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Integration Of Ultra-high-resolution Nano Tracers Flow Diagnostics With A Multi-stage Completion Program For Post-frac Flow Assurance, Fault Evaluation And Well Spacing Optimization in Eagle Ford

SPEAKER: Talgat Shokanov

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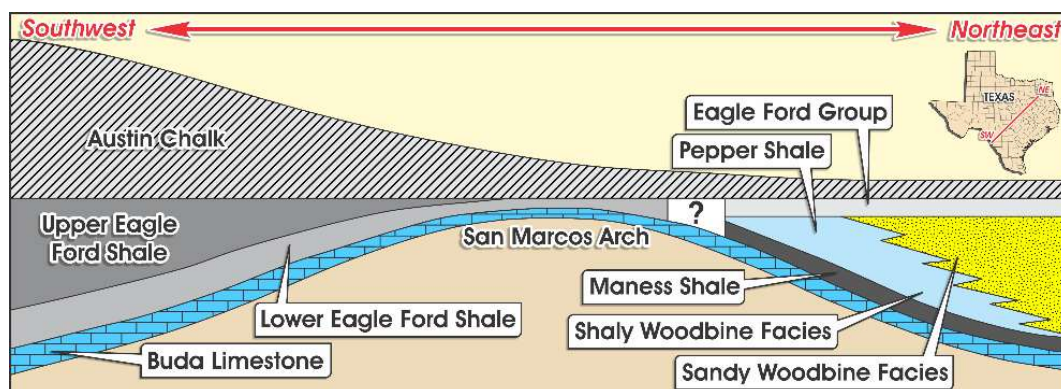
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Agenda

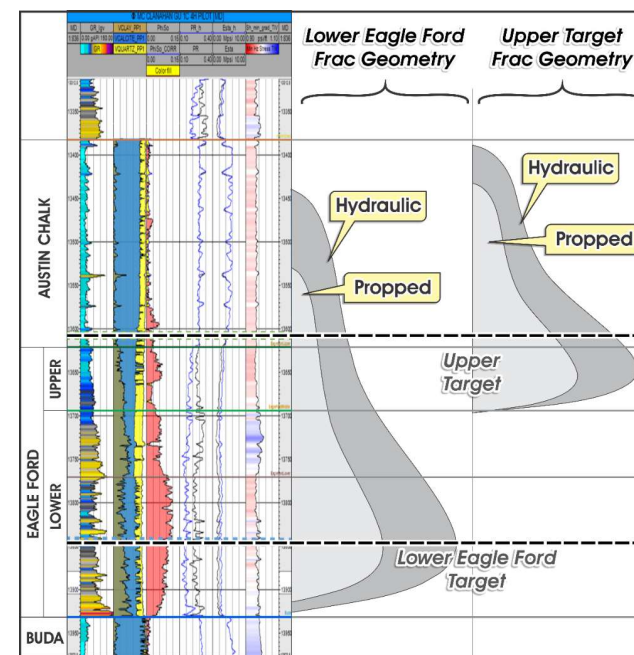
- Development Overview and Study Objectives
- Ultra-High-Resolution Nanoparticle Tracer Technology Overview
- Injection and Sampling Schedule for Traced and Offset Wells
- Subsurface Nanoparticle Tracer Results Integration
- Subsurface Fault Evaluation
- Conclusions

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Development Overview and Study Objectives



Eagle Ford regional cross section



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Well Placement and Completion Design

Completion Strategy:

Well spacing: ~ 400ft

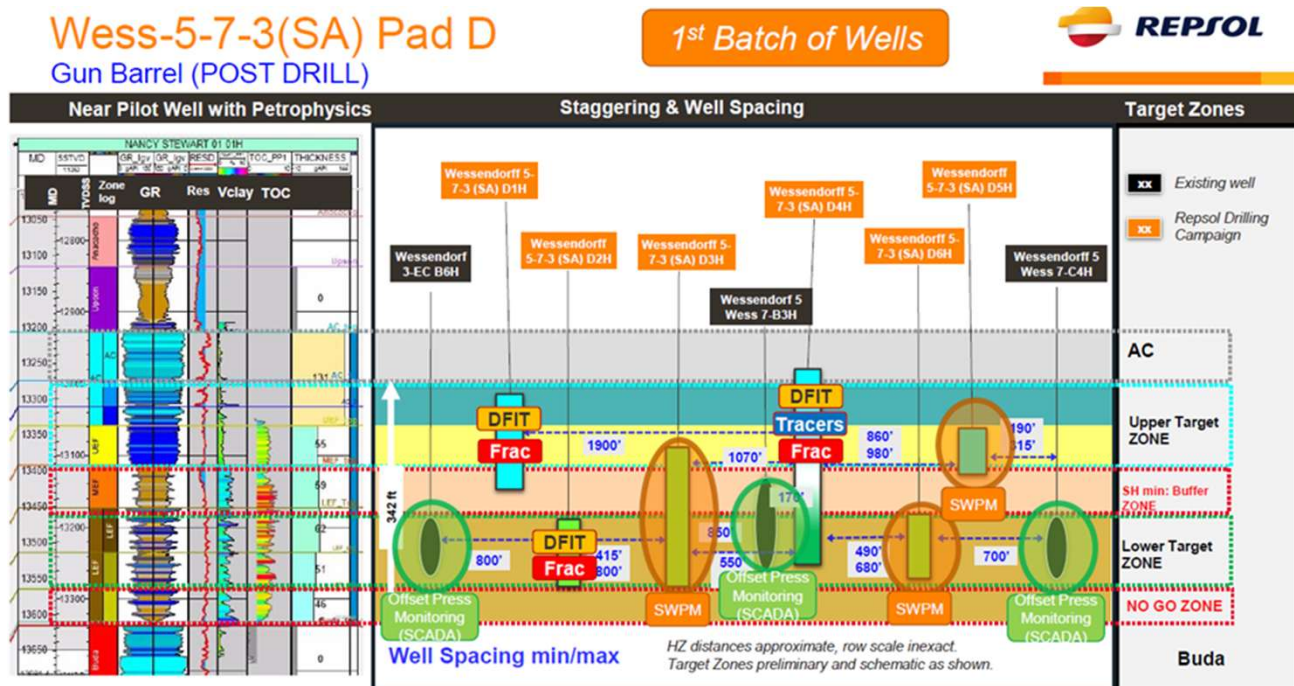
Proppant and fluid:

- 100 mesh
- 3,000 ppf
- Slickwater

Perforation: 3spf - 0 deg

Plug and perf:

- 9 cluster/stg
- 15 ft cluster spc
- 9,000 to 10,000 ft lateral length



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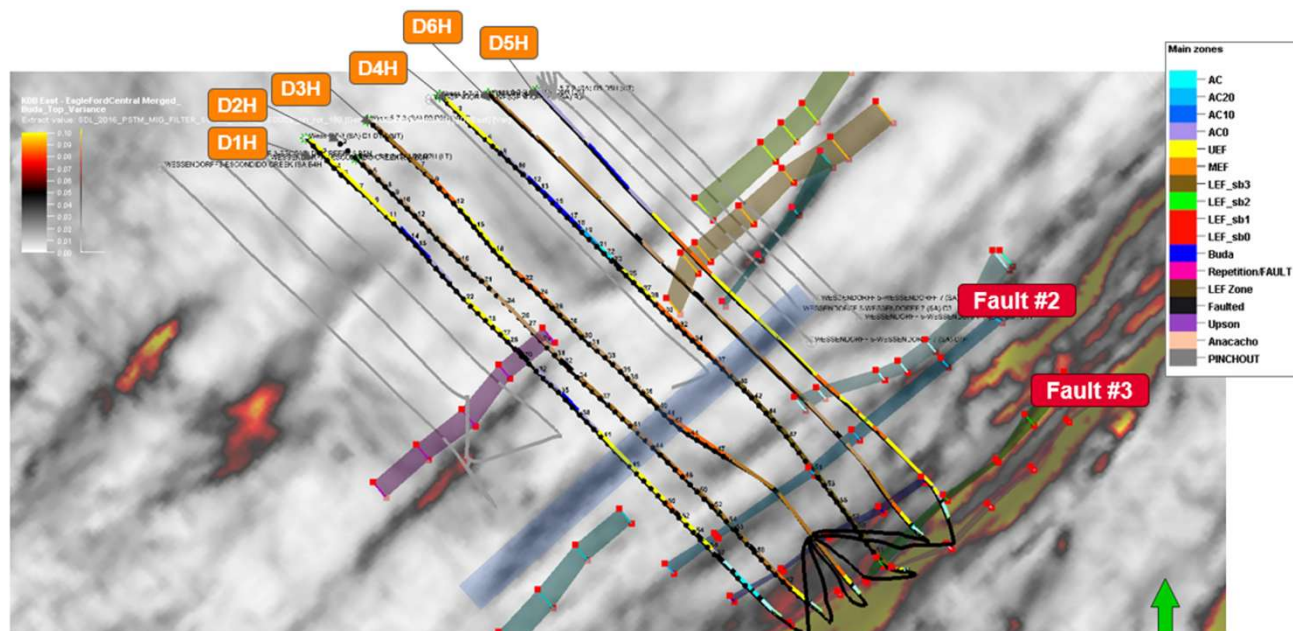
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Ultra-high-resolution Nanoparticle Tracer

