



SAFETY AND OPERATIONAL RISK MITIGATION BY INTEGRITY LOGGING FOR A WELL ABANDONMENT ACTIVITY

20 April 2016

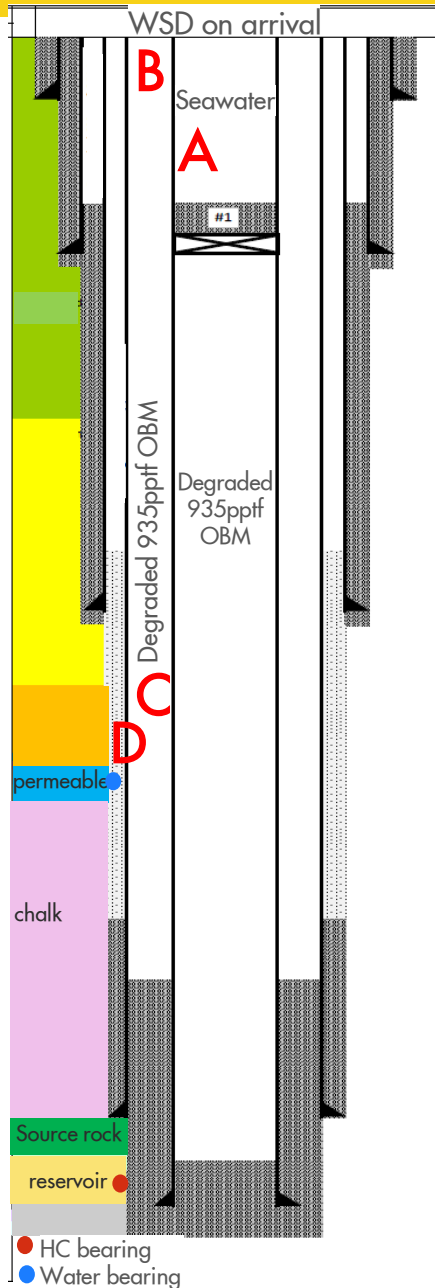
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Petrophysicist Shell

CONTENT

- Introduction and anticipated risks
- Planned well abandonment program and data acquisition
- What actually happened during well abandonment:
 - Verified casing integrity above plug
 - Inflow test to confirm isolation reservoir
 - Annular interpretation at planned cutting depth
 - Annular interpretation below the hanger
- Conclusions

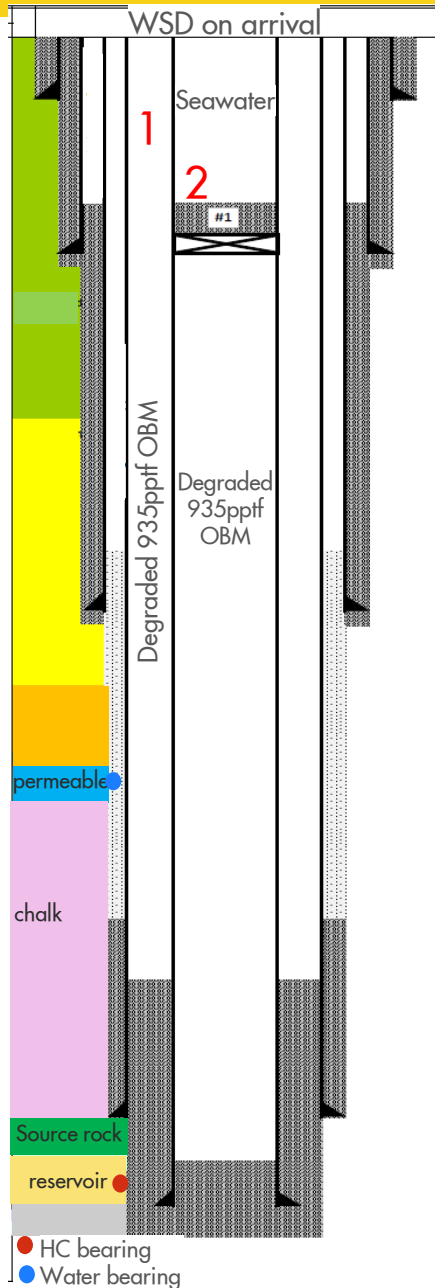
Cased hole logging provided vital information for identifying and mitigating safety risks, enabling us to make the right decisions.

INTRODUCTION



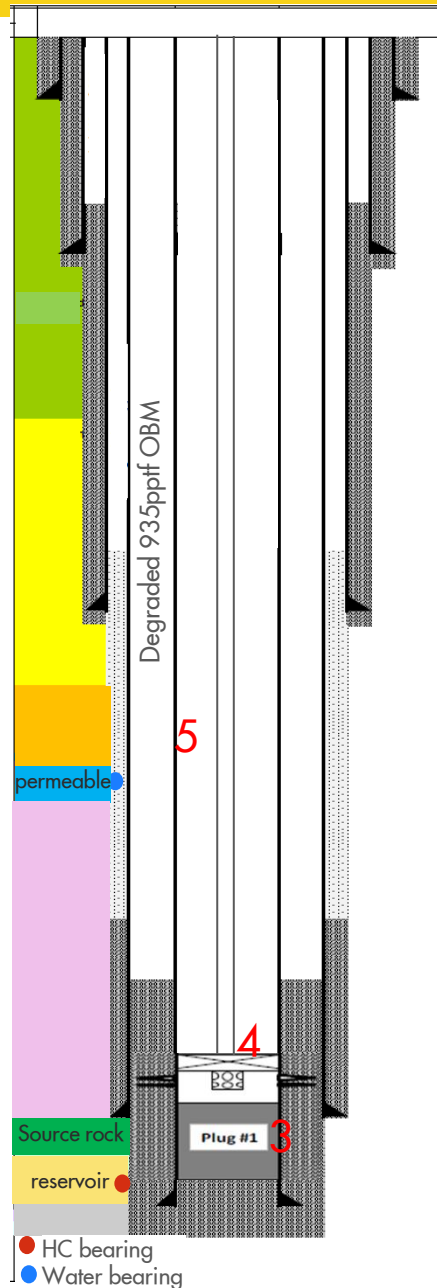
- HPHT subsea well
- Suspended
- Risk of hydrocarbons to surface in case of failure of annular cement, production casing or shoe
- Further anticipated risks:
 - A. Casing burst
 - B. Gas in annulus
 - C. Solids hampering pulling production casing
 - D. Damaging intermediate casing

PLANNED ABANDONMENT PROGRAM (REFERENCE CASE)



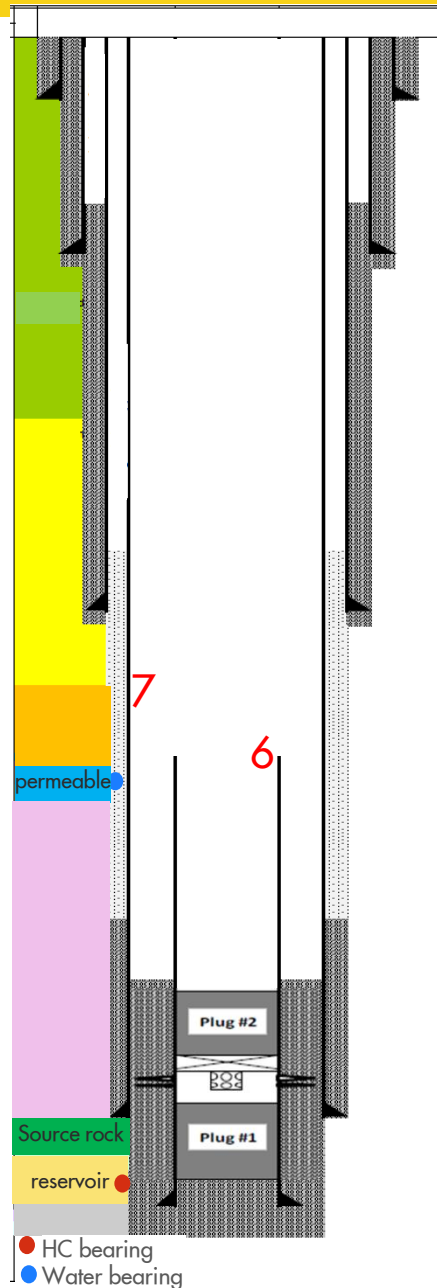
1. Check integrity production casing above plug and absence gas cap in annulus
2. Drill out shallow plug
3. Cement plug #1
4. Perforate & inflow test => no inflow
5. Log production casing
6. Cut-pull production casing
7. Log intermediate casing for cement
8. Plug #3 (section mill in case of poor cement)
9. Cut intermediate casings, plug #4

