Fluid circulation in the Perth Basin
A case study for geothermal reservoir use

E.ON Energy Research Center
ACS | Automation of Complex Power Systems
EBC | Energy Efficient Buildings and Indoor Climate

Motivation and Purpose

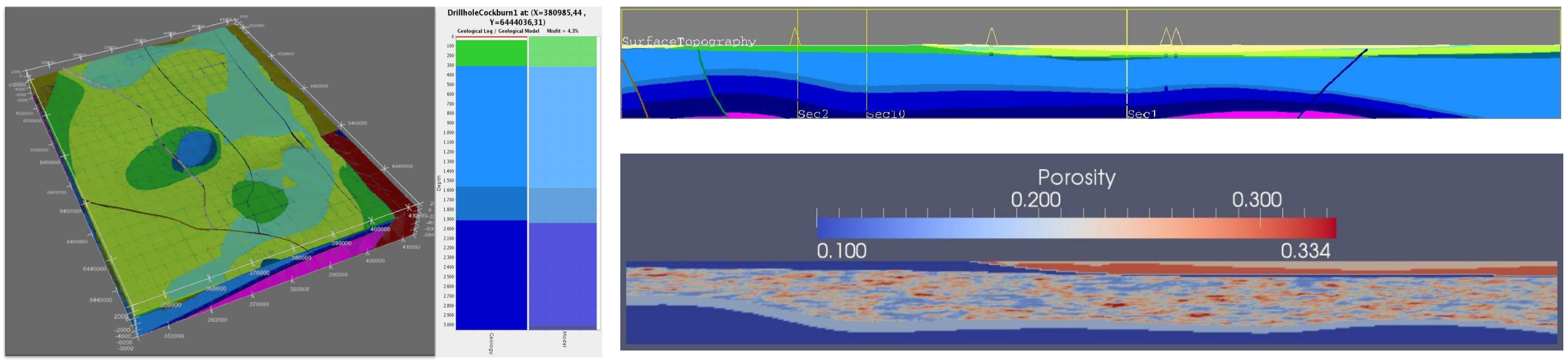
As energy demand constantly grows while conventional, nonrenewable energy resources dwindle, it is crucial to identify potential unconventional energy resources, which can fill in that potential gap. Electric energy required by compression chillers constitutes 85% of the power demand in Perth. Utilizing geothermal water of temperatures in excess of 65 °C directly in sorption chillers could decrease CO_2 emissions by 724 000 tons per 300 buildings per annum (Regenauer-Lieb, 2011).

