

AAPG

# EXPLORER

August 2018



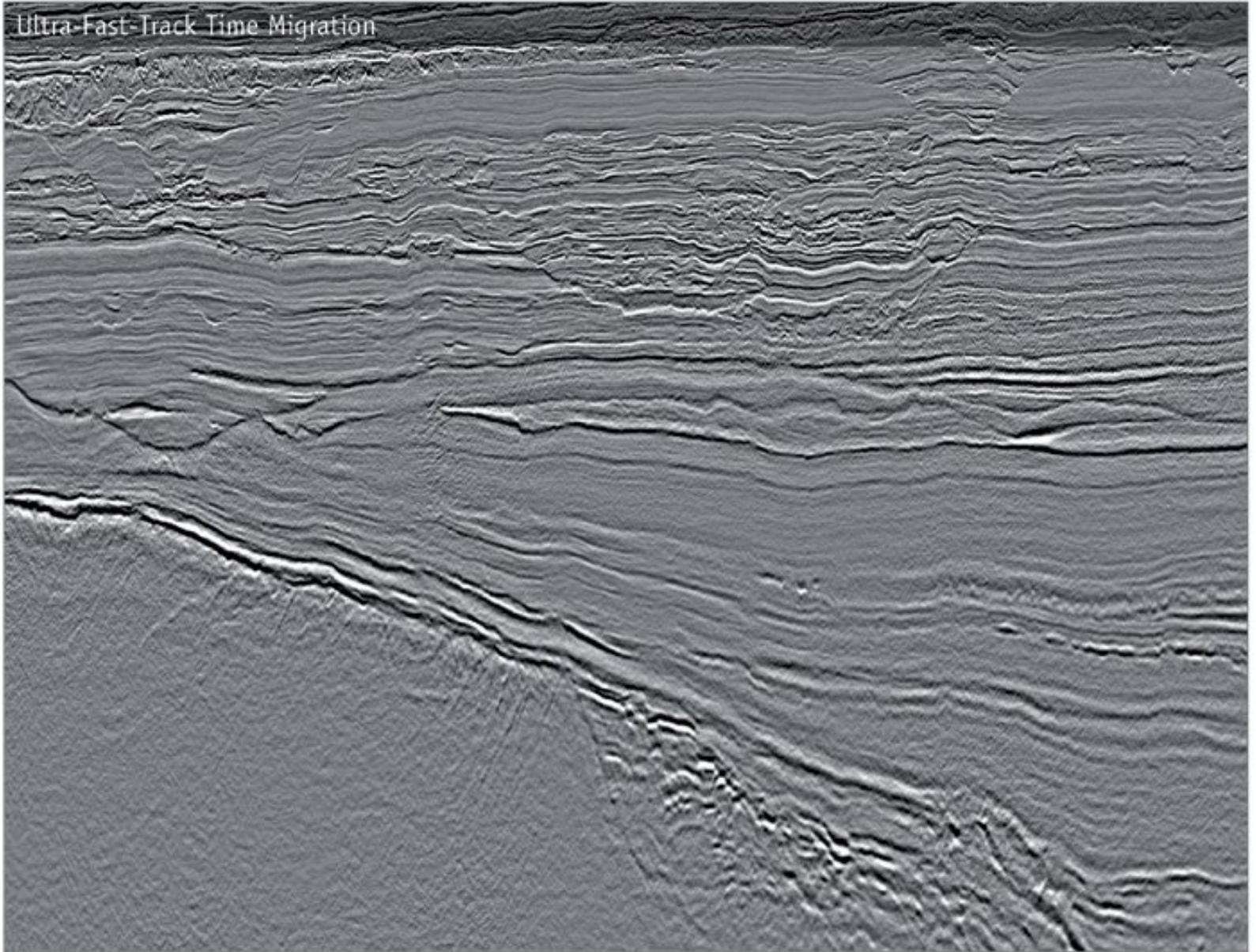
## From Antarctica to the World

*See page 10*



# Zambezi Delta 3D Survey Mozambique

PRIME PROSPECT



CGG has just completed acquisition of 15,400 km<sup>2</sup> of multi-client 3D seismic data in the outer Zambezi Delta, west of the Beira High. This will be the first phase of a **JumpStart™** integrated geoscience package, incorporating gravity, magnetic, well and geological information, and designed to accelerate understanding of the petroleum systems in the area. Fast-track PreSTM data will be available in Q4 2018 and the final PreSDM data set in Q4 2019.



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Passion for Geoscience



# The Role of Petroleum in Sustainable Development

The petroleum industry plays a critical role in sustainable energy development.

Elena Melchert, director of upstream R&D for the Office of Oil and Natural Gas of the U.S. Department of Energy, reinforced this perspective when she spoke at a topical luncheon at the Unconventional Resources and Technology Conference that was recently held in Houston in July.

"Oil and gas production from American reservoirs underpins the U.S. economy, energy security and national security," she said.

That statement is also true for global sustainable development: Oil and natural gas production underpins the global economy, promotes energy security, enriches communities and enables environmental stewardship.

The petroleum industry makes up between 4.6 and 6.5 percent of the global economy. Finding, developing and producing oil and natural gas provides many AAPG members with rewarding and technically challenging careers. Transportation fuels, electricity generation, chemical feedstocks and the countless number of practical items we use every day that are derived from petroleum add significantly to the global economy. Petroleum products make our lives easier in many ways and can provide for continued economic growth and prosperity. Petroleum products can also be part of the solution for those with little or no access to energy.

Energy security is defined by the International Energy Agency as "the uninterrupted availability of energy sources at an affordable price." The petroleum industry, in balance with market-driven forces, invests in both long-term and short-term projects to meet the world's energy needs, continuing to provide and improve energy security. Last year, approximately



**"An economic, optimized and viable petroleum industry is what defines sustainable petroleum development. It is how geoscientists in the petroleum industry contribute to the global economy, promote energy security, enrich communities and enable environmental stewardship."**

80 percent of total energy was sourced from hydrocarbons. Future projections for petroleum's contribution to the energy mix vary but remain significant in all credible projections, even with significant growth of alternatives. Our industry stands ready to meet future demand.

Another factor rarely discussed is that

the petroleum industry has a long history of investing in health, education and cultural programs in the communities where we live and operate. From health programs in developing countries, to support of STEM programs in schools and academic research in universities worldwide, to funding for arts and culture, the petroleum industry invests

heavily in social progress.

When the basic needs of individuals, communities and cultures are met, the better our capacity to invest in the environment. The petroleum industry's annual reports and sustainability reports document our conscientious protection of the environment with respect to subsurface and surface operations. In those same reports and on their websites, there are examples of the generous contributions to ecological and environmental projects that contribute to a sustainable world. As an example, this July ExxonMobil announced it will invest \$20 million in Guyana for research, sustainable employment, and conservation

See Stewards page 4 ►

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Paolo Tello Guerrero, a petrophysicist for ALS Petrophysics and environmental activist, stands atop Antarctica's Deception Island. Photo by @pateguerrero.

## Artificial Intelligence

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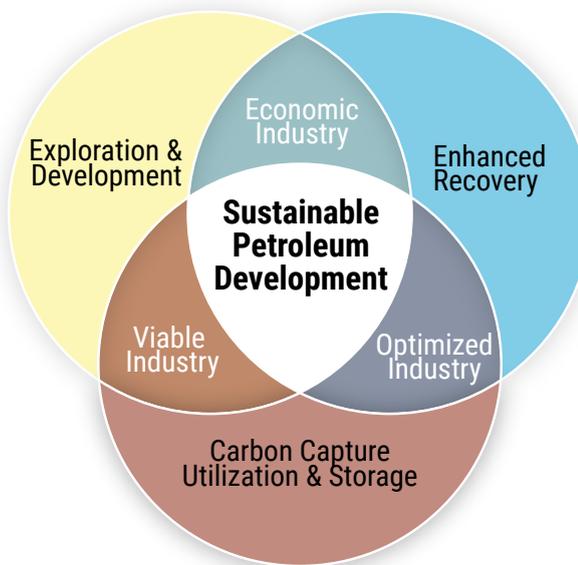
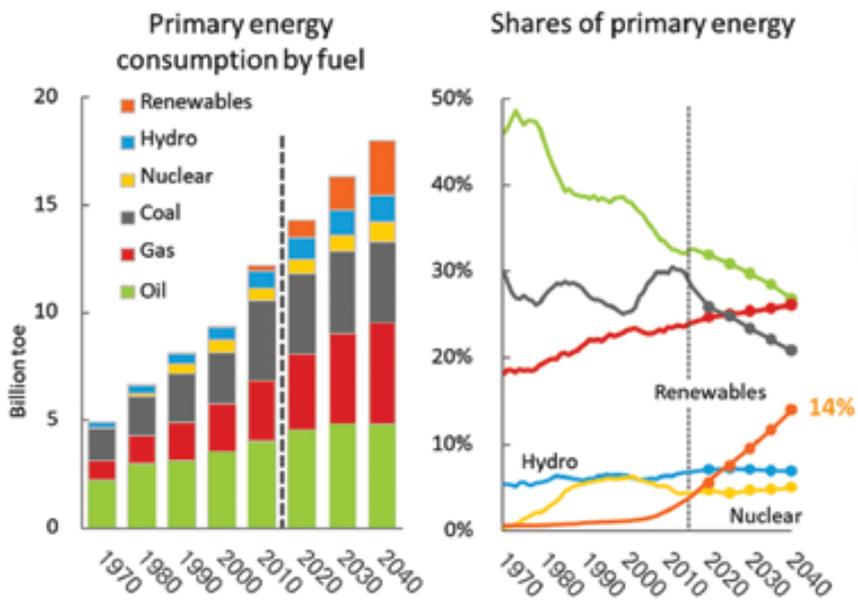
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## Stewards from page 3

of the country's ecosystems as part of their Guyana-Suriname Basin exploration project.

As petroleum geoscientists, we take seriously our commitment to being stewards of Earth's natural resources, both below ground and above.

### The Role of Petroleum Geoscience in Sustainable Development

Our purpose as geoscientists is to understand the properties of sedimentary basins that may contain petroleum and many other diverse resources. These resources can be long-lived assets, producing energy far into the future, based on our interpretation of the geologic systems and application of technology that enable environmentally responsible development.

This activity has multiple phases, and define three pillars of petroleum's role in sustainable development:

- **Exploration and development:** The role of geoscientists in exploration is to understand petroleum systems in global basins. The best interpretation of the stratigraphy, structure, reservoirs and fluids increases the likelihood of successful exploration and appraisal projects. A thorough understanding of subsurface geology helps plan infrastructure in a way that minimizes the surface impact and reduces emissions from operations. On the sustainable development diagram, this is an "economic industry."

- **Enhanced recovery:** Geoscientists build geologic models and improve their understanding of reservoir systems to evaluate re-development and enhanced recovery options to maximize recovery of reserves. Geoscience creativity, in concert with technology, helps to define new pays or to evaluate the application of new drilling and production methods that add value to mature oil fields. These projects take advantage of existing infrastructure and maintain established communities for an "optimized industry."

- **Carbon capture, utilization and storage:** As part of reservoir management strategies, CCUS helps use carbon productively to increase ultimate petroleum recovery. Operating in the present with a view to the needs of the future is part of being a "viable industry."

An economic, optimized and viable petroleum industry is what defines sustainable petroleum development. It is how geoscientists in the petroleum industry contribute to the global economy, promote energy security, enrich communities and enable environmental stewardship.

### What's Sustaining You This Month?

What sustains me this month is the rock-based technology and innovation of the petroleum industry that was on display at URTEC. When we combine our best ideas with the technology to implement them we can maximize recovery of reserves and minimize our environmental footprint.

Post your photos of technology, innovation and observations from the office to the field and let us know what sustains you. #AAPGSustainsMe  
Onward!

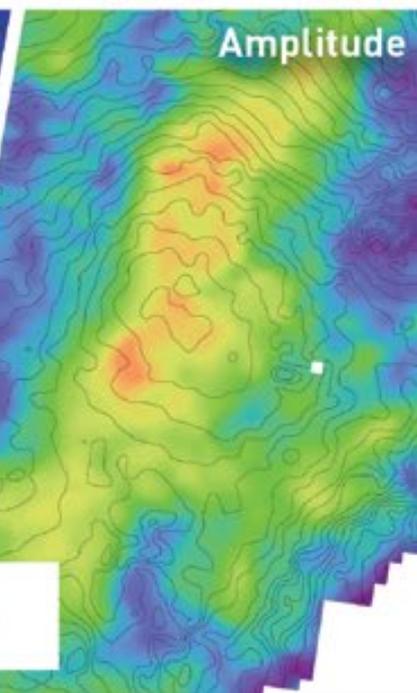
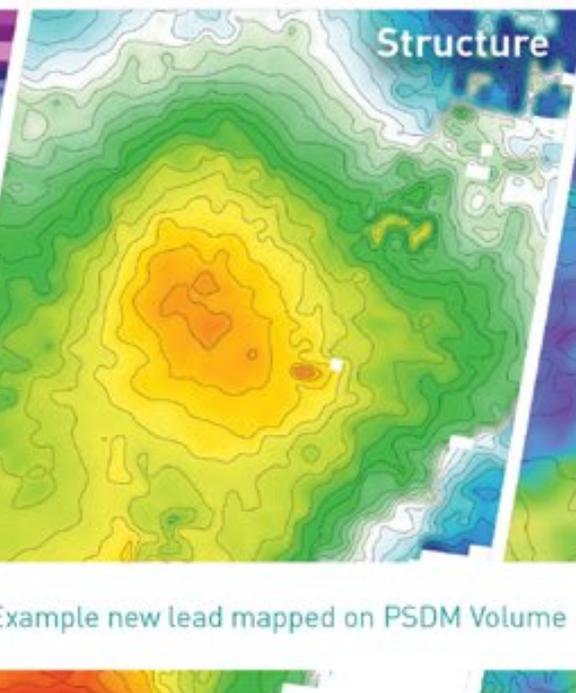
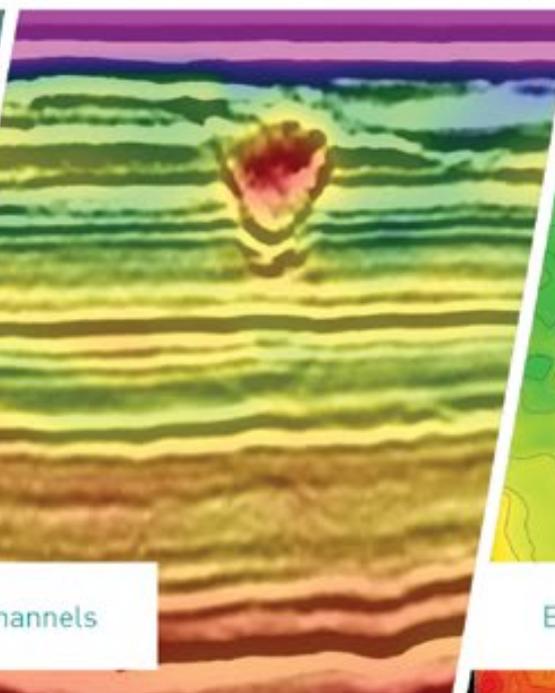
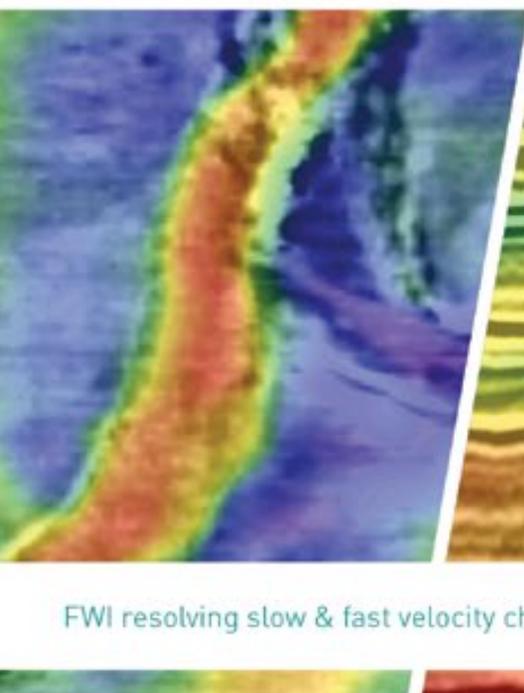
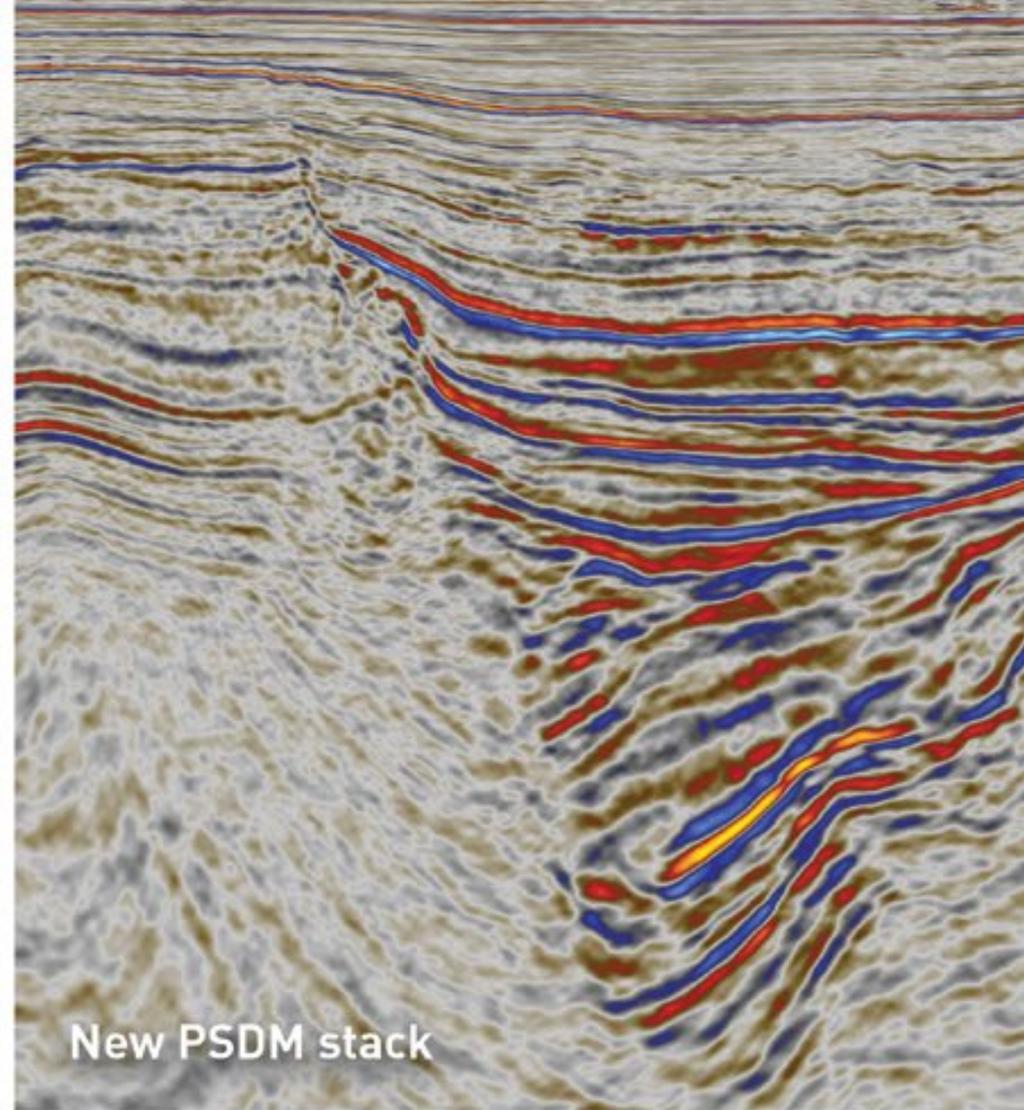
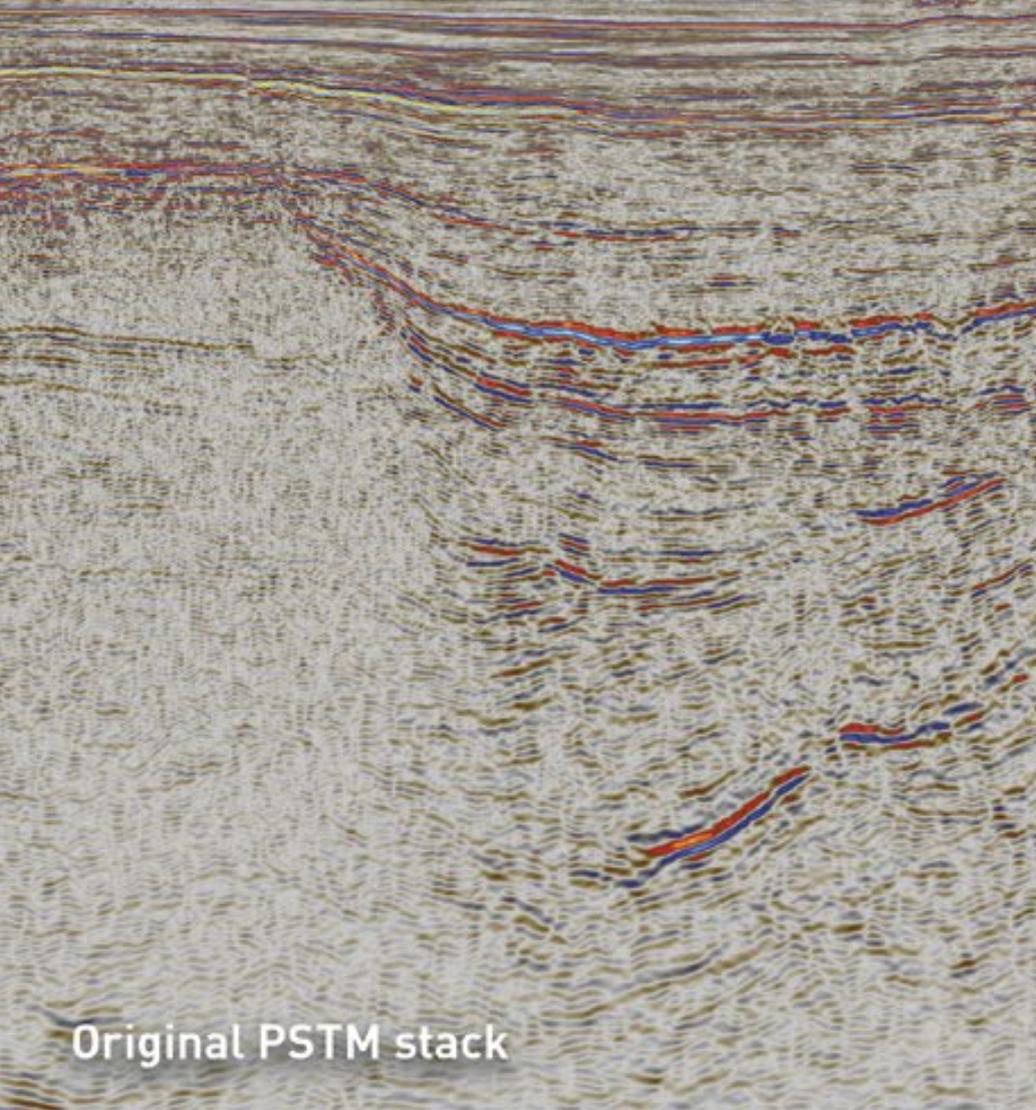
*Jenici M. Cox*

