AUGUST 2017 | 100 AAPG ANNIVERSARY

EXPLORER

North to the Future

Alaska's NPRA and ANWR could soon be open for exploration.

See page 8.

Vol. 38, No. 8
AUGUST 2017

100TH AAPG ANNIVERSARY
EXPLORER

PRESIDENT'S COLUMN

Keep Looking Up!

BY CHARLES STERNBACH

The Great American Eclipse occurs on Monday Aug. 21 and it will be the first total solar eclipse to cross the entire mainland United States in 99 years. The moon's shadow will pass over Wyoming, Nebraska, and Illinois – a few of the states that produce energy for our domestic consumers. The sun will be covered for one to two minutes during the total solar eclipse for those in the path.

The AAPG Astrogeology Committee has a field trip planned to Casper, Wyo. to see the eclipse in the morning. I hope many geoscientists will be able to enjoy this amazing experience.

When the view of the sun returns, I know I will be thinking about how fortunate we all are to have dependable energy in our lives!

With regard to that dependable energy, we are living in historic times. The shale revolution has proven itself to truly be a revolution. This has huge global geopolitical Impact as the United Stats has once again joined the "Ten Thousand Barrels a Day Club" along with Saudi Arabia and Russia.


STERNBACH

> There is a second wave of exploration going back to old places but with new thinking and new technology.


On Nov. 13, 2012, this NASA photo shows a narrow corridor in the southern hemisphere experienced a total solar eclipse. The corridor lay mostly over the ocean but also cut across the northern tip of Australia.

Rise of the Super Basins

Helping all our members add to the global energy supply is AAPG's prime goal and will be for a very long time.

Research shows that we have underestimated petroleum systems. There is more generative potential in tight fine-grained rocks and source rocks themselves than previously known. Combine that with our ever-improving ability to extract energy sources from nano-scale spaces, and we have an energy revolution. Previous models vastly underestimated resource potential, which is why last month's Explorer focused on "Why we keep *not* running out of oil."

The reason I am so interested in super basins, and why all of us should be, is that these top 25 basins have significant infrastructure and the potential to add hundreds of billions of barrels of oil and gas equivalent. My hat is off to Pete Stark and Bob Fryklund of IHS for their thought leadership in defining this concept. This thinking is in dramatic contrast with visionary conferences of the past.

In the year 2000, coincident with a new century, Marlan Downey, Jack Threet and Bill Morgan hosted a symposium on "Resources for the 21st Century." Reviewing AAPG Memoir 74, a product of this conference, it is clear that the thinking of the day was that to find new energy reserves, one must go, primarily, to new places!

This is still true today as seismic imaging enables us to see exciting energy potential along conjugate margins, deep water, ultra deep water and pre-salt, for example. But remarkably, there is a second wave of exploration going back to old places but with new thinking and new technology. This means that there are different skill sets required for our workforce, depending on whether you are in the short cycle (unconventional) or long cycle (conventional) part of our business. Energy companies are finding niches in either or both arenas.

Tom Ahlbrandt and the U.S. Geological Survey expanded our concepts on total petroleum systems. I highly recommend watching his 2015 Halbouty Lecture, posted on the AAPG website at aapg.to/DiscThinkLC (it's case sensitive).

Given the recent reemergence of mature basins, and the desire for AAPG to be visionary as we plan for our second century, plans are underway for a "Global Super Basin Conference" in Houston late February next year. Details of the conference will be forthcoming, but for now we will focus on top petroleum basins that "keep on giving." As we return to petroliferous basins that are being revitalized by new waves of technology we will review critical technologies. These include: seismic imaging, horizontal drilling, hydraulic fracturing, multi-stage stimulation, design of fluids and proppants, and digital instrumentation of oil fields (for example).

Technology Transfer

We will focus on technology transfer within and between basins. Within each super basin there is a long history of innovation. The Permian Basin is a prime example. So too is the Gulf of Mexico. Gulf of Mexico exploration started out in the onshore. Then the oil and gas industry invented bright spot technology, found deepwater turbidite reservoirs, invented subsalt and pre-salt imaging and engineering breakthroughs have recently lead to revitalization of tight rocks onshore.

These waves of technology have rejuvenated a rich super basin for nearly

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View to the south along Hue Creek at the northern front of the Shublik Mountains, which are south of the Alaska National Wildlife Refuge. See story on page 8. Right: Upper Cretaceous distal turbidite beds in western ANWR 1002 Area.

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The AAPG EXPLORER (ISSN 0195-2986) is published monthly for Members by the American Association of Petroleum Geologists, 1444 S. Boulder Ave., P.O. Box 979, Tulsa, Okla. 74101-3604, 1-918-584-2555. email address: postmaster@aapg.org. Periodicals Postage Paid at Tulsa, OK and at additional mailing offices. POSTMASTER: Please send address changes to AAPG EXPLORER, P.O. Box 979, Tulsa, Okla. 74101. Canada Publication Agreement Number 40063731. Return undeliverable Canadian address to: Station A, P.O. Box 54 • Windsor, ON N9A 6J5 • email: returnsIL@imex.pb.com.

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Announcing the Vlasta Dvořáková International Ambassador Service Award

By ANDREA MOSCARIELLO, AAPG Europe Region Advisory Counselor

A new international award has been established to honor the memory of Vlastimila "Vlasta" Dvořáková.

This award is given to those who have promoted growth and awareness of the AAPG organization internationally, outside the United States, and created opportunities for the Association to reach a wider audience of geoscientists worldwide. The award will help recognize the importance of AAPG volunteers dedicating themselves to promote the mission and programs of the Association, fostering cooperation with other geoscience organizations, as well as growing the organization and its cultural and ethnical diversity.

Quota and Opportunity

Dvořáková was born March 15, 1960, and grew up in Bzenec, Czechoslovakia, where her father was an agricultural agent for the central government and her mother was a village clerk. As a consequence of travels with her father, she developed a desire to study tropical biology. However, she was denied the opportunity to study biology because of a quota system that favored the children of party members. Dvořáková therefore took advantage of an opening for a student of geophysics at the University in Brno.


DVOŘÁKOVÁ

After two years in Brno, Dvořáková gained admission to the Charles University in Prague, Czechoslovakia's premier university, where she finished graduate studies in geophysics. Later she joined the Geofyzika Company in Brno, Czechoslovakia, where she worked with Jan Uhmann in the petrophysical laboratory and with Čestmír Tomek on seismic surveys. Around the time of the fall of the "Iron Curtain," she joined František Hrouda in the search for deeper understanding of the magnetic susceptibility of rocks at KAPPA (AGICO) Ltd. She then worked for a series of private companies, including GeoGas, Duke Engineering and Services, and Framatome, before beginning work with the Czech Geological Survey.

Part of Dvořáková's role with the survey was public outreach. When the global debate on hydraulic fracturing emerged around 2009, she became the voice of reason in central Europe, representing the middle ground between industry and fearful activists. She gave many interviews on TV and radio, speaking authoritatively about petroleum geology and oil and gas business.

Career and Legacy with AAPG

Dvořáková joined AAPG in 1996 and began an illustrious volunteer career that greatly strengthened the European connection to AAPG. Among her many important international volunteer roles were technical program chair for the 2007 Athens International Conference and Exhibition (ICE), sponsorship co-chair for the 2011 Milan ICE, member of the House of Delegates since 2006, member of the Professional Women in Earth Sciences (PROWESS) Committee since 2008, and coordinator of the Visiting Geoscientist Program.

Dvořáková also served in important roles in the Europe Region. In 2006, she joined the Europe Region Council, which led to her becoming president of the Europe Region in 2011. After serving her two-year term, she remained a strong voice and hardworking servant of the Region, taking part in a conference call during the Denver Annual Convention and Exhibition (ACE) in 2015 – only 10 days before her passing and without drawing attention to her failing health.

Dvořáková was passionate about the AAPG Imperial Barrel Award (IBA) and was a major contributor to the success of the Europe Region competition held annually in Prague. Dvořáková's last expression of pride in AAPG was to acknowledge the pleasure she took in the Europe Region team winning the 2015 Global IBA championship in Denver shortly before her death. It is fortunate, given her premature passing, that AAPG had already recognized Dvořáková's service with Certificates of Merit in 2008, 2012 and 2013, and the Distinguished Member of the House of Delegates Award in 2012, although these awards do not capture the breadth and depth of Dvořáková's contributions to AAPG and the profession of petroleum geoscience.

Dvořáková was a brave person who believed that women should have the same opportunities in life and science as men. She was brilliant with foreign languages. She grew up with parents who spoke German and Czech, and

See **Award**, page 14

Could the World's Oil Supply Outlast Demand?

By DAVID BROWN, EXPLORER Correspondent

Old thinking predicted a limit on how much crude oil the world can produce annually:

Peak Oil.

Newer thinking said the world is going to have plenty of crude oil production but will reach a limit on the amount of crude consumed per year:

Peak Demand.

The newest thinking sees oil demand reaching a maximum, falling off to some degree, then remaining at a fairly high level:

The Demand Plateau.

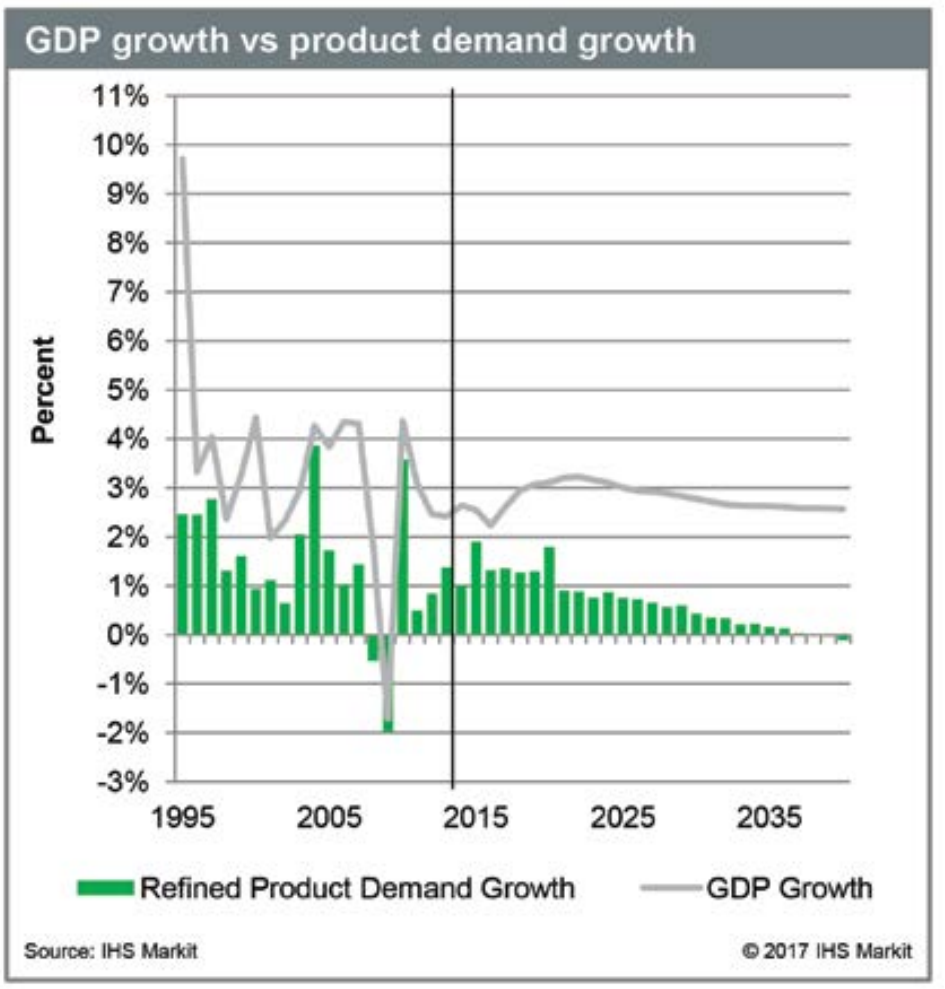
Refining is a key component in crude oil demand, commonly referred to as the "call on crude" in the refining business. As we know, refiners as a whole aren't having any trouble getting oil right now, with the world still in a position of crude surplus.

Stephen Jones serves as vice president on the refining and marketing business side for IHS Markit in Houston. He said some types of crude oil are less expensive to produce and generally available; other types are relatively expensive to produce and come into the market when oil prices rise.

"At a given point there is plenty of crude available, in either case," Jones said. "When you kind of work it all through, that supply outlook is really an outcome of the market."

While rising oil prices encourage production of crude, high prices also slow demand growth and reduce crude consumption.

"Our views are that demand drives the price of crude, and crude will be available," Jones said, but warned "the price can rise to a level that can temper demand growth or even kill it."



Eventually, he said, the world reaches a level where oil prices cause a plateau in demand.

Plateau Predictions

Nobody knows exactly when that will happen. The International Energy Agency (IEA) is on record saying that Peak Demand won't happen until sometime after 2040, and recently predicted that global oil supply could struggle to keep pace with demand after 2020.

"We are witnessing the start of a second wave of U.S. supply growth, and its size will depend on where prices go," said Fatih Birol, the IEA's executive director.

