SEALED WELL

A New Approach to Assessing & Remediating Annular Gas

BioSqueeze

SEALED WELL

BioSqueeze

Biomineralization Technology

Biogenic Calcium Carbonate Crystallization
Non-pathogenic soil bacteria precipitate mineral similar to limestone via metabolic activities

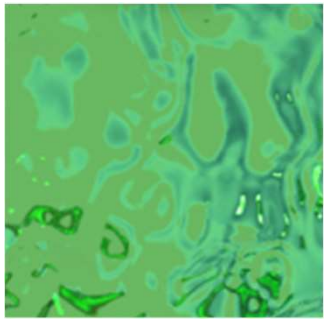
Biofilm
Microbes readily bond to themselves and virtually any material (rock, cement, steel) they contact

Natural Solution
Aqueous, controlled reaction capable of crystalizing in conditions up to 170 °F from 5 – 11 pH to form a 100% inorganic seal

01

Cracks Form and Leak Methane

02

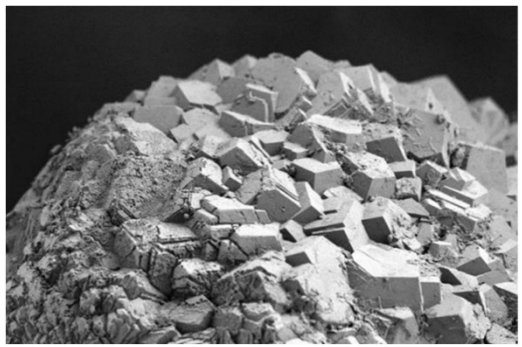


BioSqueeze® Fluids Pumped

03

Impermeable Seal Created

Natural Soil Bacteria



Biomineralized Calcite Crystals

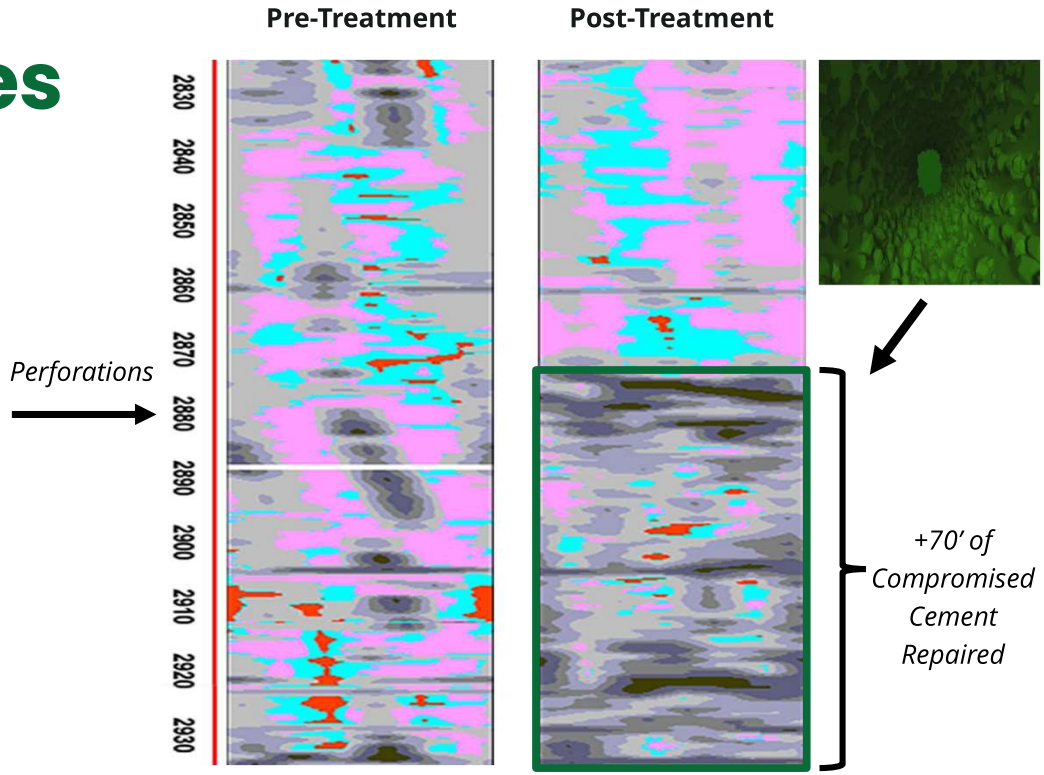
Advantageous Properties

Penetration
Low viscosity fluid system (1.05 cP) capable of accessing small pathways too tight for other materials (2024 well showed over 700’ of upward sealing)

No Drillout Required
The process leave the wellbore full drift, require no drillout.

Self Diverting Fluids
As permeability is reduced, fluids follow the path of least resistance, occupying pore space in compromised cement

Impermeable Seal & Compressive Strength
Leakage pathways repaired with limestone to create a gas tight barrier 7x stronger than class G cement



Technology	Minimum Fracture Gap
Cement	400 µm
Polymer Resin	310 µm
Epoxy Resin	120 µm
Micro Cement	120 µm
Biomineralization	1 µm

A human hair is ~ 60 µm wide

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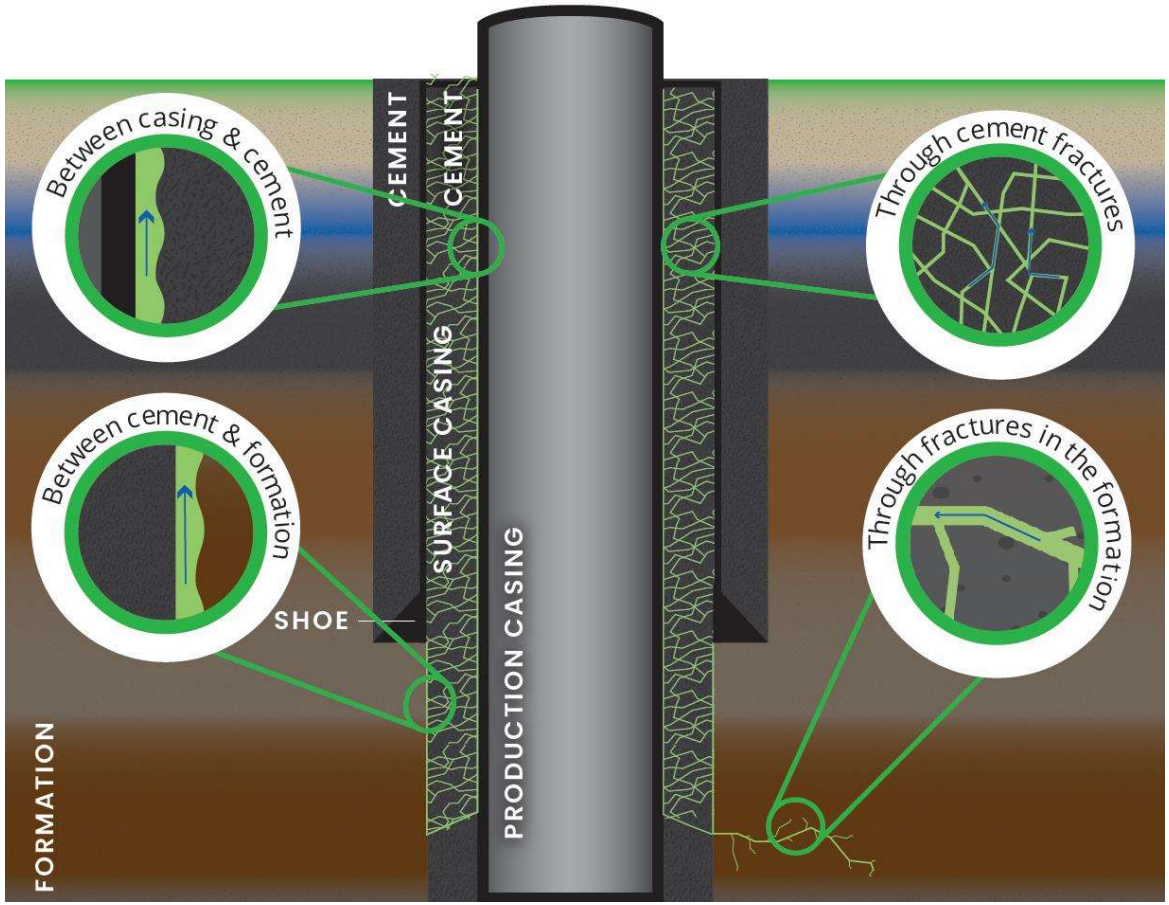
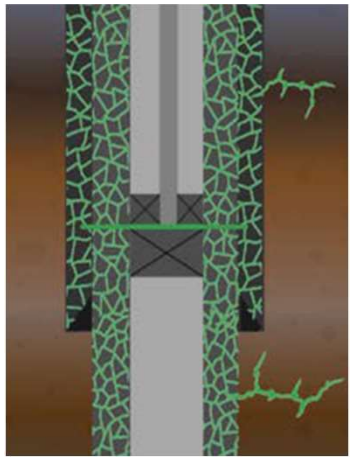
Annular Gas Leaks

