Geoscience

SPE Seminar: Introduction to E&P
The Geological Society
4 November 2025

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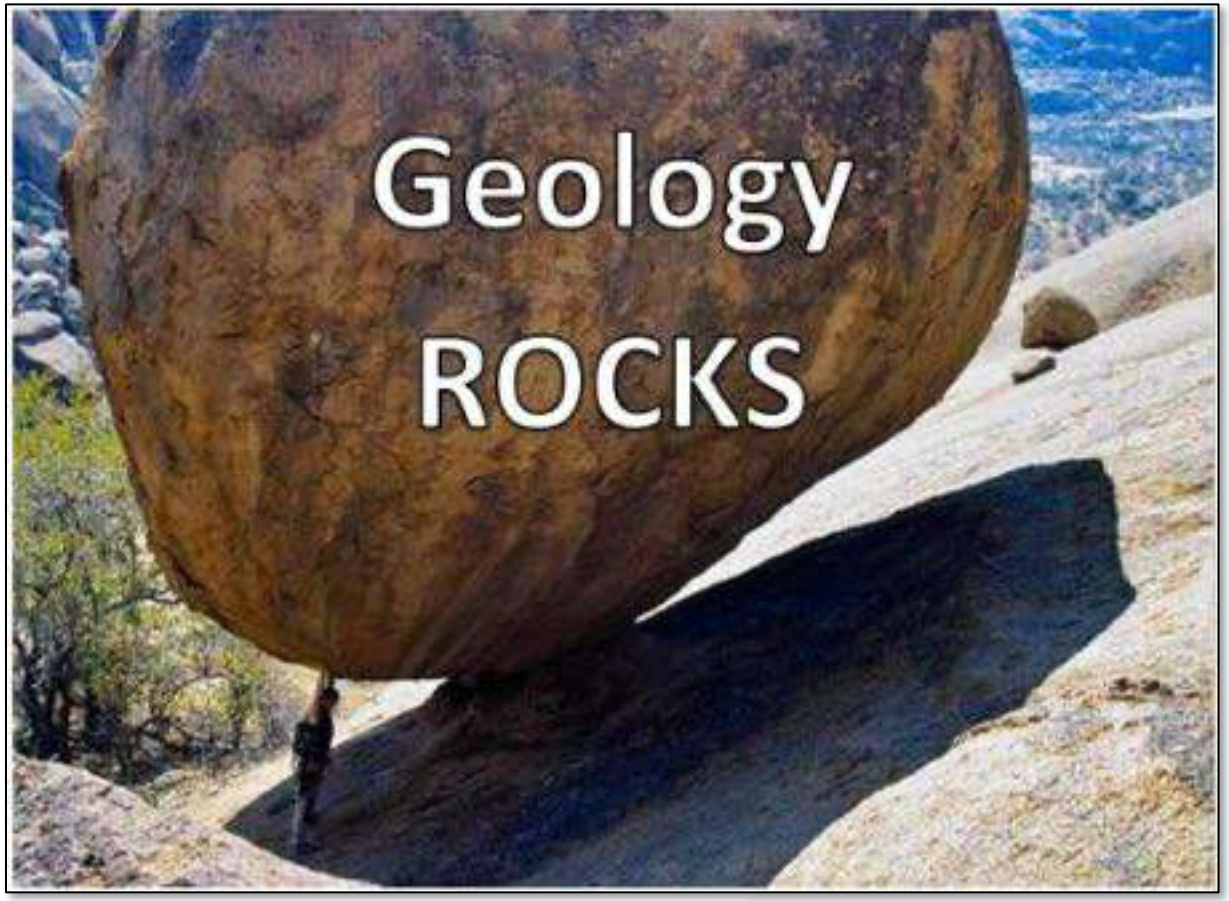
Contents



Types of Rocks

Igneous

- Forms from magma or lava solidification
- Hard, no layers

Granite

Intrusive
slow magma cooling

Obsidian

Extrusive
rapid lava cooling

Sedimentary

- Forms from sediment compaction
- Crumbly, layered

Sandstone

Clastic
compacted broken rocks

Limestone

Chemical
compacted dissolved minerals

Coal

Organic
compacted biogenic matter

Metamorphic

- Forms by transformation of other rocks
- Relatively hard, may or may not have layers

