ESF Project „*Establishment of interdisciplinary scientist group and modelling system for groundwater research*”

Geometrical model of the Baltic artesian basin

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Contents of presentation

1. Description of Baltic artesian basin
2. Algorithms of geometrical structure model
3. Highlights of geometrical structure
4. Examples of groundwater flow model results
5. Summary

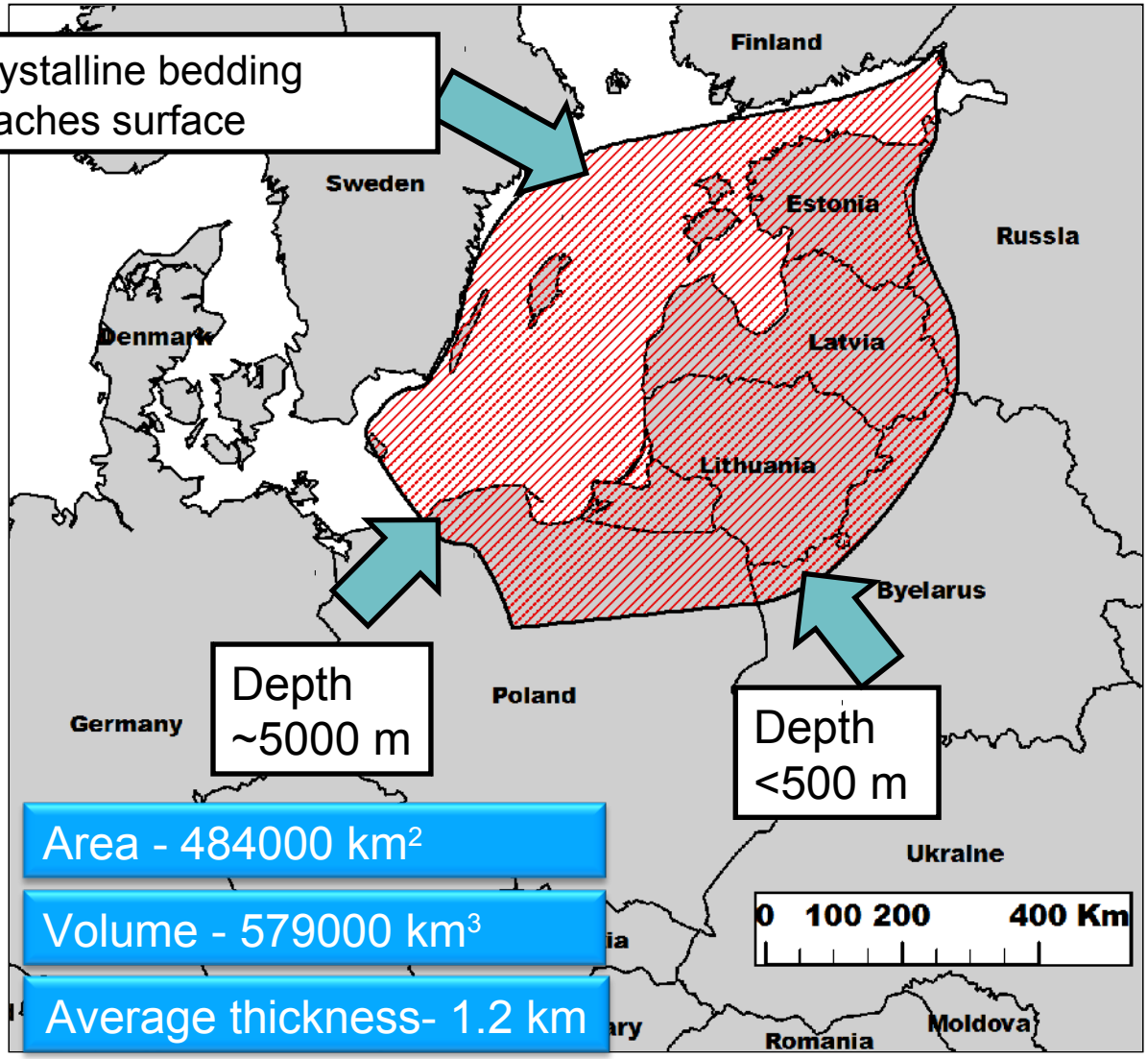
Motivation

There exist several local modelling studies of ground water flow for the parts of the Baltic artesian basin (BAB)

The aim of the present work is the development of a closed hydrogeological mathematical model of the whole BAB

This presentation focuses on the development of the geometrical model of the BAB

Area of study

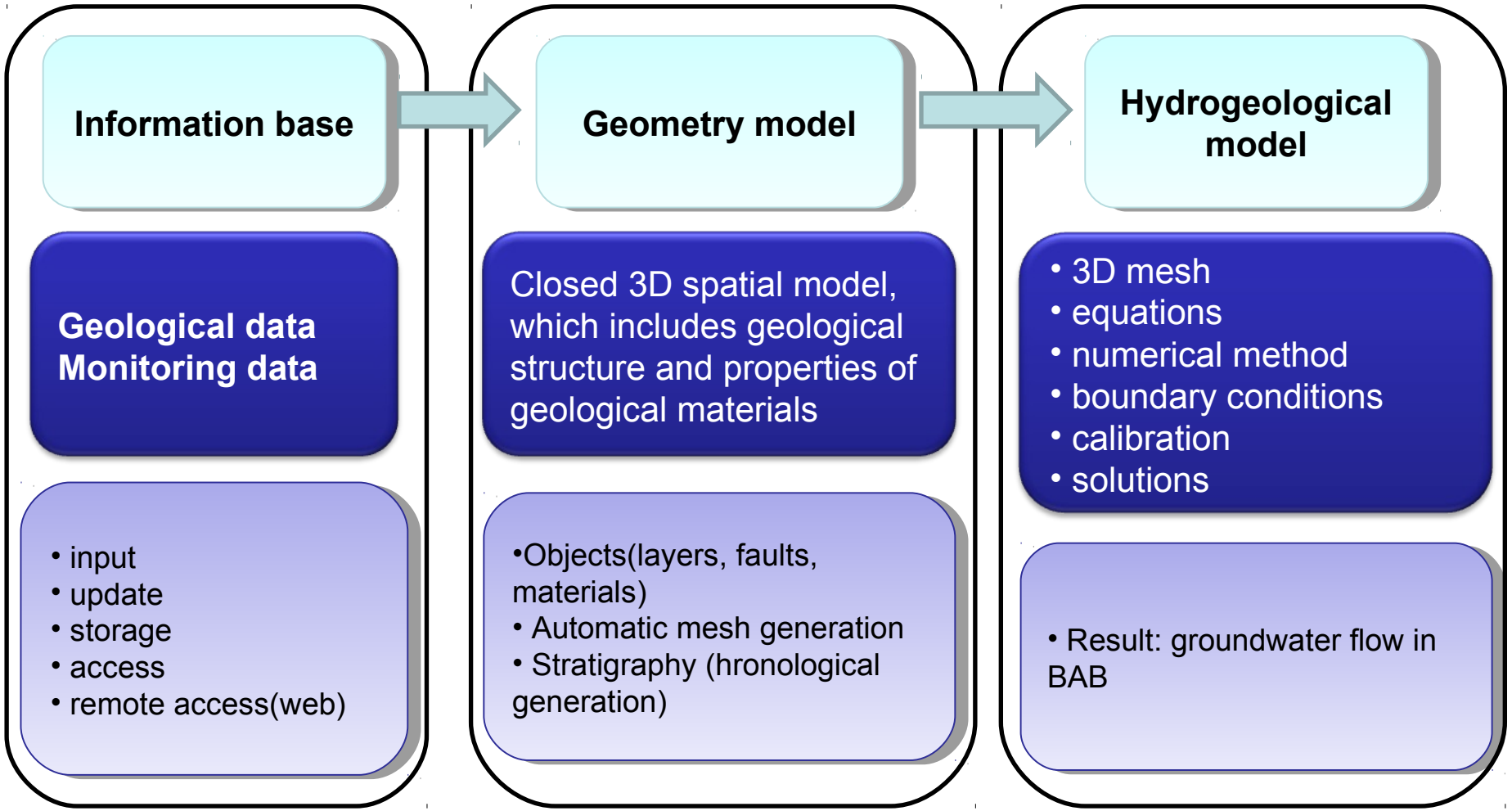


Baltic artesian basin (BAB) is a multi-layered and complex hydrogeological system up to 5000 m deep

BAB fully covers the territory of Latvia, Lithuania and Estonia, parts of Poland, Russia, Belarus as well as large area of the Baltic Sea, including island of Gotland.

