



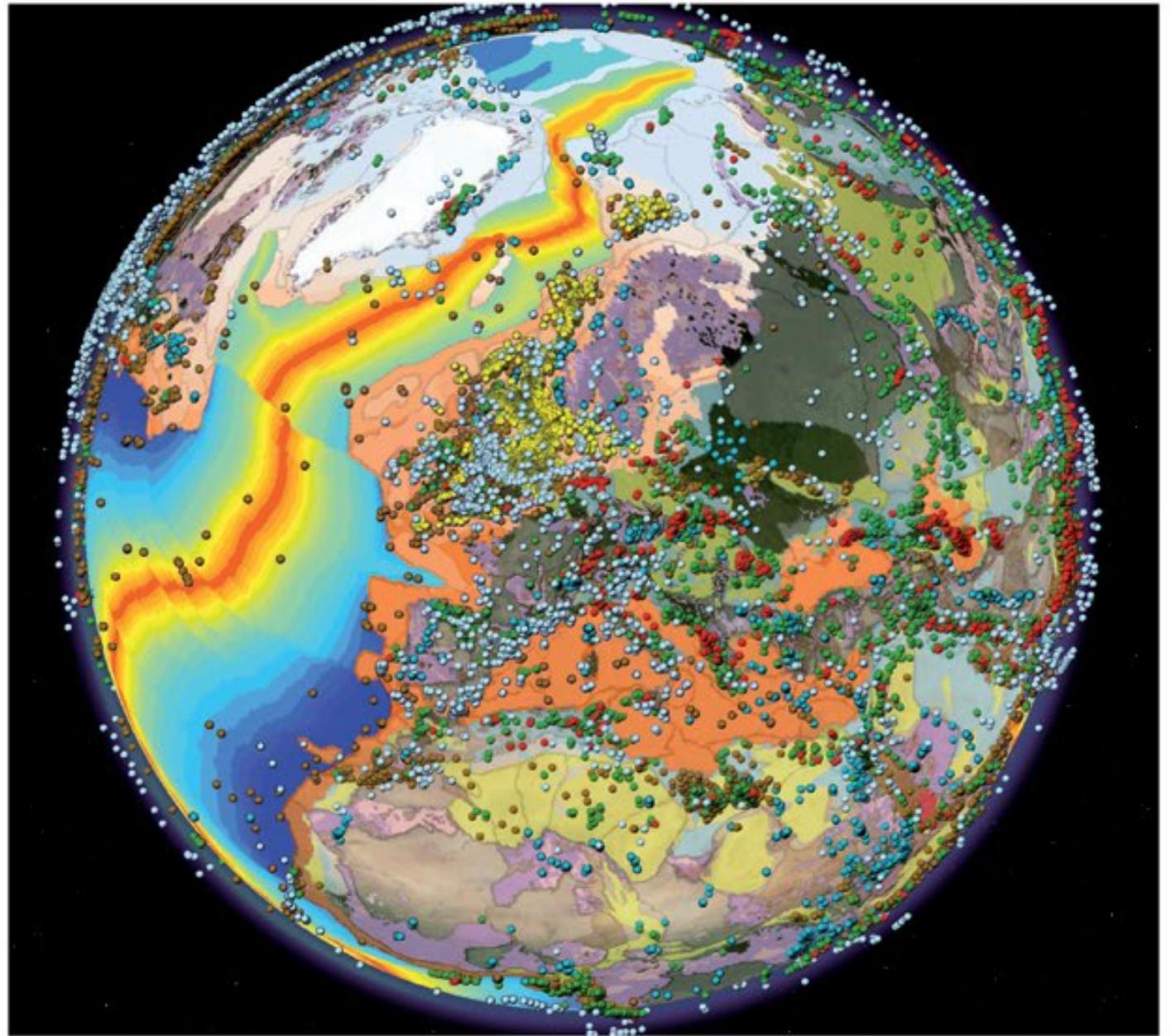
**Exploration
Conundrum**

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DISCOVER



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Energy Transitions and Conference Transitions

“When you think about the future of energy in the year 2025, seven years from now, I see _____?”

This was one of the digital interactive questions asked at the Energy Transitions Forum in Amsterdam last month. The answers from a room of energy professionals were telling: diversity, renewables, energy, change, hybrid, oil, gas.

The Forum addressed how companies and geoscientists can broaden their roles for energy transitions that can include a lower-carbon future. The concept for the ETF originated with the AAPG Europe Region leadership and was realized under the leadership of Max Brouwers, Shell's vice president for exploration in Europe, Russia and the Caspian, a diverse committee of high-level energy experts, an enterprising shadow committee of young professionals and students, and the organizational excellence of Val-Johnston Jones and Marta Diaz of AAPG's Europe Region office.

The two-day Forum set a new standard for interactive conference communication. In addition to the opening questions with real time projected digital responses, speaker-participant interaction was encouraged with panel Q&As, strategic networking breaks, in-depth exploration of topics through café sessions, thought-provoking TED-style talks, and an IBM Design Thinking work session to crowdsource questions and answers about the energy transition.

The Future of Energy

The dynamic speakers for the plenary session opened the energy transition dialogue. With unbridled enthusiasm, Christiana Figueres of the United Nations Framework Convention on Climate Change delivered a message of responsible lower-carbon energy development, followed by



From left: Adam McCarthy of Equinor, Erik Sens of Shell, Olivia Lewis of Schlumberger, Sharinia Kangandran of Imperial College and Jonathan Rodgers of Shell

Lucia van Geuns of The Hague Centre for Strategic Studies, who provided a pragmatic view on the role fossil fuels will continue to play in sustainable energy solutions.

Ivo Bozon of McKinsey and Company brought a global management company perspective. He noted that when economics and society come together to change to lower-carbon energy at scale, we will be at a tipping point for energy solutions. Ashild Larsen, chief information officer of Equinor, concluded the session with the memorable advice, “The game to transform the energy industry is on, the opportunity is at the intersection of people and technology.”

The afternoon session on sustainable development balanced speakers who

addressed how oil and natural gas, continued exploration, and carbon utilization and sequestration are fundamental to the energy equation with speakers who addressed alternate energy, harnessing energy from transport and energy efficiency. Iain Stewart, professor of geoscience communication at Plymouth University and a geoscience popularizer and presenter for a number of BBC television shows (as well as AAPG's 2014 Geosciences in the Media Award recipient), who later would give a TED-style talk on “New Skillset, New Skill Pipelines,” weighed in on the importance of the petroleum industry embracing sustainable development (aapg.to/RockStarCool).

Day 1 ended with café sessions that encouraged participants to explore energy

options on topics including: sustainable minerals and materials solutions, lithium, combined geothermal and hydrocarbon developments, and carbon capture, utilization and storage. AAPG Members and conference participants John Kaldi and Susan Landon were invited to add geoscience perspectives to the CCUS and sustainable development café sessions, respectively.

Digitalization

Day 2 brought perspectives on digitalization from data-savvy companies outside the petroleum industry, young professionals, and students.

Luq Niazi of IBM addressed how geoscientists have a history managing Big Data with an innovative mindset and are uniquely positioned to “explore” and adopt new technology for emerging challenges. He illustrated the value of IBM's cognitive analytics and the power of artificial intelligence to analyze geoscience documents with a shale sweet spot example that had 90-percent accuracy.

Arno van den Haak of Amazon Web Services presented a disruptive view on the petroleum industry where data is the natural resource. For the petroleum industry, AWS can use its machine learning to automatically enhance incomplete datasets based on known data and their high-performance computing to run reservoir models in real time. Imagine: “Alexa – using today's production data in the Version 2 reservoir model, what change in production will occur if CO₂ injection is increased by 10 percent in the No. 1 pilot well?”

Lindsey Lomas of Schlumberger summed up digitalization from an insider's

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ON THE COVER:

Cape Town, South Africa will be the venue for this year's AAPG International Conference and Exhibition, Nov. 4-7. Lion's Head mountain overlooks the “City Bowl,” and it's just one example of the dramatic geology of the region.

Nanotech

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EXPLORER.AAPG.org

Volume 39
Number 10
Oct 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: returnsll@imex.pb.com.**

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Sponsored students at the Forum

Next Generation from page 3

point of view: "Technology is not going to replace geoscientists – it lets us focus on the less obvious and more impactful interpretation."

Next Generation Geoscientists

The Young Professionals and Student Panel highlighted the reality of digitalization in the petroleum industry. This is the group that grew up with technology, and their career choices will be based on how digitalization will affect them. They all recommended students take a data science or machine learning course.

Adam McCarthy of Equinor, called out professionals of all levels from CEO down to "get trust in the space to use

digitalization." Erik Sens of Shell, noted that locating and connecting databases is important and will drive collaboration. Olivia Lewis of Schlumberger agreed with the need to collaborate and, as a reservoir modeler, to work on improvements in visualization.

Student Sharinia Kangandran, was perhaps the most insightful, whose thesis at Imperial College is on machine learning for facies classification in carbonate cores. Her baseline work illustrated the interpretation inconsistencies from experienced geoscientists. When the baseline was defined, machine learning had an 89-percent identification accuracy. After the panel, Sharinia was offered interviews from three companies at the Forum!

Design Thinking Session

One of the most relevant sessions for AAPG was the IBM Design Thinking Session facilitated by the YP Shadow Committee. Participants divided into groups and worked through the process to provide creative and innovative solutions to questions. Two groups addressed the challenge: "Design a better way for graduates to improve the image of the geoscience profession within the wider society."

The YP's and students came up with two very different ideas to address petroleum geoscience:

- ▶ Crowdsource a startup oil and gas company responsible for all the CO₂ byproduct associated with the hydrocarbons produced.
- ▶ Produce a reality show to demonstrate the good works of the petroleum industry.

AAPG's Sustainable Development Ad Hoc Committee agrees with the fundamental concepts of these ideas and will be working to communicate the geoscience of CCUS projects and examples of the health, environmental and social responsibility projects of the petroleum industry.

What Sustains You?

What sustains me this month is the more than 400 students, 16 recruiting companies and many dedicated AAPG members at the AAPG Student Expo in Houston last month. The depth and breadth of global geoscience talent seeking to work in the petroleum industry is uplifting. Thank you Shushanta Bose, Expo chair; Martha Lou Broussard, honorary co-chair; Jacob Siegel, vice chair, and all the members of the Student Expo Committee for an outstanding job. Students, if you didn't get the interview you hoped for, broaden your resume to include data science and your search to include companies like Amazon Web Services, GE, Google and IBM.

On a personal note, I want to express my sincere condolences to the family, friends and colleagues of the three geoscientists, Henry Martínez, Laura Flórez and Camilo Tirado, who were killed while doing field work in northern Colombia. I met Henry at the recent AAPG Latin America and Caribbean Region Student and Young Professional Leadership Summit in Bogotá. He was a natural leader and eager to take on the challenges of exploring for resources for energy solutions. Your time with us was short, but your impact on our lives great. Henry, your memory sustains me.

Onward,

Jenici M. Cox

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Understanding Our Restless Earth

Robert R. Berg Outstanding Research Award

“Skiing,” said Carlo Doglioni, “is a sort of dancing with beauty, forests and landscapes which allow you to reach a peaceful relation with mountains.”

Doglioni, professor of Earth Science at Sapienza University in Rome, along with Mark G. Rowan, is this year’s recipient of the Robert R. Berg Outstanding Research Award, which is presented to honor a singular achievement in petroleum geoscience research. Doglioni received it for “inspiring generations of field geologists, crafting a unified theory of plate movement and earthquake mechanisms, and reminding us that ‘we are the earth.’”

And, yes, you read right – he’s talking about skiing.

Considering Doglioni’s ability to see the interconnectedness between science and the slalom is perhaps reason enough that AAPG should, perhaps, have an award for prose as well.

To Doglioni, the marriage of the data and the experiential is the key to his life in geology and why this award is the perfect recognition of it.

“If you really want to be an active part of the world,” he said, “you have to know it, and geology is the basic knowledge you need to discover in order to penetrate the mystery of the planet we live on.”

‘We Are the Earth’

On the Venetian Alps, where he was born, growing up in the Dolomites – which he called a “paradise of nature,” he said you literally could feel the environment and have a “daily understanding that we are the Earth.”

At Bari University in Apulia in Southern Italy, where he was an associate professor, Doglioni



Southern border of the Dolomites, Venetian foothills in northeastern Italy. Fault-propagation fold associated to the active Belluno thrust. T, Tertiary, J, Jurassic, DP, Upper Triassic. Doglioni and Carminati, 2008 Mem. carta Geologica d'Italia.



DOGLIONI

“It was a duty for me to bring my small contribution in understanding earthquakes in order to eventually minimize the disaster generated by these events. Therefore, studying earthquakes melts together the passion for science with the wish to be useful to society.”

began thinking beyond the obvious stratigraphic relationships and began considering the impact of dynamic tectonics. He looked homeward for inspiration and clarity.

“In Italy there are two mountain belts, the Alps and Apennines, but they are so different. The Alps are higher, involve deep-seated metamorphic rocks, thick-skinned tectonics is

dominant, they have two shallow foredeeps, a thick crust and lithosphere, no back-arc basin and a shallow subduction zone. The Apennines are exactly the contrary, having low topography, one single deep foredeep, the accretionary prism is mostly composed by sedimentary rocks, i.e., dominant thin-skinned tectonics, a widespread back-arc basin and

a steep westerly directed subduction zone,” Doglioni related.

He said these asymmetries mimic the differences between the eastern (e.g., Cordilleras, Andes) and the western Pacific subduction zones (Aleutians, Marianas, etc.).

“All this is in agreement with the global tectonic polarity, i.e., the westward drift of the lithosphere relative to the underlying asthenospheric mantle detected in any hotspot reference frame and manifested by the tectonic equator that is about 28 degrees inclined with respect to the geographic equator. These observations highlight a mainstream of plate motions. Moreover, the Gutenberg-Richter law shows how seismicity is globally controlled; therefore, there must be a force at the planet scale fueling plate tectonics. This supports that mantle convection acts contemporaneously with an astronomical engine and geodynamics is a self-organized chaotic system in which several forces work together,” he explained.

To put it another way, Doglioni said the Earth is forever restless and there needs to be a constant vigil on watching and recording that restlessness.

“Everything in our environment is controlled by gradients, any type of gradients, e.g., pressure, temperature, electric, chemical, economic, societal, etc. The Earth is alive because it steadily regenerates gradients or is controlled by gradients, either internal or external, maintaining the active system. It is essential to fully understand and quantify those interdependent gradients.”

See [Earthquake](#) page 8 ▶



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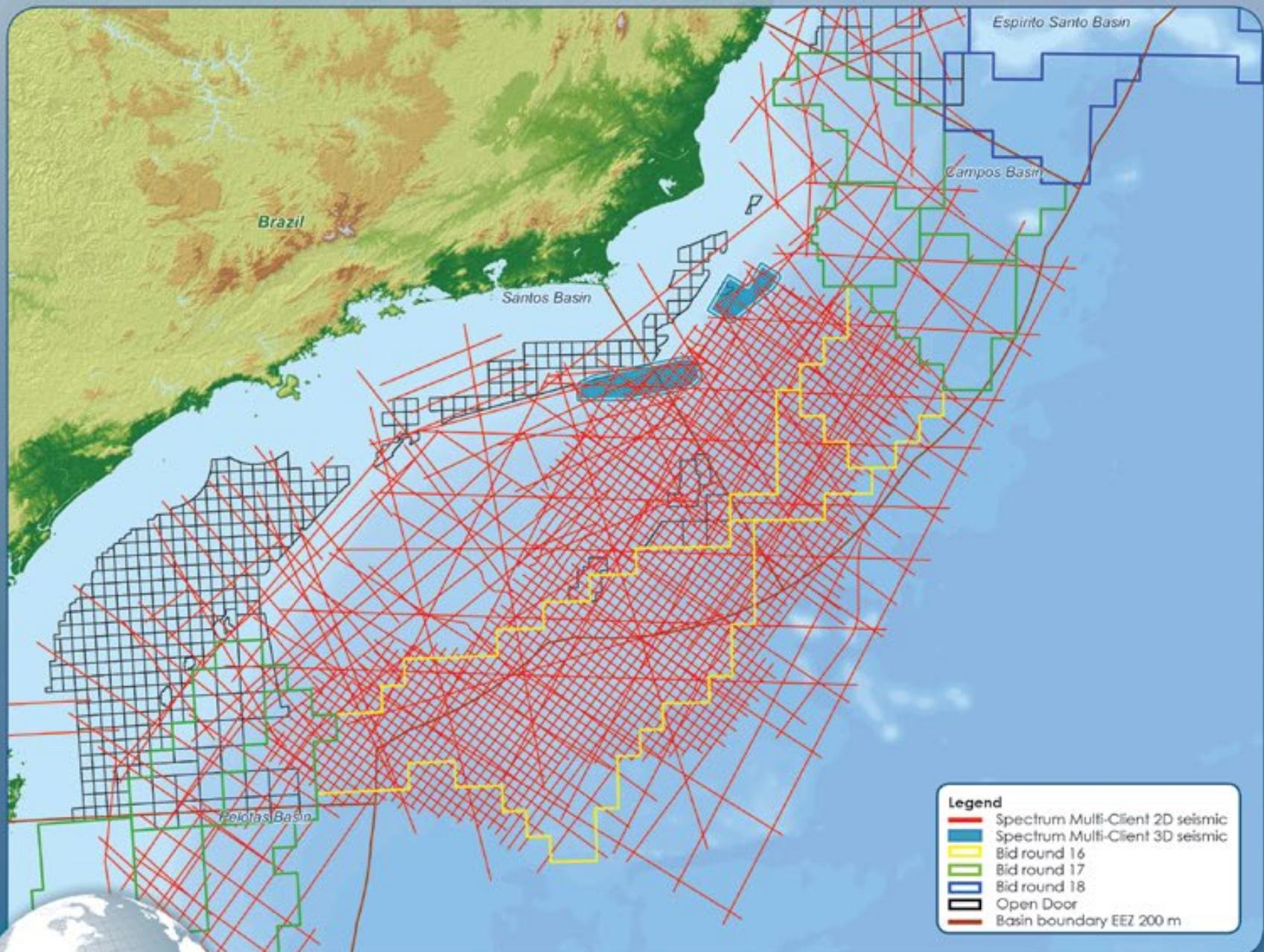
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This seismic covers a vast area where the prolific pre-salt play is confirmed to extend out from giant discoveries into the 16th Round Sector area. The 2D data, acquired in a 10 km x 10 km grid, allows crustal structure to be defined, thereby enhancing thermal maturity modelling and imaging of base salt and syn-rift source rock sequences. The prolific Barra Velha sequence is now mappable from Tupi, Jupiter and Libra into open acreage.

Multiple giant structures with billion barrel low-risk oil potential are mapped within Brazil's 16th Round Sector. This regional seismic data allows prioritization of the main play fairways, structural trends and oil prone areas, as well as deep crustal fault distribution mapping for CO₂ risk mitigation. Yet-to-find analysis of the area covered by this dataset exceeds the 60 billion barrel potential resource already discovered in the pre-salt play.

Earthquake from page 6

More Than Science

For four decades, including his work at the Universities of Basilicata (in Potenza) and Sapienza, as well as global field excursions and visiting posts at Oxford, Columbia and Rice Universities, Doglioni continued studying this living, breathing and sometimes cranky Earth.

"I started my studies in geology when the 1976 magnitude 6.5 Friuli earthquake devastated northeast Italy and caused 1,000 deaths. Four years later in southern Italy, Irpinia, another magnitude 6.9 event had 3,000 victims. In both events, a vast population was homeless and the economy was widely disagggregated," said Doglioni.

It was, for him, more than a science pursuit.

"It was a duty for me to bring my small contribution in understanding earthquakes

in order to eventually minimize the disaster generated by these events. Therefore, studying earthquakes melts together the passion for science with the wish to be useful to society. Earthquakes are part of the lively Earth, so our planet is simply doing its job, manifesting its vitality, we have only to understand how it works," he said.

To understand the power of such events, he said, he first needed to classify them, as is done in botany.

"I think we need to distinguish them as a function of the energy they dissipate, those that move crust in favor or against gravity. They show different phenomenology, which may allow us to arrive to unravel the basic mechanisms governing the different settings. We must invest in studying the mechanisms of earthquakes and improve the networks for monitoring them in order to have the right numbers of the potential ground shaking and possibly to arrive detecting reliable short-term seismic precursors," Doglioni explained.

He believes the seismicity in Italy, as is the case in many countries, is a fundamental issue to be faced by science, culture, government regulations and common sense.

He spoke of the 15 million buildings in Italy, most of which are vulnerable to earthquakes.

"In the aftermath of an earthquake, people are very sensitive to the problem and solidarity is very pronounced. However, the tendency is to forget as soon as possible the disasters, counteracting the necessary actions of prevention and possibly prediction of future events," he said.

Politics in Italy, too, will play a part on future successes and failures.

"The new political shift in Italy (the government, now compromised of the anti-establishment Five Star Movement and the populist Northern League) will be judged also on how it will act for improving the diffusion of education and how decisions will be science-based," he said.

Doglioni has worked as well in Japan, El Salvador, taught at Rice and Columbia Universities, and has seen how each nation responds to earthquakes.

He carries it all with him.

"Each country has its outstanding specialists and scientific history. The earthquake problem may be divided into the geological, seismological and engineering aspects. Wherever I have been, I learn something in one of the different disciplines," he said.

He is not pessimistic, but does see the work ahead.

"I think we still have to work quite a lot for improving the resilience of our countries, both from a scientific and technical point of view and from the communication of risk."

He wants a more holistic approach to the study and the understanding. To that end, even though he has co-authored more than 200 peer-reviewed research papers – 18 of which were published in 2017 – on seismicity research and activity, he is focusing on new areas of research, communication and service.

The Rest of the Journey

As for the Berg Award, he made special thanks for Alfonso Bosellini, Albert W. Bally, Daniel Bernoulli, Hans Peter Laubscher and Giorgio Vittorio Dal Piaz for not just giving him the knowledge he needed, but encouraging his passion.

"They guided me inside the secrets of stratigraphy, tectonics, seismic interpretation, transmitting to me the love for geology."

The award isn't the end of something – it's the middle.

"Such a recognition is a stimulus to pursue the journey in understanding the mechanisms of geodynamics," said Doglioni.

Of the teaching he does, which still gives him great satisfaction, he is most empowered by what has yet to happen, both in the classroom and in himself.

