Society of Petroleum Engineers

SPE Workshop: North Sea and Europe Area Stimulation

7-8 November 2017

Mercure Hotel Den Haag Central,

The Hague, The Netherlands

Traceable proppant application to assess fracturing diversion efficiency

Pedro Saldungaray
CARBO Ceramics
Technical Manager EH

Overview

- Traceable proppant & Diversion technologies introduction
- Case histories: 2 different diversion techniques
- Results and conclusions

Objectives

- Two different “reservoir diversion techniques” were evaluated
  - Alternative to conventional mechanical diversion based on wellbore segmentation: packers, baffles, ball sealers
  - Rely on acting inside the frac itself: arrest frac propagation or manipulate breakdown pressure
  - Independent on completion or reservoir type

- The operator wanted to determine:
  - The effectiveness of the technique
  - Whether fractures can be initiated at every perforated interval
  - Whether the fractures are longitudinal or at an angle to the wellbore

Diversion Techniques Evaluated

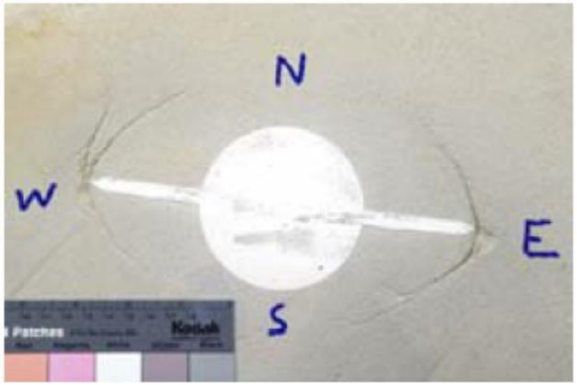
In-formation particulate diversion

- Uses a blend of degradable particles and/or fibers to temporarily isolate fractures and propagate new fracs into untreated zones

Picture source: www.slb.com

Jetted perforations in OH

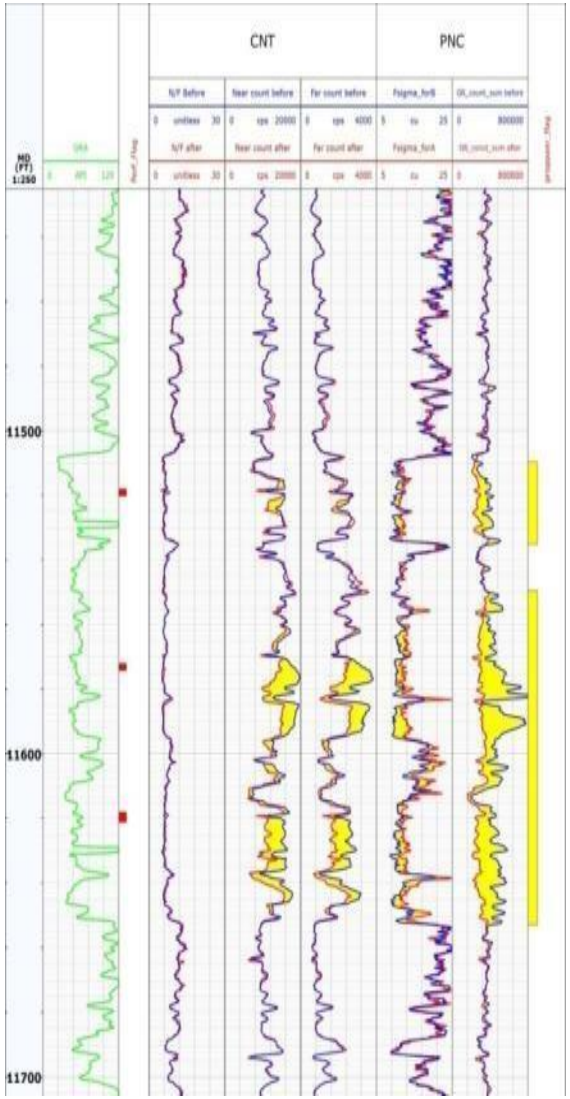
- Uses jetted perforations to create weak frac initiation locations



