Proceedings World Geothermal Congress 2026, Calgary, Canada, June 8—11, 2026

Nationwide Subsurface Thermal Conductivity Mapping for the Assessment of the Shallow Geothermal Potential in Germany

Tom V. Schintgen[1]*, Björn A. Holstein[1], Thorsten Agemar[1], Muhammad Anees[1], Michael Dussel[2], Domenico C.G. Ravidà[2], Inga S. Moeck[1,2]

LIAG Institute for Applied Geophysics, Hanover, Germany[1]*, Department of Structural Geology and Geothermics, Geoscience Center, Georg-August University of Göttingen, Germany[2]

*tom.schintgen@liag-institut.de

INTRODUCTION

Assessing the geothermal potential of shallow geothermal technologies, such as borehole heat exchangers (BHEs) (e.g., Miocic et al. 2024), is a primary objective of the WärmeGut project. It is inspired by the European GeoPLASMA-CE project, which developed methods for presentation and evaluation of the shallow geothermal potential and criteria for a sustainable use based on relatively small pilot areas (Hofmann et al., 2021).

Estimating the shallow geothermal potential in Germany requires both a nationwide estimate of mean subsurface thermal conductivities for different BHE lengths and a reasonably accurate shallow-subsurface temperature model. Maps of the shallow geothermal energy potential will be made accessible to the users via the public Geothermal Information System GeotIS. It includes a tool that estimates the potential share of local heat demand that could be covered by standardized BHEs, based on the heat demand density of different building classes and the available space for drilling.

We present preliminary results of thermal conductivity mapping based on the Geological Overview Map of Germany at the scale of 1:250,000, which provides an adequate approximation of the geology in the first few meters of depth. This near-surface geological information can be combined or complemented with geological profiles and lithological information from boreholes to create a layer model representative of the depth range up to 400 m for shallow geothermal use in Germany.

METHODS

Currently, the 16 German State Geological Surveys provide various thermal conductivity maps for borehole heat exchangers that are based on different presentations, data, methods, scales and resolutions. However, a comprehensive reproduction of subsurface thermal conductivity of entire Germany would require a consistent and detailed 3D geological model, and, as most essential parameters, a representative dataset of measured thermal conductivity values for each geological unit, in addition to information about the groundwater table. However, the main challenge of subsurface characterization is related to the lithological, structural and hydrogeological heterogeneity and complexity.

In our approach for the realization of a nationwide thermal conductivity map, we employed the harmonized Geological Overview Map of Germany at the scale of 1:250,000 (BGR, 2024) and assumed that the subsurface is water saturated, which is important with regard to the thermal conductivity of porous or fractured rock. The assumption of water saturation is valid, because rocks in Germany are generally wet to saturated at shallow depth, and thus we can ignore fragmentary information about the water table. For parametrization, we use thermal conductivity values recommended by the German guideline VDI 4640 with a focus on the design of borehole heat exchanger and collector systems for shallow geothermal energy use (Figure 1).

