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Chevron's Undersea Imaging

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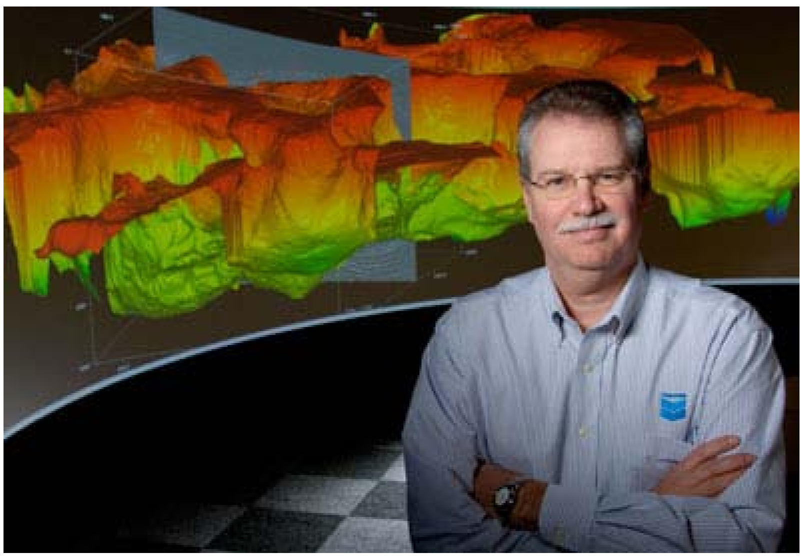
In Chevron's 50-story complex in downtown Houston, geophysicists are sniffing out the next generation of deepwater oil wells. To do so they're pushing the frontiers of imaging technology to peer beneath miles of water, rock and salt layers thousands of feet thick--all in the hopes of finding billions of barrels of oil trapped below.



Chevron has 100 prospective drilling spots in the Gulf of Mexico, but its highest hopes for a resumption of deepwater drilling lay in an area called the Lower Tertiary Wilcox trend, near where the continental shelf drops off into deep water. It may be home to 12 billion barrels of oil, says James Cearley, Chevron's exploration manager. This is not easily accessed oil, though. "Deepwater wells cost $100 million each to drill, so Chevron invests in lots of seismic data to mitigate the risk of a dry hole," says Cearley.

In Houston Chevron's geologists literally sit on top of 8 petabytes of seismic data--enough to fill 900,000 DVDs--housed in two floors of computer servers. Each day they collect roughly 5 terabytes of new data. The 10,000 square miles of 3-D renderings the geologists have stitched together constitute one of the most comprehensive models of the geology of the Gulf of Mexico.

Seismology for oil exploration differs from earthquake seismology, which measures naturally generated seismic waves. To hunt for oil, specialized seismic companies shoot deafening sonic booms down into the rock and use sensors to gather the reflected energy; Chevron then has its computers parse out what lies beneath. Each material has a unique "seismic velocity," which helps determine the difference between rock and oil. Imaging techniques are so good that geologists can approximate standing inside a rock formation to look for the spots most likely to hold oil.

Imaging through rock is one thing, but seismic data get scrambled when it bounces off layers of salt deep under the seabed. To begin peering through the salt, Chevron in the early 1990s deployed a $1 million Cray supercomputer to process gulf seismic data in three dimensions. Emboldened, the company spent $50 million to lease two 3-by-3-mile blocks from the U.S. government. There, hiding under a layer of salt as thick as 15,000 feet, Chevron found the Tahiti field, which now produces 125,000 barrels per day from reservoirs 25,000 feet deep.

This year Chevron retired its last supercomputer and replaced it with $10,000 of gear on every desktop. What would have taken three months to render on a Cray in 1993 now takes two hours or less on a PC, says Barney Issen, Chevron's senior geophysicist in charge of interpreting seismic data. To crunch heavy loads, Chevron networks its computers into Linux-based clusters with hundreds of processors operating in parallel. They use high-speed graphics cards to run a customized rendering platform called Go-CAD, built by **Paradigm Software**.

These days a lot of Chevron's combined brain and computer power is tuned to peer into the gulf's promising Lower Tertiary Wilcox trend. For decades geologists have discovered bountiful oil and gas onshore in the Wilcox zone. In the deep water, large swaths of Wilcox sediment slumped over the side of the continental shelf and were swallowed by a layer of salt that dates back to when the American continents pulled away from Europe and Africa. In 2005, when Chevron discovered oil in the subsalt Jack 2 well, the offshore Wilcox emerged as a giant new resource. Chevron plans to invest $7.5 billion to develop Jack.

"When I started, geologists were considered heretics for dreaming that there could be salt canopies with reservoir-quality rock beneath them," says Issen, 54. Now they understand that as sediment builds up on top of salt, it pushes the salt out of the way. Like an upside-down lava lamp, in time the sediment sinks under the salt.

Think of the salt layer as one of those glass blocks used to build bathroom walls. It lets light and color through, but you can't make out any detail. However, if you can figure out the curves (topography) on the front and back of the glass, you can write computer algorithms to correct for them. With the right algorithms backed by enough computing power, the salt layer can be transformed from a blinder into a lens. Issen shows a 3-D projection of a prospective well called Buckskin. A purple blob of older sediment slumps underneath the salt layer, and a "bump" in the rock is a telltale sign that oil is trapped beneath. "You don't get to see that it is a bump until you've sorted out all this stuff [the salt] above it," explains Issen. Last year Chevron announced that test wells drilled 29,000 feet deep into Buckskin found oil-bearing sands 300 feet thick.

Seeing through salt hasn't yet been perfected. "Sometimes what we thought we were looking at wasn't there at all," says Cearley. Even so Chevron is improving its impressive 3-D seismic model of the gulf all the time. The latest development allows geophysicists to tweak algorithms on the fly--in effect, adding a little more salt here or more sandstone there to see if it helps to smooth out the image.

Chevron is working with national labs at Sandia and Livermore, applying advances made in nuclear weapons simulation to seismic rendering. Seismic specialists like CGGVeritas and Schlumberger's WesternGeco are coming up with new ways to bounce sound waves off rocks. Says Chevron's geosciences manager Mark Koelmel, "We're going to have to come up with better ways to parse the data, because we're going to have a lot more data."