nanoActiv®

by Nissan Chemical

Presented By:

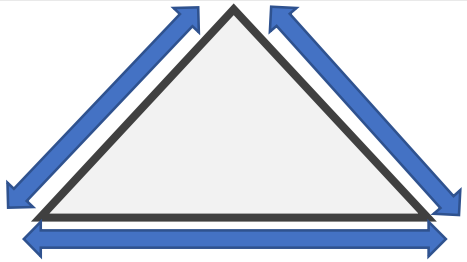
Nitro-Lift® TECHNOLOGIES LLC

Nitro-Lift's Relation to Nissan Chemical & nanoActiv®

- Vertically integrated energy service specializing in
- Upstream: Onshore and Offshore Hydrocarbon Recovery
- Midstream: Pipeline and G&P Services
- Downstream: Refinery and Industrial Services
- Oil and Gas Fabrication

- ~400 Master Service Agreements in place

Exclusive U.S. Distributor, Exclusive Service Provider & Process Developer



nanoActiv® by Nissan Chemical

MESSER Gases for Life

Product Developer:

- Multibillion international chemical company.
- Developer and producer of **nanoActiv® HRT**.
- Initial focus of nanoActiv® was in the initial production of the well, after recognizing the potential of nanoActiv®, Nissan sought a partnership with Messer to help develop an enhanced oil recovery method using the nanoActiv particles.

Technical Support & Process Developer:

- Multibillion international industrial gas company (acquired Linde America).
- Assisted in the development of deploying **nanoActiv® HRT** using nitrogen, carbon dioxide, water, and methane.
- Messer had worked with Nitro-Lift for years on several projects. Messer quickly recognized the value of utilizing Nitro-Lift's "down-hole" and nitrogen expertise and brought Nitro-Lift under a NDA in 2016.

Why nanoActiv® HRT and EFT?

Recovery Factors have been, historically, low for most oil and gas reservoirs.

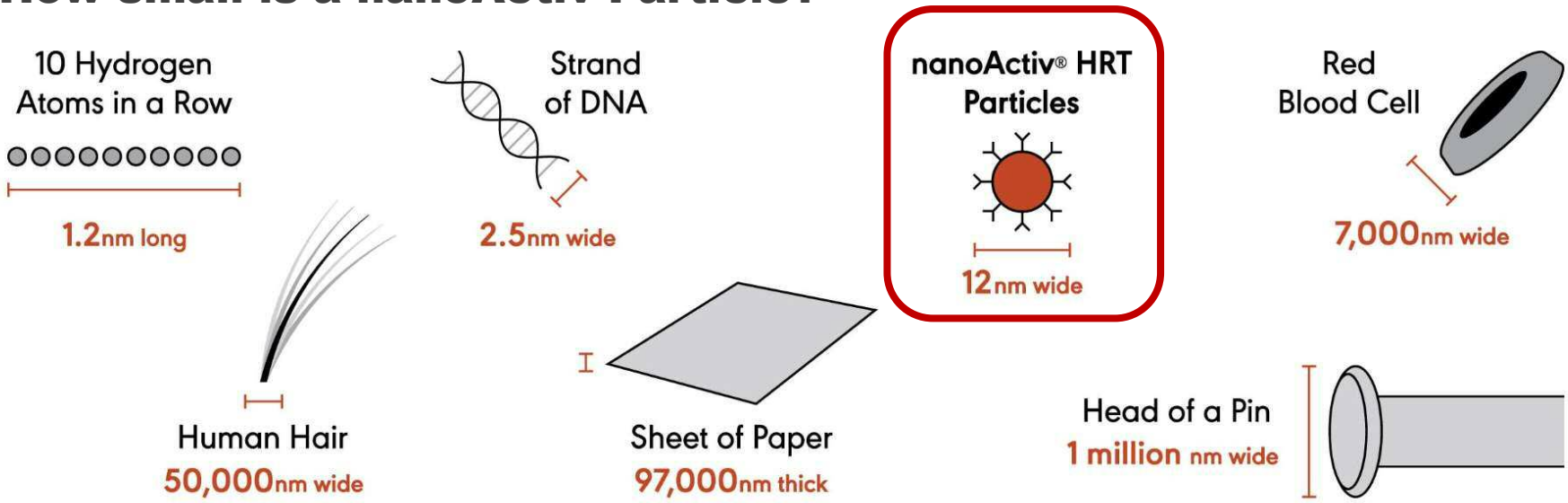
Nissan Chemical developed nanoActiv® HRT and nanoActiv® EFT in response to this problem.

The 3 primary applications for nanoActiv® are:

- EFT during completion and stimulation operations.
- HRT to stimulate wells on decline and “Frac Hit” mitigation.
- EFT & HRT during EOR processes (Waterflood, Huff ‘n Puff, CO2 ops, etc.)

Size Matters

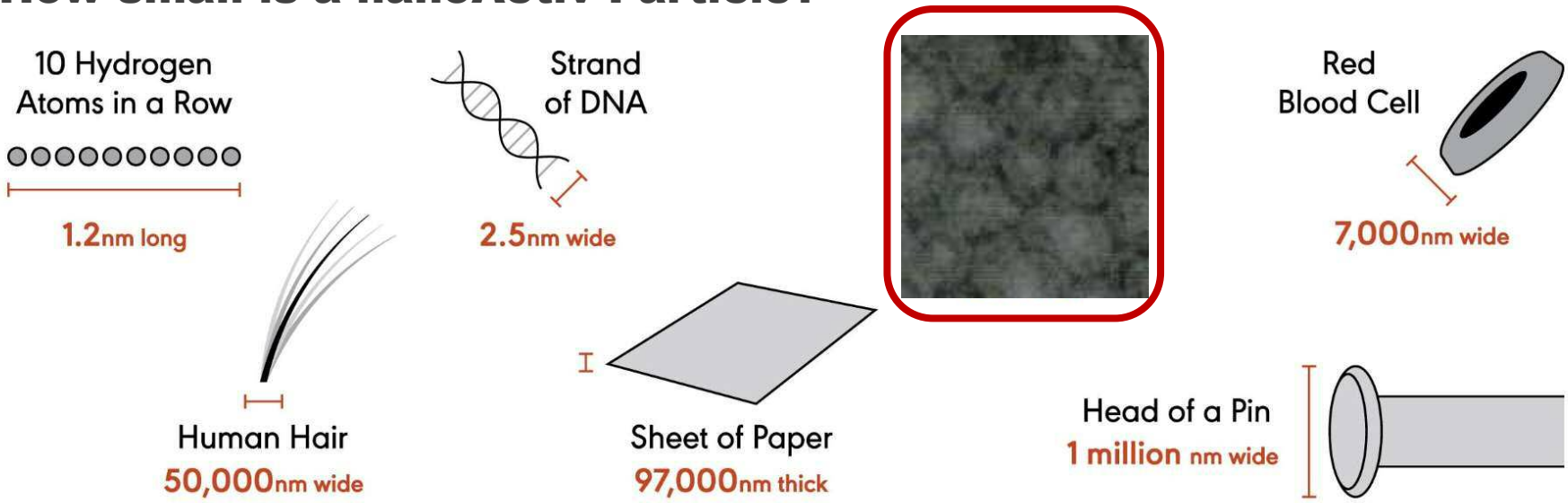
How small is a nanoActiv Particle?



nanoActiv® particles cover a vast amount of surface area, specifically, they can cover ~20,000X more surface area than ONE grain of sand.

Size Matters

How small is a nanoActiv Particle?



