GEUS

Geological modelling in Denmark – An overview

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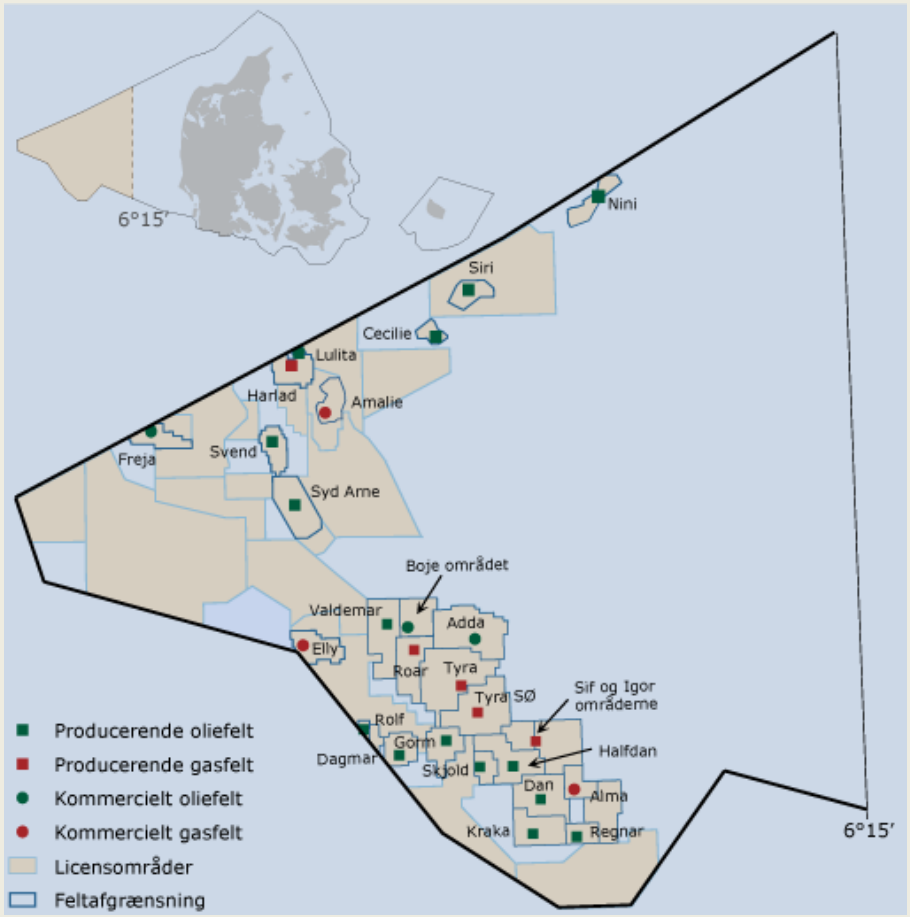
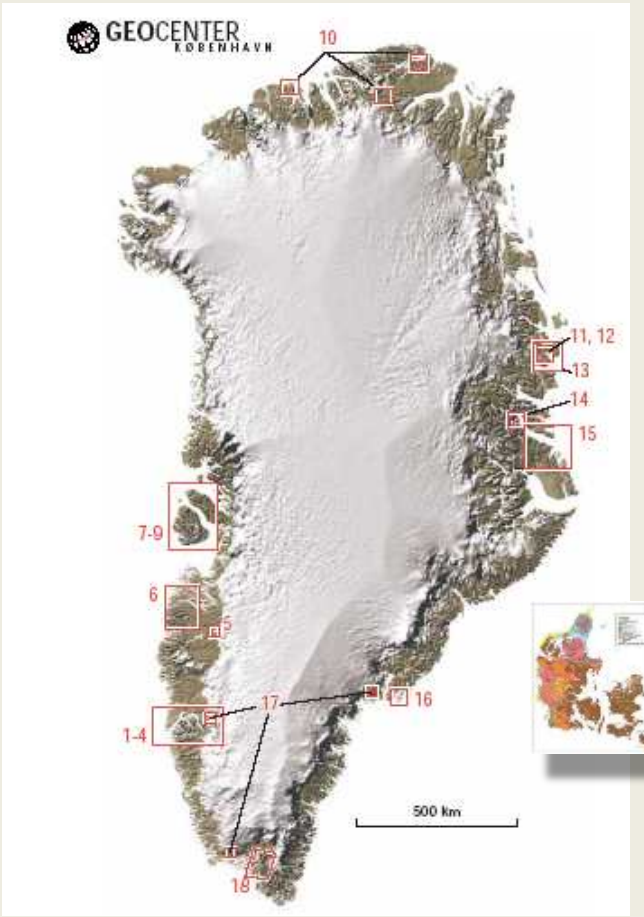
Geological Survey of Denmark and Greenland
Ministry of Climate and Energy

TNO Workshop on 3D geological modelling methodologies
Utrecht 17th-18th September 2013

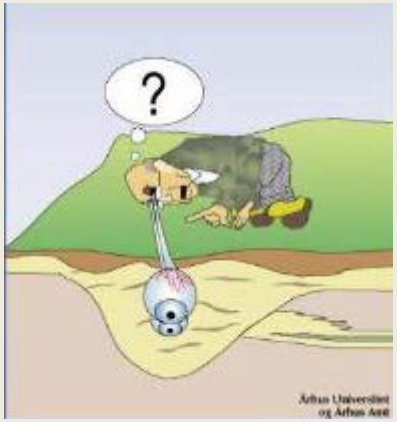
Geological Survey of Denmark and Greenland





Source: Danish Energy Agency

Which types of models/maps?



