Evaluating carbon storage sites in hydrocarbon prone basins: a workflow supporting the Energy transition initiative

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Agenda

- Introduction

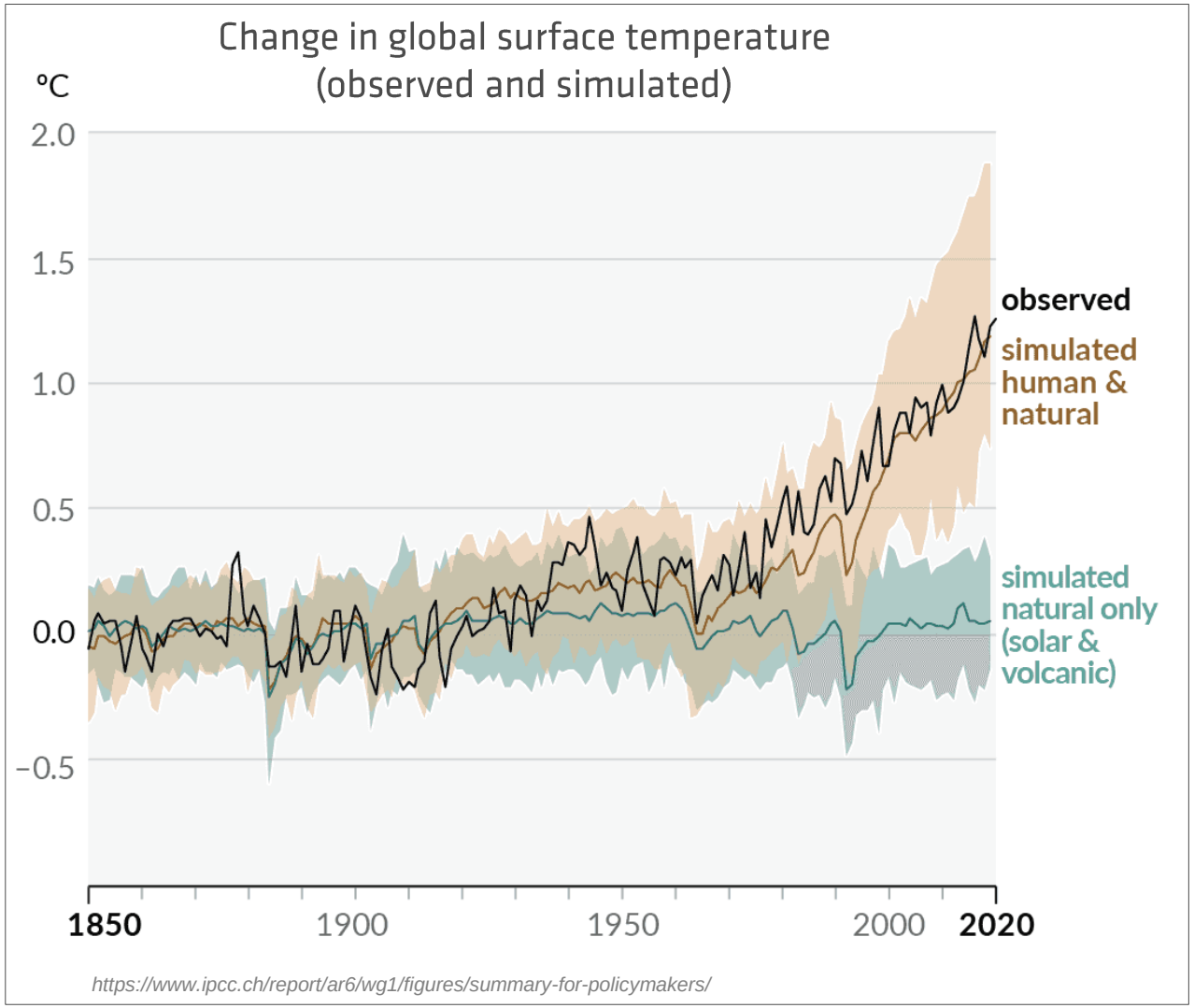
- CCS Integrated G&G workflow supporting the Energy Transition
  - Capacity and Containment characterization
  - Monitorability and monitoring

- Applications: Evaluating CCS in hydrocarbon prone basins:
  - Southern Gas Basin (Europe)
  - What about Colombia?

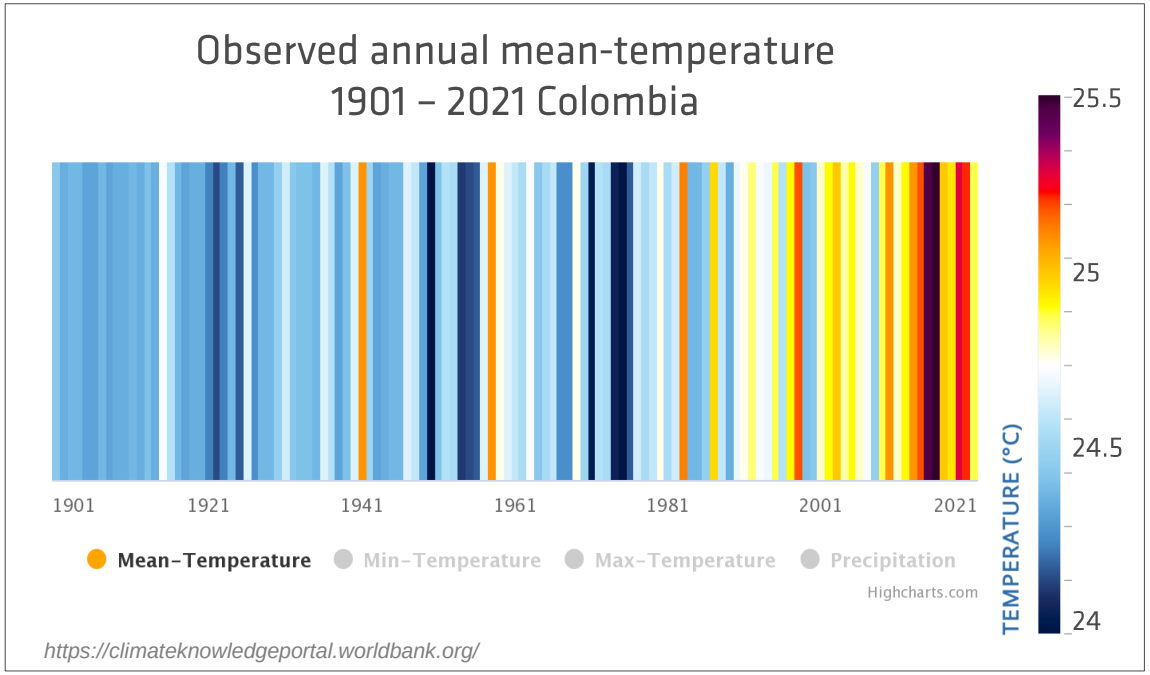
- Summary and road ahead

Introduction

Climate Change is a Global Challenge

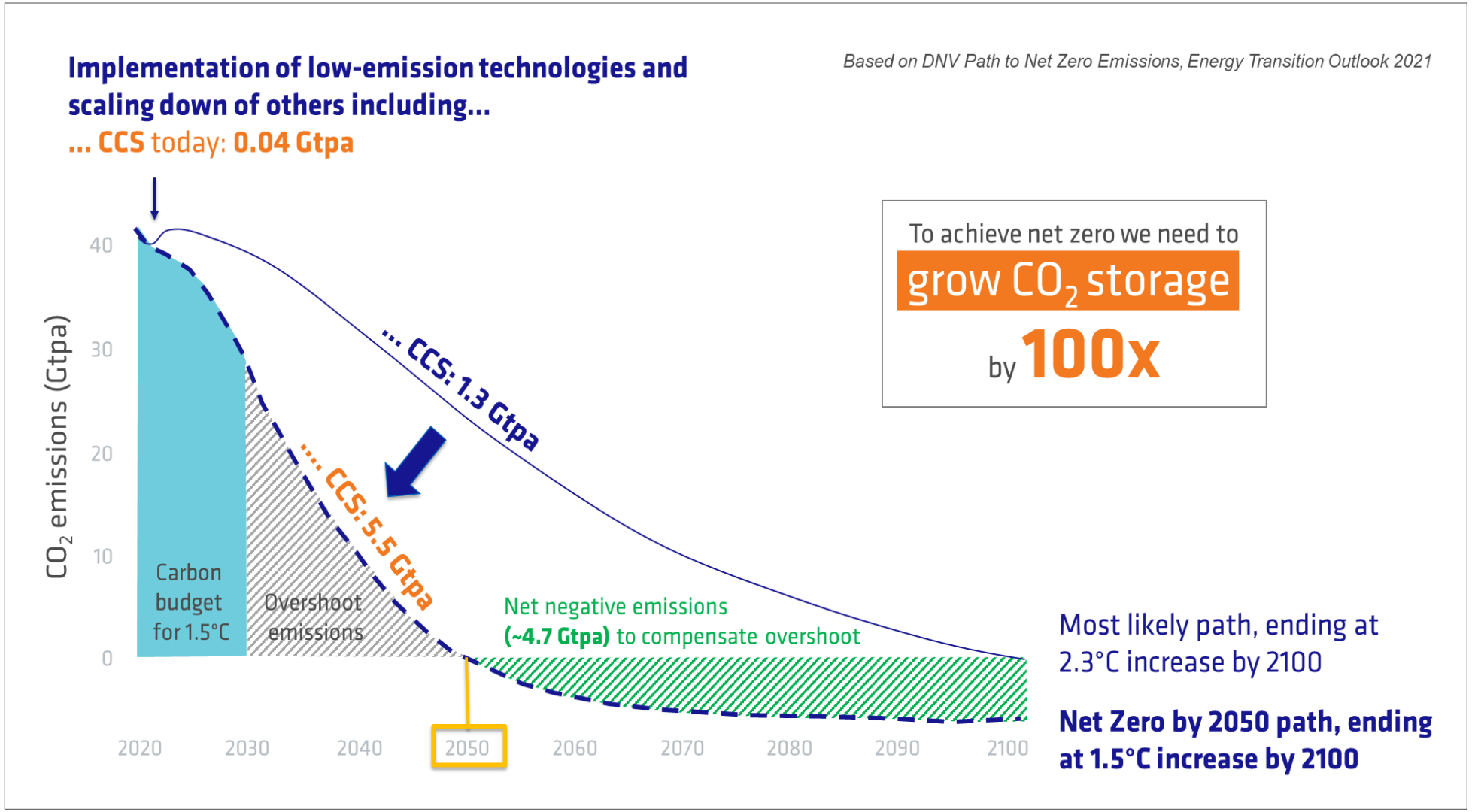


https://www.ipcc.ch/report/ar6/wg1/figures/summary-for-policymakers/



https://climateknowledgeportal.worldbank.org/

Carbon Storage is Essential to Combat Climate Change



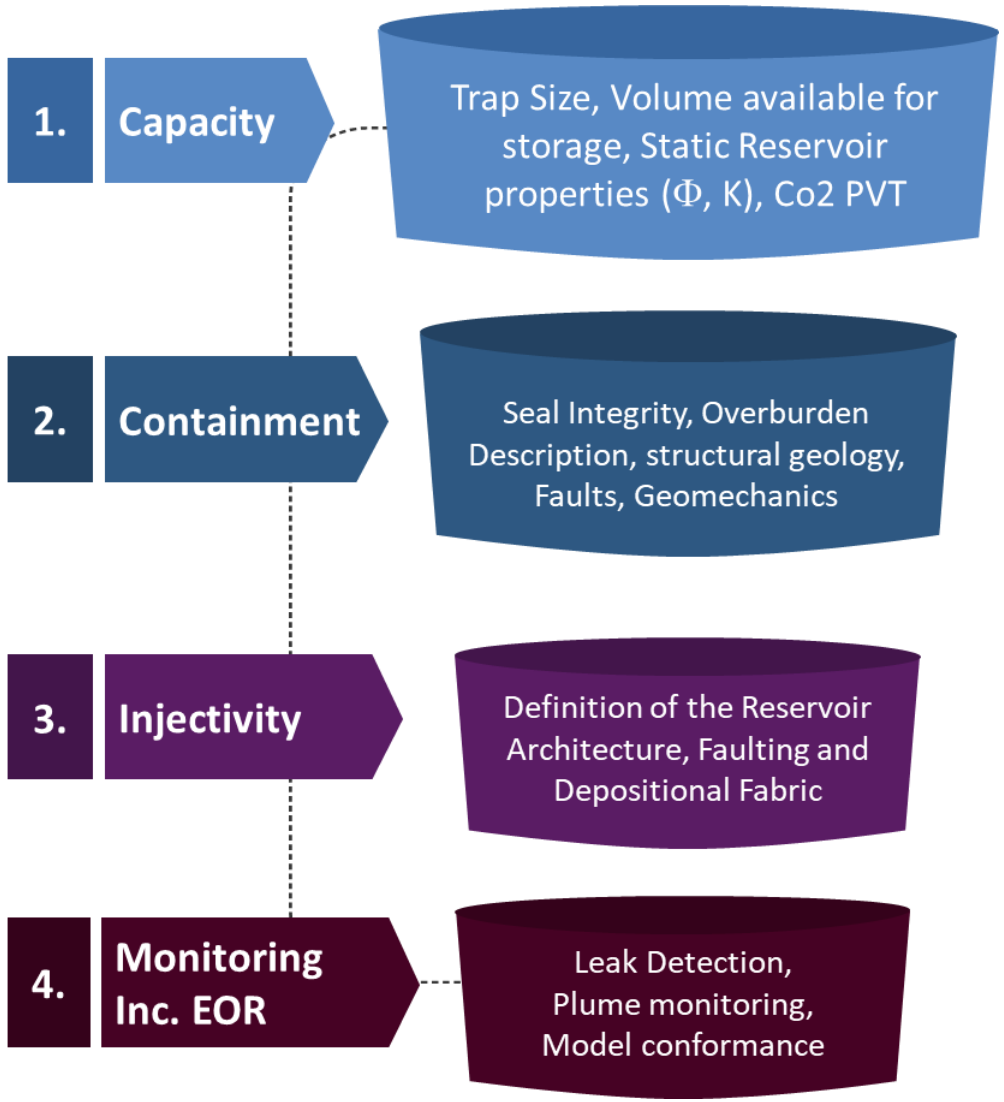
- Urgent need to capture and store CO2
- This needs to be done quickly and as efficiently as possible
- Sites Screening & ranking

Setting the Scene & Objectives

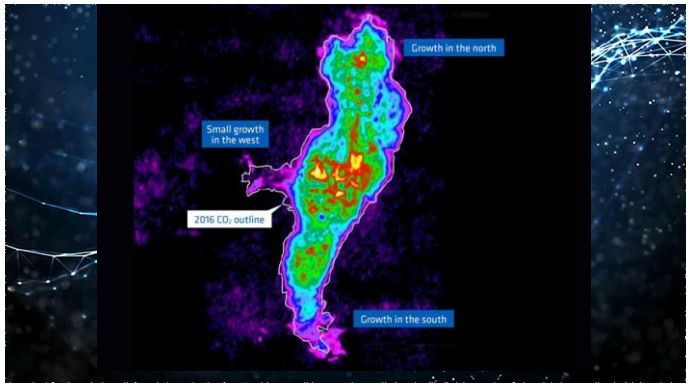
- Thus:
  - What can be done?
  - What can be done efficiently?
  - How can we use our “conventional” workflow for this problematic?

