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GEOTHERMAL SYSTEM OF YANGBAJAN GEOTHERMAL FIELD

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ABSTRACT

In 1988 a geothermal borehole with measured temperature of 202 °C at depth of 970 m was drilled in the north hydrothermal alteration area and this fact proved the Yangbajan geothermal system with the lateral geothermal fluid movement from NW to SE. This paper describes the geothermal system and resources assessment of the field, and method of exploration as well.

INTRODUCTION

Tibet---famous for its skyscraping mountains---is also an important source for geothermal energy. Just 90 km NW of Lhasa, the capital of Tibet is the Yangbajan Geothermal Field(Fig. 1).

Although the field consists of a rather small area (10 km^2), a variety of hydrothermal activities have been discovered here: the West Boiling Spring reaches 92 °C; the boiling point at Yangbajan (4300 meters above sea level) is 86 °C. South of the field is a hot water lake(50 °C) that takes up an area of 7300 m^2.

Very interesting place---North of the field is an hydrothermal alteration area of about 4 km^2. Here some bubbling thermal surface is too hot to touch---just a few centimeters beneath the ground the temperature exceeds the local boiling point. Here also sulphur mining is in process, and semi-transparent sulphur crystals mass at the crack of the stratum, while from the "rotten egg ditch" the odor of sulphur wafts.

The exploration started in the field in 1975, and first 1 MWe experimental wet steam power station was build in 1977. Now 13 MWe power station has been built in the south and supplies over 45% of total power comsumers in Lhasa, and another 20 MWe power station in the north is under construction.

In 1975-1979 a number of exploratory geothermal wells were drilled and at that time the highest temperature recorded was 172 °C. And on the basis of analyses of rock strata, temperature and chemical composition of the geothermal fluid in all these wells we arrived at the important point of view: the high-temperature geothermal flow does not come from beneath the SE of the field, although many boiling springs and Hot Lake are there, but from beneath the NW hydrothermal alteration area at the foot of Mt. Nyaigentanglha[1,2].

A few years later, drilling of the borehole in the north hydrothermal area obtained high-temperature of 202 °C at depth of 970 m and proved the above mentioned point of view.

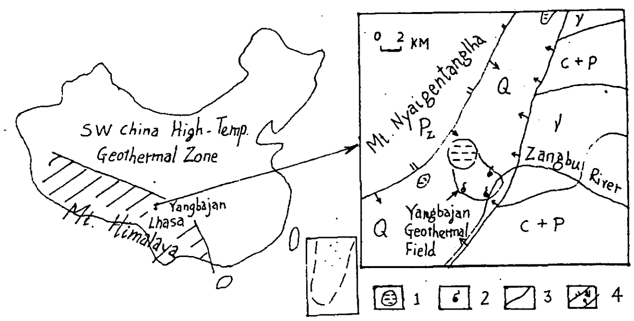

Fig. 1 Location and geological map of the Yangbajan area

1-hydrothermal alteration area; 2-hot or boiling springs; 3-geological boundary; 4-faults
Q-Quaternary sediments; C+P-Carbonic-Permian slate, clastic rocks; P-Paleozoic gneiss; γ-granite(about 60 million years old)

GEOLOGICAL FRAMEWORK

The Yangbajan geothermal field is located in the elongate basin 5 km wide and 100 km long at the foot of Mt. Nyaigentanglha, where there are many geothermal fields. The Yangbajan Geothermal Field the most famous one of them. The main rocks in the Yangbajan and surrounding area are Paleozoic gneiss, granite(about 60 million years old), Carbonic and Permian slate, clastic rocks, and Quaternary sediments(Fig. 1).

GEOTHERMAL RESERVOIR

In the Yangbajan geothermal field the geothermal fluid is stored in the two deffirent formations, one---in the silicified grit of Quaternary Period and second---in the basement rock(granite). The form of the silicified grit is just like a "tongue" from northwest (hydrothermal alteration area) to southeast (Zangbu River). The depth of the top of the grit aquifer varies from 250 m in the northwest to 70 m in the southeast, and from about 250 m to 100 m in thickness. As there are a lot of fissures in the silicified grit, the permeability of the aquifer is high, and the flow rate of a single production well can reach 191 T/h (Fig 2, Fig. 3).

