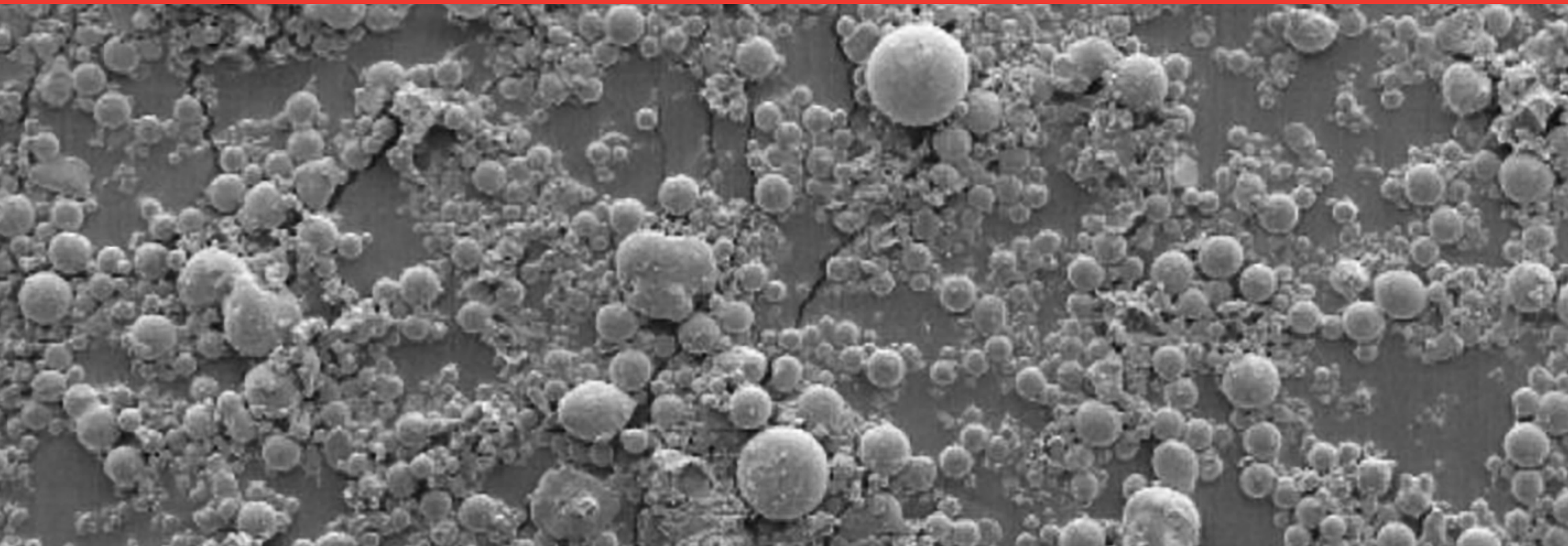
DEEPROP®

Significant Uplift Achieved with Production Enhancement Product

DEEPROP supercharges production uplift and extends a well's life in complex plays providing a two to four month ROI.



zeeospheres™

DeepropFrac.com

Executive Summary

This paper introduces Deeprop® 1000, a small, strong microproppant that extends shale well production and reduces decline rates by targeting a shale reservoir's secondary fracture network. Deeprop® 1000 is proven to deliver significant benefits to shale operations by:

- Propping open narrow secondary fractures that are too small for conventional proppants to extend the productive life of the well.
- Flattening a well's decline to recover more hydrocarbon on a longer timescale.
- Lowering treating pressures to boost pump rates and prop open fractures deeper into the formation.
- Recovering the completion costs lost when conventional proppants, which cannot prop open a reservoir's vast secondary fracture network, are used.
- Paying for itself in as little as four months.

Deeprop® is proving its potential in ongoing field operations in major shale plays across the US, including the Barnett, Woodford SCOOP, Utica, and Permian Basin. Average uplift after 25 months is 40%, and test wells over 36 months have uplifts ranging from 10% to as high as 81%. And, operators recover their ROI in 4 months or less.

