GEO ExPro

GEOSCIENCE & TECHNOLOGY EXPLAINED Vol. 3, No. 6 - 2006

www.geoexpro.com

Geotourism:
The Jurassic Coast

Reservoir Management:
Microfossils Help Steering the Drillbit

Resources:
Heavy Oil in the Lime-Light

ExPROFILE

Dr. John Ludden

GEOLOGY GEOPHYSICS RESERVOIR ENGINEERING

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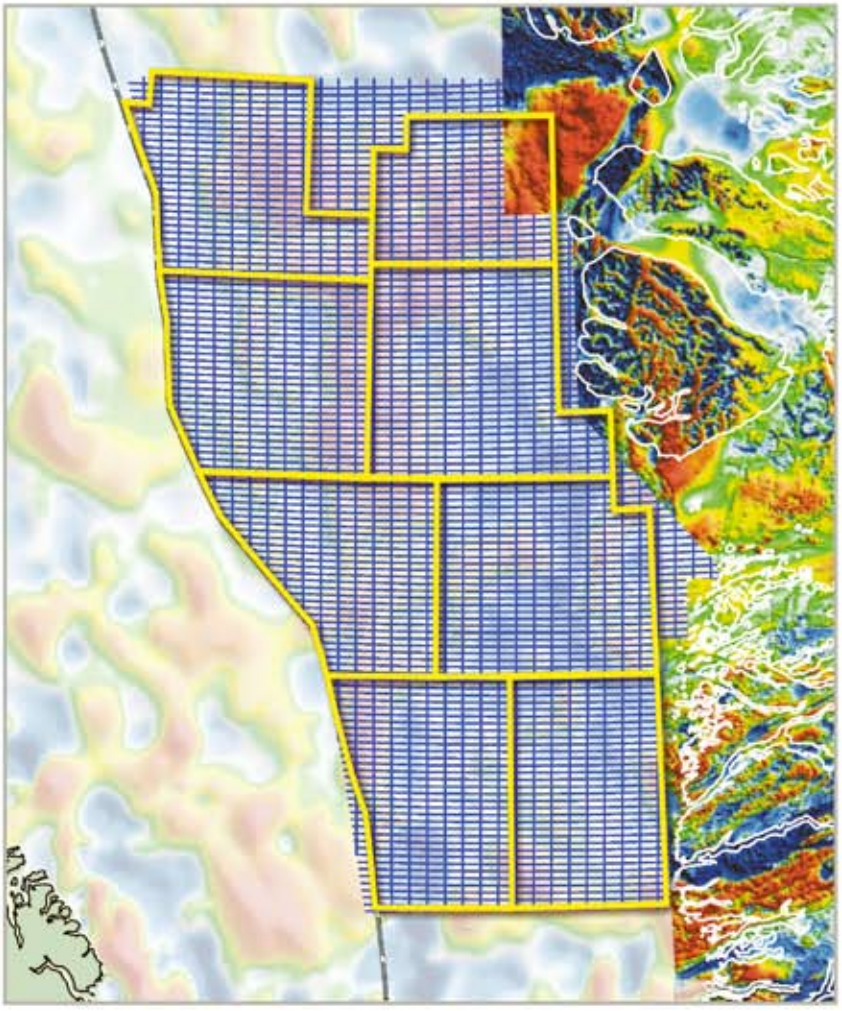
WEST GREENLAND

New Aeromag for the 2006 License Round



High-resolution aeromagnetic data has been acquired over onshore coastal areas in West Greenland for mineral prospecting, also over the onshore sedimentary basins of the Disko and Nuussuaq. These onshore data will now be merged with the newly acquired offshore aeromag survey, and provides an excellent correlation to the onshore sedimentary Cretaceous basins partly covered by Paleocene volcanic rocks.

TGS-NOPEC Geophysical Company (TGS) with sponsor NUNAOIL are pleased to announce a new aeromagnetic survey offshore west of Disko and Nuussuaq. The 37,000 km DWAM-06 survey is covering all the 2006 License Round blocks now on offer.

In particular the DWAM-06 survey is important for:

- Aiding structural interpretation in an area where seismic imaging is challenging.
- Mapping of basement structures.
- Mapping of volcanic rocks expected to be present in part of the area (variations in thickness of magnetic sequences and depths).
- Aiding design of future seismic to be acquired in the area.
- Mapping of faults, cross-trends and intra-sedimentary structures.
- An integrated interpretation report will be available by the end of October.

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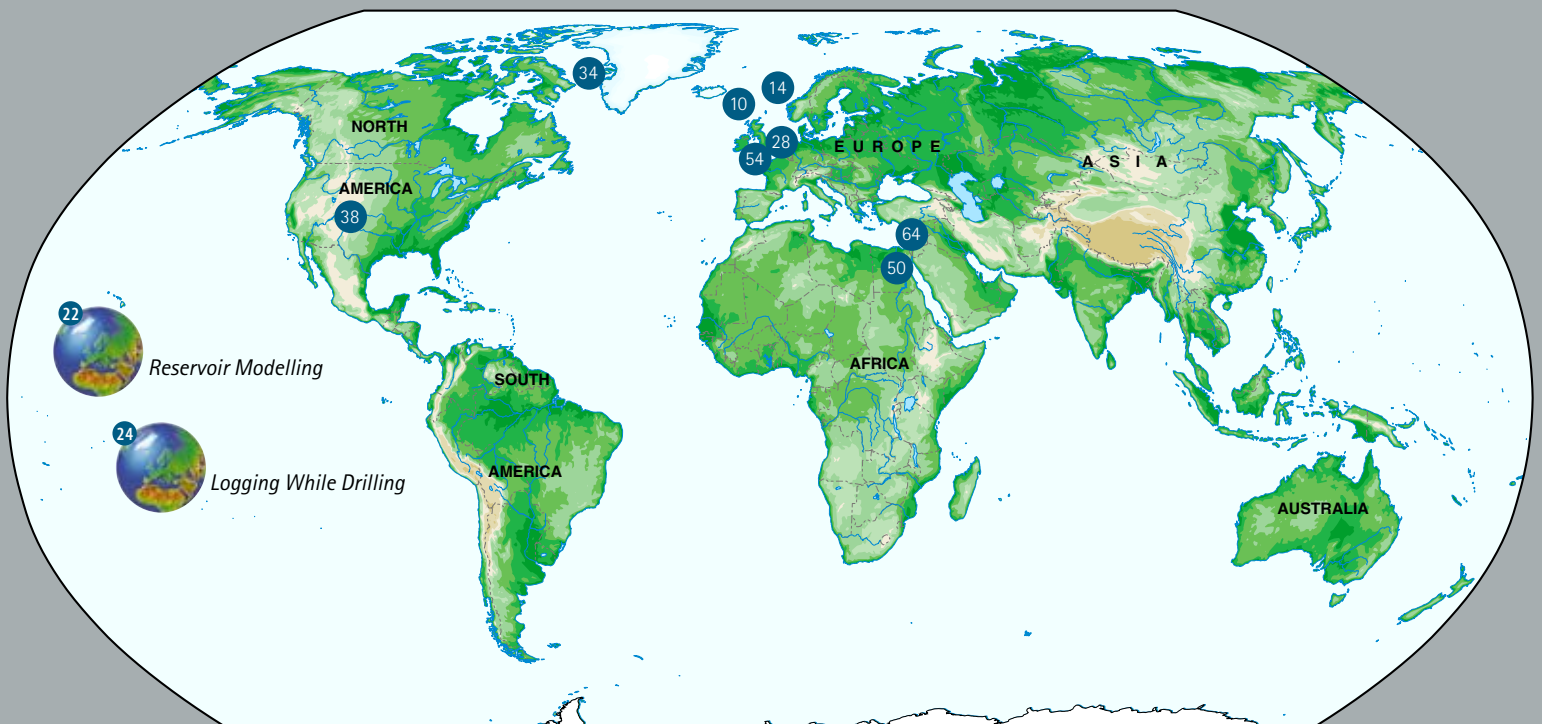
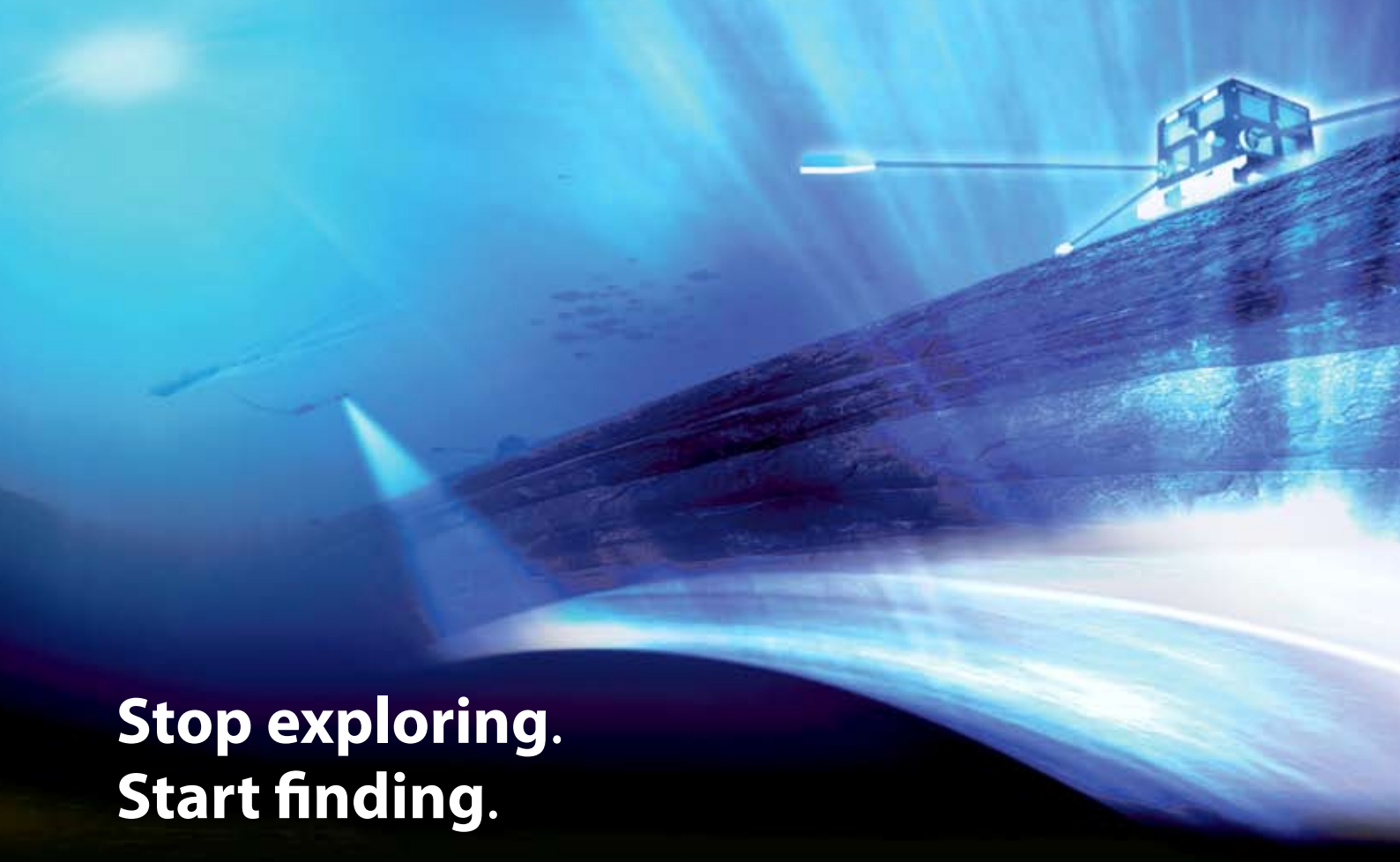
Manoeuvring in the reservoir
Biosteering – guiding the drillbit using microscopic fossils – has proved to be a useful technique when drilling in complex reservoirs. Examples from the Norwegian Sea demonstrate how the biostratigrapher needs to work in close cooperation with both the technician preparing the samples and the well site geologist.

Oil seeps
Oil seeps within volcanic rocks clearly indicate the presence of mature source rocks offshore West-Greenland. Onshore exposures also give clues to the presence of reservoir rocks, and recent seismic data demonstrates various play concepts.





Stop exploring. Start finding.

The last 20 years have seen huge advances in exploration technology. But success rates continue to decline.

It's been a hit-and-miss affair

In its pursuit of new hydrocarbons, the exploration industry has relied on indirect evidence.

Traditional exploration workflows, which evaluate petroleum systems, source rocks, seals and structures, are good at establishing the locations where hydrocarbons *can* exist.

But, emgs' award-winning seabed-logging technology is able to show whether hydrocarbons *do* exist.

Improving the workflow

Seabed logging remotely measures subsurface resistivity contrasts. Of course, as formation resistivity is the industry's most effective hydrocarbon indicator and has been for the past 75 years, it makes perfect sense to include seabed logging in the exploration workflow.

The new standard

Today, with more than 200 commercial surveys recorded, seabed logging is revolutionising how the industry finds hydrocarbons.

Seabed logging is enabling new exploration strategies such as scanning frontier and mature regions for new leads. These strategies are delivering prospects earlier than traditional methods. And operators continue to use seabed logging to rank prospects before they commit further resources.

It's hardly surprising then, that every day more and more exploration professionals are building seabed logging into their workflows. Indeed, right now over 35 leading operators worldwide are using seabed logging to evaluate existing prospects – and to find new ones.

Seabed logging
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Relying on Multiclient Seismic Data

While hydrocarbon resources are said to be scarce nowadays, it is comforting to know that there are still many unexplored geological provinces around the world. In fact, it is sometimes necessary to point out that frontier exploration acreage does still exist, as there is a tendency amongst explorationists to be very pessimistic about the future of oil. Several examples – including both *conventional* as well as *unconventional* hydrocarbons – have been brought to you in previous editions of GEO ExPro, and a couple more are included in this issue.

Bearing this in mind, it is interesting to note that we are about to enter an exciting, as well as challenging, phase of exploration in the East Mediterranean. Despite the region's closeness to known hydrocarbon provinces, or maybe just because of this, it is only the offshore Nile Delta that has been explored to any extent. Offshore Israel, Lebanon, Syria, Turkey and Cyprus have seen little work done lately, with the exception of a couple of non-exclusive surveys.

Photo: Halfdan Carstens

Future drilling in the deep water of the East Mediterranean may prove giant oil and gas fields in this virtually unexplored geological province.

Once again, it has been shown that the seismic companies are in the forefront of exploring frontier geological provinces. Taking the initial risk and burden of getting the authorities to plan for the licensing of open acreage, they invest heavily, first in business development, then in seismic data acquisition, processing and interpretation.

As for the East Mediterranean, over the next few years we can expect to see several campaigns to lure the oil industry into exploration in virgin territories. With Egypt's Nile Delta success story in mind, we believe this should be a fairly easy task.

Halfdan Carstens
Editor in Chief

Photo: Halfdan Carstens

Finding the Reservoir

Geologists and geophysicists work hand in hand to fine the best well location, it being an undrilled prospect or a new target in a producing field. In most cases, 2D, 3D and 4D seismic data are being used.

While drilling, however, it is left to the well site geologist to determine when the reservoir is entered, or – in the case of horizontal drilling – to find the best well path based on all information available.

The well site geologist is therefore surrounded by both technological wonders and sound geological knowledge (i.e. the expertise) in order to make decisions that are crucial for the performance of a future producing well. As demonstrated in this edition of GEO ExPro, he or she can get valuable information from both LWD-instruments and paleontologists, the latter are experts on microscopic fossils and can help guide the drillbit.

In this photo, two mud loggers from Geoservices are assisted by the drilling supervisor before giving their advise as to which formation is being penetrated when drilling an exploration well on a Gullfaks satellite in the North Sea.

Photo: Halfdan Carstens

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Driving home the repeatability

Photo: Tore Karlsson

Julie Marshall - Product Champion, Advanced Spread Control assisting a player of 'The Repeatability Challenge' at the SEG in New Orleans .

Visitors to the WesternGeco booth at the recent SEG convention in New Orleans were invited to enjoy 'The Repeatability Challenge'. In this way they got a personal experience of the repeatability provided by the source and streamer steering of the Q-Marine technology (GEO ExPro No. 3,2006).

Sophisticated seismic techniques have been the cornerstone of the consistent increase in the E&P industry's exploration success rate. These days the industry is looking beyond exploration and applying seismic technology to reservoir management tasks. Time lapse or 4D seismic surveys have thus become a significant segment of the marine seismic market, in particular in the North Sea. Repeatability from survey to survey through a 4D project is critical for the quality of the information resulting from a time-lapse project.

Participants in the game were invited to steer the seismic vessel with the source and streamer spread through a pre plotted track close to islands, rigs and moving vessels with varying directions of currents. Success was measured by the resulting closeness to the pre plot and streamer collisions meant 'going back to start'. In the first round the 'pilot' could only steer the vessel and had to take into account the expected movement of the source and streamer spread. In the second round the source and streamer steering system was activated to help the player to keep the spread on track.

Q-Marine is a member of the WesternGeco family of Q systems together with Q-Land and Q-Seabed. A unique feature for Q-Marine is the source and streamer steering which allows Q-Marine surveys to be significantly more repeatable than conventional acquisition according to WesternGeco. Q-Marine streamers contain the Q-Fin steering device, remotely controlled wings that enable both precise depth control and horizontal steering. Horizontal streamer steering provides feather correction, safe streamer separation control, active steering for optimal coverage and 4D repeatability.

The GEO ExPro representative at the SEG, having had a chance to play the game, can confirm that the WesternGeco repeatability message will not be forgotten! If you missed it at the SEG you will have a new chance at PETEX in London in November.

CGG wins SEG Award

The Society of Exploration Geophysicists (SEG) has honored CGG with its Distinguished Achievement Award.

This prestigious award is awarded from time to time to a company, institution or other organization for a specific technical contribution or contributions that have, in the unanimous opinion of the Honors and Awards Committee and the Executive Committee, substantially advanced the science of exploration geophysics.

The SEG is honoring CGG for its contributions to the science of exploration geophysics over the past 75 years. Founded in 1931 by Conrad Schlumberger, CGG has remained independent and has throughout its history contributed to the advancement of the field of geophysics.


Photo: Courtesy of SEG

CGG's Chairman and CEO, Robert Brunck, was presented with the Award at a ceremony held by the SEG Honors & Awards Committee on the opening afternoon of the 2006 SEG Convention in New Orleans.

CGG employs 4,000 people, from over 30 nationalities, working at 50 sites around the world and is a force among international industry associations. CGG currently operates through two divisions: Sercel is a supplier of land and marine seismic acquisition systems, while CGG Services cover onshore and offshore seismic acquisition, seismic data processing and reservoir imaging. Late 2005, CGG acquired Exploration Resources with seven new vessels and Multiwave, the leader in ocean bottom seismic.

ABBREVIATIONS

Numbers
(U.S. and scientific community)

M: thousand	= 1 x 10^3
MM: million	= 1 x 10^6
B: billion	= 1 x 10^9
trillion	= 1 x 10^{12}

Liquids

barrel = bbl = 159 litre

boe:	barrels of oil equivalent
bopd:	barrels (bbls) of oil per day
bcpd:	bbls of condensate per day
bwpd:	bbls of water per day

Gas

MMscfg:	million ft^3 gas
MMscmg:	million m^3 gas
tcfg:	trillion cubic feet of gas

LNG

Liquified Natural Gas (LNG) is natural gas (primarily methane) cooled to a temperature of approximately -260 °C.

NGL

Natural gas liquids (NGL) include propane, butane, pentane, hexane and heptane, but not methane and ethane.

Reserves and resources

P1 reserves:
Quantity of hydrocarbons believed recoverable with a 90% probability

P2 reserves:
Quantity of hydrocarbons believed recoverable with a 50% probability

P3 reserves:
Quantity of hydrocarbons believed recoverable with a 10% probability

Oilfield glossary:
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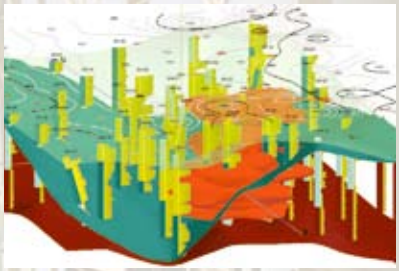

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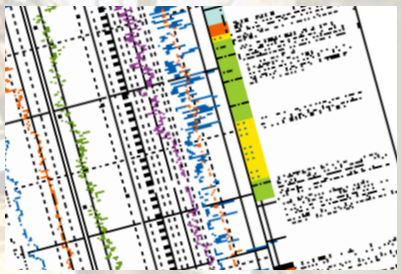

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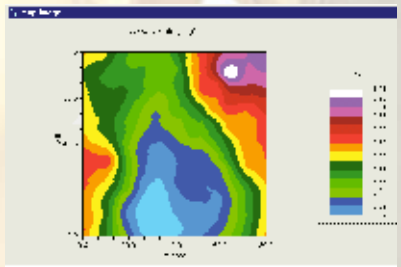

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Finding Oil without a Drilling Rig

An innovative technology is now being developed that will facilitate the drilling of wells and verify the presence of hydrocarbons in both frontier and mature areas without a conventional drilling rig.

"The Badger may contribute to a doubling of the exploration activity, while at the same time being environmentally friendly as there are no emissions to air or sea," says Managing Director Kjell Erik Drevdal.

Sigmund Stokka, Research Manager with International Research Institute of Stavanger (IRIS), Norway, and an expert in drilling technology research, was the first person to consider drilling and logging holes without using a conventional drilling rig by developing an idea that came to him in 1999. Stokka envisaged a drill bit – a slim electronically powered drilling system that carries sensors and continuously records subsurface data – digging a hole like a frantic badger.

Cheaper boreholes may be the result of this development, and if successful, it may open up a revolution in drilling technology that is also environmentally friendly. In 2005 the technology was awarded a 2nd place in the Norwegian DnB NOR National Innovation competition.

"The Badger Explorer, as it is named, drills into the ground and buries itself without the risk, cost and complexity of a rudimentary drilling rig," explains Kjell Erik Drevdal, Managing Director of Stavanger-based Badger Explorer ASA.

The tool consists of a drill bit driven by an electromotor, a cutting, transport and injection device, and a drum of spooled cable, through which power is supplied from the surface and data signals are transferred up to the surface.

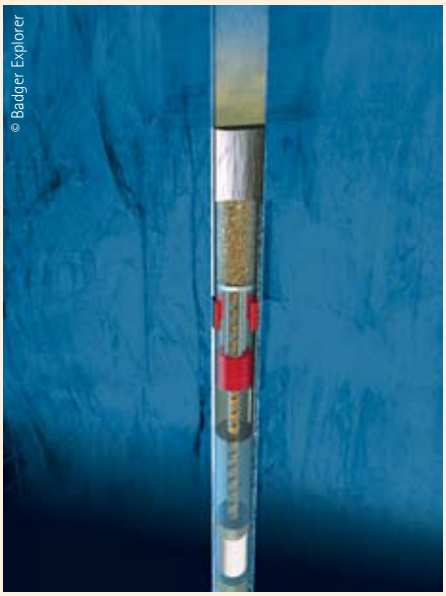
Developing the Badger Explorer is now entering a final phase."The idea was established seven years ago, and the first two years were spent preparing a patent application and then actually getting it," says Drevdal. It took another three years to establish the project, which included financing through the Norwegian petroleum research fund PETROMAKS, as well as additional oil company funding.

"Now, during what we call the pre-project phase, the activity level has increased exponentially, and early this year the company was included on the Norwegian OTC list, meaning that you and I can buy shares in the company," says Drevdal. During this "financing phase" the design and testing of full-scale modules have been completed, and several successful further tests have been done, including transporting, depositing and compressing drill cuttings.

"We are soon entering the commercialisation phase, meaning that we will conduct full scale prototype testing both onshore and offshore and, hopefully, we will be operating the first commercial Badger Explorer in about two years time," says Drevdal.

"Successful implementation of this technology will result in a dramatic cost reduction compared to today's drilling methods," claims Drevdal. His motto is 'The deeper the water, the better', as "the cost of using Badger Explorer is estimated to be a third today's traditional methods in moderate water depths (150-1000m), while in deeper water (above 1000m) drilling costs that are a tenth of today's method may be achieved".

Badger Explorer, about 30m long with a diameter of 15cm, is transported to the drilling location by boat and then lowered on wire to the sea floor and put in a start position assisted by ROV and a guide frame.



