GEOScene3D ...by I•GIS

3D hydrogeological conceptual model building in Denmark

Presentation outline

- Our lessons learned working with groundwater mapping and 3D modelling
- 2 examples of 3D model conceptual models
  - Rural area, regional model
  - Urban area
- Future trends in 3D modelling approaches
- Summary – lessons learned as seen from IGIS

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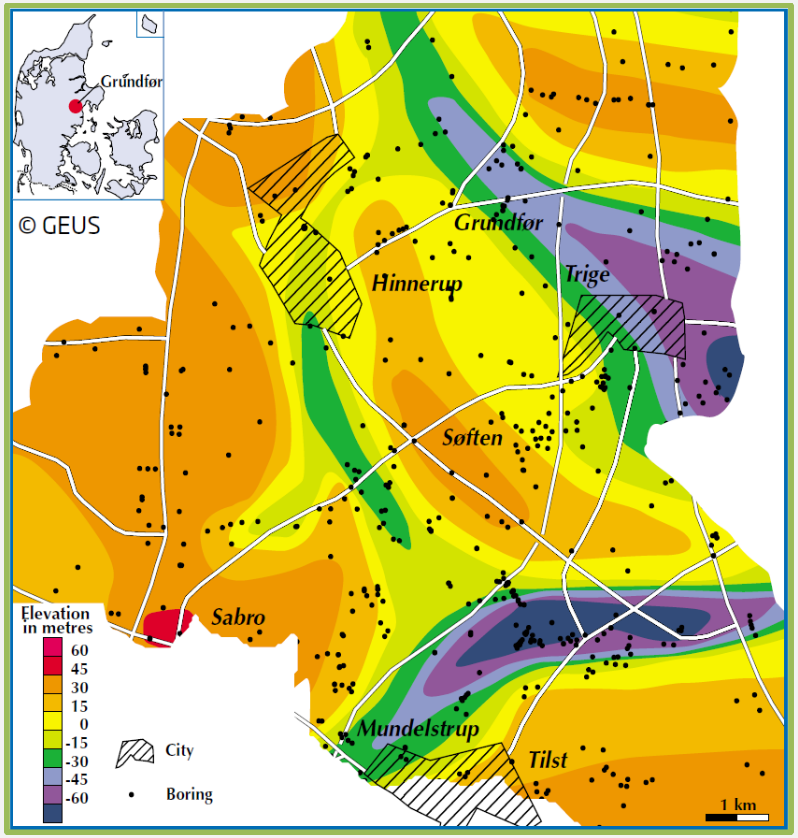
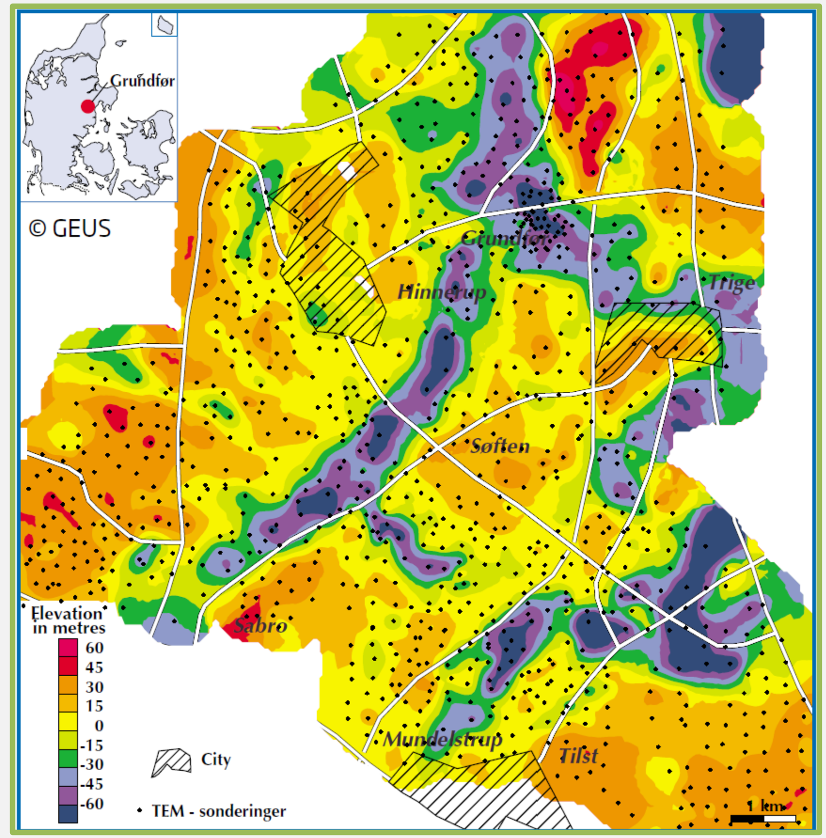
mid 90's - Pre DK-SGMA

Wells Only



Map based on 518 boreholes

Geophysics Added

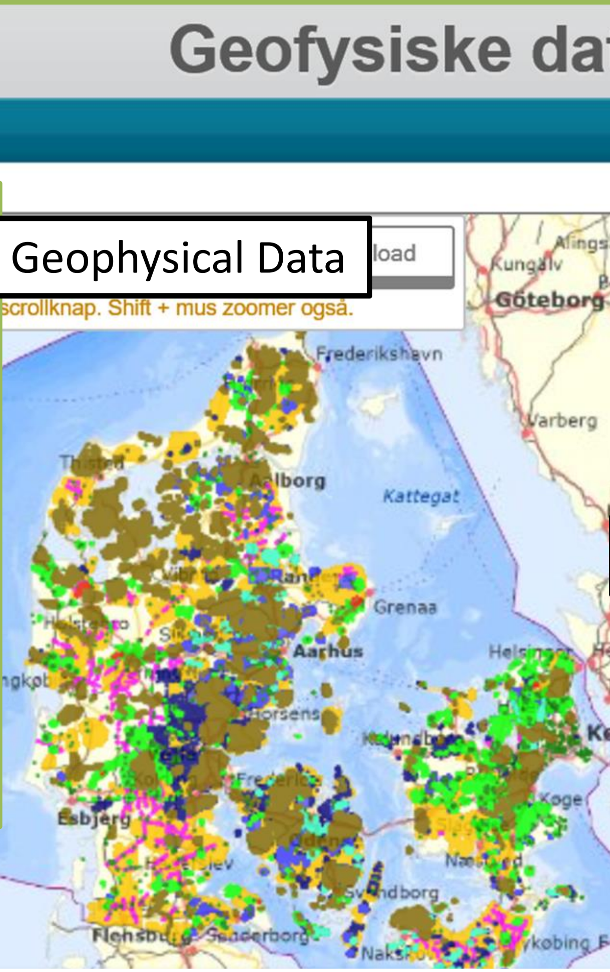


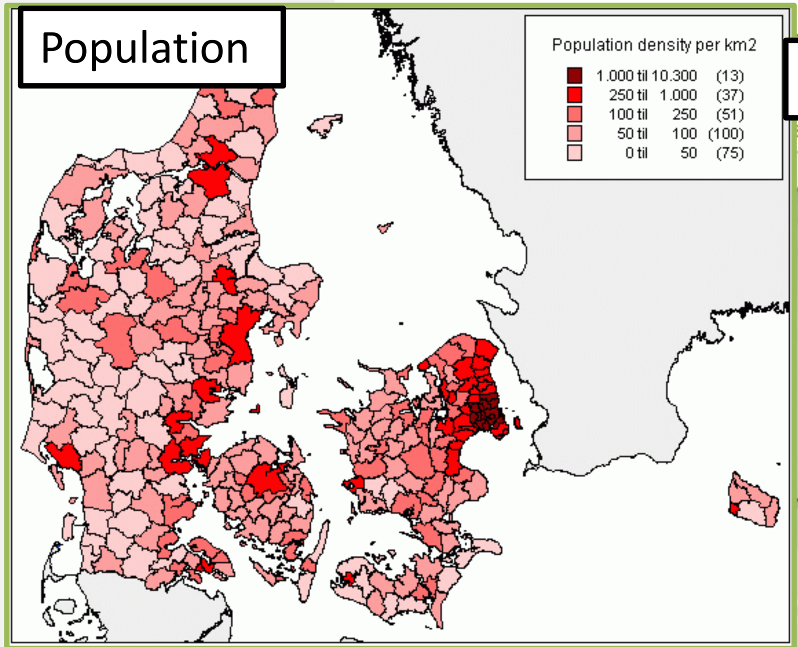
Map based on 1,400 TEM soundings

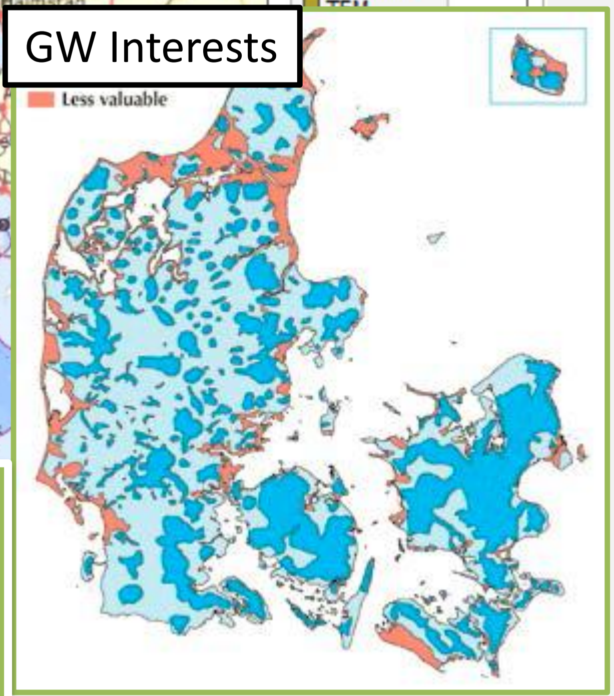
- Flow model adds up … but does not correspond to what is experienced in the field
- We need a better geometrical 3D understanding and more data

Lesson: Geophysics provides spatial information and is fast and cost efficient
Lesson: Build a detailed hydrogeological model, flow models alone will lack detail.

