SOME NEW STUDIES IN BINH CHAU GEOTHERMAL AREA, SOUTH VIETNAM

Nguyen Hong BANG and Nguyen Thac CUONG
Division for Water Resources Planning and Investigation for the South of Vietnam
59 Street 2, Binh An Ward, District 2, Ho Chi Minh city, Vietnam
e-mail: nhbang@hcm.vnn.vn

ABSTRACT

The paper introduces and describes Binh Chau geothermal area with illustrations of geological, geochemical and temperature data obtained in previous stages of survey. The latest studies conducted in Binh Chau geothermal area include more detail investigations, imaging electrical survey, drilling investigation wells, determination of hot mineral water reserves and evaluation of prediction geothermal energy in Binh Chau geothermal source. The results of the studies are quantitative data that reserves Q = 300 m^3/day and calculated prediction geothermal energy in Binh Chau geothermal source E = 15.3 MWe.

Keywords: Iron staining, intermittent bubbling, geothermometer temperatures, reservoir, heat loss, enthalpy.

1. INTRODUCTION

Binh Chau thermal source was surveyed and described by Hoppe et al. (1986) as an artificial depression, created when a spa servicing tourist place was developed. There are some manifestations like several large hot pools and warm ground. In the central pool, measured temperatures is up to 80^{o}C at the mud below the water. Some new studies here were conducted from 2004-2006 years. Firstly, it was evaluation of hot mineral water potential. This work developed into north Binh Chau geothermal source with aim to exploit hot mineral water for convalescence. The work required to use imaging electrical method for location of two exploration wells. Secondly, prediction of geothermal energy in Binh Chau geothermal source was calculated by volume calorie method. The studies have shown quantitative results feasible for utilizable exploitation and for power generation in industrial medium scale in Binh Chau geothermal area.

2. DESCRIPTION

Binh Chau thermal area is situated about 95 km east-south-east of Ho Chi Minh City, 4 km from the coast and at an elevation of 15 rn above sea level (Fig.1). It takes its name from the village of Binh Chau, located 5 km to the south and has been developed into a spa servicing tourists.

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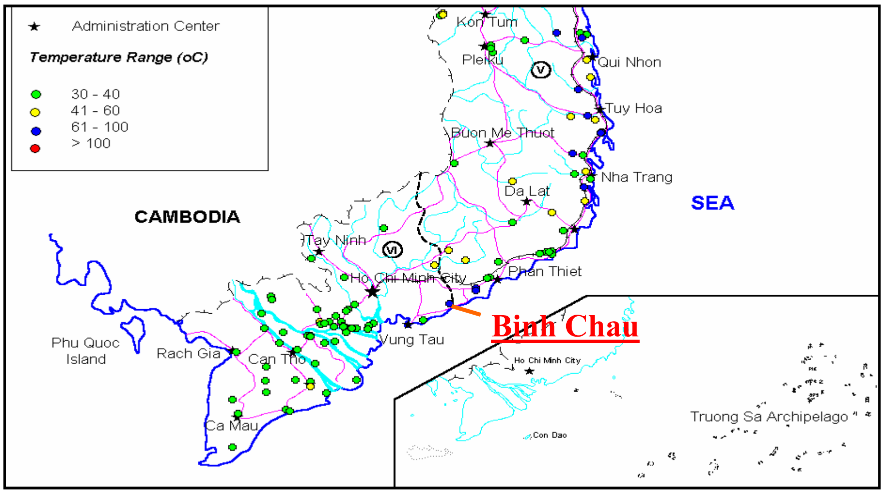

Fig.1: Location of Binh Chau geothermal source

The thermal area is situated in swampy ground described by Hoppe et al. (1986) as an artificial depression, created when the spa was first developed. The vegetation consists of long grass and thin forest cover. The thermal activity at Binh Chau includes several large hot pools (Fig.2) and warm ground. Some of the pools are fed by discharges from beneath while others appear to be ponded outflows. There is no steaming ground or gas vents. One of the pools had some weak and intermittent bubbling. No scale, siliceous or calcareous, was found although there was a small amount of iron staining. The water in all the pools is clear. In previous stages, the total flow from the thermal area were not estimated; measured flows from the individual outflow channels about 5 l/s. The temperatures of large, shallow pools appeared to be affected to some degree by evaporative heat loss. Temperatures up to 80^{o}C were measured in the mud below the water.

