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the Games



THE INTERNATIONAL MAGAZINE OF THE BP GROUP

ISSUE 3 2012

BP MAGAZINE



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MAKING HEADWAY

BP Magazine reports on the company's continuing programme to reduce risk in its drilling operations around the world.

Welcome. Occasionally, when you wait for an important event to arrive, the anticipation can be so great that the reality is an anti-climax. But, from the first moments of the London 2012 Opening Ceremony, it was clear that this year's Olympic and Paralympic Games were going to live up to expectations – and often exceed them. As an Official Partner of London 2012, BP was at the heart of the action, cheering on its athlete ambassadors and explaining its business and technologies in a series of showcase exhibitions. We celebrate some of the highlights of the Games in our special picture story (page 34). Elsewhere, we visit Trinidad and Tobago to find out more about BP's long-standing relationship with the dual-island nation (page 8); speak to some of the people tasked with implementing the 26 recommendations from BP's investigation into the Deepwater Horizon accident in the Gulf of Mexico (page 18); and learn why research into advanced materials might help the industry construct lighter, yet stronger, facilities in the future (page 26).

Lisa Davison > Editor

BP MAGAZINE

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Cover image: The *Stena Carron* drillship operating in the North Sea. The vessel began drilling BP's North Uist well earlier in 2012. **Photography by Stuart Conway**

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08 Caribbean duo The dual-island nation of Trinidad and Tobago has a long history of producing hydrocarbons and over the years, BP's role within the local industry has grown significantly. In 2011, the company contributed around 55% of the nation's natural gas production. *BP Magazine* visits the Caribbean to find out more. By Amanda Breen **Photography by Marc Morrison**



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18 Progress report Since the publication of BP's investigation relating to the causes of the Deepwater Horizon accident in the Gulf of Mexico, the company has made significant progress in implementing the report's 26 recommendations. By Helen Campbell **Photography by Richard Davies/Damian Gillie/Mehmet Binay/Stuart Conway/Marc Morrison**

26 Advanced thinking Materials such as steel play an important role in an industry that manages facilities and pipelines, which is why BP is working with four universities to establish a new \$100 million advanced materials research centre. By Lisa Davison **Photography by Richard Davies**

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For the record

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the quarter in numbers

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The number of Olympic and Paralympic medals won by BP's athlete ambassadors at London 2012.

100

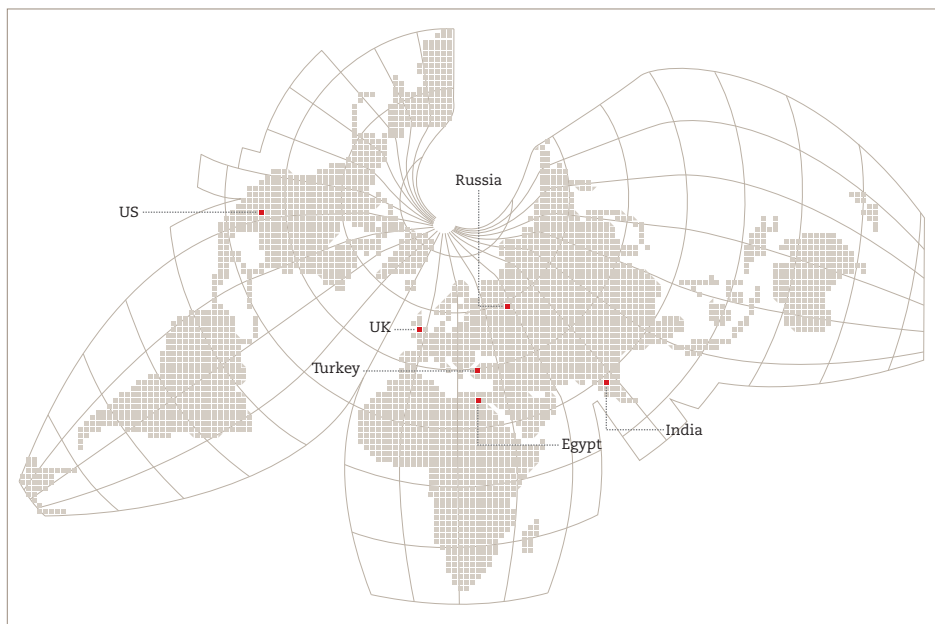
The number of years that BP has had a presence in Turkey.

\$1 million

The amount BP has donated to the American Red Cross and The Salvation Army to support disaster relief efforts in Louisiana and Mississippi, following Hurricane Isaac.

1,650 billion

The world's oil reserves in barrels at the end of 2011.



Field sale: the Marlin platform in the Gulf of Mexico.

US: Gulf of Mexico assets sale

BP has agreed to sell its interests in a number of oil and gas fields in the deepwater Gulf of Mexico to Plains Exploration and Production Company ('Plains') for a total of \$5.55 billion, as part of a previously-announced plan to divest the assets and position its Gulf portfolio for long-term

growth. BP is selling its interests in three BP-operated assets: the Marlin hub, comprised of the Marlin, Dorado and King fields (BP working interest, 100%); Horn Mountain (BP, 100%) and Holstein (BP, 50%). The deal also includes BP's stake in two non-operated assets: Ram Powell (BP, 31%)

and Diana Hoover (BP, 33.33%). The divestment is in line with BP's global strategy of playing to its strengths, including the development of giant fields and deepwater exploration. It also reflects a greater focus in the Gulf of Mexico on producing more high-margin barrels from fewer, larger assets.

Egypt

Gas discoveries

BP Egypt has made gas discoveries at Taurt North and Seth South in the North El Burg offshore concession, located in the Nile Delta. These are the fourth and fifth discoveries made by BP in the concession, following Satis-1 and Satis-3 Oligocene deep discoveries and Salmon-1 shallow Pleistocene discovery.

US

Refinery sale

BP has reached agreement to sell its Carson refinery, California, US, and related logistics and marketing assets to Tesoro Corporation for \$2.5 billion in cash (including the estimated value of hydrocarbon inventories and subject to post-closing adjustments), as part of a previously announced plan to reshape BP's US fuels business. "[The] announcement is a significant step in the strategic refocusing of our US fuels business," said Iain Conn, chief executive of BP's global refining and marketing business. "Together with the intended sale of Texas City, this will allow us to focus BP's operations and investments exclusively on our three northern US refineries, which are crude feedstock-advantaged, and their large and important marketing businesses."

Russia

Talks over TNK-BP

During the summer, BP has been in negotiations over the potential sale of its

50% shareholding in TNK-BP, one of Russia's leading oil companies. In July, BP entered into a 90-day period of good faith negotiations with its partners in TNK-BP, Alfa-Access Renova, as required by the company's shareholder agreement. Shortly afterwards, BP also began negotiations with Rosneft, the Russian energy company. At the time of going to press the negotiations were continuing, with the 90-day period due to end in mid-October. TNK-BP, which was formed in 2003, has upstream and downstream operations in Russia and Ukraine and other assets in Brazil, Venezuela and Vietnam.

UK

Portrait unveiling

A new portrait of double Olympic champion Dame Kelly Holmes (below) has gone on display at the National Portrait Gallery, London, UK. The portrait is the work of artist Craig Wylie, and was commissioned as part of



his first prize in winning the 2008 BP Portrait Award competition. The portrait is a large-scale (172cm x 115cm) head and shoulders oil painting. The size of the work is important to the artist, who says that the act of painting creates "a kind of hyperreality through amplification." Sittings for the portrait took place in late 2011, during which Wylie took a number of photographs of Dame Kelly from which to work.

India

PTA agreement

BP and JBF Petrochemicals have signed an agreement for licensing BP's latest generation purified terephthalic acid (PTA) technology. JBF intends to build a 1.25 million tonnes per annum unit at the Special Economic Zone in Mangalore, India, to produce PTA, the primary feedstock for polyesters used in textiles and packaging. JBF expects the Mangalore plant to come onstream at the end of 2014.

UK

Technology deployment

BP and its partners are deploying new technology that could significantly increase the amount of oil that can be recovered from the UK's largest hydrocarbon resource. The Clair Ridge development, west of Shetland, UK, is the first sanctioned, large-scale, offshore enhanced oil recovery (EOR) programme using reduced-salinity water injection (*LoSal*[®] EOR). The Clair Ridge development includes around \$120 million for the desalination facilities to create low-salinity water for 'waterflooding' from sea water. BP estimates this will enable the production of around 42 million barrels of additional oil, compared to waterflooding with conventional seawater, making a significant contribution to the estimated 640 million barrels of recoverable oil from the development. For more on BP's EOR efforts, see page 42.

Larger than life

With its ability to analyse anything from catalysts to rock samples to biological matter, BP's first transmission electron microscope has the potential to open up the company's analysis capability to multiple branches of science.

Understanding the way in which materials react under different temperatures and pressures, as well as their interaction with other fluids, is vital in the oil and gas industry. A particular material's quality, chemical composition and durability can have a dramatic impact on its corrosion resistance, wear properties, and other critical functional behaviour.

The science behind this involves understanding the relationship between those behaviours and the structure of materials at an atomic or molecular scale. To do that effectively, you need the right tools and, so, BP has invested in a new microscope capable of analysing materials at this scale. This will be critical for understanding a wide range of behaviours, including how catalysts function, how lubricants modify metal surfaces, and how corrosion occurs and can be prevented.

The microscope, known as a transmission electron microscope (TEM), operates at an incredibly small scale and has the ability to obtain direct images, right down to atoms. This provides direct information about what is occurring within a material at a chemical level.

Unlike scanning electron microscopy – widely used in the oil and gas industry – which bounces electrons off the surface of a sample to produce an image, the TEM shoots the electrons straight through the sample. It works a bit like a projector, where light is passed through a slide and an enlarged image projected onto a screen. Inside the microscope, a beam of electrons is focused using an electromagnetic lens

and then projected onto a CCD camera to produce a vastly enlarged image. As with the projector, the sample must be thin enough for the electrons to pass through in order to obtain a clear image. Electrons interact with the sample as a result of a variety of physical properties, such as density and crystallinity. Proper positioning of the detectors and camera can then capture the scattered and unscattered electrons, creating distinct images. BP's TEM can produce images with a resolution as small as 0.2 nanometres (a nanometre is one-billionth of a metre), smaller than the size of many atoms.

Chemical composition

Besides images, the equipment can simultaneously provide details of chemical composition, using an array of detectors to obtain the unique x-ray and electronic signatures of the atoms being studied. In addition, advanced data processing software can detail chemical composition obtained at an individual pixel level to create an integrated map of a material's composition. Incredibly, this information can now be collected in a matter of minutes, where, just a few years ago, such an analysis would have taken hours or simply been impossible. This can provide the key chemical insight into what is occurring within a specific material.

The range of uses for the TEM is wide, but of particular interest to BP are corrosion and catalysis. Understanding the forces that effect corrosion is vital for an industry with millions of kilometres of pipeline. Using a technique known as

passivating, pipe can be protected with a light coating of material, such as a metal oxide, to create a barrier against corrosion. Using the TEM, the chemical composition and thickness of the fine layers of passivation can be measured and analysed. Meanwhile, BP's downstream business creates value by transforming materials through catalysis. Exactly how catalysts work, though, remains an incomplete picture and so the microscope can be used to analyse active sites on catalysts in order to understand how they function, what interferes with their performance and how they might be used more effectively.

The analytical capacity of the TEM is only as powerful as the skills of the people who use it, though. BP's team of electron microscopists brings together scientists with years of experience in helping anyone from a metallurgist out on an oil and gas platform, for example, needing to analyse inconsistencies or defects within a pipe, to a process engineer wanting to understand the chemistry of materials that flow through their process equipment.

The TEM also allows teams around the world to work together remotely. Using the company's communications networks, scientists in multiple research facilities can view samples in real time, with a greater level of interaction than previous techniques allowed.

