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On the impact of spatial heterogeneous permeability distributions on the development of free convection cells in the Perth Basin, Australia.

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Recent increase in exploration of the geothermal energy potential of the Perth Metropolitan Area (PMA) results in the need for reliable and robust reservoir models in order to explore rock properties and temperature distributions in the subsurface, where free convection in the main reservoir (Yarragadee Aquifer) is likely to occur [1]. While the structure of the Perth Basin has been refined recently, the heterogeneity and spatial complexity of permeability was up till now mainly neglected.

An integrated, three dimensional tectonostratigraphic model of the PMA is constructed, using the modeling software "3D GeoModeller" and data of numerous artesian and petroleum wells. Comprising the region around the city of Perth, the model covers an area of about 5000 km^2 up to a depth of 4.5 km, with focus on adequate representation of the main reservoir.
We further construct a numerical model for fluid flow and heat transport in the Yarragadee Aquifer. Porosity distributions are deduced from well logs and linked to permeability by a calibrated correlation, based on a fractal approach. Three different cases are simulated using the FD code SHEMAT-Suite, in order to assess the influence of spatial heterogeneity of porosity and permeability on the development of free convection cells.

1. constant porosity and permeability for the entire aquifer
2. porosity and permeability decreasing with depth, thus reflecting compaction
3. a conditional random permeability field within prescribed limits and for given correlation length

In order to improve understanding of model correctness, as well as identification and comparison of convection cells in different simulations, we are developing a specialized visualization tool tailored to this purpose.

The three different scenarios show distinctions in the distribution of convection cells. Where the Yarragadee Aquifer is in contact with overlying aquifers, regions of downflow develop. These in turn have a strong impact on the regional flow field and therefore temperature. The heterogeneous distribution of permeability seems to control the convection pattern on a smaller scale.

References

[1] Schilling, O., Sheldon, H.A., Reid, L.B., Corbel, S. 2013. *Hydrothermal models of the Perth metropolitan area, Western Australia: implications for geothermal energy.* Hydrogeology Journal, Vol. 21, 605–621.