

## **THAILAND GEOTHERMAL ENERGY: DEVELOPMENT HISTORY AND CURRENT STATUS**

Manop RAKSASKULWONG<sup>1</sup>

<sup>1</sup>Geological Survey Bureau Department of Mineral Resources, Rama 6 rd., Ratchthewi, Bangkok 10400, Thailand  
e-mail: manop@dmr.go.th : manop\_raksa@yahoo.com

### **ABSTRACT**

Geothermal in Thailand, manifest as hot springs, have been collected for chemical and physical analysis studies since 1946. There are 116 hot spring manifestations in northern, western, central and southern Thailand. Hot springs are of non-volcanic origin as inferred from isotopic relationship between  $\delta D$  and  $\delta^{18}O$ . Hot springs, surface temperatures range 40-100 °C, is clear, colorless with white algae, white-yellow and red scar of calcium carbonate, sulphur and iron disseminate on soil and rocks. Chemical analysis discloses that hot springs yield pH 6.4-9.5, total dissolve solid 130-24,800 ppm, alkalinity of bicarbonate 47-1,079 ppm and fluoride 0.055-20.4 ppm. Nine hot spring areas are saline. Geothermometer calculation using silica, calcium and potassium contents denotes subsurface temperature of the five highest reservoir temperature ranges 180-210 °C.

Geothermal energy utilization has been classified as for electricity generation and direct uses. Power plant with capacity of 300 kW, applied binary cycle, was completed in 1988. Geothermal direct-use is categorized mainly as for bathing, swimming and spa where natural hot spring discharges are piped to the storage tank or flow naturally down stream. Most of direct uses have been developed by government sector except at the San Kamphaeng, Chiangmai province and Tapotharam temple hot spring, Ranong province partly developed by private sector. Total capacity of direct utilization in southern Thailand is estimated to be 10.12 MWt with an annual utilization of 173.05 TJ. Future geothermal utilization should be set a master plan for multi-purposes as electricity and direct-uses. High potential geothermal field utilization has to conduct and plan for electricity and direct utilization in agricultural, medical and health spa.

**Key words:** Thailand, geothermal energy, multipurpose utilization, health spa, therapy

### **1. INTRODUCTION**

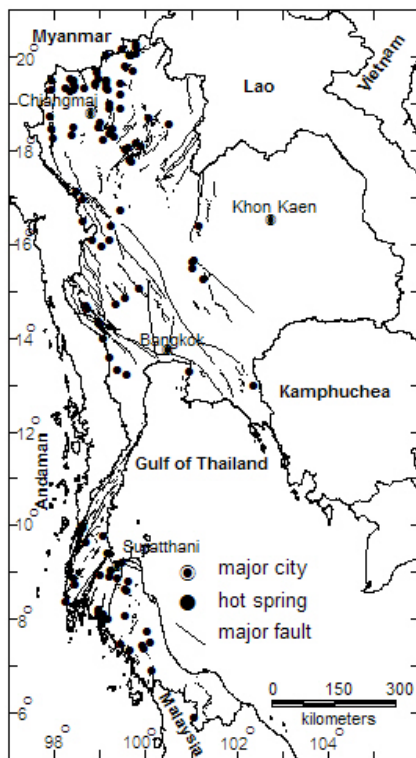
Hot spring, a natural phenomenon indicating that the earth's interior is hotter than its surface, has been studied by chemical and physical analysis since 1946. At present, there are 116 hot spring manifestations with surface temperatures ranging from 40-100 °C, scattered from northern, western and southern Thailand (fig. 1). They occur not only within volcanic outcrops, but also within granitic and sedimentary rocks of various ages.

Hot springs in northern Thailand have been studied on the purpose to extract and utilize the geothermal energy since 1977 while hot springs in western and southern Thailand have been preliminary studied since 1988 and 1989 respectively. Due to higher enthalpy, hot springs in northern Thailand have been developed and utilized more than other part of Thailand.

