Presented at the Workshop for Decision Makers on Direct Heating Use of Geothermal Resources in Asia,
organized by UNU-GTP, TBLRREM and TBGMED, in Tianjin, China, 11-18 May, 2008.

UNITED NATIONS UNIVERSITY
GEOTHERMAL TRAINING PROGRAMME

TBLRREM TBGMED

REINJECTION IN SANDSTONE RESERVOIR IN TIANJIN

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ABSTRACT

There exists two types of geothermal reservoir in Tianjin; porous sandstone fractured, weathered carbonate. 50% of the exploration in Tianjin takes place in the geothermal sandstone reservoir. After years of research, the problem of reinjection into geothermal reservoir in carbonate rocks has basically been solved. But there still exists many problems with regards to recharge into reservoirs in Neogene sandstone, which mainly reflect the low and short duration of recharge. Therefore, solving the problems of sandstone recharge is important to the sustainable development and utilization of geothermal resources in Tianjin. In recent years, we have made some research on recharge well drilling technology, reinjection plug problems, and reinjection systems of the Neogene Guantao formation sandstone reservoirs. And we have acquired some good experiences.

1. INTRODUCTION

There are two kinds of geothermal reservoirs in Tianjin; porous sandstone fractured, weathered carbonate. Through years of research, the reinjection problems of carbonate rocks reservoir have basically been solved. But the injection problems of geothermal sandstone reservoir still exist, mainly with regards to the low reinjection rate and short duration. The production from geothermal sandstone reservoir exceeds 50% of the total production of the city. Thus, it is important to resolve the reinjection problems for the sustainable development and utilization of geothermal resources in Tianjin. In recent years, we have chosen the Neogene Guantao formation geothermal sandstone reservoir for reinjection testing in the Wuqing, Dongli and Dagang Districts, and we have studied reinjection well drilling technology, reinjection plugging problems and ground reinjection systems.

2. BASIC CHARARCERISTICS OF RESERVOIR

During the late Oligocene, the North China Plain was razed to the dustpan basin. And in the Miocene period the Yanshan uplift zone became the main source area. Because the transport and deposition of sediments in the lower river bends and braided rivers, fluvial clastic rocks were formed. Aalluvial-pluvial fans and fluvial sedimentary deposits were well-distributed on the North China Plain. These deposits mainly include mottle silt rocks and sand gravel rocks. The Neogene Guantao formation ultimately formed clastic fluvial rocks with obvious sedimentary cycles. These rocks are mainly located in the Wuqing sag and Huanghua depressions, in Tianjin. Clastic rocks in Tanggu, Beitang and the northwest of Xiaozhan mainly consist of gravel, while other areas mainly consist of gravel and sand.

The top of the Guantao formation is a thick sand layer, the bottom is a gravel sand layer and the middle part is a silt stone layer. The total thickness is 200~600m, whereof sand and gravel account for a thickness of 70~360m. The porosity of the formation is 15%~32.4% and its permeability is 773~2631×10-3μm^2. There is a compact gravel layer at the bottom of the Guantao formation, with a thickness of 30 - 60m. The grain size diameter is 5mm. The mean porosity is about 20%. Through exploration, determining physical properties of rock samples, analyzing geothermal condition and hydrogeological condition, it can be assessed that the Guantao formation is a medium-low temperature heat storage layer with normal consolidation process. Investigations also show that the source of the heat is from deep heat conduction and that the water supply comes from lateral runoff recharge.

3. ANALYSE OF THE REINJECTION PLUGGING

3.1 The analysis of physics plugging

A >0.45 μm filtered particle carried in suspension by the fluid in most of the wells has been analyzed by SEM (Scanning Electronic Microprobe). The result indicates that Plagioglase, quartz, K-feldspar, FeS and ZnS seem to be the most common components carried by the fluid, in addition to a certain number of possible other components, such as NaCl, CaCO3 and others. When filtering 50 ml water, quantity of matter accumulating on the filter film is very high. Despite that this type of quantitative analysis is not precise, it still pointes that suspension solid transmission in geothermal fluids is an important factor, and better quantitative analysis are absolute necessary.

3.2 The analysis of chemistry plugging

The activity of anions, cations and several intermediate compounds in geothermal solutions, as well as the saturation index for the most significant minerals in the Tianjin geothermal wells have been computed using the PHREEQC-2.11 simulation code. There seem to be three types of minerals that potentially may precipitate during reinjection around the bottom of the Tianjin wells: 1) quartz (chalcedony), 2) calcite and 3) Fe-Zn oxides (hydroxides) and sulfides. Among them, the Fe-Zn oxide

and the sulfide have been found in the 25 sample wells. Having discovered large amounts of similar solid components in matters collected by filtration, proves that the water is saturation in these components in these exploitation wells .This result of the hydrogeochemistry is surprising, and leads to the assumption that iron and zinc comes from oxidation of the well tube and water conveying pipeline.

