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Study of Geothermal Water Environment and Reservoir Protection

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ABSTRACT

For over 20 years, the author's knowledge in the areas: domain of developing geothermal resources, geothermal energy management, and environment prospect has been studied. Accumulating a large quantity of hydro-chemical data for low temperature geothermal reservoir, Systematic study hydro-chemical feature, and its effect to the environment around water circulation and environmental geological problem down to depth of 4000 meters. Combine demonstration of geothermal engineering project, bring forward for reservoir prospect, improving rate of utilization of the geothermal energy, prospect geothermal resources, and for reducing environmental pollution.

INTRODUCTION

Geothermal heat is a new kind of energy that is clean and has proved to be reliable. Geothermal water contains many microelements. It can meet the social demand and help to improve the global environment.

The world geothermal meeting in the year 2000 called on many countries all over the world to dispose and utilize the sustainable and clean geothermal energy. At the present, 55 countries are using geothermal energy directly. The main forms of usage are in the fields of heating, bathing, greenhouse, aqua-product cultivation and industrial processing.

China is rich in geothermal energy; the geothermal reserves make up 7.9% of that part of the world. Tianjin is one of the cities in China that started to explore, develop and utilize geothermal energy in early years. In the 1980s, with the aid of UNDP and the Italian government the Chinese government invested a lot in Tianjin. This included geothermal investigation and exploration, delineating 10 geothermal anomalies, evaluating 3 large-scale geothermal fields, and handing over many technical and scientific research reports. The highest flow temperature in the geothermal fields of Tianjin reaches 98 □, and the maximum exploration depth is 4000m below the surface. Geothermal resources have been widely used in industrial production, heating, bathing, greenhouse, aqua-cultivation, medical treatment and health care, mineral water development, and tourism. Geothermal energy plays an important part in promoting economic development, improving urban and rural environment, and raising the quality of life.

The geothermal fields in Tianjin are classified under the medium-low temperature conductive type. The main reservoir layers are as follows.

1. The Sandstone void reservoir: It includes both the Tertiary Minghuazhen group and the Guantao group reservoir. The hot water takes HCO_3—Na as the dominant chemical type and HCO_3•Cl—Na as the secondary one. The mineralization degree is 800 ~ 1300 mg/l, SiO_2 content is 21 ~ 32 mg/l, and F' is 3 ~ 8mg/l. The corrosive index is greater than 3.0. The scaling amount is less than 125 mg/l, and the hard scale factor is less than 0.25. The water belongs to slightly corrosive hot water with soft sediments that can be used directly.

2. The Bedrock karst fracture reservoir: It includes Paleozoic Ordovician system, Upper Proterozoic Qingbaikou system, Longshan group, Middle Proterozoic Jixian system, Tieling group and the Wumishan group. Hot water from the Ordovician system takes SO_4—Cl—Na as chemical type. The mineralization degree is 4300~4500 mg/l, SiO_2 content is 28 ~ 31 mg/l, and F' is 4.0 mg/l. The corrosive index is greater than 10. The scaling amount is greater than 500 mg/l and hard scale factor is greater than 0.5. The water belongs to strong corrosive water with hard sediments. The surface equipment has water scale after extraction. The downhole videotape shows that scaling is serious down the well shaft. Thus the water cannot be used directly and measures should be taken to prevent corrosion and scaling. Waters from Longshan group, Tieling group and Wumishan group are almost the same in quality. The chemical type is mainly Cl—SO_4—Na. The mineralization degree is about 2000mg/l. SiO_2 content is 50 ~ 70 mg/l and F' is 8 ~ 10 mg/l. Corrosive index is 3 ~ 4 and scaling amount is 125 ~ 250 mg/lm and hard scale factor is 0.25. The water belongs to medium-corrosive water with medium sediments. Certain measures should be taken during extraction and utilization.

The chemical types and variation rules are almost the same for hot waters in sandstone reservoir and in the bedrock reservoir. From northwest to southeast, the content of bicarbonate radical ion decreases and the degree of mineralization gets lower. This chemical variation rule of geothermal water shows similar characteristics with that in the oil production area in North China. Studies shows that the content of indicating element SiO_2 and F' in delineated geothermal anomalies has a normal relationship with temperature. The shape of its isolines fits with geo-temperature gradient (See Fig.1 and Fig.2). This indicates that the content of SiO_2 and F' in hot water is controlled by the conditions of bedrock embedding, lithological characteristics and variation temperature field.