With its ability to analyse anything from catalysts to rock samples to biological matter, the TEM has the potential to open up BP's analysis capability to multiple branches of science. BP's TEM is installed at its research facility at Naperville in the US. ■

**Allows simultaneous
remote microscopy
at locations based
thousands of miles apart**

**Enables chemical
mapping at
nanoscale,
30 times faster
than previous
technology**

**The first ever
TEM was built
in 1931**

**A TEM produces
images with a
resolution as
small as 0.2
nanometres**

**Delivers
simultaneous
imaging and
chemical
analysis**



Local operator: (clockwise from top left) operator at the LNG company Atlantic; a swimming lesson at the pool at the Mayaro Resource Centre; BP's Cashima platform located approximately 70 kilometres (45 miles) east of Galeota Point; some of the community projects BP supports take place in schools in Mayaro. Opposite: the offshore team on the Rowan Exl II drilling rig.



PARTNERS IN THE CARIBBEAN

The dual-island nation of Trinidad and Tobago punches well above its weight in the global economy, thanks to its plentiful hydrocarbon reserves. The same is true within BP, with operations in Trinidad and Tobago accounting for around 12% of the company's total global oil and gas production. It's a long and fruitful relationship that BP hopes will continue to flourish and grow in the years to come.

Report > Amanda Breen Photography > Marc Morrison





Growth business: BP operates 13 offshore platforms, including Cassia (below right), onshore oil and gas processing terminals, and is the largest shareholder in the LNG company Atlantic, with its four liquefaction units, or trains (right).

F

ive centuries ago, when explorers were sailing the globe in a bid to discover new lands, many passed through Caribbean waters on their way to the Americas. Among them was the British navigator, Sir Walter Raleigh, who – it is said – came across a ‘lake’ of asphalt on the south-western corner of Trinidad in the 1590s. Pitch Lake, as it is known today, is one of the world’s largest natural deposits of this sticky, black substance – created by deep deposits of oil that are forced to the surface, where the lighter elements of the hydrocarbon evaporate to leave behind the heavy asphalt. Adventurers such as Raleigh used the substance to seal their ships’ hulls, before continuing a voyage.

These days, exploration in the region is not about finding new territory to mark on an atlas, but identifying further hydrocarbon deposits hinted at by the ones those early navigators first came across. The expanse of dark viscous material that seeps up through the ground at Pitch Lake provides visual confirmation of the rich natural resources that lie beneath these islands’ surface and off their coastlines.

Trinidad and Tobago enjoyed its first oil boom after 1910, although the abundant natural gas in its reservoirs was only fully appreciated several decades later. From the late 1970s, gas began to dominate the

country’s energy market, as it does today. The dual-island nation produced more than 700,000 barrels of oil equivalent in natural gas on a daily basis in 2011, of which BP’s Trinidad and Tobago business – BPTT – contributed around 55%. The company operates 13 offshore platforms, onshore oil and gas processing terminals and is the largest shareholder in the liquefied natural gas (LNG) company, Atlantic, with its four liquefaction units, or trains.

“We are a business that has gone through tremendous growth, especially since the start-up of the first LNG train in 1999,” says BPTT regional president, Norman Christie. “This country’s natural gas production grew from 1.3 billion to 4.3 billion cubic feet a day between 1999 and 2010, and our own production more than doubled in that period.”

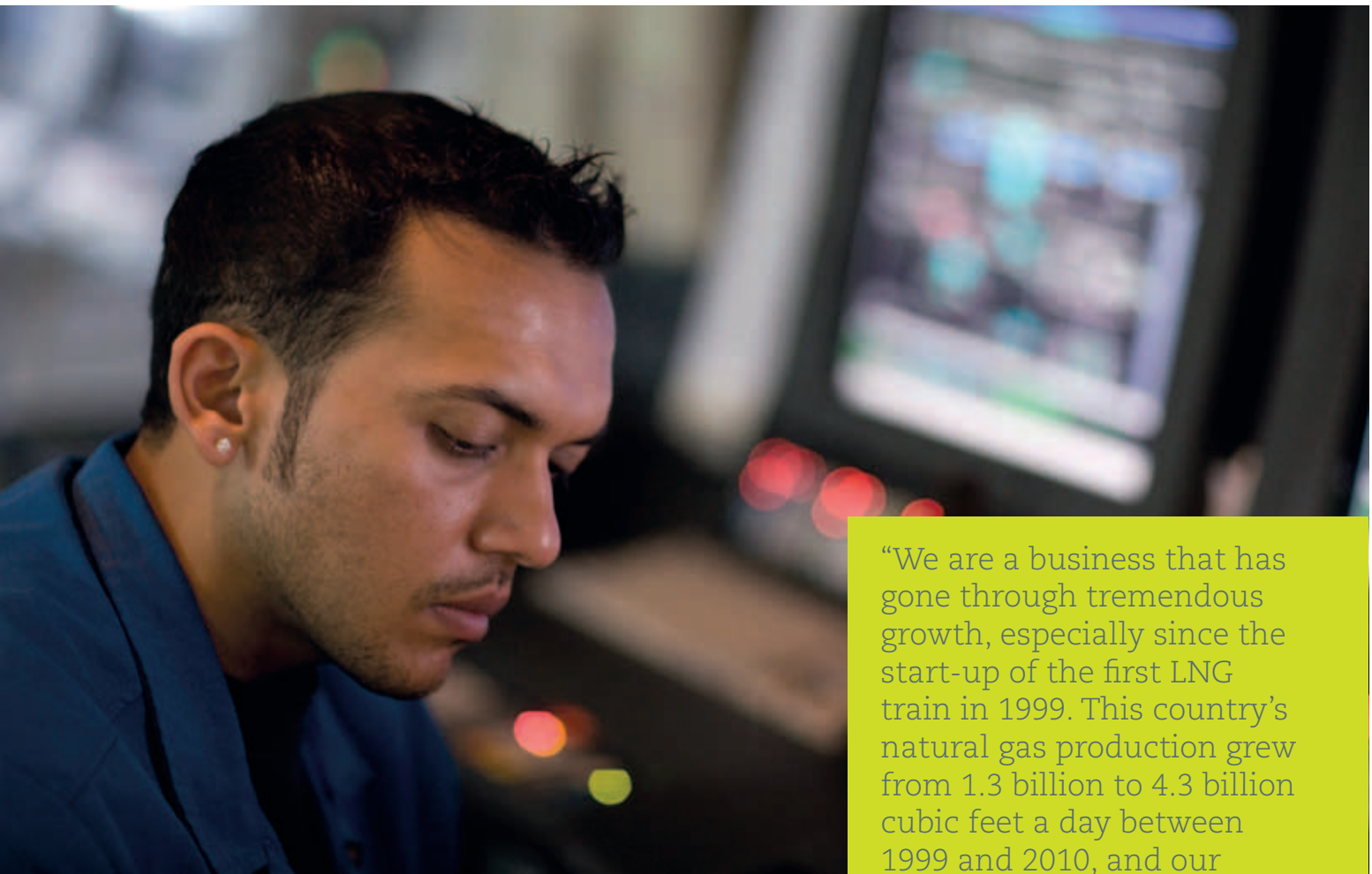
Today, BPTT contributes around 12% of BP’s total oil and gas production globally. The challenge for the organisation now lies in maintaining that level, to provide consistent value for company and country. With natural gas projected to be the world’s fastest-growing fossil fuel by 2030 and demand for LNG increasing in countries such as China and India, the business is looking at how it will meet the long-term supply needs through its existing position, by maximising recovery from producing reservoirs.

“One of our goals is to really exploit our base production, in an efficient way, using existing wells,” says Keith Bally, vice president of the resource team. “We are looking at bringing wells back online and recompleting different reservoir zones, those we haven’t produced from before, in what we call ‘secondary pay’. In this way, we are looking to reap rewards and the potential is huge.”

There are also potential new opportunities in existing fields where resource appraisal has been difficult in the past, due to the limitations of technology to ‘visualise’ what lies beneath layers of shallow gas. To better understand the subsurface in those areas, a \$200 million ocean bottom cable (OBC) seismic acquisition programme is underway, that will cover around 1,000 square kilometres (386 square miles).

“We have brought in new technology to generate improved subsurface images; we expect this to mean a lot for the region in terms of what we can unlock, with clearer seismic lines that eliminate shallow gas effects,” Bally continues. Five specialist OBC vessels spent six months in the Caribbean, completing part of phase one by April.

The vessels will continue their work in Trinidadian waters later this year. For



“We are a business that has gone through tremendous growth, especially since the start-up of the first LNG train in 1999. This country’s natural gas production grew from 1.3 billion to 4.3 billion cubic feet a day between 1999 and 2010, and our own production more than doubled in that period.”

Norman Christie



Bally, obtaining new seismic data covering the majority of BPTT's gas fields makes a strong statement: "We are demonstrating to our stakeholders that we are leaving no stone unturned. It's also about creating excitement within the organisation that we are looking to the future and beyond the expiry of existing gas contracts."

Seismic data

New exploration offers long-term potential for the business, too. Following the signing of production sharing contracts in May for access to two ultra-deepwater blocks, 300 kilometres (185 miles) off the north-east coast of Trinidad, planning has begun to gather seismic data from the new acreage in 2013.

"Although one of our strategic tenets is to maximise value from our current position, these two new blocks also present hope of a much longer future for BPTT and, therefore, by extension, for the country as a whole," says Christie. With the new exploration acreage at depths of around 2,000 metres (6,560 feet) – compared with operations to date in less than 500 metres of water (1,640 feet) – BPTT will turn to global company expertise to develop its capability in this new local frontier.

"Some of the work will be done

in Houston, US, where we can take opportunities for our national staff to join divisional teams so they can learn and bring their knowledge back here," says Christie. "This is a big deal, as we make the most of all BP has to offer and demonstrate why it is valuable to have an international oil and gas company in the country."

While the business eyes these new prospects, it is also growing in employee numbers. A massive recruitment drive in 2011 resulted in 200 vacancies filled – making the company one third larger than it was less than two years ago. "We need a pipeline of national talent that we can keep replenished," Christie continues, "so where appropriate, we offer staff the experience to work and learn elsewhere in BP, thereby developing talent that will eventually return to Trinidad."

Engineering services manager Victor Singh believes that the opportunities on offer in the country also provide a varied career path for his professional discipline. "From a learning and development perspective in engineering, we have both onshore and offshore projects, working on an infrastructure that ranges from 40 years old to brand new. This includes risk-reduction activities, production enhancements for the future and adding



"We have brought in new technology to generate improved subsurface images; this will mean a lot for the region in terms of what we can unlock, with clearer seismic lines that eliminate shallow gas effects."

Keith Bally

value to the business through the installation of new technology.”

Alongside the development of long-term plans to sustain and grow current levels of production, BPTT has begun a programme of work to ensure the integrity of ageing infrastructure and continue to manage risk at operational sites. A series of upgrades is now complete on the 30-year-old Immortelle platform, including a new helideck, fire protection system and a \$60 million accommodation refurbishment.

“From a safety perspective, we have replaced the helideck, relocated the control room to the top deck for improved blast protection, enclosed stairways and installed a positive pressurisation heating, ventilation and air conditioning system,” explains Singh, who is among the engineering team to work closely with the safety and operational risk function to identify and design the modifications.

Modernisation programme

As well as improving offshore facilities, modernisation has taken place in the onshore oil terminal at Galeota Point, which dates back 40 years in places. Here, three pipelines bring crude ashore, where it is stabilised and stored, until it is collected by tanker every 10 days. With its beach-

side location and the ambient air saturated in sea salt, corrosion is an ongoing challenge for the site, as area operations manager, Lyndon Mohess explains: “We are constantly looking at new methods and technology to manage this – for example, through improved inspection techniques to provide more data on our pipework and through extensive maintenance activity to protect the facility.”

Oil spill emergency drills also take place on a regular basis here, as hydrocarbons are loaded onto tankers in a marine environment. Exercises see BPTT’s incident management team step into action in the company’s headquarters in Port of Spain, while teams on the ground test the response plan and deploy protective boom in the water to make sure that staff and contractors have experience in such tasks, should the need arise.

In addition to local drills at Galeota Point, major incident response exercises are held twice a year, involving more than 100 people, including the incident management team, its business support team, and a variety of national agencies and service contractors. In July, the scenario was a simulated gas release from a pipeline, affecting a local community, and a resulting fire with multiple casualties. For

Allan Subero, director of crisis, continuity and emergency response in the region, such exercises identify valuable lessons.

