.

THE NEW YORK TIMES

January 14, 2011

The Will to Drill

By BENJAMIN WALLACE-WELLS

Oilmen are optimists, by creed if not always by nature, and early last spring things looked, as those in the industry like to say, prospective. The deepwater rigs in the Gulf of Mexico were steadily drilling, with no suggestion of any impending calamity, and oil was flowing from the vast finds in offshore Brazil. Circumstances looked particularly prospective to a geophysicist named Jim Farnsworth, who works for Cobalt International Energy, a company that held a group of leases 50 miles from the mouth of Angola s Cuanza River basin. It was at that site, he had come to believe, that an enormous basin of oil lay, beneath an obscuring layer of salt, in rocks deep below the bottom of the sea. The industry had been over this territory a decade earlier; a few scattered wells were drilled into the Cuanza basin, and then, having found little oil, the companies plugged them. In seismic images, you could still see the pipes, running through the sediment of the ocean floor.

Farnsworth said he thought those wells hadn t gone nearly deep enough. He had his eyes on a buried ridge that lay some three miles below the ocean surface. His team of geologists thought a multibillion-barrel oil field was running along the crest of the ridge. They had worked over the seismic images, processing and reprocessing them until the feature came looming into view. In all my years as an explorer, you don t see structures that big very often, Farnsworth told me. No one knew if it actually held oil. But Cobalt acquired the leases and named the prospect Gold Dust.

I first met Farnsworth in August, at Cobalt s Houston offices, as his team was preparing to travel to Luanda, to make its final presentation to the Angolan government before it drilled. As best as Cobalt s scientists could figure, Gold Dust displayed near-perfect conditions for gathering oil. The shape of the basin suggested a lake, dried and pinned against the slope of the ridge. In the images were a set of features that looked like branches on a tree; they could have once been the fingers of a delta that fed carbon-rich sediment down into the lake some 150 million years ago. If that was the case, all of that prehistoric carbon would have spent millennia transforming into oil. An outside team had come to examine the data Cobalt assembled for Gold Dust; if the ridge held oil, the scientists concluded, it would likely hold between three billion and six billion barrels of it.

Oil exploration has an unexpected quality of whimsy. The artistry lies in acts of narrative imagination, the ability to take disparate wisps of data and insist that oil must exist in a particular spot and then to entice a company with your enthusiasm. The independent assessor s figures put the chance of a strike at 1 in 3, and Cobalt estimated that drilling a single exploratory well in that region would cost $100 million. Those are strong odds in the industry, 1 in 3, because the success rate for exploratory wells is generally between 10 and 30 percent. But still, the well would most likely fail. I think it s a great story, Farnsworth said, but you can get caught up in the enthusiasm. Yet if no one ever got caught up in the enthusiasm, nothing would ever be drilled.

Oil reserves have been declining for a decade, and it is an article of faith among petroleum geologists that the easy oil easier to find, less complicated to drill has all been extracted and that the explorers are now into the hard oil. When the Deepwater Horizon rig, drilling an exploratory well deep into rock through a mile of water and three miles into the ocean floor off the Louisiana coast, struck a highly pressurized pocket of oil and gas, causing an explosion, it was in some ways a consequence of this iterative, competitive game, each generation of discoveries pushing further into the unknown.

A few years ago, the industry norm was to drill at depths of 15,000 or 20,000 feet. Now the frontier is 35,000 feet, where engineers find higher temperatures and pressures. The scarcity of new reserves has been driving companies into plays that have previously been seen as extremely high risk and high cost, said Brian Maxted, the chief executive officer of Kosmos Energy, a deepwater-exploration company in Dallas. The trend recently has been in going toward ever-deeper waters and ever-more challenging environments.

These circumstances have also subtly redefined what it means to be a wildcatter and changed too the oilman s relationship with risk. There are still a few relics in the industry who fit the old image flamboyant, big-talking backslappers but Farnsworth, who was lured to Cobalt from a job running worldwide exploration for BP, is pretty much the opposite of all that. He is neat, controlled and a bit of a worrier; his mind is filled with probability ratios.   Everything we do is managing risk,   he told me. It s also about managing his disappointments.   Frankly, what I remember are the stupid dry holes I drilled,   he said. Part of this is perhaps inherited; three generations of Farnsworths before him worked in steel, and they may have bequeathed a sensitivity to the ways in which majestic industries decline and their certainties fade. But it has made him well suited for this moment, when the finds have become harder and exploration is stalked by doubt.

