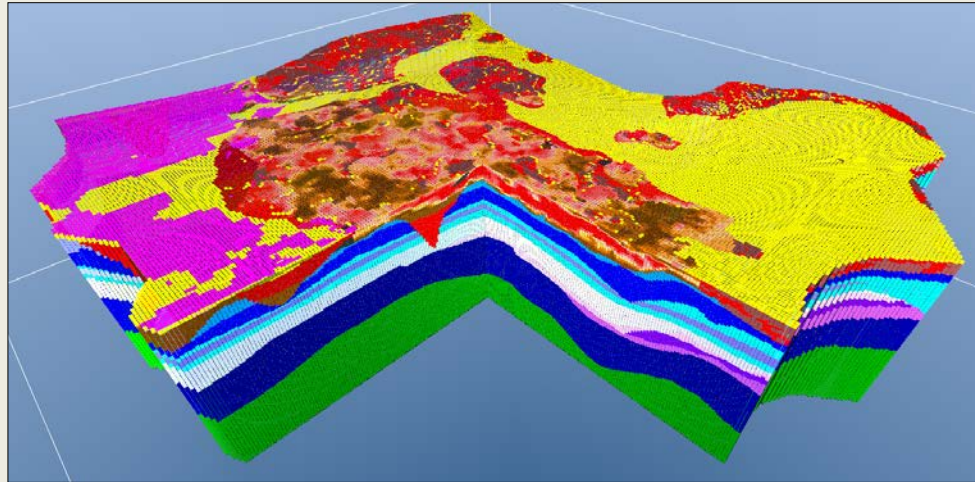




  
G E U S



# Examples of hydrogeological and geological modelling from geophysical data

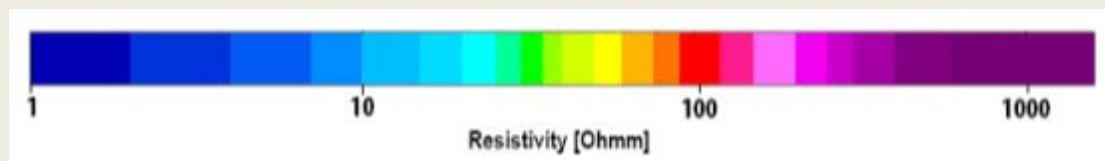
Flemming Jørgensen

Geological Survey of Denmark and Greenland

## Translating resistivity to geology or hydrogeology – limitations:

- The degree of saturation
- The ion content of the pore water
- Clay content
- Clay type
  
- Vertical resolution capability
- Horizontal resolution capability
- Weak resolution of resistive layers
- Spatial variations in property
  
- Depth of penetration, DOI
- Coupled and noise-infected soundings
- Model equivalency, model uncertainty
- The type of model used – blocky or smooth model