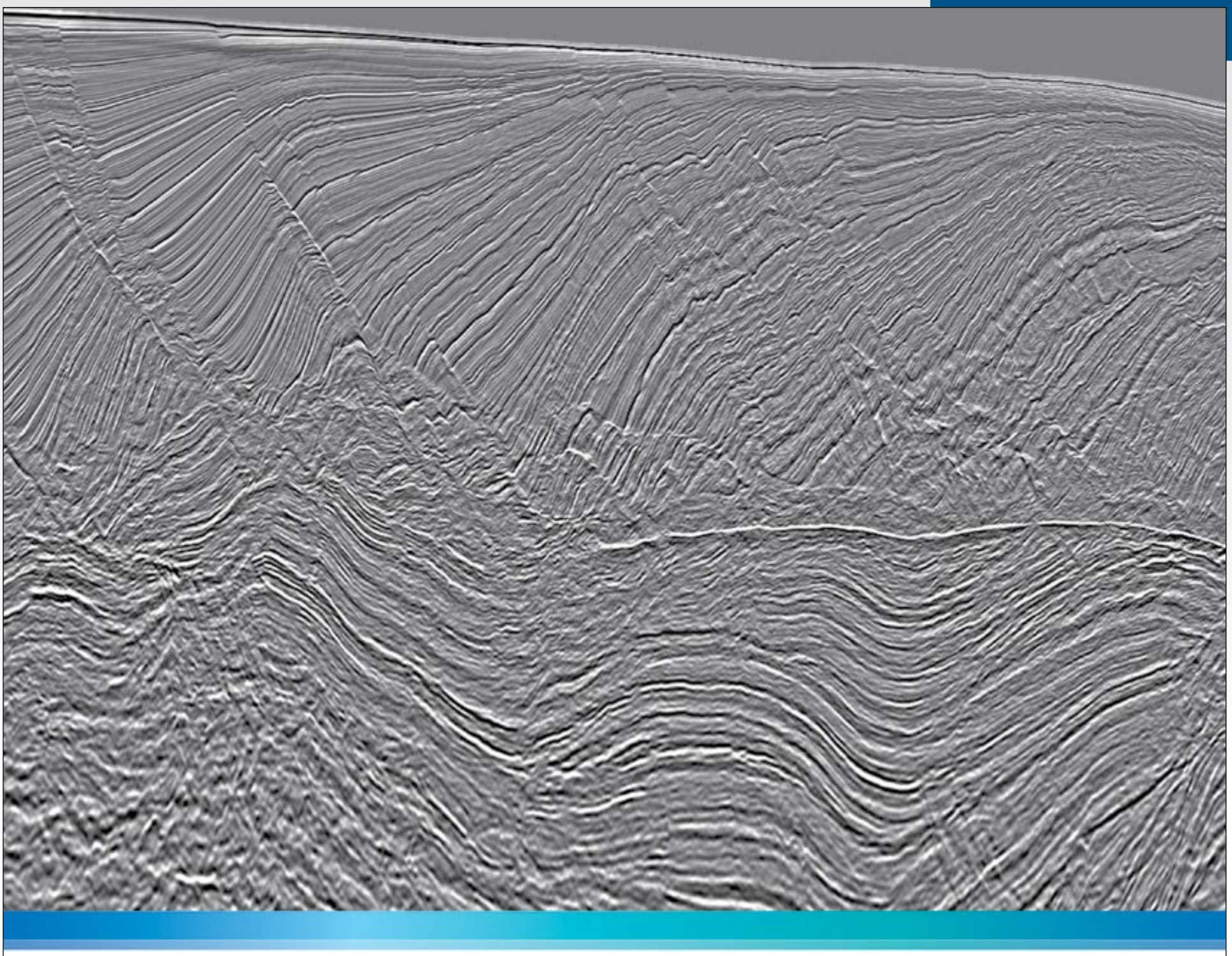
"We don't see a peak in oil demand any time soon. And unless investments globally rebound sharply, a new period of price volatility looms on the horizon," Birol added.

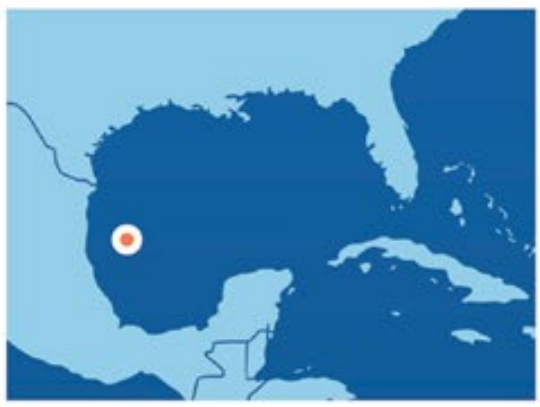
Jones said IHS Markit sees demand easing out earlier than that. "We aren't calling for a bendover, a fully definable peak," he said, "but between late 2035 to 2040, you start seeing demand growth flattening and possibly even declining slightly."

That doesn't mean the refining industry is in trouble, said Sandeep Sayal, senior director on the refining and marketing business side for IHS Markit. For one thing, demand for petrochemicals is expected to grow strongly.

"We're fairly bullish. The word on the street is, 'This is the end of the refining industry. All these electric cars are coming into the market.' But, the refining

See **Assumptions**, page 13





Western Ridges North Imaging

Offshore southern Gulf of Mexico

The PGS Western Ridges 2D seismic program consists of 17 500 kilometers of 2D subregional coverage in the offshore southern Gulf of Mexico. Employing PGS GeoStreamer technology and acquired in collaboration with Schlumberger and Spectrum Geophysical, these data image structural elements of the Quetzalcoatl extensional system along the continental shelf of eastern Mexico and the associated Neogene contractional system on the continental slope to the east.

Deliverables for this program include Kirchhoff and RTM PSDM stacks with associated PSDM gathers and migration velocity model, as well as Kirchhoff PSTM stack, and PSTM gathers with associated stacking and migration velocity fields. Additional products include gravity and magnetics data.

Please contact: Tel:+1 (281) 509 8000 | Email: gominfo@pgs.com

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Below: Heavily oil-stained Oligocene sandstone exposed on Marsh Creek anticline, ANWR 1002 Area. Katakturuk River is in the background. Photos by David Houseknecht.

Alaska's ANWR and NPRA Might Soon Open

By HEATHER SAUCIER, EXPLORER Correspondent

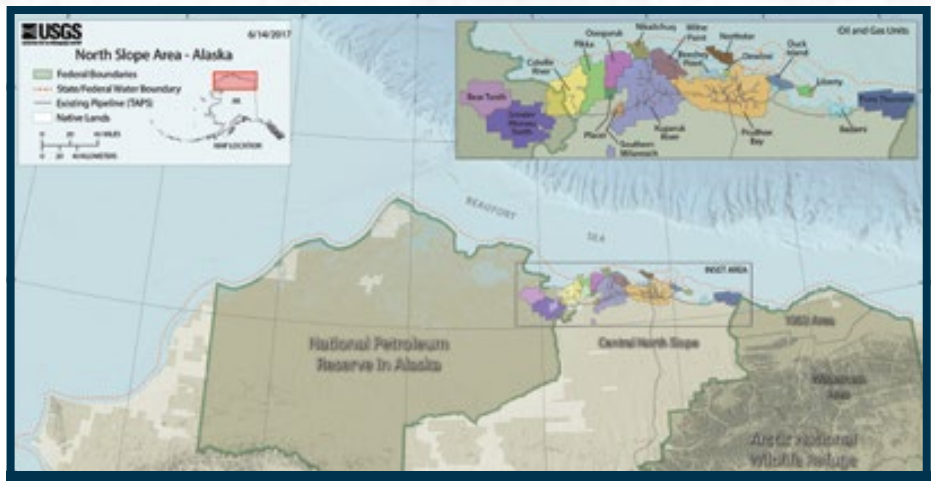
Acting with a goal of "geopolitical security," U.S. Secretary of the Interior Ryan Zinke has begun a heavy push to open Alaska's oil-rich, yet off-limits, federally-owned areas after decades of legislation and land management policies have kept some of them essentially out of reach.

In a May 31 secretarial order, Zinke called for opening of parts of the National Petroleum Reserve – Alaska (NPRA) to lease sales and for updating resource assessments of both NPRA and the Arctic National Wildlife Refuge (ANWR) coastal plain. The order follows two bills introduced to the Senate and the House earlier this year calling for exploration in ANWR.

While the areas to be leased in NPRA were not yet announced at press time, the U.S. Geological Survey (USGS) has been directed to produce new assessments of technically recoverable oil and gas resources for both NPRA and ANWR. It is not yet clear whether the federal government will wait for the assessments or if it will choose to fast-track a lease sale in NPRA.

"We are very optimistic," said Andy Mack, commissioner of the Alaska Department of Natural Resources. "The prospect of these areas for leasing and production is extremely exciting for Alaska. It will attract investment and hopefully lead to successful drilling and production and throughput in the Trans-Alaska Pipeline System."

Now that the secretarial order has opened more doors in NPRA, there is reason to believe that after decades of failed attempts by previous administrations and politicians to make ANWR accessible for exploration, this time could be the clincher. With a Republican-controlled Congress and a president who is taking a "California or bust" approach toward energy development, new assessments of ANWR might become a political catalyst for one of the largest, unexplored, potentially productive onshore regions in the country to show the world its worth.



Map of Arctic Alaska showing National Petroleum Reserve in Alaska, Arctic National Wildlife Refuge and 1002 Area, central North Slope, and – in white shading – Native lands. Map includes oil and gas units and pipeline system, which includes Trans-Alaska Pipeline System (TAPS) and feeder pipelines from producing fields.

New assessments of ANWR might become a political catalyst for one of the largest, unexplored, potentially productive onshore regions in the country to show the world its worth.

Alaska's Federal Lands

Established in 1923, NPRA is the largest block of federally managed land in the country. In the USGS' 2010 assessment of its 22.8 million acres, it estimated that NPRA contains 895 million barrels of technically recoverable oil and 52.8 trillion cubic feet of natural gas. Yet in 2013, the previous administration made approximately 11 million of those acres unavailable for leasing. The Department of the Interior (DOI) reports that this acreage contains an estimated 350 million barrels of oil and 45 trillion cubic feet of natural gas.

Zinke's order calls for the lawful review and development of a revised Integrated Activity Plan for NPRA that strikes an "appropriate" statutory balance of promoting development while protecting surface resources. It also calls for an evaluation on "efficiently and effectively maximizing the tracts offered for sale" during the next NPRA lease sale, which has not yet been announced.

"This is land that was set up for the sole intention of oil and gas production, however years of politics over policy put roughly half of NPRA off-limits," Zinke said in a May 31 press release from the DOI. "Working with the Alaska Native community, Interior will identify areas in the NPRA where responsible energy development makes sense and devise a plan to extract resources," he said. "We will do it in a way that both respects the environment and traditional uses of the land as well as maintains subsistence hunting and fishing access."

In 1980, the Alaska National Interest Lands Conservation Act established ANWR, a 19-million acre area of mainly majestic mountains and upland meadows in the eastern Brooks Range. In Section 1002 of that act, however, Congress deferred a decision on future management of ANWR's 1.5-million acre coastal plain, commonly known as the "1002 Area" in recognition of its "enormous" oil and gas potential and its importance as wildlife habitat, stated the USGS in its most recent 1998 assessment of the area.

"I am a geologist," Zinke said. "Science is a wonderful thing. It helps us understand what is going on deep below the surface of the earth. We need to use science to update our understanding of the 1002 Area of the Arctic National Wildlife Refuge as Congress considers important legislation to responsibly develop there one day."

Many Native Americans who rely on tax revenue and royalties from oil and gas development strongly support Zinke's efforts. North Slope Borough Mayor Harry Brower, Jr., an Inupiat whaling captain, stated, "North Slope Borough residents recognize the importance of oil and gas to our local economy and the ability of our Borough and city governments to provide public services."

Opening the 1002 Area to exploration requires approval from Congress, and Alaskan politicians are already marching toward that goal. U.S. Sen. Lisa Murkowski and U.S. Rep. Don Young, both R-Alaska, introduced bills in January in the Senate and House, respectively, that call for the 1002 Area of ANWR to open for the benefit of their state and the nation.

"Opening up the 1002 Area would attract all the usual suspects

See **Potential**, page 10

Albian to Cenomanian deltaic deposits in the Nanushuk Formation exposted on Marmot syncline, about 100 miles south of Prudhoe Bay. TAPS pipeline in background.

Geologists examine Upper Cretaceous strata along the Sagavanirktok River, 65 miles south of Prudhoe Bay. Oil seeps from Cenozoic sandstone near the top of this exposure helped guide the earliest exploration efforts in northern Alaska, contributing to the Prudhoe Bay discovery.

Potential
from page 8

already exploring on the North Slope," explained David Houseknecht, AAPG Member and senior research geologist for the USGS. "But it also would attract a much broader audience of domestic and international companies."

North Slope Potential

NPRA has long been thought to have significant oil and gas potential. That is why former President Warren Harding set the area aside in 1923 as the Naval Petroleum Reserve No. 4 when the Navy was converting its fuel source from coal to oil.

