

How Halliburton advances in horizontal drilling and fracturing helped unlock the Bakken Shale

A unique partnership powered by new ideas and technology led to overwhelming success in a field other companies had abandoned

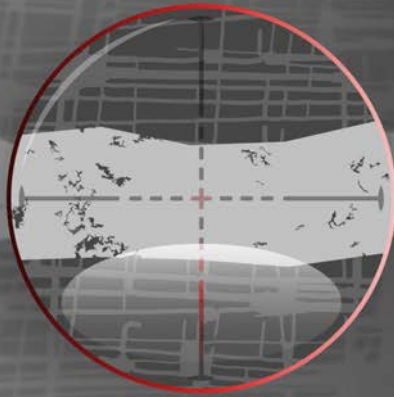


OVERVIEW

In 1996, after most companies had abandoned the Williston Basin, geologist Dick Findley still felt the oil-rich shale could be accessed economically by fracturing the length of a long horizontal well. The only problem: no one had ever done it. Findley interested Lyco Energy (now Enerplus) in his theory. But initial results were mixed. Investors agreed they needed greater expertise in horizontal drilling and horizontal hydraulic fracturing, a new idea at the time.

They asked Halliburton to join the team, not as a service provider, but as an equity partner. Halliburton took on the risk. Working with the other partners, Halliburton designed a well and completion, then tested the concept. Findley's idea was validated the instant pumping commenced. Since then, this partnership has drilled more than 230 wells in the field which is currently producing close to 9,000 barrels of oil per day (BOPD). Just as important, the technology used in the Bakken spawned a shale drilling boom in the U.S. and elsewhere around the world.

CHALLENGE	SOLUTION
<p>Succeeding where many others had failed Other energy companies knew there were hydrocarbons locked in the Bakken Shale. But the source rock was only two to five meters thick. Vertical wells could not produce enough oil to be economical. By the mid-1990s, all had abandoned the play.</p>	<p>Increased well interface boosted production This project differed from previous efforts in two significant ways. First, engineers employed a horizontal wellbore within a narrow dolomite zone running between two shale layers. Second, they fractured it in stages, longitudinally to maximize contact between the frac plane conduit and the wellbore.</p>
<p>Geosteering within a narrow layer The dolomite zone itself was winding and narrow – as little as six feet thick in places. Keeping the wellbore within it was a challenge. If the horizontal wellbore and fractures weren't exact, vast areas of the reservoir could be bypassed, reducing the payback. New diversion techniques would also be required to help ensure adequate proppant placement along the entire length of the wellbore.</p>	<p>A technologically advanced partner Halliburton employed new geosteering technologies that kept the wellbore centered in the target zone and properly aligned on the optimum azimuth. Innovative diversion techniques were used to create maximum proppant placement throughout the length of the wellbore. These initial innovations have fueled over a decade of rapidly improving techniques that are continuing to unlock unconventional plays around the world.</p>
<p>Great potential, but even greater uncertainties Lyco Energy had tested the potential of Findley's plan in its own pilot project, but realized it lacked the capital and technology necessary to make the project successful. Investors were skittish because of the great number of companies that had walked away from the challenges.</p>	<p>Halliburton shared the risk and helped unlock shale Halliburton believed its expertise would make the difference. So it took an equity position and focused its best people and equipment on the problems. The investment paid off. There are now 205 rigs working in the Bakken, with thousands of others active in shale plays around the world.</p>



MARGIN OF ERROR: LESS THAN 15 FEET MAX

The lateral sections of the first Bakken well had to stay within a layer of dolomite no thicker than 15 feet (5 m) at its widest points—and less than 6 feet (1.8 m) at its narrowest.

**2.87
MILLION
FEET DRILLED**
...AND COUNTING

Since 2000, Halliburton has drilled more than 2.87 million feet of wells in the Bakken Shale.

THE BAKKEN SHALE
NOW PRODUCES
400,000
BARRELS OF OIL A DAY

In 2000, most companies had abandoned the Bakken Shale. A decade later, the area is booming. By 2015, analysts predict the Bakken could produce as much as a million barrels a day.

WELLS AS LONG AS **12,000 FEET**,
FRACTURED IN UPTO **40 LATERAL STAGES**

Halliburton has continued to refine its fracturing technology since the Burning Tree State well was drilled in 2000. Today, horizontal sections extend to 12,000 feet. Halliburton fractures them in dozens of stages to optimize the treatment.

