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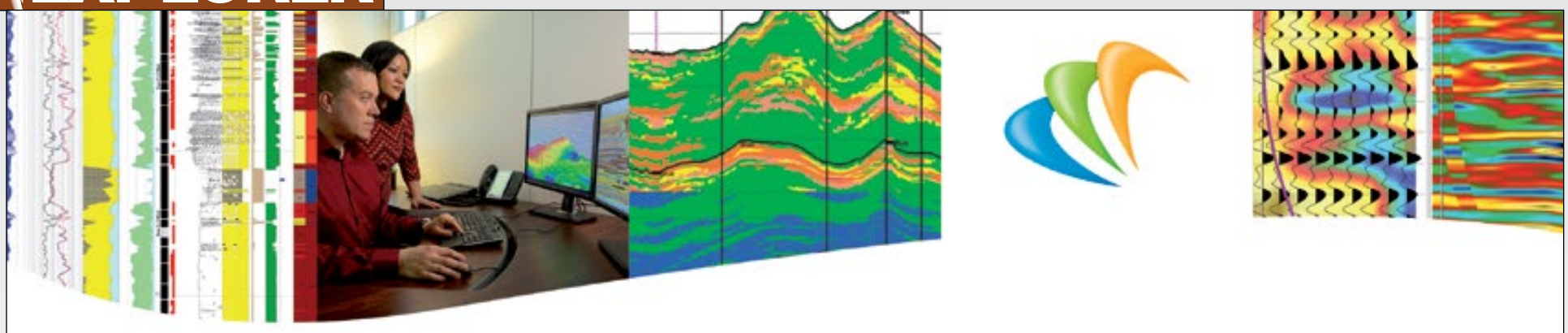

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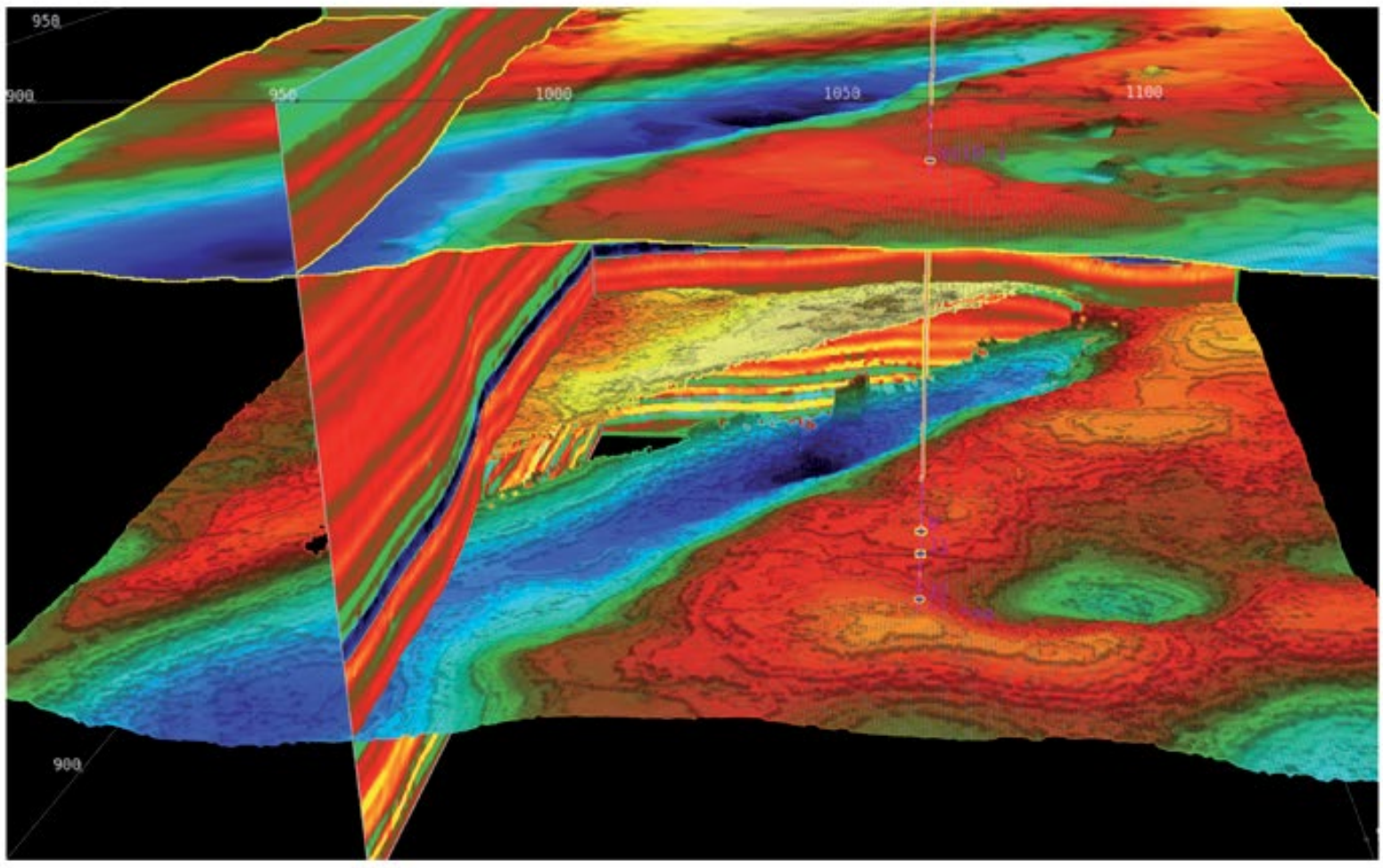

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Vol. 37, No. 10
October 2016

PRESIDENT'S COLUMN

On Membership, Hydraulic Fracturing and Policy

BY PAUL BRITT

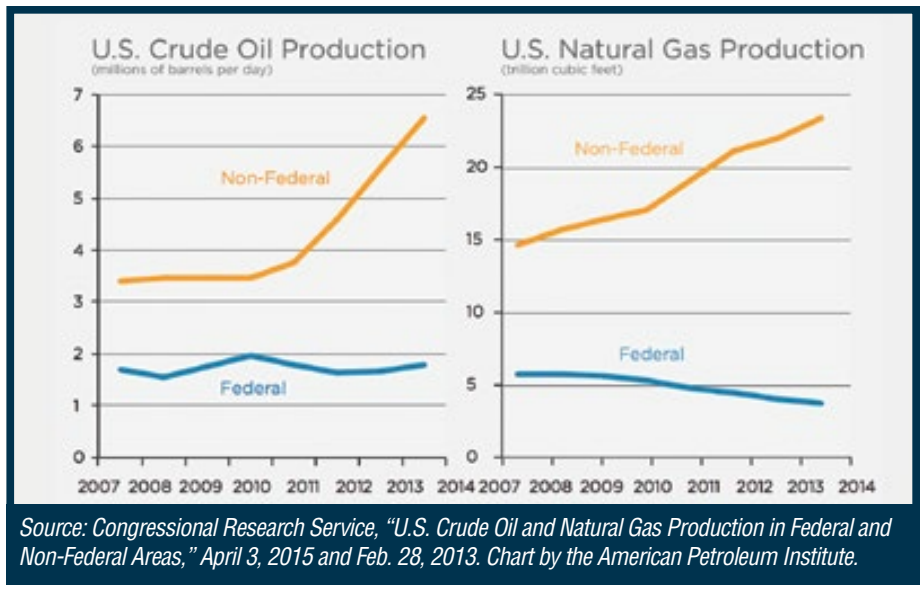
While I was at the Unconventional Resources Technology Conference in San Antonio, it was brought to my attention that we have a Member who just had her 103rd birthday. Marie Gramann of Brownwood, Texas joined AAPG in 1948, became a Life Member in 2015 and holds her AAPG membership very dear. There was an article about her in the December 2013 EXPLORER that details her career.

What is it that makes AAPG so special to so many Members?

American Members with whom I've spoken typically cite its excellence in science, its professional standards and its professional community. I have had the opportunity to visit with AAPG student chapters and student leaders from various countries outside of North America who have a tremendous excitement about their involvement with AAPG. When I asked them why are they so excited about belonging to the *American* Association of Petroleum Geologists, I get mostly the same answers: that it is the premier association for technical excellence and professional community. They have many choices of scientific associations from which to choose, and they choose AAPG as their home association.

To many AAPG Members, their membership may simply be for access to the Bulletin and EXPLORER. However, to many more, it is an association of choice, made so over the years by their participation in events, professional networking and friendships, and is in fact a point of pride.

From talking with many Members, the reasons seem diverse, and yet there is a theme running through them that makes them similar to the reasons already mentioned: they want to belong to something, and not just for a magazine subscription.



Source: Congressional Research Service, "U.S. Crude Oil and Natural Gas Production in Federal and Non-Federal Areas," April 3, 2015 and Feb. 28, 2013. Chart by the American Petroleum Institute.

BRITT

The Executive Committee is working hard to fulfill those expectations for new and old Members. As everyone should know by now, the headquarters staff has gone through reductions and reorganization to continue to meet Member's needs and expectations. Convention attendance for all associations has been down by 30 percent or more in the last year, AAPG being no exception. We are working on ideas to streamline programs and events to deliver membership value, and in some cases to increase membership value in publications and other programs. There will be more on these in the coming months.

For now, though – Marie, since I failed to get a card out to you, I just wanted to say: *belated Happy Birthday!*

Hydraulic Fracturing in the Crosshairs

During my recent visit to Cape Town, South Africa, for the 35th International Geological Congress, the subject of "frac'ing" came up repeatedly among South African petroleum and academic geoscientists.

South Africa imposed a moratorium on hydraulic fracturing in 2011, which has since been repealed, then restored in some areas. Some exploration licenses have been denied and others approved in the Karoo formation. The future of unconventional shale exploration there is still in limbo, largely due to a well-organized anti-frac'ing movement within the country, which has fostered public opposition to hydraulic fracturing. Opponents cite misconceptions and disproven examples as the basis for banning shale exploration in South Africa, all of which can be seen on their websites.

Local geoscientists are seeking ways to overcome this onslaught of disinformation.

Another difference cited in the case of South Africa and many other countries around the world, in contrast to the United States, is private ownership of mineral rights. Most countries have public, or government, mineral ownership. Therefore, the local surface owners or tenants see no direct benefit of oil or gas operations near them. In this respect, North America is nearly unique in the world. In fact, if the minerals were government-controlled in the United States, one could argue that the recent petroleum boom that occurred from about 2008 until last year would never have happened. Exploration and production activity was flat or declined on federal lands during the same time that production was dramatically increasing in the rest of the United States.

We see many similar efforts in other countries, including the United States, where passionate misdirection and misstatement of facts are used to affect public policy. As professional geoscientists, we should be interested in presenting the factual case for those topics where geoscience and policy intersect. I would say that it is even a responsibility to be sure that policy that affects geoscience is based on sound and factual geoscience rather than a collection of misstatements and misrepresentations of fact. Hydraulic fracturing, exploration access to public lands, carbon storage, energy supply and more are not just North American issues, but worldwide issues affecting the energy geoscience professional.

Policy will be determined with, or without, scientific input. Which would you prefer?

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REGULAR DEPARTMENTS

Photo courtesy of Apache

ON THE COVER:

The Mars Curiosity rover recently drilled into target rock called "Buckskin" on lower Mount Sharp. Onboard analysis of the rock inside the rover's CheMin instrument revealed that the rock contains a mineral called tridymite. It was the first detection of the mineral on the planet. The discovery of the mineral suggests the planet may have had explosive volcanoes at one time. Photo courtesy of NASA. See page 12.

Left: Apache's Alpine High acreage lies in the southern portion of the Delaware Basin, primarily in Reeves County, Texas. See page 6.

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SIGs and TIGs Take Off

By BRIAN ERVIN, EXPLORER Managing Editor

It's been just over a year and a half since the AAPG House of Delegates approved the formation of SIGs and TIGs, and the new classification structure is steadily catching on.

There are currently about 50 of them in various stages of development, with more expected in the months to come as AAPG Members continue to rally around shared interests and as established committees make the transition to the more nimble new structure.

Also, AAPG has a few improvements in the works to help hasten the process of forming a TIG/SIG.


NASH

> "You have access to more diversity, which brings more expertise into a group, and that's exactly what this is about."


STEFANIC

What's a TIG/SIG?

In case you're among the quickly shrinking but still sizeable minority of AAPG membership that isn't up to speed on the new group structure, "TIG" and "SIG" stand for "Technical Interest Group" and "Special Interest Group," respectively.

"TIGs and SIGs are responsive, flexible, grassroots groups that can go where their members want them to go," said Susan Nash, AAPG's director of Education and Professional Development, who oversees the formation and organization of TIGs.

"It puts people who are interested in the same ideas in a group to talk and collaborate," said Vern Stefanic, AAPG's director of Administration and Programs, who oversees SIGs.

"You have access to more diversity, which brings more expertise into a group, and that's exactly what this is about," he added.

"The TIGs function as springboards for connecting and creating content for presentations, workshops, education, publications and more. TIGs and SIGs are all about opportunity," added Nash.

She explained that the advantages the new group classification has over other organization models within AAPG are many. For instance, there is no membership cap on TIGs or SIGs, unlike committees, which are limited to 10-12 members. Also, they don't have the bureaucratic hurdles or accountability to the Executive Committee that Divisions have.

And, there's no limit to the number of SIGs and TIGs any given person can join, and AAPG membership is not a requirement for participation.

"You can participate in as many SIGs and TIGs as you'd like and there is no pressure at all. You can also involve other societies and their members. The potential is unlimited," said Nash.

"AAPG provides a platform and place for individuals to connect, create content, meet (face to face and virtual), collaborate and start up activities that can result in enhanced exploration and development," she added.

Progress So Far

When the HoD first approved the new structure at the AAPG Annual Convention and Exhibition (ACE) in Denver last year, the Young Professionals Membership Committee, under the leadership of Meredith Faber and Jonathan Allen, was the first to make the transition to a SIG. The YP SIG has since organized special career-focused sessions at ACE and the Unconventional Resources and Technology Conference (URTeC), YP icebreakers and meet-and-greet sessions, and YP-focused short courses.

"The YPs already are a model blueprint for committees and other groups who would like to become a SIG. They embraced the concept enthusiastically," said Stefanic.

"The YP SIG is extremely well-organized, with groups spread around the entire globe that are active and dedicated to providing the umbrella for a variety of activities. Their groups plan and support social events, recreational activities and community service projects, which in turn has created a sense of purpose and loyalty among their members," he continued.

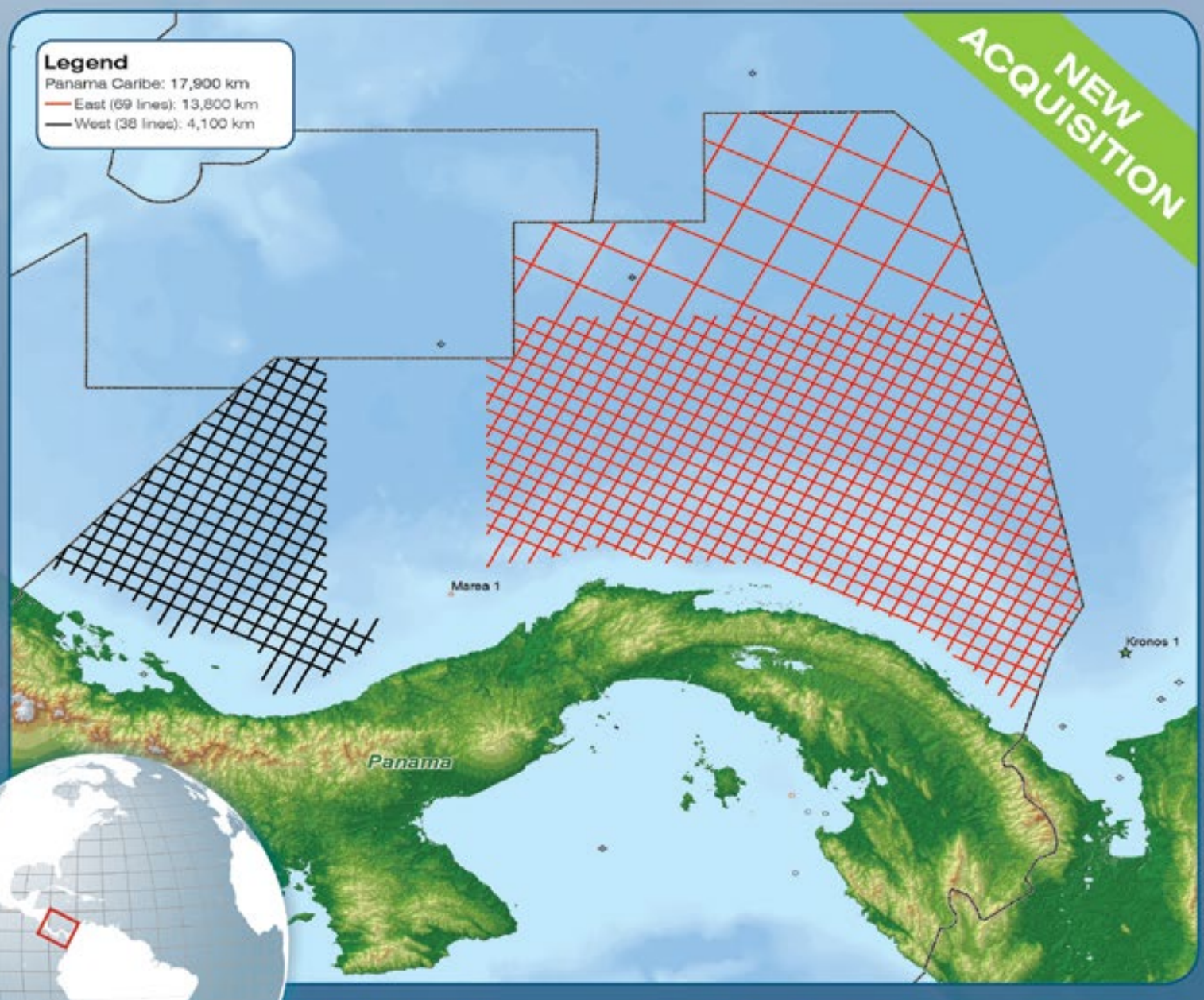
See **SIGs**, page 8

multi-client seismic

PANAMA

Offshore Panama

New Multi-Client 2D Seismic Data for License Round



Now that the Environmental Permit has been approved, Spectrum aims to commence acquisition of an 18,000 km long offset 10x10 km grid over Panamanian waters in October 2016. This new 2D survey will provide high fidelity images of the subsurface geology, including the prospective Tertiary and Cretaceous section as well as the deeper crustal features.

