EXPLORATION RESULTS OF THE ULUBELU GEOTHERMAL PROSPECT, SOUTH SUMATRA, INDONESIA

SUNARYO, D. HANTONO, S. GANDA AND NUGROHO

PERTAMINA Geothermal Division, Jakarta, Indonesia

ABSTRACT

The Ulubelu prospect is centred in a terrain dominated by several large andesitic volcanoes, which have been active over the last 4 million years. The geological, geochemical and geophysical surveys have currently been carried out to confirm these level prospectivity. The results from these methods delineate that the prospect area is about 30 Km2. The chemical geothermometers indicate maximum reservoir temperatures as high as 260°C, with zone of upflow could exist beneath Ulubelu area at the north and lateral flow of thermal water to the south.

INTRODUCTION

The Ulubelu geothermal prospect is located in Lampung Province, South Sumatra, It is situated about 80 Km from Tanjungkarang (Figure 1). The rapid increase of the industrial development which is affects parallel to electricity demand, will create a possibility of increasing the electric generation in South Sumatra.

Figure 1 : Location map of Ulubelu Prospect

A program of geothermal study have been started since 1990, this program led to develop of Ulubelu prospect, where Pertamina plans to develop 80 MWe electric generation which would be operated commercially in year 2000. In term of supporting this planing, State Electricity Company (PLN) is currently developing 150 KV interconnected transmission line throughout South Sumatra which is expected to be ready in 1994. For further geothermal studies, Pertamina has conducted exploration activities including geological, geochemical and geophysical survey. By judging the data, these surveys concludes that geothermal prospect in this area will be feasible to develop.

GEOLOGICAL SETTING

Sumatra at present forms part of the oblique subduction between the Oceanic India-Australia plate and the Eurasia plate. The stresses resulting its have been released periodically by strike slip fault movements to produced the major Sumatra fault system, which axially bisects the island (Rock et al, 1982). Beside that magma movement which is associated with subduction has affected to the rising of Sumatra volcanic arc, extending virtually the entire length of Sumatra, also the occurrence of volcanic activity along this Sumatra fault system suggesting the potential for shallow magmatic heat source and zone of permeability. The relatively thin extensive recent volcanism led to the formation of the Sumatra which is overlie folded and fractured Neogen sediments also unconformably overlie Pre-Tertiary basements. Generally the stratigraphy consist of rock from Pre-Tertiary to Recent ages, which is composed meta sediment-sediment, intrusive, volcanic rocks and alluvial deposit (Rock et al, 1982). The Ulubelu geothermal prospect lies within this chain and also related to the occurrence geology of Sumatra fault system. Although the NW-SE trending faults generate the surface of the prospect, there is also a network of faults formed by secondary extension striking mostly WNW-ESE (Kristanto A.S, 1991). These faults are