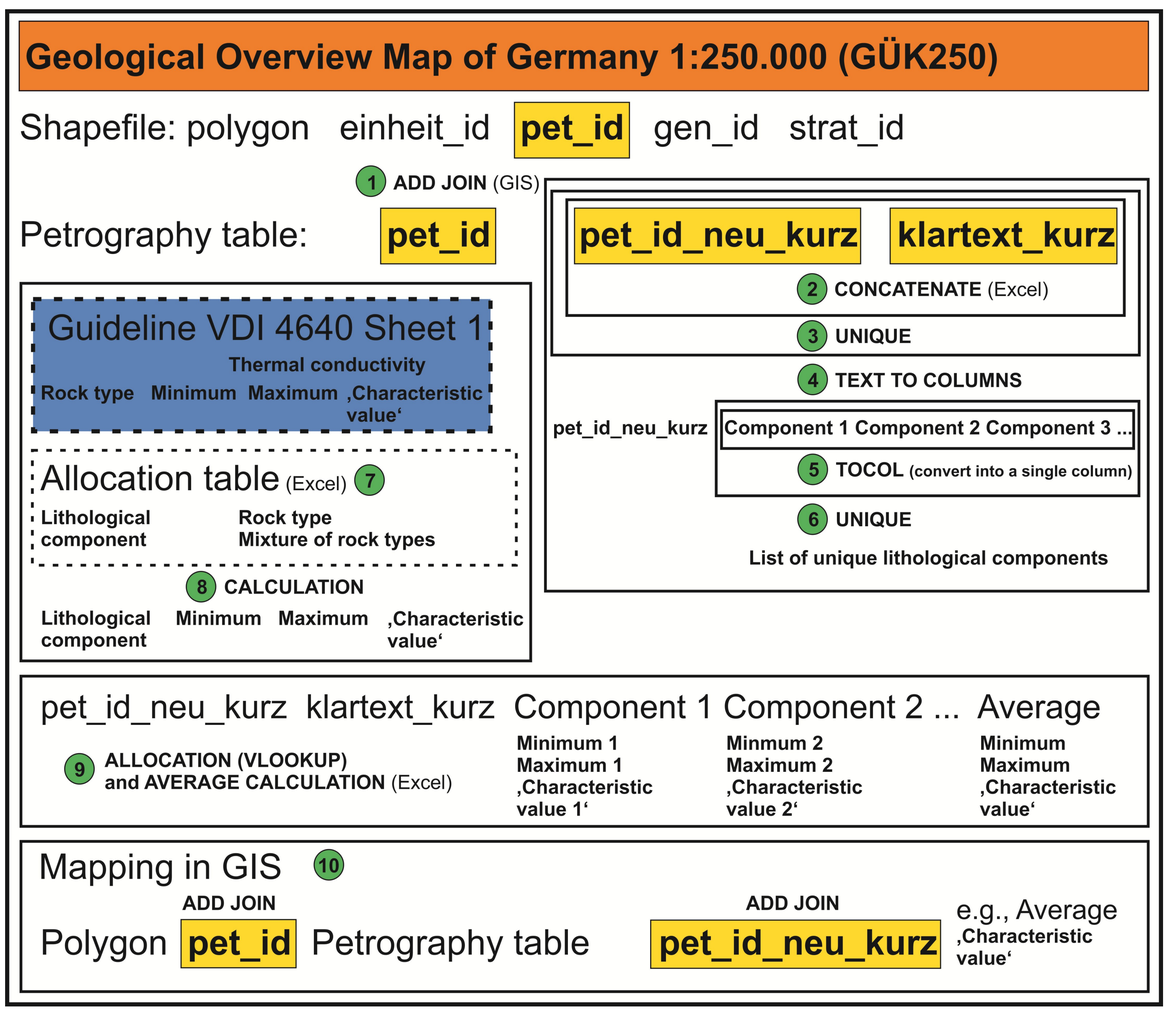


Figure 1. Simplified representation of the workflow for the production of a nationwide thermal conductivity map for Germany, based on the Geological Overview Map of Germany at the scale of 1:250,000 (BGR, 2024) and the German guideline VDI 4640 Sheet 1 with a focus on the design of borehole heat exchanger and collector systems for shallow geothermal energy use.

RESULTS

We present the first thermal conductivity overview map based on near-surface geology at the scale of 1:250,000 covering entire Germany (Figure 2). The younger sedimentary basins like the North German Basin, the Upper Rhine Graben in southwestern Germany and the Molasse Basin in southern Germany, which are characterized by Quaternary and Tertiary sediments, are characterized by thermal conductivities in the range of 0.4 to 2.4 W/(m*K), whereas the values characteristic of Mesozoic rocks range from 1.9 to 3.5 W/(m*K) and those characteristic of Palaeozoic and older, frequently metamorphic or igneous rock, range from 2.1 to 6.0 W/(m*K).