PLANNED ABANDONMENT PROGRAM



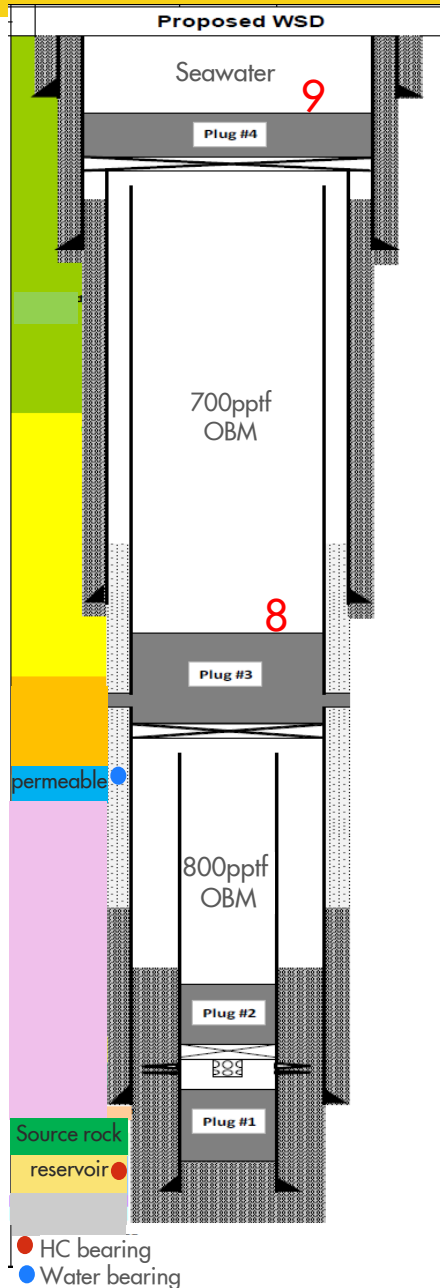
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PLANNED ABANDONMENT PROGRAM



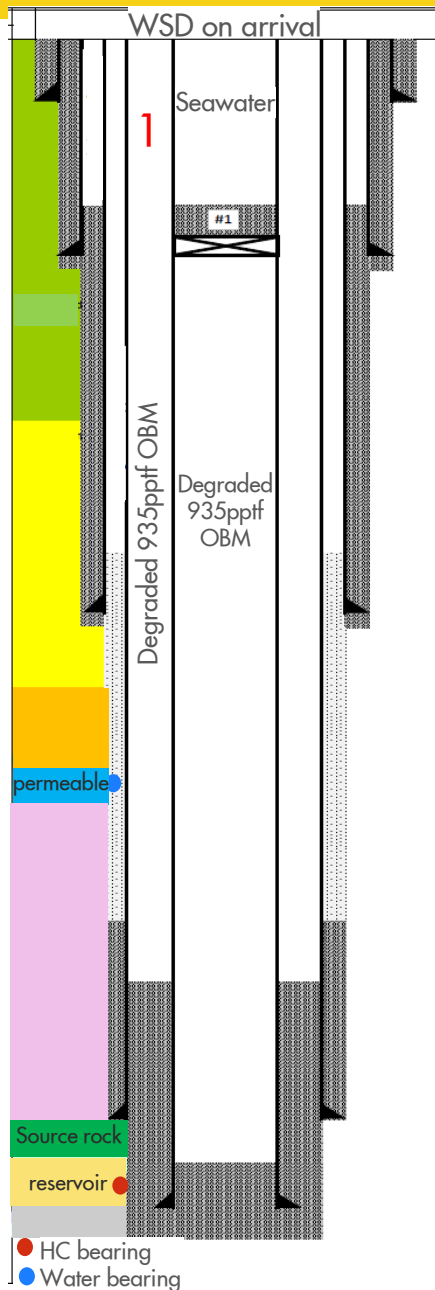
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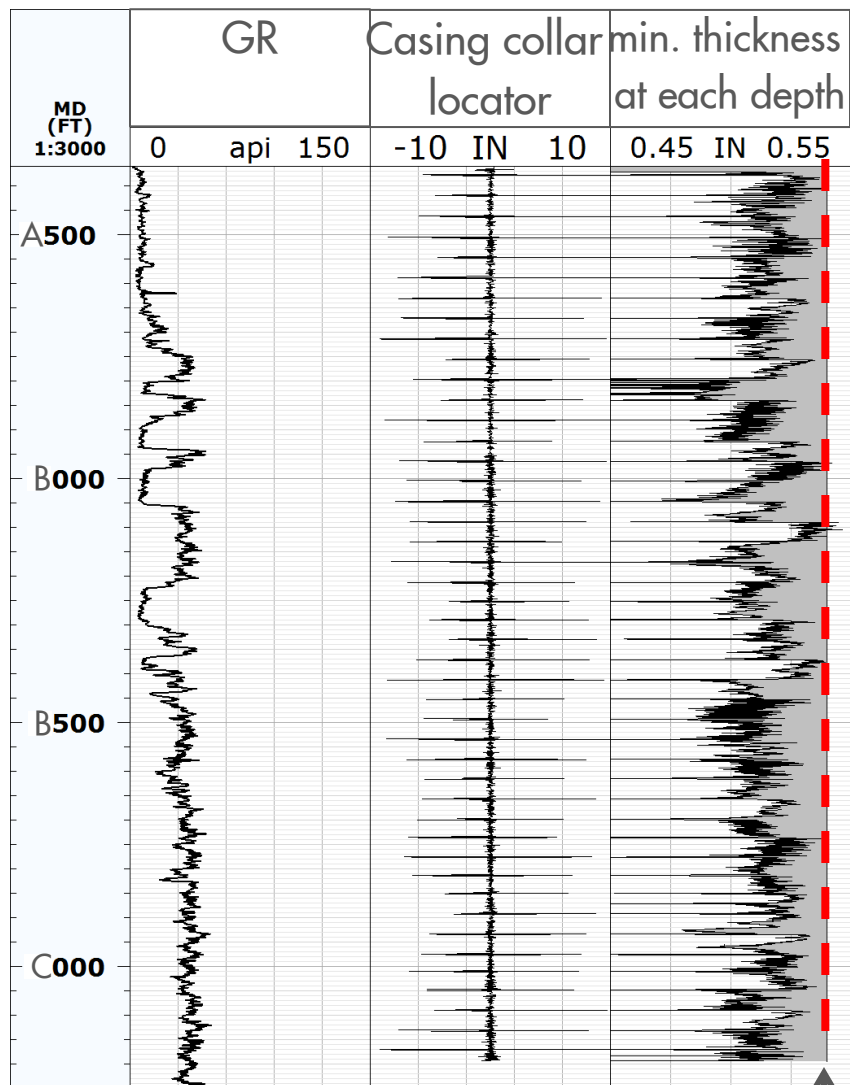
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EXECUTION: CASING INTEGRITY



