks both offshore and onshore
- Best practices and hurdles in onshore exploration and development
- Maximizing recovery

Uncertainty Reduction Using New Techniques in Geophysics, Petrophysics, Reservoir Engineering and Reservoir Characterization.

Natural Resources and Ore Geology
- Resource development
- Present and future requirements

Environmental Sustainability and Carbon Capture & Storage: highlighting responsible development.

Machine learning present and future role in exploration through to exploitation in Latin America

IMPORTANT DATES

Call for Abstracts Closes	21st September 2020
Online Registration Deadline	23rd November2020
Second EAGE\HGS Conference	1 - 3 December 2020

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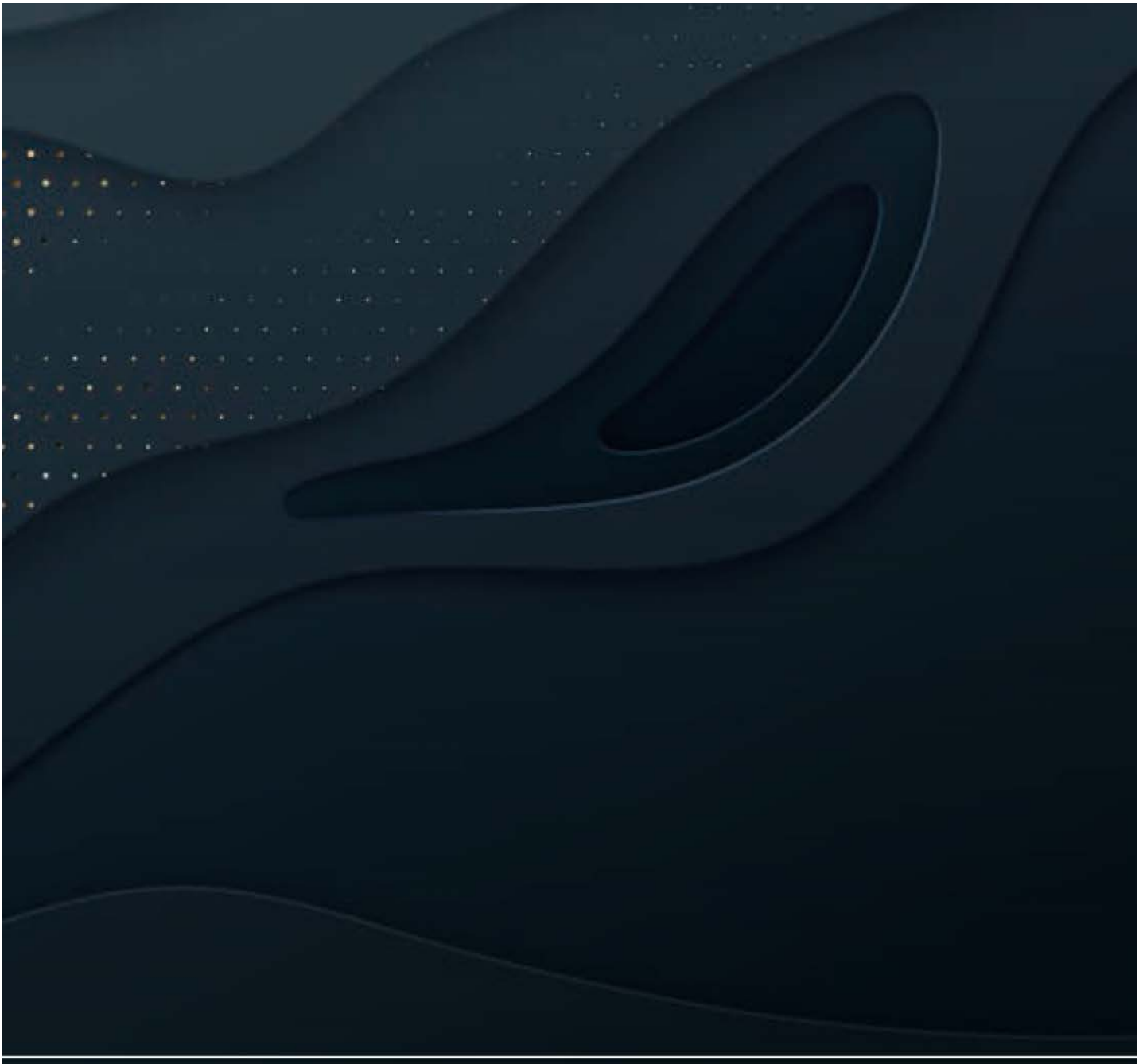
CONTACT US

Contact EAGE Latin America Office for all questions regarding abstract process, submissions, or for all other questions regarding this event + 57 310 8610709. laz@eage.org, americas@eage.org

SECOND EAGE/HGS CONFERENCE ON LATIN AMERICA •



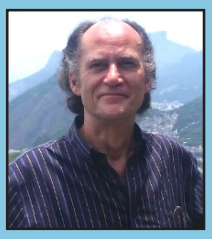
A Live Webinar!

Velocities, Imaging, and Waveform Inversion

The Evolution of Characterising the Earth's Subsurface

Featuring Dr. Ian F. Jones - ION Geophysical

November 9-11, 2020 9:00 am – 1:00 pm Houston Time



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

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Announcement of Paul M. Basinski Memorial Scholarship

The Undergraduate Scholarship Foundation of the Houston Geological Society is very pleased to announce the creation of the Paul M. Basinski Memorial Scholarship which has been established by his loving wife, Rene Basinski. Paul was a long time HGS member and supporter and she could think of no better way to honor his memory than supporting the next generation of geoscientists. The Foundation provides scholarships each year to students from seven local universities.

The Paul M. Basinski Memorial Scholarship will be a scholarship given to one of our scholars, selected by the Foundation Trustees, that demonstrates the most personal and scholastic growth, rising above obstacles to succeed. Rene Basinski believes that this type of individual would reflect the values that she and her husband, Paul, cherished.

Monday, October 12, 2020

Virtual Meeting via Zoom
12:00–1:00 p.m.
HGS Members $10 Non-Members $30 Students $5
https://www.hgs.org/civicrm/event/info?id=2240
Registered Attendees: A confirmation email will be sent upon registration with meeting links.
Event contact: Bryan Guzman – vice.president@hgs.org

Guochang Wang
Engineering Department
Saint Francis University
Loretto PA

3-D Geological Model of Shale Reservoirs Using Significant Amounts of Horizontal Well Data

A high-quality 3-D geological modeling of shale reservoirs is significant for improving the performance of shale plays by benefiting shale reservoir evaluation, numerical simulation, horizontal well drilling, and so on. Distinct from conventional reservoirs, data in horizontal wells are common in shale reservoirs. These data in horizontal wells cause various issues in 3-D structural and property modeling. As for 3-D structural modeling, the main challenge is to deal with the complicated spatial relationship between horizontal laterals and formation surfaces; as for 3-D property modeling, reservoir data acquired from horizontal wells is extremely uneven (enriched in drilling target zones and missed below drilling target zones), failing to determine frequency distribution of reservoir properties.

