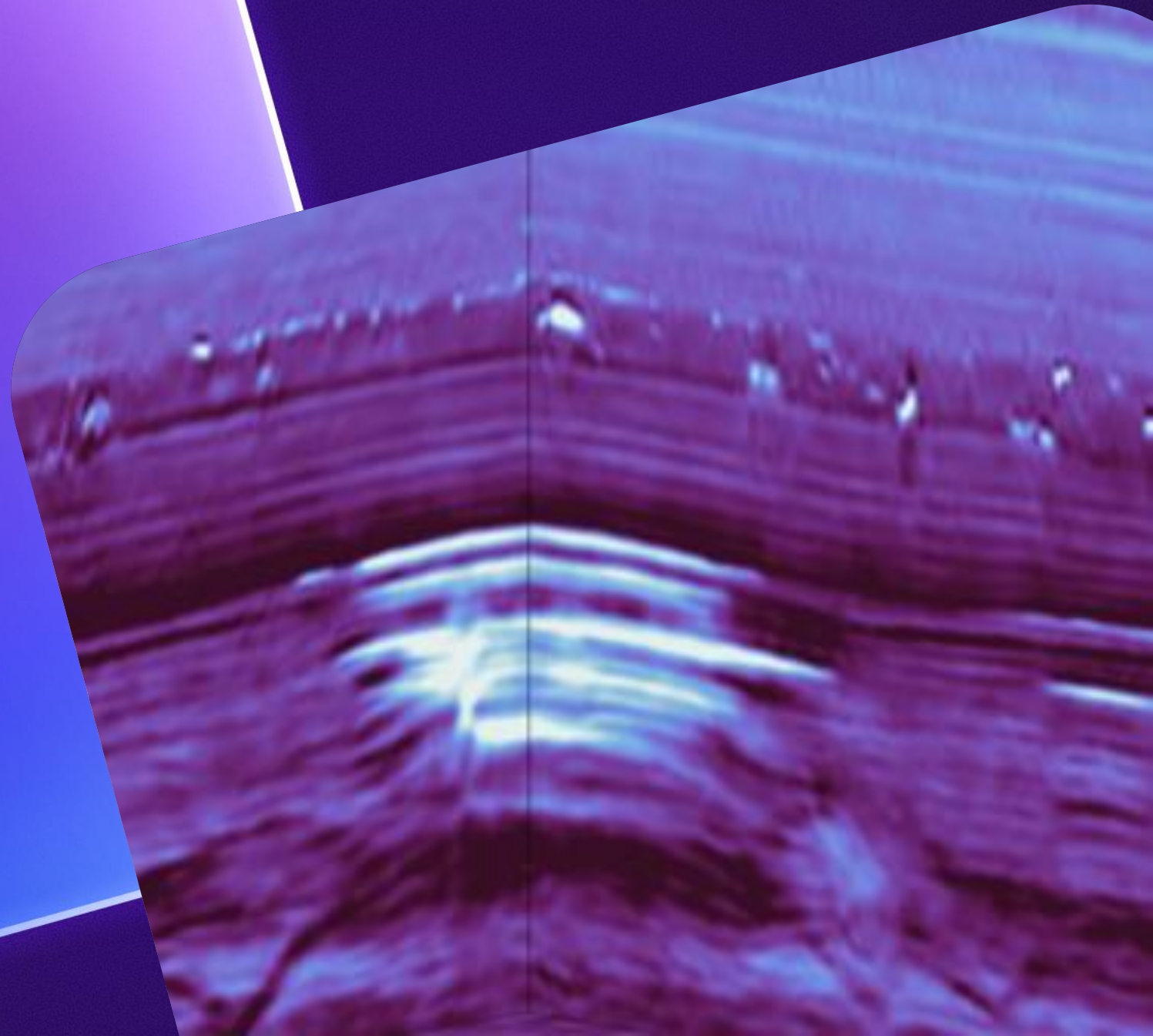




# CONXISE

Targeted Ultra Sparse  
Full Wavefield Monitoring



# Carbon Storage Monitoring – Objectives?

## ■ Conformance

- CO2 Plume model = CO2 Plume reality?
- Saline aquifer / Depleted reservoir?

## ■ Containment

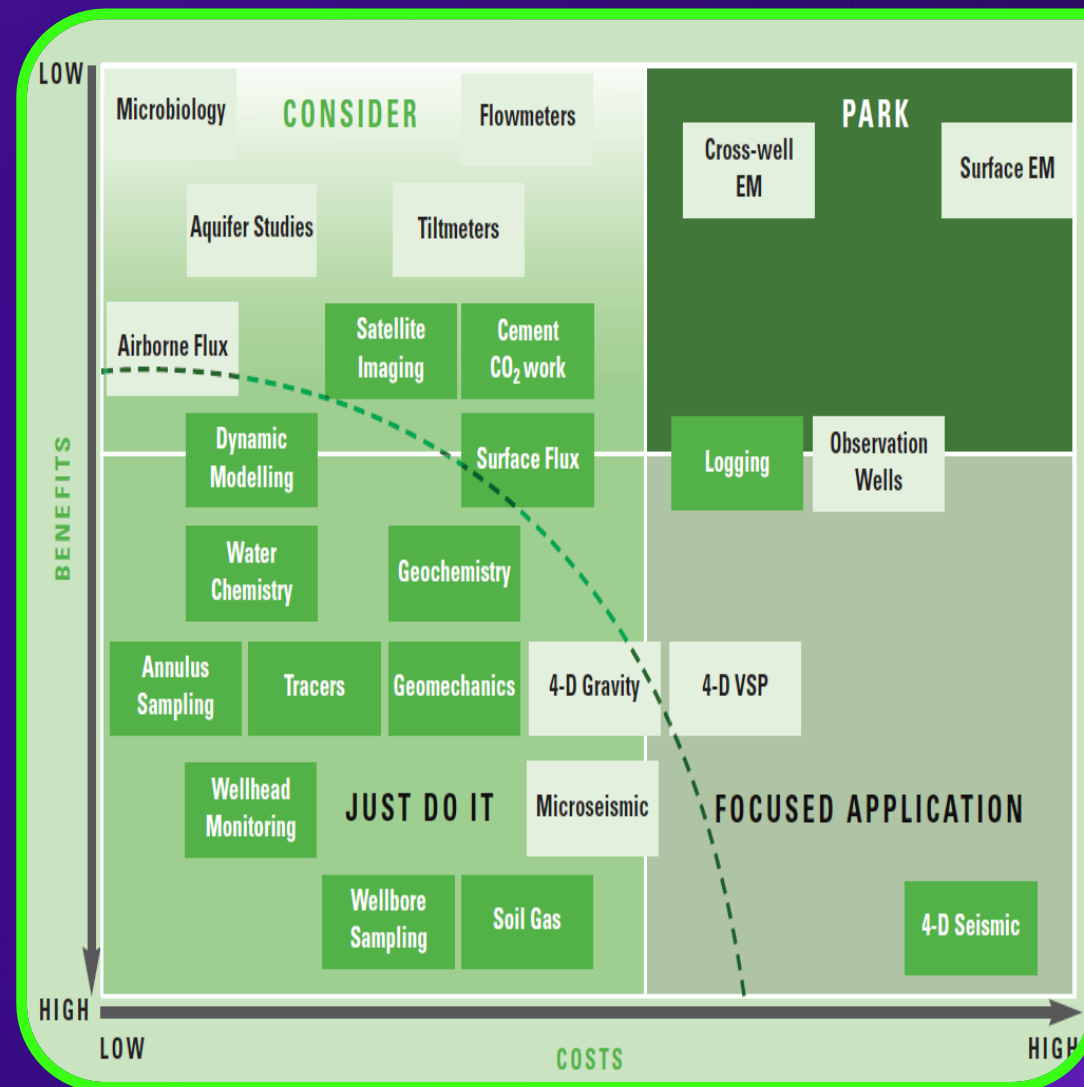
- Overburden monitoring
- Detect leakage and irregularities

## ■ Confidence

- Stakeholders & Regulators
- Risk Assessment & Management

## ■ Cost!

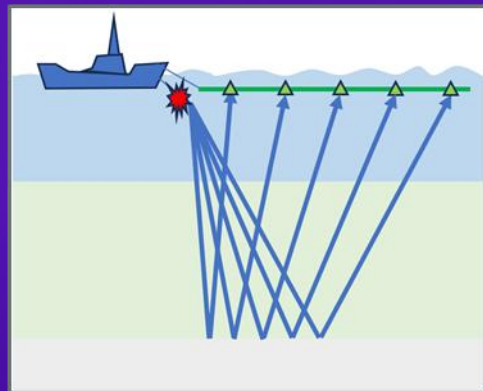
- 4D Seismic?
- Novel seismic technologies?



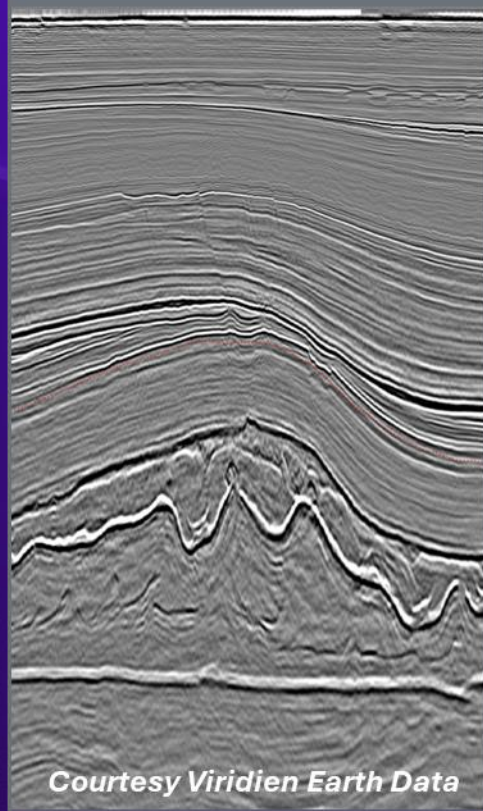
CO2 Monitoring by Satellite at In Salah. 7th Annual Conference on Carbon Capture & Sequestration. I. Wright., 2008

(Image courtesy of World resources Institute, CCS Guidelines)

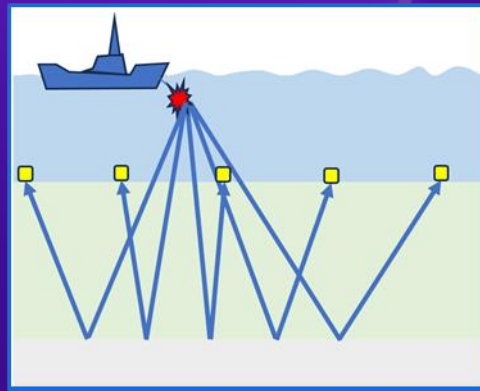
# Novel Seismic Monitoring – Technologies



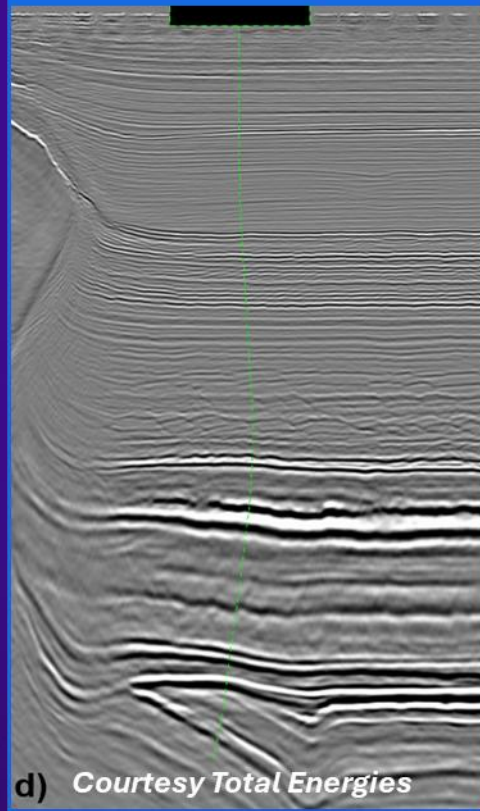
Short Towed Streamer (XHR)



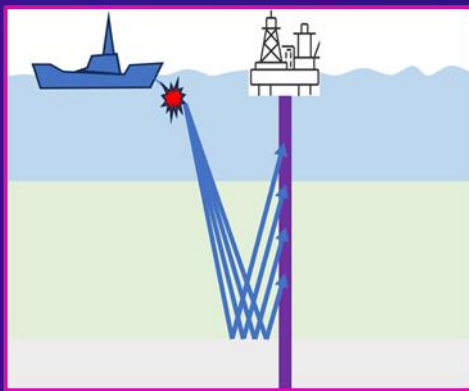
Courtesy Viridien Earth Data



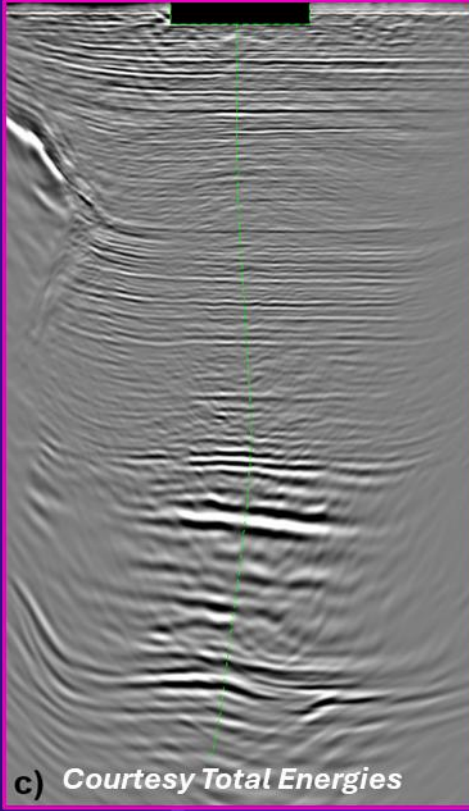
Ocean Bottom Seismic (OBS)