It is the main drinking water source in the Baltic countries

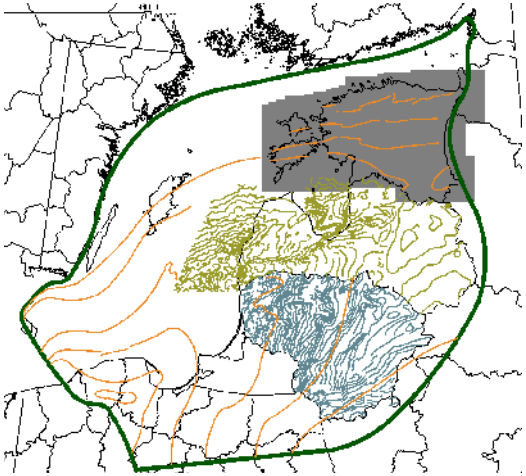
Scheme of integrated model system development

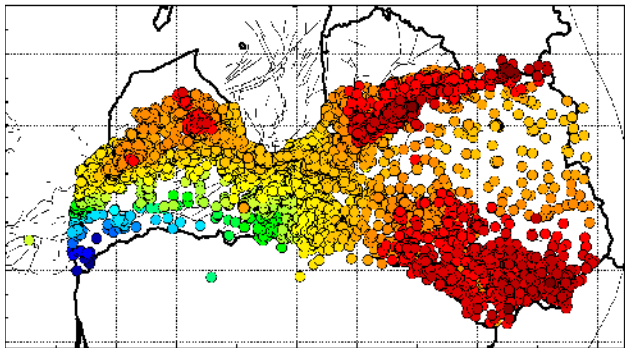


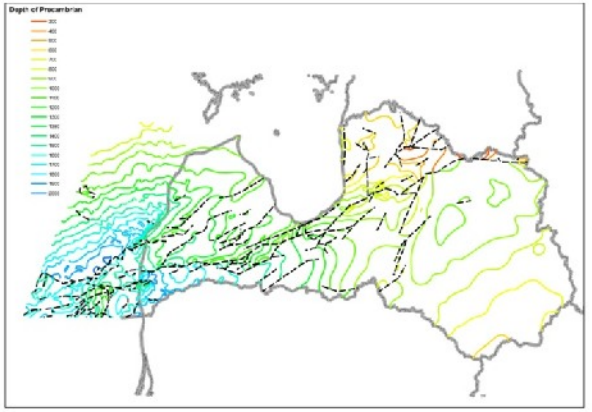
Data sources

Unification of the heterogeneous information from different sources with uneven data coverage, are performed. Algorithms are developed for this purpose considering the priority, importance and plausibility of each of each data sources in integrating topography and lithology data as well as borehole data

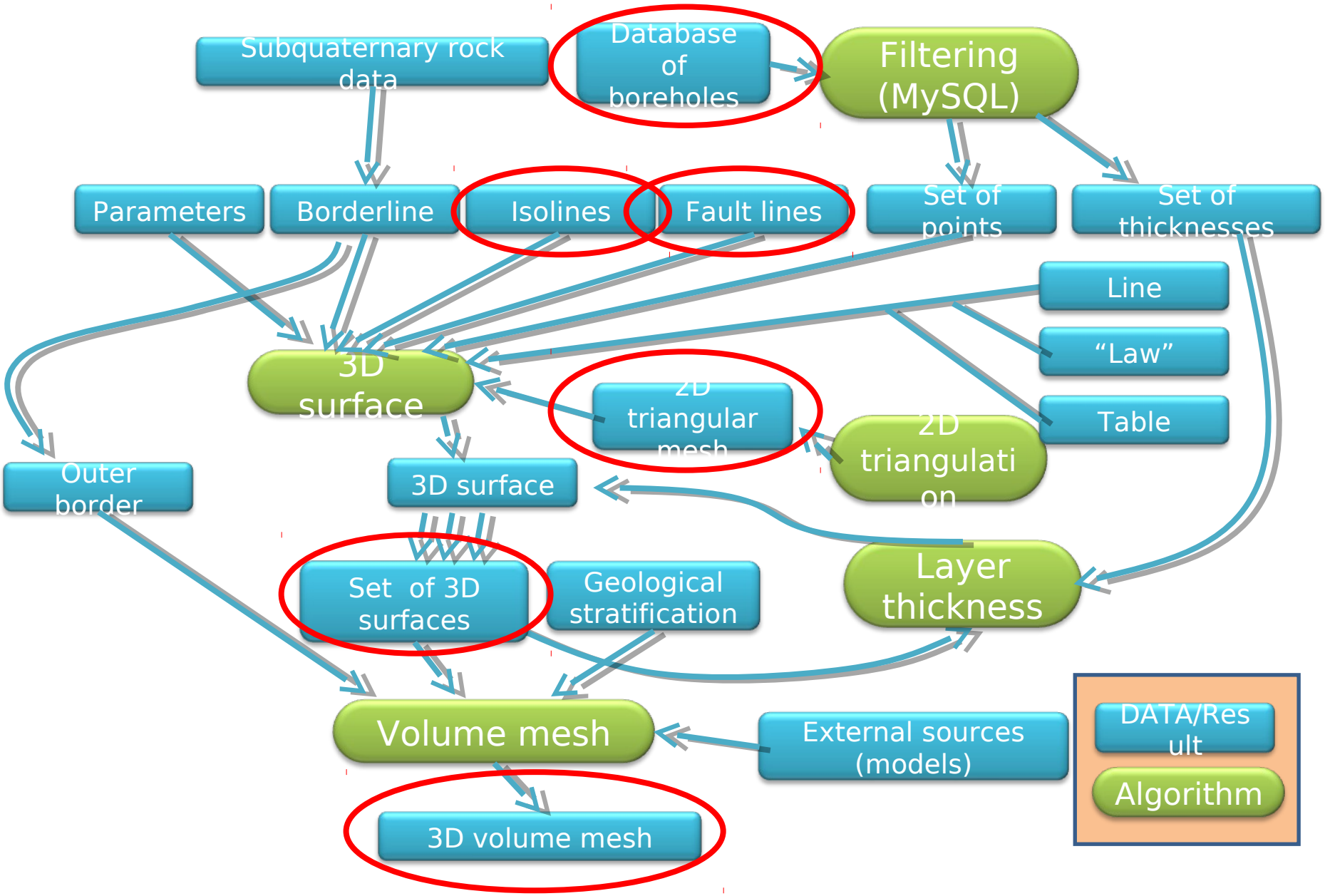
1. Stratigraphic information from boreholes in Latvia and Estonia
2. Maps of height isolines of geological layers for Latvia and Lithuania
3. Maps of sub-quaternary deposits in Latvia and Lithuania
4. Maps of fault lines on the crystalline basement surface in Latvia, Lithuania and Estonia
5. Buried valley data from Latvia and Estonia
6. Earth topography data
7. Baltic sea depth data
8. Data from published geological cross-sections, information from books and other sources.