**Searcher in ARGENTINA**

Malvinas Basin 2D Reprocessing  
Argentina 2D & 3D Reprocessing  
Argentina Well Database  
Argentina Basin Analysis Report

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## Explore with TGS' depth imaging toolbox

### Unmask new potential and derisk leads

TGS has recently completed PSDM reprocessing in the Moray Firth (offshore UK) utilizing FWI to solve the complex network of slow and fast velocity Quaternary channels.

By combining FWI with TGS' Image-guided tomography, the new depth images are revealing exciting new plays and hydrocarbon prospects.

Let TGS be your source data provider for mature regions of the North Sea and help deliver the most from your exploration and production efforts.

See the energy at [TGS.com](https://www.tgs.com)



*The Bakken shale play, along with the Utica, Eagle Ford and Delaware basin, together could account for more than half of the upcoming M&A activity, according to DrillingInfo.*

# Boom Expected in Upstream M&A

**E**xpect a boom in upstream oil and gas mergers and acquisitions activity in the coming months.

More than \$50 billion in deals are now in play in the upstream sector in the United States alone, according to DrillingInfo, a research and data analytics firm based in Austin, Texas.

Worldwide, DrillingInfo has identified \$165 billion in potential energy-related transactions across all industry segments. That signals a high level of asset sales in the near future.

In part, the M&A outlook in the U.S. reflects a shift by the oil and gas industry toward a more concentrated geographic focus. This creates a certain amount of risk, as some companies become single-basin, pure-play operators instead of spreading their bets across multiple areas.

While companies may be selling off unwanted properties, what's coming into the market now isn't junk. Plenty of attractive assets are up for grabs.

"The interesting thing about today's market is the quality of these asset packages being shed by high-quality operators," said Brian Lidsky, senior director for DrillingInfo in Houston.

As an example, the company cited highly desirable assets in the Permian, Eagle Ford, Haynesville and Fayetteville unconventional plays already put up for sale by BHP, which is narrowing its focus to global deepwater.

"Those are all high-quality, significant assets which would fit very well into a portfolio like BP, who's been rumored to be buying the package, or could fit well into an independent E&P company," Lidsky said.

Upcoming property offers could include billion-dollar packages in the Bakken, Marcellus, Eagle Ford, Niobrara, Haynesville and Fayetteville, he said.

"It is certainly not a Permian (Basin) dominated set of assets out there for sale," Lidsky noted.

## Who Are the Buyers?

On the buying side, investment money appears to be coming from a variety



LIDSKY

**"Overall what we're seeing is a little bit of a shift in the U.S., particularly among the independents. A lot of our independents are shifting to focus on a single basin to get to efficiency and positive cash flow."**

of sources, including major companies looking to enhance their portfolios, overseas investors hoping to secure future hydrocarbon supplies and well-funded private equity groups.

"We expect buyers to run the gamut from private equity, where since 2017, over 70 teams have been provided with more than \$15 billion of committed capital, to the majors, and to Asian, European and Middle Eastern players," he said.

Lidsky described the private equity groups as being under pressure to spend accumulated investment dollars.

"Private equity traditionally has looked to deploy their capital at early stages of resource plays, or maybe with knowledge to buy land that might be part of the core of a play," he said.

Publicly-traded independents that have mastered unconventional resource technology or that have extensive knowledge of a play also are potential buyers, if they get Wall Street's backing, explained Lidsky.

"It is not unforeseeable that Wall Street would support some of these 'masters of the technology' to go out and acquire some of these quality assets," he said.

And overseas companies with investment money continue to eye large asset sales as a way to enter – and establish themselves in – U.S. unconventional resource plays.

"Particularly on the gas side, there is some strong interest out of Asia," where companies and countries see a share of future U.S. natural gas production as "a natural hedge against their LNG demands," Lidsky said.

## Single-basin Focus

In the U.S., the Utica, Bakken, Eagle Ford and Delaware basin unconventional plays together could account for more than half of the upcoming M&A activity, DrillingInfo projected.

It expects about one-third of the total U.S. sales to be in conventional resource plays, the rest in unconventional.

M&A prospects also look promising in the oil and gas midstream and downstream segments, DrillingInfo said. And it called the rapidly evolving market for royalties and minerals "very strong."

The industry is already seeing some \$1 billion-plus deals. In a single transaction in July, Total closed on the acquisition of Engie's global portfolio of LNG assets for an overall enterprise value of \$1.5 billion. Additional payments of up to \$550 million could be made by Total if oil markets continue to improve in coming years.

Large U.S. independents typically spread their interests over multiple resource play areas as unconventional developed, Lidsky observed.

"What we are seeing in the marketplace is that companies historically have had portfolios that covered two, three, four separate major resource plays," he noted.

Especially among publicly traded E&P companies, he said, the focus now has shifted from reserve growth to a mandate of production growth and cash-flow growth. Some of those companies are reviewing their property holdings and finding decades of non-core prospects to divest.

"For instance, QEP is selling off a very high-quality Bakken package as QEP turns to becoming a pure-play Permian Basin player," Lidsky said.

Upstream trends affecting the U.S. industry today include increased emphasis on production optimization and full-field development, and a tighter focus on core competencies and core operational areas.

"Overall what we're seeing is a little bit of a shift in the U.S., particularly among the independents. A lot of our independents are shifting to focus on a single basin to get to efficiency and positive cash flow," Lidsky said.

"That also comes with single-basin concentration risk," he added.

Early Bakken players faced single-basin risk with inadequate oil pipeline capacity, limited availability of development infrastructure and equipment, a shortage of experienced local manpower, and not enough available housing when workers could be attracted to the area.

Today, Permian Basin players are seeing the effects of single-basin risk as the basin's oil production has swelled toward takeaway capacity.

New pipeline construction is planned to move Permian Basin oil, but transportation bottlenecks could lead to additional crude-price discounting before relief arrives. The basin "has reached a level today where pipelines are at capacity," Lidsky said.

Oil prices have an effect on the level of upstream M&A activity, Lidsky noted, and the crude-price rebound over the past 12 months has already strengthened the outlook for asset sales.

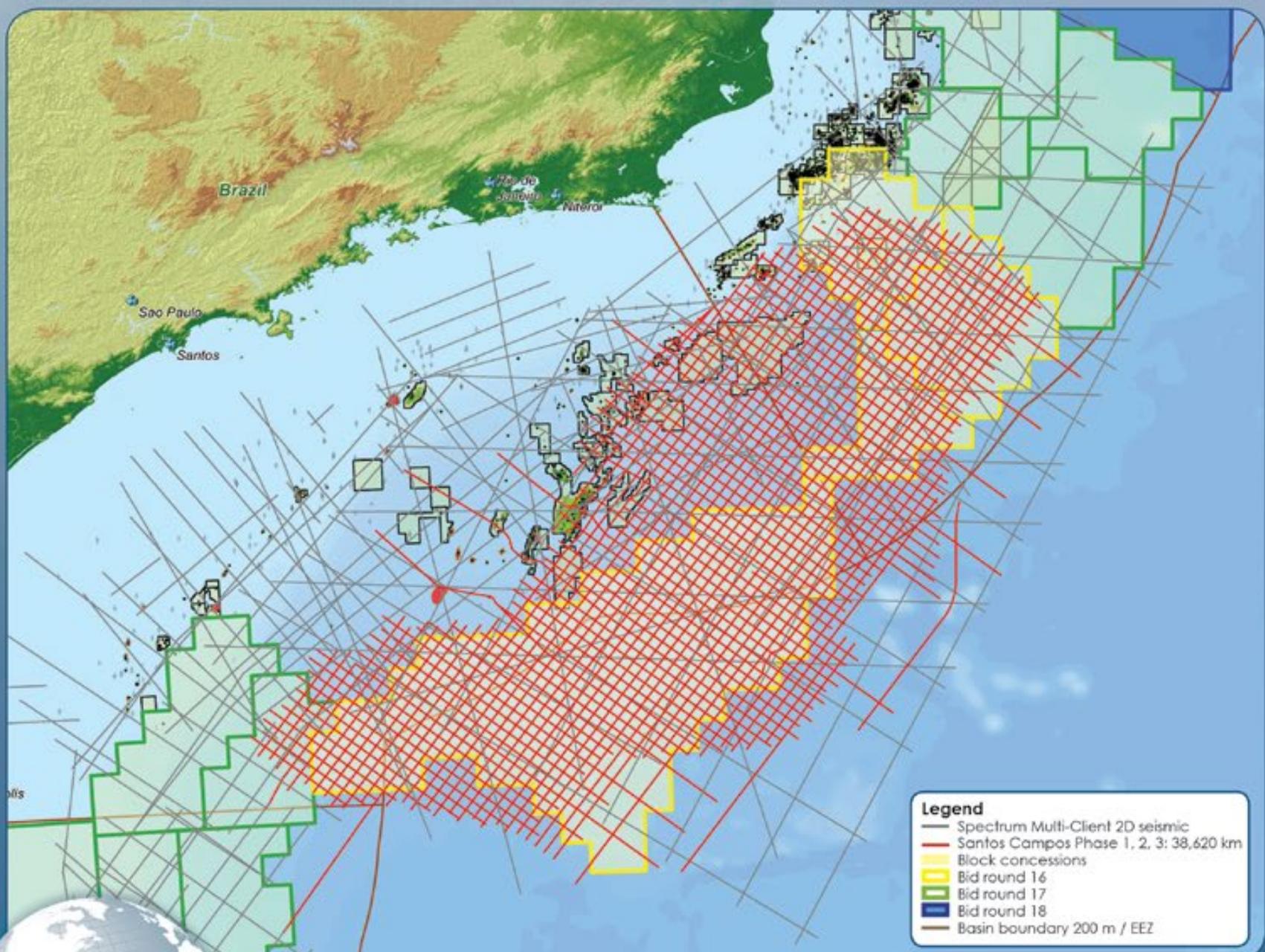
"One positive is, the consensus is that the risk of oil prices crashing below \$50 is over," he said.

At the same time, companies are finding lots of surplus upstream assets to put up for sale.

"The market now probably is best characterized as: It's a buyers market," Lidsky said. [E](#)

# Brazil: Santos Campos 2D

Multi-Client 2D Seismic for the Exploration Journey to Giant Oil



Spectrum holds more than 38,000 km of long offset 2D seismic data in the Santos-Campos basin over some of the most exciting open exploration acreage in the world. These surveys, acquired between 2012 to 2018, have now been de-ghosted and are available in both Pre-Stack Time and Depth Migration (Kirchoff & RTM).

This seismic covers a vast area where the prolific pre-salt play is confirmed to extend out from giant discoveries into the 16<sup>th</sup> 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 16<sup>th</sup> 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 CO<sub>2</sub> 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.

# Are There Benefits to Climate Change?

News reports and editorials about human-caused climate change are a daily feature of modern life, as politicians, environmental activists and industry leaders grapple over how to mitigate or avert the expected global catastrophe to ensue.

Gregory R. Wrightstone takes a different view.

"We see that many of the predicted climate calamities ... are, in fact, not happening, and that conditions are improving in many cases," he said.

Wrightstone is an AAPG Member and author of the book, "Inconvenient Facts: The science that Al Gore doesn't want you to know."

He spoke at a topical breakfast session last month at the annual Unconventional Resources Technology Conference entitled "How Rising Temperatures and Increasing CO<sub>2</sub> Are Benefitting the Planet and the Human Condition."

Wrightstone explained that his book and presentations focus on what is happening today and the recent past.

"We find that the predictions of pending climate doom are just that – predictions of what may occur 30 or 50 years in advance, based on climate models that over-predict warming due to increasing CO<sub>2</sub> by 2.5 to 3 times too much. It is important to distinguish between speculation of what may occur and what is demonstrably happening today," he said.

Rather than global catastrophe, though, increasing CO<sub>2</sub> levels in the atmosphere are having a positive overall effect on the planet and its inhabitants, he argued.

Wrightstone said the evidence shows Earth is growing greener, and temperature-related deaths are declining.

## 'Hobgoblins of Alarm'

Then why are new reports of climate-related developments viewed with such alarm?

"Many scientists within the government and private institutions are heavily invested both psychologically and professionally in advancing the narrative of human-caused climate catastrophe. Good news about an improving planet dispels the idea of imminent doom related to our burning of fossil fuels and typically goes unreported – like the greening of the Sahara has – or unfunded," Wrightstone said.

"H. L. Mencken warned us of the need for governments to create imaginary 'hobgoblins of alarm' in order to frighten the population into accepting onerous and harmful regulations such as the Paris Climate Accord. No nation would accept such economically crippling

"It is estimated that the cost of the full enactment of the Paris Accords would be to remove \$1.5 trillion per year from the world's economies, yet only decrease warming by less than half a degree Fahrenheit, while necessarily raising the cost of energy for all the world's citizens."

regulations unless they could convince their citizens of the immediate need to enact them and they have succeeded masterfully," he contended.

## Increased Greening

Wrightstone said data shows that parts of the Earth are growing greener.

"Probably the greatest example of a prospering planet comes from the work of NASA showing a 'greening' of the Earth," he said.

Wrightstone cited a study entitled, "Greening of the Earth and its drivers," by an international team led by Zaichun Zhu, a researcher from Peking University, China, using satellite data from NASA's moderate resolution imaging spectrometer and the National Oceanic and Atmospheric Administration's advanced very high resolution Radiometer instruments. It was published in the journal Nature Climate Change in April 2016.

"According to Zhu, 25 to 50 percent of the Earth has increasing vegetation – greening, while only 4 percent shows a net loss – browning. Several factors are contributing to this remarkable planetwide improvement, including CO<sub>2</sub> fertilization, soil moisture increase and, to a lesser degree, a retreat of tundra and tree lines owing to the gradual warming," he said. "One huge story is revealed in the southern Sahara where 300,000 square kilometers of the Sahel region are turning from desert into a lush grassland. Google 'NASA' and 'Greening' to see for yourself. The NASA experts attribute it to climate change."