Final processed data will be available in Q2 2017 in anticipation of a formal license round announcement in H2 of 2017.

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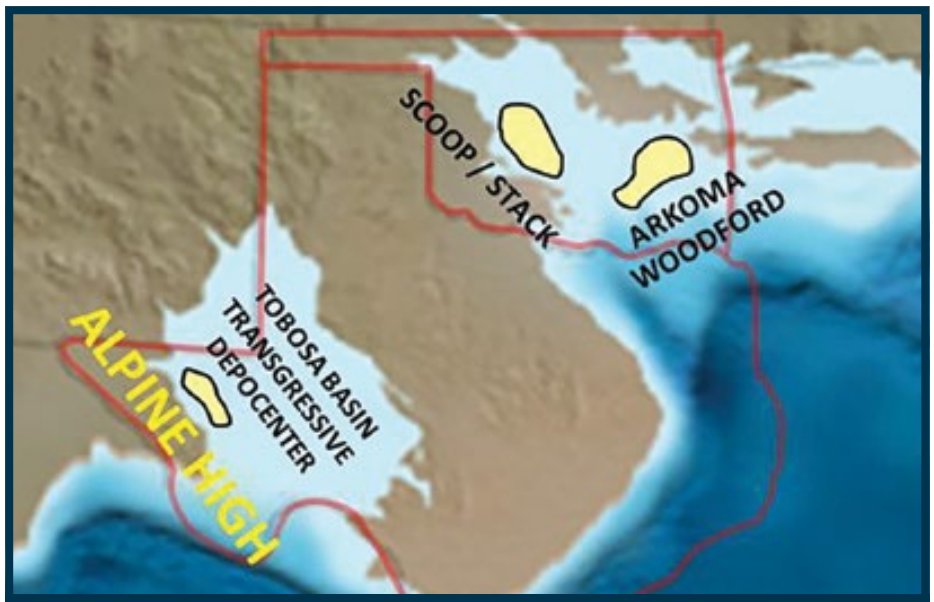
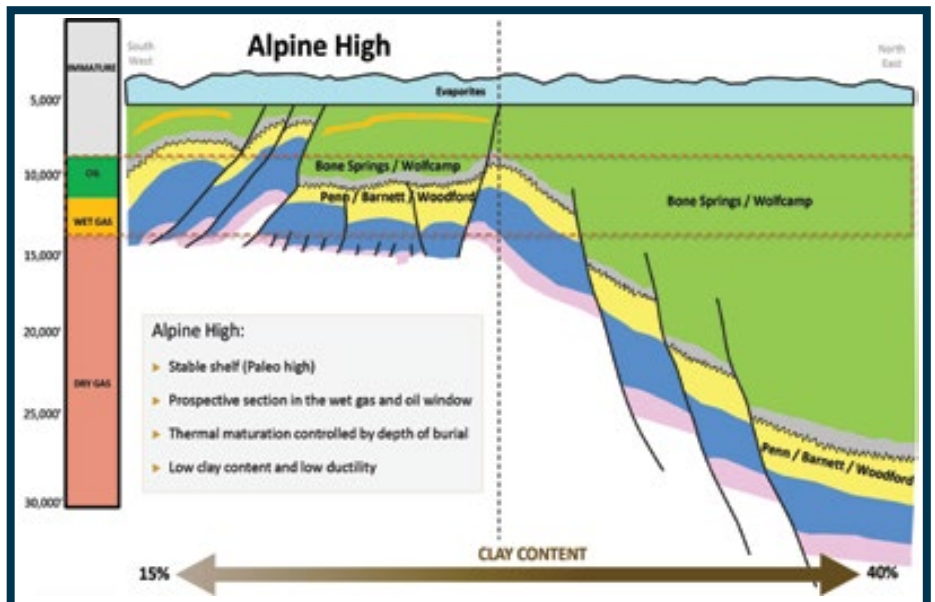
Spectrum





Graphics courtesy of Apache.

Apache Announces Huge Discovery in Permian

By LOUISE S. DURHAM, EXPLORER Correspondent

Good news in the oil and gas industry comes in dribs and drabs during this continuing, yet slightly improving downtime.

The dearth of upbeat happenings no doubt added to the excitement when Apache Corp. announced in early September that it had made a major oil discovery in the Delaware Basin, a sub-basin in the western portion of the famed oil-rich Permian Basin, which covers 86,000 square miles primarily in Texas.

Apache reported that the new play, dubbed Alpine High, is the result of two years of extensive geological and geophysical effort, methodical acreage accumulation and strategic testing and delineation drilling. The locale occurs in the southern part of the Delaware Basin, principally in Reeves County, Texas.

"While other companies have focused on acquisitions during the downturn, we took a contrarian approach and focused on organic growth opportunities," said Apache CEO and President John J. Christmann IV.

"These efforts have resulted in the identification of an immense resource that we believe will deliver significant value for our shareholders for many years," he emphasized.

The company's effort to acquire mineral rights ultimately led to an assemblage of 307,000 contiguous acres at an average cost of $1,300 per acre. In contrast, current Permian prices can reach as much as $30,000 owing to the latest onslaught of speculative fever.

Estimated hydrocarbons in place on Apache's acreage tally 75 trillion cubic feet of rich gas, or more than 1,300 BTUs, and three billion barrels of oil in a couple of zones alone.

In fact, Apache estimates that the field in its entirety could hold the oil and gas equivalent of as much as 8.1 billion barrels.

This specific locale in the Delaware Basin has long been overlooked for the most part with the belief that its clay-rich makeup would make it ill suited for hydraulic fracturing.

Permian Basin

The Permian Basin overall has been attracting innumerable oil finders since the original commercial oil well in the Basin was reportedly completed in 1921. This marked the discovery of Westbrook, the area's first

See **History**, page 8

still jamming

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SIGs
from page 4

"The outreach potential is unlimited and the networking potential is huge," Stefanic added.

The YP SIG was followed soon after by other standing committees, while others took advantage of the newly afforded flexibility and autonomy to form other SIGs and TIGs without prior committees.

Examples of some of the more active interest groups are as follow:

- Astrogeology
- CO_2 EOR
- Creativity in the Exploration Process
- Decision Analysis for G&G Development
- Water Issues
- Cuba
- Data Mining
- Deepwater and Shelf Gulf of Mexico
- Petroleum Economics/Reserves
- Reservoir Revitalization
- Drilling Issues
- Fracture Characterization
- Shale Plays
- Triggered and Induced Seismicity

Nash said there are several new TIGs and SIGs in the works, some of which are close to inception, while others are still crystalizing as ideas.

"Some of the TIGs are still at the conceptual level, with a topic and focus and leaders – AAPG helps the organizers achieve outcomes," she explained. "For example, two or three TIGs may come together to support a Geosciences Technology Workshop (GTW) by providing ideas and suggestions for presenters, and AAPG's science directorate supports the efforts by helping locate the latest publications and cutting edge research, and to invite presenters."

"I'm really excited about a new TIG on drones. They are very active," Nash said.

One such activity is a GTW in December in Houston: "New Opportunities with Drones," which will cover technical and legislative advances enabling the use of drones to assist in exploration, environmental compliance, 3-D modeling, vegetation surveys and other applications in the field.

And, Stefanic said the AAPG Professional Women in Earth Sciences (PROWESS) Committee is the next existing group to transition into a SIG.

Improvements In Store

Nash said a comprehensive list of current SIGs and TIGs will eventually be included on the AAPG website with contact information for each interest group.

Given the autonomy and self-determinant nature of the new organizational model, she said each TIG and SIG can maintain a list of members to share with AAPG, in the interest of providing support in communication and planning meetings.

For now, she said organizers are using the LinkedIn Build Your Own Business Opportunity group for initial communication, with 509 members currently in the group.

If anyone is interested in forming a TIG or SIG, contact Nash at SNash@aapg.org.

History
from page 6

large oil field. Westbrook was followed by a series of high profile discoveries, including the Yates field in 1926 and the Wasson and Slaughter fields in 1937.

Despite its long and prolific history, the Permian has endured its share of bad times when activity languished sufficiently to turn it into a kind of sleeping giant harboring more than 100 billion barrels of oil in place, according to the U.S. Geological Survey.

Annual production from the Basin hit a low point of 850,000 bopd in 2007.

It slowly reversed course to reach 1,350,000 in 2013, the U.S. Energy Information Administration noted.

Persisting Permian

In past years as the industry has developed new and enhanced technologies, including improved horizontal drilling and ever more sophisticated hydraulic fracturing techniques, multiple-stacked pay zones, such as in the Delaware for example, have become readily accessible – and profitable – targets.

When a well completion encompasses two or more formations, resulting in commingled production, the payoff can be significantly better than the usual one-off completion.

The beckoning formations at Alpine High include the popular operator-favorite Bone Spring and the underlying Wolfcamp, along with the Mississippian-age Barnett and the late Devonian/early Mississippian Woodford.

Commingle the Wolfcamp and Bone Spring and you have the Wolfbone.

New technologies and efficiencies will enable Apache to exploit the Alpine High field, which contains between 4,000 and 5,000 feet of stacked pay, according to the company.

Apache reported that as many as 2,000 to 3,000-plus future drilling locations have been identified just in the Woodford and Barnett. These target zones are in the wet gas window and are expected to produce a combo of rich gas and oil.

It's estimated that well costs in development mode for a 4,100-foot lateral will tally about $4 million per well in normally pressured areas and $6 million in over-pressured conditions.

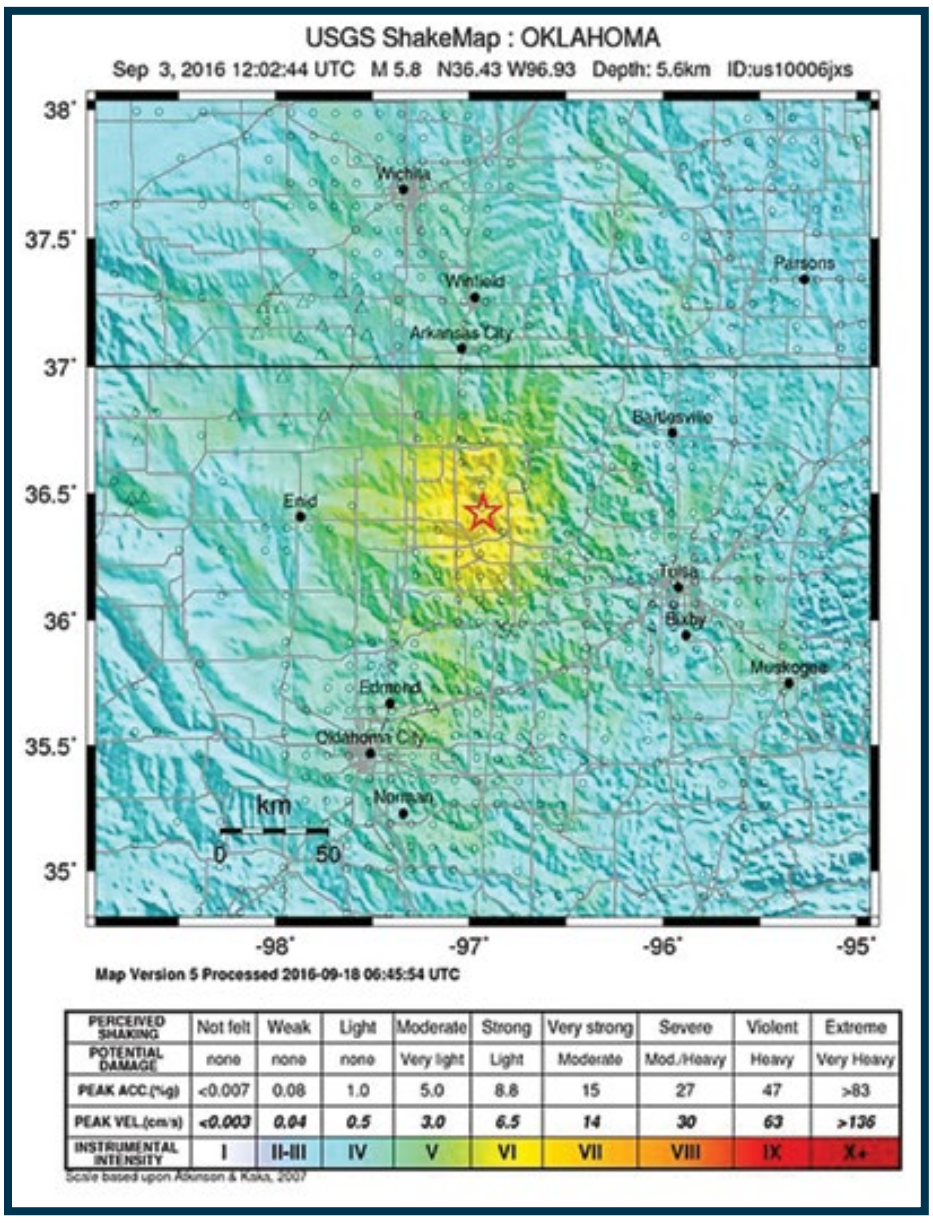
Drillbits already are turning, and today there are 19 wells in the play. Only nine of these are currently producing, and they're churning out limited volumes owing to current infrastructure constraints in the area.

The producers include six wells in the Woodford formation, one in the Barnett and one each in the Wolfcamp and Bone Spring.

Induced seismicity

A Deeper Look At Oklahoma Earthquakes

By KELSY TAYLOR, EXPLORER News Editor



Oklahoma experienced the largest earthquake in the state's history in early September. It carried a 5.8 magnitude and could be felt more than 1,000 miles away.

The earthquake was among a number of others that have occurred in a state that isn't normally associated with them.


BOAK

Jeremy Boak, the director of the Oklahoma Geological Survey, recently organized a presentation for the Tulsa Geological Society to address some of the questions and concerns of earthquakes in the state.

He explained that Oklahoma experienced an average of two earthquakes per year with a magnitude of 3.0 or greater between the 1980s and 2008. In 2015, that number rose to a staggering 907 in the span of just one year.

What he referred to as the "earthquake pulse" began in 2009 and reached a peak in 2015.

"It peaked at about 4.5 per day and is currently at 2.5 per day this year. The rate has been rapidly decreasing, though we still expect to have some pretty substantial earthquakes," he told the EXPLORER.