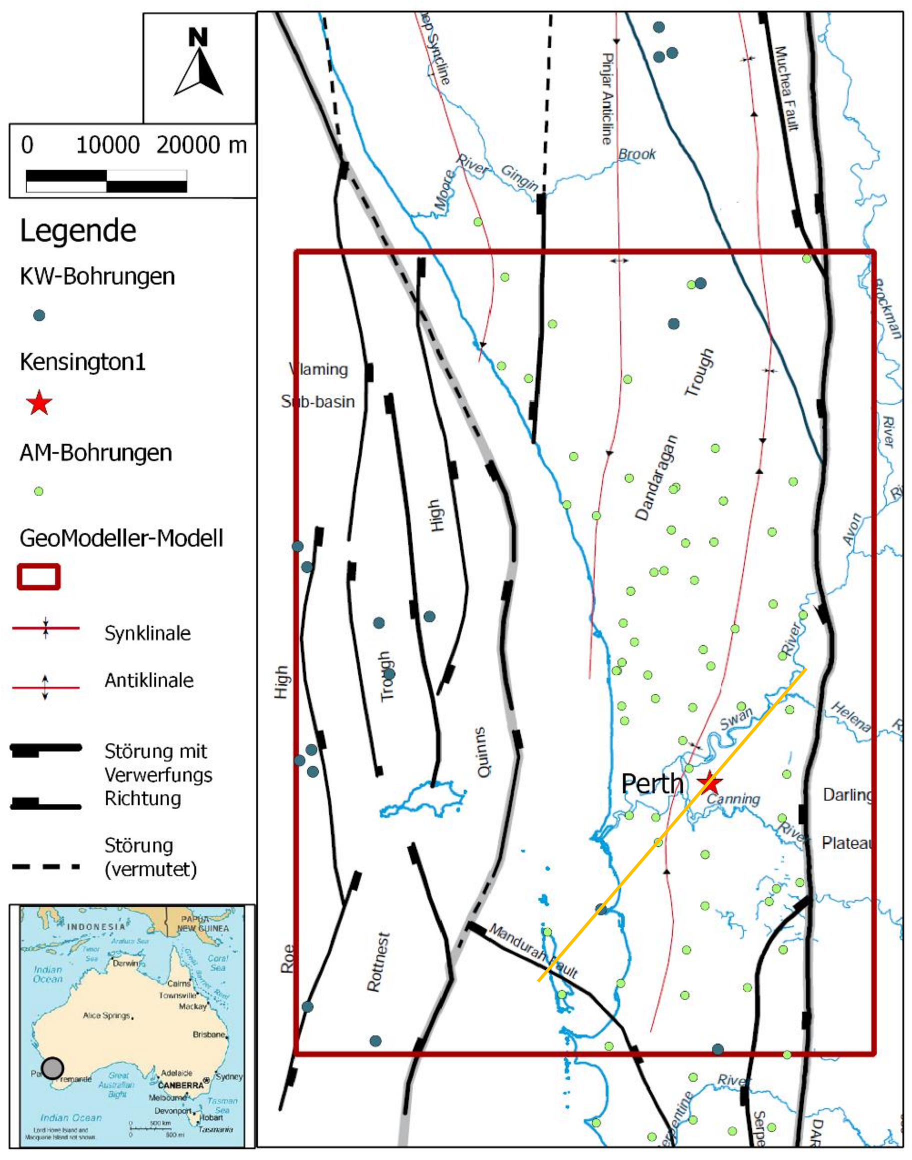
The Perth sedimentary basin comprises thick, highly permeable lithological formations, the Yarragadee Aquifer. This aquifer is well suited for geothermal energy extraction. Due to thickness and average permeability, the occurrence of free convection cells within the Yarragadee Aquifer is probable. Possible convection in the subsurface increases the spatial uncertainty with regards to the temperature at a certain depth. By using numerical and stochastic methods, we want to address this problem of spatial variable convection cells / geothermal gradients in order to minimize economical risks when locating geothermal Installations.

3D Structural and stratigraphic Model

In order to simulate subsurface temperature distribution and flow, we build a 3D structural model of the Perth basin, comprising the main aquifers and aquitards with focus on the Yarragadee Aquifer. Information from 83 wells in the region make up the data basis for the geological model, connected with geologic cross-sections throughout the basin. A DEM of 90 m resolution was merged with bathymetric data to generate the model topography.

