Finding Petroleum

What digital tools can improve exploration performance?

Drones in onshore seismic recording

Developments with vibroseis

Cableless onshore recording - do we need real time data?

Electromagnetics via towed streamer

Bringing together a range of subsurface data

Event Report, New Geophysical Technologies, Feb 24, 2016, London

Special report

New Geophysical Technologies

Feb 24, 2016, London

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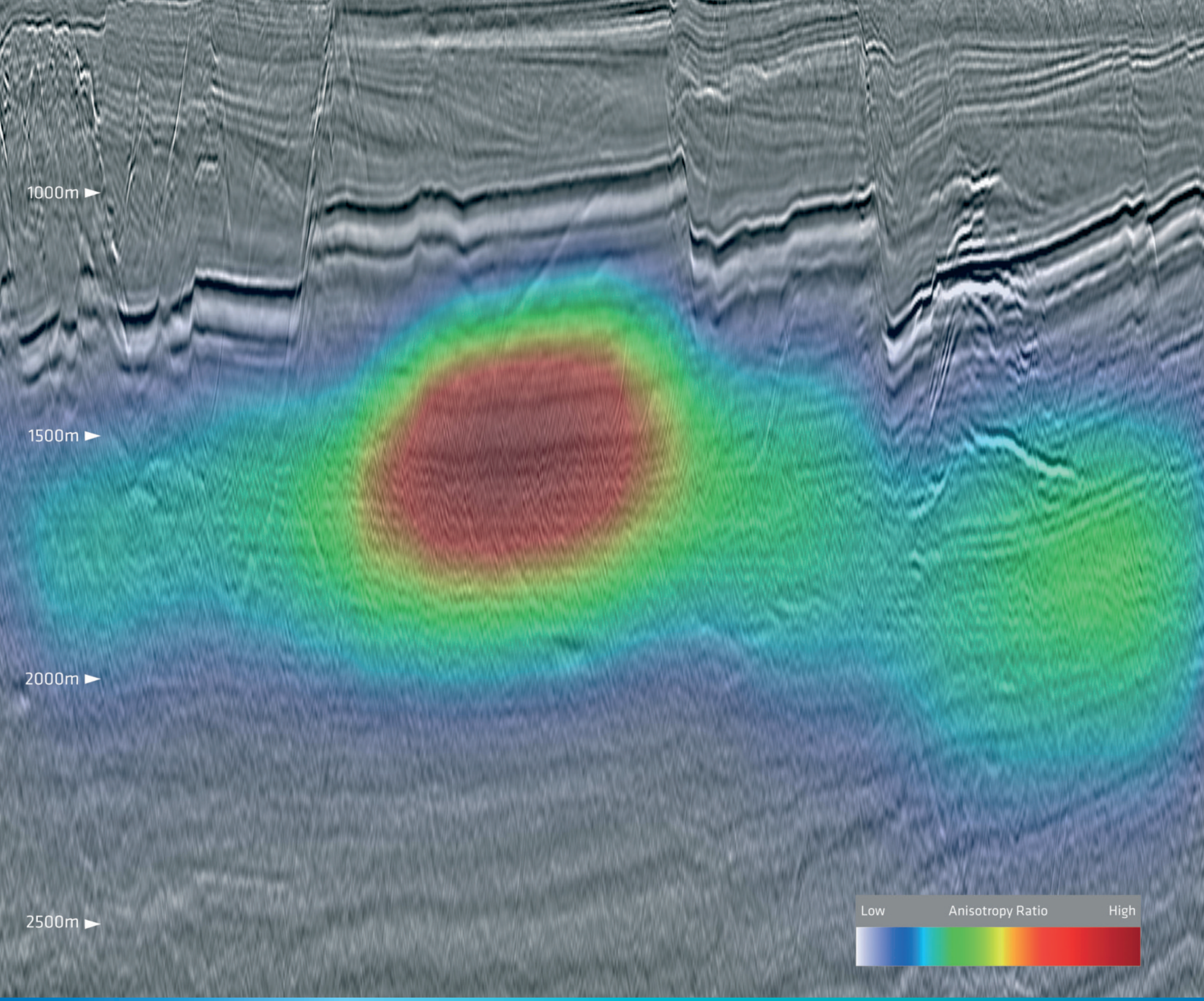

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How do we improve exploration success?

Finding Petroleum's forum in London on February 24, "New Geophysical Technologies", looked at new technologies which can help us get a better understanding of the subsurface.

It included an overview of where we need to go from Conference Chairman David Bamford; using satellite imagery for planning surveys in advance and drones for uploading data (and perhaps placing wireless seismic recorders) from UK start-up Feather Tech; and developments in vibroseis technology and onshore seismic recording from INOVA Geophysical.

We also covered recording electromagnetics by towed streamer from PGS; how data science can help geoscientists from Teradata; and how NEOS interprets data from a multitude of different technologies at the same time.

An interesting point which emerged is the necessity of achieving competitive advantage, which means finding reservoirs which other companies have not been able to find – since there are many different companies looking for oil in the same part of the world.

This could mean different things, such as higher trace density surveys giving higher resolution images, better quality seismic source equipment, and better use of data analytics. This is an area where cost cutting is unlikely to help.

Note: slides and videos are available for free download from the conference agenda page where permission has been provided by our speakers – see **www.findingpetroleum.com/event/6cc29.aspx**

This is an Event Report from our forum in London on February 24, 2016, "New Geophysical Technologies"

Event website

http://www.findingpetroleum.com/event/6cc29.aspx

Some presentations and videos from the conference can be downloaded from the event website.