- Danish North Sea: Oil and gas related models/maps
  - Focusing at depth (>500 m)
  - Many models are not publicly available
- Greenland: Minerals exploration
  - 2D Maps
- Onshore Denmark: Groundwater
  - 2D maps
  - Groundwater related geological models 2D, 2½D and 3D
  - Catchment areas and areas with groundwater interests
- Onshore/offshore Denmark: Raw materials
  - 2D maps
  - Local models
- Research and other purposes
  - Maps
  - 2D, 2½D and 3D models

Timeline

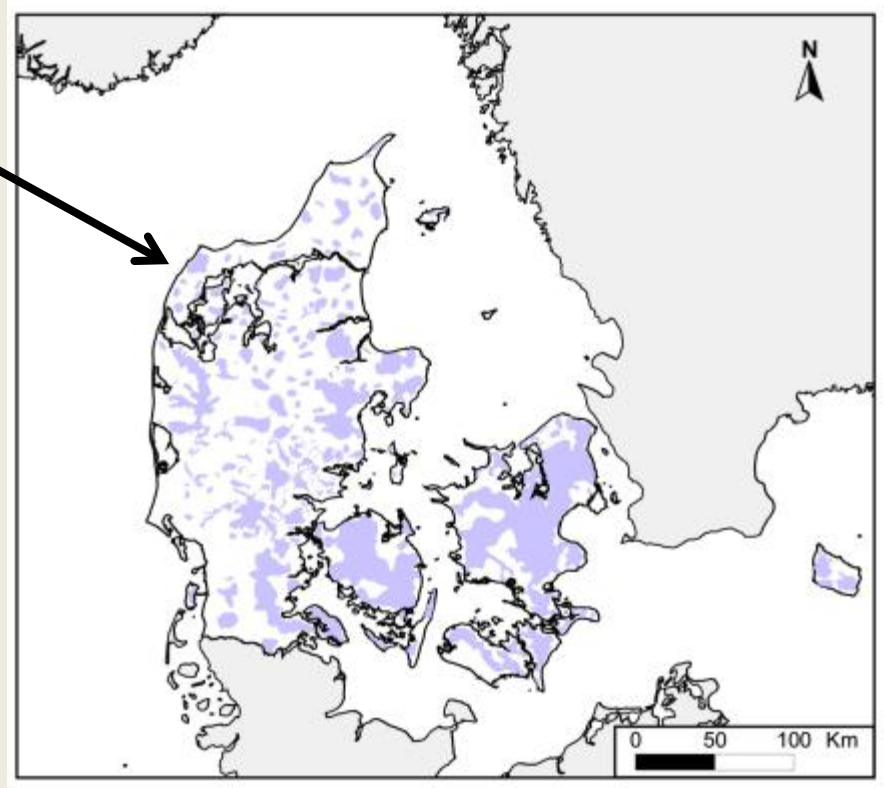
1998: The National Groundwater Mapping project starts

Models:
- 2D models
- ”Paper”
- Maps/profiles

Made by…:
- Consultants
- Counties
- Universities
- GEUS (DGU)

The National groundwater mapping project

- Initiated in 1998
- Expected end: 2015
- Areas with groundwater interests
- Financed by water consumers paying extra 4 cents per m^3 of water



Goals:

- To map aquifers, vulnerability and groundwater quality
- To establish geological and hydrogeological models
- To point out groundwater protection areas and to establish plans for future water supply

Timeline

1998: The National Groundwater Mapping project starts

- ✓ Large scale mapping
- ✓ Data collection
- ✓ New methods
- ✓ National databases

- ✓ Geological models
- ✓ Modelling software development (2D/2½D)

- ✓ Growing need for detail
- ✓ Dense data grids

- ✓ 3D software developm.
- ✓ Data amount increasing
- ✓ Sophisticated methods
- ✓ High demands!

- ✓ Advanced 3D interpretation
- ✓ Procedures?
- ✓ Documentation? QA?
- ✓ Uncertainties?

- ✓ Need for standards
- ✓ Guidelines from GEUS

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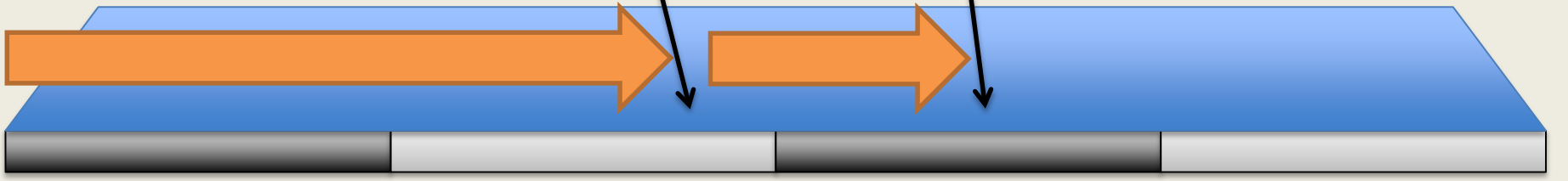
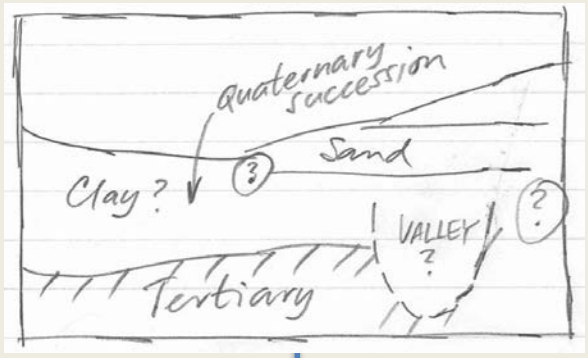


