

THE GEOTHERMAL RESOURCES OF CHANGWAT RANONG SOUTHERN THAILAND

Saman Chaturongkawanich and Santi Leevongchareon
Geological Survey Division, Department of Mineral Resources, Rama 6 Road, Bangkok 10400, Thailand

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ABSTRACT

Four geothermal resources in Changwat Ranong, an important province along the west coast of southern Thailand, have been investigated. They are: Wat Thapotharam Hot Spring Area (RN₁) , Ban Thung Yo Hot Spring Area (RN₂) , Ban Porn Rang Hot Spring Area (RN₃) and Khlong Bang Rin Hot Spring Area (RN₄)

Stratigraphically , the oldest rock unit is composed of pebbly sandstone, greywacke, arkose, siltstone, mudstone, conglomeratic sandstone of Carboniferous-Permian age, and locally gneiss, schist, quartzite and hornfels. Quaternary alluvial deposit of gravel, sand, silt and clay and the recent nearshore sediment deposits of sandy clay and clay, are distributed on the western part of the study area. The batholith of granitic rocks in Cretaceous age are of 2 types: porphyritic, two-mica, tourmaline, granite and leucocratic granite. Andesitic dykes extruded along the fracture planes in granitic rocks. The faults and joints are observed in NW-SE, E-W and N-S directions. which are the main conduits for hot water transmission from deep - seated reservoir to the surface.

All four hot springs are associated with Cretaceous granite. The natural surface manifestation are seepages and hot pools. The hot water is clear, pH 8.3-8.4, some CO₂ bubbles, very little H₂S , minor algae and alteration mineral of calcite. The general chemical constituents are as follows : TDS 320-330, Na 46.1-48.4, K 2.8-3.2, Ca 41.3-44.8, Mg 0.01-0.03, Fe 0, Mn 0-0.01, HCO₃ 182-219, F 5.2-7.5, SO₄ 19.3-45.3, Cl 4.8-11.0, SiO₂ 72.0-81.3 mg/l . The subsurface temperature calculated by SiO₂ geothermometer is about 120°-126° C. The high potential hot spring area is Wat Thapotharam, due to its high flow rate (about 600 m³/day) and high surface temperature (65° C).

1. INTRODUCTION

History of hot springs distribution in Thailand has been first recorded by Brown and Buravas (1939) . They described about 27 hot springs resources in Thailand, most of them appeared between longitude 98° – 100° E. There are 11 hot springs in northern part, 6 in central part, 1 in eastern part, and 9 in southern part. One of the most famous hot springs in southern Thailand is Changwat Ranong which is composed of 3 natural hot pools with the maximum surface discharge of 68° C.

Changwat Ranong is located about 570 km south of Bangkok. The morphology of the study area can be divided into 5 categories : **the eastern high mountain range** with the highest peak of 630 m above MSL, **the north and south mountain** with the highest altitude of 400 m above MSL, **scattering hills** with the altitude about 40 m above MSL, **the central colluvium and terrace, the western alluvium and coastal plain**. There are several streams, e.g. Khlong Dan, Khlong Haad Som Paen, Khlong Ranong, Khlong Ko Kam, Khlong Bang Rin, Khlong Porn Rang , Khlong Hin Lao, and Khlong Ngao etc., which flow approximately from the east to the west

direction and then drain through the Andaman Sea. Most of the streams are subparallel drainage pattern which is dominantly fault controlled Only few streams show sub - dendritic drainage pattern. All four hot springs in Changwat Ranong occur along the banks of these streams as hot pools or seeps.

The average rainfall is 4,183.7 mm per year and the mean maximum rainfall is 808.5 mm per month in August (data during 1961-1990, taken from Ranong station, Meteorological Department, Ministry of Communication, Bangkok). So Changwat Ranong has one of the greatest infiltration rate in Thailand.

2. GEOLOGICAL SETTING

The geological map of Changwat Ranong (original 1:25,000 scale) covering four hot springs (about 200 km²) (Figure 1.), displays the distribution of sedimentary and metamorphic rock of Carboniferous-Permian age, various types of granitic emplacements in Cretaceous age, and the Quaternary deposits of clay, silt, sand and gravel.

2.1 The Carboniferous-Permian rock

This rock formation is exposed mainly in the western part of the study area. It covered the morphology of **The north and south mountain and scattering hills**, which is approximately one-fifth of the study area. It can be lithologically subdivided into two units,: the Sedimentary rock unit and the Metamorphic rock unit. **The Sedimentary rock unit** is composed of graywacke to pebbly sandstone, siltstone, claystone, arkosic sandstone and conglomeratic sandstone. The depositional environmental of the unit is turbidity flow. **The Metamorphic rock unit** is composed of gneiss, schist, quartzite and hornfels.

