

Brandenburg 3D – a comprehensive 3D subsurface model, conception of an infrastructure node and a web application

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1. Introduction

The Energiewende and the increasing scarcity of raw materials will lead to an intensified utilization of the subsurface in Germany. Within this context, 3D geological modeling is a fundamental approach for integrated decision and subsurface management processes. Initiated by the development of the European Geodata-Infrastructure INSPIRE, the German State Geological Offices started digitizing their predominantly analog archive inventory. Therefore the project B3D strives to develop a new 3D model as well as a subsequent infrastructure node to integrate all geological and spatial data within the Geodaten-Infrastruktur Brandenburg (GDI-BB) and provide it to the public through an interactive 2D/3D web application. The project B3D is funded with resources from the European Fund for Regional Development (EFRE).

2. Initial Data and Workflow

To create a 3D-geological model of Brandenburg, a number of analog input data was used, e.g. borehole data of oil and gas exploration in the former GDR, seismic cross sections and seismic maps, the selection is shown in Tab. 1. From this data, a comprehensive geological 3D model of Brandenburg was constructed. This model encompasses the most important regional horizons, along with a large-scale fault-network and a detailed Zechstein-salt surface. Also two detailed models in the east and south-east of Berlin have been constructed, which are also available through the web application. To provide an efficient workflow, the individual work packages have been executed simultaneously. The overall workflow for the digitalization and the modeling part of the project is shown in Fig. 1. All data has been stored, regardless of format, in a new data infrastructure including a new designed database called GeoDaB. This Geodatabase has been integrated into the Spatial Data Infrastructure Germany via OGC-conformable services. In addition, a plug-in free web application, called ‘B3D’ was implemented, that allows an interactive real-time visualization and manipulation of the 3D models and the 2D well and map data in most common web browsers.

Table 1: Data selection.

| Digitized data | |
|------------------------|------|
| Borehole data | 780 |
| Seismic cross sections | 2520 |
| Seismic maps | 236 |

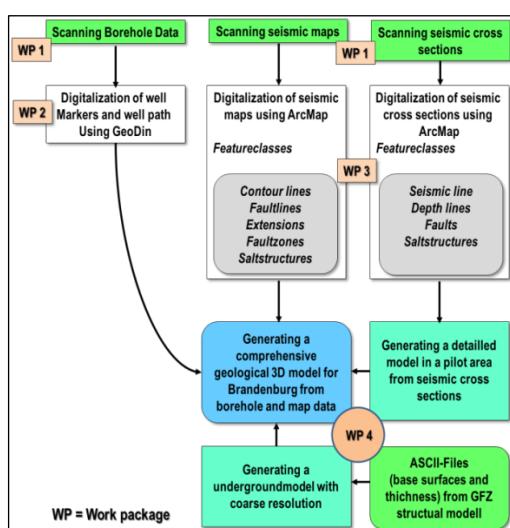


Figure 1: Workflow within the project B3D.

3. Data Infrastructure

The initial state of the system architecture at the Federal Geological Survey in Brandenburg consisted of an Oracle database for borehole data that was accessed through the proprietary software tool GeoDIN. All other digital geospatial data were stored on local hard drives. To foster the use of geological 3D data within the Federal Geological Survey and to provide the envisaged services to the public we had to expand this rudimentary architecture by several new components (Fig. 2).

At the first level, called GeoInformationSystem we integrated an export tool for the well archive and stored all new data in a PostGreSQL database that can be accessed with tools such as ArcGIS and GoCAD through customized interfaces. To store the 3D data the Software GST is used. We implemented a publishing tool, that allows the publication of approved 2D and 3D data sets to a web server at the second level that in turn provides it through OGC services to the web application and with this to the public.

At the third level the web application is located. What we wanted to do was to develop a web application that features a classical 2D client („2D Mapviewer“) and also a 3D client („3D Earthviewer“) with components typical of a WebGIS like an overview-map and a layer-tree. In principle both viewers can be independent of one another but we joined them in a higher-level architecture the „Brandenburg 3D Portal“.

The functionality of the web application, shown in Fig. 3 is based on a client-server architecture and on both sides we used Open Source Software components. On the server side, the database used is PostgreSQL with the extension PostGIS in the newest version which allows for extended 3D-functionality directly in the database. All OCG Web Services are published via the software GeoServer which acts as the reference implementation of the OGC Web Feature Service (WFS) standard that provides the interface that allows requests for geographical features.

