

FRACTURED ROCK CONSOLIDATION FOR HDD

Revissermar Mountain Crossing Case Study

Melina Almeida - Petrobras
Carlos Chaves - DrillCon
Jan Laenge - DrillCon

30th DCA Annual Congress - Rome, 02/Oct/2026



COLLABORATION

Successful projects are built together.

CLIENT



Investigation · Risk assessment · Basic design

CONTRACTOR



Executive planning · Execution · Field adaptation

One case. Two perspectives. One integrated solution.

AGENDA

From anticipated risk to field response.

1

Subsoil characterization
Risk analysis
Basic design

2

Executive design
Consolidation strategy
Execution

3

Results
Conclusion

 Serra da Sapucaia / Revissermar

Fractured rock can compromise HDD feasibility

Steering deviation

The drill bit may be deflected at the fractures

Hole cleaning deficiency

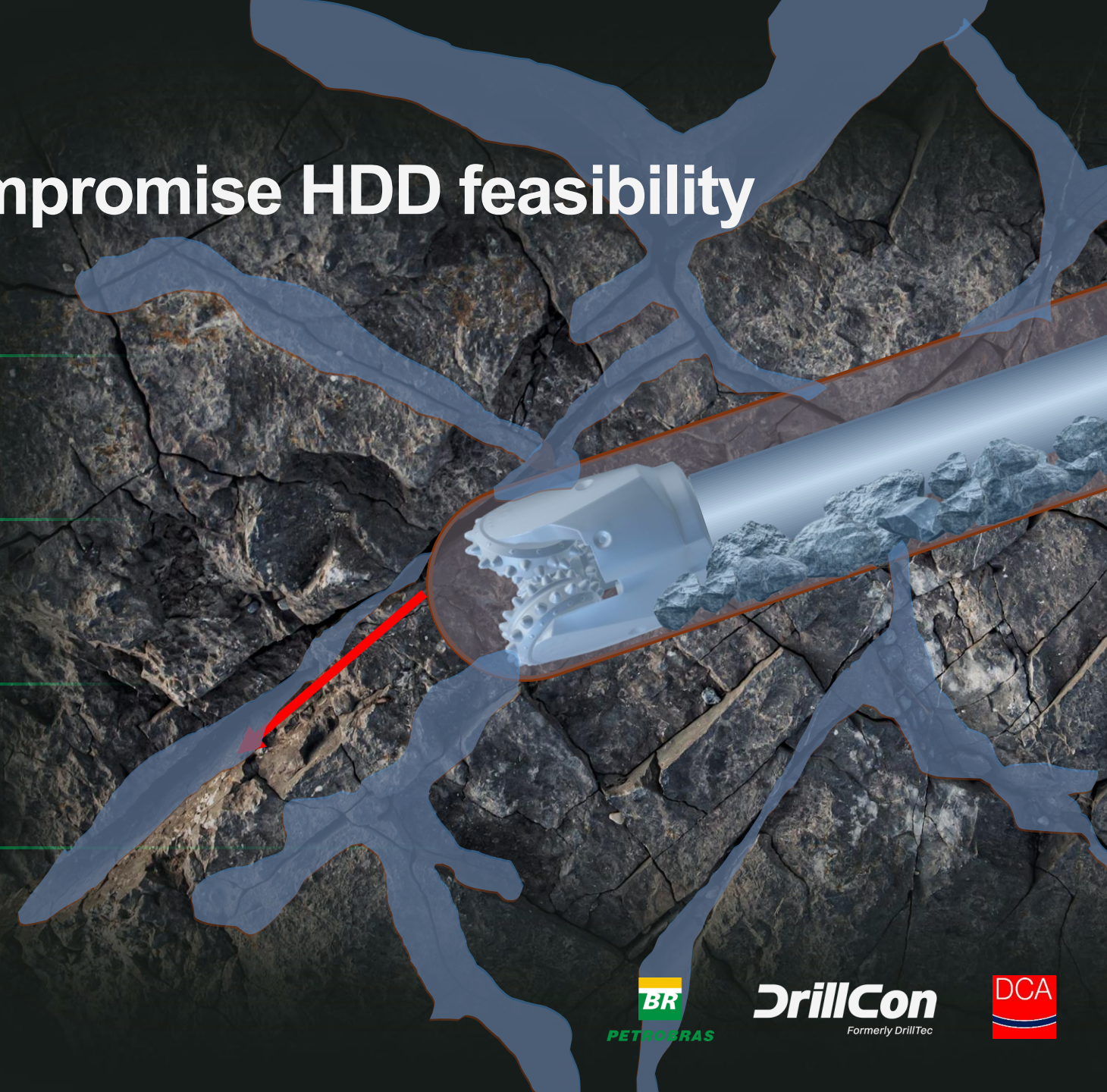
Larger fragments may remain inside the hole