Slate

Foliated
has layers

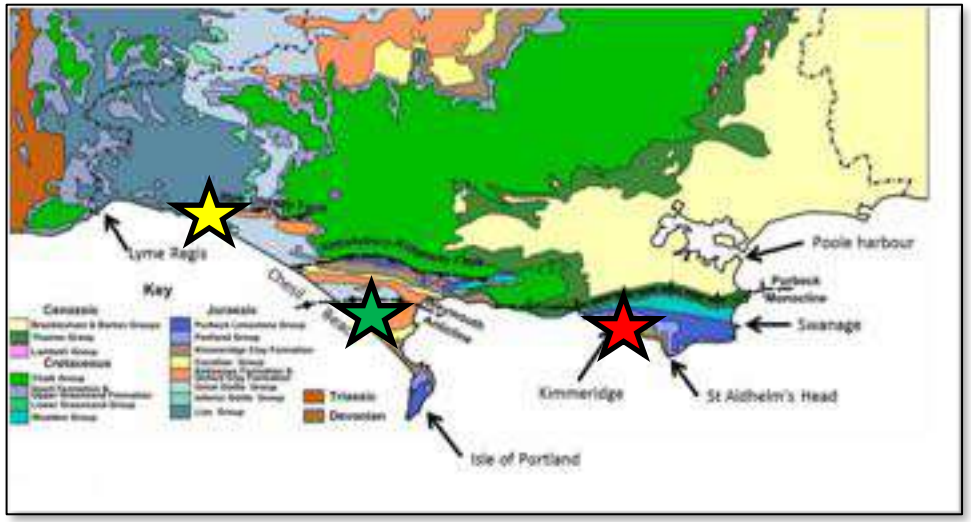
Marble

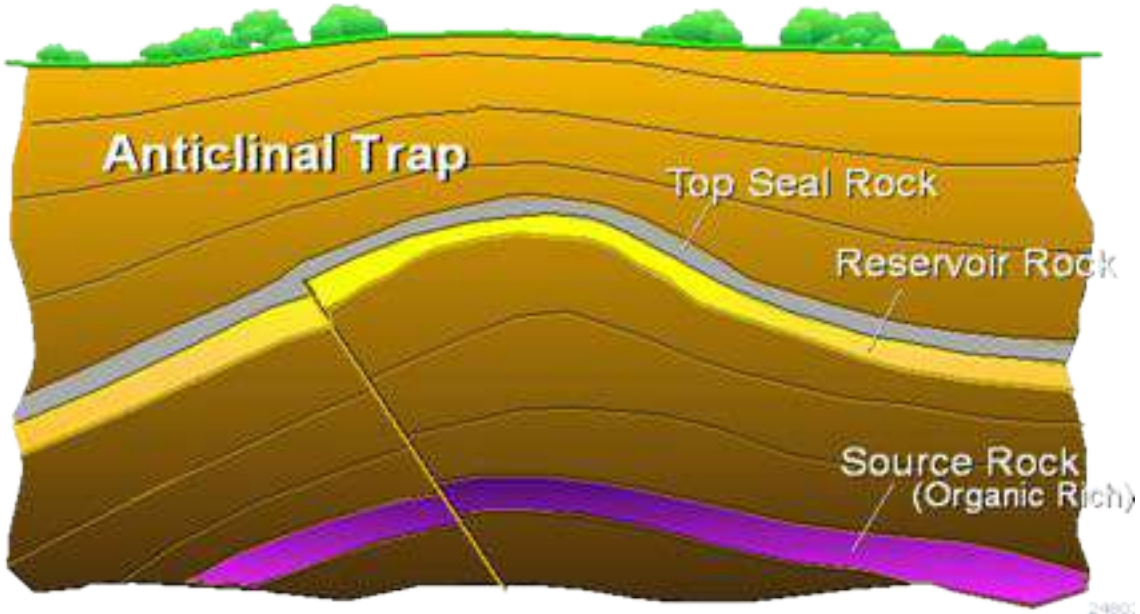
Non-Foliated
no layers

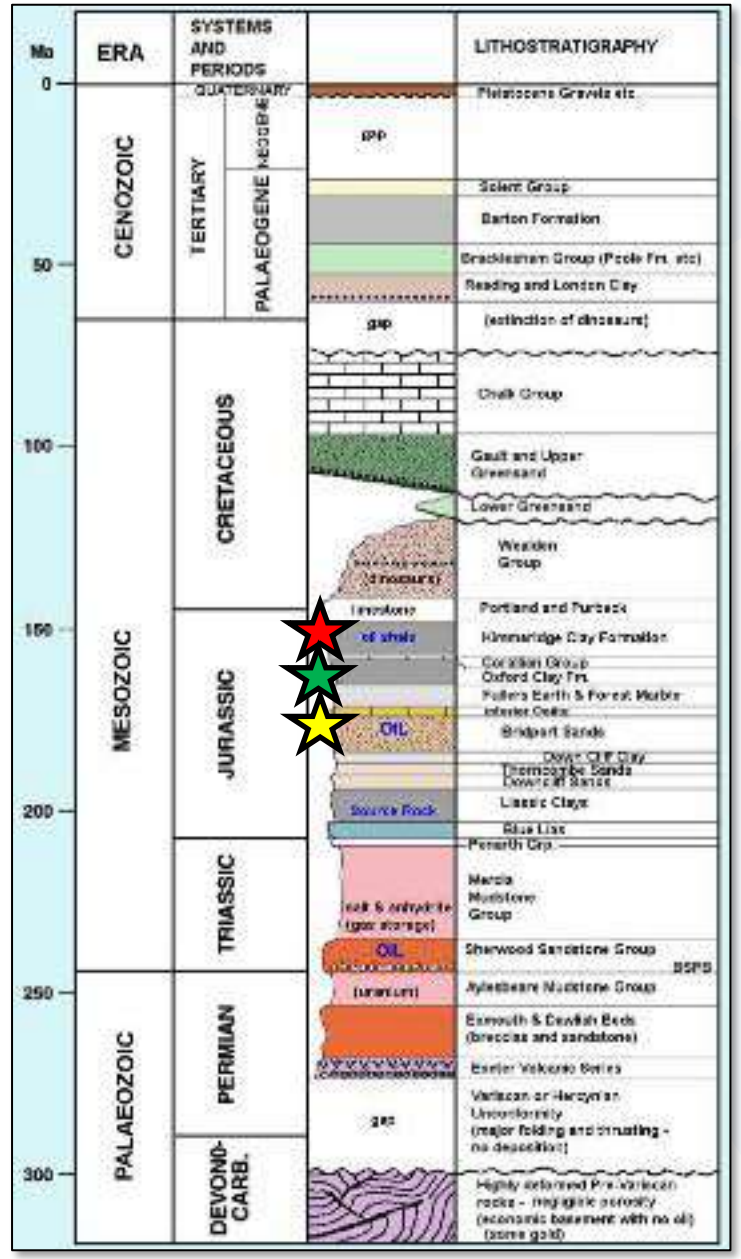
sciencenotes.org

Petroleum System

- Source Rock
- Reservoir Rock
- Seal / Cap Rock
- Trap







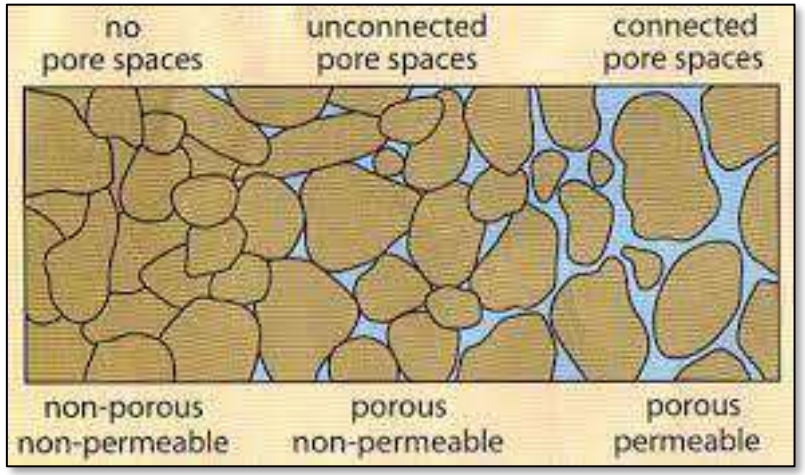
Source Rock

- Buried organic matter
- Anoxic conditions (lack of oxygen)
- Maturation through pressure & temperature
- Oil window: 60–120 °C, 2-4 km
- Gas window: 120–180 °C, 4-6 km

Photo: Ian West (https://wessexcoastgeology.soton.ac.uk/index.htm)

Reservoir Rock

- **Globally, nearly all reservoir rocks are either carbonates or sandstones**
- **Good porosity**
  - Storage of hydrocarbons
- **Good permeability**
  - Flow of hydrocarbons



Source: UC Denver

Photo: The Guardian online

Seal Rock / Cap Rock

- Impermeable layer above the reservoir rock
- Typically composed of shale, chalks, clays, anhydrite or salt

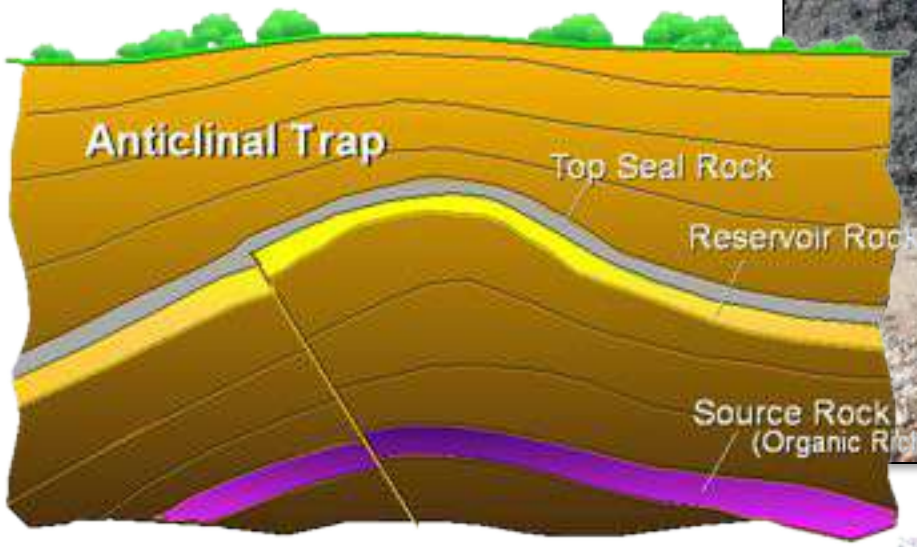
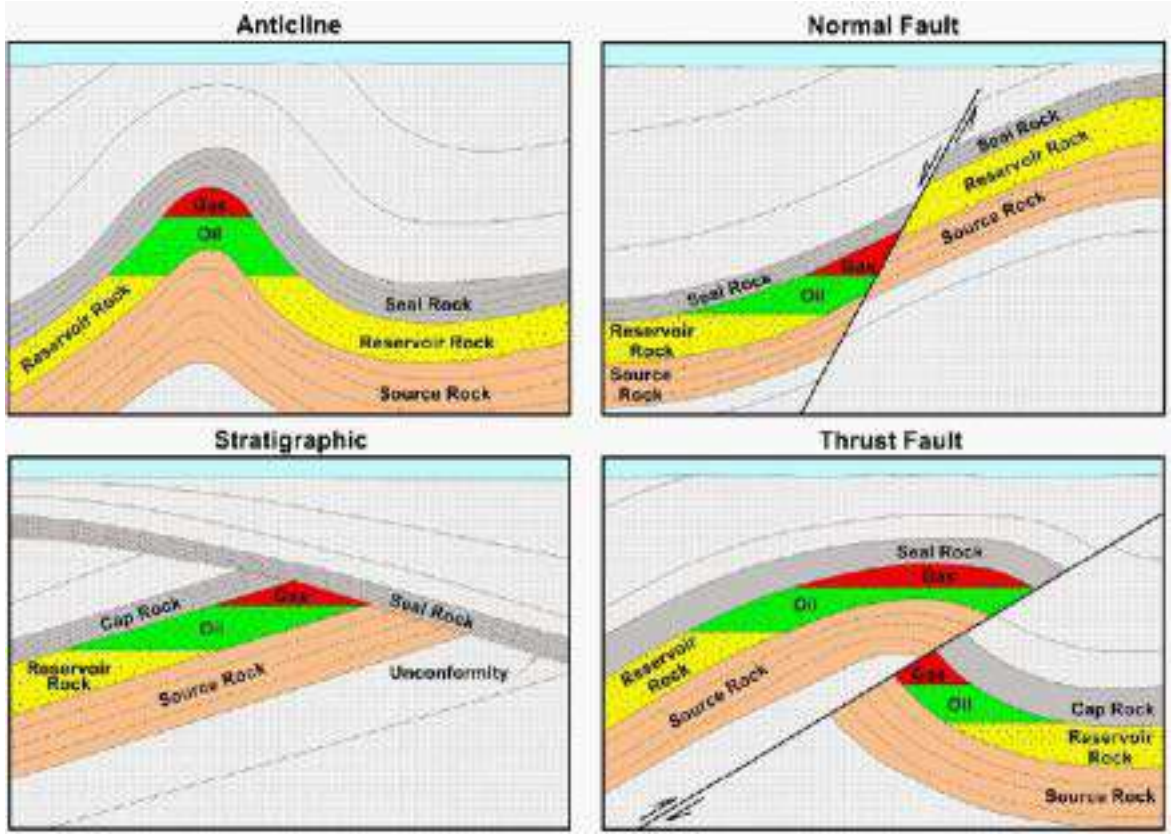


