



**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



*“Novel Proppant Consolidation System Moves  
From Deepwater to Onshore For Stimulation and Sand Control”*

*Daryl Johnson, Todd Roper, Thu Lieng*

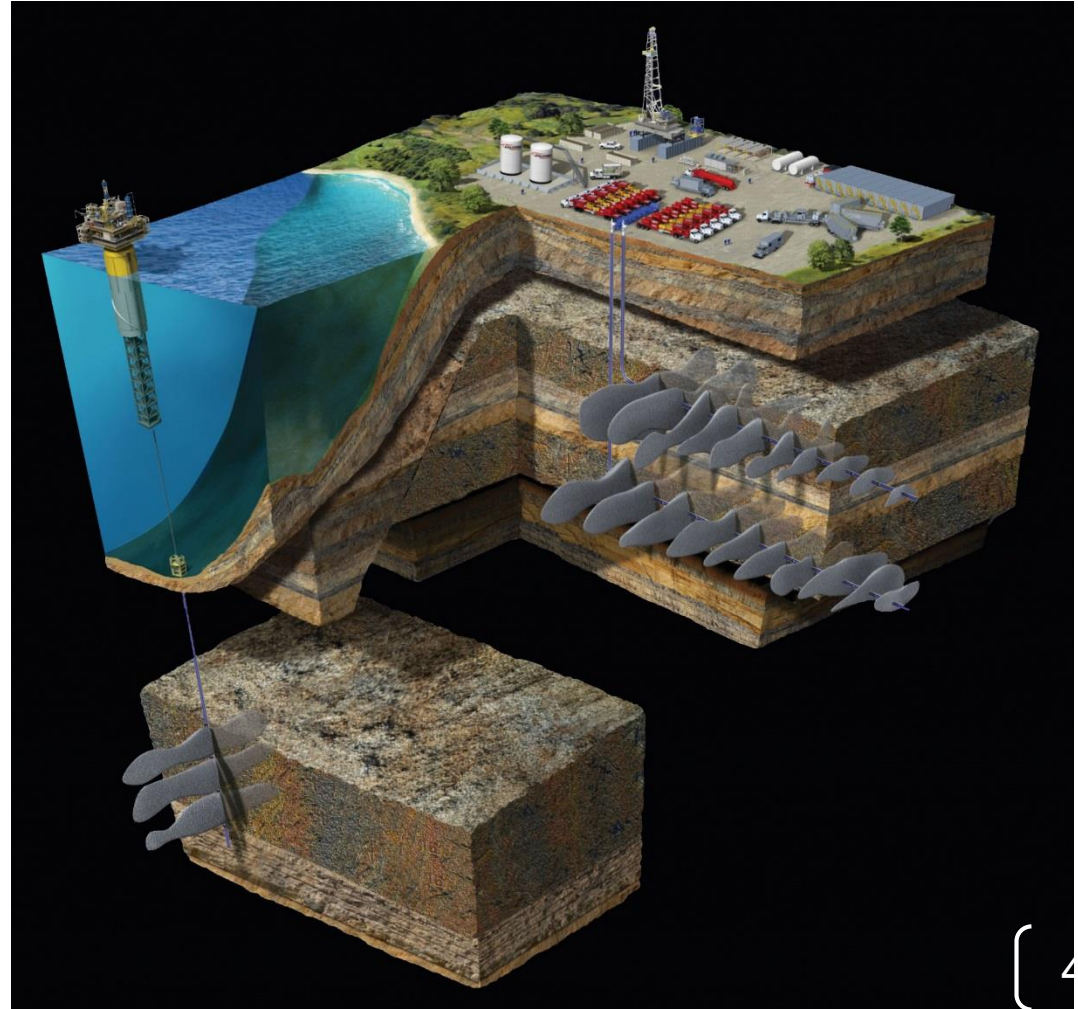
**CARBO** CERAMICS &  
TECHNOLOGIES



Society of Petroleum Engineers

# The Challenge: Stimulation of CHFP Injection & Production Wells Requiring Sand Control; Then Bring It Onshore

- 1) *Provide a robust, high permeability, proppant stimulation system that can sustain ultra-high water injection or production rates of 20K-70K bpd, withstand frequent cycling and provide secondary sand control in the annulus*
- 2) *Provide a cost effective stimulation with sand control option for land based injection & producing wells*
- 3) *System must be compatible with new production chemical technologies*

