

GEUS services at Field Scale

Relevant for Oil and Gas activities

Compiled by Niels H. Schovsbo

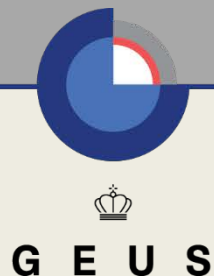
GEOLOGICAL SURVEY OF DENMARK AND GREENLAND
DANISH MINISTRY OF ENERGY, UTILITIES AND CLIMATE



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Relevant for Oil and Gas activities

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GEUS services

Relevant for Oil and Gas activities

Compiled by
Senior Researcher Niels H. Schovsbo, ph.d.

Geological Survey of Denmark and Greenland
Danish Ministry of Energy, Utilities and Climate

Services at GEUS - a selection

- Laboratory for organic geochemistry and petrology
- Core analysis laboratory
- Petrophysical evaluation
- Seismic equipment and processing expertise
- Reservoir modelling and flow simulation
- Diagenesis and provenance
- Biostratigraphy
- Core descriptions
- Fieldtrip and training

EAGE 2018 Copenhagen GEUS training and scientific engagement

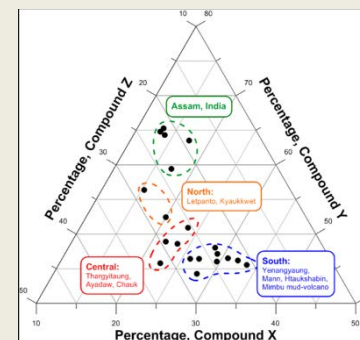
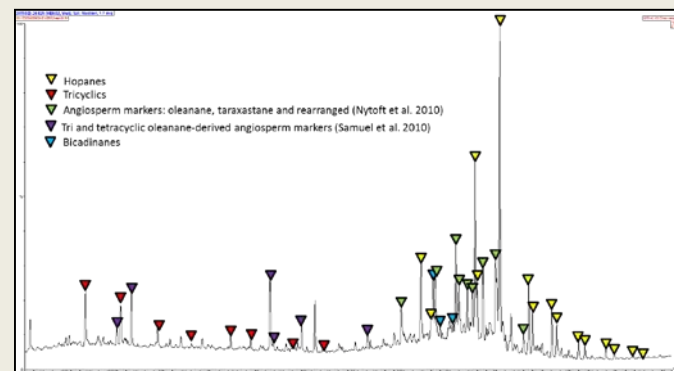
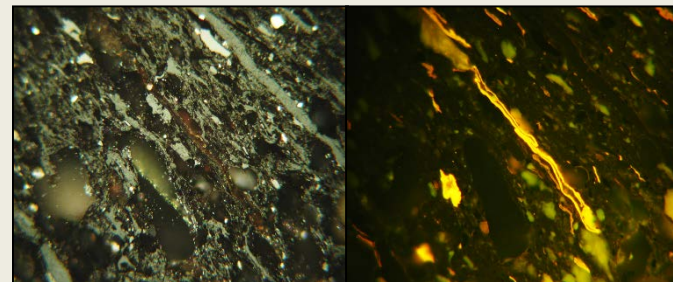
Services at GEUS – contacts

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- Biostratigraphy (Dybkjær, Karen kd@geus.dk)
- Core descriptions (Ineson, Jon R. ji@geus.dk)
- Fieldtrip and training (Frykman, Peter pfr@geus.dk; Skovbjerg, Erik esr@geus.dk)

GEUS regional studies and data (Skaarup, Nina nsk@geus.dk)

Laboratory for Organic Geochemistry and Petrology

- Organic Petrology (microscopy):
 - Maceral composition of coals and dispersed organic matter
 - Vitrinite reflectance analysis of coals and dispersed organic matter
- Organic Geochemistry:
 - Comprehensive analysis of coals, oils, and petroleum source rocks
 - Total Carbon, Total Sulfur, Total Organic Carbon and Rock-Eval type pyrolysis (HAWK) analysis
 - Solvent extraction, and group type fractionation
 - Biological marker analysis by GC, GC-MS and tandem GC-MSMS
 - Special competences within isolation and identification of unknown biological marker compounds and synthesis of biological marker standards



Core Analysis Laboratory

Flooding experiments at reservoir conditions,
Pressure up to 690 bar, temperature up to
150 degC

