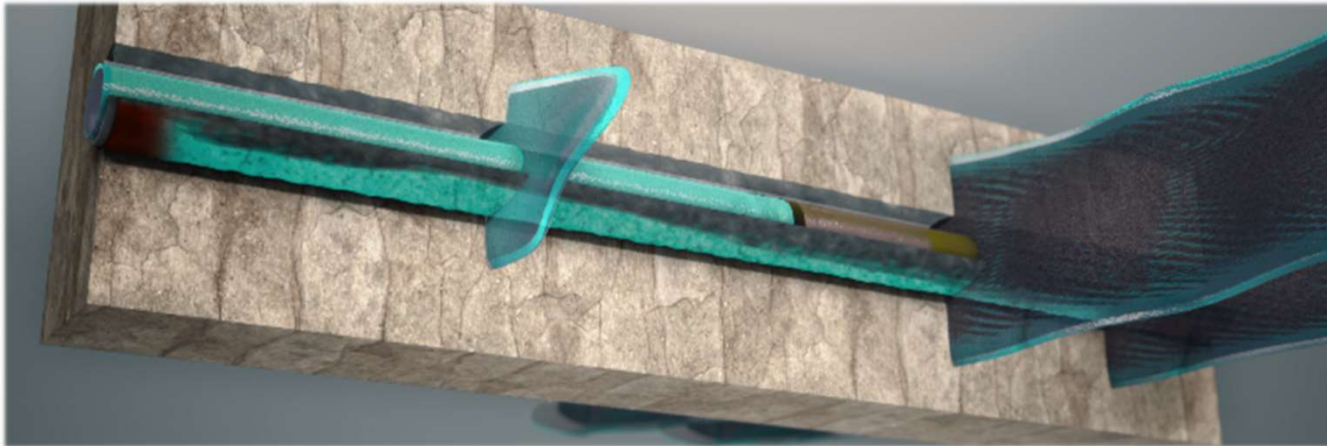


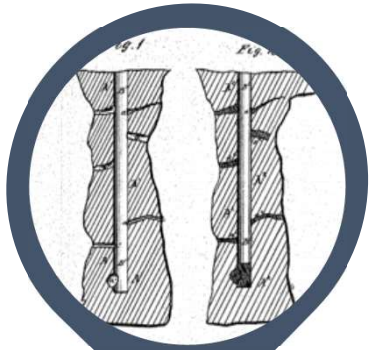
New cement system for effective zonal isolation in horizontal wellbores



Anatoly Medvedev, Schlumberger

October 16th SPE Westside Study Group meeting

Epigraph

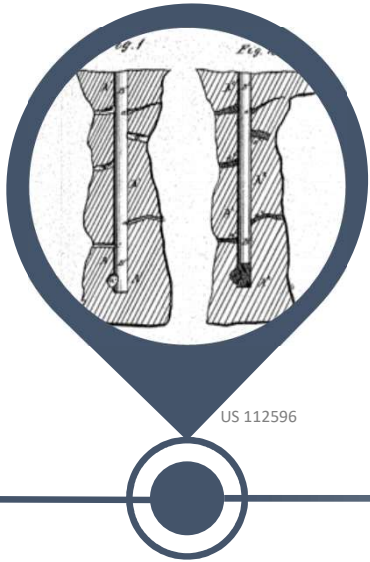


US 112596

1871

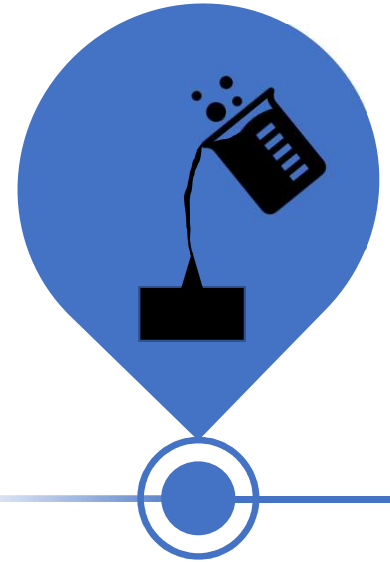
- US 112596, Drilling Oil Wells, J.K.Hill

