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GeoMol17 – A 3D Structural Model of the Geology of the Swiss Molasse Basin

Robin Allenbach[1], Roland Baumberger[1]

1 Introduction

Late 2017 saw the completion of GeoMol17, the high-resolution model of the Swiss Molasse Basin (Landesgeologie 2017). The model is accessible via web browser and allows the user to view the model and its components from any angle. A set of tools is available to adjust the vertical exaggeration of the model and to slice the model along the X, Y and Z-axis, allowing the user to focus on a specific area or depth. A description of further functionalities follows below.

Uses of the model are varied. At the Swiss Geological Survey (SGS), one of our aims is to provide project planers with representations of the subsurface at a very early stage of a project. These can be used to convey the complexity of the subsurface or to make cost calculations based on depth of the target or if and what kind of additional data needs to be acquired to plan a project. A series of by-products of the model described below provide additional tools for communicating, planning and carrying out subsurface exploration projects. Apart from projects targeting the subsurface we envisage educators and laypeople using the model to gain insight into what lies beneath our feet and encourage an interest in that part of our environment which is hidden from view.

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2 GeoMol15 versus GeoMol17

During the course of the GeoMol project, two separate 3D geological models were completed (viewer.geomol.ch). The seismic interpretations of Sommaruga et al. (2012) served as input for the first model, GeoMol15 (see also Baumberger & Allenbach 2016). Additional surface geological data, seismic interpretations and an updated velocity model contributed to producing GeoMol17 (Landesgeologie 2017). While the Mesozoic and Cenozoic stratigraphy modelled in both versions of the model remain the same, the modelled tectonic structures and geological horizons are different due to the higher density of seismic data and the updated velocity model in GeoMol17. The higher data density allowed the definition over 600 fault planes in GeoMol17 as opposed to 22 in GeoMol15.

The model overviews (Figures 1 and 2) as well as the geological sections extracted from the respective models, accurately show the different levels of detail between the two models.

3 GeoMol Functionalities

A set of 2D functionalities available with the GeoMol viewer allow the user to place a virtual borehole and retrieve a stratigraphic column from any location within the model boundary or to extract a geological section from the model along a trace defined by the user. Depth sections extracted from the model display geological boundaries in areas and depths defined by the user. Users

