# Building a complex geological model using Parametric Surfaces

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**Introduction**: The city of Vienna is situated upon thick layers of Neogene Sediments comprising the Vienna Basin fillings. Since large parts of the Vienna Basin are densely populated, geothermal power and heat could play a significant role in the future. Assessment of the thermal regime of the deeper structural levels of the basin is crucial for a geothermal exploration in this relatively low potential area. As temperature data from great depths are heavily uneven distributed, standard inter- and extrapolation techniques did not deliver satisfying results. This is why numerical modelling was applied. This poster focusses on the implementation of a state-of-the-art geological 3D model in the COMSOL environment.

**Geological background:** The Vienna Basin can roughly be divided into two parts, the "Hochscholle" and the "Tiefscholle" regions separated by the Leopoldsdorf fault. While the thermal regime of the Hochscholle is affected by a distinct thermal water circulation system where thermal water rises at the Leopoldsdorf fault causing a positive anomaly, the aquifers of the Tiefscholle are supposed to remain static. For simplification reasons, the model was split into two parts and calculated separately. The whole model built-up was the same procedure for both models. The two geological 3D models were created using the software package GOCAD.
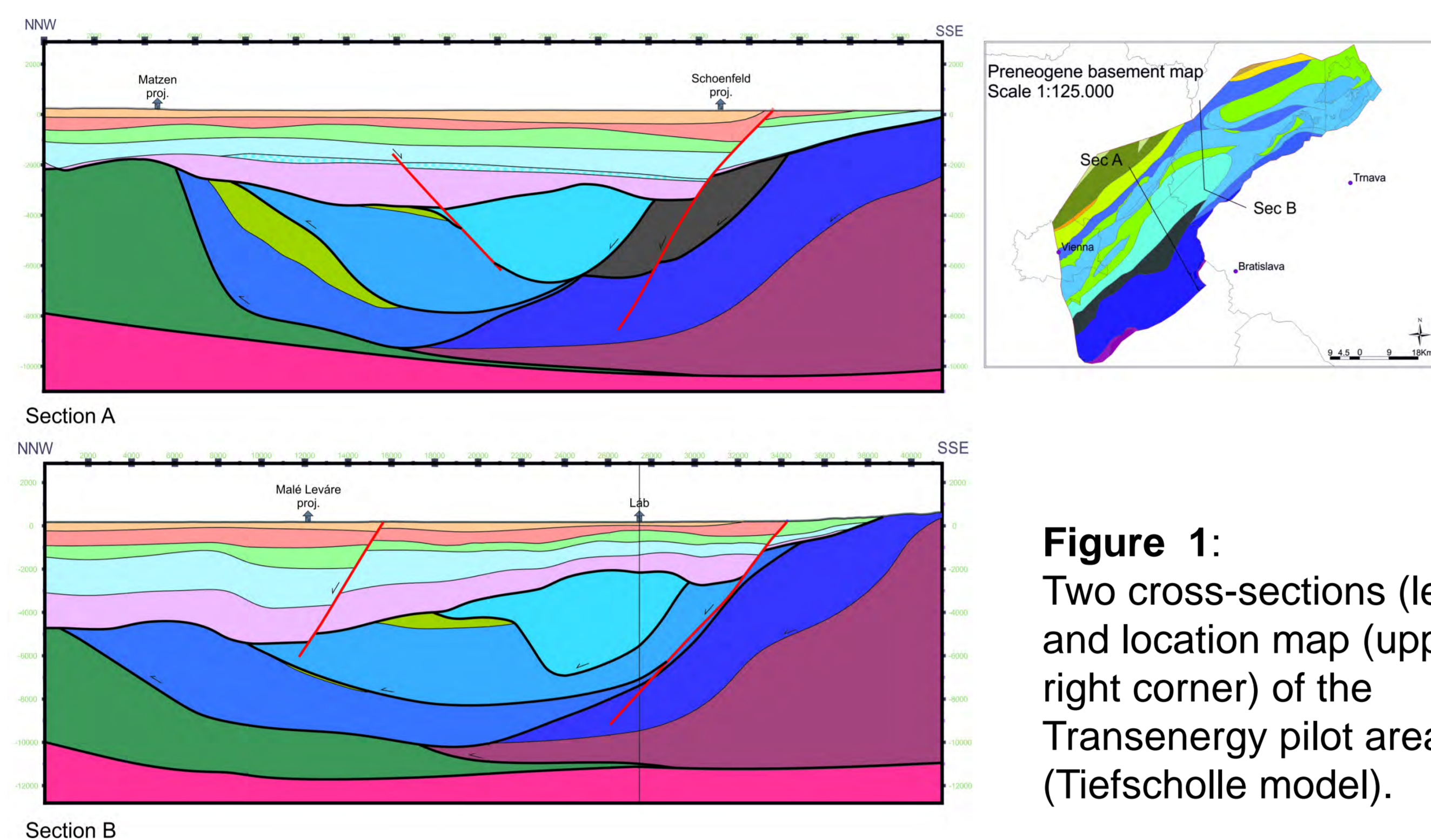