Introduction

Proppants, the large class of solid materials including sand and man-made ceramics, are critical to keeping induced hydraulic fractures open after a fracturing operation. And while nearly all fracing jobs would fail without conventional proppants, microproppants are very effective at maximizing production potential from secondary fracture systems.

Consider this: the production decline for shale wells is steep, with 60 to 70% of the initial production lost in the first year (**Figure 1**). Typically, this steep drop will continue for a couple of years before the wells experience a more gradual, steady-state decline for many years.

To boost production and ease the decline rate in shale wells, communication between the reservoir's secondary fracture network and the wellbore is critical. However, conventional proppants are typically too large to enter narrow secondary fractures and keep them open for extended periods.

For the proppant to enter a fracture, the fracture width must typically be three times the mean particle size of proppant. Using this metric as a guide, **Table 1** outlines the fracture aperture required to accept various proppant sizes.

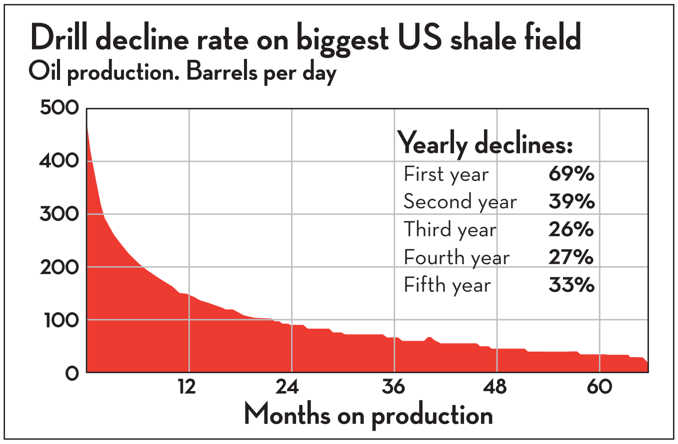


Figure 1 – Typical production decline for a shale well.

Proppant	D90 Size in Microns*	Bridging Factor	Fracture Aperture (mm)	Fracture Aperture (inches)
20/40	825	3	2.475	0.097
40/70	502	3	1.506	0.059
100 Mesh	303	3	0.909	0.036
Deeprop® 1000	70	3	0.210	0.008

Table 1 – Bridging size for various proppants (*Particle size measured by laser diffraction using a Mastersizer 2000).

For a 100-mesh sand, the hydraulic fracture width needs to be wider than a half millimeter (or 0.02 inches) to accept the proppant.

The table highlights another, more promising option for very small fracture apertures. The proppant known as Deeprop® 1000 is an order of magnitude smaller than conventional proppants, which opens up the potential for tapping into the production oil and gas trapped within the vast secondary fracture network of many shale wells.

Deeprop® 1000 – Tiny proppant, massive potential

Zeeospheres (*deepropfrac.com*) developed its Deeprop® 1000 microproppant specifically to optimize reservoir recovery and mitigate steep production declines. A small, strong, perfectly spherical manmade proppant (**Figure 2**), Deeprop® 1000 targets the reservoir's secondary fracture network—specifically, those fractures that are too small to accept conventionally sized proppants. And, the material's high crush resistance (60,000 psi) allows it to maintain conductivity at very high closures (see **Table 2** for a full list of properties).