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Layout by Laura Jones, Very Vermilion Ltd

Cover art by Alexandra Mckenzie

Digital Energy Journal

www.d-e-j.com

Future Energy Publishing,
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London, N7 9DP, UK
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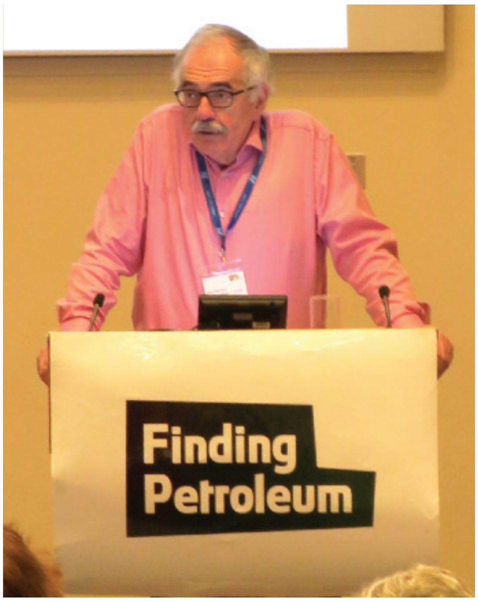
digital energy journal

David Bamford – can better tools improve exploration performance?

The exploration industry does not have a very good record over the past few years – can analytic tools help improve performance, asked Conference Chairman David Bamford

The oil and gas industry's exploration record over the past few years has been "thoroughly dreadful", said Conference Chairman David Bamford in his opening remarks.



Mr Bamford is a former Head of Exploration with BP.

"For frontier new wells, the 2014 to 2015 success rate was 1 in 25. That's not a viable proposition for anybody," he said.

The last time the oil and gas industry wanted to make a big effort to improve exploration success was in the late 1980s and early 1990s, when regional 3D seismic started to be introduced, which massively improved the efficiency of exploration. This led frontier exploration in some countries, and for some oil majors, to reach a success rate of over 75 per cent.

Oil companies need to work out how they can achieve similar success rates now.

One place to start is looking at the tools geophysicists and geologists are using, Mr Bamford said.

"Rule driven interpretation", where you follow a series of steps to understand the subsurface, working with seismic data, with rules based on the physical properties of different rocks, is very widely used in the industry.

It leads to the production of "gross depositional environment" and "common risk segment" maps, and has become the 'stock in trade' of oil and gas explorers.

But everybody does this now. Rather than being an advantage if you do it, it is a disadvantage if you don't do it. In other words you could say rule driven interpretation has become a commodity, Mr Bamford said.

In order to move to the next level, you should be looking at techniques like data mining or better data inversion techniques (creating a model of the subsurface by working out what subsurface structure would lead to the data which you have recorded).

Data mining is a way companies can make better sense of the enormous amounts of data they have to deal with. For example, some US onshore companies can have 12,000 wells, 6,000 regional reports, 24,000 cores, and multiple production samples. They have a massive range of subsurface data, including satellite, he said.

There are also much more sources of data – including data recorded from the sky (satellites, aeroplanes, drones), seabed recording, electromagnetic and other types of magnetics, gravity sensors.

A geoscientist might take this data and say, I can't look at it all, I'll just work with a small part of it, he said. But computer analytic techniques can work on the whole data very quickly.

You could use a computer analytic tool to work through all publicly available data for North Sea wells, for example.

This sort of analytical techniques can improve objectivity, or less likelihood that you will ruin the work by basing it around a pre-conceived idea which turns out to be wrong.

There is also a great deal of human judgement involved when people try to manually work out how data is clustered, or make a guess at a data trend from seeing various data points. Analytics tools can automatically find clusters and a best fit line.

Seismic should probably still be treated as the 'main' tool for understanding the subsurface. But you can use other technologies to help you improve the understanding you get from the seismic, he said.

"Seismic remains the most powerful, least ambiguous, most resolution," he said. But seismic, interpreted in 3D, provides a framework for all the other geophysical technologies to slot into.

So we are not saying how do we invert EM data to make a model of the earth, we are saying how do we use EM data together with our seismic to try to work out whether a certain reservoir contains water or not.

Perhaps the industry is still looking for a technical means of integrating all available geophysical data together, he said. "I've not seen anything that truly integrates all those geophysical technologies."

There are some methods which integrate two of them, such as 2D seismic and gravity data, but no methods to integrate all of them at once.

Perhaps it is fair to say that data integration is the biggest problem to solve, he said.

Unfortunately, in this era of low oil prices, companies are sometimes more interested in finding ways to reduce the cost of seismic interpretation, than they are in finding ways to improve the effectiveness of seismic interpretation, so the interpreters can find more targets with more certainty.

Feather Tech – introducing drones to seismic

Onshore seismic recording is very expensive compared to marine seismic, says UK start-up Feather Tech. Perhaps the economics could be improved using advanced satellite data to plan vibroseis routes, and drones to harvest data from wireless seismic recording systems

UK start-up company Feather Tech is researching ways to use advanced satellite and drone technology in seismic recording.

Satellite data could be used to plan vibroseis routes in more detail before the survey starts, including making sure the trucks do not have to go up inclines over more than 10 degrees, which can tip them over, and they do not get stuck in quicksand.

Drones flying overhead could take a fast upload of data from wireless seismic recording systems – and perhaps ultimately they could be used to automatically place wireless seismic recording systems in the ground, like Amazon is planning to make deliveries.

From Imperial College

All of the staff of Feather Tech are formerly from, or currently at, Imperial College in London.

Serje Heyer, CEO, graduated in applied physics in 2010 and worked since then in private equity, financing oil and gas exploration consortiums in former Russian states and West Africa

Pisak Chermprayong, Chief Technology Officer, is doing a PhD in aerial robotics at Imperial. He was part of a team which built a drone which could fly, float and dive, and was one of 6 finalists in the United Arab Emirates "Drones for Good" award in February 2016.