"Teaching obliges you to keep updated, but, most important, you feel useful in transferring to the new generations the beauty and power of science in getting a more sustainable society," he said. [E](#)

Doglioni (center) with friends and mentors Albert W. Bally (left) and Daniel Bernoulli (right), during a field trip to Hungary in 1991



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Theme 8: Deep Integration of Data and Disciplines

Theme 9: Exploration Frontiers, Energy Minerals, and Planetary Geology

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Supercomputing Pushes Oil Exploration Boundaries

Saudi Aramco hopes to push the boundaries of exploration by creating and encouraging new technologies.

In its 2017 Annual Review, the company said it is pursuing the promise of “the fourth industrial revolution” through big data and supercomputing and investigations into nanotechnology applications.

The world’s leading producer of crude oil and condensate reported 332 billion barrels of oil equivalent in fields it operates. The company also reported the discovery of two new oil fields, Sakab and Zumul, and a gas reservoir, Jauf.

“Given scales of our reserves, even small percentage increases in recovery rates and production efficiency can significantly boost long-term supply,” the company reported.

Upstream research activities are performed primarily in-house, with support from SA’s Global Research Network research centers in Houston, Boston and Beijing and technology offices in Aberdeen, Scotland and Delft Netherlands.

iQuest Forums

Aramco also continued its series of iQuest forums this year, with experts traveling to Menlo Park, Calif., to meet with Silicon Valley experts and entrepreneurs on the use of artificial intelligence, machine learning and data analytics in the upstream petroleum sector.

The forums are aimed at seeking out new ideas to enhance exploration and production.

“This initiative is supporting the company’s efforts to not only solve today’s operational industry challenges, but also

help write the next chapter on energy sustainability,” the company reported.

“We are seeking out disruptive technologies that will take us further, that will truly result in a ‘quantum leap’ in upstream capabilities and efficiencies,” said Ali A. Al-Meshari, manager of SA’s Exploration and Petroleum Engineering Center – Advanced Research Center, or “EXPEC ARC.”

The two-day iQuest forum included more than 70 participants. Representatives from EXPEC ARC, Aramco Services Co. and Aramco’s Houston research center conversed with Silicon Valley tech leaders – company owners, CEOs, scientists, investors and university professors – specializing in AI/machine learning, data analytics and computational methodologies. EXPEC ARC International Advisory Council members also attended along with SA-sponsored students.

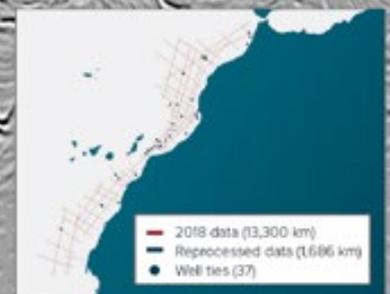
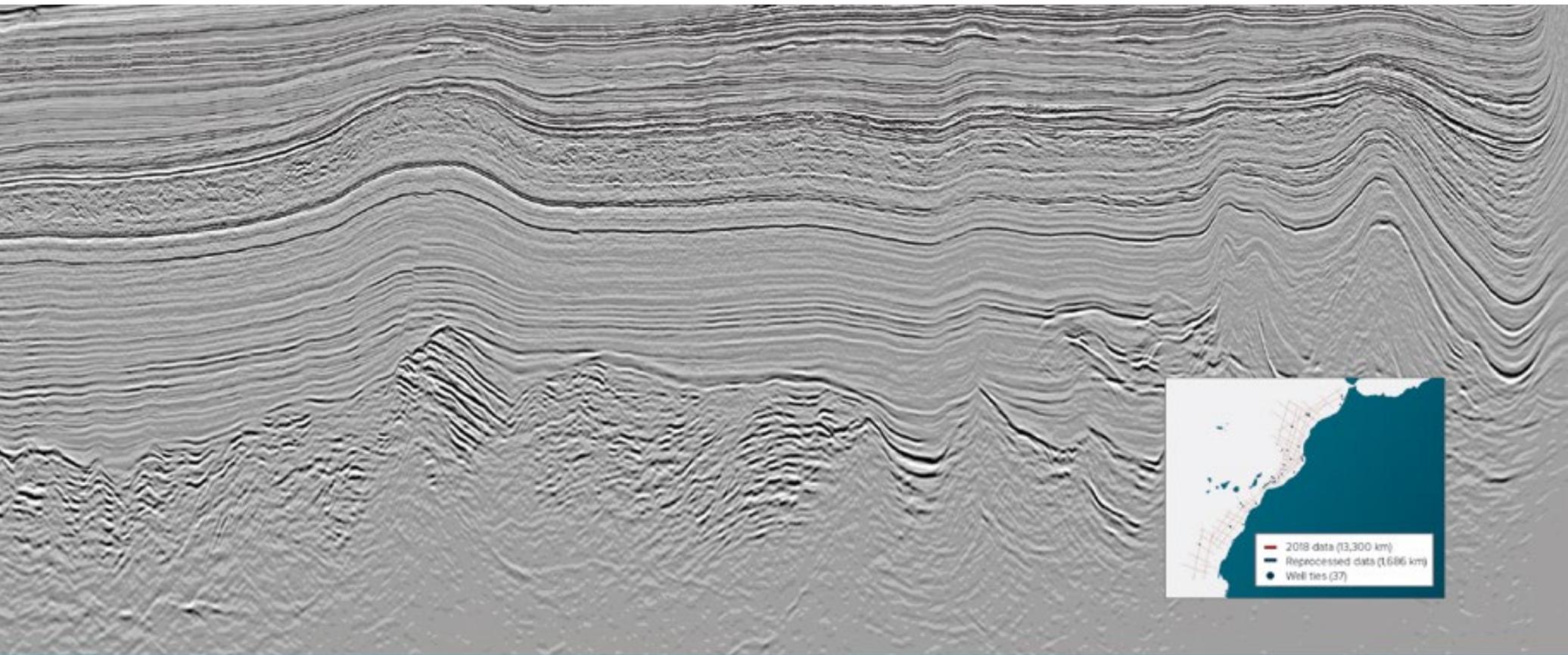
“We see huge potential in the use of artificial intelligence to extract deeper value from the data we collect and store on our field operations. We are excited about the possibilities, to enhance our decision-making capabilities and break new ground,” Al-Meshari told the group.

Weichang Li, a petroleum engineering consultant at Aramco’s Houston research center, gave a presentation on the significant impact that AI/machine learning could have in the energy industry. He specifically illustrated opportunities where domain experts and computer scientists could work together to apply these new breakthroughs and improve, for example, seismic data processing, interpretation and well log analysis, production monitoring



An advanced materials researcher at Saudi Aramco’s Boston R&D Center uses X-ray diffraction to determine properties critical for research programs ranging from corrosion to catalysts.

See Data page 15 ►



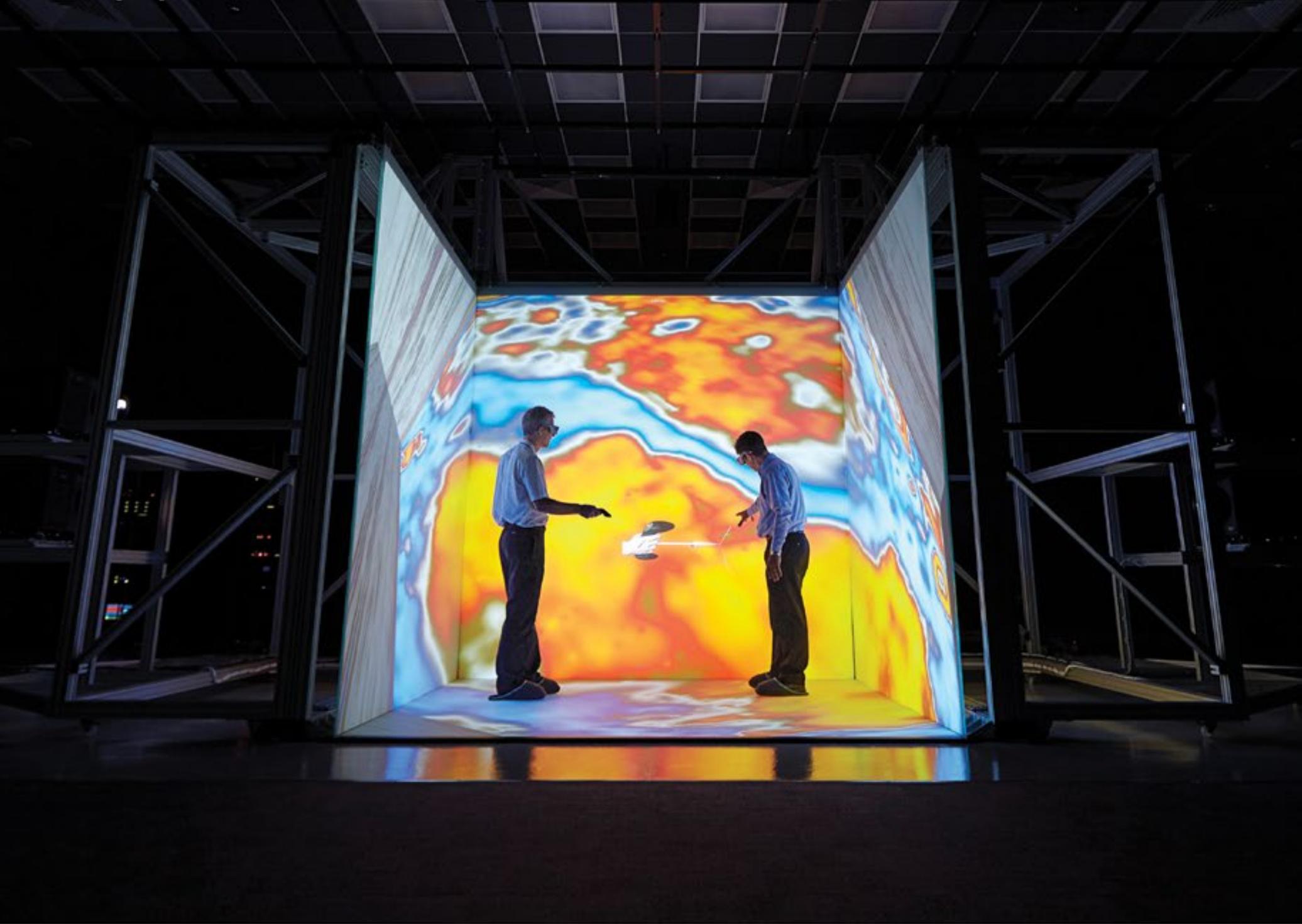
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The Exploration Conundrum

In a world awash in oil, discoveries are at an all-time low.

The global outlook for crude oil and natural gas production might seem complicated. But really, it's arithmetic. The more oil and gas resources the industry discovers or identifies today, the more oil and gas the industry can produce in the future.

And that might be a problem.

Oil companies made huge cuts in their exploration budgets during the 2015-17 industry downturn, canceling or postponing up to \$1 trillion overall in scheduled and planned projects. At the same time, success rates for international exploration dropped to 50-year lows.

The outlook for future reserves has stumbled, if not tumbled.

Not only does the oil and gas industry need to keep exploring, it has to explore both efficiently and effectively if it wants to provide sufficient production to meet the world's energy requirements in the decades ahead, according to industry experts.

"Exploration is critical today and will continue to be critical to the oil and gas industry. What you tend to see in a downturn is that people cut back on their exploration budgets, and we saw that in the recent downturn, as companies went into survival mode," said John England, a partner specializing in oil, gas and chemicals for consulting firm Deloitte LLP in Houston.

'Chronic Underinvestment'

"Something we saw in the downturn is that you can do more for less," England added, a sentiment echoed by Andrew Slaughter, executive director of Deloitte's Center for Energy Solutions in Houston.

"Operators need to fill the exploration funnel so they have exploration projects for the years ahead," Slaughter said. "For total capex I think 2017 was a low year with a bit over \$20 billion expended on exploration, but we got a few more wells in there" through efficiency and cost reduction, he noted.

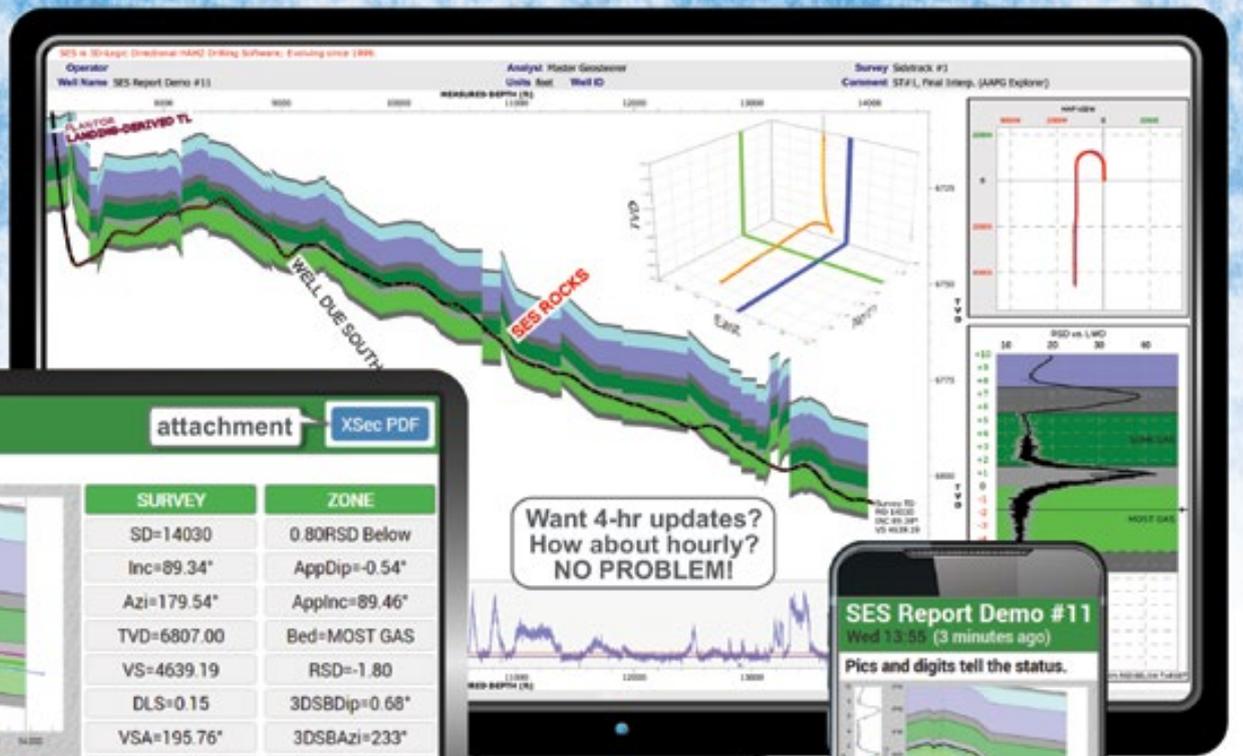
Exploration investment "is always going to be the minority, the riskier part of capex. This notion of doing more with less, I think it's positive for exploration," Slaughter observed. "You're getting more for the dollars you spend, so the unit costs per barrel are continuing to improve."

Continued on next page ►



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DLS=0.15	3DSBDip=0.68°
VSA=195.76°	3DSBAzi=233°
Units=ft./100ft	MD=13988.00

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SURVEY	ZONE
SD=14030	0.80RSD Below
Inc=89.34°	AppDip=-0.54°
Azi=179.54°	AppInc=89.46°
TVD=6807.00	Bed=MOST GAS

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◀ Continued from previous page

In its report "Oil 2018," the International Energy Agency noted that the current oil price rally has rewarded Saudi Arabia, Russia and other companies taking part in output cuts, while also unleashing a new wave of production growth from the United States.

"Coupled with gains from Brazil, Canada and Norway, oil markets now look adequately supplied through 2020. There is no call for complacency, however, and more investment is needed now to ensure secure supplies to meet robust demand growth," the report warned.

Global energy demand is rising steadily, so the response from the supply side is crucial, the IEA noted. The recovery from the historic drop-off in industry investment during the downturn "has barely started, investment was flat in 2017, and early data suggests only a modest rise in 2018," it added.

"This is potentially storing up trouble for the future. An added concern is that investment is overwhelmingly focused on the light tight oil sector in the United States. As a result, upstream investment may be inadequate to avoid a significant squeezing of the global spare capacity cushion by 2023, even as costs have fallen and project efficiency has improved," the IEA report said.

According to the Baker Hughes international rig count, 1,925 oil and gas rigs were operating in the United States in November 2014. By the start of 2017, that number had fallen to 683. During the same period, the worldwide active rig count dropped from 3,670 to 1,918. The oil industry veered sharply away from exploration and focused on increasing production from known fields.

"When we have a downturn, everybody goes to drilling development wells and appraisal wells. They're trying to get their production up," said Bob Fryklund, chief upstream strategist for IHS Markit in Houston.

Ironically, the industry's success in increasing production, coupled with an influx of oil and gas from unconventional resource plays, deepened and extended the price downturn. Executives began to use the phrase "lower for longer" and generally shied away from long-term exploration commitments. The industry began eating up its own reserves without filling the pantry for coming years.

"In the simplest form, without exploration you don't have any new resources to develop," said Julie Wilson, research director of global exploration for research and consultancy firm Wood Mackenzie in Houston. When companies increase production, she explained, "you're still depleting a known resource. But when you go out and do exploration, you find new resources you can develop."

Under-investment in exploration in recent years has generated speculation about a future production shortfall, especially in crude oil, a gap between demand and supply if unconvensionals can't offset declining

conventional production.

An analysts' note in July from New York research and brokerage company Sanford C. Bernstein and Co. said "chronic underinvestment" by the oil and gas industry is setting the stage for the next oil price spike, which could take crude to \$150/barrel or more. Investors who've been urging management "to reign in capex and return cash will lament the underinvestment in the industry," the analysts predicted.

"Any shortfall in supply will result in a super-spike in prices, potentially much larger than the \$150 a barrel spike witnessed in 2008," the analysts wrote. "If oil demand continues to grow to 2030 and beyond, the strategy of returning cash to shareholders and underinvesting in reserves will only turn out to sow the seeds of the next (boom/bust) super-cycle."

Reserves Replacement

Not everyone agrees with that outlook. "We don't necessarily believe what everybody else is talking about, that there's going to be this big gap," Fryklund said. Historically, when more production is needed to meet demand, "the industry arises to solve the problem," he noted.



FRYKLUND

Today, the industry is coping with what Fryklund calls "the exploration conundrum – discoveries right now are at an all-time low not seen since the 1950s. Yet we're awash with oil." He said most of that added oil came from field growth, the increase in a field's productive capacity through improved techniques and technologies, as well as increased output from unconventional plays.

But a third important element for production – reserves replacement – could be in jeopardy. Bernstein and Co. reported that proven reserves of the world's largest companies have dropped by more than 30 percent on average since 2000, with only Exxon and BP having any increase, bolstered by acquisitions. Companies draw on their known reserves to produce oil and gas, and most companies try to replace the reserves they deplete each year to ensure production in the future – and for large companies with lots of reserves to replace, that can be a problem.

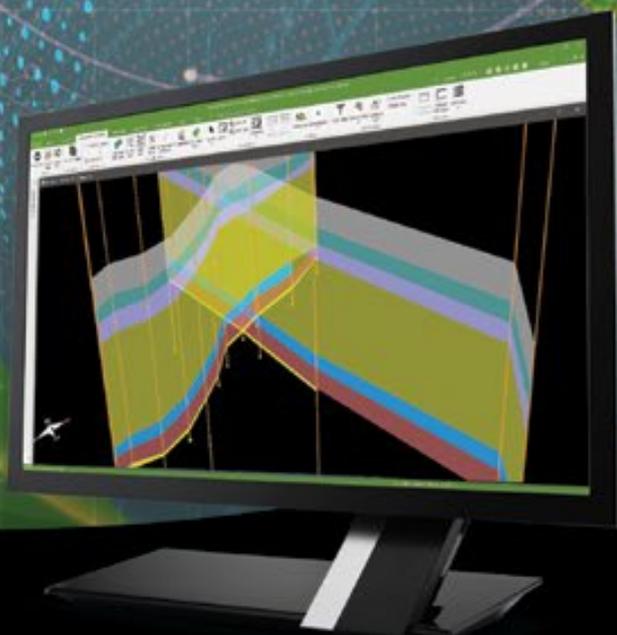
Deepwater exploration, an expensive form of oil and gas hunting, continued during the downturn and goes on today because companies want "legacy assets" from large-scale discoveries, Wilson said. Those legacy assets can boost reserves for years and years, even decades. "They throw off tons of cash flow throughout their lives," she noted. "Companies expand their drilling and see further exploration opportunities to tie wells back in."

"Legacy assets like that don't come along every year. You don't find them all the time. They are rare beasts, but when you get one they're company-makers, even for a major,"

See **Megaprojects** page 16 ▶



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McMaster University has a strong commitment to achieving diversity among faculty and staff that reflects the diversity of our student body. The successful candidate will be committed to inclusion and excellence and the Department is especially interested in candidates who can contribute, through their teaching and/or service, to the diversity of the academic community. Women, persons with disabilities, First Nations, Metis and Inuit persons, members of racialized communities and LGBTQ-identified persons are strongly encouraged to apply. Gender diversity is being addressed at McMaster University through our policies and actions. One recent action in this area was the completion of a gender pay equity study and a resultant base salary adjustment applied to all female faculty members in July 2015.

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Applicants should submit a cover letter outlining their research interests, curriculum vitae, a brief teaching dossier including a statement of teaching philosophy (maximum of two pages), as well as a one-page statement on equity and diversity. Academic reference letters are required at the time of application;

applicants should ask three (3) referees to send their letters of reference electronically to Ms Marge Geroux, School Administrator at geroux-@mcmaster.ca.

Complete applications must be made online at www.workingatmcmaster.ca/careers (Faculty Positions, Job ID 22194) to the attention of:

Dr. Greg Slater
Chair, Search Committee
School of Geography and Earth Sciences
McMaster University
1280 Main Street West
Hamilton, Ontario, Canada, L8S 4K1

Review of complete applications will begin November 1st 2018, and continue until the position is filled. The effective date of appointment is expected to be July 1st, 2019, but negotiable. All applicants will receive an on-line confirmation of receipt of their application; however, only short-listed applicants will be contacted for interviews.

All qualified candidates are encouraged to apply; however, Canadian citizens and permanent residents will be given priority. To comply with the Government of Canada's reporting requirements, the University is obliged to gather information about applicants' status as either Permanent Residents of Canada or Canadian citizens. Applicants need not identify their country of origin or current citizenship; however, all applications must include one of the following statements in their application package:

Yes, I am a citizen or permanent resident of Canada

No, I am not a citizen or permanent resident of Canada.