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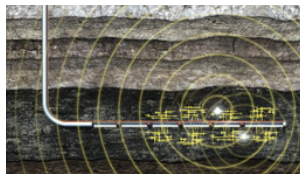
A vast reserve suddenly became economical to produce

Oil was first discovered in the Bakken Shale in 1953. The formation, located deep within the Williston Basin, stretches across 200,000 square miles in Montana, North Dakota, and South Dakota and north to Canada. Geologists long suspected it might be one of the largest untapped oil fields in North America. The challenge was getting the oil out of the tight shale. Though major producers attempted to develop the field for more than four decades, none were able to make widespread drilling economical.

By the 1990s, most companies had pulled out of the area. However, independent geologist Dick Findley continued to study the formation. In a field he named “Sleeping Giant” (now known as Elm Coulee), he identified a narrow but porous strip of dolomite running between two shale layers where hydrocarbons had previously been found. If the dolomite was drilled and fractured in the right direction, he theorized, it would draw in oil from the shale above and below. He hoped this “two-for-one” approach would make the vast Bakken economical to produce where other approaches had failed.

Bringing the right partners together

Findley brought his idea to Cosco Capital Management, which recommended a partnership with Lyco Energy. Together, they revisited several abandoned wells where the new strategy could be tested with minimal development costs by drilling new laterals. Results were mixed. To prove the concept, they needed to drill a longer horizontal well and fracture a greater percentage of the reservoir. That was when they solicited Halliburton’s help.



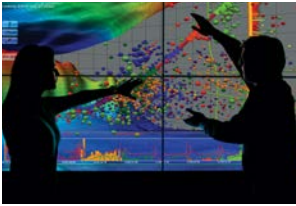
Aligned interests reduced financial and technical risk

In 1998, Halliburton had made a strategic decision to begin investing in a limited number of energy projects with particular promise. Halliburton was drawn to Sleeping Giant because, if successful, the solutions implemented there could be adapted to shale plays across North America and around the world. Halliburton’s participation gave Lyco, Findley, and their investors immediate access to some of the best directional drilling and fracturing expertise in the world.



The project represented Halliburton’s – and the world’s – first attempt to place fractures along the full length of a horizontal well in multiple stages. If successful, this would be the key to making shale plays commercially viable. It would also create a shale boom worldwide.

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Under less than optimal conditions, proof of concept was achieved

Halliburton's participation significantly accelerated development time. Within a few months, Halliburton conducted a field study, designed the well and completion, and developed a pilot program to test the design.

Drilling began in early 2000. The well, christened Burning Tree State, called for a 10,000-foot vertical well with a 3,000-foot lateral section. Geosteering problems stopped the horizontal section at 1,200 feet, but Halliburton completed the well anyway to test the concept and proceeded with fracturing. Production instantly exceeded all expectations. As word spread, other companies came rushing back to the Williston Basin.

Continuing to improve shale economics

Well design has changed significantly since 2000. Halliburton has experimented with different drilling tools, liners, fluids and fracture techniques to find the optimal combination and improve economics even more. Horizontal laterals are longer now, running between 4,000 and 12,000 feet. Halliburton also uses non-cemented liners with open hole isolation packers and sliding sleeves to efficiently treat multiple frac stages in the wellbore. Laterals are fractured in smaller stages to limit the amount of fracturing equipment and personnel required on-site. In addition, after trying a wide range of fluids and proppants, engineers currently use a mixture of polymer and sand. As a result, production has continued to improve.

From pilot program to full field development and beyond

To date, the Sleeping Giant partnership has drilled more than 230 wells. With new best practices in place, engineers are even revisiting older wells and re-fracing them. Many have been restored to their original production levels.

Across the entire Williston Basin, companies have drilled more than 1,500 wells that produce a total of 400,000 barrels of oil every day, with 205 rigs at work on new construction. By 2015, the Bakken Shale could be producing as much as one million BOPD. In fact, a 2008 study by the U.S. Geological Survey estimates that nearly 4 billion barrels of oil may be recovered from the formation over its productive life.

Arguably, Sleeping Giant represents one of the biggest breakthroughs of a generation. While every shale play is different, success in the Williston Basin has fueled development in other shale formations across North America, Europe, Asia, Australia and South America.