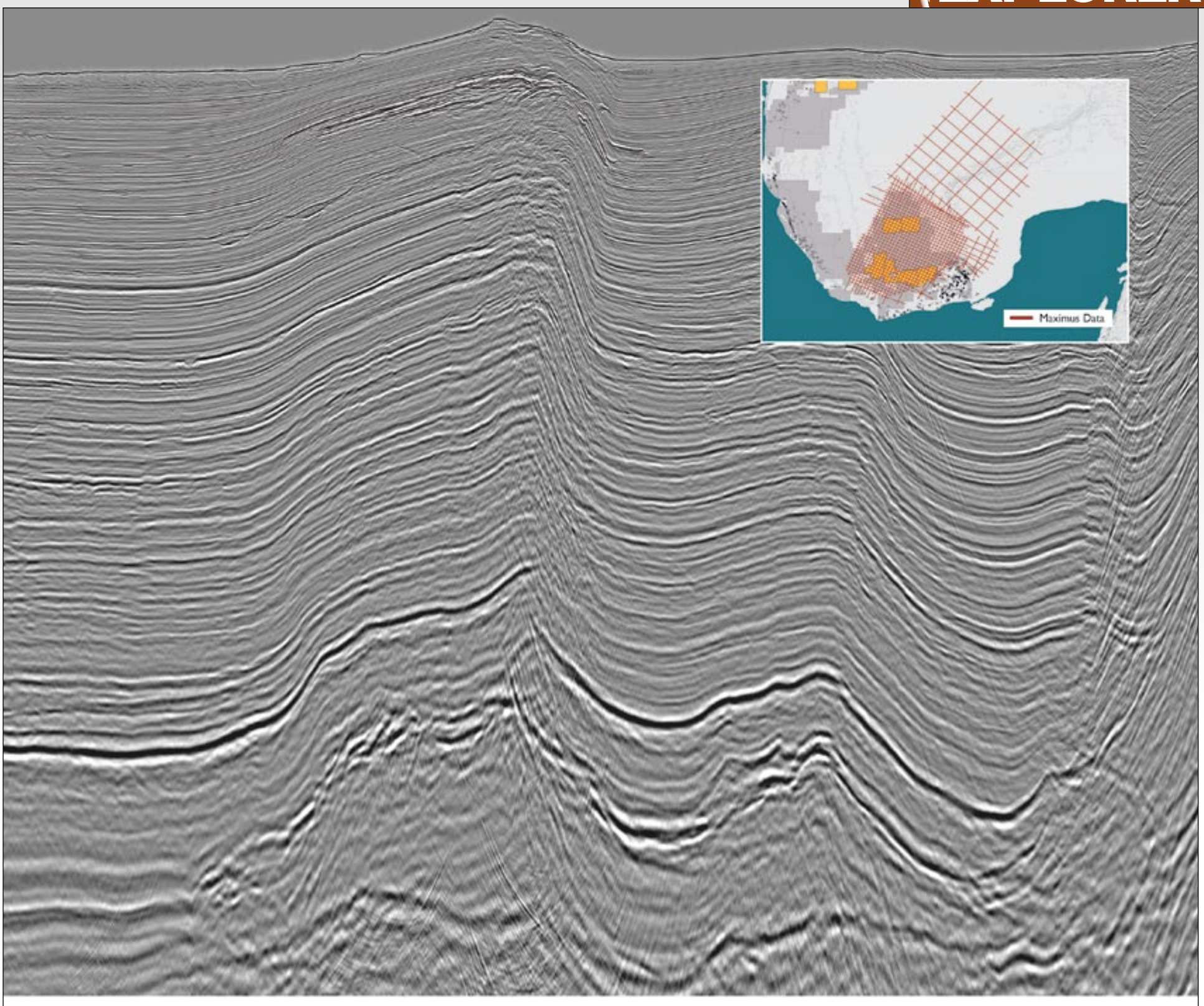
More than 95 percent of the earthquakes have occurred in an area that makes up just 17 percent of the state.

"There are around 14-15 counties that share most of the earthquakes in Oklahoma, they tend to be west of Tulsa and north of Norman. This is the same area where injection sites are located."

Many feel that the earthquakes are being triggered by wastewater, which is created from oil and gas production and then injected deep into the earth. Boak explained that the pressure that's attributed to this increases and decreases, which can cause faults to move.

To address the recent pulse of earthquakes, "The Oklahoma Corporation Commission has taken a series of actions beginning in 2014 and 2015 where larger earthquakes have occurred. This includes stepping down the injection in the area. And it has had a measurable affect."

Following the September earthquake, regulators reduced the volume of wastewater at some of the injection sites and completely shut down others. At the time of publication, this included 67 well sites in more than 1,100 square miles of the state.



Curiosity Drives Wonder About Mars

By BARRY FRIEDMAN, EXPLORER Correspondent

Morrison at NASA's Jet Propulsion Laboratory in Pasadena, Calif., next to a "scarecrow," which is a replica of the Curiosity rover, but without the instrumentation. All images courtesy of NASA.

It took nine months to get there. No traffic.

It was Curiosity, a Mars Science Laboratory rover.

It left Earth in November of 2011 and reached its destination in August of 2012 as part of NASA's Mars Exploration Program. It was designed to assess whether the place ever had an environment able to support small life forms called microbes, which is a fancy way of wondering what, if anything, could live (or could have ever lived) there.

One of the fascinating things about the mission – other than, you know, it being *Mars* – is that Curiosity, which is presently parked in a place called Gale Crater, has to be controlled from Earth.

And that's where Shaunna Morrison comes in. Along with being a University of Arizona Geosciences doctoral candidate, she has participated in the Mars Science Laboratory (MSL) mission as a payload uplink/downlink lead (PUDL) for the chemical and mineralogy X-ray diffraction instrument, CheMin.

This is a big deal, for this is an advanced robot – the most advanced suite of instruments ever sent to Mars – including 17 cameras, radiation detectors, environmental sensors, spectrometers and a diffractometer. Specifically, the CheMin is used to identify minerals within soil and rocks, to see, ultimately, what secrets they hold.

Morrison's work, specifically, includes not only operating the diffractometer, but more importantly, analyzing the data. It is just some of what she will discuss with students and teachers during her lecture, called "Assessing the Red Planet's Habitability using the Rover Curiosity," at the Society of Exploration Geophysicists (SEG) Annual Meeting in Dallas this month as part of the organization's Applied Science Education Program.

"Geoscience studies earth and earth processes – many of the principles and processes on Earth also apply to other rocky planets," she said.

And while there are differences between Earth and Mars, obviously, their similarities – especially in terms of rocks and superficial features, she said, may be quite similar.

"In fact, a lot of the terrain on Mars is analogous to early Earth, allowing us a rare glimpse into what our planet looked like billions of years ago. The Mars rovers allow us to analyze martian surface material as we would in a laboratory – we're able to figure out what rocks and minerals are made of, get important clues about how they were formed and develop much more informed theories on the geologic history of Mars. Orbiters are also crucial in this endeavor as they provide remote sensing data and aerial images."

> **"Getting young people involved in pushing science forward is critical to our future – to the growth and sustainability of our economy and quality of life."**

Inspiring Wonder

As an education tool for high school students, the operation of the CheMin – the video game nature of it all – would be especially fascinating.

It is, but not for the reasons you think.

"Oddly enough, kids don't seem to get excited about it," she said, correcting the characterization, adding that what she does has more to do with coding/programming.

But then she added, smiling, "I don't tell them that."

She doesn't have to, as it turns out, because they seem taken by the enormity and grandeur of it all.

"I find they're more curious about bigger questions: Is there life on other planets? When will we go to Mars? How is Mars different from Earth (rocks, atmosphere, gravity)?"

The wonder of it all, she said, is, in fact, the main appeal.

"I show them the video of the launch and the entry-descent-and-landing and they go wild for that; seeing the heat shield light up as the atmosphere heats it to glowing temperatures, watching the sky crane lower the rover to the surface and then jettison, they love seeing engineering marvels," said Morrison.

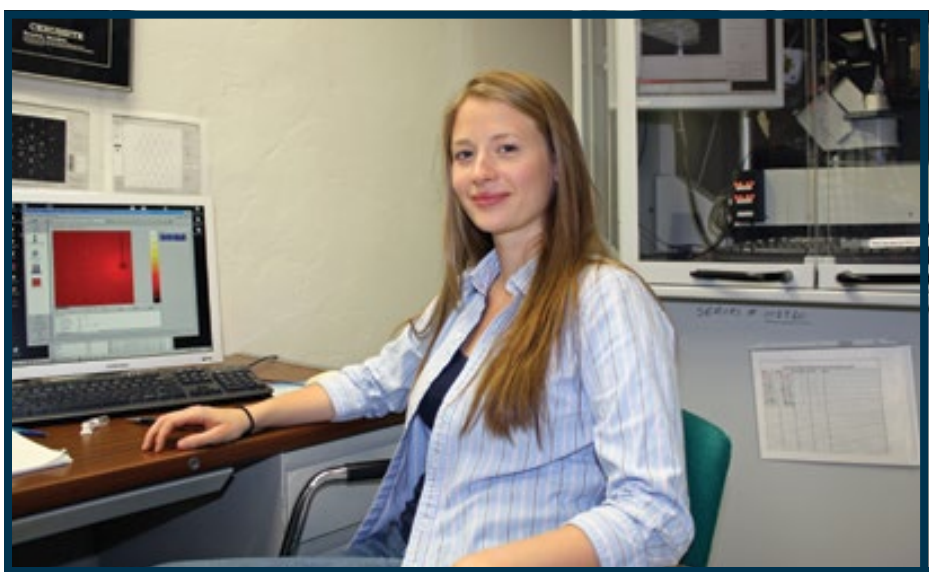
Terrestrial Benefits

While the serious work of Curiosity is a deeper exploration and understanding of the history and possibilities of life on Mars, and while her command of CheMin will no doubt illicit many questions during the lecture, Morrison talked about the ancillary benefits of the mission.

"I hope to get young people excited about STEM [science, technology, engineering and mathematics] and to convey the importance of such scientific endeavors. Science and NASA space

See **Call to Action**, page 16

The similarity between terrestrial and martian minerals allows for CheMin analysis on Mars using Earth minerals as reference.



Shaunna Morrison is a payload uplink/downlink lead for the CheMin X-ray diffraction instrument on the Curiosity rover.

Distinguished Lecture Program Celebrates 75 Years

By KELSY TAYLOR, EXPLORER News Editor

This year marks the 75th anniversary of the Distinguished Lecture Program, one of the oldest and most prestigious programs of AAPG.

The program selects scientific leaders from every corner of petroleum geology to create and share lectures at affiliated societies and universities around the world.

The Association created the program in 1941 and it consisted of four lecturers who visited nine locations during the year. Word began to spread and the program grew to include 23 locations the following year.

Today it reaches more than 650 locations, with plans in place to make it more efficient while maintaining its effectiveness in sharing science to more people than ever before.

The mission of the Distinguished Lecture Program reflects the mission of the Association, which is to foster scientific research, advance the science of geology, promote technology and inspire high professional conduct.

"It brings international geoscience experts to audiences that do not normally have access to such speakers, allowing the best science and technology to be widely disseminated," explained Matthew Jackson, current co-chair of the Distinguished Lecture Program and previous lecturer.

"The lectures inspire students, sow the seeds of new ideas and spread examples of good practice," he added.

Bruce Fouke, 2014-15 AAPG Asia Pacific Distinguished Lecturer, is given a traditional welcome by the University of Petroleum and Energy Studies (UPES) AAPG Student Chapter committee members.

The Perks of Lecturing

And, the lecturers find it to be as rewarding as the attendees do.

Jackson said of his Distinguished Lecture tour that he most enjoyed meeting "a wide range of professional and student petroleum geoscientists and was hugely impressed by their enthusiasm and thirst for knowledge."

"I was quizzed, questioned, enjoyed long and fruitful discussions, and made new contacts that have persisted to this day. I learned as much as I educated others," he added.

Jackson said he also had the opportunity to visit a number of places he might have otherwise missed.

"Wherever I went, I was generously entertained. Having thoroughly enjoyed serving as a Distinguished Lecturer, it is a pleasure to now be involved in selecting each new generation of lecturers," he said.

Becoming a Distinguished Lecturer

The lecturers are nominated and then selected by vote each year by the Distinguished Lecture Committee. The main qualifications for prospective lecturers are that they are leaders in their discipline, capable of delivering entertaining and informative lectures and are worthy ambassadors of AAPG.

Current lecturers include Stephen Begg, Timothy Collett, Thomas Dunn, Kitty Millliken, Per Kent Pedersen, Paul Wagner, Peter Rose and Stephen Constable. A full list of their lecture titles are available on the program's website, which is accessible by clicking "Career" at the top of the AAPG homepage.

While all of the speakers are impressive, Kitty Milliken is touring less than two years after receiving the Robert Berg Outstanding Research Award and the Pratt Award, and Timothy Collett carries celebrity status as an expert in geothermal topics.

Popular requests for the lecturers include Thomas Dunn's "The Value of Looking at Rocks in the Era of Advanced Instrumentation and Computer Modeling" and Stephen Begg's "Eliciting Expert Opinions and Uncertainty Assessments for Decision Making."

The Foundation

The AAPG Foundation has been an important part of the Distinguished Lecture Program since 1985. The Foundation established five named funds

See **Outreach**, page 16

AAPG Education Upcoming Education Events 2016

AAPG HEDBERG RESEARCH CONFERENCE CENTER

Mudstone Diagenesis: Implications for Exploration and Development of Unconventional Reservoirs

16-19 October 2016 | Santa Fe, New Mexico

The purpose of this conference is to foster the free exchange of new ideas among leading experts from industry, academia and government on the controls and impacts of inorganic and organic diagenesis on mudstone hydrocarbon generation, reservoir properties and seal quality.

Until recently, most researchers investigating shales concentrated their research efforts towards understanding: (a) hydrocarbon generation and expulsion, (b) seal capacity and (c) overpressure generation. Most data used to support these investigations were derived from organic geochemistry, relatively low magnification optical petrography and bulk rock characterizations. Notably lacking from these studies is the characterization and evaluation of the potential impact of mudstone diagenesis.

New analytical techniques in scanning electron microscopy (SEM) have allowed the investigation of mudstone properties down to the nanometer scale. New SEM observations of mudstone micro-texture have revealed the presence of authigenic cements, and have captured various stages of the transformation of organic matter during petroleum generation. An improved understanding of mudstone organic and inorganic diagenesis is required to advance the ability to better predict shale reservoir quality and heterogeneity.

GEOSCIENCES TECHNOLOGY WORKSHOP

Making Money with Mature Fields - Geosciences Technology Workshop

5-6 October 2016 | Houston, Texas

The goal of this workshop is to review mature fields and to identify the amount and nature of oil that can be recovered, and to evaluate competing strategies for economically producing the remaining reserves. In addition to looking closely at fields, we will review new and improved technologies that may help revitalize reservoirs and overcome problems such as low pressure, paraffin, corrosion and more. We will identify companies willing to offer a "no money down" approach, or other forms of innovative financing. In addition to reviewing the technology, we will review case studies.

Themes

- Mature fields: examples and profiles
- Typical issues resulting in oil left behind
- EOR
- New technologies and techniques
- Is there funding? Where? How? Who?
- Reality checks: water, environmental issues, infrastructure
- Opportunities and economies of scale: how to make the economics really work

New Opportunities with Drones: New Needs, FAA Rule Changes, New Technologies

1-2 December 2016 | Houston, Texas

Commercial opportunities for drones are headed for explosive growth thanks to new technology and regulations (Rule 107) which are removing many barriers to entry and are expanding their applications. Drones are used in the oil and gas industry from upstream to downstream, and in many other industries.

But, how do you get started? Or, if you have commercial drone/Unmanned Aerial Systems (UAS) operations, how do you expand your business? Welcome to a workshop in which we will bring together experts, equipment providers, robotics experts, and others knowledgeable in a wide range of commercial drone usage, which includes monitoring in the oil industry, digital outcrop surveying, safety and security monitoring, utility inspection, real estate, agriculture, construction, environmental protection, and more.

SHORT COURSES

Carbonate Depositional Systems

3-4 October 2016 | Houston, Texas

This course will alternate between lectures and practical exercises involving cores, logs and seismic data.

The course starts with an introductory lecture that summarizes key differences between carbonate and siliciclastic depositional systems, followed by a review of the Dunham classification of carbonate rocks and grain types. An exercise involving outcrop samples will allow participants to describe samples and relate them to depositional environments. The second lecture is on carbonate depositional environments, and it will systematically examine modern environments, outcrop equivalents and subsurface reservoir examples of each environment. An exercise involving cores and logs will illustrate ramp depositional environments and their effect on reservoir architecture during "greenhouse" times.

Carbonate sequence stratigraphy will be discussed in theory and practice. A core-log-seismic exercise will show how predictable variations in reservoir development occur during ice-house cycles on a shelf and isolated platform.

This course will conclude with a discussion summarizing prediction of depositional facies, stratigraphy and reservoir development in a variety of different settings.

The Petroleum Geochemistry Toolkit for Petroleum Exploration and Development

3-4 October 2016 | Houston, Texas

The petroleum geochemist's task is to determine if a regionally extensive source rock is present, if the source rock reached sufficient maturity to generate large volumes of hydrocarbons, what type of hydrocarbons will be generated, timing of peak generation (current or historic), and migration of the generated hydrocarbons (trap access). These petroleum geochemistry elements and processes need to be understood to properly assess risk and high grade play in both conventional and unconventional resource play opportunities.

This course will provide sufficient background to better understand basic principles of petroleum geochemistry, how best to use geochemistry in their exploration or development study area, determine the limitations of geochemical data/interpretation, and types of samples and analysis required to evaluate a basin, region, play or well.