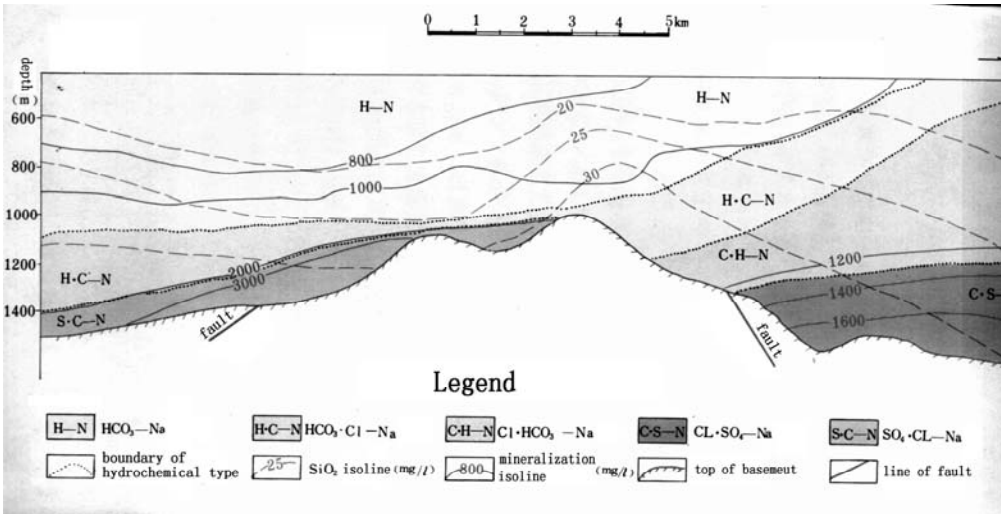

Fig. 1 Hydro-chemical sketch section map of CZ

For more than 30 years, Tianjin has had a history of geothermal energy development. This energy has been used more and more widely. A geothermal space heating system, which is the largest in China, has been set up in Tianjin. The heating area makes up 77% of that of the country. Evidence of economical and environmental effects has been seen. In order to improve the effectiveness of geothermal energy utilization, a comprehensive geothermal utilization project has been carried out in Tanggu District, Tianjin City. Aided by the loan from north Europe and the techniques and equipment introduced from Iceland, the project set up items for heating, bathing, swimming, health care and aqua-cultivation, realizing automatic management of geothermal utilization. This project improved the effectiveness of geothermal energy utilization and is a successful demonstration in the field. In the demonstrating area in Tianjin's urban area, tail water from geothermal space heating is used secondarily by means of floor radiation technique and heat pumps. Good results have been gained with improving utilization effectiveness and lowering drainage temperature of the tail water, reducing heat contamination. In 1996, Tianjin took the lead in studying and carrying out a re-injection technique in bedrock reservoir. Two slant wells were drilled into a same reservoir layer, forming a pattern of doublet development, which includes one extraction well and one injection well. Eight years have passed since then. Re-injection experiments have achieved good results and rich data. Until now, 15 re-injection wells had been drilled in Tianjin and the experiment is still undergoing according to the plan.

Although there have been wonderful achievements in the geothermal development and utilization in Tianjin, a gap still exists between Tianjin and more advanced geothermal utilization in the countries such as the US, Iceland, France, and New Zealand. Two of the main problems are that the tail water's drainage temperature is high, and the resource utilization ratio and re-injection amounts are low. From the angle of geothermal water environment and protect reservoir, the author considers that it is very important to study the following problems for sustainable development and utilization of geothermal resources in Tianjin:

1. Track assessment to be conducted for concentrated extraction areas in geothermal fields. Total production amount should be controlled according to the available reserve approved by the Committee of Mineral Resources to keep the pressure in reservoir layers. Digital models for geothermal reservoirs should be set up to direct reasonable development of geothermal energy.

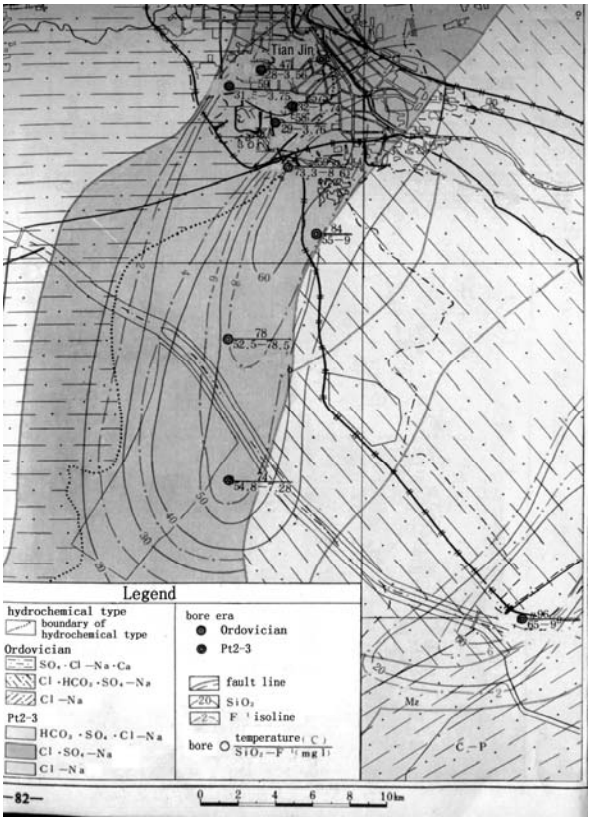

Fig. 2 Hydro-chemical plane map of the basement

2. Cascading usage of geothermal energy to be advocated to lower drainage temperature of tail water and reduce heat contamination. Corrosion and scaling problems should be stressed and solved when designing geothermal usage works. Geothermal tail water should be consistent with the quality standard of water drainage.

3. Strengthening water quality inspection during re-injection to prevent gas and chemical wall up and protect the reservoirs.

4. Based on the study results of bedrock re-injection, a block in a same tectonic unit with clear geothermal fluid

boundary conditions should be chosen to conduct bedrock doublet experiment. By using sealed doublet system, usage ratio can be improved, and corrosion and scaling and contamination by drainage can be avoided. At the same time, reservoir pressure can be kept and surface subsidence can be prevented, and the lifespan of the reservoir be prolonged. France has the experience and available techniques. Developing geothermal energy by doublet is environmental system engineering. It is the best choice for reaching the goal of sustainable utilization of geothermal energy in the 21st century.

The above suggestions have been accepted into the Report of Policy Study of Sustainable Geothermal Development in Tianjin. The author looks forward to having discussions and exchanging experiences with the experts from other countries during the coming meeting to make mutual efforts for the development of geothermal industry.