- Can regional dataset be of value for characterizing:
  - Capacity
  - Containment

- How can we assess the monitorability and monitoring?
  - Interactive rock physics atlas: rockAVO

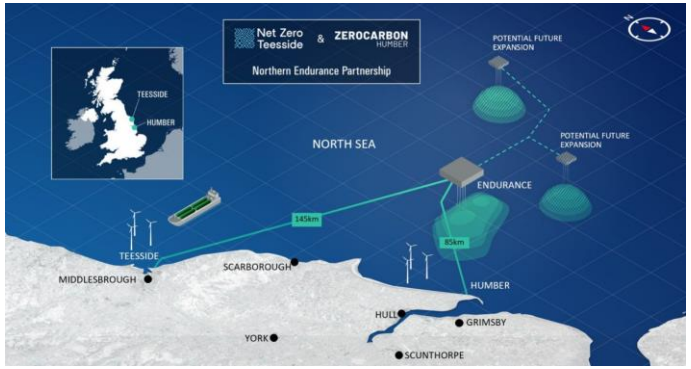


Why PGS as your partner for characterizing carbon storage site?

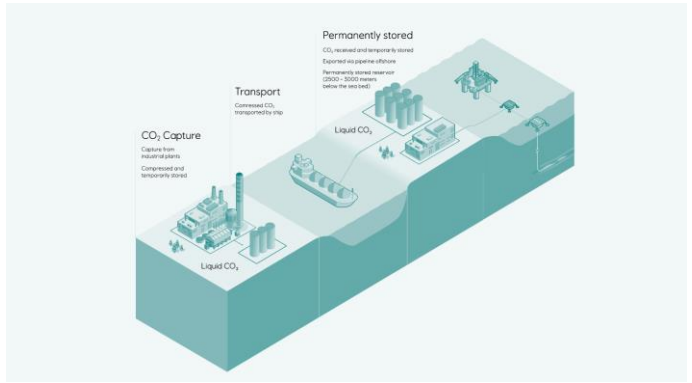


Monitoring | Sleipner
Processing & Imaging
Sleipner Monitor Survey

Partnership | Australia
Develop Carbon Storage
Offshore Australia



Acquisition | Endurance
3D High Resolution
Development Survey



Acquisition | Northern Lights
3D High Resolution
Baseline

CCS Integrated G&G workflow supporting the Energy Transition

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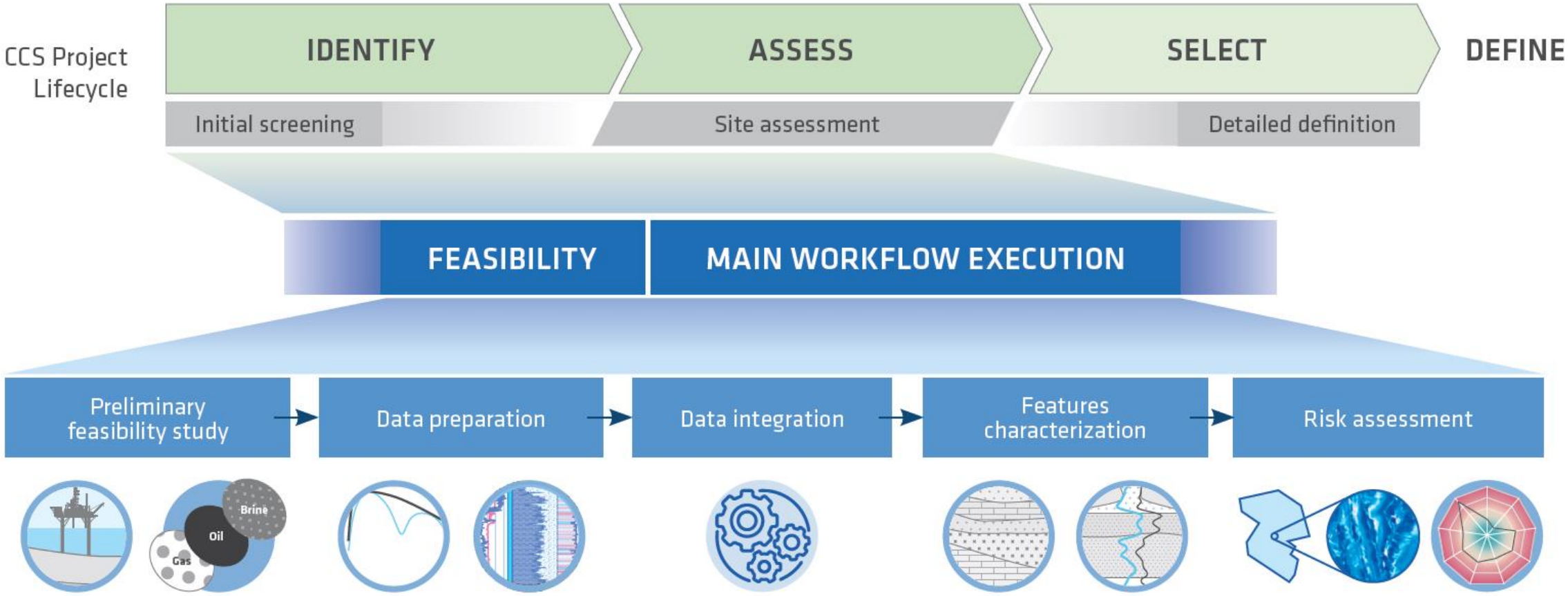
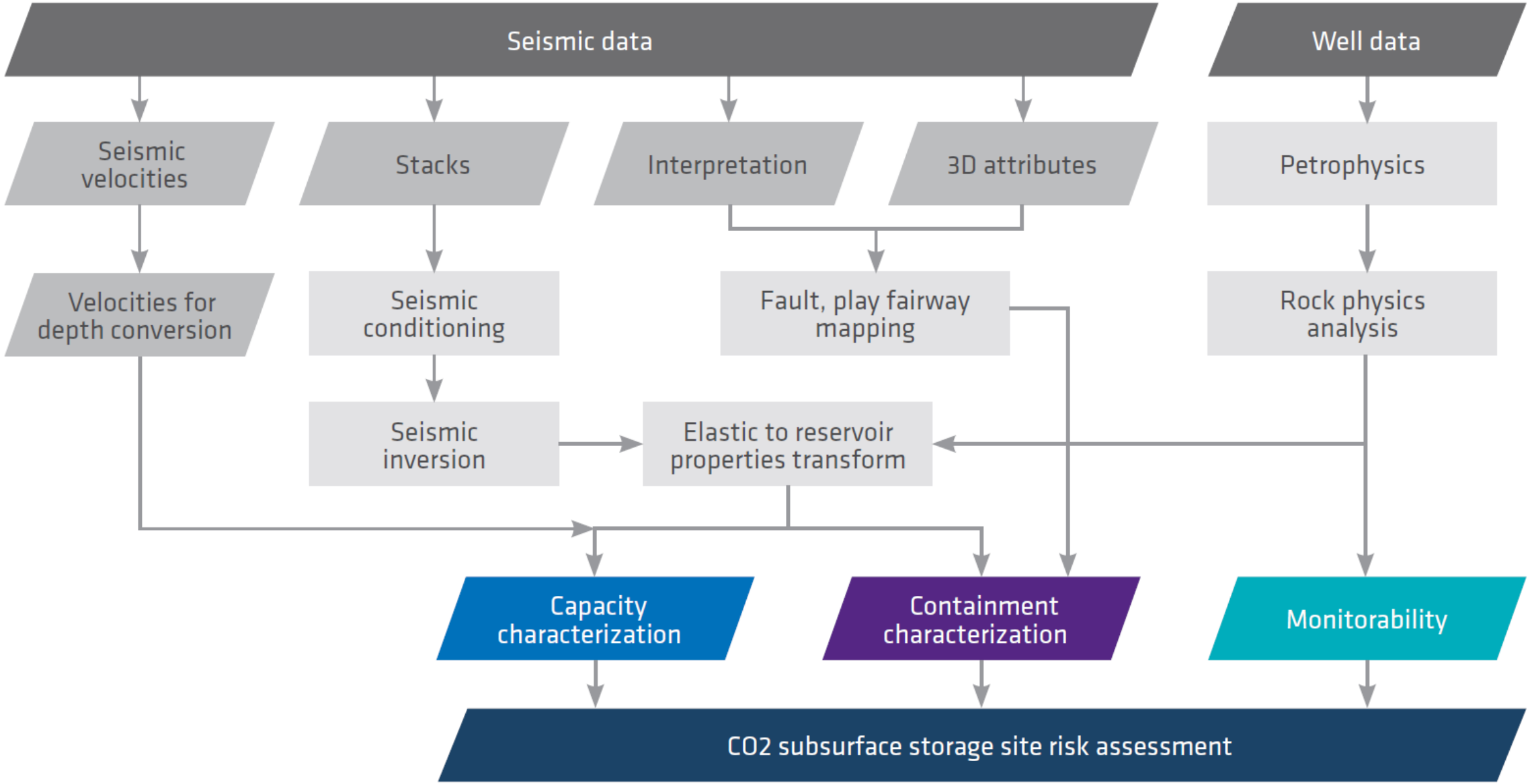
Capacity and Containment characterization

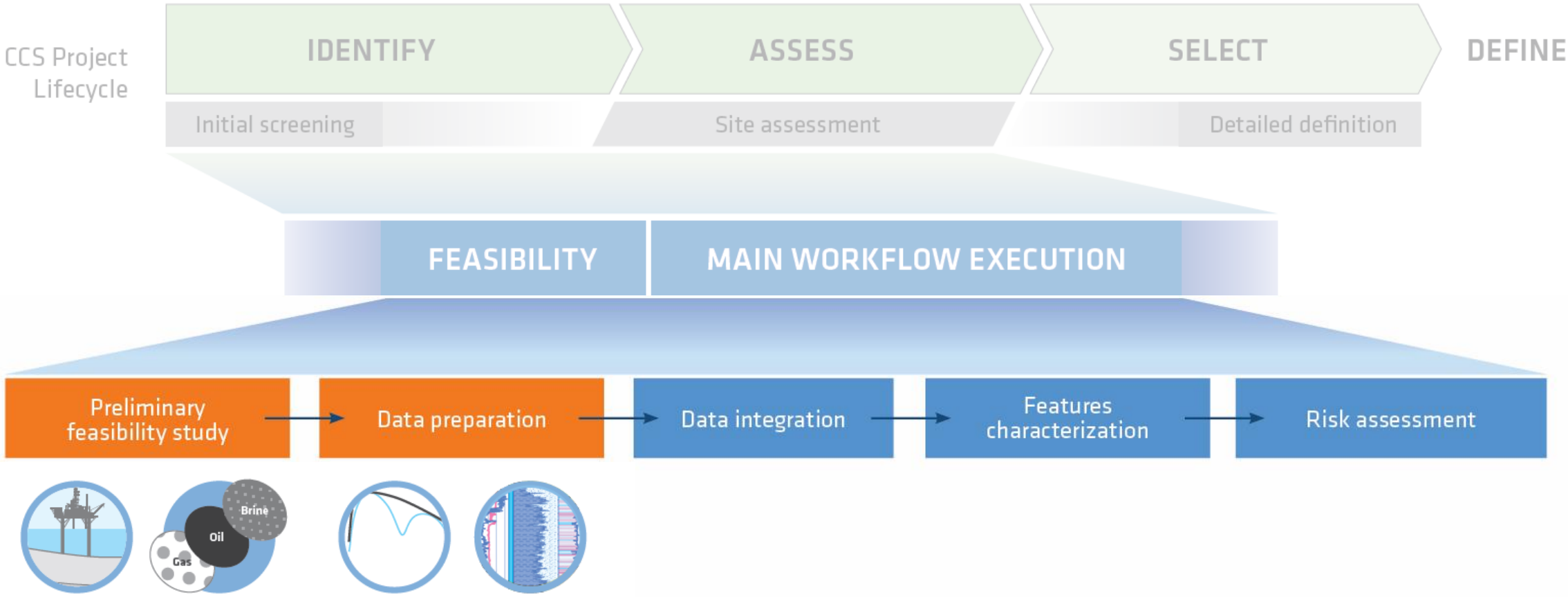
Possible CCS Integrated Workflow



Capacity and Containment Proposed Workflow

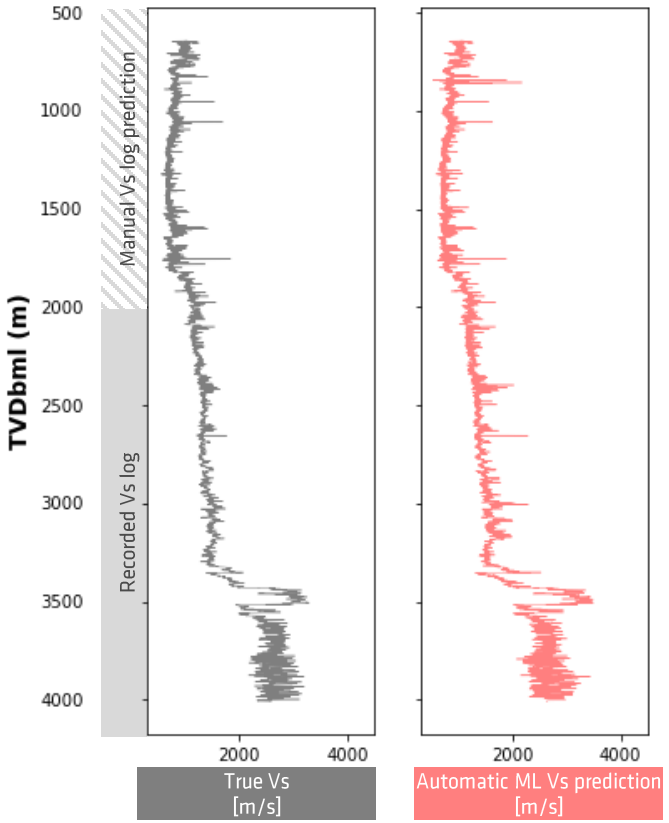


Possible CCS Integrated Workflow



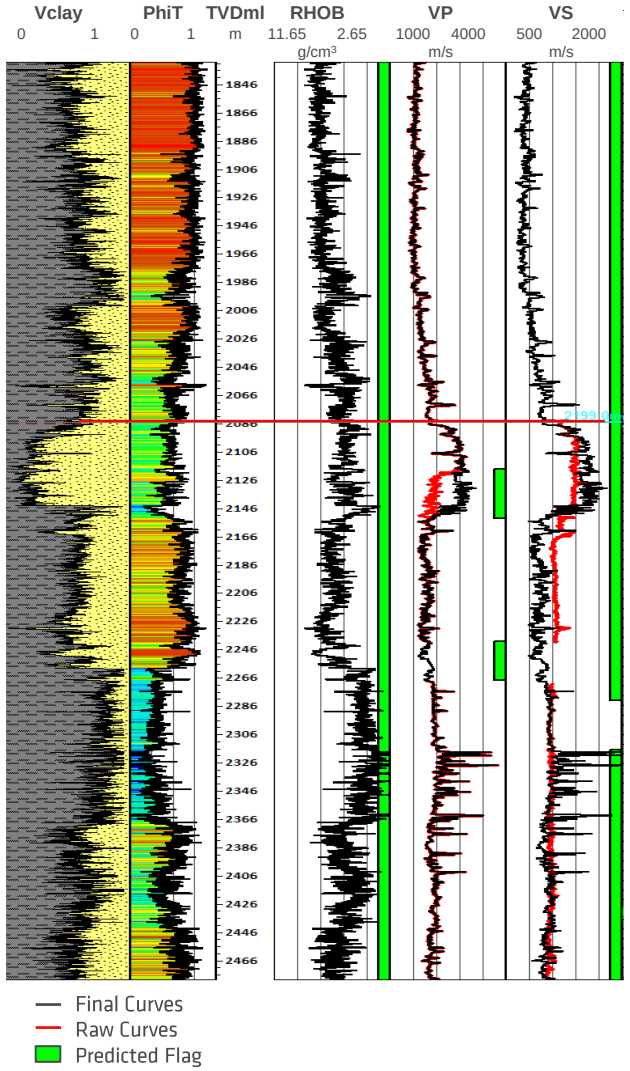
Assessing the Link Between Elastic and Reservoir Properties from Wells

