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GEOTHERMAL EXPLORATION AND DEVELOPMENT IN THAILAND

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ABSTRACT

IMany geothermal manifestations and hot springs of medium to low enthalpy have been found scattering around the country of Thailand, especially in the northern part, the southern part and the western part. The surface temperatures of the hot springs range from 40˚C to 100˚C. Systematic studies of geothermal resources started in 1973 by the National Energy Administration of Thailand (NEA) and Kingston Reynolds Thom & Alladice indicated that utilization of geothermal energy for power generation and agricultural application was warranted. The Electricity Generating Authority of Thailand (EGAT), in cooperation with the French Energy Agency, Japan International Cooperation Agency (JICA) and Chiang Mai University, has developed a geothermal power project in Chiang Mai province.

In 1989, EGAT succeed in the installation of the 300 kWe binary cycle geothermal power plant at Fang area. Up to now this power plant has a capacity to generate and transmit more than 13 million kWh of electricity to the local distribution grid. The exhaust hot water from the power plant is used for demonstrating crop dryer, air conditioning and cold storage.

A similar project has been developed in Mae Hong Son and Chiang Rai province, which mainly emphasizes on shallow level exploration for multipurpose uses.

1. INTRODUCTION

There are more than 90 hot springs with surface temperatures ranging from 40˚ to 100˚C scattering throughout the country with more than 40 of them located in the northern part (Fig.1). The preliminary results from reconnaissance surveys which had been done by the National Energy Administration (NEA) of Thailand and Kingston Reynolds Thom & Allardice Ltd. of New Zealand in 1973 indicated that utilization of geothermal energy for power generation and agricultural application was warranted. However, the studies of geothermal potential did not begin until late 1979. A working group consisting of personnel from the Electricity Generating Authority of Thailand (EGAT), the Department of Mineral Resources (DMR) and Chiang Mai University (CMU) was formed with the aim to define the potential of geothermal development for power generating which leads to the set up and implementation of the tentative schedule for geothermal energy development in northern Thailand.

2. EXPLORATION HISTORY

Since 1979 the working group has investigated more than 30 well-known hot spring of northern Thailand although the exploration drilling had not begun until 1981 (Table 1). The exploration has subsequently been narrowed down to the five most promising areas, namely Fang, San Kampaeng, Pa Pae, Tepanom geothermal areas in Chiang Mai province and Mae Chan geothermal area in Chiang Rai province (Fig 2). The calculated reservoir temperatures are close to or above 180˚C. After conducting scientific, sociological and economical analyses, San Kampaeng and Fang geothermal areas were selected as the sites for detail studies.

During 1982-1988 EGAT cooperated with Japan International Cooperation Agency (JICA) in

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carrying out the pre-feasibility study on geothermal development in San Kampaeng, in order to utilize geothermal energy for electricity generation.

During 1982-1992, EGAT cooperated with the French Environment and Energy Management Agency (ADEME) in studying the use of geothermal energy for electricity generation and multipurpose uses in Fang geothermal area.

During 1983-1986, DMR established the geothermal exploration project to evaluate the potential of 50 geothermal areas in northern part of the country using geological and geochemical prospecting. The technical assistance from the United Nation Development Program (UNDP) under the contract of TCD CON 32/83 was also a part of this project. The UNDP project covered 9 selected geothermal areas, namely: Ban Pong, Ban Nong Krok, Pong Kum, Tepanom, Nam Mae Mon, Nam Mae Hul, Ban Sop Pong, Ban Pong Nam Ron and Ban Mae Chok geothermal areas. The expert mission from Geothermica. Italiana Srl., Italy, performed the fieldwork during 1983-1984. The geophysical and drilled well data available in some geothermal areas were also used for evaluating the project.

Apart from two main exploration methods, DMR carried out the geophysical work and drilling work in Pong Kum, Ban Sop Pong, Ban Pong, Ban Nong Krok, Ban Pun Jane, Mae Chok and San Kampaeng geothermal areas.

In 1982, the department of Energy Development and Promotion (DEDP) in cooperation with CMU carried out the detailed study in Ban Nam Ron, Ban Phu Toei, Ban Phu Kham and Ban Wang Kham geothermal areas in Petchaboon Province to define the potential of these low enthalpy geothermal system. The exploration work included the geological geochemical and resistivity surveys.

During 1992-1995, DEDP established a 5-year geothermal exploration plan with the target to exploit hot water from shallow depth wells for small scale direct uses in the agro-industrial application especially in crop drying. The extensive plan to estimate the actual potential of the prospect was commenced in 1993. The resistivity surveys were carried out covering the prospecting area in order to locate and delineate the resistivity structure and then some shallow exploration wells were drilled at the selected location to examine the subsurface condition. During 1994-1996, nine geothermal areas namely: Mae Chan, Tepanom, Muang Ngam, Pha Bong, Nong Haeng, Mae Kasa, Pong Pu Fuang, Ko Kha and Pha Sert geothermal areas were investigated.