Methane Leaks
Debonding, wormholes, and fractures in cement create leakage pathways for gas that are difficult to seal

Channels & Micro Annuli
Many of these leaks are very narrow, making them inaccessible for high viscosity sealants

Groundwater Contamination
Annular leaks are a significant threat to groundwater quality





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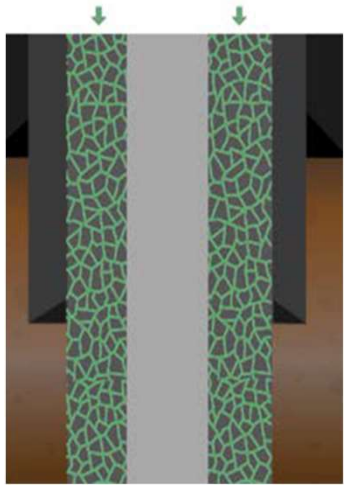
Diagnostics and well history are analyzed to inform a downhole intersection strategy to:

- Eliminate Gas Migration
- Repairs Casing Leaks
- Shuts Off Unwanted Water
- Stabilize Fines



Deep Penetrating Annular Surface (DPAS™) BioSqueeze®

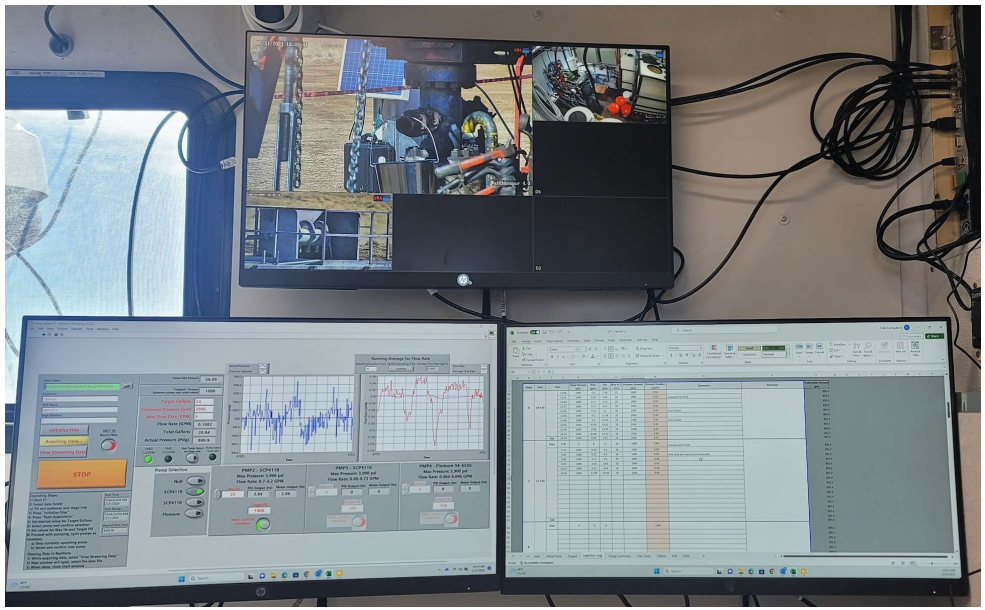
Rigless solution to eliminate gas and protect groundwater:

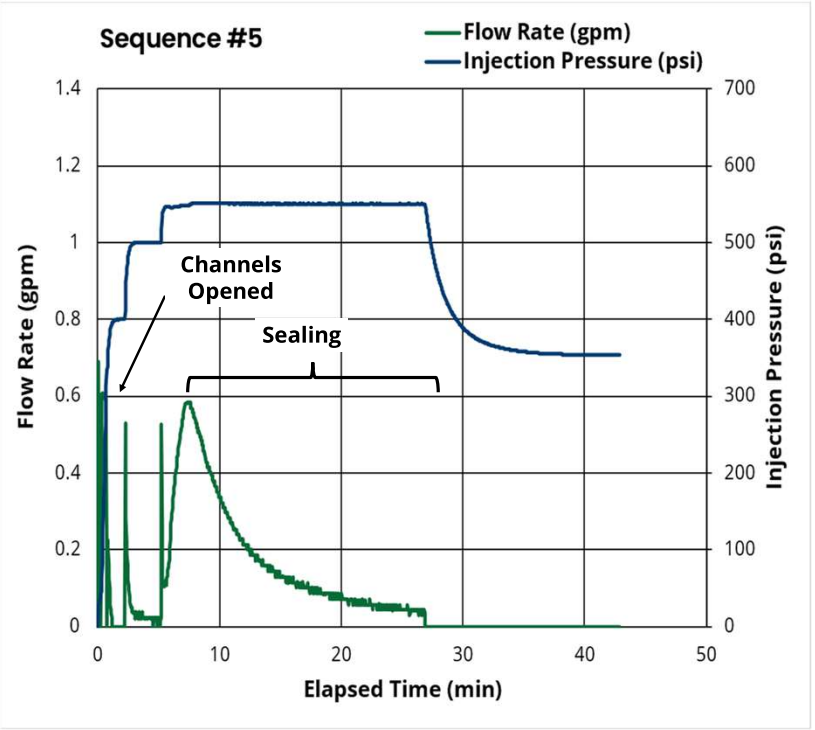
- Delayed Reaction System (DRS™) delivered directly into leakage pathways
- Fluids pose no risk to the aquifer and penetrates over 1,000 ft from the point of injection