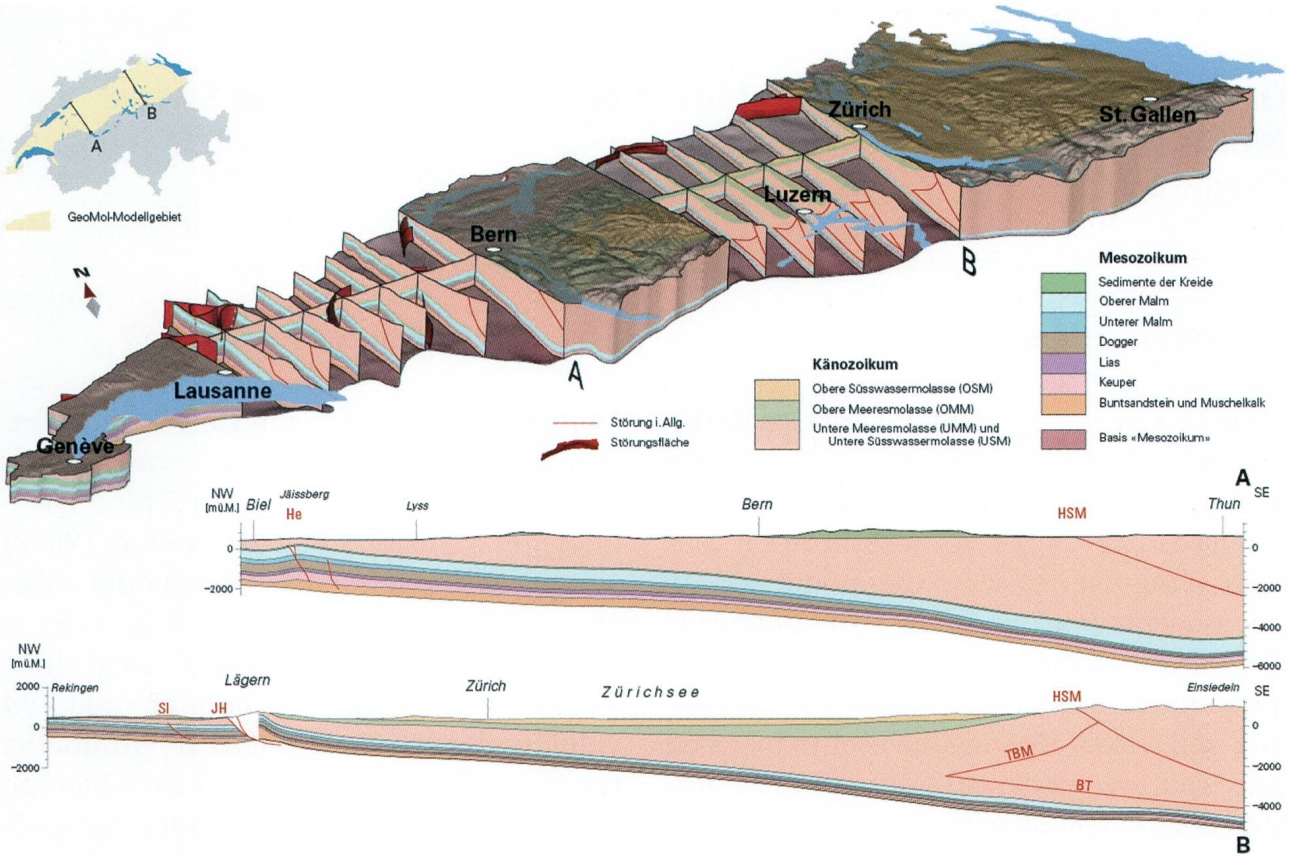

Fig. 1: The low-resolution GeoMol15 model and two representative sections extracted from the model. The model contains some gaps due to tectonic complexities, which did not allow for a meaningful representation in the model. Such a blanked-out are is visible in the Lägern of section B above. The model remains a useful, lightweight digital representation of the geology underlying the Swiss Midlands. Landesgeologie (2017).

can save these images locally and use them for their own purposes.

GeoMol is primarily a 3D structural representation of the geology beneath the Swiss Midlands. However, a number of by-products are also available with the GeoMol report (Landesgeologie 2017) and will become successively available online (map.geo.admin.ch). One of the most important being the Data Coverage Maps produced for every modelled horizon (Fig. 3). As the name already implies, these maps show what kind of geological data is available per modelled horizon and differentiates between outcrop, borehole, geological section and seismic section. While not exhaustive, project planners can use these to get a quick overview of what kind of subsurface data is available in the Swiss Midlands. Their primary function is to show what kind of data flowed into the modelling of each horizon but they also give a relative indication of the reliability of the model and its by-products. Areas with dense data and especially areas with deep wells are considered the most reliable, while areas with sparse data tend to be less reliable. Further by-products include seismic interval velocity grids of the modelled geological horizons (Fig. 4). These represent the most up-to-date basin-wide interval velocity grids of the most relevant stratigraphic intervals beneath the Swiss Midlands usable for time-to-depth conversions of horizons mapped on seismic data. Elevation (Fig. 5) and thickness maps of these intervals are also available allowing project planers to get representations of the specific geological intervals in the very early stages of a project before carrying out project specific seismic interpretation and mapping.

4 Practical Applications of GeoMol15 and GeoMol17

The first practical application of the GeoMol15 model was for optimizing track trajectories for the Cargo-sous-terrain project (cargosousterrain.ch). The project team used the GeoMol bedrock elevation model to calculate the amounts of consolidated and unconsolidated rocks as well as ground water levels encountered per trajectory. All these factors have an effect on the costs of a trajectory. Several geothermal projects are currently using GeoMol17 for planning. The most evident being the canton of Geneva's GEothermie 2020 (geothermie2020.ch). The canton of Geneva participated in the GeoMol project with the aim of using the model for planning in geothermal projects in Geneva. New data acquired during the exploration phase of the geothermal project provided additional data for a first update of the Geneva model. This case illustrates the ideal cycle of a geological model: plan new geophysical surveys and in later stages boreholes using a geological model, which is then enhanced using the new data. Geological 3D modellers may obtain, use and further develop the geological surfaces used for the GeoMol model. Please contact the authors for additional information.

