AAPG EXPLORER
FEBRUARY 2018

The End of Fossil Fuels in Europe?

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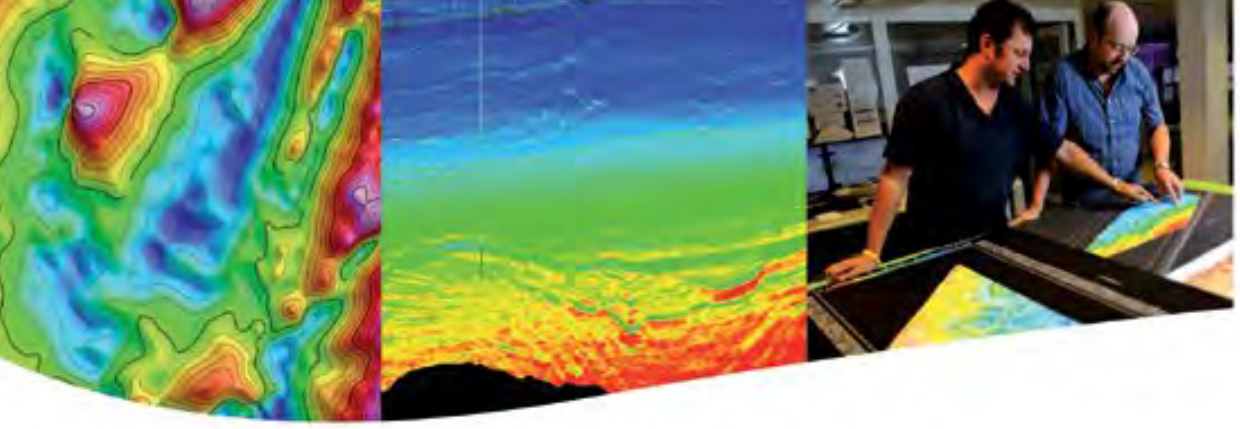
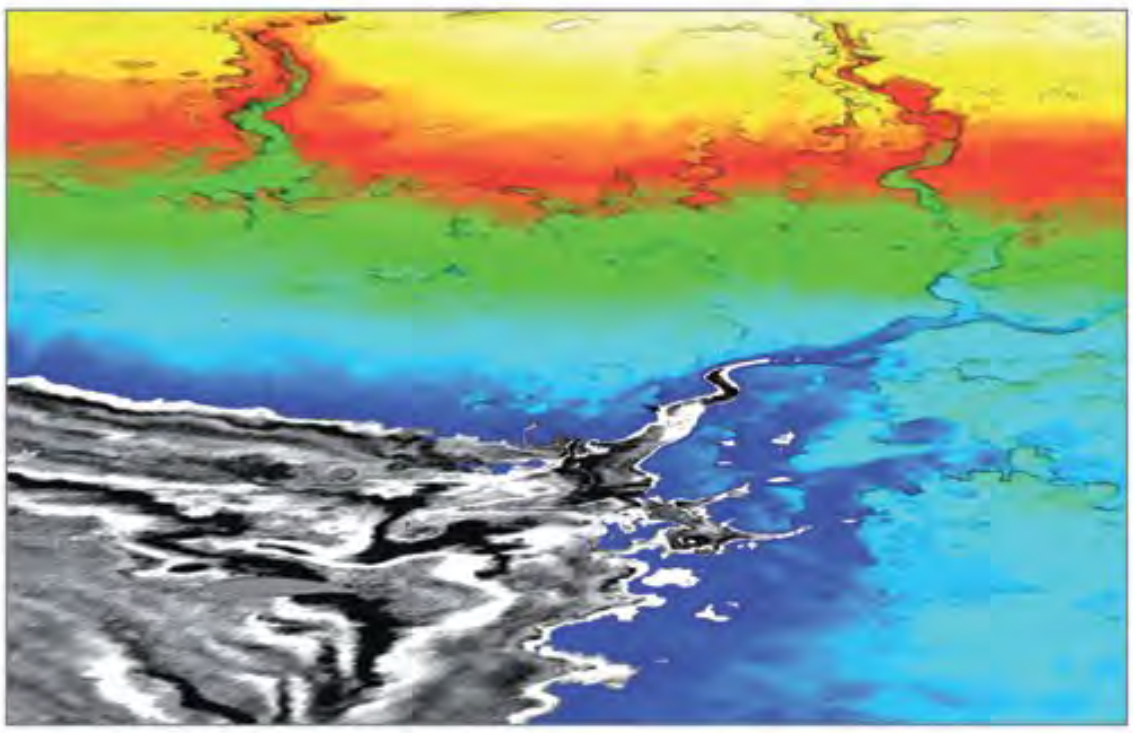
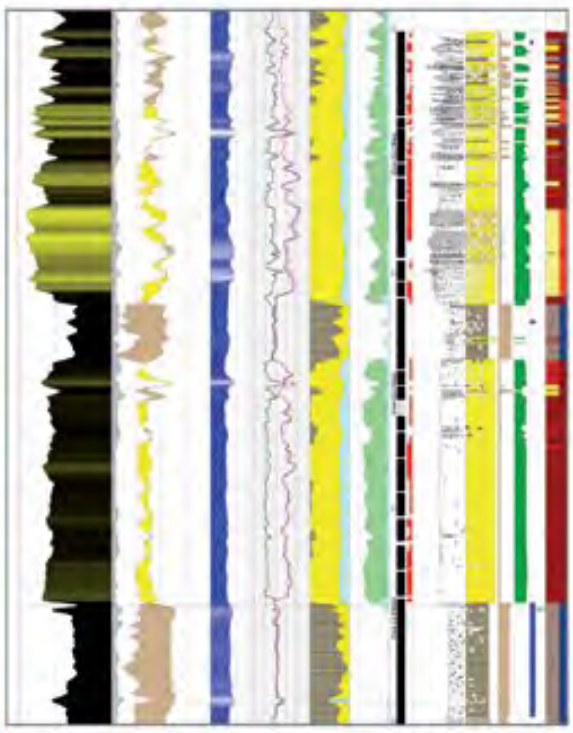
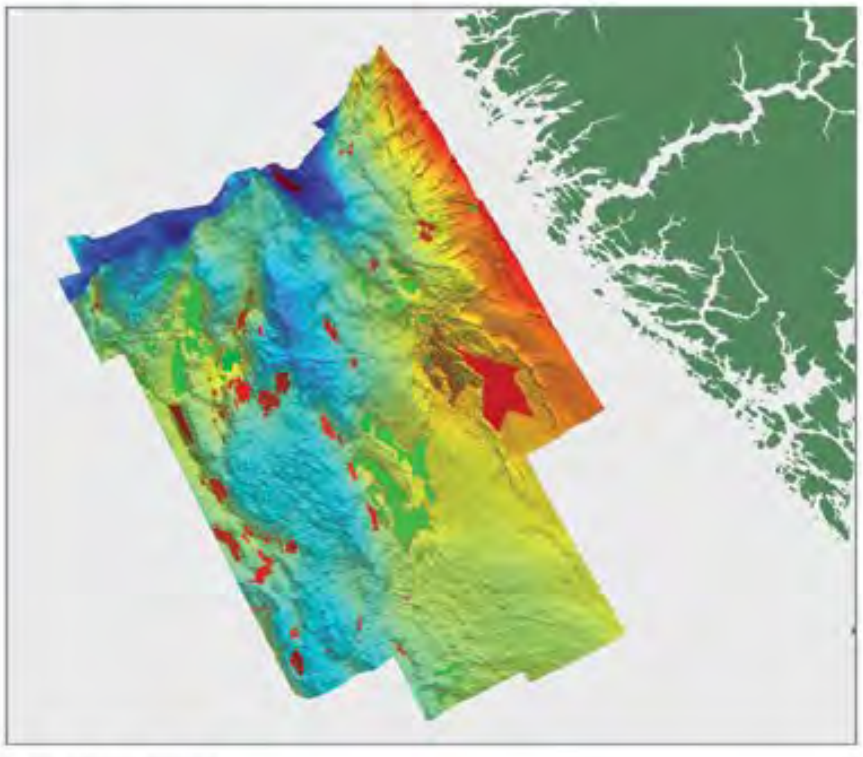


JumpStart Your Exploration

North Viking Graben







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Passion for Geoscience

By CHARLES STERNBACH 3

President's Column

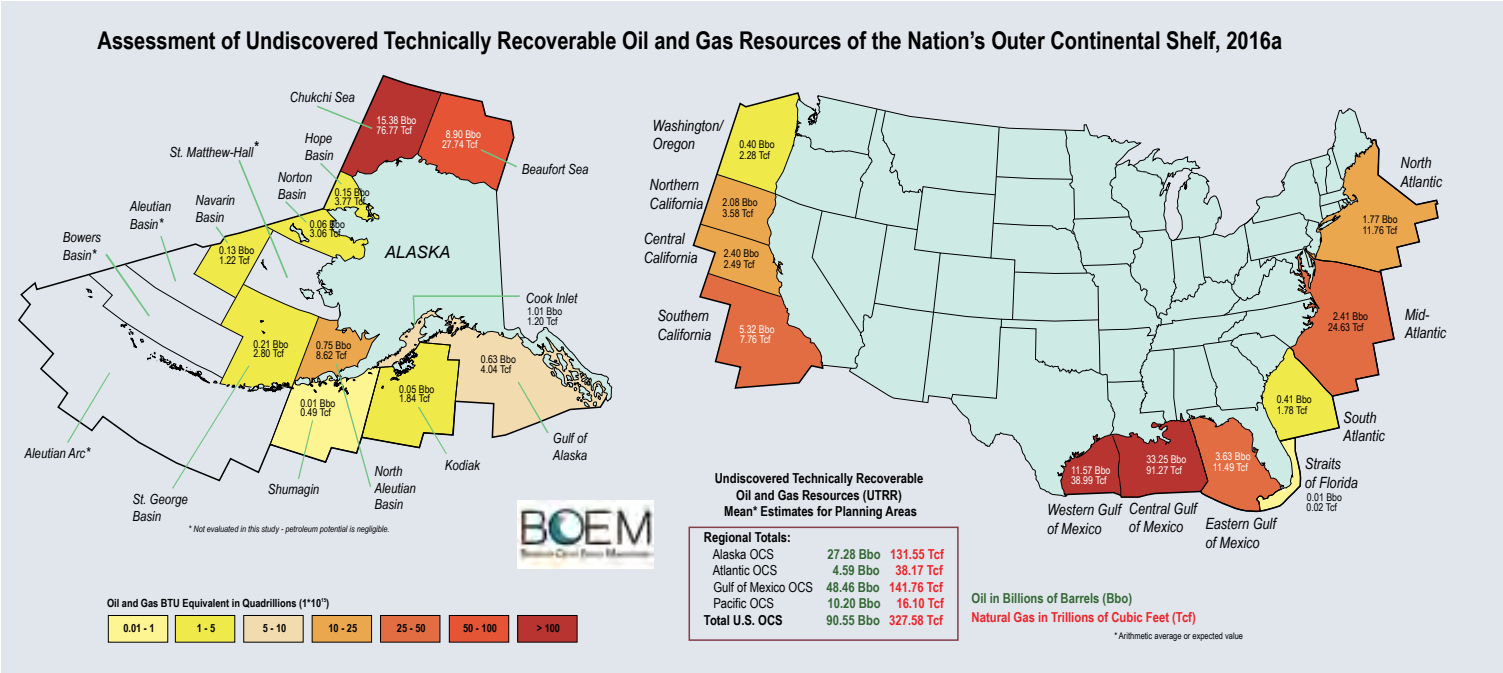
Resources, Guideposts and Future Directions

Many years ago, when I was on the undergraduate Columbia College eight man rowing team in New York, I recall navigating treacherous wakes from speeding motorboats, unexpected boats passing in front of our path, birds swooping down on us, hazards in the water, unanticipated squalls, sudden rain, wind and choppy water. As the leader (coxswain) on the crew team, I sighted distant guideposts and kept the crew motivated. As a manager, I made sure our efforts were efficient, synchronized and moving toward victory. As I think back fondly on those college days, I realize that I learned a lot from my crew team experience on guiding and leading people. I learned that "leadership" is doing the right things, while "management" is doing things the right way.

AAPG needs both.

Key guideposts for AAPG include relevant scientific content for our members. This includes the super basin phenomenon of our age. Super basins are important because they hold the world's greatest known petroleum deposits. Optimizing infrastructure and reducing the carbon footprint by sensible choices leads to sustainable energy for decades ahead. Registration for the Global Super Basins Leadership Conference on March 27-29 is now open: superbasins.aapg.org/2018

Scanning for guideposts also includes a careful watch on new trends of possible game-changing developments around the globe (more on that to follow).



'Energy Capital of the World'

I would like to salute Houston, Texas, as a resource to all AAPG members and to recognize some of the many AAPG leaders who are moving us toward energy focused guideposts.

Most people are proud of their hometown. I am no exception. For 34 years I have deliberately chosen to live in Houston. Many AAPG members live in or near Houston. The Gulf Coast is the largest section of AAPG with 6,500 members. Numerous international members travel through Houston, attend conferences in Houston, teleconference with partners in Houston, or will serve in one or more Houston- based postings sometime during their careers. I hope AAPG members will continue to benefit from Houston's extraordinary resources. Houston remains a gateway of technology – especially offshore technology – to the world.

I would like to focus on some information you might not know about Houston, the fourth most populous city in the United States. Houston's nicknames include: H-Town, Space City and the Bayou City. Many consider Houston the "Energy Capital of the World."

Here are a few venues of great importance to our energy industry:

The George R. Brown Convention Center is the home of NAPE, the North American Prospect Expo; AAPG Annual Conventions; IHS CERA Week, and many AAPG Gulf Coast (GCAGS) section conferences. The George R. Brown convention center has hosted more than 8,000 geoscientists at AAPG's best attended meetings. I am sure readers will remember networking and education experiences at these Houston annual meetings, which are among our Association's most attended events.

As an example of Houston's rich offerings, perhaps 15,000 to 19,000 geoscientists, land men and women and investors will be attending the North American Prospect Expo (NAPE) Feb. 7-9. This is just days after this column hits inboxes around the world. AAPG is a proud co-sponsor of this event. For those of us in the prospect-generating and investment business, I have heard NAPE compared to a "geological theme park." Overheard on the floor: "Are you buying, selling or kicking tires?" I have seen deals struck while standing in a lunch line. Such is the adventure of a global prospect marketplace!

The Houston Petroleum Club has hosted local society meetings for decades going back the 1950s in Houston. The Petroleum Club used to be in the Exxon Building at 800 Bell Street, but has now moved to the 35th floor of 1200 Louisiana Street. The Club is the venue for monthly luncheon meetings of the Houston Geological Society and Society of Independent Professional Earth Scientists. The Club also features an amazing mineral collection and signature Gulf Coast salt dome cross-section wall mural.

Houston has great corporate venues for geosciences professional meetings. Anadarko, Southwest, Marathon, Noble,

See Playmaker, page 4 ▶

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ON THE COVER: The wind energy park "Schneebergerhof" in Germany's Rhineland-Palatinate and others like it are a major component of Germany's "Energiewende" policies intended to minimize reliance on fossil fuels. Photo by Armin Kübelbeck.

Volume 39
Number 2
Feb 2018

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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Playmaker

from page 3

Chevron and other companies have arranged for societies to use their conference space in affordable ways. AAPG's Division of Professional Affairs is hosting an upcoming April 26 Playmaker Forum in Houston in the Marathon Oil Conference Center. The topic will be the Haynesville and re-emerging resource plays of the Gulf Coast (see page 24). Kudos to Bill DeMis and his team who organized it!

The Houston based Offshore Technology Conference will be April 28-May 3 at NRG Center near the Astrodome and Reliant Stadium (home of the Texans football team). AAPG is a co-sponsor of OTC. In recent years, more than 100,000 industry participants have attended this meeting. I would like to recognize Buford Pollett and his team for creating a great geoscience technical program. Last year, I participated in a panel discussion on "Women Leaders in the Energy Profession" at OTC, chaired by Kim Faulk.


STERNBACH

> "The challenges are great. But explorers like to explore and AAPG members do not shy away from challenges, especially when the prize is also great."

I am hopeful we will be able to address the offshore initiative mentioned below in future AAPG and OTC events. The OTC program has evolved from just offshore Gulf of Mexico to include offshore international areas. The offshore Gulf suffered under government regulations and moratoriums. With changing regulations I hope we will see new seismic surveys, new drilling and major discoveries.

U.S. Coastal Opening

Recently, on Jan. 11, the U.S. Department of Interior and the Bureau of Ocean Energy Management announced opening additional U.S. offshore coastlines for oil and gas exploration. This initiative would take many years to unfold and implement. I believe AAPG needs to lead the conversation about the geoscience that will be needed to deliver the energy that these offshore areas could offer the world. If there is an opportunity to lead, AAPG must assess and prepare. Please contact me with your thoughts. For more information, see the offshore area BOEM map at boem.gov/National-Assessment-2016.

The challenges are great. But explorers like to explore and AAPG members do not shy away from challenges, especially when the prize is also great: 90 BBO and 327 TCF (according to the BOEM). Possible areas to explore include offshore areas of the Atlantic, eastern Gulf of Mexico, California, the Pacific Coast and Alaska.

More Resources: Houston Museums

The Houston Museum of Natural Science now features the redesigned Weiss Energy Hall 3.0.

The new Wiess Energy Hall is on the floor above the famous Morian Hall of Paleontology (notable for its T-Rex dinosaurs displayed in action poses) and is designed to explain the oil and gas and renewable energy industry using colorful animations and theme park-like rides into the subsurface. You owe it to yourself and your family to see the "Energy City of the Future" laser light exhibit. This just opened in November 2017.

There is also the Offshore Technology Museum in Galveston. This museum is actually a decommissioned offshore jackup rig where visitors can walk on the drilling platform under the derrick and also learn from three floors of museum exhibits about offshore drilling.

And, there is NASA's Space Center Houston, which has been the site of several AAPG field trips. Many field trip participants remember tours of the Apollo 18 Saturn V Rocket Park and the historic 1970s Mission Control room. But, recent AAPG field trips have also lead geoscientists to the Mars Yard where NASA is testing lunar and Mars rovers. AAPG has bestowed Honorary Membership on Apollo 17 lunar geologist Harrison "Jack" Schmitt. The Apollo 17 capsule and moon rocks Jack (and others) collected are permanently on display at Space Center Houston.