Source: SPE-97415

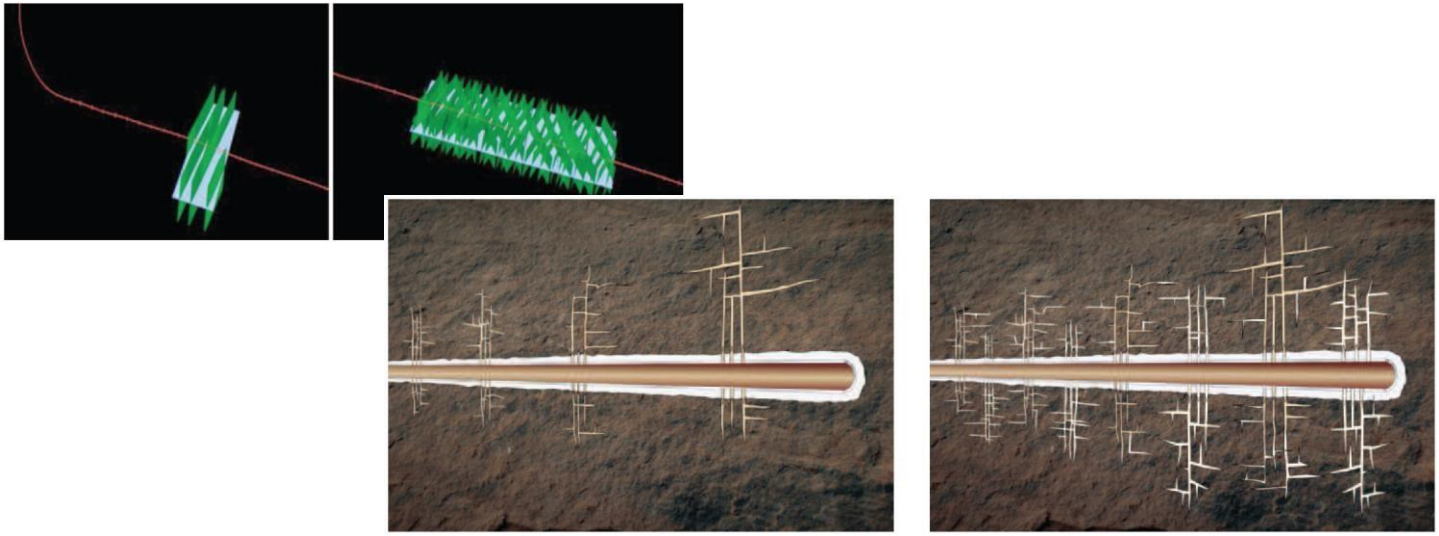
Evaluation: traceable proppant to assess diversion efficiency

- Inert tracer added during proppant manufacturing
  - Environmentally friendly, reduced HSE footprint
  - Simplified logistics, handling and disposal
- Detected with standard neutron tools
  - Differencing technique between before/after frac logs
  - Compensated Neutron Log: depressed neutron counts
  - Pulsed Neutron Log: increased Sigma or increased tracer elemental yields
  - Detectable for the life of the well
- Identifies which perfs have been stimulated
- Measures frac height and connectivity at the wellbore
- Assesses diversion efficiency



