

Preliminary assessment of the potential of  
the Shahe geothermal reservoir in  
Lishuiqiao, Beijing, P.R. of China

**Guðni Axelsson**

**Greinargerð GAx-2001-03**

*EnEx Ltd./Gudni Axelsson, August 10<sup>th</sup> 2001*

## **Preliminary assessment of the potential of the Shahe geothermal reservoir in Lishuiqiao, Beijing, P.R. of China**

### **MAIN FINDINGS**

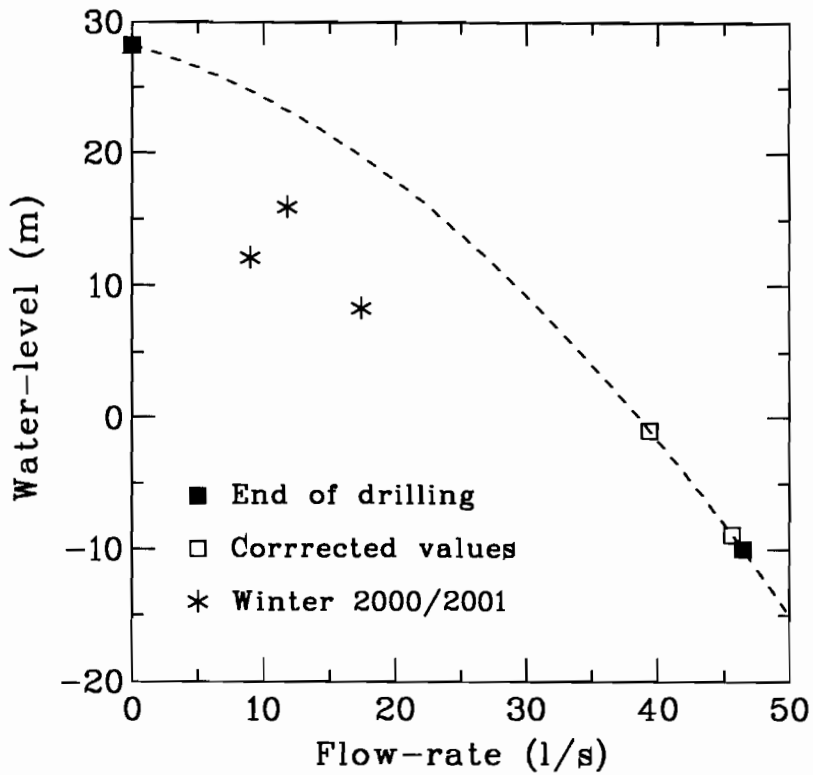
As part of the feasibility study for a geothermal district heating system in Lishuiqiao, Beijing, a preliminary assessment of the potential of the Shahe geothermal reservoir is being conducted. The main findings presently available are reviewed below.

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 ShaRe-06. 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 during last winter as well as considerable indirect data, such as geological information. Some very important additional data were collected, however, during a well test of well ShaRe-06 in July 2001 and sent to Iceland for analysis.

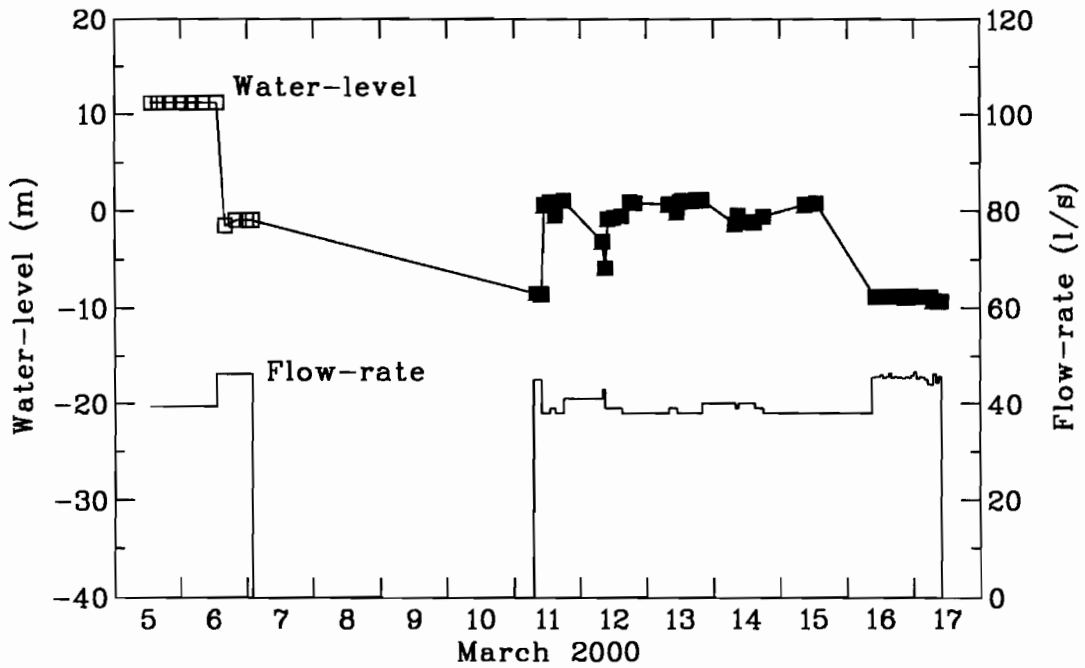
A model has been set up to simulate the long-term behaviour and potential of the geothermal reservoir. This model is, of course, no more accurate than the available data allows. Two models are in fact set up, one pessimistic and the other optimistic, showing the uncertainty involved in the forecasts. In this respect the importance of highly careful monitoring of well ShaRe-06 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 becomes 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.

