WELL LOGGING AT THE SAN KAMPHAENG GEOTHERMAL AREA, NORTHERN THAILAND

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ABSTRACT

Geophysical well logging at San Kamphaeng geothermal area began in 1981 for six shallow drill holes (500 m depth) and recently for a deep drill hole of 1,500 m depth (GTE-7). Geophysical well logs are composed of ES-logs (resistivity and self-potential measurements), caliper and temperature logs.

The ES-logs show high fracture permeabilities throughout the GTE-7 well bore at many depth levels, but the temperature gradient of this drill hole is normal (33° C/km). The temperature gradient would be increased if fracture permeability were associated with a major fault zone. The heat source for this geothermal area may be a deep-seated body near the area of the GTE-6 and GTE-4 wells.

INTRODUCTION

The geothermal characteristics of the San Kamphaeng area have been studied since 1978 to evaluate the electric-generating possibilities by a working group consisting of representatives from the Department of Mineral Resources (DMR), Chiangmai University (CMU), and the Electricity Generating Authority of Thailand (EGAT). The area was chosen as one of five promising potential resources for a detailed study after a five-year master programme (1978-1983) had been completed.

To evaluate the geological characteristics and the distribution of geothermal fluids in the area, a shallow drilling program (to 500 m depth) was started in 1981. This project consisted of six drill holes (GTE-1 to GTE-6), all of which except GTE-3, reached 500 m. GTE-3 was stopped at a depth of 150 m because its geology and geothermal gradient were not interesting.

The first deep drillhole with a projected depth of 1500 m was started in July 1984 and stopped at a depth of 1227.34 m in March 1985.

Geophysical logs for all of the drill holes (GTE-1 to GTE-7) consisted of ES-logs (resistivity and SP), and temperature and caliper logs.

To up-date the information on the heat source of the San Kamphaeng geothermal system, this paper reviews the geophysical well logs and their geological implication for the heat source at the San Kamphaeng geothermal area.

GEOLOGY AND DRILLING REPORT

The San Kamphaeng geothermal area is situtated in a valley between the mountainous areas of Doi Luang in the west and Mae Tha in the east. These mountain ranges, oriented in a north-south direction, are Carboniferous clastic sequences of the Mae Tha Formation. Hot springs are found along the streams in the Permian sequence of sedimentary rocks (Figure 1). These rocks are siltstone, shale, bedded chert, massive limestone and tuff. This sequence of rocks was mapped as the Kiu Lom formation in the Ratburi Group by Piyasin (1972). Volcanic rocks consisting of basalt, breccia, agglomerate and tuff of Permo-Triassic age (Piyasin, 1972; Chuaviroj and others, 1980) are exposed in the middle of the valley and in the northern part of the area. The Jurassic age of these volcanic rocks (Chaturongkawanich and Chuaviroj, 1983) is based on a K-Ar age of 163 ± 8 million years, as dated by Sasada (1983, unpublished data).

Drillhole GTE-7 was located by low resistivity values obtained from magnetotelluric data (JICA, 1983). The drill rig for this deep hole is a dual drill of rotary table and spindle system model GSR-100 CL.

Core samples of HQ size were taken from 30 m to total depth. After the wire line core was drilled to the required depth, the well was enlarged by reaming with a tricon-bit for casing installation as shown in Figure 2.

