

WELLSTRØM

With Control, comes Confidence

Fully Controllable Electrically Deployed Bismuth Alloy Barrier

Johan Kverneland, TotalEnergies

Gert Rege, Wellstrøm

The Future of Well Barriers:

Rig-less, electrical, controllable & verifiable permanent well barrier technology

Wellstrøm Technology 2024

Criteria for high-performance alloy barriers

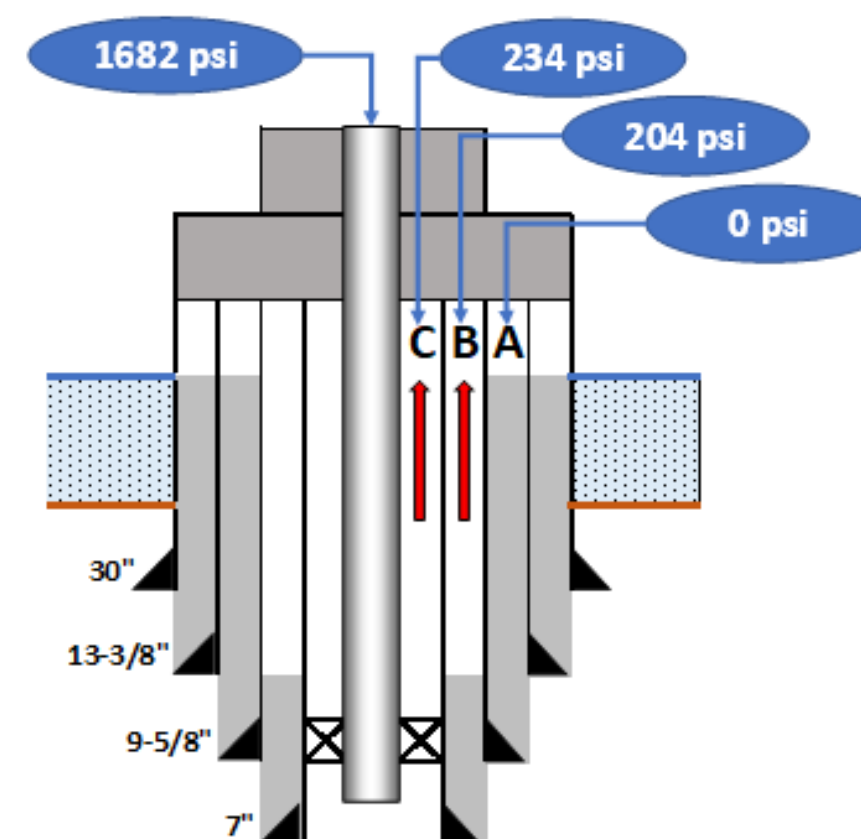
❑ Barrier system able to remediate a fully-cemented 9-5/8" x 13-3/8" casing

- ✓ Seal in drilling mud (OBM and WBM) and wellbore solids.
- ✓ Seal against flowing gas of up to ca. 1,5 litre/min
- ✓ Provide a 3,000 psi (210 bar) differential seal against both fluid and gas under Normal Pressure and Normal Temperature conditions