Epigraph



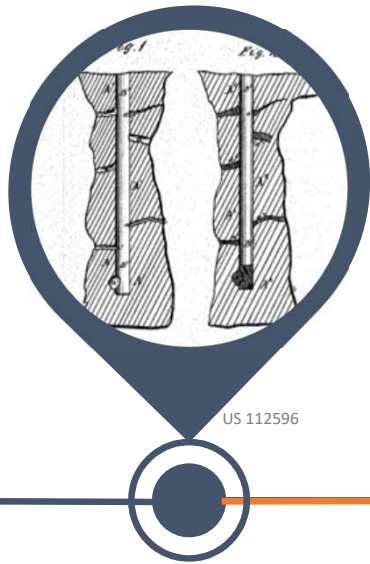
1871

- Ultimate goal: Controlled drilling fluid to cement conversion



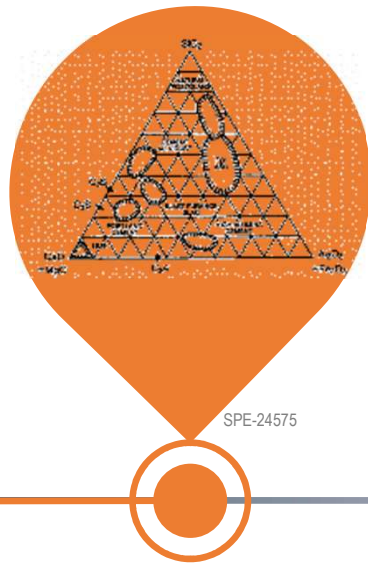
Future

Epigraph



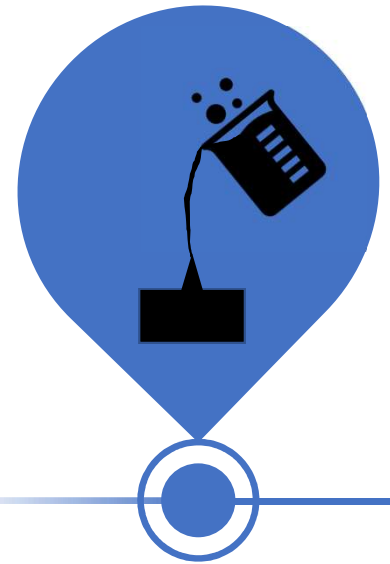
US 112596

1871



SPE-24575

1969

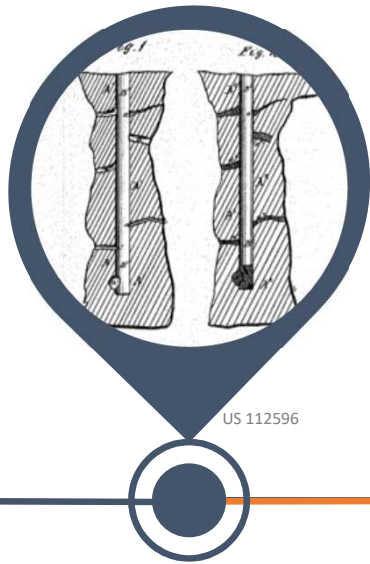


Future

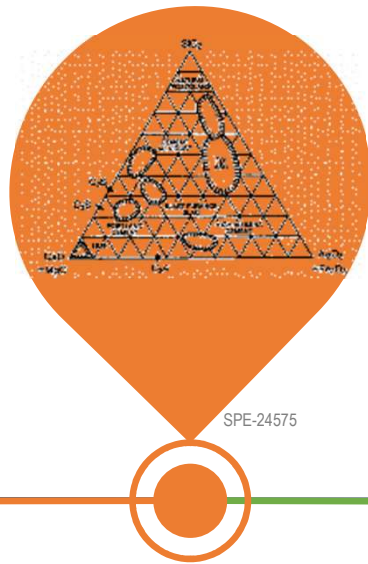
Mud-To-Cement (MTC) concept

- F. T. Jones, and D.C. Oliver. "A New Material to Cement Well Casing", The Oil and Gas Journal. October, 1969
- K.M. Cowan, A.H. Hale, and J.J. Nahm, Shell Development Co. "Conversion of Drilling Fluids to Cements With Blast Furnace Slag: Performance Properties and Applications for Well Cementing", SPE-24575, 1992

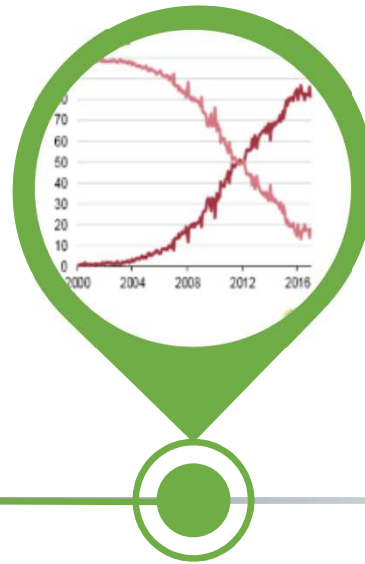
Epigraph



1871



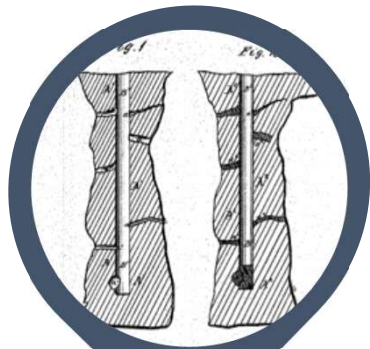
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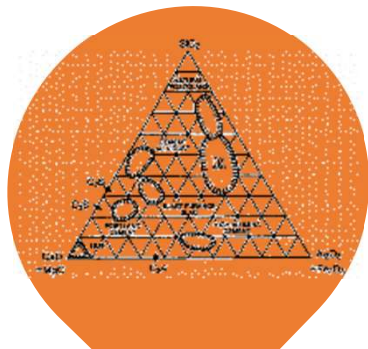
Future