Applications: water-flooding evaluation, EOR,
geochemical reactions

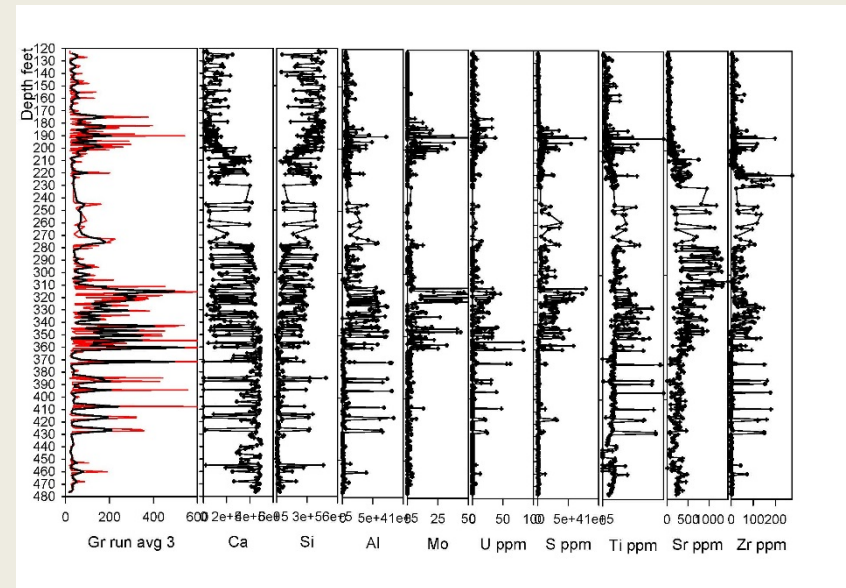
- Determination of capillary pressure.
- Determination of electrical properties.
- Determination of Archie parameters (m , n)
- Cap rock experiments: Gas storage, CO₂ storage,



Full Core Rig for samples with
diameter up to 12.3 cm

Hand-Held XRF characterisation

- Hand held Niton™ XI3t Gold+ XRF device (HHXRF). Provides semi-quantitative element concentrations of up to 42 elements. Measuring time 150 seconds



Example of HH-XRF data recorded in a well

Petrophysics

- Generation of CPI logs: Log interpretation, V_{shale} , porosity and saturation estimates
- Log facies analysis.
- Permeability models based on core porosity-permeability relations.

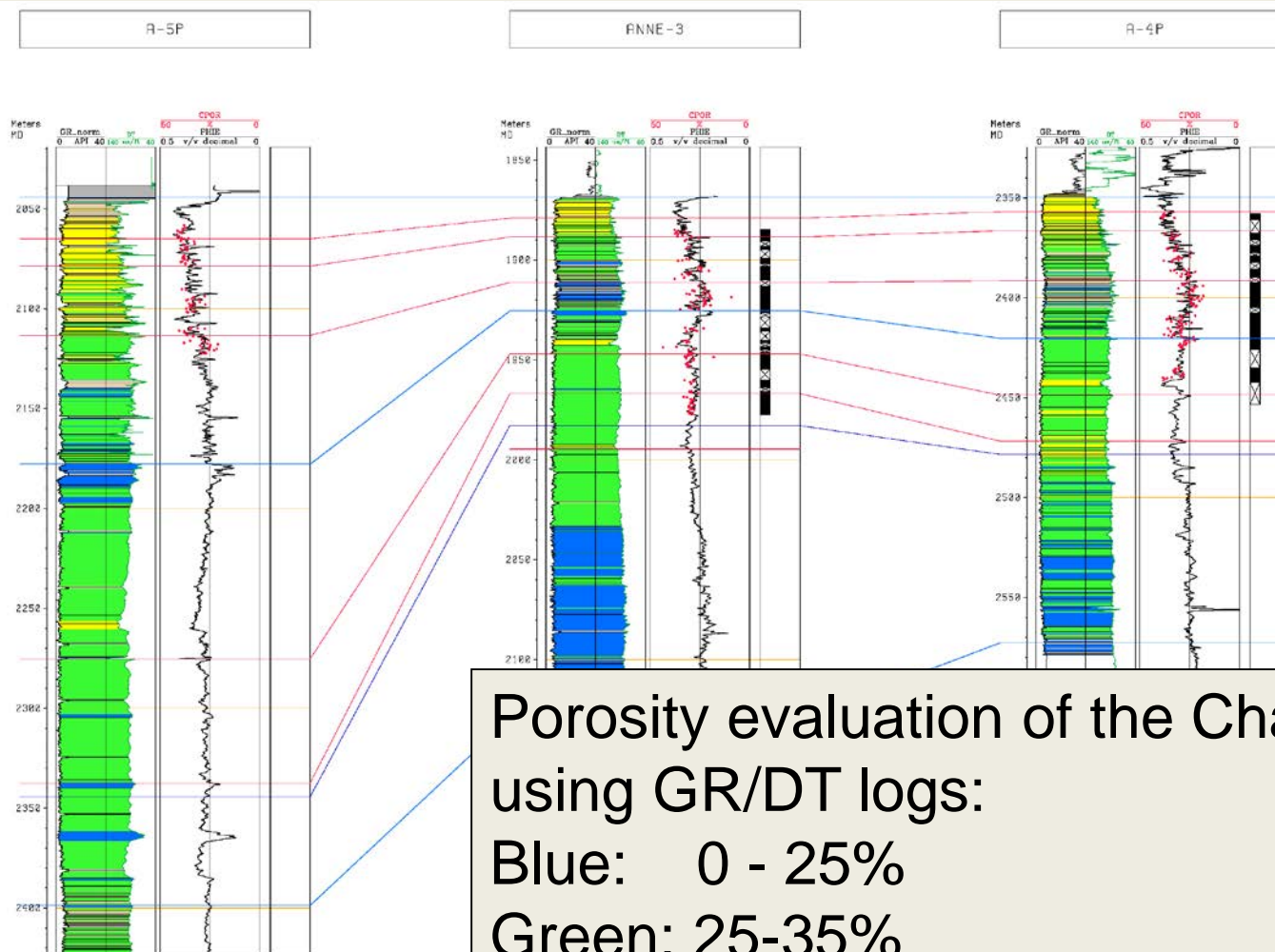
Applications:

- Log correlation (well-to-well correlations).
- Reservoir subdivision based on log data, i.e. reservoir zonation. Calculation of zonal averages (wrt. thicknesses, porosities, and hydrocarbon saturations).
- Reservoir property maps

Log analysis software:

- StratWorks & PetroWorks, DecisionSpace, Techlog, Petrel

Log correlation (Kraka Field wells) and GR/DT-log Facies along with traditional porosity interpretation



Porosity evaluation of the Chalk Group using GR/DT logs:
Blue: 0 - 25%
Green: 25-35%
Yellow: >35%

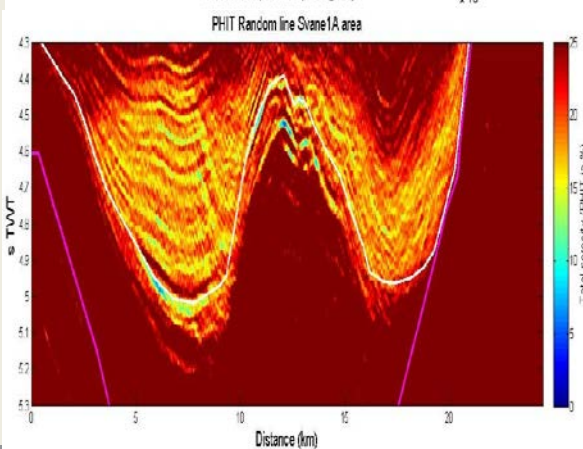
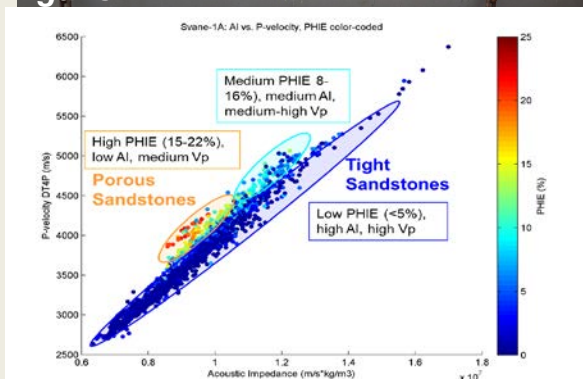
Seismic equipment and processing expertise

Equipment for seismic data acquisition:

Flexible system. Can be used in ice-covered operations. Applicable for shallow seismic studies (even 3D seismics), normal reflection seismic work and deep crustal studies.