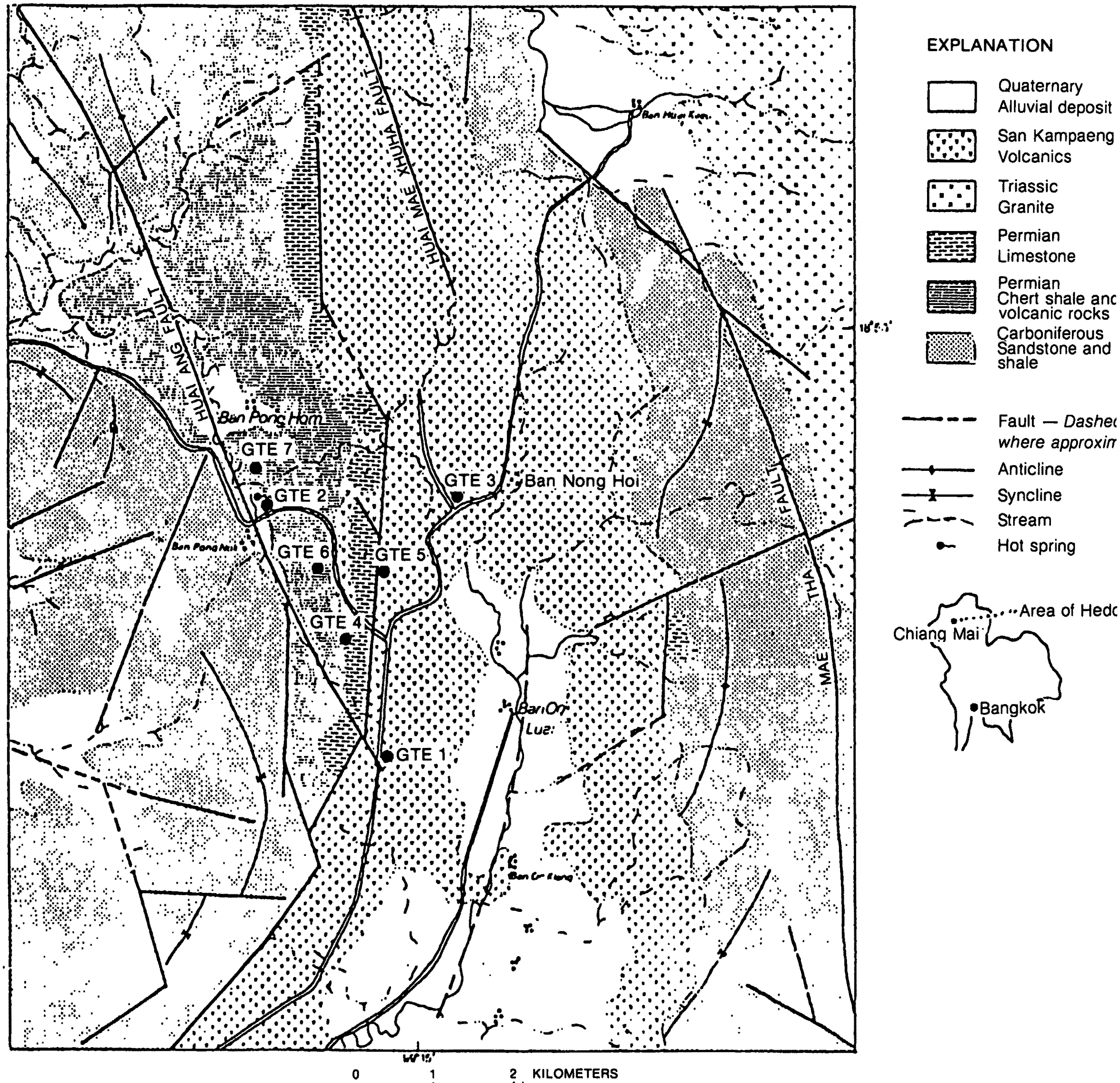


Figure 1. Generalized geologic map of the San Kamphaeng geothermal area. Complied from Chuaviroj, Chaturongkawanich and Sukawattananan (1980), Pothong, Sriprasert and Jaibun (1982), JICA (1983) and after Sertsrivanit and others, 1985.

GEOPHYSICAL WELL LOGGING AT SAN KAMPHAENG

The geophysical well logging at San Kamphaeng geothermal area consisted of electrical logs (resistivity and self-potential), caliper logs and temperature measurements.