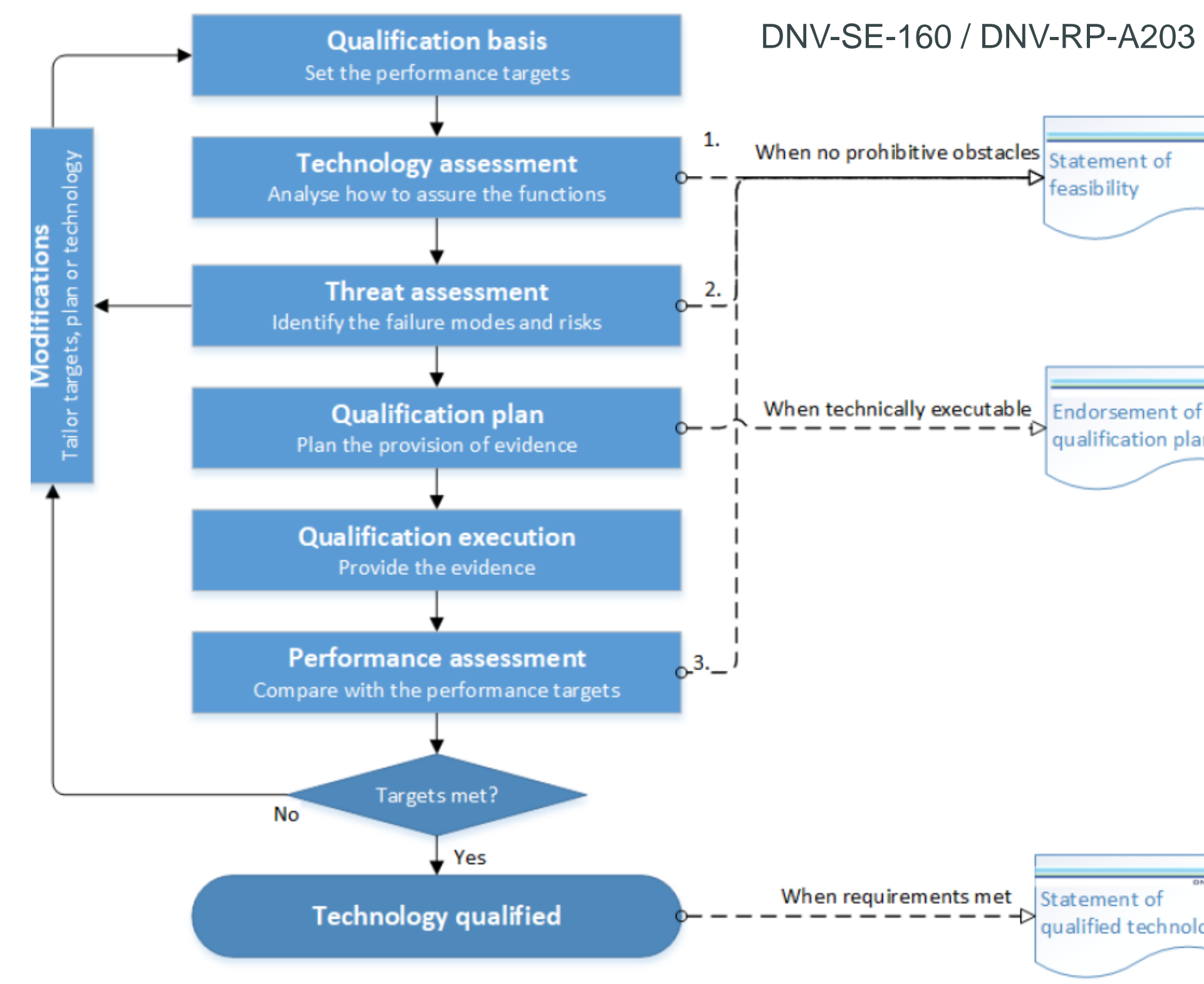
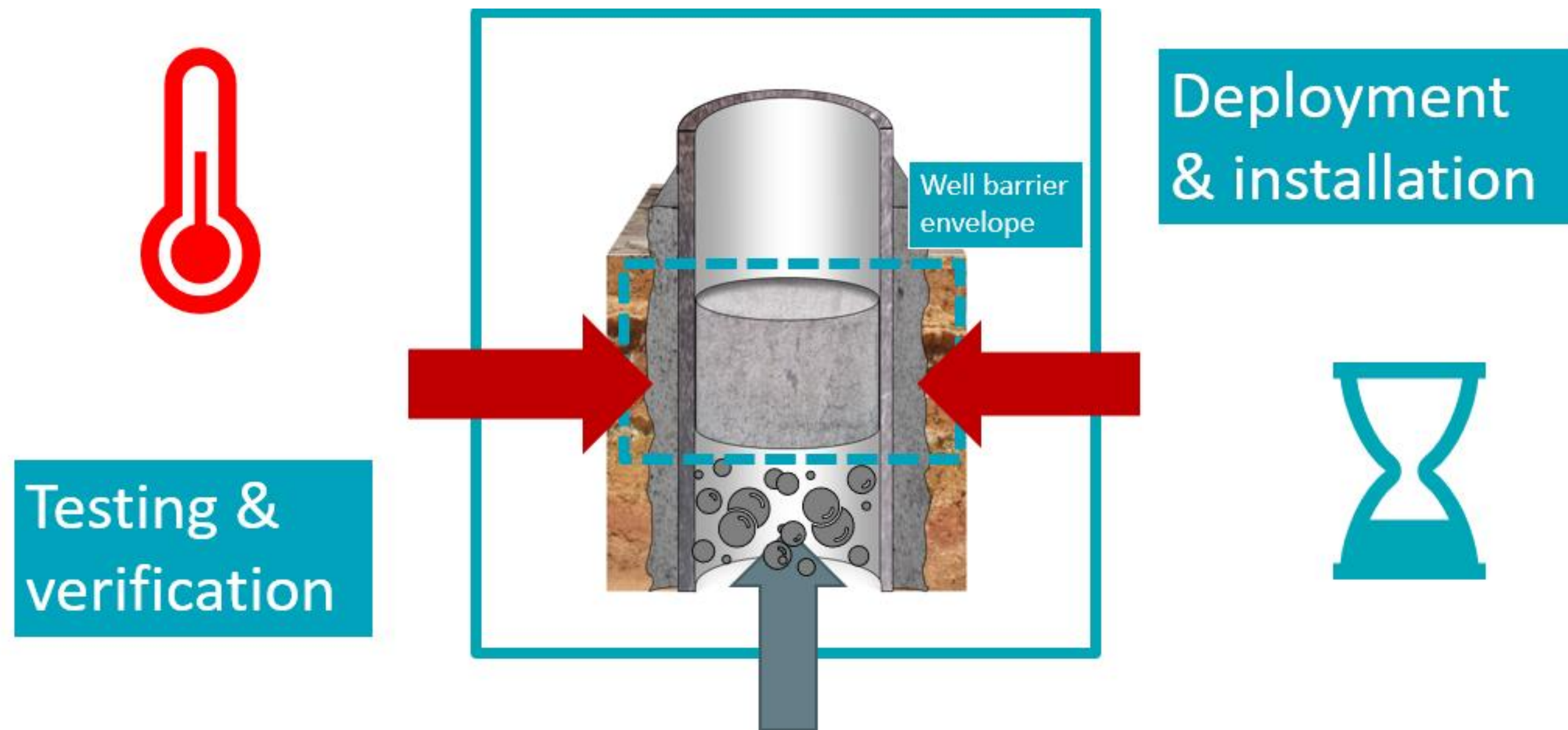
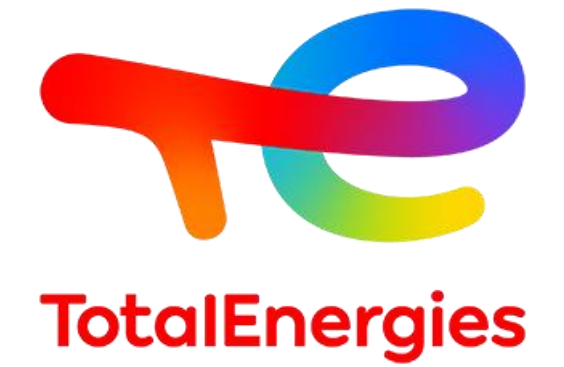
❑ Plug must be:

- ✓ Able to be re-melted and re-set.
- ✓ Set at low temperatures, to prevent damage to casing/cement/caprock
- ✓ Process must be fully controllable, monitorable, repeatable and verifiable
- ✓ Alloy placement verifiable by logging (preferably conventional technologies)
- ✓ Material selection and design to mitigate against alloy creep
- ✓ Capable of providing reliable sealing for up to 1 million days / ca. 3,000 years
- ✓ Deployed rig-less to up to 5000m MD incorporate depth control

Refer to SPE-216616-MS



Wellstrøm barrier Qualification with Astrimar and DNV



Objectives

- Qualify Wellstrom T-1000 M3 Alloy Barrier to DNV-RP-A203, OEUK (Offshore Energies UK) and NORSOK requirements

Achievements

- Launched qualification project with Astrimar, reliability specialists in June 2023, 3 FMECA workshops held in Aberdeen
- Qualification Basis, FMECA review & Qualification Plan action workshop held 19/20th March 2024 in Pau. DNV representative present as independent observer.
- Consult Norwegian PSA April 23rd in Copenhagen + also UK NSTA & HSE