Thayne Thanthawarithisai, Chief Scientist, graduated top of his class in electrical engineering at Imperial College and is currently a PhD student.

A fourth staff member is Joshua Burrill, a lawyer, who helps the company with legislative issues connected to drones, of which there are many.

The company also works closely with a company called Terrabiotics, which specialises in gathering data about the ground from satellite check. It is led by Gareth Morgan, who has a PhD in remote sensing from Imperial College.

Feather Tech started in business developing technology to combine Unmanned Aerial Vehicles (UAVs, or drones), with wireless sensor systems, although it did not immediately see that onshore seismic recording could be an application for it.

The starting problem to tackle is the cost of onshore seismic recording. Offshore, costs can be \$5,000 / km2. But onshore, costs start at \$20,000/km2 for simple environments like desert, rising to \$250,000/km2 for high mountainous regions. Placing and retrieving seismic recording devices takes a lot of manpower and time, compared to operating a marine vessel.

Planning surveys

Feather Tech starts with the idea that the cost of seismic surveys could be reduced if hazards were better identified before the survey started.

There are stories about vibroseis trucks getting stopped in salt pans (known as 'Sabkha' in the Arabic world). These can contain a thick layer of mud hidden below a crust of salt, which have destroyed seismic recording trucks.

The quicksand can be hard to see visually, because from eye level it looks the same as other desert. But it can be seen clearly by analysing data recorded by satellite, including an analysis of the visual and infrared light given off by the sand.

Feather Tech, working together with partner company Terrabiotics, can analyse the area where you plan to record in advance, and flag up the areas of salt pan, so you can plan the survey around it.

Satellite data can also be used to map terrain. Vibroseis trucks can tip over if there is an incline of over 10 degrees. Using images from 2 different satellites, you can build a high resolution terrain model with resolution of under 50cm and grids of under 1m, which is enough to differentiate surfaces with an incline of more than 10 degrees, Mr Heyer said.

Of course, all of this work can be done before you even enter the country.

Feather Tech did a project for a client looking for just quicksand and high inclines, and could do it at 85 per recent less cost than the traditional way of doing it he said.

This work also proves 70 per cent cheaper than scanning terrain using LIDAR (laser based) surveys, the standard method.

After working with Feather Tech, one oil major client no longer uses LIDAR to scan before doing seismic surveys, Mr Heyer said.

Wireless seismic recording

Feather Tech also wants to make wireless seismic recording easier.

Wireless seismic recording promises a lot of cost reduction over cabled recording, because it avoids the effort and trouble of cables. But it (arguably) has the disadvantage that you don't know everything is working properly or not until you retrieve the recording devices after the survey is finished. Perhaps partly for this reason, wireless seismic has under 10 per cent market share of the onshore seismic recording market, he said.

If data is communicated during the survey, either quality control data or the entire seismic recording, the data needs to go long distances horizontally, and can be blocked by vegetation.

Feather Tech is developing technology to send data from the seismic recording devices upwards to a UAV flying overhead, where the data can be stored

It is developing drone technology which can actually place seismic recording devices in the field. The difficultly level of this depends on how simple the ground is (ie it is much easier to place a wireless receiver on flat concrete than a grassy mountainside), Mr Heyer said. The robot can also place signal boosters where they are needed.

The nodes could then be collected by robot.

It will all lead to improved company safety (less people in the field), less environmental damage from cables and heavy equipment in the field, and less cost.

Questions

In the questions session, one audience member noted that for many onshore seismic surveys, the number of local people you employ is a major factor in gaining approval from local governments. Governments are more interested in the contribution you can make to society by providing employment, than they are by the contribution you can make by helping find oil. In this case, having a manual work intensive process can be to your advantage.

Another audience member raised security concerns about drones in many parts of the world. For example in Egypt drones are illegal and will be confiscated at the airport.

“Before we asses legal feasibility we're more focused on technical feasibility - can we demonstrate that we can do this in a cost effective manner, Mr Heyer replied.

Another audience member noted that there are already wireless seismic systems on the market which communicate all of the wireless data (horizontally) back to base stations, with many systems in use around the world, in a variety of different terrains.

INOVA Geophysical – advances in vibroseis and wireless seismic

US seismic equipment company INOVA Geophysical is known for its development of onshore source (vibroseis) and recording technology. Andy Bull, VP for Emerging Technology, explained what advances have been made to date.

Onshore wireless seismic recording is moving towards a third generation of technology, said Andy Bull, VP of Emerging Technology with INOVA Geophysical.

He was speaking at the Finding Petroleum forum in London on February 24, “New Geophysical Technology”.

INOVA Geophysical was formed as a joint venture between US seismic company ION Geophysical and BGP of China.

Customer demand for wireless technology appears to be moving in two conflicting directions, with some people wanting data communicated in near real time from the wireless recording devices, and other people looking for higher trace density (so more data being recorded, leading to a clearer seismic image). These requirements are somewhat in conflict, because the more data you record, the more it costs to communicate it in real time.

A lower for longer oil price could drive more interest in onshore operations, because onshore oil drilling and production is usually much cheaper than doing it offshore. Studies have shown that 80 per cent of future deepwater projects are likely to be uneconomic at an oil price of below $60, he said, but many onshore projects will still be robust at that price, he said.

Vibroseis Techniques

There is growing industry interest in a technique known as Dispersed Source Arrays which uses high productivity techniques in conjunction with vibrators shaking dedicated frequency bands (low, mid, high) at different spatial intervals. This technique is based on research from the Delphi Consortium, in the Netherlands, showing that it can help to get a better understanding of the subsurface.
Typically, generating low frequencies requires having a specially tuned ‘custom sweep’ of the seismic signal, with the seismic source signal starting slowly at low frequencies and going gradually to a linear sweep of the higher ones. But research by INOVA indicates that it may be preferable, especially with the DSA technique, to use shorter linear sweeps for low frequency operations, he said. You can deliver more energy into the ground this way, and it also takes less time, improving operational efficiency.