The electrode arrangement for the electrical logs was set as a normal device with electrode spacings of 0.25 and 1.0 m for measuring resistivities. Resistivity values are obtained in an analog form for the different electrode spacings as R_1 and R_2 log curves. The SP-log curve was obtained simultaneously. Temperature logs were obtained by using two platinum thermister probes separated by a spacing of one meter. Both absolute and differential temperatures were recorded. For caliper logging, the maximum diameter that can be measured is 300 mm (~ 12 in.). Sonde speed for all logs was at 10 meters/minute, which is a recommended speed.

Figure 3 shows a temperature profile of the deep drill hole, GTE-7, at different logging times. This plot shows that the temperature increased as time passed, which indicates that the well bore has partially returned to equilibrium. Fracture or fracture permeability in the drill hole is evidenced by the electrical log results (Figure 4). Low

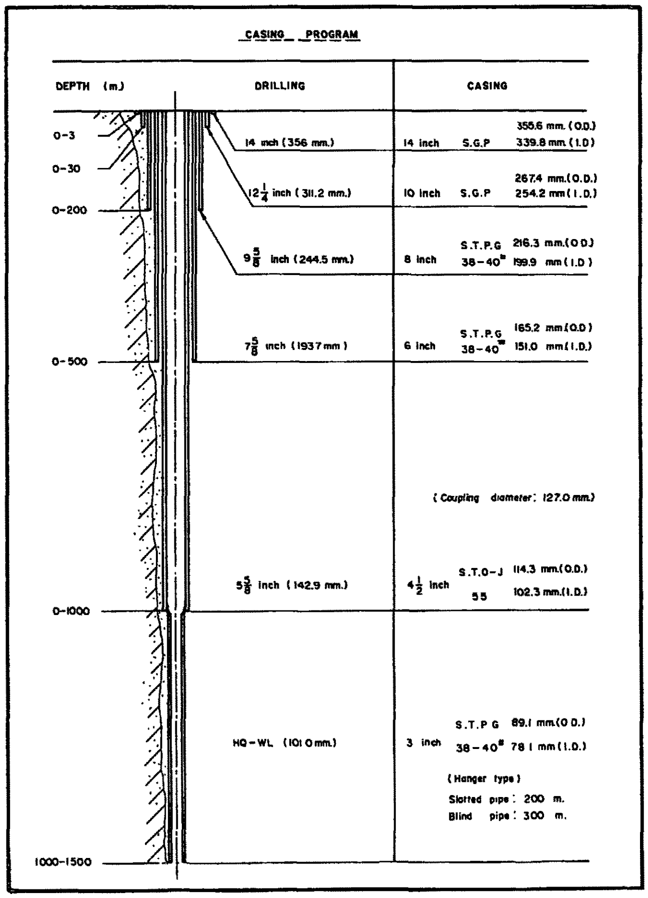


Figure 2. Casing installation for drill hole GTE-7

Table 1. Depth Intervals of High SP Values Versus Low Resistivity Values for the Carbonaceous Shale in Well GTE-7

Depth (m)	Thickness (m)
390 - 405	15
420 - 445	25
661 - 690	30
775 - 805	30
832.5 - 864	31.5

Table 2. Fracture Zones at Various Depths in Well GTE-2 (after Soponpongpipat and others, 1984)

Depth (m)	Thickness (m) [circulation loss (high fracture)]
5 - 18.5	18.5
50 - 51	1
224.1 - 227.7	2.6
244.2 - 258.7	14.5
262.7 - 267.7	5.0
337.0 - 344.5	7.5