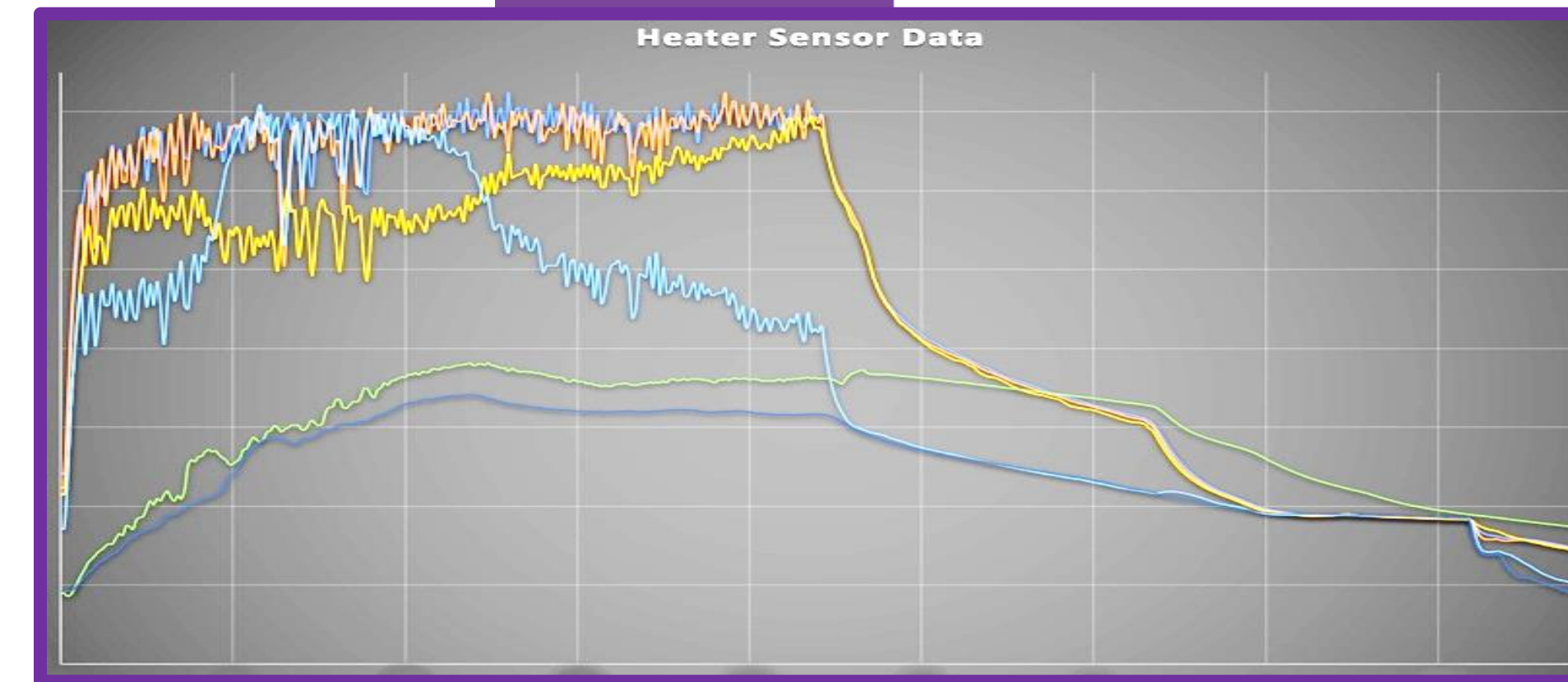
Way Forward

- Execute Qualification Plan actions as required (testing & analysis) – expected to take 18 – 24 months



Why electrical

- ❑ Controlling the heating and temperature is important to avoid caprock (and cement) damage
- ❑ Risk to outer wellbore elements:
 - ✓ Steel (blue embrittlement)
 - ✓ Cement (microannuli, cracking)
 - ✓ Caprock (crack re-opening, diagenesis)



Above the optimum range, irreversible dehydration and metamorphosis of the clay constituents of the shale happen and the **shale loses its ability to creep to form a barrier and self-heal.**

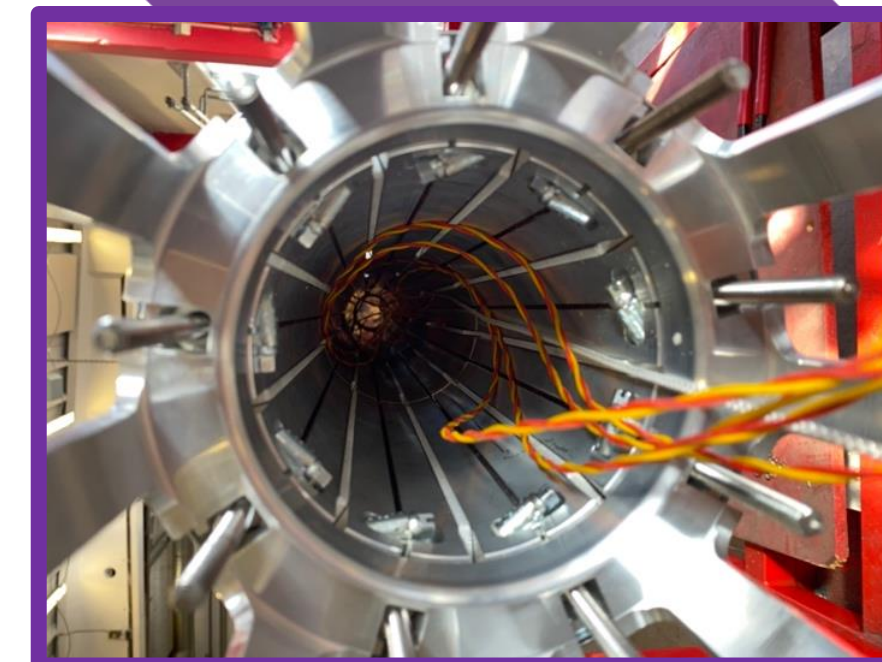
100-300°C

In the optimum range, fluid thermal expansion is effectively negated by thermally induced shale consolidation, and **barrier formation is optimally accelerated**, which is of great practical value for field implementations

At lower temperatures, thermal pore fluid expansion may lead to effective stress reduction and shear failure on shale bedding planes