The first geothermal joint working group is collaboration among the Chiang Mai University (CMU), Electricity Generating Authority of Thailand (EGAT) and Department of Mineral Resources (DMR). One of the main purposes is to appraise geothermal potential and utilize geothermal energy for electricity. An ideal utilization is to develop suitable geothermal fields for electricity generation in an order of 300 kW to 10 MW applying binary cycle system, using thermal water of temperatures ranging between 130 °C and 180 °C at reservoir depths 100 m and 1,500 m. respectively. Thermal waters release from the power plants are to be used for agricultural and industrial purposes, e.g. cold storage and barn dryer.

Preliminary chemical analyses of hot spring water, geological, geophysical and heat flow explorations indicated areas of possibility for geothermal utilization in northern Thailand. The areas express favorable reservoir structures with subsurface temperature greater than 180 °C. (Ramingwong et al., 1979, 1980; Geotermica, 1984; JICA, 1984; DMR, 1987).

Hot spring water naturally discharges are rather clear, colourless, pH ranges between 6.4 –9.5, total dissolve solid ranges



130 – 24,800 ppm. Some hot springs manifest near beach or at mangrove area exhibited saline thermal water. They are classified as simple, carbonate, alkaline and saline hot springs. Chemical contents of hot spring water and stream nearby are quite similar then hot spring water generally drains naturally to stream.

This paper reviews past, present and on going activities of geothermal energy study, development, exploitation as well as suggests for future activity.

**Figure 1** Map indicates hot spring distributions and major faults in Thailand.

## 2. EXPLORATION HISTORY

Hot spring exploration has been carried out more than 50 years on various purposes. Systematic and more sophisticated studies with collaborate and auspicious with Thais and foreigner scientists, organizations can be brief as follow.

1. Ramingwong et al. (1979), researcher from the CMU, reviewed physical geology of hot springs in northern Thailand. Their study pointed out the three highest potential of the San Kamphaeng, Fang geothermal fields in Chiangmai province and Mae Chan geothermal field in Chiangrai province (fig. 2). Most of the work of researchers from CMU studied and evaluate geothermal potential in northern Thailand e.g. Ramingwong et al., 1985; Ratanasathien et al., 1988).

2. Many geologists and geophysicists from DMR conducted geological mapping and geophysical explorations (Chaturongkawanich et al., 1980, 1985, 1997; Udomratn et al., 1985; Chuaviroj et al., 1980; Thienprasert and Raksaskulwong, 1980, 1984; Chuaviroj et al., 1984; Chaturongkawanich et al., 1985; DMR, 1987, Raksaskulwong and Chaturongkawanich, 1991; Raksaskulwong and Thienprasert, 1995).

3. Narkswasdi (1990) from the EGAT summarized multipurpose utilization of Fang geothermal field to generate 300 kW electricity applying binary cycle system.

4. Tusgate and Somboon-aneek (1997) from the Department of Energy Promotion and Development evaluated 9 geothermal fields in northern Thailand on purpose for agricultural and direct uses.

5. Many foreign organizations collaborated and auspicious in geothermal potential possibilities and exploitation studies, e.g. French Agency for Energy Management; FAEM assisted in appraisal of geothermal potential in the Fang geothermal field and start to generate electricity for 300 kW applying binary cycle in 1989. The EGAT cooperated with the Japan International Cooperation Agency; JICA to explore potential of the San Kamphaeng geothermal field during 1982-1989. The DMR cooperated with the United Nations Development Programme, UNDP to evaluate



**Figure 2** Map indicates hot spring utilization cited in text.

geothermal potential and economic of 10 geothermal fields in northern Thailand and summarize that the fields are classified as medium enthalpy fluids during 1983-1986 (Geotermica Italiana, 1984). The Akita university, Japan, studied chemical and gas isotope in 6 hot springs in northern Thailand to explain source and their circulation (Takashima and Jarach, 1987; Kita, 1989; Takashima et al., 1989). The Coordinating Committee for Coastal and Offshore Geoscience Programmes in East and Southeast Asia (CCOP), under the Japanese government sponsorship has launched Digital Compilation of Geoscientific Map phase IV, DCGM-IV, during 2001-2003 to digitally gather and compile ground water and geothermal database among member countries (Raksaskulwong, 2002).