Denmark – quick overview







- Densely populated
- Wide spread production of groundwater – <u>even in major cities</u>
- **DK-SGMA: Geophysics applied on a major scale**

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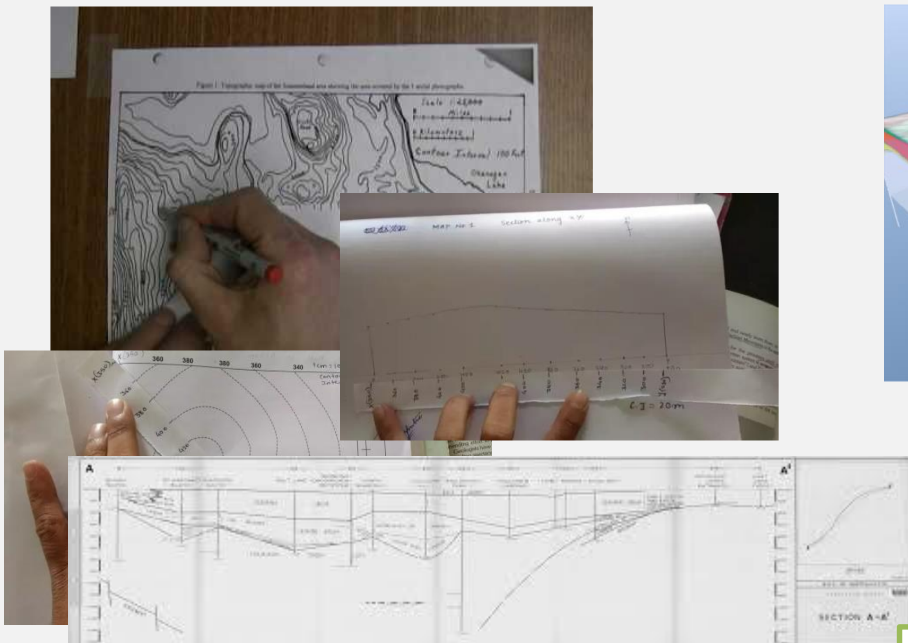
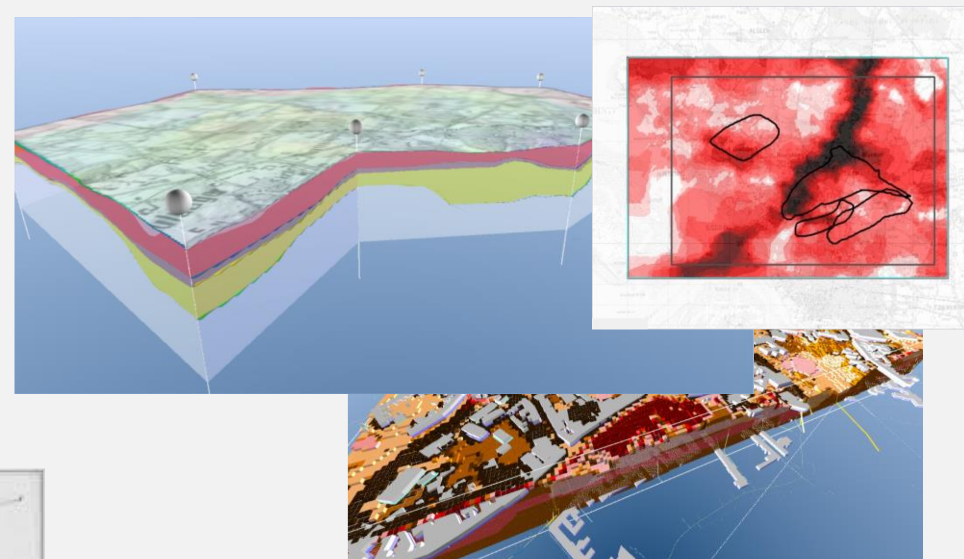
3D hydrogeological model building

1998 2017 Future





- Hand made crossections
- Layers digitized and gridded in Surfer

- Import all data into a 3D modelling environment
- Build a 3D conceptual model in one environment
- Enables iterative model development
- Fast an efficient

Lesson: Use a 3D geological modelling environment. Iterative model development & Data integration

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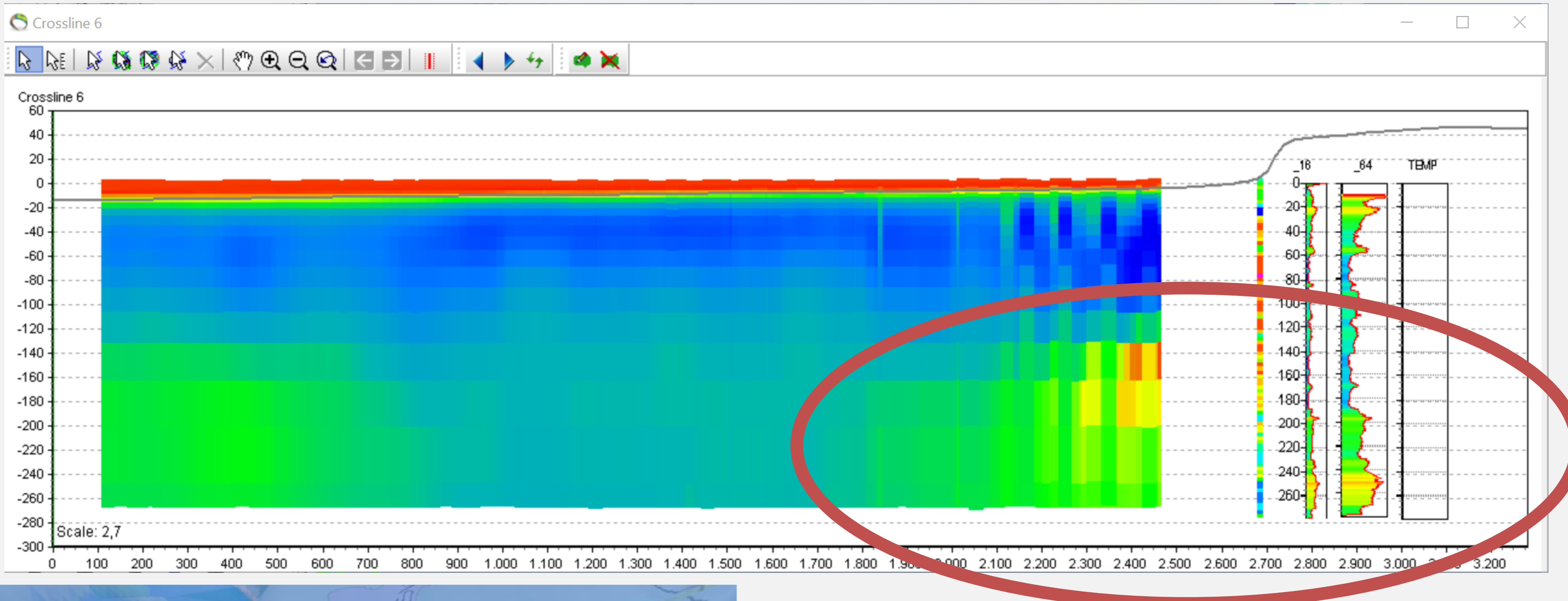
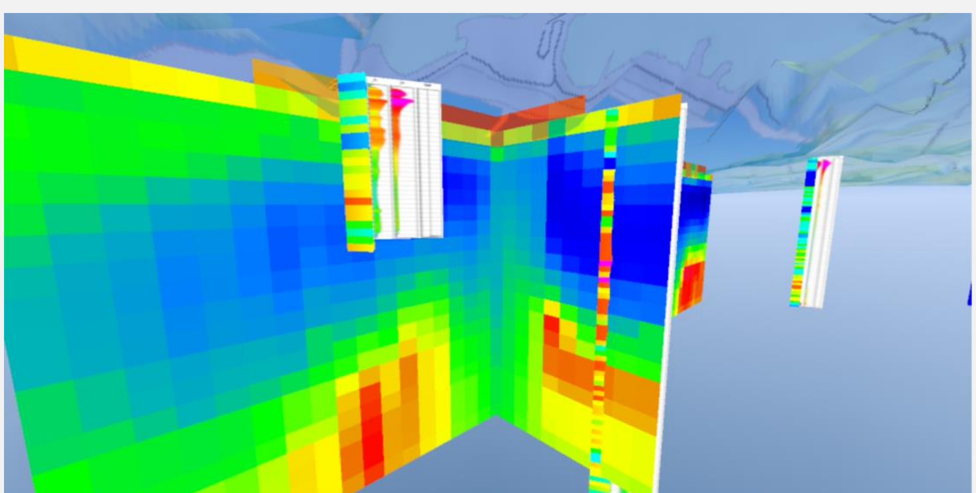
Fairytale Magic ?

