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WellStim is our flagship product for modeling matrix acid stimulation of carbonates and sandstones. It is by far the most comprehensive and advanced acidizing simulator. Its key features:

- Multiphase transient two-dimensional displacement flow (2D filtration) model taking into account heat and mass transfer
- Multistage interval-based treatment of horizontal wells
- Numerical model of terrigenous sediment dissolution with mud acid

Contents

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WellStim acidizing design of a long horizontal cased-hole completion

Challenge

An acid treatment with acid gel was performed without prior simulation which resulted in lower production and economical improvements than expected. This case shows post-job analysis by simulation in WellStim, including production and NPV optimization.
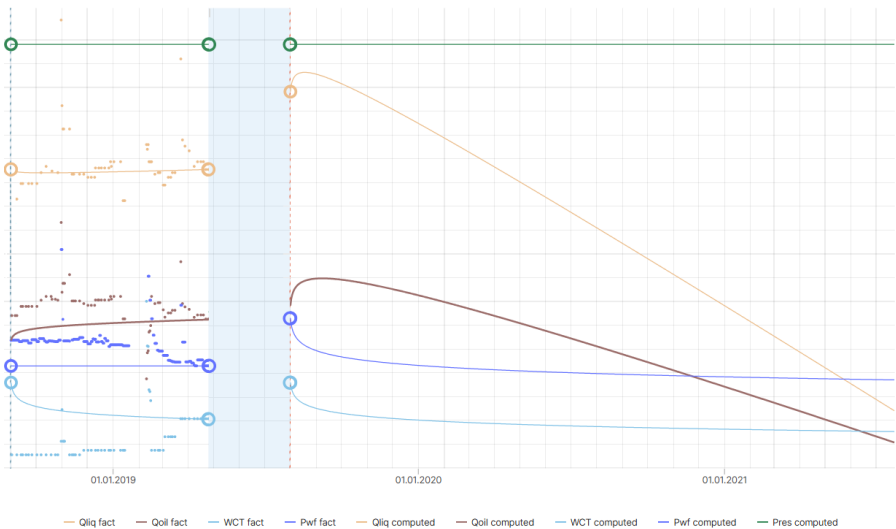
Area: North Europe
Reservoir: oil carbonate
Depth: MD – 13,100 ft, TVDSS – 8956 ft
Wellbore completion: slanted well completed with liner
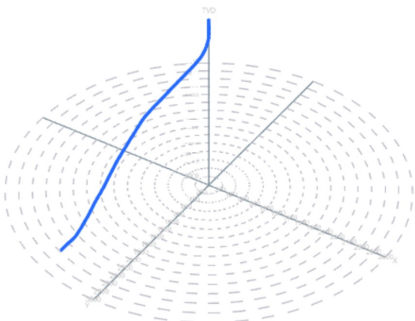
3D view of the well configuration

Solution

The production decline trend for 5 years was set and the design was calculated based on the actual acid treatment schedule.
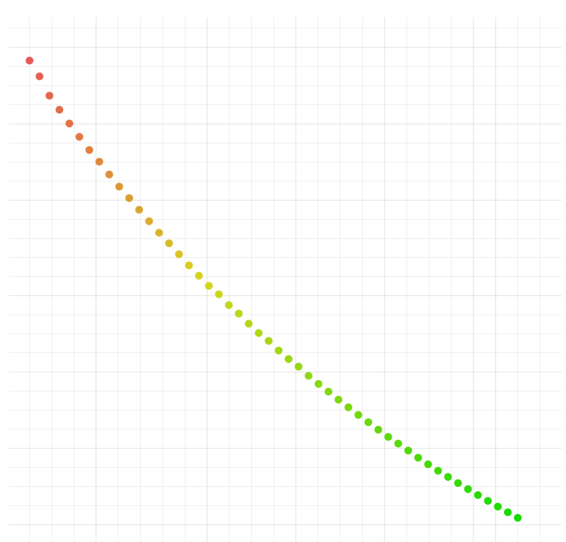

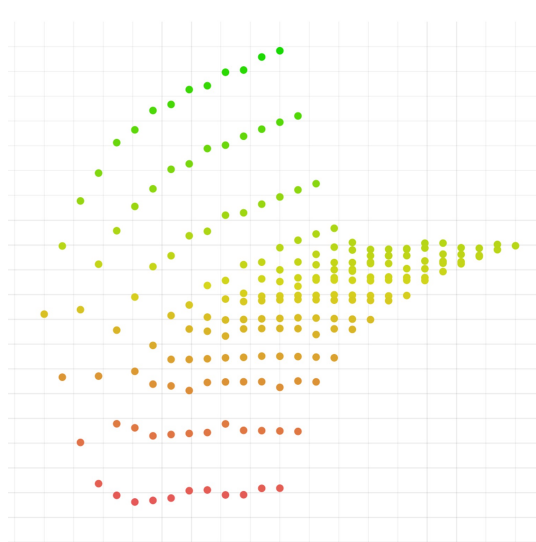Production history match (dots are actual data, lines are calculated data)