2.2 The Quaternary deposit

The formation is distributed in the central plane and western coastal plain. It can be subdivided into two units: Alluvial deposits and Nearshore-sediment deposits. **Alluvial deposits** are composed of residual sediments of gravel, sand, silt and clay, including colluvium. **Nearshore – sediment deposits** are mainly composed of sandy-clay and clay with some remnants of peat.

2.3 Igneous rocks

These are dominantly Cretaceous granitic rocks and were formed as a batholith in **the eastern high mountain range**. Minor extrusive rocks of andesite and tuff are also found along the fault and fracture planes.

The granitic rocks play an important role as the host rock of the Ranong geothermal resources, and can be subdivided into 5 categories (Kosuvan and Nakapadungrat, 1991).

Khlong Ban Rin granite (Kgr-br) It is mainly porphyritic biotite-muscovite granite, with maximum phenocryst size of 2 - 5 cm.

Khlong Ngao granite (Kgr-ng) It is porphyritic biotite granite. Phenocrysts from 10 % of mass vary in size from 2-8 cm. The accessory minerals are iron oxide and little tin.

Khao Sam Laem granite (Kgr-sm) It is mainly equigranular, fine grained granite, showing foliations in N-S and NE – SW directions. The accessory minerals are chlorite and iron oxide.

Thung Ka granite (Kgr-th) It is predominantly tourmaline muscovite granite showing equigranular texture.

Leucocratic granite (Kgr-l) It is intruded as small stocks along the Ban Rin stream.. The rock is white, fine to medium-grained, granular and hypidiomorphic texture. . The accessory mineral is garnet.

Radiometric age dating of these granitic rocks by several workers revealed the age between 66 to 122 my. e.g. the radiometric age of coarse – grained porphyritic adamellite reported by Burton and Bignell (1969) is 111 ± 6 Ma for a whole rock Rb-Sr age and 73 ± 3 Ma for a K-Ar of muscovite; another radiometric age of coarse-grained porphyritic biotite granite reported by Bignell (1972) is 122 Ma for a whole rock Rb-Sr age and 63.3 ± 2 Ma for a K-Ar of biotite.

A green andesite, extruded along the fracture plane of granitic terrain, is about 60 cm wide. It is porphyritic, has intergranular texture, and is fine to medium-grained. The essential minerals are feldspar (plagioclase, sanidine) chlorite. The accessory minerals are sericite, iron oxide. The green tuff is fine to medium-grained, and partly shows foliation. The essential minerals are quartz, feldspar, hornblende and rock fragments. The groundmass is composed of chlorite, sericite, volcanic glass and iron oxide. These extrusive rocks are found near the hot spring vicinities and seem likely to be Cretaceous age.

Structurally, the attitudes of bedding and foliation of sedimentary rocks and metamorphic rocks in the study area, generally lie in a northeast-southwest direction, and dip to the northwest and southeast directions. The major Ranong Fault Zones which lie in the northeast-southwest trending along the Andaman coast with maximum length of 300 km, while the conjugate fault lies in the northwest-southeast direction. Several hundred poles of joints or fractures, measured in the vicinity of the hot springs have been plotted on the Lambert Equal-area Projection and also on the Rose Diagram, reveal four directions : the northeast-southwest direction, the northwest-southeast direction; the north-south direction, and the east - west direction. (Chaturongkawanich and Leevongchareon, 1997)

3. GEOTHERMAL RESOURCES

The Wat Thapotharam Hot Spring Area (RN 1) ; the Ban Porn Rang Hot Spring Area (RN 3) and the Khlong Bang Rin Hot Spring Area (RN 4), are associated with Khlong Bang Rin Granite (Kgr-br). The Ban Thung Yo Hot Spring Area (RN 2) is associated with Khlong Ngao Granite (Kgr-ng)

3.1 Wat Thapotharam Hot Spring Area (RN 1) occurs at the bank of Khlong Haad Som Paen with elevation of 50 m above MSL. At present, there are three artificial concrete hot pools and some natural small hot pools and seepages. These three artificial concrete hot pools are circular shape, pool-head size

of 1.5, 2 and 2.8 m in diameter, average height of 1 m from the ground surface. The general surface discharge features are clear water, little CO_2 , little steam. There is no algae or H_2S smell. The surface temperature is 65°C . The alteration mineral of cryptocrystalline calcite is present, and the approximately flow rate is about 600 m^3 per day. The chemical characteristic of hot water shows rather low chemical constituents, slightly alkaline (pH of 8.4). The subsurface temperature calculated from $T \text{ SiO}_2$ (no steam loss) and $T \text{ SiO}_2$ (maximum steam loss), is between 122° to 126° C (Table 1.)

