GEO ExPro
GEOSCIENCE & TECHNOLOGY EXPLAINED Vol. 3, No. 2 - 2006

Mesopotamia:
Exploring the birth of civilization

Frontier Exploration:
Mozambique 2nd Round

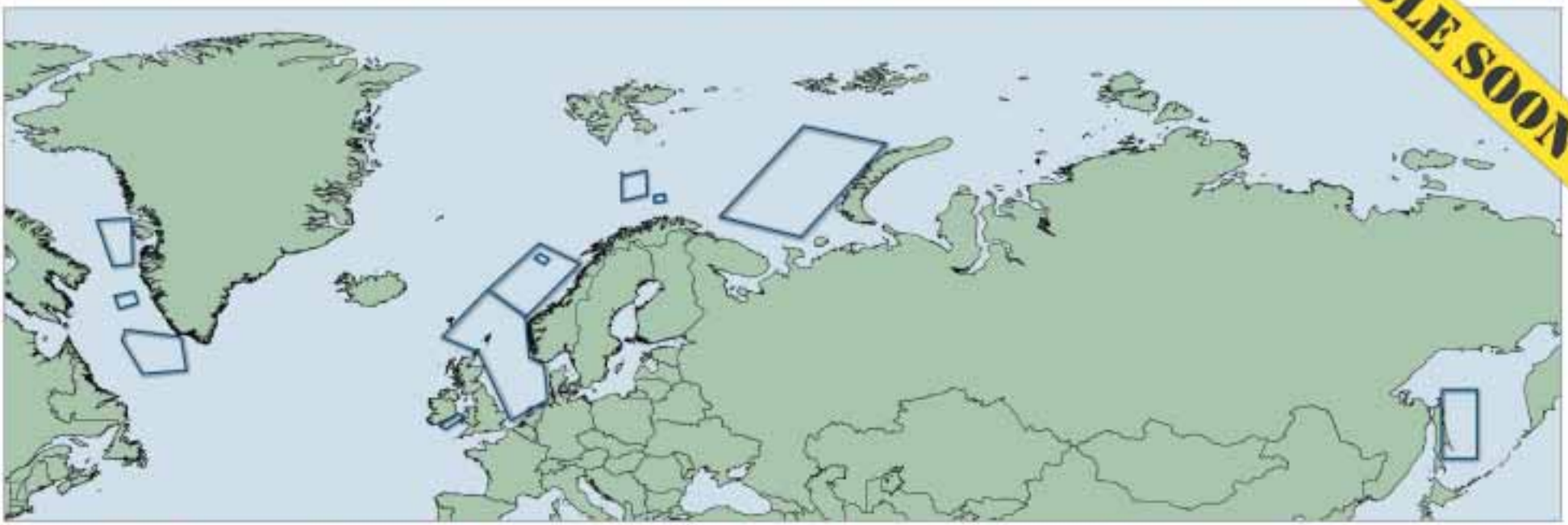
Geoscience Explained:
Sequence Stratigraphy Meets Plate Tectonics

ExPROFILE

Richard Fowler

NEW 2005 MC-PROJECTS IN THE NORTHERN HEMISPHERE

AVAILABLE SOON



GREENLAND
- 4 new 2D surveys
- Updated Geo-Atlas

NORTH SEA
- 2 new 2D surveys, approx. 18,000 km

NORWEGIAN SEA
- New 2D, over 6,000 km
- 1 new EM project

BARENTS SEA
- New 2D, 6,000 km
- 2D Repro 20,000 km
- 1 new EM project
- Updated Geo-Atlas

SEA OF OKHOTSK
- New 2D, 6,000 km
- New Geo-Report

TGS

Kjell E. Trommestad
TGS (Norway)
Tel: +47 31 29 20 00
Fax +47 31 29 20 10
kjell.trommestad@tgsnopec.no

Stein Ove Isaksen
TGS (Norway)
Tel: +47 31 29 20 00
Fax +47 31 29 20 10
stein.ove.isaksen@tgsnopec.no

Erling Frantzen
TGS (Norway)
Tel: +47 31 29 20 00
Fax +47 31 29 20 10
erling.frantzen@tgsnopec.no

Seismic Well Log Integrated Products TGS Imaging

Have you seen us lately?
www.tgsnopec.com

GEO ExPro
GEOSCIENCE & TECHNOLOGY EXPLAINED Vol. 3, No. 2 - 2006

Coloumns

Features

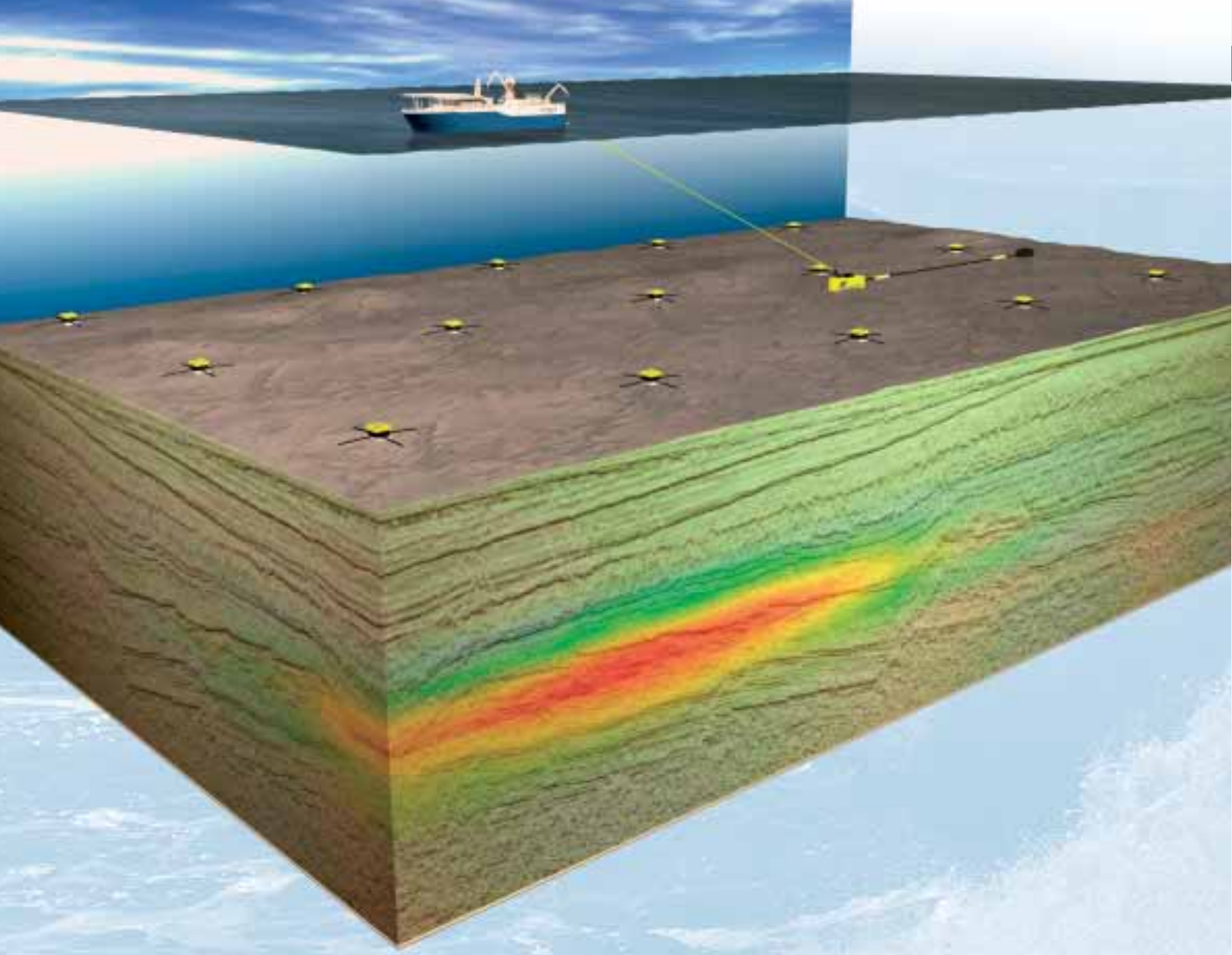
EXPLORATION

GEOSCIENCE EXPLAINED

RESERVOIR CHARACTERIZATION

The 2nd round
Mozambique is now embarking on a new exploration campaign. This time the focus is on the onshore and offshore Rovuma Basin in the northern part of the country. The authorities have good reason to be optimistic, as both source and reservoir appear to be present, writes Morten Smelror who has done regional mapping.

Episodic Global Tectorics
The Earth may be affected by relatively short-lived episodes of increased tectonic activity separated by longer intervals of relative quiescence. If true, this may have important implications for how we interpret the history of the earth and exploit its resources, writes Ashton Embry who has developed his ideas when mapping in the Canadian Arctic.



SeaBed Logging

A new dimension to hydrocarbon detection

emgs

The SeaBed Logging Company

www.emgs.no emgs@emgs.no

RSK27381

Rejected!

Most of us would bluntly say that geology has nothing to do with politics. We tend to believe that geological research is independent of political constraints.

This is of course not true. We know from the days of the Cold War that exchange of ideas between the East and the West were restricted, and both sides complained because scientists could not move freely between the two rivalling sides.

Now we are faced with a new "Cold War", and four geoscientists have unintentionally ended up in the midst of it. The scene is the Middle East. Iran, to be specific.

The story goes like this: Last fall a paper about the structural geology of the Zagros Fold-Thrust Belt, an area that contain major parts of the Iranian oil reserves, was submitted to AAPG Bulletin ("The AAPG Bulletin is a technical journal that is recognized in the industry as the leading peer-reviewed publication for information on geoscience and the associated technology of the energy industry," according to their own web-site). The paper was written by representatives from the National Iranian Oil Company, the International Institute of Earthquake Engineering and Seismology, Iran, the Shahid Beheshti University, Earth Sciences Faculty, Iran, and Centre for Integrated Petroleum Research, Norway, i.e. 3 Iranians and 1 Norwegian.

The authors were later notified that the paper had been accepted following a normal peer-review. Then everything became silent. The authors heard nothing, and instead of receiving a proof, a new letter arrived from the AAPG Science Director.

The message was clear and simple: The paper could not be published.

After having conferred with AAPG legal counsel, the director notified the authors that "we cannot publish your paper because the United States government restricts publishers from publishing papers that have an affiliation with the government of Iran."

The director adds "your paper is interesting and well written. I am sorry for the inconvenience caused to you by allowing it to advance to this stage before we became aware of this governmental restriction."

Scientists should be even more sorry. As well as the society at large. It is hard to believe that a scientific article with a pure geological content has to be withdrawn because of political restrictions.

Halfdan Carstens
Editor in Chief

GEO ExPro
www.geoexpro.com

GeoPublishing Ltd
15 Palace Place Mansion
Kensington Court
London W8 5BB, U.K.
+ 44 20 7937 2224

Managing Director
Tore Karlsson

Editor in Chief
Halfdan Carstens

Editorial enquiries
GeoPublishing
c/o NGU
7491 Trondheim, Norway
+ 47 73 90 40 90
halfdan.carstens@geoexpro.com

Advertising enquiries
Media-Team
Ellinor Kittilsen
+ 47 22 09 69 10
ellinor@media-team.no

Marketing Coordinator
Kirsti Karlsson
+ 44 20 7937 2224
kirsti.karlsson@geoexpro.com

Subscribtion
GeoPublishing Ltd
+ 44 20 7937 2224
15 Palace Place Mansion
Kensington Court
London W8 5BB, U.K.
kirsti.karlsson@geoexpro.com

GEO ExPro is published bimonthly for a base subscription rate of GBP 35.- a year (6 issues).

We encourage readers to alert us to news for possible publication and to submit articles for publication.

Layout: Skipnes AS

ISSN 1744-8743

Photo: Halfdan Carstens

The Source Exposed

The North Sea Graben has produced substantial quantities of oil and gas since the early 1970's. The US Geological Survey has estimated that it still contains 2.2 to 14.8 billion barrels (350 million to 2.4 billion m^3) of undiscovered oil, entirely offshore within the territorial waters of Denmark, Germany, the Netherlands, Norway and the United Kingdom.

The source rock of this petroleum system - deposited in Late Jurassic to earliest Cretaceous time - outcrops in England, and the type locality we find in Kimmeridge Bay on the southern coast (Dorset). The Kimmeridge Clay Formation can here be studied in detail. In this same area there are several oil fields, including the giant Wytch Farm. This field is, as it turns out, sourced from older shales (GEO ExPro No. 5/6, 2005).

Photo: Halfdan Carstens

The Kimmeridge Clay Formation is responsible for billions of barrels of oil and gas produced from sandstones and carbonates in the North Sea. Most geoscientists dealing with petroleum geology of this prolific province are aware of it. The question is if people outside our own ranks also ought to know this?

2008: Planet Earth

"It is with great pleasure that I can announce the decision by the General Assembly of the United Nations to proclaim 2008 as the International Year of the Platet Earth. On the 22nd of December the UN General Assembly adopted by consensus a Resolution by the United Republic of Tanzania and co-signed by 82 nations, to proclaim 2008 as the UN Year of Planet Earth," says Eduardo F.J. de Mulder, Chair Management Team of the International Year of Planet Earth.

The press release issued by the UN after adoption of the Resolution, reads as follows:

"By a draft on the International Year of Planet Earth, 2008, which the Committee approved without a vote on 11 November, the Assembly would declare 2008 the International Year of Planet Earth. It would also designate the United Nations Educational, Scientific and Cultural Organization (UNESCO) to organize activities to be undertaken during the Year, in collaboration with UNEP and other relevant United Nations bodies, the International Union of Geological Sciences and other Earth sciences societies and groups throughout the world. Also by that draft, the Assembly would encourage Member States, the United Nations system and other actors to use the Year to increase awareness of the importance of Earth sciences in achieving sustainable development and promoting local, national, regional and international action."

"The Committee, to which the Press Release refers, is the Second Committee of the UN General Assembly where the International Year was discussed in two terms and approved before it was brought in the Plenary Session of the General Assembly. In fact, the International Year of Planet Earth will be a triennium, starting in 2007 and closing by the end of 2009, with the UN Year of Planet Earth 2008 in the centre," says Eduardo F.J. de Mulder.

For additional information: http://www.esfs.org/

The United Nations did in December declare 2008 as the UN Year of Planet Earth. The Year's purpose is, among other matters, to "discover new natural resources and make them available in a sustainable manner, enhance understanding of the occurrence of natural resources so as to contribute to efforts to reduce political tension increase interest in the Earth sciences in society at large and encourage more young people to study Earth science in university."

Sound of Geology; International Workshop in Bergen, 26.-28. April 2006

Per Avseth, Norsk Hydro, heads up the organizing committee.

As postulated by Erasmus Montanus, the well-educated fictive character of the famous Bergen author Ludvig Holberg, "stones cannot fly!" True, but they can sing! No, we are not talking about Rolling Stones.

The technology of artificially produced seismic sound waves propagating through the earth have recently advanced to the level that allows geophysicists to derive not only structural images, but also rock and fluid properties from seismic signals. *Sound of Geology* is an upcoming international scientific workshop, which aims at strengthening the link between geophysics and geology within petroleum exploration technology and reservoir characterization.

An increasing global demand for oil and gas has turned exploration into a very important scientific topic. The persistent high oil price opens up for practical application of recently developed (and expensive) seismic and electromagnetic acquisition, processing and interpretation techniques. Conventional exploration technologies and cultures are challenged, and the scene for development of new methods is wide and open. At this workshop we will discuss integration methods, specifically how geological processes like deposition and compaction (mechanical and chemical) control the volumetric and seismic properties of sedimentary rocks. The field of rock physics plays an essential role during the quantification of geology from seismic data, and thus will be the red thread of this workshop.

Several international capacities within the fields of sedimentology, diagenesis, rock physics and seismic data analysis have been invited to present the current status of research and technology in academia and oil industry. The workshop, which is organized by CIPR, Norsk Hydro and Statoil, has been advertised in leading scientific journals including in GEO ExPro, and tens of scientists, practitioners and students from all over the world have submitted their contributions. Around 100 participants will meet in downtown beautiful Bergen for 3 days at the end of April (26.-28.). The social program will include an ice-breaker at the workshop venue, Royal SAS Bryggen Hotel, as well as a culinary dinner at the famous mountain restaurant on Fløyen.

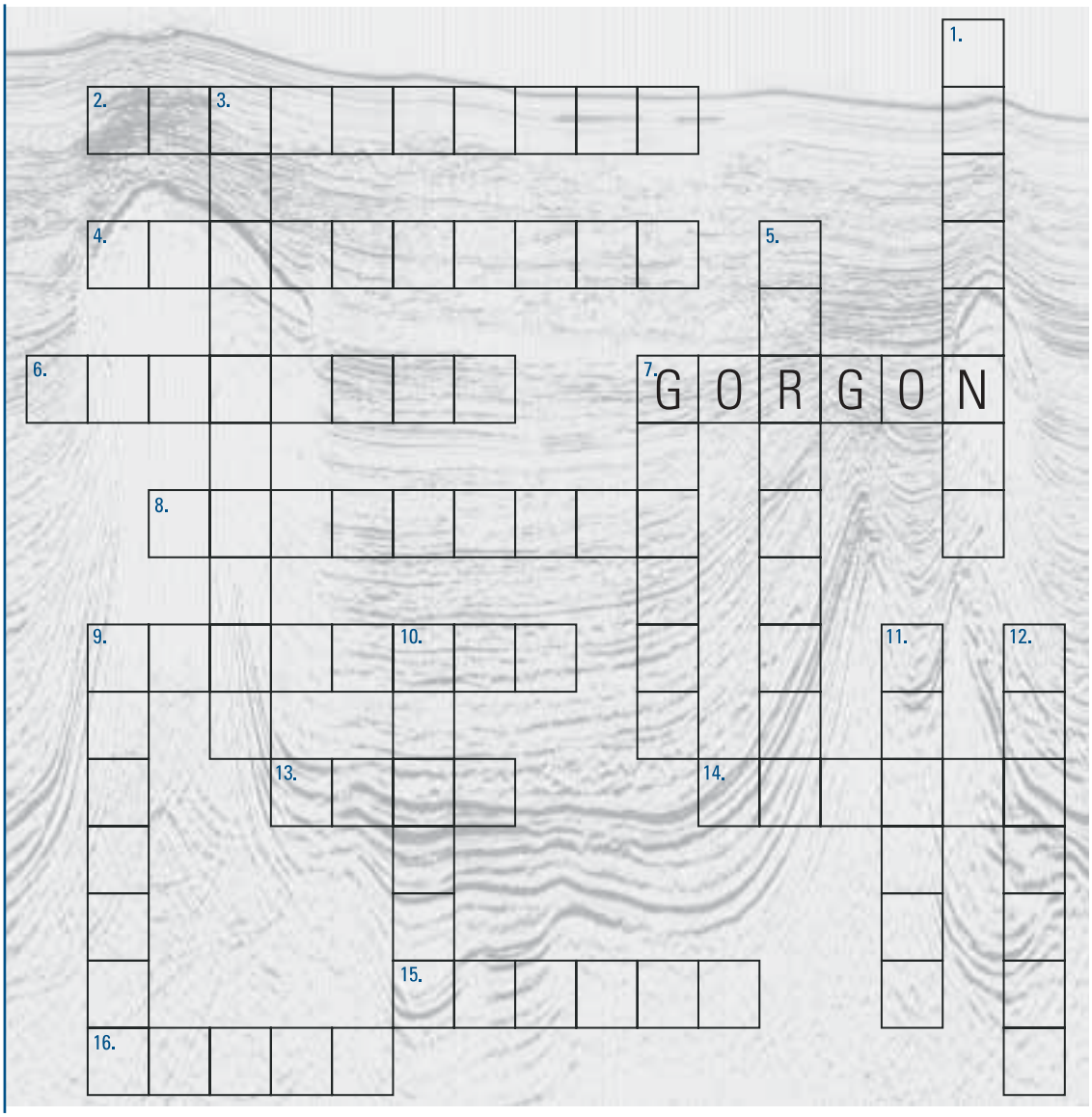
People who are interested in joining this workshop can register via the following website: www.soundofgeology.info. With limited space, it is first come first serve, so do not hesitate.

Per Avseth

LOOKING FOR A HYDROCARBON FIELD?

Across:
2. Highest peak in the western hemisphere (hint: Argentina)
4. First giant Texas oil find
6. Giant Ape, also a Gulf of Mexico field
7. Giant Australian offshore gas field
8. Famous heavy rock band
9. Russian Barents Sea giant
13. 4th planet from the sun
14. Giant find in Kazakhstan
15. The most famous Disney character
16. A Norwegian bogeyman, also an oil field

Down:
1. Largest Eastern Canada oilfield
3. New field in Mauritania
5. Big offshore storm, also a Deep Shelf (GOM) discovery
7. The biggest of the big in Saudi Arabia
9. Norwegian for "Snowhite"
10. Long-billed ocean fish, Brazilian name
11. A fortified wine
12. Significant UK find, also a type of vulture



www.tgsnopec.com Seismic Data Well Log Data Integrated Products TGS Imaging

Leading the search for world class fields.