# Data interpretation

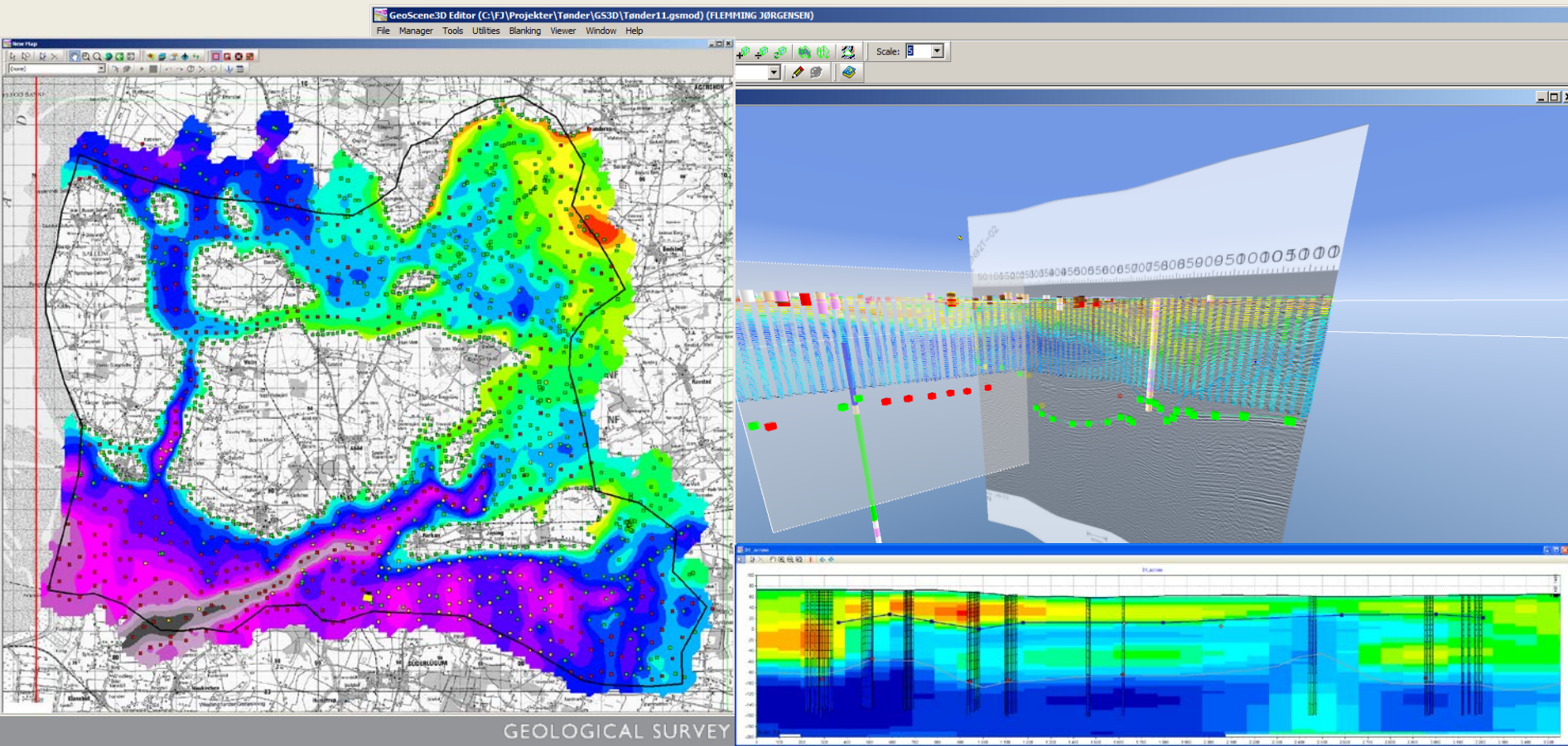


Some Danish sediments:

Sediments	Resistivity ( $\Omega$ m)	
Meltwater sand and gravel	>60	
Clay till	25–50	
Glacio-lacustrine clay	10–40	
Neogene mica silt/sand: Miocene	>40	
Neogene mica clay: Miocene	10–40	
Paleogene clay: Eocene–Oligocene	5–12	
Paleogene clay: Paleocene–Eocene	1–7	
Danian limestone	>80	

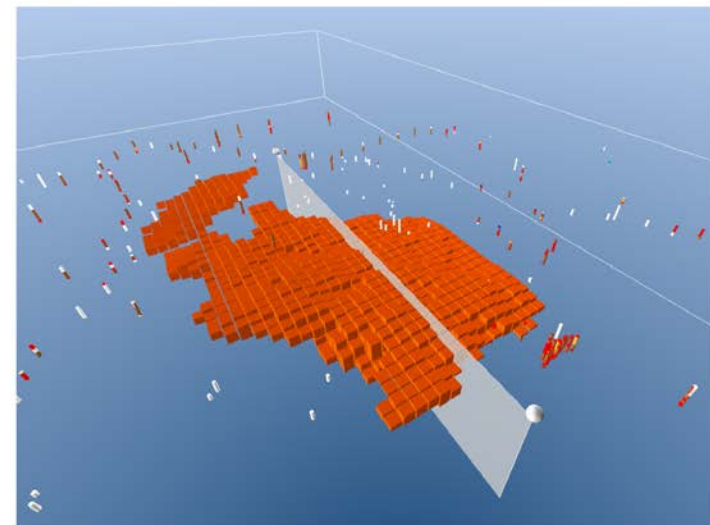
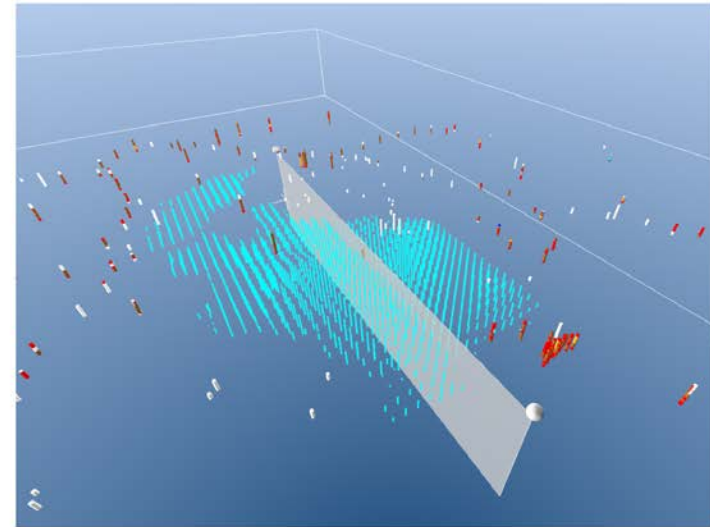
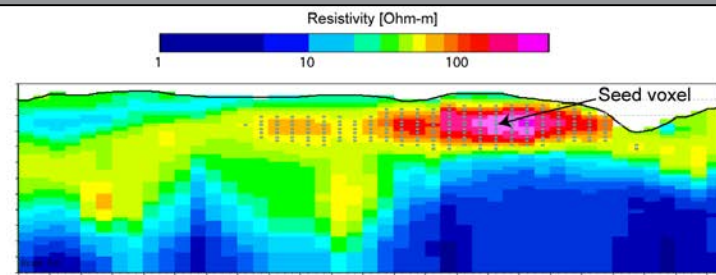
## Layer-based modelling

Basic digitalisation of interpretation points on maps, profiles and directly in 3D space



