Freitag, 27. Februar 2026, 11.00 Uhr
Ortenauhalle Kongress 1
Tiefe Geothermie

Friday, 27 February 2026, 11.00 am
Ortenauhalle Congress 1
Deep geothermal energy

Identifying thermal convection using basin modeling and fluid mechanics in the Upper Rhine Graben

Identifizierung thermischer Konvektion mithilfe von Beckenmodellierung und Strömungsmechanik im Oberrheingraben

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Economic development of sedimentary geothermal systems is often associated with reservoirs controlled by convective heat transfer. Basin modeling provides an efficient approach to understand the pressure and thermal regime and to identify areas where conductive or convective heat transfer processes are dominant on a regional scale.

We present a basin modeling workflow for these hidden sedimentary geothermal systems, from regional screening towards the prediction of localized, thermally anomalous patterns. This workflow has been applied to the geologically and thermally complex Upper Rhine Graben. The basin model is constructed using the publicly available GeORG (2013) dataset focusing on the central-to-northern part, extending from Haguenau in the south towards Landau in the north. To assess the regional conductive rift-related thermal regime, we first applied a crustal model integrating information on lithospheric thickness and rift evolution from Ziegler and Dezes (2005). During model calibration, we considered diagenetic processes to predict the cementation-reduced porosity. The comparison of temperature and vitrinite reflectance data with these initial regional results showed that lithospheric thinning alone could not account for local thermal anomalies, in particular along the western margin of the study area. Here convective heat transfer is likely to contribute significantly locally. To identify areas with significant contribution of convection we calculated the dimensionless Rayleigh number, which represents an indicator for free convection in fluid mechanics (e.g., Schmeling and Marquart, 2014).

Results from our initial model with laterally uniform litho-facies distribution indicate a higher tendency for convection cells along the western margin of the study area (including Soultz, Rittershofen, and Landau) with the highest values for the Rayleigh number within the Buntsandstein Formation. These findings correlate well with observed thermal anomalies characterized by elevated geothermal gradients reinforcing the hypothesis of active thermal convection. Our study demonstrates that the Rayleigh number is a robust diagnostic tool within basin modeling workflows for regional screening and quantification of convective heat transfer, especially in areas with sparse well control.

References

GeORG Projektteam, 2013, Geopotenziale des tieferen Untergrundes im Oberrheingraben, Fachlich-Technischer Abschlussbericht des INTERREG-Projekts GeORG. https://www.geopotenziale.org/products/fta?lang=1. accessed August 27, 2025.

Schmeling, H. and Marquart, G., 2014, A scaling law for approximating porous hydrothermal convection by an equivalent thermal conductivity: theory and application to the cooling oceanic lithosphere, Geophysical Journal International, 197, 645-664. https://doi.org/10.1093/gji/ggu022.

Ziegler, P.A. and Dezes, P., 2005, Evolution of the lithosphere in the area of the Rhine Rift System, International Journal of Earth Sciences, 94, 594-614. https://doi.org/10.1007/s00531-005-0474-3.