Photo: Ian West (https://wessexcoastgeology.soton.ac.uk/index.htm)

Trap

- Oil & gas less dense than water
- Structure required to retain/capture the hydrocarbons



GeologyIn (https://www.geologyin.com)

Photo: Ian Patterson (https://www.geography.org.uk)

Photo: Ian West (https://wessexcoastgeology.soton.ac.uk/index.htm)

Well Data

- Cuttings
- Core Data
- Logging Data

Cuttings at the rig site

Photo: Geodata & Drilling (www.geodatadrilling.com)

Photo: Geolotec (www.geolotec.com)

Geologist: *Is a person that studies geology*

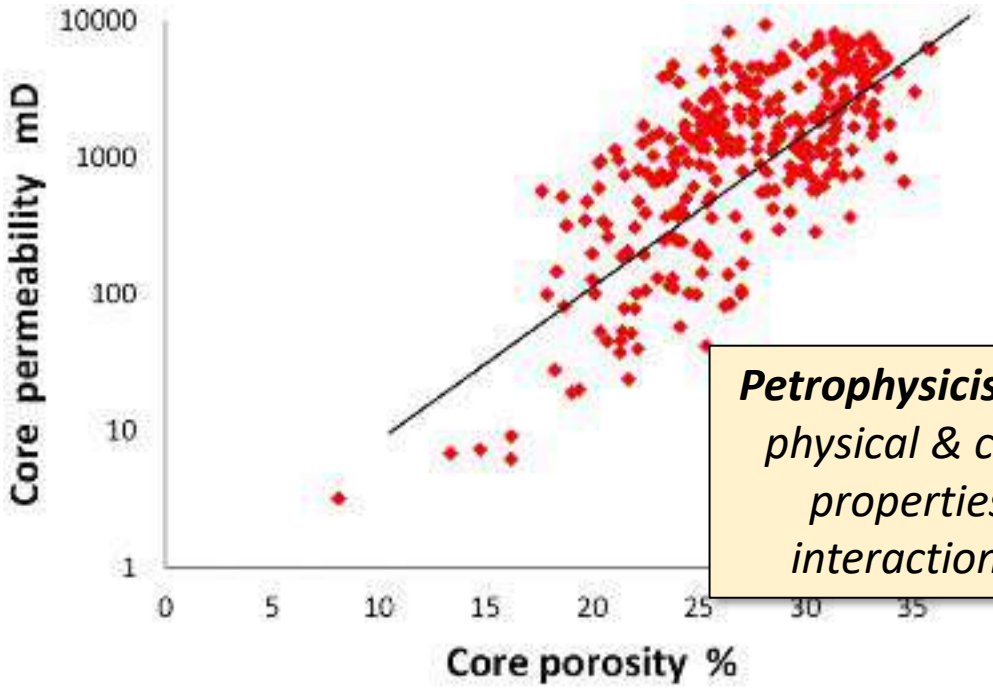
Core

Photo: West Michigan University

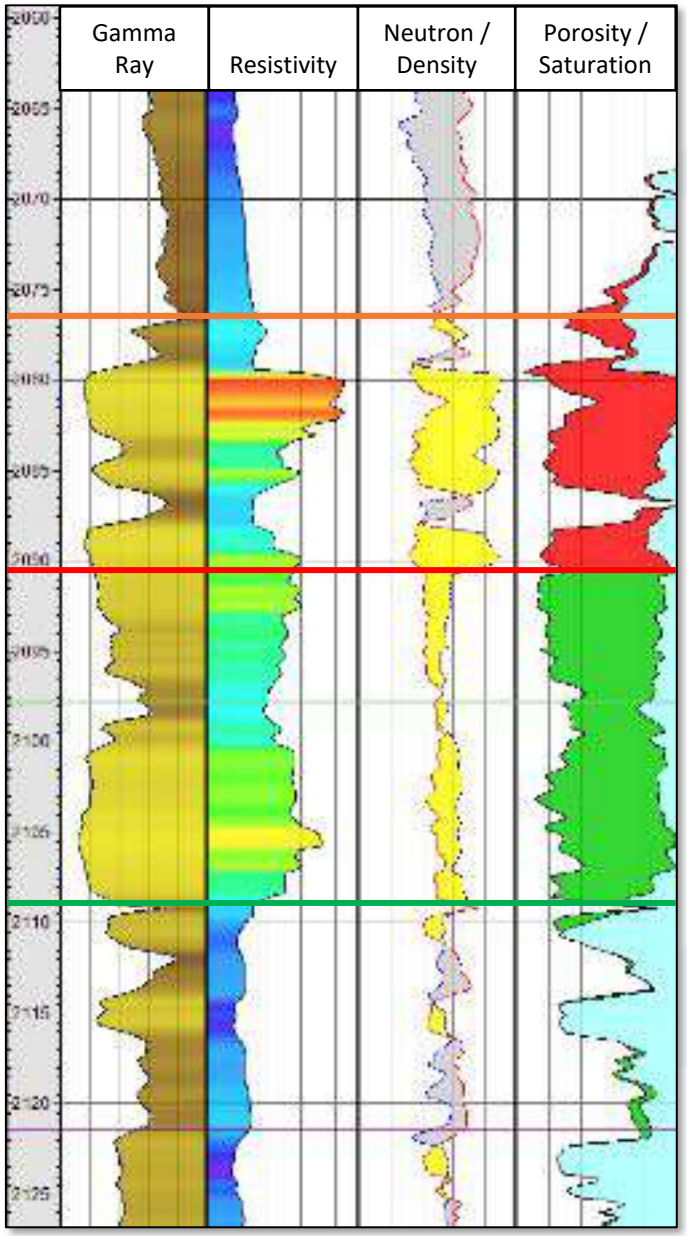
Logging Tools

Interpretation of Well Data

- **Petrophysicist analyses the acquired log data**
- **Core data integrated with log interpretation**
- **Results of well data analysis tell us:**
  - Depth of reservoir
  - Porosity
  - Saturation (ratio of hydrocarbons to water)
  - Reservoir thickness (gross & net)
  - Hydrocarbon type

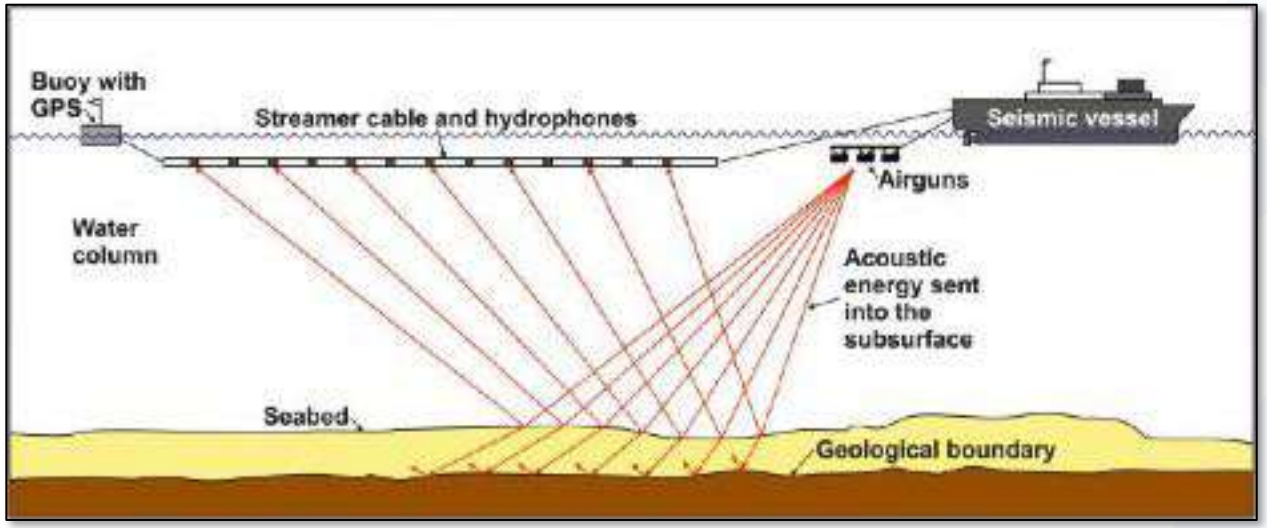


Petrophysicist: *Studies the physical & chemical rock properties and their interaction with fluids*

