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REVIEW OF GEOTHERMAL POTENTIAL AND DEVELOPMENT PLAN OF THAILAND

Sittichai Naksuksakul, Chanon Thaicharoen

PTT Research and Technology Institute, PTT Public Company Limited, THAILAND
e-mail: sittichai.n@pttplc.com and chanon.t@pttplc.com

Kriangsak Piralai,
Department of Groundwater Resources, Ministry of Natural Resources, THAILAND
e-mail: kpirarai@gmail.com

and

Sorawit Nuntjaruwong
Department of Alternative Energy and Energy Efficiency, Ministry of Energy, THAILAND
e-mail: sorawit@dede.go.th

ABSTRACT

Triggering by an incident of Fukushima nuclear power plant in 2011, the development of nuclear power plants have globally been delayed in many countries included Thailand. In response, the Thai government has updated the Alternative Energy Development Plan for 2012-2021 targeting 25% renewable energy of the total energy use in the country. Geothermal energy development has also been placed in the plan. The geothermal energy was known for more than 30 years as the operation of Fang power plant, in the northern Thailand, with capacity of 300 kWh since 1989, and still producing nowadays. Even though there were several exploration programs in other potential hot springs, mainly the geothermal energy in those areas were developed for agricultural and tourism purposes. In addition, most of the high-temperature hot springs are located in the National Park in which prohibit for further development. In 2010, Department of Alternative Energy and Energy Efficiency in cooperation with Department of Groundwater Resources and PTT Public Company Limited have established a program for geothermal energy exploration for potential assessment. The program will be started by mid of 2013.

This paper presents the overall situation of geothermal energy exploration and development in Thailand. The geothermal energy exploration in Thailand has been conducted for over thirty years. The explorations were mainly conducted for a shallow depth survey in North of Thailand. The geothermal sources in Thailand are categorized into low to medium enthalpy geothermal resources. The main phenomena indicating heat sources of geothermal energy in Thailand are presumed to be associated with granitic rock intrusion.

Recent studies indicate more complicated heat sources are encountered. The rejuvenated young plutons are possible heat source in spite of the prevailing older granitic rocks exposed in the areas. On the other hands, the lesson learned from Tertiary oil fields onshore Thailand illustrated the significant influence of young basalts intruded into the Tertiary basins and thermally increased the source rock maturity to oil window stage. The Tengchong region in Yunnan is famous geothermal area in China. The basement is Mesozoic granitic rocks overlaid by young basalts possibly originated from mantle. These two conceptual models of geothermal heat sources will be assessed within the upcoming geothermal exploration program.

INTRODUCTION

Up to the present, in Thailand, hot springs are known as a main natural source of geothermal energy that can be utilized for various ways depending on the availability of water energy. Consequently, the surveys regarding to geothermal energy in Thailand were mainly focused on the hot spring locations. However, there has been limited data and no detailed studies on hot springs in other parts of the country. In the past, it was believed that sources of geothermal energy in Thailand are mainly involved with granitic bodies.

According to the success of Tertiary oil fields onshore, in Suphan Buri basin, Thailand, the new conceptual model is about to believe that young basalts intruded into the Tertiary basins are sources of thermal to enhance the source rock maturity to oil window stage.

This paper is to present the overall situation of geothermal energy exploration and development in Thailand, which has been conducted for over thirty years, and to propose new conceptual model for geothermal sources in Thailand in order to develop geothermal energy to meet the national alternative energy development plan.