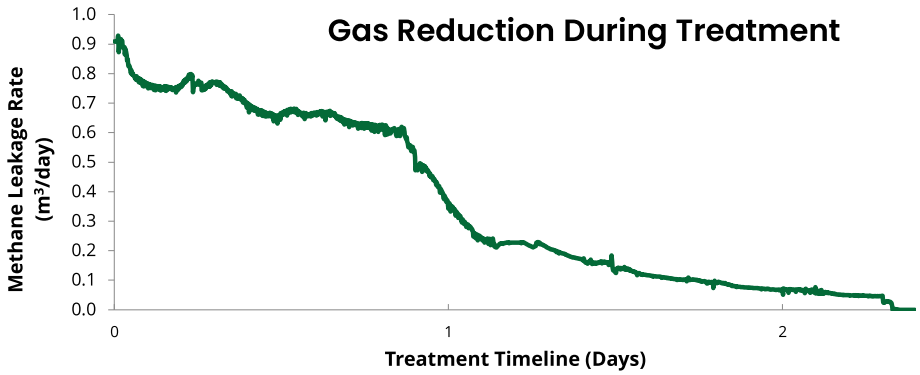
Real-Time Results

Pumping & Monitoring Equipment
State of the art system optimized for precision permeability modification

Established Procedures
Over 150 wells sealed to date, many where all available options had been exercised







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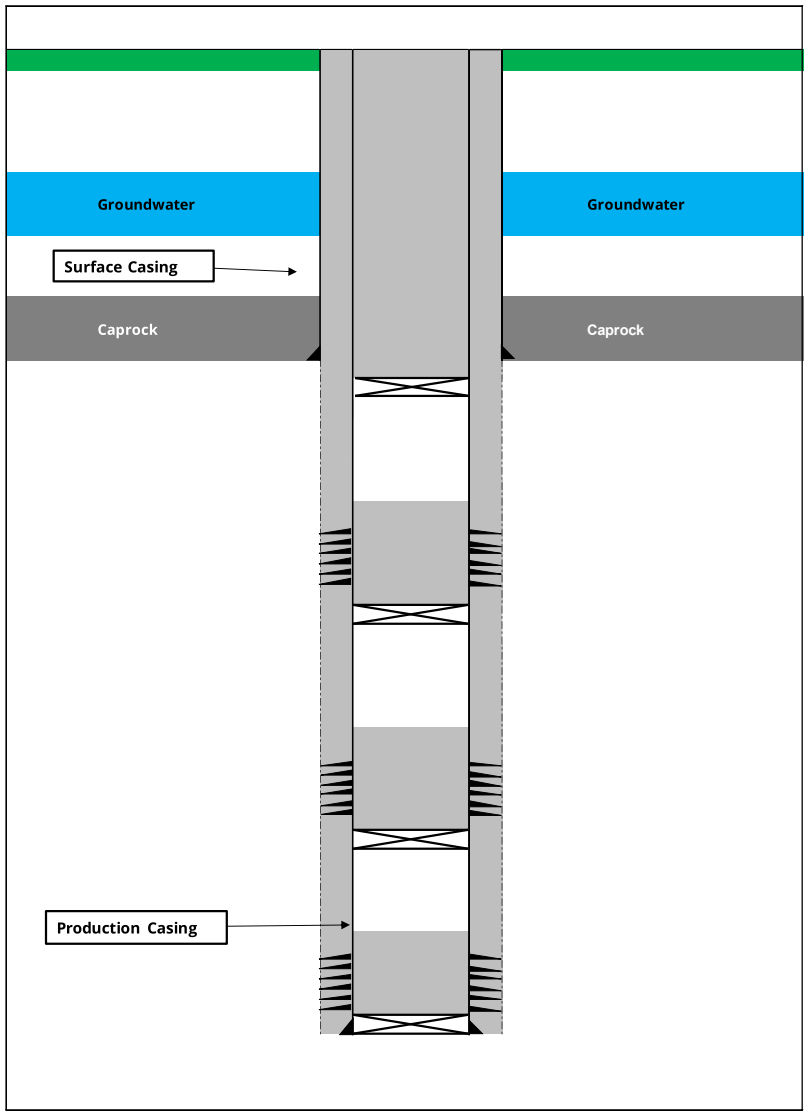
Conventional Remediation Limitations

Limited Diagnostics
To minimize costs, diagnostics are kept to a minimum – typically an RCBL

Inconsistent Operating Procedures
Placing a premium on efficiency, pre-job planning is often overlooked, and decisions are made on the fly

Inadequate Sealants
Common materials like cement and resin excel at filling voids, not repairing compromised cement

Unpredictable Expenditure
Costs exceed budget due to failed attempts



Job Design Process

Through our experience, the key to successfully sealing a wellbore is identification of flow pathways and creating an effective connection for injection.

The BSI design process increases the success rate by systematically evaluating candidates for viability and designing a holistic approach for treatment.

Information Gathering

- WBD (as-built)
- CBL/RCBL – digital format
- Quantification of surface gas expressions (% LEL, PBUT, bubble tests)
- Well construction daily reports and PJRs
- Acoustic/Noise-Temp Logs
- Isotope analysis
- Openhole Logs
- Offset well analysis

Candidate Review

- Advanced Cement Imaging (ACI™)
- Cement Integrity
- Data alignment
- Confidence level

Job Design

- Type
  - Downhole squeeze
  - Surface squeeze
- Depth of entry
- Entry method
  - Perforations
  - Gator Cuts
  - Notching
  - Multi-string cutter

Despite its potential, the cement bond log is probably one of the most abused, misused, and misunderstood logs used in the oil field today.

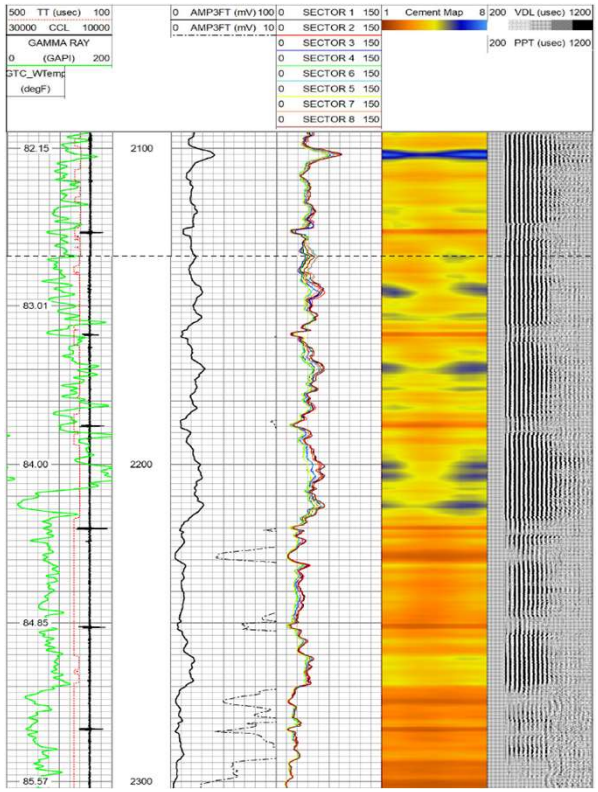
Miscalibration, inadequate information, and a severe lack of standardization are enough to push petroleum engineers into a morass of bewilderment.