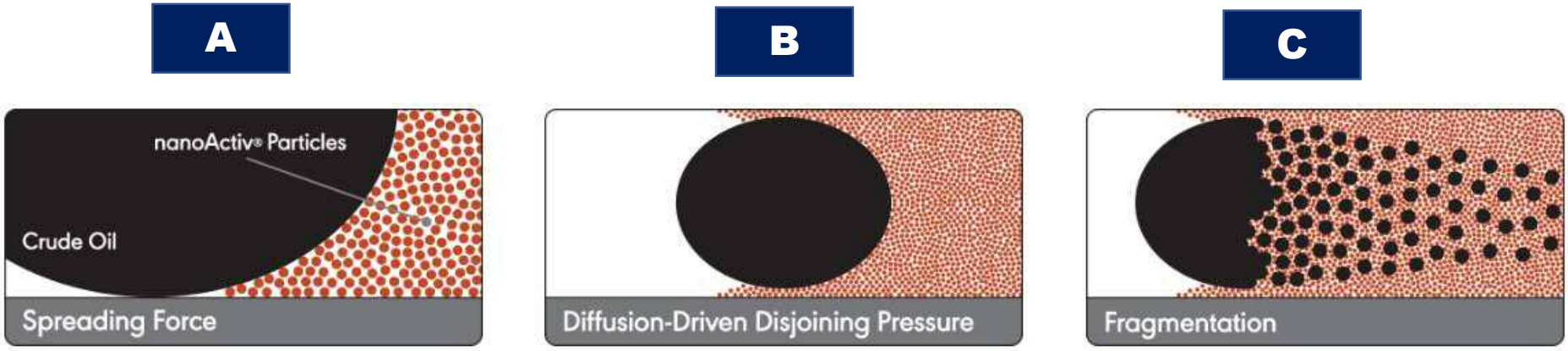
Actual nanoActiv® EFT nanoparticle stabilized droplets at 100,000X magnification under transmission electron microscope (TEM).

How do nanoActiv® particles work?

A. nanoActiv® mixture is pumped into the formation and displaced using water, nitrogen or carbon dioxide as a carrier fluid.

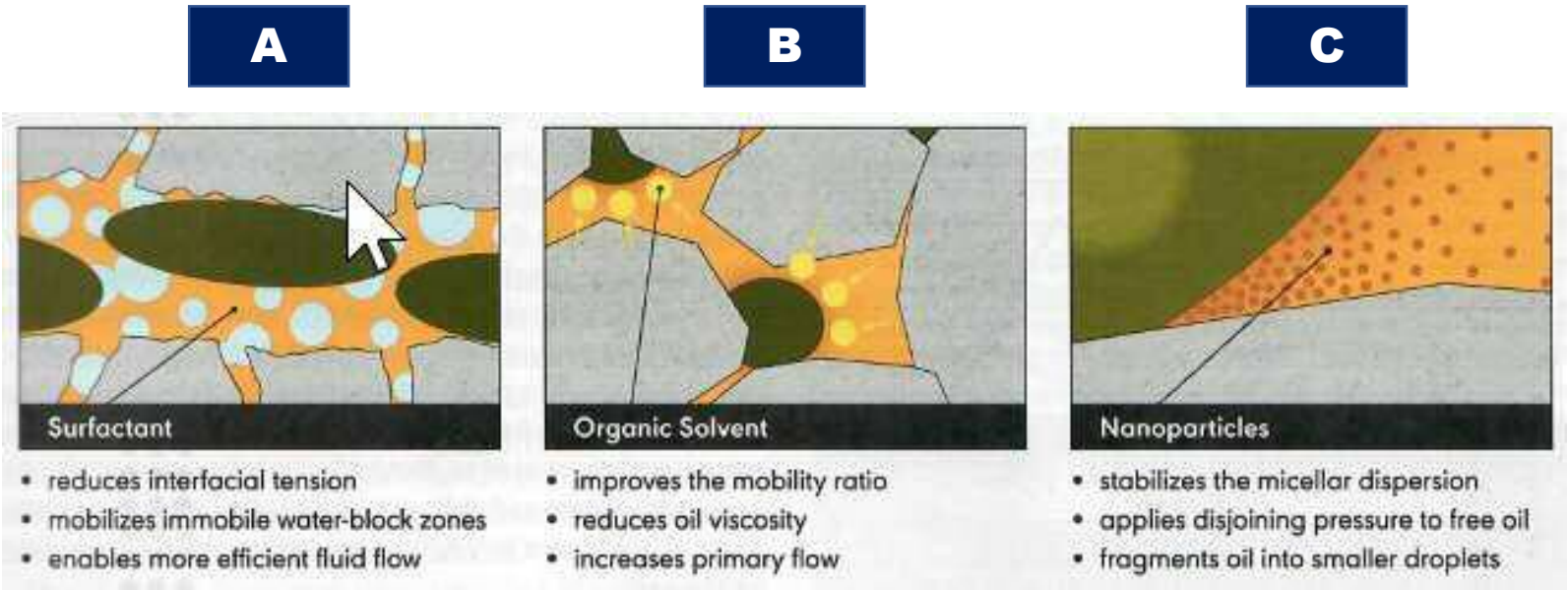
B. As nanoActiv® moves through the reservoir, the nanoparticles preferentially move to the rock surface in open and/or closed pores and dislodge oil by fragmentation into smaller droplets through Brownian motion.

C. The smaller oil droplets flow to the wellbore and are brought to surface under natural flow or artificial lift.



How does nanoActiv® EFT work?

A. Surfactant
B. Organic Solvent
C. Nanoparticles



Brownian Motion

Brownian Motion is the erratic random movement of microscopic particles in a fluid, as a result of continuous bombardment from molecules of the surrounding medium

https://www.youtube.com/watch?v=cDcprgWiQEY&feature=youtu.be

A gas molecule in the air moves around on its own until it hits another gas molecule which makes it change direction. Since there are so many gas molecules, it will constantly bump into other molecules (roughly 10^{14} collisions per second - that equals the total number of Google searches performed worldwide over 79 years!)

Three Primary Applications

Frac Hit Mitigation

Frac Hits are a growing problem in the industry as infill drilling occurs, wells communicate robbing pressure and significantly reducing the production of the parent well.

nanoActiv injected by water and/or Carbon Dioxide or Nitrogen can has been proven to protect parent wells from frac hits.

New Completions

New wells using nanoActiv EFT as a surfactant have seen 20% better performance than wells treated with competitors.

Enhanced/Improved Oil Recovery

Newer drilled wells with a sharp decline have been injected with a combination of nanoActiv®, followed by an inert gas (N2 or CO2) have yielded increased production reducing the appearance of the decline curve.
Older wells who have declined to the point of producing 5 to 10Bpd or 20Mcfd have seen sizable increases in production.
Sustainability- Wells treated 2 years ago are still showing increased production.

Benefits of EOR/IOR Recovery
Increase in productivity from 12% to 500%+.
Target 90-day payback on verticals and 180- to 360-day payback on horizontals. (some paybacks have been 18 – 60 days)
Less cost-intensive method than refracking.
Treatments results last longer, reducing periodicity of repeated treatments.
Fast implementation and rapid time-to-production.
Extend production life to forego plugging liability obligation.