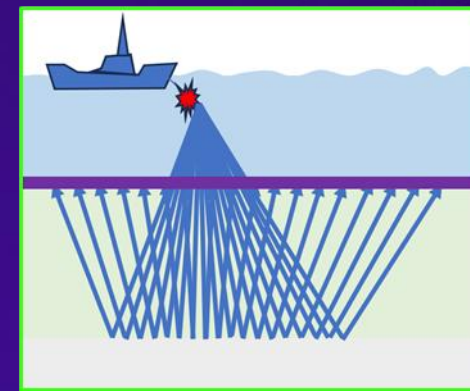
d) Courtesy Total Energies



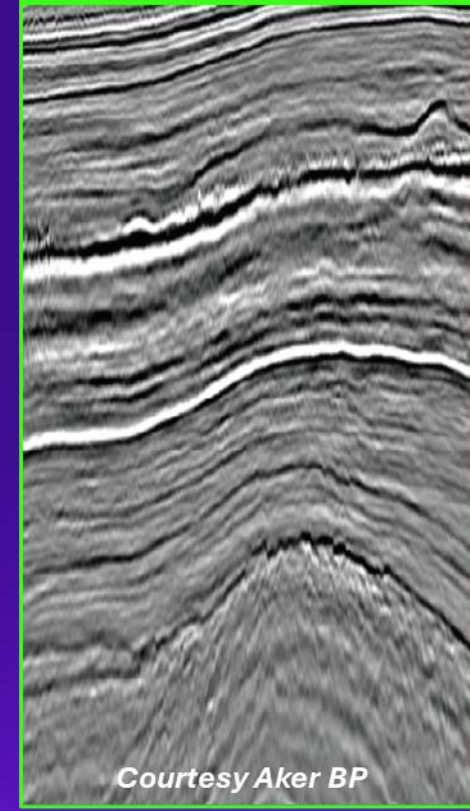
DAS-VSP



c) Courtesy Total Energies

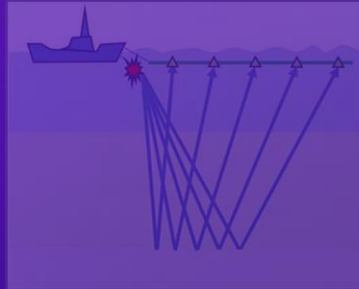


Surface DAS

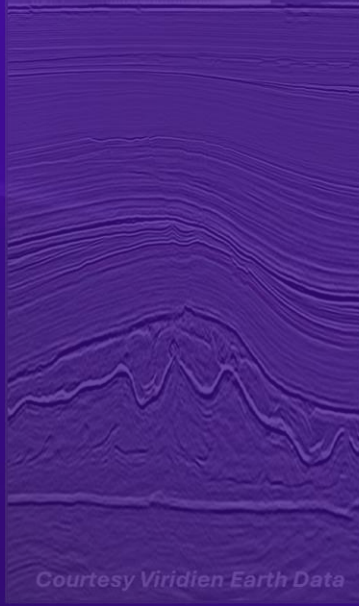


Courtesy Aker BP

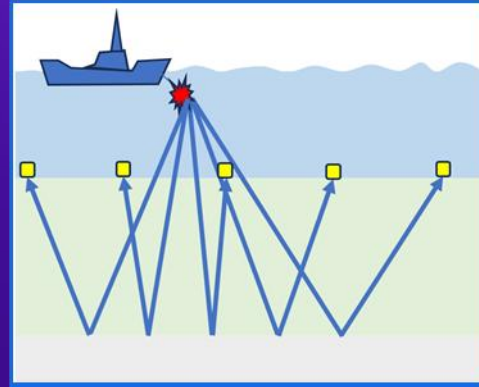
# Novel Seismic Monitoring – Technologies



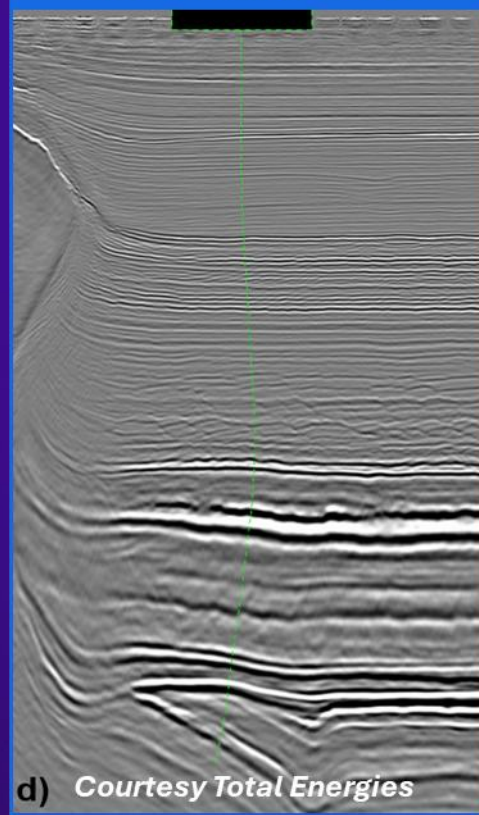
Short Towed Streamer (XHR)



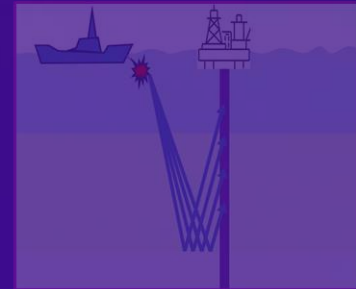
Courtesy Viridien Earth Data



Ocean Bottom Seismic (OBS)



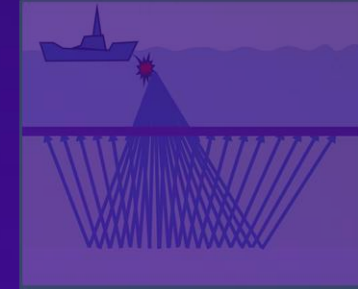
d) Courtesy Total Energies



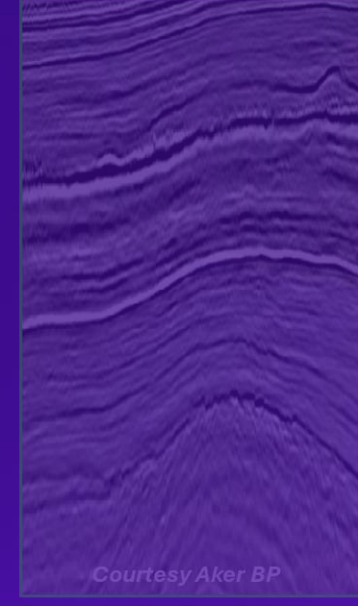
DAS-VSP



c) Courtesy Total Energies



Surface DAS

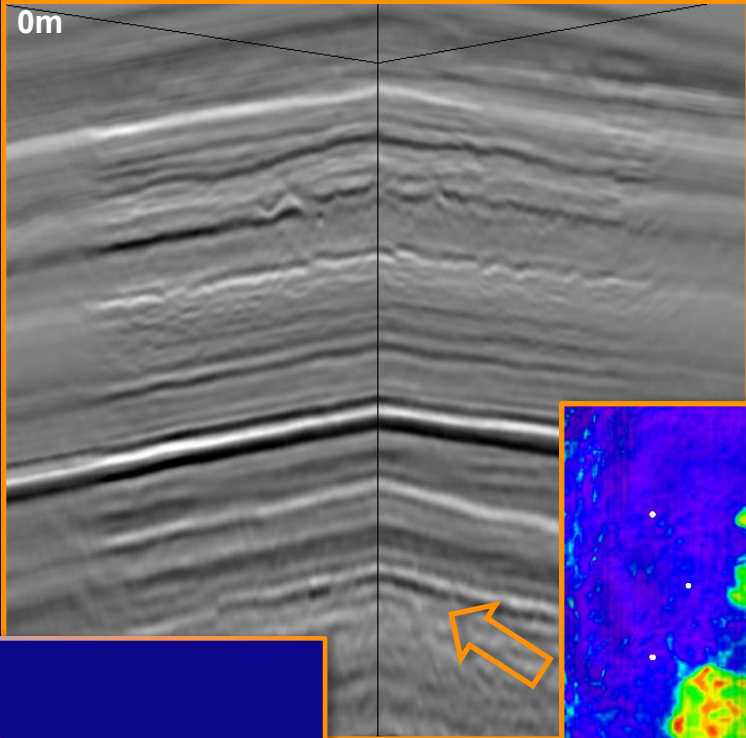
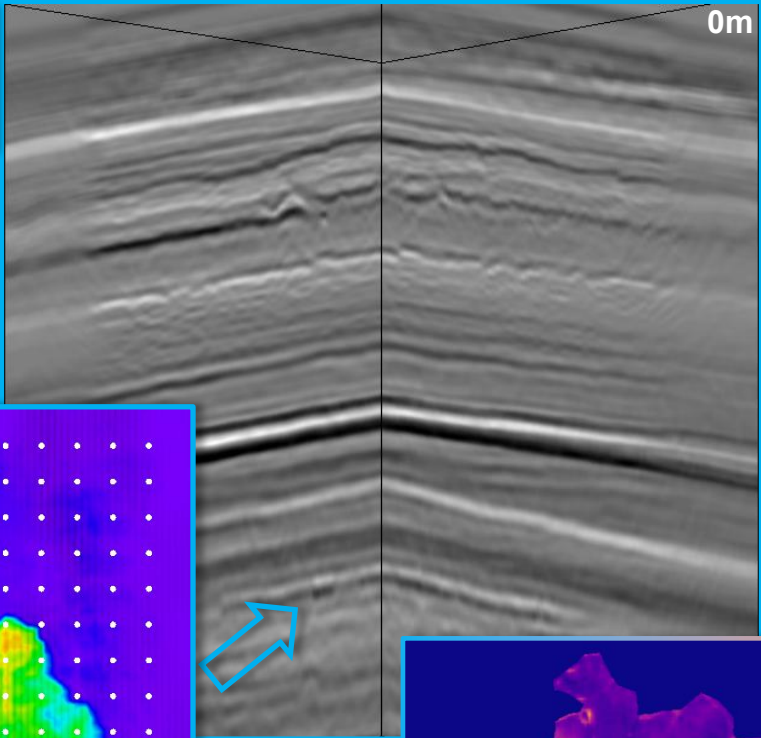


Courtesy Aker BP

# Novel Seismic Monitoring – Optimised OBN

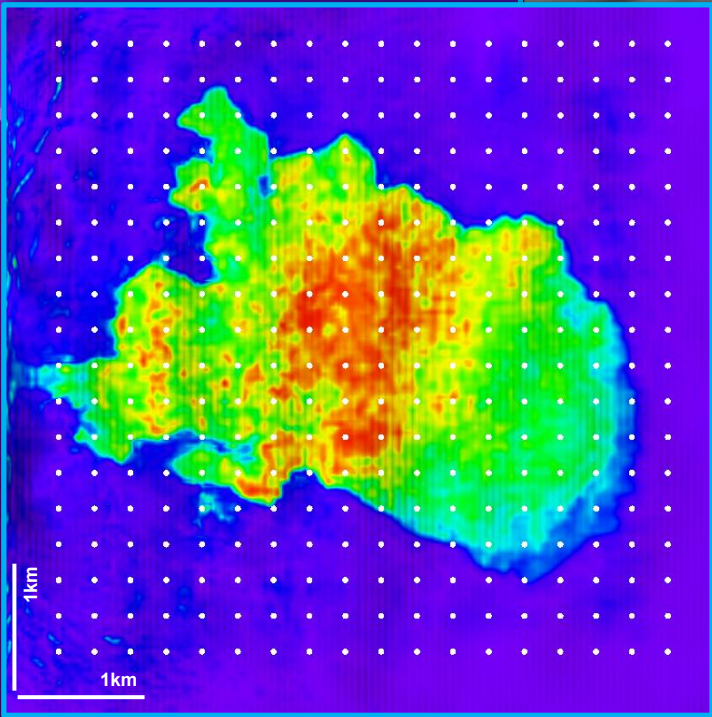


4D FWI Image (Monitor)  
OBN: 324 (300m x 300m)  
Shots: 50m x 50m

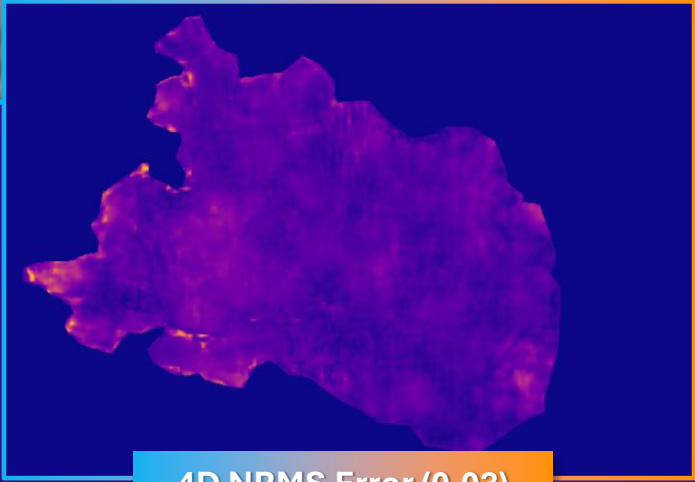
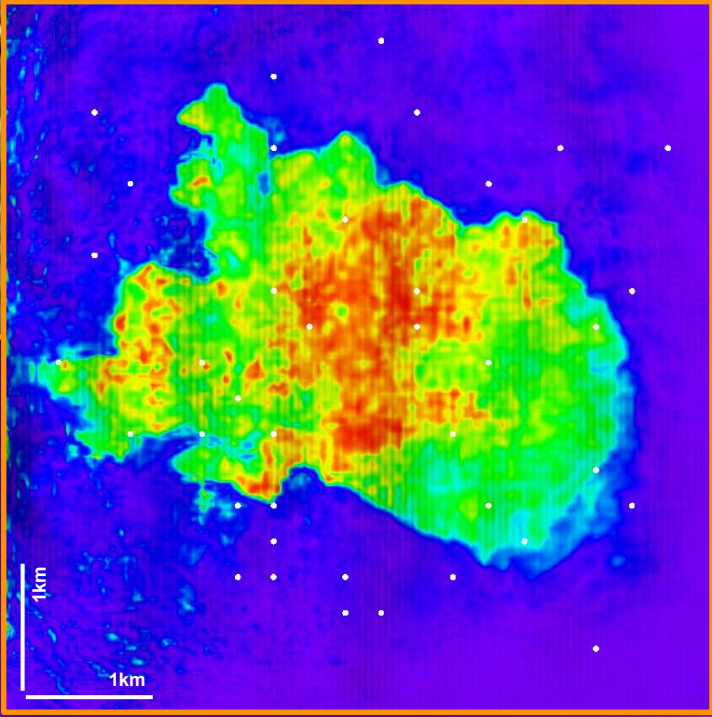


4D FWI Image (Monitor)  
Nodes = 50 (Optimised)  
Shots = 50m x 50m

4D NRMS Full nodes

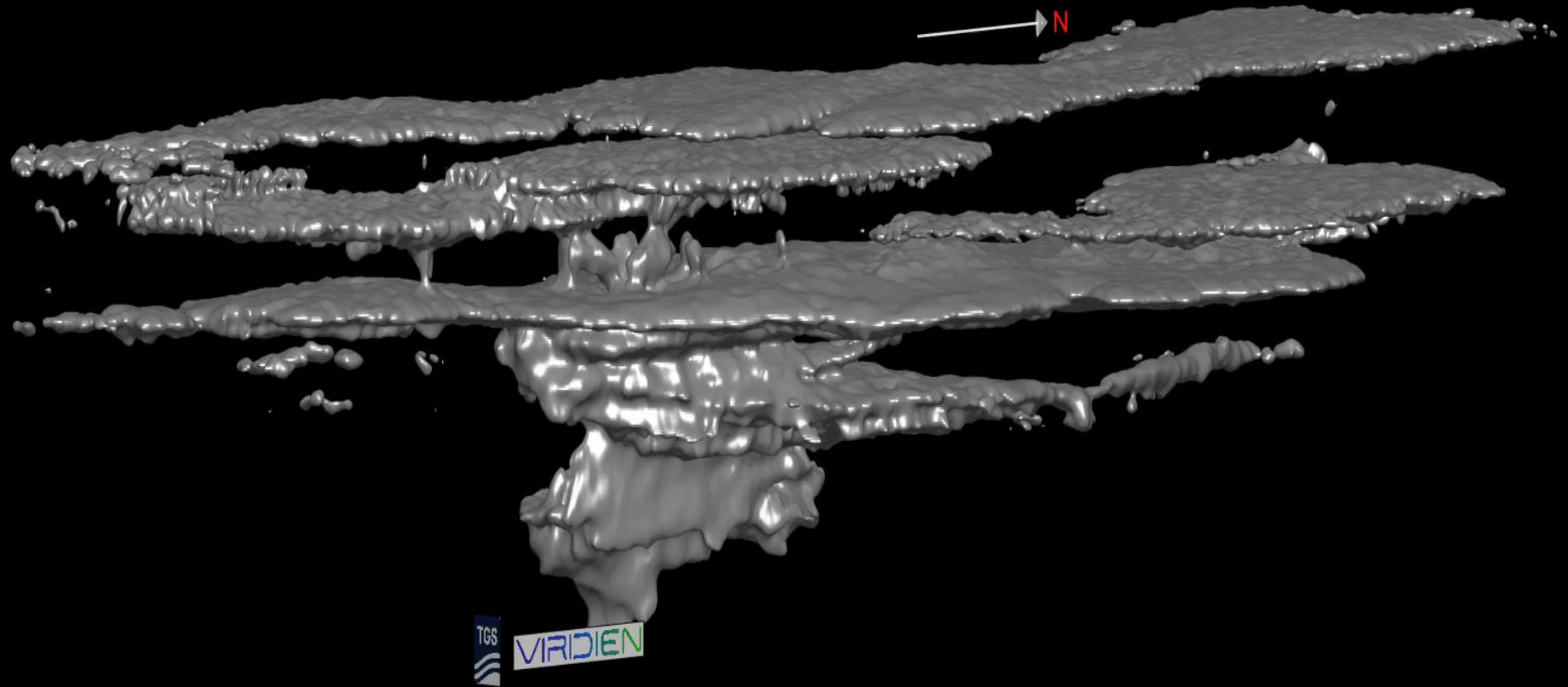


4D NRMS Sparse nodes



4D NRMS Error (0.03)