Houston Geological Society

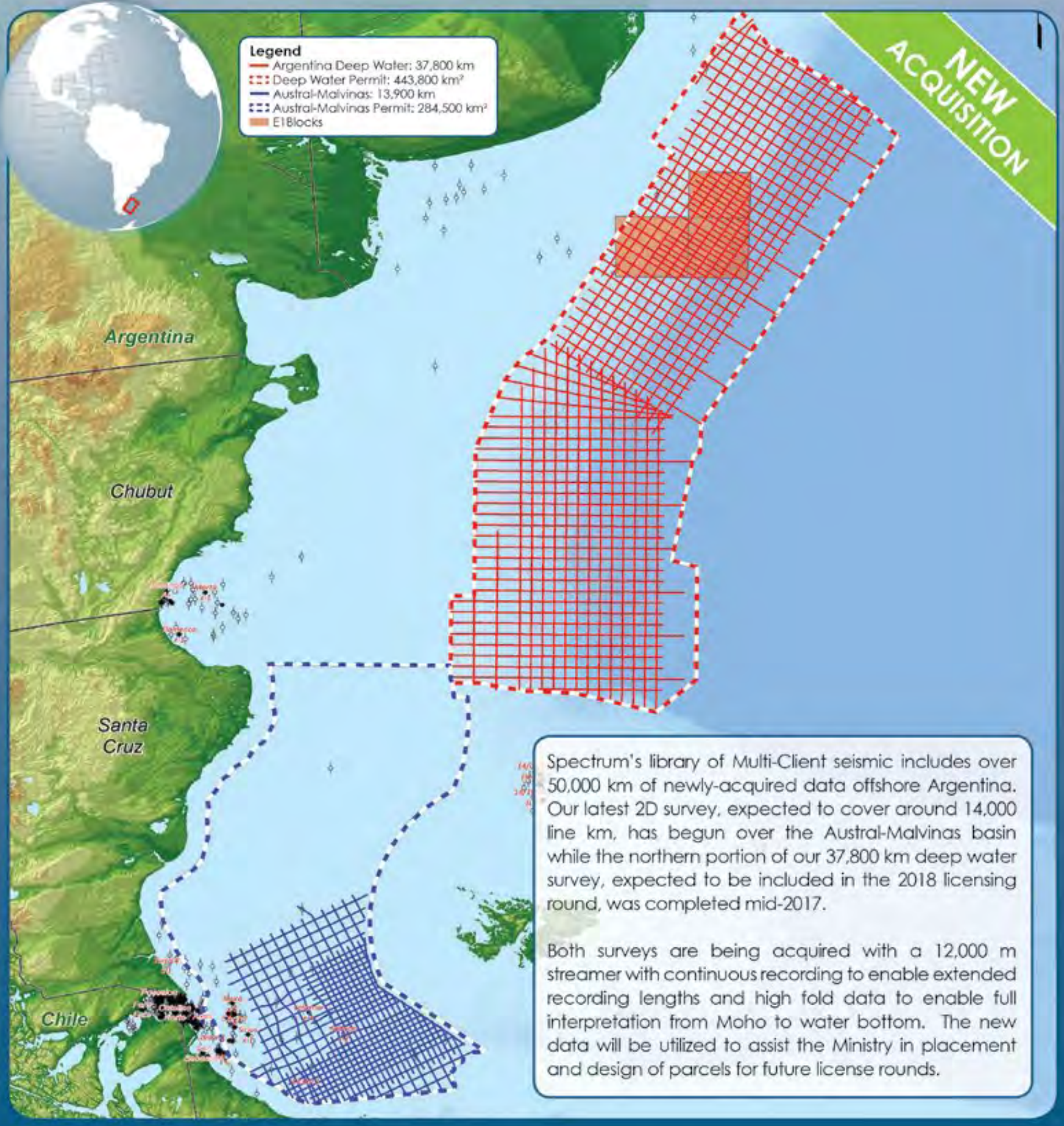
As past general chairman and organizer for AAPG Annual Houston conventions, past president of HGS and past president of GCAGS, I have seen Houston's gems shine from many different facets. One of these gems is the Houston Geological Society (now 95 years old). With close to 3,000 members, the HGS hosts up to six events per month and more than 40 meetings per year. HGS invented and expanded many special theme concepts including the Mud Rocks Conference (March 6-8) and the Africa Conference (Sept. 11-12, co-hosted with the Petroleum Exploration Society of Great Britain). Thanks to HGS President John Adamick, President-Elect Cheryl Desforges and team for their leadership.

As we navigate the choppy waters of the energy business, I am pleased we are steering AAPG toward energy guideposts to help members find and produce energy for the world long into the future!

Charles A. Sternbach

Offshore Argentina

New Multi-Client 2D Seismic For Future Licensing Rounds



Spectrum's library of Multi-Client seismic includes over 50,000 km of newly-acquired data offshore Argentina. Our latest 2D survey, expected to cover around 14,000 line km, has begun over the Austral-Malvinas basin while the northern portion of our 37,800 km deep water survey, expected to be included in the 2018 licensing round, was completed mid-2017.

Both surveys are being acquired with a 12,000 m streamer with continuous recording to enable extended recording lengths and high fold data to enable full interpretation from Moho to water bottom. The new data will be utilized to assist the Ministry in placement and design of parcels for future license rounds.

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Heads of delegations at the 2015 United Nations Climate Change Conference (COP21), which led to the signing of the Paris Agreement. Many of the new energy policies out of Europe stem directly from the Nationally Determined Contributions pledged by countries under the accord. Photo by Presidencia de la República Mexicana.

The End of Fossil Fuels in Europe?

Can government policies trump market forces?

News out of Europe late last year delivered some eye-popping jolts to the global oil and gas industry.

In December, the World Bank Group announced in Paris that it will stop financing upstream oil and gas projects in the world's poorest countries after 2019.

During the same month, the French Parliament approved a law banning exploration and production of oil and gas within France and its territories by 2040.

And European countries continued to target the phase-out of gasoline and diesel vehicles. The Netherlands said it will mandate electric vehicles sales only, starting in 2025. Norway will sell only electric and hybrid vehicles starting in 2030. Scotland plans to eliminate sales of gasoline and diesel cars in 2032, the rest of the United Kingdom and France in 2040.

But on second glance: Is there less here than meets the eye?

The actions by the French Parliament and the World Bank were seen as more symbolic than impactful, and Europe's ability to eliminate gasoline and diesel vehicles looks questionable, at best.

"My read of history and ongoing tracking of oil substitution and efficiency policy suggests governments are better at announcing dramatic energy transitions than actually achieving them," said Robert McNally, president of the Rapidan Energy Group in Washington, D.C.

McNally served as senior director for international energy on the National Security Council and special assistant to the president on the National Economic Council in the George W. Bush White House.

A member of the U.S. National Petroleum Council, he was an energy consultant for the campaigns of 2008 presidential candidate Mitt Romney and Florida Sen. Marco Rubio in 2010.

Columbia University Press recently published McNally's book "Crude Volatility: The History and the Future of Boom-Bust Oil Prices," an examination of the supply and demand swings that have characterized the oil industry since its beginning.


McNALLY

> "To significantly crimp oil consumption, an affordable competitor must first arrive, and when that happens government policy won't be needed. The private sector will lead the way with alacrity."

"While I do not question public and leadership concerns about emissions, I expect Europe will relearn that proclaiming peak oil demand is much harder than achieving it," McNally predicted.

"To significantly crimp oil consumption, an affordable competitor must first arrive, and when that happens government policy won't be needed. The private sector will lead the way with alacrity," he said.

Europe in Proportion

If France does end oil and gas exploration and production, it shouldn't make much of a ripple in the global oil market.

France ranks only 57th among the world's oil producers, according to the U.S. Energy Information Administration, generating less than half as much crude as Japan. For perspective, it produces less oil per year than Saudi Arabia produces in 9 hours.

The World Bank Group, with headquarters in Washington. D.C., is made up of five organizations including the World Bank. This group does not fund large-scale E&P. Instead, it provides loans and guarantees to developing countries for mostly small-scale energy projects. The bank's entire annual spending on energy is a small fraction of the world's total yearly E&P expenditures.

Moreover, it left itself a loophole in curtailing E&P spending, pledging to stop funding upstream oil and gas projects in poorer countries "except under exceptional circumstances."

Many of the new energy policies out of Europe stem directly from the Nationally Determined Contributions pledged by countries under the Paris Climate Accord of 2015, noted Egil Tjåland, head of the Department of Geoscience and Petroleum at NTNU, the Norwegian University of Science and Technology in Trondheim.

"We have of course no guarantee that these pledges will be honored. An obvious example of this is the U.S. withdrawal from the Paris Agreement in May 2017," Tjåland said.

"However, if these pledges are honored, there could be a significant increase in electric motor-driven systems for light-duty vehicles. To achieve this, a likely subsidy scheme for such vehicles will be needed," he added.

Slowing Oil Consumption Growth

European countries that encourage use of electric vehicles and hybrids typically give sales of those vehicles large financial advantages over gasoline-powered models. One example is Denmark, which had exempted EVs from a 180-percent import tax on cars with internal combustion engines.

When the Danish government started reducing the tax break, sales of EVs in that country fell by more than 60 percent.

In Norway, 29 percent of all new car registrations in 2016 were EVs or plug-in hybrids, far and away the highest rate in Europe, according to the International Energy Agency. Norway gives EVs attractive tax breaks and numerous cost exemptions.

See **Electric**, page 12 ▶

Photo by Armin Kübelbeck.

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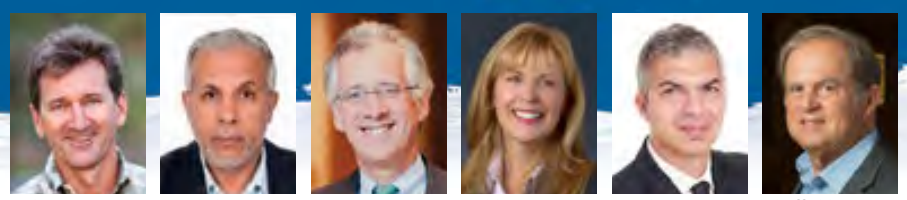

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Water tanks preparing for a hydraulic fracturing job. The United States is thus far the only country to extensively exploit hydraulic fracturing and horizontal drilling for cheap, sustainable shale gas. Photo by Joshua Doubek.

Shale Gas in the UK

Is it sustainable?

The question, as the United Kingdom sits on the cusp of developing its shale gas industry, is whether, in fact, that energy option will be the best path going forward.

In a paper, "Sustainability of UK shale gas in comparison with other electricity options: Current situation and future scenarios," published in Science of the Total Environment, by Jasmin Cooper, Laurence Stamford and Adisa Azapagic on the sustainability of shale in the United Kingdom compared with other electricity options, the authors answer is … Maybe.

"The main purpose of our paper," said Azapagic, professor of sustainable chemical engineering and head of sustainable industrial systems at the University of Manchester, "was to compare shale gas to other options (in the context of electricity generation)."

That's important, for the U.K. has not yet committed itself to shale, so before it does, the authors believe it should first explore how shale's overall sustainability stacks up against other energy options in which it could invest, especially in terms of the environmental, economic and social aspects.

Specifically, how did shale do?

Eh.

From the report's conclusion: "Therefore, while overall not the worst, shale gas is not one of the better options either."

If this were a horse race, shale would have finished in the middle of the pack, ranking anywhere from 4th to 8th place out of the 9 options.

"Assuming all the indicators have equal weight," Azapagic said – and by this she means, for instance, that the carbon footprint is as important as cost – shale falls behind solar/wind-hybrid photovoltaics, nuclear, conventional gas and liquefied natural gas, but ahead of biomass, hydro power and coal.

She quickly pointed out that this is not really a horse race, due to the number of other factors that go into such findings. Still, she maintained, the overall results are instructive to those in the United Kingdom who will make the decision.

"It's worth bearing in mind that this ranking is quite specific to the U.K. and, of course, it's not necessarily true that all indicators are equally important," she said.

> "Since public opposition is a major contributor to national policy in many countries and regions, this may make the difference between frac'ing being banned or supported. We have seen that in several countries that have banned frac'ing."

Primary Concern

But one that is – the environment.

"Environmental issues are one of the main reasons for considerable public opposition to shale gas in the U.K., Europe, USA and elsewhere," she said.

Azapagic, who is also editor-in-chief of "Sustainable Production and Consumption and Process Safety and Environmental Production," contends that if shale producers could demonstrate genuine improvements to those environmental impacts, if they placed those results in context with other energy technologies, and if they interacted better with others scientists and scientific literature, the industry could reduce that opposition.

"Since public opposition is a major contributor to national policy in many countries and regions, this may make the difference between frac'ing being banned or supported. We have seen that in several countries that have banned frac'ng," she said.

AZAPAGIC

> "Given the very rapid reductions in prices for renewables in recent years, it is possible that countries pursuing a more renewable-intensive economy will be at an advantage."

Is Shale Over-Hyped?

Which raises the question of whether, after decades of shale technology, its benefits have been oversold?

Azapagic said the answer largely depends on what question you're asking.

"This depends on context. Much of the benefits in the USA have come from the displacement of coal, and our paper supports the notion that shale gas is more sustainable than coal," even while lagging behind the sustainability of other energy options.

This notion of sustainability, which was the lynchpin of the study, involves, as mentioned, the environmental, but also the economic and societal.

The report was an attempt to deal with all three.

"The latter is harder to quantify than the former two, and in this case, we have used several metrics to try to account for the societal impacts of energy generation. These are the potential to provide employment, the expected number of worker injuries, public support index and a measure of security of supply," she said.

The study indicates that some countries may – and, again, that "may" is operative – have jumped on the shale bandwagon too soon. When asked whether those countries that have since banned hydraulic fracturing are more free to explore other energy sources than those that put their proverbial exploration eggs in the shale basket, Azapagic said it's possible.

"This is difficult to answer, but relates to the concept of the so-called 'technological lock-in,'" she said.

She is talking here about the possibility that investing in large amounts of infrastructure for a particular type of energy provision (gas) locks the economy into a way of doing things that becomes suboptimal in future.

"Given the very rapid reductions in prices for renewables in recent years, it is possible that countries pursuing a more renewable-intensive economy will be at an advantage," she said.

But this is speculation, she readily admits, and is difficult to predict. Further, what worked in the United States and the reasons it has worked might not be helpful for the energy dynamic in the U.K.

Unless the U.K. is smarter in its approach.

Determining Factors

Azapagic said it is possible to arrive at an outcome where shale gas is the best option, but three significant aspects have to change:

- The exploration of shale gas would need a 329-fold reduction in environmental impacts.
- There would need to be a 16-fold increase in employment.
- The electricity mix would need to encompass less rather than more shale gas.

These steps would be significant, complicated and, she concluded, largely unrealistic.

She knows that government officials weigh their energy needs differently than stakeholders, especially in relation to the aforementioned sustainability indicators.

In the United States, for instance – the only country to extensively exploit shale gas so far – the main benefit, Azapagic said, has been a decrease in energy costs.

She said, "Of course there are many other variables such as human health impacts (incurred and avoided) and, without an accurate predictive model of whole-economy impacts, it is difficult to make an informed judgment" of the future of shale in the U.K.

Just recently, according to the International Energy Association, U.S. crude oil production is set to exceed the output of Saudi Arabia for the first time in decades. Clearly, shale has much to do with that.

Still, what drives shale in the United States might not apply in the U.K.

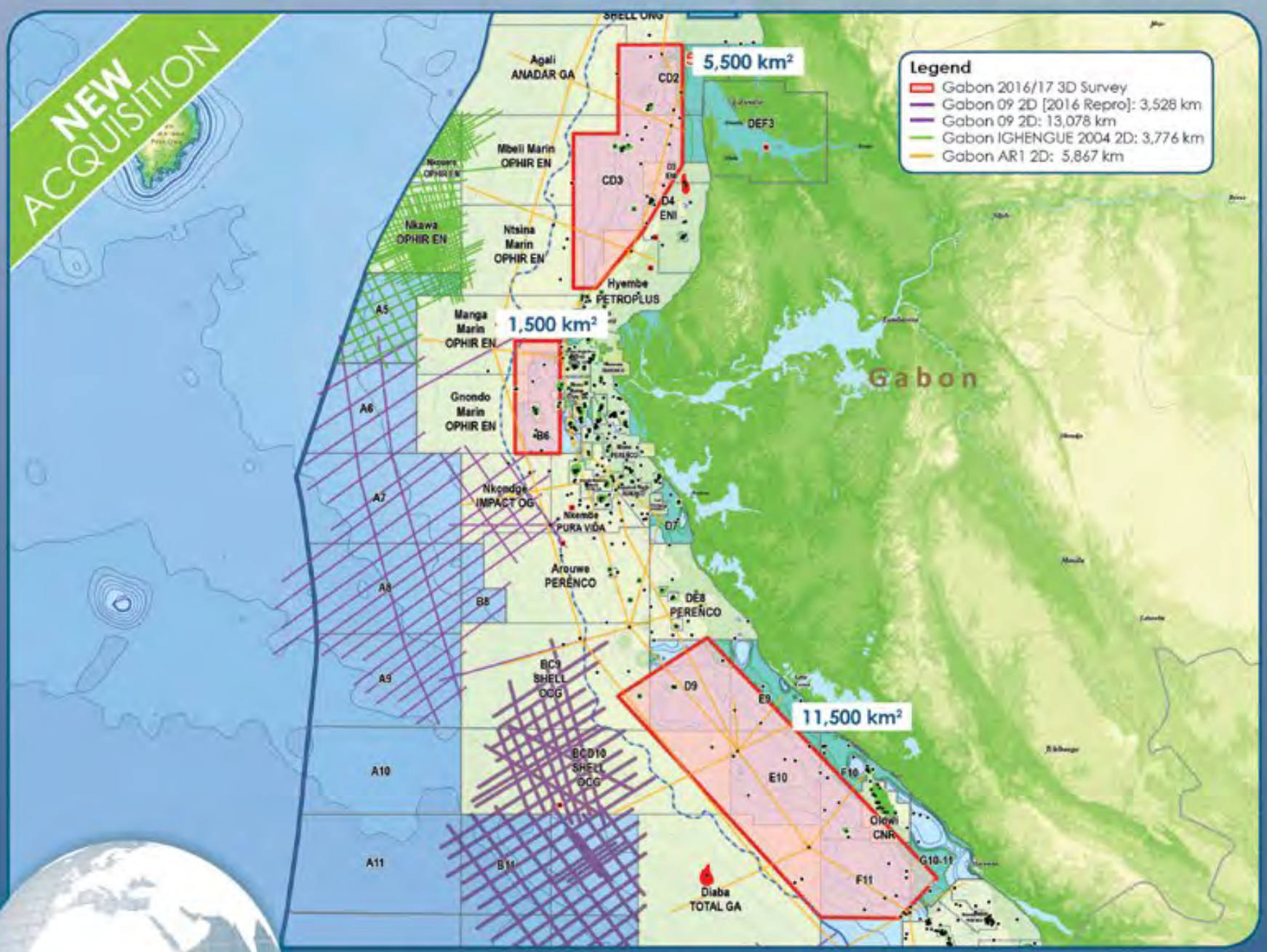
"In the USA, for instance, shale gas is considerably cheaper than we predict it to be in the U.K., so for many people in government this benefit might outweigh other impacts. In our case, we would hope that the U.K. will take these findings into account."

