GEOTHERMAL EXPLORATION DRILLING IN THAILAND

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ABSTRACT

The first two geothermal exploration wells in Thailand have been drilled in the vioinity of San Kampaeng Geothermal System. Available scientific data reveal that, among the five promising geothermal systems in Thailand, San Kampaeng Geothermal System warrants the highest potential for power generation. Both exploration wells are 500 m in depth. The first well (GTE-1) penetrated entirely into the Permo-Triassic volcanic rocks of basaltic and andesitic nature. Temperature gradients are steady both in the shallow agd deep portions of the hole with the value of 120 °C/km. The second well (GTE-2) penetrated sedimentary successions of interbedded Palaeozoic shale, sandstone and limestones. Temperature gradients in the first 250 m is approximately 120°C/km. In the deep portions, from 250-500 m, the temperature gradients decrease to approximately 40-50 °C/km. Several shallow drill holes were also drilled in the surface manifestations areas of the hot springs. A number of wells, with depth less than 30 m, geysering, discharge hot waters with temperatures above boiling point. The third exploration well, with target depth of 500 m, is presently being drilled.

GENERAL BACKGROUND INFORMATION

In Thailand over 60 hot springs, with surface temperatures ranging from 40-100 °C are found scattered throughout the country. The hot springs are on record as early as 1946, however, systematic study to assess the value of this indigenous resource was not started until late 1977. Preliminary results from separate reconnaissance surveys by Chiang Mai University and Kingston Reynolds Thom & Allardice Ltd. of New Zealand indicated that utlization of geothermal energy for agricultural applications and power generation was warranted (Macdonald et al, 1977; KRTA, 1978). A Working Group consisting of personnel from Electricity Generating Authority of Thailand (EGAT), Department of Mineral Resources (DMR) and Chiang Mai University (CMU), was formed and a tentative schedule, 1978/83, of the geothermal energy development programme of northern Thailand was drawn up. The Working Group has since then progressively made investigation of most of the hot spring areas, various aspects of relevant scientific data of more than 30 hot springs that exist in northern Thailand have been made available (Fig.1).

The Working Group has eventually narrowed the search from 30 prospects to 5; San Kampaeng, Fang, Mae Chan, Mae Chaem and Pa Pae hot springs (Reference nos. 3, 1, 27, 7 and 2, Fig. 1), with the calculated subsurface temperatures being close to or above 180°C. However, only three out of five most promising areas (Reference nos. 1, 3 and 27, Fig. 1), taking into account of relevant scientific, sociological information and budgetary constraints, were selected for detailed studies. Initial studies to compile basic data, assigned and carried out separately by the three organisations, were completed in early 1980. According to the programne schedule, it has been initially agreed that consultations with external and unbiased experts are necessary to give their views, evaluations and recommendations on the available and relevant scientific data obtained by the initial intensive studies of the three selected geothermal systems. Final reports are prepared under different aspects and by the responsible working parties. Reports are sent to the experts prior to their visits to the local sites for their general reviews and familiarity. Three parties of foreign geothermal experts from Japan and the United States visited the local geothermal sites, at different periods of time. These were made possible through financial assistances from the Government of Japan, CCOP, and USAID, under various technical aid programmes. The first party consisted of Kiyoo Kawada and Isao Takashima, Senior geologists from the Geological Survey of Japan, who visited during 18-27 August 1980. The second party consisted of A.W. Langhlin and R.L. Jermance of Geoscience Division of Los Alamos Scientific Laboratory, University of California, U.S.A., who were in Thailand during 10-29 September 1980. R.O. Fournier of U.S. Geological Survey, Menlo Park, visited 9-21 October 1980. It is agreed by local and overseas experts that there is a good probability that medium to high temperature geothermal resources are present in Thailand at accessible depths (Kawada and Takashima, 1980; Langhlin and Jermance, 1980; Fournier, 1980; Ramingwong et al, 1980). The most promising area, San Kampaeng geothermal system close to the city of Chiang Mai, is finally selected for a case study and exploration drilling programme. However, due to some technological difficulties, the, drilling was not started until late 1981.