4. DRILL OF REINJECTION WELL

Referring to successful experiences of water injection in oil wells, it is important to prevent the suspended solid particle from entering the reservoir tier in order to keep the passage unhindered, when studying the construction techniques of the reinjection well casing at the YR9 reinjection well in Yang Cun, in the Wu Qing District. The is the first exploration using double deck cage screens when filling gravel into the geothermal well, exceeding 2000 meters in depth. The cage screen parameters are as follows:

- centre casing diameter, 177.8 mm
- making 17mm holes in the casing with 12% porosity
- winding silk on the nexine with a spacing of 0.7 mm
- winding silk on the outer layer with a spacing of 0.5 mm
- The quartz gravel diameter, 0.8 ~ 1.2 mm
- 10mm thick
- Washing for 25 days continuously after well completion
- water-yielding ability, 15 ~20 m3/h.

The Analysis result: the double deck cage screens with above mentioned parameters hinds heavily to the water, resulting in a blocked water passage. After adopting the perforation method, to open up the cage, filtering the water pipe and aquifer, the water yield is 93.8 m3/h and the stabilized water temperature is 73.5 °C at the head of a well.

According to the experience in the construction progress of the YR9 reinjection well, the technology of double deck cage filter in the the Hua Tai geothermal reinjection well in the Dong Li District was carried out with some adjustment, its parameters were as follows:

- centre casing diameter, 177.8 mm
- making 17mm holes in the casing with 12% porosity
- winding silk on the nexine with a spacing of 1.5mm
- winding silk on the outer layer with a spacing of 1.2mm
- quartz gravel diameter, 2 ~ 4mm ,
- thickness 10 mm..

At the same the following technical measures in were adopted in building the well :

- improving the slurry function by cutting down the slurry seeping into and blocking up the reservoir tier
- taking measures to clear the well blockage before putting down the tubes by manually taking off the mud skin between the filter pipes and the reservoir;
- using effective well-washing technologies of alternating water pressure by i.e. increasing the depths of the deep flue pipe and making sudden power cut-offs.

In the pumping tests after washing well , the depth of the water pump was at 128 m , the motionless water level at 63m,the move water level at 123 m, the water yield was 105 m3/h, and the water temperature was 82°C.

The test proved that the method is close to ideal. The deficiency of a major drawdown is due to the great resistance of the double deck cage filter to the water.

The cage screens mainly serves as the liquefaction quicksand tier, andis not applied to regular consolidated Guantao strata. Before being put to use, specification should be ascertained for the filter according to reservoir characteristics, i.e. sandstone grain diameter, porosity, hydraulic conductivity, etc.

5. THE GROUND REINJECTION SYSTEM

In order to prevent physical and chemical jam we make use of secondary filtrating equipment in the reinjection system. The primary filtration is rough, the precision is of 50μm, whereas, the secondary filtration is extractive, with a precision of 3-5μm. There are pressure cabins at the ends of the filtration pot. If there is a pressure difference in the cabins the finer particles will resort in the filter pack. In practice, the precision of secondary filtration is high and its effect is good. To prevent gas blockage, there is a vent installed at the head of the reinjection well.

6. REINJECTION TEST

Two test sites were established in the Wuqing and Dongli districts, in 2004. Here, two reinjection wells have been drilled in the Guantao group reservoir. The two levels filter system was used in the ground reinjection system, and the productive reinjection tests have been conducted. In the Wuqing district the temperature of the reinjected fluid is 42~52°C, pumped at a reinjection rate with a decrease from 49 m^3/h to 20 m^3/h. The stable water level is at about 10m depth. In the Dongli district the temperature of the reinjected fluid is 50°C, with a reinjection rate of about 16 m3/h. The stable water level is at about 15m depth.

7. CONLUSIONS

In summary, through the study of reinjection well-drilling technology and the ground reinjection system, the problems of physical and chemical reinjection plugging have been resolved, but decreasing reinjection rates remain a problem.

REFERENCE

Cheng wanqing, Lin Jianwang., 2005.10: *The stage reinjection report of porous reservoir in Middle-low temperature geothermal field in Tianjin*, Tianjin Geothermal Exploration and Development Designing Institute

Tianjin Bureau of Geology and Mineral Exploration and Development, 1982: *People's Republic of China Ministry of Geology and Mineral Resources geological memoirs of Tianjin*, The Geological Publishing House.