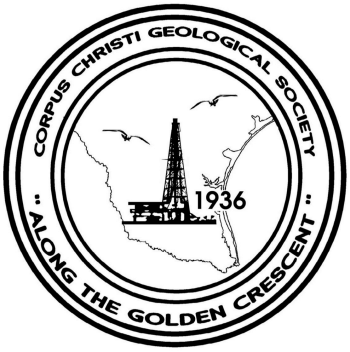
BULLETIN

Corpus Christi Geological Society



and

Coastal Bend Geophysical Society

April
2016
ISSN 0739 5620

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TABLE OF CONTENTS

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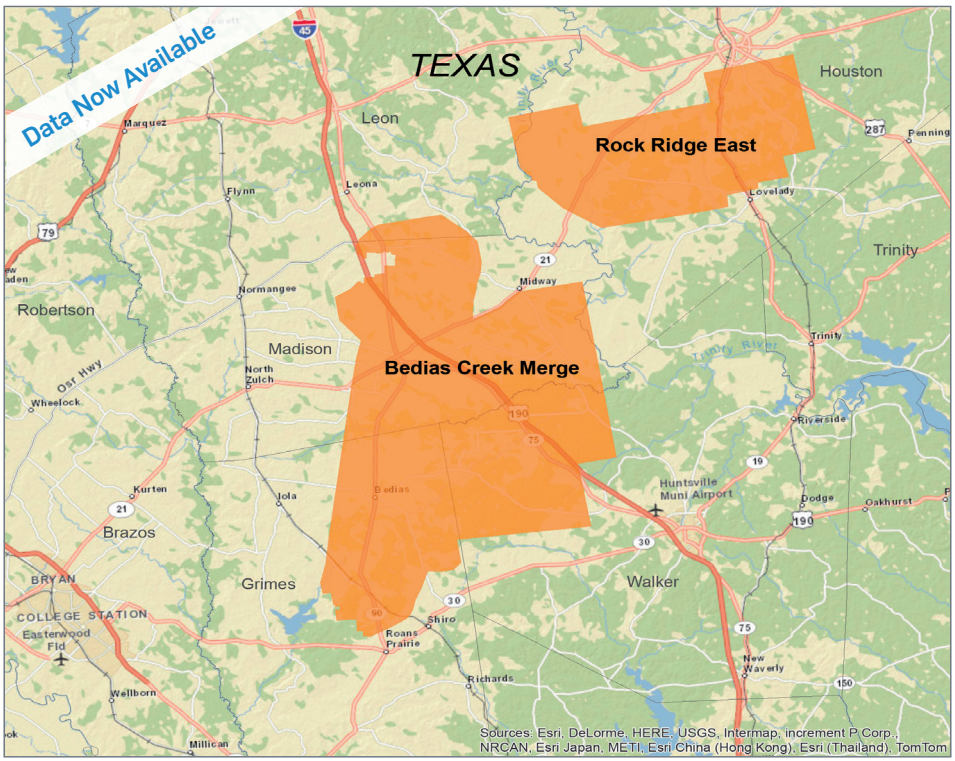
Bedias Creek Merge
Madison, Grimes, Walker, and Leon Countires, Texas



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2015-2016
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2015-2016

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Education			

Visit the geological Web site at www.ccgeo.org

CCGS/CBGS JOINT MEETING SCHEDULE 2015-2016

September 2015						
S	M	T	W	Th	F	S
		1	2	3	2	5
6	7	8	9	***10***	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30			

Sept. 10, 2015
5:30p.m.—8:30p.m.
Kickoff BBQ
Hoegemeyer's Barbeque Barn

October 2015						
S	M	T	W	Th	F	S
				1	2	3
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11	12	13	14	15	16	17
18	19	20	21	22	23	24
25	26	27	***28***	29	30	31

Oct. 28—11:30a.m.—1:00p.m.
Speaker: Neil Peake, CCG Geo Consulting Seismic Reservoir Characterization.
"Unconventional Reservoirs: An Integated Workflow Incorporating Surface Seismic, Mineralogy, & rock Properties in the Haynesville Shale."

November 2015						
S	M	T	W	Th	F	S
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15	16	17	***18***	19	20	21
22	23	24	25	26	27	28
29	30					

Nov. 18—11:30a.m.—1:00p.m.
Speaker: Lorenzo Garza & Joe Stasulli, Railroad Commission of Texas. "Horizontal Drilling in Texas: A Tale That Begins in the Austin Chalk, but Whose Ending Has Yet To be Written."

December 2015						
S	M	T	W	Th	F	S
		1	2	3	4	5
6	7	8	***9***	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

Dec. 9—11:30a.m.--1:00p.m.
Speaker: Dmitri Bevc,Ph.D., Chevron, SEG Distinguished Lecturer "Full Wave-Form Inversion: Challenges, Opportunities and impact"

January 2016						
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10	11	12	13	14	15	16
17	18	19	***20***	21	22	23
24 31	25	26	27	28	29	30

Jan. 20--11:30a.m.—1:00p.m.
Speaker: Charles Sicking, VP of R&D/Chief Geophysicist, Global Geophysical Services, Inc. "Predicting Frac Performance and Active Producing Volumes Using Microseismic Data"

February 2016						
S	M	T	W	Th	F	S
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14	15	16	***17***	18	19	20
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28	29					

Feb. 17—11:30a.m.—1:00p.m.
Speaker: Richard Coffin, Ph.D., Dept. Chair, Physical & Envir. Sciences, Texas A&M Univ.—Corpus Christi. "Integration of Geochemistry & Geophysics Applied to Coastal Gas Hydrate Assessment"

CCGS/CBGS JOINT MEETING SCHEDULE 2015-2016

March 2016						
S	M	T	W	Th	F	S
		1	2	3	4	5
6	7	8	9	10	11	12
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April 2016						
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May 2016						
S	M	T	W	Th	F	S
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8	9	10	11	12	13	14
15	16	17	*18*	19	20	21
22	23	24	25	26	27	28
29	30	31				

March 16-11:30a.m.-1:00p.m. Speaker: Thomas Ewing, Ph.D., Texas Bureau of Economic Geology; Frontera Exploration Consultants, Inc.; Yegua Energy Associates, LLC "Building Texas: Insights from the "Texas Through Time Project"

April 20-11:30a.m-1:00p.m. Speaker: Lee Billingsley, Ph.D., Abraxas Petroleum Corp. "Geoscience Applications to Economic Development of a Relatively Shallow, Low Gravity, Structurally Complex Eagle Ford Oil Development, Atascosa County, Texas"

May 18-11:30-1:00p.m. Distinguished Speaker: State Representative Todd Hunter, District 32

Calendar of Meetings and Events
Calendar of Area Monthly Meetings

Corpus Christi Geological/Geophysical Society.....	Third Wed.—11:30a.m.
SIPES Corpus Christi Luncheons.....	Last Tuesday—11:30a.m.
South Texas Geological Society Luncheons.....	Second Wed—noon San Antonio
San Antonio Geophysical Society Meetings.....	Fourth Tuesday
Austin Geological Society.....	First Monday
Austin Chapter of SIPES.....	First Thursday
Houston Geological Society Luncheons.....	Last Wednesday
Central Texas Section of Society of Mining Metallurgy & Exp....	2nd Tues every other month San Antonio

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PRESIDENT'S LETTER

GCAGS Convention – Volunteers Needed!

The CCGS will be publishing the Convention Announcement Brochure for the GCAGS 2016 to be sent out to over 9000 Gulf Coast members in May. Become a sponsor before February 29, 2016 to be recognized in the Convention Announcement Brochure. You will also be recognized on our website, at the convention by signage, and in the Convention Program Guides as well.

Thirty-five percent of any proceeds above the cost of the convention stay with the Corpus Christi Geological Society. The CCGS is very active in the local community:

- Teacher workshops for local K-12 science teachers will be offered during the convention at no cost, including handouts for the classroom.
- Rocks and Minerals presentations are made to schools, boy and girl scouts.
- USGS terrain maps, South Texas Ice Age Murals, and Bones are provided to schools.
- The CCGS is trying to display large beautiful boulders at each area middle school with display signs. They show igneous, metamorphic and sedimentary rocks. These are expensive, but are in high demand.
- The CCGS is also collecting ice age mammoth bones to not only display in schools, but all local libraries.
- Geology tables at Earth Day/Bay Day are manned with minerals and ice age bones.
- CCGS members are Science fair judges and display ice age bones at "science day" in schools.
- The CCGS scholarship committee provides scholarships to local TAMUCC, Del Mar College, and TAMUK earth science students, averaging $15,000 per year.

This downturn has become quite a problem for us. We have about a dozen members who have volunteered to help with the upcoming convention in September, and that is greatly appreciated. Things are progressing in-so-far as poster sessions, presentations and field trips, but we are desperate for more industry or personal sponsors for the convention.

I urge each and every one of you to put a call or a personal visit with just one company or individual to pledge a sponsorship. This slowdown has caused us to be SHORT OF FUNDS.

We have approximately 300 members. We need your individual help. The dozen volunteer members are overworked and certainly underpaid. Please help your society.

Michael E. Lucente

2016 Annual Shrimp Boil

Dewey's Beer Garden

On the back deck
2302 Rodd Field Road
(between Holly and Saratoga)

Friday, April 15, 2016
Starting at 5:30
Boiled Shrimp or Grilled Chicken
and all the fixin's!