Roles and Responsibilities of a Development Geologist, For Beginners

7 October 2016 | Houston, Texas

This course is intended to help development geologists (and geophysicists) with 0 - 2 years of experience in this role quickly become effective contributors to field development. A workflow, from field mapping and target identification through to well planning, support and post-well evaluation, will be covered, with best practices highlighted. Both drilled wells and workovers will be mentioned. Please note that the "how to" aspects of mapping, log analysis, and other specific geological tasks will not be covered in this course. The team aspects of the development geologist's work and the importance of "people skills" will be emphasized. Some brief ideas on career progression for development geologists will be mentioned. Course contents are applicable to a range of company settings, from large to very small, onshore and offshore.

www.aapg.org/career/training/

Morrison at NASA's Jet Propulsion Laboratory where she practiced maneuvering the rover.

Call to Action
from page 12

programs have benefited society immeasurably through technological advancement and discovery – without it we wouldn't have LEDs, LCDs, satellites and most of our high-technology."

More than just a victory lap, she sees Curiosity as a call to action.

"Getting young people involved in pushing science forward is critical to our future – to the growth and sustainability of our economy and quality of life."

For her, personally, the study of Mars augments the study of Earth, the study of ourselves.

"Mars interests me most because, in many ways, it provides a snapshot of early Earth, allowing us to address questions about our own planet that would be inaccessible otherwise."

It's about being neighborly.

"Being so close, it allows us to compare the differences between our planets and gain more insight into solar system formation," she added.

There's a romantic sense to it all as well, and Morrison believes the intrigue comes from the fact that because Mars is our closest neighboring planet, it may some day be approachable.

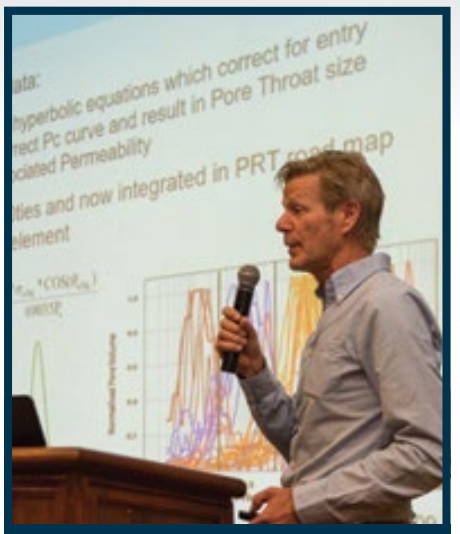
"We could have a chance at visiting and possibly inhabiting."

There is something else, too.

"I think big science and lofty goals drive a society forward: it gives us something to work for, something to unite upon and something to dream about."

It is, as it's always been, needed.

"Nothing creates peace, prosperity and advancement like a common goal beyond our day-to-day troubles."



Jeroen Kenter, a previous Distinguished Lecturer, speaks during one of his tours with the program.

Outreach
from page 14

in honor of past lecturers, which are contributed to thanks to the generosity of their family, friends and colleagues.

The funds are: the Alan P. Bennison Distinguished Lecture Fund, Merrill Haas-Wallace Pratt Distinguished Lecture Fund, Dean A. McGee Distinguished Lecture Fund, Roy M. Huffington Distinguished Lecture Fund, and J. Ben Carsey Distinguished Lecture Fund.

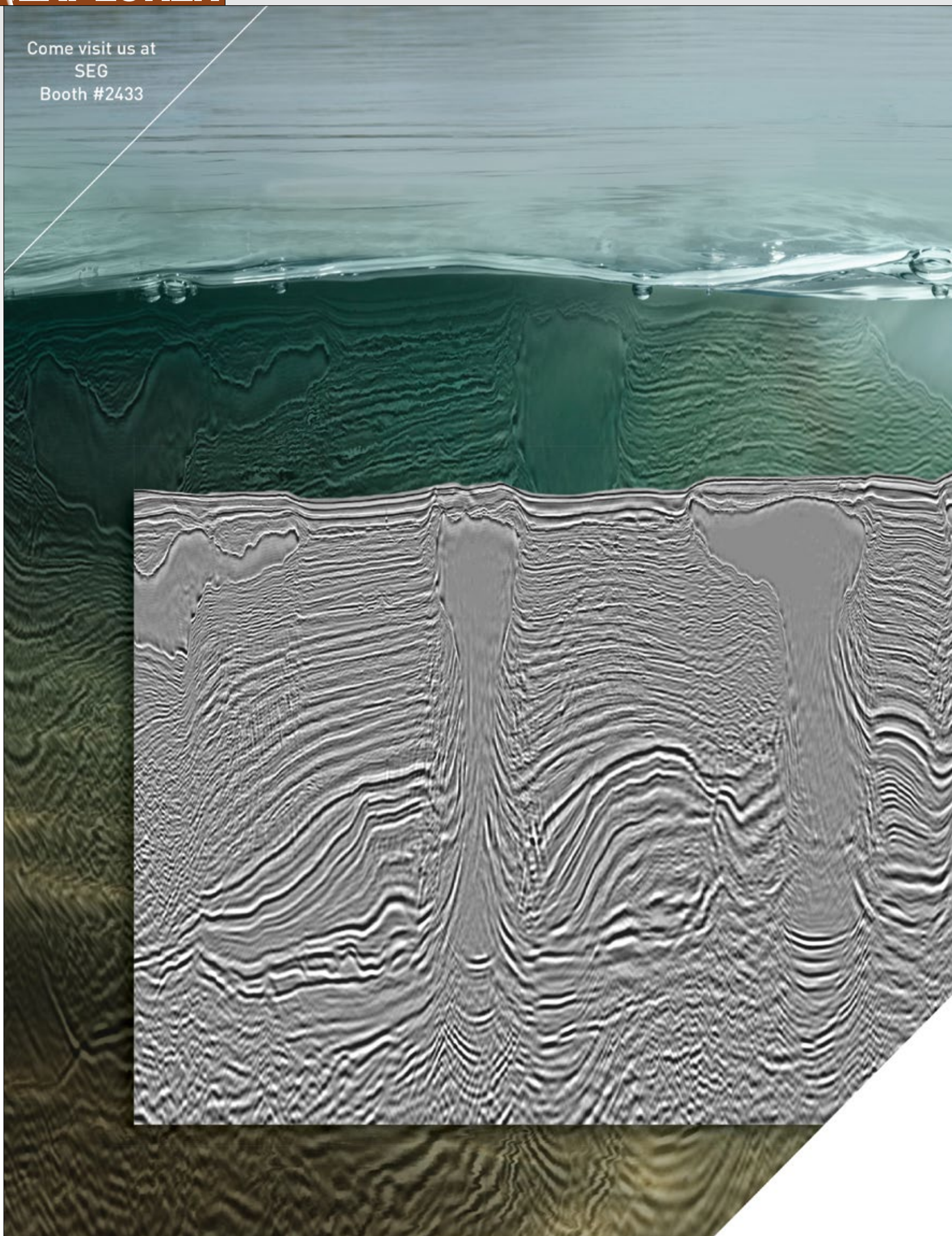
The Foundation has been the primary funder for the program, providing over $4 million since it's involvement.

New Ways to Reach Out

This year, the program will include a new way to reach even more people around the world. Selected lectures will be recorded and posted on the program's website and will be easily accessible to anyone who would like to view them.

"Whilst a recorded lecture can never entirely replace the immediacy of a presentation in person, and not all lectures may be suitable for dissemination in this way, we recognized that recorded lectures are still a very valuable route to increase the number of petroleum geoscientists across the world who can benefit from the program," Jackson explained.

To learn more about the Distinguished Lecture Program, visit http://aapg.to/j4e9d. For information about establishing a named fund for the program, contact the AAPG Foundation at 918-560-2644.


Come visit us at
SEG
Booth #2433

Set your sights.
Gulf of Mexico

Declaration WAZ 3D covers 8,884 km2 (381 OCS blocks) in the Mississippi Canyon, DeSoto Canyon, and Viosca Knoll protraction areas of the Central Gulf of Mexico and was acquired to better image deep structural elements while improving subsalt and salt flank illumination.

Through integration with TGS' underlying orthogonal Justice WAZ 3D survey, Declaration provides broadband multi-azimuth (M-WAZ) data with offsets to 16 km. The data is being processed using the latest TGS imaging technology including Clari-Fi and Orthorhombic migrations. Final data will be available by December 2016.

Let's explore.

TGS

See the energy at **TGS.com**

Historical Highlights is an ongoing EXPLORER series that celebrates the "eureka" moments of petroleum geology, the rise of key concepts, the discoveries that made a difference, the perseverance and ingenuity of our colleagues – and/or their luck! – through stories that emphasize the anecdotes, the good yarns and the human interest side of our E&P profession. If you have such a story – and who doesn't? – and you'd like to share it with your fellow AAPG Members, contact Hans Krause at historical.highlights@yahoo.com.

The Cuban Oil Boom and the Discovery of Jatibonico Oil Field

By JOHN D. SILVERNAIL

Following the end of the Second World War, there was a great hope that the same oil prospectivity found in Venezuela might also exist in Cuba. Established international companies acquired concessions from the government as quickly as possible and new local companies were being formed every day to compete with them. The government limited the number and size of concessions a company could have, so at least one firm was formed as an umbrella, or an amalgam, of companies and investors, each with one concession. Some of these were public with stock on the market, some were private. Some U.S. drilling contractors also acquired contracts and shipped rigs to the island to get in on the new oil boom.

As I recall, a Cuban who lived in the town of Jatibonico named Echeverria (I can't recall his first name) had noticed oil stains in the limy soil at the surface of a small hill in a sugarcane field east of the town and obtained a concession from the government. He blocked out the concession in rectangular tracts and made a deal with a group of Cuban businessmen (Grupo Jarueca) who owned a small oil refinery in Cabaiguan, Rafinería Cabaiguán (affiliated with Esso). Tracts within the concession were allocated to Grupo Jarueca in a near-checkerboard pattern – or, at least, the best checkerboard pattern one could hope to allocate with rectangular tracts.

Jatibonico is approximately in the center of Cuba (see figure 1). The town is on the extreme western edge of Camagüey province (now Sancti Spiritus province). The principal industry is, or was, the Central Jatibonico sugar refinery.

After the end of the war, the Cuban government bought a National 75 drilling rig to stimulate exploration. Grupo wanted to use the rig but the government required them to get an experienced contractor to run it: enter Kerr-McGee. Formed in the 1930s (which was relatively recent to the period under discussion) by U.S. Sen. Robert Kerr of Oklahoma and Dean McGee, former chief geologist for Phillips Petroleum, Kerr-McGee Oil Industries had mainly been a drilling contractor, making money drilling wells for others and sometimes earning a portion of the operating position as part of its fee. The company was also in the exploration business with geological offices in Oklahoma City, New Orleans, Amarillo and Midland. Kerr-McGee was the operator and drilling contractor on the first producing well in the Gulf of Mexico out of the sight of land in Ship Shoal Block 32 in 1947. The well was drilled from a platform with a converted LST for the tender, and that established its name and bona fides to the outside world.

To satisfy the government, Grupo made a deal with Kerr-McGee to use the National 75 to drill the first well in what would soon become Jatibonico Field. Well No. 1 was drilled on the hill to a depth below 7,000 feet. Buster Golding was the tool pusher and, I suspect, the drillers and a few other rig hands on the initial well were also Kerr-McGee employees. Kerr-McGee was strictly the drilling contractor on the first well; however, some geologists who worked for a major oil company in Havana sat the well for Grupo.

The stratigraphic section for the initial well consisted of an upper pale green marly shale and then, at about 1,100 feet, a green and black series of volcanic rocks or tuffs of Cretaceous age (figure 2). The geologists told their company the well was a dry hole. When it reached total depth, casing was run and the well was tested in a number of zones in the volcanics chosen by a consultant for Grupo. Those zones were non-productive, so Buster was directed to perforate a zone at about 1,100 feet at the top of the volcanics where there had been a good show of oil on the pits when the well was being drilled.

As they say, "the rest is history."

After the well had been tested (and this is my recollection of what I was told by Buster), the manager of the company that had provided the geologists brought his entire staff of geologists to the rig. He asked Buster to open the well to flow to the pits. He then said (according to Buster), "Gentlemen, that is oil – spelled O-I-L. Get to know what it looks like. That is what you are looking for."

I omit the name of the company deliberately.

Figure 1. Location of the towns of Jatibonico and Sancti Spiritus. Former Las Villas and Camagüey provinces are included within the red border.


SILVERNAIL

AAPG Life Member John D. Silvernail started his more than 60 year career working on a seismic crew in South Dakota for Kerr-McGee. He then became an independent and consulting geologist primarily in South Louisiana and adjacent offshore areas. He has worked for a number of small companies and done consulting work for individual clients as well as major multinationals. In addition to Cuba, Silvernail worked in The Netherlands and Ras-al-Khaima, United Arab Emirates. He currently resides in Shreveport, La.

Arrival in Cuba

Kerr-McGee took over operations for the subsequent wells, although the official name on the wells was still Grupo Jarueca. Wells No. 2 and 3 were also drilled before I became involved; Kerr-McGee sent a geologist from Midland, Texas, to sit them. Both were sited short distances from Well No. 1., which turned out to be the structurally highest well on the top of the volcanics in the field (figure 2). I was sent to Cuba at the beginning of Well 4, and I think I was selected because I was young, single, knew well-site work and had roughnecking experience.

So, off I went in the fall of 1954, speaking no Spanish and never having been out of the country. Buster was my guide in getting to Jatibonico for the first time.

Buster and I, along with the production people sent to handle problems, lived in a house on the eastern edge of Jatibonico. The house was constructed of wood, had a high ceiling – 15 or more feet high – and was divided into rooms by walls approximately eight feet tall; there was sight-privacy but not sound-privacy. The building included a kitchen and eating area, a bathroom and a few small bedrooms. There was electricity, a telephone and running water – in other words, all the comforts of home. The porch was wide enough for me to park a war-surplus Jeep owned by Rafineria Cabaiguán under cover so it didn't block the road. We employed a local woman who cooked and kept the place clean. One day she was furious with me because she wanted a mop bucket and I didn't understand the word "cubo." I finally caught on and bought her one. Additionally, I was elected to buy the meat because I was the only one who wasn't bothered by the open-air meat market.

Kerr-McGee, or perhaps Grupo, eventually obtained a work-over rig designed to pull and lay down single joints of tubing. Buster had fitted it out with a monkey board so the drill pipe could be racked vertically. The rig probably had been used for Wells 2 and 3 but was definitely used for No. 4 and subsequent wells. When I arrived, the National 75 was still stacked at the location of Well No. 1. The rig hands were all Cuban and they taught me the Spanish I needed to know at the wellsite. Our main contact with Grupo for the operations was a man named Bill King who operated Rafineria Cabaiguán. Bill had been in the U.S. Army Air Forces during the war; I believe he had been smart enough to marry the daughter of the local governor. He complained to me that before we showed up he was getting rusty in English but after dealing with us his Spanish was going bad.

A company named Cuban-Canadian Oil (CC) made a deal for other tracts on the concession some time after the discovery well had been completed. I think it was in early 1955 when CC brought in a rig and crews from Pennsylvania. The equipment was shipped on rail cars delivered to Jatibonico on the main railroad down the center of the island (figure 1). At that time there was a rail-ferry service between the United States and Cuba. Once in town, the cars were moved to a track used by the Central Jatibonico sugar refinery that ran out through the cane fields. The refinery's locomotive was an old 10-wheeler type built about 1910; it didn't have much pulling power so the wheels would slip before the load would start to move. The equipment was unloaded near CC's first drilling site and I watched some of the unloading.

Cuban-Canadian's people were not good about letting us know what they were doing, and one especially egregious example was when CC staked and started drilling a well on Grupo's main producing block. There was a real stink about that when Kerr-McGee formally notified CC that it was drilling on our tract; one result, I was later told, was that Cuban President Fulgencio Batista said the problem must be settled immediately or all of Kerr-McGee's people would be thrown out of the country in 24 hours. The dispute was quickly settled with CC getting a small portion of our block around its well.

Field Operations

We used the surveyor from the sugar refinery to stake the wells. I would give him the location in feet from a nearby well and he then converted the distances to meters (he taught me the magic number of .3048) and hacked a path through the cane to the location. He also provided the ground-level elevations of the drill sites. We measured the well depths in feet; the production was found at depths between approximately 1,100 and 1,400 feet. The oil was heavy, about 12 degrees API gravity and the produced water was fresh. There wasn't much difference in specific gravity between the two so we had difficulty separating them during production. Eventually we constructed a tank battery and a heater-treater close to the location of Well 1. The heater-treater was used to separate the oil and water and, after some experimenting by a Kerr-McGee employee from Oklahoma with production experience, an additive was found that would cause the oil and water to separate when run through the heater-treater. The oil was sold to Esso and trucked to Havana where Esso sold it as road sealant, as there was not enough volume to warrant refining.

