New world records in 4D seismic using innovative digital subsurface solutions

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Geophysicist, Lundin Energy Norway / AkerBP

Schlumberger Digital Forum 2022
KKL Luzern, Switzerland
September 20th, 14:45pm
Subsurface Characterization

What is actually 4D time-lapse seismic?

Garden photo with Chico taken @ 12:10pm

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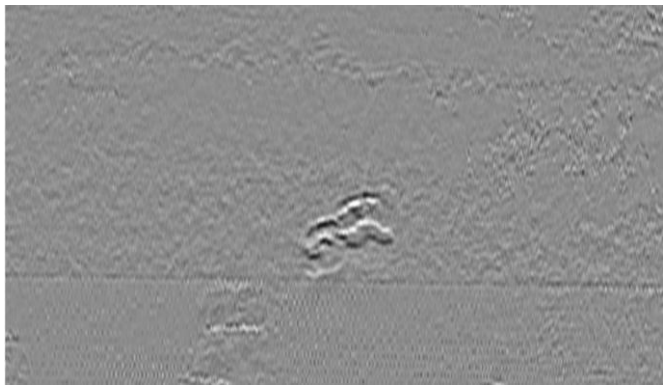
Two photos, converted to seismic and then subtracting these two from each other



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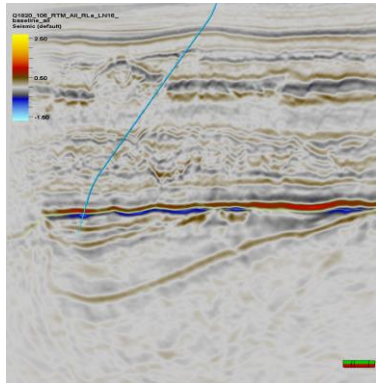
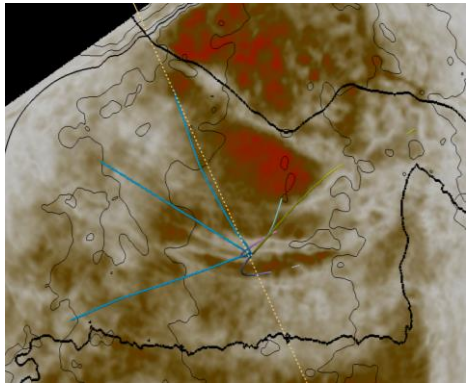
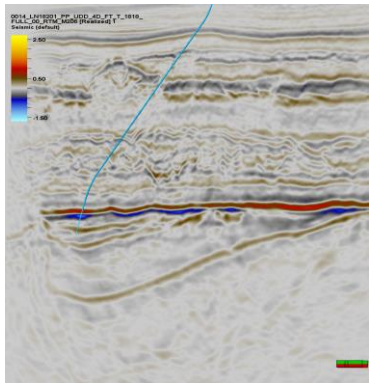
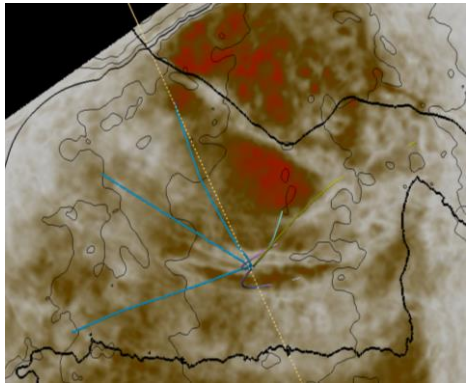
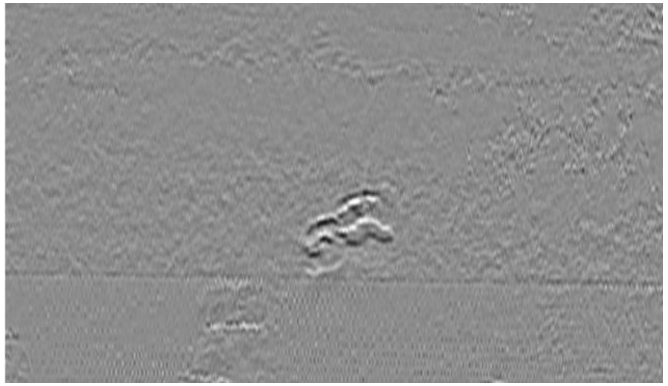
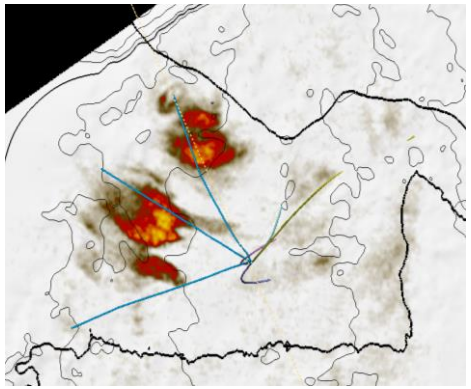
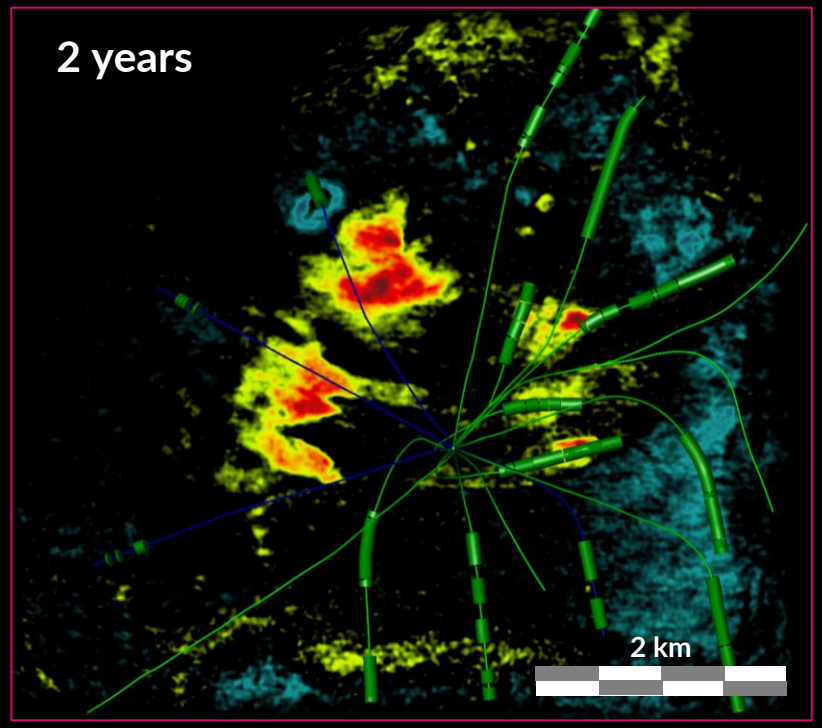
Garden photo with Chico taken @ 12:10pm				Seismic image acquired and created in 2016 Amplitude is displayed at reservoir level
10 seconds later, he has moved				Same seismic experiment repeated, but in 2018 Amplitude is displayed at reservoir level
Two photos, converted to seismic and then subtracting these two from each other		 Water replaced oil in the reservoir		2018-2016 4D difference. You can “see” the water that has been injected to support pressure

Seeing is believing

4D time-lapse reservoir images from the Edvard Grieg field in the North Sea

2016 2018 2020 2022

2 years



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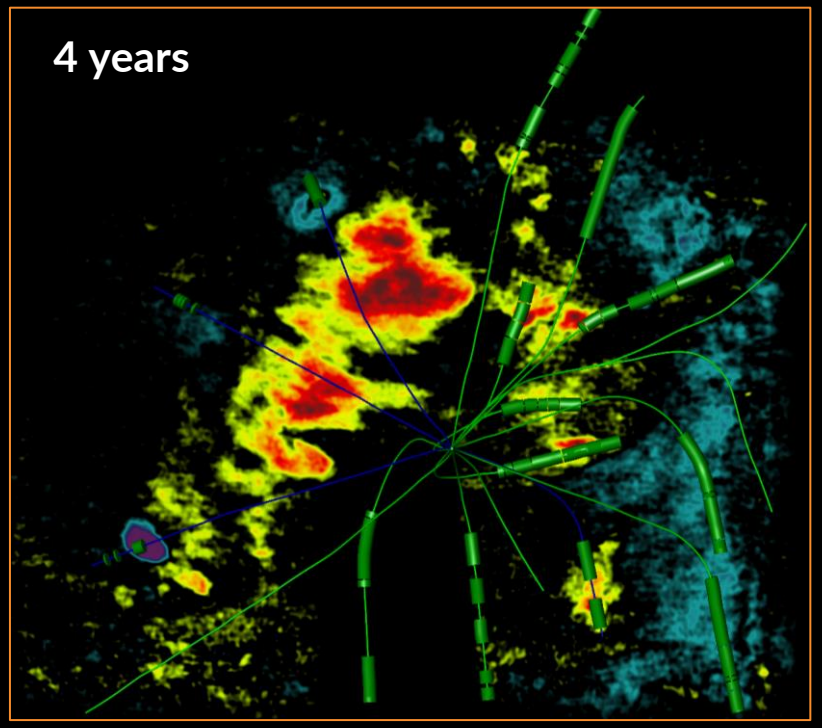
4 years



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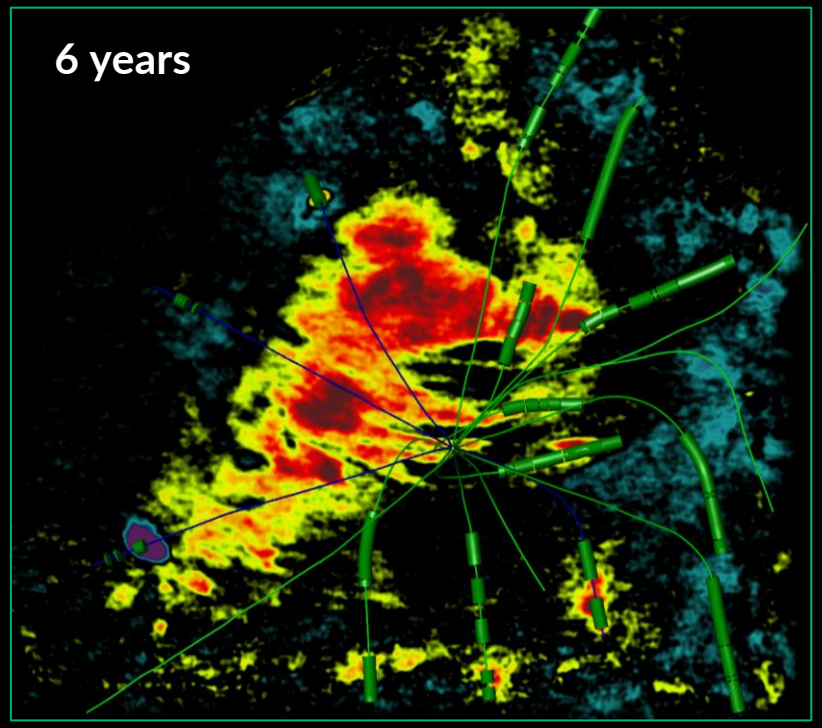