When northeastern NPRA was opened to leasing in 1999 and 2002, areas adjacent to Teshekpuk Lake were included, and 10 wells were drilled on that acreage by the industry – motivated mainly by the 1994 Alpine discovery, Houseknecht said. After disappointing results, those leases were relinquished and the Obama administration took the land off the leasing table in 2013.

Yet, after the relatively recent announcements of significant discoveries by Armstrong Oil and Gas, ConocoPhillips Alaska and Caelus Energy Alaska in the more shallow Nanushuk and Torok formations, there is an increasing certainty that a major fairway stretching from the Colville River Delta to the west margin of Smith Bay could hold the next hydrocarbon boom for Alaska.

Armstrong and its partner, Repsol, have reported 1.2 billion barrels of recoverable oil in its Pikka discovery, which was announced in 2015. Caelus estimates its 2016 find in Smith Bay at nearly 6 billion barrels of oil in place. If its anticipated recovery rate of 30 to 40 percent is correct, its producible oil potential would be between 1.8 and 2.4 billion barrels. ConocoPhillips reported last January that its Willow discovery in the Greater Mooses Tooth Unit may contain more than 300 million barrels of recoverable oil.

"These lowstand shelf margins where these big discoveries have been made run north-south over eastern NPRA and then turn to the west near the coast," Houseknecht explained. "They all trend right under the area currently not available for leasing."

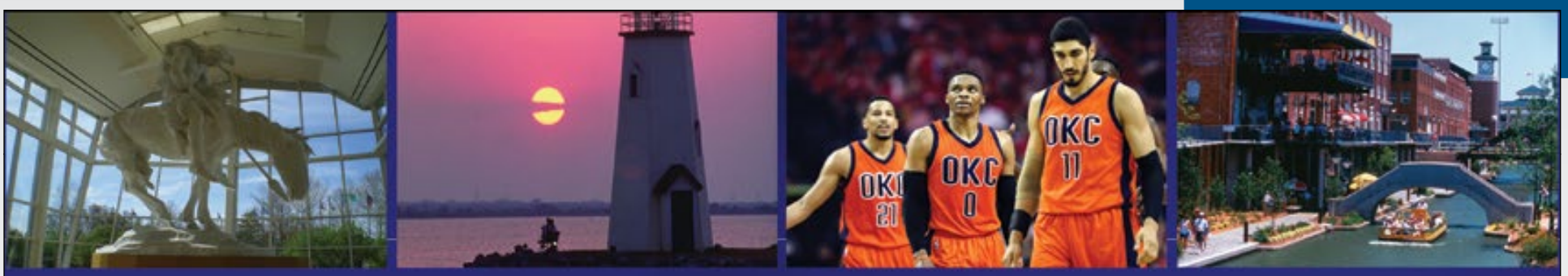
He added, "Almost the entire area that is currently off limits will be prospective for stratigraphic traps to the western coast of Smith Bay. If a lease sale were held tomorrow, a lot of companies currently on the North Slope and companies that haven't explored the Slope in the last couple of decades, I pretty much guarantee would show up in force to participate in that lease sale."

Needed: Updated Information

To develop an accurate understanding of the resources present in NPRA and in the 1002 area of ANWR – where resources are virtually unknown save for a small amount of data from 2-D seismic collected in 1984-85 – Houseknecht is quickly budgeting for the reprocessing of existing seismic data as well as accessing 3-D seismic.

"It is clear that there is potential for these stratigraphic traps to produce hundreds of millions or even billions of

See **Seismic**, page 12



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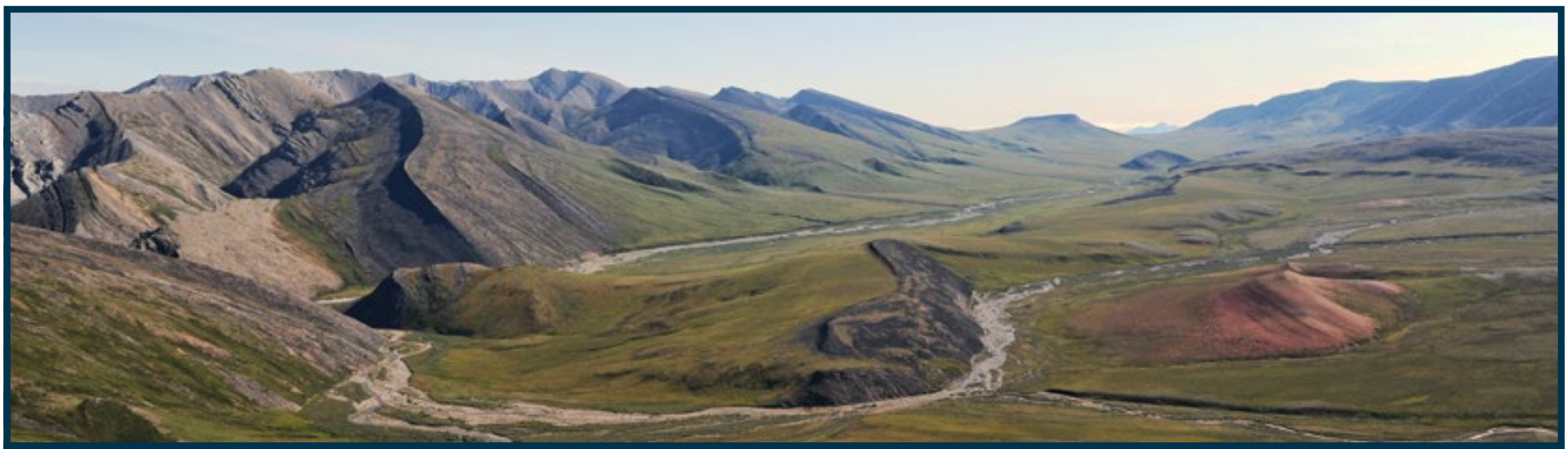

Eastward view along south flank of Sadlerochit Mountains and Ignek Valley. Orange-weathering rocks near center of valley are oil-prone Cretaceous source rocks. Oil generated in equivalent strata in the subsurface to the west partly or largely charged many oil fields in the region.

Seismic
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barrels of oil," he said. "But these traps are very subtle seismically. Using 2-D seismic makes it impossible to identify and map these stratigraphic trap geometries."

Mack said the Alaska government is working to release 3-D seismic data of the Nanushuk and Torok plays collected by the industry near NPRA. He said he believes they will be ready for public consumption in less than a year, citing "manpower" and "internal challenges" as the main reasons for the delay in their release. "It's very exciting information," he said of the data.

If ANWR's doors were to be opened and a lease sale to occur, industry likely would want 3-D seismic data for parts or all of the 1002 Area first, Houseknecht said. In the meantime, he is working to enhance the existing 2-D seismic data in ANWR and well data from just outside its boundary. Field work both in the 1002 Area and just outside its boundaries in the Wilderness Area is now occurring to locate the presence – or absence – of source rocks, source rock quality, geochemistry of oil from seeps and oil-stained rocks, timing and geometry of structures, and the quality of potential reservoirs.

Although excited about the potential of the industry's resurgence in Alaska, Mack emphasized the commitment his state has to the environment. "We want to look at these resources and demonstrate that we can be very careful and methodical about developing them," he said. "We have explored in NPRA safely in the past, and that was a remarkable feat, and we can do that again in NPRA and in ANWR."

Near vertical, basin-floor fan deposits in the Gilead Sandstone along the Ivishak River, about 80 miles southeast of Prudhoe Bay. The lower part of the Gilead Sandstone is the terminal lowstand fan deposited east of the ultimate shelf margin of the Torok-Nanushuk clinothem.

Assumptions
from page 6

industry will be needed," Sayal said.

"In terms of petrochemical demand, I think Asia will be the marker, in terms of plastic, clothing, materials," he noted.

Whether or not they think Peak Demand will happen, and when it might happen, industry observers generally agree that demand will slow significantly in highly developed countries but will continue to increase in Asia and developing countries.

"People think of the plateau of demand as homogeneous or similar in all regions, but that's really not the case," Jones observed.

"The mature markets, being the U.S. and Europe, will decline and accelerate the decline earlier in the cycle," he said.

Last year the global consulting firm McKinsey & Company issued an outlook on Peak Demand for crude oil, based on six assumptions:

- Emerging and developing countries will drive all growth in energy demand, while European and North American demand will decline.
- Growth in global energy demand will decelerate to 0.7 percent per year through 2050.
- Chemicals will grow at more than double the rate of total energy demand, while light-vehicle demand will peak around 2023.
- Demand for electricity will outpace demand for other energy sources by more than two to one. Solar and wind will represent almost 80 percent of net added capacity and 34 percent of generation by 2050.
- Fossil fuels will dominate the total energy mix through 2050, but their share of total energy will decline to 74 percent from 82 percent.
- Energy-related carbon dioxide emissions will flatten and start to decline around 2035 as a result of the transformation of light vehicles, with more-efficient combustion engines and more electric vehicles on the roads, and the shift to wind and solar in power generation.

Subsidizing Substitution

At this point, McKinsey isn't forecasting a peak in crude oil demand, said Scott Nyquist, senior partner in global energy practice for the firm in Houston.

"In our reference case we don't have it happening. It's not in our base case," he said. "We still have demand growth for the reasonable planning period."

But he isn't ruling Peak Demand out.

Substitution of oil use by natural gas and other energy sources, projected growth in hybrid and electric vehicle sales, subsidies for renewables and energy efficiencies – all point to reduced demand growth for crude, Nyquist noted.

"Now when we see what's been going on with battery development and with subsidies, that leads to an outcome in our model where we do hit peak demand for transportation fuel by 2025," he said.

Today's White House might favor oil production over subsidies for renewables, but that won't have much effect on the global picture, according to Nyquist.

"All kinds of countries are continuing to put in subsidies. Norway is an extreme example for electric vehicles," he observed. "You look back at solar, we had subsidies in Spain, we had subsidies in Germany, then we had subsidies in California, and that kept growing the volumes."

People who didn't expect renewables to claim any significant percentage of energy production simply misjudged the effect of subsidies and regulatory intervention on the industry, Nyquist said. With support, that industry has been able to move down the learning curve.

"For a lot of the solar and wind side, they're over the hump now, so to speak. They're able to grow without subsidies – they have a lot of momentum," he said.

In power generation, recent numbers show lowest-cost solar starting to approach natural gas in cost-per-kilowatt hour.

"Four or five years ago we would have said that gas would have an advantage over solar for a long time. And here they are competing," Nyquist said.

Economic Energy Efficiency

McKinsey also has forecast growing efficiency in the energy intensity of the world economy, the amount of energy required to boost gross domestic product (GDP).

"Accounting for all sectors of the economy, the energy intensity of global growth will fall by 50 percent through 2050," McKinsey predicted.

Jones agreed that efficiencies in energy use for economic output add up to another factor pointing to slower demand growth.

"In energy intensity, in terms of cost per unit of GDP, we have an amazing record," he said.

A shift toward increased refining capacity in the Middle East, Asia and parts of the developing world, combined with more trade and competition between refining centers, could mask some of the changes in global product demand, Sayal noted.

For example, he said, in the period 2012-20, Saudi Arabia expects to increase refining capacity by 1.2 million barrels a day.

"By the same token, the (existing) refineries that are not so efficient, they could be under some threats from imports from other countries and markets," Sayal observed.

Changes in vehicle efficiency and use, particularly in cars and other light vehicles, also figure into the IHS Markit outlook.

"India and China are taking some leaps based on the pollution you see in both countries. In China by the 2020s you see the effect of LNG coming into the trucking market. In India you see smaller and more efficient cars coming into the growth," Sayal said.

But Jones said the big picture doesn't include an overall drop-off in vehicle miles, even if some of those become miles ridden in semi-autonomous vehicles instead of miles driven. Global vehicle ownership is on the increase and mobility will become more affordable for more people as technology improves and ride-hailing and car sharing services develop.

"What will happen is that the amount of driving will go up. People won't be destined to have to ride on a fixed rail. They'll have more ability to go directly from point A to point B," Jones said. "We'll have efficiency gains, but the total ridership will rise."

Projections of Peak Demand timing range from "sometime in the next decade" to "never." The oil industry is following the issue closely because of the whispered possibility of "oil left in the ground."

Said the IEA's current outlook:

"A combination of sustained high prices and energy policies aimed at greater end-use efficiency and diversification in energy supplies might actually mean that peak oil demand occurs in the future before the resource base is anything like exhausted."

Conference
from page 3

100 years. Even a long-lived AAPG Member's career spans only part of the evolution of any richly endowed basin. That is why AAPG leads the way in providing technology transfer from past to future generations of explorers. (See "Heritage of the Petroleum Geologist" by M. T. Halbouty in the July 1967 AAPG Bulletin.)

The "Global Super Basin Conference" will not only explore the innovative history of individual super basins but will also offer opportunities to share best practices *between* super basins. AAPG plays a key role in areas that were fertile crescents for developing oil-finding skills that have been transported by AAPG members around the world. In a talk I give on giant fields by decade (work done with Robert K. Merrill, AAPG Memoir 113, in press) one can see from decadal time slices of giant field discoveries how oil finding "know how" progresses outward around the globe, which can be found online at AAPG.to/vpm17mccs.