During 1994-1996, Pai geothermal areas including Ban Muang Rae and Ban Muang Paeng geothermal area, in Pai district, Mae Hong Son province, northern Thailand (Fig. 2) were investigated by EGAT to implement for shallow reservoir development. The result shows that the potential is not suitable for electricity generation.

In 1996, EGAT carried out the resistivity surveys and shallow exploration drilling at Mae Chan geothermal area in Chiang Rai province, northern Thailand.

Latest, in 1998, EGAT carried out the resistivity surveys and shallow exploration drilling at Ban Nong Haeng geothermal area in Khun Yuam district, Mae Hong Son province (Fig. 2). This is one of the projects of new energy resources development, which EGAT has made endeavor to implement in Mae Hong Son province.

3. GEOTHERMAL SYSTEM

Geothermal Resources in Thailand are considered to be low to intermediate temperature resource with reservoir temperature up to 225°C (Hochstein, 1988). The studies of geothermal resources in northern part of Thailand indicated that all of hot springs is distributed around Cenozoic basins, granitic batholiths (Barr et al, 1979). There are no active volcanoes in Thailand. The heat source of hot spring is considered as the decay of radiogenic elements in rocks, especially granitic rocks that are widely distributed in Thailand. Most of the reservoirs are likely associated with faults or faults sets which have very steep dips. The Geothermal system in Thailand can be classified into 2 types, namely, narrow fracture zone system (less than 100 m wide) and wide fracture zone system (more than 100 m wide). A conceptual model of the system is shown in Fig. 3a and Fig. 3b.

4. GEOCHEMICAL CHARACTERISTIC OF HOT SPRING WATER

The Chemical composition of hot spring water in northern Thailand can be summarized as follow:

1. Surface temperature is up to 100˚C
2. pH range from neutral to slightly alkali (7-9.5)
3. Low chloride content (less than 32 mg/l) and high fluoride content (up to 25 mg/l)
4. Low calcium and magnesium content (less than 6 mg/l and less than 0.6 mg/l respectively)
5. Na-HCO_3 type composition

5. EGAT'S GEOTHERMAL EXPLORATION AND DEVELOPMENT

San Kampaeng Geothermal Area

The San Kampaeng geothermal development project has been conducted under technical collaboration between EGAT and Japan International Cooperation Agency (JICA) in 1982. The objective of this collaboration was to define the geothermal potential of the area. The detail investigation on geology, geochemistry, geophysics and exploration drilling were carried out during 1982-1988. Two deep exploration wells, GTE-7 and GTE-8, were drilled in the prospecting areas to the depth of 1,277 and 1,300 meters respectively. The first well, GTE-7, was dry with the bottom hole temperature of 99o C. The second well, GTE-8, encountered fracture zones at various depths from 330-920 meters and only the last fracture at depth of 920 meters, discharged 40 t/h of water at 125o C. Estimated potential of the San Kampaeng geothermal reservoir is up to 5 MW through binary cycle system. However, cost-effectiveness of binary cycle geothermal power plant is higher than conventional thermal power system.

Fang Geothermal Area

In 1982, the cooperation between EGAT and the French Agency for Energy Management (AFME) was established to carry out the Feasibility Study on Fang Geothermal Development Project to install a binary cycle demonstration plant of 100-300 kWe using hot water from the shallow reservoir. The geological survey and detailed resistivity survey were carried out to examine the shallow resistivity structure, to delineate mineralized hot water zone and to locate shallow production wells. Some shallow wells were drilled for various exploring purposes which some of them discharging hot water. From late 1985 to early 1986, two exploration wells, FGTE-14 and FGTE-15, were drilled in low resistivity anomalous zones discharged hot water of 125 ˚C, with total flow rate of 22 liters per second. After the production test was done to confirm the production reliability, EGAT decided to procure a binary power plant of 300 kWe capacity for demonstration. The power plant was installed and has been connected to the local grid system since December 5, 1989. Up to now this power plant has capacity to generate and transmit more than 13 million kWh of electricity to the local distribution grid. The exhaust hot water from the power plant is used for demonstrating crop dryer, air conditioning and cold storage (Fig. 4 and Fig. 5). Nowadays, Thailand mainly emphasizes shallow level exploration for multipurpose uses.