After a quarter century of growth, TGS and its family of global companies continue to deliver great data in the right place at the right time. From 2D and 3D seismic acquisition and processing to well log and integrated data products and services, TGS provides the knowledge that begins the search. Leverage information and people from a world class company to find your way to world class fields. We can support your next exploration program in more ways than ever. Visit our web site for more information.

TGS

www.world-class-data.com

TGS-NOPEC Geophysical Company • NORWAY +47 31 29 20 00 • USA +1 713 860 2100 • UK +44 (0) 1234 272122 • AUSTRALIA +61 8 9480 0000

Software for the Asset Team

The new Houston-based company 3GiG has developed a software product which will help asset teams to store, track and manage prospect information, from the initial lead to the final plugging and abandonment of a well and beyond.

3GiG's multidisciplinary team Andrea Gallagher (Project Manager), Eric Williams (VP research and development), Kandy Lukats (President and CEO) and Tim Altum (Founder) test the new version of Prospect Director.

Multidisciplinary asset teams are very important in the search for hydrocarbons. But can every member of your team access all the relevant information on a prospect, without being swamped with unnecessary data? Can they retrieve everything they need without replicating tasks? And what happens to all that data after prospect evaluation?

Kandy Lukats, President of 3GiG, became aware of the importance of the workflow process in prospect management as Managing Consultant and then Vice President of Exploration and Development Systems at Landmark Graphics. In these positions she helped clients understand the issues in their business processes and how to apply technology to solve them. She found that companies all had similar concerns in the area of prospect management.

"Talking to the industry, as I was, it became apparent that companies had no real way of managing or storing exploration or development leads and prospects," Kandy explains. "Oil and gas executives were constantly frustrated by the loss of ideas and drillable prospects from their company through the movement of staff. They needed a solution that would allow the individual asset team members to streamline their work processes and cut cycle time on well approval, but which would also allow the enterprise to store and retrieve ideas. These prospects represent the intellectual property of an oil company and they were constantly disappearing."

Eventually, Kandy moved from Landmark so she could concentrate on resolving these issues. She partnered with geologist Tim Altum, who had developed a prototype prospect management system for Devon Energy, which he felt could fill this niche. In 2003 he founded 3GiG with Eric Williams and a software development team, with the purpose of developing the product further. Kandy joined them in 2005 as President and together they are intent on proving that this is the product the industry has been waiting for!

Their software, Prospect Director, is a web-based product which "goes from lead generation, through prospect development to well planning and drilling. It follows through completion, production, workover and recompletion, right through to plugging and abandoning the well. It was designed in collaboration with asset teams and business unit managers to meet their needs"

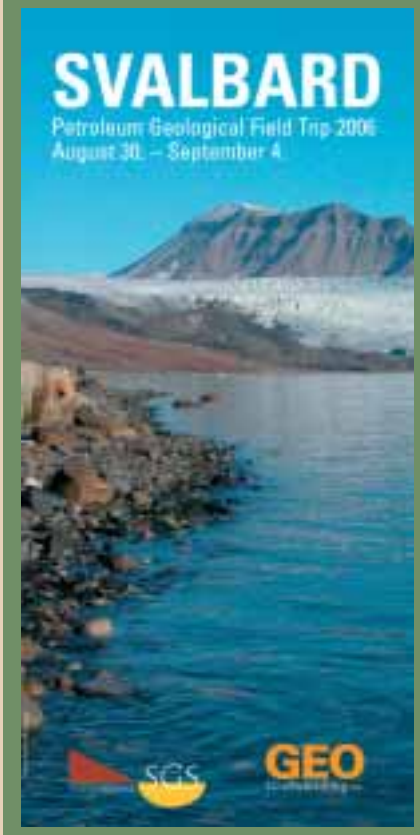
"We believe that if you work with the people who need the product, you get the best results, says Kandy. "So by talking extensively with asset teams we discovered which parts of the prospect management process are common and which are unique to each company, and have designed the product around that. It is then easily customised to meet a client's specific requirements: effectively, it 'thinks like the asset team'." The aim is to enhance the prospecting efficiency of an organisation through increased productivity by removing repetition, automating the business process and reducing cycle time.

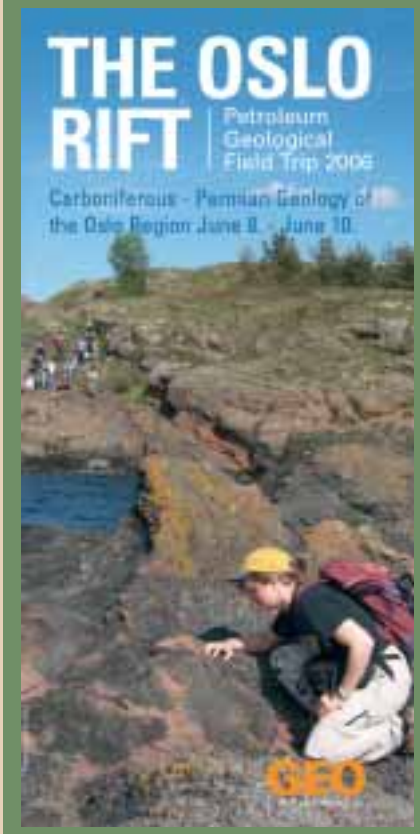
Kandy feels that the real importance of the product will be seen in the future. "Its true value lies in the ability to perpetually store information on leads, prospects and wells from any application. As the search for oil gets more and more intense, we will be going back to these old leads, and easy access to the data previously generated will be imperative."

Kandy is asked where the brief but snappy name of their company comes from – something to do with saving gigabytes of information perhaps? She laughs. "Well, it should be that, shouldn't it? Three guys started the company from their homes - so actually it stands for "3 Guys in a Garage!"

Jane Whaley

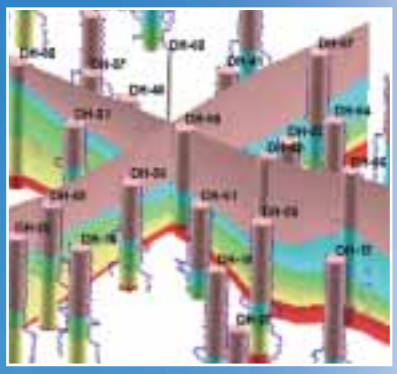
2006 Field Trips





For information and registration:
www.geoaktuelt.no or
www.geoexpro.com

Call Before You Drill

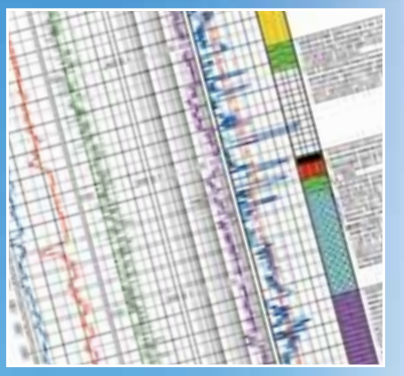


RockWorks

3D Subsurface Data Management, Analysis, and Visualization

All-in-one tool that allows you to visualize, interpret and present your surface and sub-surface data using popular tools such as maps, logs, cross sections, fence diagrams, solid models and volumetrics.

$1,499



LogPlot

Powerful. Flexible. Affordable.

Display geotechnical, geophysical, mud logging, and oil/gas data as a graphic strip log. Plot single page logs for shallow borings, or multi-page/ continuous logs for deep wells.

$599

Petroleum Engineering Toolkit

Calculations Required for Managing Oil and Gas Properties

Microsoft® Excel® based software which will calculate ÿuid properties; predict **future well performance from reservoir** properties; design and size pumping units; perform well economics; and more.

$995

RockWare
Since 1983

www.rockware.com

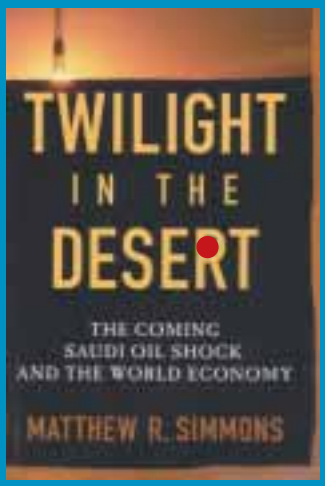
Earth Science Software • GIS Software • Training • Consulting

European Sales
Vicolo dei Saroli 1 • 6944 Cureglia, Switzerland
++41 91 967 52 53 • F: ++41 91 967 55 50
europe@rockware.com

US Sales
2221 East St • Golden, CO, USA 80401
303.278.3534 • F: 303.278.4099
sales@rockware.com

Will there be a Saudi oil shock to shake the World economy?

"Twilight in the desert" by Matthew R. Simmons



John Wiley & Sons, Inc., Hoboken
New Jersey, 422pp. (2005)
ISBN-13: 978-0-471-73876-3
ISBN-10: 0-471-73876-X

Matthew R. Simmons' name is closely affiliated with the term "Peak Oil". However, he was not the first oil man to point to the fact that oil and gas are limited and non-renewable natural resources, implying that sooner or later the production rate will erode, creating a peak in the production profile. Rather, it was Michael T. Halbouty who pointed to that such a development was probable for the United States oil production, and he became famous for his very precise prediction of when this was going to happen, namely in the mid 1950s.

But few would argue against the fact that Simmons has contributed strongly to make the concept of "Peak Oil" a focus of a hot debate about the future global oil production profile to such a degree that the petroleum community to some extent is divided into two camps. Simmons himself claims that the geologists dominate the group of those who accepts the "Peak oil"-concept, whereas economists tend to take the opposite standpoint. His recent book "Twilight in the Desert. The coming Saudi Oil Shock and the World Economy" intends to expand on this view.

In recent presentations, Matthew R. Simmons has been careful to emphasize that his present view on the "Peak Oil"-concept does not imply that there is a present oil crisis. Neither does it mean that the World is running out of oil in the near future. Instead, there is an imbalance between the production and the increasing demand related to the rapid growth of the Chinese and Indian economies. "Twilight in the Desert" points to what Simmons estimates to be one of the great unknowns in this calculation, the robustness of the future production profiles of the Saudi Arabian supergiants.

The reasoning is built on some very basic observations:

- The Saudi contribution to the total World oil production – 13 per cent – is significant. This production has leaned, and continues to lean, heavily on only four supergiants (the Ghawar, Safanya, Abqaiq and Berri fields; all carbonate reservoirs), that yield approximately 80 per cent of the total. These fields are old. They were discovered between 1947 and 1963 and all reached their peak production between 1973 and 1981.
- The supergiants have been heavily exploited because they have been the key elements in the role as swing-producer that has been taken on by Saudia Arabia to maintain a relatively stable international oil market in periods of emerging crises in oil supply. According to Simmons, this has been done simply by opening and closing valves in existing wells. This could be done because of the extremely good reservoir properties of these fields and, in particular, the existence of sub-horizontal zones of extreme permeability, so-called super-K zones. These make the reservoirs handy for swing production, but is also their Achilles heel: A water breakthrough into the high-K zones would be catastrophic.
- An abrupt decrease in the production rate of any of the supergiants would immediately give dramatic effects in the international oil market, and probably cause waves in the World economy.

According to Simmons, the risk that this could happen in the relatively near future should raise concern. This opinion is supported by documentation that world-class reservoir management systems and expertise is, and has for a long time been, available to Saudi petroleum community. Hence, the properties of the reservoirs are well described and their behavior is analyzed by the use of state-of-the-art modeling tools. This implies that there is probably no potential to enhance the present and future production by the introduction of methods and technology that are available today.

Simmons includes in his analysis a technical evaluation of the total petroleum resources of Saudi Arabia as well as an assessment of its future exploration potential. He goes into great detail and depth in his descriptions of all the major fields and their history, and even includes a chapter on reservoir geology to make his technical assessments accessible for the non-geologist. There are also useful listings of data and a description of the methods used. His observations are well documented: The reference list includes more than 200 references to technical publications, mainly SPE-reports.

But the book offers more than a technical assessment of the Saudi petroleum potential and its risks. It also gives the reader a condensed overview of the history of Saudi Arabia as a developing country with an extreme dependence on its petroleum resources. Saudi Aramco is, of course, given a chapter of its own. The book also gives some glimpses into the Saudi role in the international political picture.

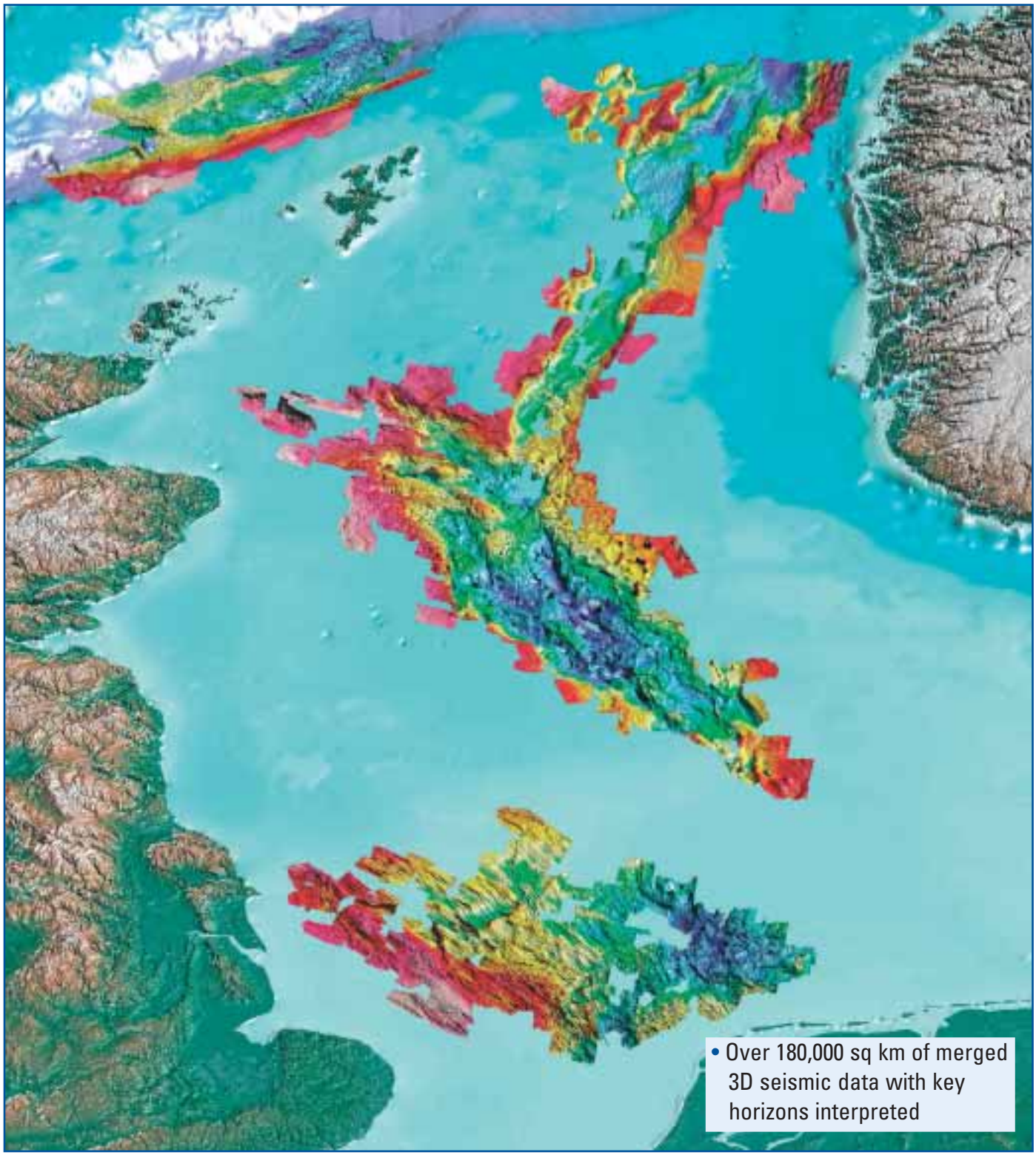
In conclusion, "Twilight in the Desert. The coming Saudi Oil Shock and the World Economy" gives a unique view of the future of world petroleum resources. It is unusually well documented for a book of its genre and therefore gives the reader an opportunity to draw her own conclusions. Simmons has paid a price for his ambition to make the book "the full story", though. This has caused the text to loose its fluency in places. Also, the text may seem a little unbalanced when it comes to the historical and technical perspectives. Some readers may also be annoyed by its repetitiveness.

But overall, it is very clear that Simmons' willingness to share his knowledge about the Saudi oil industry has resulted in a book worth reading for anyone who is interested in the future global energy situation. And this is completely independent with respect to whether one shares the view on Simmons' "Peak Oil"-concept or not.

Prof. Roy H. Gabrielsen
Department of Earth Science
University of Aarhus
Denmark

MegaSurveys

We have NW Europe Covered



- Over 180,000 sq km of merged 3D seismic data with key horizons interpreted

Mark Martin
Tel: +44 1932 266497
mark.martin@pgs.com

Tor Åkermoen
Tel: +47 6751 4221
tor.aakermoen@pgs.com

A Clearer Image
www.pgs.com

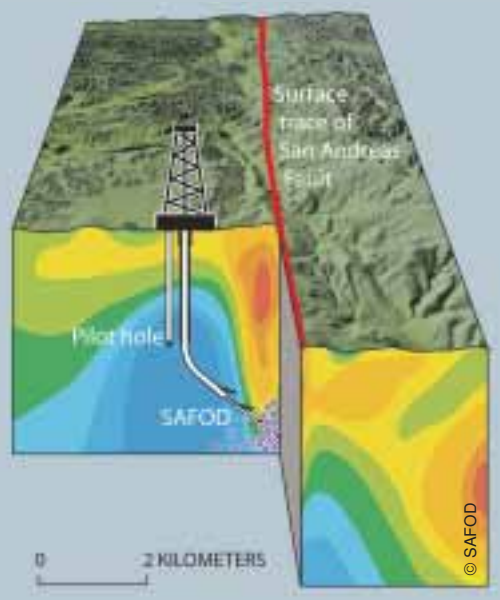
PGS

April 18 1906

We are soon approaching the 100th anniversary, to the day, of the San Francisco earthquake. In the early morning of April 18, 1906 the town was almost totally ruined. First was the tremor, lasting less than a minute. Then came the fire, with its severe impact. The earthquake and fire took almost 1000 lives, and millions of dollars worth of damage in California. The earthquake and fire would go down as one of the worst natural disasters to hit a major city in United States history.

The earthquake has been estimated to approximately 7.8 on the Richter Scale.

Due to several other earthquakes that have occurred worldwide lately, the interest in research that aims to predict earthquakes is greater than ever before. This is largely the reason behind the drilling of a spectacular, deviated well to more than 3000 m at Parkfield, California. This is in fact the very first time anyone has been drilling into a fault along a plate-boundary with the purpose of acquiring scientific data.



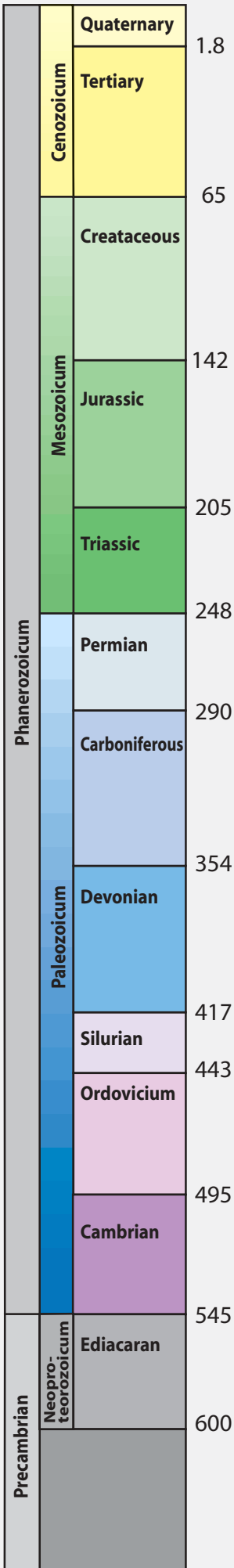
The drilling operations were completed August 28, 2005 after drilling to 3072 m true vertical depth. The well will be continued in 2007 with coring in multi-lateral wells.

This project, run by SAFOD – San Andreas Fault Observatory at Depth – is motivated by the need to answer fundamental questions about the physical and chemical processes controlling faulting and earthquake generation within a major plate-bounding fault. The well was targeting a microearthquake zone, and the drilling location is spot on the vertical plate boundary at the extreme northern end of the rupture zone of the 1966 earthquake that measured 6 on the Richter Scale).

