# Joint presentation for EGU2020-19662 and EGU2020-4685 in

# Session ERE2.6: Exploration, utilization and monitoring of conventional and unconventional geothermal resources

EGU2020-19662

## The geothermal potential of sedimentary basins – case study for Berlin, Germany

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EGU2020-4685

## Influence of fluid flow and heat transport on predictions of geothermal potentials in sedimentary layers of Hesse (Germany)

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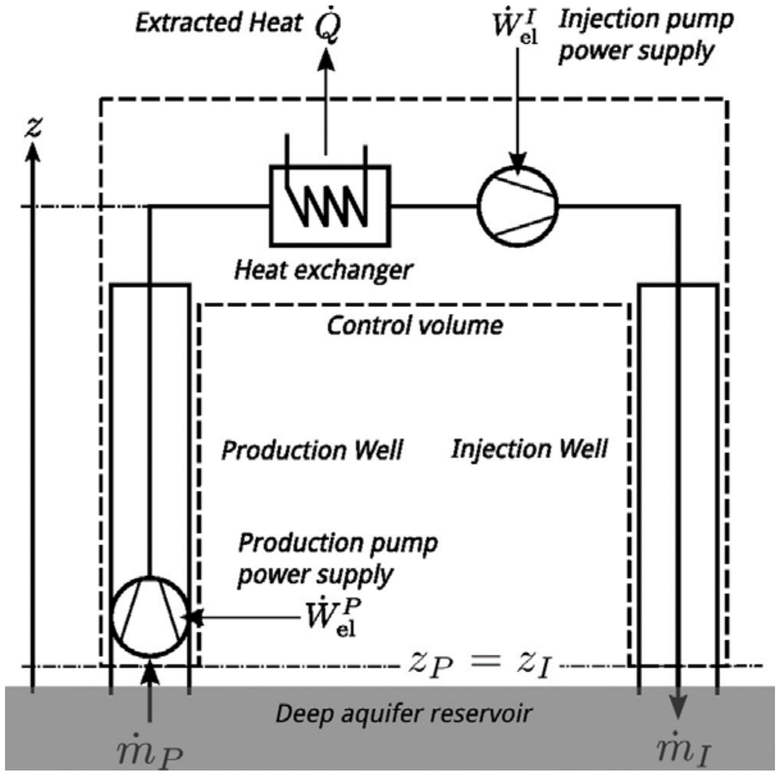
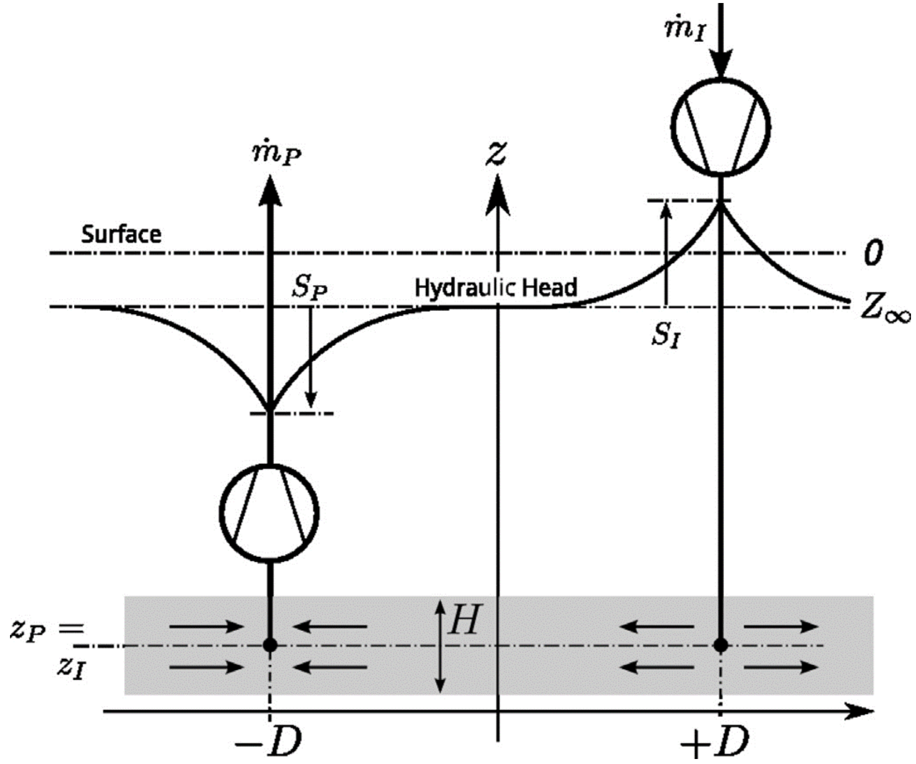
# Predict Geothermal Potential via Heating Power of a Geothermal Doublet

after Kastner et al. 2015[1] as presented in Frick 2019[2] and Koltzer 2020[3]
For more details about the methodology please refer to the papers above