6. Due to most hot springs manifest in government own land, then local government sector developed as recreation area. Master plan with geographical and architectural drawing has been implemented since 2000.

### **3. PHYSICAL AND CHEMICAL CHARACTERISTICS**

Hot spring, specified as temperature higher than 37 °C, manifest as warm-hot pool, boiling and geyser. The water is clear, colorless with white algae, white-yellow and red scar of calcium carbonate, sulphur and iron disseminate on soil and rocks. Chemical analysis discloses that hot springs yield pH 6.4-9.5, total dissolve solid 130-24,800 ppm, alkalinity of bicarbonate 47-1,079 ppm and fluoride 0.055-20.4 ppm. Nine hot spring areas, situated within 5 km. away from sea shore in southern Thailand are saline. Geothermometer calculation using silica, calcium and potassium contents denotes subsurface temperature of the five highest reservoir temperature ranges 180-210 °C.

Hot springs are considered to be of non-volcanic origin as inferred from isotopic relationship between  $\delta D$  and  $\delta^{18}O$ . The chemical contents are characterized by high alkali-sodium and bicarbonate but low concentrations of dissolved chemical species (Takashima and Kawada, 1981; Kita, 1989). Hot springs located in northern and western Thailand yield fluoride content higher than 5 ppm and spread out rotten smell of  $H_2S$  and sulphur.

### **4. GEOTHERMAL ENERGY POTENTIAL**

Preliminary study of hot springs in Thailand predicts that hot springs in northern Thailand are classified as medium enthalpy while the others are low enthalpy. Geothermal study of 50 hot springs in northern Thailand based on utility classification divided into 5 categories. Very high geothermal potential yields reservoir temperature higher than 180 °C with suitable reservoir structure at rather shallow depth, has 5 fields. High geothermal potential yields reservoir temperature between 140-180 °C, provides suitable reservoir structure, has 17 fields. Moderately high geothermal potential yields reservoir at high temperature but provides limited or restricted reservoir structure, has 4 fields. The other geothermal fields are classified as low geothermal potential and undetermined geothermal potential.

### **5. HEAT SOURCE AND GEOTHERMAL SYSTEM**

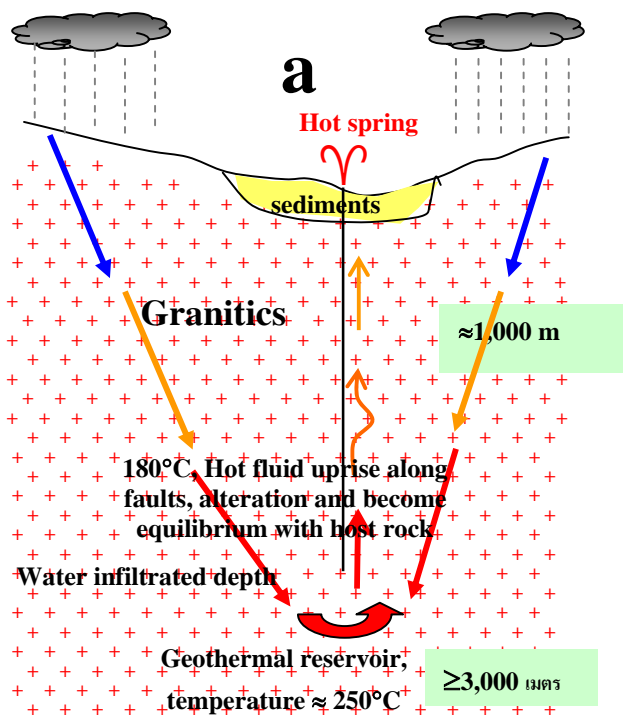
There are neither active nor recent volcanic rocks associated directly with hot spring manifestations. About two-third of the hot springs are found to related to some active geologic fractures, lineament and granitic plutons of various ages. Geothermal heat sources have been summarized by many workers (Geotermica Italiana Slr., 1984; Takashima, and Jarach, 1987; Takashima, et al., 1989; Raksaskulwong and Thienprasert, 1995).