The San Andreas Fault stretches for some 1,300 km through California and goes down to a depth of 15 km into the earths crust. The fault, a right-lateral strike-slip fault, marks a transform boundary between the Pacific Plate (moving southeast) and the North American Plate (moving northwest). In 1906 the fault was blamed for the destructions, but it had moved only some few meters. It has, however, been active for 15-20 million years, and the total relative movement is more than 500 km.

The drilling takes place in Parkfield, California.

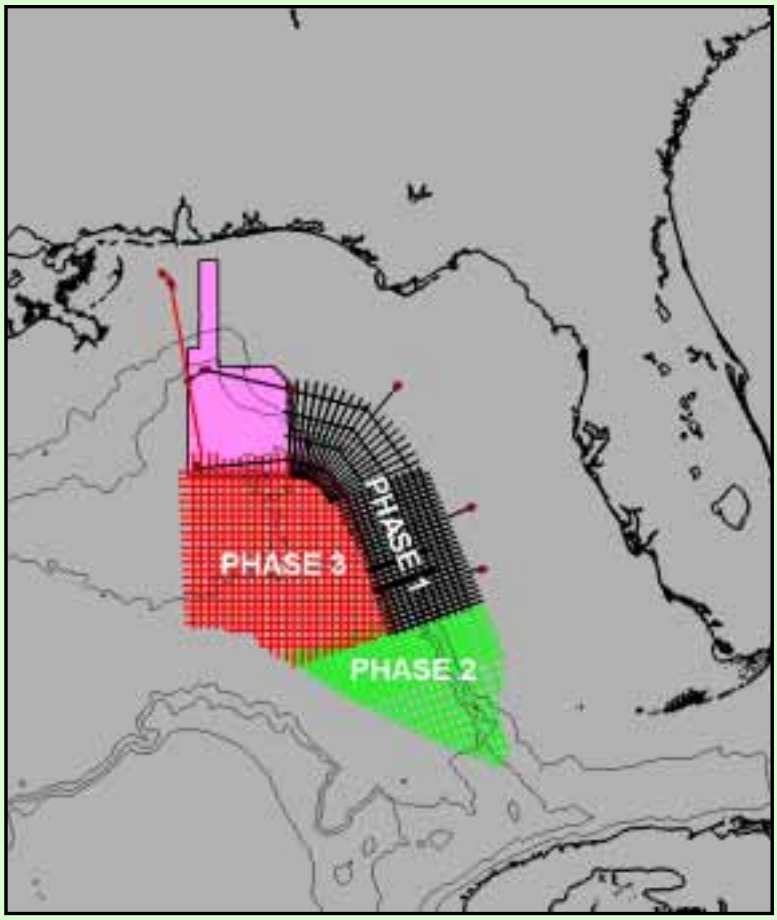
The San Francisco earthquake had its epicenter just outside town, but the crust ruptured both north and south of the town.

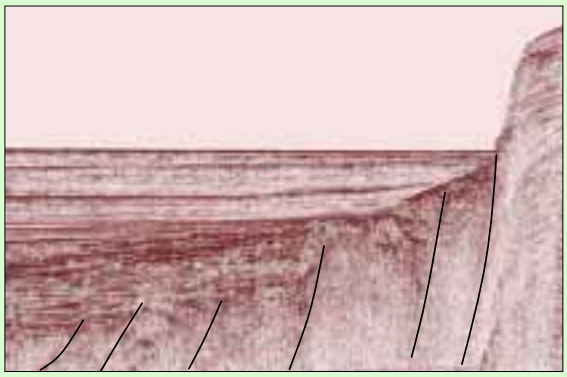


WEST FLORIDA

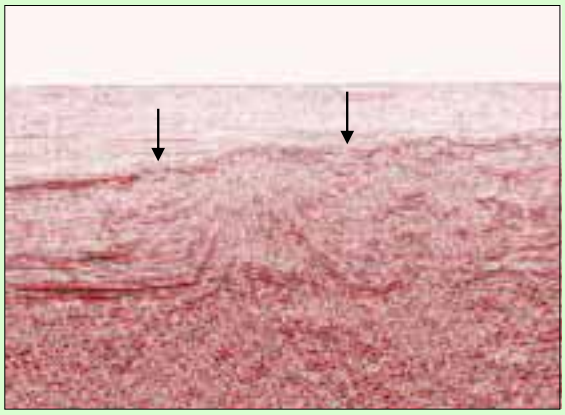
MULTI CLIENT SEISMIC SURVEY

PROGRAM MAP





UNEXPLORED ROTATED FAULT BLOCKS



TYPICAL SALT STRUCTURE WITH FLANK BUILD UP (?) (PROCESSED LINE)

PHASES
PHASE 1: 10,000 Km
PHASE 2: 7,000 Km
PHASE 3: 12,000 Km

STATUS
DATA READY 2ND QUARTER 2006

PRODUCTS
GRAVITY
MAGNETICS
INTERPRETATION IN TIME AND DEPTH
STACKING VELOCITY CUBE
INTERVAL VELOCITY CUBE
GEOPHYSICAL WELL LOG ANALYSIS
PSDM
AVO

PETROLEUM POTENTIAL

The WF survey area is considered a hydrocarbon-prone area.
Based on adjacent geology, one can expect that the source rocks are:

1. Upper Jurassic Oxfordian to Kimmeridgian carbonates and shales.
2. Tithonian carbonates and shales.
3. Lower Cretaceous Aptian to Albian carbonates and shales.

Petroleum traps:

1. Middle Jurassic fault blocks.
2. Upper Jurassic deep water microbial buildups on the outer portions of the carbonate ramps.
3. Lower Cretaceous rudist reef rudstones, boundstones and slope carbonate deposits, as well as fore-reef debris rudstones and shelf derived grainstones, which are expected to lie seaward of the Lower Cretaceous
4. Norphlet sandstone, drape over.
5. Stratigraphic traps.
6. Large Tertiary sand lobes.
7. Salt Diapirs.

CONTACT INFORMATION

Kjell Finstad Office: +1 - 2816470602, ext 211
Cell Phone: +47 – 91128308
Email: kgf@ggs.biz

GGS Global Geo Services
SPECTRUM

Frontier with high expectations

Mozambican authorities have good reasons to be optimistic when embarking on a new exploration campaign. Seeps of oil and gas are well documented at several localities in the Rovuma Basin, and potential source rocks are considered to be present throughout the area. Good quality reservoir rocks with high porosity have also been identified during a recent onshore mapping project.

The 2nd round

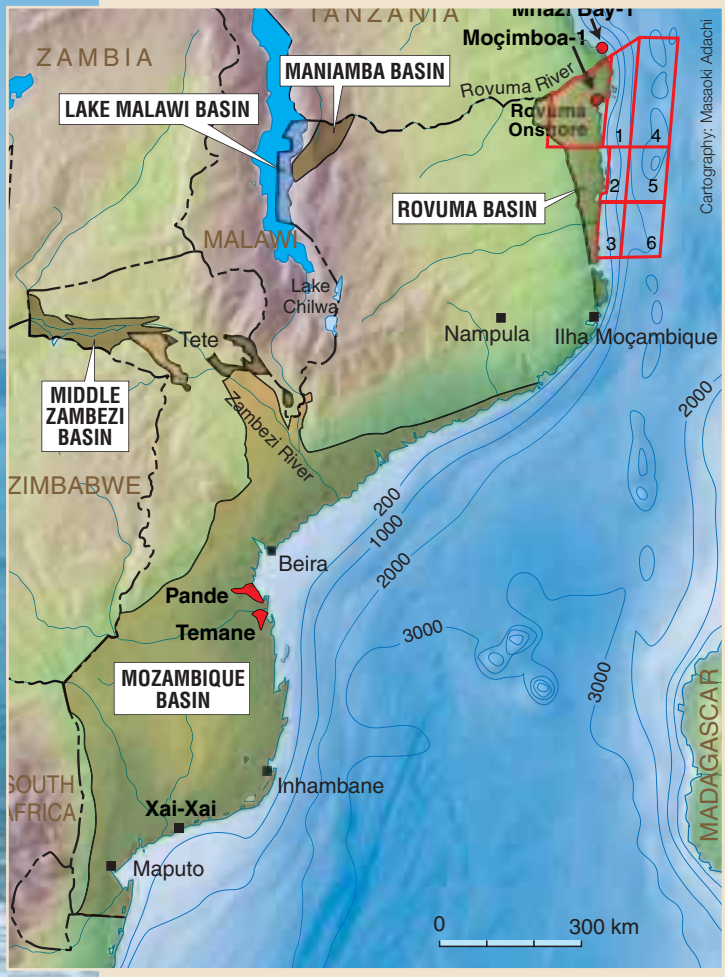
Instituto Nacional de Petróleo (INP) closed the Mozambique Second Licensing round on the 31st of January 2006.

This round focused on the onshore and offshore Rovuma Basin in northern Mozambique. The areas on offer extend from the border with Tanzania in the North, to the port city of Nacala in the South.

INP has reported that seven applications have been received covering all blocks in the round (both onshore and offshore). Three companies have applied for the onshore acreage (Artumas, Petrobras and Rockover), while six companies have applied for the offshore blocks (Anadarko, Artumas, ENI, Norsk Hydro, Petrobras and Petronas). Block 1 was the most sought after, with four applications. Recently, the offshore Rovuma Basin Areas 2 and 5 were licensed to Norsk Hydro.

The evaluation of the bids has started and it is anticipated that license awards will be made by June 2006 (http://www.inp-rovuma.com/).

View towards the Indian Ocean from the Cabo Delgado lighthouse, with raised reefs and an inner wave cut carbonate platform exposed at low tide.



Mozambique, located in southeast Africa, has a 2,500 km coastline with the Indian Ocean and a wide coastal plain that varies in width from 150 to 600 km. The major part of the country consists of undulating plateaus. Mountainous areas occur along the border with Zimbabwe. Precambrian rocks underlie approximately half of the country, mainly in the north and northwest. Karoo sediments (Permian-Triassic) occur in small areas of northern and northwestern Mozambique and Karoo volcanics are exposed in the Lebombo Mountains, close to the border with South Africa. Mesozoic to Cenozoic sediments underlie large parts of southern and central Mozambique (the Mozambique Basin) and northeastern Mozambique (Rovuma Basin).

Morten Smelror, Geological Survey of Norway (NGU), Roger Key, British Geological Survey (BGS), Elias Daudi, National Directorate for Geology (DNG) and Fernando Njange, National Directorate for Geology (DNG)

European explorers had visited the Rovuma Basin long before the petroleum industry became attracted to the area. Dr. David Livingston (1813-1873), the Scottish doctor and missionary who is considered one of the most important European explorers of Africa, explored the River Rovuma in 1859 and discovered Lake Chilwa in Malawi. We presume he was as fascinated by the quiet beauty of the landscape of this region as we were during our recent mapping efforts in the same area.

In 1866 Livingstone again travelled along the River Rovuma. This time he was aiming for Lake Tanganyika (reached in 1869) and later ventured further to discover the source of the Nile. Nothing was heard from Livingstone, and his welfare became a matter of international concern. When staying in a village along Lake Tanganyika in 1870, Livingstone was met by a rescue party led by Henry Morton Stanley, who is said to have greeted the explorer with the famous remark, "Dr. Livingstone, I presume?"

The Rovuma Basin

For the last 3 years geologists from Norway, Great Britain and Mozambique have been working in northern Mozambique for the purpose of mapping the 160,000 km^2 area at a scale of 1: 250 000. Last summer the team also studied, onshore, the sedimentary rocks onshore the Rovuma Basin, which is now going to be actively explored for oil and gas. The findings support the high expectations, but also document some of the major uncertainties for success in the exploration of this frontier area.

The Rovuma Basin is about 400 km long and 160 km wide and is centred on the Rovuma Delta near the border between Mozambique and Tanzania. The basin extends both onshore and offshore, cover-

BGS geologist John Powell studying poorly sorted sandstones along the beach section at Ponta Vermelha, near Moçímboa da Praia.

ing over 70,000 km^2 of northeastern Mozambique, approximately the same size as the Viking Graben of the North Sea.

The Rovuma Basin belongs to the East African passive margin system. The basin history is directly linked to the progressive break-up of southern Gondwana, and the sedimentary succession of the basin can be divided into five tectono-stratigraphic mega-sequences reflecting the different break-up stages: These are as follows:

1) The first stage was Pre-rift during the Permo-Triassic; these sequences are poorly known in the basin, but are expected to be equivalent to the Karoo succession with continental clastics, possibly containing coal-beds.
2) Syn-rift sediments comprising predominantly continental clastic sediments deposited in a series of half-grabens during the Triassic to Early Jurassic. A period with southerly migrating marine influence led to the deposition of evaporites in the northern parts of the basin.
3) An early drift phase in the Mid Jurassic-Mid Cretaceous during which restricted shallow-marine limestone and marine clastics were deposited on the western platform of the evolving ocean. As Madagascar separated southeastwards from the African mainland during the Middle Jurassic, a passive margin developed. An extensive carbonate platform developed before it gradually became covered by prograding Upper Jurassic to Middle Cretaceous marine clastics. As much as 3 km of sediments may have been accumulated in the deepest part of the Rovuma Basin.
4) During the Mid-Cretaceous to Paleogene late drift phase the platform areas became depositional sites for open marine marls and argillaceous limestones.
5) The final phase is marked by deltaic progradation from the Oligocene to the present. In the Oligocene, the East African Rift System experienced uplift and doming, and the Rovuma Delta system began to form. During the succeeding period from mid-Tertiary to Recent, the development of this delta system continued and a thick, eastwardly prograding clastic wedge accumulated in the northern Rovuma Basin.

Petroleum systems

Potential hydrocarbon plays in the Rovuma Basin include traps in pre-rift fault blocks (Phase 1), stratigraphic traps in Middle-Upper Jurassic shelf-edge carbonates and Middle-Upper Cretaceous sands (Phase 4). Younger plays include stratigraphic traps in Lower Tertiary basin-floor fans and structural traps associated with deltaic growth faults in Oligocene-Miocene deltaic sands (Phase 5), as proven by the Mnazi-Bay 1 discovery in the Tanzanian sector. There is also interest in potential structural traps for Upper Jurassic-Lower Cretaceous sand reservoirs on the Ibo High (Phase 3).

Potential source rocks are considered to be present in the syn-rift and early drift sequence throughout the basin, but little has been documented. Analyses of the several seeps encountered in the basin point to two distinct types of oils, proving active petroleum systems. These are interpreted as having been derived from source rocks of Jurassic (Phase 2 synrift?) or older age.

The Rovuma Basin system contains several intervals of good quality reservoir rocks. The pre-late drift continental deposits (pre-Lower Cretaceous) found onshore in the northwest Rovuma Basin are generally expected to show mostly low net-to-gross ratios due to diagenesis, but the contemporaneous paralic and shallow marine clastics towards the east and southeast are expected to have fair to good reservoir potential, with moderate to minor reduction of porosity. The Aptian-Albian succession comprises reservoir sands of good quality. The main reservoir unit in the Moçimboa-1 well comprises channel sandstones deposited towards the proximal part of a turbidite fan.

The recent onshore mapping program has documented that similar turbidite sandstone systems are present over larger areas to the south in the Rovuma Basin. Similar to the Aptian-Albian fans found in the onshore parts of the basin, good reservoir units are expected in Upper Cretaceous-Lower Tertiary fan systems in the offshore domain. Good quality reservoir rocks are also proven in the delta plain and slope

Hydro awarded two blocks

In February, an Exploration and Production Concession (EPC) Contract for Areas 2 and 5 in the Rovuma Basin offshore Mozambique was signed between the government of the Republic of Mozambique, the national oil company Empresa Nacional de Hidrocarbonetos de Moçambique (ENH) with 10 % and Norsk Hydro Oil and Gas Mozambique (operator) with 90%.

Areas 2 and 5 cover approximately 14,500 km^2 immediately to the east and north of Pemba, the provincial capital of the Cabo Delgado Province. Water depths in the areas range from shallow to more than 2,000m. Following implementation of the contract the first priority will be to complete an environmental impact assessment prior to conducting initial seismic operations.

Morten Smelror, senior author of this article, studies hydrocarbon seeps in Tertiary sandstones at Wimbe Beach. The seeps lie below the high water mark and are mostly heavily biodegraded.

and pro-delta sandstones in the Upper Tertiary Rovuma Delta. The Mnazi Bay-1 well drilled in Tanzania just north of the Mozambican border in 1982 tested gas rates up to 14mmcf/d from Oligocene sands of the Rovuma Delta Complex.

More than petroleum

Mozambique is a developing country with one of the highest population growth rates in Africa. Years of civil war, droughts and floods have severely impeded" foreslår justert til "Mozambique is one of the world's poorest countries with one of the highest economical growth rates in Africa. Years of fight for independence, civil war, droughts and floods have severely impeded the development of the country, but twelve years after the end of the civil war, inflation is under control and the country is gradually being rebuilt. However, according to UN statistics, 38% of the population still lives on less than US $1 per day.

The country has a large natural resource potential. At present, the economy is largely based on agriculture, fisheries, tourism and transport and only a small percentage of the total mineral resource is currently being exploited. Mozambique has potential for mining for coal, titanium, minerals and gold, as well as a range of less exotic products that are all essential for basic development,- such as building stones, aggregates and fertilizer minerals. Since the end of the civil war increasing amounts of gold, gemstones, marble and graphite, as well as coal, have been mined. World-class titanium-rich sands were discovered inland, near -Xai, about 250 km north of

Exploration history

Exploration for hydrocarbons in Mozambique goes back to 1904 when the early explorers discovered thick sedimentary strata in the onshore basins. In the earliest years, however, poor technology and lack of funds halted those early exploration attempts.

After the termination of the 2nd World War, international oil companies moved into Mozambique and carried out extensive exploration, mainly onshore but with limited activity offshore. In 1961, Gulf Oil discovered the **Pande Gas** field in the Mozambique Basin (present reserves are 3.5 Tcf). The small gas discovery, **Búzi**, 50 km southwest of Beira was discovered in 1962 and the **Temane** field in 1967 (present reserves 1.2 Tcf). Exploration activity declined in the early 1970's due to political unrest.

New activity was established in the Mozambique Basin in the early 1980's with the creation of Empresa Nacional de Hidrocarbonetos de Moçambique (ENH). In the following years extensive work was carried out to map and appraise the Pande Field. A breakthrough was made in 1993 when it became clear that the Pande Field could be mapped using direct hydrocarbon indicators (DHI) from seismic data and it turned out that there was a giant bright spot at the top of the reservoir. The method was later also used to map the Temane field with good result.

An extensive drilling campaign conducted by the South-African oil company Sasol in 2003, which included exploration and production wells in the Pande/Temane Block, allowed the expansion of gas reserves, including additional reserves in the **Inhassoro Gas Field** that was also discovered during this campaign.

Gas from the Temane field was put on stream in 2004, most of the gas being exported to Secunda in South Africa via a 865 km long gas pipe line.

Exploration in the Rovuma Basin started 25 years ago when CGG in 1980 acquired a total of 15,211 km of aeromagnetic data. The following year approximately 1,000 km of seismic were shot by Geco in the offshore Rovuma Basin as part of their larger survey covering the northern part of the Mozambique continental margin. These data were acquired in preparation for the 1983-licensing round, in which Shell and Esso were awarded the onshore portion of the Rovuma Basin.

In 1986, the onshore **Mocimboa-1** well drilled by Esso encountered strong gas shows in Albian sandstones. Due to drilling problems the well was plugged and abandoned untested. The license was relinquished later that year, and this is the only well drilled onshore in the Mozambican part of the Rovuma Basin. Exploration activities in the Tanzanian part of the Basin have resulted in the AGIP-Amoco **Mnazi Bay-1** gas discovery, which is currently being planned developed. Further north of the Rovuma Basin by the Mafia Basin is the AGIP **Songo-Songo** gas discovery, which started production in June 2004. This was drilled just north of the Mozambican border in 1982 and tested gas at rates up to 14 mmcf/d from Oligocene sands of the Rovuma Delta Complex.

During the 1980s 2,100 km onshore seismic, 300 km offshore seismic, gravity data, and 15,000 km aeromagnetic data was acquired.

Interest in the Mozambique part of the Rovuma Basin was renewed in the 1990's. This was largely in response to the political stability that had been achieved following some 20 years of civil war. In 1994 Mozambique Petroleum NL acquired 3,800 km of new seismic, and in 1998 Western Atlas was contracted by Lonrho de Rovuma Petroleum (Lonropet) to acquire 3,200 km of 2D offshore seismic data. Lonropet had received a seven years contract (from 1995) to the exploration rights both onshore and offshore.

In March 2000 the first Mozambique Licensing Round was announced, offering 14 blocks, mainly in the Mozambique Basin covering the shallow and deep Zambezi area.

Having received seven applications in the 2nd licensing round, Mozambique is again entering a new era in their efforts to find commercial quantities of hydrocarbons.

Coral exposed on the raised carbonate platform at Ponta Uifundo.

Small traditional fishing boats at Tandauganhui Village.