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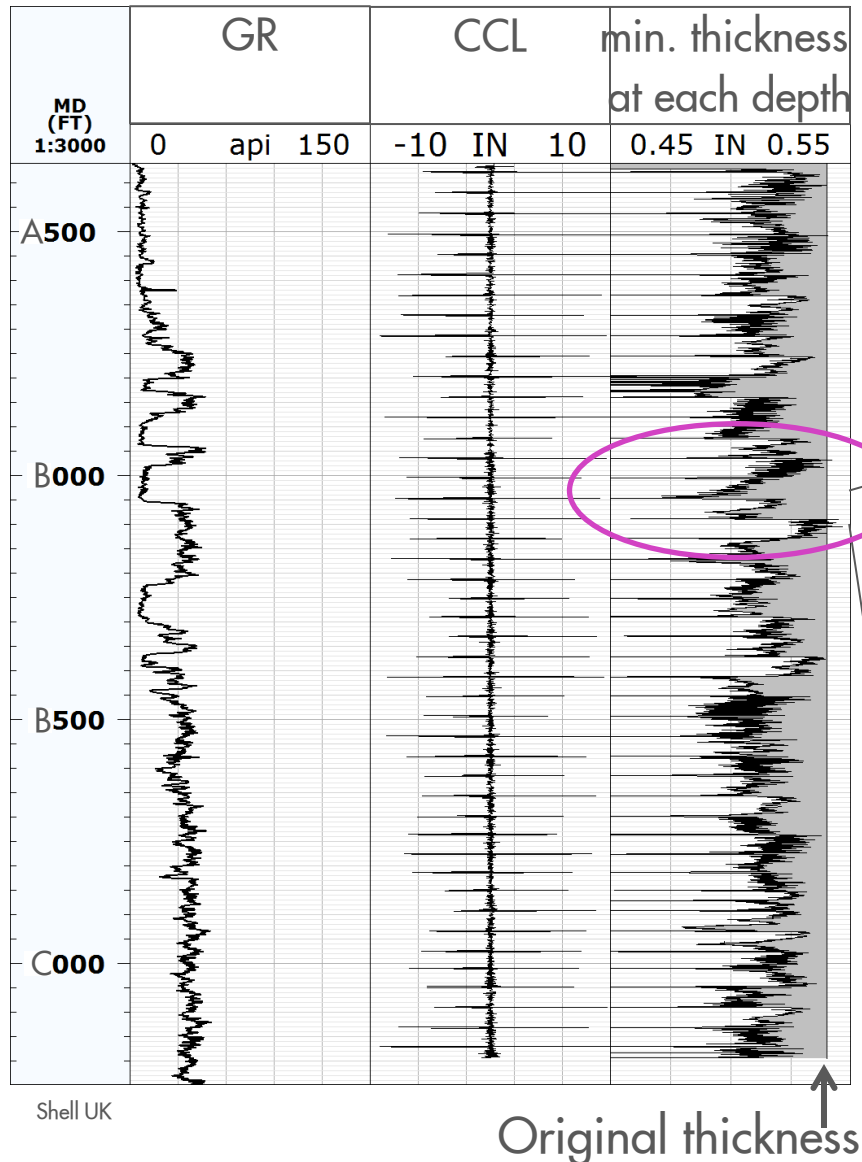
CASING INTEGRITY



- **Objective:** determine if casing is thick enough to withstand possible high pressure

Original thickness

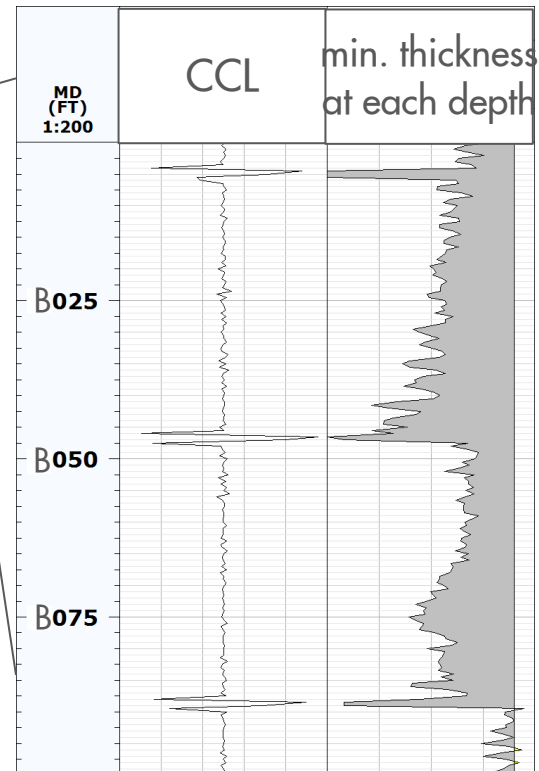
RESULTS: CASING INTEGRITY



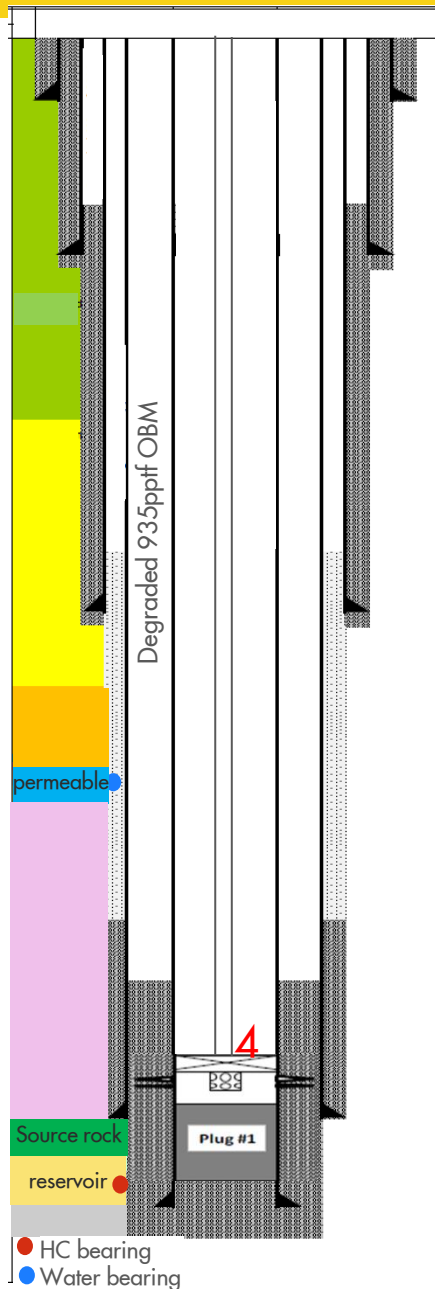
Result:

- average 96%, minimum thickness 85% of original thickness >> minimum required
- no gas in annulus

Conclusion: Safe to drill out plug



EXECUTION: INFLOW TEST

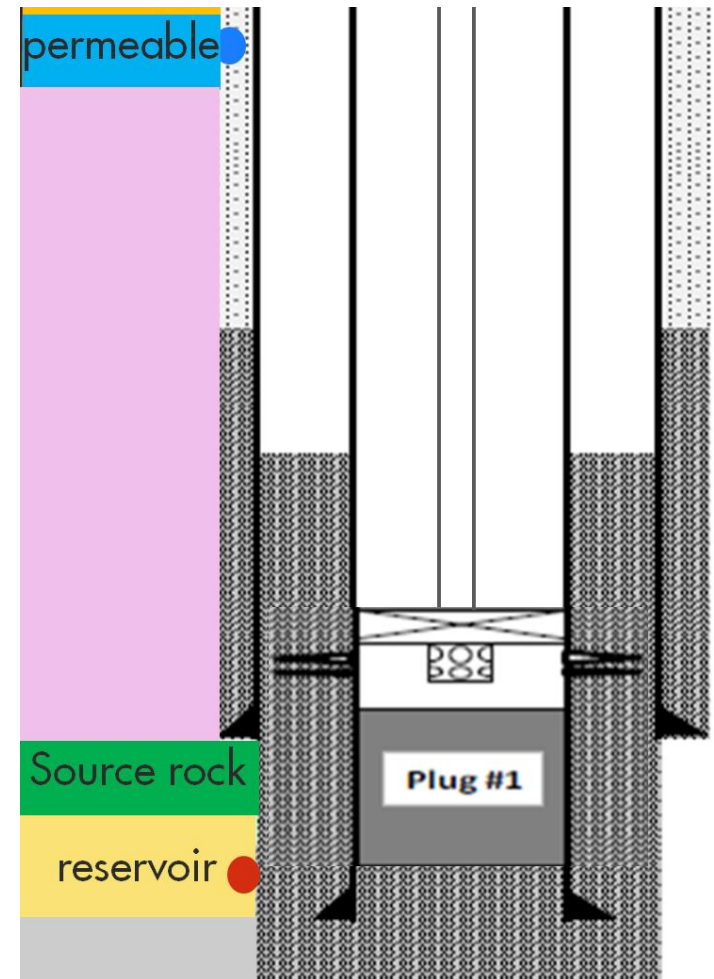


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2. Drill out shallow plug
3. Cement plug #1
4. Perforate & inflow test
5. Log production casing
6. Cut-pull production casing
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8. Plug #2 (section mill in case of poor cement)
9. Cut intermediate casings, plug #3, plug #4

INFLOW TEST

Objective:

Confirm isolation of the reservoir



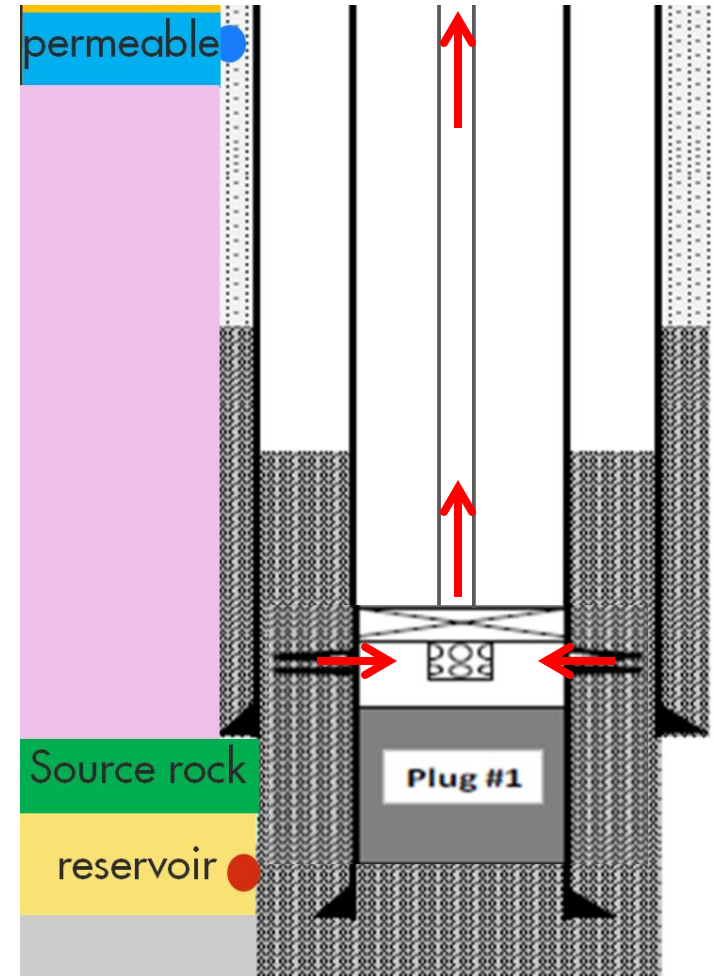
INFLOW TEST

Objective:

Confirm isolation of the reservoir

Observation:

Gas inflow



INFLOW TEST

Objective:

Confirm isolation of the reservoir

Observation:

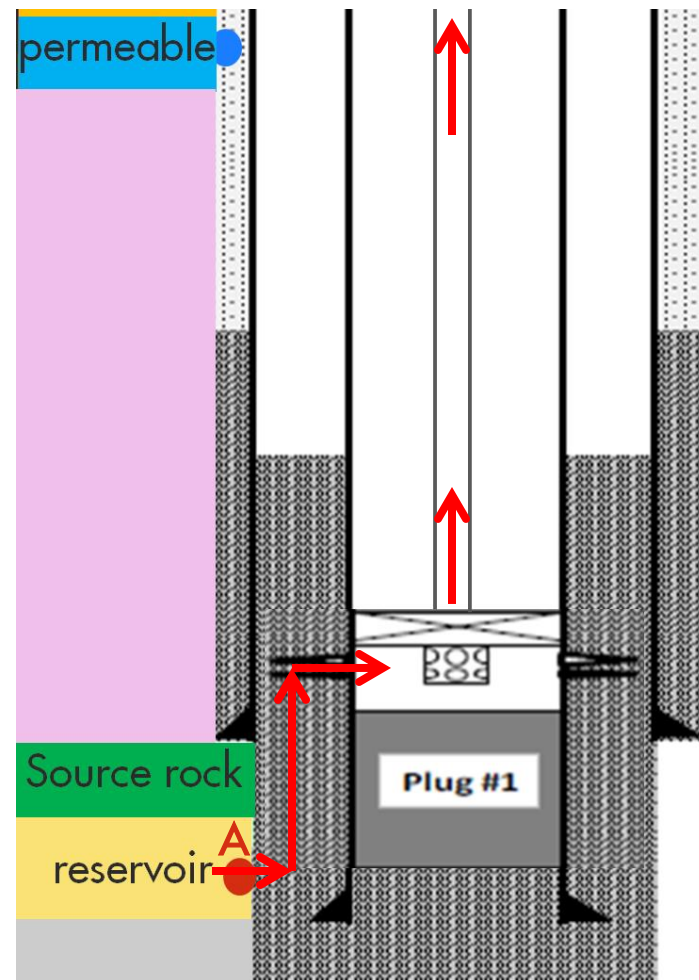
Gas inflow

Possible source A:

From the reservoir

Consequence:

Reservoir not isolated => suspend the well and further work on how to isolate it



INFLOW TEST

Objective:

Confirm isolation of the reservoir

Observation:

Gas inflow

Possible source B:

From overlying source rock

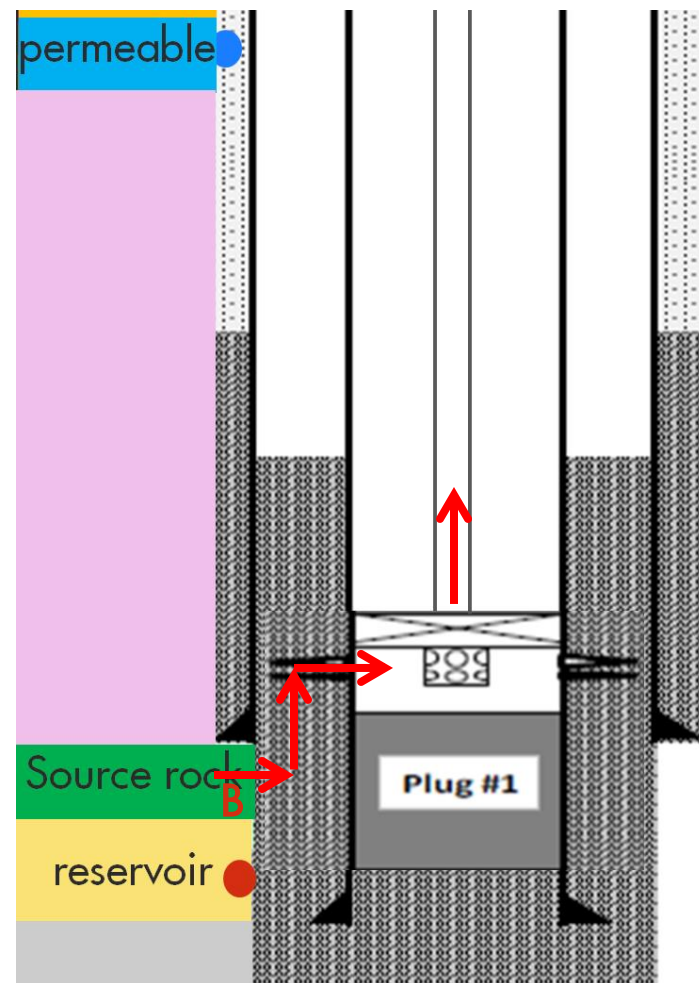
Consequence:

Limited volume

Reservoir isolated

Set additional plug

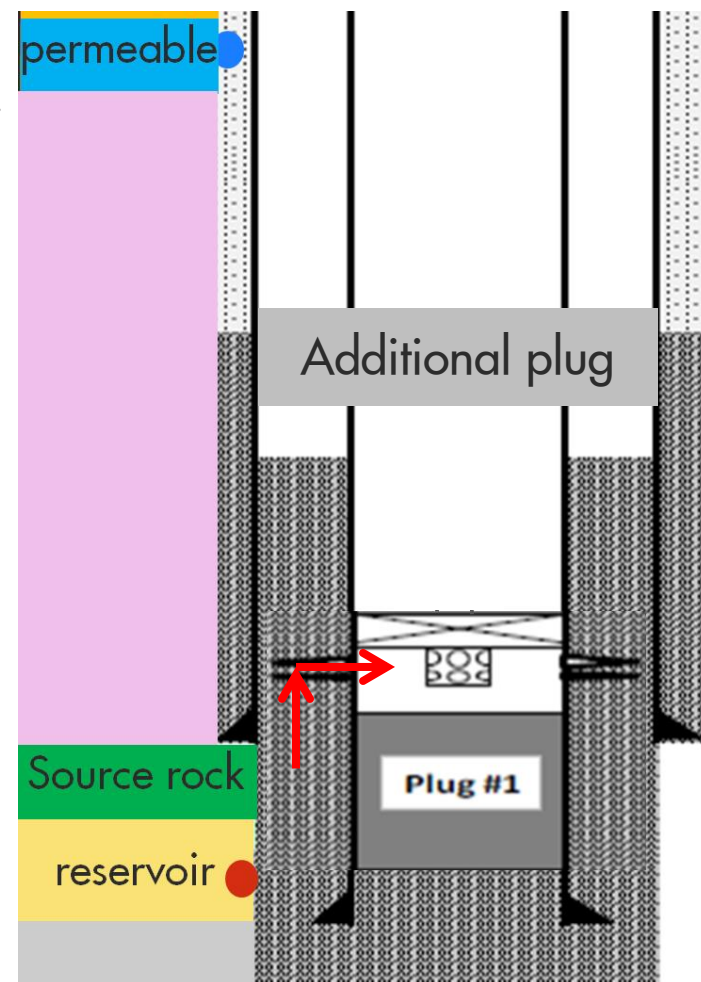
=> Continue abandonment



INFLOW TEST

Distinction source A or B

- Plug #1 prevents logging over reservoir, e.g. cement log or noise log
 - More inflow tests:
 - **Results:**
 - Source inconclusive
 - Low inflow rates (0.4 l/min)
 - **Decision:** low flow rates manageable.
- Set additional plug
and continue abandonment.



