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Taking radioactivity out of fracture monitoring

A new nonhazardous detectable proppant eliminates need for specialized meters, handling and permits to detect placement in the wellbore.

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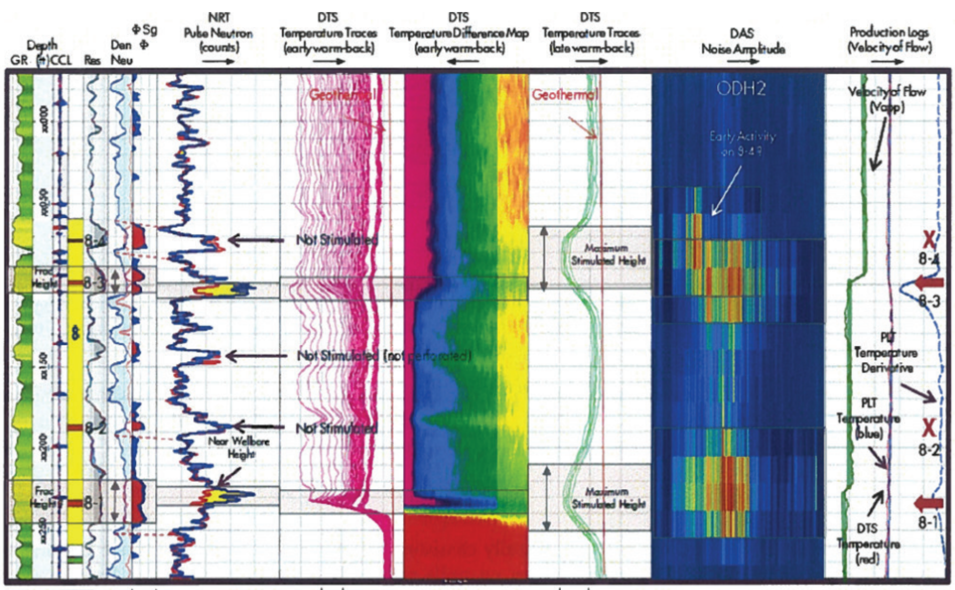
The capacity to precisely measure the propped fracture height and placement and, above all, ensure optimal near-wellbore connectivity is essential for maximum and sustainable production from unconventional reservoirs. Detecting the placement and height of propped fractures and confirming all stages have been thoroughly stimulated required comingling radioactive tracers in the fracture fluid followed by post-treatment gamma ray spectroscopy.

The mere mention of radioactivity sends up a host of red flags, which are reflected in stringent regulatory oversight. The pumping of radioactive tracers under high pressure mandates specialized handling and safety monitors (Geiger counters) to detect any leaks as well as the associated issues with the tightly regulated disposal of contaminated flowback, increasing both HSE footprint and costs.

The lack of available methodologies capable of accurately detecting a created fracture geometry without the associated HSE and economic barriers spurred the development of the field-proven CARBONRT inert tracer technology. Capable of distinctly measuring fracture height as well as location, the detectable proppant is composed of an inert material pumped as part of the fracture fluid stream and, unlike radioactive tracers, does not require specialized meters, handling, training, permits or certifications. Initially developed solely for wells completed with ceramic proppant, the technology has evolved to include sand-completed wells, where it also is used for long-term monitoring of cement and wellbore integrity.

Engineered with a high neutron capture cross-section, the traceable material is detectable with a standard neutron log, thereby generating a direct measurement of the propped fracture height and location rather than an interpretation. To better understand the myriad dynamics of a fracture treatment, the inert tracer technology often is integrated with multiple diagnostic technologies such as microseismic, fiber-optic temperature, and fiber-optic acoustic and production logs, among others. Likewise, the CARBONRT platform functions as the enabling technology for the FRACTUREVISION proppant-delivered fracture evaluation service, which yields high-definition measurements that can be used throughout the productive life of the well to enhance fracture and completion design, well spacing and field development plans and more accurately calculate EUR.



