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Overview of Geothermal Resource Evaluation of Bang – Le Thuy - Quang Binh

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ABSTRACT:

The present study is a small part of Truong Son mountainous orogenic belt running along from the North to the South of Vietnam. It has been listed as the potential geothermal resource of Vietnam with measured and inferred temperature range to change from 95^{o}C to 138.1^{o}C at depth smaller than 1 km. The geothermal manifestations in the area are located along the valley of Kien Giang stream. A boiling reservoir at depth causes geothermal manifestations such as hot water, gas and hot ground. The distribution of geothermal manifestations and analysis results showed that it can be controlled by faults and fractures in an E-W, N-S direction. Some areas of the stream valley, bedrock was brecciated, altered and covered by geothermal sinters. The reservoir reserve calculations based on the geological, topographical, tectonic factors and the comparison of Vietnam geothermal resources have shown that a pilot binary cycle geothermal plant can be built with minimum capacity 4.129 MW (90% probable), maximum capacity: 13.678 MW (50% probable).

1. INTRODUCTION

Vietnam is a Southeast Asian country that has been seen the market economy since the Vietnamese Government implemented it's open policy. In general, Vietnam like many countries of the world, has experienced a shortage of energy in recent years. Many renewable resources such as hydro plant, solar, wind, wave, biomass and geothermal etc., have been planned to develop in the coming 10 years economic development plan. The geothermal resource of Bang in Quang Binh in the central part of Vietnam has been seen as a potential resource to develop a pilot binary cycle geothermal power plant. Many investors have carefully considered if they should invest into the pilot binary cycle geothermal plant in the Central province or not, because Vietnam has no renewable energy laws. German experts have advised that this geothermal resource should be used directly by installing a pipe line from Bang to the coastal Sun Spar Resort of Dong Hoi city. This view of geothermal water direct use has been supported strongly because it has been used for bathing, tourism, and canning in Quang Binh.

