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Aberdeen Section

Fiber-Optic Sensing for Field Development
Asset Integrity & Optimization Workshop

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Aberdeen, UK

Integrated DAS and DTS for Production and Injection Monitoring: Understanding Dynamic Fluid Behavior Across the Full Wellbore

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A LUNA company

Outline

I. Methodology

II. Production monitoring case

- Well and project information
- Production allocation DAS & DTS dataset
- DAS LF strain change vs downhole pressure gauge

III. Injection monitoring case

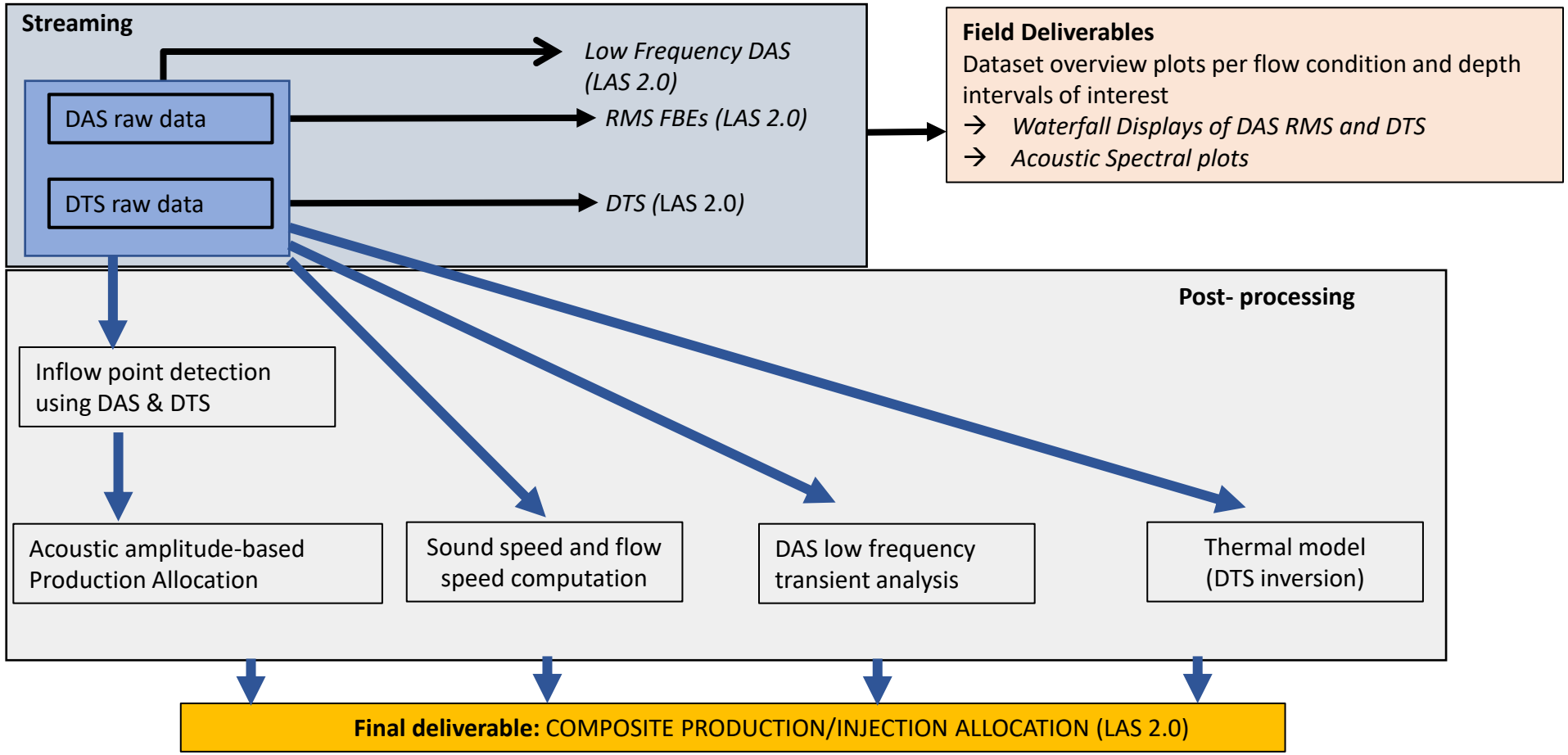
- Well and project information
- Low injection flowrate DAS & DTS visualization
- Crossflow analysis during different well conditions
- DAS based Injection allocation results

IV. Summary and conclusions

V. Q&A

Methodology

Data processing workflow - flow monitoring

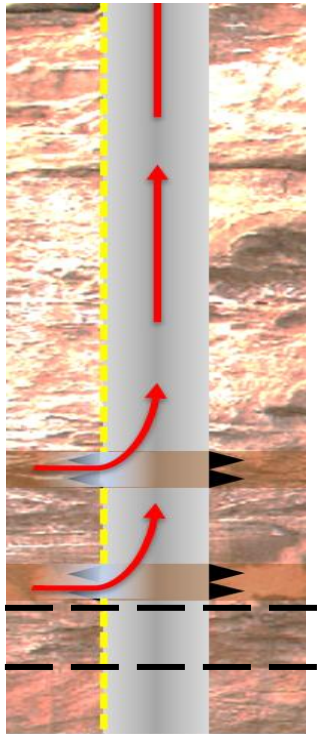


Methodology

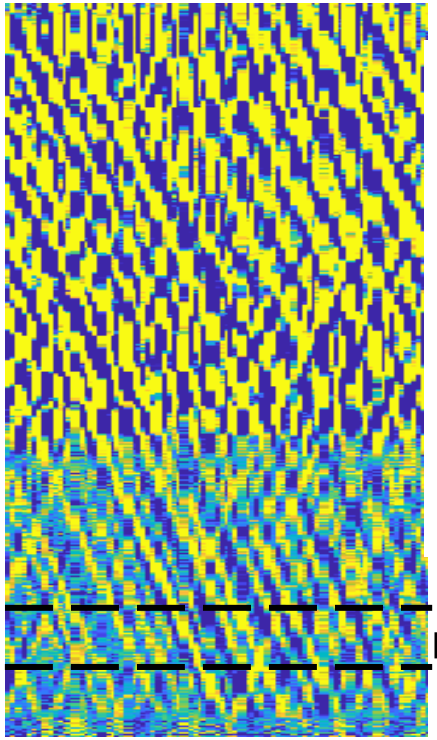
Data processing workflow - flow monitoring workflow