The significant structures that control the RN1 system are the intersection of the almost east-west trending fault along Khlong Haad Som Paen and the almost north-south trending fault.

3.2 Ban Thung Yo Hot Spring Area (RN2) appears in the colluvium, with altitude of 15 m above MSL, and also near an abandoned tin mine. At present, the RN2 discharges into an octahedral artificial concrete pool, each side of this octahedral pool is 2 m. long, and about 0.8 m high above ground surface. The surface discharge is warm clear water (about 40°C), with little CO_2 . No H_2S smell, algae, and alteration minerals. The hot water is slightly alkaline (pH of 8.3). The subsurface temperature is about 121° C (Table 1.). Faults and fractures controlling the RN2 system strike northwest-southeast and north-south .

3.3 Ban Porn Rang Hot Spring Area (RN3) is exposed in a small valley near Khlong Porn Rang, with elevation about 60 m above MSL. The surface manifestation covers an area of $30 \times 80 \text{ m}$. At present, the RN3 discharges as natural hot pools and seepages, two artificial circle-shaped concrete pools with the approximate diameter of 1.5 m and an artificial oval - shaped concrete pool with the pool-head size $4 \times 6 \text{ m}$. All these three pools are about 1.2 m high above ground surface. The surface discharge is clear hot water (average temperature of 55°C), little steam, little CO_2 , no H_2S smell, little yellow algae, low flow rate. (less than 1 l/sec in each pool) The chemical characteristic of hot water shows rather low chemical constituents, slightly alkaline with pH of 8.4. The subsurface temperature is about 120° C (Table 1.) Faults and fractures controlling the RN3 system strike northwest-southeast and almost north-south directions similar to the RN2 system.

3.4 Khlong Bang Rin Hot Spring Area (RN4) are predominantly exposed in Khlong Ban Rin as hot pools and seepages. The hot water seeps from several fractures which are a few centimeters to one meter deep beneath the stream water level. The surface discharge features are clear hot water with the approximate temperature of 50°C , little CO_2 , no H_2S smell, no algae. No hot water samples have been collected.

CONCLUSION

1. Hot spring systems in Changwat Ranong are associated with Khlong Bang Rin Granite and Khlong Ngao Granite of Cretaceous age.
2. All hot springs are fault controlled and likely to be formed as fractured shallow reservoir.
3. Heat sources of these thermal systems may be the anomalously high heat flow from high heat generating capacity of granite or radiogenic heat from granitic rock. There is no direct measurement of heat flow in the granites of this area. But the heat flow data measured from oil borehole in the gulf of Thailand indicated 1.5-2 HFU. (Raksaskulwong and Thienprasit, 1995).
4. The chemistry of the hot waters are quite similar and they contain low total dissolved solids.
5. Low Na and Cl contents confirm no invasion of sea water from the Andaman Sea. The hot water in all the springs may come

from the same reservoir, be slightly diluted and possibly come from meteoric water (Gigenbach, 1977) 6. The subsurface temperatures calculated by SiO_2 geothermometer fall within the range of 117°-126° C while the surface temperatures are between 40°-65° C 7. The surface discharges are clear hot water, slightly alkaline, little CO_2 , no H_2S smell, some algae appearances. 8. The major faults and fractures controlling the hot spring system trend NW-SE, E-W and N-S. 9. The hot spring area with the greatest potential for usage is the RN1 due to its high flow rate (600 m³/day) and greatest outflow temperature (65° C). Nowaday, the RN1 is not only one of the most famous sight-seeing place in Changwat Ranong, but also the only hot water supplier to the nearby hotels of Changwat Ranong. The oldest hotel, Jansom Thara which is about 800 m west of the RN1, has used the hot water from the RN1 via pipeline for hot spa for decades. The provincial develop plans are to promote the RN1 for tourist visiting place and to pipe hot water to storage tanks before supplying to local communities. west of the RN1, has used the hot water from the RN1 via pipeline for hot spa for decades. The provincial develop plans are to promote the RN1 for tourist visiting place and to pipe hot water to storage tanks before supplying to local communities.

