Proceedings World Geothermal Congress 2005
Antalya, Turkey, 24-29 April 2005

# Geothermal Resources in China

Zhang Baiming

189 Weigou Road Hedong District Tianjin China

Geothermal Exploration Designing Institute, Tianjin, China

tjgizbm@public.tpt.tj.cn

**Keywords:** Geothermal, Geothermal Resource, China

## ABSTRACT

Geothermal resource is widespread in China. The region with the richest resource is in the south-west of China which makes up about 51% of total found resource. Huabei makes up 17.27%, south center makes up 15.89%. The northeast and northwest regions of China are the poorest regions of geothermal resource which makes up about 3%. The growth rate of geothermal utilization in China has been 12% per year during the last decade. The total district heating in China serves 10 million $m^2$. The heating market in the cities of Northern China is enormous and the geothermal resources widespread. Most of the geothermal reservoirs in China are in sedimentary formation, however, many of them have very limited recharge. Because of this, some geothermal fields have been doing reinjection into the reservoirs.

## 1. INTRODUCTION

Thermal springs have been used for bathing, washing and cooking for thousands of years in many countries. There are over two thousand years old records of geothermal usage in China. In the early 1970's, some provinces and cities begin to exploration, research and develop for geothermal under the enthusiastic suggestion and leadship of the famous geoscientist Prof. Li siguang. During 1980's, lots of achievements were obtained because the state continued to offer great of funds for geothermal development. Since 1990's, the geothermal markets have been broadened and made great progresses of geothermal development with the rapid developing processes and growing need for geothermal resource in China.

## 2. MAIN FEATURES OF GEOTHERMAL

China is rich in geothermal resources. The formation and distribution of geothermal resource are controlled by tectonic plate and characteristics. There are high temperature geothermal resources (>150 ºC) related to magma or volcanoes and deep circulation of water along faults and fractures which mainly occurs along so called plate boundaries with high regional conductive heat flow. There are also widespread low temperature geothermal resources (<150ºC) in China that are in the sedimentary basins. The geothermal resources in the basins can be very extensive, since the basins themselves are commonly hundreds of kilometers wide. The temperature of the thermal water depends on the depth of the individual aquifers and the heat flow in the area concerned, temperature is usually in the range of 40-100ºC at depths less than 4000 m. (Figure 1)