A single-stage example of the inert tracer technology used in conjunction with integrated diagnostics is shown. (Source: CARBO; SPE Paper #168603)

Durable detection

Fundamental to the nonhazardous tracer is the incorporation of a proprietary chemically inert material with no half-life deterioration of its detectable properties. Since the tracer proppant is permanently identifiable, an operator has the flexibility of conducting logging months or years after the initial fracture job to identify any underperforming zones requiring restimulation.

The inert tracer is uniformly distributed throughout each grain of proppant during the manufacturing process. Infusing the tracer into the ceramic proppant assures consistent and uniform distribution of the traceable marker throughout the near-wellbore fracture zone. Along with the capacity to measure near-wellbore proppant volume to evaluate critical wellbore connectivity, the tracer enables accurate measurement of proppant coverage to identify any understimulated zones. Notably, the tracer is unique in that it accurately measures propped fracture height, which is vital for calibrating the stresses above and below the formation. When used in conjunction with a fracture model, the propped fracture height determination also provides an indication of the actual fracture geometry.

Enhanced calibrations

The intrinsic value of propped fracture height data was clearly demonstrated in a sweeping near-field study in Wyoming's Pinedale Field where, owing to wide downhole variances, the operator required a more precise evaluation of hydraulic fracturing geometry to reduce the analytical uncertainties and determine overall stimulation effectiveness.

The traceable ceramic proppant was incorporated as part of an integrated near-field diagnostics analysis that included distributed temperature sensing (DTS) and distributed acoustics sensing (DAS) monitoring. As the fiber-optic DTS and DAS techniques monitored fluid location, the inert tracer measured propped fracture height to identify nonstimulated and understimulated fracture stages. Over the course of one year, integrated fracture diagnostics were conducted in 83 stages of five wells.

By pinpointing proppant location and subsequent propped fracture height, the tracer revealed that 53% of the stages evaluated were shorter than predicted, leaving only 63% of the available net sands effectively stimulated. Unlike DTS and DAS technologies, the tracer successfully predicted where production would originate using only propped coverage. The previously unavailable intelligence provided a critical missing link for calibrating fracture models and designing future stimulation and completion strategies for the field.

Filling the sand gap

As originally engineered, the inert tracer could be used only in wells completed with ceramic proppant. A development initiative was undertaken to expand the technology for application in sand-completed wells. The inert tracer technology represents the industry's only proppant-delivered tracer designed exclusively for evaluating fracture geometry and wellbore integrity in wells stimulated with sand proppant.

The second-generation inert traceable proppant goes beyond measuring fracture height and placement to assess the perforation and completion efficiency of sand-completed wells but extends to evaluation of overall wellbore integrity. Once added to the cement slurry prior to pumping, the tracer material enables the location and thickness of the cement to be detected through the casing. As the tracer likewise is permanently traceable with no half-life deterioration, cement integrity can be monitored for the productive life of the well.

Shortly after its development, the inert tracer technology for sand-completed wells was used in conjunction with the proprietary proppant-delivered fracture evaluation service for the purpose of helping a Permian Basin operator optimize its stimulation and completion programs. Relatively new to the play, the operator requested quantifiable data, particularly to determine the possible adverse effects of widespread overflushing on near-wellbore connectivity. A sand-completed well with five fracture stages and a cumulative 11 perforation intervals was selected for the test.

The integrated evaluation showed that only the fifth stage, which was stimulated without overflushing, exhibited high wellbore connectivity. Only two of the six clusters in the overflushed first stage accepted proppant; while the second stage displayed high near-wellbore connectivity, proppant was detected in only one of the two perforation clusters. The third and fourth stages, meanwhile, were shown to have low near-wellbore connectivity and an extremely short propped fracture height.

The fracture analysis, including data acquired with the inert tracer technology, concluded that by avoiding overflushing in future stimulation and completion programs, the operator would increase near-wellbore connectivity by 30% with a corresponding 10% projected increase in production. E&P

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