Automatic missing log prediction and petrophysical analysis with ML algorithm

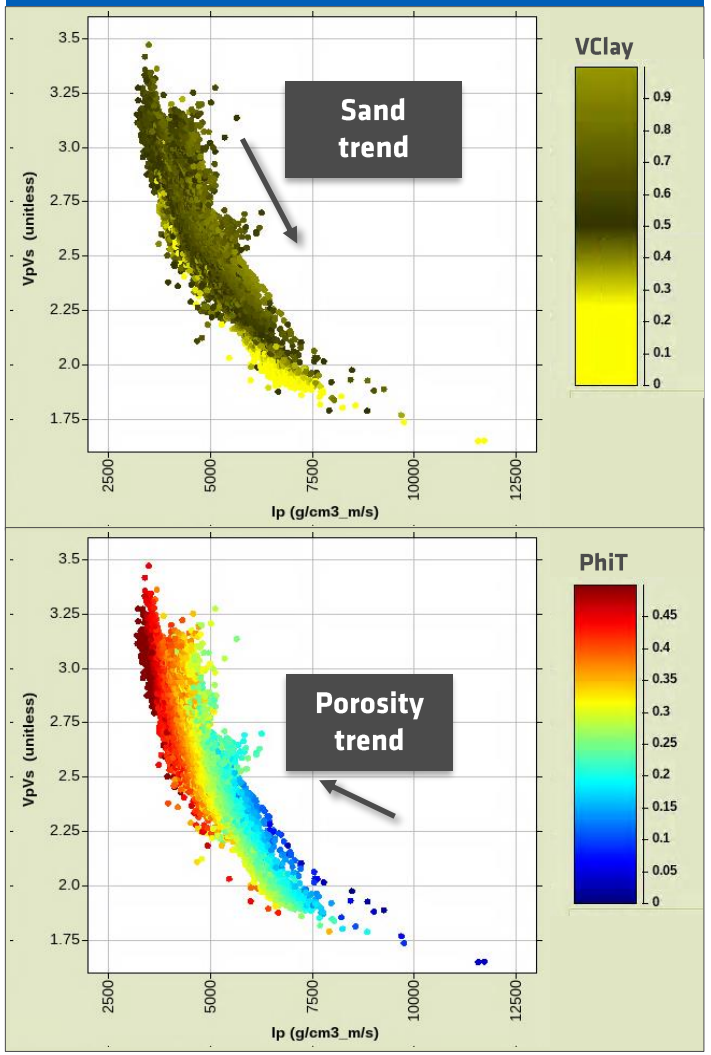


Good match of automatic Vs prediction with recorded section (bottom) and prediction performed by petrophysics (top)

Petrophysical interpretation

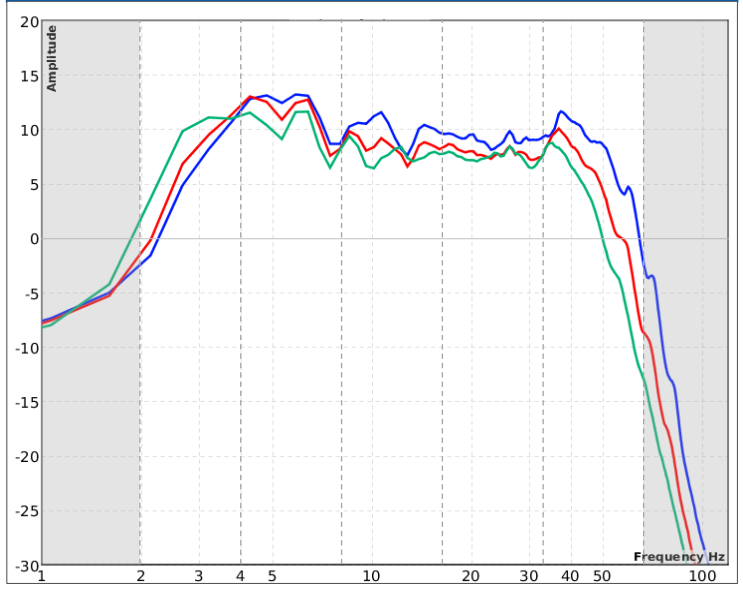


Rock physics analysis



Optimizing Input Seismic Data Quality at the Potential Storage Level

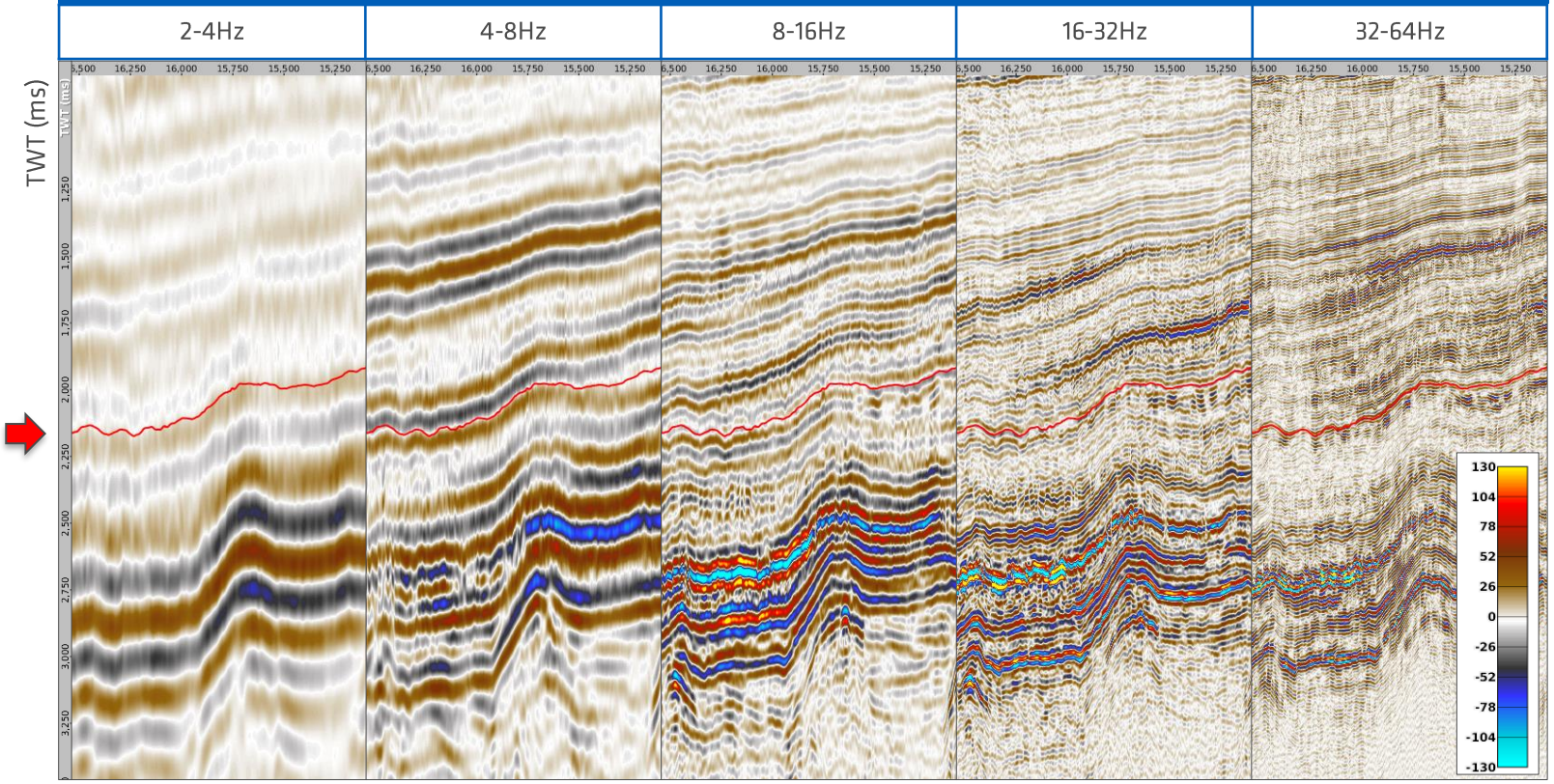
Amplitude spectra analysis



Angle stacks:

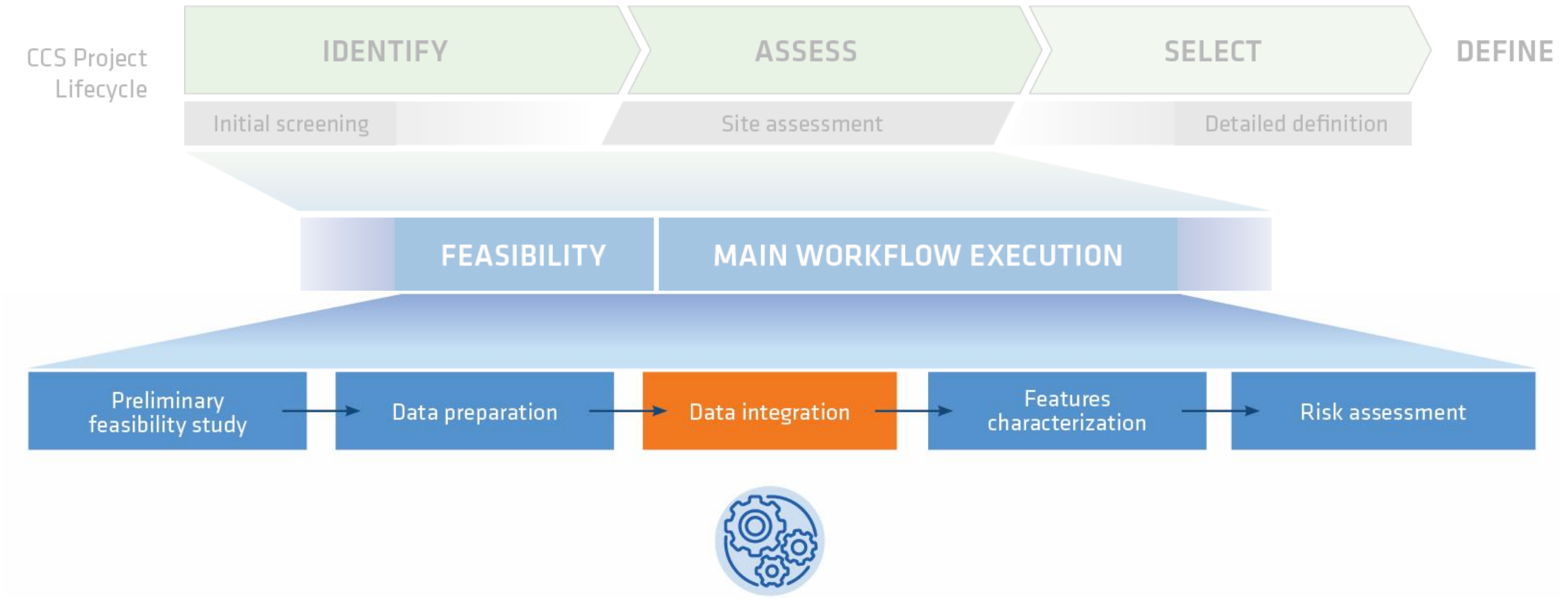
Near: 5°-17° (mean angle: 11°)
Mid: 17°-27° (mean angle: 22°)
Far: 27°-33° (mean angle: 30°)

Octave panel decomposition



Imaging final angle stacks → Seismic data input QC → Reservoir Oriented Processing → Optimized angle stacks at CCS level