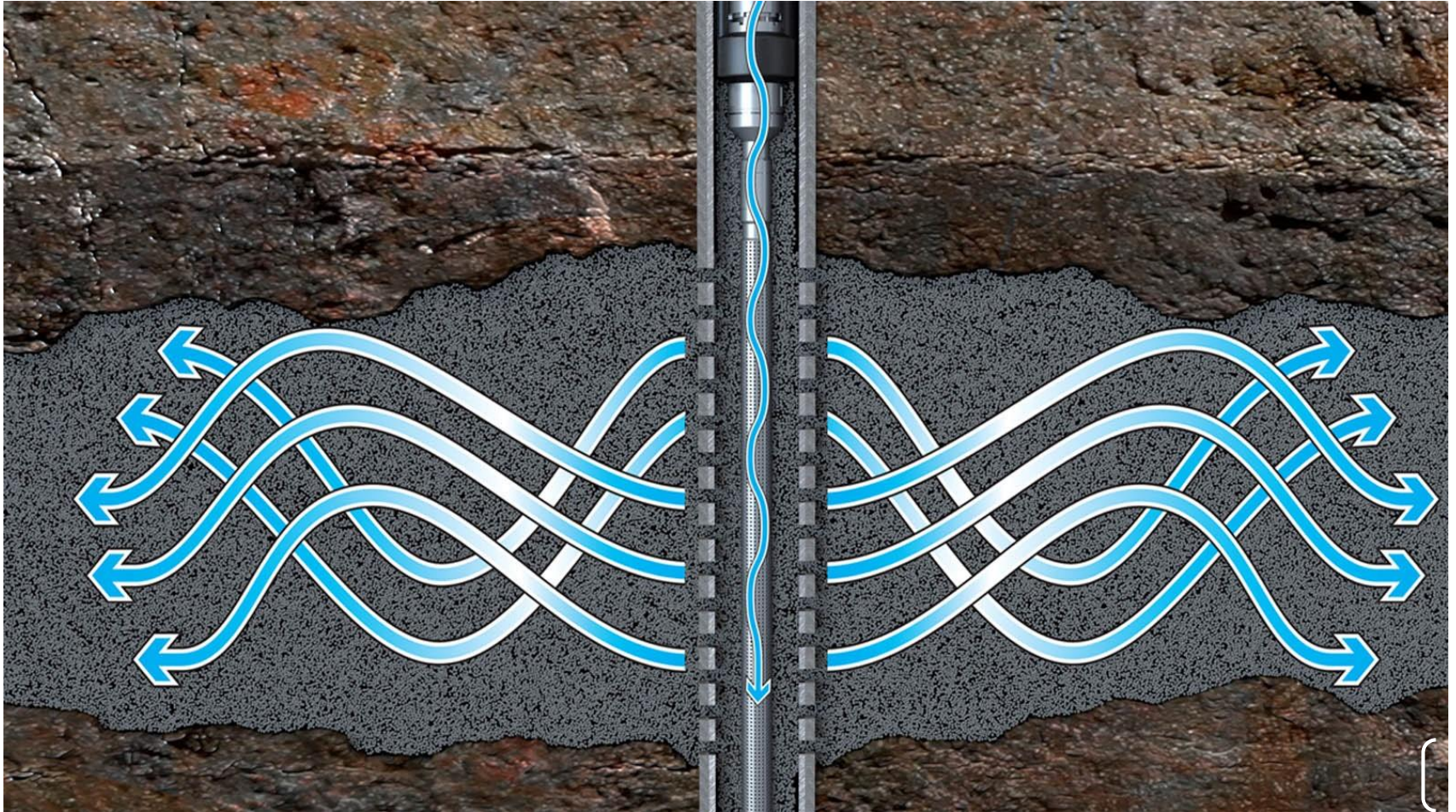


# Quick Resin Coated Proppant Refresher

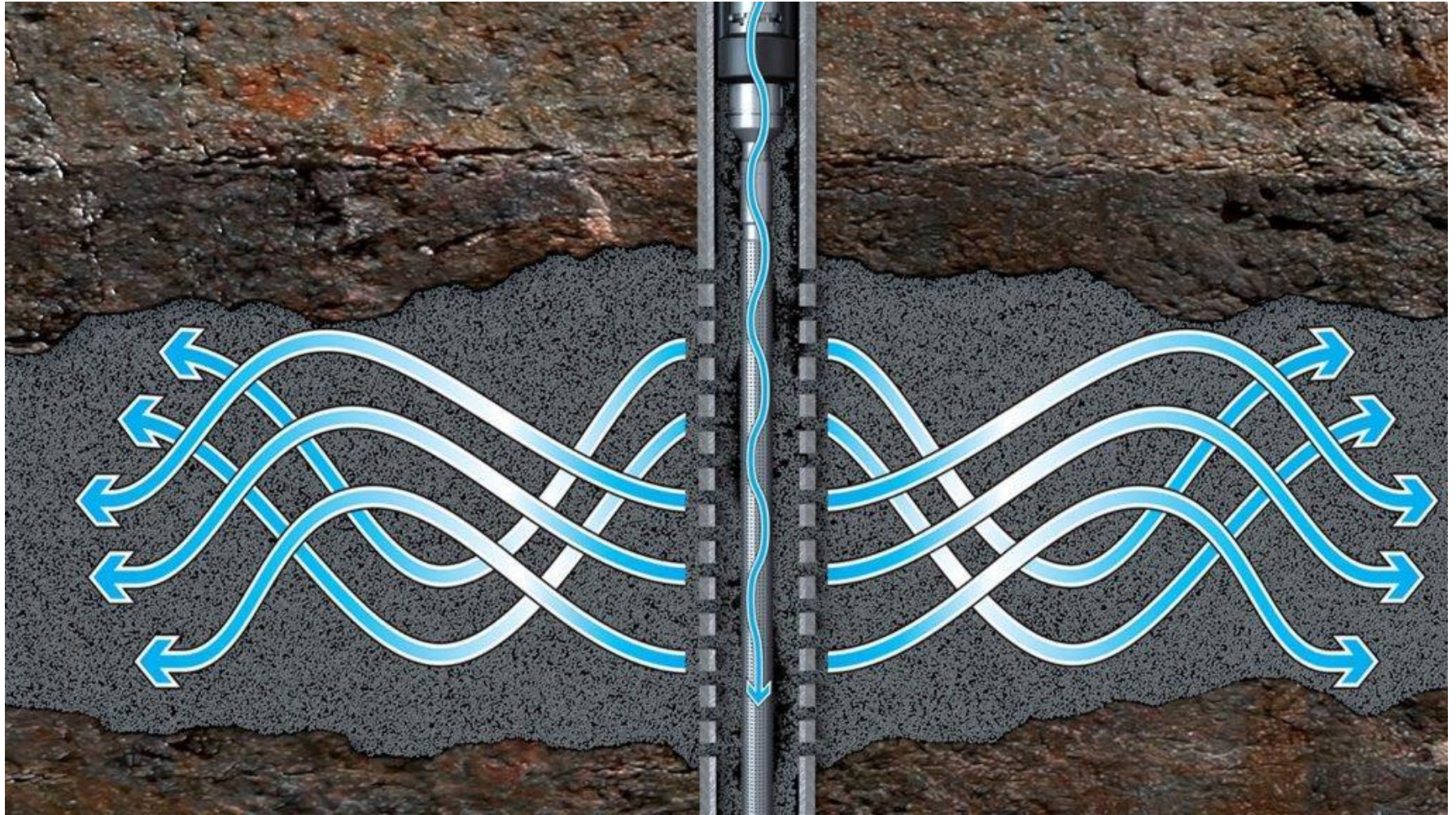
- Two main “types” of RCP, Curable and Pre-Cured
  - >90% of RCP used in oilfield is Curable: Able to Bond with Temp & Closure Stress, but WILL NOT BOND IN THE WELLBORE *or ANNULUS*
    - Prevents proppant flowback & prop pack rearrangement
    - Flexible bonds enhance cyclic tolerance during production cycles
    - Bonded pack minimizes embedment in low YM (soft) formations
    - Coating encapsulates/protects the substrate proppant grain
  - Pre-cured resin coating used mostly for strengthening silica sand or minimizing abrasion by proppant of downhole and surface production equipment
    - No particle-to-particle bonding capability