Hot springs can be classified based on their water circulation into 2 types (Geotermica Italiana Slr., 1984; DMR, 1987).

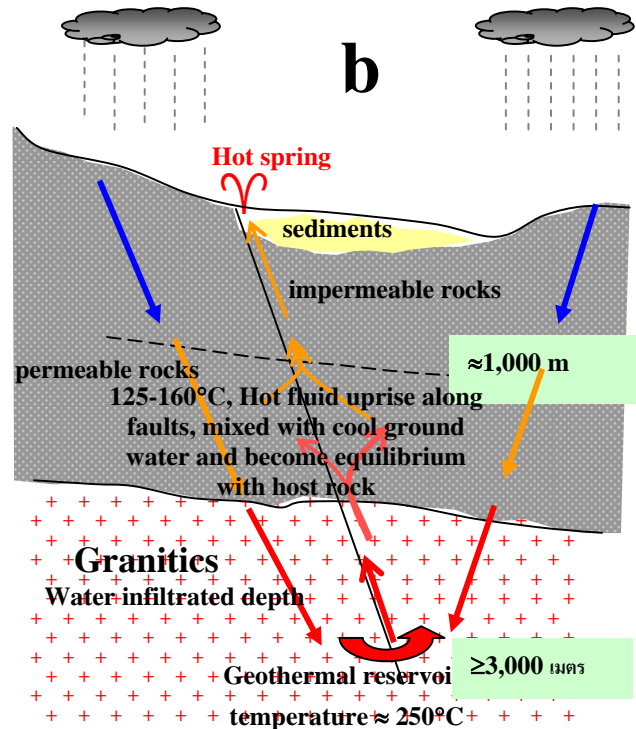
1. Natural flow of meteoric and surface water from ground or rock infiltrates through granitic rocks, receives or exchanges heat with burial hot rock, buoyant under great pressure and returns to the surface through fracture and fault as hot spring. The granitics are inherently impermeable, serves to contain and control the flow of geothermal fluids that migrate through complex network of faults and fractures (fig. 3a).

2. Natural flow of meteoric and surface water from ground or rock infiltrates through overlying permeable bedrock and further deep down to granitic rocks, receives or exchanges heat with burial granitic hot rock, buoyant under great pressure and returns to permeable reservoir. Temperature as well as pressure in the reservoir decline but seep or leak of hot fluids to surface through fracture and fault as hot spring (fig. 3b).

Meteoric and surface water percolate through ground



Meteoric and surface water percolate through ground



**Figure 3** Cartoon illustrates types of geothermal origin and circulation. (a) type 1, circulate and reservoir within granitics and (b) type 2, circulate through permeable and impermeable rocks but reservoir in sedimentary and/or permeable rock.