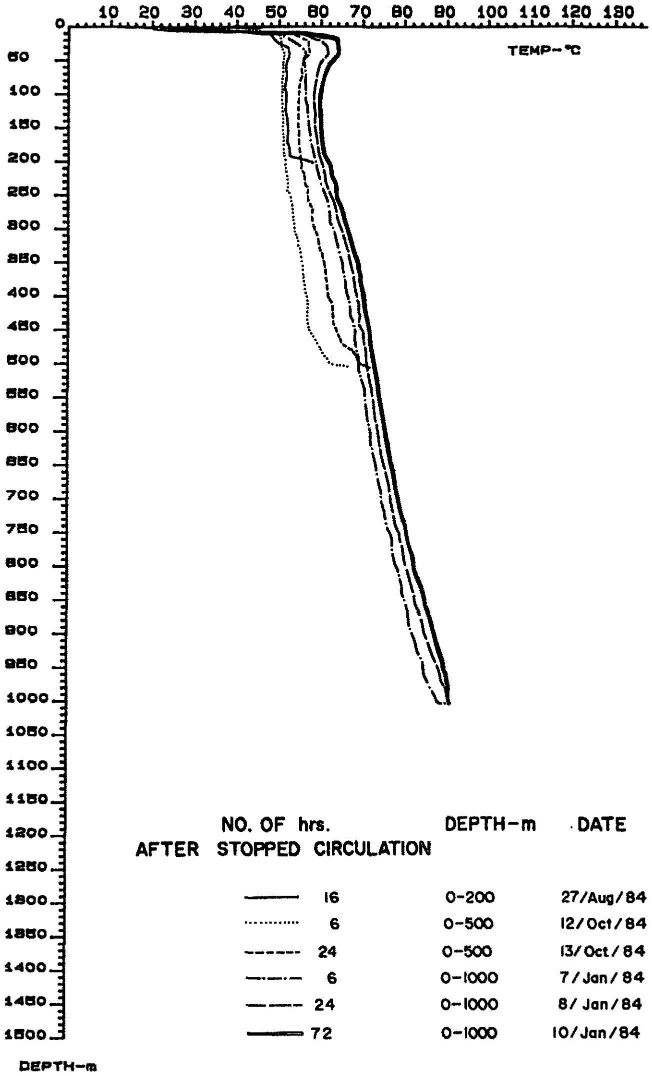