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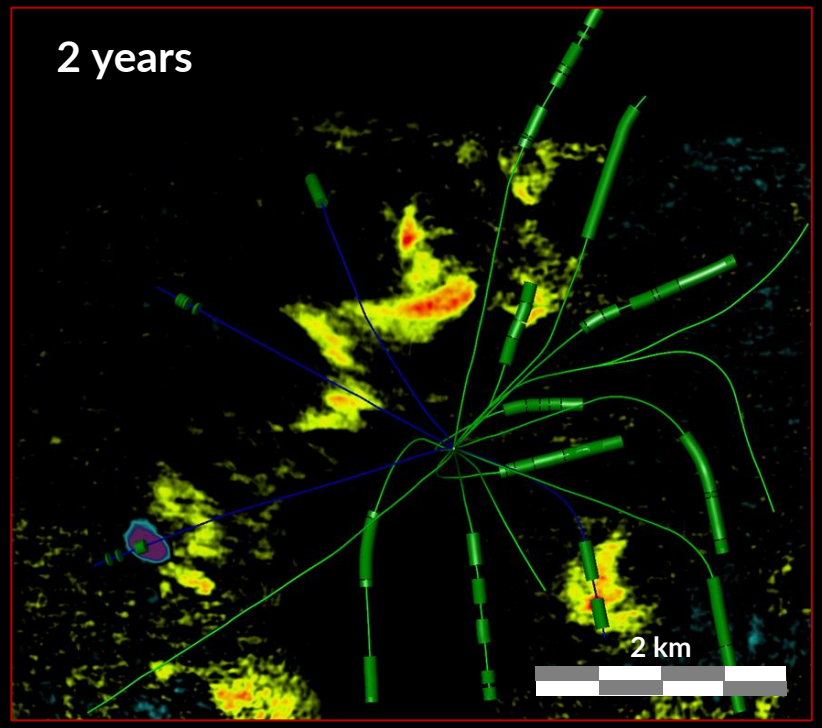

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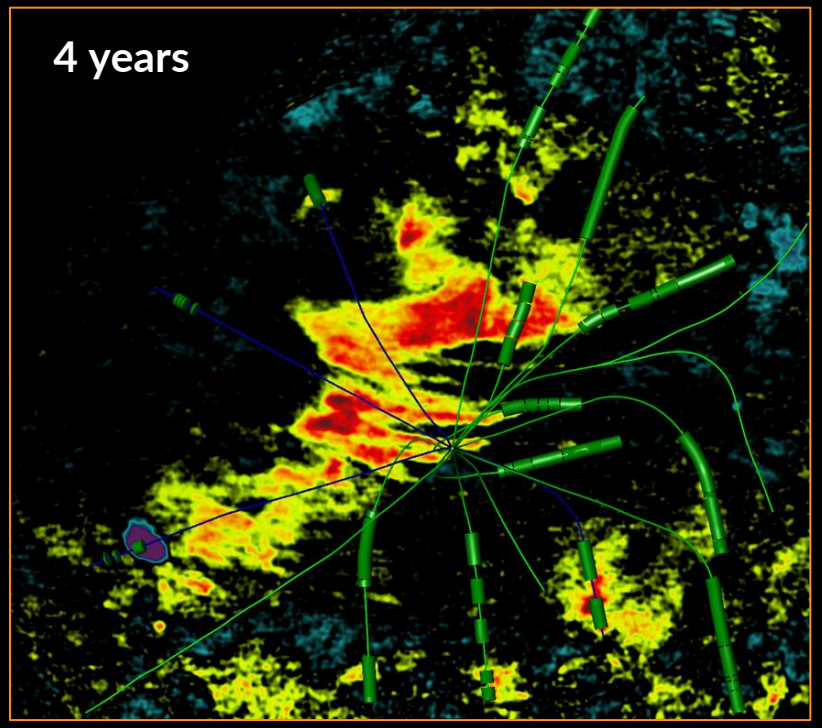

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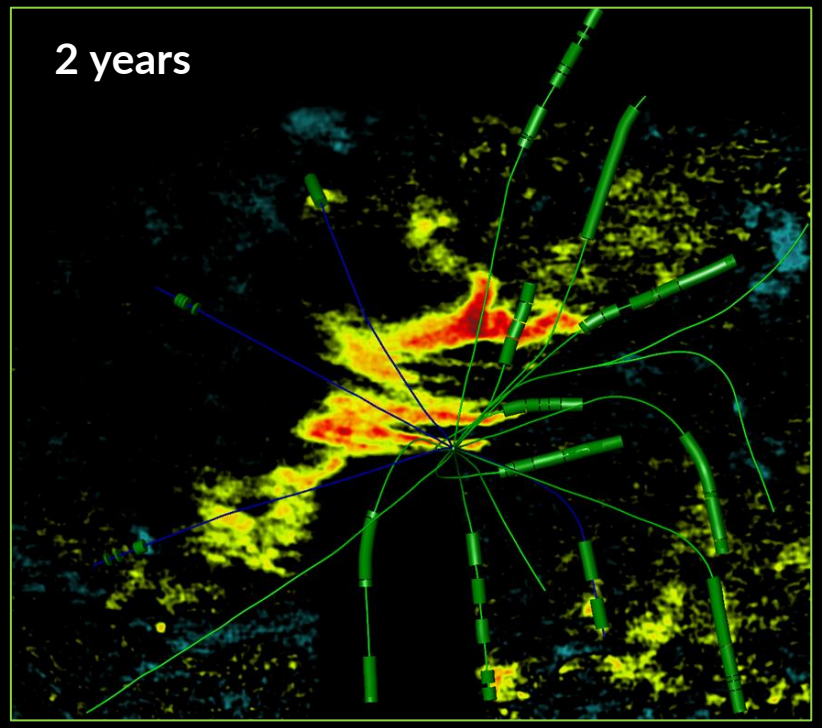
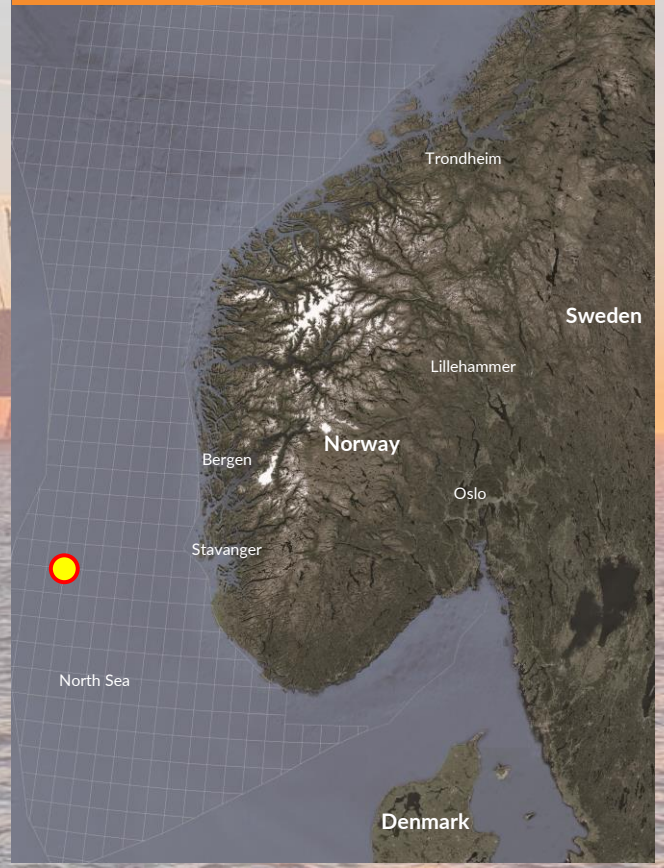


The Edvard Grieg Field

Brief historic overview

The Utsira Area

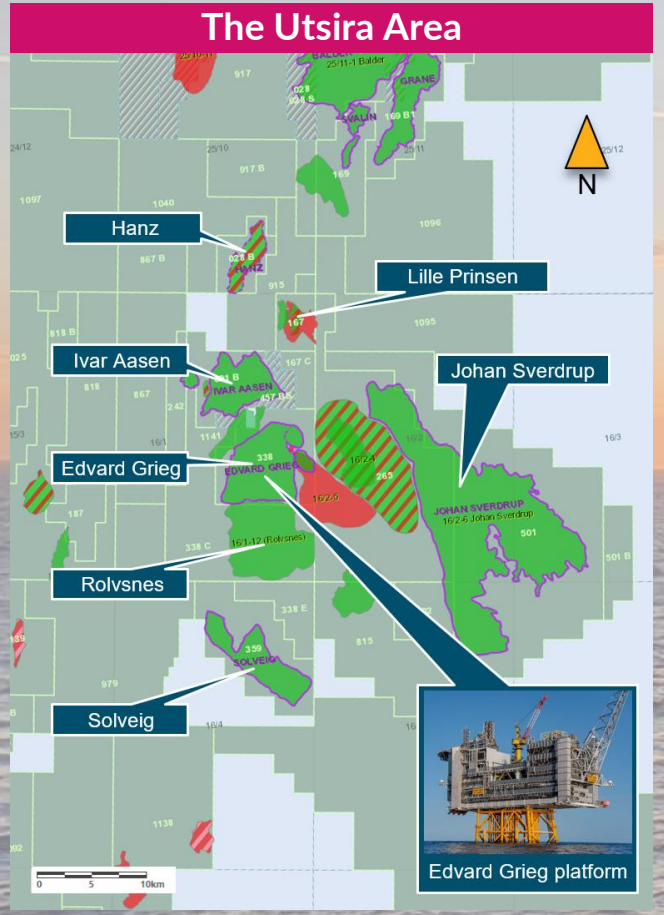
Southern Norway



EAME Earth Map

The Edvard Grieg Field

Brief historic overview



- PL338 – 1st license of Lundin Norway from 2004

AkerBP 65%

Lundin Energy Norway

OMV 20%

wintershall dea 15%

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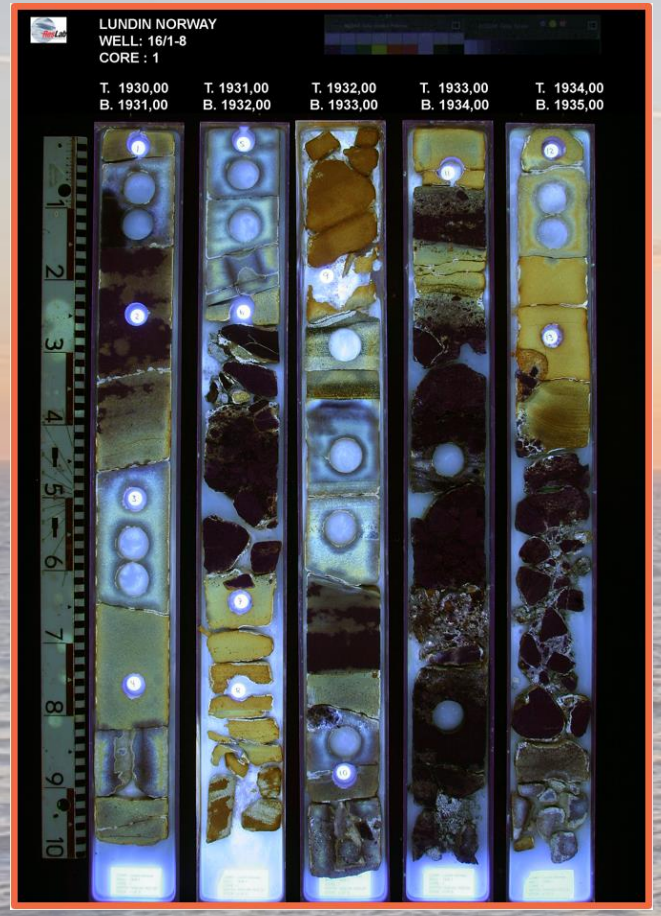