This low frequency linear sweep method is made possible by advances in source controller technology, which automatically limits the stroke at low frequencies and reduces the risk of damage to the vibrator.

Low Frequency Energy

There is also technology development going into improving the low frequency energy which the vibroseis truck can deliver while maintaining a more stable wavelet which improves data quality and can give additional insight into the subsurface.

INOVA is developing a vibroseis which can almost double the amount of low frequency force energy delivered into the ground. The force from a vibrator can basically be calculated using Newton’s “F=ma” – the vibrator has a reaction mass, which travels towards the ground, and the bigger the travel distance, or stroke, the more acceleration it can gather.

“We've been working on a new vibrator design,” he said. “We've increased the weight of the reaction mass, we've significantly increased the stroke length and we've redesigned the base plate and hydraulic system.”

It has extensively tested this vibroseis' capability at low frequencies, in one test using geophones installed in a well at 7,500 feet depth, recording high energy seismic between 1 and 4 Hz.

Source controllers

INOVA is also developing its 'source controller' technology, which provide complex feedback control to the vibrator as it executes each sweep.

The quality of source controllers on the market today can vary. In a test INOVA compared a recording from its most recent model with another on the market, and found phase and amplitude control varied significantly and led directly to a much more stable wavelet, depending on controller type, even when both were configured for the same sweep in the same location. There were also differences in how the controllers managed harmonic distortion.

"The wavelet with controller A is more stable and uniform," he said.

Cableless

Looking now at cableless seismic recording, the market may now be approaching a third generation of equipment, he said.

The first generation, introduced in the 1990s, had a low battery life and limited channel count. The second generation, which was introduced around 2005, had a higher channel count and better battery life but has struggled to seriously challenge cable systems across all regions.
The third generation, will almost certainly be smaller and lighter and probably cheaper. They will take advantage of ongoing improvements in power consumption, energy density, GPS performance and high sensitivity sensors.

It was worth noting that today's second generation systems already achieve a very high level of reliability, which can be measured in terms of a trace yield of over 99 per cent, he said.

While the cost of cabled systems is still coming down, it may soon hit a floor, because of the underlying cost of copper, he said. Cableless systems currently cost around 1.5x to 2 x as much as cabled systems but this multiple is likely to reduce over time.

Managing communications infrastructure for real-time cableless recording systems gets substantially more complex, as the amount of data and the number of channels increases. This problem also gets much worse in complex terrain or high canopy environment, where, ironically, the benefits of cableless are stronger compared to an easier 'open desert' environment, he said.

The company recently did a project in a tree-covered hillside area of the Marcellus Shale, US, using 2678 autonomous nodes. If a radio communications infrastructure had been required for real time data transmission, it would have needed about 60 radio masts, which would have been operationally complex to install, move and maintain without disrupting production or infringing on permit restrictions. Radio communications infrastructure like this can take "a lot of trial and error to optimise," he said. "While the idea of real time data is seductive, it does have its challenges."

Trace density

Meanwhile, other parts of the market are looking more closely at the benefits of improving trace density, with experts saying that the increase in trace density has been one of the biggest contributors to the improvement in seismic data quality over the past few years.

Having a high trace density means that the impact of noise such as 'air blast' – when noise from the source travels through the air to the receivers – can be much reduced.

In a study, INOVA found that for a synthetic 45 fold survey with 1800 traces per km^2, the suppression of air blast noise was "not that great". By increasing the fold to 180, with 7200 traces per km^2, there was "immediate improvement in air blast suppression. Going to 700 fold, 20,000 traces per km^2, meant that the noise suppression is "very effective," he said.

This approach could offer significant advantages compared to radio-based systems but requires some significant improvements in cableless technology and reductions in per channel cost.

Audience comment

After the talk, one audience member noted exploration managers are successful if they manage to find something which other people haven't found (even though they were exploring the same part of the world) – and one way to do that can be to use a higher trace density than your predecessor did. "It is pretty well proven that trace density gives you that difference," he said.

One audience member noted that geophysicists are getting much less concerned about real time quality control of wireless seismic recording, as they get more confident in it.

One audience member noted that a big driver in higher resolution onshore seismic surveys is multiclient projects, where a seismic company determines what form the survey should take, rather than a single client.

Many seismic contracts issued by oil companies are made around acquisition specifications for 2D recording, originally written in the 1970s, and haven't evolved since then.

Another audience member said the data processing capability can also be a limitation on how much seismic data you can record. "There's not many people who have had too much experience in processing of this data," he said.

One audience member noted that the 'pull' in the market for higher processing is often coming from Middle Eastern National Oil Companies, who are more comfortable giving out long term contracts, to make it viable for manufacturers to develop the technology.

Watch Mr Bull's talk on video and view slides at **http://www.findingpetroleum.com/event/6cc29.aspx**

PGS – electromagnetics via towed streamer

Seismic company PGS has developed a technology for recording marine electromagnetic data with a streamer towed behind a vessel. *This article is written by Joshua May of PGS*

PGS' controlled source Towed Streamer electromagnetic (TSEM) system is designed to operate in shallow water environments.

As a rule of thumb, resistivity can be confidently recovered down to a depth of 3,000m below mud line in water depths of up to about 500m.

To ensure client confidence in the suitability of the technology to their specific prospect or geophysical challenge, PGS conducts feasibility studies free of charge, often resulting in a positive outcome on a target which may have previously been considered marginal from an EM imaging perspective.

The EM streamer and associated equipment are specifically designed to look and handle, where possible, like a towed streamer seismic system. This not only ensures safe deployment and recovery by highly skilled offshore crews, but also efficient rigging of vessels new to TSEM acquisition and reduced HSEQ exposure by minimising the use of non-standard equipment.