"The increase in soil moisture is due to a combination of increased precipitation and the CO<sub>2</sub> fertilization effect. The increased precipitation occurs because higher

temperatures allow for increased water vapor in the atmosphere, which then leads to increased precipitation. Increasing CO<sub>2</sub> fertilization effect leads to smaller sized stomata and lessened water requirements, leaving more moisture in the soil. This increased soil moisture is leading to decreases in forest fires, droughts and intense heat waves, to name a few examples," Wrightstone continued.

## Heat-related Deaths

Likewise, predictions of higher death rates resulting from increasing heat and extreme weather are not materializing.

"We once again see the opposite is occurring," he said, referencing a study entitled, "Mortality risk attributable to high and low ambient temperature: a multicountry observational study," by a team led by Antonio Gasparrini, a professor of biostatistics and epidemiology for the London School of Hygiene and Tropical Medicine. The study was published in the July 25, 2015 issue of the medical journal, The Lancet.

"In the largest study of its kind, Gasparrini reviewed 74 million temperature-related deaths from 14 countries and found that 20 times as many people died from cold as from heat. It only naturally follows that any temperature increase would significantly decrease that number. In the United States there has been a 98-percent decline in extreme weather-related deaths since the early 20th century and the numbers continue to decline," Wrightstone explained.

"The effects of warming and increased CO<sub>2</sub> have been overwhelmingly positive to date, with increasing food production leading the way owing to CO<sub>2</sub> fertilization, increased soil

moisture and lengthening growing seasons," he added.

In addition to boosting agriculture, increased soil moisture helps lead to "decreases in forest fires, droughts and intense heat waves, to name a few examples," Wrightstone reiterated.

## The Key to the Future

The important, but often missing aspect of the debate over climate change, he said, is the geological perspective.

"One of the first things we learn studying geology is the law of uniformitarianism, which is often described as 'the present is the key to the past.' In climate science this should be turned on its head to use the geologic past to predict the future, or 'the past is the key to the future,'" Wrightstone explained. "For more than 600 million years the Earth has been a laboratory with rising or falling temperatures and CO<sub>2</sub> levels that we can use to predict what may happen by looking at the deep geologic past."

"Too often in the climate science debate, only the most recent events or shortened time frames are used, rather than utilizing the longer geologic viewpoint," he added.

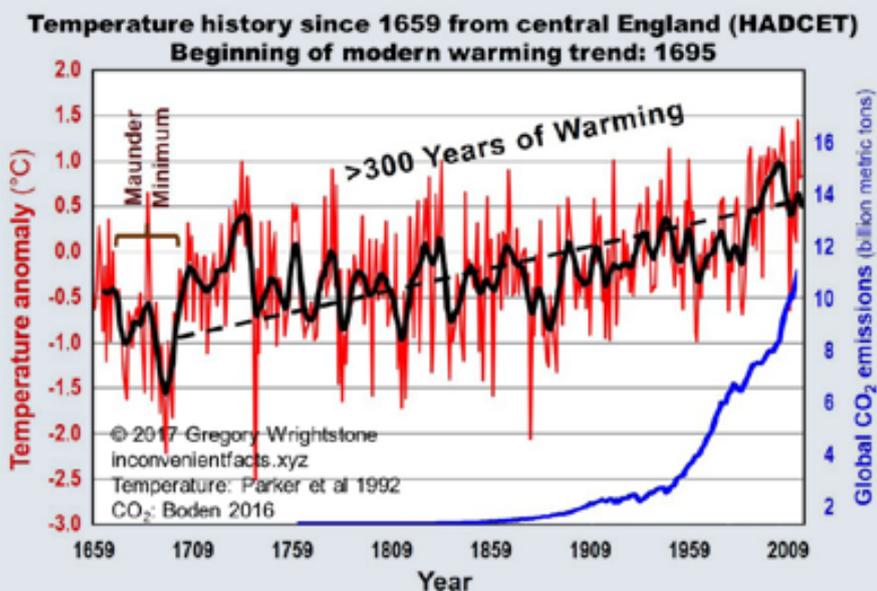
Human measurements provide only a "snapshot in time," extending back only a few hundred years, he said.

"One mantra of those promoting human-driven warming is that current temperatures are 'unusual and unprecedented.' That is true if one looks only at human-measured temperature records that begin in the midst of the Little Ice Age. The longer, geologic perspective of the last 10,000 years, dating back to the beginning of our current interglacial period, show that there were nine other similar warming periods, of which five had higher rates of warming than the 20th century, and all had significantly higher temperatures," he said.

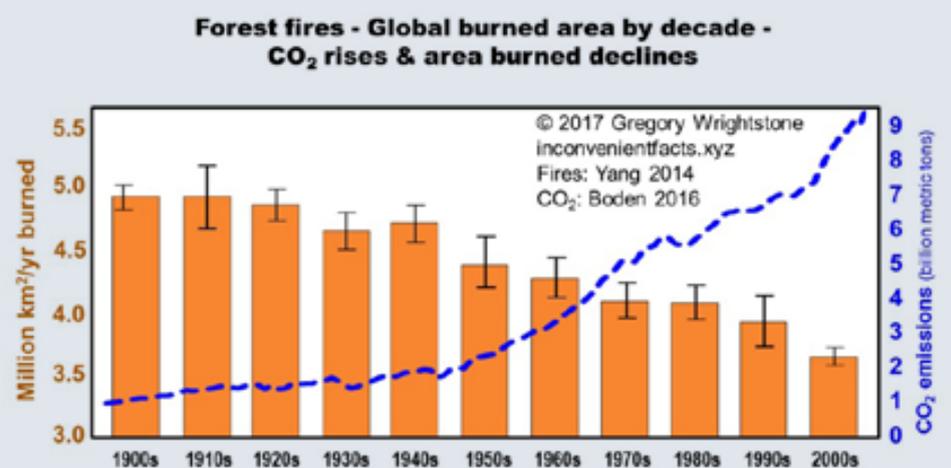
Wrightstone said we shouldn't be alarmed by reports that CO<sub>2</sub> levels have topped 410 parts per million.

"An increase of 130 ppm since the beginning of the Industrial Revolution barely registers as a blip when viewed in the longer geologic perspective. The average concentration prior to our current geologic period was 2,600 ppm, more than six times the current level. Inspection of this longer time frame shows that CO<sub>2</sub> levels have been in a dangerous 140-million-year decline. They fell to 182 ppm at the end of the last ice age, the lowest levels since the Precambrian and perilously close to the 150 ppm 'line of death,'

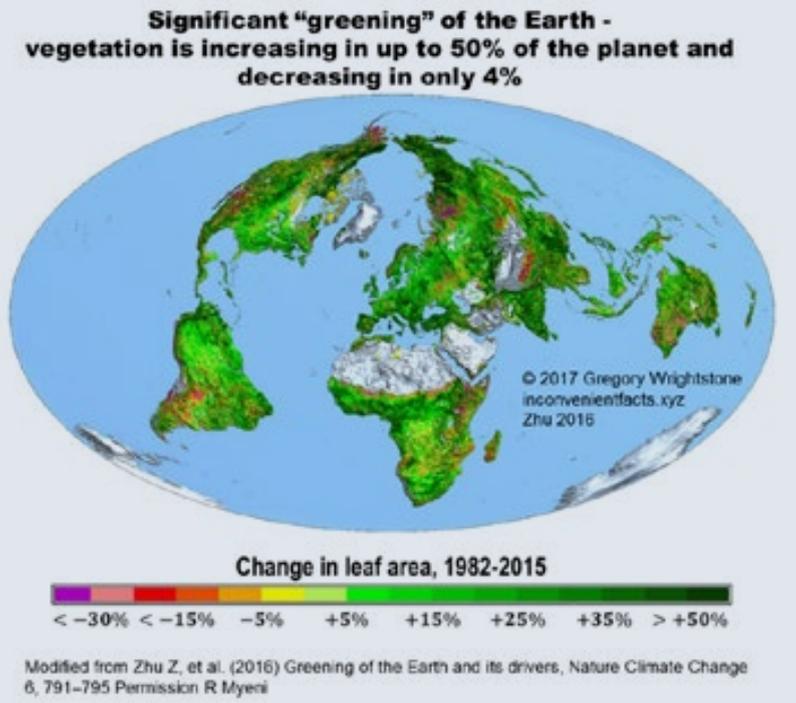
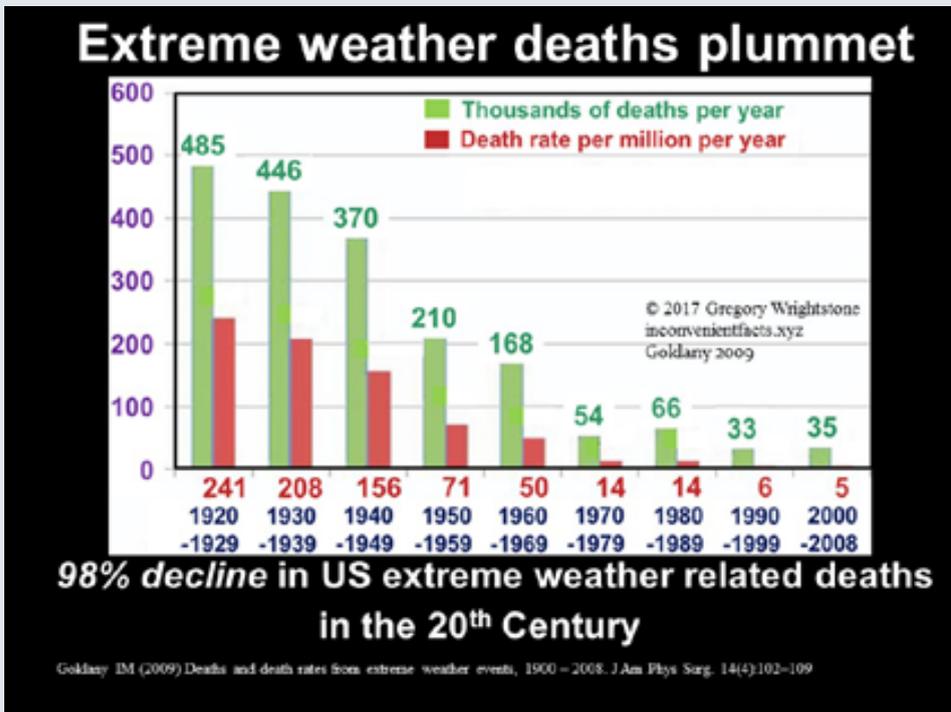
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Source temperature data: Parker DE, Legg TP, Folland CK (1992) A new daily Central England Temperature Series, 1772 – 1991. Int. J. Clim., Vol 12, pp 317–342. [www.metoffice.gov.uk/hadobs](http://www.metoffice.gov.uk/hadobs)  
Source CO<sub>2</sub> data: Boden TA, Marland G, Andres RJ (2016) Global CO<sub>2</sub> emissions from Fossil-Fuel Burning, Cement Mfrctr. & Gas Flaring 1751-2013. CDIAC, Oak Ridge National Lab., U.S. Dept of Energy, Oak Ridge, TN, USA.



Source area burned: Yang, J. Tian H, Tao B, Ren W, Kush J, Liu Y, and Wang Y (2014) Spatial and temporal patterns of global burned area in response to anthropogenic and environmental factors: Reconstructing global fire history for the 20th and early 21st centuries, J Geophys Res Biogeosci, 119, 249–263  
Source CO<sub>2</sub>: T.A. Boden G. Marland and R.J. Andres. 2016. Global Regional and National Fossil-Fuel CO<sub>2</sub> Emissions. Carbon Dioxide Information Analysis Center



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below which plants can't live. We don't have too much CO<sub>2</sub>; we are CO<sub>2</sub> impoverished," he explained.

"High levels of CO<sub>2</sub> are not dangerous. Earth has experienced many hundreds of millions of years with levels greater than 10 times what they are today and both plants and animals flourished. The U.S. Navy's submarines often exceed 8,000 ppm (20 times current levels) and there is no danger to our sailors," Wrightstone reiterated.

The Downside of Climate Change

He acknowledged that warming does have potential downside effects, however, such as flooding from increasing precipitation, and

movement and changes to fish, animal and plant populations.

"The greatest negative from warming would, of course, be continued global sea-level rise," he said. "Sea level has risen about 400 feet since the last ice age but has varied as Earth has gone through cooling and warming periods over the past 10,000 years or so."

Historical records show a sea level higher than today from the Medieval Warm Period (950-1250 AD), which dropped as temperatures fell during the Little Ice Age, he said.

"Our current period of rising sea level began around 1800 when summer ice loss began to exceed winter ice accumulation leading to glacial retreat – long before man could have any impact on climate. Sea level rise has been fairly constant at around eight inches

per century (20 centimeters) since the early 1800s," he said.

The Courage to Do Nothing

Wrightstone also had a lot to say about where to find reliable data, and how to use it reliably.

"Much of the data in my book and in my presentations are drawn from official government sites such as NASA, NOAA and peer reviewed studies," he said.

"We see that otherwise good data can be manipulated through cherry-picking of time frames, selective reporting of results and interpretations of the data to further an agenda. In many cases data that doesn't support the idea of human-caused warming is conveniently ignored," he added.

Wrightstone argued that humans would be better served if decision-makers took a hands-off approach to climate policy instead of pursuing economically damaging policies that will have little impact on climate, Wrightstone said.

"The summary for my book is titled 'The Benefits of Principled Inaction.' The first and most important conclusion is that the correct policy to address climate change is to have the courage to do nothing," he said. "It is estimated that the cost of the full enactment of the Paris Accords would be to remove \$1.5 trillion per year from the world's economies, yet only decrease warming by less than half a degree Fahrenheit, while necessarily raising the cost of energy for all the world's citizens. Policy should, in the end, be based on objective truth, not a politically-driven agenda." [E]

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# From Antarctica to the World

*Oil and gas physicist becomes environmental activist*

Antarctica is not known for its hospitable environment or its warmth.

But for Paola Tello Guerrero, a 32-year-old from Bucaramanga, Colombia, Antarctica represents connection, passion and inspiration. The icy continent lit an inner fire that she is taking around the world.

Tello was one of 80 women scientists from 20 countries to visit Antarctica in February as part of a leadership outreach initiative for women with science, technology, engineering, mathematics and medicine backgrounds. Called "Homeward Bound," the initiative aims to create a network of 1,000 female scientists working on sustainability initiatives during a period of 10 years.

She also founded "Antártida para Valientes" (Antarctica for the brave), a Colombia-based project to advance the role of women in science, communicate about climate change and teach children and young people about the importance of environmental stewardship.

## From Algorithms to Advocacy

Tello studied physics at the Industrial University of Santander and discovered geoscience during an internship at the Colombia Petroleum Institute run by Ecopetrol, the country's national oil company.

"The opportunities for a physicist are very broad; we are good at math, programming and describing phenomena," she said. "The field where I found the opportunity to use my skills was in geosciences. The Earth is the most fascinating topic to study, and it is complex at the same time. That's why the Earth sciences need experts from different areas."

After four years working in Colombia, Tello moved to England and took a job at ALS Petrophysics. She maintained ties to Colombia and became involved in professional women's networks in her native country and in the United Kingdom.

In 2016, she discovered Homeward Bound, an Australia-based program focusing on leadership development, strategic capability, science collaboration and science communication. Participants were trained in three stages during the 12-month period, with

content delivered virtually, on the ground in Ushuaia, Argentina and on-board the ship in Antarctica.

The project fascinated Tello, who understood that participants needed three characteristics: a science background, leadership ability and a passion for climate advocacy.

As a physicist involved in women's leadership initiatives, she checked the first two boxes.

"The third one was the trickiest," she said. "Though I have a passion for climbing, hiking, cycling and yoga – all related to nature – I needed a stronger argument."

She realized that, because she works in the oil and gas industry, she might not be considered by some to be the most likely advocate for climate change. But she wasn't ready to give up.

"I had an ace up my sleeve," she said. "I explained that, because climate change is our most important and urgent topic, we need efforts and solutions from inside and outside of all industries. The oil and gas industry plays a crucial role in climate change solutions."

Homeward Bound accepted Tello's application and welcomed her into the program.

## Challenges and Rewards

In the year prior to traveling to Antarctica, Tello worked a full-time job and raised \$16,000 for travel and underwent a series of training sessions with fellow participants.

She said, "2017 was just a crazy and wonderful year for me, from gathering the resources to finance the expedition; keeping on top of my work and the program at the same time; constant learning about Antarctica, leadership, project development, climate change; meetings and discussions with the group of

scientists. There were so many challenges." The challenges improved her focus and her determination, she said.

"I decided to give the best of me to this opportunity, dedicating every night, every effort, and saying 'no' to all other activities," she said. "At the end it was all worth it."

A particularly fond memory was having lunch with Susan Scott, an Australian physicist who won the Nobel Prize in Physics in 2017 for her work with gravitational waves.

Tello said most days on the ship involved research topic discussions, visits to scientific stations and landings.

"During ship sessions, we had a mandatory break every time we saw whales," she said.

Tello said programs like Homeward Bound give women a voice, both in science and in their communities.

"Each of us is conscious of the value of this opportunity and the responsibility involved," she said. "These programs are made to call the attention of the society to important topics like the gender pay gap, the female underrepresentation in leadership roles, vulnerability of women in front of climate change."

## Taking Antarctica to the World

In addition to benefitting personally from the experience, Tello decided to use her experience to help those in her home country.

"Coming from a small city in Colombia, I never imagined myself going to the last continent to be explored by man," she said.

"When you are in a multicultural program like Homeward Bound, you really are the representation of a country," she said. "I brought the Colombian flag and the best values of Colombian society with me: hard work, creativity, adaptability and a deep social commitment."

Since returning from Antarctica, Tello has worked to share her experience with others and to continue pursuing her two passions of children and education.

Through Antártida para Valientes, Tello engages universities, grade schools and other institutions in discussions about Antarctica, climate change and women in the sciences. She visited seven cities in Colombia and two in England and spoke with more than 5,000 people in 2017.

Her "Letters to the Penguins" initiative teaches children about the human impact on the environment and encourages children to come up with solutions for caring for oceans and managing energy more efficiently.

Tello explained how sharing experiences in Antarctica helps create a dialogue with people she visits.

"Antarctica is a territory of science, peace and collaboration thanks to the agreement signed in 1959," she said. "It is the perfect symbol to transmit good values, encourage the curiosity and the passion for science in children and adults and promote actions for the care of the planet."

Managing a project in Colombia from England represents a new challenge for Tello.

"I sleep few hours, work very hard, and up until recently the project was on my shoulders," she said.

Recently the Antártida para Valientes gained national and international media attention, and with the attention came volunteers.

Tello now enjoys support from 18 companies that provide services or goods

Continued on next page ►



Paola Tello Guerrero, a petrophysicist for ALS Petrophysics and environmental activist, stands atop Antarctica's Deception Island. Photo by @pateguerrero.