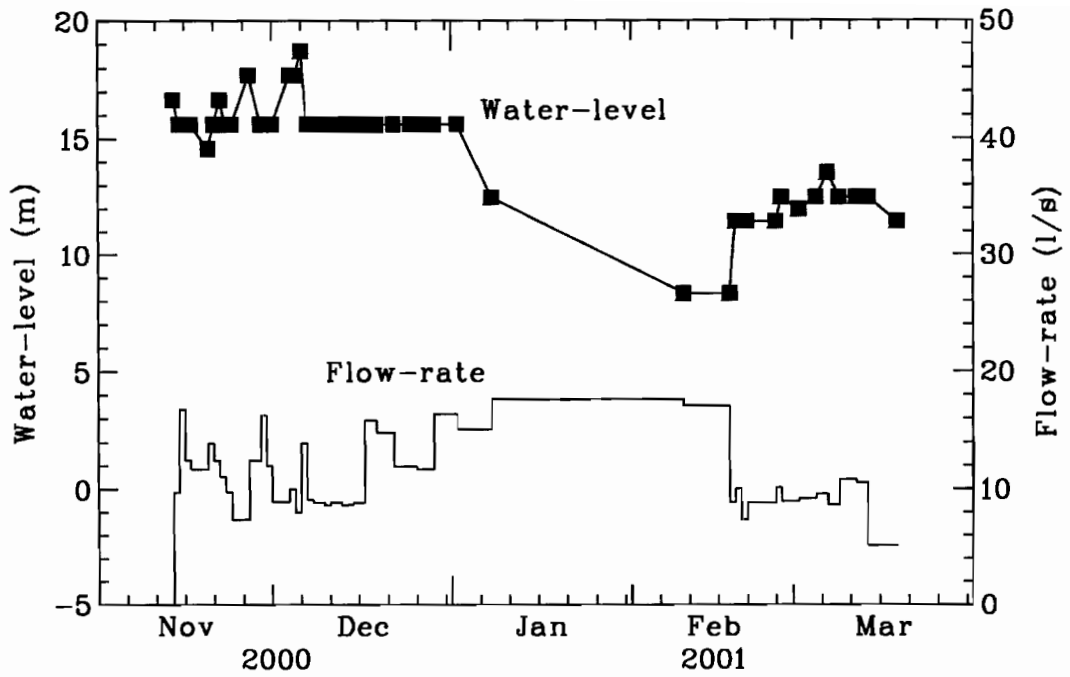
The potential of the geothermal reservoir is controlled by water level changes. Figures 1 – 4 show the available data on production and water level. The data on the production characteristics of the well in Figure 1 show that well ShaRe-06 is quite productive and able to produce up to 40 l/s, or more, in the short-term. The data in figures 2 and 3 (see also data from 2000/2001 in Figure 1) indicate that a considerable long-term water level decline has taken place in the geothermal reservoir, perhaps as great as 15 m or so. This is quite a large considering the rather limited production from the reservoir. In addition this decline does not seem to recover when production is reduced or stopped. This indicates that the reservoir is either closed or with rather limited recharge. Therefore, the production potential of the reservoir appears to very 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.