“Our focus is always on prevention: how do we ensure that mitigation measures are in place to manage our risks? But, in the event of an emergency, we need to be prepared, with support from external agencies.

“What we’ve learned is the need for continued integration with different response organisations and regulatory authorities. We have mutual arrangements with other upstream and downstream operators, so if there is an emergency, we can ask for support or offer it. Our aim is to look after people’s safety, the safety of those in the community where we operate and the protection of the environment.”

BPTT has also taken reasonable steps to protect its business in the face of a changing gas market. The gas that is produced and converted into a liquefied



On point: BP’s oil terminal at Galeota Point (below) has gone through a process of modernisation. Corrosion is a challenge for the site as a result of the salt air and the team is constantly looking for new methods and technologies to manage the issue.





THE HEART OF THE COMMUNITY

One of the effective ways that local groups share a message with their wider community in the rural coastal province of Mayaro, on the south-eastern corner of Trinidad, is to employ the services of the affectionately-named ‘mike-man’. This is an individual who drives around each street in select villages, playing prerecorded messages from a loud speaker fixed onto the roof of a pick-up truck. Essentially, it’s the modern version of the town crier, who announces anything from summer camps to funerals.

With a base in the heart of the community, at the Mayaro Resource Centre, BPTT often complements its conventional communication channels by using mike-man as a way to reach local residents, to publicise the many activities, courses or family days that take place at the facility.

While the community has developed significantly over the past generation, and has its own radio and television stations, mike-man is still used. “It’s still an effective means of communication here,” says BPTT’s Rene-Marie Wilson, manager of the Mayaro Resource Centre. A former sports complex for oil and gas employees from the nearby Galeota Point terminal, the centre today is open to all after it was handed over to the community. “The mike-man drives the streets to ensure that people without televisions or those who face challenges getting into town on a regular basis for a newspaper are kept informed. By announcing what’s happening at the centre in this way, we can reach a wider audience.”

There’s plenty on offer at the resource centre, which houses a number of different

organisations on a permanent basis, including an open campus of The University of the West Indies; CREDI – the Catholic Religious Educational Development Institute – which runs a bachelor programme in education; and Servol – Service Volunteered for All – which offers academic and vocational support to students who have fallen out of mainstream education. Each group makes use of the classrooms and office space at the centre, allowing local residents to study closer to home rather than travelling long distances to the main urban academic institutions.

Aside from learning facilities, the centre also provides leisure facilities to the Mayaro population, including the only public outdoor swimming pool in the region, basketball and tennis courts and a gymnasium.

As part of its ongoing commitment to the community where it operates, BPTT oversees a number of projects from the resource centre, often focused around capacity-building and professional development. Monthly workshops for non-governmental and community-based organisations have seen more than 2,000 individuals

receive training in areas such as finance, governance and accountability, events management and conflict resolution.

“This programme is aimed at community organisations with the potential to run their own activities in Mayaro to equip them with the required skills to apply for grant funding from BP,” Rene-Marie explains. “We see the results of the workshops in project proposals and the structured and professional way in which the projects are implemented.”

Supporting small business growth in this rural region, where agriculture and fishing still play significant roles in the local economy, has been a long-term effort for BPTT. Back in 2002, the company provided a seed-fund of US\$1.2 million (or TT\$7.2 million) to launch the Mayaro Initiative for Private Enterprise Development (MIPED), the country’s first privately-developed micro-finance lending organisation.

Within three years of its inception, the not-for-profit group became self-sustaining, thanks to the repayment of micro-credit loans it had made, which then allowed further funds to be made available for other would-be small business owners. Marking its 10th anniversary in August, the organisation – with its headquarters at the Mayaro Resource Centre – has issued more than TT\$40 million in loans, supporting the creation of small businesses from watermelon farms to craft studios, daycare centres to mini-markets.

Among those to receive a MIPED loan are Imran and

Leanna Ali, a couple who run a chicken farm in Bristol Village. In operation since January 2011, the business has established a strong customer base and is ready to expand into other areas of agriculture following the growth and success of the poultry trade. After borrowing money from family to initially get the business off the ground, Imran needed to make a substantial investment for the all-important chilling system to keep their meat fresh on the premises.

“I didn’t know where to start to pay for the ice machine, but a friend told me about MIPED and two weeks later, after some site visits when the loan officer could see how much we depend on chilling our product, I had a cheque in my hand.

“If I hadn’t turned to MIPED, I would have been nowhere. The biggest constraint we faced was access to funds for agriculture from the conventional banking system. Today, we are going strong; after 16 months, the business paid itself for an automatic scullery and new bathroom facilities. We’ve also repaid our initial investors.”

Loans from MIPED range from TT\$2,000 to TT\$100,000, and the overall default rate is low – around 3% of total loans. “This is because we keep a close relationship with our clients and that is the key to the success of the programme,” says Rachael Hosein, MIPED manager. “We work together to ensure that business plans are viable and offer training in areas such as bookkeeping. We want these start-ups to make a profit and become sustainable, so they can help to build the community.”

The Mayaro Initiative for Private Enterprise Development – in numbers

TT\$7.2 million

– the original seed fund investment from BPTT

TT\$42.3 million

– total value of loans disbursed since inception

37%

of MIPED loans provided to agricultural sector

2,084

full-time jobs created from 2003 until 2012



Social fabric: once a sports complex for oil and gas employees, the Mayaro Resource Centre now belongs to the community and has a swimming pool and gym facilities. Several academic organisations also have services available at the centre, including an open campus of The University of the West Indies, CREDI, which runs a bachelor programme in education, and Servol, which offers academic support to students who have fallen out of mainstream education.

“Our export business has altered dramatically from one focused on the US market, to a more global portfolio. After the tsunami and nuclear crisis in Japan last year, the demand for gas there increased, so we see many more cargoes transported there and to other parts of Asia, as well as South America and Europe.”

Baaj Sirinath

» form in Trinidad often travels a long way to reach its final destination. In the recent past, more than two-thirds of US LNG requirements were supplied from these small islands. But the global gas market has seen significant changes, according to Baaj Sirinath, BPTT’s manager for markets and midstream.

“Our export business has altered dramatically from one focused on the US market, to a more global portfolio. After the tsunami and nuclear crisis in Japan last year, the demand for gas there increased, so we see many more cargoes transported there and to other parts of Asia, as well as South America and Europe.

“As a company, we have used our commercial flexibility and leveraged our worldwide presence to adapt to a changing market. Our global network of trading capability and shipping has proved invaluable in this respect.”

Even though long-term growth is forecast for the LNG market, it is likely that demand in certain geographies will continue to fluctuate as countries develop their own gas resources, in particular, unconventional sources such as shale gas. According to BP’s Energy Outlook 2030, for example, the US will become a net exporter of natural gas, with its import dependency declining significantly in future.

But with established LNG production facilities – including one of the world’s largest trains in operation – there is optimism that Trinidad is a step ahead

of other markets, thanks to the massive investment that has already been made. “The advantage here is that the country already has the LNG facilities – others have yet to develop them, which takes time and money. Meanwhile, the demand for gas is steadily increasing. What will be important for BPTT is continued flexibility, the ability to respond and export cargoes where they are needed, according to seasonal demand,” says Sirinath.

For two islands that cover an area slightly smaller than the US state of Delaware, Trinidad and Tobago certainly play an active role in the regional and global economy, thanks to their hydrocarbon resources. And, as the nation marks 50 years of independence from Britain this year, it is time to reflect on both its history and future. For BPTT, it’s an opportunity to take stock of its distinct local identity, while recognising that operating in the Caribbean is not just about business.

“Our aspiration is to actively participate in the country’s development and to have a positive impact on every citizen and employee,” Christie concludes. “That means a lot more than simply doing business well; it’s about making a connection on a personal level, too. Things like supporting our Olympic and Paralympic teams until 2016, or encouraging enterprise development in communities where we operate, we believe that brings mutual benefit for the company and nation.” ■



Development opportunities: the Rowan Exl II drilling rig (above); students at the Mayaro Resource Centre take advantage of classroom facilities located within the centre, which allow them to study closer to home. Opposite: operators on BP’s Cassia platform.





EMERGENCY
SHOWER
& EYE WASH

Report > Helen Campbell

Photography > Richard Davies/
Damian Gillie/Mehmet Binay/
Stuart Conway/Marc Morrison

FROM RECOMMENDATION TO REALITY

Immediately after the Deepwater Horizon accident in the Gulf of Mexico, BP asked its most senior safety professional, Mark Bly, to lead an investigation relating to the causes of the incident and make recommendations to help prevent such accidents from occurring. The investigation led to 26 recommendations for reducing risk in BP's drilling operations. Since the report's publication in 2010, BP has made significant progress in implementing those 26 recommendations. *BP Magazine* finds out more.

Worldwide business: BP carries out drilling activities around the world. The images on the following pages are all taken from drillships and rigs involved in work for the company. Main image: onboard the drillship *Discoverer Luanda* in Angola.





In September 2010, four months after the Deepwater Horizon accident in the Gulf of Mexico, BP released its Deepwater Horizon Accident Investigation Report, known as the Bly Report, concluding that the accident resulted from a complex, interlinked series of failures involving multiple parties.

The report was the work of an investigation team led by BP's head of safety and operations, Mark Bly, and consisted of more than 50 technical and other specialists, drawn not only from BP but also the wider energy industry.

The team made 26 recommendations specific to drilling, aimed at further reducing risk. Accepting all of these recommendations, BP committed to their implementation across its worldwide drilling operations and the recommendations are now in the process of being implemented into the well designs by engineers and operations personnel.

That implementation is overseen by the global wells organisation (GWO), established by BP in April 2011 to facilitate a stronger, centralised and standardised approach to all BP-operated wells activity.

"Our mission is to deliver safe, compliant and reliable wells for BP," says Richard Lynch, head of GWO. "We have to be very clear about the work we are doing and the risks involved, and have plans in place to manage those risks."

Diverse locations: drilling activity at BP's Endicott field, Alaska (far left); the *Discoverer Enterprise* drillship, Gulf of Mexico, US (left); and a drilling rig at the Rumaila field in Iraq (bottom).



“Our mission is to deliver safe, compliant and reliable wells for BP. We have to be very clear about the work we are doing and the risks involved, and have plans in place to manage those risks.”

Richard Lynch

“Successfully delivering the report’s recommendations will standardise the way we work, and give us the baseline from which we can learn, as we continue to address the risks we encounter and the complexities we have into the future.”

The 26 recommendations include areas fundamental to drilling, such as well control, pressure testing, cementing, blowout preventer (BOP) assurance, rig audits and contractor management. Implementing these recommendations across all BP-operated drilling activity in 14 separate business regions is an enormous undertaking that involves more than 190 deliverables, such as the creation of new documents, training and testing of appropriate staff, and establishing verification processes to help assure the changes are implemented and sustained. The 85-strong implementation programme team consists of a central group based in Houston and others embedded in BP’s businesses. Determined to take the right path from the start, the team took time to carefully examine each recommendation

in order to fully understand what it required and what impact it would have, before starting to create, via a six-step process, the documents, operating practices and engineering technical practices (ETPs) that set out in detail what is required for BP’s businesses to conform to the new or revised practices.

“We spent several months getting it all articulated and agreed with group leadership and the investigation team,” says Steve Haden, vice president of engineering and operations, and the person leading the programme.

The team adopted a ‘strategic implementation planning’ (SIP) tool to enhance systematic planning and management of all the milestones, including the evidence that tells BP that the recommendations are being correctly implemented on a global scale. Implementation is a seven-step process. By the end of August 2012, more than 100 of the individual deliverables had been completed and 10 of the recommendations had been completed.

At least 14 are expected to be closed by year-end 2012.

For many of the recommendations, a major part of the planning and implementation process is developing the right training materials, identifying the individuals who need to be trained and then delivering that training, in many cases on a large scale. This is particularly the case for the recommendations that deal with well control and zonal isolation – the process of preventing fluids encountered while drilling from flowing up or down the wellbore.

“To assure we are targeting the right people, we did a lot of work with the safety and operational risk [S&OR] organisation and the relevant engineering authority, and we work very closely with our upstream learning centre in Houston,” Haden says.