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Job applicants requiring accommodation to participate in the hiring process should contact the Human Resources Service Centre at 905-525-9140 ext. 222-HR (22247) or the Faculty of Health Sciences Human Resources Office at ext. 22207 to communicate accommodation needs.

Applicants are asked to describe, within their application package, their commitment to and demonstrated experience advancing equity, diversity and inclusion in post-secondary education, community-based or other professional settings (as requested above).

As part of the application process, you are invited to complete a brief diversity survey at the following link: <https://surveys.mcmaster.ca/limesurvey/index.php/229188?lang=en>. The survey is voluntary. All information collected is confidential and will not be shared with the hiring manager. The results of the survey are for institutional planning purposes, and support our efforts to promote diversity, equity, and inclusion.

If you have any questions about the Survey, please feel free to contact the Employment Equity Specialist, by phone (905-525-9140 ext. 24395) or email (duwaisom@mcmaster.ca). For additional information about McMaster University's Employment Equity Framework, please visit the McMaster Employment Equity website.

Megaprojects from page 13

Wilson said.

While the industry has made some significant offshore discoveries in recent years, discoveries overall have become smaller and more remote, she said. "In the pre-crash boom years, what we were finding was that discoveries were becoming less and less commercially viable. You needed a very high price for those small, frontier discoveries, and the cost environment was suffering from high inflation," Wilson observed. "We saw a lot of volumes being found in giant discoveries, but they were finding a higher percentage of natural gas."

"What they're looking to do offshore is to bring resources online more quickly. Operators now are looking to be more nimble and begin production quicker," she said. "In areas where, before, they've needed a very large discovery for commercial production, the size needed for commerciality might come down with this new nimble approach."

Fryklund talked about this change more in terms of flexibility, especially for offshore megaprojects.

"Companies do need to have more flexibility now," he said. "There's an inherent conflict in our business that says you have to manage for the future, but you have to deliver today – i.e., pay your dividends quarterly."

"It's this whole concept of capital flexibility and that generally means a shorter-term tie up. The problem is, if you look at the offshore it takes a lot longer. How do you compress that?" said Fryklund.

"The global average (for deepwater) was seven years from discovery to first oil. And you had billions of dollars tied up," he noted, adding that offshore projects are coming onstream faster now. "People have been working on giving the offshore and megaprojects more flexibility."

'Niche' Exploration

Wilson said the industry has seen a change in exploration philosophy recently. Some companies are moving to become pure play operators devoted to one type of play, choosing an offshore or unconventional or conventional onshore niche, or operating in a limited geographical area. "Since the downturn we've seen exploration shift. Companies have high-graded their portfolios. In deepwater, they're going after the best-quality reservoirs they can target," she observed.

"The U.S. Gulf of Mexico is interesting now because some of those mid-sized companies have exited to focus onshore, Noble Energy being one. You're seeing a bifurcation," she said. "Anadarko used to be one of the biggest wildcatters in the U.S. Gulf of Mexico, but they're currently not active there."

"The departure of some of the mid- and large-caps is part of that pure-play evolution. In the past, companies had a diversified risk profile, and investors accepted that, but now investors want them to have one risk profile, then they can pick and choose which risk profile(s) they want to invest in," she noted.

Some of the most active companies in the U.S. Gulf are backed by private equity, Wilson said. "They have a niche position. They tend to go for plays and projects they can turn around more quickly," exploring near existing infrastructure, conducting a great deal of preplanning and even working out tariffs in advance.

"Part of today's shift is for companies to focus on their particular niche. The majors are so large they will be in everything. In order to grow, they have to participate in all growth avenues, like acquisitions and discovered resource opportunities as well as exploration. But when we think of exploration around the globe, more and more companies are working toward their niche," she said.

Large-scale Projects Needed

Somehow, maybe because it conducts big offshore exploration and production activities, the oil and gas industry developed a reputation for being adept at large-scale projects. That's one of the least deserved business reputations of all time. Not only has the industry been, in general, bad at megaprojects, it's often been downright terrible.

Angus Rodger, research director for Wood Mackenzie in Singapore, said during the last decade the average industry development started six months later than planned and began \$700 million over budget.

"The scale of under-performance was staggering," he noted.

Late delivery and cost overruns became so routine that the top 15 project failures of the last decade were a cumulative \$80 billion over budget, Wood Mackenzie reported.

But here's some good news: A growing number of medium-to-large industry projects have been delivered on target during the past year, including areas notorious for cost blowouts like the Arctic and the Caspian Sea, according to WoodMac.

Eni's supergiant Zohr gas field offshore Egypt is often cited as a poster child for the industry's new level of efficiency. After a slick exploration program opened Zohr, the largest gas field in the Mediterranean, the company began production in December 2017 – less than two and a half years after discovery. Eni claimed the fast online start was a record for that type of project.

Other examples of improvement include BP's West Nile Delta and Atoll deepwater projects and its shallow-water gas Shah Deniz Phase 2 development, and Woodside's Persephone and Wintershall's Maria subsea tie-backs.

Earlier this year, Shell brought onstream its Kaikias oil and gas field in the Gulf of Mexico, with four wells completed subsea in 4,500 feet of water, nearly a year ahead of schedule. Kaikias "epitomizes how the deepwater sector has – for now – transitioned to a simpler, lower-cost business model," the WoodMac report noted.

There are reasons for this kind of improvement in exploration and production operations. First and foremost, the price collapse in the recent downturn scared everybody, leading to a laser-focus on efficiency and reduced costs.

In addition, WoodMac cited several other contributing factors:

- ▶ Spare capacity throughout the supply chain, leading to better performance and lower costs: In some basins, including the Gulf of Mexico and the pre-salt play offshore Brazil, drilling efficiency has improved dramatically.

- ▶ Service sector collaboration and alignment on contracts, mostly in northern Europe

- ▶ Improved project management, with operators having more people focused on looking at fewer elements, and under-utilized service companies offering their best team for each major contract

- ▶ Greater corporate discipline, as tougher project screening and more stringent investment hurdle rates have increased the industry's attention on execution and cost control

- ▶ More planning before the final investment decision, with more contracts signed and sealed pre-sanction, often with preferred partners versus putting everything out to bid

- ▶ Reduced project scope, and more tie-backs and brownfield projects that use existing infrastructure

Some of the improvement in on-target and on-budget project delivery comes from the industry deemphasizing megaprojects

See **Comeback** page 32 ▶

Data

from page 10

and optimization; drilling efficiency and risk mitigation, source rock characterization and crude oil assay analysis.

An Aramco Sun article noted that the invited Silicon Valley experts “generally agreed that the oil and gas industry has done an exceptional job collecting and storing data over the decades, but its value has not been fully optimized. Vast quantities of information have been captured and stored, they said, but these data sets are spread across numerous business spheres, operational areas and domains – and often not shared. This makes it virtually impossible to extract the deep value ‘hidden’ within the data without the application of AI/machine learning.”

More forums are planned.

“We want to continue the mission to seek out technological breakthroughs – both around the world and within our own research centers,” Al-Meshari said. “It’s important to develop these partnerships and create synergies that fortify Saudi Aramco’s important role as a global technology leader.”

Applying New Technologies in the Field

The Annual Review reported that in the last year, the company pursued advanced well completion technologies, artificial lift optimization and debottlenecking of production systems.

Unconventional gas exploration targeted Northern Arabia, South Ghawar area and Jafurah Basin east of Ghawar.

In the Red Sea, the company used an autonomous system deploying seismic nodes on seabed via reinforced armored rope, reducing the cost of 3-D seismic data acquisition in two blocks measuring 800 and 900 square-kilometers. The choice of location was informed by large scale hydrographic survey, a first for these waters. SA said the results are expected to help optimize field operations and facilities including rig movements, laying of pipeline and supply vessel routes.

The review said nanotechnology shows the potential to enable monitoring and analysis of reservoir performance – and possibly intervention – directly from within the reservoir.

“In 2017, we identified scalable formations of surface nanoparticles,” which were then set to be used in a single well chemical tracer field test this year,” the company reported.

The report also noted that by using cameras and sensors to document geological features, SA’s GeoDrone helps improve safety and accuracy of field data while reducing costs, since geologists can conduct virtual field trips from their desktops.

The company reported that it increased the power and speed of GigaPowers, its parallel oil and water enhanced reservoir simulator, and TeraPowers, its next-generation reservoir and basin simulator, to improve its computational modeling.

SA also developed GeoDrive, a next-generation, integrated seismic imaging platform that enables ultrahigh-resolution subsurface mapping and characterization, and tested the platform in collaboration with the King Abdullah University of Science and Technology.

“Our geophysical expertise, integrated with the power of Shaheen II, a KAUST supercomputer, successfully produced a 3-D image of subsurface geologic layers at a record resolution of 7.5 meters. This capability will enhance our understanding of challenging subsurface environments and help optimize drilling for exploration

and production,” the company said.

SA said its state-of-the-art Advanced Geosteering Center in Dhahran “enables real-time monitoring of drilling rigs hundreds of kilometers away to achieve precise, optimal well placement.”

Live drilling and downhole data are transmitted by satellite to the center, where teams of experts analyze the information to make real-time decisions. Positioning wells for maximum reservoir contact results in enhanced well productivity and lower development costs.

“In 2017, our geosteering program achieved 97-percent reservoir contact efficiency,” the company reported.

SA also is testing the use of seawater in hydraulic fracturing to reduce its use of fresh water. One field trial was completed last year and three more in 2018. [E](#)



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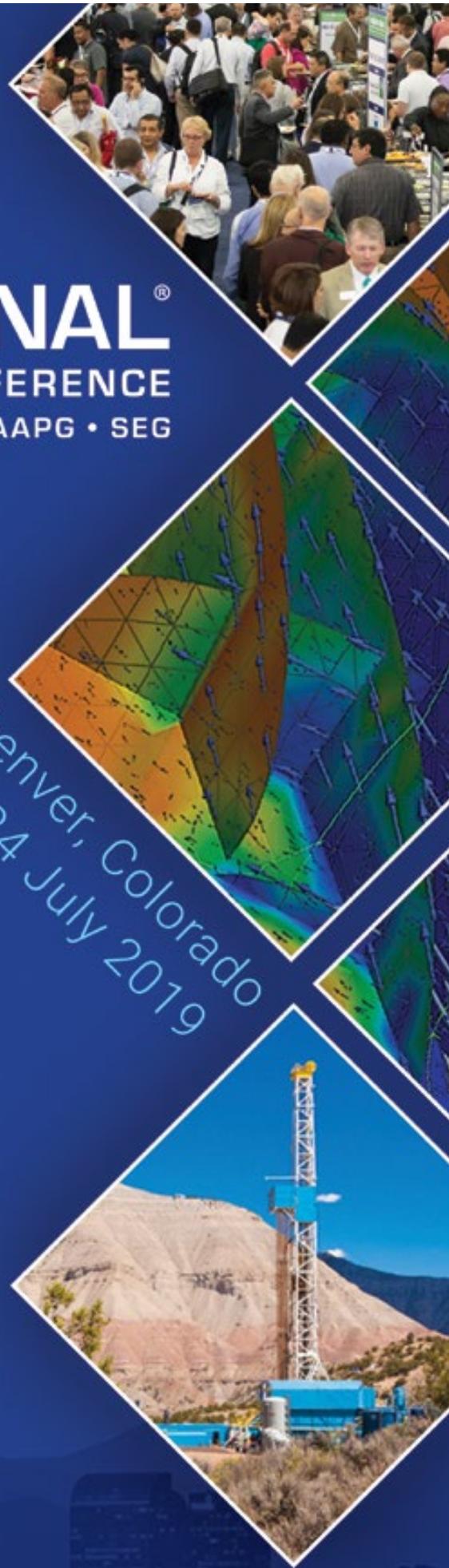
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Mexican Reform Creates Offshore Boom

The date is important – Aug. 11, 2014.

That was the day Mexican President Peña Nieto signed a package of laws designed to attract and encourage foreign investment into the country's oil, gas and electrical grids. Before that – since 1938, actually – the country's energy potential and riches were controlled by state-owned Petróleos Mexicanos, or PEMEX. With the reform codified, the country was open for business and companies like Shell, Total, BP, Petronas Repsol and BHP rushed in.

"The Reform has been amazingly fast (multiple bid rounds in a single year), transparent, and I think highly positive when compared to other Latin/South America exploration hotspots in Brazil, offshore Guyana and even Colombia."

That's Read Taylor, executive director of upstream for Sierra Oil and Gas, which advertises itself as Mexico's First Independent Oil and Gas Company. Sierra was not only part of the early reform, it helped define its potential.

But more on that in a minute.

Taylor said the reform's progress has been impressive.

"The government has delivered and received high interest from the industry, including all the majors and local Mexico companies as well. It has come to us at a fast pace. Sierra was able to respond and we feel very happy about what the government has done and how we were able to evaluate quickly and respond successfully," he said.

He's being modest.

Sierra's Zama oil discovery, located in the Sureste (southeast) Basin, was one of the top ten discoveries in the last ten years in Mexico. Sierra, for its part, holds a 40-percent stake in it.

"What's interesting to me," Taylor said, "is the story behind each success. It's always through a mix of hard work, smart people, good data, detailed technical work, some luck or good fortune along the way and perseverance. Zama's story is just like that."

Results of Reform

He could have been talking about any discovery, but this one happened in a place without a history of them.

"This was in the early days of the reform. Sierra as a company could not qualify by itself so we had to reach out to several potential partners to collectively qualify. In addition, we had to teach them about the basin, the petroleum system of Mexico, the play types, the CNH guidelines, the commercial terms, the contract etc. All of which we had spent one or two years investigating before the reform started," he said.

Sierra then put together a group, which included Glencore and Talos; unfortunately, just before the final qualification deadline, Glencore dropped out.

"This is when oil price was crashing from over \$100 a barrel to around \$50. We had to quickly go find another partner or we would not have been able to bid in the very first round of

the reform," said Taylor.

Luck, hard work, timing and one great contact later, the deal was in place.

"Fortunately, I have a good relationship with Premier, a world class global explorer, and over a week they accepted to join with us."

How successful was it?

"The Zama feature is estimated to have up to 1.7 billion barrels of oil (stock tank oil initially-in-place) perhaps up to 2.3 billion barrels STOOIP. We believe this has the potential to produce 150,000 to 180,000 barrels of oil per day. We are currently developing our appraisal plan and expect first oil early 2023."

Taylor sees Zama as more than just Sierra's success, even though the company received an award from the Association of International Petroleum Negotiators in London for the discovery of the year.

"It's great for our company as the clear first mover in Mexico, our investors who trusted us, our consortia members who trusted us and for the Reform and quite frankly for Mexico," said Taylor.

The reform, clearly, was the catalyst, but pronouncements and hope are not the same as actualization and success and overcoming obstacles. To this point, Taylor mentioned the improved rules governing drilling and the flow of information.

"The government has instituted caps on bid levels, extended the contracts a bit and cleaned up several of the legal contractual challenges," he said.

He has also been impressed with country's openness and desire to get these things right.

"I was in Brazil with Devon going back to Round 0. I see a lot of similarities between the two and certainly see the promise of Mexico. I think Mexico has taken well the learnings from various countries and taken the best points of contracts and process from them and applied them."

He believes Mexico may soon be, if it isn't already, the place to be for such discoveries.

"Due to the attributes of the Mexican petroleum system, specifically its oil rich source rocks, its under-explored nature, high structural propensity, multiple play types, I rank Mexico offshore over Brazil offshore as far as an arena for new YTF (yet to find) exploration," said Taylor.

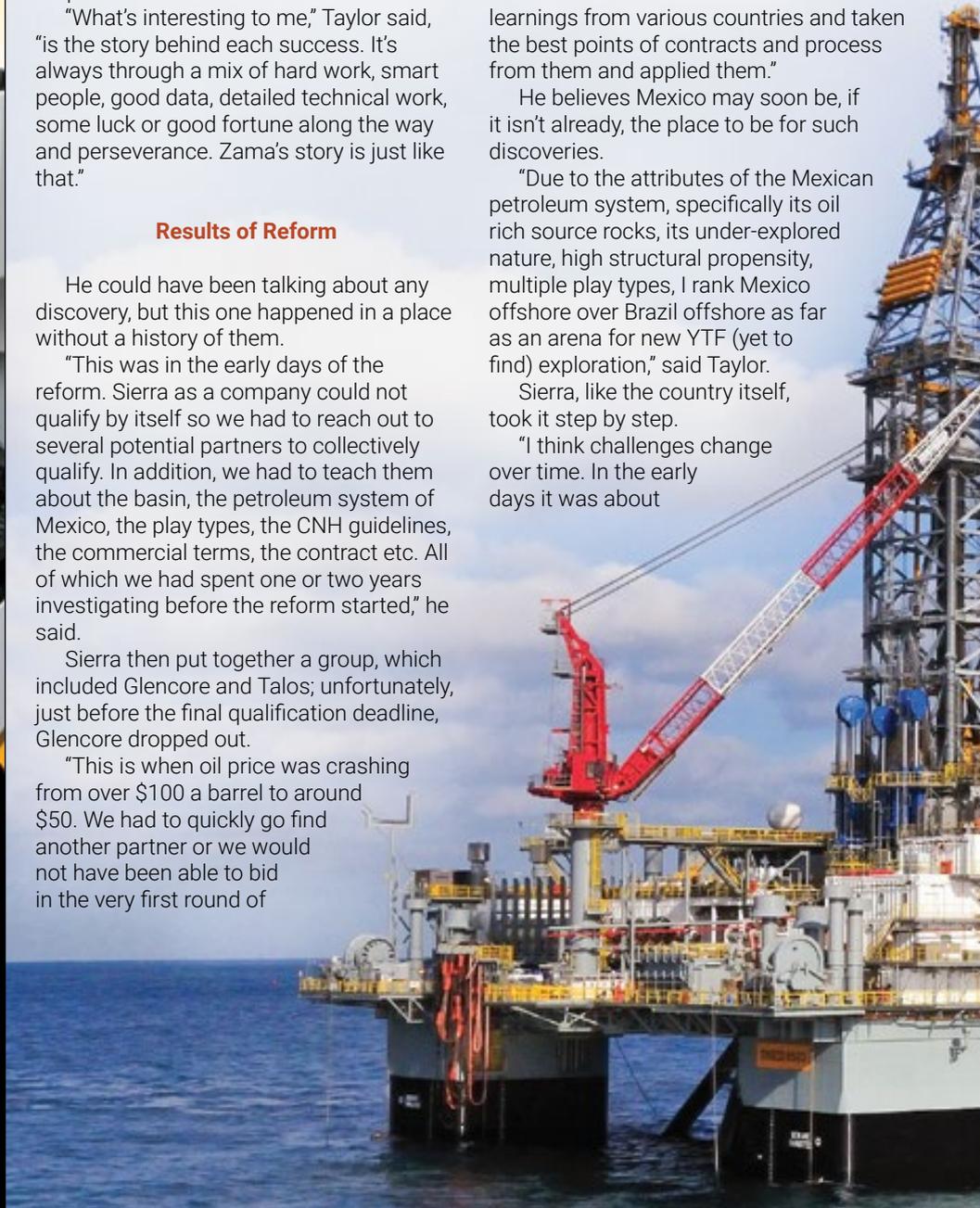
Sierra, like the country itself, took it step by step.

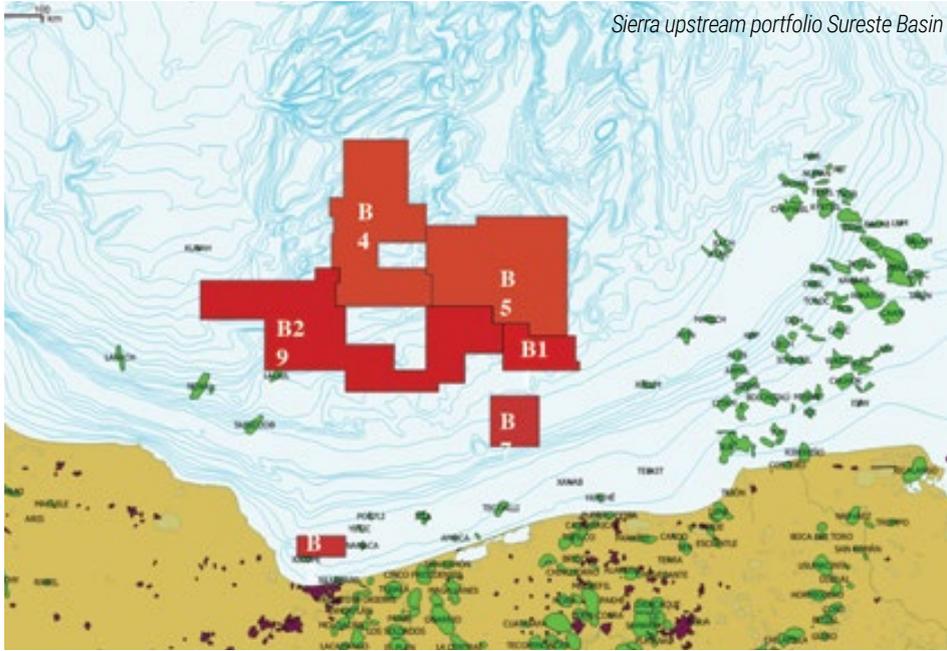
"I think challenges change over time. In the early days it was about

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understanding the contracts, tax systems reporting, how to get VAT (value-added tax) refunded and how to deal with letters of credit or parent guarantees. We then moved into a stage of operational challenges. I think the Consortia handled that very well and we drilled a low cost well safe and environmentally clean with the highest technology available," he said.

He said Sierra now looks ahead to contracting efficient low-cost development options, including offshore platforms and processing or floating storage production storage and offloading and or transportation through a new and developing offshore grid system.

"It will come down to managing timelines with permitting and approvals, getting our appraisal plan done in time working, etc. The government will play a role in these and they will be quite busy managing all the efforts of all of the consortia and interested parties."

He welcomes its involvement.

"We will need their support and timely management."

Unconventional versus Offshore Investment

As to the supply glut of recent years, the dearth of major discoveries, the very roll of offshore is a topic of discussion, but Taylor is still sanguine about Mexico.

"I think the news is good. It's all about who can make the smartest capital choices (capital is competitive across the globe) have the biggest and the lowest cost discoveries and developments. Oil has stabilized and in fact rebounded to almost \$80 dollars today. At CERA recently it was an interesting debate about where companies (will) push capital toward unconventional or offshore exploration," Taylor explained.