Theory on SOS measurements and Doppler derived Flow Speed

Well schematic

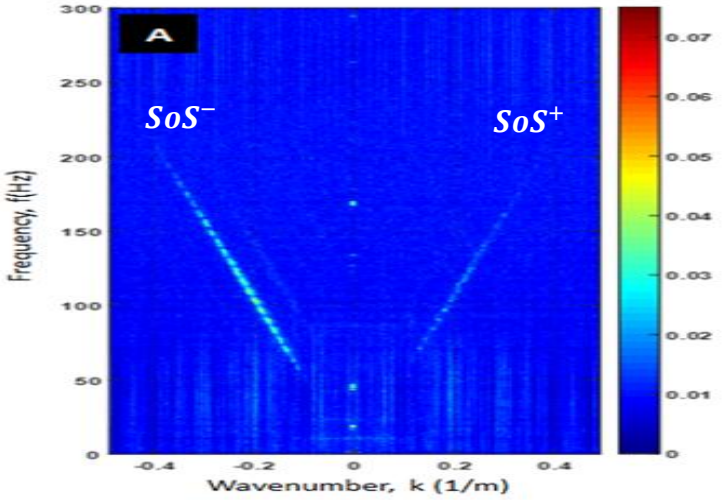


Acoustic waterfall

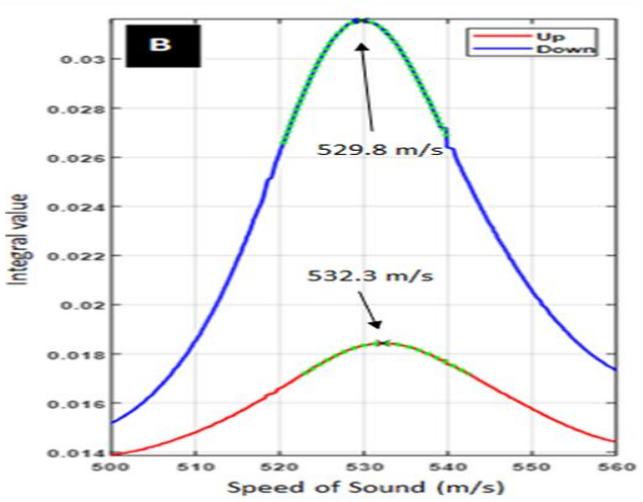


Time

Kw plot: 2-D FFT of the acoustic data data



Radial scan of the kw plot



$$SoS^+ = c + v$$

$$SoS^- = c - v$$

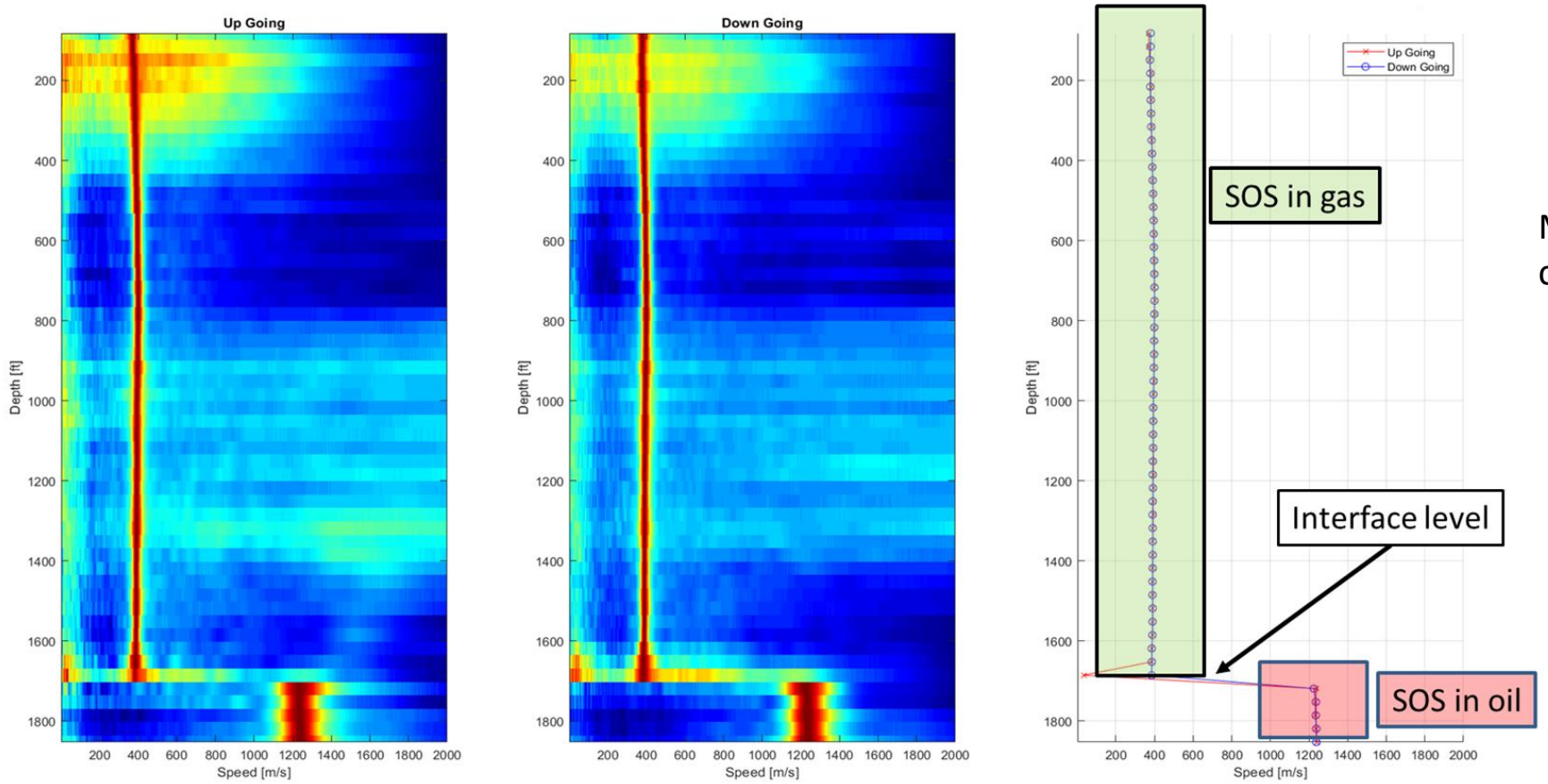
Average SOS, $$c = \frac{SoS^+ + SoS^-}{2}$$

Flow velocity, $$v = \frac{SoS^+ - SoS^-}{2}$$

Methodology

Data processing workflow - flow monitoring workflow

Oil-Gas liquid level interface monitoring via Speed of Sound monitoring



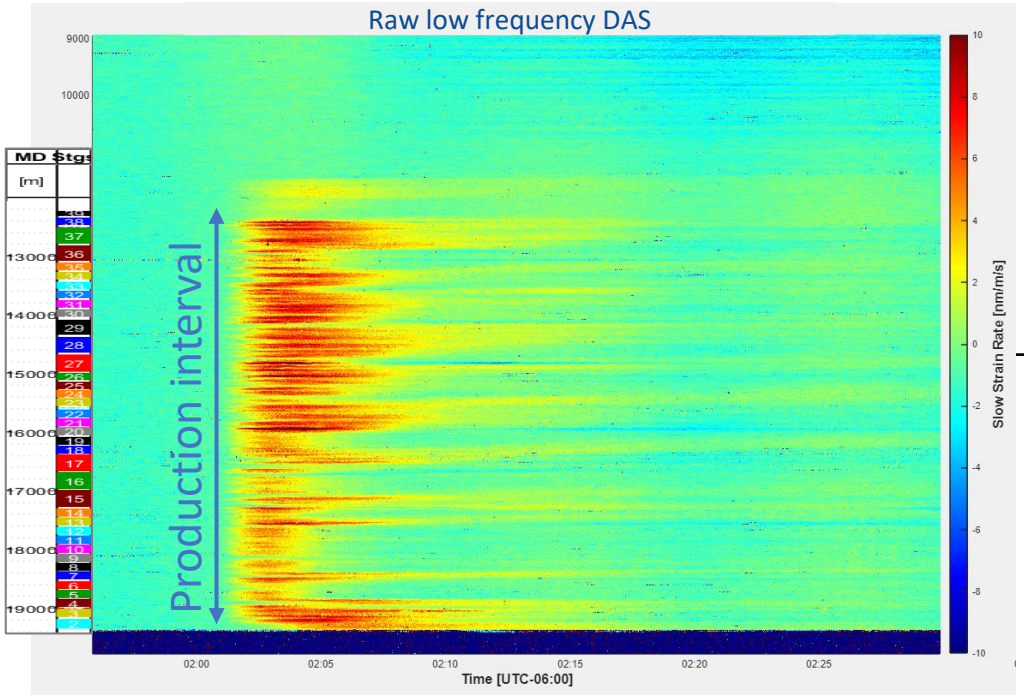
Monitoring of both Fluid composition & Liquid level