Post-fracture flow mapping:

- Deployed nanoparticle tracers
- Easily deployed, clearly tagged, safe, non-radioactive tracers
- Maintain stability at excessive reservoir temperatures
- Light specific gravity of 0.9 – 1.17 g/cm³
- 220 distinct tracers, allowing for great versatility
- Critical for optimizing stage-level design.



Physical properties	FloTrac tracers
Specific gravity, g/cm ³	0.92 – 1.17
Temperature limit, F	2,000
Number of FloTrac tracers	220 unique tracers

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Current Landscape of Flow-profiling Technologies

	Production Logging (PLT)	Chemical Tracer	Fiber Optic (DAS & DTS)	Nanoparticle Tracer
Type of Technology	Logging	Chemical	Downhole Fiber Optics	Smart Tracers
Temperature Limit	700°F	350°F	500°F	2,000°F
Detection Accuracy	Medium	Low	Very High	High
Production Profiling Timeline	Short-Term	Middle-Term	Long-Term	Long-Term
Deployment Requirements	Intervention with Logging	Multiple Tracers per Stage	Downhole with Completion	Single Tracer per Stage
Mobile Lab with Onsite Analysis	Yes	No	Yes	Yes
Results Turnaround Time	2 Weeks	3 Weeks	3 Weeks	Near Real-Time
Precision in “Fracture Hits” Mapping	No	Medium	No	Very High
Cost to E&P Operators	High	High	Very High	Low

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Injection and Sampling Schedule for Traced and Offset Wells

Stage	Stage Type	Clean vol (bbls)	Cum. Clean (bbls)	Density (ppg)	Slurry vol (bbls)	FR (gals) @ 1 gpt	Bo (gals) @ 0.2 gpt	Stage Prop (lbs)	Rate (bpm)	Time (min)
1	Slickwater	12	12	0	12	0.5	0.1	0	10	1.2
2	Acid	48	60	0	48	0.0	0.0	0	10	4.8
3	Slickwater	714	774	0	714	30.0	6.0	0	90	7.9
4	Slickwater	700	1474	0.25	708	29.4	5.9	7,350	90	7.9
5	Slickwater	700	2174	0.5	716	29.4	5.9	14,700	90	8.0
6	Slickwater	1000	3174	0.75	1034	42.0	8.4	31,500	90	11.5
7	Slickwater	1200	4374	1	1254	50.4	10.1	50,400	90	13.9
8	Slickwater	1200	5574	1.25	1268	50.4	10.1	63,000	90	14.1
9	Slickwater	1200	6774	1.5	1281	50.4	10.1	75,600	90	14.2
10	Slickwater	1200	7974	1.75	1295	50.4	10.1	88,200	90	14.4
11	Slickwater	500	8474	2	545	21.0	4.2	42,000	90	6.1
12	Slickwater	390	8864	2.25	430	16.4	3.3	36,855	90	4.8
13	Slickwater	390	9254	2.5	434	16.4	3.3	40,950	90	4.8
14	Flush	357	9611	0	357	15.0	3.0	0	90	4.0
		9611			10,097	401.7	80.3	450,555		117.5

Pumping schedule and tracer injection timeline highlighted during each stage (in green)

