ASSESSMENTS GEOTHERMAL POTENTIAL OF BANG AREA
QUANG BINH PROVINCE

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ABSTRACT

The Bang geothermal area is located at Bang commune, Le Thuy district, Quang Binh province. There are 3 main zones of hot springs and seepages along Bang stream. Geological and geochemical surveys of the area were performed. The geothermometry results indicate that the Bang geothermal resource is medium enthalpy and most promising geothermal sites in Vietnam.

Keywords: Bang geothermal area, hot springs, geothermal resources; thermal waters; geochemistry; isotopes, Vietnam.

1. INTRODUCTION

Bang (also known as Lo Voi) is said to be the most important thermal site in Vietnam. The area is said to include numerous thermal springs at about 200 m elevation amongst hills west of the coastal plain. Boiling conditions are present at several springs, and the spring area is surrounded by travertine (calcium carbonate) deposits and traces of sulfur deposition. Flow rate is about 40l/s or more. A temperature of 100\degree C was measured either at the surface or at 10-14 m depth in the single well. The surface thermal area has been described as 0.25 km\textsuperscript{2} (ORMAT Vietnam, 1998), and it is likely that the thermal anomaly is at least twice that size.

There are 3 main zones of hot springs and seepages along Bang stream. The aim of survey is to determine the longitude and latitude of three zones of hot springs and seepages, to determine location of hot springs, positions of T -measurement site at central hot pool and well, and the construct a sketch map of surveyed area.

- The A zone occurs in a small, perched valley and is the most intense of all the surface activity sites, with steaming hot springs which form large (1 to 2 m diameter) travertine mounds and shallow pools. Thermal springs occur in and adjacent to a small east trending stream and immediately north of an outcrop of Neogene basalt, which may be the basement and source of heat at depth. A small diameter flowing artesian well has a reported temperature of 105\degree C at a depth of 55 m.
- The zone B is located upstream, approximately 700m northwest of zone A. At zone B, 17 seepages occur in the bottom of the stream.
- The C zone is located in the south bank downstream, approximately 1 km southeast of zone A, with three steaming hot springs which discharge from large (1 to 2 m diameter) mounds and a shallow small pool.

2. PURPOSE AND METHODOLOGY

Bang geothermal resource assessment in this paper is base on the compilation of exiting information and site survey conducted by Electricity of Vietnam (EVN), and VIGMR that can be used to provide initial estimates of the size and temperatures of the subsurface reservoir. The compilation should include the collection of geological map and reports that describe rock types, structure and the surface thermal manifestations (hot spring and seepages), geochemical and isotopic composition of the thermal fluid, geological data such as seismic survey data.

Flow measurements

Two techniques of flow measurements were used in Bang geothermal area: Stream gauging method and V-notch method. Stream gauging method is used to measure the flow rate of the Bang stream. It is set up at downstream and upstream of seepage zone B. The mass flow rate of Bang upstream is 1.615 m\textsuperscript{3}/s (1615 kg/s) and down stream is 1.653 m\textsuperscript{3}/s (1653 kg/s).

To estimate the recoverable heat energy reserves in the promissing sites, we have applied a calculation technique usually used in early exploration stage. This method is "Deterministic Method".
3 GEOLOGIC SETTING

2.1. Sedimentary rocks: Upper Ordovic - Lower Sillur. Longdai formation (O3-S1ld)
The sedimentary rocks are composed of clay stone, sandstone and siltstone, which alternate each other. Each layer of sandstone has a thickness of 3-4 cm. This formation has a thickness of 800 to 1000m and average permeability.

2.2. Neogene (N): The Neogene basalt rocks are distributed at northwest, approximately 6 km north of Bang area, which may be the basement And source of heat at depth. The basal rock has grey colour, high density.

2.3. Quaternary (Q): The Quaternary sedimentary rocks are distributed mostly along both sides of Kien Giang stream. The Quaternary sediments are divided into the following units:
   a) Elluvial sediments (elQ1): The elluvial sediment is distributed at the north area on hill slope. It consists of basalt and sandstone pebbles (1-5 cm).
   b) Alluvial sediments (aQ2): The alluvia consist of granite and sandstone pebble (2-4 cm), and sediments of sand.

![Geologic Map of Bang Geothermal Area](image)

3. GEOLOGIC STRUCTURE:

At Bang area there are two sets of deep faults, which trend north and northwest.
Kien Giang fault (F1): This fault trends in north - south direction along the Kien Giang River. The fault created a brecciate zone of 40 m wide.
Bang fault (F2): This fault trends in northwest - southeast direction and created a brecciate zone of 20 m wide.
At Bang area there are also some small shallow faults trending northeast - southwest.
Base on geological setting and structure, there are subsistence of magma tic and young tectonic activities. This is a favorable condition for the development of geothermal system.
4. GEOTHERMAL MANIFESTATION

Silica sinter (or Travertine) makes a small mound (1-1.5m diameter). Hot springs flow out accompanying the H$_2$S gas smell. The flowing temperature of geothermal up flow is 98.3-100°C, pH is neutral, and the water type is Na-HCO$_3$ type. Reservoir temperature can be estimated by using chemical equilibrium between water and various minerals. The basaltic rocks of Pleistocene - Pliocene are distributed near the Bang site. Heat source of geothermal manifestations at the Bang site could be supposed to be magmatic. Although geothermometry might not indicate a proper reservoir temperature at the Bang site, the deep reservoir temperature might be 150°C from our experiences.