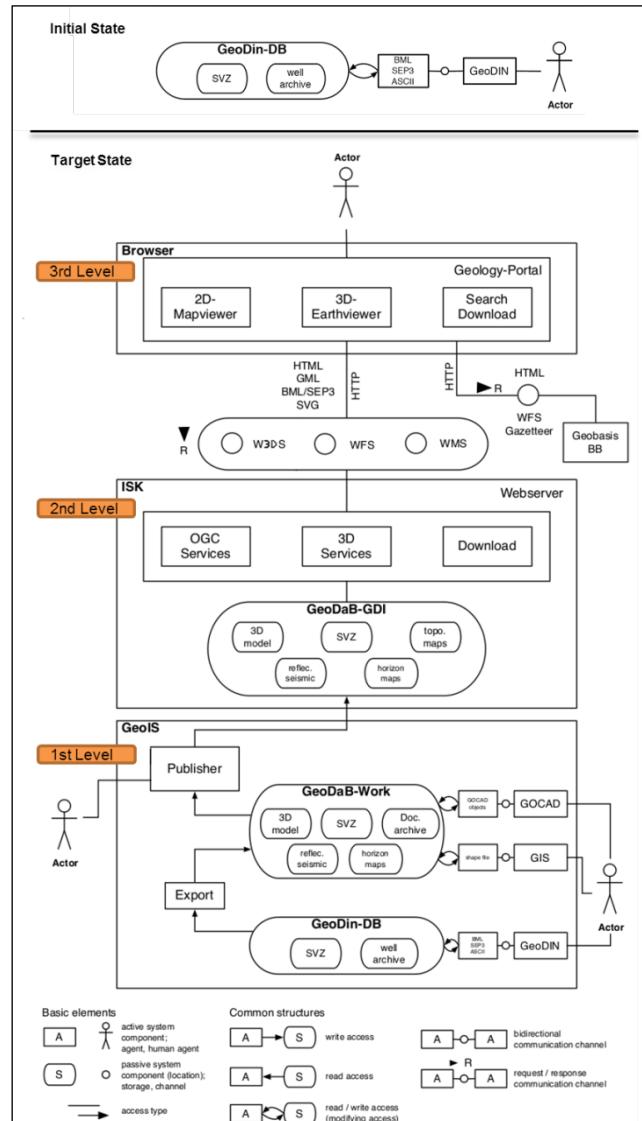


Figure 2: Architecture of the new developed infrastructure.

In addition, GeoServer also implements the Web Map Service (WMS) that serves geo-referenced map images and the W3DS (Web 3D Service) to serve 3D data. The W3DS is not a standardized service

yet, but is a candidate under consideration by the OGC. In addition several other components have been implemented, such as a print functionality and interfaces for specific database requests for the creation of virtual boreholes and cross-sections.

On the client side, the web application leans on the JavaScript API WebGL that allows the interactive rendering of 2D and 3D graphics. WebGL uses means of GPU accelerated usage of physics and image processing as part of the web page canvas and does not require the use of additional plug-ins. WebGL is supported by most web browsers (e.g., Google Chrome, Mozilla Firefox, Safari, and Opera). For the 2D Mapviewer the JavaScript Frameworks ExtJS 4, OpenLayers and GeoExt 2 are used. These Javascript libraries provide the Graphical User Interface or GUI, dynamic map content and the display of map interface components such as a legend, a layer opacity slider, attribute display tables, and zoom functions.

The 3D Earthviewer follows a similar structure as the 2D Mapviewer and is also based on ExtJS. But here ExtJS is enhanced by the X3DOM library for the presentation of 3D content. X3DOM allows the visualization and free interaction with 3D-models on the basis of the X3D-format. It enables the possibility to change the vertical exaggeration of the 3D model and to set the layer visibility. For the smooth integration of X3DOM into the ExtJS-framework we enhanced the API to allow for additional functionality. Also a new library called „X3DOMExt“ was created. It allows the frictionless communication between a X3DOM scene and ExtJS. These enhancements now allow the creation of dynamic layer trees and a panel for the 3D scene. So we have created a similar functionality and user experience that you know from GeoExt in a 2D client also in a 3D client. By using ExtJS as a base for the two viewers it was possible to base several components on the same code and give both viewers an almost identical look & feel.