The consensus was split.

"It was about 50-50 (percent), amongst the experts. Most majors have turned back towards expanding exploration budgets between 20 and 30 percent."

Taylor thinks that's the smart move.

"Companies realize they can't cut exploration budgets and maintain balance sheets reserves or traction with their shareholders anymore without strategic stories. They need to explore and increase reserves production with high potential and low-cost developments or low capex per barrel developments. That's perfect for Zama and Mexico. The Sureste Basin has the answer to that question."

Sierra is not alone anymore in trying to find the answer, for there are now 26 or 27 new companies operating now in the Sureste offshore basin. That's a tall order for a country that only a few years ago only had one player in the region – itself.

New Government

Prior to Mexico's recent presidential election, there were concerns that the focus and commitment to the industry and the reform might change, which President-elect Andres Manuel Lopez Obrador has attempted to assuage by promising to "respect" the reforms, while also pledging to inject \$9.4 billion (U.S.) into the state-owned energy companies with the goal of ramping up production.

"So, a couple of things. We are a business supported by large and highly expert funds in Mexico, U.S. and London. As a business entity it would not be appropriate to meddle in Mexico politics. We as a company spend a lot of time looking at the landscape the country risk issues and we have purposely hired ex-government staff to help us understand where any issues might be. We spend a lot of time in analysis and risk assessment on this," said Taylor.

Still, he knows things can change for Sierra, specifically, and the industry, generally, with a new government.

Sure, it's possible, he admitted, "but I believe in the sanctity of our contracts."

The future can thank the past for that.

"As I understand, it took seven to eight years to move into the reform and the number of global companies and amount of investment committed by other majors in Mexico and specifically the last bid round tells me very smart people believe this is here to stay." 

The Zama-1 well in the Sureste Basin, drilled by the Ensco 8503 rig

Tenure-Track Assistant Professor in Structural Geology

School of Geography & Earth Sciences, McMaster University

The School of Geography & Earth Sciences (SGES) at McMaster University in Hamilton, Ontario, Canada, invites applications for a full-time, tenure-track position at the Assistant Professor level beginning July 1st, 2019 in the field of Structural Geology.

The successful candidate must have a Ph.D. at the time of appointment in earth sciences, geology, or a related geoscience discipline. We are particularly interested in an individual who is field-based with a strong academic background and an excellent research record in their field. Research areas could include, for example, plate tectonics, tectono-geomorphology, geomechanics, and/or geohazards, especially using an earth systems approach, to enhance our School focus in water, resources and the environment. Experience with methods that enhance the School's strengths in spatial analysis (while not essential) would be an asset. The candidate is expected to develop an externally-funded, vigorous research program and must have a strong commitment to excellence in both undergraduate and graduate teaching and supervision, with an emphasis on experiential learning, especially including field experiences.

McMaster University is a globally renowned institution of higher learning and a research community committed to advancing human and societal health and well-being. Our focus on collaboratively exchanging ideas and approaches makes us uniquely positioned to pioneer groundbreaking solutions to real-world problems leading to a Brighter World. The Faculty of Science works to create global impact by advancing scientific discovery and knowledge, and promoting greater understanding. Our innovative, interdisciplinary approach generates new methods and insights, results, and lasting change. The School of Geography & Earth Sciences has 23 full-time faculty members with expertise in a breadth of fields in geography, earth science, and environmental studies/science. As a multidisciplinary School, SGES welcomes a wide range of students interested in geography and environmental studies & science, earth sciences, and geographic information science.

McMaster University has a strong commitment to achieving diversity among faculty and staff that reflects the diversity of our student body. The successful candidate will be committed to inclusion and excellence and the Department is especially interested in candidates who can contribute, through their teaching and/or service, to the diversity of the academic community. Women, persons with disabilities, First Nations, Metis and Inuit persons, members of racialized communities and LGBTQ-identified persons are strongly encouraged to apply. Gender diversity is being addressed at McMaster University through our

policies and actions. One recent action in this area was the completion of a gender pay equity study and a resultant base salary adjustment applied to all female faculty members in July 2015.

Faculty members at McMaster University enjoy numerous personal and professional benefits. University employees are offered an excellent benefits package that includes, but is not limited to, extended health care benefits, dental care, group life, long term disability, worldwide travel assistance, and a retirement plan. Progressive policies are in place to assist faculty women and men who become parents or are needed to care for family members. Salary will be commensurate with qualifications and experience.

Applicants should submit a cover letter outlining their research interests, curriculum vitae, a brief teaching dossier including a statement of teaching philosophy (maximum of two pages), as well as a one-page statement on equity and diversity. Academic reference letters are required at the time of application; applicants should ask three (3) referees to send their letters of reference electronically to Ms Marge Geroux, School Administrator at geroux@mcmaster.ca.

Complete applications must be made online at www.workingatmcmaster.ca/careers (Faculty Positions, Job ID 22196) to the attention of:

Dr. Antonio Paez
Chair, Search Committee
School of Geography and Earth Sciences
McMaster University
1280 Main Street West
Hamilton, Ontario, Canada, L8S 4K1

Review of complete applications will begin November 1st 2018, and continue until the position is filled. The effective date of appointment is expected to be July 1st, 2019, but negotiable. All applicants will receive an on-line confirmation of receipt of their application; however, only short-listed applicants will be contacted for interviews.

All qualified candidates are encouraged to apply; however, Canadian citizens and permanent residents will be given priority. To comply with the Government of Canada's reporting requirements, the University is obliged to gather information about applicants' status as either Permanent Residents of Canada or Canadian citizens. Applicants need not identify their country of origin or current citizenship; however, all applications must include one of the following statements in their application package:

Yes, I am a citizen or permanent resident of Canada
No, I am not a citizen or permanent resident of Canada.

McMaster University is located on the traditional territories of the Haudenosaunee and Mississauga Nations and, within the lands protected by the "Dish With One Spoon" wampum agreement. In keeping with its Statement on Building an Inclusive Community with a Shared Purpose, McMaster University strives to embody the values of respect, collaboration and diversity, and has a strong commitment to employment equity. The diversity of our workforce is at the core of our innovation and creativity and strengthens our research and teaching excellence. The University seeks qualified candidates who share our commitment to equity, diversity and inclusion. While all qualified candidates are invited to apply, we particularly welcome applications from women, persons with disabilities, First Nations, Métis and Inuit peoples, members of visible minorities, and LGBTQ+ persons.

Job applicants requiring accommodation to participate in the hiring process should contact the Human Resources Service Centre at 905-525-9140 ext. 222-HR (22247) or the Faculty of Health Sciences Human Resources office at ext. 22207 to communicate accommodation needs.

Applicants are asked to describe, within their application package, their commitment to and demonstrated experience advancing equity, diversity and inclusion in post-secondary education, community-based or other professional settings (as requested above).

As part of the application process, you are invited to complete a brief diversity survey at the following link: <https://surveys.mcmaster.ca/limesurvey/index.php/472522?lang=en>. The survey is voluntary. All information collected is confidential and will not be shared with the hiring manager. The results of the survey are for institutional planning purposes, and support our efforts to promote diversity, equity, and inclusion.

If you have any questions about the Survey, please feel free to contact the Employment Equity Specialist, by phone (905-525-9140 ext. 24395) or email (duwaisom@mcmaster.ca). For additional information about McMaster University's Employment Equity Framework, please visit the McMaster Employment Equity website.

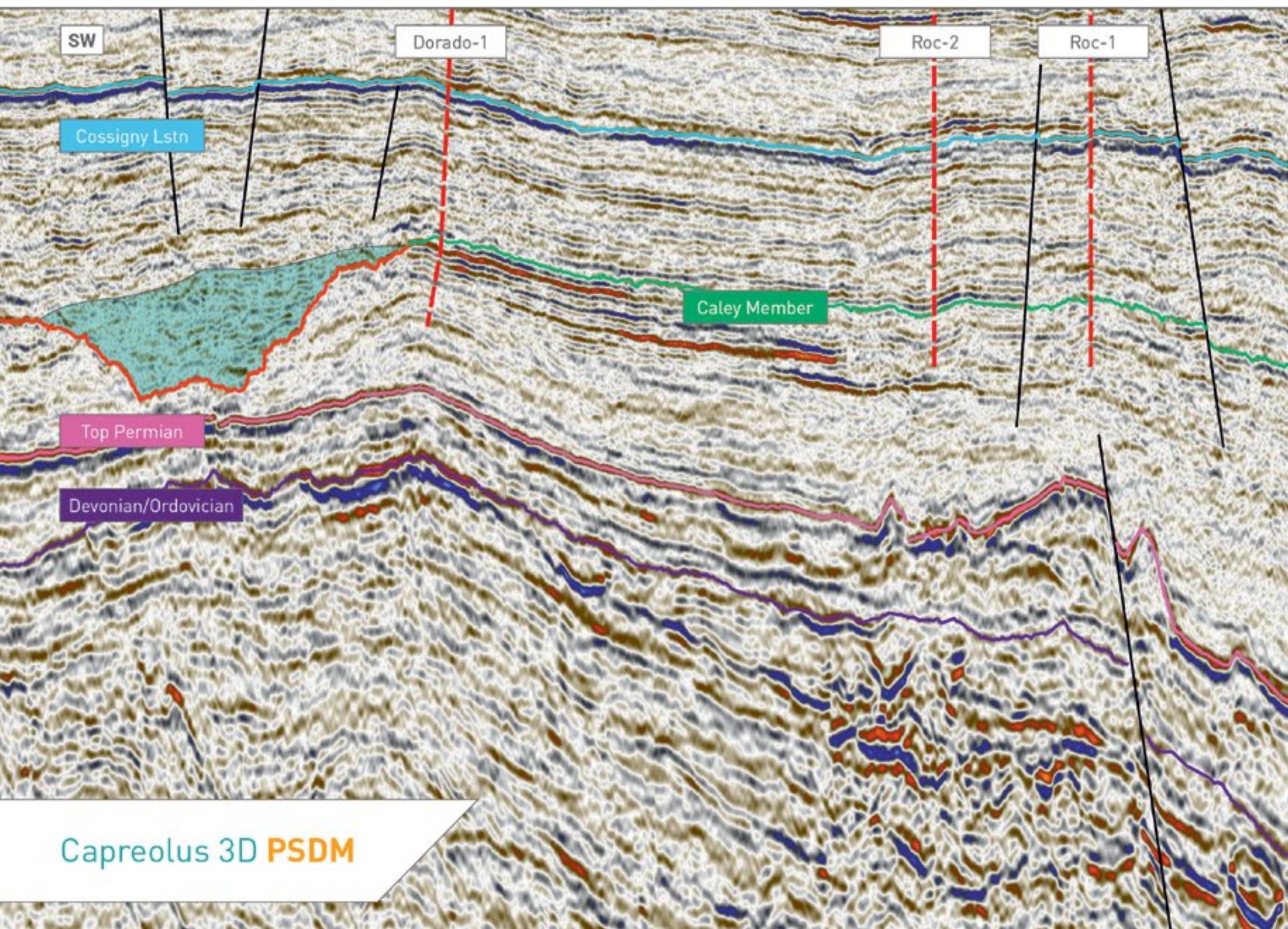
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Offshore Western Australia

TGS have an excellent 2D and 3D multi-client seismic database linking the Phoenix, Phoenix South, Roc, and Dorado discoveries with the 2018 gazettal acreage release blocks W18-4 and W18-5 closing March 2019.

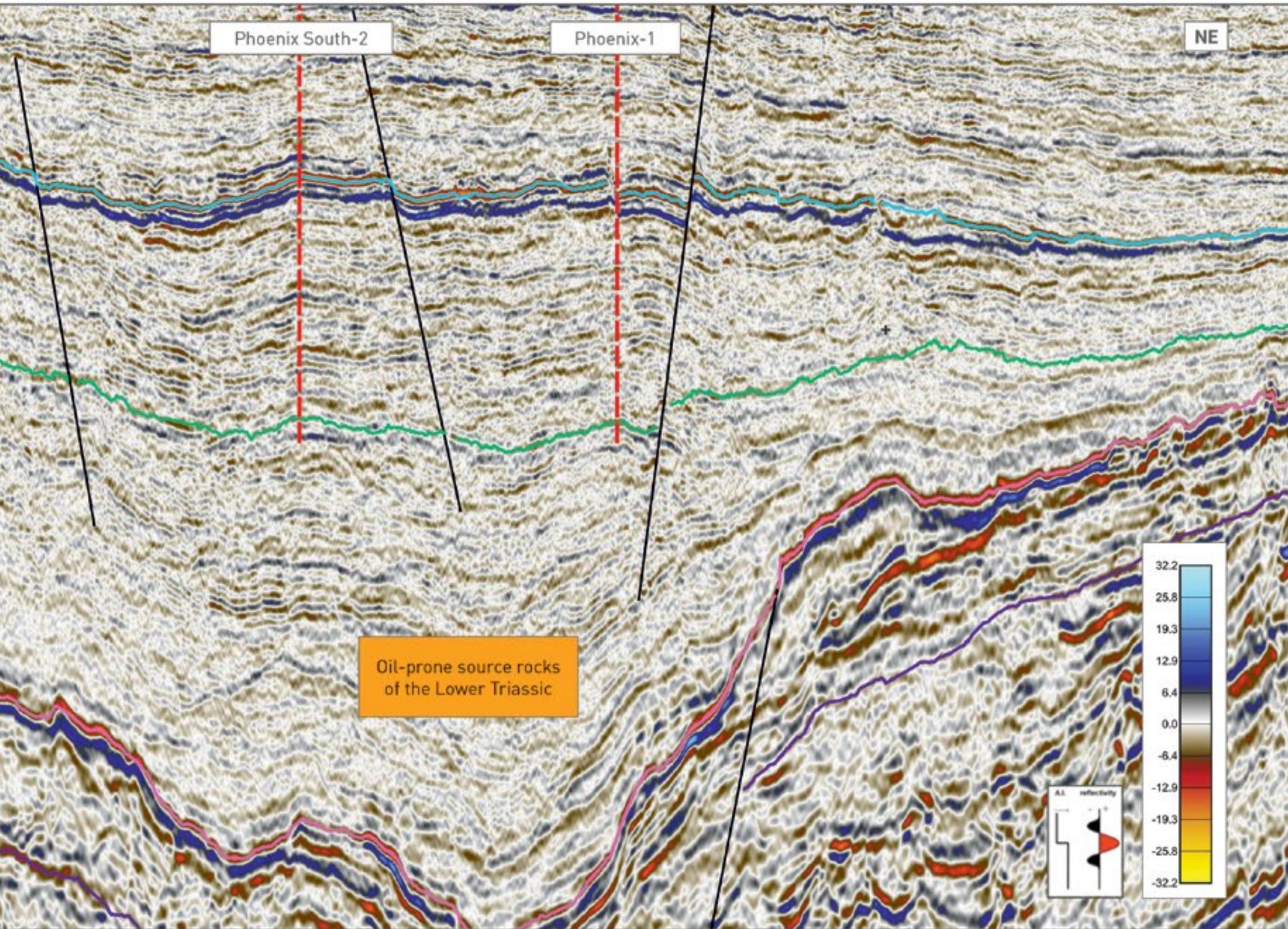
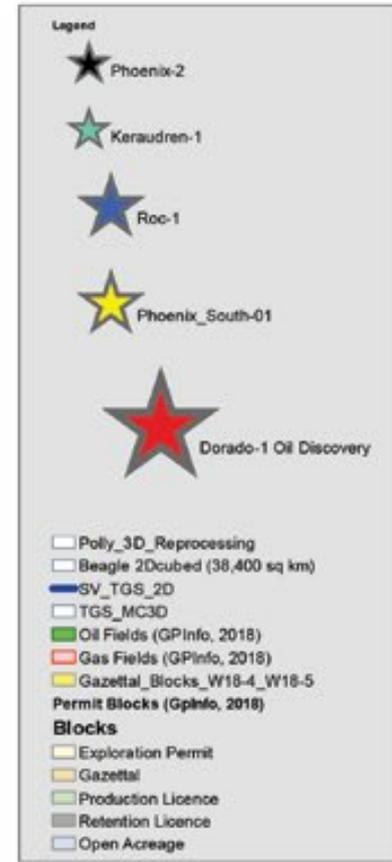
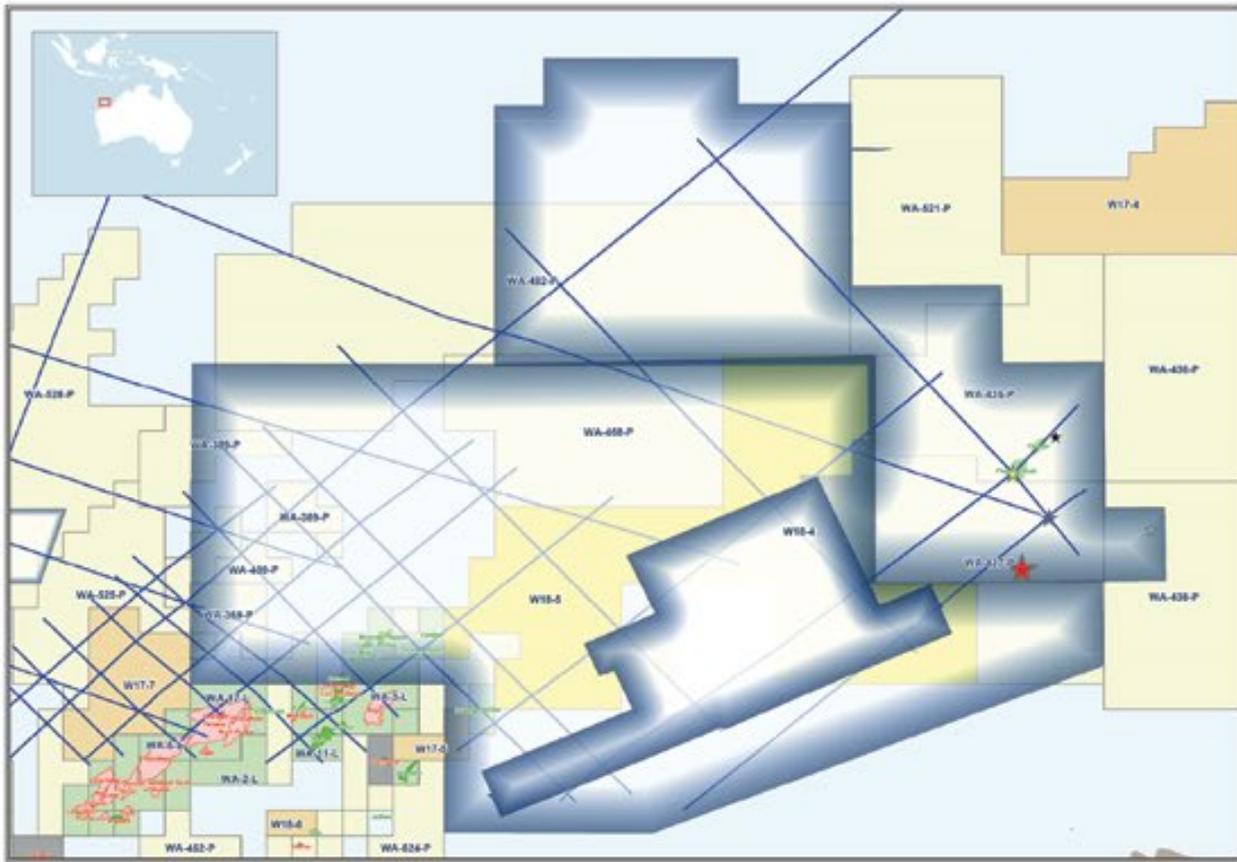
- The Bedout Sub-basin, offshore Western Australia, has the third largest oil discovery in the history of the North West Shelf at 2C gross contingent resources of 286 MMBOE (120m net oil across three reservoir intervals and a separate 10.5m net gas condensate column in the Lower Keraudren Fm). The Capreolus 3D covers 22,315 km² of the highly prospective Bedout Sub-basin, offering modern and high-resolution imaging of the new Triassic oil play, deeper Permian and potential Palaeozoic prospectivity. PSDM data is available now.
- The North West Shelf Renaissance 2D gives a broader basin coverage and is designed to focus on tying modern and deeper key wells where an uplift in deep seismic imaging is most valuable. PSDM data is available now.
- Polly 3D (7,536 km²) is currently being reprocessed via Broadband PSDM workflows. Fast track PSTM data will be available by mid-November and final PSDM data by end of 2018.
- Beagle 2D^{cubed} is currently being processed using existing open file 2D data and will provide a continuous coverage of data (38,600 km²) for regional study over open acreage and the 2018 gazettal acreage. Data will be available at the end of November 2018.