What concerned Cobalt executives about Gold Dust was that the rock at these depths might have been too compressed   by the pressure of the overlying sediment   to make it a good reservoir for oil. Oil needs to find light, porous reservoir rock so that it has a place to collect. Currently, there is no way to examine the deep Angolan geology directly, but a former Cobalt geologist named Mike Lentini believed he had found a convincing analogy. Geologists know that the rocks on the Brazilian coast are close relatives to the deep Angolan rocks   these rocks were formed eons ago at the same time and in the same place. In 2002, Lentini was on the Brazilian coast, and he saw rock that was strikingly light and porous   the perfect reservoir for oil. If the relationship between the geologic history of Brazil and Angola was as precise as Lentini thought it was, then the Angolan rock that Cobalt hoped to drill into might still hold oil. It was a conditional, hopeful insight. But it was enough to get Cobalt into this region of Angola a little bit early and win the pick of prospects. Knowing the details of Brazil s geology, Lentini told me,   was like having the Rosetta Stone.   It gave the industry license to dream; analysts soon speculated that the finds off Angola might compare with the giant ones off Brazil.

The possibility of a boom commands particular attention now, because the industry s faith in a limitless future has begun to diminish. The International Energy Agency   which had until recently been optimistic about oil   concluded last fall that the world has very likely already passed its peak oil production.

  The deepwater was one of the last big exploration plays on the planet,   says Gerald Kepes, a partner and head of upstream and gas at PFC Energy, a consulting firm.   We re now looking at the second half of the global deepwater play. You can see the end of it, maybe 25 years from now.

This is not the only way of looking at the data; other analysts, recalling the technological advances and the unforeseen finds that have marked exploration s history, are more positive. But that optimism also depends, in some part, on whether the mass of subsalt off Angola s coast approaches the size of that off Brazil s. And the first clues to answer that question will be revealed, in part, by what Cobalt finds at Gold Dust.

Each exploration geologist has his own imagined map laid on top of the real one, pinpointing where he believes the globe s undiscovered hydrocarbons its oil and its gas must lie. The maps concentrate on the earth s tectonic margins and in the deep water on those areas downslope of the deltas that empty the earth s largest rivers. Big rivers the drainage basins for the continents are usually where you begin, says Dan Worrall, who was a top exploration geologist at Shell.

Oil is generated deep in the earth, from the crushed remains of the continent s rotting organic matter phytoplankton, plants, algae. Over millions of years, given the presence of precisely the right time, temperature and pressure, this material can cook into oil. The hydrocarbons in the Gulf of Mexico were bequeathed by the Mississippi River and the ancient rivers that preceded it; those lying off Angola s shore were deposited by the Congo River and its forerunners, as well as older lakes; and those off Nigeria, by the Niger River. Oil is a product of ancient life.

But these conditions are rarely found in neat balance. Oil requires three elements: the charge (the oil itself), a reservoir (a layer of rock as porous as patio flagstone, into which oil can flow) and a trap (most often a subterranean fault, which physically keeps the oil from leaking). If a river has dumped too much sediment on top of the remains of ancient algae, it will overcook the matter and turn oil first into natural gas and then into unusable material. Too little sediment means no oil at all. These are rare and precise conditions, and there are only a few rivers big enough to produce what explorers call the elephants, the finds large enough to justify the enormous costs of deepwater drilling. And so the elephant hunt takes place on a concentrated, focused map, and any suggestion of a new basin brings great attention.

For most of the last two decades, offshore Ghana was written off. Even the crudest measures were able to detect seeps of oil, emerging from cracks in the earth. Yet there was no obvious geologic feature that might trap the oil, and the area was thick with dry holes what had been there, geologists were convinced, had long ago leached away into the ocean or remained trapped in accumulations too small to be economically recoverable. But Maxted and the other scientists at Kosmos, one of Cobalt s competitors, saw something in the plate tectonics and geology that looked promising: a pinchout of rock along the continental shelf, where Maxted thought the rock character may have shifted, trapping oil inside. There were none of the more obvious geologic lures faults, young rock which is why most companies had passed Ghana by. They named the prospect Jubilee; it is one of the most significant finds of the last few years. We blew Ghana off; the industry blew it off, Scott Sumner, a former Cobalt geologist, told me. We forgot Jed Clampett, Beverly Hillbillies geology: If you see an oil seep, drill.

