COMPLETIONS

Progress in the mix

By examining how cement works at the molecular level, scientists at Halliburton created a lighter but stronger and more flexible cement for horizontal shale wells. **Jennifer Pallanich** talks to the team.

One of the primary problems in horizontal shales is that the harsh environments in subterranean basins require lighter slurries to prevent breaking down the formation during the cement job.

A secondary issue is preventing lost circulation, which occurs when the slurry flows into the formation rather than returning up the annulus to the desired top-of-cement location.

In 2011, Halliburton went to work engineering a cement that would become known as NeoCem. The company invested five years and $6 million in research and development to create a lighter but stronger and more ductile slurry, says Ron Morgan, Halliburton's chief technical adviser for cementing.

"We studied the physics and the chemistry. We've gone back to the basics, physico-chemistry," Morgan says.

"There are some very bright chemists that started looking at this from a basic chemistry point of view of how cement does its work."

Ordinary Portland cement is commonly composed of calcium, silica, aluminum, iron and other ingredients. Halliburton's

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experts looked at how cement "does what it does", he says, then looked at how to accomplish that while reducing Portland cement but adding other materials to achieve the required mechanical behaviours.

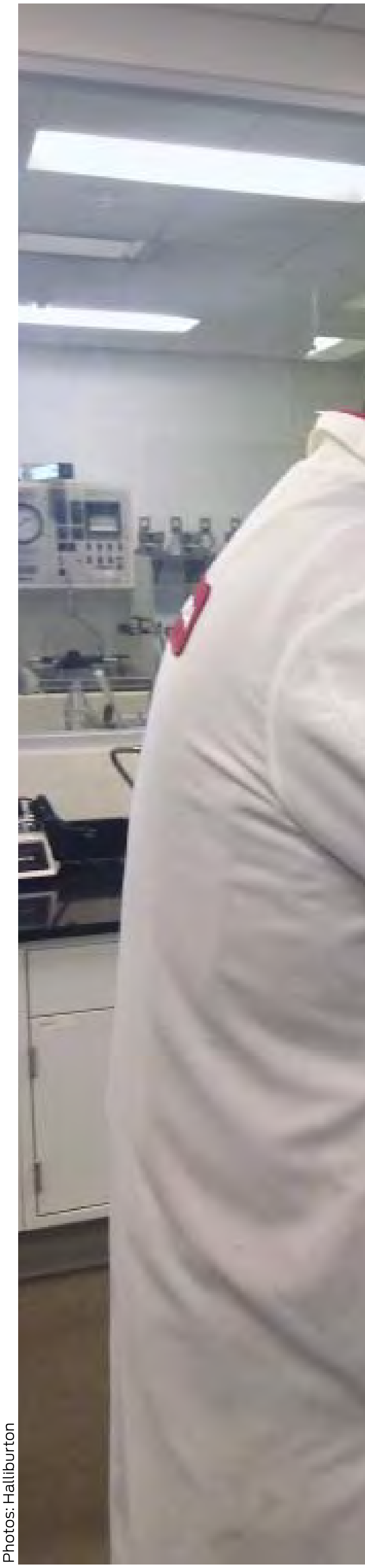
Using its iCEM modelling software and the central laboratory at the Northbelt Technology Center in Houston, Halliburton cementing specialists identified a way to quantify whether a given material could meet the needed requirements. Researchers drew on the institution's understanding of the unique chemistries of more than 150 materials.

"We developed internal proprietary methods to measure the efficacy or functionality of a given material," Morgan says.

Those methods, whether applied in the Houston facility or in field laboratories, make it possible to evaluate and help maximise the use of local materials to make the lighter cement.

"We're not looking at it the same way we did 10 years ago. It's a different approach to building a slurry. It's a different, engineered approach," Brian Pfeiff, Halliburton account representative to Continental Resources, explains.

Photos: Halliburton



RIGHT BLEND: NeoCem co-inventor TJ Pisklak prepares a mixture for mechanical properties testing in the Halliburton Northbelt Laboratory.