Maputo. Small-scale mining for gold has attracted many thousands of miners and migrant workers, and the International Labour Organization (1999) estimates the number of people involved in small-scale mining in Mozambique at up to 700,000.

Mozambique is also considered to have major potential for hydroelectric power, in addition to Cabora Bassa, one of three large dams on the Zambezi river system. This is Africa's second largest dam and the largest power-producing barrage on the continent. The dam began to fill in 1974 and the lake has reached a maximum length and width of approximately 250 and 38 km.

Development of the Petroleum Sector

Until 1995 both the responsibilities for commercial and governmental functions linked to hydrocarbon exploration and exploitation in Mozambique had been placed within the National oil company Empresa Nacional de Hidrocarbonetos de Moçambique (ENH). In order to split the commercial and governmental functions the National Directorate for Coal and Hydrocarbons (NDCH) was set up under the administrative control of the Ministry of Mineral Resources and Energy.

In May 2002 the Norwegian Petroleum Directorate (NPD) signed an agreement with the National Petroleum Institute in Mozambique, with the objective of assisting the development of the petroleum sector in Mozambique. In 2005 the NDCH was converted to an autonomous body, Instituto Nacional de Petróleo (INP), under the new Ministry of Mineral Resources. INP still have all governmental functions previously held by NDCH, except the responsibilities of coal.

Norwegian support to the development of the petroleum sector in Mozambique started as early in 1983. During the first years the main focus was on commercialization of the Mozambican gas resources and assistance in promoting Mozambican exploration acreage. From 2002 to 2005, experts from NPD provided assistance with the assessment of discovered resources, licencing of new acreage (including the Rovuma Basin), petroleum data management, and supervision of the large Pande/Temane Natural Gas Project. Through the last project most of the gas is now brought to markets in South Africa via an 865 km long pipeline, as well as some gas to local markets in Mozambique. Further institutional support and cooperation between INP and NPD is planned over the next three years.

Onshore mapping

During the last three years the Geological Survey of Norway, the British Geological Survey and the National Directorate for Geology (DNG) in Mozambique have jointly conducted a project aimed at mapping the bedrock in Northern Mozambique. The Norwegian engineering consultancy company, Norconsult, which has long experience of work in Africa, is the lead agency in the consortium. The fieldwork was completed in 2005.

The project is financed by the Nordic Development Fund, as part of a comprehensive program for mineral resource development under the overall management of the World Bank. The main contract covers an area equivalent to 18 single-degree map-sheets at a scale of 1:250,000, and selected sheets at 1:50,000, in an area of 160,000 km^2. The maps form a basis for assessing the mineral resource potential of the country. They are the property of Mozambique's Ministry for Mineral Resources, which will be responsible for their release to industry and for their broader use in resource management.

"The bedrock in northern Mozambique is mainly Precambrian, formed ca. 1,100 million years ago. There are gold diggings in the northwestern part of the field area and extraction of marble as dimension stone, garnet and semi-precious stones in other areas. Both Tanzania to the north and South Africa to the west have diamond mines," says project manager Ron Boyd, NGU.

"Kimberlite, which is the right sort of host-rock for diamonds, has been found in northern Mozambique, but no diamonds as yet, and a great deal of work needs to be done before we know if the country has potential for economic deposits of diamonds," Boyd adds.

During the 2005 field season the team from NGU/BGS/DNG covered the Cabo Delgado Province, which includes the Rovuma Basin on the northeast coast. Here, the sedimentary succession dips very gently (3^0) from the west towards the coast, and small exposures of the sedimentary formations are found along roadsides, streams, smaller cliffs, in local quarries, and along the coastal shoreline to the very east. The results from the mapping program and follow-up analyses are expected to constrain the lithostratigraphy, and provide new insight on the chronology and mineralogy of the sedimentary formations of the Rovuma Basin.

Mapping of early rift-conglomerates and sandstones west of Ngapa.

Preparation and packing of samples at the Motoro Field Camp.

Now Available Online

OFFSHORE NORTHWEST EUROPE WELL DATA

A2D Technologies, the leading online provider of digital well log data, now offers GeoData sets in the North Sea, Norwegian Sea, Barents Sea and offshore West Ireland. Deliverables include edited HQLD well log data, interpreted borehole litho-, sequence- and chrono- statigraphy, synthetic seismograms, modeled borehole zonations to include lithology, main depositional environment and depositional facies associations. Data interpretation by regional experts Aceca, a TGS-NOPEC Company.

Visit www.A2D.com to search for and order the data you need, plus sign up for instant notification when new release and recaptured legacy data becomes available.

A2D
A TGS-NOPEC COMPANY

Well Log

Your Well Log Data Marketplace

www.a2d.com

A2D Technologies, a TGS-NOPEC Company

US: 1.888.LOG.LINE • UK: +44 (0) 208.541.5885

© Schlumberger

Dolomite-limestone alternations – from outcrop to 3D model

While rock climbers try to avoid the thin, porous and microfractured dolomites, geologists involved with reservoir characterization go to great length in order to give a detailed account of their distribution in carbonate reservoirs in relation to their tight limestone counterparts.

Photo: Wolfgang Blendinger

Wolfgang Blendinger and Edwin Meißner

The literature abounds with geological publications attempting to explain dolomitization qualitatively. Very few papers, however, address geometrical aspects of dolomite distribution in carbonate reservoirs for the purpose of reservoir characterization.

Quantitative mapping of dolomite distributions in carbonate reservoirs is important because dolomites often are porous, while limestones are tight. Unless densely spaced well data are available in a given field, geometrical data are best collected from outcrop analogues. This requires demanding fieldwork, excellent outcrops and tedious analysis on a bed-by-bed basis, which is why it is only rarely done.

A Triassic analogue

We have mapped the distribution of limestone and dolomite in a Triassic carbonate platform in the Dolomites, northern Italy. Edwin Meißner carried out the fieldwork in fulfilment of the requirements for his diploma thesis.

Not only are these platforms located in the type area of the mineral dolomite, they possess geometries similar to subsurface analogues. The platforms are high in relief, that is, they accumulated mainly vertically and were surrounded by deep water during deposition. Such platforms are known as hydrocarbon reservoirs in many areas, but are particularly common in the Paleozoic of the northern Caspian, such as the supergiants Tengiz, Karachaganak, Astrakhan and Kashagan fields.

Triassic isolated carbonate platforms

The Triassic isolated carbonate platforms have many characteristics of so-called mud mounds. The flanks are largely in-situ deposits, made up of cyanobacterial boundstone ; the platform tops were flat and consist mainly of aggregate grainstone. No reefs protected them from the deeper water. The calcareous parts of these platforms mostly show very poor porosity and permeability, which is mainly due to early plugging of the porous sediments by calcite cement soon after deposition. In spite of this, such platforms can host enormous hydrocarbon accumulations if porosity is created during burial and subsidence. One of these processes creating porosity is dolomitization. In addition, fracturing and poorly understood thermal karst formation plays a role.

The outcrop selected is situated on top of an ancient carbonate platform, the Pale di San Lucano massif, located in the spectacular Dolomites of northern Italy, and which may be more famous for excellent outdoor recreation facilities than for constituting a superb geological laboratory. These carbonates are of local commercial value as hydrocarbon reservoirs in the subsurface of the Po plain of northern Italy. They have also been used as carbonate reservoir analogues by many major oil companies for several decades.

The Pale di San Lucano platform, like many others, is only partially dolomitizied and displays a horizontally bedded platform core consisting of grainstone, now largely removed by erosion, surrounded by steeply dipping (ca. 25-38°) flank deposits of boundstone. The total thickness of the platform is around 1500m and represents about 4-5 million years of deposition. While the lower part of the platform core shows a mainly aggrading development, the uppermost 120m expanded laterally like a mushroom and prograded over the flank deposits.

The platform interior rocks of the Seconda Pala di San Lucano are well bedded and superbly exposed in the glacial "amphitheatre".

The Pale di San Lucano massif (Seconda Pala di San Lucano) is a 1500 m thick carbonate platform of Middle Triassic age within the Dolomites of northern Italy. It preserves a well-developed prograding platform interior on top, whereas the platform core has been largely removed by erosion. The 3D model was constructed for the platform interior.

Tedious work

On the Pale di San Lucano, the progradational part has been preserved in a spectacular outcrop in a glacial "amphitheatre". Access to this outcrop is not easy and requires basic alpinist skills. Thanks to the alpine support and logistics supplied by Ilio De Biasio of Cencenighe (in fact, he helped us in cliffs up to the III grade) we could access this outcrop. This four-week field campaign, which was four hours by foot from the nearest settlement, would have been impossible without his support.

The horizontally bedded, platform interior prograding carbonates consist of limestone and dolomite and were logged

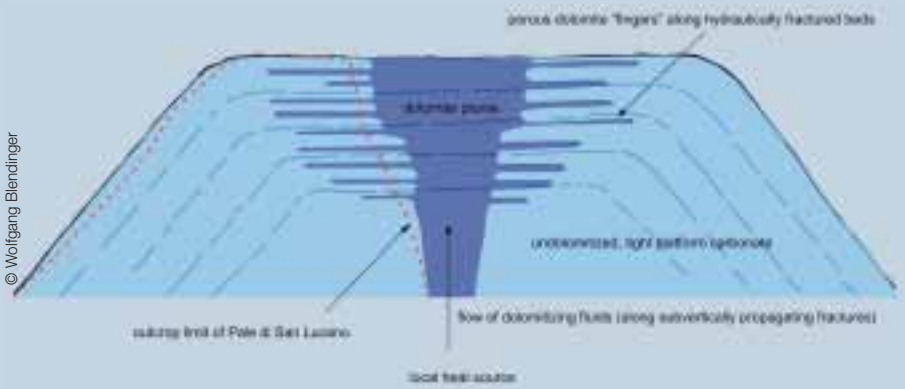
[1] "Boundstones are carbonate rocks which are bound together in the original depositional environment by framework building organisms."
[1] Grainstones are grain-supported carbonate rocks with no lime mud.

The platform interior rocks show distinct colour variations from yellowish (mostly dolomite) to grey (mostly limestone) that follow layering. Calcareous beds in the cliff of Campanile della Besauzega are marked with red numbers corresponding to the bed number. Edwin Meißner is encircled for scale.

in six stratigraphic sections, bed by bed. Control points were accurately mapped using portable GPS equipment. Interbedded are approximately 10 cm thick (acidic) tuff layers and, locally, volcaniclastic breccias, which have not been modelled. A total of 224 beds were identified in the 120 m thick interval covering an area of about 0.4 km^2, and in each section the mineralogy, as assessed from the intensity of the reaction with hydrochloric acid and subsequently coded from 2 (dolomite) to 6 (limestone), was logged as properties for each bed individually. Dolomite beds are often, but not always, yellowish, while calcareous beds are often, but not always, grey. Dolomite beds typically preserve a vuggy porosity estimated at an average 10%. Limestone, not only in this particular outcrop, but in most analogous settings, is always tight and exhibits immeasurably small permeability and correspondingly low (less than 1-2%) porosity.

Dolomite is, accordingly, very often friable and notorious among alpinists for its challenges. Limestone cliffs offer significantly better opportunities for rock climbers because of their compactness due to the absence of microfractures.

The layered distribution of the two end members limestone and dolomite could suggest a very early, syndepositional dolomitization, but small-scale dolomitization fronts show an abrupt change from limestone to dolomite, both upward and downward, within a few millimetres to centimetres. This indicates that individual beds were dolomitized when already covered by calcareous platform carbonate and, probably, by much younger deposits (burial dolomitization).



A model explaining the selective burial dolomitization of platform carbonates, as mapped on the Pale di San Lucano. Hydraulic fracturing parallel to the original bedding, causing a dense microfracture network in the vicinity of the main fracture, may have facilitated flow of dolomitizing fluids rather than the pure matrix flow favoured by most researchers on dolomitization. This type of "natural" hydraulic fracturing requires fluid pressures above lithostatic, and such pressures are normally achieved by a local source of heat in the deep subsurface. For the Dolomites, a Triassic source of heat is readily "available" both during and after platform growth in the Dolomites (widespread volcanic activity), but the regional distribution of dolomite indicates that dolomitization of the Dolomites is a much younger, probably Tertiary, event. Identifying, mapping and dating such sources of heat may, in fact, become more important than classical reservoir predicition based on depositional trends of carbonates.

Result quantification

The lateral change from limestone to dolomite and the abundance of dolomite (the so-called "net to gross") can be rapidly extracted from such a model. In the 224 modelled layers, 54 show a change from dolomite to limestone towards the platform margin (24%). Twenty layers show the opposite trend (9%), exclusively caused by the (partial) section in the northwestern model corner, which is located near a small fault possessing a dolomite "halo". In the remaining layers (67%) no trend is observed (homogeneous mineralogies).

The average property map, created from the "net to gross" model (net dolomite = dolomite cell thicknesses/bulk cell thicknesses), shows a general trend to lower "net-to-gross" from the platform centre to the platform flanks (range of values form 0.57 to 0.77).

Significance for models

Because dolomite is "porous" and limestone is "tight", the dolomite distribution of the modelled outcrop suggests that the reservoir quality is decreasing form the platform interior towards the platform flank.

This trend could, because following the pattern of platform progradation, easily be misinterpreted as "depositionally controlled", but dolomite geometries like those mapped on the Pale di San Lucano indicate dolomitization under burial conditions. The outward decreasing dolomite abundance indicates a source of dolomitizing fluids overlapping the (now eroded) platform centre of probably hydrothermal origin. A model for hydrothermal dolomitization has previously been developed for another ancient carbonate platform in the Dolomites. Why the dolomitizing fluids selectively percolated laterally along some beds is enigmatic, because the precursor limestone lithologies all indicate completely tight matrix conditions.

Hydrothermal dolomitization is so far one of the few plausible processes that could turn completely tight precursor limestone into reservoir rocks in the deep burial environment. Candidates for this type of reservoir are not only isolated carbonate platforms, but also shelf carbonates (Khuff and Arab reservoirs of the Middle East, for instance, where similar porous dolomites of enigmatic origin are inter-

Book before **Friday 31st March** and save up to **£150**

Production Forecasting for Upstream Oil & Gas

Implement the latest techniques and strategies to maximise your production forecast reliability

Venue: Swissôtel The Howard, London, UK
2 Day Conference: May 22nd-23rd 2006
Forecasting workshops: 24th May 2006

Your company fails to produce oil in line with reserves estimations. Profits crash along with your stock value, and investment confidence in you crumbles

Could this happen to you?

What steps could you take to prevent this?

Faced with Sarbanes Oxley compliance for reserves, and increasing demand for forecasting production on assets where secondary or tertiary recovery techniques are being used, NOW is the time for you to update your production forecasting methods.

Production Forecasting 2006 boasts a panel jam-packed with your **chosen industry leaders** demonstrating the reliability of their innovative approaches to production forecasting.

If you want to save time and money, **book today** to investigate how the latest tools and techniques could benefit you.

- **Ensure complete Sarbanes-Oxley compliance** by linking your production forecast to your reserves estimates
- Never get caught out again by facilities constraints: **build an integrated systems model** which links surface and subsurface uncertainties
- **Forget the old probabilistic vs. deterministic debate**: discuss how you can integrate approaches to production forecasting to achieve reliability
- **Build a reservoir model which is fit for purpose:** uncover the latest technological solutions to enable you to adapt strategy to your timeframe

If you want to **place your company at the forefront of the current oil production boom**, you need production forecasts that are reliable enough to justify investment.

REMEMBER: You need to act NOW to rejuvenate your forecast strategy in line with new technology
DON'T MISS OUT: Meet the demands for increasing diversity in energy resources and recovery methods used while the time is right.

Post Conference Forecasting Workshops - 24th May 2006

Get proof that the latest technological models work. Attend the workshops and get a demonstration, plus case history proof of the reliability of the following solutions - Learn everything they couldn't cram into a 45 minute presentation!

Workshop A:
Practical techniques for estimating probabilistic production forecasts: get focused advice on how you can develop your approach to field development to make investment decisions clearer.
IPRES Norway AS

Workshop B:
Reservoir modelling for mature reservoirs: planning facies, efficient waterflood developments and forecasting incremental waterflood production. Gain valuable experience that is directly applicable to your work.
GrailQuest Corp.

Workshop C:
Integrated production planning through unified systems models: link your facilities to your reservoir to your economics. Just how do your subsurface and surface uncertainties interact?
Serafim Ltd.

Media Partners

Don't miss out on the chance to get the latest industry advice from these experts:

Shell Global Solutions

Norwegian Petroleum Directorate (NPD)

Petro-Canada

Marathon Oil Corporation

Heriot-Watt University

GrailQuest Corp.

Gaffney, Cline & Associates

Serafim Ltd.

Jubilant Enpro Limited (Oil & Gas)

Petroleum Experts

University of Edinburgh

Qittitut Consulting

IPRES Norway AS

Danish Energy Authority (DEA)

Plus an exclusive parallel case study from

The Met Office (UK)

Researched & Produced by
IQPC
bring knowledge to life

0800 652 2363 or
+44 (0)20 7368 9300

+44 (0)20 7368 9301

enquire@oilandgasiq.com
www.oilandgasiq.com/2654a

Photo: Ilio De Blasio

Wolfgang Blendinger (here sampling limestone near Monte San Lucano) has served 15 years in the petroleum industry with supergiant Shell and the German company Veba Oil. Since 2000 he has been a professor of petroleum geology at Clausthal Technical University, Germany.

Photo: Edwin Meißner

Edwin Meißner (here on the Campanile della Besauzega; campanile is italian for "bell tower", hence the bell!) is a diploma student of geology at Clausthal Technical University and has carried out the field work and part of the reservoir modelling described in this article.

bedded with tight limestone). It is in these areas where the proposed hydraulic fracturing and associated dolomitization can be tested, through tedious studies of the geometries and mineral paragenesis associated with dolomites.

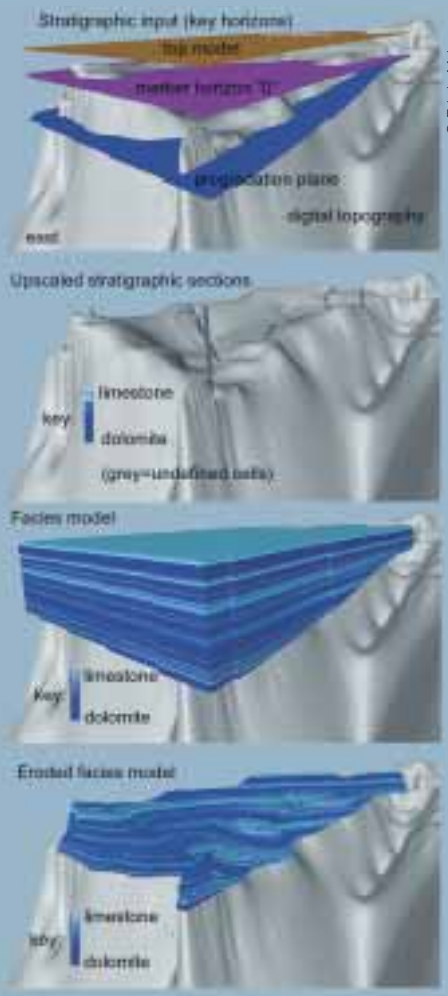
3D model construction from outcrop data

The digital model construction in IRAP-RMS (version 7.4) started with the interpolation of a topography surface from point data, which were digitized manually from topographic maps. The second step was the construction of a reference bed representing the accurate dip direction and angle of the logged interval. The measured beds were interpolated with constant thickness from an artificial well in the centre of the model area and gridded downward and upward, respectively, from the marker horizon "0". In the lower part, the gridded horizons were truncated against the progradation surface.

A 3D grid consisting of grid cells with dimensions of 5x5m (*x. y)* and thicknesses of the individual beds was modelled for the Seconda Pale di San Lucano, covering a total area of about 500x700 m. The path of the logged stratigraphic sections was loaded from accurate (error +/- 0.1 m) GPS data. The grid cells encountered by the actual stratigraphic sections, i.e. the intersections of the path of the logged sections with the 3D grid, were then assigned discrete values for the different mineralogies resulting in so-called "blocked wells" with a discrete number (codes 2 to 6) as property. The properties were interpolated between the stratigraphic sections using the "parameter interpolation" functionality of RMS.