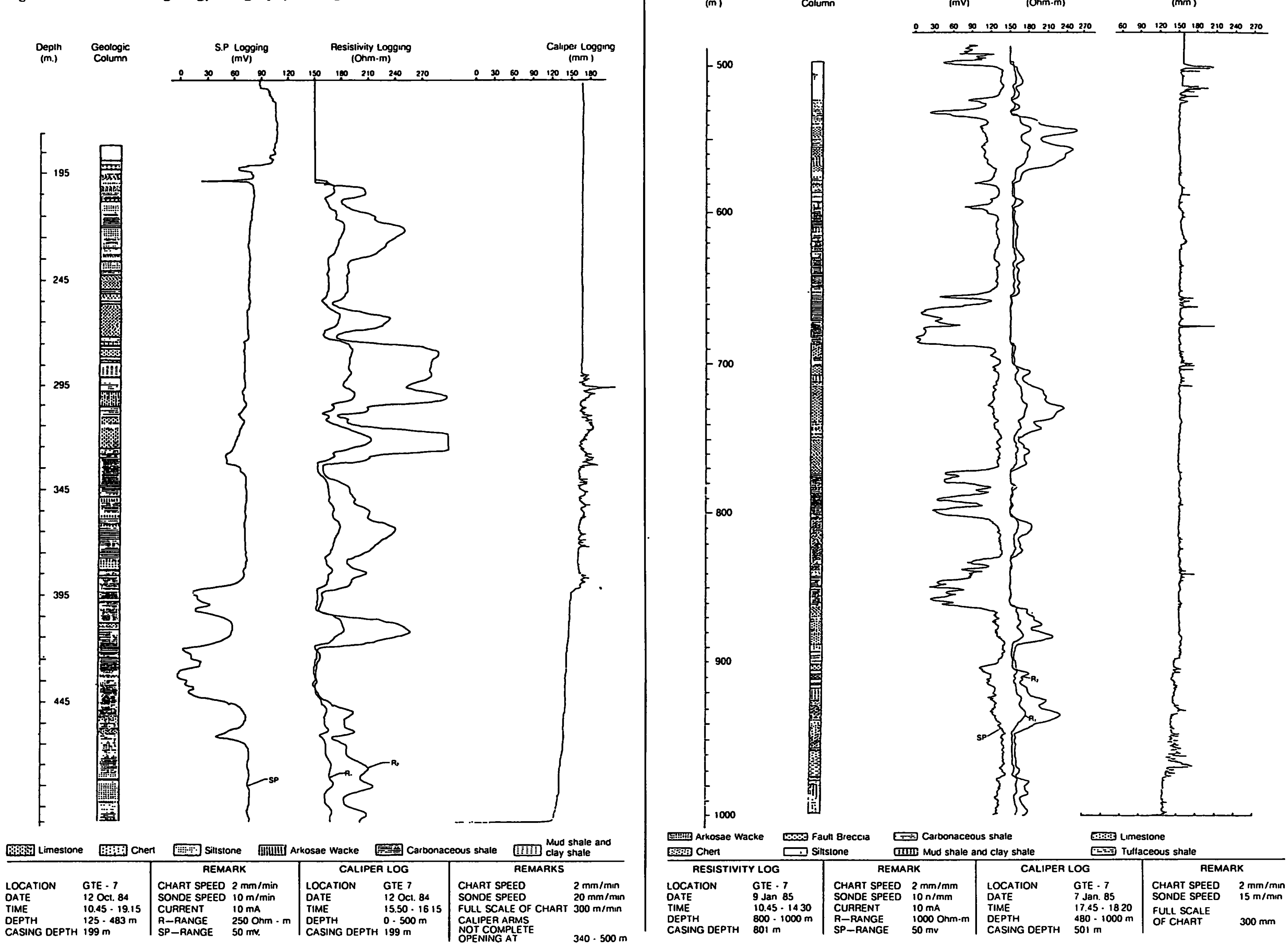