FERTL, PILKINGTON, & SCOTT
"A LOOK AT CEMENT BOND LOGS"
JPT, JUNE 1974

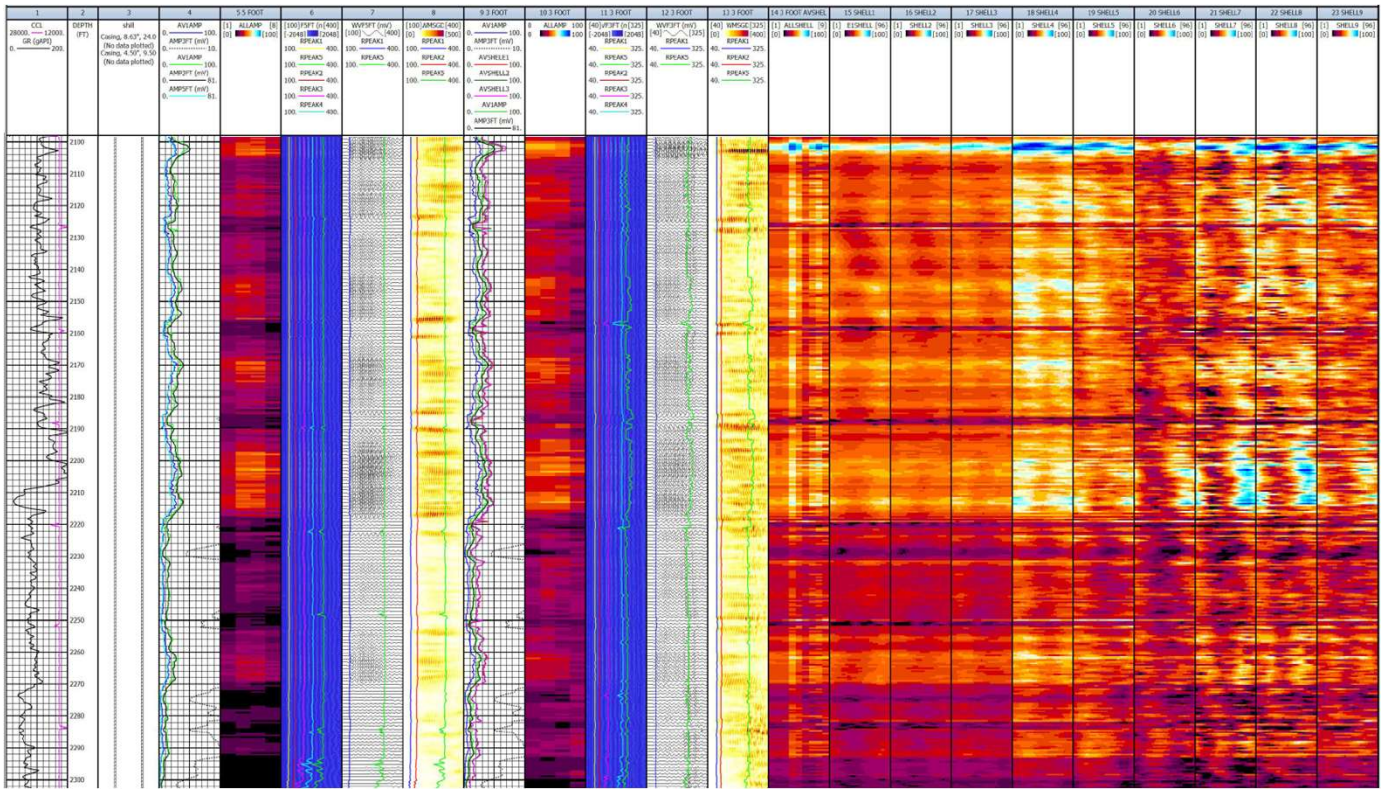
CBL vs ACI™

CBLs are a basic cost-effective diagnostic tool valuable for assessing cement integrity, but often leave us with more questions than answers. An ACI™ can be run using data already gathered by the CBL tool to provide additional information about annular cement integrity without running another diagnostic tool downhole.

Cement Bond Log (CBL)



Advanced Cement Imaging (ACI™)



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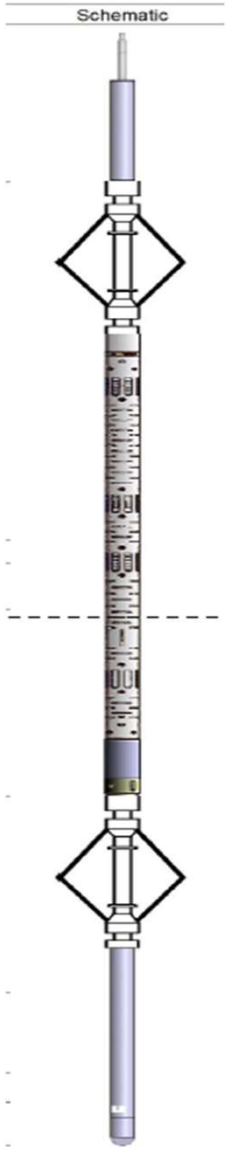
How it Works

Waveform & Amplitude Analysis

- The transmitter emits sound waves which interact with the different wellbore media and are then picked up by the receivers.
- Each CBL waveform has multiple amplitude values with varying signatures when annular space is filled with either a solid or liquid.
- Evaluating the amplitudes of CBL waveforms can provide improved cement sheath evaluation.
- Amplitude of free pipe inside the production casing is used to calibrate bond for the other regions.

Radial Data Provides Cross Sectional View

- Using the same analysis on data provided by sectored receivers from an RCBL tool provides detailed information on radial continuity of bonding/channels.
- Shells are generated that provide granular data for each region (from casing outward) that can reveal integrity issues often unseen using standard diagnostics.