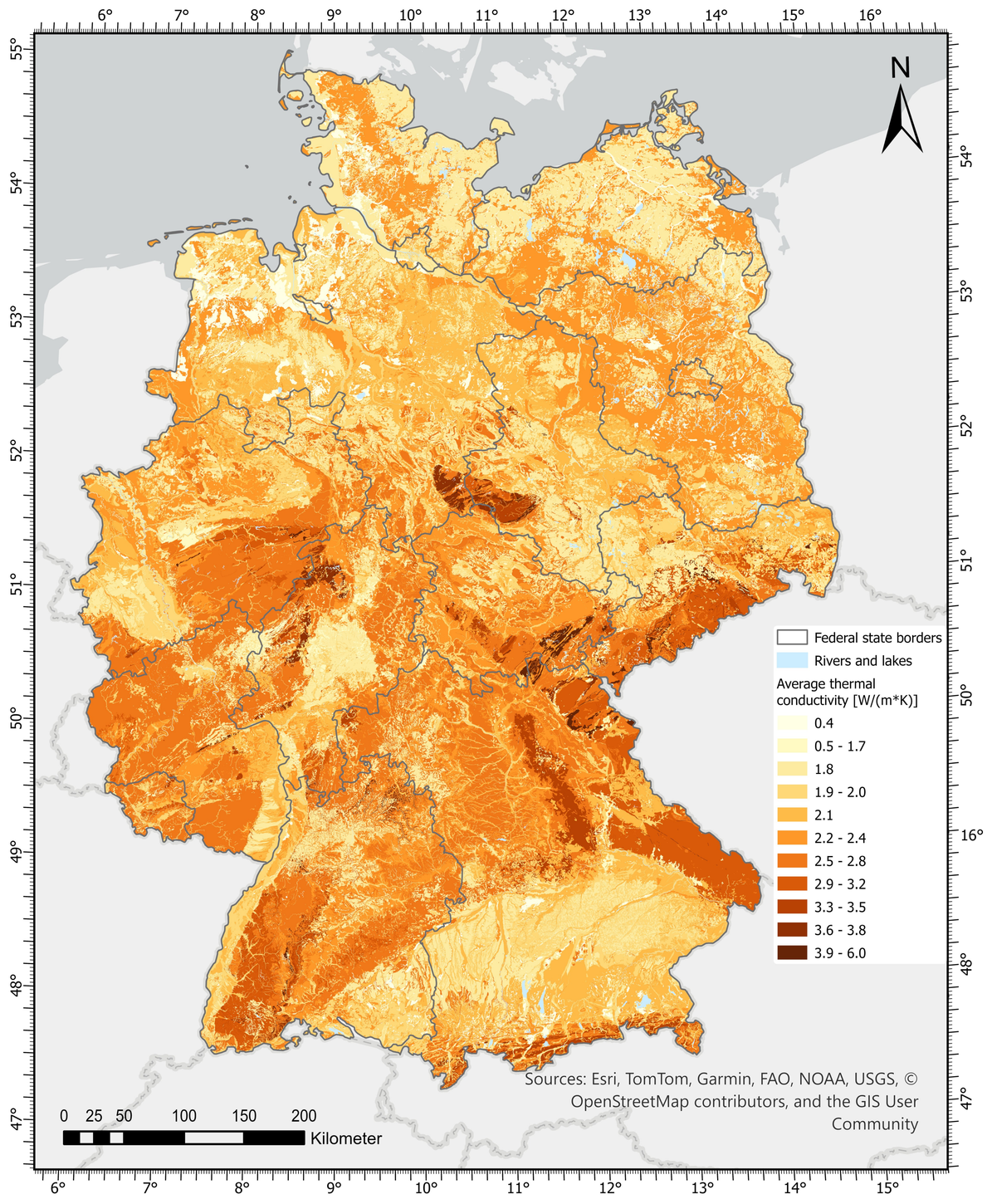


Figure 2. Subsurface thermal conductivity map of Germany (scale 1:250,000) based mostly on near-surface geology provided by the geological overview map GÜK250 (BGR, 2024) and on thermal conductivity values recommended by the German guideline VDI 4640 for designing borehole heat exchanger and collector systems for shallow geothermal energy use.

