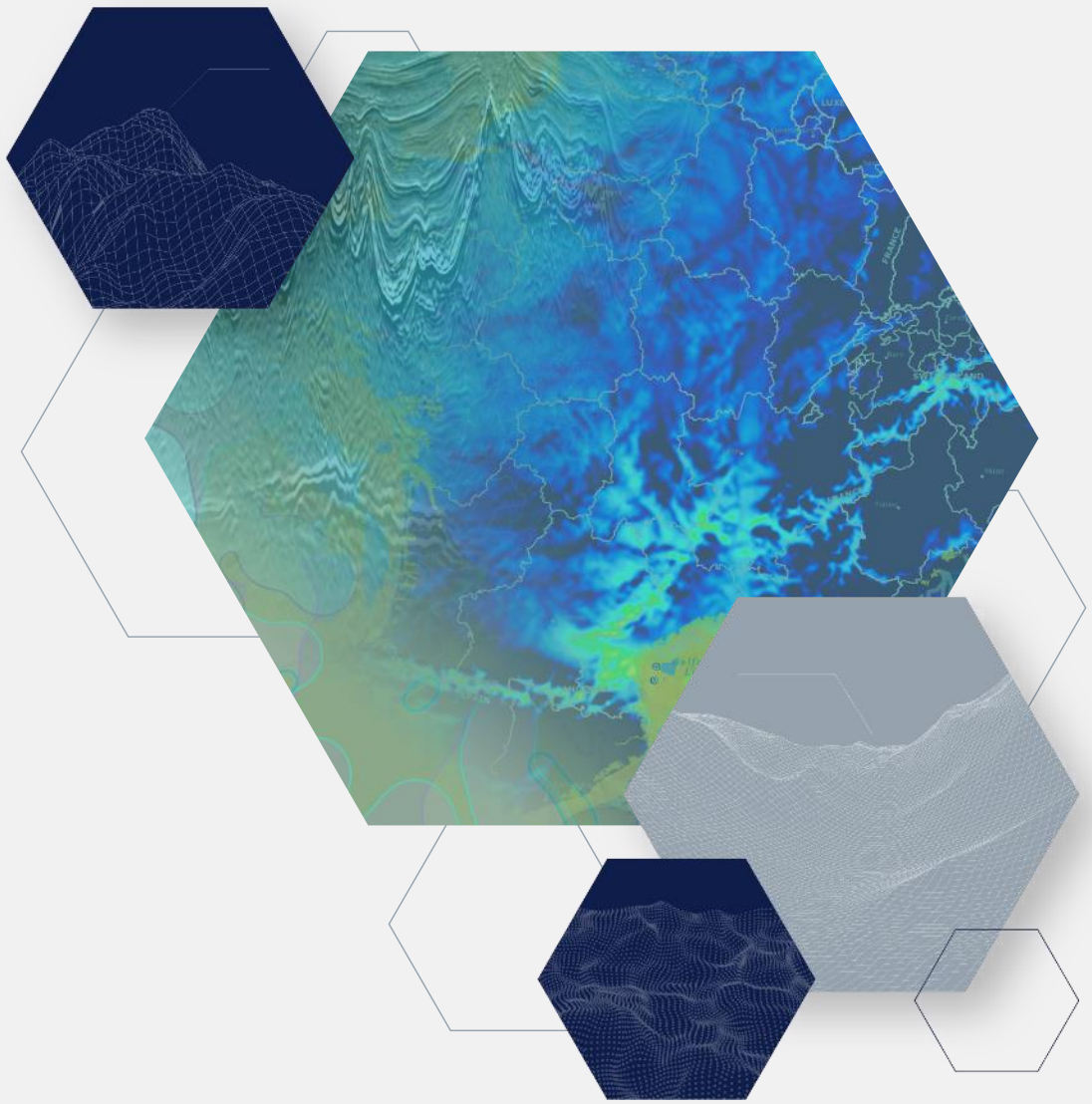
DECEMBER 2023

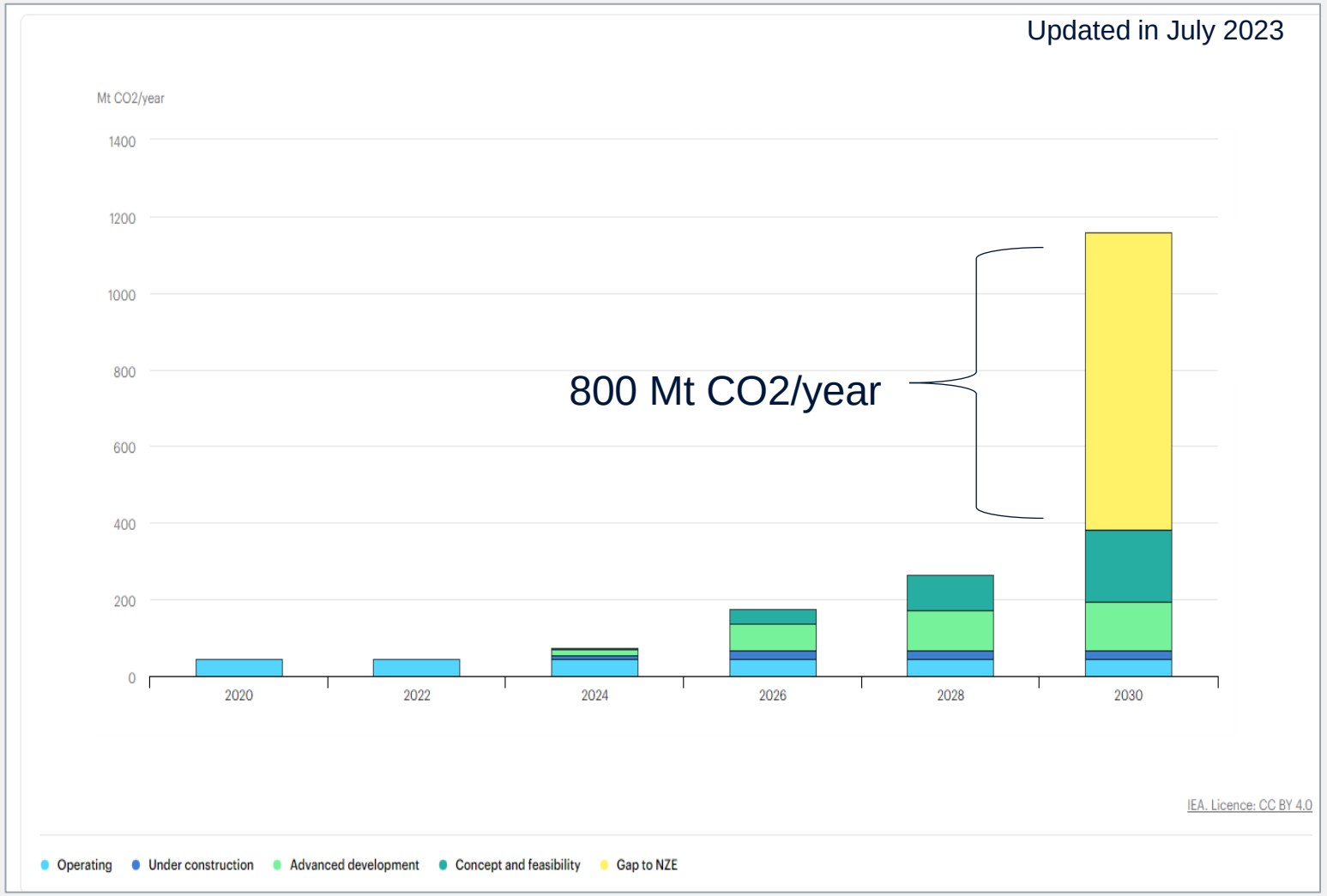


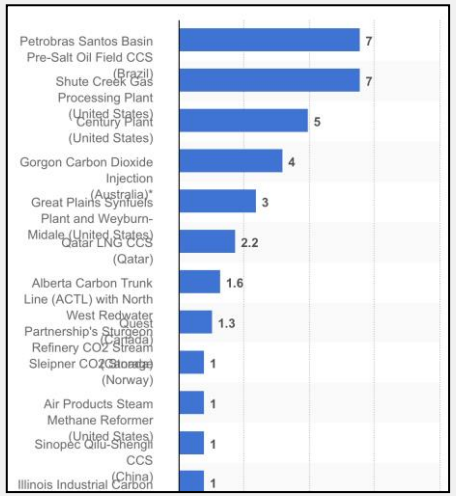
Carbon Capture and Storage: From Prospecting to Monitoring