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Case Studies

RECENT SUCCESS ACROSS A BREADTH OF CHALLENGING SCENARIOS

Well A – SCVF

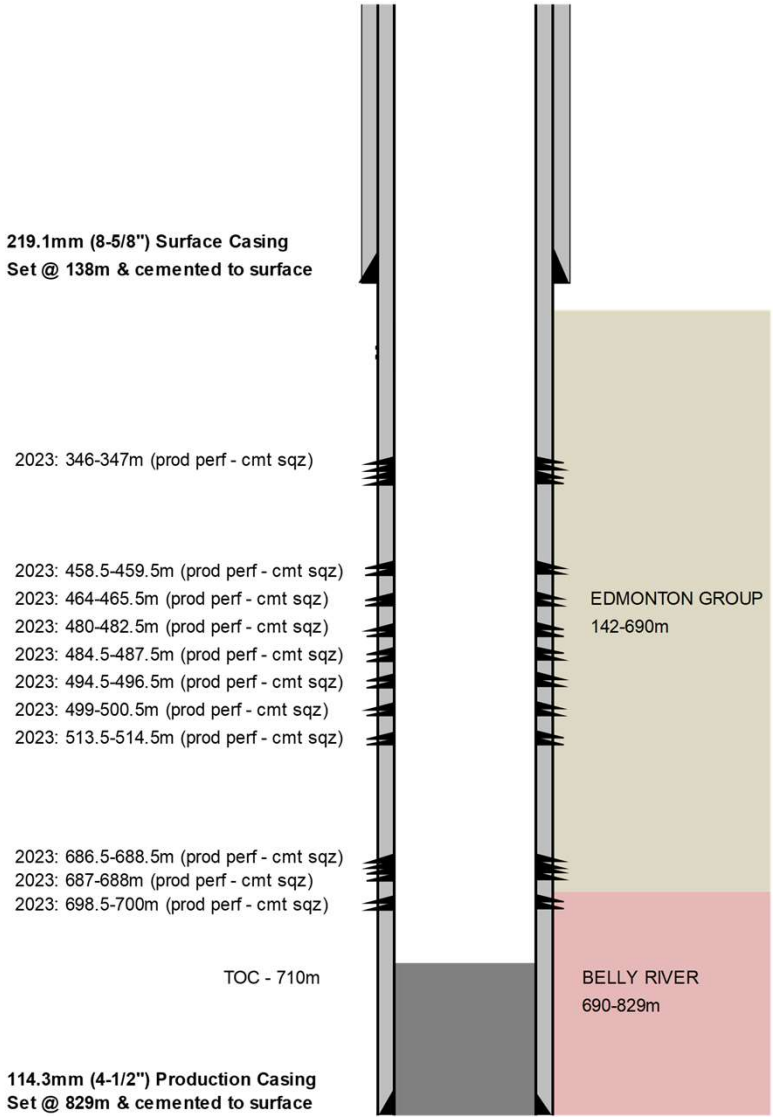
Alberta, Canada

Background

- 2004 - Drilled
- 2023 – Abandonment operations began:
  - Various logs run
  - Cement squeeze producing Horseshoe Canyon and Lethbridge Coals

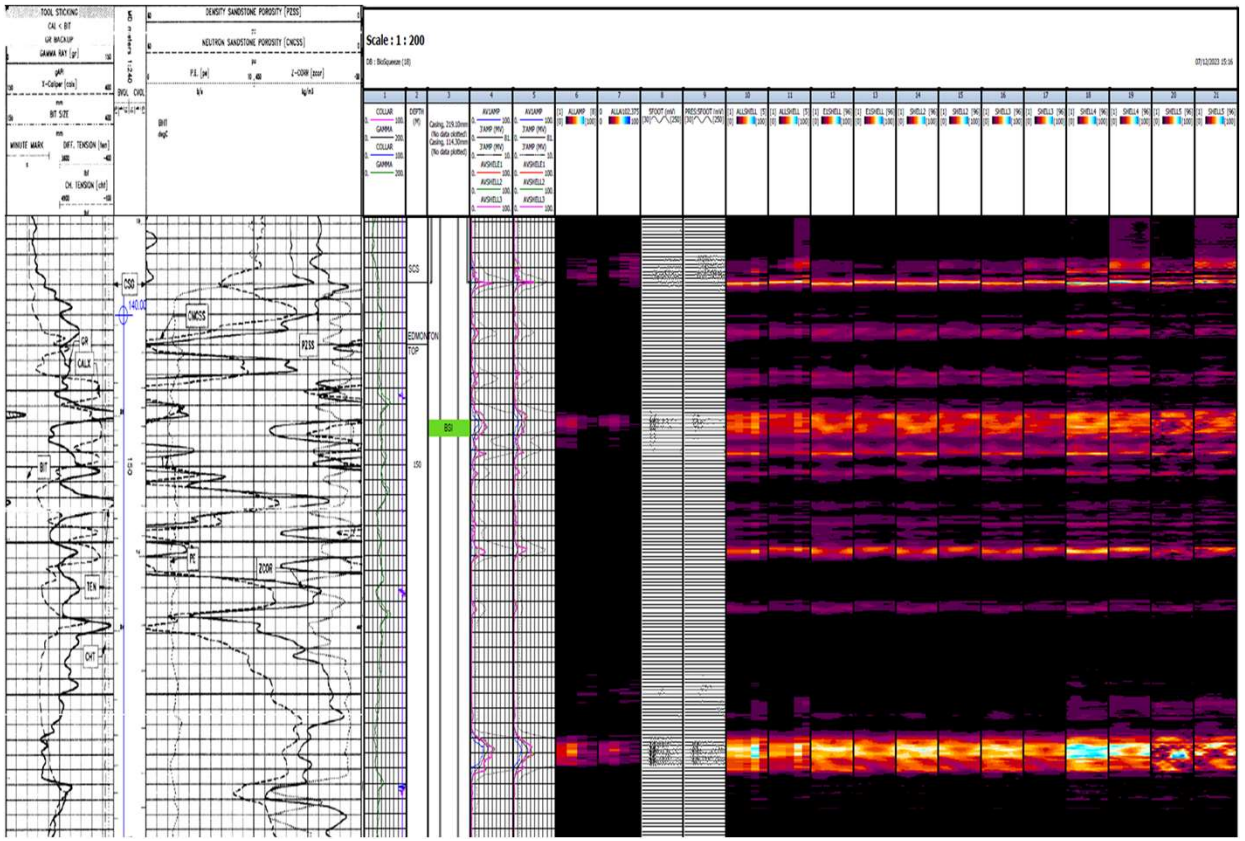
Analysis

- Diagnostics - CBL, noise-temp, CHAT, isotope analysis
  - Source determined to be Edmonton Group
- Offset analysis
  - 75% of ID'd SCVFs are Edmonton
  - Majority of lost circulation events are Edmonton and Shallower
- Plan to intersect above previous interventions
- Openhole logs
  - Prevalent coals within the Edmonton
  - 150 mm (6") washouts



Well A – SCVF

Alberta, Canada



219.1mm (8-5/8") Surface Casing
Set @ 138m & cemented to surface

2023: 147-148m (BIOSQUEEZE)

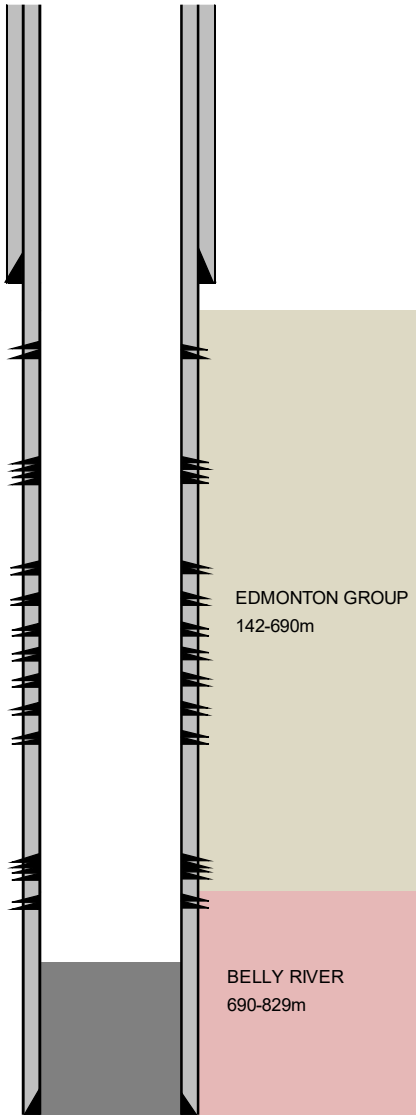
2023: 346-347m (prod perf - cmt sqz)