DISCUSSION

Consistent thermal conductivity maps have been produced at the European scale (Ramos-Escudero et al., 2021). Heim et al. (2022) developed a more sophisticated workflow by combining borehole data, geological maps, a digital elevation model and hydrogeological data to produce a GIS layer model of the small German state of Hamburg.

However, the objective of the WärmeGut project is to estimate the shallow geothermal potential of entire Germany, which basically requires comprehensive and ideally consistent and harmonized data for each relevant parameter. The thermal conductivity map presented here represents the first step to reach this target.

The next step is to analyse thermal conductivity contrasts in the thermal conductivity map to develop a layer model by using additional information such as specific boundaries of geological units. We are also collaborating with the Geological Surveys of the 16 German federal states to incorporate representative thermal conductivity values based on measured samples and to include more accurate compositional data of the geological units.

CONCLUSIONS AND OUTLOOK

The thermal conductivity map based on near-surface geology at the scale of 1:250,000 represents the first overview map that shows the near-surface thermal conductivity distribution covering entire Germany. In combination with a shallow-subsurface temperature model, it serves as input information for a calculation tool that estimates the potential share of local heat demand that could be covered by standardized BHEs, based on the heat demand density of different building classes and the available space for drilling.

However, in order to provide mean subsurface thermal conductivities for different BHE lengths, the presented thermal conductivity map needs to be refined by incorporating statistically representative values for geological units based on measurements and to be transformed into a layer model using specific boundaries of geological units based on significant thermal conductivity contrasts.

REFERENCES

BGR (Bundesanstalt für Geowissenschaften und Rohstoffe): Geologische Übersichtskarte der Bundesrepublik Deutschland 1:250.000 (GÜK250), https://services.bgr.de/geologie/guek250, last accessed on 11/29/2025.

Heim, E., Laska, M., Becker, R., Klitzsch, N.: Estimating the subsurface thermal conductivity and ist uncertainty for shallow geothermal energy use—a workflow and geoportal based on publicly available data, Energies, 15, 3687, (2022).

Hofmann, K., Görz, I., Riedel, P., Heiermann, M., Franěk, J., Jelének, J., and Holeček, J.: Das EU-Projekt GeoPLASMA-CE: Erdwärme—harmonisierte Methoden zur Darstellung und Bewertung des Potenzials sowie Erfolgskriterien für eine nachhaltige Nutzung, Endbericht, Schriftenreihe des Sächsischen Landesamtes für Umwelt, Landwirtschaft und Geologie, 7, (2021).

Miocic, J.M., Schleichert, L., Van de Ven, A., and Koenigsdorff, R.: Fast calculation of the technical shallow geothermal energy potential of large areas with a steady-state solution of the finite line source, Geothermics, 116, 102851, (2024).

Ramos-Escudero, A, García-Cascales M.S., Cuevas J.M., Sanner B, and Urcheguía J.F.: Spatial analysis of indicators affecting the exploitation of shallow geothermal energy at European scale, Renewable Energy, 167, (2021), 266-281.

VDI 4640 Blatt 1: Thermische Nutzung des Untergrunds—Grundlagen, Genehmigungen, Umweltaspekte, Dezember 2021.

Acknowledgements

This study is part of the WärmeGut project, which is funded by the German Federal Ministry for Economic Affairs and Energy (grant number 03EE4046A).

The authors would like to thank the Geological Surveys of the 16 German federal states, whose hints, advice and contributions to the project are highly appreciated by the WärmeGut team.

Supported by:
Federal Ministry for Economic Affairs and Energy
on the basis of a decision by the German Bundestag