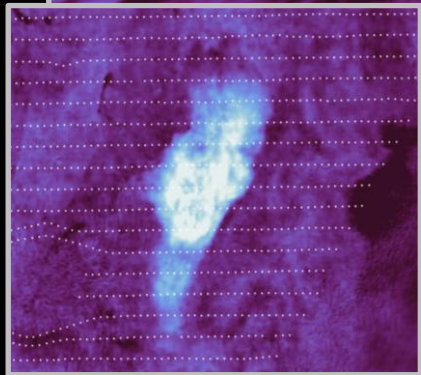
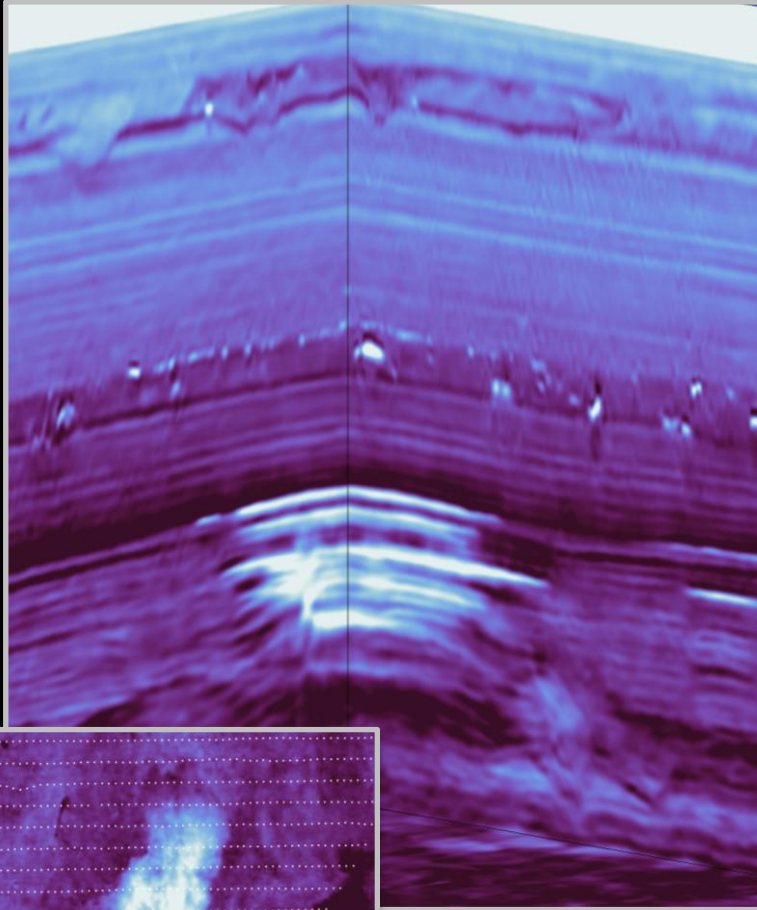
# Novel Seismic Monitoring – Optimised OBN



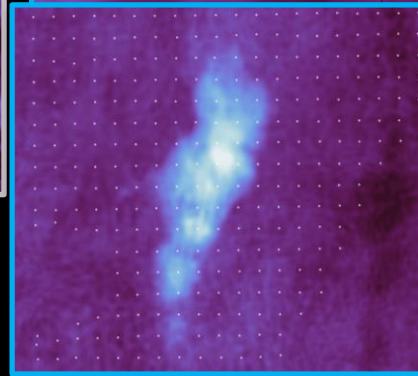
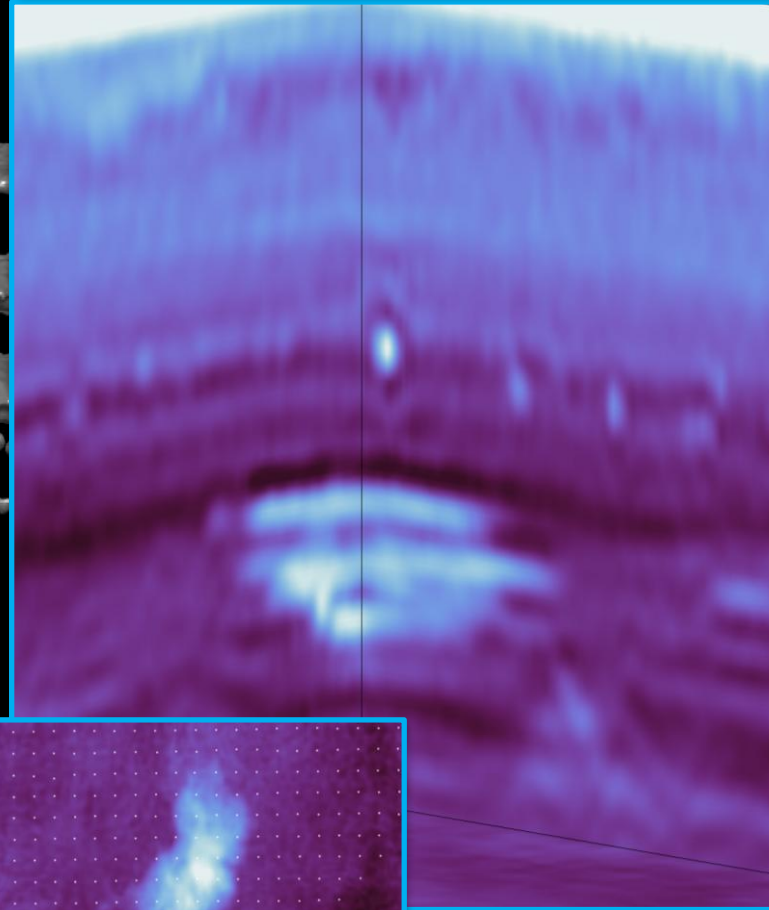
*Courtesy of Viridien Earth Data*

# Novel Seismic Monitoring – Optimised OBN

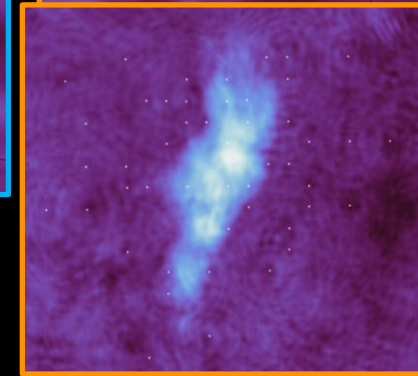
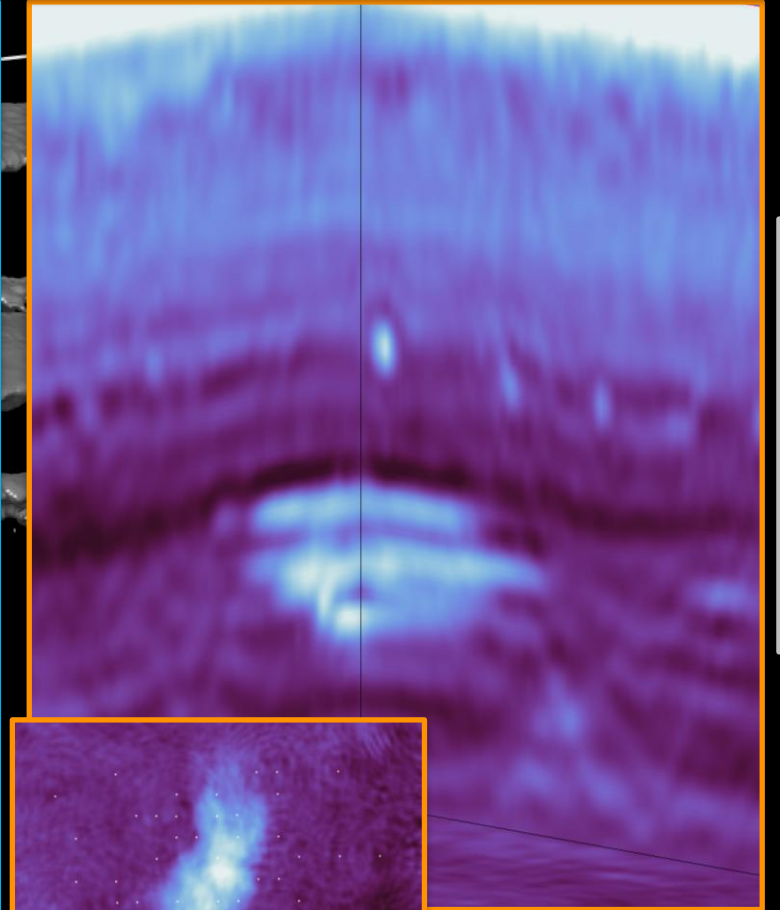
70 Hz FWI (50mx300m OBN, 25mx50m shot)



14 Hz FWI (300mx300m OBN, 25mx50m shot)



14 Hz FWI (50 optimised OBN, 25mx50m shot)

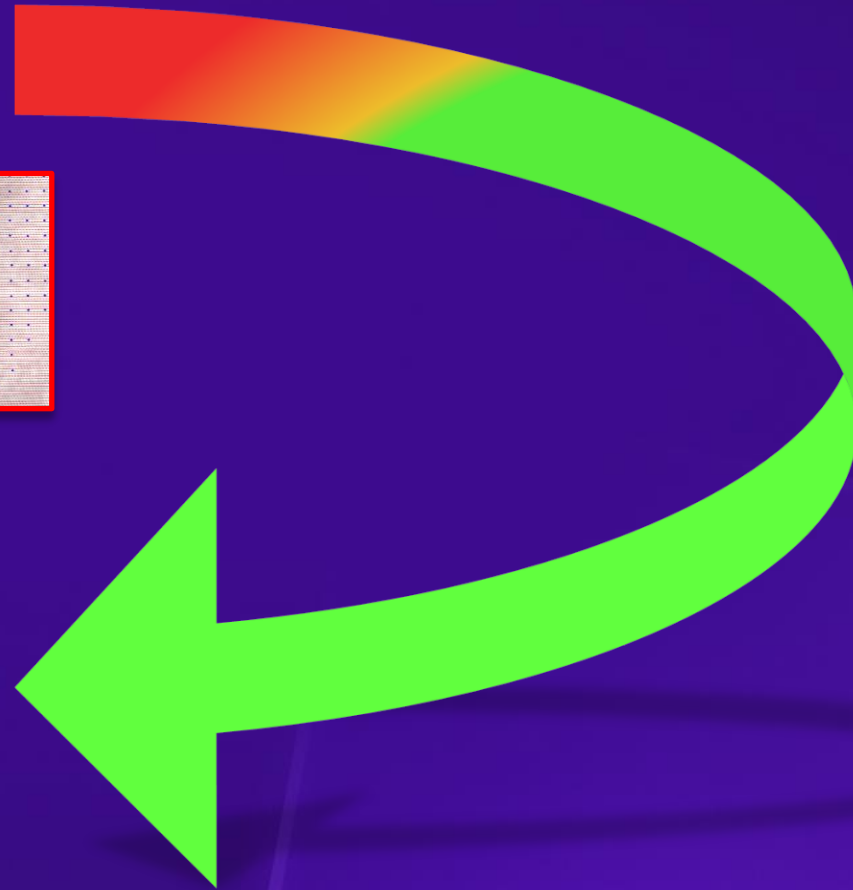
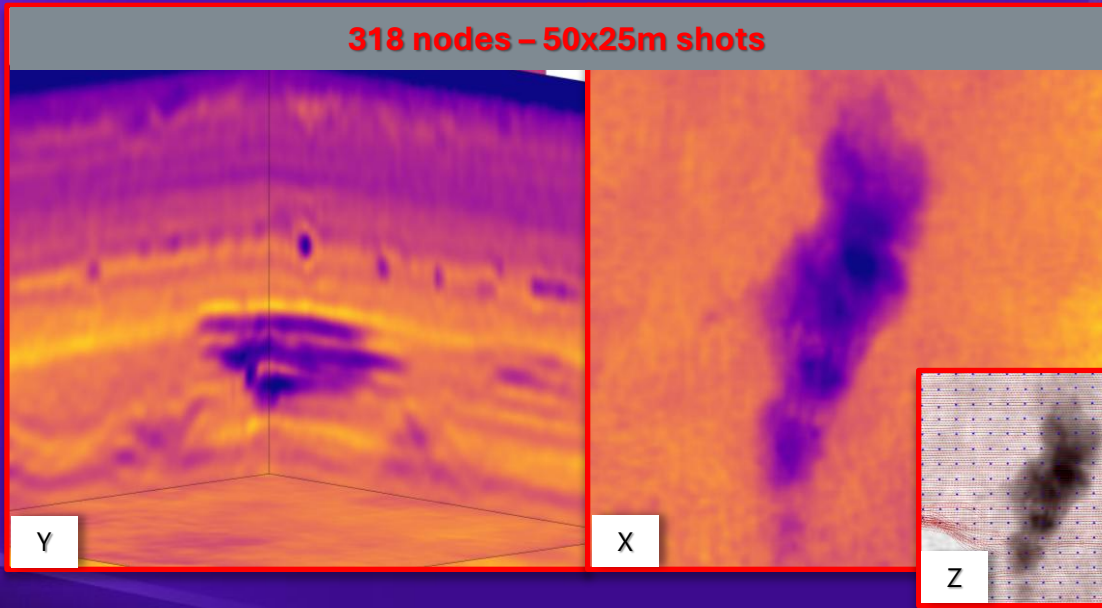


