

Preliminary assessment of the potential of  
the Yanqing geothermal reservoir, Beijing,  
P.R. of China

**Guðni Axelsson**

**Greinargerð GAx-2001-04**

## **Preliminary assessment of the potential of the Yanqing geothermal reservoir, Beijing, P.R. of China**

### **MAIN FINDINGS**

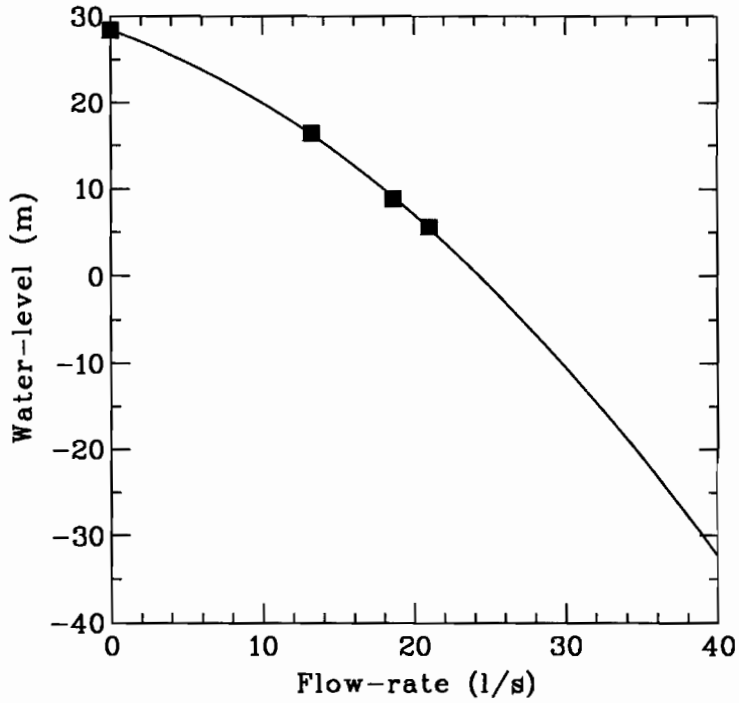
As part of the feasibility study for a geothermal district heating system in Yanqing, Beijing, a preliminary assessment of the potential of the Yanqing geothermal reservoir has been carried out. The main findings are reviewed below.

The information, which is available at present for a preliminary assessment of the geothermal reservoir, has been reviewed. Rather limited information is available, principally because only one deep geothermal well has been drilled in the area, well NY-01. Most of the information was provided by Chinese counterparts during a fact-finding mission to Beijing in March/April 2001. This includes test data from the end of drilling the well, the production history of the well for the last few years as well as considerable indirect data, such as geological information. Some essential additional data were collected, however, during a production test of well NY-01 in May 2001 and sent to Iceland for analysis.

