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Revised hydrogeological model of the hydrothermal system Waiwera (New Zealand)

Andreas Grafe[1,2], Thomas Kempka[2,3], Michael Schneider[1], and Michael Kühn[2,3]
[1]Freie Universität Berlin, Institute of Geological Sciences, Malteserstr. 74-100, 12249 Berlin, Germany
[2]GFZ German Research Centre for Geosciences, Telegrafenberg, 14473 Potsdam, Germany
[3]University of Potsdam, Institute of Geosciences, Karl-Liebknecht-Str. 24–25, 14476 Potsdam, Germany

The geothermal hot water reservoir underlying the coastal township of Waiwera, northern Auckland Region, New Zealand, has been commercially utilized since 1863. The reservoir is complex in nature, as it is controlled by several coupled processes, namely flow, heat transfer and species transport. At the base of the aquifer, geothermal water of around 50°C enters. Meanwhile, freshwater percolates from the west and saltwater penetrates from the sea in the east. Understanding of the system's dynamics is vital, as decades of unregulated, excessive abstraction resulted in the loss of previously artesian conditions. To protect the reservoir and secure the livelihoods of businesses, a Water Management Plan by The Auckland Regional Council was declared in the 1980s [1]. In attempts to describe the complex dynamics of the reservoir system with the goal of supplementing sustainable decision-making, studies in the past decades have brought forth several predictive models [2]. These models ranged from being purely data driven statistical [3] to fully coupled process simulations [1].

Our objective was to improve upon previous numerical models by introducing an updated geological model, in which the findings of a recently undertaken field campaign were integrated [4]. A static 2D Model was firstly reconstructed and verified to earlier multivariate regression model results. Furthermore, the model was expanded spatially into the third dimension. In difference to previous models, the influence of basic geologic structures and the sea water level onto the geothermal system are accounted for. Notably, the orientation of dipped horizontal layers as well as major regional faults are implemented from updated field data [4]. Additionally, the model now includes the regional topography extracted from a digital elevation model and further combined with the coastal bathymetry. Parameters relating to the hydrogeological properties of the strata along with the thermophysical properties of water with respect to depth were applied. Lastly, the catchment area and water balance of the study region are considered.

The simulation results provide new insights on the geothermal reservoir's natural state. Numerical simulations considering coupled fluid flow as well as heat and species transport have been carried out using the in-house TRANSport Simulation Environment [5], which has been previously verified against different density-driven flow benchmarks [1]. The revised geological model improves the agreement between observations and simulations in view of the timely and spatial development of water level, temperature and species concentrations, and thus enables more reliable predictions required for water management planning.

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