ANP workshop - December 2023

KATJA AKENTIEVA – VP NEW ENERGY SOLUTIONS, WESTERN HEMISPHERE

Capacity of current and planned large-scale CO2 capture projects vs. the NetZero Scenario 2020-2030





Large scale CCS operating facility

- Accelerate projects
- Unlock new capacity
- Create adequate regulatory support

IRA, the largest climate investment in US history

Estimated to drive emissions reductions to 42% below 2005 levels by 2030

Carbon Capture finance provisions
CO2 sequestration credits under 45Q extended to facilities starting construction before 2033
$85/t in saline aquifers for CCS from industry/power (previously $50/t) $60/t for CCU from industry/power $180/t for CCS in saline aquifers from DAC (previously $50/t) $130 for CCU from DAC
Direct pay (up to 5 years, up to 12 for certain entities)
Threshold on qualifying facilities is lowered significantly (DAC Facility, Electric Generator, all other)

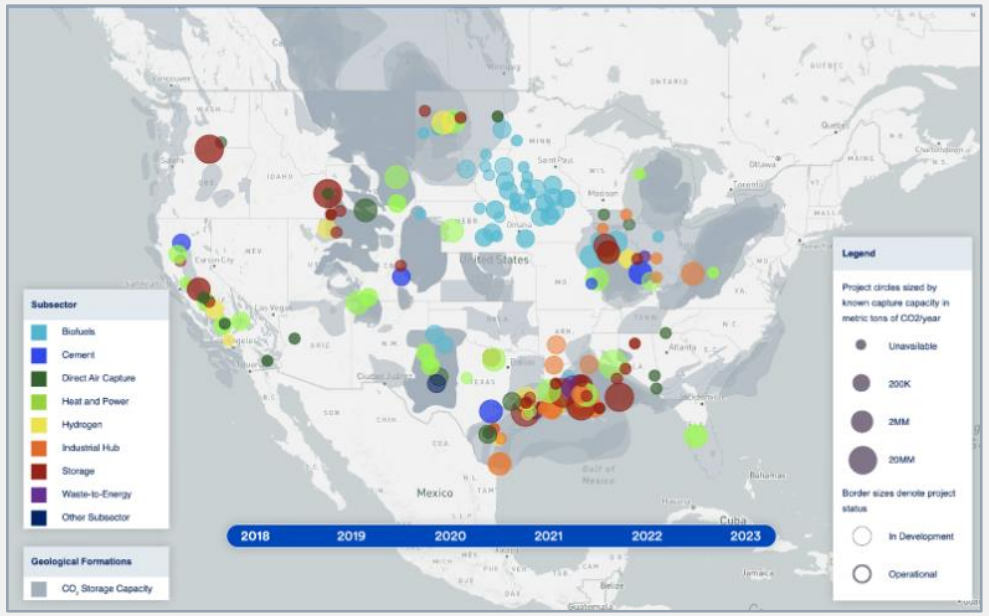
Offshore Wind finance provisions
The investment tax credit (ITC) stays at 30% for projects entering construction before 2026. A new ITC, planned to phase out will be at 6% rising to 40% for facilities which pay prevailing wages and meet apprenticeship requirements. This includes bonus credits (equal to 10%) based on wage and workforce requirements.
The IRA provides a new tax credit for domestic production of components and related goods (e.g. 10% of the sales price for installation vessels)
It also includes clean hydrogen tax credits up to $3/kg for projects entering construction before 2033.

One year later key takeaways:

1. Projects are becoming more widespread and innovative:
- Applications for CCS increasingly diverse and technologically advanced.

2. Carbon Storage takes center-stage
- Growing investment in and attention on the build-out of storage resources
- Five-fold growth in application submissions
- Project announcements cluster around storage potential

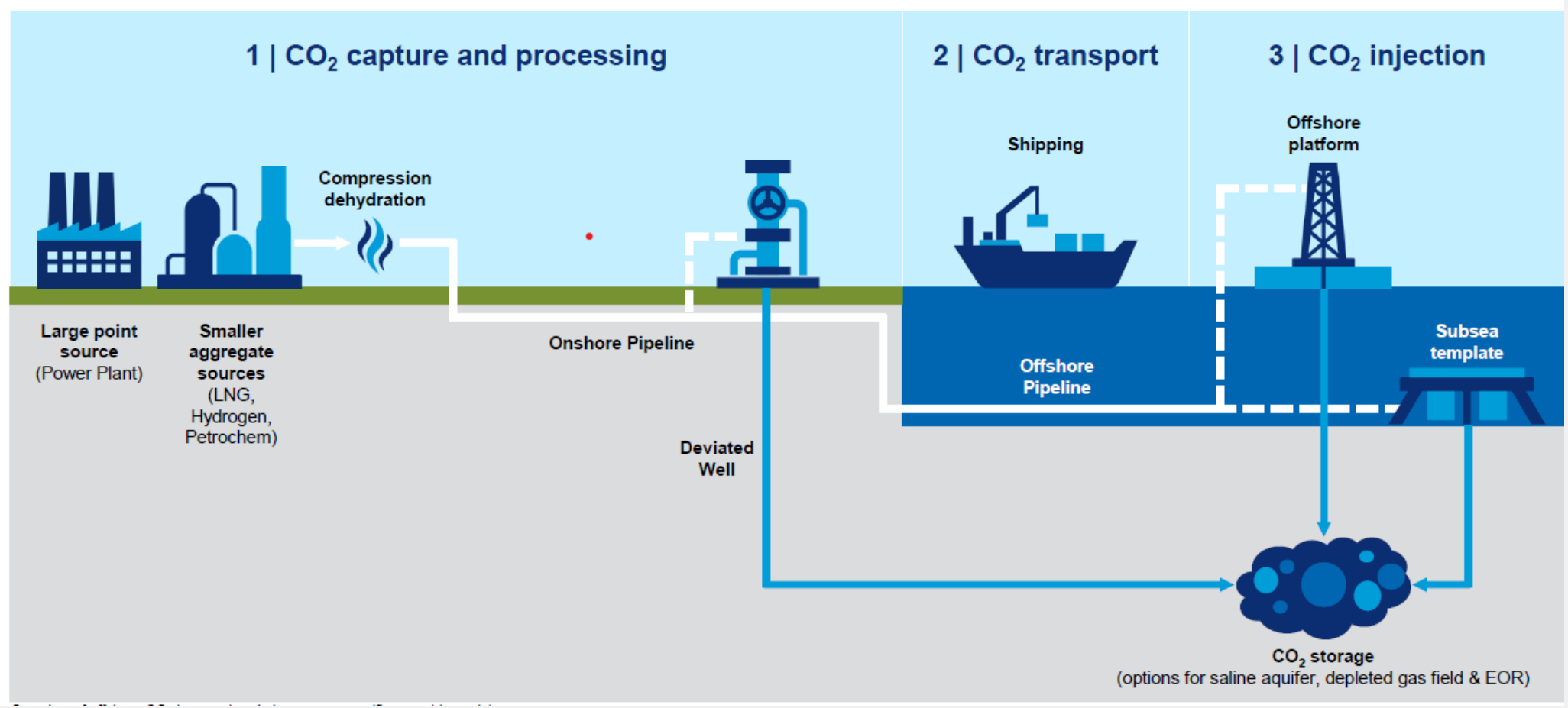
3. Progress continues but challenges remain
- Regulatory bottlenecks, infrastructure, social licensing
- Clarity on federal tax credit application (ITC) - Orsted