To overcome these problems, we have developed a comprehensive method to effectively use horizontal well data in 3-D geological modeling. Pseudo vertical wells (PVW) at and between formation tops are used to provide more controlling points for structural models with a suitable estimation of isochore/isopach map of formations/layers. And, frequency distribution of a certain reservoir property could be estimated by either using vertical well data only or removing the repeated segments of horizontal laterals. We have used the developed method in several shale plays, such as Marcellus Shale in Southwestern PA, Longmaxi-Wufeng Shale in Fuling Shale Gas Field, etc. Although there is still room to improve the method, it has helped us to improve quality of 3-D geological models of shale reservoirs. ■

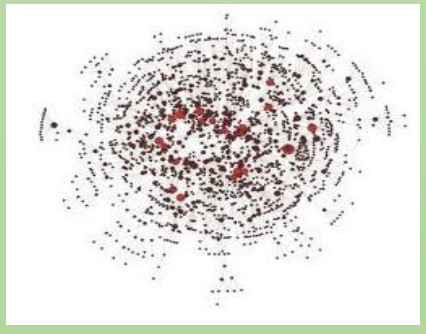
Biographical Sketch

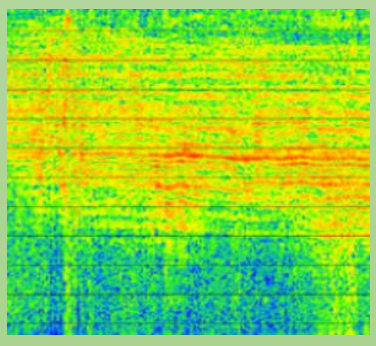
Guochang Wang is currently an associate professor at Saint Francis University. He received his Bachelor degree in petroleum engineering from China University of Geosciences (Wuhan) in June 2006 and his PhD degree in geology from the West Virginia University in August 2012. Then, he, as a postdoctoral fellow, worked at University of Chinese Academy of Sciences in Beijing, China for two and half years. He joined Saint Francis University in March 2015 and now is an associate professor in Petroleum and Natural Gas Engineering Department. His research focused on shale reservoir characterization through petrophysical analysis, 3D geological modeling, SEM image analysis, seismic interpretation, machine learning, hydraulic fracturing simulation, reservoir simulation, and various other techniques.

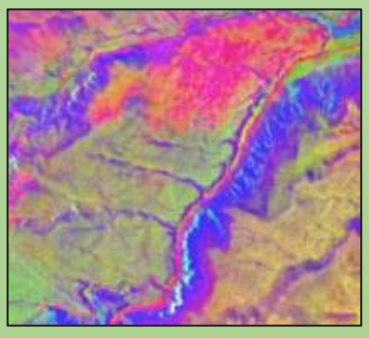
GSH Gets Down to Business: a new business-oriented online series

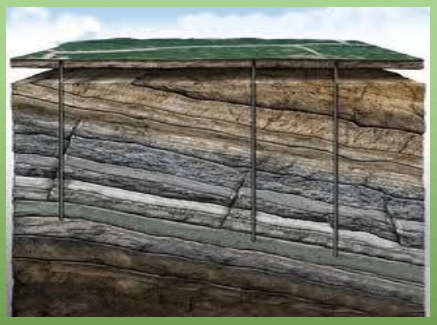
The traditional technical marketing meeting, whether it is a proprietary client in-house event or a booth presentation at a convention, is another casualty of Covid-19. The GSH has now started a new online presentation series, where geophysical companies are able to deliver information on their latest products and services to GSH members and friends! Key features are:

* A vendor offers their commercial presentation as an online event through GSH.
* The event is announced, promoted and managed by GSH; attendance is free.
* As in a booth presentation, both potential customers and competitors may be attending.
* After the presentation, there will be an interactive Q&A session.
* Attendees contact information will not be shared by GSH, however, vendor contact is available and attendees are free to share their contact information.









Interested vendors please contact the GSH at 281.741.1624 or office@gshtx.org

Wednesday, October 14, 2020
Virtual Meeting via Zoom
7:00–9:00 p.m.
HGS Members $10 Non-Members $30 Students $5
https://www.hgs.org/civicrm/event/info?id=2236
Registered Attendees: A confirmation email will be sent upon registration with meeting links.
Event contact: Matthew Cowan – mrcowan1@hal-pc.org

Brianna Clark
Stephen F. Austin State University

Applications of Digital Remote Sensing to Quantify Glacier Change in Glacier and Mount Rainier National Parks

Digital remote sensing and geographic information systems were employed in performing change over time area and volume calculations on glacial landscapes. Characteristics of glaciers from two geographic regions, the Intermountain Region (between the Rocky Mountain and Cascade Ranges) and the Pacific Northwest, were estimated for the years 1985, 2000, and 2015. Glacier National Park was studied for the Intermountain Region, whereas Mount Rainier National Park was representative of the glaciers in the Pacific Northwest. Within the thirty year period of the study, the glaciers in Glacier National Park decreased in area by 27.5 percent while those on Mount Rainier only decreased by 5.7 percent. The differences in these percentages can be attributed to the warmer temperatures of the Intermountain Region coupled with lower amounts of snowfall when compared to the Pacific Northwest. Volume loss calculations were also performed, but digital remote sensing and GIS were less successful at estimating this glacial parameter. ■

Biographical Sketch

Brianna Clark received the Associates Degree in General Studies in 2015 from San Jacinto Community College in Houston, TX. She graduated with the Bachelor of Arts in English with a minor in Environmental Science from Stephen F. Austin State University in 2017. Brianna spent a year in South Korea teaching English as a second language to secondary education students. In Fall 2018, she returned to the United States to pursue a Master of Science in Environmental Science with a minor in Geospatial Science. She completed the MS from Stephen F. Austin in May 2020. Currently, she remains at SFA pursing a PhD in Forestry, serving as instructor for a Natural Resource Policy course.

Wednesday, October 28, 2020

Virtual Meeting via Zoom
6:00 –7:00 p.m.
HGS Members $15 Non-Members $35 Students $5
https://www.hgs.org/civicrm/event/info?id=2239
Registered Attendees: A confirmation email will be sent upon registration with meeting links.
Event contact: Bryan Guzman – vice.president@hgs.org

Anton Wroblewski
ConocoPhillips

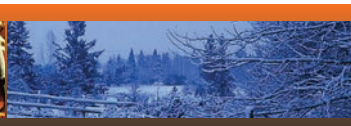
No Ammonites? No Problem! How Paleocene Trace Fossils in Wyoming Complicate Sediment Routing Histories for the Wilcox

Sediment routing to the Paleocene-Eocene Wilcox Group is recognized to have peaked dramatically between 62-59 Ma, with 3x the Cenozoic average sediment supply. This has been related to capture and closure of the "California River Drainage" but new ichnological data from southern Wyoming reveal another major driving mechanism. Early (65-63 Ma) and Late (58 Ma) brackish-water environments necessitate marine flooding and reduced sediment flux to the Gulf Coast at least twice during the Paleocene. Contradicting the simple model of a fully continental Rocky Mountain Western Interior during the Paleocene, fluvial drainage patterns were influenced to a large part by previously unrecognized marine flooding events. ■

Biographical Sketch

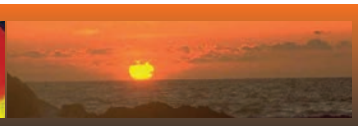
Obsessed by rocks and the crawly things that live under them since he was a toddler in Brooklyn, NY, **Anton Wroblewski** went on to get a PhD (2002) in sedimentology and stratigraphy at the University of Wyoming, under Dr. Ron Steel. Following his wife to Chicago where she was in grad school, he taught undergrad geology courses at Northeastern Illinois University from 2003-2006 but felt the irresistible call of industry. Jumping at the opportunity to join ConocoPhillips as a technical specialist in 2006, he hasn't looked back. With fieldwork taking him from the North American Western Interior to South Africa's Karoo Basin, and a variety of outcrops across Europe, Anton's worked on dozens of projects in the North Sea, Bohai Bay, Chile, Indonesia, Barents Sea, the Caspian region, Sverdrup Basin, West Greenland, Canada, and most recently the US Gulf Coast and Alaska North Slope. Also, an adjunct professor at the University of Utah (since 2018), Anton continues to be baffled, enthralled, frustrated, and enlightened by the rocks and remains of crawly things that echo from days gone by.