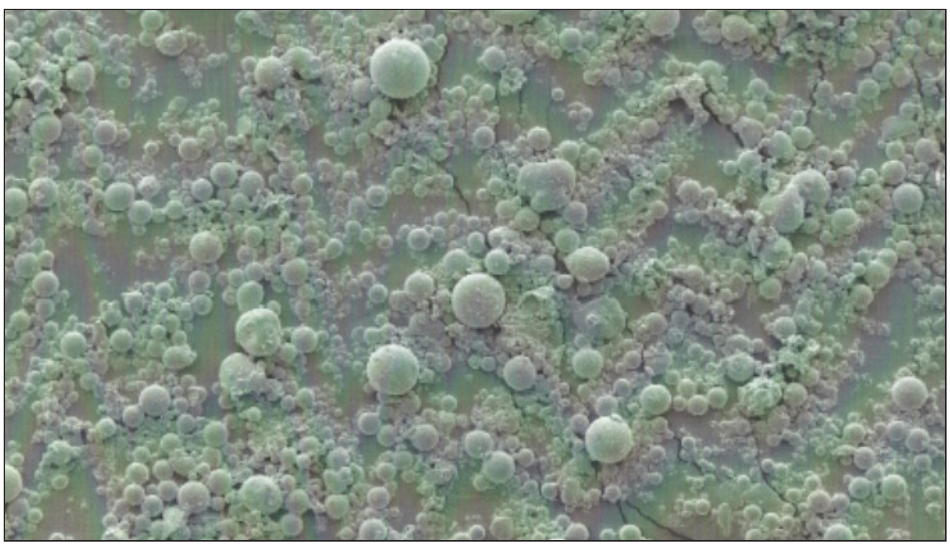


Figure 2 – Deeprop® 1000 SEM photo.

Introducing Deeprop® 1000 into the narrow stimulated fracture system contributes to long-term conductivity, which translates to a flattening of the decline curve.

In the field, Deeprop® 1000 has proven most effective in shale formations with a Young's modulus of 2.5 million or greater and a permeability of less than 5,000 nano darcies. Fortunately, most of the major shale plays across the US fit these characteristics. When Deeprop® 1000 is applied in these formations, it allows reserves to be recovered earlier and for a longer period of time, which ultimately increases total recovery from the well.

DEEPROP® 1000	
D50	25 microns
D95	115 microns
Full Particle Distribution	5-200 microns
Density	2.5 gm/cc
Sphericity	1
Roundness	1
Acid Solubility in 15% HCl	0.80%
Compressive Strength	60,000 psi
Temperature Stability	2,200degF

Table 2 – Deeprop® 1000 Physical Properties.

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Work by Dharmendra, Gonzales, and Ghassemi at the University of Oklahoma indicates that an additional 1,500 square meters (16,000 square feet) of fracture area in the Eagleford and 818 square meters (8,880 square feet) in the Utica can be propped with Deeprop® 1000 compared to 100-mesh sand (**Figures 3** and **4**).[5]

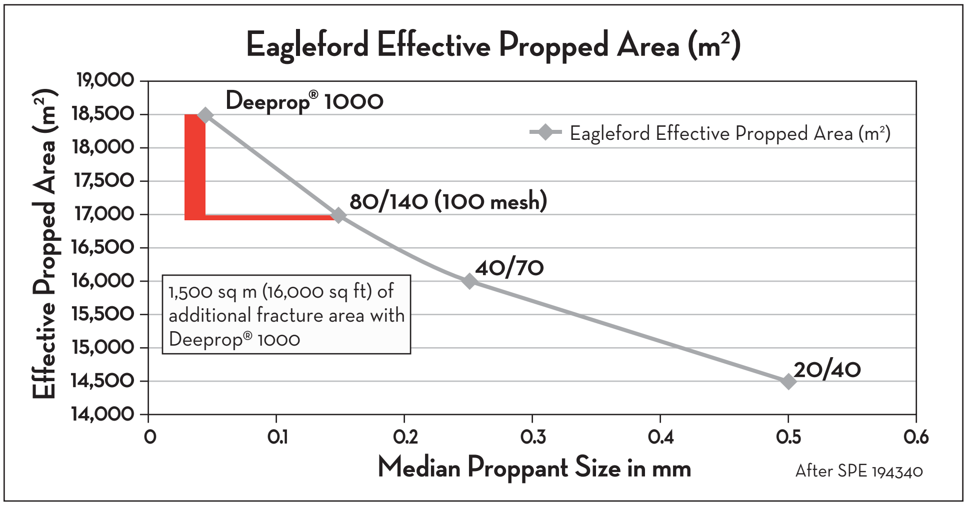

Figure 3 - Comparison of the Effective Propped Area vs Proppant Size in the Eagleford.