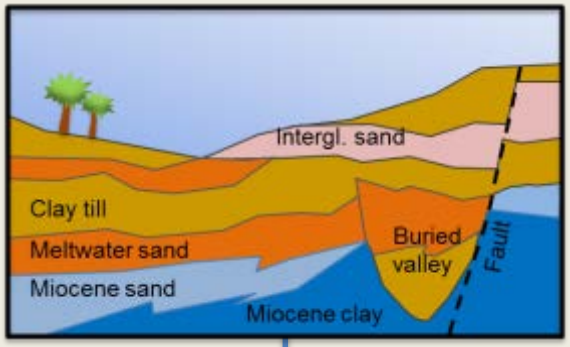
GEUS guidelines for geological modelling

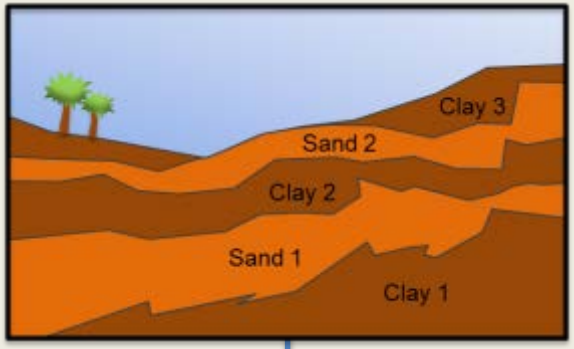
- Harmonization of models
  - Re-use of older models
  - Merging of different models
  - Updating existing models

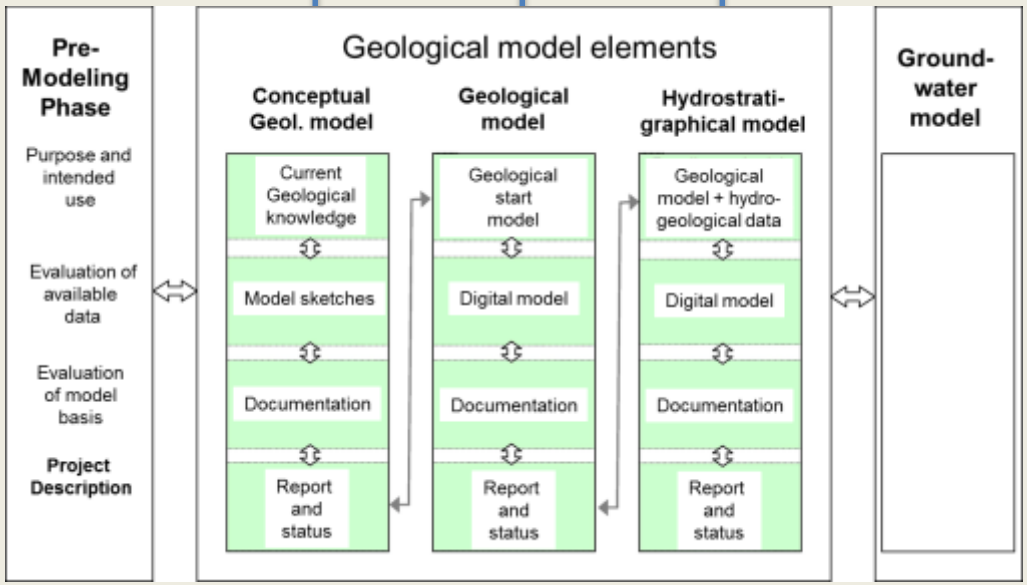
- New models would then:
  - Follow the same workflow
  - Contain the same basic elements
  - Be based on the same set of considerations and definitions
  - Be more thoroughly documented
  - Be easier to pass on to 3. parties
  - Be easier to update and to combine with other models

Geological modelling related to groundwater









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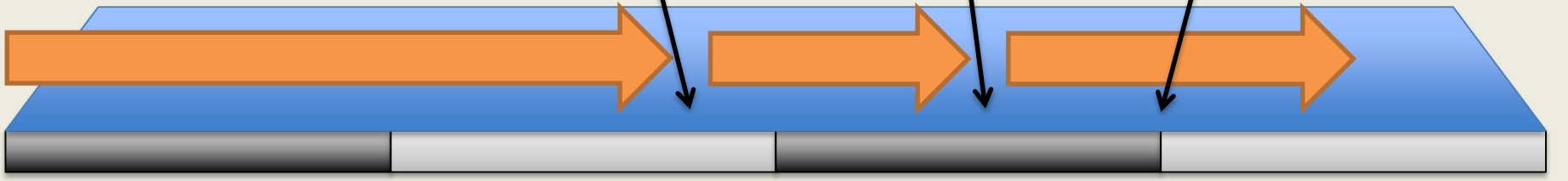
2010: GEUS initiates work on a National 3D model