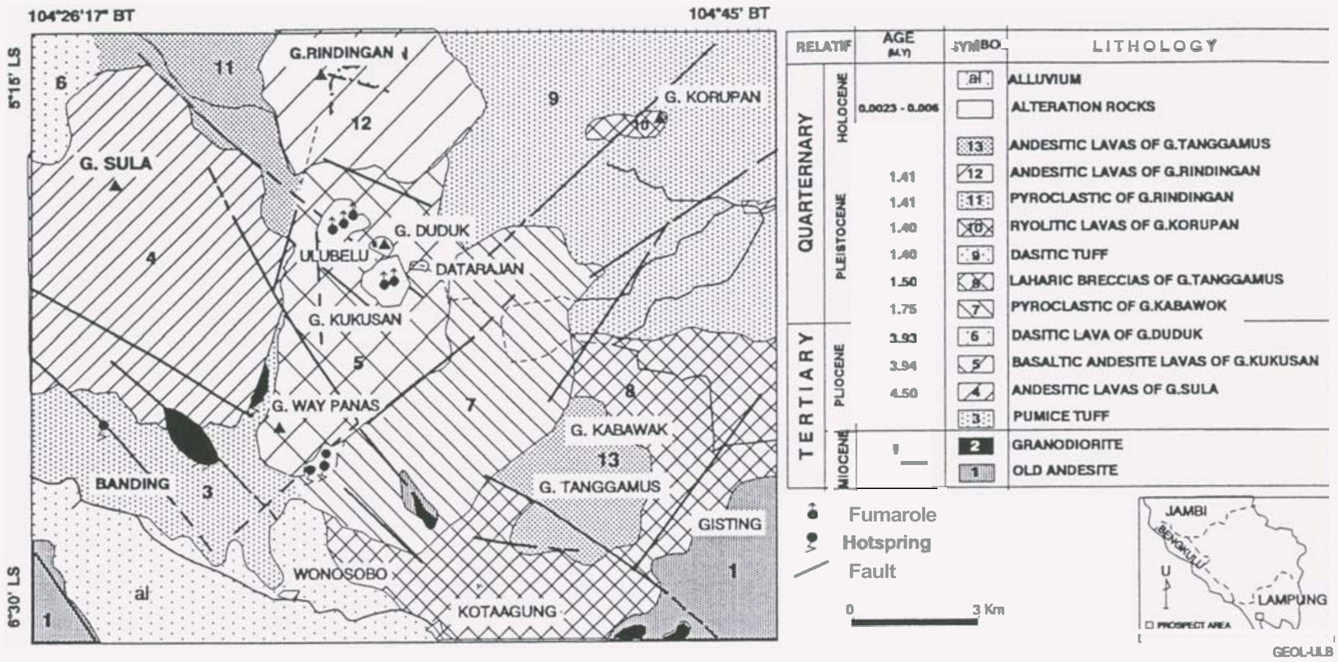


Figure 2 Geological map of Ulubelu, South Sumatra, Indonesia (Masdjuk M, 1990)

supposed to control the permeability the Ulubelu prospect. The local stratigraphy consist of andesitic and basaltic breccias, tuffs and lavas (Figure 2). G. Rindingan and *G.* Tanggamus are young andesitic cones Mio-Pleistocene built on the northern and southern of the Ulubelu prospect, suggested these deposits mostly derived from two volcanoes. A little dacite dome (G. Duduk) encountered in central part and close to surface thermal features. It has been dated at approximately 3.93 Ma age (Masdjuk.M, 1992). Exposed in the southeast part of the prospect and also underlying it, are lava and breccias andesitic as well as Miocene granodiorite intrusion. Some of quaternary volcanic rocks in the area have been hydrothermally altered in a manner which indicates mainly steam heating, but also the action of acid condensates.

GEOCHEMTSTRY

Surface thermal features in the Ulubelu prospect consist of several fumaroles, steaming ground, mud pools and hot springs. Which is mostly hot acid sulfate springs associated with fumaroles at elevation 900 m a.s.l.

Thirteen springs and three gas samples were collected from selected sites during 1990. The results analyzed are reported in Table 1. By the chemical constituents of hot springs, they can be classified as sulfate waters and chloride waters. This combination is typical of high temperature liquid water geothermal system in mountain terrain.

The sulfate content is highly variable due to derived from oxidation of hydrogen sulfide in the vadose zone. There is not chemical evidence for the presence of magmatic steam in the acid spring waters, it is indicated by a little fluorine and chloride concentration in the springs. On the other hand at elevation 150 m a.s.l, discharge neutral springs occur in the southern part have an appreciable chloride content. The chloride concentrations of around 600 - 875 ppm and Cl/B ratios of 35-50. The low Cl/B ratios are caused by relatively high B contents which is indicated a possibility of interaction between reservoir water and sedimentary rock. The relatively high ratios of Cl/SO4 with little magnesium concentrations, suggesting these waters coming from deep reservoir. Solute geothermometer is indicated minimum deep temperatures of around 200°C.