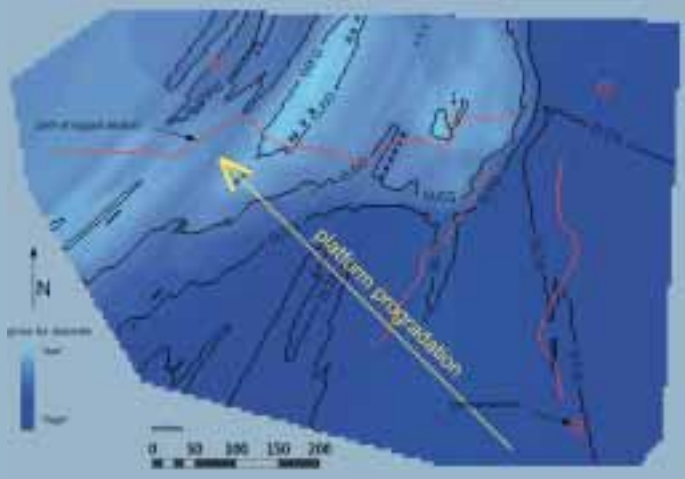
Because the observed dolomitization fronts are stratiform and do not crosscut layering, the interpolation was carried out per layer. The interpolation radius was set to 1000 m (x, y) to avoid undefined cells. The circular interpolation geometry was adopted because of the unknown exact lateral dolomitization trends.

Finally, the 3D model was "eroded" with the topography surface resulting in a 3D model of the present outcrop situation.



© Edwin Meissner

The different modelling steps in a 3D view (screenshots from RMS 7.4) from the northeast.



© Edwin Meissner

Net-to-gross map for dolomite of the model area (screenshot from RMS 7.4).

FUGRO ROBERTSON

Introducing our new chemostratigraphy tool...

The Stratigraphic Toolbox is a repository containing all of your stratigraphic needs...

...from real-time wellsite biostratigraphy to high resolution sequence stratigraphy

For further information please contact:

Fugro Robertson Limited
Llandudno
North Wales LL30 1SA
United Kingdom

Telephone: +44 (0)1492 581811
Facsimile: +44 (0)1492 583416
E-mail: info@fugro-robertson.com
Website: www.fugro-robertson.com

Episodic Global Tectonics: Sequence Stratigraphy Meets Plate Tectonics

Photo: Ashton Embry

Ashton Embry received a PhD in stratigraphy from the University of Calgary in 1976. Since 1977 he has been with the Geological Survey of Canada where he is currently a Senior Research Scientist. His research efforts have been centred on the sedimentology and stratigraphy of the Devonian and Mesozoic strata of the Canadian Arctic Islands and he has conducted fieldwork in this area since 1969. He has been working on applications of sequence stratigraphy to sedimentary successions since 1974 and has published on specific methodologies for using this discipline for improving correlations.

Based on recent advances in plate tectonics, sedimentology and sequence stratigraphy, I suggest that the Earth is affected by relatively short-lived episodes of increased tectonic activity separated by longer intervals of relative quiescence. If true, this may have important implications for how we interpret the history of the earth and exploit its resources.

Two prominent unconformities are marked by the red lines. The lower one is an angular unconformity that places Upper Triassic shale (dark) on Carboniferous clastics and carbonates (light). Yelverton Pass, northern Ellesmere Island.

Ashton Embry, Geological Survey of Canada, Calgary aembry@nrcn.gc.ca

From the early 1960s to the mid 1990s sedimentary geology enjoyed many exciting new developments which included the formulation of plate tectonic theory and consequent insights into the origin and development of sedimentary basins, major advances in sedimentology that allowed detailed facies analysis and paleogeographic reconstructions, and the development of sequence stratigraphy that provided insights into allogenic controls of sedimentary successions and the generation of predictive stratigraphic models.

It seems we have reached a bit of a plateau regarding big, new concepts and methods in sedimentary geology. However, cyclostratigraphy appears to one field that promises to bring new understanding and improved time control for sedimentary and tectonic processes. We may also be on the verge of another major shift in thinking, and this comes from a combination of the aforementioned three advances achieved in the latter half of the 20th century – plate tectonics, sedimentology and sequence stratigraphy.

Episodic Diastrophism

The methodologies, interpretations and insights from these three pillars of sedimentary geology have led to a concept that I call "Episodic Global Tectonics". Its main thesis is that the Earth is affected by relatively short-lived episodes of increased tectonic activity separated by longer intervals of relative quiescence. The widespread episodes of increased tectonism seem to occur with a frequency of 1-2 million years and vary substantially in magnitude. Currently they are best expressed within sedimentary successions but igneous and metamorphic terrains potentially also harbour indicators of such episodic crustal instability.

A similar concept was debated in geological circles during the 1800s and the first half of the 20th century. However, after 1950 the concept has been essentially ignored although it can be found in a few papers. In this article I will provide a summary of early thinking on this concept, the evidence that has indicated to me it is worth considering, a theoretical model that might account for such a phenomenon, and some of the implications for geo-

logy if episodic global tectonics actually did occur throughout earth history.

In the 19th century episodic global tectonics was widely accepted and each geological period was seen as being bounded by unconformities that represented global "revolutions". By the end of the century the concept was under considerable debate, and it was questioned if unconformities indicated "great earth movements affecting all quarters of the globe" or were due to "an aggregation of local events dependent on local conditions uncontrolled by overmastering agencies of universal dominance". The author of these quotes was the influential American geologist, Thomas Crowder Chamberlin, known best for his method of multiple working hypotheses. He favoured the former explanation and in 1909 proclaimed "diastrophism as the ultimate basis of correlation".

The Rise of Sea Level

During the first half of the 20th century natural, worldwide divisions of earth history were generally accepted but many interpreted them due mainly to tectonically driven rises and fall of sea level rather than to widespread epeirogenic uplift. In 1949 James Gilluly, in his presidential address to the Geological Society of America, declared that "worldwide orogenic revolutions do not appear to have been demonstrated" and few have dared to raise the concept of episodic global tectonics since that time.

One individual who gently kept the concept alive was Larry Sloss who, in the same year as Gilluly declared that global tectonics was a non-starter, gave birth to sequence stratigraphy by coining the term sequence for a stratigraphic unit bounded by unconformities. Sloss' sequences were bound by major Phanerozoic unconformities that extended over much of North America, and by the early 1970s he was claiming that the same unconformities were present on the cratonic portions of other continents. Furthermore he had no doubt as to the tectonic origin of such unconformities and thus Larry Sloss became the "keeper of the faith" for episodic global tectonics until his death in 1996.

Ironically, when Sloss was proposing tectonic mechanisms to explain his observations, his former student, Peter Vail, along with his Exxon colleagues, revolutionized sequence stratigraphy with seismic sections and a eustasy-driven, deductive model of sequences and their bounding unconformities. The Exxon eustatic model was accompanied by incredibly detailed and precisely dated sea level charts and it washed away any thoughts of global tectonism. The geological community, with the proviso that local tectonics "enhanced" unconformities in some cases, ecstatically embraced eustasy as the long sought key to global correlation.

Three unconformities are marked by the red lines. The lower one puts Middle Triassic shales on Lower Triassic fluvial sandstones. The middle unconformity has Upper Triassic limestone on Middle Triassic shale. The upper one is within the Upper Triassic and at this locality about 200 m of strata have been removed at the unconformity. Greely Fiord, northern Ellesmere Island.

The red lines mark prominent maximum regressive surfaces within the Lower Triassic succession. These conformable surfaces form readily recognizable sequence boundaries well within the basin and correlate to unconformities on the basin flank. Otto Fiord, northern Ellesmere Island

Mesozoic Sequence Boundaries, Sverdrup Basin

At the same time as the Vail eustasy-based sequence model was sweeping over the geological community, I was studying the 9 km thick Mesozoic succession in the Sverdrup Basin of Arctic Canada. Numerous major unconformities punctuated the

strata and I employed sequence stratigraphy for subdividing the succession into pragmatic units for facies analysis and paleogeographic reconstructions. One of the major improvements that Exxon scientists made to sequence stratigraphy was to extend the definition of a sequence boundary from "only an unconformity" as used by Sloss to one which included a "correlative conformity". This allowed sequence boundaries and the sequences they enclosed to be correlated over much, if not all, of a basin.

I discovered that the sequence bounding unconformities that occurred on the flanks of the Sverdrup Basin joined basinward with conspicuous stratigraphic surfaces that marked the initiation of major transgressions. I referred to such readily recognizable surfaces as "maximum regressive surfaces" and they were ideal for the use as the conformable portion of the sequence boundary. These surfaces, which could be dated by paleontology, provided a convenient age designation for the sequence boundary. These observations differed from what was portrayed on the Exxon deductive sequence model which placed the maximum regressive surface (their transgressive surface) stratigraphically well above the unconformity. Such a difference is likely due to their use of a non-actualistic sinusoidal base level curve as a primary input parameter in their model. When a reasonably actualistic base level curve (e.g. one based on eustasy or episodic tectonics) is used for sequence modeling, the start of transgression coincides with the initiation of base level rise. This in turn results in the unconformity and the maximum regressive surface forming a single unbroken boundary from basin edge to basin center as is observed in most cases.

Tectonics and Sequences

Now that I had my sequence boundaries clearly defined and well dated, the question of whether they were of eustatic or tectonic origin arose. I first went with a eustatic origin because they matched events on the Exxon sea level curve. However, I was not comfortable with this because various features of the boundaries strongly favoured a tectonic origin.

The characteristics which had tectonics written all over them included:

- The strata below the unconformities were often tilted and in some cases faulted
- There were major changes in depositional regime across the boundaries
- There were major changes in sediment composition and direction of source areas across the boundaries
- There were significant changes in tectonic regime and subsidence rates across the boundaries

Almost exactly 20 years ago I let the data rather than the prevailing theory guide my interpretations and postulated that the Mesozoic sequence boundaries of the Sverdrup basin were mainly of tectonic origin. Further work over the past two decades has only solidified this position.

The top of the Lower Triassic sequence is marked by a prominent maximum regressive surface (red line) near the basin centre. The strata consist mainly of slope and outer shelf shale and siltstone with some thin outer shelf sandstone just below the boundary. Nansen Sound, northern Ellesmere Island

Global Comparisons

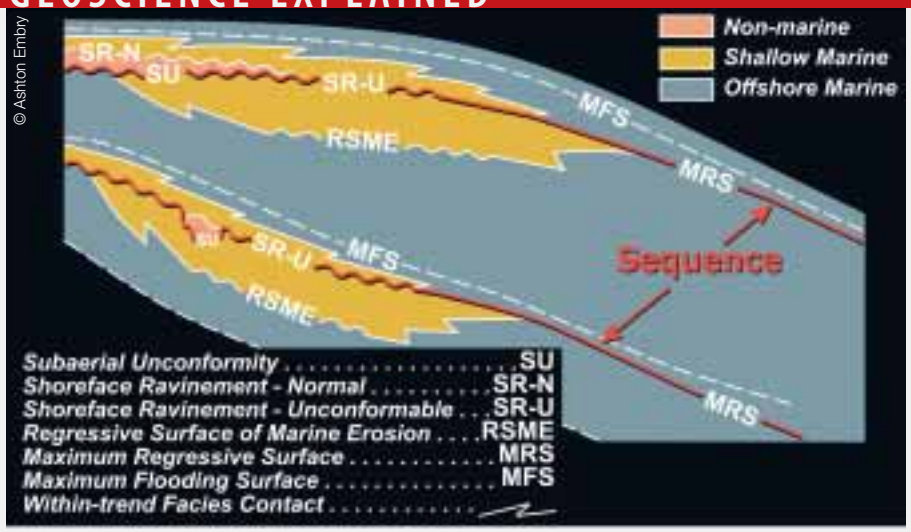
It was somewhat disturbing to me that tectonically driven sequence boundaries of the Sverdrup Basin matched very well with events on the Exxon global sea level chart. I decided to review the literature for the occurrence of major sequence boundaries in the Triassic in other basins throughout the world to see if my Triassic boundaries were due to a local tectonic phenomenon or were expressions of something larger.

The literature descriptions plus observations made on field excursions to the Triassic of the southwestern USA, Svalbard and northeastern British Columbia left no doubt in my mind that the major Triassic sequence boundaries I had recognized in my corner of the world dominated the Triassic stratigraphy in basins on at least four continents. The available evidence also indicated that the Triassic sequence boundaries in a number of basins had characteristics supportive of a tectonic origin. Thus I was faced with the hard-to-escape interpretation that significant tectonic episodes affected large areas of the Triassic world and that they were separated by long intervals of relative quiescence. Derek Ager's oft quoted quip that "the stratigraphic record is like a soldier's life; long intervals of boredom separated by short intervals of terror" took on new meaning.

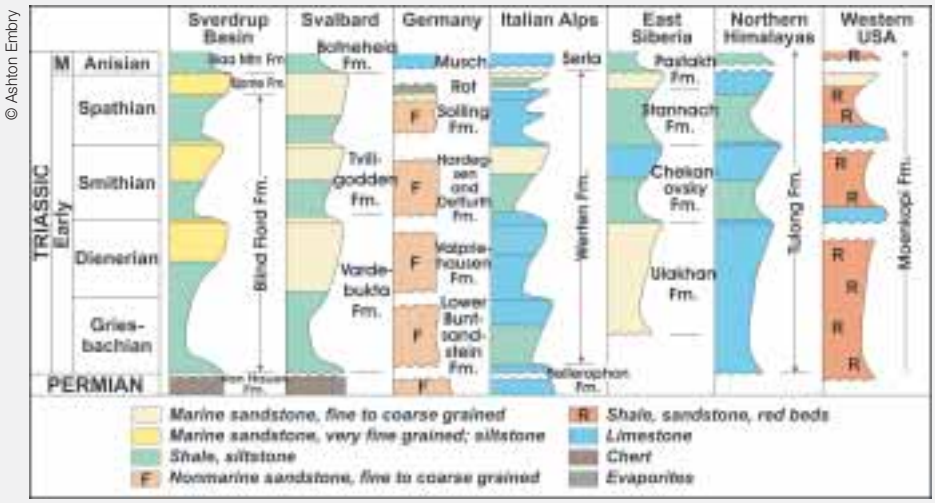
The Triassic was of course the time when Pangea was in full bloom and one way of rationalizing such widespread tectonics was that I was actually looking at only one continent, albeit a super one. I then looked at my Jurassic unconformities that also had all the indicators of a tectonic origin. And like the Triassic ones they were also represented on the Exxon sea level curve, especially the early version that only included the major Jurassic events. A literature search revealed that these too were common in many basins around the world seemingly confirming the Exxon interpretation. However, in many cases the Jurassic unconformities also bore the telltale signs of tectonics being a major factor in their generation. This convinced me that very widespread, perhaps global, sequence boundaries were not necessarily proof of a eustatic origin and that tectonics could also produce such a phenomenon.

In Search of a Mechanism

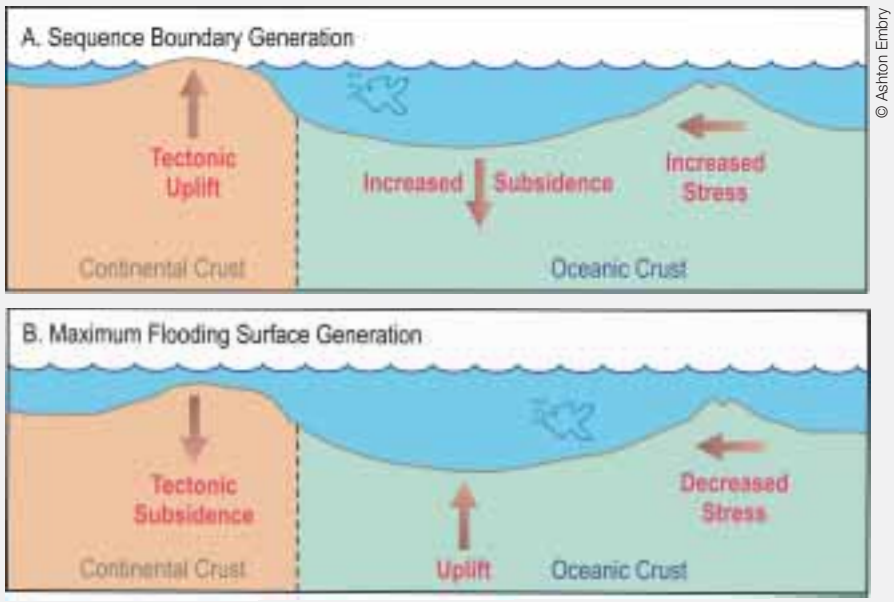
The occurrence of widespread, synchronous, tectonically generated sequence



Sequence stratigraphic model with the sequence boundaries coinciding with unconformities on the basin flank and maximum regressive surfaces farther basinward.



Early Triassic sequence boundaries from various basins in North America, Europe and Asia. The same boundaries are in all the basins and they are of tectonic origin.



A schematic model illustrating the roles of tectonics and eustasy in the generation of episodic global sequence boundaries. Changes in horizontal stress regimes due to changes in spreading rates and/or directions result in both eustatic and tectonic effects. These tectonically-driven effects result in global sequence boundaries that show the effects of tectonism.

boundaries is a clear expression of episodic global tectonics and it begs for a reasonable theoretical model to explain such a phenomenon.

Larry Sloss over 30 years ago appealed to "episodic changes in the proportion of melt in the asthenosphere below the continents" as a driving mechanism (*Sloss and Speed, 1974*). I offered up the hypothesis of episodic changes in the spreading rates and/or directions of the interlocking plates affecting the horizontal stress field that in turn would drive tectonic movements on the margins of sedimentary basins (*Embry, 1997*). This model also included a eustatic component related to tectonic deformation of the oceanic crust.

Recently I stumbled on a wonderful paper that postulated that perturbations in mantle convection and consequent effects on crustal processes drive the generation of global, large scale sequence boundaries (*Collins and Bon, 1996*). Overall I think this hypothesis of mantle-driven crustal dynamics may be the best explanation so far for episodic global tectonics and I recommend this paper to anyone interested in some mind-expanding hypothesizing.

Implications

I certainly shy away from the cliché of paradigm shift for the concept of episodic global tectonics but it does have some implications for how we interpret the history of the earth and exploit its resources.

It provides the elusive "natural order" to earth history and the sequence boundaries would contribute to global correlations and the refinement of the global time scale especially for the Precambrian. The occurrence of predictable episodes of tectonism would help to focus resource exploration because the consequences of such relatively short-lived events might well include petroleum trap formation and mineralizing fluid migration.

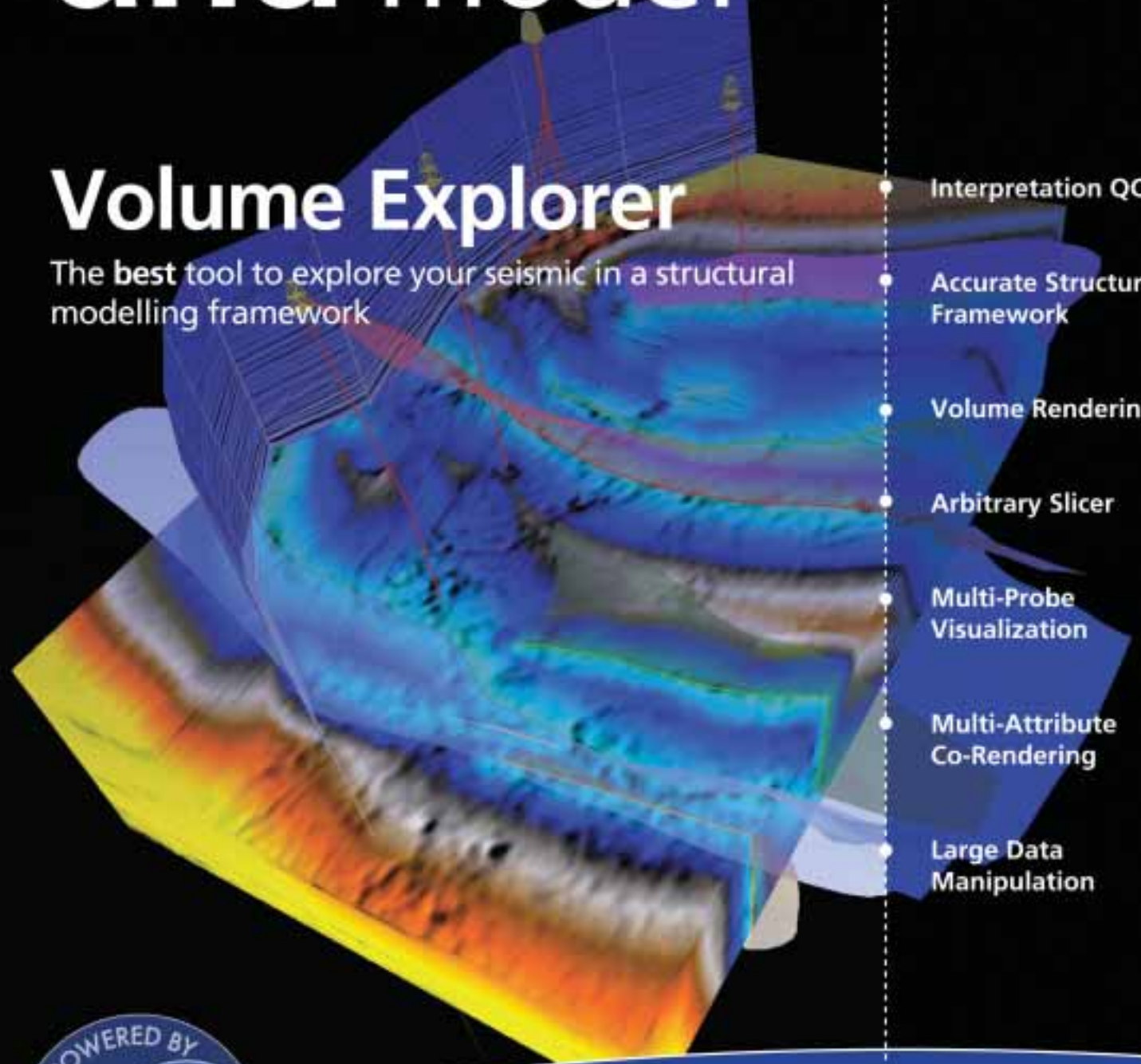
I am hopeful the academic and industrial geoscientific communities will take this hypothesis seriously and will begin testing its validity. Right now there is some tantalizing evidence that supports it and its implications are too profound to let it lie dormant in the shadow of the over-extended and poorly supported eustasy model. Anyways, we owe it to Larry Sloss to see if he was right on this one as he was on so many other things.

seismic interpretation

visualize and model

Volume Explorer

The **best** tool to explore your seismic in a structural modelling framework



- Interpretation QC
- Accurate Structural Framework
- Volume Rendering
- Arbitrary Slicer
- Multi-Probe Visualization
- Multi-Attribute Co-Rendering
- Large Data Manipulation

POWERED BY GOCAD

www.earthdecision.com

earth decision

India - an Unprecedented Opportunity

Recent exploration successes have fuelled interest in the Indian hydrocarbon industry. With the economy booming and a vibrant, young, well-educated workforce, this may be a good time to investigate the interesting new hydrocarbon opportunities being offered by the Indian government.