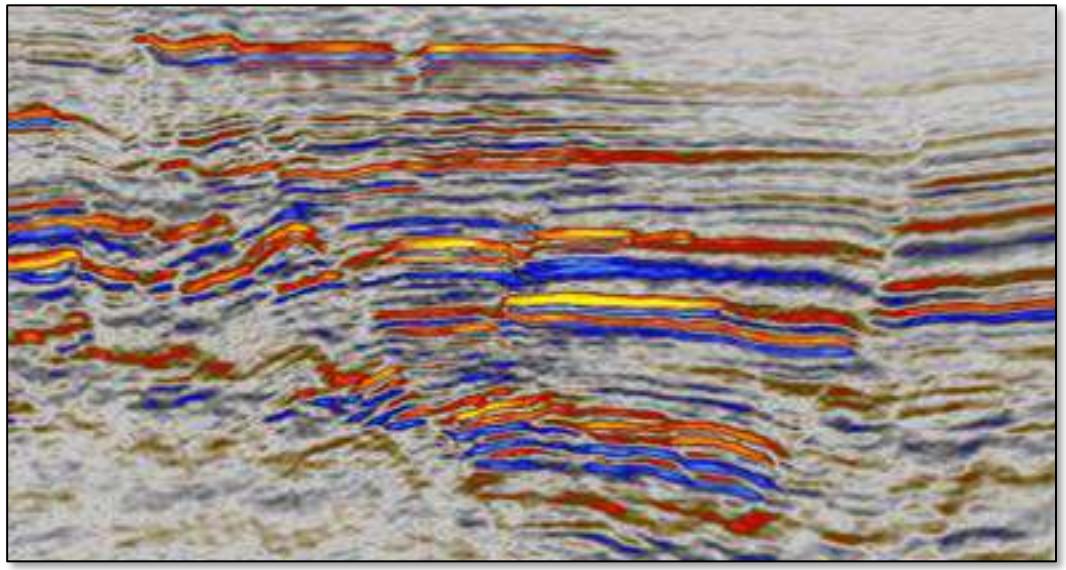


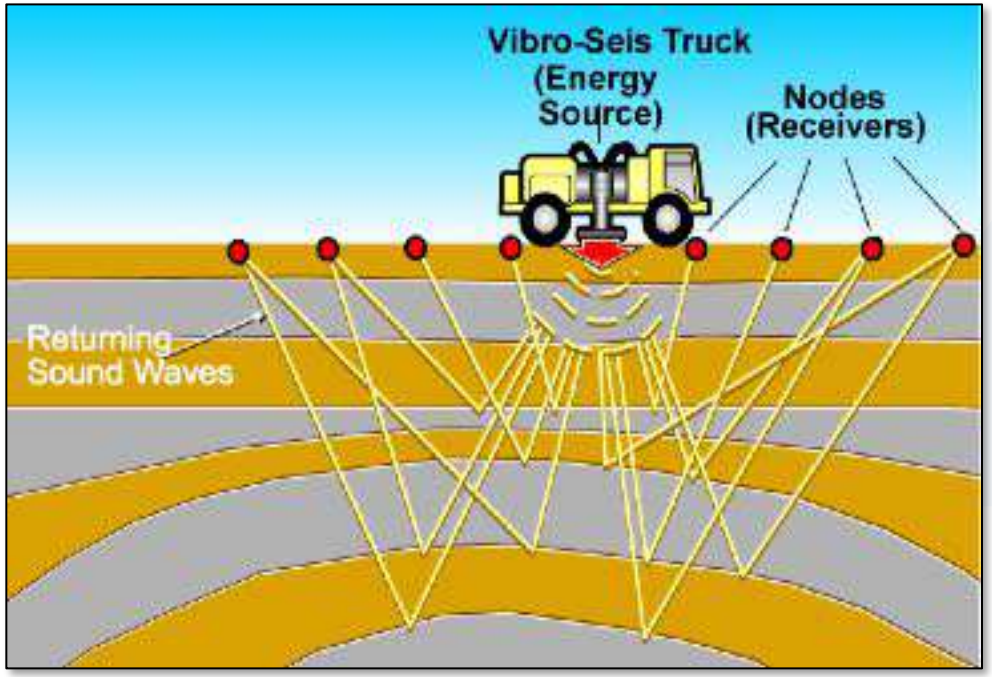
Seismic Data

- **Technique uses sound energy:**
  - Sound energy is transmitted into the earth with energy reflected back off rock layers
- **Seismic surveys can be undertaken onshore & offshore**
- **Extensive data processing undertaken to produce an image of the subsurface / rock layering**
- **Surveys undertaken as 2D profiles or 3D volumes**



Cox, D., et. al., 2020





GeoSiam (https://www.geosiamservices.com)