US Carbon Capture Activity and Project Map. Source: CATF

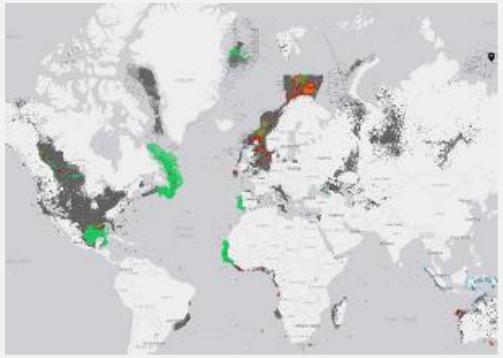
Gulf of Mexico has huge CCS opportunity but needs infrastructure investments

$$$$



The World’s Leading Energy Data Company

MC Data Library



- World's largest 2D and 3D library
- USD 5bn invested over 40 years
- Onshore and offshore
- Frontier and ILX
- Proven technology and innovation

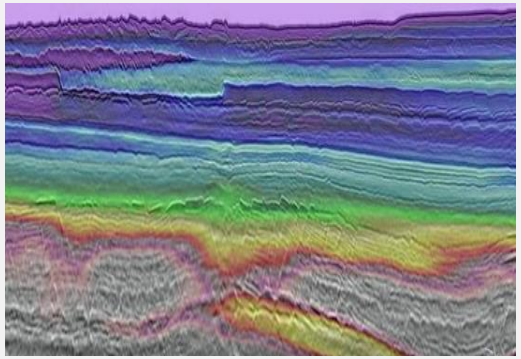
Ocean Bottom Nodes

- World’s leading OBN company
- Technology leader
- Strong track record in key basins
- Completed 100 OBN surveys
- Industry leading safety records

New Energy Data

- Data offerings for renewables
- Wind axiom combining public and proprietary data with AI
- Carbon storage capabilities
- 4C Offshore intelligence
- Performance optimization software through acquisition of Prediktor

Data Processing



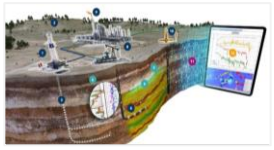
- 250 processing employees globally
- Unmatched compute capacity
- Proprietary and MC business model
- DAS and VSP Imaging
- Land and marine

TGS data-driven solutions across full CO2 storage cycle

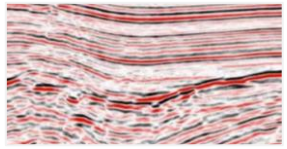
Leveraging subsurface data, proprietary technology and expertise for successful carbon sequestration

ASSESS | **MATURE** | **DISCOVER** | **VERIFY**

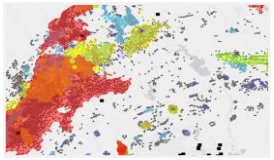
Basin Evaluation → Bid/Site Evaluation → Prospect Maturation → Inject → Appraise → Monitor



Well Data Products
Industry's largest well data library



Seismic Data & Imaging
Industry's largest subsurface data library



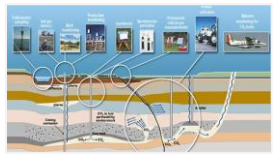
Carbon AXIOM
Screening platform for unlocking and assessing CO2 storage

GREEN SAND

CCS innovation consortium
Partners in Project Greensand, about to initiate sequestration

TGS | magseis fairfield

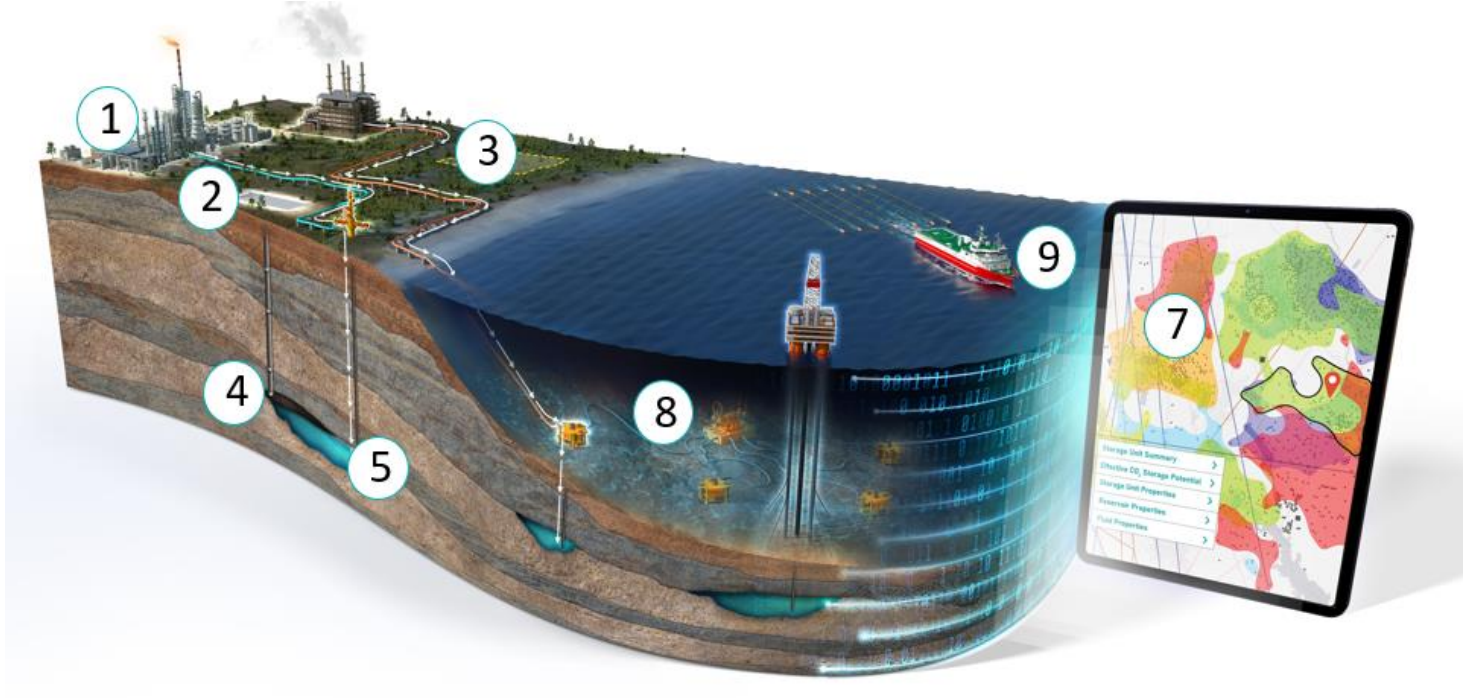
Acquisition & Imaging
3D XHR and node solutions for base and monitoring surveys



