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BP disaster: Rare mix of geological factors created rich but dangerous reserves

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In the oil business, geologists tell stories. Here was a river, they will say. Here was a shallow sea. Here is where the sea dried up and left only salt. Here is where the sea formed anew, and widened, and deepened, and where sediments from another river, and the carcasses of microorganisms, were deposited, buried, baked, until finally -- the enchanting payoff of the story if you're an eager-beaver oil executive -- the organic matter turned into oil.

The Gulf of Mexico is full of such stories. Unfortunately, the story of one well, named Macondo, drilled by the rig Deepwater Horizon, has turned into a tragedy.

The geology of the gulf is pretty close to perfect for the creation of oil reservoirs. There are salt sheets and domes that form impermeable caps on oil fields. There are abundant rock formations that have been deformed into hump-shaped strata known as anticlines, natural traps for oil.

"It traps oil and gas beautifully," said **Roger Anderson**, **a Columbia University geophysicist** who has long studied Gulf of Mexico geology.

Anderson compares the deep-water gulf to Texas and Oklahoma more than a century ago. The "oil patch" had its famous moments, such as the Spindletop gusher in Beaumont, Tex., in 1901, which blew out at 100,000 barrels (4.2 million gallons) per day, and the Wild Mary well, which spewed out of control for 11 days in Oklahoma City in 1930. That region still produces, but there aren't many big discoveries still to be made in the pincushioned ground.

Not so the deep water. There's oil out there, in reservoirs that can top a billion barrels.

"It's like the old days. It's true frontier," Anderson says.

Shaped by great rivers

It's not the only such place in the world. There's abundant oil in deep water off the coasts of Brazil and West Africa, for example. But the gulf has its own near-unique geology, shaped by the great river that flows into it. The Mighty Mississippi, the Father of Waters, drains almost everything from the Rockies to the Appalachians. Millions of years ago, the Red River, which forms part of the Texas/Oklahoma border, was as big as the Mississippi. These rivers dumped dead organisms into the gulf in prodigious quantities.

Those nutrients help feed thriving ecosystems and some of the richest fisheries in the world. But the gulf is also an isolated sea, almost walled off from the Atlantic Ocean by Cuba and the Florida and Yucatan peninsulas. That means the gulf lacks the deep-water circulation of open ocean.

Bad circulation means lots of anoxic layers, dead zones, places where there's so little oxygen that organic matter doesn't decay. That's great for the eventual creation of an oil field.

"What oil and gas is is undecayed dead organisms. Microorganisms, not dinosaurs. So the small foraminifera and algae that lived in the ocean and lived in the Mississippi River died and got swept out to sea and got buried under all the mud coming out of the Mississippi. As it got deeper and deeper, it got hotter and hotter and got cooked into oil," Anderson said.

Ken Deffeyes, a retired Princeton geologist who once worked for Shell Oil and has written about the gulf, said, "The Mississippi Delta and the Niger Delta are the only two really productive, big deltas in the world. The Amazon, nothing. The Ganges, nothing or very, very little."

The geology story has been unfolding for more than 40 million years, to the very origin of the gulf as a rift in the crust of the Earth. The gulf is widening to this day. Cuba is sliding away from Texas. The Yucatan peninsula is retreating from Louisiana. At its deepest point, the Gulf of Mexico is more than 12,000 feet deep.

Valuable but lethal

The oil-hunters know the sub-sea escarpments and canyons the same way hikers know mountains and rivers. They have explored the Sigsbee Escarpment, the long cliff at the edge of the abyssal plain; they've poked holes in the Mississippi Fold Belt and the Perdido Fan Fold Belt.

There is one tricky consequence of the fact that the Mississippi River deposits so much sediment in the gulf. The rapid layering of mud in deep, low-oxygen water leads to high rates of gas formation.

The gas is valuable, potentially. It's also the major cause of the loss of well control -- blowouts. Gas was the lethal agent in the Deepwater Horizon explosion.

So for the petroleum executives (if not for the shrimp and fish and turtles and so on), the gulf is a good place to drill holes in the sea floor. But it's also a place that demands great care.

That's true even in the shallows. But the drilling rigs have marched -- or sailed, to be more precise -- right off the continental shelf, into very deep water, using satellite technology and precision thrusters to fix themselves over wells drilled on the continental slope and in the depths beyond. The oil industry looks at the gulf covetously, for this is where roughly a third of the U.S. domestic oil production comes from, increasingly from the deep water.

The oil companies do not drill randomly. Where the oil is, and in what quantity, are the questions that preoccupy oil companies that need huge amounts of capital to drill a deep-water well.

"That well is going to cost you 40 to 50 million dollars to drill, and you can't afford to drill a lot of dry ones," said Dennis O'Neill, a computer scientist who has worked for decades in petroleum exploration.

So the companies use sound and radar to take snapshots of what's hidden below the sea floor. A large vessel will tow anywhere from eight to 20 cables, each thousands of feet long and studded with hydrophones, which are microphones that float in the water. The vessel will fire an air gun that creates a sound that propagates through the water and down through the sea floor into the rock below. The microphones pick up echoes; software creates a picture that helps the geologists craft a story of what's below the sea floor: the type of rock, the faulting, the salt layers, the potential traps for oil.

"In a perfect geophysical world, when you listen to the echoes of the sound propagating and bouncing back through this rock, and plot it on a piece of paper, you'll see what looks like a layer cake of the geological structures," O'Neill said. If the picture that emerges matches a plausible "story" of oil, the company can decide whether to drill the site.

"The only way to test the hypothesis is to drill a well," O'Neill said.

The long-term question, one that has incited great debate, is how much oil is still out there, yet to be discovered and potentially commercial.

Deffeyes, a leading proponent of the idea that the world needs to be concerned with an inexorably downward turn in oil production known as "Peak Oil," said it's time to prepare for the post-oil age. Indeed, he says, we need to move beyond all of the nonrenewable energy resources.

The professor says, "We have about 100 years of coal plus uranium plus natural gas plus oil. But you've got to start switching to natural gas now. You've got to start building more nuclear power plants. But your goal in 100 years: You've got to be 100 percent solar -- that's wind, plants, biodiesel -- all those things are directly or indirectly solar."

When will Peak Oil happen?

"It happened in 2005," Deffeyes said.