Model construction algoritms

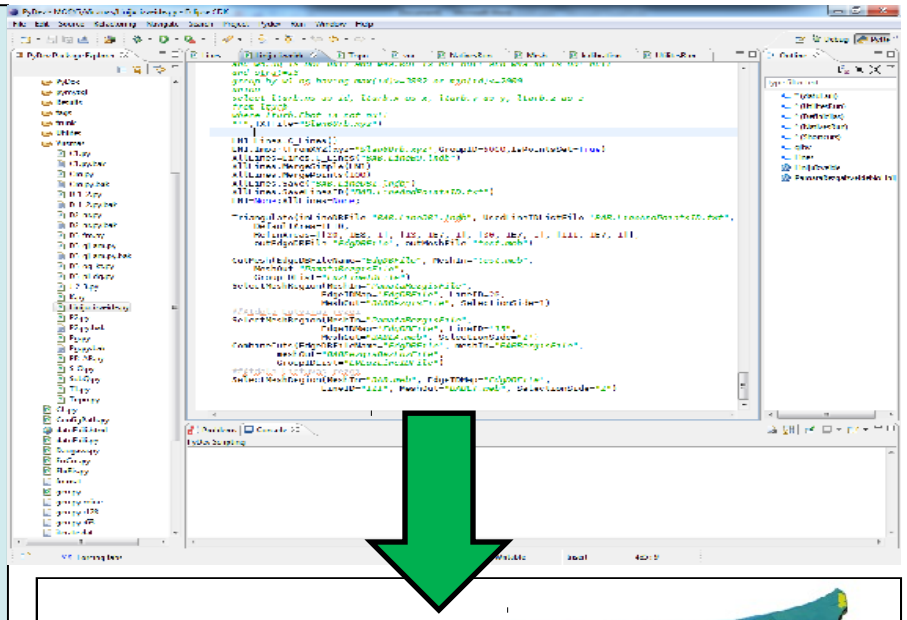


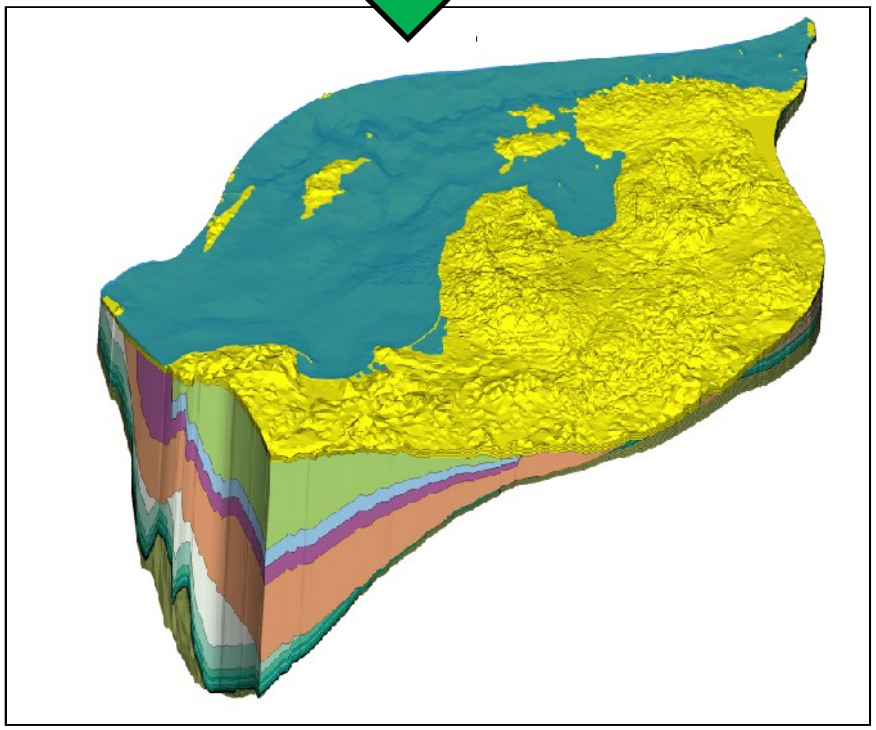
Geometry generation – automated scripting

The construction of the geometric mesh is implemented by specially developed script in Python.

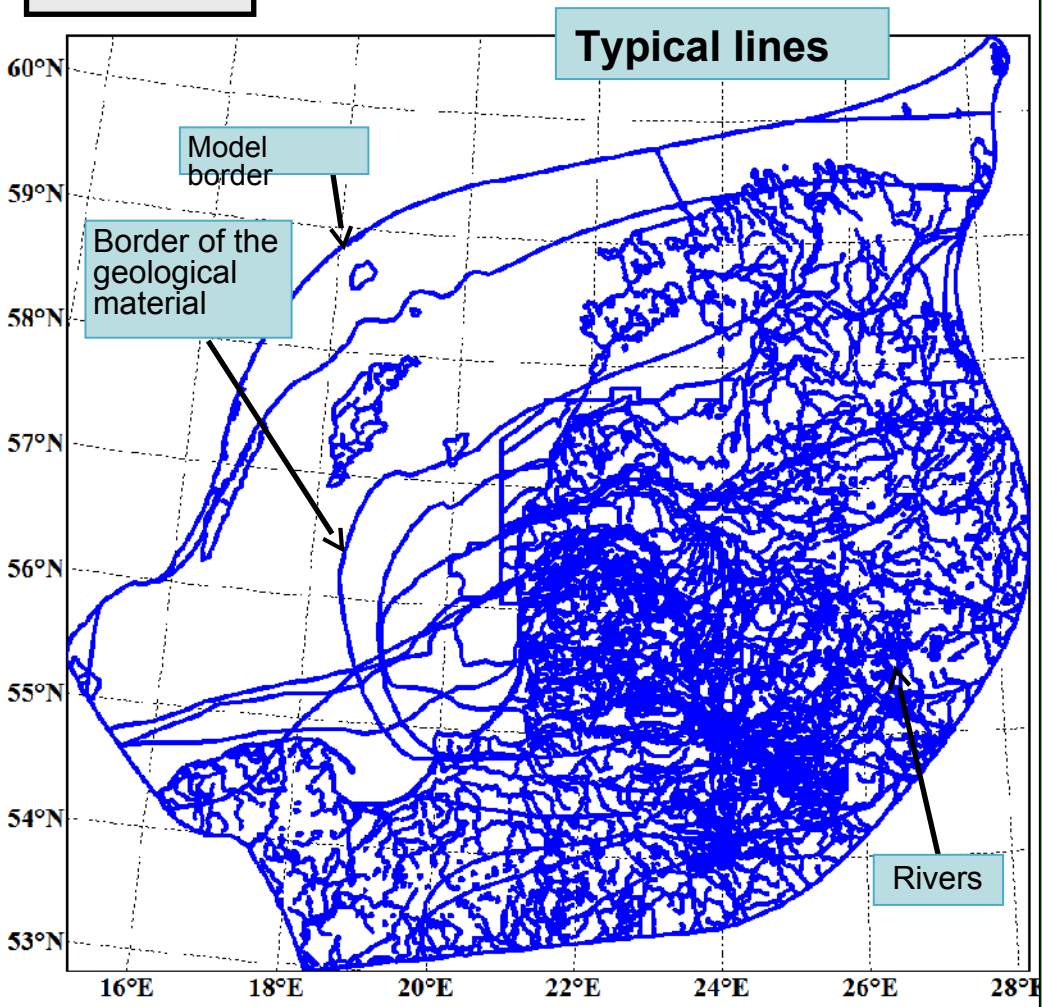
Scripting has several advantages:

1. flexibility in choosing ways to build the structure;
2. parallelization in developing/updating of different structure elements;
3. documented and repeatable structure building path;
4. possibility to rebuild the structure with slight or significant modifications at any time;
5. possibility to build, and maintain several structures of different complexity simultaneously;
6. extension to the next stages of the model development – calculation of groundwater flows and mass transport and model [auto]calibration.





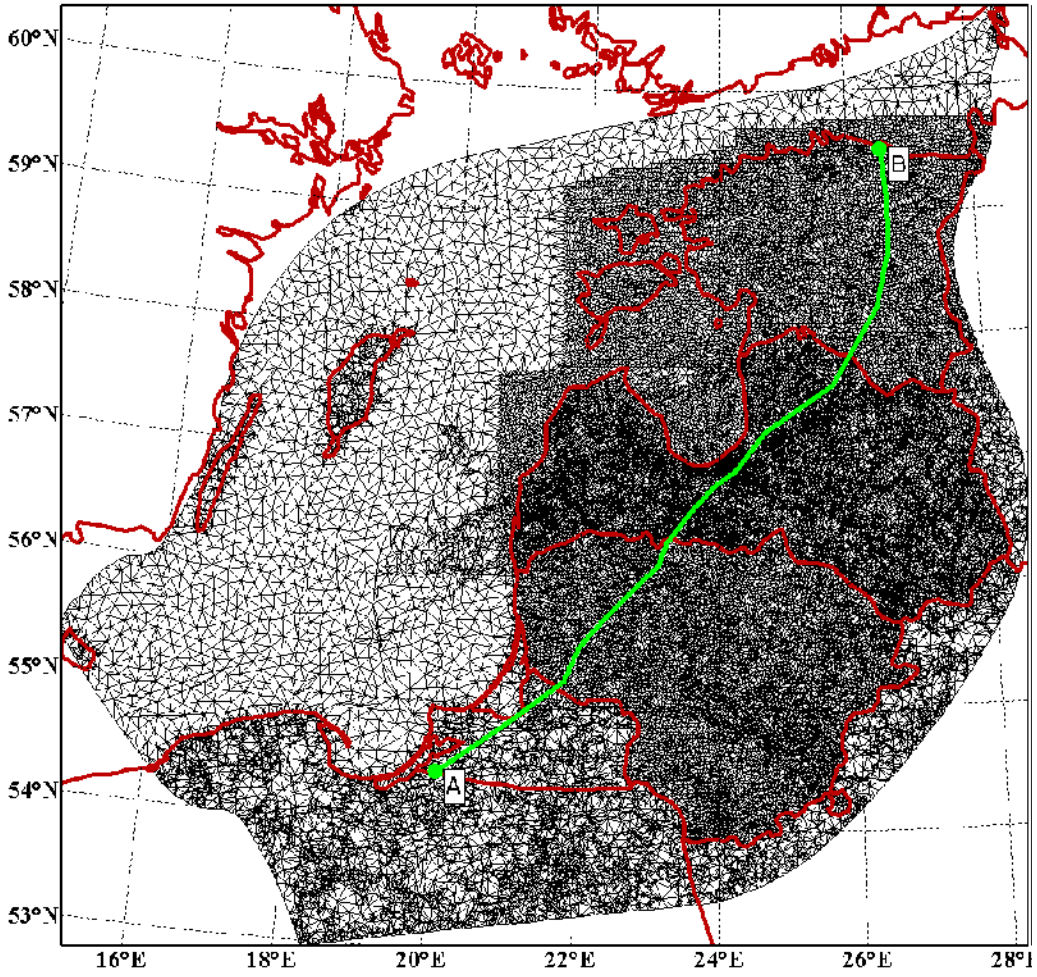
Mesh



Edges of triangular mesh coincide with the line data

- Finite element (FE) method was employed for the calculation of the 3-dimensional groundwater flows with free surface.
- 3D mesh was constructed layer-wise.
- The triangular mesh in horizontal plane was constructed including characteristic lines such as rivers, borders of countries and areas of presence of geological layers.
- Fault lines are also taken into account considering the displacements along the fault
- Most of the 3D finite elements are triangular prisms. Pyramids and tetrahedra are used near the fault lines and wedge lines of geological layers.