E. van Oort, The University of Texas at Austin

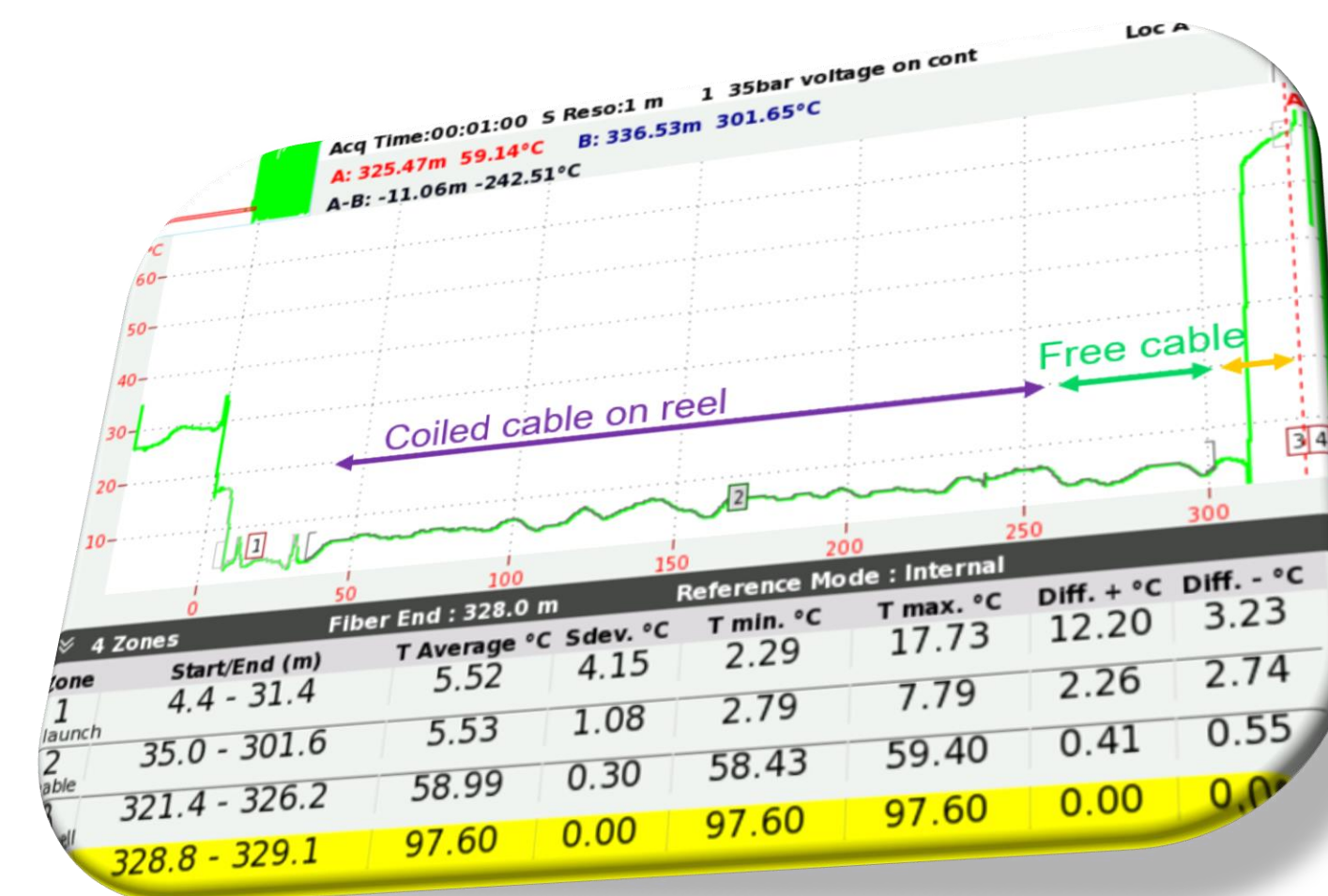
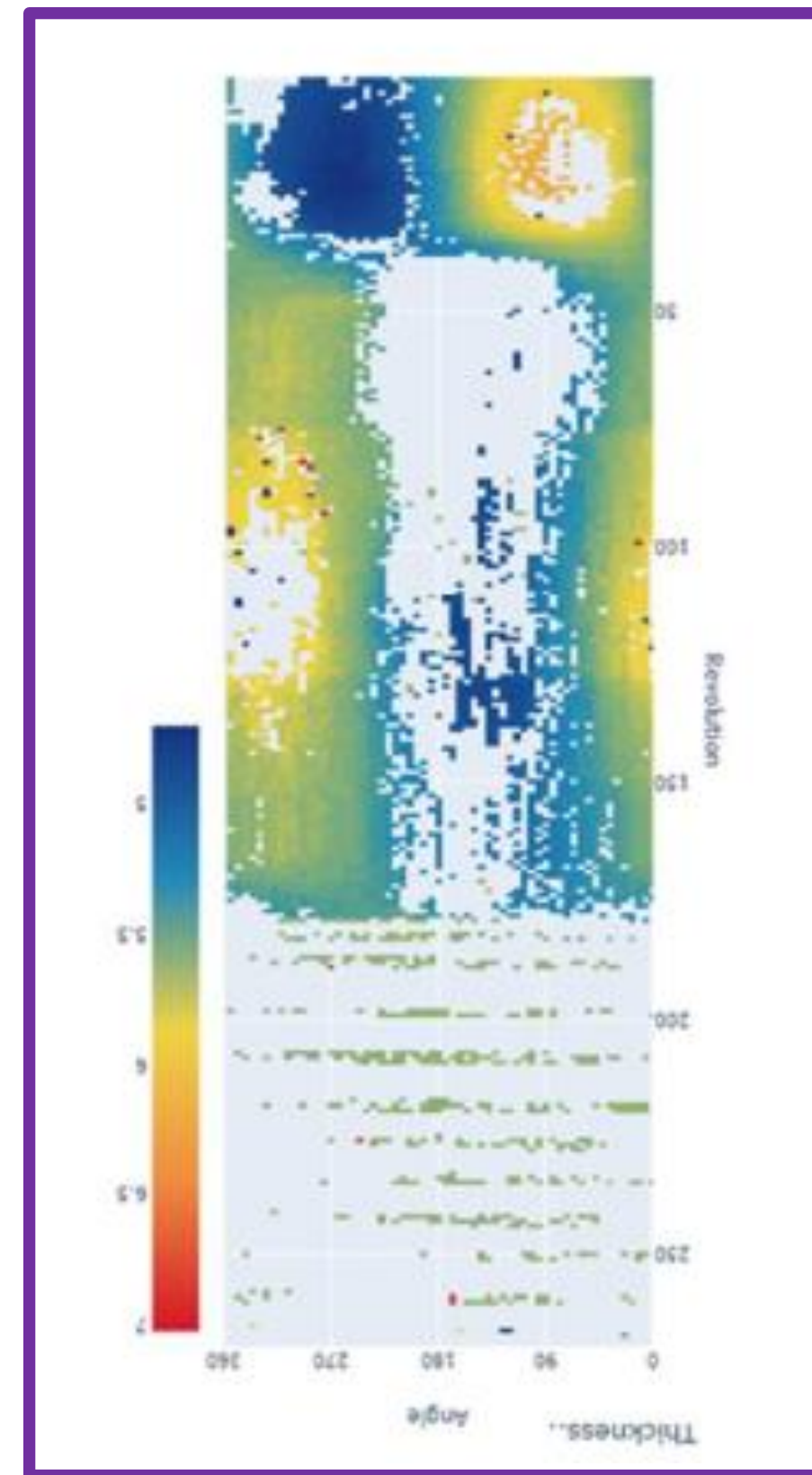
- ❑ Important to design the heating cycle (with help of CFD simulation etc.) to avoid overheating the sealing caprock – potentially highly detrimental within this zone.
- ❑ Electrical controlled heating with live monitoring ensures complete control on the wellbore conditions.