2023: 458.5-459.5m (prod perf - cmt sqz)
2023: 464-465.5m (prod perf - cmt sqz)
2023: 480-482.5m (prod perf - cmt sqz)
2023: 484.5-487.5m (prod perf - cmt sqz)
2023: 494.5-496.5m (prod perf - cmt sqz)
2023: 499-500.5m (prod perf - cmt sqz)
2023: 513.5-514.5m (prod perf - cmt sqz)

2023: 686.5-688.5m (prod perf - cmt sqz)
2023: 687-688m (prod perf - cmt sqz)
2023: 698.5-700m (prod perf - cmt sqz)

TOC - 710m

114.3mm (4-1/2") Production Casing
Set @ 829m & cemented to surface



Well A – SCVF

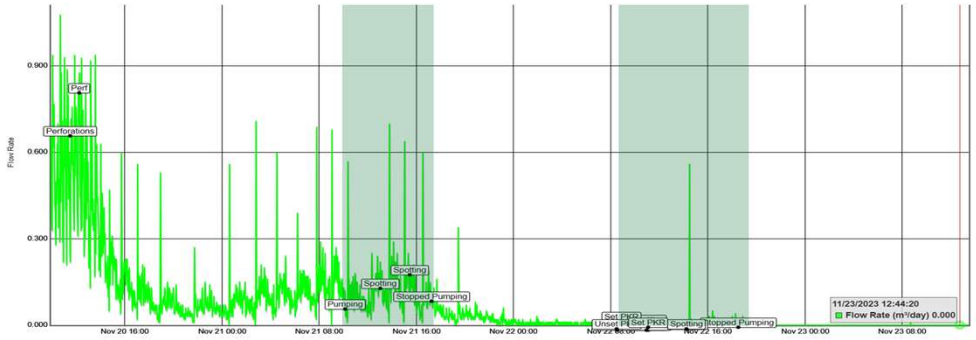
Alberta, Canada

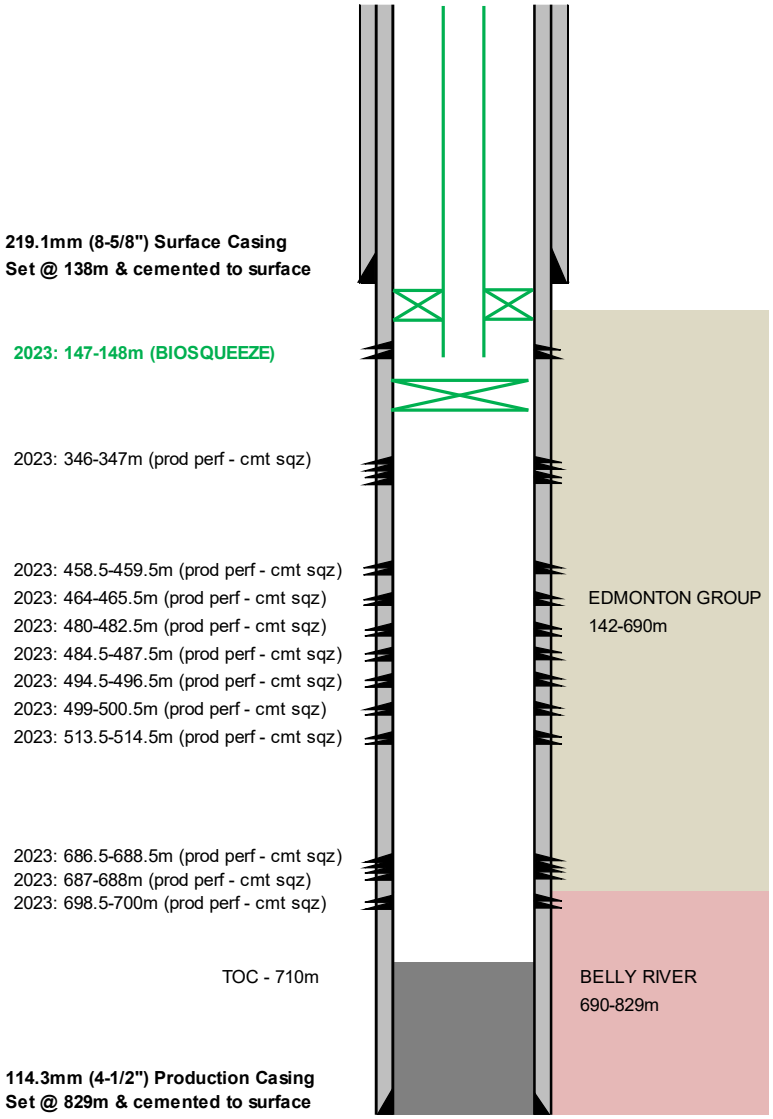
Preparation

- Perforate 147-148m
  - 118 SPM (36 SPF) UZI perf guns
  - Overlay 38 SPM (12 SPF) Deep Penetrating charges
- Set RBP at 148.5m
- 60mm (2-3/8”) tubing to 148m
- Set 114.3mm (4-1/2”) Packer at 146.5m
- Conservative Pumping Strategy: ~1.0 psi/ft gradient, no acid

Results

- Injection Rates: 0.25 gpm to 0.008 gpm (32.08 gal injected)
- Pre-BSI, Pre-Perf SCVF: 0.62 m3/day (21.9 scf/day)
- Pre-BSI, Post-Perf SCVF: 0.12 m3/day (4.2 scf/day)
- Post-BSI SCVF: 0 m3/day





