BAB V1 GEOMETRICAL MODEL: INTEGRATING HETEROGENOUS AND UNEVEN DENSITY DATA INTO 3D GEOLOGICAL MODEL

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INTRODUCTION

Although specialized tools allow to model complex geological bodies in 3D using geological maps, survey records and borehole data, building a viable regional geological model is still a challenge. One of the main difficulties in 3D reconstructions lies in the data heterogeneity and its interpretation, where is need to deal with accuracy, representation at the scale of interest and reliability.

3D regional geological model was created for the Baltic artesian basin (BB) for modeling the groundwater flow. Large amount of the geological data describing the geological structure of the BB was available however the data coverage is very uneven and heterogeneous.

A number of problems have been previously solved associated with collection, harmonization and post-production of cartographic and borehole data, which includes control of various data input, generalization and topological issues (Dēliņa et al., 2011; Jātnieks et al., 2011). Also mathematical algorithms have been created that consider the priority, importance and plausibility of each data source in integrating topography and lithology data as well as borehole data (Sennikovs et al., 2011).

In this research we scope to further data post-processing, validation and integration in model system as well as collection of new data. However for certain areas is the need to use low resolution data and interpretations from literature information, making geological generalization and interpretation that is based on knowledge about geological evolution of the territory.

DATA

Table 1. ***Geological data sources that are used in construction of model geometry.***

Territory	Boreholes	Structural maps (Relief data, fault locations and displacement values)	Geological maps (Geological boundaries)	Literature information (Books, publications...)
Latvia	X	X	X	
Estonia	X		X	
Lithuania		X	X	
Russia				
Kaliningrad (RUS)			X	X
Poland			X	X
Baltic Sea		X		X
	Latvia and Estonia: data for full geological section from approx. 40 000 boreholes (vertical resolution approx. 0,5 -1 m).	**Latvia and shoreline:** 4 structural surfaces (M 1:1 500 000): Crystalline basement, Ordovician, Middle Devonian Parnu, Upper Devonian Amata; **Lithuania:** 20 structural surfaces (M 1:200 000): Crystalline basement, Cambrian, Ordovician, Silurian, Lower, Middle and Upper Devonian, Permian, Jurrasic, Carboniferous and Sub-quaternary.	**Latvia:** Bedrock geological map (M 1:200 000); Tectonic map of Caledonian structural complex (M 1: 1 500 000); **Lithuania:** Bedrok geological map (M 1:200 000); **Estonia, Kaliningrad:** Structural-geological formations map of the Soviet Baltics republics (M1: 500 000); **Poland:** Geological map of Poland without Cainozoic sediments 1: 1 000 000	**Baltic Sea, Russia, Kaliningrad, Poland:** Digitised isolines of Crystallinne basement surface (approx M 1: 2 000 000); **Poland:** Digitised isolines of Cambrian surface and Sub-Devonian surface (approx. M 1: 2 000 000) **Baltic sea, Poland:** Digitised point cloud for Sub-Permian surface.

Collected geological information in many cases are undersampled. Sufficiently detailed information is available only for territories of Latvia, Estonia and Lithuania which is the main and most important area of model. Rest of model area is poorly characterized.