~~?? Geophysics = Magic = No hard work ☺ ??~~

Geophysical Magic?



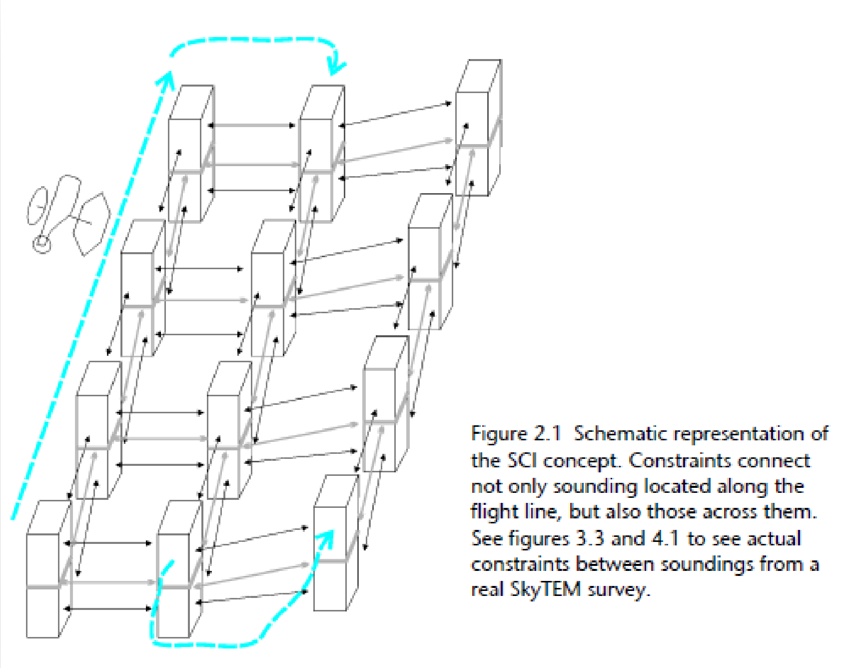


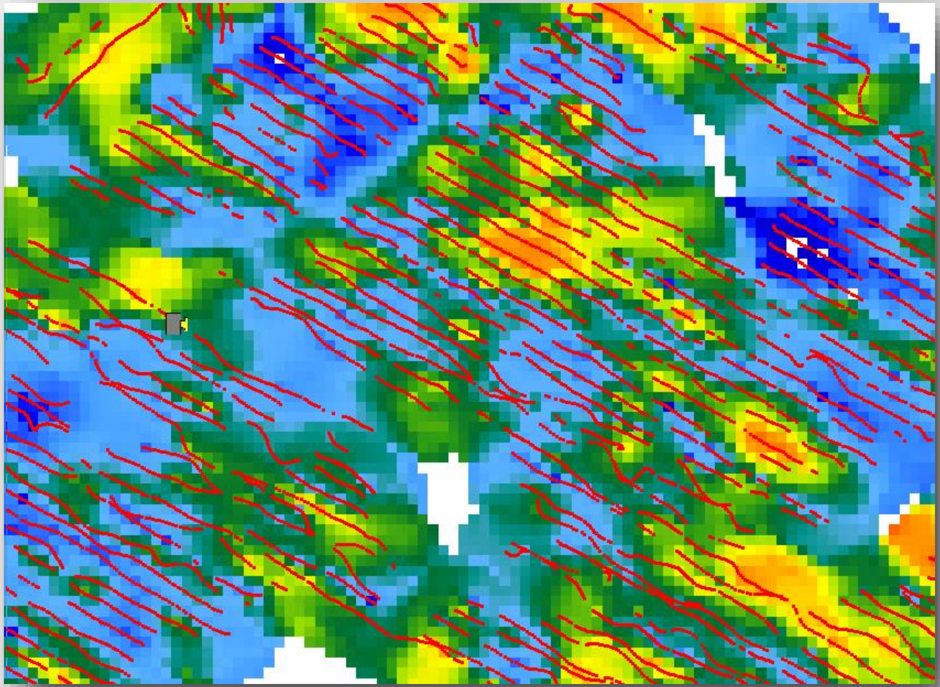
Saltwater – Clay ?
Data are ambiguous… combine more data

Geophysical Magic?

The **COLLECTION PROCESS** and **PROCESSING** of data also have an influence on the results

SkyTEM (LCI/SCI – tolkning)





Lesson: Know the strengths and weakness of your data – and combine them

2 Model Examples

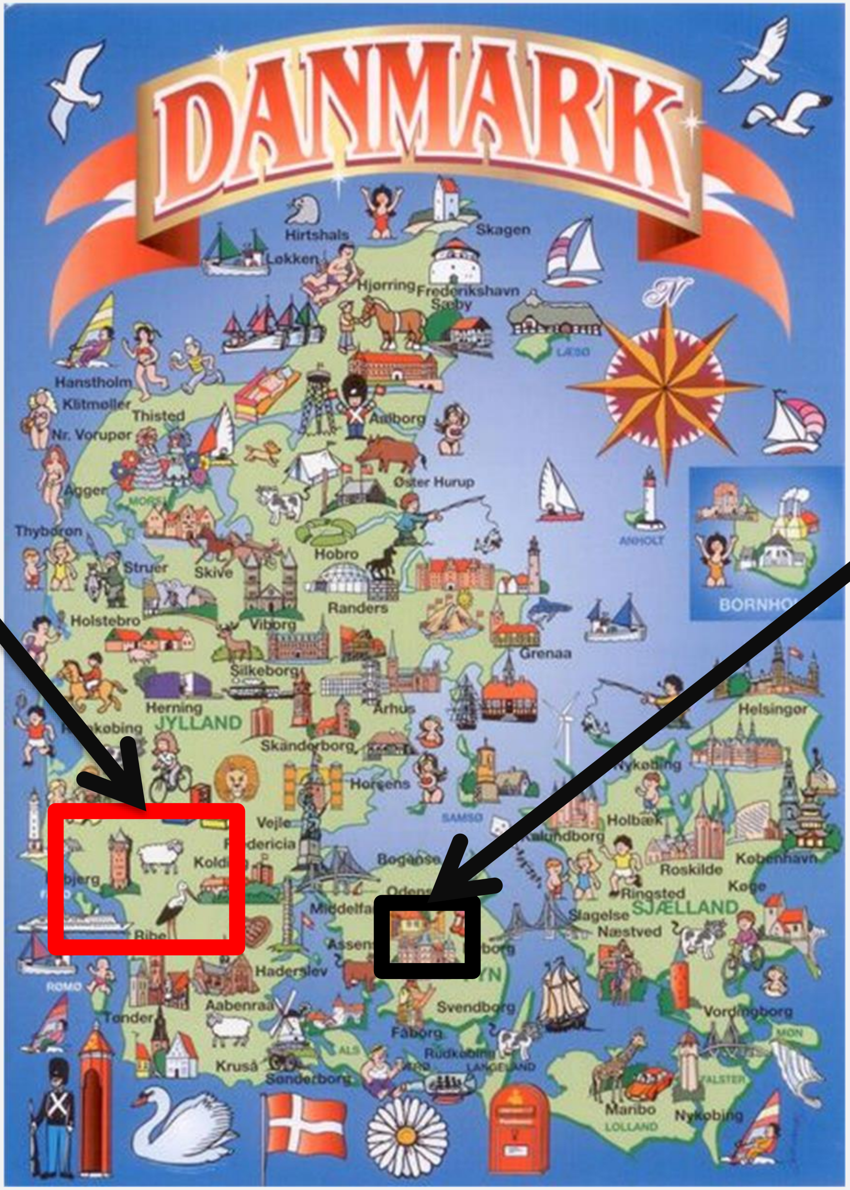
Esbjerg

SETTING
- Rural Area

DATA
- AEM data
- TEM 40
- Seismic data
- Borehole data
- Log data
- Chemical data

MODEL TYPE
- 3D Layer Model
- Regional Scale

35x30 KM = 1050 KM2
(21x19 Miles = 259460 Acres)



Odense

SETTING
- Urban center

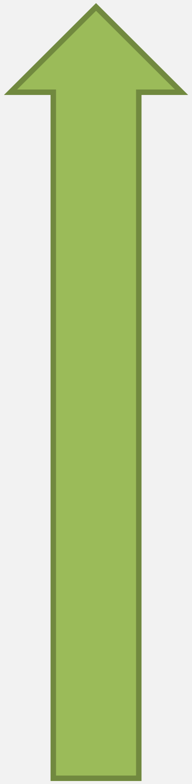
DATA
- Log data
- GIS data
  - Sewers/pipes
  - Houses
  - Roads

