



...don't expect the scarcity of fossil fuels to drive us toward alternative energy

The Oil Frontier

By Bryant Urstadt Photographs by Paul Taggart

The easy oil is gone. To get to the new oil, you board a yellow Bell 407 helicopter outside New Orleans and fly south, touching down 140 miles offshore, on a ship that's drilling holes in the seabed nearly a mile below.

Along the way, you fly down a 50-year timeline of American offshore oil extraction. Through the glass panel at your feet, you watch the delta slide by with its flat islands of green and its fishing camps, occasionally passing the remains of a barge rig—the first and simplest waterborne oil rigs, which simply settled in the mud and drilled. After the barrier islands come the brown waters of the continental shelf of the Gulf of Mexico. Here, the platforms increase in number but are only slightly more complicated; of the roughly 4,000 platforms in the gulf, most are simple scaffolds standing on the bottom in 30 to 200 feet of water.

But the barge rigs and the fixed-leg platforms are the past. So you keep flying, and the rigs grow scarcer but larger, until you leave the silty waters and hit the blue of the deep water, which shimmers like an opal lit from within.

Out here, 4,300 feet above the seafloor, floats *Discoverer Deep Seas*. Leased by Chevron, it's a ship that would have been too expensive to use 10 years ago, a ship that represents 20 years of advances in the art and science of oil extraction. It's not particularly beautiful. With its derrick amidships and its rusty waterline, *Deep Seas* looks like a ghost tanker trying to make off with the Eiffel Tower. But it is a breathtaking expression of ingenuity, and a glimpse of what we'll increasingly have to do to get energy.



sources: we are getting much smarter about finding and extracting oil.



HERE THERE BE OIL
The *Discoverer Deep Seas* floats 190 miles south of New Orleans.

BUSINESS END Drill bits on *Deep Seas* run about \$80,000 each. Beneath the ship's derrick is the "moon pool" (opposite), where the drill string is submerged, piece by piece.



The ship is so big that my incomplete tour will take a day. It's 835 feet long—on end, it would be the height of an 80-story skyscraper—and 125 feet wide. Because it is so tightly packed with machinery, a visitor winds through *Deep Seas* rather than walking its perimeter, as one might on a cruise ship, and never gains a full sense of its size.

My guide is Eddie Coleman, the lead drill-site manager on *Deep Seas*. A quiet Texan in a denim Chevron shirt and jeans, Coleman has spent the past 32 years offshore, working two weeks on and two weeks off, shuttling between his home of Brookhaven, MS, and platforms and drillships progressively farther offshore and more advanced. Like most of the people I meet in this business, he says he wouldn't want to do anything else.

Coleman is in a decent mood, but he could be happier. Last night, the drilling in a well that Chevron calls PS002 stalled at 20,351 feet. *Deep Seas* doesn't produce oil; it drills for it, capping the wells and leaving them to be put into "production" by equally expensive and complicated floating platforms. The oil field that *Deep Seas* is exploring is called Tahiti, and it's about 24,000 feet below a 5-by-1.5-mile section of seafloor leased from the Minerals Management Service of the U.S. government, in an area known as Green Canyon. PS002 is the second well of a scheduled six, and the whole field is slated to go into production in 2008. Chevron hopes to pump 125,000 barrels a day out of Tahiti.

Pumping is a long way off, though, and now the drilling has stopped, too. "We tagged something," explains Coleman, "but we're not sure what. So we're tripping right now." To "trip" means to bring the drill bit back up or send it back down. Coleman and a team back in Houston have decided that the casing, the tube that is dropped down in increasingly narrow segments as drilling progresses, in order to maintain the integrity of the well, has probably gotten out of round or developed a spur of some kind. So once they've tripped the bit back up, they'll send down a mill to bore out the casing. And when they've retracted the mill, the bit will have to be tripped down again.

The trip takes about 12 to 13 hours either way, and it's expensive. *Deep Seas* is leased from a company called Transocean, and the daily rent is about \$250,000. With the cost of labor and equipment, drilling in Green Canyon costs Chevron around \$500,000 a day. Casing, for instance, costs around \$100 per foot. The drill bits run around \$80,000 each, and there are 140 to 175 well-paid people onboard, from cooks to highly trained geologists. Developing the Tahiti field will cost about \$3.5 billion.