Drill cuttings will be transported from the drill bit and up through the tool while a hydraulic piston compresses the cuttings and forces them up and out to the borehole wall. The drilled hole above the tool is permanently plugged and sealed with cuttings during the drilling operations. Information about the formations and the fluids are logged continuously and the information is transmitted through the cable to the seafloor and then further to a buoy at the surface. Finally, the signal goes by satellite to onshore operation offices.

Test holes made by Badger Explorer. There is no need for drilling mud or casing.

Whilst the management will be pleased about saving money , the geologists will be a little disappointed, as they will have neither cuttings nor cores to work with.

reservoir modeling

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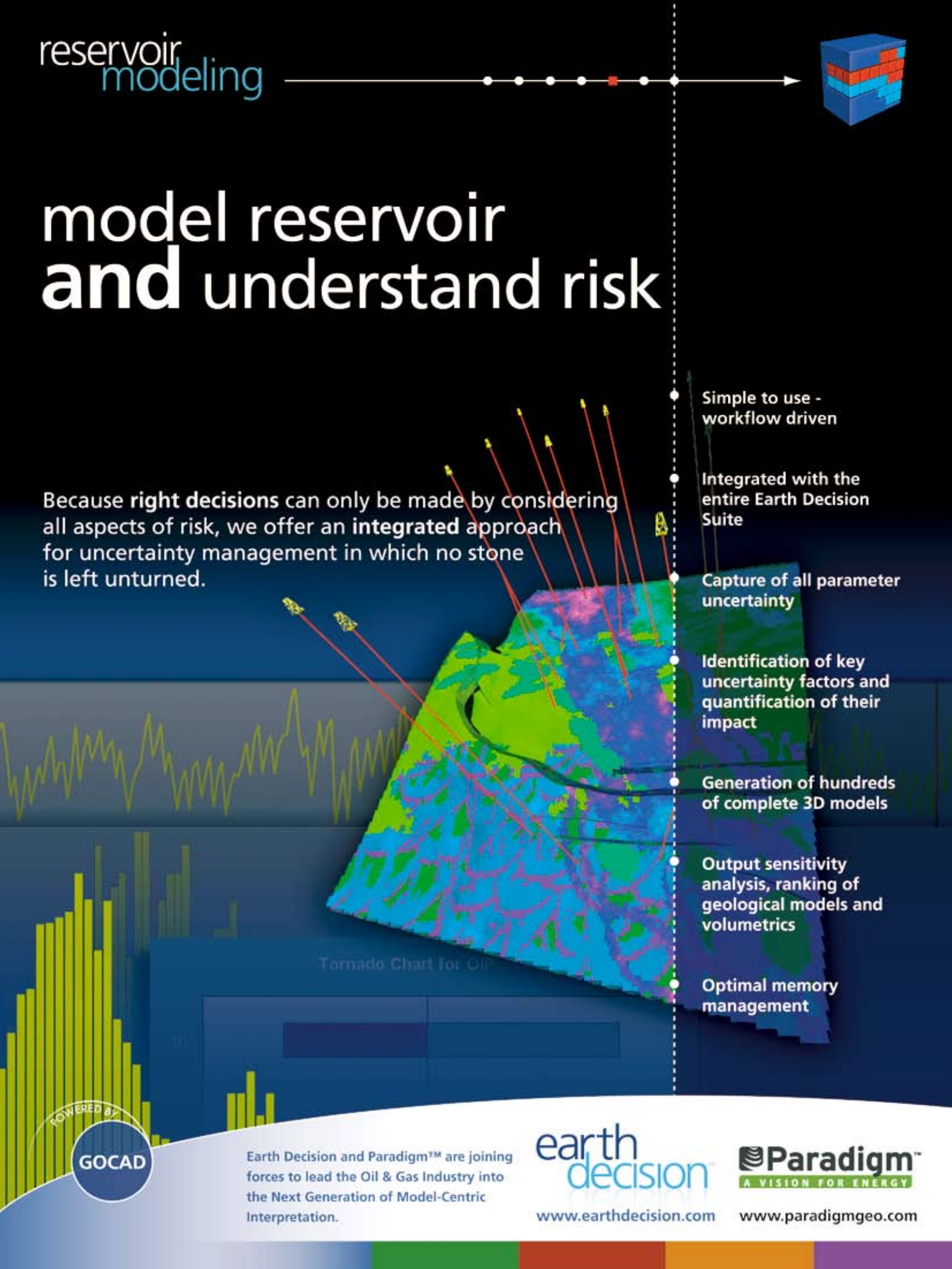

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New Portable Log Scanner

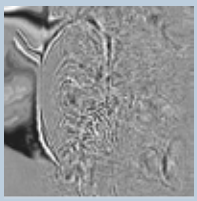
Javan Meinwald, Vice President of Sales at Neuralog Inc., with NeuraScanner II.

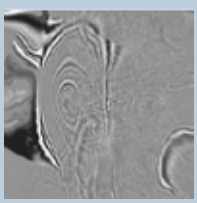
NeuraScanner II will aid in preserving the oil and gas industry's huge paper-based knowledge stores, being able to rapidly and accurately scan paper logs, maps, core photos and reports.

"With the need to preserve data for the future, Neuralog, has upgraded the NeuraScanner that was first introduced in 1999. The new NeuraScanner II has improved image quality, speed, reliability, and portability," explains Javan Meinwald Vice President of Sales at Neuralog.

"The exploration and production industry has huge paper-based knowledge stores in danger of being lost as fragile logs and other documents degrade. The NeuraScanner is the industry's only purpose built log scanner and enables the user to preserve logs, maps, core photos, reports and other data commonly found in the E&P environment wherever it exists. Millions of logs have been scanned with the original NeuraScanner. Millions more remain, and for this reason Neuralog Inc. invested in technical innovations for NeuraScanner II," says Meinwald.

The new scanner has been a big hit. Don Kotowych, Director Data Acquisition Services at A2D Technologies, a TGS-NOPEC Company, which has the world's largest log image library says: "Neuralog makes a really unique scanner, and when we have projects here in the USA and half way around the world it is the main scanner we consider. We deploy our teams with laptops and NeuraScanners to get the job done in Nigeria, throughout Canada, Russia and elsewhere. We are impressed with the new NeuraScanner IIs which are substantially faster and make better quality images day in and day out."





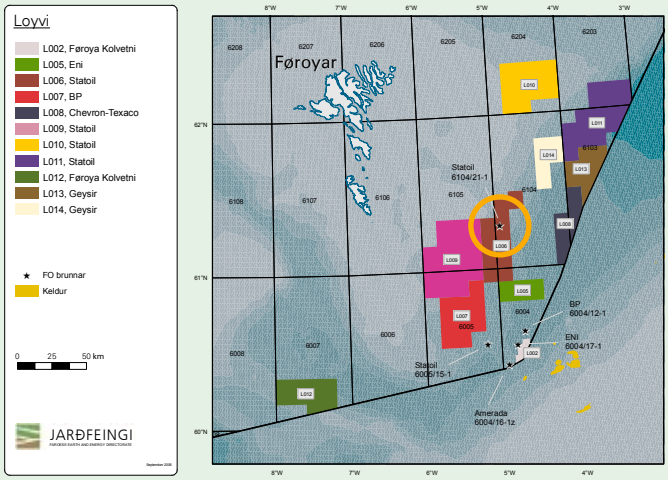
ERRATA

The Sub-Salt Imaging Challenge

The figure caption on page 28 in GEO ExPro No 4/5, 2006 should read as follows:

"Comparison of Narrow and Wide Azimuth seismic depth slice from BP Gulf of Mexico model data (Taken from: Farnsworth, OTC, May 2005)." We apologize for this mistake.

Traces of Gas



Map of licenses granted on the Faroese Continental Shelf. Licenses 001 to 007 were awarded in the 1st licensing round in August 2000, while licenses 008 to 014 were awarded in the 2nd licensing round in January 2005. In the autumn of 2005 an agreement was reached between the license holders of licenses 001, 003 and 004 and the petroleum authorities on a transfer of wells to licenses 006 and 007. Licenses 003 and 004 were at the same time relinquished. Source: www.jf.no

The last well drilled offshore the Faroe Islands, and the first sub-basalt well, did not find commercial quantities of hydrocarbons. The well 6104/21-1 in Licence 006 operated by Statoil did, however, encounter traces of gas. Dong Energy, Anadarko, Shell, Amerada Hess, BG group, Faroe Petroleum and Atlantic Petroleum are partners in the license.

The Faroe Islands Exploration Conference 2006 was held in September with more than 160 attendees. It was opened by Minister of Trade and Industry, Bjarni Djurholm, who said there is an increased exploration interest in the Faroese area. He also said preparations for the third Faroese licensing round are now under way, and that it will probably be announced in the autumn of 2007 as scheduled.

Thorshavn, the capital of the Faroe Islands.

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Meeting challenges head on

Mountain flying in British Columbia for multi-client partner JEBCO Seismic.

As oil companies are facing increasing pressure to replace reserves while reducing exploration risk, the demand for geophysical solutions is running at an all time high. Service companies around the world have bursting order books and a backlog of work orders; one company experiencing this surge in demand is privately owned ARKeX Limited.

ARKeX, which is based in Cambridge, UK, uses its advanced airborne gravity gradient imaging technology to provide detailed exploration information enabling new levels of depth and understanding in geologic interpretation. The company flies a Lockheed Martin-developed full tensor gravity gradiometer system (FTGeX) and uses specialist software tools developed in-house to assist in the interpretation of gravity gradient data.

Gravity gradient imaging is a non-invasive airborne imaging solution that is ideally suited for obtaining detailed geological information cost-effectively with minimal environmental impact. It enables companies to efficiently screen large areas, not only accelerating the decision-making regarding where to concentrate seismic surveys, but also supplementing other geophysical data. In particular gravity gradient imaging is ideally suited to work in combination with seismic surveys to form an integrated subsurface picture.

Applications for gravity gradient imaging include prospect evaluation determining detailed structures (faults, edges, depths), identifying structure beneath 'fuzzy seismic', field development and delineating salt morphology. In addition, it can be used for direct gas and commodities (diamonds, copper, zinc, gold, nickel, iron) detection, and oil/water contacts (4D effects).

Traditional land seismic surveys have significant cost, timing and environmental considerations, whereas airborne surveys provide a rapid imaging solution of limited environmental impact, expense, and logistical considerations. Even where land seismic surveys have been performed, integration of ARKeX data with existing 2D or 3D seismic data provides improved geological understanding, especially in areas where the geology inhibits clear seismic imaging.

The ARKeX technological solution incorporates gravity gradiometry, magnetic gradiometry and digital terrain mapping (LIDAR). Integrating data from these components results in a valuable exploration dataset that provides regional overview through to prospect evaluation.

Earlier this year, ARKeX commissioned a study of senior exploration and production professionals which revealed some interesting points: industry awareness of the value of gravity gradiometry is increasing and the technology is now considered a significant alternative to other imaging techniques especially in regions where access is difficult. In some situations, the study revealed that exploration companies believe airborne gravity gradiometry (AGG) to be suitable for screening a greater area of terrain more effectively than seismic data, and for a lower cost; in other environments the industry considers AGG to be a technology that complements seismic data. This all adds up to a shorter exploration to production time cycle and an increase in the probability of success.

rxt Reservoir Exploration Technology

Following the success of our first crew's continuing operation in the Gulf of Mexico...

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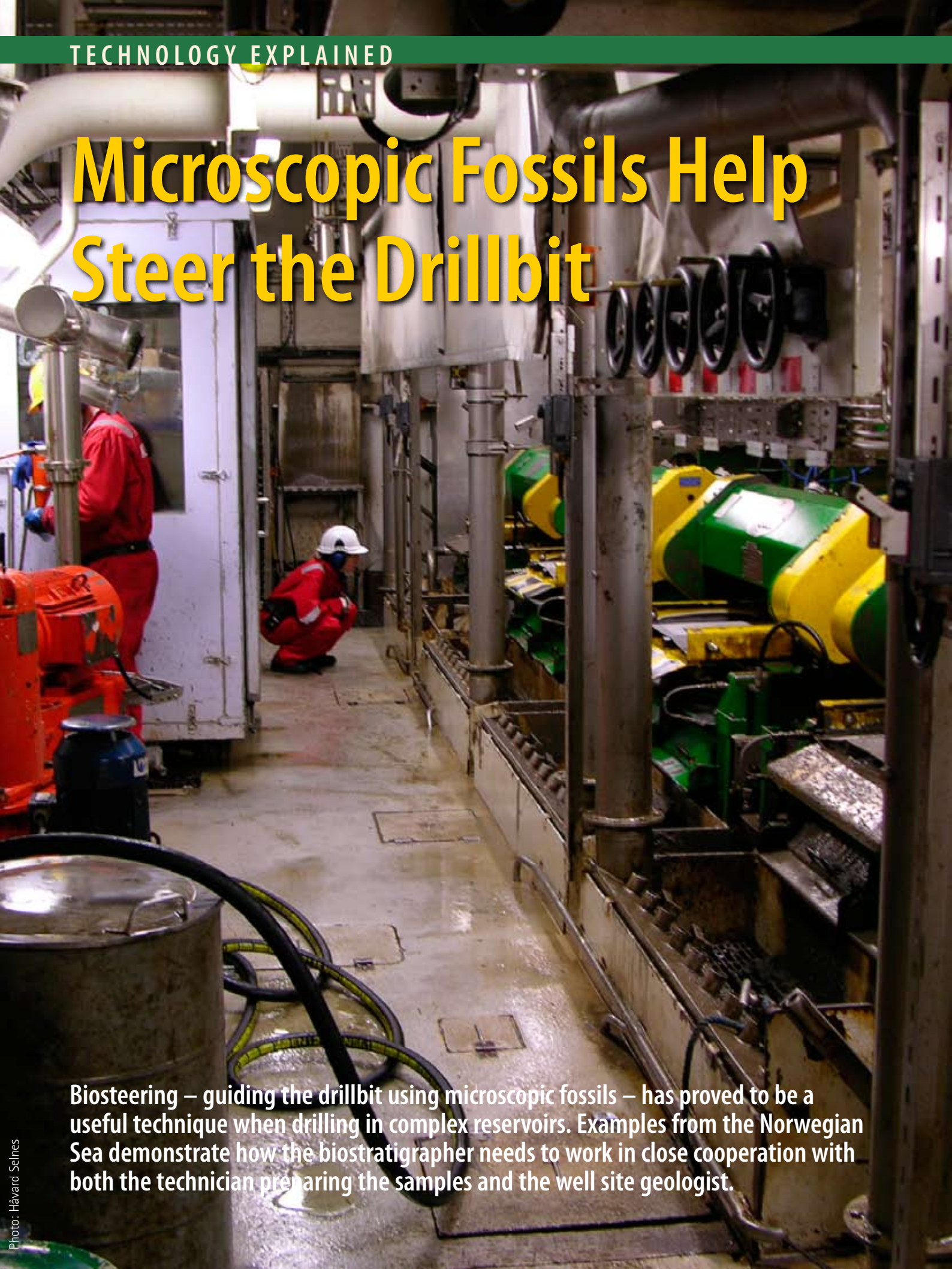
Microscopic Fossils Help Steer the Drillbit



Biosteering – guiding the drillbit using microscopic fossils – has proved to be a useful technique when drilling in complex reservoirs. Examples from the Norwegian Sea demonstrate how the biostratigrapher needs to work in close cooperation with both the technician preparing the samples and the well site geologist.

Photo: Håvard Selnes

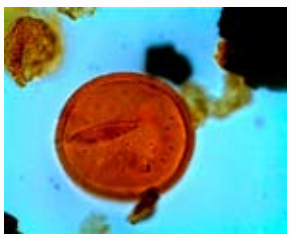
Håvard Selnes, Applied Petroleum Technology (APT AS)

The science of biostratigraphy is a well-established discipline when drilling exploration, appraisal and development wells in geologically complex areas. The knowledge obtained from analysing the microfossil content of the sediments whilst drilling is very useful. This is especially the case when it is necessary to obtain a detailed account of which layers are penetrated by the drillbit on its way down to or through the reservoir.

Biostratigraphy is also used when drilling through reservoirs with complicated stratigraphy to detect faults and unconformities and, since the introduction of horizontal wells, its importance in development drilling has increased substantially. It can help optimise the well path in multiple sandstone beds separated by shale barriers, or show the faults with throws that cannot be resolved on a seismic scale in any detail. Complex reservoirs of this kind are found in the Norwegian Sea, in fields such as Heidrun, Norne and Njord, all producing from Jurassic shallow marine deposits situated in densely faulted areas. The giant Troll field in the North Sea, on the other hand, exemplifies a typical layer cake geology in which the method has no merit.

Be prepared!

The successful use of biostratigraphy when drilling a well requires thorough biostratigraphic studies of well samples and reported data before travelling to the wellsite. It is necessary to make a detailed account of the distribution of microfossils (plants and plant remains) in each horizon that will be penetrated. This is called biozonation and means that the wellsite palaeontologist will have a good knowledge of the fossil contents of each layer before going to work. This is certainly the most important tool that the biostratigrapher can use and without it, he or she is almost helpless. When on site, day or night, the biostratigrapher uses the **biozonation** to assist getting an accurate account of which formations are being drilled through.



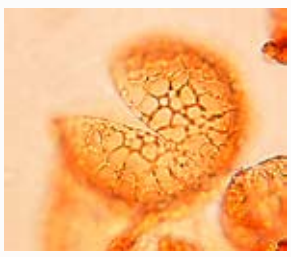


Photo: Håvard Selnes

The rock samples (ditch cuttings) are taken from the shale shakers and carried to the on-board laboratory for cleaning and extracting fossils.

Photo: Håvard Selnes

Slide with fossil plant remains under the microscope.

Photo: Håvard Selnes

Numerous slides are prepared to find the right well path.

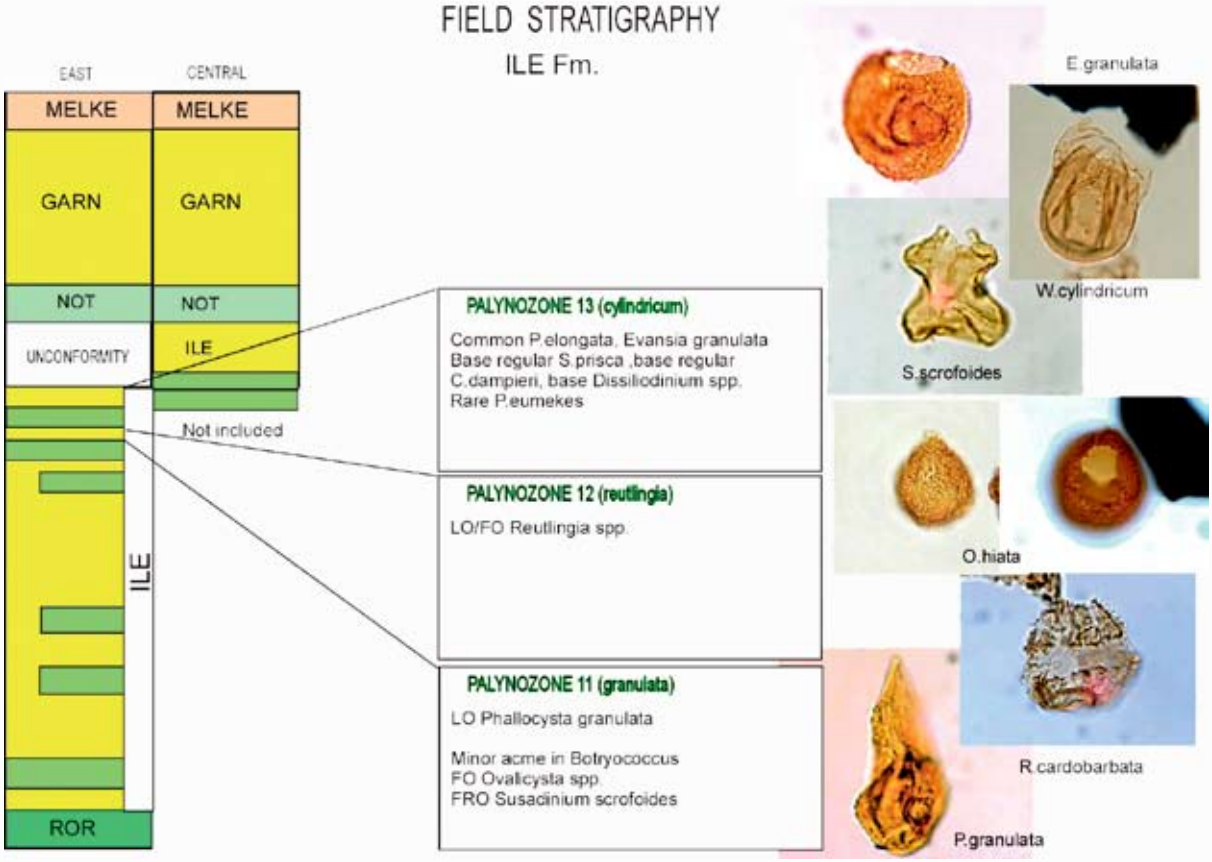
In development drilling, the biozonation is based on data from cores taken during exploratory drilling. However, there are significant lateral changes within a sedimentary basin and the biozonation for one particular field may be of limited value for another.

The biostratigrapher is part of a team of geoscientists who follow the drilling from minute to minute. This includes the wellsite geologist as well as the project geoscientists onshore. A palynologist is a biostratigrapher who specializes in microscopic plants and plant remains with a tool kit consisting of the biozonation scheme, a microscope and the software to handle the analyses. Biostratigraphic observations and interpretations are evaluated alongside other geological data obtained during logging and drilling. This enables important decisions to be made, such as whether to change the well trajectory from its planned course.

The team

When drilling through a reservoir in the

Photo: Håvard Selnes



Biozonation is a necessary tool – a reference scheme - for the palynologist when analysing the samples, as it shows which fossils that should be found within a given layer.

Norwegian Sea, it is common to have a biostratigraphic team consisting of at least a palynologist and a technician, although for a full 24 hours service 2 palynologists and 2 technicians are needed, with each team working 12 hour shifts. The composition of the team depends on the predicted geological challenges that they are faced with and the expected speed of drilling.

The technician, responsible for extracting the valuable plant fossils, is in charge of a laboratory within a pressured container that is moved to the rig when it is needed. Within it there is a water supply, sink, fumehood, hot plates, centrifuge, sieves, and a HES outfit for safe handling of potentially hazardous chemicals. The rock fragments are dissolved in strong acids, and the fossils constitute the resulting product, as they are insoluble in most acids.

The technician's skill is extremely important in order to obtain a good result. It is a difficult and tedious task to extract fossils, particularly from sandstone reservoirs that can often be very poor in fossils. The analyses and the conclusion to be drawn by the palynologist depend totally on the quality of the preparations. The value of a good technician can therefore not be overestimated.

Good planning essential

On the average, depending on how deep the actual drilling goes, it takes about an hour to circulate cuttings from the drill bit to the surface. The preparation process takes another hour, and then the palynologist needs an hour or so for the analysis. Altogether this means that it may take up to 3 hours from drilling into a certain bed or formation before the palynologist can give his or her opinion. This may sound fairly slow compared to the snap decisions

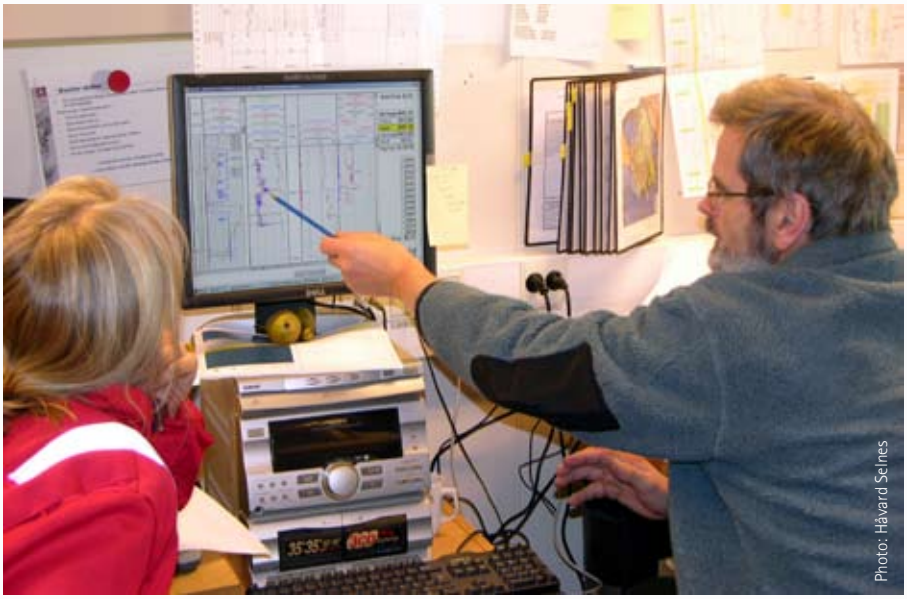


Photo: Håvard Selnes

Having analysed and interpreted the sample with reference to the biozonation, the next step for the biostratigrapher is to discuss any ambiguous results with the well site geologist (right). In this case, the discussion takes place in front of the MWD-logs (measurements while drilling), that are all recorded in real time.