Figure 3. Temperature profiles of well GTE-7, San Kamphaeng geothermal project, for different hours after circulation stopped.

resistivity values of the carbonaceous shale in the GTE-7 hole correlate with the high SP values at different depths, as seen in Figure 4 and listed in Table 1.

A fracture zone is also interpreted at the depth interval 900 to 940 m (Figure 4). Rocks in this range are siltstone, mud-shale and clay shale, limestone and chert. Fault breccia is observed at depths between 904-908 m. There are many fracture permeabilities at different depths in GTE-7 but the temperature gradient is still low (approximately 33° C/km, which is near normal). This may mean that the heat source is not near GTE-7, otherwise the fracture permeability must be related to a major fracture zone of the area. Fracture permeability of the carbonaceous shale in GTE-2 is realted to the Huai Ang fault zone (Figure 5) at a depth of 250 m (Chuaviroj and others, 1983). This makes the temperature or geothermal gradient of GTE-2 high. The temperature gradient increases from 120° C/km to 140° C/km at the depth of 250 m (Chuaviroj and others,

Figure 4. Correlation of geology and geophysical logs of well GTE-7, 190 to 1000 m



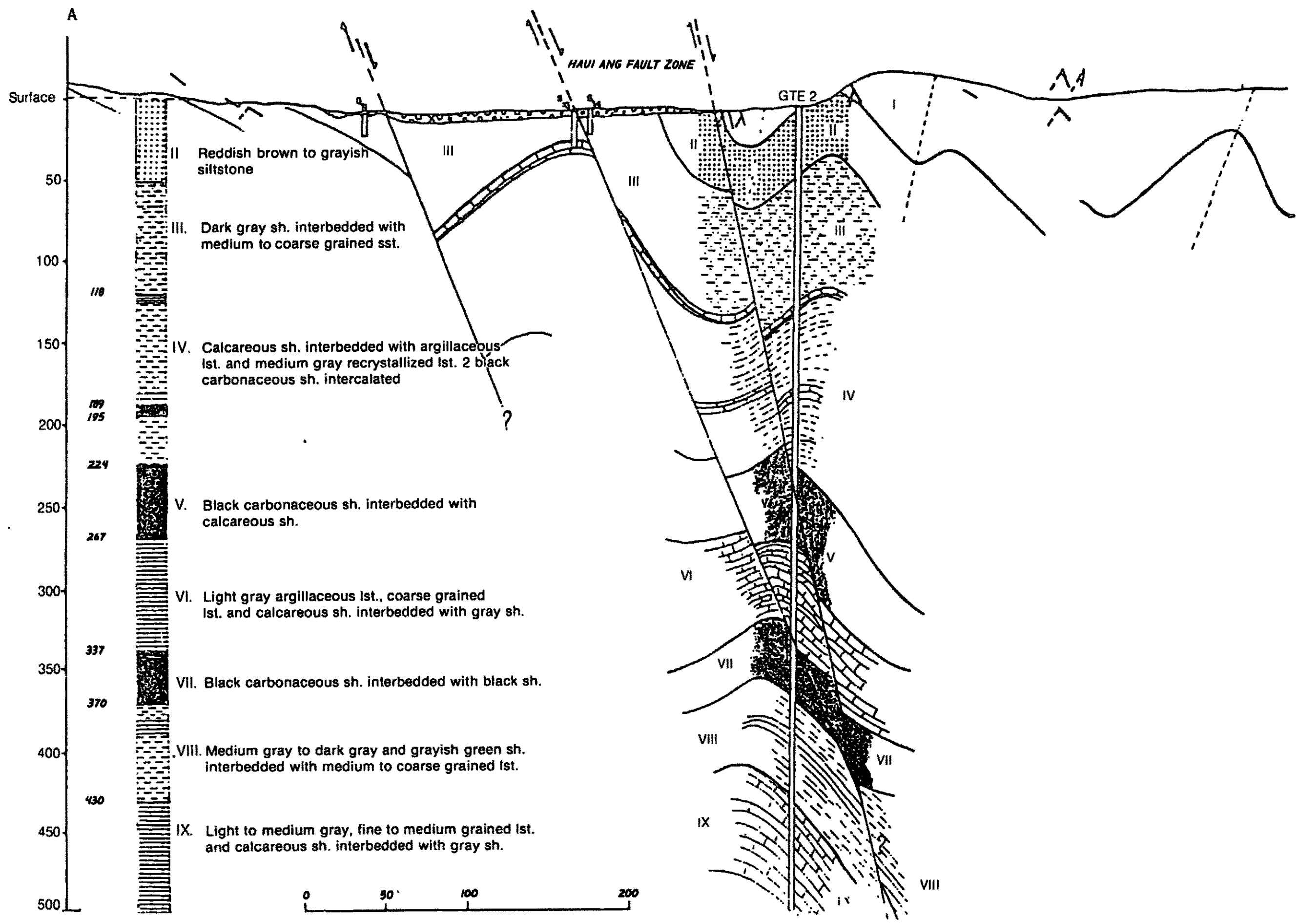


Figure 5. Interpreted structure along the east-west trend through well GTE-2 (taken from Chuaviroj and others, 1983)

1983). Table 2 lists high to excellent fracture zones in GTE-2 at different depths, with the thickness of these fracture zones.

For the shallow holes, plots of temperature profiles from GTE-1 to GTE-7 are shown in Figure 6. An isothermal contour map of temperatures from GTE-1 to GTE-7 at a depth of 300 m (depth chosen because data values are limited for some holes) shows an isothermal temperature anomaly (Figure 7) at GTE-6. At depths deeper than 500 m, the temperatures of GTE-5 and GTE-4 are likely to increase (see Figure 6, dashed lines). Now, considering the locations of these drill holes (Figure 1), the thermal anomaly is expected to be in the area of the GTE-5, GTE-6 and GTE-4 drill holes but at a deeper depth than these drill holes.

