SGP-TR-151-8

PROCEEDINGS

TWENTY-FIRST WORKSHOP GEOTHERMAL RESERVOIR ENGINEERING

January 22-24, 1996

Stanford Geothermal Program
Workshop Report SGP-TR-151

PROCEEDINGS, Twenty-First Workshop on Geothermal Reservoir Engineering
Stanford University, Stanford, California, January 22-24, 1996
SGP-TR-151

EXPLORATION OF ULUMBU GEOTHERMAL FIELD, FLORES-EAST NUSA TENGGARA INDONESIA

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ABSTRACT

This paper describes the progress made in developing geothermal resources at Ulumbu Flores, Indonesia for utilization mini geothermal power generation. Two deep exploratory wells drilling drilled by PLN confirmed the existence of the resources. The well measurement carried out during drilling and after completion of the well indicated that the major permeable zone at around 680 m depth and that this zone is a steam cap zone, which is likely to produce high enthalpy steam.

The above information indicates that well ULB-01 will produce a mass flow at least 40 tonnes per hour, which will ensure a 3 MW (E) Ulumbu mini geothermal power plant.

1. INTRODUCTION

The Ulumbu Geothermal field is located in the Manggarai District Flores Island of Indonesia. The nearest principal village is Ponggeok situated about 9 kilometres west of the field on the main district road between Ruteng the capital of Manggarai District to north and Iteng to the south coast.

A full scientific programme of geological, geochemical and geophysical exploration was carried out.

Following this, two (2) deep exploration wells (ULB-01 and ULB-02) were drilled succesfully, and well testing will be implemented after reinjection well is drilled. PLN assures that geothermal energy at Ulumbu will substitute the diesel generation wherever it is economically feasible.

This paper describes the ongoing proggress of the exploratory drilling of Ulumbu field for the mini geothermal project and discusses the geoscientific investigation and environmental aspects during the drilling implementation.

2. SCIENTIFIC INVESTIGATION

The quaternary volcanics are distributed in the island of Flores mostly in the Central part of the region.

The most prominent volcanic region is Manggarai District, including the Ulumbu geothermal field, which has been selected as one of the first area for geothermal exploration due its high concentration of thermal manifestation.

A full scientific programme of geological, geochemical and geophysical exploration was carried to identify and assesses the resources.

Following this, two (2) deep exploratory well were drilled to check the result of the scientific investigations, so that geothermal energy development can be made on an extensive scale to ensure power production.

2.1. GEOLOGICAL SETTING

The Poco Leok volcanic complex within which the Ulumbu geothermal system occurs reach on elevation of approximately 1600 metres.

It has been erupted onto a miocene basement to comprise volcanics including lavas, breccias and tuffs and possible calcareous sediment of similar age. The complex be formed from tuffs and andesite lavas erupted from Mandosawu volcanic center approximately 7 kilometers to the north of

Poco Leok and successive lava flows and breccias of the Rii eruptions and later volcanism.

Renewed volcanism followed formation of the Rii Caldera and the product breccias and lavas known as the Poco Leok volcanic, partially infill it. The Poco Leok centre which is about 1.5 kilometres from the Ulumbu thermal features, has not been volcanically active historically.

The Ulumbu geothermal field on the flank of the Poco Leok volcanic complex at an elevation of some 650 metres above sea level.

The quaternary rocks rise to an elevation of approximately 1600 metres and rest on a Tertiary basement comprising mainly lavas, breccias and tuffs and possibly calcareous sediment.

The tertiary basement rocks to have been down faulted to south along an east-west trending fault known as Cancar fault.

The resulting Cancar depression is assumed to have been partially infilled successively by massive dacitic lava flow erupted during early quaternary volcanism centred north of Ulumbu probably in the vicinity of Mandosawu Volcanic Range.

3. GEOCHEMISTRY

The thermal features at the Ulumbu geothermal field are devided into 3 groups, namely the hot spring which has the hottes fluids (near local boiling point), hot spring with moderate temperature (maximum temperature 68°C) and warm spring (temperature 30 - 50°C).

The hottes fluids are those which discharged in the river Waikokor valley at elevation of 630 and 665 metres. The features include pools of boiling point water and fumaroles together with associated hydrothermaly altered ground wich discharge gas and steam. Geothermometry of the fumarole gases indicates a high sources fluid temperature, probably greater than 200°C and possibly as high as 300°C. Hot spring occurs some 1.5 km east of Ulumbu at elevation of 820 metres to 920 metres.

The chemistry of these spring is similar to those at Ulumbu except that they have a neutral pH and contain appreciable concentration of calcium and bicarbonate. And also similar origin to the Ulumbu features.

Warm springs occurs some 5 km west of Ulumbu at lower elevation 430 metres. The relative low sulphate content of these bicarbonate rich neutral pH waters indicates that they are most likely to have formed by condensation of high CO_2 or low H2S being steam into ground waters. No deep water being discharged in any of these features sample thus far. The steam and gas analyses indicates deep fluid temperature of the least 250°C and possibly temperature to 300°C. The water chemistry shows the warm spring in the west are farther from the source than those at Kokor and Lungar.

4. GEOPHYSIC

The Geophysical study include resistivity mapping, electrical sounding with maximum AB/2 spacing of 1000 metres and 2000 metres has been done at Ulumbu geothermal field.

The interpreted resistivity data for Ulumbu area shows a low resistivity layer sandwich between an upper shallow layer and basement of higher resistivity. The low resistivity layer has a model thickness of approximately 600 - 800 metres. The resistivity model shows a broad continous layer of very low resistivity between Rii Caldera and Wae Meseh. Where it intersects the ground, the top surface of this layer is closely associated with the locations and elevation of that springs. It is reasonable to conclude, therefore, that this layer is caused by hot geothermal fluids flowing through porous and altered rocks toward lower elevation in the west and southwest.