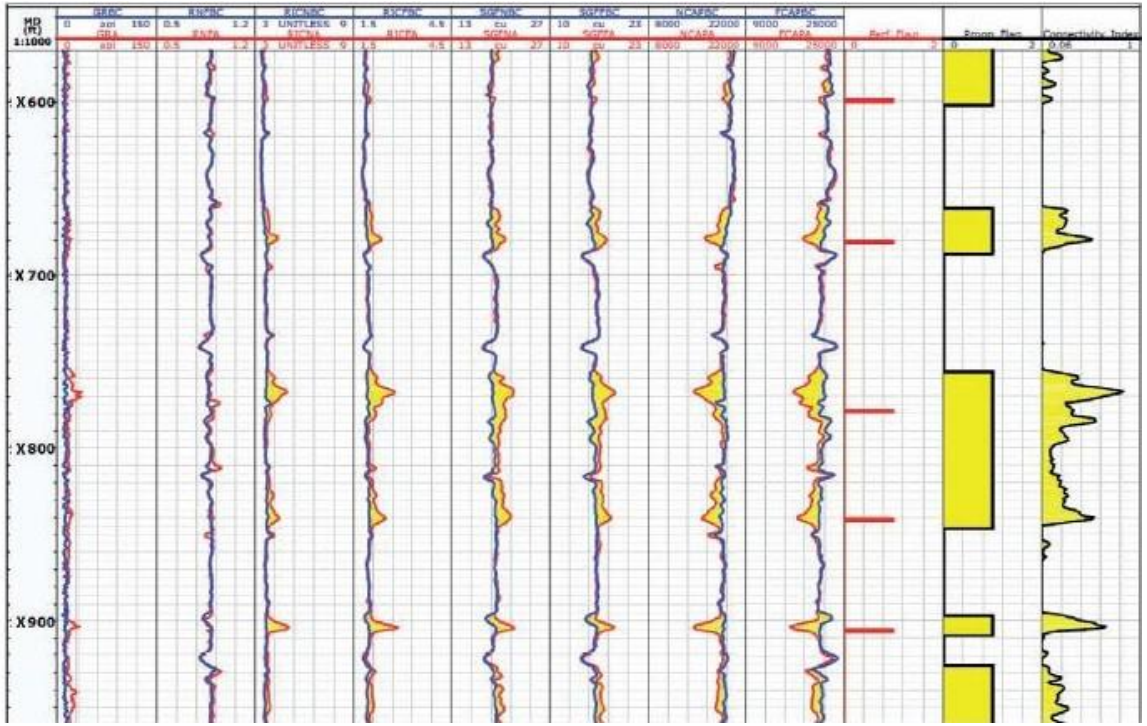
Well A – Diversion and Perfs Efficiency

- Horizontal well completed with a 4 ½” liner in a 6 ¼” borehole
- 50 perforated clusters treated in 8 frac stages, 5 to 8 clusters per stage
- Traceable proppant 30/50
- Halliburton RMT pulsed neutron tool used for the evaluation



Well A – Diversion and Perfs Efficiency

- Traceable proppant tailed into 8 stages of a horizontal, cased hole completion using diverter
- Traceable proppant observed in all 8 stages
- Perforation flags aligned with proppant flag markers
- NWB Connectivity Index – qualitative measurement of connection between wellbore and formation scaled from 0-1