Integrating TSEM and seismic

In order to ensure maximum understanding of the subsurface, PGS encourages the integrated interpretation of TSEM and seismic data.

To achieve this, PGS can acquire either TSEM data over existing 2D or 3D seismic data in 'EM only' mode, or 2D GeoStreamer and TSEM data simultaneously from a single vessel.

When acquiring 3D EM surveys, PGS operates with a single EM streamer with a line spacing of less than 1.5km, which enables both "2.5D" resistivity sections to be produced as well as 3D resistivity volume(s). Data acquired with a line spacing of above 1.5 km is considered "2.5D" (ie partway between 2D and 3D) and produces resistivity sections rather than a volume.

PGS has acquired EM data over a large number of known hydrocarbon accumulations with publically available well logs, ensuring that its clients can remain confident in the technique even in frontier areas, as well log resistivity values compare well to TSEM data.

One advantage of the TSEM system is the high density of data on both the source and receiver side, ensuring accurate, high resolution inversion results, with a particular uplift in resolution in the shallow subsurface.

In one survey, by combining this dense data with the efficiency of towed streamer acquisition, it was possible to acquire over 200 km2 of high density EM data in a single day, in the Barents Sea in 2014.

While TSEM can be used to great effect to de-risk large frontier areas such as the Barents Sea or the Fastnet Basin offshore Ireland, other applications should also be considered.

For example, estimation of gas saturation of 3D seismic identified shallow gas prospects, imaging the overburden of a producing field from a drilling hazard perspective, and even monitoring how the distribution and saturation of this shallow gas changes over time.

Near field exploration is particularly relevant in these current challenging times, when we are all looking for ways to reduce cost and improve value. TSEM may be able to provide the key to unlocking reserves close to existing infrastructure, potentially reducing the production cost per barrel and delaying decommissioning.

To improve the resolution and structural conformity of resistivity data, seismic horizons can be used to guide the inversion.

This guiding is softer than the more traditional constrained inversion. The inversion is able to anticipate a significant change in resistivity at a specific horizon, but remains free to populate the cells above this horizon in a manner which best fits the model.

While guided inversion can improve the resolution, unconstrained inversion remains a high value product in itself, especially when interpreted in conjunction with dual-sensor broadband GeoStreamer data.

Unconstrained inversion can highlight potentially prospective structures identified on the seismic and add an independent attribute for an improved understanding of the subsurface.

Seismically guided anisotropic 2.5D inversion of Towed Streamer EM data significantly improves the lateral and vertical resolution of resistivity anomalies, adding further value to the complementary seismic and EM data through integration of the two.

Returning to the theme of data density, PGS' standard EM streamer setup (8,700m in length) has 72 receiver pairs which vary in length from 200m at the nears, to 1,100m at the far offsets.

These overlap, and ensure a dataset rich in both frequencies and offsets, it's this rich, densely sampled dataset which provides such uplift in resolution when compared to traditional EM acquisition methods.

The high density 3D EM data acquired in the Barents Sea, for example, can also be used in more detailed reservoir level workflows, adding further value to the TSEM data.

Sensitivity at depth is also improved through this dense data, if the shot spacing for example is reduced from PGS' TSEM standard of 250m to 1,000m there is a notable decrease in sensitivity at depth in the subsurface.

PGS has invested in a significant MultiClient EM data library in the Barents Sea over the last three years.

This started from the proof of concept simultaneous EM and GeoStreamer acquisition over known discoveries during 2013, leading to the large scale high density 3D EM surveys conducted during 2014 and 2015.

When acquired, interpreted and integrated with seismic the maximum value can be extracted from TSEM data.

This makes it a highly cost effective method to de-risk frontier areas, improve well location decisions, provide drilling hazard identification and monitor changes in gas saturation over time.

The key differentiators of Towed Streamer EM over traditional acquisition methods are acquisition efficiency and the dramatic increase provided in data density; resulting in cost effective and accurate mapping of subsurface resistivity.

You can download Mr May's slides at **http://www.findingpetroleum.com/event/6cc29.aspx**

NEOS – multi-physics interpretation, integration and predictive analytics

NEOS has developed its techniques and workflows to build models of the subsurface utilising many different types of survey data, including seismic, electromagnetic, gravity, hyperspectral, magnetic, surface geology, well data and radiometric. The company uses each dataset to image the same geology but with different physical properties, reducing exploration risk and cross constraining the datasets.

NEOS, a company based in California's Silicon Valley, has developed its techniques and workflows to build models of the subsurface utilising many different types of survey data, including seismic, electromagnetic, gravity, hyperspectral, magnetic, surface geology, well data and radiometric. The company uses each dataset to image the same geology but with different physical properties, reducing exploration risk and cross constraining the datasets.

NEOS interprets and integrates the datasets; following this, predictive analytics algorithms are run to gain valuable insights, such as where the subsurface is most similar to a producing well or where there is analogous geology to a specific regional play.

Investors include Microsoft founder Bill Gates, and Silicon Valley venture capital firm Kleiner, Perkins, Caufield and Byers. Much of NEOS' work has been in North and South America, including a large study in Argentina. In addition a project onshore and near-shore Lebanon was recently completed.

Although non-seismic measurements make up a substantial proportion of NEOS' workflows, seismic data often provides the framework for building interpretations of the subsurface, providing vertical constraints to the other datasets. To improve the company's seismic capabilities, it recently purchased the onshore seismic data processing and imaging group from ION Geophysical – now called the NEOS Seismic Imaging Group (SIG) - whose advanced techniques such as AVO analysis, depth imaging and azimuthal velocity anisotropy analysis add significant value to an integrated earth model as well as being able to offer conventional seismic processing to clients.