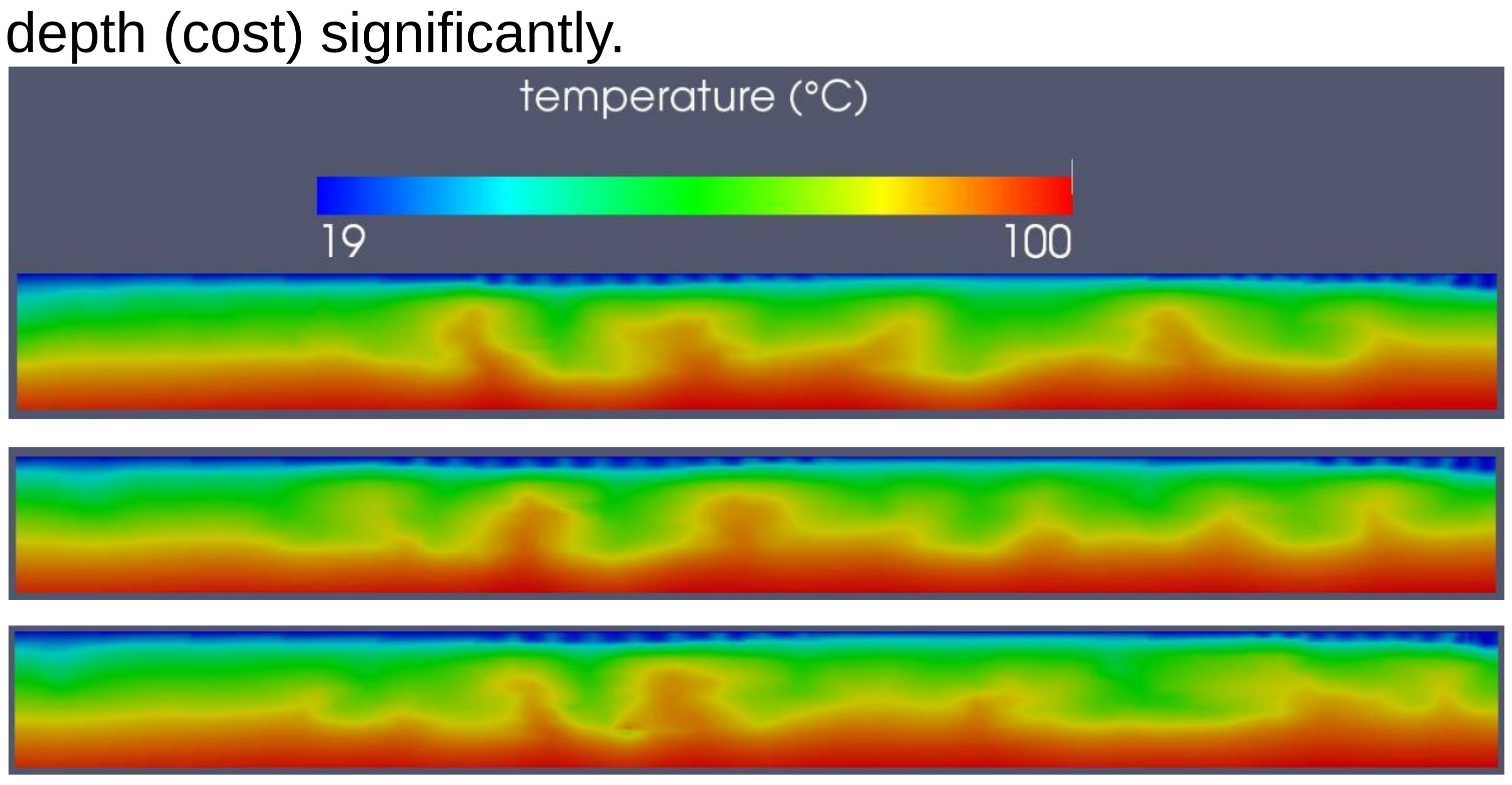
Various tools, e.g. well-model comparison, help to find weaknesses and to adjust the model.