RSVP by Tuesday April 12th - $30.00 in advance
(Money will not be taken at the door)
Please send completed form and payment
(check payable to EA) to:
Leslie Blake ~ 409 Santa Monica Pl. ~
Corpus Christi, TX 78411

Corpus Christi Geological Society,
Coastal Bend Geophysical Society, and
Corpus Christi Energy Auxiliary

Please list the names of all those attending in your group, and the number of chicken or shrimp plates. All plates $30.

Names:

_____ _____ Chicken Plates
_____ _____ Shrimp Plates
_____ $_____ Total
_____ _____ check number
payable to EA

CBGS PRESIDENT'S LETTER

News - NAPE attendance wasn't as slow as I thought it would be, but I had low expectations--11,300 did attend. On February 25, 2016 the LNG carrier *Asia Vision*, chartered by Cheniere Marketing, LLC departed from the US and is heading to Brazil. The USA is now exporting LNG. What does that mean for South Texas gas markets/prices? Don't know. Business -

CBGS golf tournament being scheduled. Scholarship applicants solicited.

Education/Events - - GSH

Interpretation Technology Symposium/Exhibition - April 13-14 Norris Conf. Center, Houston City Centre

Numerous technical luncheons if you happen to be in Houston. Check following link.

Geophysical Society of Houston Calendar

CBGS has a revenue sharing agreement with GSH. Please mention CBGS if you register for any GSH events.

- SEG

SEG Convention, 16-21 October, Dallas

SEG has 450+ eLearning courses online from $0.99 to $150.00(most expensive I saw)

Error! Hyperlink reference not valid.

- AAPG

AAPG Convention, 19-22 June, Calgary

- HGS

Mudrocks Conference, 8-9 March, Woodlands

- NAPE

August 10-11, Houston

- OTC

May 2-5, Houston

Thought for the month "Have patience. All things are difficult before they become easy." Saadi

Monthly O&G Statistics

Texas Oil and Gas Info	Current Month	Last Month	Difference	Month's Report
Texas Production	MMBO/BCF	MMBO/BCF	MMBO/BCF	
Oil	74.6	76.8	-2.2	Dec
Condensate	10.2	11.1	-0.9	Dec
Gas	625	646	-21	Dec
	Current Month	Last Month	Last Year - Monthly	
Texas Drilling Permits	510	727	1,102	Jan
Oil wells	141	159	254	
Gas wells	41	42	90	
Oil and Gas wells	282	440	697	
Other	46	86	61	
Total Completions	1,204	993	1,997	Jan
Oil Completions	951	788	1,450	
Gas Completions	197	151	344	
Other	56	54	203	

Lonnie—CBGS President

CORPUS CHRISTI GEOLOGICAL SOCIETY
COASTAL BEND GEOPHYSICAL SOCIETY

LUNCHEON MEETING ANNOUNCEMENT

WEDNESDAY, APRIL 20TH, 2016

Location: Congressman Solomon P. Ortiz International Center, 402 Harbor Drive, Corpus Christi, TX 78401 http://ortizcenter.com

Bar Sponsor: To be announced ***(sponsors needed!)***

Student Sponsor: Core Laboratories and Global Geophysical Services

Time: 11:30 am Bar, Lunch follows at 11:45 am, Speaker at 12:00 pm

Cost: $25.00 (additional $10.00 surcharge without reservation; No-shows may be billed and non-RSVP attendees cannot be guaranteed a lunch); *FREE* for students with reservation (discounted by our generous sponsors)!

Reservations: Please RSVP by 4PM on the FRIDAY before the meeting!
E-Mail: wes@gislerbrotherslogging.com

Please note that luncheon RSVPs are a commitment to the Ortiz Center and must be paid even if you can't attend the luncheon.

Core Lab RESERVOIR OPTIMIZATION — http://www.corelab.com

Global Geophysical Services — http://www.globalgeophysical.com

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SPONSORSHIPS FOR THE TUESDAY PINT NIGHT SOCIAL GATHERINGS AND WEDNESDAY LUNCHEON MEETING BARS ARE OPEN!!!

Please consider a CCGS/CBGS sponsorship!!! It's a great way to advertise both your company and the services it provides!!!

Geoscience Applications to Economic Development of a Relatively Shallow, Low Gravity, Structurally Complex Eagle Ford Oil Development, Atascosa County, Texas

Presented by: Lee Billingsley, Ph.D., Vice President/Exploration, Abraxas Petroleum Corporation, San Antonio

Summary

Development of the Eagle Ford oil accumulation in South Texas may generally be divided into two gradational trends, black oil and volatile oil. The black oil trend is characterized by: shallower depth, thinner Eagle Ford interval, lower gravity oil (<35°), lower GOR (<1000 to 1), and generally poorer economic returns than the volatile oil trend. Many areas of Eagle Ford development are also structurally simple with only regional basinal dip. However, Abraxas Petroleum Corporation is developing an area in the black oil trend that is structurally complex due to graben faulting and resultant folding. Because of the faulting during Eagle Ford deposition, the Eagle Ford interval expands from about 100 ft thick outside the graben to about 180 ft within the graben. The expanded interval provides opportunity, but economic development in this part of the trend requires extreme attention to detail and high coordination between geology, geophysics, drilling and completion.

Interpretation of the 3D seismic data set over the field area requires drastic geologic assumptions in order to accurately convert to depth. Velocity values based on the drilling and geosteering of nine, widely spaced horizontal wells indicates that velocity is faster near the downthrown side of growth faults. Improved interpretation of the 3D seismic data has resulted in improved geosteering of the horizontal wells.

Stratigraphically, the Eagle Ford was divided into 13 parasequences in an attempt to determine if certain intervals had different characteristics during frac treatments and resulting productivity. Frac gradient plots indicate that areas near faults have subnormal gradients, but position within the Eagle Ford does not exhibit a consistent trend. However, well performance relative to Eagle Ford completion interval does indicate a correlation.

About our Presenter:

Dr. Lee Billingsley earned his B.S. in Geology in 1975 from Texas A&M University. He earned his M.S. in Geology from the Colorado School of Mines in 1977, studying the stratigraphy of the Trinidad Sandstone in Walsenburg, Colorado. Dr. Billingsley earned his Ph.D. from Texas A&M University in 1982, studying the folding mechanisms related to growth faulting in the Texas Gulf Coast.

Dr. Billingsley worked for both Tenneco Oil Company and American Quasar Petroleum before founding Sandia Oil & Gas Corporation in 1983. He served as the President until Sandia merged with Abraxas Petroleum Corporation in 1998. He has since served Abraxas as its Vice President of Exploration, focusing on horizontal drilling and utilization of 3-D seismic in the Permian Basin and Eagle Ford in Texas, the Bakken/Three Forks and Powder River Basin in Colorado, Wyoming, and the Dakotas. He has over 34 years of experience as an exploration geoscientist, has served as the President of the American Association of Petroleum Geologists during 2006 and 2007, and also teaches graduate courses in Advanced Stratigraphy and Petroleum Geology at the University of Texas, San Antonio.

Plans for the GCAGS are moving along nicely. The Call for Papers was a great success. Rick Paige, Bob Critchlow, and Allen Lassiter have done an excellent job! We have over 100 abstracts for oral presentations and over 60 abstracts for poster presentations in eighteen technical categories. The convention will have an outstanding technical program! Check out the categories on our website: www.gcags2016.com.

We need local volunteers to coordinate with the convention management company in the areas of exhibits and audio/visual. We also need a social media whiz and a volunteer coordinator. Let me know if you're interested.

We are soliciting sponsorships. I personally ask you to consider sponsorship. Several companies have committed and we appreciate their early support and confidence.

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ALS Oil and Gas	Topaz
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SEI	Patron
SEIMAX Technologies	Patron
Stalker Energy, L.P.	Patron
Leon E. Comeaux & Associates	Friend

Please join this great group of companies and add your support to the convention. If you commit by the end of March, your logo will be included in the convention announcement brochure that will be mailed to all Gulf Coast Section AAPG members – around 9,000 folks.

See the sponsorship form in the bulletin or contact Lonnie Blake (361-876-6614) or me for more information.

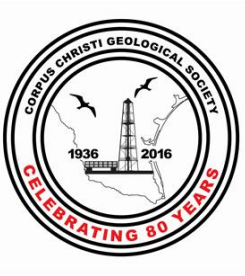
Thank you now for your support,

Looking Back *Thinking Forward* . . .