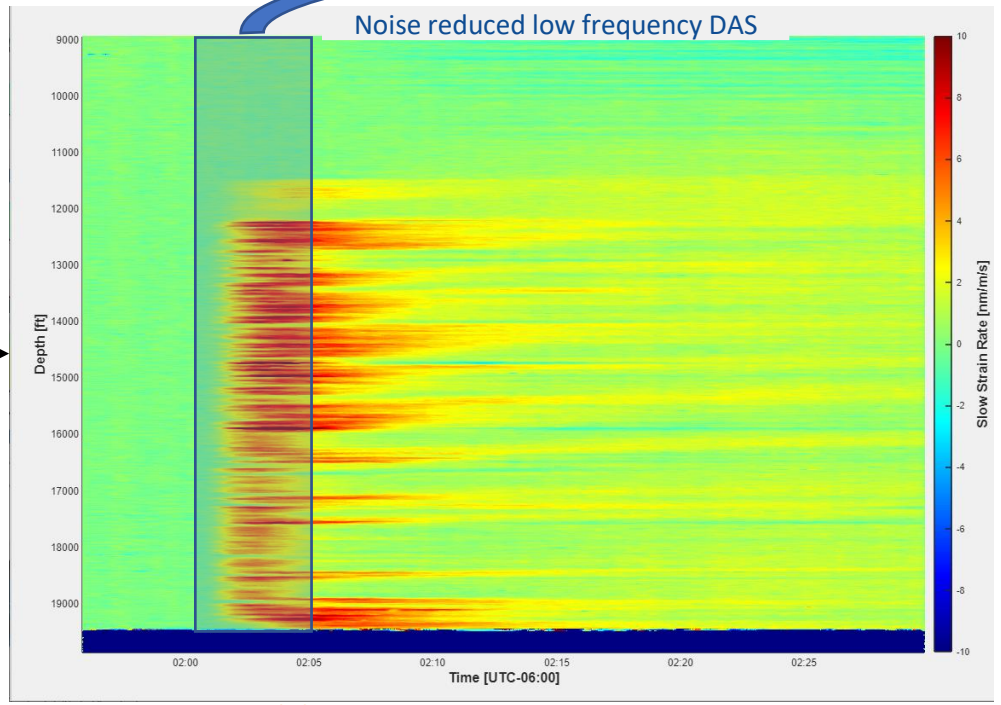
Methodology

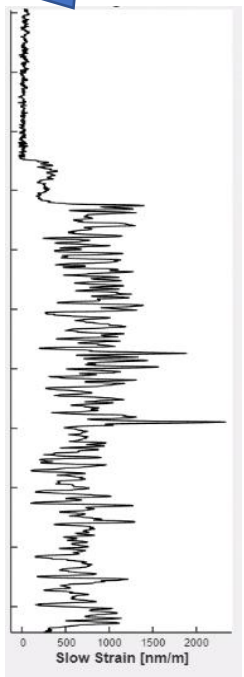
Data processing workflow - Flow monitoring workflow

Low frequency DAS transient analysis

Low frequency DAS → Noise Reduction → Integrate over selected time period → Integrated Low frequency DAS