1550 m/s

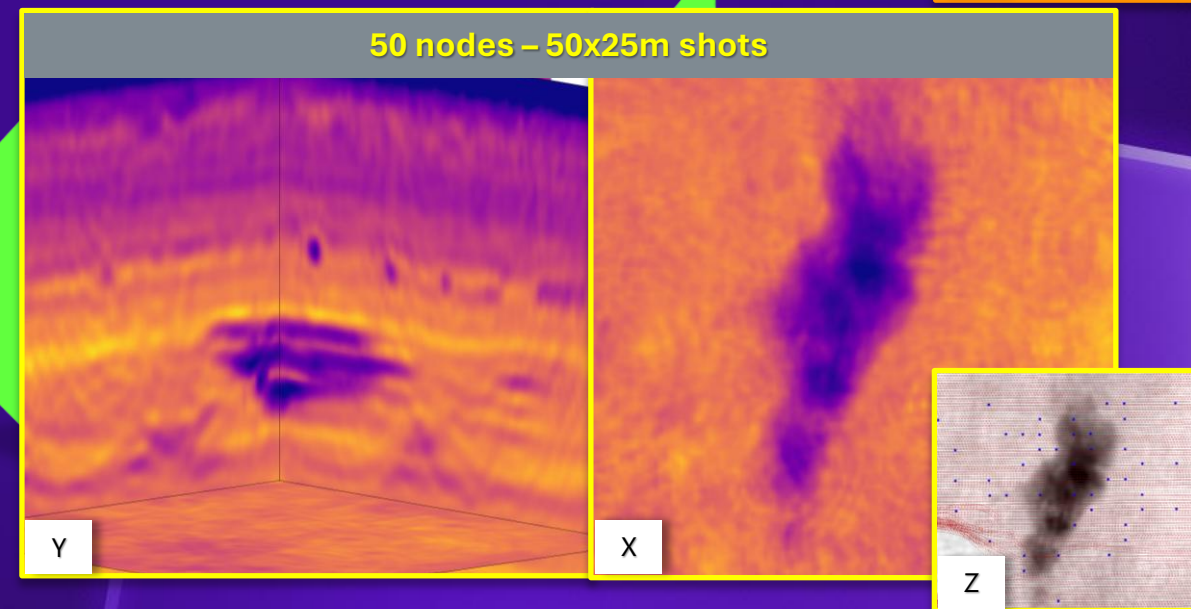
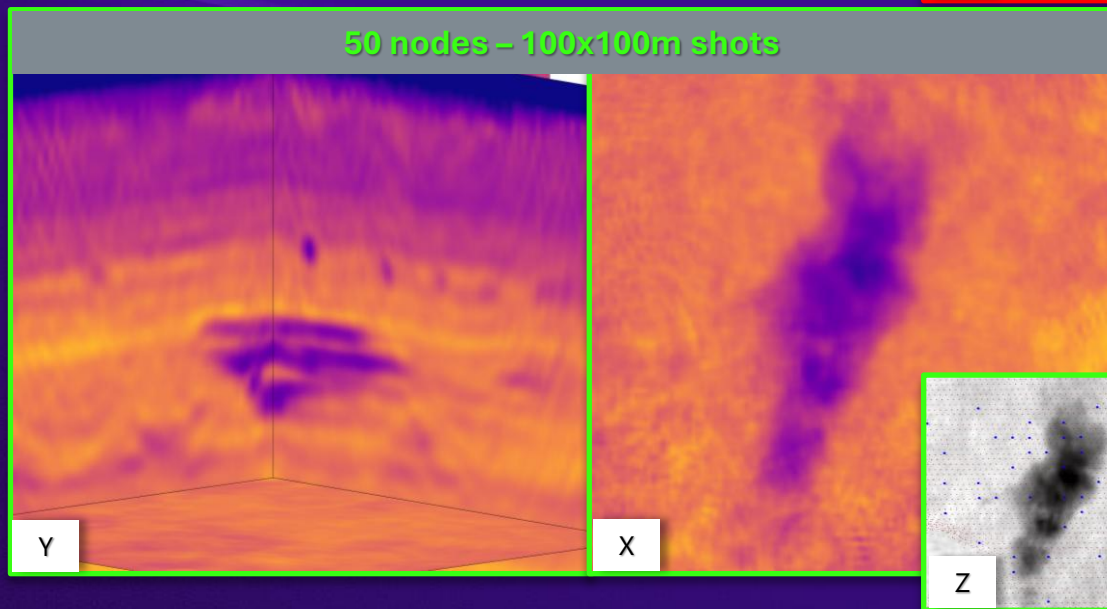
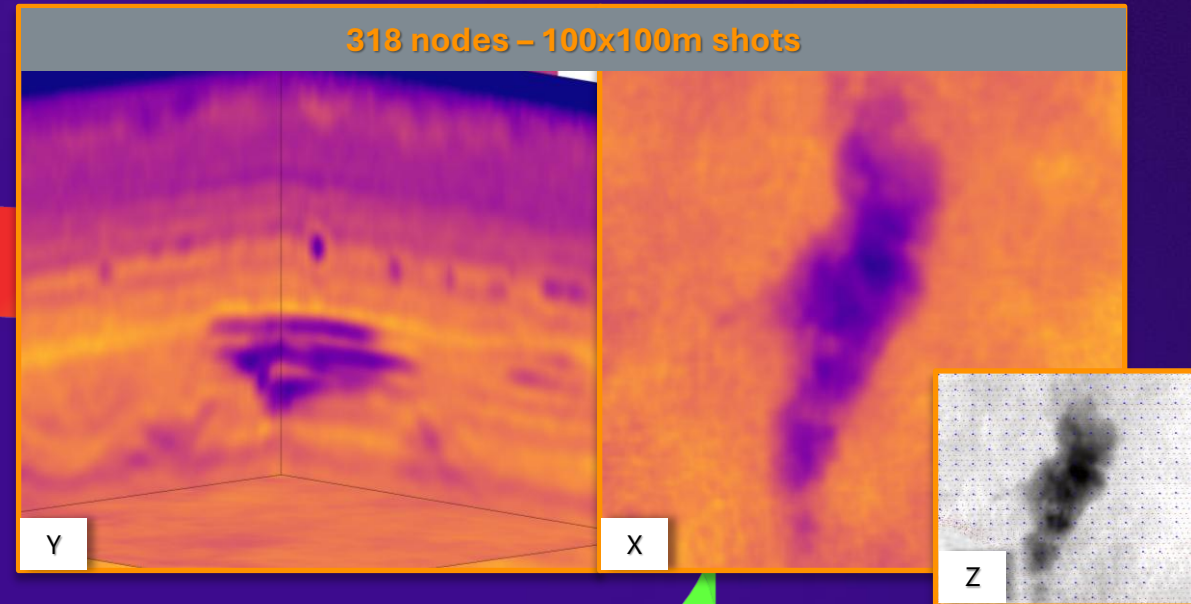
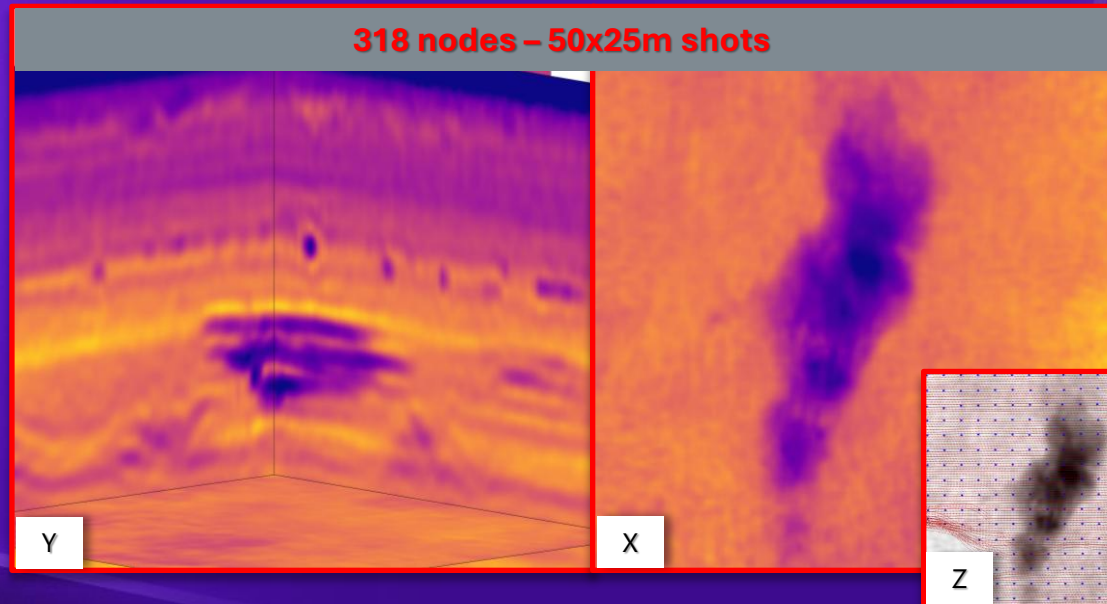
2200 m/s

*Courtesy of Viridien Earth Data*

# Novel Seismic Monitoring – Optimised OBN



# Novel Seismic Monitoring – Optimised OBN

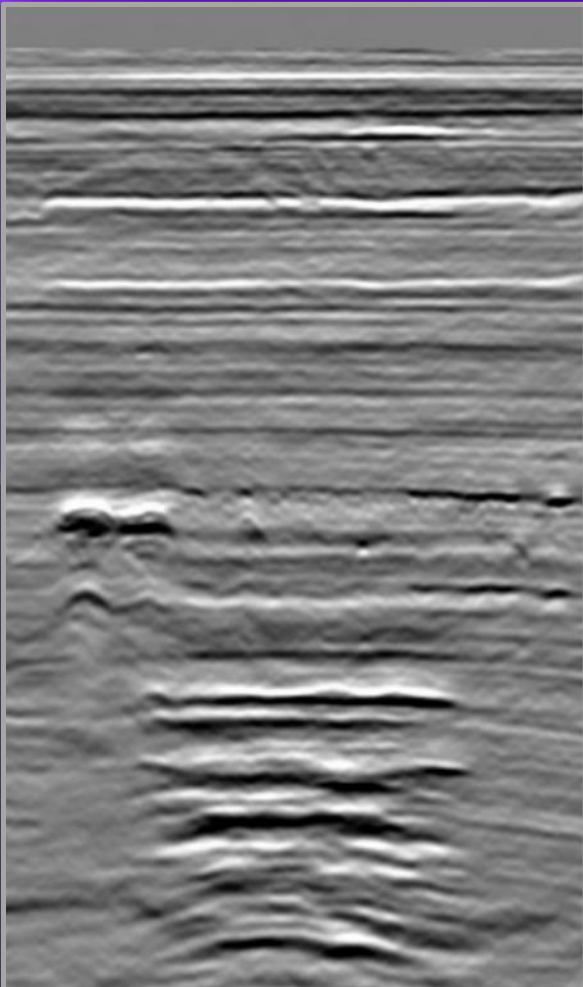


*Courtesy of Viridien Earth Data*

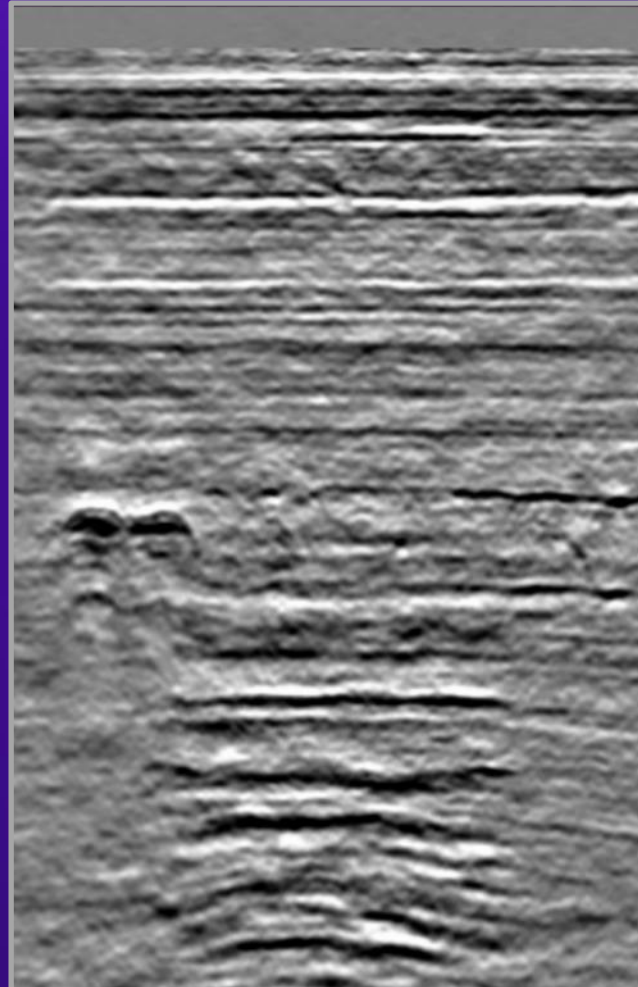
# Novel Seismic Monitoring – Optimised OBN



JPMI: Joint Primary & Multiple Imaging (Full bandwidth)



Full grid JPMI

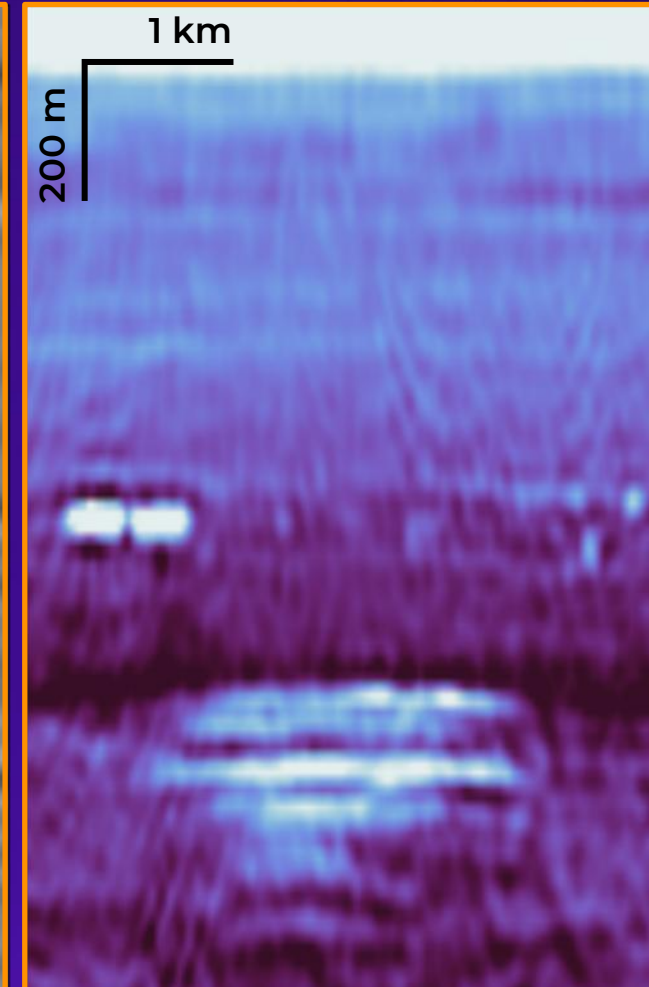


Optimised 50 node JPMI

Full Waveform Inversion (30 Hz)