## Schematic Power Plant




## Hydraulic Configuration




Heating Power:

$$\dot{Q}_{OP} = \dot{m}_{OP} * c_f(T^I - T^P)$$

With
$\dot{m}_{OP}$ = Production Mass Flux,
$c_f$ = Heat Capacity of Fluid,
$T^{I,P}$ = **I**njection/**P**roduction Temperature

Modified after Kastner et al. 2015[1]

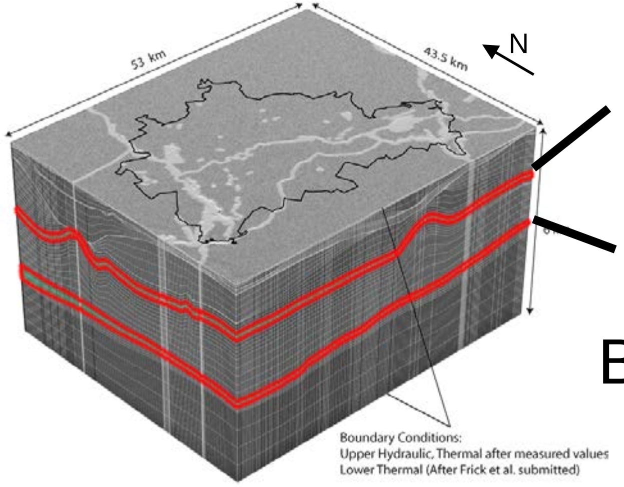

[1]Kastner, O., Sippel, J., & Zimmermann, G. (2015). Regional-Scale Assessment of Hydrothermal Heat Plant Capacities Fed from Deep Sedimentary Aquifers in Berlin/Germany. *Geothermics*, *53*, 353–367. https://doi.org/10.1016/j.geothermics.2014.06.002
[2]Frick, M. (2019). *Towards a more sustainable utilization of the urban geological subsurface: Insights from 3D thermohydraulic models* [PhD Thesis, FU Berlin]. https://refubium.fu-berlin.de/handle/fub188/23868
[3]Koltzer, N. (2020). *Influences of the hydrodynamics on the thermal field of the Upper Rhine Graben and implications for predictions of its geothermal potentials* [PhD Thesis]. RWTH Aachen, *submitted for publication*.

# Input Parameters for Calculation of Geothermal Potentials of Berlin and Hesse

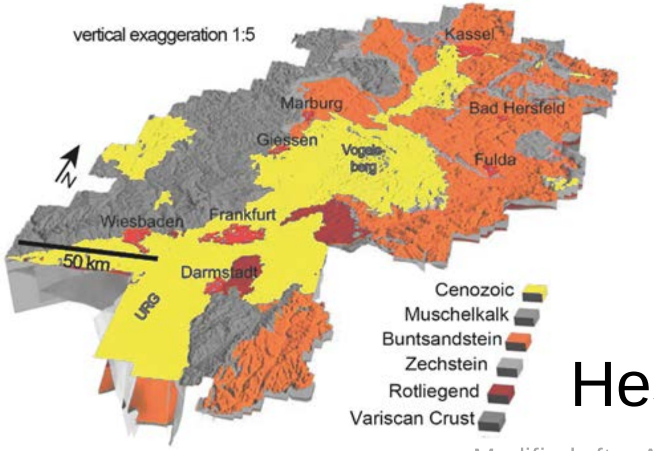
**1) Geological Structure:**
We utilized detailed geological models for both model regions as shown in Frick et al., 2019[1] (Berlin) and Koltzer et al., 2019[2] (Hesse) focusing on promising reservoirs (see Figures on the right).
We use the **reservoir thickness** as well as **reservoir depth** as input parameters.