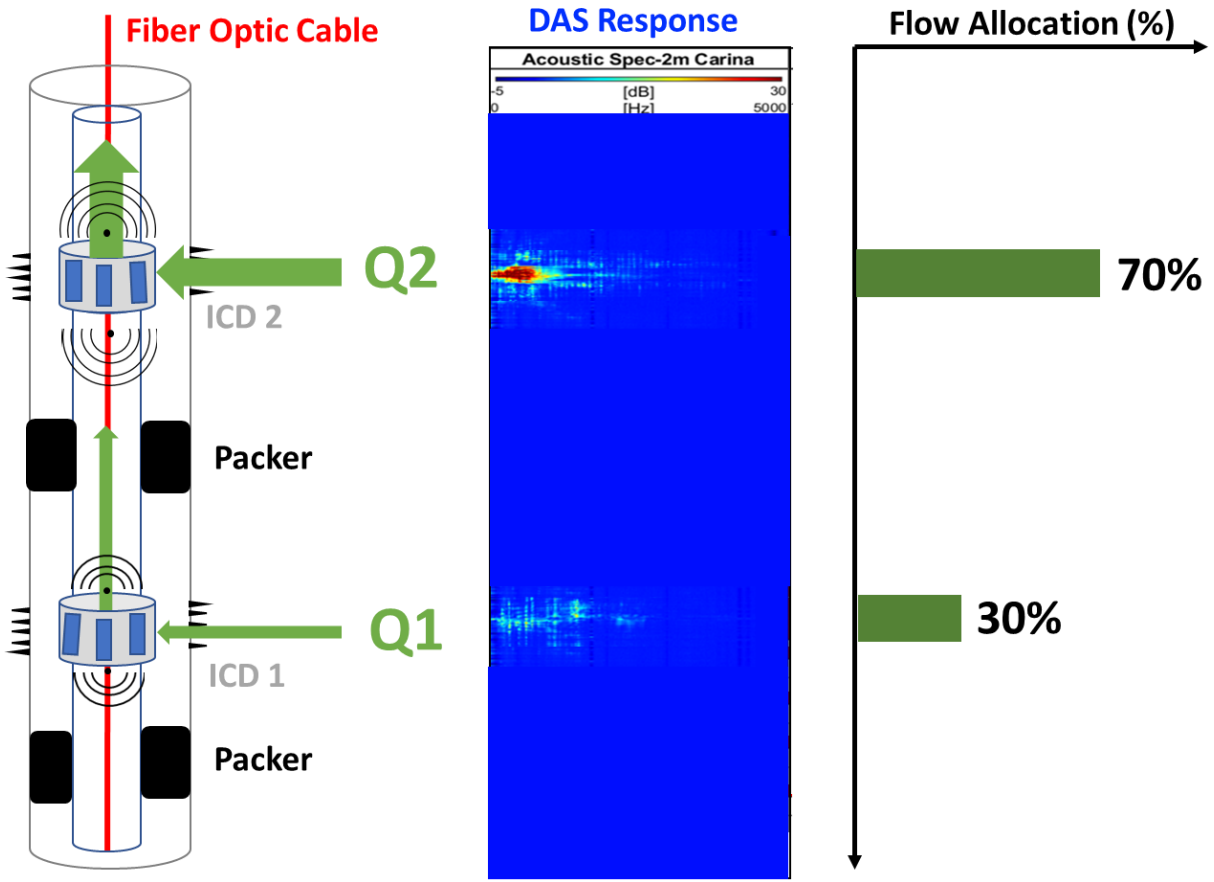


* Example taken from a previous dataset

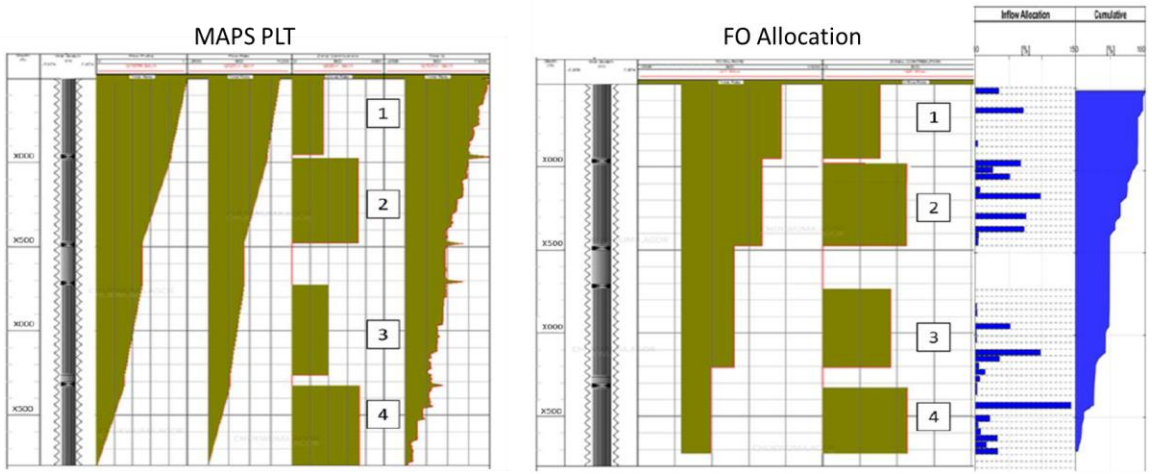
Methodology

Data processing workflow - flow monitoring workflow

Production allocation using DAS noised-based logging



Comparison between PLT and FO allocation

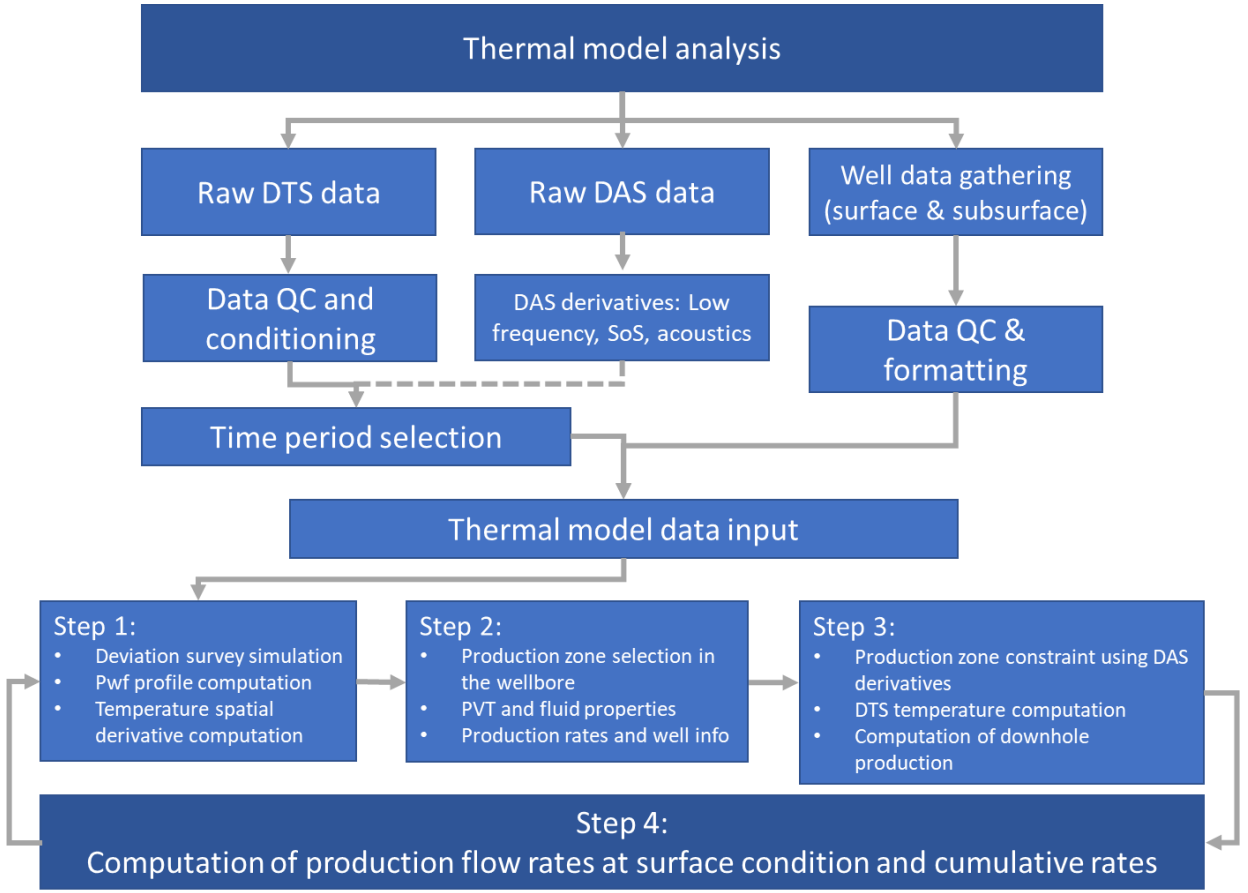


Hveding, F., 2020, ADIPEC November 2020, ***SPE-203267-MS***.
Production Flow Comparison Between Distributed Fiber-Optic Sensing and Conventional PLT in a Cased Hole Horizontal Wellbore With ICD;

Methodology

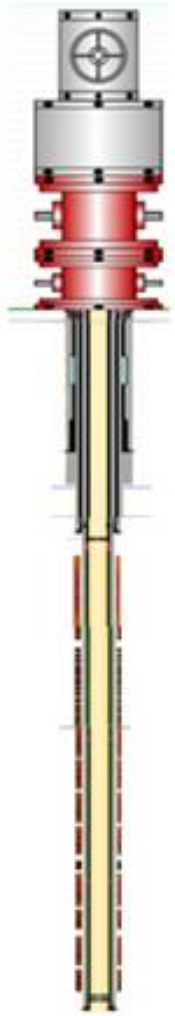
Data processing workflow - flow monitoring workflow

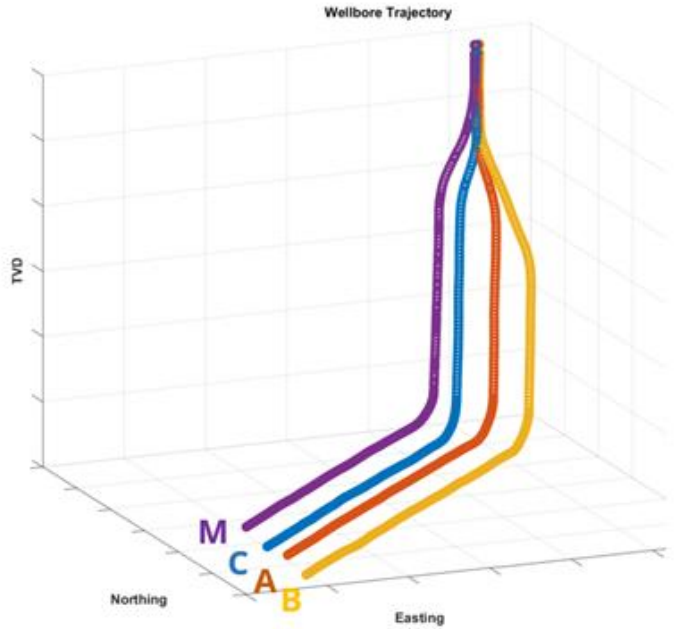
Production allocation thermal modelling using DTS & DAS derivatives



1st Case study - Producer

Well information





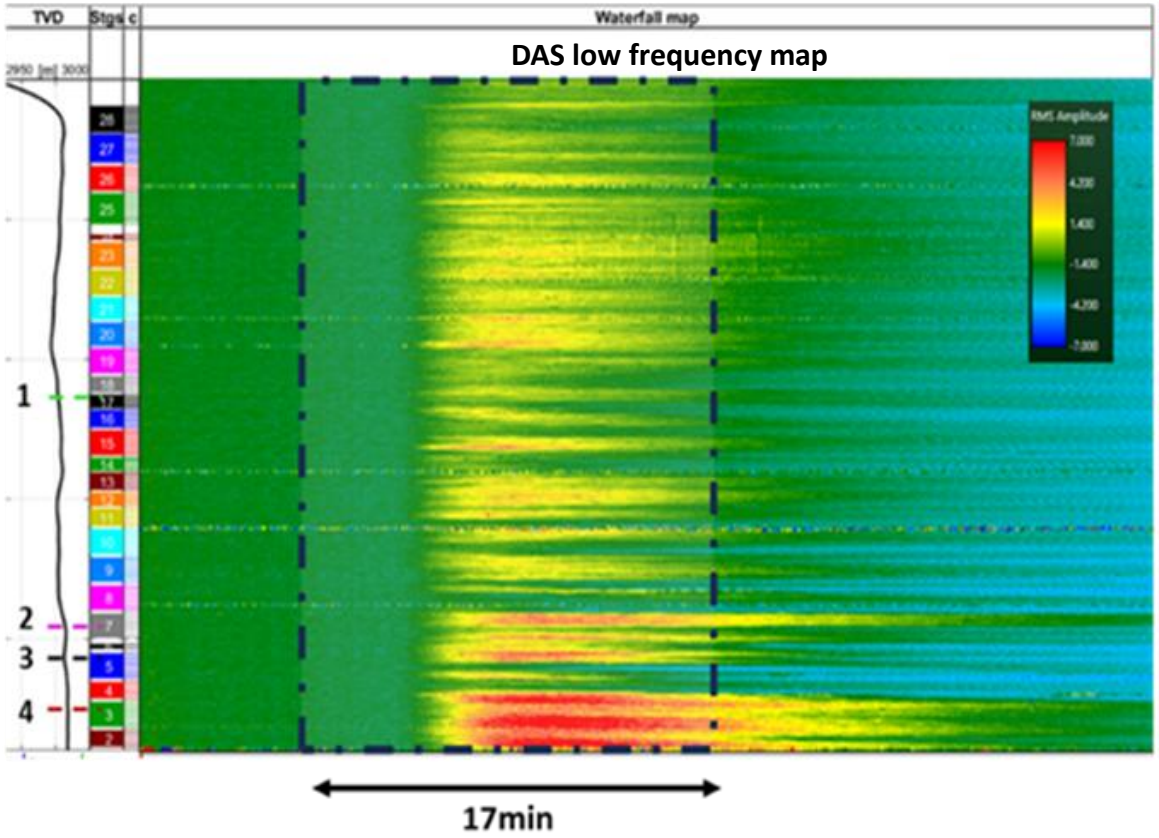
- Montney, northwestern Alberta, Canada
- Horizontal Gas condensate to volatile oil
- Ball drop/open hole packer system to cemented plug & perf limited entry
- Deployment method: permanent fiber optic system