- Change in market situation

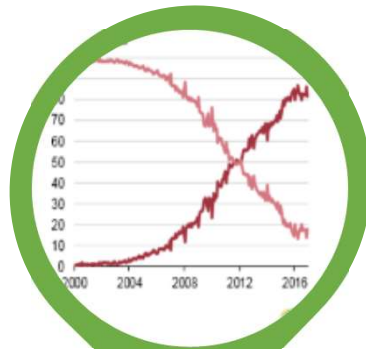
Epigraph



US 112596



SPE-24575



1871

1969

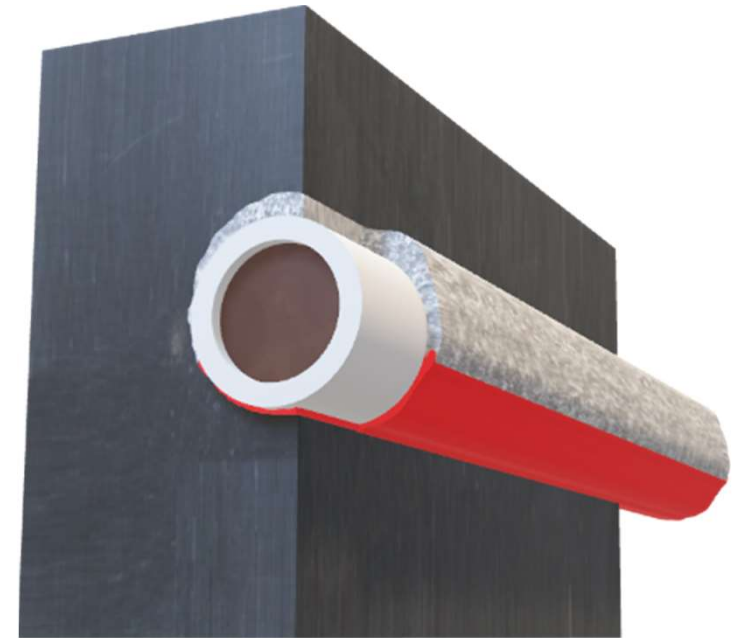
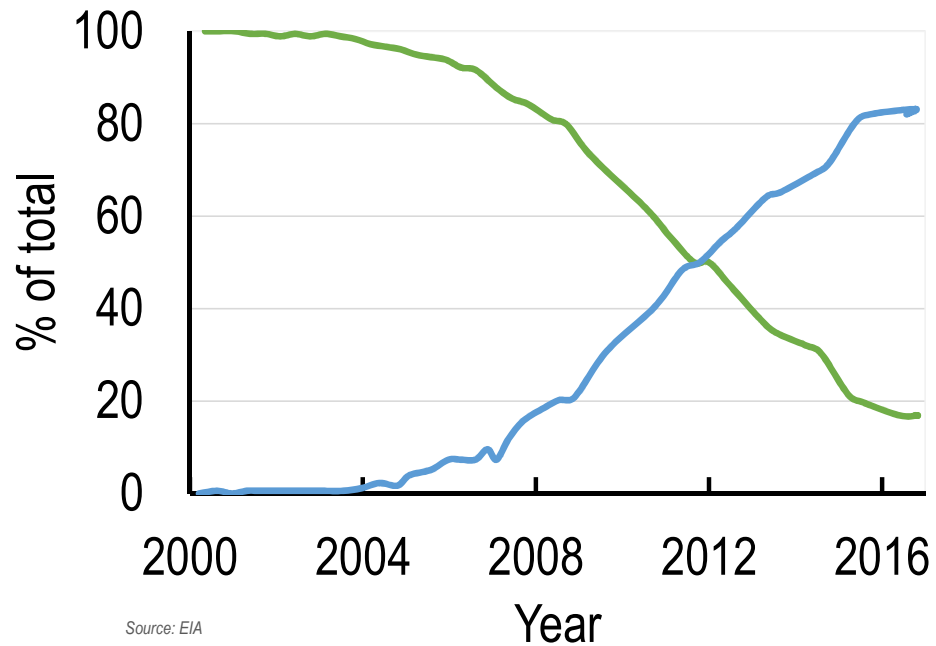
2011

2018

Future

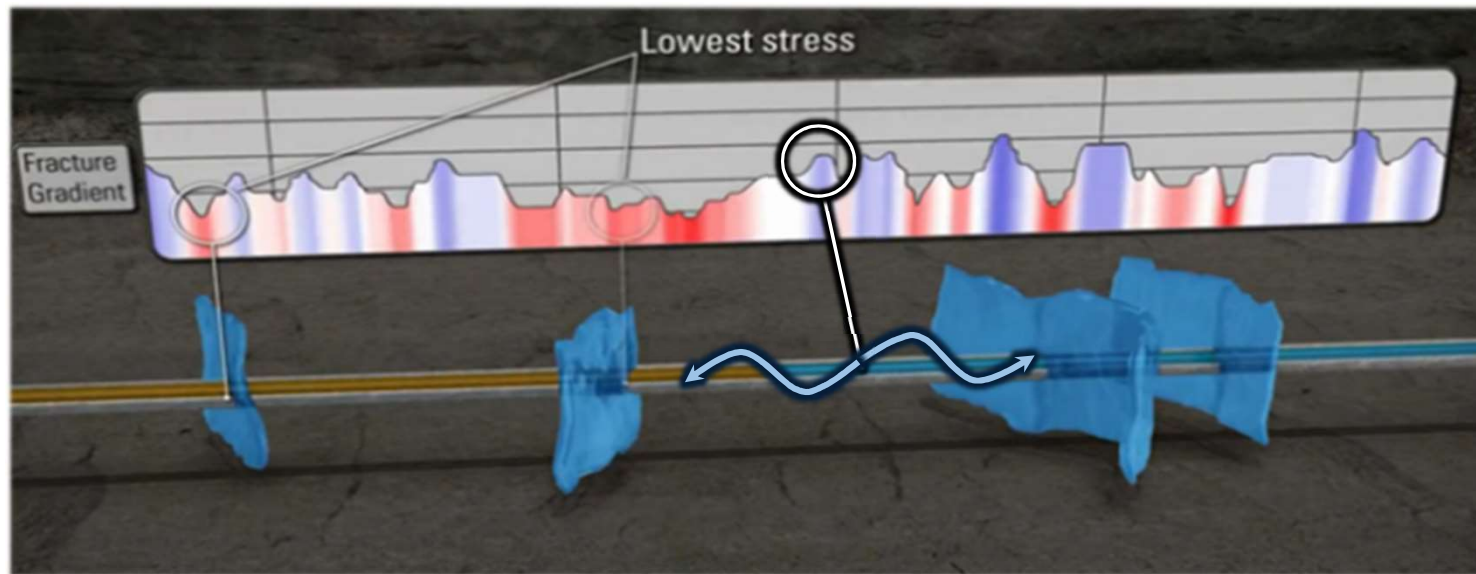
- P. Kolchanov, D. Perroni, A. Medvedev, Y. Gao, R. Tercero, L. Todd, B. Lungwitz (Schlumberger), K.M. Cowan, W. Turner (Occidental Petroleum) "Effective Zonal Isolation in Horizontal Wells: Mitigating Negative Impact of Mud Channels", SPE-191561-MS, 2018