Tello (right) aboard the ship in Antarctica

### ◀ Continued from previous page

for school visits and for her expedition, and her employer values her social contributions and allowed her to take time off work to travel to Antarctica.

She said she is on a mission to make this pilot project a worldwide reality.

"There is a group of people that believe we can replicate this initiative and get more messages to the penguins, which is one of the outcomes of the project, we are dreaming to create small ambassadors of the planet at home, schools in the parks, everywhere!" she said. "The children tell us how they will be brave to care for the planet. They feel brave. It's very powerful."

### Letters to the Penguins

For Tello, the most rewarding part of her work is interacting with the children she visits.

"This work has given me the happiest days of my life. Seeing the faces of surprise, admiration, fear and happiness that the story awakens in them is fascinating," she said. "No age, gender or nationality can resist the Antarctica story."

Tello described their words as "powerful,

touching and funny."

She shared the words a 9-year-old girl wrote after discussing plastic pollution: "Dear penguin, I did not realize I was hurting you."

Other memorable messages included, "Paola, today I felt like a scientist. I felt I went to Antarctica," and "Dear penguin, I promise you I will turn off the lights and unplug my family's devices every night."

Tello's team is conducting research to evaluate the content of the penguin letters.

"We want to know what impact the letters have on the children, how they communicate, how the children's cultural backgrounds impact how much they learn. All of this will allow us to develop better tools to communicate the message," she said.

### Spreading the Initiative

Tello also uses social media to report her experiences to a broader audience. Every Monday, she posts photos from rocks she saw on the expedition and uses the hashtag #geolunesantartido (Antarctic Geo Monday). On Wednesdays and Fridays, Tello shares a diary of her adventures using Instagram and her

Facebook account, @pateguerrero.

She is planning a three-week trip to Colombia later this month, and she plans to visit schools in five cities.

She continues to seek companies and organizations interested in supporting her initiative and leaving an example for girls who might want to follow in her footsteps.

Tello hopes to return to Antarctica one day and spend some time working there.

"Antarctica has all the possible landscapes. Silence has a new meaning for me. The lack of human presence makes it unique and perfect. The animals are a gift to see. The total experience is just impossible to describe," she said. "Antarctica is a crucial component of the global climate system. This is one of the reasons 30 countries operate with scientific stations to study climate change effects, the ozone depletion and the global sustainability of the marine life."

Until her return, Tello said she remains committed to the foundation she calls "a dream come true."

"We want to get people from all social and cultural backgrounds and engage them with this magic territory to empower them to have a society more respectful of the environment and of women," she said.

### Inspiring Other Young Women

Tello noted that, after delivering more than 30 presentations to girls in Colombia, she noticed some interesting trends.

"In general, girls participated less than boys, and they are more likely to be embarrassed or concerned about how others judge them," she said. "Additionally, the figure of a role model is powerful, and the way the girls look at you as a reflection of their dreams is absolutely moving. I am really grateful for this."

Though she realizes that her experience may not reflect attitudes of all girls in Colombia, she is determined to use what she has learned to be a positive influence.

"At the end of my presentations, girls are more likely than boys to get close to me, to mention their favorite subjects or to tell me about their latest science homework assignment," she said. "One day one girl told me, 'I thought that studying rocks was boring; now I know it is not.' You can imagine my happiness."

When asked what advice she would give to girls interested in pursuing a career in science, Tello has one word: Read.

"Books are a big trigger of imagination and curiosity, and that is key in science," she said. 📖



Tello has collected more than 500 "Letters to the Penguins," written by children who share strategies for mitigating the negative effects of climate change.



Tello visiting 1-2-3 For Me School in Bucaramanga

# Understanding the Interplay of Natural and Induced Fractures

If a taint exists on the use of geophysics to evaluate fracturing operations, it is this:

"T ain't easy.

In fact it's downright difficult, said Arash Dahi Taleghani, associate professor of petroleum and natural gas engineering in the Department of Energy and Mineral Engineering at Penn State University.

Dahi Taleghani's research areas include studying how natural fractures can affect hydraulic-fracture geometry and using seismic for modeling natural fractures and post-treatment fracture analysis. That work becomes more challenging as fracture complexity increases.

But, "the point is, it's fracture complexity that allows us to produce more oil and gas from the formation," Dahi Taleghani said.

Unconventional reservoirs – especially shale reservoirs – tend to be heterogeneous, with different characteristics in different directions. That leads to seismic anisotropy as direction affects seismic wave velocities.

When using seismic to assess fractures, "anisotropy needs to be considered, and another thing that needs to be taken into account is the amount of heterogeneity that exists" in the reservoir, Dahi Taleghani noted.

He and his fellow researchers also have found that diagenesis and mineralization can be important in evaluating the relationship between natural and induced fractures, especially in the case of cemented natural fractures.

"We take the diagenesis into account – this is important," Dahi Taleghani noted.

"Natural fractures are not always smooth and clean. You have some roughness that is possibly in the direction of the fracture propagation," he said.

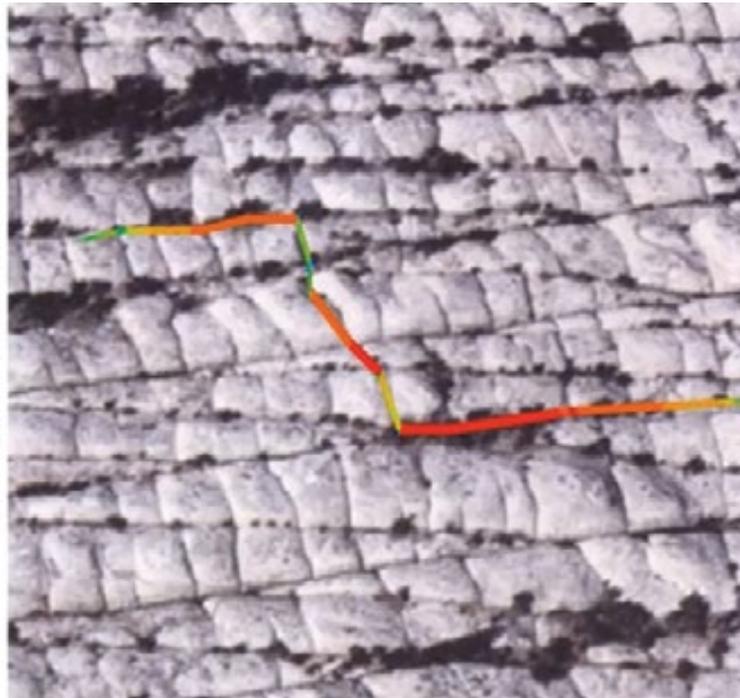
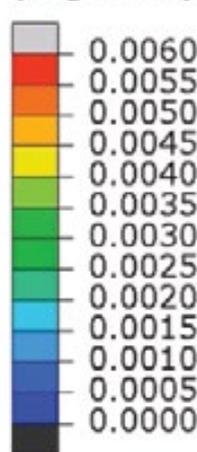
Depending on the interaction between hydraulic fracture propagation and cemented natural fractures, three outcomes are possible. The natural fractures might have little effect, or might even act as a barrier to propagation.

In a third scenario, however, an expanding hydraulic fracture can reactivate and extend natural fractures even without intersecting them.

"They are acting, actually, as a weak path for fracturing the rock," Dahi Taleghani said.

A paper he co-authored with Jon Olson from the University of Texas-Austin found "when natural fractures are perpendicular to the direction of the hydraulic-fracture growth, the largest possible debonded zone may form,

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This simulation overlain on an outcrop shows existing natural fracturing creating a pathway for the propagation of an hydraulic fracture.

which is equivalent to the most optimum case to stimulate a reservoir."

Because of this possible interplay between hydraulic and natural fractures, the paper concluded that "complex fracture-network modeling capability is an integral part of predicting well performance in the naturally fractured reservoirs that are common in unconventional plays."

How to do that modeling effectively remains a question, even now.

## Horizontal Transverse Isotropy

According to the seismic company CGG, given the target depth of formations in shale gas basins being exploited today, the maximum stress is vertical, giving rise to Horizontal Transverse Isotropy.

In HTI, the natural fracture system is comprised of vertical fractures which cause anisotropic effects on seismic waves as they pass through. The effects are observed as changes in amplitude and travel time with azimuth.

In those formations, conventional seismic information can be useful in stress measurements and in studying

geomechanical properties, CGG said. To calculate stress values, linear slip theory for geomechanical properties is used.

"As seismic data measure dynamic stress, results are then calibrated to the static stress that is effectively borne by the reservoirs at depth, making it possible to predict the hoop stress and the closure stress as key elements defining the type and motion of fractures," CGG said.

Useful geophysical tools include appropriate data acquisition and detail-attentive amplitude versus azimuth processing, as well as amplitude versus offset, interpolation and inversion.

"But the typical seismic cannot detect fractures because of the resolution of your seismic picture. However, you can see the difference that the anisotropy makes in different directions," Dahi Taleghani said.

## Microseismic in Unconventionals

The huge amount of data and processing time required to evaluate fracturing in unconventional reservoirs using conventional seismic also presents a problem, he said. So the industry has turned increasingly

to the application of microseismic in unconventional.

"With microseismic the data processing is a bit easier because of the size of the files and existing constraints," Dahi Taleghani noted.

"We are basically listening to the noise from the hydraulic fracturing. Microseismic has flourished a lot in the past 20 or 30 years because of the shale revolution," he said.

Using microseismic doesn't produce ideal results in assessing fracturing operations, according to Dahi Taleghani. The signals tend to be weak, hence microseismic has a high noise/signal ratio, he said.

"Always, you have a large uncertainty in identifying the exact location of these events," he noted.

He uses both kinds of seismic data in his research, with one goal being to place existing natural fractures within the context of hydraulic fracturing operations and estimate the results.

"Based on the data, we try to come up with an optimization algorithm to characterize these natural fractures," he said.

Assessing the success of those efforts leans somewhat on conjecture. To evaluate the effectiveness of their models, researchers need detailed, real-world production data and production results, information that operators do not release.

"You need to have extensive production data, which is unfortunately not available because the companies are very careful about their proprietary data," Dahi Taleghani said.

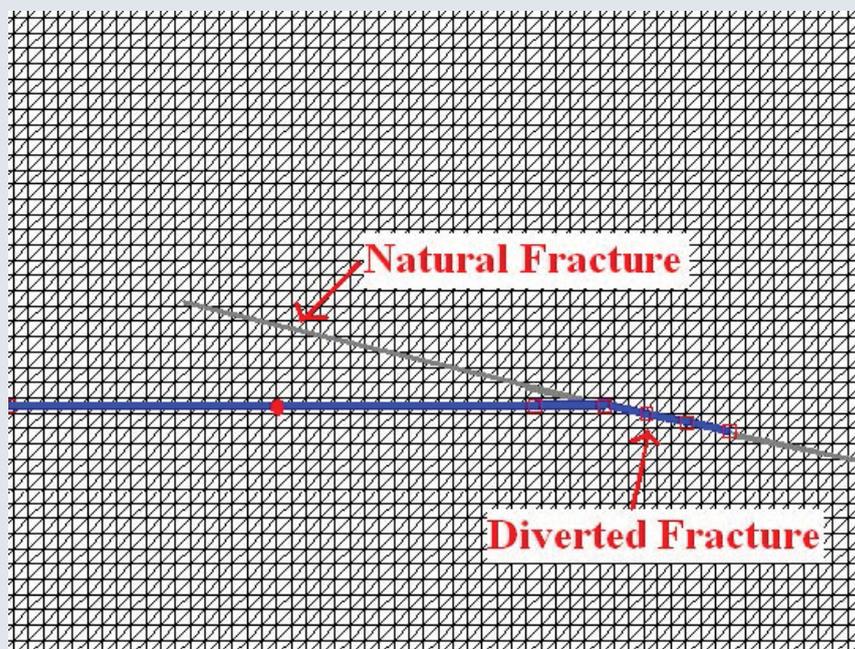
So researchers use known data, statistical projection and other tools to create synthetic data sets "for examining the robustness of the proposed workflow," he explained.

"We can use these synthetic data sets to reproduce the natural fracture sets. In this sense, it was successful," Dahi Taleghani said.

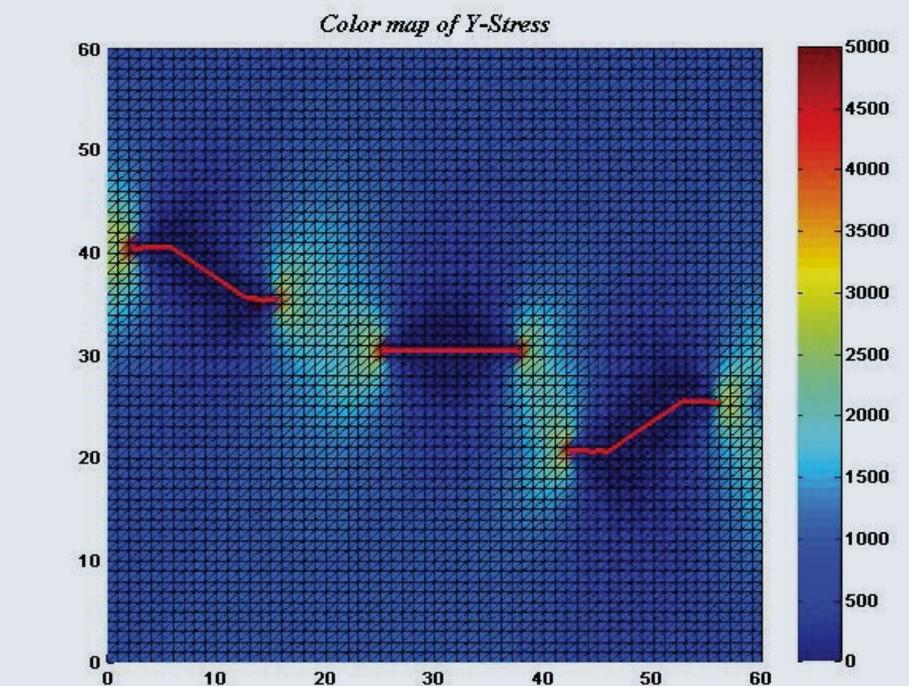
Getting to a truly effective, broader application of geophysics to fracturing analysis obviously will take increased cooperation between industry and researchers, he said.

"I think more support from the industry can open the way. And this will also help them" to improve current technology and increase production, Dahi Taleghani observed.

But because of the lingering effects of the recent industry downturn, "it has become very difficult for these companies to commit to a research project, or even to provide any money," he said. [E](#)



A schematic illustration of a low-angle fracture diversion (18degrees). The cemented natural fracture is plotted in gray, and the hydraulic fracture is plotted in blue. The location of the wellbore is depicted by a red circle.



Modelling multiple crack propagation in XFEM. The specimen is under uniaxial tension in the vertical direction.



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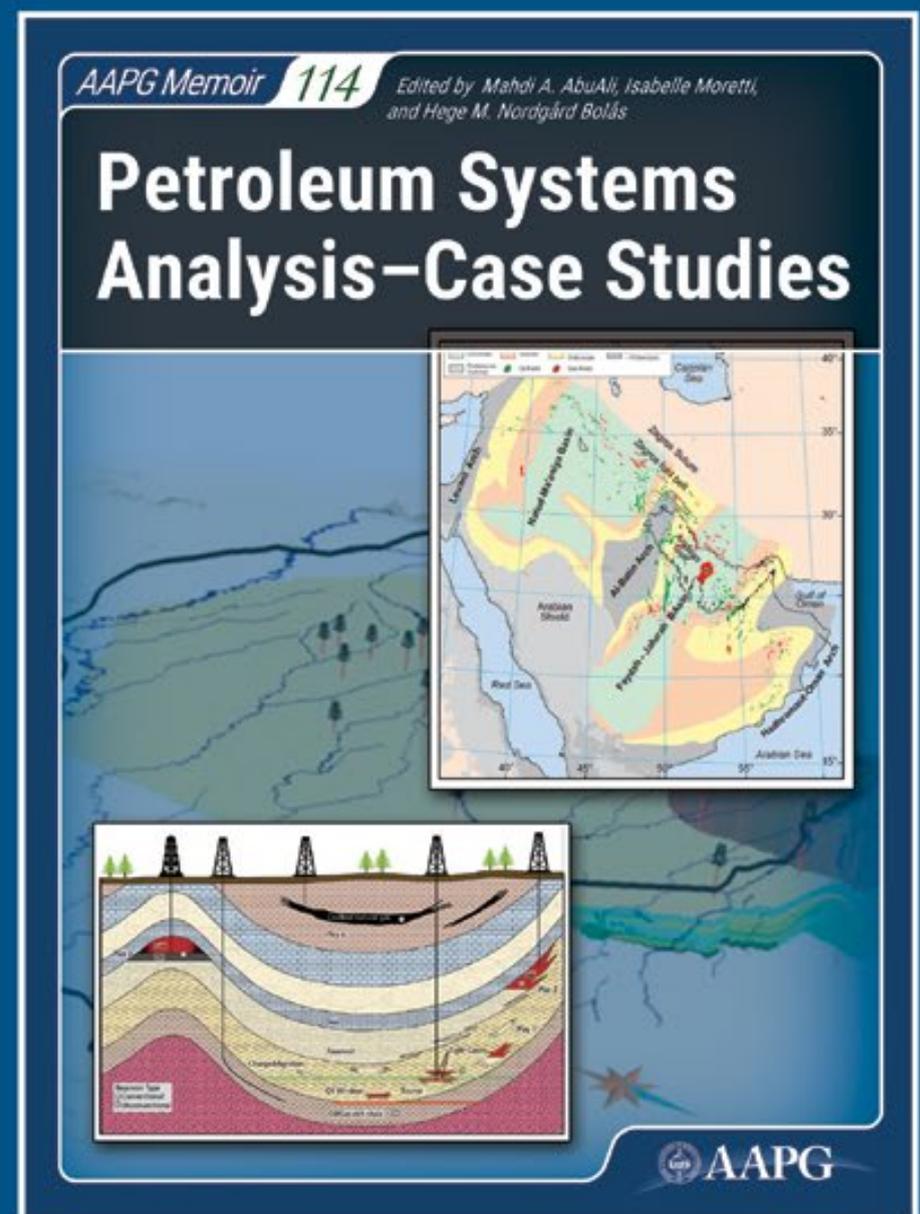
Edited by Mahdi A. AbuAli, Isabelle Moretti, and Hege M. Nordgard Bolas

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# Mapping the Red Fork Sandstone with Multispectral Coherence

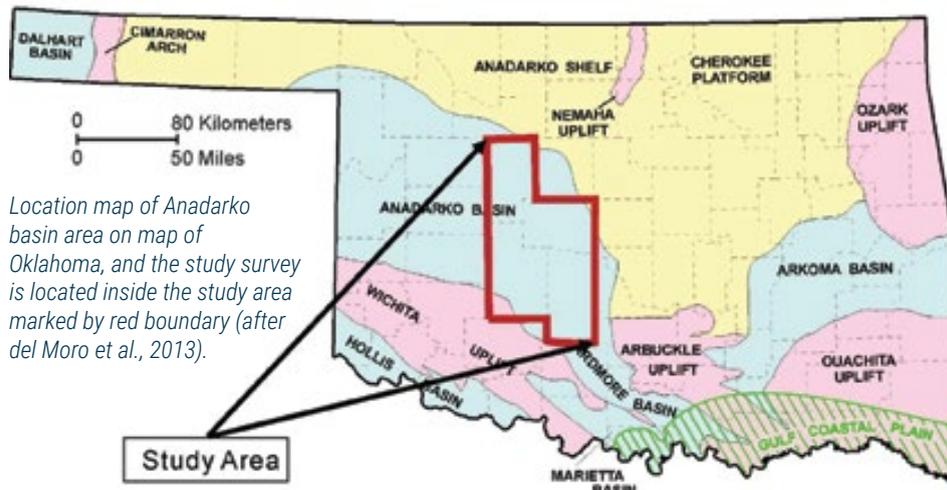
Exploration and development drilling along the upper region of the Middle Pennsylvanian Red Fork Sandstone has been going on since 1979 in the western part of the Anadarko basin of Oklahoma. This is fine-grained low-permeability gas and gas condensate produced at depths ranging from 12,000 to 14,000 feet from stratigraphic traps. Because of the depths and the reservoir characteristics, the Red Fork play is very sensitive to gas prices, and the good quality reservoir sandstone is tough to predict due to the complexity of the depositional environment.