SAN KAMPAENG GEOTHERMAL SYSTEM

Geologic map of the San Kampaeng geothermal system is presented in Fig.2. The area is underlain by Carboniferous Sedimentary sequences of quartzitic sandstone, arkosic sandstones and siltstones. The rocks expose in mountaineous area as high ridges, particularly in the eastern and western partsof the area. Permian rocks, consist of well bedded to thick bedded limestone, chert, shale and siltstone, overlain conformably on the Carboniferous sequences. Hot spring manifestations, cover an area of approximately 0.6 square kilometer, occur in the Permian sequences. Permo-Triassic volcanic rocks of basaltic composition expose in the central portion and to the east of the thermal manifestations area (Chuviroj et al, 1980). The two dominant directions of fracture and joint systems are NW-SE and NE-SW. The hot springs are apparently controlled by the major fault of NW-SE direction.

Deep electrical dipole-dipole resistivity probing up to the depth of 1000 m apart from the shallow seismic refraction surveys, have been carried out in the vicinity surrounding the hot springs area. Several zones of low resistivity values, 25 ohm-m, are evident, suggesting the possible zone of thermal water accumulation. Temperature measurements in the existing groundwater wells, up to the depth of 80 m, indicate an unusual high geothermal gradient and heat flow with the maximum values of 90°C/km and 6.80 HFU (Wattananikorn et al, 1982).

EXPLORATION DRILLING WORKS

The first goethermal well ever drilled in Thailand (GTE-1) was commenced on September 25 1981 (Plate 1). The well is located approximately 3.5 km from the hot springs area, close to the major NW-SE trending fault which is believed to act as a major upflow zone of the hot springs (Fig. 2). Drilling of GTE-1, with the total depth of 500 m, was completed on December 24, 1981. Temperature profiles and lithologic log are presented in Fig. 3. The second exploration well (GTE-2), located in the area of hot springs, started on January 7, 1982. Drilling of GTE-2, also with the total depth of 500 m, was completed on-March 25, 1982. Afterdrilling completion, hot water with a temperature of 70°C is continuously flowing from GTE-2. The flow rate is approximately 5 l/min. Temperature profiles and lithologic log of GTE-2 are presented in Fig. 4. The third exploration well (GTE-3) with the target depth of 400 m was started on August 4, 1982, and is now in the stage of drilling. Apart from the deep exploration wells mentioned, a number of shallow wells with depth ranges from 10-20 m, have also been drilled with the purpose of investigating shallow subsurface temperature variations and at the same time to be used as seismic shock-point wells. Three wells produced hot bubbling and geysering waters, with temperatures ranging from 100-130°C and flow rates from