Barrier verification

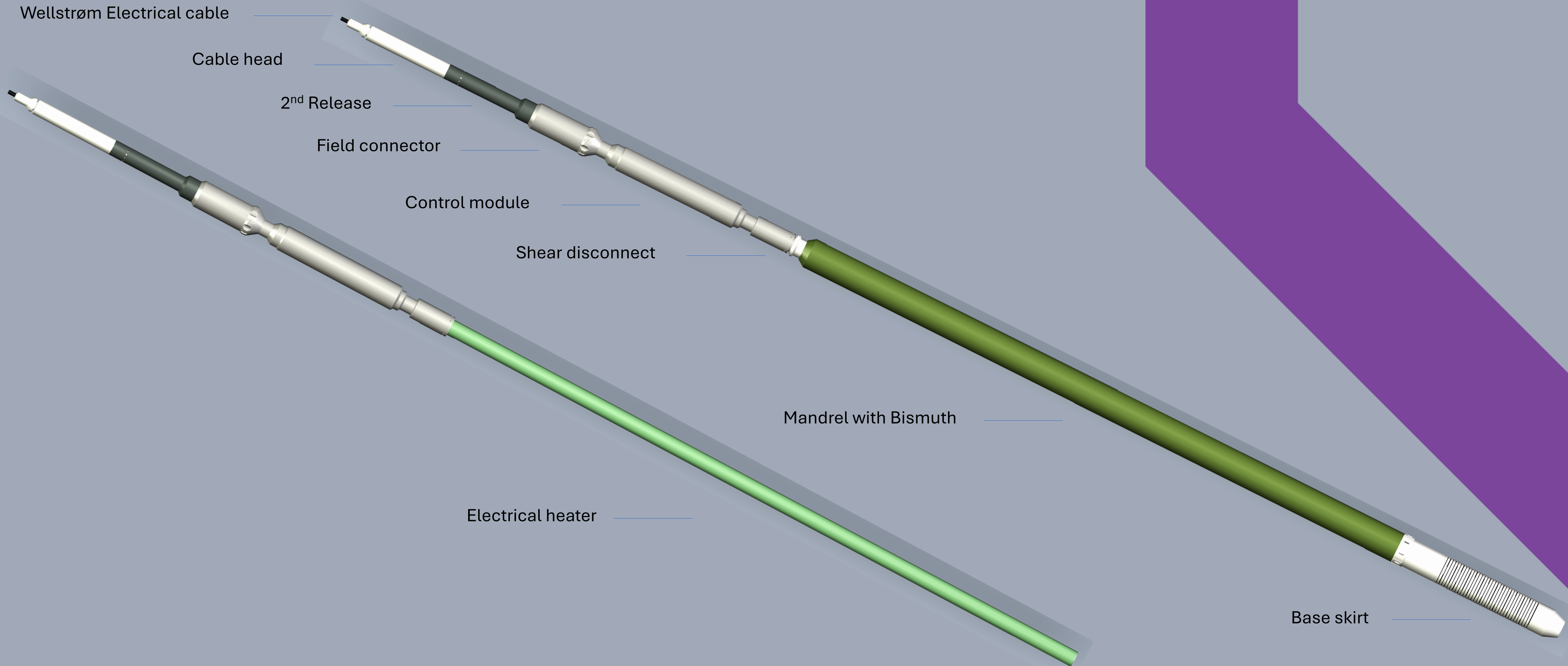
Distributed Acoustic and Temperature on Single Modus fiber

- Wellstrøm's core mission is to provide a solution that address industry concerns on barrier verification.
- Wellstrøm's barrier technology is therefore designed with verification requirements in mind, and the unique inner mandrel of the T- concept facilitates this.
- Ultrasonic testing has yielded promising results in being able to detect M3 alloys in the annulus through multiple strings.
- Incorporates verification of gas-tight seal using active downhole monitoring technology and tracer gas.



Wellstrøm T-1000

9 5/8» x 13 3/8» csg.