Optimised 50 node FWI image



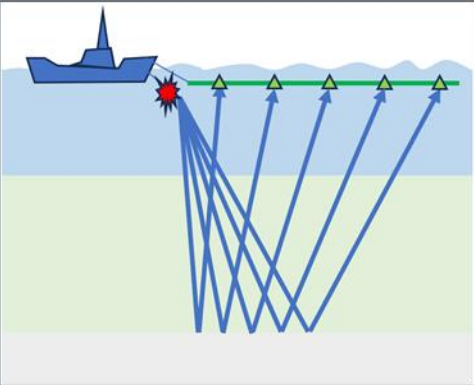
Optimised 50 node velocity

Optimization of ultra sparse acquisition and advanced 4D imaging for monitoring of the Sleipner CO2 Plume, 87th EAGE Annual Conference & Exhibition

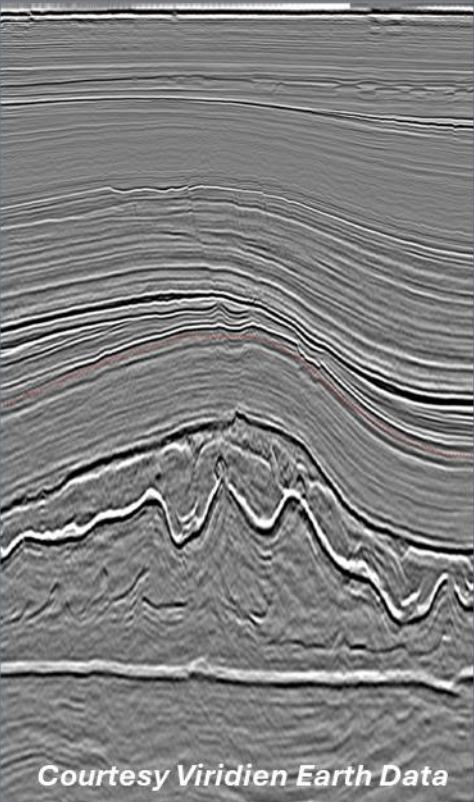
F. Oggioni\*, M. Ledger, S. Hou, S. Hollingworth

Courtesy of Viridien Earth Data

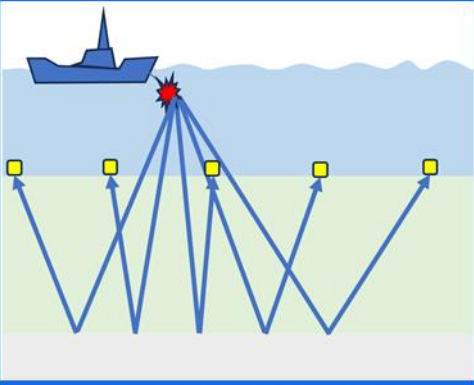
# Novel Seismic Monitoring – Technologies



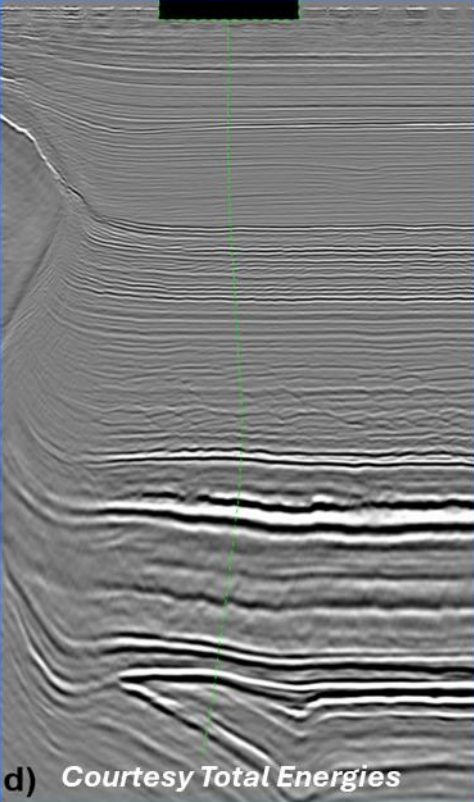
Short Towed Streamer (XHR)



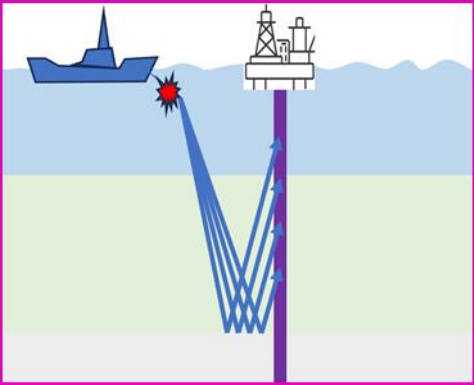
Courtesy Viridien Earth Data



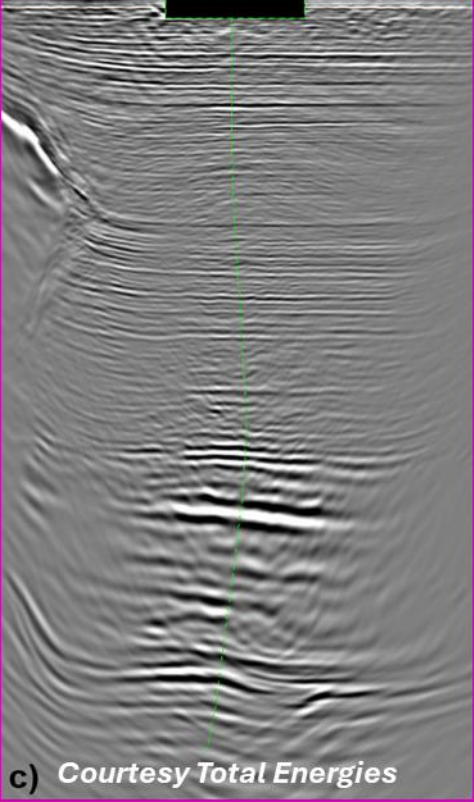
Ocean Bottom Seismic (OBS)



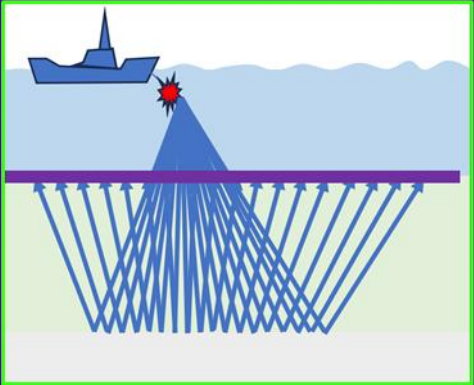
d) Courtesy Total Energies



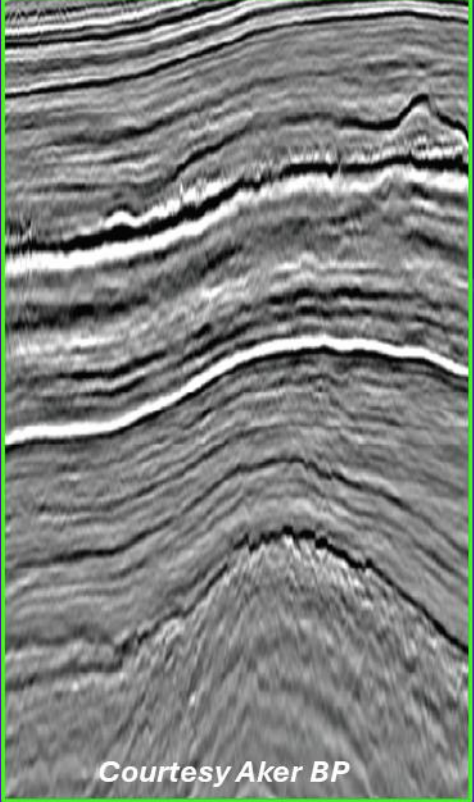
DAS-VSP



c) Courtesy Total Energies

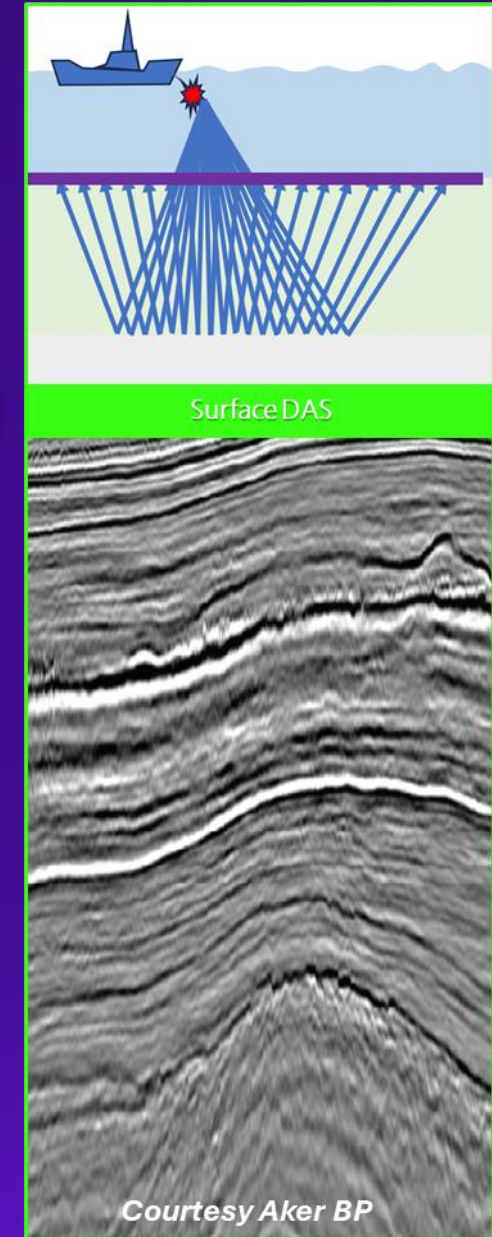
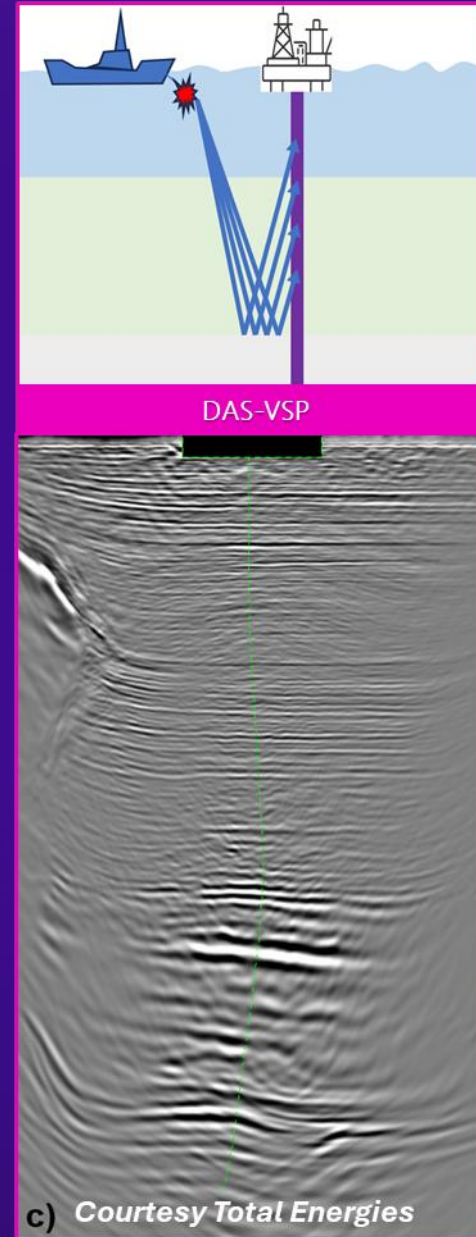
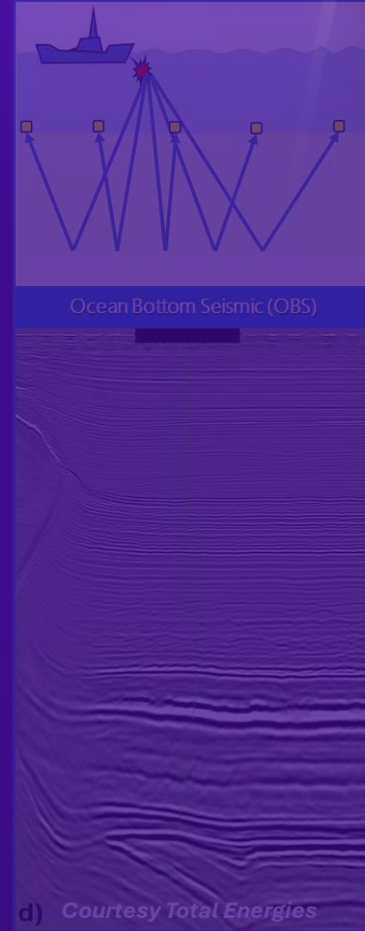
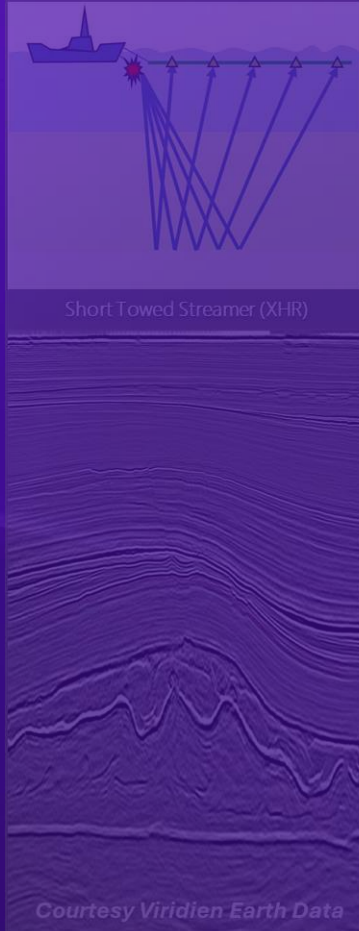