Dawn Bissell
General Chairman
361-960-2151

2016 GULF COAST ASSOCIATION
OF GEOLOGICAL SOCIETIES
ANNUAL CONVENTION

CORPUS CHRISTI, TEXAS



The Gulf Coast Association of Geological Societies and the Gulf Coast Section of SEPM

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What a great way to put your organization forward:

GCAGS – 9000 members, the largest AAPG Section
- 600 - 1000 geoscientists attend
- 900 Professionals representing 450 companies from 14 states and 2 countries attended in 2015

Benefits of sponsorship

- Reinforce your company's name and logo
- Visibility in the exhibit hall
- Stand out from your competitors – give your products and services and edge
- Enhance your standing in the industry
- Earn a profile among young geoscientists – your future workforce

Sponsorship packages – designed to maximize your investment

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- **Sapphire (S) $5,000+**
- **Topaz (T)$1,000+**
- **Patron (P)$500+**

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A sponsorship package can include your name and brand on one of these events, products, or publications. Choose from among:

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- Icebreaker reception – $25K exclusive
- All-Convention luncheon – $25K exclusive
- Presidents' reception – $25K exclusive
- Field trips & short courses – $25K exclusive
- Poster sessions – $10K exclusive
- Judges'/Speakers'/Poster Presenters' breakfast – $5K exclusive
- Technical session rooms – $5K per room exclusive for duration of convention
- Coffee breaks – $5K exclusive

Package Benefits

(depending on level)

- Complimentary Registrations (based on sponsorship level: D—5, E—3, S—2, T—1)
- Logo on banners and signs posted in exhibit hall and elsewhere
- Recognition at keynote speaker address
- Pre- and post-show attendee mailing lists
- Thank-you recognition in the convention program book
- Company name and link on website
- Ads in Transactions volume:
  - D—full-page color
  - E—full-page black & white
  - S—half-page black & white
  - T—quarter-page black & white
  - P—logo

(all ads on Transactions CD can be in color)

GCAGS 2016 will prove to be a great opportunity to build your goodwill and brand.
For more information or to make your sponsorship commitment contact:

Lonnie Blake: Phone 361-876-6614
sponsorships@gcags2016.com
-or-
Dawn Bissell: Phone 361-960-2151
bissells@swbell.net

The Gulf Coast Association of Geological Societies
And the Gulf Coast Section of SEPM

66th Annual GCAGS Convention

September 18-20, 2016

Corpus Christi, Texas

CORPORATE SPONSORSHIP INVOICE

Sponsoring Company _____

Amount _____

Contact Person _____

Email _____

Confirm Here How You Want Your Sponsor Name to Appear: _____

If You Have a Logo You Would Like the GCAGS to Use Please Email It To: gcags2016sponsorship@gmail.com

Mail This Form with Your Check (payable to 'GCAGS 2016') To:

ATTN: GCAGS 2016
Corpus Christi Geological Society
PO Box 1068
Corpus Christi, Texas 78403

Amount _____

Sponsor Package _____

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- Topaz (T)$1,000+
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Thank you for your generous support!

BLOOD DRIVE

THE BLOODMOBILE – IN **APRIL, 2016**
WILL BE AT SOME CONVENIENT LOCATIONS
PLEASE CALL 855-4943 for those locations or see below

ATTENTION!!!

We spoke to the Blood Center about locating us on their computers. They have us listed as C.C. Geological Society. Our number with them is 4254 & it would be helpful if you can give them that number also.

Thanks! Mike Lucente

FOR CURRENT SCHEDULES & LOCATIONS OF THE BLOODMOBILES YOU CAN LOG ON TO:

www.coastalbendbloodcenter.com

When you're running through those April showers –
Working in the garden or blowing around in the C.C. wind -
Zoom on over to the Bloodmobile!!
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The Discovery, Reservoir Attributes, and Significance of the Hawkville Field and the Eagle Ford Trend: Implications for Future Development

Richard K. Stoneburner

Pine Brook Partners, 1301 McKinney St., Ste. 3550, Houston, Texas 77010

ABSTRACT

The discovery of the Hawkville Field in LaSalle County, Texas, in October 2008 by Petrohawk Energy Corporation marked the first commercial production from the Eagle Ford Shale. Since that time the field has proved to be one of the most significant discoveries in North American oil and gas history. With cumulative production through October 2014 of over 1 billion barrels and 4.4 trillion cubic feet of natural gas, the field has been one of several that has reversed the decades' long trend of domestic oil production decline and has been a primary reason that U.S. oil production has almost doubled in the last 8 years.

The process of exploration for unconventional resources from shale reservoirs has some distinct differences from exploration for conventional reservoirs. The best way to describe the difference is that when exploring for large-scale shale reservoirs one must take an "inside out" approach versus an "outside in" approach. This applies to all aspects of the exploration process: prospect identification, geophysical analysis, stratigraphic analysis, and reservoir analysis. In the case of the discovery process for the Eagle Ford, the Petrohawk exploration team utilized three key findings to support the testing of the play: a key petrophysical data point, a set of key geochemical data points, and a geophysical model of the reservoir.

After the initial phase of exploration was deemed commercially successful, the appraisal process was primarily driven by a rigorous petrophysical analysis and associated work flows. The key building block to the petrophysics was applying the extensive data obtained from the whole-core analysis and calibrating those data to the regional subsurface data across the play. While the basic core and log data that is common to all reservoir analysis, such as porosity, permeability, and hydrocarbon saturation, forms the foundation for the understanding of the reservoir quality, the data derived from whole core such as mineralogy models derived from x-ray diffraction (XRD) and scanning electron microscope (SEM), geochemical characteristics such as total organic carbon (TOC), thermal maturity (Ro), and pyrolysis oven temperature resulting in maximum generation of hydrocarbons (Tmax) and geomechanical attributes such as Young's modulus, Poisson's ratio, and other elastic measurements are critically essential to obtaining a full understanding of the quality of a shale reservoir.

Upon entering the development phase of a large-scale shale reservoir such as the Eagle Ford, which covers over 7 million acres, the focus shifts away from the previously discussed nanoscale data to more macroscale data such as 3D seismic and the regional geologic distribution of the reservoir facies. Imbedded within the regional facies analysis is the decision regarding the optimum target selection for the horizontal wellbores and the implementation of that operation with the relatively new geologic function of geosteering. While the geologist is a key component of a successful horizontal operation, the real key to success is the collaboration of all technical functions including the drilling engineers, the completion engineers and the production engineers. Never has the need

Stoneburner, R. K., 2015, The discovery, reservoir attributes, and significance of the Hawkville Field and the Eagle Ford Trend: Implications for future development: Gulf Coast Association of Geological Societies Transactions, v. 65, p. 377–387.

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for this interaction between all functions been more critical to success than in large-scale shale development.

It is readily apparent that the Eagle Ford shale has been a highly commercial oil and gas reservoir throughout the South Texas. What has yet to be determined is the economic viability of the Eagle Ford in Mexico. There is little doubt that some area of Mexico will prove to be commercially viable, and the handful of wells that have already been drilled help support that premise. The main question yet to be answered is to what extent the play will reach across Mexico. Regional geology suggests it could be extensive, but much more drilling will need to be accomplished before that premise can be validated.

INTRODUCTION

The processes of exploration for unconventional shale reservoirs vary from conventional reservoirs primarily in terms of the regional approach. Unconventional exploration is typically an "inside out" approach while conventional exploration can be better described as an "outside in" approach. In conventional exploration he initial project identification phase begins with a basin analysis and then focuses in on some particularly aspect of the basin such as a structure, subcrop, or some other local feature whereas in unconventional exploration the basin center is usually the optimum location to begin identifying a project and then working out from there. The use of seismic data is also done in much the same manner with conventional exploration using seismic to map the basin and provide the data necessary to identify the individual prospects whereas in unconventional exploration the seismic is generally used to map the basin margins where the shale reservoir development is suboptimal. Likewise, stratigraphic interpretation and mapping of the reservoir quality is important locally in conventional exploration whereas in unconventional exploration knowledge of the stratigraphy and reservoir quality is imperative over the entire basin area.

EXPLORATION PROCESS FOR THE HAWKVILLE FIELD

The exploration team that lead the identification of the Eagle Ford shale as a thermogenic reservoir and who subsequently identified the Hawkville Field area as being an optimum location to explore for a commercial oil and gas accumulation began in early 2008 by mapping the Eagle Ford shale from the Mexican border to the Louisiana border. The abundance of penetrations along the Creatceous shelf and shelf margins provided excellent subsurface control with which to focus in on the areas where the reservoir was the thickest and of the highest quality. This area was identified to be southwest of the divergence of the Edwards shelf margin and the Sligo shelf margins in LaSalle and McMullen counties, Texas (Fig. 1).

Once this area of the basin was identified the "inside out" process was employed to define the prospective area that became the identified project. There were three key findings that were critical to the development of the project. The first was petrophysical in nature and involved the openhole log suite from the Swift #1 Pielop well that was drilled in 1992 in south-central LaSalle County, Texas. Figure 2 is a section of this log from the top of the Eagle Ford shale reservoir facies through the Buda limestone. The curves displayed from left to right are the gamma ray, resistivity, and density logs. All three provide evidence of this formation being a thermogenic hydrocarbon-bearing reservoir. The gamma ray character is indicative of an organic shale as evidenced by the relatively high gamma ray readings throughout the Eagle Ford and yet it also has multiple thin beds of higher gamma ray material interspersed over the approximately 280-foot section. This log character is indicative of the formation having sufficient coarser grained constituents that help preserve porosity and permeability in a shale reservoir. The resistivity curve also provides positive support for a productive shale reservoir in that the entire section is in excess of 20 ohm-meters with a significant portion of the formation in excess of 50 ohm-meters, with those beds correlative to the ones that display the lower gamma ray response. The density porosity curve is also indicative of a high-quality shale reservoir. The entire section is in excess of 9% porosity with a large percentage having in excess of 20% porosity. Although the log is calibrated to a limestone matrix and therefore these porosity readings are not truly indicative of effective porosity in the reservoir, the anomalously high density porosity is indicative of a rock with an relatively high kerogen content that has a bulk density much lower than that of 2.71 gram per cubic centimeter limestone matrix.