The dominant gases from fumaroles are CO, about 97 mole% and H_2S 2 - 3 mole%. The D'Amore & Panichi, 1980 gas geothermometer indicates a reservoir temperature about 260°C, whereas gas geothermometer which are based on ratio molal C02 and H2S (Giggenbach, 1990) give result more uniform about 250°C.

Soil mercury surveys have been carried out over the area. anomalous results are located over the steam heated zones in the Pagaralam and Datarajan, which is associated with several fault systems. There is large areas of elevated soil mercury content grater than 260 ppb and occasionally coincide with thermal features (Figure **3).**

Figure 3 Compilation map of Ulubelu prospect
South Sumatra, Indonesia

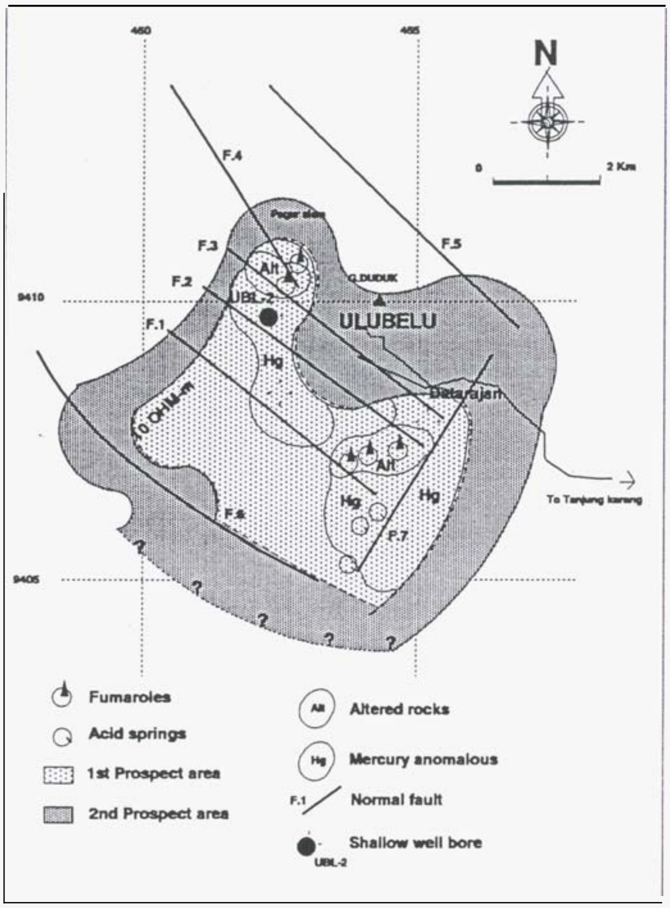
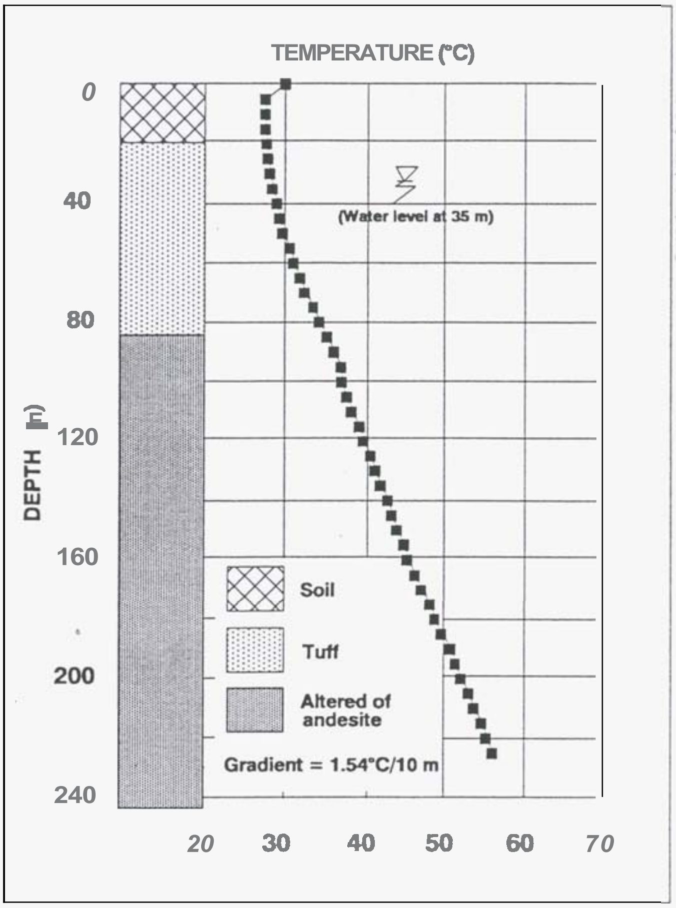