October 2020



Sunday	Monday	Tuesday	Wednesday
	Reservations: The HGS prefers that you make your reservations on-line through the HGS website at www.hgs.org. If you have no Internet access, you can e-mail office@hgs.org, or call the office at 713-463-9476. **Reservations for HGS meetings must be made or cancelled by the date shown on the HGS Website calendar, normally that is 24 hours before hand or on the last business day before the event**. If you make your reservation on the Website or by email, an email confirmation will be sent to you. If you do not receive a confirmation, check with the Webmaster@hgs.org. Once the meals are ordered and name tags and lists are prepared, no more reservations can be added even if they are sent. **No-shows will be billed.**		
4	5	6 **HGS Board Meeting** *6 p.m.*	7
11 Earth Science Week SEG Virtual Convention	12 **HGS General Lunch Virtual Zoom Meeting** *"3-D Geological Model of Shale Reservoirs Using Significant Amounts of Horizontal Well Data," Guochang Wang, Page 17*	13	14 **HGS E & E Virtual Zoom Meeting** *"Applications of Digital Remote Sensing to Quantify Glacier Change in Glacier and Mount Rainier National Parks," Brianna Clark, Page 19*
18	19	20	21
25	26 **GSA 2020 Virtual Meeting**	27	28 **HGS General Dinner Virtual Zoom Meeting** *"No Ammonites? No Problem! How Paleocene Trace Fossils in Wyoming Complicate Sediment Routing Histories for the Wilcox," Anton Wroblewski, Page 21*

GeoEvents



Thursday Friday Saturday

1 Virtual Africa Conference 2020: Day 1 *Page 7* GEOGULF 2020 GCAGS Convention	**2** Don't wait, make your reservations online at hgs.org	**3**
8 Virtual Africa Conference 2020: Day 2 *Page 8* NeoGeos Virtual Trivia *Page 28*	**9** Houston Student Expo Virtual Event *Page 26*	**10**
15 Virtual Africa Conference 2020: Day 3 *Page 9*	**16** POSTPONED STGS Fall Field Trip Texas Hill Country	**17**
22 Virtual Africa Conference 2020: Day 4 *Page 10*	**23**	**24**
29 Virtual Africa Conference 2020: Day 5 *Page 11*	**30** **Virtual Pre-registered Prices:** Virtual Meetings members ..... $10/15 Emeritus/Honorary members..... $10/15 Student members ..... $5 Nonmembers $30/35	**31**

December 1-3, 2020
Virtul Second EAGE/HGS Conference on Latin America
Page 12

Renew Your HGS Membership HGS.ORG

Houston Geological Society
President's Night Award Dinner

On June 30th we hosted our annual President's Night Award Dinner remotely via Zoom.
Here we provide additional recognition for those individuals who have gone above and beyond for the HGS.

Rising Stars

Jake Schultz – NeoGeos™ Committee
Jake is a recent addition to the NeoGeos but has made a big impact on the group. Jake has been of huge help to the currently planned events and is now taking the lead on some of the big events we have planned for 2020. Jake is currently a Geologist and XTO/ExxonMobil in their Permian Basin unit.

Lanette Marcha – Family & Friends Fall Fun Day event, Educational Outreach Committee
Lanette was selected as a reliable and dynamic speaker by the Chair of the Educational Outreach Committee to represent the HGS and the profession of geology in a high profile event. This was the Exploring Energy Conference, which is put on by Independent Petroleum Association of America/Petroleum Equipment Suppliers Association at University of Houston for seniors interested in careers in engineering and geoscience.

Tiffani Kennedy – NeoGeos Committee
Tiffani has been a very active committee member in the NeoGeos since the start of 2019. Some of the great events we had in 2019 and 2020 could not have been done without her time dedication to the logistics of the events. She is also the brainchild behind GeoTrivia Nights and the Whiskey Tasting Charity Event planned.

Chairman's Award

Chi Vinh Ly – Geomechanics Conference Session Chair and committed volunteer for the past 3 years
Chi helped to make the conference successful by his help with organization of the conference and keeping the speakers on tract and audience engaged.

Joe Lynch – Joe is a long time Foundation Trustee and long serving treasurer
This year Joe has taken on the responsibility to find a new investment house for our funds and has spent many hours working through the best options, presenting to all the trustees and financial subcommittee. It is efforts like Joe's that keep the Foundation and the HGS strong & viable for the future.

Rich Germano – Vendor Corner Chairman 2015-2020
Created the Vendor 4 corners campaign and brought in thousands for the HGS Scholarship funds.

President's Award

Casey Langdon – NeoGoes
For his hard work and dedication to the NeoGeos Committee, New NeoGeos logo, Trivia Night, numerous "NeoGeos Happy Hours" and his recent ventures to help with virtual meetings during the 2020 Pandemic.

Distinguished Service Award

Elliot Wall – HGS Golf Tournament Chairman 2017-2020

Tarek Ghazi – HGS Treasurer-Elect 2017-2018, Treasurer 2018-2019

Umesh Prasad – Geomechanics Conference Chairman 2017-present

Umesh Prasad of Baker Hughes has been running the Geomechanics Conference as Technical Chairman for the past 4 years. He has done a fantastic job and brought in several talks to make our conference a great success. This has been is a very profitable conference for HGS.

Honorary Life Membership Award

Mike Deming – Awards Committee Chairman

Mike joined the HGS in 1978 and has been actively volunteering since 1991. Mike has been the Awards Committee Chairman for the past 18 years as well as served on other committees. Mike was also on the HGS Board of Directors for 3 years. Mike has been helping the office staff with everything from cleaning out the flooded storage unit at the HGS office building after the 2015 flood, hauling boxes of rocks to conferences, extra help with registration at events and always with a smile on his face. This is Mike's last year volunteering with the HGS as the Awards Chairman and he will be greatly missed.

HOUSTON STUDENT EXPO

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- End of Day Happy Hour
- HGS Sponsored Trivia

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- How to Network Virtually
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A collaboration between GSH NextGen and HGS NeoGeos
Geo Trivia
Oct 8th, 5:30 - 7pm
Virtual trivia via Zoom and Kahoot. Instructions will be provided soon. Register Here!
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The Impact of Completions Operations on Induced Seismicity: A Study on the Montney Reservoirs in the KSMMA

By Matt Mayer, TGS

The Heritage Field in Northeast British Columbia has emerged as one of the more successful unconventional plays in Canada. While the field was originally explored in the mid-1980s, development really accelerated during the rise of unconventional plays in the mid-2000s. The dominant formation in this unconventional play is the Triassic age Montney Formation. While improvements in unconventional drilling and completions technologies have fueled this growth, the complex structural geology of the region may have also contributed to unintended consequences. Across the continent, many studies have linked unconventional drilling and completion activities to elevated numbers of low-intensity seismic activity, and in 2018 a new project, the Kiskatinaw Seismic Monitoring and Mitigation Area (KSMMA), was initiated across a majority of the Heritage Field to study the impact of unconventional completions in highly fractured reservoirs on induced seismicity. Analysis of TGS production data validates that enhanced completion activity resulted in higher initial production rates across the board [**Figure 1**] but indicates that strategic development decisions could potentially reduce induced seismicity by shifting production priorities and strategies.