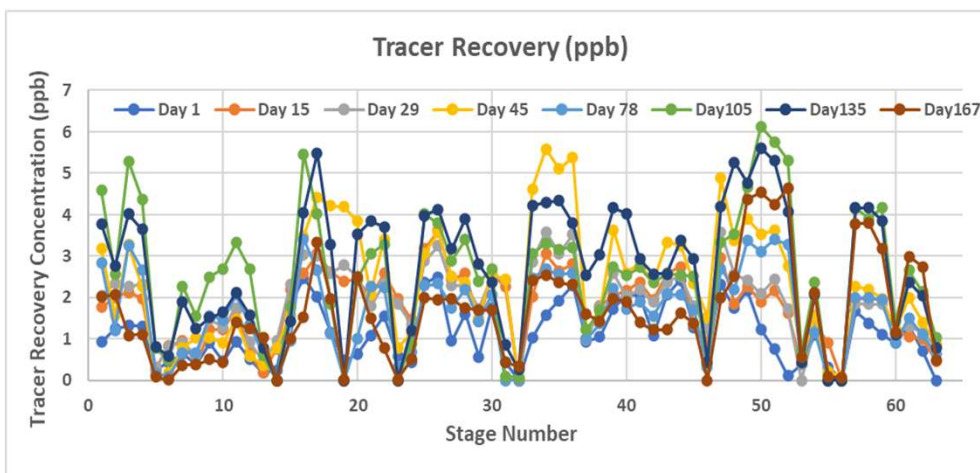
	D3H 4 Wess 5-7-3 D3H New Well + SWPM Monitor	B3H 7 Wess 5 Wess 7 B3H Parent Well Monitor	D4H 8 Wess 5-7-3 D4H New Well + Tracers Treatment Well	D1H 8 Wess 5-7-3 D1H New Well + DFIT Monitor	D2H 8 Wess 5-7-3 D2H New Well + DFIT Monitor
Production Time [days]					
5					
10					
15	X	X	X	X	X
20					
25					
30	X	X	X	X	X
35					
40					
45	X	X	X	X	X
50					
55					
60	X	X	X	X	X
65					
70					
75					
80					
85					
90		X	X	X	X
95					
100					
105					
110					
115					
120		X	X	X	X
125					
130					
135					
140					
145					
150		X	X	X	X

Sampling schedule for traced well and 4 offset wells 9

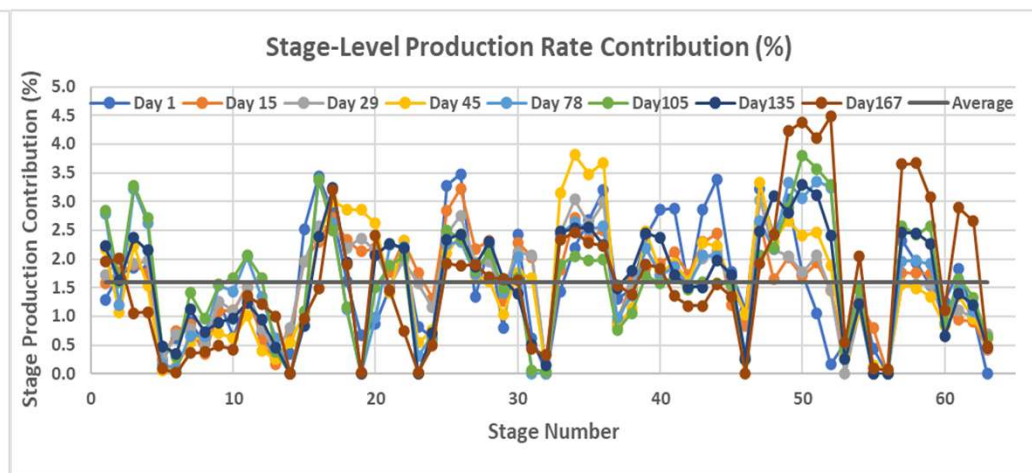
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Stage-level Tracer Recovery and Rate Contribution

Sampling Date:	9/18/23	10/2/23	10/16/23	11/1/23	12/4/23	12/31/23	1/30/24	3/4/24
Days from 1st sampling	1	15	29	45	78	105	135	167



Stage-by-stage nanoparticle tracer recovery concentration from samples collected on various days