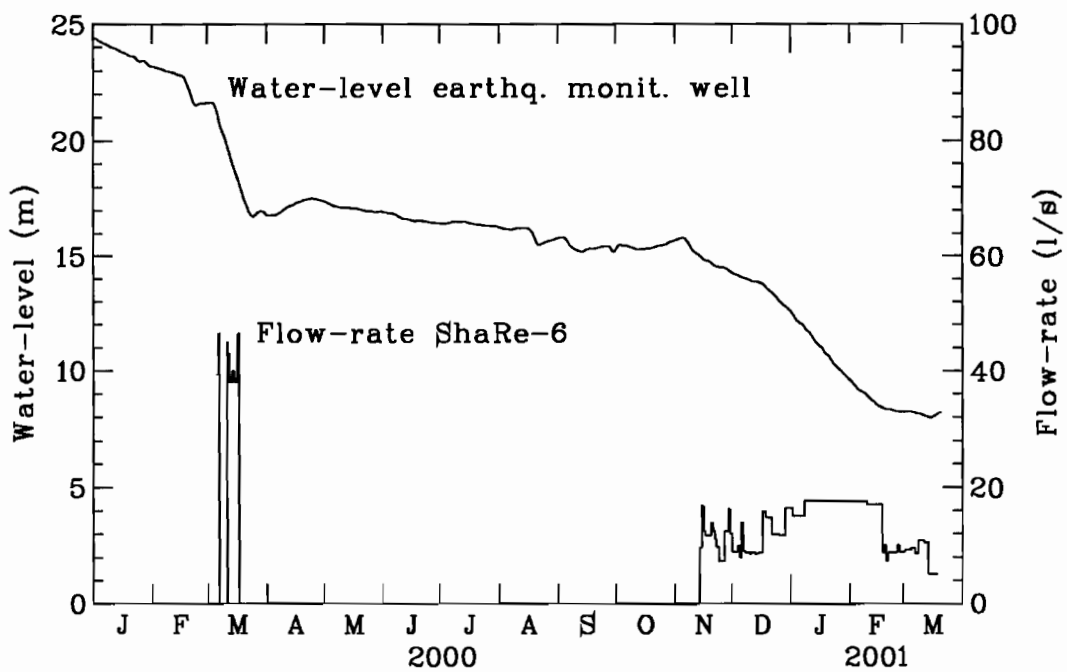
**Figure 1.** Results of step-rate test of well ShaRe-06 at the end of drilling with additional data from the winter of 2000/2001.



**Figure 2.** Production and water-level history of well ShaRe-06 after end of drilling in March 2000.



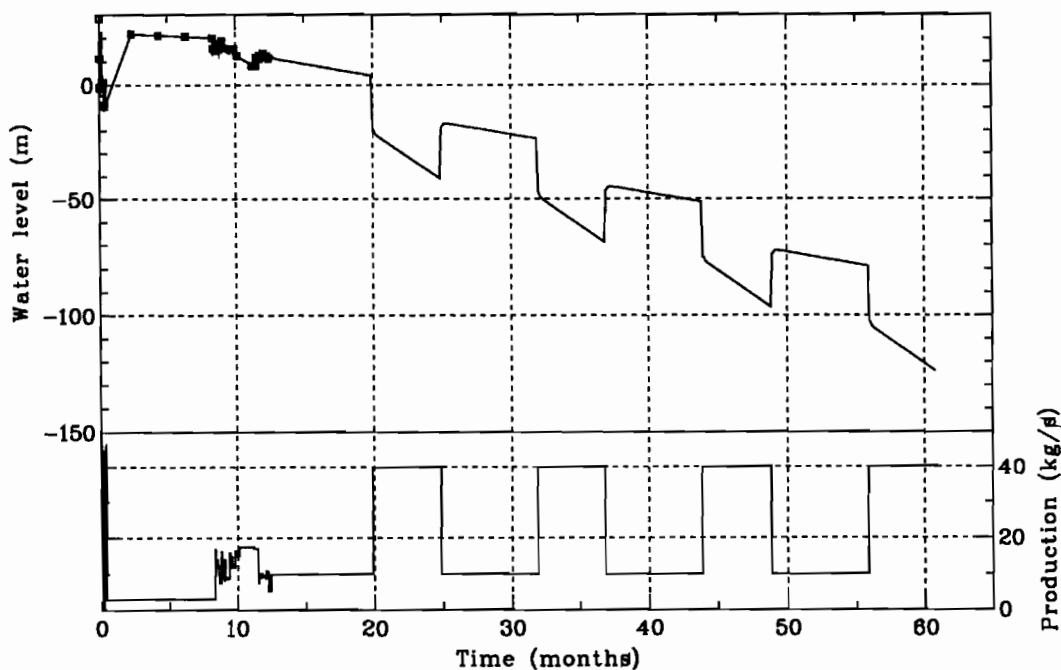
**Figure 3.** Production and water-level history of well ShaRe-06 during the winter of 2000/2001.