Market changes



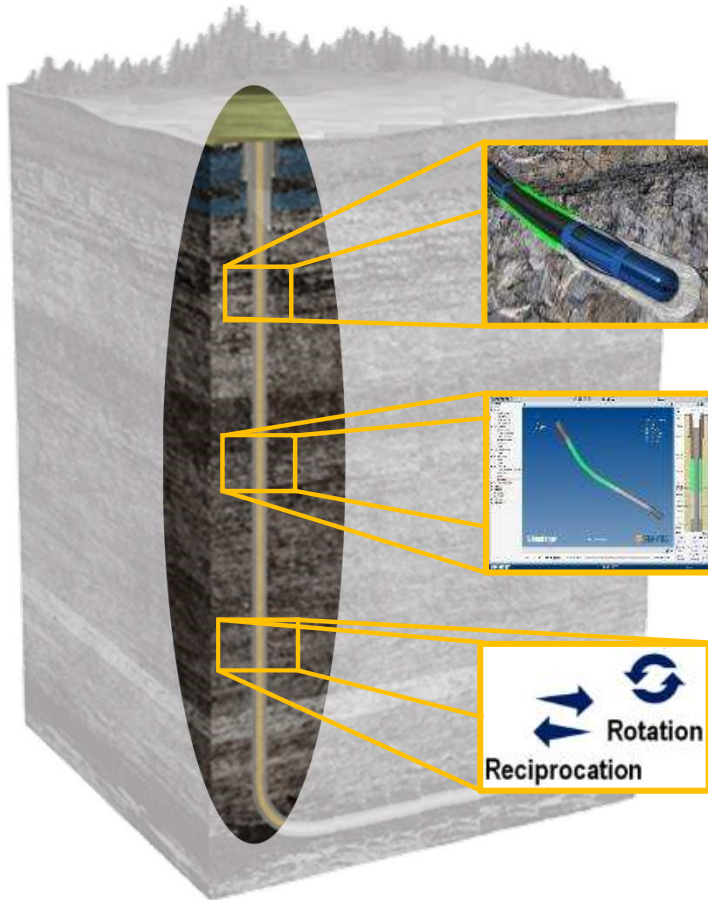
- Increase in horizontal drilling
- High eccentricity affects mud removal

Effect of cement on completion quality



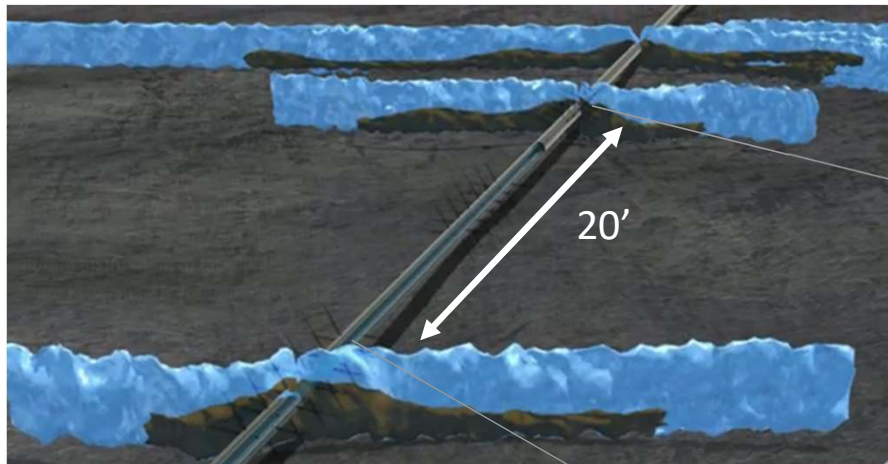
- Cement maximizes control of fracture initiation point
- Cement prevents fluid communication between intervals