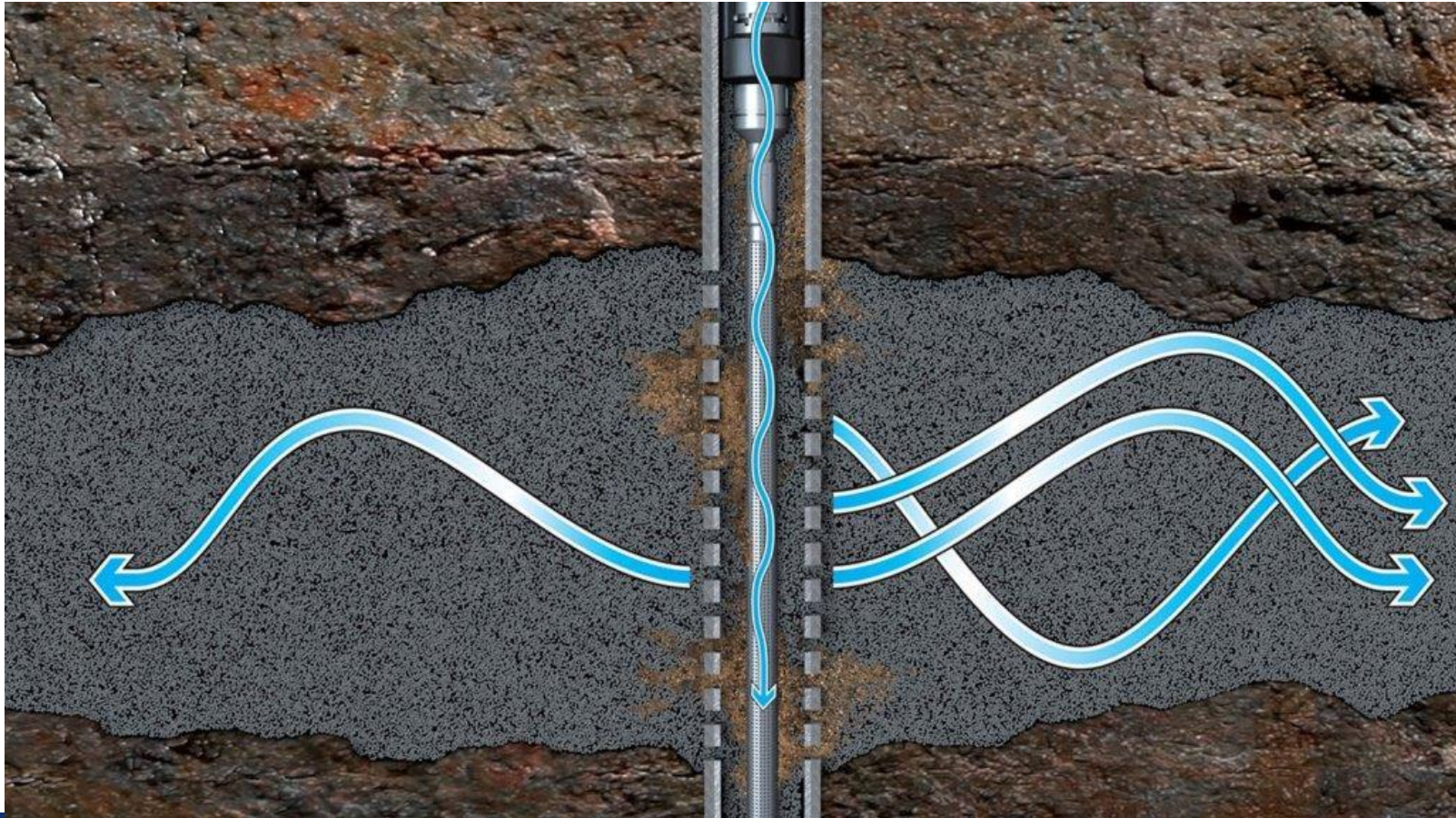
# CHFP Injector – Initial Injection



# CHFP Injector – Voids in Annular Pack Starting

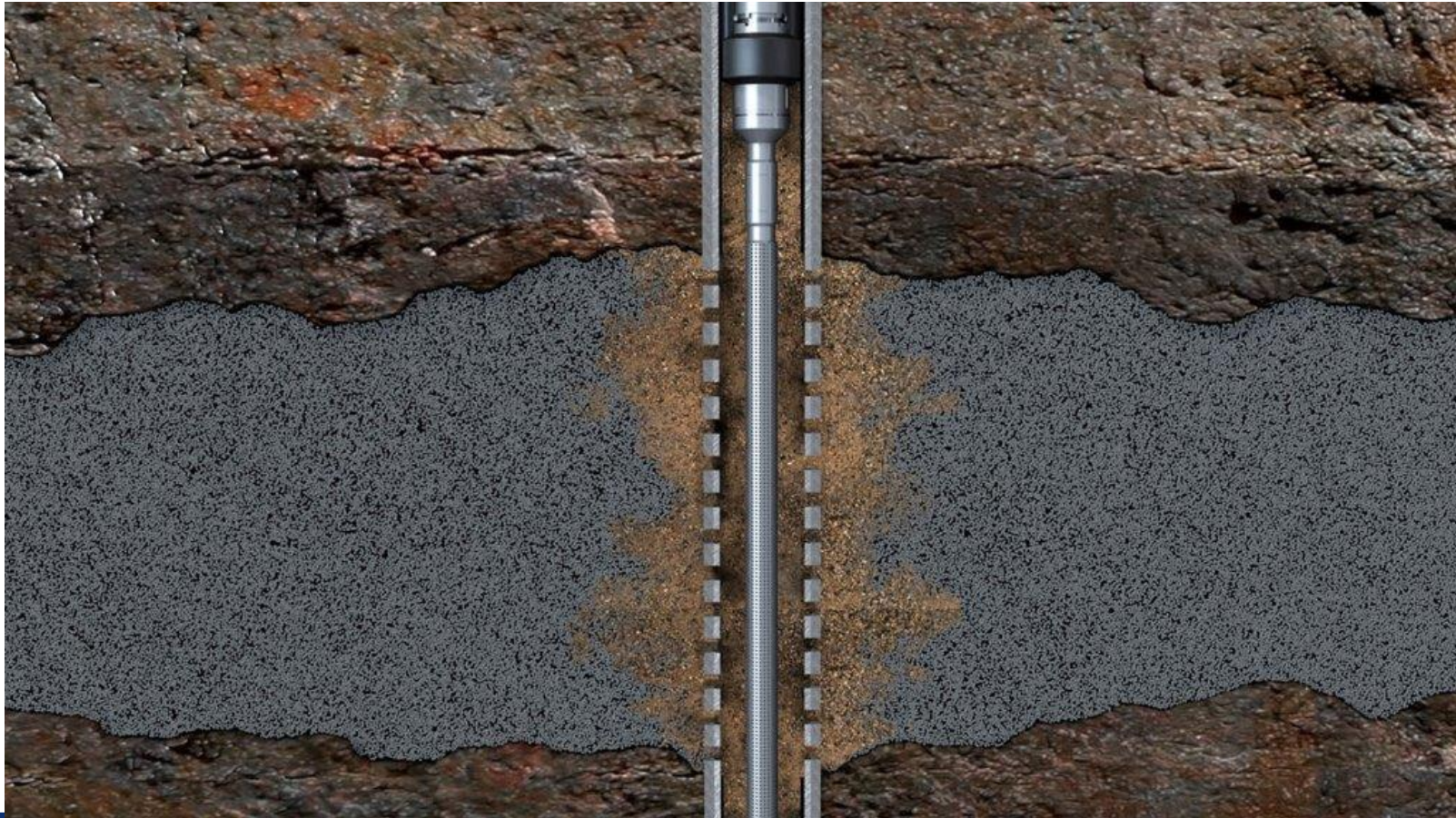


# CHFP Injector – Injection Reduced, Fines Invade Pack