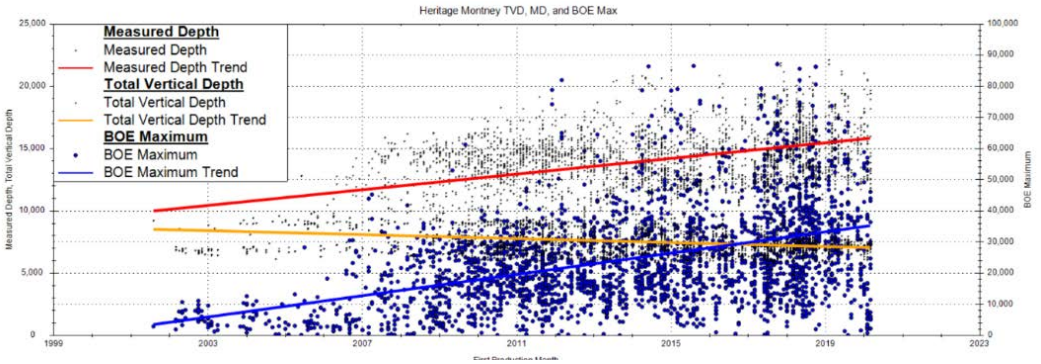


Figure 1: *Heritage Montney TVD, MD, & BOE Max over time*

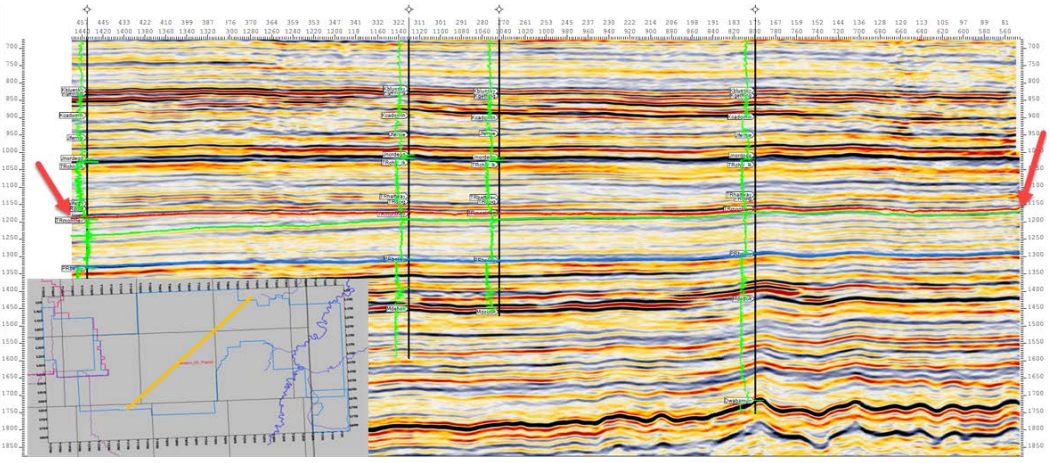


Figure 2: *Dawson 3D Survey Line*

The Montney Formation is split into three separate members – the upper member (Montney A) is a proximal prodelta facies with laminated siltstone beds, the middle member (Montney B) is a distal prodelta facies with pinstripe light and dark grey laminated siltstone beds, and the lower member (Montney C) a shelf facies with more homogenous dark grey siltstone [**Ref 1**]. A preliminary study of the fault structure by Kryzan and Watson, including operations within the KSMMA, indicate that completions operations in the Upper Montney may produce fewer induced seismicity events than those in the Middle or Lower Montney members [**Ref 2**]. Although these findings are preliminary, it may still be worthwhile to investigate the implications by identifying the production characteristics of the three Montney members.

Characterizing production from the Montney members first requires differentiating which wells are producing from each of the three members. While production data in Canada is typically reported in pools, unfortunately production from all three members are grouped into a single Montney pool. Fortunately, a seismic line from the Dawson 3D survey [**Figure 2**] in this area shows that the top of the Montney Formation is level laterally across the field. Therefore, total vertical depth may be used to infer from which of the Montney members each well is producing. Although the thicknesses and boundaries between the Montney members may be heterogenous, this is the best concept we can use to identify producing members of the Montney on a field-wide scale. A histogram of reported total vertical depths among Heritage

The Impact of Completions Operations on Induced Seismicity *continued on page 30*

The Impact of Completions Operations on Induced Seismicity

continued from page 29

Montney Wells [**Figure 3**] indicates the presence of three regimes that could correlate with the three Montney members.

By breaking up the Heritage production into the different Montney members, the production from each member can be characterized and interpreted. **Figure 4** shows the KSMMA shape imposed on top of the Heritage Field, with the color of the well spots indicating the producing Montney member. There does appear to be a trend of producing from deeper members of the Montney as you move from the Northeast of the field to the Southwest. As stated previously, although the top of the Montney is level across this field, it appears that the sub-group thickness and boundaries may trend in this direction also, with lower members becoming thicker and pinching out upper members as they move Southwest. Finally, **Figures 5** and **6** show the oil and gas type curves for the three Montney members. Although Montney B and C average 30-50% higher gas production than the Montney A, the Montney A averages 60-70% higher oil production than either of the two other members. It should also be noted that reporting of condensate production in the area has historically been inconsistent, but when reported is classified as oil by TGS. The preliminary results for this study indicate that completions operations in the liquid-phase reservoir tend to have a lower impact on induced seismicity than in the gas-phase reservoirs. Although there are likely rock properties at play here that will surely be evaluated in future studies, these results raise the possibility that reservoir fluid interactions also play a role in induced seismicity events. ■