Surface DAS



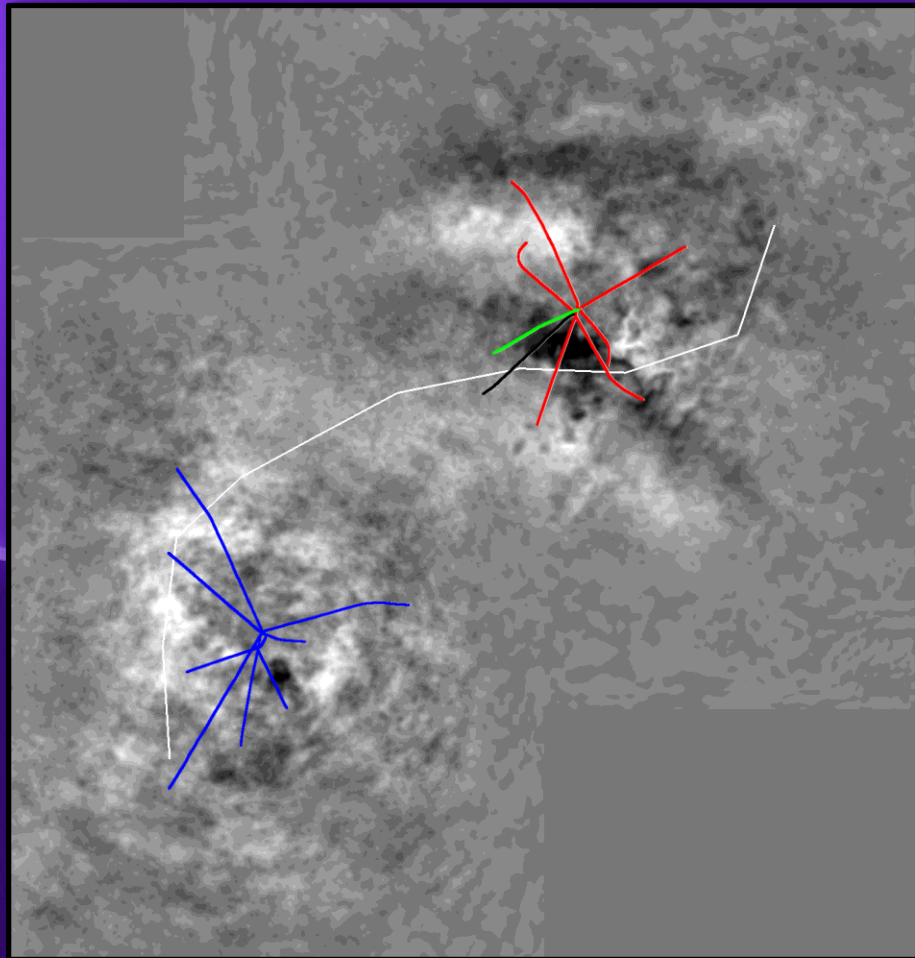
Courtesy Aker BP

# Novel Seismic Monitoring – Technologies

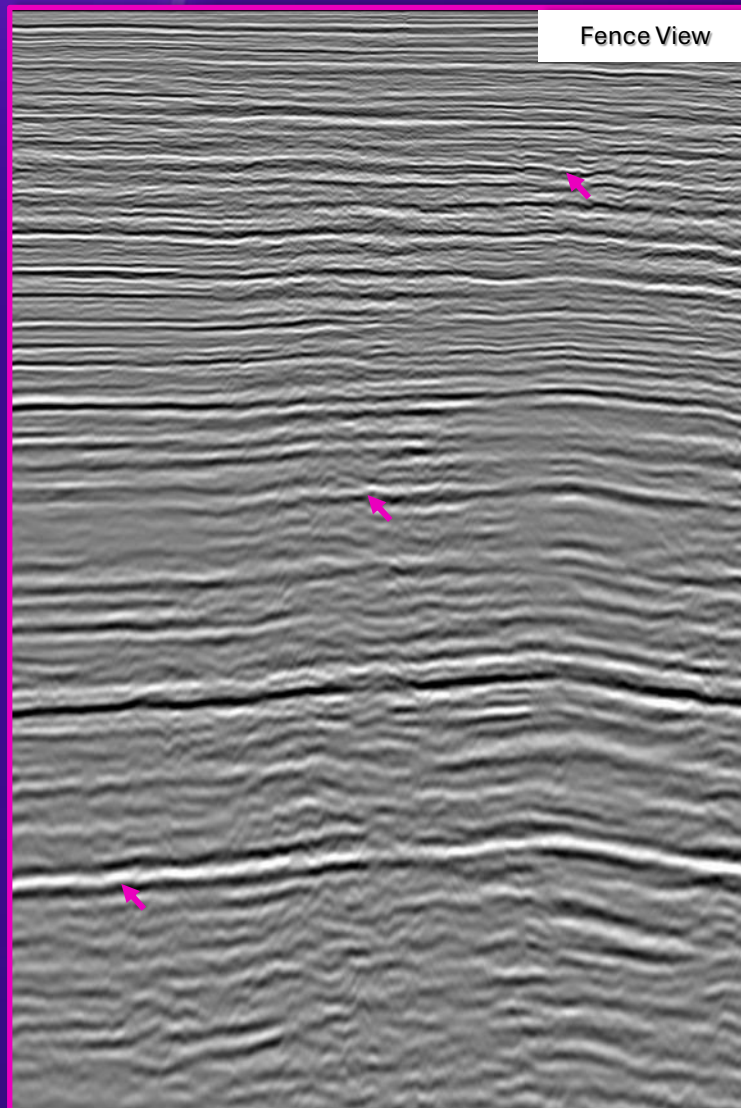


# Novel Seismic Monitoring – DAS VSP (JPMI)

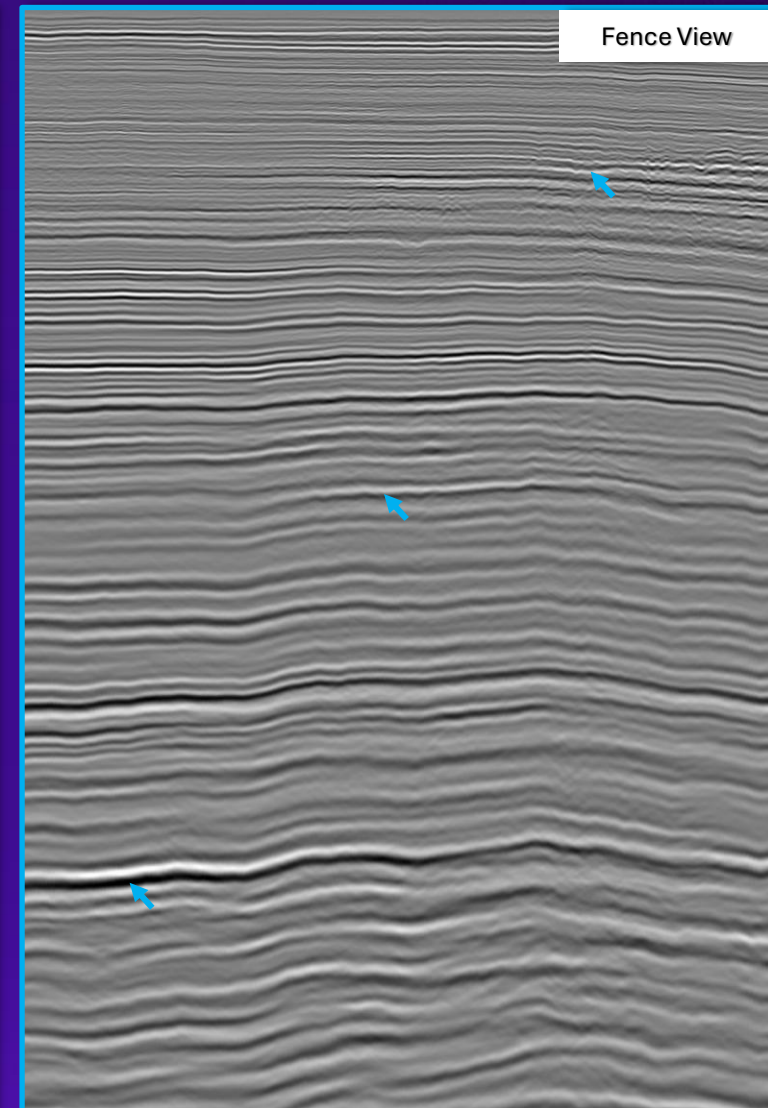
Courtesy of ADNOC



0m



Fence View



Fence View

7km

DAS VSP, 16 wells, JPMI (2024)

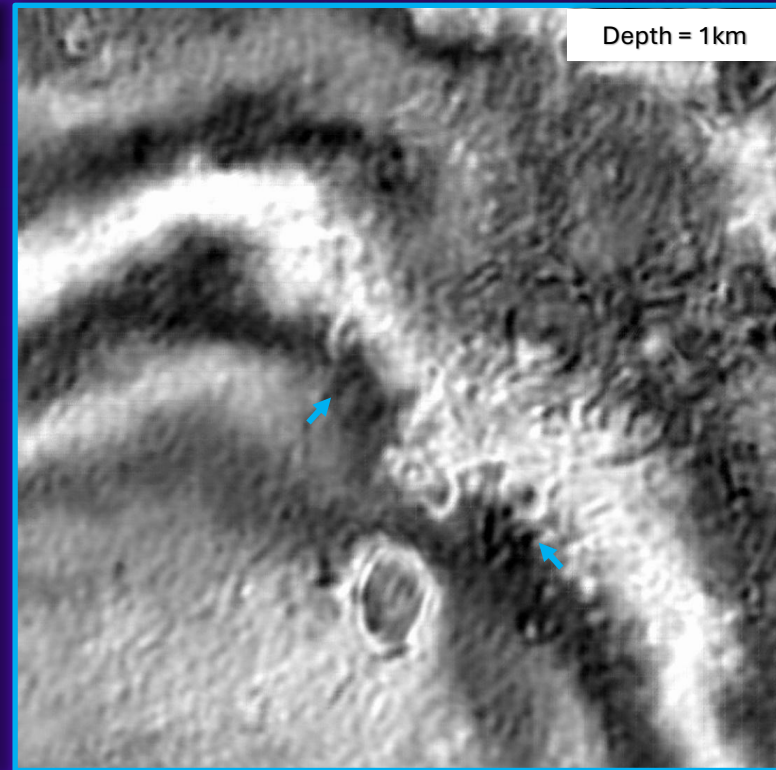
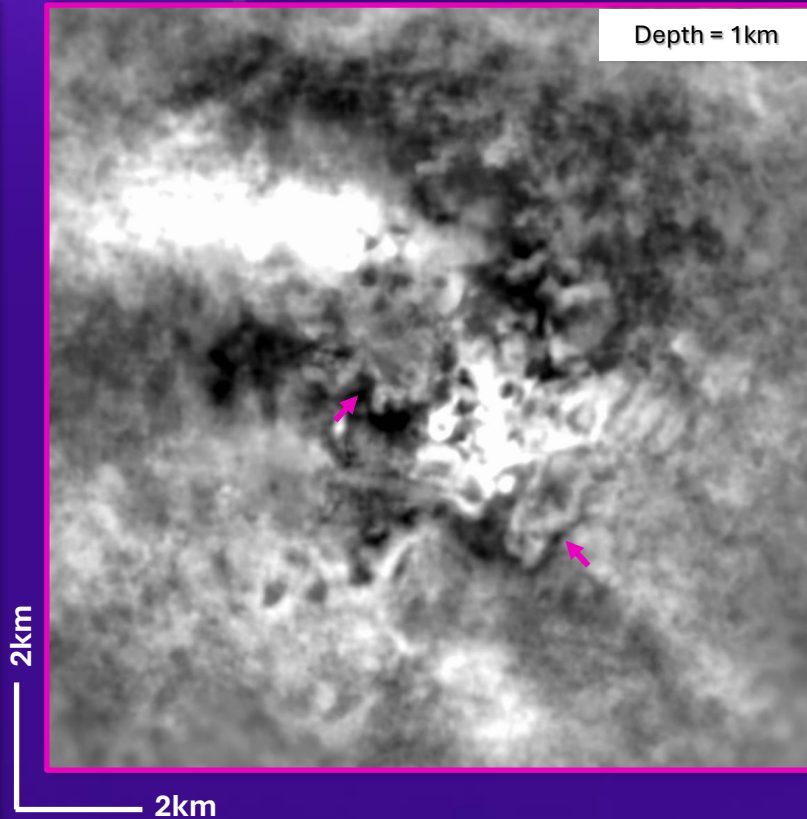
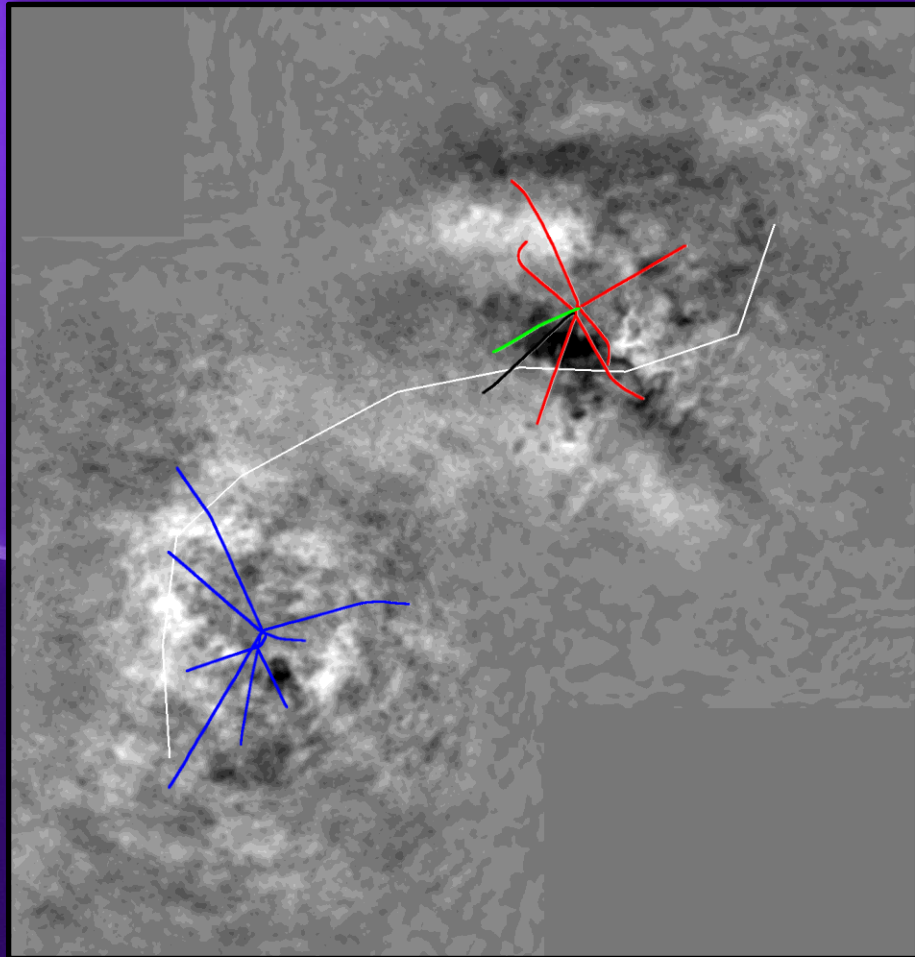
Ocean Bottom Cable (2018)

Joint Primary and Multiple Imaging - A Singular Imaging Route for 16 DASVSPs 86th EAGE Annual Conference & Exhibition

I. Iliev, S. Morgan\*, A. Kornev, C. Abrahams, H. Moore, M. Farshad, G. Cambois, M. Mahgoub, M. Waqas

# Novel Seismic Monitoring – DAS VSP (JPMI)

Courtesy of ADNOC



Joint Primary and Multiple Imaging - A Singular Imaging Route for 16 DASVSPs 86th EAGE Annual Conference & Exhibition

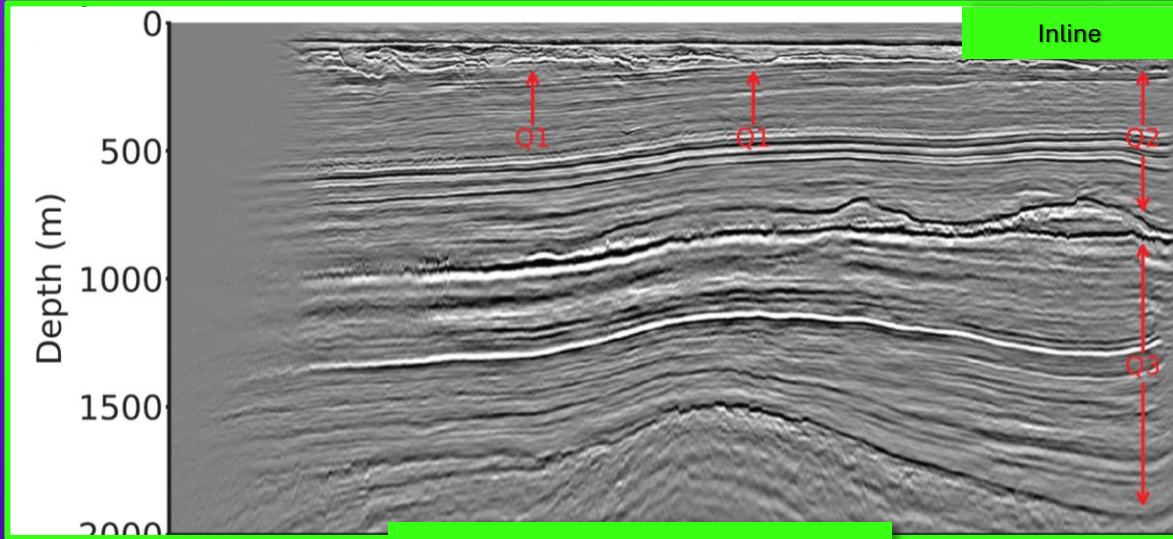
I. Iliev, S. Morgan\*, A. Kornev, C. Abrahams, H. Moore, M. Farshad, G. Cambois, M. Mahgoub, M. Waqas