MODEL TYPE
- 3D Voxel Model
- Small Area

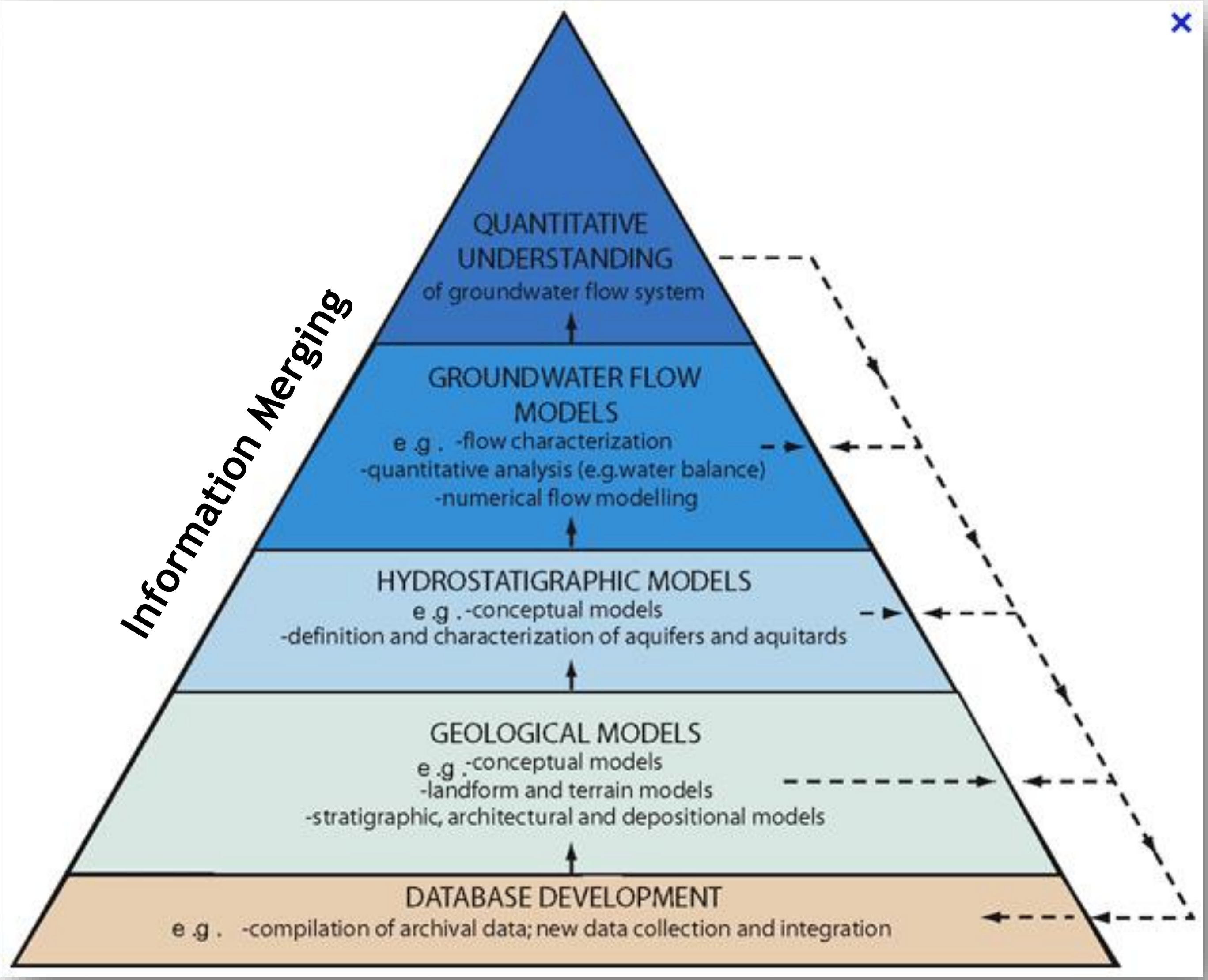
3D hydrogeological Modelling

3D Modelling is reduction of complexity to get to a higher Level of understanding

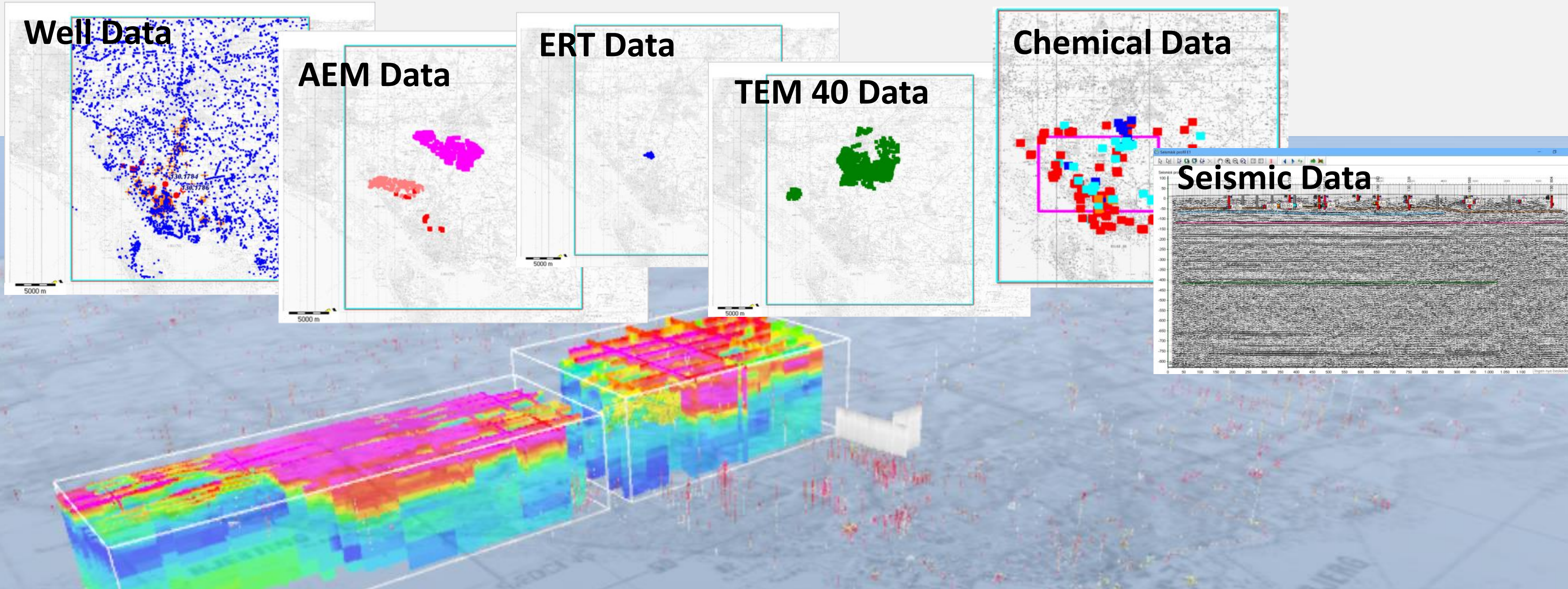
"Simple"



Complex



3D Geological Modelling & Data



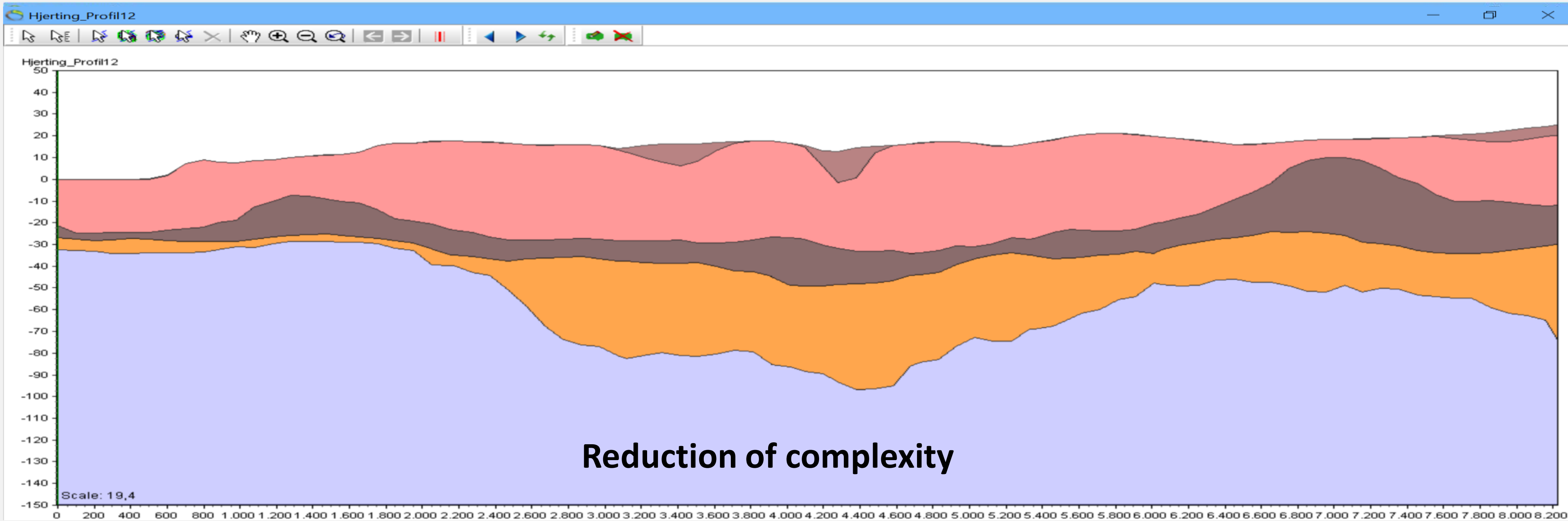
Lesson: Locate and develop the right tools for the job