In conclusion, AAPG is off to a great start in FY 2018. AAPG will focus on our goals and providing valuable scientific and professional content to fulfill our mission. We are also looking at education, research, and early workforce trends for the next decade. But that, dear friends, is another column, for another day!

Charles A. Sternbach

Dvořáková accepting a gift from past AAPG President Will Green during the opening ceremony at ICE 2007 in Athens, Greece.

Award
from page 4

Russian was a primary language of education during the Iron Curtain days. In addition to those languages, Dvořáková could communicate in Slovak, Polish, and a few words of French. Non-European AAPG members who listened to Dvořáková's charmingly accented English pronunciations during committee meetings probably were not aware that she did not speak a word of English until after the fall of the Iron Curtain, when she was about 30 years old.

As her colleague Istvan Berzci noted, "(Vlasta) opened the door of central and eastern Europe for the AAPG … She lived the first two decades of her professional carrier in a communist country almost isolated from the west. She understood and respected the mentality of the people in the central and east European countries with their tumultuous and tragic centuries."

Everyone who met Dvořáková remembers how she combined precise work and timeliness with emotional engagement. Her female friends admired her fashion sense and personal style. She was a successful geoscientist, volunteer and role model, and a witty and warm friend to all who knew her.

She left us all too soon on June 12, 2015, after a difficult disease and we will miss her greatly. As her dear friend Terry Engelder noted, "She gave a lot of herself and her means to participate with her friends and colleagues within AAPG. They were her world and meant everything to her and she never had a chance to say goodbye."

The Award

As Dvořáková demonstrated with her relentless service to the Association, this new award is dedicated to a Member or Associate who has demonstrated excellence, enthusiastic participation, organizational creativity, leadership, integrity, dedication and passion the activities of the Association and their promotion and organization outside the United States. The individual must have served in volunteer positions within the organization for a minimum of five years, either at the regional or global level. He or she must have played a leadership role in promoting and organizing international events (ICE, Regional conferences, workshops, etc.), establishing greater connection and collaboration between the regional professional and academic societies and the Association, thus aiding the Association in expanding its outreach and opportunities.

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.

John Joyce Carter

From Civil War Hero to Petroleum Entrepreneur

By S. GEORGE PEMBERTON and ERIN A. L. PEMBERTON

John Joyce Carter came to America at the age of three and grew to become a highly decorated Civil War hero and a successful oil businessman.

He was born in Westport, Ireland, on June 16, 1842, the son of John Carter, a wealthy storekeeper, and Cecelia Joyce Carter. His parents died soon after his birth and unscrupulous relatives and others lost his father's estate. They then married off John's only sister, Honora, to a 19-year-old cousin who was soon to sail to America, and his sister undertook the care of her brother. They relocated to Nunda, N.Y., a small town just outside Rochester, sometime around 1845.

When the Civil War broke out, Carter served as a private with the 33rd Infantry Regiment of the New York State Volunteers. He was promoted through the ranks during his enlistment, eventually attaining the rank of captain.

The Battle of Antietam

The Battle of Antietam was fought on Sept. 17, 1862, and was the culmination of the Maryland Campaign of 1862, the first invasion of the North by Confederate Gen. Robert E. Lee. The 12-hour battle began at dawn on Sept. 17. For the next seven hours there were three major Union attacks on the Confederate left. More men were killed or wounded at Antietam than on any other single day of the Civil War. Federal losses were 12,410; Confederate losses 10,700. Although neither side gained a decisive victory, Lee's failure to carry the war effort effectively into the North caused Great Britain to postpone recognition of the Confederate government and gave President Lincoln the opportunity for which he had been waiting to issue the Emancipation Proclamation.

John Carter, as a second lieutenant commanding Company B of the 33rd New York, moved across the fields of the Mumma Farm to the right toward Dunker Church. They were separated from the rest of the brigade because they were forced to halt to allow an artillery battery to pass. By the time Carter's men could resume their advance, the rest of the brigade had gone ahead a considerable distance. Confederate forces occupying the West Woods fired upon the regiment's right wings; the regiment flew into confusion and began falling back in disorder. Carter reacted instantly, throwing his company across the pike just north of Dunker Church. Unnoticed by the Confederates, Carter commanded his men to halt and close ranks. The company then touched off several volleys as fast as they could, directly into the Rebels' flank throwing them back in disarray. The chaos created by Carter's company gave them enough time to wheel the 33rd about and cap their weapons. The entire regiment then delivered two volleys into the Confederates, who were already beginning to break from Carter's sudden assault. Though severely outnumbered, Carter then ordered his company to charge into the enemy's flank with a yell so loud that the Confederates became convinced a large force had descended upon them from nowhere and fled back into the woods.

Vintage magazine ad from Oil and Gas Journal. The picture was taken at the Carter Oil Company's Sistersville, W.V., headquarters in 1889. The two men holding the dog are Col. John J. Carter, founder of the company and Will H. Aspinwall, one of the first geologists ever hired by an oil company, employed by Carter when others scorned the use of "rock hounds." The image comes from the author's collection.

The early history of the oil industry in North America is populated by people who took risks and challenged the norms. John J. Carter was such a man.

Carter was awarded the Congressional Medal of Honor for his initiative and bravery.

During the two years after Antietam, Carter took part in the battles at Williamsburg, Mechanicsville, Golding's Farm, Fredericksburg and Marye's Heights/Salem Church. Carter was mustered out with his regiment on June 2, 1863.

Wanting to continue to serve the war effort, Carter received permission to raise a company of cavalry, which he accomplished in 30 days. He was then mustered in as captain of Company D of the 1st New York Veteran Cavalry on Oct. 10, 1863, and served in this capacity until February of 1865. As a cavalry officer, Carter was wounded twice, had five horses killed under him in action, refused amputation of his leg, led four successful cavalry charges in as many engagements and saw battle at places like Upperville, Snickersville, New Market, Winchester and Waynesboro with the Army of West Virginia.

CARTER

After four years, three months and 15 days of service in the Grand Army of the Republic, Carter was mustered out of service at Rochester, N.Y., on Aug. 2, 1865.

Carter Oil

After the war, Carter returned to Nunda, N.Y., and married Emma Gibbs in June of 1866, but they soon relocated to Titusville, Pa., and opened a clothing store.

In 1877 he invested in an oil-drilling venture, which was very successful.

In 1893, he founded the Carter Oil Company and served as president of that company until his resignation in 1915.

The Carter Oil Company became an affiliate of the Standard Oil Company in 1895 and, as president of the Carter Oil Company, Carter was called upon by Standard Oil to make inspection trips and report on existing conditions and prospects for further development by Standard Oil. From 1906 to 1913 Carter was asked to examine opportunities in California, Japan and Peru, where he proposed the purchase of extensive holdings in oil-bearing properties. Carter was also instrumental in purchasing holdings in Oklahoma just before he retired.

In 1915 the Carter Oil Company opened a western division and began producing oil in the west.

Carter, now 73, resigned as president. Following his resignation, Carter Oil expanded further, opening an office in Tulsa in 1915, and between 1915 and 1926, huge oil pools were developed in Oklahoma and Kansas, and soon after established the Carter Oil Research Laboratory. In 1929, Carter Oil purchased Humble Oil and Refining Co. for $3 million and Slick-Urschel Oil leases in Oklahoma City for $5 million.

With additional purchases, this made Carter Oil one of the largest oil companies in the United States.

By 1949, Carter Oil had produced a half billion barrels of oil since 1893 and had more than 4,000 employees. In the early 1960s, Carter Oil merged with Humble Oil and Esso to become Exxon, which after the merger with Mobil is now named ExxonMobil.

Carter developed pneumonia and on January 3, 1917, he died at the age of 74 and was buried atop a small hill in Woodlawn Cemetery on the edge of Titusville, Pennsylvania.

Carter Oil Innovations

Carter Oil was one of the most innovative companies, not just in the petroleum business, but in general:

- In 1904 Carter instituted one of the first annuity programs for employees in the United States.
- In 1910, seeing the future of the automobile, he built the Anschutz gasoline plant in Sistersville, W.V., the largest in the world, and the first of 30 plants Carter Oil would build in West Virginia and Ohio.
- In 1913, he instituted paid vacations for workers.
- Just before his retirement, he instituted the first eight-hour workday.
- Later, death and sickness benefits were added to this package.
- Carter Oil was among oil industry leaders in exploration, drilling methods,

Continued on next page

S. PEMBERTON

S. George Pemberton is currently the C. R. Stelck Chair in petroleum geology and a distinguished professor in the Department of Earth and Atmospheric Sciences at the University of Alberta. The main thrust of his research pertains to the application of ichnology to petroleum exploration and exploitation. His recent work has been on the application of ichnology to the flow of fluids through the reservoir in both clastic and carbonate settings. He has actively worked on major hydrocarbon bearing units all over the world.

Erin Pemberton is a geoscientist covering the fields of sedimentology and stratigraphy with a keen interest in seismic stratigraphic analysis and depositional systems interpretation. She recently graduated with her doctorate in geology and geophysics from the University of Calgary and now works in the Subsurface Technology-Sedimentology and Stratigraphy Group at ConocoPhillips in Houston.

E. PEMBERTON

Continued from previous page

production and refining techniques as well as marketing practices.

Carter Oil was also a pioneer in utilizing technology and a scientific approach to petroleum exploration, and Will H. Aspinwall is considered one of the first full-time geologists ever hired by an oil company. Carter employed him when others scorned the use of "rock hounds."

A Carter Oil Legacy: Sequence and Seismic Stratigraphy

The Carter Oil Company Research Laboratory was one of the industry's best and was the initial employer of Peter Vail, Robert Mitchum and John Sangree. The lab eventually merged with Humble Oil to form the Exxon Production Research Laboratory and all three men were instrumental in the development of Seismic and Sequence Stratigraphy. Stratigraphy, once considered to be a somewhat routine and mundane discipline consisting mainly of the dry cataloguing of lithostratigraphic units, has undergone a dramatic renaissance. With the advent of the genetic stratigraphic paradigm over the last three decades, stratigraphers have radically altered how we perceive and, therefore, interpret the rock record.

Genetic stratigraphy lies at the core of three main stratigraphic paradigms: genetic stratigraphic sequences, allostratigraphy and sequence stratigraphy. The recognition of stratigraphic breaks is essential in any genetic stratigraphic paradigm but, also, is commonly a difficult task, particularly in subsurface analysis. Discontinuities reflect processes that are external to the depositional system (allogenic), which may initiate or terminate deposition of sedimentologically related facies successions. Interpreting the origin of the discontinuity can be vital in resolving depositional environments of associated deposits and in determining the allogenic controls on depositional systems. To accomplish this requires the integration of facies relationships, physical sedimentology, seismic stratigraphy and sequence stratigraphic techniques.

Map of the battlefield of Antietam/Sharpsburg depicting Union and Confederate forces on Sept. 17, 1862. Antietam was the bloodiest single day of the Civil War, with almost 23,000 soldiers killed or wounded. Courtesy the Library of Congress.

Vail, Mitchum and Sangree all completed doctorates at Northwestern University, with the team of W. C. Krumbein, Ed Dapples and Larry Sloss, who discarded the old notions of geology and taught exciting new, open-minded stratigraphy and sedimentology.

At Carter Oil, Vail, Mitchum and Sangree played key roles in nurturing the growing concepts of both seismic and sequence stratigraphy. When Vail introduced these concepts, the effects on stratigraphic geology and seismic interpretation were comparable to that of plate tectonics on structural geology. It represented a fundamental paradigm shift and changed forever how we view and interpret rocks. Analysts say that Vail visualized sequence stratigraphy, Mitchum wrote it down and Sangree sold it. These concepts then were born at Northwestern University and nurtured at the Carter Oil Research Laboratory in Tulsa before being unveiled at Exxon Production Research.

The early history of the oil industry in North America is populated by people who took risks and challenged the norms. John J. Carter was such a man – an immigrant from Ireland who came to America and fulfilled the American dream. His journey took him from the battlefields of Antietam where he was awarded the Congressional Medal of Honor to the oil fields of Pennsylvania and establishing Carter Oil, which segued into ExxonMobil, nowadays the world's largest private oil company.

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.

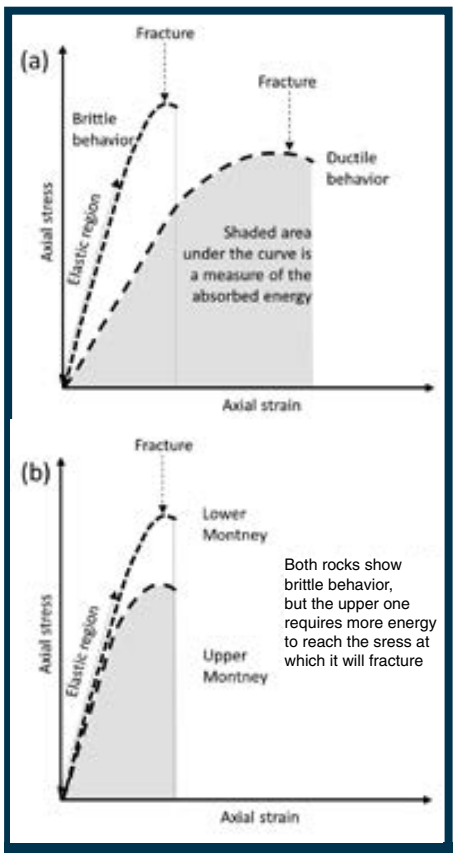

Figure 1: (a) Brittle versus ductile behavior of rock samples as seen on a stress-strain graph. (b) Both rocks showing brittle behavior, but one requires more energy to reach the stress level at which it will fracture.