Drilling fluid loss

Drilling fluid may be lost through fractures

Groundwater influx

Groundwater may enter the bore and affect mud quality



MITIGATING THE EFFECTS OF FRACTURED ROCKS

Consolidation

Fill fractures and cavities

Reduce fluid migration

Limit block detachment

Improve drilling control

TWO POSSIBLE APPROACHES

Consolidation alternatives

FROM THE SURFACE

Cement grouting / Jet grouting

Difficult to target at high cover

FROM INSIDE THE HOLE

Cement squeeze through the pilot hole

Localized treatment around the HDD path



CASE STUDY

Revissermar Mountain Crossing

Border between Itaboraí and Maricá · State of Rio de Janeiro, Brazil

Ø22" API 5L X70

Gas pipeline

753 m

HDD length

117 m

Maximum cover

Deep rock crossing

Localized highly fractured zones

HDD End Point



HDD Start Point

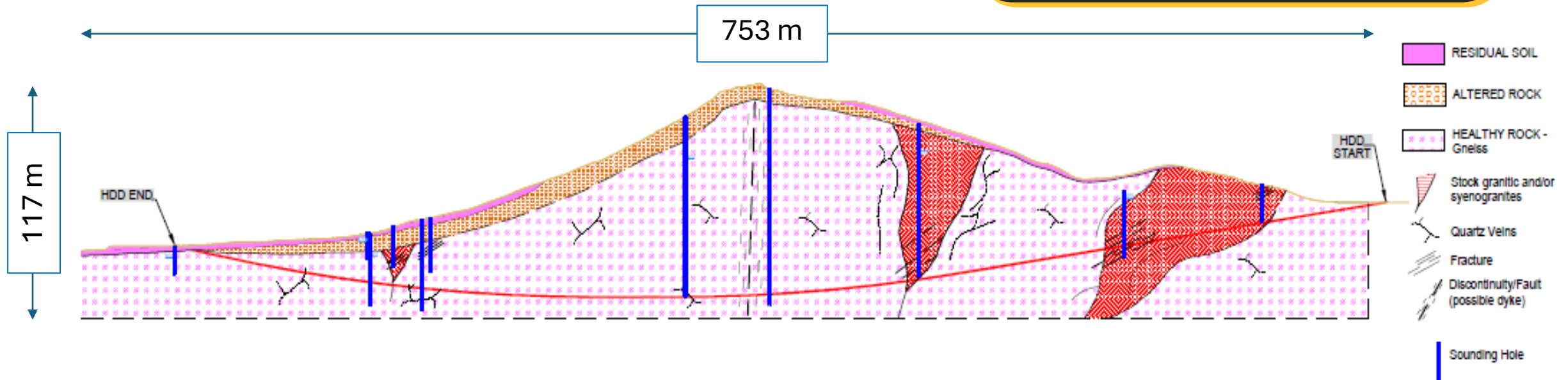


Investigation program

- 11 boreholes
- Electrical geophysics
- Seismic investigation
- Pressure permeability tests
- UCS and abrasiveness tests
- Petrographic description