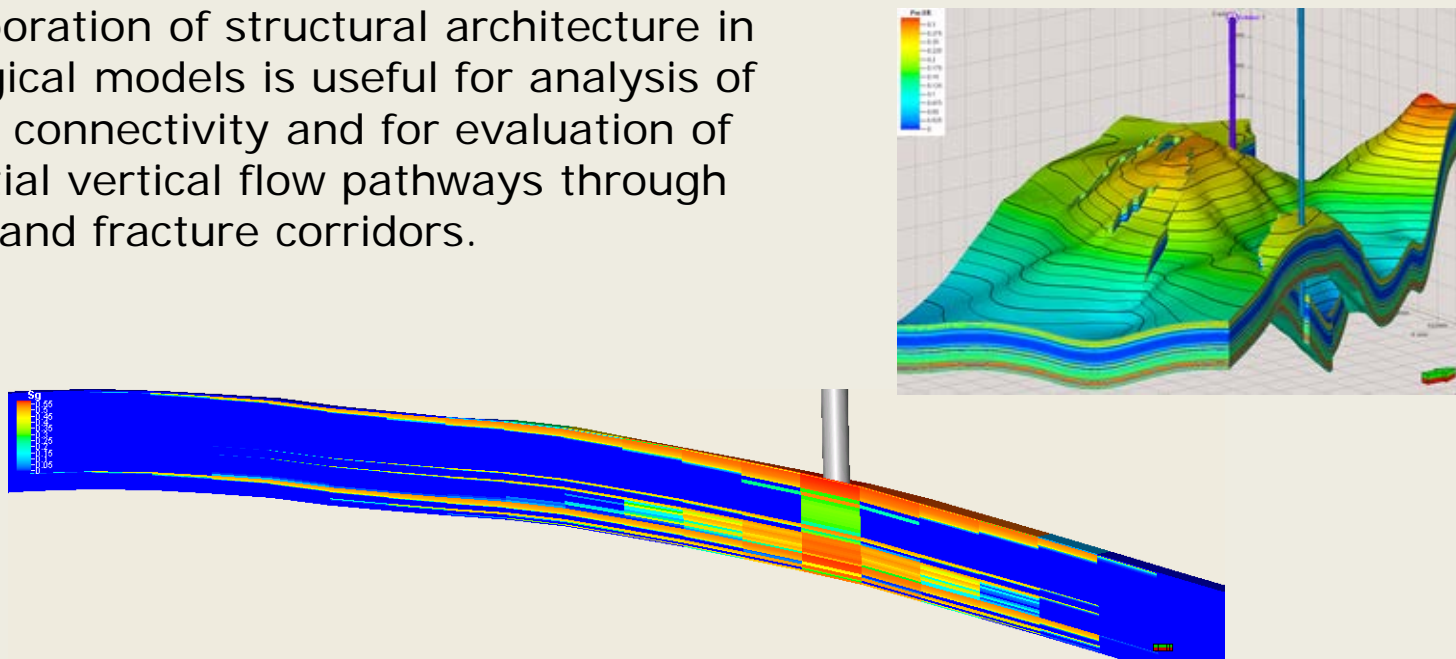
Processing expertise:

- Post-Stack spectral whitening to improve seismic vertical resolution by whitening the frequency
- Inversion of seismic data into acoustic impedance and porosity.
- AVO – inversion
- Forward Modelling



Reservoir modelling and flow simulation

- Incorporation of structural architecture in geological models is useful for analysis of lateral connectivity and for evaluation of potential vertical flow pathways through faults and fracture corridors.



- Vertical section in the reservoir model through the injection well showing CO₂ saturation (free gas-phase supercritical CO₂) after 10 years injection. Although the model is constructed in a fairly coarse grid, the intra-reservoir sealing layers are clearly reflected in the grid and influence the spatial distribution of the injected CO₂.
- Modelling assignments: Oil & Gas, CO₂ geological storage, geothermal energy production and subsurface heat storage.

Diagenesis

Understanding the effect of mineralogical changes on porosity and permeability of reservoir sandstones

Oil / gas related:

Diagenesis studies based on cores and cuttings samples

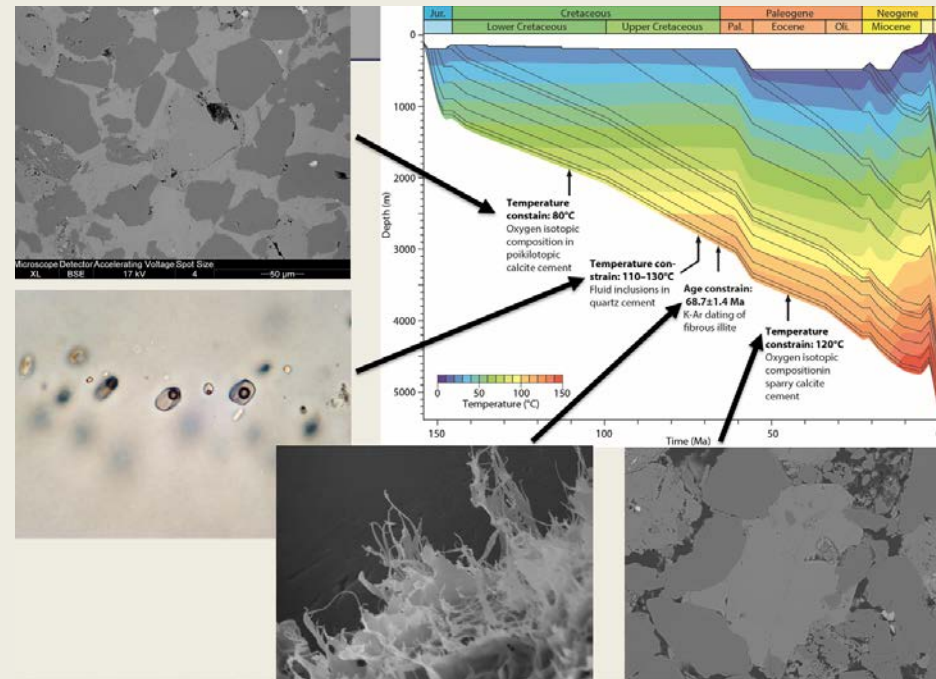
Diagenesis on well and field scale

Multi-disciplinary studies

Mineral quantification by traditional point counting and SEM
Mineralscan

Burial temperature measurement from fluid inclusion analysis of quartz cement

Laboratory experiments with rock water interaction at elevated temperatures



Examples of recent projects

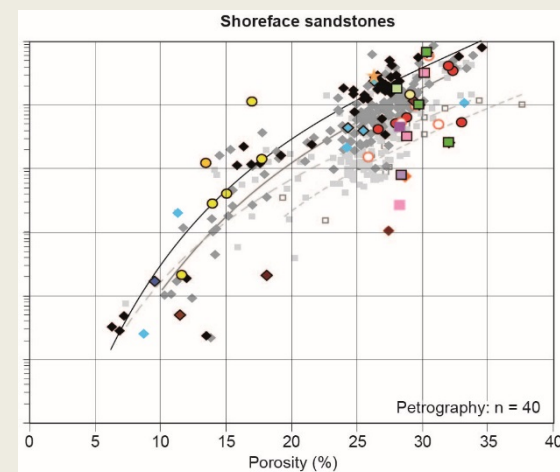
1. Diagenesis of Upper Jurassic sandstones, Danish Central Graben