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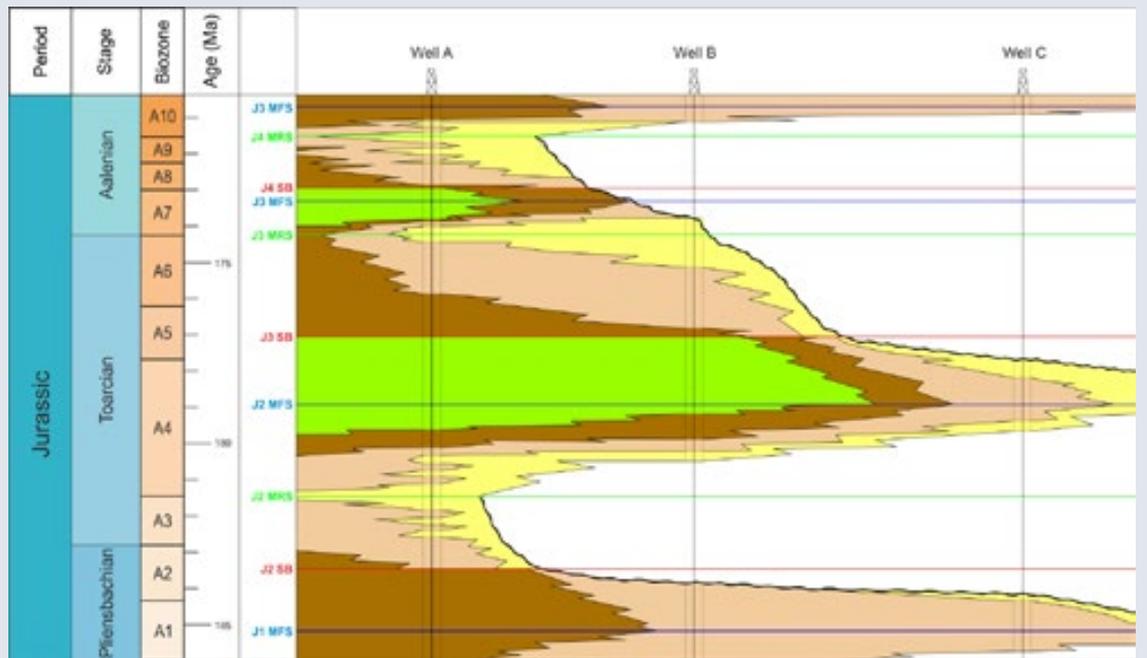
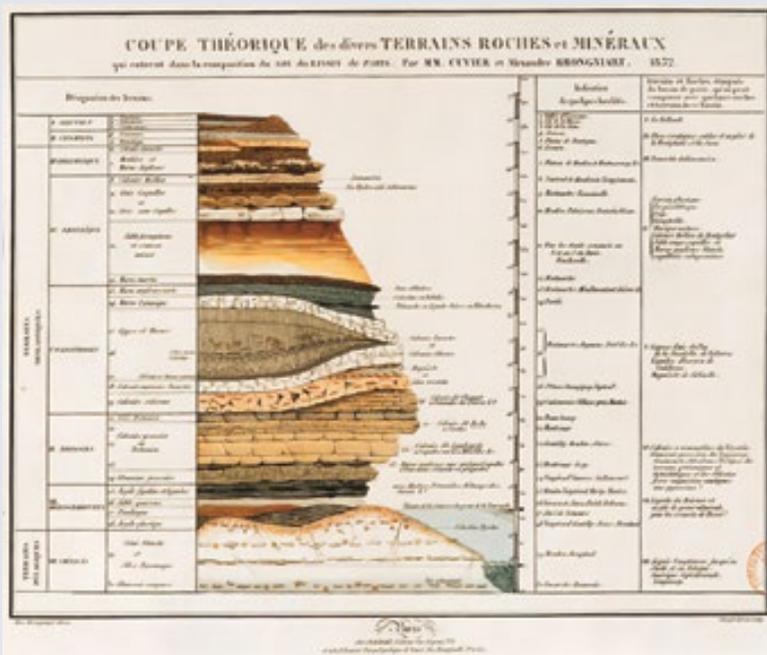
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Historical Highlights

Catastrophism and the Historical Roots of Sequence Stratigraphy



Left: Stratigraphic succession in the Paris Basin, as illustrated by Cuvier and Brongniart in 1832 (updating a figure first produced in 1811). Lithologies are depicted, as well as an interpretation of the succession in terms of palaeoenvironments. Of note was the observation that palaeoenvironments changed abruptly. This contributed to Cuvier's idea that Earth history was punctuated by catastrophes. Modern sequence stratigraphers will not be surprised that this section is "up systems tract" and therefore likely to include sequence boundaries recognised by time gaps and abrupt changes. Right: The predictive power of sequence stratigraphy. Facies (as depicted by the various colours) can be predicted between well locations using biostratigraphically-constrained sequence stratigraphic surfaces as a guide (figure prepared by Andrew Davies, Halliburton).

Alongside 3-D seismic, long-reach horizontal drilling and the application of plate tectonics to exploration, sequence stratigraphy has been one of the greatest scientific advances within the petroleum geology industry of the last 50 years.

Although practiced by Peter Vail and his colleagues at Exxon from the 1960s onward, sequence stratigraphy came to the wider attention of the industry with the publication of the seminal AAPG Memoir 26, "Seismic Stratigraphy: Applications to Hydrocarbon Exploration," in 1977. Since then, it has been embraced by the industry because the integration of time-significant surfaces with stratigraphic architecture provides great predictive insight at a variety of scales and extracts value from many data types.

Sequence stratigraphy includes the interpretation and prediction of sedimentary facies and architecture resulting from changes in relative sea level (the interplay of sediment supply, tectonics and eustasy). If the eustatic component can be isolated, then this provides an enhanced ability to correlate and to predict facies geometries. The validity of eustatic sea-level curves remains controversial, both in terms of demonstrating their proof and of attributing driving mechanisms; nonetheless, however, a growing consensus exists in the stratigraphic community that there are synchronous global sea-level events through geological time. Yet their frequency, amplitude and pace remain much debated.

Cuvier and Catastrophism

The debate around eustasy strongly echoes a debate that engaged the geological pioneers of the 19th century. "Catastrophism" was the term used to describe the notion that Earth's history had been punctuated by major events that had caused extinctions and affected sedimentation patterns. The validity of this concept was a question that vexed the early geologists of Britain and mainland Europe (the distinction of Britain versus mainland Europe is worth making because catastrophism had more opposition in Britain and more support in mainland Europe).

The primary author of catastrophism was the brilliant French scientist, Baron



Following a doctorate on Middle East geology, Mike Simmons joined BP and worked in a variety of roles in international exploration. He took time away from industry to be the Shell-funded head of the Department of Geology and Petroleum Geology at Aberdeen University. Simmons then led the CASP research group at the University of Cambridge before joining his former BP colleagues at Neftex. He is currently the technology fellow for geosciences and exploration at Halliburton (Neftex is now a part of the Landmark business unit within Halliburton). He is also an honorary professor at the University of London and a scientific associate of The Natural History Museum. His research interests encompass petroleum exploration workflows, especially integration with sequence stratigraphy; regional stratigraphy and petroleum geology, specifically the Middle East and Black Sea regions; applied biostratigraphy; and the history of geology.

Georges Cuvier. The noted natural history writer, Stephen Jay Gould, described Cuvier as "perhaps the finest intellect in 19th century science." Based at the Natural History Museum in Paris, Cuvier made immense

contributions to zoology, paleontology and geology. He recognized that the form of animals could be reconstructed by understanding the function of bones and organs, a discipline now termed "comparative

anatomy." A gallery he created in the museum that housed more than 16,000 zoological specimens, illustrating form and function, was one of the scientific sensations of the early 19th century.

Having studied living animals, Cuvier became increasingly interested in fossils and applied comparative anatomy to determine the form of creatures very different from anything living. He recognized a huge Cretaceous marine lizard (now called a "Mosasaurus") and a flying reptile that he called a "petro-dactyle." These and other seemingly fabulous creatures gave Cuvier cause to reason that worlds must have existed in the past, inhabited by extinct creatures very different to those around us. This conclusion then led to a need to understand the history of the Earth, providing a rallying call for geology to develop a purpose that would enable geoscience to match the achievements of physics and astronomy.

Accordingly, Cuvier's geological interests rapidly expanded beyond the determination of the nature of fossils. In 1811, in collaboration with the mineralogist Alexandre Brongniart, he presented "Essai sur la géographie minéralogique des environs de Paris," or "Essay on the mineralogical geography of the surroundings of Paris," which contained not only a geological map of the Paris Basin, but a stratigraphic synthesis in the form of a novel sedimentary log. In the manner of William Smith in Britain, Cuvier and Brongniart used the fossil content of the strata for subdivision and correlation. Moreover, they determined a series of alternating freshwater and marine environments, representing a pioneering attempt to reconstruct the geological history of a rock succession.

This type of analysis led Cuvier to conclude that Earth's history had been episodically interrupted by sudden "revolutions" that caused faunal extinctions.

In 1812, he wrote, "Life upon the Earth in those times was often overtaken by these frightful occurrences. Living things without number were swept out of existence by catastrophes. Those inhabiting the dry lands were engulfed by deluges, others whose



Cartoon by Tove Birklund depicting biostratigraphers arguing over which fossil event to use to define a stage boundary

Continued on next page ►



Baron Georges Cuvier as painted by W.H. Pickersgill (1831) and engraved by George T. Doo (1840)

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home was in the waters perished when the sea bottom suddenly became dry land; whole races were extinguished leaving mere traces of their existence, which are now difficult to recognize, even by the naturalist. The evidences of those great and terrible events are everywhere to be clearly seen by anyone who knows how to read the record of the rocks."

The comparison with sequence stratigraphy is obvious: sea-level changes profoundly affect the rock record.

Cuvier's description of Earth history as a series of former worlds inhabited by exotic extinct creatures, with each world in turn being destroyed by catastrophe, generated a popular, romantic interest in geology and paleontology. Here was a scientific challenge for the age – to reconstruct and place in order these lost worlds; in other words – to determine the

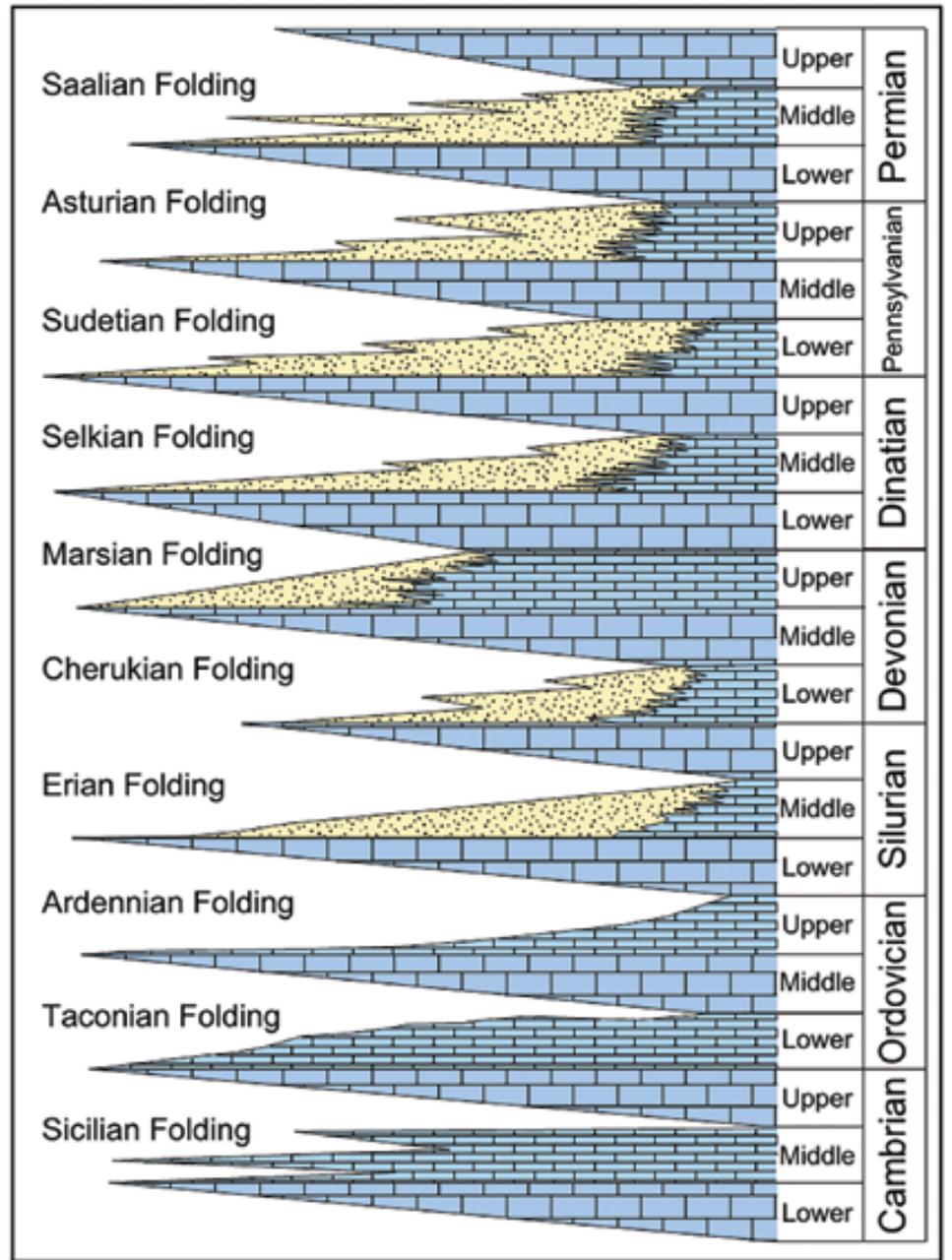
history of our planet back into deep time.

This challenge was picked up by many of Cuvier's disciples. Foremost among these was Alcide d'Orbigny, a pioneering micropaleontologist and scientific explorer. He integrated catastrophism with the formal subdivision of geological time by introducing the concept of stages (e.g., Cenomanian) linked to global events. For d'Orbigny, these were "the expression of the boundaries which Nature has drawn with bold strokes across the globe." Stages were viewed as the results of transgressions separated by unconformities created by sea-level fall, once again drawing a comparison with modern sequence stratigraphy.

'The Present as the Key to the Past'

However, there were those who vehemently opposed catastrophism. Foremost among these was Sir Charles Lyell, whose "Principles of Geology" (1830-33) provided a manifesto for a gradualistic view of Earth history and uniformitarianism: a steady-state Earth. Like Cuvier, Lyell was obsessed with making geology more scientific. Geology needed a set of laws by which to operate in order to be judged as a true science. This need meant that "All theories are rejected which involve the assumption of sudden and violent catastrophes and revolutions of the whole Earth, and its inhabitants." It also meant that "No causes whatever have from the earliest time ... to the present, ever acted, but those now acting and that they have never acted with different degrees of energy from which they now exert." Apparent sudden changes can be explained by the imperfect nature of the geological record, he argued. Such a doctrine had also been expressed by one of the founding fathers of geology, James Hutton, in the late 18th century.

See **Neocatastrophism** page 27 ▶



Amadeus Grabau's interpretation of global cycles of deposition with Palaeozoic strata



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Geophysical Corner

Convolutional Neural Networks

If they can identify an oncoming car, can they identify lithofacies in core?

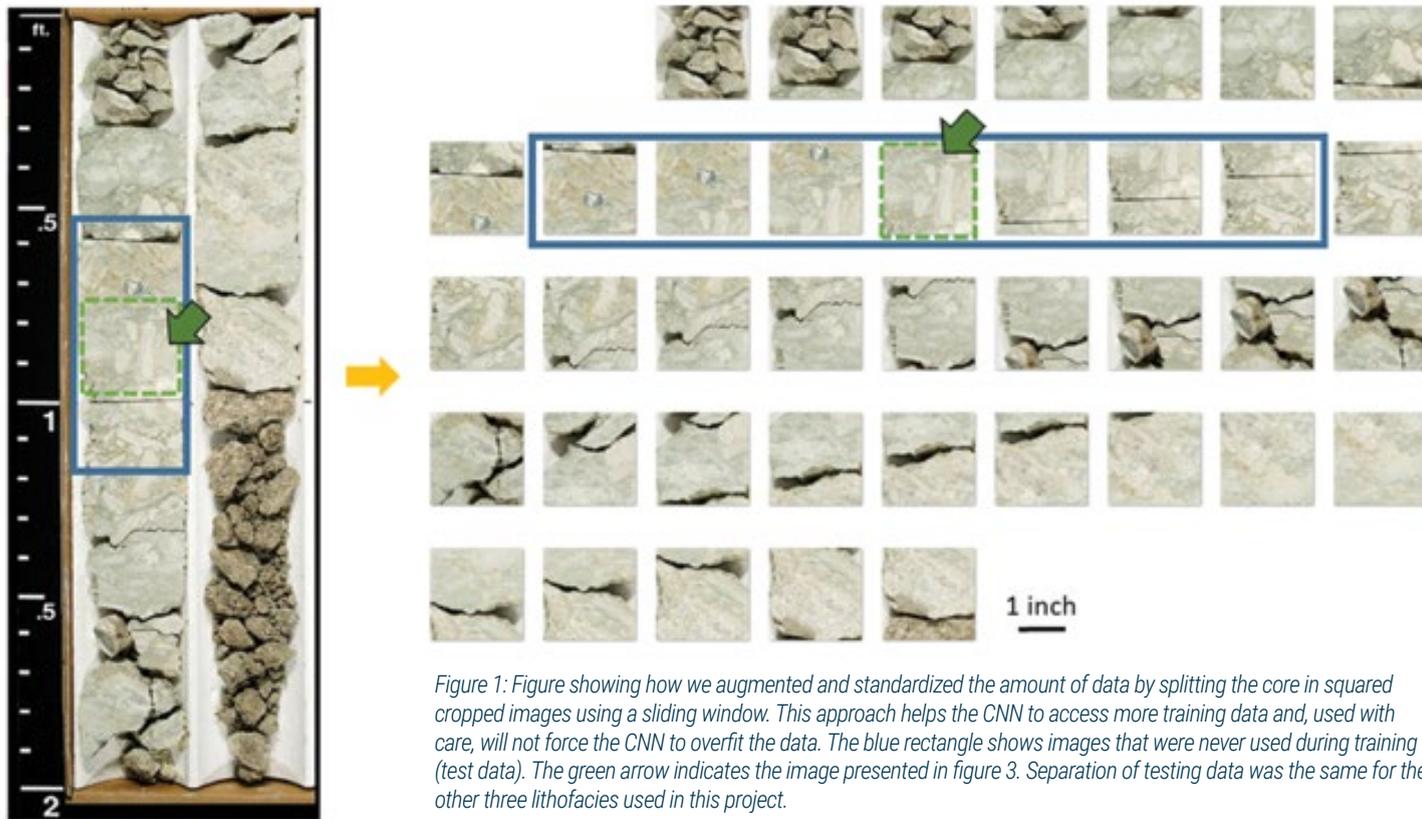


Figure 1: Figure showing how we augmented and standardized the amount of data by splitting the core in squared cropped images using a sliding window. This approach helps the CNN to access more training data and, used with care, will not force the CNN to overfit the data. The blue rectangle shows images that were never used during training (test data). The green arrow indicates the image presented in figure 3. Separation of testing data was the same for the other three lithofacies used in this project.



AAPG Member **Kurt J. Marfurt** serves as the Frank and Henrietta Schultz professor of geophysics within the ConocoPhillips School of Geology and Geophysics at the University of Oklahoma in Norman, Okla.

rules. Imagine how a child can understand complex and difficult-to-grasp entities based on examples, such as “what is a cube?” The first example of a cube can be a six-faced die. In this example, the child may observe that each side of the die exhibits a different number of dots, the object has a color, a size, and so forth. Given this single example, the child may struggle creating a mental model of a cube. Does a cube have something to do with a particular size, or perhaps with different numbers of dots on each side? The same child then learns that a cardboard box might be termed a cube; later, that the shape of the ice in their drink is also a cube. After a sufficient number of examples are provided, the child builds a mental model of a cube even in the absence of a formal definition. Moving forward, the child approaches the world with a set of attributes in mind whenever a new object requires shape classification. Other classes of objects might have completely different characteristics (what is a tree?) or shared characteristics (what is a parallelogram?) and can be added to the child’s knowledge.

Just like the child who draws upon examples to learn object classification, the CNN needs examples to understand the characteristics of each “class” it tries to differentiate. Our work focuses on transferring the learning of a complex CNN trained on more than one million random images to correctly classify a lithofacies on well core images. The great advantage of “transfer learning” is that layers that have been previously trained with a significant amount of labeled data can be reused to address different objectives without any alteration. Our job then is to use an already trained model (a CNN model that has several rules for several different images) and add an additional lithofacies identification layer.

Preliminary Results

One of the most important factors contributing to the robustness of CNN models is the amount of labeled data that can be used for training. We used well core images captured through modern photographic equipment to generate the set of data to feed our CNN. The particular section used for this project consisted of approximately 50 feet of core from the Mississippian limestone and chert reservoirs in the Anadarko Shelf, Grant County, Oklahoma. The set of core images show four different lithofacies: bedded skeletal peloidal packstone-grainstone, chert breccia in greenish shale matrix, spiculitic mudstone-wackestone and splotchy packstone-grainstone. To ensure images supplied to the CNN are consistent, the first stage of the process consists of careful cropping and selection of the images to be used as input for the training.

Advances in deep learning and artificial intelligence promise to not only drive our cars but also taste our beer. Specifically, recent advances in the architecture of deep-learning convolutional neural networks have brought the field of image classification and computer vision to a new level. Very deep convolutional neural networks emerged in 2014 and have achieved new levels of accuracy in several artificial intelligence classification problems. Current CNN models are able to differentiate the image of a leopard from that of a scooter, but moreover can differentiate images of leopards from their biological cousins – cheetahs and snow leopards. Deep convolutional neural network architecture achieved a 3.5-percent top-5 error (how frequent the model fails to predict the correct class as one of the top 5 guesses) and 17.3-percent top-1 error in a visual recognition challenge in 2015. The current benchmark in object category classification and detection consists of hundreds of mixed-object categories and millions of images.

Although machine learning has been significantly used in geoscience fields, the application of this technique in core-based lithofacies identification, a key component to better understand oil and gas reservoirs, remains limited. Machine-learning techniques have been intensely used to aid seismic-facies classification, lithofacies classification from well logs, and even for seismicity studies. Cored wells are important as they provide the only ground-truthing for subsurface reservoirs, including data on lithofacies variations. The goals of core-based rock-type descriptions are to identify key lithofacies and facies associations, evaluate facies stacking and identify stratigraphic surfaces, interpret depositional environments, evaluate relationships between rock properties and lithofacies, and help operators identify optimal zones for designing completions. Traditional core-based lithofacies identification is costly, time consuming and subjective (e.g. different geologists describe the same core with different results).