Seismic Surveys

- Seismic surveys undertaken onshore and offshore

Onshore: Vibroseis Truck

Offshore: Seismic Vessel

Onshore: Urban Acquisition

Signall Hill Petroleum

Seismic Interpretation

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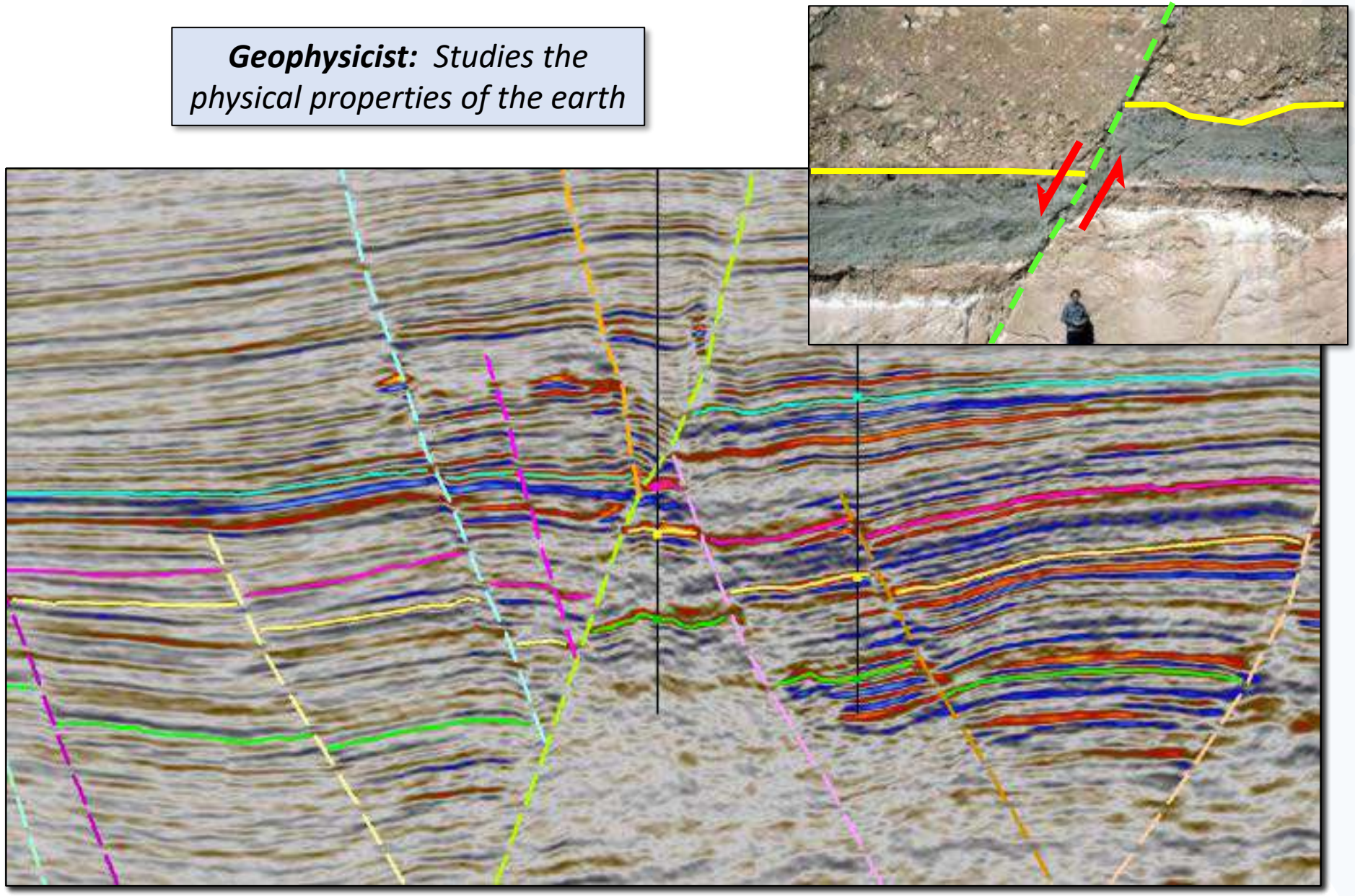
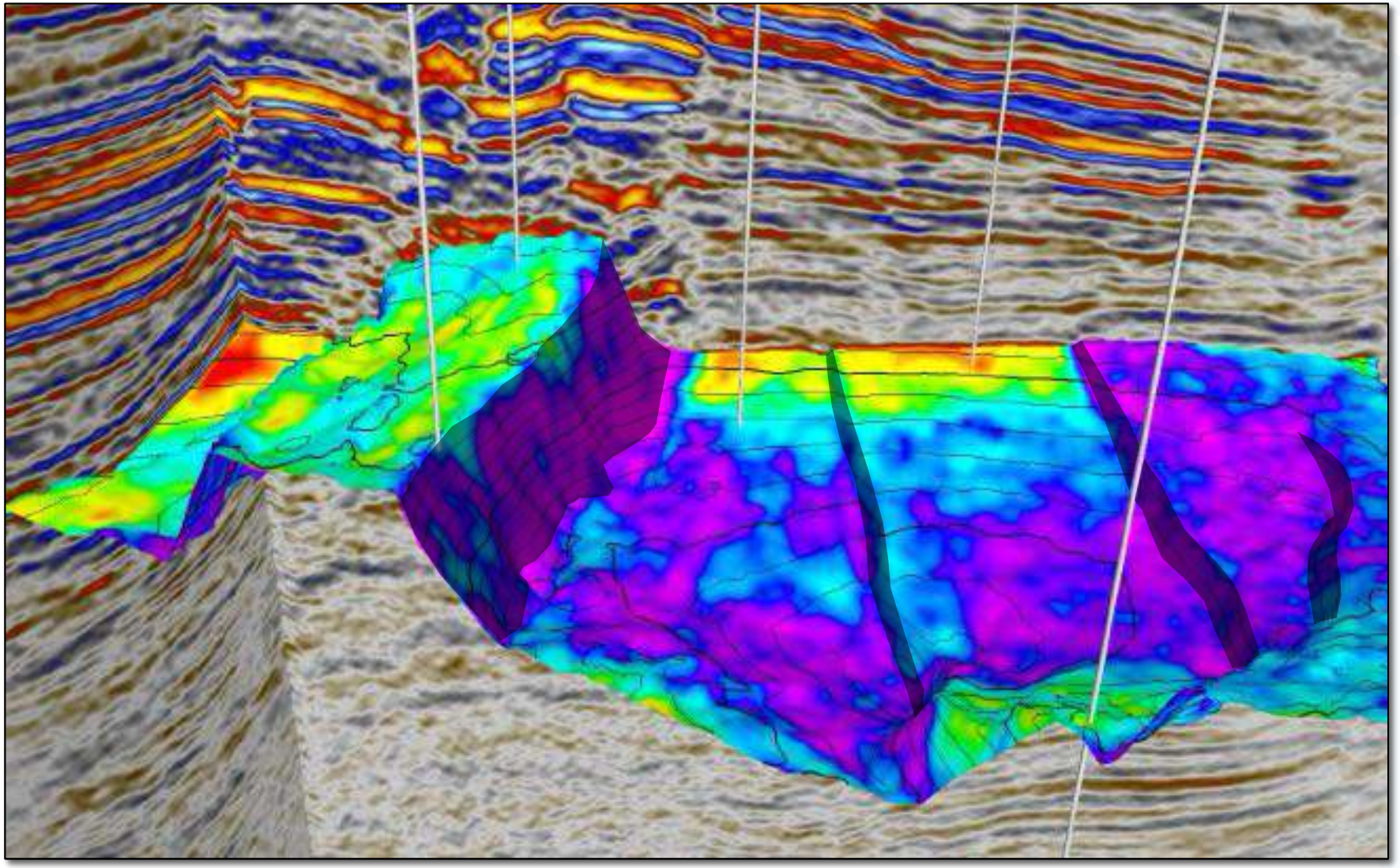
- **Well data guides interpretation (well-to-seismic tie)**
- **Interpret faults**
- **Interpret horizons**
  - Representing rock layer boundaries

Geophysicist: *Studies the physical properties of the earth*



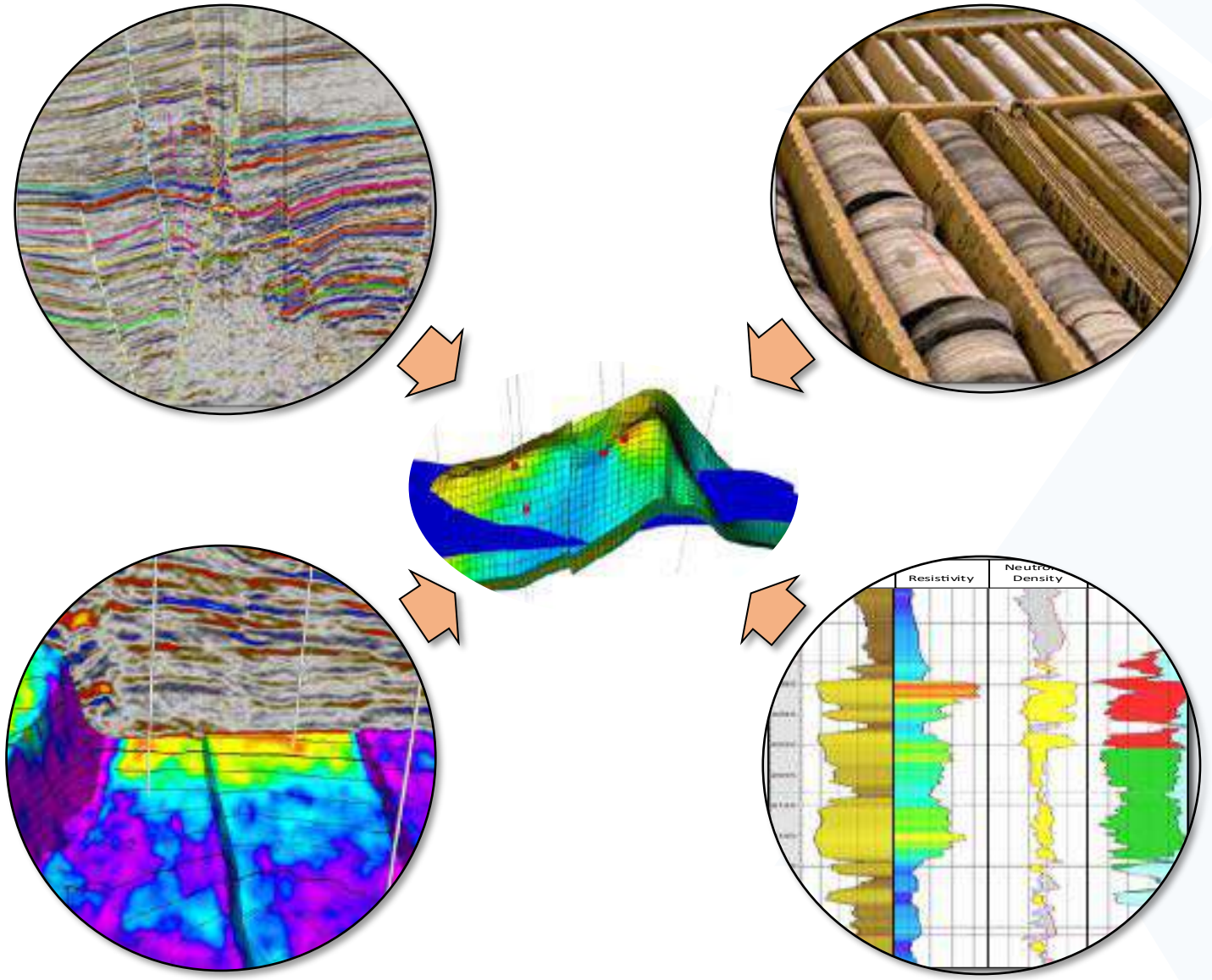
Seismic Interpretation

- **Make a structure map**
- **Project seismic attributes onto map**
- **Sound waves can be impacted by the fluid fill in the reservoir rock**
  - DHI (Direct Hydrocarbon Indicator)