Mesh



Finite element mesh, view from the top.

Higher resolution of mesh in areas with sufficient geological data

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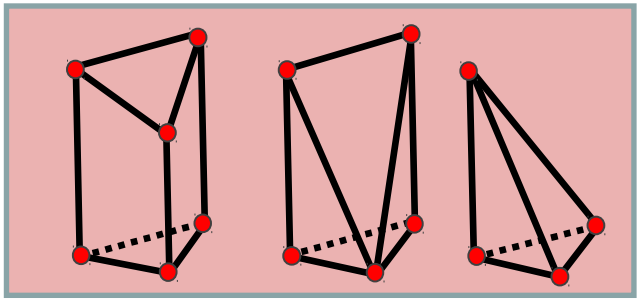
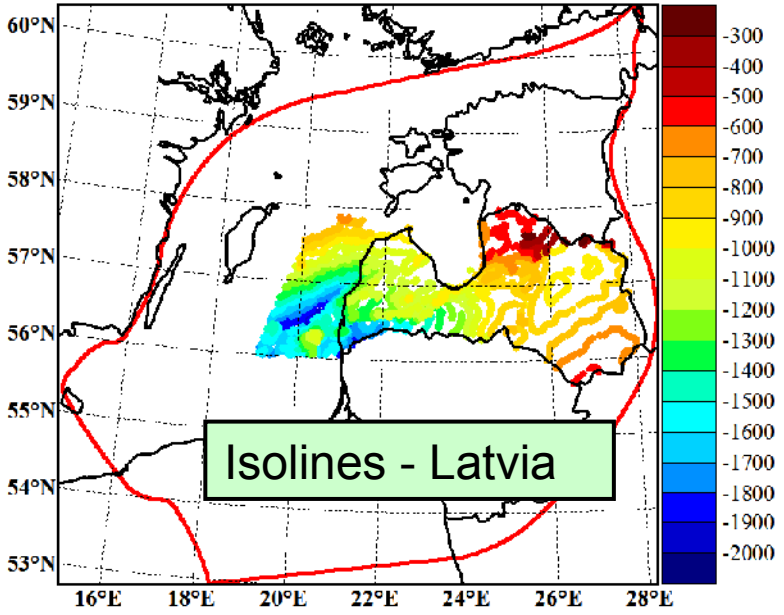
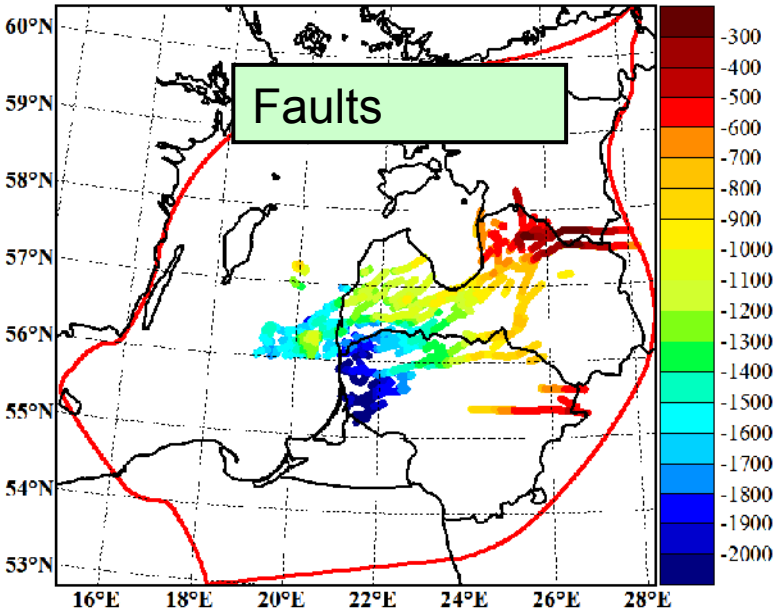
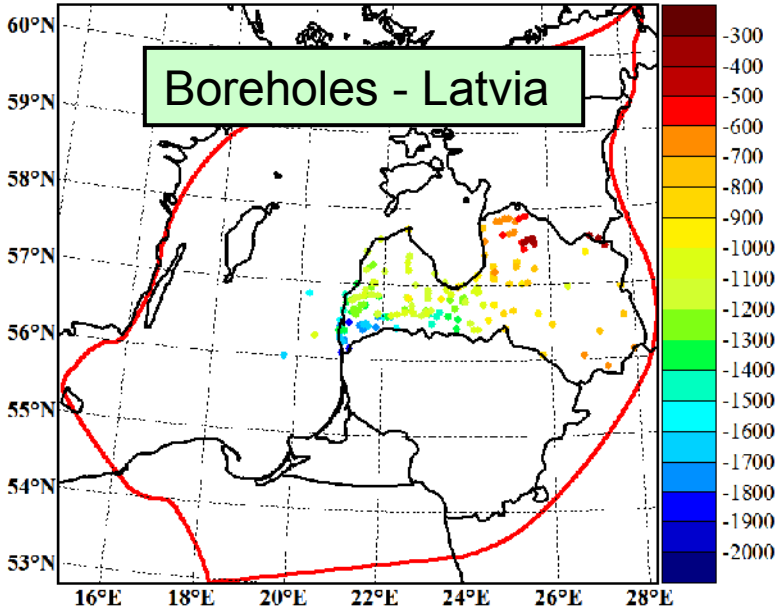
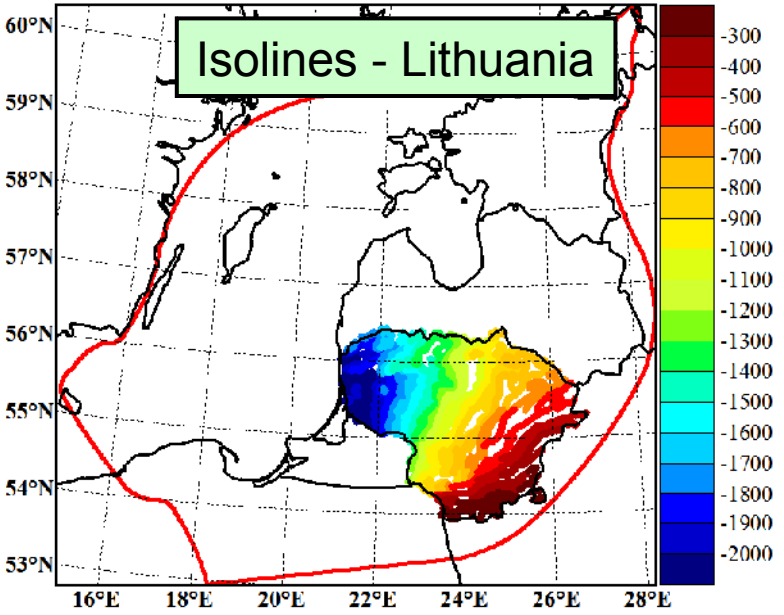


Example of model construction sequence – basement









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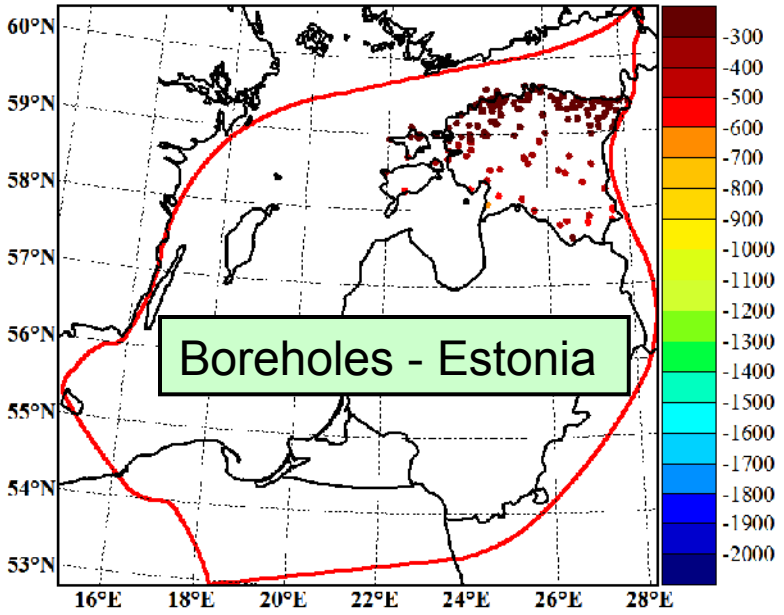