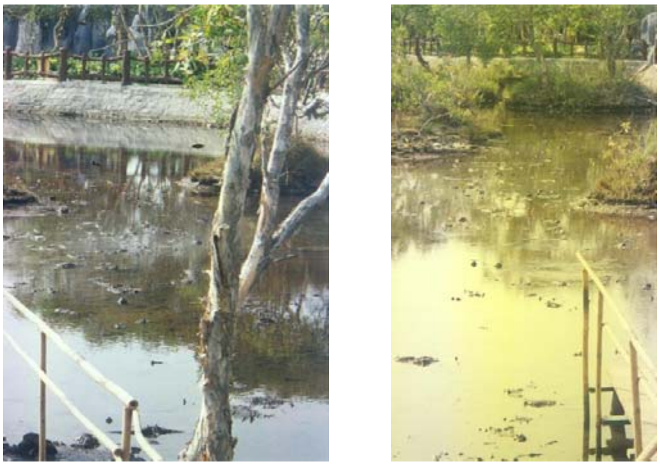

Fig.2: Hot pools at Binh Chau geothermal area.

3. GEOLOGY AND GEOCHEMISTRY

Geology: Basement rocks within Binh Chau thermal area consists of Dapren Epoch-Upper Series-Creta Formation (K_2dp) eruptive riolite and tuff-reolite. They are overlain by Quaternary sediments. The nearest outcrops of eruptive riolite are also observed some 2 km further inland and in some places in deep stream bottom and holes. Quaternary sediments include sands, some gravel and silt of Pleistocene (mvQ_{I-III}) and Holocene (abQ_{IV}). The thermal activity is considered to be fault system controlled. There are two fault systems towards NE-SW and NW-SE (Fig.3).