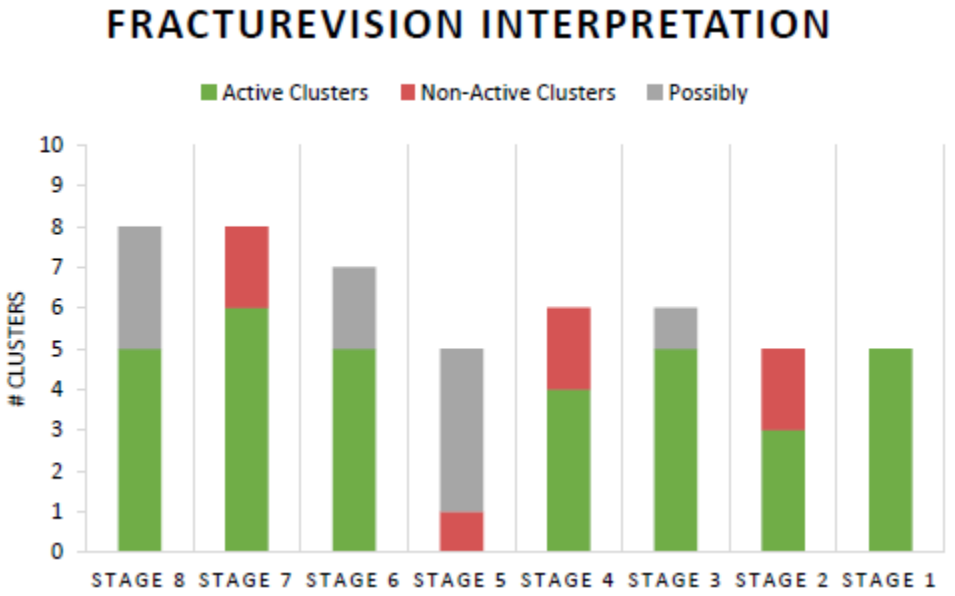


Well A – Diversion and Perfs Efficiency

Cluster efficiency

- "Active": Traceable proppant present in the fracture
- "Possibly": weak or questionable signal
- "Inactive": Traceable proppant not present in fracture

Note: Inactive clusters were generally at the bottom set of clusters

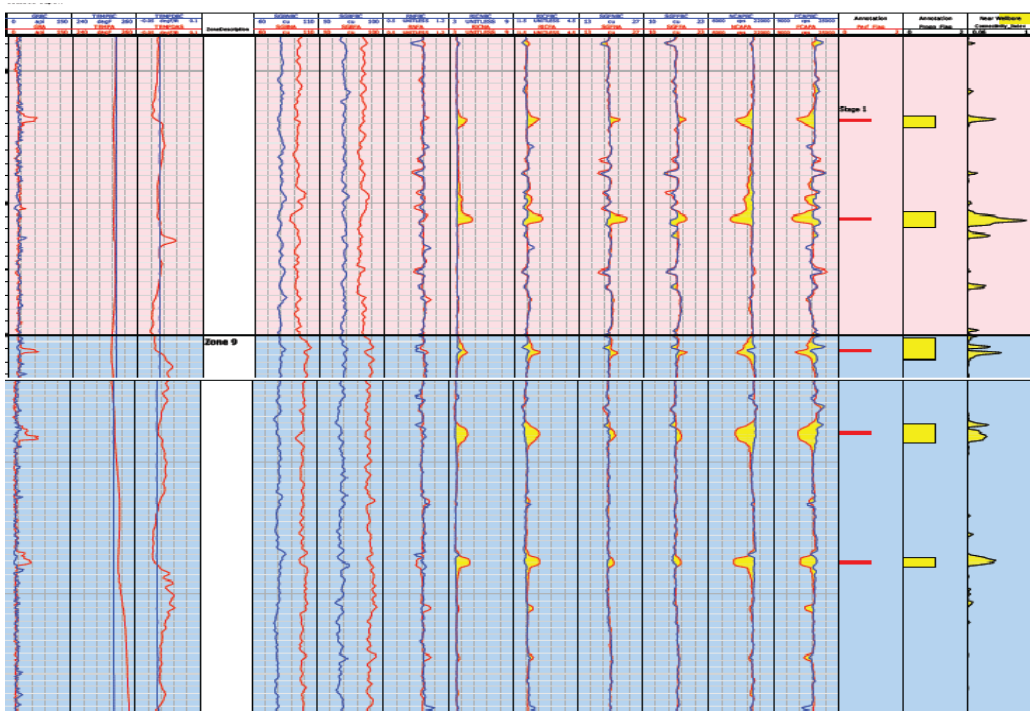


Well A – Diversion and Perfs Efficiency

Evaluation of fracture orientation

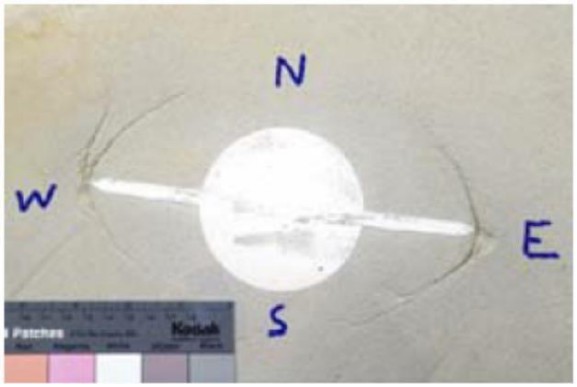
- Stage 1 – Traceable proppant signals are proportional in filtered formation sigma and count rates
- Indicates fractures are generally perpendicular to wellbore