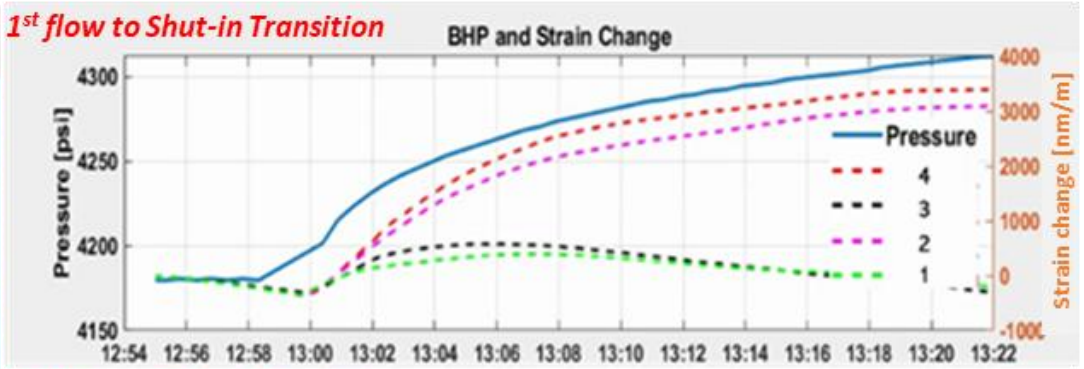
Objectives

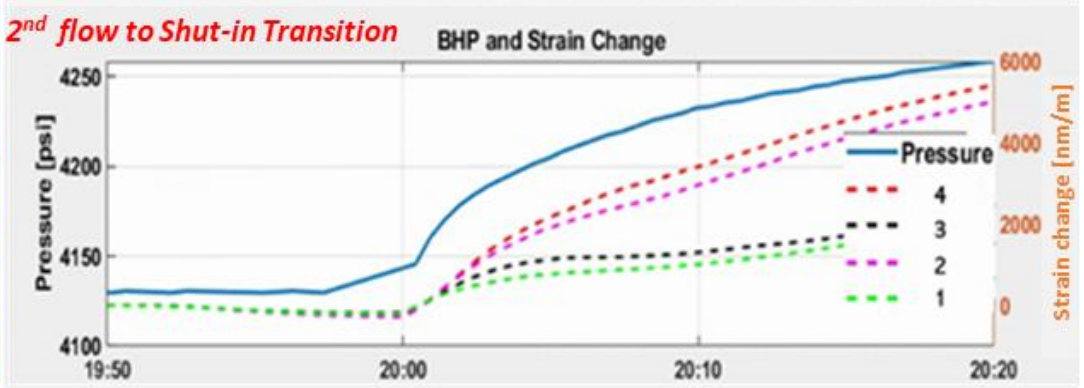
- Production allocation and cluster efficiency evaluation

Dawson, P, Jimenez, E, Mahue, V, Kitchen, J, Mehrok, M, Zinselmeyer, R, Wygal, B. **URTeC June 2024 4054931** "Repeat DAS and DTS Logging for Production and Cluster Efficiency Evaluation on a Gas Condensate Producer in the Montney Formation." https://silixa.com/resources/technical-papers/

DAS Slow Strain Transient Analysis Flow To Shut-in transitions vs downhole pressure gauge response

