Technical University of Munich

Characterizing the Heterogeneity of Transmissibility and Hydraulically Active Zones in the Deep Geothermal Reservoir in Bavaria

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Motivation

- **Deep geothermal energy** holds great potential for **reducing CO_2 emissions**
- **Germany's deep geothermal potential** is estimated to be **70 GW**, but it is **far from being fully utilized**

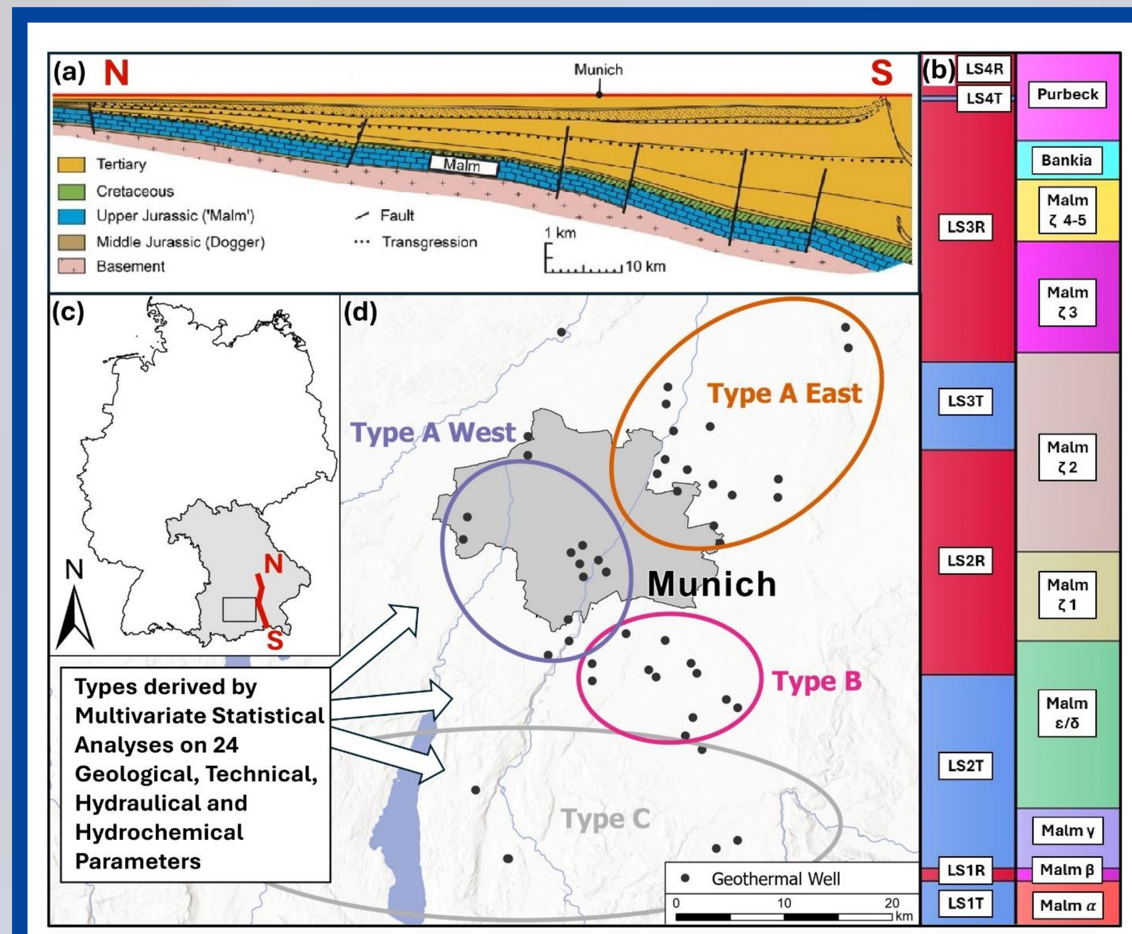
Key barrier:
High uncertainties in potential prognoses due to **high reservoir heterogeneity**

Solution:
Improved reservoir characterization

- **Volume flux** and **temperature** as key parameters for **thermal power output** of geothermal plants
- Flux depends on **hydrogeological characteristics** of the reservoir controlled by **transmissibility** and **permeability**

Goal:
Refine spatial distribution of **hydrogeological characteristics** of the **Upper Jurassic–Lower Cretaceous reservoir ('Malm'–'Purbeck')**

Study Area



a) Cross-section of **the North Alpine Foreland Basin**, dipping from north to south, with the **'Malm'-'Purbeck'** reservoir in blue.

b) The **'Malm'-'Purbeck'** reservoir has traditionally been described using a lithostratigraphic subdivision into **'Malm' α-ζ** and **'Purbeck'** which relies on the presence of specific lithofacies, it is sensitive to lateral facies changes, thinning, and pinch-out, resulting in stratigraphic gaps and ambiguities when applied at the basin scale. Instead, the succession is subdivided into four large **sequence-stratigraphic units**, each comprising a transgressive **(LS T)** and a regressive **(LS R)** phase.