GEOTECHNICAL MODEL

Gneiss / granite, quartz veins, localized highly fractured zones, and possible fault/dyke (250 MPa)



BASIC DESIGN TRANSLATED RISK INTO MINIMUM REQUIREMENTS

From geotechnical model to contractual requirements

Rig **150 tf push/pull, 6,640 kgf.m torque**

Triplex pump **500 GPM**

Recycling system **750 GPM**

Final reaming **1.4 to 1.6 x pipe OD**

Drill string **API 7G, S135 Premium**

Steering system **Secondary magnetic field**

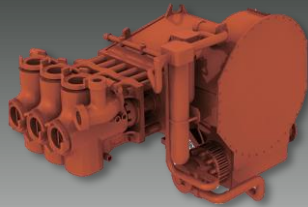
Cutting tools **TCI bits and TCI reamers**

Consolidation **Specific procedure required**

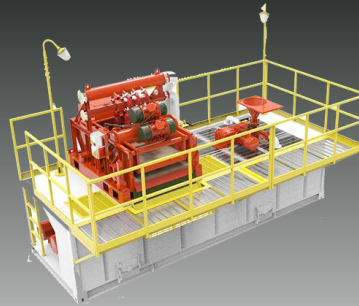
Selected for project conditions



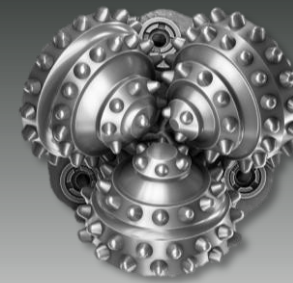