5 GeoMol Updates

Finalization of the first GeoMol17 updates are nearing completion. These focus on the area between approximately the Emmen River and Lake Constance and will be available

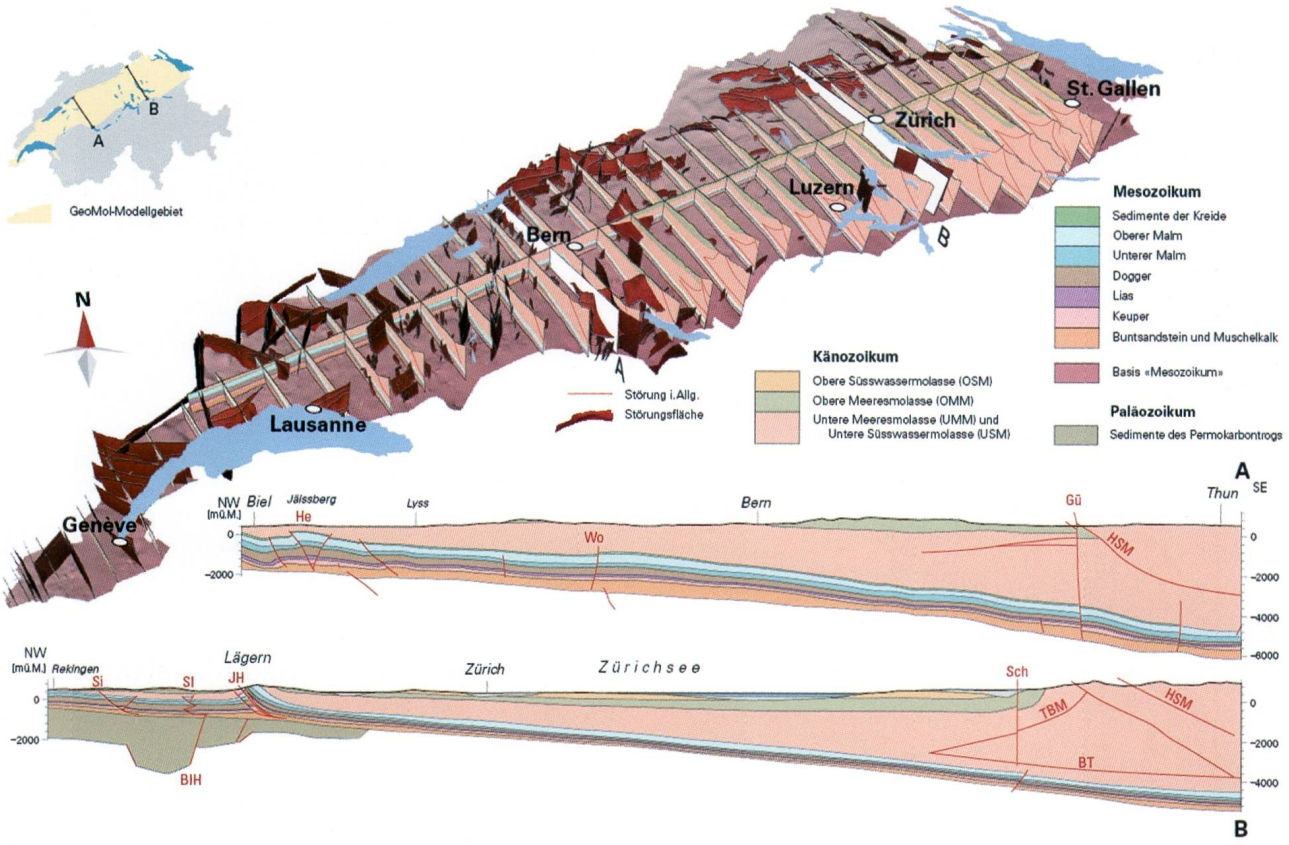

Fig. 2: The high-resolution GeoMol17 model with an improved representation of tectonic complexities such as the Palaeozoic trough shown on the north-western end of section B. Note that the Lägern is no longer blanked-out and features a much higher level of tectonic complexity than the GeoMol15 model. Landesgeologie (2017).