Some training is highly specialised and touches perhaps 40 or 50 positions, while some, such as well control, touches more than 800 people, almost half the GWO workforce. Another example is zonal isolation, where BP has trained more than **»**

600 people, delivering 25 workshops in three months.

Once the training is completed, BP's management of change process puts the new practices into place. To confirm that a recommendation is closed, both centrally and in the regions, S&OR evaluates all the evidence in the regions.

The recommendations vary in complexity. As a result, some have been delivered more quickly than others, but all 26 are being worked on in parallel. In some of the larger regions, and depending on the recommendation, the process may take several years.

"We are going to do this the right way," says Haden. "We will not risk the quality of the documents, and we will not risk the quality of the implementation. Pace is important, but it is much more important to do this in a very systematic and controlled way to achieve the sustainable result we want."

That sustainability means that all BP's upstream businesses will be operating from a globally-aligned platform, setting the right foundation for continuous improvement.

"I know that the investigation team thought long and hard about what they learned and I am confident this is the right way to help achieve safe, compliant and reliable wells," says Bernard Looney, BP's executive vice president for the developments division. "The overarching objective is to make a difference, and to do it right means it may take some time."

Looney continues: "That is not to say there is not a sense of urgency. There is no end point to this, but at the same time, with 88 well operations going on across the world, we need to have confidence that this is making a difference today, tomorrow, next week, and, importantly, in the years ahead."

Much of the report and its recommendations focused on verification. And every single wells employee, from Looney and the wells leadership team to the individual engineer, has a responsibility, a duty, to ask themselves: 'how do I know?'

Looney concludes: "If you are accountable for something, it is not enough to think it is okay, or to hope it is okay. I have to know it is okay. That is my job, and it is everyone's job."

"We will not risk the quality of the documents, and we will not risk the quality of the implementation. Pace is important, but it is much more important to do this in a very systematic and controlled way to achieve the sustainable result we want."

Steve Haden



BLY REPORT RECOMMENDATIONS IN EGYPT

In deep water, in a high-pressure, high-temperature (HP/HT) reservoir and with a new rig, the *Maersk Discoverer*, the Salamat-1 well is one of BP's highest-profile exploration wells this year.

"The Bly Report and its recommendations have really changed the way the region prioritises," says Dave Cocking, region vice president for wells in Egypt.

Under the recommendations, well design focuses closely on zonal isolation at the beginning of the planning process. Like other operations around the BP world, the Egypt wells team also audits its suppliers, for example with staff visiting suppliers' laboratories to satisfy themselves that a cement formulation has been tested and verified in the correct way to deliver the properties that BP wants, the equipment properly calibrated and the people properly trained.

Pressure testing has been strengthened, with details of how it must be done now detailed in the relevant practice requirements and multiple levels of sign-off throughout the process.

Cocking says the team has received the human resources it needs to do the additional work that the recommendations bring. It's a big job, and it is making a big difference.

"Engineers here tell me the report is making things clearer, more specific and easier to work with," he says.

"People do believe and feel that we are stronger for it."

Bird's eye view: drilling activities at Shah Deniz, Azerbaijan (main image); and the *Maersk Discoverer* drilling rig in Egypt (right).



BLY REPORT RECOMMENDATIONS IN THE NORTH SEA

Although the North Sea is a mature area, its varied portfolio means it does employ a lot of new technology.

“We have high pressures and temperatures, we have deep water, and we have managed-pressure drilling here,” says Jim Cowie, region vice president for wells in the North Sea. “We are doing exploration, appraisal and decommissioning, and we have jack-up rigs, semi-submersibles, platforms, drillships, and intervention vessels, so we have a wide range of activities going on in the region.

“The key to the report is how the recommendations are strengthening our risk management. We have a stronger awareness of our risks and the mitigations in place to manage them.

“S&OR and the Bly Report programme team have been outstanding in embracing the lessons and suggestions that have been made along the way,” Cowie adds. “The SIP tool helps us plan our activity associated with the recommendations and helps make sure the North Sea is capable of coping with the load. This helps give us the confidence that we can implement the activity that is coming down the lines.”

One change that has already had an impact in the North Sea, although the recommendation itself is not yet closed centrally, is the updated BOP requirements. The North Sea team completely changed the BOP on the *Stena Carron* drillship for the North Uist well this year, to conform with the new BP policy that BOPs for BP or BP-contracted rigs have two sets of blind shear rams – the piece of equipment that, when activated, cuts through the drill string and seals the well bore.

“We asked the rig contractor to provide a new BOP for the rig, which they did,” Cowie says. “That was a huge thing to do, but it is particularly significant for the deep waters here.”

Another big activity in the North Sea is decommissioning, and the revised zonal isolation and cementing standards have an impact on this activity. The Byford Dolphin rig finished a second well on BP’s Don field earlier this year, then went to Magnus to decommission a well there, too, before coming back to Don.

Cowie says the strengthened requirements around rig audits and inspections that have come out of the report, as well as the new key performance indicators (KPIs), help the business to focus on certain areas, such as deviations.

“The new KPIs mean we focus on the right things and highlight issues that we can then monitor,” says Cowie. “For example, now we look at the number of deviations we have, why we have them and whether we have any problems with any of the safety-critical equipment that we use.”

Cowie continues: “There is no doubt implementing these recommendations is a lot of work, but there are huge benefits to the North Sea business and to BP. If an engineer comes in from Alaska, the Gulf of Mexico or wherever, they will be taught from, and will reference, the same documents. It is systematic and that is the key.” ■

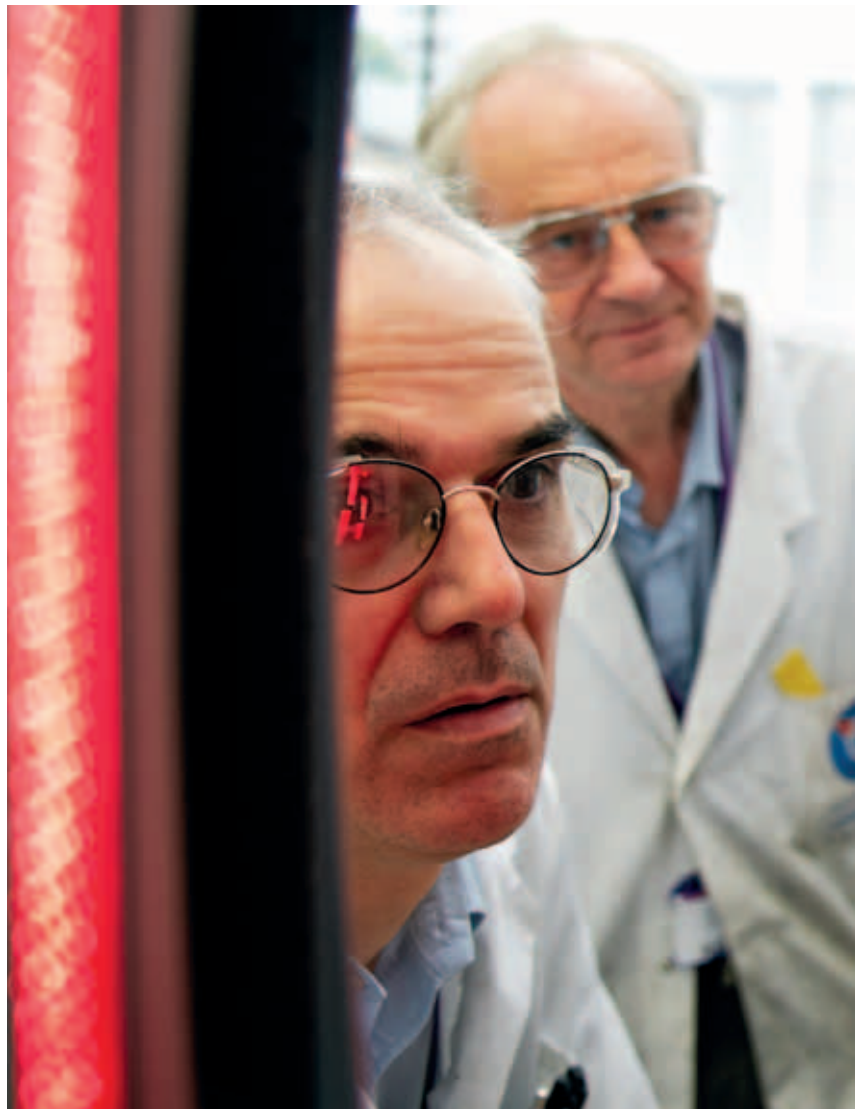
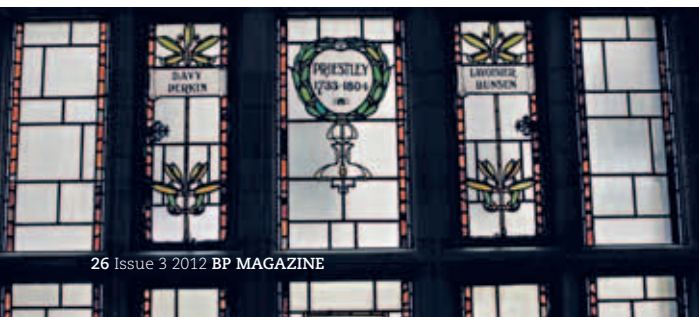
New requirements: the helideck onboard the *Stena Carron* (main vessel) in the North Sea. The team completely changed the vessel’s blowout preventer (BOP) this year to conform with BP’s policy on BOPs.





Advanced understanding

Following BP's announcement that it is to work with four universities to establish a \$100 million international research centre to advance fundamental understanding of materials, *BP Magazine* finds out why greater knowledge of materials such as steel could be vital for the oil and gas industry.



In the laboratory: (main image) conducting deflection testing of a carbon fibre composite material in the National Composites Certification and Evaluation Facility (NCCEF); (far left from top) setting up for submerged arc strip cladding (a form of welding) of a steel plate; PhD students at Manchester University carry out localised corrosion testing, in the Corrosion and Protection Centre – part of BP's Inherently Reliable Facilities (IRF) technology flagship programme; a stained glass window in the Great Hall of Manchester University's Sackville Street building.



Ever since humans first learned to use wood and stones to create tools, we have manipulated the materials around us to build better products, such as stronger infrastructure, more efficient appliances and warmer clothing. And, as our understanding of physics, chemistry, biology and mathematics has improved, so too has our ability to push the physical properties of those materials.

Take, for instance, steel. It's what is known as a structural material, meaning it's used to build things and today we find it in the construction of railways, skyscrapers, bridges, cars, pipelines, tools, washing machines and office furniture. It's even been used in sculpture.

Over the years, we have learned that steel is an alloy that can display a very wide range of properties according to both the elements added to it and its 'microstructure', which can be controlled by deforming and heating it. Powerful electron microscopes have revealed that steels are made up of little crystals that can have many shapes, and contain defects that, in fact, make them very strong. The more we know about steel, the more we can manipulate its properties and the more uses we can find for it.

All of this is vital to an industry that relies on many types of material – steel

included – in order to operate safely, reliably and efficiently. This is why BP has established a \$100 million research centre, known as the BP International Centre for Advanced Materials, or the BP-ICAM. The centre will lead research aimed at advancing the fundamental understanding and use of materials across a variety of energy and industrial applications.

The centre will have a 'hub and spoke' structure, with the 'hub' located within The University of Manchester's Faculty of Engineering and Physical Sciences. The 'spokes' and other founder members are based at the University of Cambridge, Imperial College London and the University of Illinois at Urbana-Champaign.

Over the next 10 years, each university will work together to carry out research into seven primary areas (see box), with the initial focus on structural materials, such as new metal alloys and composites; smart coatings for increased protection from the extreme environments and to extend a structure's usable life; and membranes for separation, filtration and purification.

Speaking at the centre's launch, BP's chief executive, Bob Dudley, explained why these focus areas were chosen: "Advanced materials and coatings will be increasingly important in finding, producing and processing energy safely and efficiently in the years ahead, as energy producers work at unprecedented depths, pressures and temperatures, and as refineries, manufacturing plants and pipeline operators seek ever-better ways to combat corrosion and deploy new materials to improve their operations."