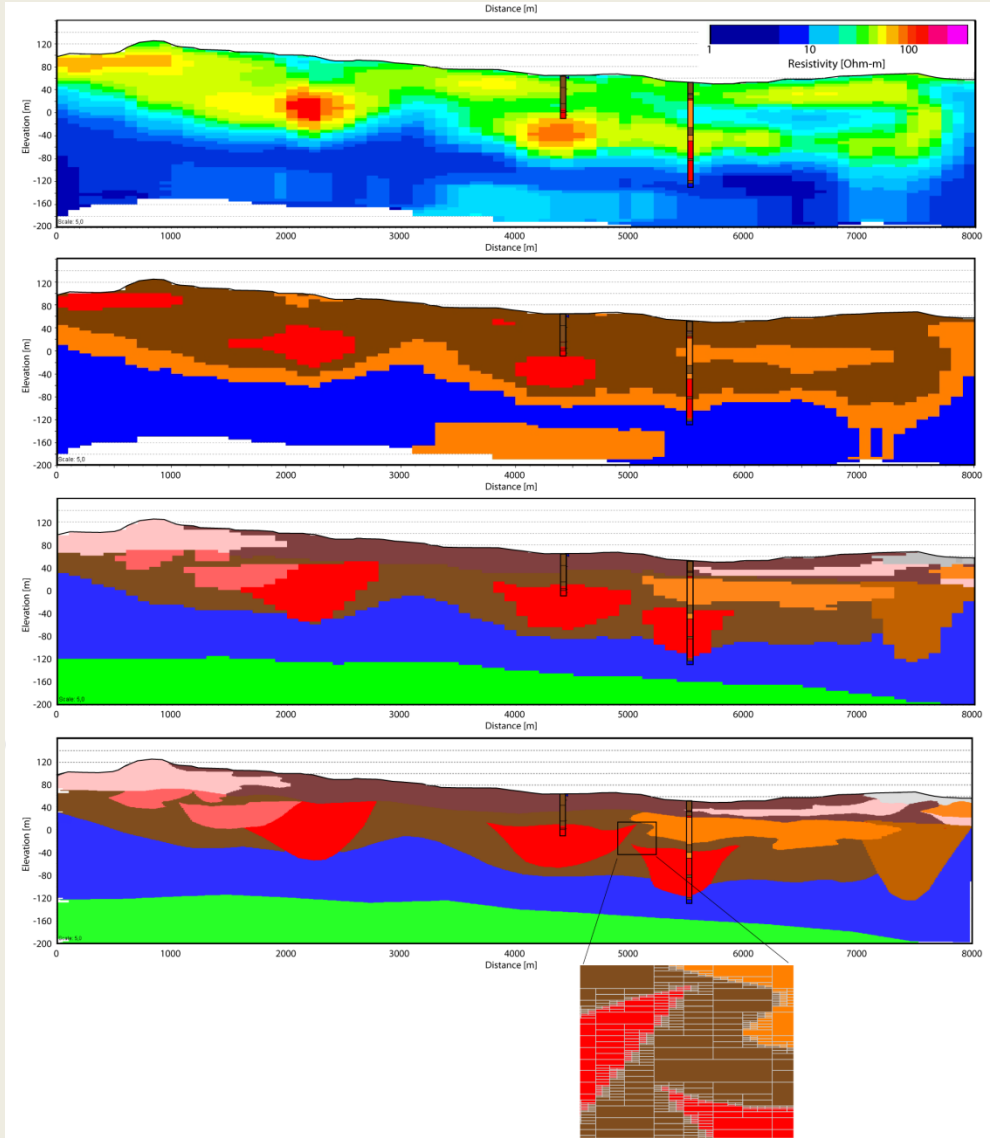
## Voxel modelling tools

- Region grow selection

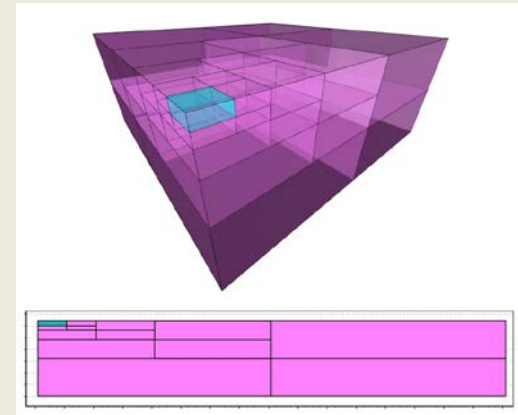


Jørgensen, F., Møller, R.R., Nebel, L., Jensen, N.-P., Christiansen A.V. and Sandersen, P.B.E 2013: A method for cognitive 3D geological voxel modelling of AEM data. *Bulletin of Engineering Geology and the Environment*.