Clearly, then, determining where all those potential hydrocarbons are located requires integration of rock and log data. Logs need to be calibrated to cores in order to estimate depositional environments accurately and to make a reasonable assessment of diagenetic overprints.

Since 1998, 7,551 barrels of oil and 316,515 thousand cubic feet of total gas have been discovered.

There's much more down there and that's what we're talking about here.

Fangyu Li, a postdoctoral research associate in the College of Engineering at the University of Georgia, said the latest technology in multispectral coherence, specifically as it relates to bringing together seismic and other sources of information to better map all that, is developing to a point where scientists can see more of what's down there and they can see it more clearly. Fangyu presented his doctoral dissertation, "Seismic Data Multi-Spectral Analysis, Attenuation



Estimation and Seismic Sequence Stratigraphy Enhancement Applied to Conventional and Unconventional Reservoirs" last year, and the Red Fork Sandstone was included in one of the reservoirs studied.

## Advances in Multispectral Coherence

About 20 years after its inception, seismic coherence volumes have been routinely used to delineate structural and stratigraphic discontinuities such as channels, faults and fractures, to highlight incoherent zones such as karst collapse and mass transport complexes, and to identify subtle tectonic and sedimentary features that might otherwise be overlooked on conventional amplitude volumes. The better the technology gets, obviously, the better the picture.

Fangyu has kept an eye on that technology.

"About coherence techniques, in general, there are three generations: C1, cross-correlation based, C2, semblance based, and C3, decomposition based," he said.

This is not all the technology that has been developed, either. Fangyu said different methods to calculate coherence were invented, such as higher-order statistics-based methods, "but the C1, C2, C3 are most common until now."

For him, personally, his multispectral coherence is based on C3 coherence, meaning instead of using the seismic data, he uses the spectral voices as the input.

"The innovations are how to use the spectral voices and how to display the results," and this, he believes, is its advantage over other methods.



LI

"We notice the coherence images calculated from different spectral voices are showing different features, which is important for geophysical and geological interpretation where the coherence images at different

frequencies can show different stages of the incised valley," he said.

The seismic combines the coherence images from different frequencies to generate a single map, which shows different scale features together.

## Better Hardware Needed

The advances of the seismic coherence, he said, is in the delineation, because one usually wants to interpret the most broadband data possible. Of course, this means the hardware through the years has had to catch up with the software.

"Speaking of making the work easier, computer hardware development needs to be mentioned," he said. "The storage is larger, as we need to generate spectral coherence images, if we need a result per frequency slice, the storage is tens or hundreds larger than the original. Second, the computation power, since the coherence calculation needs to be done repeatedly on every frequency slice – if it was ten years ago, it was too slow."

You need – and this is almost too obvious a point – a good monitor, as well.

"In addition, the display is better than before, so more details can show," said Fangyu.

"Because, if the data quality is not good, there is no value to look deep into it. So, in the future, when the data quality keeps increasing, the coherence results will be better and better," he said.

The most important step, then, in coherence computation is to ensure that the processed data exhibit high bandwidth, are accurately imaged, and are free of multiples and other types of coherent noise. Once in the interpreter's hands, many seismic amplitude volumes benefit from subsequent post-stack structure-oriented filtering and spectral balancing.

New techniques provide more and more important information.

"With the new information, detailed interpretation can be made, and better reservoir characterization can be expected," said Fangyu.

Much of this work is being done at the Attribute Assisted Seismic Processing and Interpretation consortium in the University of Oklahoma, where Fangyu is presently located.

He warns, though, the downside is that the wealth of information is only part of the story. Sometimes it's too much and it's contradictory.

"For example, if you are provided a coherence image from the full bandwidth data, you can find discontinuities. However, now you are provided two spectral coherence images from different frequencies, and they are showing different features. What is your interpretation?"

As for the skills needed in those charged with such work, it's about what you'd expect, Fangyu said.

"The interpreters need to know what features to look for and what spectral responses are corresponded to what structures or rock types," he said.

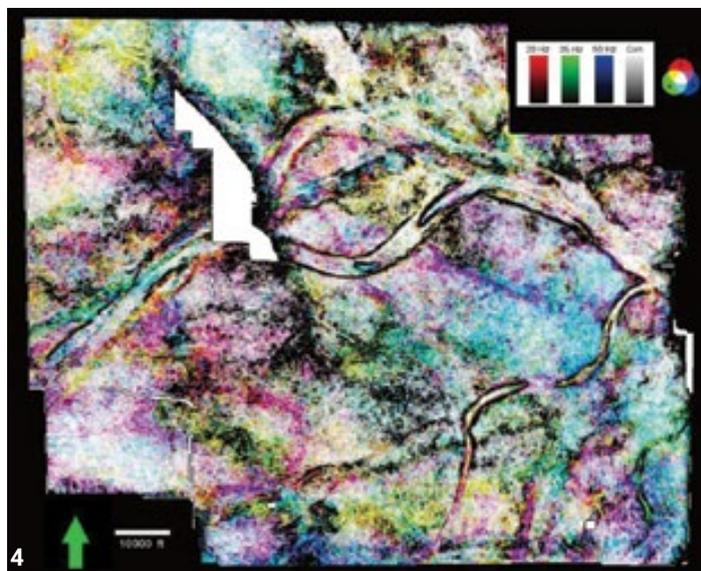
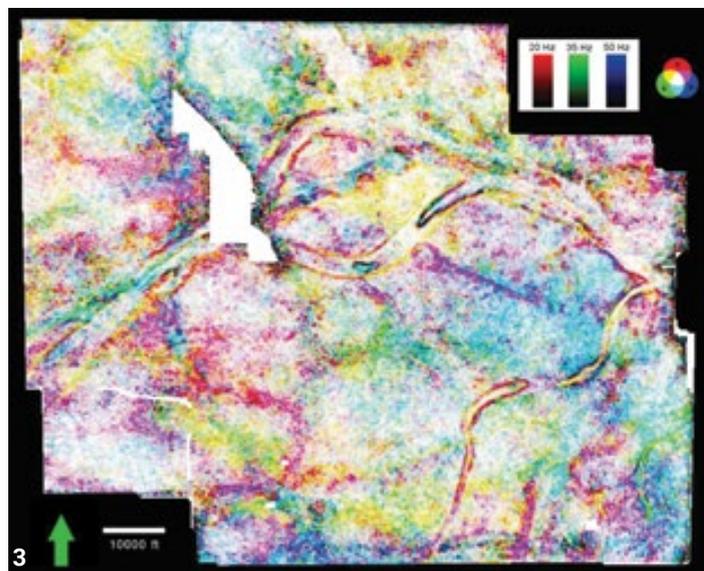
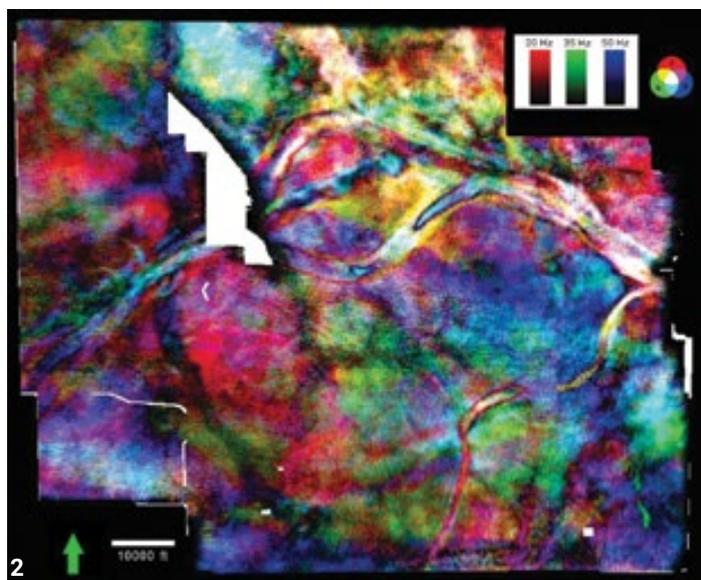
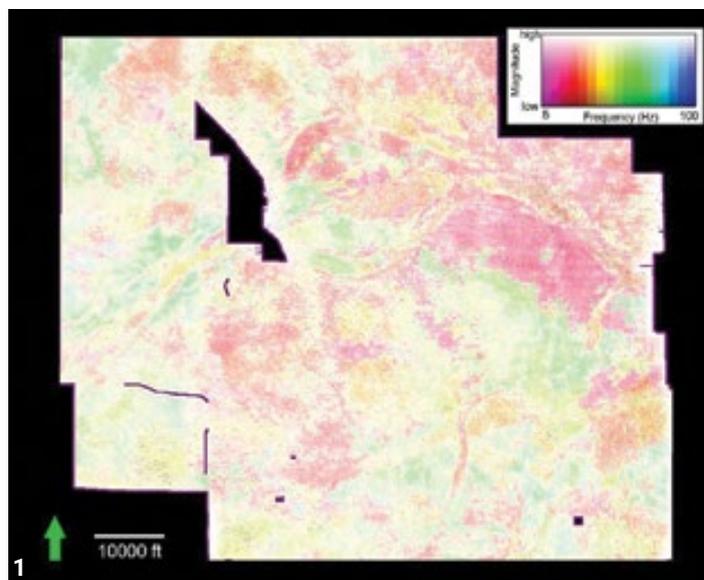


Figure 1: Dominant (or peak) spectral frequency image of the Red Fork horizon, which shows that the target horizon has different tuning thickness. The magnitude of the spectral component is plotted against a gray scale, thereby modulating the image. Figure 2: RGB blended spectral magnitude components at 20 Hz (in red), 35 Hz (in green) and 50 Hz (in blue). Figure 3: RGB blended image of coherence corresponding to Figure 1.6 computed from the 20 Hz (in red), 35 Hz (in green) and 50 Hz (in blue) spectral components. Figure 4: The same image shown in Figure 1.7 but now co-rendered with that of Figure 2b. Edges that are not overprinted in black were delineated by coherence computed from the corresponding spectral components, but not by the broad band coherence computation.

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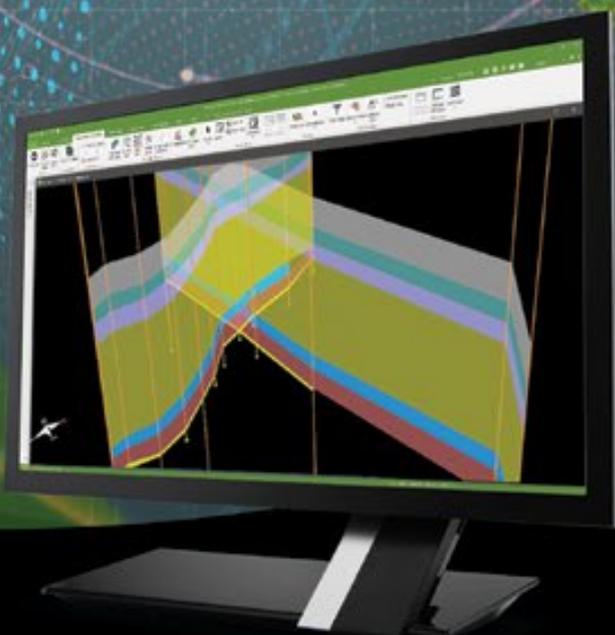
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# 'Energy Opportunities' Signals Bright Oil Future for Latin America

**B**id rounds, new technologies and the region's energy future will be topics of discussion at the Energy Opportunities Conference, Exhibition and Business-to-Business Session in Cartagena, Colombia from Aug. 22-23.

Convening regulators, operators, service providers and investors from Mexico to Argentina, the event includes one-stop shopping for anyone interested in an overview of investment opportunities in the region's energy sector.

"We are moving beyond our technical arena to explore regulatory aspects, industry-government collaboration, industry-community relations, plus looking to the future of alternative energy and technologies," said Victor Vega, Latin America and Caribbean Region immediate past president and general vice chair for Energy Opportunities.

### Multiple Objectives

For Elvira Pureza Gómez, Latin America and Caribbean Region president-elect, the conference provides an important service to those working in the region's public and private energy sector.

"We understand that industry and government leaders are busy people, and they have little time to travel across the region to advance their projects," she said. "This conference brings all the stakeholders to one place and allows them to accomplish several objectives at once."

John Londoño, offshore Colombia exploration manager at Colombia's national oil company Ecopetrol, said the conference represents a unique opportunity for the region.

"In a single event we will have some of the most influential individuals responsible for energy matters for governments, regulators and national companies from the American subcontinent. The vital participation of operators and international service companies complete the perfect picture of a conference, which, as the first of its kind, promises to sow the seeds of integration and discussion of common interests and agendas – which is often lacking – so that all participants can benefit significantly," he said.

"We have the advantage of having a similar cultural and historical background, which should help us to better understand and exchange ideas and opportunities with our Latin American peers," he added.

### Promoting Colombia and the Region

Londoño added that hosting the regional conference is beneficial for Colombia, which signed a peace agreement with FARC guerrillas in 2016 and whose newly elected

president, Iván Duque, will take office two weeks before the event.

"This is a special opportunity for the country to show its energy potential and to show industry the steps being taken, from the regulatory point of view, including the fiscal, legal and environmental framework, to materialize all this potential," he said.

"At the same time, the conference provides us the opportunity to learn from experiences, both positive and negative, of our international peers, and to do an introspective and comparative exercise to see our current position in the energy industry, particularly related to oil and gas."

Presidents from Ecopetrol and Colombia's National Hydrocarbon Agency serve as general chairs for the conference, and the opening ceremony includes remarks from the newly named minister of mines and energy, María Fernanda Suárez.

ANH will host a private meeting for regulatory agencies and ministries the day before the conference.

Gómez noted that the conference provides a forum for other Latin American and Caribbean countries to showcase bid rounds and investment opportunities.

"Many people know about bid rounds in Colombia, Brazil and Mexico. They may not be so familiar with the shallow bid round coming up in Trinidad and Tobago or opportunities in Barbados or Nicaragua," she said. "Energy Opportunities allows the lesser known countries to present on the same stage as their larger peers."

The Regulatory Agency Panel in the conference program includes an overview of opportunities in Colombia, Peru, Suriname and Bolivia, and the Country Snapshots session features additional opportunities throughout the Caribbean and Central and South America.

### A New Concept

Vega developed the conference format along with AAPG staff and colleagues in the region.

"I have always felt that as geoscientists we don't get as involved as our petroleum engineering colleagues in business-related items, but as explorationists we are always the first to arrive to a country to look for opportunities," he said. "I thought about this idea to combine different aspects that are very important for doing business and to integrate them with new tendencies around alternative energies."

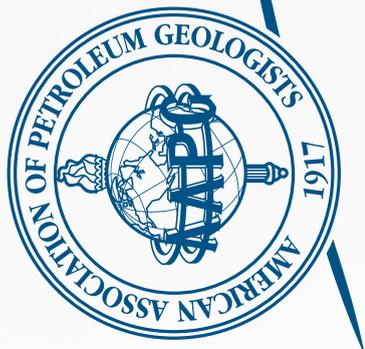
Pedro Alarcón, current Latin America and Caribbean Region president, described the conference as "really necessary" and said the

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# EVENTS

# AAPG



## **Energy Opportunities**

Cartagena, Colombia

*22–25 August 2018*

## **Energy Transition**

Amsterdam, The Netherlands

*5–6 September 2018*

## **GTW – Thailand**

Back to the Future – The Past and Future of Oil and Gas Production in the Asia Pacific Region

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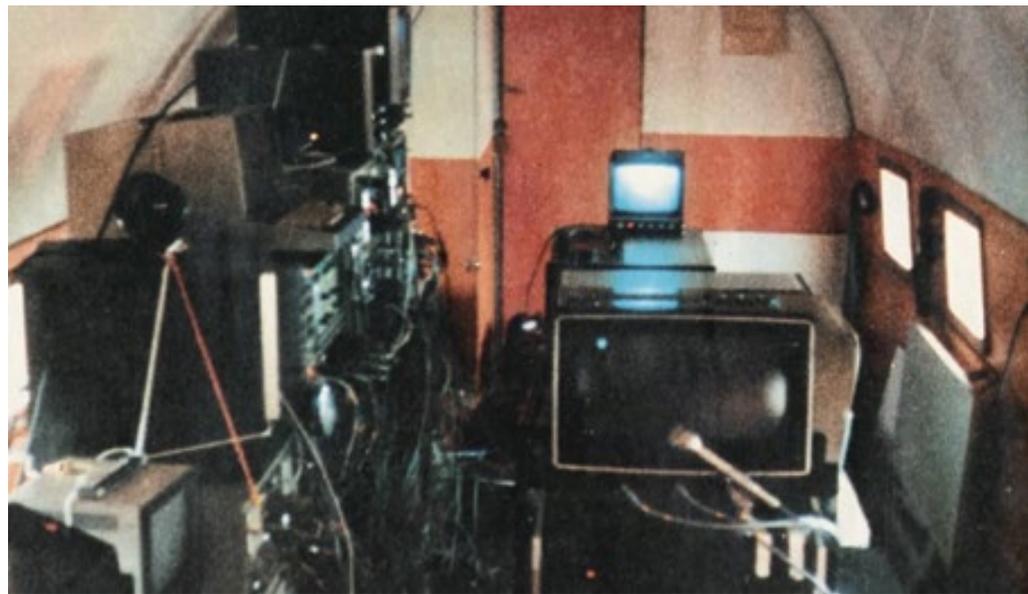
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## Historical Highlights

# The Great Oil Sniffer Hoax



Aldo Bonassoli showing his "high-tech" electronic material



Sniffer device mounted aboard an airplane

Since the early days of petroleum exploration, the industry has met diviners and dowzers who, by using esoteric techniques, simple devices or sophisticated artifacts designed by themselves, have tried to fool companies by claiming they were able to detect oil in the subsurface.