To address some of these challenges, we evaluate whether a CNN can help a specialist on an image-recognition task. CNN results are directly related to

the amount of labeled data used during training. As more and more examples are provided to the CNN, higher accuracy rates are generated, thereby developing improved

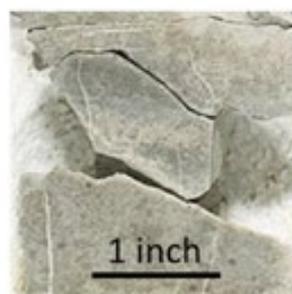


Figure 2: A Bedded skeletal peloidal packstone-grainstone sample image from the core not used in the CNN training

Lithofacies	Probability
Bedded skeletal peloidal packstone-grainstone	0.82
Chert breccia in greenish shale matrix	0.15
Spiculitic mudstone-wackestone	0.02
Splotchy packstone-grainstone	0.01



Figure 3: A chert breccia in greenish shale matrix sample image from the core not used in the CNN training

Lithofacies	Probability
Bedded skeletal peloidal packstone-grainstone	0.00
Chert breccia in greenish shale matrix	0.96
Spiculitic mudstone-wackestone	0.00
Splotchy packstone-grainstone	0.04

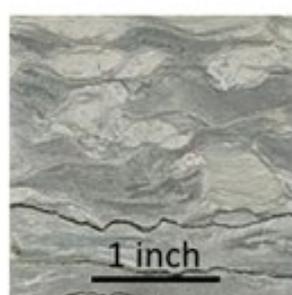


Figure 4: A spiculitic mudstone-wackestone sample image from the core not used in the CNN training

Lithofacies	Probability
Bedded skeletal peloidal packstone-grainstone	0.01
Chert breccia in greenish shale matrix	0.02
Spiculitic mudstone-wackestone	0.89
Splotchy packstone-grainstone	0.08

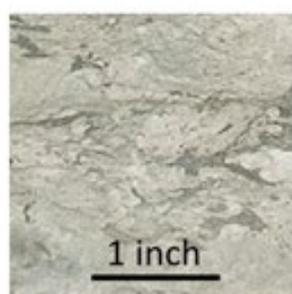


Figure 5: A splotchy packstone-grainstone sample image from the core not used in the CNN training

Lithofacies	Probability
Bedded skeletal peloidal packstone-grainstone	0.00
Chert breccia in greenish shale matrix	0.07
Spiculitic mudstone-wackestone	0.02
Splotchy packstone-grainstone	0.91

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Rafael Pires de Lima obtained his bachelor's in geophysics from the Universidade de São Paulo in Brazil and master's in geophysics from the University of Oklahoma. He is

currently on a leave of absence from the Geological Survey of Brazil to pursue his doctorate in geophysics at the University of Oklahoma. He has experience in seismic processing, gained during his time working for Schlumberger in Brazil, and non-seismic methods, obtained at the CPRM. His research interests include image processing, seismic attributes, and machine learning applications for geoscience research.



Fnu Suriamin earned his bachelor's in geological engineering from Padjadjaran University and master's in geology from the Colorado School of Mines. He worked

in Core Lab and Halliburton Sperry Sun Drilling Services in Jakarta. He was previously a geoscientist/petrophysicist with ExxonMobil in Jakarta and Petrofac Malaysia Ltd in Kuala Lumpur. Currently, he is completing his doctorate at the University of Oklahoma and is a petroleum geologist and petrophysicist at the Oklahoma Geological Survey. His research interests include petrophysics, reservoir characterization and modeling, mathematical geology and petroleum geology.



Matthew J. Pranter holds the Lew and Myra Ward Endowed Chair in Reservoir Characterization and is a professor of geology and geophysics at the University of Oklahoma.

He received his bachelor degrees in geology and geological engineering from Oklahoma State University and the Colorado School of Mines, respectively; his master's in geology from Baylor University and his doctorate in geology from the Colorado School of Mines. He was previously a geology professor at the University of Colorado at Boulder and a senior research/reservoir geologist with ExxonMobil Upstream Research Company and Conoco. His research interests are in reservoir characterization and modeling, sedimentary geology and petroleum geology.



G. S. (Lynn) Soreghan received her bachelor's in geology from the University of California, Los Angeles, and her doctorate in geology from the University of Arizona.

She worked for Amoco Exploration and Production Company before joining the faculty in geology and geophysics at the University of Oklahoma, where she currently holds the position of director and Eberly Family Chair. Her research focuses on sedimentary geology and paleoclimate, especially of Earth's deep-time past.

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We used a sliding window technique to extract consistent squared, cropped sections from the original core image (figure 1). This cropping process further augmented the number of samples of our initially small collection, which helps the CNN. We exclude part of the cropped pictures from the training set to be used as testing data (figure 1) after the CNN is trained. After the cropping process the bedded skeletal peloidal packstone-grainstone, chert breccia in greenish shale matrix, spiculitic mudstone-wackestone and splotchy packstone-grainstone lithofacies had, respectively, 285, 165, 605 and 285 images that were used for training.

The validation accuracy during training achieved 96 percent. After the training process, we can use the CNN model to predict the lithofacies of a suite of images (extracted from the same core) never used in the training. The CNN classification results are shown in figures ????? to 5, where the probability of each lithofacies is shown in the accompanying table.

Future Work

Although our CNN classification test was created with very few images and their variations, the preliminary results are quite promising. Overall, the CNN model selected the correct lithofacies with a significantly higher probability when compared to the other options. Use of images of similar sizes and qualities facilitates the lithofacies identification, as sedimentary features will maintain proportion – the CNN will not mistakenly classify conglomerates as sandstone, as size is preserved. Improved training requires incorporation of a larger number of examples to enable generation of a model sufficiently robust to overcome complications such as variances in color, core quality and textures. The move toward digitization of oil and gas data will provide the big-data enrichment to enable evaluation of the CNN methodology for examples from around the world. Changes in sedimentation characteristics, texture, core size and colors will complicate the picture, but hopefully lead to deeper learning. 



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

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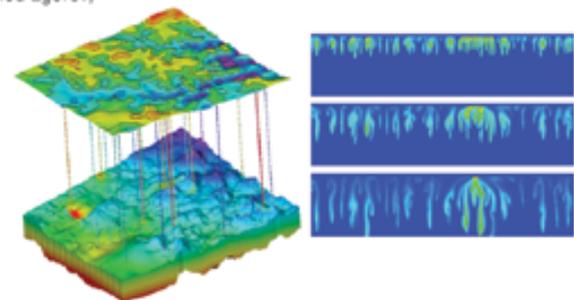
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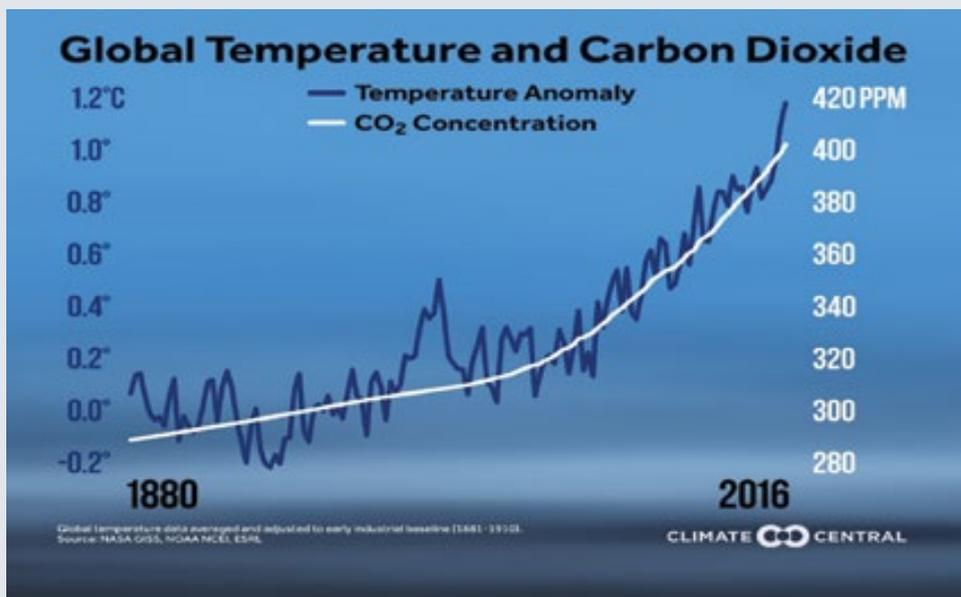


Figure 1. Global temperature has increased approximately 1.3 degrees C since 1880. A sharp increase in the rate of temperature rise was observed after 1950 which coincided with the increase in CO₂ content in the atmosphere. CO₂ content is now 411 ppm.

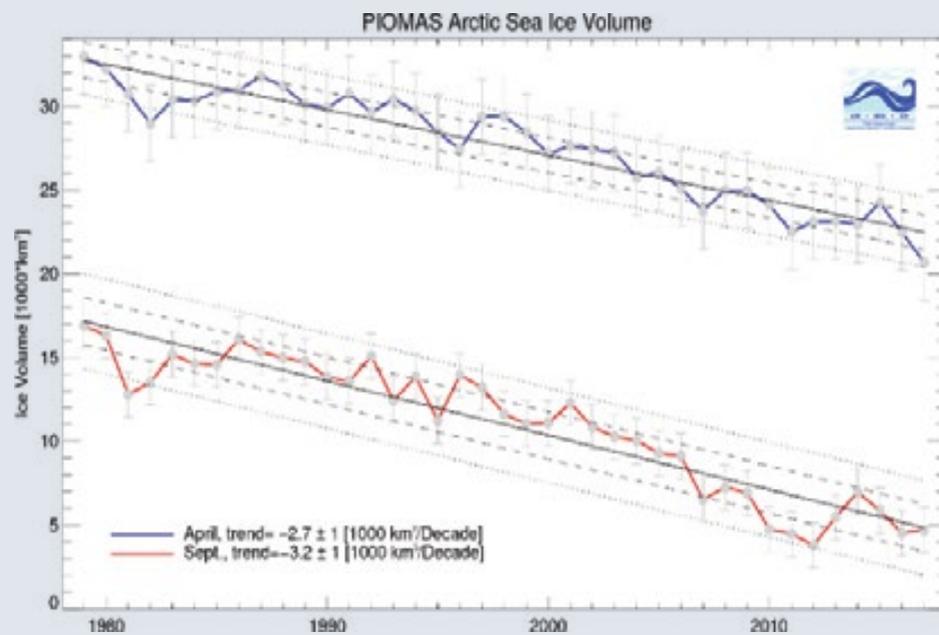


Figure 2. Between 1980 and 2016, the northern polar cap lost 70% of its ice volume during the September minimum.

An Earth Scientist's Perspective on Climate Change

Geoscientists have a special obligation. We are the historians of Earth's past, much as medical researchers have a responsibility regarding the understanding and honest communication of the functions of the human body and lawyers to understand and correctly interpret the law. Many of the tools we have established in our search for oil and gas, from plate tectonics to seismic stratigraphy, to study of paleoenvironments and paleontology, are being applied to understanding the geologic past in ways that document climate change.

To deny what is happening is also

to ignore what our own profession and science is telling us and is a disservice to the public at large who depend on our expertise to help them make informed decisions.

The 20th century witnessed the greatest rise in living standards in human history, supported by the energy provided from fossil fuels. Now, however, we face the consequences; the great challenge of the 21st century, which may define how we live in the future: how to deal with a changing climate caused in large part by the emission of CO₂ due to the burning of these fossil fuels.

The evidence for climate change comes from three main sources:

- ▶ The actual measurements taken from the ground, water, atmosphere and from space in recorded history
- ▶ The scientific principles behind the effects of solar radiation, the components in our atmosphere and an understanding of the applicable chemistry, physics and mathematics
- ▶ The geologic record of the past, which clearly demonstrates the changes in climate in the past and how to relate those changes with current processes

Global Warming

Careful measurements have documented the world temperature rise over the past century, particularly since 1950, with the overall rise of 1.3 degrees Celsius since 1880 (see figure 1). The rate of increase is accelerating and is now about 0.25 degrees per decade. The past three years (2015-17) have been the hottest ever recorded. However, temperature increases have not been uniform, north and south polar regions (above 60-degree latitude) have been warming at approximately twice

Continued on next page ▶

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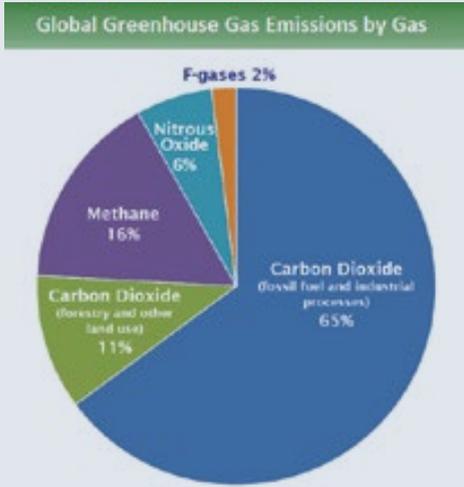


Figure 3. Greenhouse gas emissions are dominated by CO₂ (76 percent) followed by Methane, CH₄ (16 percent) and Nitrous Oxide, N₂O, (6 percent). 80 percent of CO₂ emissions come from burning of hydrocarbon fuel and related industrial processes. Source: EPA, 2017

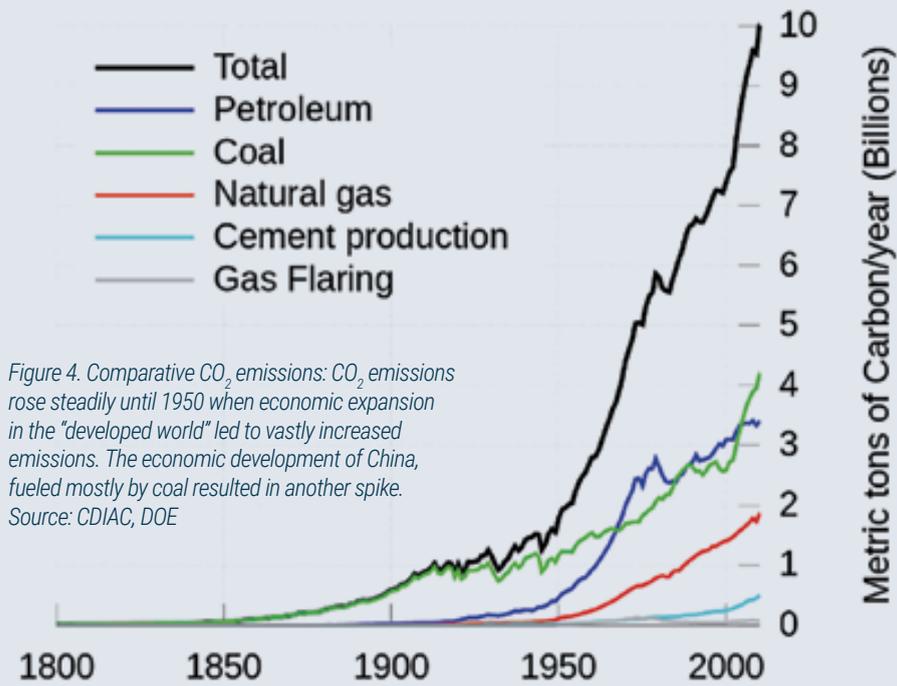


Figure 4. Comparative CO₂ emissions: CO₂ emissions rose steadily until 1950 when economic expansion in the "developed world" led to vastly increased emissions. The economic development of China, fueled mostly by coal resulted in another spike. Source: CDIAC, DOE



Ray Leonard earned his bachelor's in geology from the University of Arizona and a master's in geology from the University of Texas at

Austin. He is currently president of Anglo Eurasia, a consulting firm for the oil and gas industry. He has held executive positions with Amoco, FIOC, the Russian Oil Major YUKOS, the Hungarian National Oil Company MOL, the Kuwait Energy Company and was most recently CEO of Hyperdynamics, an independent oil company exploring for oil and gas in West Africa.

He has been recognized for his technical excellence by AAPG, being named a Distinguished Lecturer in the field of geochemistry and by professional publications on the origin of overpressure and geology offshore Trinidad, the North Sea and East Siberia and Russian oil and gas reserves.

He has been active in the debate regarding world oil and gas reserves for many years, presenting and publishing at forums such as Council on Foreign Relations (1994 and 2014), Center for Strategic Studies (2001), International Energy Agency (2003), the AAPG Hedberg Conference (2006), Aspen Forum (2008), Emirate Center for Strategic Studies (2013) and 26th World Gas Conference (2015).

He can be reached through his website, RayLeonard.consulting, or by email at contact@rayleonard.consulting.

Continued from previous page

the rate of tropical and temperate latitudes. The effects on both polar caps have been immense: as carefully monitored by NASA, the September (minimum ice period) north polar cap has lost 70 percent of its ice volume in the 1980-2016 period (figure 2). This would project to a September ice-free pole by around 2040. West Antarctica temperatures have actually risen at four times the planetary rate since 1950. The yearly ice loss from Antarctica has tripled in the 2007-17 period and the ice surrounding Antarctica reached an historic minimum in November 2016.

The rapid reduction in temperature differential between the poles and temperate and tropical latitudes, particularly in the northern hemisphere is weakening global circulation systems, such as the jet stream.

This results in slower moving and stalled frontal and/or high-pressure systems and can produce prolonged record-breaking heat waves as seen this summer in East Asia and Northern Europe, and catastrophic levels of precipitation, such as we have seen in Houston last year. The number of extreme precipitation events on an annual basis doubled in the United States in the past 20 years compared with the last half of the 20th century. The warming of the polar regions, plus the increased temperature in higher altitude at lower latitudes is melting the ice caps and glaciers, contributing to an accelerating average sea-level rise of 1 millimeter per year from 1880-1920, 2 millimeters per year from 1920-1980 and 3 millimeters per year from 1980-2010.

Ocean temperatures have also increased and the thermal expansion of water is

contributing to about a third of sea-level rise.

Increasing Green House Gases

The warming of the planet, particularly in the past 50 years is primarily due to increases in the atmosphere in heat trapping gasses. These gasses include carbon dioxide (CO₂), methane (CH₄) and nitrous oxide (N₂O). Taking into account their heat-trapping properties, they account for 76 percent, 16 percent and 6 percent, respectively, of the greenhouse gases in the atmosphere (figure 3). Approximately 80 percent of CO₂ released in the atmosphere (32 gigatons annually) comes directly from the combustion of fossil fuels, mostly from the combustion of coal, oil and natural gas. That amount has doubled in

See Coal page 26 ▶

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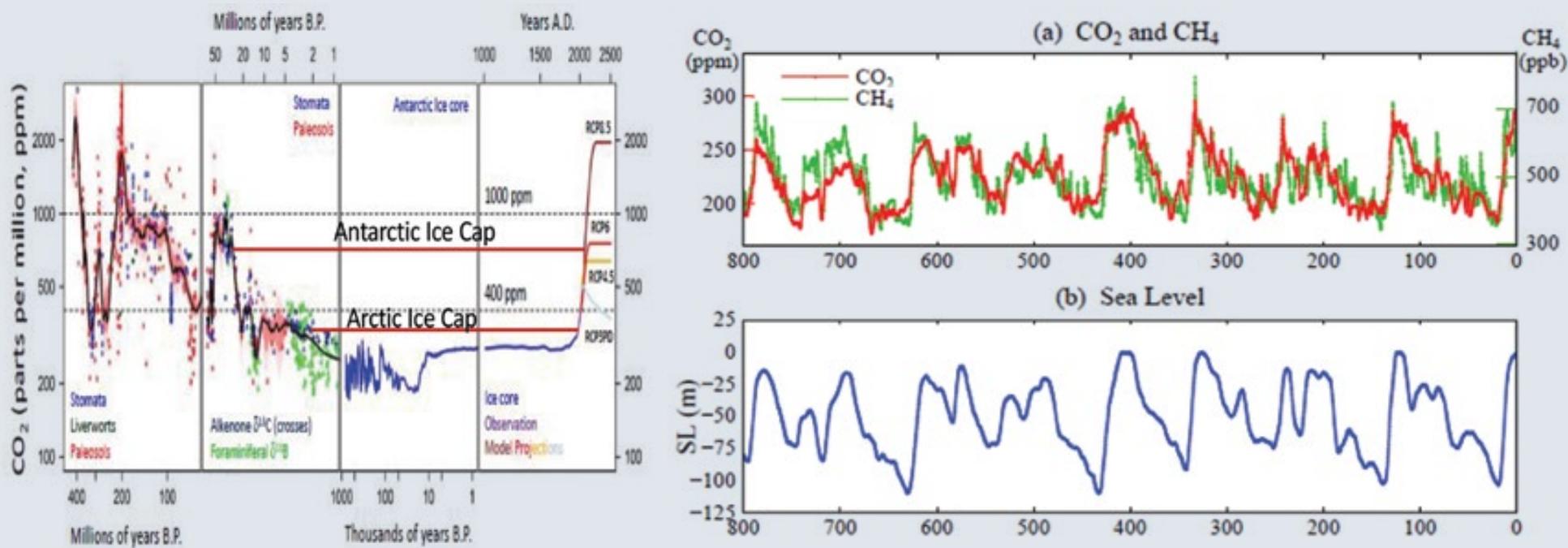


Figure 5 (left). The fossil record demonstrates the 800 ppm CO_2 level in the Mesozoic and Paleogene and the lower levels afterwards, coinciding with the formation of the Antarctic and then Arctic ice caps. Our rise above 400 ppm and inevitable rise to 500 ppm by 2050 shows that we are reaching levels not seen since the Paleogene. Source: adapted from Foster (2017) and Menendez (2018). Figure 6 (right). The record from ice cores over the past 800,000 years documents the range of CO_2 content of 180-300 ppm, the cycle time of 50,000-1000,000 years and the interpellation of atmospheric CO_2 content with sea level rise and fall. Adapted from Hansen and Sato, 2013.

Coal from page 25

the past 50 years on an annual basis.

The largest proportion (42 percent) comes from the burning of coal, followed by oil at 34 percent and natural gas at 18 percent (see figure 4). Coal is far more CO_2 intensive in emissions than oil, with gas being the cleanest hydrocarbon fuel. The burning of hydrocarbon fuels is estimated to account for only 20 percent of the GHG emissions of methane, whose rise is more closely correlated with overall human population and other activities and processes.

However, the melting of the permafrost accompanying the warming of the Arctic is beginning to cause massive methane

emissions that are as yet unquantified, which may increase the methane warming effect. Most of the GHG emissions of N_2O come from agriculture, with only 10 percent due to the burning of fossil fuels, so that increase is again more closely related to human population rise.

The largest factor, therefore, in climate change, is the level of CO_2 in the atmosphere. From the fossil record we have multiple means of estimating the level of CO_2 in the past (figure 5). Certain plants form differently depending upon CO_2 level in the atmosphere. Chemical composition of shells of marine organisms also differ with CO_2 atmospheric variation. From air bubbles in ice cores recovered from up to 800,000 years ago in the Antarctic, these variations have been tested and verified. Throughout most of

the Mesozoic, a period with overwhelming geological evidence of warm climate and higher sea levels than the present, the CO_2 level was around 800 parts per million. By the end of the Cretaceous, it had declined to about half that level before rising again in the Paleogene (65-30 million years ago) warming period, during which it rose back up to around 800 ppm. There is much geologic evidence that the CO_2 rise and consequent Paleogene warming was due to increased volcanism. About 30 million years ago, it again declined to about 400 ppm and at that time, along with a cooler climate, the Antarctic ice sheet formed. About 3 million years ago, a further decline is recorded, to below 300 ppm with evidence of the formation of the northern polar cap.

Since that time, as documented in detail by ice cores from the last 800,000 years (figure 6)

the CO_2 level has fluctuated between 180 and 300 ppm, with the lower number associated with a cold climate and extreme glaciation with sea level of about 100 meters below the present. We emerged from the last glaciation period about 12,000 years ago and the CO_2 level has ranged from about 260 to 280 ppm through historic times until the late 19th century with the lower levels associated with "mini-ice ages" and the higher with the warmer periods.