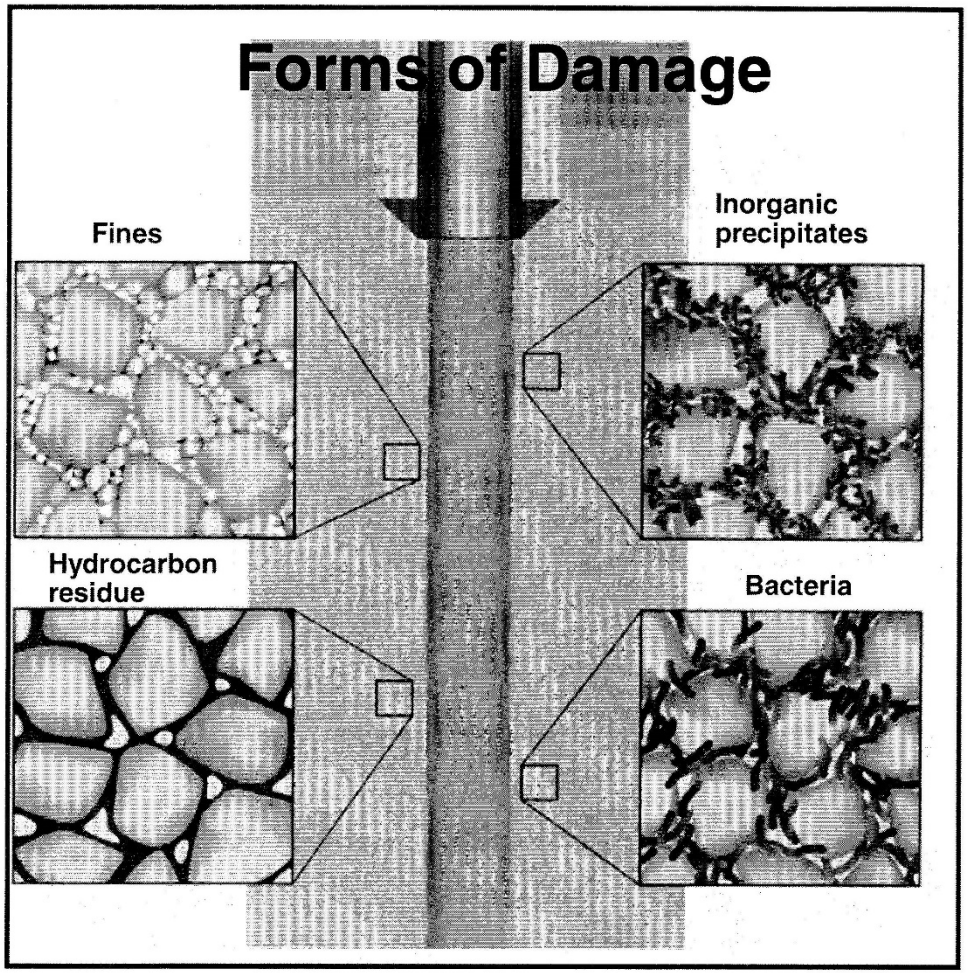
Hele-Shaw Test

Hele-Shaw flow is defined as Stokes Law flow between two parallel flat plates separated by an infinitesimally small gap which is important to micro-flow.

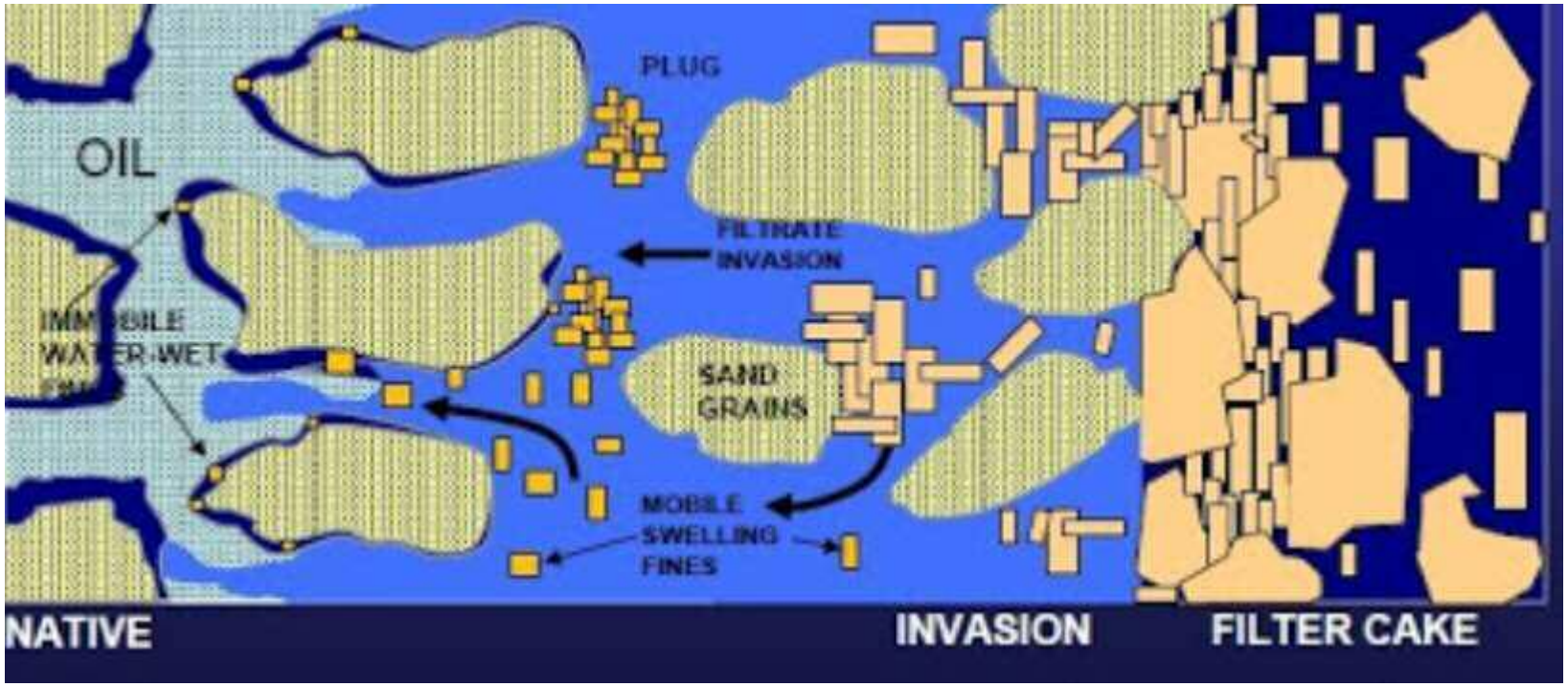
https://youtu.be/DK9Fe_2m__o

nanoActiv® attaches itself to the glass changing the interfacial tension and breaks the hydrocarbon droplets into smaller sized droplets requiring less energy to flow. This same principle promotes hydrocarbon "breakup" in the pore space and thereby released out of the rock.

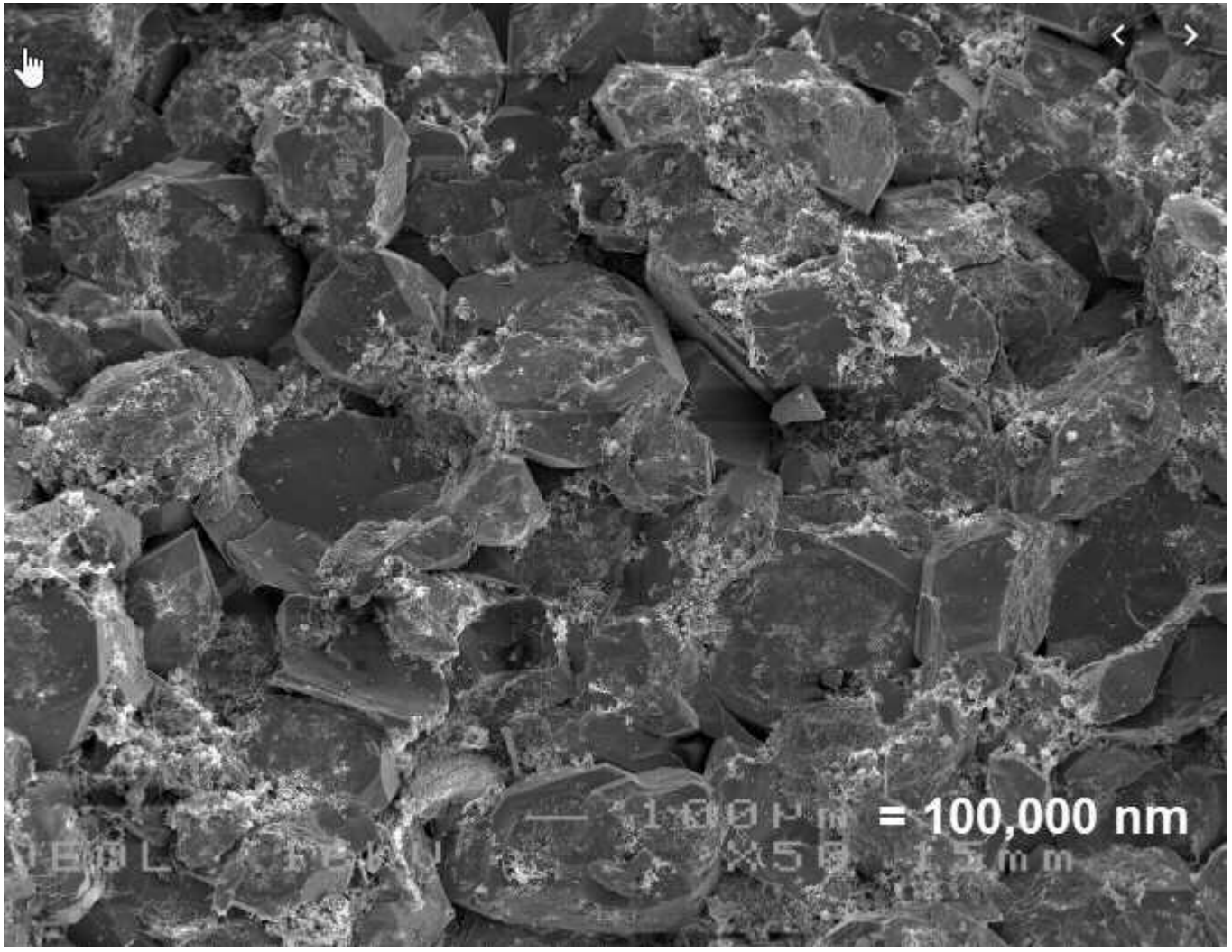
Formation Damage



Formation Damage from Drilling Fluid



SEM - Formation Damage



In this illustration, 8,300 nanoparticles 12 nm in diameter will fit side-by-side on the light gray line.