## 6. GEOTHERMAL DEVELOPMENT AND UTILIZATION

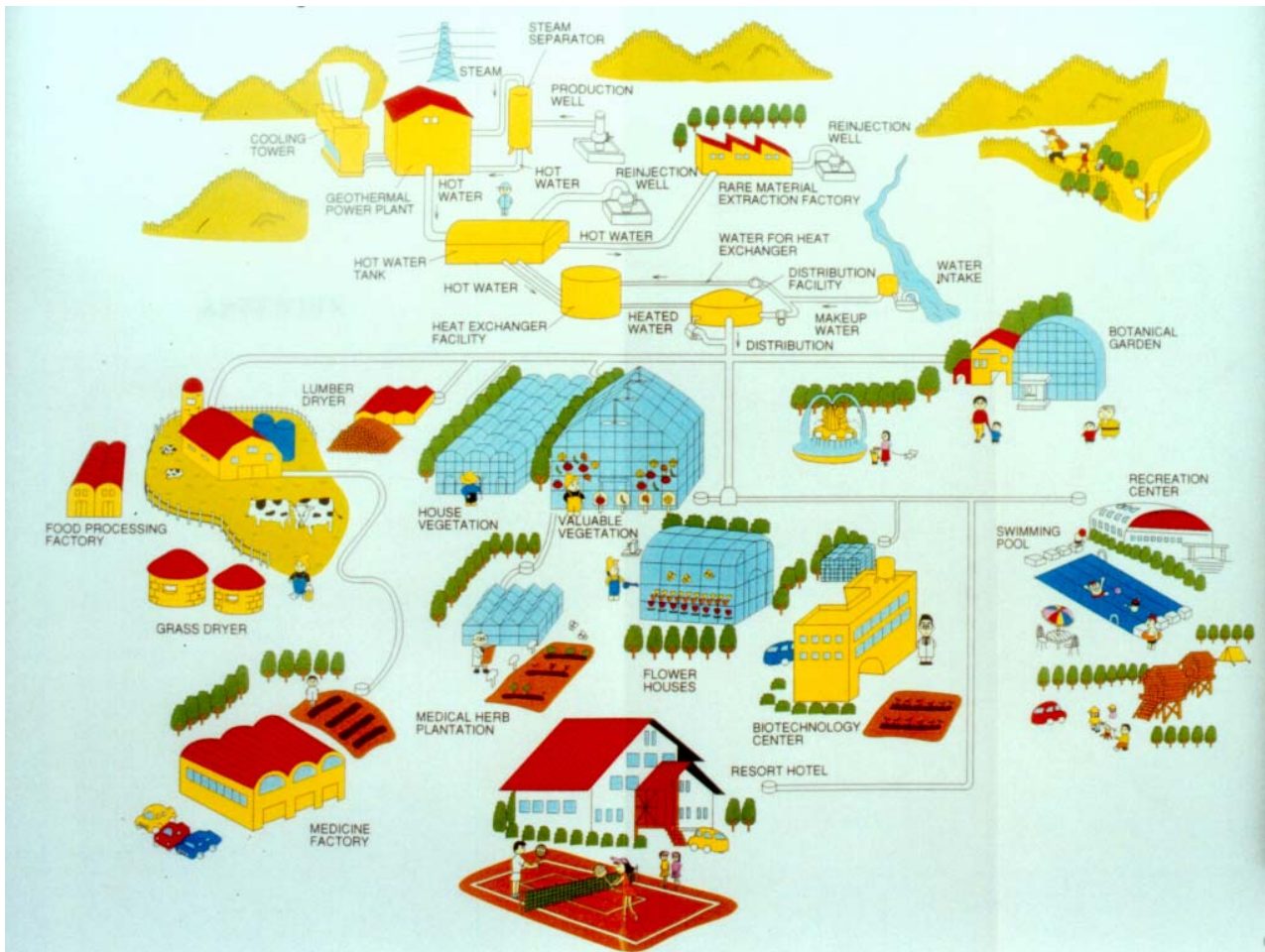
Geothermal utilization in high temperature reservoir should be plan as multi-purposes exploitation while low potential geothermal can be utilized as recreation and tourist health spa (fig. 4).