Of course, these forms of divination are not exclusive of oil exploration and they have been a subject of discussion and controversy for many years.

The most popular non-scientific and simple devices are a rod, stick, fork or an object hung from a chain like a pendulum, through which by surveying the terrain, the dowser claims to locate underground water, oil, metals or any hidden object. More sophisticated artifacts include a prototype constructed by the dowser, who claims to detect energy, rays, radiations, vibrations or waves that allow him to locate water or oil in the subsurface, even the depth and the amount to be found. Of course, the inner content of the prototype and the geological or physical energy that is detected by the artifact is never clearly revealed and is always kept secret.

In France, during the late 1970s, two eccentric inventors claimed they could directly detect oil in the subsurface from an exceptional device mounted on board an airplane, resulting in one of the most famous frauds in petroleum exploration history. The fraud had great media and political impact in France at that time, becoming popularly known as "L'affaire des avions renifleurs," or "The Great Oil Sniffer Hoax."

### Direct Detection of Oil from an Airplane

In the mid-1970s the world was in the final days of the first oil shock. Most western countries were anxiously trying to secure oil supplies as a national priority, preparing for any future oil shortage. The French Elf-Aquitaine, similarly as other state-owned companies, had the objective of providing the demand of national energy by exploring and producing hydrocarbons at home and abroad.

In May 1976, Elf-Aquitaine signed a top-secret agreement with a company named "Fisalma" for the exclusive use of a supposedly revolutionary method of directly detecting oil in the subsurface from an airplane. The agreement was signed at the headquarters of the Union Bank of Switzerland in Zurich. Fisalma was a Panama-based company, representing the interests of two eccentric

*Almeria exploration permits, where the exploration well Cabo de Gata-1 (Elf, 1980) was drilled in the well-known volcanic region of southeastern Spain*



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Asia and Spain. He is also an active member of different professional associations of petroleum geoscientists such as AAPG, European Association of Geoscientists and Engineers, the Petroleum Exploration Society of Great Britain and AGGEP.

inventors: Alain de Villegas, a Belgian aristocrat and civil engineer, and his associate Aldo Bonassoli, an Italian TV repairman. This new breakthrough technology was considered by Elf's top management as the "Holy Grail" of hydrocarbon exploration, capable of giving France a tremendous competitive advantage and promoting a considerable reduction in oil-finding costs.

The two inventors claimed that their technology and detector devices were innovative and extremely advanced, but there was no coherent description of the technique behind the devices, and it was masked in confusion. It was speculated that they were measuring gravity or magnetic fields, two standard geophysical techniques, but it was also argued as a system of waves or radiations, electronic scanning or even sub-atomic particles, such as neutrinos.

These were waves that were able to pass through solids and liquids that gave back a reverberation, "a kind of radar effect," that were recorded in a device on the ground or mounted in a plane that merely flew over. The recorder device's inner content was not disclosed. Externally, it consisted of different electronic instruments and TV monitors, all the paraphernalia interconnected through a big mess of cables.

At that time Elf was headed by Pierre Guillaumat, a mining engineer from the elite École Polytechnique, who had extensive background in oil exploration and had been Elf's president since the company was formed in 1967. The president and Elf's executives, for reasons difficult to understand, did not question the technology. The two fussy and suspicious inventors did not allow Elf engineers to examine the equipment, either

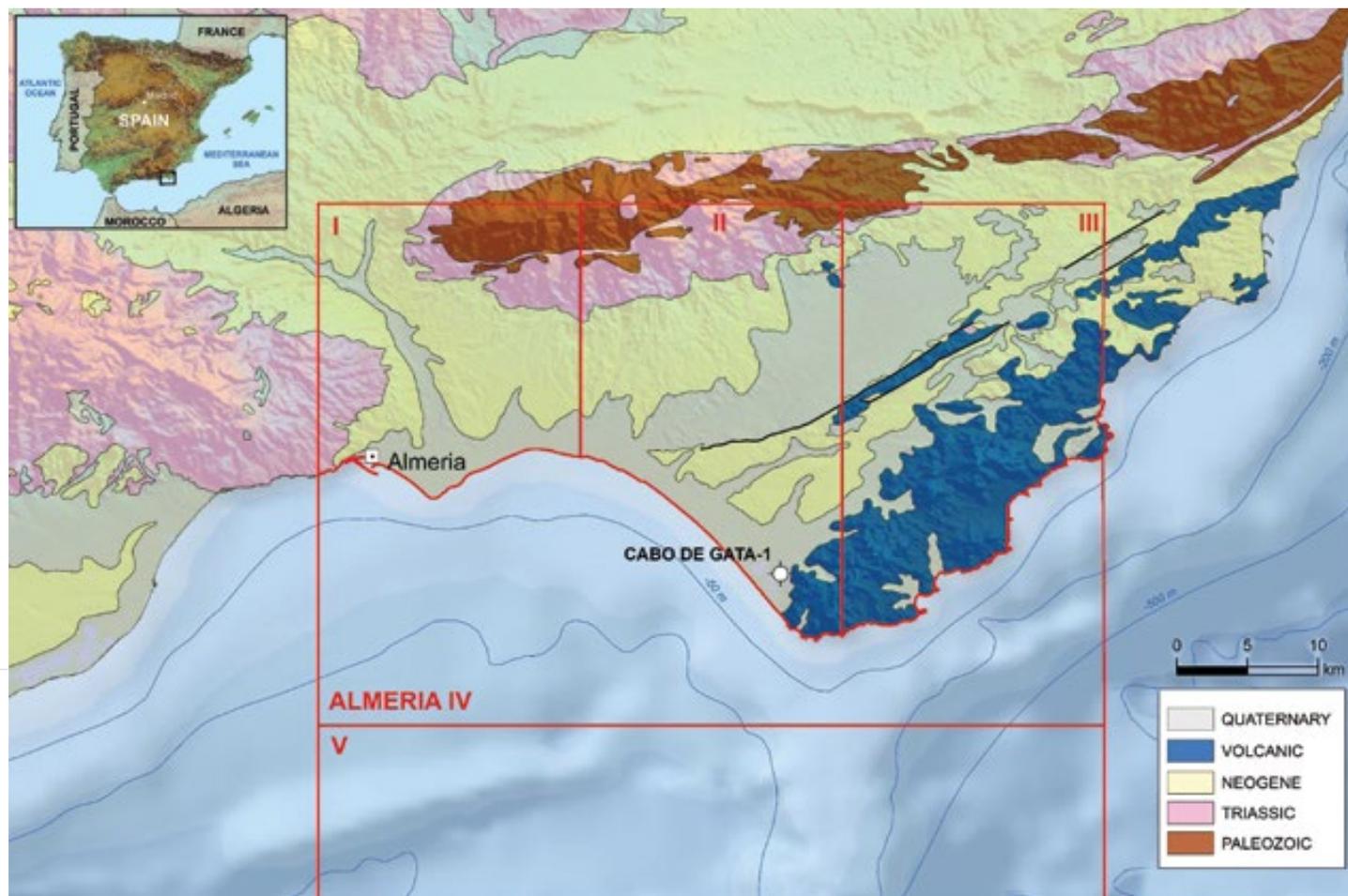
claiming it emitted dangerous radiation or because it was ranked as ultra-secret. They refused to answer any question about the device and the technique involved. The poor information provided was loose, mutable, unclear and contradictory. When the inventors were upset, they threatened with "selling it to the Americans" or to a Middle East country to call off the inquisitive persistence.

The inventors also claimed that, when flying over the oceans, the device even managed to detect nuclear submarines that were at that time deemed undetectable. Following this supposed ability, from an industrial secret, the invention was then classified as military top-secret.

### Testing the Device by the Drilling Bit

Testing of the device started in 1976. It was mounted in the cabin of a twin-engine propeller plane, hidden behind curtains and flown over known oil and gas fields. When flying over a producing oil field, the device flashed lights and beeps in real time, displaying colored shapes on the TV monitors, which supposedly represented virtual images of the subsurface. A paper copy with a sort of map was printed, showing the outline of the oil field, looking very similar to the field's contour map available within the Elf's internal reports

See **Testing** page 20 ►



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A similar Fokker F-27 aircraft was used for the "oil sniffing" surveys.

## Testing from page 18

and databases. The Elf observers, including Guillaumat, were completely convinced by the tests that the devices were genuine and they were impressed by the remarkable high quality of the output maps. Several secret flights were run over France, Spain, Portugal, Netherlands, Ireland, Switzerland, the North Sea, Brazil and South Africa.

The device was further tested by drilling highly expensive and deep exploration wells in France and South Africa, in locations where the inventors had detected hydrocarbons through previous surveys. The skeptic Elf geologists had no other instructions other than to collaborate with the inventors. Geophysicists, electronic experts and computer scientists in Elf had the mission of "learning and understanding."

The Montegut well was spud by Elf in the

Aquitaine Basin in southern France in January 1977, reaching a total depth of 4,483 meters without encountering any hydrocarbon. The inventors justified the failure because the well was not properly positioned and therefore missed the oil reservoir.

A second drill test was run in 1977, in the onshore portion of the Zululand Basin in South Africa, where the sniffer device had identified a large 'bone shape' hydrocarbon accumulation. The well was spudded against the opposition of the Elf geologists, who questioned this basin being oil-prospective. At 6,083 meters and after penetrating more than 2,000 meters of basaltic rocks, the drilling pipe was stuck some 1,500 meters below where the hydrocarbons had been predicted by the inventors. The well was then plugged and abandoned after nearly 600 days of drilling and 100 million French francs spent. This time the well failure was rationalized by the inventors who stated that drilling should have continued 200 meters deeper! Of course, the Elf geologists who had questioned the device



The two inventors are in the middle: the Italian Aldo Bonassoli (grey jacket) and Belgian Alain de Villegas (light blue overcoat).

and the pseudo-science behind it felt they had been duped.

Nevertheless, and in spite of the drilling failures, another contract was signed in June 1978 between Elf-Aquitaine and Faisalma, the company representing the inventors. The secret technique was again to be tested, this time in Spain.

### Oil Pooled in Volcanic Rocks in Southeast Spain?

Six hydrocarbon exploration permits located in southeastern Spain, named Almeria I to VI, were awarded in March 1979 to "Investigaciones Geológicas, S.A.," a totally unknown company in the petroleum exploration business. Three permits were located offshore and three onshore. Surprisingly, the onshore permits had the commitment of drilling one exploration well during the first two-year exploration period and, what was even more puzzling, two of them were located partially covering the Cabo

de Gata region, a well-known Miocene volcanic complex!

In May 1980, by following the instructions of the Elf headquarters and ignoring the recommendations of its geologists, the Elf-Aquitaine subsidiary in Spain farmed in with a 5-percent interest in all six of the Almeria permits, becoming the operator. This deal invited speculation about who was actually behind the exploration venture in this volcanic region, and why.

Elf spudded the Cabo de Gata-1 exploration well in July 1980. The well had been located based on a flight by the sniffer airplane over the region, which precisely identified oil below a mountain peak within the volcanic terrain. It took some time to convince Elf management to move the well downhill to a more manageable drilling location. In August 1980, the well reached a total depth of 1,128 meters, all drilled through volcanic, mainly andesitic rocks, tuffs and volcanic ash. The

Continued on next page ►

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Monitor supposedly showing virtual images of the subsurface

#### ◀ Continued from previous page

well was plugged and abandoned without any hydrocarbon indication, establishing another milestone in drilling volcanic rocks for oil exploration! It was very difficult for the Elf representatives in Spain to explain this humiliation, but they alleged that Elf had participated with only 5 percent in the operation. However, after a time, they discovered that Investigaciones Geológicas, S.A. received all funds from the sponsors of the sniffer plane, through an intermediary society based in Liechtenstein fully supported by Elf.

The sniffer device was then widely questioned, since all the exploration wells drilled based on this revolutionary technique had failed to encounter a single drop of oil.

#### The Hoax is Unmasked

The hoax was discovered when the nuclear French scientist Jules Horowitz denounced the device that could allegedly detect oil from the air as an elaborate fraud. Horowitz took roughly a few seconds in a simple test to discredit the device. When Bonassoli told him his machine could detect a straight metal ruler from behind a wall, Horowitz took the ruler and went quietly to the next room. The device printed out a perfectly clear outline of a straight ruler ... whereupon Horowitz emerged holding the real ruler, which he had previously bent into an L shape without telling anyone.

When the hoax was acknowledged the detector was opened, revealing it contained a series of video recorders, with a cluster of electronic devices attached to a photocopier look alike; in fact, that is exactly what it turned out to be eventually: a bunch of equipment connected to a simple photocopier. When testing the sniffer device above known oil fields, subsurface maps had been previously provided by a mole inside Elf, who facilitated the inventors the technical and geological information Elf had on those fields, so that the maps delivered by the photocopier had been previously manipulated, adjusted and loaded into. Similarly, the images displayed on the TV monitors had been prerecorded and were activated by the inventors by remote control. The devices were no doubt recognized as fakes and returned to the inventors.

It was considered that failing to notice the falsification of the device would be a political embarrassment that would damage Elf's international reputation. The sniffer affair was therefore muted by the French government at the time, headed by Valéry Giscard d'Estaing, president from 1974 until May 1981, when the socialist François Mitterrand became president.

#### Political Scandal in France

The sniffer plane story was forgotten until it went public on Dec. 21, 1983, following an investigation by the satirical weekly *Le Canard Enchaîné*. The journal revealed the

existence of a secret report issued in January 1981 by the French Accounting Court on the sniffing aircraft case, of which all copies had been apparently destroyed. The airing of the fraudulent affair immediately became a national scandal, especially when it turned out that the people who had gotten fooled by the two inventors also included the former President Giscard and Prime Minister Raymond Barre. The secret report illustrated how the project had been personally approved by Giscard, which forced him to appear in a rush on TV on Dec. 22 giving all kind of explanations and showing agitatedly a paper copy of the secret report which had allegedly been destroyed.

The secret report was made public in January 1984. It described the numerous irregularities of the affair, the lack of any proper testing of the devices and processes, the absence of investigation or vetting of the inventors' personalities and scientific backgrounds, the disregard of cost control procedures, the creation of a pyramid of subsidiaries and how the inventors managed to convince the French president and the Elf-Aquitaine top management that they were on to something "that could change the fate of France, even the world."

The scandal had an important impact in the political life of France during early 1984, with fierce verbal attacks and confrontation between the ruling socialist party and its right-wing opponents, until it gradually faded from public consciousness.

Now, more than 40 years later, it is still difficult to understand how such a simple and naïve trick had been able to fool, and for so long, the top management of a major oil company, and against the opinion of its own technical staff.

#### Epilogue

The total amount of money invested by Elf in the sniffer plane affair has never been clarified. It is estimated between \$50 million and \$250 million, depending on the source, but it is even less clear where the money wound up.

Nobody was brought to justice and nothing happened to Aldo Bonassoli and Alain de Villegas. Both inventors had faked the sniffer device, but surprisingly, they appear to have believed in their invention. In early 1984, Bonassoli was back in Italy, where he continued expressing faith in the sniffer machine and denied that he had made any money out of the affair. He always declined to discuss the technique in detail, saying that it was still secret. He threatened to hand over his machine and know-how to the Italian government and announced that the Soviets had expressed interest in the device. However, nothing ever came of the announcement. Alain de Villegas, meanwhile, disappeared from the scene. Apparently, he had run away to South America where he started to build landing strips for flying saucers. Rather than tricksters, they both appear to have been lunatics! 📺

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## Geophysical Corner

# Some Machine Learning Applications in Seismic Interpretation

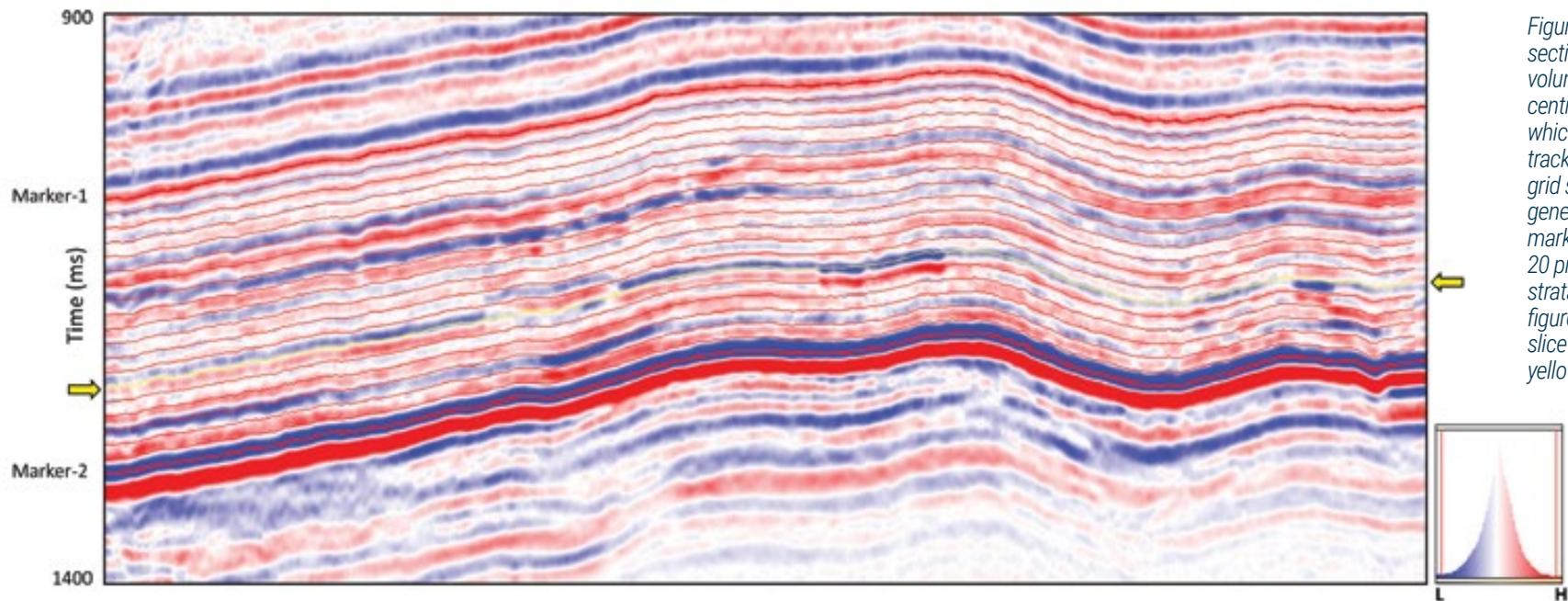


Figure 1: Segment of a section from a 3-D seismic volume from south-central Alberta, Canada, which has two markers tracked on it. The strata grid shown overlaid was generated within these two markers and divided into 20 proportional slices. The strata displays shown in figures 2 and 3 are along slice 14 indicated with the yellow arrows.