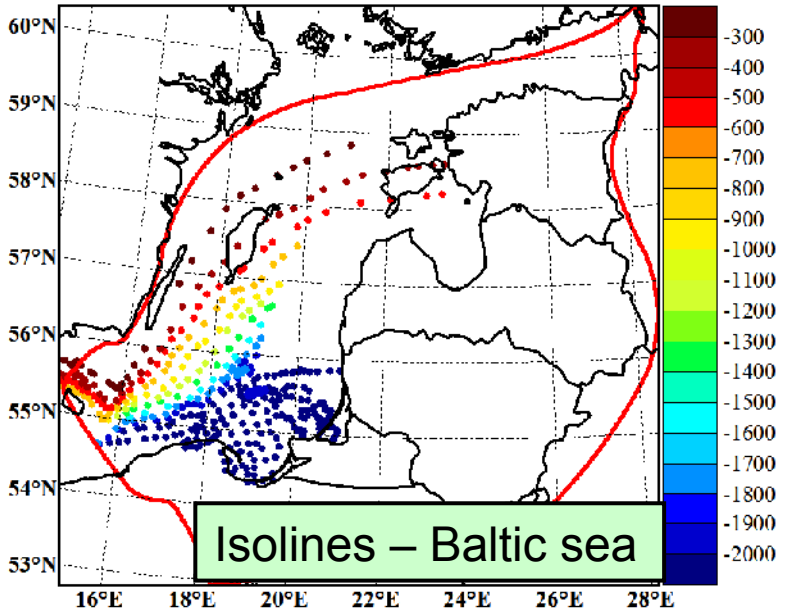

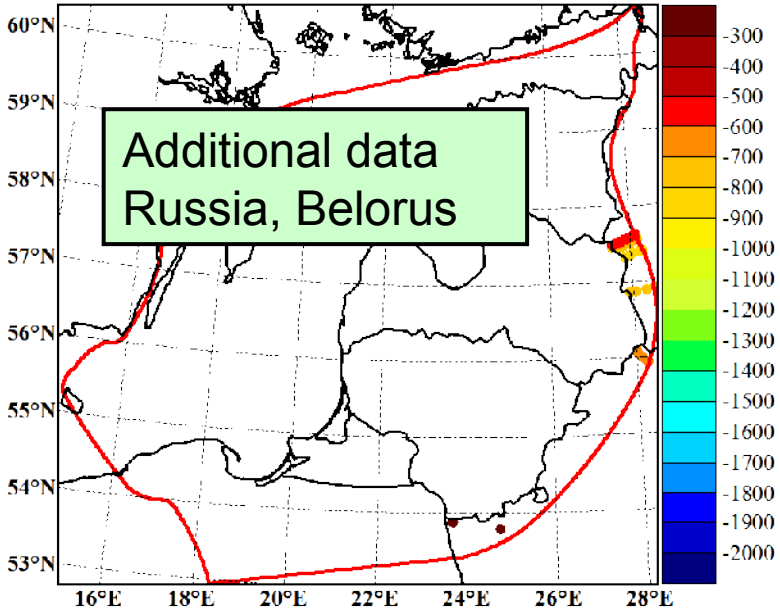

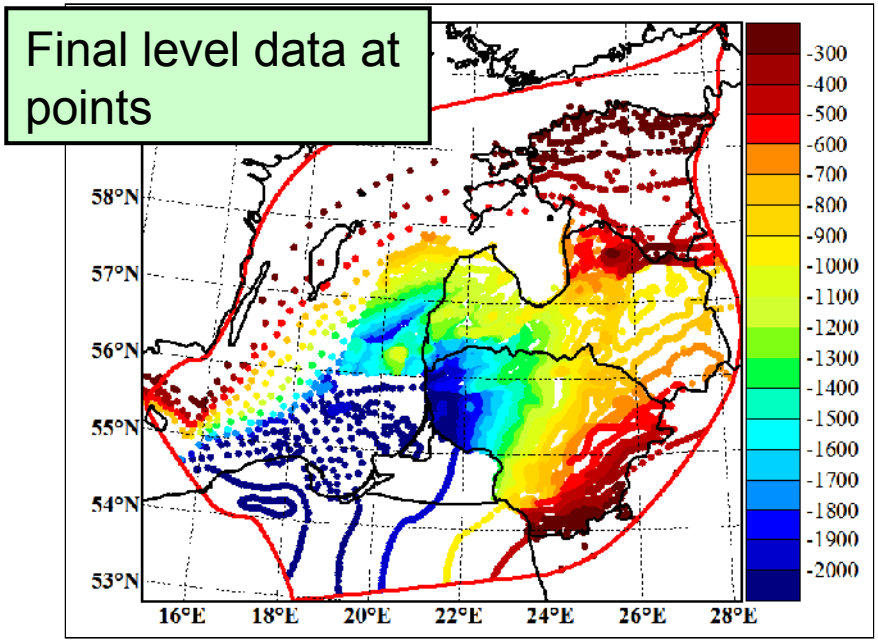

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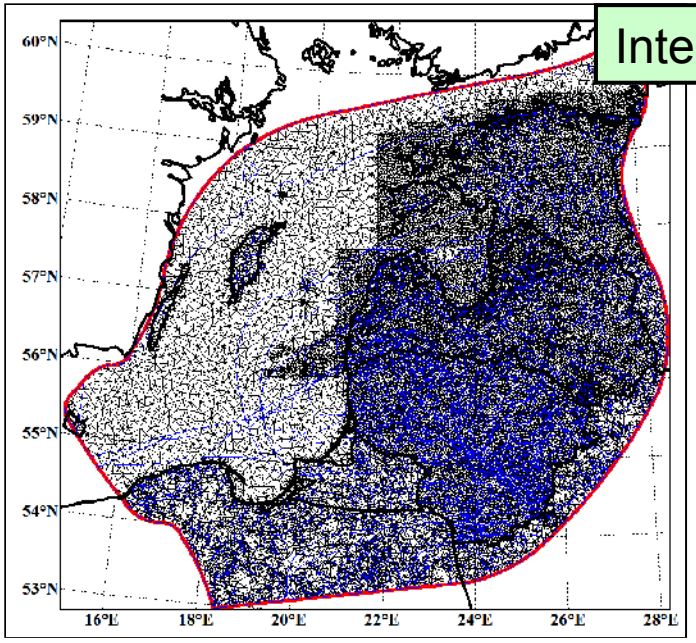
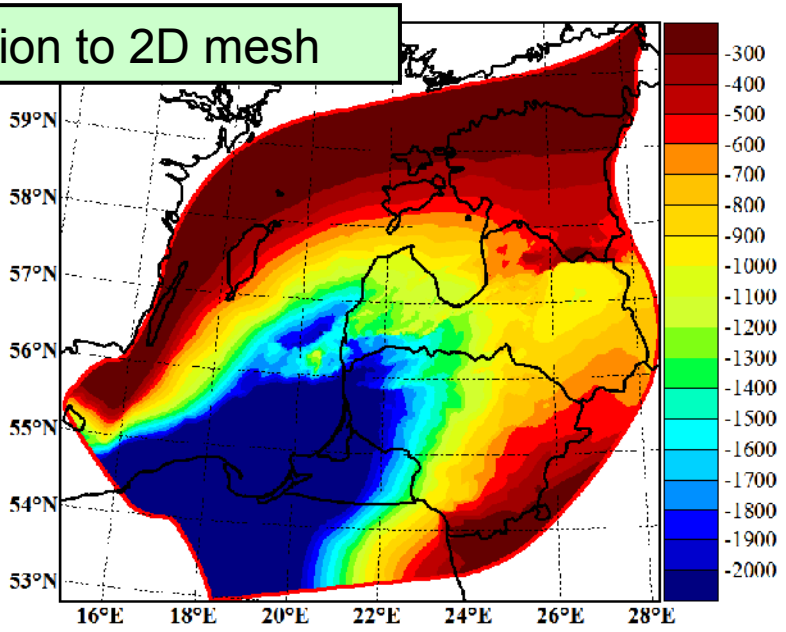
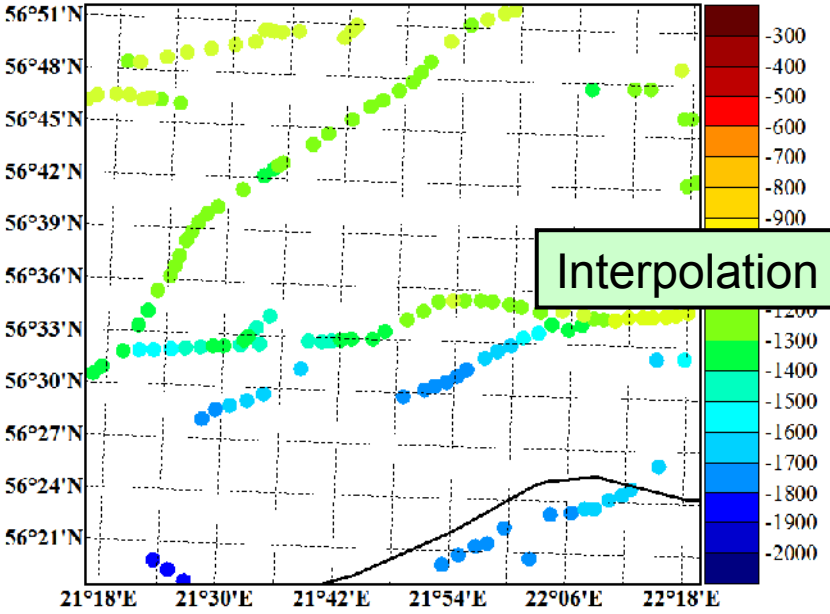
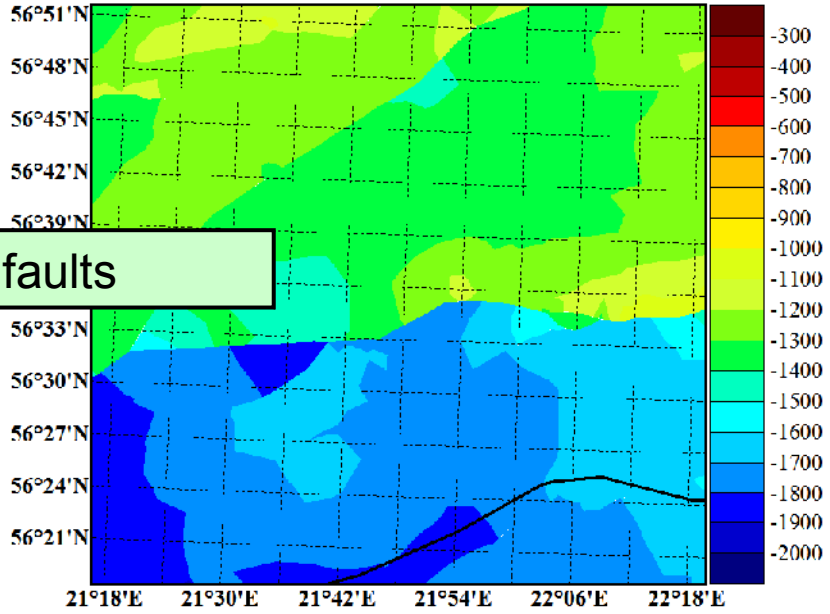


