Geological 3D model of Halle/Saale – complex fault-zone modelling (Germany)

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Abstract

Based on 12 depth corrected and interpreted seismic profiles, a large number of drilling-holes and geoelectric measurements a consistent geological 3D model of Halle/Saale was created. The ambition was to visualize in detail the solid rock complex, which is composed of 11 different horizons. For the modelling process the software Move^{TM} from Midland Valley Exploration was used (MVE 2011). The new 3D model can be used as a database for further investigations in the field of groundwater flow and transport modelling or infrastructure and land use planning.

1 Introduction

Since the early 19th century, scientists aim to reconstruct the complex geology of Halle/Saale (ANDRAE 1850, VELTHEIM 1824). Since this time the geology of the site experienced almost 200 years of geological investigation and controversial interpretations (RAPPSILBER & SCHWAB 2006, BREITKREUZ et al. 2009).

The study area covers 135, 02 km² and represent the urban region of Halle/Saale. The underground consists of 11 stratigraphic units distributed over two very different geological blocks separated by faults (Fig. 1). In the northeast lies the Halle-Wittenberg fault-block with deposits of the Rotliegend (Lower Permian, ~290 Ma), Tertiary (~65 Ma) and Quaternary (~2,6 Ma) periods. In the southwest the Merseburg fault-block is located, with Zechstein (Upper Permian, ~257 Ma), Buntsandstein (~250 Ma), Muschelkalk (~243 Ma) and Cenozoic (~65 Ma) deposits. Both were separated by the Halle-fault, which is cretaceous (~85 Ma) in age and has a complex character (SCHWAB et al. 2006, BACHMANN et al. 2008).

With the support by modern 3D modelling software in combination with GIS applications a new approach of reconstruction and visualization of the underground was possible.

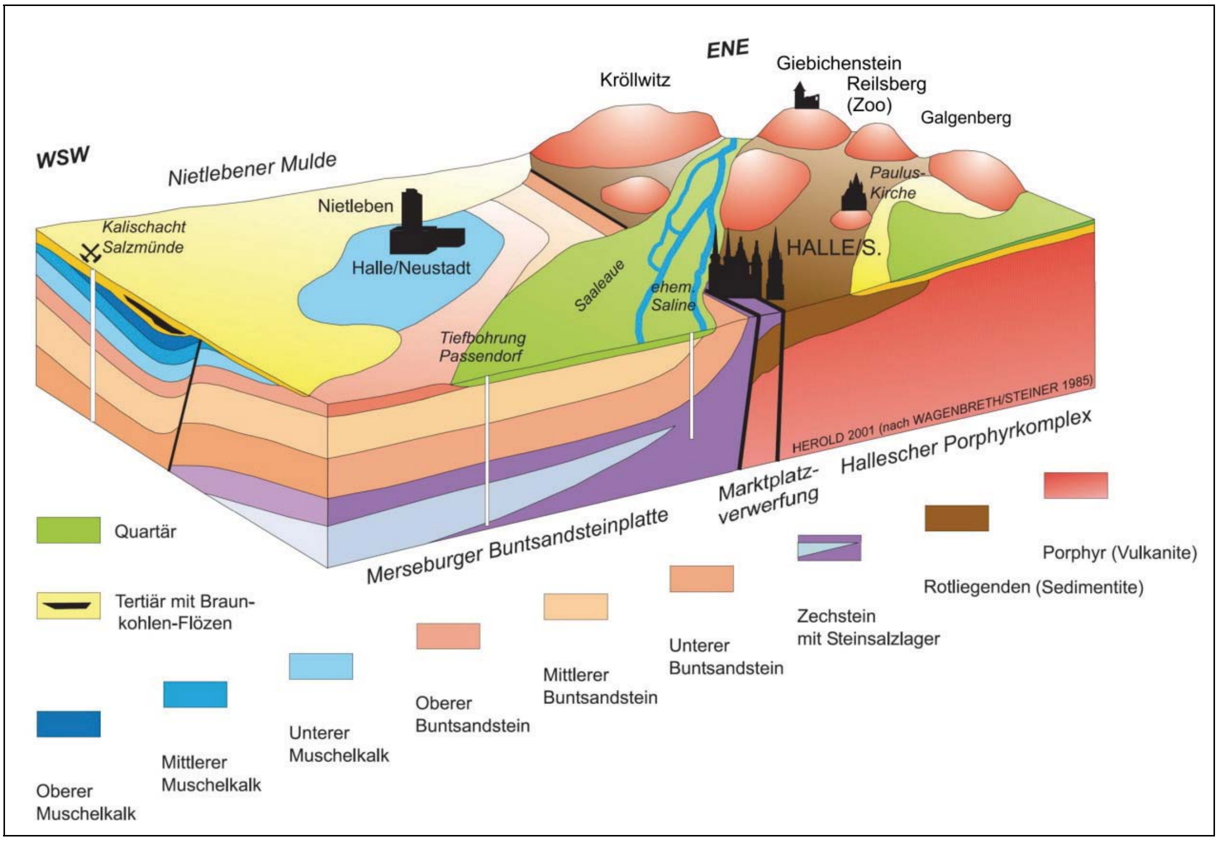

Figure 1: Schematic geological block diagram in the area of Halle/Saale (following Herold 2001, Wagenbreth & Steiner 1990)