Environmentally, a future electricity mix with a lower penetration of shale gas is more sustainable than the one with higher contribution, but if higher importance is placed on the economic or social aspect, the high shale gas mix outranks the low due to the relatively low cost of shale gas compared to renewables.

"The intention of our work," she concluded, "was to show where shale gas sits in relation to the other electricity technologies with respect to sustainability, aiming to inform various stakeholders, including governments."

Offshore Gabon 3D

New Multi-Client 3D Seismic in Open Acreage + Regional 2D



Spectrum, in collaboration with the Direction Générale des Hydrocarbures (DGH) are undertaking a number of shallow water 3D seismic surveys in open blocks, to provide the industry with state of the art 3D broadband data. A variety of plays are targeted to allow a new generation of oil exploration in these prolific basins.

Seismic is being acquired in both north and south of the country. The 11,500 km² southern survey, now complete, is the definitive dataset to image the pre-salt and, for the first time, intra syn-rift plays can be targeted. In the North, acquisition of a 5,500 km² 3D survey has now begun and will image pre and post-salt targets. Further acquisition is planned in Central Gabon, at the western edge of the Ogooue Delta where the under-explored shallow water plays are post-salt, proven and close to existing infrastructure.

Data will be made available for future License Round evaluation facilitating immediate activity when the blocks are awarded.

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'Habitus' (2013 - ongoing) is an art installation by Robyn Woolston (robynwoolston.com), commissioned by Edge Hill University, which announces the Anthropocene epoch, Vegas-style.

Defining the Anthropocene Era

New research identifies epoch-defining 'golden spike'

Let's call it an epochal step in the right direction.

We're talking here about the Anthropocene, generally, and the Anthropocene Working Group, specifically, and the recent discovery of physical, chemical and biological markers that underscore the very notion of the phenomenon as a new unit of the geological time scale.

According to Jan Zalasiewicz, professor of inaugural lectures and paleobiology at the University of Leicester, a strong proponent of the Anthropocene and a member of the team, the recent work is promising.

"It is new information when organized as context for a potential Anthropocene 'golden spike,' though it is based upon data collected in many previous studies (almost all of them collected without the Anthropocene in mind at all). And perhaps not a breakthrough, but very useful in showing where and how our future efforts should be channeled," he said.

Zalasiewicz and his group recently published a study in the journal Earth-Science Reviews detailing their research.

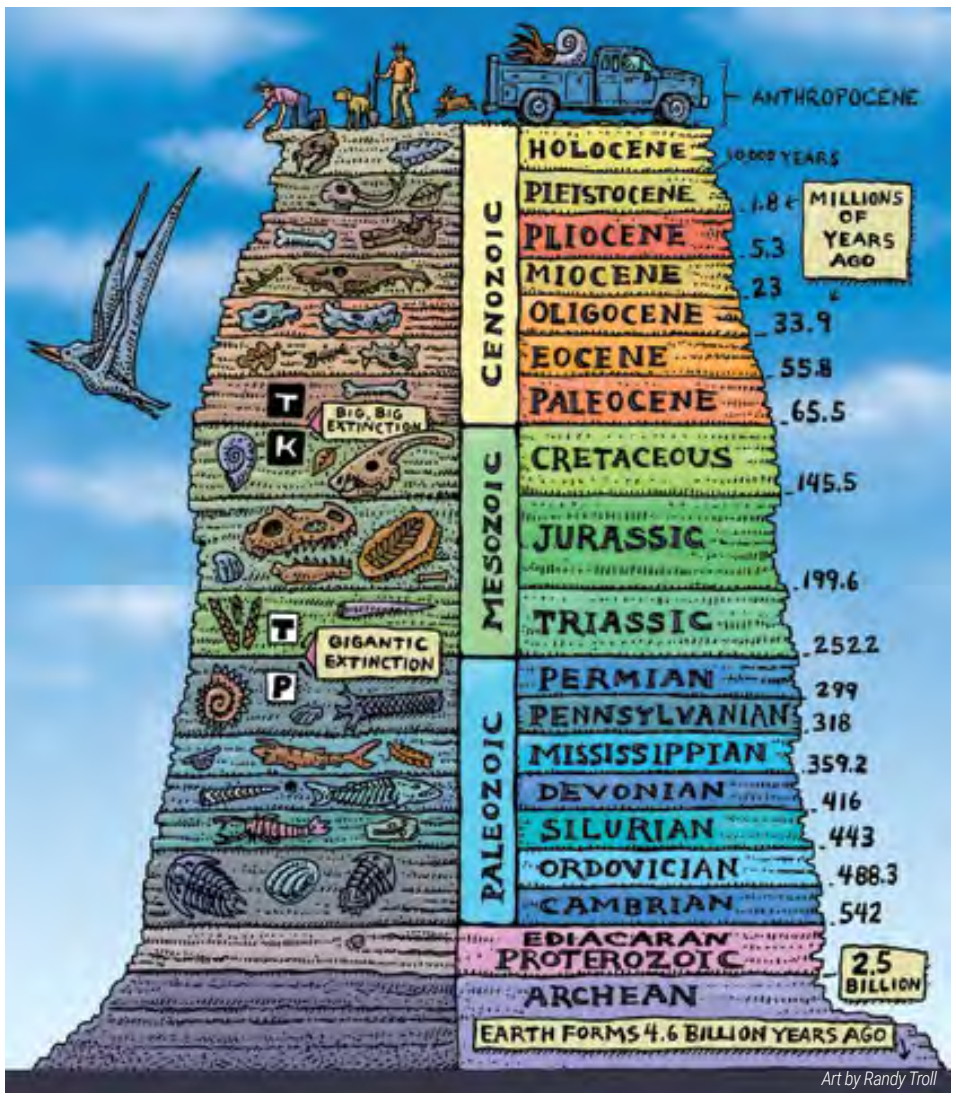
He wants to emphasize that this doesn't settle the debate – for there are still detractors out there – but does " … provide a very great deal of information regarding the technical issues of formalizing the Anthropocene."

Specifically, based on current knowledge, approximately 70 years into this proposed new time interval, the new research indicates that the Holocene-Anthropocene transition is a good deal more sharply definable than most epochal boundaries, using a range of information, and in this respect rivals the Cretazceous-Paleogene boundary.

"It does have novel signals such as those of the techno-fossil record and of artificial radionuclides, as well signals (e.g. the change in carbon isotope values) of the kind that have been used to help characterize or define other epochal boundaries (e.g. the Paleocene-Eocene boundary is defined by its carbon isotope signal)," Zalasiewicz explained.


ZALASIEWICZ

> "Whether the Anthropocene becomes formal or not, it's a very real and distinct phenomenon stratigraphically."



Art by Randy Troll

The practical effect will help future research locate and specify future "golden spike sections," he added.

The Debate

The term "Anthropocene" was first coined, almost improvisationally, by Paul Crutzen, a Nobel Prize-winning atmospheric chemist, at a conference in 2000 in Mexico City. Literally meaning "the Age of Man," its origins, according to proponents like Crutzen, began around the middle of the 20th century and rests on the assumption that humans are altering the planet, including long-term global geologic processes, at such an accelerated pace that a new epoch is upon us in the geological time scale.

(The late biologist Eugene Stoermer, who had been using the term informally for years, was quoted in The New York Times back in 2011 as saying he never formalized the term until Crutzen contacted him.)

Zalasiewicz said the term started off organically, then became semi-formal, through the Stratigraphy Commission of the Geological Society of London (a formal body, but with no direct power over the time scale) – and then became formal with the Anthropocene Working Group of the International Commission on Stratigraphy.

It has been, Zalasiewicz said, "a kind of evolution of interest," including disciplines beyond the scientific community, including environmental, anthropological, political, and social.

The immediate question for the AWG is whether "Anthropocene" should be added to the International Chronostratigraphic Chart.

Fundamentally, the debate centers on whether humans have changed the figurative and literal landscape to such an

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extent that recent and currently forming geological deposits include a signature that is distinct from those of the Holocene and earlier epochs.

Zalasiewicz thinks it has, even before the latest research, which, he believes, is reason enough for the term to be recognized.

"One of the advantages would be stabilizing the meaning within geology, and therefore helping precise communication," he said.

"Whether the Anthropocene becomes formal or not, it's a very real and distinct phenomenon stratigraphically," he said, adding that the work and research will continue regardless of an official recognition.

The criticism of the Anthropocene comes from those who, for starters, think the term is arrogant in the thinking that human beings are a geologic force on par with nature, in fact superseding it. By proof, critics point to the named epochs covering the last 145 million years and how none are named for the cause of the changes to the planet – until now.

More substantive is this criticism, best described in a 2013 Smithsonian Magazine article by Joseph Stromberg, "What is the Anthropocene and Are We in It?":

"Many stratigraphers (scientists who study rock layers) criticize the idea, saying clear-cut evidence for a new epoch simply isn't there. 'When you start naming geologic-time terms, you need to define what exactly the boundary is, where it appears in the rock strata,' said Whitney Autin, a stratigrapher at the SUNY College of Brockport, who suggests Anthropocene is more about pop culture than hard science. The crucial question, he said, is specifying exactly when human beings began to leave their mark on the planet: The atomic era, for instance, has left traces of radiation in soils around the globe, while deeper down in the rock strata, agriculture's signature in Europe can be detected as far back as A.D. 900. The Anthropocene, Autin said, 'provides eye-catching jargon, but from the geologic side, I need the bare bones facts that fit the code.'"

Zalasiewicz in his office at the University of Leicester.

For his part, Zalasiewicz welcomes the criticism and thinks the debate is healthy.

"It is an essential part of the testing of this concept – for the Anthropocene to be taken seriously, the science behind it must be robust and based on sound evidence," he said.

Navigating the Controvery

He believes the research indicates that the Anthropocene is not, in fact, just a difference in epochal interpretation or degree of the Holocene Epoch of the Quaternary Period, but a change in kind, pointing to distinctive changes to the Earth due to the introduction of artificial radionuclides, plastics, fly ash, metals such as aluminum, pesticides and concrete.

Those in the Anthropocene camp believe that humans have made epoch-scale changes to the Earth's geology, changes substantial and dramatic enough to have ushered in this new era and should be recognized as such.

As to the charge of political tinkering, Zalasiewicz believes that an examination of the Anthropocene Working Group's

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> "Oil will remain the lifeblood of modern civilization for the coming decades because it offers a vastly more affordable and energy-dense fuel for transportation, a vital sector for economic growth, living standards, and security."

Electric

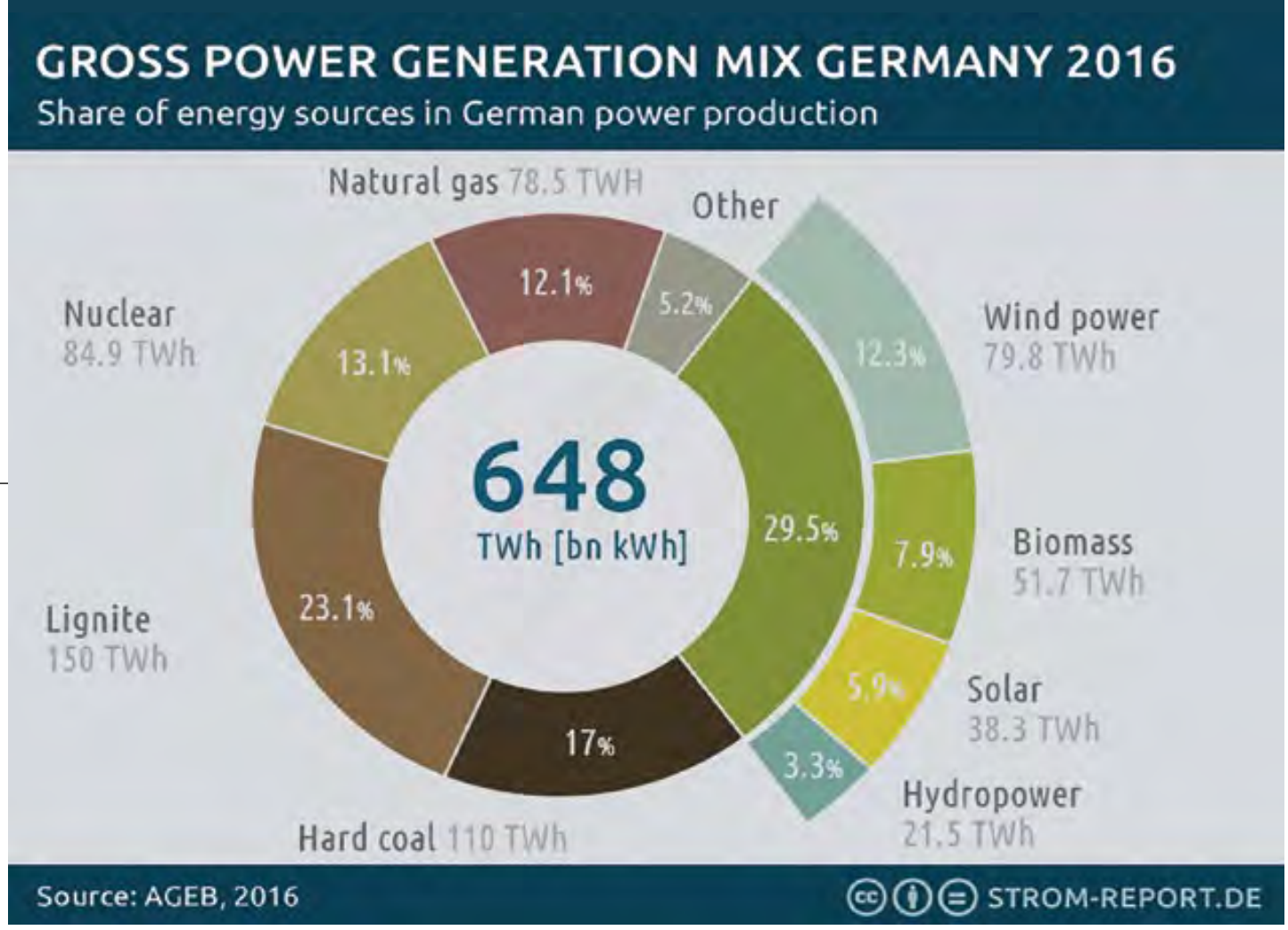
from page 6

Andreas Halse, environmental spokesman for Norway's Labour party in Oslo, was quoted by the "Financial Times" as saying, "What we have proven in Norway is that if you give enough subsidies and impose enough restrictions on fossil fuel vehicles, people will buy electric."

Policymakers will continue trying to address real concerns about emissions and environmental impacts, McNally said. He thinks governments might be successful in controlling ambient emissions, such as particulates, because cost-effective regulatory solutions can be found.

"But for climate change it will be more difficult, since there are no affordable regulatory options to meaningfully replace oil use with alternative fuels or power trains," McNally observed.

"Officials have tried to force biofuels and electricity into the transportation fuel. And they have mandated more efficient cars. But these efforts have not significantly slowed growth in oil consumption," he said.



The Grid

Then there's the question of powering EVs.

"One of the critical factors for a transition to electrical vehicles is affordable electricity. For a country like Germany, with its 'Energiewende,' electricity is generated from renewables, gas, nuclear energy and coal," Tjåland observed.

"Even when renewable energy increased to nearly 30 percent of electric power generation in 2016, a substantial amount of coal – 40 percent, where 27 percent is brown coal in 2016 -- has been used in times of low wind- and solar-power generation, and also to replace the phase-out of nuclear power," he said.

Germany's current policy of Energiewende – literally, "energy transition" – began as an attempt to move away from nuclear power and to add more electric-generating capacity from renewables. But the country's centralized electric grid has had problems dealing with the more widely distributed renewable power sources.

The German government acknowledges that significant infrastructure investment will be needed in the future, leading to higher grid costs.

Forecasts

For forecasting the effects of European energy policies, Tjåland cited IEA's 2017

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World Energy Outlook. The outlook contains several scenarios projecting future global energy consumption.

In the most ambitious scenario based on climate change policies, called the Sustainable Development Scenario, IEA gave the following forecasts to the year 2040:

Oil demand: down 25 percent.

Gas demand: up 15-20 percent.

Coal demand: down 53 percent.

But, "in a New Policies Scenario, which aims to provide a sense of where today's policy ambitions seem likely to take the energy sector, the following forecasts are given," Tjåland noted.

Oil demand: up 11 percent.

Gas demand: up 45 percent.


TJÅLAND

"We have of course no guarantee that these pledges will be honored. An obvious example of this is the U.S. withdrawal from the Paris Agreement in May 2017."

Coal demand: up 5 percent.

The IEA's outlook emphasized the effects of China's future energy policies much more than European policies, or policies anywhere else in the world. "When China changes, everything changes," the report said.

Under its New Policies Scenario, China's energy demand growth is projected to slow to an average of 1 percent per year to 2040.

Even if national energy policies do reduce future oil demand, that won't alter the industry's supply-demand dynamic, according to McNally.

"We could – and did – see boom and bust oil price cycles when demand was a fraction of today's, such as the 1920s and early 1930s," he commented.

"But to the broader question of whether European policy measures will sharply reduce demand for oil, I think it is very unlikely. Despite enthusiasm for electric vehicles and falling battery costs, there is no commercially viable, large-scale competitor to internal combustion engines on the horizon," he said.

McNally sees little chance that policies in Europe or elsewhere will lead to a near-term shift away from hydrocarbons.