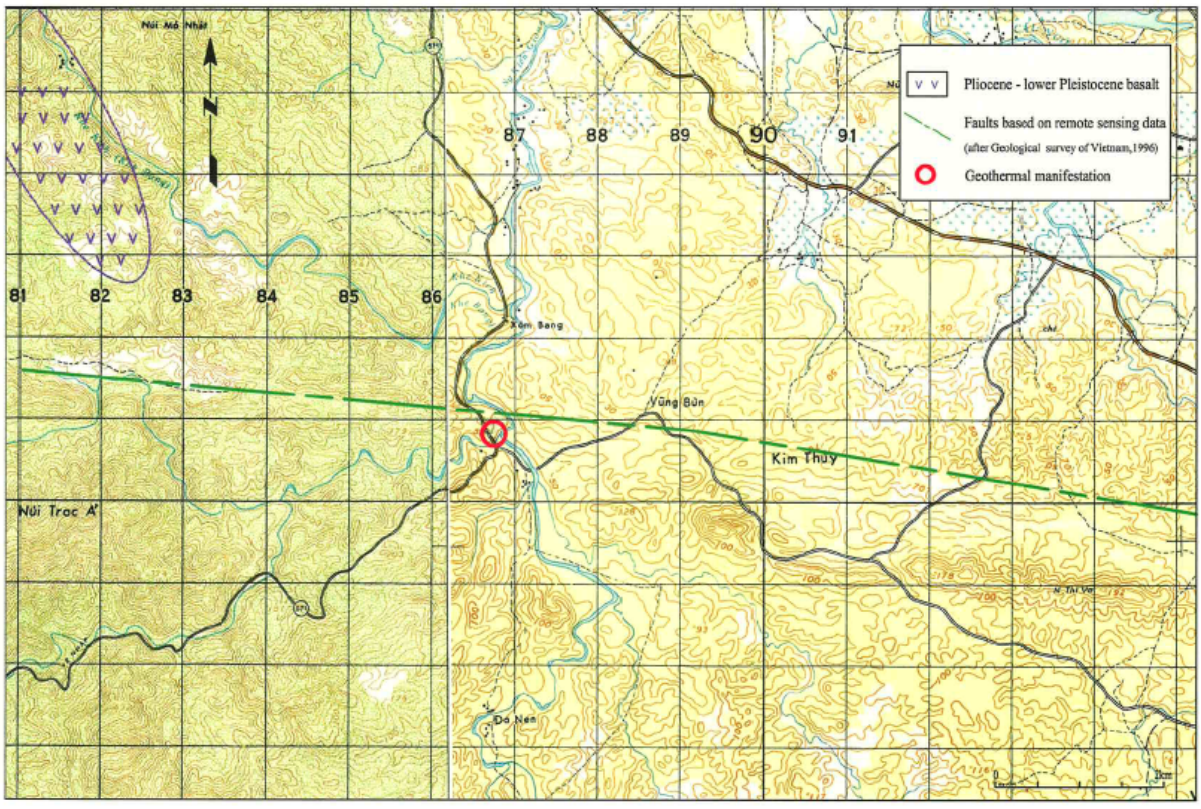

Figure1: Red circle is the location of the Bang geothermal resource, intended to explore (according to data of J-Power).

2. GEOTHERMAL RESOURCE OF BANG.

The Bang geothermal resource is located in Kim Thuy commune, Le Thuy district, Quang Binh province. In 1977 – 1980, the Survey Institute of Water Resource Design of Water Resource Ministry investigated the hydrogeology, geology and engineering characteristics of this geothermal resource in detail. The Institute drilled to a depth of 50m and measured the temperature and the water flow of the borehole. In 1995 – 1998, the Research Institute of Geology and Mineral Resources of Ministry of Resources and Environment implemented a project to survey Bang geothermal resource and calculated the temperature of the host reservoir by geothermometry. In 2006, geothermal experts of J-Power of Japan and the Research Institute of Geology and Mineral Resources of Vietnam did a survey and reported to the Vietnamese Government. Bang geothermal resource occurs in many points along the stream valley on the left of Kien Giang river. The valley widens to about 100 m and runs 2km.

2.1 Geological characteristics.

2.1.1 Stratigraphy:

Upper Ordovician- under Silurian formation (O_3-S_1ld): includes sandstone, siltstone, clay stone and shale imbedded in each other, some time interbedded in the old extrusive. The formation accounts for more than 90 % of the area of Bang geothermal resource.

Quaternary formation (Q): includes the dense massive, dark- brown colored basalt strongly sheared to distribute in the Northwest direction of Bang geothermal resource, about 6 – 10 km far from the resource mentioned above. Some geothermal experts confirm the resource can be related to the young basalt.

Deluvial mixed soil (el Q_{III-IV}) is distributed on the hill escarpment to thicken up to 1-3m.

Alluvial (a Q_{IV}) includes sand, grit and pebble distributed along the stream terraces and the valley.

2.1.2 Fault system:

In the area of Bang geothermal resource two faults exist, developed according to North West – East south and North south directions.

The North West – East south fault is developed to cut across the hot water area of Bang geothermal resource to form the quartz breccias containing sheared zone widened up 15m running along the valley. This fault has been seen as the one related to the Bang geothermal resource. North south fault is seen as the minority one to cut across the Bang area to create favorable conditions for the development of the geothermal resource.

2.2 Geothermal manifestation of Bang geothermal resource.

The geothermal water – containing zone in the sheared zone is distributed250 m along the stream valley to form three small areas with many silica and travertine dunes. The dunes have diameters about 1-1.5 m.

The first area: The hot water occurs in many continuously linked points distributed equally in the area 350 m^2.

The second area that is near the firs area has 17 hot water points occurring in the stream bed in an area of 300m^2.

