GEOTHERMAL FLUIDS AND SURFACE MANIFESTATION IN GOU AREA, FLORES ISLAND: AN APPLIED OF GEOSCIENTIFIC SURVEYS

Herry Sundhoro, Sjafra Dwipa, Janes Simanjuntak, Asnawir Nasution,
Arif Munandar, Setiadarma, Ashari, Rachman Hasan.

Volcanological Survey of Indonesia, Jl. Diponegoro no 57 Bandung, Indonesia.
Phone: 022-7272604, fax: 022-7202761

Key words : Gou area, geothermal fluids, surface manifestations, applied of geo ssientific surveys

ABSTRACT

The accessbility of geothermal fluids from the bottom to the surface is marked by geothermal surface manifestations, such as: hot springs, steams, gasses and altered rocks.

It is important to understand the relationship between fractures or faults and geothermal manifestation on the surface. The general relationship between fractures or faults and geothermal surface manifestation presumably could be identified by geoscientific survey. The geo scientific survey in Gou geothermal area uses 3 combined methods, those are geological, geochemical, and geophysical surveys.

General view for Gou area are: stratigraphy is contributed by volcanic and sediment Quaternary rocks, while those rocks is underlain by the Tertiary basement rocks

The high contour values of mercury belong to soil air is concentrated around Managara and Watuh Wuti hot springs, which the maximum concentration of Hg is up to 564 ppb. The lateral distribution of low resistivity (< 10 Ω m) is concentrated also around those hot springs, and it is opened to the north-east area, while the concentrations area of these low resistivity is least 2 Km^2 . The vertical distribution of low resistivity is between 350 – 700 m beneath the surface and maximum penetrated is only 700 m depth. This phenomena appears, that altered rocks in this area is formed by geothermal fluids.

This paper discuses result of geoscientific in Gou area, Flores island, and the tentative model is presented.

1. INTRODUCTION

Gou geothermal area is located about 4 Km Northern part of Bajawa city, Ngada district, Flores island, East Nusa Tenggara. The surveyed area covers an area of about 10 km^2, and it lies between 8°42'00" - 8°44'50" S latitude, and 121°03'30" - 121°07'00" E longitude **(Figure-1)**.

Ngada district has a population of about 211.000 peoples. The rain fall average in this area is low, only 139 mm/year. The installed electric power generated from diesel is used for domestic energy demand, such as: lighting, industrial, harbour, transportation, hotel/ restaurant, hospitals, education etc (Ngada dalam Angka, 1996)

Stratigraphy of Gou area is contributed by volcanic, and sediment Quaternary rocks,. while those rocks is underlain by the Tertiary basement rocks. Geothermal discharges are: hot springs, and slightly altered rock. Both manifestations occur along conduit of the NE-SW trending faults. It's named Mengeruda fault.

The utilization direct use geothermal energy in Ngada district could supports an economical growth for people and the local government. The most simplest and cheapest utilization of the direct use geothermal energy here are used for swimming (pool), bathing, and might be for curing or SPA. How ever a small scale geothermal power was being explored in Mataloko for next alternative energy demand here. It is approximately 10 km in the southern part of the surveyed area.

The aim of geoscientific surveys in Gou geothermal area is to identified a general relationship between geothermal fluids beneath the area and surface manifestations, which fractures or geological structures are the major channel for transfering it from the bottom to the surface.

2. SURFACE MANIFESTATIONS AND ALTERATION

Thermal features on the surface of Gou area occur along a conduit in the NE-SW trending fault (Mengeruda fault). Features include hot springs, and altered rocks. The Hot springs temperature are up to 47.5°C, and all waters are characterized by a high concentration of acid sulphate water discharges at the surface. Surface alteration of argillitic type occur also in the vicinity of hot springs along the Mengeruda fault

3. THE RESULT OF GEOSCIENTIFIC SURVEYS

Flores island is a part of Banda Island arc, which comprises Upper Cenozoic volcanic rocks with volcanogenic and carbonate sediments (Hamilton,1979).

The volcanic rocks are dominantly of mafic to intermediate calc-alkaline composition, and are uncorformably underlain by the Tertiary rocks. The oldest rocks are sedimentary of Miocene age, and exposed at Nangapanda village in the southern part of the island (Bemmelen, 1949). The Quaternary rocks in area is derived from Mt. Inie Lika, It is approximately abaut 2-3 km in the Western part of the surveyed area. The volcanic rocks from the oldest to the youngest consist of: Bajawa syn-caldera rocks unit, Lacostrin sedimentary rocks, Mt. Mataloko volcanic rocks unit, Mt.Inie Lika lava, and the secondary or surficial deposits is alluvial. These volcanic rocks are dominantly of andesitic to basaltic andesite composition, there is however a dacitic- ryolitic rock. This rock is belong to Bajawa caldera products (syn-

caldera rocks unit) **(Figure-2)**. The primary minerals present in the Quaternary volcanic rocks are mainly: plagioclase, orthopyroxene, clinopyroxene, and volcanic glass.