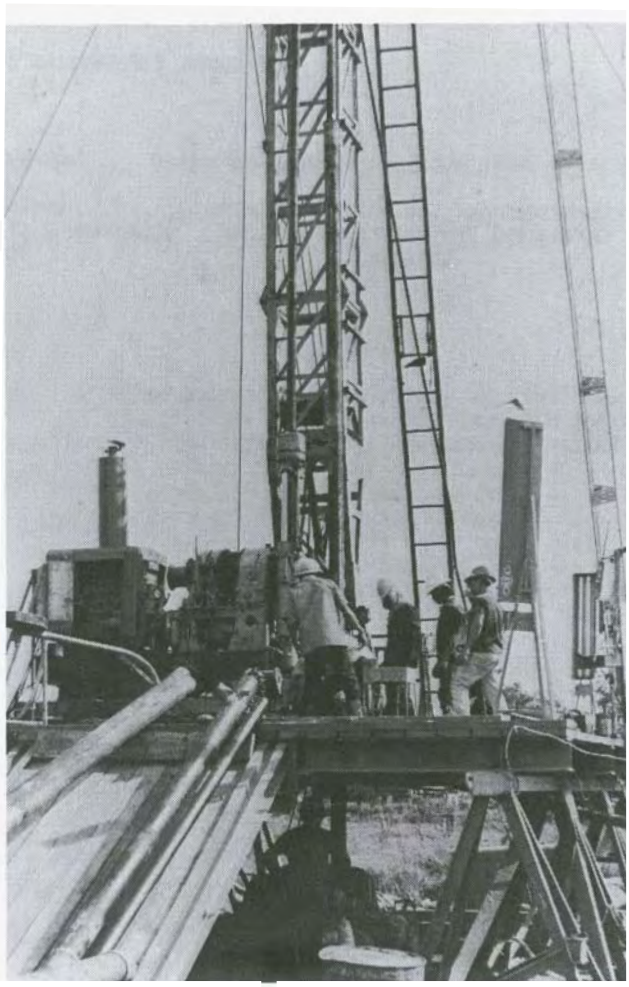

PLATE 1: Drilling rig, Longyear 44, in operation.

greater than 10 l/s (Plate 2). Distribution of subsurface temperatures in the vicinity of San Kampaeng hot springs area are presented in Fig.5. Technical data of GTE-1 and GTE-2 and the outstanding shallow wells are presented in Table 1.

CONCLUSIONS

Temperature profiles of GTE-1 and GTE-2 (Fig. 3 and 4) in the vicinity of San Kampaeng goethermal system, northern Thailand, indicate an abnormally high above regional geothermal gradients. Extrapolation of the temperature profiles reaches the temperatures of 180-200°C, the calculated reservoir temperatures, at the depths around 1.5 to 2 km. Extrapolation is justified providing that the thermal conductivity of the rocks is more or less similar throughout the entire depth and that heat flow is primarily by conduction. It is interesting to note that in the hot springs area, the 100 C isotherm is apparently very steep (Fig. 5). Moreover, the area of high temperature and heat flow is not

confined only to the area of thermal manifestations but extends extensively, at least 3-4 km, to the southeast of the hot springs area. Preliminary data obtained from the exploration wells suggest that a deeper evaluation drilling programme to the depth of interest, to evaluate the potentials of geothermal resource in northern Thailand, is justified. A three-year pre-feasibility study in the San Kampaeng Geothermal Development Project, a Technical Cooperation Project between the Government of Thailand and the Government of Japan (JICA), is now underway. Additional detailed studies are being carried out to assist in locating the future deep evaluation well, to the depth of at least 1500 m.

PLATE 2: Water and steam discharging from GTE (S-13)

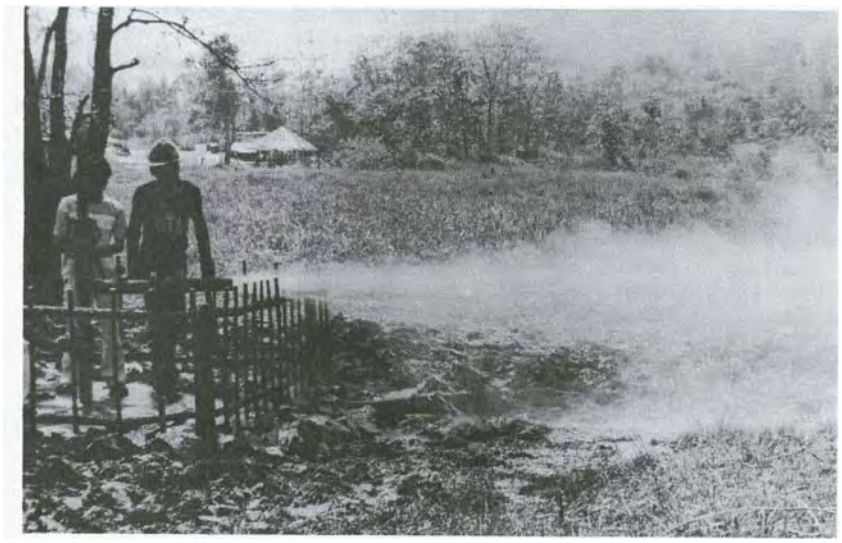

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TABLE 1: Technical data of Geothermal Shallow Exploration Wells, San Kampaeng Geothermal System, Chiang Mai, Thailand.