EXECUTION: LOG PRODUCTION CASING

Objectives:

At planned cutting depth:

5A. Identify solids

5A. Check casing centralisation (flush casing)

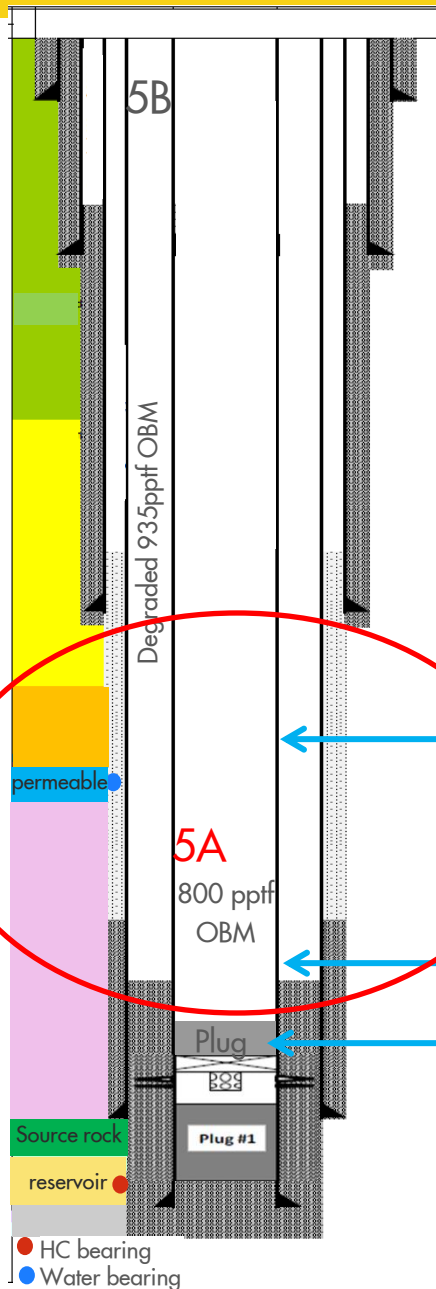
Below hanger:

5B. Check absence annular gas

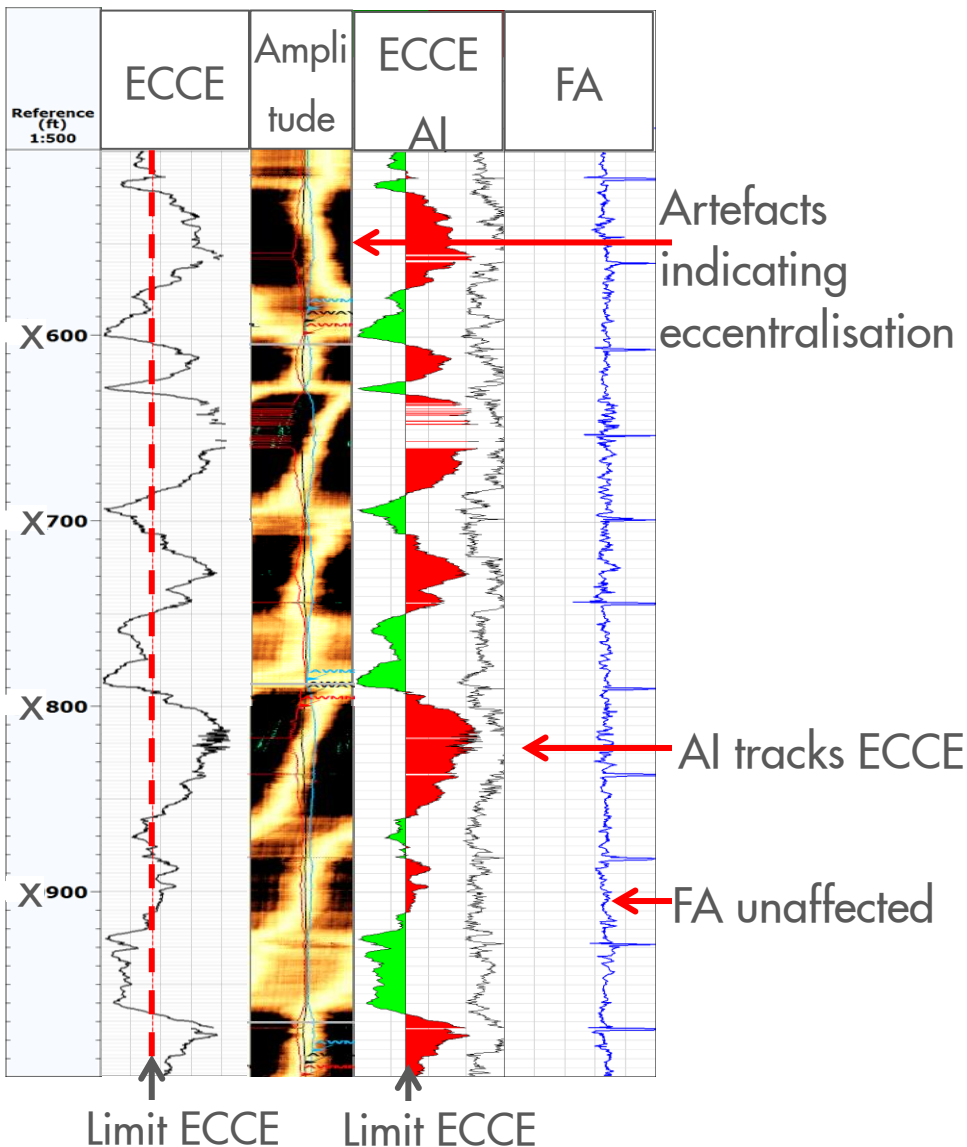
Planned depth plug #3

Cutting depth additional plug

Plug to safely suspend operations due to bad weather



LOG QC ISSUE



Primary objective:
Identify possible presence solids

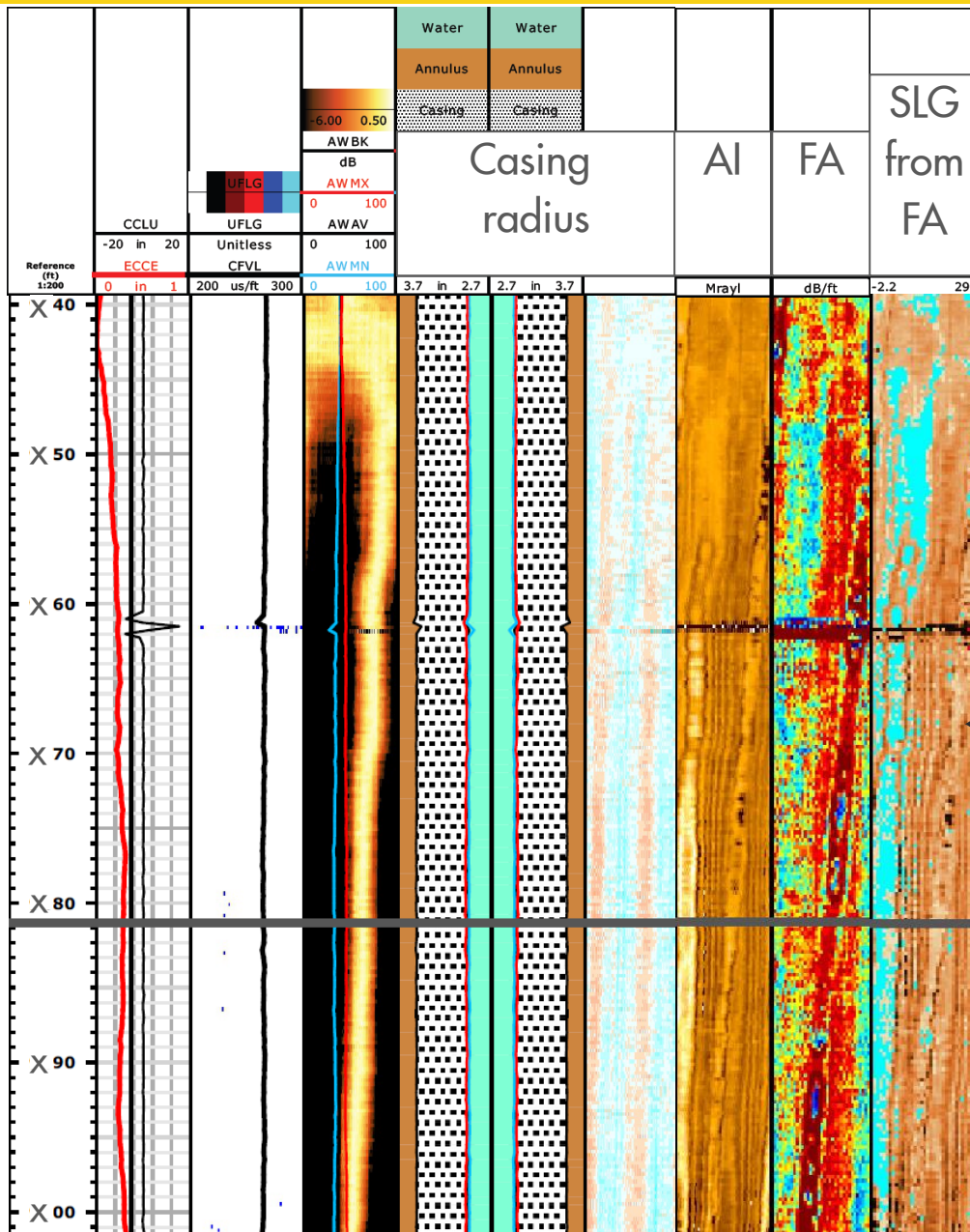
Log QC issue:
Large interval with tool eccentricity outside acoustic impedance QC limit