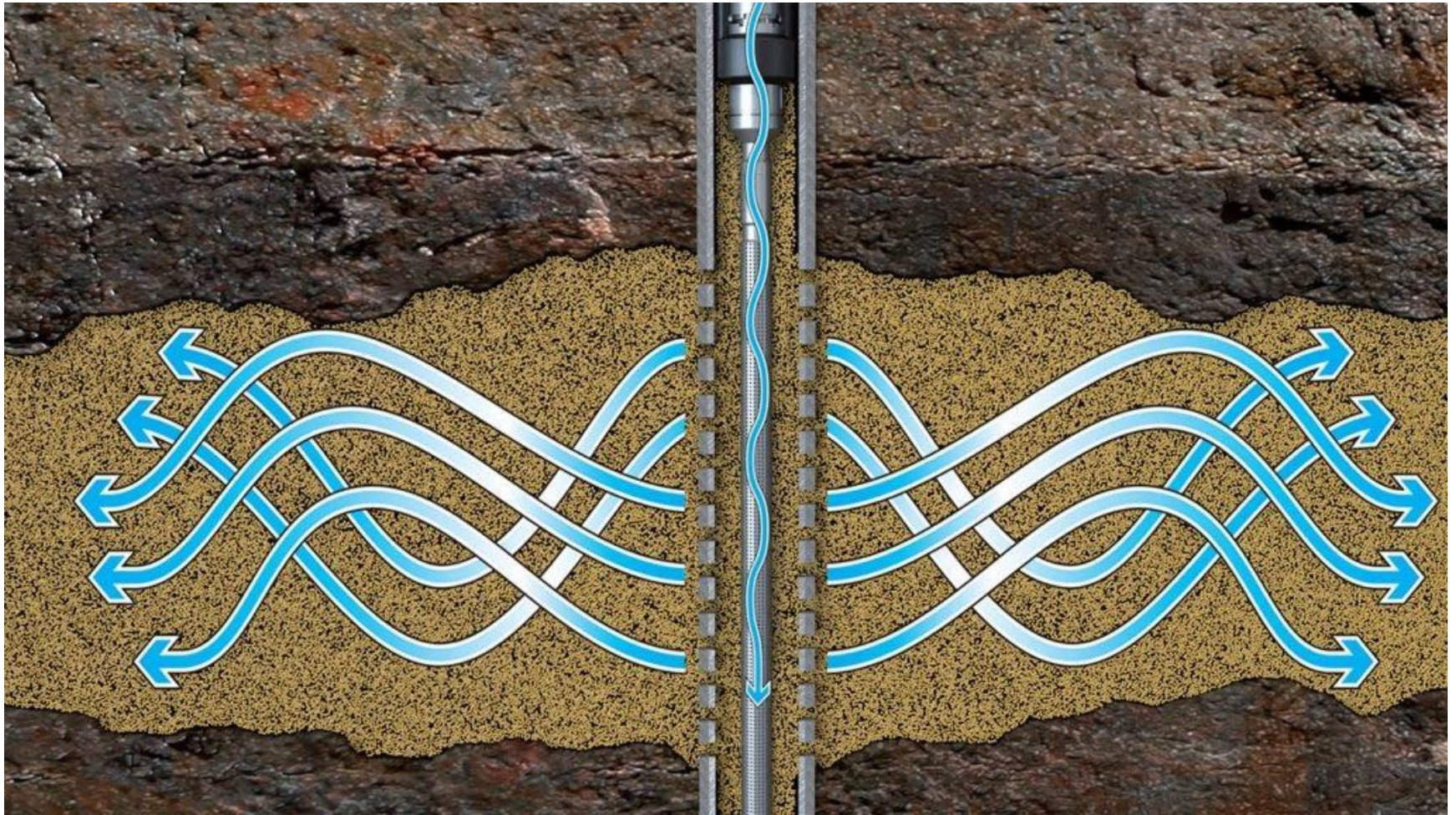




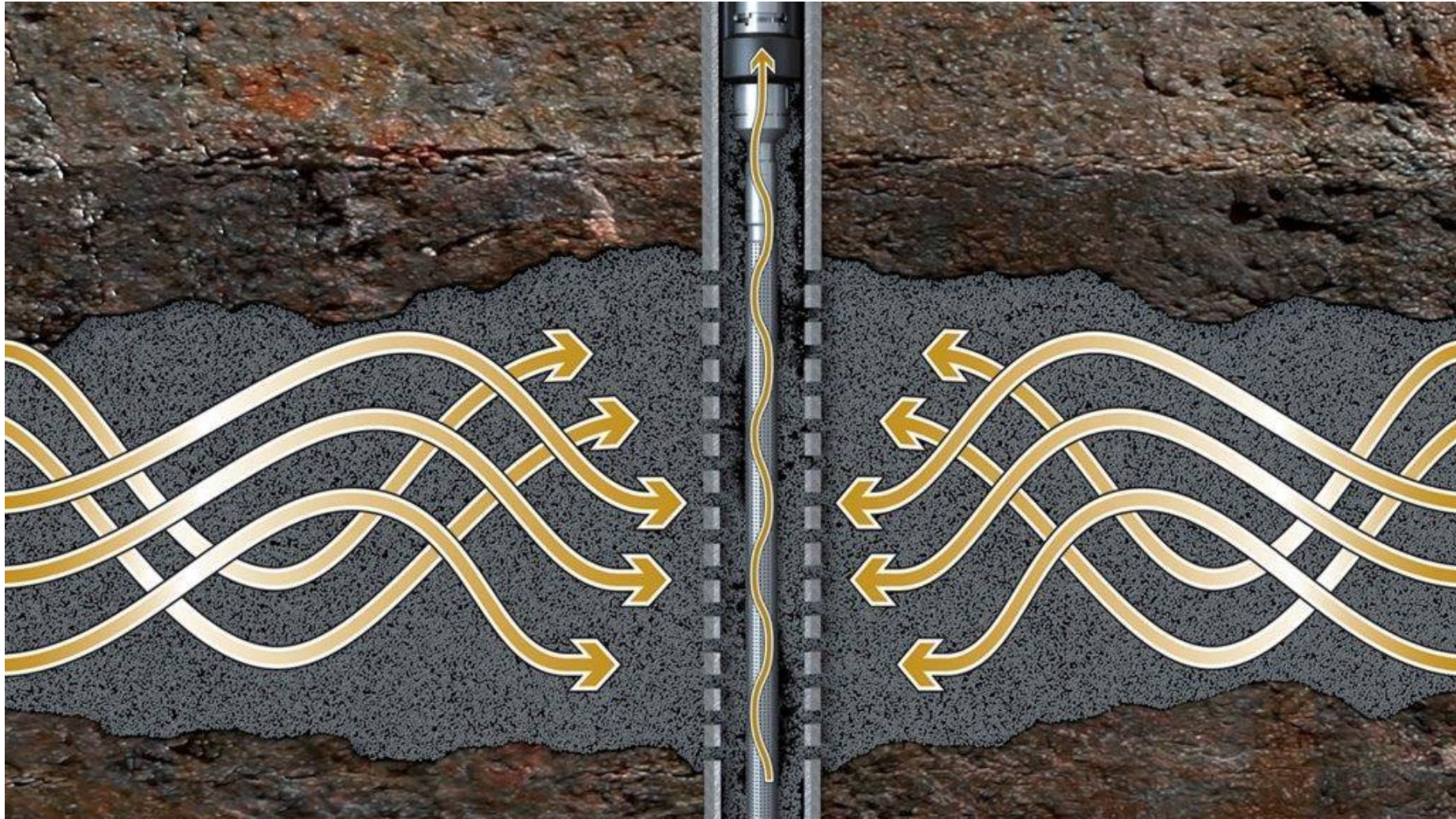
# CHFP Injector – Injection Reduced To .....Zip



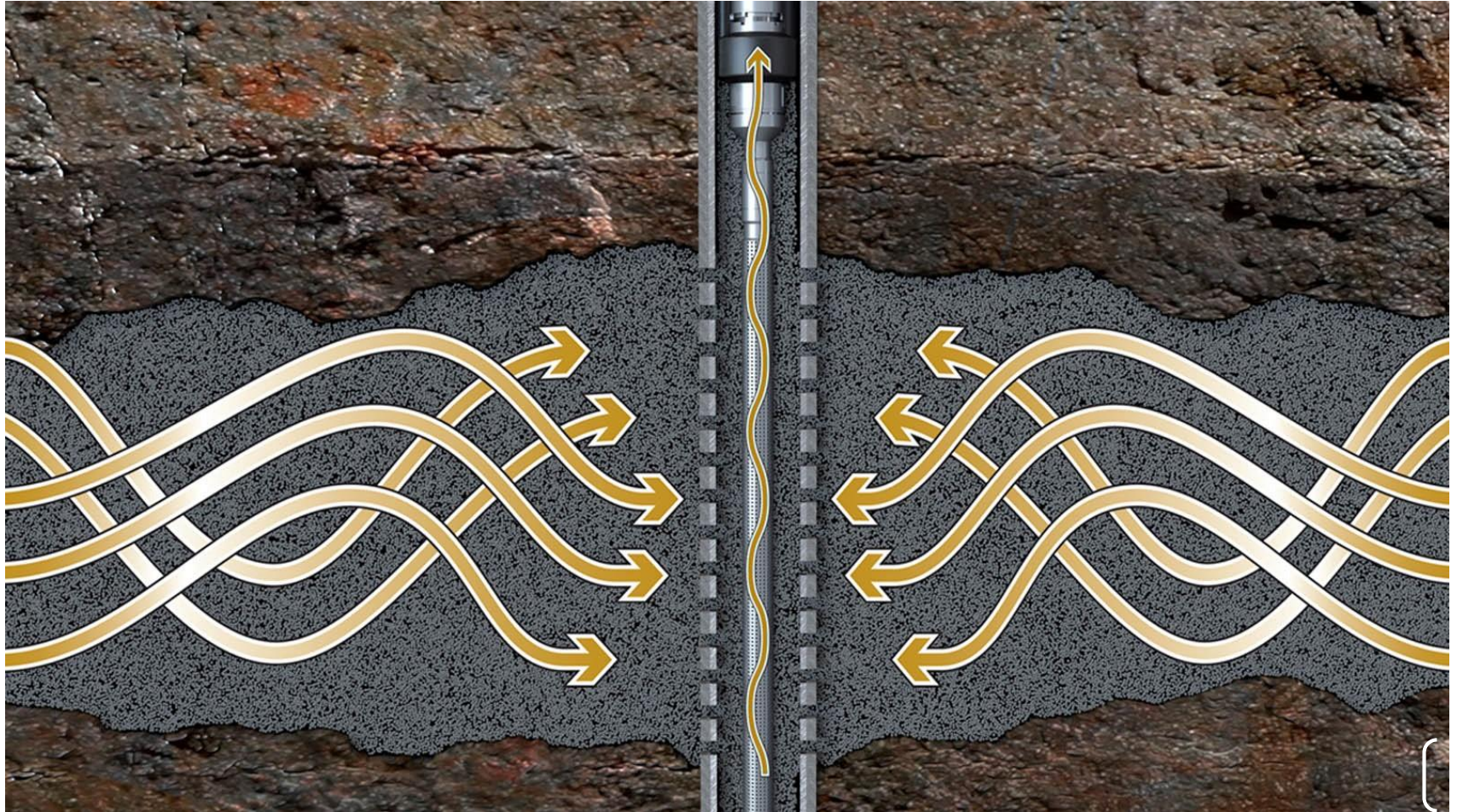
# CHFP Injector Goal – Bonded Packs Locked In Place