Possible CCS Integrated Workflow

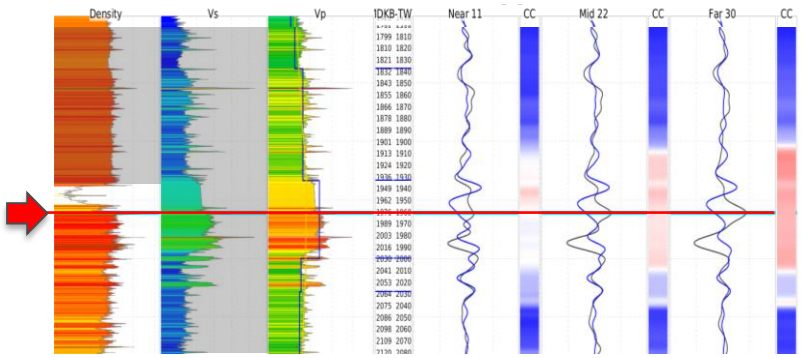


The Better the Input Data, the More Accurate the Subsurface Prediction

Wells

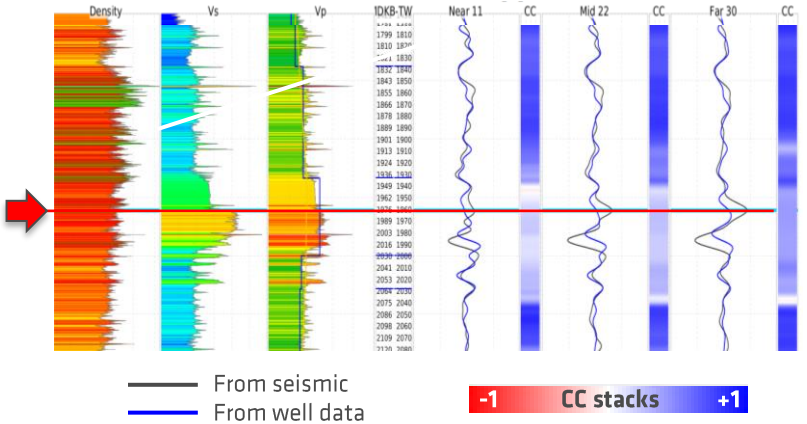
Challenging calibration wells - seismic

Basic log prediction when missing



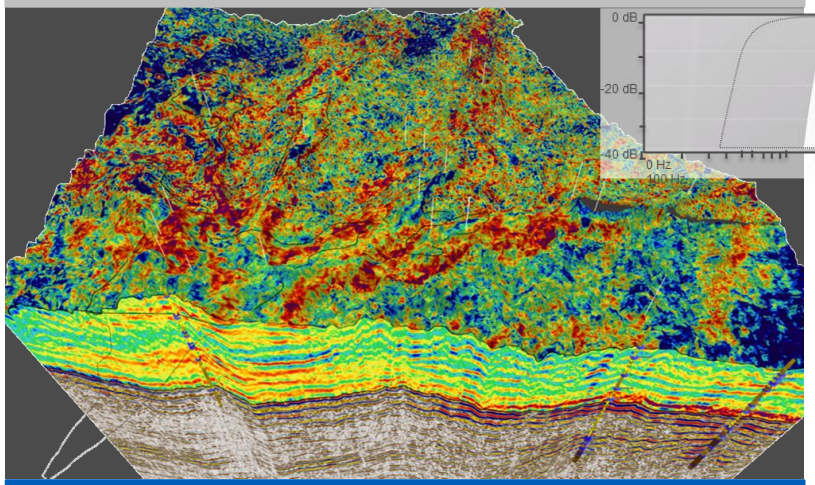
Great calibration wells - seismic

Conditioned wells logs

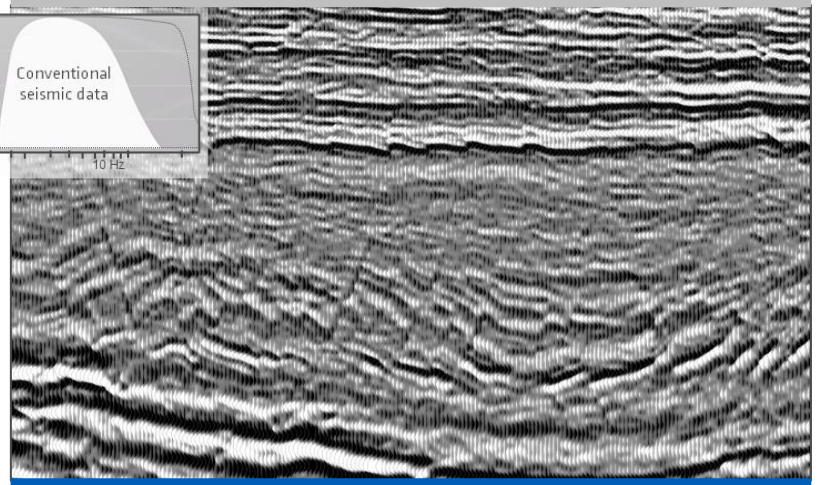


Seismic

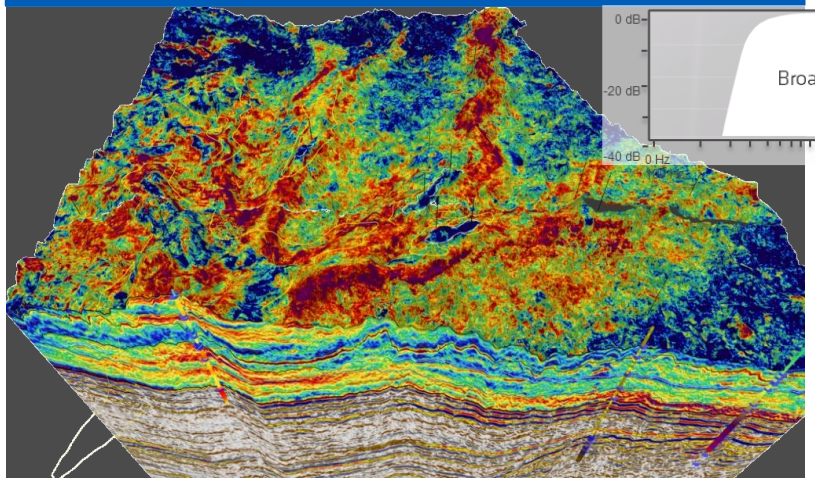
Challenging lithology mapping



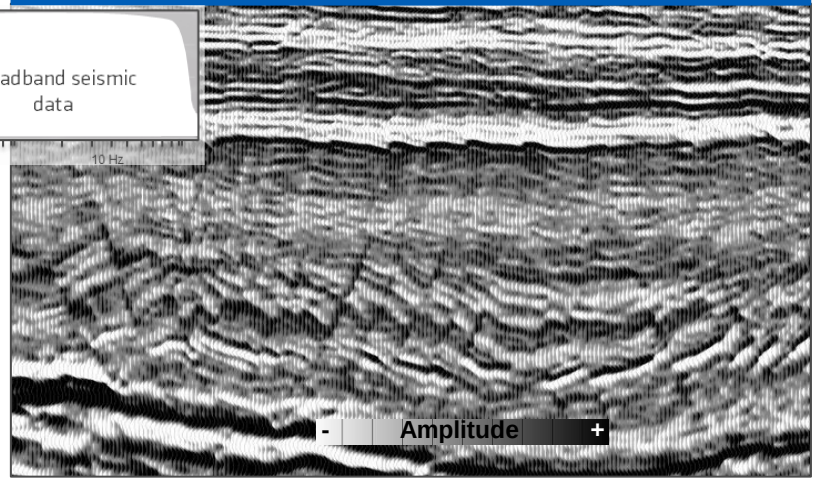
Challenging fault interpretation



Clear mapping of lithologies



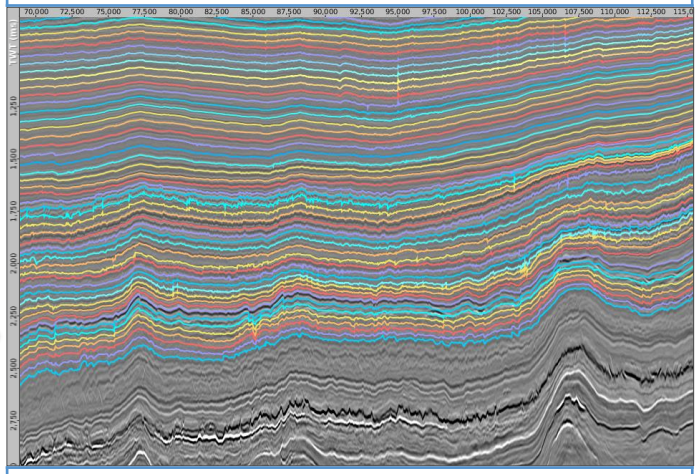
Eased fault interpretation



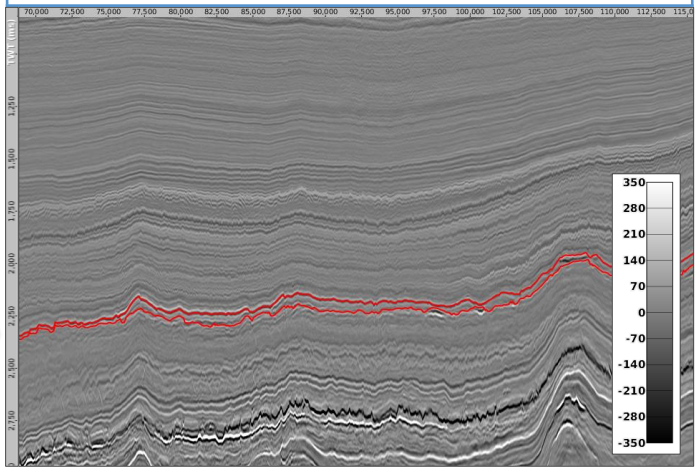
Integrating Geology to Predict the Storage Reservoir in the Subsurface

Horizons interpretation

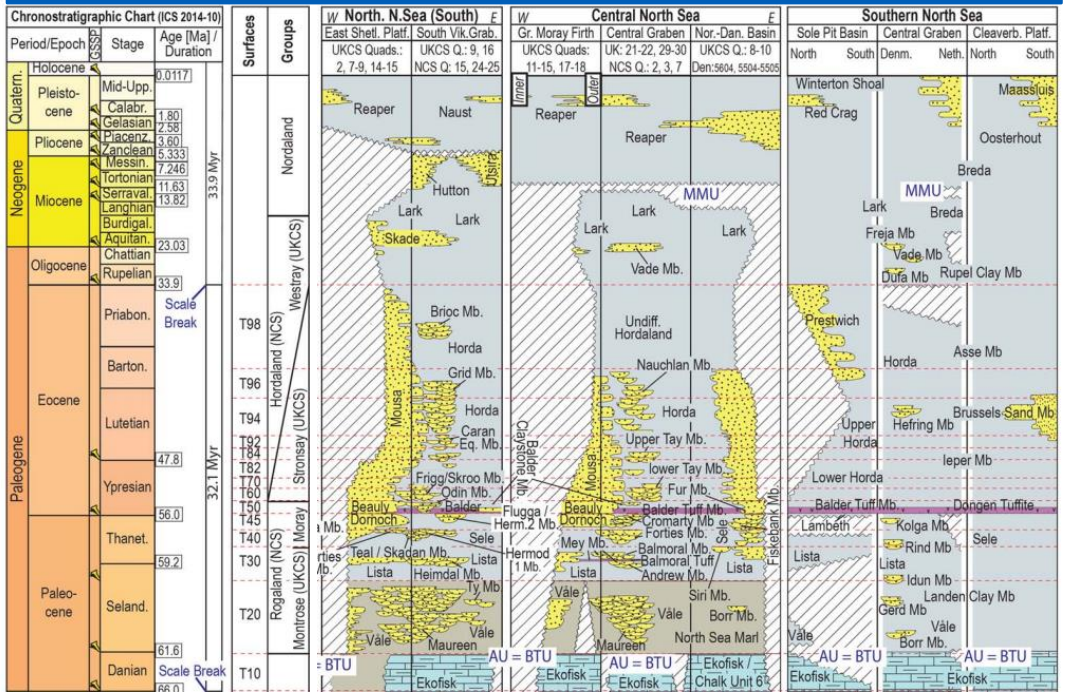
Automatic 3D high-resolution



Refined interpretation



Stratigraphic chart of the North Sea

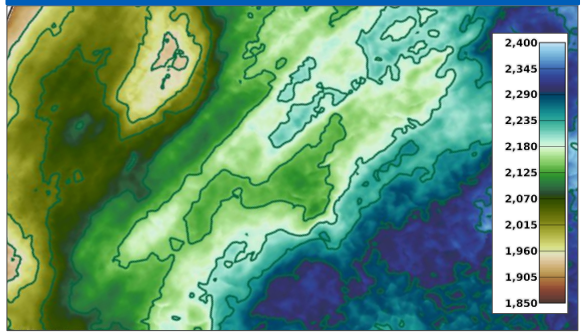


(Patruno et al. 2022)

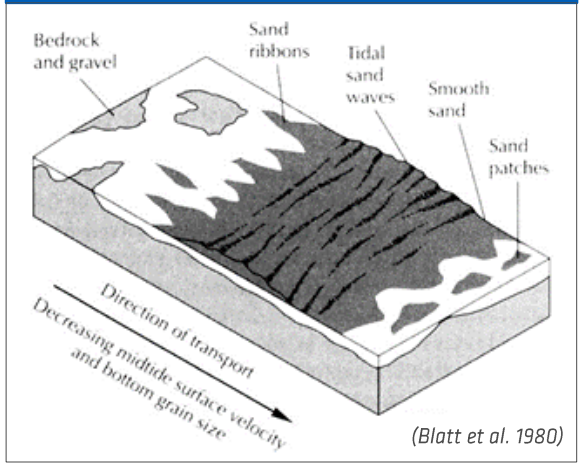
Spectral decomposition,
seismic coherency cube, dip volume

Complex fault system interpretation

Top capacity structure (m)

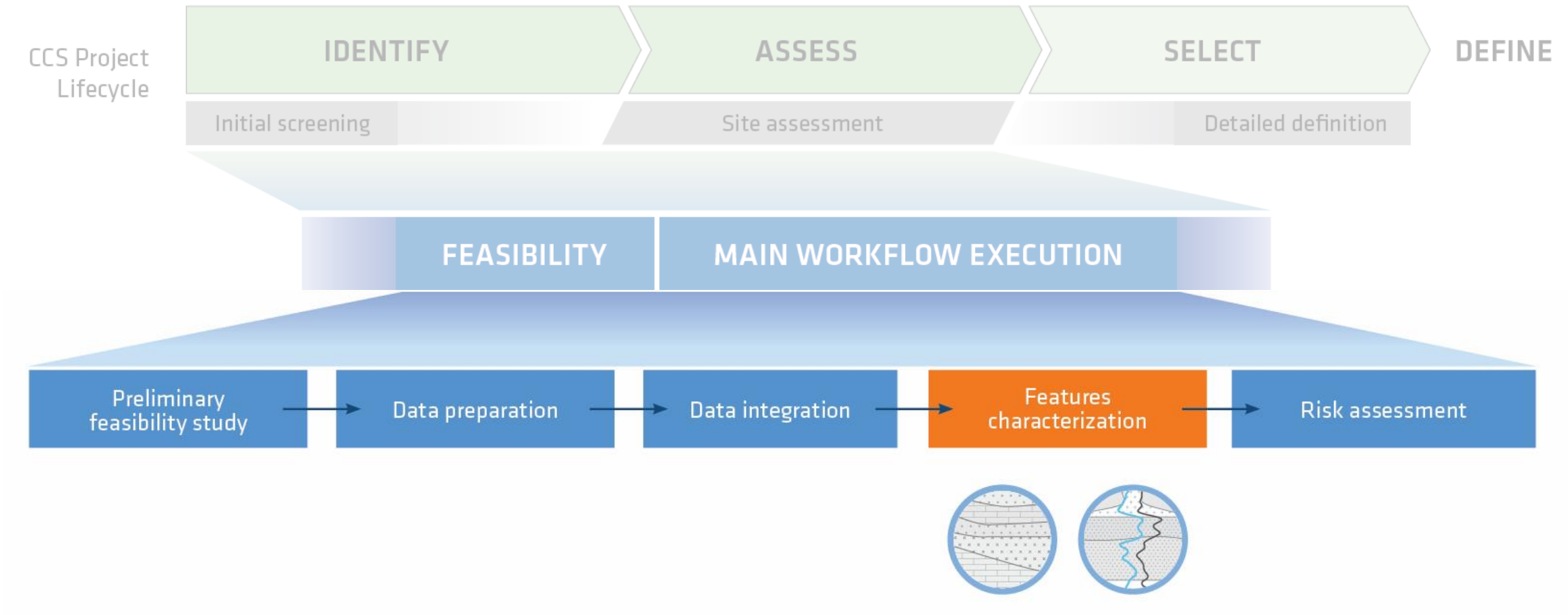


Depositional environment



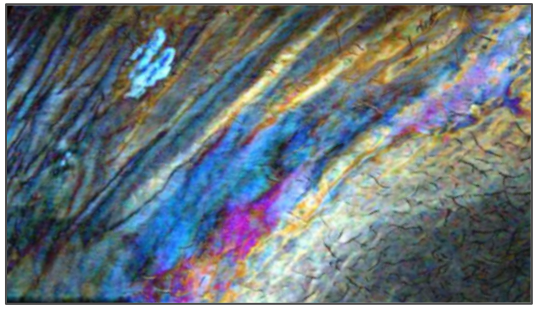
(Blatt et al. 1980)