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The pumping schedule was optimized to increase the efficiency of acid treatment. The following relationship charts were produced:
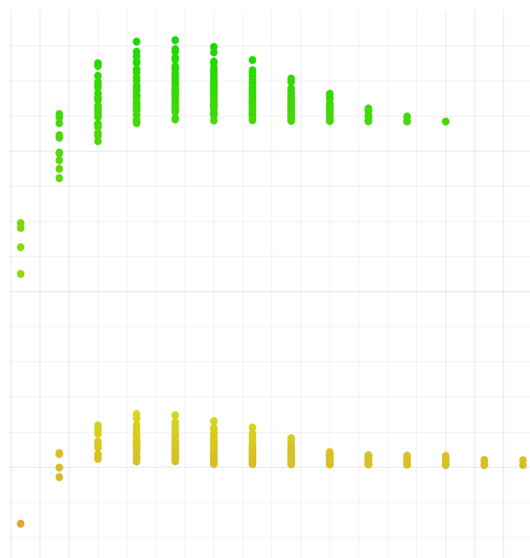
Acid volume (x-axis) vs NPV (y-axis)

Injection rate (x) vs Skin (y)

Acid gel volume (x) vs NPV (y)

Optimization resulted in the following adjustments:
- Reduce the number of acid and acid gel stages
- Decrease the acid volume to 15,840 gal in two stages (7,920 gal + 7,920 gal)
- Pump acid gel before acid, not after
- Increase the acid gel volume to 15,840 gal in two stages (13,200 gal + 2,640 gal)

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Results

WellStim optimization improved acid coverage, increased oil production and NPV.
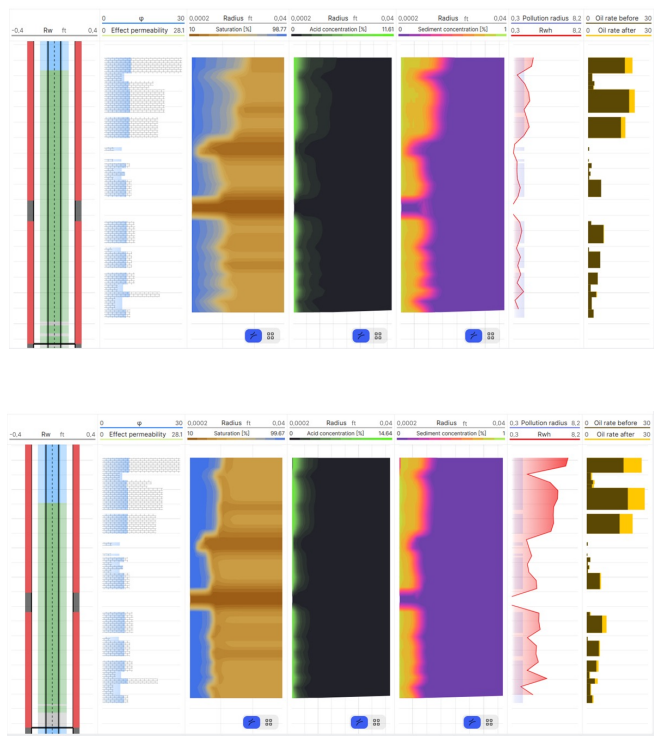
Integrated profile with simulation results, actual at the top, optimal at the bottom

Parameter	Actual, not optimized	Optimal design
Oil rate, bpd	815	996
Skin	-1.1	-2.1
NPV, '000 USD	354	1532
Additional oil production over 14 months, '000 bbl	31	114
Max wormhole depth, ft	2.7	7.0

The optimal design was calibrated based on the actual trend of post-stimulation production decline.
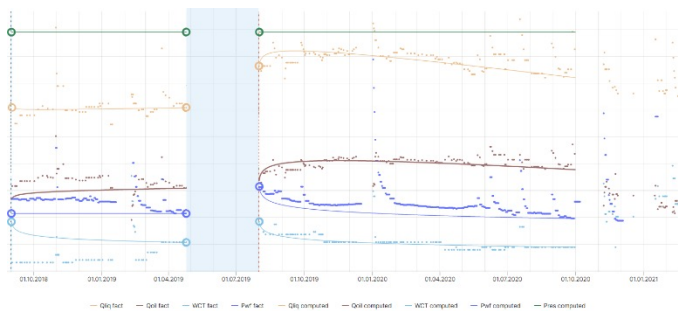
Production analysis (trendlines are based on the actual data)

Parameter	Actual, not optimized	Optimal design
NPV, '000 USD	978	2 335
Additional oil production over 14 months, '000 bbl	73	170

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WellStim acidizing design shows high convergence with actual job parameters in a horizontal well

Challenge

A bullhead acid treatment with diverter pumped though the annulus was performed using WellStim design. The actual post-stimulation production results show high convergence with the WellStim-modeled post-stimulation production.