5. EXPLORATORY DRILLING

Two production wells ULB-01 and ULB-02 and one reinjection well was drilled whithin the Ulumbu geothermal system. Well ULB-01 was drilled vertically to a depth of 1887 metres and Well ULB-02 was drilled directionaly to a depth of 878.7 meters, 4,5 metres to the north east of well ULB-01. A reinjection well ULB-03 was drilled directionaly from the well ULB-01 pad in south easternly direction to a depth of 951 metres.

Environmental constrain preclude utilization of surface disposal of effluent geothermal fluids, such effluent fluids produced from the production well.

Information collected during the drilling of well

ULB-01 indicates underground formation to the total depth of 249 metres are mainly consistings of volcanic breccia, pyroclastic deposit (tuff) and volcanic lava (andsite) and formation from 249 metres to the total depth of 838 metres are mainly volcanic breccia interlayed by volcanic lava. Volcanic breccia shows relatively high degree of alteration that indicates fluid flows through rock porous.

The loss zone below 680 metres and possible presence of Adularia below 770 metres might indicates some reasonable permeable zone from 680 - 853 metres. The loss zone between 680 metres to 853 metres as the permeable zone also is indicated from the result of geophysical exploration. The formation to the total depth of 1887 metres are mainly calcareous sediment.

5.1. MEASUREMENT DURING DRILLING

Measurement within the drill string made during the drilling which was run into the well. The measured pressure at 450.7 m (CT) depth was 24.1 bar which is a water level at 214 m assuming a column of 20°C water.

The increase in temperature at about 670 m was also monitored. Monitoring exercise was carried out a further 38 hours later.

The temperature incured from 152.1°C to 166.4°C the heating rate indicated that high temperatures might be expected in this zone.

When the initial target depth for the well of 1500 m was monitored to evaluate the likely productivity of the well and to decide whether to drill to deeper levels. Rapid heating occured over the entire length of the well even at 700 m where there is a temperature inversal.

Simple Horner analysis of the temperatures built up data indicated formation temperature of about 240°C at 500 m, less than 200°C at 700 m and about 220°C at both 1000 m and 1480 m.

In general such analysis give minimum temperatures, however this information indicates that the major permeable zone in the well at about 700 m maybe relatively cold inflow.

However, it is interesting that that the stable well head pressure should reach about 27.6 bar, a pressure which is very close to the minimum pressure saturated steam at maximum enthalpy.

This would tend to indicate that there is steam cap the reservoir. The temperature excepted at this depth will be about 235°C if this is a steam zone. In an attempt to hasten the heating of the 700 m zone the well put on bleed through a 2 inch pipe.

The well was bleed for two hours during which time only gas, with a distinct smell of H_2S, was observed existing the bleed line.

The pressure of gas from the bleed line decrease over the two hours periode. With in thirty minutes of closing the bleed line a well head pressure of 9 bar was recorded and this steady increase a to 27.6 bar.

Immediatly after the well was shut in temperatures were recorded between 600 m and 800 m depth. The desired effect was achived in that temperature at 700 m increased from 123.99°C to 137.8°C however the temperature increase was not high as was excepted.

The geothermal water from the well was estimated to be approximately 40 tonnes/h. It is likely that this fluid originates from the 1800 m zone as similar drilling condition prior to reaching this depth did not result in greater fluids returns than were being pumped.

6. ENVIRONMENTAL ASPECTS

Some of the principle social issues raised during the exploration well drilling is the complains of the local communities to PLN :

The implementation of the realignment of the road away from Lale, in order to avoid the discruption of having heavy vechicles and other trafic pasing through the midle of the village.

The implementation of the special religous ritual for land compensation of the drilling site (ULB-01, ULB-02), because this drilling site is a Lingko Rame owned by peoples of village of Wewo.

According to the local tradition a Lingko Rame is direcly related to a Rumah Gendang and is owned and exploited by the Tua Teno (head man) and his rural elite family. This special agriculture field is inherited from one generation on the other generation. The Lingko Rame at the drilling site (ULB-01, 02 and 03) is called Lingko Nio. It is very fertile field.

The local communities has give an alternative to realignment of the temporary road to the land behind the village. The people has no objective to give their land away to clear the way for the alternative road.

7. CONCLUSIONS

Resistivity data, together with the distribution and chemistry of fumaroles and hot springs suggest the existence of an extensive hydro thermal system centred in the Poco Leok - Ulumbu locally.

The geothermometry indicates a source fluid temperature probably greater than 260°C.

The result of exploratory drilling, especially ULB-01 which was drilled to a depth of 1887 m with the top 838 m consisting of volcanic breccia with subordinate andesitic and basaltic lavas and tuffs. These volcanic rocks are quaternary age.

The 1049 m of rocks in the lower part of well belong to the Flores Island tertiary sedimentary sequence.

Hard limestones make up over half of this sequecne, the remainder of the tertiary rocks are dominated by volcano clastic (sand stones). Laumontite is found to be stable in the temperature range of 150°C to 220°C and within ULB-01 is observed within the quaternary volcanic below 400 m.

Epidote was observed in the well below 700 m, indicating that temperature below this depth should be in over 230°C to 250°C.

Major zone of permeability have been found at about 680 m and at about 1800 m. A minimum of 40 tones/h can be produced from the well.

In order to avoid social complict, PLN have to be taken to solve the problems of realignment temporary road and special religious ritual is needed to establish a Lingko Rame.

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