# Cognitive, manual voxel modelling, octree discretization



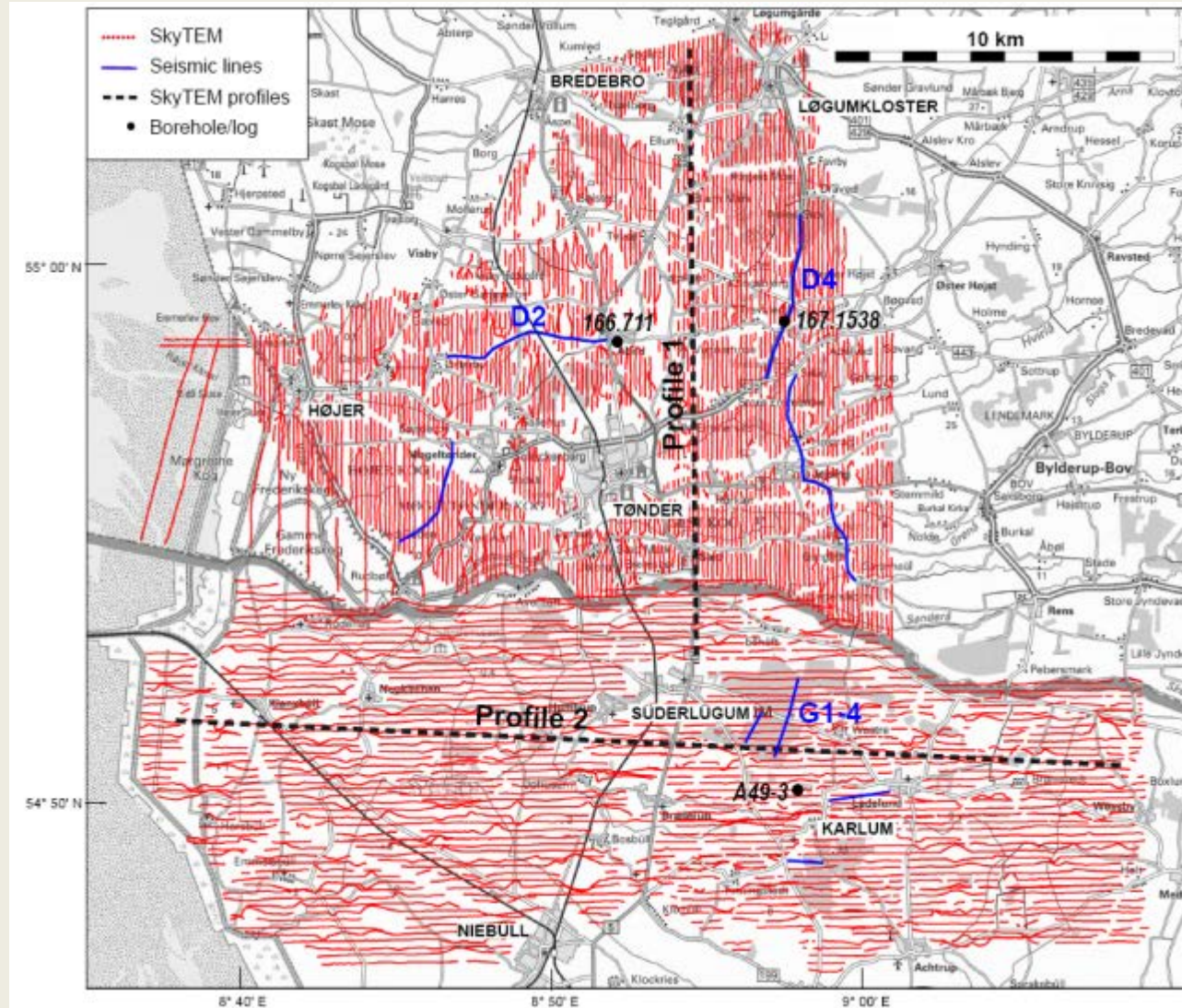
- Voxels can be divided into 8 equally-sized in order to increase the level of detail



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*.