Fig. 2 showed the boreholes No. 13 and No. 14, which have the maximum temperature (before 1988) of 171 - 172 °C, are sited near the northwest hydrothermal alteration area. And the fluid from bore No.13 contains mineralisation 2.21 g/l, Cl 651mg/l and HBO_2 298 mg/l, the highest among all existing boreholes and springs at that time, for instance bore No. 7 located in the south part of the field contains mineralization only 1.25 g/l, Cl 279 mg/l. It appears that high temperature water with high mineralization and Cl, B etc. comes from the deep thermal water flow beneath the northwest hydrothermal alteration area connected with Quaternary magma activity. This kind of high temperature water flow with Cl-Na type mixed cold water with low mineralization (about 0.1 g/l) and HCO_3-Ca type coming from both west and east sides out of the field, and then the mixed water with Cl-HCO_3·Na-Ca type is formed in the southeast part of the silicified grit aquifer.

GEOTHERMAL SYSTEM

It is presumed that the present aativity of the Yangbajan geothermal field is the post-intrusive action of sulphur deposit in the north of the field(Fig. 3). The passage through which the deep geothermal flow passes may be the fault at foot of Nyaingentanglha beneath the sulphur deposit (the hydrothermal alteration area). Cold recharge water ①passes a nearby heating volume and mixes with juvenile water from cooling mamga, rising in temperature and decreasing in density and forming a deep thermal flow ② which rises along the fault beneath the sulphur deposit. Due to pressure reduction and changes in the oxide-reductive condition, sulphur steam ③, mercury, etc. are separated and produce hydrothermal alteration and sulpher deposit. Then as it is pushed by cold water at the foot of Nyaingentanglha ④ from the outside of the field the deep thermal flow turns to horizontal movement to be a mixed thermal water flow ⑤ .

It was assumed that the Yangbajan geothermal field was formed in the Quaternary period, with its hydrothermal alteration and sulphur steam remaining active up to now.

RESOURCES ASSESSMENT

The heat volume method is used for caculation for high temperature geothermal fields, when the extent, thickness and temperature of the geothermal reservoir are ascertained, the estimated resources are proved. The outlet water temperature is 90 °C. For fractured reservoirs(limestone or dolomite) the

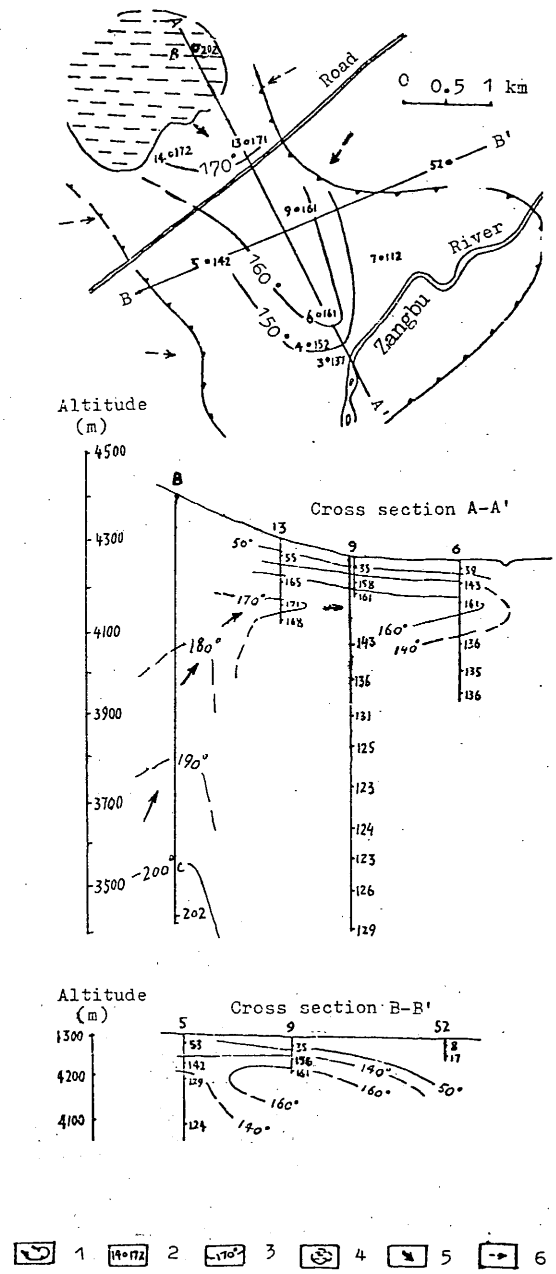

Fig.2 Temperature distribution of the Yangbajan geothermal field.