GTE - Geothermal exploration well with target depth less than 500 m
GTE(S) - Shallow test well with target depth less than 50 m

GTE-1	Date started:	September 25, 1981
	Date completed:	December 23, 1981
	Total depth:	500 m
	Drilling mach:	Long Year 44
Casing & Hole diameter:		Hole 6.75 in from 0–100 m 4.89 in from 100–226 m 3.78 in from 226–425 m 2.98 in from 425–500 m Casing 5.5 in casing cemented from surface to 100 m, 2.0 in water pipe from surface to bottom hole, cementing is from 100 m depth downward. The bottom is closed with screwed valve.
	Temperature:	80.4°C at 462 m depth (see Fig. 3)
	Flowrate:	The well is installed by water pipe casing and cemented in order to prevent inflow of water. However, after one month of installation, inflow of water is observed and causing the well to be silted up to a depth of 462 m. Water is under pressure and slowly overflowing at the surface. Overflow water is cold water. The well will be used for long term temperature and heat flow measurement.
	Lithology:	Greyish green basaltic andesite all through 500 m.
GTE-2	Date started:	January 7, 1982
	Date completed:	March 25, 1982
	Total depth:	500 m
	Drilling mach:	Long Year 44
Casing & Hole diameter:		Hole 6.75 in from 0–51 m, 4.82 in from 51–100 m, 4175 in from 100–118 m 3.78 in from 118–500 m Casing 5.55 in casing cemented from surface to 51 m, 2.0 in water pipe from surface to bottom hole, perforated at different intervals.
	Temperature:	106°C at 500 m depth (see Fig. 4)
	Flow rate:	Hot water is slowly overflowing with the discharge rate of 5 l/min.
	Lithology:	Chert, shale, sandstone successions. Abundant pyrite crystals and white waxy minerals at top 30 m.
GTE (S-2)		
	Date completed:	January 11, 1982
	Total depth:	12.50 m
	Drilling mach:	MBD, rotary rock-bit
	Casing:	Open
	Hole diameter:	2.98 in diameter widened to 1.5 m at ground surface
	Temperature:	99°C at ground surface
	Flow rate:	4.5 l/s shooting and bubbling to 0.5 m above ground surface (shooting height was 2–3 m when drilling newly completed)
	Lithology:	Grey chert, highly weathered at top. Lower parts are sandstone with abundant pyrite crystals and white waxy minerals (clay minerals).
GTE(S-12)		
	Date completed:	January 27, 1982
	Total depth:	10.50 m
	Drilling mach:	MBD, rotary rock-bit
	Casing/hole diameter:	3.78 in casing, cemented to 6 m depth, open hole to total depth
	Temperature:	105.5°C at 3 m depth, 99.0°C at top of casing (60 cm above ground surface)
	Flow rate:	Geysering at 5 min at an interval of 5 min with flow rate of 3–5 l/s. Geysering height is 10 m.
	Lithology:	As GTE (S-2)
GTE (S-13)		
	Date completed:	February 5, 1982
	Total depth:	31.5 m
	Drilling mach:	MBD, rotary rock-bit
Casing/hole diameter:		3.78 in casing, cemented to 9 m depth, open hole to total depth 99.5°C at top of casing (60 cm above ground). At depth 21 m measured temperature is 130°C. Hot water shooting to 12–15 m above ground surface, water to steam ratio estimated to be 2:1.
	Flow rate:	Greater than 10 l/s.
	Lithology:	Interbedded sandstone and shale with abundant pyrite crystals and white waxy minerals (clay minerals).