Industry best practices



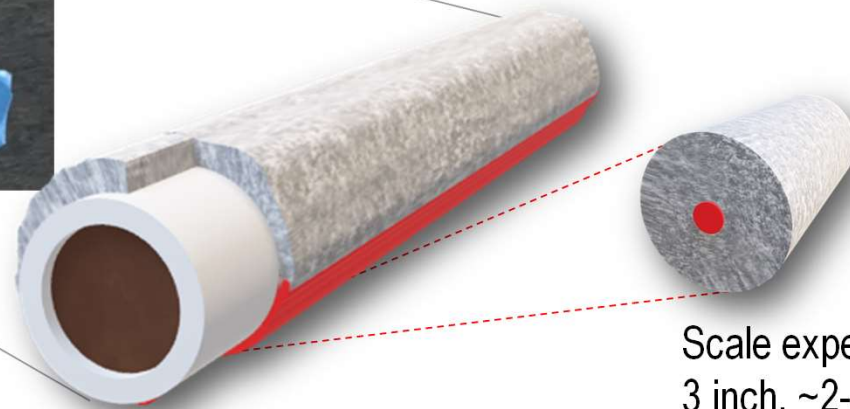
- SPE-173365 (Chevron) Selection of perforation clusters location based on cement quality
- SPE-181684 (Schlumberger) Fracture initiation process
- SPE-172937 (BP) Cement placement is critical for fracturing
- URTeC-2691375 (Schlumberger) Refracturing candidate selection
- JPSE 139, 254-263 (Texas A&M, Berkeley Lab) Incomplete cementing may cause shear failure
 - *Other literature is available because this is an area of increasing concern.*

Laboratory testing approach



Distance between stages: > 20 ft

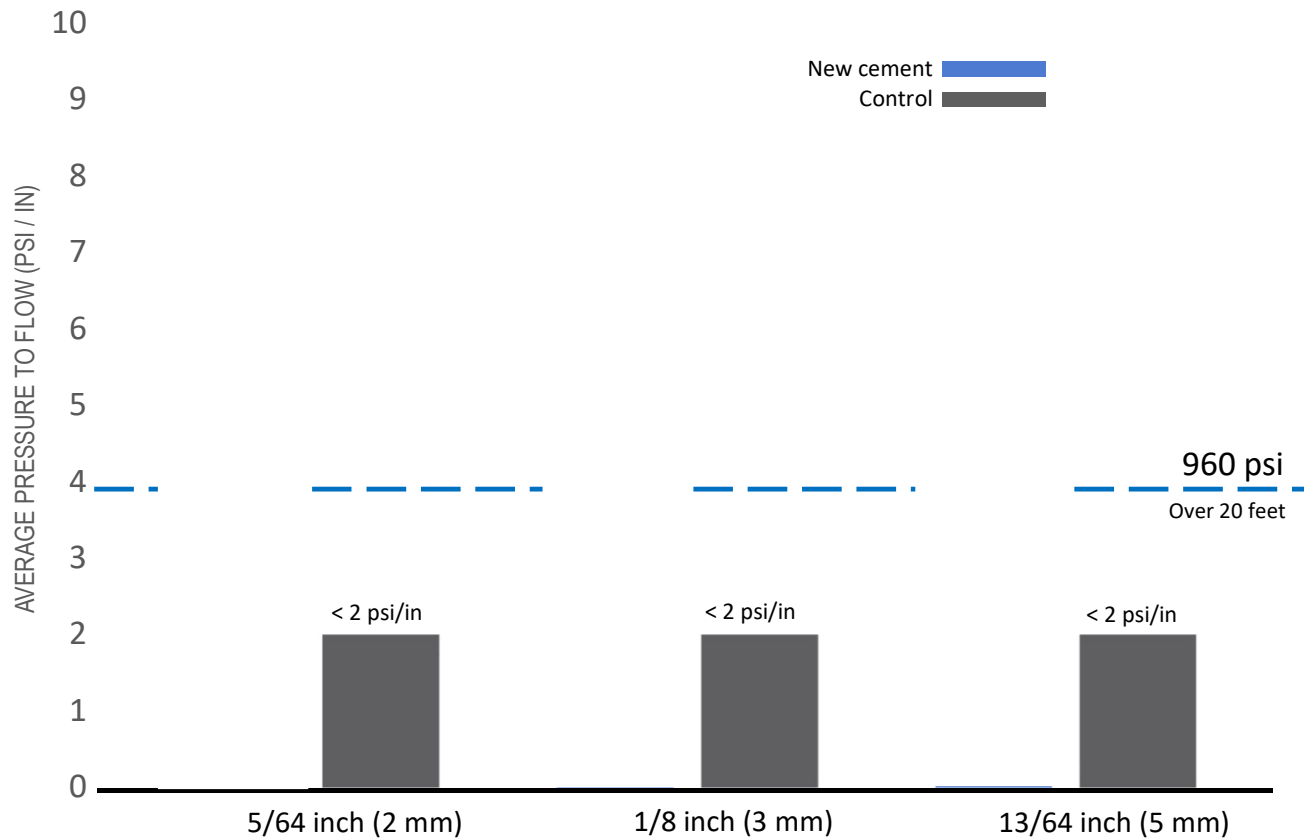
Average pressure difference: 500-1000 psi