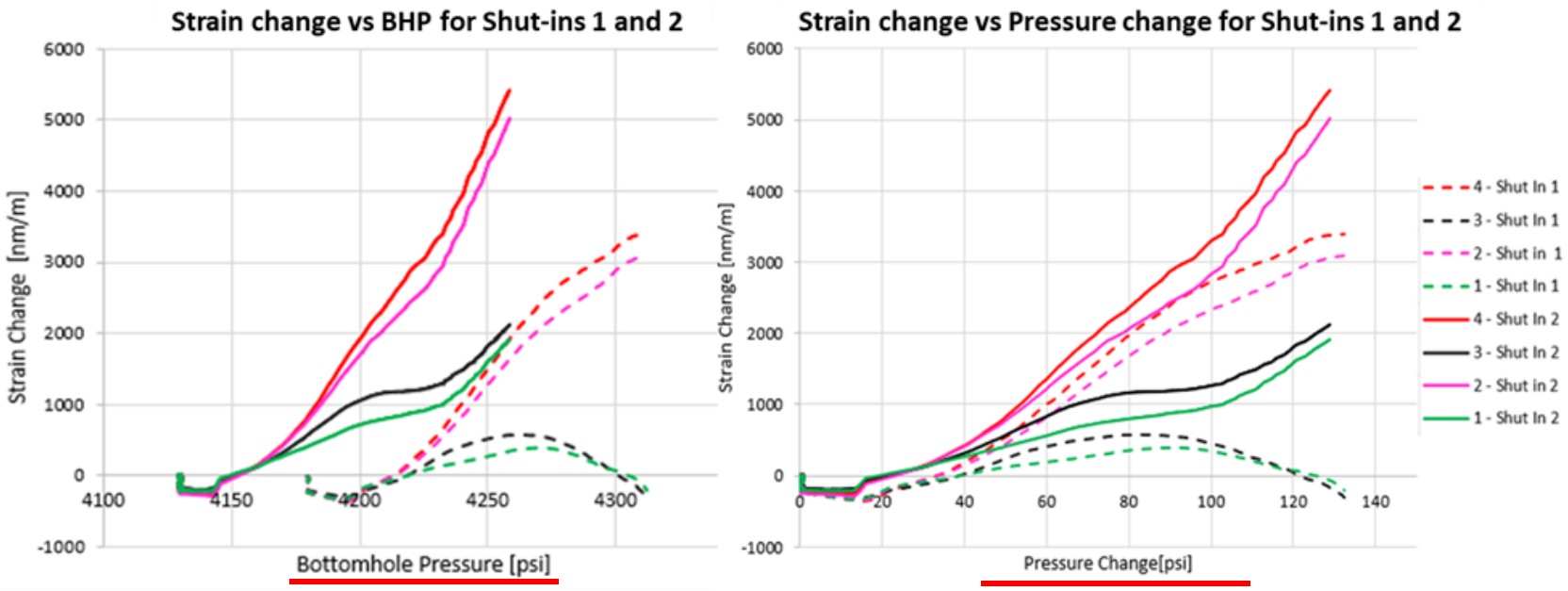






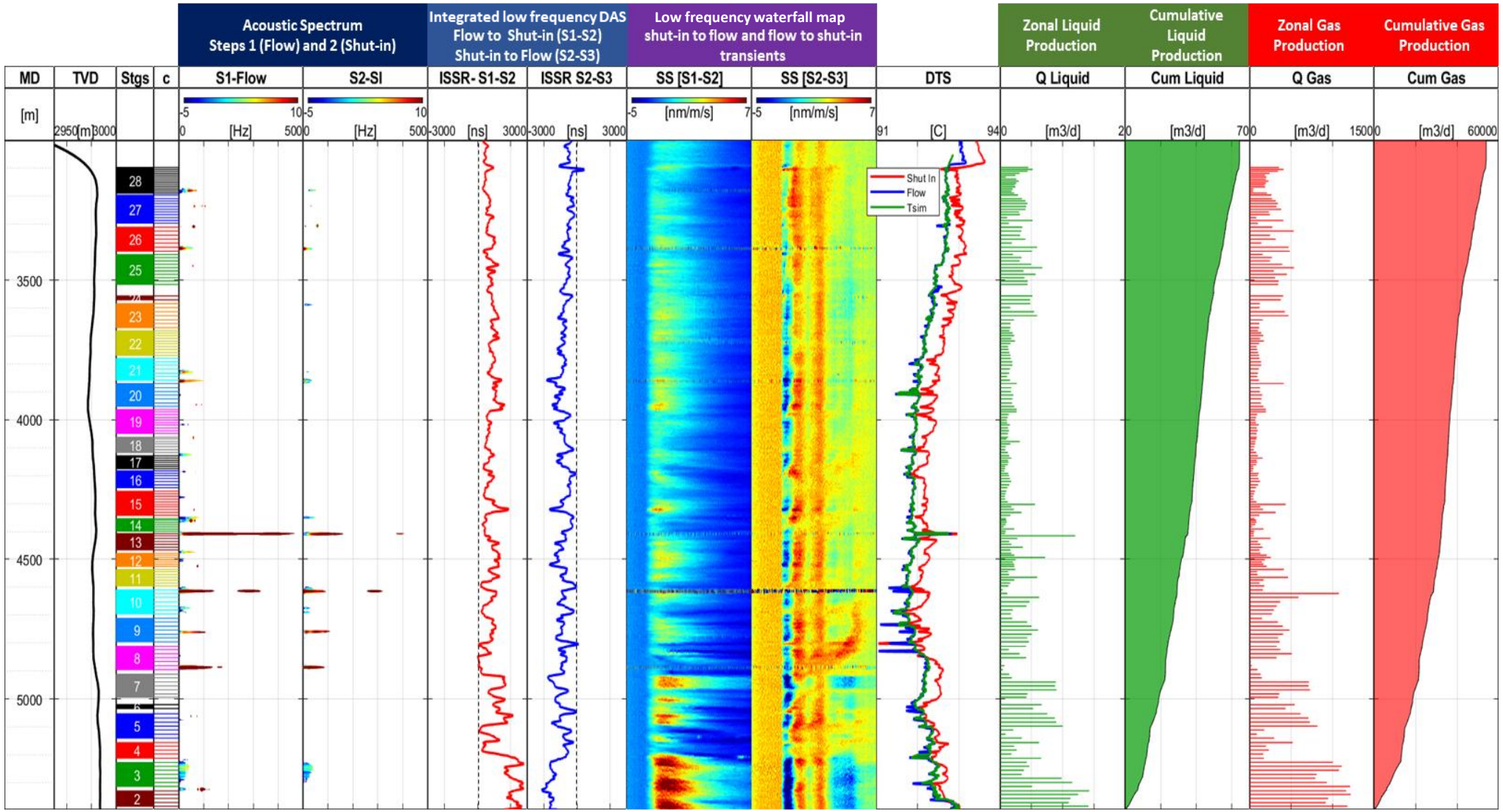
- Localized strain increases over the lateral as the well transitioned from flow to shut-in
- Permanent DH Press at the **heel**
- Good relationship between BHP and strain changes at zones 2 and 4. Zone 1 and 3 did not follow the same trend

Strain Change vs. downhole pressure gauge



- The second shut-in displays a higher level of strain changes achieved by all zones
- For the same pressure change, the strain change can exhibit multiple values, possibly due to the difference in fracture conductivity, fracture geometry such as width and height, as well as the fluid type flowing through the fracture

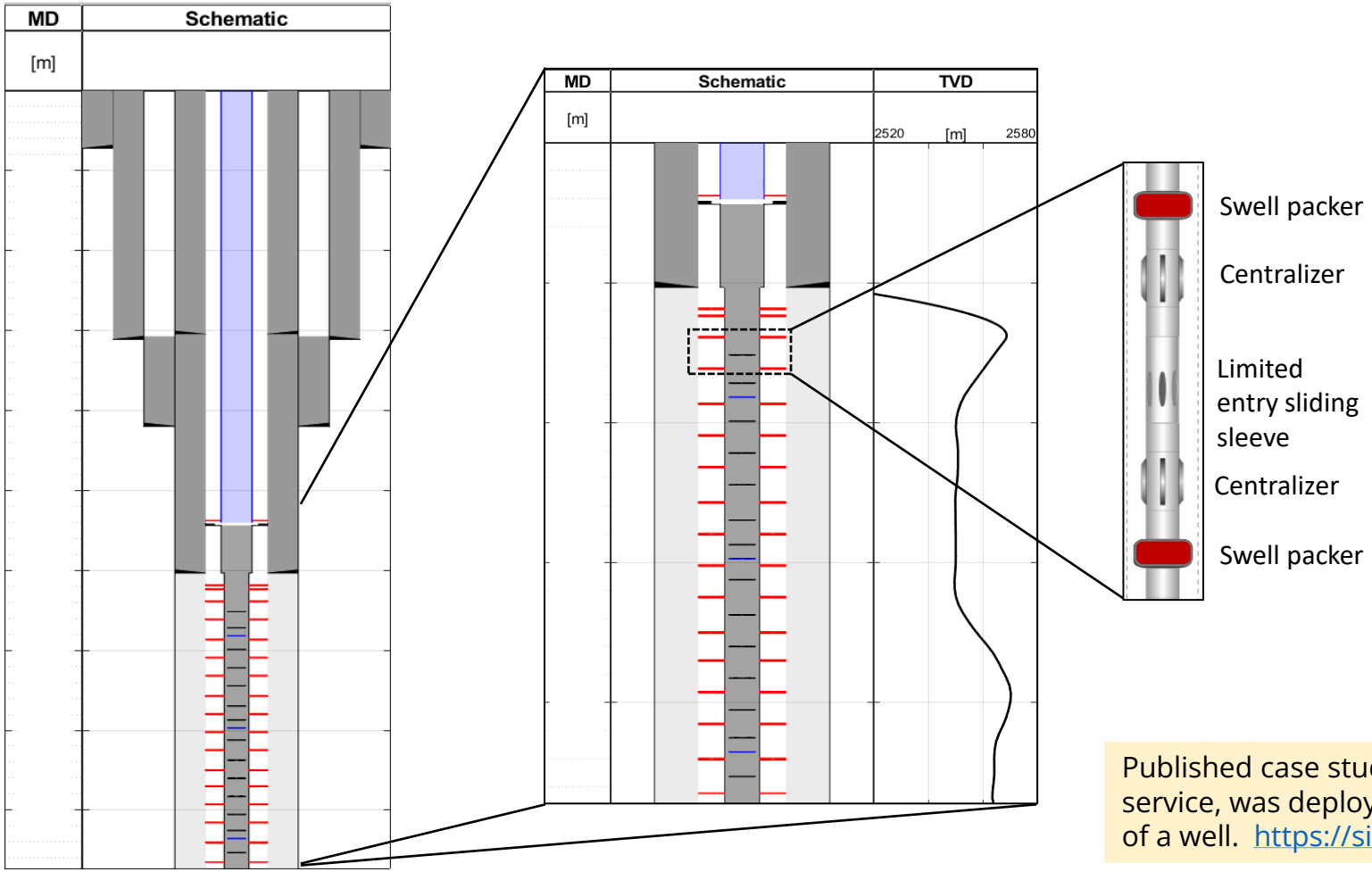
Production allocation in multi-frac well with low acoustic response



- Stages 2,3,5,7,10,25, and 28 showed higher level of gas and oil production
- Stronger strain change from the toe stages
- Weak acoustic response