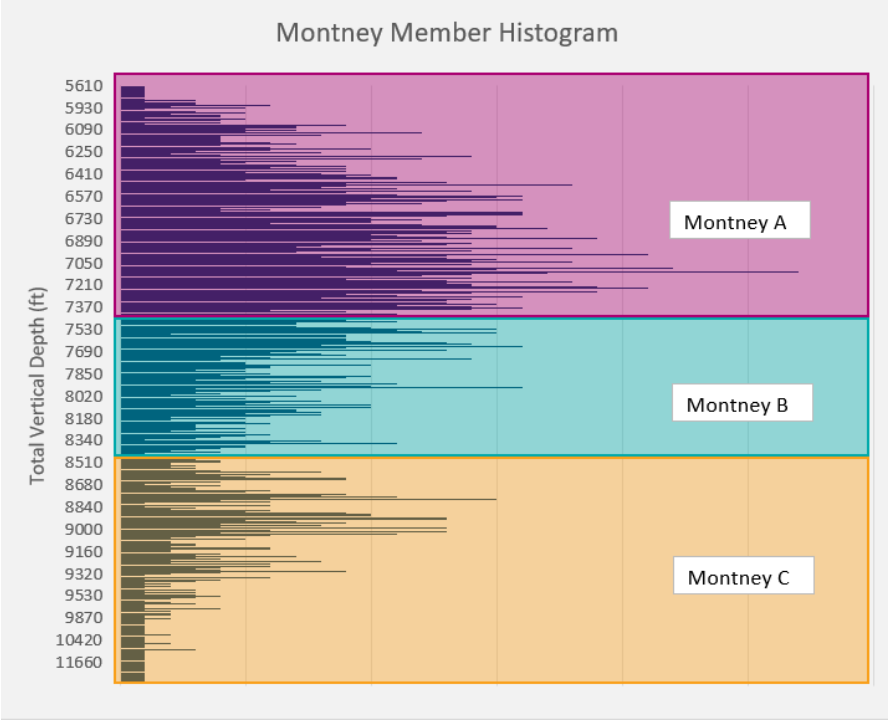


Figure 3: *Heritage Montney TVD Histogram*

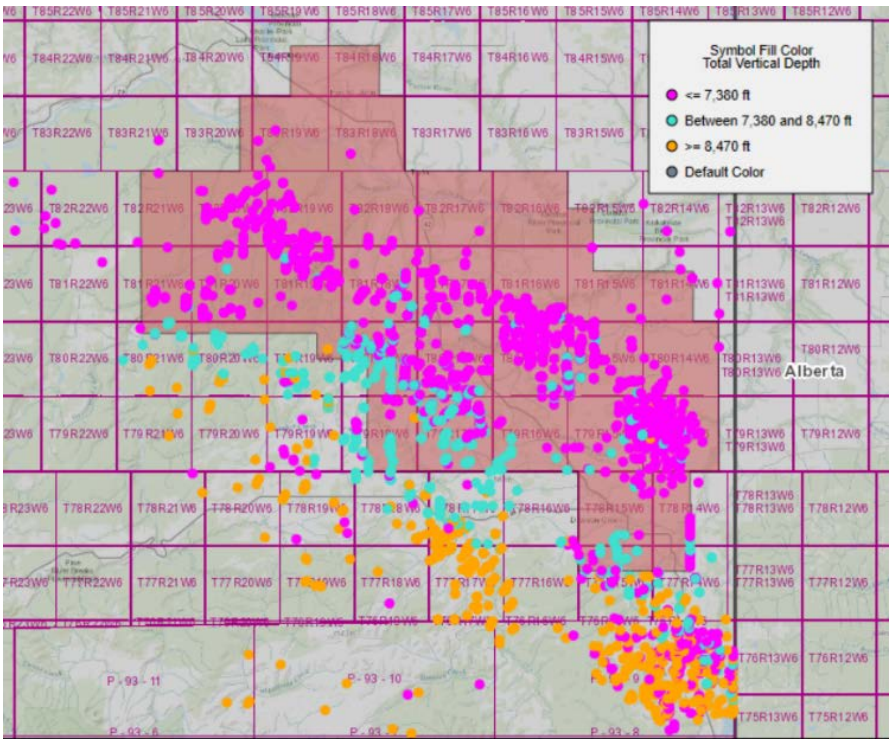


Figure 4: *Heritage Interpreted Producing Montney Members*

References

Proverbs, I.P., et al. "Facies Architecture and Sequence Stratigraphy of the Lower Triassic Montney Formation, NE British Columbia: Fundamental Controls on the Distribution of 'Sweet Spots' in a World-Class Unconventional Reservoir." Bulletin of Canadian Petroleum Geology, 2017, pp. 237–258.

Fox, Amy D, et al. 2019, Induced Seismicity Study in the Kiskatinaw Seismic Monitoring and Mitigation Area, British Columbia for the BC Oil and Gas Commission, ftp://ftp.bcogc.ca/outgoing/Induced%20Seismicity%20in%20KSMMA_Report%20Appendices/Appendix%20A%20-%20Geophysical%20Review/Appendix%20A%20-%20Geophysical%20Review.pdf.

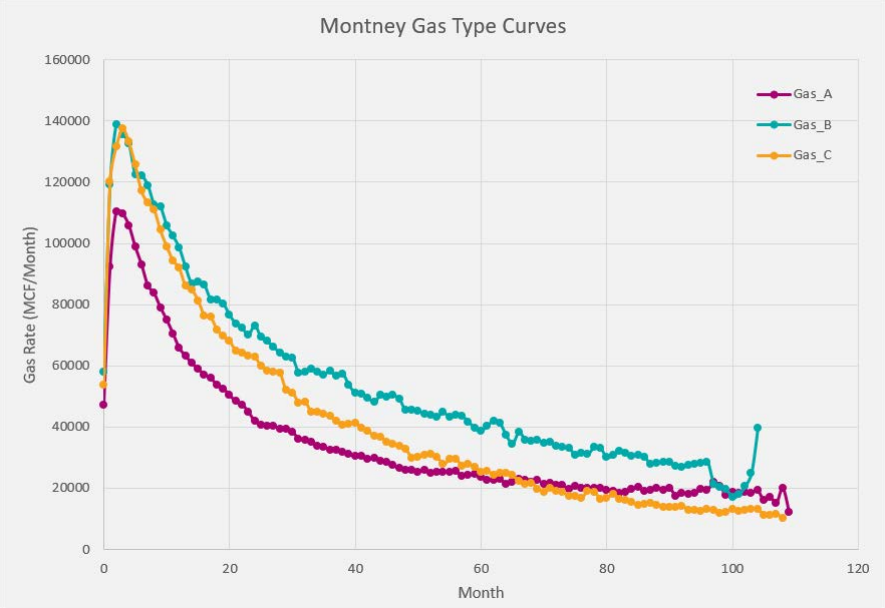


Figure 5: *Montney Member Gas Type Curves*

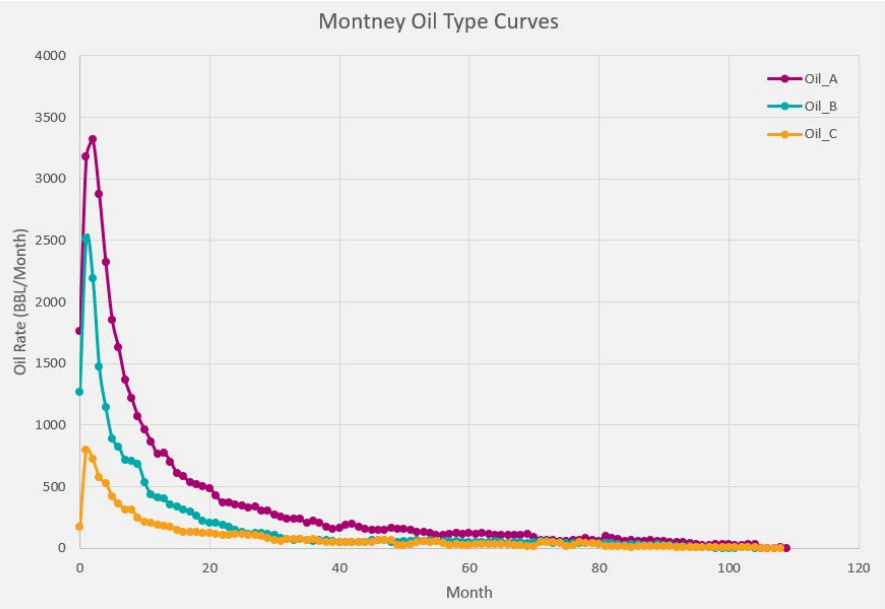


Figure 6: *Montney Member Oil Type Curves*

South Texas Geological Society Seminar & Field Trip

OVERVIEW OF THE AUSTIN CHALK IN SOUTH TEXAS AND LOUISIANA:

Depositional Setting, Diagenesis, Porosity Evolution, and Play Development

Seminar Lecturer: Jeffrey Dravis

The Upper Cretaceous Austin Chalk trend in south Texas and Louisiana continues its resurgence in interest. Areas like Karnes Trough in south Texas, and central Louisiana, remain the areas of interest right now, but many companies also are exploiting established field areas like Pearsall and Giddings, and expanding into East Texas. Geoscientists who explore in the Austin Chalk, or hope to exploit existing Chalk field trends, should possess a firm understanding of the Austin Chalk's regional depositional and diagenetic framework. This includes appreciating the influence of regional and local paleogeography, preexisting topography, and underlying structural framework. Developing an appreciation of the various diagenetic pathways that affected Austin Chalk porosity and permeability evolution is critical as well, since fractures are only a part of the story.