The technical cooperation on Fang Deep Geothermal Development Project, under the extended agreement with the French Environment and Energy Management Agency (ADEME), in order to define the potential of deep reservoir was started in 1990. The detail geological survey, electrical survey and geochemical survey were implemented in order to locate the deep reservoir and its controlled structure. After completed the field surveys, the intermediate deep wells (FX1-FX4) were drilled with a target for 500 meters deep in the prospecting points. The second well, FX-2, encountered a fracture at 270 meters depth and produced 25 t/h of hot water having a temperature of 125 ˚C. The well FX-4 encountered the fractures at the depth of 268, 337 and 417 meters and had bottom hole temperature of 130 ˚C. The total hot water flow rate is about 36 t/h. The other wells, FX-1 and FX-3 were non-productive and had bottom hole temperatures of 108 ˚C and 113 ˚C respectively. The data obtaining from the survey indicated that the reservoir is most likely associated with faults or fault sets which are laid down very steep dip. By this reason it is very high risk to encounter this faults by normal vertical drilling so it is unreasonable to drill the deep vertical exploration well in this moment.

Pai Geothermal Area

After EGAT has succeed in developing the first geothermal demonstration plant in Fang geothermal area, EGAT set up the plan to develop the shallow reservoirs as multipurpose project at Ban Muang Rae and Ban Muang Paeng geothermal areas in Pai District, Mae Hong Son Province during 1994-1996.

The geophysical surveys using DC resistivity method were carried out covering the prospecting area in order to locate and delineate the resistivity structure, to investigate the geological structure which associated with the geothermal system, such as fracture zones, depth of granite basement and to locate area for shallow exploratory wells.

The resistivity survey consists of three methods: resistivity profiling, vertical electrical sounding (VES) using Schlumberger array and combined head-on resistivity profiling. The aim of the combined head-on resistivity profiling is to investigate the low resistivity structures associated with fracture zones which can act as a vertical channel for outflow of hot water in the upper part.

Ban Muang Rae Geothermal Area

At Ban Muang Rae geothermal area, the resistivity profiling survey which is the method for investigating the lateral variation of resistivity at desired depth was carried out with current electrode spacing of AB/2 = 50, 100 and 200 meters for 10 profile lines with an approximate length of 500 meters per line. The result shows that the low resistivity zone (less than 60 Ω-m) appears along the west of Pai River.

Eight survey lines of resistivity profiling were selected to carry out the combined head-on resistivity profiling survey using AB/2 spacing of 100 and 200 meters. The survey result shows that there is a main fracture zone trending NE and nearly vertical dipping to be detected. The fracture zone can be coincident with the result of resistivity profiling survey.

Vertical Electricity Sounding surveys was carried out for 6 stations using perfect and imperfect-Schlumberger array. Most measurement stations are located in the west of Pai River. The result shows that the alluvial deposit layer has apparent resistivity varies between 25 to 300 Ω-m. The weathered granite or altered granite has apparent resistivity between 12 to 15 Ω-m and unaltered granite basement has resistivity between 350 to 950 Ω-m. The section in the NE direction shows the depth of granite increase to the south.

After finishing geophysical survey the twelve heat holes of 50 meters deep were drilled. Furthermore three exploratory drilling wells of 200 meters deep with the hole diameter of 5 5/8 inches were drilled along the fracture zone. The results of these drilling wells were non-productive. The result indicates that the bottom hole temperature is about 93.3 ˚C and the highest temperature is 96 ˚C at the depth of 170 meters.

Ban Muang Paeng Geothermal Area

The resistivity profiling survey was conducted by using current electrode of AB/2 = 50, 100 and 200 meters for 7 profile lines with an approximate length of 500 meters per line running across Huai Mae Paeng Fault. The low resistivity zone at AB/2 of 200 meters lies along Huai Mae Paeng Fault and hot spring. This low resistivity zone may indicate the fracture zone trending nearly NS and NE-SW

Five survey lines of resistivity profiling were selected to conduct combined head-on resistivity profiling survey. The survey result shows that there are three fractures being detected. These fractures can be correlated to the result of resistivity profiling survey.

Fourteen measurement stations of Vertical Electrical Sounding were carried out around the hot spring area. The survey results indicated that the low resistivity layer of 20-35 Ω-m at the depth of less than 60 meters exists at the west side of Huai Mae Paeng Fault covering the hot spring area. This low resistivity zone may indicate the alteration zone of granite basement associated with hot water.

The eleven heat holes of 50 meters deep were drilled after finishing geophysical temperature. The survey result shows that the high temperature zone is situated around the hot spring and extends to the north parallel to Huai Mae Paeng Fault. After finishing heat hole drillings, four shallow exploration and production wells of 250 meters deep were drilled. Three of them discharged hot water with bottom hole temperature of 94 ˚C and total flow rate was about 25 liter per second with low pressure (nearly atmospheric pressure). Due to the survey result showing low potential resource, EGAT decided to postpone the developing of this geothermal area for electricity generating. However, This hot water can still be used for agricultural purpose.