The third area has only one hot water occurrence point. The hot water is strongly discharged and has higher temperature than the other areas.

The hot water and gas have H_2S gas, and neutral pH. The total mineral content reached 530mg/l, and has been listed as Na-HCO_3.Total flow of hot water is measured to be about 50 l/s. There is a borehole that reaches a depth of 24 m. The temperature in the borehole is measured to reach 105^{o}C.

Photo 1: The geothermal water exploitation borehole location of Quang Binh Coservo Company.

Photo 2: The location of geothermal water and gas discharge in the breccias zone in the stream line.

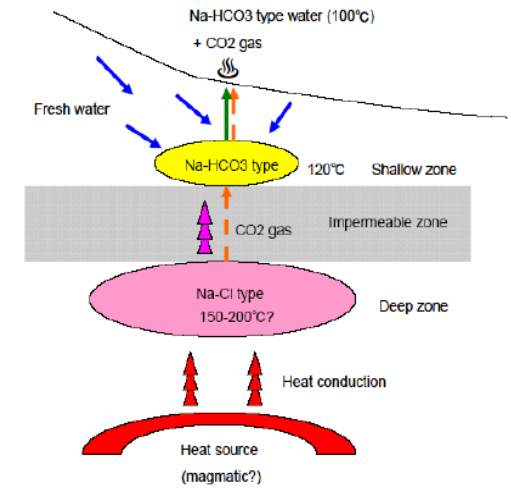

Figure 2: The geochemical modeling of Bang geothermal resource (according to data of J-Power).

2.3 Geochemical characteristics of Bang geothermal resource

Hot water of Bang geothermal resource has low total mineral content, and is mixed with ground water and surface water. In chemical composition, the hot water includes Na content 157mg/l to account for 90% e. Content of K accounts for 4% e, content Ca^{2+} to change about 2%. HCO_3 has tmd 405g/l to account for 83% e. Content of Cl^- and SO_4^{2-} is very small to account for only 10% e. Content of Li is relatively high (0.02 mg/l). Content of B is 0.15mg/l. Based on the hot water analysis results, Bang geothermal reservoir is estimated to have two different levels; the depth from 200 m to 300m has temperature about 120 – 130^{o}C including Na- HCO_3 mainly. The under part of the geothermal reservoir (the deeper level) has depth from 450 to 700m, with estimated temperature from 138.1 to 214.0 (based on geothermometry of Quartz and Fournier & Potter, 1982, Na-K-Ca of Fournier & Potter, 1979). The under part of geothermal reservoir has been seen as the objective to develop a pilot geothermal plant in Central Part of Vietnam.

Table 1: Calculation table of three elements Cl- SO_4 – HCO_3

No	Location name	K- Na- Mg			Cl- SO_4 – HCO_3		
		Mg (%)	Na/100 0 (%)	K/10 0 (%)	HC O3 (%)	Cl (%)	SO4 %
1	Bang	71.65	16.26	12.0 9	93.5 4	1.95	4.50

The calculation elements for the reservoir mass, area, thickness, permeability and temperature of Long Dai formation have been shown. Every calculated element has been calculated in minimum, in average, and in maximum based on the survey data, the exploration data in the past and modeling of the geothermal resource.

3.PRIMARY POTENTIAL ESTIMATION.

3.1 Estimation method.

There are many calculation methods applied to the exploration stages of geothermal resources, in order to estimate the geothermal resource energy reserve of Bang in Le Thuy- Quang Binh. We have used the estimation method of geothermal energy reserve that has been used by US (USGS, 1979).

3.2 Potential calculation.

The calculation methods include:

- The reservoir temperature: It has been calculated based on the geothermometry: Minimum: 138.1 ^{o}C; Maximum: 214.0 ^{o}C.
- The reservoir area: There is no geophysical sounding data measured in the geothermal resource. There are some boreholes drilled in Bang but their depths are from 40 m to 55m. The purpose of the boreholes was to collect the geothermal water for COSERVO Mineral Water Company. The data mentioned above can not be used to calculate the reservoir area. The reservoir area of Bang has been calculated based on the geology data, the geological structure data, the topography data and the compared geothermal manifestations in all of Vietnam.