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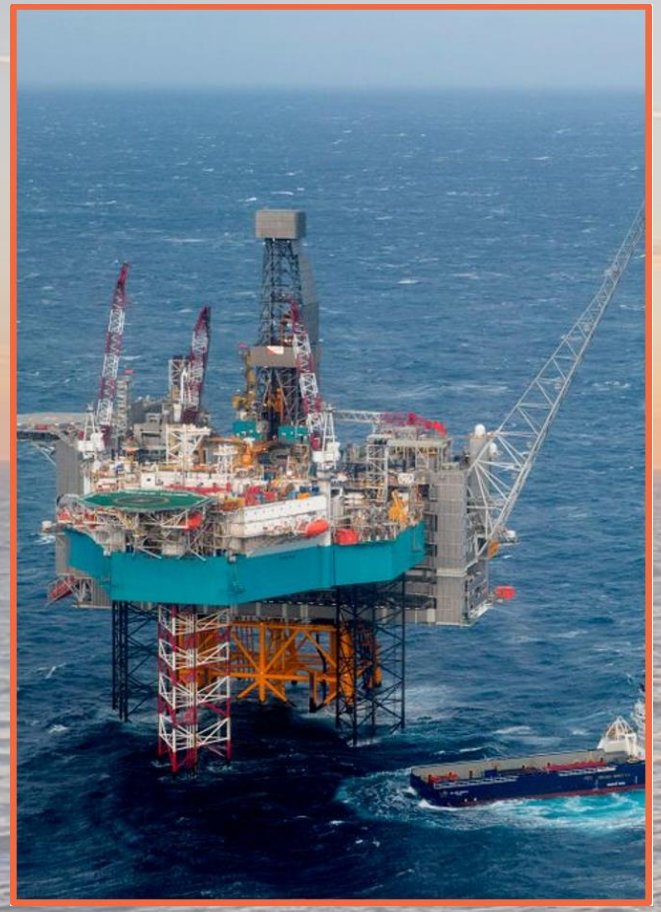

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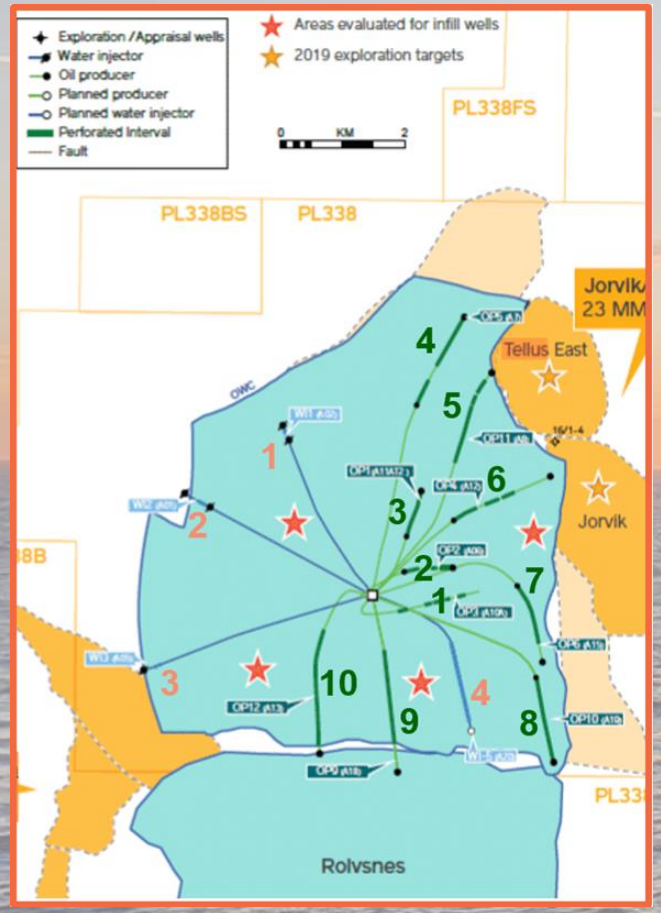

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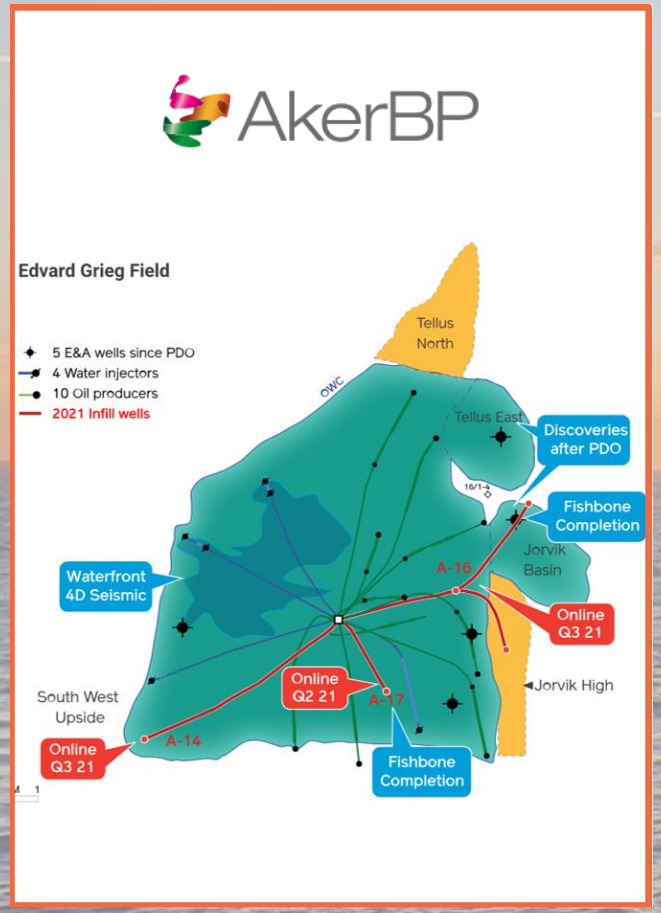

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- 1st infill drilling campaign in 2021; 2nd planned for 2023

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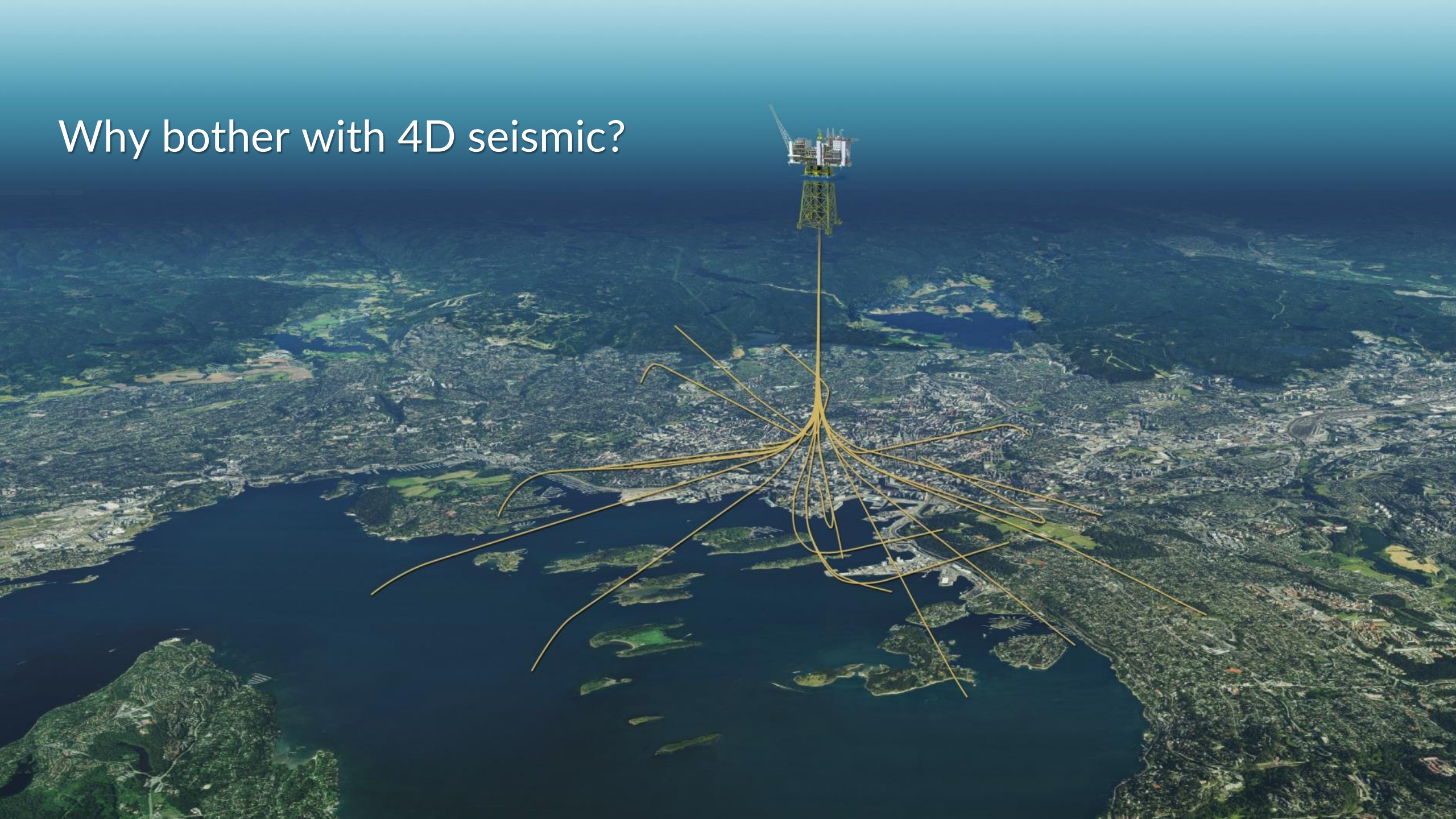
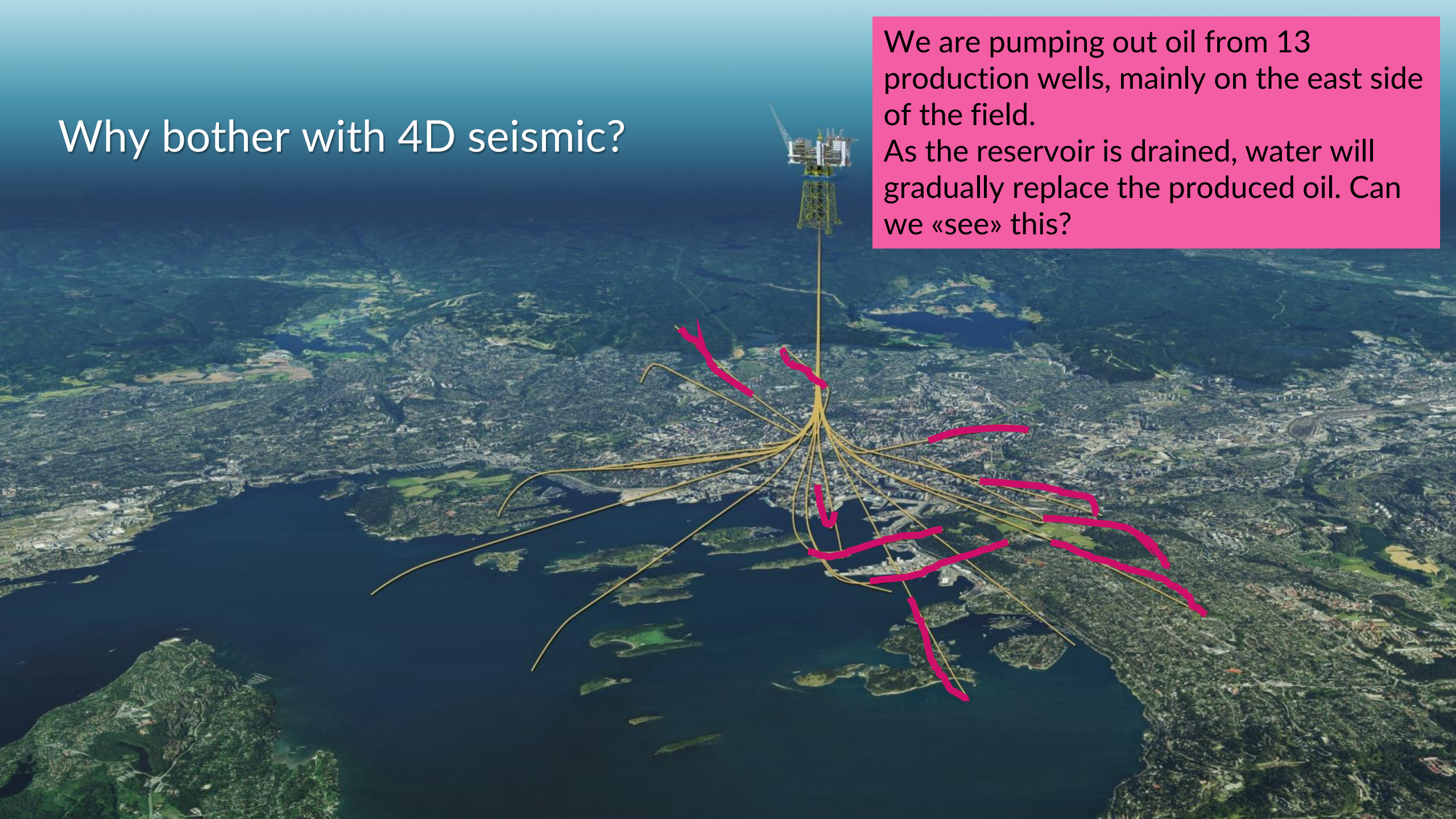
Why bother with 4D seismic?