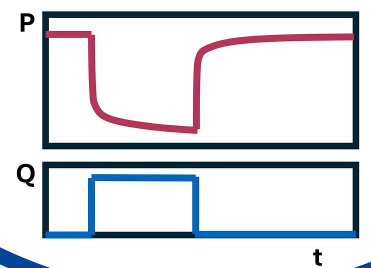
c) The Bavarian part of the **North Alpine Foreland Basin** extends from the **northern Alpine margin** to the **outcrops of the Swabian and Franconian Alb**

d) **Schölderle et al. (2025)** used a robust database with geothermal well data (geophysical, technical, geochemical and hydraulic) to perform **multivariate statistical methods** to derive **spatially divided clusters** in the greater area of Munich in the North Alpine Foreland Basin

Method

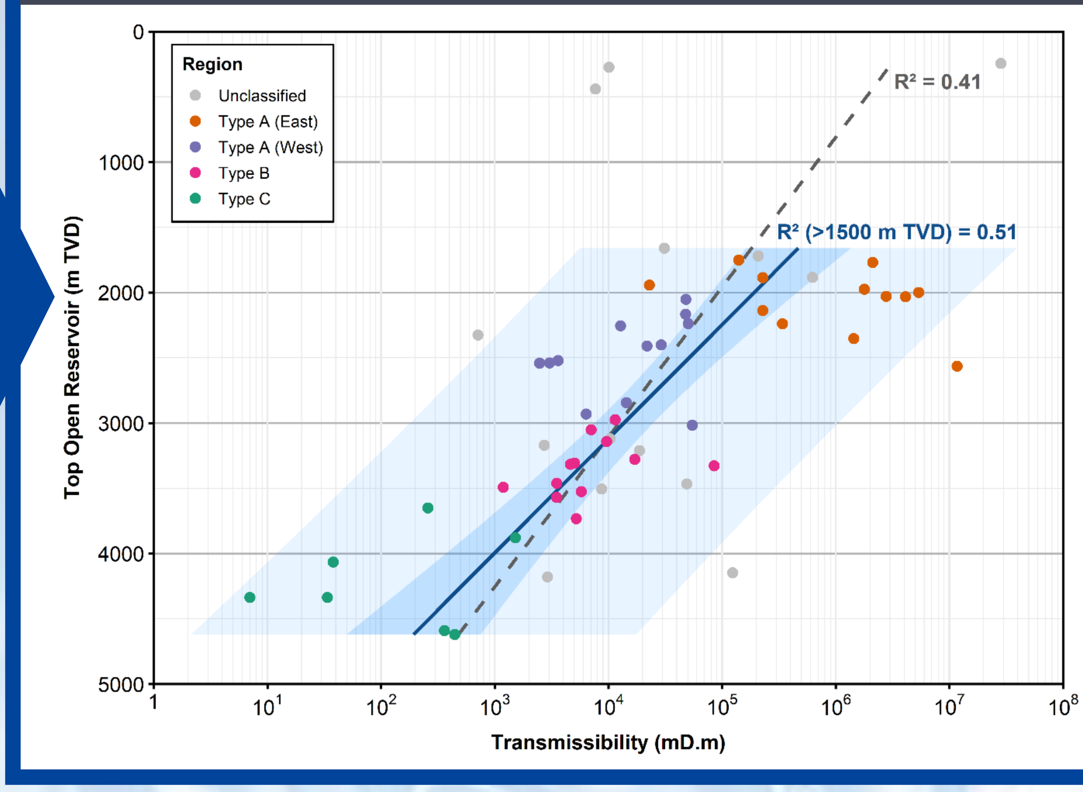
Transmissibility from Well Test Data

- Transmissibility is an overall measure of the **potential of the reservoir**
- **Transmissibility = Permeability * Thickness**
- Quantifying through the evaluation of **well tests**
- The pressure and flow data set is analysed



Results

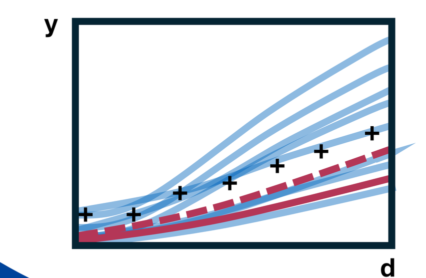
Integrative Transmissibility in Relation to Depth