**300 tf / 90 kN.m
HDD Rig**



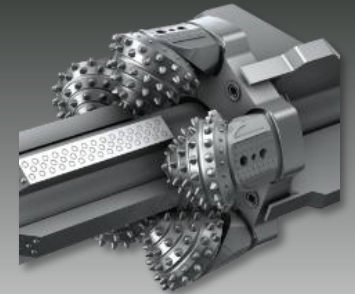
**700 GPM
Triplex Pump**



**Recycling System
Scalper + Desander
+ Desilter**



**Ø10 5/8" TCI
IADC 617
Drill Bit + Mud
Motor +
P2 + PWD**



**Ø26" and 34" TCI
IADC 627
Reamers**

Five main steps

STEP 1

**10 5/8" pilot
hole**

STEP 2

**26" pre-
reaming**
Hole opener

STEP 3

**34" final
reaming**
Hole opener

STEP 4

**34" swab /
cleaning**
Barrel

STEP 5

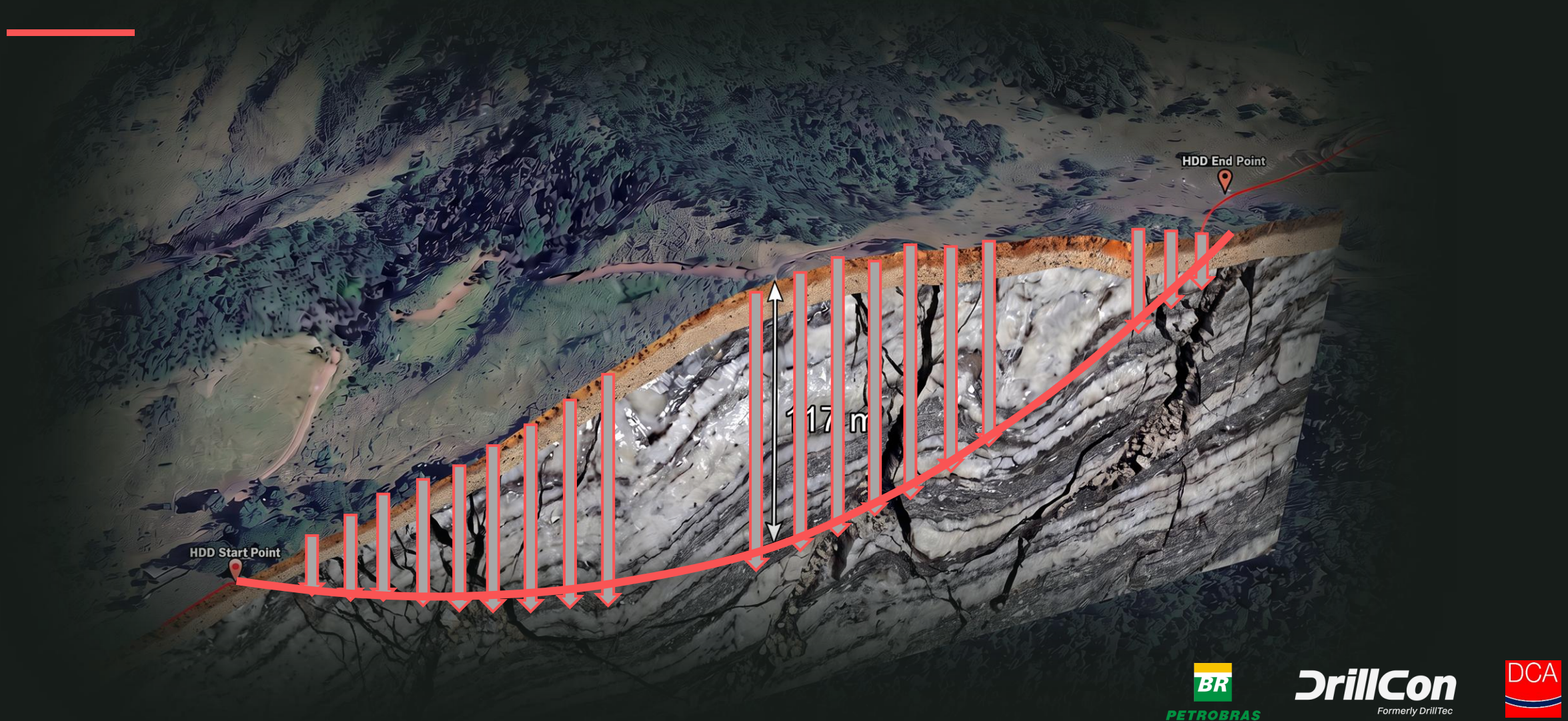
**22" pipeline
pullback**

Final bore diameter: 1.54 x pipe OD

Calculated pullback force: 45 tf

THE KEY EXECUTION QUESTION

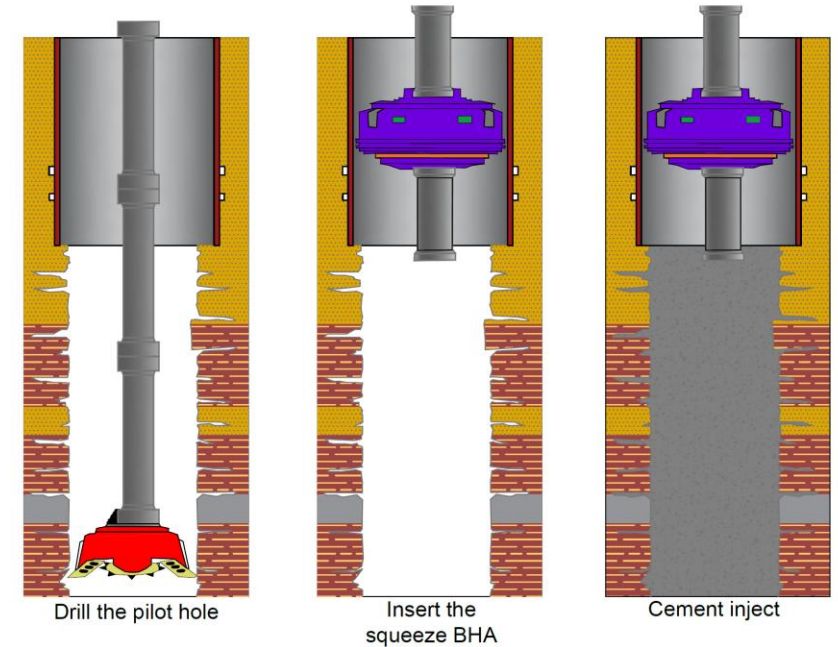
How to deal with the fractured rock zones?