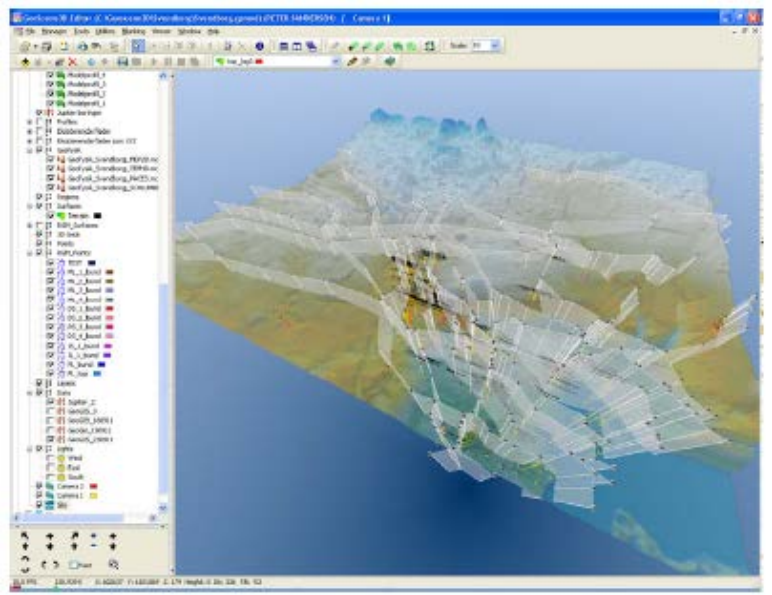


A National 3D Geological Model for Denmark

- 2012: a National 3D Geological Model became part of GEUS' long term strategy
- The goal is to construct a geological model and make it accessible to the public
- The model should contain the current geological knowledge, be a repository of geological interpretations
- The model is planned to be gradually build up; starting with "basic"/important surfaces/elements and then adding further elements along the way
- Model content is expected to be layers and voxels (+ other interpretations and informations)
- Separate models for the Danish area and Greenland – but based on the same considerations, principles and procedures

Digital geological modelling at GEUS

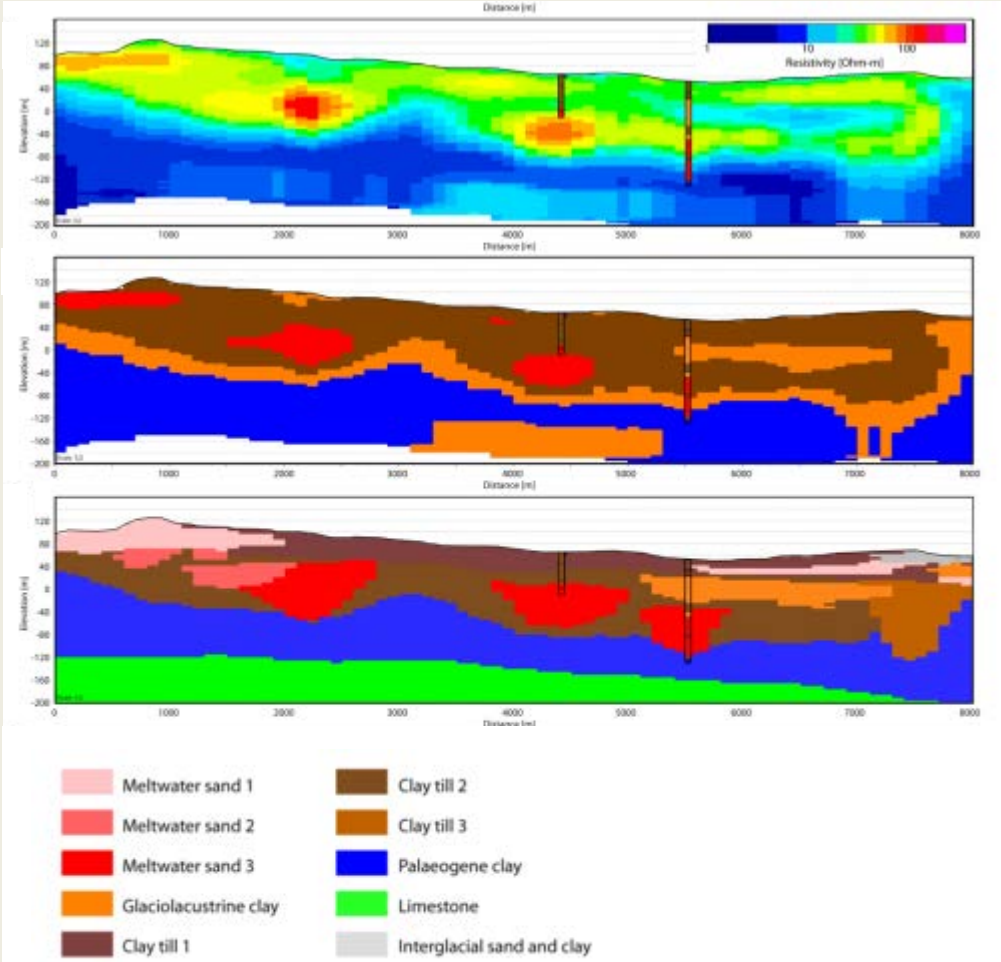
- 3D modelling projects since 2009 (groundwater related)/GeoScene 3D
- Advanced modeling of areas with especially complex geology (Nature Agency, Regions etc.)
- The “DK-model” – a national hydrostratigraphic model based on existing hydrostratigraphic models, borehole data etc. Fixed (limited) number of layers
- R & D of modelling methods and procedures, test and development of modeling software