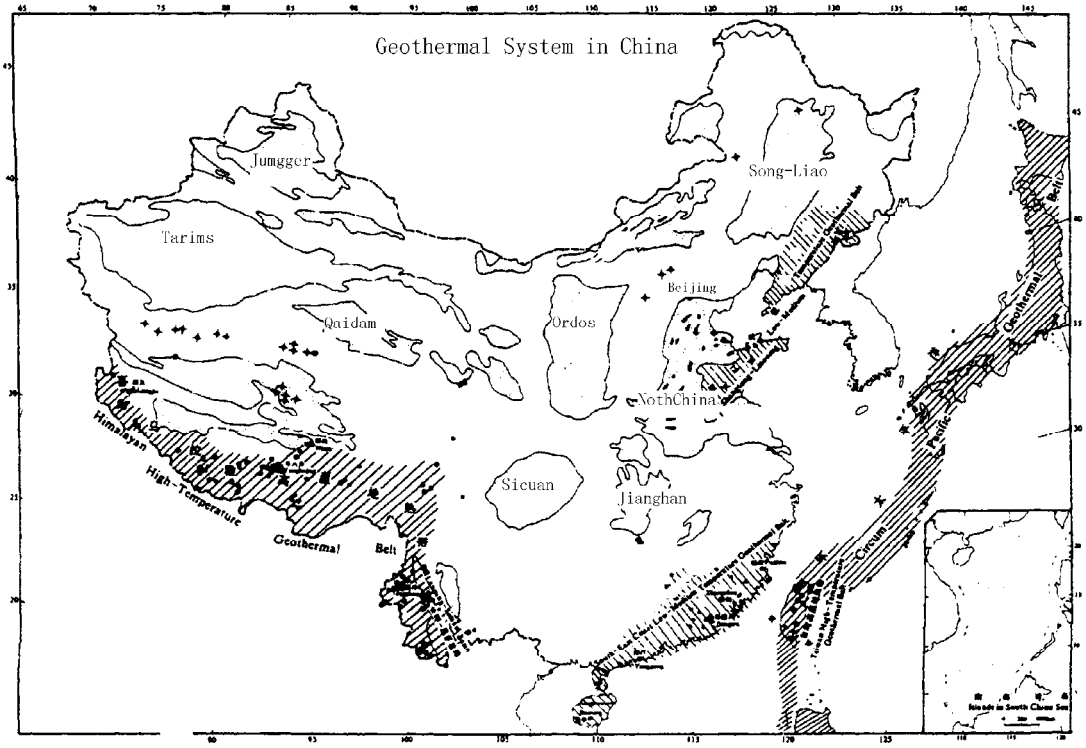


**Figure1: Geothermal resources in China**

### 2.1 Magma Activity Type Geothermal Resource

This type of geothermal resource is related to magma activity and volcano in the later part of Tertiary/ Quaternary Period. In the case that there is caprock, large parts of geothermal anomaly area are formed. Geothermal gradient is usually ten times more than the normal in this case. For example, geothermal gradient is 2.45-3.07 ºC/m in Tengchong of Yunnan and 2.9-3.3 ºC/m, in Yangbajing of Tibet. Caprock is made of igneous rock, sedimentary rock or soft-sediment of Quaterary. The hot water is artesian or flowing. Temperature of hot water is as high as 145-200ºC. TDS of hot water is less than 5000ml/L. Alimentation of hot water mainly comes from precipitation.

**Table 1. Hot water activity in Tibet**

| Name | Number of spring | Temp. (ºC) |
|---|---|---|
| Senza-Xietongmen | 200 | 8.5-94 |
| Naqu-Yangbajing | 29 | 36-92 |
| Ger-pulan | 14 | 18-93 |
| Gangba-Zisong | 8 | 48-88 |
| Cuona | 16 | 14-88 |
| Bomi-Guyu | 58 | 18-96 |

### 2.2 South-east China Deep Circulation Geothermal Reservoir

Deep hot water circulates along faults and fractures with high regional conductive heat flow. Most of the hot springs form in these areas. Geothermal activity may be found from the number and density of hot springs (Figure 2). Temperature of hot water is less than 100ºC. TDS of hot water is about 100-1500 ml/L. The alimentation of hot water mainly comes from precipitation through deep circulation.

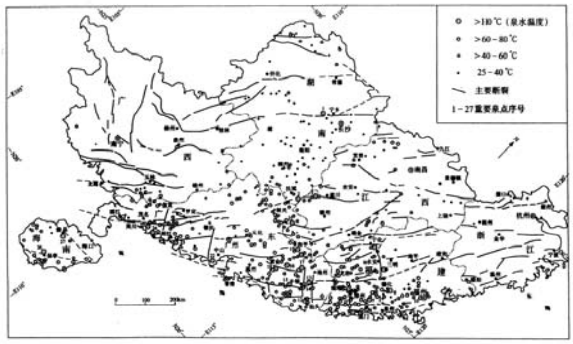


图 2-75 中国东南沿海地区温泉分布图

**Table 2. Hot springs in South-east China**

| Name | Temp. (º C) | Flow rate (L/s) | TDS (mg/l) | Chemical Type |
|---|---|---|---|---|
| Hunan | 88-91 | 4-10 | 100-300 | $HCO_3$-Na |
| Jiangxi | 82 | 20 | 400 | $HCO_3$-Na-Ca |
| Fujian | 55-97 | 1-17 | 240-13500 | $HCO_3$-Na, Cl-Na, $HCO_3$-$SO_4$-Na |
| Hainan | 83-88 | 4-8 | 260-320 | $HCO_3$-Na, $HCO_3$-Ca-Na |

**Table 3. Main characteristics of basins of China**

| Name | Area ($10^4$ $km^{2)}$ | Reservoir | Temp (ºC) | Depth (m) | TDS (mg/l) |
|---|---|---|---|---|---|
| Shong-liao | 14.78 | N+K | 30-50 | 800-2000 | 1000-5000 |
| Huabei | 17.6 | N+Pz | 30-90 | 1000-4000 | 1000-5000 |
| Subei | 3.2 | N | 34-57 | <1600 | <1000 |
| Weihe-Fen | 2.4 | N | 33-40 | <1000 | <1000 |
| Jiang-nan | 2.8 | N+K | 30-95 | 1000-3500 | 250-3000 |
| Ordos | 16 | K+J+T+P | 27-39 | 400-1500 | 1000-5000 |
| Si-chuan | 13.6 | J+T+P | 25-69 | <2400 | Salt |

### 2.3 Mesozoic And Cenozoic Basin

Mesozoic and Cenozoic basins are widespread large Mesozoic down-faulted basins. The total area is $350x10^4km^2$. Foundation of the basin is made of Proterozoic erathem and Paleozoic erathem that are carbonate rocks and clastic rocks. The thickness of foundation is more than 2000-4000m. At the end of Yanshan movement, the basin have been pulled apart and deposited down by a mount of Mesozoic and Cenozoic clastic depositions that have thicknesses of more than 1000-4000m, the thickest is about 11000m. These are shallow geothermal resource reservoir and serves as caprock of the deeper reservoir. The foundation of the basin is formed by a series of horst fault structure that are NE-SW in direction because of several tectonic activities. These structures are very good for geothermal resource concentration and storage. Especially near the fault and on the top of the uplift, fracture is also well developed in carbonate rock.