2. Laboratory experiment imitating the effect of CO₂ storage on Triassic and Jurassic sandstones, onshore Denmark



3. Diagenesis of geothermal reservoir sandstones of Triassic and Jurassic age, onshore Denmark



4. Analogue studies to the Rosebank discovery: Siliciclastic sandstones interbedded in volcanic rocks, East Greenland



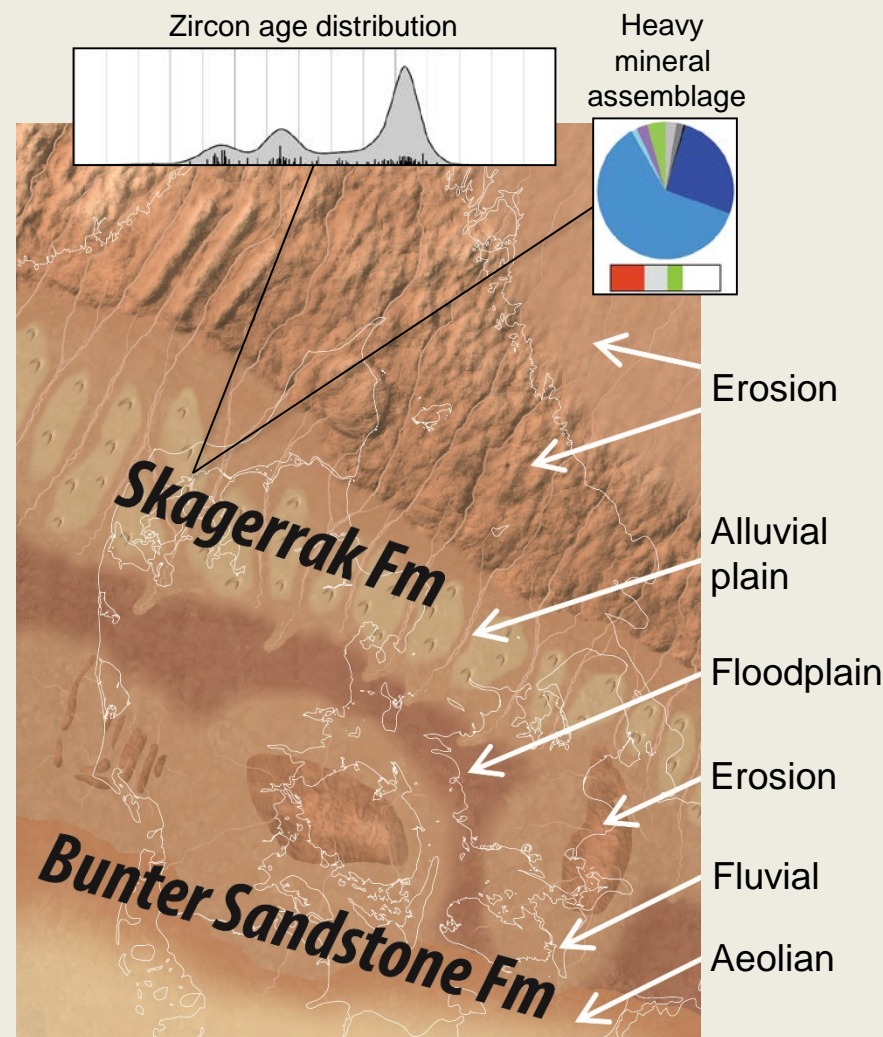
Provenance

Applications

- Determine sediment source areas and transport pathways including possible reworking
- Make paleogeographical reconstructions and estimate the reservoir distribution and architecture
- Identify variations in mineralogical maturity and thereby also in diagenesis and reservoir quality

Methods

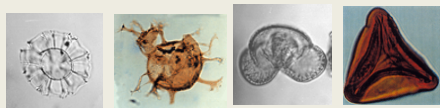
- U/Pb age dating by LA-ICP-MS of heavy mineral grains such as zircon, rutile, titanite, monazite, xenotime
- Heavy mineral chemistry by Mineralscan (EDS/SEM) of the entire heavy mineral assemblage
- Trace element composition in both light and heavy minerals



Biostratigraphy

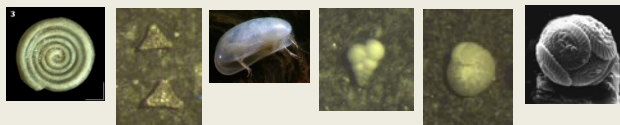
- Dating rocks using fossil assemblages

Palynology



Karen Dybkjær, Sofie Lindström,
Henrik Nøhr-Hansen, Kasia Sliwiska

Microfossils & Nannofossils



Emma Sheldon

Ammonites



Peter Alsen

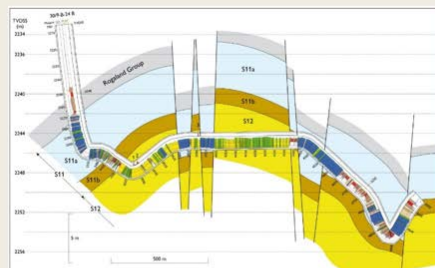
Bivalves



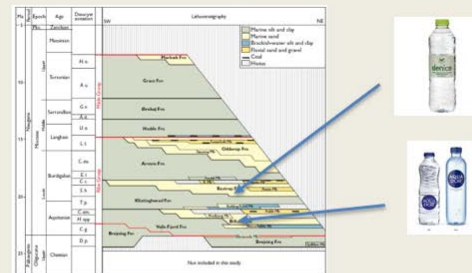
Bodil Lauridsen

Examples of recent projects

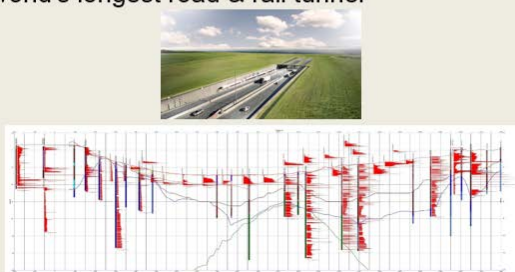
1) Reservoir stratigraphy and architecture



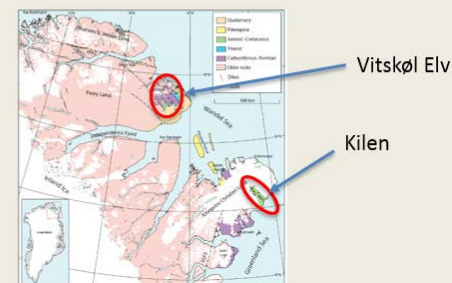
2) Onshore Denmark lithostratigraphy / biostratigraphy, mapping of Miocene aquifers



3) Biostratigraphic study of lithologies under the Femern Bælt in preparation for building the world's longest road & rail tunnel



4) North-east Greenland mapping, basin correlation with Canada & Svalbard



Core description - siliciclastic and carbonate

Experienced sedimentologists
(North Sea, Greenland, DK)