We used Halliburton for logging and completions. The logging truck was based in Sancti Spiritus, a nearby town west of Jatibonico situated in Las Villas province. I think Halliburton sent it to Cuba with the expectation that, if the equipment were available, the company would get the business. The electric log was the only log available, and I don't remember if there was the equivalent of a micro-log. Perforations were made using short, sharp steel bullets shot out of barrels screwed into a long tool that looked like a sidewall

Continued on next page

Continued from previous page

core device. Both the logging engineer and the cementer were Americans and lived in Sancti Spiritus, but the logging truck operator was a Cuban named Nick Lopez. I understand that after Castro took over, Nick became an engineer for Halliburton and, I believe, was based in Argentina.

I was in Cuba for several wells between November 1954 and May 1955 when the drilling was stopped for the rainy season. On the way back I flew into New Orleans and in the terminal the cacophony of people speaking English bewildered me as I had become so accustomed to hearing Spanish. During that summer, I was the spare geologist and was loaned to the Amarillo office to sit wells in the Oklahoma panhandle. After that assignment I asked what the company planned next for me and was told, "New Orleans." My answer was, "At least they have decent coffee." My fate was sealed, partially because I had learned to really enjoy the dark-roast, almost syrupy Cuban coffee.

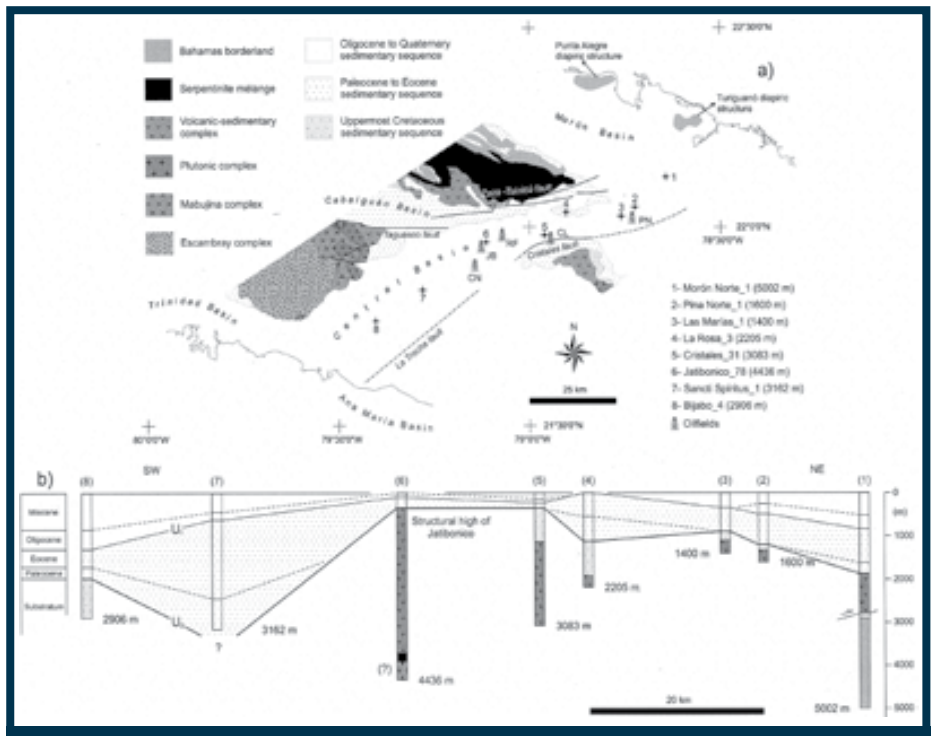


Figure 2. SW-NE cross-section through Jatibonico Field (structural high), within the Central Basin of the La Trocha Fault Zone (from Cruz-Orosa et al., 2012).

End of the Line

In early September 1955, I transferred to Kerr-McGee's office in New Orleans and, in addition to my normal duties in South Louisiana, handled the Cuban wells during the drilling season of 1955 to 1956, commuting for each well. I would leave New Orleans when a well spudded, fly to Havana, then to Santa Clara and then take the bus to Jatibonico. I reversed the route to get back to New Orleans. On at least one occasion, I took a load of pump parts down with me as personal baggage and got through customs with no problem by simply telling the customs man what they were. There was no duty for drilling equipment going into Cuba because the government was encouraging exploration. After I arrived in either Cuba or New Orleans it usually took about a week or so for the food at either end to start tasting good. Fortunately, I had learned enough Spanish to be able to spell my name over the telephone when I made an airline reservation to the States and have it spelled correctly on my ticket.

Cuban-Canadian drilled one well some distance west of the field, though I don't remember exactly where in relation to the town of Jatibonico. The test penetrated a sand above the volcanics that were encountered, but much deeper than in the field, and it was the first real sand penetrated near the field. Cuban-Canadian was going to test the sand through casing so I sat around at the well site that night while the zone was being perforated and tested with a consulting geologist I had never met before. He had bought a pineapple, and pared it, so we ate it while we visited. I enjoyed listening to stories about his early experiences running a core-drill rig in California. His name was Cam Sproule (namesake of the AAPG J.C. "Cam" Sproule Memorial Award) and I didn't know who he was at the time (so much for being young and green).

Unfortunately, the zone tested salt water.

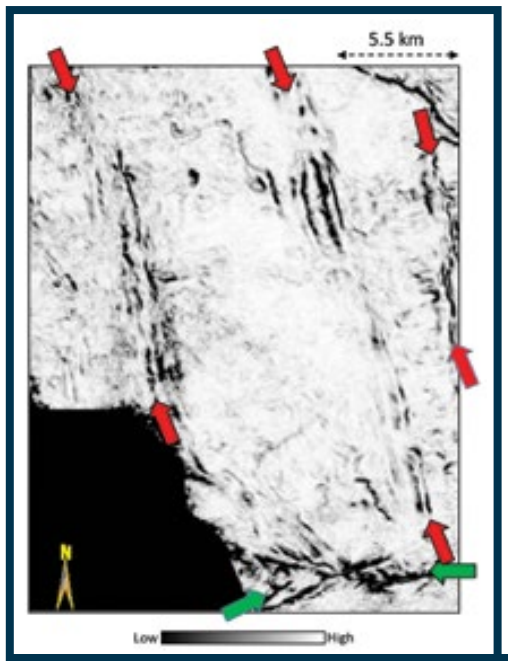
Kerr-McGee had to stop drilling in the field at the end of May 1956 because there were money problems with Grupo. I returned to the States, bringing in as personal baggage a cardboard box full of little paper envelopes containing all the dried cuttings, my sample logs and electric logs from the wells in addition to my luggage. Getting the box of cuttings through the customs agents in New Orleans was an interesting experience, to say the least.

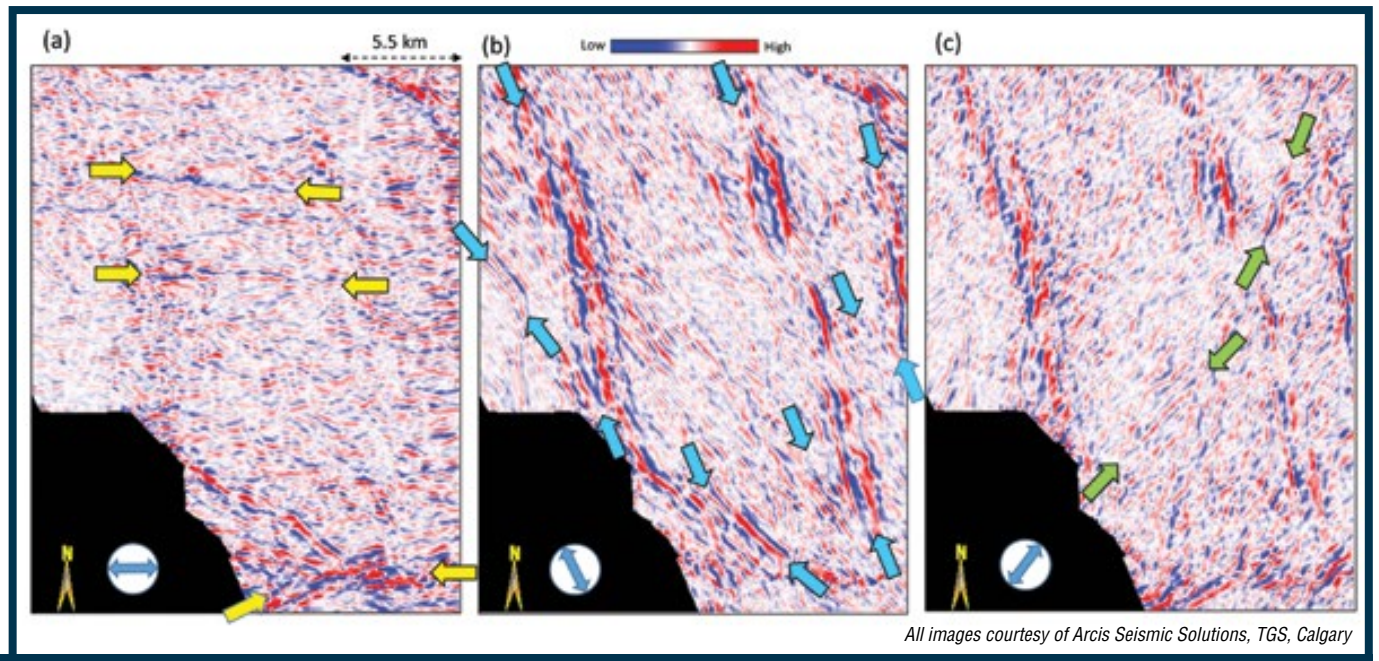
Unfortunately for me and for Kerr-McGee, the revolution started the following year. Foreign and private businesses were taken over by the new government and that was the end of Kerr-McGee's connection with Jatibonico Field, as well as my own.

In the end, the field was discovered by pure luck based on some traces of oil at the surface, and the quick thinking of an enterprising individual who got the concession and persuaded others to drill a test well. As far as I know there was no seismic, or even gravity data used prior to the drilling of Echeverria 1. That initial well tested a zone that had flowed oil during drilling and that is how the field was discovered.

The significance of the Jatibonico discovery was that it was the first new field to be found since the Second World War, and its discovery reignited oil exploration in Cuba. Majors to small private start-up companies snapped up acreage and drilled wells at a rapid pace until 1959, when the revolution was ultimately successful and all the concessions were nationalized.

The Geophysical Corner is a regular column in the EXPLORER, edited by Satinder Chopra, chief geophysicist for Arcis Seismic Solutions, TGS, Calgary, Canada, and a past AAPG-SEG Joint Distinguished Lecturer.





All images courtesy of Arcis Seismic Solutions, TGS, Calgary

Figure 1 (left): Stratal display through a coherence volume at a level close to t=1600 milliseconds. Fault lineaments striking -30 degrees from north are indicated by red arrows. Another lineament striking approximately east-west is indicated by green arrows. Figure 2 (right): Stratal slices through long-wavelength Euler-curvature attribute volumes with strikes of: (a) ±90 degrees, (b) -30 degrees, and (c) +30 degrees as indicated by the insets. In essence, Euler curvature is an azimuthally filtered version of the most-positive and most-negative principal curvatures, accentuating faults and flexures along any desired strike direction. The subtle lineaments seen in (c) may correspond to splay faults or relay ramps controlled by the major faults shown in (b).

Interpreting Fault and Fracture Lineaments with Euler Curvature

By SATINDER CHOPRA and KURT J. MARFURT


SATINDER

> **The level of detail seen on the composite display is much higher than what is seen on the equivalent coherence stratal display.**


MARFURT

Geometric attributes such as coherence and curvature are commonly used for mapping faults, joints and large fractures, or fault damage zones. There are several curvature attributes that are available to a seismic interpreter, but the two most popular attributes are the most-positive and most-negative curvature.

They are not only intuitively easy to understand, but they provide more continuous maps of faults and fractures. There is another attribute, called Euler curvature, which has useful applications when calculated for 3-D seismic volumes. We had described this attribute and some of its applications in our Geophysical Corner article published in the December 2011 issue of the EXPLORER. We revisit it in this issue and describe how an interpreter can determine the fault or fracture lineaments in different orientations in more detail, by putting them together in a 3-D viewer.

Such a display can provide convenient interpretation of the lineaments of interest.

Determining Euler Curvature

Euler curvature is determined from the most-positive and most-negative curvature magnitudes as well as their strikes. Because the reflector dip magnitude and azimuth can vary considerably across a 3-D seismic survey, it is more useful to equally sample azimuths of Euler curvature on a horizontal x-y plane and project the lines onto the local dipping plane of the reflector. In this way, Euler curvature can be calculated in any desired azimuth across a 3-D seismic volume to enhance the definition of specific lineaments. Such enhanced lineaments along specific azimuths can be brought together for interpreting azimuth-dependent structure for convenient interpretation.

We describe here the application of Euler curvature to a 3-D seismic volume from the Montney-Dawson area of northeastern British Columbia, Canada. The data volume displayed is close to 500 square kilometers.

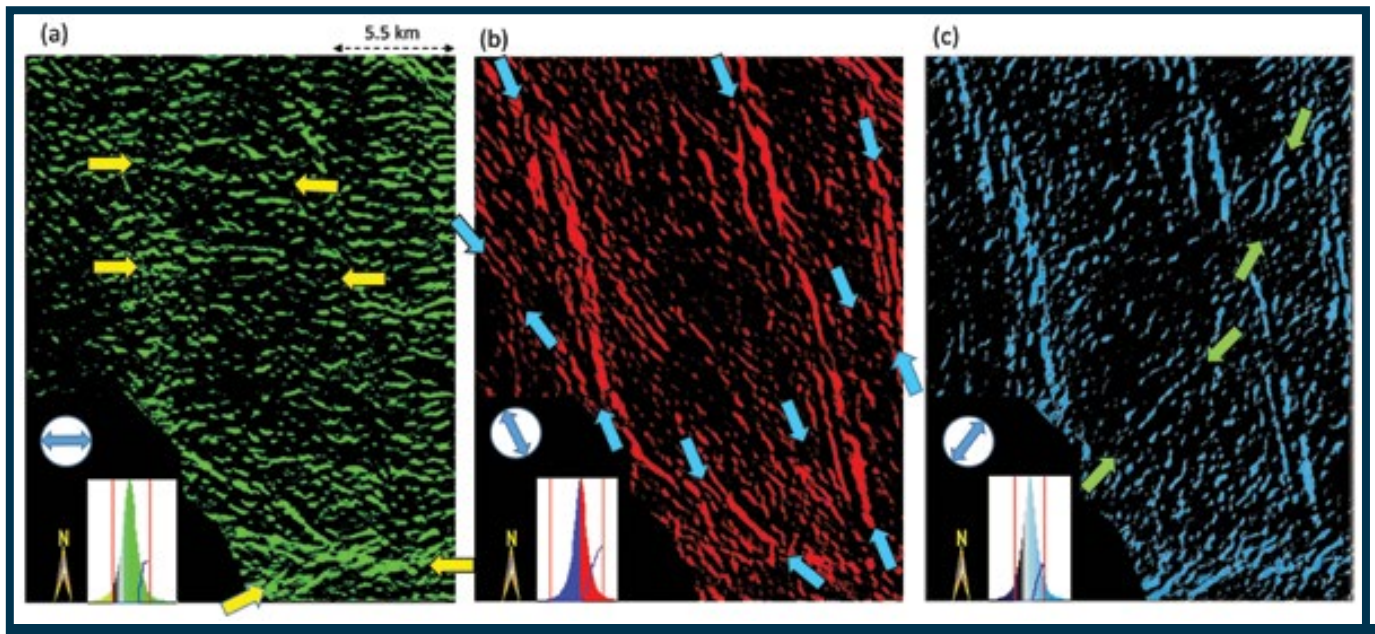
In figure 1, we show a stratal slice through a coherence volume which shows fault lineaments in the NNW-SSE orientation indicated by red arrows. An east-west oriented fault indicated by green arrows is seen at the bottom of the display. These prominent lineaments can easily be seen on the vertical seismic sections where the reflectors exhibit finite offset across the faults. The challenge for an interpreter is to identify and interpret less obvious, more subtle lineaments that may also exist in the zone of interest.

In figure 2, we show stratal slices through three long wavelength Euler curvature attribute volumes corresponding to ±90 degrees, -30 degrees and +30 degrees. Notice how the fine lineaments in the three orientations stand out as indicated by the yellow, blue and green sets of arrows.

In shale resource plays, we might know the present day orientation of the maximum horizontal stress (SH), from image logs or azimuthal anisotropy analysis. If the tectonic history is such that natural cracks and fractures are parallel to these lineaments, the lineaments parallel to the SH orientation might be of particular interest, with areas of anomalously higher degree of curvature being potential sweet spots. Alternatively, we may wish to co-render the three chosen orientations together using an RGB color bar.