But strikes of this magnitude are comparatively rare. According to United States Geological Survey data, the earth, as it was before oil companies started drilling, held between five trillion and six trillion barrels of oil, most of which has been discovered or remains inaccessible. In 2000, the U.S.G.S. estimated that there were around 650 billion barrels on the planet yet to be found, and most analysts say that the estimate is a pretty good one. We may still see some new basins on the scale of offshore Ghana, Kepes, of PFC Energy, says. But there aren t going to be new Gulfs of Mexico or Nigerias that we haven t yet discovered.

These legendary basins have sustained careers for the life of the industry. The seduction of the Gulf of Mexico has always been its complexity the physics of continental shift compressed into a small, enclosed basin. The gulf has been the laboratory in which explorers experimented with the deep they call it the GOM, as if it were a discarded character from Tolkien. The first deepwater play came in minibasins on the slope that had caught young sands as they tumbled out of the ancient Mississippi; now there are the Perdido folds, in very deep water, that bunched up like a rug on a slick floor, trapping oil underneath. This play depends upon a compacted sheet of sandstone and shale deposited here approximately 50 million years ago by the uplift that produced the Rocky Mountains and, almost as an afterthought, sent an anaconda of sediment sliding down toward Texas and out into the sea. The depths here are so extreme that Shell, which operates the enormous Perdido field, has moved more equipment to the sea floor. The wells extend out each one long and flexible, like the legs of a mantis over an area as large as metro New Orleans.

 We ve got four, five, six years left in the Gulf of Mexico, James Painter, who leads Cobalt s team there, told me. He could imagine a couple of possibilities beyond that, but neither was perfect there were very likely to be gas fields deep underneath the continental shelf, where high pressures make drilling very complicated, and there might be a Cretaceous play left in the gulf, though that was iffy. In my mind, we ve got one more shot, he said.

Last February, Richard Sears, a geophysicist who was vice president for exploration and deepwater technical evaluation at Shell and is now senior science adviser to the National Oil Spill Commission, appeared at the TED ideas conference in Long Beach, Calif., to give a talk about the future of energy. Sears says that there are between 30 and 50 years left before a broad gap opens between worldwide oil supply and demand. It is hard, he says, to describe a situation that is either a lot more optimistic or pessimistic than that. At TED, Sears held up a pincushion of the globe, with red thumbtacks stuck in. Each thumbtack represented an oil basin. This is it, he said. This is the oil in the world. Geologists have a pretty good idea of where it is.

These last 650 billion barrels are the hardest. There are still some areas Iran or Iraq or Russia where you can literally fly over in a plane and see big structures lying right out there, and they are undrilled, Farnsworth told me. But much of that territory has been reserved for national oil companies, and so in the last decade 43 percent of the industry s new reserves have come from the deep water. It s gotten harder all along. And the structures, generally, have gotten smaller.

But as the map has compressed, and the possibility of finding new basins has dwindled, explorers have returned their attention to the regions where vast deposits of oil have already been found, in the belief that new technologies might allow them to drill deeper. These aspirations drove new finds earlier this decade in offshore Brazil, and the continued work in the Gulf of Mexico. They also compelled the industry toward Angola, where Western oil companies have sustained production onshore and in shallow water for decades, even through a long civil war. There had been some deepwater exploration and production, but few had looked beneath the broad layers of salt.

Salt, in the deep water, is the hydrocarbons shroud, the mask that obscures the prize. Geologists use seismic instruments to map the earth s layers shooting pulses of compressed air down into the subsurface and measuring the time it takes for the sound to travel back to the surface. But salt the evaporates of ancient oceans, trapped deep in the rock scatters the signal. And so for years the zones that interested oil companies looked like blurred daubs underneath the thick aprons of salt it was difficult to distinguish sedimentary layers or to scout for traps. Companies left those areas alone and explored where they could see. By the middle of the decade, though, seismic techniques were finally becoming refined enough to permit companies to make out the details of subsalt geology. In the Gulf of Mexico, deepwater is more or less a subsalt business right now, Keith Jantz, a geophysicist at Cobalt, says.

In 2006, geologists working underneath salt layers in Brazil s Santos basin discovered the Tupi Field so vast that it prompted Brazil s president at the time, Luiz Inácio da Silva, to compare it to a second independence. If finds of this size could now be detected below the Brazilian salt, then perhaps they could be found in Angola too.