Digital geological modelling at GEUS

- Focus on use of AEM data in combination with borehole data
- Manual/cognitive modelleling
- Manual voxel modelleling
- Geostatistical voxel modelling

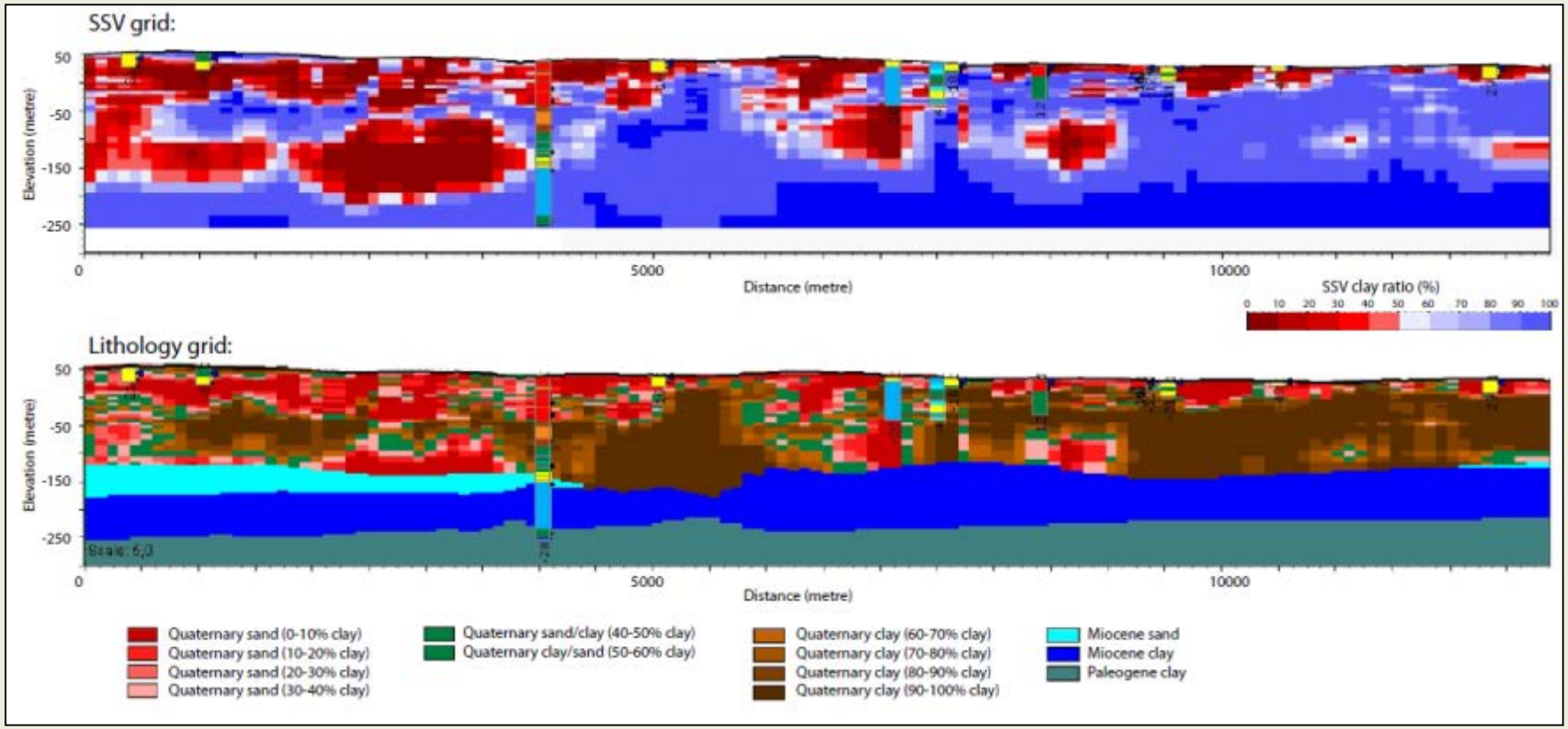
Cognitive, manual voxel modelling



Jørgensen, F., Møller, R.R., Nebel, L., Jensen, N.-P., Christiansen A.V. and Sandersen, P.B.E 2013: A method for cognitive 3D geological voxel modelling of AEM data. Bulletin of Engineering Geology and the Environment.