## 3. GEOTHERMAL ENERGY USE IN CHINA

High temperature geothermal resources are concentrated in Tibet, Yunnan and Taiwan. Development of high temperature geothermal use for electricity production rose from 1MWe in 1977 to 28.18MWe in 2001 in Tibet. The total installed electrical capacity of Tibet is 28.18MWe: Naqu 1Mwe, Langjiu 2Mwe and Yangbajing 25.18Mwe. The annual electrical generation is more than 100GWh in the last decade in Yangbajing. In high temperature geothermal field, hot water is not only used for electrical generation but also for green house, swimming pool and district heating. It has a very important function in the economic and social development of Tibet.

Deep Circulation Geothermal Reservoirs are located in southeast China. Fujian is one of the provinces that is rich in deep circulation geothermal resources. There are 193 hot springs all over the province. The amount of geothermal water produced was $18.16Mm^3/a$. In 1986, the first geothermal water plant in China was set up in Fuzhou, the capital city of Fujian province. 5500m3/d of hot water are supplied to hotels, factories, and other industries. A 21.8km hot water pipeline, the longest one in China, was completed in 1993 in Anxi County in the province.

China is at the top list of countries that directly uses geothermal energy. The growth rate of geothermal utilization in China has been 12% per year during the last decade. Particularly in North of China, low-medium temperature geothermal resources are widely used for space heating, bathing and spas, agriculture and aquaculture. The space heating networks in the country have reached over 10 million $m^2$ with the largest district heating system in Tianjin, Beijing, and Xian. The largest single district heating system is in Tianjin.

More than 200 geothermal wells were drilled in Tianjin, and the annual production is $12Mm^3$. The main productive reservoirs are porous reservoir in sandstone and karst-fractured reservoir. The area of all the 10 geothermal fields is 8700km2, accounting for about 775 of the area of municipality. The municipal government pays great attention to geothermal management and has set up the Geothermal Management Division in 1994. As a special administrative agency of the geothermal resources, the division is responsible for the technical development and the optimal use of geothermal resource in Tianjin. In recent years, a lot of work has been done on geothermal utilization, reinjection, reservoir engineering modelling and data system development for geothermal management.

There have been 33 geothermal wells drilled for production in Tanggu since 1987. The production of geothermal water is about $5Mm^3/a$. most of the geothermal energy is used for space heating, and the area has reached $0.9Mm^2$, the largest in China. About 150 office buildings and schools have been using geothermal water daily.

The first geothermal well was drilled in 1971 in Beijing. Since then, there are more than 200 geothermal wells in use, producing about 10 million $m^3/a$ of 40-88 ° C geothermal water used for space heating, domestic hot water, greenhouse, fish farming, swimming pool and mineral water production. Before 1983, there were no governmental policies or regulations concerning geothermal in Beijing. The geothermal division of Beijing was set up for the management of geothermal resources in 1984. From that time, some management policies were enacted: controlling increasing amount of geothermal production, planning geothermal usage, and encouraging reinjection.

## 4. DISCUSSION

Geothermal resource is rich in most provinces of China. They are starting to use the environmentally friendly energy source, geothermal energy. Most of the geothermal reservoirs in China are in sedimentary formation. Many of the reservoirs are closed or almost closed systems. These reservoirs have very limited recharge.

The main weakness is the lack of comprehensive management and monitoring of geothermal reservoirs under exploitation in some provinces of China. Especially in the early period of exploitation, several operators are pumping hot water from the same reservoir. This leads to fast pressure drop and significant land subsidence in the producing area.

Reinjection into the reservoirs is absolutely necessary to sustainable use of the geothermal resource. Reinjection has become a routine operation in Tianjin.

## REFERENCES

Zengyi, Wangdahong, Gubin, and Jiaoxingyi: Sustainable Utilization of Geothermal Resources and Environment Protection in Tibet, Proceedings of 2002 Beijing International Geothermal Symposium.

Zhaoyunhua, Huangdefu: Geothermal prospects in Fujian Province, China, Proceedings of 2002 Beijing International Geothermal Symposium.

Chenmengxiong, and Mafengshan: Groundwater Resources and Environment of China, 2002.

Xuehuafeng, Wangyong: Simulation of Feasibility of Geothermal reinjection in Xian, China, Proceedings of 2002 Beijing International Geothermal Symposium.

Wangkun, Lichunhua: The Reinjection Tests in Basement Geothermal Reservoir, Tianjin, China, Proceedings of 2002 Beijing International Geothermal Symposium.

Chenjianping: Geothermal Management in The city of Beijing, Proceedings of 2002 Beijing International Geothermal Symposium.