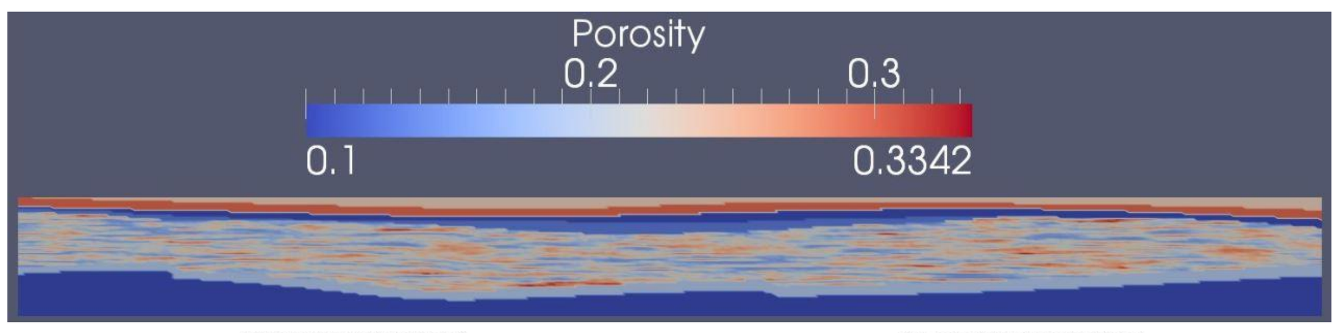


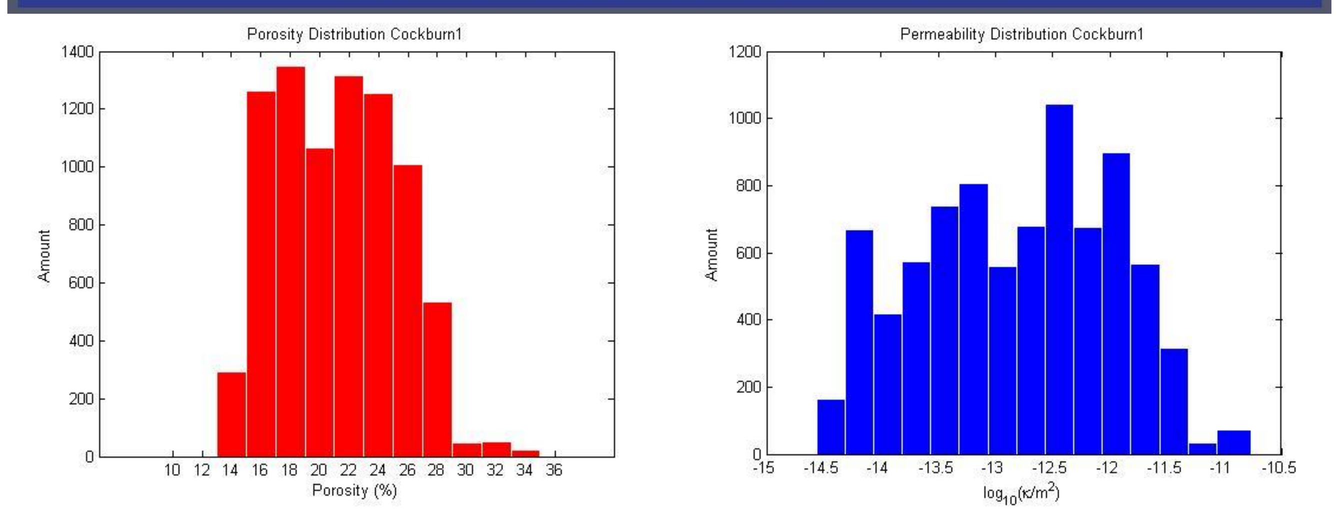


Monte Carlo Reservoir Simulations

In a first step, we extracted a 2D section from the 3D geological model. Detailed well-log analysis was carried out in order to estimate a range of porosity for the Yarragadee Aquifer. Following the approach of Pape et al. (2000), histograms for permeability distributions are deduced from the porosity data. As the spatial distribution of key parameters, i.e. porosity and permeability, in the subsurface is unknown, they are varied stochastically (conditional) in the Yarragadee Aquifer. By using Monte Carlo simulations, we estimate the impact of spatial permeability heterogeneity on the evolution of convection cells, as upwelling hot water can reduce necessary drilling depth (cost) significantly.







Conclusions

Our simulations show that free convection is likely to occur in the Yarragadee Aquifer. After a simulated time of 10 000 years, distinct convection cells developed in our models. However, with respect to their shape, the spatial position of the convection cells is similar in all model realizations. Keeping in mind that the heterogeneity in porosity and permeability is different in all realizations, we can conclude that the overall model geometry has a significantly greater impact on the spatial/temporal development of convection cells. Heterogeneities in the permeability field may yield different shapes of the convection cells.

That is to say, a reservoir model has to be as precise as possible concerning its geometry in order to give a valid estimation of possible upwelling regions and associated favorable drilling sites.

Pape, H., Clauser, C. and Iffland, J., 2000. Variation of Permeability with Porosity in Sandstone Diagenesis Interpretes with a Fractal Pore Space Model. Pure appl. geophys. **157**, 603-619, Birkhäuser Verlag, Basel.

Regenauer-Lieb, K., 2011. Geothermal Cities. CSIRO Preview **153**, 25-28

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