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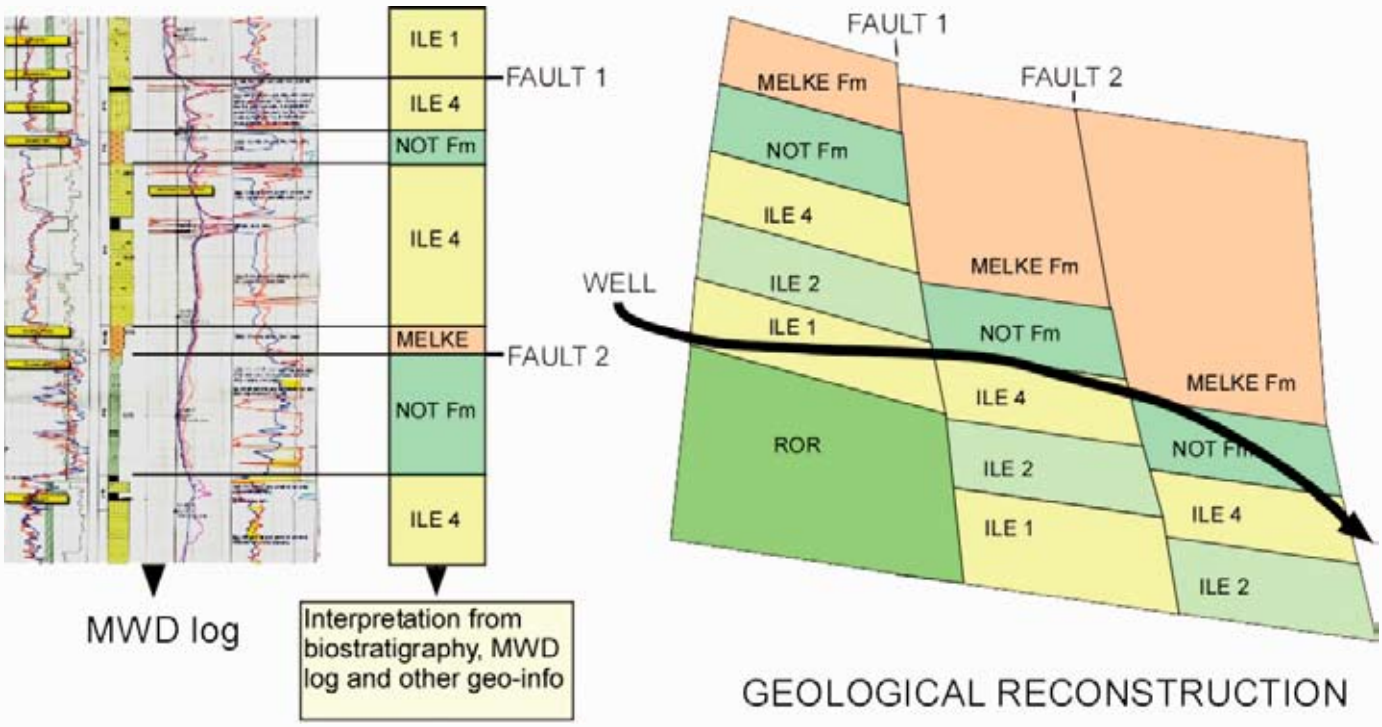

Well trajectory illustrating the need for steering the drill bit because of faults.

that can be taken on log signals, but it could make an important contribution to the right judgment being made. Compared with the long time it takes to send samples to laboratories on land, the rig-based biostratigraphy is practically *real time*.

The rate of drilling (ROP) depends on the rock that is being drilled through. In indurated limestone stringers the drilling rate may be only a few centimetres per hour, but in loosely consolidated sandstones, the rate may easily be as much as 60 metres per hour. Typical drilling rates are in the order of 10 to 30 metres per hour in rocks of Mesozoic age in the Norwegian Sea.

Given that the drilling rate is about 20 metres per hour, and that the palynologist's analysis is delayed by 3 hours, the analyses will typically be 60 metres behind the drill bit. With only one palynologist and one technician on board, crucial samples may be easily missed. Good planning is therefore vital. Experienced staff able to plan their work within the allowed 12 work

Håvard Selnes studying plant remains in the microscope in order to determine in which formation the drillbit is.

The technician prepares the samples for analysis. His or her skill is extremely important if the palynologist is to do a good job.

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hours per day are essential to the overall performance. However, in some critical cases it is deemed necessary to have an extended team to ensure a full 24 hours coverage.

Pitfalls

The challenge for the palynologist is that the total number of fossils in the sample is often small and possibly poorly preserved, bringing a risk that the identifications will be false, with serious implications for the decisions that are to be made. For this reason, one sample is frequently not enough. It is necessary to analyse several and try to establish a trend in order to come to a confident conclusion.

In addition, when undertaking the interpretations there are further possible pitfalls that the team needs to be aware of and to take into consideration before drawing their conclusions. For example, reservoir rocks often contain fossils that belong to older formations. These have their origin in the rocks that were eroded and later redeposited when the reservoir rock was formed. With a large accumulation of redeposited fossils the biostratigrapher may easily think that the drilling has reached older beds than it has. Similarly, reservoir rocks may contain fossils that belong to younger formations, as fossil bearing rocks above the drill bit (but not above the casing sho e) may shed fragments (cavings) into the hole and contaminate the samples. It is almost impossible to avoid this happening, and in some cases it can seriously disturb the process and interpretation.

The palynologist finally compares his conclusions with the biozonation scheme developed in the research phase of the project and gives his opinion to the well-site geologist. If everything is according to the plan, drilling will continue. However, if there is strong evidence, or even indications, that the last section of the drilling is not according to expectations, both the well-site geologist and the project geologist on duty become involved and a consensus must be reached before making a decision on how to proceed.

Communicating the results to non-biostratigrapers is probably the most challenging part of the biostratigrapher's work. Decisions regarding the drilling have to be taken then and there, and the drilling managers seek unambiguous answers from the contributors. There is nothing between yes and no.

Photo: Håvard Selnes

Entering the laboratory for a clean-up.

Examples

In our first example from a (Middle) Jurassic Ile Formation reservoir in the Norwegian Sea, the biostratigrapher was quickly able to determine that the drillbit had penetrated a fault and which formations that were reached on the far side. With well logs only, this would be an almost impossible task, but using the work of the palynologist, it was possible to adjust the direction of the drillbit to get back to the best part of the reservoir.

Another example of the use of biostratigraphic data is in optimising the casing point. The reason for setting the casing in the very top of the reservoir is to seal off a potentially unstable shale formation. In principle, it is easy to detect a sandstone formation when entering it, but the trouble may be that it is not the required reservoir sand, but a local sandstone stringer or lens above, encased in the sealing shales. The logs will not tell the thickness of the sandstone before it has been drilled through, and there is a risk of setting the casing shoe too high above the main reservoir, with consequent borehole instability.

The reverse may also be the case. The drilling team wants to avoid entering the reservoir before the casing is set because of an abnormally pressured reservoir. Using biostratigraphy, it may be possible to find an optimal location for the casing shoe within the overlying cap rock.

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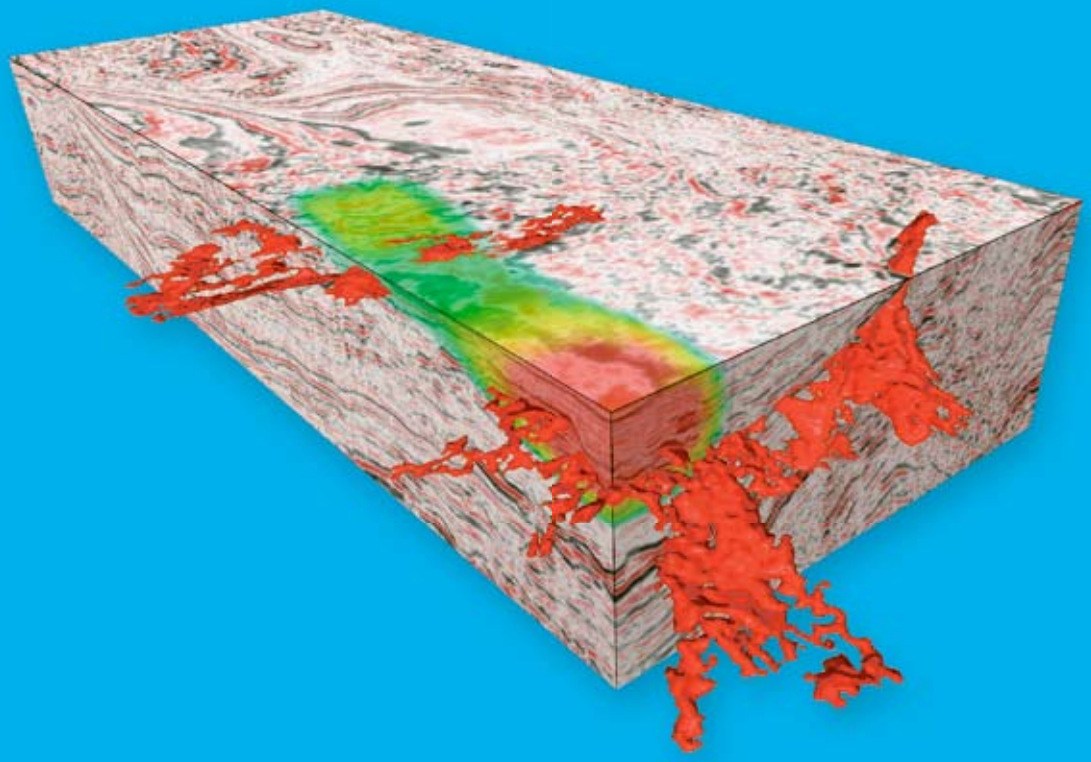

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Much ado about nothing?

Has integrated 3D reservoir modelling really changed the way we work, or has it been just "much ado about nothing"?

Lars Edward Kjellesvik, Kjellesvik Reservoir Management Services AS; lars.edward@kjellesvik.com

Only a few years ago, the buzz phrase in the industry was "The Shared Earth Model", and a lot of emphasis was put on "the benefit of the integrated asset teams". According to everyone from CEO's to humble geologists, we were all going to find and produce more hydrocarbons with focused teams taking advantage of the latest technology. Now the question is, did anything change? And did we take advantage of all the new tools that we bought?

Photo: Halfdan Carstens

Lars Edward Kjellesvik was for 11 years a key participant in the development of Irap RMS and Roxar Software Solutions, as well as the predecessors. For the last year and a half he has worked as an independent consultant advising on reservoir modelling and management for small independents and international supermajors alike.

From 2D maps to 3D modelling

One of the most significant development in reservoir modelling and management over the last 15 years has been the development of integrated reservoir modelling tools, such as Irap RMS, Petrel and Earth Decision. We have used these tools to revolutionise the way we model, visualise and understand the geology of hydrocarbon reservoirs, in order to make more informed decisions. But moving geology from 2D maps to detailed 3D models does not really create an integrated reservoir model. It just gives better geological understanding.

Unfortunately, however, we have not yet been able to take full advantage of the most valuable contribution the integrated reservoir modelling tools offer to the E&P industry: the integrated reservoir model itself.

It is fair to say that the latest releases of integrated reservoir modelling applications provide an adequate technology for the main elements of a reservoir model, such as structural framework, petrophysical properties, initial fluid distribution, dynamic properties and simulation. They also provide workflow management tools and allow integration of third party technology if required. This means that these tools facilitate the construction and maintenance of integrated reservoir models by integrated asset teams.

Defining the reservoir model

At this stage it is useful to step back and quickly look at what a reservoir model actually is. My definition is as follows:

"A reservoir model is a consistent representation of all available relevant data and knowledge of a reservoir, built for the purpose of calculating the volume of hydrocarbons and optimizing recovery from the reservoir".

Reservoir management is therefore about providing input to the reservoir model and acting on decision-support information from the model.

Based on this, the reservoir model can take many shapes and forms, depending on the available data and the reservoir management decisions that we need to make. The reservoir model required for exploration would, for example, be different from the one required for an IOR project. The only common factor is the procedure for designing the reservoir model.

Designing the reservoir model

In my experience, the reservoir model is in most cases still created in the classical way; starting with interpreting seismic data, then building the structural framework, populating petrophysical properties, upscaling the model and finally creating the simulation. Each modelling stage is done in relative isolation, using dedicated software tailored to each task. After each stage the geoscientist or engineer exports the model from his or her software, and then the next stage commences.

This procedure is repeated regardless of the purpose for building the model. Far too often the result is that the majority of the time allocated for the study is consumed before the fault modelling is completed, leaving little or no time for what could be critical items towards the end of the process. Time can also be wasted on parts of the modelling that in the end may prove to be of little importance to the purpose of the model itself. It is therefore necessary to spend more time on the design of the reservoir model.

In order to build the best possible reservoir model we need to answer the following questions (in this order):

1. Which reservoir management decisions do we need to make?
2. Which variables from the reservoir model give us the best decision support information?
3. Which elements of the reservoir model critically influence these variables?
4. How can we be sure that these elements are properly incorporated in the model?

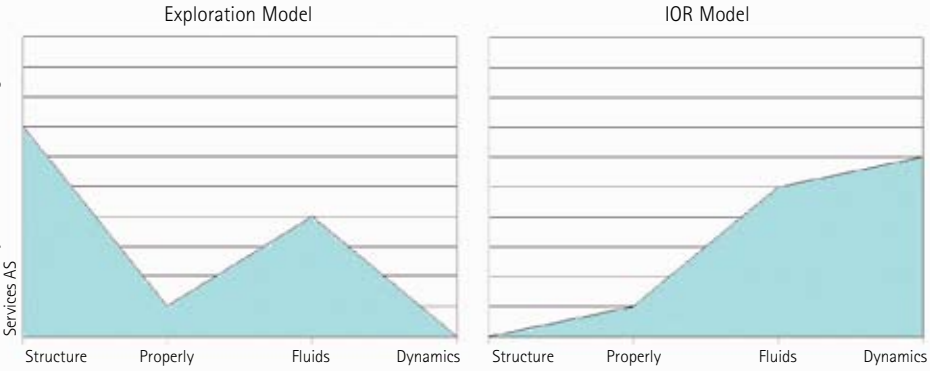


Illustration: Kjellesvik Reservoir Management Services AS

An alternative reservoir model built to investigate the value of well stimulation will look very different from the exploration model.

These questions need to be answered by the entire asset team together to ensure that all aspects are properly investigated.

As a result of this process, we should have a fairly good understanding of where we need to focus our resources and efforts, resulting in a reservoir model that gives robust answers to our challenges.

Even though the resulting model itself will be built by, for instance, the geologist or the engineer, it is critical that the asset team takes joint ownership of the model. After all, the result of, for instance, the petrophysical analysis, is going to end up in the properties model, which should make it as interesting to the petrophysicist as to the geologist. Similarly, the fault seal analysis undertaken by the structural geologist will end up determining the flow pattern in the simulation model, so this should have been jointly investigated with the reservoir engineer.

"Could have been more"

In summary, I am afraid that a lot of the potential rewards of integrated 3D reservoir modelling are lost between moving data between specialised software packages, through lack of time to properly design the reservoir model and as a result of poor cross discipline communication. The software developers have provided or are in the process of providing the tools, but the industry has not taken advantage of them yet.

So in the end it can be said that integrated 3D modelling has been "much ado about something – but it could have been much more"

Photo: Halfdan Carstens

Detailed knowledge of the fluvial sandstones in the Pyrenees (The Ainsa Basin) is important input for modelling of the Snorre field Triassic reservoir in the North Sea.

One software package

The main challenge with integrated reservoir modeling is that it requires excellent communications between the disciplines, both the individuals and their data. Ideally, the entire modelling procedure should be performed in one software package with all relevant data loaded for QC purposes. This would, for instance, allow the impact of changes in the seismic interpretation on ultimate recovery to be easily tested.

The benefits of building an integrated 3D reservoir model within one software package are obvious:

- No time is lost in importing and exporting data between applications
- A fully integrated model invites the entire asset team to sit together during the entire modelling process, and not only for formalised reviews
- Workflow management tools are available to automate model updates through the entire workflow
- QC is significantly improved by having seismic data, petrophysical data, the geological data and the simulation model together
- Communication is greatly improved
- It is easier to do proper model updates rather than "engineering fixes"

So why is it that the reservoir engineers, geophysicists and petrophysicists do not want to drop their specialist software and join the geologists in the brave new world of integrated 3D reservoir modelling?

The strongest reason is obviously that any tool with a development history focused on delivering what a specific profession needs will have functionality that a "wider" application can never get. Also in some instances regulatory requirements prohibit changes and in many cases partners or time constraints could restrict changes of software.

I consider, however, that the majority of the reservoir modelling work that is being done could be handled by the integrated reservoir modelling applications - and that the benefits greatly outweigh the disadvantages.

We do not expect to ever get to the point where one package can ever deliver specialist functionality for all disciplines, so there will always be a need to do part of the modelling outside the chosen integrated reservoir modelling tool, but the benefits must be significant enough to justify the cost of going outside the optimal workflow.

Demonstrating Capability

Major improvements have been made over the last two decades in measuring drilling parameters (MWD) and logging formation characteristics (LWD) whilst drilling. During the logging of two North Sea fields, the advantages and quality of real time data in horizontal wells have been fully demonstrated.

Trond Gravem, Baker Hughes INTEQ

Measuring the properties of geological formations and reservoir fluids has traditionally been performed with logging tools run on an electric wireline, a technique that was developed in the 1920's. For a long time this was the only method of acquiring accurate subsurface data in boreholes.

The benefits of wireline logging are obvious - the measurements are performed in a static environment, the contact between the tools and the formation is good, the depth control is excellent, and the tools used are proven through several decades of operations.

With high rig costs and increased focus on operational efficiency, there are also certain inherent disadvantages with wireline logging. The data acquisition requires a halt in the drilling operation and, given that there is a problem in getting the tool into the hole or retrieving it, wireline logging introduces added risk for time delays and in a worst-case scenario, the hole may be lost.

Wireline logging is therefore now used in wells with added focus on the quality of the formation data, in wells where the risk of getting stuck is low, or where there is a requirement for specialized services, such as sampling of formation fluids.

Steering the drill-bit

Since the early 1980's, huge resources have been spent on developing a method to perform data acquisition simultaneously with the drilling operations, i.e. in real time. This technique is called Logging While Drilling (LWD). Since the introduction of the Gamma Ray tool more than 20 years ago, there has been a rapid development of more advanced LWD measurements.

Through LWD, it is possible to optimize well positions, avoid drilling hazards and drill more efficiently. The operators expect the downhole data to be as updated as possible, i.e. they want real-time data and data acquired as close to the drill bit as feasible.

Engineers from Baker Hughes INTEQ on the rig floor following the MWD/LWD tools being run down the well.

Recent developments in LWD have made it possible to acquire high-resolution electrical borehole images. For the geologist, real-time interpretation of structural and sedimentary features from borehole images can be used to steer the drill bit in the reservoir section. The purpose would be to stay inside a desired sedimentary package based on the rapid interpretation of sedimentological criteria (e.g. sedimentary steering by using predictive models of sandbody geometry and internal architecture). This can give forewarning of approaching features in the proposed drill path, such as.fracture intensity increasing towards a fault zone, and avoid or mitigate adverse features that may have a negative impact production , for example by avoiding reservoir roof rocks by steering away in advance.

North Sea experiences

On several field developments, INTEQ has provided multiple advanced formation evaluation measurements and thereby replaced the need for wireline logging.

Data acquisition wells operated by Norwegian oil company Hydro in the North Sea, such as Oseberg West Flank and Grane, are based on LWD-acquired formation evaluation data. It has been demonstrated that LWD systems can provide data for comprehensive formation evaluation and petrophysical analyses, and that the LWD technology is capable of operating with high reliability and at the same time delivering excellent data quality[1].

In Grane well A, comprehensive formation evaluation data was obtained throughout the 1,617m reservoir section and acquired in a single drilling run to TD over 107 circulating hours. In Grane well B, the same data was acquired in a 2,030m horizontal reservoir section that was drilled in a single run of 236 circulating hours.

Spending up to 2 weeks in the hole with continuous operations is quite impressive, given the tough drilling conditions coupled with highly advanced electronics and computer technology integrated in the downhole tools.

The data collected in these wells was extensive and included gamma ray, resistivity, neutron porosity, formation density, image logs, acoustic travel time, formation pressure and mobility (TesTrakTM) and extra deep reading resistivity measurements.

By collecting the data during drilling in a single run, the whole logging process is made more efficient and the wells are put on stream earlier than if an extensive wireline logging program been selected.

The technology

The LWD technology adds significant value for several reasons:

(a) Reservoir geometry is better understood by combining different log measurements with seismic data. The near-wellbore measurements, such as gamma ray and density wellbore images, can be used to interpret stratigraphy while the variety of resistivity measurements may be employed to interpret wellbore geometry. By combining this information with formation pressure and the seismic interpretation, the reservoir model may be improved. The understanding of log responses in horizontal wells is a key factor in this.

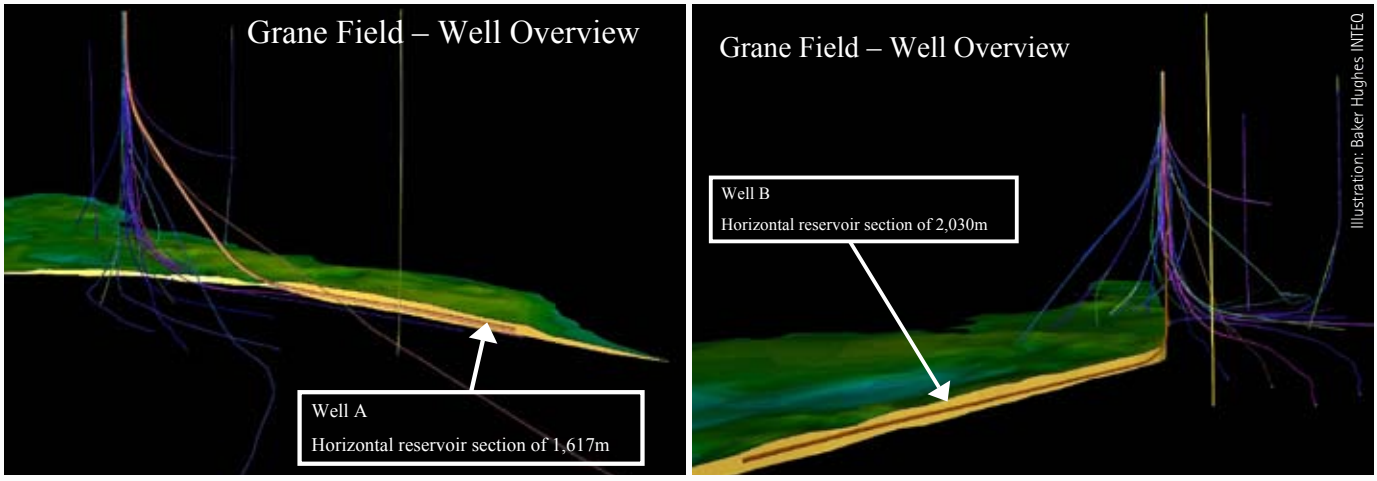
(b) Acoustic compressional (P) and shear wave data (S) are provided in a full range of formation types. In acoustic terminology, formations are split into fast and slow. Acquisition of shear waves in slow formations has been a challenge. The unique quadruple acoustic excitation method also enables the acquisition of quality shear

Mud Pulse Telemetry

Mud pulse telemetry is today the most commonly used method of transmitting data from the measurement tools in the well-bore to the rig at the surface.

While drilling, mud is pumped from the surface down through the drill-string, through the measurement and logging tools (MWD/LWD), then through the drill bit and back to the surface through the annulus between the drill-string and formation.