Field Trip Leaders: Tom Ewing, John Cooper, David Ferrill

Tom Ewing will show and discuss depositional details of Austin Chalk Group outcrops in the San Antonio area pointing out their implications on hydrocarbons exploration. John Cooper will explore the stratigraphy of the Austin Chalk Group in Bexar County from lower to upper contact and integrate geophysical logs to make ties to the subsurface. David Ferrill will discuss faulting and fractures seen in fault zones exposed in the San Antonio area. David's discussion will focus on understanding typical normal fault patterns and using these patterns as an aid in predicting the fracture zone width when planning oil and gas exploration.

NOTE: The field trip will be moderately strenuous, especially in the event of rain

Friday, November 6th, 2020

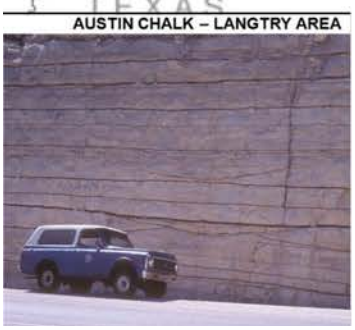
Coffee & pastries at Petroleum Club (7th Floor, 8620 N. New Braunfels, SA TX).....8 AM
Buffet Lunch.....note rescheduled dates.....Noon
Conclusion and *happy hour*.....5 PM

Saturday, November 7th, 2020

Passenger bus departs Petroleum Club (8620 N. New Braunfels, SA Tx) parking lot....8 AM
Box lunch .....Noon
Return to Petroleum Club by.....5 PM

$380 per person (compare to $895 in Houston with no field trip)
(seminar only: $320—field trip only: $100)

for reservations and payment instructions email: johnlonggeologist@gmail.com
or go to https://stgs.org/civicrm/event/info?id=84&reset=1 please register prior to April 16th, 2020



Geochemistry of the Petroleum Systems of Several U.S. Rocky Mountain Basins

By Catherine M. Donohue, Craig D. Barrie, J. Alex Zumberge, John E. Zumberge and John B. Curtis
GeoMark Research, Houston, TX

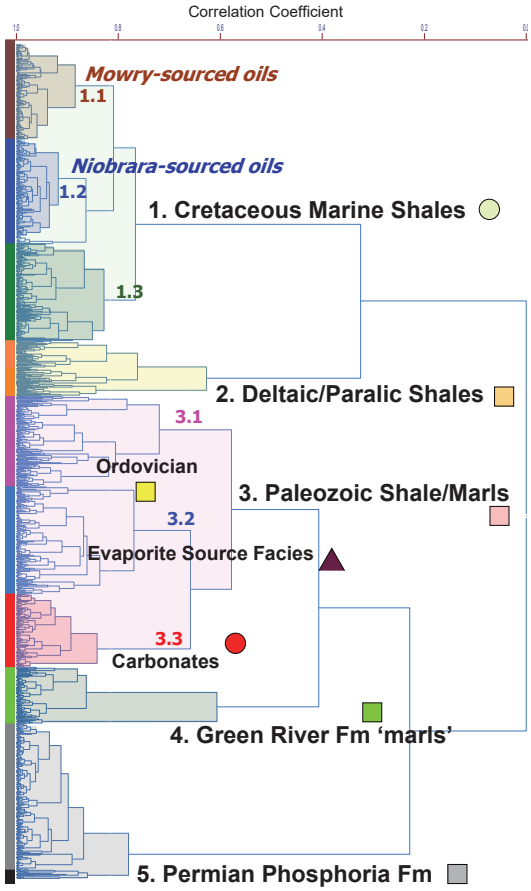
The US Rocky Mountain-Region extends from Northern New Mexico to the Canadian Border (**Figure 1**). Over this extensive region there are at least 16 individual basins known to be petroleum producers and sourced from stratigraphic formations ranging from Ordovician to Tertiary in age. Although these basins are historically known for their conventional production, industry developments over the past 10-15 years have meant that their promise as unconventional resource plays have been realized. Across these Rocky Mountain basins there are 5 major petroleum families associated with specific source horizons. In this paper we briefly outline the source, distribution and sub-groupings of these major oil families and the importance of understanding their nature for future exploration and exploitation.

Introduction

The Rocky Mountains of the United States are a significant part of the history of the American Dream of economic success: from the gold rush to the black gold rush, the natural resources of this expansive area have drawn significant investment from both small and large players since the early 1900's. While several conventional hydrocarbon plays are still in production, the North American unconventional play renaissance over the past decade has brought new life to the basins along the Rocky Mountain trend, including the Williston, Powder River, San Juan Basins and others (**e.g. Zumberge et al., 2013, Zumberge et al., 2016, and Curtis et al., 2017**). This long history of production has allowed for the collection and analysis of an extensive library by GeoMark Research of more than 1800 produced oil samples (**Figure 1**).

Geochemistry of the Petroleum Systems of Several *continued on page 34*

A. Hierarchical Cluster Analysis (HCA) Dendrogram



B. Oil Family Distribution across the Rocky Mountain Basins

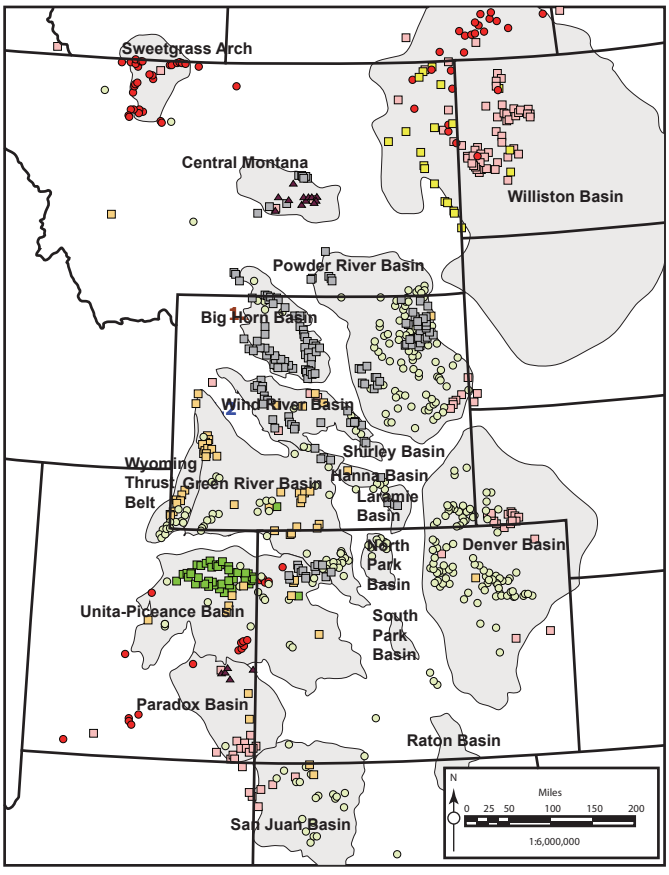


Figure 1: – **A.** *Hierarchical Cluster Analysis (HCA) dendrogram of the 1800 oil samples included in the Rocky Mountain Study. The 5 major oil families are highlighted, along with the two most recognizable families of the Cretaceous Marine Shales.* **B.** *Geographic distribution of the 1800 oil samples included in the study, color-coded relative to the oil families defined in Figure 1*