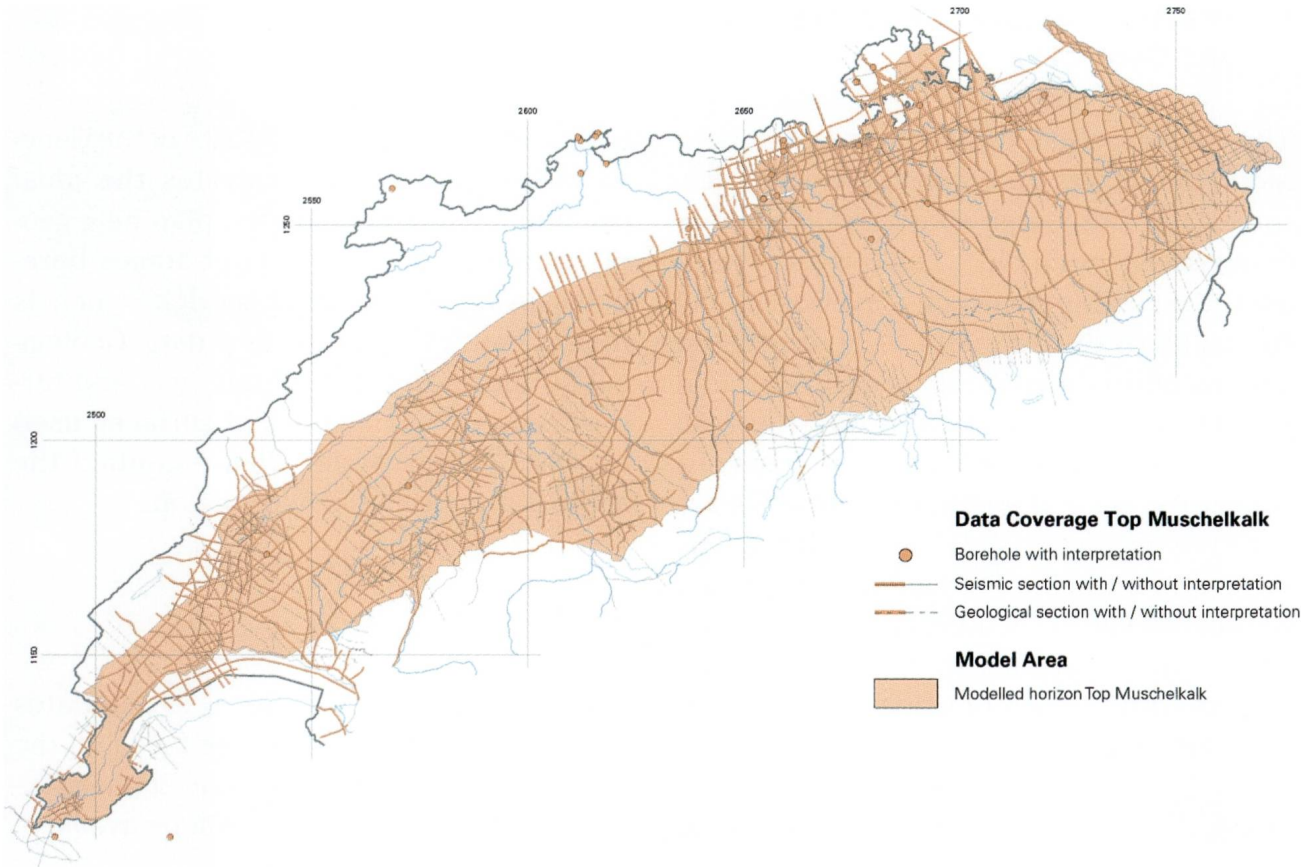

Fig. 3: Data coverage map of the Top Muschelkalk. See legend for details. Landesgeologie (2017).