**Figure 1**: Two cross-sections (left) and location map (upper right corner) of the Transenergy pilot area (Tiefscholle model).

**Model build-up:** Four main horizons (top Crystalline, base and top Calcareous Alps, topography) were triangulated and exported from GOCAD. Subsequently, the ascii tables were imported into COMSOL as 'Interpolation Functions' to serve as input arguments for 'Parametric Surfaces'. The outlines of the geological units were digitized and imported as polygons, further extruded and combined with the according surfaces. In this way, it was possible to combine multiple surfaces to one surface model. As a final step, this surface model in combination with a bounding block was converted to a solid. The solid model consists of five subdomains representing the major geological units.
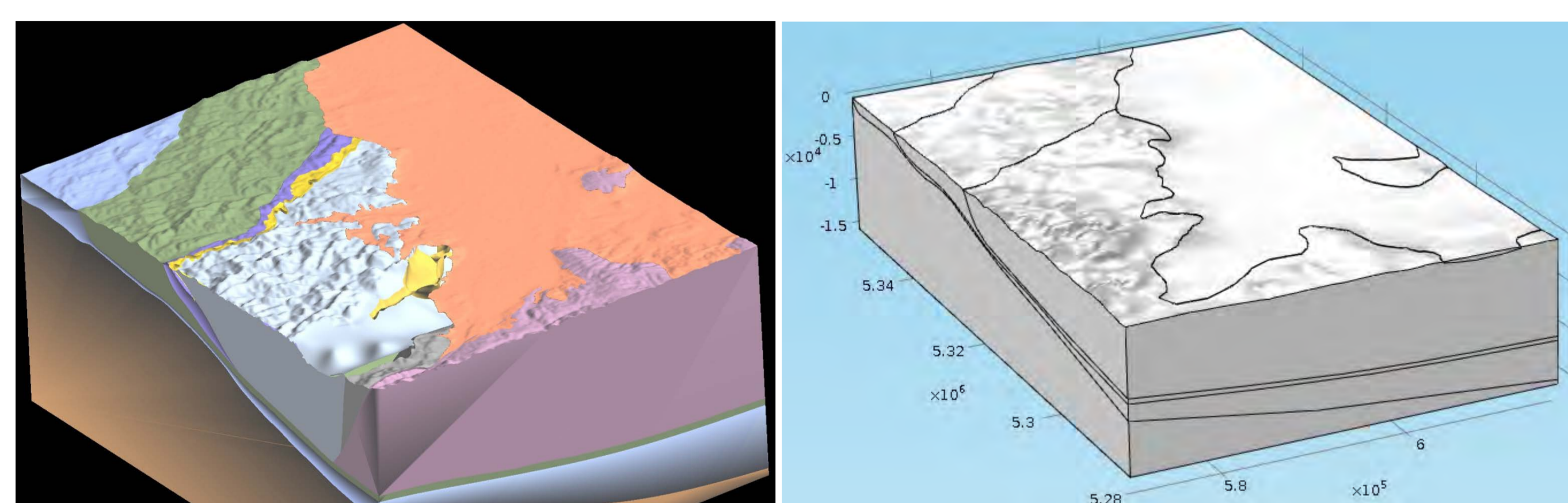