HISTORY OF GEOTHERMAL ACTIVITIES IN THAILAND

Although the geothermal energy exploration in Thailand has been conducted for over thirty years, the explorations were mainly conducted for a shallow depth survey in North of Thailand. The geothermal sources in Thailand are categorized into low to medium enthalpy geothermal resources. The main phenomena indicating heat sources of geothermal energy in Thailand are presumed to be associated with granitic rock intrusion. The following examples are the highlight geothermal activities in the past;

Fang Geothermal Power Plant

In 1990, Electricity Authority of Thailand (EGAT) in cooperation with French Environment and Energy Development Agency had agreed to study the potential of deep geothermal reservoir and its controlling structures in Fang area. Sixteen exploration well (FGTE series) and about 20 slim holes (BH series) were drilled and tested. The hot water flow rate varied from 20-30 l/s and temperature range 120-130 C. EGAT had decided to build the power plant as the demonstration project for Thailand. The power plant has capacity of 300 KW using binary cycle technology. It is to be noted that Fang reservoir is most likely associated with faults or faults sets which are laid down very steep dip (Korjedee, 2002) Therefore, It is high risk to encounter the faults by deep vertical drilling.

San Kamphang Geothermal System

EGAT and Japan International Cooperation Agency (JICA) conducted a technical collaboration for San Kamphang geothermal development in 1982. The details exploration through geochemistry, geophysics and drilling exploration were carried out during 1982-1988. Two deep wells of > 1200 m were drilled and found that one well is dry and other wells could produce water rate of 11 l/s at 125 C (Raminwong et al, 2000 and Korjedee, 2002). The estimate potential was unexpectedly high as 5 MW but the project had not been developed due to economic reasons. However, the San Kamphang hot spring is one of the famous tourism and recreational area in Thailand. In addition, the geothermal resource is also directly used for agricultural preservation at commercial scale.

The other geothermal areas that had been explored were Pai and Nong Haeng in Mae Hong Son Province, and Mae Chan in Chai Rai Province. Mostly the exploration program was at shallow level (about 200 m or less) by EGAT. Since then, the geothermal exploration program had been delayed due to its riskiness; high cost of exploration, low success rate, and high investment.

THAILAND RENEWABLE ENERGY POLICY

The energy demand in the country increases every year corresponding to the population and economic growth. Fossil fuels, informs of oil, natural gas and coal, accounts more than 90% of energy consumption. In addition, about 66% of power generation is from natural gas while only 7 and 2% from hydro and renewable energy, respectively. The situation is rather vulnerable in term of energy security due to the fluctuation of oil and gas prices. In early 2010, the Cabinet had approved the Power Development Plan 2010 that included 5 unit of nuclear power plant of total 5000 MW by 2030 and expected the first plant t be operated in 2020. As an incident of Fukushima nuclear power plant in 2011, the cabinet has decided to reduce and delay the development plan of nuclear power plant (PDP 2010 revision 3), and promoted the renewable energy and clean coal development instead.

Ministry of Energy has established Alternative Energy Development Plan 2012-2021 (AEDP 2012-2021) by targeting the renewable and alternative energy development for 25 percent of total energy consumption through the following strategic directions;

1. Promoting the community to collaborate in broaden producing and consuming renewable energy.
2. Adjusting the incentive measure on investment from private sector appropriated with the situation.
3. Amending the laws and regulations which do not benefit to renewable energy development.
4. Improving the infrastructure as system of transmission line, power distribution line, including a development towards Smart Grid System
5. Public relations and building up comprehensive knowledge for the people.

6. Promoting the research work as mechanism to develop the integrated renewable energy industry.

By 2021, the power generation from renewable energy is 9,201 MW comprised of wind, solar, hydropower, biogas, biomas, municipal solid waste (MSW) and new energy as seen in Table 1. The new energy comprised of geothermal and tidal wave has been introduced for the first time in the country expecting capacity of 1 and 2 MW, respectively by 2021.