"Oil will remain the lifeblood of modern civilization for the coming decades," he said, "because it offers a vastly more affordable and energy-dense fuel for transportation, a vital sector for economic growth, living standards, and security."

Opinions
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research should dispel any doubts as to the group's motivations, and he does not believe the work is pitting scientists against politicians against environmentalists.

"On the whole, I don't think so – though there have been many different opinions on the Anthropocene from many communities (and indeed a number of different interpretations of the Anthropocene, which is why we on the AWG are cleaving closely to the 'stratigraphical Anthropocene'). The various proxy signals of the Anthropocene might be considered part of the evidence for global environmental change, though on the AWG we are considering them impartially, as geological signals to compare with those of the geological past," he explained.

He is careful about editorializing too much on the subject.

"There are wide ranges of opinion from proponents of the 'good Anthropocene' to those who consider that the changes associated with this putative epoch are largely deleterious (to the biosphere, and ultimately to humans). Again, our task is to examine the stratigraphic evidence as best we can," said Zalasiewicz.

The What Versus the When

These epochal moments are not like elections – they don't have specific start and end dates. In fact, some epochal moments have lasted thousands of years. The actual start date of the Anthropocene, Zalasiewicz said, is less important than the fact of it.

"If we are using chronostratigraphic criteria, then it is probably best to consider it as the start of a very long unit of time, in which Earth history might evolve in a number of ways. In the same way, the Eocene epoch did not terminate after the carbon release/global warming event that triggered it had died down, after 0.1-0.2 million years of perturbed climate – this was sufficient to set the Earth on a new trajectory, with the next epoch (the Oligocene) not defined until another major change, 20 million years later. This is an imperfect comparison, but perhaps demonstrates the kind of temporal measure that one might make," he said.

As for what happens now, in light of the new findings, Zalasiewicz said, "We hope to have a formal proposal based on a good deal of detailed and focused analytical work ready by 2020, but this may well be optimistic (it would be a good deal faster than most geological boundary work, and there is still a great deal of organizational work to do). We will do the best we can. As regards a decision, I have no reliable crystal ball here – we simply wish to do the science as well and honestly as we can."

By SUSIE DANIELS, NUNO PIMENTEL, RUI PENA DOS REIS, NICOLA SCARSELLI

ICE Field Trips Provide Rare Opportunity

Field trip group looking at the Lower Jurassic section at stop 10 (Peniche, 70 kilometers north-northwest of Lisbon). These marine marly limestones are one of the main source-rocks of the Lusitanian Basin and have sourced oil-seeps visited at stop 7. Photo by G.Garcia.

As the lights went out on the AAPG International Conference and Exhibition in London late last year, the field trip leaders reported back their experiences from visiting classic geology localities in the United Kingdom and Europe.

With ICE in one of the most iconic European capitals, the organization committee wanted to shape an ambitious field trip program that would look beyond the British Isles. Against all odds dictated by the unfavorable state of the industry, three field trips accompanied from start to end the success of ICE in London, two of which are detailed below.

Portugal

Nuno Pimentel and Rui Pena dos Reis reported from the Lusitanian Basin in Portugal:

The Lusitanian Basin, located in the Western Iberian Margin, provides a unique opportunity to look at an extensively exposed North Atlantic Margin. This, complemented by great landscapes and a mild Portuguese autumn, brought a good number of attendees to this field trip, the only one to have taken place outside the U.K.

Thirteen professionals from different companies joined us for a three-day field trip looking at significant geologic features of the three major petroleum systems of the Lusitanian Basin, namely the Silurian black-shales and Triassic siliciclastic reservoirs, the Pliensbachian marine source rock and Lower Cretaceous siliciclastic reservoirs, and Oxfordian lagoonal source rock with Upper Jurassic carbonate and siliciclastic reservoirs.

The visit has been based in large outcrop observations, mostly along coastal cliffs. Selected seismic lines, well data and geochemical analyses have also been shown and discussed. Geodynamic evolution, basin architecture and salt tectonics (including seismic scale piercing diapirs) have been presented. Overall, the

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Experimenting with Gas Cycling for EOR

This shows a proprietary Core Lab pressure-volume-temperture PVT cell, used to determine the properties and phase behavior of the crude oil.

> "Each time we strip a little oil out, it can change the formula of the remaining oil in the rock . . . We have to understand how the oil will react with different compositions of injected gas."

Researchers at Core Laboratories have conducted laboratory tests that demonstrate that, in certain cases, production from unconventional reservoirs can be increased by several percentage points.

In oil production from unconventional reservoirs, several percentage points can mean a difference of millions of dollars.

Core's Vice President of Reservoir Description Larry Bruno said they have achieved those results in the lab and he expects the company's clients to begin taking the technology – referred to as gas cycling or engineered gas injection – into the field.

Bruno said a typical well in an unconventional reservoir in the Permian Basin is about 9 percent of reserves.

"In the laboratory, we've demonstrated that we can get that into the low to mid-teens," Bruno said.

"If a tight well is expected to produce a million barrels … a successful engineered gas cyclic injection program may yield 1.3, 1.4, 1.5 million," he said.

In an earlier interview with Bloomberg, company CEO David Demshur said the technique could be applied for an additional investment of $1 million to $2 million. That could mean an additional 1 to 2 million barrels, he said.

Enhanced oil recovery techniques in conventional reservoirs typically involve pushing the oil from injector wells to producer wells with water or gas. In these unconventional reservoirs, the rock is just too tight, Bruno said.

The lab work on the reservoir fluids revealed that if the oil was exposed to certain compositions of gas, the oil would vaporize and enrich the gas. When the pressure is dropped on the enriched gas, liquids condense and are recovered. The gas can then be re-injected.

Bad Rocks, Containment and Timing

As with any new technology, there are potential challenges. Bruno said a thorough understanding of the rock and fluid properties is the essential starting point. Also, maximizing the surface area of the fracture network and the stimulated rock volume are key components.

Good reservoir rock is a limiting factor.

"You can't make good rock out of bad rock," Bruno said.

Containment can also be a concern.

If the formation is "leaky," the injected gas might dissipate away from the target zone, he said.

To address this concern, Core has been engaged to deploy its proprietary tracers in the injected gas.

"We can see if the tracers show up in a different zone or well bore, outside of the targeted reservoir interval", he said.

"A properly stimulated tight formation with effective seals above and below is favorable," Bruno said.

If hydraulic fracturing is limited to the zone of interest, the injected gas may be contained. Alternatively, the injected gas may escape if the fractures go beyond the target zone, or through faults or other leaks.

"Containment will either be a natural strength or deficiency of the formation," said Bruno.

Time issues also are being studied, such as how long to let the injected gas remain in place during each cycle, how many cycles are optimal, and when in the life of the well to begin the process.

"Each time we strip a little oil out, it can change the formula of the remaining oil in the rock," he said. Researchers can adjust the recipe of the gas to achieve the best results, he said. "We have to understand

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Jonny Imber leading discussion of the plumose marking and arrest lines on one rather magnificent fracture within the Bituminous Shales of the Whitby Mudstone Formation. Photo by Susie Daniels.

England

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attendees had the opportunity to approach different source rocks, reservoirs, seals and traps, as well as their spatial and time-relations, within a rift-to-drift framework.

Weather conditions were excellent for the season (up to 90 degrees Fahrenheit and no wind) and the atmosphere was quite enjoyable, promoting the discussion with the field trip leaders and also within the group. We had excellent feedback from everyone and we hope that these three days will stay in their memories and might also bear fruit along the exploration challenges of those who visited us.

England

Susie Daniels, Jonny Imber and Michael Mawson reported from the Fractured Reservoirs field trip in northeast England:

Experiencing an authentic (mild but damp) English autumn, 13 professionals from six different companies visited fractured reservoir localities in northeast England. We examined fracturing in both comparatively homogeneous and heterogeneous sequences, the shale-rich Lower Jurassic (Lias Group) Whitby Mudstone Formation and carbonates of the Upper Permian (Zechstein Group) Roker Formation, respectively, and considered the impact of faults and fractures on fluid flow.

With a total organic carbon approaching 20 percent, the Jet Rock of the Whitby Mudstone Formation in the Cleveland Basin represents source rock/shale oil reservoirs and seal units, and is an analogue for the less well-exposed Weald Basin in southern England, and the time equivalent Posidonia Shale in the Netherlands and southwest Germany. Exposures on clean, wave-washed platforms and in cliff sections provided the basis for discussions on the lateral and vertical variation in natural hydraulic fractures, mechanical boundaries and interaction between fractures.

The unabating rain proved too much for the final outcrop, but didn't dent enthusiasm for evening dialogue, which began with seismic sections and well logs in preparation for the Zechstein carbonates.

The Zechstein carbonate rocks of northwest Europe are hydrocarbon reservoirs from the northern North Sea to Poland, and include some of the oldest fields to have been discovered and produced. The spectacular exposures of mainly shallow water (platformal) carbonates in northeast England have undergone varying diagenesis, including dramatic collapse brecciation caused by evaporite dissolution during uplift and exhumation. The variation in fracture properties linked to facies, faulting and evaporite dissolution were evident and could have borne much longer examination in the County Durham sun.

Overall the trip benefited from the expertise, enthusiasm and interest of the participants, providing much discussion amongst the group.

◀ Continued from previous page

how the oil will react with different compositions of injected gas."

"We're in the early innings with this. We're still trying different things," he added.

"Our role is to validate the process in the lab, getting the right engineered gas in contact (with) a specific oil. In the lab, we've demonstrated that we can recover incremental oil with multiple cycles," he explained.

Traditionally, EOR efforts begin late in the life of a field.

"Maybe we don't need to wait so long. Perhaps we can change the shape of the decline curve if we start at midlife or earlier," Bruno said.

Eagle Ford and Beyond

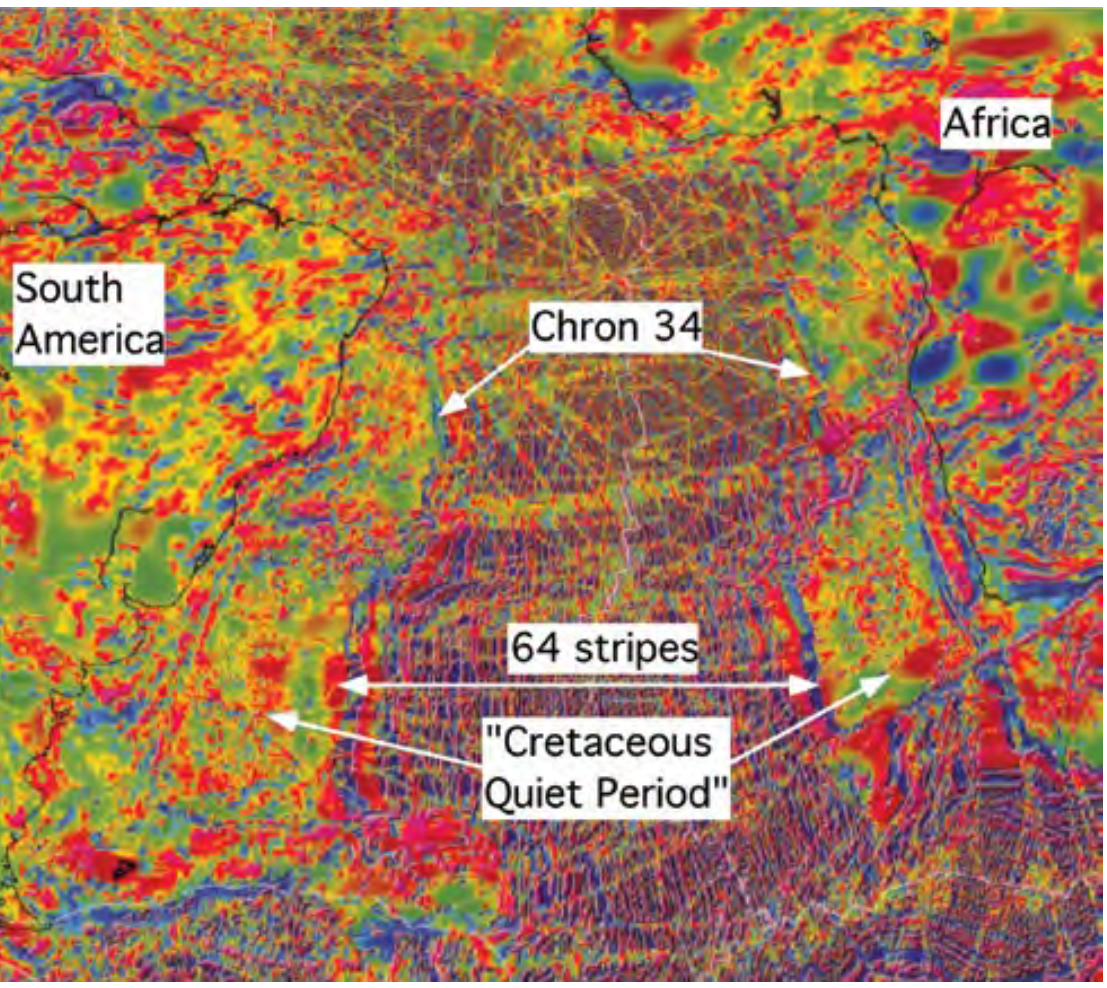
Last year, Core Laboratories announced the formation of a multi-company consortium in the Eagle Ford to pursue the technology, and Core is looking forward to working in other basins.

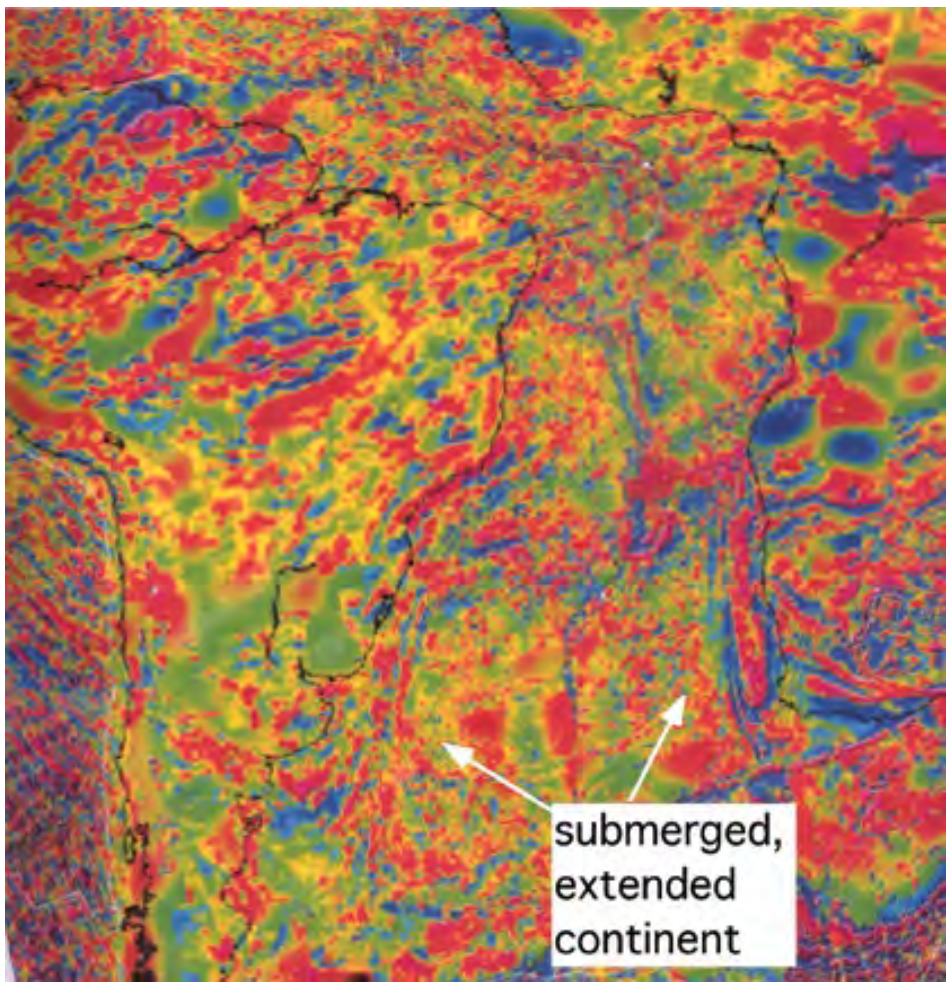
"That's high on our list of conversations right now," Bruno said.

The consortium approach benefits companies who are able to view shared results he said.

"Some clients have done rudimentary field injection projects. We get feedback and that directs additional lab work," Bruno said.

Bruno said the technology will be useful in many areas, with some horizons in the Permian already under investigation.





Not Written in Stone

Plate tectonics at 50

The Plate tectonic paradigm – "the unifying theory of geology" – has just turned 50.

In 2017, the Geological Society of London's William Smith Meeting celebrated this historical occasion, perhaps with a touch of self-congratulation, but with little discussion of alternative ideas.

Plate tectonics (PT) is an enormous topic with a convoluted history. This article highlights some problems, some old ideas, emerging data and some different possibilities.

Supercontinent Pangaea began to fragment in the Triassic. PT holds that from the Jurassic onward, mid-ocean ridges (MORs) generated new seafloor that separated continents. Here, magnetic stripes record reversals of Earth's magnetic field and spreading progress.

This crust is consumed by subduction, which creates blueschists and new continental crust below volcanic arcs. Collision raises mountains.

PT's predecessor theory, continental drift, used the fit of South Atlantic coastlines and fossil distributions as basic arguments for the former connection of South America and Africa (see figure 1). Mantle convection distributed continents.

Continental Reconstruction

Magnetic data (see figure 2) suggest an intriguing alternative to coastlines/bathymetric contours for Pangaean reconstruction. Large areas without magnetic stripes below the South Atlantic adjacent to South America and Africa supposedly record the Cretaceous Quiet Period, when magnetic field reversals paused for 40 million years. Alternatively, a similar signature suggests they are foundered parts of adjacent continents. They reconstruct well (see figure 2). A similar signature appears off eastern North America where seafloor fractures that continue onshore to Palaeozoic/older Appalachian offsets indicate ancient, continental origins.

> "Published PT teaching is complacent. It should adapt to emerging data, include multiple working hypotheses and enable students to think and choose."