Area: Central Asia
Reservoir: oil carbonate
Depth: MD - 4400 ft, TVDSS - 2500 ft
Wellbore completion: horizontal open-hole
Length of open-hole lateral 440 ft
4.5" Casing @ 4000 ft
2.5" Tubing @ 3900 ft
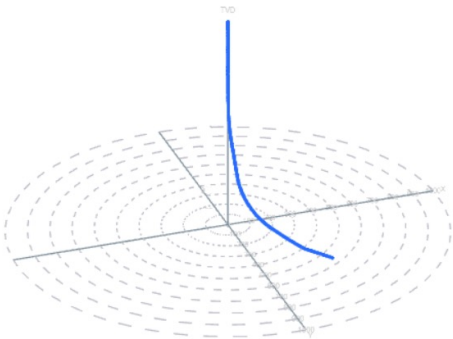
3D view of the wellbore configuration

Solution

Production data history match was performed for the last 8.5 years. Key parameters including fluid rate, oil rate, water cut, pore pressure, bottomhole flowing pressure were matched with previous stimulations in the well. Skin change was estimated before and after every historical stimulation. The current skin value was estimated as 2.1.
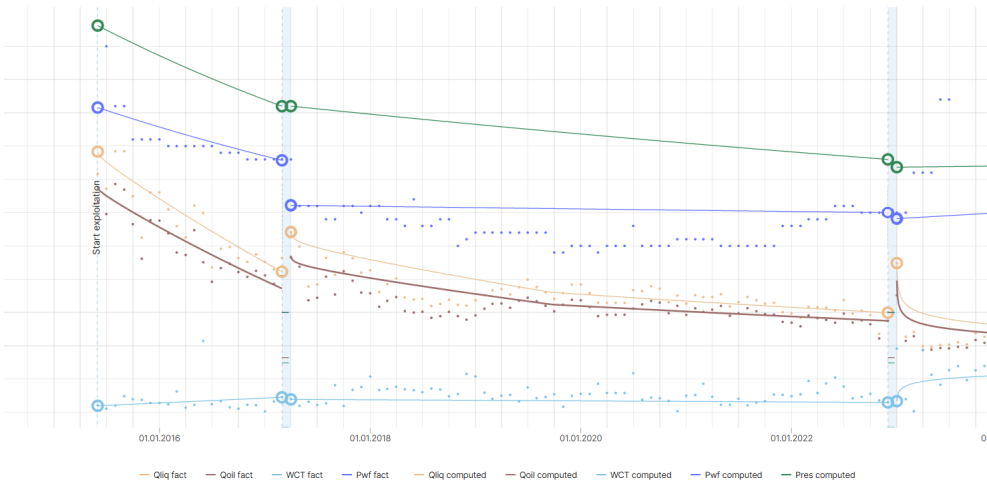
Production analysis (dots are actual data, lines are calculated data)