The petrophysical support proved to be a very positive finding and one that provided confidence that the project had commercial merit; however, it was important to determine what critical geochemical characteristics were present in the rock. To measure for the geochemistry it was necessary to find drill cuttings from a well in

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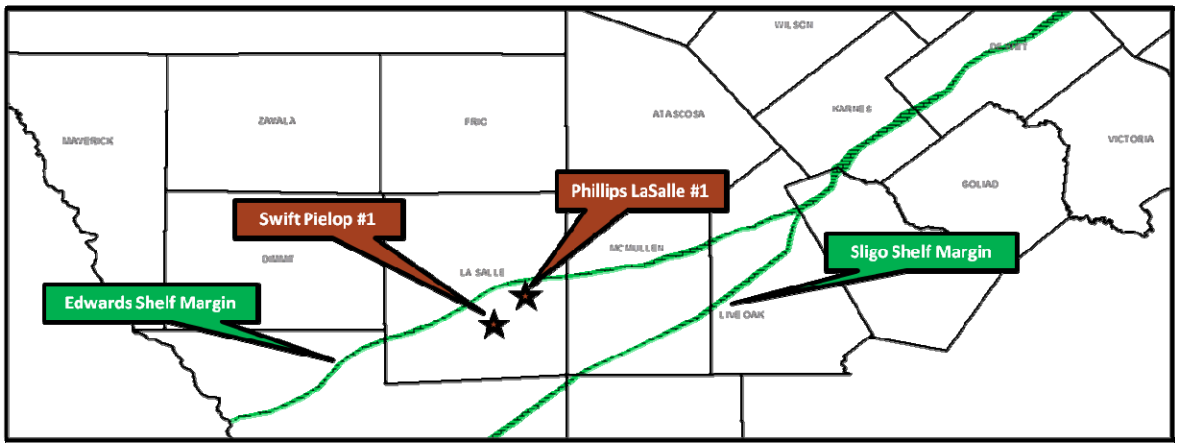

Figure 1. Regional map of South Texas with Cretaceous shelf margins and key wells represented.

the project area that could be analyzed by a laboratory. After extensive research at the Bureau of Economic Geology (BEG) drill cuttings and core repository in Austin, Texas, it was determined that the cuttings from the Phillips #1 LaSalle, drilled in 1952, were available at through the BEG. Samples were sent to the lab and it was determined that TOC, Ro, pyrolysis oven temperature resulting in maximum generation of hydrocarbons (Tmax), and Tr (oxygen index) were all above what are generally perceived to be the minimal values for a thermogenic shale reservoir.

Once the petrophysics and geochemistry analysis was deemed favorable, the confidence level was reasonably high that the reservoir was capable of generating and producing hydrocarbons. What was not readily apparent was where the thickest reservoir development occurred. While there was sufficient subsurface control to analyze the petrohysical and geochemical nature of the rock, the subsurface control was nowhere nearly sufficient to allow for mapping the reservoir with any degree of confidence, which was necessary to make an effective land play. Fortunately it was determined that due to the extreme variability of the reservoir thickness across the area, from less than 100 feet to greater than 250 feet, that the 2D seismic data provided a geophysical response that allowed for accurate isochron mapping of the reservoir interval. Additionally, there was an extensive grid of 2D available across the project area. As can be seen on Figure 3, a "doublet" developed where the reservoir thickness exceeded 100 feet. This allowed for a very confident map to be made that accurately interpreted the area of the thickest reservoir facies development.

Upon the conclusion of the petrophysical, geochemical, and geophysical research regarding the prospectivity of the Eagle Ford Shale as a viably commercial thermogenic reservoir, it was decided that a concerted land effort should be initiated to procure oil and gas leases on all of the available land that was supported as having greater than approximately 100 feet of Eagle Ford reservoir facies. This effort was initiated in April 2008 and proved to be incredibly successful. The success of the leasing effort was a result of a combination of factors. First, the buy outline encompassed an area that had very little historical oil and gas production. However, regionally there was considerable production. To the north was a Cretaceous trend of oil and gas production, most notably the Pearsall Field. It was a very extensive field and had undergone several periods of oil and gas development, most recently a period of horizontal development during the late 1980s and early 1990s. To the south was the Tertiary trend, which extended across the entire Gulf Coastal area. The lack of production in the immediate area of the project allowed lease bonus consideration to be kept at modest prices, yet the proximity of production provided mineral owners that were knowledgeable of the benefits of oil and gas exploration. The second aspect that benefitted the leasing effort was the fact that the land was generally divided into large ranches that made the leasing of such a large area relatively simple. The net result of the leasing effort was the accumulation of approximately 160,000 net acres in about 3 months time. Lastly, we decided to take the leases into a company, First Rock Inc., which was owned by a partner in the project, Gregg Robertson. By doing so, we were able to avoid alerting the public that Petrohawk, a well-known shale exploration company, was undertaking an extensive leasing effort that most likely would have alerted both mineral owners and local oil and gas companies that a shale exploration project had been identified in South Texas.

Upon the conclusion of the leasing effort the STS 241 #1H well was permitted, again under the name of First Rock Inc., and was spud on July 8, 2008. The drilling of the well went without significant delay or mechanical

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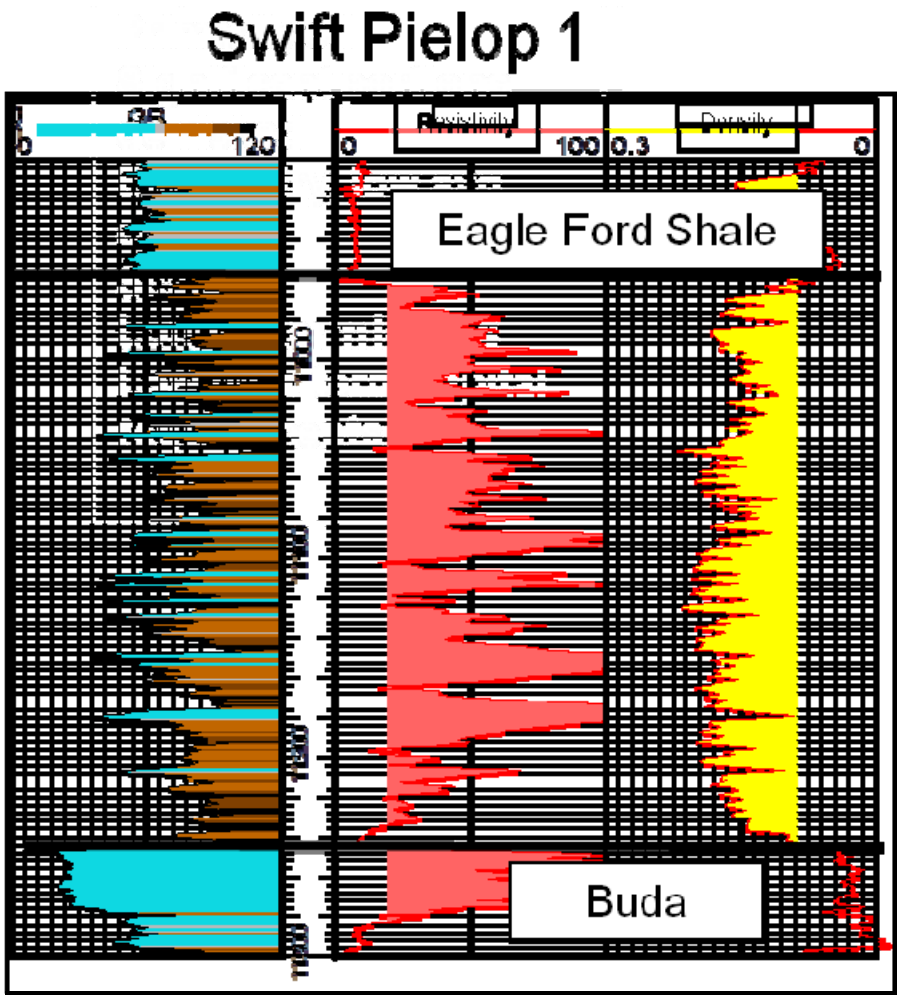

Figure 2. Openhole log (gamma ray, resistivity, and density porosity) from the Swift #1 Pielop well, LaSalle County, Texas.

issue and the well reached a total measured depth of 14,465 feet on August 23, 2008, with a lateral length of approximately 3200 feet. During the drilling process a 90-foot core was taken in the Eagle Ford and an extensive openhole log suite was run. A completion was designed that entailed 10 stages and the well was fracture stimulated with slickwater and approximately 2.1 million pounds of sand in early October 2008. The well was tested on October 14 at a rate of 5.5 million cubic feet of gas per day and 167 barrels of condensate per day on a 25/64-in. choke with 2050 pounds per square inch flowing tubing pressure. Even though over a dozen other horizontal wells had been drilled and completed in the Eagle Ford trend prior to this date, the STS 241 #1 was the first well to produce commercial volumes of oil and gas.