Possible CCS Integrated Workflow

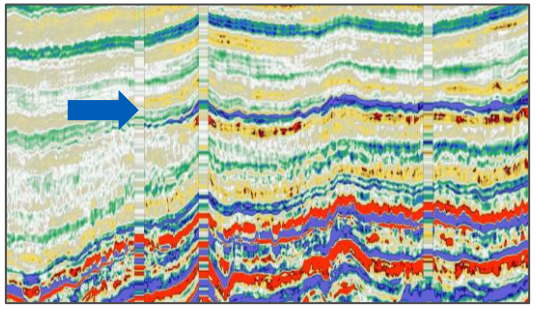


Appraising Capacity Efficiently with Seismic and Well Data

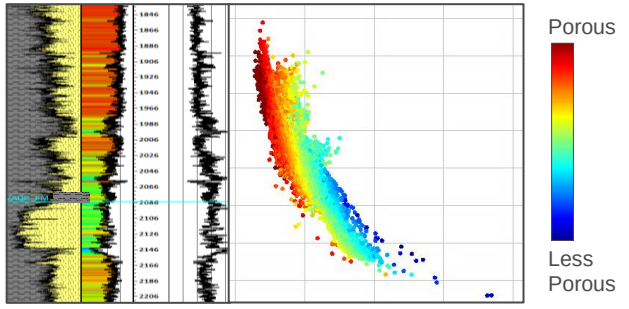
Seismic morphology



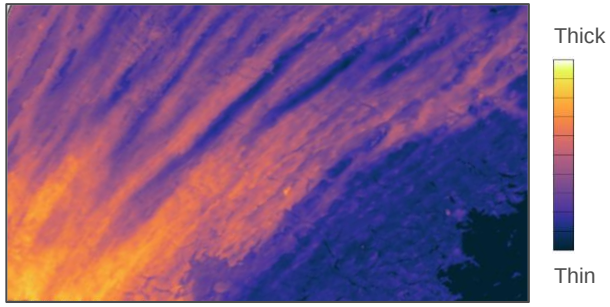
Acoustic impedance



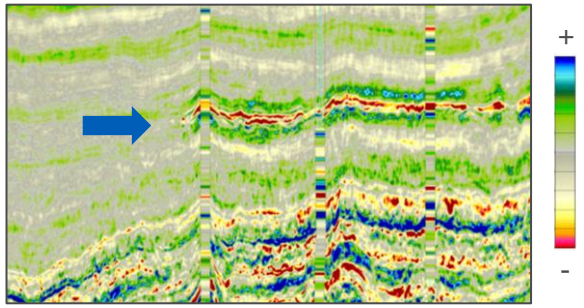
Reservoir property transform



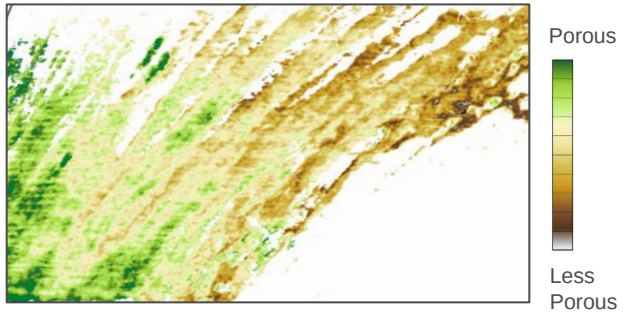
Thickness



Vp/Vs



Porosity

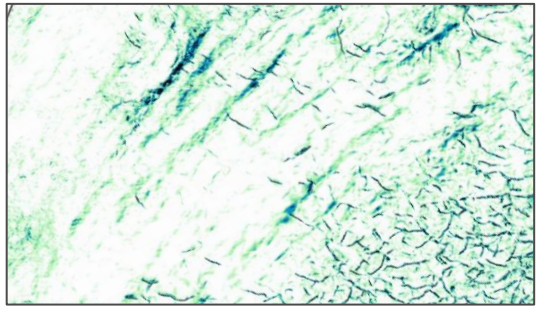


Gross rock and Pore volume for

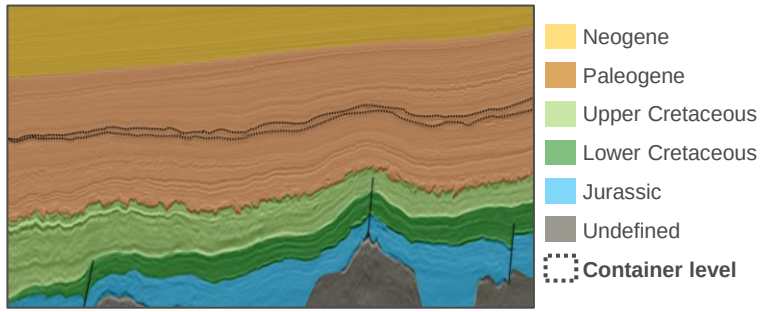
CO_2 Storage Capacity Calculations

Ensure Containment with Seismic and Well Data

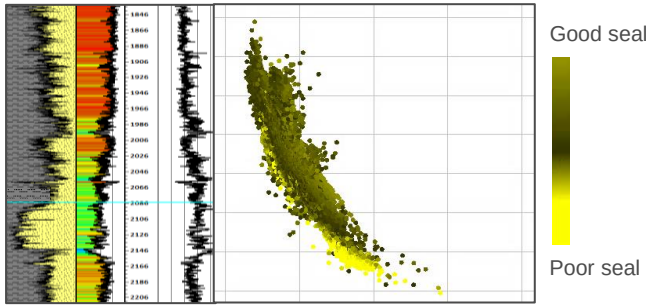
Faulting



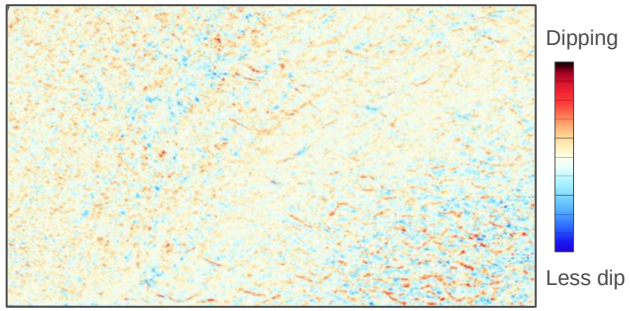
Geological knowledge



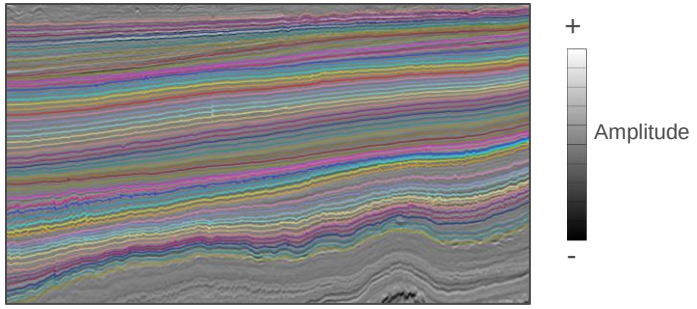
Seal property transform



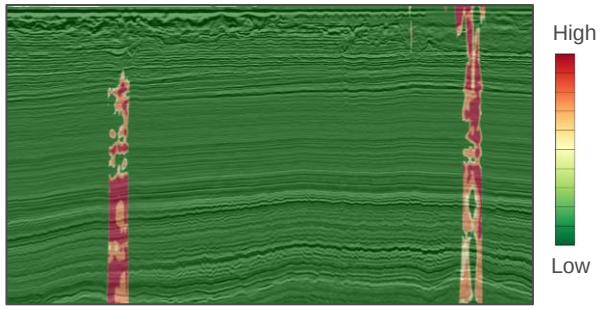
Seal geometry



High-res 3D interpretation



Leakage risk



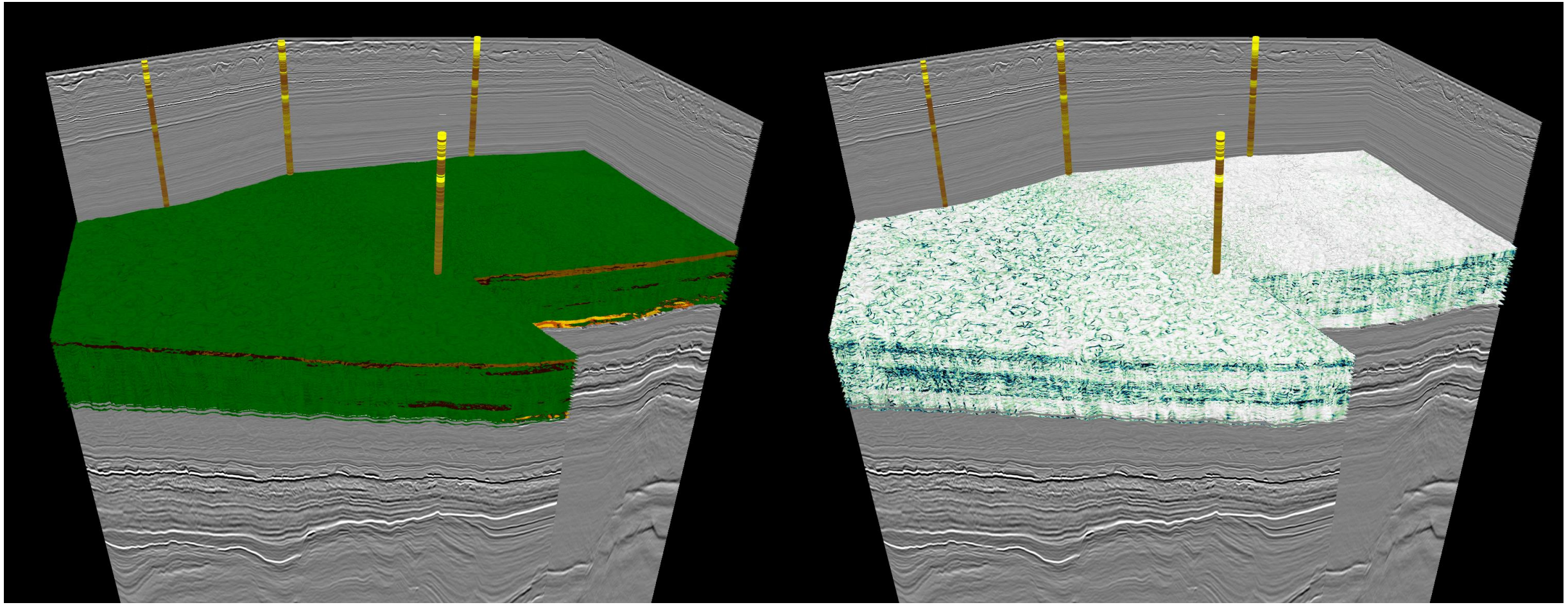
G&G Integration for

CO_2 Containment Assessment

Screening the Capacity and Containment Characteristics

Lithology prediction

Faulting



Capacity quality

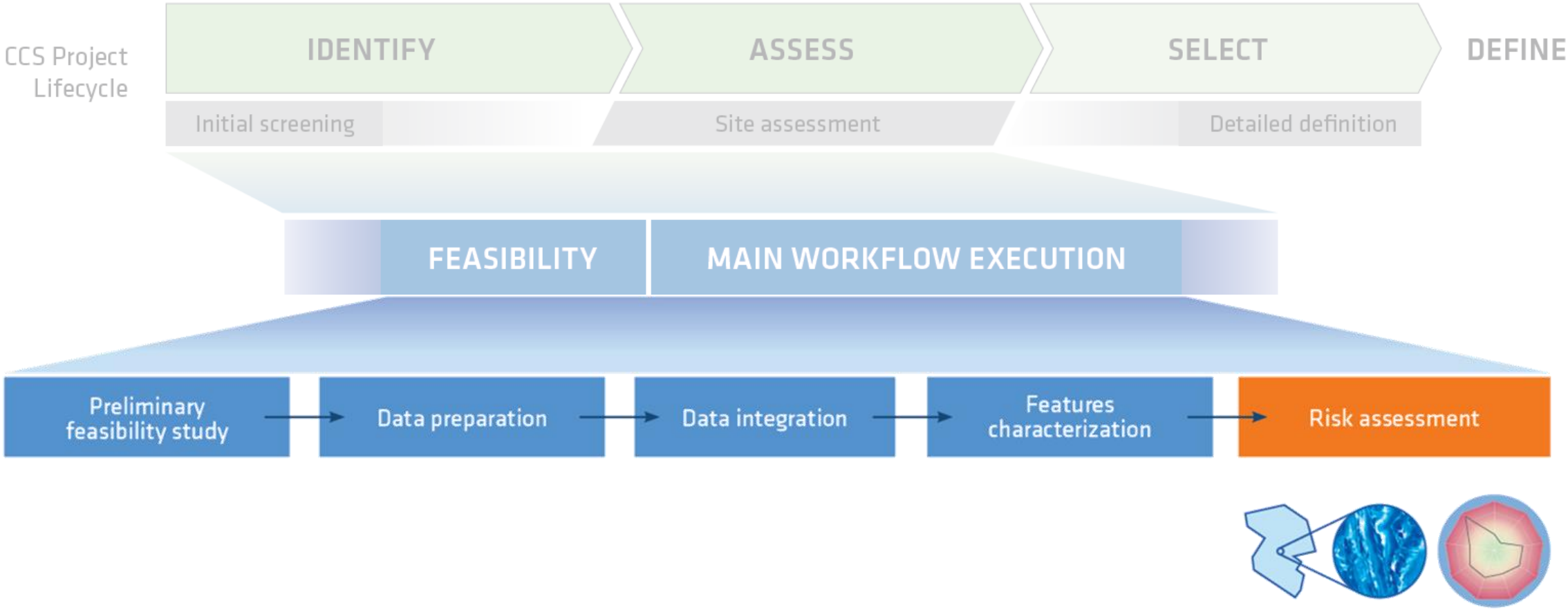
\+ ++

Containment quality

\- +

Coherent Incoherent

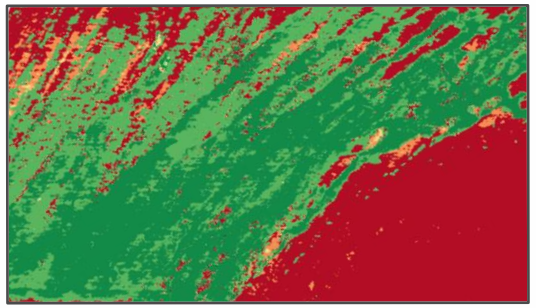
Possible CCS Integrated Workflow



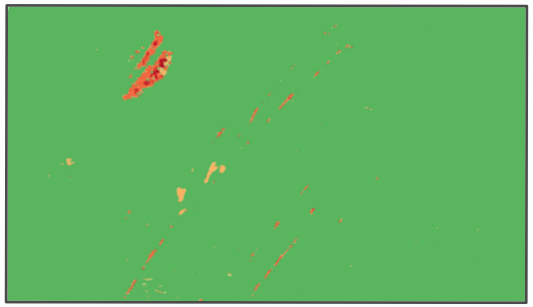
“Automatic” Risk Assessment for Capacity and Containment

3D attributes (lithology prediction, faulting, reservoir properties)