HEAT SOURCE IMPLICATION

The geophysical well log results show that the heat source must be related to a major fault zone, not to fracture permeability, to exhibit a high temperature gradient.

JICA (1983) believes that a deep-seated granitic body or younger intrusive body along fault zones plays an important role as the heat source at the San Kamphaeng area. This heat source is probably confined to a depth beneath GTE-6 and GTE-4. This result has been shown by Wakabayashi (1985) in block diagram, see Figure 8. Sertsrivanit and others (1985) have also postulated a heat source for the San Kamphaeng geothermal area from magnetic bodies at depth, which is near the fault adjacent to the east of the massive limestone hills (see map in Figure 1).

ACKNOWLEDGEMENTS

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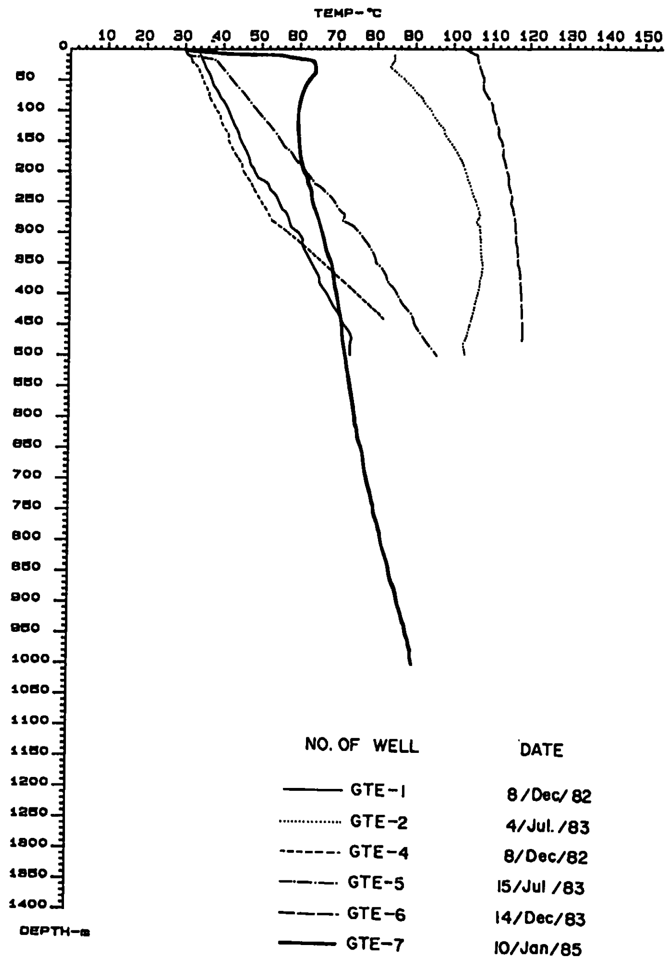

Figure 6. Temperature profiles of wells GTE-1 through GTE-7, San Kamphaeng geothermal project