Considering the large areal extent of the prospective acreage, it would be difficult to consider that the appraisal process began after the completion of just one commercially productive well. There were two follow-up wells that were drilled to delineate the discovery. The Dora Marin #1 well was drilled approximately 15 miles west-southwest and the #1 Donnell Estate well was drilled approximately 15 miles east-northeast from the STS 241 #1 well. The #1 Dora Martin well was completed in February 2009 for approximately 9.0 million cubic feet of gas per day and the #1 Donnell Estate was completed in April 2009 for approximately 450 barrels of oil per day and 1.0 million cubic feet of gas per day. These three completions validated the play concept over a large area of the project leasehold and resulted in it moving from the exploration phase to the appraisal phase. Not only did these wells confirm the presence of commercial hydrocarbon production on the project, but it also

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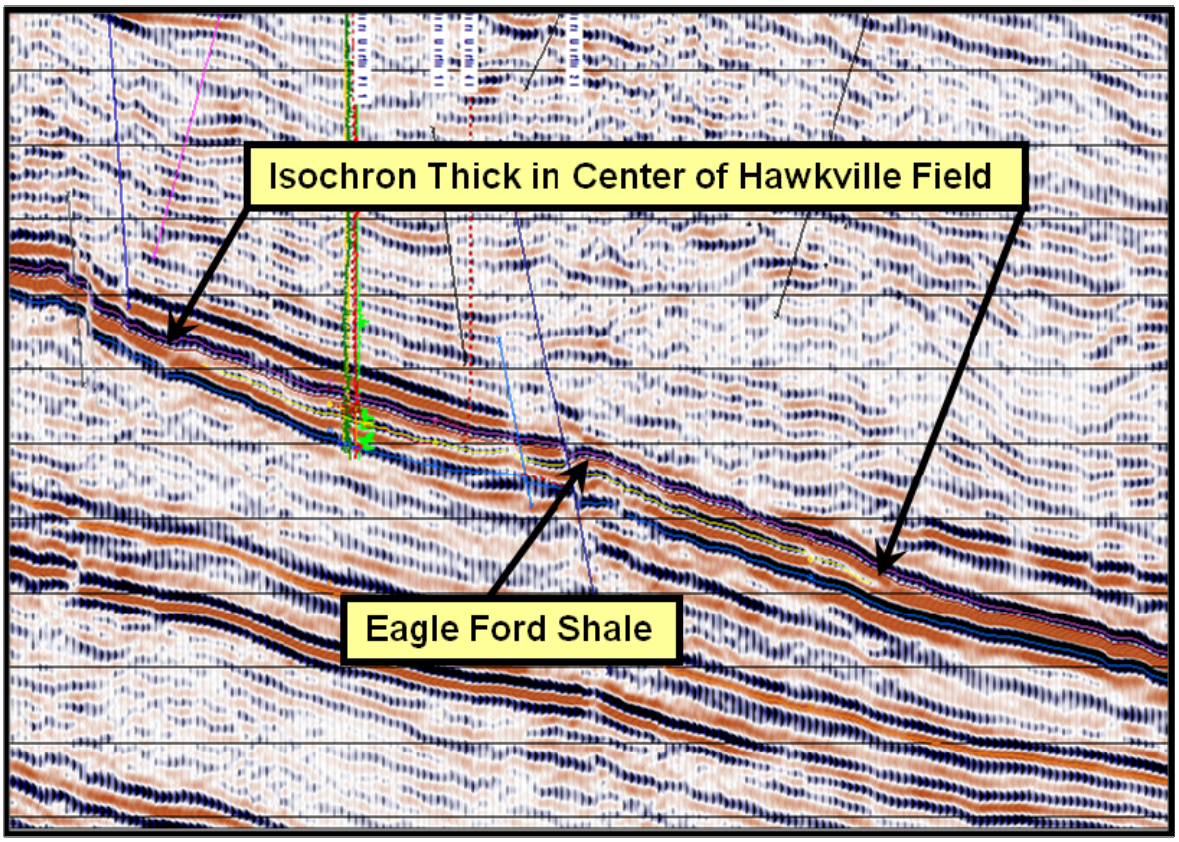

Figure 3. 2D seismic line through Hawkville Field (seismic data courtesy of Seitel, Inc.).

roughly delineated the depths at which the reservoirs contained dry gas, gas condensate, and crude oil with associated gas.

APPRAISAL PROCESS FOR THE HAWKVILLE FIELD

There are many things that are critical to validating and improving economic validity of an oil and gas discovery in a large-scale shale reservoir, including improving and refining the drilling operations, optimizing the completion operations, and scaling the production operations for the appropriate volume and product mix. However, there are probably none as important as gaining a thorough understanding of the reservoir rock.

This understanding began with the acquisition of data during the exploration phase. These data include extensive petrophysical and geomechanical data through the openhole logging process, as well as the physical acquisition and evaluation of rock samples through the coring process. However, this is only the beginning of the process of understanding the reservoir rock. It would be ideal if these extensive datasets of log and core could be obtained on a large number of the postexploration phase wells. However, obtaining these data on a field-wide scale is cost prohibitive and there will most likely only be a handful of wells with a complete openhole log and whole-core dataset. Therefore the challenge is to use the limited set of these "complete" datasets as calibration tools in conjunction with the less extensive, or "incomplete," datasets that are available from wells that had been drilled and logged before the exploration process or from appraisal wells that do not possess a full suite of petrophysical data.

The calibration process is therefore the key to taking a limited number of "complete" datasets and establishing relationships between them and the wells that have "incomplete" datasets, which are numerous. The key to establishing these relationships is the use of cross plots. By understanding the relationship that two measurements have with one another it is possible to prescribe a reliable proxy for one of those measurements presuming

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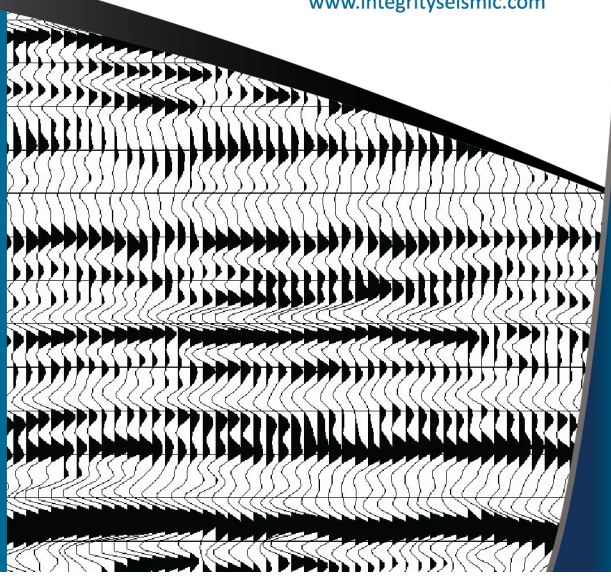

the other is available. The following are a few of the more pertinent measurements that we obtain from both open hole logs and/or whole core analysis:

- Porosity (total and hydrocarbon filled)
- Permeability
- Bulk density
- Water saturation
- Mineralogy
- Shear wave velocity
- Spectral gamma ray
- Total organic carbon (TOC)
- Thermal maturity (Ro)
- Young's modulus
- Poisson's ratio
- Compressional-wave velocity

The following are a few of the combinations of these measurements that have somewhat dependent relationships that when crossplotted with each other can provide a meaningful interpretive analysis of the measurements:

- Porosity vs. permeability
- Total porosity vs. hydrocarbon-filled porosity
- Clay percentage vs. Young's modulus
- Static Young's modulus vs. dynamic Young's modulus
- Bulk density vs. TOC
- Permeability vs. hydrocarbon-filled porosity
- Young's modulus vs. Poisson's ratio

Figure 4 is a composite log representation of these measurements. As well as displaying the curves that are resultant from the openhole logging process, there are also single point measurements from the core analysis plotted on the associated log curve that provides a visual representation of the relationship between the log-derived data and the core-derived data.

While the interpretation of the crossplot relationships is critically important to creating an expanded dataset of measurements from the reservoir rock, there are many other data that need to be understood in order to have the necessary understanding to optimize economic benefit. The most important of those data might be the mineralogy and associated fabric of the rock. Figure 5 is a chart that displays the mineral constituents from the Austin chalk and Eagle Ford shale. The most interesting aspect of these data is the extremely low clay percentage, 10–15%, that is found in the Lower Eagle Ford, or what we refer to as the Hawkville facies. The most common mineral present is calcite at approximately 70–75%, with the next most common being quartz at approximately 10%. These are what can be termed coarse-grained constituents of the rock, or at least relatively coarse grained. It should also be noted the high kerogen content at slightly more than 10%. It is this type of mineralogy that makes these rocks more accurately termed as mudrocks than shale and that also makes them excellent thermogenic reservoirs.

Figure 6 is a good visual example of the fabric of mudrocks such as the Eagle Ford. The image on the left is a petrographic slide of the Eagle Ford that is cut at the standard thickness of 30 microns and is being viewed on a 0.5-millimeter scale. The result is what one would typically expect from a mudrock, that being a rock that is dominated by fine-grained minerals and lacks a grain-supported fabric. The slide on the right is the same rock sample but has been cut much thinner at 20 microns and is at a scale 20 times more magnified. The result is a rock that is actually very well supported by its coarser grained constituents and one that has intergranular porosity and associated permeability, albeit as nanodarcy levels. Figure 6 is a similar measurement as to the mineralogy of the Eagle Ford, but in this case it is not a single example from a well but instead a cross section including four wells along the Gulf Coast Eagle Ford trend. The section covers approximately 200 miles from the Maverick Basin through Hawkville Field to the San Marcos Arch and finally into the East Texas Basin. The primary interpretive analysis of this mineralogic cross section is the high carbonate content and low clay content that is found in areas southwest of the San Marcos Arch versus the lower carbonate content and much higher clay content that occurs in the East Texas Basin. This is the result of the increased sand and shale deposition that was introduced into this area from the northern portions of the East Texas Basin.