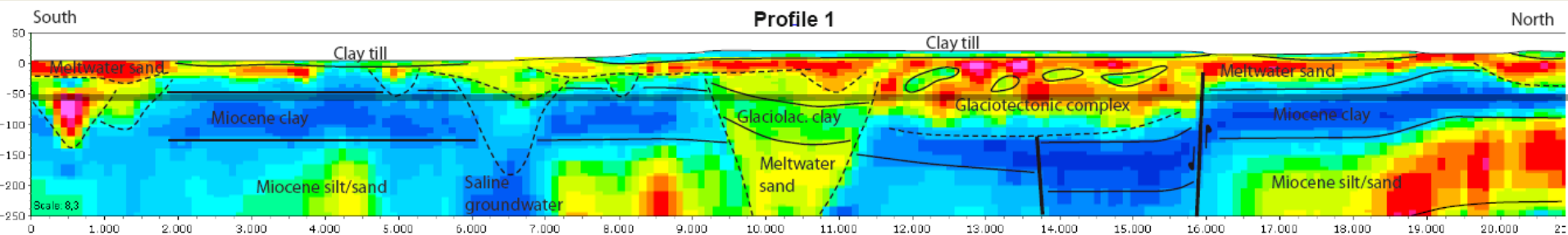
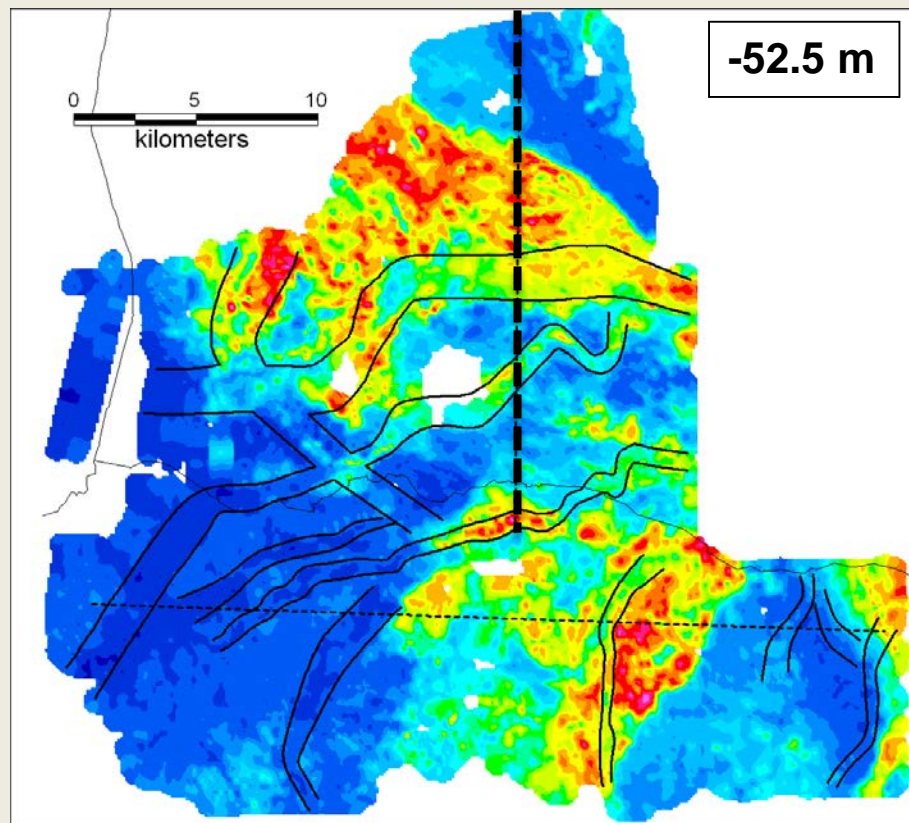
# The Tønder-Leck survey

- 3230 line km
- 166 and 250 m spacing
- 721 km<sup>2</sup>



Jørgensen, F. et al. 2012: Transboundary geophysical mapping of geological elements and salinity distribution critical for the assessment of future sea water intrusion in response to sea level rise. *Hydrology and Earth System Sciences*, 1845-1862.