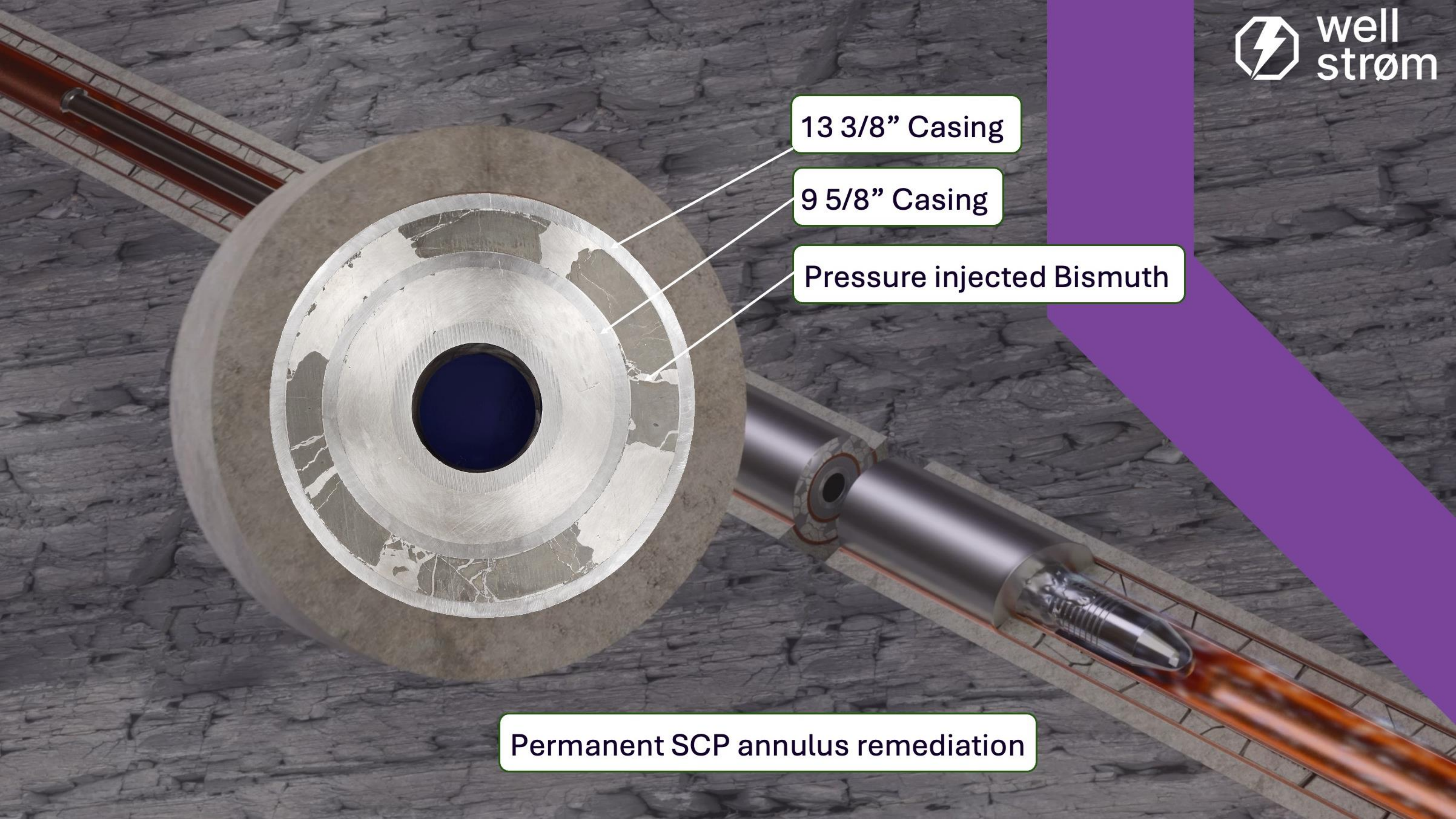


13 3/8" Casing

9 5/8" Casing

Pressure injected Bismuth

Permanent SCP annulus remediation



T-1000 Full-Scale Tests

□ Barrier system able to remediate a well-cemented 9-5/8" x 13-3/8" casing.