Figure 4 Temperature gradient of ULB-2
South Sumatra, Indonesia



GEOPHYSICS

Geophysical data including resistivity, gravity and magnetic surveys show a prospective area of about 30 Km2 converted by some of young breccia and andesitic lava flow. The result of the traversing Schlumberger array AB/2 = 1000 m is shown in Figure 3.

It can be seen that the area has a apparent resistivity of less than 10 Ohm-m occurs in the central region, which is most likely associated with a zone of active hydrothermal fluid upflow. The gravity and magnetic surveys were also completed for structural controlling and delineating prospect. However anomalies pattern does not provide any clear indication of boundary and subsurface structures but it could be important components of the geothermal system. A shallow well bore is currently being drilled at the central anomalies. The result of measurement shown thermal gradient is relatively high (Figure 4). The temperature tends to rise continuously and approximately an 28° C temperature difference exists between the bottom and top of the water level (Pertamina, 1992). There is an indication that a little or no variation in thermal pattern within the well, which is reflected a conductive zone.

DISCUSSION AND CONCLUSION

The prospect occurs in moderate-high terrain with the presence some discharges boiling neutral spring and fumaroles. There are two principle local structural trends i.e, NW trending faults, parallel and subparallel to the Sumatra fault system. The second structure is NE trending faults, which is associated with intensive altered rock and some fumaroles. These faults likely control the permeability of geothermal systems in this area. The reservoir is inferred to be associated with fractured Neogen sediments and Pre-Tertiary basements overlain by Quaternary volcanics. No specific geological event or feature has been identified as the probable cause for emplacement of the heat source for the system, but the chemists indicates that deep alkali chloride water ascend and that deep H_2S oxidizes discharged as acid sulfate in the central region. This is also reflected by mercury anomalies, it is supposed to be a corresponding with up flow zone.

A notable feature of the Cl-water discharge in flat-moderate terrain indicating a liquid dominated system occurs in the Ulubelu prospect. In addition, a pattern of 10-15 Ohm-m resistivity extend to the flat terrain and might reflect an outflow structure of neutral hot water. Due to their acidity and shallow mixture with other waters, no reliable data from surface liquid discharges in high terrain which can provide useful information about subsurface temperatures, whereas the gas geothermometer gives the temperature of 260°C.

By using these data are inferred three dimensional model geothermal of Ulubelu prospect as can be seen in figure 5. Initial exploration drilling should be planned to investigate the deep characteristics of the reservoir within boundary prospect close to shallow well bore ULB-2, which is considered base on several prospect data and accessibility aspects.