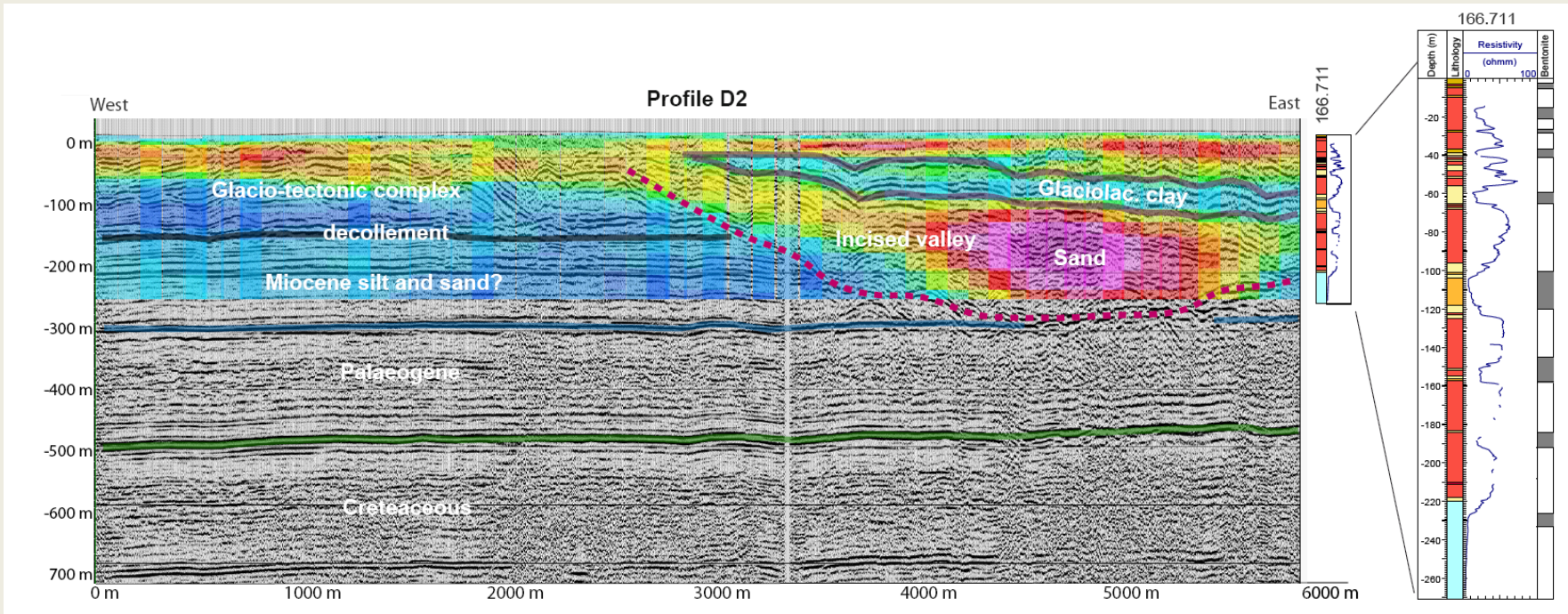
# Geological interpretations



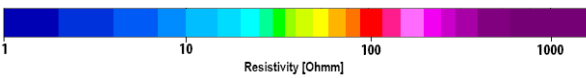
Jørgensen et al. 2012



# Geological interpretations

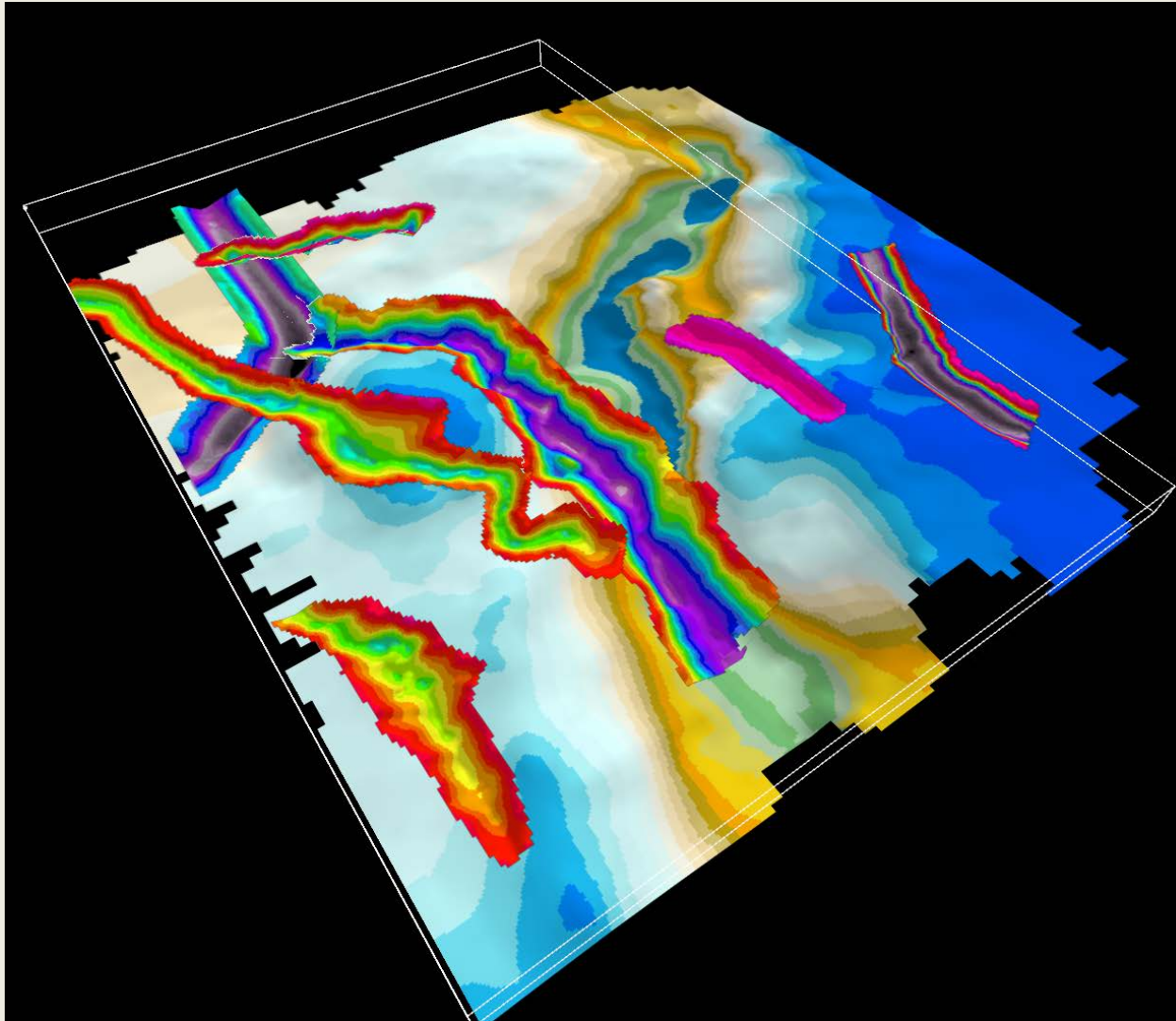


- | Borehole lithology:   | Seismic interpretations:                                    |
|---|---|
| <span style="color: red;">■</span> Meltwater sand           | <span style="color: purple;">—</span> Glaciolacustrine clay |
| <span style="color: yellow;">■</span> Clay till             | <span style="color: grey;">—</span> Decollement             |
| <span style="color: orange;">■</span> Glacial/intergl. clay | <span style="color: red;">- - -</span> Valley incision      |
| <span style="color: lightblue;">■</span> Glaciolac. silt    | <span style="color: blue;">—</span> Top Palaeogene          |
| <span style="color: cyan;">■</span> Miocene clay            | <span style="color: green;">—</span> Top Cretaceous         |
| <span style="color: darkblue;">■</span> Palaeogene clay     |   |