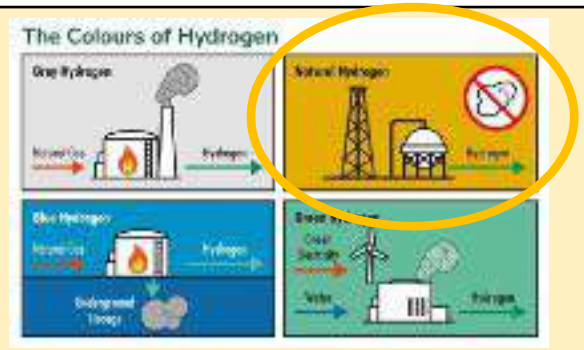


Petroleum System Evaluation

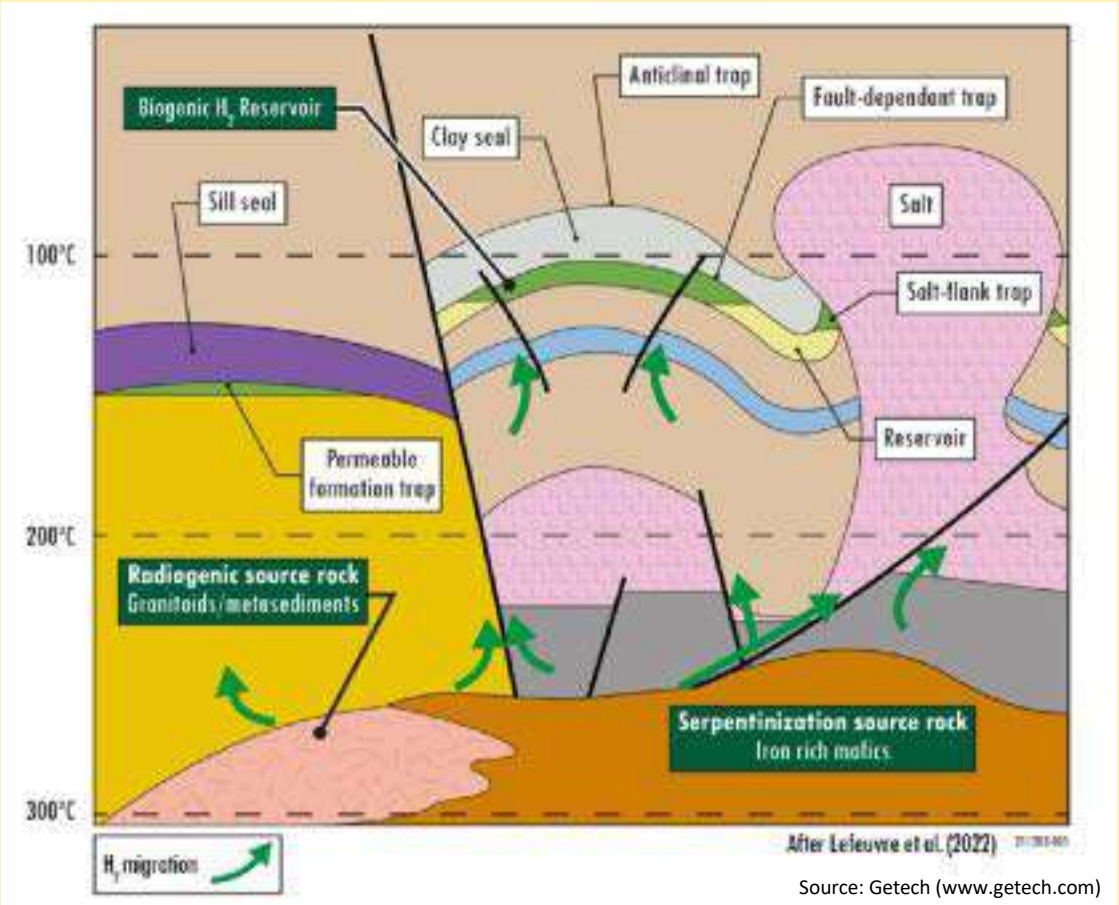
- **Integrate all geological & geophysical data and interpretations**
  - Petroleum system evaluated
- **Results in a subsurface model - Used for:**
  - Prospect size & risk
  - Field development
  - Well locations



Geoscience in the Energy Transition

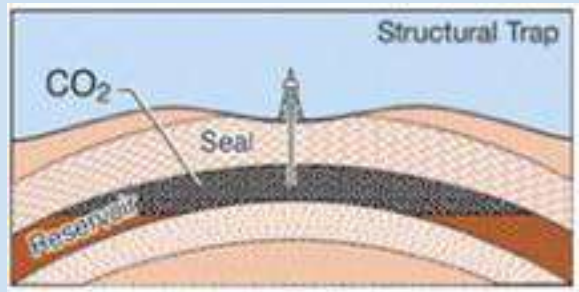


- **Natural Hydrogen / Gold Hydrogen**
  - Analogous to the petroleum system

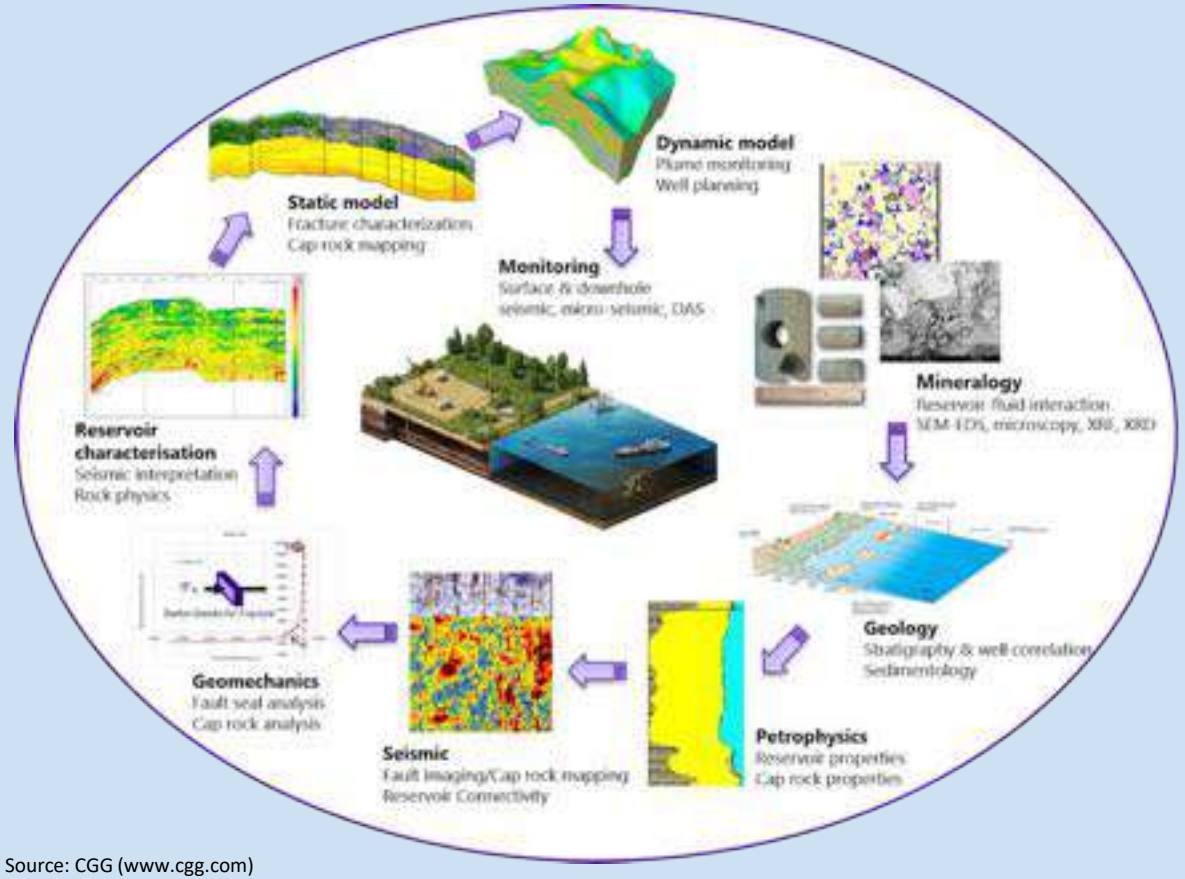


Source: Getech (www.getech.com)

- **CCS (Carbon Capture & Storage)**
  - Same geological & geophysical data, and interpretation & modelling techniques to the petroleum system evaluation