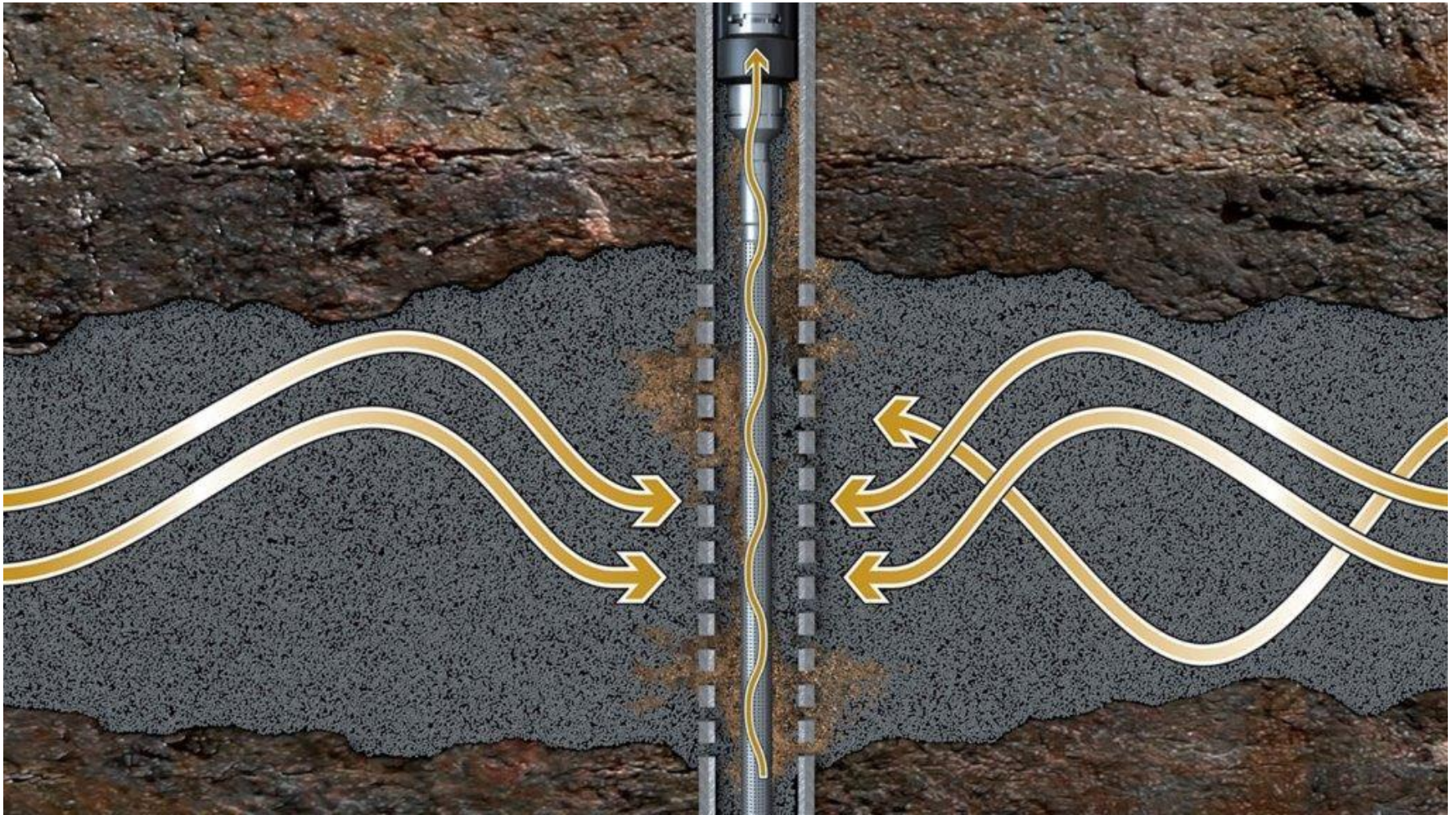
# CHFP Producer – Voids Started



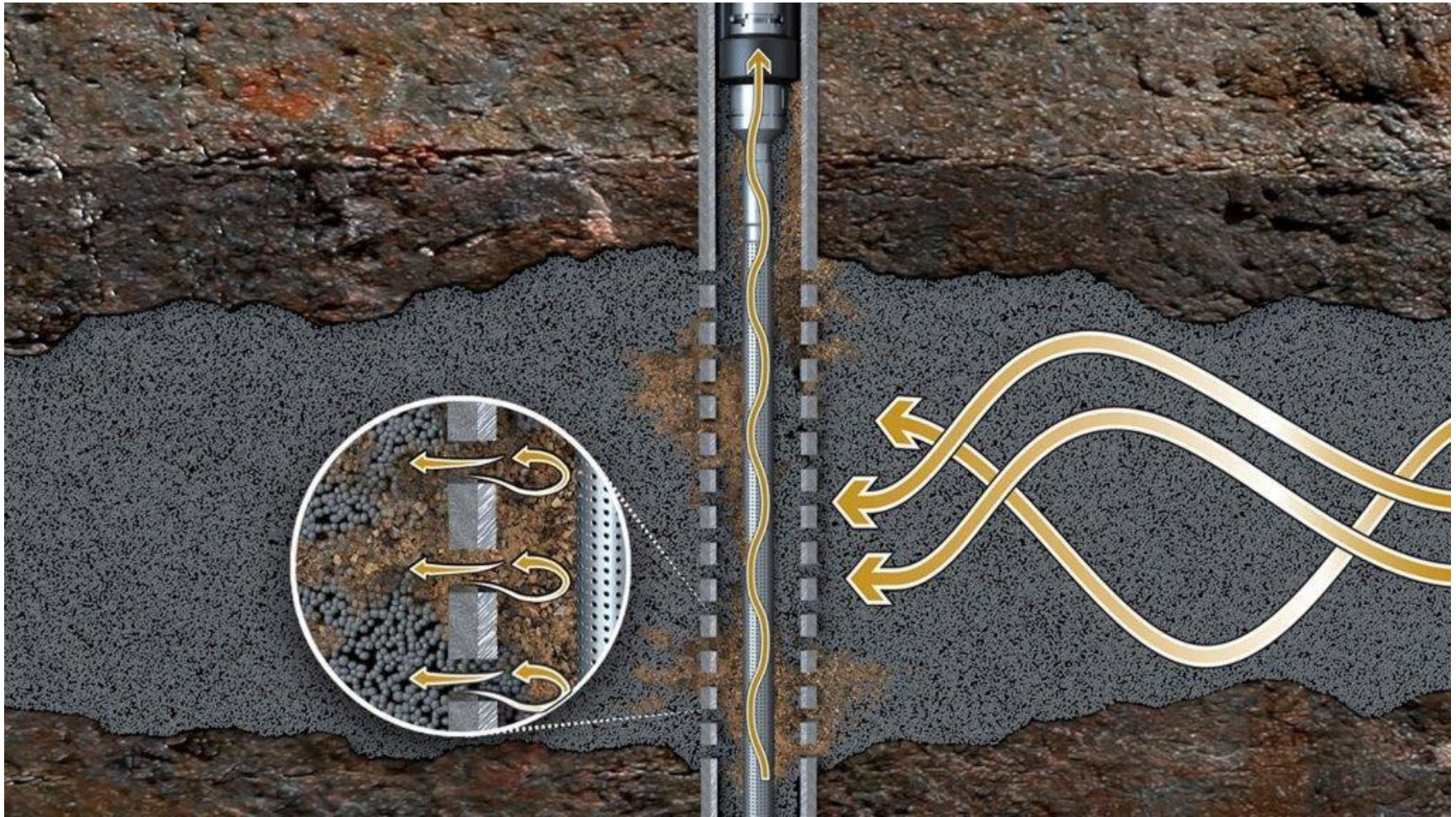
# CHFP Producer – Initial Completion & Production