The impact that our understanding of materials science has had on other industries is around us every day, as BP's associate director for the BP-ICAM,

Bob Sorrell, explains: "If you look at computers, information that we once stored in something the size of a packing crate that cost thousands of dollars now fits into a small phone costing just a couple of hundred. Developments in the miniaturisation of materials and faster processing power have made this possible."

It's our understanding of materials at this miniature, or nanoscale, that is making such developments possible. But first, it's useful to know just how small we're talking. BP's chief scientist, Ellen Williams, explains: "Nanoscience and nanotechnology have revolutionised the way we analyse a material's properties. We use nanometres as a form of measurement and to understand just how small that is, you can imagine pulling out one of your hairs and trying to slice it into 10 pieces lengthways. That would be pretty difficult! Now imagine slicing it into a 100,000 pieces – that's almost unimaginably small. But a nanometre is just 1/100,000th the diameter of that hair. With modern tools, we can image materials down to that scale now, and when we talk about advanced materials, we're most often talking about driving controlling structure at the nanometre scale to modify the properties of the material. That way we can take a look at the challenges facing our industry with fresh eyes."

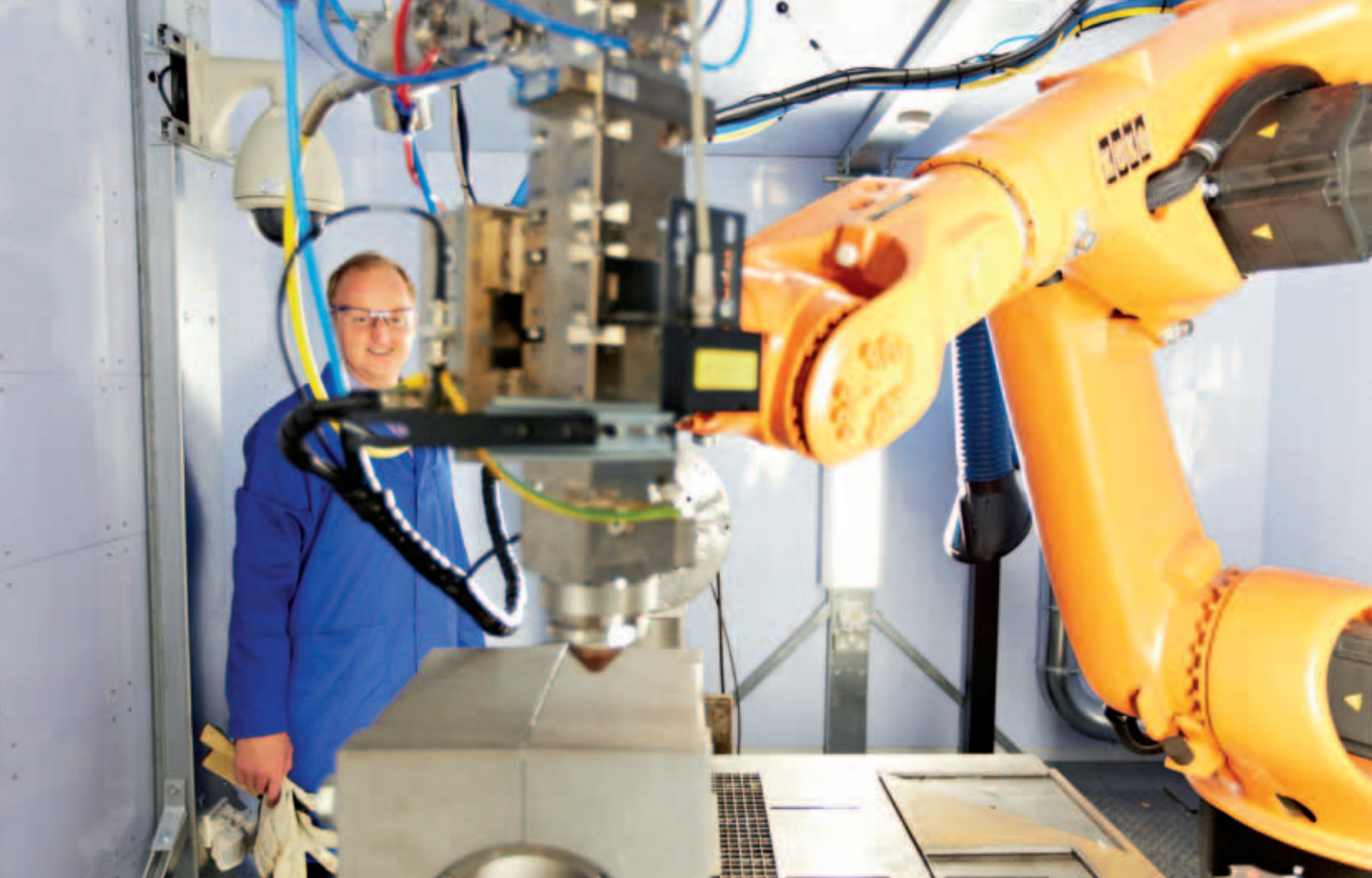
One area that will be of particular interest to the BP-ICAM is corrosion. While BP has deployed new sensors to help it detect corrosion at an earlier stage in its facilities, understanding how corrosion forms in the first place could change the way it is managed. With greater understanding of how corrosion forms and what that does to a metal, smart protective coatings that 'heal' themselves could be produced. The coating could contain, for example, tiny, hollow beads filled with an

Practical testing: Dr John Walton (below) with the Kratos Axis ultra x-ray photoelectron spectrometer in the Corrosion and Protection Centre. Right: Dr John Francis in the manufacturing technology research laboratory with a 16 kilowatt fibre laser coupled to a s-axis Kuka robot.



BP-ICAM will focus on seven areas:

- Structural materials
- Smart coatings
- Membranes
- Functional materials
- Catalysis
- Energy storage
- Energy harvesting



A DECADE OF PARTNERSHIP WITH MANCHESTER UNIVERSITY

BP has relationships with around 200 universities worldwide and holds a number of long-term strategic partnerships with leading universities in the UK, US, China and Russia.

Its partnership with the University of Manchester dates back to 2003 and, over the years, has grown into a strategic relationship that covers research and development, recruitment and scholarship opportunities for students. In addition, BP contributes to curriculum content through participation on advisory boards, provision of guest lectures, project topics and data donation to undergraduate and postgraduate projects.

The partnership also includes executive education and the Projects and Engineering College is a key component of career development for BP leaders in engineering and project management. Since 2008, more than 600 BP staff have attended the Manchester-based programme, which is designed and delivered in collaboration with the university, using its expertise to ensure that the subject matter is geared towards BP employees.

The relationship with Manchester is overseen by a group of sponsors, including Colin Bailey, vice president and dean of the university's Faculty of Engineering and Physical Sciences, and senior BP executives. These include two Manchester alumni: BP's chief financial officer Brian Gilvary and Angela Strank, who, until recently, was technology vice president for global fuels and lubricants and now works as executive assistant to chief executive Bob Dudley. BP's group head of engineering, John Baxter, is also one of the sponsors.

Manchester University itself was established back in 1824, when

local businessmen created the Manchester Mechanics' Institute to educate the local workforce in support of the growing textile industry in the area.

Almost 200 years later, it has maintained its lead in engineering and science and is associated with 25 Nobel prize winners, ranging from Ernest Rutherford's pioneering research that led to the splitting of the atom, to Andre Geim and Konstantin Novoselov's recent work on the new material graphene. Currently, the university has three Nobel Laureates on its staff.

According to Gilvary, the creation of the BP-ICAM is a further example of how BP is finding new ways of working with the academic world to solve industry challenges. "This announcement represents a deepening of our already very broad relationship with Manchester University. The university's educational expertise has been of great value to us and we are now also benefitting from its outstanding research capability as a centre of excellence in engineering and science."

Strank agrees: "I am very pleased that the university has been selected to form the hub of the BP-ICAM. It is well-deserved recognition of Manchester's world-class expertise in science and engineering and the calibre of both the faculty and staff. The quality of graduates that we recruit from Manchester is extremely high, many through our BP scholarship programme. This will give us a stronger link with many more postgraduates and further raise BP's profile as a potential future employer at the UK's largest university. I look forward to seeing more of the most talented Manchester graduates applying to work with BP."



epoxy that would release if the coating was damaged, breaking the beads. Likewise, other coatings that release biocides potentially could be applied to pipelines that are prone to biofouling – organisms that grow on the surface of metals and eventually plug up pipes.

But the BP-ICAM also hopes to tackle future challenges. The upstream industry is discovering oil and gas at unprecedented depths, temperatures and pressures, where lighter, yet tougher, materials are needed to bring the reserves to the surface. Meanwhile, the potential to develop new membranes through which water, but not salt, can pass could help reduce the costs of desalination process used to produce water with low salt content that is very effective in maximising oil recovery.

Greater understanding of materials is also vital to the downstream business, which manages thousands of kilometres of pipelines and will increasingly have to process heavier, more acidic products. Meanwhile, lubricant technology can benefit from developments in smart coatings that can reduce friction in an engine. And in low-carbon energy, greater understanding of materials science could lead to lighter blades for wind turbines

and advanced membranes to create more efficient fermentation processes for the production of ethanol or even biobutanol, which is a more effective biofuel.

The ultimate challenge is to scale the understanding up from the nano level to the macro and therefore create opportunities for practical application. Every time you change the scale of a material, the properties change, so what might be hailed as a metal that is 30,000 times stronger than steel, may only be so at the molecular level. As soon as you produce a tonne of it, for example, the material's behaviour changes.

So, it's important to be able to model the material's behaviour and this requires enormous amounts of computer processing power.

BP's university and laboratory manager for operations, HSSE and engineering, Sheetal Handa, has had first-hand experience of this leap in processing ability. "Fifteen years ago, as an academic, one of my tasks was to scan the structure of proteins to look at how they worked. It used to take me weeks. With the latest computer, I can now do that in about 10 minutes. I can also conduct hundreds

of thousands of experiments in one go and use data analytics to look at the billions of pieces of data they produce to try and pick out patterns."

Universities are at the cutting edge of these technologies, so BP reasoned that academic partnership was vital for the industry to create true advances in materials science. Each of the four universities in the BP-ICAM went through a rigorous selection process and was chosen for its core strengths in materials science. It is BP-ICAM's aim that all four will work collaboratively, sharing data, technology and personnel to create the strongest opportunity to advance industry understanding.

According to Sorrell: "All four universities are outstanding. They have world-class facilities and people, and bring different strengths to this programme. We felt very comfortable when we went through the selection process that Manchester would be excellent at bringing all the parties together to work in a collaborative way."

Manchester is already home to BP's Projects and Engineering College and a major collaborator member within BP's Inherently Reliable Facilities technology flagship programme, which includes a



Atomic view: Professor Philip Withers and Dr Rob Bradley (left), in the Henry Moseley x-ray imaging facility, carrying out 3D x-ray tomography with a 50 nanometre NanoXCT microscope, which has the highest spatial resolution in the UK. Below: a PhD student in the Corrosion and Protection Centre conducting carbon dioxide testing in a cell within the controlled environment of a glove box. Bottom: Professor Grace Burke (foreground) and Dr Sarah Haigh operate the UK's only Titan G2 ChemiSTEM electron microscope.

BP-funded research laboratory in corrosion. It was selected as the hub of the BP-ICAM for its vision in taking some of the most advanced scientific tools in modern materials science and applying them to real-world challenges facing the industry.

Colin Bailey, vice president and dean of the Faculty of Engineering and Physical Sciences at Manchester, believes the university has world-class credentials that make it the ideal hub for the BP-ICAM. "The work we do on advanced materials underpins all our activities in engineering and science, covering all sectors. What makes Manchester distinctive is that we seamlessly work across disciplines, bringing together the skills and resources needed to address the challenges facing industry and society at large."

Those facilities include the Henry Moseley x-ray imaging facility in Manchester that will support work into structural materials and smart coatings; state-of-the-art laser equipment that can study surface chemistry and corrosion processes; modelling and simulation facilities; in-situ crystallisation studies; and a third-generation synchrotron – a type of particle accelerator – providing an unique imaging beamline owned by the university

at the Diamond Light Source in Didcot, which provides three-dimensional images of what is happening inside materials.

Bailey says: "Our imaging beamline at the Diamond Light Source allows us to directly quantify the behaviour of materials from the nanometre to the millimetre scale in the harsh environments that they experience either in their production or their use."