The CO_2 level began to rise as the industrial revolution gathered momentum and reached 300 ppm around 1900 and slowly rose to around 320 ppm by 1950. At that point, the explosion in economic activity and use of

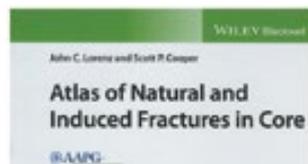
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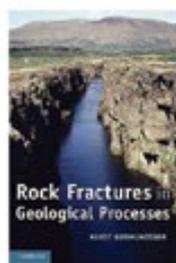
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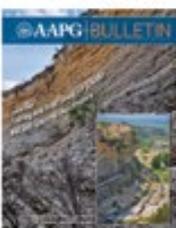
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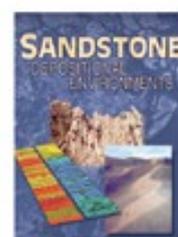


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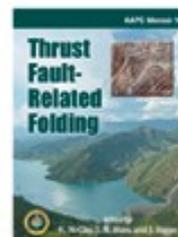
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hydrocarbon fuels, especially oil, led by the United States, Europe and the Soviet Union pushed the level to 380 ppm by 2000. The industrialization of China, mainly fueled by coal, has been the most prominent factor in the rise in this century to the current level of 411 ppm. At the current increase of 2.7-3 ppm per year, consistent with the emission of 40 gigatons of CO₂ emitted annually, a level of 500 ppm will be reached around 2050, a level not seen since the end of the Paleogene warming period, 30 million years ago.

Rising Sea Level

Based on the historical record and present-day observations and trends, by that time, the late summer north polar cap will be largely gone and the glaciers of the northern hemisphere, including Greenland, melted or well into the process of melting. The climate will have irrevocably changed in ways we are only now beginning to understand as the temperature differential between the poles and temperate and tropical latitudes will be further diminished. Sea level rise will be less than one meter by that time, but the rate of rise will be increasing. However, 90 percent of the planet's ice above sea level is locked in the Antarctic ice sheet, protected by surrounding ice, and it is this melting that would cause the catastrophic sea level rise that would change the world as we know it. The fossil record indicates that it was when the CO₂ level dropped significantly below 800 ppm that the Antarctic ice sheet began to form, and the achievable task facing mankind is to slow and

then halt the rise in CO₂ atmosphere content and find a way to gradually reduce it so that the CO₂ level remains significantly below the 800 ppm level.

Conclusion

To deny the existence of global warming and climate change means to ignore or suspect that data provided by worldwide weather stations and NASA satellites has somehow been fabricated or altered. Looking at a half century of data, the trend and correlation between temperature and atmospheric CO₂ content is obvious. The data from the Arctic and Antarctic is most troubling as it demonstrates an acceleration of the process beyond many of the earlier predictions.

There are natural climate variations documented in the ice cores of the past 800,000 years. These are likely due to eccentricities in the Earth's orbit and variations in solar radiation. However, those natural variations over that time period caused CO₂ levels to range from 180 ppm to a maximum of 300 ppm with cycle times of 50,000 to 100,000 years. We have had a 50-percent increase in CO₂ from 280 to 411 ppm since 1880 – less than 150 years, with more than half of that increase in the past 40 years! This increase can be directly tied to the amount of CO₂ emitted from the burning of fossil fuels and is clearly not "normal variation." ☒

(Editor's Note: The opinions and positions stated here do not necessarily represent those of the EXPLORER editorial staff nor those of AAPG leadership or membership, but are the author's own.)

of astronomical forcing of cycles in the sedimentary record provides a hybrid of uniformitarianism and catastrophism. The processes are ongoing, yet can lead to sudden, dramatic shifts in sedimentation patterns.

In this context, could global sea-level changes be related to the definition of chronostratigraphic units, as originally envisaged by Cuvier's disciple, d'Orbigny?

Stages are now defined by the Global Boundary Stratotype Section and Point methodology. A GSSP is an internationally accepted reference section in which the lower boundary of a stage is defined by a specific stratigraphic horizon. This horizon is generally associated with an event in the rock record – typically an inception or extinction of a key fossil species. The choice of horizon/location and associated event can be the subject of contentious debate; as such, there are a significant number of stages that are currently not defined by a GSSP. Even those that are remain the subject of ongoing discussion.

Therefore, a case can be made for linking a global sea-level event to a stage boundary definition. Peter Vail commented on this possibility in 1977: "Using global cycles with their natural and significant boundaries, an international system of geochronology can be developed on a rational basis."

The scientific community still remains wary of this approach because the reality of eustasy continues to be debated. Nonetheless, Cuvier appears to have been vindicated. Sudden transgressions and regressions are a part of Earth history, aligning sequence stratigraphy with some of the earliest interpretations of the rock record. ☒

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

Neocatastrophism from page 21

For much of the rest of the 19th and 20th centuries, it seemed as though Lyell and uniformitarianism prevailed in the debate. Students were taught "the present is the key to the past" and that the remarkable should be dismissed as an explanation for geological phenomena. However, there were those who persisted in recognizing the importance of "events" in Earth history. This included the great Austrian geologist Eduard Suess, who introduced the concept of eustasy to describe global transgressions and regressions.

The New Catastrophism

In the first half of the 20th century, the notion of episodic global or regional changes in sea-level found favor with an influential set of stratigraphers, including T.C. Chamberlin, E.O. Ulrich, Eliot Blackwelder, Joseph Barrell, Amadeus Grabau, Johannes Umbgrove, Harry Wheeler and, eventually, Larry Sloss, who pioneered the use of sequences in their modern sense. Grabau was happy to describe "The Rhythm of the Ages," a reflection of his views on stratigraphy reflecting eustasy.

By the late 1960s and '70s, iconoclastic geologists, such as Derek Ager, talked of "The New Catastrophism" and stressed the importance of events in the stratigraphic record. For Ager, geological history could be likened to the life of a soldier: "Long periods of boredom and short periods of terror." Gradualistic processes occurred, but were punctuated by the unusual, be those asteroid impacts or events originating much closer to home, such as intense volcanicity, brief periods of global anoxia, or submarine landslides.

Against this background of neocatastrophism, the concepts of sequence stratigraphy and eustasy could be considered as viable. Relatively short-term sea-level fluctuations were likely, and some might well be global in nature (their local expression modified by tectonics and sediment supply). The relatively recent acceptance

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Schedule of Events

Friday, October 12

- 10:00am-1:00pm Exhibitor and poster setup
- 12:00pm-6:00pm Registration
- 1:00pm-7:00pm Exhibit hall open
- 1:00pm-5:00pm Symposium - Technical and poster sessions
- 5:00pm-7:00pm Welcome Reception

Saturday, October 13

- 6:00am-7:00am Breakfast
- 7:00am-5:00pm Field Trip (lunch provided)

The field trip, led by Drs. Christopher Fielding and R.M. "Matt" Joeckel, will see participants traveling through southeastern Nebraska to examine a series of Pennsylvanian exposures, comprising thick fluvial and estuarine sandstones overlain by thin-bedded sandstones-mudrocks that are incised into the limestone-mudrock cycles typical of the latest Pennsylvanian (Virgillian) succession of SE Nebraska. Participants will gain an appreciation for the diagnosis of sedimentary environments in these strata, their stacking patterns, and their capacity to act as reservoirs of natural fluids. The Indian Cave Sandstone is a producing oil reservoir horizon in southern Kansas.

- 6:00pm-10:00pm Dinner (Keynote) and Cocktail Reception

Sunday, October 14

- 7:00am-8:00am Breakfast
- 7:00am-12:00pm Exhibit hall open
- 8:00am-12:00pm Core workshop and poster session
- 12:00pm Conference ends

Proposals for oral or poster presentations, drillcore displays and commercial exhibitors are welcome!

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Profitable Development of Shales
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Tel Aviv, Israel
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Houston, Texas
4–6 March 2019

APPEX
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27–30 August 2019

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GEO2020
17–19 March 2020



YPFB corporation president and event leadership recognizing Young Professionals for their contribution to the GTW Bolivia organizing committee. Top (left to right): Elvira Pureza Gómez, AAPG Latin America & Caribbean Region president-elect; Oscar Barriga, YPFB Corporation president; Asterio Ayaviri, retired YPFB; Eduardo Paz, YPFB Chaco general manager; Javier Esquivel, YPFB Corporation exploration and development manager. Bottom (left to right): Emily Smith Llinás, AAPG; Ana María Goncalves, YPFB Chaco; Andrea López Total; Angelvis Tovar, GEOX Services; Mauricio Guizada, Petrobras; Vladimir Machaca, YPFB; Valentina Cáceres, YPFB

Bolivia Joins the Big Leagues

First AAPG workshop highlights the country's hydrocarbon potential

Bolivia's role as a South American gas market supplier was a key theme at the Geosciences Technology Workshop Bolivia 2018, AAPG's first technical workshop in the country, held this summer in Santa Cruz de la Sierra.

The workshop, entitled "Optimizing Exploration and Development in Thrust Belts and Foreland Basins," drew 180 participants from 54 companies and 16 countries throughout the Americas, Europe, Asia and Australia.

National Attention

The high-profile guests drew national attention, and local media outlets covering the GTW described Bolivia as playing in the "big leagues."

All the national and independent companies operating in Bolivia attended the event, which included talks by the minister of hydrocarbons and the president of Yacimientos Petrolíferos Fiscales Bolivianos, the state-owned energy company.

Luis Alberto Sánchez, minister of hydrocarbons of the Plurinational State of Bolivia, inaugurated the event recognizing the significance of having AAPG in the country.

"This type of workshop is very important for us because it promotes an exchange of experiences between countries, knowledge of modern technologies and optimization of tools to be more efficient and to get results," he said. "One of our goals for the nation today is achieving ultra-efficient exploration."

Sánchez noted that in addition to exploring conventional resources, Bolivians need to learn more about the country's unconventional resource potential. He cited figures conducted

by Paris-based Beicip FranLab, one of YPFB's principal consultants.

"Beicip reports that conventional resources in Bolivia are above 130 TCFs; for unconventional resources the figure is four digits," he said.

Sánchez cited another goal for the country: transforming resources into reserves.

"It is geology that makes this transformation possible, and that is why a pillar of our industry," he said.

He noted that Bolivia is a country with high prospectivity, a privileged geographical location and access to strong markets.

"There is interest in Bolivian gas, and not only from our neighbors. Today we envision LNG exports.

Global Reach

Interest in Bolivia brought an international audience to the GTW, which included 22 oral presentations, 22 posters and seven exhibitor stands representing companies in China, Australia, France, Argentina and Canada.

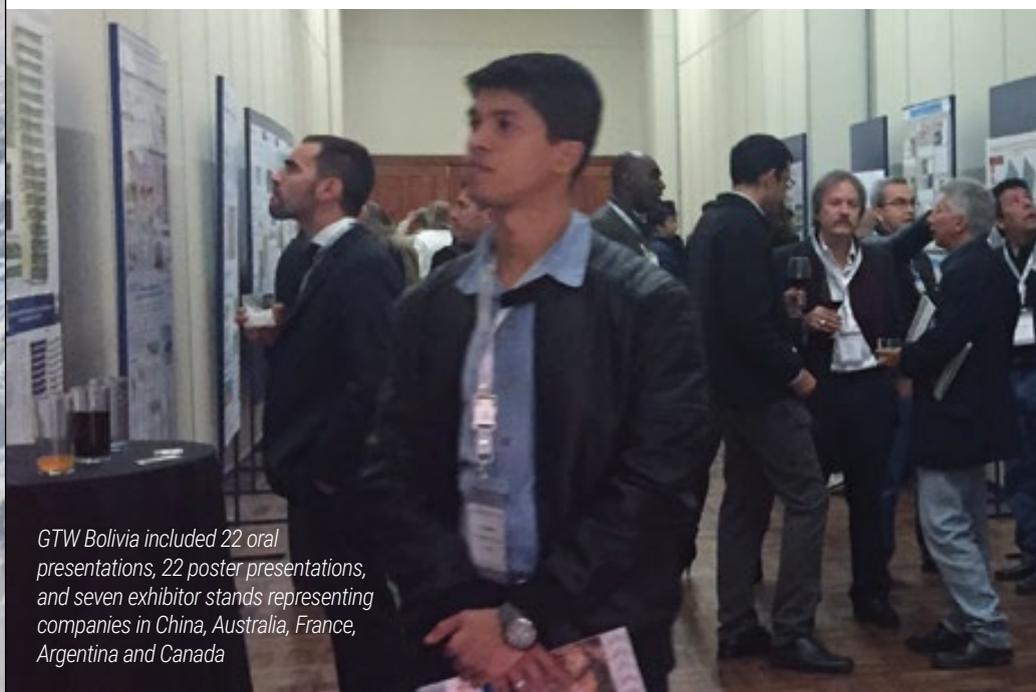
The general managers from YPFB Chaco and YPFB Andina, YPFB upstream units, attended the event alongside regional managers from Repsol, Petrobras, Shell and Total.

The Bolivian Hydrocarbon Chamber of Commerce, Bolivian Geological Society and the SPE Bolivia section provided local support.

Event sponsors included Repsol, CNPC BGP, Paradigm, BeicipFranLab, Bolpegas, Halliburton and 3D Geo.

Elvira Pureza Gómez, AAPG Latin America

Continued on next page ►



GTW Bolivia included 22 oral presentations, 22 poster presentations, and seven exhibitor stands representing companies in China, Australia, France, Argentina and Canada

◀ Continued from previous page

and Caribbean Region president-elect and general co-chair, described GTW as a "premium technical conference."

"I appreciated learning about Bolivia's complex geology, prospectivity and seeing outstanding work being done by industry and professionals who are applying the latest technology and shifting paradigms," she said.

Gómez, who oversees exploration and production activities at Nexen Colombia - CNOOC subsidiary, described GTW as a positive step forward both for Bolivia and for AAPG.

"Workshops have a positive impact on technical networking, which is crucial in exploration phase to succeed," she mentioned. "It is really important to connect the region technically, and having a workshop in Bolivia for first time is the initial to achieving this goal."

A Century of Exploration

The workshop started with a panel entitled "100+ years of Hydrocarbons in Bolivia." Industry pioneers, including national industry legend Asterio Ayaviri, told stories about early discoveries in Margarita Field, currently Bolivia's primary producer in the South Sub-Andean region. They also described how YPFB was founded 1936.

The focus expanded through four half-day sessions: Petroleum Systems and Complex Structural Geology, Data Integration and Enhanced Subsurface Imaging, Technologies to Reduce Risk and Maximize Production and Future Exploration Potential in Bolivia and Beyond.

Technical presentations and subsequent roundtable discussions focused on Bolivia's hydrocarbon potential, successes and challenges related to exploration and in foreland basin and thrust belts and the potential for development of unconventional resources.

YPFB Corporation President Oscar Barriga closed the workshop with "Expanding Paradigms—Ensuring Future Success for Bolivia's Oil and Gas Industry," a presentation highlighting exploratory projects conducted in the Sub Andean, Altiplano and Plains regions during 2015 and 2018 and previewed opportunities in the Altiplano, Madre de Dios and Pantanal Basins.

Future Potential

Session Chair Fernando Alegria, Bolivia exploration group lead at Shell, said he believes Bolivia as the potential to be the Southern Cone's natural gas provider.

He also recognized challenges, including the quality of acquired seismic information as well as issues related to the environment and communities.

For Bonora, Bolivia provides both challenge and promise.

"(Bolivia) has a great petroleum system that is generating a lot of hydrocarbons but with very difficult and challenging traps," he said, adding that wells are expensive and take a long

time to drill.

"Technical challenges are difficult but can be resolved. The biggest challenge is the poor hydrocarbon contracts that, coupled with technical and costly operations, make entry into Bolivia very difficult for new and existing companies," he said.

Bonora recognized that the government is trying to improve both technical and legislative issues.

"A lot will depend on the success of the projects currently drilled. If successful, this will generate continuous investments from current operators and may be attract new investors," he said.

Javier Esquivel, GTW general co-chair and YPFB exploration and development manager, said Bolivia provides great opportunities for companies like Repsol.

"Bolivia has the third highest number of gas reserves of any South American country, and nearly 50 percent of its territory – 549,290 square kilometers – has great hydrocarbon potential," he said.

Esquivel described how in recent years the Bolivian government commissioned important regional studies and developed a portfolio of exploratory projects in multiple basins in both traditional and non-traditional petroleum zones.

"The government, through the Hydrocarbon Ministry and YPFB, currently has 80 exploration areas available for investment, with a total potential of 136 trillion cubic feet yet to find," he said.

Esquivel highlighted two incentives for companies interested in working in Bolivia, legal security and available information.

"Guaranteeing legal protection for operators is our most important incentive for private investment. Additionally, we have a legal framework designed to encourage the exploration and exploitation of hydrocarbons in Bolivia," he said.

Esquivel also noted how YPFB, through the National Hydrocarbons Information Center, has access to a database with information is found for each of the available areas.

"This means that companies don't have to start from scratch when they come to work in Bolivia," he said.

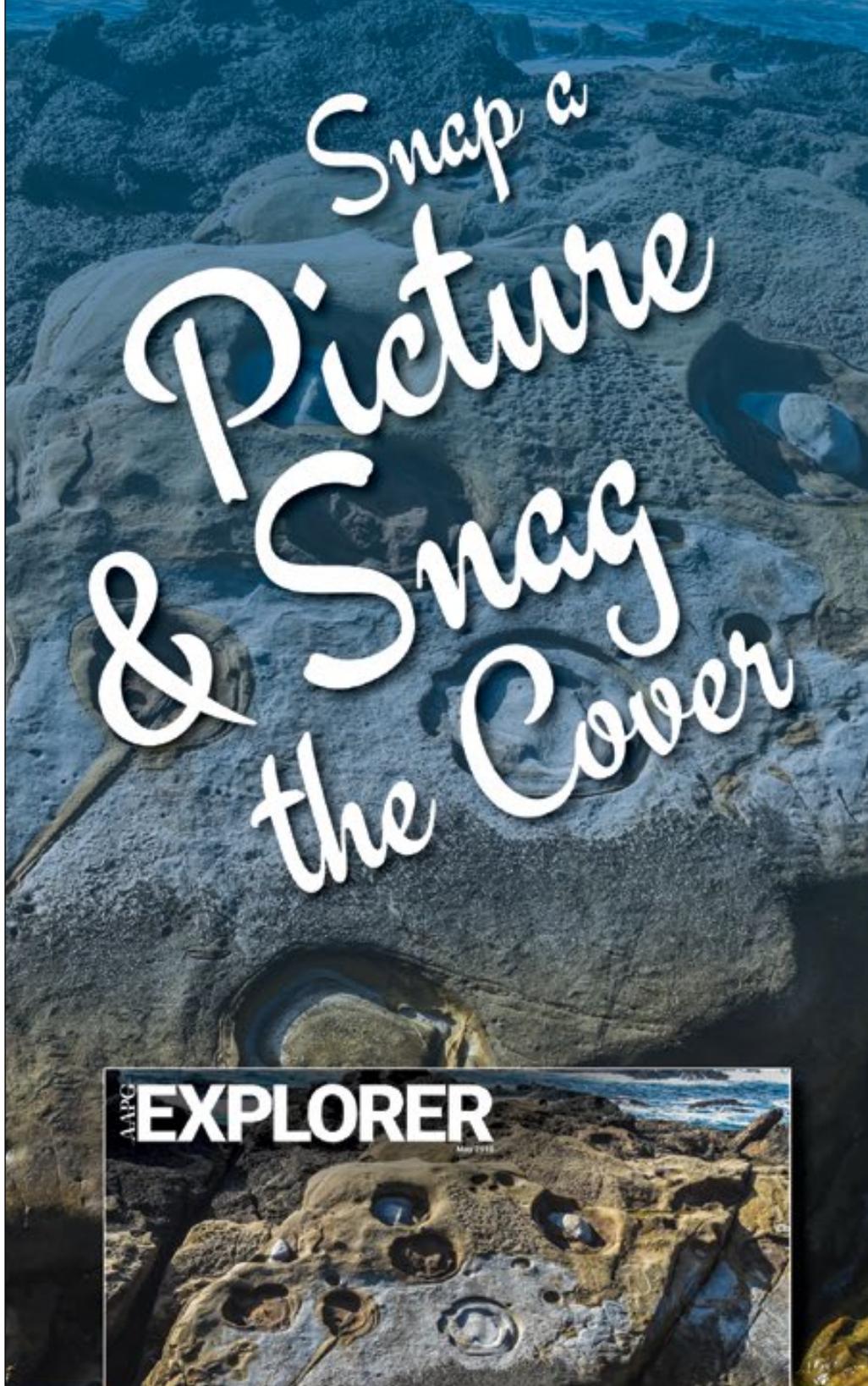
Future Collaboration

For Gómez, GTW Bolivia represents the beginning of a new era for AAPG in Bolivia and Bolivia inside the AAPG organization.

"This GTW showed AAPG what Bolivia has to offer and showed Bolivians how AAPG can be one of their best resources for sharpening their technical and professional skills, developing their careers and connecting with colleagues worldwide," she said.

Gómez hopes that GTW Bolivia is just the beginning of a longstanding partnership between Bolivian geoscientists and AAPG.

"Bolivia has a huge potential, not only in terms of natural resources, but also in its people," she said. "The technical competency, professionalism and enthusiasm of Bolivian professionals, both young and seasoned, is inspirational and very exciting for our region." 