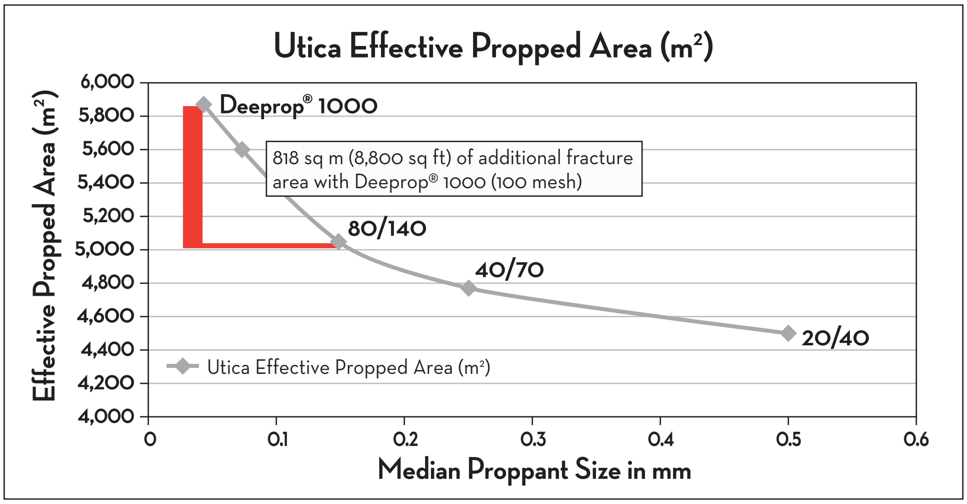

Figure 4 - Comparison of the Effective Propped Area vs Proppant Size in the Utica.

Published Proof

Several research studies have demonstrated Deeprop® 1000's potential to enhance the permeability of microfractures and vastly improve production in field applications in the Barnett and the liquids-rich Woodford formation located in the South-Central Oklahoma Oil Province (SCOOP).[1, 2]

An article in the *Journal of Petroleum Technology (JPT)* caught the attention of the industry.[3] Further studies in 2018 clearly showed the benefits of using a smaller proppant like Deeprop® 1000 to increase the propped area of an induced fracture.[4-6]

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Better Transport with No Mixing

Individual Deeprop® 1000 particles settle much slower than 100 mesh (see **Table 3**), which means that the material is transported much deeper into a fracture simply due to better proppant transport.

A physical slot flow test conducted by **FracTech Laboratories** (www.fractech.com) in the UK helped ease operator concerns about mixing Deeprop® 1000 into larger mesh proppant packs during placement. The Deeprop® 1000 immediately separated from the 30/50

Description	Vs (ft/sec)
20/40 Sand	4.28
40/70 Sand	1.07
80/140	0.22
Deeprop™ 1000	0.029
μ (cps) = 1 SG of Fluid = 1 SG of Proppant = 2.6	

Table 3 – Stoke's Law settling velocity for various proppants.

sand to form a fluidized bed ahead of the sand. The two materials did not mix and there was little, if any, settling of the Deeprop® 1000.

Reducing Frac Hits

Reservoir engineers from several operators have shared a common observation regarding Deeprop® 1000's impact on surface treating pressure and its relationship with frac hits. The surface pressure initially drops when Deeprop® 1000 hits the formation, likely due to near wellbore rock abrasion. Pressure then increases due to bridging and diversion of the treatment fluids into several new clusters and finally drops as the new clusters open and accept fluid.

This diversion created by Deeprop® 1000 allows for better cluster efficiency and reduces the frequency of frac hits. For an operator, this translates to greater production compared to the offset wells, as the Deeprop® laden fluid is distributed more efficiently into clusters that are not normally treated by conventional frac fluid treatments. Better frac fluid distribution to expose more of the shale formation also minimizes the volume of treatment fluid entering the first few clusters. This reduces both the fracture length being generated from these clusters and the likelihood that they will hit the drainage area of an offset well.

...the operator achieved an average production increase of 25,187 bbls with Deeprop®, **a 40% jump over non-Deeprop® wells**.