Scale experiment:
3 inch, ~2-4 psi/in

- Mud channel laboratory model with well-controlled parameters

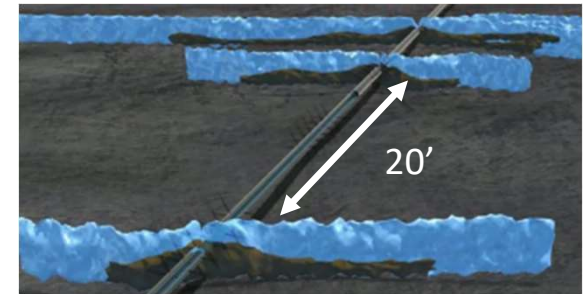
Laboratory validation example



SPE-191561-MS

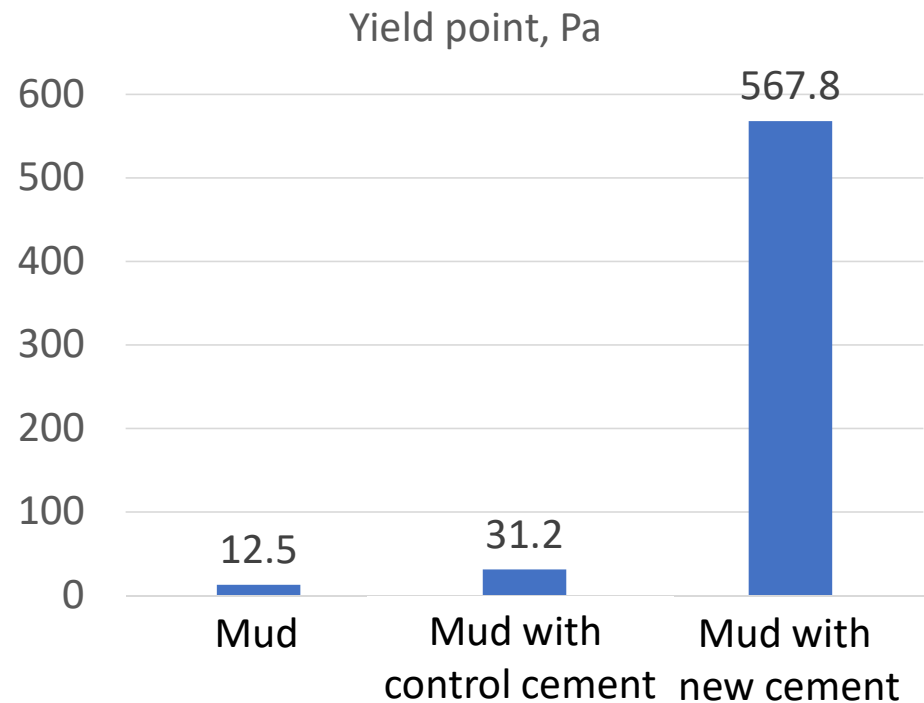
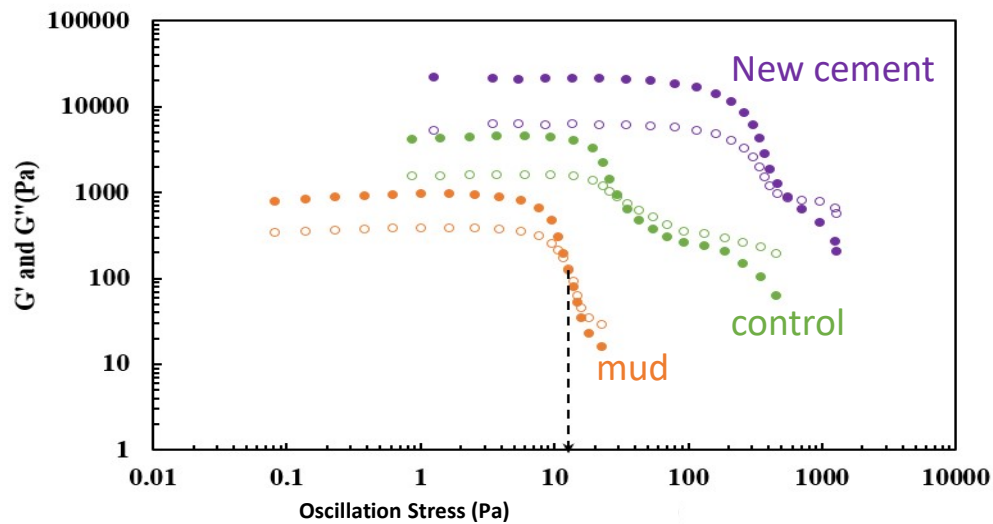