We start in figure 3 by plotting each set of lineaments against an R, G or B colorbar, setting the larger positive values to be opaque. Then in figure 4, we co-render

See **RGB**, page 25



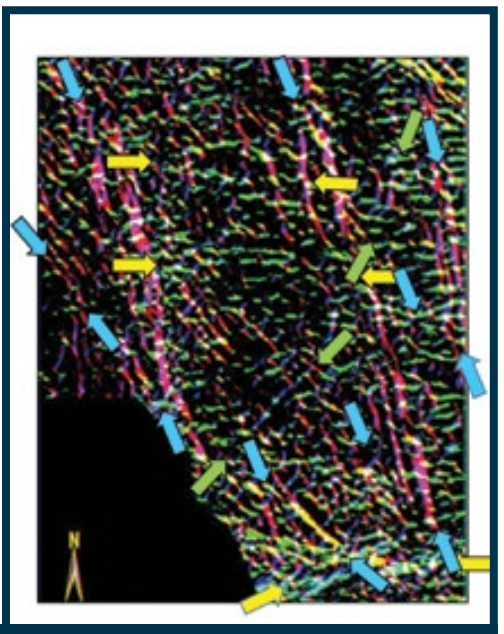


Figure 3 (left): The same stratal slices shown in the previous figure, but now plotted against green, red and blue color bars using opacity to enhance the most positive anticlinal features. Figure 4 (right): Co-rendering the three images of the anticlinal lineaments in figure 3 together using a modern 3-D viewer and thus generating a composite display amenable to extracting more detailed interaction between the three hypothesized fault sets.

New Tech: Pocket-sized Gravimetry

By KEN MILAM, EXPLORER Correspondent

In the "less is more" department, researchers at the University of Glasgow in Scotland are developing a device that could potentially revolutionize the field of gravity sensing.

Borrowing from smart phone technology, they have developed and demonstrated a fingernail-size gravimeter.

Richard Middlemiss and several colleagues with the university's Institute for Gravitational Research published results of their research in the journal Nature.

"Gravimeters have been around for decades. The problem with them is they generally cost hundreds of thousands of pounds, or dollars, and they weigh 10 kilograms, 20 kilograms, up to hundreds of kilograms," he said.

Middlemiss said the device could be produced much more economically than current gravimeters.

"What we've done is we've taken the technology that's used in a mobile phone – that's the thing that turns the screen sideways when you tilt it (an accelerometer). ... We've made this thing massively more sensitive and massively more stable and we're now able to use that as a gravimeter," he added.

The new gravimeter created by researchers at the University of Glasgow in Scotland's Institute for Gravitational Research uses the same type of micro-electromechanical system (MEMS) used in smartphones' internal accelerometers. Image courtesy of the University of Glasgow.

FAGON

> "There are lots of applications, not just in oil and gas but in greater geophysics as well."

HAMMOND

Application in the Field

AAPG Member Joseph P. Fagan Jr., president of Centennial Geoscience Inc. in Littleton, Colo., agreed that if the device can be fully developed and mass-produced commercially, it could be an important advancement for the field and for energy exploration.

"We're going to have to watch and see how it develops. It has a lot of promise and it really is exciting," Fagan said. "If it can be effectively mass-produced, it would reduce overall costs. You could place gravimeters in the field for real-time or ongoing monitoring," he said.

"To me, acquiring gravity and magnetic data is the logical first step to help design an exploration program," Fagan said.

He said gravimetry, especially airborne, has been advancing in quality and cost-effectiveness, and a further reduction in cost and improvement in convenience would go a long way.

"If it (gravimetry) helps and prevents you from shooting a couple square miles (of seismic) you didn't need, it has probably already paid for itself," he said.

He said airborne geophysical methods have extra value when land access is a problem.

"Since these data are all acquired remotely, there are no feet on the ground," he said.

How It Works

The team's new device, which they have named "Wee-g," uses the same cheap, mass-producible micro-electromechanical systems (MEMS) used in smartphones' internal accelerometers. While the MEMS technology in phones uses relatively stiff and insensitive springs to maintain the orientation of the screen relative to the Earth, Wee-g employs a silicon spring about a tenth of the thickness of a human hair. This allows Wee-g's 12 millimeter-square sensor to detect very small changes in gravity, according to the university release.

The team used the device to measure the Earth tides from the basement of the university's Kelvin building. Earth tides are a subtle effect from the moon and the sun exerted on the Earth's crust. The pull of the sun and the moon displace the crust, creating a very slight expansion and contraction of the planet of around 40

See **Gravimetry**, page 25

Using Image Data for Mineralogy

By LOUISE S. DURHAM, EXPLORER Correspondent

Hydrocarbon production from shale reservoirs continues to fly in the face of the early naysayers who predicted that these rocks would spit out considerable volumes up front, only to become dormant immediately thereafter.

Even amid the ongoing challenging price environment, shale production numbers are sufficient to encourage a relatively high level of new leasing activity.

Much of this active scene can be attributed both to all-new technology and successful tinkering with what's been tried before.

Still, it's no slam-dunk.

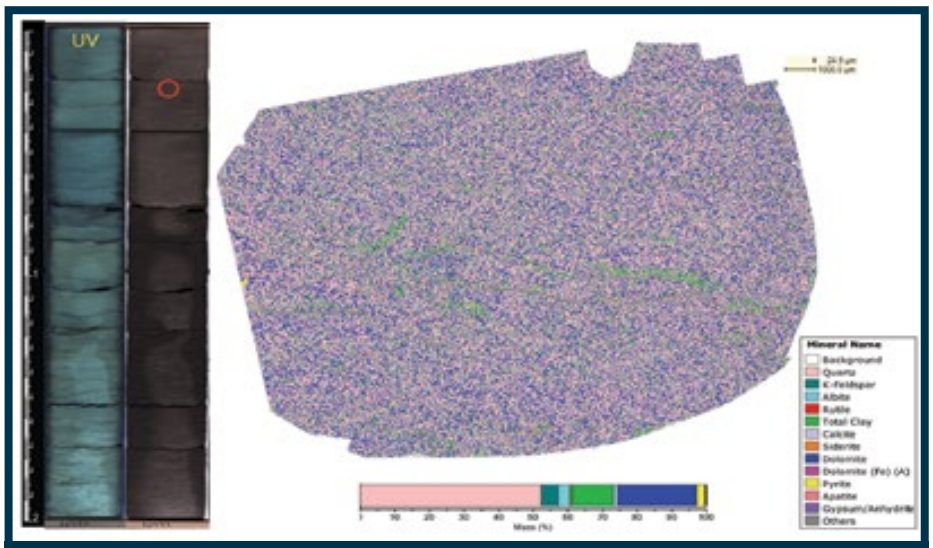
Conventional reservoirs harbor relatively sizeable pores with good permeability, whereas unconventional accumulations demand a great deal of specialized coaxing to move through the limited exit avenues indigenous to tight rocks.

Understanding the complex makeup of these reservoirs is essential, and it requires considerable evaluation and time.

Independent Whiting Petroleum is doing its part to stay on top of the challenge. The company assembled its own rock laboratory that uses the latest techniques to yield an enhanced understanding of pore systems and oil movement through these tight rocks.

It's all about data and interpretations generated using imaging technology. In fact, certain petrographic and petrophysical data of unconventional pore systems can't be acquired any other way, according to AAPG Member Lyn Canter, rock lab manager at Whiting.

She noted that these techniques have enabled improved drilling efficiency, evaluation of reservoir intervals for hydraulic fracture potential and the optimization of horizontal drilling targets in real time.



Core and QemScan images from Middle Bakken pay facies showing detrital quartz and dolomite siltstone to very fine grained sandstone with clay distributed along discontinuous depositional layers. Images courtesy of Whiting Petroleum.

Specialized SEM

In fact, the rock lab team is employing scanning electron microscope (SEM) technology, which has been around for a number of years.

But with a nod to the "everything old is new again" adage, Whiting uses a specialized scope built to help with automated mineralogy, which is a technique designed for the mining industry for assay work more than a decade ago. This automated mineralogy has been ported to sedimentary rocks in the oil and gas industry. Canter noted that other companies also have this capability.

One key aspect of the X-ray detectors onboard the SEM used in Whiting's rock lab is the ability to identify the elements present at a particular spot on the rock samples placed in a sample tray.

"We can set the rate and the size of the sample, so if we need to collect a lot of X-ray spectra, we can," Canter said. "This thing scans the samples and through an algorithm, combines these data into likely mineral occurrences.

"We can set the 25 most common sedimentary minerals we think should be in groups of samples and can analyze for those, so it's quantitative," she noted. "We also receive as a product of this a 2-D false-color mineral map that shows the distribution of all minerals in that sample. That influences how you interpret certain things like wireline logs, facies.

"Also, certain minerals have very different degrees of hardness and density, so you can start to group your minerals into like categories that help you understand how that zone, if it's porous and a target for you, might respond to a certain type of stimulation in completing the well.

"All of that is done with that one machine," Canter emphasized. "We use that particular SEM to help us understand our reservoirs with an emphasis on those kinds of properties we would be collecting."

It's a tedious operation, which requires characterization at the micro- and nano-scales.

If clays are layered, this impedes fracturing breakdown whereas dispersed clays are a different story. So the ability to group a locale into brittle vs. ductile is a big deal.

Spatial Distribution

Canter emphasized that spatial distribution of minerals is key to

See **Properties**, page 27

RGB
from page 22

these three images by simply adding the R, G and B components of the images in figure 3. In this way each lineament is assigned a specific color, while areas of crossing lineaments combine to form intermediate colors using the well understood RGB color model.

This image provides a composite of all the lineament orientations and is very useful in terms of the more detail that it provides for interpretation.

Conclusions

The level of detail seen on the composite display is much higher than what is seen on the equivalent coherence stratal display. We find merit in putting Euler curvature lineaments together in a 3-D viewer for their convenient interpretation.

The next step would be to calibrate these seismic attribute based lineaments with lineaments interpreted from image logs. One challenge for doing this is usually the scarcity of the latter data. We do emphasize the importance of image logs in such confirmatory exercises.

We appreciate the help extended by Thang Ha and Fangyu Li, students at the University of Oklahoma, in fixing the image shown in figure 4.

(Editor's note: Kurt Marfurt is an AAPG Member and professor of geophysics at the University of Oklahoma.)

Event to Address the 'Great Crew Change'

The Knowledge Management Challenge will be held Nov. 16-17 in Abu Dhabi, United Arab Emirates. The event will highlight the best practices and lessons learned in the field of knowledge management.

Due to the imminent "Great Crew Change," in which experienced professionals are expected to retire in large numbers over the next few years, knowledge management is a strong emphasis throughout the industry.

The main concern is that key knowledge could be lost during this change and that young professionals will be challenged to learn and advance faster than they're ready, before they have the opportunity to fully absorb that crucial knowledge and experience.

The event will share current information about knowledge management, how to address the expected challenges, case studies from the region, justification of the impact of initiatives and new technologies that are expected to impact the field in the future.

Leading experts in the field will speak during the event and a forum will be held that will provide the opportunity for discussion to share ideas. Posters are welcome for display during the event and registration is now open at the website below.

For more information about the Knowledge Management Challenge, visit http://aapg.to/yw94l.

Gravimetry
from page 23

centimeters.

"The Earth tides are a well-established phenomenon, which we're able to accurately predict using mathematical models," said Giles Hammond of the university's School of Physics and Astronomy, one of the co-authors of the paper.

"One of the factors which separates gravimeters from simple accelerometers is stability, allowing users to monitor variations in gravity over the course of several days or weeks. We used our Wee-g system to monitor the Earth tides under Glasgow over the course of several days, and our results aligned perfectly with the variations in gravity that the model had predicted," Hammond continued.

"The significance of this is two-fold: firstly, we've shown that a MEMS device can maintain its stability over a long period of time, and secondly, that a device which could easily be built using existing mass-production technology can act as a very accurate gravimeter," Hammond added.

"Wee-g opens up the possibility of making gravity measurement a much more realistic proposition for all kinds of industries," said Middlemiss. "Gravity surveys for geophysical exploration could be carried out with drones instead of planes and networks of MEMS gravimeters could be placed around volcanoes to monitor the intrusion of magma that occurs before an eruption – acting as an early warning system."

The detector, built at the university's James Watt Nanofabrication Centre, is a collaboration between the School of Physics and Astronomy (Institute for Gravitational Research) and the School of Engineering (Electrical and Nanoscale). The work is one of the first research outcomes from QuantIC, the UK's "centre of excellence for research, development and innovation in quantum enhanced imaging," which was established in late 2014.

"What's going on here is we're taking our fundamental core research and we're actually translating it into applications that can be taken up by industry," said Hammond.

"In this particular application, the industries involved might be oil and gas prospecting, defense security or industries interested in environmental monitoring," noted Hammond.

Fagan said he agreed the research is promising.

"There are lots of applications, not just in oil and gas but in greater geophysics as well," he said.

Identifying Facies Using Microseismic Analysis

By DAVID BROWN, EXPLORER Correspondent

Researchers from the University of Calgary found just what they weren't looking for when they monitored microseismic signals from an unconventional resource unit in the Hoadley field in central Alberta.

Their work produced a new advance in reservoir characterization using microseismic data.

Hoadley, discovered in 1977, is a giant gas-condensate field. Its main reservoir lies in the Glauconitic formation of the Lower Cretaceous Upper Mannville group, a shallow-marine and nonmarine clastic wedge.

"We've been collecting our own data on Hoadley and publishing (research papers) on that. In this particular instance it was a tight sand reservoir, maybe more heterogeneous than a shale reservoir," said David Eaton.

Eaton is a professor of geophysics and the Natural Sciences and Engineering Research Council of Canada/Chevron industrial research chair in microseismic system dynamics in the geoscience department at the University of Calgary, and an AAPG associate member.

He was a co-author of the 2016 paper describing the new approach, "Reservoir characterization using microseismic facies analysis integrated with surface seismic attributes," published in Interpretation, the peer-reviewed journal issued jointly by AAPG and the Society of Exploration Geophysicists.

Other authors were Per Pedersen, a petroleum geologist in the department,


RAFIG


McDOUGALL


EASTON


PEDERSEN

and students Aamir Rafiq and Adrienne McDougall.

Seismic Serendipity

It was Rafiq's interest that ultimately led to the new approach.

"What he was really interested in doing was partitioning the reservoir," Eaton explained. "That sort of evolved into what we're calling 'microseismic facies analysis.'"

The university set up its own equipment to monitor multistage hydraulic fracturing treatments at the tight-sands unit in September 2012. Acquisition of continuous passive seismic data continued for more than 10 months during flowback and production.

ConocoPhillips was a sponsor for the project, hoping to learn more about the results of fracturing and production in the unconventional reservoir, Eaton said.

But the researchers got more than the usual amount of seismic input.

"When we were monitoring that, we noticed that we were picking up a big uptick in data. It turned out we were picking up signals from a 3-D seismic survey right on top of us," Eaton said.

And when someone does a 3-D seismic shoot where you have a microseismic monitoring project, you're going to notice.

"We were getting many thousands of detections," Eaton noted.

It turned out to be serendipity. When the researchers developed their theories about microseismic facies analysis, they had the 3-D survey results as another view and a sort of reality check.

"The 3-D seismic was very important to help us validate the concepts," Eaton said.

The researchers came out with a new method of partitioning an unconventional reservoir into distinct facies units, based on their microseismic response.

And enhanced, microseismic-based input to help direct field development, the original target of the research project?

Not so much.

"We saw a lot of interesting phenomena. But we didn't actually see what we were looking for," Eaton said.

The Experiment

The Hoadley Flowback Microseismic Experiment began with four main scientific objectives:

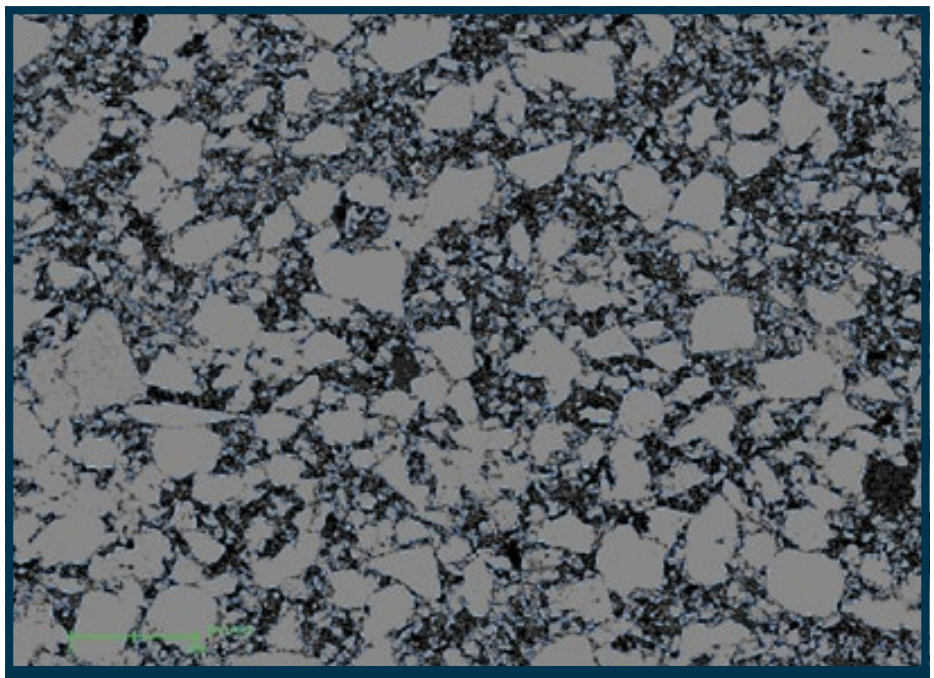
- Undertaking real-time monitoring of an open-hole multistage fracture treatment in the Glauconitic member;
- Performing long-term monitoring of post-frac microseismicity during flow-back and production;
- Developing a geomechanical model for that activity; and
- Integrating the analysis of microseismic data with ancillary studies, including rate-transient analysis and production analysis.