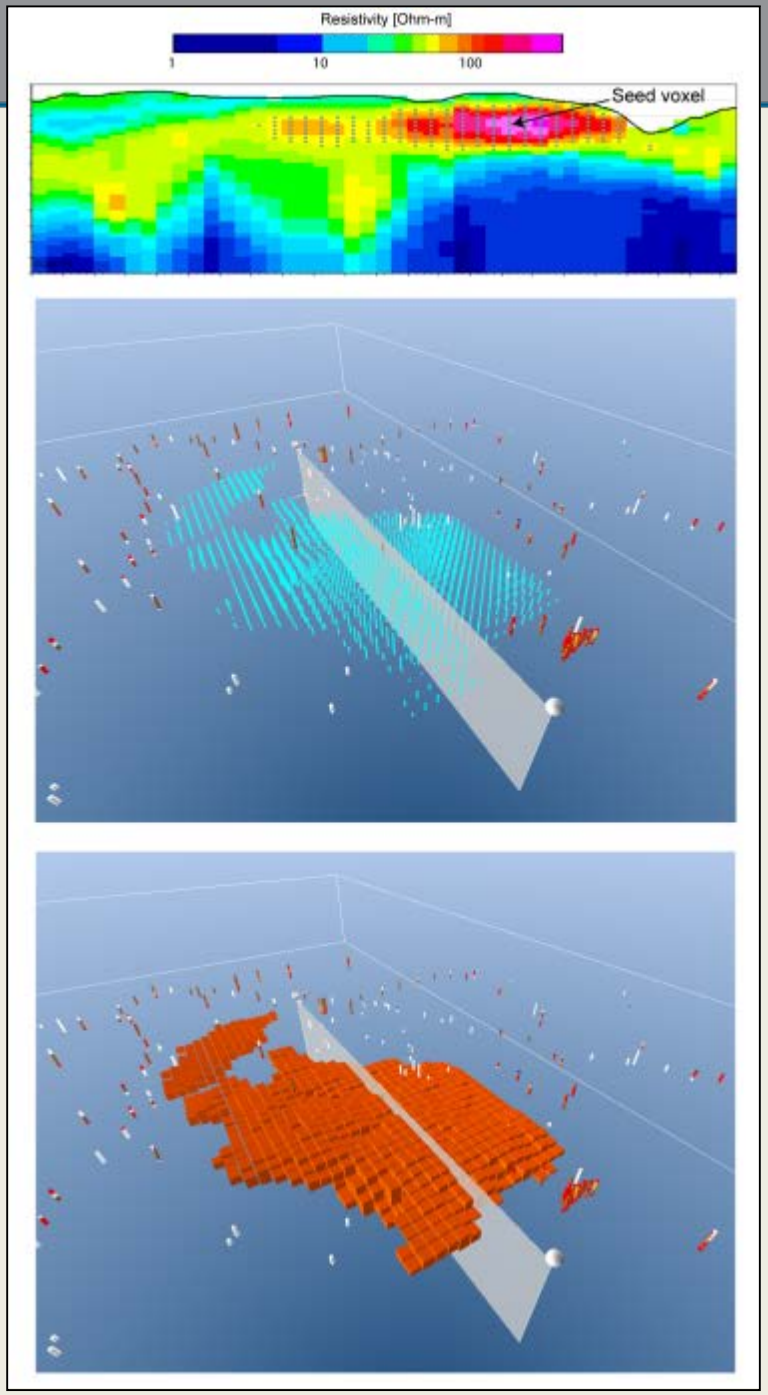
Geostatistic distribution of lithology

- A geostatistic tool is developed to handle resistivity data (SSV; Aarhus University)
- Resistivity is spatially translated to clay content by inversion using borehole information.



Voxel modelling tools

- Region grow selection



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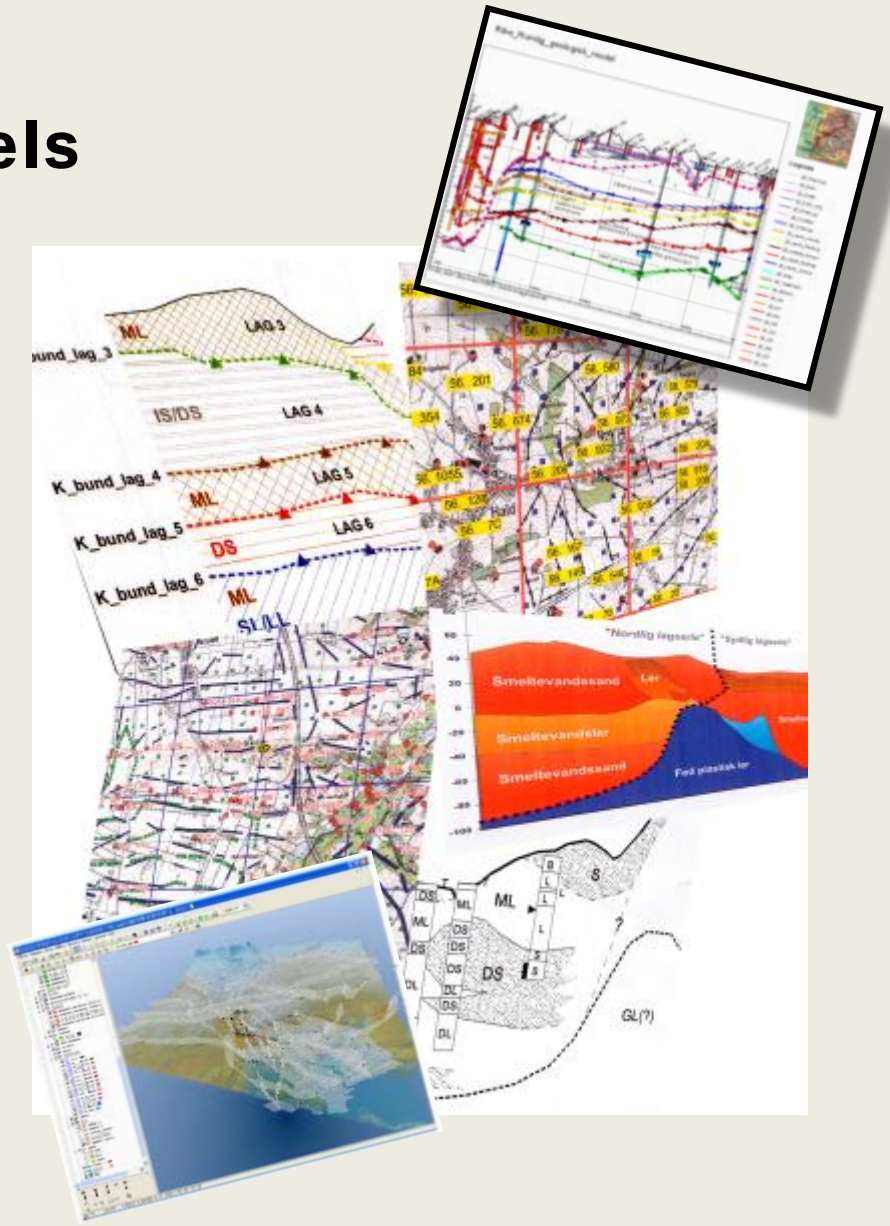
A national 3D geological model: Challenges!