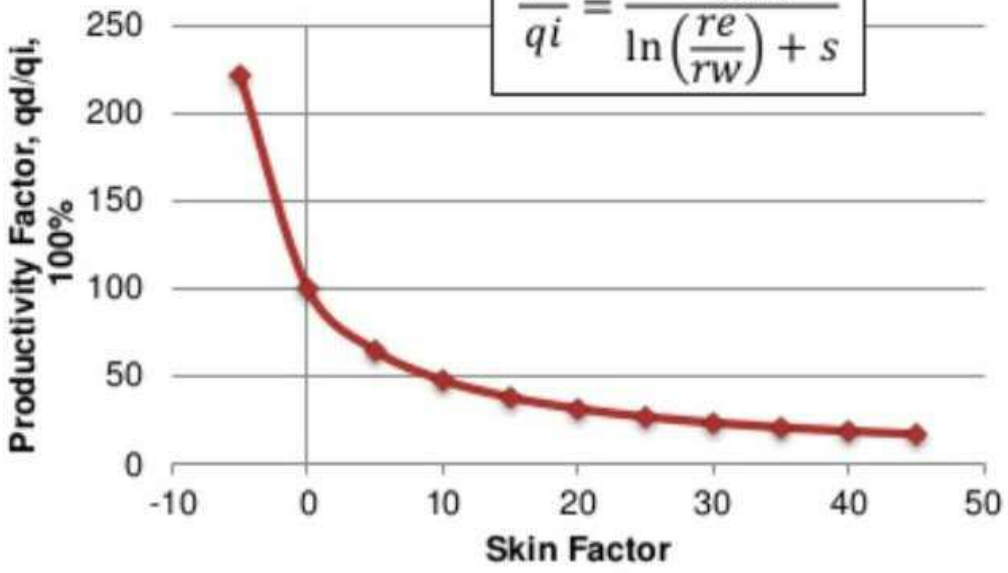
Skin Effect on Production

- A simple experiment to examine the skin factor effect on flow rate is to use darcy law:

$$q = \frac{kh(p_e - p_{wf})}{141.2B\mu\left[\ln(r_e / r_w) + s\right]}$$

- Then divide the flow rate in the damage case with flow rate of no damage (s=0)

$$\frac{qd}{qi} = \frac{\ln\left(\frac{re}{rw}\right)}{\ln\left(\frac{re}{rw}\right) + s}$$



Assumptions:
re= 2980 ft
Rw=0.328 ft

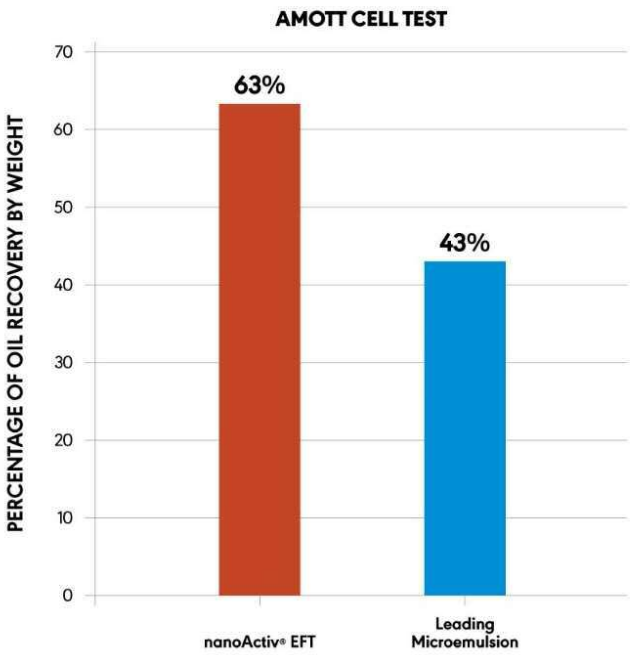
Well Treatment Comparisons

Possible Results	Refracturing	Acidizing	nanoActiv®
Physical Alteration	+	+	+
Chemical Alteration	-	-	+
Chemical Reaction	-	-	+
Precipitation	-	-	+
Solid Plugging	Possible	-	+
Permeability Alteration	+	+	+
Wettability Alteration	-	-	+
Fines	-	-	+
Emulsion Block	-	-	Possible
Water Block	-	-	+
Sludge Formation	Possible	Possible	+

Chemical Comparison

Benefit Attribute	Factors	nanoActiv® Technologies	Leading Microemulsion	Generic Surfactant
Speed of Oil Production	Production performance enhancement	✓	✓	✓
	Potential for early oil to surface	✓	✓	✓
	Longer lasting production with lower percentage decline rate	✓	✗	✗
Persistence	Duration of effectiveness compared to conventional methods — 3 times longer	✓	?	?
Effectiveness at Different Temperatures	90–175° F	✓	✓	✓
	175–275° F	✓	✓	✓
	275–350° F	✓	✓	?
Foaming	Ability to reduce foaming	✓	✓	✓
Paraffin Mitigation		✓	✗	✓
Mechanical vs. Chemical Approach	Wedge effect — disjoining pressure	✓	✗	✗

✓ Applicable ✗ Not Applicable ? Unknown

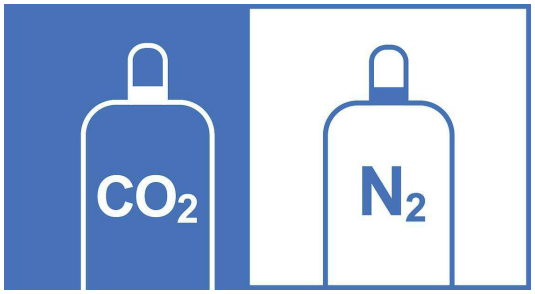


The Amott Cell test is used for the determination of oil recovery based on the spontaneous imbibition of oil into a core plug followed by extraction of oil out of the core using the formulation to be screened. The figure above shows the results of Amott Cell testing performed in Boise Sandstones cores.

nanoActiv® EFT outperformed the leading microemulsion technology by 20%.

nanoActiv® HnP (Huff'n Puff)

nanoActiv® HnP, a Messer *Boost*-EOR™ solution, is a proprietary, multi-spectrum, re-stimulation/enhanced recovery treatment for wells with declined production. Combining the properties of gas and nanoparticles creates a unique, synergistic treatment that addresses multiple potential production issues simultaneously. A successful treatment may enhance production for six months or more.