1-isotherm 10 °C at depth of 5 m; 2-number of boreholes and maximun measured temperature in bores; 3-isotherms (°C); 4-hydrothermal alteration area; 5- direction of movement of geothermal water flow; 6- direction of movement of the cold water specific volume was taken as 0.6 cal/cm^3 °C[3].

If the pipe and power plant efficiency is 0.1 and explortation covers 25 years, the electri potential for the Quaternary silicified sandstone in Yangbajan is estimated to be 26 MWe. since the Yangbajan geothermal field has an extensive lateral water flow of about 5363 m^3/hr through a cross sectional area, an additional 54 MWe has been estimated. Finally, the total verified electric potential is estimated to be 80 MWe for the Quaternary aquifer in Yangbajan.

In addition, in Yangbajan's basement, which is granite, a high temperature flow regime with K/Na geothermometer temperatures of 207 to 222 °C might exist and possible electric potential might reach 62 MWe.

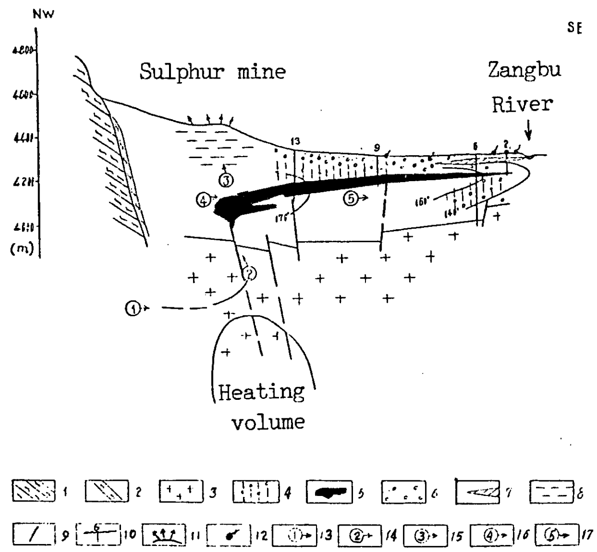

Fig. 3 Schematic diagram of the Yangbajan geothermal system [1] (Yang Qilong, 1980)

1-gneiss of Paleozoic Era; 2-breccia; 3-granite; 4-till of Quaternary; 5-silicified grit controlled aquifer; 6-grit; 7-clay; 8-alteration area; 9-faults; 10-boreholes; 11-steam ground; 12-hot or boiling springs; 13-cold recharge water; 14-cold water at the foot of Mt. Nyaigentanglha; 17-mixed geothermal water flow

CONCLUSIONS

1. Discovery of 202 °C in the borehole in the north hydrothermal alteration area approves that the Yangbajan geothermal field has fine electric potential for future development and also means the forecast of the high-temperature water flow coming from beneath north alteration area is varified. Since the bore with temperature of 202 °C is located in edge of the alteration area, the higher temperature might be found in the centre of the alteration area.

2. The main exploitation area for power generation should be on the north part of the field. according to the resources assessment a capacity of 30 MWe for power generation could be guaranteed by the resources.

3. The complex utilization of the waste hot water of about 90 °C for greenhouse and woolen industry etc. should be developed in the Yangbajan area.

4. Attention should be paid to the reinjection of the waste hot water (flow rate about 1 m^3/sec, about 90 °C after power generation). We suggest to begin feasibility study to use the cold water from the Zangbu River as intermedium heated by the waste water, then transported by pipelines to Lhasa for hot water supply.

REFERENCES

Yang Qilong,1980, Geothermal Resources and Their Present State of Reseach, Special paper presented at a meeting of the Standing Advisory Committee on Geothermal Training, Pisa, Italy.

Yang Qilong, 1982, Geotemperature Measurement in Geothermal Exploration, 4th New Zealand Geothermal Workshop, Part 2,p 485-489.

Yang Qilong, Xi Kuide and Zhang Zhenguo, 1985, Preliminary Assessment of the Geothermal Resources of China, 1985 International Symposium on Geothermal Fnergy,Hawaii, p. 43-52.

L.J.P. Muffler and L.Rybach, 1981, Geothermal Systems: Principles and Case Histories.