Method

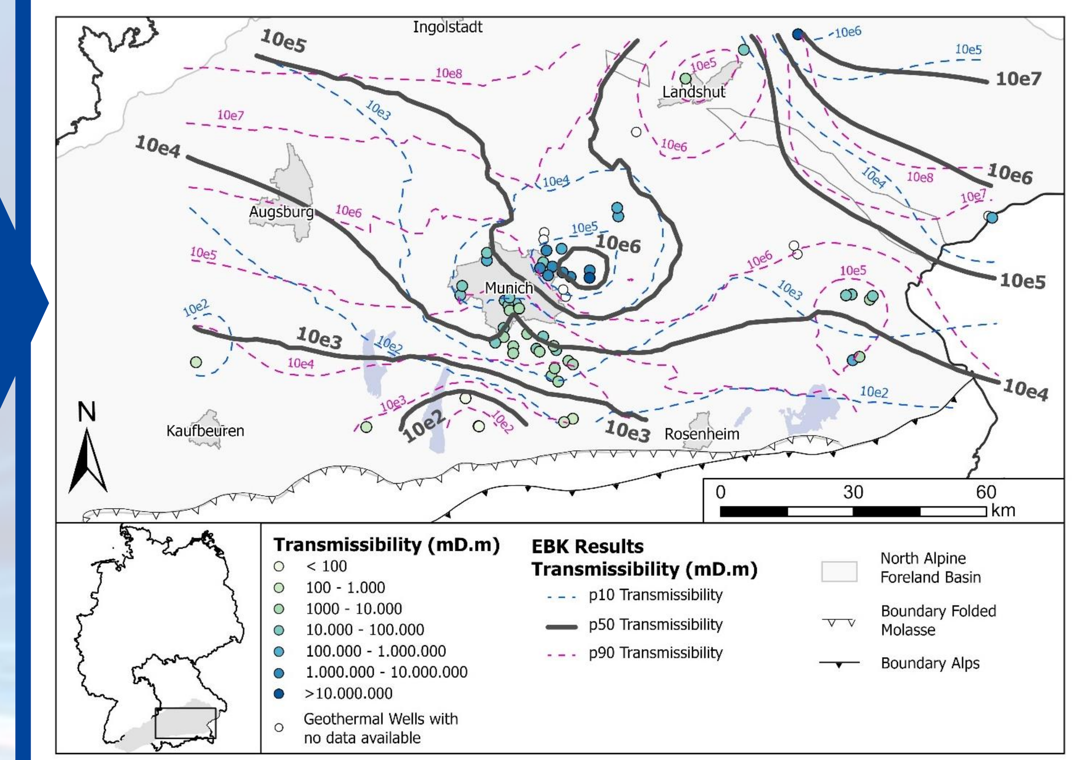
Empirical Bayesian Indicator Kriging

- Method adresses key limitations of classical kriging by **incorporating uncertainty** directly into **semivariogram modelling**
- Selected for this study due to the **high heterogeneity** of the reservoir **and uneven spatial data distribution**