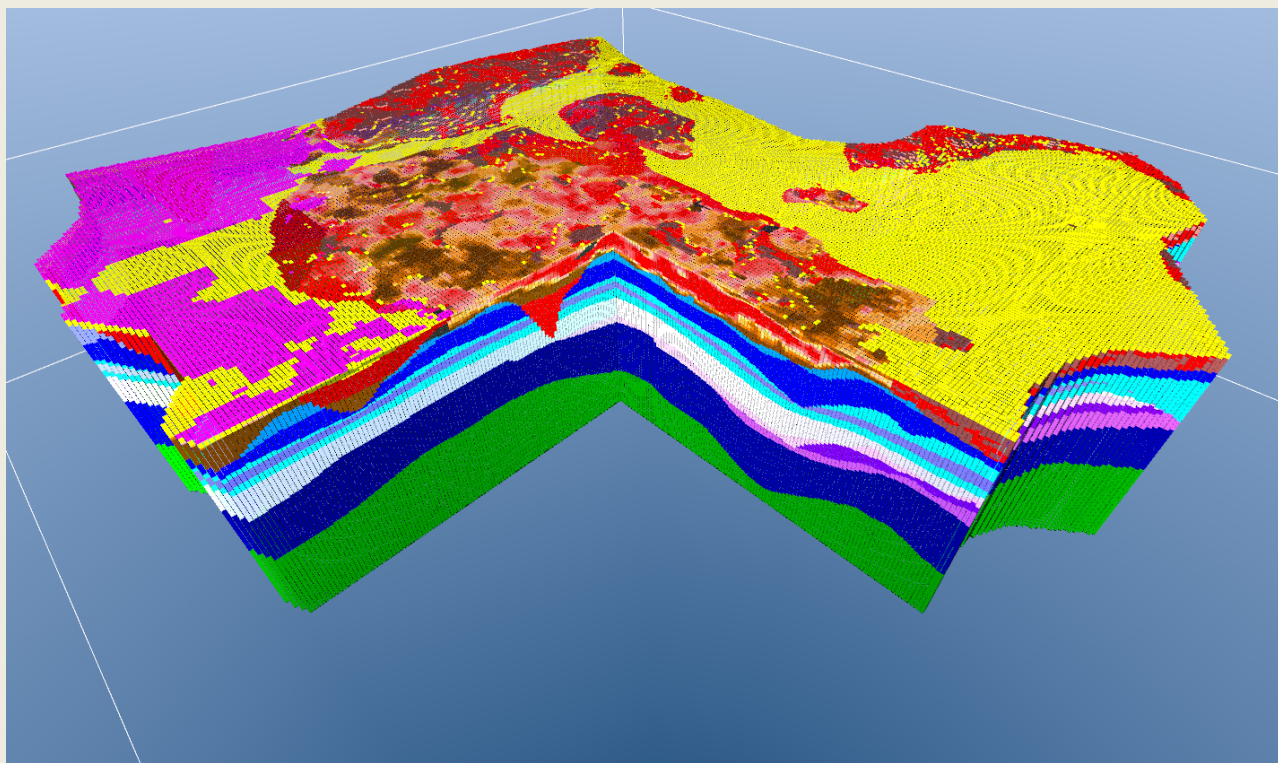


Jørgensen, F. et al. 2012: Transboundary geophysical mapping of geological elements and salinity distribution critical for the assessment of future sea water intrusion in response to sea level rise. *Hydrology and Earth System Sciences*, 1845-1862.