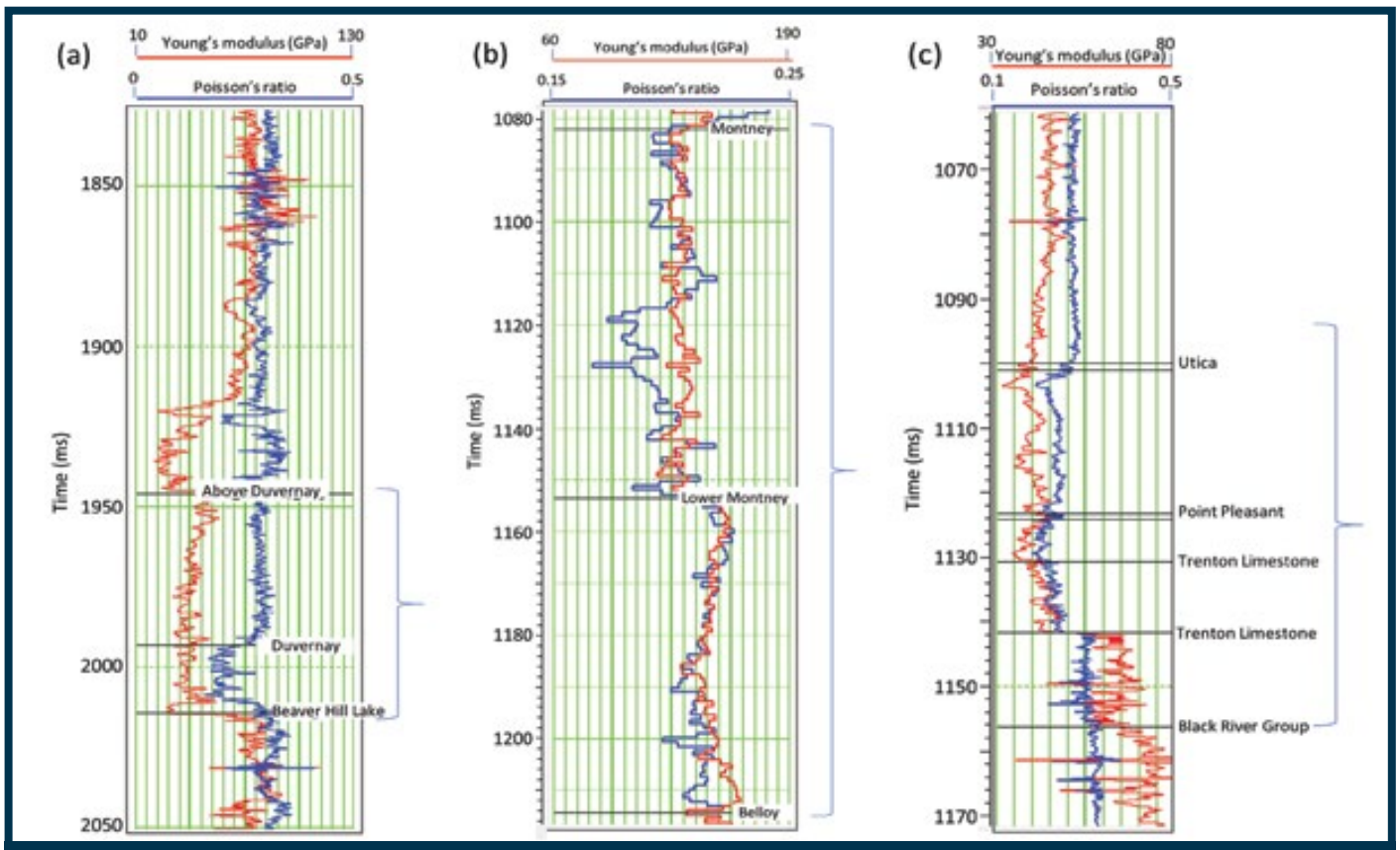

Figure 2 (above): shows the Young's modulus and Poisson's ratio curves for well data from (a) Duvernay shale in Kaybob area in central Alberta, Canada, (b) Montney shale in British Columbia, Canada, and (c) Utica shale from eastern Ohio, US. Notice a crossover between them only for Upper Montney. Such a crossover is not seen for the Duvernay and Utica shale intervals. The crossplots between Young's modulus and Poisson's ratio for well data shown in Figure 2 are shown in Figure 3 (below). The cluster points are all colour-coded with Gamma Ray values. Notice, the cluster points corresponding to the shale intervals of interest exhibit different values of Young's modulus and Poisson's ratio.

Misconceptions about Brittleness, and the Talk about Fracture Toughness

By SATINDER CHOPRA and RITESH KUMAR SHARMA

Hydraulic fracturing in very low permeability shale formations enhances the flow of fluids with the propagation of complex fractures through them, and is used for their exploitation. But effective propagation of complex fractures depends on a rock's ability to fail in a brittle manner. One might argue that all rocks should fail in a brittle manner when put under stress, as we do not expect any ductile behavior in rocks analogous to metals.

However, not all rocks exhibit similar brittle behavior, and thus we need to be able to quantify this property in rocks. Consequently, different methods have evolved over time, which are based on (a) mechanical properties, (b) their rock composition, and (c) the use of elastic parameters characterizing the rocks.

During the last decade, as the shale resource characterization has come to the fore, the term "brittleness" has become a buzzword. Interestingly, though we look for a way to quantify brittleness of rocks, there is no universally accepted definition or measurement of brittleness, and more than two dozen methods have been suggested by different authors under the aforementioned three categories. The underlying assumption in these methods is that a formation with high brittleness is easy to fracture, which is not always true. We have discussed the brittle versus ductile behavior of rocks in terms of stress-strain curves in our article published in the Geophysical Corner of the October 2015 issue. We include figure 1a here showing such a difference in behavior in terms of their energy absorption.

The methods in categories (a) and (b) above make measurements or carry out analysis on rock samples, and use that information to compute a brittleness measure. Methods under category (c) can determine elastic parameters from seismic data and after appropriate corrections compute a brittleness measure. As these methods yield spatial distribution of brittleness from 3-D seismic data, they are found to be attractive.

CHOPRA

SHARMA

Let us try and analyze the elastic parameters that are used in these methods.

Poisson's ratio is a measure of the *strength* of the rock, and Young's modulus is a measure of the *stiffness* of the rock. We assume that brittle rocks need lesser effort to break, so their Poisson's ratio should be low. At the same time, we associate high stiffness with the quality of the rock that would fracture easily and the fractures stay open, or its Young's modulus is high. Thus, we look for high

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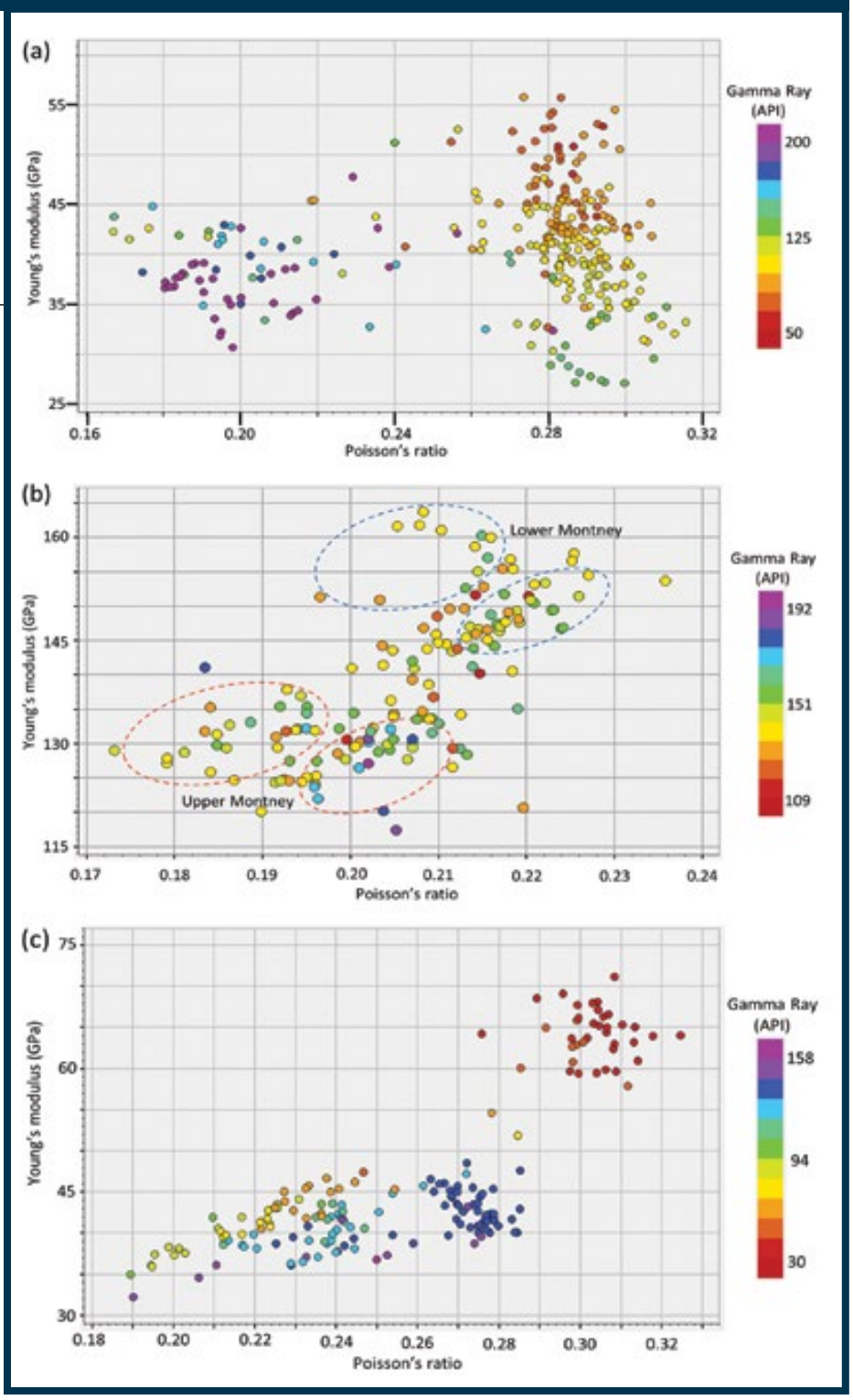

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Young's modulus and low Poisson's ratio for finding brittle pockets in our attempts at finding sweet spots in shale formations.

This combination of high Young's modulus and low Poisson's ratio as a measure of brittleness may not be true for all shale formations, as different shale formations exhibit different characteristics based on their mineralogy. In figure 2 we show the Young's modulus and Poisson's ratio curves and their cross plots for three separate shale formations. The first one is the Duvernay Formation in the Fox Creek area in central Alberta, Canada. The second example is from the Montney Formation in British Columbia, Canada, where the Upper and Lower Montney shales are cross-plotted. Notice the Lower Montney exhibits high Young's modulus and high Poisson's ratio, whereas the Upper Montney show low to intermediate Young's modulus and low Poisson's ratio. Our third example is from Utica Shale in Ohio, and it shows low Young's modulus and low Poisson's ratio.

Fracture Toughness

Let us go back to figure 1a and try and understand the different definitions in terms of the stress-strain diagram. A material is said to be brittle when it breaks without absorbing much energy, and without undergoing any significant deformation. On the stress-strain diagram we can distinguish a ductile rock that absorbs more energy from a brittle rock, which absorbs less energy. The difference in the areas under the curves is a measure of the energy difference. As we hear the term brittleness, the above distinction flashes in our minds and we believe that the brittle rock is easier to break.

There is fallacy in this belief.

If we look at the stress-strain curve for the Lower Montney that exhibits high Young's modulus and high Poisson's ratio, and compare it with Upper Montney that exhibits low Young's modulus and low Poisson's ratio, then they would look as shown in figure 1b. Notice, Upper Montney shale would fracture at a much lower stress than Lower Montney. What this suggests is that Upper Montney should be easier to fracture than the Lower Montney, but we still label Lower Montney as being more brittle.

Engineers and geomechanics experts cringe at the mention of "brittleness," as they know that geoscientists are confusing the definition of brittleness with something they imply as better fracability.

So, where do we go from here?

One way would be to think of the rock that we are looking at, to be brittle and at the same time require less energy to break. This could be understood by considering the stress state at the tip of a propagating fracture. A rock can withstand fracture tip stresses up to a critical value, which is referred to as the critical stress intensity factor; this ability of a rock to resist fracturing and propagation of pre-existing fractures is known as "fracture toughness." It is an intrinsic rock property.

The consequent strain energy build up needs to reach its critical value, before a pre-existing fracture propagates. This balancing of the critical stress intensity and critical strain energy release rate can help determine fracture toughness in the tensile mode of fracture propagation that we are interested in. The fracture toughness thus emerges as a measure of a rock to resist fracture growth. Rocks with low fracture toughness promote fracture propagation.