Because of the resulting financial pressure, *Deep Seas* hasn't been back to shore since it was launched five years ago. Every six months or so, a supply ship pulls up alongside and pumps a million gallons of diesel onboard. The fill-up takes about 24 hours. The diesel runs six generators,



which send five megawatts of power to each of six electric omnidirectional thrusters, which keep the ship in position. On a calm day like this, the thrusters, fed by GPS data and overseen by a team of dynamic-positioning operators on the bridge, keep the 100,000-metric-ton ship essentially stationary; it drifts only by inches over the well below.

A Race to the Bottom

The term "deepwater" generally refers to wells drilled in more than 1,000 feet of water, and Chevron, like all the big oil companies, has kept a weather eye on deepwater prospects for years. An exploration well in the leased Green Canyon region, for instance, was drilled in March 2002, and it went down 28,411 feet, through a two-mile-thick layer of salt and into a 400-foot-deep pay zone of sand and oil.

In November 2002, Chevron began developing the oil field, starting with a series of appraisal wells drilled at its estimated north and south ends to offer a clearer idea of what was there. The results were better than Chevron expected. The pay zone looked to be 1,000 feet thick and 7.5 square miles in size. If all goes well, Tahiti ought to be about a 500-million-barrel field, a huge find in today's market.

Lured by such prospects, oil companies have been pressing into ever deeper water, with Chevron, Kerr-McGee, and BP leading the field in the Gulf of Mexico. Abroad, major prospects include the waters off West Africa, the South



China Sea, and possibly even the Mediterranean. From 1997 to 2003, the number of deepwater projects in the Gulf of Mexico grew from 17 to 86. The number of ultradeepwater projects in the gulf, those in more than 5,000 feet of water, has more than doubled in the last two years alone. In the past 10 years, as inshore wells have slowed down, deepwater oil production has risen more than 840 percent.

When Chevron began developing Tahiti, it ordered a platform. Like everything in the deepwater field, platforms are moving toward new heights of size, complexity, and cost. They can't simply rest on columns driven into the seabed, so they have to float; but otherwise, their design varies. Some platforms, like BP's *Thunder Horse*—currently the largest, it is bigger than the largest aircraft carriers and took 15 million man-hours to build—float on pontoons. Tahiti's platform will be designed as a spar, which is often likened to a Coke can. The spar is delivered horizontally to the site and then tipped into place as its bottom fills with saltwater ballast.

At a time when oil prices have been as high as \$75 a barrel, such costly equipment more than pays. It follows that Chevron and Transocean have already worked out a long-term lease on a yet larger ship, *Discoverer Clear Leader*, which is to be delivered in 2009 and will cost Transocean some \$650 million to build. Similar in many ways to *Deep Seas*, it will have a larger drive unit at the top of the derrick, allowing it to drill in up to 12,000 feet of water, boring as far as 40,000 feet below sea level. It's expected to cost Chevron roughly \$750,000 a day to lease and operate.

Twelve thousand feet of water is bordering on the practical limit of exploration, at least in the Gulf of Mexico. It may not be as far as technology can take deepwater drilling, but it is probably as deep as Chevron will need to go to get oil. "Get any deeper, and you're leaving the sedimentary deposits of organic matter that make oil," says Paul Siegele, who oversees the company's offshore exploration and development in the gulf. "The bottom of the deep ocean is just solid basalt." Not that the oil companies haven't started to survey the deepest ocean floors anyway, just in case.

Roughnecks and Mud

Coleman takes us through the *Deep Seas*' 200-bunk living quarters, its offices, and the bridge, and then out onto a catwalk that hovers over the deck. Below is a rack holding "risers," 75-foot-long sections of pipe that house the drill string on its way to the seafloor. The drill string isn't actually a wobbly piece of cable but a series of 130-foot-long hollow pipes "strung" together, which push the bit down through the risers and into the earth. Enormous cranes lift each section of riser onto a conveyor belt. The belt then tips and guides each riser into position in the derrick.

The catwalk follows the riser belt onto the drill floor of the 226-foot-tall derrick. It's the derrick, a giant scaffold

narrowing toward a peak, that you think of when you think of an oil well. From it hangs the hook holding the drive that spins the drill string and the bit below. There used to be a guy way up there, on what's called the monkey board, but automatic pipe-racking systems have recently replaced him. Dozens of sections of drill string are stacked inside the *Deep Seas*' derrick, and they swing with the slow motion of the ship. Beneath the drill floor—which we'll visit later—is the moon pool, the one spot of transcendent beauty on *Deep Seas*. There, the risers and the drill string within vanish into a pellucid square of water, fish shimmering around them.