Field trial

Continental Resources had wells in the South Central Oklahoma Oil Province (SCOOP) where they had been unable to consistently get slurries to the desired top of cement in the intermediate casing strings. The slurries were breaking down the weak formation, resulting in significant losses of both drilling fluids and slurries.

"One of your worst nightmares is you can't get the cement where you want it," Morgan says.

When Halliburton proposed a NeoCem solution to Continental, Pfeiff says, "it was a mixed bag" of responses. Some people were doubtful because it was a change in the slurry material, while others were excited about the possibilities.

"The wells that Continental was drilling, and their activity in the SCOOP was becoming ever more challenging," he says. The cement jobs before had been of the "pump and pray" variety.

iCEM Service models showing comparisons of NeoCem and traditional slurries led to buy-in from the operator, Pfeiff says. Continental signed on for a five-well pilot programme that began July 2015.

"We did it with 100% success. We logged and could clearly see the bonding. We had success with tops and returns," he says. "One of the really promising things is we expected no returns on one well. We re-established returns on cementing, when before there were total losses."

Pfeiff says NeoCem repeatedly passed the formation integrity tests, showed improved bond logs, and reached top of cement on the Continental jobs.

"We have taken this from concept with Continental to wide-spread adoption," he says. "Every well they drill in the southern region has NeoCem in it. Not just the intermediate (casing)."

The technology has evolved since the companies began working together on the SCOOP pilot. Continental has been a first adopter of NeoCem for multistage, single-density, foam, single design variable density and multi-mile extended lateral jobs, he says.

"They've done very difficult and challenging wells."

SOLID STATE: Halliburton says NeoCem is 4% to 10% lighter than traditional Portland cements but provides up to 32% more compressive strength.

Track record

As of late January 2017, Halliburton had pumped over 500,000 barrels of NeoCem for over 90 different customers on more than 1,350 jobs. Compared to traditional slurries, Morgan says, it has consistently shown a 32% improvement in compressive strength.

"Usually when you make a cement lighter, it's not stronger," he says. "It's like we're making a stone wall out of lighter rocks and bricks but stronger than a conventional brick wall. We've done that by understanding the chemistry and physics down to the microscopic level."

According to Morgan, NeoCem has shown 170% improvement in toughness and a 35% improvement in relative elasticity. He says customers also report a 50% improvement in the operating range of the equivalent circulating density (ECD) pressure. The ability to mix a single-density blend that can be pumped at multiple densities for both the lead and tail will help save operators money by eliminating the requirement for a two-stage downhole tool, he adds.

NeoCem addresses many fundamental engineering concerns, Morgan notes. The slurry has improved stability in »

» liquid form to prevent particles from settling out. It can be prepared at Halliburton's bulk plant and pumped with existing equipment, so the engineer can use familiar equipment. Because of the slurry's lower viscosity, it can be pumped in small spaces in lateral sections, meaning it fills in the "tiniest spaces behind the casing, and that's what gives us a good bond log," he says.

The slurry develops its mechanical strength in 40% to 50% less time than traditional slurries, which reduces rig time, he says, adding that a majority of operators report improved or significantly improved bond logs.

Improved elasticity helps it better withstand the multiple frack stages commonplace in horizontal wells, Morgan says.

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"It takes a very tough, ductile, forgiving cement not to shatter up and down the wellbore when they're pressuring up for a frack job."

The improvements have not come at the cost of affordability, he points out. "The customers are expecting nanotechnology prices, and they're pleasantly surprised when it's not."

NeoCem has about one-fifth of the internal market share in Halliburton's North American cementing division, Morgan says, and the adoption rate in Permian basin intermediate and production cementing has reached 60% of the company's jobs.

The service company has efforts under way to take the technology to the Eastern Hemisphere and Latin America, where local sourcing of materials could help simplify the supply chain. "We're pushed every day, with longer laterals and lower ECD limits," Pfeiff says.

"Can we go and tighten up properties on heavier slurries? Can we go even lower weight than we are? We are currently pushing the boundaries in every direction."