Manchester also has the best electronic magnetic resonance spectroscopy facilities in Europe, including six spectrometers operating at frequencies between one and 90 gigahertz in continuous wave and pulsed modes. The involvement of the Photon Science Institute, located at the university, also brings to the centre optically-detected magnetic resonance and new experiments to develop electron magnetic resonance that works at higher frequencies. These techniques are vital in studying what are known as 'radical-species'. These are materials that contain unpaired electrons and are often implicated in the breakdown of oil-based chemicals and additives, such as lubricants.

What is clear from talking to everyone involved is that BP-ICAM's goals are firmly rooted in the real world. It offers academics and their students the chance to develop their understanding of the fundamental science behind the materials that make up our world, but with the intention that some of the discoveries they hope to make one day will end up in the technology used out on a platform, or thousands of metres below sea level, or in a refinery, or the fuel it produces. The universities will have academic freedom to publish fundamental science resulting from the BP-ICAM's work, while commercial agreements will cover specific technological applications of the work.

"That way," says Sorrell, "the collaborative approach between the four world-leading universities combining modelling, characterisation, fabrication and testing capabilities will enable BP to push forward its understanding of materials science and offers the potential to develop advanced materials that allow us to operate in the challenging environments we are facing in a safer and more reliable way." ■

THE PARTNERS' VIEW

Professor Andrew Livingston, Imperial College London:

"Imperial has world-leading expertise in membrane and separation materials, and will be leading this activity in the BP-ICAM programme. Imperial's membrane capabilities include materials chemistry, membrane fabrication, imaging and characterisation, as well as engineering analysis of membrane applications and membrane manufacturing processes. The imaginative scope and innovative structure of the BP-ICAM will allow us to integrate our expertise with other partners, and to achieve a process scale understanding that is anchored in the molecular structures of membrane materials, and their molecular-scale interactions with membrane systems."

Professor Norman Fleck, the University of Cambridge:

"The Cambridge faculty looks forward to fruitful research activity of direct usefulness to BP. The scope is broad and will initially include the development of new steels that resist corrosion and hydrogen embrittlement, and anti-foul coatings. The Cambridge groups have broad expertise in materials design, characterisation and testing, and modelling skills, from first principles calculations to macroscopic top-down approaches."

Professor Nancy Sottos, University of Illinois at Urbana-Champaign:

"The University of Illinois research programme for the BP-ICAM will focus on the development of smart, highly-resilient materials based on a simple, yet elegant, paradigm in materials design – autonomy. Autonomous materials systems are able to respond and adapt automatically to external triggers, without human intervention. Inspired by the autonomous function in biological systems, we aim to develop structural materials and smart coatings that can sense and self-regulate, self-heal and protect, self-organise and even remodel."





Towering success

Around 110 students from secondary schools took part in the annual Young Scientist Day at BP's International Centre for Business and Technology in southeast England, where they were challenged to design, construct and test a model oil platform, all for \$100 million. The platform needed to stand or float in 30 centimetres (10 inches) of water and had to support a number of weights, with more points awarded to those carrying the greatest weight. The event was supported by members of BP's Challenge graduate programme and interns, who gave up their afternoon to help out. Students were given a brief outline of the different types of oil and gas platforms in operation, before discussing their own designs. An array of materials – including paper cups and plastic bottles – were available and once complete, the platforms were tested. During testing, each team was interviewed by a design judge who assessed the ingenuity of the design, and how similar the completed platform was to the team's design on paper. The winning design went to Cranfield Community School, with second place going to Feltham Community College and third to Chiswick School. ■





The inspiration





Photography > Getty Images/Stuart Conway



generation

It was years in the planning, but this summer, the London 2012 Olympic and Paralympic Games created a host of memories that will stay with athletes and spectators for years to come. As an Official Partner of London 2012, BP was there among the supporters, cheering on its athlete ambassadors, sharing its work with visitors and guests and making the odd dream come true. Over the next few pages, *BP Magazine* relives some of the biggest moments.

Above: Sanya Richards-Ross (US) celebrates winning the gold medal in the women's 400m final, 5 August.
Opposite (clockwise from top): Gold medallist Oleg Panyutin (Azerbaijan) at the medal ceremony, following his win in the men's triple jump F12, 8 September; the Opening Ceremony of the London 2012 Olympic Games took place in the Olympic Stadium on 27 July; Mohammed Al Hammadi (UAE) poses with his silver medal following the men's 200m T34, 4 September; Jessica Ennis (Great Britain) poses with her gold medal, 4 August; Richard Whitehead (Great Britain) crosses the finish line to win the men's 200m T42 final, 1 September; and an aerial view of *The Olympic Journey: The Story of the Games*, a BP-supported public exhibition at the Royal Opera House that featured artefacts from the Olympic Museum in Lausanne, Switzerland.



Top: José Armando Sayovo (Angola) and his guide Nicolau Palanca, compete in the men's 200m T11 semi-final, 4 September. José went on to win gold in the final. **Right (clockwise from top):** women's -44kg powerlifting silver medallist Çiğdem Dede (Turkey) poses on the podium with gold medallist Ivory Nwokorie and bronze medallist Lidiia Soloviova, 31 August; Russian gymnast and gold medal Olympian Olga Korbut poses with aspiring gymnast Annie Walker and her sister, Milly. Olga was one of 16 Olympians featured in *The Olympic Journey* at the Royal Opera House. She met Annie at the exhibition after the eight-year-old wrote to BP. Fatma Omar (Egypt) celebrates a world record lift in the women's -56kg powerlifting, 2 September. Fatma went on to win the gold medal; and Matt Stutzman (US) competes in the men's archery individual compound-open ranking round, 30 August. Matt went on to win the silver medal.





Above: one of two BP showcases at the Olympic Park. Called Fuelling the Future, the 'pop-up' pavilion was designed to project a sense of low impact on its surroundings and invisibility by reflecting the surrounding environment. Inside, visitors sat in a circular room that rotated slowly as a short 360° film took the audience on a tour around the BP world. **Left:** throughout the Olympic Games, around 2,200 guests, including government ministers and heads of national oil companies, visited BP's technology showcase, also located at the Royal Opera House. Called The Technology Experience, the highly immersive showcase used a series of special effects more commonly seen in Hollywood movies to highlight BP technology, such as advanced seismic imaging, refining and petrochemical conversion technologies, advanced fuels and lubricants and lignocellulosic biofuels.



Main image: Stef Reid (Great Britain) competing in the women's long jump F42/44 final, 2 September. Stef went on to win the silver in the event.

Far right (from top): Ilham Zakiyev (Azerbaijan), in white, competes against Wilians Silva in the bronze medal match of the men's +100kg judo, 1 September. Ilham went on to win the medal; the Closing Ceremony of the London 2012 Paralympic Games; and Shelly Woods (Great Britain) competes in the women's 800m - T54 heats, 4 September. Five days later, Shelly went on to win silver in the women's T54 marathon.







Team BP Olympians medal table:

Rebecca Soni, USA Women's 200m breaststroke; women's 4x100m medley relay; women's 100m breaststroke	2	1	
Sanya Richards-Ross, USA Women's 400m; women's 4x400m relay	2		
Jessica Ennis, Great Britain Women's heptathlon	1		
Lizzie Armitstead, Great Britain Women's road race		1	
Rovshan Bayramov, Azerbaijan Men's 55kg Greco-Roman wrestling		1	
Riza Kayaalp, Turkey Men's 120kg Greco-Roman wrestling			1
David Marsagishvili, Georgia Men's wrestling 84kg Freestyle			1

Team BP Paralympians medal table:

Tatyana McFadden, USA Women's 800m - T54; women's 400m - T54; women's 1,500m - T54; women's 100m - T54	3		1
Oleg Panyutin, Azerbaijan Men's triple jump - F12; men's 4x100m Relay - T11/T13	1		1
José Armando Sayovo, Angola Men's 400m - T11; men's 200m - T11	1		1
Fatma Omar, Egypt Women's powerlifting -56kg	1		
Afag Sultanova, Azerbaijan Women's judo -57kg	1		
Richard Whitehead, Great Britain Men's 200m - T42	1		
Mohammed Al Hammadi, UAE Men's 200m - T34; men's 100m - T34		1	1
Ibrahim Ahmed, Egypt Men's shot putt - F38		1	
Çiğdem Dede, Turkey Women's powerlifting -44kg		1	
Rudy Garcia-Tolson, USA Men's swimming 200m individual medley - SM7		1	
Kübra Öçsoy, Turkey Women's team table tennis - Class 6-10		1	
Stef Reid, Great Britain Women's long jump - F42/44		1	
Matt Stutzman, USA Men's archery individual compound - open		1	
Shelly Woods, Great Britain Women's marathon - T54		1	
Dogan Hanci, Turkey Men's archery individual compound - open			1
Ilham Zakiyev, Azerbaijan Men's judo +100kg			1





Right: Richard Whitehead and Jessica Ennis (both Great Britain) wave to the crowds in the heroes parade that took place one day after the close of the London 2012 Paralympic Games. Around 800 athletes travelled on 21 floats through the streets of London to celebrate with cheering fans. **Left:** Rebecca Soni (US) celebrates after finishing first and setting a new world record in the semi-final heat of the women's 200m breaststroke, 1 August. Rebecca went on to win gold in the final the next day. **Top (from left):** Ibrahim Ahmed (Egypt) competes in the men's shot putt F37/38 final, 5 September. Ibrahim went on to win the silver medal; Lizzie Armitstead (Great Britain) poses with her silver medal following the women's cycling road race, 29 July; and BP's giant periscope made up part of the BP Walk in the Olympic Park, which enabled BP to tell visitors how it was contributing to a lower-carbon Games. The periscope allowed spectators to have their photograph taken for free in front of the Olympic Stadium in exchange for signing up to have their Games travel carbon footprint offset by BP Target Neutral.

THE RECOVERY FACTOR

With the search for giant reservoirs increasingly challenging, the ability to sweep more oil and gas out of existing reservoirs is an invaluable tool to a company such as BP. Enhanced oil recovery is not a new idea, but the results from techniques that BP has spent years developing are proving very exciting. *BP Magazine* reports.

Close inspection: An operator in BP's laboratories in Sunbury-on-Thames, UK, monitors the pressure and temperature readings on a rig.



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very single day at its Prudhoe Bay oilfield in Alaska, BP produces gas, along with crude oil, lots of gas. It refrigerates it to around 40°C below freezing and re-injects into the reservoir almost as much gas as is used across the whole of the UK every day.

The process of refrigerating the gas enables BP to extract liquid hydrocarbons that can be blended into the crude oil and sold, but it also allows the company to increase oil recovery from Prudhoe.

BP is leading the way in driving up the amount of oil that can be recovered from the fields it operates. The groundbreaking ideas associated with this practice, known as enhanced oil recovery (EOR), have got the attention of the oil industry world-wide. So what's involved in EOR?

What is a reservoir?

To a non-specialist, a 'reservoir' might conjure images of a large volume of liquid sloshing around in one place. But it is, in fact, rock with millions of tiny holes – or pores – that fill with oil and gas. These pores act as storage spaces. The type of rock in the reservoir will determine the rock's porosity and a reservoir can look like anything from a chunk of airport runway, in other words, extremely compacted, with microscopic pores, to coarse sandstone, with pores that are visible to the naked eye. This variation is caused by the grain sizes within the rock and by the depth at which the reservoir rock is buried. The deeper the rock, the higher the temperature and pressure, causing the rock to compact, and cement to form between the grains.

The nature of the reservoir's pores, or, more precisely, how connected they are – its permeability – is important when it comes to removing the hydrocarbons from the subsurface. The size of the pores determines the rock's ability to store oil and gas, while the permeability determines the rate at which oil and gas will flow from the rock into a wellbore.

Maintaining pressure

In BP, the effort to enhance oil recovery is led by its Pushing Reservoir Limits™ (PRL) team, one of a number of technology flagship programmes in BP. PRL research and development manager Raymond Choo says: "In a typical reservoir, around 10% of the oil can be retrieved by simply drilling a hole, sticking a pipe into the reservoir and



letting the natural pressure force oil up the well to the surface. As the oil is produced, so the pressure falls in the reservoir until it can no longer support a column of oil to the surface. At this point, the well stops flowing.

