Into deeper water

Oil exploitation: The world's apparently unquenchable thirst for oil is fuelling a boom in exotic kinds of exploration technology for use in much deeper waters

"FIVE to ten years ago, if you came to me with the idea of a directional well that stretched 25,000 feet...I'd have said you're dreaming. But today, we're just kicking them down one after the other." So says Brian Kuehne, an oil driller at Royal Dutch/Shell. He and his colleagues from the drilling side of the business were gathered at the firm's regional office in New Orleans to brief *TQ* on the impact of recent technological advances on oil exploration and production (E&P).

Using fancy charts and slides, potted histories and personal anecdotes, the drillers claimed that astonishing breakthroughs were transforming their business. Sceptically, your correspondent headed to Shell's Ursa platform in the Gulf of Mexico to see for himself. The drillers were indeed wrong: their claims were far too modest.

This $1.5 billion platform is one of the most sophisticated in the world. For a start, its remarkable "tension-leg" design allows it to sit safely atop 3,800 feet of treacherous water—a depth thought unconquerable only a few years ago. The floating city of steel is so heavily instrumented that its control room looks like something out of "Star Trek". Ursa pumps so much oil—115,000 barrels or so a day—that it has paid for itself in less than three years of operation.

And there is plenty more to come. On the day your correspondent was present, the crew drilled an elaborate multi-directional well that twisted and turned its way to a giant pocket of oil 28,000 feet away from the platform. Gone are the days of straddling an oil-field and drilling vertically down to get at it. "We drilled wells in the same way for 100 years," says Raoul Restucci, boss of Shell's Exploration and Production Company. "But, in just the past few years, we've seen dramatic changes in technology that are greatly reducing the cost of accessing a molecule of oil." Mr Restucci should know: his firm has produced two-thirds of all the deep-water oil ever pumped from the Gulf of Mexico.

The secret to Shell's success in such risky realms is technology—plus an attitude that ensures that the company profits from that technology. However, Shell is not alone in pushing E&P technology to the limit. ExxonMobil, the other oil major investing seriously in such technological know-how, is also using ultra-deep-water platforms.

At ExxonMobil's laboratories in Houston, located up the road from Shell's own much-trumpeted research institute, teams of top researchers present a dazzling display of the sort of technology that supports the firm's $10 billion a year in upstream capital spending. The company has come up with "next generation" seismic-imaging techniques that allow reservoirs to be visualised on a screen in minutes rather than the months it would have taken a few years ago.

How? Clever software and advanced algorithms are part of the answer. But brute force has its place as well. Tucked behind a semi-circular screen of a virtual-reality amphitheatre at ExxonMobil's laboratory is over $80m-worth of high-end computing infrastructure, i[...] supercomputers (known as th[...] "analytic brain"). Ask the resi[...] searchers whether claims about [...] few years of technological chang[...] aggerated, and the response is as s[...] is breathless: "We are on the cus[...] matic technological breakthroug[...] ploration and production."

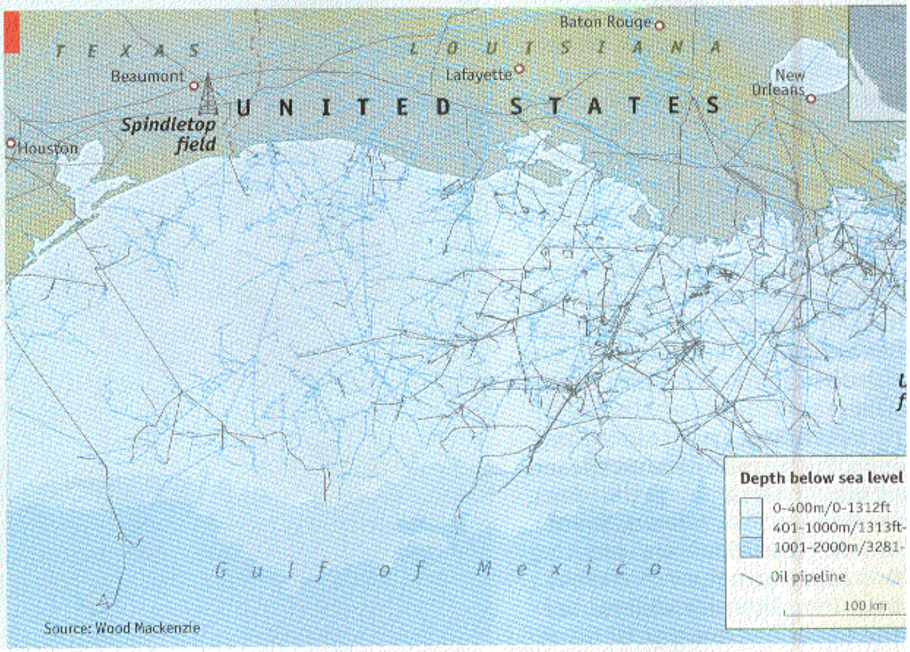
Why now? Part of the answe[...] the enormous promise of deep-v[...] ploration—the oil industry's final [...] It was the development of tech[...] such as advanced seismic imag[...] encouraged firms to venture into [...] hospitable (and, once, unpromis[...] rain. In turn, the early and spe[...] success of developments such as [...] driving further innovation.