*13 lbm/galUS diesel-based mud



Mud resists flow under stimulation pressures

Drilling fluid rheology



- Significant increase in yield point after 3 days



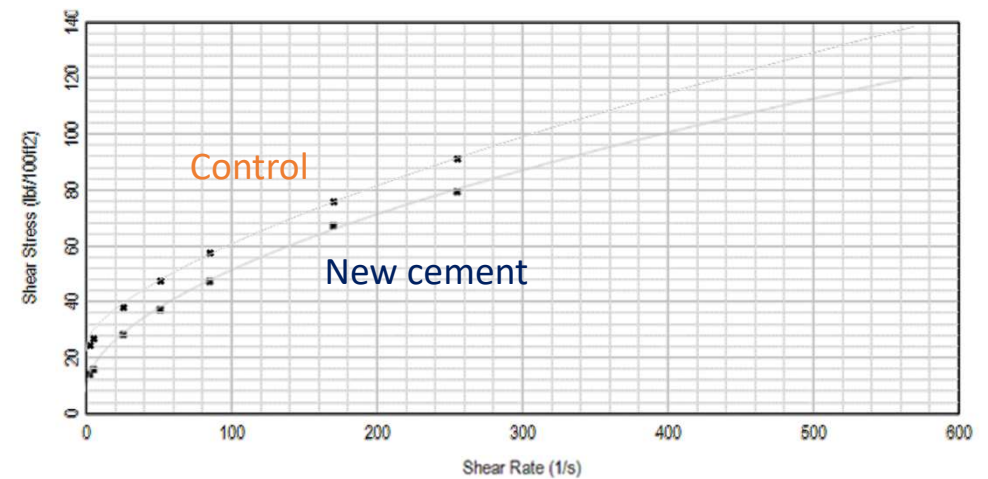
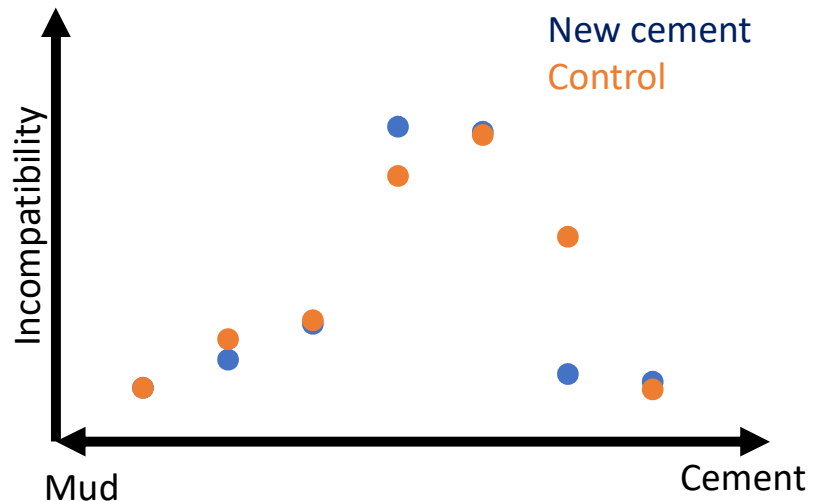
Fulcrum

Conventional

TRACEABLE®

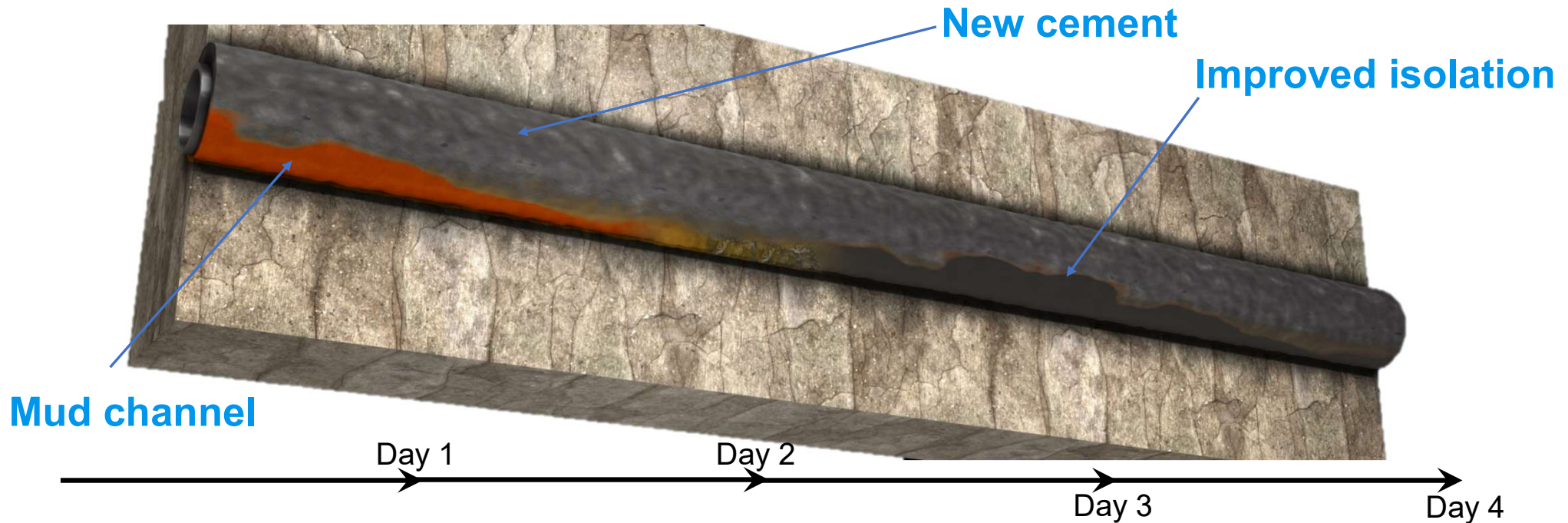
0.00 M 0.00 S

No effect on cement properties



- No effect on cement rheology, mud compatibility, or mechanical properties

Isolation mechanism



- Turn remaining mud channels into a thick paste: channel mud rheology increase
- New approach in well cementing

Field cases

CASE STUDY

Schlumberger

Fulcrum Technology Delivers 100% Isolation for 102 Fracturing Stages in Oklahoma

Memory gauges in prior wells recorded 22% to 43% stage-to-stage communication, indicating fluid communication behind the casing.