CO_2 or N_2

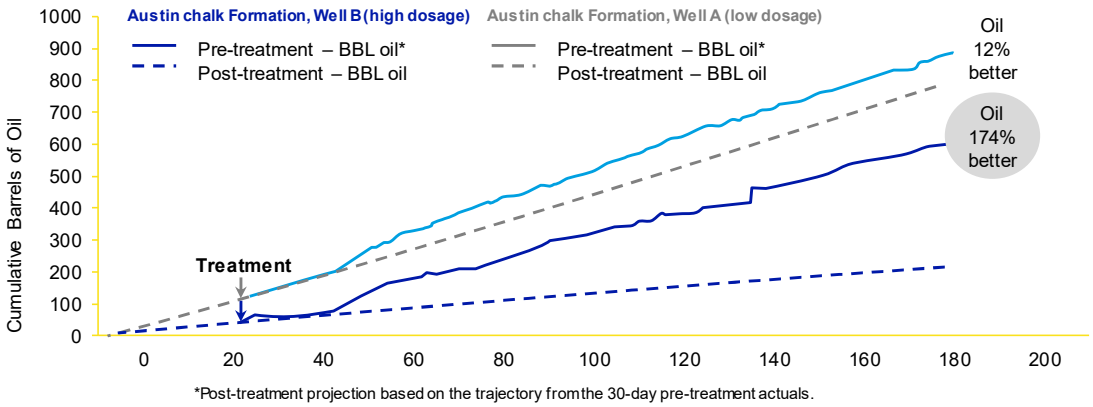
nanoActiv® HRT
&/or EFT

Huff'n Puff

nanoActiv® HnP
powered by Messer

Nano/Gas UCR Treatments

First case study results in Austin Chalk and Buda Limestone - 20173

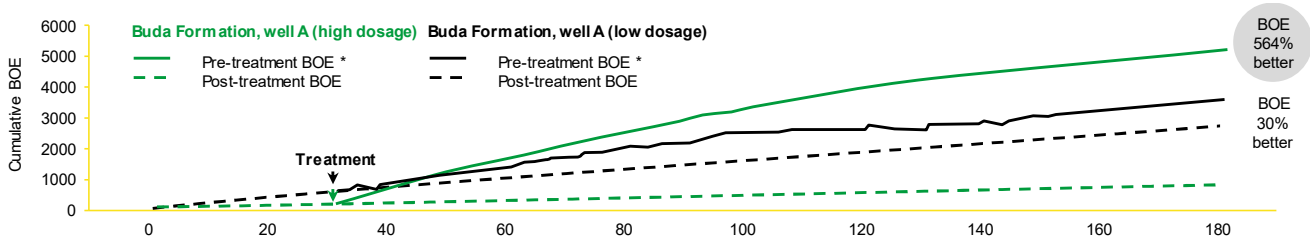


*Post-treatment projection based on the trajectory from the 30-day pre-treatment actuals.

60 tons N_2 / 2500 - 7500 gals nanoparticle solution
NAG
1 day inject; 3-7 day soak

Key Take-aways:

- All wells treated responded to treatment.
- Dosage most important factor of well response.



*Post-treatment projection based on the trajectory from the 30-day pre-treatment actuals.

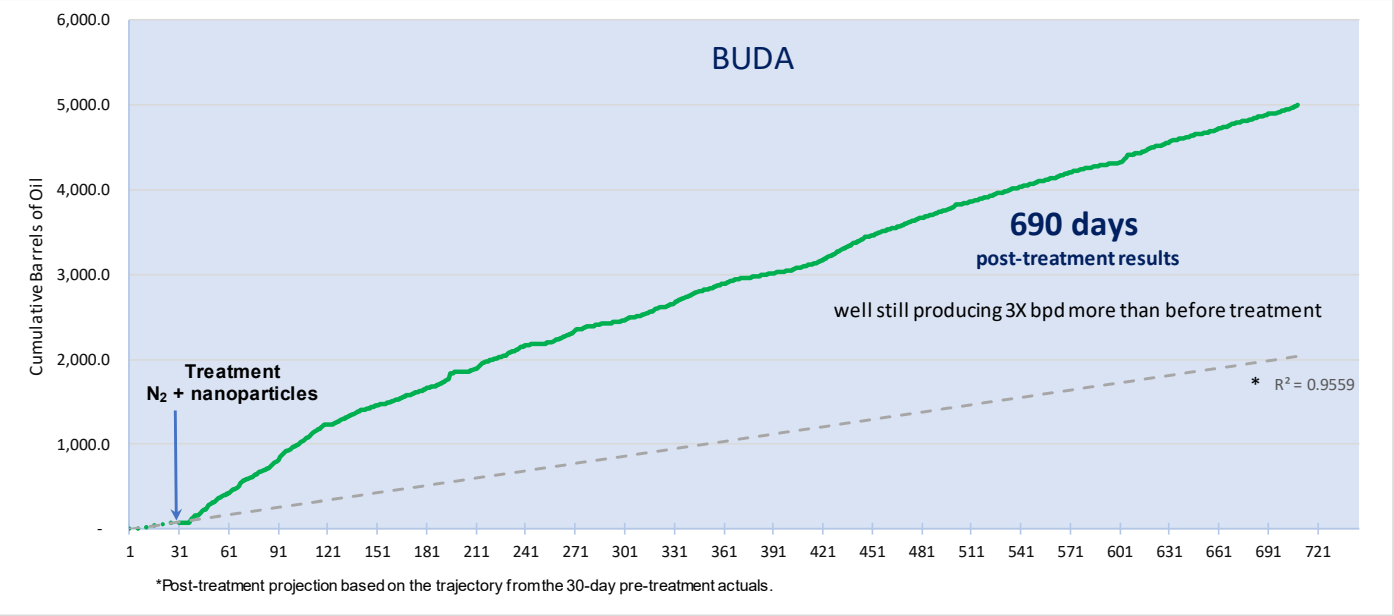
nanoActiv® HnP powered by Messer

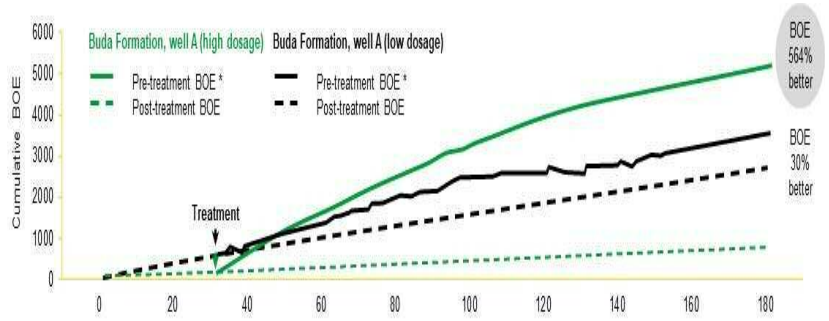
Buda Well update – nanoActiv® and N2

Oil enhanced recovery treatment 690 days post-treatment

Treated mid-May 2017 with: 2,500 gal of nanoActiv® HRT; 60 tons of N_2; 5 stages

Original 180 day results and still going strong 690 days later!