Knowledge of the geomechanical properties of the reservoir rock is also critically important when evaluating the economic viability of a thermogenic mudrock reservoir. Two of the most important measurements that can be made from both openhole dipole sonic logs as well as whole core are Young's modulus and Poisson's ratio. Young's modulus is a measure of the ability of a material to withstand changes in length when under lengthwise tension or compression. Sometimes referred to as the modulus of elasticity, Young's modulus is equal to the longitudinal stress divided by the strain. Poisson's ratio is best explained by considering that when a material is compressed in one direction, it usually tends to expand in the other two directions perpendicular to the direction of compression. Poisson's ratio thus is the fraction (or percent) of compression divided by the fraction (or percent) of expansion for small values of these changes. Both of the measurements provide indications as to the level of anisotropy of a material, or in this instance a rock formation under the stress of overburden and other natural forces. A good way to visualize the effects of anisotropy on a material is shown with the images in Figure 7. The image on the left is a completely isoptropic material such as the glass used in the windshields of automobiles. This type of glass is used to reduce risk from injury during accidents. When subject to a force this glass shatterd equally in all directions. The image on the right is a glass that displays a very high degree of anisotropy. When subject to a comparable force this glass shatters in a highly preferential direction, which is indicative of a highly anisotropic material. The question that relates to the economic viability of a mudrock is which of these

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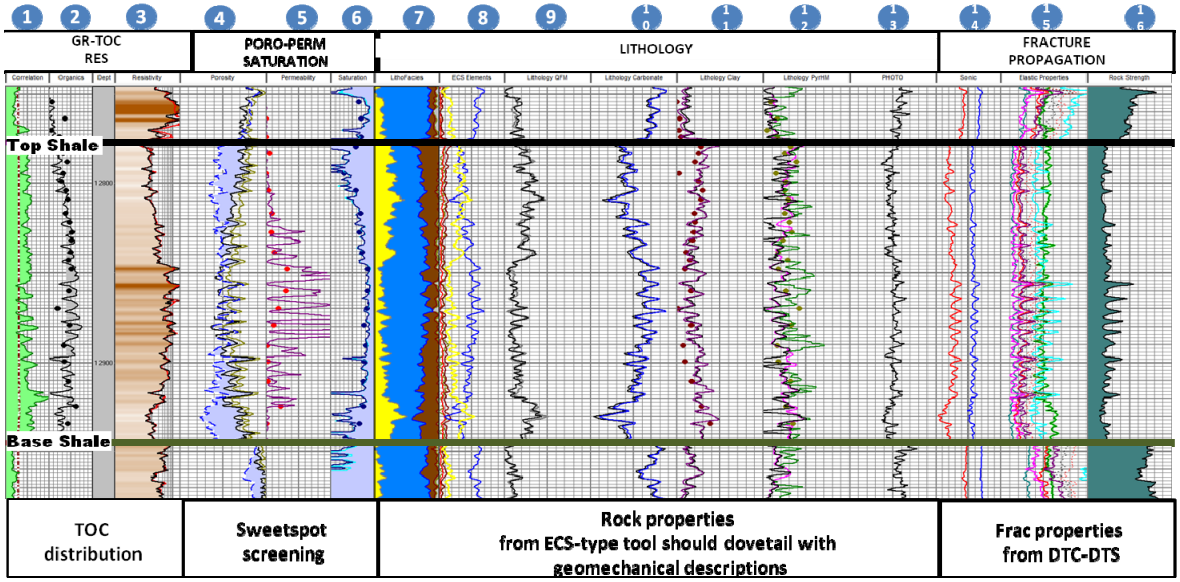

Figure 4. Composite type log for an Eagle Ford well.

qualities would be most beneficial to establishing a commercial reservoir as a result of creating induced permeability using the hydraulic fracturing process? At first glance one might presume that the isotropic medium would create a fracture network that would expose the most surface area of the reservoir. However, the issue with an isotropic medium such as this is that a true fracture is never initiated and the rock simply balloons out. The reservoir never breaks down and the most likely result is a fracture screenout after only a limited amount of fluid and sand has been placed in the reservoir. However, the truly isotropic medium also presents limitations to the ability of the hydraulic fracturing process to maximize stimulated rock volume (SRV). The limitation is a result of the fracture very early establishing a dominant wing length and therefor lacking the complexity that is desired. It is essential to maximize SRV and to do that the fracture system needs to have some element of complexity, which is lacking in this example. Therefore, it seems that a combination of the two images whereby the rock displays sufficient anisotropy to establish a fracture but also is capable of creating more complexity than one that has a strong preference to grow in a single direction and plane.

DEVELOPMENT PROCESS FOR HAWKVILLE FIELD

The transition from appraisal to development in a field the size of Hawkville, or a trend as areally extensive as the Eagle Ford, is very subjective. One could argue that the appraisal process encompasses that period during which the leases are held by production, or HBP, and down spacing of each unit begins. This definition seems to entail more drilling that would be necessary to appraise a field, so for argument's sake we will define the appraisal process as one that took the well count from 3 at the end of the exploration process to a total of 30 at the end of the appraisal process. While completely arbitrary, it is an order of magnitude more than the exploration well count and the number of wells that have been drilled has allow gaining extensive geologic and engineering knowledge.

One element that is critical to the successful development of a field area this large is the acquisition of 3D seismic data. While many of the mudrock field areas are relatively benign structurally because they are by definition basin-centered reservoirs in many cases, it is still imperative that the seismic data be acquired. This is primarily driven by the fact that all the wells are being drilled horizontally, which increases the risk of a geohazard such as a fault of unforeseen dip change having an adverse, and often times catastrophic, effect on the effectiveness of that lateral. Figure 8 is a map that displays the acquisition of both existing 3D seismic data as well as the acquisition of new 3D seismic data that resulted in a merged survey that covered approximately 600 square miles. Even though the cost was quite high, when one considers the amount of capital required to fully develop the field

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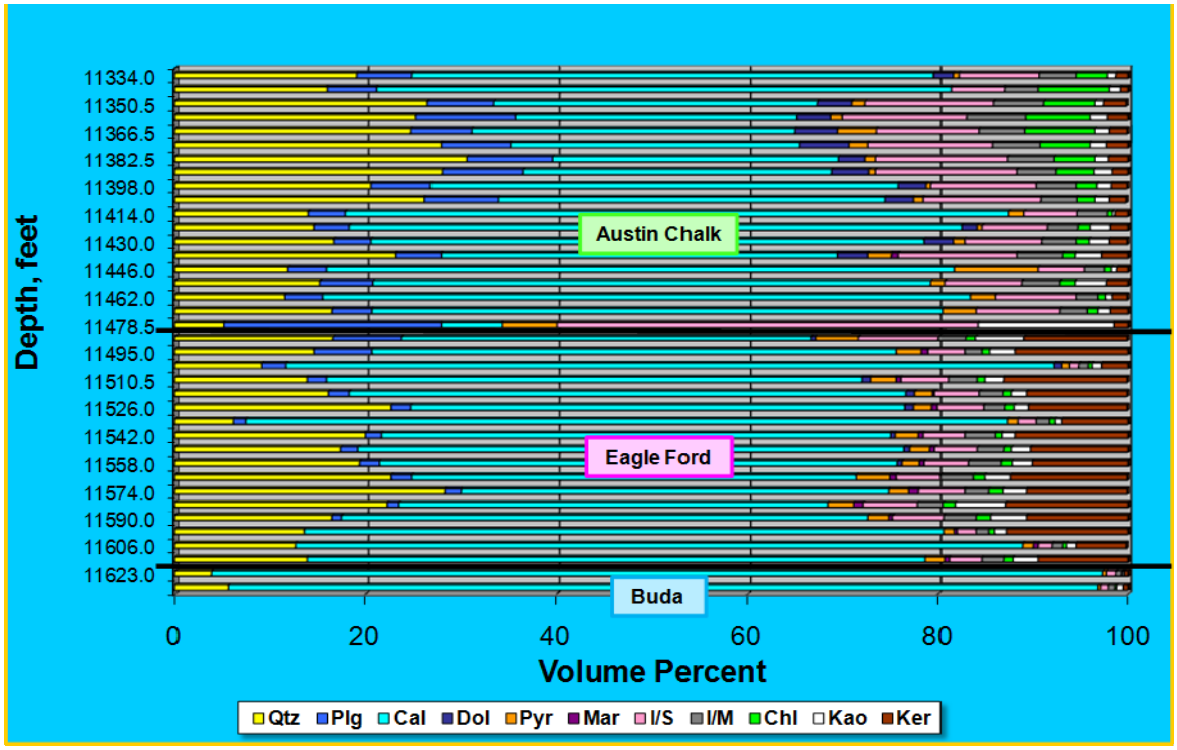


Figure 5. Mineralogical assessment of the Austin Chalk and Eagle Ford (courtesy of Core Laboratories).

it became obvious that it was only a very small component of the fully developed field cost.

The other aspect of developing a large-scale mudrock field such as the Hawkville Field in specific and the Eagle Ford trend in general is the amount of functional collaboration between the technical disciplines that is absolutely imperative to optimize the performance of the field. The life cycle of a well is so interdependent on all of the disciplines within and exploration and production organization. It begins with the land function and the challenges presented from both a regulatory perspective as well as a legal perspective that, if not managed properly, can be at the least an impediment to development and at worst create a loss of title. The geological function is truly one that is imbedded in the entire cycle of the well. It begins with deciding on the optimum surface location, to choosing the proper target which drives the overall well design, to steering the drilling process though that target as accurately as possible, and lastly to collaborating with the completion engineers to optimize the fracture design. For all of the phases associated with the well cycle to be successful it is imperative that the land, engineering, and geological functions work in concert like they have never required to do when developing conventional onshore fields.