**Figure 4.** Production history of well ShaRe-06 along with water level data from an earthquake monitoring well north of Lishuiqiao.

Figure 4, which shows the water level data from an earthquake observation well a few km north of well ShaRe-06 shows the water-level decline in the reservoir very clearly. In addition it seems to indicate that production from another well, or other wells, may be causing some of the decline. This points to an extremely important aspect of the utilisation of the Shahe reservoir, which is the influence of production by other users outside the area designated to the Lishuiqiao project, but inside the same geothermal field. This will of course put a limit to the maximum production and must be taken into account. Information on this aspect is lacking at the present point in time. Either a guarantee must be provided by the Beijing Government that this production by others, from the same reservoir, will be within acceptable limits, or a common management of the reservoir must be set up in co-operation between the different users.

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 fairly well, but the data are limited as already mentioned and, therefore, the models should not be considered very accurate. Figure 5 shows an example of the predictions calculated by the model, for a case of well ShaRe-06 being used at full capacity (40 l/s) during the winter time, but a 20 l/s average yearly production. These calculations 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 draw-down is very great, and even though reality may not be as bad as this prediction, it indicates that full reinjection will be essential for any large scale (a few wells like ShaRe-6) utilisation of the reservoir. With full reinjection the long-term draw-down should be much less than indicated in the figure. It may be mentioned that according to the model the surface area of the reservoir is about 120 km<sup>2</sup>, which appears to be quite reasonable.



**Figure 5.** *Predicted water-level changes in well ShaRe-06 for 4 years of full utilisation, closed (pessimistic) model and no reinjection.*

Reinjection will play a two-fold role in Lishuiqiao. 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 Lishuiqiao project right from the beginning. Without reinjection the production potential of the reservoir appears to be quite 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 Shahe geothermal reservoir in Lishuiqiao:

Stage 0, 2001-2002: Present situation with utilisation of well ShaRe-06 and possibly drilling of a new well drilled during fall of 2001. Careful monitoring essential.

Stage 1, 2002: Drill of 1-2 additional production wells and one reinjection well. Based on success rate in other parts of Beijing one failed well may be expected.

Stage 2, 2002-2005: Utilise two wells at full capacity (2 x 20 l/s = 40 l/s on the average, water temperature expected about 70°C, 2 x 40 l/s = 80 l/s maximum) for 2-3 years. Reinjection into one well (assuming 90-100% of water produced being reinjected). Careful monitoring and some testing, in particular concerning the reinjection (i.e. tracer tests). Re-evaluate reservoir potential through a reservoir simulation study. A comprehensive reservoir management program for the Shahe geothermal reservoir should be set up involving all parties utilising the resource. Training of Chinese counterparts 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 (<100 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 Shahe geothermal reservoir in Lishuiqiao may be summarised as follows:

1. Well ShaRe-06 is quite productive and able to produce 40 l/s, or more, in the short term.
2. Limited production appears to cause considerable long-term water-level draw-down, 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 very limited. Reinjection should also be considered as part of any modern environmentally friendly geothermal utilisation.
4. Geothermal production outside the area designated to the Lishuiqiao project, but from the Shahe reservoir, will limit the production possible. Any such outside production must be within acceptable limits. A comprehensive management

program for the Shahe reservoir, involving all parties utilising the resource, must be set up.

5. 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 two production wells (2 x 40 l/s winter production, 2 x 20 l/s average production) is proposed, as well as full reinjection. The ultimate potential does at this moment not appear to be greater than about 100 l/s average production, with full reinjection, according to a pessimistic appraisal.
6. Data on the Shahe geothermal reservoir in Lishuiqiao is limited at the present stage. Therefore, careful monitoring of all wells, further data collection and detailed testing, such as tracer tests, is emphasised in the coming months. The drilling of a new production well in the area, to confirm the existence of the resource, is also emphasised. Finally, training of Chinese counterparts is emphasised, to facilitate successful co-operation in the future.

*Orkustofnun, greinargerð GAx-2001/03*