2nd Case study – Injector well

Well information

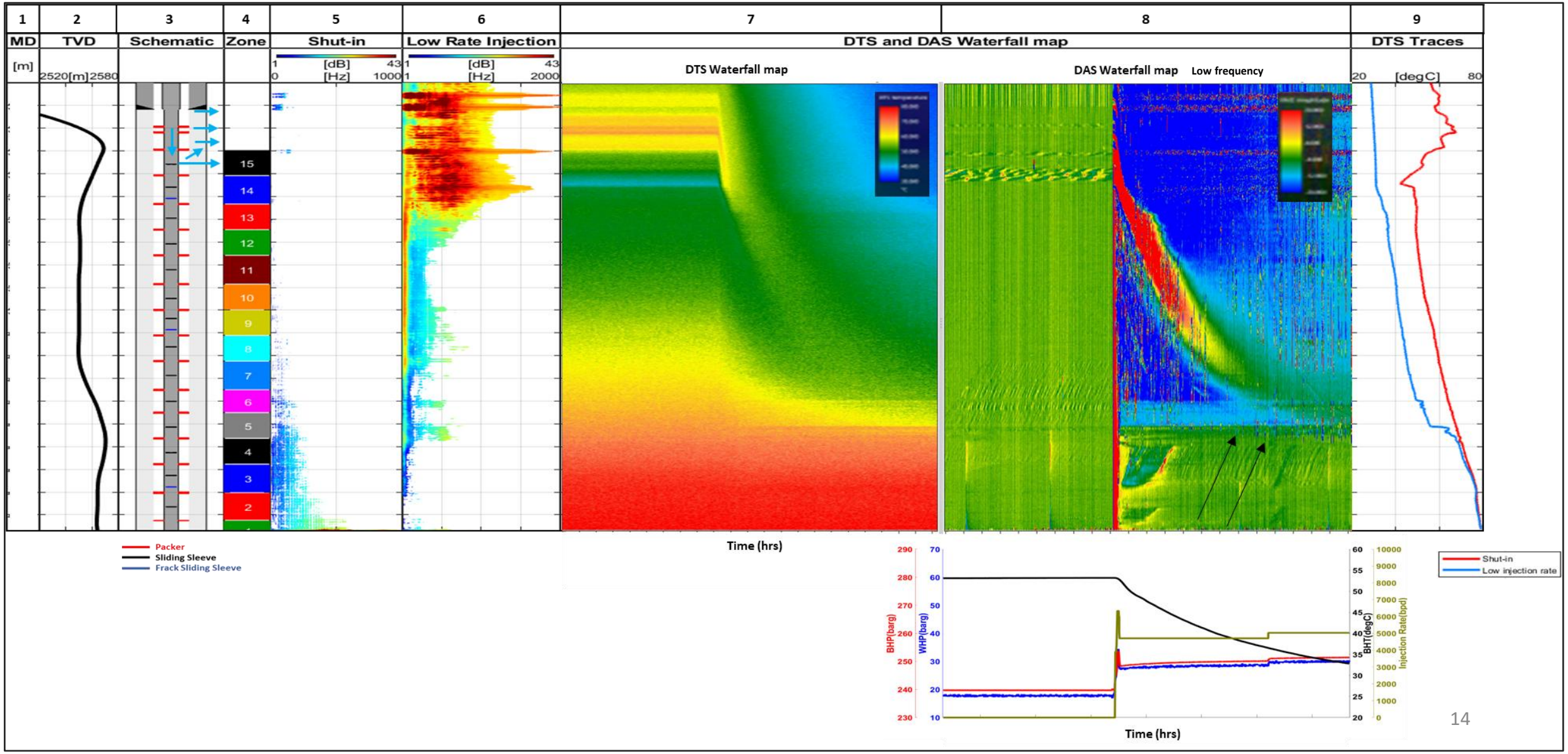


- Horizontal water injection well in the North Sea
- Drilled through formation A into formation B
- Provide pressure support & improve sweep efficiency in formation B
- 15 limited entry sliding sleeves
- Each sliding sleeve zone is isolated by swellable packers

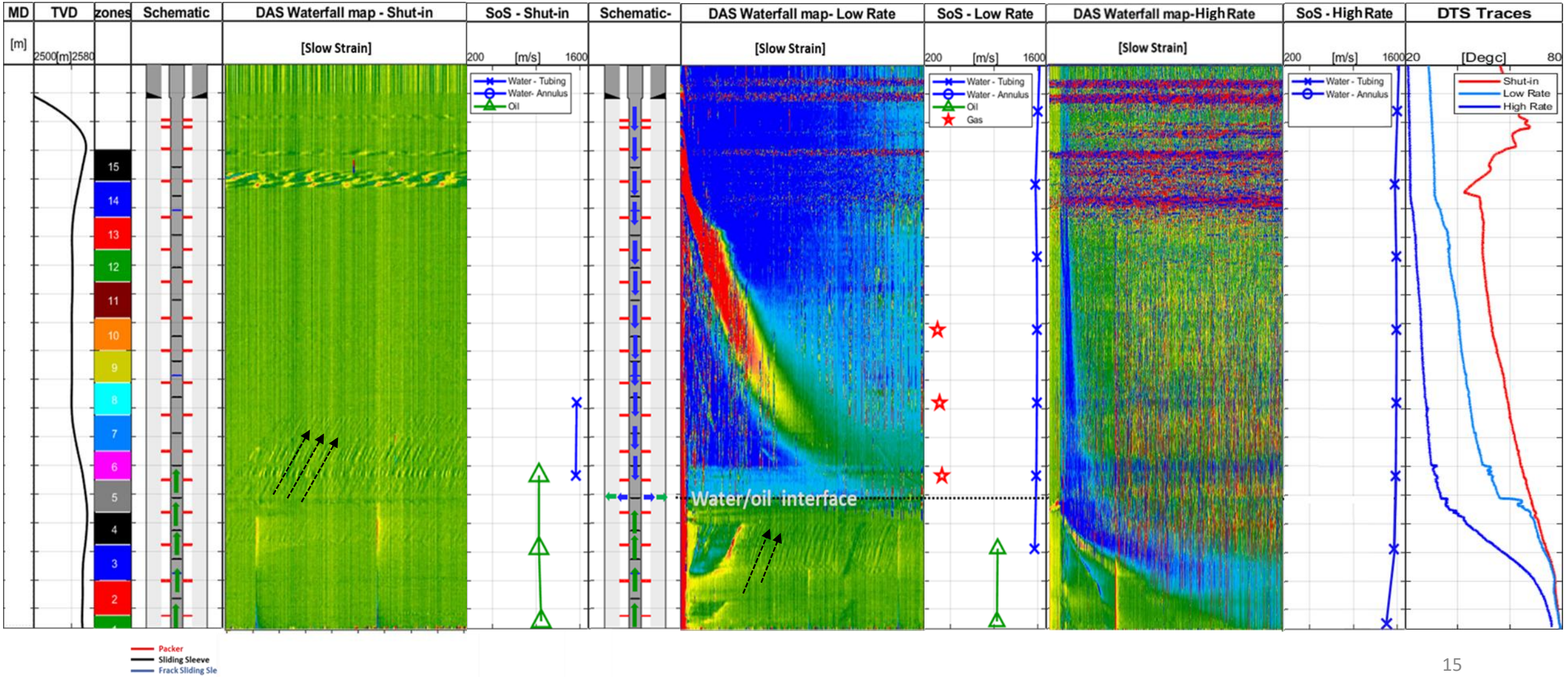
Objectives:

- Data acquisition (ILT) to understand injection profile in the wellbore.