- Wrong tool – wrong result

Lesson: Collect data to a central Data Management Storage system

- A One-stop data shop ¨- Ensures updated data
- Promote collaboration on modelling – everybody looking at the same version of data
- Traceability and history - Enable future updating of model

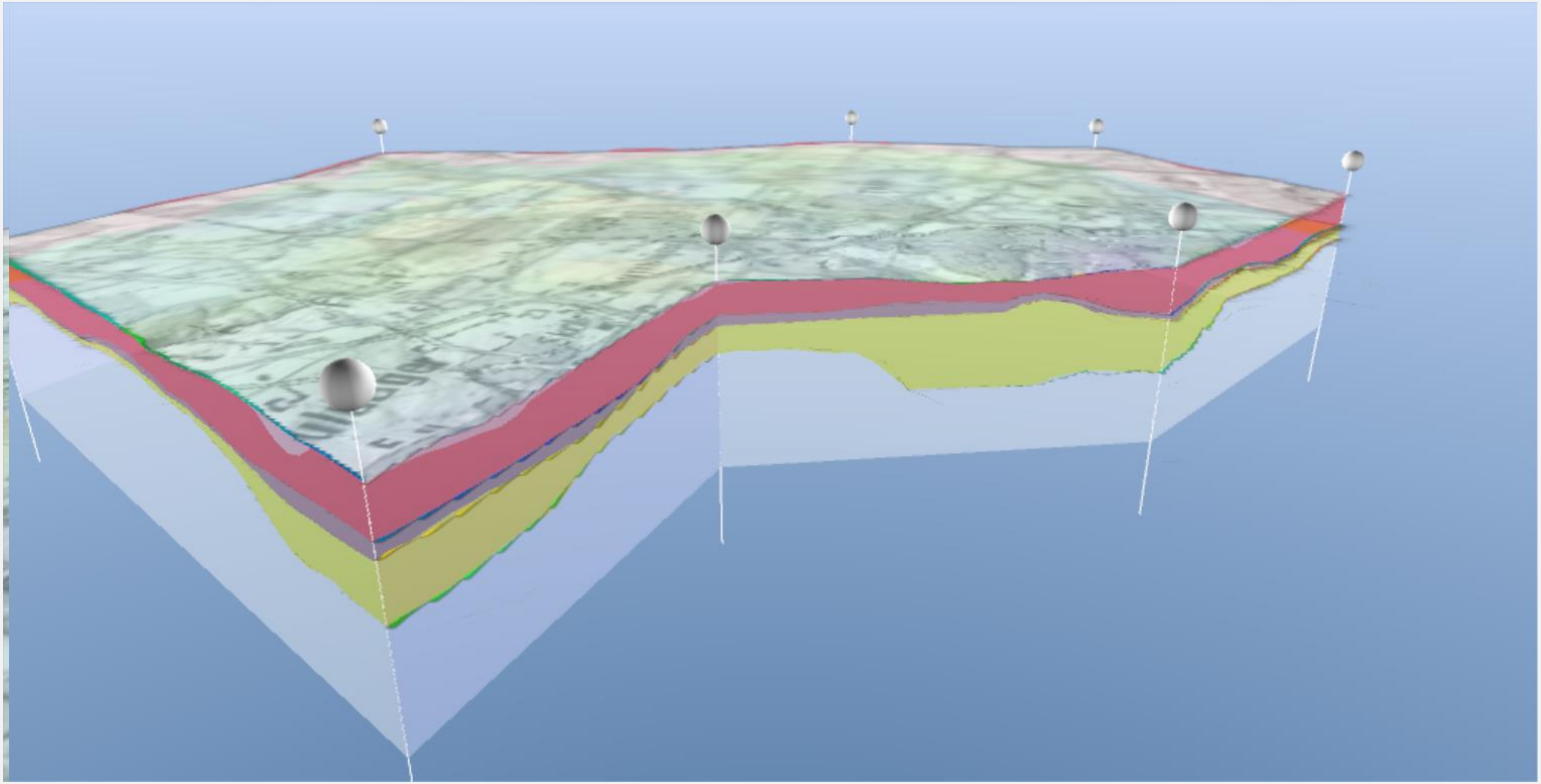
3D Geological Modelling



Combining information example…
Non-oxidated groundwater indicates protected reservoir…combined with well data, AEM and ERT this delineates the layer surfaces, the buried valley structure and the protecting clay cover layer

Lesson: Get all data into one environment
Lesson: Combine several data types in your modelling work

3D Geological Modelling



Lessons from building 3D Model regional hydro geological model

- an iterative and interdiciplinary process
- Combines many different geoscience disciplines (chemistry, geophysics, hydrology, geology, GIS)
- A staff with a variety of skills is needed

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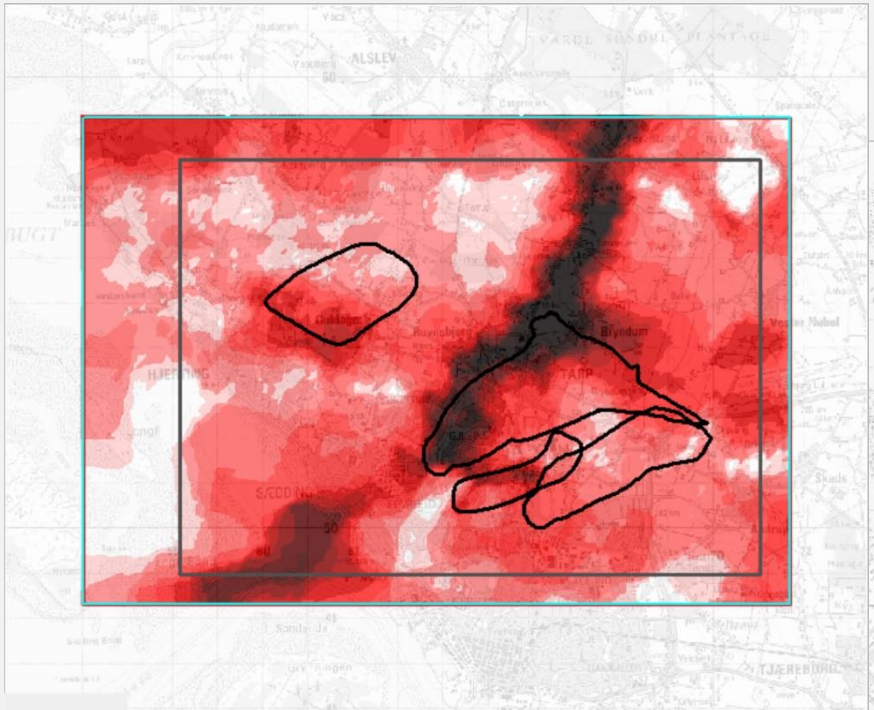
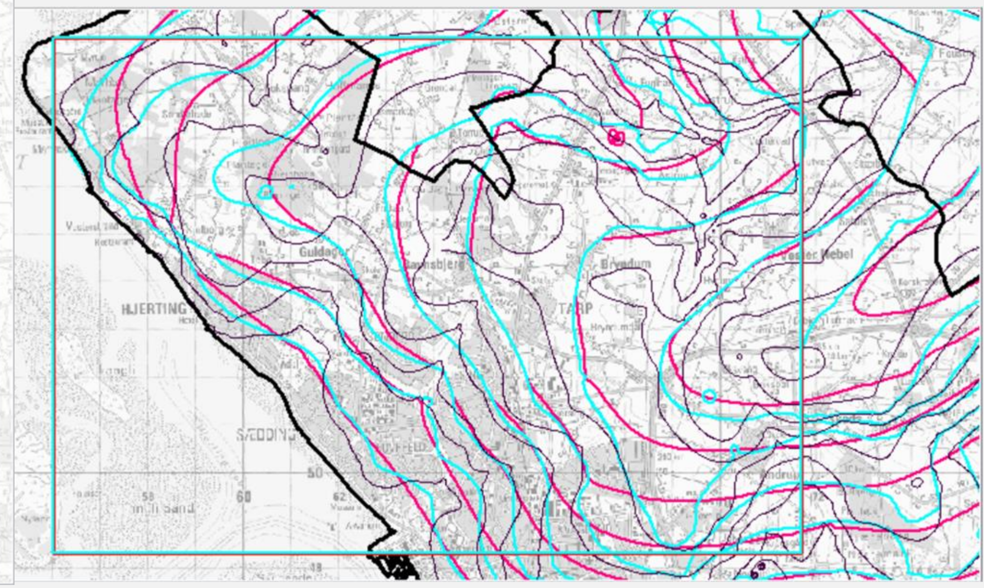
3D Geological Modelling