## Buried valleys

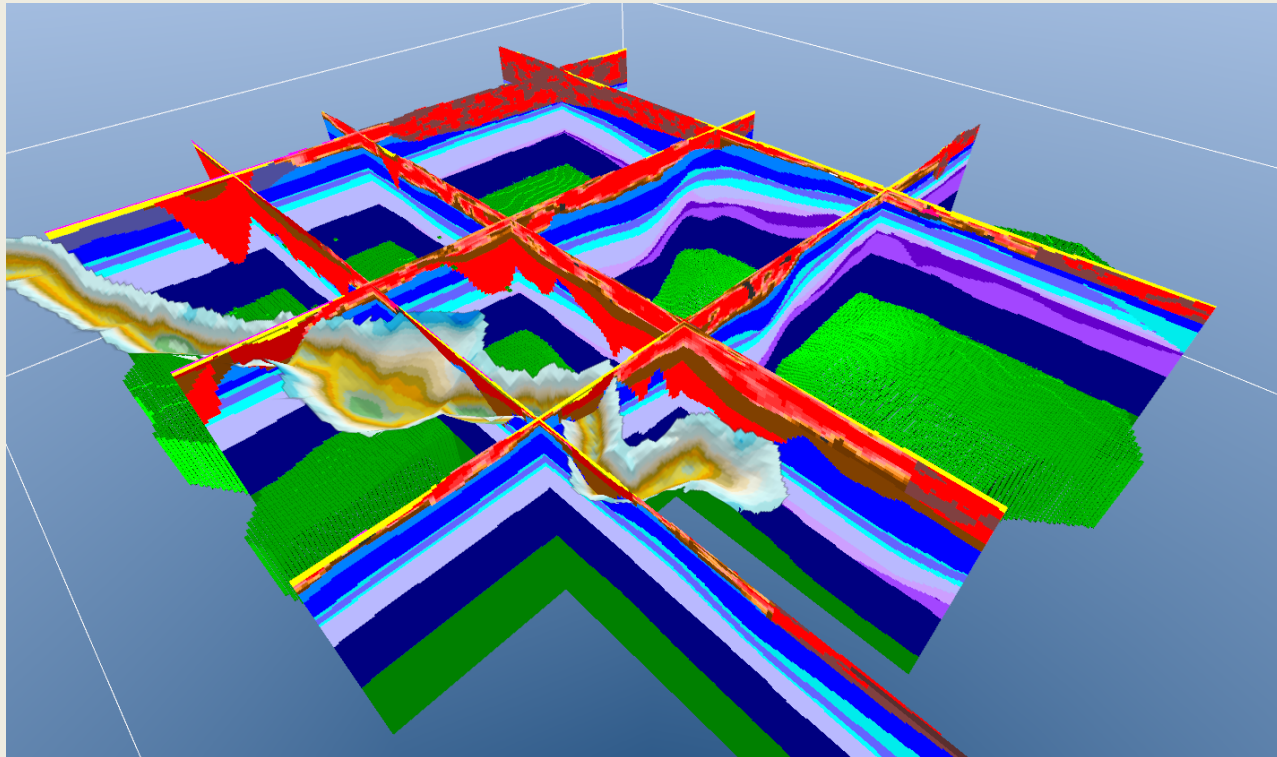


# Final voxel model



- SGS\_SGEMS sand
- SGL\_SGEMS clay
- SV10\_SSV 0-10%
- SV20\_SSV 10-20%
- SV30\_SSV 20-30%
- SV40\_SSV 30-40%
- SV50\_SSV 40-50%
- SV60\_SSV 50-60%
- SV70\_SSV 60-70%
- SV80\_SSV 70-80%
- SV90\_SSV 80-90%
- SV100\_SSV\_100%
- PG\_Post\_glacial
- PS\_Sandur
- EM\_Eem
- MA\_MaadeGroup
- OD3\_Odderup\_S3
- AR3\_Arnum\_L3
- OD2\_Odderup\_S2
- AR2\_Arnum\_L2
- BAS\_Bastrup\_Sand
- KL19\_Klintinghoved\_Clay\_Lower\_9
- PL\_Paleogene\_Clay
- BK\_Danian\_Limestone
- KL10\_Klintinghoved\_Clay\_Upper\_10
- MADE\_MaadeGroup\_deforme
- LG1\_DS\_Abild\_Valley\_Sand
- CLAY\_Abild\_Valley\_Clay
- CLAY\_Hoejer\_Valley\_Clay
- SAND\_Hoejer\_Valley\_Sand
- CLAY\_Toender\_Jejs\_Valley\_Clay
- SAND\_MoegelToender\_Valley\_Sand
- CLAY\_MoegelToender\_Valley\_Clay
- SAND\_LoegumKloster1\_Valley\_Sand
- SAND\_Toender\_Jejs\_Valley\_Sand\_Upper
- QS\_Quaternary\_Sand
- QL\_Quaternary\_Clay
- QSEDSA\_QuaternarySediments\_Saltwater
- Q\_MC\_Q\_MC

# Voxel model, valley surface



- SGS\_SGEMS sand
- SGL\_SGEMS clay
- SV10\_SSV 0-10%
- SV20\_SSV 10-20%
- SV30\_SSV 20-30%
- SV40\_SSV 30-40%
- SV50\_SSV 40-50%
- SV60\_SSV 50-60%
- SV70\_SSV 60-70%
- SV80\_SSV 70-80%
- SV90\_SSV 80-90%
- SV100\_SSV\_100%
- PG\_Post\_glacial
- PS\_Sandur
- EM\_Eem
- MA\_MaadeGroup
- OD3\_Odderup\_S3
- AR3\_Arnum\_L3
- OD2\_Odderup\_S2
- AR2\_Arnum\_L2
- BAS\_Bastrup\_Sand
- KL19\_Klintinghoved\_Clay\_Lower\_9
- PL\_Paleogene\_Clay
- BK\_Danian\_Limestone
- KL10\_Klintinghoved\_Clay\_Upper\_10
- MADE\_MaadeGroup\_deforme
- LG1\_DS\_Abild\_Valley\_Sand
- CLAY\_Abild\_Valley\_Clay
- CLAY\_Hoejer\_Valley\_Clay
- SAND\_Hoejer\_Valley\_Sand
- CLAY\_Toender\_Jejs\_Valley\_Clay
- SAND\_MoegelToender\_Valley\_Sand
- CLAY\_MoegelToender\_Valley\_Clay
- SAND\_LoegumKloster1\_Valley\_Sand
- SAND\_Toender\_Jejs\_Valley\_Sand\_Upper
- QS\_Quaternary\_Sand
- QL\_Quaternary\_Clay
- QSEDSA\_QuaternarySediments\_Saltwater
- Q\_MC\_Q\_MC