Well B – DPAS

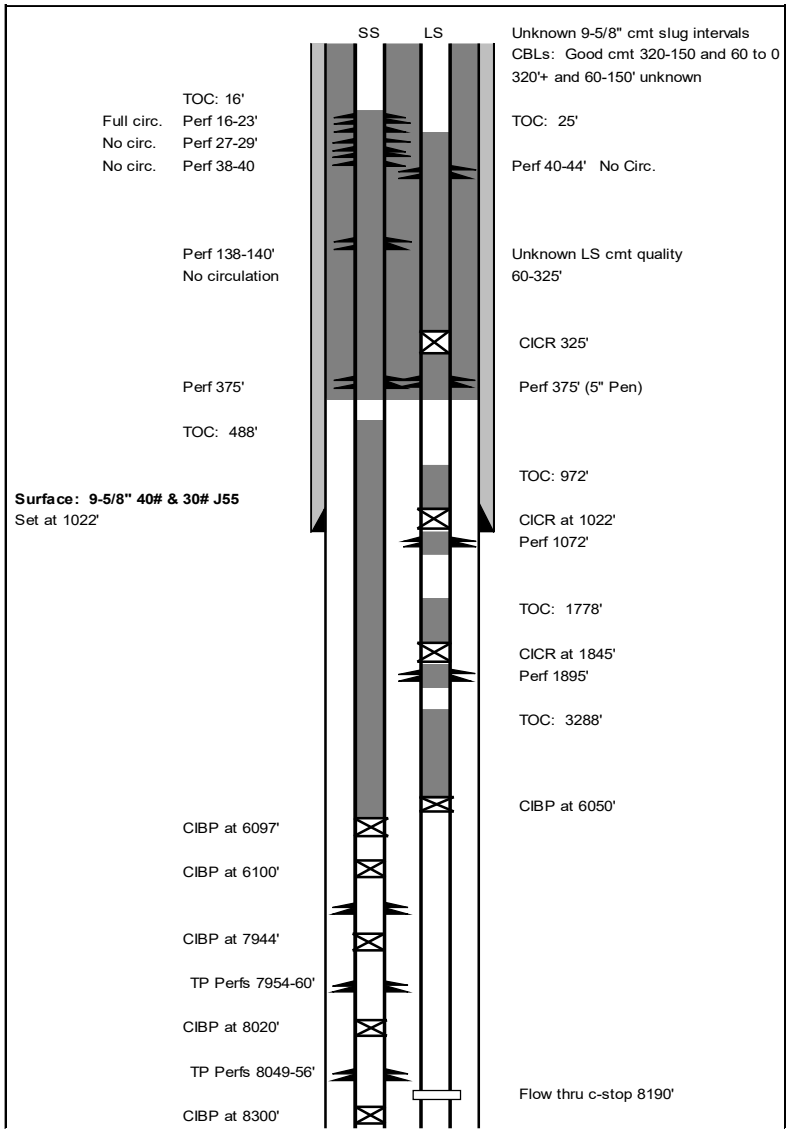
Texas, USA

Background

- Drilled in 1998 with 2 2-7/8” production strings.
- All strings cemented at/near surface
- Sustained casing pressure on all strings (4 month buildup)
  - 9-5/8” Surface – 183 psi
  - 2-7/8” Short String – 83 psi
  - 2-7/8” Long String – 9 psi
- Pre-Squeeze Bubble Tests
  - 9-5/8” Surface – 6 bubbles/min
  - 2-7/8” Short String – TMTC bubbles/min
  - 2-7/8” Long String – 4 bubbles/min

Analysis

- Diagnosis – CBL on Long String and Acoustic log
  - Perfs at 375’ compromised casing and allowed gas influx
- Shallow perforations on both production strings



Well B – DPAS

Texas, USA

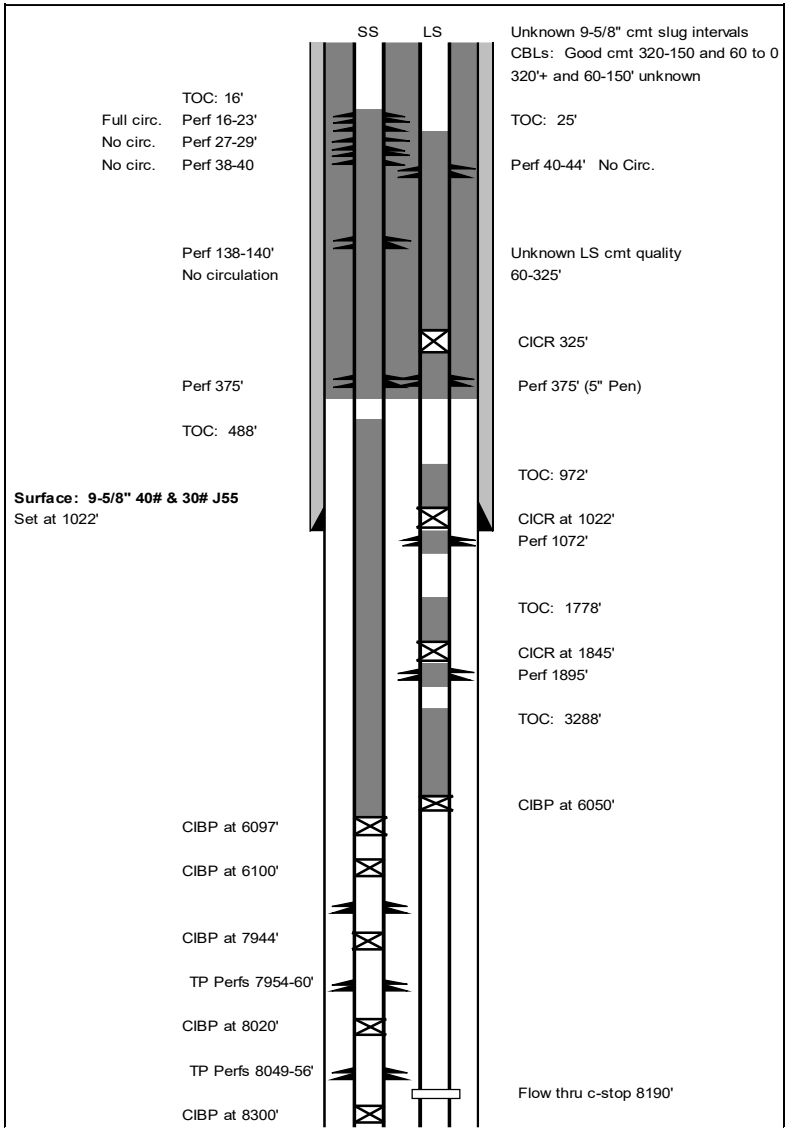
Preparation

- All strings were strapped to confirm cement top
  - Surface: 2’
  - Short String: 16’
  - Long String: 25’
- Due to sustained casing pressures on each string, a DPAS treatment was planned for each
- Connect BSI DPAS manifold to desired injection string

Results (first to last day of squeeze)

- Surface Casing:
  - 0.049 gpm to 0.004 gpm
  - 6 bubbles/min to 2 bubbles/min
- Short String:
  - 0.004 gpm to 0.003 gpm
  - TMTC bubbles/min to 1.3 bubbles/min
- Long String:
  - 0.006 gpm to 0.002 gpm
  - 4 bubbles/min to 2.3 bubbles/min