Geochemistry of the Petroleum Systems of Several

continued from page 33

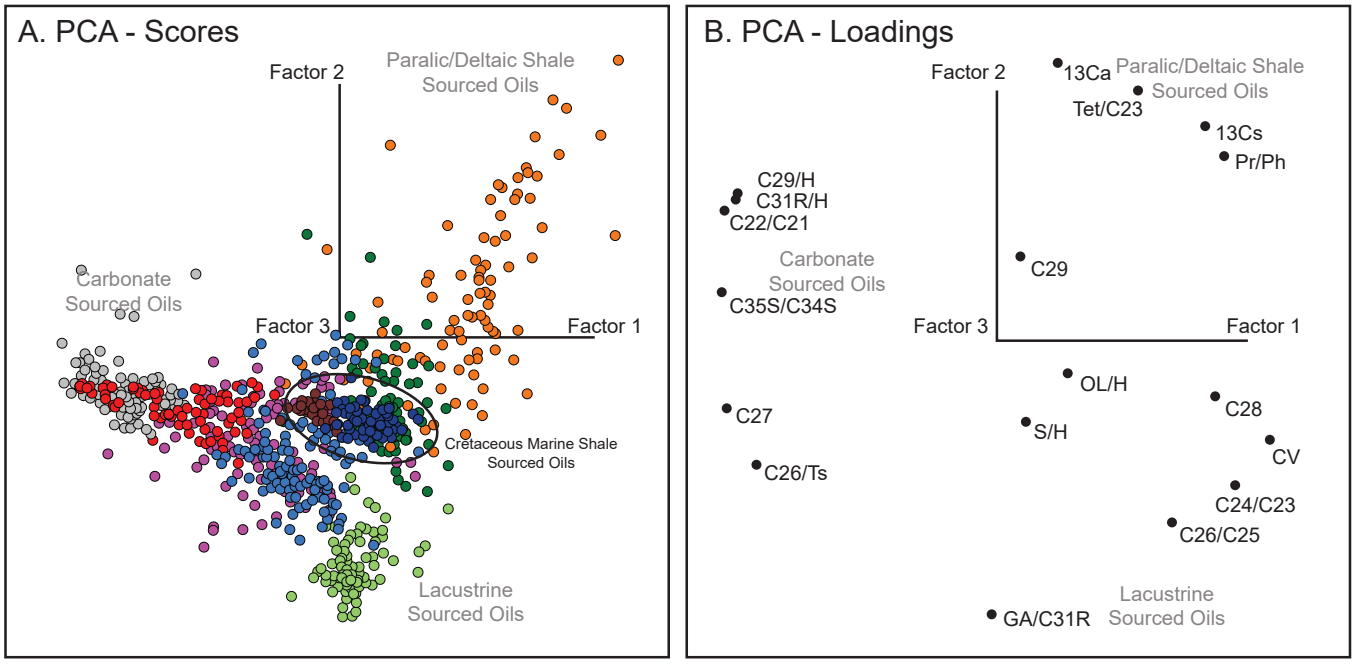


Figure 2: *Principal Component Analysis (PCA) plots. A. PCA Scores plot of the 1800 oil samples included in the study, color-coded relative to the oil families defined in* **Figure 1. B**. *PCA Loadings plot showing the distribution of the biomarker and isotope parameters used to generate the HCA dendrogram (***Figure 1***) and the spatial distribution of the oil samples in the Scores plot.*

This dataset can be examined to better understand the many active petroleum systems in the region and to aid in assessment of the still substantial resource in these areas. In this paper we will briefly discuss three of the major petroleum systems in our Rocky Mountains dataset to give a flavor of the valuable information geochemistry holds for operators to enhance their understanding of these systems.

Geochemical and Statistical Workflow

All of the oils discussed – and collected in the study – were prepared and analyzed using standard laboratory procedures, at the same facility, and with the same methodologies. The analytical program was designed to emphasize genetic parameters of the oil samples, so that a more confident source rock interpretation should be conducted. In this case, the analytical program included SARA analysis, saturate and aromatic isotopes, whole oil GC, and GCMS of saturate and aromatic oil fractions. Full details of the analytical procedures followed can be found in **Zumberge, et al., 2005**. The analytical results were assessed using multivariate statistical analysis via Pirouette™ chemometric software (Infomertix). Hierarchical Cluster Analysis (HCA) was performed to better understand the samples' geochemical relationships and determine the correlation coefficient among samples (**Figure 1**). The groupings in the HCA dendrogram are used to divide the dataset into oil "families" or "tribes". Five main families are defined across this dataset. To understand the geologic and geochemical drivers behind the HCA family assignments, Principal Component Analysis (PCA) was completed (**Figure 2**). The PCA plot can be used to visualize the complex relationships of the measured properties and reveal the strongest influences on what generated the oil family groupings. Notice that the axes in **Figure 2** are the same for both Scores (display of samples) and Loading (display of measured variables). The axes are the three largest factors (shown in x, y, z space) that account for the similarities/differences between the samples. Geoscientists can look to the Loadings plot (and tabular data that expands beyond 3 factors) to aid them in using the measured variables to determine the depositional environment of the source rocks that produced these oils, i.e., lacustrine vs carbonate environment or upwelling vs shallow water deposition. These environments are related to Rocky Mountain paleohistory, and at the end of this interpretive process, the Rocky Mountain families are defined by source age and geochemical character. Further details on statistical approaches to understanding petroleum systems can be found in **Zumberge, 1987**.

The source characteristics of the five major oil families identified across the Rocky Mountain Basins are:

1. Cretaceous Marine Shales
2. Deltaic/Paralic Shales
3. Paleozoic Shale/Marls
4. Green River/Tertiary "Marls"
5. Permian Phosphoria Formation

The nature of three of these families (1, 3 And 5) are briefly discussed in the following sections. The Deltaic and Green River marl families are not discussed here, but still represent substantial potential within the Rocky Mountain region.