Determining Fracture Toughness

Finally, as answer to the question above, we need to develop a way to determine fracture toughness from seismic data. This would help us determine brittle pockets that exhibit lower fracture toughness, and thus represent more meaningful sweet spots that engineers describe as fracture efficient.

In figure 3 we show a horizon slice from an inverse fracture toughness volume from the Duvernay Formation. Overlaid on this display is the induced seismicity data, which has been collected to monitor the seismicity in the area. Notice the seismicity trend matches the higher values of inverse fracture toughness, and provides the required confidence in its interpretation.

In conclusion, fracture toughness measures should be preferred over brittleness, as the latter does not yield information about fracability of the formation. Fracture toughness measures from seismic data would allow more confident picking of sweet spots on 3-D seismic data volumes, and the subsequent accurate planning and designing of hydraulic fracturing.

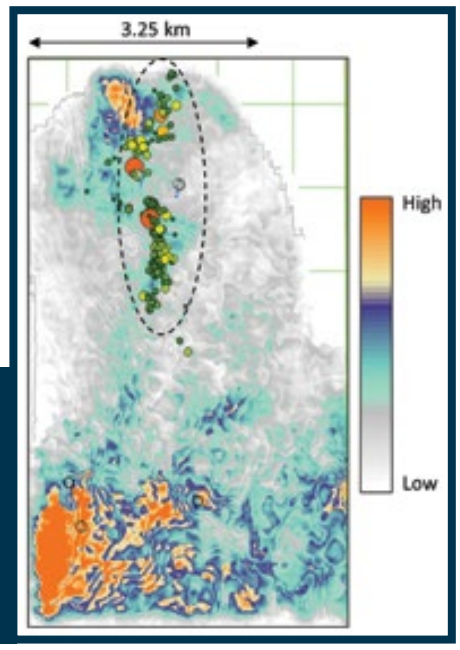


Figure 4: Horizon slice from inverse fracture toughness measure volume for the Duvernay formation in the Fox Creek area in central Alberta, Canada. Notice, the high values of inverse fracture toughness measure (or low values of fracture toughness measure) correlate well with the induced seismicity data overlaid on the display. Induced seismicity data is courtesy of Repsol Oil and Gas, Canada.

Basin Modeling on the Verge of Major Advances

By DAVID BROWN, EXPLORER Correspondent

To understand the future of basin modeling, you need to know the ABCs of some relevant computing tools.

Also D and E.

In coming decades, these tools in combination will enable the industry to do basin modeling at a greatly advanced level of interpretation and scale.

Here's a quick guide.

A.

Analytics is the identification and interpretation of meaningful patterns in data, derived from computer processing, statistics, and both real-time and historic monitoring. It draws on information resulting from the systematic analysis of data.

B.

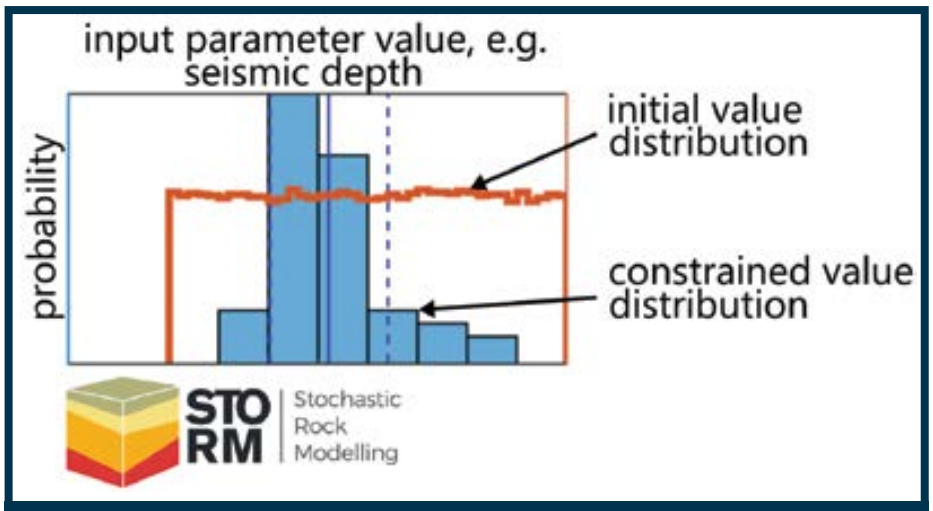
Bandwidth optimization refers to techniques for increasing data transfer speeds and efficiencies, especially across wide-area networks.

C.

Cloud computing uses a network of servers hosted on the Internet to store, manage and process data, providing shared computer processing resources and data to computers and other devices on demand.

D.

Distributed computing allows networked computers to communicate and coordinate their actions to perform a defined series of tasks or to achieve a goal. Data processing power can be amalgamated in a distributed network, along with shared data, software programs and storage devices.



StoRM, or "stochastic rock modeling," uses geological information to set up probabilistic distributions of input parameters. Image courtesy of the Norwegian University of Science and Technology.

E.

Edge computing enhances cloud computing systems by performing processing at or near the source of the data, at the edge of the network. It reduces the bandwidth needed between the data sources and data processors by performing analytics and knowledge generation near the data source.

Big Data

Advances in basin modeling today target the handling and utilization of enormous sets of data. One well site can produce terabytes of data daily, said Sashi Gunturu, founder and CEO of Petrabytes Inc. in Houston.

Petrabytes analyzes oilfield data in the cloud with 3-D and 4-D visualization of large datasets, applying an artificial intelligence (AI) model and using analytics throughout the asset lifecycle in seismic, drilling, completion and reservoir monitoring.

Gunturu said the company converts data to images "rather than trying to process every single point of data, which might not be so effective." The outcome is pattern recognition for basin modeling based on millions of images, he said.

"If you have a million images, it's almost impossible for a human being to process. That's where you need an AI approach," Gunturu said. "We are able to do this because of the scale of the cloud, and edge computing."

Data that's already gone through some processing and analysis is often referred to as "rich data." A key advantage of edge computing comes from processing data at the data-capture site.

"You compute as much as you can at the well-site location, and you only transmit rich data to the cloud," Gunturu said.

In addition to real-time, sensor-captured data from the field, publicly available historic data can be analyzed and added to enhance the basin modeling process, according to Gunturu.

"The big thing is combining the public data with the active, measuring data. It's a combination of the pre- and post-processing with real-time modeling," he noted. "At the end of the day, the interpretation is an integration of all this."

"The big piece is, as the data gets bigger and bigger you need a distributed infrastructure. Onshore it works really well because it's all well connected. Offshore, the data transmission and the connectivity

See **Probability**, page 29

An 'Under the Radar' Wildcatter

Terry Mather wins Norman H. Foster Outstanding Explorer Award

By BARRY FRIEDMAN, EXPLORER Correspondent

"I was always looking for a deal where I could get some slice of the pie."

That's AAPG Emeritus Member Terry Mather, this year's Norman H. Foster Outstanding Explorer Award winner, talking about motivation, talking about his life in exploration (specifically wildcatting), talking about the excitement, and talking about – at times – the letdown, where there wasn't a slice of the pie.

Terry Mather doesn't like talking about himself. Many of this year's AAPG award winners share that trait. In Mather's case, he said, "I like flying under the radar," an attitude that comes, generally, out of his own modesty, but specifically and perhaps more importantly, from years of respect for his investors, who have not wanted their upcoming projects bandied about in self-glorification or idle gossip.

But he will tell you this.

"It's been a fun, exciting career. I'm retired now."

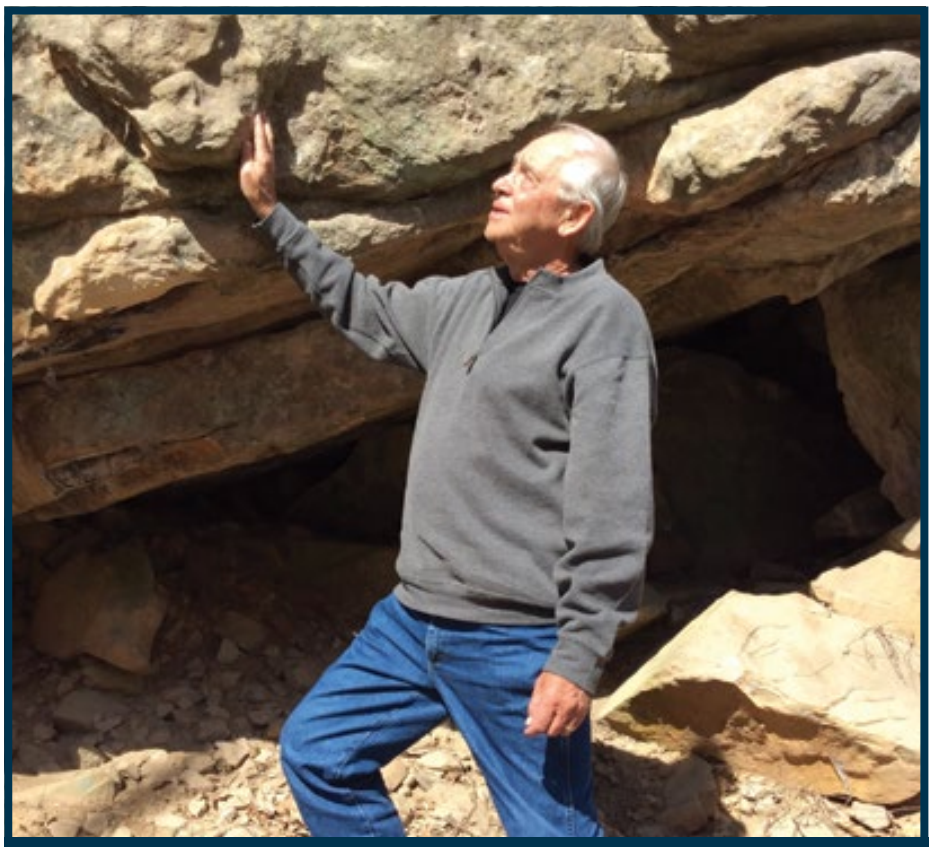
And then admission.

Other than its effect on his portfolio, "I don't really worry about oil prices."

Perhaps not, but he once told a magazine reporter in 1991 that he was a wildcatter.

And once a wildcatter, always a wildcatter.

While Mather's career has been long and successful, finding active plays in both Kansas and Colorado, he is perhaps best known for his work in western Idaho and eastern Oregon, plays – and he exhales when he talks about it – that took almost half a lifetime to come to fruition.



Mather at Devil's Lake State Park in Baraboo, Wis.

"This was such a wild wildcat," he said of the Idaho project, "but on the other hand, I started working on it in 1983, and finally got it drilled successfully in 2010."

He laughs about it now, especially the ten years he took off from the project, but you can still hear the exhaustion in his voice when the topic comes up.

"I mean, here's a state with no production, yet the geology seemed to set it up that there was good reason to think there was active hydrocarbons. Turns out that was the case."

Mindset of a Wildcatter

In retrospect, it still seems daunting to him.

"Trying to convince somebody to drill in a virgin state in a virgin basin – that was a real challenge."

But it worked.

Jack Eells, his partner at the time, commented, "How many explorers can lay claim to opening a new basin, let alone a new state? When was the last?"

The whole notion of motivation for Mather is not something he spends much time on, but he'll take a crack at a question about the mindset of being a geologist, being a wildcatter.

"I'll tell you, it's tough to define. You have to have the enthusiasm," he said, obviously, but added, "You have to focus on your strength, and by that I mean knowledge of the geological details, depositional models, structural models, and you have to listen carefully to your trusted peers and the contributions they make and their criticisms."

And this. Always this.

"Of course you have to be very, very

See **Art Form**, page 25

EM Tech As a Cost-Saving Complement to Seismic

By LOUISE S. DURHAM, EXPLORER Correspondent

Resistivity measurements are inarguably a basic necessity in the E&P realm where the distinction between water-filled pores and those containing resistive hydrocarbons in the reservoir is essential.

In the past, downhole wellbore logging was the only way to get a handle on formation resistivity.

While this approach remains the accepted standard in some instances, more sophisticated technologies are basking in the limelight. The downside is that widespread applications of certain newer developments in general await better times in the industry – read "higher commodity prices" – to reach their full potential.