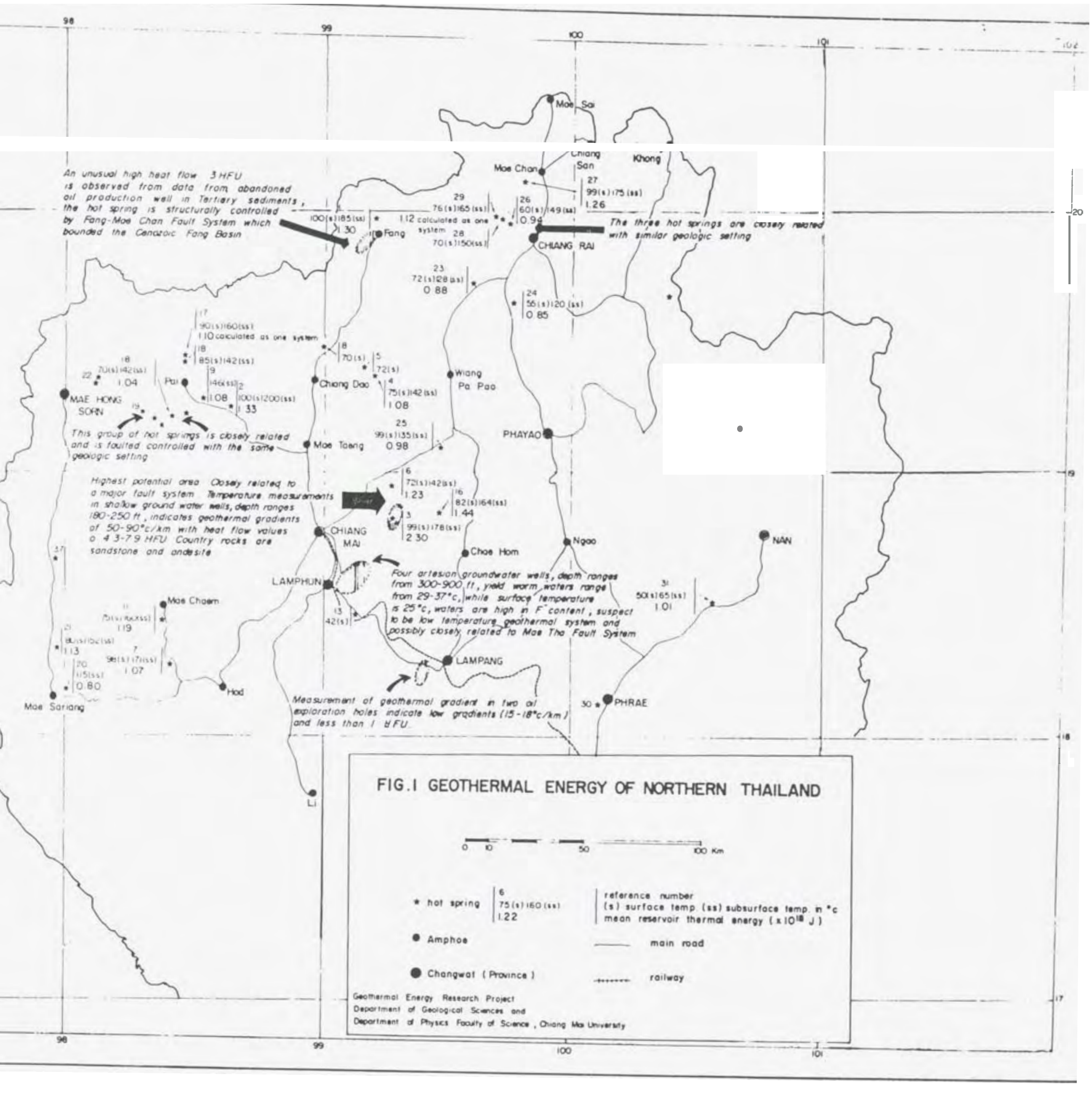

FIG.1 GEOTHERMAL ENERGY OF NORTHERN THAILAND

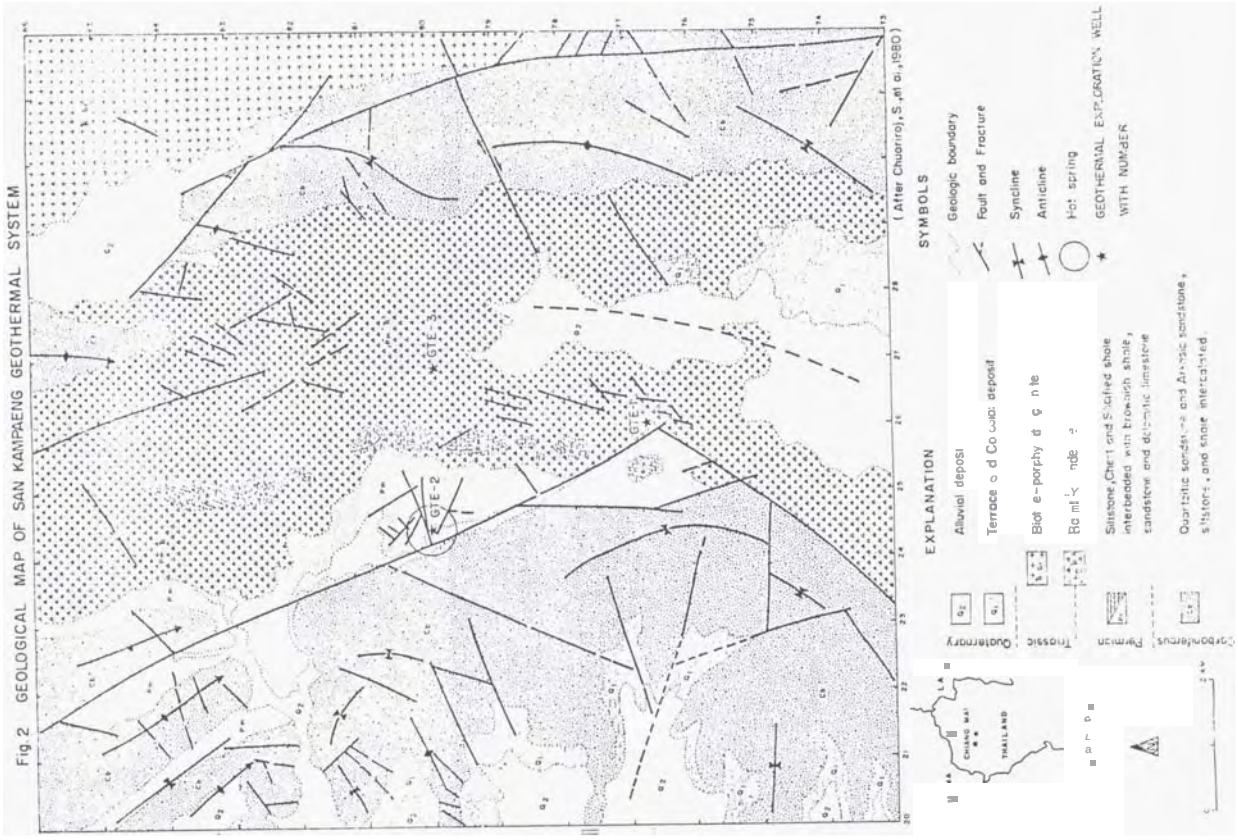
Fig 2 GEOLOGICAL MAP OF SAN KAMPAENG GEOTHERMAL SYSTEM
(After Chuenroj, S. et al., 1980)
SYMBOLS
Geologic boundary
Fault and Fracture
Syncline
Anticline
Hot spring
GEOTHERMAL EXPLORATION WELL WITH NUMBER
EXPLANATION
Alluvial deposi
Terrace and Colluvial deposit
Biotite-porphyritic granite
Rhyolite
Siltstone, Chert and Silicified shale interbedded with brownish shale, sandstone and dolomitic limestone
Quartzitic sandstone and Arkosic sandstone, siltstone, and shale intercalated
Quaternary
Tertiary
Permian
Carboniferous
GTE-1
GTE-2
GTE-3
CHIANG MAI
THAILAND