4. Data processing for web application

Another difficulty concerned the principal ways of data storage and processing steps that are needed to deliver the information via the internet. The principal challenge that needed to be faced was the following: we have a 3D subsurface data set that originates from GoCAD which uses Triangulated Irregular Networks (or TIN) for displaying surfaces that have a Z-information attached (TinZ). To be stored in our PostgreSQL/PostGIS database, this data needs to be exported in the WKT-Format. Once the data was imported to PostGIS we had to undertake additional processing steps until we could publish the data through the W3DS. Because surprisingly, the data volumes and complexities generated during the modeling process were too large to be delivered through the internet. So after we had imported the data in PostGIS we had to simplify or reduce the data so that they could be used in a web application (Fig. 4). So what you need to do is you have to calculate different Levels of Detail

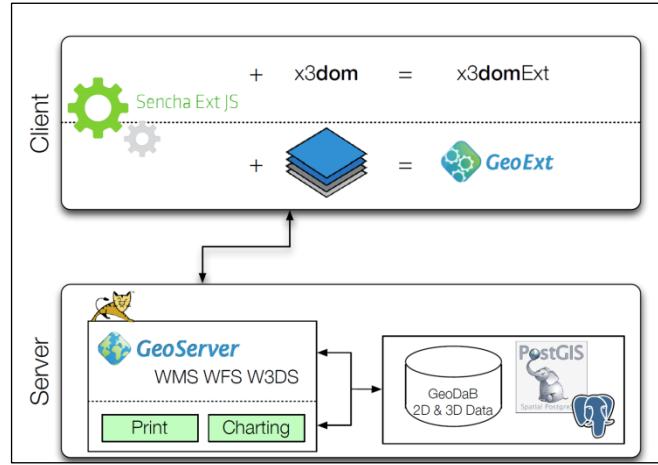


Figure 3: Client-server architecture.

from the initial data. We accomplished this with CGAL, a C++ geospatial library that provides easy access to reliable algorithms for computational geometry. We had to use CGAL because up until now, PostGIS does not provide a comparable functionality. In addition to the simplification and the calculation of several Levels of Detail we had to convert the TinZ geometry from GoCAD to a PolygonZ geometry.

5. Web application

Due to a legal dispute, the geological survey of Brandenburg is currently not allowed to publish any data generated within the project Brandenburg 3D.

As mentioned above, the 2D- and 3D-Viewer are joined in web portal called “Brandenburg 3D”. At its homepage there are some information about the project, the functionalities and the project partners. From the homepage one also get access to the 2D- and 3D-viewer. The 2D Mapviewer (Fig. 5) has a variety of functions that are known from other regular WebGIS clients. For example you have tools for navigation, loading of external WMS (1), changing of spatial reference systems (2), and a styler in the context menu of the data within the layer tree (3), to change the appearance of the maps.

In addition we developed a number of extra tools that grant access to the third dimension of the geo-data. For example we have a special filter and search functionality that returns the depths of boreholes or the thicknesses of geological layers (5). You can also search for wells that have been drilled during a certain time period or for seismic lines of certain length. And you can request detailed meta-information on individual well locations and seismic lines by clicking on them within the map (6). In addition, you can also request virtual boreholes and virtual cross-sections. That means that you can click on any point of the map or the 3D-model and you will get either a virtual borehole profile or a virtual cross-section.

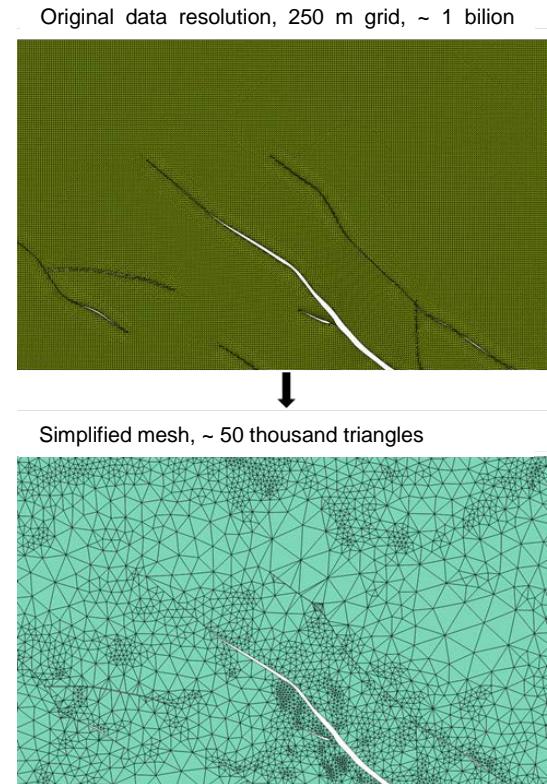


Figure 4: Original resolution and simplified mesh.