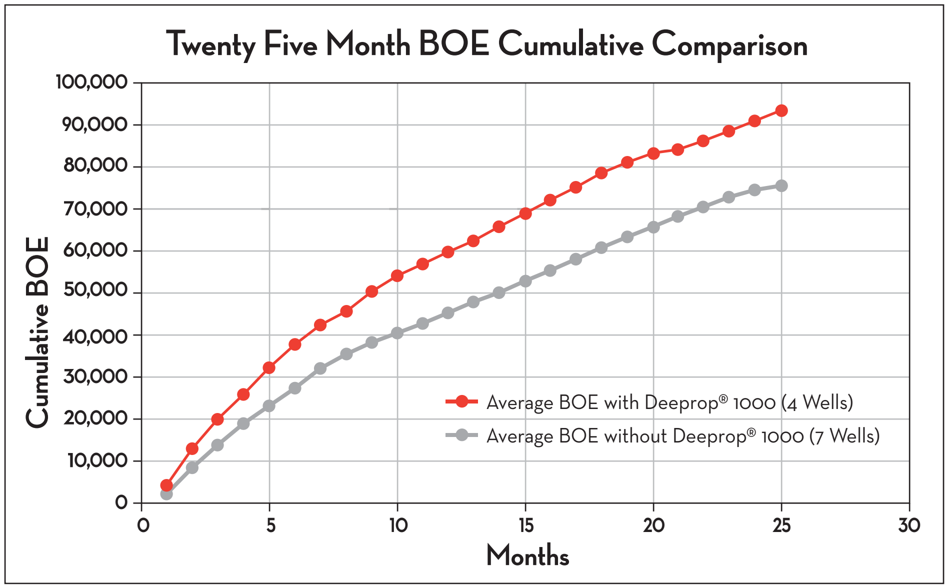

Figure 5 – Twenty-Five Month BOE Average Cumulative Production of the 11 wells used in the Barnett Shale study.

Proving its Potential

To date, Deeprop® 1000 has been pumped in the Barnett, Woodford (SCOOP), Utica and Wolfcamp (both the Delaware and Permian basins) shales. Highlights of these field applications are discussed below.

Barnett Shale (Texas)

Devon conducted an 11-well trial in Wise County, Texas, the first Deeprop® field application reported in the literature.[1]

Four of the wells were treated with Deeprop® 1000, with the remaining seven offset wells used as a control. A total of 4,200 lbs of Deeprop® 1000 mixed in a liquid slurry was added to the pad at a concentration of 0.1 lb/gal. As **Figure 5** shows, the wells start at about the same average cumulative BOE production but the Deeprop® 1000 wells begin to take off, with the uplift continuing to improve over time. This is consistent with the idea that Deeprop® helps open up a larger conductivity propped fracture area.

The lateral length of the Deeprop® wells varied from 3,792 ft to 5,252 ft and from 3,952 ft to 6,124 ft for the offset wells. Normalizing the data on a per-foot basis and using a lateral length of 4,000 ft, the operator achieved an average production increase of 25,187 bbls with Deeprop®, a 40% jump over non-Deeprop® wells.

Woodford Shale (SCOOP) (Oklahoma)

Industry knowledge of the SCOOP suggests that two years ago, the drilling operation made up 60% of the cost of constructing a well, with the remaining 40% taken up by completion activities. Advances in drilling automation have recently flipped this cost breakdown. Today, 35% of a well's cost is attributed to drilling and 65% is due to completion operations.

