3D-URG: 3D gravity constrained structural model of the Upper Rhine Graben

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Jessica Freymark[1], Judith Bott[1], Magdalena Scheck-Wenderoth[1], Kristian Bär[2], Manfred Stiller[1], Johann-Gerhard Fritsche[3], Matthias Kracht[3], Maria Laura Gomez Dacal[1]

1. *GFZ German Research Centre for Geosciences, Potsdam, Germany*
2. *TU Darmstadt, Darmstadt, Germany*
3. *Hessisches Landesamt für Naturschutz, Umwelt und Geologie, Wiesbaden, Germany*

1. Licence

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3. Abstract

We provide a set of grid files that collectively allow recreating a 3D geological model which covers the Upper Rhine Graben and its adjacent tectonic domains, such as portions of the Swiss Alps, the Molasse Basin, the Black Forest and Vosges Mountains, the Rhenish Massif and the Lower Rhine Graben. The data publication is a complement to the publication of Freymark et al. (2017).

Accordingly, the provided structural model consists of (i) 14 sedimentary and volcanic units; (ii) a crystalline crust composed of seven upper crustal units and a lower crustal unit; and (iii) two lithospheric mantle units. The files provided here include information on the regional variation of these geological units in terms of their depth and thickness, both attributes being allocated to regularly spaced grid nodes with horizontal spacing of 1 km.

The model has originally been developed to obtain a basis for numerical simulations of heat transport, to calculate the lithospheric-scale conductive thermal field and assess the related geothermal potentials, in particular for the Upper Rhine Graben (a region especially well-suited for geothermal energy exploitation). Since such simulations require the subsurface variation of physical rock properties to be defined, the 3D model differentiates units of contrasting materials, i.e. rock types. On that account, a large number of geological and geophysical data have been analysed (see Related Work) and we shortly describe here how they have been integrated into a consistent 3D model (Methods). For further information on the data usage and the characteristics of the units (e.g., lithology, density, thermal properties), the reader is referred to the original article (Freymark et al., 2017). The contents and structure of the grid files provided herewith are described in the Technical Info section.

4. Methods

The presented 3D structural model is the result of an extensive data integration process. In a first step, we visualized and collectively analysed geological maps, smaller-scale 3D structural models, depth and thickness maps, drilled formation tops and interpreted seismic horizons (See Related Works) using the software Petrel (©Schlumberger). After identifying the main lithological units to be differentiated by the intended 3D model and correcting for inconsistencies between the layers, the scattered information on the top surface elevation of the units was interpolated to obtain regular grids with a horizontal element spacing of 1 km (Convergent Interpolation algorithm of Petrel). More details about the original datasets (e.g., their regional extents, sources etc.) used to model the topology of the structural horizons are listed in the Supplementary Material 1 of Freymark et al. (2017).

In order to mitigate insufficient coverage of the region with deep seismic profiles revealing the internal structure of the sub-sedimentary crystalline crust, we have performed 3D gravity modelling, in particular to assess the depth position of the interface between the upper and the lower crust in areas at large distance from any seismic constraints. Therefore, we have assigned an observation-constrained density value to each model layer and, by using the software IGMAS+, interactively modified the top of the lower crust until the gravity field computed for the 3D density model was consistent with the observed free-air gravity anomaly.

5. File description

The model grids are provided as tab separated ASCII files, one for each model unit while their structure is identical. As indicated by the headers of these files, column #1 contains the easting (X coordinate), column #2 the northing (Y coordinate), column #3 the depth of the top of the model unit [m above sea level] and column #4 the thickness of the respective layer [m]. The model horizontally extends by 290 x 525 km.

Depth and thickness information is provided for regularly (1 km) spaced grid nodes which are identical for all model units. These grid nodes are assigned coordinates of the UTM Zone 32N. For an overview of the thickness maps of all layers, we again refer to the Supplementary Material 1 of Freymark et al. (2017). The file names include the name of the corresponding model unit and a number that refers to the structural position of the unit; for recomposing the 3D model, one would have to order the grids with increasing number to build the model from top to bottom. The vertical resolution of the final 3D model is heterogeneous since it corresponds to the variable thickness of its units.

Please also note that the thickness of the gridded units is set to 0.1 m at places where the units are actually observed to be absent. We accept this offset value since (i) this minor vertical shift of grid nodes significantly simplifies the transformation into a 3D model ready for applying the Finite Element Method (e.g., for heat transport simulations) and (ii) a thickness difference of 0.1 m does not critically affect lithospheric-scale calculations of gravity anomalies and the conductive thermal field.

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