Figure 5
3 D Model of Ulubelu geothermal prospect

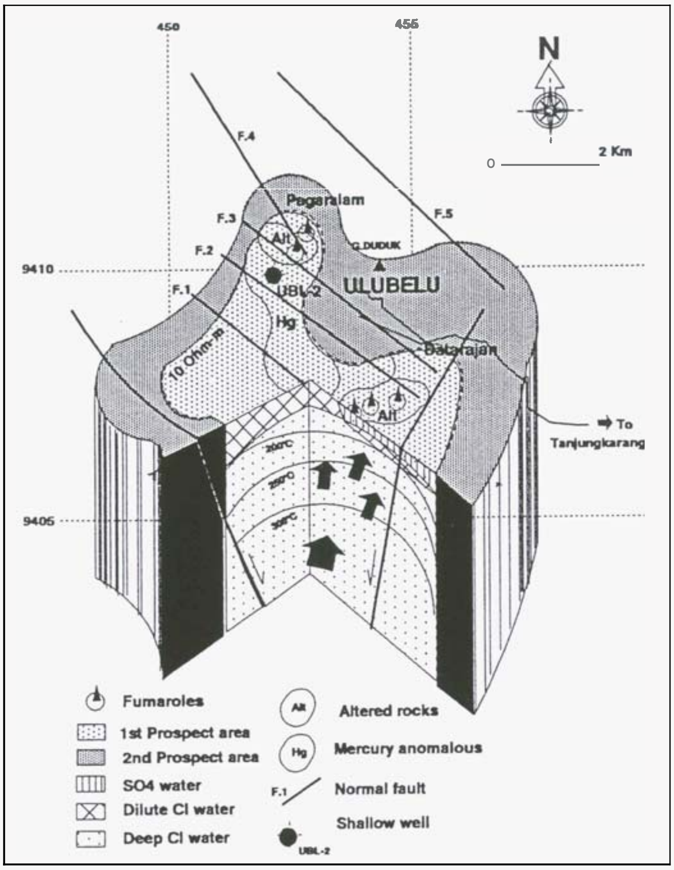


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TABLE 1 SPRING AND GAS CHEMISTRY OF ULUBELU

SAMPLE	T (°C)	pH	Na	K	Ca	Mg	Li	NH4	Cl (in ppm)	HCO3	SO4	F	B	SiO2	Cl/SO4	Cl/B	T.Na-K (°C)	T.SiO2
NUB-2	98	1.8	3	3	1.8	0.84	0.01	-	5	-	2770	0.1	0.1	65	-			
NUB-3	98	1.8	7	6	12.5	5.57	0.01	-	3	-	3420	0.2	-	255	-	-		-
NUB-4	95	4	8	2	7.0	2.00	-	2.20	2	-	121	0.30	-	63	-			
NUB-5	96	5	13	6	10.4	7.00	-	0.02	3	-	178	-	-	426	-			
SUB-3	99	7	479	37	14.8	-	2.00	0.04	799	30.1	61.4	2.5	16.1	195	13.0	49.6	195.80	178.23
SUB-5	99	7.8	402	35	24.4	0.51	1.59	-	590	111.0	50	1.6	12.4	171	11.8	47.6	205.39	169.53
SUB-6	99	7	543	56	16.9	-	2.30	0.01	853	24.6	66.2	3.0	18.5	277	12.9	46.1	219.64	203.28
UWL-27	98	8.2	458	40	19.8	0.40	1.61	0.08	705	85.0	60	1.7	19.7	295	11.8	35.8	205.64	208.07
UWL-31	96	8.1	470	38	12.3	0.10	1.70	0.16	725	47.0	81	1.9	19.7	337	9.0	36.7	199.41	218.52
UWL-32	95	7.7	393	32	10.8	0.40	1.27	0.16	584	114.0	49	1.7	16.0	260	11.9	36.4	199.98	198.56
UWL-36	98	7.9	554	57	14.6	0.10	2.03	0.24	876	24.0	72	2.4	23.4	420	12.2	37.4	219.44	236.83
UWL-49	98	8.1	500	45	13.6	0.10	1.79	0.16	775	27.0	66	2.3	19.7	283	11.7	39.3	208.11	204.90
UWL-158	97	8.2	560	55	12.9	0.10	1.84	0.24	856	31.0	58	2.5	22.2	424	14.8	38.6	215.44	237.65

SAMPLE	T(°C)	CO2	CO	H2S (in mole percent)	CH4	H2	T.D&P (°C)	T.CO2-H2S
SS-7	98	96.60	5.5E-05	2.80	0.55	0.0397	205	254.77
SS-8	97	97.50	0.00010	2.22	0.06	0.2270	230	259.22
SS-9	100	96.44	0.00026	3.10	0.13	0.2780	260	252.89