But pinpointing an exact location is painstaking work. For the better part of a year and a half, Jantz and a few other geologists had been staring at the seismic images of a prospect off Brazil called Aegean, for which Cobalt holds a lease and is planning to drill. Like Gold Dust, Aegean lies underneath a layer of salt. To detect features underneath the salt, a seismic boat is sent out, towing an array of receivers along several five-mile-long cables. The crew shoots compressed air into the subsurface at intervals of 123 feet and measures the reflection s velocity. The resulting picture looks like static on an old television. But now, after a year of processing, the image looked more like a fingerprint, with ridges and valleys, and you could make out what was attractive about the prospect in the first place: a series of features 30,000 feet below the sea. The fault, Jantz hoped, formed a trap for oil.

In the area where Cobalt planned to drill, there was a deposit that Jantz thought might be shale. While they re drilling, if the engineers expect to encounter one substance and suddenly hit another, it could cause problems. Another geophysicist, Roland Chen, mentioned a recent such surprise that took millions of dollars worth of drilling muds in order to unstick the pipe. Jantz, it turned out, worked on that project.

I heard they should have known from the seismic, Chen said.

They should have known, Jantz said.

What troubled Chen and Jantz about the Aegean prospect was the difficulty they were having resolving the boundary line that separated what they thought was good reservoir rock, rich in oil, from what they thought was salt. On the image, the boundary looked nearly vertical. Industry experience is that seismic images below salt have trouble with angles over 50 degrees, Jantz pointed out; he was worried that, in the real world, the delineation between salt and sediment interference might be very steep. The scientists worked over the image examining it from different angles, separating out data to make a partial image. For long periods of time they stared silently at the projection, in a dark conference room, willing the earth to reveal itself. It didn t.

This kind of uncertainty clouds most new projects. One geologist told me he would show me the tools he used to find oil when all else failed; he then produced a divining rod and a crystal ball. It was a joke, but one made frequently enough that he had a divining rod and a crystal ball lying around. The essential mystery of exploration that it is impossible to know precisely what exists below until you begin to drill and the push into more complicated depths and environments mean that an engineer often has only a dim read on what he is drilling into: unexpected pressures, slopes and formations. The enduring oddity of the Deepwater Horizon spill was that it took place in a prospect where major problems seemed unlikely comparatively shallow, very well mapped, mature.

It s frustrating to me, Farnsworth told me. It s never going to change, but the general public always thinks, I should be able to get a gallon of gasoline, and it should be damn cheap, and whether I choose to drive a 10-mile-per-gallon car or a 40-mile-per-gallon car should have no impact on that price. We know how hard it is to explore for oil, and we know how hard it is to get it out of the deep water. And there s been this incredible disconnect, which might have been lessened by the spill, between what people think it takes to get gasoline in their car and what we do.

There is an element of uncertainty in every complicated engineering endeavor. In July 2003, in the Pacific, a Japanese fishing boat was sunk by a flying cow, Robert Bea told me. Bea is a professor of civil and environmental engineering at the University of California, Berkeley, and a leading scholar of risk; he also spent many years working in research and management at Shell. The cow, it turned out, was part of an illegal cattle shipment bound from Anchorage to Russia; as the plane approached its destination the smugglers became nervous about their cargo and began shoving it out of the plane. No risk analysis can ever be complete. No one can predict a flying cow.

Drilling engineers suffer from the tyrannies of darkness and depth, and these conditions limit what they can do when these systems do fail. The real problem with going so deep is not that the possibility of failure is greater, Bea said. But if something does fail, the consequences are so much greater. In shallow water, you can physically contain a spill. But at this kind of depth that becomes dramatically more difficult.

I visited Houston late last summer, and though the hole in BP s well had been filled, the industry s executives still seemed wary and grim. The rigs that could move had largely gone overseas, and those that couldn t were sitting motionless in the gulf. The fallout from the spill will change how we explore, says Joseph Bryant, chairman and C.E.O. of Cobalt.

Stricter regulations mean that it will take much longer to do the same things. Large companies have the resources to wait, but wildcatting independents don t. To play the game now, you ll need a deep portfolio of opportunity spread out over years, he says. If you want to be an explorer in the gulf, you can t just drill one well anymore.

Bryant shattered his knee a few days earlier, when the horse he was leading across a Wyoming stream got spooked and jumped into him, smashing the executive against a rock. This is an insensitive thing to say, but I ll say it anyway, Bryant said. When all the dust has settled on [Deepwater Horizon] and believe me, no one s felt the pain more than I have people will start remembering all those ghastly images of the oil coming out of that well and start thinking that s 10 million dollars a day flying out the end of that pipe. That s a lot of money.