In today's PT, paleontology takes a back seat. A new book published by the Geological Society of London, "Crustal Evolution of India and Antarctica: The Supercontinent Connection," edited by N.C. Pant and S. Dasgupta, relates India to Antarctica using geochronological data/petrology. Fossil data relate India to neighboring Eurasia. Dinosaurs, freshwater snails, catfish, cichlid fish, angiosperms, flightless birds and manatees evidence communication between supposedly long-separated areas. Monkeys and rodents travelled 2,600 kilometers from Africa to South America (early Cretaceous separation) in the Oligocene. Mammals migrated between Africa and Madagascar (Jurassic separation) as recently as the Eocene-Miocene. Explanations offered include swimming, rafting or island hopping.

Foundered continental areas are an interesting alternative.

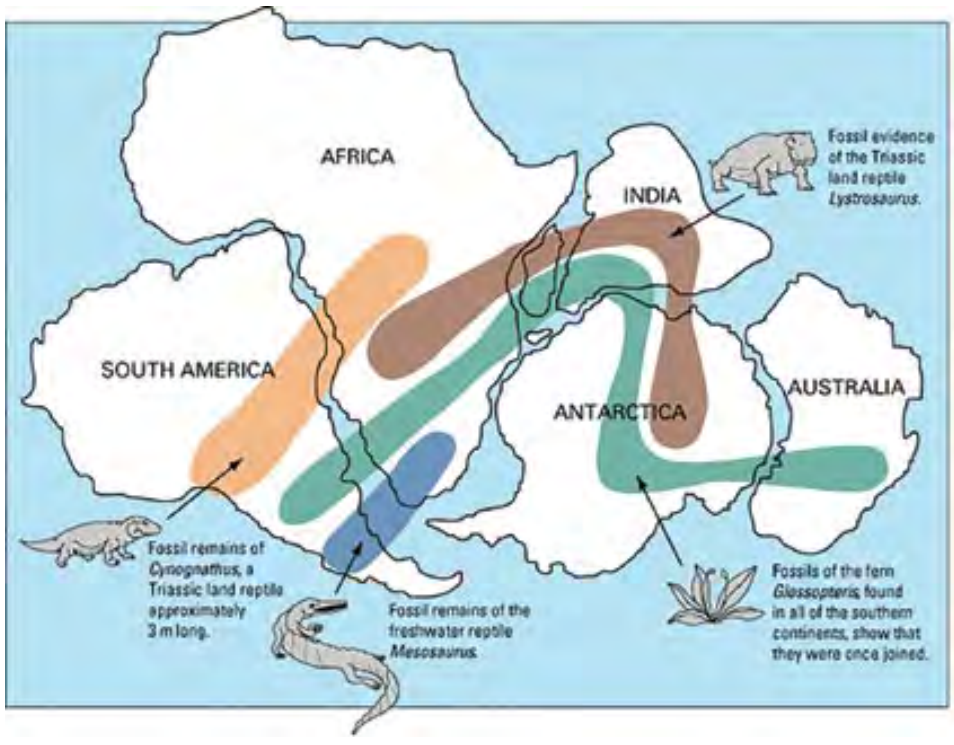


Figure 1. As noted by Snider-Pellegrini and Wegener, the locations of certain fossil plants and animals on present-day, widely separated continents would form definite patterns (shown by the bands of colors), if the continents are rejoined. Image courtesy of the United States Geological Survey.

Convection and Sea Floor Magnetic Stripes

Today's PT maintains that subduction slab pull is the major driver of spreading. This seems to be a non-starter – no spreading, no pull, and vice-versa. 2-D models of mantle convection cells rising at MORs, diving below subduction zones and carrying continents apart are still alive but could they be segmented in the third dimension? MOR offsets up to several hundreds of kilometers along fractures surely rule them out.

A major pillar of PT is that sea floor magnetic stripes, sometimes attributed to magnetic field reversal, others to high versus low intensity, record spreading. They also occur in continental rifts.

Moving ever further offshore, seismic surveys reveal lightly stretched continental crust followed by thinning from 30 kilometers to less than 10 kilometers, and thence to highly extended crust, presumed continent-ocean boundaries and "oceanic" crust. The crust is being stretched. That seems to rule out ridge push as a spreading driver.

Extended crust carries asymmetric basins, between 60 and 200 kilometers wide and up to 25 kilometers deep, where reflections, some with sedimentary architecture (truncation, onlap), dip toward bounding faults (seaward-dipping reflections, or SDRs). Here, magma rises to intrude sills and extrude basalt. Stretching also results in serpentinization (with magnetite) of exhumed peridotite, generating magnetic anomalies unrelated to MOR spreading.

Could they explain seafloor magnetic stripes?

Deep sea drilling aimed at calibrating increasing age of oceanic crust away from MORs encountered basalts assumed to be "basement," but some contained sediment clasts and some deeper basalts were interbedded with sediments. Perhaps "oceanic" crust includes extended continent basins far offshore. Is there any evidence?

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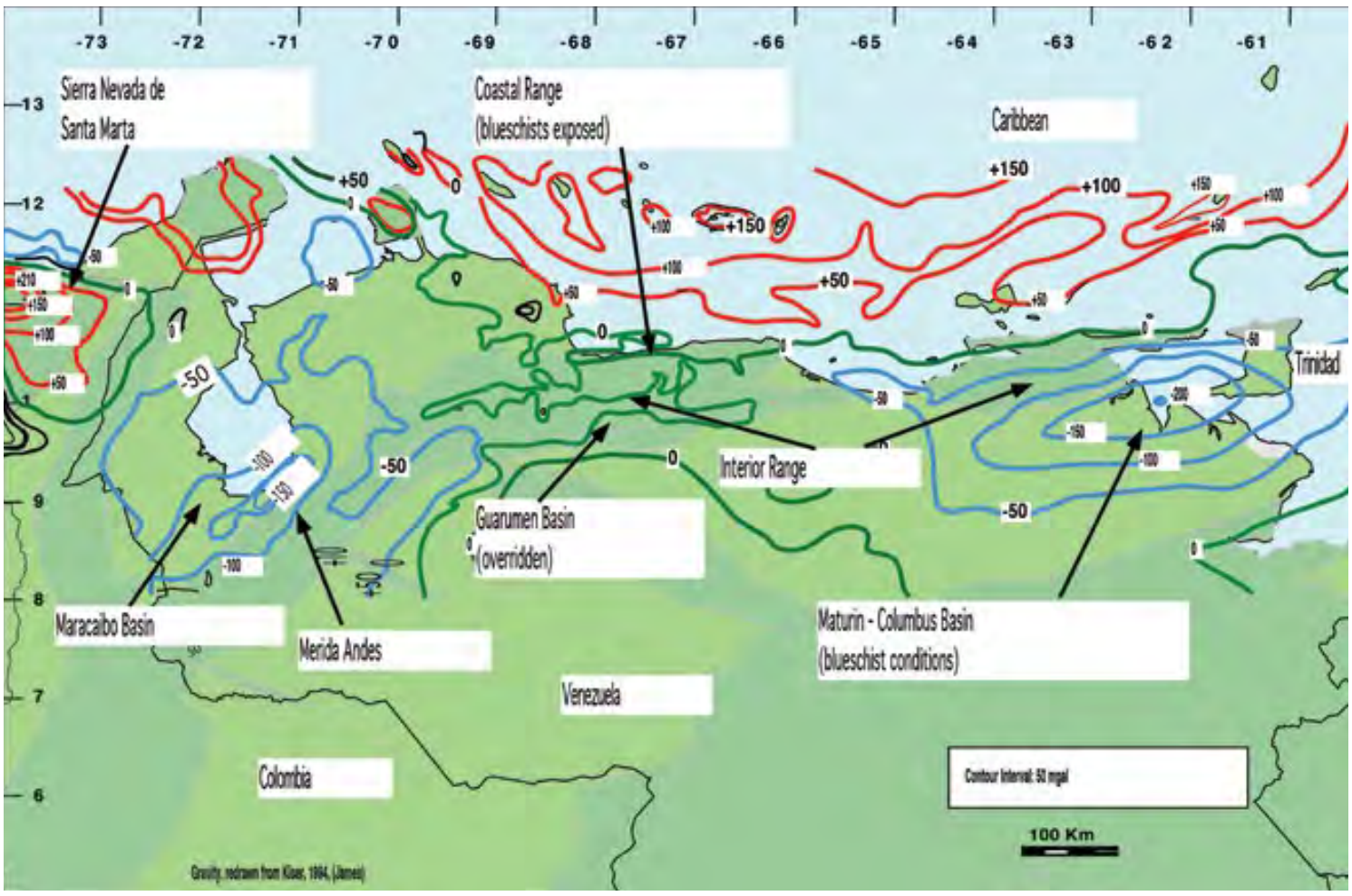

Figure 2 (far left). This signature of non-striped submarine crust similar to adjacent Africa and South America suggests subsided, extended continent. Image extracted from the Magnetic Anomaly Map of the World by J.V. Korhonen of the Commission for the Geological Map of the World in Paris.

Figure 3 (middle). Removal of striped crust (fig. 2) indicates reconstruction of much larger Pangaean Africa and South America, with significant implications for occurrence of continental material on the ocean floor, fossil distributions and exploration possibilities.

Figure 4 (right). This gravity map of northern South America indicates dynamic, eastward-migrating, deep (blueschist conditions) foreland basins pursued by inverted, overriding uplifts exposing metamorphic rocks.

◀ Continued from previous page

Continent Below Oceans

PT overlooks numerous samples of continental material dredged from ocean floors, some with trilobites and graptolites, (e.g., Bald Mountain, 80 kilometers-cubed of Proterozoic granite, and King´s Trough in the North Atlantic).

Rocks as old as 2 billion years occur on the Mid-Atlantic Ridge Peter and Paul's islands. Proterozoic-Paleozoic zircons occur in gabbros on the Mid-Atlantic Ridge.

Continental isotopes are widespread in Indian Ocean basalts. Proterozoic zircons in lavas on Mauritius suggest ancient basement, newly christened "Mauritia" in 2013, below the island and adjacent Mascarene Plateau. Magnetic data indicate a large submerged continental area to the east.

In the South Atlantic, granite was in 2013 discovered on the northwest-to-southeast Rio Grande Ridge (outer edge of South America's magnetic extension). Basalts on the "conjugate" Walvis Ridge show continental signature. Both are seen as migration tracks over the same Tristan da Cunha hot spot but they are oblique to seafloor fractures (flowlines). Both ridges are associated with those large extensions of neighboring continents and SDRs are present.

Precambrian-Devonian zircons have just been reported in lavas of the Galapagos Islands, a 20 million-year-old supposed hotspot 1,000 kilometers west of South America. Mesozoic zircons occur on Iceland, 13-15 million years old, on the Mid-Atlantic Ridge.

In 2017, Zealandia was nominated as a newly recognized continent. This fragmented, largely submerged area between Australia and New Zealand is the size of India. It explains plant and animal distributions in

See **Pangaea**, page 22 ▶

Geophysical Corner

The Fabric, or Internal Structure, of Rocks

The Patterns of Anisotropy, Part 1

Geology is the correct starting point for any geophysical discussion in AAPG. This two-part article starts with the rock, progresses to the wave and concludes with our increased understanding of the rock. If you, dear reader, can stay for both parts, you will gain a basic understanding of how anisotropy in P-P seismic reflection data can add to our understanding of the rocks, specifically the reservoir, at depth.

Rocks are composed of minerals and contain layers, porosity and pore fluids and are influenced by a tri-axial stress field (for the most part), plus local structure – faults, fractures, folds and small variations in curvature.

Four words provide the fundamental description of rocks: homogeneity, heterogeneity, isotropy and anisotropy.

"Homogeneity" means spatial invariance in a property laterally and/or vertically. For example, the P-wave velocity (V_P), the shear-wave velocity (V_S) and density – the three primary characteristics we seek to learn from seismic data – are spatially invariant laterally or vertically.

"Heterogeneity" means that there is a lateral or vertical change in V_P, V_S, and/or density: facies changes or the vertical stratigraphic column. The layers of sedimentary rocks are the primary heterogeneity that we map using reflections that arise at impedance (velocity times density) contrasts.

"Isotropy" means that, for a given volume of rock of interest, whatever measurement you wish to make shall yield to you the same value, no matter which direction in which it is measured.

"Anisotropy" means that, for this volume of rock, the direction in the measurement is made shall determine its value.

These four words usually exhibit scale-dependency. That is, the frequency used for the seismic measurement will determine your assessment of the rock. For the purposes of this article, I am speaking of the surface seismic reflection data, with frequencies of 5-100 Hertz (5-100 cycles per second).

Permeability and Velocity

Examples of anisotropic quantities are permeability and velocity. Engineers are familiar with the permeability (K) anisotropy of rocks: $K_{vertical}$ is not equal to $K_{horizontal}$; some reservoirs exhibit a K_{Hmax} which is not equal to K_{hmin}. V_P and V_S are notorious for being anisotropic in the sedimentary layers that can contain hydrocarbon reservoirs.

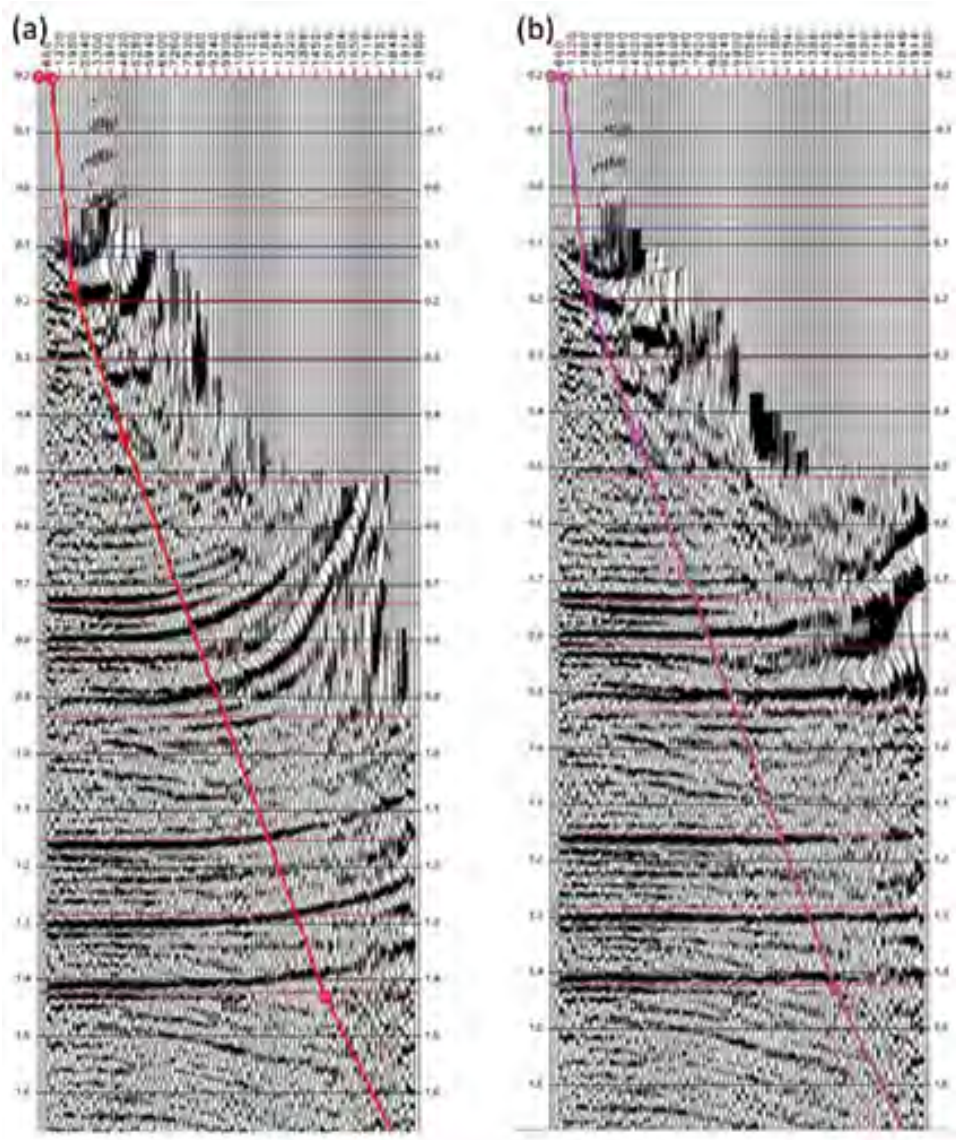

Figure 1. P-P reflection seismic data, one gather with traces ranging in source-receiver offset from 660 feet to 19,800 ft. These two gathers illustrate the effect of VTI (layer anisotropy) on P-P data. (Left) The reflectors are fairly flat on the near offsets, The curve up is due to the faster velocity encountered on the greater offsets. The red line is a possible mute function. (Right) The same data after the eta (nonhyperbolic moveout) correction. Now the reflectors are flat in time across the gather, ready for stack. The pink line is the mute function: the offsets greater than the mute are zeroed prior to stack. Stacking the data now will increase the S/N because now all the events are aligned and in phase. (Figure courtesy of TGS.)

"All anisotropy arises from ordered heterogeneity smaller than the wavelength."

This sweeping statement from Don Winterstein's paper in Geophysics, " Velocity anisotropy terminology for geophysicists," remains unrefuted. The wavelength is determined by the frequency and the velocity (frequency x wavelength = velocity). The ordered heterogeneities smaller than the wavelength can include shale clay platelets and finely layered rocks. Other ordered heterogeneities may be one set of vertical aligned fractures. The word "fracture" is very unspecific: it lumps together stress-aligned microfractures (arising from unequal horizontal stresses) whose apertures are too small to flow fluids, and macrofractures that flow fluids. We would prefer to find (and document) a method that will empirically disentangle these two situations, even at the risk of arousing the ire of the theoreticians. If there are heterogeneities ("crack-like pores") smaller than the wavelength, but they are disordered, then we are back to seismic isotropy. True matrix porosity will look the same for all azimuths. The word "azimuth" in this article is the direction from source to receiver that the wave travels.

Rock Symmetry

In the world of anisotropy, there are four words or phrases that need to be known: transverse isotropy, orthorhombic, monoclinic and triclinic. These words indicate a certain symmetry (order in the heterogeneities) that we want to know about. The symmetry of the rock is imprinted upon the wave. By recording and displaying the symmetry of the wave, we deduce the symmetry of the rock. Although the more accurate statement is that the wave is influenced by the symmetry of the last layer through which the wave travels, geophysicists have various means to try to peer through the upper layers in order to see the reservoir conditions. We have to strip off the effect of the upper layers, in order to see the properties of the layer of interest (the reservoir). To "display the symmetry of the wave," I refer to inspecting interval travel times, amplitudes, frequencies, etc., as a function of azimuth and offset, from 0-180 (north to south) or from 0-360 (north to south to north), preferably the latter.