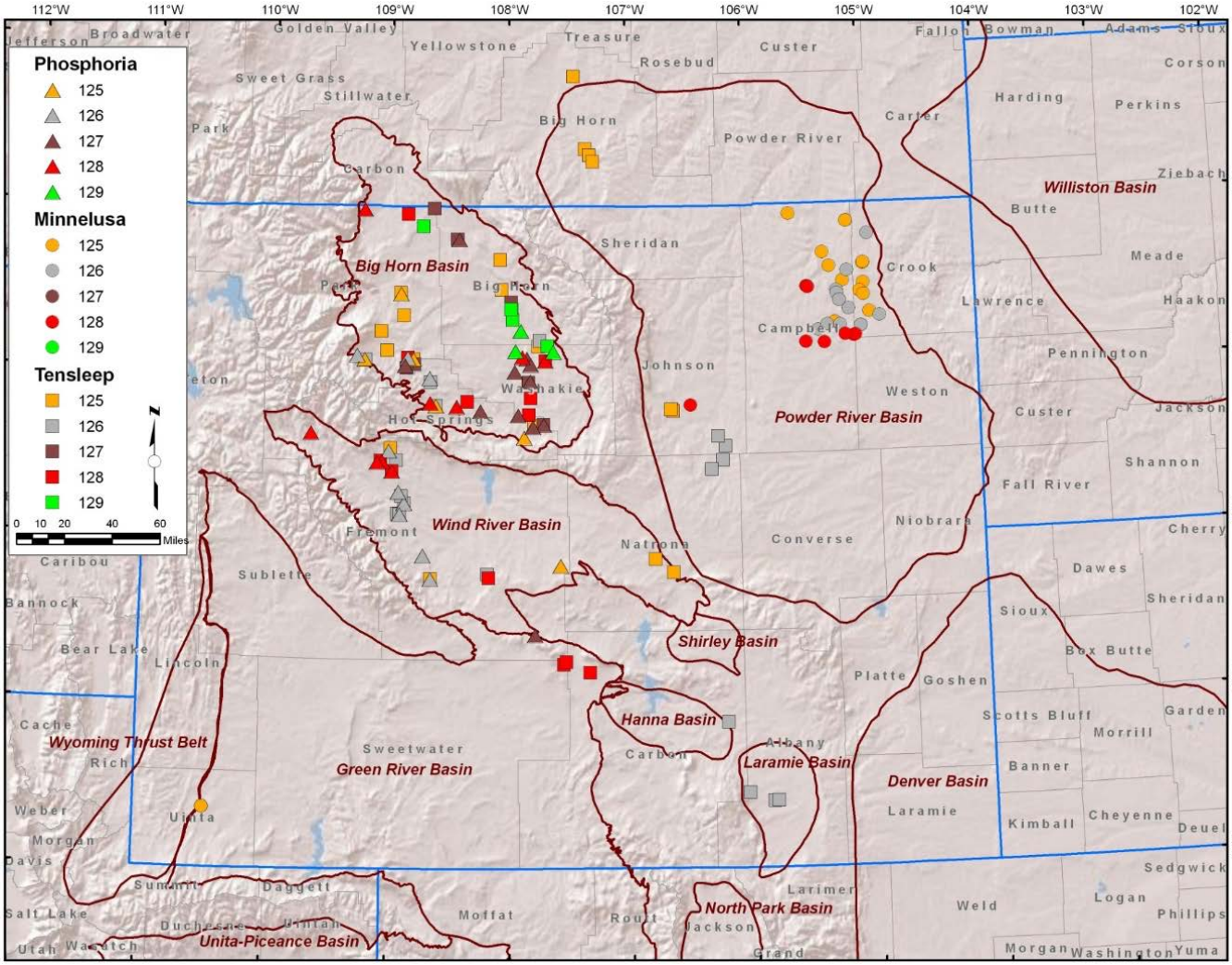


Figure 3: *Minnelusa-reservoired oils in eastern Powder River belong to the same sub-families (125, 126, & 128) as in the Big Horn and Wind River. This similarity in biomarker and isotopic composition suggests that all the identified Powder River Basin oils were generated from the same (i.e., Phosphoria) or very similar source rocks (e.g., Middle Minnelusa.)*

Major Oil Families of the Rocky Mountain Basins

Family 1.0 Cretaceous Marine Shales

The Cretaceous Marine Shales family encompasses samples tied to the Niobrara, Mowry and Greenhorn or "other" Cretaceous marine source rocks. These source rocks are associated with productivity and preservation during deposition of the Western Interior Cretaceous Seaway (e.g. **Landon et al., 2000**). This family can be subdivided into 3 sub-families which correlate to the Niobrara (**1.1**), Mowry (**1.2**), and Greenhorn/Graneros/Carlile/Pierre (**1.3**) as shown in **Figure 1a**. The Niobrara-sourced oils are distinct from the other groups based upon the presence of stronger upwelling biomarkers, including C40 carotenoids that suggest upwelling within the seaway was particularly strong during this time. The Mowry-sourced oils contain aryl isoprenoids, indicating pervasive euxinic conditions compared to the rest of the Cretaceous sourced oils. The differing sterane abundances across these Cretaceous sourced oils are also key to defining these sub families. The C28 and C29 steranes (produced from diatoms and green algae, respectively) are more abundant in the Niobrara, supporting the evidence of strong upwelling from the aryl isoprenoids. The Mowry oil family has a higher preponderance of C27 relative to C28/C29, making it distinct from the Niobrara family. These Cretaceous oil families are correlative beyond the boundaries of the individual basins (**Figure 1**), and can be interpreted across a range of maturities, as the basins have experienced different burial and thermal histories. The oils used in this study confirm active Cretaceous source environments that are correlative across the region, including the Powder River, Big Horn, Wind River, Green River, Piceance, San Juan and Denver Basins.

Family 3.0 Paleozoic Shale/Marl

The Paleozoic system in the Rocky Mountains has received little exploration attention compared to most of the other oil families discussed, such as the Niobrara or Mowry. **Figure 1b**, shows the that Paleozoic correlative source rock is present as

Geochemistry of the Petroleum Systems of Several *continued on page 37*

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Welcome New Members

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far north as the Williston Basin, through all the central basins such as the Powder River, Green River and Denver Basins and as far south as the San Juan Basin. These oils confirm both the source presence and quality of organic matter deposited during this time, and with appropriate thermal maturation should support meaningful exploration opportunities. These Paleozoic-sourced oils can be divided into three sub-families, partly based upon their sterane biomarker distribution that helps to further refine their age and depositional environment. Sub-family 3.1 (**Figure 1a**) is characterized by high amounts of C28 sterane, an unusual feature for Paleozoic rocks. Stronger upwelling signatures are present in sub-family 3.3 (**Figure 1a**,) (C26/Ts) whereas the higher C29 sterane signature in sub-family 3.2 correlates with a more terrigenous environment of deposition. These details can be applied to stratigraphic models of these basins to map and delineate the extent of the effective source rock deposited during this time, quantifying the remaining exploration value.

Family 5.0 Permian Phosphoria Formation

The Phosphoria oils are generated from the Upper Pennsylvanian/ Permian Phosphoria Formation and equivalent formations and cover a wide geographic distribution in the middle and northern Rocky Mountains area (**Figure 1b**). The oils in this family are characterized by biomarkers indicating a carbonate source and strong upwelling indicators. There is a strong correlation between this oil family and age equivalents such as the Pennsylvanian/ Permian-aged Minnelusa Formation in the Powder River Basin. This suggests that the same source-rock and generation conditions were widespread during this time (**Figure 3**), indicating untapped potential in age-equivalent strata throughout this portion of the Rocky Mountain region. Operators can use the geochemical environment description along with a paleoenvironmental restoration of Phosphoria deposition to predict where and why upwelling was prevalent and map the extent of this rich source rock(s). Additionally, the carbonate source rocks can also be tied to stratigraphic models and paleoenvironmental maps can be created to derisk future exploration locations.

Conclusions

The brief descriptions of the oil families identified across U.S. Rock Mountain Basins, discussed above, should add impetus to any exploration program. The key is to use the geochemical data to expand upon current stratigraphic models and provide more detail to the understanding of the depositional environment and correlations that can be made based on paleorestorations. These data clearly illustrate that the source rock correlations extend beyond basin boundaries and operators can project data from existing programs into new opportunities along equivalent plays. The U.S. Rocky Mountains will continue their legacy of golden opportunities for those who are both first movers and grounded with a good petroleum system understanding. ■

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