Some usages of the 3D hydrogeological model
Directly : Reservoir thickness, volumetric calc., protection from pesticides, new well locations, urban development

Reservoir specific Potentiometric Maps: Used for screening of pumping impact, e.g. streams or other pumps, general managing the resource

Export to flow modelling: For further processing, e.g. in MODFLOW, Mike She or similar…

Lesson: The 3D conceptual model is used on its own – and is the foundation for several derivatives

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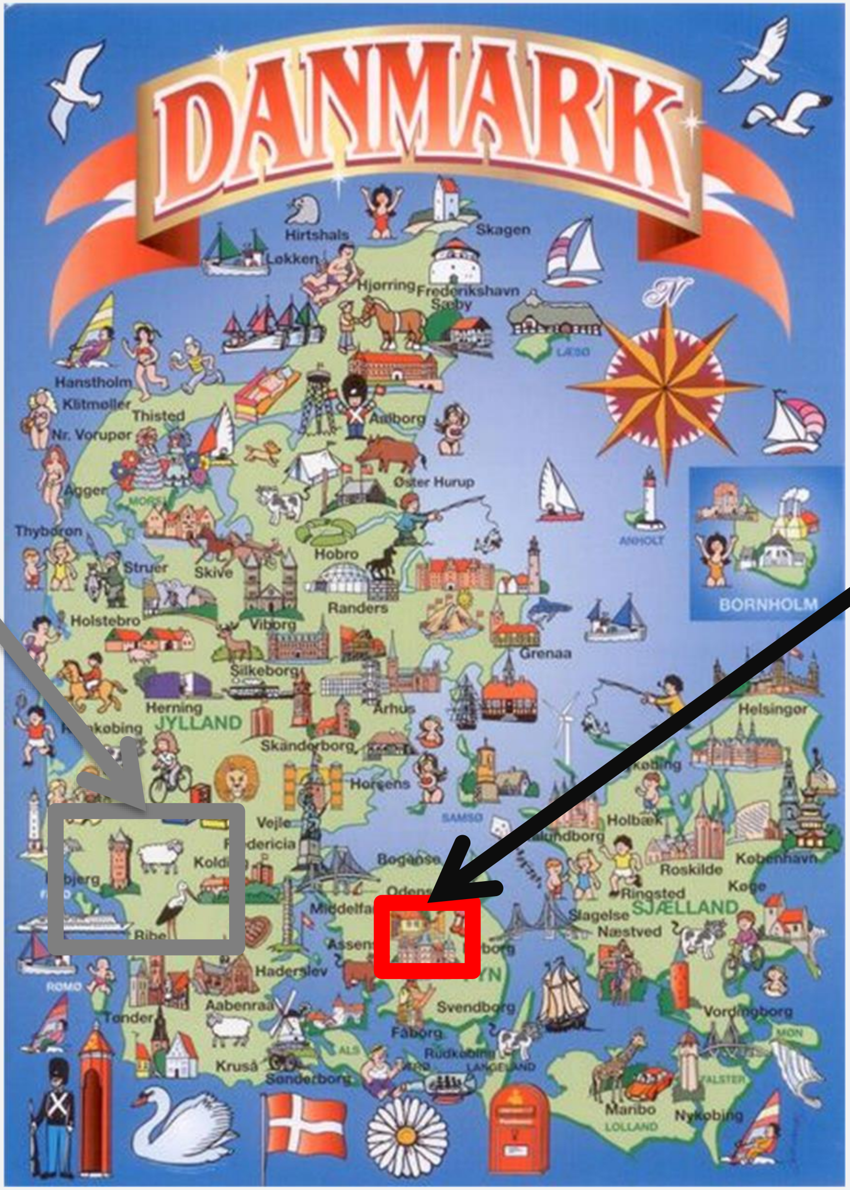

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MODEL TYPE
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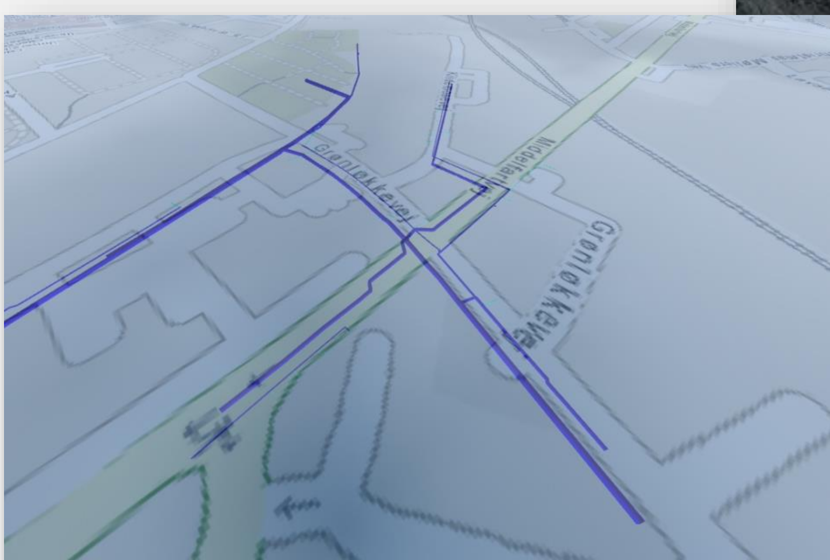
- Small Area – city block

Urban Modelling

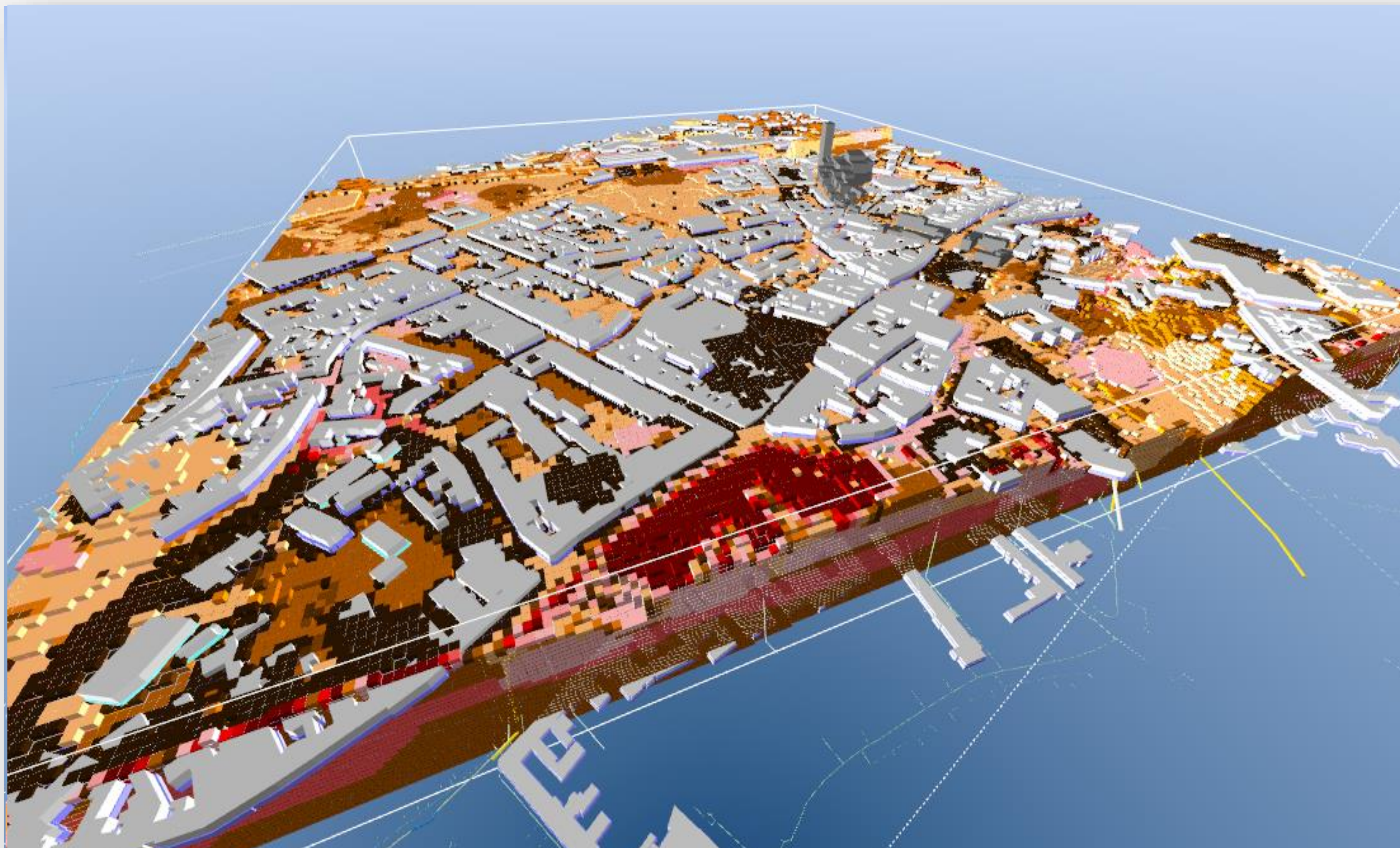
Urban Environment

- The geology is “man made”
- Other data types
  - Standard GIS data (roads, houses, sewers…)
  - Dual-EM geophysical data
  - Well and Log data