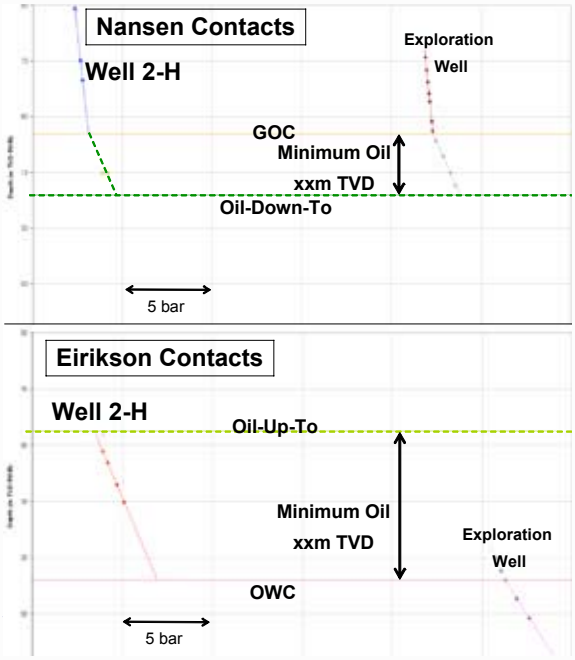
The increase in number of advanced measurements puts a higher demand on data transmission speed. Mud pulse telemetry is limited with regard to bandwidth and can only give 10-12 bits per second (bps) data transmission. To maximise the real-time value from the advanced measurements, will need kilo-bps capacity. The newly introduced wired drillpipe technology can be the solution for supplying this capacity. Several oil companies in the North Sea are currently planning test runs.

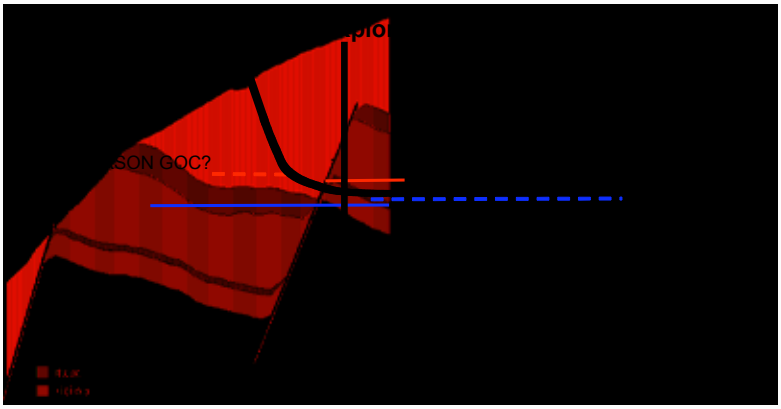


Well profiles for Grane wells A and B.

1) In technical papers written jointly by Hydro and Baker Hughes INTEQ, LWD operations from the Grane and Oseberg West Flank fields were presented that exemplified how combinations of highly advanced LWD technologies have been run successfully ("Multiple Advanced Logging-While-Drilling Technologies Optimized for Drilling and Well Placement" given at the Offshore Technology Conference in May 2006 and "Application and Interpretation of Multiple Advanced LWD Measurements in Horizontal Wells" at the Society of Professional Well Log Analyst - SPWLA Annual Conference in June 2006).

Illustration: Hydro





Interpreted pressure results of Oseberg West Flank Well 2-H. The upper plots display the reservoir fluid gradients and the fluid contacts interpreted in the Nansen and the Eiriksson formations. The lower cross section summarises the interpreted fluid contacts (GOC – gas-oil-contact; OWC – oil-water-contact).

data in the full range of formations (fast and slow).

(c) In minimal time, accurate formation pressure tests are acquired through a combination of good drilling practices, teamwork on the rig and the downhole intelligent optimisation system. Less than five minutes were needed to obtain three formation pressures per depth station. For these two case wells, formation pressures were acquired at a total of 62 depth stations, with a sealing efficiency of 98.5%. Formation pressure data was used for gradient plots and provided information on the type of reservoir fluid encountered and pressure communication in the reservoir.

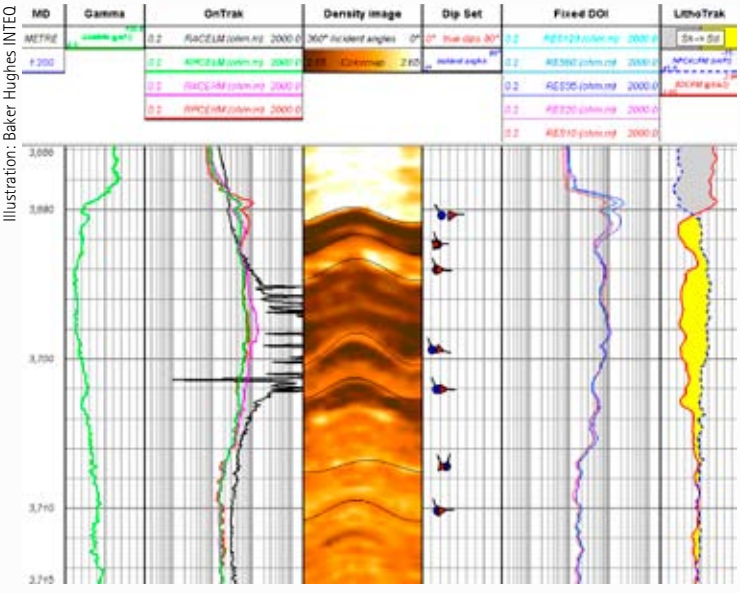
In horizontal wells, special resistivity responses are experienced when crossing formation boundaries. Software processing methods such as inversion, enhance the measured resistivity. Combining inverted resistivity data with borehole image interpretation will help to enhance the determination of bed thickness as well as increase the accuracy of the true resistivity for that particular bed and improve the definition of the bed thickness. The result is a better definition of reservoir thickness and extent and a clearer idea of the amount of hydrocarbons present.

In real-time

The family of LWD-services has developed into reliable and value-adding services for today's advanced world of drilling and logging wells. The wealth of information now available in real-time helps to position the well accurately and facilitates in the mitigation of drilling hazards.

The main advantages of using MWD and LWD are thus optimisation of well placement, increased operational efficiency by reducing non-productive-time, improved knowledge of the reservoir and hence, enhanced production.

Illustration: Baker Hughes INTEQ



Comparison log between industry standard LWD resistivity logs (track marked OnTrak) and inverted resistivity log (track marked Fixed DOI) to show the enhanced interpretation available when combining the density image log with the fixed depth of investigation resistivity curves.

MWD and LWD

Measurement While Drilling (MWD)

MWD includes measurement and acquisition of directional data (wellbore inclination and azimuth), pressure in the wellbore and drilling dynamics measurements such as vibration and shock. MWD thus provides geometrical information on well position and helps to drill the well safely and efficiently.

Logging While Drilling (LWD)

LWD is logging the properties of the formation and reservoir fluids while drilling and before drilling fluids invade the formation, similar to open-hole, wireline logs. The most frequently used measurements include gamma ray, resistivity, density, porosity, acoustic travel time and formation pore pressure.

MegaSurveys

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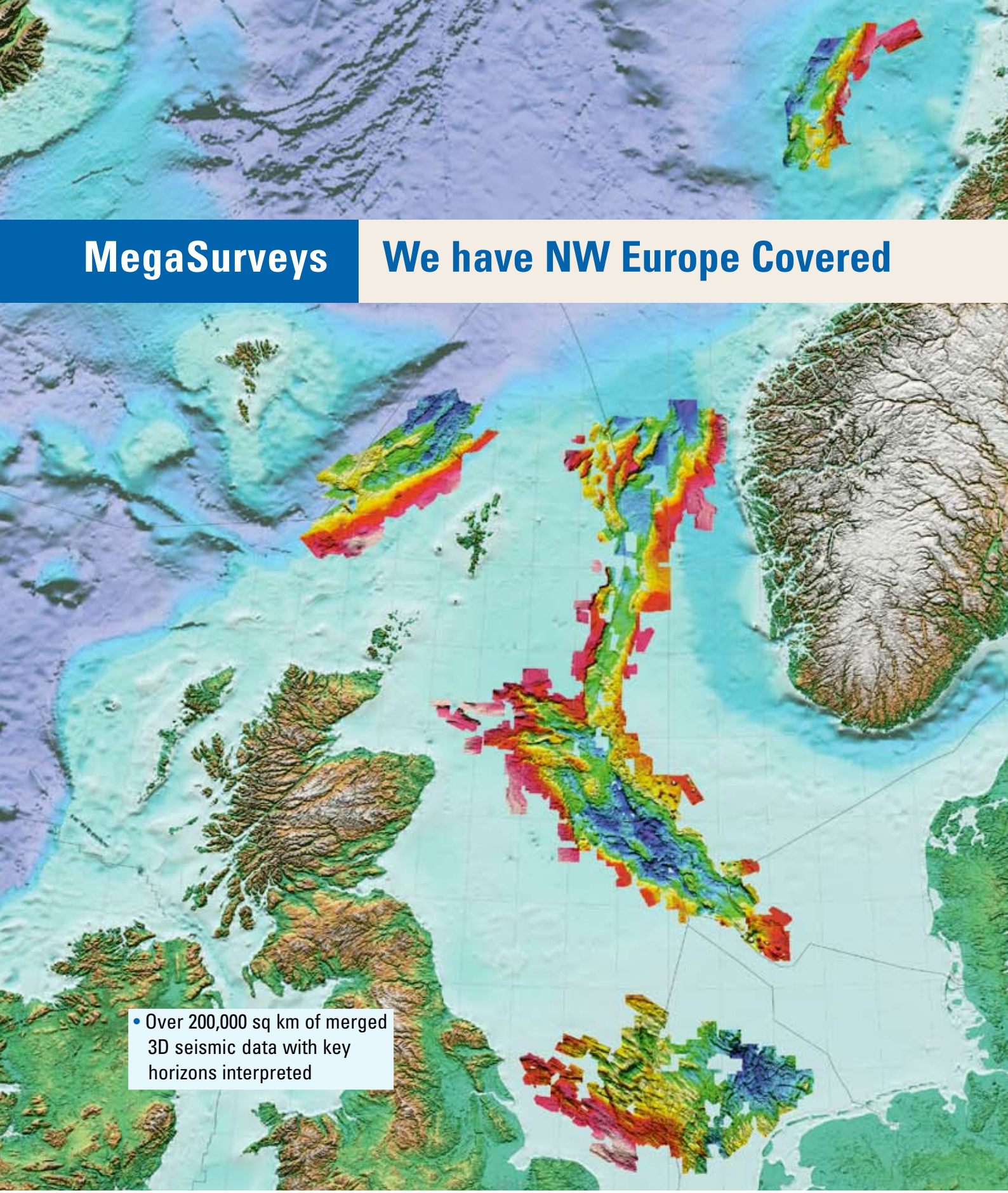

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Cinderella comes of Age

As the oil price rises and technology develops, interest in alternative forms of hydrocarbons such as 'heavy' oil has increased.

Photo: Nautical Petroleum

Steve Jenkins is Chief Executive of Nautical Petroleum, which specialises in developing known heavy oil discoveries in the North Sea. Steve has had a varied career as a geologist throughout the world and became interested in heavy oil while working in Kazakhstan and South America.

Jane Whaley, Associate Editor

"Heavy oil has always been the Cinderella of the petroleum industry," declares Steve Jenkins, CEO of Nautical Petroleum. "While there was nicer 'sweet' stuff to get hold of, the heavy oil was considered a nuisance. With rising oil prices, rapidly developing technologies and declining reserves of light crude, there is now much more interest in heavy oil."

Six trillion barrels

It is estimated that there are over six trillion barrels of heavy oil in place waiting to be exploited worldwide – almost six times the entire known conventional oil reserves. It is found throughout the world, but especially in South America, Canada, China and Russia. The largest accumulation of heavy oil in the world is in the Orinoco Fold Belt in Venezuela, while in Brazil it is estimated that the offshore heavy oil reserves alone could make the country self-sufficient in oil.

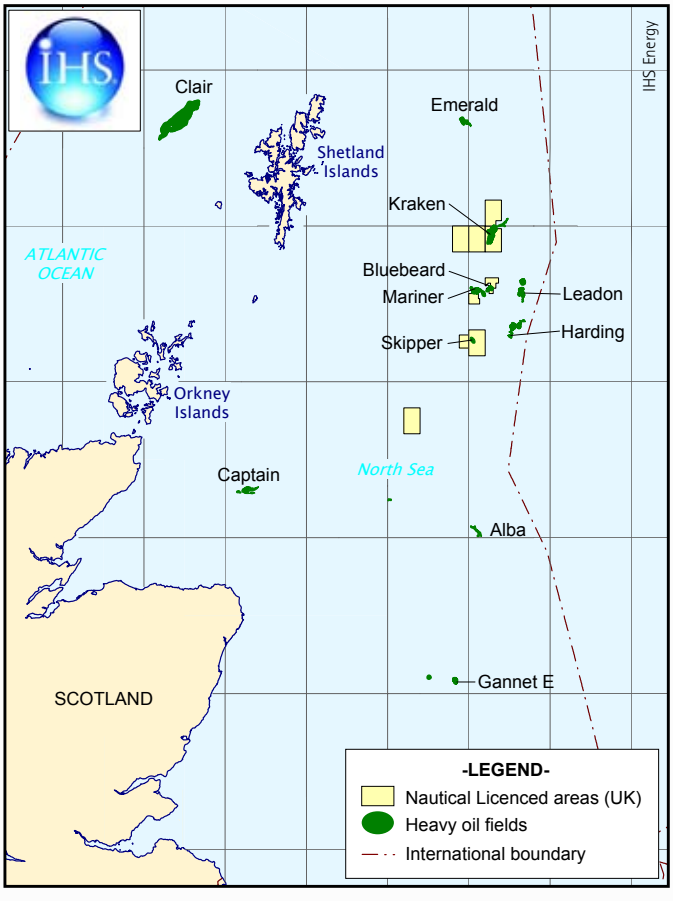
A number of companies have recently been investing much effort and large amounts of money in developing this resource, but Nautical Petroleum is the only company in the North Sea which deals exclusively in heavy oil. "In fact, we avoid light oil, explains Steve. "A sister company, Quadrise, manufacture fuel for power generation using heavy oil, so Nautical was set up partly to feed this ready market, although we are not obliged to sell to Quadrise. But, in addition, we realised that no one was actually specialising in the field of heavy oil here and with the oil price rising, we knew that the time of heavy oil had arrived"

"It is true that heavy oil appears to be more difficult and expensive to produce and process, but there are advantages," Steve explains, when asked why heavy oil is of interest to Nautical. "What you lose in the quality of the oil, you gain in reservoir quality. Heavy oil tends to be found in good quality, shallow sandstone reservoirs, with excellent permeability and porosity and at depths of less than 1,500m, particularly in the North Sea. Wells are therefore relatively cheap, as it often takes less than two weeks to drill to that depth, offsetting the additional cost of processing the heavy oil."

"Typically, a heavy oil field in the North Sea has a thick oil column with a large aquifer and sometimes a substantial gas cap. North Sea heavy oil also has the advantage of being unusually low in sulphur, usually less than 1.5%, although it does have a high acid content."

Heavy oil specialist

"The Mariner Field on the East Shetland platform was discovered in 1981, and extended well tests have been performed, so the resource was proven when we decided to specialise in this market. We formed the company with this intention in 2005



Heavy oil is a type of crude oil which is very viscous and does not flow easily. Excluding extensions and prospects, there are 19 UK Sector North Sea heavy oil fields. These range in size up to around a billion barrels of oil-in-place, although the majority are below half a billion barrels. The fields are located in water depths of around 100m, with the reservoirs themselves at depths of 600 ˆ 1,800m subsea.

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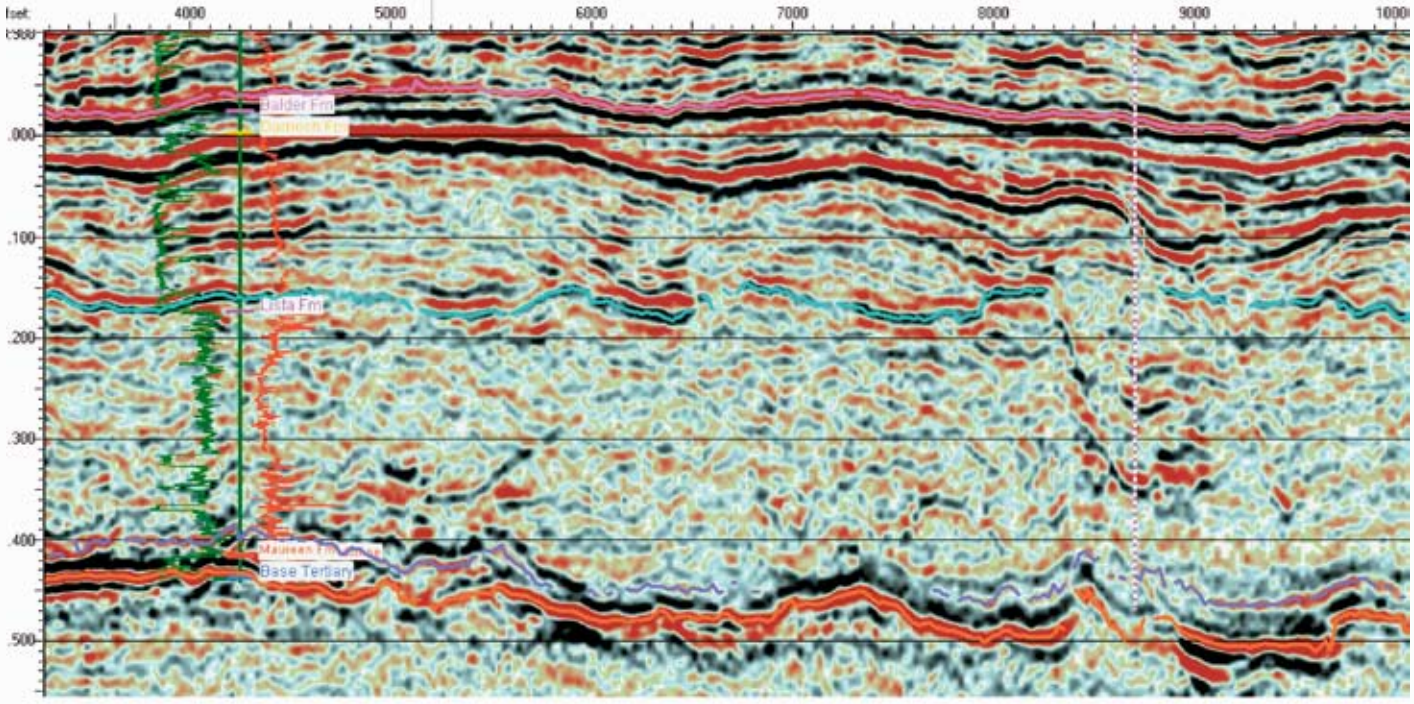

Drilling for oil in the North Sea: most North Sea crudes have a heavy oil fraction, but Nautical Petroleum is concentrating on fields where heavy oil makes up the bulk of the hydrocarbons.

and listed on AIM (the London based Alternative Investment Market) in April 2005. By August of the same year we had purchased Alba Resources, giving us a 26.7% stake in the Mariner Field, which is operated by Chevron and due to have a Field Development Plan submitted next year, with first oil in 2009."

As part of our plan to become the major heavy oil specialist in the North Sea we applied for and were awarded a number of blocks on the East Shetland Platform, all of which hold good prospects and discoveries. We then bought a majority operating interest in the Skipper and Bluebeard discoveries, also on the East Shetland platform, and hope to start developing these in the near future."

"Our ambition to be recognised as the major heavy oil company in Europe was taken a step further when we were invited as heavy oil experts to prove the commerciality of discoveries on the St. Laurent permit in southern France."

Nautical have an unusual company philosophy for progress. "We outsource everything" says Steve. "There are only 3 actual employees of the company – myself, my PA and the Finance Manager. However, we always use the same companies or consultants for our G&G work, our engineering tasks, operating contracts and the rest. In this way we always have access to the experts in each field, but don't lose corporate memory."

"We also actively study our markets to find the best outlets for our oil at any one time. We sell the heavy oil throughout the world, not just to our sister company Quadrise. Milford Haven is actually the only place in mainland Britain which can refine these hydrocarbons, but heavy oil is coming 'off plateau' in Europe, so there is spare refining capacity in many places. And there is a huge market for it in the Far East."

Technology plays a part

Advances in technology have played their part in the development of the production of heavy oil. "One of the major improvements in recent years has been in the stability and reliability of pumps," explains Steve. "Because of the thick nature of the oil, very strong subsea pumps are required, but in the past these broke down regularly. Nowadays, pumps in the Captain Field continue working for years without even routine stops for maintenance. We are able to pump progressively more viscous crude with these pumps."

A feature of heavy oil production is an early water cut, because of the nature of the hydrocarbons. This results in a lower recovery factor, typically less than 25%, although there are exceptions like Captain, which has a 32% recovery rate. "Onshore, steam lift is useful in shallow fields, but this is obviously of limited use offshore, as it is very difficult to keep the steam at the required temperature. However, we have

Heavy oil in the UK

Although a number of heavy oil fields were identified in the North Sea in the 70's and 80's, technological limitations meant that these were not commercial at the time. Heavy oil has, however, been produced as a by-product from otherwise light oil fields in the North Sea for a number of years.

Heavy oil is found in large, but mostly unexploited quantities on the UK Continental Shelf – in fact, it is estimated that there are six or even as much as ten billion barrels in place in the region. The largest accumulations are on the East Shetland Platform, but it is also found in the North Moray Firth, the Viking Graben, West of the Central Graben, as well as west of the British Isles.

Excluding extensions and prospects, there are 19 UK Sector North Sea heavy oil fields. These range in size up to around a billion barrels of oil-in-place, although the majority are below half a billion barrels. The fields are located in water depths of around 100m, with the reservoirs themselves at depths of 600 – 1,800m subsea. The Captain Field in the Moray Firth, which went on stream in 1997, was the first exclusively heavy oil field in the North Sea. Alba, Gannet E, Gryphon and Harding have all followed and there are plans for a number of other fields to start producing in the next few years.

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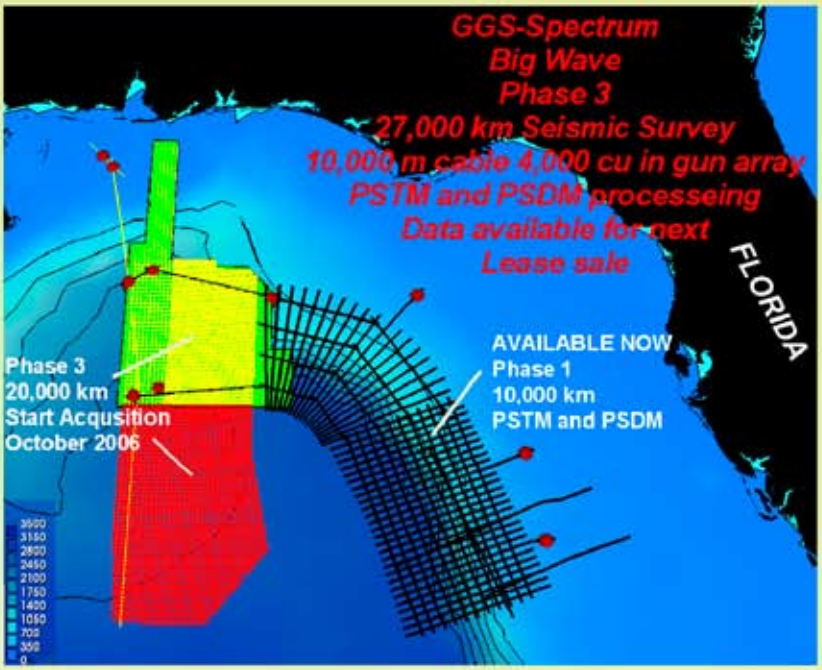
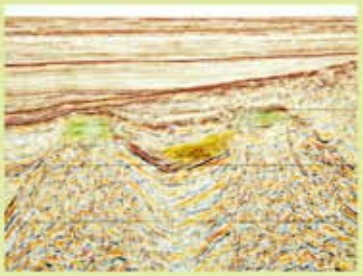
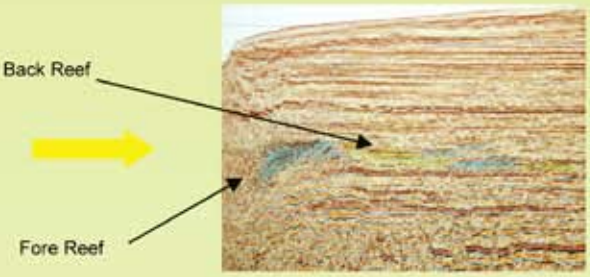


Deep Plays

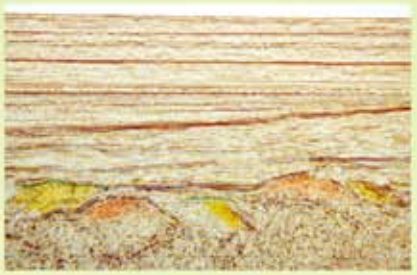
Platform Plays



Reefs



The GGS-Spectrum Big Wave Survey has already highlighted a number of different play types and possible world class exploration opportunities both on the platform and in the deep water areas.