The principal order in the heterogeneities smaller than the wavelength is the layering of the rocks: we routinely expect to find a plane of isotropy in the bedding plane. If there is a plane of isotropy we have transverse isotropy (TI). Now we have to state the **normal** to the plane of isotropy. Transverse isotropy with a vertical axis, VTI, is the layer anisotropy (see figure 1). Transverse isotropy with a tilted axis is TTI (dipping beds). VTI or TTI means that the P wave traveling parallel to the bedding plane will have the same

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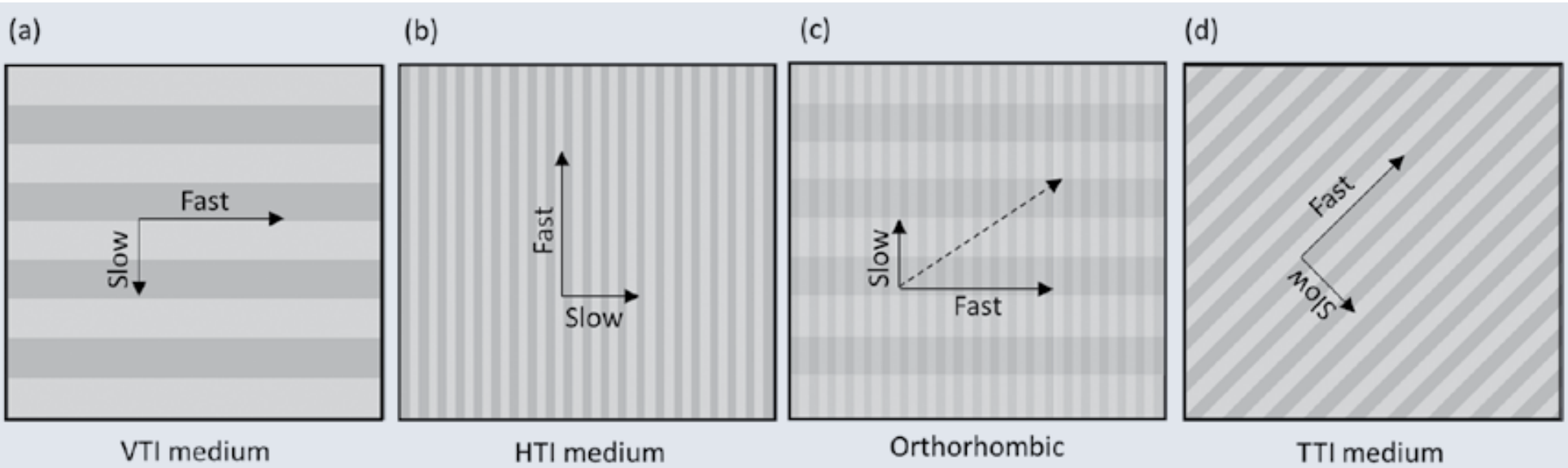

Figure 2. VTI: sedimentary layers. HTI: one set of vertical aligned fractures. Orthorhombic: VTI + HTI. TTI: tilted TI, dipping sedimentary layers. The length of the black arrow is proportional to velocity (measured in direction that arrow points). The 3-D picture of the orthorhombic black arrows has the dashed arrow being into the plane of paper and parallel to the vertical aligned fractures. (Figure courtesy of Satinder Chopra.)

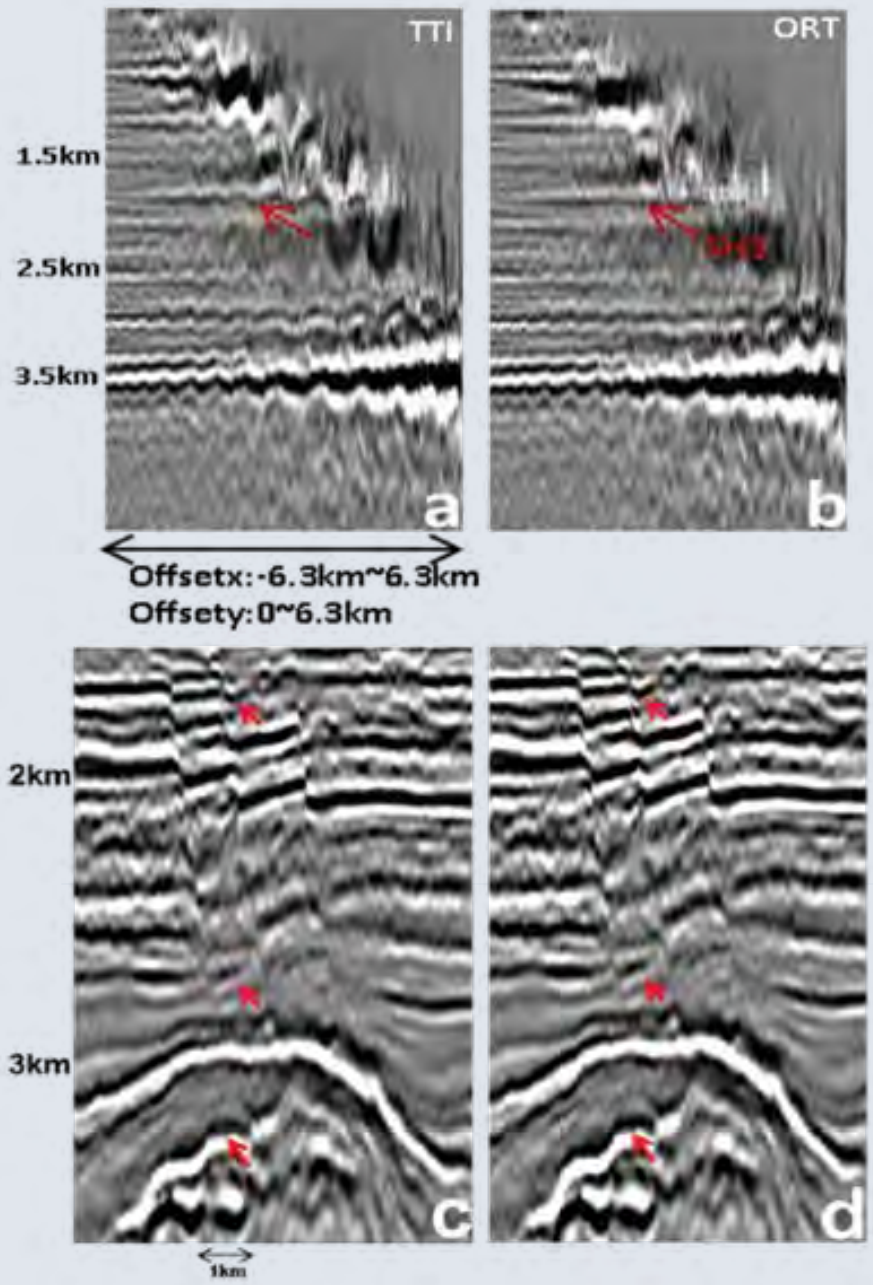

Figure 3. P-P reflection data from an ocean bottom survey, offshore Vietnam. a) An azimuth-sectored TTI common image gather after four iterations of tomographic update from water bottom to top of basement (anticline reflector at ~3-kilometer depth). Data is sorted as a "snail" gather, meaning there are a suite of offset bands within which the azimuths go from North to South. The TTI prestack depth migration has taken care of the layer anisotropy, but has left in the azimuthal traveltime wobble, see red arrow. b) Initial ORT common image gather. The ORT velocity field has specified the VTI and HTI effect sufficiently to flatten the event (red arrow). c) Azimuth-limited TTI stack section. d) Initial ORT stack section. The red arrows point to locations where the ORT prestack depth migration has improved the image. Because the azimuthal traveltimes are corrected, the stack can use all azimuths and all offsets, for superior S/N. Moreover, we now have the ORT migration velocity field to use in interpretation: a very important step. (Adapted from Jiao, et al., 2017)

◀ Continued from previous page

(faster) velocity whether it travels north or east or south, etc. However, normal to the bedding plane, the P wave velocity will be slower. Figure 2 presents schematically the symmetry terms.

Transverse isotropy with a horizontal axis, HTI, is the symmetry of one set of vertical fractures: the P-wave traveling parallel to the fractures will travel faster, while the P-wave traveling normal to the fractures will travel slower. Evidence of azimuthal P-P travel times is visible in figure 3 (a) where the farther offsets show the travel time variation by source-receiver azimuth (a wobble, red arrow). The data are sorted first by offset group, then by azimuth within each offset group. The corrected travel times for orthorhombic processing are shown in Figure 2(b). The red arrow indicates where the azimuthal travel time variation is greatly reduced.

This medium is also bi-refringent ("two waves") for the shear-wave: the vertically propagating shear wave with particle motion parallel to the fractures will travel faster; the vertically propagating shear wave with particle motion perpendicular to the fractures will travel slower. Shear-wave splitting occurs when the shear-wave with arbitrary polarization (particle motion skew to the fabric of the rock) enters the medium with one set of vertical aligned fractures: the one shear wave will become two shear waves.

Orthorhombic (ORT) is flat layers with one set of vertical aligned fractures; flat layers with two sets of orthogonal fractures is also allowed in the ORT symmetry. Note that you don't know whether I'm referring to stress-aligned micro-cracks or macrofractures that flow fluids or some combination thereof. It turns out that across North America (and the rest of the world) about a 2 percent azimuthal variation in the P-wave V RMS is common (according to Ed Jenner, a senior geophysicist at NEOS). The word "azimuth" refers to the source-to-receiver direction (usually referenced to north when data is delivered to the client). We know that macro-fractures that flow fluids are rather rare, not found everywhere all the time. Therefore, our seismic data is telling us that there is a background ubiquitous effect across continents that causes azimuthal variation in the P-wave velocities: it is likely the unequal horizontal stresses. When our migration (imaging) algorithms accurately specify the velocity field that changes with space (heterogeneity) and offset

See **ORT**, page 23 ▶

Pangaea

from page 19

the South Pacific. There is much more, however. Magnetic data indicate very large extensions to the north and east. Permian-lower Cretaceous sandstones in New Zealand's eastern Torlesse Terrane, 3,500 kilometers long, 300 kilometers wide and 30 kilometers thick, came from here.

Pangaean Reconstructions and Earth Size

Proliferating models of Pangaea, its breakup and dispersal show Increasing complexity, recognizing ever more small terranes and their migrations, but they overlook important data.

One objective, to model paleoclimate and thence source rock presence, requires knowledge of ocean currents. Mid-Jurassic/Miocene shallow-water deposits and subaerially weathered rocks, now 1 – 7 kilometers deep, in Deep Sea Drilling Project sites in the Atlantic, Indian and Pacific Oceans must have been influenced by these, but reconstructions do not show them. Those large subsided continental masses need to be taken into account as well.

Reconstructions show oceanic crust east of Japan and New Zealand, and west of South America. But Japan received sediments from the east in the Palaeozoic-Paleogene and a million cubic kilometers of Devonian micaceous sediments in Bolivia and Argentina came from the west. Geological, geophysical and dredge data evidence Precambrian, younger continental crust under northwest Pacific abyssal plains. It subsided below deep sea at the end of the Jurassic, but you can still see it on the magnetic map.

The reconstructions use constant size Earth. There are 75,000 kilometers of "spreading" ridges and only 30,500 kilometers of trenches and 9,000 kilometers of collision zones. Production of more crust than consumption implies that the Earth is expanding.

Space-geodetic data show that the solid Earth expanded about 0.24 millimeters annually in recent decades. Growth increments on fossil corals and brachiopods show that days per year declined from 424 in the Middle Cambrian to 365 today – like a pirouetting ballerina extending her arms, Earth grows and slows.

How?

Serpentinization of shallow mantle peridotite results in up to 40-percent volume increase and release of heat. Is this responsible for elevation of MORs, with their black smokers? Does radial growth contribute to continental separation, extension and subsidence?

Origin of Continental Crust

Intra-oceanic volcanic arcs are characterized by high silica andesite (named from the Andes of South America). This cannot derive from subducting slab low-silica basalt so we have an "andesite problem." For PT, the rock reflects "new" continental crust formed by complex partial melting of sediments, the slab, the mantle or the mantle wedge (or combinations of these) in "subduction factories." This is where continental crust forms.

Recently discovered Precambrian and Palaeozoic zircons produced by the volcanoes of and continental seismic velocities below island arcs Izu-Bonin, Luzon, Vanuatu, Solomon Islands, East Java and the Lesser Antilles show they are underpinned by original continent. There is no andesite problem and subduction factories are not required.

Blueschists (high-pressure/low-temperature metamorphism) are seen as classic indicators of fossil subduction zones, involving descent of material to 40–80 kilometers over millions of years, metamorphism, and then unexplained resurrection. However, some radiometric data suggest metamorphism only slightly younger than predecessor rocks. There are no blueschists in the Central American or Lesser Antilles subduction arcs. Along the north and south Caribbean margins, metamorphism increases and high-pressure/low-temperature rocks occur close to strike-slip faults. Some are even interbedded with sedimentary equivalents.

How Do Mountains Form?

While normal faults might involve tens of kilometers of displacement and thrusts up to several hundreds, strike-slip displacements can be many hundreds. These latter, primordial faults form a conjugate northwest and northeast global pattern. Transtention/transpression within this generates secondary north-trending extension and east-trending compression. The polygonal blocks these define are repeatedly shuffled within this global fabric.

Africa supposedly converged 2,000 kilometers with Eurasia, pushing up the Alps. Yet there is no uplift along the same boundary to the west in the Atlantic. The Alps and Carpathians carry European brachiopods. There is nothing African present. India is supposed to have migrated 7,500 kilometers north across the Indian Ocean to push up the Himalayas, but fossils relate India to Eurasia. Head-on collision of far travelled continents is not indicated. Perhaps strike-slip plays a role.

There is an interesting, dynamic, natural strike-slip laboratory along northern South America (see figure 4). Right-lateral offset generates eastward-younging foreland basins followed by inversion into overriding uplifts. The 200 milligal negative gravity anomaly, the world's largest at sea level, over the eastern, Maturín Basin suggests a root without a mountain. Major hydrocarbon reserves occur here. Industry data (sediment thickness, overpressures, low heat flow) point to blueschist conditions at depth.

The 210 milligal positive anomaly over Colombia's 5,800 meter Sierra Nevada de Santa Marta, the world's highest ocean-side mountain, indicates a mountain without a root, overriding the Caribbean.

The Mérida Andes, also strike-slip related, lie halfway over the 150 milligal negative gravity anomaly in the southern Maracaibo Basin – the mountain is arriving over its root. It has already covered the Guarumen Basin and inversion further north exposes blueschists in the Coastal Range. Graphitic rocks record former hydrocarbon systems.

Unlike the Atlantic, the Pacific is

Continued on next page ▶

Keith James is a consultant geologist and a fellow of the Institute of Geography and Earth Sciences of Aberystwyth University in Wales, UK. Previously, he worked with Shell in Gabon, Spain, Venezuela, the UK, Holland and Houston, where he then joined Conoco as chief geoscientist of international studies. He is interested in the geology of Middle America (see notice of planned Hedberg Conference) and global tectonics.

Heloise Lynn started her career with Texaco in 1975. Thereafter, she completed her doctorate in geophysics from Stanford University in 1980. Then she worked for Amoco-BP. Since 1984, she has consulted in anisotropy, multi-component, and multi-azimuth seismic data. In 2015, she was presented with the Fessenden Award of the Society of Exploration Geophysics for her contributions to the industry on the use of azimuthal anisotropy contained in field data to extract geologic information.

ORT

from page 21

(layer anisotropy) and azimuth (unequal horizontal stress and/or vertical aligned fractures), then our images are clear and crisp.

ORT is the current standard symmetry for the industry … plus we have as "attribute" volumes the quantification of the velocity fields – and these we use in interpretation. Velocity is affected by lithology, porosity, pore fluids, horizontal stress (in the direction of source to receiver) and fracture sets. From laboratory studies, we know that stress in the direction of source to receiver has a proportional effect upon the P-wave velocity. The standard explanation for the laboratory observations is that increasing the stress in one direction will close the micro-cracks that are normal or near normal to the increased stress; this closure of the cracks normal to the increased stress will increase the P-wave velocity.

Interval velocities (V_{INT}) average large volumes of rock, bounded by reflectors, and tend to change slowly spatially. The reflection amplitudes, however, are a spatially high-resolution dataset: they record the local contrast in impedance. The macro-fractures that flow fluids usually govern the azimuthal amplitude signatures: at least, this can be an initial hypothesis, to be tested against your own seismic data and calibration data. Since azimuthal V_{INT} and azimuthal amplitudes are arising from different volumes of rock, they need not agree. If they do agree, that's fine. When they don't agree, we note the heterogeneity between the two different rock volumes.

To be continued in next month's Explorer.

Acknowledgements: My thanks to Mike Perz of TGS-Calgary for his kindness to supply figure 1 in this article. I thank Satinder Chopra for requesting this article after he soldiered through my Geophysical Society of Houston webinar, "Azimuthal P-P for Better Imaging, Fractures, and Stress Analysis" in December 2017.

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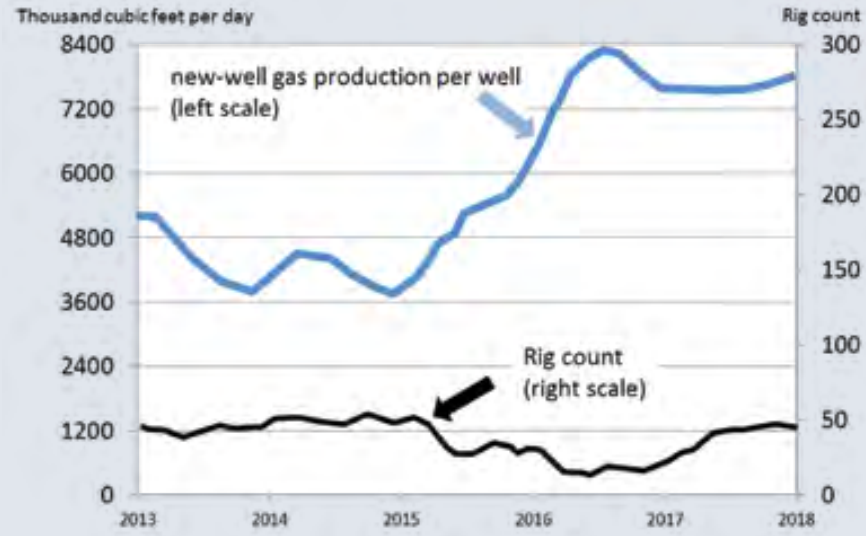
markedly asymmetric – the East Pacific Rise (EPR) approaches South America and converges with North America. Magnetic data indicate large areas of extended, subsided continent west of the Rise but none to the east. Yet large amounts of conglomerates/sandstones in the Andes came from the Pacific. Crustal thicknesses here up to 70 kilometer speak of merger.