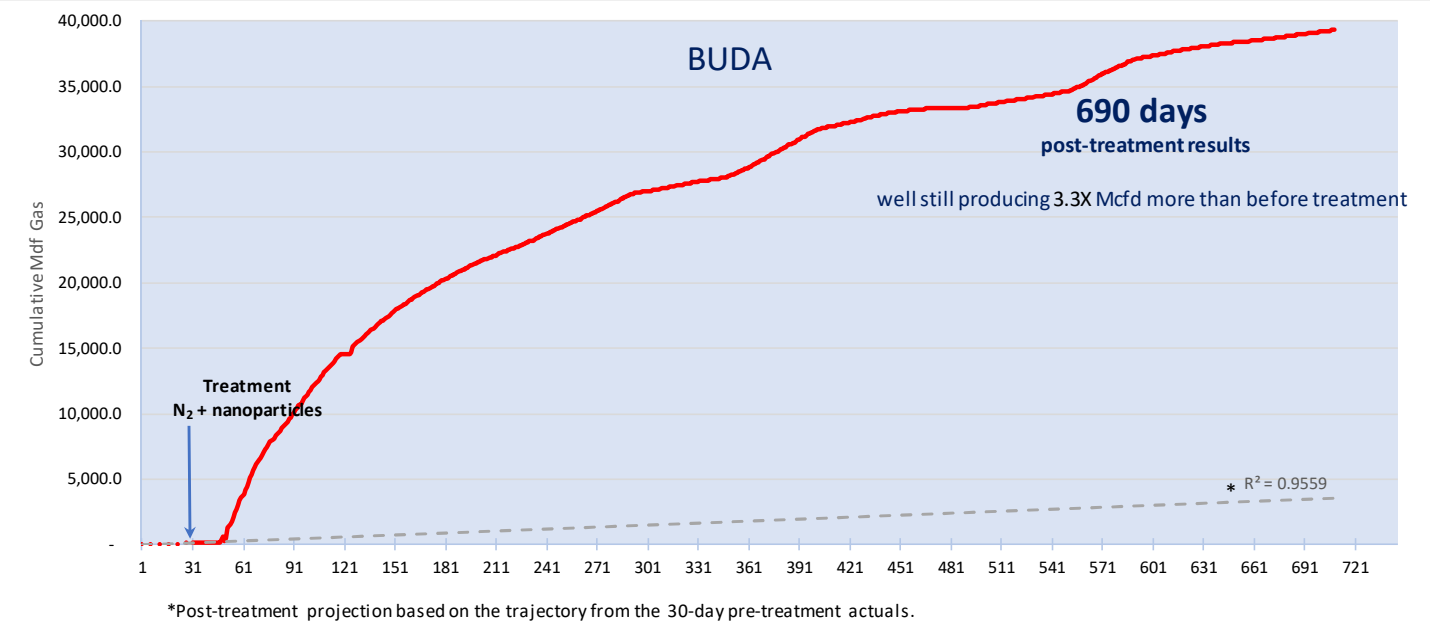
nanoActiv® HnP powered by Messer

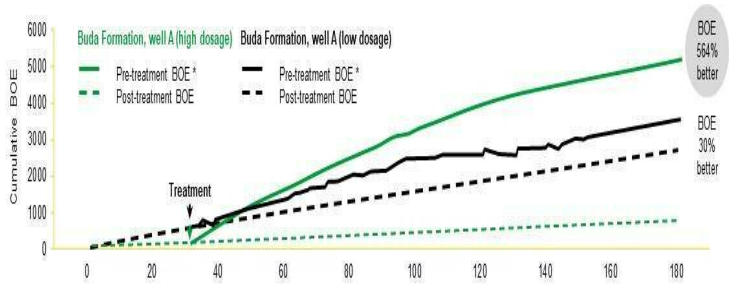
Buda Well update – nanoActiv® and N2

Gas enhanced recovery treatment 690 days post-treatment

Treated mid-May 2017 with: 2,500 gal of nanoActiv®HRT; 60 tons of N_2; 5 stages

Original 180 day results and still going strong 690 days later!



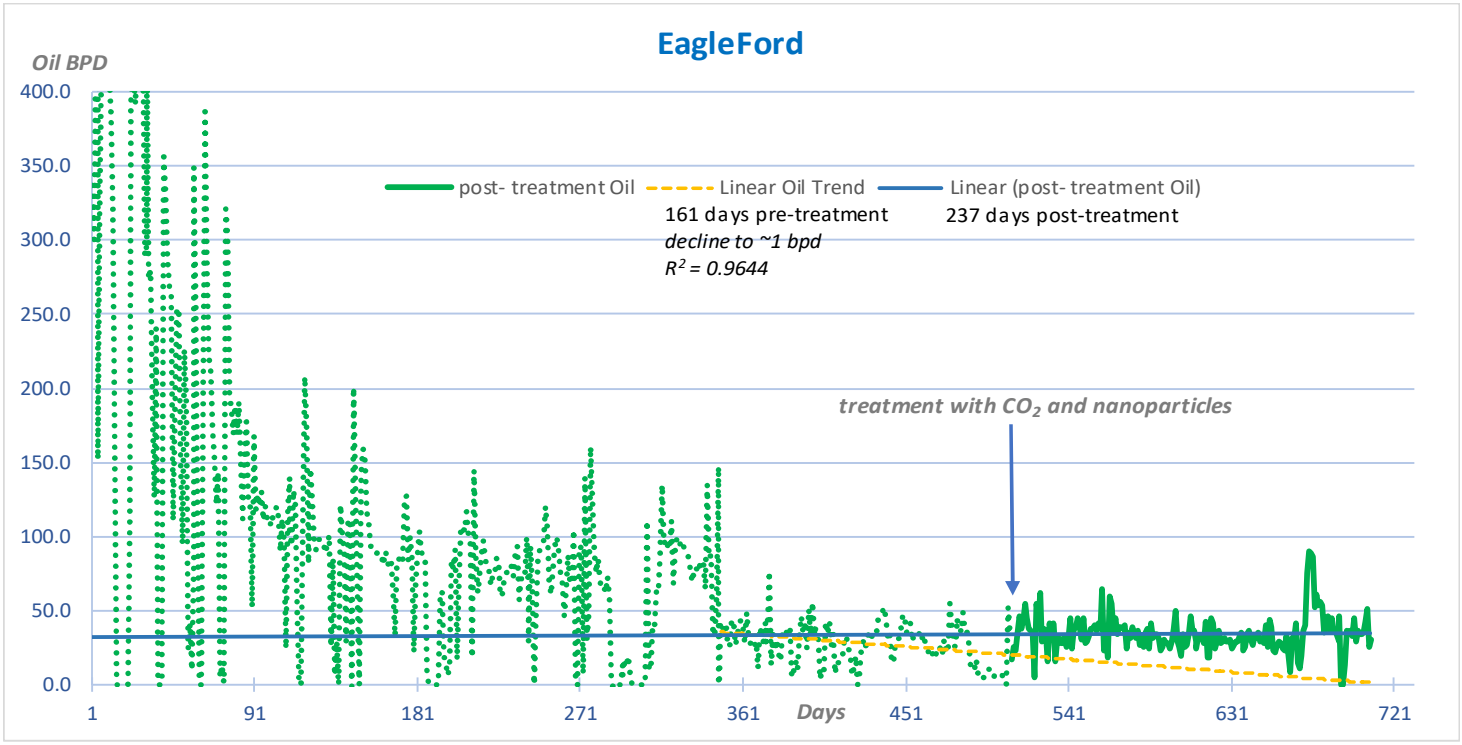


nanoActiv® HnP
powered by Messer

Designed UCR nano/gas Treatment

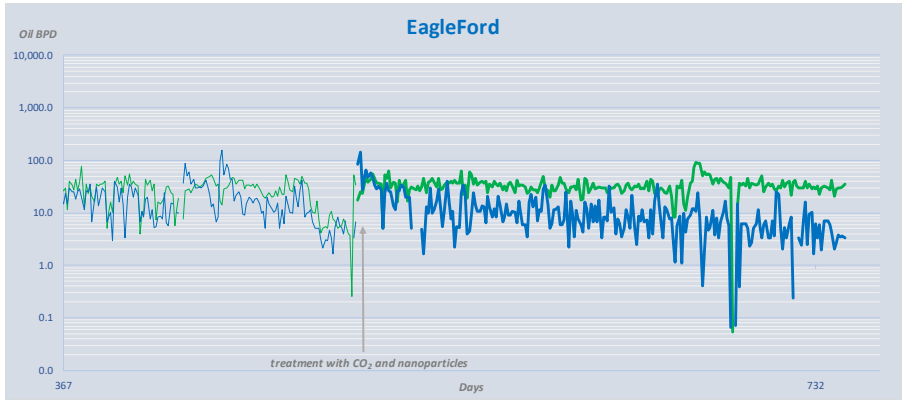
based upon key learnings from first field case study

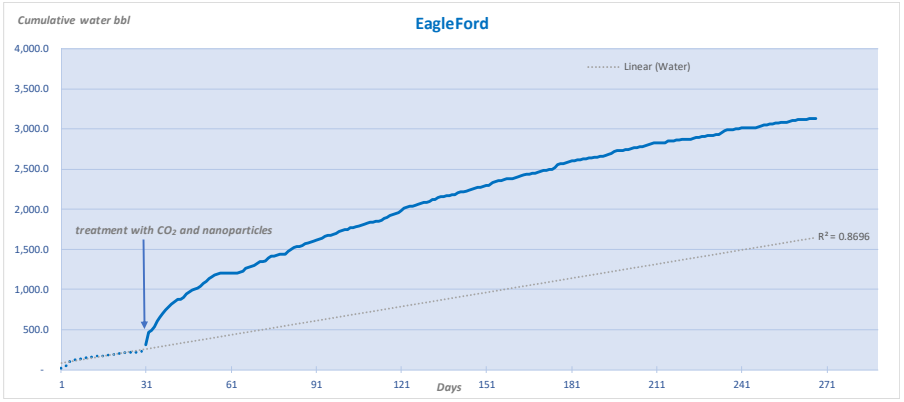
Treated mid-May 2018 with: 7,000 gal of nanoActiv® HRT; 160 tons of CO_2; 11 stages NAG (10 with diverter)



nanoActiv® HnP
powered by Messer

Eagleford nano/gas Treatment results (continued)