The final frontier

With all the continents (save Ar[...] having been drilled to death over [...] century, geologists believe that [...] few "elephant" fields left to be di[...] on land. Just about the only vir[...] tory left is under the sea.

Drilling under the sea is noth[...] For decades, the North Sea and [...] Gulf of Mexico have been big oi[...] ers. Until recently, however, ma[...] gists were convinced that offs[...] would be found only in shallow [...] The sorts of rock conducive to p[...] accumulation, they argued, w[...] found only in ancient river de[...] other formations close to shore.

Veterans of the oil industry re[...]



Source: Wood Mackenzie

multi-directional well that twisted and turned its way to a giant pocket of oil 28,000 feet away."

only a few years ago, the notion of finding oil under thousands of feet of water was ridiculed. However, thanks to advances such as seismic imaging—plus some lucky strikes by a few intrepid deep-water pioneers—that view has been debunked. Oil majors are now betting that enormous amounts of oil are trapped under the ocean off Brazil, West Africa and the Gulf of Mexico.

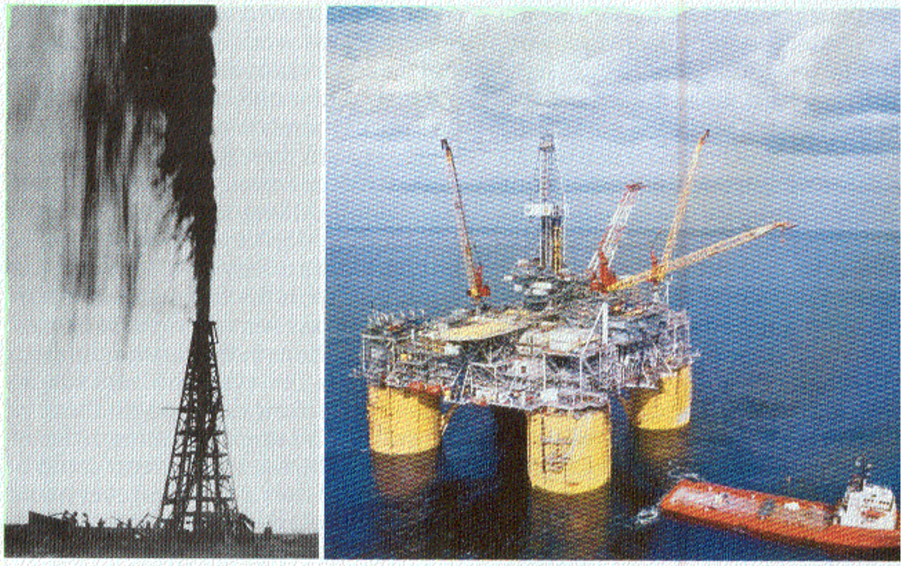
Flying from New Orleans to Ursa, the history of America's offshore exploration can be seen below like a busy and crowded scene from a Brueghel painting. The shallow waters teem with activity as oil rigs, supply vessels, drilling ships and the like go about their business. The skies are full of helicopters ferrying crews and visitors to and from the rigs. And hidden beneath the surface lies a lattice of pipelines that pump the oil and gas ashore (see map on the previous page).

Today, all of that activity peters out along a line where the underwater contour sinks to below 1,500 feet. But James Dupree, head of deep-water production in the Gulf of Mexico for BP, predicts that, in a decade's time, a similar map will show the infrastructure extending out to waters where the depth is more than 5,000 feet. But turning that vision into reality is going to be one of the biggest challenges the oil industry has ever faced.