Mae Chan Geothermal Area

EGAT carried out the resistivity profiling using current electrode spacing of AB/2= 100 meters for 5 profile lines with approximate length of 800 meters. Combined head-on resistivity profiling method was carried out for 5 profile lines with electrode spacing of AB/2 = 100 meters and 3 profile lines with electrode spacing of AB/2 = 200 meters. The result shows that the low resistivity anomalies and preferred faults correspond with the main faults of the area. The result of combined head-on resistivity profiling survey shows that three faults trending NE-SW cross the area can be detected.

Eleven exploratory wells of 50 meters deep were drilled. The result shows the good sign for shallow reservoir development and a thermal anomaly extends to South-East of the area. EGAT had planned to drill 2-3 of 200-300 meters deep holes, but due to the economic crisis, EGAT decided to postpone the deep drilling program.

Nong Haeng Geothermal Area

In early 1998, EGAT planned to develop energy resource in Mae Hong Son Province, especially renewable energy such as solar energy and geothermal energy. Nong Haeng geothermal area is one of the projects which EGAT attempts to develop for electricity generation from geothermal energy. Resistivity profiling survey and combined head-on resistivity profiling survey were carried out for the same 8 profile lines of length 900 and 400 meters which lie in two directions (NE and NW direction) The result indicates that the low resistivity zone (less than 60 Ω-m) appears in the center of the area around the hot spring. This low resistivity zone shows in the NW-SE direction. On the other hand a high resistivity which is coincident with the high topography exhibits in the east. The result of combined head-on resistivity profiling shows that the main fault is not detected. Only small fracture zones trending nearly E-W and NW-SE can be founded in the area.

Thirteen measurement stations of Vertical Electricity Sounding survey were conducted throughout the area. The data of three measurement stations that are located in the east of the area are not reliable. This is because the steep slop of topography. The data were also analyzed and interpreted by PNOC, Philippines, in the under foreign co-operation in 1999. Resistivity models show that the low resistivity (less than 50 Ω -m) is shown at the depth of less than 100 meters and the thickness of the low resistivity ranges from about 20 to 30 meters.

The seven heat holes of 50 and 70 meters deep were drilled in order to define temperature gradient. The result indicates that the bottom hole temperature is about 73.8 ˚C and the highest temperature is 83.0 ˚C at the depth of 42 meters. Numerous fractures are encountered at that depth but no hot water discharges. The result shows a thermal anomaly extends to South-East of the area. The 30 Ω-m resistivity anomaly at 20 m depth coincides with the area of high temperature of the bore holes. The 30 Ω-m resistivity anomaly is about 12,500 square meters and at a very shallow depth of about 20 meters. The conclusion of the survey result indicates that the shallow reservoir is low potential to develop for electricity generation and not suitable to drill 250 meters deep wells for the next step. In addition, in order to define the higher temperature reservoir, as estimated by chemical geothermometer, such modern geophysical survey as magnetotelluric (CSAMT) method is required because of topographic concerns and in order to obtain more detail at deeper level

6. MULTIPURPOSE PROJECT

Since Thailand is an agricultural country, many of the agricultural products, especially in northern Thailand, should be kept in a cold storage in order to reduce the post-harvest losses. Among these products are: onion, potato, lychee, longan etc. Tobacco, agro-industry, chili, earth-bean and garlic are the other important main products, which will also require curing by drying system.

At San Kampaeng geothermal area, CMU and Mae Jo Institute of Agricultural Technology carried out the research work with the financial support from the NEA to use the discharging hot water from the exploration well for tobacco curing and earth-bean drying. Unfortunately, after the research was run-over, there is no more in use of these dryers. In 1989, the Tourist Authority of Thailand (TAT) and the San Kampaeng cooperative village were joined together to develop this hot spring area as the tourist spot and to promote the thermal water for bathing, which are become popular nowadays.

At Fang geothermal area, exhausted hot water from the power plant is again used for demonstrating crop dryer, air conditioning and cold storage (using absorption type) with ice storage. Meanwhile, the Mae Fang National Park constructed the public bathing pond and sauna room to serve the visitors. Recently, the Food Processing Section of the Royal Project - Royal Recommended Project is constructed a new larger crop dryer to preserve his products. Cooled water of about half million cubic meters per year is chemically safe enough to discharge for crop planting in nearby area.

7. STATUS OF ON-GOING PROJECT

The Geothermal Exploration in Thailand is considered subject to Assessment of Mae Hong Son Geothermal Resources Project. This project has requested National Energy policy Office of Thailand to sponsor for geochemical and isotopic surveys in other 7 hot spring areas, which are selected from the 16 existing hot spring areas, in Mae Hong Son province. These studies will be carried out with the cooperation of Electricity Generating Authority of Thailand (EGAT) and Chiang Mai University (CMU). The project is aimed at evaluating the potential of development, as multipurpose project, and promoting the development of the natural resources in the province. Recently, the demand of electricity in this province is increased and the shortage of electricity will occur if the transmission lines are not constructed.