Since the EPR hit the trench Pacific/North America strike-slip motion has occurred along the San Andreas Fault. From Alaska to Mexico the North American Cordillera carries far travelled (hundreds of kilometers) distal/oceanic thrust sheets, detached from subducted Pacific crust to overly Precambrian-Mesozoic shelf sequences.

Extended/thinned continental crust is perhaps easily thrust onto continental margins. Paleozoic and Mesozoic troughs in Peru, with steep western boundaries and gentle eastern slopes, contain 10-12 kilometer thick prisms of shallow deepwater deposits (upward concave SDR reflections possibly indicate basinward velocity decline). Bounding growth faults acted as volcanic conduits. They resonate with those asymmetric basins seen on deepwater seismic.

These "vanished continents" once linked North America, southeast Asia, Australia and South America. They explain plant and animal fossil distributions.

Obviously, many will disagree. That's fine, discussion is good. But don't overlook those large areas of subsided continent remaining to be recognized. They could carry huge reserves. Someone will eventually lay claim to them. Meanwhile, published PT teaching is complacent. It should adapt to emerging data, include multiple working hypotheses and enable students to think and choose. If not, the writing in stone might eventually read "RIP."



New Methods Drive Haynesville Renaissance

Improved technology and innovation have pumped new life into the Haynesville Shale as a natural gas source.

But, according to Bill DeMis, it has done much more than that.

"The Haynesville is going to be the swing producer that sets the price of natural gas in the U.S.," said DeMis, former senior vice president and chief geologist at Goldman Sachs.

"Clearly, new technology and innovations in the Haynesville (shale play) are driving the play to higher profitability, despite flat natural gas prices,» said DeMis. "The techniques being refined in the Haynesville will ultimately propagate to less-profitable tier-2 and tier-3 shale plays. These second tier shale plays will become the resource drivers of tomorrow."

DeMis said new "super-sized" hydraulic fracturing methods, access to pipeline and LNG export, have turned the Haynesville into a profitable monster.


DeMIS

> "We're seeing American ingenuity and innovation in resource plays leading to the insourcing of jobs back to the U.S. because companies know they have a continuous commodity supply at a reliable price."

The "super-sized" fractures involve pumping two tons or more of sand per foot into the horizontal wells.

Moreover, existing Hayneville wells that have been re-fractured using new methods are on track to produce more gas than the original well completion.

The re-emergence of the Haynesville, along with other Gulf Coast resource plays, has inspired an AAPG Playmaker Forum, chaired by DeMis and scheduled for April 26 at the Marathon Conference Center in Houston. The theme is "Haynesville and Re-emerging Resource Plays of the Gulf Coast."

While the Haynesville story will be the focus of the forum, other resource plays of the Gulf Coast, such as the Austin Chalk and Eagle Ford, will also be highlighted during the one-day meeting. Speakers will detail the formations' geology, the economics, and the evolution of the improved fracturing designs.

The forum includes more than a dozen speakers from oil and gas majors, independents and investment bankers. Thomas Bowman, president of TDB Oil Corporation, will co-chair the event.

'Propageddon'

DeMis said the new hydraulic fracturing methods driving the resurgence are especially exciting.

"The Haynesville came online in 2008. By 2010, the bloom came off the rose," he said.

Peaking at more than 200 wells, the play fell off until about the middle of 2016, DeMis explained.

"Wells were expensive to drill and the

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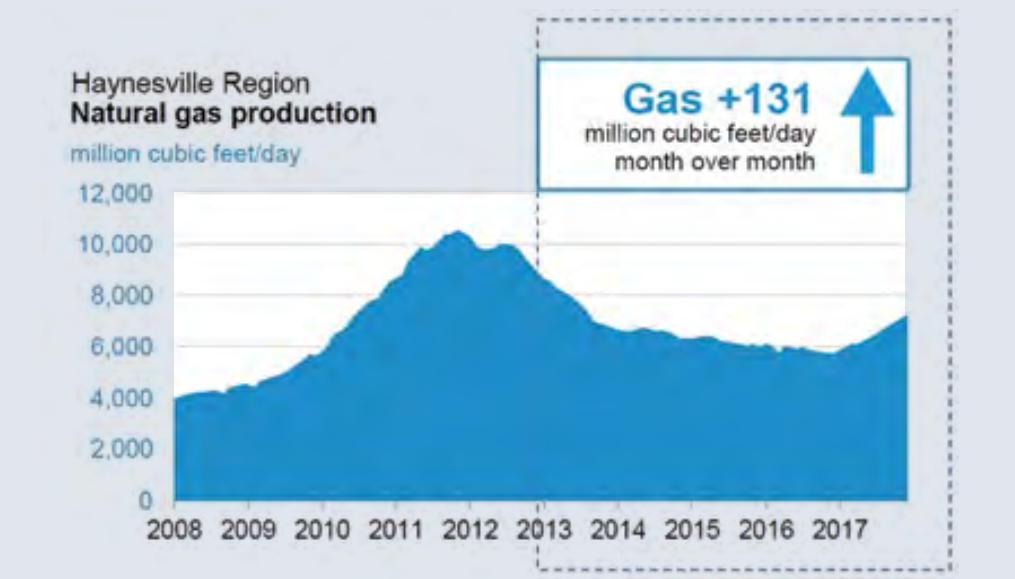

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Marcellus shale land-rush sucked the air, and money, out of the room," he added.

Today, Haynesville rigs rates are rising and production per well has doubled, he said.

In late 2016, Chesapeake Energy made headlines with a Haynesville well, dubbing the project "Propageddon," DeMis noted.

The record-setting project used more than 25,000 tons of sand in a single well: "It was incredible – output from the well increased 70 percent over traditional frac'ing techniques," Jason Pigott, vice president of operations, said during a presentation.

The monster dose of sand is able to prop open more and larger cracks in the rock, freeing more gas.

Longer lateral drilling also helps with efficiency of cost. Drilling longer laterals takes more than just whimsy, DeMis said.

DeMis called the frac'ing revolution "a true, industry-disruptive technology, similar to the impact that Uber had on transportation or Amazon had on retail marketing."

"We're seeing American ingenuity and innovation in resource plays leading to the insourcing of jobs back to the U.S. because companies know they have a continuous commodity supply at a reliable price," he said.

Goodrich Petroleum Chief Operating Officer Robert Turnham Jr., who will be speaking at the forum, told Natural Gas Intel: "All things being equal, longer is better and more proppant is better, at least in the Haynesville. As far as choking these wells back, we think it's an integral part of ultimately getting the maximum recovery of the resource in place and we limit our drawdown to roughly 30, maybe as much as 50 psi per day. Simply put, it's just being gentle on the formation by not pulling the well too hard."

Revising Resource Estimates

Demis said a 2010 United States Geological Survey assessment put the amount of resources in the Bossier and Haynesville in the Gulf Coast Basin at 70 trillion feet of cubic gas, but a new report released in April 2017 attributes over 300 TCFG for the Bossier and Haynesville across the entire Gulf Coast, from Florida to Mexico.

"As the USGS revisits many of the oil and gas basins of the United States, we continually find that technological revolutions of the past few years have truly been a game-changer in the amount of resources that are now technically recoverable,» said Walter Guidroz, program coordinator of the USGS Energy Resources Program.

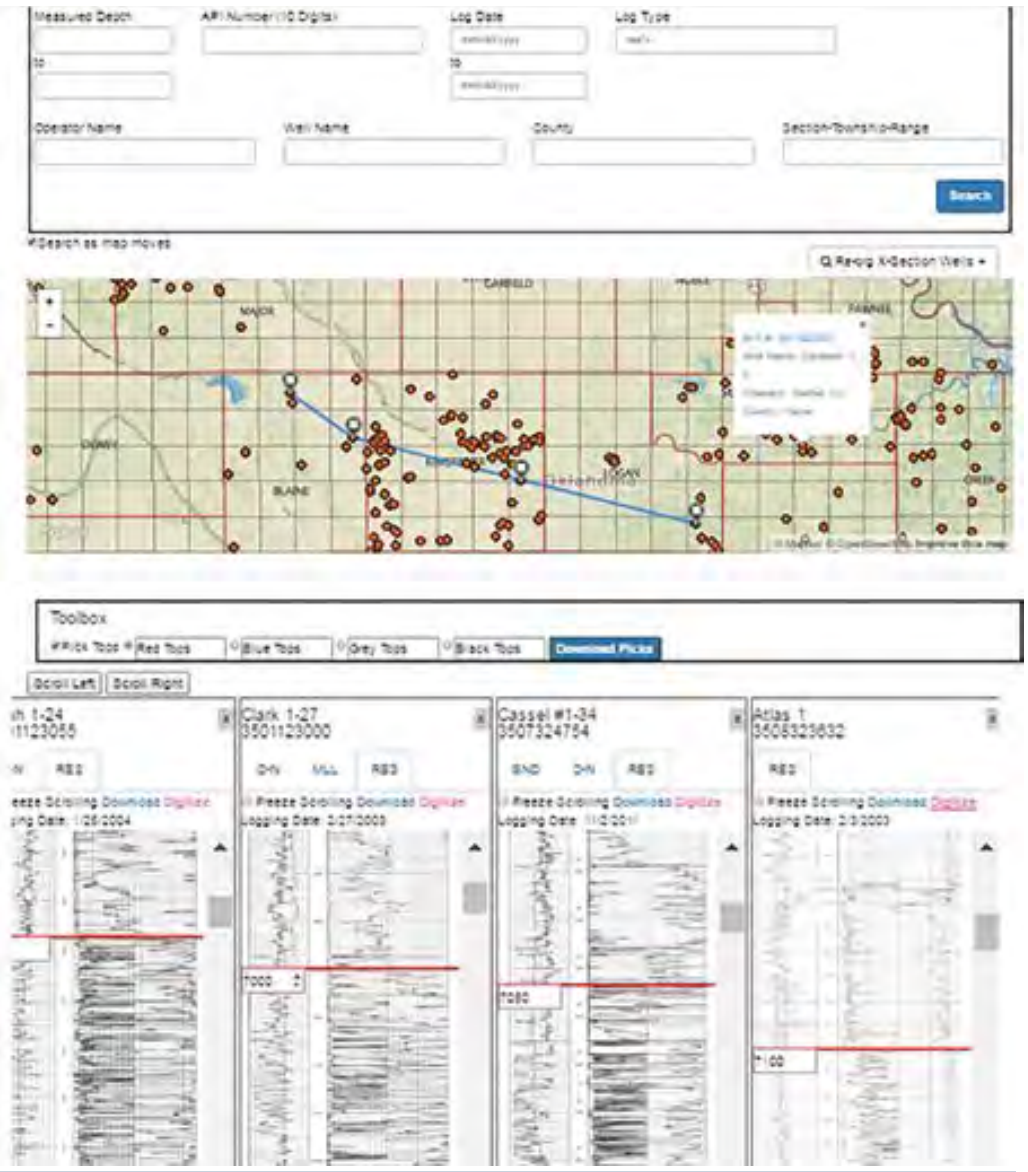
"It's amazing what a little more knowledge can yield," said USGS scientist Stan Paxton, lead author of the assessment.

The EIA estimates the Haynesville Shale has 147 TCFG of commercially recoverable gas, Demis said.

Moreover, with the infrastructure already in place in the region, "There will always be a market for Haynesville gas," he said.

DeMis said the Haynesville is here to stay.

Startup Focuses on 'Geoprogrammology'



A screenshot of the WellLogData online application.

KERNAN

> "We've participated in other pitch events that are more broadly technology and it is difficult to explain what it is we do to an audience that doesn't work in oil and gas science."

When Henry "Ted" Kernan started his online platform WellLogData, he was trying to fix a problem he had long encountered as a geologist: how to best view and interpret a large number of image logs for onshore U.S. basins.

Most software, he noted, is made for offshore fields, where wells are in the hundreds. Onshore there is data for millions of wells.

"Most of that is present in images, and the original digital registry has been lost," he said. "Digital well logs overwhelmingly come from tracing these images, but digitization has been ad hoc throughout the decades."

Enter WellLogData, his geologic and engineering interpretation platform.

Using a Software as a Service Web (SAAS) model, Kernan's platform is able to preload onshore data, including the well log, production, FracFocus and completion information, through an online browser.

"WellLogData makes it easier to view these files," he said, "and we are developing new techniques to digitize them in a standard, complete way that will provide much more information than has been extracted so far."

Currently, users can click on a well spot in seven states and create a cross-section directly online, he said.

"We have depth-registered a significant number of logs so that users can also pick tops and plot perfs, driller tops and casing depths," he said.

For an additional cost, he added, users can download the original image file, a depth registration file and order LAS curves.

"We are expanding our functionalities to provide standard LAS outputs for all wells and additional search functionalities for well-header information," said Kernan. "We also have the ability to digitize, depth register and organize other TIFF image libraries, providing a while-label solution."

Entrepreneurial Obstacles

As a startup, Kernan faces challenges, he said.

"One large challenge was in developing the technology," he said. "I've called myself a geoprogrammologist for over a year

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Interested applicants should forward resumes to Grant Eidson, Paisano Energy Advisors, 4441 Buena Vista Street, Dallas, TX 75205.

Geology Merit Badge Program at the Summit

The books have closed on the successful 2017 Boy Scouts of America National Jamboree, held at the Summit Bechtel family Reserve High Adventure Base near Beckley, W.Va.

The 2017 program offered scouts two different settings to learn about geology. A team comprised primarily of AAPG Member geologists volunteered their time to lead the geology program at the event.

The formal geology merit badge classroom was located in a high-traffic zone, Action Point, between two sub-camps and a mountain bike and skateboard park. It hosted twice-daily classes, a rock and mineral collection for visitors to inspect and touch, and a continuous-stream table demonstration of erosion, deposition and stream processes.

At Action Point they received 1,456 visitors who entered and asked at least one question with 250 Scouts completing the Geology Merit Badge.

The second setting was in the nature study area, where the group shared space with several other groups (orienteering, geocaching, bird study, nature photography, etc.) and maintained a geophysical station and hands-on rock and mineral museum. It also offered twice-daily docent lead geology hikes to a nearby quarry where the scouts learned about the depositional features and fault planes.

Scouts were able to qualify for a special nature pin if they could answer questions from all eight nature program areas represented, so visitors stayed for a lengthy amount of time. In all, 2,215 visitors participated in outbound experience and 14 scouts earned their geology merit badge here.

BSA offers 138 different merit badges in their program. In 2016, the geology merit badge placed 30th in overall popularity, and more than 18,500 scouts earned the badge in that year.

Historically, nearly 688,000 have earned the geology merit badge.

The merit badge program is designed to expose scouts to different careers and hobbies. The AAPG Foundation has been a sponsor of this program since 1993. Funding for this event provided though the E.F. Reid Scouting Fund.

For a full report go to foundation.aapg.org.

HART

> "BSA offers 138 different merit badges in their program. In 2016, the geology merit badge placed 30th in overall popularity, and more than 18,500 scouts earned the badge in that year."

Continued from previous page

now, but certainly it was never part of my master's program at (Colorado School of Mines.)"

It was while working at ExxonMobil that he envisioned many of the key functions he has been able to put into practice with WellLogData, though he lacked the skills at the time to make it all possible, he said.

"We now face the same challenges any other startup faces, but having crossover skills – and working with other geoprogrammologists – helps us overcome them," he added.

Kernan also credited the AAPG Pitchapalooza event at last year's AAPG Annual Convention and Exhibition in Houston for helping to overcome some of those obstacles. It allowed for networking opportunities and offered a place to hone messaging of the product, he said.

"We've participated in other pitch events that are more broadly technology and it is difficult to explain what it is we do to an audience that doesn't work in oil and gas science," he said.

Looking forward to 2018, the company is growing but continues to try to stay lean. WellLogData is looking for more customers and strategic partnerships with other players, Kernan said. A video introduction and free demo access are available at WellLogData.com.

New Applied Hydrogeology Certificate Programs at Western Michigan University

Western Michigan University (WMU) offers both graduate and undergraduate-level Certificate Programs in Applied Hydrogeology: https://wmich.edu/geology/academics/hydrogeology-certificate. These 15-credit certificates are based on WMU's well-known hydrogeology program, which provides applied analytical, field, and technical skills to prepare students for successful careers in hydrogeology and environmental consulting.

Our 6-credit hydrogeology summer field course, the oldest in the US, helps students gain experience and develop problem-solving skills essential to field work. Different 1-week modules focus on water well design, installation and development; sampling; near-surface geophysics; aquifer testing and analysis; and contaminant transport and remediation. Students sample water and aquifer materials, collect and analyze data using industry-standard software, use those data to determine field hydrogeochemistry, present results orally, and write technical reports. This 6-week-long course is taught May–June and again July–mid August. The first week is the OSHA-required 40-hour HAZWOPER training that consulting firms prize in job candidates.

Certificate students also select three courses (9 credits) online (e.g., hydrogeology, contaminant hydrogeology, hazardous waste remediation, soils, aqueous geochemistry, and surface water hydrology) or face-to-face to complete the Certificate. All 15 credits from the graduate certificate can count toward a Master's degree at WMU if desired. Applications are now being accepted for the Graduate and Undergraduate Certificates in Applied Hydrogeology. Students can begin any semester. Contact Michelle Gates, Dept. of Geosciences, at michelle.l.gates@wmich.edu or (269) 387-5485 for more information.

Foundation Update

Amoruso Receives AAPG Foundation's Top Honor

Legendary AAPG and AAPG Foundation giant John Amoruso has yet another honor to add to his list of achievements: he is this year's recipient of the L. Austin Weeks Memorial Medal, the AAPG Foundation's highest honor.

Amoruso, a Houston-based geologist who is among the most honored Members in AAPG history, is receiving the Weeks Medal for his exemplary leadership and philanthropic support to the Foundation for over 30 years.