The sedimentary basins of India, onland and offshore up to the 200m isobath, have an areal extent of about 1.79 million km^2. So far, 26 basins have been recognized and they have been divided into four categories based on their degree of prospectivity. In the deep waters beyond the 200m isobath, the sedimentary area has been estimated to be about 1.35 millon km^2. The total thus works out to 3.14 million km^2 of which about 30% is unexplored.

Jane Whaley

The Indian hydrocarbon industry is very buoyant at the moment. There have been a number of recent discoveries, including some in the Krishna-Godavari deepwater, off the northeast coast and in the Bay of Bengal, as well as major finds onshore in Rajasthan and other known producing basins.

"These recent successes mean that perceptions in the international oil and gas industry of the hydrocarbon potential of India have changed significantly in recent years," says Bernadette Anderson, Project Manager for the NELP VI and CBM III Licensing Round Promotion at Fugro Robertson.

Virgin Territory

Last month the Directorate General of Hydrocarbons of India (DGH) announced a series of new exploration opportunities, covering a range of risks from untouched deepwater offshore blocks, onshore acreage in established hydrocarbon hot spots, and also 10 blocks for the exploration and production of Coalbed Methane (CBM).

This is the sixth round under the New Exploration Licensing Policy (NELP), and oil and gas companies are invited to bid on a total of 55 blocks; 25 on land, 6 in shallow water and 24 in deepwater, much of the available area being in water depths greater than 3,000 metres. The Coalbed Methane round is the third CBM offer, and the

What is Coal Bed Methane?

Coalbed methane is a clean burning fuel with the same chemical compound as natural gas, but formed under different circumstances. Methane (CH4) is produced when organic material is turned into coal during burial as both the temperature and the pressure increases. If, during this process, the coal is saturated with water and methane is trapped within the coal, the result is coalbed methane, known as CBM.

The coal is effectively both the source and the reservoir rock, and the gas storage capacity of coal is very high - many times that of conventional reservoirs at low pressures and shallow depths.

The occurrence of CBM has been known for many years, but it was initially treated as a potentially explosive hazard during underground mining. Traditionally, fans were used to extract the gas into the atmosphere, which not only loses an energy source but adds to the 'greenhouse effect' in the atmosphere. In fact, methane from mining is reported to contribute about 9% to total methane emissions.

Extraction of coalbed methane from unmined coalbeds commenced in the early 1900s, when a rancher in Wyoming, USA, drilled a water well into a coalbed and started heating buildings with the produced gas, but it is really only in the last 10 years that it has been recognised as an easily extracted commercial energy source. It is extracted by pumping large volumes of water out of the coal in order to release the water pressure that traps the gas within the coal. Large numbers of wells are needed in order to explore for and produce CBM – possible 10 times as many as required for conventional gas.

rxt RESERVOIR EXPLORATION TECHNOLOGY

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

RXT are pleased to announce that we have commissioned our second marine four component crew which will commence commercial operations in the North Sea in Q2, 2006

Our unique combination of the most experienced marine seismic management team in the industry and the highest calibre operations personnel is delivering high quality marine OBC data at commercially attractive rates ...

... just like we promised.

For more information please contact -

Larry Wagner
+1 281 660 6024
larry.wagner@rxt.com
Houston

Chris Walker
+44 77 1219 6149
chris.walker@rxt.com
London

Pam Voll
+47 67 82 8416
pam.voll@rxt.com
Oslo

or visit www.rxt.com

government believes that the areas offered have good prospectivity and are considered to hold sizeable reserves.

According to the DGH, one of the most exciting aspects of the NELP VI Round is thought to be the deepwater blocks in the Bay of Bengal. This is completely virgin territory, where there has been no exploration to date, with the exception of a few regional seismic lines. These blocks lie relatively close to recent deepwater discoveries by Cairn Energy and Reliance in the Krishna-Godavari Basin.

Other areas likely to attract interest are in the Assam-Arakan region in the northeast of the country. This is a well-established hydrocarbon province, where reservoirs are found in a wide range of lithologies from fractured granite basement in the Assam shelf to Oligocene to Miocene sandstones in the fold and thrust belt.

Coalbed Methane

India is keen to increase the rate of development of non-conventional hydrocarbons and is therefore offering very good terms in its Coalbed Methane Third Round offering (CBM III). The offered blocks are all in known active coalfields and considered to offer excellent prospectivity.

It is estimated that India holds 162 Tcf (4,536 billion m^3) of Coalbed Methane resources in 44 major coal and lignite fields. The resource is under-exploited, with more than half the potential CBM areas essentially unexplored. In the previous CBM rounds a total of 16 blocks were awarded, opening up 7,800 km^2 for exploration. The production potential in these blocks is estimated to be in the region of 23 MMscmpd.

Exploration in these areas has already yielded significant returns in Central India, where at the Sohagpur Coalfield, for example, in-place gas volumes in excess of 3.5 Tcf (98 billion m^3) have been discovered. In Eastern India, further reserves of more than 2.5 Tcf (70 billion m^3) have been identified, and commercial production is expected to commence by 2007.

Unique Features

Coalbed Methane is primarily found in intracratonic Permian basins in peninsular India. Smaller deposits are found in Tertiary sediments in nearshore and shelf basins in western, southern and northeastern India.

Indian coalfields have some unique features which suggest that CBM should be a viable proposition, such as thick seams and highest seam density in the world, with sizeable coal reserves. They exhibit high thermal maturity and permeability with high gas content, and are often found in a low stress regime in a relaxed structural setting. CBM bearing horizons are found at easily extractable depths between 250 and 1,200m.

The Godavari Valley Coalfield is the major coal producing area in South India and is an example of an existing coal operation which the DGH considers has good CBM potential. The Lower Permian Barakar Formation is the main coal-bearing unit, with as many as 10 coal seams, and the down-dip side of the main areas of coal extraction are considered the most prospective for CBM. An area of 386 km^2 is offered for exploitation under CBM III, and the gas-in-place estimate for the block is 1.05 TCF (29.4 billion m^3).

Bernadette Anderson is Project Manager for Fugro-Robertson, who is helping promote the NELPVI and CBMIII opportunities with the Indian Government.

High Level of Interest

"Opportunities for investment in conventional oil and gas exploration and in the coalbed methane sector appear promising, and the level of interest shown backs this up. This really is an unprecedented opportunity to enter one of the fastest growing hydrocarbon industries in the world," concludes Bernadotte Anderson of Fugro-Robertson.

History of Exploration in India

India has several hydrocarbon provinces, and the latest estimates by the Indian authorities of total *in-place* hydrocarbon resources, inclusive of deep waters, are in the region of 205 (32 billion m^3) billion barrels oil and oil-equivalent gas. Total oil production in 2004 was over 670,000 bopd and that of gas 320 MMscmd, or 545 barrels of oil equivalent per day.

According to the BP Statistical Review of World Energy 2005, India had *conventional* oil and gas reserves of 5.6 billion barrels (906 million m^3) and 32.6 Tcf (920 billion m^3), respectively, at the end of 2004.

Hydrocarbons have been produced in India since the 1880s. In fact one of the first producing fields in India, Digboi, discovered in 1889, is still producing today and is reported to be the world's oldest continuously producing oilfield. Pre-independence, oil was only produced from the northeastern and northwestern parts of the country, but after 1948 the national government pushed for further development of the hydrocarbon industry, realising its importance to the economy. Gradually, new onshore hydrocarbon areas were opened up, and production increased from a modest 4,000 bopd in 1950 to more than 160,00 bopd in the early 1970s.

Offshore exploration started in the 1970s and was rewarded with the discovery of the giant Mumbai High Field (Bombay High) in 1974 , along with other major oil and gas discoveries in the western offsoore. Oil production in India peaked in 1989 at 685,000 bopd, of which Mumbai High accounted for 440,000 bopd.

In 1997 the government of India sought to deregulate the petroleum sector by introducing the New Exploration Licensing Policy (NELP) to encourage exploration. Key features of NELP include minimum expenditure commitment, foreign participation up to 100%, with no mandatory state or NOC participation, a seven year income tax holiday, and generous royalty levels.

By contrast, exploration for Coalbed Methane in India only commenced in 1997 when the government formulated a policy for the extraction of this valuable commodity, offering six areas of interest under the first CBM round in 2001, with similarly attractive terms. Production is expected to commence in the near future.

SVALBARD

Petroleum Geological Field Trip 2006
August 30. – September 4.

Contacts:
Siggerud GeoServices;
Erling I. Hæntz Siggerud
+47 91 77 08 76
erlsigg@online.no
erling.siggerud@siggeo.no

GEOPublishing AS;
Halfdan Carstens
+47 73 90 40 90/90 56 35 95
halfdan@geo.as

For informasjon og påmelding:
www.geoakkurat.no

SiggerudGeoServices SGS

GEO
GeoPublishing as

It's All About Data

Photo: Jane Whaley

"Our ability to accumulate and add value to data underpins our business," says Dr. Richard Fowler, Managing Director of Fugro Robertson, the North Wales based data and information company. He tells GeoExpro about recent developments in one of the oldest service companies in the UK oil industry.

Fugro Robertson is one of the world's leading geoscience companies, providing services and products to the upstream oil and gas industry. The Managing Director, Richard Fowler, has spent his entire working life with the company, having seen it through a few different names and aliases and a number of changes of ownership and structure. It is now part of the giant Dutch engineering and geotechnical group, Fugro, which Richard thinks is "the right home for Robertsons."

From new ventures to biosteering

"Our work is concentrated in two main fields" Richard explains "We undertake our traditional geoscience and technical work, and we also have the new Fugro Data Solutions business.

The established geoscience and engineering sides of Fugro Robertsons business covers everything from new ventures to asset valuation. "Tellus is our flagship product. It is a global exploration database which focuses down from region to basin and then to play, the final components being detailed play fairway maps," explains Richard.

"Another product is EOS (Exploration Opportunity Screening), where we use our extensive database to study selected countries each year, chosen by a 'club' of 10 companies. Interestingly, in the past these clients tended to be small independents, but as companies have divested themselves of their research groups we now have the majors involved."

Biostratigraphy and geochemical analysis is core to the business, but even they have changed a lot in the last 10 years. Richard says "Conventional well stratigraphy has declined recently, but 50% of our biostratigraphical revenue now comes from well biosteering, where zone biostratigraphy is used to keep a well within the right part of the reservoir. This has proved a very cost-effective way of steering horizontal production wells. For example, when a well crosses a fault, how do you know whether the reservoir has moved up or down? If you know the stratigraphy of the horizontal zones, it is easy to tell where you are in the reservoir. At the moment this technique requires two people working on a well, but we are looking into the feasibility of undertaking the analysis remotely using a downhole camera."

Richard Fowler is Managing Director of Fugro Robertson, the North Wales based data and information company, and has worked or the company for nearly 30 years.

New Directions and Intelligent Storage

In addition to the traditional geochemical and consultancy work, Fugro Robertson has branched off in new directions, adding value to existing data by a variety of means. An example of this is what Richard Fowler refers to as "intelligent storage".

The company consolidates, stores and catalogues the hard data archives for oil companies. When the client requires a particular dataset, Fugro Robertson rapidly finds, scans and digitises the data and creates a web portal, so the client can access everything it needs digitally. "Our first contract was with BG" says Richard. "56 large lorries full of data arrived here for us to sort out. And it wasn't just data; we found everything from dead plants to a gorilla suit in those boxes! We are using the high quality skills we hold in-house to understand this data, such as great web skills, cutting edge GIS, scanning and digitisation. This part of the business has been hugely successful. Ten years ago we had 5,000m^2 of storage space – next year we expect to have more that 200,000 m^2. Because we hold the data we are also able to offer additional value adding data services to our clients."

Richard goes on to explain their exciting new product, Merlin, which concentrates on source rock prediction. "This is a revolutionary product, in that source rocks are treated as sediments, rather than as a collection of geochemical features," he explains. "Understanding why a source rock is where it is and from that predicting where else it could be is crucial. You need to look for area of low or non exiastant tidal rip, high preoductivity and certain climate situations. We have incorporated client data with palaeoclimate data from the Meteorological Office and palaeotidal information from the Proudman Oceanographic Centre to identify climate patterns and areas of high productivity conducive to the formation of source rocks. It uses very complex algorithms and had to be run on the huge Met Office and Proudman computers. The output is an interactive series of paleoclimatological maps of the world through geological history, virtually on a month by month basis. This is serious 'blue sky research' undertaken in conjunction with a very select group of subscribers.

Most successful floatation ever

But why is a company working largely in the oil and gas sector based in North Wales, many miles from the centres of the industry like Aberdeen and London? "Robertson Research was founded by Frank? Robertson back in 1961 before the UK oil industry had even started." Richard Fowler explains. "Frank owned a shipping company which was involved in ferrying rock from the quarries along the North Wales coast. When the quarries fell on hard times, he was offered ownership of them. Knowing nothing about the business, he drafted in a top geologist from the University of Glasgow and established a non-profit making organisation, Robertson Research Company Limited, both to service the quarries and also undertake contract research in various geotechnical disciplines. This explains our existence here in this beautiful part of the country."

Then in 1972 the first well was drilled in the North Sea and Robertson Research expanded into the petroleum sector, which rapidly became core to the business. The company grew fast and in 1978 Richard Fowler, who hails from the Glasgow area originally, joined the geological

Photo: Jane Whaley

Robertson Research are based in North Wales close to the Snowdonia National Park. The mountains can be seen from their elegant Head Office in Llandudno.

team, having already been sponsored through his Ph.D. in Sedimentology in Aberdeen University by Robertsons. "It was perfect timing", says Richard. "First oil had just arrived from the North Sea and the Sedimentology Division – indeed the whole of Robertsons – enjoyed a huge growth curve in the early 80s. I became Manager of the Sedimentology Group in less than 2 years and built it up from 7 to about 25 people by 1986. All the big fields were coming on stream, and Robertson Research were the geological consultants for the major privatisations such as the formation of Britoil, and the creation of Enterprise Oil for the oil assets of British Gas. They were great, exciting times! We were doing jobs which Robertsons had never done before, and doing them well. On the back of that I became a Robertson Research International Director in 1986."

In fact, Robertson Research were doing so well that they floated on the London Stock Exchange in 1984. "At the time it was the most successful floatation ever! Richard laughs. "It was something like 167 times oversubscribed!"

Successful MBO

However, the floatation was followed in 1986 by the oil price crash and then in 1987 by the stock market crash. Robertsons responded to this by attempting to diversify out of the oil industry. "We looked at our talents and strengths and worked out what else we could do with them. For example, the drawing office moved into publishing and the labs started a successful business analysing engine oil. Four main divisions were set up, covering the fields of minerals and water, environmental analysis, agriculture and petroleum geoscience. We also moved into acquisition mode, and eventually bought 18 companies in as many months, mostly small UK consultancies."

"Of course, if you try to merge lots of small consultancies together, you inevitably end up trying to force lots of different personalities to make a coherent company – a very difficult task!" as Richard points out. "By 1991 the share price was moribund and the company was sold to Simon Engineering, a Stockport based company which was keen to establish itself in the environmental and oil and gas industries."

Simon made a few changes, including losing the long established Robertson name, but it ultimately proved to be an unsuccessful venture and eventually Richard and the management staged a successful MBO for £12.5 million in 1996. The revamped company, reverting to the name of Robertson, proved much more successful, paying off the debt in less than 3 years. By 2001 the company was up for sale again, and was snapped up by the giant Fugro Group for £63 million. Richard was the only one of the original MBO team who decided to stay with the company because "(Richard - could you supply me with a sentence here?)

Fugro Robertson is now the biggest private sector employer in North Wales, with over 300 staff. It has offices around the world, including Houston, India, the Middle East, Indonesia and Australia, often using the Fugro worldwide offices as a jumping off point.

Innovation in the service sector

Richard Fowler has some interesting thoughts on the relationship between the oil companies and the service industries. "Oil companies are very keen on good value from the service companies, and can sometimes tend to squeeze maybe a bit too hard. This can push risk down the value chain and potentially create a few problems. I think that, although they don't realise it, a significant portion of the success of oil companies is actually due to the fact that the service sector is fleet of foot and innovative and are also prepared to take risks themselves."

Although Robertson has changed its name and undergone various metamorphoses over the past nearly 50 years, Richard thinks that one thing remains unchanged. "Data differentiates and underpins our business," he says." The ability to accumulate data and add value to it, with copyright and brokerage rights, is fundamental to our success. Never underestimate the value of data."

What broadband did for the internet, MEPO does for reservoir simulation.

The solution for Reservoir Engineers who want to use their knowledge, not tweak parameters.

- *Fast*
- *Auditable*
- *Better History Match*
- *New user-friendly GUI*
- *Uses your existing simulator and hardware*

Complete integrated solution for:
- *Sensitivity studies*
- *Assisted History Matching*
- *Production Forecasting*
- *Quantification of Model Uncertainty*

be dynamic

mepo@scandpowerpt.com
www.scandpowerpt.com

scandpower

Stay Informed

Get to know the industry you are involved in!

Go to www.geoexpro.com
and click on SUBSCRIBE

TERNAN

Regional Play Fairway Evaluation - the key to reducing exploration risk

Reports Available:
- UKCS Central North Sea
- UKCS Northern North Sea
- Norwegian North Sea

Coming in 2006:
- Northeast Atlantic Margin studies

North Sea Reports
- Consistent stratigraphic framework
- Analysis of over 20 plays
- Maps of reservoir, topseal and hydrocarbon charge
- Additional maps illustrating subcrop, supercrop, overpressure, etc, where relevant
- Digital stratigraphic well database

TALISMAN ENERGY

T: +44 (0)1330 825188
E: kholdoway@ternan.com | www.ternan.com

Mesopotamia – the Cradle of Civilization

Several thousand years ago, between the rivers Euphrates and Tigris, the rich and fertile soil of Mesopotamia gave birth to civilization. Today, deeply buried oil and gas reservoirs provide Mesopotamia with energy resources that are seen by many to be the cause of geopolitical conflicts and simultaneously fuel and threaten our civilization.