CONSOLIDATION CONCEPT

Cement injected directly into the pilot hole

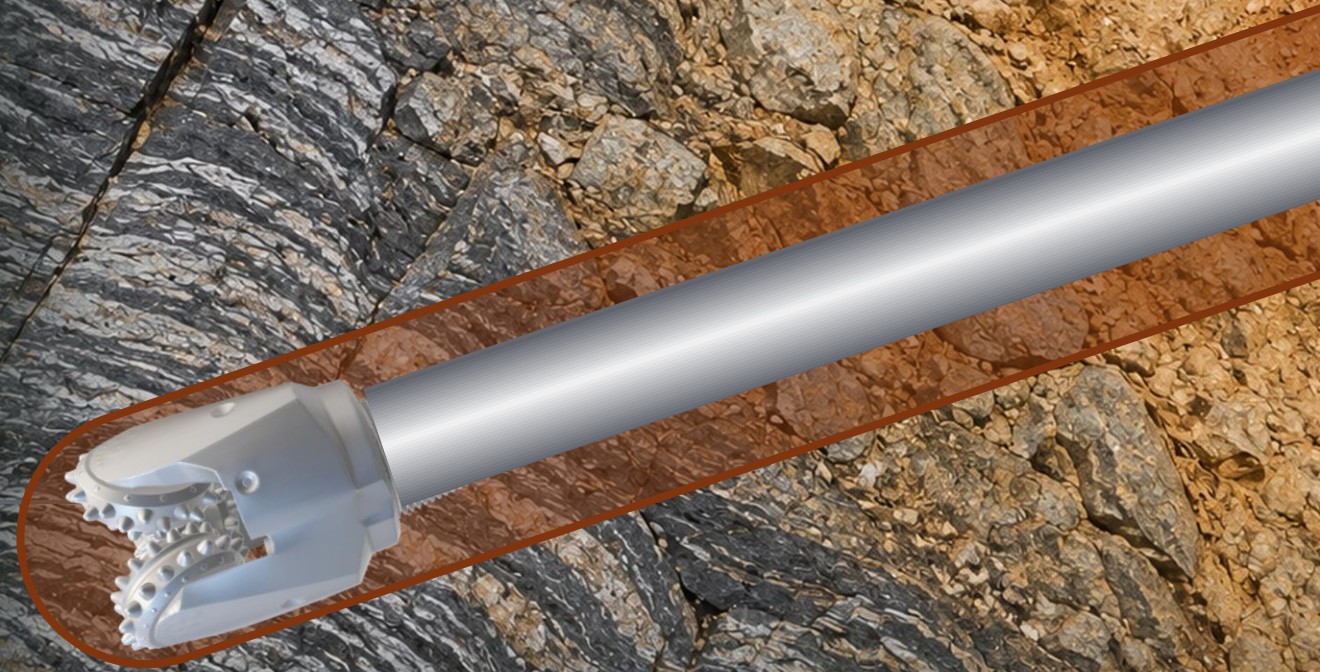
- Squeeze technique (from the petroleum industry)
- Similar logic to oilfield cementing
- Packer to isolate the section and specific BHA
- Controlled pressure injection
- Objective: seal fractures around the bore



Creating a sealed section for pressure grouting

- Prepare the entrance section
- Allow pressurization
- Prevent returns through the annulus

A Pilot hole until rock interface



Creating a sealed section for pressure grouting

- Prepare the entrance section
- Allow pressurization
- Prevent returns through the annulus