PROCESS

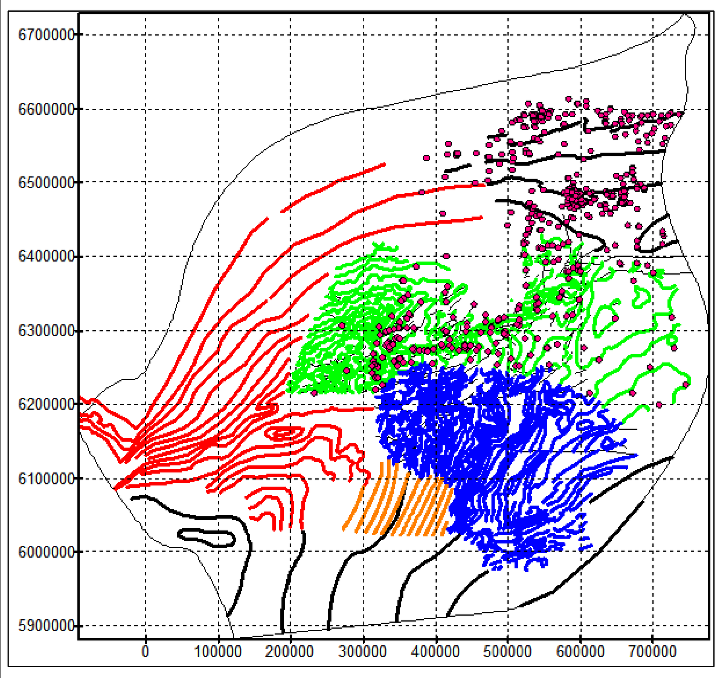

Fig 1. ***Various data sources for Crystalline basemen surface***

Relief data integration. To logically combine data from different sources into single coverage for each geological surface, was performed the data unification on area boundaries, by checking the compatibility of Z values of each data source.

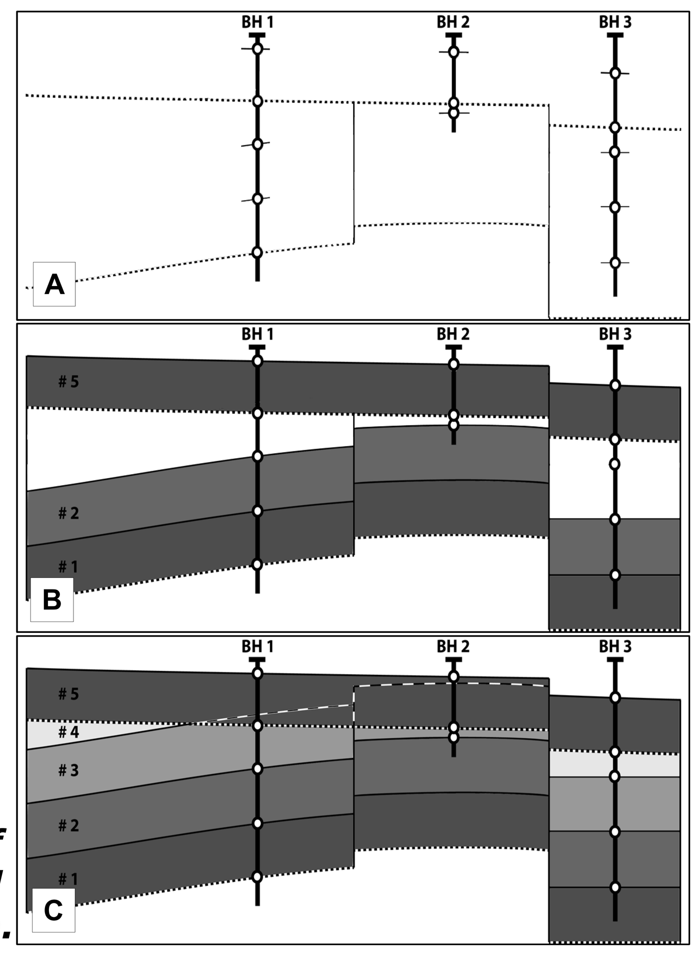

Fig 3. ***Principles of geometrical reconstruction.***

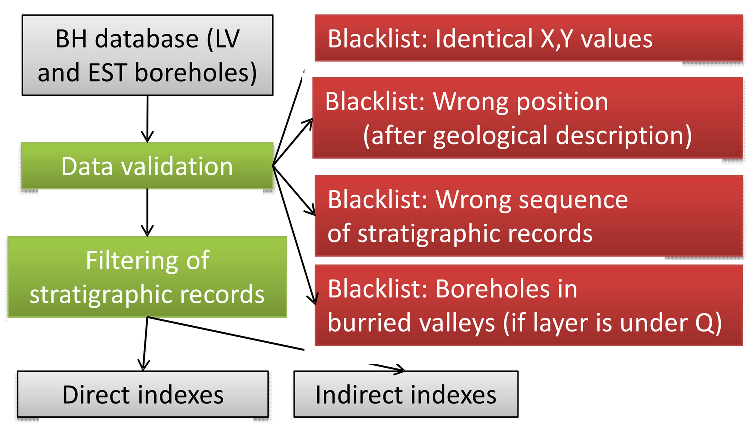

Fig 2. ***Borehole data processing.***

Borehole data filtering and validation.

Records of incorrect borehole location and geological information were blacklisted in excluding tables and not used in further data processing.