**Figure 2**: Geological model of the Hochscholle block. Comparison between GOCAD (left, 2 x exaggeration) and COMSOL (right).



a. Topography
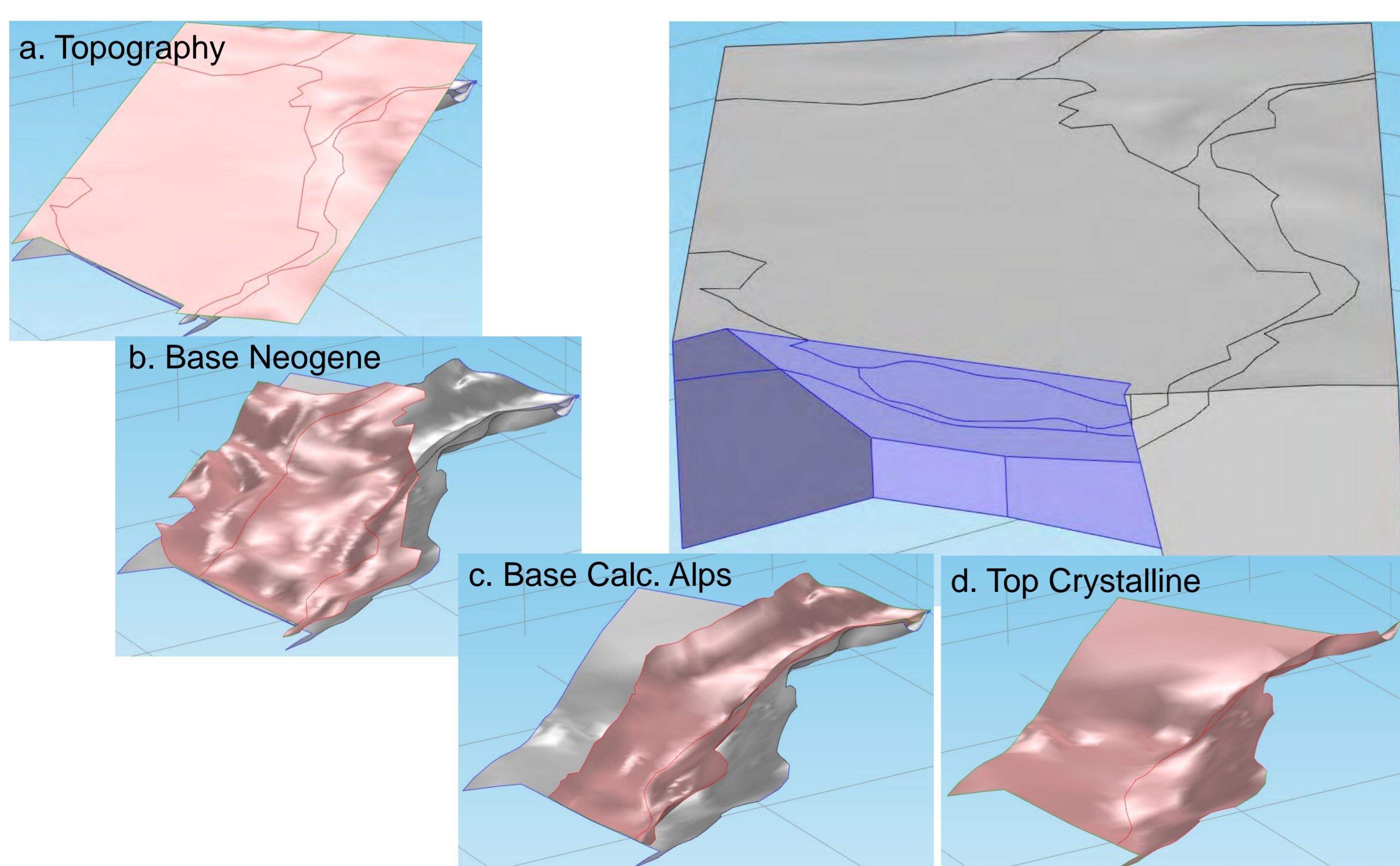b. Base Neogene
c. Base Calc. Alps
d. Top Crystalline

Figure 3: Tiefscholle model, the blue boundaries represent the Leopoldsdorf fault (simplified), where the temperature distribution is exported from the Hochscholle model and applied as BC here.