Geothermal utilization is classified as:

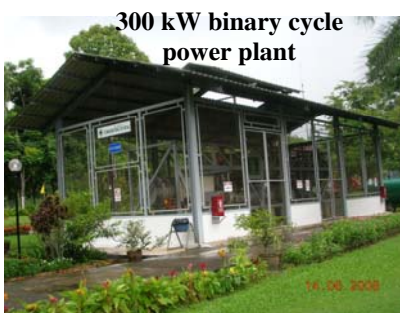
1. Electricity: Schematics drawing and summarized of multipurpose utilization of the Fang geothermal field to generate 300 kW electricity applying binary cycle system is reviewed in Narkswasdi (1990) (fig. 5).
2. Direct utilization: Due to almost all hot springs manifest in the forest reserve or government property, then direct heat uses have been developed by government sector. Most hot springs develop as recreation area and spa for healthy therapy by local community, provincial government sector. There are only three hot spring locations at the San Kamphaeng, Chiangmai province, Tapotharam temple, Ranong province and Bho Dan, Phang Nga province develop by private sector (fig. 2).

Recreation, generally, arranges bathing and soaking facilities without master plan until year 2000 that most local government sectors set up master plan and architecture to allure tourists to the area (fig. 6). Raksaskulwong (2003) calculates total capacity of hot spring direct utilization in southern Thailand. He estimated using amount of flow rate and temperature of inlet and outlet water piped to tourist attracted area, resort and spa. He concluded that direct utilization of hot spring is 10.12 MWt with an annual utilization of 173.05 TJ.

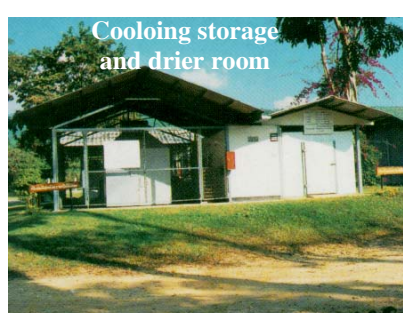




**Figure 4** Cartoon illustrates multi-purpose utilization of geothermal energy (WGC 2000 brochure).



**Recreation and tourist visit**



**Figure 5** Photos shows facilities of geothermal multi-purpose development at the Fang geothermal field.



**Figure 6** Photos shows some hot spring bathing facilities in Thailand.

## 7. CURRENT STATUS AND FUTURE DEVELOPMENT

Geothermal is one of clean alternative energy that can reduce global warming. Investment on geothermal utilization to electricity generating may be risky but exploitation on multipurpose basis is attractive and economic. Geothermal exploitation can provide more jobs to people who live far away from the city as well as create flowing of money and expand growing of community. Government should subsidize money or assists in technical research, advertisement and return most benefit to local community.

Thailand situates in tropical region then bathing in hot spring can not pursuit or allure people. With human awareness of being physical, Thai people begin to bath in hot springs as they anticipate that hot spring provides healthy and physically treatment for some sick. Due to almost all hot springs manifest in the forest reserve or government property, then direct heat uses have been developed by government sector. Local community and other related government sector should be aware of hygiene and bathing atmosphere. They should sustainable exploit the resource instead of polluting. Safety and naturally in ecotourism style should attract more tourist to come. Other utilization i.e. green house of cool plantation can fascinate more people.

Future geothermal utilization should set master plan for multi-purposes as electricity and direct-uses. Future for high potential geothermal field utilization is for electricity and direct utilization in agricultural, medical and health spa. Amount of moneys spend for each hot spring area are different but in general, hot springs located in the tourist cities and/or along highway or conveniently accessible with high potential will get priority and more money expenditure. Many hot spring areas allocate camping location and facilities as well as physical therapy e.g. Thai traditional massage. It is getting more and more popular among old and young people to bath in the hot spring.

## 8. CONCLUSIONS

There are 116 hot spring manifestations with surface temperatures ranging from 40-100 °C, scattered from northern, western and southern Thailand. They are of non-volcanic origin as inferred from isotopic relationship between  $\delta D$  and  $\delta^{18}O$  but occur, manifest within volcanic, granitic and sedimentary rocks of various ages. Hot springs in northern Thailand have been studied on the purpose to extract and utilize the geothermal energy since 1977 while hot springs in western and southern Thailand have been preliminary studied since 1988 and 1989 respectively. Due to higher enthalpy, hot springs in



northern Thailand have been developed and utilized more than other part of Thailand. Chemical contents characterized by high alkali-sodium and bicarbonate but low concentrations of dissolved solid. Hot springs located in northern and western Thailand yield fluoride content higher than 5 ppm and provided rotten smell of H<sub>2</sub>S and sulphur.