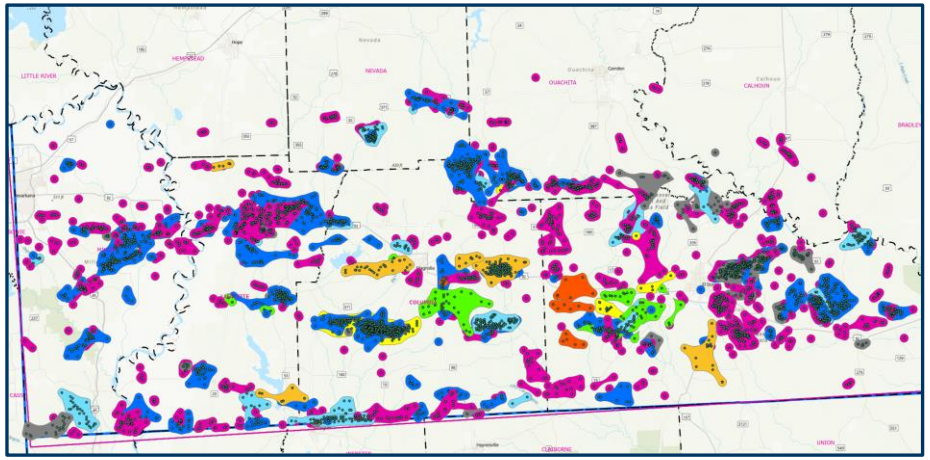
Data Gateway
Injection and post closure monitoring and data management

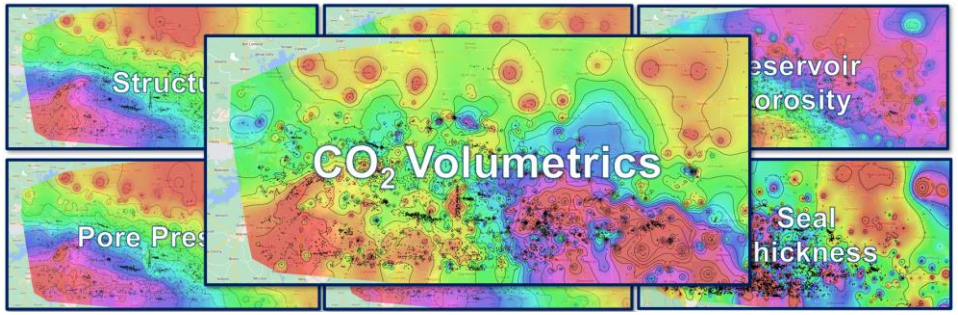
TGS

Supporting CO_2 Storage Cycle from Prospecting to Monitoring



6





Data

1. Emitters (Capture)
2. Pipelines (Transportation)
3. Property ownership
4. Storage locations
5. Wellbore locations

Technology

8. DAS-VSP monitoring
9. XHR

7 Data Delivery

SaaS platform · Data layer visualization · Subsurface data export
Data interrogation & filtering · Distance/area measurement
Property ownership filtering

6 Subsurface Storage Assessment

Well analysis · Petrophysical modeling · Storage unit mapping
Prospective storage estimates · Source sink matching
Variability of storage/Reservoir/fluid properties

What is Carbon AXIOM?

An interactive screening tool for assessing viability of new CCS projects

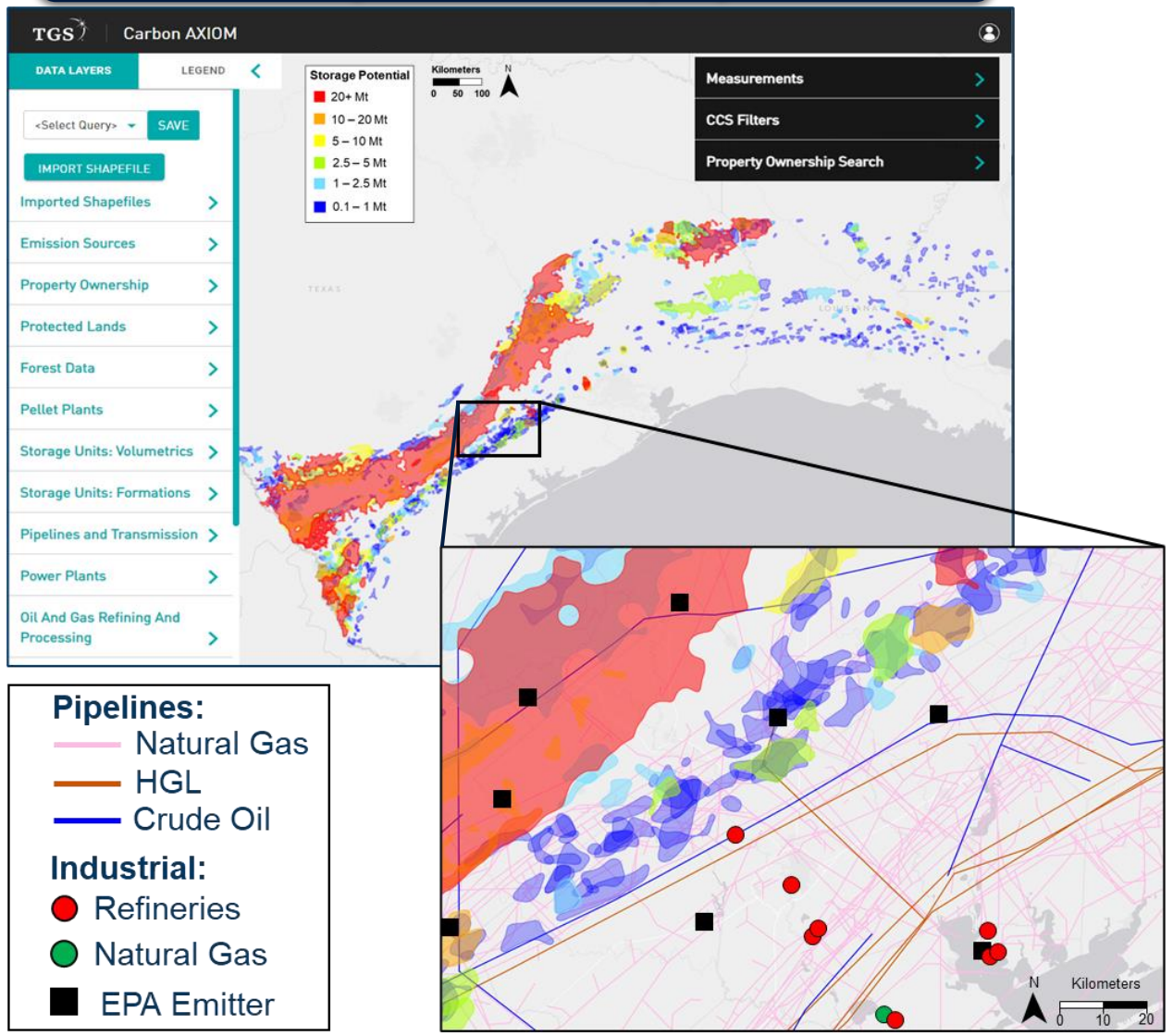
Capture
Power, Refining, & Processing Plants
Emitter Locations