- Long (indefinite) time schedule
- High degree of planning
- Continuous funding
- Continuous maintenance of model, methods and procedures
- Development of databases and web-interfaces
- High degree of expectancy from users has to be matched – otherwise the model will not be popular (used)
- The heterogeneous geology in Denmark has to be mapped in 3D – Which way is best?
- Can we transfer old standards to the new model? (Abbreviations, colour scales, stratigraphy etc.)
- Can we use the existing models in the national model?

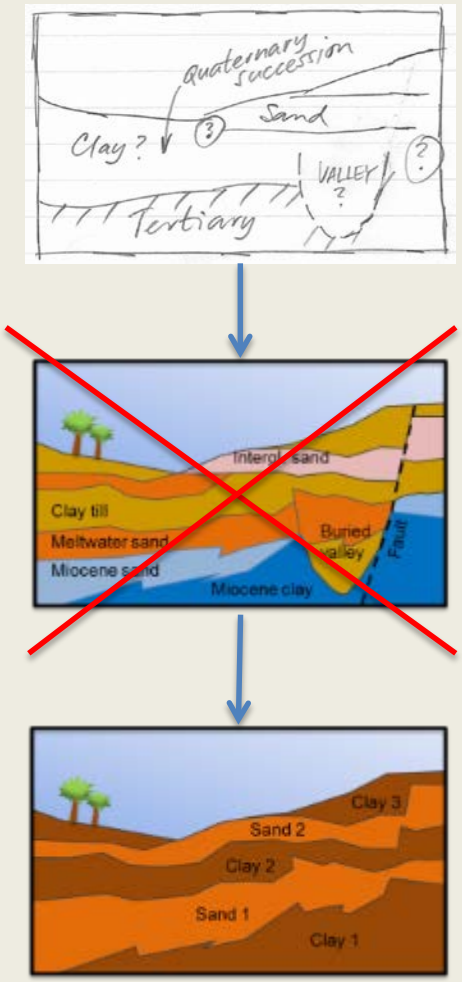
Existing geological models

- Differences in:
  - age
  - purpose
  - model types
  - degree of detail
  - data types and data spacing
  - degree of documentation
  - output……..etc…..
- Very heterogeneous!
- Input for the national 3D model?



Problems related to existing models

- Geological models in groundwater mapping project:
  - Geological models as described in Guideline 3
  - "Why make a geological model?"
  - Low budgets create need for shortcuts – shortcuts meant skipping the geological model (!)
- Hydrostratigraphic models
  - Hydrogeology; fixed layers for the Danish area (7-13 layers). Aquifers and aquitards
  - Target: the hydrostratigraphic DK model
- Typical problem: No room for innovations and iterations in budgets. Tight time schedule!
- *Models cannot be used directly in a national 3D geological model*



Where are we now?

- Initial phase; we have data, models, databases, modeling experience and modeling expertise
- We are in the process of describing the model content and the level of attainable detail
- We need to further discuss and define the modeling framework and the level of ambition
- How do we use interpretations from older models and maps?

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2010: GEUS initiates work on a National 3D model