Workflow

NEOS believes an integrated analysis of many data sources can individually and collectively improve insights into the subsurface. A typical project would include the following geological and geophysical datasets;

-Electromagnetic data provides information about the resistivity of rocks, giving an understanding of lithology and hydrocarbon charge.

-Radiometric data detects radioactivity of the surface and near-surface, which can be useful for understanding shallow fractures, the total organic carbon (TOC) of shale units at the surface as well as some indirect hydrocarbon indicators.

-Gravity data measures lateral density contrast in the subsurface, which is used for structural analysis.

-Magnetic data is also used for structural analysis, identifying volcanics in the sedimentary section, as well as assessing basement heterogeneity.

-Hyperspectral sensors, by measuring absorbed and reflected light (both visible and invisible) at hundreds of points across an energy spectrum, can identify both direct and indirect indicators of hydrocarbons.

Seismic datasets, well information and surface geological mapping are also integrated into their workflow.

"The benefit of using all of these different technologies – is looking at the same thing but through different physical properties," said James Dodson, Business Development Director at NEOS. "Each is individually valid, but when you bring them together you reduce uncertainty."

"We have some datasets more applicable to shallower interpretations, some at reservoir level, some at depth."

Once the company has manually interpreted and integrated all available data, creating a 3D earth model, the next step is to bring in predictive analytics, or statistical modelling, including some data mining techniques, to spot trends, correlations and patterns.

"This workflow is highly repeatable, completely scalable, from 1 million km2 to 100s km2," he said. "We've done work in some very remote regions with not a lot of data available.

We can also use huge datasets, such as with seismic data onshore US. We can integrate data of different vintages and resolutions."

DJ Basin, Colorado

NEOS was asked to help develop subsurface understanding of the DJ Basin in Colorado, where there is a large amount of seismic data and production information from many wells.

Wells had been drilled on the basis that they were close to an already producing well, he said. But the results were variable, with wells producing between 25 and 500 bopd.

The oil company "asked us to give them a reason to drill somewhere that's a bit more intelligent, and potentially find new areas for leasing," Mr Dodson said.

Several airborne datasets were acquired, interpreted, integrated, and assessed to determine which data seemed most important in predicting a well's production, and how to therefore predict where the best and worst performing wells could be located for future drilling.

The output was a generated map that indicated areas to avoid and areas that could be recommended for drilling. The project team also identified a new field in the south of the project area that the oil company leased and successfully drilled, confirming the team's predictions.

Onshore & near-shore Lebanon

NEOS, in partnership with the Lebanese Petroleum Administration (LPA), has completed a project in Lebanon to better understand the regional prospectivity, including the onshore northern half of the country and the near-shore along the Mediterranean coastline, and to high-grade acreage throughout the survey area to support future leasing, drilling and G&G investments.

The project builds upon heightened exploration interest in the Eastern Mediterranean region as a whole and is aimed at identifying geological features that extend into the project area from offshore structures, Syria's onshore petroleum systems as well as several other regional plays.

For the study, approximately 6,000km2 of new data, including gravity, magnetic, hyperspectral, magnetotelluric (MT), and radiometric data was acquired. NEOS acquired, processed, interpreted and integrated the data in just 7.5 months, which included four airborne and one ground-based dataset.

The first stage of the study was to interpret the datasets individually.

The gravity, magnetic and electromagnetic data was used to get an idea of the subsurface structure.

Magnetic data was used to identify volcanics within the sedimentary section as well as basement heterogeneity.

The surface was mapped using hyperspectral and radiometric data. The hyperspectral data analysis showed that there are many oil seeps onshore Lebanon; this being exciting because it is direct evidence of a working hydrocarbon system.

The second step of the study was to manually integrate the data. Ultimately, the aim is to create a 3D model where "everything complements each other and cross correlates," he said.

There was a small amount of borehole data available, which could be used to show interval thickness and rock properties.

2D models were created using surface geology, strike and dip information, regional knowledge and rock property information. These models were used to forward calculate the gravity and magnetic signal, which was compared to the acquired data, with the models being altered until the forward calculated and acquired signals matched.

The hyperspectral data was integrated into the model, showing where seeps appeared at surface fault locations, within specific rock units or above subsurface structures, such as anticlines.

The third step in the process was to apply the predictive analytics techniques. The project team used geological knowledge and geophysical attributes from fields in nearby Syria, identifying regions in the subsurface of Lebanon with similar geological and geophysical properties.

"In Lebanon we found analogues to onshore Syrian fields" he said. "We also have analogues to offshore Triassic deep gas. We have four different play types."

Neuquén Basin, Argentina

In Argentina's Neuquén Basin, NEOS' aim was to 'highgrade' the acreage of a supermajor, i.e. try to work out which parts of the land were most likely to provide oil.

The work included estimating thermal maturation and TOC of the shales, as well as interval thickness.

NEOS acquired magnetic, gravity and hyperspectral data, and did a lot of geochemical work, analysing seeps on the ground. There was some seismic and well data available.

Magnetic data was interpreted and used to help create a geothermal model of the basin (its temperature gradient).