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The acid job was done using WellStim design. Post-stimulation analysis of the actual treatment data showed high convergency of design vs actual parameters.
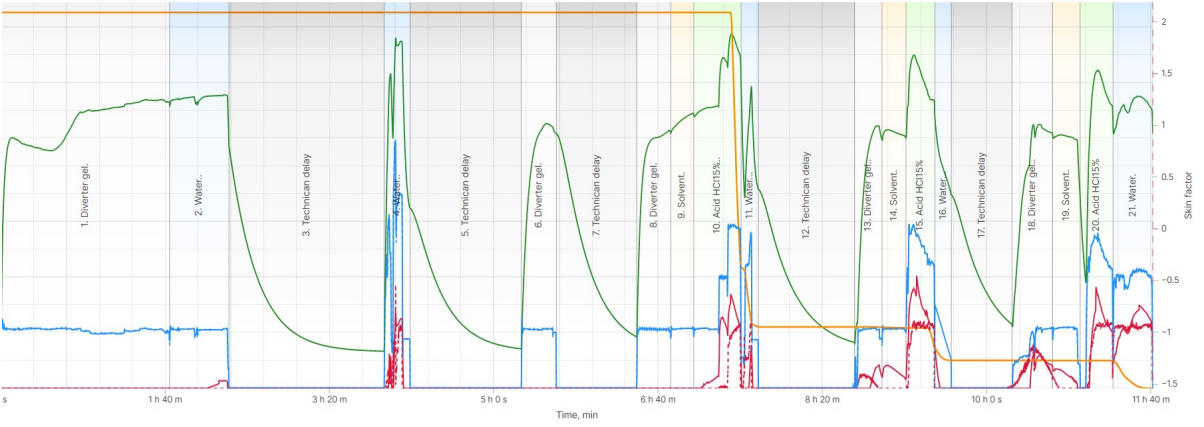
Treatment plot
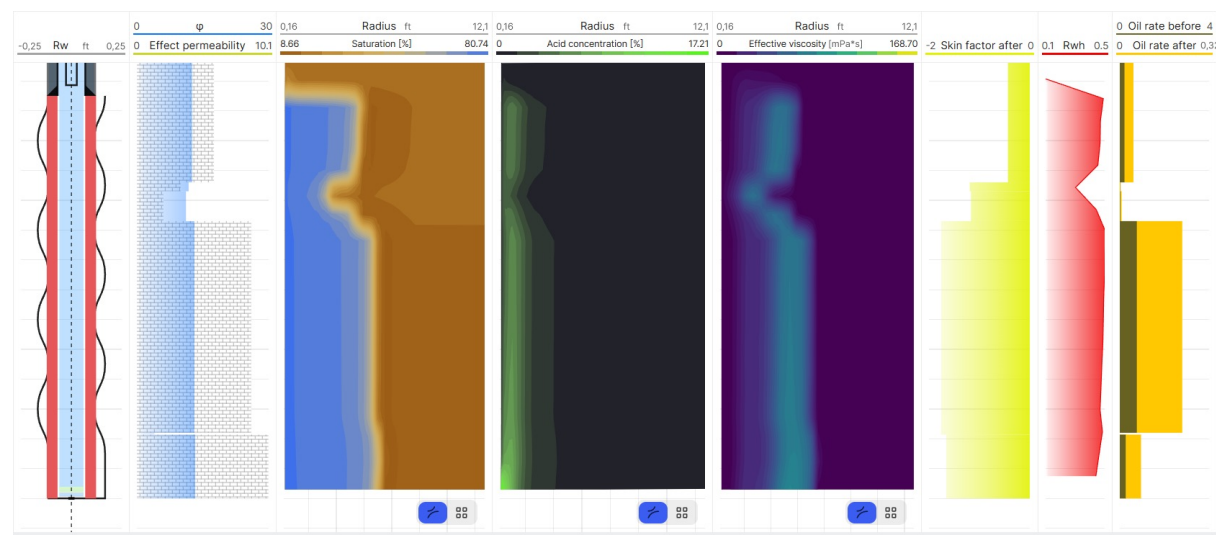
Integrated profile with stimulation results

Parameter	Before	After	Change
Fluid rate, bpd	11	38	27
Oil rate, bpd	10	35	25
WC, %	16.6	16.6	0
BH Flowing Pressure, psi	220	132	-88
Skin	2.1	-1.54	-3.64
Dissolved rock volume, ft³	-	88.6	88.6

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Results

Actual production data was uploaded to WellStim a few months after the treatment. WellStim production analytics module estimated the convergence of design vs actual parameters.
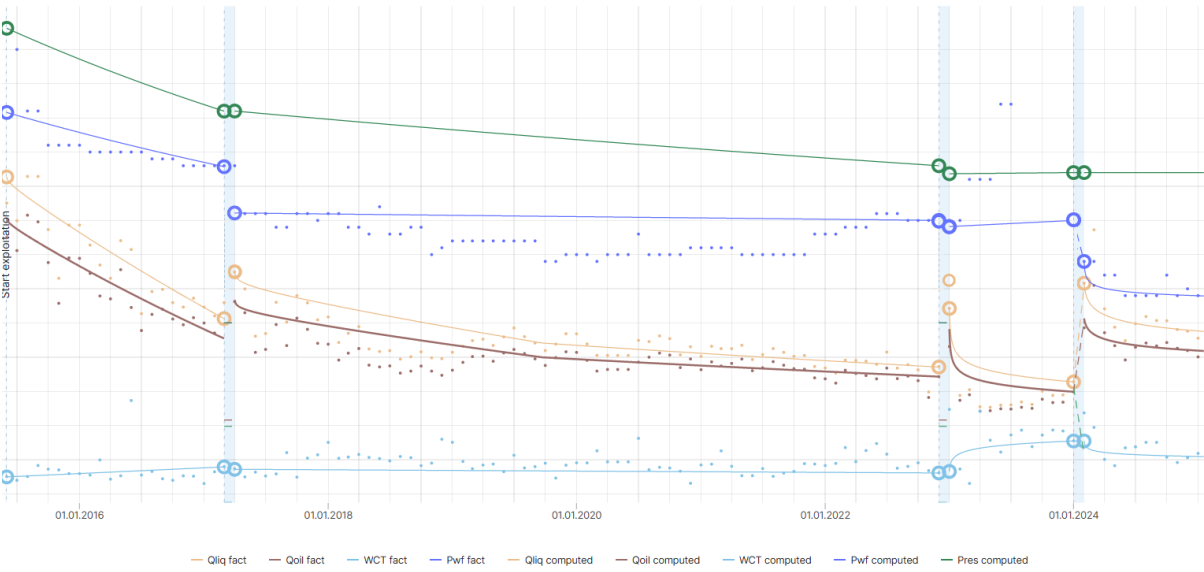
Production analysis including post-treatment data