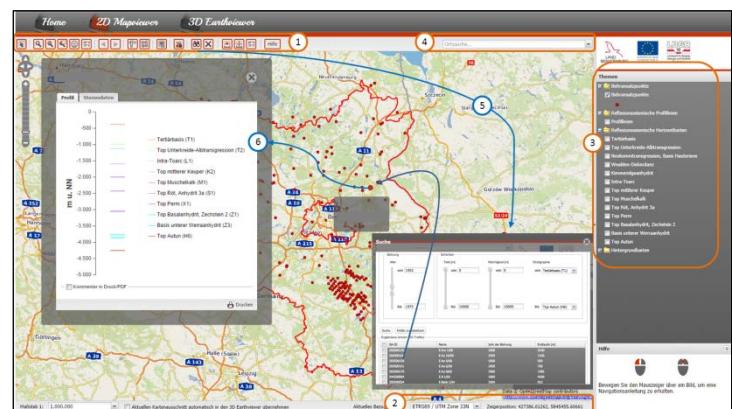


Figure 5: Design and functionalities of the 2D-Viewer.

The 3D-Viewer has almost the same look and feel like the 2D-Viewer (Fig. 6). In the 3D-Viewer it is possible to freely move within the model (rotate, zoom in and out (1)), to interactively make individual layers (in)visible (2) or to request additional information from objects by moving the mouse over it. You also get attribute prompts through a mouse-over functionality, which works in the same way in the 2D client. So you can get additional information on the elements displayed in the 3D scene. A central feature is the possibility to create virtual boreholes or cross-sections at any arbitrary position within the model (3). Within the 3D-Viewer also the virtual well path or seismic cross section is visualized. The profiles that get generated (4) through this method can be exported to a PDF. To provide a fast visualization and interaction with the 3D model, all data within the web application are generalized. One can have a look at the original data resolution within a bounding box of 10x10 km through a special functionality of the 3D-Viewer. Besides it is possible to visualize the nodes that build the surface (Fig. 7).

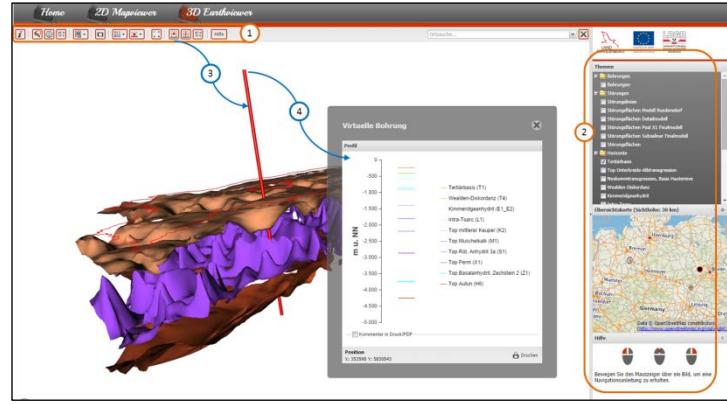


Figure 6: Design and functionalities of the 3D-Viewer.

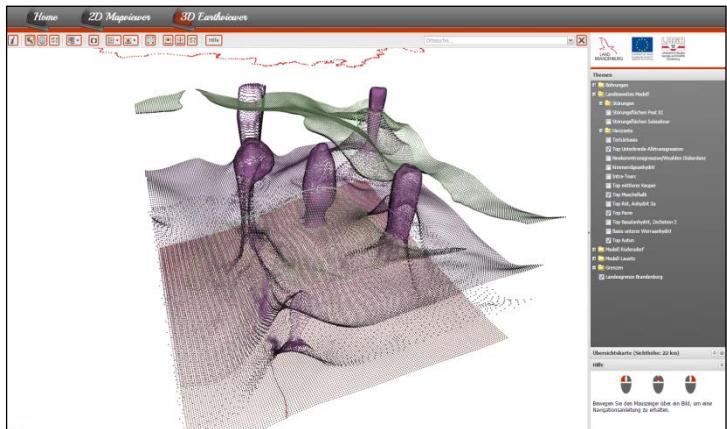


Figure 7: Visualization of nodes within the web application.

6. Next steps

In the near future the system should be extended by additional functionalities and additional data, for example it should be possible to view seismic cross sections in the 3D viewer or to integrate parametric voxel models, time series or sensor data into the web application. It is also conceivable to advance the query functions to deal with the different parameters of the 3D model to locate areas with certain temperatures, which occur for possible use as a geothermal site. Also the integration and analysis of time-varying data is possible.

7. References

BEAK CONSULTANTS GMBH 2010. Konzeption für die Durchführung des Projektes „Modellierung und web-basierte dreidimensionale Visualisierung des geologischen Untergrunds von Brandenburg. Freiberg, S. 145.

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Brandenburg 3D web application 2014, currently offline for legal reasons.

<http://www.lbgr.brandenburg.de/cms/detail.php/bb1.c.348647.de>