Why bother with 4D seismic?

We are pumping out oil from 13 production wells, mainly on the east side of the field.
As the reservoir is drained, water will gradually replace the produced oil. Can we «see» this?



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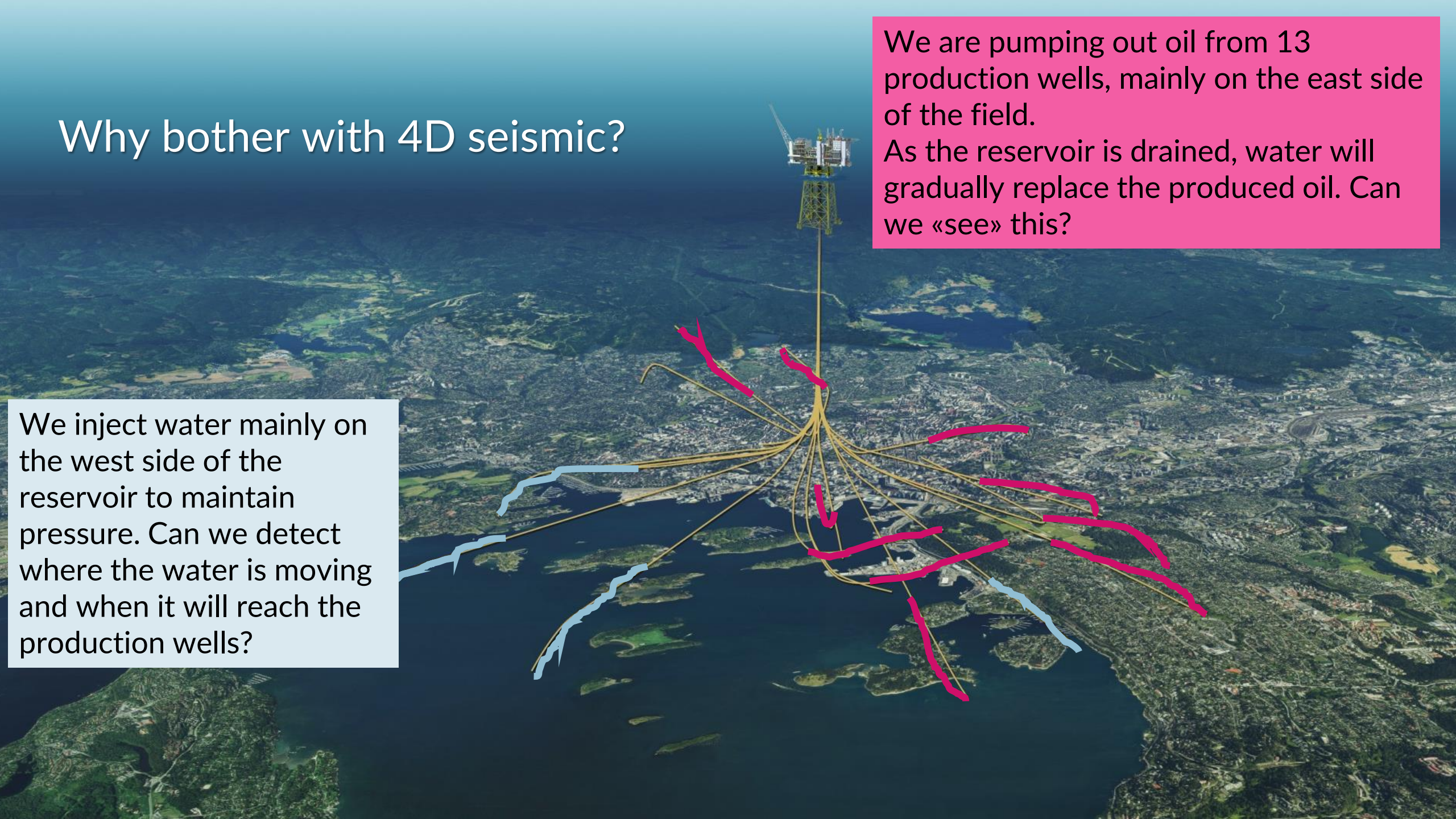

We inject water mainly on the west side of the reservoir to maintain pressure. Can we detect where the water is moving and when it will reach the production wells?

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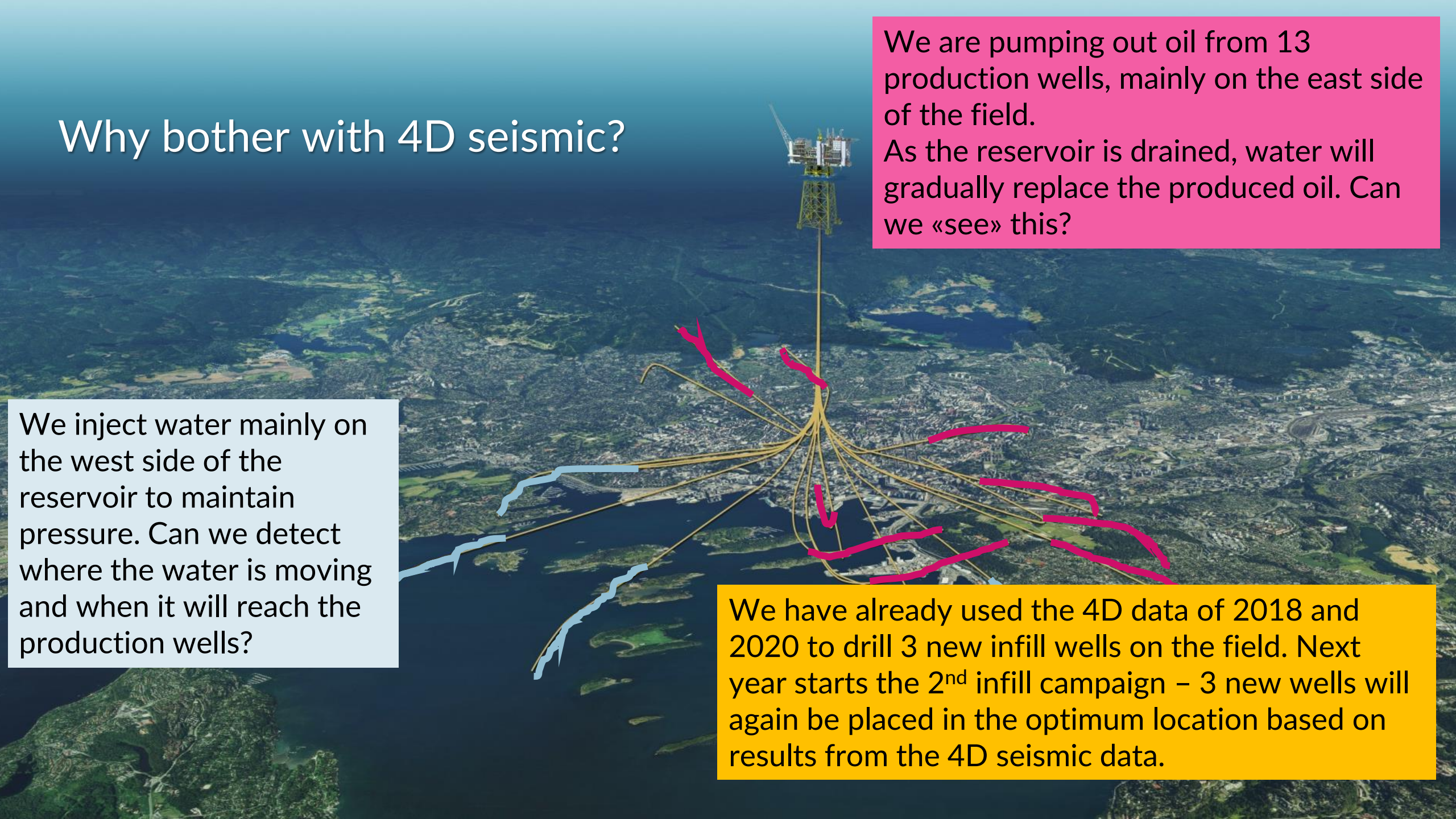

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We have already used the 4D data of 2018 and 2020 to drill 3 new infill wells on the field. Next year starts the 2nd infill campaign – 3 new wells will again be placed in the optimum location based on results from the 4D seismic data.

4D seismic is a reservoir monitoring tool. You can observe what is happening down in the reservoir and react based on «real» observations. This allows us to increase the recovery factor of the field substantially. Historically we may see an increased recovery factor of ~10%.
30-50mill barrels x ~50usd/bbl = 1.5-2.5 billion dollars.

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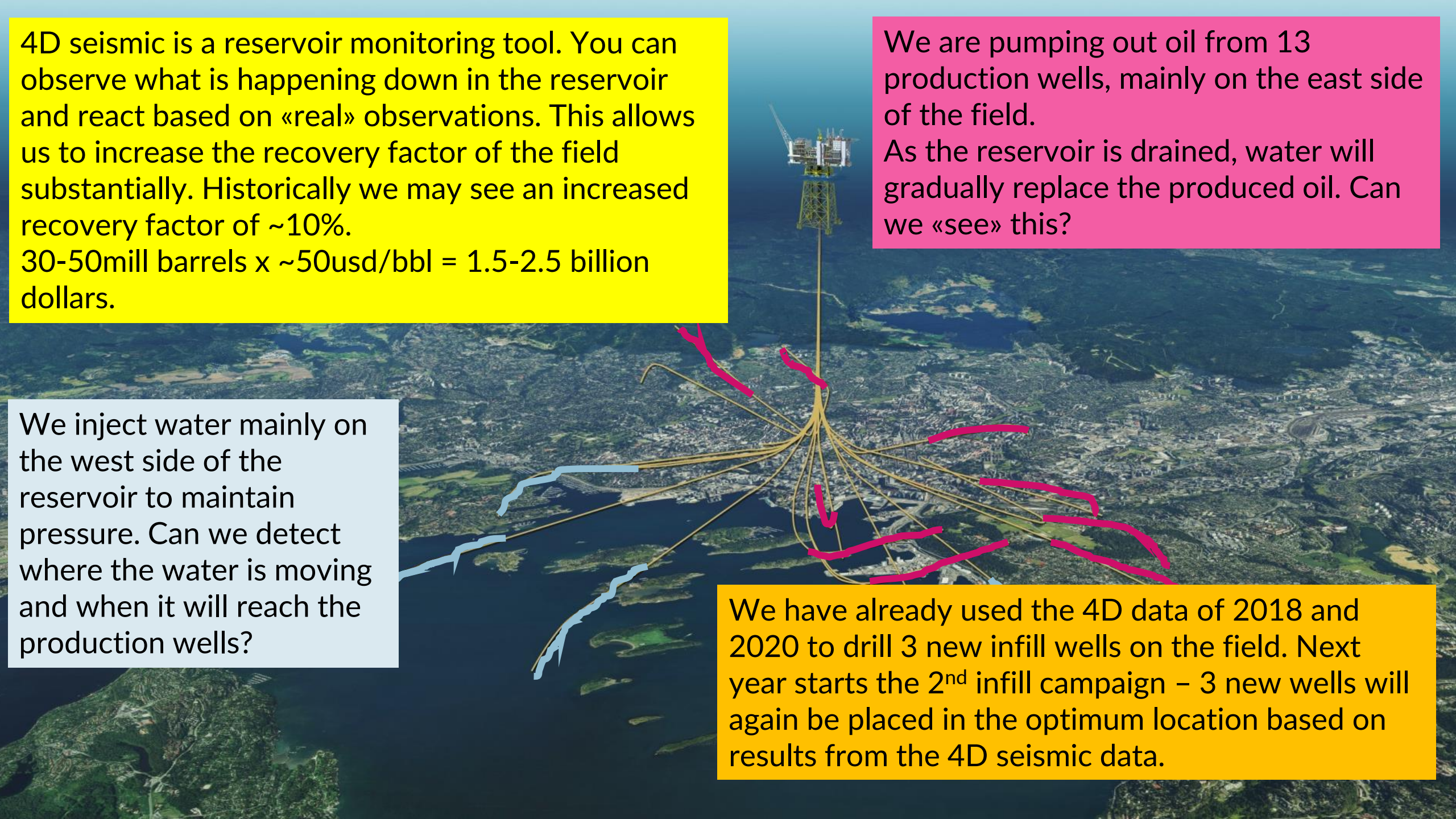