**Figure 4**:
*Right*: GOCAD surface model showing the inner structure of the Calcareous Alpine Units (between surface b. and c. in figure 3). These structures are too complex to be rebuilt as parametric surfaces, that is why only the material parameters are varied through 3D interpolation functions.
*Bottom*: View „into" the basin from SW with a NW-SE section across the model area, the greyscale surface represents the top of the crystalline basement.
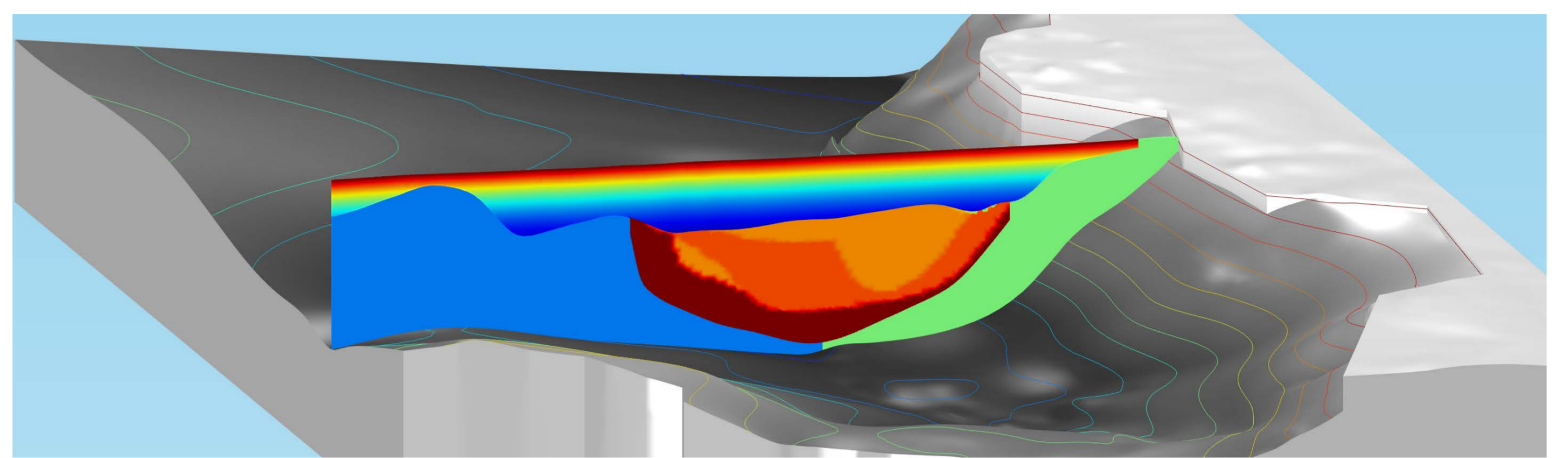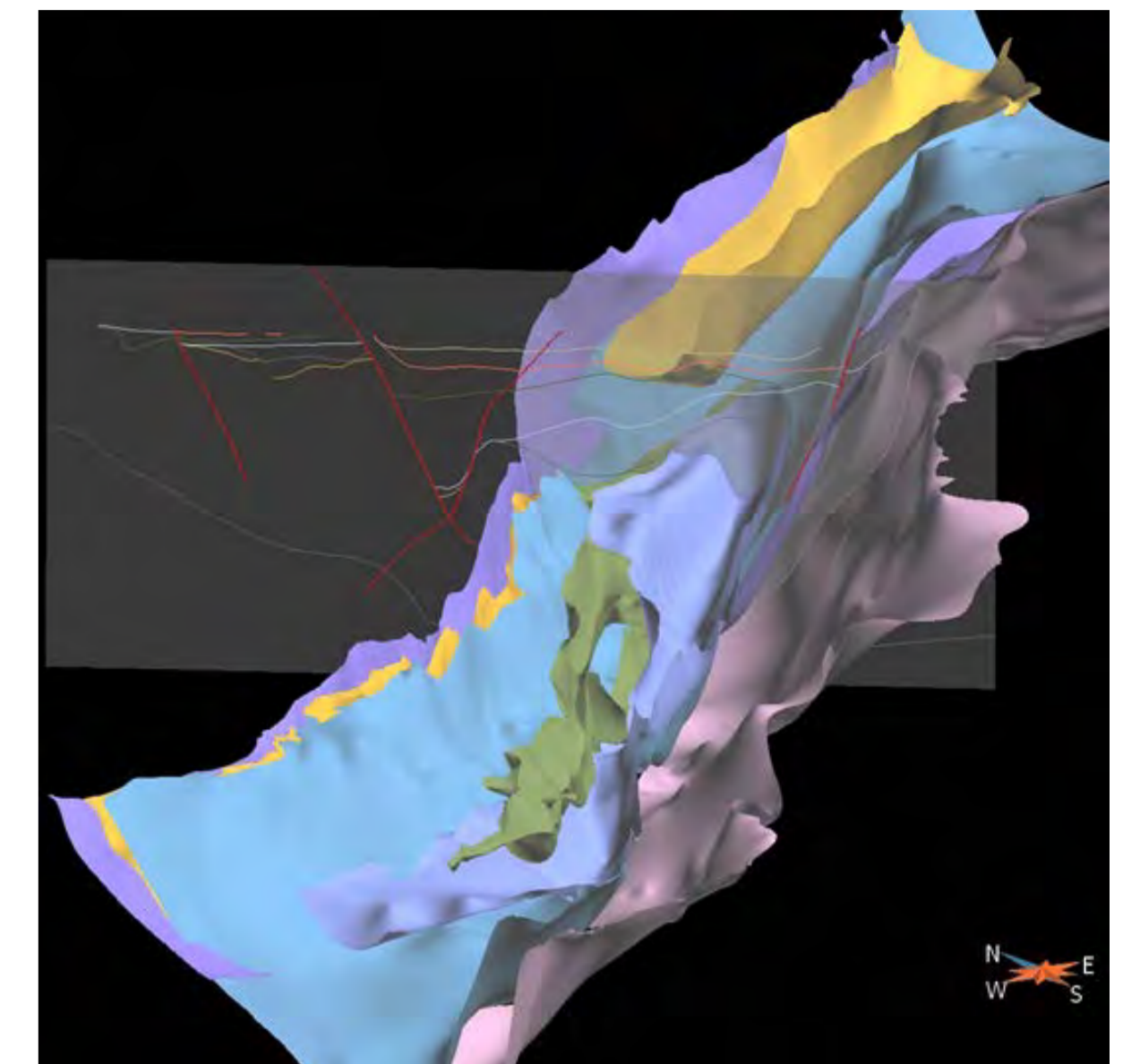