Geological information were classified into several groups after detalization of stratigraphical data:

- Stratigraphic indexes that clearly attributed to model layers and primarily used in creation of model geometry and strata thickness reconstruction;
- Indexes that defines transition between multi stratigraphical units and do not belong to one particular layer - used as support and validation data. stratigraphic unit but also the transition between multi units.

Construction of model geometry is based on assumption that post-depositional deformation produces no significant changes in sedimentary strata volume – the strata thickness and its length in a cross sectional plane remains unchanged, except as a result of erosion (Dahlstrom, 1964).

Reconstruction is divided into **3 main steps**:

A - Reconstruction of base surfaces with known displacement amount along the faults (dashed lines).

B – Non-eroded layers with known full thickness (#1, #2,#5) were reconstructed by initial thickness reconstruction and successive aggregation to the base surfaces taking over the slip amount along faults from those surfaces.

C – Eroded layers with known full thickness (#3) after initial thickness restoration, elevation values in places of erosion are taken over from erosion surfaces.

Layers with unknown full thickness (#4) is reconstructed assuming that they are topographically similar to the underlying layers and layer volume can be reconstructed by filling volume between underlying layer and erosional surface.

RESULTS

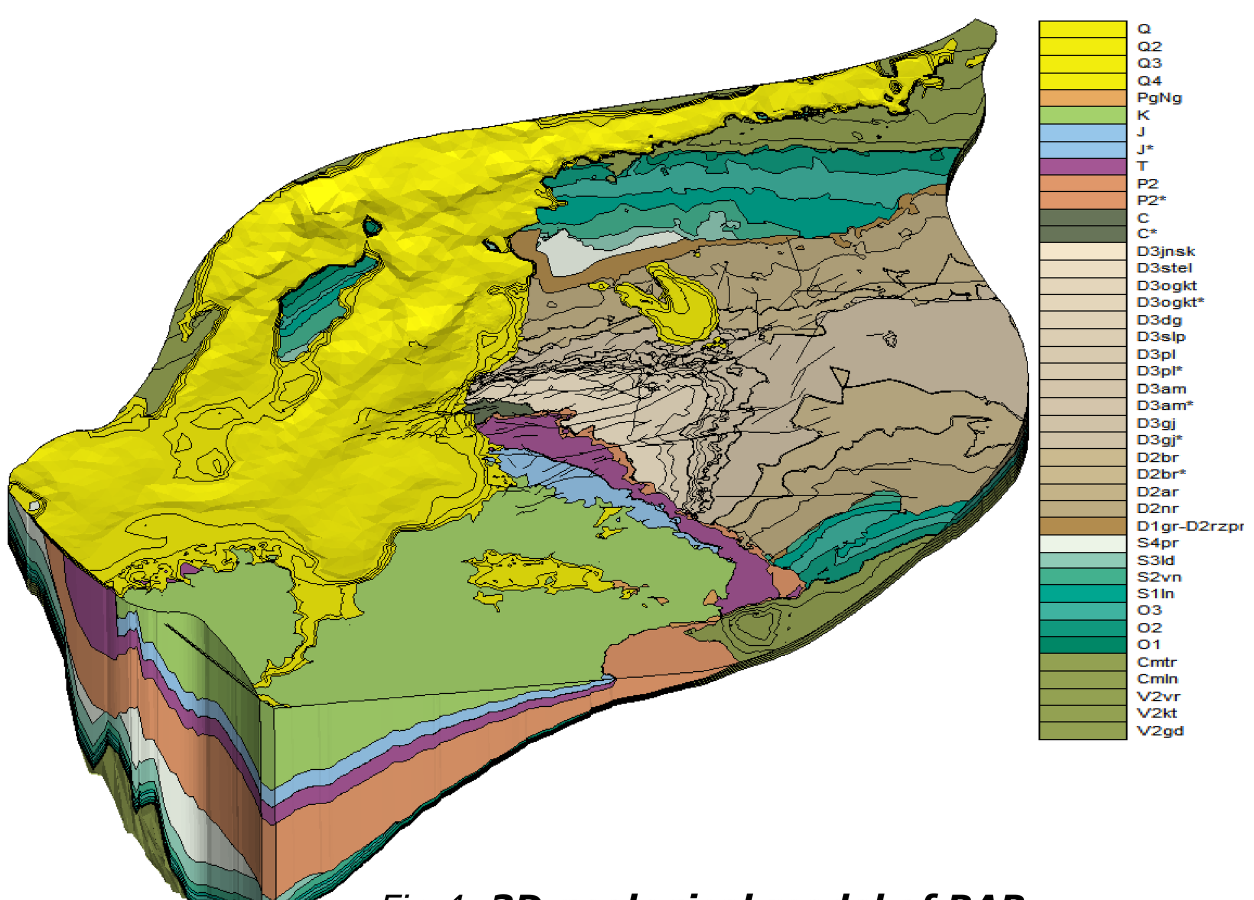

Fig 4. ***3D geological model of BAB.***
Horizontal slice at -50m a.s.l.

Poorly described lateral margins of the layers where reconstructed by taking into account the volume geometry - constant regional thickness and stratigraphic relation constraints were developed between sedimentary layers and Devonian (Fig 5), Permian and Quaternary regional unconformities.