A Pilot hole until rock interface

B Ø20" forward reaming

Creating a sealed section for pressure grouting

- Prepare the entrance section
- Allow pressurization
- Prevent returns through the annulus

- A Pilot hole until rock interface
- B Ø20" forward reaming
- C 13 3/8" casing installation
- D Packer + annular cementing + well closing head (BOP)



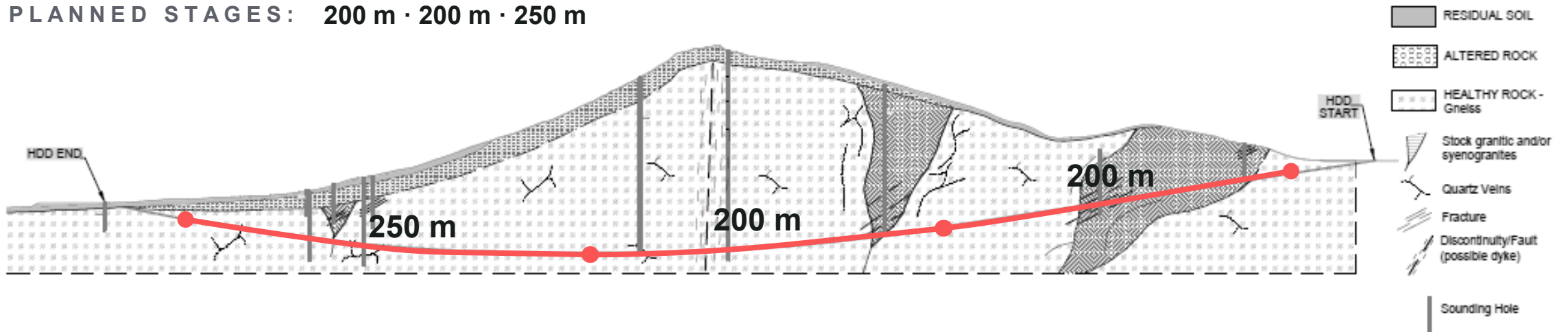
Cement: strong enough to prevent returns, yet brittle enough to allow removal

Not yet the rock consolidation stage; this is the preparation that makes it possible.

PLANNED GROUTING SEQUENCE

Original plan: three consolidation stages

PLANNED STAGES: 200 m · 200 m · 250 m



STEPS IN EACH STAGE:

A

Drill 200 m

B

Cement open hole

C

Re-drill cemented section

Drill and grout from the higher side; use hydrostatic head to support consolidation.