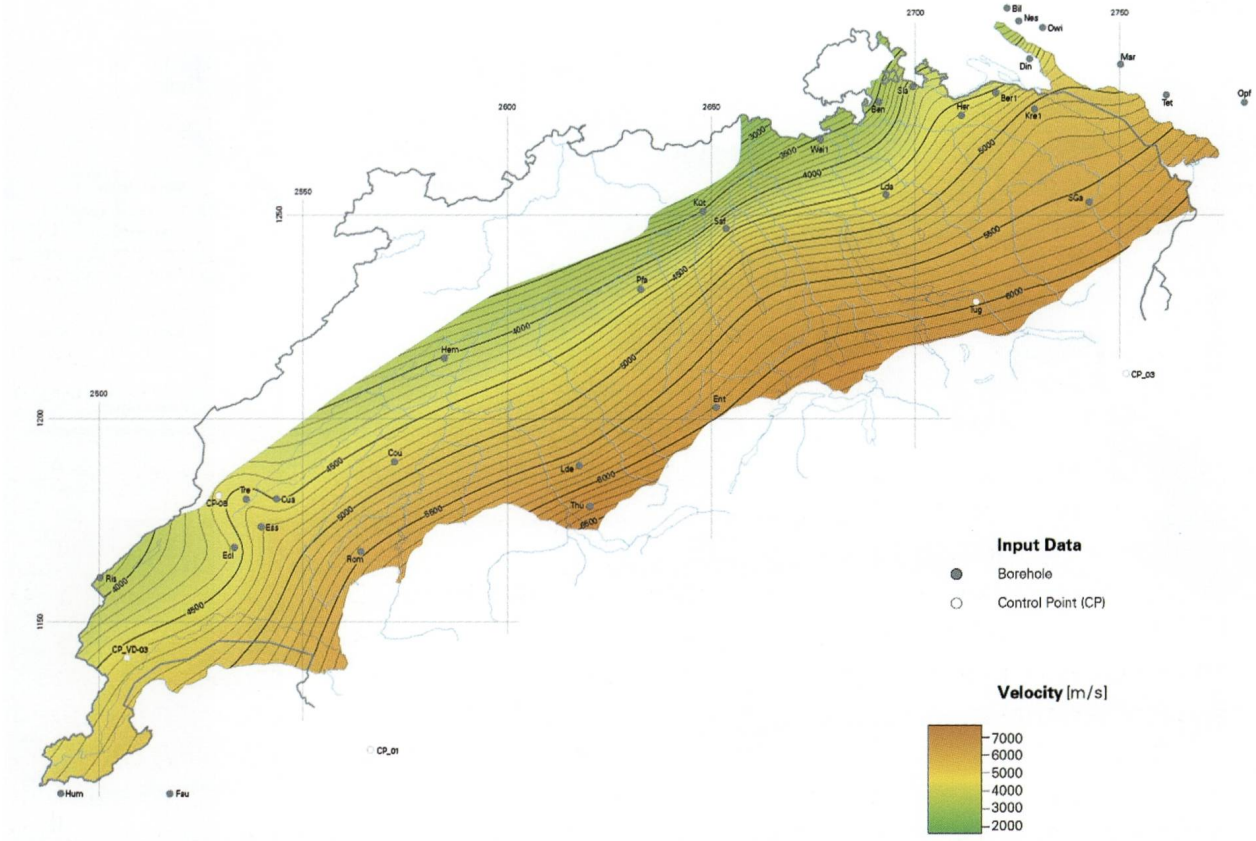

Fig. 4: Interval velocity map for the Lower Malm. Only boreholes with data that contributed to the velocity model are shown. Velocity data from wells in France and Germany minimized extrapolation effects around the model boundary. Adding synthetic control points in areas with little or no well data reduced artefacts resulting from the gridding algorithms. Landesgeologie (2017).