“Big data” and “data analytics” are the buzzwords these days. The oil and gas industry has always had large volumes of data to acquire, process and interpret, and since the introduction of 3-D and 4-D seismic data acquisition, the handling of large quantities of data has only become more challenging. As our industry moved from large mainframe computers coupled with array processors to scalable multiprocessors for crunching large volumes of data, seismic software, data storage and visualization capabilities have been able to keep pace.

But, in the last decade, our industry grappled not only with ever-larger volumes of data, but also with increased data heterogeneity. Fortunately, advancements in handling such large, heterogeneous, “big data” volumes, have come along. Recent developments in data analytic capabilities applied to other industries hold significant promise for those of working in the hydrocarbon exploration and development.

“Data analytics” refers to a special class of analytical tools or methods that are used to study complex systems, many of which are not amenable to traditional analysis, such as multivariate statistics.

## Deductive versus Inductive

To better understand traditional interpretation versus data analytic workflows, we need to distinguish two terms: “deductive” and “inductive” reasoning. Using logic or

reason to form a conclusion or opinion about something is deductive, whereas using examples to reach a general conclusion about something is inductive.

Interpreters routinely use deductive reasoning, analyzing the data using principles of geology, physics and petrophysics. Examples might be as simple as constructing synthetics to tie a well log to seismic data, or as complex as defining the environment of deposition using pattern recognition and modern analogues. There are two limitations to this approach. The first is that, try as we will, we may not be able to understand the physical reasons why one area of a survey is more productive, or alternatively completes better, than another. The second is that we may simply not have enough time to carefully correlate multiple attribute volumes using principles of physics and geology.

In contrast, data analytics uses inductive reasoning to find patterns between multidimensional data volumes. Petrophysical analysis tells us that there is a theoretical basis for porosity to correlate to P-impedance and is an example of deductive theory-based reasoning. In contrast, if there is a statistically significant correlation between TOC and P-impedance for multiple wells in a specific play, and if we can successfully



CHOPRA

validate this correlation on new wells, we have an example of transductive (good for a limited number of data sets only) or inductive (good for most data sets) data-based reasoning. Often, we do not know the reason behind a good correlation but given significant validation, we can use it as a statistically valid prediction tool. In other cases, the correlations identify a feature that can be explained by an already established theory. In still other cases, the correlations allow us to formulate a hypothesis based on physics or geology that, with further validation, can lead to a new theory.

## Supervised and Unsupervised Learning

Machine learning algorithms can be broken into supervised and unsupervised learning subsets. Supervised learning is perhaps the easier subset to understand. Here, the interpreter provides training data, or “labels,” to the algorithm in addition to multiple seismic attribute volumes. Common labels include the names of seismic facies described by interpreter-constructed polygons or of assignment of voxels along a well bore to measured lithology, geomechanical behavior, or fracture intensity. Key to supervised learning is selecting attributes that differentiate the feature of interest from the background geology.

As in cross plotting electric log properties, a shortcoming of supervised learning is that it will only search for explicitly defined features, such as carbonate versus dolomite versus

shale. If there is also anhydrite in the system, it may be misclassified into one of the defined classes. Common machine learning techniques include:

- ▶ Decision trees
- ▶ multilinear feedforward neural networks
- ▶ probabilistic neural networks
- ▶ support vector machines

Unsupervised learning is slightly more difficult to understand. Here, the training data are a random set of voxels drawn from multiple attribute volumes themselves. The objective is to find patterns that in some measure represent the bulk of the data. A point of confusion is that most interpreters think of patterns as a reflectivity pattern seen on vertical, horizontal or horizon slices. These latter structural and spectral patterns are measured by seismic attributes. Rather, in unsupervised learning, the “patterns” are measured across multiple attribute volumes at a given voxel. For example, a salt dome might be represented by the four-dimensional attribute pattern of low-coherence, high entropy, low envelope and low reflector parallelism, while conformal sand/shale reflectors might be represented by high coherence, low entropy, moderate to high envelope and high reflector parallelism.

Not all the tools in the data analytics

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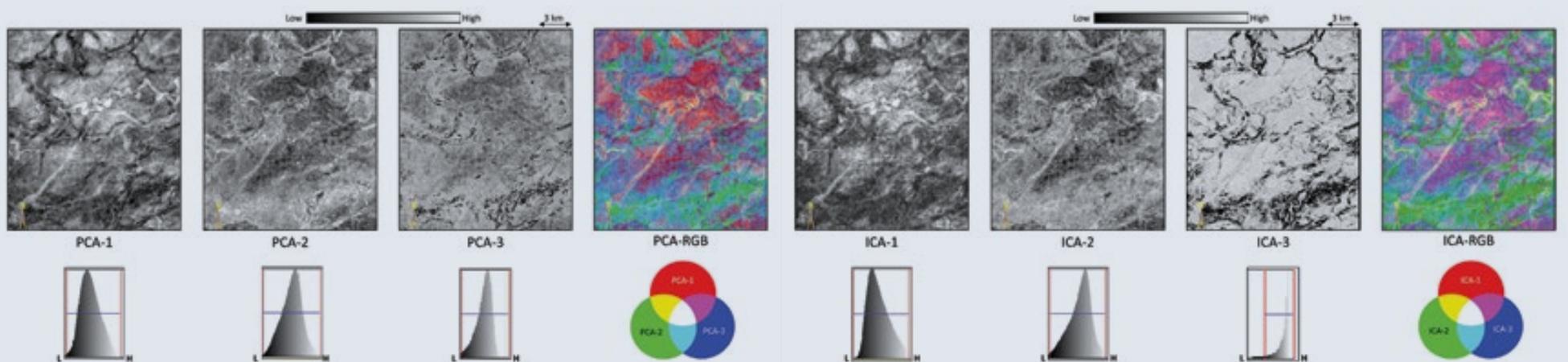


Figure 2 (left): Stratal slices from the first three principal components, and their co-rendered display using red (R), green (G) and blue (B) colors. Paleo channels of different dispositions and sizes are seen on the displays. Each of the first three displays exhibit somewhat different information. The RGB display puts it all together. Figure 3 (right): Stratal slices from the first three independent components, and their co-rendered display using red (R), green (G) and blue (B) colors. The different paleo channels seen in figure 2 are seen here again, but with somewhat different definition, which is interestingly seen more pronounced in the ICA-3 display. The RGB display puts all the information together, and the overall channel definition seems to be better in the ICA-RGB display.

## ◀ Continued from previous page

toolbox are new. For example, principal component analysis, self-organizing mapping, fuzzy logic, support vector machines, neural networks, etc. have all been used in interpretation for some 20 years, but in relatively focused applications, such as multi-attribute analysis along a picked horizon, or multi-log analysis along a small set of wells. The major limitation has been the "big" part of our modern data. The advent of multicore desktops machines, graphical processor units and interpreter access to supercomputers previously limited to seismic imaging and flow simulation, along with advances in software development now allow the analysis of large data volumes.

### Humans Still Needed

A common misconception is that machine learning will replace human interpreters.

The most common use of decision tree-based machine learning is a horizon autopickers. Autopickers have been in use for 20 years – yet each horizon needs to be examined and usually modified by a human interpreter.

First-break pickers for statics corrections have used neural networks for at least 10 years. Here, the human processor needs to quality control the results and add additional control (or corrections) where needed. The role of the interpreter will change from mundane picking to evaluating alternative hypotheses and evaluating the results. It is a pity that, these days, we see and hear about expert knowledge getting phased out by way of chosen or forced retirements due to the economic downturn from which we are still recovering. Can we somehow capture this expertise as part of a rule-based machine learning application? If so, data analytics applications on big data, where the machine learns from the human quality control, and where the interpreter poses new hypotheses, is the future for your industry.

There are several ways of combining multiple attributes, with visualization in red-green-blue (RGB) color space, coupled with transparency as one of the more powerful means. Unfortunately, such a color display is limited to three, and with transparency, four attributes. One of the methods commonly used for this purpose is principal component analysis, and a more recent one is independent component analysis. Both these methods 'churn' the different attributes and yield one, two or three volumes that represent the maximum variation in the input attributes. Such analysis reduces the redundancy in the input attributes. We present the results of our investigation into the application of both these methods on a seismic data volume from central Alberta, Canada.

### Machine Learning Tools

Principal component analysis is a useful statistical technique that has found many applications, including image compression and pattern recognition in data of high dimensionality. We are familiar with the usual statistical measures like mean, standard deviation and variance, which are essentially one-dimensional. Such measures are calculated one attribute at a time with the assumption that each attribute is independent of the others. In reality, many of our attributes are coupled through the underlying geology, such that a fault may give rise to lateral changes in waveform, dip, peak frequency and amplitude. Less desirably, many of our attributes are coupled mathematically, such as alternative measures of coherence or of a suite of closely spaced spectral components. The amount of attribute redundancy is measured by the covariance matrix. The first step in multi-attribute analysis is to subtract the mean of each attribute from the corresponding



David Lubo-Robles received a bachelor's degree in geophysical engineering from Simon Bolivar University, Venezuela, and a master's in geophysics from the University of Oklahoma under Kurt J. Marfurt. He is a student member of the Society of Exploration

attribute volume. If the attributes have radically different units of measure, such as frequency measured in Hertz, envelope measured in millivolts, and coherence without dimension, a Z-score normalization is required. Mathematically, the number of linearly uncorrelated attributes is defined by the value of eigenvalues and eigenvectors of the covariance matrix. The first eigenvector

Geophysicists and currently is pursuing a doctorate in geophysics at the University of Oklahoma, studying under Marfurt and Matthew Pranter. His research interests include the development and application of modern machine learning and pattern recognition techniques, together with quantitative interpretation skills, including pre-stack inversion and seismic attribute analysis to delineate geologic features

is a linear combination that represents the most variability in the scaled attributes. The corresponding first eigenvector represents the amount of variability represented. Commonly, each eigenvalue is normalized by the sum of all the eigenvalues, giving a percentage of the variability represented. By convention, the first step is to order the eigenvalues from the highest to the lowest.

amenable to hydrocarbon accumulation.

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.



The eigenvector with the highest eigenvalue is the principal component of the data set (PC1); it represents the vector with maximum variance in the data and represents the bulk of the information that would be common in the attributes used. The eigenvector with the second-highest eigenvalue, called the

See PCA page 29 ▶

## Interpretation® upcoming submission deadlines

### MAY 2019

#### ► Interpretable seismic velocity

**Submission deadline: 1 August 2018**

Special-section editors: Jianxiong Chen, Alfred Liaw, Xianhui Zhu, Xin Wang, Tao Li, Priyank Jaiswal, Yafei Wu, and Xin Cheng

#### ► Near-surface impact on seismic exploration

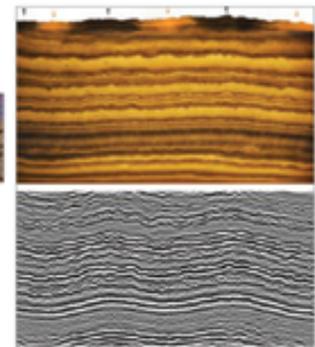
**Submission deadline: 1 August 2018**

Special-section editors: Claudio Strobbia, Daniele Colombo, Rick Miller, Andreas Laake, and Cedric Schmelzbach

#### ► Seismic geometric attributes

**Submission deadline: 1 October 2018**

Special-section editors: Xinming Wu, Hongliu Zeng, Haibin Di, Dengliang Gao, Jinghui Gao, Kurt Marfurt, Saleh al Dossary, and Geoffrey Dorn



### AUGUST 2019

#### ► Insights into digital oil field data using artificial intelligence and big data analytics

**Submission deadline: 1 October 2018**

Special-section editors: Vikram Jayaram, Andrea Cortis, Bill Barna, Atish Roy, Deepak Devegowda, Jacqueline S. Floyd, Pradeepkumar Ashok, Satyam Priyadarshy, Aria Abubakar, Chiranth Hegde, and Emmanuel Schnetzler

#### ► Geologic and geophysical characterization of ultra-deep reservoirs

**Submission deadline: 1 October 2018**

Special-section editors: Rui Zhang, Shu Jiang, Yongsheng Ma, Zhiwen Deng, Jiajia Sun, and Xinming Wu

#### ► Machine learning in seismic data analysis

**Submission deadline: 1 November 2018**

Special-section editors: Haibin Di, Lei Huang, Mauricio Araya-Polo, Youzuo Lin, Anne Solberg, Tao Zhao, Xinming Wu, Vikram Jayaram, Jun Cao, Satinder Chopra, Erwan Gloaguen, Saleh Al-Dossary, Ghassan AlRegib, and Hongliu Zeng

#### ► Brazil

**Submission deadline: 1 November 2018**

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**Submission deadline: 1 December 2018**

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**Submission deadline: 20 January 2019**

Special-section editors: Huyen Bui, Daniel Bean, Bill Berger, Eric Cauquil, Andy Hawthorn, Brett Judy, Andreas Laake, William Sager, Craig Scherschel, Niall Sloney, Fabian Vera, and Steve Wardlaw

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Interpretation, copublished by SEG and AAPG, aims to advance the practice of subsurface interpretation.



# IBM's AI Adviser Promises 'Transformation' of Oil Exploration

**O**f all the changes coming in the oil and gas industry, artificial intelligence is likely to be one of the most significant.

"I think we are living in a truly unprecedented time that AI technologies have the potential to transform the exploration and production processes," said Ulisses T. Mello, director of IBM Research – Brazil (BRL).

Mello is an IBM distinguished engineer and led the Smarter Natural Resources and Discovery area at BRL until 2012. He also is an IBM Global Research executive for the chemicals and petroleum industry sector.

IBM has developed an AI-based adviser to aid and enhance seismic interpretation in partnership with Galp, a Portuguese energy group with a global footprint.

The tool can facilitate creation of enhanced geological models, risk assessment of new prospects and optimization of the placement of new oil wells, Mello said.

Petrogal Brasil and IBM Research-Brazil undertook the three-year research project under the Brazilian National Petroleum Agency R&D incentive regulatory framework.

Exploration "is very knowledge intensive and the way every expert does his or her work varies significantly, depending on the expert's previous experience and his or her tacit knowledge," said Mello.

"This project is not about pure application of AI technologies (like machine learning and deep learning). It has a strong component of Knowledge Representation and Reasoning, as well as the use of continuous learning from the professionals," he added.

"I would say that capturing and normalizing the level of knowledge involved in seismic interpretation was a big challenge," Mello said.

"Relatively reduced data volume was also



MELLO

**"We are in the infancy of this transformation. There are substantial challenges ahead of us but some of the benefits of narrow AI are ready now. Some may see this as hype, but this is coming for real."**

an issue," he added.

While the oil and gas industry as a whole has massive amounts of data, the amount of information available on a particular asset can be limited in most companies. To get good results, this data must be augmented with other forms of knowledge, Mello explained.

## Easing the Workload

The new tool uses AI and other state-of-the-art technologies to interact with scientists.

The scientists can use the tool to create and enhance geological models, devise faster and more efficient risk assessment and optimize placement of new wells, he said.

The tool uses knowledge gleaned from previous interpretations and experiences that are captured on a practice-driven knowledge representation system. It uses new data and interaction with users to learn and continuously improve its capabilities.

"The prototype integrates relevant information from multiple sources, including seismic images, academic papers, notes, and reports. Using AI techniques, it presents suggestions to geoscientists with supporting evidence," Mello said.

He said the tool has been well accepted by geoscientists working on the project.

"Most scientists tend to have a workload that involves both mechanical and intellectual work. Most would prefer to work on the intellectually challenging work. The adviser helps in both ways by accelerating the completion of the mechanical work and pointing out information and knowledge that could be helpful for a more comprehensive, efficient and rewarding work. With that understanding, most of the users that we have worked with in this project have not only accepted but embraced the technology. This technology is coming to help and improve productivity and effectiveness, and most professionals really value that," Mello said.

He said the tool also can help young professionals develop their expertise more quickly and can help avoid individual bias in interpretation. It also helps users compare information from different projects, different geographies and different decades.

## Evolving the Technology

Another goal is to make the tool easily accessible.

"The technology is supposed to be a sidekick that can be embodied using some rich forms of interfaces, ranging from mobile

apps to chatbots. At this point we have a traditional web-based prototype and we are doing digital ethnography studies to define what is the best way to have the tool being consumed by scientists," Mello said.

Mellos aid the adviser has been applied to several real cases in Brazil and worldwide.

"We have early indication of very significant gains. Now we are formalizing a process for assessment and benchmarking to have the value quantified with rigor using well defined business and technical key performance indicators," he said.

Mello said the researchers hope to add many more capabilities to the adviser.

"The exploration process has phases in which very limited data is available and as the processes advance, more data and knowledge are acquired. The value of information varies along the evolution of the asset, so there is a lot of room to use AI techniques such as Transfer Learning from mature analog assets to less mature ones. This a direction that we would like to grow," he said.

He said the specific project with Galp had about 10 people assigned to it but suggested that figure could be misleading because the project leveraged the support of technologies developed by IBM research and Watson. IBM research employes about 3,000 scientists, with about 100 people in natural resources, including oil and gas, Mello said.

Mello said AI is poised the transform the oil and gas industry.

"We are in the infancy of this transformation. There are substantial challenges ahead of us but some of the benefits of narrow AI are ready now. Some may see this as hype, but this is coming for real," he said. [E](#)



AAPG

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[ACE.AAPG.org](http://ACE.AAPG.org)

# AAPG Foundation's K-12 Initiatives Fund Future Geoscientists

Ask geoscientists how their enchantment with Earth science began and chances are, the first sparks of fascination will have taken place in childhood. Whether that first experience was pocketing an interesting rock or fossil to add to a collection, or noticing the stratified layers of earth while vacationing on summer break, the foundation of many geoscientists' careers was established at an early age.

That's why it's important to give young people the opportunity to light that spark.

By funding K-12 educational initiatives, the AAPG Foundation invests in the next generation of geoscientists, the educators who inspire them, the future advancement of geoscience and technology and the education of the general public.