Truncation of clastics

The survey has shown there is a full sedimentary section in the deep waters of the Gulf of Mexico with likely source rocks, trapping mechanisms, age and thermal environment for hydrocarbon accumulations.

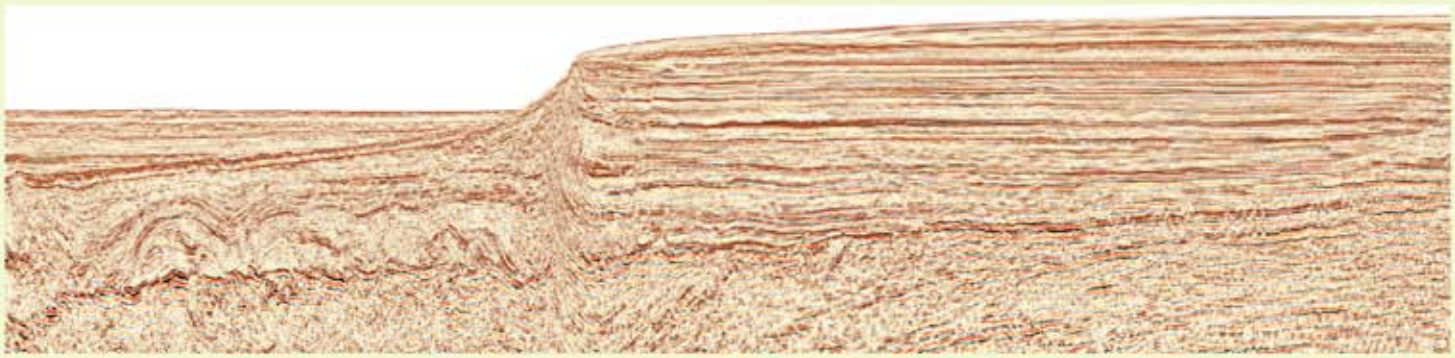
Giant subtle traps

In front of the escarpment

Jurassic horst/graben (buried hill) plays
Jurassic/Cretaceous plays associated with salt tectonics
Oligocene and Miocene clastic onlaps and drapeovers
Cretaceous Carbonate fan and detrital plays

On the platform

Cretaceous Shelf Edge reefs and fans
Thrombolitic and Patch reefs
Large regional four way closures
-at depth with clastic reservoirs



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been investigating using hot water flood to increase the temperature and therefore the viscosity of the oil, in order to aid recovery, and this is looking promising."

"The development of extended horizontal wells has also been very important in the economic viability of heavy oil," Steve adds. "They assist recovery, as they permit minimal pressure reduction while maximising access to the oil without the water cut."

Promising future

Steve Jenkins thinks that Nautical has a promising future ahead. "We intend staying exclusively in heavy oil, investing in the North Sea and possibly elsewhere in Europe. We now have 10 blocks in the North Sea, including five discoveries, plus our French licence. We are actively seeking out further assets containing known heavy oil resources, while moving towards appraisal and production from our existing blocks."

"With the correct technology and planning, we consider that the production of heavy oil can be very lucrative, Steve says. "We reckon it costs between US $15 and $20 to get it out of the ground, so with present prices this is profitable. There is plenty of heavy oil available in the North Sea; for example, the Captain Field is already pumping about 60,000 barrels a day, while Alba is at 50,000."

"We estimate that 250,000 bopd could be added to North Sea production from heavy oil alone. This is a substantial figure and would be good for 'UK plc,' as well as for ourselves. The Cinderella of the North Sea has finally come of age."

What is heavy oil?

Heavy oil is a type of crude oil which is very viscous and does not flow easily. It has a viscosity of more than 5 centipoises (water is 1, cream about 20, motor oil is 100, corn syrup is 10,000) and low API gravity of between 10 and 22° (Brent crude is 38-39° API). The oil usually has low hydrogen to carbon ratios, high carbon residues, and large amounts of 'heavy' hydrocarbon fractions such as asphaltenes, heavy metal, sulphur and nitrogen, although the North Sea is exceptional in having low sulphur and low heavy metals.

The high density and low viscosity of heavy oil are very significant, as these present special problems in the production of the hydrocarbons, requiring different types of enhanced oil recovery methods. Steve Jenkins explains this further: "Although the API figure is the most often quoted way of describing heavy oil, viscosity is the most significant factor when considering production. The important aspect is the viscosity of the oil in the reservoir, which is often a function of reservoir temperature and the gas-to-oil ratio. Oils with similar APIs can have very different viscosities."

The specific characteristics of heavy oil are due to the source and its migration through time. As Steve explains, "As the oil migrates to shallower depths it is washed by meteoric waters. Once it has attained these shallow depths and consequent lower temperatures, bacteria are much more active, leaving behind the lower molecular weight alkenes. Heavy oil is therefore a result of biodegradation. "

Offshore West-Greenland

In 2005 the Bureau of Minerals and Petroleum in cooperation with Nunaoil A/S and TGS-NOPEC acquired more than 3,200 km of new 2D seismic data offshore West Greenland in the Disko-Nuussuaq Region. The interpretation of the data in combination with other existing seismic and onshore geological studies gives reason to believe that source, reservoir, seal and traps are all present.

Photo: Reidun Myklebust, TGS

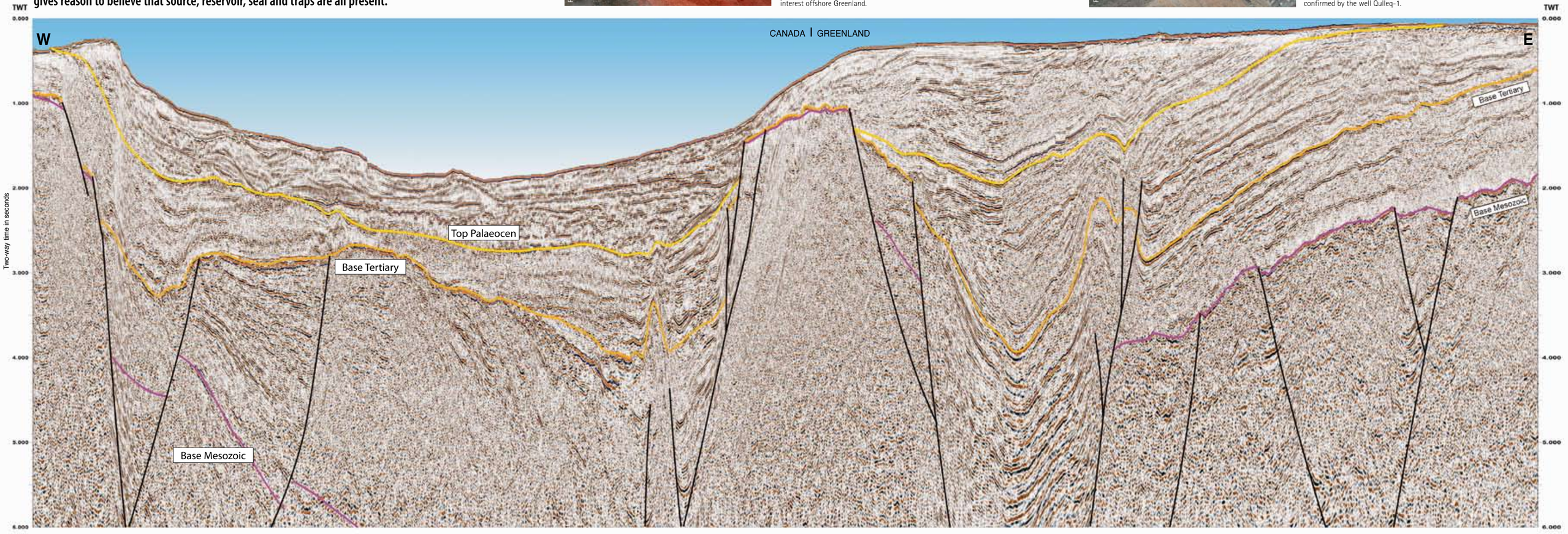
Source rocks

A landslide on the northern side of Nuussuaq has exposed organic rich shales that caught fire after the slide event. Combined with numerous oil seeps from Disco and northwards, this has resulted in renewed exploration interest offshore Greenland.

Photo: Reidun Myklebust, TGS

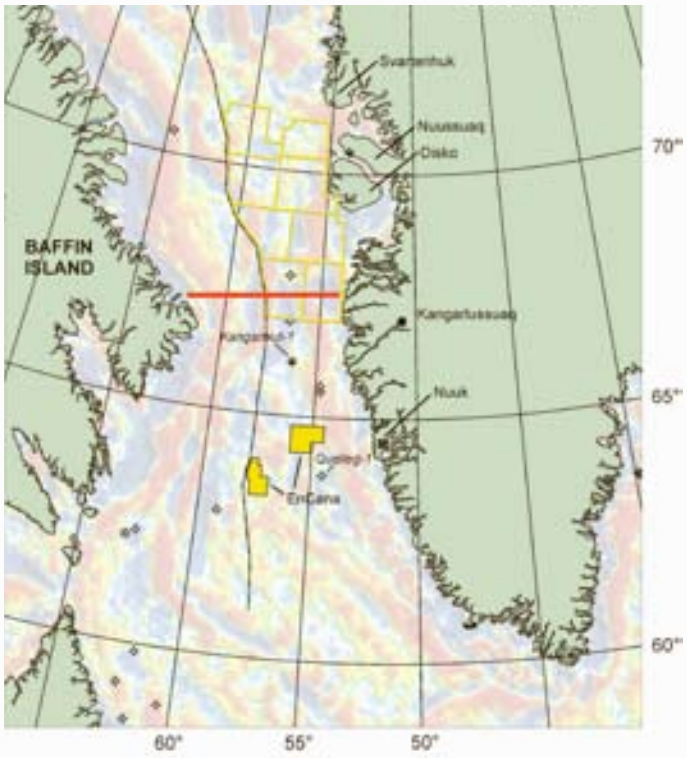
Reservoir rocks

Cretaceous to Palaeogene deltaic and turbiditic sandstones are nicely exposed in the Nuussuaq Basin that developed in Late Cretaceous times and onwards. The presence of reservoir rocks in the offshore basins was confirmed by the well Qulleq-1.



Frontier Exploration

Despite previous disappointments, geologists can now demonstrate the probable presence of prolific source rocks, good reservoir rocks and huge structures in an area that is now open for licensing.



In July 2006 the Disko West Licensing Round offshore West-Greenland was officially opened. Altogether 8 very large blocks, each one of them 8,000 to 14,000km^2 (a North Sea quadrant is approximately 6,000km^2), making up an area of approximately 92,000 km^2. The blocks are all located north of the Arctic Circle, i.e. between 67 °N and 71 °N. The closing date for applications for new licenses to explore and exploit oil and gas is December 15th 2006. The Greenland Government plans to grant the new licenses in March next year.

Poor seismic coverage, in combination with outdated geological models, has so far largely kept the oil industry away from the West-Greenland offshore sedimentary basins. There is also a scarcity of borehole data, as only six wells have been drilled so far. Several wells have, however, been drilled in shallow waters of the Labrador Shelf, proving a working hydrocarbon system further south and west, although most of the finds predominantly contain gas.

The acquisition of modern seismic data, gravity profiles and aeromagnetic surveys has during the last six years gradually changed the oil industry's view of the prospectivity west of Greenland. The authorities in Greenland (Bureau of Minerals and Petroleum; www.bmp.gl) has thus experienced an increased interest in the oil potential offshore West-Greenland. In the upcoming licensing round offshore the Disko-Nuussuaq region, 12 international oil companies have been pre-qualified as operator. The criteria for qualifying as an operator are chosen to protect the fisheries activities in the area, and the unique populations of whales, walruses and bird colonies.

Exploration History

Hydrocarbon exploration offshore West Greenland was initiated in the beginning of the 1970's. Five exploration wells resulted. None had oil shows, but one of the wells detected gas under high pressure (Kangamiut-1). A production test only yielded drilling fluids.

Oil seeps were first registered on the Disko Island in 1992 due east of the area that is now offered for licensing. In the following years numerous seeps were recorded over a wide area, extending from northern Disko through Nuussuaq peninsula to the southern part of Svartenhuk peninsula further to the north. In 1996, additional oil shows were reported from a 3000m deep exploration well drilled on Nuussuaq by the Canadian company Grøn-Arctic Energy Inc. Oil proved to be present throughout the whole volcanic rock sequence.

In the period 1999–2003, commercial geophysical companies acquired extensive new non-exclusive seismic data offshore West Greenland, and in 2000, a group led by Statoil drilled Qulleq-1. The well was dry but showed the existence of good quality Upper Cretaceous sandstone reservoir rocks.

An onshore well drilled to a depth of 3000m on Nuussuaq peninsula in 1996 proved the existence of hydrocarbons in thick sandstones, and later mapping has registered numerous oil shows along the Disco coast (opposite from the rig) in Cretaceous – Tertiary sedimentary as well as Tertiary volcanic rocks.

The only existing exploration licenses offshore Greenland, awarded in 2002 and 2005, is operated by the Canadian company EnCana (compare map). No wells have been drilled on these licenses yet.

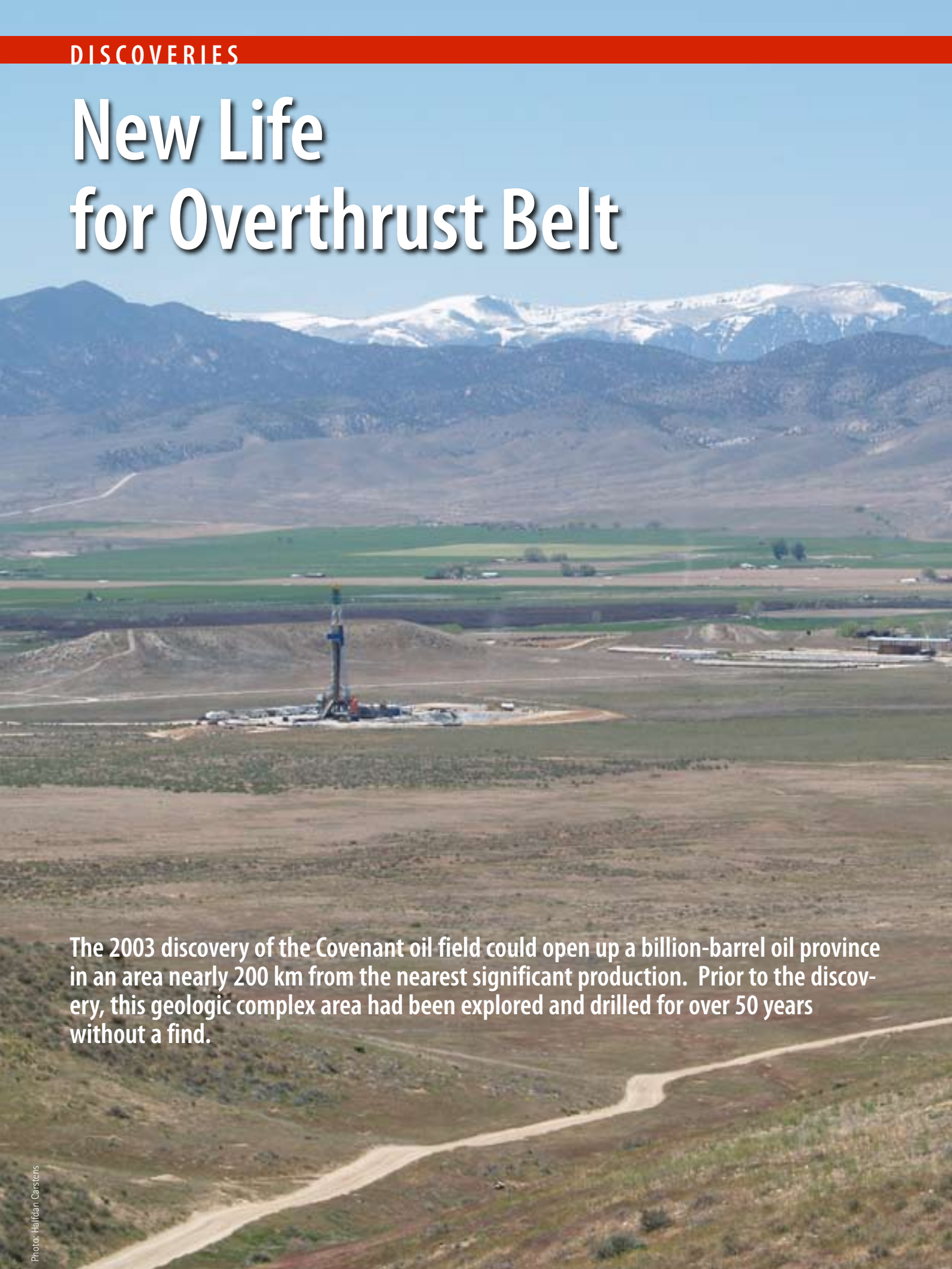
The Petroleum System

The seismic data acquired over the last 5-10 years have revealed the existence of very large sedimentary basins offshore West-Greenland. An integrated evaluation of seismic, gravity, magnetic and satellite data – primarily collected trough the last 5 years – confirms the possible existence of a very large interconnected Mesozoic grabens with petroleum deposits along the so-called Ungava Fault Zone with the Central Ungava Horst consisting of Precambrian granites. This basin system links the petroleum deposits in the Labrador-sea south of 60 °N, with the collected oil seeps on Disko-Nuussuaq, all the way up to 71 °N.

Numerous and widespread oil seeps next to the license round area, in combination with amplitude anomalies and shallow gas related features observed in the seismic data, clearly indicate the presence of source rocks. There are so far documented 7 different distinct types of oils ranging in age from Paleocene through the Cretaceous, Jurassic and all the way down to the Paleozoic, thus giving the possibility of several different play concepts.

Reservoir rocks do also exist in several stratigraphic intervals. There are many good analogues onshore, and throughout Cretaceous and Paleocene huge quantities of sand were poured into the basins. The seismic data indicate the possible presence of Jurassic rocks in the offshore basins, even if they have not yet been found onshore or offshore.

New Life for Overthrust Belt



The 2003 discovery of the Covenant oil field could open up a billion-barrel oil province in an area nearly 200 km from the nearest significant production. Prior to the discovery, this geologic complex area had been explored and drilled for over 50 years without a find.

Photo: Halfdan Carstens

Wolverine Gas and Oil's Cedar Ridge 18-1, located about 80 km north of the Covenant discovery well 17-1 Kings Meadow Ranch No. 1, is the first well drilled on a new structure after this successful test. Well drilling operations are completed, but the well is suspended and it may be reentered at a later date. To date, six additional wells have been permitted in this area. In the area to the south nearer the discovery, Wolverine has drilled two wildcat wells, the company is currently drilling a third, and three new well permits have been applied for.

The Rocky Mountain Foreland fold and thrust belt now has three productive salients. The Canadian segment has the longest production history starting with the discovery of the Turner Valley field in 1924. The discovery of the Pineview field in 1975 started a major exploration phase in the northern Utah-Wyoming segment where several giant oil and gas fields have been found. Now, with the late 2003 discovery of the Covenant field, the central Utah segment becomes the focal point of exploration for this trend.

The Cretaceous to Early Tertiary compression, involving the formation of the foreland basin, led to large-scale thrust sheets and locally complex and highly deformed areas. It is these thrust faults and associated anticlines that form most of the traps for oil and gas in Central Utah and the hingeline area to the north where the Pineview and Anschutz Ranch East fields are found. Now, the hingeline roughly marks the boundary between the Basin and Range and the Colorado Plateau provinces.

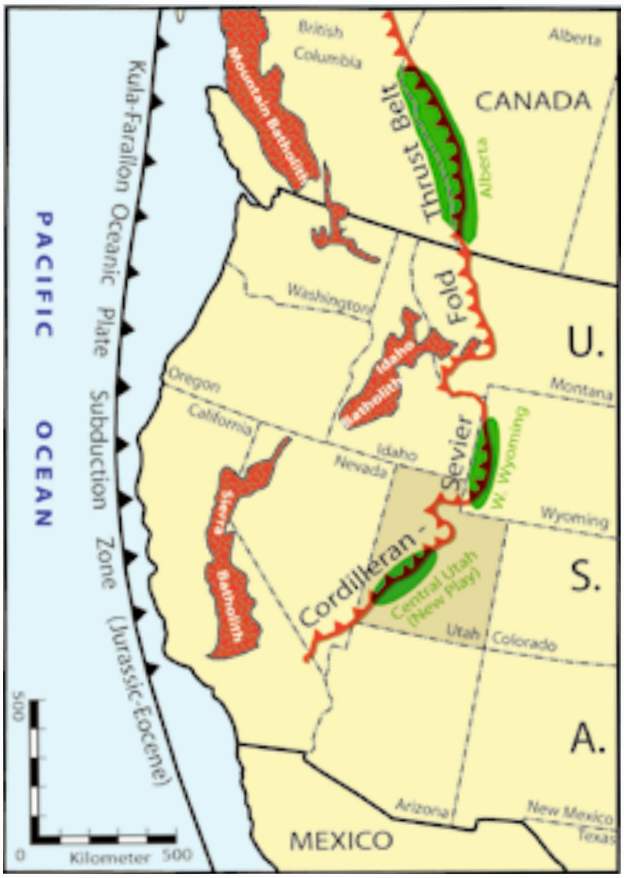


Illustration: Energy & Geoscience Institute; Modified from GEO ExPro No. 4/5, 2006

Thomas Smith, Associate Editor

The Covenant oil field lies along the Rocky Mountain Foreland fold and thrust belt that extends from the Canadian Arctic through the United States and into Central America. Prior to its discovery in late 2003, the complex geology of the central Utah thrustbelt had frustrated explorationists for over 50 years with 115 wells drilled without a discovery.

Numerous discoveries have been made in Canada and the United States along this belt, including 18 giant (using international terminology, proved reserves exceeding 500 million bbls oil (80 mill. m^3) or 3 trillion ft^3 gas) oil and gas fields.

The nearest of these giant fields is the Anschutz Ranch East field (discovered in 1980) located in northeast Utah next to the Wyoming border, over 300 km to the northeast. The Covenant discovery lies 200 km to the southwest of the nearest production, that being in the Uinta Basin. This discovery thus opens up a promising new onshore play containing numerous undrilled structures in an area that is at least 240 km long and 60 km wide.

The discovery

Hard work and persistence paid off for Wolverine Gas and Oil, a private independent out of Grand Rapids, Michigan. Doug Strickland, exploration manager for Wolverine, worked the Utah hingeline for 25 years, keeping a close eye on leasing and drilling activity for the area. Their opportunity came in 1999 when Chevron decided to pull out of the Rockies and offered Wolverine their large acreage position. Prior to that, Chevron held most of the exploration leases and seismic data in the area. Wolverine ended up obtaining a 260 km^2 Federal unit and Chevron's 2-D seismic data.

Wolverine geophysicist Keith Johnson reworked the seismic data identifying a series of hanging-wall anticlines. Consultants Dan Schelling worked the structure and David Wavrek developed the petroleum system model. According to Strickland "The data from the 5,200 m well Chevron drilled in 1981 would prove to be a key piece of information to identify the prospect that led Wolverine to drill the 17-1 Kings Meadow Ranch No. 1." Using dipmeter data from the Chevron well and conventional 2D seismic data, geoscientists

determined they could get much higher on the structure.

The highly deformed and salt-rich Jurassic Arapian shale that forms the cap rock also makes drilling difficult. Wolverine used downhole drilling motors and the latest in mud systems to keep the well on target. The Navajo Sandstone was encountered 425 m higher than anticipated. The well is believed to have been drilled to 3,270 m total depth.

The well was completed and started producing good quality light crude (40 degree API gravity (0,83 g/cm^3) in May 2004. The Navajo Sandstone here is 360 m thick, with the top 150 m oil bearing. A second reservoir, the Twin Creek Limestone, with little primary porosity is likely to produce from fractures.