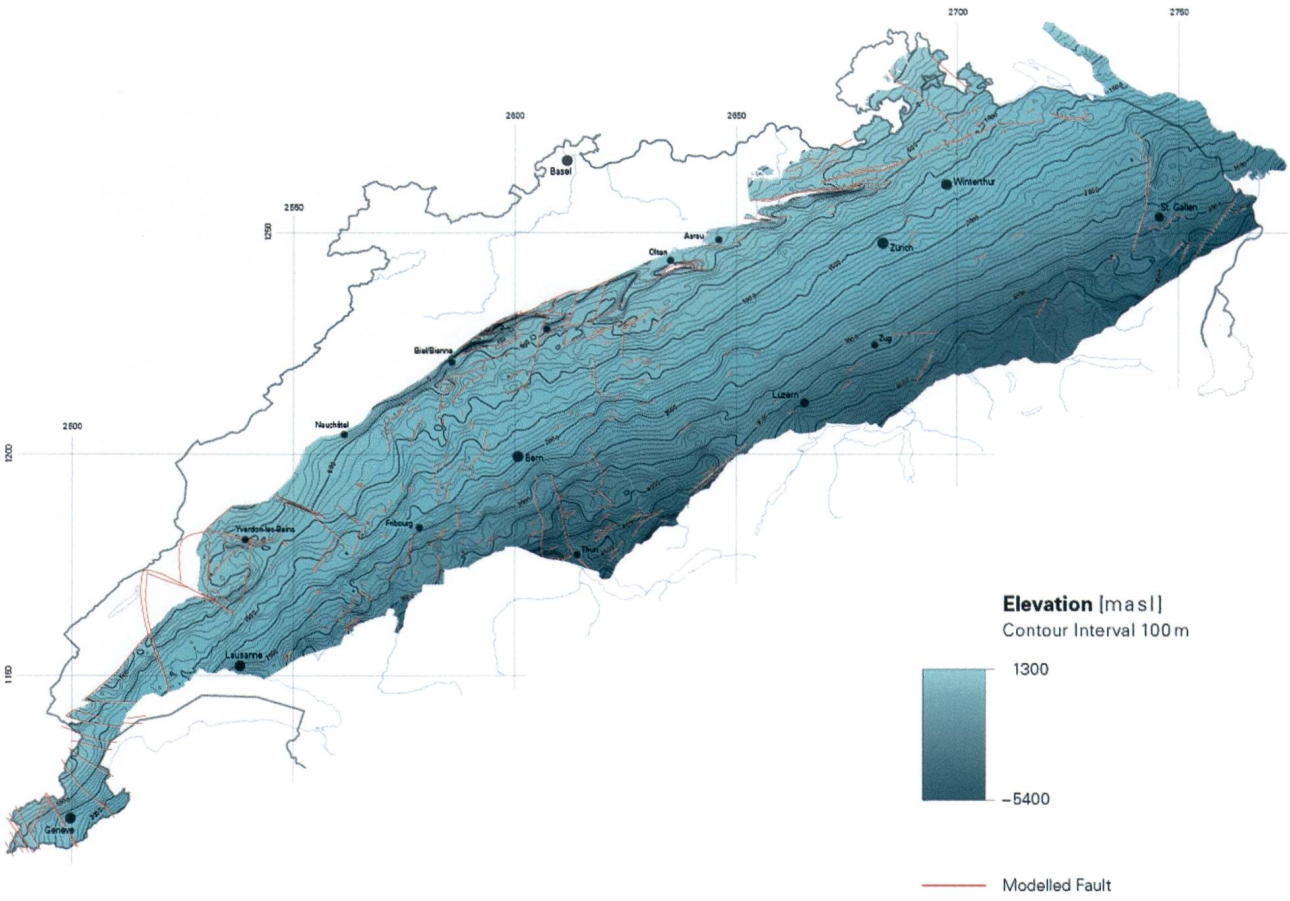

Fig. 5: Elevation model of Top Lower Malm with 100 m contour intervals and faults cutting the surface. Landesgeologie (2017).

early next year. The partner modellers of the GeoMol project have already made updates of their respective models (see also Landesgeologie 2017). After a renewed check of the boundaries and reassembling the models into a homogeneous model, we expect to publish this version in 2020.

This year has also seen the integration of a temperature model of the Swiss midlands into the GeoMol15 model (Fig. 6). This temperature model represents the first parameter model, which we have developed with the aid of a GeoMol model and populating it with the temperature model originally calculated by Geowatt (Geowatt 2015). Extracting temperature values per modelled horizon and per depth-slice from the 3D model will be possible.

6 Future developments

Updates over the entire model perimeter like the one seen from GeoMol15 to GeoMol17 are unlikely to recur in the near future. It is however, the intention of the SGS to upgrade the GeoMol 3D models either content-based (integrate higher resolution geological 3D models) or parameter-based (integrate e.g. geophysical or petrophysical properties).