Interpolation to 2D mesh

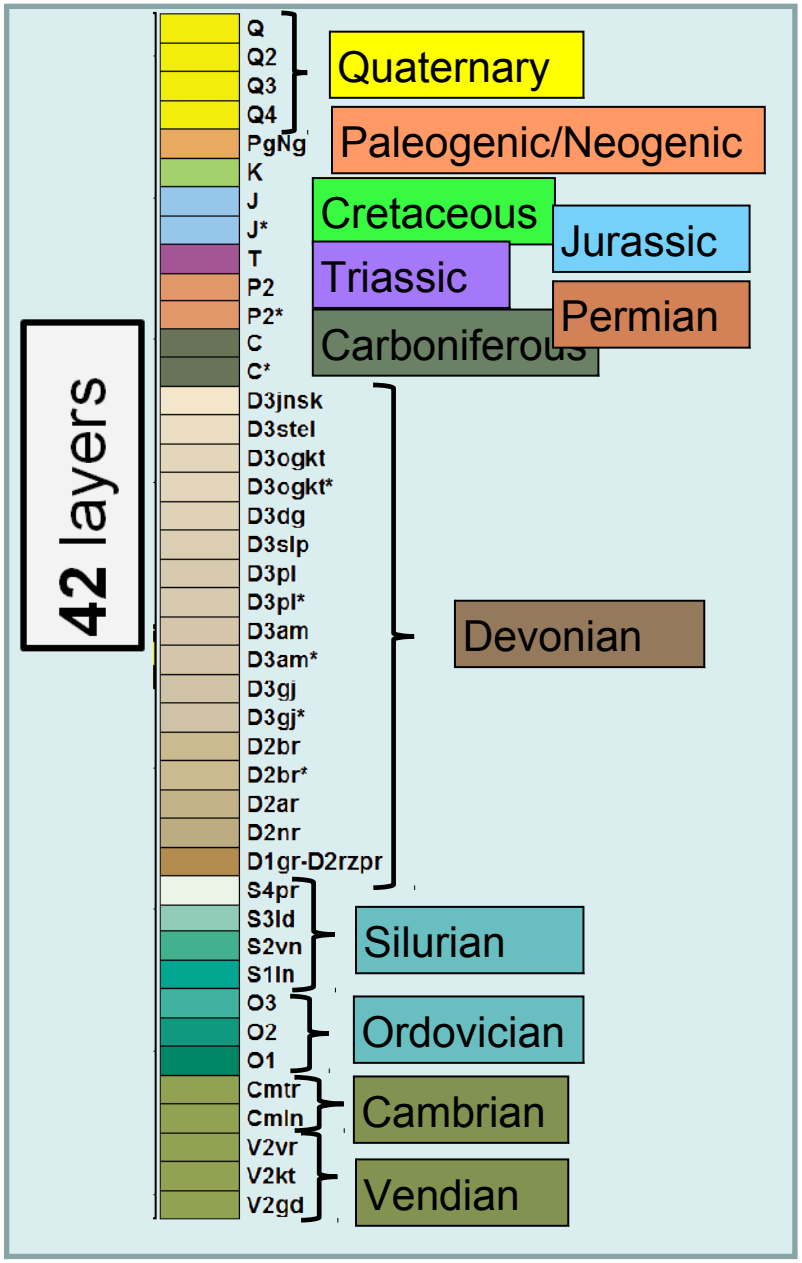




Interpolation of faults



Geological structure



Geological structure consists of 42 layers distinguished on the basis of each geological unit hydraulic properties and geological data resolution. The number of layers are allowed to vary across the domain.

It includes aquifers and aquitards from Vendian up to the Quaternary deposits.

Quaternary sequence is treated as four layer structure with variable number of layers across the domain.

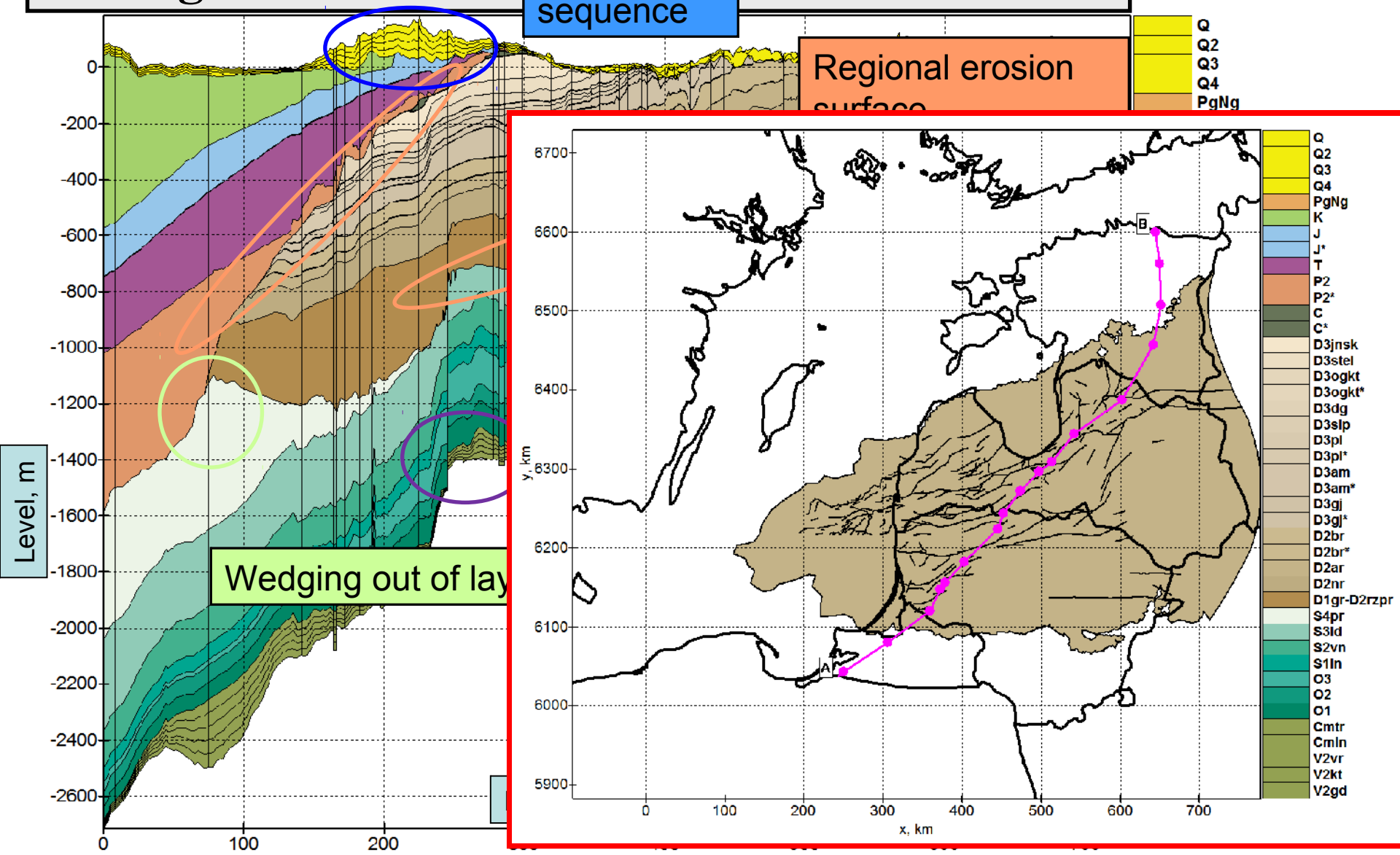
Fault displacements are incorporated into the model taking into account data from the published structural maps.