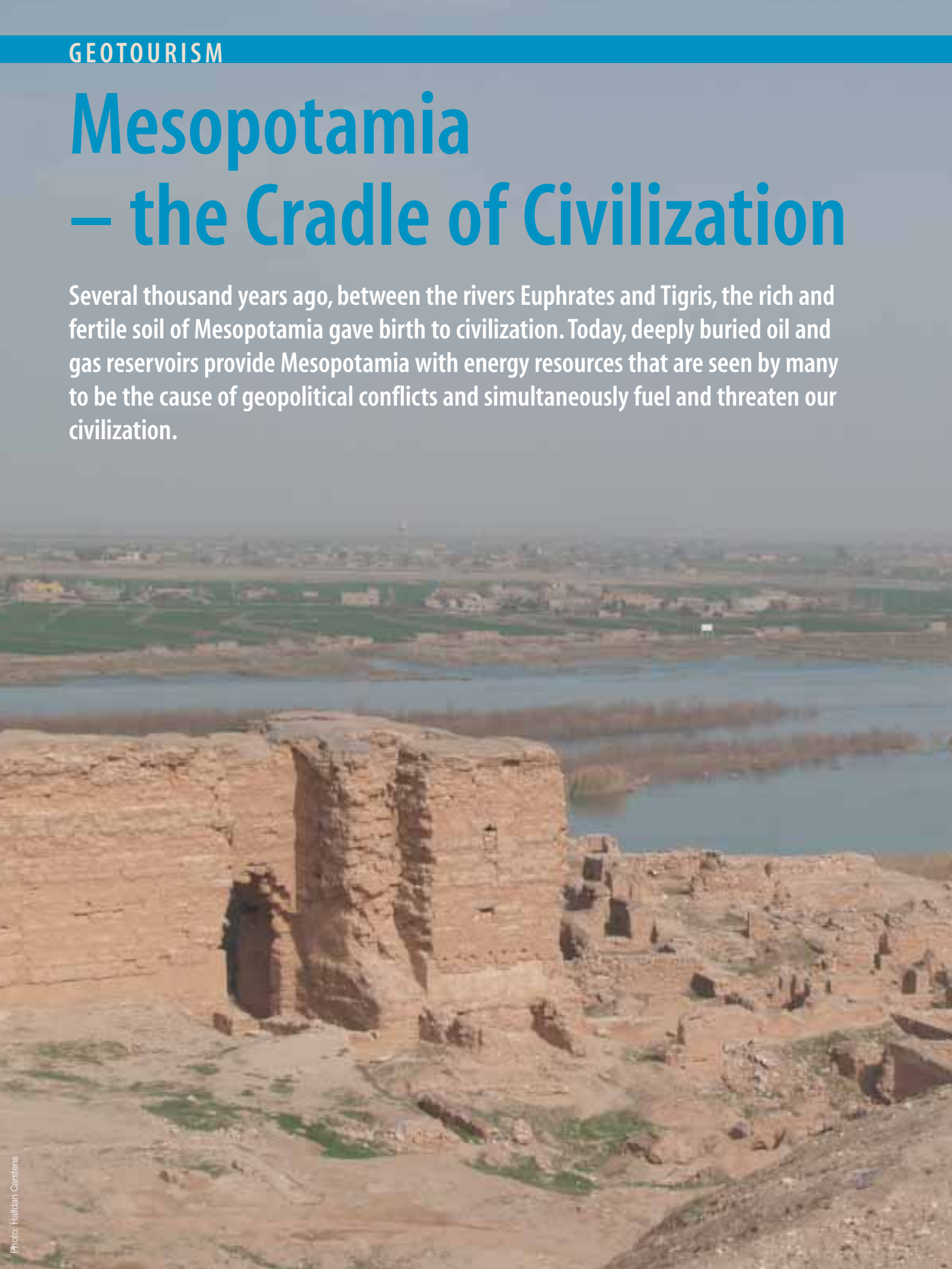


Photo: Halfdan Carstens

Mesopotamia is a Greek word meaning 'between the rivers'. Mesopotamia is the alluvial plain lying between the rivers Tigris and Euphrates that both rise in Turkey and pass through Syria and Iraq. In southeastern Iraq they become one river – Shatt al Arab – that empties into the Persian (Arabian) Gulf. More commonly, the term Mesopotamia includes these river plains in totality as well as the surrounding lowland territories bounded by the Syrian Desert to the west, the Arabian Desert to the south and the Zagros Mountains to the east. Northern Mesopotamia is made up of hills and plains. The land is fertile due to seasonal rains and the rivers and streams flowing from the mountains. Early settlers farmed the land and used timber, metals and stone from the mountains nearby. Southern Mesopotamia is made up of marshy areas and wide, flat, barren plains. The rivers were used for transport, but were also the means by which the people of Mesopotamia could live and develop cities, as they provided water to drink and to irrigate the surrounding land. Once the land was irrigated, it could produce crops and other foods for the people to eat.

The barren desert stands in strong contrast to the green areas surrounding the river.

The Euphrates is the largest, the longest, and by far the most important of the rivers of the Middle East. Along with the Tigris, it provided much of the water that supported the development of ancient Mesopotamian culture. The melting of the snows in the Armenian highlands in the month of May causes the annual inundation. The entire course is almost 2800 km and the watershed area is more than 750,000 km^2. The Euphrates is linked with the most important events in ancient history. The city of Ur, found at its mouth, was the birthplace of Abraham (an important person in Judaism, Christianity as well as in Islam), and on its banks stood the city of Babylon. The river Euphrates is, along with Tigris, two of the four rivers that flow from the Garden of Eden (the place where the first man and woman (Adam and Eve) lived after they were created by God) according to Genesis.

Halfdan Carstens

The rich and fertile soil along the Euphrates is in sharp contrast to the dry and desolate sands of the Syrian Desert that covers a large part of Syria, Jordan, Iraq and Saudi Arabia. Long before the unbearable heat of summer, when temperatures may reach 55 °C, occasional spring rain showers give the ground a bleak, greenish colour proving that there is a little nourishment for a few sheep and camels. Bedouins roam the desert as they have done for thousands of years. Landrovers and huge trucks dominate the paved road on their way to and from oil fields on the east bank of the Euphrates River.

A Safe Place to Visit

While Iraq continues in a state of civil unrest, Syria can be considered and excellent alternate destination to provide tourists a glimpse of Mesopotamia. In fact, it should not be regarded as a alternate at all. Syria in itself is a very attractive destination in its own right, due to its friendly people, ease of travelling and precious archaeological sites that are not overwhelmed by flocks of busy tourists on their way to the next attraction.

In a matter of few days you can easily combine the hectic Al-Hamidyeh souq in the capital Damascus (that claims to be the oldest site of continuous settlement in the world), the spectacular ruins in Palmyra (where you are free to wander around the bulk of the remains at any time) and colourful shopping in small, picturesque villages along the banks of the Euphrates River. Travelling south on the east side of the river - towards the border to Iraq - you can also spot drilling rigs and production facilities belonging to Total and the Al Furat Petroleum Company.

Most importantly, you will find the Syrian people very friendly, from the shepherd guarding his herd of camels in the desert to the owner of the grocery store who invites you to a cup of tea after having purchased spices at bargain prices. For travellers used to protecting their belongings from pickpockets, it is also a relief to know that in Syrian, even in Damascus, petty crime is far less of a problem than in major European cities.

You just feel very safe and comfortable as a tourist in Syria. Having spent one week travelling around, it is my experience that the Syrians are all courteous and welcoming to foreign visitors. The country's

Near Mari, along the Euphrates.

It is Friday, and the entire family including 3 generations has a picnic by the ruins. For geoturists it is interesting to learn that these buildings are built out of gypsum (calcium sulphate dihydrate, CaSO4.2H2O).

It is flat, and it is barren. It is hard to believe that it is possible for the camels to graze in the middle of what we would call a desert. For the Bedouins however, this is a steppe which is used for food in springtime.

appeal as a destination is enforced by the fact that it played a pivotal role in the early history of both Christianity and Islam.

The Cradle of Civilization

Civilization developed in Mesopotamia simultaneously with Egypt in a region called the 'Fertile Crescent', a rich food-growing area in a part of the world where most of the land is too dry for farming. Mesopotamia was the alluvial plain lying between the Tigris and Euphrates rivers, composing parts of Iraq and Syria, and this is where we find some of the best farmland.

Writings from Mesopotamia are among the earliest known in the world, giving Mesopotamia a reputation of being the Cradle of Civilization. It is said that Mesopotamia was the place of the legendary Garden of Eden. On the spot where the Tigris meets the Euphrates, the holy tree of Adam emerged symbolizing the Tree of Life in the Garden of Eden.

The Paleolithic period in the Near East stretches back about 1.5 million years. In Syria the oldest evidence of human activity in the form of crude stone tools is 700,000 years old. Some 60,000 years ago the Neanderthal also learned to make fire using stone implements.

In the Paleolithic period, humans lived by hunting and gathering. This type of economy required a large degree of mobility, as the supply of food in any place was limited. The river plains were well suited for this because throughout millions of years, the rivers have laid down thick deposits of fertile silt.

At the end of the last ice age, 15,000 years ago, a development began which led to the living conditions we know today.

In the 10th millennium B.C., humans began to lay in stores of food and provisions – a development that led to decisive changes in the way of life, socially as well as economically. It enabled him to stay in one place and survive the winter. He became settled. In the course of the 9th to the 7th millennium B.C., food production techniques evolved; in this case including the cultivation of crops and domestication of goats and sheep.

Climate Change

The development of agriculture meant that a settled lifestyle became well established. At first, people settled in individual units which only slowly emerged to form villages. The production of food meant that

When visiting one of the archaeological sites northwest of Dayr as war, I spotted a drilling rig far into the desert. I decided to venture in that direction and reached the rig after a long, pleasant walk amidst sand and sheep. The rig was drilling for the Syrian Petroleum Company (SPC) and had reached a depth of 2452m. Taken by surprise by this strange tourist with some basic knowledge of drilling and geology, I was welcomed to have a tour of the site. Afterwards I was invited to tea with the drilling supervisor and the tool pusher in the supervisor's office, for them apparently a welcome break in the daily routine of drilling wells. The well site geologist was, regrettably, asleep after a long night describing rock fragments within the reservoir section. Although I was not impressed by the technical standard of the operations, their hospitality was unsurpassed.

humans began to interfere with the balance of nature. Land was cleared and cultivated, and the growing herds of domesticated animals overgrazed the naturally prolific grass plains. Human reshaping of the natural environment – still continuing to this day – had begun.

A society based on a pronounced degree of agriculture and livestock can be found for the first time in the 7th millennium B.C. Supplies of food and a settled way of life were guarantied to such an extent that specialization in craftsmanship became possible. The use of particular raw materials such as obsidian (volcanic glass) and turquoise (now possibly the most valuable, non-transparent mineral in the jewellery trade) provides evidence of long distance trade at this early point in time.

The climate became so arid at the end of the 7th millennium B.C. (yes, they also had to struggle with climate change) that most settlements in the steppes were abandoned. People thus settled along the main rivers and the coastal regions further west (The Mediterranean). Sophisticated eating habits and methods of storage encouraged the introduction of ceramic pottery, and from then on, pottery – as we know from numerous museums – became the cultural index fossil.

Farmers and fishermen probably started to settle the Mesopotamian plain around 5,500 B.C. Over time, their small villages grew into large settlements. Agriculture and livestock farming formed the economic basis of society. Evidence has been found in irrigation farming.

At the end of the Early Bronze Age (ca. 3500-2000 B.C.), a development that can best be described as urbanization became established.

Good for Science

Syria remains one of the least-visited countries in the world. For geoturists and geoscientists wanting to explore the sprawling cities, high mountains, barren deserts, coastal plains, fertile riverbanks or the numerous archaeological sites, this is of course good news, as there is no problem getting around and find decent hotels at budget prices. Being an ordinary tourist can easily be combined with small geological excursions to extrusive basalt formations and outcops of sedimentary rocks that are all well exposed. The old ruins are themselves geological targets as they are built out of a variety of rocks.

Photo: Halfdan Carstens

In the middle of the Syrian Desert we find Palmyra, probably the most beautiful and magnificent of the Syrian historic sites. This Arab commercial metropolis used to be on the old Silk Road, a trade route linking the East Asian empires of Persia, India and China.

Photo: Halfdan Carstens

The Omayad Mosque is located in the heart of the Damascus at the end of Al-Hamidyeh market. Built in 705 A.D. when Damascus was the capital of the Arab Islamic state.

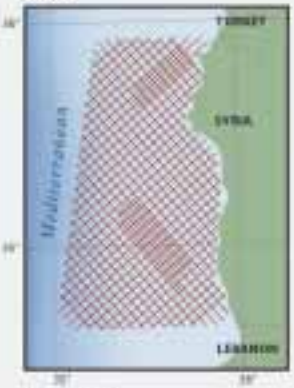
Photo: Halfdan Carstens

Oil is being piped through the desert, from the old civilization in Mesopotamia to the new "civilization" in Europe.

inseis

Offshore Syria and Colombia Multi Client 2D Seismic Surveys

SYRIA



Regional 2D survey
- Survey size: 5,000 km
- Streamer offset: 7,000 m

Data available

COLOMBIA - PACIFIC AREA

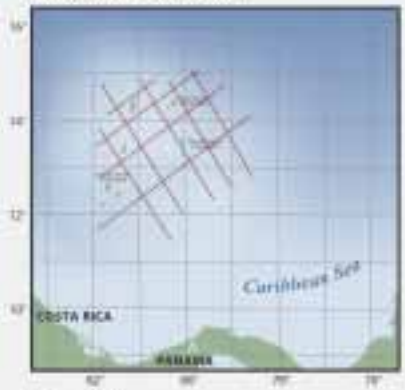
Regional 2D survey
- Survey size: 3,863 km
- Streamer offset: 10,050 m

Data available: End April -06

Semi Detailed 2D survey
- Survey size: 4,251 km
- Streamer offset: 8,100 m

Data available: End May -06

COLOMBIA - CAYOS AREA



Regional 2D survey
- Survey size: 2,990 km
- Streamer offset: 10,050 m

Data available: Mid June -06

Norway Office:	Jan B. Gateman	phone: +47 67 82 84 08	mobile: +47 95 06 37 58	e-mail: jan.gateman@inseis.com
	Steinar G. Karlsen	phone: +47 67 82 84 10	mobile: +47 91 31 67 69	e-mail: steinar.karlsen@inseis.com
Colombia Office:	Edgar Baquero	phone: +57 1 620 8865	mobile: +57 300 212 9417	e-mail: edgar.baquero@inseis.com

www.inseis.com

Meet us at AAPG, booth no 963 & EAGE, booth no 850

apt
Applied Petroleum Technology
www.aptec.no

SERVICES:
- Petroleum Geochemistry
- Biostratigraphy
- Sedimentology
- Structural Geology
- Bio steering offshore
- Hydrocarbon core & cuttings scanner
- Organic Petrology
- Fluid Inclusions
- Inorganic Geochemistry
- Water (Geo)chemistry
- Production Monitoring

APT is a commercial company offering high quality analyses and consultancy services to the oil industry.

APT draws on more than 25 staff and associates of dedicated and highly experienced technicians and professionals.

Address: APT AS, P. O. Box 123, 2027 Kjeller, Norway • Tel +47 63 80 60 00 • Fax +47 63 80 11 38
Contact information: Nigel Mills • E-mail nm@aptec.no • Tel +47 63 80 64 51 • Mob +47 93 49 70 38

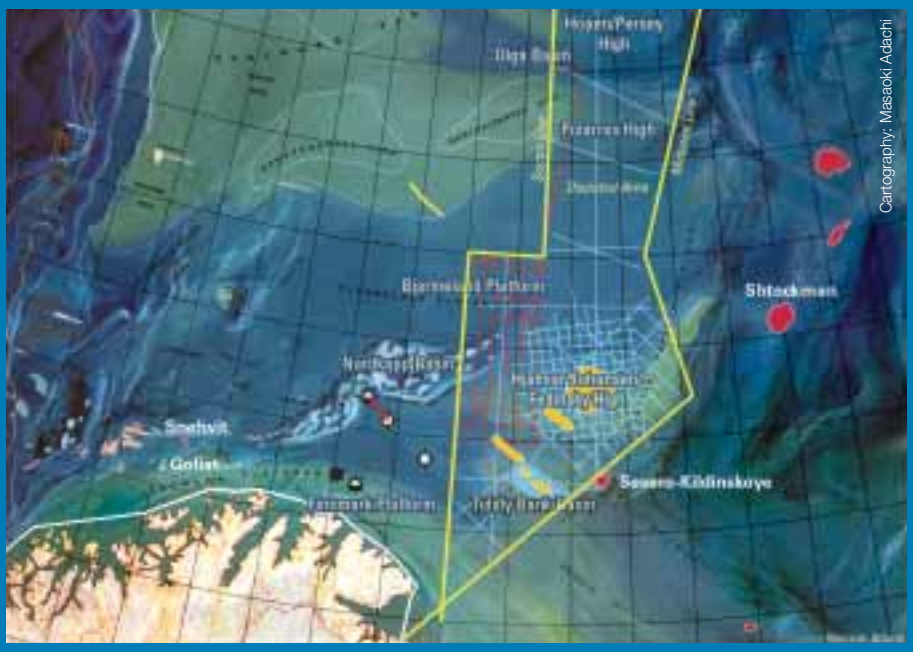
Barents Sea "Nondiscussed" Area

The disputed area between Norway and Russia in the Barents Sea, equalling the Norwegian North Sea in size, has a different petroleum system than the proven oil and gas provinces to the west and east. With pre-Jurassic source rocks, the most obvious targets are in Triassic clastics and Paleozoic carbonates.

Nils Ræstad, Sagex

An open and free discussion based on factual knowledge is a cornerstone of scientific understanding. However, sometimes facts can obstruct progress, especially in politics. For the last 30 years the Norwegian geoscientists have largely kept silent regarding the geology of the disputed Barents Sea area, so as not to interfere in the boundary negotiations that the Norwegian Foreign Department has been conducting on and off with the Russians. This lack of factual knowledge in this area has left the field open to speculation and journalistic sensationalism with regards to its potential for oil and gas production.

A disputed area the size of the Norwegian North Sea with large identifiable structures not too far from several giant gas fields naturally creates curiosity and speculation (Geo ExPro No 1/2005). What do the current data actually tell us about the petroleum geology and prospectivity? The Russians collected geological and geophysical data into the early 1990s in the disputed area and are regular publishers in scientific journals. On the Norwegian side the Norwegian Petroleum Directorate (NPD) has only published titbits of information on their website, and the major oil companies operating in the region are keeping quiet.



The disputed area is limited to the east by the Norwegian claim along the midpoint line. The Russians argue for a sector line division that the Soviet Union unilaterally claimed already in 1926. In the current negotiations a compromise agreement has reportedly now been reached on the northern part of the border, but there is as yet no agreement on the southern potentially most prospective part of the area. Prospects identified by the Russians are shown in yellow. Proven gas fields (red) and oil fields (green) outside the disputed area are also shown. 2D Seismic lines acquired by the Russians are shown in blue and by the Norwegians in red.

Structural outline

The main structural elements in the disputed area are from south to north: the Finnmark Platform, the Tiddly Bank Basin, the Hjalmar Johansen (Fedinsky High), the Nordkapp Basin, the Bjarmeland Platform, the Central Bank High and the Hopen/Persey High. To the east lie the hydrocarbon prolific South and North Barents basins, while to the west the Hammerfest Basin has finally proven its commerciality (GEO ExPro No 1, 2006).

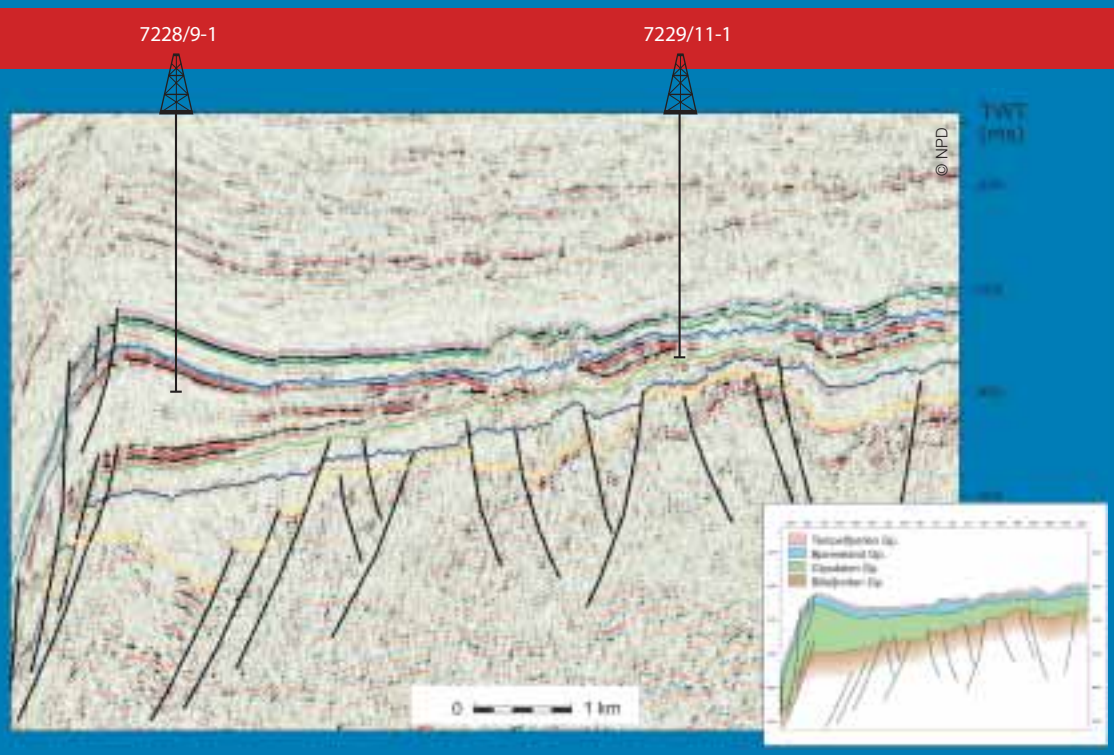
However, it is misleading to postulate that huge Russian gas discoveries in the Jurassic to the east can be duplicated in the disputed area based on its proximity. The reason is the presence of a marked transition from the Jurassic aged gas fields in the Barents basins up on to the platforms where the Jurassic aged sediment cover is thin and lying at a shallow depth.