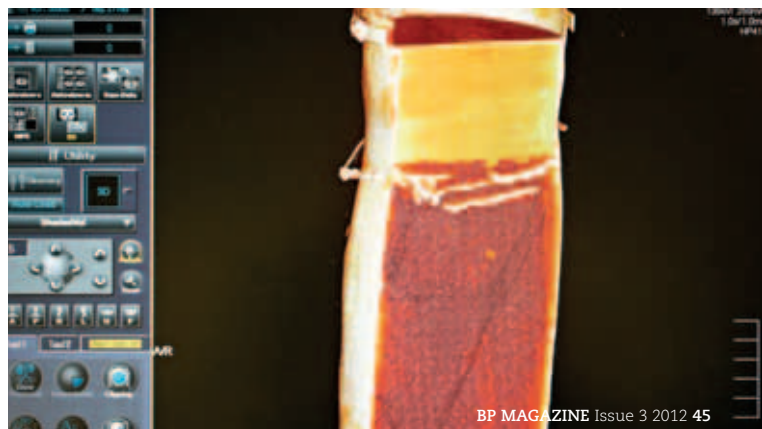
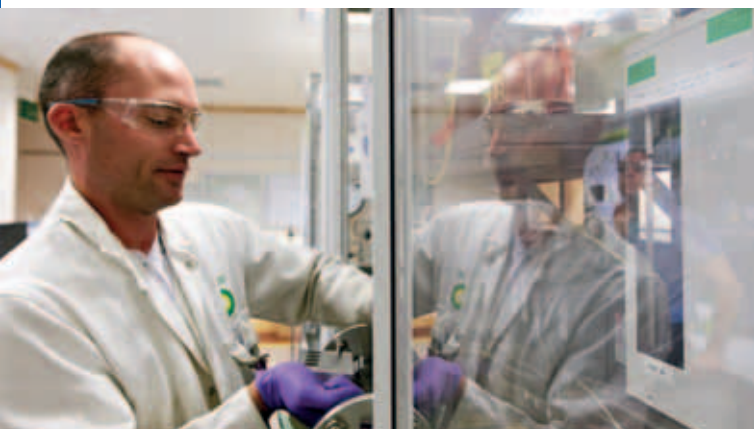
“To get more oil out, we have to maintain that pressure, usually by injecting water – a ‘waterflood’ – or gas. In either case, the injected fluid flows through the pores in the rock, forcing the oil ahead of it. But the injected fluid follows the easiest path, so some pores are missed. Another factor is that some of the oil remains stuck to the surface of the sand grains or trapped in the pores. Also, the injected fluid doesn’t spread out fully from the injection well to access all the rock. These factors combined mean the worldwide average recovery from an oilfield is around 35%.”

An oilfield’s recovery factor is calculated by multiplying together four factors, known as ‘fractions’: pore scale displacement, sweep, drainage and cut-off (see panel on page 46 for an explanation on each of these).

Conventional EOR

BP’s enhanced oil recovery efforts are focused on increasing the pore scale displacement and sweep factors, as these are the smallest of the four and, therefore, have the greatest room for improvement. For some time now, various technologies have been available to improve the efficiency of waterflooding – for instance, substances called surfactants are used to improve the pore scale displacement. Surfactants are similar to washing-up

Daily operations: (far left) a scanning electron microscope image of a core sample. Below: (clockwise from top) measuring the dimensions of a plug sample using digital callipers. This happens before a sample has any experiments carried out on it; performing an enhanced oil recovery water flood on a rig under reservoir conditions; a computed tomography (CT) image of a core sample; loading a core holder into a rig.



liquid; they help to remove oil from the surface of sand grains and reduce the amount that gets trapped in the pores. But they are expensive and, since they are consumed by the rock, you have to inject a lot of them. Another method is to use polymers to thicken the water, which can help to increase the recovery.

Gas injection – the method used at the Prudhoe Bay oilfield in Alaska since 1986, is another option. By processing natural gas to modify its characteristics, BP is able to recover a lot more oil than would otherwise be possible. Some of this gas is used to create what is called

Innovative technology: (below) scanning a whole core sample using a state-of-the-art CT scanner; (below right) making up brines to inject into plug samples.

miscible gas. This gas is very good at pore scale displacement and typically extracts up to 95% of the oil from the rock it sweeps. Prudhoe Bay is the world's largest hydrocarbon miscible gas project.

Similar programmes are in operation in BP-operated fields in the North Sea. EOR at Norway's Ula field began in 1999 and is estimated to account for around 70% of the current oil production there. At the Magnus field, EOR started in 2001 and is estimated to account for around 30% of current production.

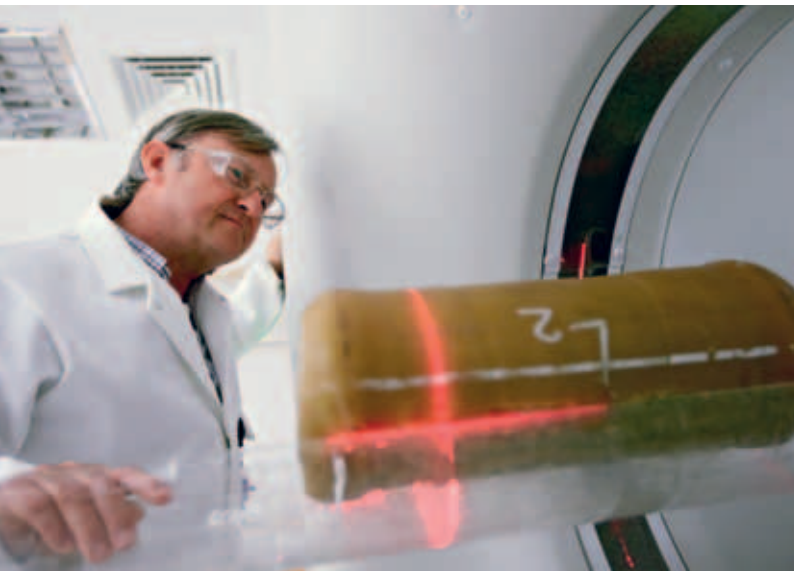
PRL and the new technologies

BP's leading technologies have come about as a result of a deliberate choice by BP's PRL team. Rather than simply continue the industry's progress in incremental development of existing technologies, the team chose to focus on revolutionary low-cost EOR techniques.

Low salinity water (LoSal® EOR)

Seawater is commonly used in traditional waterflooding techniques, injecting it into reservoirs to maintain pressure. The PRL team saw evidence that low salinity water containing almost as little salt as drinking water can release oil that would otherwise remain bound to the sand grains. The team carried out many inhouse laboratory tests using real reservoir rocks, followed by further tests in rock around actual wells, before finally conducting a full-blown, multi-million-dollar field trial at the Endicott field in Alaska. Here, the team injected low salinity water into one well and monitored the resulting oil production from another.

Todd Buikema, manager of the PRL deployment team, says: "The development of LoSal EOR technology has taken 20 years, with BP publishing numerous papers reporting on progress as it



THE RECOVERY FACTOR FRACTIONS

- 1. The pore scale displacement fraction:** how good the injected substance is at forcing oil from the gaps in the rock that it accesses.
- 2. The sweep fraction:** how good the injected substance is at spreading out from the injection well and accessing all the rock.
- 3. The drainage fraction:** how much of the reservoir is not in contact with any wells (for instance, because they are isolated by natural faults in the rock).
- 4. The cut-off:** how long you are able to continue producing the field until it becomes uneconomic due to physical or commercial constraints.

pioneered the way forward. All this effort has been rewarded with the world's first sanctioned offshore low salinity project at Clair Ridge in the UK. The Clair Ridge platforms will be equipped with desalination equipment to reduce the salinity of the 145,000 barrels per day of injected water that are needed.

"This should deliver approximately 42 million barrels more oil than a flood with conventional seawater would," says Buikema. "This translates to around \$3 per incremental barrel, which is pretty impressive in the world of EOR."

The technology is so effective that BP has decided that low salinity waterflooding should be the default for all future sandstone waterfloods. Other low salinity deployment projects are at various stages of development, including plans to include *LoSal* EOR in the second phase of the US Gulf of Mexico's Mad Dog field.



Improving sweep with Bright Water™ particles

The properties of sandstone rock vary a lot, depending on the size and mix of the sand grains it's made from and whether other features are present. Sandstones tend to form as a sequence of layers, some of which may have low permeability and some high. Often, there are a few layers with much higher permeability than the rest of the field. Fluids flow most easily through the more permeable layers, so, this is where water from the injection well will naturally go and rapidly push out the oil.

But, these more permeable layers quickly fill with water, which then starts to be expelled along with the oil. Once this happens, any more water entering this layer is wasted as there is little oil left to push through, so the water cycles through, down the injection well, rushing through the water-filled layer and up the production well. Because these layers tend to 'steal' a disproportionate amount of the injected water, they are referred to as 'thief zones'.

To combat this, BP had the idea of a particle that could block off these zones deep in the reservoir between the injection well and the production well and co-developed technology known as Bright Water particles. Paul Denyer, Bright Water particle deployment manager, explains: "The particle is a long-chain molecule held in a tightly-bound ball – rather like a ball of wool. These balls are so small that they can be added to the injection water and pass unimpeded through the reservoir rock. When cold seawater is injected, it is warmed up in the thief zone by the hotter, unswept rock above and below it. This breaks some of the links in the Bright Water particle and the tightly-bound ball pops open into something around 10 times bigger.

"These bigger molecules struggle to get through or become completely stuck in the tighter gaps between the sand grains and the water flow is dramatically reduced. The result is that the injected water is forced to take a new path and sweep new rock, which then increases the oil recovery from the field."

BP has demonstrated the performance of the Bright Water particle in fields in Alaska and its Argentinian joint venture, Pan American Energy, and elsewhere. Bright Water particle treatments performed so far by BP have provided additional hydrocarbon resources estimated to be

more than 20 million barrels above what might otherwise have been recovered without treatment, and at an attractive EOR cost.

Winning teams

The PRL group that came up with these innovative solutions is organised into four teams covering research and development, laboratory, deployment, and computation rock physics – developing new technologies for reservoir characterization and performance prediction that are important to optimising oil recovery. The teams are centralised in BP's two main upstream technology centres in Sunbury-on-Thames, UK, and Houston, US.

The world-class laboratories they use contain equipment such as whole-body medical CT scanners for seeing inside the rock samples. With a successful track record established, the PRL teams are growing to cope with the new technologies and to ensure that BP extracts the maximum benefit from their deployment.

PRL technology innovation leader Andrew Cockin says: "BP has been a leader in EOR for a long time. We operate the world's largest hydrocarbon miscible gas project, as well as several other significant projects, such as at Magnus and Ula. We have created novel, highly-cost-effective EOR technologies and have more EOR technologies under development to revolutionise EOR further and increase the recovery factor."

EOR is starting to show that it has the potential to make a real contribution to resource replacement. Cockin says: "Historically, oil companies moved on to new fields when conventional oil production fell to uneconomic levels. As the hunt for new giant oilfields gets harder, so the desire to recover more from existing fields increases. When national oil companies are considering who to partner with, the ability to recover more oil is a quality they value more and more.

"This is a good time to be working in enhanced oil recovery and a valuable area for BP to be a world leader." ■

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- *LoSal*® EOR is a registered trade mark of BP plc
 - Pushing Reservoir Limits™ is a trade mark of BP plc
 - Bright Water™ is a trade mark of Nalco Energy Services LP

THE GOLDEN GIRL

BP has supported 62 international athletes, as they prepared for the London 2012 Olympic and Paralympic Games. Among them is wheelchair athlete Tatyana McFadden who, eight years ago, emerged as the youngest member of the US Paralympic track and field team, aged 15. She came home from Athens with a silver and bronze medal, but, despite her success on the world stage, when she joined high school later that year, she was not allowed to participate in the athletics team. Rather than give up, Tatyana and her family took legal action, which eventually resulted in new legislation in 15 states, giving students with a disability the right to compete alongside their peers in school sports. Today, Tatyana is a full-time student at the University of Illinois at Urbana-Champaign, where she juggles training for both sprinting and long-distance events with classes in child and family development. She has come a long way since her early childhood in a Russian orphanage, where she did not have access to a wheelchair and learned to walk on her hands. Adopted in 1994 by Deborah McFadden, then commissioner of disabilities at the US Health Department, Tatyana returned to St Petersburg for the first time last year, where she presented one of her marathon medals to the orphanage director who cared for her.