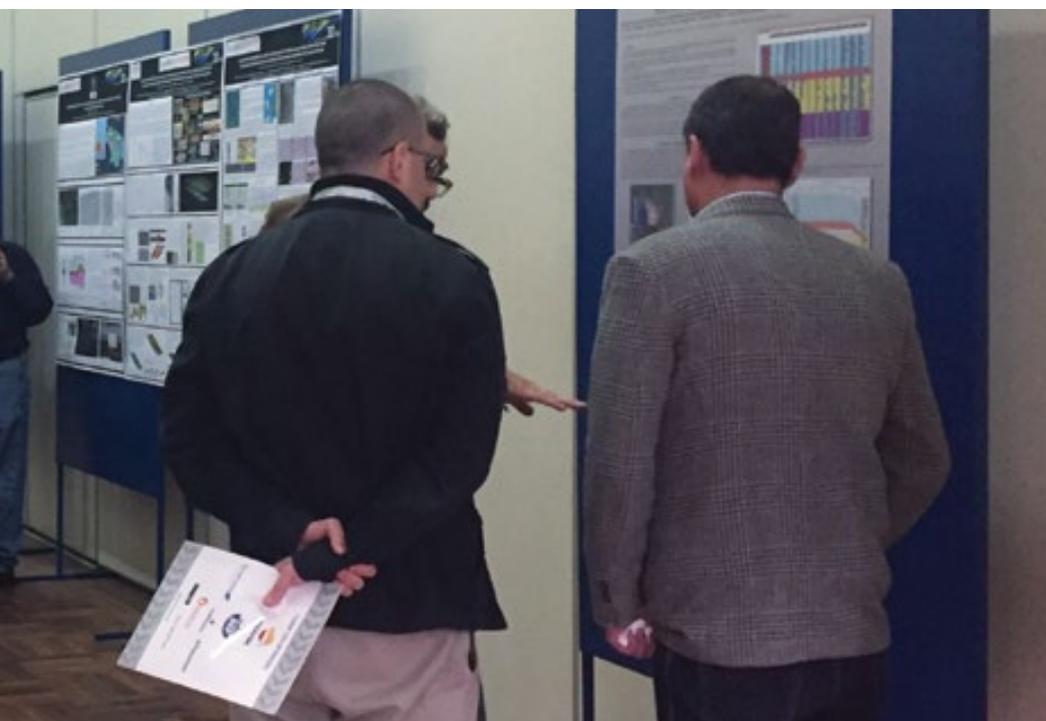
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Here's a hint:
Photos with a story behind them go to the front of the line.

AAPG **EXPLORER**



Foundation Update

41st Annual Trustee Associates Meeting



Nestled between Idaho's Boulder-White Clouds and the Sawtooth Range, between a batholith and Paleozoic sediments, and the volcanic Snake River Plain is a narrow, linear hollow known as "Sun Valley." Sun Valley has been a seasonal home to many celebrities, including American novelist Ernest Hemingway, and champion skiers since the late 1930s.

And for a few wonderful days in August, Sun Valley Resort was home to our Trustee Associates for their annual meeting. Thanks to our hosts, David and Bonnie Hawk, we enjoyed the company of three special speakers, fly-

fishing, golfing, art tours and more.

Idaho University geology professor Michael McCurry led us on a field trip to Craters of the Moon National Monument – a vast ocean of lava flows with scattered islands of cinder cones and sagebrush. Emeritus Professor Spencer Wood, of Boise State University, gave a presentation about the public data of the Little Willow Field and relevant geology of the Payette Basin.

Lastly, we were entertained at our farewell dinner by Dick Fosbury, an American retired high jumper and Olympic gold medalist who revolutionized the high jump event with his

unique "back-first" technique, the "Fosbury Flop."

Another highlight of the event was the first-ever Trustee Associates auction, where bidders vied for a piece of Bruneau jasper, a meteorite, a core lamp and – the most memorable and highest bid went to – a mounted jackalope head!

Despite the many beautiful distractions Sun Valley had to offer, we conducted two Foundation business meetings and elected new Trustee Associate officers. Larry Jones was elected as the new chair, Martin Shields as vice chair, and Bill Monroe will complete his

second year as secretary/treasurer.

The Trustee Associates are a vital part of the Foundation and their annual meeting is a great opportunity to stay current on Foundation business while enjoying the company of both old and new friends. We hope you will consider joining us next year in Kohler, Wis., at the American Club – a five-star, five-diamond hotel that has served as an icon of gracious hospitality for 100 years.

If you would like to find out more about the Trustee Associates program, please contact the Foundation office at 918-560-2644 or foundation@aapg.org. 

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Increasing oil prices in 2018 have revitalized many Shale Oil Operators, ultimately growing production across US Shale Plays. According to the International Energy Agency (IEA), demand still looks to exceed supply in 2018, causing downward pressure on oil prices. The current challenges of Shale Oil Operators are to remain profitable, make efficiency gains, and sustain production growth all while keeping costs low with the drilling, completing, and commissioning of new wells.

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This Hedberg research conference will focus on the changes in petroleum systems analysis from the late 1970's to present day. The goal of this conference will be a "passing of the torch" with an exchange of ideas from experienced specialists to young professionals. The attendees will be a mix of seasoned experts with a depth of knowledge and historical perspective, and exploration and development petroleum systems staff on the learning curve. The last 30 plus years have seen tremendous change in the methods and technology applied on the analysis and evaluation of geochemistry data and on the building and evaluation of petroleum system models. This conference will provide an open forum where the field's pioneers will share their knowledge on the history and development of these tools and the up-and-coming petroleum systems staff will share innovative applications and new ideas.

The conference has been subdivided into six oral sessions and an open poster session. In addition, there will be three keynote lectures from world experts who have pioneered petroleum geochemistry and petroleum systems modeling.

Comeback from page 14

in the recent downturn, the WoodMac report observed, but added, "This is not sustainable longer term in an industry underpinned by large, cash-generative assets."

Translation: The oil and gas industry needs large-scale projects to generate sufficient future production.

"For exploration to make a comeback, it also needs better project delivery," Rodger said. "Because for exploration to get back into the black and become a value creator, it's not only about capitalizing on cheaper rigs and more cost-efficient development solutions, but also ensuring they can be consistently executed."

"Investments won't hit more stringent 15-20 percent IRR (internal rate of return) hurdle rates if half of that is lost through bad delivery," he added.

Hydrocarbon explorers "by their very nature like to go to new, untested and often frontier provinces," Rodger noted. "For companies to have faith they can make money from remote new plays, and therefore invest in exploration, they must also have renewed confidence in their own ability to competently execute new greenfield projects, both small and large in scale," he said.

Project Efficiency and the Digital Revolution

Whether or not oil companies can hold on to the efficiency gains and cost reductions they secured during the downturn is "the burning question for the industry," said Deloitte's England.

"History will tell you that costs will go up with prices, pretty much in lockstep. Some people are saying, 'This time will be different.' And there's some evidence of that," he noted.

"I think we are in the first stages of the digital revolution, and that will help the industry retain those efficiencies."

Given that revolution, "the opportunities we're seeing are amazing. Even just drilling rigs, the amount of digital technology people are putting into drilling rigs is fantastic. And that not only makes them more efficient but, over time, also safer," England said.

Digitalization is "taking off in more and more places, in more and more companies. They're working with their suppliers and their services to bring in digital technology," Slaughter added. He co-authored an article for Deloitte that stated "advancement in technologies, the falling cost of digitalization, and the ever-widening connectivity of devices provide a real competition-beating opportunity to upstream oil and gas companies who play the digital revolution right."

"The lower-for-longer downturn and moderating operational gains have provided an extra incentive – or turned the opportunity into a need – for companies to save millions from their operating costs and, most importantly, make their \$3.4 trillion asset base smarter and more efficient."

Digital efficiencies show up throughout the oil industry now, from remotely controlled offshore drilling rigs to sensor-packed intelligent wells. Coupled with other advanced technologies, they have helped drive the development of unconventional resources. And unconvensionals are making the industry see the concept of "exploration" in a new light.

(Editor's Note: This is the first of a two-part series. Look for Part 2 in next month's EXPLORER, which will discuss how innovations in unconvensionals, geopolitical tensions, environmental concerns and economic implications will affect the "Exploration Conundrum.")

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DPA from page 34

her entrepreneurial spirit and ability to seek out and find new business opportunities. I thought it would be interesting to hear from one of our own DPA members on her journey to success.

Past DPA President Robert Shoup has offered to teach two courses at ACE: "Quality Control Techniques for Reviewing Prospects

and Acquisitions" and "Black Belt of Ethics." Bob is chief geologist with Subsurface Consultants and Associates.

Bob and Deborah both have served in leadership positions with the DPA, the House of Delegates and in their respective sections and regions. They are great AAPG and DPA members. They exemplify the DPA motto "From prospects to discoveries, professionalism leads the way."

I hope you will join us at one of these events and if you are not certified, I hope you will join us. 



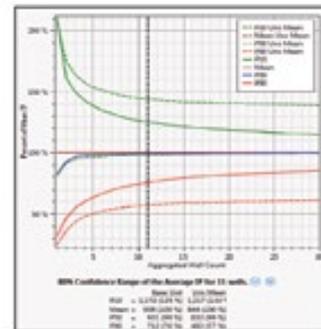
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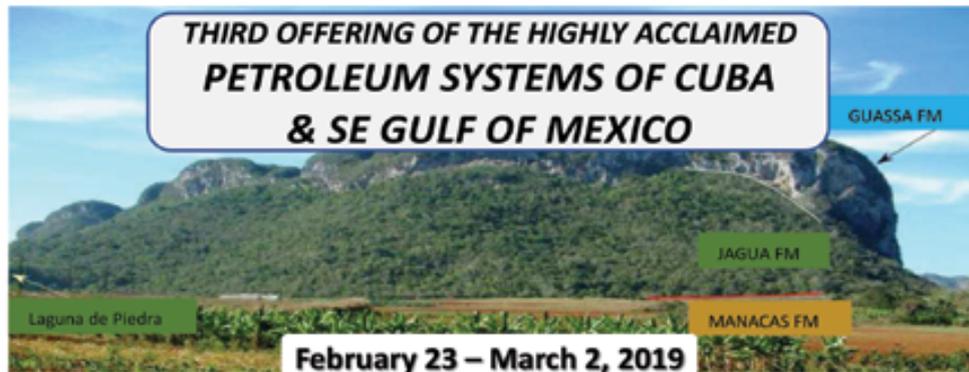
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Email Session Topic, Short Course/Workshop and Field Trip proposal submissions to: SEPM2020Topics@sepm.org

- Topics should have title, short description and suggested key speakers
- Courses, Workshops and Field Trips should have title, short description, number of days and leaders/instructors.



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Gas Hydrates – From Potential Geohazard to Carbon-Efficient Fuel?

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Natural gas hydrates have been studied extensively in the past three decades broadly, because they may constitute a geohazard, become an energy resource, and play a role in climate change. While the latter is the topic of significant blue-sky research, the petroleum industry is largely focusing on possible hazards to offshore installations from gas hydrates. Government-led research meanwhile is investigating the potential of hydrates as an energy source.

This workshop aims at capturing the current state of research into gas hydrates and at projecting a way forward for mitigation of this potential geohazard and extraction of hydrates as possible low-carbon energy resource. It will start with latest developments in exploration and appraisal methods as well as lessons learnt from gas hydrate production tests. Geomechanical models and results from laboratory experiments will focus on hazards from gas hydrates to offshore installations. Finally, novel production methods involving CO₂ sequestration, will be introduced in order to assess the possible role of gas hydrates as an energy source in a carbon-constrained future.

Keynote Speakers

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- Gareth Crutchley, GNS Science, New Zealand
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The continent of Africa has beguiled geologists for centuries. Its varied and beautiful landforms and geological features, its mineral and energy resources, its cultural heritage – it's the birthplace of our species – all combine to form a rich experience of sights and sounds, aromas and flavors.

Once you've been to Africa, you want to go back.

And that's why, after 10 years, we're heading back to Africa next month – back to Cape Town, for the 2018 AAPG International Conference and Exhibition.

Led by General Chair Femi Esan, president-elect of the Africa Region, and his co-chairs Sa'ïd Al-Hajri, past-president of the Middle East Region, Nosa Omorodion, past-president of the Africa Region, and Neil Hodgson, president-elect of the Europe Region, the organizing committee is a global group of petroleum professionals who have crafted a stellar technical program.

Science and Business Content at ICE 2018

Highlights of the meeting include an executive plenary session with a panel of experts discussing "Global Energy Supply and Demand: Where Does The Road Lead?" And recognizing the significant and growing role that Africa plays in the global oil and natural gas markets, an executive plenary panel will explore "Capitalizing on Africa's Success; Energy for Economic Prosperity."

Another panel will focus on technology and its increasingly important role in allowing the economic discovery and



CURTISS

"AAPG is a scientific and professional association – we use the science of petroleum geology to find and commercially produce a commodity. You can't separate science and business in our line of work. In fact, connecting the commercial and technology elements of African oil and gas allows for better decision-making."

production of petroleum.

Super basins will also feature prominently at ICE 2018 with a dedicated forum covering large basins in Africa and the Middle East, the sources of significant hydrocarbon volumes with much more left to discover.

Special sessions covering the business and regulatory environment, the intersection of exploration and production activities and the environment, the growing importance of natural gas and a review of the history of petroleum E&P in Africa will highlight important topics confronting our business today.

But it's not all forums and special sessions at ICE 2018. The technical program committee, co-chaired by Alessandro Gelmetti of Eni and K.B. Trivedi of PetroSA, worked hard to deliver a selection of talks and posters that span all aspects of E&P in both conventional and unconventional reservoirs, and covering important basins from across the globe.

From tectonics, sequence stratigraphy and sedimentology to petroleum systems and basin modeling, we have technical sessions designed to demonstrate how your colleagues and peers are applying science to improve our understanding of Earth systems and solving

real-world business problems.

African petroleum geology will be a significant feature of the technical program, too, along with adjacent basins in the south Atlantic and Mediterranean. We're also crossing disciplines, with sessions focused on geological and geophysical integration, petrophysics, and rock mechanics.

Attendees come to ICE for science, and they won't be disappointed.

AAPG/AOW Prospect Forum

But one special feature of ICE 2018 is that we are holding our scientific and technical conference alongside the premier African energy business conference of the year: Africa Oil Week. AAPG is a scientific and professional association – we use the science of petroleum geology to find and commercially produce a commodity. You can't separate science and business in our line of work. In fact, connecting the commercial and technology elements of African oil and gas allows for better decision-making. So, we've teamed up with AOW to develop the AAPG/AOW Prospect Forum.

Running from Tuesday through Thursday

and open to all ICE 2018 delegates at no additional charge, the Prospect Forum will provide a venue for national oil companies and government authorities, independent oil and gas companies, and service companies to showcase opportunities and data sets.

One of the concepts that AAPG wants to promote is the value of exploration, and the Prospect Forum is designed to do just that.

Other Offerings at ICE

Another way we promote exploration is through the International Pavilion, a regular event at both the Annual Convention and Exhibition and at ICE. Once again, countries from across the globe will join us in the International Pavilion, providing attendees with the ability to quickly survey bids rounds and investment terms, get an update on current exploration activity and areas with new data available. It's a world of opportunity right there on the ICE show floor.

Finally, if you would like to take a short course we've got you covered at ICE 2018 with both technical and regional courses. And if you want to get into the field you can do that, too.

Once you've been to Africa you want to go back. And that's why AAPG is headed back to Cape Town for ICE 2018. Join us there from November 4 to 7 as together we shape the future in a changing energy landscape.

By MARK GALLAGHER, DPA President

Divisions Report: DPA

Are You a Professional?

Are you DPA certified?

In early August, we learned that a Texas Sunset Review Board had recommended the elimination of the Texas Board of Professional Geoscientists. This was a surprise, but I understand it was part of an annual review process. The response period was very short. Our local AAPG-affiliated societies quickly organized an information campaign and defense for the TBPG. Additionally, the AAPG Executive Committee penned a letter in support of the TBPG.

This shows the importance of strong, well organized local affiliates.

This situation also raises several questions about the professional status of geologists in our society and how we view ourselves. It is easy to work inside a company and call yourself a "professional," and harder when you work for yourself or if you are in direct contact with the public.

Who determines your professional status? Government, the AAPG or the individual?

There are multiple answers to this question. In the end, licensure and certification help protect the public from individuals who call themselves geologists but have no credentials.

There should be a decision from the Sunset Review Committee by November.

We the Division of Professional Affairs offer certification in petroleum geology, geophysics and coal geology, and I hope we will expand this list before the end of my term. Our certification is a peer-review process and it confirms your abilities as a geologist.



GALLAGHER

"Who determines your professional status? Government, the AAPG or the individual? There are multiple answers to this question. In the end, licensure and certification help protect the public from individuals who call themselves geologists but have no credentials."

If you want to become certified or have questions, please go to the DPA page on the AAPG website to review the process and download an application: AAPG.org/divisions/dpa/certification.

I would like to recognize and thank Houston Geological Society President Cheryl Desforges and DPA President-elect John Jordan for their counsel and ideas in this matter.

One last word on certification – the DPA and AAPG are looking into global certification with other international geoscience organizations.

Upcoming DPA Activities

The convention season will soon start and in the next eight months, the DPA will sponsor five luncheon meetings and two short courses at three AAPG Section meetings and the AAPG Annual Convention and Exhibition in San Antonio.

The DPA will also host a Playmakers Forum in Oklahoma City next spring. The

theme of the next Playmakers will be the "business of geology." We will present more information in the next DPA Division Column and on the DPA Correlator.

We will kick off the convention season on Tuesday, Oct. 2 with the 68th Gulf Coast Association of Geological Societies Convention in Shreveport, La. Our speaker will be Jeff Jones, technical director of Quantum Energy Partners. The title of his presentation will be "Looking into the 21st Century." Jeff has been with Quantum from its inception. His uses his broad technical experience to help evaluate new and existing opportunities as well as existing portfolio company activity. Special thanks to Tom Wyche, the DPA luncheon chair for the GCAGS meeting. Tom is a good friend and a great geologist.

The following week, the AAPG Eastern Section will co-sponsor a meeting with the Society of Petroleum Engineers in Pittsburg, Pa. The organizers are expecting a large turnout for this convention and the DPA will sponsor two ethics luncheons. The speaker for both luncheon meetings will be AAPG

Distinguished Lecturer in Ethics David M. Abbott, Jr.

On Monday, Oct. 8, Abbott will discuss "Honesty: Avoiding the Misuse of Models," and on Wednesday, Oct. 10, he will discuss "Geoscience Ethics: Public Protection Versus Confidentiality." Abbott started his career with the Security and Exchange Commission as a geologist and has been a consulting geologist since he left the SEC. His works include more than 50 papers on professional ethics.

The DPA greatly appreciates the work of our Eastern Section counselor, Jonathan Brady. His leadership and enthusiasm will make this program a success for both geologist and engineers.

On Tuesday April 9, the DPA will sponsor an Ethics Luncheon at the AAPG Southwest Section in Irving, Texas. This event will be chaired by Margo Liss, vice president and staff geologist for DeGolyer and MacNaughton. Margo is very close to naming the speaker and it will be announced in the next DPA Division Column. We appreciate Margo's leadership in chairing this event.

Next May, at the San Antonio ACE, the DPA will sponsor our annual luncheon, two short courses and, with AAPG as co-sponsor, the Discovery Thinking Forum. Deborah Sacrey will be our featured speaker at the luncheon and will discuss "reinventing yourself as a geologist." I have known Deborah for several years and I have always been amazed at

See DPA page 33 ▶

Make Better Decisions on Brazil Exploration Opportunities



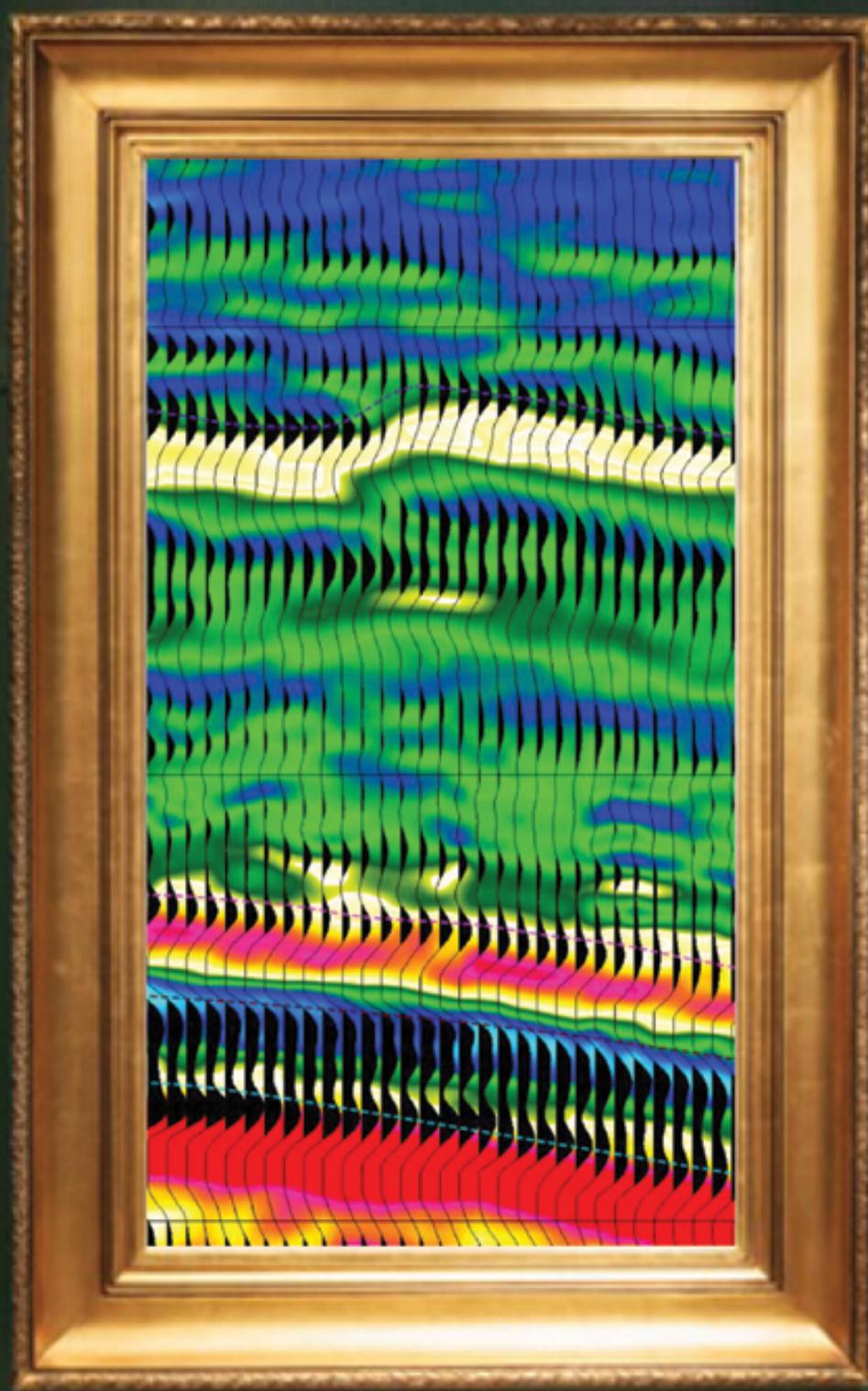
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