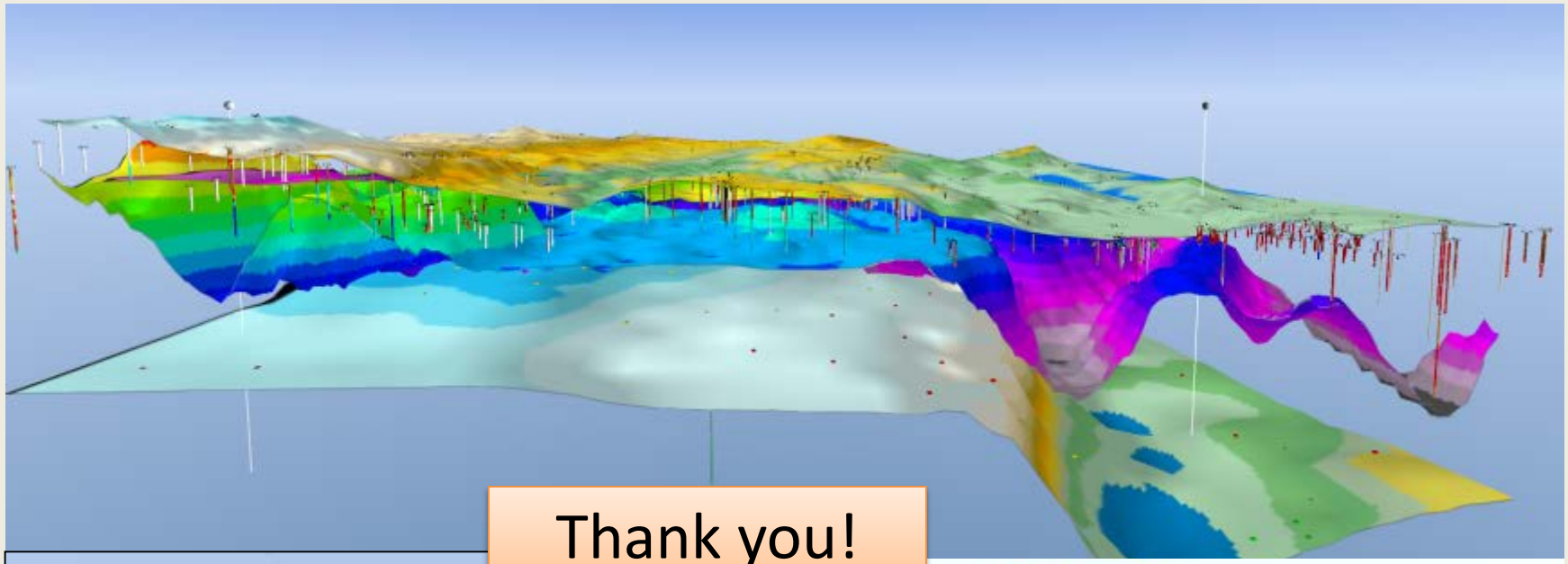
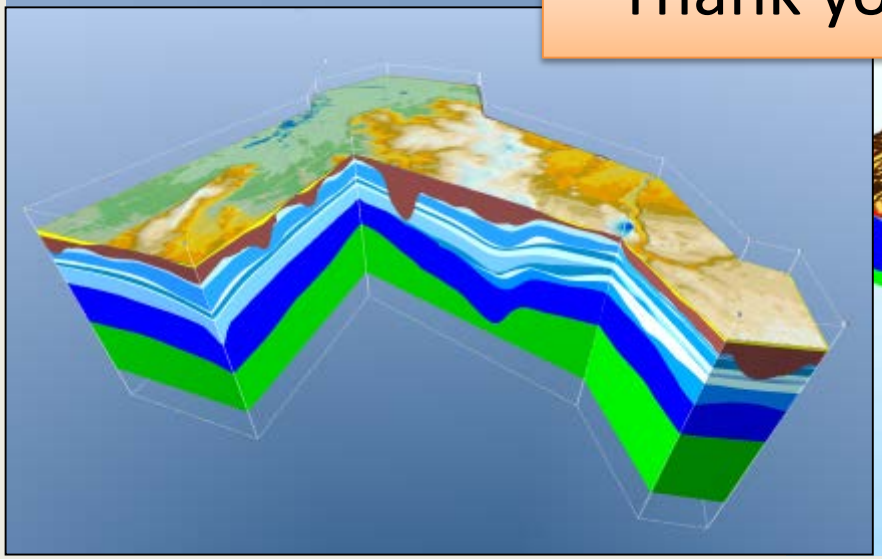
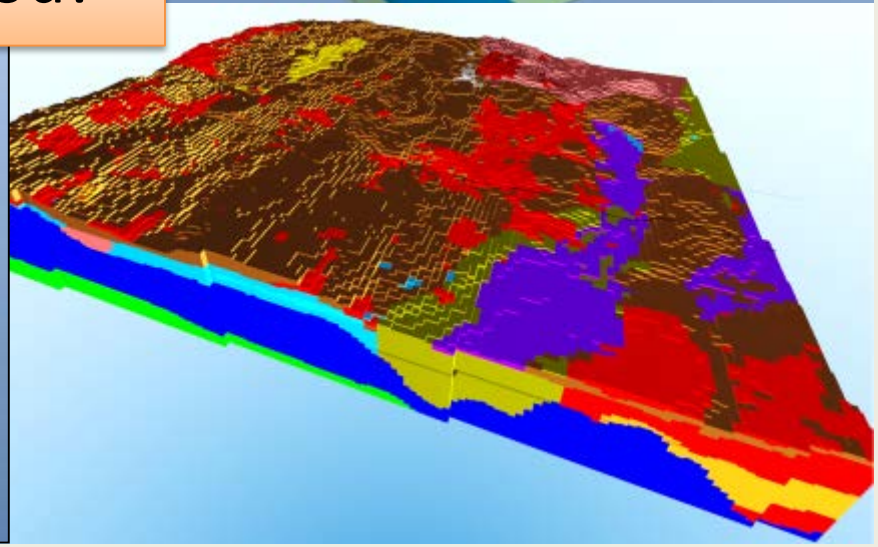
- ✓ Modelling continues!

2015: The National Groundwater Mapping project ends

- ✓ Then what?

- ✓ Mapping continues?

1980 1990 2000 2010 2020



Thank you!