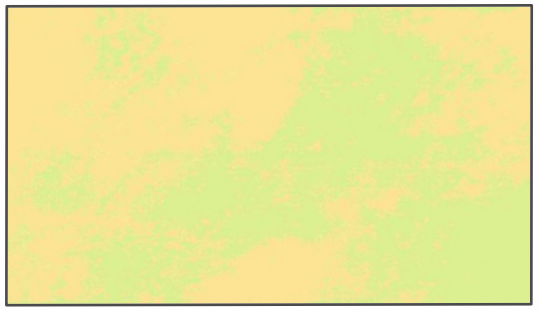
Storage reservoir lithology



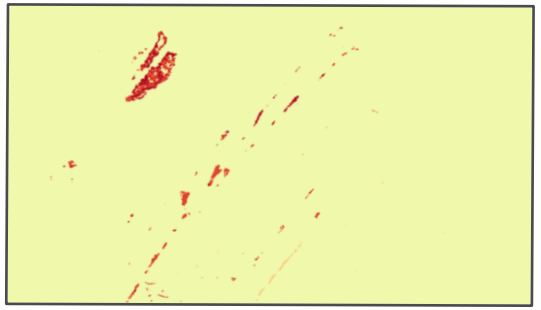
Seal lithology



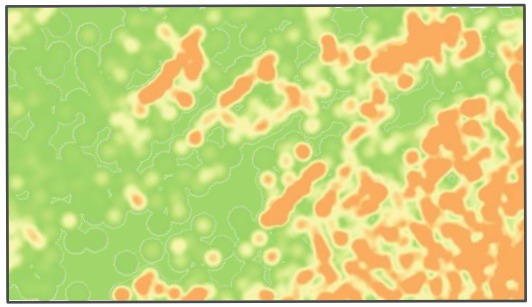
Overburden lithology



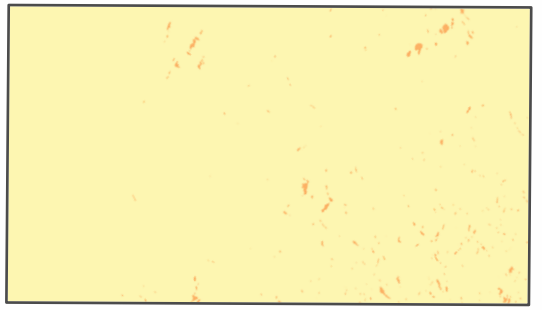
Sandstone connectivity



Seal integrity



Seal geometry



High risk

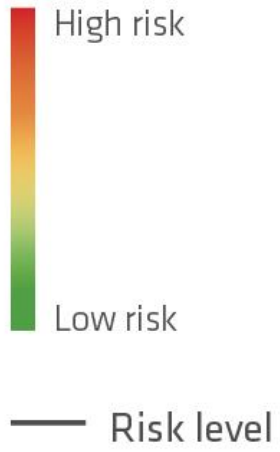
Low risk

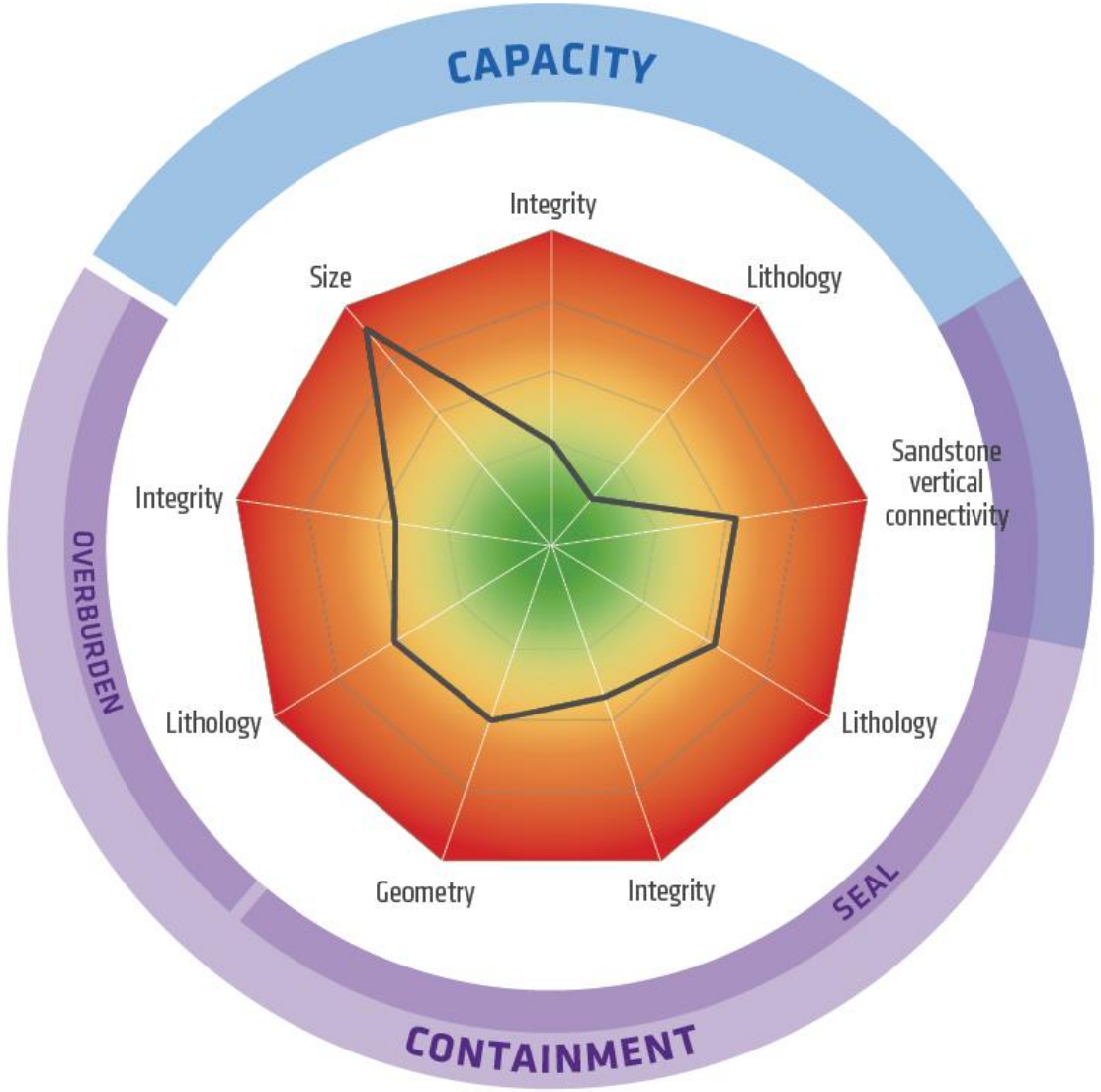
Common Risk Segment maps

Potential Candidate for CO_2 Storage Site

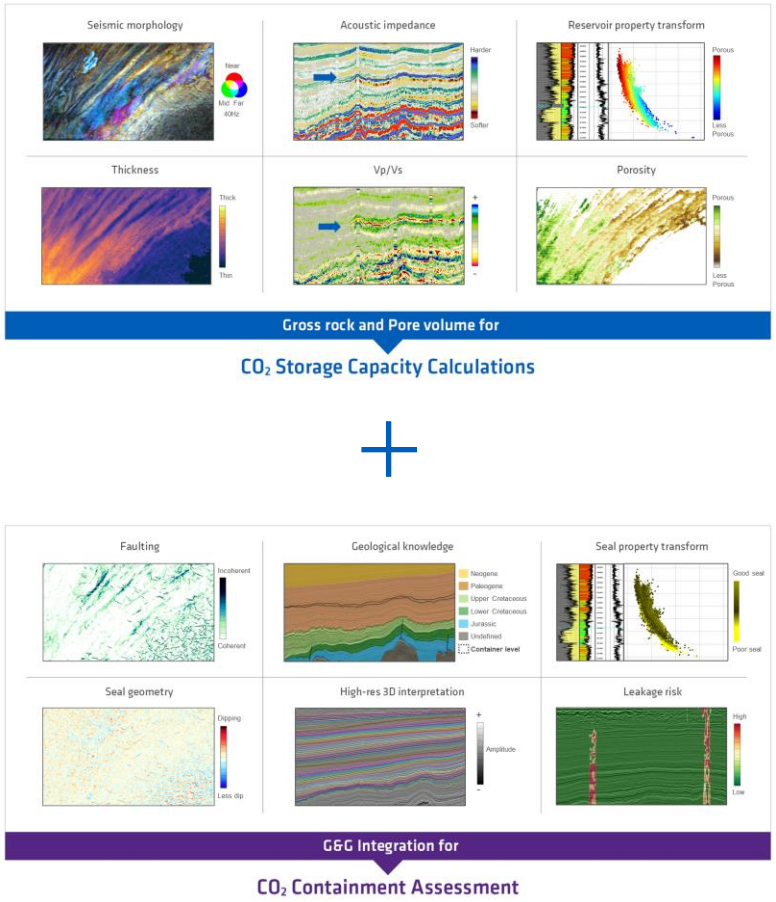
“Automatic” Risk Evaluation for Capacity and Containment

What is the risk associated with this storage site?

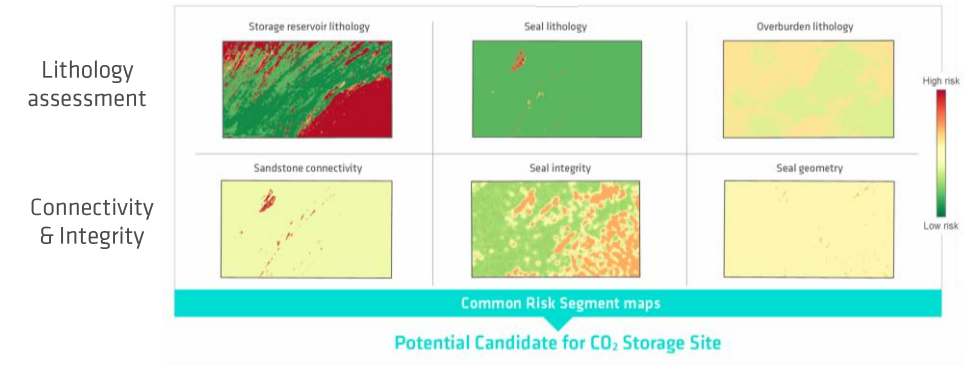




“Automatic” Risk Evaluation for Capacity and Containment

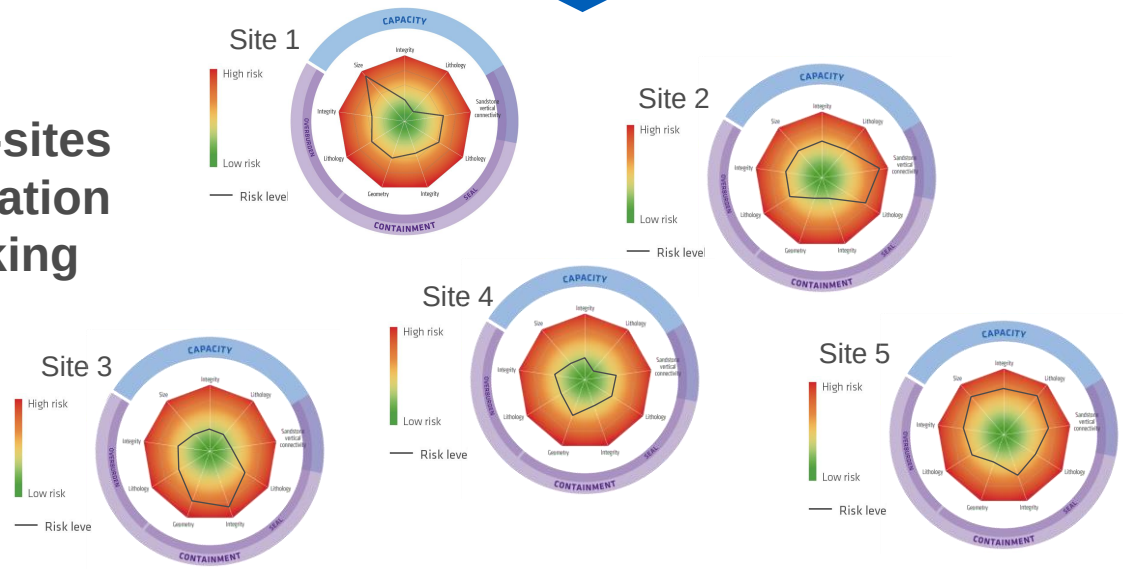


Integration for: lithology prediction, faulting, reservoir properties

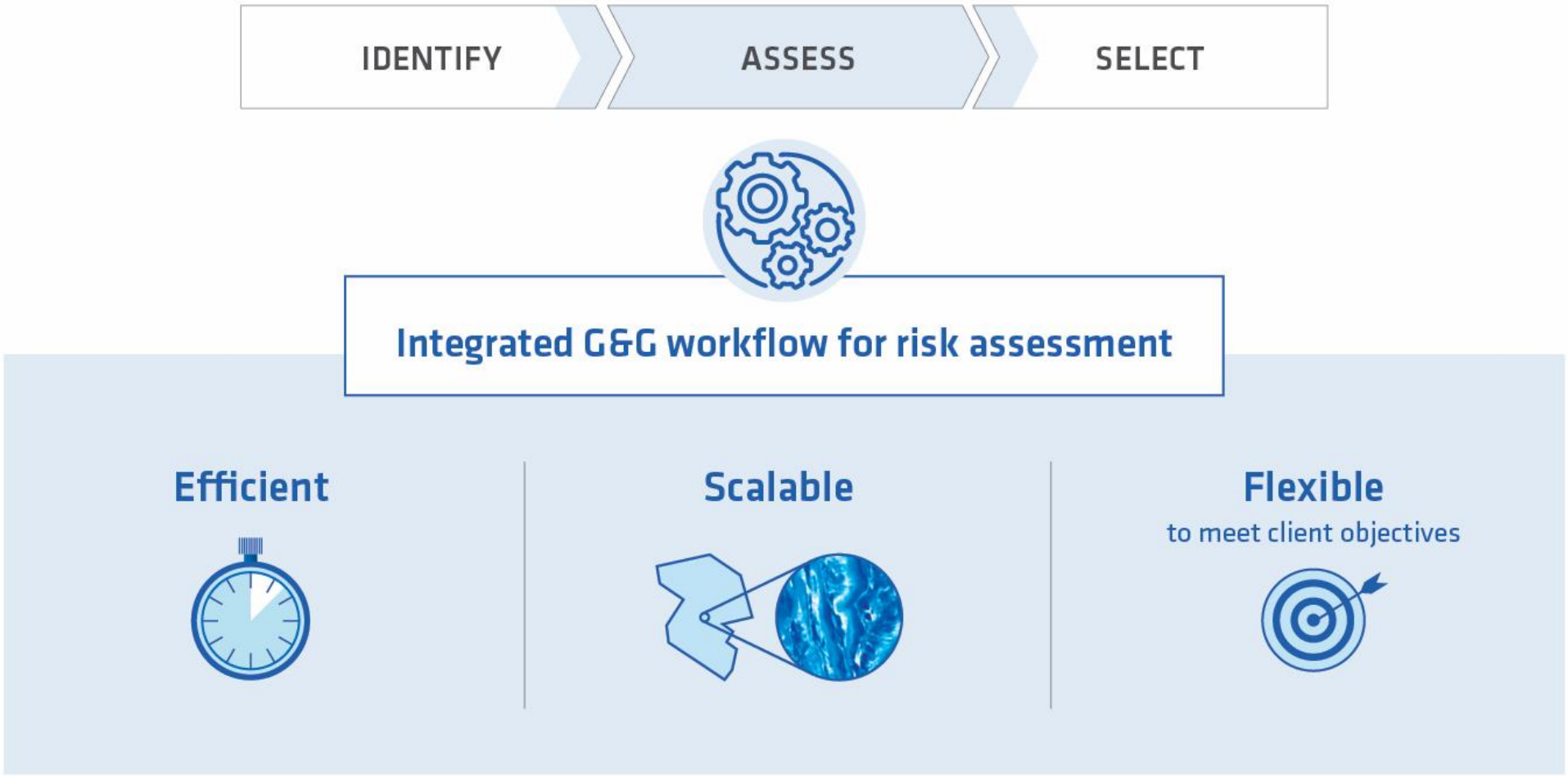


Site evaluation automation

Multi-sites evaluation ranking



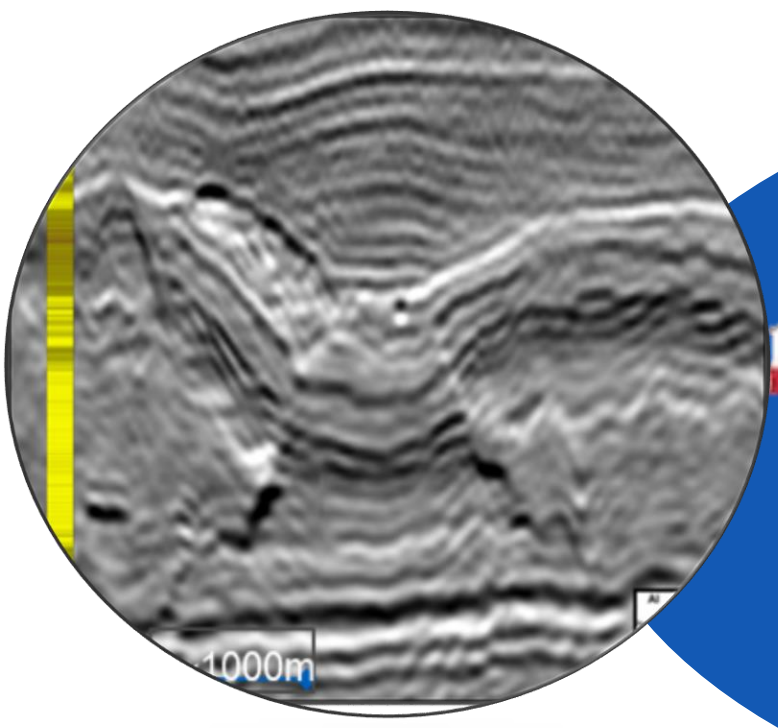
PGS Efficient, Scalable and Flexible Workflow for CCS Site Characterization