Moreover, the Royal Forest Department has requested technical assistance from EGAT to develop hot springs in 22 Natural Park areas through out the country for recreating purpose. The scope of development is exploration of existing natural hot springs and development for hot water utility and other related tourist facilities.

8. FUTURE ACTIVITIES

At San Kampaeng, A small amount of geothermal fluid from shallow reservoir of San Kampaeng Geothermal Area is used for recreation and tourist attraction. EGAT has been trying to cooperate with the local authority to establish a government-private joint project to use the existing discharge fluid for commercial scale crop drying and cool storage, to preserve agricultural product of nearby villages. However, the project so far has not been successful due to the lack of financial support.

As deep reservoirs are most likely associated with very steep dipping fractures, it is very difficult to develop resources by using normal techniques. Directional drilling is considered the most suitable and effective method to apply with deep geothermal resources. Even though directional drilling is considered cost-effective, its investment cost is presently high. Thus, EGAT emphasizes to develop the shallow reservoirs for multipurpose uses in the area with electricity shortage such as Mae Hong Son Province.

In another move to alleviate the power shortage problem in the province, EGAT tries to develop the Ban Nong Haeng geothermal prospect but still lacks CSAMT equipment and experience in this exploration field. In this regard, EGAT is going to apply to JICA for the grant aid in Project-type Technical Cooperation to procure the CSAMT equipment.

9. CONCLUSIONS

Geothermal in Thailand is still in progress. We believe that the development of medium enthalpy geothermal resources can support the energy demands and utilize for multipurpose project. Fang binary cycle power plant together with hot water utilization is the first project in Thailand, which is fully implemented. In point of fact, Thailand is located out of the volcanic zones, all the experiences of this unique application in exploration, installation and operation as well as social and environmental prospects are very useful for formulating the future geothermal energy planning. This is the great benefit to Thailand and the world as a whole. In addition, the problems of development being faced now are the low potential of the resources, lack of personnel, lack of technology know-how, and lack of budget.

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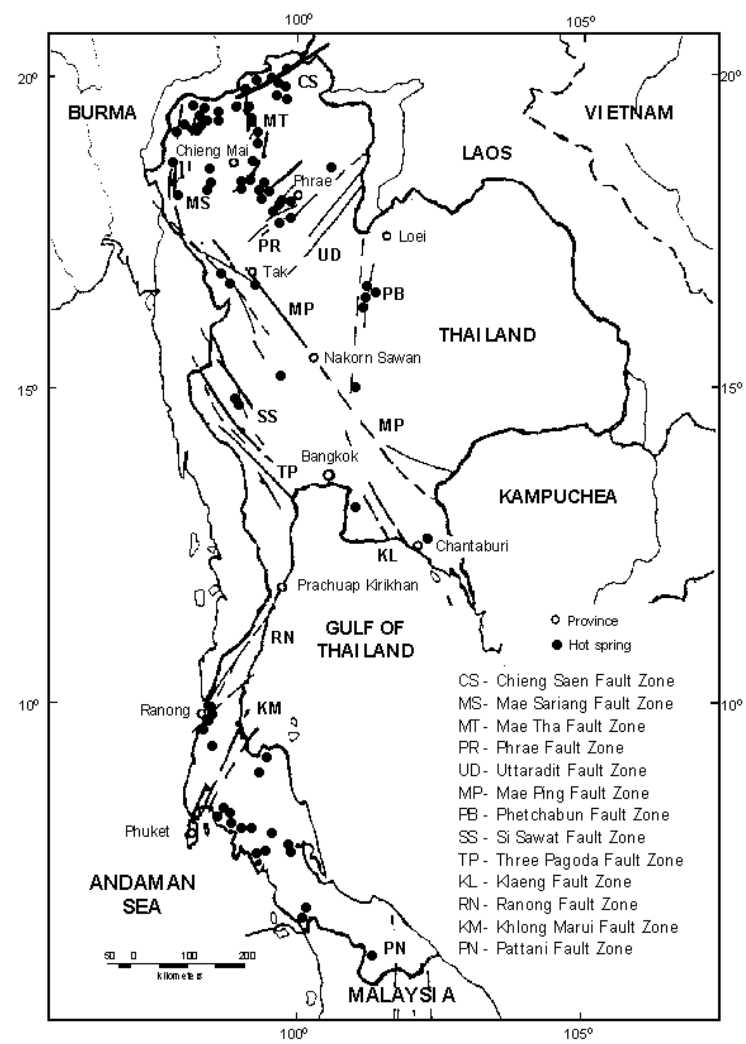

Fig. 1 Major fault zones and hot springs in Thailand.