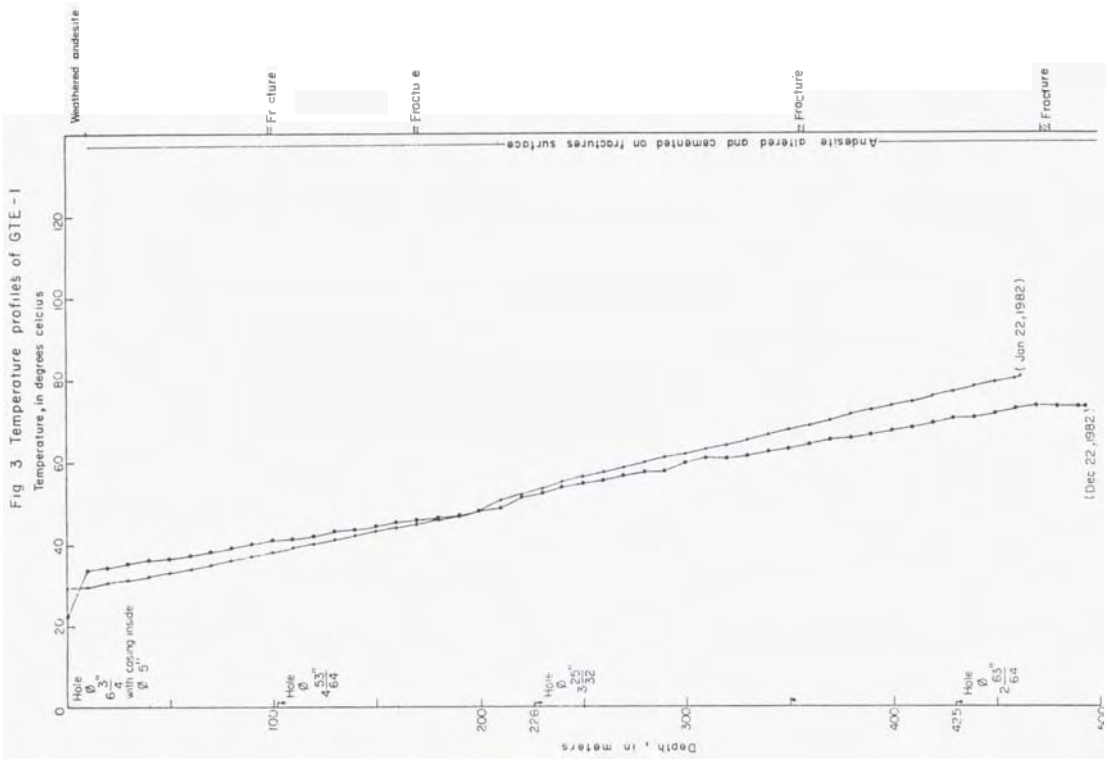
Fig 3 Temperature profiles of GTE-1
Temperature, in degrees celcius
Depth, in meters
Weathered andesite
Fracture
Fracture
Fracture
Fracture
Andesite altered and cemented on fractures surface
Hole Ø 6-3" with casing inside Ø 5"
Hole Ø 4 53/64"
Hole Ø 3 25/32"
Hole Ø 2 63/64"
(Jan 22, 1982)
(Dec 22, 1982)

Fig 5 Subsurface temperature distribution, San Kamphaeng Hot spring area

Fig 4 Tempera