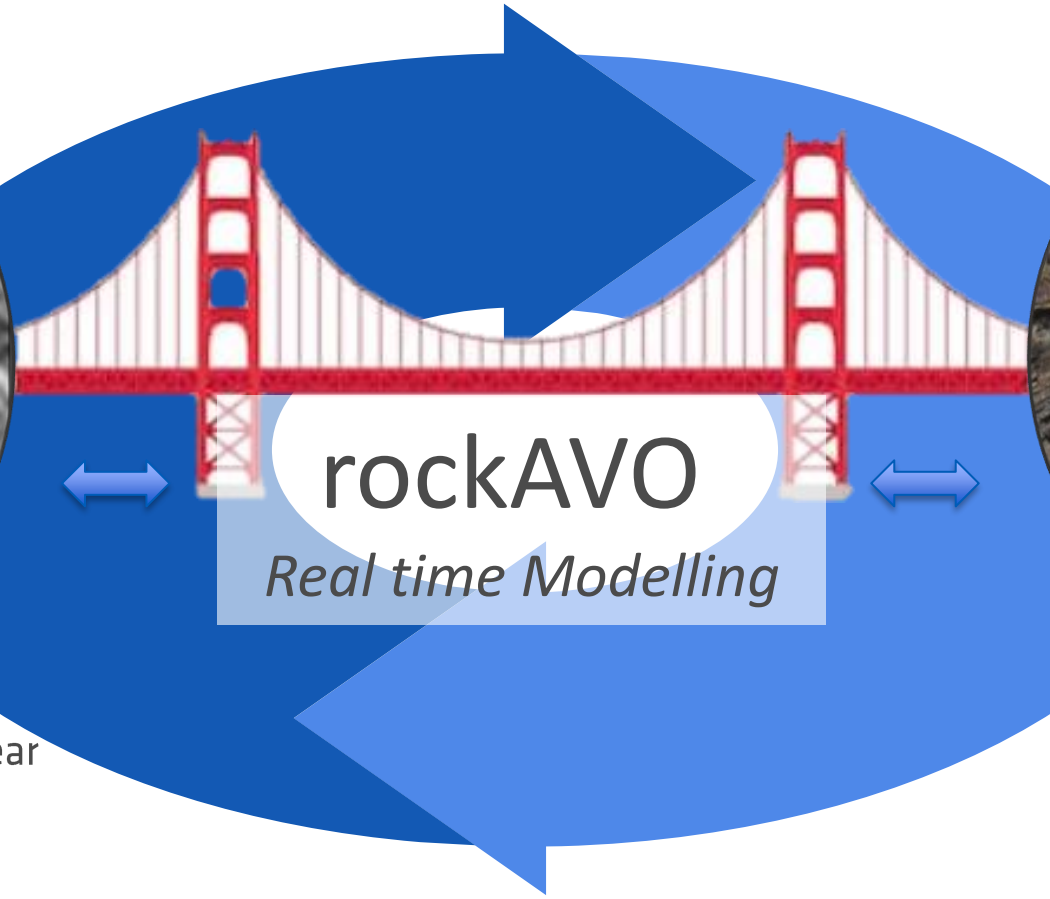


CCS Integrated G&G workflow supporting the Energy Transition

Monitorability and Monitoring

What is Rock Physics? the Bridge Between Geology and Geophysics





PSTM/PSDM
gathers
Angle stacks
Full stacks

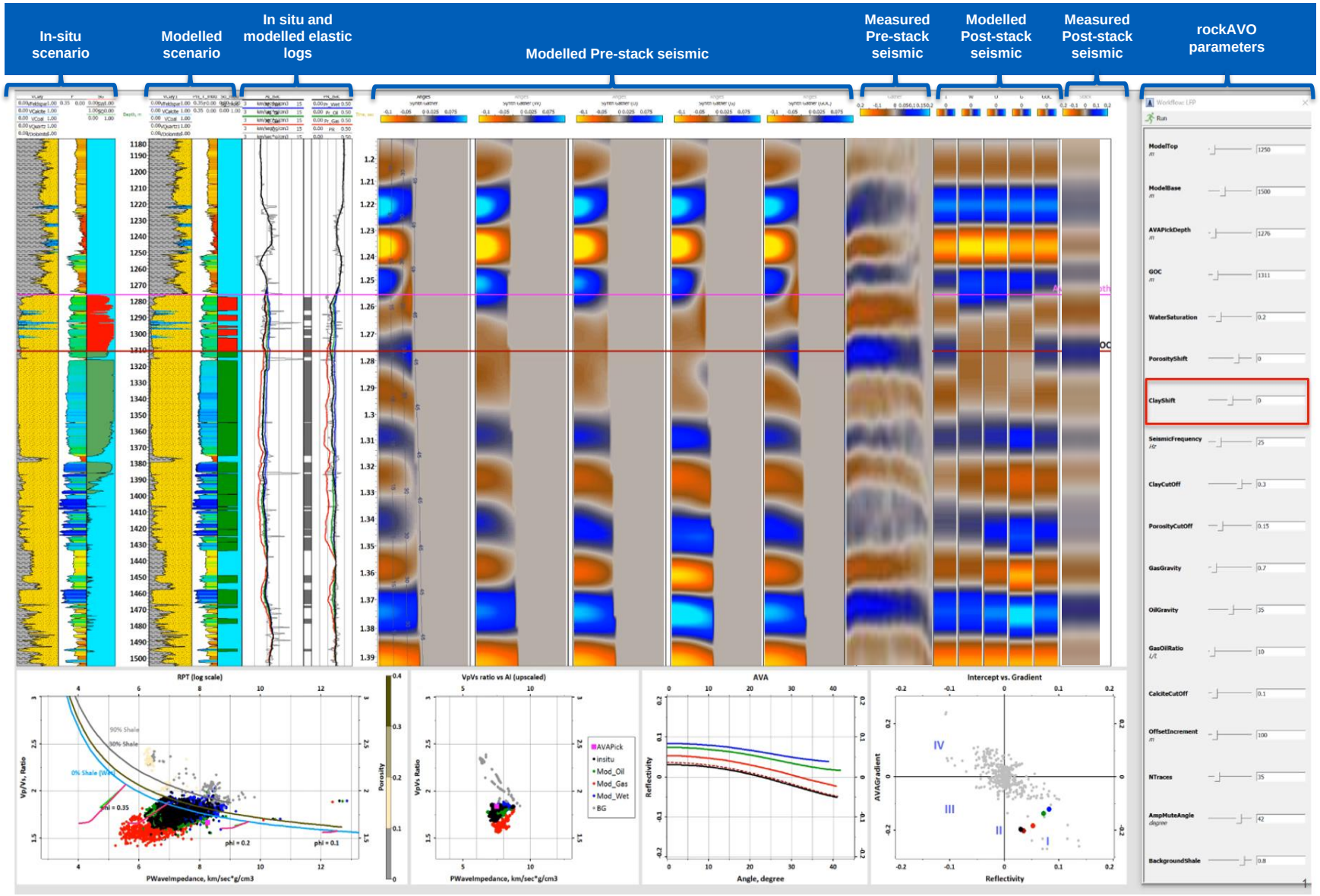
Acoustic/Shear
impedances
Vp/Vs
$\lambda\rho$, $\mu\rho$, ν, E

Minerals
Porosity
Pore shape

Fluids
Pressure
Cement

The link between geological properties and elastic properties

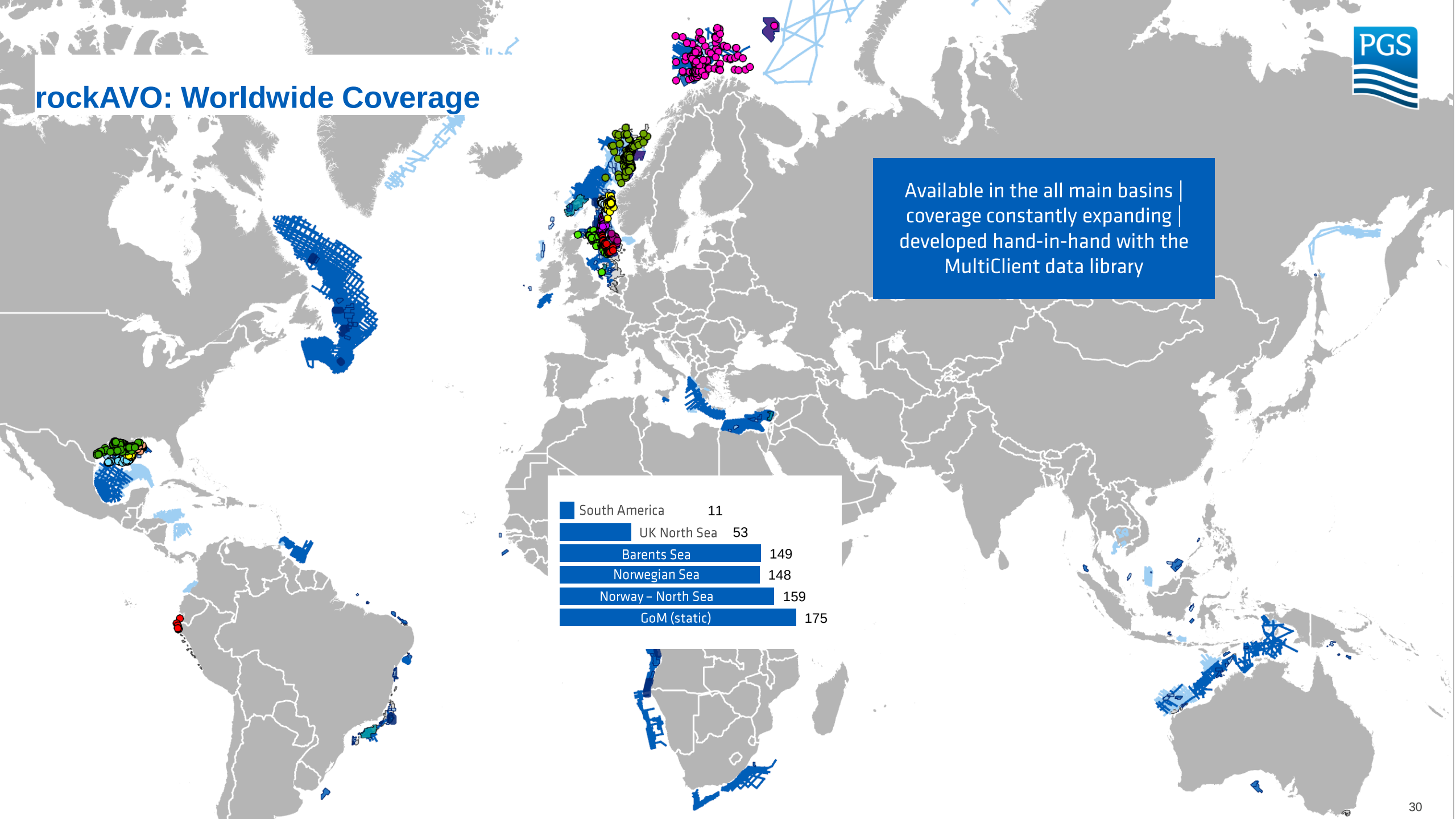
rockAVO: Interactive Rock Physics Atlas



- **rockAVO** transforms a **static hardcopy** study into a **dynamic living report**.
- **rockAVO** has been designed as **a portal** into a **rock physics database** and is delivered with the study data.
- **rockAVO** represents **a step-change** in the way **explorationists** access rock properties information **without** the need to be a **rock physics expert**.

rockAVO: Worldwide Coverage

Available in the all main basins | coverage constantly expanding | developed hand-in-hand with the MultiClient data library



Applications: Evaluating CCS in hydrocarbon Prone Basins

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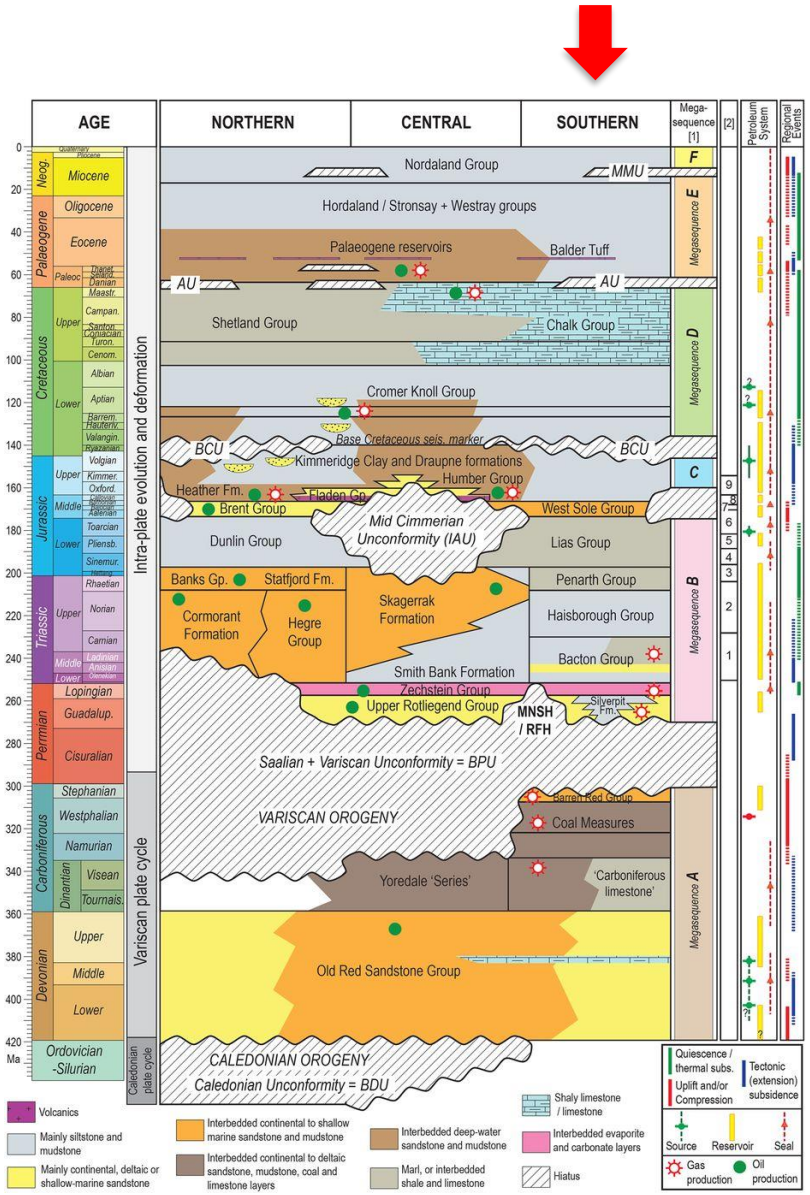
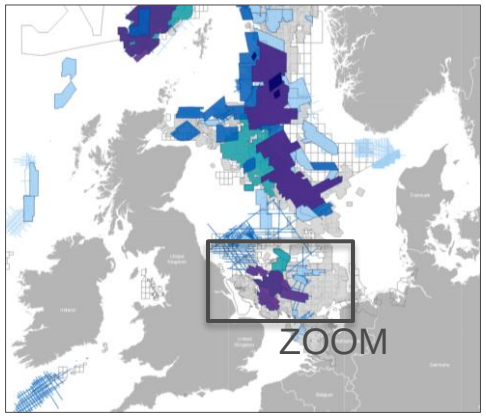
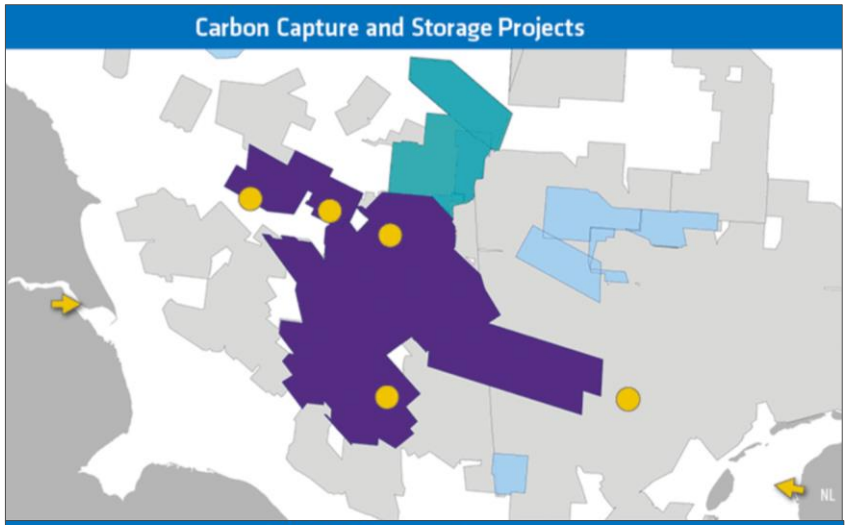
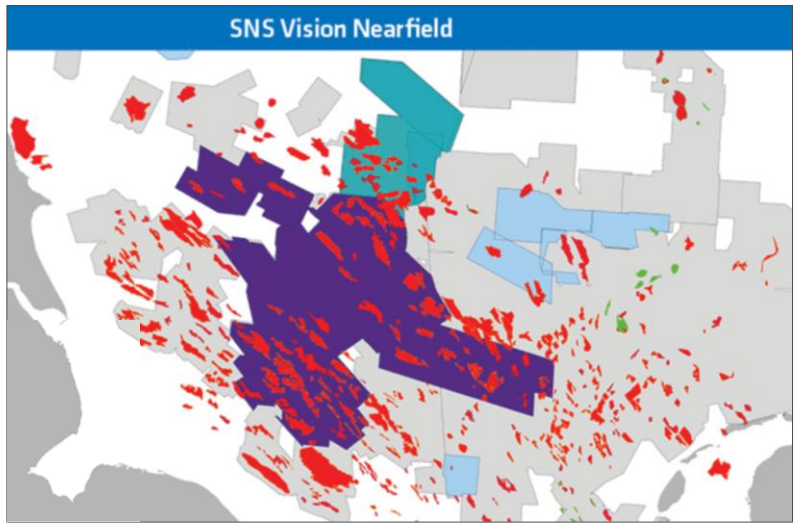
Southern Gas Basin (Europe)