Consequence:

- Acoustic impedance reads too high
- False identification of solids
- FA not affected (higher tolerance)

ECCE= tool eccentricity
AI= acoustic impedance
FA= flexural attenuation

AT PROPOSED CUTTING DEPTH: SOLIDS



Primary objective:
Absence/presence solids

AI affected by ECCE
but also FA shows
presence of solids

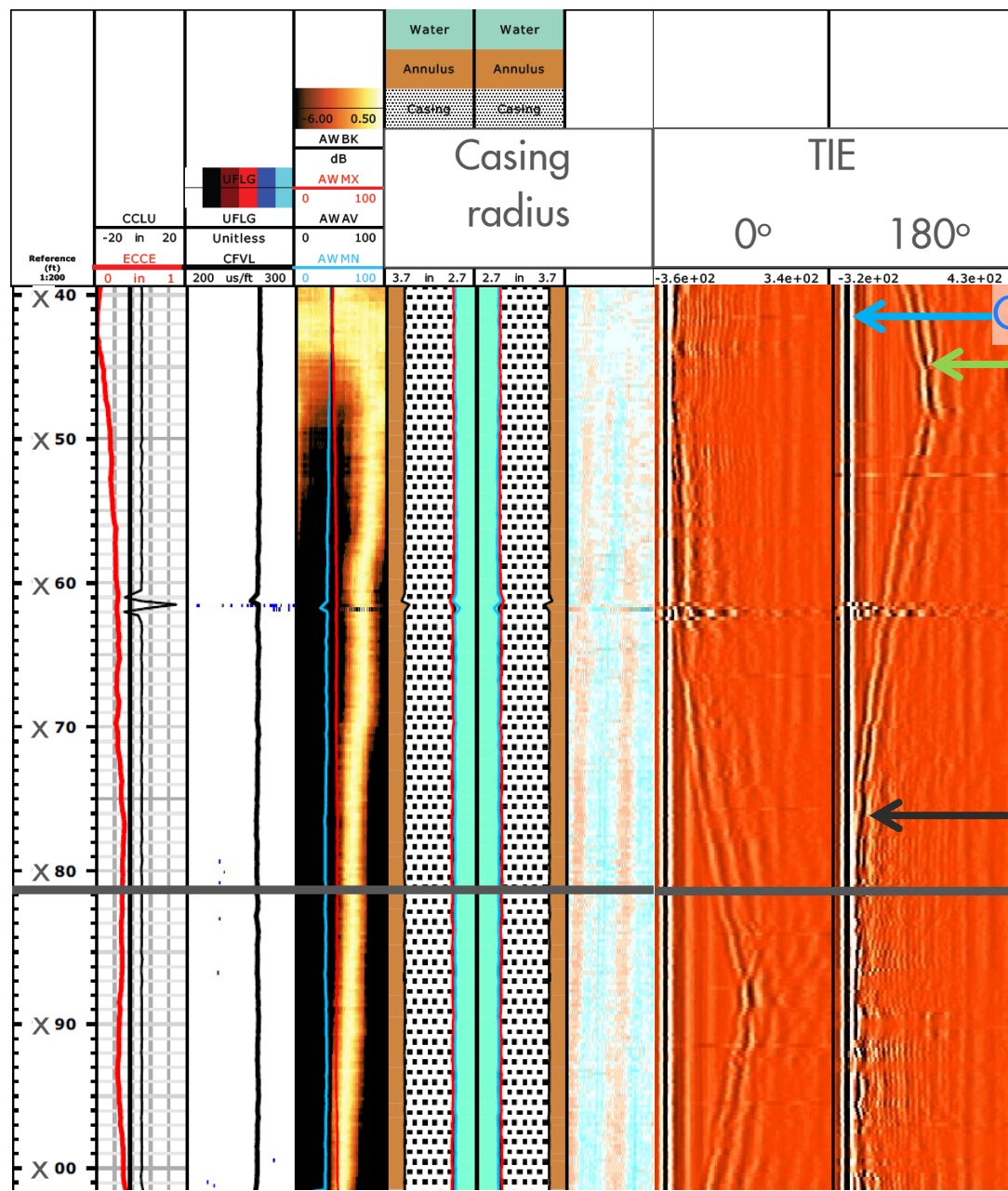
Proposed cutting depth

SLG= solid-liquid-gas map

AT PROPOSED CUTTING DEPTH

Secondary objective:
Casing centralisation

AT PROPOSED CUTTING DEPTH



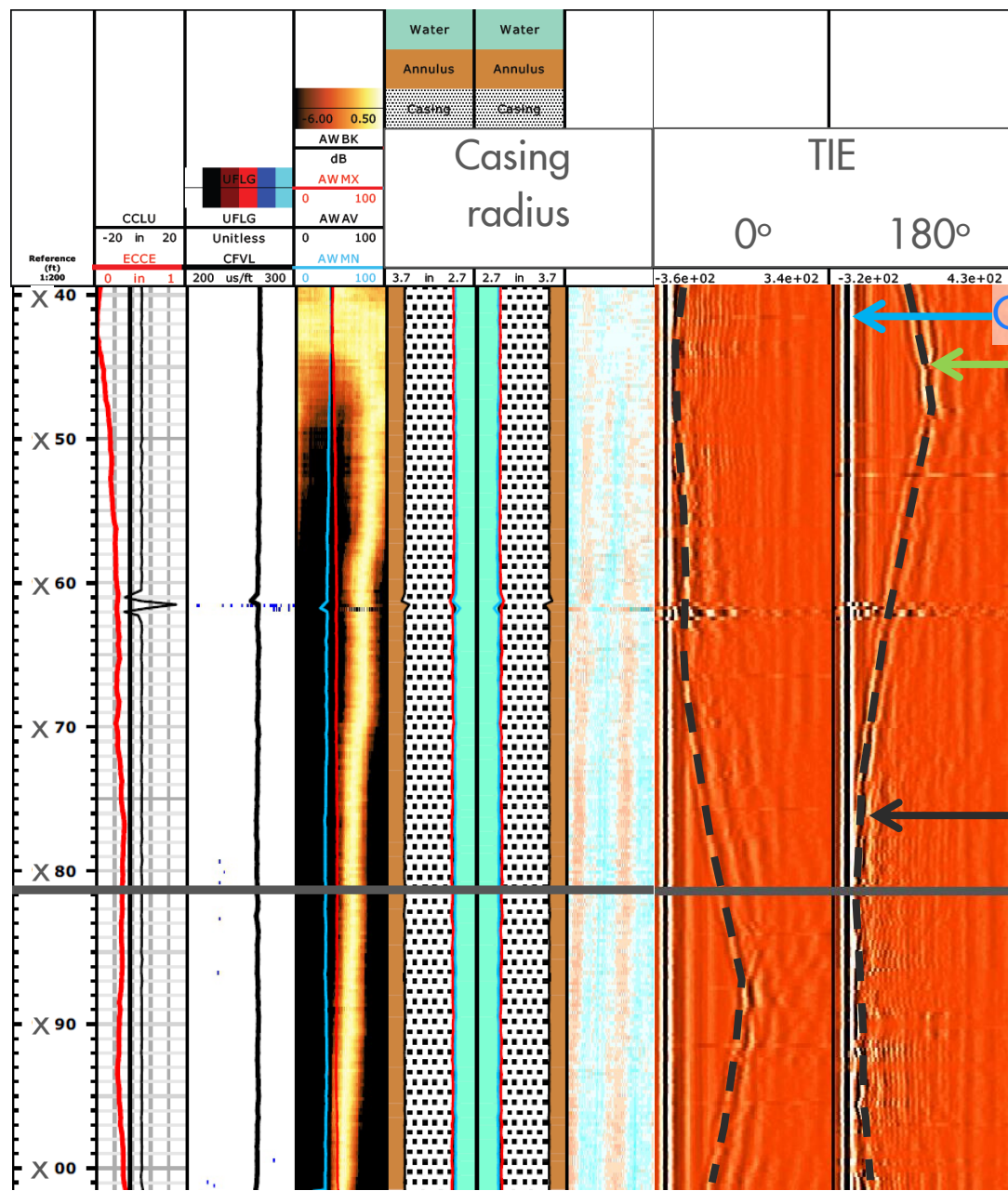
Secondary objective:
Casing centralisation