# CHFP Producer – Fines Invasion of Voids



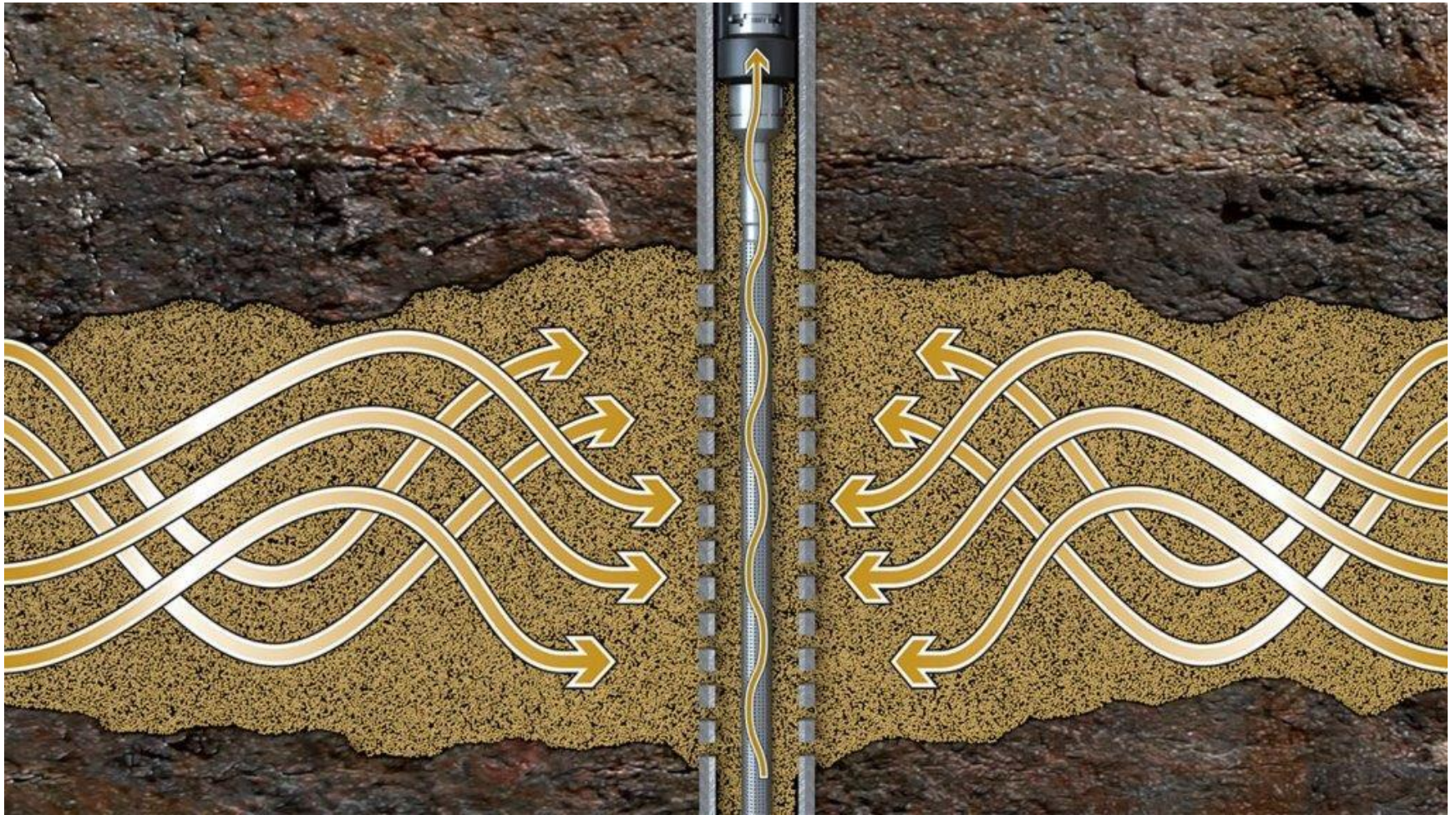
# CHFP Producer – Annular Vortex Creates Larger Voids



# CHFP Producer – Production Dramatically Reduced



# CHFP Producer Goal – Prop Packs Locked in Place





# Performance Requirements

- Frac and pack in continuous operation with a single proppant slurry
  - Activator run as a standard liquid additive
  - Compatible with frac fluid systems
- Bonds the annular pack in low or non-compressive environments and low temperatures
  - Locks in a high permeability pack and prevents washouts during pressure surges
  - Maintains connection between annular pack and propped fracture
- Sufficient working time to allow shifting tools
- Inert tracer for evaluation of pack integrity, near wellbore connectivity & propped pack height
  - For the life of the well
- Compatible with production chemical infused proppants
  - Can be used with up to 20% infused production chemical proppants without compromising UCS of the pack
- Bonded pack can be removed if necessary



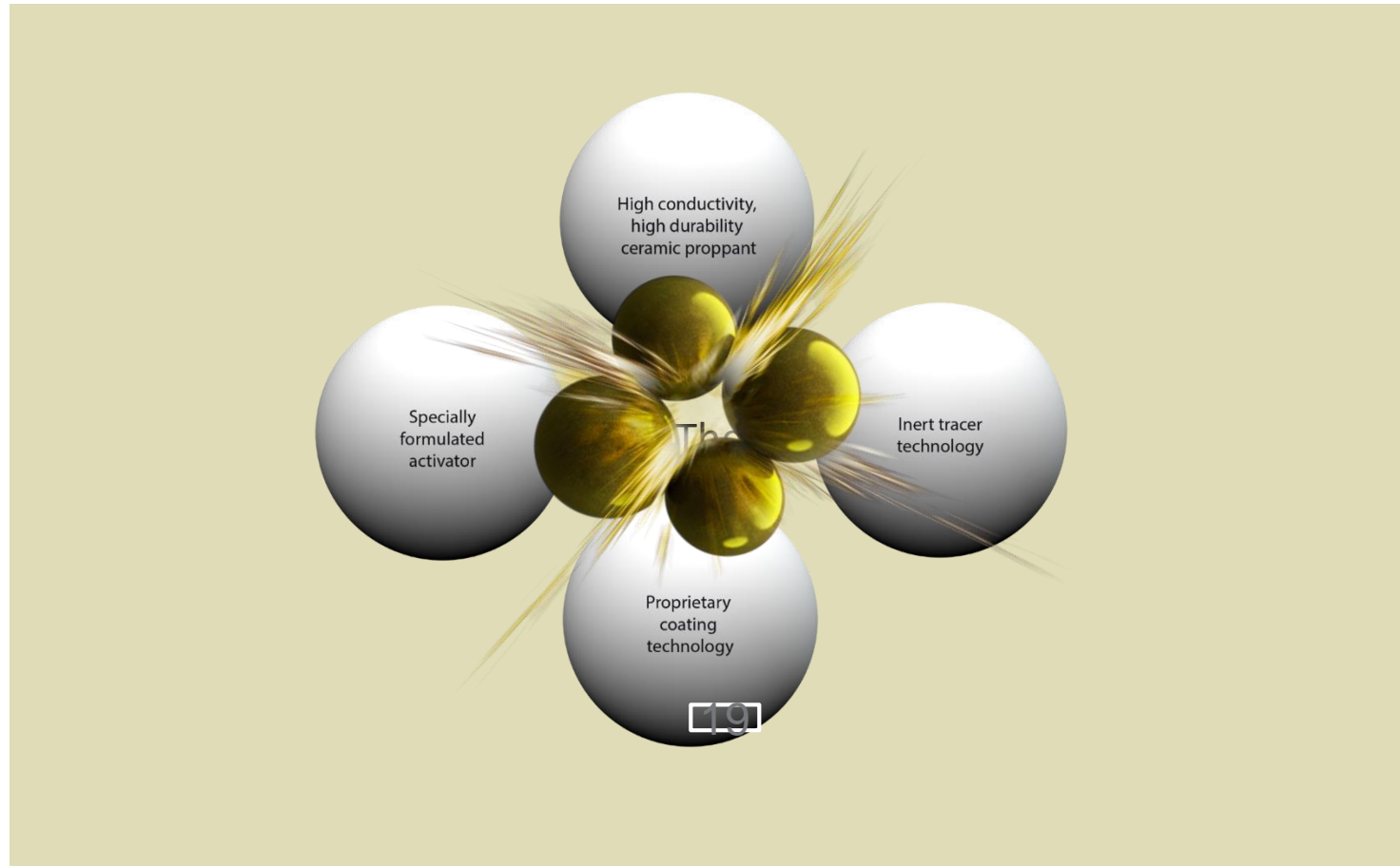
## The Result: *“If at first you don’t succeed, ………”*

- Our first RCP system submitted FAILED
- The **30th** product tested worked!
  - Passed all 12 Operator protocols
- A unique solution for prop pack stimulation and annular consolidation for injectors and producers
- Creates a highly conductive and permanent proppant pack in non-compressive environments
- Maintains frac and annular pack connection
- Prevents propped pack rearrangement
- Minimizes proppant embedment
- Allows proppant pack quality verification of both the propped frac height & annulus for the life of the well
- Encapsulates the substrate to help prevent chemical attack
- Can be removed from wellbore to pull tools at a later date