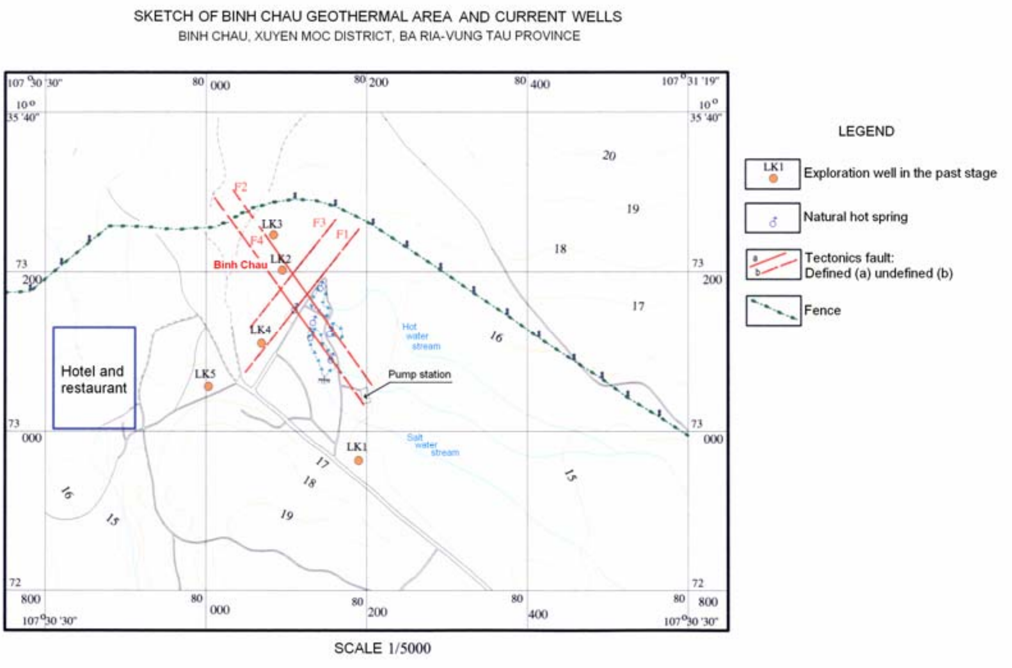

Fig.3: Sketch map of Binh Chau geothermal area and current wells

Geochemistry: Analysis results of samples collected from wells and major spring discharge points have shown that they are relatively mineralised with a TDS of about 3400 mg/l. The waters have a neutral pH, Na-Cl composition but also have high Ca and $S0_4$ concentrations indicating a possible seawater source. Gas content of CO_2, H_2S, F in the waters is very low. Geothermometer temperatures for the Binh Chau waters are generally low. Measured silica concentrations indicate quartz saturation and quartz max steam loss temperatures of 115-140^{o}C, K-Mg temperatures of 110-120^{o}C. The Na-K geothermometers of Foumier (1979) give temperatures of 150-160^{o}C and the Na-K geothermometers of Giggenbach temperature is 170-178^{o}C. Overall, the impresion from The Na-K geothermometers and 170^{o}C can be considered a rnaximum

4. FURTHER STUDIES

4.1. Evaluation of hot mineral water potential: This study required to develop into north Binh Chau geothermal source and the work was aimed to exploit hot mineral water for convalescence.

- Imaging electrical method was used to locate two exploration wells. Two imaging electrical lines CS1, CS2 were designed (Fig.4). The results of imaging electrical method are shown in Fig.5, Fig.6.

