'Best-of-Play' Scorecard: Utica Shale

In the high reservoir stress environment of the Utica shale play, high quality proppant selection is vital to resist cycling stresses and retain conductivity ultimately, enhancing production.

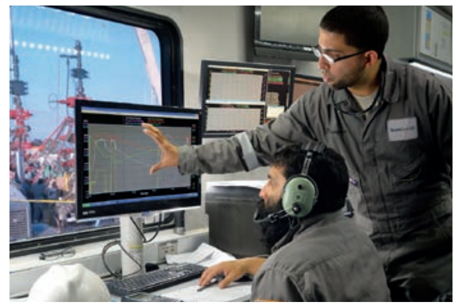
Utica, Marcellus Shale, Ohio

Executive summary

Underlying much of the northeast U.S. and extending across the border into Quebec, the triple-window Utica Shale has evolved from a source rock to a highly prospective dry gas, natural gas liquids (NGL) and oil asset. Closely aligned with the overlaying and gas-rich Marcellus Shale, the Utica holds estimated undiscovered and technically recoverable reserves of 38 tcf of gas and 940 million bbl of oil, according to the latest U.S. Geological Survey (USGS) reserve assessment.

While the Utica traverses no less than eight states across the northeast and midwest, Ohio is the epicenter for nearly all E&P activity. A long oil producing state, Ohio's midstream infrastructure is designed around the delivery of shallow, low-volume oil production, rendering it ill-prepared for the rapid upsurge in high-rate gas production. Consequently, the resulting takeaway issues force operators to periodically shut-in production, which, in turn, has been shown to aggravate the decline rates of Utica gas wells, where the frac stimulation programs typically employ tremendous volumes of lightweight conventional sand as frac propping agents.

This review examines the rationale and results of a STRATAGEN® comparative analysis that documented the sustained drainage benefits of replacing sand with lower-volume ceramic proppant. The study revealed conclusively that unlike the white sand used largely in this high reservoir stress environment, intermediate-strength ceramic proppant resist cycling stresses, thereby retaining conductivity and enhancing production sustainability even after the wells have been intermittently shut-in.



A competitive analysis confirms that higher and longer-term gas production can be achieved by employing the higher conductivity afforded by the ceramic proppant pack at considerably lower volumes.

Geological deposition/composition

The Upper Ordovician Utica Shale, the source rock for the Marcellus Shale and other overlying producible formations, is described as an organic-rich black shale with well-defined NGL, oil and dry gas components. Ion-milled scanned electronic micorscopy (SEM) images of the Utica, which has a high total organic content (TOC) of up to 4.85%, even show rock characteristics that closely resemble those of the Eagle Ford. The Utica underlies the Marcellus by as much as 7,000 ft and reaches a depth of more than 14,000 ft as it extends eastward. The Utica has an average thickness of roughly 300 ft, with a maximum thickness of more than 1,000 ft.

As delineated, the aerial reach of the Utica Shale extends roughly 170,000 sq mi across the Appalachian basin from northeastern Tennessee to southeastern New York and from central Ohio to eastern West Virginia and into Quebec. It has been said if the full breadth of the Utica was found to be commercial, geographically it would be the largest known dry and wet gas shale play.

Drilling & Production Evolution

Despite its tremendous geographical reach, all Utica drilling and production is centered in its Ohio fairway, which in recent years has attracted an ever-growing number of operators. Although Ohio has long been recognized primarily as an oil producing theater, the rapid acceleration in Utica horizontal drilling activity has transformed the state into one of the nation's fastest growing natural gas production areas. By September 2014, gas production in the Ohio sector of the Utica had spiraled to an estimated 1.3 bcfd, compared to the previous high of roughly 155 MMcfd in January 2012, according to the U.S. Energy Information Administration (EIA).

The rapid escalation of dry gas production caught Ohio's takeaway infrastructure, which was designed around shallow and low-rate oil volumes, unable to keep pace. Consequently, pipelines and gathering systems all-too-often encountered oversupplied capacity, regulatory restrictions, production connection priorities and similar issues that forced operators to periodically shut-in their wells, pending moderation of the delivery constraints.

Typical Completion/Stimulation Scenario

In-situ reservoir pressures of Utica dry gas reservoirs, as exemplified in Ohio production wells, fall in the 6,000 to 7,000-psi range. Actual closure stresses, meanwhile, can reach between 8,000 to 10,000 psi, representing at worst a 4,000-psi differential. Despite a high-stress environment that generally mandates intermediate-strength ceramic proppant, Utica operators typically run lightweight 30/50-mesh white sand in their frac stimulation programs at enormous volumes - up to 1 million lb/stage - with the objective of hedging production rates. With laterals being completed routinely with 35 to 40 stages, per-frac jobs in the Utica represented some of the largest in the U.S.

Widely accepted local convention held that using a tremendous volume of sand at the onset would adequately compensate for progressive losses as the well is depleted. However, between the intrinsically high-stress environment and the cycle stressing associated with the periodic shut-in of producing wells, it readily became apparent that the sequential conductivity loss of lightweight sand proppant jeopardized optimum and sustainable production.

Specifically, in the cycle stressing process, when production is initiated, an installed sand-based proppant pack undergoes stress changes as the well produces - production increases stress as the reservoir pressure decreases. Consequently, when production stops, which is a common occurrence in Ohio given the restrictions on the gas gathering system, the stress on the proppant pack is reduced. Meanwhile, when production is restored, wellbore pressure decreases, which once again, increases stress on the proppant, thus characterizing the back-and-forth stress cycling phenomena.