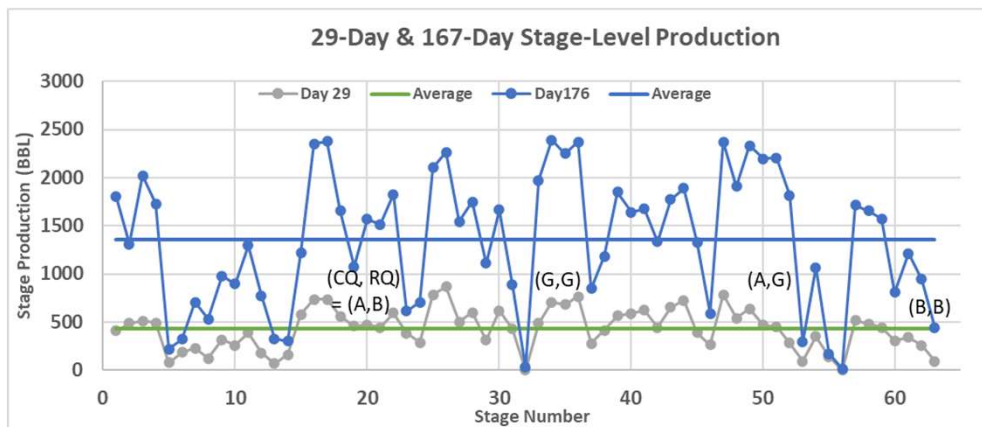
Stage-level production rate obtained from the nanoparticle tracer recovery results

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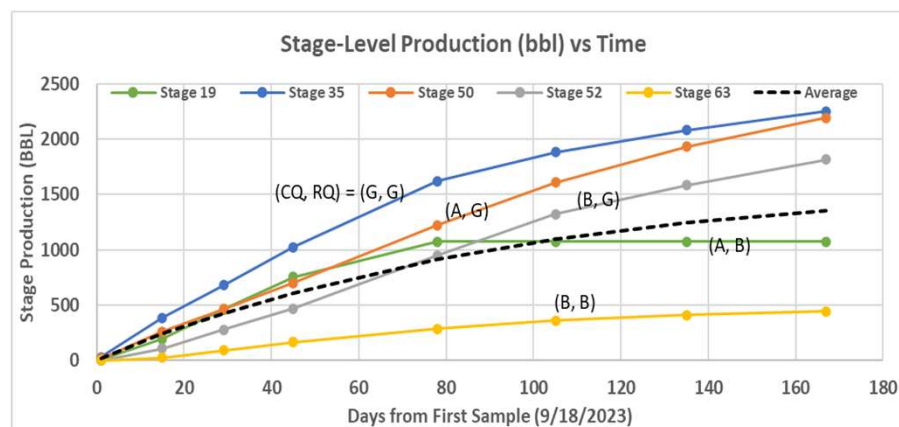
Stage-level Reservoir and Completion Quality Analysis

Assumptions:

- Use short-term (e.g., 30-day) production as a proxy for completion quality (CQ).
- Use long-term (e.g., 180-day) production as a proxy for reservoir quality (RQ).
- Within +/-10% of average is defined as Average (A); 10% above as Good (G), 10% below as Bad (B).
- Example: Stage 19: (CQ, RQ)=(A, B); Stage 35: (G, G); Stage 50: (A, G); Stage 52: (B, G); Stage 63: (B, B).