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But….

This is all fine and no surprise – however – it must be emphasized that you have to **be able to act** on the 4D results.

- Time is of the essence – from the time the 4D seismic is "taken" till final results and impacts can be made on the well paths – reservoir model etc. has to be **as short as possible!!!!**
- We are talking days. Not weeks.
- How can we optimize turnaround? By digital means!

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the west
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and whe
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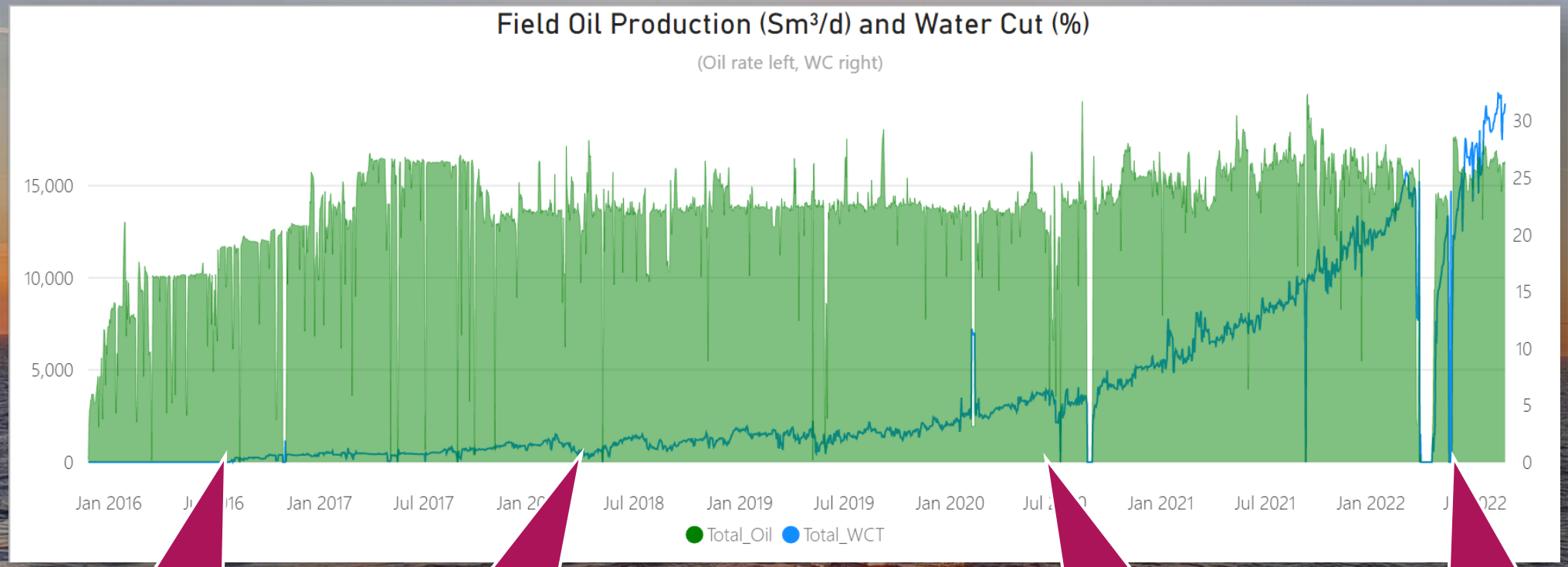
Seismic Monitoring – “See what happens in the reservoir”

Retrievable Ocean Bottom Cabled Q-seabed system (Tasman/Topaz/Emerald/Cook)



OBC 2016

OBC 2018

OBC 2020

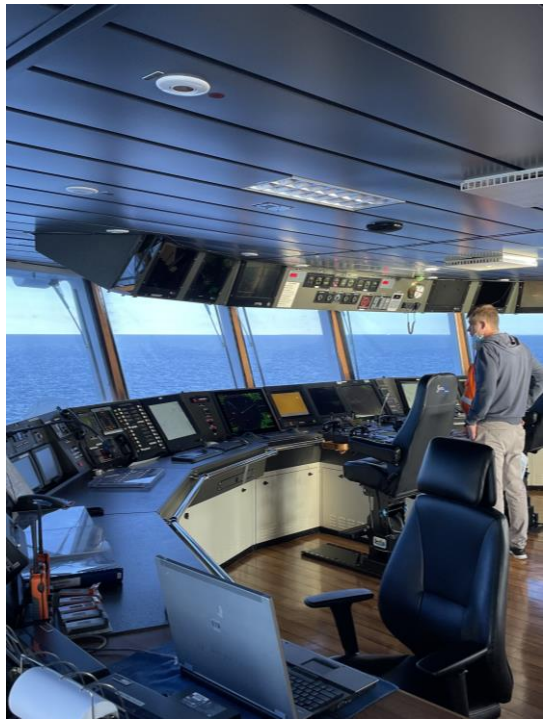
OBC 2022

The corporate strategy and how 4D seismic fit in

Always work towards a common goal & lead the transformation of E&P

Operate safely and efficiently

Decarbonise our business



Deliver growth on time, cost and quality

Establish the next wave of profitable growth options

Let me share how we transform these into our 4D seismic world and break new barriers

The corporate strategy an mic fit in

Alway f E&P

Operate safely and efficiently

Decarbonise ou

th on time, cost d quality

Establish the next wave of profitable growth options

Cheaper

Faster acquisition

Utilize more of the data

More for less

Less and smaller equipment

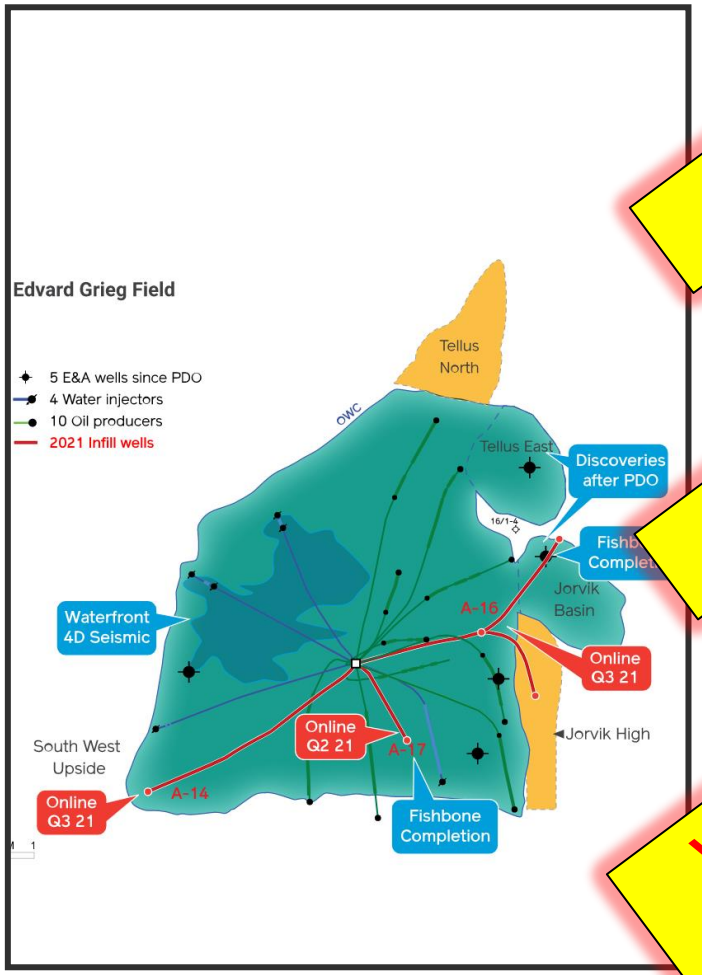
Quality improve-ment through innovation

Be smart & digital

Let me share how we transform the eismic world and break new barriers

Reducing turnaround – delivering *"fresher"* 4D data

The project goals we initiated prior to the 2020 campaign



Cost

Time

Value adding

- **Faster acquisition**
  - Laying sensors faster – cables/PRM
  - Shooting faster – less shots or more sources
  - Reduce needed offsets 2km, and triple source
- **Get data onshore faster**
  - Remote raw SEG-Y QC
  - Data dumps weekly – and faster
  - Optimize and transfer via satellite
- **Faster processing turnaround**
  - Pre-test flows and VMB from legacy data
  - Define smart 1-click processing flows
  - Pre-define 4D attributes
- **Utilize more of the 4C OBS data**
  - Fast image output of both PP and PS data
  - Fast output of both angle stacks and gathers
  - Joint inversion of PP- and PS- data

~~1 month~~ *3 weeks*

~~3 days~~ *1 day*

~~7 days~~ *4 days*

~~6 months~~ *2 months*

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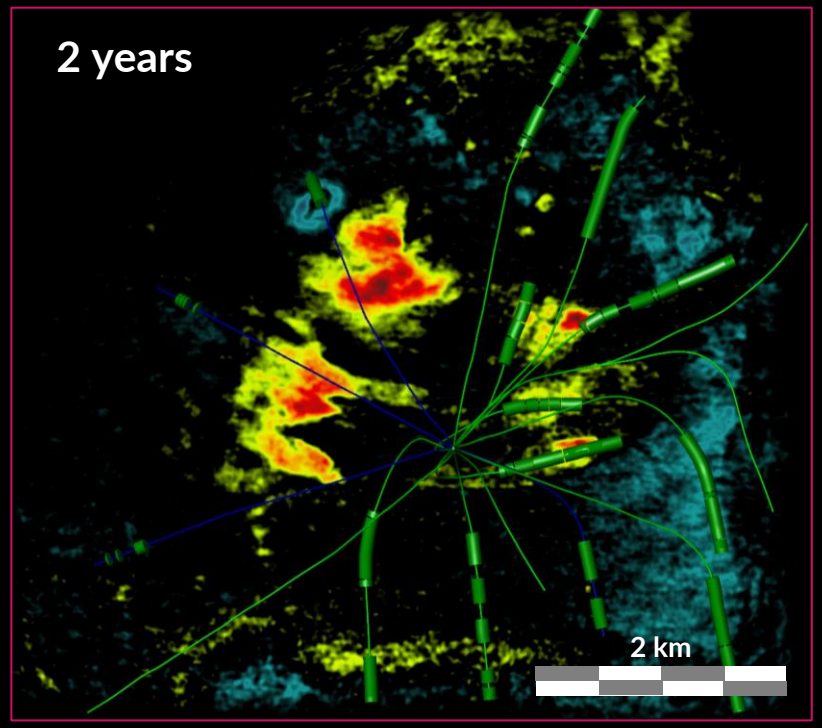
2 years