**2) Physical Properties:**
The physical properties of each reservoir are divided into **fixed** and **variable**:
**Fixed**: Natural hydraulic head $Z_\infty$ [m], Effective Porosity φ [], Permeability $\kappa$ [m²]
**Variable**: Salinity $c$, Fluid density $\rho$, Dynamic viscosity $\mu$, Specific heat capacity $c_f$ and most importantly: Reservoir **Temperature** $T^P$ [°C].
Temperatures are taken from the most recent model realization considering coupled thermohydraulic simulations for Hesse (Koltzer et al., 2019[2]) and for Berlin with anthropogenic forcing (Frick et al., 2019[2]).
Sensitivity to considered physics (conductive, advective, convective) was also investigated (Manuscript in preparation).

**3) Doublet Configuration:**
Reinjection temperature $T^I$ [°C], Reservoir Lifetime a [years], Well Caliber R [m]




Berlin



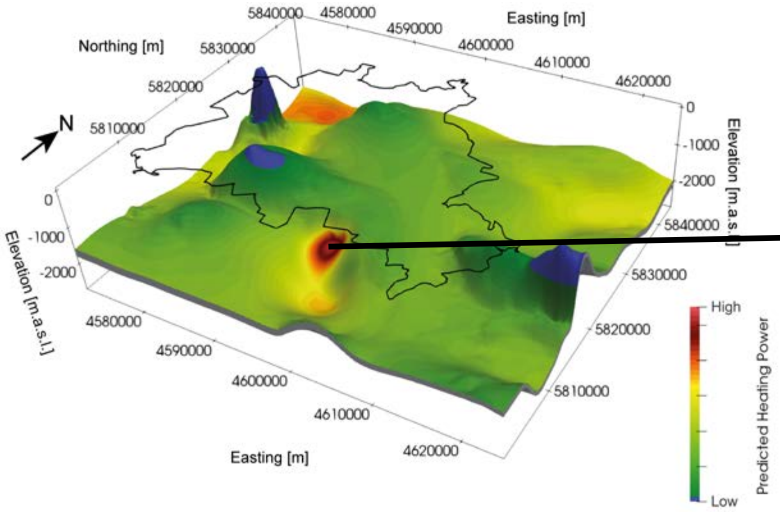

Hesse

Modified after Arndt 2012[4]

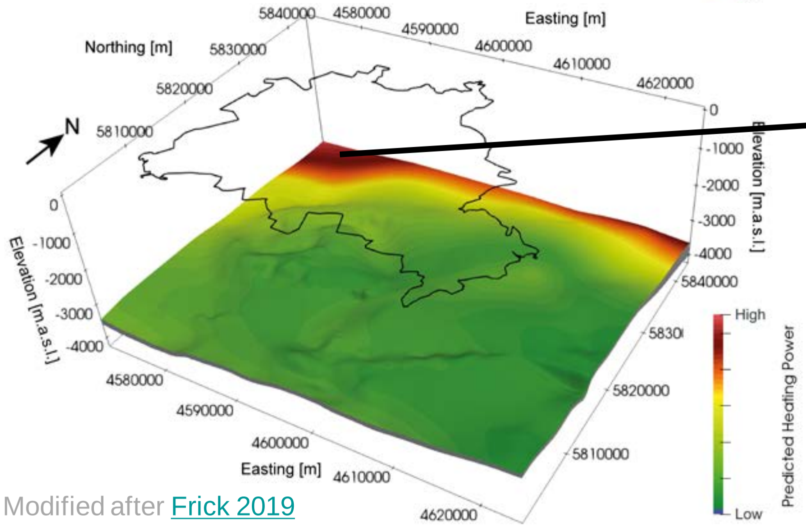
[1]Frick, M., Scheck-Wenderoth, M., Schneider, M., & Cacace, M. (2019). Surface to Groundwater Interactions beneath the City of Berlin: Results from 3D Models. *Geofluids*, *2019*. https://doi.org/10.1155/2019/4129016
[2]Koltzer, N., Scheck-Wenderoth, M., Bott, J., Cacace, M., Frick, M., Sass, I., Fritsche, J.-G., & Bär, K. (2019). The Effects of Regional Fluid Flow on Deep Temperatures (Hesse, Germany). *Energies*, *12*(11), 2081. https://doi.org/10.3390/en12112081
[3]Frick, M., Scheck-Wenderoth, M., Cacace, M., & Schneider, M. (2019). Boundary condition control on inter-aquifer flow in the subsurface of Berlin (Germany) – new insights from 3-D numerical modelling. *Advances in Geosciences*, *49*, 9–18. https://doi.org/10.5194/adgeo-49-9-2019
[4]Arndt, D. (2012). *Geologische Strukturmodellierung von Hessen zur Bestimmung von Geopotenzialen* [Dissertation]. TU Darmstadt.