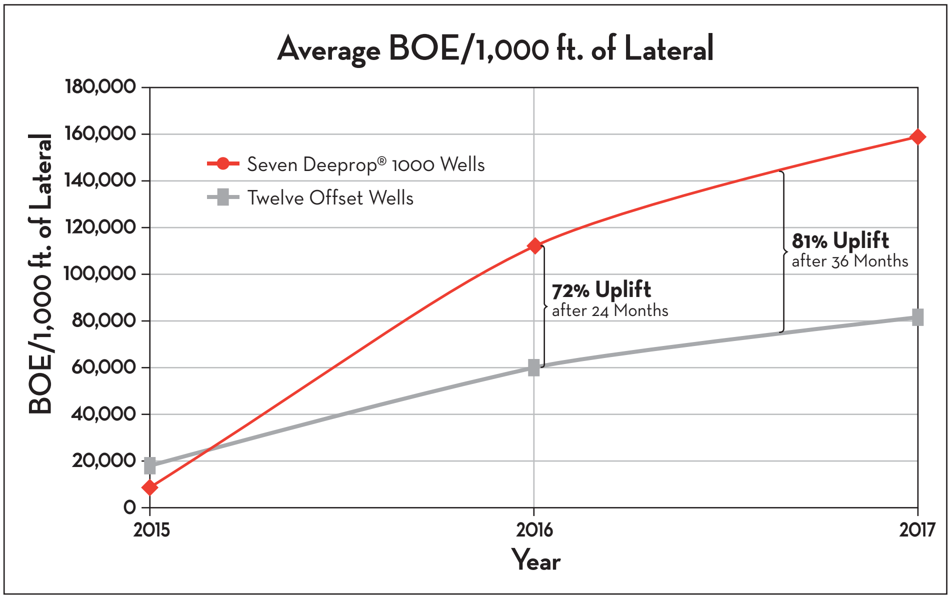

Figure 6 – Woodford (SCOOP) averaged cumulative BOE/1000 foot of lateral for seven Deeprop® 1000 wells and 12 offset wells.

> SCOOP operators were interested in testing the premise that for an additional investment of just $200K or less on microproppant, they could reach the smaller fractures and achieve vastly superior stimulation to recover that lost cost.

For a well that costs $5 million to drill and complete, it is not uncommon to spend $3.5 million of that on the completion. A well might lose as much $700K (20%) of that completion cost when using traditional fracturing techniques, because a conventional proppant like 100-mesh sand cannot reach the secondary fracture network of the reservoir. SCOOP operators were interested in testing the premise that for an additional investment of just $200K or less on microproppant, they could reach the smaller fractures and achieve vastly superior stimulation to quickly recover any additional cost.

An operator in the SCOOP conducted a study of seven Deeprop® 1000 wells offset by 12 wells. As with the Barnett wells,

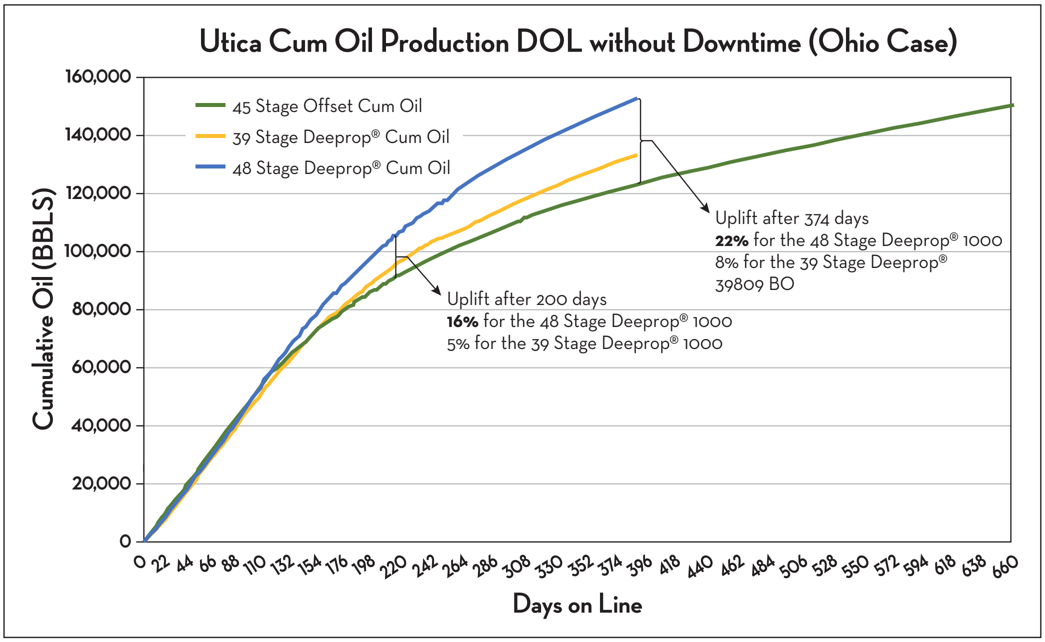

Figure 7 – Cumulative Oil for the Eastern Ohio case.