Right now, two roughnecks—and yes, they still call themselves roughnecks—are helping guide sections of drill string down an opening in the drill floor, directing a machine that connects the segments. Overseeing the roughnecks are about eight guys watching computers in the glassed-in driller shack. They monitor information from sensors embedded in the drill, which measure things like how much weight the hook at the top of the derrick is holding, the pressure inside and outside the drill string, and the speed at which the bit is turning.

We leave the derrick and head down a few stories to see the mud module, which looks a little like a cross between a brewery and a sewage treatment plant. "Mud" is one of the most important tools in the driller's kit, though it is rarely thought about or mentioned outside the industry. A synthetic or petroleum-based lubricant, mud is sometimes said to look like chocolate milk. Deepwater drilling requires the synthetic version, which was developed in the mid-1990s. It has two outstanding qualities: it maintains its lubricating properties under higher pressures than the traditional diesel-based mud, and it's not classified as a pollutant by the U.S. Environmental Protection Agency. In the mud module, just past the derrick, are stored 15,000 barrels of the stuff, which—at \$165 a barrel—is a king's ransom in mud.

Mud does more than lubricate, though. It is pumped down the well—through the drill string and out the bit—and it comes back up inside the riser, bringing with it "cuttings," chips and shards of sediment and rock. Mud can be made in different weights, and at great depth it exerts immense pressure on the casing and on the walls of the "hole"—the freshly drilled bottom of the well. That keeps equally huge geological pressures from collapsing the well or, worse, starting oil flow too early, which is the definition of a "blowout." Spindletop, the 1901 Texas well that rained something like 800,000 barrels of crude on amazed prospectors, is the classic example of a blowout.

After leaving the mud module, we head back along the deck until we meet *Hercules*, a remote-controlled submarine, which is currently sitting under a crane and ready to swing out alongside the ship. At 4,000 feet below, everything is done by the unmanned *Hercules*; it is simply too



WEATHER EYE On the bridge, operators monitor (clockwise from upper left) drilling data, the moon pool, the chopper deck, and two depictions of the ship's position over the well.

deep for human divers. *Hercules* is a box of mechanical arms, propellers, cameras, and lights overseen by contract technicians. Of its two remote arms, one is controlled by joystick and the other by a glove of sensors attached to the hand and arm of the operator. The setup is accurate enough to turn a half-dollar-sized bolt with a wrench.

The \$8 Million Question

In some ways, *Deep Seas* itself is a remote vehicle, directed by Chevron's Houston office. This becomes clear on our return to Houston, where, the next morning, we watch Curt Newhouse at work. It's just before 8:00, and Newhouse is sitting in a room with 20 other people, trying to make a decision. If his decision is wrong, it will be expensive; in his job, pretty much every type of error is. "No matter what, it always seems to take about \$8 million to fix," he says.

A Louisiana native, Newhouse has been working at Chevron for 24 years and is now senior drilling superintendent for *Discoverer Deep Seas*. Even though he's running things, he's only onboard about four to six times a year.

The room he's sitting in is called the WellDecc, or Well Design and Execution Collaboration Center. Here, every morning, Newhouse and a group of geologists, petroleum engineers, and earth scientists—the subsurface team—gather to decide what to do next on *Deep Seas*.

In the WellDecc is a conference table that does not quite accommodate all the staffers. Crammed in, they all face a wide screen, which has a number of windows projected on

it, controlled by a desktop computer and a wireless keyboard in front of Newhouse. One window is a video feed of the team on the *Deep Seas*, while another shows the group in the WellDecc. Another window is a graphic display of the progress of the bit, and the last is dense with numerical measurements from the well. Newhouse will move and manipulate these and add others throughout the conference.

Newhouse's staff has been watching everything that has happened on the drillship in the past 24 hours. Information about mud weight, bit depth and speed, the resistance of the material being bored through (to determine whether it contains oil or water), and the kind of stuff coming up with the mud is all uploaded to Houston, where it is pored over in each cubicle until the group gathers each morning.

Because of what he has learned about yesterday's drilling, geologist David Rodrick is worried that the bit is moving too quickly through the layers of the Miocene era, which settled between 5 million and 25 million years ago.

There are many such layers—containing a lot of sand—and Chevron numbers them by their rough age in millions of years. In this well, the bit is at M12, the pay zone is at M21, and each level is at a different pressure. Drilling from one layer down to another is a delicate operation, and the integrity of the hole is maintained by the pressure of the mud pumped into it. Too little pressure and the hole or the casing above it could collapse. Too much and leaks could develop, or fractures in the rock, disturbing mud circulation.