2 Methods

The database of the model consists of 12 interpreted and depth corrected seismic profiles in image format, which contain faults and horizon data (Fig. 2). In addition 2743 boreholes of the Landesamt für Geologie und Bergwesen with information about stratigraphy and depth were used (Fig. 3). Furthermore the trend of the main Halle-fault and several smaller near surface faults were taken from several publications (HÄNIG & KÜSTERMANN 1995, KÜSTERMANN 2006, DÖRRER & SEIDEMANN 2006) (Fig. 4).

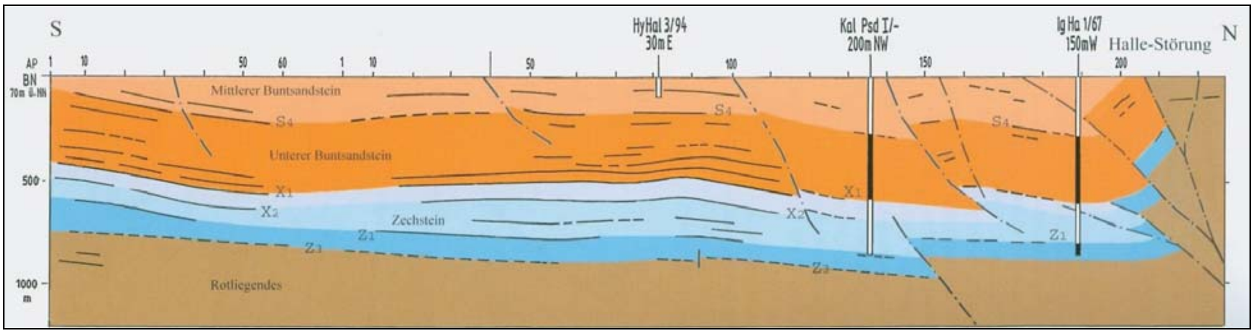

Figure 2: Example of a seismic profile used for the modelling process

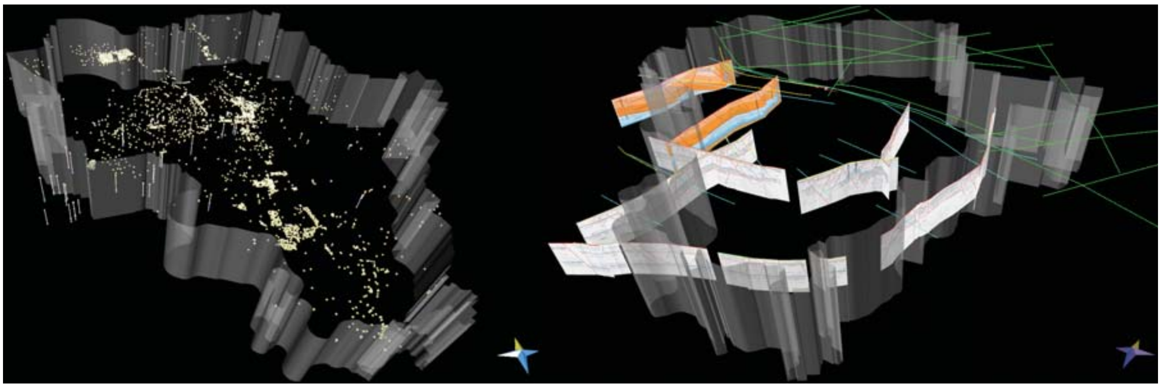

Figure 3 (left): City boundary of Halle/Saale with bore-holes used for the 3D model

Figure 3 (right): City boundary of Halle/Saale with seismic profiles and fault lines on the surface

A digital elevation map (DEM) with a raster width of 10 m represents the model surface. Furthermore a geological (Fig.5) and topographic map was inserted.

From this collection of information and the support of local geologists, who are familiar with the geological conditions, the model was generated with Move™ (MVE 2011).

Figure 5: The geological map of Halle/Saale and environment draped on the DEM of the study area

3 Discussion and Preview

The 3D geological-model created with Move^{TM}, is the first attempt to visualize the solid rock complex including the ambivalent fault-zone of the Halle-fault. Especially along the fault-zone and near the urban centre significant information about the trend of the horizons and the geometry of the faults were missing. With the support of local geologists and the extrapolation of existing data the 3D model was realized. Due to the lack of information in parts of the study area, the model may be partly inaccurate. If further information via drilling-projects or seismic measurements becomes available, the model can be tested for its reliability.

Based on this, further research in groundwater transport and flow modelling is accomplishable, particularly with consideration of the remediation and monitoring of contaminated sites.

Furthermore infrastructure planning and land use planning will be easier in future with a complex 3D model. The ability to visualize complex geological contents can therefore be regarded as a key approach to solving such problems.

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