Parameter	Actual	Design
Fluid rate, bpd	39	38
Oil rate, bpd	36	35
WC, %	16.6	16.6
BH Flowing Pressure, psi	132	132
Skin	-1.76	-1.54

Design vs Actual oil production convergence is 97.7%.
The ability to calibrate a model to the geological and mechanical characteristics of the reservoir—using laboratory study results and accurate historical production data analysis, including current skin assessment—enables a high degree of convergence between predicted and actual parameters after acid treatment.

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WellStim acidizing design of a horizontal cased-hole completion with multi-stage hydraulic fracturing

Challenge

The well is characterized by a multistage hydraulic fracturing. The presence of hydraulic fractures in the near-wellbore zone is often a complicating factor for designing an acid treatment.

Area/Formation: Wolfcamp C, Permian basin, USA
Reservoir: shale
Depth: MD – 15400 ft, TVDSS – 11153 ft
Wellbore completion: horizontal well completed with multistage hydraulic fracturing liner
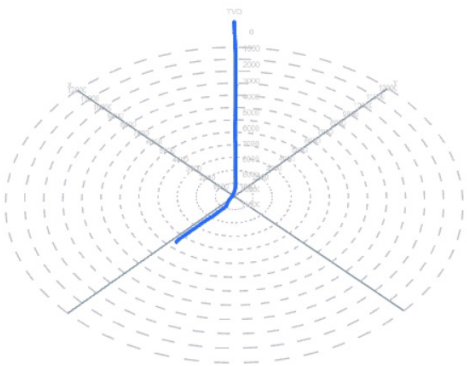
3D view of the wellbore configuration

Solution

A simple pumping schedule consisting of only two stages (15% HCl and water flush) was selected for better illustrative and extrapolative purposes.
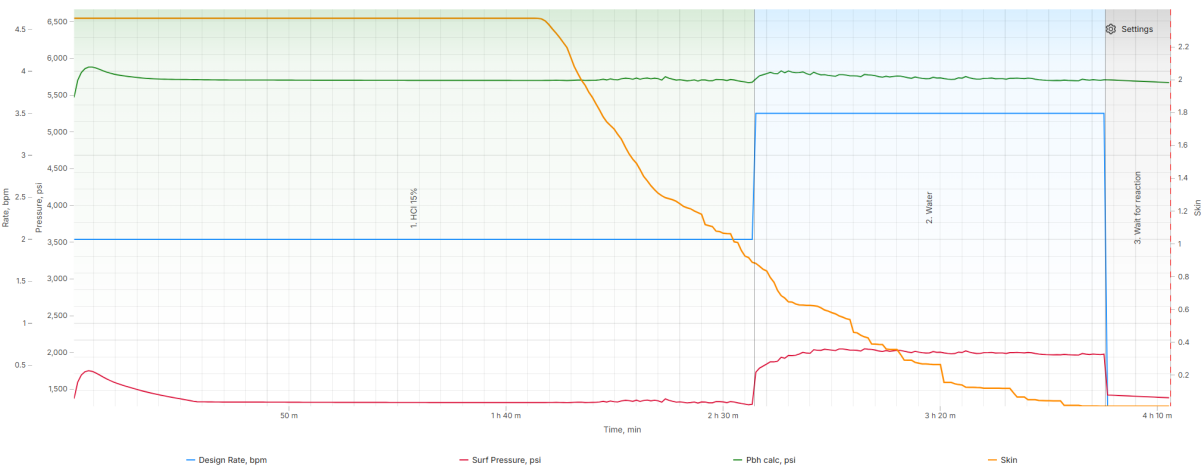
Treatment plot
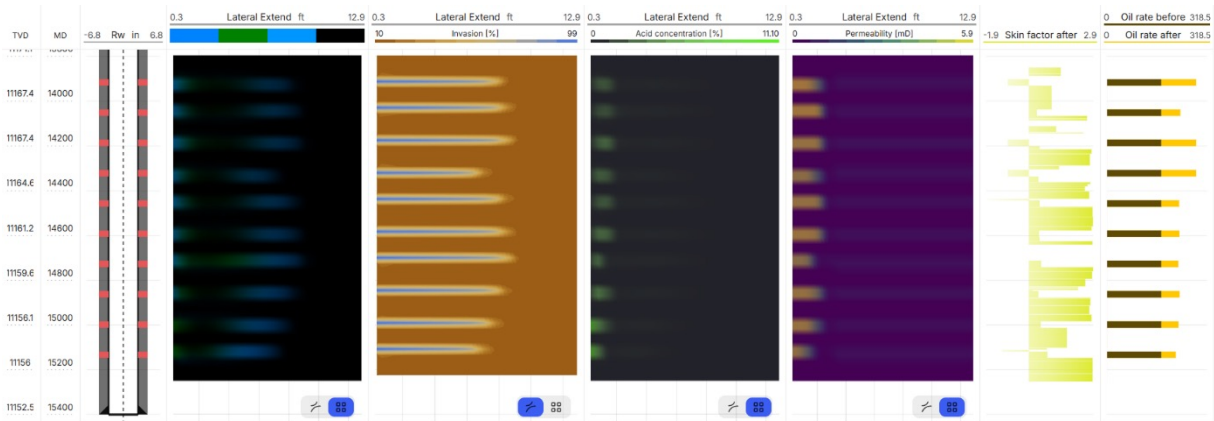
Integrated profile with stimulation results