In the short term, the SGS will publish a 3D temperature model covering the Swiss Molasse Basin, based on the GeoMol15 models (incl. isotherm maps, depth serialized maps and top of horizons maps). These set of new information will be available online in the first quarter of 2019. On the other hand, the SGS will produce or acquire smaller, higher resolution geological 3D models and integrate these into GeoMol17.

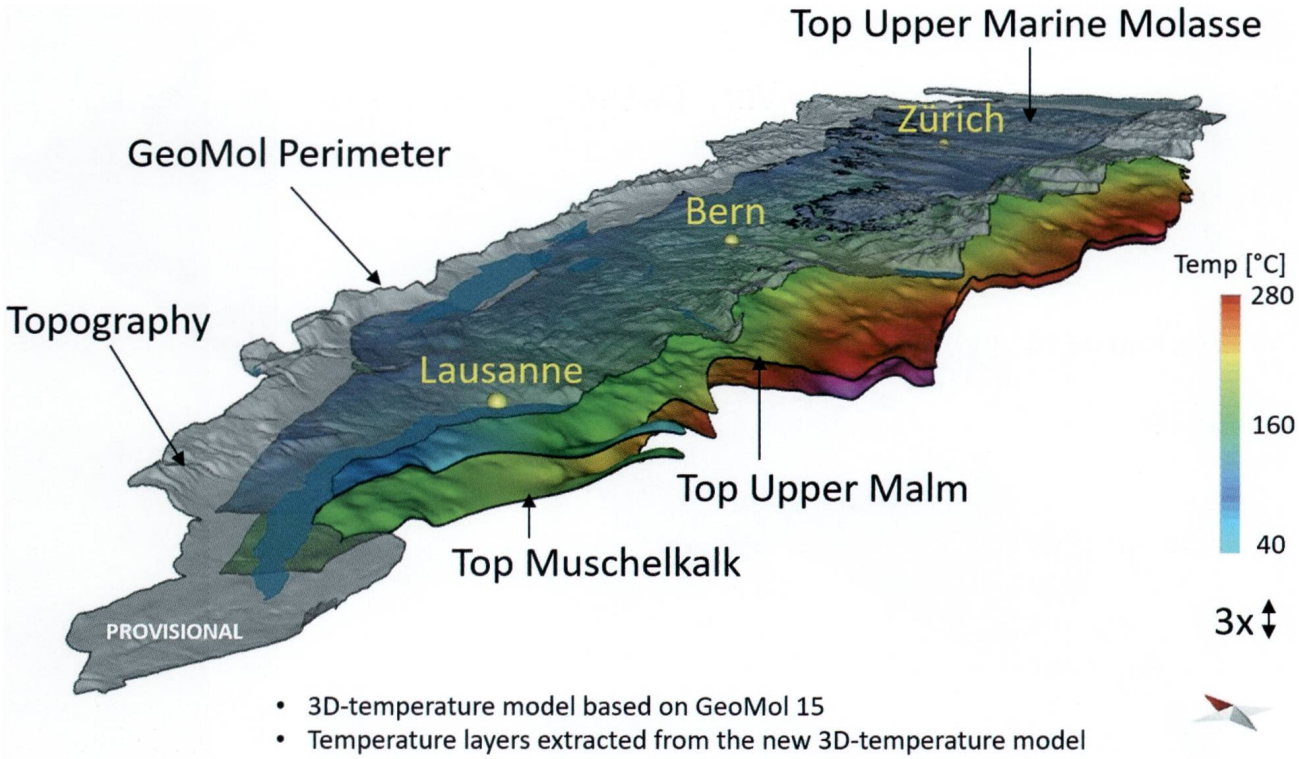

Fig. 6: A view of the prototype of the 3D-temperature model.

In the medium to the long term, the SGS aims to achieve a nationwide coverage with geological 3D models of different types and resolutions. In consequence, other regional-scale models covering e.g. the Jura Mountains or the Alps will join GeoMol17. However, due to complex geology in several parts of Switzerland and sparse data abundancy in many remote regions, the development of geological 3D models will take some time and requires investigation regarding workflows and modelling methodologies.

In the long term, geological 3D models are the backbone of a multi-dimensional geological knowledge base of Switzerland. This new approach to access geological data is going to incorporate not only maps and models of the SGS. It will also allow its partners and invite any third parties to join in and to share their geological data with the geological community in Switzerland.

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