The Crystalline (**grey**), Flysch Units (**blue**) and the Mesozoic Carbonates (**green**) are considered to have constant material properties. The variation of parameters within the Calcareous Alps (**red, dark orange, orange**), consisting of Bajuvaric-, Tirolic-, Juvavic-, the Gosau Units and the Greywacke Zone (not visible in this section), are taken into account through 3D interpolation functions. The properties of the Neogene Sediments, particularly the porosity, are approximated using depth-dependent functions (exponential approach [6]).

**Results & Outlook:** The primary result of this study is the temperature distribution in the Vienna Basin that will be used for scenario modelling. Moreover, geothermal resource quantification (Heat in Place) can be calculated and exported from COMSOL. As a main output, compiled temperature and isothermal maps will be created and presented on an ARCGIS.com web portal accessible via the project homepage (http://transenergy-eu.geologie.ac.at/). Temperature measurements are used for validation of the model.

## Comparison: Depth of 100 °C isotherm [metres below surface]



Numerical model
Interpolation of well data
Difference [m]

Topography
Interpretation

Crystalline outcrops: Relatively cold systems, no well data

Flysch units: Resolution of geological input not sufficient. Place for further research

Extrapolation error: No data available

Vienna and Pannonian Basins: relatively warm systems, a lot of data! (hydrocarbon exploration)

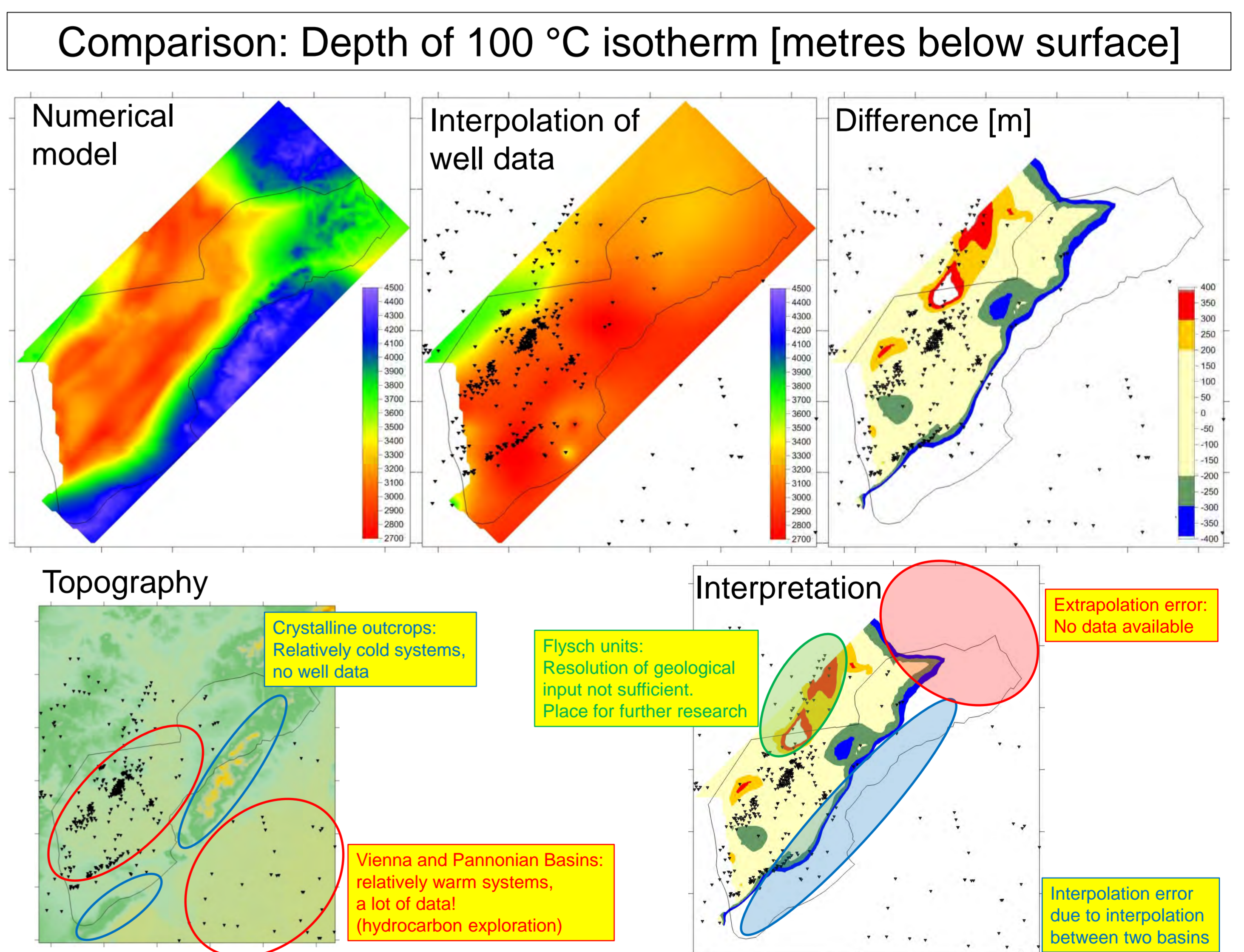Interpolation error due to interpolation between two basins

**Figure 5**: The comparison between modelled and interpolated temperature distribution points out the advantage of numerical modelling. In areas with high data density, the interpolation shows good results and therefore can be used for validation of the model.