Results

Spatial Distribution of Integrative Transmissibility



BeM-TG Bayern

Bayerisches Landesamt für Umwelt

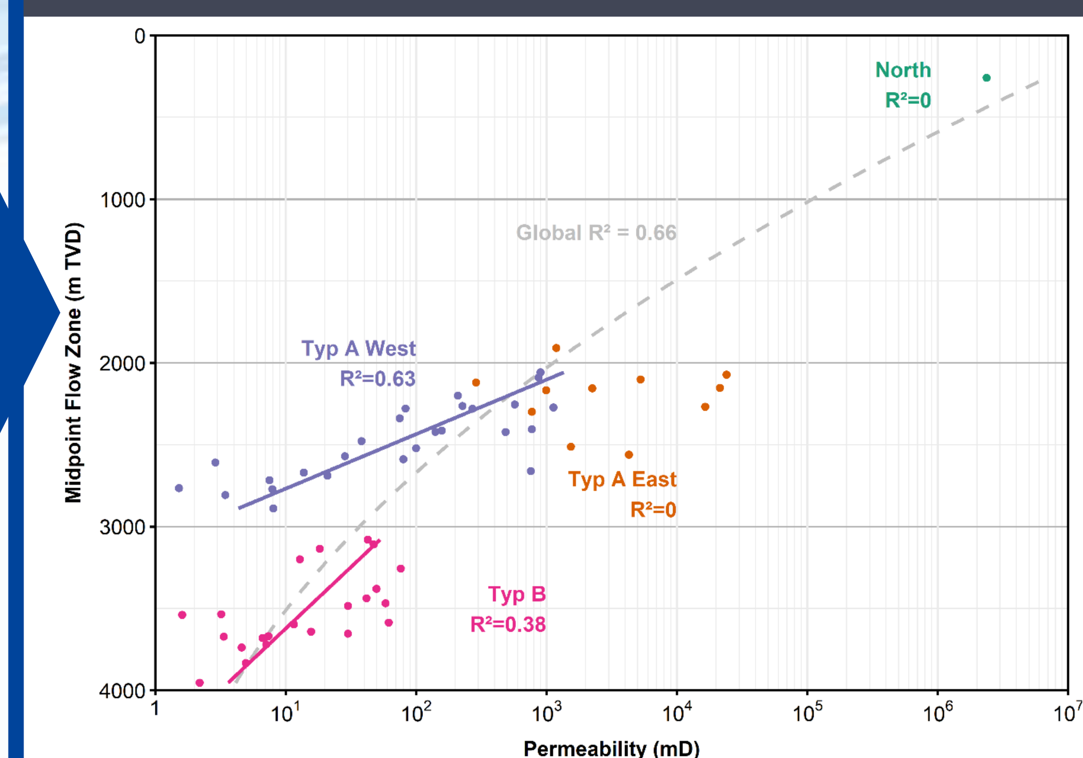
Method

Permeability of Flow Zones

- **Flow zones** identified via **flowmeter spinner** or **fiber optic** measurements
- Each zone characterized by **depth**, **thickness**, and **flow contribution**
- **Effective permeability** per **flow zone** derived by combining **flow zone thickness**, **flow contribution** and **transmissibility**

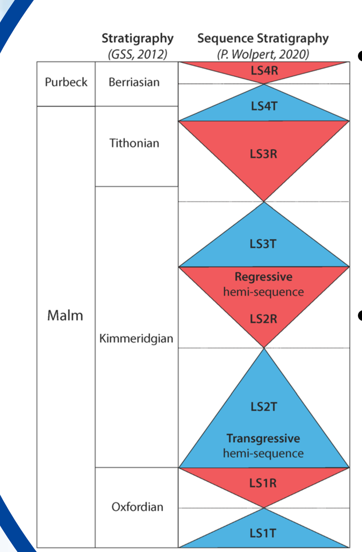
Results

Permeability of Flow Zones in Relation to Depth



Method

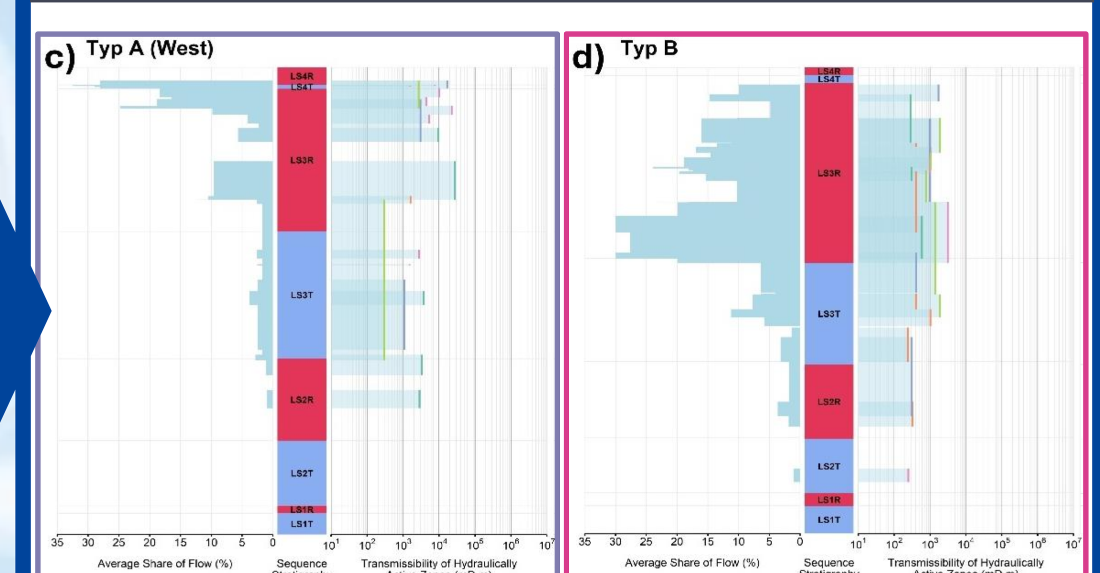
Sequence Stratigraphy



- Spatial correlation is more robust when referencing **sequence-stratigraphic position**
- Visualization reveals **basin-wide and local trends** in occurrence and transmissibility of hydraulically active zones

Results

Spatial Distribution of Flow Zones



- **Position** of **flow zones** in the **sequence stratigraphy in different regions**

Conclusion

Update of the **spatial distribution** of **integrative reservoir transmissibility with a probabilistic approach.**

For the first time, **hydraulically active zones** considered in **relation to depth** and in a **sequence stratigraphic framework**, both **spatially resolved**.

The results contribute to a **deeper understanding** of the **hydraulic properties** of the reservoir and will be used for **production and interference prognosis** in the **BeM-TG Project.**

Literature:
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