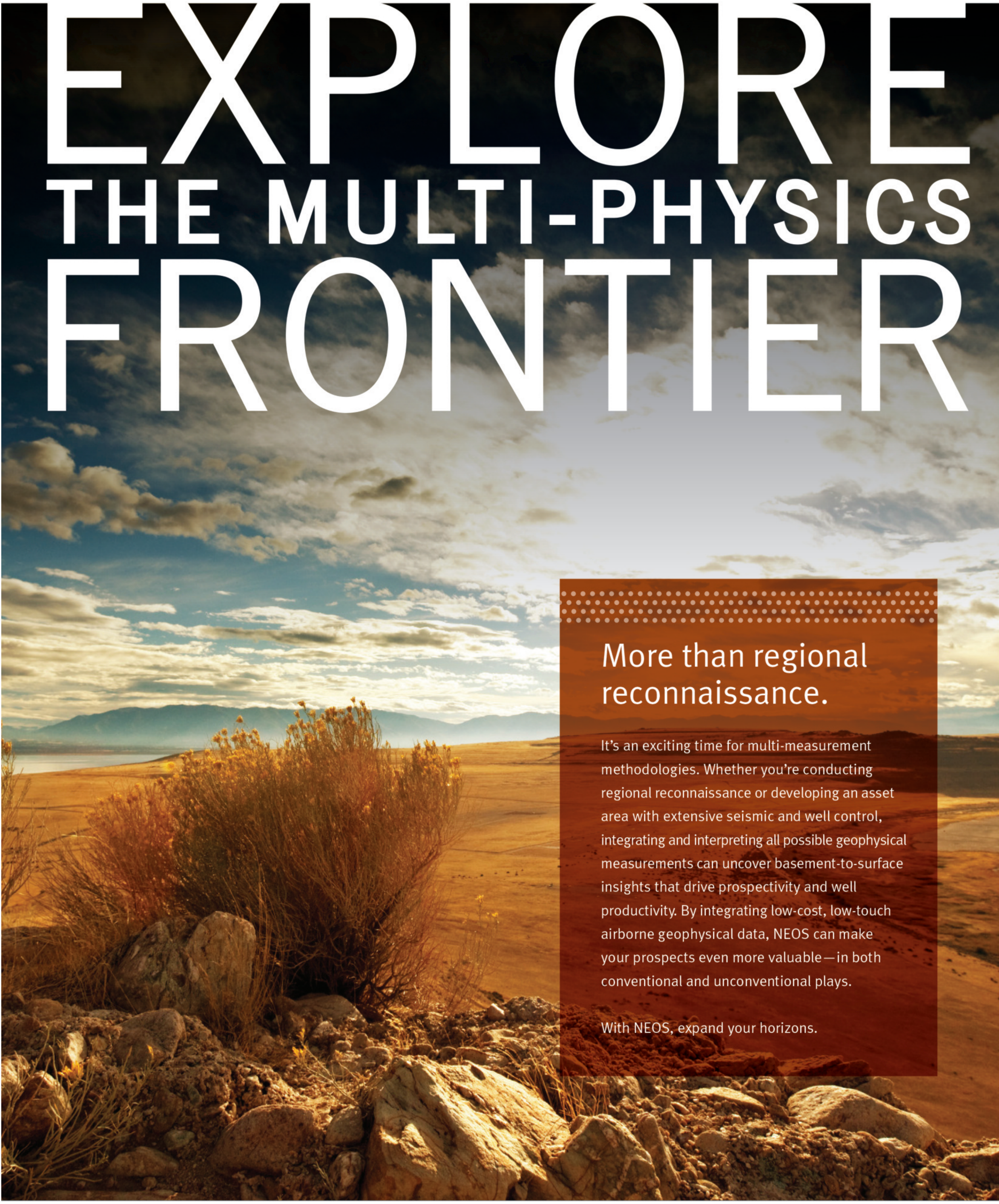
All of the results were integrated to create a 3D earth model; following this, a toolbox of predictive analytics algorithms were applied.

The project team was able to create a map of the Vaca Muerta shale, predicting where oil, condensate and dry gas production would be high.

The supermajor has subsequently drilled in the project area, with one well drilled in a manually highgraded area, and another drilled in an area highgraded by the predictive analytics methods.

"Both wells encountered oil, one of them is the best producing well they have in the basin," Mr Dodson said. "The other is not far behind. From our perspective, this a really good result."

You can download Mr Dodson's slides and watch his talk on video at
http://www.findingpetroleum.com/event/6cc29.aspx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More than regional reconnaissance.
It’s an exciting time for multi-measurement methodologies. Whether you’re conducting regional reconnaissance or developing an asset area with extensive seismic and well control, integrating and interpreting all possible geophysical measurements can uncover basement-to-surface insights that drive prospectivity and well productivity. By integrating low-cost, low-touch airborne geophysical data, NEOS can make your prospects even more valuable—in both conventional and unconventional plays.
With NEOS, expand your horizons.

List of attendees 'New Geophysical Technologies', The Geological Society, London, February 24, 2016

Stuart Amor, Analyst

Evi Otobo, Senior Geoscientist

Helena Zapata, Geoscientist

David Roberts, Consultant, 3-DMR

Allan Induni, Geoscientist

Christian Bukovics, Partner, Adamant Ventures

Paul Murphy, Key Account Manager, Oil and Gas Division, Airbus Defence and Space

Feargal Murphy, ARKeX

Iain Poole, Barnett Waddingham LLP

Simon Gozzard, Geophysicist, BG Group

Steve Callan, Sales & Marketing, BGP Marine

Tim Papworth, General Manager Armenia, Blackstairs Energy Armenia LLC

Sean Goodman, Geophysicist, Bridgeporth

Derric Richardson, Bridgeporth

Bryn Austin, Director & Geological/ Geophysical Consultant, Brynterpretation Ltd

Sean Barber, Business Development Manager, Cereno

Mike Oehlers, Chief Geologist, CGG Robertson NPA Satellite Mapping

Julia Kemper, Senior Staff Geophysicist, Chariot Oil and Gas

John Glass, Consultant Geologist, Cloverfield Consulting Ltd

Micky Allen, Consultant

Ian Jack, Mostly Retired, Consultant

Eleanor Jack, Consultant

Peter Farrington, Consultant Geophysicist

Robert Ward, Advisor, Decision Frameworks

Alexandra McKenzie, Artist, Digital Energy Journal

Ramtin Hosseini-Kamal, Geotechnical Engineer, DNVGL

David Jackson, Global Manager G&G New Ventures, Dolphin Geophysical

Chris Anderson, Marine Sales Manager, Dolphin Geophysical Ltd.