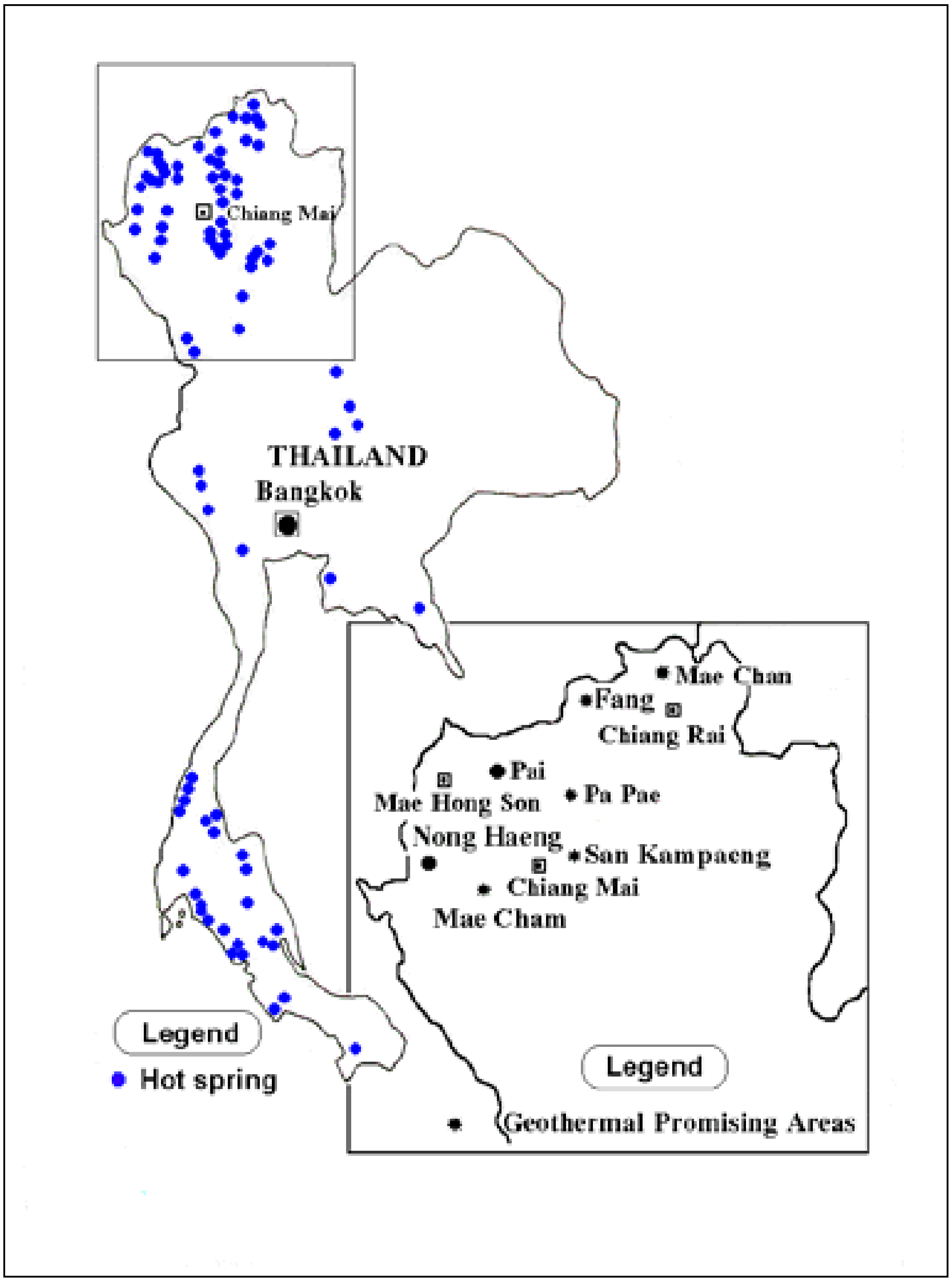

Fig. 2 Location of geothermal promising areas

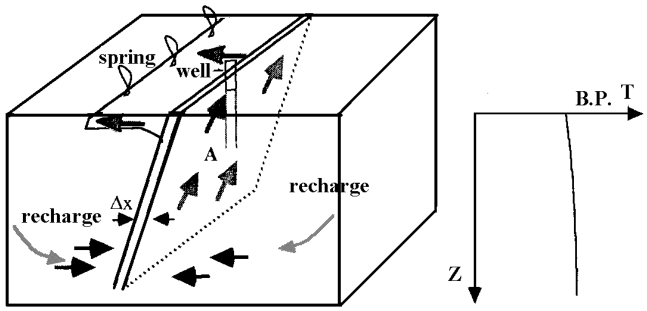

Fig. 3a Schematic model of a narrow fracture zone system with a small shallow outflow