Transport
Pipe- and Transmission Lines
Property Ownership & Protected Areas

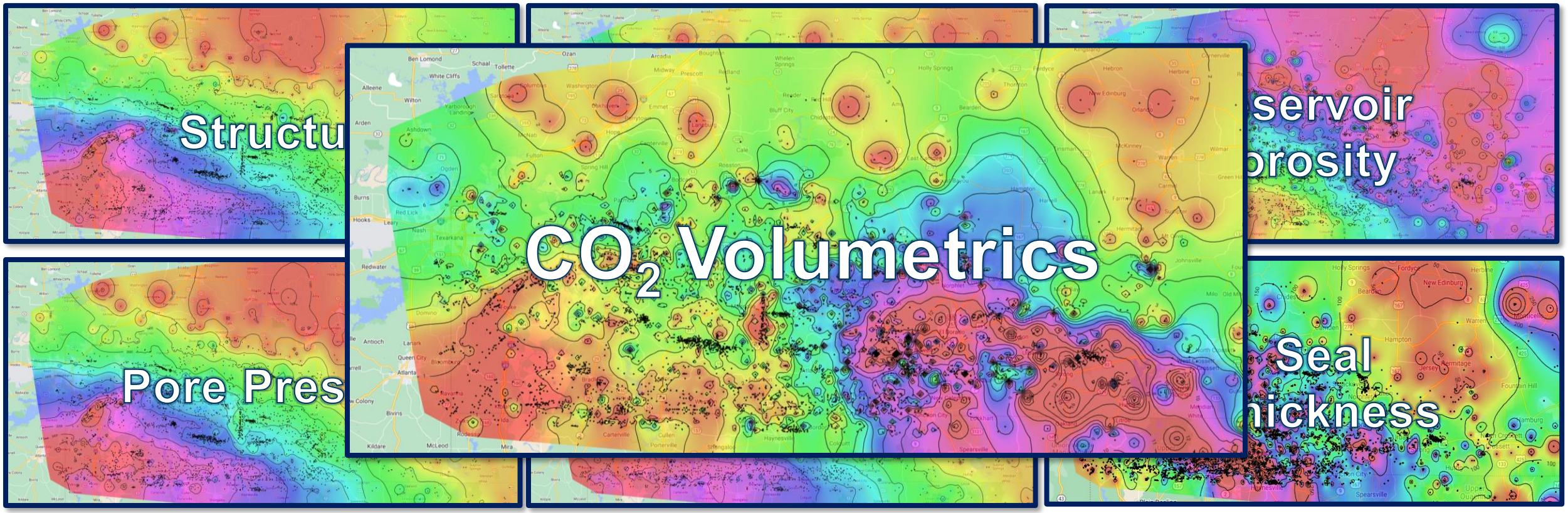
Reservoir and Storage Attributes
Depleted Hydrocarbon Reservoirs
Saline Aquifers

Delivery
Interactive Cloud-Based Platform

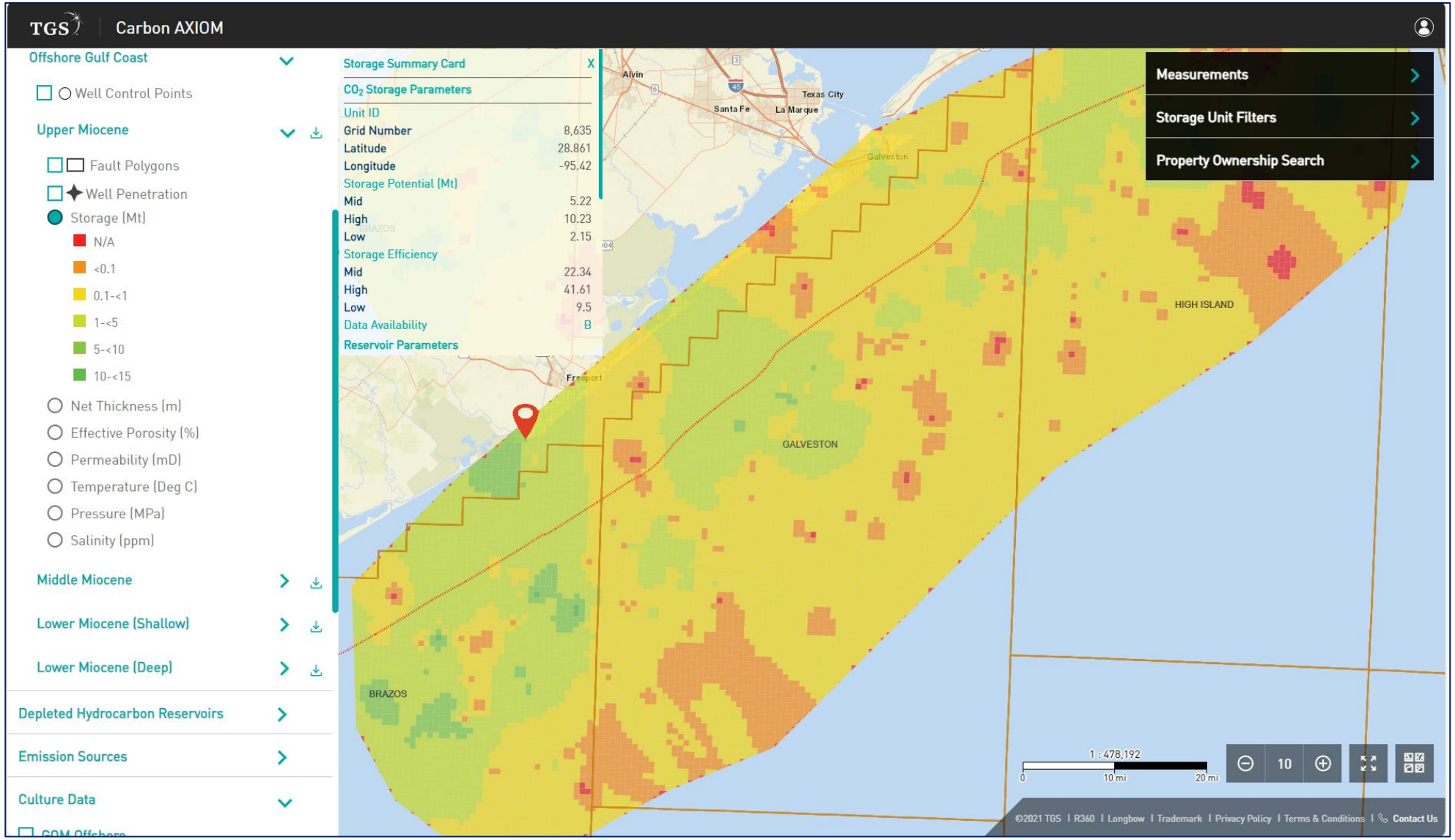
Exports
Storage Properties (Composite CSV)
Storage Pool Shapefiles



Detailed Evaluations by Formation for CO_2 Volumetrics



Carbon AXIOM: Saline Aquifer Storage - Gulf of Mexico example



CCS Monitoring Objectives

- Todays geophysical technologies can meet the requirements of monitoring CO_2 in the subsurface

- **Ensure Conformance:** to indicate the long-term security of CO_2 storage by showing that pressure and CO_2 accumulation inside the storage site are consistent with model-based forecasts and, if necessary, calibrate and update these models. Evaluate and, if necessary, adapt injection and monitoring to optimize storage performance. Collect the monitoring data necessary to support CO_2 inventory reporting.