Stage-level production at different times after production starts



Stage-level production rate from the tracer recovery vs time

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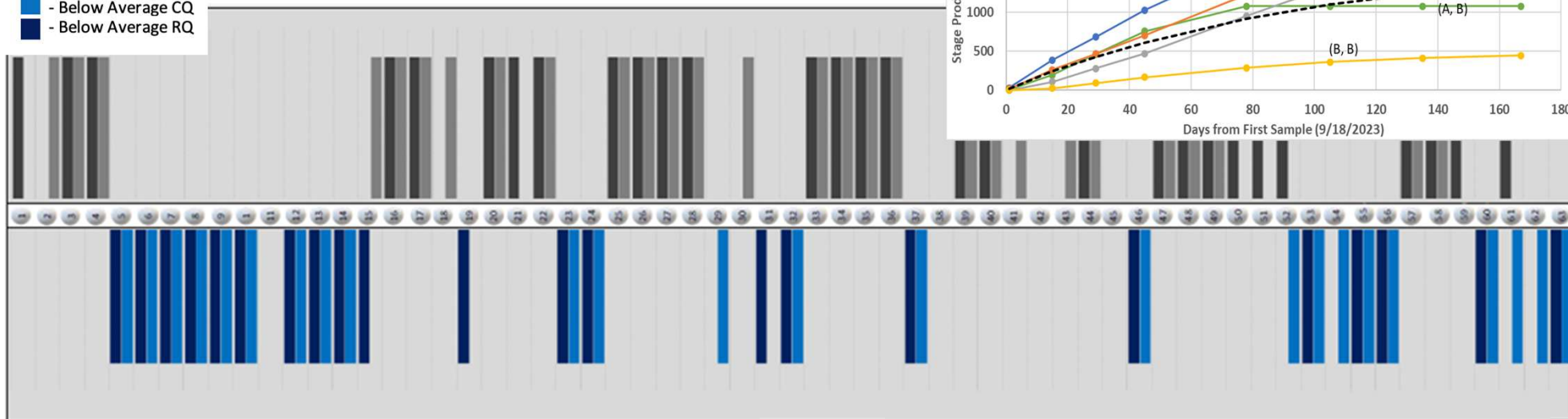
Stage-level Completion & Reservoir Quality (CQ & RQ) Analysis

Observations:

- Poor CQ gives poor stage production
- Production is mostly from good stages.

Legend:

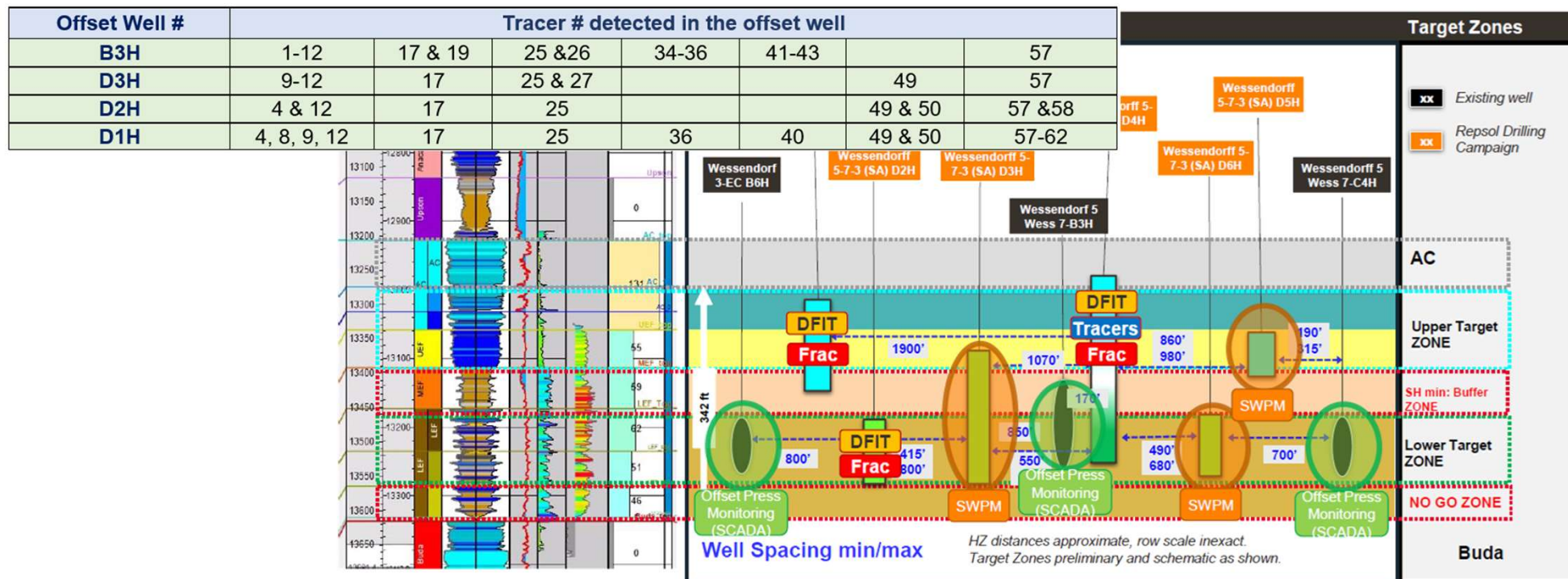
- Above Average CQ
- Above Average RQ
- Below Average CQ
- Below Average RQ