Stable isotopic composition of Bang thermal waters, characterized by $\delta^D = -50$ and $\delta^{18}O = -7.5$ mean values, lie on or close to the world meteoric water line. The oxygen and deuterium isotopic chart showing all thermal waters listed lies on close to the SMOW line.

5. PRELIMINARY CAPACITY ESTIMATION

1. Basic Deterministic Method

The principle of the stored heat method is to estimate the heat stored within the defined reservoir volume, both in the rock and fluid and above some base temperature which must be stated. The stored heat includes both the heat stored in the rock and the heat stored in the reservoir fluid. The reservoir volume is usually taken as the area extent multiplied by the drilled depth plus some additional storage volume, assumed to exist below the drilled depth, commonly another 500 m. The equation used to calculate the stored heat is as follows:

$$Q = A.h \left\{ \left[ C_r \rho_r (1-\phi)(T_i - T_f) \right] + \left[ \rho_{wi} S_w (h_{wi} - h_{wf}) \right] \right\}$$

Where: $Q = \text{stored heat, kJ}$

$A = \text{area extent of the reservoir, m}^2$

$h = \text{average reservoir thickness, m}$

$C_r = \text{specific heat of the rock at reservoir conditions, kJ/kgK}$

$T_i = \text{initial average reservoir temperature, °C}$

$T_f = \text{base temperature, °C}$

$S_w = \text{water saturation}$

$h_{wi}, h_{wf} = \text{water enthalpy at base temperature, kJ/kg}$

$\rho_r, \rho_{wi} = \text{rock and water density at reservoir temperature, kg/m}^3$.

In order to estimate the possible size of a power development, it is necessary to apply some additional factors to the total stored heat estimate. These include:

- $R_f$: A recovery factor to determine the amount of stored heat that can be extracted. The recovery factor is calculated here to be 2.5 times the void space with an upper limit of 50%. This is usually taken to be 20 to 25%.

- $n_c$: conversion efficiency for converting the recovered heat to electricity. This is usually taken to be 10% for liquid-dominated geothermal system.

- $L$: power plant life, second ($= \text{years} \times 31.5 \times 10^6$). It is common to use 20 to 30 years.

- $F$: power plant factor. In many geothermal plants, this factor is between 90% and 95%. For binary plant this factor usually taken to be 95%.

The final estimate of power potential (MWe) is calculated using the following equation:

$$E = \frac{(Q R_f n_c)}{F L}$$

Where:

$E = \text{power plant capacity, MW electrical}$

$Q = \text{total stored heat, MJ} (= \text{kJ} \times 10^3)$
2. Preliminary Bang power plant capacity estimated

In 1985, with purpose of petroleum exploration, the Viet So Petroleum company conducted a seismic survey in Quang Binh area. Base on seismic data, the area of Bang are estimated between 20 to 30 km$^2$ and it’s thickness is estimated about 800 to 1000m.

In order to estimate power plant capacity, it is necessary to assume that density of reservoir rock is 2.6 kg/m$^3$, void space is 12%, Cr is 0.9 kJ/kg °C, Sw is 1 and Tf is 120 °C (this temperature is injection temperature of binary power plant which will be built in Bang). The power plant life is 30 years. The result is as follows:

<table>
<thead>
<tr>
<th>Parameter and capacity</th>
<th>Min values</th>
<th>Max values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial temperature (°C)</td>
<td>140</td>
<td>150</td>
</tr>
<tr>
<td>Area (km$^2$)</td>
<td>20</td>
<td>30</td>
</tr>
<tr>
<td>Thickness (m)</td>
<td>800</td>
<td>1000</td>
</tr>
<tr>
<td>Estimated capacity (Mwe)</td>
<td>22</td>
<td>63</td>
</tr>
</tbody>
</table>

Therefore, the Bang geothermal reservoirs are capable of supporting 20 MW binary geothermal power plants.

6. CONCLUSION

Base on seismic data, the area of Bang are estimated between 20 to 30 km$^2$ and it thickness is approximately 800m.

The characteristics of chemical and isotopic compositions show that Bang’ geothermal fluid are bicarbonate dilute, near-neutral pH. Meteoric source. Geothermometers indicate that temperature of geothermal fluid in the Bang reservoir is between 140 and 150°C. Totally capacity factor assessment at the Bang geothermal site is 20 MW. That the Bang geothermal resource is medium enthalpy and most promising geothermal sites in Vietnam. For this reason Binary Technology are suitable for developing of geothermal power plant.

In the future need more objectives of geothermal exploration to estimate the size of the resource, determine the type of geothermal field, locate productive zones, and determine the heat content of the fluids that will be discharged by the wells in the geothermal field.

REFERENCES


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