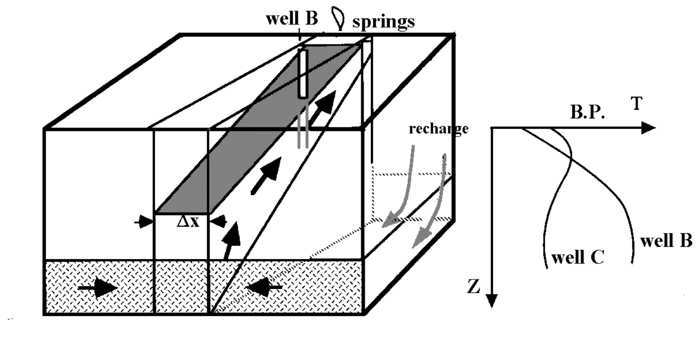

Fig. 3b Schematic model of a wide fracture zone system with an inclined upflow of hot water

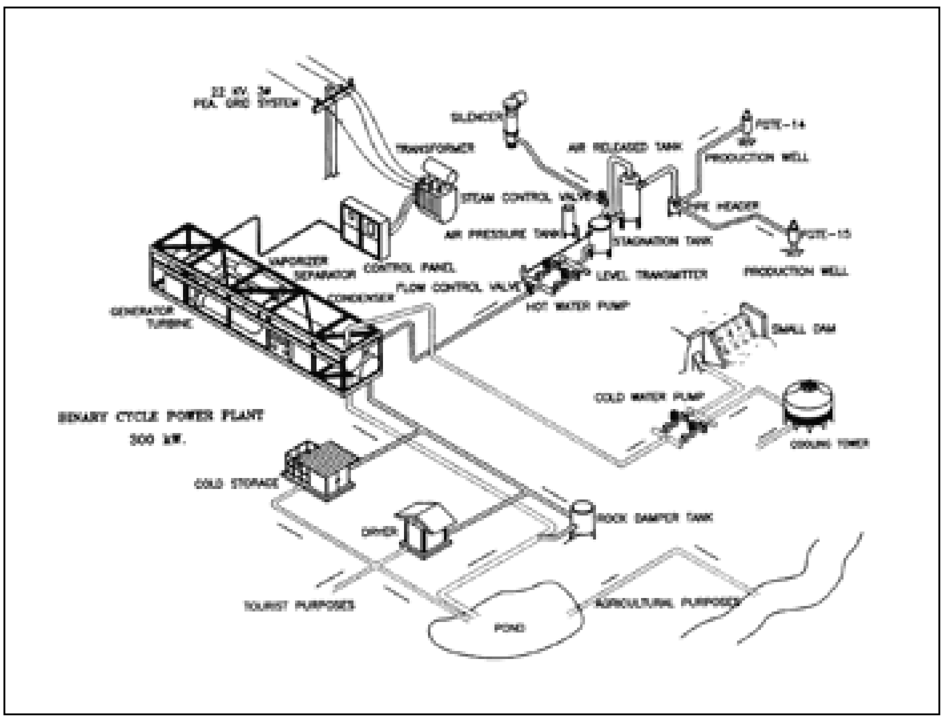

Fig. 4 Pictorial diagram of Fang geothermal multipurpose project

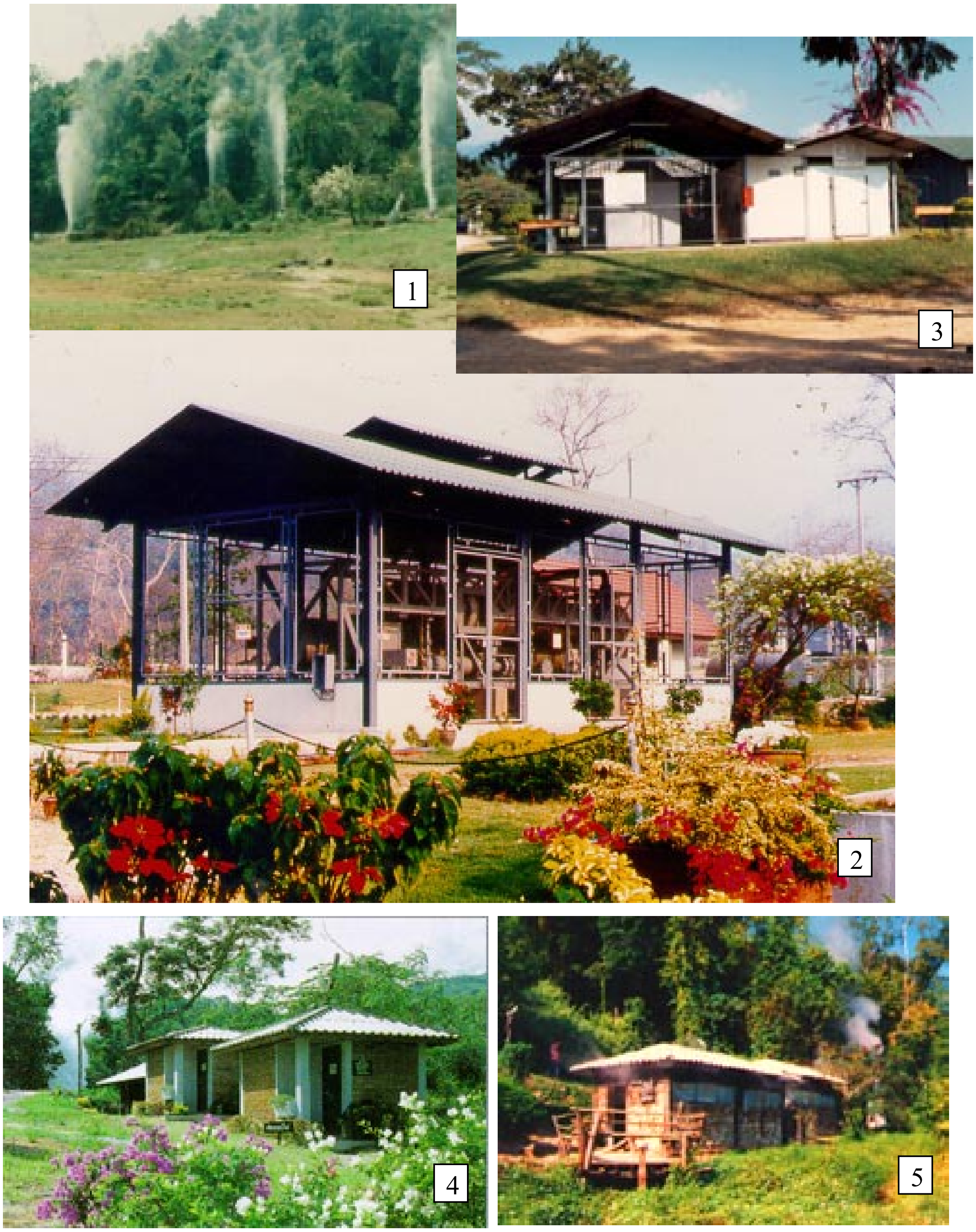

Fig. 5 Fang geothermal multipurpose project

1- Geyser from shallow wells
2- The 300 kW binary cycle geothermal power plant
3- Dryer and cold storage for agriculture products
4- Hot bath
5- Steam sauna

Table. 1 Summary of Exploration Drilling for Geothermal Energy Recourses in Thailand (After Praserdvigai, 1999)

Geothermal Area	Drilling		Responsibility/ Duration	Remark
	Depth (m)	No. of Well		
San Kampaeng	<100	40	EGAT/	- The development project
	<500	6	1981-1987	was postponed
	1,227	1		
	1,300	1		
Fang	<100	27	EGAT/	- 300 kW binary cycle power
	<200	7	1982-1994	plant is under operated
	<150	10		- Deep Reservoir exploration
	<500	3		was postponed