Thomas Chidsey, petroleum section chief for the Utah Geological Office, says "Wolverine has ten productive wells with one dry hole. These wells are producing 4,900 barrels per day. Total production through April 1, 2006 was 1.5 million barrels oil (238,000 m^3), 200,000 barrels of water (32,000 m^3) and no gas."

Doug Strickland says that at least two additional wells will be drilled to develop the 650 hectare (6,5 km^2) field but would not elaborate on total reserves. Other sources put reserves between 75 and 200 million barrels (12 and 32 million m^3). Pinnell and Moulton, in a 2005 Oil and Gas Journal paper, estimate from Wolverine's own seismic structure map that 896 million bbl (142 million m^3) may be recoverable.


Photo: Wolverine Gas and Oil

Pictured in the Rattle Snake Range in eastern Nevada is Doug Strickland, the man who did not give up on the Central Utah Thrust Belt. He has worked the area since 1978, first with Chevron and finally with Wolverine Gas and Oil since 1999. In between, he worked as exploration manager with W. R. Grace and as a consultant.


Photo: Thomas Smith

The Navajo Sandstone is an aeolian derived, quartzose and cross-bedded sandstone that forms the spectacular cliffs found in many of the national parks in Utah, as here in southern Utah's Zion National Park.

Reservoirs

The primary reservoir objective is the Lower Jurassic Navajo Sandstone, called the Nugget, to the north in Wyoming. It is an aeolian, quartzose sandstone that is over 360 m thick and in most producing areas considered an exceptional world-class reservoir. This sandstone also forms some of the most spectacular outcrops in southern Utah and particularly those in Zion National Park. Other reservoirs include the fractured Twin Creek limestone that directly overlies the Navajo and deeper Paleozoic carbonates that could have enhanced porosity from karsting as well as fractures.

Cap rock

The cap rock is the Jurassic Arapian Shale, 1,700 m of mudstone with layers of halite, gypsum and anhydrite. These highly reflective layers make seismic interpretation more difficult and make drilling to a precise spot challenging.

Source rocks

The source rock for the area is believed to be organic rich Mississippian (Lower Carboniferous) and Permian rocks. The Utah Geologic Survey has taken oil samples from the Covenant discovery well and will do more work on source typing in the near future.

Renewed activity for the area

Seventy-plus dollar oil and the recent Covenant discovery have sparked record drilling and leasing activity. A similar Utah discovery in the thrust belt to the north, Pineview, set off five years of exploration activity where 175 wildcats were drilled and 11 new fields discovered including two giant fields (Anschutz Ranch East and Whitney Canyon-Carter Creek). Most of the discoveries were across the state line into Wyoming. Kent Hoffman, Deputy State Director of Lands and Minerals for the Bureau of Land Management (BLM), anticipates a record of 1,000 drilling permits this year, most of which deal with the Uinta Basin.

The central Utah thrust belt is receiving its share of exploration attention. Strickland said that two exploration wells have been suspended, one abandoned and a fourth is currently under way. The Cedar Ridge 18-1 and the Peter Ridge well are currently suspended and may be reentered

Photo: Wolverine Gas and Oil

The discovery well, Wolverine's 17-1 Kings Meadow Ranch No. 1, encountered nearly 150 m of Navajo Sandstone pay trapped in an anticlinal fold associated with Cretaceous to Early Tertiary compressional deformation. The well flowed good quality, 40 gravity oil from 130 m of net pay with an average porosity of 12 percent and 100 mD of permeability. Currently, the field is producing 4,900 bopd from 10 wells.

in the near future. No data is currently available on these wells. He also said Wolverine has five to six additional exploration wells planned. In addition to drilling, they have acquired over 760 km of 2-D seismic data. Other companies are actively leasing with some leasing fees now over $1,000 an acre (4,000m^2). Some of the other independents leasing in this area include Pioneer Oil and Gas, International Petroleum LLC, Armstrong Petroleum, Petro Hunt, and Craig Settle. In addition to the wells Wolverine has planned, nine more exploration wells are being permitted.

The BLM August 2006 Lease Sale (sales are held quarterly) netted more than 8 million dollars and 154 of the 200 parcels were sold. The sale covered 1350 km^2 across the state, but typically in historically non-producing areas. Nearly half of the parcels in this lease sale were in the Cedar City Field Office, an area that has seen little development. Prior to the Covenant oil discovery, BLM had rarely received nominations by the industry for oil and gas parcels in central Utah. Since then, Utah BLM has leased over a million acres (4,000 km^2, or 2/3 of a North Sea quadrant) in its central Utah field offices. Iron County Commissioner, Dennis Stowell, said they are very supportive of leasing and potential new development in their area.

Geochemical leads

Pinnell and Moulton report (Oil and Gas Journal) that using similar satellite techniques used by Dr. Greg Nash (described in the remote sensing box) to measure relative amounts of kaolinite in the surface rocks could be useful in identifying potential exploration targets. Microseepage of hydrocarbons is believed to stabilize kaolinite in a reducing environment, creating higher levels over hydrocarbon bearing structures.

Pinnell and Moulton, who mapped such

Utah Geological Survey, Energy and Minerals Program

The Utah Geological Survey, Energy and Minerals Program provides general geologic information through research, oil and gas well logs, a core research center, and data analysis to government agencies, industry and individuals.

The research, using mineral lease funds, includes a new program titled "Characterization of Utah's Hydrocarbon Reservoirs and Potential New Reserves". One of the reservoirs currently under study is the Navajo Sandstone, the reservoir for the Covenant field. In cooperation with Brigham Young University, geologists will study outcrops in the San Rafael Swell in southern Utah to determine the lateral and vertical characteristics of this important reservoir.

Scanned oil and gas well logs are available for viewing and downloading over the Internet. Many of the logs were scanned and made available to the state of Utah from a generous donation by A2D Technologies. Currently over 25,000 logs from 8,000 wells are available and more images are being added to their web collection.

The Utah Core Research Center offers the region's only publicly available and most complete collection of geologic cuttings and core from Utah. The facility currently holds cuttings form more than 3,500 drill holes, core samples from over 700 drill holes, a collection of type oils, coal, and miscellaneous samples from many other sources. Material may be examined on-site or borrowed for a fee. In addition, the facility offers core workshops benefiting both university and industrial research.

Photo: Thomas Smith

Tom Dempster of the Utah Core Research Center.


Photo: Halfdan Carstens

The Jurassic Arapian Shale with EGI's Greg Nash taking samples.

a geochemical anomaly over the Covenant discovery, are seeing this trend repeated across the area. This geochemical data indicate more potentially productive structures along several of the thrust trends. They have identified at least 30 geochemical anomalies located on gravity-defined structures.

The story unfolds…

Fifty years of exploration without a discovery wrote the introduction. The Covenant oil discovery is just the first chapter of what could be a long and productive saga. Wolverine's Doug Strickland should know - he has worked this area off and on for nearly 30 years - sums it up this way "I am very fortunate to have been involved in the discovery of Covenant Field, as these events happen only once in the lifetime of a geologist. The discovery was built from the work of several geologists since the 1950's, and the persistent efforts of a few over the last 15 years."

"The discovery of Covenant is by far the highlight of my career, and I intend to be involved in the discovery of several more fields in central Utah," says Doug Strickland, having made himself famous as a true, old-fashioned oil finder.

Remote sensing

The image shows the area of the central Utah Thrust Belt near the recent Covenant field discovery. Energy and Geoscience Institute (EGI) created the image by fusing a one m digital orthophoto with a multispectral ASTER (Advanced Spaceborne Thermal Emission and Reflectance Radiometer) image.


Illustration: Energy & Geoscience Institute

The Arapien Shale cap-rock is easily discriminated from surrounding Tertiary volcanic rocks by color. The different colors within the Arapien Shale are related to mineralogical differences that can be mapped using band ratios and multivariate analysis. Blue polygons outline Arapien Shale and dark red polygons outline Tertiary volcanics. Grid coordinates are UTM Zone 12 (NAD83).

Dr. Greg Nash of EGI is using a variety of remote sensing techniques to study Utah's central thrust area. "Detecting mineralogical differences, like the presence or lack of illite, gypsum, calcite, and hematite, can be accomplished using image analysis. These differences are, in part, caused from the effects of hydrocarbon microseepage creating a reducing environment," he says.

For example, microseepage can alter illite to kaolinite. Using ASTER to map the presence of kaolinite in the Arapien Shale, will facilitate microseepage mapping. Combining ASTER with multispectral satellite imagery and 1m spatial resolution black and white digital orthophotos aid in structural characterization and refine the area's geologic maps. Using the spectral character of ASTER imagery and increasing the spatial resolution with the digital orthophotos down to 1m, the analyst can use 3D visualization to map faults, folds, and other geologic features.

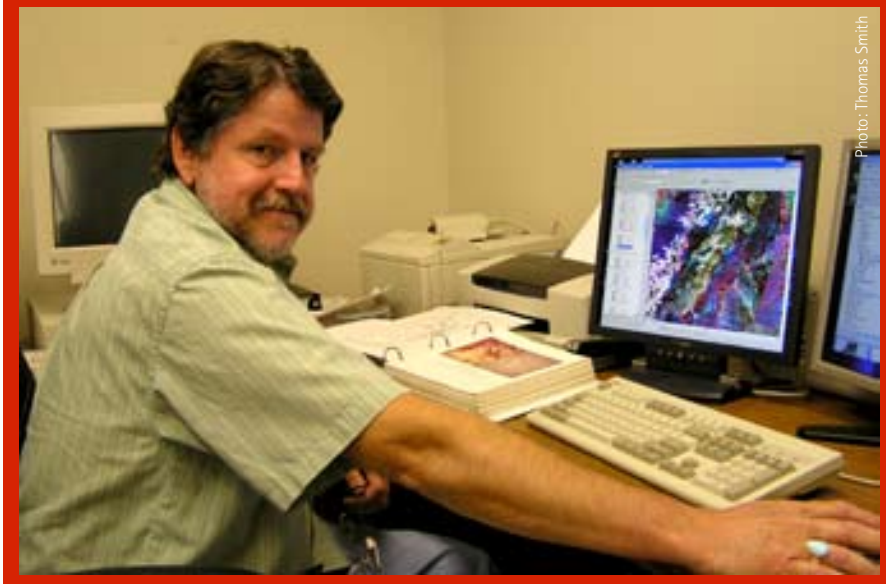


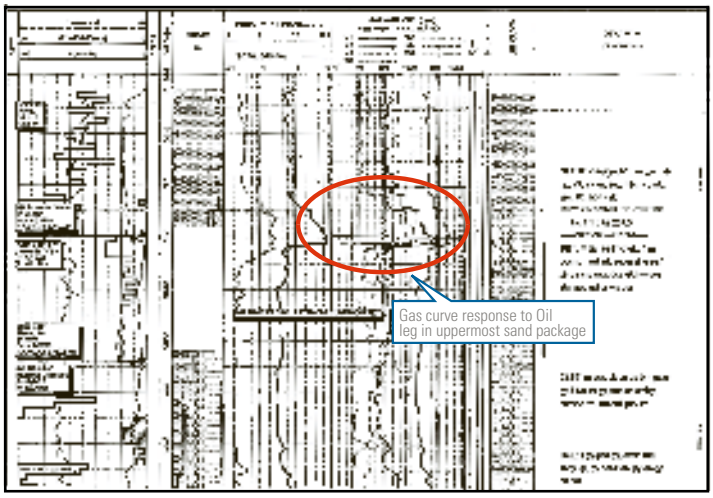
Photo: Thomas Smith

Dr. Greg Nash at his workstation in the Energy &Geoscience Institute.

MUDLOG GAS CURVES

CHROMATOGRAPH ANALYSIS

Aceca has a project in progress that aims to complete an exercise to capture gas curves as presented on mud logs in LAS format. These will be referenced to MD RKB presenting the formation gas records as collected from the cuttings that pass over the shakers during drilling. The total gas and gas fractions ranging from C1 to C5 are recorded by the mud logging unit and presented as gas curves on the mud log (or formation evaluation log). These data are not typically available in original digital format and historically have not been reported in a digital format to the authorities as part of the normal digital well data submission for released wells.



Example Section: Well 15/5-6

DELIVERABLES

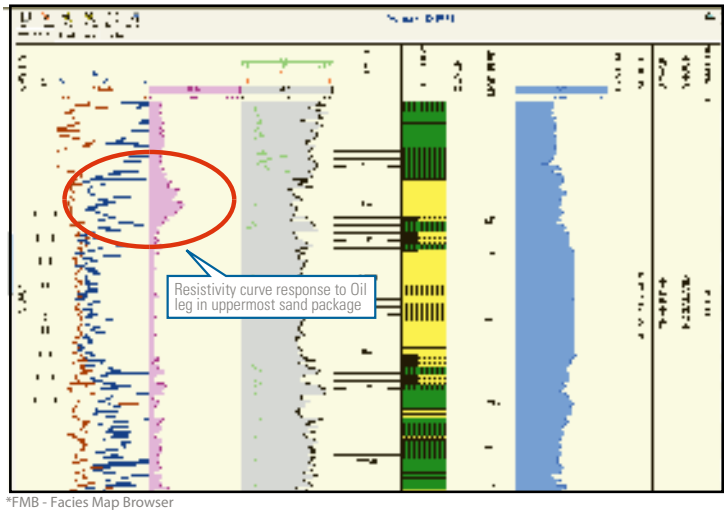
- Meta data records
- Gas curve database
- ROP
- WOB
- Mud weight

GEOGRAPHIC AREA

All released Exploration and Appraisal wells on the Norwegian CS are to be included. Clients will be invited to purchase data for all wells in the following areas:

- Norway SNS (south of 60° N)
- Norway NNS (60° - 62° N)
- Norwegian Sea (62° - 70° N)
- Barents Sea region (70° N+)

Recognition of the same oil leg over the example section as presented in the FMB



*FMB - Facies Map Browser

Please contact us at info@aceca.no for further details

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Twilight years for the North Sea?

After a period of decline, exploration for hydrocarbons in British waters is experiencing a new lease of life. This is due in part to high oil prices, but is also in response to UK government initiatives aimed at arresting activity decline curves.

Jane Whaley, Associate Editor

Since gas first flowed from the West Sole Field in the Southern North Sea in 1967 , the exploitation of hydrocarbons has been a major source of revenue for successive UK governments. After a partial decline in the 1990's, the industry is once more buoyant, with more and more companies showing interest in the United Kingdom Continental Shelf (UKCS).

Evidence of this is shown by the most recent 24th Seaward Round, which closed in June 2006. UK Energy Minister Malcolm Wicks reported that the licensing authority (the Department of Trade and Industry, known as the DTI) had received the greatest number of applications for 35 years. A total of 121 companies sought acreage, 25 of which would be new entrants, one of the Government's aims being to attract new players to the arena. This strong interest follows on from a very successful 23rd Round in 2005, when 152 oil and gas production licences were offered on a record number of blocks to 99 companies, including 24 new entrants. Seventeen wells were firmly committed to, an amount unsurpassed for over a decade.

The DTI split the UK continental shelf into seven designated areas. In the last two rounds the whole of the North Sea was open for oil and gas exploration for the first time since 1968. The next round will also include the largely unexplored Rockall Platform and Western Approaches, a huge tranche of acreage to the west of Scotland.

New initiatives needed

This is all in stark contrast to the situation 5 years ago, when the majors were withdrawing from the North Sea, viewing it as a mature province, while smaller companies found the area expensive to enter. Exploration drilling dropped to an all time low in the first half of 2002, and the UK Government realised that they had to introduce some major initiatives to encourage the sector.

A government survey undertaken in 2003 indicated that companies ranging from major to small independents saw a number of barriers to successful exploration on the UKCS at the time. These included global competition for limited funds, and the high costs of exploration and production. There was a lack of confidence in the fiscal regime, while prospects were considered too small and exploration risk too high, with restricted access to attractive opportunities on the UKCS.

Some of the funding issues have been helped by the substantial rise in oil prices seen in recent years, while the government addressed the lack of confidence in the fiscal regime through enhancing tax relief on exploration costs. The major initiatives introduced, however, looked at the issues of risk and the lack of attractive opportunities, particularly for smaller companies. These included simplifying the sale and purchase of offshore assets to ease the entry of new players, devising new ways of licensing acreage and initiatives to encourage companies to look at 'fallow' areas.

Promote brings in £90 million

In 2003 the UK government introduced the Promote Licence to encourage small companies with knowledge and expertise but limited funding, to enter blocks on a shorter-term basis for a reduced initial fee (GeoExPro 2005, No 4/5, p.42), for further information on the Promote Initiative).

Two years on, the UK Government considers that the results of this initiative prove both the innovative drive of the firms involved and the success of the Promote Licence concept. Of the 54 such licences awarded in 2003, 24 have been given approval to continue into the next phase of the licence. Work commitments include 15 wells, seven new seismic surveys and one proposed development. Importantly, it is thought that the Promote Initiative has resulted in around £90 million (US$157 million) being secured for further exploration on the UKCS.

Another new concept was the Frontier Licence, introduced to encourage exploration in the west of Shetland and Rockall areas, which to date have had relatively little exploration when compared to the North Sea. By allowing companies to take on larger areas for initially lower fees and with less commitment, huge swathes of the underexplored offshore can be reviewed and analysed, allowing them to focus down on the areas they identify as being more prospective.

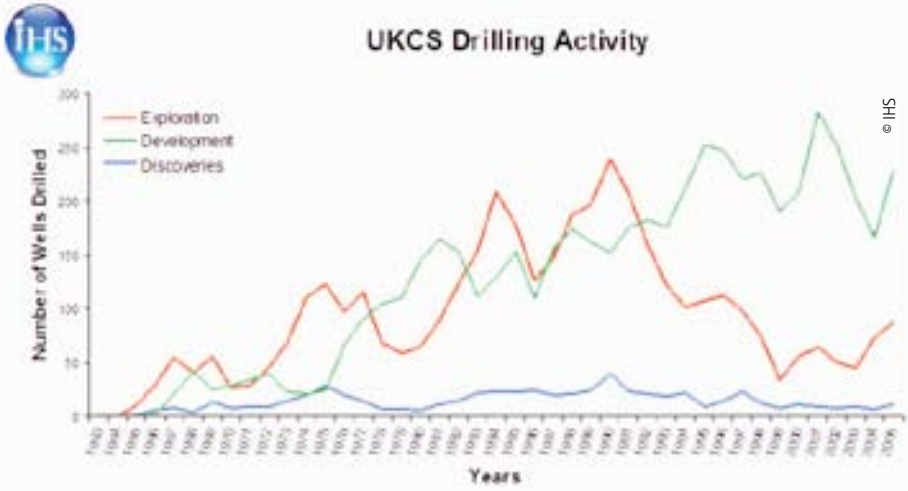
To help unlock the potential of acreage held but not being exploited, the DTI introduced the Fallow Field Initiative in 2002 to ensure these assets are either worked up or divested. Both blocks and discoveries are considered fallow after three years of inactivity. The Initiative aims to promote the development of these fallow blocks and discoveries, either by providing the current licensee with a farm-in opportunity, by finding an outright buyer or by enabling the release of the acreage back for re-licensing.

What might the future hold?

The Promote and Frontier initiatives have certainly encouraged further investment in exploration, but they have also raised some fundamental questions about the economics of the hydrocarbon industry.

For example, have these innovations actually been responsible for the discovery of hydrocarbons that would not have otherwise been found? Will a strong oil price result in the majors taking advantage of Government initiatives to encourage exploration in 'frontier areas' such as the Atlantic Margin? Alternatively, if the majors begin to withdraw from the UKCS, will the small 'Promote' companies be able to cope financially with a decaying infrastructure and will they become increasingly sensitive to fluctuations in the oil price?

BP's Andrew Field in the Northern North Sea came on stream in 1996 and has produced more than 300 million barrels of oil. It lies in 115m of water about 200km from Aberdeen, close to the Norwegian border.



The introduction of the "Promote" Licence in 2003 resulted in an upturn in drilling and discoveries on the UKCS.

As these small companies begin to invest more heavily in their acreage and need to transform their cheap Promote Licences into fully-fledged Production Licences, what funding options will be available to them? Will the temptation be to sell up and move on?

Time will eventually give us answers to these questions. For the moment, the hydrocarbon industry certainly seems to be rewarding the efforts of the UK Government and DTI with interest and commitments which provide a great vote of confidence in the future of the UKCS.

Acknowledgements: *Many thanks to Paul Webber, Regional Manager, NW Europe, IHS, for assistance with this article.*

UKCS Licence Types

To encourage investment in the UK Continental Shelf, companies can apply for acreage under three different types of licence.

The **Traditional** seaward licence has an initial term of four years for exploration, after which there is an additional four years period to compile and submit a field development plan. This is followed by a production period of 18 years, which can be extended. After the first term 50% of the licence must be relinquished, with a further relinquishment of all acreage not covered by a field development plan at the end of the second term.

To encourage smaller companies and new entrants to assess and promote the potential of an area, the DTI introduced the **Promote** licence. Acreage is taken for an initial two-year period, followed by a two-year 'Drill or Drop' option. The licence rental fee for this initial period is 10% of that for a traditional licence.

The **Frontier** licence, introduced in 2004 has been designed to increase the amount of oil and gas activity in the underexplored parts of the UKCS such as the West of Shetland region. Under this Licence the rental fee will be cut by 90% of the rate for a traditional licence for the first two years, and extended exploration and development periods are allowed. This allows companies to acquire relatively large amounts of acreage, although 75% of this must be relinquished after two years.

In the 2006 24th Seaward Licensing round 62 applications were for Promote Licences and 80 for Traditional Licences, in addition to seven Frontier Licences.

Ageing Infrastructure

While the UK government are encouraging the continuing exploration of the UKCS, the industry is having to face up to an increasingly pressing problem – the age and state of decay of much of the existing infrastructure.

The first gas from the UK continental shelf came ashore back in 1967 and the first oil in 1975, so many of the platforms, pipelines and associated structures are over 30 years old and ageing fast. The harsh environment of the North Sea is taking its toll, compounded by the fact that many companies cut investment levels in infrastructure sharply after the oil-price collapse in 1998. At least 11 pipelines have already been mothballed and others are showing signs of decay.

Therefore a major issue for oil companies in the North Sea is that of maximising the return from an ageing infrastructure with a minimum of further capital expenditure. Shell, for example, is reported to be spending $1 billion (£600 million) to renew old platforms and infrastructure in the North Sea just to keep the facilities fit for use over the coming decades. Industry experts estimate that most North Sea platforms are capable of surviving another two decades of production, but only if sufficient investment is made.

Commercial discoveries in the North Sea are now much smaller than 30 years ago, the average field being 30 million barrels of oil equivalent, compared to Brent and Forties, whose reserves were estimated at over 2,500 million barrels. These new fields are too small to support their own pipelines and production facilities and most will rely on existing installations for their economic development. Initiatives aimed at encouraging smaller, ideas-rich but cash-poor companies to explore in the North Sea assume a mature environment with infrastructure offering spare capacity. This results in tensions between the owners of infrastructure and companies seeking access. More importantly, it raises the question of who will cover the cost of maintenance and repairs to this aging network.

Jane Whaley

The Elgin Platform is one of the most advanced in the world. The jack-up design means that, unlike older rigs with concrete bases, it could eventually be lifted from the sea floor and reused elsewhere.

Solutions Log

Location:
Wyoming, USA

Problem:
BP needed to image below an environmentally sensitive area within a short acquisition window. Stratigraphy and anisotropy are complex. Well production correlates with fracture intensity, which is difficult to characterize using legacy seismic data.

Solution:
BP committed to a field trial using FireFly™, I/O's revolutionary cableless recording system that enables high station count, full-wave acquisition with a reduced environmental footprint. By applying the latest advanced processing techniques, I/O's GXT subsidiary will deliver high-resolution subsurface images and fracture intensity maps that will help optimize BP's drilling program.

BEFORE COMMITTING OVER $1 BILLION TO A MAJOR DRILLING PROGRAM, BP TURNED TO ADVANCED SEISMIC SOLUTIONS FROM I/O.

When the imaging challenges are extreme, E&P firms turn to I/O's advanced seismic solutions. In this case, I/O collaborated with BP to develop a new approach to land imaging. Compared to conventional methods, FireFly enables dramatic increases in sampling density at similar cost and with reduced environmental impact. After the data is processed by GXT using advanced imaging methods like vector tiling, BP will have the insights needed to optimize a billion dollar investment program.

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Discovery Shows Onshore Potential

A recent onshore oil discovery proves that the potential of the Nile Delta is not confined to the deep offshore.