Report > Amanda Breen Photography > Getty Images

TATYANA MCFADDEN

Sport: wheelchair athletics
Events: 100m, 200m, 400m, 800m, 1,500m – all T54 category – and marathon

Age: 23

Main achievements:

2004, silver medal in 100m and bronze in 200m at Paralympic Games in Athens; 2008, silver medals in 200m, 400m and 800m, and bronze in 4x100m relay at Paralympic Games in Beijing; 2009, winner of wheelchair division, Chicago Marathon; 2010, winner of New York City Marathon; 2011, four gold medals in 200m, 400m, 800m and 1,500m, and bronze in 100m at the IPC Athletics World Championships in Christchurch, New Zealand; 2011, winner in wheelchair division of the Chicago Marathon.



Finish line: Tatyana celebrates as she wins gold in the women's 800m T54 final at the London 2012 Paralympic Games, 5 September 2012.



On competing in London...

This is my third Games and I was just itching for a gold medal. Winning gold in the women's 400m T54 was an exciting experience and I got goosebumps when I was sitting on the podium. I had to focus on the start, the transition and finish in that race because it was always going to be a tough race against the best of the best. I didn't know how far ahead I was, but knew that if I slowed down at all, then the others would catch me up. The buzz in the stadium definitely helped me. The crowd is there to support, help and encourage and I think it gives the athletes an extra energy. It was the same in the 800m event. I just pushed with spirit and all the training I've had in the past four years. I let the crowd carry me and I let my faith and my family carry me.





Athlete ambassador: left, Tatyana poses for one of her official BP shots. Above, Tatyana competes in the women's 400m T54 heats during the London 2012 Paralympic Games, 3 September 2012. She went on to win gold in the final. Right, Tatyana poses with her gold medal from the women's 800m T54 final. Tatyana won three gold medals and a bronze at the London 2012 Paralympic Games.

On the importance of education...

In sport, you can always pick up an injury that may mean you can no longer compete and then what do you have left? No-one can ever take a college degree away from you, so that's why I choose to study now, at the same time as pursuing a sports career. I like learning as well and it's nice to have something to focus on other than just racing.

I have to be very disciplined to fit in everything; I had to set out a schedule where I train in the morning and then do classes in the afternoon, or the other way round. You have to manage your time really well. It's tough; I don't want to miss training or be late for class.





On her fight for equality in sport for people with disabilities...

It was overwhelming to compete at my first Paralympic Games in Athens [in 2004]. Aged 15, I had no idea what I was doing, but at that moment my dream came alive. When I came home, I don't think my high school understood what sport was about. It's about inclusion and that's what both the Olympic and Paralympic Games demonstrate.

I wanted to show the school that we are all the same. We are all humans and

want to be part of society. It was definitely a battle to join the track team; we had a lawsuit, but we sued for no money. It was just for the opportunity for people with disabilities to be involved with sports. That is very important and the legislation changed lives and opened doors for a younger generation, like my sister, Hannah.

It is hard to educate others about what the Paralympics really mean, how we are elite athletes just like

the Olympians. Things are improving, though; sponsorship opportunities have increased and that brings more exposure to the public.

Going back to my experience at school, I remember my friends, who are still friends today, used to tell me they didn't know how to ask me over to their houses, as they didn't want to offend me if I couldn't get up their steps. I told them 'you're offending me by not inviting me over.' It's just a learning process.

On being a BP London 2012 athlete ambassador...

I'm honoured to be supported by BP – along with the eight other US ambassadors, the company has been here for us as we pursue what we love to do. It makes me want to train harder and become faster. There have been plenty of fun activities, meeting people across the country, and it's been great to be included in all those opportunities.



Leading lady: above, Tatyana poses for an official BP photograph that includes the company's branding. Top left, Tatyana competes in the women's 100m T54 at the 2008 Beijing Paralympic Games. She won four medals in 2008 – silver in the 200m, 400m and 800m and a bronze in the women's 4x100m relay.

On returning to Russia, her country of birth...

I remember leaving the orphanage when I was six years old; we went to a hotel and I thought 'wow, is this America?' It was definitely an eye-opener: I'd never seen anything before and I didn't even have a wheelchair. When I arrived in the US, I got a wheelchair and then another. They gave me the freedom that I never had before.

I was really sick as a child – you would not recognise me; I was so anaemic, pale and weak. But when I went back to St Petersburg last year, after the London Marathon, I was healthy and a champion. I felt it was time to return and the whole experience was so fulfilling. I was excited to see all the children there – it was an honour.

I gave my New York Marathon medal to Natalia, the director, I guess as a way to say thank you for keeping me alive and protecting me over the years. It was really important to me. I have other chances in life to win medals, but she is the real hero.

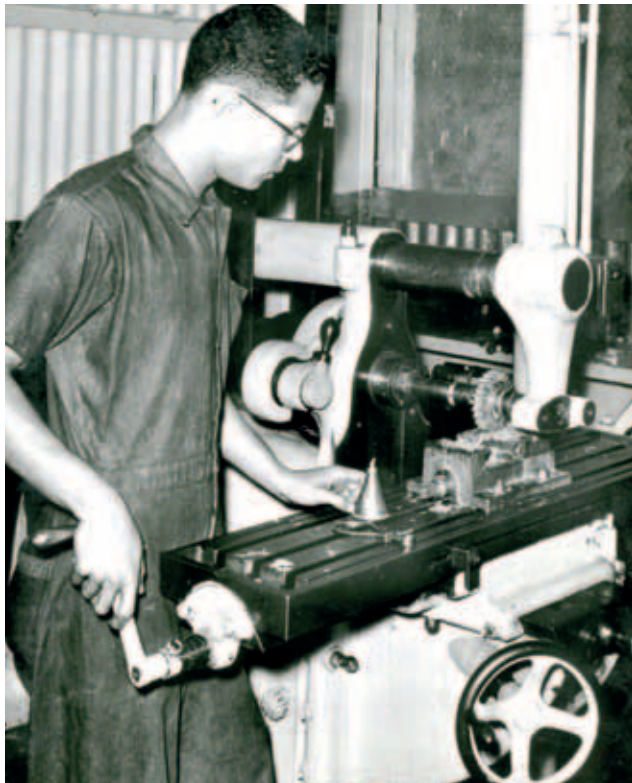


CARIBBEAN CHRONICLES

Trinidad and Tobago enjoyed its first oil boom after 1910, although the abundant natural gas in its reservoirs was only fully appreciated several decades later. These photographs record some of the earliest days of the dual-island nation's hydrocarbon industry.

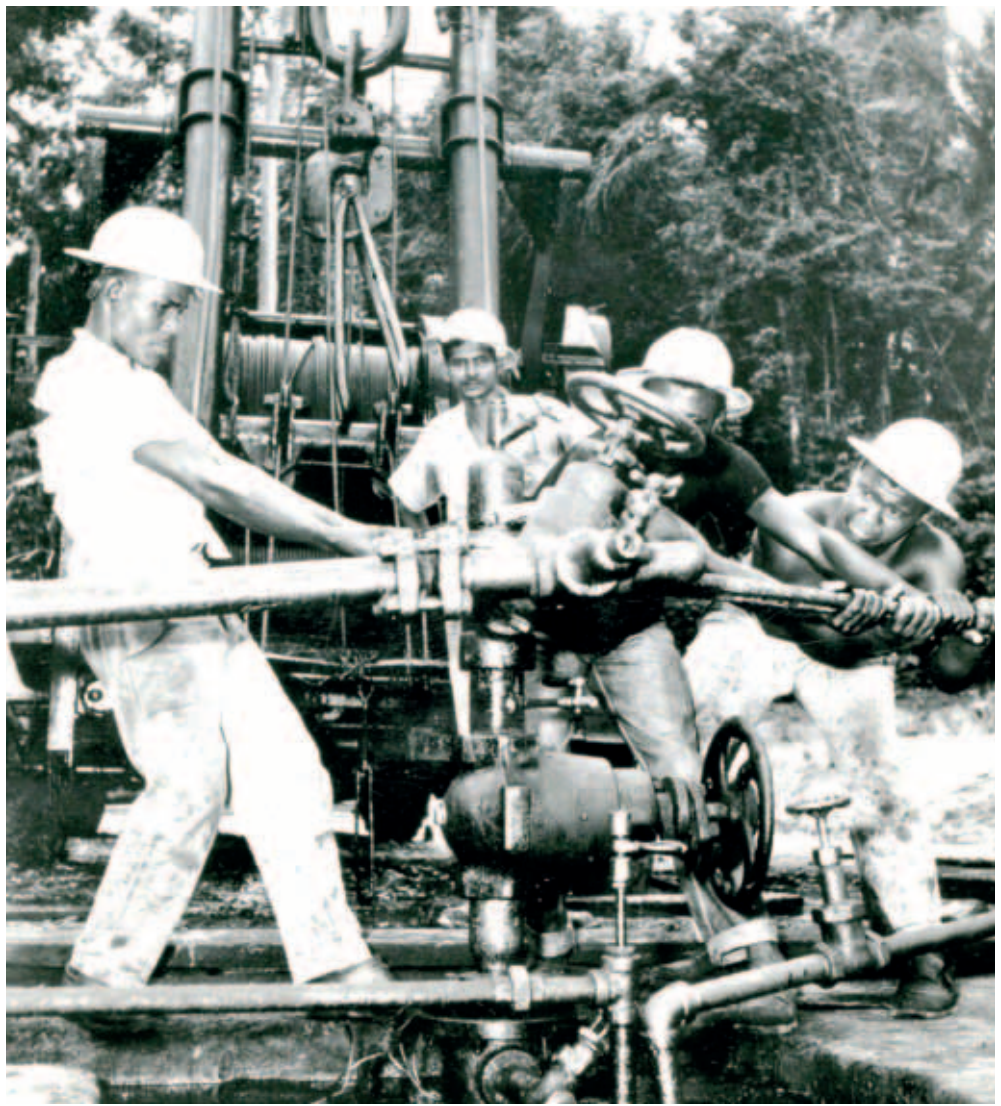


Far left: a photograph of well number 15, located in 44 acres of the Perseverance Estate, near Guapo. Taken on 11 February 1922, a handwritten note on the top of the photograph records that the estimated flow at that time was 14,000 barrels. **Above:** oil workers – known as roughnecks – from Kern Trinidad Oilfields Limited, are photographed beside drilling equipment at an onshore field. BP acquired Kern in 1961. This photograph was taken in 1930-1. **Left:** the Boodoosingh absorption plant. Photograph taken March in 1925.



Top: a section of Dalley Village, the Trinidad Petroleum Development Company's housing programme for foremen and more senior employees. BP acquired the company in 1960.
Left: an apprentice for the Trinidad Petroleum Development Company mills a test piece of equipment in the apprentice trade school, 1957.
Above: buildings on the Perseverance Estate near Guapo, June 1925.

Right: a production department well servicing crew from the Trinidad Petroleum Development Company. Having completed subsurface repairs to a well, the crew is shown replacing the Christmas tree prior to resuming production of oil, 1959. **Below:** a mobile drilling platform operated by Trimmar in the Gulf of Paria. When drilling is being carried out, the platform stands clear of the water on eight legs that support it from the seabed. To the left of the platform is a production test barge used for measuring and separating the oil and gas flow from any new well, which is not connected to the field-gathering system, 1964. **Bottom right:** the driller on a heavy diesel engine drilling rig adjusts the automatic feed control, which maintains a constant load on the drilling bit as it drills a well, 1957.





In a whirl

BP photographer Stuart Conway captures a frenetic dance during a visit to Turkey. This image was shot at a show at the Hodjapasha Cultural Centre, which is located in a restored 550-year-old Turkish bath in Istanbul. During the show, dances from different regions of Anatolia were performed, as well as group and solo oriental dances with modern choreography and specially-designed costumes and live music.

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