Planned vs. executed

CASING

Planned	50.0 m
---------	--------

Executed	35.5 m
----------	--------

Rockhead encountered closer to surface

CONSOLIDATION

Planned	3 stages
---------	----------

Executed	2 major stages
----------	----------------

Strategy adjusted based on drilling response

PILOT HOLE RESULTS

Controlled trajectory through fractured rock

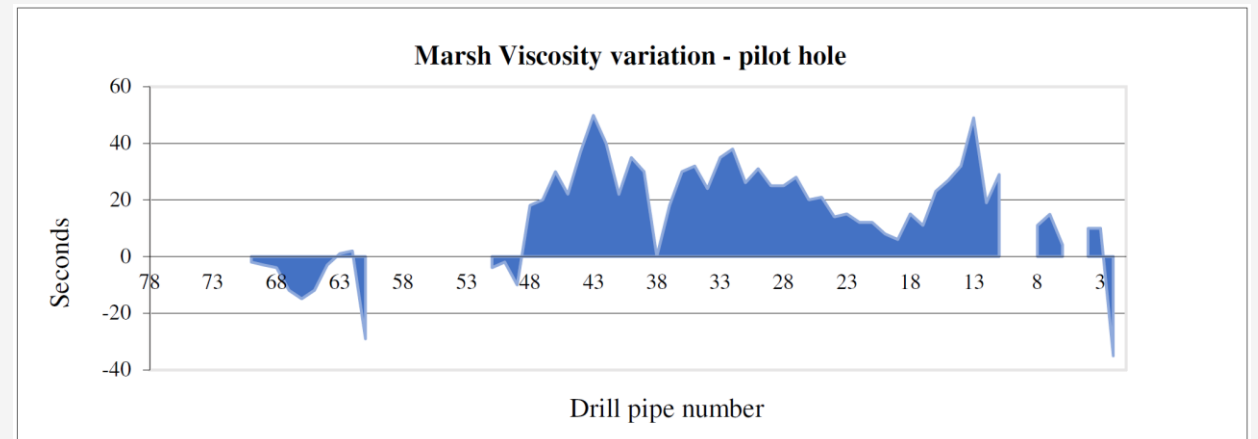
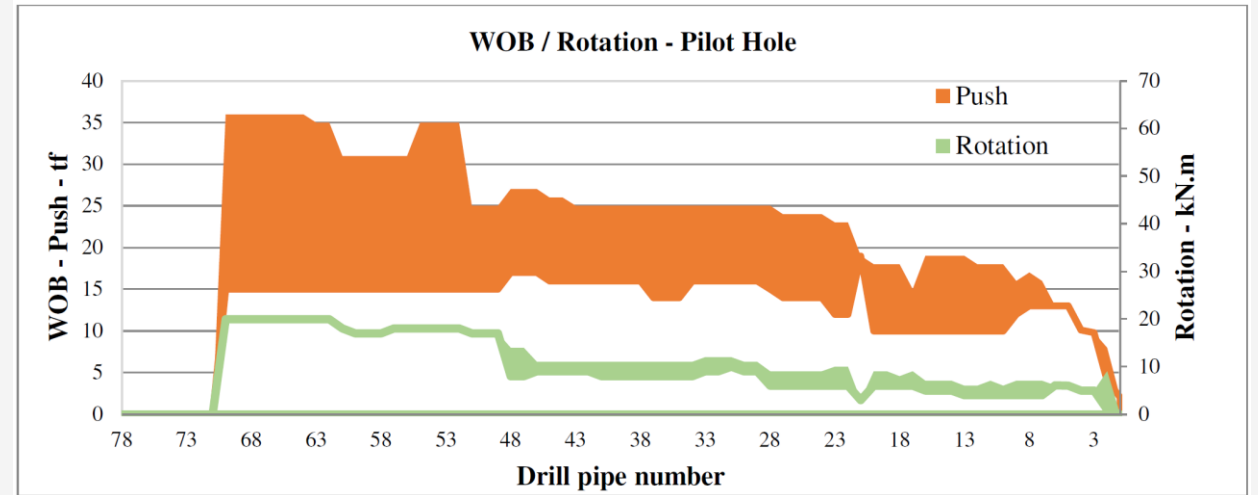
Pilot hole duration

27 days

Exit point deviation

0.22 m

- Radii within limits for 22 in. steel pipe
- Close to planned geometry
- Higher force / torque near final section



Reaming confirmed the benefit of consolidation

Ø26" reaming

- Uniform parameters
- No fluid losses
- 19 days

Ø34" reaming

- Minor force and fluid variation near fractured section
- 10 days

Cleaning

- Additional cleaning pass required before pullback

PULLBACK RESULTS

Continuous and controlled installation

32_{tf}

Max. pull force

6.5_h

Pullback duration

58_{days}

Drilling duration - in rock

Rig transferred to the opposite side

Continuous pullback

Below calculated force of 45 tf

No issues recorded



CONCLUSION

What made the crossing feasible

Robust ground investigation

Geotechnical model and risks translated into design requirements

Fit-for-purpose equipment and tooling

Cement squeeze consolidation

Continuous monitoring and field adaptation

FINAL MESSAGE

Design predicted the risk.

Drilling revealed its extent.

Grouting controlled it.

Field adaptation made it efficient.

Thank you.