Jane Whaley, Associate Editor

"RWE has been in Egypt for more than 30 years and is one of the longest standing operators in the country," says Erik Karlstrøm, Exploration Manager and Deputy General Manager of RWE Dea, Egypt. "We have acreage in the Gulf of Suez, the Western Delta and the offshore Nile Delta, including a share in the recently discovered sub-salt Raven Field. However, our most exciting new discovery has been on our onshore Nile Delta acreage."

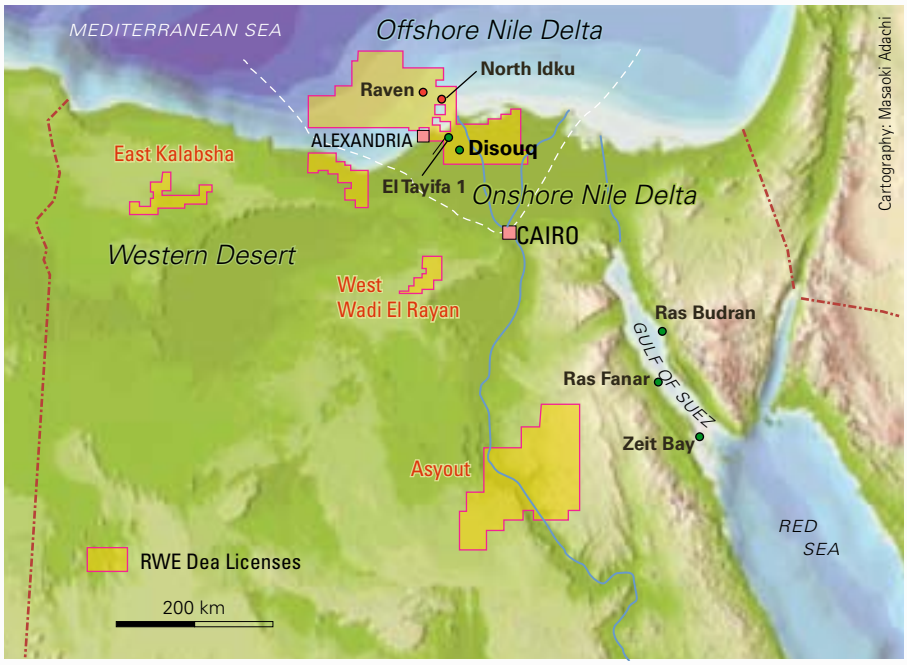
Focusing on the Nile Delta

While there has been a lot of interest in the offshore Nile Delta, RWE Dea has decided to focus its main operating efforts in the less obvious part of the Nile Delta, on the shore, east of Alexandra.

"We are very enthusiastic about the onshore area, where we have just made an oil discovery in what is considered to be a gas basin," says Erik. "The deep water Nile Delta discoveries were made on new 3D seismic data, but the onshore was only covered by 2D data, so we had neither penetration to deeper reservoirs nor good areal resolution to see if the deep potential continued onshore. Both onshore and offshore, the shallower reservoirs of Pliocene age had proved disappointing, as the section is too sandy, with no proper seal, and production drops off rapidly. However, as we found in the Raven Field last year, the deeper targets of Early Miocene age and older could seal off much higher columns of gas and condensate."

"We decided to take this experience and extend it onshore. Late last year we drilled El Tayifah 1-X on our Disouq licence, 120 km north of Cairo, choosing a shallow location over a deep-seated structure of similar age to the Raven reservoir. When we deepened the well early this year, we found 48° API oil – almost good enough to put straight into your tank!"

"The high pressure in the well told us of a good sealing capacity, but did not allow proper testing," Erik adds. "Having proved the existence of hydrocarbons, though not



In addition to the on- and offshore Nile Delta, RWE have acreage in the Gulf of Suez, where 3 fields (Ras Budran, Ras Fanar and Zeit Bay) have been producing since the early 1980's. It is a non-operating partner in the Western Desert, an area of conventional onshore oil exploration, with small fields and quick returns, where a mere 5 weeks production sometimes covers the cost of a well.

Erik Karlstrøm (left), Exploration Manager and Deputy General Manager of RWE Dea Egypt, on site at the onshore Nile Delta El Tayifa well.

their volume, we are now undertaking 3D seismic surveys in the area."

Tremendous potential

In Erik's opinion the onshore and shallow water Nile Delta is still an immature province with tremendous potential. "In many ways, we know less about the Nile Delta now than we knew about the Mississippi Delta in the mid eighties. We thought of that as a mature delta with declining production. Some companies left, but others stayed and drilled deeper, and found a new, prolific play."

"Only about 185 wells have been drilled in the whole Nile Delta, less than half of them offshore. Most of the potential is in gas - in fact, we hope to start gas production from our onshore licences in 2008 - but there is also oil. Hopefully, shallow gas production will pay for the high risk wells targeting the new deep potential, but there is substantial financial risk involved in acquiring 3D seismic data over large, densely populated areas, and in drilling down to the deeper accumulations which may possibly make a substantial return in the future. You need a supportive management team which understands risk, reward and the time it takes."

Efficient, with local flavour

Coming from Norway, Erik finds drilling in the Nile Delta a fascinating contrast to the North Sea. "Everything is so immediate here," he says. "I'm not used to being so close to operations. In Norway there are always people from different companies participating in discussions about a well hundreds of miles away in the North Sea. Here, I can leave the office, and in a couple of hours I am at the well site, which is surrounded by farmland. In fact, 20 million people live within the 6,000 km2 of our Disouq licence, the size of a North Sea quadrant. We are 100% operators, which gives us great freedom – no partners to worry about!"

"We will spud the El Tayifah appraisal well in October this year and are actively looking for new licences. A large investment has been made in seismic data and well commitments, although no commercial discovery has been proven, so we haven't opened the champagne yet! All the exploration to date has been aimed at Tertiary prospects, but Cretaceous targets are deeper possibilities in the Nile Delta," explains Erik.

He thinks that RWE in Egypt is a very satisfying and enjoyable environment to work

RWE's Disouq licence area covers 6,000 km^2 of agricultural land and is home to 20 million people. It is very intensively farmed and beans, maize, cotton, millet, rice, and wheat are all grown, but traditional methods of irrigating the land with donkey-driven wells are still in use.

in. "Everything runs remarkable smoothly, quickly and efficiently with its strong Egyptian flavour," Erik comments. "People seem surprised when I say that about Egypt, but it is because we have been here a long time and everyone knows our name. It is also vital to respect the fact that the people we deal with here are proud of their working ways. We have a good staff that understands what they are doing and how to handle the authorities."

Eating salt fish

"In Egypt, you have to spend a lot of time sitting down with people, talking and building relationships." Erik explains this further. "A typical example was when we wanted to acquire 3D data onshore in the Disouq acreage, among all those farmers.

The first thing to do is to visit the top military man in the area. He wants to know what you are doing, how you are going to bring prosperity to the area, and how many people you are going to employ, but he is also interested in you as a person. A good relationship is based on personal experience and judgement. You drink tea, and then after a while he invites you to eat salt fish with him – a speciality of the area, apparently - and you talk a little bit about football. Then, just as you are leaving, he says fine, go ahead, and the paths are smoothed. It's an interesting, but very enjoyable way of doing business!"

Photo: RWE Dea

Erik Karlstrøm and Aly Gadallah in the RWE Dea office in Cairo, where 25 geologists and geophysicists are employed, more than half of whom are Egyptians.

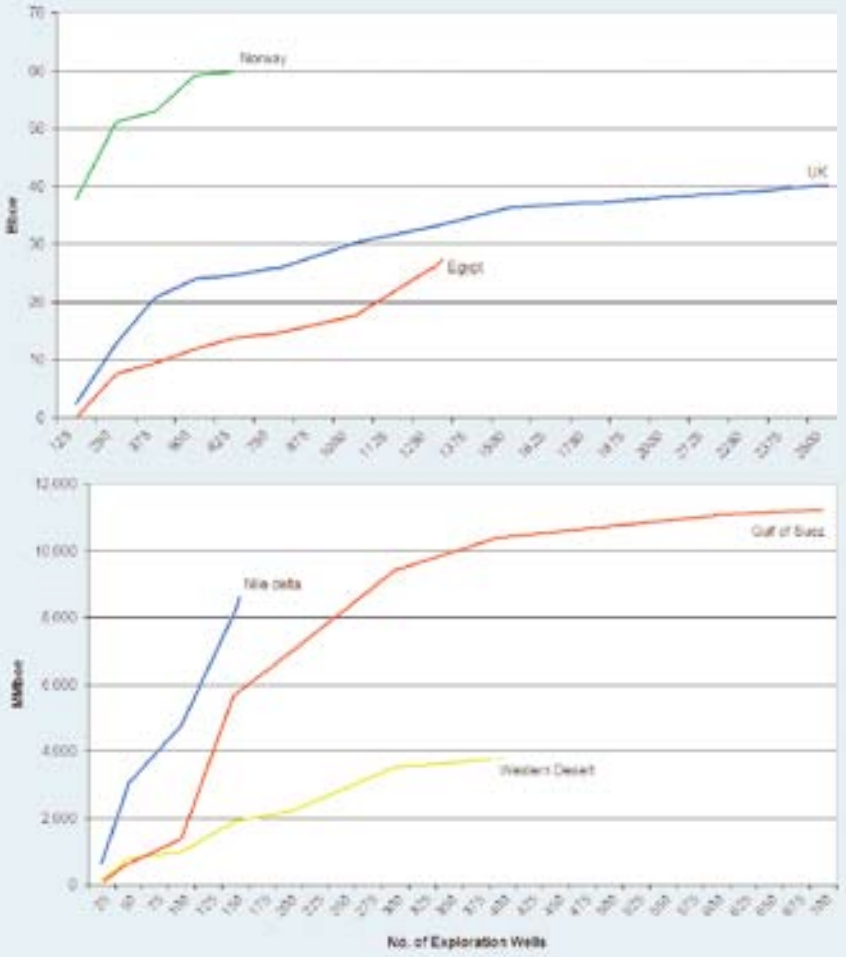
Egypt's Reserves may pass UK total

Exploration in Egypt started in the Gulf of Suez in 1906, although the Western Desert and the Nile Delta areas were not investigated until the 1960's. However, as the creaming curve shows, the Gulf of Suez and Western Desert areas are already reaching a mature stage. By contrast, there has been an explosion of interest in the Nile Delta in the last 3 or 4 years, fuelled by the discovery of the Raven Field, among others.

"The real potential in Egypt lies in the Nile Delta," confirms Erik Karlstrøm. "Since we began drilling here, the creaming curve for total Egyptian reserves, which had begun to flatten off, started to rise again, and we may see total production pass that of the UK. The USGS yet-to-find estimate for the whole Nile Delta is between 9.4 and 15 billion barrels (1.5 – 2.4 billion m3) of oil equivalent. The average discovery size in the delta is much larger than in the Western Desert, with a typical prospect being 400 – 500 billion cubic feet (Bcf) of gas. In addition, the success rate is excellent – we have drilled 18 wells in the offshore Nile Delta with our partners, and 17 have been discoveries!"

"Roughly speaking," adds Erik, "about 68 trillion cubic feet (Tcf) of gas have been discovered since 1990. The reserves figure grew rapidly after the 1999 discovery of North Idku and is rising even more steeply since the Raven discovery. This has induced many companies to return to Egypt, while others, like Statoil, have come to the country for the first time."

Hany Soliman, Undersecretary for Gas Affairs at Egypt's Ministry of Petroleum and Mineral Resources, recently announced that they expect Egypt's natural gas reserves to reach 100 Tcf by 2011, up 47% from the current level. To cater for this increase, a third Egyptian LNG train is about to be approved, and others will follow.



Creaming curves for the main exploration areas in Egypt clearly show that, while the Gulf of Suez has reached a mature stage, there is good potential for growth in the Nile Delta. The line depicting total Egyptian reserves has started to rise again and it is interesting to compare it against those for Norway and the UK.

Striving for Excellence

Photo: Paul Whitney, BGS

After an impressive career in research institutes in the USA, Canada and France, Dr. John Ludden has now taken on the challenging role of Executive Director of the British Geological Survey. We talk to him about his career and his hopes and plans for the institution.

Jane Whaley, Associate Editor

Dr. Ludden has one simple but ambitious plan for the British Geological Survey (BGS) - to make it the best geological survey organisation in the world. "We are well up in the rankings now, but by maintaining excellent standards, continuing to be at the forefront of scientific research and attracting well known scientists, we should become the best."

BGS undertakes vital work

"The Survey plays a very important part in research into earth sciences both in this country and internationally, and it is vital that we continue with this role. It is imperative that basic research into 'how the earth works' continues, such as key studies we are undertaking at the moment on redefining the earth's oldest fossils," says Dr. Ludden, newly appointed Director of the BGS. However, we must not lose sight of the 'small', less dramatic work while we are undertaking projects with high visibility and world class scientific input," John adds. "The BGS must continue to look at routine issues, like coastal erosion, weathering and variations in the water table. In fact, I think that our greatest value to the UK is in our long term records, which no university or other institute has the resources to undertake. Look, for example, at our extensive records from the oil industry – we have information on every drill hole in the North Sea."

Dr. Ludden is very enthusiastic about the overseas work which the organisation undertakes. "The BGS is well known for this and I think it is a vital area of activity," he explains. "At any one time we have about 30 people working overseas and it is amazing how much work they achieve. These overseas offices must be maintained, partly for the reputation and stature of Britain and the Survey, but primarily because of the importance of the work they undertake. For example, we have an ongoing project in Afghanistan at the moment, where we are involved in mapping and training local people. These projects help towards the strategic development of the host country and have impact on wealth creation and the development of partner institutions."

Dr. John Ludden is the recently appointed Executive Director of the British Geological Survey. He is a geochemist whose distinguished career has led him to senior research posts in the USA, Canada, France and now the UK.

Dr. John Ludden with other members of the board of the British Geological Survey at the annual BGS Forum.

Challenges ahead for the BGS

"I've worked with surveys, with mining and other industries, but I'm basically an academic, and I think I was taken on to maintain the academic excellence of the BGS while working within the need for commercialisation," says Dr. Ludden. "This is one of the many challenges which lie ahead of us. At the moment, 50% of our funding comes from commissioned work and 50% from NERC, the UK Natural Environment Research Council. From next year we will be required to compete for some of this NERC money with other centres such as the British Antarctic Survey and the Centre for Ecology and Hydrology. While this is a challenge to the BGS, it is also an opportunity to increase collaboration. Coming from outside, I can see that some of our research is too isolated and it is important for us to work with other organisations."

Collaboration, particularly at the European level, is one of the major features that Dr. Ludden believes he brings to the BGS. "I have a lot of experience of projects at the pan-European level, including the European Ocean Drilling Consortium, which I helped initiate. Through these, I have wide understanding of compiling joint funding bids."

"A growth area for the BGS is information services and products, which raise a significant amount of money for us," says Dr. Ludden. "However, we have a challenge in commercialisation and knowledge transfer in general. We need to develop new models for commercialising our products and expertise."

BGS and the hydrocarbon industry

Dr. Ludden would like to see more collaboration between the BGS and the oil industry. "We don't want to compete in finding oil," he explains, "but I am interested in working together, particularly on 'big science'. Major projects like detailed mapping of the Atlantic Margin, for instance, could be undertaken jointly and would be of benefit to all. The government could help in this area by instigating tax incentives to encourage oil companies to work with academic institutions."

"Our work on climate change and environmental issues, including the economics of CO_2 sequestration, is of vital importance to the hydrocarbon industry," Dr. Ludden adds, "especially our studies on the effect of reinjecting CO_2 to increase pressure in reservoirs.' Also of great interest and an area of potential collaboration is our work on extending the life of non-renewable resources, including projects where we have been investigating the behaviour of reservoirs under different conditions."

Distinguished academic career

'Striving for excellence' could be John Ludden's motto, and has marked out his distinguished career, both as an academic scientist and as a research institute manager. He gained a 1st in Environmental Sciences from Lancaster University, a subject he chose because, as a teenager, he liked fishing! "I wanted to be a hydrologist, but Environmental Sciences gave a wide back-

ground in Earth Sciences and I very soon became interested in volcanoes. This led me to a Ph.D. studying the petrology of volcanoes on Reunion Island in the Indian Ocean."

He took a post-doctoral fellowship at the Woods Hole Oceanographic Institute in 1976, before being made Assistant Professor and then Professor of Geology at the University of Montreal in Canada. As well as undertaking research, supervising Ph.D. students and running the department, John became proficient in French.

Dr Ludden's research has concentrated on the study of the sources of mafic magmas through time and on mineral exploration in the early earth. This has led him to many prestigious awards and positions, such as Outstanding Scientist, Association of Geologists, Quebec, and President of the International Association of Geochemistry, as well as a number of editorial and honorific posts in both North America and Europe. He has published over 100 papers and contributed to many books. However, it is in the field of research management that Dr. Ludden has most conspicuously made his mark.

Research management

He was first involved in this while Professor of Geology in Montreal, when he was simultaneously Director of the Institut de Recherche en Exploration Minérale. "Excellence is the key to being a good administrator in a research institution," John says. "The head of the organisation must ensure that academic standards are kept up, that good original papers are being published. He or she must be involved in all aspects of the organisation, teaching and research as well as administration."

John believes that sabbatical periods are very useful to enhance and broaden an academic's mind. One of his aims within the Geological Survey is to ensure that staff are able to visit universities or industry and that this is reciprocated, so the BGS may benefit from the experience and knowledge of visiting academics and industrialists.

After a sabbatical year in France gave Dr. Ludden "the flavour of Europe again," he became Director, Fédération de Recherche at the CNRS in Nancy, France in 1996. Then, in 2002, he became Director of the Earth Sciences division of the CNRS in Paris, providing management and scientific research strategy for the earth, ocean and atmospheric sciences at 35 laboratories across France. This was a very prestigious post which he enjoyed greatly. "A number of these senior posts in research organisations are held by non-French nationals, in order to broaden the institute's knowledge with expertise from outside France. Not being French had advantages – if I railroaded something through or went over several heads, they just assumed I didn't understand the system!"

"As the administrator of a French research institute you are expected to be an active scientist as well, so I was also Research Director at the Institut de Physique du Globe de Paris, where I worked on isotope geochemistry and petrology applied to sea-floor geosciences," Dr. Ludden adds. "Similarly, I want to ensure that in the BGS everyone involved in management, myself included, keeps up their academic life through research and visiting professorships."

John very much enjoyed living in France. "The lifestyle in Paris is great. Although ready for a change after a number of years in the CNRS, I had never really planned to return to the UK. Then the BGS post came up and it seemed the new challenge I was looking for – and it's nice to be back."

In other words …

Dr. John Ludden is obviously enjoying his new job. "My objective is that at the BGS we continue to undertake projects with high visibility and world class scientific impact, while meeting our important national needs."

In other words, BGS must strive for excellence!

Photo: J. Evans, BGS

In 1985 the BGS moved from London to Keyworth in Nottinghamshire, where most of the 800 people who work for the survey are now based. An aerial photograph of the main BGS buildings in Keyworth shows the rather sprawling nature of the campus. A major £10 million rebuilding programme is in place and by 2010 the Geological Survey will be housed in new purpose-built offices and laboratories on this site.

The British Geological Survey

The British Geological Survey, or the Geological Ordnance Survey, as it was then known, was set up in 1835, making it the world's oldest geological society. Its first Director was Henry Thomas De La Beche, who initially studied geology as a gentlemanly hobby, until financial difficulties led him to pursue it as a career. The setting up of the Survey had the strong support of the Geological Society and its President, Charles Lyell, who considered that its functions should always combine the academic side of geological science with commercial aspects "bearing on agriculture, mining, road-making, the formation of canals and rail-roads, and other branches of national industry."

In 1841 De La Beche also founded a small museum of geology, then known as the Museum of Economic Geology, which later developed into the Geological Museum, now part of the Natural History Museum in Kensington, London.

In 1845 the Geological Survey Act set in train the geological mapping of the whole of Great Britain and Ireland. Over the next century the Geological Survey of Britain, then based primarily in London, came under the direction of various parent organisations until the formation of the Natural Environment Research Council in 1965, when it was also joined with the Overseas Geological Survey. In 1984 it was renamed as the British Geological Survey.

The main remit of the BGS is to be the nation's principal supplier of geological information while acting as the primary custodian of the UK's geoscience information. It has a core programme of long-term surveying, monitoring and databasing, underpinned by applied research, whilst also undertaking commissioned projects which enhance the main objectives of the organisation.

As the Geological Ordnance was originally a military organisation, field officers of the Survey were required to wear a uniform of blue serge with brass buttons and top hat. Maybe Dr. Ludden should consider reinstating this during his tenure as Director!

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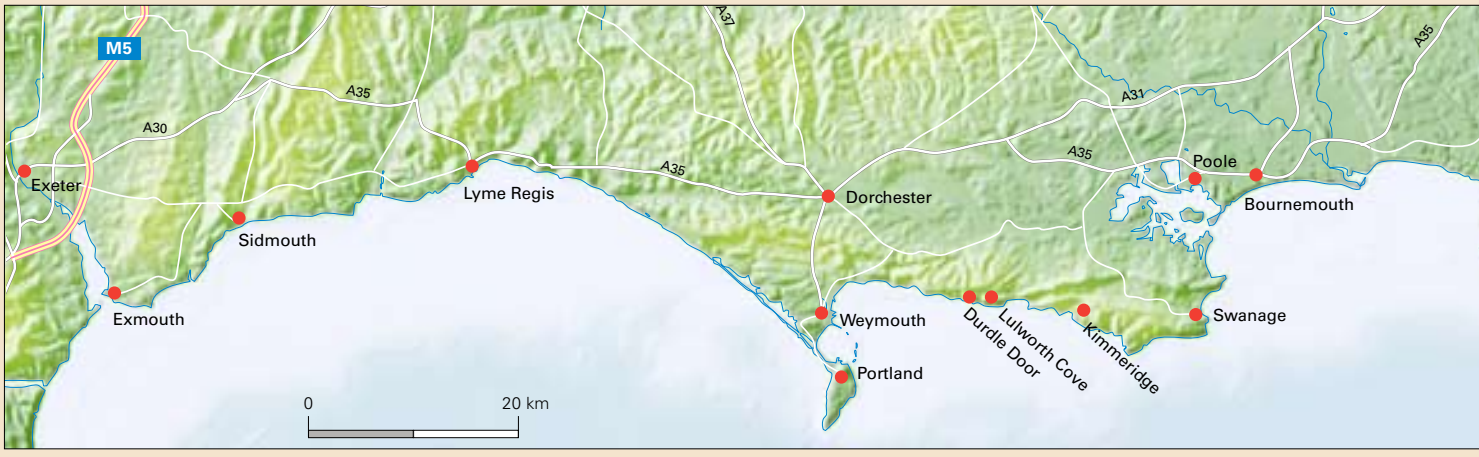
"The Jurassic Coast is an outdoor classroom for the study of geology, geomorphology, geography and biology."

Photo: Halfdan Carstens

The rocks at Kimmeridge Bay were once the floor of a fairly deep, subtropical sea rich in life. Within the bay, we find the type section for the Upper Jurassic Kimmeridge Clay Formation, which is the dominant source rock of the North Sea. It is also noteworthy that Kimmeridge is an international name; all around the world rocks of this age are known as Kimmeridgian. Blocks of stone from dolomite beds occur at intervals in the grey Kimmeridge Clay. They have formed during the generation of hydrocarbons in the organic-rich muds.



The Jurassic Coast

A few days of holiday can be well spent by walking leisurely through an almost complete Mesozoic succession along the south coast of England. Outcrops of colourful shales, sandstones and carbonates can be studied without the need for detailed prior knowledge. The rest of the family will also enjoy abundant fossils, beautiful beaches, lagoons and numerous bays, as well as small, picturesque towns next to the cliffs.

Located on the south coast of Britain, the Jurassic Coast comprises a segment of undeveloped coast and countryside between East Devon in the west and Dorset in the east. More than 80% of this is cliffed coastline. This unique area has a combination of internationally renowned geological features considered by both palaeontologists and geomorphologists to be one of the most significant research sites for their respective fields of study.A World Heritage Site, it includes a near-continuous sequence of Triassic, Jurassic and Cretaceous rock exposures, representing almost the entire Mesozoic Era. The sequence of Jurassic strata exposed between Lyme Regis and Swanage is said to be among the best sections of marine Jurassic-age rocks to be found anywhere in the world.