Four reconstructed regional erosion surfaces (upper Ordovician, Devonian, Permian and Quaternary) are included into the model.

Geological structure

Quaternary sequence

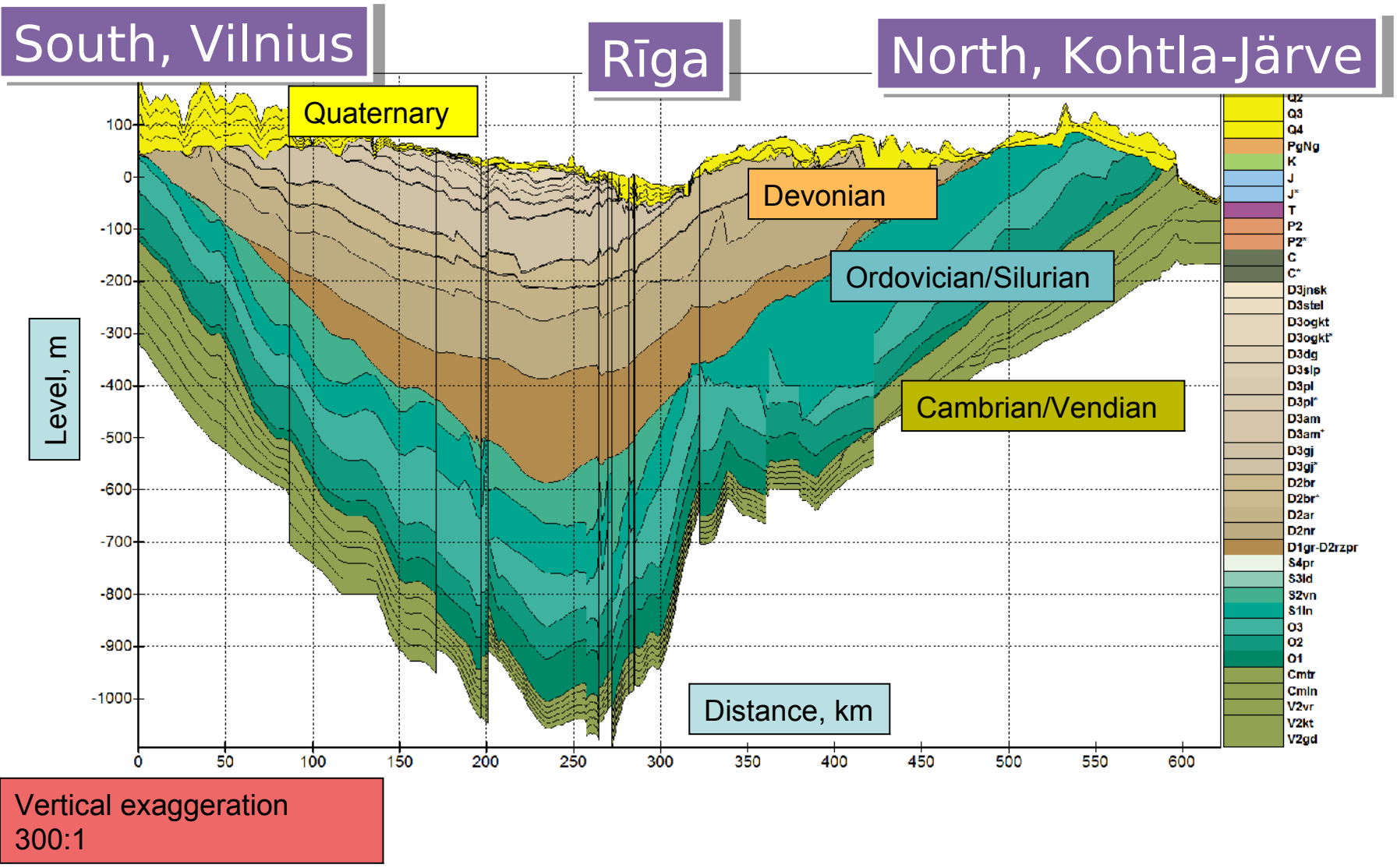
Regional erosion surface



Vertical exaggeration 200:1

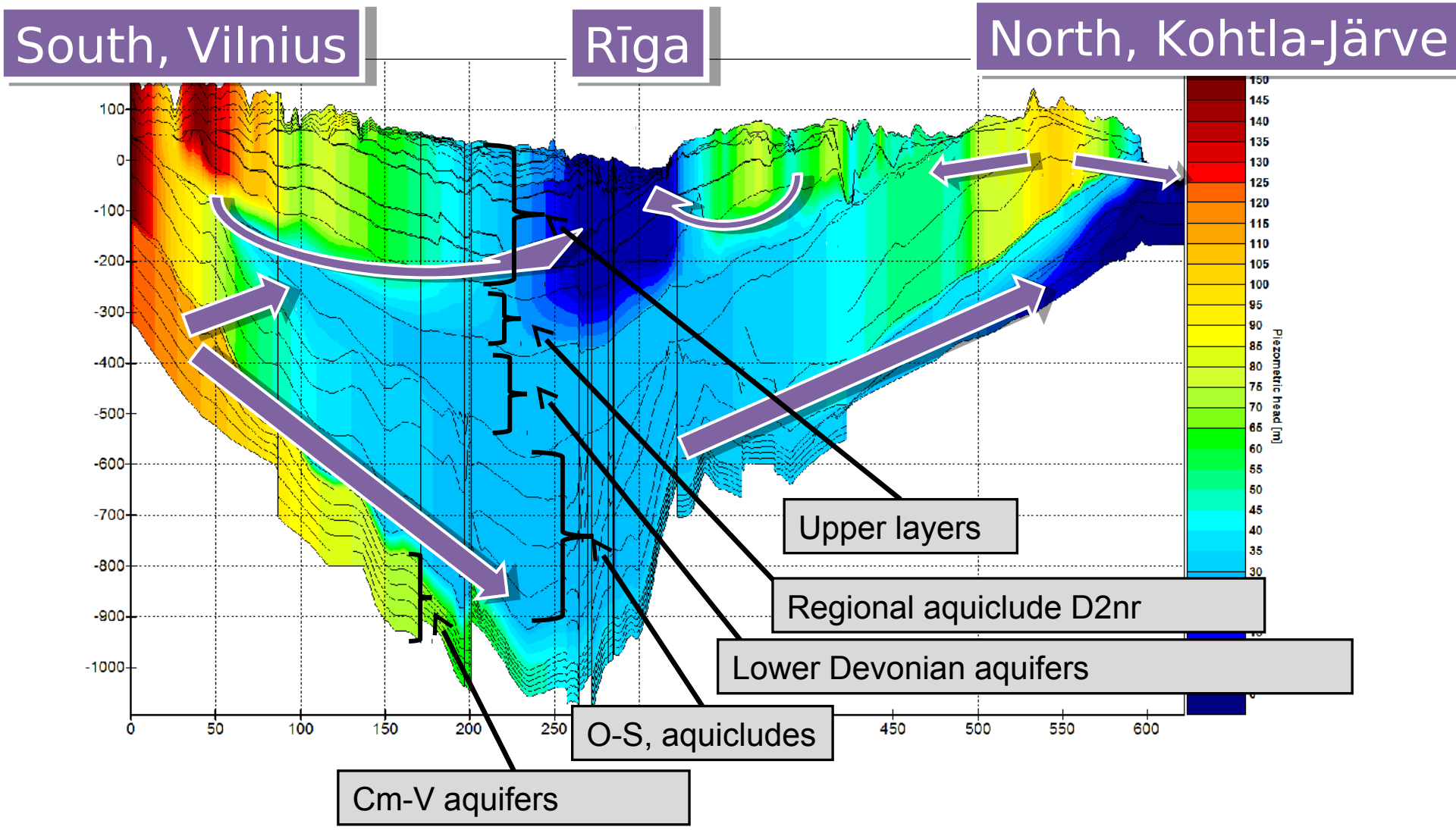
Vertical section from soutwest to northeast along line A-B