That is because finding, drilling, producing and transporting hydrocarbons in ultra-deep water will be hideously expensive without several breakthroughs in E&P technology. Although the picture is unclear for the industry as a whole, the few companies with deep enough pockets are taking the long view, and see the billions required to develop such technologies as prudent—even necessary—investments. As Ken Miller, vice-president for technology at ExxonMobil Upstream Research Company, puts it, "this undoubtedly accelerates technology development, because we simply cannot afford to drill our way to knowledge at $30m-40m per deep-water test well."

Bigger than elephants

Aside from the race to deep water, three other forces are now driving Big Oil's technological frenzy. The first is the need to squeeze more out of existing oil-fields. That makes sense, and not just because there are few elephants left to discover. A century after the industry's first gusher tapped Spindletop in Texas, discovering new oil-fields and trying to suck them dry remains more miss than hit.



From Spindletop in Texas to Ursa in the Gulf of Mexico

The average recovery rate for an oil-field remains a dismal 30-35%. In other words, of all the oil proven to exist in a given reservoir, companies typically get only about a third to market. So technology that raises the recovery rate by just 5% across a firm's portfolio would contribute much more to the bottom line than hunting for new elephant fields to exploit.

The key is not simply to cajole more oil from the oil-bearing rocks of a main reservoir, but also to tap smaller fields nearby that were previously uneconomic, by using such tools as multi-directional wells. Euan Baird, the boss of Schlumberger, an oil-services company, has his sights set even higher. He wants to develop techniques—particularly real-time monitoring of wells—that will lift recovery rates to 50% or 60% within a decade.

The second factor behind the oil industry's present scramble to embrace the new E&P technology is that oil reservoirs are self-depleting assets. Once a well is drilled, an unrelenting geological process is unleashed that depletes the reservoir even if none of the oil is pumped out. Not counting exploitation, today's mature fields are declining by an average of 7-8% per year. In Venezuela, the natural depletion is as high as 25%. The reasons for this vary from place to place, but have to do with the interplay between water, natural gas, sand and other forces "downhole", over which man has little control.

In recent years, the oil industry has spent vast sums on such techniques as sand management, exotic cement coatings for wells and other techniques to slow the natural depletion process. But the problem can only get worse. For thing, most of the world's oil-field ageing fast; for another, the techno that increases production levels tod likely to accelerate depletion rates to row. This is the curse of the E&P busi firms have to run just to stand still.

The third force behind big oil's tec logical push is the world's insatiabl petite for hydrocarbon fuels. In its l "World Energy Outlook", the Inte tional Energy Agency (IEA) forecasts global production of oil must rise fro day's level of less than 80m barrels a to around 115m barrels a day by 2020 pected demand is to be met. Experts a Houston office of McKinsey, a mar ment consultancy, reckon that when an incremental demand is added to existing task of compensating for de tion, the result is equivalent to addi whopping 65m barrels a day of oil duction over the next two decades. producers in non-OPEC countries a meet that challenge, the IEA believes must invest about $1 trillion (in tod money) upstream over the next deca much of it on technology.

One of the few things that the in try's scientists agree on is that there be no single "silver bullet" technol More likely, there will be a flurry of vances in three broad areas, which gether, should add up to impro recovery rates and lower costs. Such provements will come from better vis isation of reservoirs, better placen and drilling, and—crucially—better n agement once the wells are in product

The desire for better visualisatio

average 'finding and development' cost of oil ha
fallen to a third of the $20 a barrel it was."

oil reservoirs is longstanding. During the early days after the Spindletop discovery, oilmen turned to "doodle-buggers"—soothsayers who claimed to be able to detect oil underfoot using a forked stick. By the 1920s, the industry had started using a crude form of seismic analysis—setting off a stick of dynamite in a hole to detect unusual patterns in the waves reflected to the surface.

However, it was the arrival of 3D seismic imaging in the late 1980s and 1990s that transformed the industry. By helping to make sense of what is going on inside the rocks below the earth's surface, this has made the process of finding oil much less of a hit-and-miss affair. By McKinsey's reckoning, the net benefit to the global oil industry from 3D seismic imaging (through reduced drilling costs, additional reserves exploited and so on) amounts to $11 billion a year.