Table 1: Target Renewable Energy on Power Generation by 2021

Energy Resource	Power Generation (GWh)	Installing Capacity (MW)
1. Wind	1,283	1,200
2. Solar	2,484	2,000
3. Hydropower	5,604	1,608
4. Biomass	14,008	3,630
5. Biogas	1,050	600
6. MSW	518	160
7. New Energy	10	3 (Geothermal: 1 MW) (Tidal Wave: 2 MW)
Total	**24, 956 GWh**	**9,201 MW**

Note: MSW stands for Municipal Solid Waste

RECENT EFFORT FOR GEOTHERMAL DEVELOPMENT IN THAILAND

In 2011, Department of Alternative Energy and Energy Efficiency (DEDE), Department of Groundwater Resources (DGR) and PTT Public Company Limited (PTT), have signed a memorandum of understanding (MOU) on geothermal energy development in Thailand. The ultimate goal is to develop the pilot model of geothermal energy in Thailand as part of the AEDP 2012-2021. This indicated the willingness of the government to move toward the physical obstacles of this resource. The working group comprised of representatives from these organizations has been formed to plan and implement the project.

The project is divided in to 2 phases; exploration and resource appraisal, and well development. The power plant planning will be considered at the latter phase. Initially, the scopes of project will be

i) to review the hot springs in Thailand with specific focus on the northern part.
ii) to select few hot spring sites with high potential for further exploration
iii) to perform geology, geochemistry, and geophysics surveys which included resistivity, seismic, and magnetotelluric serveys etc., and
iv) to interpret and target the reservoir

The second phase of work will be comprised of flow test analysis, reservoir modeling and well development in which expected to complete by 2016.

In parallel, the working group also has responsible for addressing the other related issues;

- Laws and regulations for geothermal energy development
- Collaboration and partnership with key
- Community and public relations
- Capacity building at different levels; national, provincial, and local level.

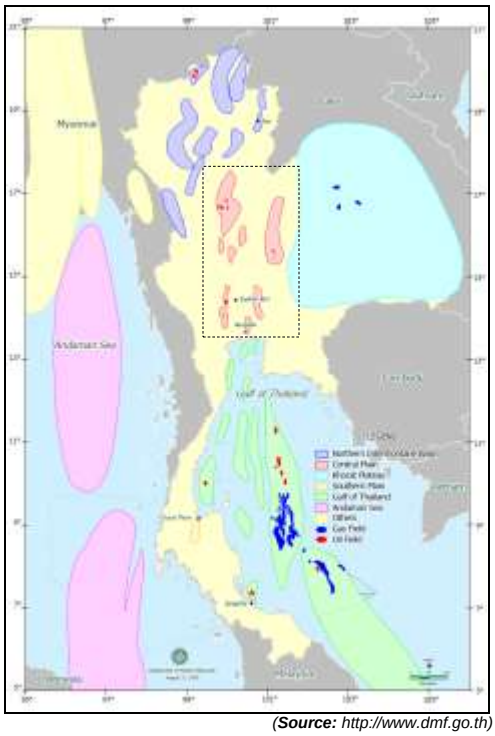
CONCEPTUAL MODEL DEVELOPMENT

Petroleum provinces in Thailand are geographically categorized into six regions, the Northern Thailand, the Central Plain, the Northeastern Thailand, Southern Thailand, the Gulf of Thailand and the Andaman Sea. Petroliferous basins are mostly Tertiary in age.

The Central Plain consists of a number of north-south trending half grabens formed by conjugate transtensional shear during early Tertiary age. Oil fields have been discovered in the Phitsanulok, Suphan Buri, Kamphaeng Saen and Petchabun basins. Hydrocarbons are mainly produced from Oligocene-Miocene fluvio-lacustrine sandstone. However, a significant amount of oil produced from fractured and weathered granites of pre-Tertiary rocks are continually increasing (Figure 1)

The Suphan Buri basin (Figure 2) is located between two parallel NW-SE trending strike-slip faults, the Mae Ping Fault zone in the northeast and the Three Pagodas Fault zone in southwest.