Results

Parameter	Before	After	Change
Fluid rate, bpd	1968.71	2800.17	831.46
Oil rate, bpd	1732.47	2464.15	731.68
WC, %	12	12	0
BH Flowing Pressure, psi	4500	4500	0
Skin	3.0	0.01	-2.99
Dissolved rock volume, ft³	-	1611.05	1611.05

This case demonstrates WellStim's capability to design a horizontal well model with a multistage hydraulic fracturing tail section in a predominantly shale formation, followed by a detailed simulation and visualization of the treatment process.

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An acid volume optimization can be useful for determining the efficiency and profitability of the acid treatment.

Volume Stage 1 - HCl 15%	Liquid rate, bpd
200	3139.82
190	3112.08
180	3093.92
170	3056.30
160	3048.53
150	3010.70
140	2989.20
130	2977.41
120	2960.64
110	2947.98
90	2914.16
100	2911.17
80	2892.22
70	2875.81
60	2819.97
50	2787.65
40	2764.01
30	2655.98
20	2552.35
10	2448.90

X axis: Volume Stage 1 - HCl 15%   Y axis: Liquid rate, bpd
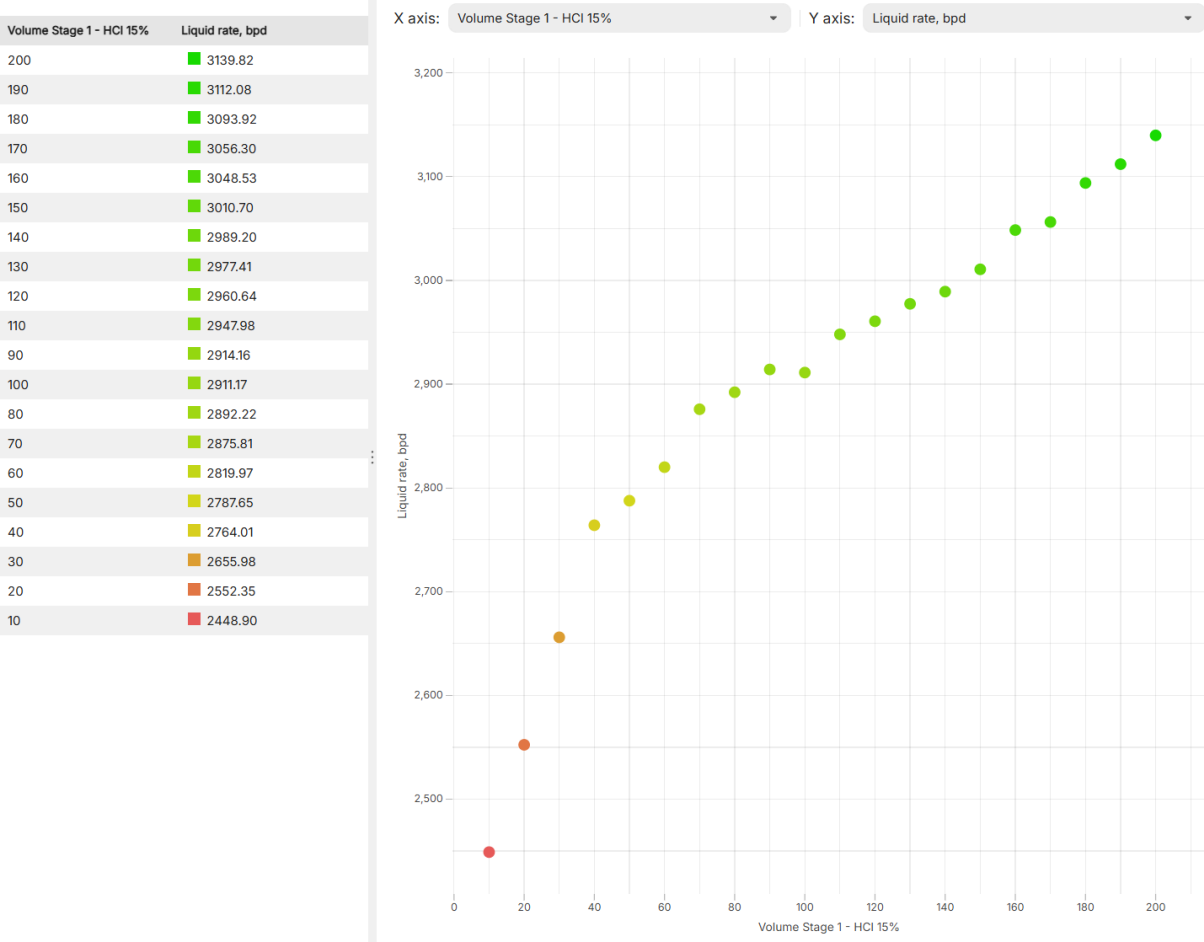
Acid volume (x-axis) vs Production rate (y-axis)