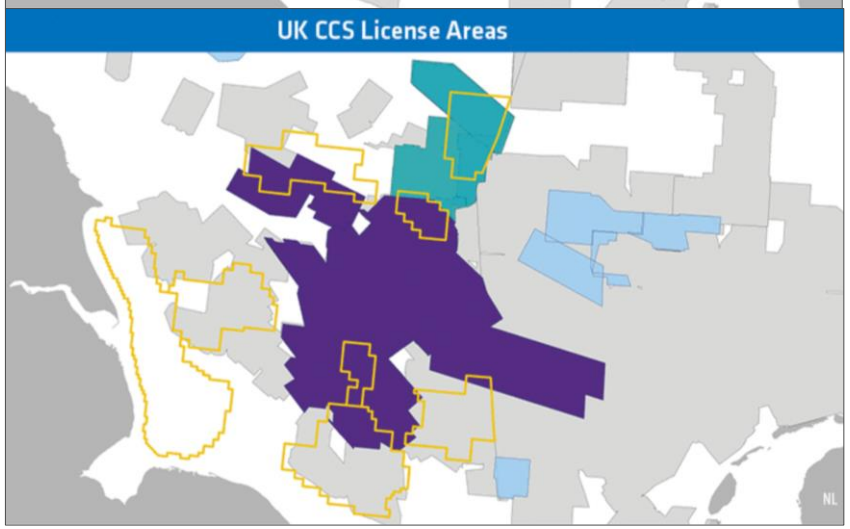
Why Rejuvenation of the Southern Gas Basin Reflects the Realities of Energy Transition

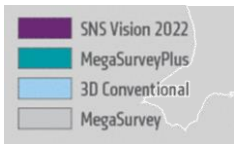








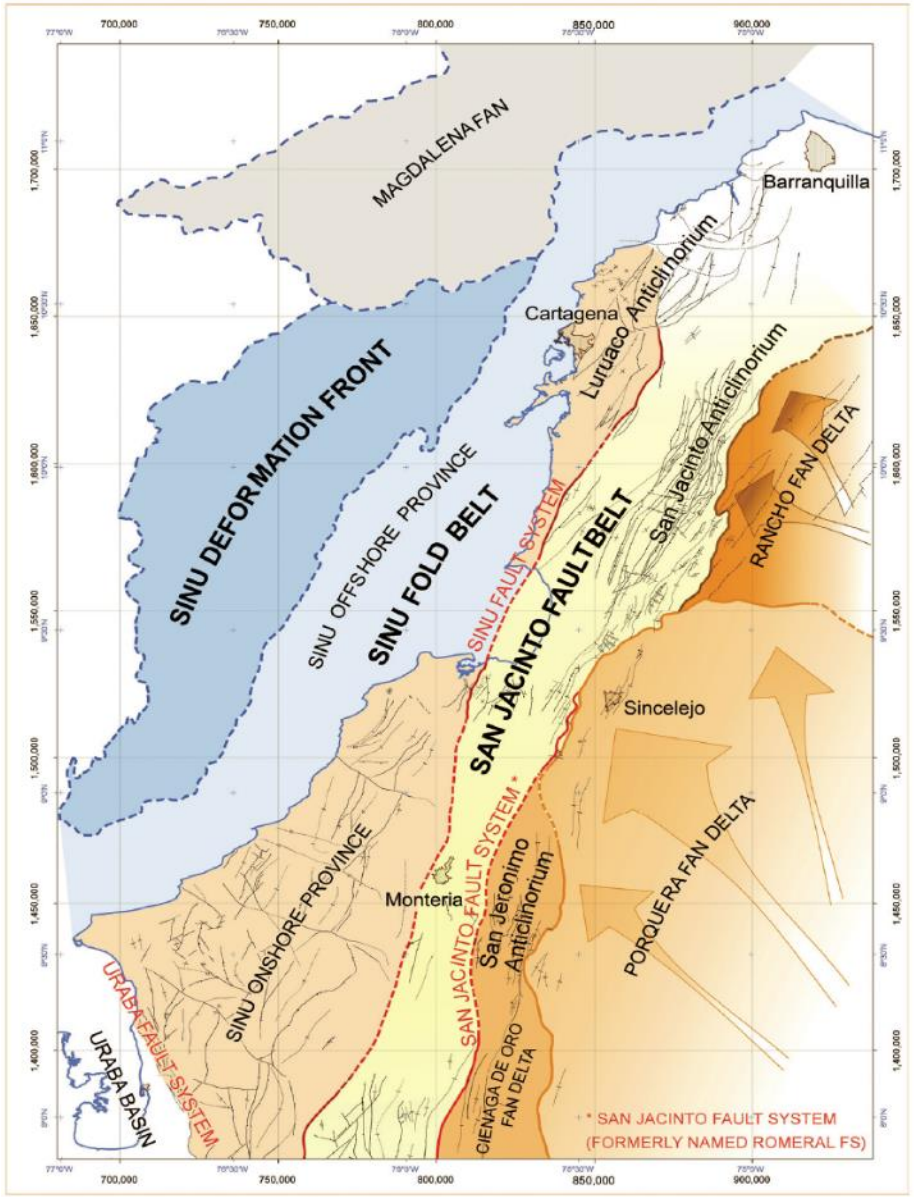


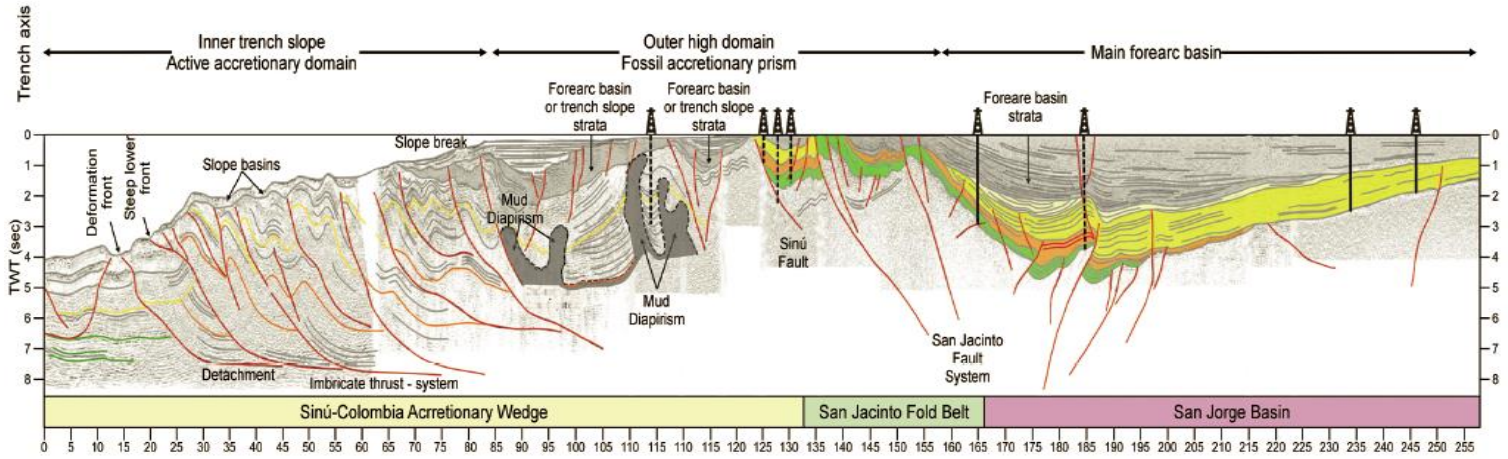


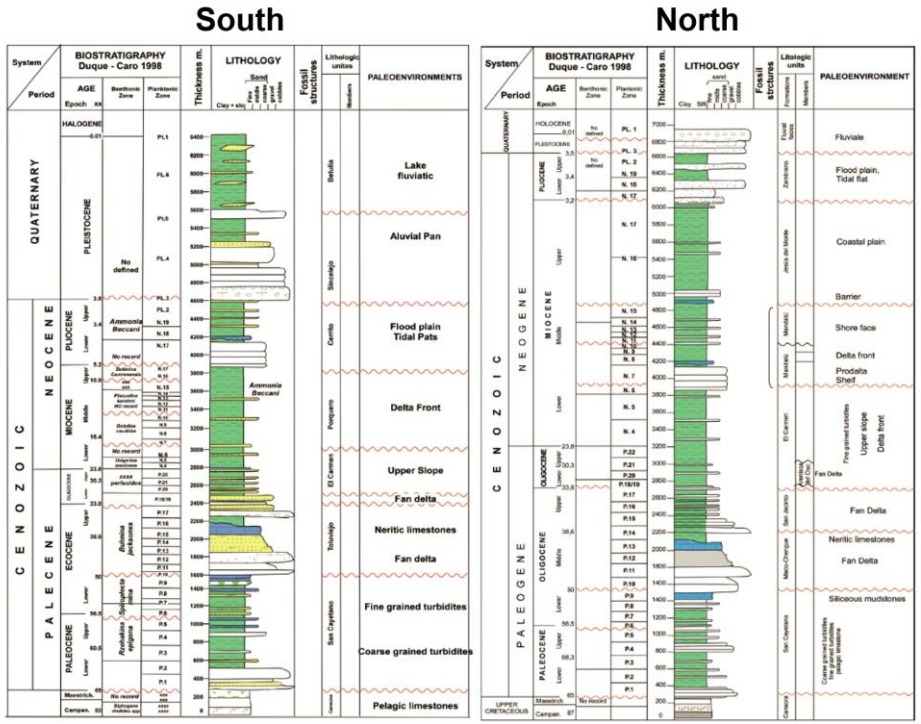
Applications: Evaluating CCS in hydrocarbon Prone Basins

What about Colombia?

Sinu Basin - General Structure Settings







Regional Geology of Colombia (2011)

Summary and road ahead

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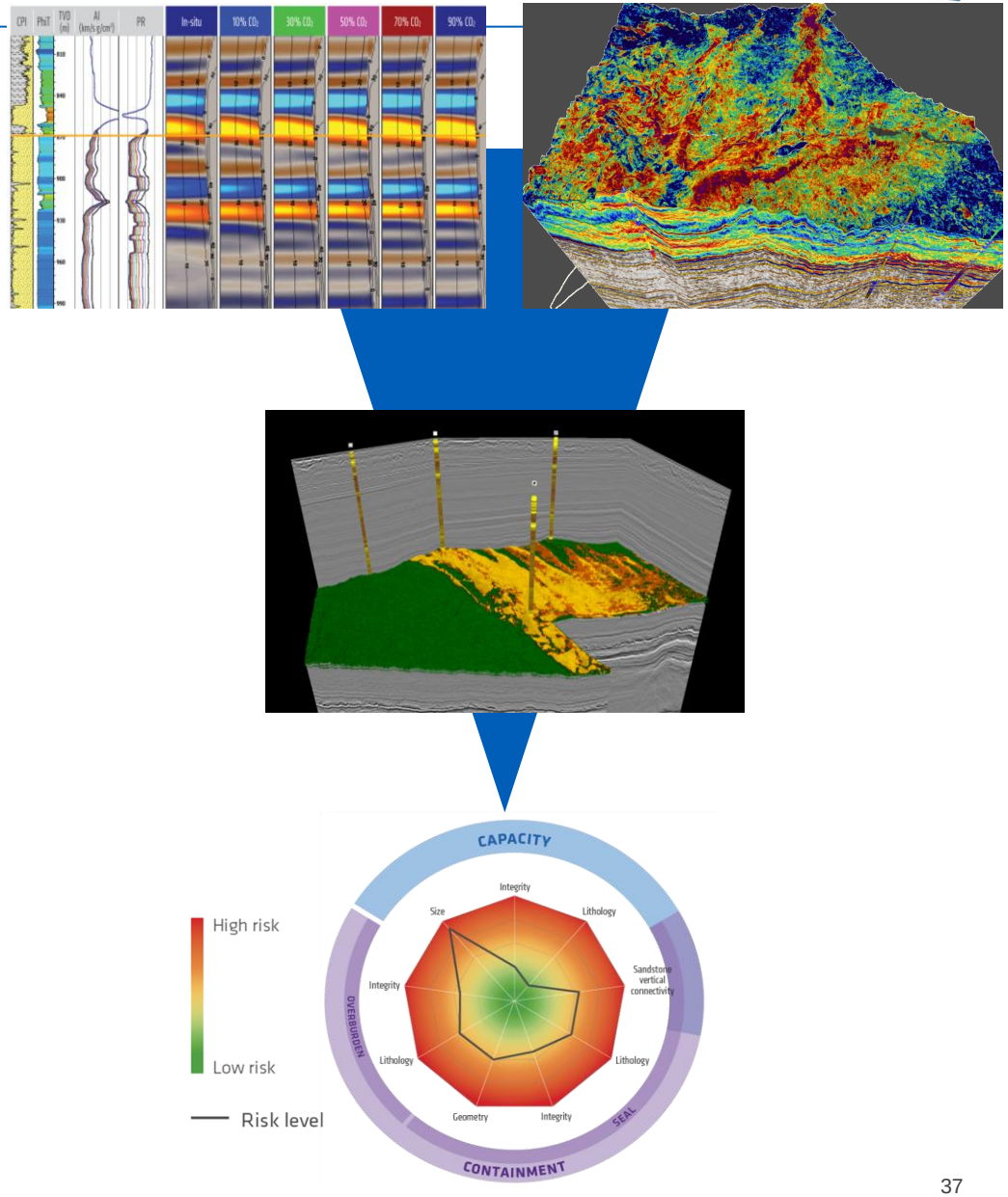
- Integration of high-quality G&G data (well and seismic) allows:
  - More data driven approach
  - Improve understanding of the subsurface and
  - Reliable characterization of the capacity and containment.

- Conventional O&G workflows/techniques & technologies (front-end) is well adapted to CCS objectives, and therefore suitable for CCS areas.

- Consistent and well adapted/developed workflow for capacity and containment.

- Monitorability-Feasibility can be performed through an interactive rock physics.



Summary and road ahead

- The integrated workflow developed as been tested in the North Sea as the UK (and Europe more broadly) appears as one of the leader for the Energy Transition Initiative.
- Potential for rapid and efficient screening process and for further automation.
- PGS as an integrated company, masters the whole value chain from acquisition, imaging to CCS site identification and characterization and can be the partner of choice.
- We are looking forward to perform this type of analysis around the globe and contribute to reduce the global CO2 footprint.

Thank you for your attention