Still, there is plenty of room for improvement. Today's visualisation techniques, for example, are not particularly good at seeing through salt layers (such as those found under the deep waters of the Gulf of Mexico). A flurry of research initiatives to remedy such shortcomings is under way. One ExxonMobil researcher even claims that his firm is developing detection techniques that will accurately locate hydrocarbons with 100% certainty. How might this magic actually work? Unsurprisingly, the firm is not prepared to give an answer.

There is no question that accurate seismic data will lead to better placement and drilling of wells. Today's drillers are already using techniques that were unimaginable by roughnecks in the 1970s. On the Ursa platform, for example, the drillers that hit that pocket of oil 28,000 feet away did so without extreme effort and without risking having their fingers chopped off by whirling pipes. Nearly all the dangerous work is now mechanised, and the supervision is done not at the drill but in a comfortable control room that is well out of harm's way.

Things still do not go completely like clockwork, however. As Tommy Morrison, Shell's drilling supervisor on Ursa, admits, "You don't know you're going to hit oil till you actually hit it." Yet even that could change in the future. Smarter drill bits that encase sensors capable of measuring conditions in the surrounding rock could act as the eyes and ears for the driller. By looking far enough ahead of the drill bit and communicating to the operator in real time, adjustments could be made so that the rig found oil every time. Other technologies in the works include improvements to multidirectional wells, and "slimhole" drilling.

But perhaps the most ambitious of all is better management of wells once they are in place. Here, the use of chemicals pumped down the well under high pressure could enhance the fracturing of low-permeability rocks—thereby increasing production. Installing compressors at the bottom of wells could help to stave off the decline in reservoir pressure over time, and so boost oil and gas recovery.

Another idea is "downhole processing". Instead of coming up with oil, firms often end up producing gas or even water. Techniques for separating oil, gas and water using equipment embedded in the well itself, or installed on the sea floor, could prove a dramatic improvement. If combined with new techniques for re-injecting unwanted water or gas back into the reservoir, this approach could prove to be a far cheaper and more productive way of extracting oil.

Further off are wells that will, in effect, run themselves—calling for help only when things go wrong. Schlumb
developing wells that are equippe
elaborate electronic sensors and fu
rather like computer servers, wit
own data networks and Interr
dresses. Mr Baird draws inspiratic
the medical world: "Today we mar
wells as if the patient had to die
treatment, since wells cannot d
their symptoms to us. In future, re
monitoring of wells will help ale
that we can rescue the patient—or
delay his demise."

Putting the wells online

The Schlumberger boss goes furtl
predicts that the oil-exploration b
will become increasingly like the
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Anderson of Columbia Universit
York, is confident that "the wired,
oil patch will allow instant access
monitoring of all the company's
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But as wells become more an
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is any guide. Thanks largely to tech
cal advances, the average "finding
velopment" cost of oil has fallen tc
of the $20 a barrel it was two decac
Meanwhile, the average "lifting" c
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Such improvements may be o
beginning. Dr Anderson is now a
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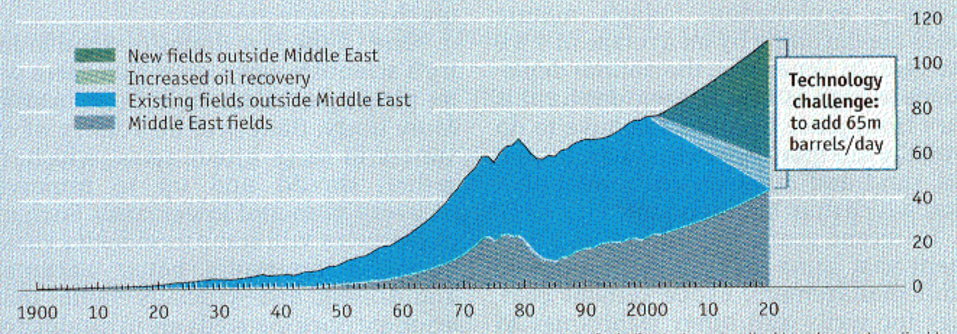
could help the oil industry to s
deep-water exploitation costs by a
as 50% and cut delivery time in ha
the much greater pay-off possible
water (each of the various wells
forms like Ursa are ten times bigg
typical onshore wells) and one
glimpse of the new economics tl
technology could deliver. ■

Demanding task

Global oil* production, m barrels/day



Source: McKinsey

*Including hydrocarbon liquids and natural gas liquids