Vertical cross section from south to north

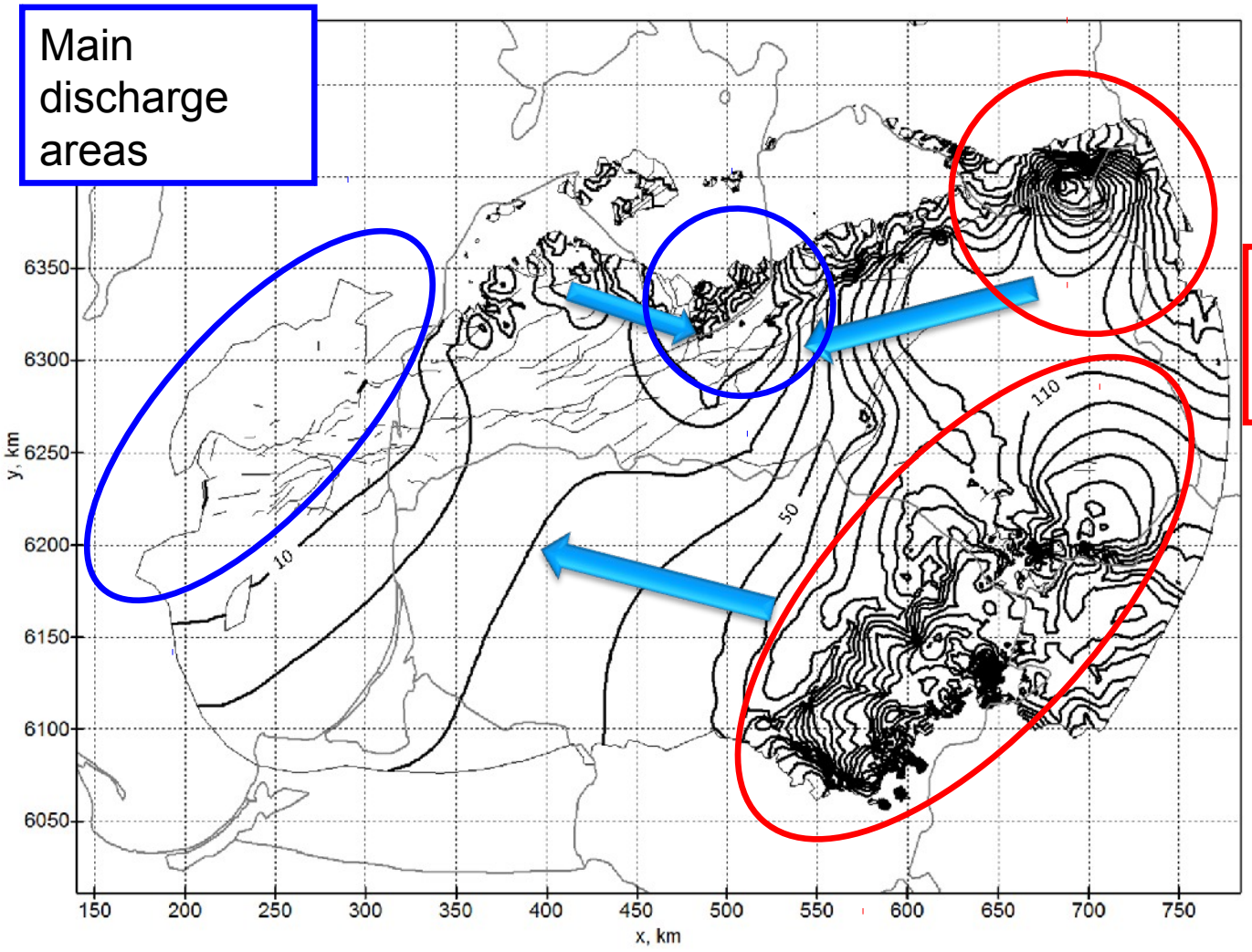


Vertical exaggeration
300:1

Distribution of piezometric head in south-north vertical crossection



Distribution of head in D3gj layer, schematic flow directions



Summary

Data for the bulding of regional model of Baltic artesian basin has been collected and prepared

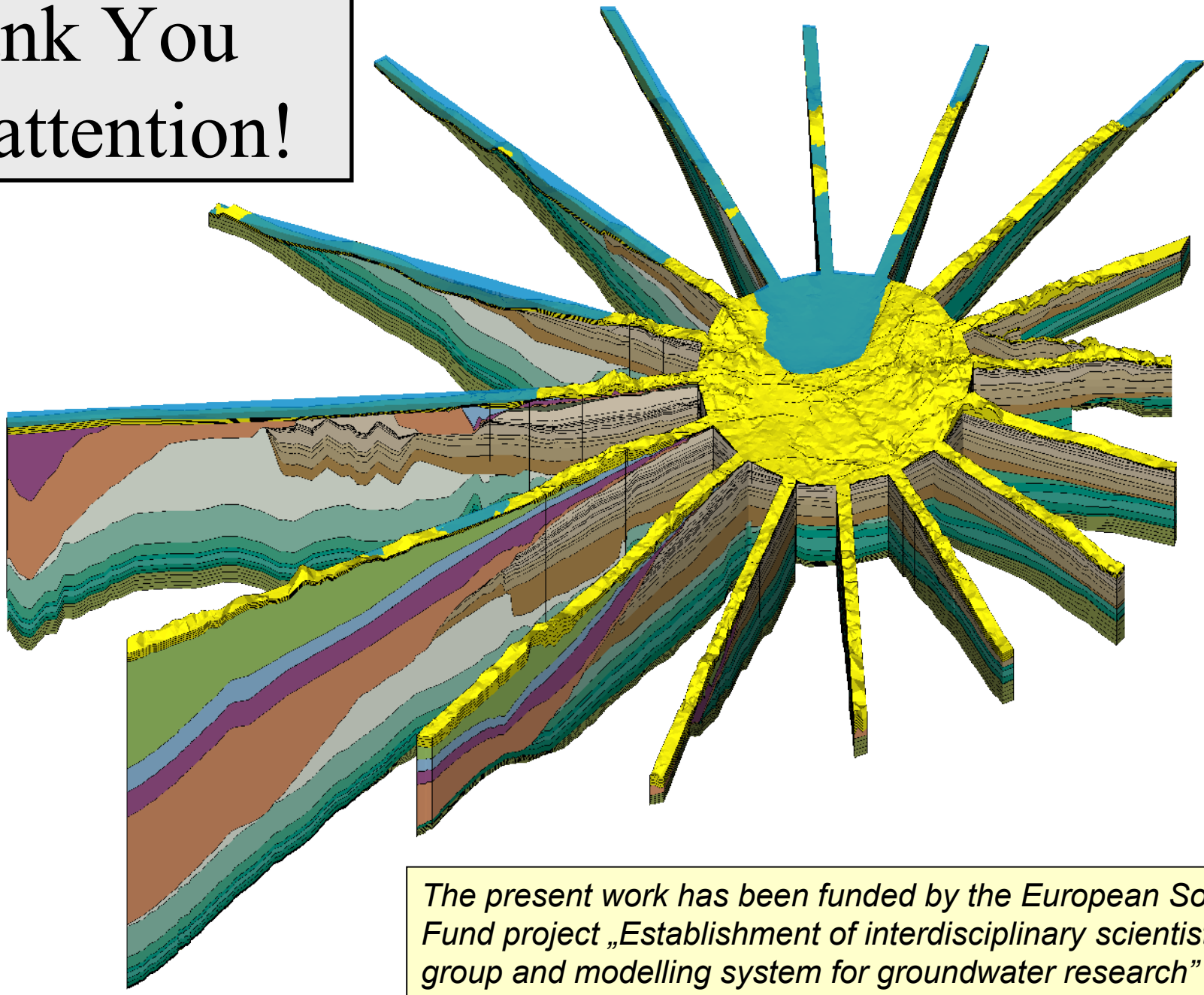
Geometry model of the Baltic artesian basin geological structure is developed, consisting of 42 layers

3D finite element mesh for the groundwater flow and mass transport calculations are prepared.

Automated script for the generation of the geological structure and 3D finite element mesh was prepared allowing for the paralel, repeatable and documented building of the model.

The present work has been funded by the European Social Fund project „Establishment of interdisciplinary scientist group and modelling system for groundwater research" (Project Nr.2009/0212/1DP/1.1.1.2.0/09/APIA/VIAA/060)

Thank You for attention!



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