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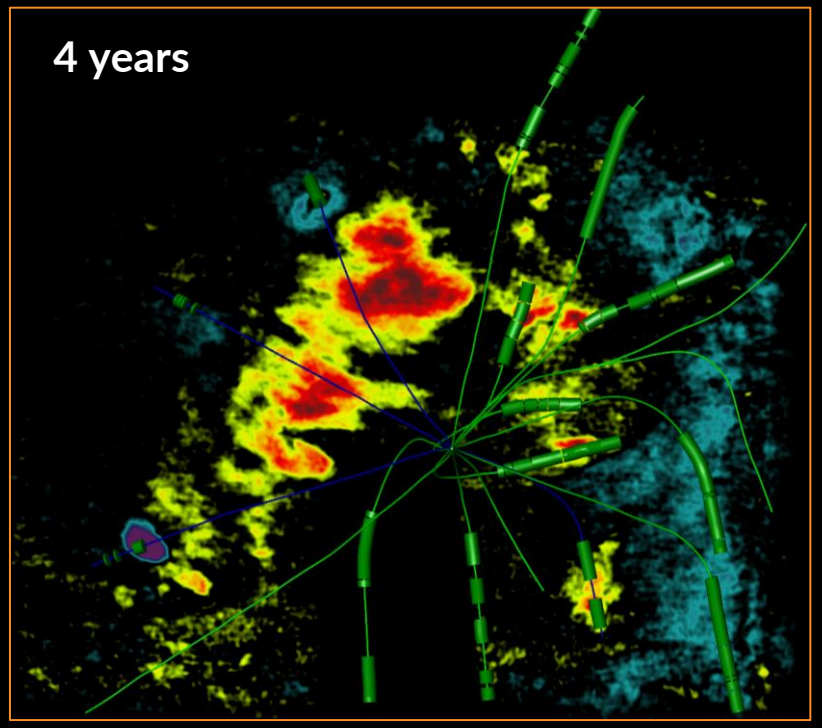

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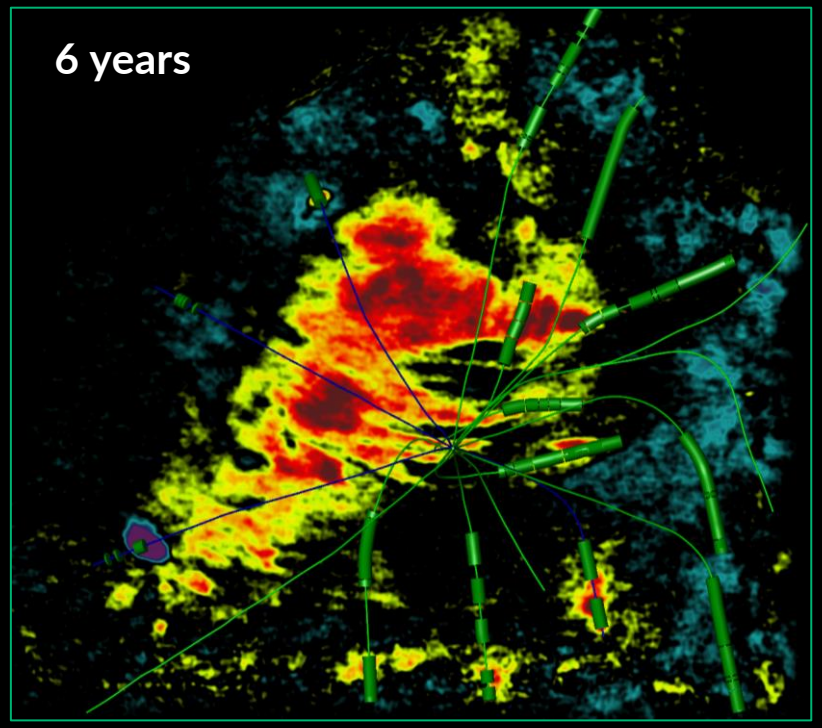

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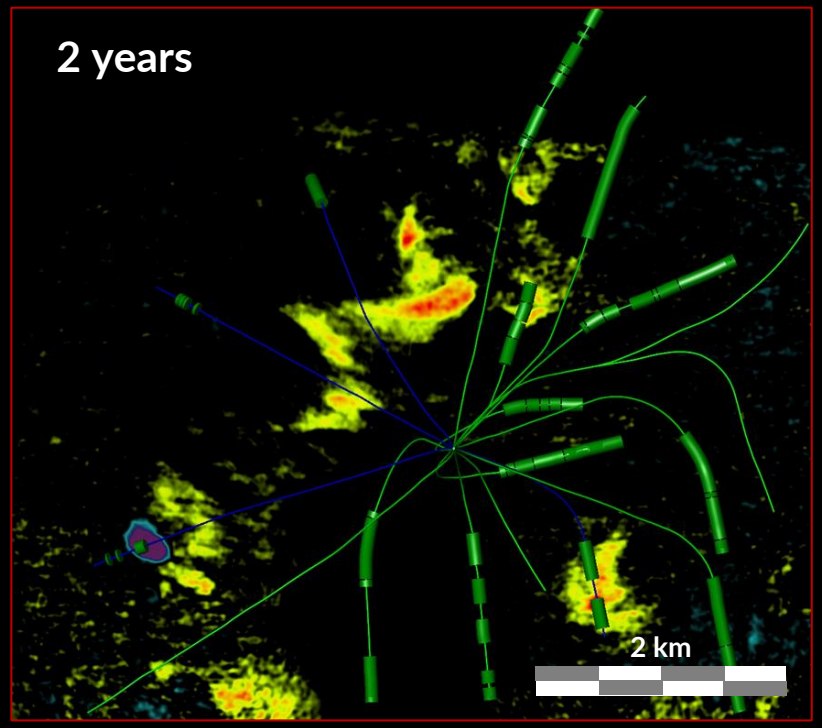

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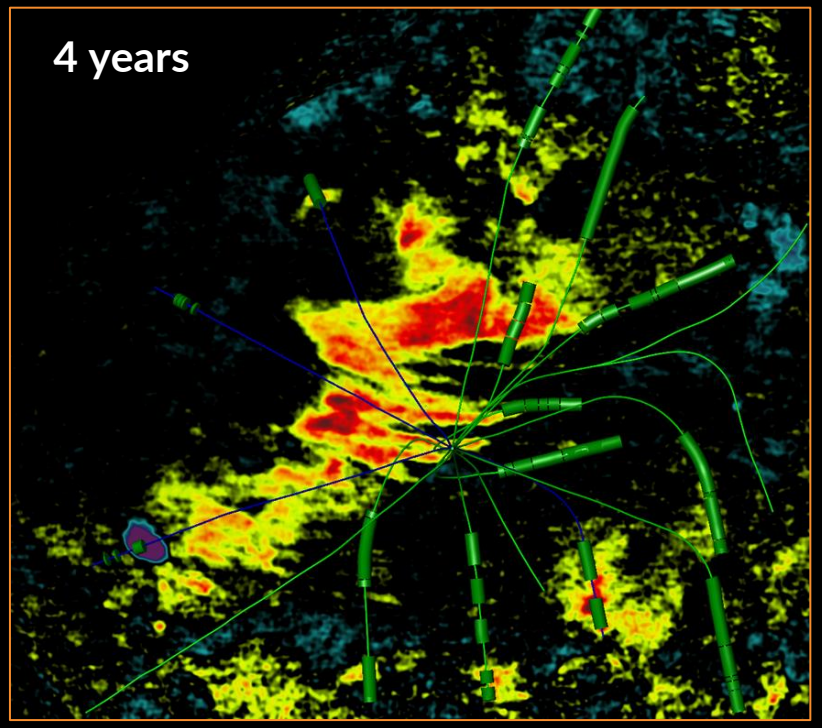

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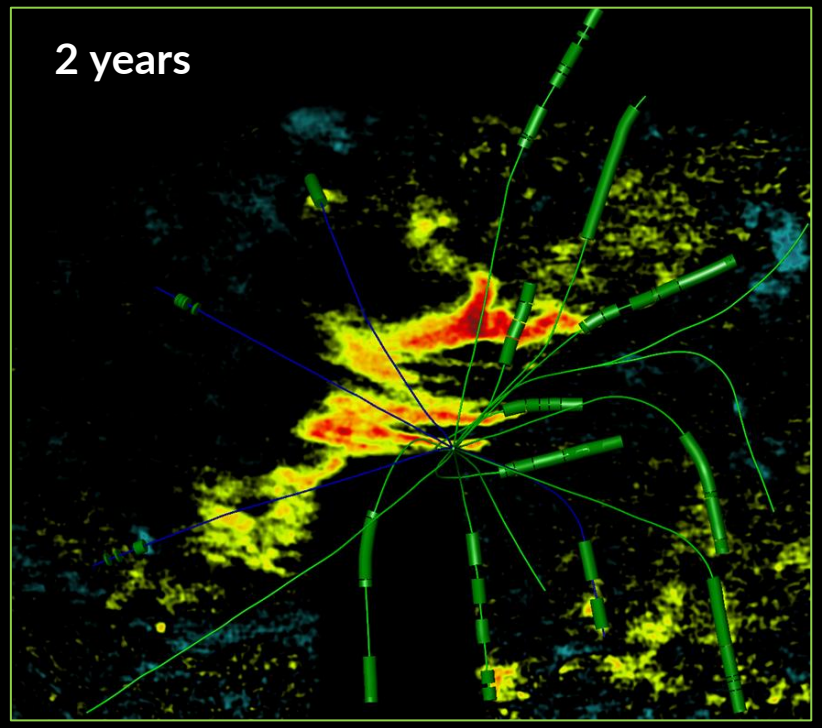