Halfdan Carstens

The Jurassic Coast, a narrow coastal strip of land lying between the top of the cliffs and the low water mark, was in 2001 awarded World Heritage Site status and became recognised as a place of "outstanding universal value". The Jurassic Coast includes 155 km of unspoiled cliffs and beaches along the East Devon and Dorset coast.

The main reason for its inscription as England's first natural World Heritage Site is the unique insight it gives to the Earth Sciences. Sedimentary rocks of Triassic, Jurassic and Cretaceous age record 185 million years of the Earth's history, and this rare geological display enables both the study of coastal geological processes that are changing the landscape, as well as the evolution of life through fossils that are easily found along almost the entire coast.

Impressive web-site

Dr. Ian West has spent most of his life as a geologist amongst the coastal cliffs and has an intimate knowledge of the beaches, bays and lagoons of the Wessex Coast. After many years as a lecturer at Southampton University, he is now retired and working from home.

"The Dorset and East Devon World Heritage Coast provides classic and well-known exposures of the Triassic, Jurassic and Cretaceous strata of southern England. It is important because they are varied, easily accessible, described in detail and in many cases, type sections or reference sections for understanding the Mesozoic geology of Europe," Ian explains.

"Because of rapid variation in rock type within a short distance, there is a wide variety of geomorphological features clearly visible. The coast is active and moving northwards rapidly as the English Channel continues its post-glacial expansion. The "Jurassic Coast" is not a static feature but is moving inland at a rate in places of a metre per annum. Remarkable geomorphological features such as Chesil Beach are the result of this," says Ian.

Ian is now heavily involved in building and updating a web-site concerning the Jurassic Coast: http://www.soton.ac.uk/~imw/. It is run in cooperation with the School of Ocean and Earth Science at the National Oceanographic Centre in Southampton and has an impressive content with both text and numerous photos. Nevertheless, he has some clear ambitions with respect to the web-site: "My plan is to substantially expand this website over the coming years," he says.

Named by quarrymen

As often as he can, he takes his car and drives down from Southampton to one of the many spectacular localities for another visit. With hammer and lens in hand, there are always new things to discover for the curious geologist.

"The large area of coastal cliffs provides a good opportunity to study the geological details which provide important information on the ancient environments. Because the cliffs of this classic area are within easy reach of London and Oxford, they have been studied in detail since 1814. In addition, geologists have given names and numbers to the strata of these cliffs. Names have also been applied to the strata by quarrymen in the past. Thus, individual beds of rocks have their own names: Glass Bottle, Cinder, Under Picking Cap, Skull Cap, Top Copper, Saurian Shales, Feather Bed, Spangle, Shrimp Bed, etc., etc. If you know a bed of rock by name you have a more personal interest in it and this increases one's enthusiasm to understand its history," Ian says.

"In addition to the Mesozoic strata, there are major features of geomorphological interest, including the famous Chesil Beach. The landslides involving the Lias in West Dorset and the Kimmeridge Clay in East Dorset are of great importance. The area is of special interest to petroleum geologists, partly because it lies close to the Wytch Farm Oil Field. It has the best Kimmeridge Clay exposures in the world and these include various bituminous shale source rocks and in particular, the Blackstone - the Kimmeridge oil shale. It has been worked since Iron Age times and was important to the Romans."

Photo: Halfdan Carstens

Dr. Ian West acquired an intimate knowledge of England's south coast by working the area throughout his entire career. He has made the geology of the Kimmeridge Bay and the Wessex Coast of southern England, available to the whole world through his comprehensive website http://www.soton.ac.uk/~imw/.

Photo: Halfdan Carstens

The area's important fossil sites and classic coastal geomorphologic features have contributed to the study of earth sciences for over 300 years.

The world famous section

"The Triassic rocks of East Devon are desert fluvial and sand dune sediments that were originally brown. They include the Sherwood Sandstone that constitutes the lower reservoir of the Wytch Farm oil field. The strata are red now because of water loss from ferric hydroxides during the heat of a long period of burial. The latitude was about 20 °N and conditions were like those of the Sahara Desert. Gypsum and salt deposits are common. The halite is being used for gas storage on the Isle of Portland where these Triassic strata are deep underground," Ian explains.

The Jurassic strata are from the shallow seas that flooded the rifted basins preceding the formation of the Atlantic Ocean. They originated in less arid conditions; the environment was warm Mediterranean and the palaeolatitude about 30 to 35 °N. Most of the deposits are limestone and sandstones of very shallow seas and the dark shales of rather deeper water. The latter were at times poorly oxygenated and the Kimmeridge Blackstone and the Black Ven Marls are black because of some similarities to the modern Black Sea environment. In the organic-rich shales the skeletons of marine animals, such as ichthyosaurs and plesiosaurs, have been well-preserved. The Dorset coast, and in particular, Lyme Regis, has received its fame from the creatures of the black waters.

"The Cretaceous is very varied because of large fluctuations in sea level, connected with the opening of the Atlantic and large variations in the rate of sea-floor spreading. The lower part is the product of paralic lagoons and of rivers and shallow deltas. This was followed by a change to marine sediments, and in the warm "greenhouse" environment the iron-rich clay mineral glauconite was developed on a large scale. As sea level rose because of the high spreading rate, the land around was flooded and the supply of clastics was greatly reduced. Thus came the pure white chalk sea of planktonic algal debris," says Ian.

The coastal landscape results from the way the power of the sea has acted on rocks of different resistance. At Lulworth, only twenty or so kilometres from Bournemouth, limestone forms a massive barrier against the sea. A small stream has caused a horseshoe bay by allowing the sea to enter the valley and remove the softer clays lying behind the limestone barrier.

The World Heritage Coast Scheme

The value of the Dorset and East Devon World Heritage Coast is obvious. Says Ian: "It is protecting from development or destruction some of the best, most important and classic coastal sections of Mesozoic strata in England. Many of these strata are richly fossiliferous and there is easy access in many places. Because the area has been studied for almost 200 years there are numerous publications on the strata and its fossils."

The Dorset and East Devon World Heritage Coast was opened in 2001 by Prince Charles, and is now well known and well accepted. It is surprisingly narrow, in many places it is only a few metres wide, and it does not include the cliff top coastal footpath or any land at all at the top of the cliffs.

"It would have been even better if a reasonable amount of cliff top land could have been included. However, in many places this deficiency is made up for by the fact that the National Trust and Country Parks

The Jurassic Coast is also renowned for the study of beach formation and evolution on a retreating coastline. Chesil Beach, famous for the volume, type and grading of pebbles, is one of the best-studied beaches in the world. It is an outstanding example of a barrier beach. The Isle of Portland is in the foreground.


Photo: Halfdan Carstens

The Jurassic Coast has a unique status in the history of geological science. Regarded for more than 200 years as among the best available research sites anywhere for geological inquiry, the output of research has fundamentally shaped the development of geological thinking.

own parts of the cliff top. The councils enforce strict planning regulations. Thus most of it consists of good cliff exposures with relatively unspoilt cliff-top land above. A good, long-distance, coastal footpath is present above it," explains Ian.

"All in all, the Dorset and East Devon World Heritage Coast protects what is quite probably the world's most well-known coastal sections of Mesozoic strata. Most of it has changed little since the 1940's and there has only been limited loss of sections near the main towns. However, if it had not been protected for the future, it could have become an ugly concrete and rock armoured coast, with expensive second homes littering the cliff top. It is now preserved for geology, research and education and as a general natural environment for the public. It is greatly valued and will continue as a national and international treasure," concludes Dr. Ian West, dedicated geologist and a frequent visitor to the "sacred" Jurassic Coast.

For more information: www.JurassicCoastline.com.


Photo: Halfdan Carstens

The Jurassic Coast can boast a range of internationally important fossil localities that have produced well-preserved and diverse evidence of life throughout the Mesozoic.

The "nodding donkey" on the cliff top has produced more than 3 million barrels of oil since 1959 (GEO ExPro no 5/6, 2005). The oil formed in rocks that were laid down on a stagnant sea floor in Early Jurassic times. In other places, oil seeps, where oil leaks to the surface from underground accumulations or mature source rocks, are evident.


Photo: Halfdan Carstens

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Knowledge and experience in prospect evaluation and play assessment
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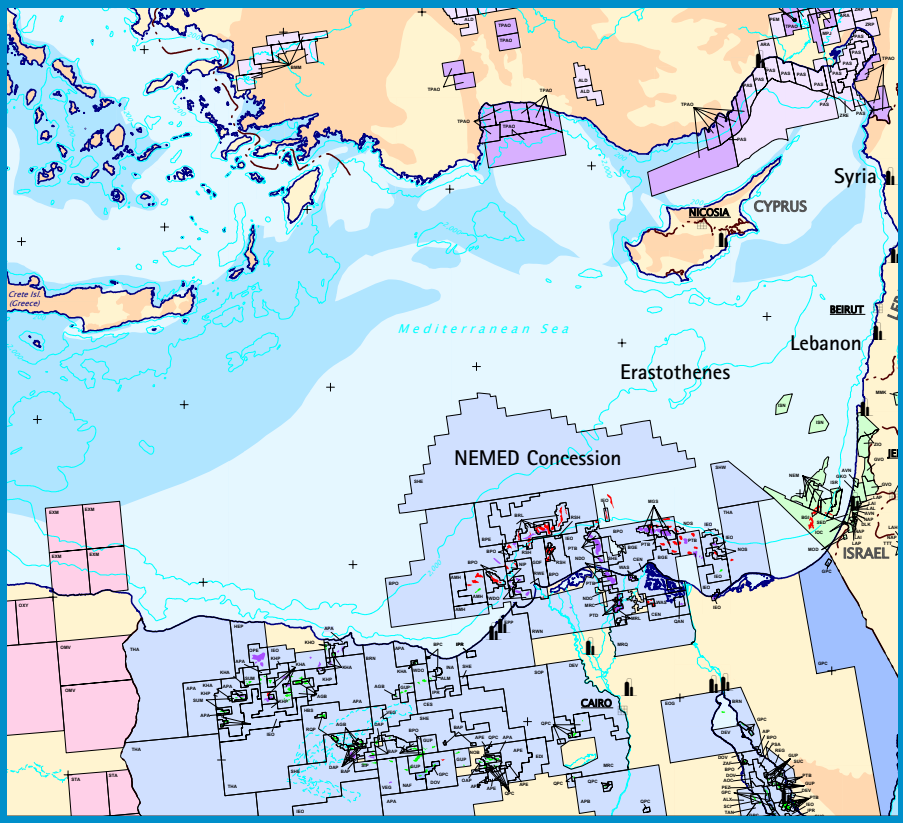
Keen interest in learning the use of new software tools for geophysical modeling and interpretation

VALUABLE QUALIFICATIONS:

Experience in seismic interpretation and well log analysis
Negotiation skills

Moving Into the Frontiers ...

Many wells have been drilled in shallow shelfal waters in the East Mediterranean, including Egypt, Palestine and Israel, and vast resources of gas have been proven in the Nile Delta of Egypt. The deep waters of the East Mediterranean are, however, basically unexplored, the only exception being the North East Mediterranean Deep Water (NEMED) concession in the distal part of the Nile Delta where Shell was awarded 41,500km2 in 1998. Here, following 2D and 3D seismic, two wells have proven gas in Tertiary sandstones, and three more wells will be drilled next year. Shell initially estimated that the concession could hold reserves of at least 15 Tcf of gas and over a billion barrels of oil.



Licenses and fields in the East Mediterranean indicate that there is lots of open acreage offshore all of the countries bordering this region. In offshore Cyprus, Lebanon, and Syria there has been very little exploration.

Cyprus

An area of approximately 60.000km2 south of Cyprus, including the distal Nile Delta and the intriguing Eratosthenes structure (60km by 70km, with oil slicks associated), the latter being clearly evident on bathymetric maps, will be made available for licensing next year.

PGS has, based on an exclusive agreement to acquire MC2D and MC3D data offshore Cyprus, acquired some 7000km of 2D in water depths of 800-3000m data that ties both four ODP wells and the NEMED wells to the south that is now available. The ODP wells were drilled in 1995 over the Eratosthenes structure and proved the presence of both Tertiary and Mesozoic sediments. The grid is fairly loose with a line spacing of 5x5 km at the best. This data will form the basis for the first offshore license round for Cyprus at the end of 2006 and into 2007.

Lebanon

In Lebanon, PGS has entered an exclusive agreement with the Ministry of Energy and Water for the acquisition of offshore multi-client 3D seismic. Phase 1 involves approximately 1000 km2 that will be acquired in the Levantine Basin during 1st quarter 2007. The survey will be run within water depths of 1500mís.

ìFollowing acquisition, processing will take another five to seven months. We should therefore expect a licensing round at the end of 2007,î says Business Development Manager Middle East & CIS, Mark Spencer Jones with PGS Geophysical AS.

ìThe offshore Lebanese basin totalling some 25,000km2 is totally unexplored. However, we look upon this acreage as prospective as information from seven onshore wells drilled between 1947 and 1967 and the Jurassic well discoveries offshore Israel indicate the presence of source, reservoir and seal. All Lebanese onshore wells having dark bitumen shaleís and several of them having shows of hydrocarbons,î Jones says.

Syria

Syria, has recently said that they intend to announce the first offshore concession round towards the beginning of 2007. They look upon this as an historical event since ìthe offshore sector of Syria up to now has been a virgin territory with limited knowledge about the geological and structural situation.î

The Ministry and Syrian Petroleum Company (SPC) will divide the offshore area into an unspecified number of blocks and invite international oil and gas companies to tender for Exploration and Production Sharing Agreements. The number of blocks and terms will be announced officially in the beginning of 2007.

The Norwegian seismic company Wavefield Inseis has in cooperation with Syrian authorities acquired 5000km of 2D in preparation for this forthcoming licensing round. Sagex has on behalf of Wavefield Inseis prepared a multiclient interpretation report based on all available geological and geophysical data. Both the seismic data and the interpretation report are now available for interested international oil and gas companies.

Still Plenty to Play For

In his role as President of PESGB, Chris Flavell is a co-organiser of PETEX 2006, the Society's biannual Conference and Exhibition, in November. We talk to him about the role of the PESGB in the UK oil industry.

What first made you interested in PESGB?

I've been a member for nearly 20 years, since colleagues introduced me to it. I think it is a great technical organisation, but it is also a fantastic networking opportunity. I try to go to the evening meetings or to the social afterwards. I meet lots of industry friends and colleagues there and it is always very useful and informative.

When I was asked if I would stand for office, I thought "well, I've got a lot out of it, it's probably about time I put something back." Basically, you can put as much or as little into it as you want. I am careful that my 'day job' doesn't suffer, but I think PESGB is important. There are several meetings to attend, and with this being a 'PETEX year' there are inevitably more meetings. But I think it is worth it.

How significant is PETEX to the industry?

I think PETEX is one of the best conferences around. The quality of talks is excellent and the calibre of speakers, especially keynote speakers, top class. The range of topics covered is very wide, - UK, international, technical, case studies, even alternative energy. The exhibition has superb stands and demonstrations, and is a great networking opportunity. We also have the International Pavilion, which attracts dignitaries and government representatives from all over the world, giving countries a chance to talk to a wide range of people.

How can the PESGB encourage more young people into the industry?

I think this is very important. A few years ago, in the late 1990's, the industry stopped recruiting graduates and, as a result, we have very few people with 6 – 8 years experience. This had the knock-on effect of making fewer young people interested in the industry because they felt there would be no jobs. To ensure this doesn't happen again, the PEGSB already help the universities with MSc courses. During my year of tenure we have been pushing to get more facilities for teaching earth sciences into schools and we've helped fund a website to provide general teaching aids for teachers so they can encourage an interest in the subject. This has been my big drive as President.

Photo: Halfdan Carstens

Chris Flavell is President of the Petroleum Society of Great Britain (PESGB), one of the UK's main societies for the promotion of education in the scientific and technical aspects of petroleum exploration. Originally a geophysicist, his career has spanned a number of companies and he has worked all over the world, including Malaysia, India, China, Algeria, Ireland and the North Sea. He is based in London as UK Exploration Manager for Tullow Oil, which has interests in the North Sea, the Indian sub-continent and Africa.

Can the UK Government assist the industry more?

On one side, the Department of Trade and Industry is very helpful. The Fallow Field 'use it or lose it' initiative, and the stewardship campaign and the access to infrastructure initiative have been very useful. The Promote Initiative, another DTI scheme, has got new players and ideas into the North Sea, although it has yet to be proved a huge success at actually discovering oil.

By contrast, the Treasury does not always help the industry. The introduction of supplemental corporation tax to 40% in 2001, followed by the incremental 10% in 2005 was very short-sighted. Production profiles in the UKCS are falling, and we are no longer self-sufficient in hydrocarbons. Surely the Treasury should be introducing measures which will encourage investment, not frighten it away? Companies will move elsewhere, where the risk is higher but the return potentially huge.

Should we be involved in the search for alternative energy?

The majors are already involved and investing heavily in renewables. PESGB has a function to promote interest and awareness in all aspects of the industry, and we actively participate with seminars like the session at PETEX. Quite how big a role the industry will finally take, particularly the independents and smaller companies, I don't know, but the ball is definitely rolling in that direction.

What of the future of the UK oil industry?

The UKCS is clearly a mature province after over 40 years, but I think there is still plenty to play for. Tullow, for example, have been very active in the North Sea in recent years, with a good level of success. There is less interest from the majors, but for the independents, with lower thresholds of materiality, relatively small but high value discoveries are crucial. Some majors, like ConocoPhillips, have never left the North Sea - they view it as steady cash-flow, while they look elsewhere for high risk but potentially high value finds.

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New Global Oil and Gas Study

This is not another grass roots global energy outlook. Instead, it promises to be the most comprehensive overview ever done.

Have the recent flood of articles about "life after oil" from the likes of National Geographic, Newsweek, The Wall Street Journal, the evening news, web sites, books and the oil company's own ads gotten people worried about our energy future? Have we reached "peak oil"? A new Global Oil and Gas Study by the National Petroleum Council (NPC) will attempt to answer some of the energy concerns through the year 2030. **This study promises to be the most comprehensive ever done**. Donald Paul, Vice President and Chief Technical Officer of Chevron, outlined some of the details of this study at a special session in San Antonio at the 2006 Society of Petroleum Engineer's annual convention.

The U.S. Secretary of Energy, Samuel W. Bodman, requested in 2005 that the NPC undertake a major study of global oil and gas. The study will address key strategic dimensions of supply, demand, technology, and geopolitics and policy. The NPC Agenda Committee voted to launch the study in December 2005 and established the Executive Committee to organize and conduct the study.

Key questions to be answered by this report are as follows: 1) What does the future hold for global oil and natural gas supply? 2) Can incremental oil and gas supplies be brought on-line, on time, and at a reasonable price to meet future demand, without jeopardizing economic growth? and 3) What oil and gas supply strategies and/or demand-side strategies does the Council recommend the United States pursue to ensure greater economic stability and prosperity?

This is not another grass roots global energy outlook or a "peak oil" study. There are currently over 100 outlooks available, both historic and current. This study will utilize reliable data and relevant reports from all credible, publicly available sources and will solicit from a broad range of interested parties.

The entire energy system will be examined. Teams will look at alternative energy, environmental considerations, geopolitical events, technological advances, global demand, global economy, and global supply to see how all these will affect policy options. The study is organized into four Task Groups that will examine supply, demand, technology, geopolitics and policy. Within the first three Task Groups are 12 "crosscutting" subgroups whose findings will be shared across the entire group.

In supply, teams will consider refining, infrastructure, gas to liquids, liquefied natural gas, bio-fuels and renewables. In the demand area, future consumer and social trends, as well as key economic variables, will be considered. The technology group will look beyond core work on oil and gas. Areas of study will include energy efficiency, unconventional hydrocarbons, nuclear, coal, CO_2 sequestration, and technology development. The geopolitical and policy group will interface with all the other task groups. Outreach will include non-government organizations, environment, diplomatic, and academic communities. The goal is to identify key factors likely to result in sub-optimal realization of resource development and distribution, and recommend mitigating actions where warranted.

The study is currently underway with Don Paul emphasizing the scope, complexity and timing. Ongoing communications with teams and input from all interested parties will be essential to complete the study. The entire process is open and public with plans to share all goals and findings. A draft of the study is due out in the first quarter of 2007 and the final by June of 2007. More information is on the NPC website.

NASA Goddard Space Flight Center Image

CONVERSION FACTORS

Crude oil
1 m^3 = 6.29 barrels
1 barrel = 0.159 m^3
1 tonne = 7,49 barrels

Natural gas
1 m^3 = 35.3 ft^3
1 ft^3 = 0.028 m^3

Energy
1000 m^3 gas = 1 m^3 o.e
1 tonne NGL = 1.9 m^3 o.e.

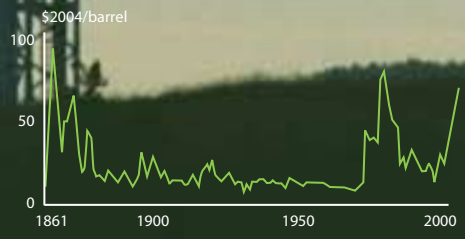
Numbers
Million = 1 x 10^6
Billion = 1 x 10^9
Trillion = 1 x 10^{12}

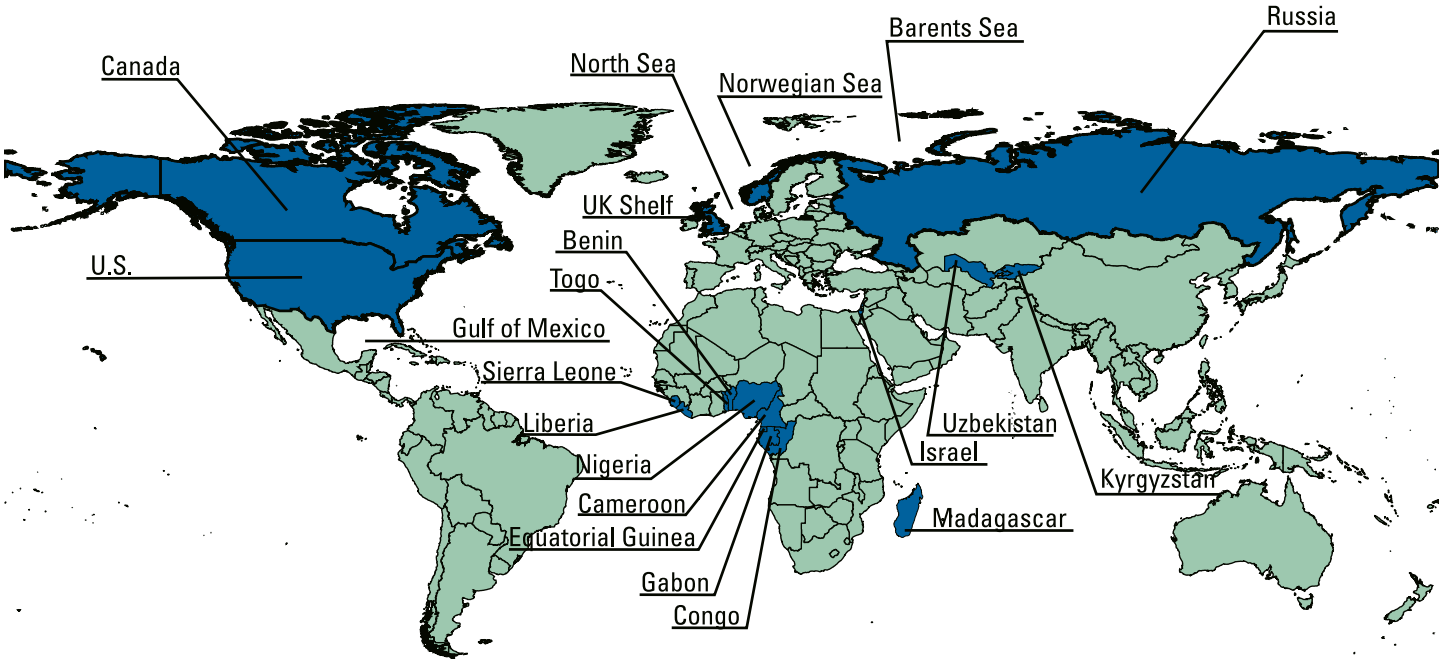
Supergiant field
Recoverable reserves > 5 billion barrels (800 million Sm^3) of oil equivalents

Giant field
Recoverable reserves > 500 million barrels (80 million Sm^3) of oil equivalents

Major field
Recoverable reserves > 100 million barrels (16 million Sm^3) of oil equivalents

Historic oil price





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