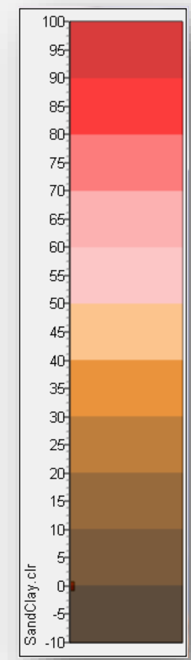
Urban Modelling Example

1. Interpolation of log and geophysical data into sand/clay fraction cells
2. Usage of GIS information to model man made structures



5. Bygninger og øvrige strukturelle elementer indarbejdes. Lagflader fra regional model indlæses og voxeleres

Voxler: 5x5x0,5 m

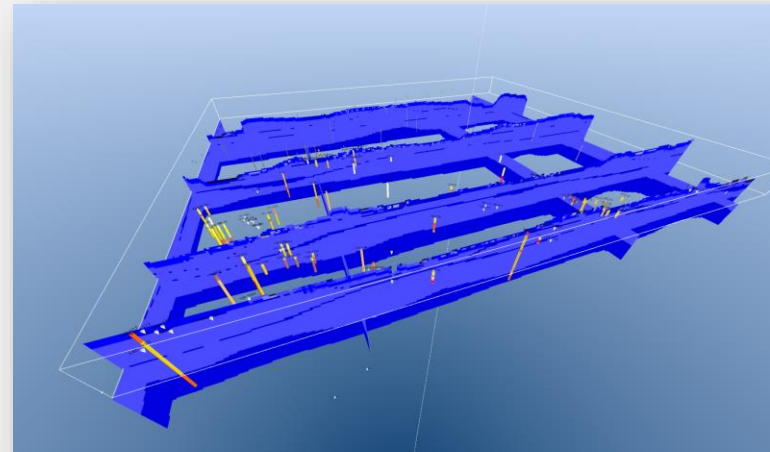


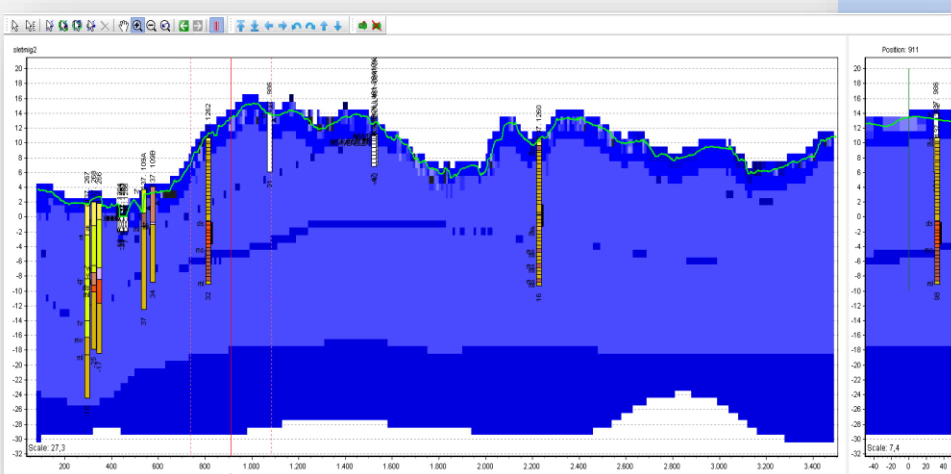
Urban Modelling Example

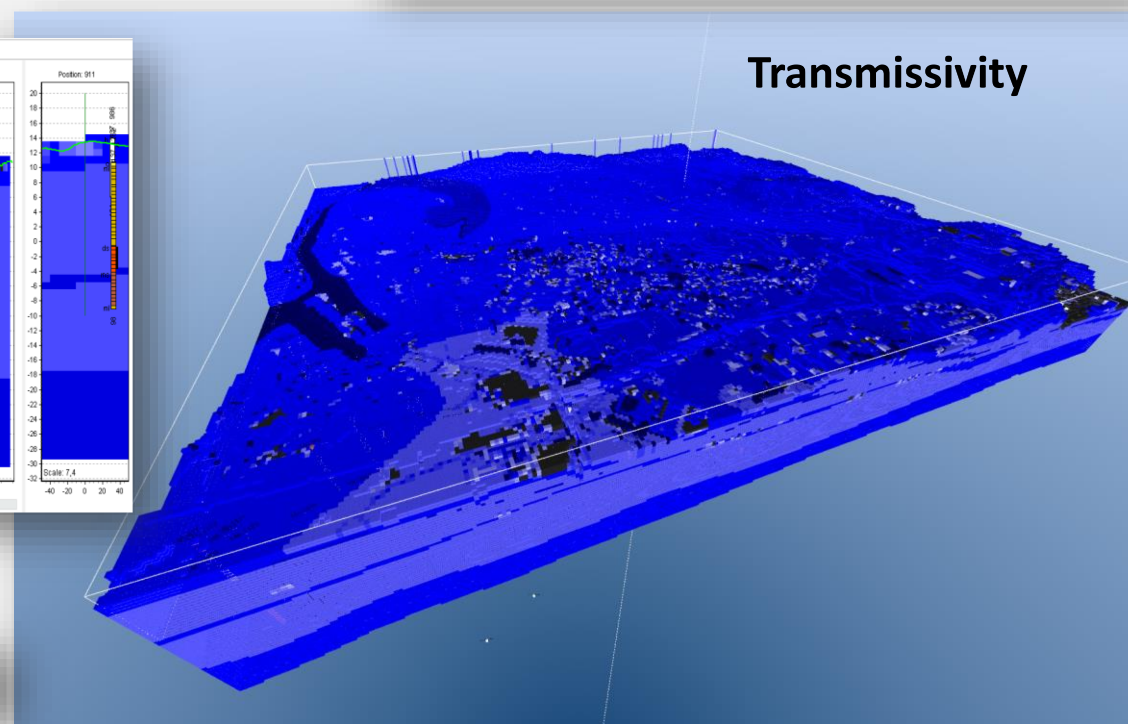
Usages of an Urban Voxel Model

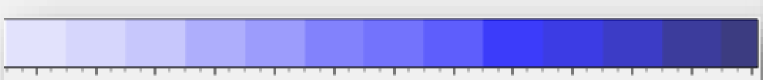
- Local infiltration of storm water
- Location of contamination path ways
- Protection of Groundwater
- City planning and development