The detrimental effects of stress cycling are particularly magnified in sand-based proppant. Not only are they subjected to stresses outside their normal range, being non-spherical, sand proppant is unable to displace some of the point loading on their surface. Therefore, when the well is shut-in, the proppant pack is re-stressed, with small sand fragments of different configurations helping break apart other fragments, resulting in yet more loss of conductivity. With the sequential loss of conductivity in sand-propped wells, the decline curve rate subsequently accelerates after each shut-in.

Though the economics suggest sand-based stimulation was sufficient early in the producing life of a well, the benefits appear to fall appreciably as the well matures. STRATAGEN sought to examine the production characteristics of representative wells to evaluate whether replacing conventional sand with considerably smaller volumes of intermediate-strength ceramic proppant would yield more sustainable production rates.

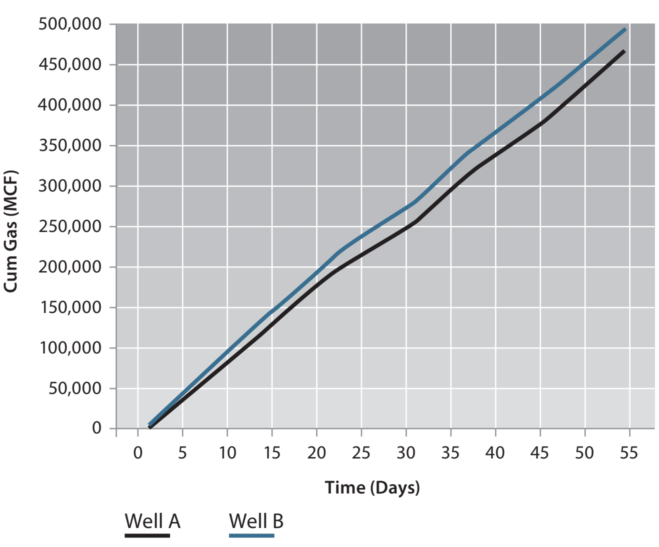
After a client provided representative well data, STRATAGEN specialists used the FRACPRO® fracture design and analysis software to analyze the frac data, while production data was run through the STRATAGEN reservoir analysis workflow, designed specifically for developing shale gas reservoirs.

The data irrefutably confirmed that the well was in an exceptionally high-stress and high reservoir-pressure environment with the Delta P (ΔP) values showing minimal pressure change between the two.

An evaluation of the data from the one-year-old sand-propped well showed that during eight months of production, the well had been shut-in at least three times, each for up to a week. The data verified that the decline curve accelerated quickly after each shut-in.

The next step in the evaluation was to orchestrate a comparative field trial to directly analyze the sustainable performance between sand and ceramic proppant.

Cumulative Production of Utica Dry Gas Wells



Compared to the well employing white sand proppant, the well using a ceramic proppant achieved a slightly better 90-day decline rate with considerably less volume and at similar costs.

Comparative Analysis Results

Two adjacent Ohio Utica gas wells were identified as targets for the comparative analysis. One was completed with the conventional 30/50 white sand proppant and the other propped with the 30/50 CARBOECONOPROP®.

Designated Well A used white sand and was drilled with a 9,100 ft lateral, comprising 38 frac stages, requiring a cumulative 16,748,880 lb of sand.

Designated Well B, using CARBOECONOPROP, was drilled with a 6,841 ft lateral and completed with 27 frac stages, requiring a total of 5,567,238 lb of ceramic proppant.

Given its 35% longer lateral and more equally spaced frac stages, Well A ostensibly should produce at an appreciably higher and longer rate than Well B, providing that both wells produce equally. Furthermore, Well B was completed with a third of the proppant volume of the sand well.

After 90 days of production, in which the economics of the ceramic-propped well correlated exactly with the sand well, Well B equaled the sustained production rates of Well A. After both wells had to be shut-in twice over the first six months of production, the 90-day decline rate for Well B was slightly lower than Well A, indicating the ceramic proppant effectively withstood the effects of cycle stressing and retained conductivity.

After 90 days of cumulative production, STRATAGEN concluded the higher sustained conductivity of the 30/50 CARBOECONOPROP low-density ceramic proppant enhanced clean-up of the frac fluid and increased gel flow and effectively created a longer frac length. While the typical frac spacing of Utica gas reservoirs was shown to be adequate, the comparative analysis confirmed that higher and longer-term gas production can be achieved by employing the higher conductivity afforded by the ceramic proppant pack at considerably lower volumes.

Select literature

- *"Assessment of Appalachian Basin Oil and Gas Resources: Utica-Lower Paleozoic Total Petroleum System," US Geological Survey (USGS), 2008*
- *"Appraising Shale Gas Reservoirs Using Stimulation Data," Lyle V. Lehman, "SPE #171548, to be presented at 2014 SPE Asia Pacific Oil & Gas Conference and Exhibition, Adelaide, Australia, Oct. 14–16.*
- *"Marcellus/Utica Shale: Operators Turn up the Heat in Frigid NE," World Oil, February, 2014*

To learn more about how the unique technologies of STRATAGEN in combination with the experience and expertise of our fracturing advisors can optimize your Utica Shale completion and field development strategies, contact your nearest STRATAGEN representative.

Talk to STRATAGEN to find out how we can help you enhance your production.

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