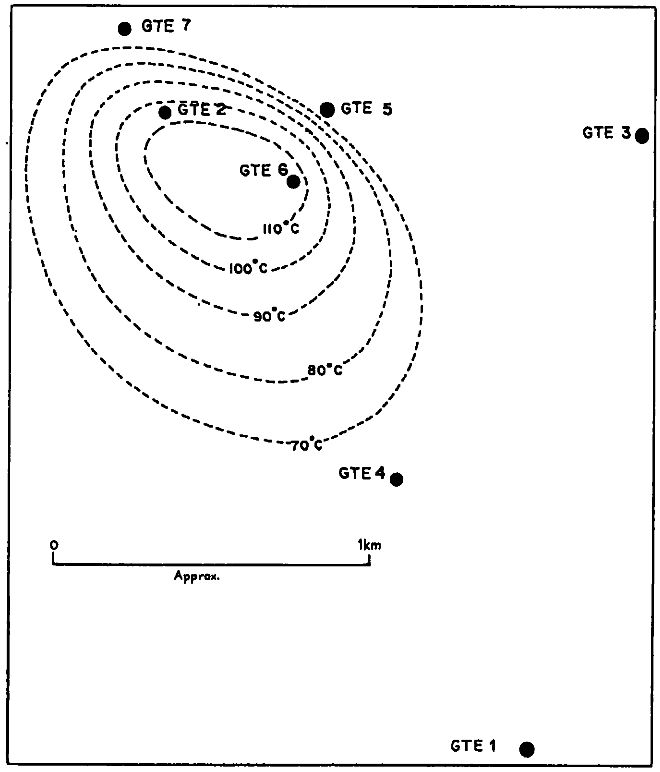

Figure 7. Isothermal anomaly at 300 m depth. GTE indicates locations of intermediate depth wells

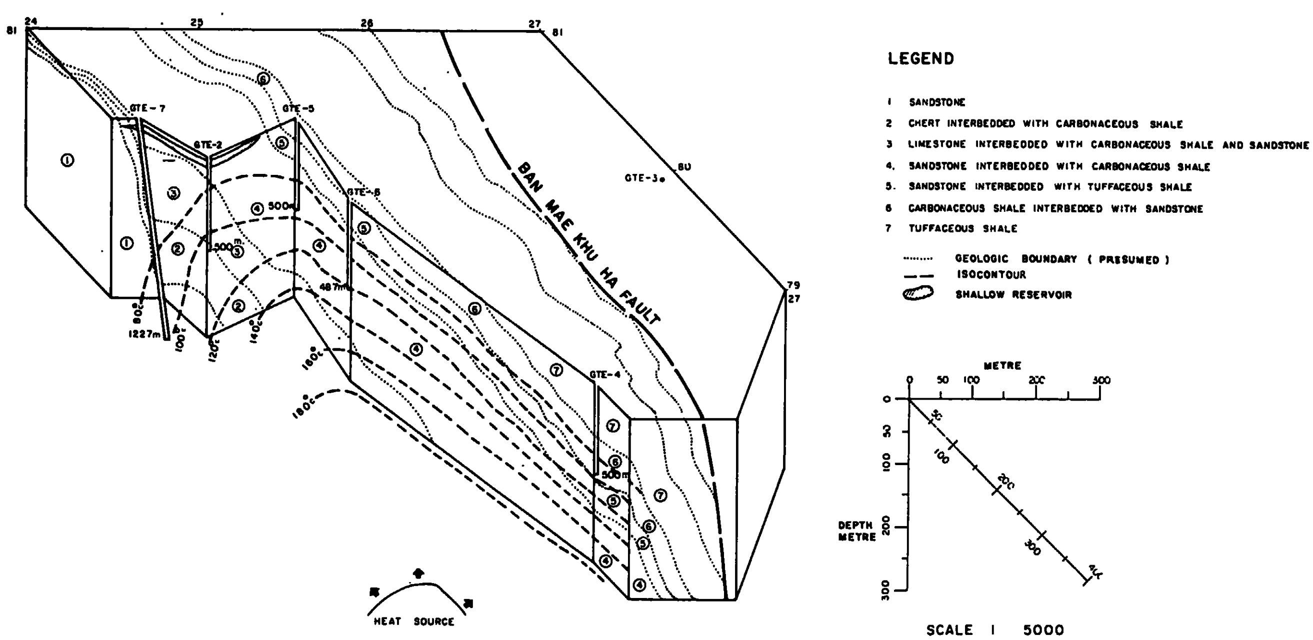

Figure 8. Block diagram of the San Kamphaeng area with a heat source (Wakabayashi, 1985)

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