THE EAGLE FORD TODAY

Since the discovery of commercial production in the Eagle Ford in 2008 the trend has shown nearly unprecedented growth. The following is a summary of some key statistics through October 2014 regarding its remarkable development:

Total number of wells drilled: >10,000
Cumulative oil and condensate production: 1.01 billion barrels
Cumulative gas production: 4.4 trillion cubic feet
Current daily production: 1.2 million barrels and 4.6 billion cubic feet
Current active horizontal rig count: 135
Estimated remaining resource: 14 billion barrels equivalent

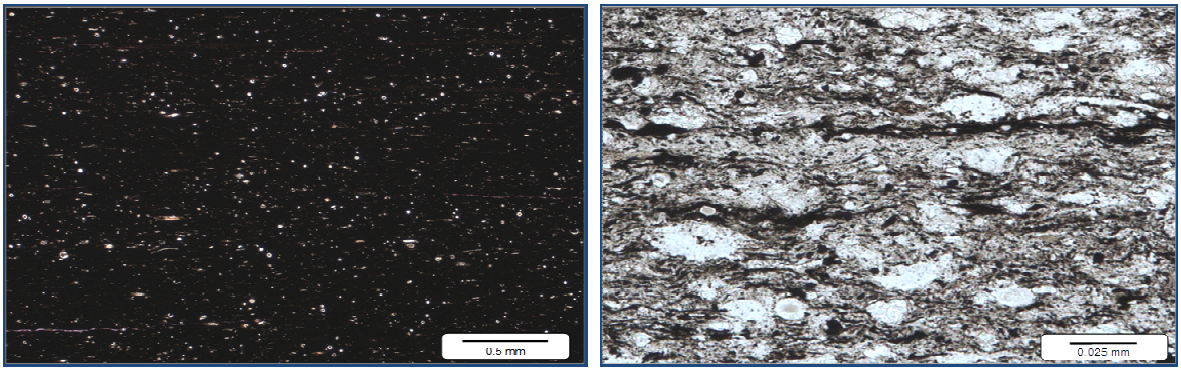


Figure 6. Petrographic slides of the Eagle Ford at varying scales and thicknesses (courtesy of Core Laboratories).

THE EAGLE FORD IN MEXICO: WHAT IS IN STORE?

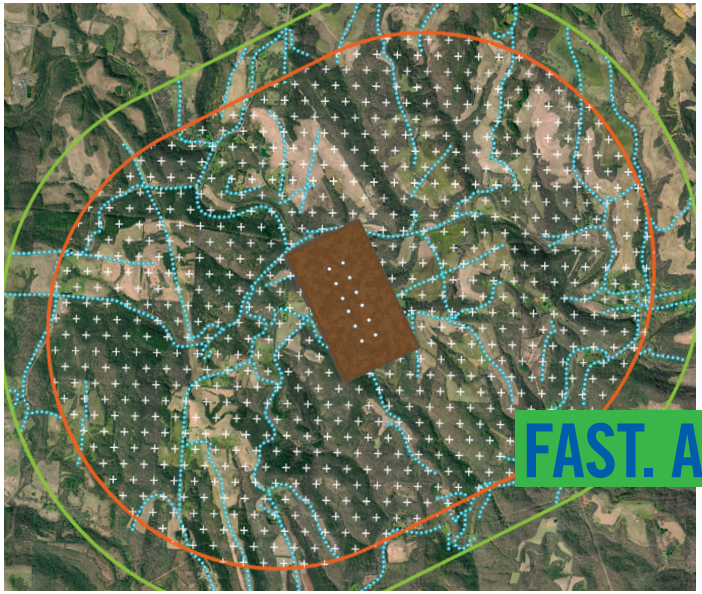
The trend of the Eagle Ford shale clearly does not stop at the US/Mexico border. The main question is how extensive is the reservoir development as it crosses the border and more importantly for Mexico, how prospective is the Eagle Ford for providing the country a significant resource to be developed commercially?

Figure 9 is a map of the Texas and Mexico Gulf Coast region with basins identified that could contain Eagle Ford reservoir facies. This map shows that the development of the trend has progressed to all of the counties in Texas that adjoin Mexico. However, the pace of that development has essentially terminated at the border. Pemex has drilled a handful of wells testing all product windows of the Eagle Ford at points near the border with the U.S. The following are the results of those wells in order of increasing depth:

Well	Initial Production
Nomada #1	No results reported
Montanes #1	110 million cubic feet and 19 barrels of condensate per day
Habano #1	2770 million cubic feet and 27 barrels of condensate per day
Emergente #1	2860 million cubic feet and 0 barrels of condensate per day
Arbolero #1	3180 million cubic feet and barrels of condensate per day

The rates from these wells are clearly much lower than what is typical of wells across the border into Texas. Without having petrophysical data from the wells drilled in Mexico to compare with the wells in Texas it is impossible to judge whether the subcommercial results are a function of deteriorating reservoir quality or if they could be related to Pemex's relative inexperience at drilling and completing shale reservoirs. Another aspect that could have a bearing on the results is the structural regime that exists in eastern Mexico. It has been validated that the Eagle Ford results in the central portion of the Maverick Basin have been much poorer than those wells drilled in the Gulf Coast Basin and one of the primary reasons for the disparity in results has been attributed to the different tectonic stresses that the Maverick Basin was subjected to.

While the extension of the Eagle Ford trend into Mexico from the Maverick and Gulf Coast Basins has been minimally tested, there are numerous other basins in the northeastern portion of Mexico that contain Eagle Ford sediment. What is unknown is how these rocks compare to their counterparts in Texas and what potential exists for them. Only extensive geologic analysis and exploratory drilling will answer that question.



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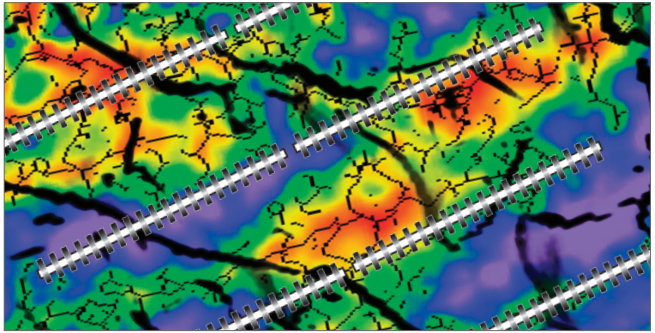

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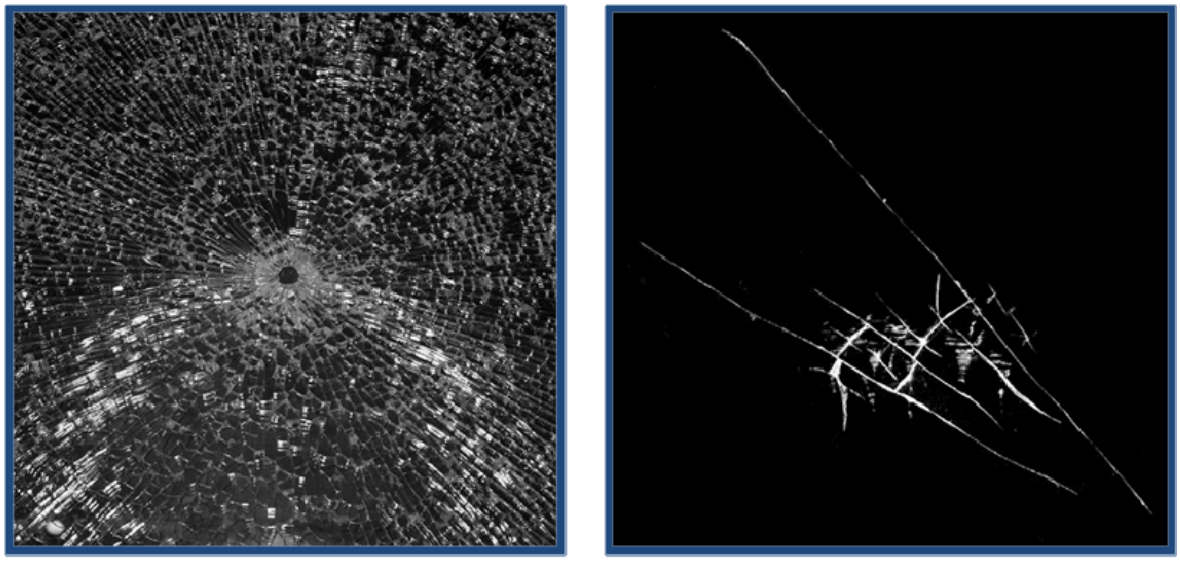

Figure 7. Examples of fractured isotropic and anisotropic glass (courtesy of Core Laboratories).