DAS VSP, 16 wells, JPMI (2024)

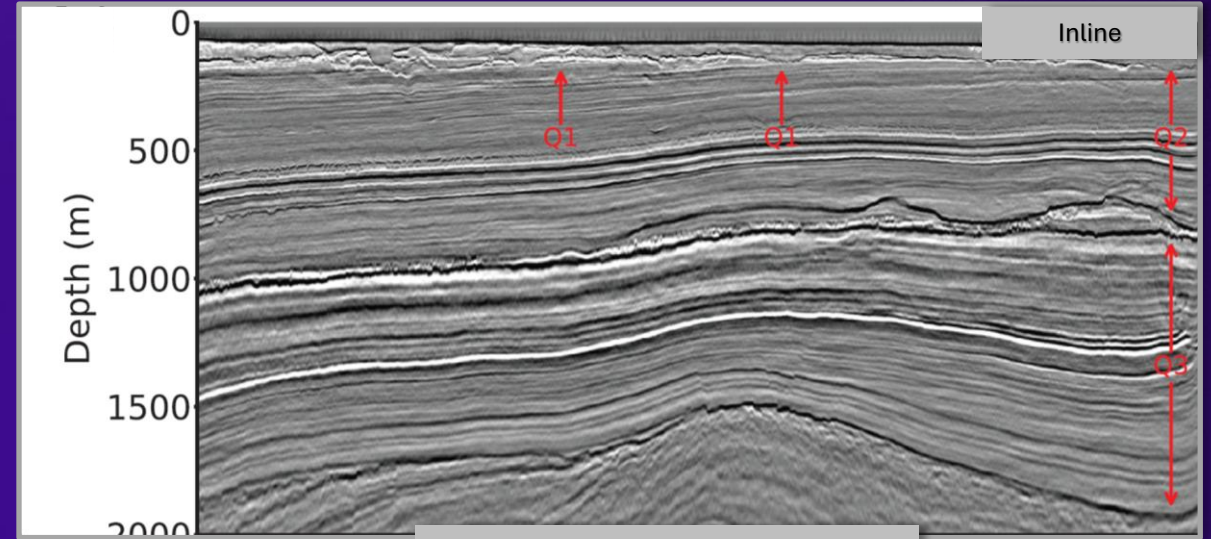
Ocean Bottom Cable (2018)

# Novel Seismic Monitoring – S-DAS (Dark Fibre)

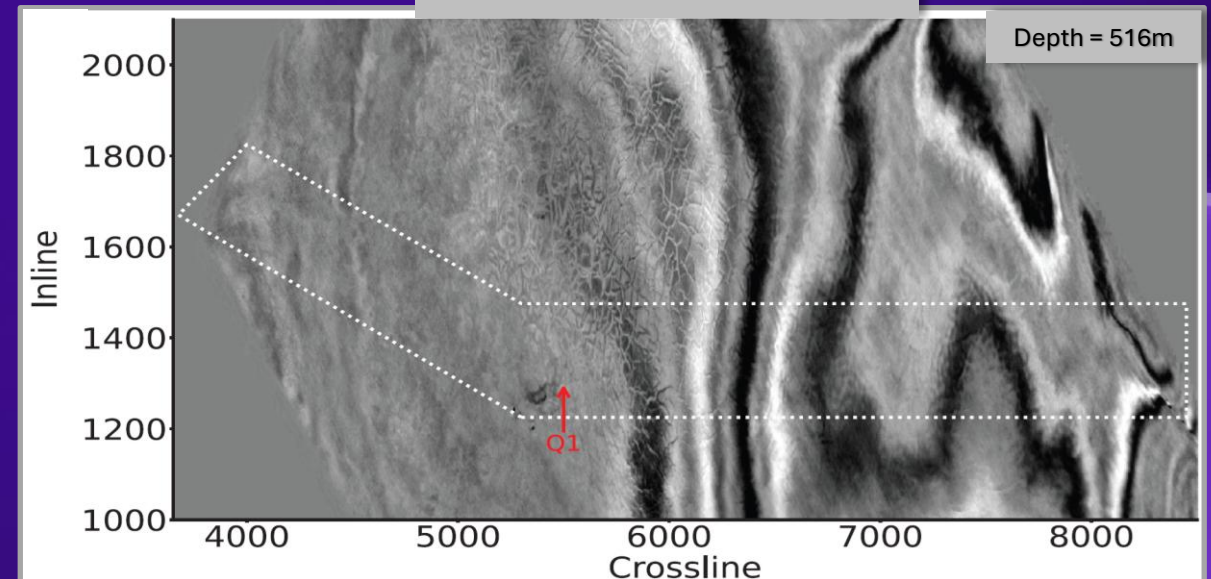
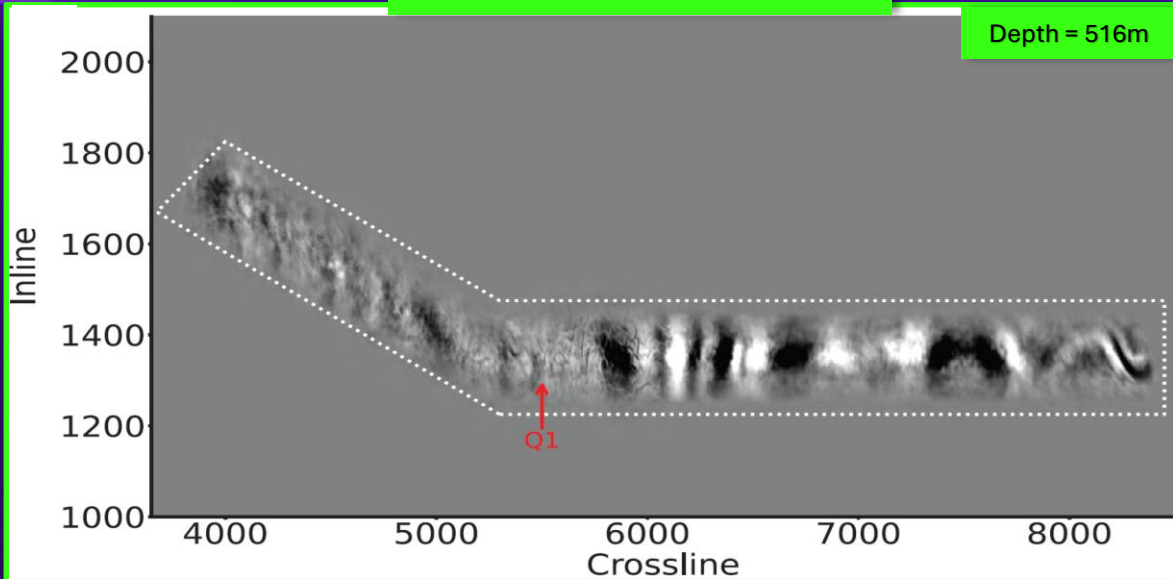
Courtesy of Aker BP



Surface DAS



3D Towed Streamer

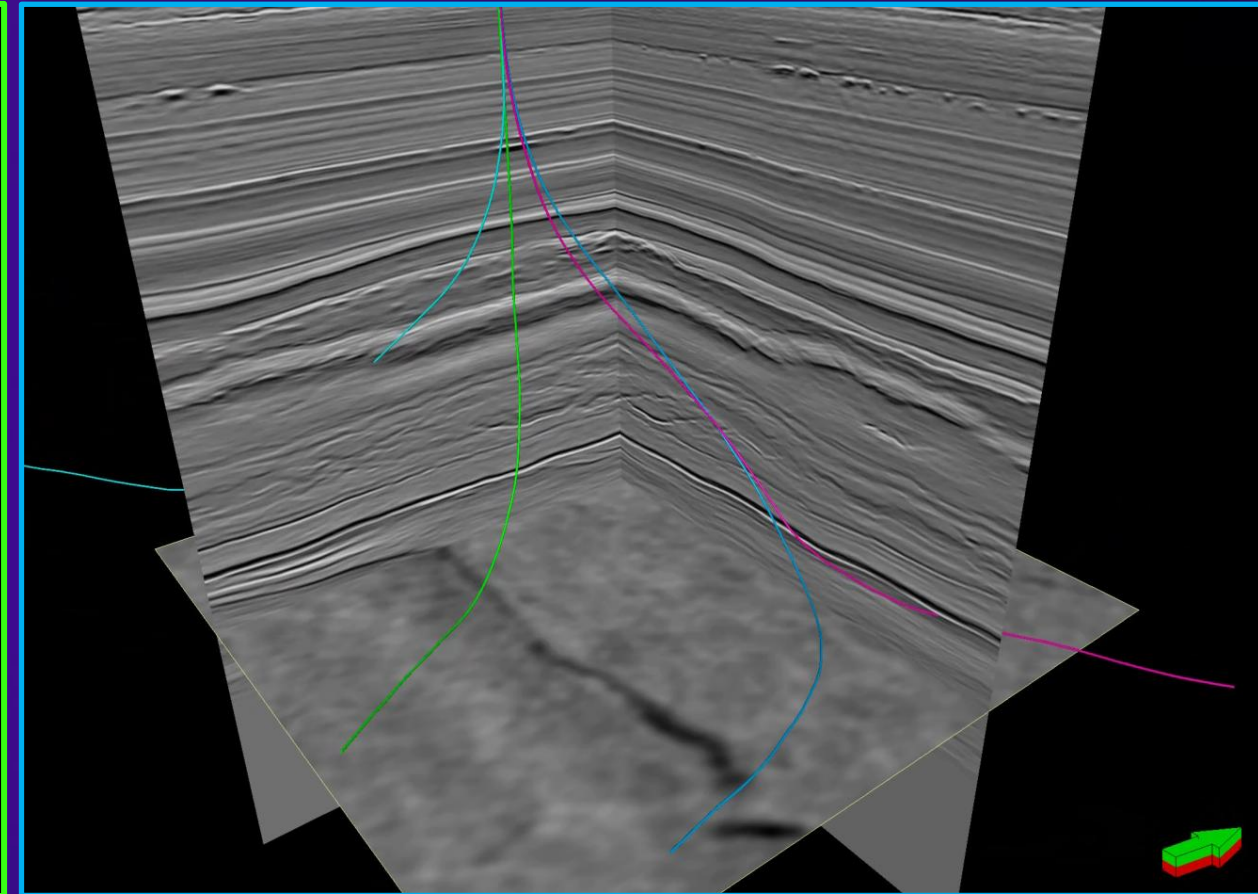
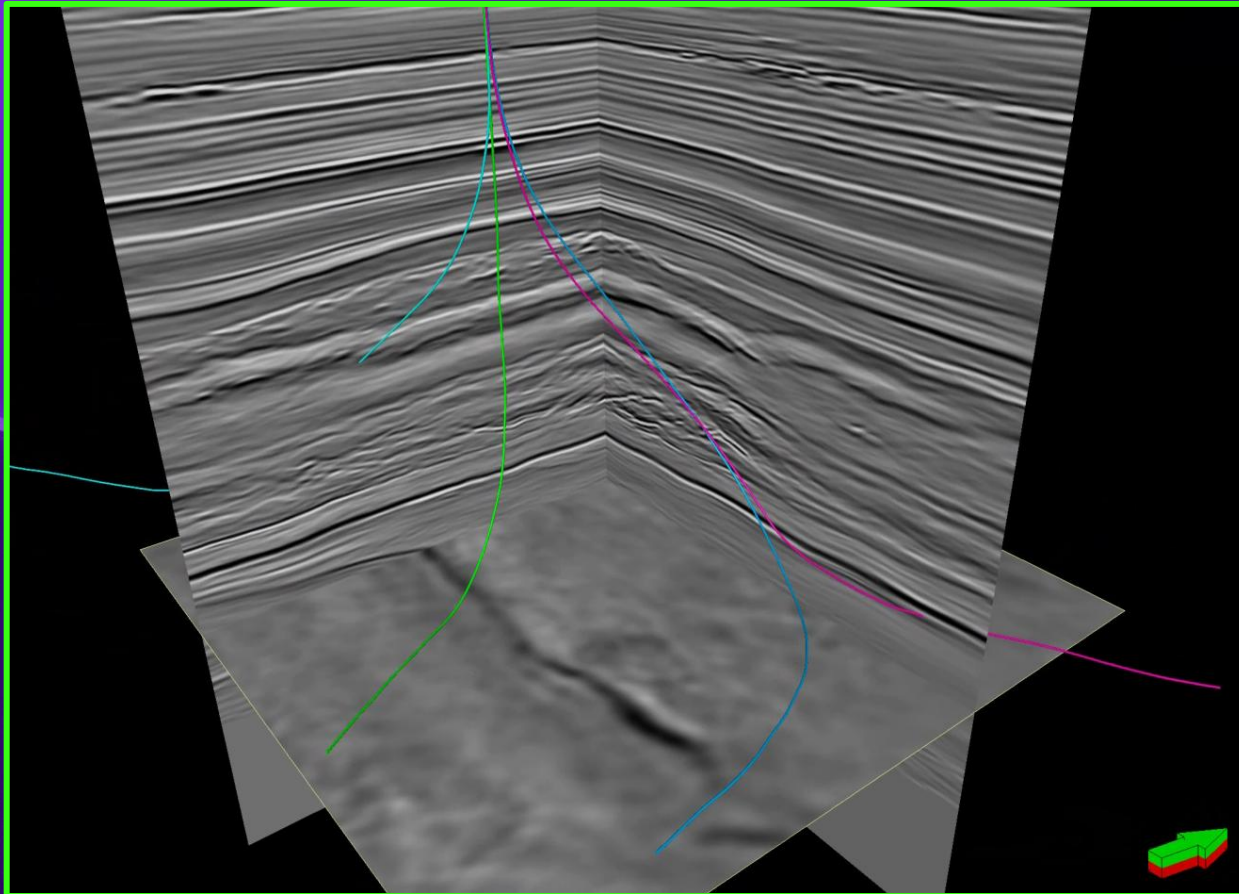


Acquisition and imaging of ocean-bottom fiber-optic distributed acoustic sensing data using a full-shot carpet from a conventional 3D survey, *GEOPHYSICS* 90: P99-P112,



DAS (5 Surface & 4 VSP)

