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Influence of earthquakes on the water level in the geothermal reservoir of Waiwera (New Zealand)

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The warm water reservoir of Waiwera on the North Island of New Zeeland has been known for many centuries. Its use by the European immigrants began in 1863. Until 1969, the installed wells were all artesian. Due to overproduction, the warm water has to be pumped from the reservoir since then (Kühn and Stöfen, 2005). In order to examine the reservoir, a monitoring well was drilled in 1982. Since then, the water level has been registered every 15 minutes. The time series shows periods without the usually inversely proportional relationship between production rate and water level (Kühn and Schöne, 2017). The extent to which earthquakes can trigger such behaviour is examined in this presentation. So it happened for example in the hours and days after the Kaikoura earthquake on November 14, 2016, that the water level increased by about 0.5 m in the monitoring well and artesian flow was observed from various production wells.

The reservoir is located at a depth of up to 400 m. The geothermal water enters it with 50°C via a fault at the base. Earthquakes above certain strength could lead to changes in the permeability of rocks and thus locally could alter groundwater dynamics. The influx changes depending on the released seismic energy (Wang and Manga, 2010). The quantity to be considered is the seismic energy density, which can be empirically calculated from the earthquake magnitude and the distance of the hydrogeological event to the earthquake hypocentre.

For the investigations presented here, all recorded earthquakes from 1986 with a magnitude above 5 were used within a radius of about 1,500 km around New Zealand. A geographic information system (GIS) was used to calculate the distances of each hypocentre to the monitoring well in Waiwera and then determine the respective energy density. To produce measurable water level changes, a threshold of 0.001 must be exceeded (Wang and Manga, 2010).

A clear correlation between the relevant earthquakes and the resulting changes in the water level cannot be proven. An important factor that makes this difficult is the different temporal resolution of the water level measurements (15 minutes) and production rates (monthly mean). In addition, a significant offset of the water level caused by earthquakes already exists at a few centimetres to a few decimetres. To identify this, a production rate dependent time series is not well suited. Instead, detecting such an offset would require data from a more or less unaffected monitoring location. However, it must also be considered that none of the recorded earthquakes has led to such a high energy density in Waiwera as the Kaikoura earthquake did.

References

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