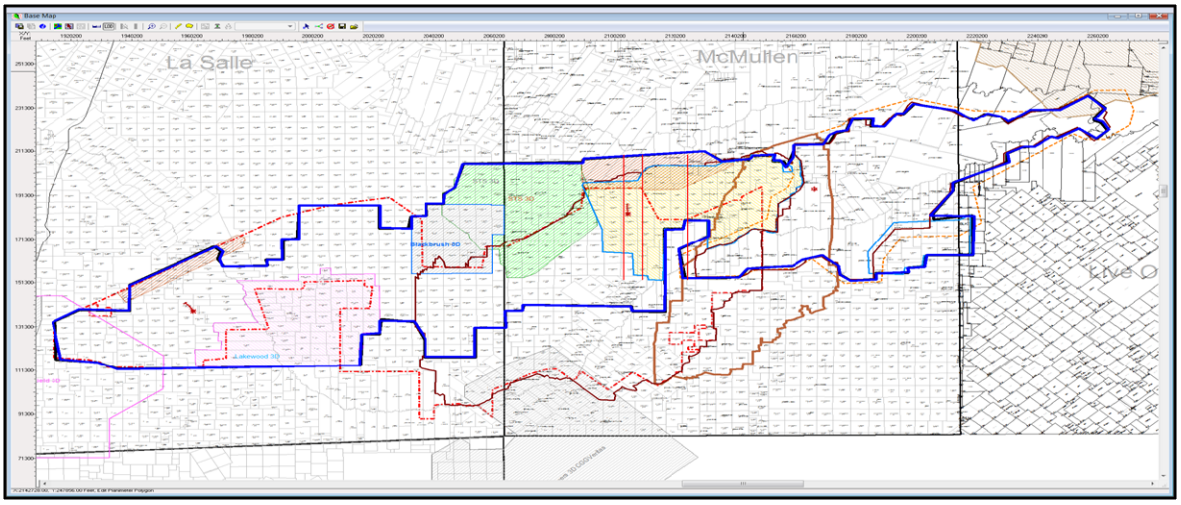

Figure 8. Map of Hawkville Field with outline of 3D seismic data.

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Figure 9. Map of Mexico with outlines of major basins and location of Eagle Ford wells completed in the Burgos Basin (courtesy of the *Oil and Gas Journal*, March 1, 2013 issue).

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Copano Bay, South
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Goose Island
Half Moon Reef
Nine Mile Point
Rockport, West
St. Charles
Tally Island
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Mosca
Nomanna
Orangedale(2)
Ray-Wilcox
San Domingo
Tulsita Wilcox
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Boedecker
Cage Ranch
Encintas
ERF
Gyp Hill
Gyp Hill West
Loma Blanca
Mariposa
Mills Bennett
Pita
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Heyser
Lavaca Bay
Long Mott
Magnolia Beach
Mosquito Point
Olivia
Panther Reef
Powderhorn
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S.E. Zoller

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Luttes
San Martin (2)
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Graceland N. Fault Blk
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Cook
*****Nordheim**
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Edinburg, West
Flores-Jeffress
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Hidalgo
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San Fordyce
San Carlos
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Tabasco
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Arnold-David, North
Baldwin Deep
Calallen
Chapman Ranch
Corpus Christi, N.W.
Corpus Christi West C.C.
Encinal Channel
Flour Bluff/Flour Bluff, East
GOM St 9045(offshore)
Indian Point
Mustang Island
Mustang Island, West
Mustang Island St. 889S(offshore)
Nueces Bay/Nueces Bay West

Perro Rojo
Pita Island
Ramada
Redfish Bay
Riverside
Riverside, South
Saxet
Shield
Stedman Island
Turkey Creek

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Greta
La Rosa
Lake Pasture
Refugio, New
Tom O'Connor

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Odem
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Garcia
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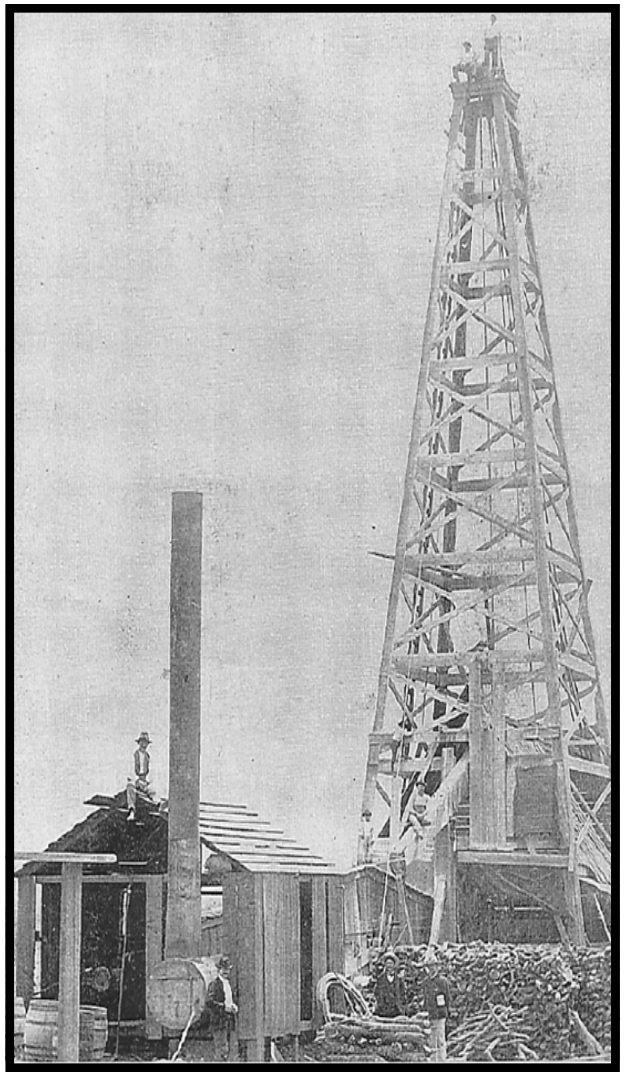

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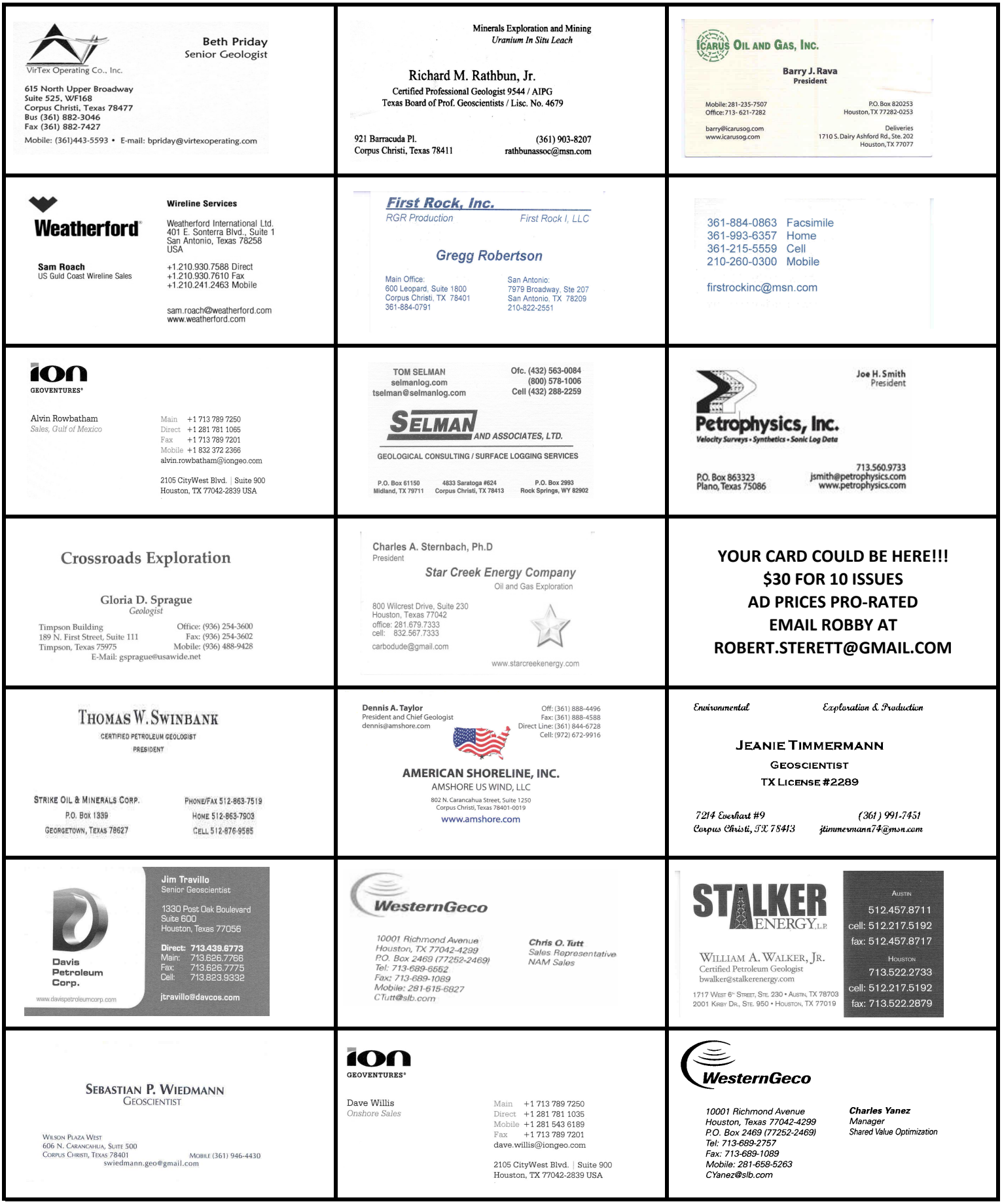
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