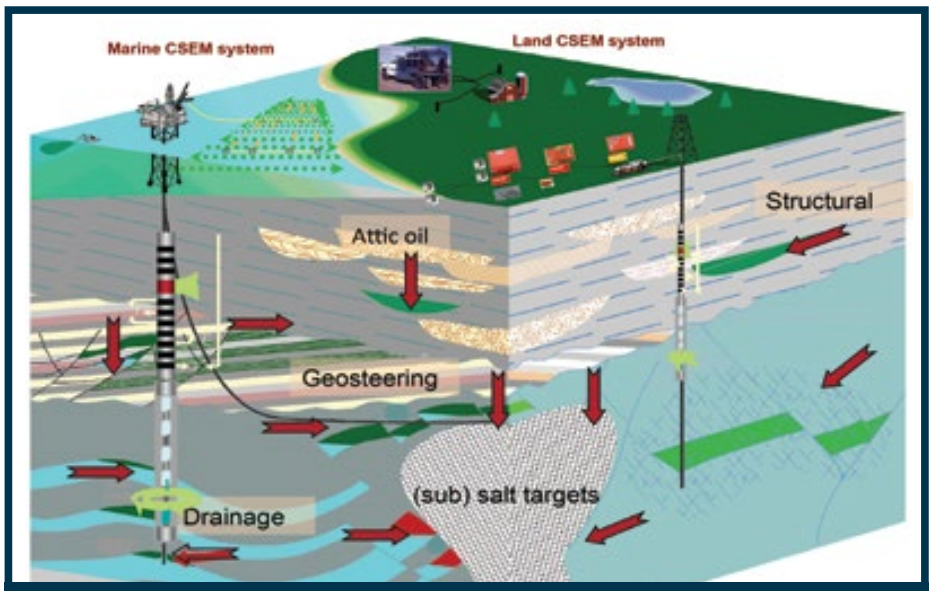
Over the last decade or so, marine controlled source electromagnetic (CSEM) technology has proven to be an effective tool to de-risk deepwater, really high cost drilling decisions. Yet it, along with magnetotellurics technology (MT), has both good days and bad days in the continuing uncertain financial environment.

Still, there's often going to be a way to make the most of valid oil industry technology despite negative external influence.

Basically, the focus here is on pore fluids and their response to electromagnetic energy (EM) in the target reservoir rock.

When applying CSEM, a self-supplied source – such as a horizontal electric dipole – transmits a low frequency electromagnetic signal into the subsurface by physically injecting current into the ground.

EM energy is noted for being attenuated rapidly in conductive sediments yet exhibiting slower attenuation and more rapid propagation in resistive environments such as hydrocarbons.



This figure shows how the electromagnetic system fits into the 3-D cube that is usually populated by seismic data. It shows a sketch of the marine and onshore acquisition scenarios with a salt dome. The high value targets are marked in red. Image courtesy of KMS Technologies.

"You can distinguish the fluid character (in the pores) by measuring the electrical resistivity of the rock," said geophysicist Kurt Strack, president of Houston-based KMS Technologies-KJT Enterprises, Inc., which he noted is the only firm manufacturing CSEM and MT equipment.

"This direct measurement is why electrical measurements are much more suited for fluid determination than other techniques," he said.

Strack is unquestionably up to speed in this milieu. Besides presiding over the company, he has been teaching EM and borehole geophysics at the University of Houston since 2000 and serves as an adjunct professor at universities overseas, including China and his home base, Thailand.

Pros and Cons of Magnetotellurics

Like CSEM, MT entails the use of sources, but these are naturally occurring electric and magnetic fields generated in the ionosphere.

MT is capable of penetrating thicker resistive layers but lacks the level of sensitivity toward thin horizontal resistors provided with the CSEM technique.

As a result, MT has great difficulty measuring anisotropy in transgresssive/regressive environments, such as sedimentary basins, where the sediment layers tend to have like physical characteristics in the horizontal direction unlike those in the vertical path.

The super-thin layers and lamina that occur in the vertical direction are unsuited to MT application.

Even so, when it comes to electromagnetics, MT has been the accepted workhorse of the industry since the 1980s.

Complementing Seismic

Although CSEM has been around for a time, it's more difficult to do, explained Strack, who noted that that's why people didn't pick up on it sooner.

Typical of this industry, perseverance was key to garnering respect for this complex application as a bona fide drilling-risk reduction technique in global basins.

There's more to come, when you consider the potential for this technology to complement seismic data for cost efficient deepwater reservoir appraisal and monitoring applications

"Recent (studies) have shown that time lapse CSEM data could play an important role in improving our knowledge of reservoir structure, fluid flow and fluid

Continued on next page

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saturation changes, requiring less degree of repeatability when proper acquisition and advanced 3-D integrated quantitative interpretation technologies are applied," Strack said.

The need to evaluate 4-D CSEM potential becomes a given.

Strack has a simplistic take on the combination of seismic – which is used principally for structure – and EM used for fluid typing.

"Seismic is like having the outside of a container where you see the bottle," he said. "EM tells you what's inside, tells you if it has oil or water."

Benefits of CSEM

Although new technology may suffer depending on industry circumstances, CSEM offers some positives that can help to elevate its use even now.

"One reason this has a hard time is because it's run independently, meaning the cost is very high," Strack emphasized. "If it's run combined with seismic, there would be the same logistics cost with only 10 percent more for the seismic to try the EM data.

"It looks like there will be a new generation after we overcome the current oil price scenario," he predicted. "It will have dramatically more channels and dramatically reduced cost in combination with seismic data, so the technology will become more readily available."

Even today, there's some rather impressive activity.

"The biggest jewel is subsalt," Strack exclaimed. "CSEM for EM salt is absolutely transparent, perfect for imaging; the salt is very resistive and the sediments very conductive. We did some fantastic


STRACK

Kurt Strack of KMS Technologies is one of the organizers of "Marine EM: Quo Vadis," a workshop to be held at the Society of Exploration Geophysicists International Exposition and 87th Annual Meeting in Houston, Sept. 24-29. The workshop will examine the use of controlled source electromagnetic (CSEM) technology as a drilling risk reduction tool.

imaging on land in Europe."

Sub-basalt offers another fertile arena for application.

Strack noted there are two kilometers of basalt north of the U.K. offshore and around India, emphasizing that CSEM and MT are being used in every exploration program in India.

He said there is essentially the same potential with Brazil and, in fact, all over Latin America, where there are volcanics.

Another promising energy niche he pointed to is geothermal exploration, where MT already is the standard geophysical technique.

When it comes to monitoring potential, the largest market Strack anticipates will be enhanced oil recovery (EOR). He commented that EOR was a $20 billion market in 2015 and is predicted to soar to $200 billion in 2010, considerably above his estimate of $80 billion.

Unconventionals loom as likely another big opportunity – think hydraulic fractures mapping.

Strack's goal for EM overall is straightforward.

"My interest is to be sure this technology survives," he noted.

Art Form
from page 23

careful about checking and re-checking the data to make sure you have it all and have it right."

Only then comes the selling, the cajoling and the marketing, which is also an art form.

"You have to have the ability to deliver your project to all audiences. Some audiences are very technically oriented, some are pretty naive."

He saw early on the difference between working for a company – the prejudices, layers of bureaucracy one needs to overcome in a large corporate setting where everyone has an opinion before the exploration begins – and the freedom of being on your own, pursuing the plays for which you have a passion and not having to worry about, for example, project size.

"The cool thing about being an independent is being able to have the freedom to explore, without the encumbrances (of a corporate set up). If you can convince a small investor, and you can go find four or five wells – 100,000 to 500,000 barrels – you're absolutely thrilled. The corporations, they could not care less about a project that size, but that much oil, or gas, represents a huge – huge – financial plus."

Love of the Chase

He said there wasn't a master plan when he graduated with a doctorate from the University of Colorado, other than that he knew he liked the oil business. He worked for six years with Shell Oil Company where he prepared stratigraphic studies in the Rockies, prospect generation in Illinois, Wyoming, Montana and Colorado, as well as being one of the first to apply stratigraphic geophysical analysis to plays. Along the way, he was responsible for supervision and prospect generation leading to the discovery of significant hydrocarbons in the Green River Basin and western Montana, and was part of a select team who founded High Plains Exploration, where he originated and sold a major, high-potential frontier play. Then, along with Eells, he founded Lariat Exploration, where they made significant discoveries in Kansas and the D-J Basin. In addition, he has had a 20-year association with Thomasson Partner Associates, headed by past AAPG President M. Ray Thomasson.

Why did he leave Shell to go out on his own?

"I didn't get to do a lot of exploration there," he said.

As for the award: "I tip my hat to all contributors to the project including others unmentioned. Also to the AAPG Executive Committee and Advisory Council who saw fit to grant me this honored distinction, you have my heartfelt thanks."

When he looks back at his career, while admitting he's "loved the chase," it was the whole process, the journey that he cherishes.

"That's why when you drill a dry hole, it's devastating."

Amoruso Resigns As Foundation Trustee

By TAMRA CAMPBELL, Administration Team Coordinator

John Amoruso, a longtime, legendary giant of both AAPG and the AAPG Foundation, has stepped down from his position as a Foundation trustee after having served in that capacity for more than three decades.

Trustee chair Jim Gibbs praised Amoruso for his dedication and leadership and said the Foundation does not have enough words to thank him for his service.

His resignation came at the official end of his term on June 30.

Amoruso, who served as AAPG president in 1983-84 and was named an Honorary Member in 1987, began his involvement with Foundation in 1984 when he accepted an invitation from Jim Wilson and then-executive director Fred Dix to join the Trustee Associates, a distinguished group of donors that support the Foundation's mission through fundraising and counsel.

In 1986, when the AAPG Foundation became an Oklahoma non-profit corporation, Amoruso was appointed a Trustee and became one of the original members of the Members of the Corporation. He served as the secretary until 1999, when he was elected vice-chair, a position he held until he stepped down.

During his time on the board, Amoruso saw the Foundation's assets grow from $5.4 million to more than $47 million today.

During those years he also took a leadership role in the capital campaign (2005-12) by becoming one of the team leaders who actively solicited new Trustee Associates and donors while promoting the Foundation's mission. The Foundation achieved substantial growth during this campaign, which has enabled the Foundation to fund programs and projects that have relevance in sharing and teaching the science to generations of future geoscientists around the world.

Left to right: David Worthington, Lee Backsen, Ray Thomasson, Jim Gibbs, John Amoruso, Larry Jones and Mike Wisda.

Amoruso was awarded AAPG's Michel T. Halbouty Outstanding Leadership award in 2007, given in recognition of outstanding and exceptional leadership in the petroleum geosciences – an honor that speaks volumes about his character and dedication to his career and science.

He also has taken an active role in shaping AAPG and the Foundation by giving selflessly of his time with service on numerous committees throughout both organizations. As he has himself said, as a member of these organizations it was his duty and honor to do so.

For example, Amoruso demonstrated his passion for sharing knowledge and preserving history through publications by generously supporting the Foundation's special publications fund – so much, in fact, that in 2013 the Foundation renamed this fund the "Amoruso Special Publications Fund." This endowed fund is used to provide grants to assist with publications cost for special projects.

He has been an important part of the Foundation – and although he will be missed, his strong example and influence remain part of the Foundation's story as it begins its next 50 years.

The AAPG Foundation would like to thank Camile for sharing her husband with us.

* * *

The current AAPG Foundation Board of Trustees is:

- ❒ **Jim Gibbs**, chairman.
- ❒ **Ray Thomasson**, vice chair.
- ❒ **Lee Backsen**, treasurer.
- ❒ **David Worthington**, secretary.
- ❒ **Larry Jones**.
- ❒ **Mike Wisda** (beginning his term).

Also, **Ted Beaumont** was elected to be a Member of the Corporation.

To learn more about the AAPG Foundation and its activities, please review the 2016 Annual Report found at foundation.aapg.org.

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

Foundation Contributions for June 2017

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L. AUSTIN WEEKS UNDERGRADUATE PROGRAM

The L. Austin Weeks Undergraduate program annually awards undergraduate geoscience students and student-led organizations with $500 grants. The grants are intended to support the educational expenses both inside and outside of the classroom.

Congratulations to the 2017 recipients!

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EMD

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until their last semester to take this required science class, I also had two freshmen getting an early start. I encouraged a very open forum class, especially involving geology-related stories on the Internet. During an introductory lecture and overview discussion on tectonics, plate motion and the crust-mantle interface, one freshman asked, very seriously, and citing some story online while holding up their smartphone, "the aliens in Atlantis, did they really move into the (hollow) Earth?"

Obviously, we had not gotten too far into the crust-mantle discussion! I had to be thoughtful and present an appearance of serious professionalism and replied, "While I absolutely hope and believe there are other intelligent beings in the universe, I suspect that if they were intelligent and advanced enough to come here, they would understand the geology of the Earth well enough to make the best choices. Let's talk a while longer and see if we can answer this question."

There are many more non-scientists than scientists and it is these we must reach, inform, and support while continuing our dedicated energy science efforts. Let's talk a while longer and see if we can answer these questions!

EMD President Doug Wyatt can be contacted at drdougwyatt@gmail.com and LinkedIn/in/drdougwyatt.

YPs Enter New Era with SIG, Leadership Team

By RYAN LEMISKI and ROBYNN DICKS


LEMISKI


DICKS

On July 1, 2017, the Young Professionals Special Interest Group (YP SIG) bid farewell to outgoing co-chairs Meredith Faber and Jon Allen. Over the past three years Meredith and Jon have revolutionized what it means to be a young professional member of AAPG, and the benefits associated with membership.

Their accomplishments are numerous, but some notables include:

- Establishing the Young Professional Exemplary Service Award. This award was presented for the first time in Houston during AAPG's 100-year ACE celebration.
- Forming and leading AAPG's first special interest group, the YP SIG, from the now defunct AAPG Young Professionals Committee.
- The Explorer ProTracks article series. These articles have helped to engage YP's from across the planet, highlighted important YP events, and has been fundamental in providing AAPG membership with a better understanding of the mission, values and goals of the YP SIG.
- Facilitating the Young Professionals Leadership Summit (YPLS). The industry downturn and its associated budget cuts led many to believe that the YPLS would fall victim to tough economic times; however, a scaled back version of the YPLS has been a big success over the past few years.