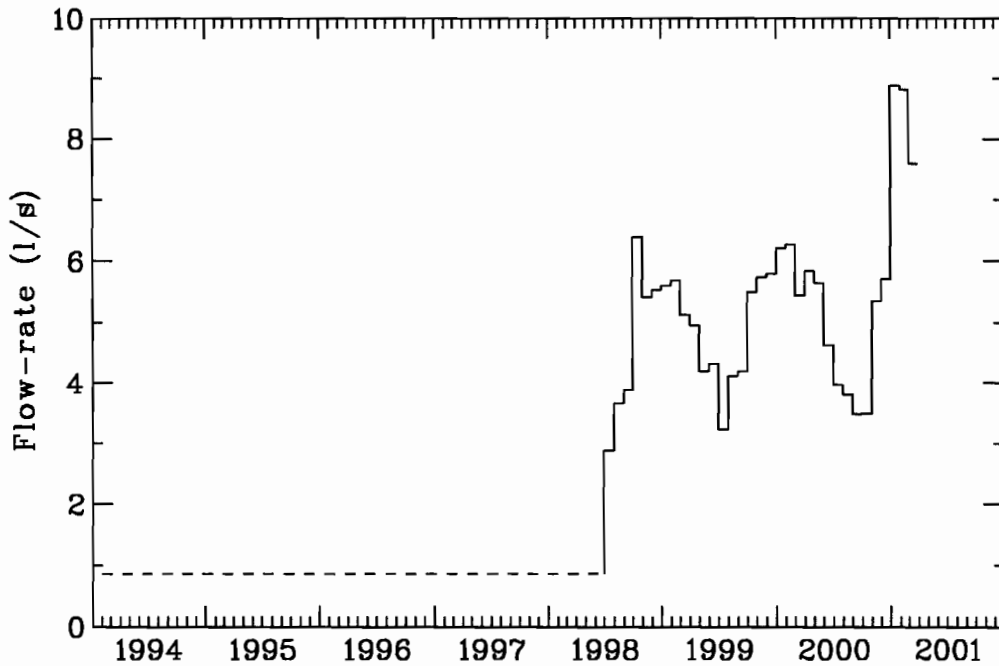
A model has been set up to simulate the long-term behaviour and potential of the geothermal reservoir. This model is, of course, no more accurate than the available data allows. Two models are in fact set up, one pessimistic and the other optimistic, showing the uncertainty involved in the forecasts. In this respect the importance of highly careful monitoring of well NY-01 and other wells drilled in the area must be emphasised because the accuracy of the model(s) will greatly increase in the coming months and years, as more data become available.

Because of the limited data available a utilisation scheme is proposed, involving a step-wise increase in production, careful monitoring, detailed testing and frequent re-assessment of the reservoir potential as more data become available. Reinjection is suggested as an essential tool in the management of the geothermal reservoir, principally for pressure maintenance but also for environmental reasons.

The potential of the geothermal reservoir is controlled by water level changes. Figures 1 – 3 show the available data on production and water level. The data on the production characteristics of the well in Figure 1 show that well NY-01 is quite productive and able to produce up to 30 l/s, or more, in the short-term. The production history of the well, up to April 2001, is presented in Figure 2. Unfortunately no data are available on the well-head pressure of the well during this time-span. Such data would have been invaluable in estimating the long-term pressure decline in the reservoir and its ultimate production potential. It appears, however, that the well-head pressure has declined from about 0.28 MPa in 1994 to 0.22 MPa in 2001. This is quite a large decline considering that the average production from the reservoir during this period was less than 2 l/s.