Note: Post-fracture report, cement bond log, and resistivity log would help further evaluate other stages



Well B – Jetted perforations

- Well B was completed in an open hole interval from the base of the 4 ½ “ in a 552 ft long section to a cement plug in the 5 7/8”.
- Vertical well.
- Six abrasive jet slots were place in the OH to provide fracture initiation points over a 250 ft long interval.

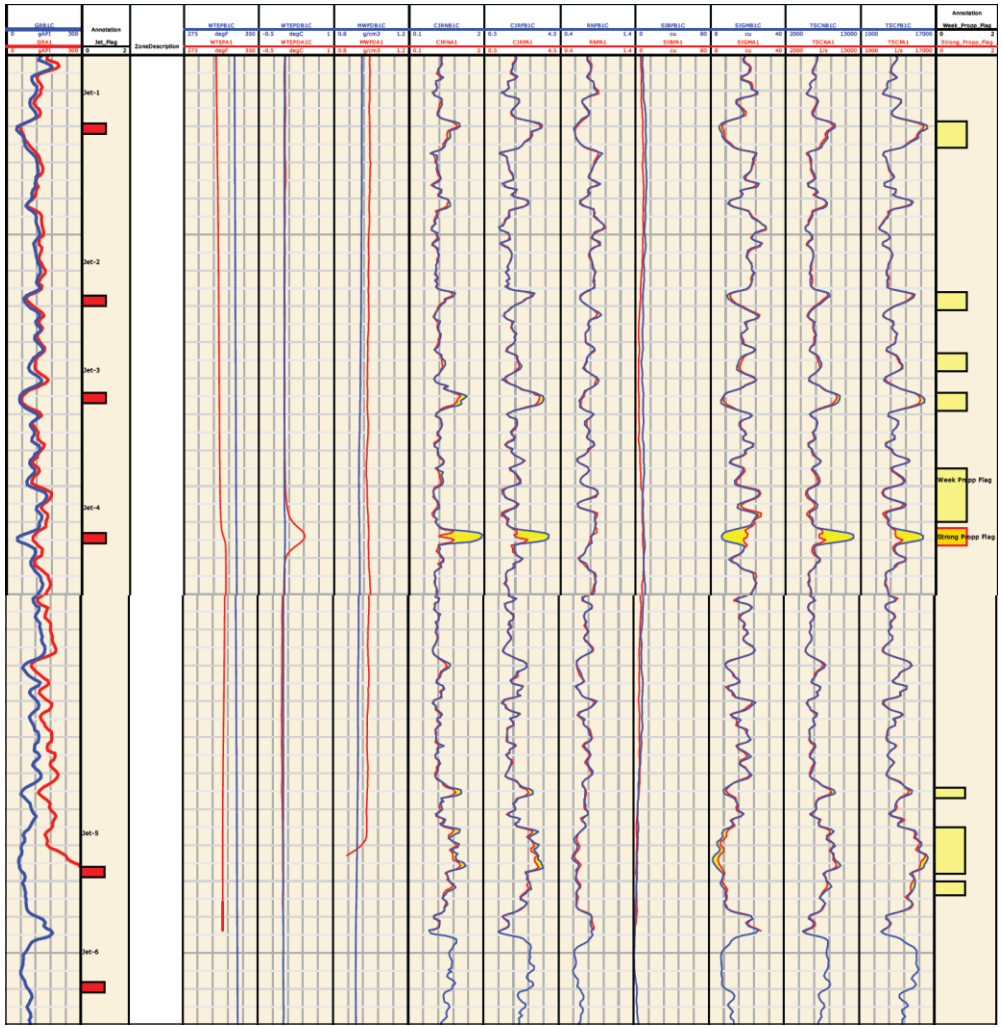


Source: SPE-97415

Stages	Depth ft	Depth ft
Jet-1	XX,769	XX,772
Jet-2	XX,817	XX,820
Jet-3	XX,844	XX,847
Jet-4	XX,883	XX,886
Jet-5	XX,976	XX,979
Jet-6	XX,008	XX,011

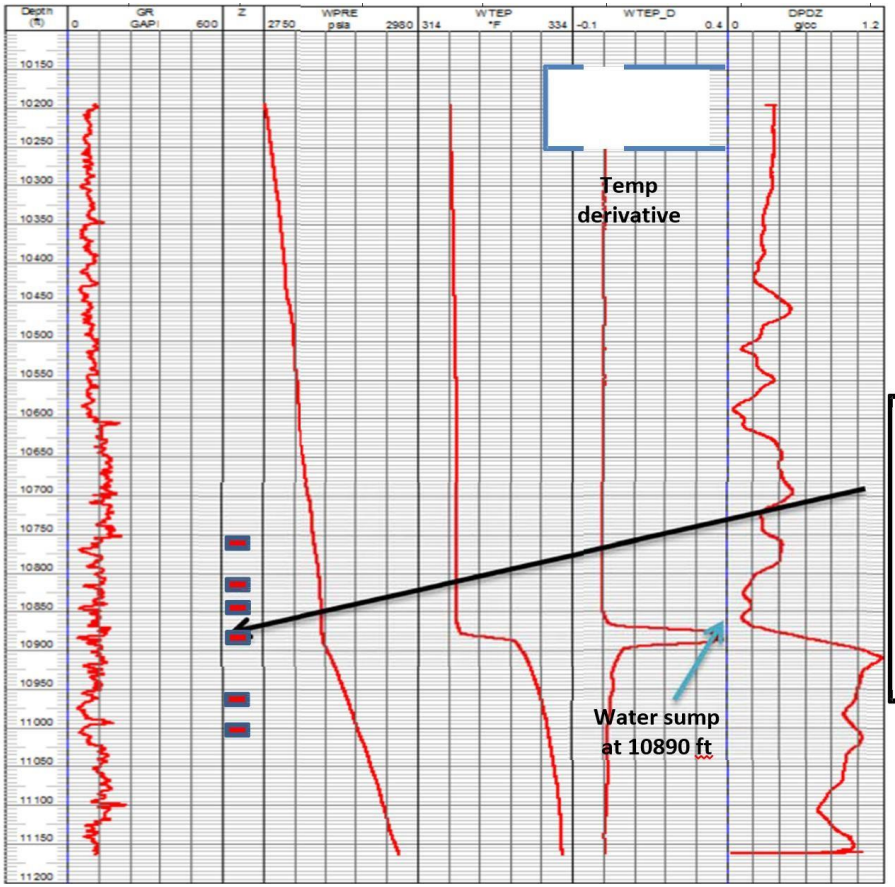
Well B – Traceable proppant interpretation

- Weak signal in jetted positions 1-3 & 5: limited frac propagation
- Strong signal in jetted perfs #4: dominant frac
- Postfrac log didn't reach jetted perf #6



Well B – Production log

- Temperature deflection shows all production is coming from jetted perforations #4
- Confirms no effective fracs propagated in the rest of the jetted zones



Conclusions

- Traceable proppant enabled diversion evaluation
- Jetted perforations seem not to work
  - Why? Contradicts theory
  - Similar experiences?
- Particle diversion seems to work
  - Similar experiences?

CARBO®

Questions?

Traceable proppant application to assess fracturing diversion efficiency

Pedro Saldungaray
CARBO Ceramics
Technical Manager EH

Thank you for your attention