Brian Donnelly, Consultant Geophysicist, Donnelly

Ian Blakeley, VP Asia, Drilling Info

Doug Gibson, Energy Analysts

Serje Heyer, Director, Feather Tech

Richard McIntyre, Sales Manager, Finding Petroleum

Karl Jeffery, Editor, Finding Petroleum

Avinga Pallangyo, Conference Coordinator, Finding Petroleum

Carlo Brentari, Geologist, Geodynamics Worldwide

Elwyn Jones, Director, GeoPartners

Alexandra Kenna, Managing Director, GEOSERVE Limited

Gaud Pouliquen, Technical Analyst, Geosoft

Michael Clutterbuck, Development Geologist, Global Energy Consultants

Faouzi Khene, GXT

Wally Jakubowicz, Managing Director, Hampton Data Services

Norman Hempstead, Director, Hempstead Geophysical Svcs

Bill Green, Account Director, Hermes Datacomms

Bani Norouzian, Business Development Manager, IHS Energy, IHS Global

Neil Dyer, Independent

Glenn Hauer, President & CEO, INOVA Geophysical

Andy Bull, VP, Emerging Technology, INOVA Geophysical

Glenn Hauer, President & CEO, INOVA Geophysical

John Davies, Director, JD Petroleum Services

Tue Larsen, Senior Exploration Geophysicist, JX Nippon Exploration and Production (U.K.) Limited

jonathan Bedford, Director, JXT

Ravi Chandran, Director, Kalki Consultants Limited

Peter Allen, Consultant, Layla Resources

Kai Gruschwitz, Senior Geophysical Advisor, Lukoil

Kai Gruschwitz, Senior Geophysical Advisor, Lukoil

David Peel, Technical Director, Lukoil

Geoff Chambers, Sr Geophysicist, Lukoil International

Amrit Brar, Marketing and Sales Manager, Lynx Information Systems

Michael Blakemore, Director, Michael J. Blakemore Ltd

Martin Hodge, Data Processing, Time Imaging & Data Management Geophysicist, MoveOut Data Seismic Services

Joseph Woodward, MSc Petroleum Engineering Graduate

James Dodson, Business Development Director, NEOS

David Buddery, Consultant, Neoseismic Ltd

David Bamford, Director, New Eyes Exploration Ltd

Helen Turnell, Principal Consultant, NR Global Consulting Ltd

Vitaliy Yurchenko, VP Sales and Marketing, ORG Geophysical

Stephen Birrell, Advisor, Ossian Energy Ltd

Bill Park, Business Advisor, Park Innovation

Robert Parker, Consultant, Parker

Tim Beal, PDF Limited

Vincent Sheppard, Chief Geophysicist, Petrofac

Anastasiia Ierofeieva, Geologist, Petrofac

David Sendra, Associate Consultant, Petrophysical Consultant

Khalil Nourafkan, Principal Geologist, Petroxin ltd

Joshua May, Sales and Marketing Manager, PGS

Mike James, Business Development Manager, Marine Contract, Africa, PGS

Denis Potapov, SCRM Manager, PGS

Steve Pitman, VP Corporate Marketing, PGS

Sergey Palenov, Sales, PGS

Kevin Shrimpton, PGS

James Page, BDM, PVE Consulting

Robert Waterhouse, Director, Rosha Resources Ltd

Martin Smith, Business Development Manager - Operations, RPS Energy

Abhi Manerikar, Exploration Director, Sand Hill Petroleum

David Webber, Seismic Operations Supervisor, Sceptre Oil & Gas

Stephen Pickering, NExT Director Learning Content and Delivery, Schlumberger

Robert Heath, Marketing Manager, Seismic & Oilfield Services Ltd

Tom Martin, Director, Shikra Consulting

Pete Nolan, Exploration Consultant, SHP

Shaun Dunn, Global Business Manager, Exploration, Sonardyne International

Duncan Irving, EMEA Oil and Gas Practice Lead, Teradata

Daniel Plant, Business Director, Terrabotics

John Sunderland, Retired, TGS-NOPEC-Retired

Jerry Jarvis, Exploration Manager, Tullow Oil

John Quigley, Chief Geophysicist - Land, WesternGeco

Andrew Zolnai, Owner, Zolnai.ca

What did you enjoy most about the event?

An interesting range of talks.
David Roberts

Good content on, for me, new subjects.
Martin Smith RPS

Talk by P.S on TSEM
Stephen Pickering

The two papers on 'data mining' and 'multiple physics' applied to exploration and development.
David Buddery, Neoseismic

The stands and informal atmosphere. It was possible to have a chat with the speakers at their stands afterwards and at the same time with other attendees. Good time keeping with the talks too and discussion afterwards.

Towed Streamer EM talk was very good

Very up to date and informative presentations. This is one of the best Finding Petroleum seminars I have been to.

Bit more forward-looking than many "new technology" events that are really just a forum for service companies to flog the latest incremental improvement in their offerings.

"This was my first Finding Petroleum event as I am new to London, and new to the Oil & Gas industry overall. For the most part, I found the presentations and the subsequent discussions quite informative. Overall, I enjoyed the opportunity to meet experienced leaders in the industry and learn - clearly a high calibre of attendees at the FP event."

"Data analytics. After the strong intro (as ever) talk content grew more interesting as the morning progressed. In addition, often pleasing to have new (young) talent on stage, especially so confident."

Introduction and continuity of theme

Relative diversity of the (sales) talks

Extended question time where necessary

David Bamford's expert overview

Hearing great ideas