Casing
Next casing

Casings
touching
whole length

TIE= third interface echo

AT PROPOSED CUTTING DEPTH



Secondary objective:
Casing centralisation

Casing
Next casing

Casings touching whole length

TIE= third interface echo

AT PROPOSED CUTTING DEPTH

Observations:

1. Flexural attenuation indicates presence of solids at possible cutting depths
2. Production and intermediate casing in contact over large interval covering possible cutting depths

Consequences:

1. Solids would hamper pulling the casing
2. Cutting would damage the intermediate casing => exposure of formation to high mud weight => temporarily suspend the well, further work on the abandonment plan

EXECUTION: LOG PRODUCTION CASING

Objectives:

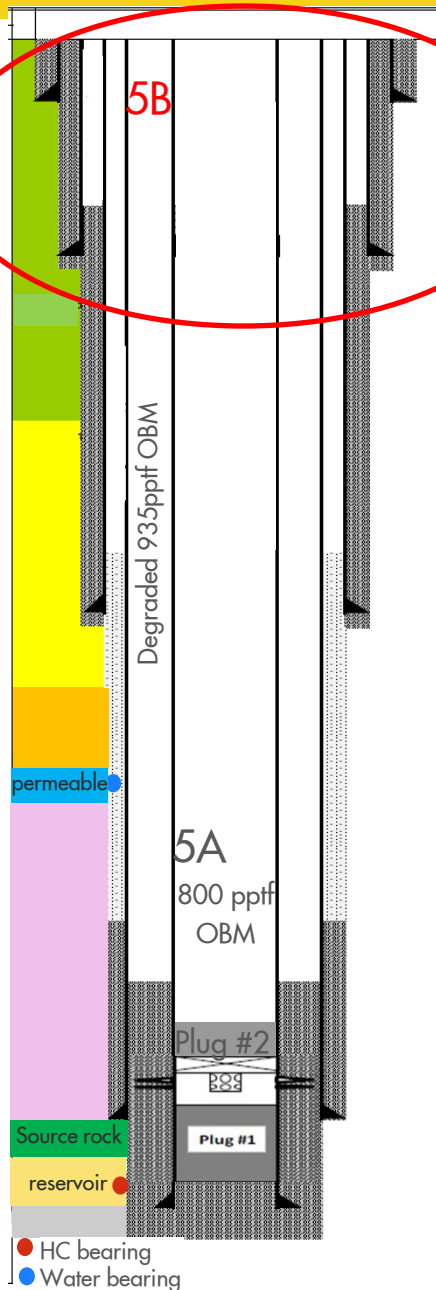
At planned cutting depth:

5A. Identify solids

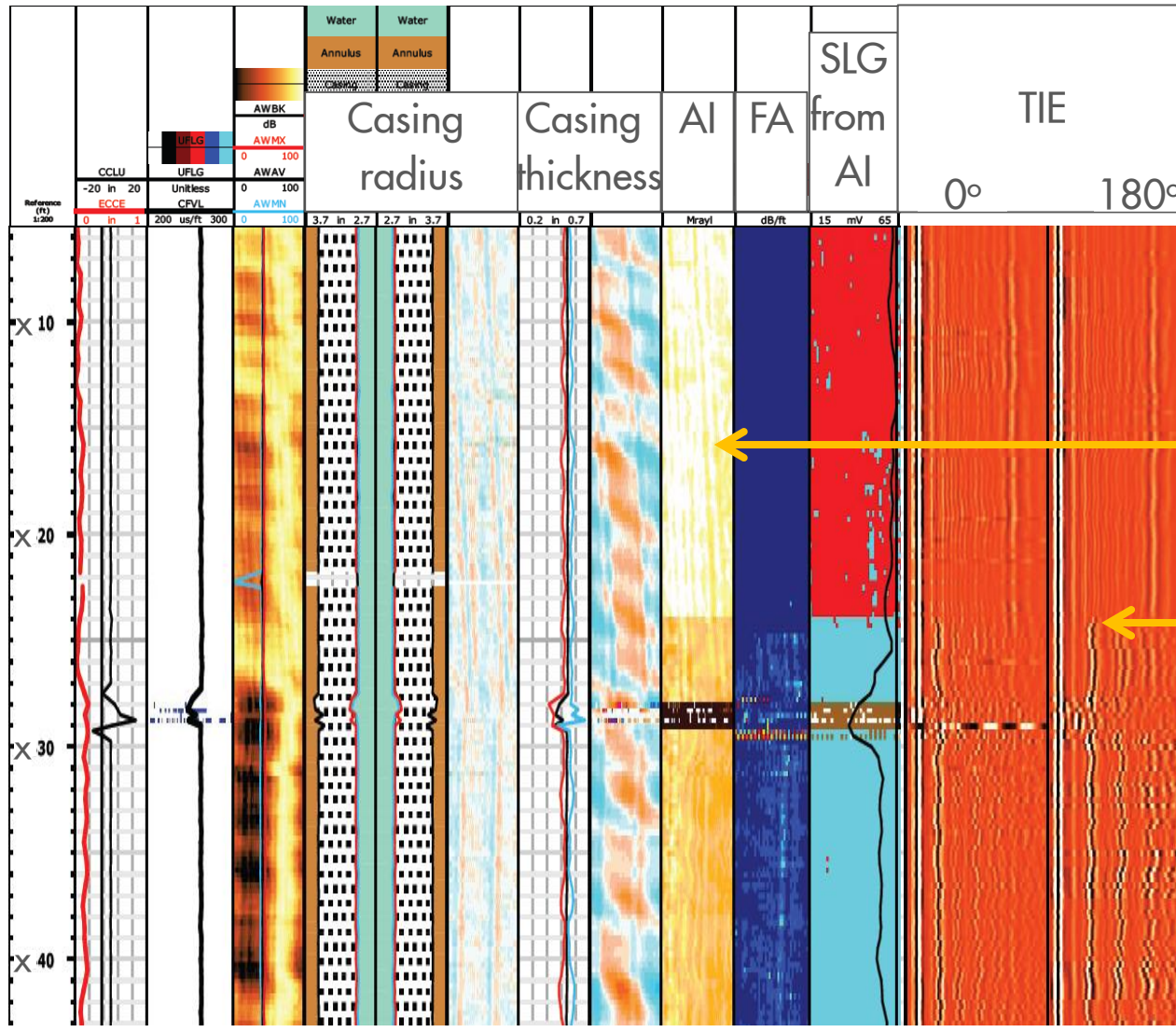
5A. Check casing centralisation (flush casing)

Below hanger:

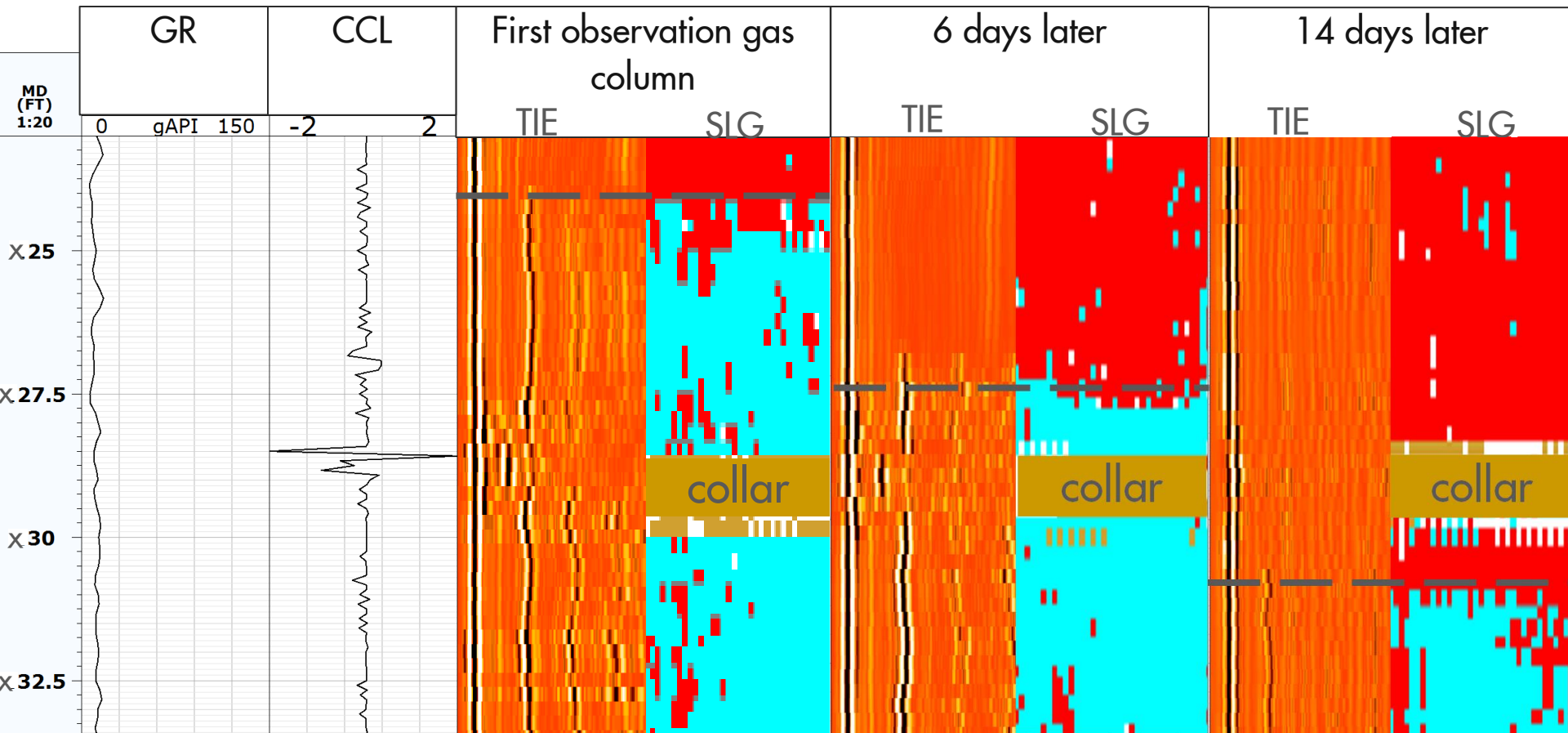
5B. Check absence annular gas



ANNULAR INTERPRETATION BELOW THE HANGER



CHANGE OF GAS/AIR/VACUUM COLUMN OVER TIME



Observations: No gas on rig arrival. Now, increasing gas/air/vacuum column in annulus

Consequence: Risk of exposure to gas/air

Decision: Temporarily suspend the well

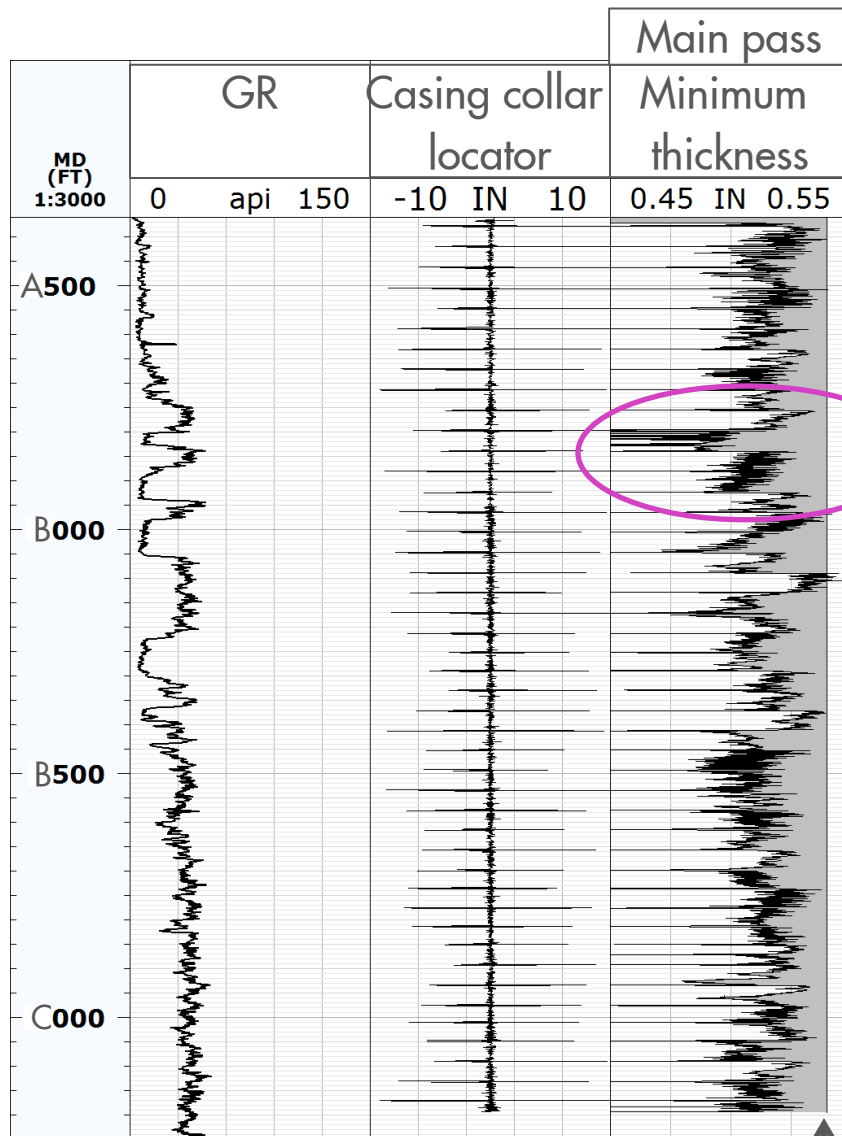
CONCLUSIONS

| | Observation | Conclusion | Decision/action |
|-----------------------------|--|---|---|
| Casing integrity above plug | 85% of original casing thickness | Casing able to withstand potential high pressure | Safely drill out shallow plug |
| Inflow tests | Gas flow but low rate | Source unclear | Continue abandonment with additional plug |
| Log at cutting depth | <ul style="list-style-type: none"> - Solids at proposed cutting depth - Casings in contact | <ul style="list-style-type: none"> - Pulling casing hampered - Risk of damaging intermediate casing | Temporarily suspend well and further work on the abandonment plan |
| Log below hanger | Gas/air/vacuum below hanger | Risk of exposure to gas/air | |

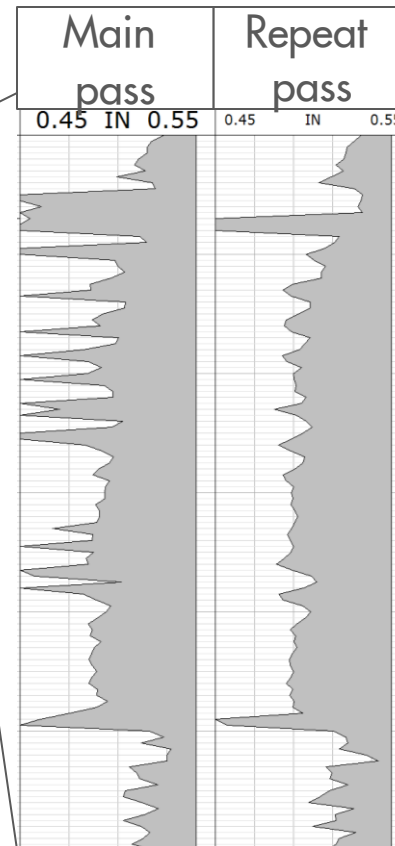
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RESULTS: CASING INTEGRITY



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Anomalies that did not repeat

Original thickness