- **Ensure Containment:** to demonstrate the current security of CO_2 storage by verifying geological containment, well integrity, and the absence of any environmental effects outside the storage complex. Also, by detection of early warning signs of any unexpected loss of containment trigger, if necessary, additional safeguards to prevent or remediate any significant environmental impacts.

TGS

Overview – Seismic Technology for Carbon Storage Monitoring

Existing Seismic

Regional Screening
Site Suitability

Multiple Data Types

This can include geophysical datasets beyond O&G seismic (e.g. geotechnical data UHR data etc.)

Note: Potential input to velocity models (i.e. XHR input)

Note: Relevance (e.g. Depletion since acquisition)

Cost: Data Purchase
Ops Duration: N/A
Env. Footprint: N/A

New Baseline Surveys

To establish a seabed to base reservoir/aquifer high resolution image

- DAS (VSP) +/- XHR
- XHR
- 3D Conv.
- Nodes

Cost: Higher run rate
Ops Duration: short duration
Env. Footprint: higher

Early Warning Systems

(Optional based on risk assessment)

Risk focused Monitors
Well / Caprock Integrity / Plume Migration

- DAS Fiber
- DAS (VSP) +/- XHR
- 1-100 Nodes

Cost: Low cost run rate
Ops Duration: long period (20+yrs)
Env. Footprint: Lower – Low - 0

Triggered / Scheduled Surveys

Full Field 4D Repeats

- DAS (VSP) +/- XHR
- XHR
- 4D Conv.
- Nodes

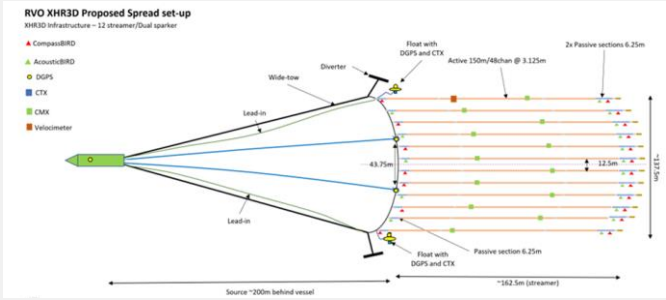
Cost: Higher run rate
Ops Duration: Short
Env. Footprint: higher

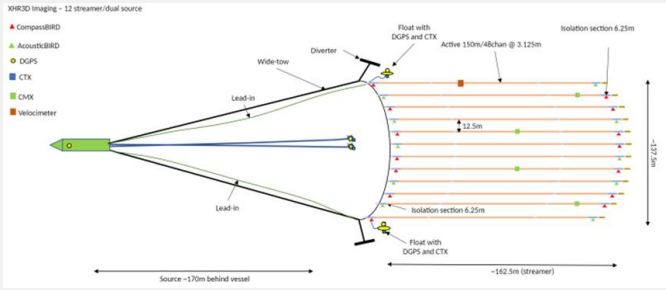
TGS

Tailored acquisition solutions for CCS and Offshore Wind

- Ocean Bottom Nodes (OBN)

- In 2018 - 2021, TGS re-designed, produced and commenced testing the XHR – Extended High Resolution 3D system
  - XHR Offshore Wind
    - Sparker
    - Offshore Renewables/Windfarms
    - Oilfield Infrastructure
    - Less than 1 meter vertical resolution sub 100 meters depth
  - XHR CCS
    - Air Gun
    - CCS Mapping & Monitoring: development of CO2 plume over time
    - De-risking: Fractures and faults imaging in the overburden
    - Reservoir 3D and 4D





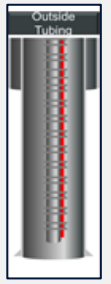
- Modular Source
  - Flexible and scalable
  - Nodes, DAS VSP

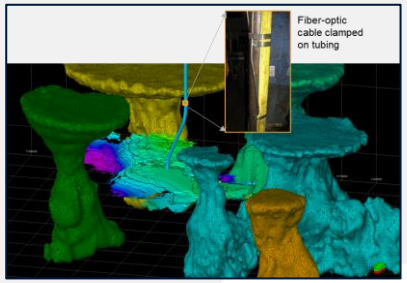
TGS DAS Technology

- Internal
  - People - Dedicated team of VSP and DAS processors
  - Toolkit - Adapted our surface seismic processing and imaging tools to VSP geometries
  - Workflow - Production workflows ready for 3D and 4D DAS VSP processing

- External
  - Partnered with HALLIBURTON to provide clients a one-stop shop for DAS acquisition and processing
  - Participating in DAS acquisitions through pre-survey feasibility studies and acquisition design

- DAS VSP
  - Distributed Acoustic Sensing (DAS) VSP
  - Downhole fiber-optic cables are used as seismic sensors to record VSP data