The YP SIG would like to thank Meredith and Jon for years of dedication and commitment to YP-related initiatives. Without their persistence, the YP SIG would not be the valuable membership program that it is today. Good luck to you both!

Beginning with the 2017–18 fiscal year, the new YP SIG leadership team comprises co-chairs Robynn Dicks and Ryan Lemiski, vice-chairs Maxim Kotenev and Juan Carlos Quinto, AAPG Programs Team Lead Susie Nolan and AAPG President-elect Denise Cox.

Region and section leads include:

- Ademola Lanisa (Africa Region)
- Reetu Ragini (Asia-Pacific Region)
- Low Wan Ching (Asia-Pacific Region)
- Marcelina Łabaj (Canada Region)
- Andrew Smith (Eastern Section)
- *Vacant* (Europe Region)
- Hunter Lockhart (Gulf Coast Section)
- Lizbeth Calizaya (Latin America and Caribbean Region)
- Pierre Karam (Mid-Continent Section)
- Abdullah Al-Kandari (Middle East Region)
- Brandi Johnson (Pacific Section)
- Nikki Oliver (Rocky Mountain Section)
- Joe Bauman (Southwest Section)

The YP SIG leadership team is focused on carrying the momentum built by previous leaders. In order to further the YP mission we hope to accomplish several goals over the next three years. These include:

> **The YP SIG strives to make AAPG membership more attractive to the YP demographic and to ensure young professional membership retention.**

1) Maintaining and enhancing programs that are currently offered through the YP SIG.

2) Encouraging AAPG student and young professional members to become members of the YP SIG. If you have yet become a member of the YP SIG you can subscribe here: aapg.org/sigs

3) Advancing all members of the YP SIG with AAPG associate member status to full, or "capital M," member status.

4) Investigate co-operative efforts with the Society for Exploration Geophysicists, the Geological Society of America, the American Geophysical Union, the European Association of Geoscientists and Engineers and other professional societies regarding petroleum industry geoscience outreach, perspectives on employment options in academia and government and the energy industry, and the potential for alternative sources of funding.

5) Establishing a mentoring network within AAPG that will allow young professionals to connect with experienced industry experts. The "great crew change" is upon us and senior geoscientists have begun leaving the workforce. It is imperative that we establish a mentorship program that will provide opportunities for experienced members to remain active so that knowledge and life skills transfer can occur.

The YP SIG strives to make AAPG membership more attractive to the YP demographic and to ensure young professional membership retention. We need your help in order to accomplish this. Regions and section leads of the YP SIG are always looking for volunteers. If you are interested in lending a hand, please contact your respective lead. Remember, AAPG allows one year of free membership with the YP SIG. Let us demonstrate to you the value of membership in this organization.

Finally, staying up-to-date on the latest YP news is easy. You can find us on various interweb social media platforms including Facebook, AAPG LinkedIn groups, Twitter (@aapgypsig), and Instagram (@aapgypsig).

Onward!

CLASSIFIEDADS

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Probability

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might not be so effective," he said.

Petrabyes hopes to establish an industry platform – essentially an interconnected digital work and processing area – for analyzing and imaging oil and gas data using cloud, distributed and edge computing, Gunturu said.

"We want to develop this collaborative part and scale it to a much higher level, especially with the sensing. We want to be that scientific platform, like a Google Docs for that platform," he said.

Stochastic Modeling

In other research, advanced computer-processing power has been applied to defining and refining data for basin modeling.

Krzysztof Jan Zieba is a researcher in the Department of Geoscience and Petroleum at the Norwegian University of Science and Technology in Trondheim, Norway, where he works on StoRM, a stochastic (analysis using randomly determined input parameters) rock modeling tool.

Traditionally, input data for basin models are determined based on "most trusted" values, Zieba said. Those values are usually derived from seismic data and geological information such as onshore outcrops and information from wells.

As a result, predictions of present and past rock properties and hydrocarbon accumulations may be based on "inherently biased" single-parameter values, he noted.

"The quality of the modeling relies on the availability of certain input data that are often unavailable or expensive. In the worst-case scenario, erroneous basin models might lead to wrong exploration targets," he said.

To address that problem, StoRM uses geological information to set up probabilistic distributions of input parameters.

Many basin input values can be described as either ranges or probabilistic distributions based on available data, Zieba said. For example, in Monte Carlo solutions, randomly sampled values of input parameters are used for creating multiple, alternative basin models.

But existing stochastic basin modeling does not test the interrelations between values of various parameters, Zieba observed.

That can lead to unlikely or even impossible results, where randomly sampled values of the input parameters cannot occur together based on geological knowledge or additional real-world measurements, he said.

"In our approach, we model basin infill history and related parameter changes forward in time from deposition of the first layer to the present by using randomly sampled input values. The modeling is an iterative process where millions of modeling runs are conducted one after another," Zieba explained.

"From millions of individual sets of input values, only a small fraction produces a rock column that matches the measurements. Only the matching values can be considered as likely ones, while the remaining ones need to be rejected in basin models," he said.

In this approach to analytics, each modeling run is calibrated to real-world observations and measurements as a reality check, Zieba said. A key calibration method compares modeled rock-unit depth boundaries to seismic depths or borehole data, he said.

Calibrations also can involve more sophisticated data, like net erosion thickness, paleo-water depth indicators or relations between paleo environments and sedimentation/erosion rates.

Future Development

The fully realized future of basin modeling doesn't exist quite yet. Gunturu mentioned the need for reduced compute time, better imaging, more capability in identifying sweet spots, creating a seamless workflow and bringing down processing costs.

Better and more capable interconnectivity is needed for computer tools, especially to give operators real-time capabilities.

"That loop doesn't exist yet," Gunturu said.

But the industry is somewhere on the verge of enhanced processing speeds and increased data inputs from seismic and sensors that will enable geoscientists to produce basin models at a level of quality and scope never seen before.

DIRECTOR'S CORNER

Going Back to First Principles

By DAVID CURTISS

Earlier last month I opened the 2015 biography of Elon Musk by Ashlee Vance and spent the weekend learning about this visionary and controversial polymath and entrepreneur.

Musk started out as co-founder of one of two companies that merged to form Paypal. It made him a wealthy man. And he used that wealth to create companies dedicated to two principal objectives: First, to make humans an interplanetary species by opening an outpost on Mars and second, by disrupting the energy sector – specifically, displacing fossil fuels through expanded and distributed solar energy production and the electrification of the transportation sector.

As if that wasn't enough, in 2012 he dreamt up the concept of the hyperloop: a ground-based transportation system with levitating trains shooting down a tunnel under vacuum at close to the speed of sound. After getting stuck in Los Angeles gridlock earlier this year, he announced a new tunnel-boring initiative to develop new technology to accelerate tunneling speeds and add the z-coordinate to L.A. traffic patterns through a network of tunnels.

What are you doing in your spare time?


CURTISS

> The public discussion of this energy transition in transportation is raising questions about how much oil is needed over the long-term.

Driving Innovation

Criticisms of Musk abound, particularly in the financial markets where he has proven unable to generate much, if any, profit with his companies. Yet, his skills as a promoter and booster are nearly unparalleled, and the result is that investors continue to pour money into his firms. And, to be fair, that's not unusual in the tech sector.

Profitably or not, he is disrupting established industries. SpaceX, his rocket launch firm, already dominates the commercial space market and is on track to control two-thirds of the commercial launch market by next year. This is the result of a resolute focus on lowering costs and innovating, activities that neither the U.S. government nor large defense contractors – his primary competitors in this sector – are known for.

Musk continually asks his engineers and scientists to take a problem back to first principles as they struggle to overcome a technical challenge. You need to be able to argue a position from the bottom up, he says, not relying on assumptions or prevailing wisdom or standards.

This approach to problem-solving – breaking it down to its component parts and testing everything – is what drives corporate innovation at his companies.

EV Mania

He's taken this same approach to the transportation sector where, last month, Tesla rolled its first Model 3 off the production line. The Model 3 is Tesla's fourth automobile, but its first with a price point that places it outside the luxury market, and Musk's plan is to scale production of this vehicle to 5,000 per week by the end of this year and 10,000 per week by the end of next year.

There were 17.5 million cars and light trucks sold in the United States last year. Producing 500,000 cars per year is a significant manufacturing achievement, but still a pretty small percentage of the total market.

Nevertheless, the oil industry is taking note and considering whether electric vehicles (EVs) could have a significant impact on global oil demand.

A July 14 article on Bloomberg.com, ominously titled "Big Oil Just Woke Up to Threat of Rising Electric Car Demand," discusses the trends and how the oil and gas industry is looking at EVs in the market place. It points out that ExxonMobil, BP and Statoil, along with the International Energy Agency have all increased the share of EVs they calculate in the global vehicle fleet in coming decades.

Volvo has announced that it will convert all of its cars and light trucks to hybrids by 2019, and France has declared that by 2040 it will phase out vehicle with internal combustion engines, so corporate and political decisions will affect how rapidly a transition to EVs occurs.

All this presupposes that the EV industry can actually deliver the volumes of vehicles needed at a price that people can afford. The projected demand for lithium and rare earth minerals for the battery packs alone is staggering.

Peter Tertzakian of ARC Energy Research Institute blogged on July 11 that all of this EV mania will have an impact on the oil and gas industry, "but it's not because electric cords are going to replace pump hoses anytime soon," because the transition isn't actually happening yet – people are not shifting in droves to EVs. They might be considering it, but it's not showing up in the sales figures.

The challenge for the oil and gas industry, as Tertzakian explains, is that while demand continues to remain strong, especially at current prices, the public discussion of this energy transition in transportation is raising questions about how much oil is needed over the long-term. And that could affect investor sentiment.

So what does that mean for E&P firms? All other things being equal, this battle will be fought on price: low oil prices will slow EV adoption; high prices will accelerate it. The winning E&P companies, Tertzakian says, will be those who innovate aggressively to keep their costs low, positioning themselves for success in either environment.

It's time to go back to first principles.

DIVISIONS REPORT: EMD

Serving the Global Need for Energy Knowledge

By DOUG WYATT, EMD President

I have taught evening classes at the local university for many years, always to science majors. In a way, I view it as therapy from my real job.

However, this past semester I had a different opportunity, teaching an Introduction to Physical Geology class to non-science majors. These were mostly seniors, ready to graduate, majoring in art, English, music and performance, and law enforcement. My goal was to teach them earth science and the broad use of the scientific method to understand their world. It was an eye-opening experience for me as I fully realized that the planet is populated mostly with non-science thinkers. The scientific method approach of observing, questioning, developing hypotheses, testing and theorizing was new to most. However, these students were fascinated with the science and concerned about the popular media discussion of global issues around energy, minerals, water, environment and human interaction. They truly wanted to learn and understand.

Many technical professional organizations are concerned with these issues. The AAPG membership, along and in conjunction with our sister organizations, is greatly involved in research, education and technology in these areas.


WYATT

> The EMD is a critical part of the muscle, bone and philosophy of the modern AAPG.

EMD's Role in the World

The Energy Minerals Division (EMD) has a very large role, mission and opportunity across all of these global topics, internally within AAPG and externally through meaningful technical reports, scientific papers, workshops, seminars, field trips and our day-to-day personal and professional interactions. Our technical and resource reports are routinely utilized by governmental and international users and our papers, workshops and field trips are important for presenting new ideas and an improved understanding of all earth-sourced energy systems.

The need for the expertise and knowledge of the EMD continues to grow, supporting an ever-increasing global demand in new energy science and utilization. Within the AAPG, the EMD scope covers much, including unconventionals, coal, coalbed methane, nuclear, hydrates and geothermal, and a growing potential role in rare-earth elements critical to technology. Our expanded reach includes the integration of other renewable energy resources such as wind and solar into the overall energy mix from those above.

The EMD is a critical part of the muscle, bone and philosophy of the modern AAPG. The inter-relationship of energy mineral resources, including discovery, extraction, utilization and integration remain more than two-thirds of the global diversified energy portfolio far into the foreseeable future. As energy mineral geologic systems are better understood, the integration and advancement of engineered earth energy systems becomes more probable and the utilization of our resources becomes more efficient. Oil, gas, unconventionals, coal, coalbed methane, nuclear, hydrates and geothermal, when considered together, represents an almost inexhaustible energy future.

A Scientific Approach

To support our membership and to provide the energy minerals science necessary for an effective energy future we must continue the successful practices of our past while developing the methods for the future. Not only must we develop and analyze the data necessary for efficient energy use, we must also analyze and develop new scientists and a better understanding of our energy planet across all peoples.

Utilizing the scientific method might be a guiding approach to do this. Observing what people know, think they know, and need to know, then questioning what they need to understand, developing a hypothesis for an approach to provide them that information, testing that our approach worked or did not work and then theorizing on next steps can help inform both scientists and non-scientists. My class of artists and musicians taught me that there is much the non-scientists want, and need, to know, and that many different approaches are needed.

Although I had mostly seniors waiting

See EMD, page 27