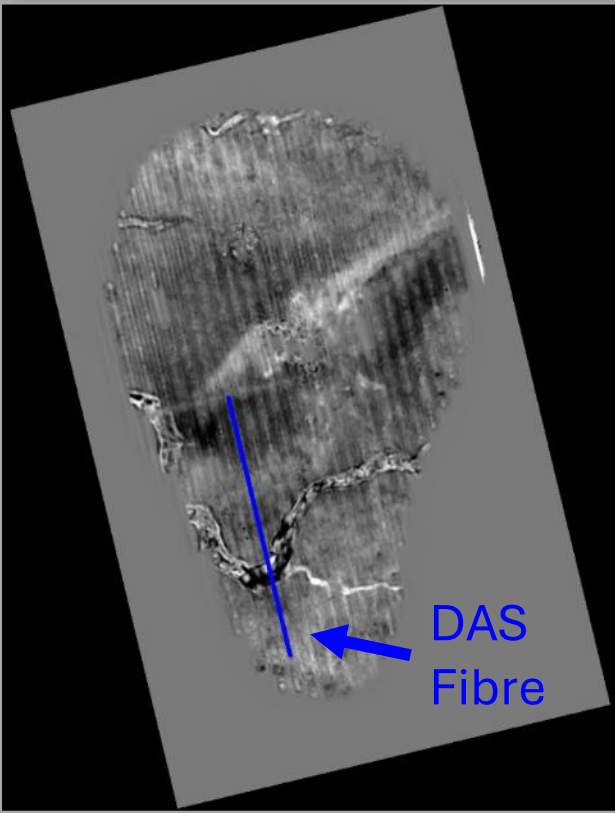
OBN (200m x 50m nodes)



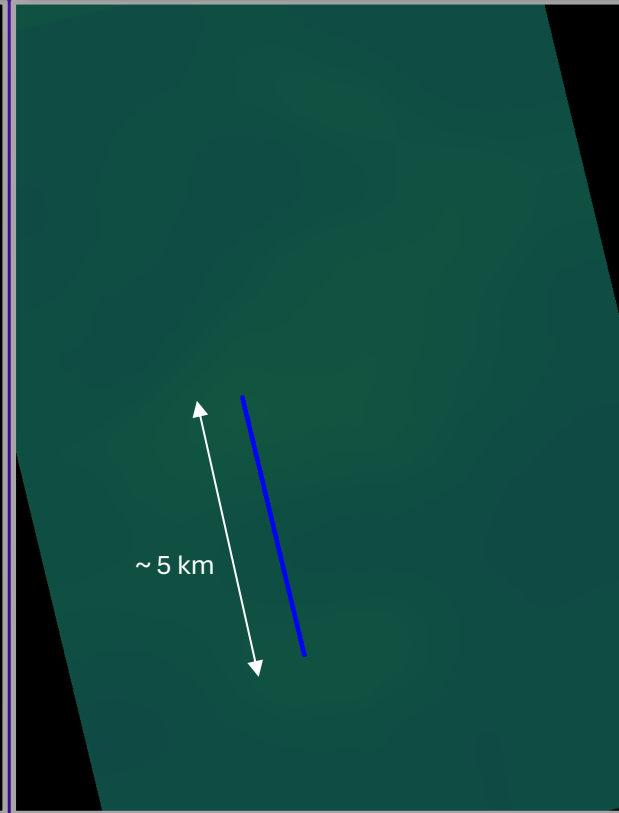
Common source (25m x 25m)

# Novel Seismic Monitoring – S-DAS Elastic FWI *Courtesy PL018 Partnership*

Full PRM array image

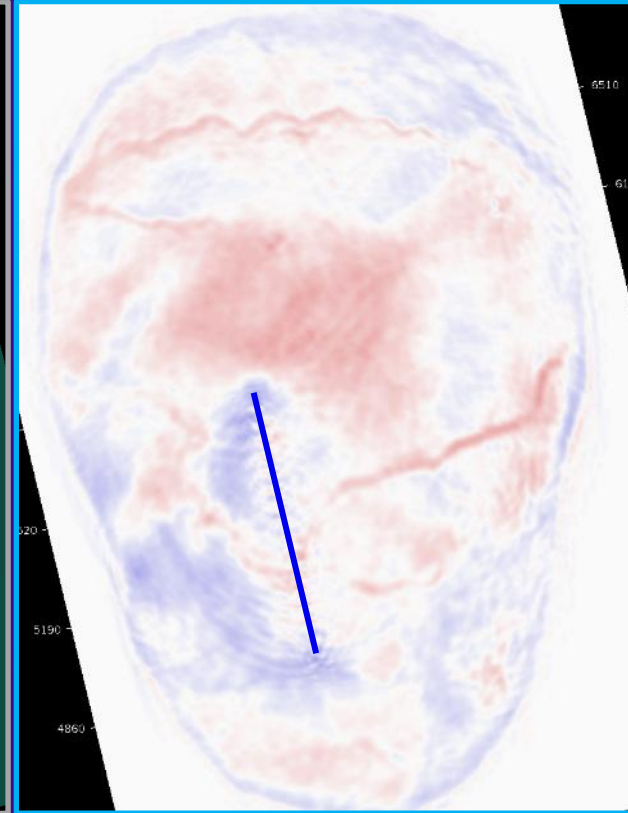


Initial velocity model ( $V_p$ )



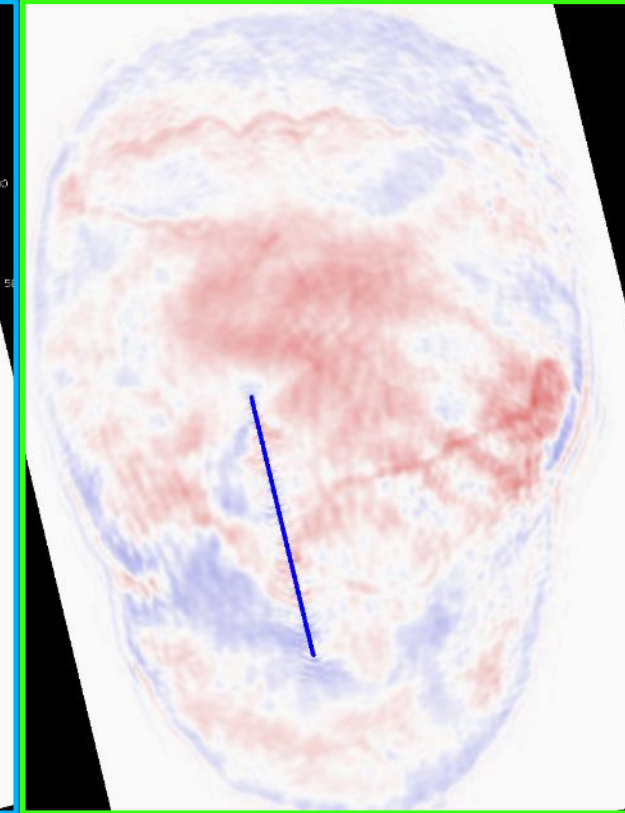
1500  $V_p$  (m/s) 2000

EFWI with PRM data (dV)



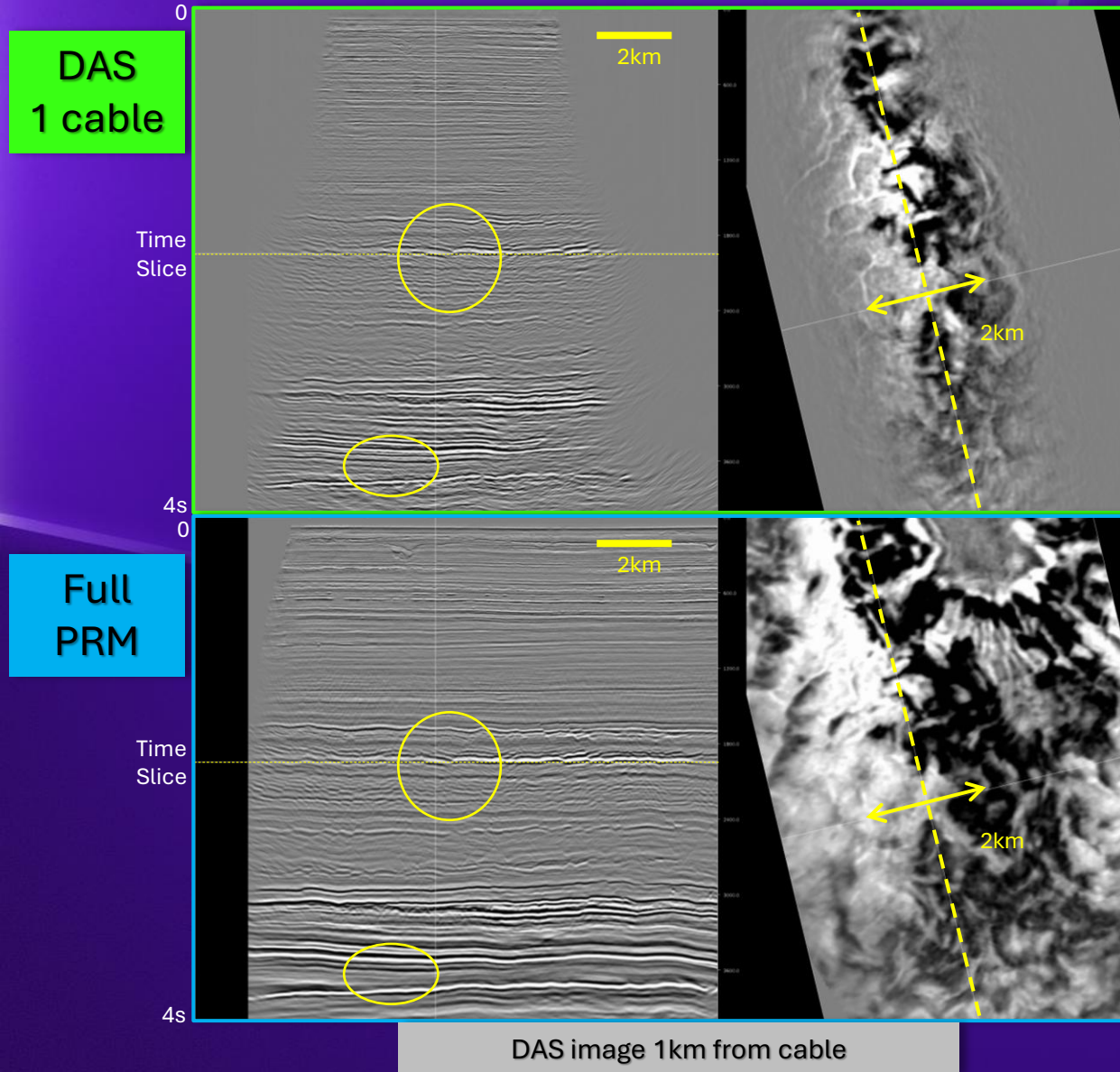
-200 dV (m/s) 200

EFWI with DAS data (dV)



# Novel Seismic Monitoring – S-DAS 3D/4D

Courtesy PL018 Partnership 



**Redacted Image**

# Carbon Storage Monitoring – Objectives?



## ■ Objectives

1. Conformance
2. Containment
3. Confidence
4. Cost

## ■ 4D Seismic

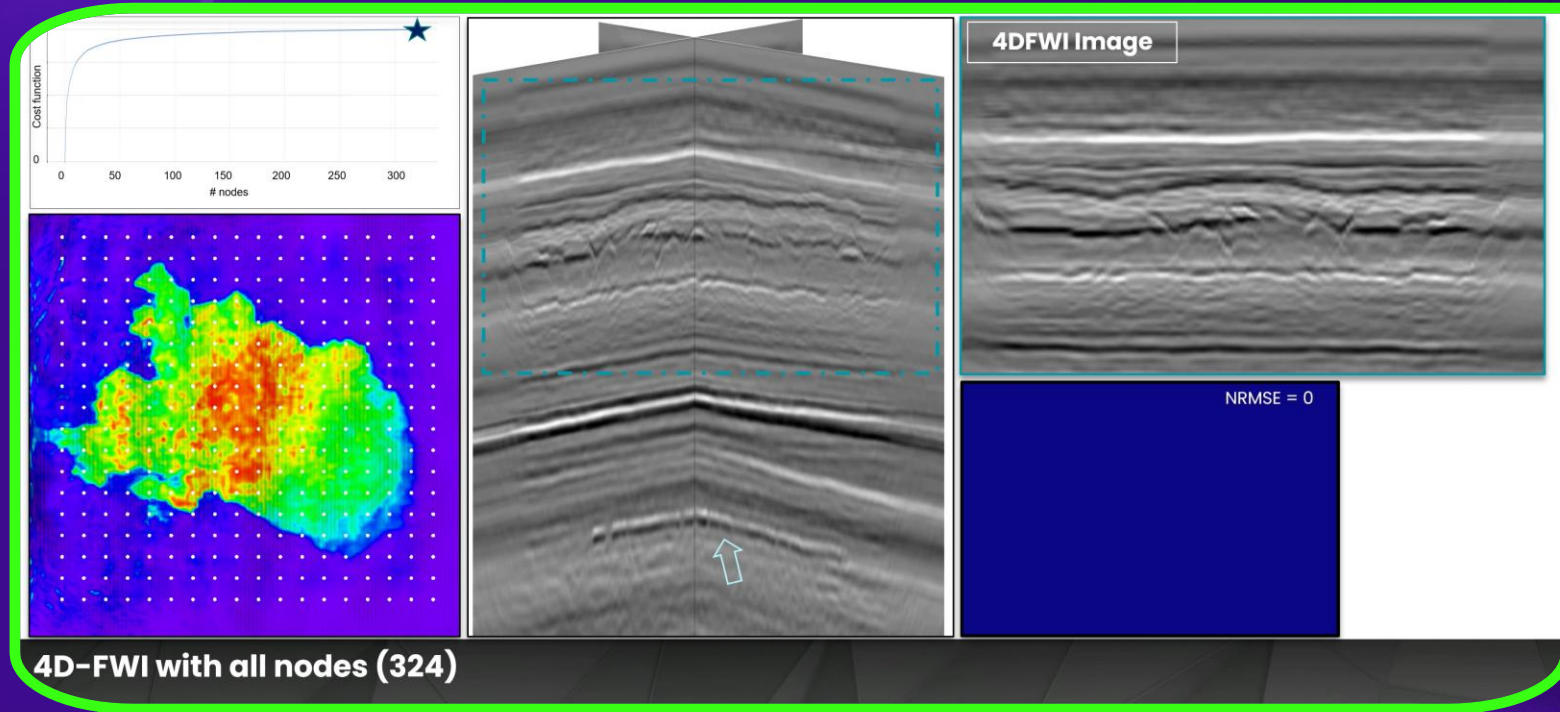
– Desired but Expensive

## ■ Novel technology

– Acquisition: Deploy Less

– Imaging: Use More

- Full wavefield
- Plume & Overburden
- Target the risks
- Reduce the costs



Optimization of ultra sparse acquisition and advanced 4D imaging for CO2 monitoring, Green Energy Transition 2025

*F. Oggioni\*, M. Ledger, R. Porjesz, S. Hou, S. Hollingworth, F. Barracano*



# ACKNOWLEDGMENTS

**ADNOC** for permission to show the DAS VSP data

**Aker BP** for permission to show the DAS VSP, Surface DAS and joint DAS datasets

**PL018 Partnership** (TotalEnergies EP Norge AS, ConocoPhillips Skandinavia AS,

Vår Energi ASA, DNO Norge AS and Petoro AS) for permission to show the Ekofisk data

**Total Energies** for permission to show the North Sea DAS VSP and OBN example

**Viridien Earth data and TGS** for permission to show the Sleipner OBN data



# CONXISE

Targeted Ultra Sparse  
Full Wavefield Monitoring