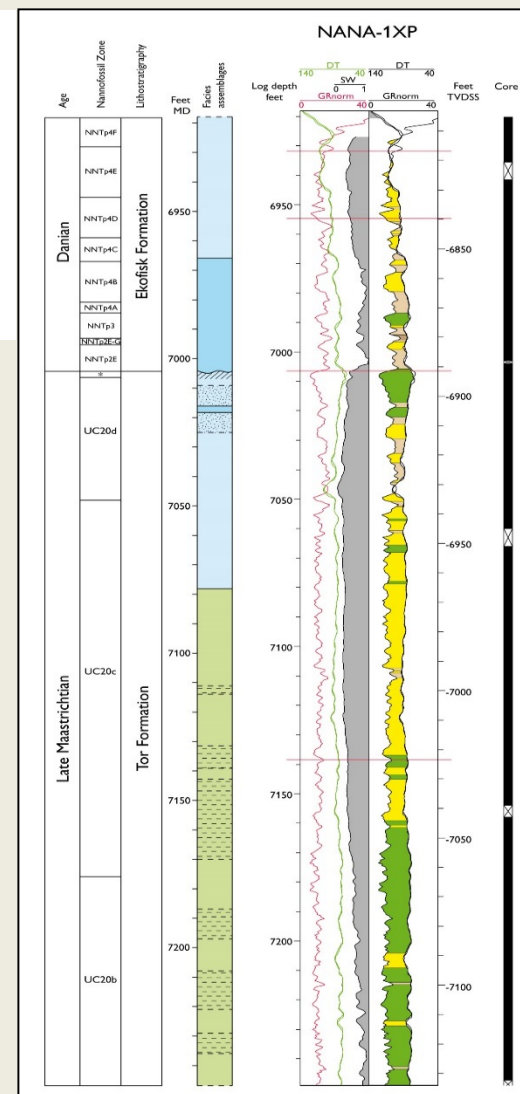
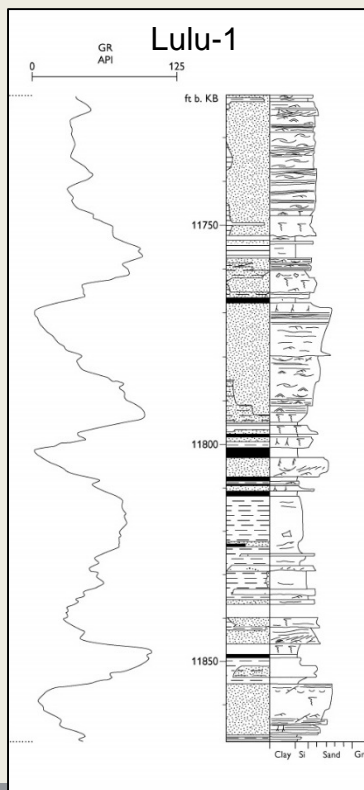
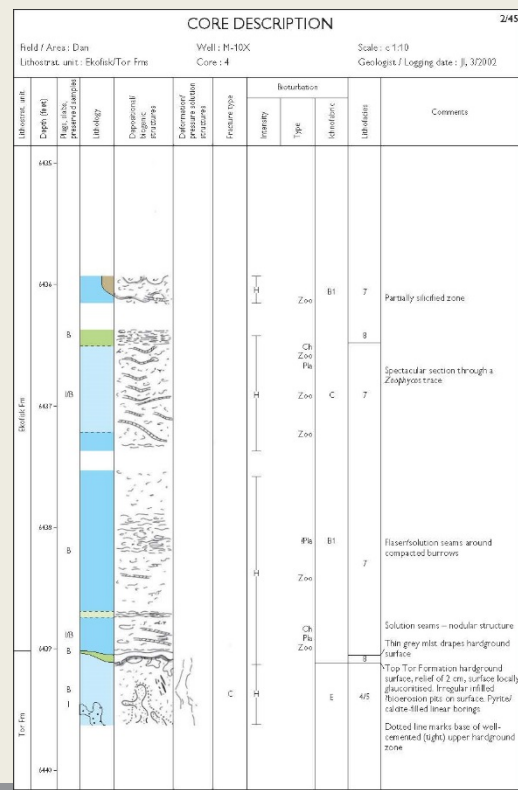
Complementary outcrop–core
perspective:

- All siliciclastic environments
(fluvial – deep marine)
- Marine carbonates,
particularly chalk



- Facies analysis, including ichnology, environmental interpretation
- Identification of key stratigraphic surfaces (SB, FS, MFS etc)
- Targeted in-house biostratigraphy (e.g. key surfaces, clasts/matrix)
- Links to wireline log data, petrophysics
- Integrated core/log/sequence stratigraphic studies
- Development of palaeogeographic models