Paleozoic and Mesozoic aged rocks subcrop below the Quaternary in the disputed area with no Tertiary aged sediments present. In the Nordkapp and Tiddly Bank basins, Triassic sands trapped against salt pillows are the main prospects. Triassic fluvial sands trapped against salt have been found to be gas bearing in the Pandora discovery in the southern Nordkapp basin. Statoil is currently testing this play model, with a second well in the basin.

Triassic potential

Triassic aged clastics are the most obvious Mesozoic target for hydrocarbon exploration on the platforms. Triassic fluvial sands have been found to be gas-bearing in the Severo Kildinskaya field close to the disputed area. The sands are reported to have reasonable porosity and relatively low permeability, but net to gross ratio and thus connectivity is a key parameter.

In the Norwegian sector, amplitude mapping on 3D seismic data have been successful in establishing Triassic clastic fairways. However, the key well drilled by Statoil last summer on the Finnmark Platform close to the disputed area, targeting a huge stratigraphic trap, was abandoned as a dry well probably because of lack of a good migra-



2D seismic line through wells 7228/9-1 targeting Triassic sands above a salt pillow on the southeast rim of the Nordkapp Basin and 7229/11-1 targeting Paleozoic carbonates on the Finnmark Platform; thus illustrating similar prospects to that will be targeted in the disputed area. Reservoir development and migration pathways hopefully will improve closer to the flanks of the South Barents Basin.
Ref: G.B. Larssen et al; Upper Palaeozoic Lithostratigraphy of the Southern Norwegian Barents Sea, Norwegian Petroleum Directorate, 2002.

tion pathway and/or poor seal.

With ample mature source rock and shorter migration pathways from the South Barents Basin up on to the platform margins in the disputed area, careful exploration with state of the art technology could result in more attractive Triassic gas prospects being discovered than those encountered so far.

Paleozoic potential

In the Paleozoic, the most attractive prospects are shallow water platform carbonates of Permian and Carboniferous age. Four wells have tested carbonate prospects on the Finnmark Platform east of the Nordkapp Basin. With one minor non-commercial oil and gas discovery, two wells with oil shows and one dry well, some of the play models are confirmed, but to date success has been limited. Reservoir development is primarily related to dissolution during subaerial exposure, or re-deposition of bioherm build-ups.

The Paleozoic oil discovery was made in a reservoir rock composed of Upper Permian spiculites, a very unusual reservoir rock type made up of silica sponge spicules that have a very limited areal potential, being easily transformed to chert during diagenesis.

The Permo-Carboniferous build-ups constitute prolific reservoirs in the Pechora Basin far to the east, and together with the Triassic clastics represent the main potential reservoir horizons in the disputed area. The Russians have pointed out numerous seismic anomalies that could be related to both Triassic sands and Permo-Carboniferous bioherm build-ups. More extensive and better quality seismic data are required in order to properly evaluate the reservoir potential.

Pre-Jurassic source

With respect to source rock, the prolific Jurassic Hekkingen Formation has barely reached maturity in the South Barents Basin to the east. However, shales in the Upper Permian Tempelfjorden Group are in the oil window along the platform margin and on the Hjalmar Johansen/Fedinsky High and are gas-prone in the deeper northern parts of the disputed area.

The recently discovered deeper oil bearing formations in the Goliat oil field to the west are important evidence for the presence of a pre-Jurassic source rock of probable Middle Triassic age.

A main problem on the Barents Shelf is the Cenozoic deep erosion that has breached earlier oil reservoirs either by fault-induced leakage or by gas expansion due to uplift. Erosion has been in the order of 1000-2000 metres in the disputed area, and is a negative factor in the prospectivity evaluation.

From a structural point of view, the Hjalmar Johansen (Fedinsky High) is a huge basement induced uplift some 130 km in diameter. The Russians have indicated and named five potential prospects in the vicinity of the high. The deepest targets in the Paleozoic are within acceptable depths for reservoir preservation. This high and the eastern end of the Nordkapp Basin are potentially the two most attractive areas for future exploration. Mapping over this structure has been based on a fairly dense seismic grid.

In conclusion, the sparse data collected so far indicate that factors necessary for hydrocarbon generation, migration and preservation are in place within the disputed area. Structures forming large potential traps have been identified. However, drilling must be used to assess the quality of the source and reservoir rocks, thereby confirming the commerciality of a discovery.

No need to rush

Negotiations to fix the offshore boundary between Russia and Norway have been ongoing for over 30 years. Oil companies are encouraging the Norwegian Government to resolve the dispute quickly, so that it would not be a potential obstacle in negotiations for Russian Barents Sea licenses.

However, with the huge areas of unexplored and undisputed territory available in the Arctic on both sides of the disputed area, there should be no need to rush for an agreement. With the ongoing Russian research and publishing of data in the disputed area, the Norwegian geoscientists should be equally active in pointing out to the Norwegian public the potential values that may be negotiated away if the desire to reach an agreement quickly takes precedence.[1]

[1] *This article is based on a multi-client report that Sagex (www.sagex.no) has generated on the petroleum geology of the Central Barents Sea.*

Contributing to a Greater Good

Dr. Lee T. Billingsley is presently President-Elect, and from July 1 he will be President of AAPG for one year. We have talked with Dr. Billingsley about his views on the petroleum industry and his visions for AAPG, an organisation that "gives a possibility to give back".

Being Vice-President of Exploration in an independent oil-company, and knowing all too well that this takes a lot of work, why did you agree to stand for election as President of AAPG?

First, Abraxas generously supported my request to run for the office, and they have continued their encouragement after my election. Second, AAPG affords me the opportunity to fulfil a basic human need, that of contributing to a greater good. In my short time as President I will strive to improve the careers of petroleum and related geologists by utilizing the resources of AAPG. Everyone that volunteers his or her time for an organization like AAPG gets rewarded by some degree of internal satisfaction. It seems that the more you give, the more you get. I really enjoy the resulting friendships with other professional volunteers and AAPG's staff.

How did you get involved in AAPG?

As a young professional I began by helping with logistics and the technical program of AAPG conventions. Also, I served in the House of Delegates and participated in committees. I learned about management of the organization when I served as Treasurer in the mid 1990s. Serving as President reminds me of a long-distance bicycle ride with a group of riders in a pace line. Each rider takes a turn as leader to make the way easier for the others. So I decided to take my turn.

With 30,000 members to keep satisfied, and several more geoscientists that ought to be members, what is your ambition for AAPG?

AAPG must continue to execute on it strengths of services and products, namely conventions, meetings, publications, Explorer magazine, and continuing education. But we need to improve the communication of our services and products to both existing members and prospective ones. Some of our existing members are not aware of AAPG's digital library, and all the resources available to them. The world's energy needs will demand more professional petroleum geologists, and AAPG needs to both encourage more students to enter the career field and inspire existing geology students to become petroleum geologists.

You have not been afraid of expressing your opinion about CO_2 and the environment. Can you elaborate upon your opinions?

From a long-term geological point of view we know that climate has been changing, not only through centuries, but also through millions of years, proving that The Earth is a dynamic system, even without human influence. In recent times human activities related to burning fossil fuels may be increasing CO_2 levels in the atmosphere. Models predict that the projected rise in CO_2 levels will cause Earth's climate to change. The uncertainty lies in the magnitude of the effect of man's activity. Since fossil fuels are the most cost efficient form of energy, restricting their use through government controls or taxation will have an economic cost. The increased cost is like an insurance premium that will be paid today in hopes of mitigating an as yet undetermined climate change in the future.

How do we then go about this problem?

As cost-effective precautions, we can utilize technology to reduce CO2 emissions by both conservation and capture. If allowed to operate, market forces will eventually reduce fossil fuel use, and alternative sources of energy will become cost effective. No matter which course of action the global community takes on CO2 emission reduction, I believe that cycles of climate change will continue. It is important that we continue to study and model climate change, so we are better equipped to put our scientific resources into **adapting** to the changes. Policies and resources focused on **adaptation** will have a more predictable outcome than policies based solely on uncertain **prevention**.

Photo: Joanne Billingsley

Dr. Lee T. Billingsley is presently Vice President of exploration of Abraxas Petroleum Corporation, an independent oil and gas exploration and production company. The San Antonio based company is listed on the American Stock Exchange (AMEX) and has operations in Texas and Wyoming. With a BSc in geology from Texas A&M, a MSc in geology from Colorado School of Mines, a PhD from Texas A&M, and 30 years practicing as petroleum geologist, Lee has a solid background as a petroleum geoscientist. Through a career long involvement with AAPG he is also very well qualified to serve as President of the world's largest organization of petroleum geologists.

Getting back to the business we are working in, why should young people study geoscience and get involved in the petroleum industry?

Petroleum geoscience is critical to supply the increasing world energy demand. All projections show that we will still need fossil fuels as our primary energy source in the middle of this century. Renewable energy can supplement fossil fuels, but it is not going to replace them. Petroleum geoscience is a very rewarding career, and I would like young people today to have the same opportunity for a fun, fulfilling career.

Does the negative pr around CO_2-emissions and the peak-oil debate concern you?

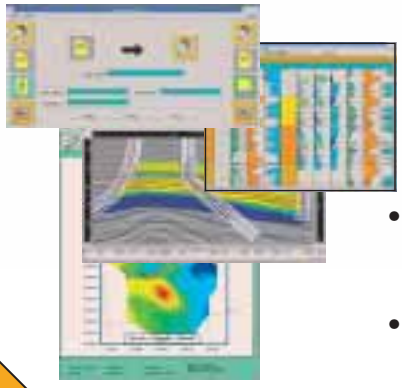
Yes, I get concerned because of the negative implications it may have on young people trying to decide on a career in petroleum geoscience. Geoscientists are basically conservationists, and we do not like to see consumers wasting our products. Humans will always need affordable energy, despite restrictions that some may view as necessary to save the planet. Geoscientists will make a difference in supplying growing energy demand.

Tigress

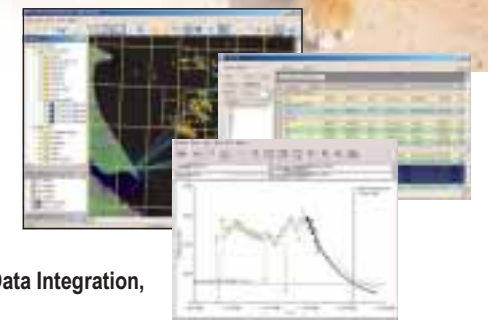
Integrated by design

About us | Products | Services

Asset Management made simple by Tigress ...



- Create a new project database in minutes
- Set project parameters, access and security
- Bulk load and QC data using the Tigress Import/Export System (TIES)
- QC, reformat and interpret your data using Tigress Geoscience and Reservoir Engineering tools
- Manage asset data with the Tigress front end GIS system – GeoBrowse
- Get regular updates on the asset using Reporting tools

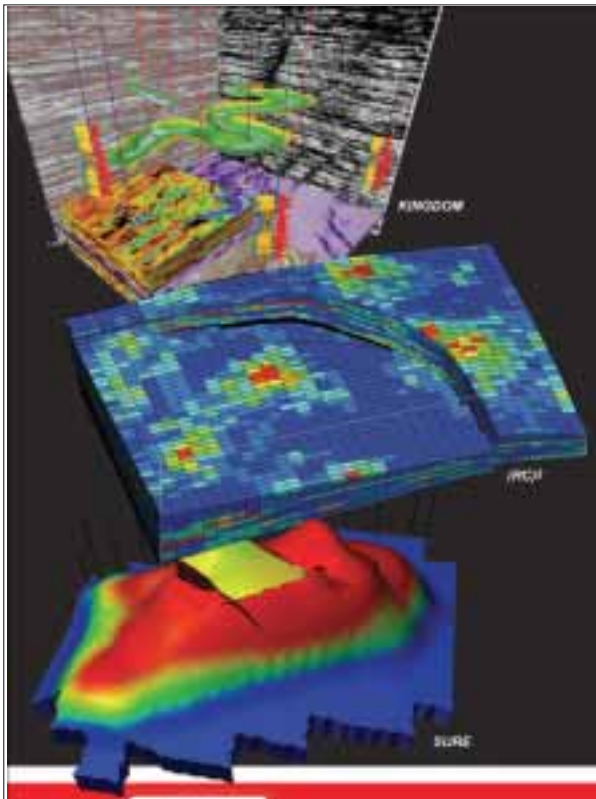


Tigress 5.0 Available Now

Come see us at the 10th International Conference on Petroleum Data Integration, eCommerce and Management, 19-21 April, 2006, Houston, Texas

Anglers Court, 33-44 Spittal Street, Marlow, Buckinghamshire, SL7 1DB, UK ~ Tel: +44 (0)1628 402400

www.tigress.co.uk



Seismic Micro-Technology, Inc.

KINGDOM Software • (RC)² Software • SURE Software

SMT provides tools for a complete upstream workflow on the Windows® platform from seismic through simulation. **KINGDOM** software is an integrated package that includes everything necessary for day-to-day geoscience interpretation in addition to advanced tools for analysis of seismic attributes, AVO anomalies, petrophysical characteristics and more. **(RC)²** is a reservoir modeling tool, which accurately handles complexly faulted reservoirs and a wide variety of depositional environments. **SURE** is an advanced reservoir simulator used for solving both black-oil and compositional problems. SURE utilizes PEBI™ gridding for improved accuracy and efficiency of simulation runs.

Please visit www.seismicmicro.com for more information about SMT software or call for an evaluation of KINGDOM, (RC)² or SURE.

www.seismicmicro.com | Houston +1 713 464 6188 | Europe: +44 (0)20 8240 6524

SMT

E&P BASED. Software FOCUSED.

© 2005 All Rights Reserved. Seismic Micro-Technology, Inc.

Syriana – a film about the truth?

Group chief executive John Brown of BP did not exactly fancy the film Syriana.

"It was a fine film, with great acting and lots of drama and excitement," he started out in his keynote speech at the Energy Institute in London in mid February. "It has lots of Oscar nominations, but perhaps, how shall I put this? ... Not a nomination for absolute truth," he continued.

John Brown gives us a synopsis: "Syriana is a film about the oil industry. About a big company which seems to be short of reserves and which, to acquire new reserves, tries to engineer a coup in an oil-rich state somewhere in the Middle East. To cut a short story short, there are a lot of guns and missiles, and a lot of people get killed."

"I'd always thought life in BP was pretty exciting. But I never quite realised what I was missing," he says comically. However, his worry is that although "Syriana might be entertaining fiction but it will, of course, shape what some people think about the oil industry."

"What are they thinking? They're thinking that it's running out. It's running out... and ninety percent of what's left is in the Middle East.

I did not exactly fancy the film either. But that was for a different reason. The intrigue takes place against the backdrop of an oil-producing country in the Middle East, where a young apparent heir to the throne is seeking to change established relationships with U.S. business interests. Sounds simple, but it soon gets very complicated, with a good mixture of royal highnesses, CIA representatives, law firms, oil company executives, terrorists, corruption - and all the rest that is needed for a political thriller, and that's a lot.

"You want to know what the business world thinks of you? We think a hundred years ago you were living out here in tents in the desert chopping each others heads off, and that's exactly where you're gonna be in another hundred.

On the positive side, we are reminded that it is a tough world out there. We get a crash-course on how to recruit terrorists; we are shown how precious oil-income to the Gulf countries are wasted on luxury, we get a small lesson in how the oil reserves in this region dwindle, and, in particular, we are introduced to political conspiracy, even if not everything is true.

We need to learn more about what is going on in the Middle East. Because it is the oil reserves of this region we rely on in the years to come.

Halfdan Carstens

Photo: Halfdan Carstens

Syriana to a large part takes place in the oil-rich Middle East. Even if we agree with John Brown of BP, that the film does not portray the "absolute truth", there is still a lot to learn about a region that most of us have limited knowledge of.

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.

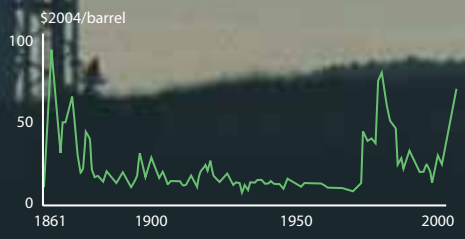
Numbers
Million = 1 x 10^6
Billion = 1 x 10^9
Trillion = 1 x 10^{12}

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

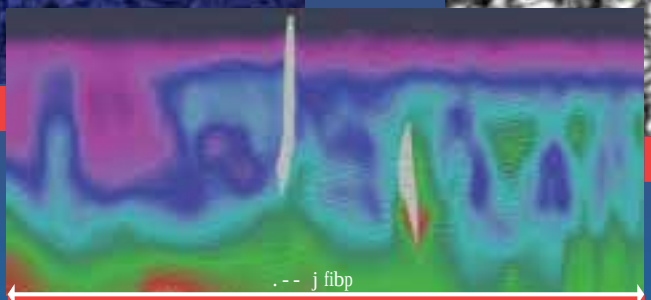
Major field
Recoverable reserves > 100 million barrels (16 million Sm^3) of oil equivalents

Historic oil price

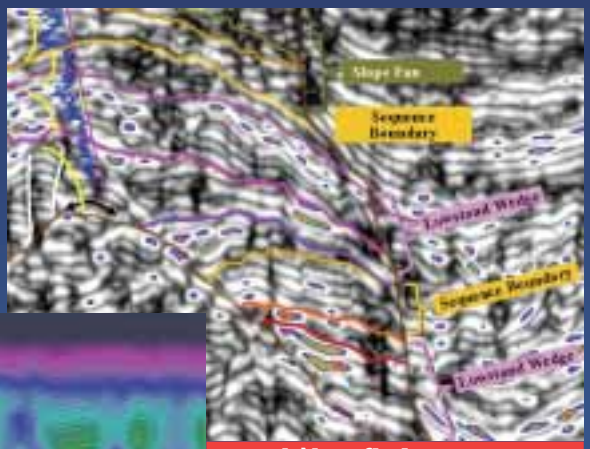


Grpq t e l *fp* C^focfbia<

>`nrfpfqflk



J riqf`ifbkq Pbfp j f` A^q^*



Mol`bppfkd

WO--- Klab Pvpqb j Qeb i^qbpq ^ka j lpq ^as^k`ba pbfp j f` pvpqb j lc fqp hfka ¬ qeb WO--- Klab Pvpqb j ^`nrfobp a^q^ ql O--- j bqbop lc t^qbo abmqe+

Mobpq^`h Abmqe J fdo^qflk Qefp .--* j fib `olppifkb fp ^k buqo^`qflk col j C^focfbia¥p j riqf*`ifbkq a^q^_^pb+ Qeb `lilo sbil`fqv lsboi^v ab j lkpqo^qbp qeb `l j mibufqv lc qeb dblildv ^ka qeb kbba clo mobpq^`h abmqe j fdo^qflk+

PMF@B Pbfp j f` a^q^ mol`bppfkd _v bumbofbk`ba molcbp* pflk^ip fp ^s^fi^_ib t loia* t fab+ C^focfbia¥p kb t PMF@B qb`eklildv pel tp `ofqf`^i pqor`qro^i^ka pqo^qf* do^mef` abq^fi buqo^`qba col j qeb pbfp j f` t^sbibq+

C^focfbia fp qeb obpl ro`b* vlr `^k abmbka lk clo rmpqob^j bumilo^qflk) clo ^`nrfpfqflk ^ka mol`bppfkd lc molmofbq^ov ^ka j riqf`ifbkq a^q^+ Clo O- vb^op C^focfbia¥p pbfp j f` hkl t ibadb ^ka rkabopq^kafkd e^p _olrdeq j ^glo ^as^k`bp ql qeb pbfp j f` fkarpqov+

C>FOCFBIA
FKARPQOFBP

Elrpqlk %.&/5.*/42*42--
Kbt Loib^kp %.&2-1*2/2*31--
Abksbo %.&0-0*4.3*.30-

G^h^oq^ %3/&/.*2/63*1232
El @ef Jfke @fqv %51&5*223*3.0-
t t t+c^focfbia+`lj

It is time to spread our wings

SeaBird Exploration Norway AS
Nedre Vollgate 3, P.O. Box 1302 Vika, 0112 Oslo, Norway
Tel: +47 2240 2700. Fax: +47 2240 2701

SeaBird Exploration FZ LLC
Dubai Internet City, P.O.Box 500549, Dubai U.A.E
Tel: +971 4 39 11 670. Fax : +971 4 39 08 785

SeaBird Exploration

www.sbexp.com