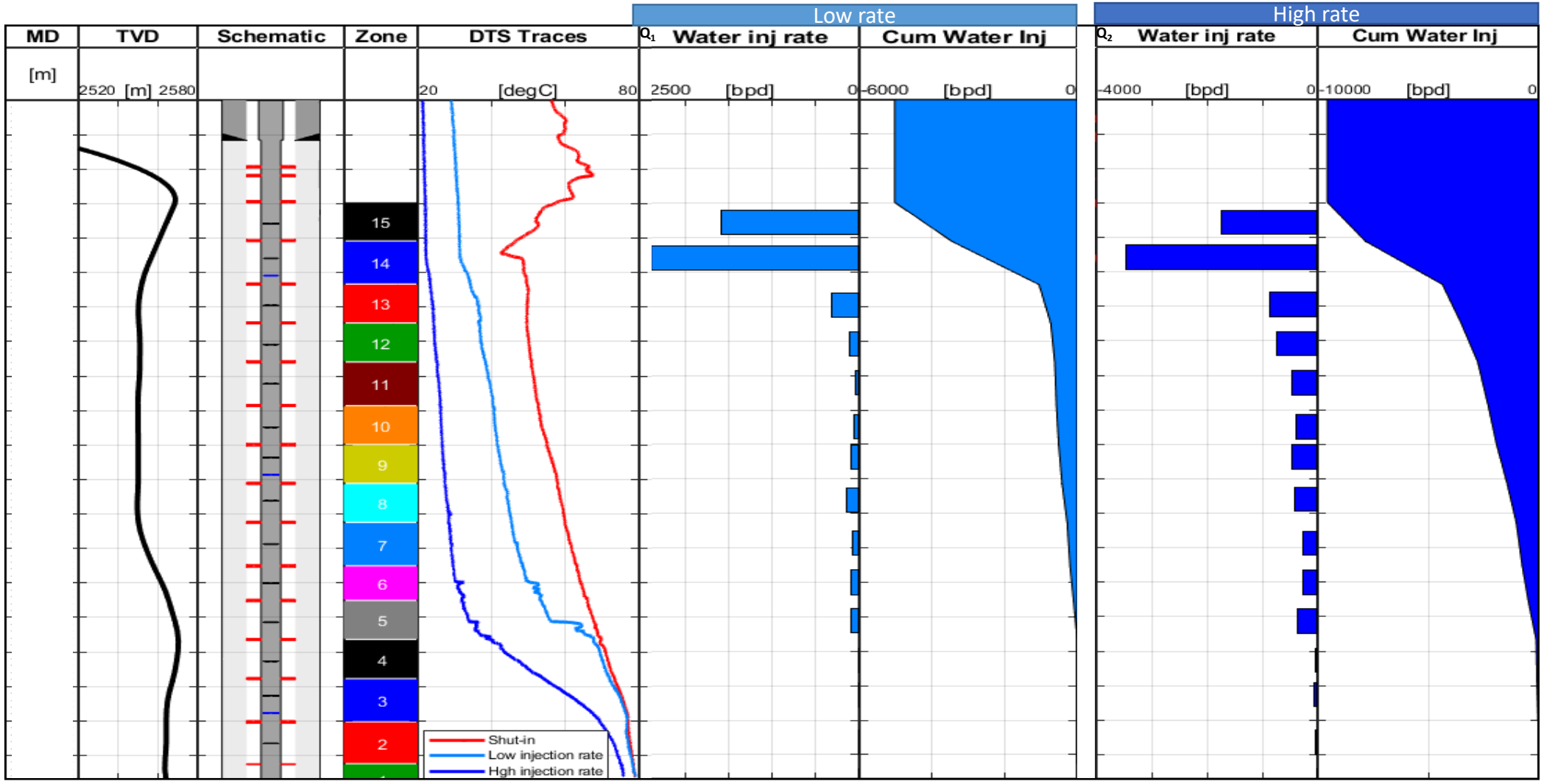
Published case study: Carina® 100xLog, the retrievable fibre optic well logging service, was deployed for AkerBP to identify the root causes of underperformance of a well. https://silixa.com/sectors/energy/oilfield-services/carina-100xlog/


1
2
3
4
5
6
7
8
9
MD
TVD
Schematic
Zone
Shut-in
Low Rate Injection
DTS and DAS Waterfall map
DTS Traces
[m]
2520[m]2580
[dB]
[Hz]
1
43
0
1000
2000
DTS Waterfall map
DAS Waterfall map
Low frequency
20
[degC]
80
15
14
13
12
11
10
9
8
7
6
5
4
3
2
Packer
Sliding Sleeve
Frack Sliding Sleeve
Time (hrs)
BHP(barg)
WHP(barg)
BHT(degC)
Injection Rate(bpd)
Shut-in
Low injection rate
Time (hrs)

Crossflow analysis during Shut-in, low and high-rate injection



Results: DAS based allocation, Low-Rate and High-Rate Injection



Conclusions

Production case:

- **LF DAS for Zonal Resolution**: Effectively characterizes zonal production in environments with weak acoustic signals.
- **LF DAS Strain-Pressure correlation**: Demonstrates a strong, non-linear correlation between LF DAS strain transients and downhole pressure changes (flow-to-shut-in).
- **Integrated Allocation methodology**: Achieves robust final allocation by combining DAS derivatives with DTS thermal modeling.

Injection case:

- **Real-time Flow Diagnostics**: Real time visualization enables immediate flow efficiency evaluation and targeted zone identification during acquisition.
- **Crossflow Resolution**: Integrated DAS/DTS successfully characterizes complex wellbore dynamics, including toe-zone oil inflow during shut-in and low-rate injection.
- **In-Situ Phase Discrimination**: Speed of Sound computation provides robust fluid identification across different operating conditions.
- **Injectivity Profiling**: Combined acoustic and thermal data accurately map injection depth limits, confirming minimal fluid uptake in lower zones.

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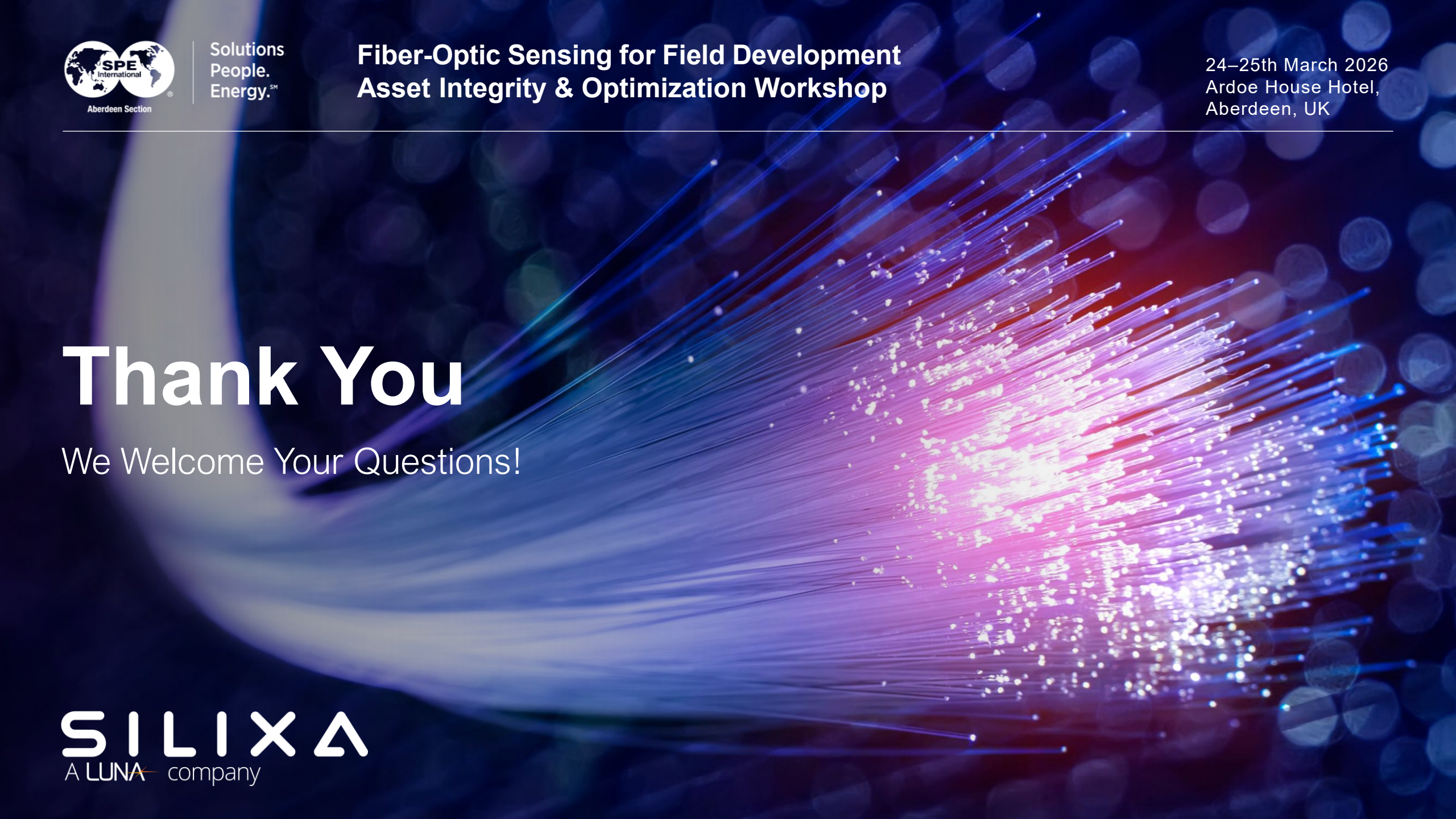

Thank You

We Welcome Your Questions!

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