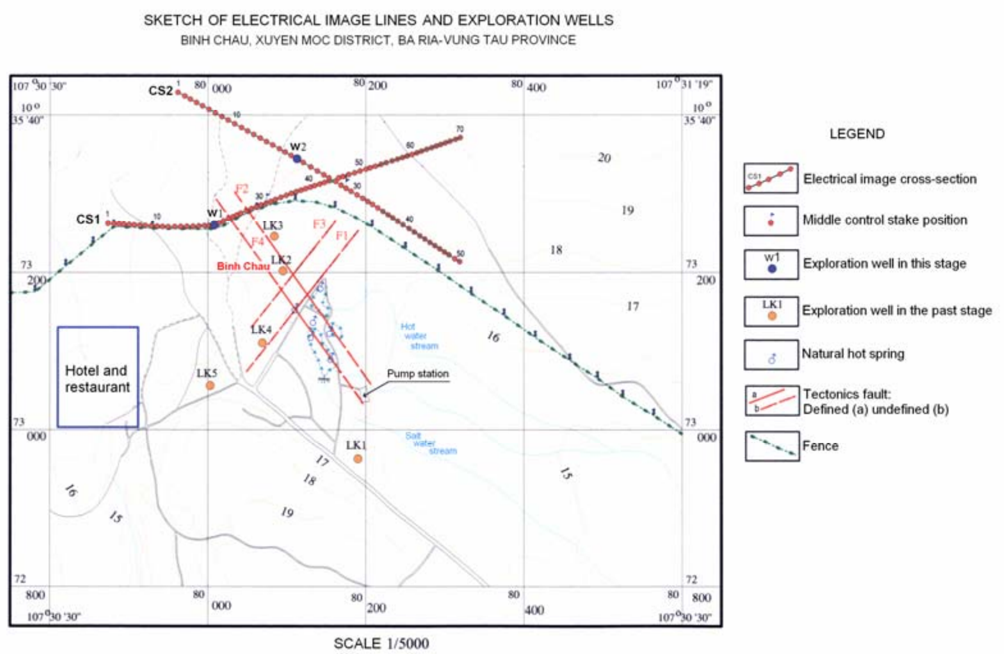

Fig.4: Sketch map of electrical image lines at north Binh Chau geothermal area

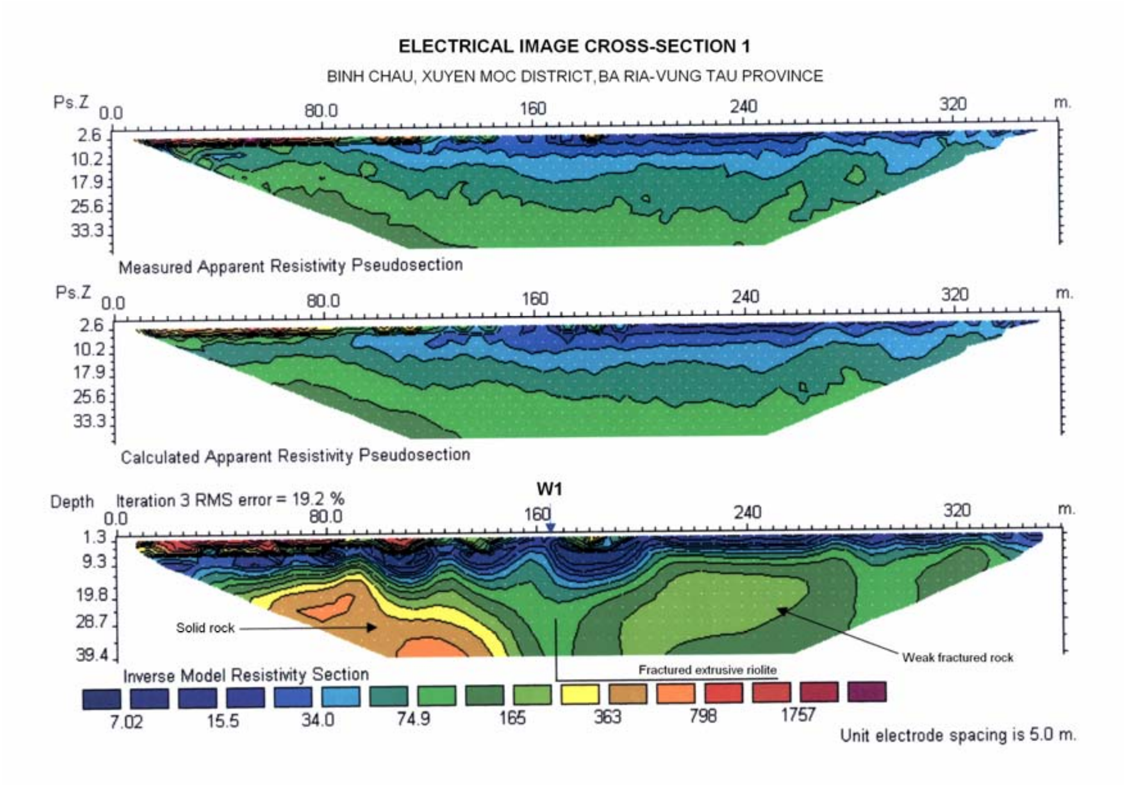

Fig.5: Electrical image cross section 1

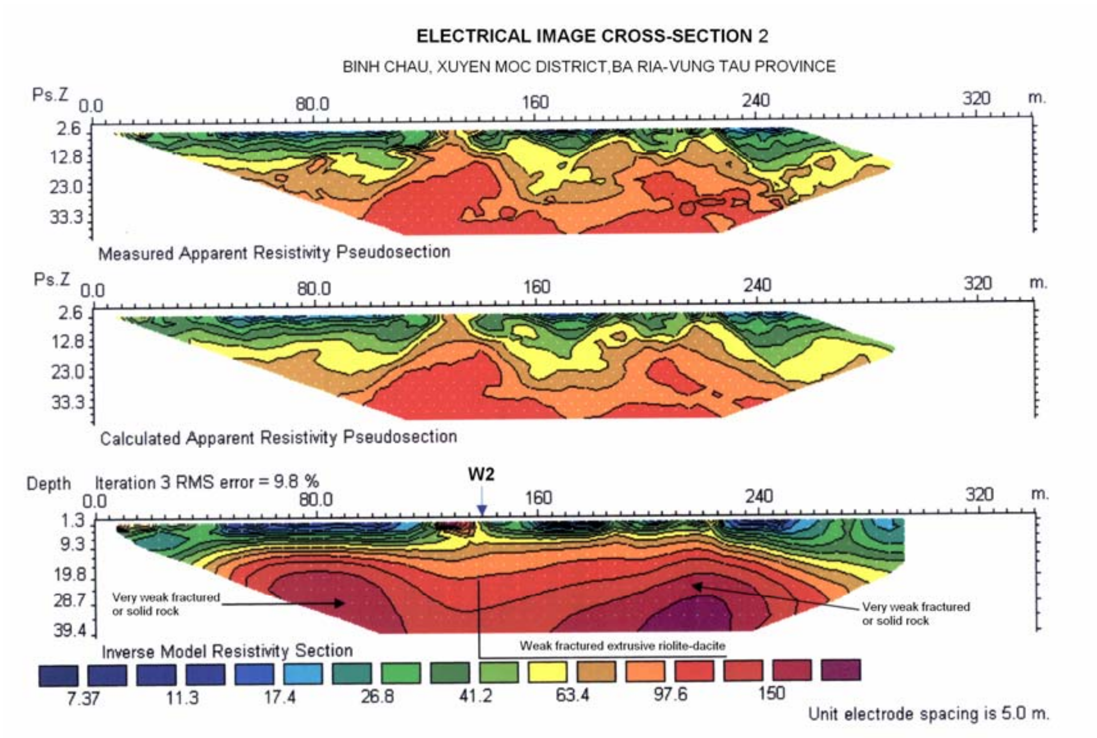

Fig.6: Electrical image cross section 2

- According to resistivity, two exploration wells W1, W2 were detemined (Fig.5, Fig.6) and drilled with depth of 63.5 m and 41.5 m. The temperature measured as 39.5^{o}C and 35^{o}C and TDS was 2.06 g/l and 2.68 g/l respectively. The yield of two wells was the same as 5.04 m3/h.

- Hydrogeological map of Binh Chau geothermal area was established from results of field works and investigations combined with previous stage study data (Fig.7). Hydrogeological characteristics are including:

+ Low productivity Holocene alluvial-swamp sediments abQ_{IV} with average thickness of 3-5 m
+ Low productivity Pleistocene-Holocene wind-marine sediments mvQ_{II-IV} with thickness from 3-5 m in the north and 15-18 m in the center of area.
+ High productivity fracture zone. Well LK2 is drilled across fracture zone of fault F2 with static water level + 0.3 m above ground surface and hot water of 82^{o}C at 15 m depth. The yield is 2.9 l/s.
+ Eruptive riolite aquitard K_2dp

- Hot mineral water reserves in Binh Chau geothermal area was evaluated around 300 m^3/day and hot mineral water type is silic-fluor-radi.