Most DPAS jobs require more time for residual gas to fully purge



Well C – Casing Leak

Pennsylvania, USA

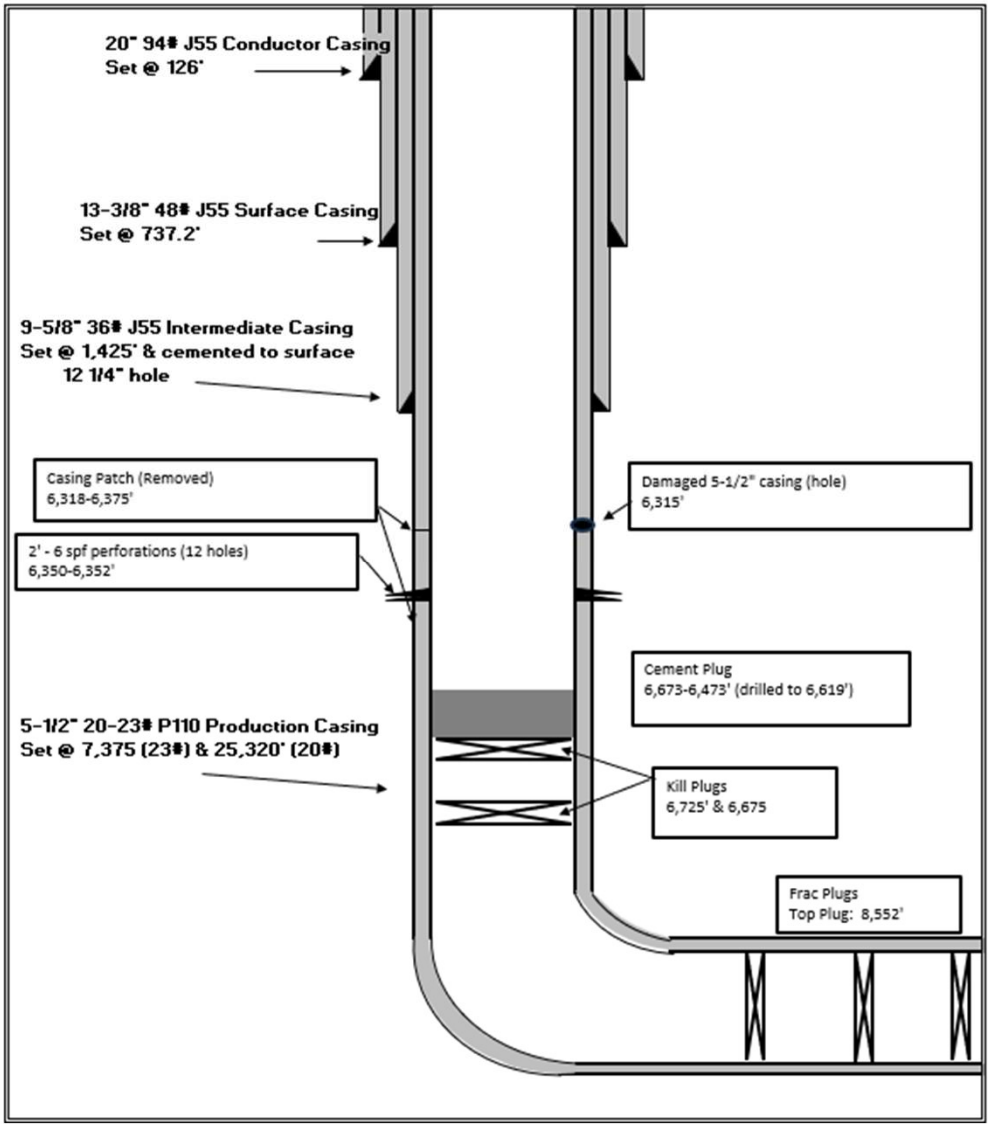
Background

- Drilled in late 2023
- Due to low cement top, well was perforated and circulated cement to surface in prep for frac ops
- Installed patch over perfs for pressure integrity
- Final frac stage communicated to the perfs and compromised the patch.
- Milled and pulled patch
- Sqz cement and resin into perfs (MITs failed)
- Bring in BioSqueeze to lockup the perfs
- While rigging in, found an additional leakage point in the 5-1/2” casing

Analysis

- Perforations
  - 29 psi loss (2.9%) in 15 mins at 988 psi

- Casing Leak
  - 79 psi loss (7.9%) in 5 minutes at 1000 psi



Well C – Casing Leak

Pennsylvania, USA

Preparation

24 Hour Ops

SQZ 1: Leaking Perfs (6,350-6,352')

- Set CBP at 6,355'
- 2-7/8" tubing to 6,352'
- Set 5-1/2" Packer at 6,348'

SQZ 2: Compromised Casing (6,315')

- Set CBP at 6,320'
- 2-7/8" tubing to 6,315'
- Set 5-1/2" Packer at 6,306'

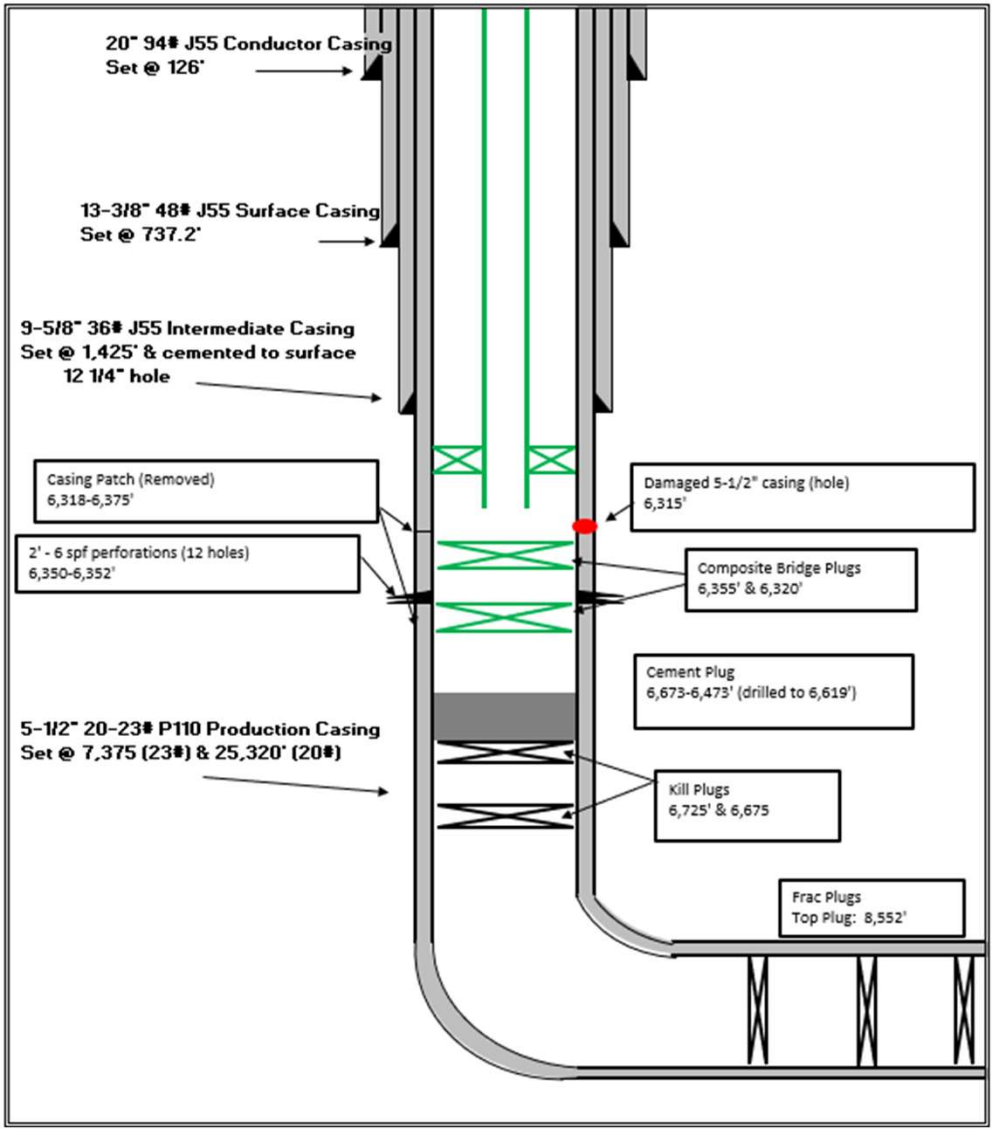
Results

SQZ 1:

- 2 psi loss (0.12%) in 15 mins at 1608 psi
- 0.002 gpm to 0.001 gpm (1.67 gal injected)

SQZ 2:

- 13 psi loss (0.81%) in 15 mins at 1600 psi
- 0.063 gpm to 0.018 gpm (46.5 gal injected)



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SEALED WELL

Conclusion

Innovative new approach improving efficiency and effectiveness of remediations

Producing significant savings in time and money compared to other remediation options

Technology has now been used to seal over 150 wells

New applications showing promise/potential