AAPG Foundation support of K-12 educational initiatives for students and educators include:

## Earth Science Week

The AAPG Foundation contributes educational toolkits to the American Geosciences Institute's Earth Science Week, the geoscience community's leading public awareness campaign. According to AGI, this "international event to help the public gain a better understanding and appreciation for the Earth sciences" reaches more than 50 million people each year and "offers opportunities to discover the Earth sciences," as it relates to "geoscience principles and issues such as energy, climate change, the environment,



natural disasters, technology, industry, agriculture and the economy."

To learn more about Earth Science Week or to view the Earth Science Toolkit, visit [EarthSciWeek.org](http://EarthSciWeek.org).

## Houston Museum of Natural Science

With more than half a million school children visiting last year, the Houston Museum of Natural Science is one of the most popularly attended museums in the United States. The AAPG Foundation provides financial support to educational science programming designed to introduce and engage museum visitors to scientific activities in the fields of geology, paleontology, biology, anthropology, astronomy, chemistry and physics.

Visit the Houston Museum of Natural Science website at [HMNS.org](http://HMNS.org).

## Teachers' Day Program

Science teachers are at the very heart of the Foundation's K-12 educational efforts because these educators provide the springboard for the future careers of geoscientists. Each year, science teachers are invited to attend the Teachers' Day Program at AAPG's Annual Convention and Exhibition to explore new methods and technologies in teaching an Earth science curriculum to their students.

Teachers' Day is an opportunity to meet other educators from around the country, to observe and practice hands-on demonstrations of classroom activities and to acquire materials designed to assist them in teaching. Teachers' Day attendees also receive a guided tour of the convention.

To learn more about Teachers' Day Program at the 2019 ACE, contact the AAPG Foundation at [Foundation.AAPG.org/programs/k-12.cfm](http://Foundation.AAPG.org/programs/k-12.cfm).

## Teacher of the Year Award

The prestigious Teacher of the Year Award is presented each year by the AAPG Foundation to a K-12 teacher within the United States who has demonstrated outstanding leadership in the field of geoscience education.

The award includes a plaque and a cash prize of \$6,000, half going to the TOTY recipient's school for educational purposes under the recipient's supervision and the other \$3,000 for the recipient's personal use.

In addition, the TOTY recipient receives an expense-paid trip for two to ACE to receive the award.

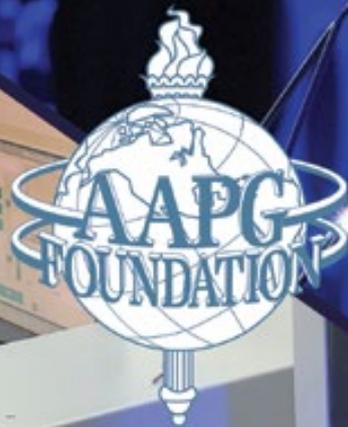
Applications for the 2019 Teacher of the Year award open on Aug. 31, 2018. For more information, visit the aforementioned Foundation website. [E](http://www.aapg.org)



## TEACHER OF THE YEAR

Opens Aug. 31, 2018 | Closes Feb. 1, 2019

The AAPG Foundation bestows this award on a K-12 teacher who demonstrates outstanding leadership in the field of geoscience education. The award includes \$3,000 to the teacher's school for educational purposes under the teacher's supervision and \$3,000 to the teacher.



The Grants-in-Aid program promotes graduate-level research in the geosciences. Grants of \$500-\$3,000 provide assistance to graduate students whose research has application to the search for and development of petroleum and energy-mineral resources and/or to related environmental geology issues.

## GRANTS-IN-AID

Opens Aug. 31, 2018 | Closes Dec. 3, 2018

Learn more. Visit

[foundation.aapg.org](http://foundation.aapg.org)

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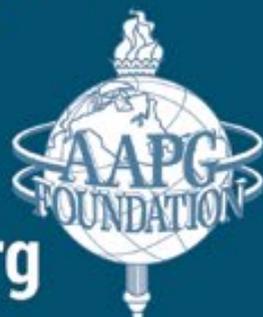
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The AAPG Foundation Trustee Associates play a vital role in the development of the AAPG Foundation's financial resources. With their guidance the Foundation is able to support more than 30 funds and programs.



To learn more about the AAPG Foundation's Trustee Associates, or how to join, please contact the Foundation office at (918) 560-2644.



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

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# Back to the Future

The Past and the Future of Oil and Gas Production in the Asia Pacific Region

27-28 September 2018 • Bangkok, Thailand

The upstream oil and gas business has two primary functions: the front-end loaded exploration phase and the development-focused harvest mode, which results in actual hydrocarbon production and revenue generation. Both of these processes require extensive geoscience input but the scope, techniques, and time involved are quite different. **This two-day workshop** will focus on these two siblings: the first day will focus on mature field development and the second day will highlight exploration potential within the Asia Pacific region.

#### Who Should Attend

- Geologists
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- Petrophysicists
- Drilling and Completions Engineers
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# 10th Hydrocarbon Exploration and Development Congress

**November 5-9, 2018**  
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Energy Opportunities will take place at the Hilton Cartagena on the Colombian City's Laguito Peninsula.



GÓMEZ

**“ We need to protect the environment and seek the greater good for communities. No matter what kind of energy project is implemented, social license is key.”**

## Program from page 16

event helps AAPG stay relevant, current and proactive.

“In other conferences, we mainly concentrate on oil and gas. This time, incorporating the role of communities and having the region's regulatory agencies present will help us to improve our exploration and production activities across the region,” he said. “We need to learn from others the best way to optimize licensing and permitting procedures and to understand the role of the geoscientist in a scenario in which the energy matrix is changing.”

#### Diverse and Inclusive Program

Gómez said the conference “is about Latin American and Caribbean energy business.”

She noted how, in addition to traditional sessions like offshore developments and unconventional resource exploration, the program includes sessions focused on alternative energies, empowering communities and protecting the environment.

“Those of us working in industry recognize that world is entering in a new era where the energy mix has to be balanced. We need to talk about multiple energy choices, their sustainability and costs and benefits, and we need to work through energy transition in the most efficient manner possible. We need to protect the environment and seek the greater good for communities. No matter what kind of energy project is implemented, social license is key,” she said.

“In addition to helping us to be us good citizens and human beings, keeping these components in mind ultimately makes our companies more successful.”

The conference also includes companies not usually present at AAPG conferences.

Speakers from S&P Global, Wood MacKenzie, Norton Rose Fullbright Baker McKenzie will discuss legal and financial considerations involved with working in the region. Nvidia, IBM and BakerHughes GE will provide an insight into how new technologies like artificial intelligence and robotics are transforming the energy sector. Also, an Associations panel provides best practices for working with industry and government.

Londoño said he is looking forward to attending as many sessions as possible.

“I see a diverse, high level, very balanced agenda that was designed in such a way that it is possible to attend most of the talks,” he said. “As a technical professional in charge of exploration, I am very interested in the subject of new technologies, but I think I will enjoy the event in its entirety.”

#### Expectations for the Conference

Londoño plans to maximize his time in Cartagena.

“I hope to understand where industry and technology are moving; I'm very interested in Artificial Intelligence and Big Data sessions; to establish new professional and commercial relationships, expand my network, and – why not? – bring in my briefcase a couple of business ideas that can be discussed in my company,” he said.

“I hope to finish the conference with a better idea of the current panorama of the Latin American energy industry, to understand where the industry is going in our subcontinent, where there may be opportunities for growth, and opportunities for improvement in what we are doing. I think that the B2B sessions summarize the spirit of the meeting, because we can come away from the conference with concrete business opportunities,” he added.

Londoño said the conference represents an important opportunity for Ecopetrol and its subsidiaries, who will deliver presentations during the offshore and communities and environment sessions.

“We also want to deliver a clear message to attendees that Ecopetrol is open for business,” he said.

#### Invitation to Attend

Vega said attending conferences like Energy Opportunities helps geoscientists to have a more active role in the energy business.

“I encourage my colleagues to explore beyond their technical arena to understand the importance of what we do, especially during exploration phases where we are looking for hydrocarbons and potentially changing or influencing economies in our region and the world. As geoscientists we have a lot to offer and share with other disciplines and organizations,” he said.

Londoño encouraged colleagues to take advantage of this historic moment for Colombia in the country's most historic city, founded in 1533.

“I extend a cordial invitation to those interested in attending to discover our new country, where the combination of the peace process and a pro-business governmental agenda signal a promising future for the energy industry in Colombia,” he said.

“Attending the conference is the perfect excuse to visit the beautiful city of Cartagena, whose historic center and exceptional cuisine make it forever charming.”

For conference information, registration and sponsorship and exhibition information visit [energyopportunities.info](http://energyopportunities.info). 

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disorder or complexity of the image, and GLCM homogeneity is a measure of the overall smoothness of the image. More information on these attributes can be found in Geophysical Corner in the November 2013 and April 2014 issues of the EXPLORER.

► Spectral decomposition frequency attributes (spectral magnitude components, peak frequency and peak magnitude): Spectral decomposition refers to the transformation of seismic data into individual frequency components within the seismic bandwidth. The derived frequency data have found application for the interpretation of bed thickness, discontinuities and distinguishing fluids in the reservoirs. Spectral decomposition has been described extensively in the Geophysical Corner columns of the December 2013, January, February, March and August issues of 2014, March 2015 and the May 2016 issue.

### Applications

The dataset chosen for this exercise is from central Alberta, Canada. We focus on the Mannville channels that are filled with interbedded units of shale and sandstone. On the 3-D seismic volume, these channels show up at the level indicated with a yellow arrow in figure 1.

The input attributes used for the principal component and independent component multivariate analysis are the multispectral coherence, GLCM-energy, GLCM-entropy, GLCM-homogeneity, spectral magnitudes at 30, 40 and 50 Hertz, and coherent energy. The stratal slices at the level of the yellow arrow in figure 1 are shown from the PCA and ICA in figure 2 and 3 respectively. The first, second and third components from both the methods are depicted as well as their co-rendered displays using RGB. Notice the second, third and co-rendered displays show crisper definition of the paleo channels for the independent components than on the principal components.

Thus, in conclusion, we state that while the data reduction in principal component and independent component analysis is powerful, the latter has an edge over the former. These smaller number of components can then be used in more sophisticated machine learning tools such as self-organizing mapping and generative topographic mapping. We will discuss the applications of these machine learning tools in another article sometime. 

*(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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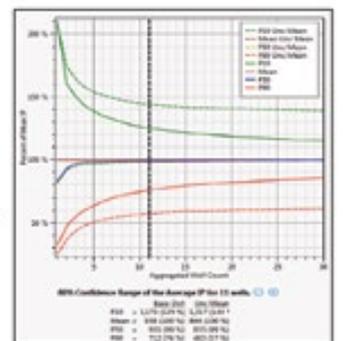
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## Director's Corner

## AAPG's New Code of Conduct

If you attended the AAPG Annual Convention and Exhibition in Salt Lake City this year, you may have noticed additional signs in the hallways and slides shown in the opening and technical sessions that introduced the AAPG Code of Conduct. It's a new element for ACE and it's something we care about in our desire to foster an environment that allows our attendees to best realize their professional goals. This month I'd like to share with you how it came to be, and more importantly, why.

Watching the news coverage in recent years has been unsettling, with accusations leveled against multiple prominent men, in positions of power, about their egregious behavior toward women. Some of them were charged with criminal behavior and convicted, others are still under investigation or quietly slipped from public view.

These cases made headlines because the individuals involved were prominent people. But there were also disturbing reports of misconduct in the geosciences.

In October of last year, the journal *Science* published an article about allegations of sexual harassment leveled against a prominent geoscientist by some of his former graduate students. As I talked to my colleagues in other scientific organizations, they revealed that they, too, were grappling with these issues.

#### Why the Code Is Needed

Still, I must confess, I didn't think we – AAPG – had a problem like this.

After all, we're a professional association. We exist to advance the science and profession of petroleum geology. Many of our members work in companies with strict policies on conduct and against harassment.



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**“We have a job to do. The world may not appreciate its importance, but they're wholly reliant on our success for energy and their way of life. That's our purpose. Let's hold our purpose in mind when we get together.”**

AAPG itself has such policies that articulate our expectations of our employees, as well as our expectations of those who interact with our employees. Surely, we know how to behave professionally.

It turns out I was being naive.

The day after ACE 2017 – our centennial celebration – I received a report that one of our members, an early career professional, was the subject of an unwelcome advance at the headquarters hotel. The action wasn't criminal, but it was unsettling and caused offense for the recipient and was clearly unprofessional.

The challenge in addressing this issue was that we had no clear policies governing these types of situations involving members or attendees at our events.

Since its inception, AAPG has emphasized the importance of ethics. In fact, our code of ethics is enshrined in the Association's constitution. But it's principally concerned with the ethical practice of petroleum geology. And, it's one of the reasons that AAPG was formed – to hold ourselves and each other to certain ethical standards and communicate those standards to the public.

But the code of ethics and its enforcement mechanisms seemed ill-fitting for this type of issue and for other forms of harassment and unprofessional conduct. We needed something more.

“AAPG is dedicated to providing a harassment-free conference experience for everyone, regardless of gender, sexual orientation, disability, physical appearance, body size, race, or religion. We do not tolerate harassment of conference participants in any form,” the Code of Conduct begins.

It goes on to describe types of behavior to be avoided and encouraged, and warns that violations of the code will result in AAPG taking the actions it deems appropriate given the circumstances.

#### Implementation So Far

We've provided several mechanisms for conference participants who are made to feel unsafe or unwelcome by reporting it to an AAPG Executive Committee or Convention staff member, reporting it anonymously via an online form, and finally by calling a toll-free number. You can find the code simply by searching “AAPG Code of Conduct” online.

After unveiling the Code of Conduct at ACE in Salt Lake City we received two anonymous online complaints about the same issue, namely the use of a racially-insensitive slide and accompanying remarks in a technical talk. The reporters indicated that it was inappropriate and could easily offend. After reviewing the slide, we agreed, and AAPG is

following up directly with the author/speaker about the issue.

This Code of Conduct is a work in progress. We're learning as we get more information through its implementation and refine the policies behind it. We're also planning to broaden it to all Association activities.

Feedback we've received has been positive. But, I fully expect to hear some grumbles that “We haven't needed this for a century – why now?”

I think there are two reasons: First, societal expectations and norms have changed and the Association must change to accommodate them. Second, the purpose of AAPG is twofold: to advance the science of petroleum geology and to promote the business of finding and developing this vital natural resource.

When we gather together as petroleum geologists we're looking to do those two things. And I'm hard-pressed to understand how the Code of Conduct undermines either. We don't need rules for their own sake, but we can use rules to accomplish these objectives.

Mutual respect, careful communication and professional conduct help us get there. They're how we attract the next generation of petroleum geoscientists into our science and industry.

We have a job to do. The world may not appreciate its importance, but they're wholly reliant on our success for energy and their way of life. That's our purpose.

Let's hold our purpose in mind when we get together. Let's hold ourselves and each other to a higher standard, as our founders intended. Let's honor and respect each other in word and deed. Let's do our jobs well.

By WAYNE CAMP, EMD President

## Divisions Report: EMD

## EMD's Plans for the Future

I am pleased to serve as president of the Energy Minerals Division for 2018-19.

EMD is the largest division of AAPG, with a long history since our founding in 1977. Our members worldwide represent a diverse group specializing in the geology of unconventional and alternative energy resources.

My main interest since joining the EMD leadership team as vice president in 2016 is to improve our service to members.

My main goals for this year are to provide frequent, easily accessible, relevant, high-quality technical content, and to improve our member engagement and communication with the regions, local societies and other geological associations. If we get these two enterprises right, then we should be able to retain and attract new members to help develop the next generation of leadership to keep AAPG a strong and viable organization for the next 100 years.

We are off to a good start.

Our members are actively working with the 2019 AAPG Annual Convention and Exhibition Technical Program Committee to again provide high-quality oral and poster sessions and short courses for the popular unconventional themes. Ursula Hammes is the EMD vice chair to coordinate our efforts with the San Antonio convention committees. EMD members have formerly proposed a session on mudstone diagenesis and a forum on bitumen. We are also planning our regular joint luncheon meeting with the Division of Environmental Geosciences, where all are invited to reconnect with old friends and foster



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**“EMD is uniquely positioned to promote alternative energy resources, such as uranium, coalbed methane and geothermal, which will become an important energy mix for a sustainable energy solution, particularly for countries that do not have or choose not to develop unconventional energy resources.”**

new relationships. DEG President Mary Barrett is also working with EMD to solicit themes of joint interest for the 2019 ACE, such as produced water disposal, carbon capture and environmental regulation.

#### Upcoming Content

EMD is uniquely positioned to promote alternative energy resources, such as uranium, coalbed methane and geothermal, which will become an important energy mix for a sustainable energy solution, particularly for countries that do not have or choose not to develop unconventional energy resources. We continue to solicit research articles to be published in the *Natural Resources Research Journal* with our joint collaboration with John Carranza, the journal's editor-in-chief. For more information and author instructions, visit Springer.com.

I am also pleased to announce that a new AAPG Memoir on mudstone diagenesis is in the final stages of preparation. It has been in

the works by several EMD members since the joint Society for Sedimentary Geology-AAPG Hedberg Research Conference held in Santa Fe, New Mexico, in October 2016. I wish to thank Beverly Molyneux of AAPG Publications for her dedicated assistance in producing this volume. I am hopeful that the book will be completed in time to be available at the AAPG Bookstore for the May 2019 ACE in San Antonio.

To promote interaction with other geological organizations, AAPG will be participating in the December meeting of the American Geophysical Union in Washington, D.C., and EMD is working with the Geological Society of America on a joint session, “Niobrara-From Outcrop to Foreland Basin,” to highlight the regional importance of this unconventional resource during the GSA joint section meeting to be held in Manhattan, Kansas in March 2019.

#### Member Engagement

EMD is in the process of updating and

expanding the functionality of our website with the assistance of longtime EMD member Brian Cardott and AAPG web producer Bogdan Michka. This will continue to be the main resource for our members to access content about our activities and resource commodity reports. We also hope to soon launch a new Discussion Forum for EMD where AAPG members can post announcements, questions and comments to help promote communication and mentoring. I also hope to utilize LinkedIn more to communicate outside our organization. To visit our website, select the Divisions tab from the AAPG homepage, AAPG.org.

Please join EMD if you are not already a member, to keep informed of our activities and content. It costs nothing additional to join if you are an AAPG member.

Finally, all of these goals and activities cannot be accomplished without the active participation of our devoted members, including our AAPG liaison, Diane Keim, who work ardently in the background to keep our division up and running. We are a little behind with our election of EMD officers, but we hope to finalize the slate of candidates for an August election. I also would like to thank past EMD President Doug Wyatt for his guidance last year and continued support. I pledge to serve EMD to the best of my ability, but I need to hear from you to let us know what we are doing right and how we can continue to improve.

I can be reached at wayne.camp@anadarko.com. [E](#)



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