Minimum: (70m x 50m x 600m) 1/3 + (30 x 10 x 600m) 1/3 = 0,76km^2.

In average: (70m x 50m x 600m) 1/2 + (30 x 10 x 600m) 1/2 = 1.14km^2.

Maximum: (70m x 50m x 60m) + (0 x10 x 600m) = 2.28km^2.

- The reservoir thickness: The thickness is the important parameter to estimate the geothermal resource. There is no depth data from drilling in this area, so the reservoir thickness has been calculated based on the geological data, the geological structure data and the comparison data from other geothermal resources in Vietnam. Minimum: 600m, Maximum: 800m.
- The rock porosity: The rock porous value is generally used: Minimum: 3%, Maximum 7%.
- The recover factor: United State Geological Survey (USGS, 1979) has used the recovery index to estimate the circulation system reserve of geothermal resource: 0.25. Minimum: 10%, Maximum: 25%.
- Specific heat and density of rock mMatrix. Both are based on representative values: 0.972 kJ/kg-^{o}C and 2500 kg/m^3.
- Rejection temperature: It is based on the average annual ambient temperature (25^{o}C).
- Utilization factor: about 0.4 for a modern binary cycle geothermal power generation system, from USGS (1979).
- Plant Capacity Factor: a value of 0.9 was used as for the typical modern geothermal power plant all over the world.
- Plant Power Life: 25 years used as a general standard.

From the calculation above, we can invest to build the pilot binary cycle geothermal power plant in Le Thuy – Quang Binh with minimum capacity: 4.129 MW (90% probable), maximum capacity: 13.678 MW (50% probable). The calculated results have been raised up as the same as the J-Power calculated results in 2006.

4. CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion.

Bang geothermal resource is closely related to structural features like faults and fractures that cut across the Long Dai formation.

The Quarternary basalt rock mass in the NW direction is seen as too old to heat the geothermal resource.

The geothermal manifestations in Bang, such as hot ground, sinter mounds, sulphur gas and some alternated zones, have shown that this geothermal resource temperature is not so high and is only suitable with a small binary cycle geothermal power plant.

The primary calculated results have shown that this geothermal resource needs to be explored in detail by

drilling deep boreholes to decide the reservoir volume, the temperature, the pressure and the discharge.

4.2 Recommendation.

Before drilling the detailed exploration wells in the Bang area, geophysical sounding measurements are needed to decide the reservoir.

Based on the geophysical data, the exploration wells planning must decide how to cut across the reservoirs. The faults in the Bang area have been estimated to cut across the reservoir in the subsurface. The exploration wells need to drill right on the faults.

5. REFERENCE

Flyn,T., Hoang Huu Quy, Phan Cu Tien and Schchet, D. (1997): Assessment of the Geothermal Resources of Socialist Republic Vietnam. *Geothermal Resources Council Transaction*, Vol. 21.

Founier, R.O. and Truesdell, A.H. (1973): An empirical Na-K- Ca geothermpmeter for natural water. *Geochim. Cosmochim.Acta*, 37, 515-525.

Geological Survey of Vietnam (1996): Geology and Mineral Resources of Le Thuy- Quang Tri Sheet. Geology and Mineral Resources Map at scale1: 200000.

Koenig, J. (1981): Evaluation of the Potential for Geothermal Energy Resources in Vietnam. A report by Geothermex Inc., California

Nguyen Thac Cuong, Cao Duy Giang and Tran Trong Thang (2005): General Evaluation of the Geothermal Potential in Vietnam and the Prospect of Development in the Near Future. *Proceeding World Geothermal Congress 2005*, Antalya, Turkey.