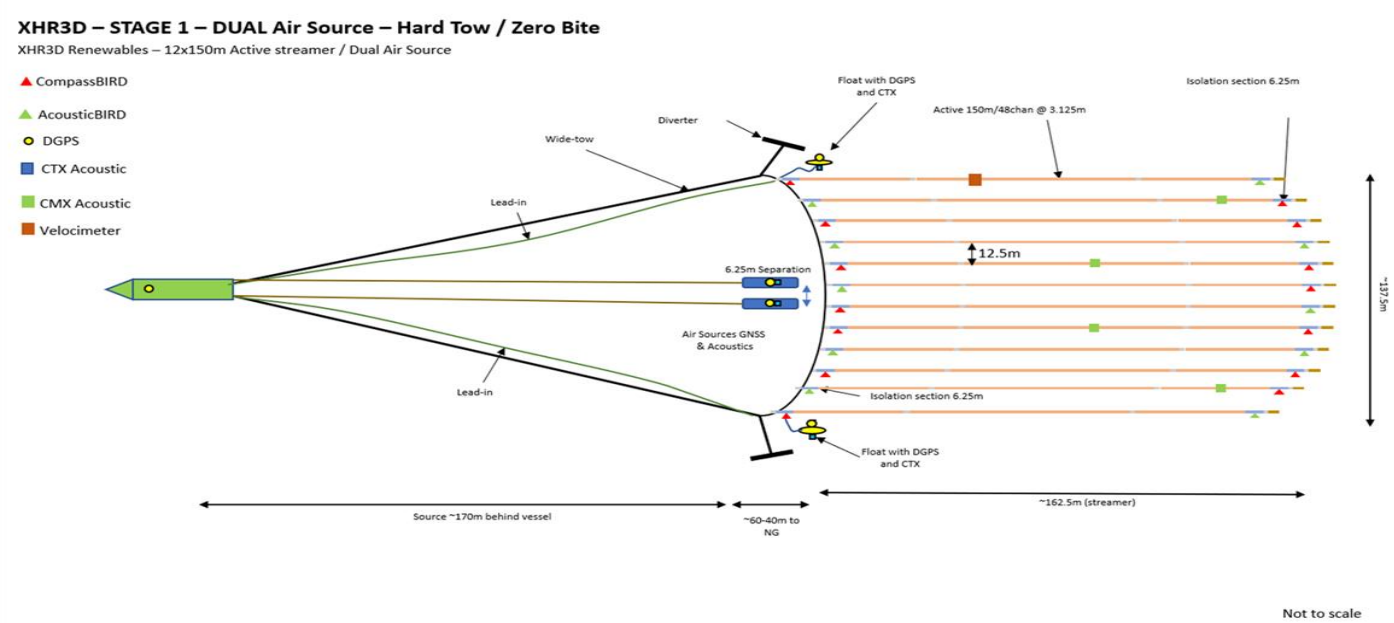
TGS

Sleipner Demo - August 2022 Test at scale

- Implement Learnings from 2021 test

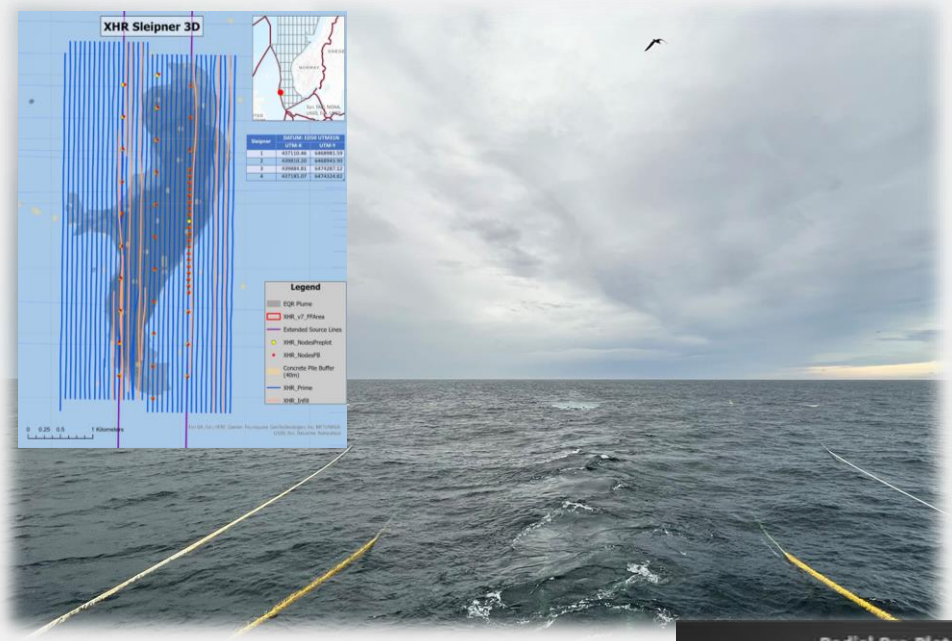
- Proof of concept
  - Deep tow
  - 12 cables
  - Full positioning solution

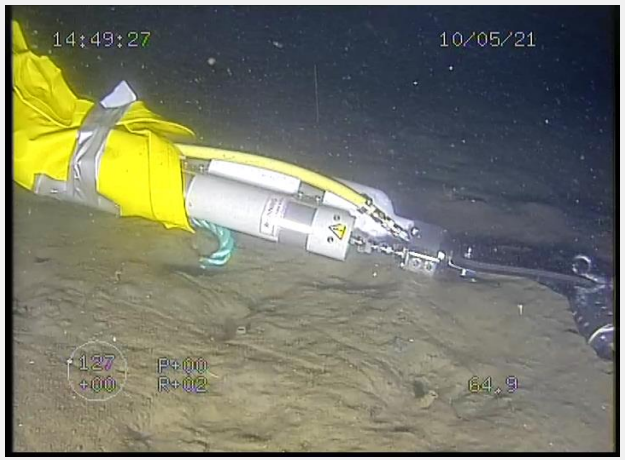
- Focus on CCS
  - Parameter optimization
  - Acquired 3D dataset over existing CCS plume
  - Acquire Repeatability test
  - Compare data to conventional datasets

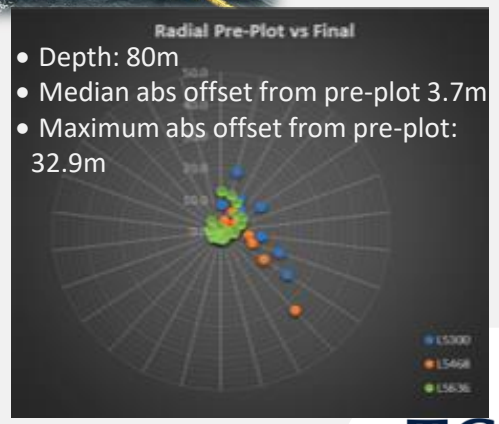


Sleipner 2022 Demo - Combining XHR with OBN

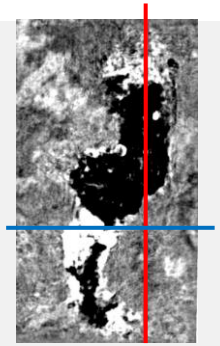
- Nodes was deployed and retrieved cost-efficiently using TGS' proprietary node drop and self-recovery technique.
- The streamer data will provide a high- resolution reflection image
- The nodal data will provide longer offsets, allowing for new ways of monitoring CCS based on refraction data, e.g., monitoring changes in velocity or attenuation in a 4D FWI scheme.