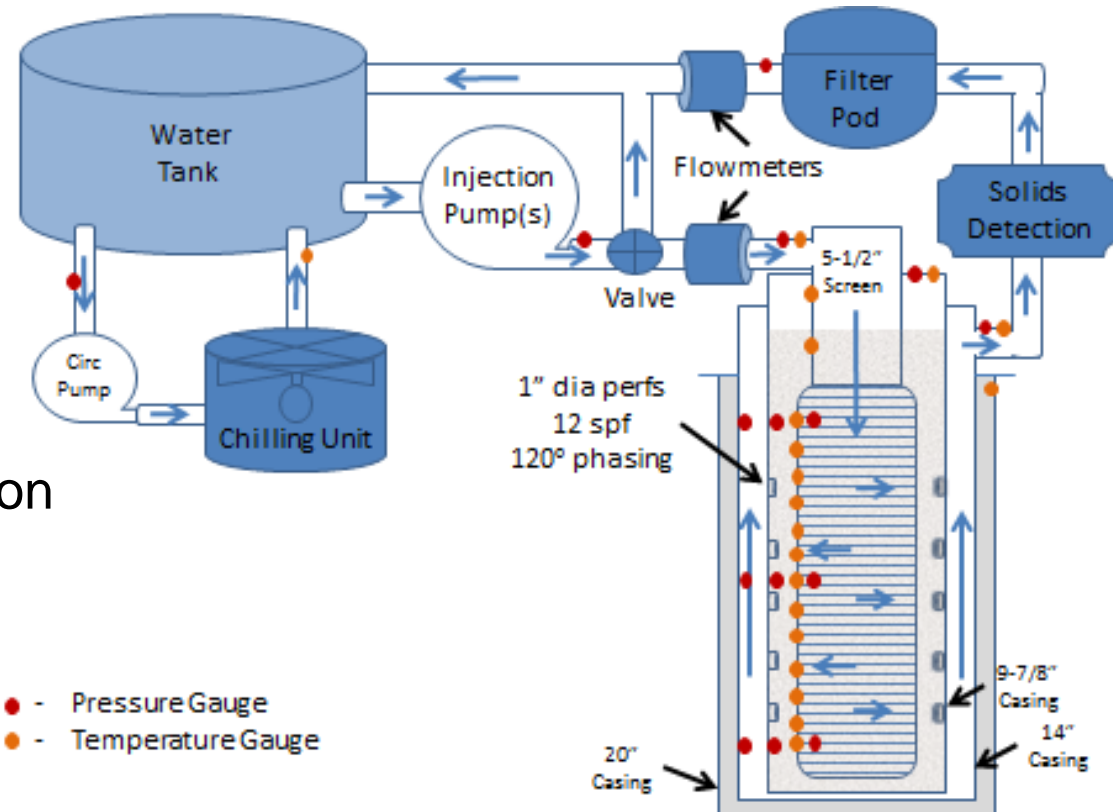
Proppant pack formed  
with zero closure stress  
@ 200F

# The Solution: Integrate Four Advanced Technologies



## Test #8 – Full Scale Water Injection

- Actual GP equipment
- Screen out annular pack
- Temp. control for well
- 30,000 bwpd
- > 3 weeks
- > 500,000 bbls cum. injection



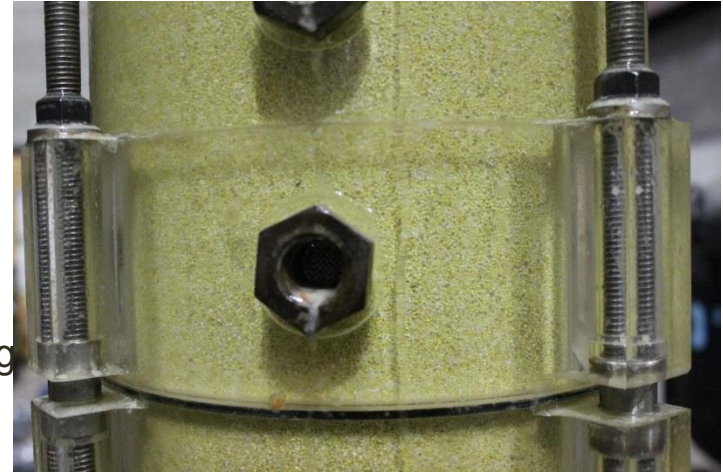
SPE-180328-MS • The Development and Qualification of a Novel Proppant System • Kevin Whaley

# Injection Well Test Facility



Fully Packed  
CHGP Assembly:  
Plexiglass Casing

Close-up of  
Packed Casing  
& Perfs

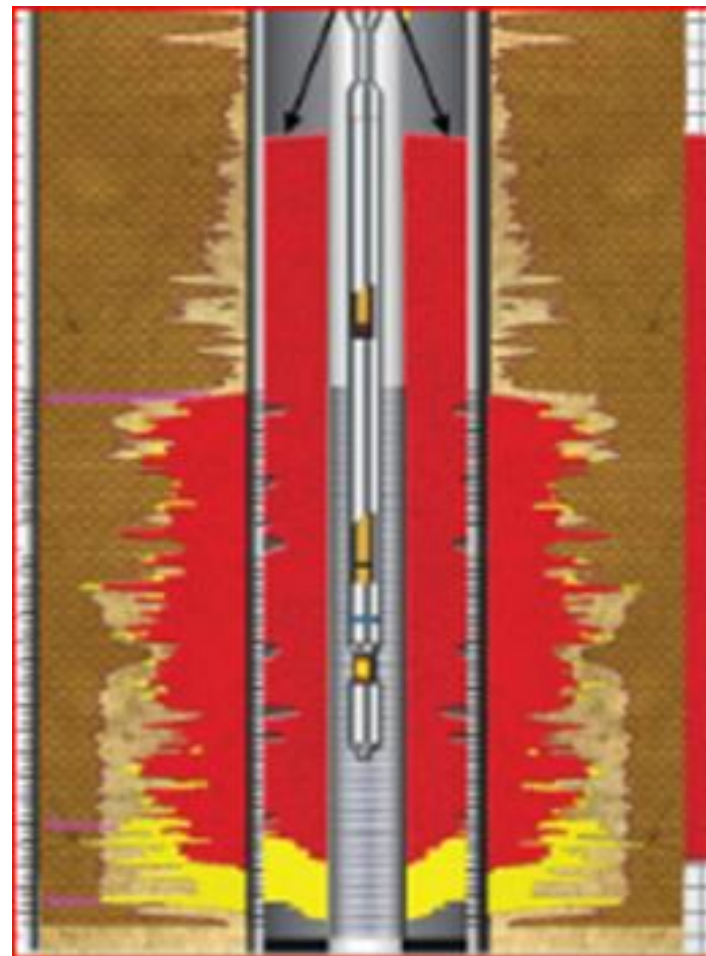


Close-up of Set  
Proppant Pack with  
Plexiglass  
“Casing” removed



# Inert Tracer for External & Internal Pack Evaluation

- Non-Radioactive Inert Tracer incorporated into proppant grains during manufacturing
- Formation Evaluation Neutron Porosity logging tools used to evaluate near & far field
- Allows the evaluation of pack integrity, near wellbore connectivity and propped pack height throughout the life of the well



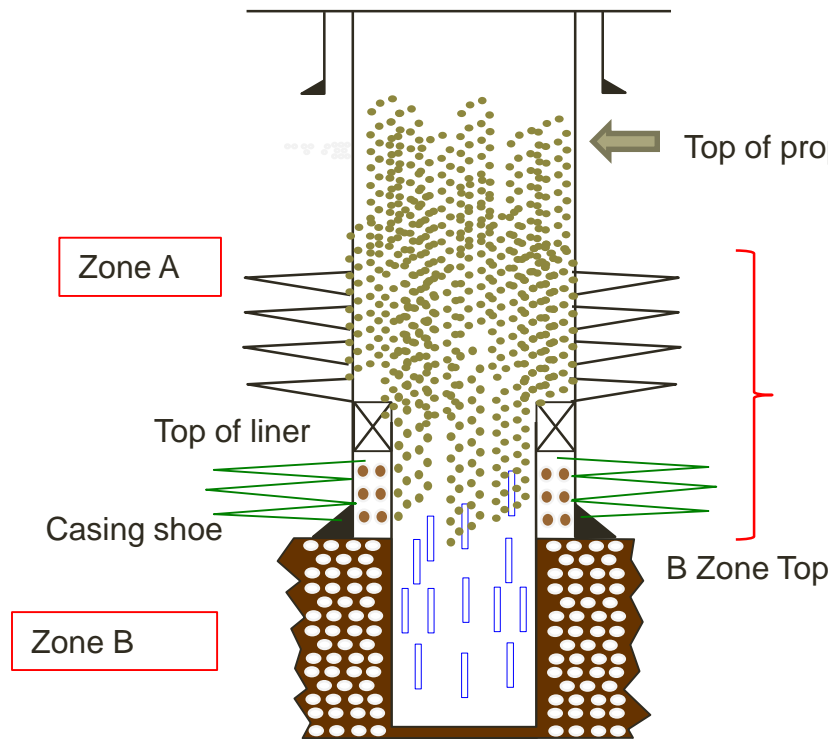
# CHFP Injector Results

- 3 Test facility wells, 2 operational field trial wells, one land implementation injector & 2 successful commercial deepwater injectors
  - Test facility & land based injector had injection rates of up to 30K bwpd
  - Land injector injectivity vs delta P increased over time
    - Final injectivity index was 68 bwpd/psi with resin coated 16/30 ceramic proppant
    - Injection test lasted 5 months; 1.5 million bbl of water injected
    - Land injector logged over 10x without any annular pack or propped frac changes
- Deepwater GOM injection well rates up to 50K bwpd
  - One well on for over a year at 20kbpd
  - Second well on line for 9 months at 50k bwpd
  - Both have resin coated 16/20 lightweight resin-coated proppant
- All wells have injection rates greater than frac pressure

