# Potential of Geothermal Energy Resource from Heat Production in Thung Nui Hot Spring Rocks Area, Satun Province Southern of Thailand

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**Abstract**. Heat production from the radioactivity of $^{238}$U $^{232}$Th and $^{40}$K of rocks in Thung Nui hot spring, Satun Province Southern of Thailand were study. The results of this research were possible used to development of hot spring for ability electricity generate geothermal resource and renewable energy in this community. The rocks sampling were collected outcrops nearly hot reservoir area. After sample grinded the radioactivity value of $^{226}$Ra $^{232}$Th and $^{40}$K were measured by gamma spectrometer. It was found that the radioactivity value of $^{226}$Ra $^{232}$Th and $^{40}$K in granite Triassic age and limestone Ordovician age rocks were 8.9 ppm 33.1 ppm and 5.1 % and 1.1 ppm 5.7 ppm and 1.3 %, respectively. In addition, Heat Energy from Radioactive Isotope content; of $^{238}$U $^{232}$Th and $^{40}$K, in granite and limestone around Thung Nui Hot spring was 4.95 μW/m$^3$ and 0.78 μW/m$^3$, respectively. This radioactivity heat production of rocks, discovered within the hot spring of Satun Province, can be developed as the renewable energy for the local use.

## 1. Introduction

Preliminary geothermal study revealed that there were high possibilities to utilized geothermal for electricity in northern Thailand while low potential in southern Thailand where main reservoir temperature ranges between 73 - 136°C [1].

Geophysical exploration of geothermal resources deals with measurements on the physical properties of the earth. The emphasis is mainly on parameters that are sensitive to temperature and fluid content of the rocks, or on parameters that may reveal structures that influence the properties of the geothermal system. The aim can be to delineate a geothermal resources; or assess the general properties of the geothermal system [2].

In geophysical studies, heat production in rocks is a key parameter for geothermal modeling [3]. Importantly, due to radioactive decay, heat production decreases with age, and in a difference way for difference rock types, because the major radioactive isotopes in crustal rocks, U, Th and K, have different concentrations, different decay constants and different abundances. For example, the relative contribution of $^{232}$Th to heat production increases with time because this element has the longest halflife of the three isotopes, while the contribution of $^{238}$U was dominant largely on early Earth and has been fast decreasing during planetary evolution. And isotropic abundances are also highly variable. Radioactive $^{40}$K makes only a tiny fraction of potassium isotopes [3].

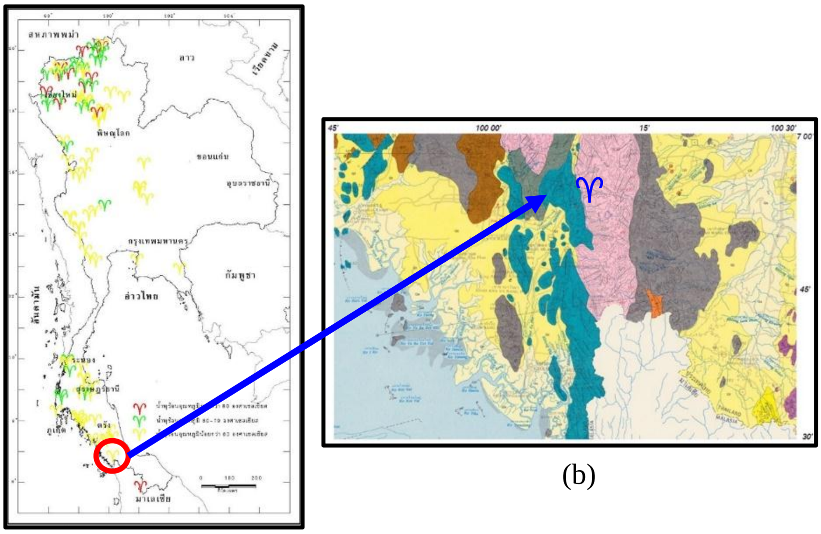
The purpose of this study is to determine heat production in Thung Nui hot spring rocks (Satun Province, southern of Thailand) on concentrations of heat producing radioactive elements (U, Th and K). Heat production studied to assess its energy source have possibility into development this for utilize electricity or renewable energy in this community.

## 2. Geology Setting

Thung Nui hot spring at latitude 6.84° N and longitude 100.16° E, geology of study area its allow from DMR geology map [4].

Limestone, gray to grayish-black, pink, recrytalline, massive to thin-bedded; argillaceous limestone and shale interbedded at the lower part, with abundant cephalopod and brachiopods in Ordovician age.

Biotite-muscovite granite, aplite, and pegmatite, graphic in Triassic age.



(a) (b)

**Figure 1.** (a) Local of hot spring in Thailand and (b) Geology in study area

## 3. Methodology

### *3.1. Radioactivities measurement*

First, start with cracking the rock samples into fine grain, Furthermore, use 2 mm grille to sieve fine rock samples, and put into plastic bowl with dimension 6.5 cm x 7.5 cm. After that, remove the sealing tape between the cover and the bowl with plastic gear attached firmly to protect the radioactive nuclides of rock samples relieved in the gas state.