One of the oddities of oil exploration is that its climactic event the moment when an exploratory well is sunk into the earth and the drill bit comes into contact with oil happens in extreme sequestration, and the geologists who have spent years preparing the prospect, obsessing over it, are reduced to watching online, from halfway around the globe. The industry practice is to attach instruments to the drill bit as it burrows through the rock, and so the geologists watch the data stream in real time, hoping to see signs of a strike but often seeing nothing at all. The interim is just a long hesitation, in which they find themselves obsessing over stray bits of information.

The geologists at Cobalt had been trying to figure out, in the analog way of exploration, how anomalous Gold Dust was. In Brazil and elsewhere in Angola, they found that companies probing underneath the salt had detected similar carbonate mounds, formed from the collections of aquatic life that collected in ancient lakes buried deep in the rock. The details of the shapes he thought he could see on seismic images of Gold Dust corresponded nicely with mounds that produced oil elsewhere. But still, the percentages hadn t changed. The likelihood of a strike was still 30 percent.

Throughout the summer and fall, with their drilling operations in the gulf suspended, the companies worked on their portfolios, processing and refining their seismic images, reranking their prospects. By the late fall, the remote Cuanza basin had become the site of a rush. Three months earlier, Cobalt was just about the only company in. Now the Angolan government is putting up more territory for lease, and analysts at Morgan-Stanley expect bids approaching $1 billion. But Cobalt had seen Gold Dust early, and it has already leased a rig to drill the prospect which the

Angolan government has since renamed Bicuar, after a national park this spring. The moratorium in the gulf helped to concentrate the industry s attention on Angola, and the Cobalt prospects, Bank of America s oil industry analysts concluded, became pivotal the key to determine the validity of Angolan pre-salt.

Farnsworth wasn t convinced that Cobalt would strike at Gold Dust, but he was convinced that there was oil somewhere beneath the Angolan salt layer. This well, the first drilled into the play, functions in some ways as a $100 million probe into the geology. His team had been working the prospect for years, and a certain obsessive antsiness had set in. Throughout the fall, Cobalt s scientists studied previous wells drilled into carbonate mounds in West Texas, in Brazil to learn what tools were needed to test how good the reservoir rock was, how perfectly the prospect sealed. They had for months continued to fret over where, precisely, to locate the well. In my view, and I ve heard this from a lot of people, Farnsworth said, these will be the most closely watched wells drilled this year.

Luanda, Angola s capital, has become a testament to what oil can bring. A few years ago the city was just emerging from decades of civil war. Now the streets are filled with cars, and for ex-pats, rents can be more expensive than in London. On a long spit of land called Ilha de Luanda, the beach is lined with cafes, and it is possible for the oil workers who congregate there in the evenings to imagine that they are on the opposite side of the Atlantic, in Rio de Janeiro where they would find a comfortingly similar geology.

The oil industry has always fit perfectly in the American Southwest. It has inherited the region s frontier ethos blunt, optimistic and aggressive and turned it into something associated not with cultural relics but with technology and success. Oilmen of Farnsworth s generation have spent their careers spreading this ethic to boomtowns around the world, along with the hopeful feeling of infinite possibility. I think a lot of that optimism is ingrained in us, Farnsworth said. We don t always think about the macro effect of the deepwater exploration tailing off in the next 30 years. We think about how can we make new discoveries and how can we do it better than the other guy.

I asked Farnsworth what he thought would happen to exploration. One possibility, he said, was that explorers would wind up in the more mundane parts of the business, refining the placement of wells and helping to guide the drill bit. You can see some of that onshore, where explorers are shifting to almost a mechanical approach, he said. But beyond the gulf, he said, there were maybe one or two more generations of real exploration work to be done   of new basins, of opening plays. It was possible to be an optimist for just a little longer.   There   s a whole rest of the world out there.

Photograph By Mark Peterson Jim Farnsworth of Cobalt International Energy, which may have found a large oil reserve off the coast of Angola.

Until about 200 million years ago, Africa and South America were part of onesupercontinent. Here is the age progression of the sea floor during the formation of modern continents   red areas are the newest, violet the oldest.

A 3-D rendering, compiled from seismic data, showing four of Cobalt   sdeepwater drilling sites (including Bicuar, formerly known as Gold Dust) off the coast of Angola.The oil is thought to be two miles beneath the ocean floor, below a layer of salt.

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