23



# Producer Recompletion Proposal for Stimulation & Sand Control in a Steam Flood

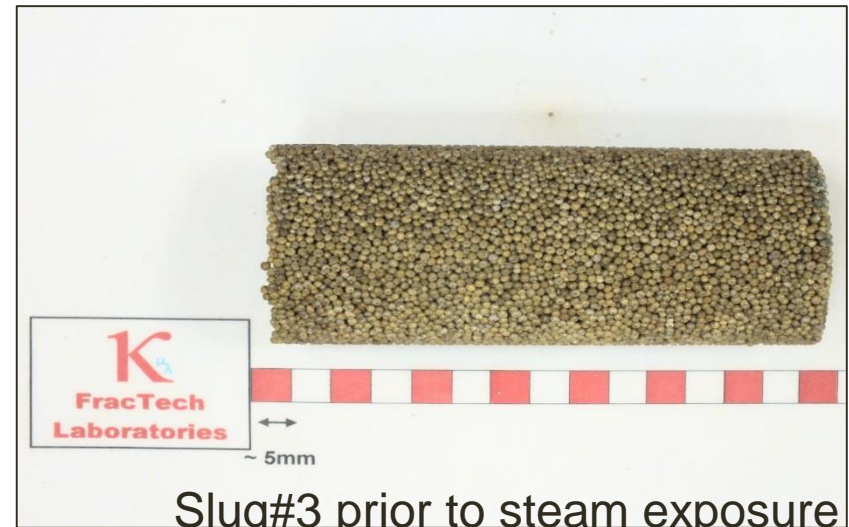


1. Clean the out the slotted liner
2. Perforate A sands
3. Frac pack stim & sand control in new perforations with resin coated proppant; leave 80 ft above top perf in casing
4. HT Scale Inhibitor needed but not available



# Steam Exposure

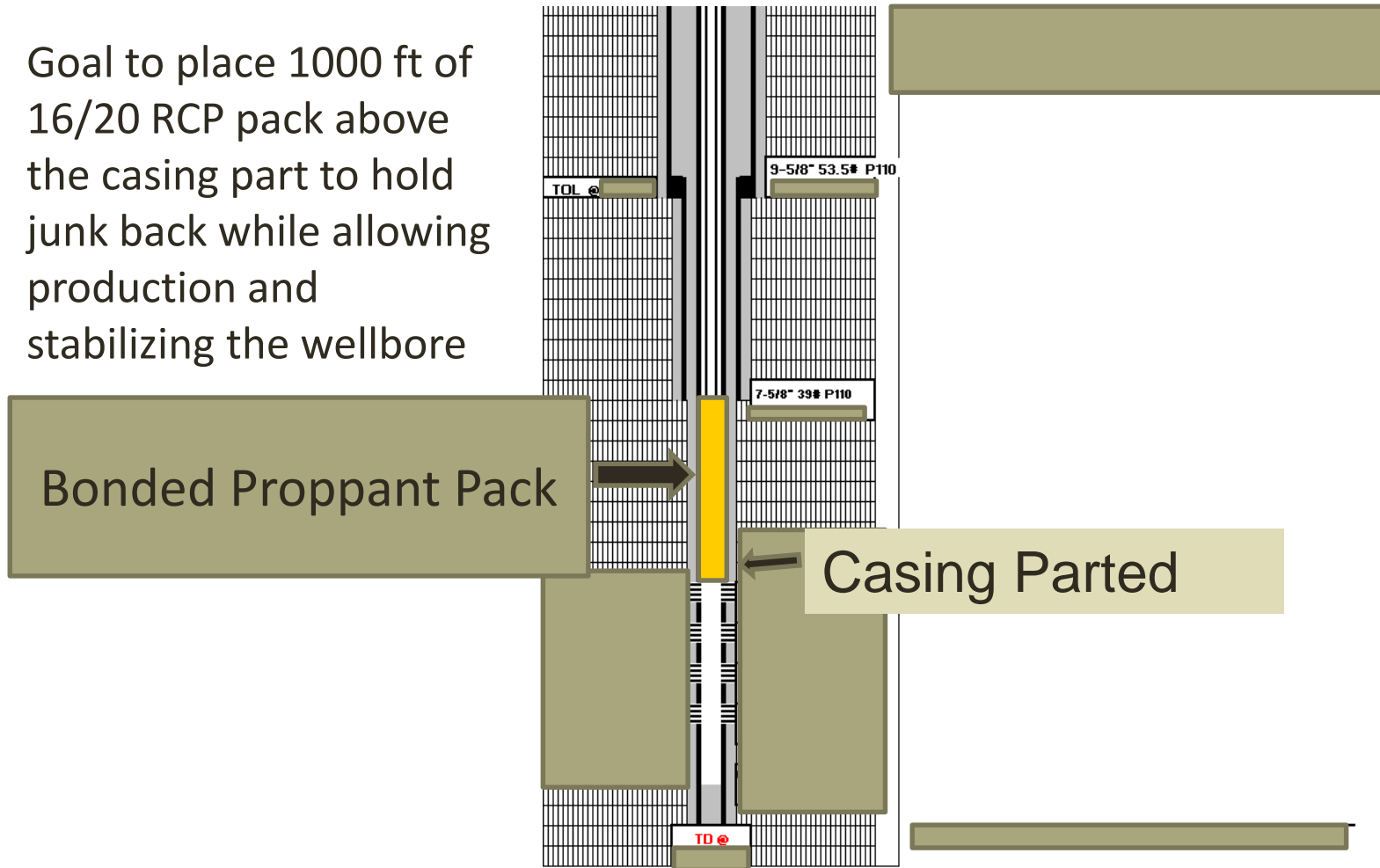
Temp, °F	Mean UCS, psi
Ambient	391 (std dev 47 psi)
540°	190 (std dev 4psi)
600°	191 (std dev 19psi)



*“Consistently, approximately 50% strength loss was seen. This was fairly independent of temperature or time. It is suggested that this strength loss may be caused by transient thermal stresses during the heating/cooling cycles rather than extended time at a particular temperature”. FracTech Report #001050512*

# STX Remedial Casing Part /Sand Control

Goal to place 1000 ft of 16/20 RCP pack above the casing part to hold junk back while allowing production and stabilizing the wellbore



# Summary

- Novel resin coated, ceramic proppant pack system is robust, cost effective & commercially viable for deepwater injectors and producers
- Non-Radioactive Inert Tracer in proppant grains allows evaluation of the propped frac height, pack connection through the perfs & qualitative analysis of the annular packor
  - Memory Neutron logging solution a must to reduce costs
- Low cost stimulation and sand control options for land based injectors and producers ready for field trials
- New porous ceramic proppant infused with production chemicals adds another dimension to enhance and maintain production
  - System performance in steam floods needs HT scale inhibitor
- *Applications are only limited by our imagination!*



# *Thanks for your time and interest!*

## **Special Thanks:**

CARBO R&D

BP GOM

Shell GOM

Halliburton GOM

Hilcorp Onshore

## *Questions?*

### Technical Reference:

SPE 180328-MS September 2016 SPE Deepwater Completions Conference –Galveston, Texas

*“The Development and Qualification of a Novel Proppant System to Enhance Performance of High Rate Soft Sand Water Injection Wells with Cased Hole Sand Control Completions”*