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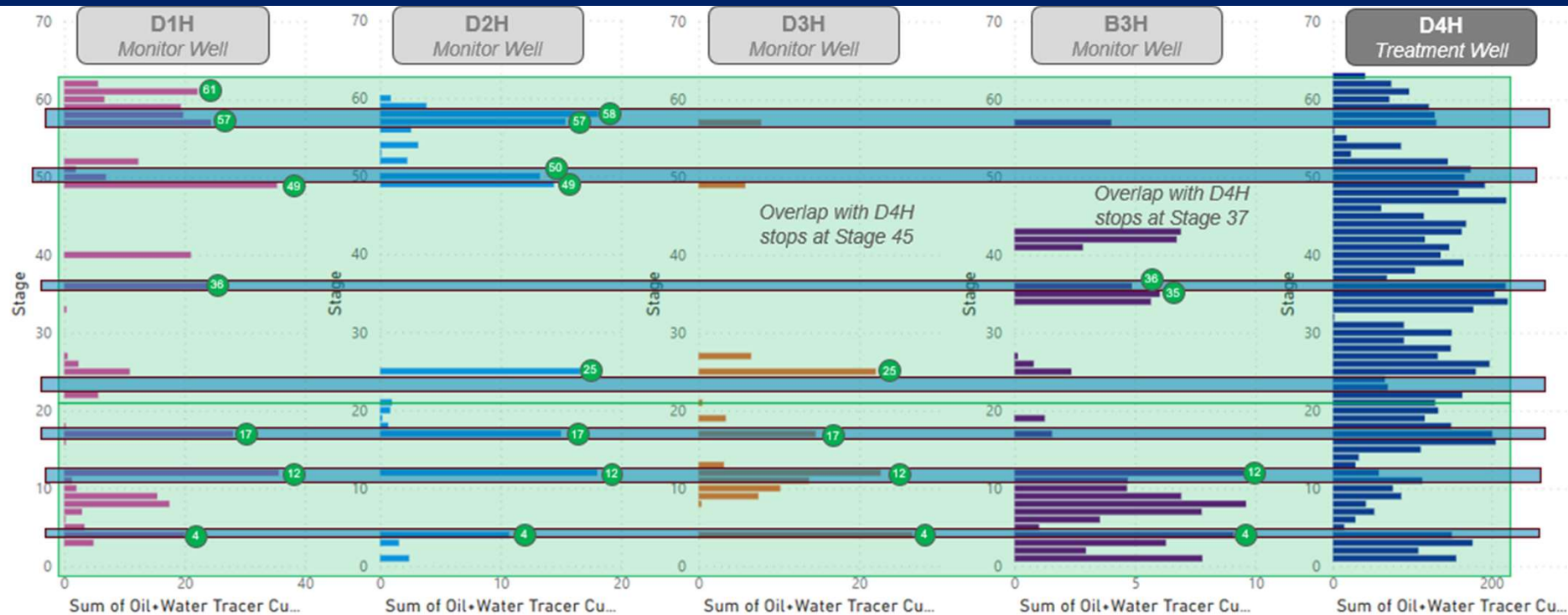
Stage-level Completion & Reservoir Quality (CQ & RQ) Analysis



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Results Evaluation - Fault Evaluation



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Conclusions

- A novel, cost-effective ultra-high-resolution nanoparticle tracer played a crucial role in generating valuable data that facilitated a comprehensive understanding of the reservoir, geological faults, and the optimization of stimulation efforts at the stage level.
- Additionally, multi-well studies furthered insight into inter-well communication, the characterization of fracture-driven interactions, and the optimization of well spacing.
- The integration of tracer data with pressure monitoring from offset wells enhanced the approach to developing the target reservoir and provided a critical performance flow profile for the entire development.
- This information was also utilized to optimize completion designs, stage configurations, and well placement strategies, significantly improving the understanding of the reservoir and the impact of geological faults on stage-level production.

**Integration Of Ultra-high-resolution Nano Tracers Flow Diagnostics With A Multi-stage Completion Program For Post-frac Flow Assurance,
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Acknowledgment

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