Monitoring equipment for the project consisted of a 12-sensor retrievable array of geophones installed at the end of a multiconductor wireline, in a vertical observation well between two horizontal treatment wells.

In each well, completion included 12 fracturing injection stages. A total of 1,660 microseismic events were recorded and located during the 24-stage treatment, including 259 postpumping events.

Surprisingly, only about half of the microseismic events were oriented in the direction of maximum horizontal stress orientation, or SHmax. The other events were oblique to SHmax and were inferred to represent reactivation of pre-existing fractures.

See **Microseismic**, page 29



Distribution of brittle (light grey) and ductile (dark grey) minerals.

Properties
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understanding mechanical properties and how they vary by zone.

For example, an operator may be evaluating the reservoir potential of a mud rock that has competent grains such as quartz, calcite or feldspars touching in 3-D space. If there is organic porosity in between those grains in terms of how the primary organics are distributed and then thermally matured, the rigid framework preserves the porosity. In contrast, if the grains are not touching, the whole zone would compact.

But a pore is more than a pore.

"If we have a certain pore throat diameter of, say, five nanometers and oil gravity at 30 degrees API, the question is whether that oil will move through those pore throats in the production time you have," Canter said. "Gas and condensate, no problem, and volatile oil possibly, no problem.

"Based on what product you have and the size not just of the pores but the throats, which are really the bottleneck in the whole thing, you have to think of the hydrocarbon molecule types that would be able to move through those throats," she cautioned.

"To QC that early on in a play concept is important because it speaks to deliverability and producibility," she said, "and that's what drives economics.

"We want those answers sooner rather than later when involved in new plays or a new concept."

Success with a recent well in Whiting's Bakken/Three Forks play in the Williston Basin in North Dakota documents the advantages afforded via application of this advanced technology.

"The Middle Bakken is the typical target in the Basin when you're in a new or questionable area," Canter said. "We recently drilled a well near the edge of the thermal maturity of the Bakken shales, so we were flirting with a line between immature, onset of maturity and mature enough to expel hydrocarbons."

A vertical core was acquired and hot-shotted to the imaging lab in Denver for analysis, which was accomplished within days while the rig remained onsite.

The in-house lab results from evaluating the zones for reservoir character, facies and mineralogy convinced Whiting to switch the horizontal target to the Three Forks, thereby expanding the productive area of the play.

"Little did we know until we pulled a core through both formations that we had a facies change that gave us a much more clay-rich Middle Bakken section," Canter noted. "The Three Forks was better behaved in terms of what you expect to see in that position in the Bakken, which is good dolomite intercrystalline porosity."

Expect to hear a great deal more about the use of this ultra-precise imaging equipment in the Williston Basin.

Whiting senior vice-president Mark Williams said recently that the industry is asking about what can be expected of the total resource potential in the Basin.

The company's experts are working on it.

Edith Allison, director of AAPG's Geoscience and Energy Office in Washington, D.C., can be contacted at eallison@aapg.org; or by telephone at 1-202-643-6533.

Science Literacy study

Facts Don't Always Shape Attitudes

By EDITH ALLISON, Geoscience and Energy Policy Office Director

A new report from the National Academy of Sciences (NAS) on how science literacy affects support for science caught my attention.

First, because petroleum geologists are interested in understanding how our science can better explain the risks and benefits of oil and gas exploration and production, as well as counter unsubstantiated claims of environmental harm. Second, the education of the next generation of petroleum and environmental geoscientists depends on government funding of university research.

The need for federal R&D funding is even greater with the recent decline in industry support; however, the American Association for the Advancement of Science reports there has been a more than 30 percent decline in federal financial support for R&D since the late 1970s.

The study is "Science Literacy: Concepts, Contexts, and Consequences" by the Board on Science Education, Division of Behavioral and Social Sciences and Education of the National Academies Committee on Science Literacy and Public Perception of Science. Readers may be interested in reviewing many elements of the report not mentioned here, including recommendations for future research.

The NAS study found a small, positive correlation between science literacy and support for science in general. However, increasing science literacy does not in itself lead to greater support for science. In addition, for controversial topics such as climate change, nanotechnology and GMO, the report found that factors such as values and beliefs strongly affect attitudes about scientific concerns.


ALLISON

> Knowledge does not directly correlate with support, but is moderated by ideology ...

Key Findings

So what is "science literacy"?

The NAS report suggests there may be more definitions than there are scientists. Many definitions include the idea that content knowledge is only part of science literacy. One definition the NAS offers is from the Organisation for Economic Co-operation and Development, Programme for International Student Assessment: "science literacy includes an interest in science and technology, environmental awareness, and valuing scientific approaches to inquiry."

Separate studies by the National Science Board (NSB) find that:

- About 80 percent of surveyed Americans agree that the federal government should fund scientific research, a figure unchanged over several decades.
- About 90 percent of surveyed Americans have confidence in leaders of the scientific community.

Multinational comparisons show that U.S. adults' knowledge of science and support for science are comparable to adults in other economically developed countries.

Science Literacy, Among Other Factors

To help explain why increasing science literacy does not lead to greater support for science, the NAS cited studies showing that knowledge does not directly correlate with support, but is moderated by ideology, such as liberal-conservative political orientation, religiosity, media use or trust in the information providers.

An example applicable to petroleum geologists' interests, although not cited by the NAS, is a March 2016 Gallup poll that shows 51 percent of Americans oppose hydraulic fracturing, up from 40 percent in 2015. This survey ties opinions about hydraulic fracturing to political affiliation, finding that Republicans' support is higher than that of Democrats and independents, although Republican support declined significantly since 2015 – from 66 to 55 percent.

Other studies suggest there are two separate discussions going on in the United States with regard to hydraulic fracturing. A 2014 paper by Charles Davis and Jonathan M. Fisk titled "Energy Abundance or Environmental Worries? Analyzing Public Support for Fracking in the United States" found that Democrats view it as an environmental rather than an energy issue. I notice that the American Petroleum Institute "Vote4Energy" campaign presents hydraulic fracturing as an energy and economic issue, which are values favored by the right.

Continued on next page

Continued from previous page

In addition, research by Gordon Gauchat in 2015, who is one scientist cited by the NAS, found that for politically conservative individuals – who tend to oppose government control over private business – the growing ties between science and regulation since the 1970s has weakened support for government-funded science.

Religious beliefs may also affect scientific attitudes. Many studies show a correlation between conservative religious beliefs and negative perceptions of science.

Confirmation Bias

Another important element many of us notice is that access to information and misinformation has increased with the growth of new electronic media. Social media also help celebrities and other non-experts flood the public with information, misinformation and opinions.

The NAS report looked at health literacy, which is a way to understand science literacy and appreciate why providing additional information seems to not affect attitudes – other factors may affect attitudes and additional knowledge may simply reinforce existing attitudes. The NAS assessment of the relationship between health literacy and behaviors suggests that social norms, personal habits or access to services affect health behavior. We all know people who don't follow their doctor's recommendations, but we expect that just explaining the facts about hydraulic fracturing will change attitudes.

Microseismic

from page 26

"Those monitored events moving back toward the well we interpreted as fracture closures," Eaton noted.

The researchers classified the seismic events into clusters and then computed several microseismic attributes, including azimuth, net seismic moment, length and duration. Based on an interactive clustering approach, 94 percent of the microseismic events were contained within 17 event clusters.

Cluster and attribute analysis then became the basis of facies identification.

Among the set of calculated attributes, incoherence, most-positive curvature and most-negative curvature provided the most clearly interpretable association with the microseismic signals, the researchers found.

"We're still trying to explore the microseismic attributes that could be used. We're working on a number of datasets, not just from Canada, but also from the U.S.," Eaton said.

Even though the two horizontal wells were treated the same in stimulation, there were significant differences in microseismic response between the wells. One showed more postpumping activity and an inferred higher density of event clusters misaligned with the stress field.

Because of the differences, the researchers interpreted the reservoir as compartmentalized, with the two wells intersecting distinct facies with varying rock fabric.

"Taken together, attribute analysis, magnitude statistics and well log analysis are integrated here to characterize reservoir heterogeneity, rock fabric and compartments in the reservoir.

"These reservoir characteristics may, in turn, reflect variations in depositional environment, structural deformation and lithofacies," the researchers concluded in their paper.

In unconventional plays, microseismic monitoring commonly has been associated with high-definition imaging of microseismic events and hydraulic fracturing results. But that has grown into numerous other uses, including reservoir characterization.

Getting More Out of the Data

Facies identification using seismic and even microseismic data isn't something new in the world, Eaton acknowledged. An earlier Barnett shale project plotted microseismic event locations over a 3-D geological model to establish the relationship between hydraulic fracturing and facies.

"What our work is highlighting is a different strategy, where they get more out of the microseismic data. It's drawing on work done, really, decades ago, using regular seismic," Eaton observed.

The University of Calgary research developed a new approach using different tools, like its approach to cluster identification and attribute analysis, and in some cases tools used differently.

"I think it's new and kind of unique to our group at this time," Eaton said, "until the world discovers it and everyone starts using it."

Baile Wins Trustee Associates Service Award

By TAMRA CAMPBELL, Administrative Representative

Richard A. "Dick" Baile has been selected as the 2016 Trustee Associates Service Award recipient for his long-term involvement in the Trustee Associates in furtherance of fulfilling the mission of the AAPG Foundation.

He joined the Foundation as a Trustee Associate in 1980 and has generously supported the AAPG Foundation through numerous contributions in honor and memory of his colleagues and friends. When presented with Foundation fundraising needs, he is often one of the first to respond to the requests.

"Dick Baile is one of the most respected businessmen in our industry," shared Trustee Associates officer Rick Fritz. "He is a unifier and a strong voice, and a supporter for both the AAPG and SEG foundations."

"He continues to be a great supporter of the Trustee Associates," Fritz added. "I can't think of anyone who better deserves this service award than Dick."

A Member of the Corporation from 1977-2012, and a past recipient of the AAPG Foundation's Chairman Award (2013), Baile has not only given monetarily to the Foundation, but has graciously given his time. His consistent attendance at meetings, even now at age 95, provides invaluable support.

Baile, an AAPG Emeritus Member, is a World War II veteran and has a degree from the University of Central Missouri. He is a long-time resident of Houston.

Baile with AAPG Executive Director David Curtiss.

Grants-in-Aid Now Open

In other news, applications are now being accepted for the AAPG Foundation Grants-in-Aid program.

Over the past 60 years, Foundation Grants-in-Aid recipients have used research funds to support thesis work surveying lands from the Bogda Mountains of northwest China to the Dinosaur National Monument in Colorado, and many other incredible geologic wonders in between.

If your thesis research applies to petroleum, energy and mineral resources, or related environmental geology issues, you should start your application today. There are 92 grants available – $260,000 in research funds – waiting to be awarded in April 2017. Research grants range from $500 to $3,000, and chances are there could be one (or more) that fits your studies.

This scholarship program, established in 1956, is open to students in various fields of the geoscience industry, including exploration of hydrocarbons, economic sedimentary minerals, paleontology, tectonics, relevant applications of environmental geology and many more.

The application cycle is a competitive one, so get an early start on this opportunity to fund your graduate level research. Application and endorsements are due by 11:59 p.m. Feb. 15, 2017.

Students enrolled in a geoscience master's or doctoral program can visit foundation.aapg.org to learn more about the process and grant requirements.

Teacher of the Year Nominations

Also, nominations are now being accepted for the Teacher of the Year (TOTY) award. Funded and presented annually by the AAPG Foundation, this prestigious award is presented to a K-12 teacher who has demonstrated exceptional teaching and leadership in geoscience education within the United States.

The 2017 TOTY winner, chosen from a slate of six finalists selected by each of AAPG's domestic Sections, will receive a $6,000 cash prize along with an expense-paid trip to AAPG's Annual Convention and Exhibition in Houston, April 2-5.

Five runner-up finalists will receive honorable mentions and a $500 cash award.

The deadline to nominate a teacher or apply is Jan. 15, 2017.

The monthly list of AAPG Foundation contributions is based on information provided by the AAPG Foundation office.

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Director of the Berg-Hughes Center for Petroleum and Sedimentary Systems

TEXAS A&M UNIVERSITY

The Department of Geology and Geophysics at Texas A&M University invites applications for the position of Director of the Berg-Hughes Center for Petroleum and Sedimentary Systems. The Berg-Hughes Center integrates geosciences, engineering and other disciplines to collaborate with industry and others to advance research and education in petroleum studies.

We seek dynamic, innovative, geoscientists with demonstrated experience in leading large, multi-disciplinary teams and in obtaining funding from both industry and government to become the Director of the Berg-Hughes Center (http://berg-hughes.tamu.edu.). This is a senior-level faculty position (Professor, or Executive Professor) in sedimentary or petroleum geology.

We are seeking candidates with strong accomplishments in applying fundamental concepts in petroleum geosciences and engineering to grand challenges in energy and natural-resource sciences, ranging from the pore to basin scale. Areas of expertise may include, but are not limited to, sedimentary processes, depositional environments, sequence stratigraphy, basin architecture, basin modeling, geologic modeling, and energy and natural-resource science. The successful applicant will be expected to provide enlightened leadership, and effective management of the center activities. The Berg-Hughes Center Director must possess the ability to engage industry other colleges and government entities in initiatives that advance scientific and technical frontiers. The Director must have working knowledge of petroleum engineering and the ability to bridge geosciences with engineering disciplines. This position will also engage faculty and industrial leaders to ensure that students participating in center activities become tomorrow's leaders. The Director will be expected to establish a vigorous and externally-funded research program in collaboration with faculty in the Department of Geology & Geophysics, other research units in the College of Geosciences, the Department of Petroleum Engineering, the Texas A&M Energy Institute and the petroleum industry. The successful candidate will also be expected to mentor junior faculty and graduate students and contribute to graduate teaching and research.

Interested candidates should submit electronic versions of a curriculum vita, statements of research interest and teaching philosophy, leadership philosophy, funding history, and the names and email addresses of at least three references, and up to four reprints at apply.interfolio.com/36755. Screening of applications will begin October 1, 2016 and will continue until the position is filled. A Ph.D. or a M.S. with greater than 20 years industry experience, or industry engagement is required at the time of employment.

The Berg-Hughes Center for Petroleum and Sedimentary Systems is a comprehensive program that integrates geosciences, engineering and related disciplines, including the Department of Geology and Geophysics and the Crisman Institute for Petroleum Research in the Harold Vance Department of Petroleum Engineering. The Department of Geology and Geophysics (geoweb.tamu.edu) is part of the College of Geosciences, which also includes the Departments of Atmospheric Sciences, Geography, Oceanography, as well as Sea Grant, the Geochemical and Environmental Research Group (GERG), and the Integrated Ocean Discovery Program (IODP).

Texas A&M University, a land-, sea-, and space-grant university is located in a metropolitan area with a dynamic and international community of 255,000 people. Texas A&M University is an affirmative action/equal opportunity employer committed to excellence through the recruitment and retention of a diverse faculty and student body and compliance with the American with Disabilities Act. The University is dedicated to the goal of building a culturally diverse and pluralistic faculty and staff committed to teaching and working in a multicultural environment. We strongly encourage applications from women, underrepresented ethnic groups, veterans, and persons with disabilities. Texas A&M University also has a policy to address the needs of dual-career partners

advance.tamu.edu/dual-career-program-information

Sedimentary Basin Analysis and Modeling Position, Berg-Hughes Center and Department of Geology and Geophysics, Texas A&M University

TEXAS A&M UNIVERSITY

The Berg-Hughes Center for Petroleum and Sedimentary Systems (BHC) and the Department of Geology and Geophysics at Texas A&M University invite applications from individuals for a non--tenure track, three-year renewable contract position as a Research Professor in Sedimentary Basin Analysis and Modeling beginning January 16,2017. This position will be a joint appointment with teaching research and service responsibilities in the Berg-Hughes Center and Department of Geology and Geophysics. This is a 9-month annual appointment.

The principal responsibility of this position is to lead the collaborative research and teaching programs in the Chevron-TAMU/BHC Basin Modeling Center of Research Excellence in the BHC and Department of Geology and Geophysics. This responsibility includes leading in the development of a robust externally funded research program in basin analysis and modeling that includes research collaboration with researchers in the petroleum industry; teaching integrative courses that introduce advanced concepts and technologies needed for unraveling the geo-history of sedimentary basins and the origin and location of unconventional and conventional petroleum resources inherent to sedimentary basins and supervising graduate students and mentoring faculty in the use of sophisticated computational and applied research approaches and techniques to solve complex geologic problems.