Ban Muang Rae	<50	12	EGAT/1994	- Unfavorable reservoir
	<200	3	1995	temperature
Ban Muang Paeng	<50	11	EGAT/1994	- Unfavorable reservoir
	<200	4	1996	temperature
Pong Kum	20-30	30	DMR/1984	- Exploration
Ban Sop Pong	20-30	16	DMR/1984	- Exploration
Ban Pong	150	1	DMR/1984	- Exploration
Ban Nong Krok	120	1	DMR/1984	- Exploration
Ban Mae Chok	100	1	DMR/1984	- Exploration
Ban Pun Jane	100	1	DMR/1984	- Exploration
Tepanom	100	3	DEDP/1994	- Exploration / Geyser well
Pong Pu Fuang	100	2	DEDP/1994	- Exploration
Koh Kha	101	1	DEDP/1994	- Exploration
Mae Kasa	100	1	DEDP/1995	- Exploration
Nong Haeng	100	2	DEDP/1995	- Exploration
Mae Chan	100	2	DEDP/1996	- Exploration / Geyser well
Pha Sert	100	2	DEDP/1996	- Exploration
Muang Ngam	100	2	DEDP/1997	- Exploration
Pha Bong	100	2	DEDP/1997	- Exploration
Mae Chan	50	11	EGAT/1997	- Thermal gradient survey
Nong Haeng	50	7	EGAT/1998	- Thermal gradient survey

DEDP: Department of Energy Development and Promotion