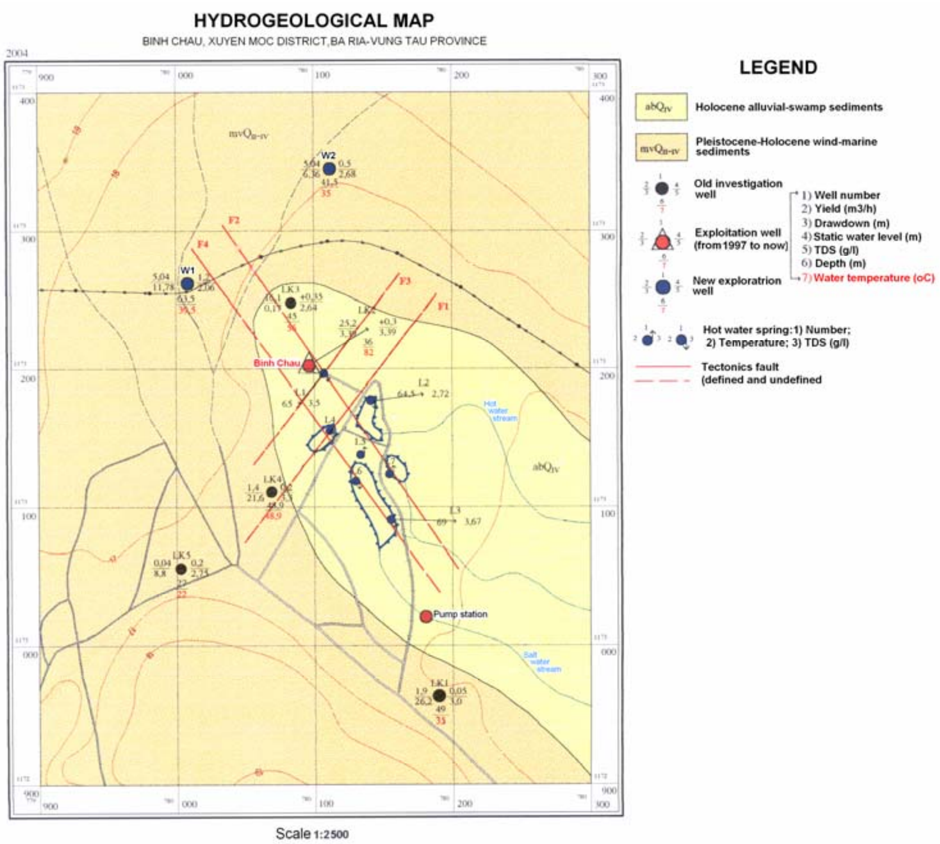

Fig.7: Hydrogeological map of Binh Chau geothermal area

4.2. Prediction of geothermal energy in Binh Chau geothermal source:

Fig.8 has shown Binh Chau geothermal anomaly with two temperature contours of 30^{o}C and 50^{o}C. There in the center is pool with main outflows of the source. Dimension of the pool are 5 m of wide, 10-15 m of long and 1-1.5 m deep. Temperature here is 82^{o}C. Outflow water is accompanied with bubbles H_2S.

Prediction of geothermal energy in Binh Chau geothermal source was calculated by volume calorie method. Calculation formula is following:

$$Q = A.h.\ \{\underbrace{[C_r\, \rho_r(1-\phi)(T_i - T_f)]}_{\text{Heat energy in rock}} \;+\; \underbrace{[\rho_{wi}\, \phi\, S_w\, (h_{wi} - h_{wf})]}_{\text{Heat energy in water}}\} \quad (1)$$

Parameters in formula (1) are as follow:

Q - Heat energy (geothermal energy), (KJ)
A - Reservoir area (m^2)
h - Average thickness of reservoir (m)
C_r - Specific thermal capacity of reservoir rocks (kj/kg^{o}C)
S_w - Water saturation
T_i - Initial temperature of reservoir (^{o}C)
T_f - Temperature after use (^{o}C)
ρ_r, ρ_{wi} - Density of rock and water at geothermal reservoir temperature (kg/m^3)
h_{wi}, h_{wf} - Enthalpy of water at geothermal reservoir and after exploitation (kj/kg)
ϕ - Porosity of rock (%)