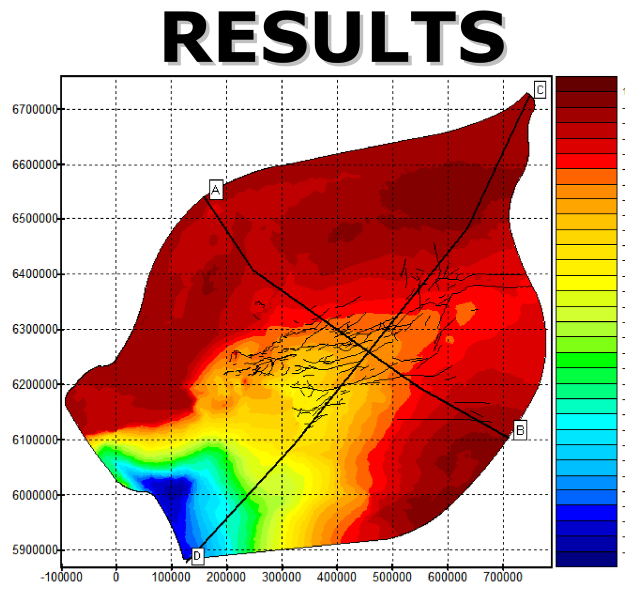

Fig 5. ***Surface of the Caledonian structural complex.***

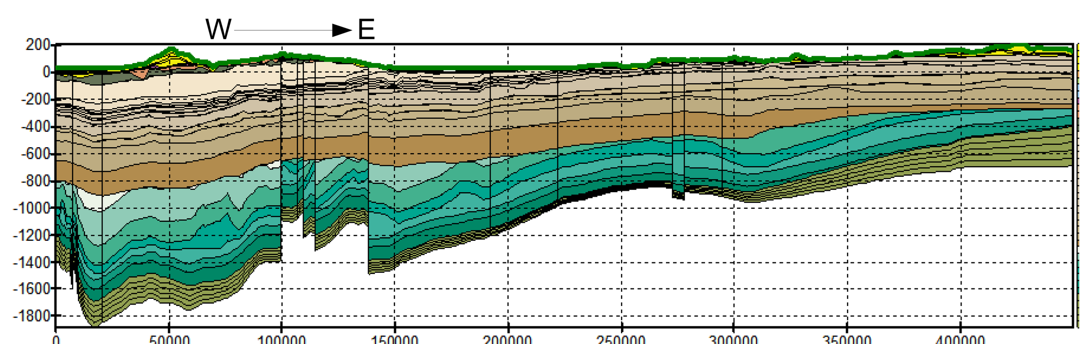

Fig 6. ***Cross section trough the territory of Latvia.***

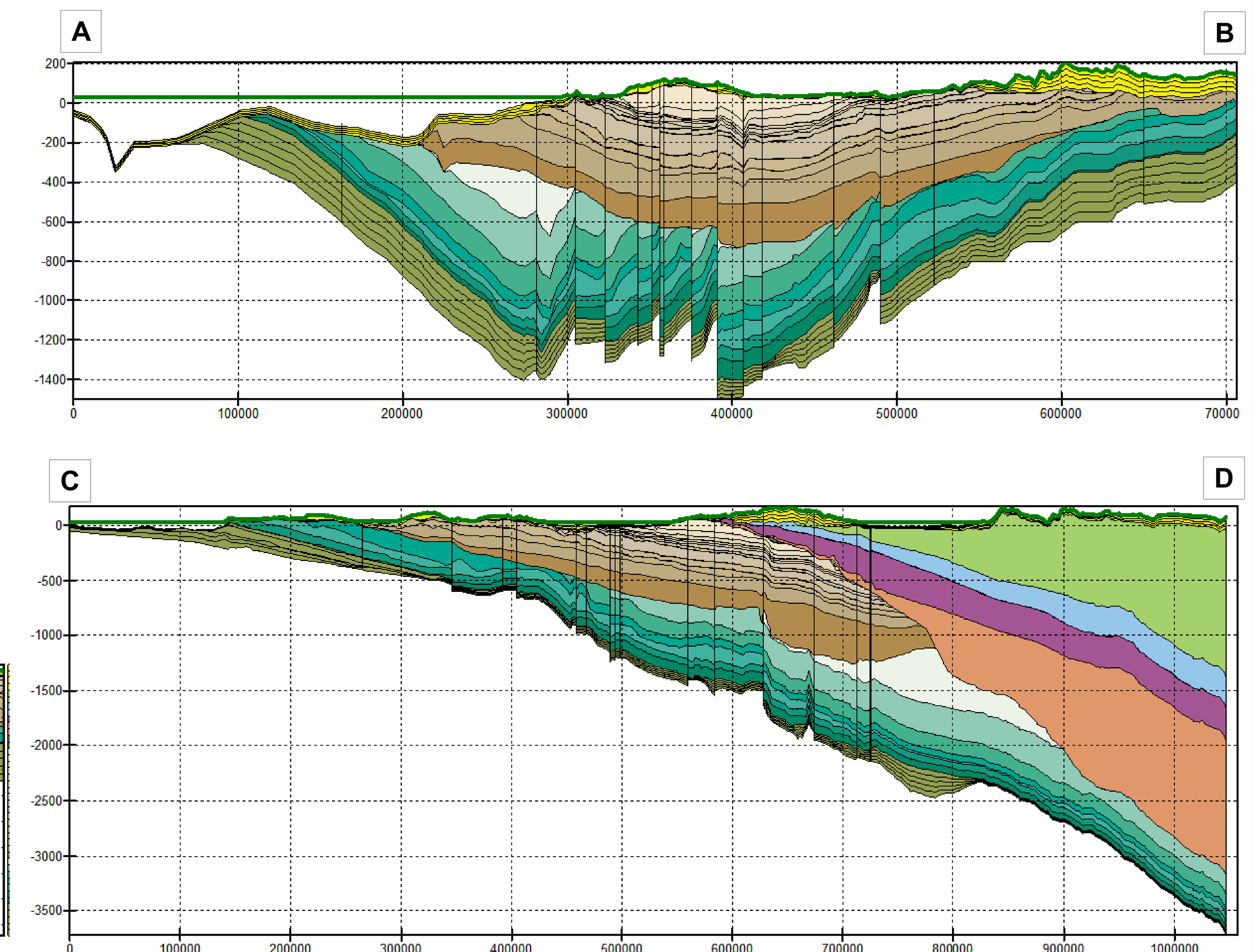

Fig 7. ***Cross sections trough the territory of BAB.*** *Profile lines in Fig 5.*

Using thickness reconstruction and stratigraphic relations of depositional layers, erosion surfaces and tectonic structures, we managed interpretation of layer bedding and tectonic structures through whole model area sound correct, especially in those areas with limited data or without available data at all.

CONCLUSIONS

Applied techniques made possible reliably reconstructing the 3D geological structure of the BB and allowed to predict surface geometry of the layers in areas of the sparse data. Chosen methodology allowed establishing the geological model that corresponds to the general notions of the BAB geological structure where territory of Baltic states is well detailed.

Subordinate model creation to the evolutional preconditions of geological structure, has reduced uncertainties associated with two aspects – discontinuity of stratigraphic sequence and layer displacement values along the faults.

Modeling results allow quantifying areas in the model structure where additional data is necessary for geological reconstruction, especially for territories of Poland and Baltic sea.

Used approach has a good potential in development of regional geological models of the sedimentary basins and is valid for spatial interpretation of geological structures form heterogeneous and sparse data, subordinating this process to prerequisites of geological evolution.

Literature

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