CHALLENGE
Improve hydraulic fracturing by ensuring that each stage is treated as designed, as compared with previous wells where 22% to 43% of fractures communicated with previously treated zones.

SOLUTION
Before each stage for the entire well, constructing the well using Fulcrum™ cement-conveyed frac performance technology.

RESULTS
Isolated 100% of the 102 stages of hydraulic fracturing, as compared to previous gauges before the project.

Technology improves isolation for optimum stimulation
Schlumberger recommended Fulcrum technology, which is delivered using a conventional cementing operation in wells with any fracture geometry. It will not reduce the risk of fracturing fluid or pressure not communicating through channels behind the casing.

Memory gauge indicates 100% isolation for all 102 stages
Schlumberger contacted the operator's first well using the Fulcrum technology. As with the previous wells, it was completed with sliding sleeves using a CT-conveyed packer with a memory gauge below it. During the 102 fracturing stages, the memory gauge recorded no indication of fluid communication behind the casing. As a result, each stage reached exactly the treatment it was designed to receive, with no stage being over- or under-treated.

Stage-to-Stage Isolation from Memory Gauge

with cement

CHALLENGE
An operator in Oklahoma drilled horizontal wells to increase oil and gas production. The operator was concerned with the risk of fluid communication behind the casing. The operator was concerned with the risk of fluid communication behind the casing.

SOLUTION
The operator was concerned with the risk of fluid communication behind the casing. The operator was concerned with the risk of fluid communication behind the casing.

RESULTS
The operator was concerned with the risk of fluid communication behind the casing. The operator was concerned with the risk of fluid communication behind the casing.

CASE STUDY

Schlumberger

Fulcrum Technology Improves Cement Bond Index by 55% in Horizontal Wells, Permian Basin

Cement-conveyed frac performance technology efficiently mitigates hole-clearing challenges by altering mud mobility—without special equipment or cement designs.

CHALLENGE
Improve cement quality across 300+ production stages in horizontal environment with real operational challenges—without increasing job completion rates.

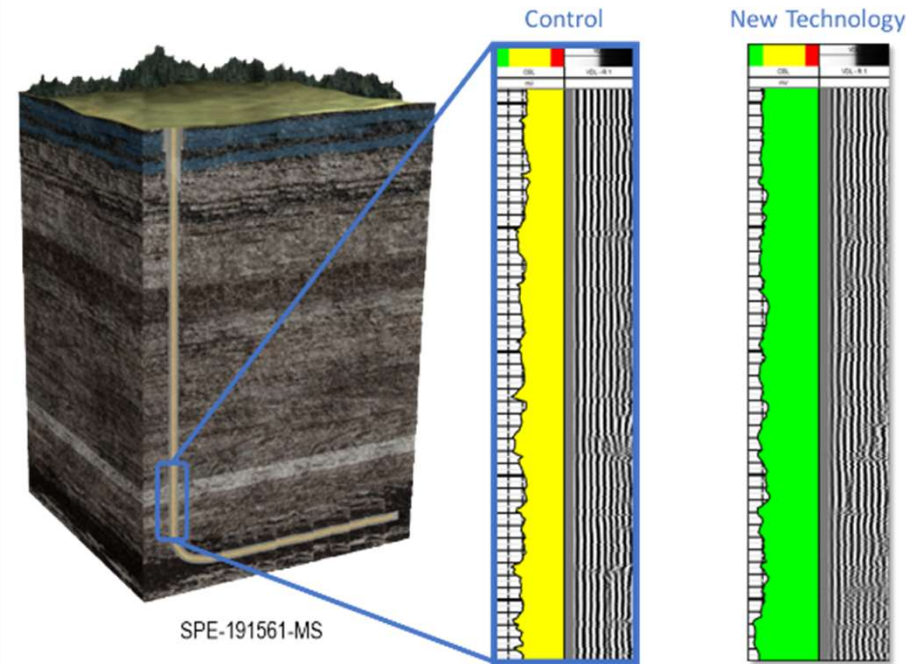
SOLUTION
Cement the wells using Fulcrum™ cement-conveyed frac performance technology.

RESULTS
Improved average cement bond index (CBI) to 0.47 as compared with 0.31 for previous locally cemented wells, with no change in completion rates.

CHALLENGE
Oil-based mud and conventional techniques result in mud channeling. A Permian Basin operator has long battled wells with 10,000 ft or more of mud channeling, leading to poor completion rates. The operator was concerned about the mobility of cement in these wells, which was a major challenge. The operator was concerned about the mobility of cement in these wells, which was a major challenge.

SOLUTION
The operator was concerned about the mobility of cement in these wells, which was a major challenge. The operator was concerned about the mobility of cement in these wells, which was a major challenge.

RESULTS
The operator was concerned about the mobility of cement in these wells, which was a major challenge. The operator was concerned about the mobility of cement in these wells, which was a major challenge.



Conclusions

- New approach in stage isolation
- First cement-to-fracturing technology
- Compatible with almost all cements and nonaqueous drilling fluids
- Next step in controlled drilling fluid – cement system