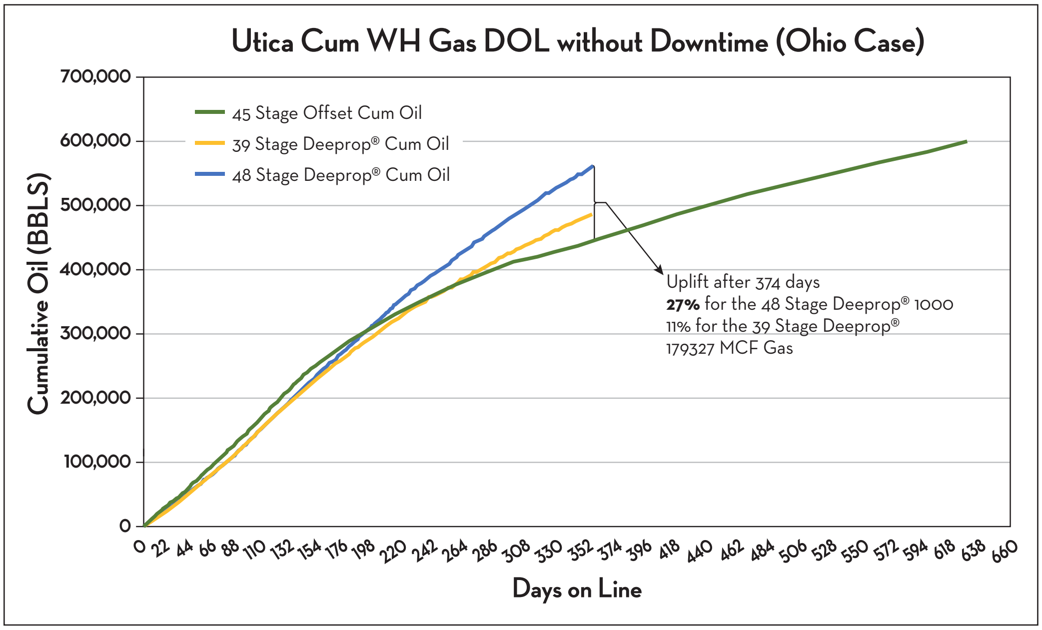

Figure 8 – Cumulative Gas for the Eastern Ohio case.

4,200 lbs of the Deeprop® 1000 were added as a liquid slurry into the pad at a concentration of 0.1 lb/gal. The subsequent production data was converted to BOE, plotted for all wells and normalized to BOE/1,000 ft of lateral (**Figure 6**). After three months the Deeprop®-treated wells began to outperform the offset wells The Deeprop® wells showed a 72% uplift after 24 months and an 81% uplift after 36 months.

Deeprop® also helped this operator reduce their treating pressure by 800 to 1,100 psi, which placed it well below the wellbore pressure limit of 11,500 psi. The treatment could then be placed at a higher pump rate, which improved fluid efficiency and exposed more rock.

Utica Shale (Ohio)

Three wells—two Deeprop® and one offset—were studied in the Utica shale, eastern Ohio, at about 7,500 ft TVD. **Figures 7** and **8** show the cum oil and gas for the three wells. Deeprop® delivered an uplift in oil production of up to 22% and a 27% uplift in gas production after roughly a year.

Permian/Delaware Basin (Texas)

Five tests are currently underway in the Permian Wolfcamp—two in the Permian basin and three in the Delaware basin—and preliminary results are encouraging. One test in the Delaware Basin currently has twenty months of production data. In the Wolfcamp A&B formations the Deeprop® well had a 12.3% and 15.3% uplift when compared to the offsets in the same formations respectively, provideding an additional 160,000 BOE (**Figure 9**).