- Set in Cemented annulus w/(mud)
- 1 liter/min flowing gas



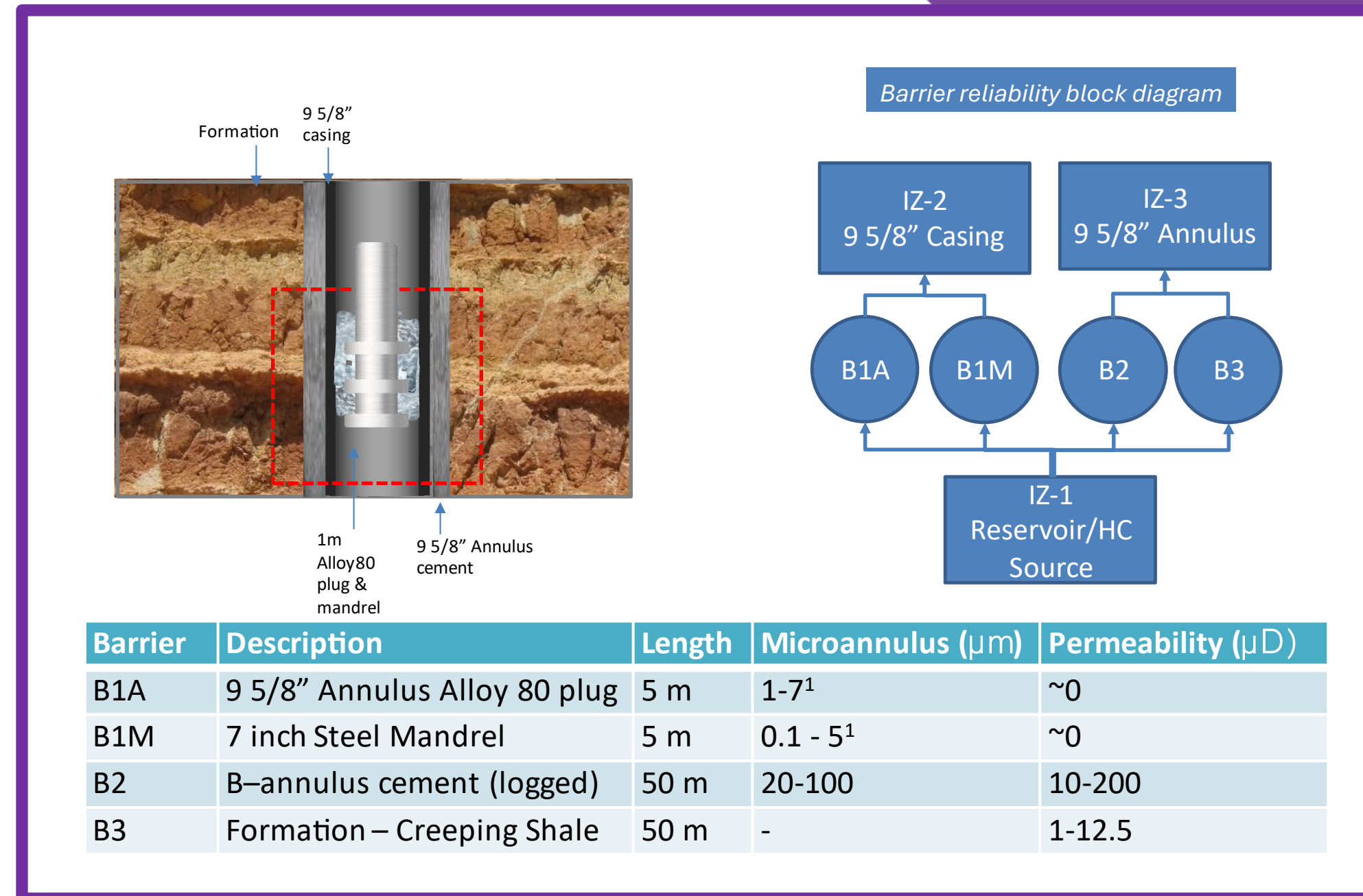
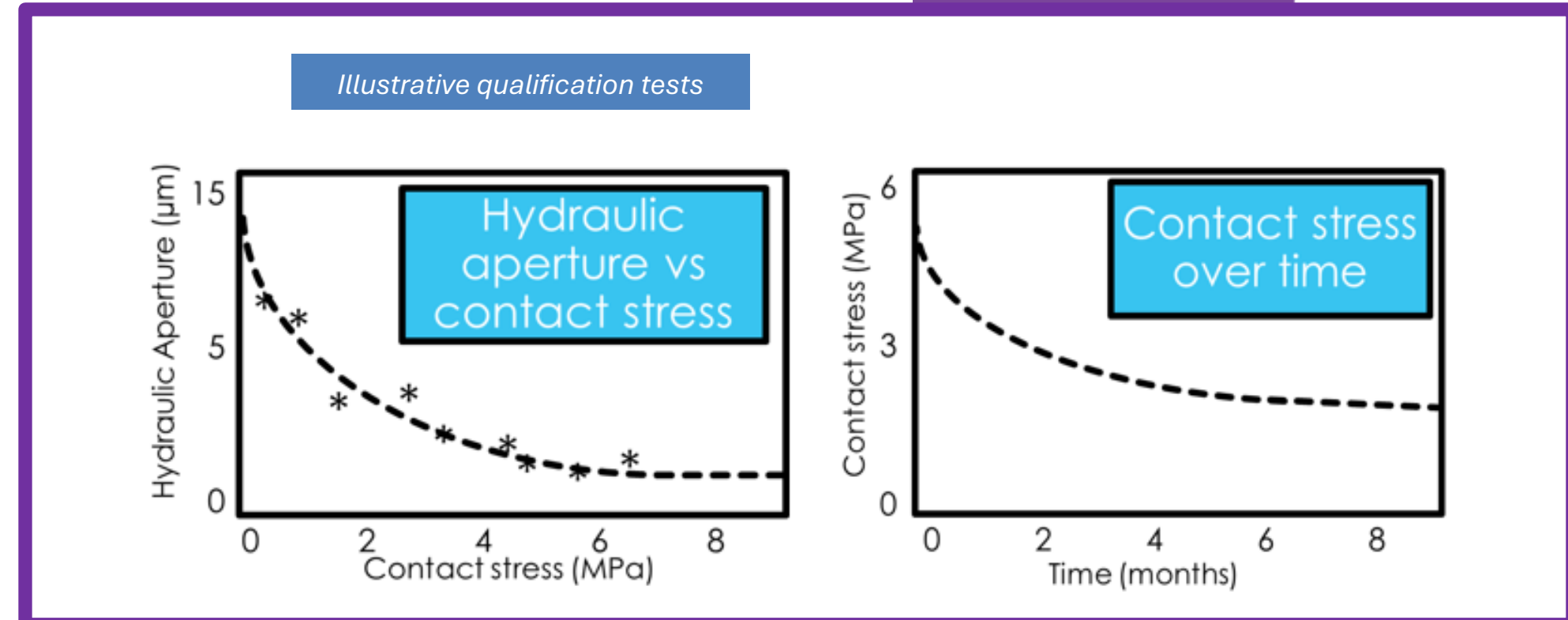
- Set in Open annulus w/seawater
- No flowing gas



Predicting barrier performance

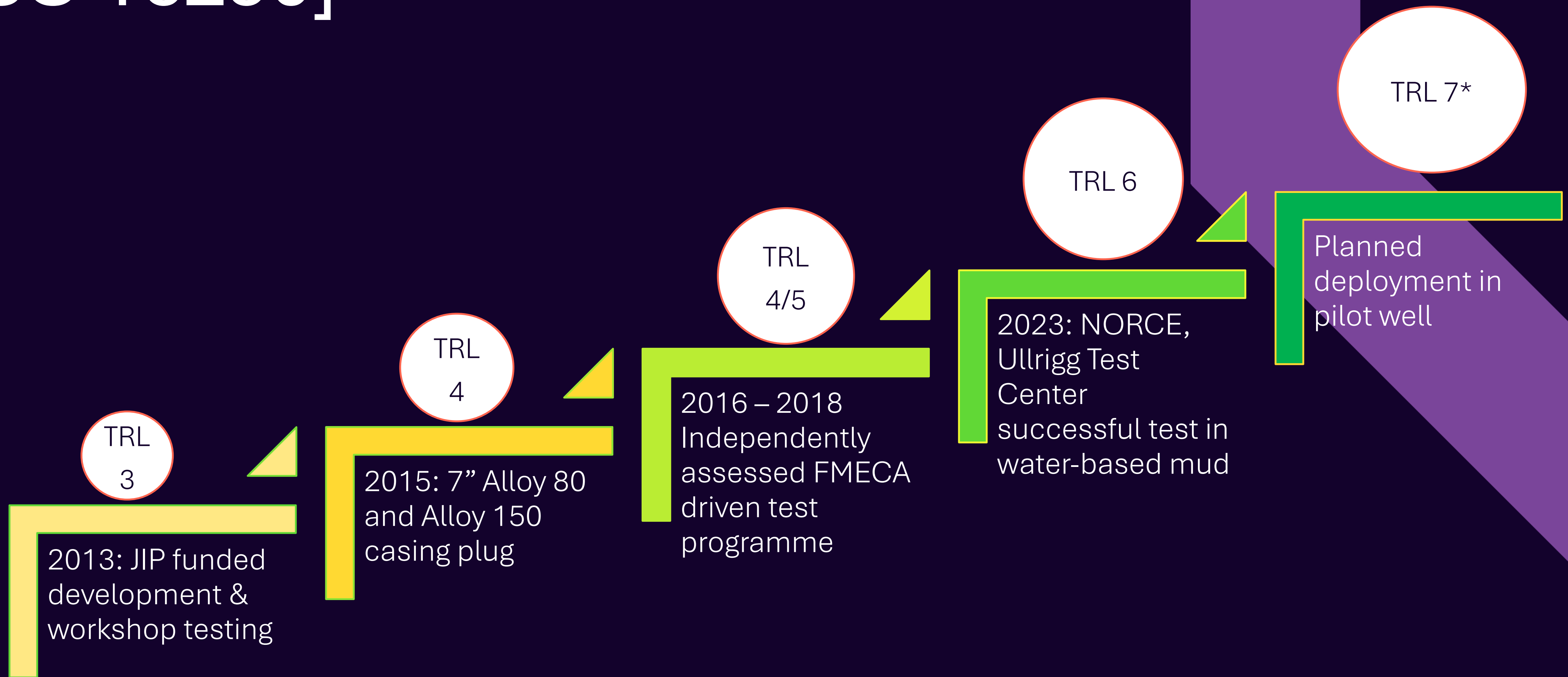
- ❑ Understanding how barrier design impacts performance
- ❑ Identifying the function and performance requirements
- ❑ Assessing failure modes and mechanisms
 - ❑ Qualification-FMECA
 - ❑ Identify qualification tests and activities
 - ❑ Installation risk & well P&A ALARP assessment