The sandstone in the eastern Suphan Buri basins were derived from a predominantly metamorphic source, while the sandstone in the western basins had a predominantly igneous source, with sediments deposited on the hanging wall of the basin derived from a metamorphic source. The sedimentary fill of this basin is non-marine; the eastern basins contain a predominantly alluvial/fluvial fill, whereas the western basins contain sediment deposited in alluvial, fluvial, deltaic and lacustrine environments. In summary, the Suphan-Buri basin is Tertiary half grabens of approximately 800 sq. km with over 3 km thick of sediments (Pradidtarn et al).



(**Source:** *http://www.dmf.go.th*)

Figure 1: Sedimentary basins in Thailand

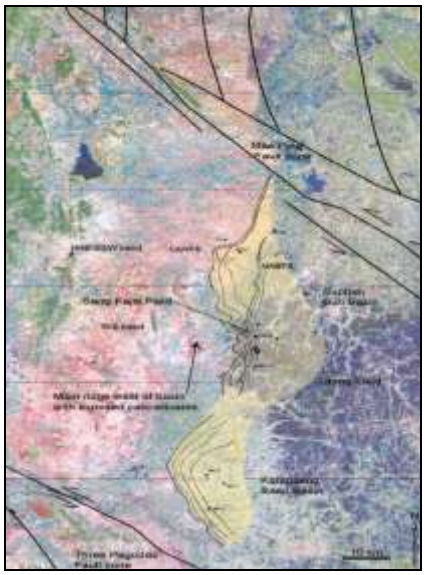
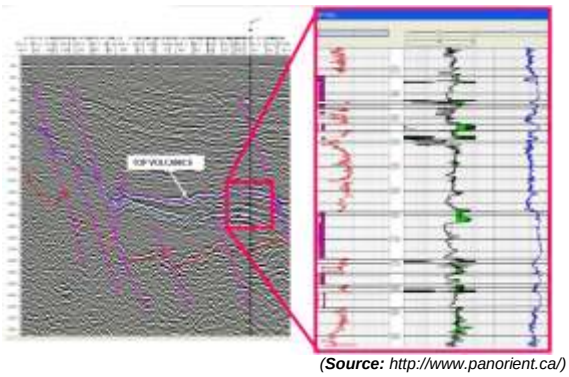


Figure 2: Suphan Buri basin

Recent studies indicate that more complicated heat sources are encountered. The rejuvenated young plutons are possible heat source in spite of the prevailing older granitic rocks exposed in the areas. On the other hands, the lesson learned from Tertiary oil fields onshore, in Suphan Buri basin, Thailand illustrated the significant influence of young basalts intruded into the Tertiary basins and thermally increased the source rock maturity to oil window stage as shown in Figure 3.



(**Source:** *http://www.panorient.ca/)*

Figure 3: Petroleum reservoir, the influence of young basalts

Y. Panjasawatwong (1983) studied the single basalt flow in the Northern Thailand. The origin of the basaltic lavas is attributed to partial melting of the pyrolite-mantle wedge. In Thailand, basalts are normally found, starting from Central to Northern Thailand (Figure 4).

The Tengchong region in Yunnan is famous geothermal area in China and is a volcanic area consisting of basalt, andesite and dacite. The basement is Mesozoic granitic rocks overlaid by young basalts possibly originated from mantle (Z. Zhifei, L. Shibin and Z. Fengsan, 1987). The basalt found in Tengchong area is also the same trend with the basalt found in Northern Thailand.

RISK ASSOCIATED AND WAYS FORWARD

According to the world energy crisis, alternative energy, including geothermal energy, plays more important role for sustainability of Thailand energy consumption. Geothermal energy is set into 10-year national alternative energy development plan (2012-2021). To develop geothermal energy in Thailand, it involves with many factors and falls into risky. Risks, associated geothermal energy development, include technical risk, financial risk, and legal and regulatory risk.

To mitigate the risk, it requires corroborating with world leading experts in geothermal exploration, carefully conducting and monitoring feasibility study, and setting up the first laws and regulatory structure for geothermal energy development in Thailand.

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(**Source:** *http://www.dmr.go.th*)

Figure 4: Geological Map of Thailand, showing the basalts