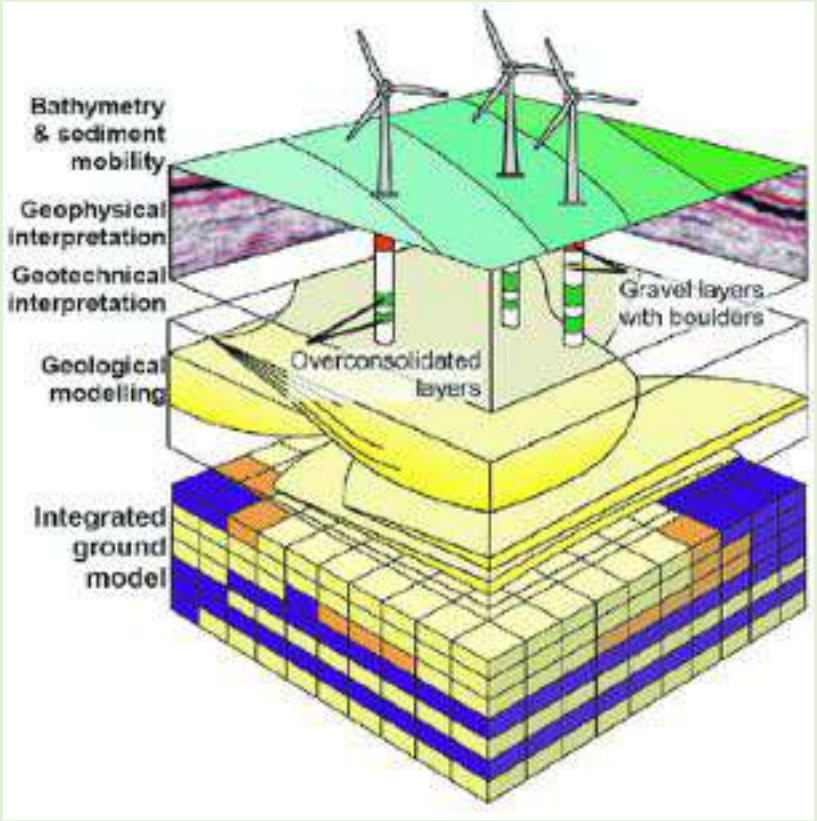
Source: National Energy Technology Laboratory (https://netl.doe.gov/)



Source: CGG (www.cgg.com)

Geoscience in the Energy Transition

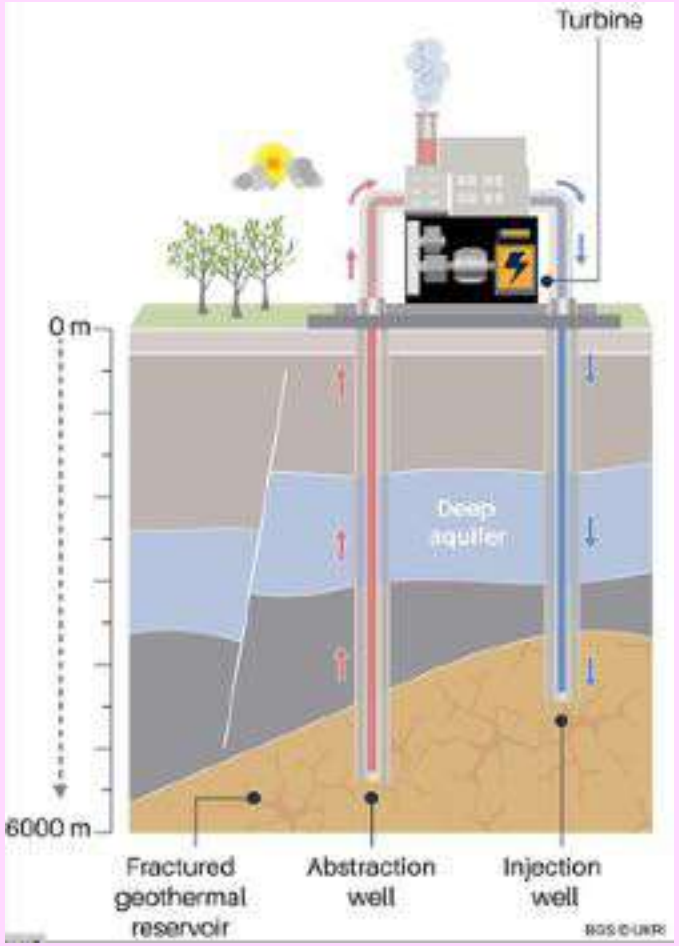
- **Wind Energy**
  - Same data types, interpretation methods as used to evaluate the petroleum system
  - Applied at a different scale and for a different purpose



Velenturf et al., 2021 (Geoscience Solutions for Sustainable Offshore Wind Development. Earth Sci. Syst. Soc. 1:10042

- **Geothermal Energy**
  - Understanding the geology key to the success of geothermal projects

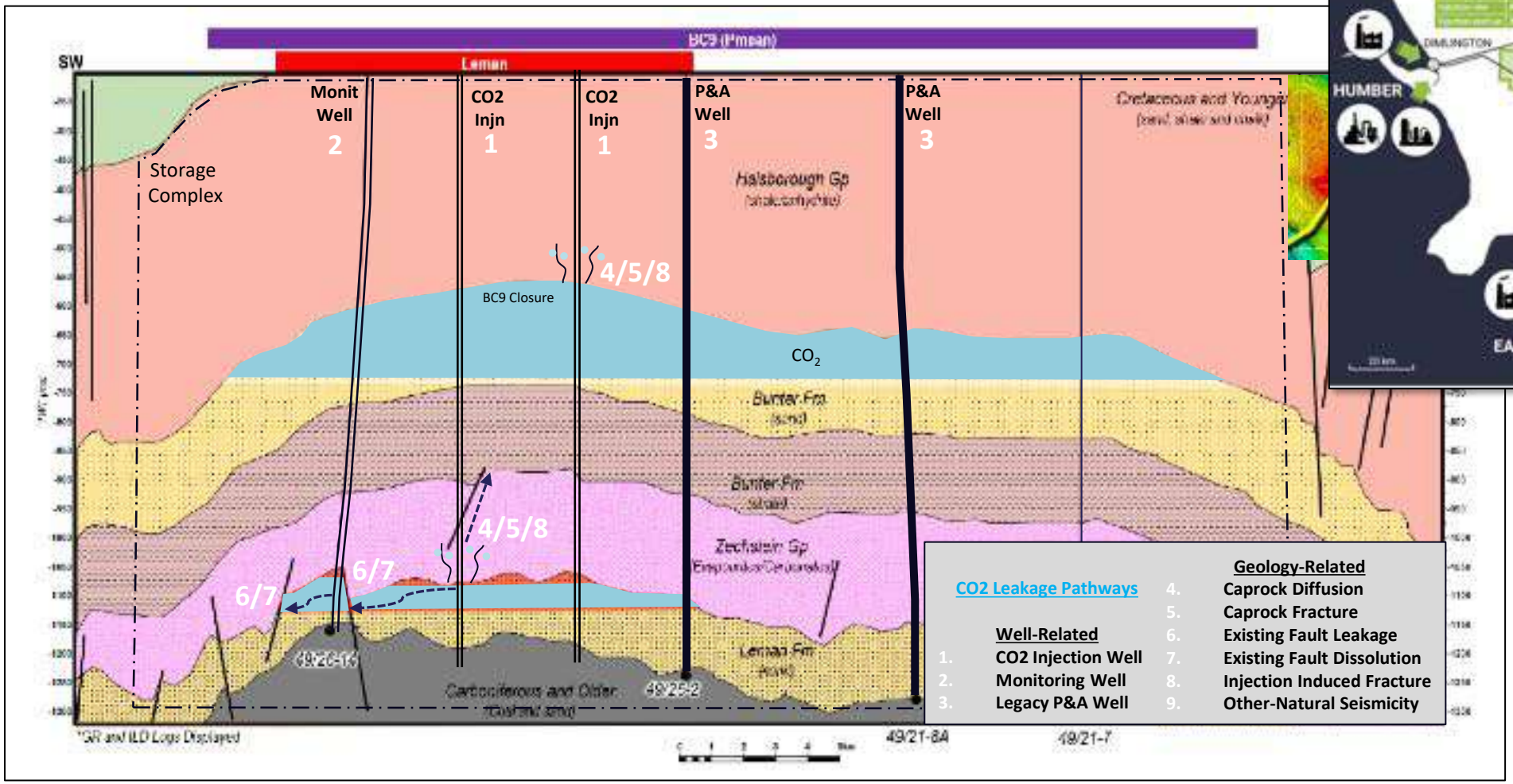
Photo: Geograph (www.geography.org.uk)