There are two types of hot spring circulation : circulate within granitic rock and circulate then heat up by deep burial granitic rock but store in permeable strata. The growth in direct heat use mostly for tourist attract, bathing and swimming, has been popular due to economic rebound in Thailand over the last decade. Tropical mineral spring spa at hot springs locality tends to remedy many kind of sickness as well as be part of physical therapy. Future geothermal utilization should set master plan for multi-purposes as electricity and direct-uses. Glorious atmosphere and hygiene recreation hot spring location will attract more tourists then bring more jobs to local community.

## **9. ACKNOWLEDGEMENTS**

I would like to express my sincere thank to Mr. Amnuaychai Thienprasert, formerly chief of the geothermal project in the DMR for his excellent guidance of geothermal exploration. Special thanks are to the director general of the DMR for offering facilities and permission to publish this paper.

## **REFERENCES**

- Chaturongkawanich, S., Wongwanich, T. and Chuaviroj, S., 1980, Geology of amphoe Fang, Changwat Chiangmai., Geol. Sur. Div., DMR, 49 pp.
- Chaturongkawanich S., Charusripun, M., Jarach, W., Surinkham, A., Soponpongpiat, P., Tansakul, L. and Phapisan, W., 1985, Geology and geothermal resources of Lopburi-Phetchabul-Kam-Phaengphet provinces : Geothermal energy project, DMR, 44 p. (in Thais)
- Chaturongkawanich S., Soponpongpiat, P. and Chuaviroj, S., 1985, Geology and geothermal resources of Pai district, Mae Hong Son province, northern Thailand : Proceedings 7<sup>th</sup> NZ. geothermal workshop, Univ. of Auckland, Geothermal Institute, p. 193-196.
- Chaturongkawanich, S., Raksaskulwong, M., and Leewongcharoen, S., 1997, Geological and geophysical exploration in the Amphoe Muang hot spring area : Changwat Ranong, DMR, 88 p. (in Thais)
- Chuaviroj, S., Chaturongkawanich, S., Udomratn, C., wongwanich, T., Sukawattananan, P. and Dhammadusdee, V., 1980, Geology of geothermal resources of northern Thailand, San Kamphaeng, Fang and Mae Chan areas : Geol. Sur. Div., DMR.
- Chuaviroj, S. and Chaturongkawanich, S., 1984, Geology and geothermal resources in northern Thailand : Geol. Sur. of Japan, no. 263, p. 69-77.
- Department of Mineral Resources (DMR), 1987, Geothermal energy in northern Thailand : Report of investigation no. 1, Bangkok, Thailand, 208 p. (in Thais)
- Geothermica Italiana Srl., 1984, Geothermal reconnaissance survey of northern Thailand : UNDP final report, Project No. THA/002/1982, PISA, 79 p.
- Japan International Cooperation Agency (JICA), 1984, Final report on pre-feasibility study for the San Kamphaeng geothermal development project in the kingdom of Thailand: Japan International Cooperation Agency, Tokyo, 399 p.
- Kita, I., 1989, Chemical and isotopic characteristics of gases and geothermal waters from the San Kamphaeng and Fang geothermal areas, northern Thailand, in Honda S., ed., Origin and reservoir characteristics of non-volcanic geothermal resources of northern Thailand : Akita Univ., Japan, p. 21-35.
- Narkswasdi, J., 1990, Fang binary cycle power plant : Paper submitted to 9<sup>th</sup> Asean geothermal meeting, Baquio: Philippines, 7 p.
- Raksaskulwong M. and Thienprasert, A., 1995, Heat flow studies and geothermal in Thailand : in M.L. Gupta and M.

Yamano eds. : oxford & IBH publishing Co. Pvt. Ltd., p.127-143.