Set the rock samples in the plastic bowl for 30 days waiting for radioactivity equilibrium, and take all rock samples out of plastic bowl to measure the specific activities of 238U, 232Th, and 40K by using a high-purity germanium (HPGe) detector and gamma spectrometry where the measurement period is 10,800 second.

### *3.2. Heat production*

Heat production values, A, are determined from known (measured) concentrations of U, Th and K ($C_U$, $C_{Th}$ and $C_K$) [3] based on the relationship originally proposed by Birch (1954) and slightly modified later [5].

$$A(\mu W/m^3) = \rho(0.0952C_U + 0.0256\, C_{Th} + 0.0348\, C_K) \quad (1)$$

Where ρ is density of rocks in $g/cm^3$, and $C_U$, $C_{Th}$ and $C_K$ are concentrations of radioactive isotopes in ppm, ppm and %, respectively.

## 4. Results

**Table 1**. Radioactivities of granite and limestone rocks.

| **Rock/Age.** | **radioactivities (Bq/kg)** | | |
|---|---|---|---|
| | **$^{226}$Ra** | **$^{232}$Th** | **$^{40}$K** |
| granite Triassic age | 109.93 ± 17.2 | 134.23 ± 9.5 | 1569.27 ± 75.7 |
| limestone Ordovician age | 13.77 ± 6.4 | 23.25 ± 7.7 | 394.12 ± 117.8 |

In table 1 show radioactivities of $^{226}$Ra, $^{232}$Th, and $^{40}$K and to calculated be concentrations of $^{238}$U, $^{232}$Th, and $^{40}$K by below equation [5].

$$C_U = 0.080947 \times A_{Ra} \quad (2)$$
$$C_{Th} = 0.246338 \times A_{Th} \quad (3)$$
$$C_K = 0.003224 \times A_K \quad (4)$$

When $C_U$ = concentration of uranium in ppm unit
$C_{Th}$ = concentration of thorium in ppm unit
$C_K$ = concentration of potassium in %
$A_U$ = radioactivity of uranium in Bq/Kg unit
$A_{Th}$ = radioactivity of thorium in Bq/Kg unit
$A_K$ = radioactivity of potassium in Bq/Kg unit

There for concentrations from radioactivities of $^{238}$U, $^{232}$Th, and $^{40}$K of Thung Nui hot spring rocks in table 2.

**Table 2**. Concentrations $^{238}$U, $^{232}$Th, and $^{40}$K in parts per million and % of Thung Nui hot spring rocks.

| **Rock/Age.** | **Concentrations** | | |
|---|---|---|---|
| | **$^{238}$U (ppm)** | **$^{232}$Th (ppm)** | **$^{40}$K (%)** |
| granite Triassic age | 8.9±1.4 | 33.1±2.3 | 5.1±0.2 |
| limestone Ordovician age | 1.1± 0.5 | 5.7± 2.2 | 1.3± 0.5 |

**Table 3**. Heat production in southern of Thailand hot spring area.

| **Hot spring** | **Rock and Age.** | **Heat production ($\mu W/m^3$)** | **Reference** |
|---|---|---|---|
| Ranong hot spring | Granite Cretaceous age. | 3.21 | [6] |
| Khao Chai Son, Phattalung Province | Limestone Permian age. | 1.12 | [7] |

| | | | |
|---|---|---|---|
| Thung Nui, Satun Province | Granite Triassic age. | 4.95 | This research |
| | Limestone Ordovician age. | 0.78 | |

## 5. Discussion

The results of heat production of rocks in study area were similar to those of other researchers. Heat production of rocks in study area are both Limestone Mountains and nearby granite mountains. This corresponds to nature of hot springs in Thailand where the geologist has divided the nature of hot springs in two types [7] and [8], the first hot springs associated with granite for example Sankampaeng Chiangmai Province hot spring and Ranong hot spring in Ranong Province. And second hot springs made of other rocks covered on granite, found in some provinces Southern of Thailand for example Chaiya District Suratthani Province and Khao Chaison District Phattalung Province. Therefor Thung Nui hot spring can be both because heat sources may come from nearby granite and tranfers hot water along fractures or small faults, they accumulate in areas where the limestone cover. This causes the heat production of limestone to be lowest and the high heat production generated by granite may be due to the small amount of granite outcrops, which may be unclear. It is important that the heat production of each source of hot springs is difference, which may be related to active fault. Which heat source of Thung Nui hot spring may be just some fracture or small faults. Unlike Sankampaeng hot spring which have active faults such as Mae Chan fault and Mae Tha fault pass through and Ranong and Suratthani hot spring it have Ranong fault and Khlong Marui fault pass through there [7] and [8]. It is, therefore, possible to develop hot springs to find alternative sources of geothermal energy in the future.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