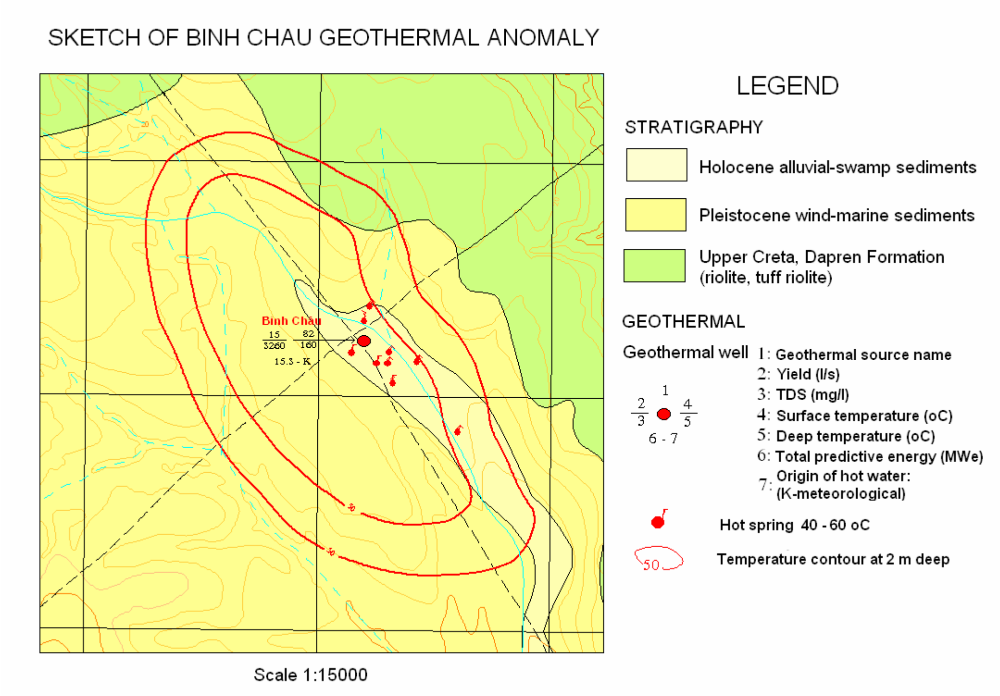

Fig.8: Binh Chau geothermal anomaly

For determination of production capacity of geothermal power-station, formula (2) was used to calculate expectation capacity E (MWe):

$$E = (Q.R_f.n_c)/(F.L) \tag{2}$$

There:
E - expectation capacity (MWe)
Q - Total heat energy in rock and water (MJ)
R_f - Recovery factor (25%)
n_c - Productivity of heat exchange (10%)
L - Production time of geothermal power-station (s), commoly 20-30 year
F - Capacity coefficient of geothermal power-station (95% for binary technolohy)

Because of incomplete study, some parameters were assumed or were took from equivalent geothermal resevoirs in the world. These parameters are: density and porosity of reservoir rock; C_r = 1 kj/kg ^{o}C; S_w = 1; T_f = 107^{o}C to 120^{o}C (Table 1).

Table 1: Input parameters and computation results of prediction geothermal energy

Area (m^2)	Thickness (m)	C_r (kj/kg°C)	S_w	T_i (°C)	T_f (°C)	ρ_r (kg/m^3)	ρ_{wi} (kg/m^3)	h_{wi} (kj/kg)	h_{wf} (kj/kg)	ϕ (%)	Q (KJ)	R_f	n_c	L (s) (30 y)	F	E (MWe)
5000000	900	1	1	160	115	2650	907.45	675.6	842.6	0.049	5.4895 E+14	0.25	0.1	946080000	0.95	**15.3**

In summary, prediction geothermal energy in Binh Chau geothermal source is 15.3 MWe at conditions deep temperture 160°C, pressure 6.18 at and volume 4.5 m^3.

5. SUMMARY

The studies gave quantitative geothermal potential results of Binh Chau hot spring source and that is feasible for power generation in industrial medium scale.

Binh Chau hot spring is one of 12 sources of country have been feasibly studied with total prediction geothermal potential capacity up to 190.6 MWe.

Investigation works used mainly surface study methods. Deep projects need to be conducted for accurate determination of reservoir parameters.

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