Raksaskulwong, M., 2002, Progressive report on the compilation of Geothermal Database in Thailand : in Proceedings of the 2<sup>nd</sup> compilers' meeting of DCGM phase IV : Groundwater and geothermal databases, 2002, CCOP, Bangkok, Thailand, 9 p.

Raksaskulwong, M., 2003, Geothermal distribution and development in southern Thailand, in Exploration and Exploitation of geothermal resources as dispersive type energy : The 5<sup>th</sup> Asia Geothermal Symposium, Kuala Lumpur, Malaysia, 25-29 march 2003, AIST, p. 79-85.

Ramingwong, T., Ratanasthien, B., Sertsrivanit, S. and Thienprasert, A., 1979, Geothermal energy resources in northern Thailand : Chiangmai Univ., Tech. pap., no. 1, 74 p.

Ramingwong, T., Ratanasthien, B., Wattananikorn, K., Tantisukrit, C., Lerdthusnee, S., Thanasutipitak, T. and Pitragool, S., 1980, Geothermal resources of northern Thailand-San Kamphaeng, Fang and Mae Chan geothermal system : Chiangmai Univ., Chiangmai, 244 p.

Ramingwong, T., Ratanasthien, B., Tantisukrit, C., Thanasutipitak, T., Lerdthusnee, S. and Wattananikorn, K., 1985, Geothermal data of five highest potential geothermal systems in northern Thailand-Fang, San Kamphaeng, Mae Chan, Pa Pae and Mae Chaem : Report submitted to EGAT, 88 p.

Ratanasthien, B., Ramingwong, T., Tunsakul, L. and Bhotirungsiyakorn, C., 1988, Origin of thermal fluids in Fang and San Kamphaeng geothermal systems, Thailand as indicated by isotopic hydrogeology : J. Geol. Soc. Thailand no. 9(1-2), p. 97-107.

Takashima I. and Kawada, K., 1981, Geothermal resources of Thailand : Chishitsu News, v. 325, p. 16-29 (in Japanese).

Takashima, I. and Jarach, W., 1987, Isotope geochemistry of six geothermal fields in northern Thailand : Bulletin of Geological Survey of Japan, v. 38, p. 33-39.

Takashima, I., Honda, S. and Raksaskulwong, M., 1989, Heat sources and hydrothermal systems of non-volcanic geothermal resources in northern Thailand, in Honda S., Ed., Origin and reservoir characteristics of non-volcanic geothermal resources of northern Thailand : Akita Univ., Japan, p. 31-49.

Thienprasert A. and Raksaskulwong, M., 1980a, San Khamphaeng geothermal energy resource geophysical investigation; resistivity, seismic refraction and one meter depth temperature reading methods : Economic Geology Division, Department of Mineral Resources, Paper submitted to the Electric Generating Authority of Thailand, Nonthaburi, 75 p.

Thienprasert, A. and Raksaskulwong, M., 1980b, Fang geothermal resource-geophysical investigation; one meter depth temperature survey : Economic Geology Division, Department of Mineral Resources, Paper submitted to the Electric Generating Authority of Thailand, Nonthaburi, 15 p.

Thienprasert A. and Raksaskulwong, M., 1980c, Preliminary study of thermal conductivity of rock in Thailand : Economic Geology Division, Department of Mineral Resources, Paper submitted to the Electric Generating Authority of Thailand, Nonthaburi, 75 p.

Thienprasert, A. and Raksaskulwong, M., 1984, Heat flow in northern Thailand : Tectonophysics, v. 103, p. 217-233.

Tusgate S. and Somboon-anek, P., 1997, Geology of some geothermal resources in northern Thailand : Dept. Energy Development and Promotion, 58 p.

Udomratn C., Chaturongkawanich, S., Tansathien, W. and Soponpongpiat, P., 1985, Application of Landsat image to geothermal resources of amphoe Pai area : APSIS paper no. 3, Geol. Sur. Div., DMR, 36 pp.