Having already drilled two wells nearby, the subsurface team knows that at M17, the pressure ramps up quickly. The \$8 million question is when to stop drilling and step down to the next size in casing, which can withstand more intense pressure. Reduce the casing size too early and you needlessly



SEA ROVER Deep Seas' remote submarine, *Hercules*, does the work 4,000 feet below.



lose valuable oil flow. “We don’t want a straw down there,” says Newhouse. “We want to see a good 30,000 barrels a day.” Stick with the bigger casing too long, and the deepest part of the well may collapse before it can be cased.

Newhouse, though, isn’t convinced the bit is close enough to the M17 sands to change the casing yet. He’s thinking about the future of the well, 10 years down the road, and he wants to see a good flow, not an overly conservative casing decision.

The group decides to continue drilling, but slowly, and to watch the numbers on their desktops as they come in. Rodrick is tentative about the decision. As the meeting is winding down, he reiterates, “You don’t want to get within 200 feet of those M17 sands, because those pressures will come up fast. If we don’t watch out, it’s going to eat our lunch.”

Looking for More

Behind the drillships and platforms, and the superintendent in the WellDecc, are the computer geeks, whose efforts to guess where the oil is are often credited with enabling the deepwater rush. One of them is Barney Issen, the Jerry Garcia of Big Oil. A guy with a beard and long wavy black hair parted in the middle, he happily admits to driving for years with a “Question Authority” bumper sticker on his car. He has questioned how the earth came to be, too. “Most of us ended up here because we had that moment on the mountain, wondering how it all came to pass, and how we could learn more about it,” he says. For Issen, that path led to a degree in geophysics—he originally wanted to work on a moon shot—and a job running the computers at Chevron.

To get an idea of where oil is, ships with special air cannons send out blasts of vibration, which travel down tens of thousands of feet and back. The velocity of the returning signals, and their round-trip times, are recorded by sensors on miles-long cables dragged behind the ship. Signals reflected by different strata have different speeds, which helps geologists picture what lies below the ocean floor. The big problem in deep water is the layers of subsurface salt, which refract vibrations in confusing ways. “It’s like trying to see things through those cubes of glass, or through the edge of a fish tank,” explains Issen.

Every year, Issen gets better at making sense of erratic signals. Computers have been getting faster and algorithms more powerful, and oil companies are beginning to be able to see through the salt with some degree of certainty.

When Chevron gets ready to talk about drilling, it gathers with investors, often other oil companies. They meet in a room they call the Visualization Center, and they all look at Issen’s models on an 8-by-25-foot screen. Sometimes the decision makers don 3-D glasses. Other companies have even experimented with projecting models of the seabed on 360-degree surround screens in an environment called a “cave,” but, says Issen, “that can be more cool than useful.” Investors bring their own models to the conversation, and a consensus about where the oil is begins to emerge. It’s still a business that requires guesswork: three out of four deepwater drills are unsuccessful. But not long ago, companies drilling on land hit oil in only one of every ten wells.

As the oil companies get better at finding the oil, though, the oil is getting harder to find. Optimists believe that the march of technology, embodied by *Deep Seas*, will enable companies to extract more and more oil from previously “depleted” fields while continuing to get better at finding and developing new fields. My visit to *Deep Seas*, and the time I spent with Chevron’s geologists, seemed to give credence to the optimists’ view of things. A shortage of oil, it appeared, was only a shortage of ships, computers, and other drilling technology.

But while it is true that a lot of good oil is left in the deep waters of the Gulf of Mexico—the Minerals Management Service estimates that about 44.5 billion barrels of oil remain to be discovered—deepwater drilling is only a small part of the solution to the oil shortage. Although Chevron considers the 500-million-barrel Tahiti field an “elephant” of a find, for example, elephants aren’t what they used to be. Saudi Arabia’s Ghawar field, which was tapped in 1951, has already yielded some 54 billion barrels and may have 70 billion more. The United States alone, meanwhile, consumes roughly 20 million barrels of oil every day.

Money will help, though. The higher prices go, the more oil companies can do. While discussing other projects, Siegele mentioned that the economic “breakover” point for mining the tar sands of Alberta was north of \$60 a barrel; oil had reached \$75 that day. There may be 150 to 300 billion barrels of recoverable oil in those sands. As for Issen, he is looking forward to mapping new territory and using better seismic imaging. “There’s a lot of uncertainty, yes,” he says. “But clearly, we think there’s real potential.” ^{TR}

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We need a realistic strategy. Since humankind will inevitably be drilling for and digging up more and more fossil fuels, we must begin to ...