The Weeks Medal is an annual Foundation award that recognizes outstanding leadership for philanthropy and service directed to advance the mission of the Foundation.

Advancing the AAPG as well as the Foundation's mission has been a career-long passion for Amoruso. He is a past president and Honorary Member of AAPG and his experience in the industry spans more than six decades, including more than 50 years as an independent petroleum geologist.

"If you like your job you will never have to work – and I love what I do," Amoruso has often said. "Geology is not only my profession, it is also my hobby."


AMORUSO

> "If you like your job you will never have to work – and I love what I do. Geology is not only my profession, it is also my hobby."

Amoruso's Career

Amoruso joined AAPG in 1958, recognizing as a young man the value a professional association could bring to his career. Once he joined he was hooked – just as he was when he took his first elective class on geology and the lectures of his professor Robert Nichols inspired him to change his career path from engineering to geology.

Amoruso quickly recognized the tremendous opportunities AAPG afforded by providing accessibility to science and networking with other geologists. When he received AAPG's Michel T. Halbouty Outstanding Leadership award in 2007 he noted that it was a joy to be involved in all levels of professional societies through hands-on participation, emphasizing the friendships developed, along with the networking opportunities.

And participate he has:

- He actively participated in AAPG by writing and submitting papers, becoming a two-time winner of the A.I. Leverson Memorial Award in the early 1970s.
- He expanded his knowledge of the science and profession by attending meetings and conventions.
- He added to his credentials by receiving his certification as a Professional Geologist through AAPG's Division of Professional Affairs.
- He shared his knowledge with students and other professionals as a Distinguished Lecturer through the Foundation's Distinguished Lecture program.

He did all that while maintaining his enormous reputation as a successful oilman, winning AAPG's Norman H. Foster Explorer of the Year award in 2010. That success also landed him recognition as one of AAPG's Discovery Thinking speakers, plus a coveted spot on AAPG's celebrated GeoLegends video archive.

His leadership skills, which he credits to his military service in the U.S. Navy, strengthened as he volunteered his time to serve on numerous AAPG committees, often accepting officer positions.

It was while serving as the president of AAPG in 1983-84 that he saw the role and value the Foundation played in supporting the geoscience community and educating public about the industry. He joined the Trustee Associates, the Foundation's major donor group that provides the backbone of financial support to the Foundation, recruiting many of his friends and colleagues to join and give their financial support to programs focused on sharing the science with the next generation of geoscientists.

"I believe that giving to the AAPG Foundation is the best way to help the Association programs," he said, "which benefit our profession and make possible outreach programs that educate and inform students and the public about geology in general and petroleum geology in particular."

In 1986, Amoruso was appointed a trustee on the AAPG Foundation's Board of Trustees, where he served for three decades, helping shape the Foundation as we know it today.

To find out more about Amoruso's career – and to hear him describe it and his award-winning oil discovery – visit AAPG's GeoLegends website, at aapg.to/GeoLegendsAmoruso1.

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Statement of Ownership, Management, and Circulation (All Periodicals Publications Except Requester Publications)
AAPG Explorer
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$75.00
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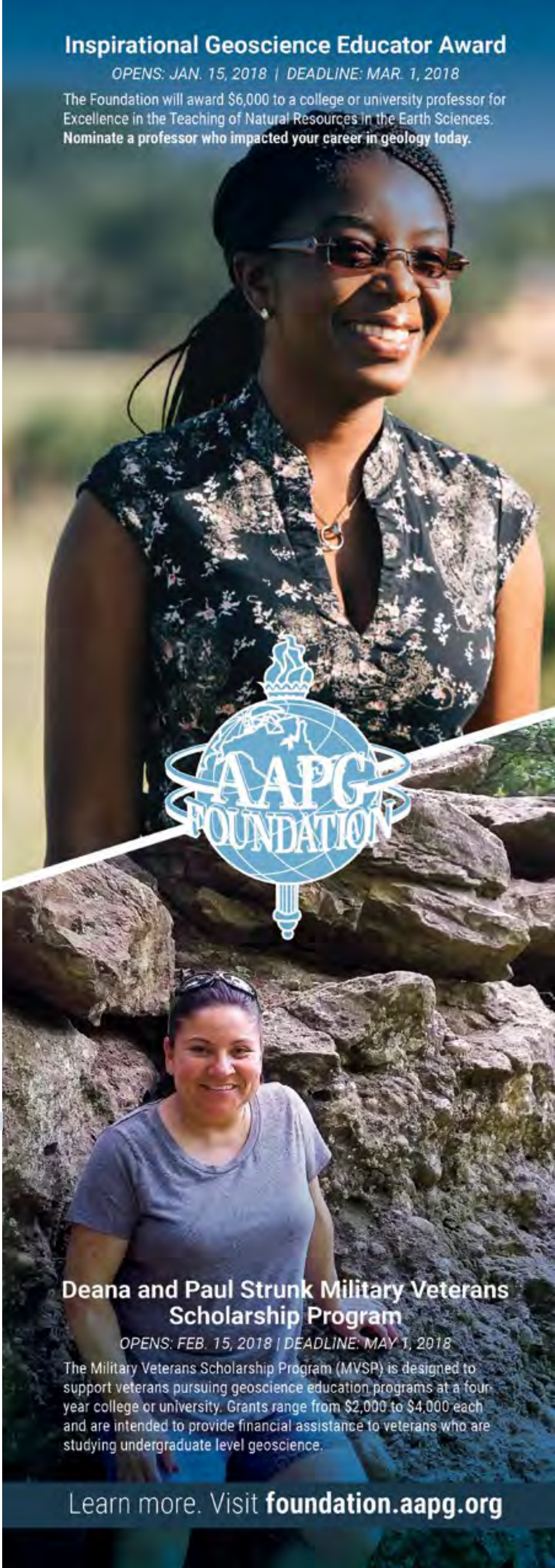


Director's Corner

Energy Dominance and the Outer Continental Shelf

Energy dominance is how the White House described the Trump Administration's emerging energy policy in mid-2017. With expanding U.S. oil and natural gas production coupled with growing exports to global markets, the muscular language signaled a notable policy shift from the previous administration, and a desire to leverage the nation's petroleum resources for its economic and security potential.

Early last month, the government took a significant step with Interior Secretary Ryan Zinke announcing the development of a new National Outer Continental Shelf Oil and Gas Leasing Program for the years 2019-2024, which, if adopted, would supersede the 2017-2022 National OCS Program developed by the Obama Administration.

"Responsibly developing our energy resources on the Outer Continental Shelf in a safe and well-regulated way is important to our economy and energy security," said Secretary Zinke.

Under the Draft Proposed Program released with the announcement, more than 90 percent of the entire OCS would be made available for leasing in the largest number of lease sales in history. And, according to resources estimates, the plan would provide access to 98 percent of the undiscovered, technically-recoverable resources on the OCS. The current program, in contrast, withdrew 94 percent of the nation's OCS from leasing.

"Today's announcement lays out the options that are on the table and starts a lengthy and robust public comment period," Zinke continued. "Just like with mining, not all areas are appropriate for offshore drilling, and we will take that into consideration in the coming weeks. The important thing is we strike the right balance to protect our coasts and people while still powering America and achieving American Energy Dominance."


CURTISS

It's time to invest now in the production of the future. It's time to explore again, and the OCS is a good place to begin.

Developing the Plan

As the secretary observed, the development of a five-year National OCS Program is a rigorous and formal process with multiple stages.

In this stage the Bureau of Ocean Energy Management, the government agency responsible for the OCS leasing program, is collecting public comment on the DPP as well as its Notice of Intent to conduct a Programmatic Environmental Impact Statement. This public comment period is 60 days long and open until March 9, 2018.

After collecting and assessing the comment received on the DPP and the Notice of Intent the Bureau will develop a Proposed Program and a Draft PEIS. These will then be published and, again, open for public comment. This time there will be 90 days to provide the government with additional information and recommendations.

Based on the responses for public comment, the Bureau will develop and publish a proposed Final Program and Final PEIS. Again, these will be open to a 60-day period for the president and Congress to provide input prior to approval of the Final Program.

At each stage the public has the opportunity to weigh in on the plan, and it's this iterative process that allows society to balance protection of people and environment with the energy needs of the nation.

Most importantly, however, the Trump Administration has, for the first time in recent memory, elected to give industry the opportunity to bid on the areas of the OCS where it most desires to explore. It is allowing industry to lead the way, investing in those projects they believe most likely to yield a return.

AAPG applauds this approach.

As articulated in its policy statement on the OCS, "AAPG supports the full exploration, development, and production of the petroleum resources on the Outer Continental Shelf and Slope of the United States."

What You Can Do

So what is needed to realize the potential of these moves by Secretary Zinke and the Trump Administration?

First, we need to weigh in with public comments during on the DPP and subsequent releases. The simplest way to do so is online at www.regulations.gov or www.boem.gov/comment.

In addition to the online responses, BOEM is holding a series of 23 public meetings across the nation, where interested parties are invited to provide comment in-person.

Second, as part of the comments, urge the secretary of the interior to permit the acquisition of new seismic data on the nation's OCS.

As Nikki Martin, president of the International Association of Geophysical Contractors, tweeted on Dec. 5 of last year, there has been a multi-year delay in permits to permit new seismic acquisition on the Atlantic OCS, ">1350 days (3+yrs) have passed since Atlantic EIS & seismic survey permit apps were re-filed; >980 days since @BOEM_DOI public comment & Atlantic road show; >860 days since @NOAAFisheries deemed MMPA requests complete for public comment..."

It's time. The industry must be able to collect new seismic data to properly assess the potential.

Third, the industry needs to allocate investment to exploration. While a retrenchment of spending is understandable during a downturn, it has persisted too long. It's time to invest now in the production of the future. It's time to explore again, and the OCS is a good place to begin.

By DOUG WYATT, EMD President

Divisions Report: EMD

EMD Expanding Horizons at 2018 ACE

Like many, I subscribe to the oil, gas and energy newsfeeds. Take your pick as to which you prefer and the reliability of their sources. Good news, bad news, ups, downs and constant change in markets, business and knowledge. There is often conflicting information, minimal new knowledge and seldom any wisdom. In many ways, it is all just noise.

This might sound harsh, but a continual view to the future is all that is required. At the 2018 AAPG Annual Convention and Exhibition in Salt Lake City, the Energy Minerals Division will be leading, looking and moving forward – viewing the future, with no noise!

Most have received the early 2018 ACE brochure. This will be an impressive and important meeting.

Overall, EMD is sponsoring or co-sponsoring 10 oral sessions and five poster sessions which include more than 160 top quality papers ranging from global and regional perspectives on unconventional resources to energy and mineral resources in our solar system. Our two short courses cover new concepts in geochemistry, an important topic across all petroleum resources, and the assessment and evaluation of unconventional resources, which are critical in the modern energy world. We are looking forward and hope to seek and impart knowledge, and maybe even a little wisdom!


WYATT

A "view" forward is a philosophy, a belief system – admittedly empowered by innovation and technology – but a belief that there is value and meaning in positive, progressive change toward a beneficial goal.

A View to the Future

When considering the future of our industry, innovation and new technologies are always discussed. It might be splitting hairs but I believe that having a "view" toward the future could be more important. "What's the difference, and why is a view forward important?" you might ask. A "view" forward is a philosophy, a belief system – admittedly empowered by innovation and technology – but a belief that there is value and meaning in positive, progressive change toward a beneficial goal. We travel over the horizon maybe not fully knowing what is there, but knowing that we can understand, adapt, change, build and grow. Our energy industry is doing nothing if not continually traveling over the horizon, yet sometimes we hesitate with the old and fear the new.

I have a personal example to illustrate this. Outside my old office at the National Energy Technology Laboratory, from probably 2002 through 2013, there was a series of old wooden large format flat map files, several filing cabinets filled with old papers, notes, samples and core, aging and stuffed cardboard boxes and map tubes, and uncounted floppy disks and reels of magnetic tape, all accumulated in one of those empty spaces where old government office hallways intersect. This accumulation of material was the original data developed, analyzed and used in the 1980s and '90s eastern shale gas research program. If you have studied the history of the development of unconventional shale gas you know that the eastern shale gas program was the seminal research and development program that led to the global expansion of unconventional shale production. They changed the world and our industry owes much of its existence to these files. The results of this work suggested and proved that black shales contained enormous quantities of hydrocarbon and that expanding their permeability by hydraulic fracturing would be possible and productive.

However, there was considerable resistance to this as "just another government study," an unnecessary expenditure, and a pervasive attitude of "We know how to produce tight gas sands and conventional oil and gas reservoirs so we don't need this," so it was several years before there was serious follow-up. It was a horizon too far.

I have a very personal anecdote about this. In 1988, I had a chance to locate a deep Ordovician stratigraphic test at the southeastern, faulted edge of the Illinois Basin. The area was undrilled for several miles around and we only had a couple of old single-point seismic lines and the regional gravity and magnetic data. I targeted, I hoped, the high side of a down to basin normal fault. We drilled, had a few shows in the Mississippian as expected, but drilled an incredibly thick black and brown Devonian shale section producing gas that bubbled in our pits all while we were continually losing circulation. The gas saturated my detector and we had to keep the mud weight higher than expected all the way to total depth. The driller thought it was coming from shallow and a local consultant thought we had popped a Mississippian zone, but I knew, and the logs confirmed, it was the Devonian shale.

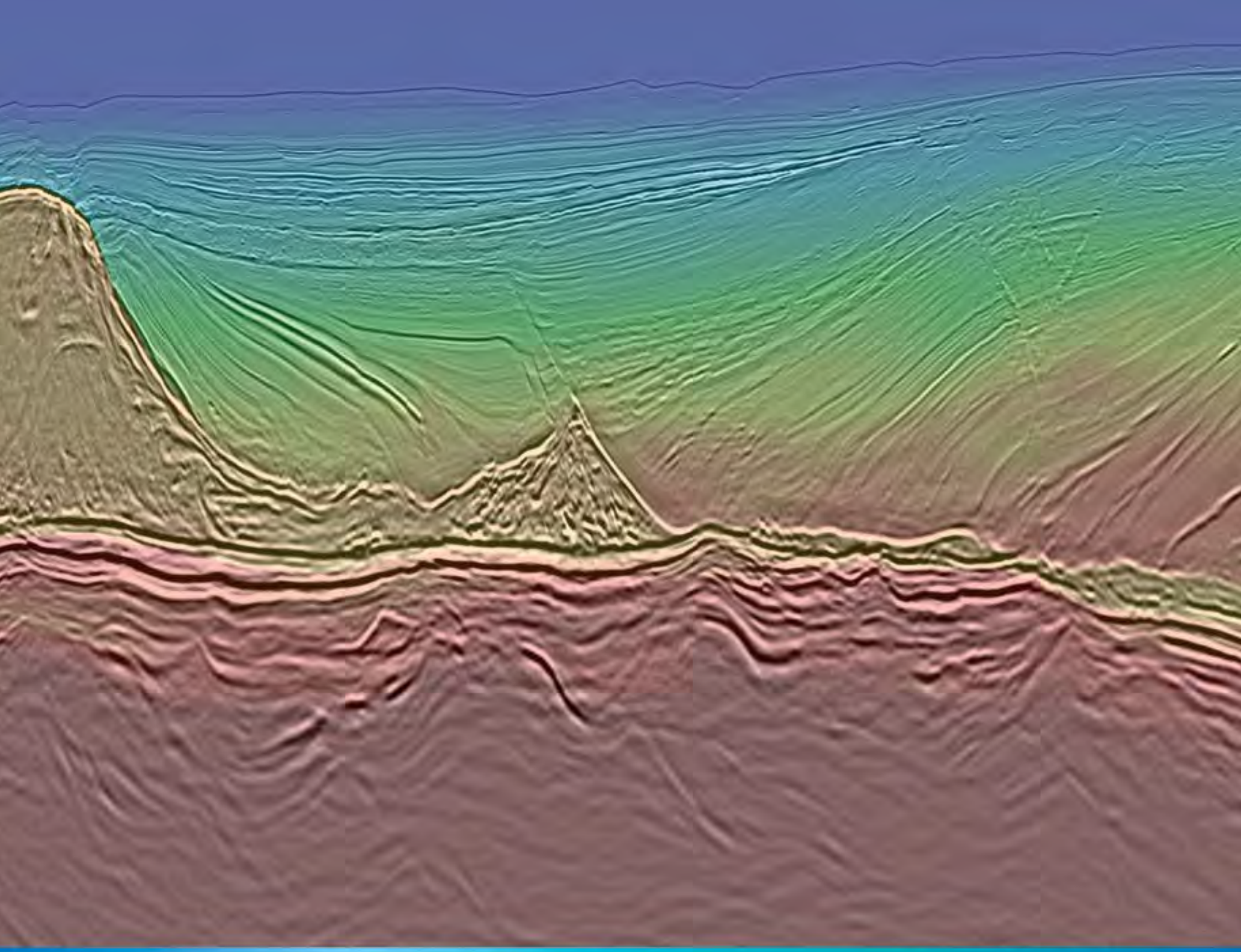
How could this be?

Shale did not produce, it was a seal! I was slammed in the face with an obvious condition that did not meet my trained expectations. I could not get past what should be in favor of what actually was. This was a bad philosophy. I was afraid to cross that horizon. My view forward was poor.

The Next Horizon, and the Next

Our goal in the EMD is to keep our membership looking forward, to develop a view across all global energy sources, to provide new knowledge and even develop wisdom. We look forward to expanding the horizon, and the next, and the next!

If you are late in paying your AAPG dues please catch up and make sure your membership in the EMD is active. Join us so we can all "view" forward together. E



Santos Basin

Brazil – Santos Vision Area 1

PGS announces the availability of Area 1 from its Santos Vision project within the pre-salt play in the Santos Basin, offshore Brazil. The total project will cover 34 000 sq.km. Exploration plays in Area 1 include: a rift/pre-rift fault-trap play in the west-central part of the area, with prospective siliciclastic reservoirs in the Paleozoic pre-rift through Lower Cretaceous rift succession; a sag/rift limestone edge play (Sagitário trend), involving subsalt structural or paleo-topographic traps in microbial platform limestone; and the Carcará North/Uirapuru sag-rift limestone play, which includes the Carcará discovery in BMS-8 and several significant closures at the base of salt.

Santos Vision Area 1 deliverables will be available for the upcoming license rounds.

Please contact: brazilinfo@pgs.com