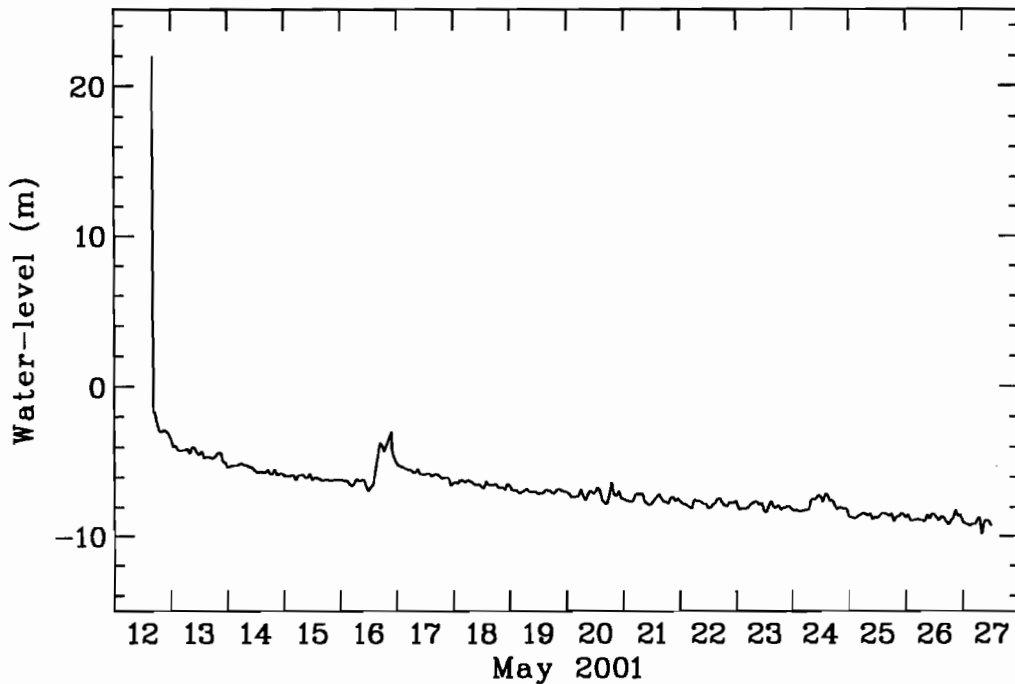


**Figure 1.** Results of a step-rate test of well NY-01 at the end of drilling in 1994. Boxes indicate measured data, while the solid line shows calculated characteristics of the well. Data are relative to well-head i.e. positive values indicate well-head pressure while negative values indicate water level draw-down.



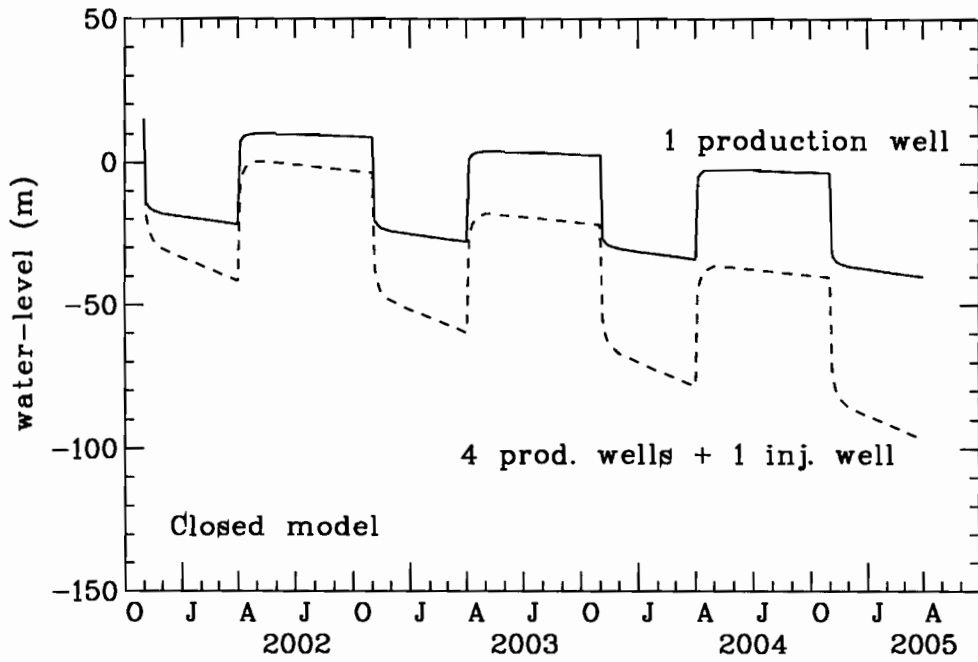
**Figure 2.** Production history of well NY-01 until April 2001. Pressure/water-level data are not available.

The data from a 15-day production test of well NY-01 carried out in May 2001 is presented in Figure 3. The data from the test are quite good and, in fact, turned out to be essential in setting up the model(s) for the Yanqing geothermal system. It is interesting to note that stable conditions are not reached during the test. The linear decline with time may indicate a reservoir, which is either closed or with rather limited recharge. Therefore, the production potential of the reservoir appears to be limited unless full reinjection is applied to provide a kind of artificial recharge. More than sufficient thermal energy is in-place in the geothermal reservoir, however.