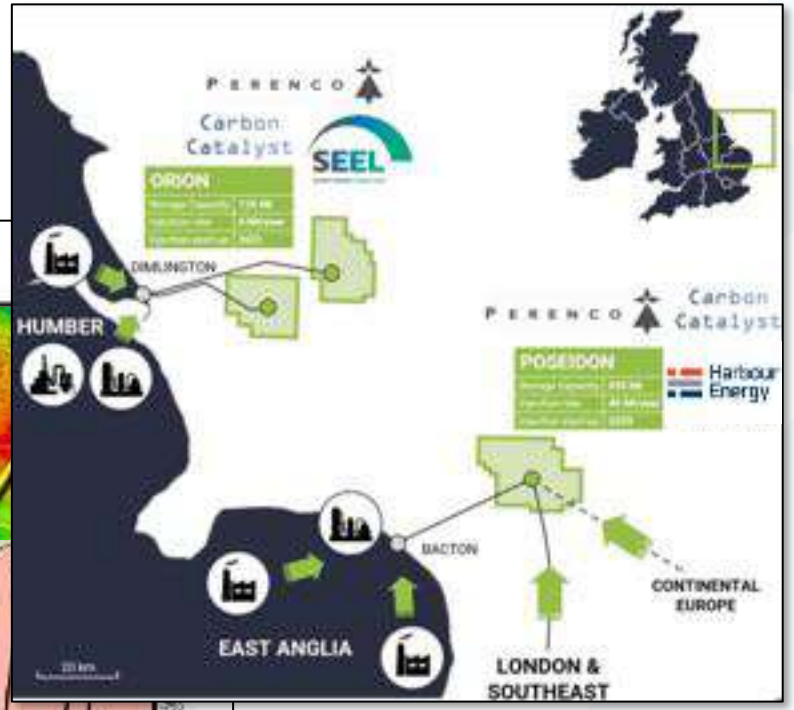


Source: BGS (www.bgs.ac.uk)

CCS – The Poseidon Project

- Carbon Storage project in Leman gas field
- Potential to store ~1000Mt of CO2
- First C02 injection test successfully took place between February and April this year





- **Reservoir rock**
  - Leman Fm Sandstone
- **Structure**
  - 4-way dip closure
- **Seal / Cap rock**
  - Zechstein Gp Evapourites

Major Challenge – CO2 Leakage

Geoscience for CO2 Monitoring – The Poseidon Project

PERENCO

First application with optic fibre

NEW!

VSP

Purpose
To image and monitor CO2 plume as it moves out of the injector well through the reservoir

Data
Detailed 3D seismic image close to the injector well

200-300m radius

First application

NEW!

Spot Seismic

Purpose
Monitor CO2 plume at spot locations further from the injector well (beyond the range of the VSP)

12 selected spots away from the injector well – modelling used to define placement

Change in seismic response over repeat surveys is a response to the CO2 plume movement

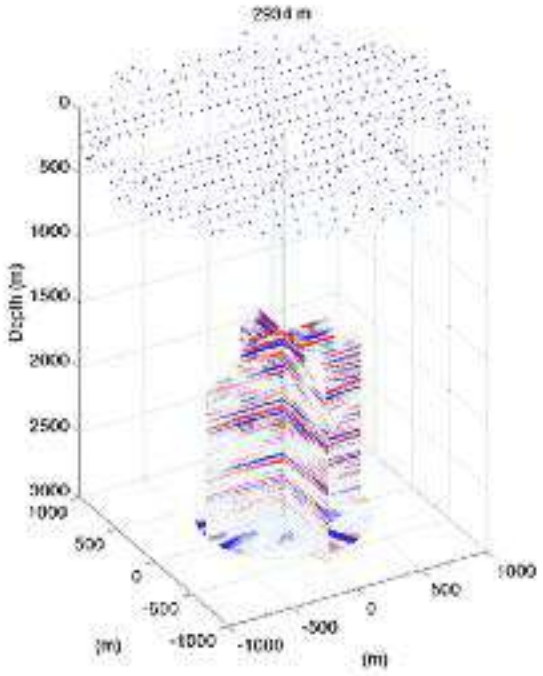
First application with optic fibre

NEW!

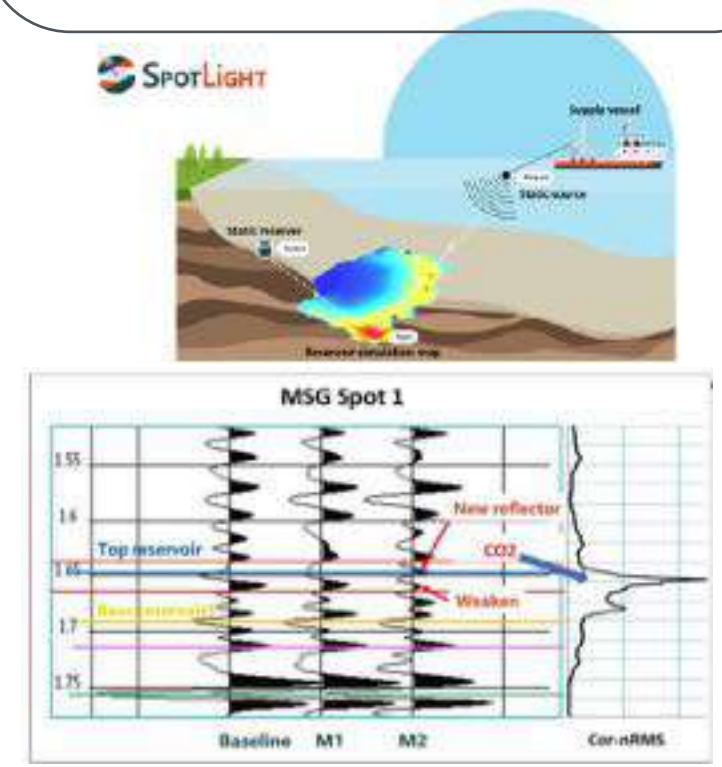
Passive Seismic

Purpose
To record micro-seismic events during and between injection

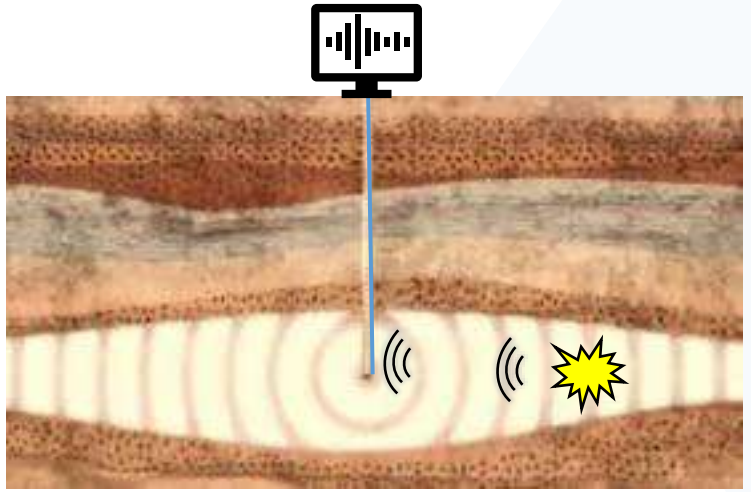
Micro-seismic event can be caused by fracturing of the reservoir during CO2 injection



Courtesy of Silixa (www.silixa.com)



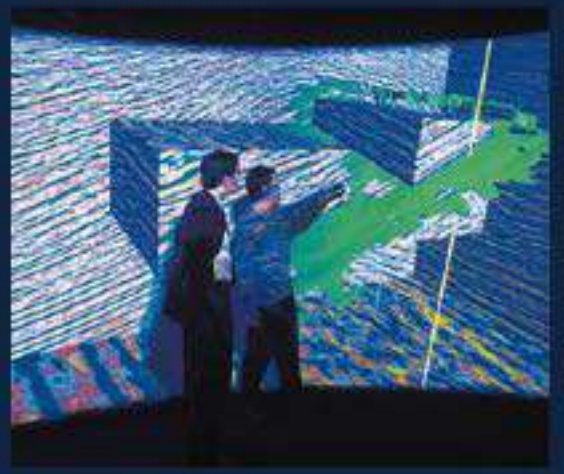
Courtesy of Spotlight (www.spotlight-earth.com)



Geologist

What my friends think I do

What society thinks I do



What my boss thinks I do

What my spouse thinks I do

What I think I do

What I actually do