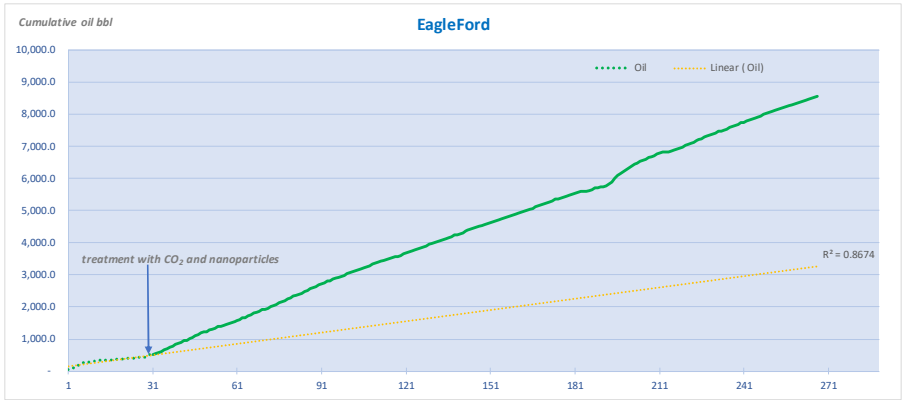


Key Take-Aways:

Hit all Success Criteria - production targets 60 days 31-37 bpd; 90 days 27-36 bpd; 37 & 32 respectively; 60-90 day payback; incremental oil net rev > cost of injection (2000+ bbl incremental lease 90 days, +5000 bbl total well treated to date); Positive treatment response lasting > 6 months; 230+ days post-treatment still going strong

Decline rate has been lowered

Offsets also experience positive response to treatment



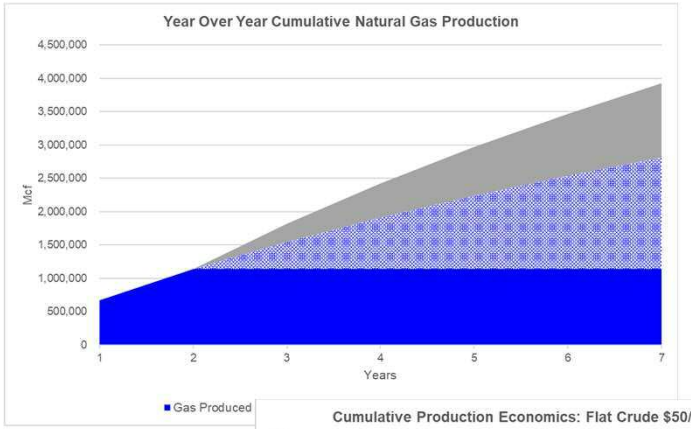
Arkoma Basin – Horizontal Wells

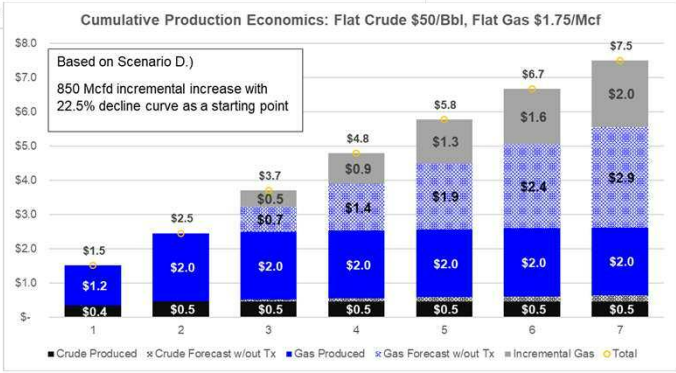
In an effort to perform a complete due diligence process, a Tulsa based exploration and production company (E&P Co.)agreed to treat two of their wells with the nanoActiv Boost EOR service offered by Nitro-Lift.

The service was performed April 26,2019.

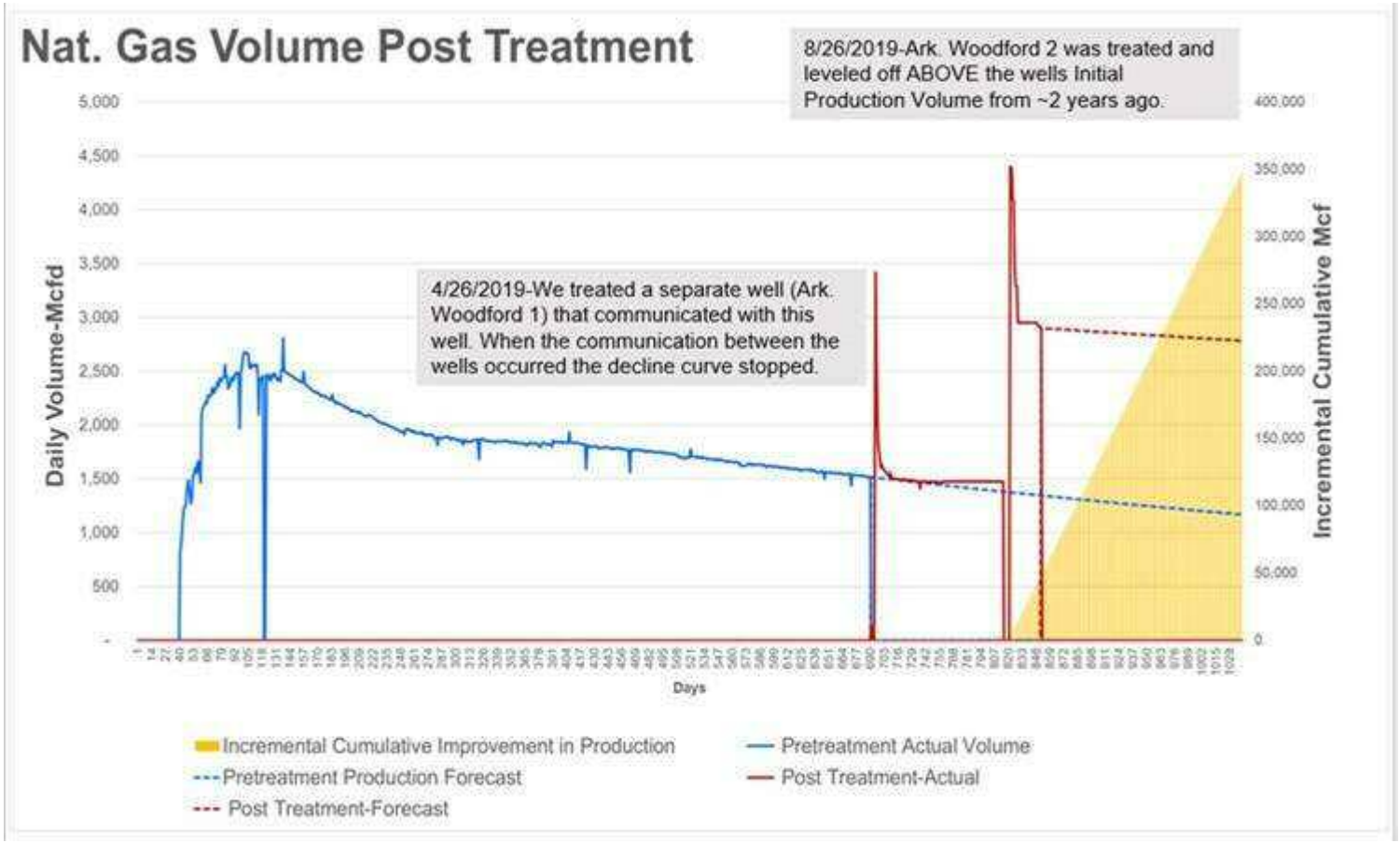
- E&P Co. selected 2 horizontal wells in the Arkoma Basin for the test (named Arkoma 1 and Arkoma 2).
- Arkoma 1 was producing 6 barrels per day (Bpd) of crude and ~1,290 Mcf per day of natural gas.
- Arkoma 1 had an offset well located on the pad site (referred to as: Arkoma 1 Offset). Within the first few minutes of the treatment Arkoma 1 Offset began to communicate/respond.
  - **The communication between the wells means that 2 wells were treated with one dose.**
  - The nanoActiv migration produced positive benefits to Arkoma 1 Offset.