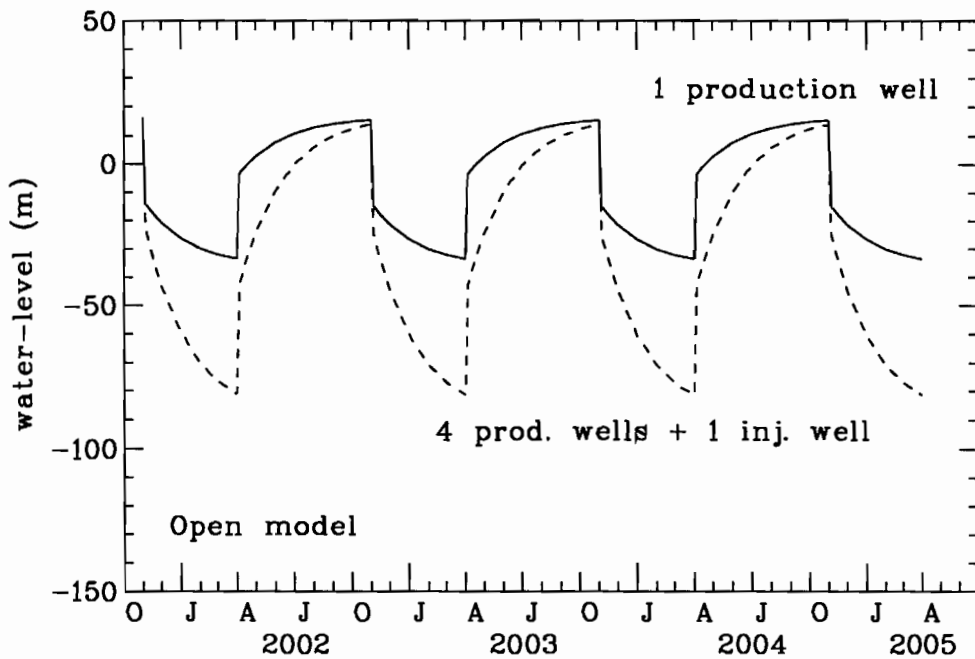


**Figure 3.** *Water-level data collected during well-test of well NY-01 in May 2001. Data are relative to well-head (see Figure 1). Production from the well was constant at 26.6 l/s, except for a short break on May 16<sup>th</sup>.*

Lumped parameter models have been set up to simulate the available water-level data and calculate future predictions. They are able to simulate the data very well, but the data are limited as already mentioned and, therefore, the models should not be considered very accurate. Figures 4 and 5 show examples of the predictions calculated by the models, for two different cases. The calculations in Figure 4 are done by the more pessimistic model, which is completely closed (no recharge), and should provide indications of the lower bounds of the water-level decline for this production case. The long-term draw-down increases rapidly, and even though reality may not be as bad as this prediction, it indicates that reinjection will be essential for any large scale (a few wells like NY-01) utilisation of the reservoir. With full reinjection the long-term draw-down should be much less than indicated in the figure.



**Figure 4.** Predicted water-level changes in well NY-01 for two future production scenarios; (a) one production well (30 l/s for 4 months, 15 l/s yearly average) and (b) four production wells (4x30 l/s for 4 months, 60 l/s yearly average) and on reinjection well (25% reinjection). Calculated by a closed model (pessimistic predictions), values relative to well-head.



**Figure 5.** Predicted water-level changes in well NY-01 for two future production scenarios; (a) one production well (30 l/s for 4 months, 15 l/s yearly average) and (b) four production wells (4x30 l/s for 4 months, 60 l/s yearly average) and on reinjection well (25% reinjection). Calculated by an open model (optimistic predictions), values relative to well-head.

It may be mentioned that according to the models the surface area of the reservoir should be between 26 and 400 km<sup>2</sup>, which may be compared with the estimated area of the Yanqing reservoir, approximately 100 km<sup>2</sup>. According to the models the average reservoir permeability is of the order of 0.2 Darcy, yet the permeability of the outskirts of the open model is very low. Thus the open model behaves as semi-closed.