Examining all of these wells together, the Deeprop® treatment has delivered major results and paid for itself in less than 4 months, on average. After 25

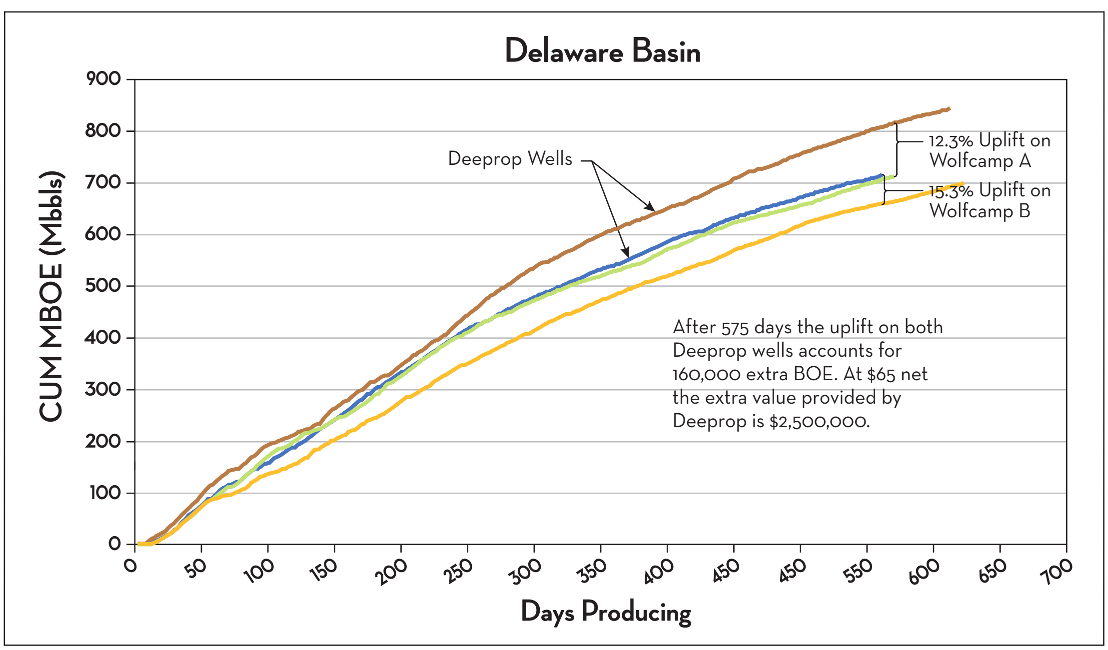

Figure 9 – Cumulative Oil for Delaware Basin case.

months, the average uplift across the Deeprop® wells in the major plays highlighted above is 40%. After 36 months, test wells have experienced uplift ranging from 10% to as high as 81%.

What Deeprop® Does for the Bottom Line

The field applications described above are proof positive of Deeprop's® ability to dramatically boost the bottom line of shale well production. Operators have seen for themselves the benefits of:

- Significantly more uplift.
- Lower treat rates.
- Generating larger productive fracture area.
- Less steep decline curves.

Are you ready to boost well production and improve your CAPEX returns?

More operators are experiencing for the themselves what Deeprop® can do to economically expand the productive life of their wells. Want to add your name to the growing list of satisfied Deeprop® users? **Contact us at Info@DeepropFrac.com today.**

Ultimately, Deeprop® can help operators in shale plays across the US, and across the globe, add years to the productive life of their wells, with an investment that pays for itself in just a few months.

Conclusion

On more than 200 wells to date, **Deeprop® 1000 delivered an average increase in cumulative production of up to 50% versus control wells.** At $45/bbl oil net, after transportation and royalty costs, a Deeprop® well producing an additional 35,000 BOE of oil (a typical increase observed in the field) adds $1.58 million in revenue to the well.

References

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