- ❑ Quantitative seal reliability modelling – STEM-flow
 - ❑ Can use industry or lab & plug test data
 - ❑ Relative assessment of barrier & system performance
 - ❑ Prediction of seal longevity/time to failure
 - ❑ Understand likely performance with technology scale-up



Wellstrøm's objective is to demonstrate assurance for operators and industry regulators of the extent that our designs meet or exceed the requirements of relevant industry guidelines (NORSOK D-10, OEUK, etc.)

Qualification Status [ISO 16290]



The story so far

❑ T-1000 -trial and full scale test

- ✓ Set plug in 1.28 SG WBM drilling fluid
- ✓ While flowing 1 liter/min gas
- ✓ Provided a high differential pressured seal @ 3000Psi gas and 3000 psi fluid.

❑ Field trial for Total Energies set to September 2023 (barrier plug)

Unfortunately, postponed due to normal oilfield operations challenges.

❑ Primary and Back-up equipment ready to go in our workshop

9 5/8" x 13 3/8" SCP remediation 1500m dept.

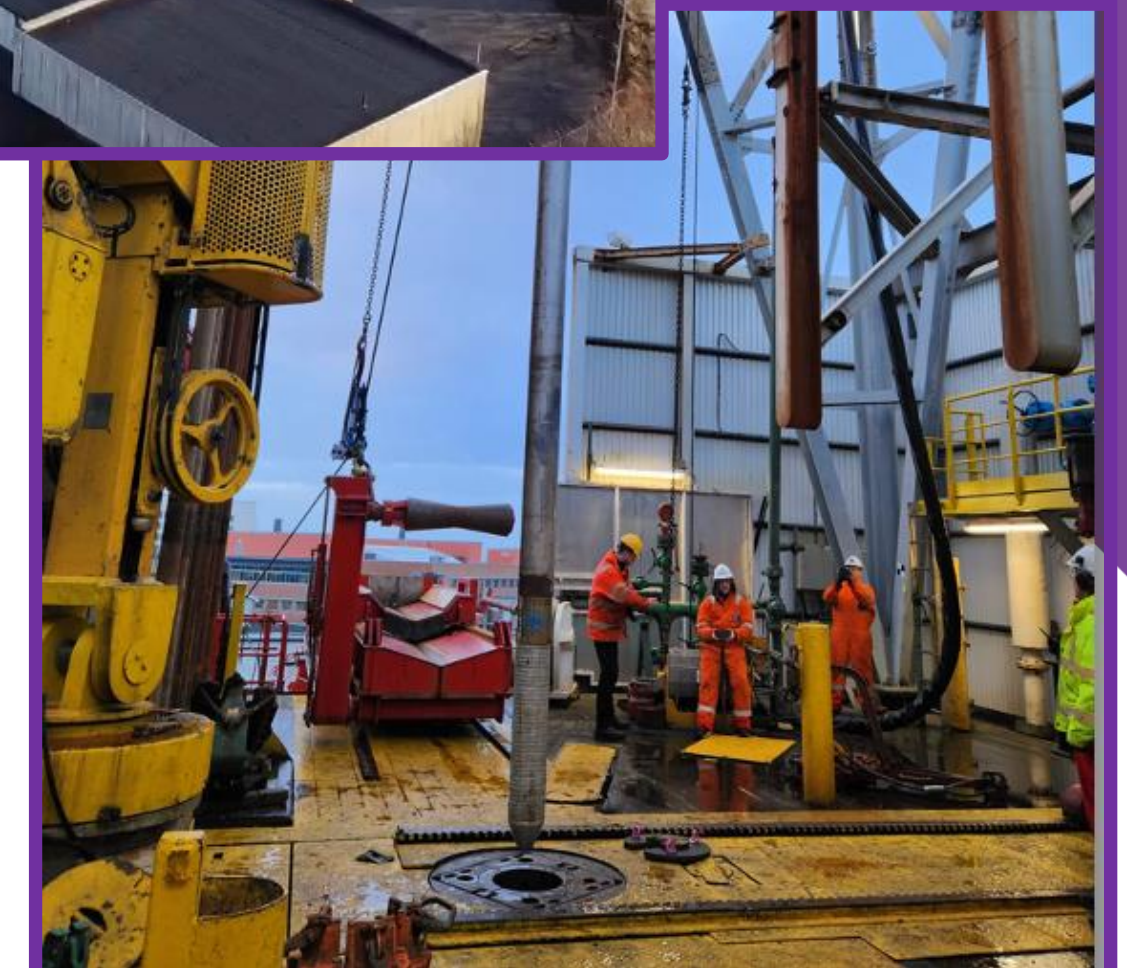
Optimal well temperature 15-90°C for prepared Bismuth

❑ New field trial opportunity for TAQA up this May/Jun (surface plug)

Rigged up test vessel last week and verified application, setting a Bismuth plug thru Gator holes into empty annulus.

❑ WHAT NEXT?

- T-3000 – 4 1/2"(5 1/2") x 9 5/8" csg plug – Q2/Q3 2026
- T-1000 – 7" x 9 5/8" csg – TBA
- Execution of Qualification Plan with Astrimar and verification by DNV





wellstrom

SURFACE CONTROLLED ELECTRICAL SET BISMUTH PLUG

Thank you

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