Detailed sedimentological logs



**Simplified logs (facies assemblages)
linked to logs, saturations etc**

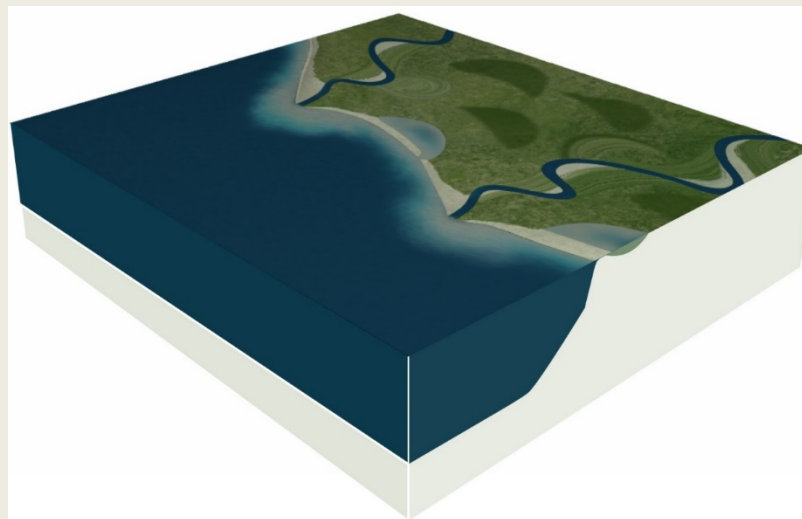
Field trip and training classes: Miocene fluvio-deltaic systems



Offshore transition



Offshore (source rock)



Fluvial channel



Spit shoreface

Palaeogeography ➡ Lithofacies model

Field trip and training classes: Cretaceous-Palaegene chalk

- Chalk as a reservoir material; depositional processes and lateral variations, diagenesis and compaction
- Field seminar illustrate chalk reservoir geology via studies of multi-scale data collection, geo-modelling with comparison to outcrop and drill core examples of carbonate facies types and fractures, and mapping of the relations between different reservoir relevant properties.



Two key localities:

- The Stevns Klint section with Upper Maastrichtian chalk, the K-T boundary profile and the lower Danian bryozoans mounds.
- The Etretat chalk cliffs in Normandy are close to seismic scale and illustrates important processes and geometric relations in a dynamic chalk system.



Field trip and training classes: Source Rocks / Unconventionals

Sedimentology

Source rock properties:

TOC preservation

Thermal maturity

Oil generation and
biomarker analysis for
oil typing

Laboratory techniques



Lower Palaeozoic shales in Skåne, Sweden

GEUS at EAGE 2018 in Copenhagen

Talks and posters	
Margrethe Thorup Nielsen	Preferred formation of porosity preserving microquartz in shoreface sandstones of the Upper Jurassic Danish Central Graben
Louise Ponsaing Lauridsen	Variations in source rock potential within the Upper Jurassic – lowermost Cretaceous in the Danish North Sea sector
Finn Mørk, Lars Kristensen, Finn Jakobsen, Claus Andersen	Porosity variations of the chalk in the Danish Central Graben
Kenneth Bredesen, Esben Dalgaard, Anders Mathiesen, Niels Balling	A rock physics feasibility study of the Geothermal Gassum reservoir, Copenhagen area, Denmark
Peter Johannesen, Karen Dybkjær, Finn Jakobsen, Lars Kristensen, Claus Andersen	The Jurassic development of the Danish Central Graben: High-resolution stratigraphy, palaeo-geography and prospectivity
Mette Olivarius, A Sundal, Ulrik Gregersen, Tonni Thomsen, Rikke Weibel, Lars Henrik Nielsen	Using petrography and provenance data to assess the CO ₂ trapping potential in sloping sandstones in the Skagerrak Strait
Mette Olivarius, R. Weibel, L. Kristensen, A. Mathiesen, H. Vosgerau, L.H. Nielsen	Geothermal reservoir quality of the Middle Jurassic Haldager Sand Formation in Denmark
Niels Schovsbo, Thomsen, E., Nytoft, P. Esbensen, K.	Oil maturity, families and oil-source rock correlations in the Danish North Sea based on biomarker studies
Core exhibitions and Workshops	
Exhibition of Jurassic cores	
Geomechanics / overburden workshop	
Excursions	
Erik Skovbjerg Rasmussen	Reservoir analogues
Jon Ineson	Miocene in Jylland, Denmark
Niels Schovsbo	Chalk at Stevns Klint, Denmark
	Lower Palaeozoic Shales in Skåne, Sweden

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Thank you for your attention

(Contact: Schovsbo, Niels nsc@geus.dk)