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WellStim design of radial drilling

Challenge

Trajectory design for three radial channels with post-drilling inflow analysis and skin assessment.

Area: Central Asia
Reservoir: oil sandstone
Depth: MD – 19,482.61 ft, TVDSS – 18,819.52 ft
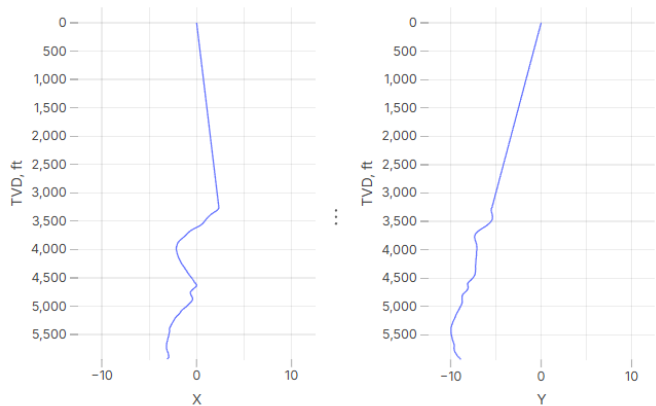
Well trajectory

Solution

Based on the retrospective analysis of the well's operating regime, the skin value prior to drilling the radial channels was determined as S = +2.83.
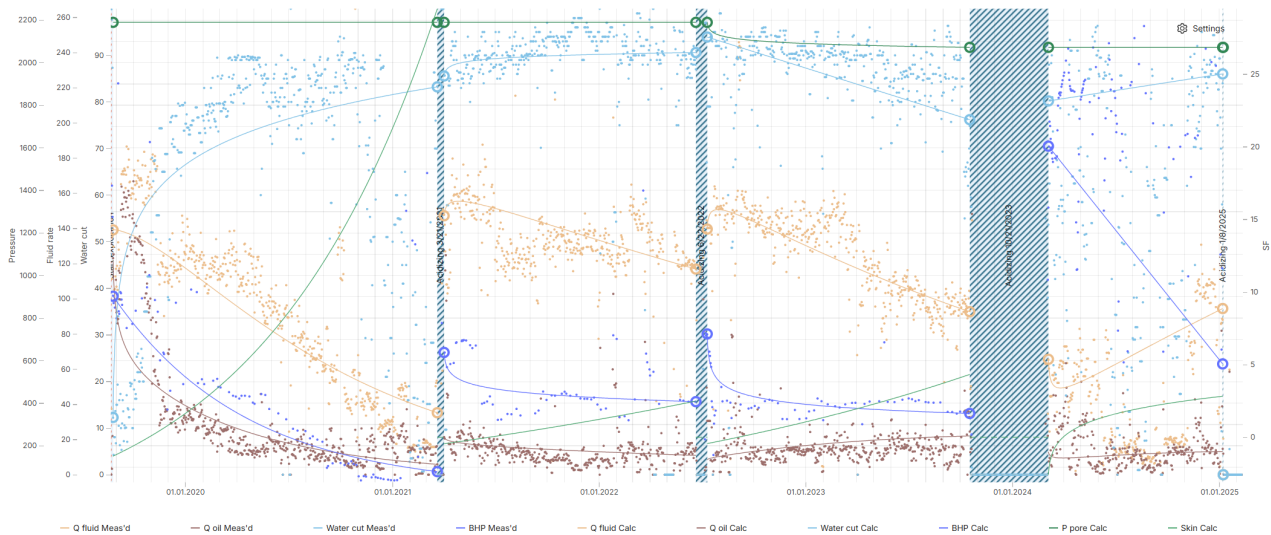
Production analysis (points – actual data, lines – calculated data)

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The main wellbore trajectory has been loaded, a petrophysical reservoir model has been constructed, and parameters have been input for the calculation of the radial channel trajectories.