Reinjection will play a two-fold role in Yanqing. First, as part of modern environmentally friendly geothermal utilisation. Second, as an essential tool for maintaining the reservoir pressure (counteract draw-down). Therefore, it is recommended that full reinjection be part of the proposed Yanqing project right from the beginning. Without reinjection the production potential of the reservoir appears to be rather limited. It should be pointed out that it may be more economical to assume that one reinjection well be drilled for each two production wells and high pressure (10-20 bar) utilised for the injection. It should also be pointed out that cooling is normally the greatest danger associated with reinjection. This should be fully avoidable if a distance between production and reinjection wells of 1-1.5 km is maintained. However, careful testing, such as through tracer tests, is essential for accurately assessing this danger.

The following plan is suggested for step-wise utilisation, testing and improved assessment of the Yanqing geothermal reservoir:

Stage 0, 2001-2002: Present situation with utilisation of well NY-01 and possibly drilling of a new well (NY-2) during the summer/fall of 2001. Careful monitoring essential.

Stage 1, 2002: Drilling of 3-4 additional production wells and two reinjection wells. Based on success rate in other parts of Beijing one failed well may be expected.

Stage 2, 2002-2005: Utilise four wells at full capacity (4 x 15 l/s = 60 l/s on the average, water temperature expected about 60°C, 4 x 30 l/s = 120 l/s maximum) for 2-3 years. Reinjection started into one well on an experimental basis, later full reinjection utilising two reinjection wells (assuming that at least 90% of water produced will eventually be reinjected). Careful monitoring and some testing, in particular concerning the reinjection (i.e. tracer tests). Re-evaluate reservoir potential through a reservoir simulation study. Comprehensive reservoir management as well as well as training of Chinese scientists and technicians should be emphasised.

Stage 3, 2004-2007: Drill more wells according to results of re-evaluation, increase utilisation and reinjection, for an additional 2-3 years. Continued careful monitoring and testing.

Stage 4, 2007-2032: Utilisation at maximum capacity (<200 l/s average production and 90-100% reinjection). Comprehensive management, careful monitoring and intermittent re-assessment by reservoir simulation.

The main results of the preliminary assessment of the Yanqing geothermal reservoir may be summarised as follows:

1. Well NY-01 is fairly productive and able to produce up to 30 l/s in the short term.
2. Limited production appears to cause a considerable long-term water-level draw-down, however, indicating that the reservoir is either closed or with limited recharge.

3. Full reinjection must be applied to counteract water-level draw-down and provide artificial recharge. Otherwise it appears that the sustainable potential of the geothermal reservoir is rather limited. Reinjection should also be considered as part of any modern environmentally friendly geothermal utilisation.
4. An utilisation scheme is proposed involving a step-wise increase in production and frequent re-assessment of the potential of the reservoir, before its ultimate potential is determined. During the first step production from four production wells (4 x 30 l/s winter production, 4 x 15 l/s average production) is proposed, as well as full reinjection (more than 90 %). The ultimate potential does at this moment not appear to be greater than about 200 l/s average production, with full reinjection, according to a pessimistic appraisal.
5. It must be emphasised that only one user should be given the rights for utilisation of the geothermal resources in the Yanqing basin. Firstly, because this allows for a more efficient management of the resource. Secondly, because the potential of the resource does, at this moment, appear to be not too great. Further exploration for geothermal resources on the outskirts of the basin, where indications have been found for higher reservoir temperature, is recommended.
6. Data on the Yanqing geothermal reservoir is limited at the present stage. Therefore, careful monitoring of all wells (including NY-01), further data collection and exploration as well as detailed testing, such as tracer testing, is emphasised in the coming months. The drilling of a new production well in the area, to confirm the existence of the resource, is essential. Finally, training of Chinese counterparts is emphasised, to facilitate successful co-operation in the future.

*Orkustofnun, greinargerð GAx-2001/04*