Lesson: Geology can be man made





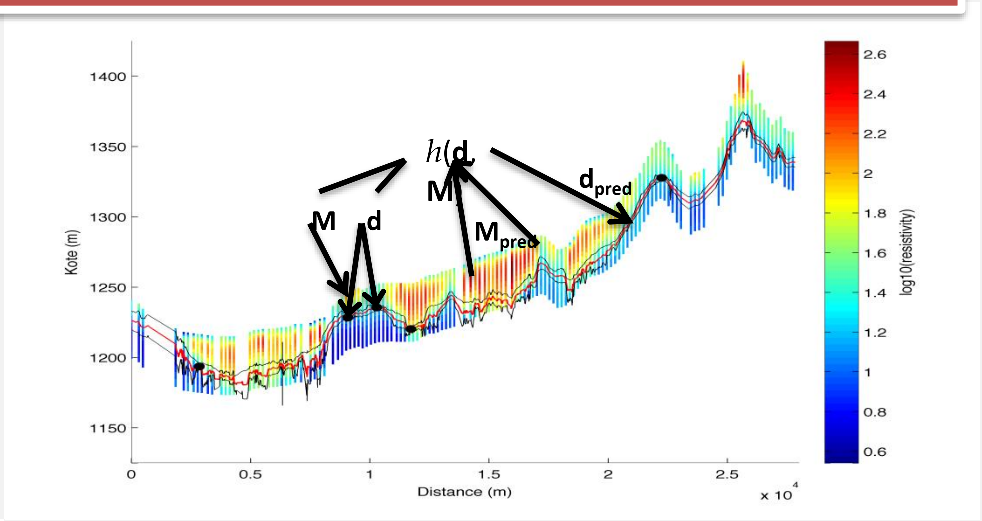




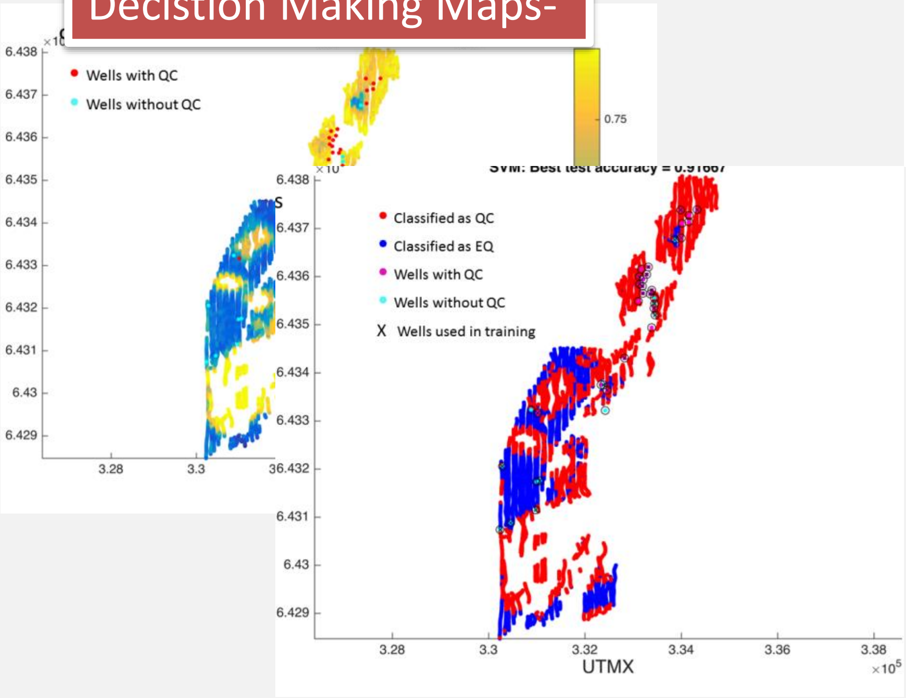
Future of 3D modelling

Machine Learning

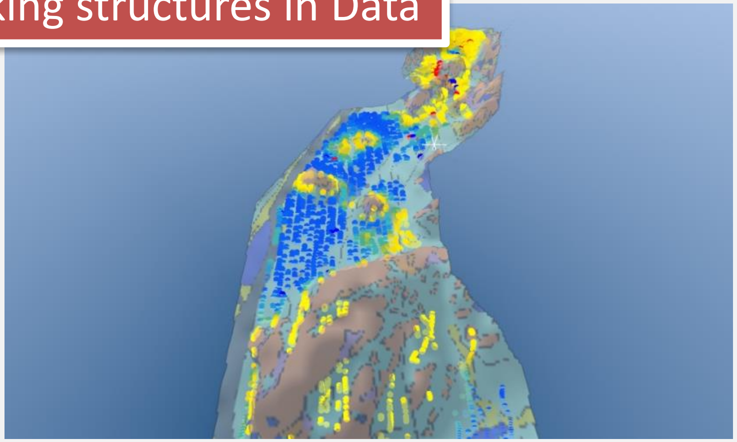
Automated Layer Modelling of AEM – Smart interpretation



Decistion Making Maps-



Seeking structures in Data



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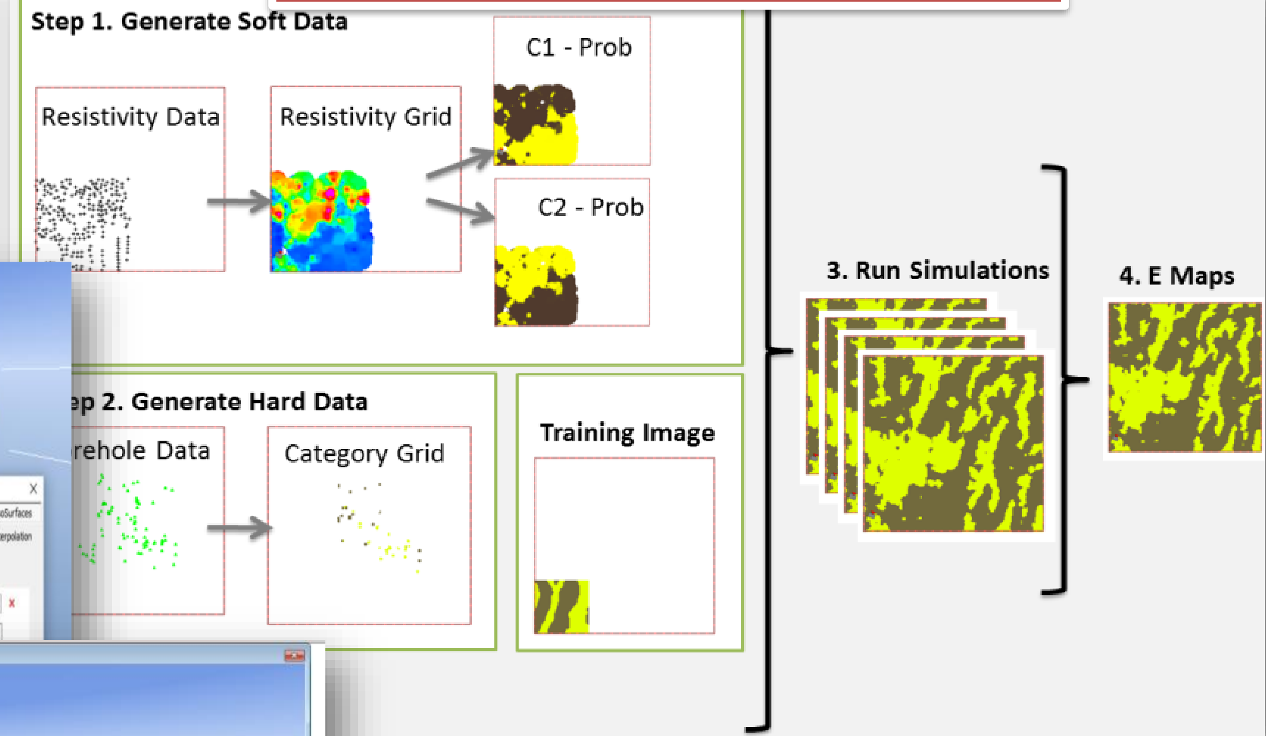
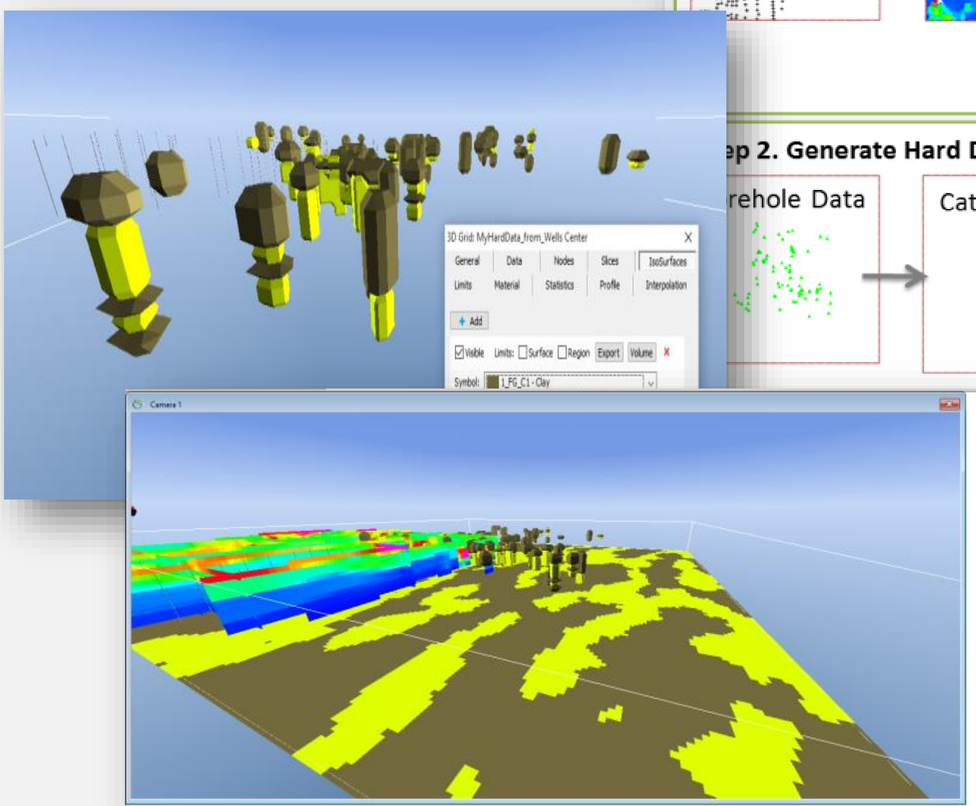
Future of 3D modelling

Multiple Point Statistics

Statistical merging of data into models





Merging information in a “probabilistic” sence

Estimating Geological Uncertainty

Modelling fine scale inheterogeniety

Summary

The 3D Modelling Process

- Build a 3D conceptual model - the flow model will miss structural details
- A multidisciplinary iterative workflow - combine all information into one environment
  - *Facilitates collaboration between the hydrologist, hydrogeologist, geochemist and geophysicist*

Data Management

- Collect data to a central Data Management Storage system
  - *Start simple – and build it from there*
- Secure the end results – with background data - in your DMS system
- Plan to revisit your work later – when new tools or methods become available

Geophysics

- Provides essential information on structure
- Understand the geophysical methods powers – and weaknesses
- Combine different data types – “*one shoe doesn't fit all*”

Embrace change!