Well operating regime before radial perforation

Fluid rate, bpd	94.35
Oil rate, bpd	83.06
WC, %	86.00
BH Flowing Pressure, psi	587.84
Reservoir Pressure, psi	2072.13
Skin	+2.83
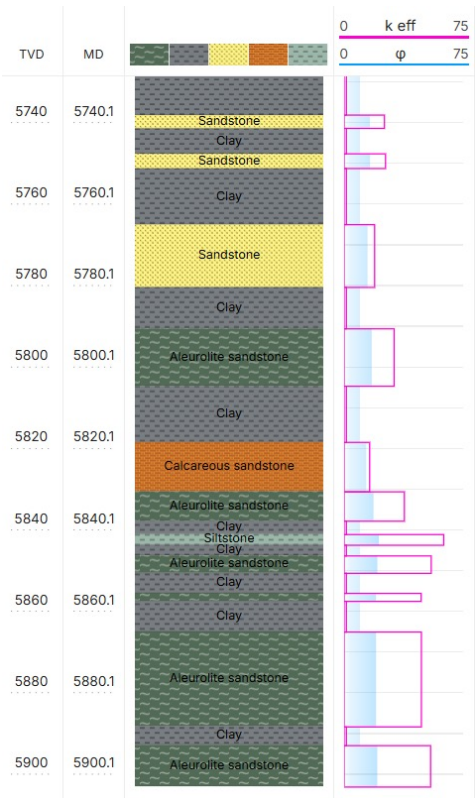
Lithological structure of the reservoir

Parameters of radial channel trajectories

Parameter	Channel 1	Channel 2	Channel 3
Measured depth of exit point, ft	5741.47	5741.47	5721.78
Borehole length, ft	45.93	45.93	45.93
Exit angle from borehole (zenith), degrees	0.07	0.07	0.05
Exit angle from borehole (azimuth), degrees	52.60	52.60	196.44
Angle build-up (zenith), degrees	88.20	88.10	88.12
Angle build-up (azimuth), degrees	0.00	120.00	-120.00
Channel diameter, ft	0.23	0.23	0.23
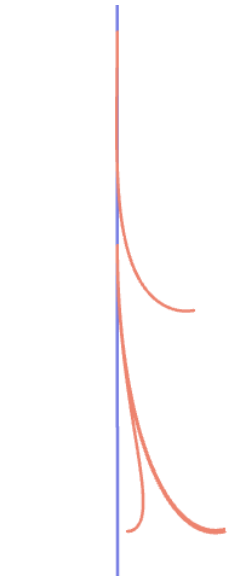
3D visualization of radial channel trajectories

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Results

The trajectories of three radial channels have been calculated, and the opened intervals have been identified.

Results	^
Wellbore diameter , ft	0.23
Entry point MD , ft	5741.47
Wellbore MD , ft	45.93
Kickpoint angle from wellbore I , °	0.07
Kickpoint angle from wellbore A , °	52.6
Angle I ascending , °	88.2
Angle A ascending , °	0
Fluid Rate , bpd	48.67
Oil Rate , bpd	6.81
Effective height MD , ft	45.60
Effective height TVD , ft	29.58

Channel 1

Results	^
Wellbore diameter , ft	0.23
Entry point MD , ft	5741.47
Wellbore MD , ft	45.93
Kickpoint angle from wellbore I , °	0.07
Kickpoint angle from wellbore A , °	52.6
Angle I ascending , °	88.1
Angle A ascending , °	120
Fluid Rate , bpd	49.16
Oil Rate , bpd	6.88
Effective height MD , ft	45.60
Effective height TVD , ft	29.45

Channel 2

Results	^
Wellbore diameter , ft	0.23
Entry point MD , ft	5721.78
Wellbore MD , ft	45.93
Kickpoint angle from wellbore I , °	0.05
Kickpoint angle from wellbore A , °	196.44
Angle I ascending , °	88.12
Angle A ascending , °	-120
Fluid Rate , bpd	21.85
Oil Rate , bpd	3.06
Effective height MD , ft	45.60
Effective height TVD , ft	29.61

Channel 3

Radial drilling completion of the reservoir

Inflow calculation from each radial channel and skin values after radial reservoir completion have been performed.

Well operating regime after radial reservoir completion

Parameter	Before radial perforation	After radial perforation
Fluid rate, bpd	94.35	214.04
Oil rate, bpd	13.21	29.97
Skin	+2.83	-3.11