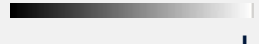


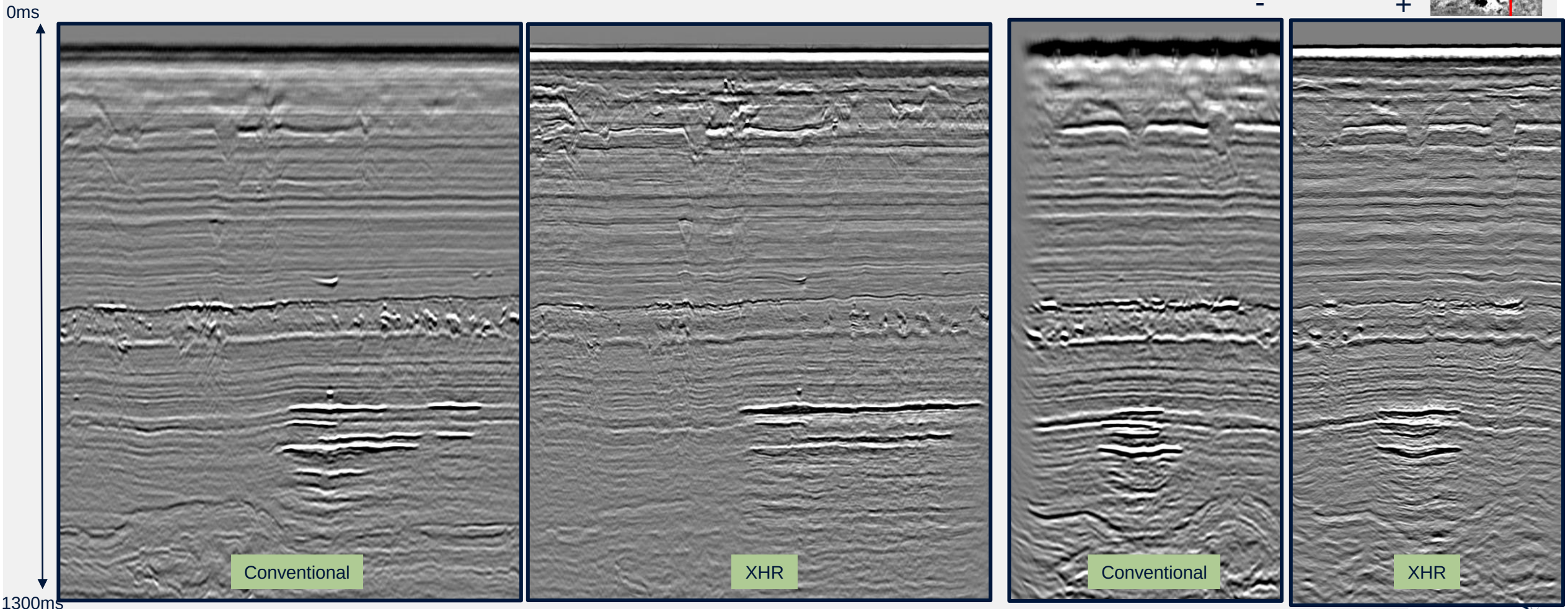




Inline and crossline comparisons



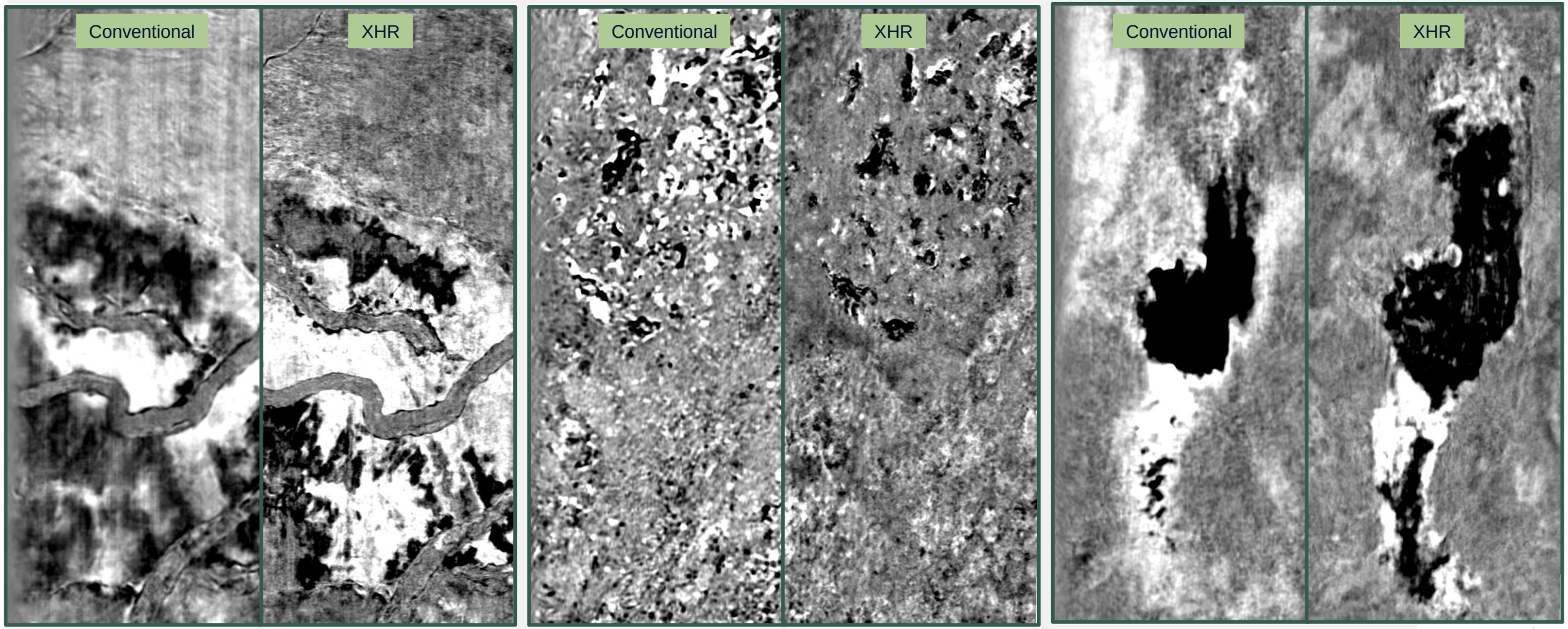




Timeslices comparisons

CARBON

- +



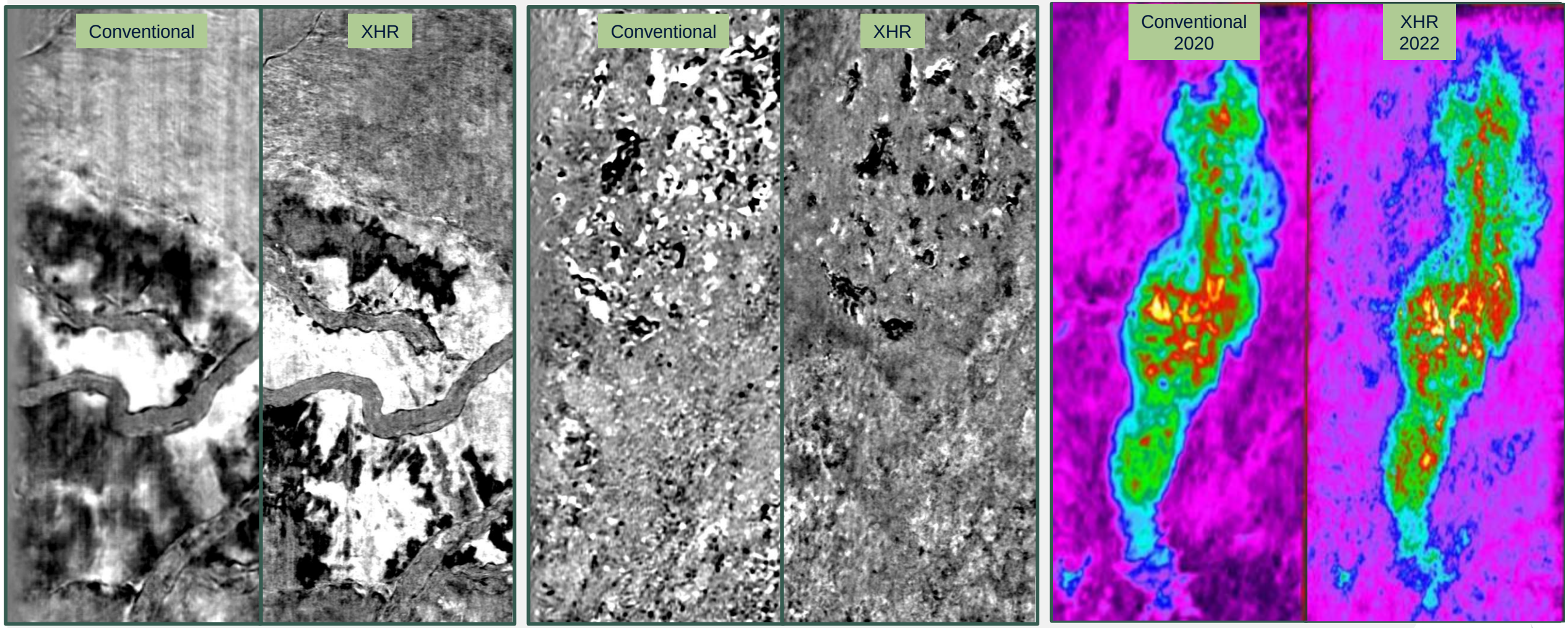
~280ms ~680ms ~880ms

TGS

Timeslices comparisons

CARBON

- +



~280ms ~680ms ~880ms

TGS

Summary

- TGS leverages its vast amount of subsurface data for CCS feasibility assessment
- CarbonAXIOM platform is an effective tool to unlock new storage capacity and evaluate risks
- XHR data provides high resolution images at the overburden and CO2 plume level
- Effective operation using the auto-recovery device
  - Good positioning
  - Safe operation
- FWI work show good results using sparse grid in shallow water
  - Good correlation seismic/velocity model

TGS

Thank you

Katja Akentieva

Katja.akentieva@tgs.com