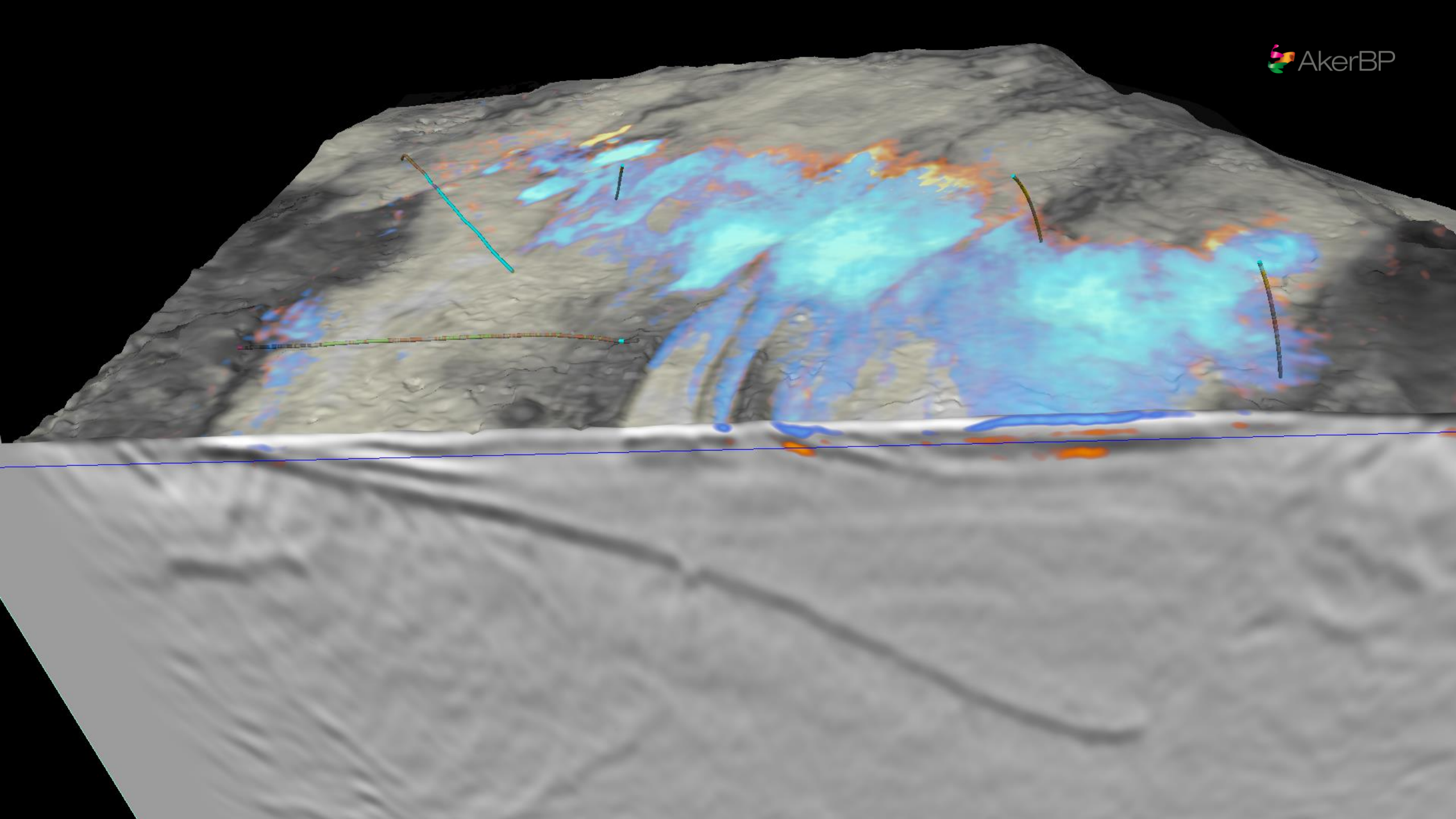
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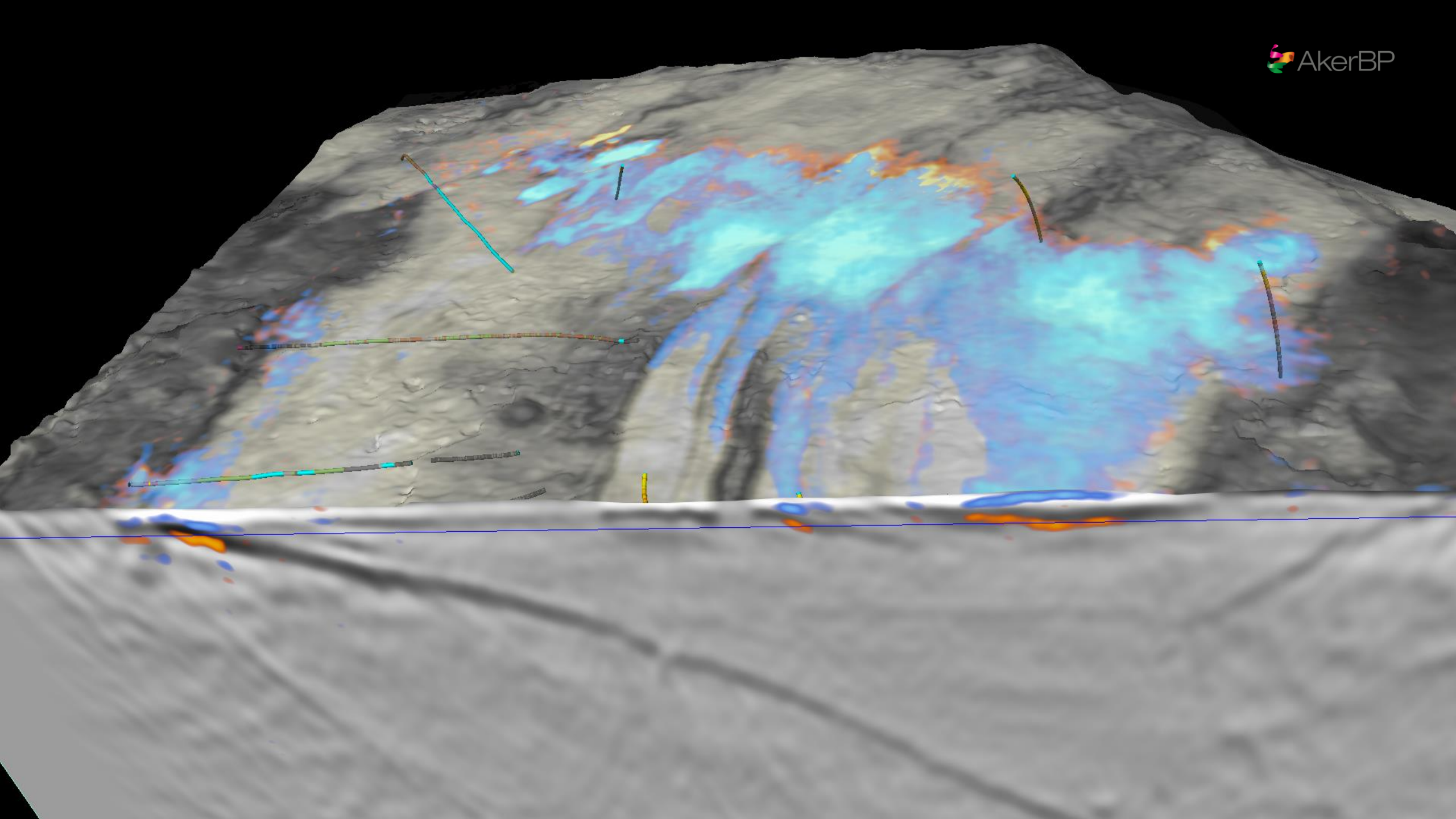
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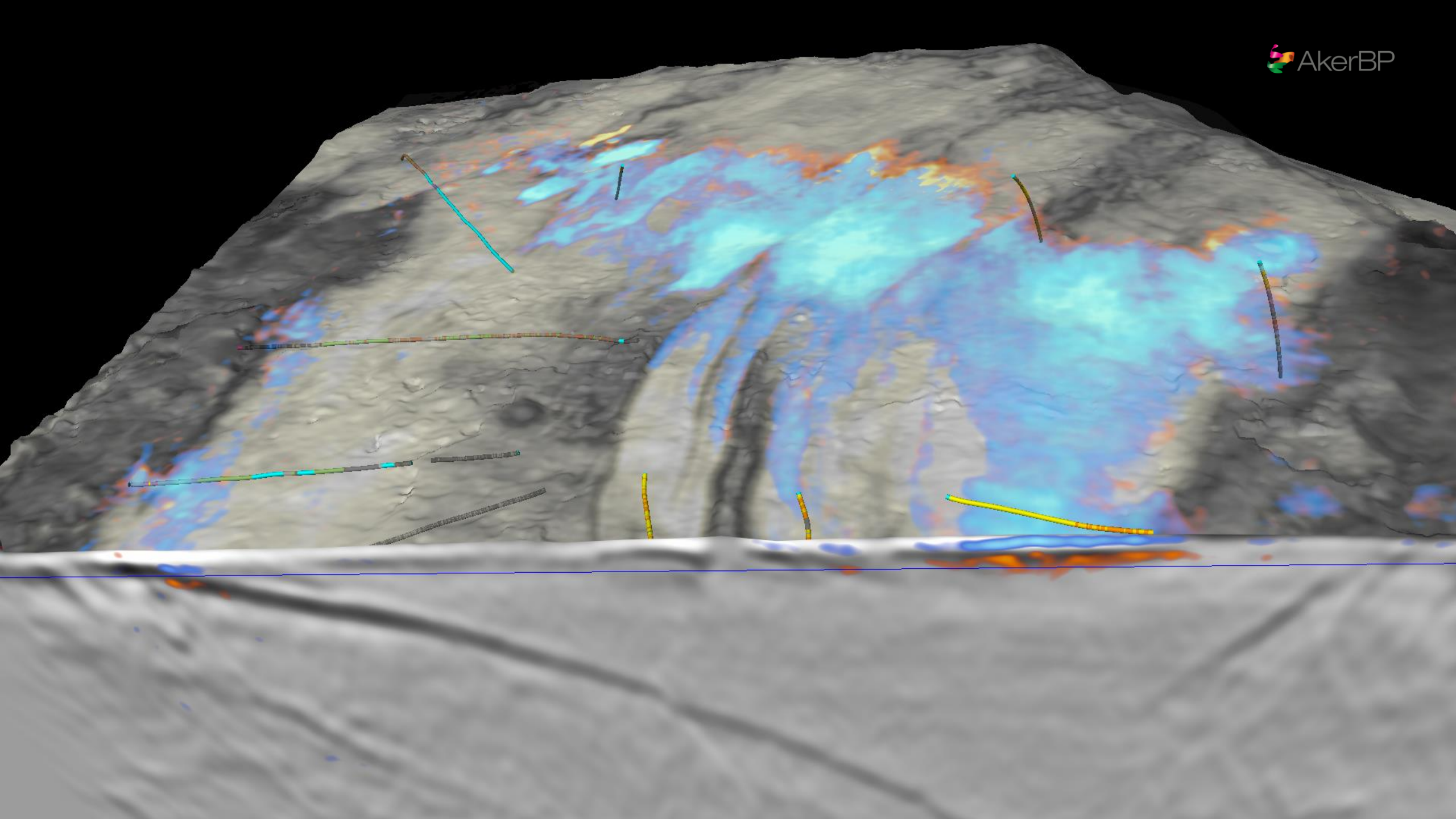
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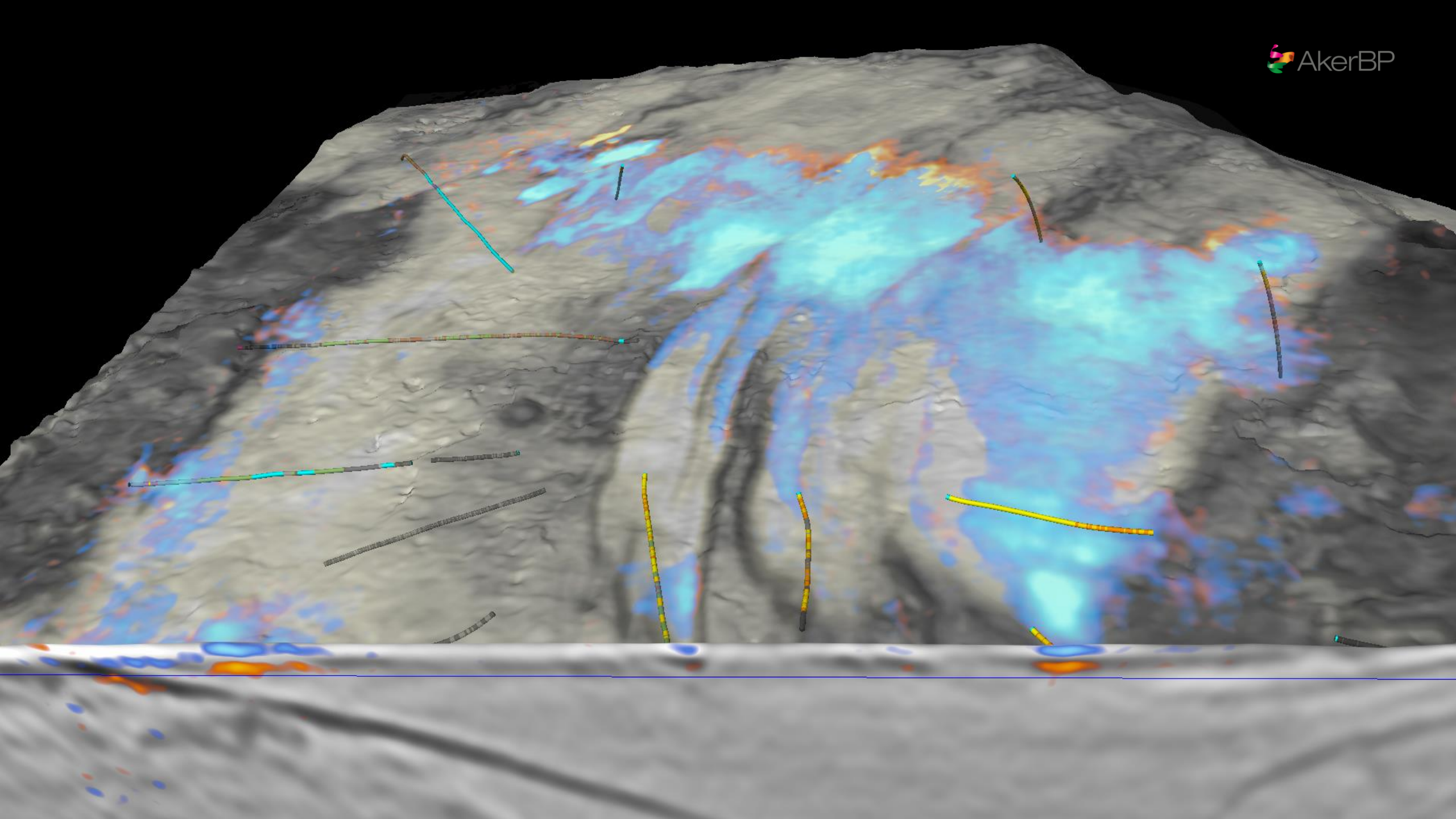
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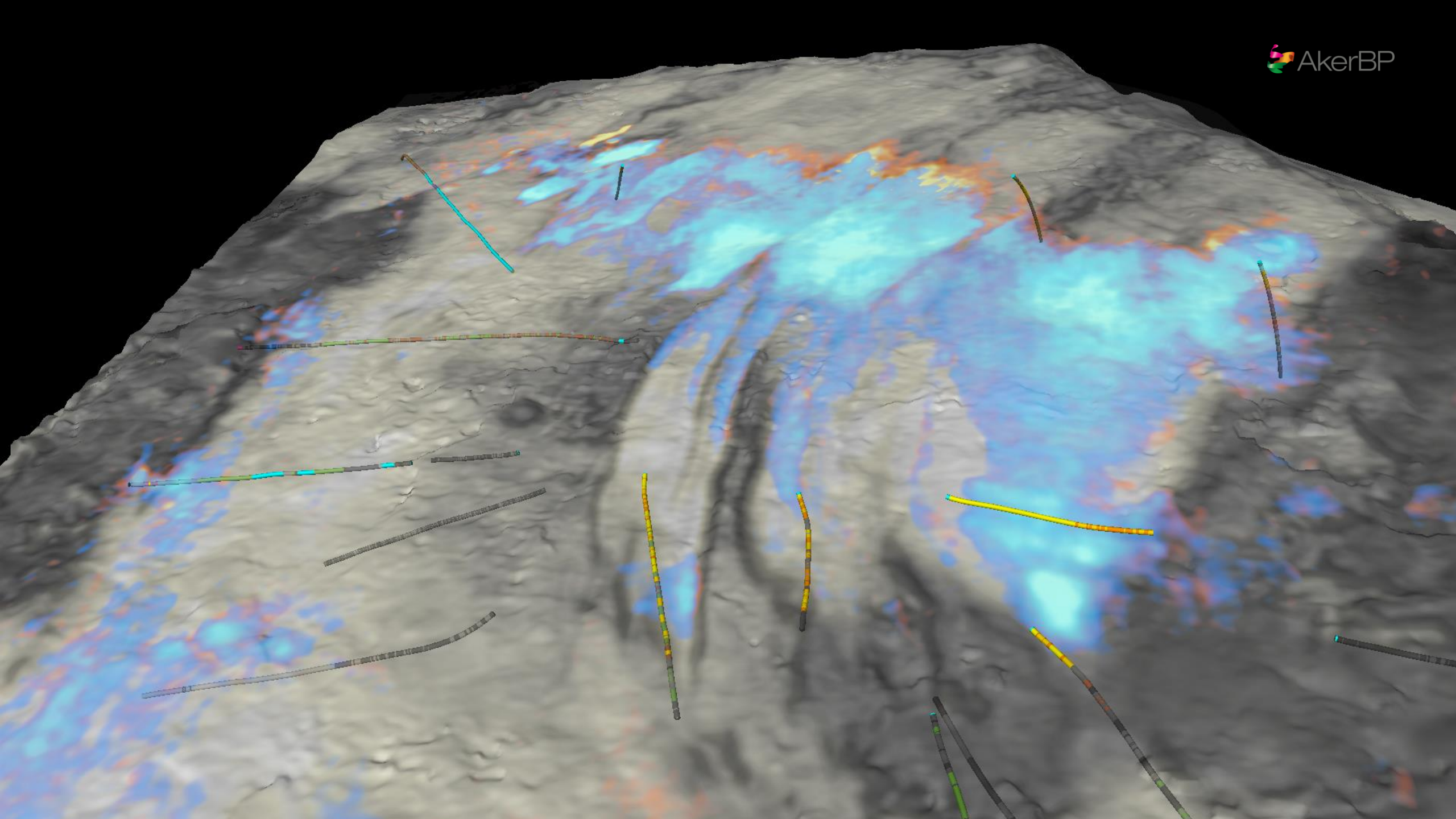
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Connecting for a New Future