# Results: Predicted Heating Power

## Berlin



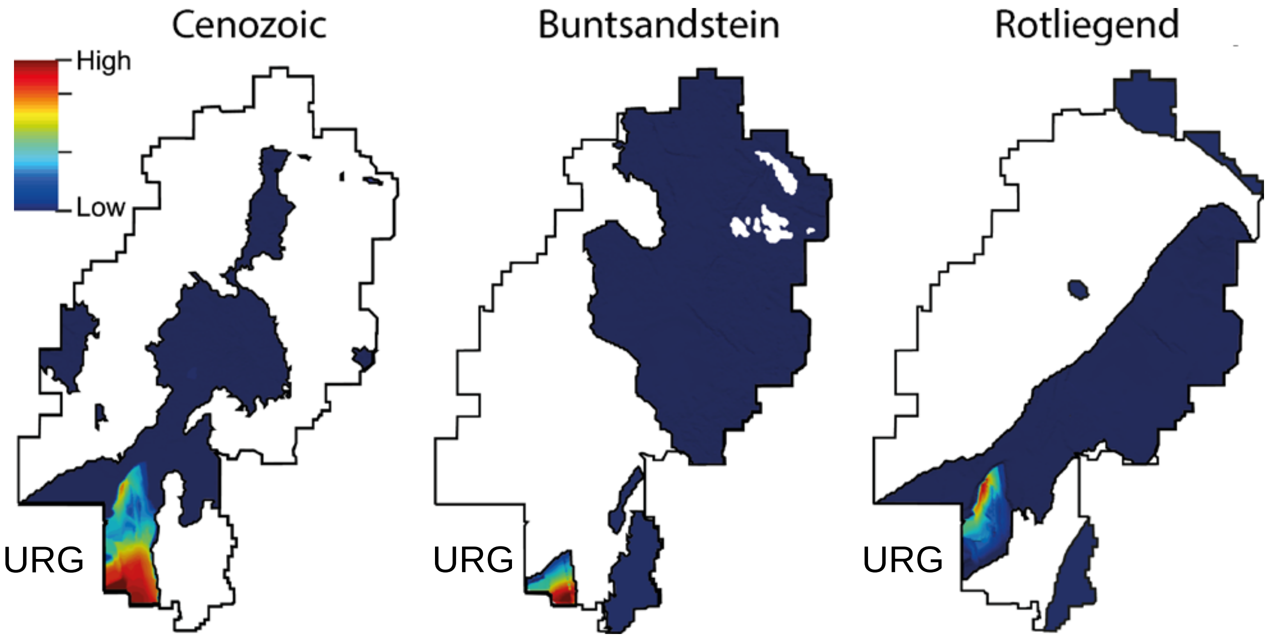

**Middle Buntsandstein**
High: Tempelhof due to high transmissivities and temperatures
Low: Over salt pillows and diapirs due to low temperatures




**Sedimentary Rotliegend**
High: Northern Model domain due to high transmissivities
Low: Central Model domain due to low transmissivities

Modified after [Frick 2019]

## Hesse




**All Reservoirs**

- Highest geothermal potential in Upper Rhine Graben (URG) due to high transmissivities and high temperatures
- Highest potentials are predicted with the higher temperatures from the conductive model (shown above)
- Coupled models show strong potential localization to convective upwelling but in general lower potentials due to forced convective cooling

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Frick, M. (2019). *Towards a more sustainable utilization of the urban geological subsurface: Insights from 3D thermohydraulic models* [PhD Thesis, FU Berlin]. https://refubium.fu-berlin.de/handle/fub188/23868



HELMHOLTZ

# Take Home Message

- Areas with geothermal potential for heat supply for both model areas predicted
- Regional geologic trends (depth, thickness) govern distribution of geothermal potential for the different reservoirs
- Tool most powerful for **estimating trends** in utilizable heating power and **identifying promising regions**
  - Geothermal potential distribution highly dependent on reservoir geometries, physical properties and the connected temperatures
  - Identified several regions with high geothermal potential
    Berlin: Tempelhof, Velten; Hesse: Upper Rhine Graben
  - High local (one virtual doublet) and regional cumulative (sum of doublets in promising area) geothermal potential
- Approach is **transferrable** to other locations and **scale independent**
- This potential estimation method should not be used as decision making tool for stakeholders but opts at identifying promising regions for more detailed studies

➢ Next step: Run local utilization scenario in area where high heating power is predicted in transient 3D coupled thermohydraulic simulations