Arkoma Basin – Horizontal Wells (continued)





Arkoma Basin – Horizontal Wells (continued)



Arkoma Basin – Horizontal Wells (continued)

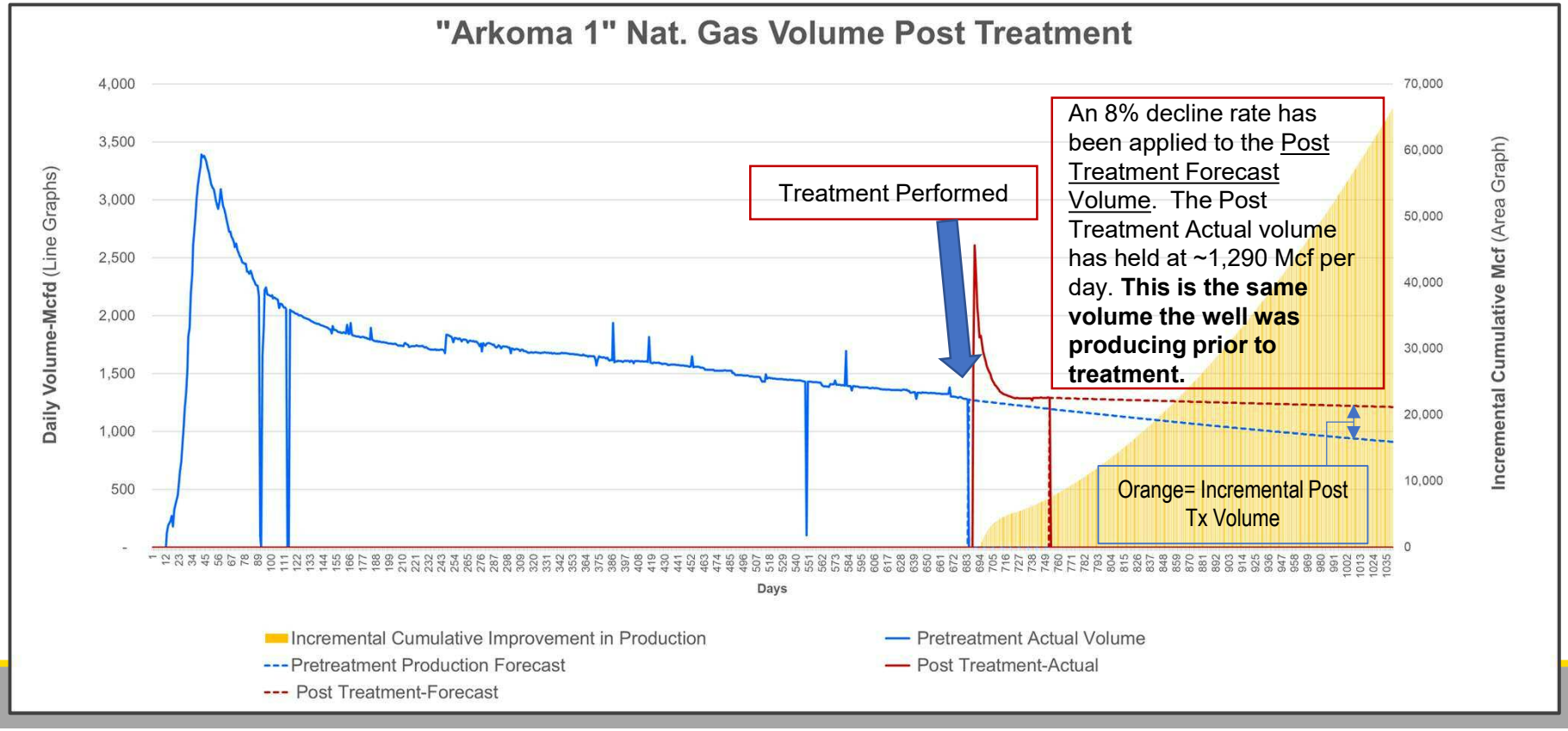
Arkoma 1 60-Day Results

Despite only receiving a ~50% dose, Arkoma 1 produced tangible results.

Natural Gas Results:

The Decline Curve has moved from a forecasted **-30%+ to 1%.**

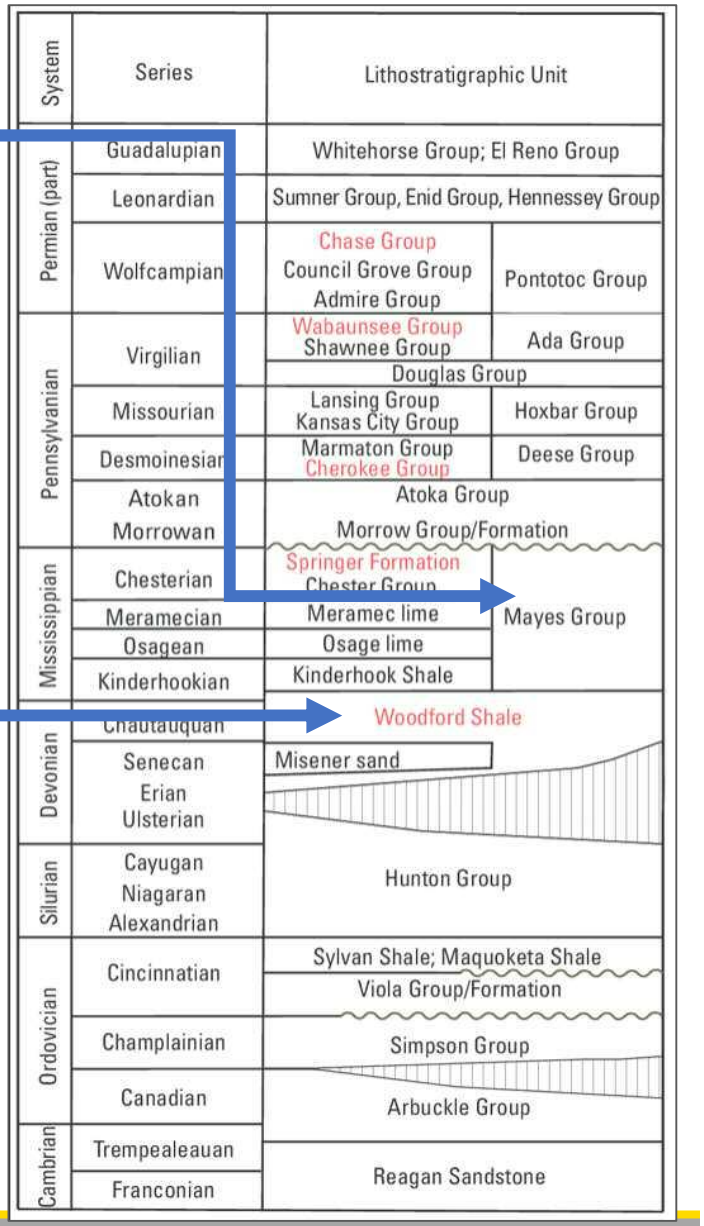
- The daily gas volumes have held to ~1,290 Mcfd (as of 6/30/2019), the same daily volume as the first day it was treated.
- The Incremental Cumulative Improvement in Production for Arkoma 1 is forecasted to produce an additional ~65,000 Mcf over the next year.
- Arkoma 1 Offset is forecasted to produce an additional ~40,000 Mcf over the next year.



Due Diligence- NanoActiv

April 29,2019 Nitro-Lift treated "Arkoma 2" a well drilled in the Mayes formation (Oklahoma).

- Arkoma 2 is a 1-year old well producing ~1,670 Mcf per day of natural gas and had NOT produced a barrel of oil in ~45 days.
- Arkoma 2 has an offset well located on the pad site (referred to as: Arkoma 2 Offset). Within the first few hours of the treatment Arkoma 2 Offset began to communicate/respond even though it was drilled for the Woodford formation.
  - **The communication between the wells means that 2 wells were treated with one dose.**
  - The nanoActiv migration is expected to produce positive benefits to Arkoma 2 Offset.
  - Arkoma Offset had not produced crude since 3/30/2019



Conclusions

- nanoActiv® EFT and HRT is paradigm shift in “well treatments”.
  - Completion and stimulation additive.
  - Mitigate frac hits.
  - EOR processes – waterflood, Huff’n Puff, CO2 flood, etc.
- Proven to increase production and EUR in various formations:
  - Austin Chalk
  - Eagleford Shale
  - Woodford Shale
  - Buda Lime
- Formation damage is mitigated due to mechanical action vs. chemical action by other leading treatment methods.

Questions?