Maximizing the value from an oilfield:

It's all about:

1: monitoring
2: monitoring
3: monitoring

Faster

Cheaper

Better

Connecting for a New Future

- Since the start of production from the Edvard Grieg field, in the North Sea, back in 2015/2016, 4D seismic has been a vital part in managing the reservoir and its production. A high spec baseline survey was performed with the Q-seabed seismic system back in 2016 and has since been repeated 3 times, 2018, 2020 and now recently in 2022. Performing the seismic offshore campaign with the highest HSE standards and at the same time as efficient as possible, is of course just the way our industry performs. However – the seismic data itself has little value unless you are able to turn around the processing and imaging as fast as possible. This is where we have put extra efforts together with the Schlumberger imaging teams in Gatwick, to push turnaround times down from months to less than 10 days from last shot until delivery of 4D seismic into the reservoir's workstation. Every single part of the workflow has been scrutinized, optimized and re-worked to focus only on critical QC aspects, thereby being able to almost automate the processing of the 4D seismic data. Starting offshore, critical parts of the data is transferred early, via satellite to the processing office to test and set up initial parametrization. Full datasets are then cut and trimmed, copied over to usb drives and sent onshore on a weekly regular schedule. Once onshore, the data is loaded locally and transferred via fast fibers to the cloud hubs, typically in less than 24h for a whole dataset. Initially, digital twins of the datasets are made from older vintages to mimic the new data, prior to arrival, so fast and simple filename replacement can be done and pre-tested flows, simply re-run, to update the seismic 4D images. New modern techniques such as up-down-deconvolution, radial-down deconvolution and RTM imaging sets new standards both for quality, turnaround and simplicity in the workflows. Both in 2020 and 2022, we have delivered 4D image results within 7-10 days of receiving the data onshore. This is truly breaking boundaries in turnaround times, specifically for 4D seismic, where a conventional processing image was not ready until at least 6 months after acquisition. The turnaround times and quality from the 4D reservoir images today, allows us to truly use 4D seismic in the well planning and actually make a definitive impact on the decision making towards key infill drilling campaigns on the field.

Keywords – and stuff to consider

- Mywork slides
- Pictures from EG campaign 2022
- Slides from Arnstein
- Faster turnaround slides EW – months to weeks
- EAGE workshop slide review
- Bahrain Slides
- What does the future of 4D look like,
- Drop nodes, data transfer, rov pickup or self inflating,
- 14 days monitoring…..
- Curve of oil production from start
- Co2 reduction
- Added value, ILX exploration, improved lithology with classification from OBS

Hvordan bruke PowerPoint-malen

Slides

De ulike slide-oppsettene er tilgjengelig i nedtrekksmenyen for «Nytt lysbilde»:

- Intro-slide
- 6 ulike oppsett for innhold
- Agenda/appendix-slide
- Kapittel-slide
- Slide med kart over lokasjoner
- Avslutnings-slide

Lister

Tekstbokser har gir punktlister som standard. Ta vekk punktet dersom det ikke trengs eller trykk på nummerert liste dersom du trenger det. Listene skal se ut som følger:

- Uten innrykk
  - Første innrykk
    - Andre innrykk
      - Tredje innrykk

1. Nummerert liste uten innrykk
   1. Nummerert liste første innrykk
      1. … andre innrykk
         1. … tredje innrykk

Fonter

Alle titlene i presentasjonen skal benytte Lato Bold og all øvrig tekst skal benytte snitt av Lato, fortrinnsvis Regular. Skrifttypene er definert i malen og ligger lett tilgjengelig i nedtrekks-menyen for skrifttyper.

Dersom du trenger å laste ned Lato-familien, er den tilgjengelig her.

Ressurs-slide

PRE-READ

CONFIDENTIAL

DRAFT

Bunn/topptekst med tittel og kapittel

Hvis du ønsker en bunntekst eller topptekst for lengre presentasjoner hvor presentasjonstittel og kapitteltittel skal være med, benytt tekstboksen som vist. Kan benyttes som enten toppteskt eller bunntekst, men det kan være lurt å tenke på om man skal ha mye fotnoter eller lange titler for å få mest mulig luft rundt teksten.

Infoboks – mengdetekst

Hvis du trenger å supplere en slide med tilleggsinfo kan du bruke infoboksen under. Denne er for litt lengre tekst som bygger i høyden

Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat.

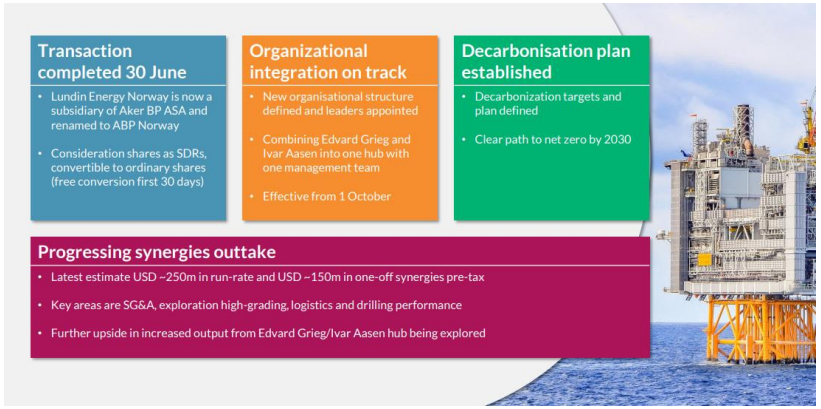
Stickers

Stickere som vist over kan settes inn dersom en slide trenger markering. Plasser objektrammen mot øvre høyre hjørne slik som “DRAFT”.

Infoboks – kortere tekst

Infoboksen under her er bedre egnet for kortere tekster til f.eks. bilder. Det er best å unngå mer enn tre linjer og boksen kan gjerne plasseres over bilder (men ikke gjennomsiktig).

Ut enim ad minim veniam, quis nostrud ex ea exercitation ullamco laboris nisi ut.



- colormap

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