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Table 1. Chemical analyses of water from thermal spring in Changwat Ranong, constituents in mg/l, TDS = Total dissolved solids T(°C) geothermometer refer to the equation from Fournier (1981). Q1 = quatz no steam loss, Q2 = quartz maximum steam loss.

| | RN1 | RN2 | RN3 |
|----------------|------|------|------|
| SurfaceT (° C) | 65 | 40 | 55 |
| pH | 8.3 | 8.3 | 8.4 |
| TDS | 330 | 330 | 330 |
| Na | 48.4 | 46.4 | 46.9 |
| K | 2.8 | 3.2 | 3.0 |
| Ca | 44.1 | 44.1 | 44.3 |
| Mg | 0.02 | 0.03 | 0.01 |
| Fe | 0.0 | 0.0 | 0.0 |
| Mn | 0.1 | 0.0 | 0.0 |
| HCO_3 | 182 | 189 | 190 |
| F | 7.0 | 5.4 | 5.4 |
| SO_4 | 19.3 | 44.9 | 44.9 |
| Cl | 4.8 | 11 | 10 |
| SiO_2 | 79.3 | 75.5 | 72.0 |
| T (° C)Q1 | 126 | 121 | 119 |
| T (°C)Q2 | 122 | 119 | 117 |

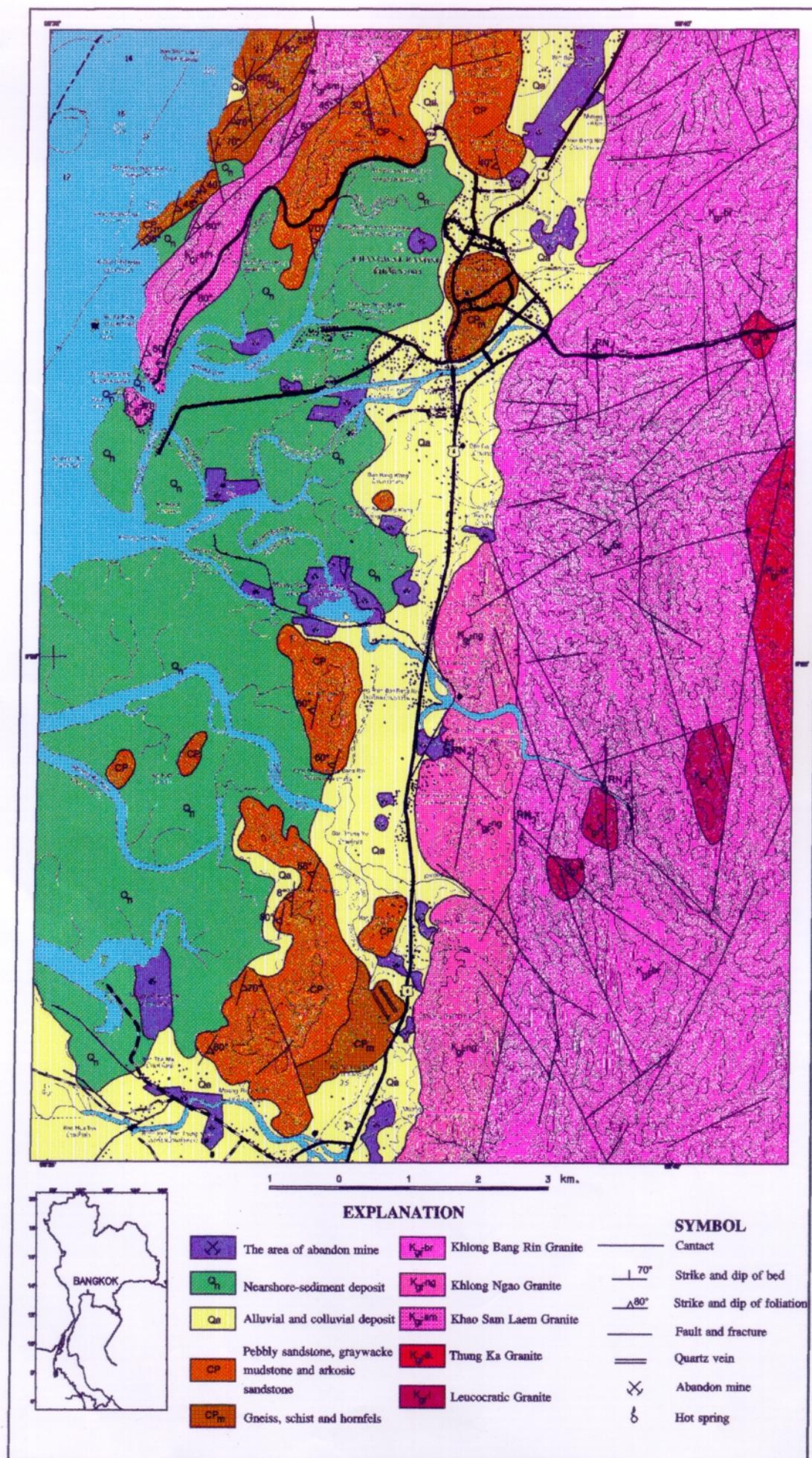


Figure 1. Geological map of Changwat Ranong