We seek candidates who have had extensive experience in sedimentary basin analysis and modeling and in serving as a team leader on multi-disciplinary research projects, and who have demonstrated the ability to develop and maintain an externally funded research program.

Applicants must have a record of success in working collaboratively with researchers in academia and the petroleum industry and be enthusiastic about teaching integrative courses and supervising graduate students in basin analysis, basin architecture, basin modeling basin geodynamics, and related areas.

Applicants must have an earned Ph.D. at the time of appointment. Successful applicants will be expected to teach effectively at the graduate level in basin analysis and modeling and related fields and in team taught courses, including classes in the Petroleum Certificate curriculum and to supervise undergraduate, M.S. and Ph.D. research including students who are interested in pursuing careers in the petroleum industry. Applicants are expected to build and maintain a collaborative research program with colleagues in the College of Geosciences the Berg-Hughes Center, the Department of Geology and Geophysics, the Department of Petroleum

Engineering and other energy related groups at Texas A&M University and the Texas A&M University System and with geoscientists and petroleum engineers in the oil and gas industry and national and international research institutions.

Interested candidates should submit electronic versions of a letter of application, curriculum vita, teaching philosophy, statement of research vision, strategies to implement that vision, and accomplishments, and the names and email addresses of at least three references to the Chair of the Basin Analysis and Modeling Search Committee, cdengo@tamu. edu. Screening of applications for the position will begin immediately and will continue until the position is filled. The Berg--Hughes Center (berg-hughes.tamu.edu) and the Department of Geology and Geophysics (geoweb.tamu.edu) are part of the College of Geosciences, which also includes the Departments of Atmospheric Sciences, Geography, and Oceanography; the Geochemical and Environmental Research Group (GERG); and the Integrated Ocean Drilling Program (IODP).

Texas A&M University, a land-,sea-,and space-grant university, is located in a metropolitan area with a dynamic and international community of 227,000 people. Texas A&M University is an affirmative action/equal opportunity employer committed to excellence through the recruitment and retention of a diverse faculty and student body and compliance with the American with Disabilities Act. The University is dedicated to the goal of building a culturally diverse and pluralistic faculty and staff committed to teaching and working in a multicultural environment. We strongly encourage applications from women, underrepresented ethnic groups, veterans, and persons with disabilities. Texas A&M University also has a policy to address the needs of dual-career partners.

https://advance.tamu.edu/dual-career-program information/

Arctic Experts Heading to ATC in October

The Arctic Technology Conference will be held Oct. 24-26 in St. John's, Newfoundland and Labrador.

This is the fifth year that the event will bring together Arctic experts and practitioners from all over the world to share experiences, ideas and network with one another.

The conference will feature a technical program made up of presentations based on more than 150 technical papers. Topics will include resources, drilling, production, exports, the environment, logistics, marine transport, regulations and mining.

In addition, a variety of panel sessions will be offered. They will discuss Arctic exploration, engineering education, the Cohasset and Panuke projects, logistics for remote oil and gas operations, insurance and legal aspects, same season relief wells and a study by the National Petroleum Council.

An Arctic orientation and networking event, The Arctic Next Wave, will invite seasoned veterans and young professionals to listen to keynote speakers, participate in roundtable discussions and network together.

The Distinguished Achievement Awards Ceremony will also be held during the conference. It will recognize and honor those who have made major technical humanitarian, environmental and leadership contributions to the industry.

The event will be held at the St. John's Convention Centre and registration is open now. For more information, visit www.artictechnologyconference.org.

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You can reach about 37,000 petroleum geologists at the lowest per-reader cost in the world with a classified ad in the EXPLORER. Ads are at the rate of $2.90 per word, minimum charge of $60. And, for an additional $50, your ad can appear on the classified section on the AAPG website. Your ad can reach more people than ever before. Just write out your ad and send it to us. We will call you with the word count and cost. You can then arrange prepayment. Ads received by the first of the month will appear in the subsequent edition.

INMEMORY

Jack Ahlen, 87
Roswell, N.M., June 8, 2016

William Blanks, 92
Denton, Texas, May 20, 2016

David Farmer, 58
Midland, Texas, June 13, 2016

William Flenniken, 93
London, Ontario, Canada, Aug. 19, 2015

Paul Garrett Jr., 91
Glenshaw, Pa., Aug. 13, 2016

Jack Goodwin, 85
Midland, Texas, June 21, 2016

Cezary Grelowski
Pila, Poland, Associate, April 28, 2009

Jimmy Prickett, 83
Wichita Falls, Texas, June 12, 2016

Roger Wilkinson, 84
Edmond, Okla., Aug. 22, 2016

(Editor's note: "In Memory" listings are based on information received from the AAPG membership department. Age at time of death, when known, is listed. When the member's date of death is unavailable, the person's membership classification and anniversary date are listed.)

STRUCTURAL GEOLOGY/TECTONICS
CONOCOPHILLIPS SCHOOL OF GEOLOGY AND GEOPHYSICS
MEWBOURNE COLLEGE OF EARTH AND ENERGY
UNIVERSITY OF OKLAHOMA

The University of Oklahoma invites applications and nominations for a tenure-track Assistant Professor faculty position in Structural Geology/Tectonics. Exceptional candidates at the Associate Professor level will also be considered. We seek a dynamic colleague who will teach and supervise students at all levels, while conducting an independent, externally funded research program in his/her field of expertise. The holder of this position is expected to (1) conduct research in structural analysis using any combination of theoretical, experimental, field and geophysical approaches; and (2) educate students in the area of structural concepts and techniques. The area of research experience and expertise is open. We expect the candidate to teach undergraduate Structural Geology and graduate courses in Advanced Structural Geology, and participate in the Introductory Field Geology course and Field camp.

The candidate must hold a Ph.D. at the time of appointment, have a research record, and an interest in teaching undergraduates and mentoring graduate students. Salary, benefits, and start-up funds will be competitive and commensurate with experience. The ConocoPhillips School of Geology and Geophysics has a large, vibrant faculty with a broad range of research activities, from fundamental to applied, and strong ties to the petroleum industry.

The student body currently includes 180 undergraduates and 95 MS and PhD students.

Screening of applicants will begin in November 2016. Interviews will take place in January and February 2017. The position will be available at the beginning of 2017 academic year (Fall 2017 semester), and the search will remain open until the position is filled. Applicants are encouraged to apply at apply.interfolio.com/37030. Submissions should include a complete vita/resume, statement of research and teaching interests, and a list of three references (including names, phone numbers, e-mail addresses, and complete mailing addresses). Questions or requests for additional information may be addressed to Chair of the Structural Geology/Tectonics Search Committee, at (405) 325-3253, or oustructuresearchchair@ou.edu.

The University of Oklahoma is an equal opportunity employer and all qualified applicants will receive consideration for employment without regard to race, color, religion, sex, sexual orientation, gender identity, national origin, disability status, protected veteran status, or any other characteristic protected by law.

APPEX Regional 2016 Set for Poland

AAPG Europe will hold their annual APPEX Regional upstream acquisition and divestment conference Nov. 8-9 in Warsaw, Poland.

The event was created 15 years ago and has since become known as an effective and productive experience enabling attendees to make important connections while buying, selling and trading prospects and properties.

APPEX Regional brings together upstream explorationists, exploration managers, deal makers and business developers who are interested in unlocking the potential of new global frontiers and discovering the secrets of long-producing mature basins.

Anyone interested in buying, selling or farming out E&P deals; expanding into new areas; finding new partners; making high quality contracts; or staying up to date in the industry should attend the event.

Some of the key focuses of the event this year are regional acquisition and divestment deal flow, unconventionals, arctic potential and onshore play potentials.

The North Sea, Eastern Atlantic, Northern Mediterranean, Southern Atlantic, Eastern Europe, Central Europe, and the Baltic and Southern Gas Basin will also be highlighted.

To learn more about the event, visit www.aapg.org/global/europe.

The tie that binds: AAPG Honorary Member Robert Lindblom presented one of his special "geology" cravats to AAPG President-Elect Charles Sternbach during this year's DPA luncheon in Calgary.

DPA
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optimization, and the ability to execute drilling campaigns of perhaps hundreds of wells.

What is common to both is the increasing need for technical and non-technical breadth, which requires a basic level of awareness and competence of the multiple disciplines required for business decisions. This will be increasingly true where geoscientists will need to work across the life cycle of a project, from early opportunity identification, to exploration and appraisal, to field development and production surveillance. Skill in each part of the life cycle better allows the geoscientist to become better-rounded and more valuable to his or her employer, and in my opinion, will provide an increased measure of job security for an uncertain future.

Anniversary Events

So why is this paradigm of interest to AAPG's Division of Professional Affairs?

The DPA sponsors multiple programs aimed at helping geoscientists in their professional development. Multiple DPA events will be featured at the 2017 Annual Convention and Exhibition in Houston next April, which will be a celebration of AAPG's 100th anniversary and also the DPA's 50th anniversary.

The DPA is planning two Discovery Thinking Forums (the 17th and 18th since the inception of this popular event in 2008), and has already lined up some fabulous papers from a multitude of geologic settings throughout the world. These talks should inspire explorers everywhere with lessons on how major impact discoveries were nurtured from concept to economic reality.

The DPA will also honor the Heritage of the Petroleum Geologist at its annual luncheon devoted to the legacy of AAPG legend Wallace Pratt, which will include issuing a second volume of the popular DPA publication "Heritage of the Petroleum Geologist" (which can be found on the DPA website at www.aapg.to/k3a5b).

The DPA will co-sponsor (along with the Division of Environmental Geosciences) a special forum on "Future Best Practices for Extraction Industries in a Lower Carbon Environment" to help members gain insight on the standards of operating practice that may be emerging to meet more stringent regulatory standards and maintain our industry's "License to Operate."

Finally, DPA's short courses will aim to help geoscientists gain breadth and professional skills with offerings in professional ethics and the business side of geology.

So wherever you work, whatever your specialty and whatever your level of experience, there will be a DPA-sponsored event that can inspire you and help you become a more well rounded professional.

I look forward to seeing you in Houston!

DIRECTOR'S CORNER

You Can Only Control You

By DAVID CURTISS

Over the last few months I've had several opportunities to talk to groups of students and young professionals about their careers and the future. The most frequent question they ask me is when I think the industry will turn around.

When will oil prices go back up and companies start hiring?

Given the current employment situation for petroleum geologists, it's foremost on their mind. But I'd submit that on a personal level, it's the wrong question. Because when you're just starting out – and even when you're starting over – what you need isn't an industry recovery.

What you need is a job – a place where you can deploy your talents and gain experience.

Now, I can already hear the grumbling: "That's easy for you to say. But if the industry is in the doldrums how can I find that job?"

There's no question that an industry recovery makes the job hunt easier. But, individually, there is nothing you can do to effect such a recovery. You don't control global supply and demand. You don't set oil prices. You can't dictate when companies decide to start hiring.

You do control your responses to the current employment environment. You can use creativity and ingenuity to uncover and create opportunities. There is a way for you to develop a path forward in the current situation. Don't shift control of your career to something, like an industry recovery, or someone outside your control.

Instead, focus on what you need to do to find that job.


CURTISS

> "Life rarely unfolds according to a grand plan. There is no future point where everything falls into place."

You Can't Have Everything

But as you seek out and create opportunities, do you know what you want for your career, or even more importantly, for your life?

Perhaps you want power, a corner office with significant responsibility and intellectual challenge, high pay, a supportive spouse, brilliant children, a nice house and cars, ample time for leisure and to pursue personal interests.

Yep, me too.

I'd also like to win the lottery.

In product design, there's a famous ternary diagram with the vertices labeled Good, Fast and Cheap. Designers then inform their clients that they get to choose two of the three to optimize the product. You can have a product that is good and produced quickly, but it won't come cheap. You can't have all three.

I find this diagram a useful metaphor for designing our lives, because while I believe you can likely have what you want most in life, I'm pretty sure you can't have everything.

Here in the United States, we are having a societal discussion about work and life. These are important conversations to have as technology changes the workplace and new generations of workers have different expectations and desires.

But these discussions concern matters we can only influence, not control, and I would submit that no matter how circumstances evolve, we should understand what we want and make decisions accordingly.

The point is that you get to decide what is important to you and optimize your life for those values.

Personal Experience

It was 1995 when I finished graduate school. I had a freshly printed master's degree in the midst of a pretty dismal job market for geologists. And it was going to get worse as oil slid to just over $9 per barrel in 1999.

My career was my top, perhaps only, priority over the next two decades, but there weren't many corporate jobs available. The result is that I built a career in the non-profit world, first in academia and then at AAPG.

That decision meant that I was not optimizing for maximum financial gain.

But what it did offer was the opportunity to accumulate knowledge and experiences. As a result, I have worked geological basins on every continent except Antarctica, and I know and have worked with people from all over globe. I also had the opportunity to work in the U.S. Congress as a Congressional Science Fellow, travel extensively and move frequently to see many parts of the world.

One result of my focus on career was that I did not get married and start a family early in adulthood. That wasn't my conscious plan, but it was the result that emerged from my decisions and the path that I chose.

I have had a rich and fulfilling career, doing what I felt was important, but I came home from each of these adventures to an empty apartment.

But priorities change and opportunities arise, and one of the biggest surprises of moving to Oklahoma was getting married nearly three years ago to my beautiful wife and bringing three impressive step-kids into my life. It was an "Insta-family" as my Dad put it.

This decision has been a rich addition to my life and career – more than I ever realized – and is accompanied by new tensions as I seek to balance my commitment to career with my new commitment to family. This is something many of you are dealing with, too.

Why am I telling you a part of my story? Because, as I continue to learn, life rarely unfolds according to a grand plan. There is no future point where everything falls into place.

"Every day is a journey, and the journey itself home," is how Matsuo Basho, the 17th-century Japanese poet, put it.

Your life and mine are built moment by moment, decision by decision. You get to choose. Choose wisely.

DIVISIONS REPORT: DPA

Managing Change in Uncertain Times

By CHANDLER T. WILHELM, DPA President

Our industry, while based on the fundamentals of good scientific and engineering practice, is nonetheless sometimes subject to the same tendency towards fad and dogmas that afflicts our society as a whole.

Decision makers, if not careful, may anchor their views from recent experience, current headlines or market demands. However, if there is one thing I have learned in my 35 years as an AAPG Member, it is that change is the norm and what is out of favor today may one day become conventional wisdom.

I can remember the paradigms that once held that geologists would never need computers on their desktops, that there were no river systems capable of delivering reservoir sands beyond the shelf and into deepwater settings, and that large oil molecules would never flow through very small pores in shales. Now these three paradigms underpin several hundred billion dollars per year of global capital investment and form the basis for what most of AAPG's roughly 30,000 Members do on a daily basis.

Having experienced firsthand these profound changes in how we practice our profession, I have come to believe that charting a successful career as a petroleum geoscientist requires flexibility, a mindset to courageously face change when required and a commitment to lifelong learning to provide the tools needed to stay competitive in the job market.


WILHELM

> Geoscientists will need to work across the life cycle of a project.

A Perfect Storm of Paradigms

Two of today's most frequently cited paradigms are "Lower for Longer" and "The Great Crew Change."

The first, of course, refers to the collapse in commodity prices following OPEC's decision in November 2014 to aggressively pursue market share, with all of the wreckage to the upstream industry that followed as companies have struggled to shore up balance sheets and restore profitability, and the prevailing view that a return to higher prices is likely many years away (if ever). The second refers to the impending retirement of the Baby Boom generation that makes up a large portion of AAPG's membership, and the need to grow the ranks of Millennials in industry and leadership positions.

These two paradigms intersect at employment levels – a leading indicator of the health of our profession and a subject of great interest to our membership. The "Lower for Longer" paradigm serves as a catalyst for reducing employee headcount in order to protect corporate bottom lines from an unknown but potentially harsh future, while the "Great Crew Change" paradigm reinforces the need to attract, retain and develop talent to prepare for a future where experienced professionals may be in great demand.

While it isn't clear how these forces will play out over the next several years, we may already be in the midst of a perfect storm as early retirements in the current market may be accelerating the "Great Crew Change."

Emerging Paradigm: Multidisciplinary Skill Sets

I certainly do not have an infallible crystal ball on what the future holds, but I do believe there are fundamental forces that geoscience professionals should contemplate when charting their own career strategies. One of the potentially most powerful is the increasingly interconnected and interdisciplinary nature of the work that geoscience professionals do.

A geoscientist working in deepwater exploration needs to master management and interpretation of large seismic datasets, develop a deep understanding of global geologic analogs and capably perform careful risk analysis from seismic data calibrated by relatively few wells. A geoscientist working in unconventionals must develop a deep understanding of reservoir sweet spots, how to drive maximum recovery from the combination of reservoir architecture and engineering

See **DPA**, page 33