Three hot springs discharge have risen up into the surface along the NE-SW geological structures, these are: Managara, Watuh Wuti and Tukapela hot springs. The flow rates of these hot springs are between 5-7 l/ minute. The maximum temperature to the surface is only 47,5°C. All hot springs are acid sulphate water types **(Table-1)**. The high concentration for Mercury belong to soil air is around Managara and Watuh Wuti hot springs, which concentration of Hg is up to 564 ppb. The high concentration of Hg around Managara and Watuh Wuti hot springs is clearly due to a NE-SW trending fault or fractures as a conduit.

Lateral distribution of low resistivity (< 10 Ωm) is clearly also concentrated in those hot springs, and it is opened to the north-east area. This prospect area least cover 2 Km^2. Vertical distribution of low resistivity (< 10 Ω m) is between 350 – 700 m depth, where as the maximum penetrated is only 700 m beneath the surface. The apparent resistivity in line B, C, D & line E show that, the thickness of the overburden resistive layers are approximately 350-600 m, and the top of clay cap layer is probably also between 350–600 m beneath the surface, where as the maximum penetrated is only 700 m thick **(Figure-3)**. All layers below clay cap is assumed to be a liquid or a steam reservoir, Which them boundary could not be detected yet during surveyed.

The tentative geothermal model in Gou area is presented in **Figure-4**. It shows that Gou manifestations are probably included into the up flow geothermal system, while the out flow geothermal system is located in the outer side of 2 Km^2 prospect area, It is located to the north-east of the prospect area.

4. DISCUSSIONS AND CONCLUSION

A reasonable conclusion is that hydrothermal fluids (hot water, steams and gasses) are rising up along the NE-SW geological structure or fractures in Gou area. The presence of surface manifestations are a referenced for starting a geoscientific surveys. The geothermal surface manifestations in Gou, such as: hot springs, steams, gasses and altered rocks are presumably also indicated to presence a geothermal energy beneath the area.

A lot of geothermal phenomena have presented in Gou area, such as: thermal features on the surface (hot water, fumaroles and other geothermal surface manifestations), altered rocks, high concentration of mercury, lateral distribution of low resistivity, and vertical distribution of low resistivity. These phenomena appear those all of them are due to geothermal fluids (hot water, steams or gasses).

During surveyed the maximum penetrated is only 700 m. The continuing survey is strongly suggested in Gou area by CSAMT or MT methods. These methods probably will be able to identifing the deeper rock formations in sub surface. The continuing resistivity survey for AB/ 1000 m is suggested also to the north – east area. This survey will be extensively clearer a geothermal prospect area in Gou.
The 2 Km^2 prospect area is presumably included into up flow geothermal system, while acid geothermal fluids are flowing down in shallow depth near the surface into the out flow geothermal system. The out flow geothermal system area is expressed by the 300-400 l/sec flow rate of acid hot spring in Mengeruda.

ACKNOWLEDGEMENT

We thank the Volcanological Survey of Indonesia for permission to publish this paper

REFERENCES

Bakosurtanal (1993) *Foto Udara Flores*, skala 1 : 50.000.

Fournier, R.O (1981) *Geothermal Eksplration and Reservoir Engineering System: Principles and case Histories*. John. Willley & Sons, New York.

Geothermal Resources Councill (1982) *Fractures in Geothermal Reservoirs*. Special Report No. 12. August 27 and 28, 1982.

Research Cooperation Project between VSI and NEDO, GSJ, West Jec, MMRC on The Exploration of Small Scale (1998/ 1999), *Geothermal Resources in The Eastern Part of Indonesia*.

Sundhoro.H, et al, 1999, *Penyelidikan Geologi, Pemetaan Alterasi Ddaerah Panasbumi Gou, Kab. Ngada, P.Flores, NTT* Perpustakaan Sub.Dit.Panas bumi, Dit. Vulkanologi.

Table-1
The Actual Chemistry Data for Hot Springs In Gou, Flores Island

Constituents	Managara	Watuh Wuti	Tukapela
PH	3.66	2.99	2.66
Cl^-	28.59	120.67	339.95
$SO_4^=$	412.24	556.68	794.12
B	1.26	1.00	6.00
SiO_2	88.00	122.00	124.00
Na^+	25.63	35.00	74.04
K^+	7.02	15.32	25.32
Li^+	0.61	1.47	3.11
Ca^{++}	114.79	128.70	163.48
Mg^{++}	6.26	22.96	58.44
HCO_3^-	0.00	0.00	0.00
Fe^{+++}	1.00	4.50	5.50
NH_3	0.05	0.07	0.13
As	0.07	0.13	0.24
F	1.00	1.00	2.00
Conductivity µhos/ cm^2	1050.00	2600.00	4600.00

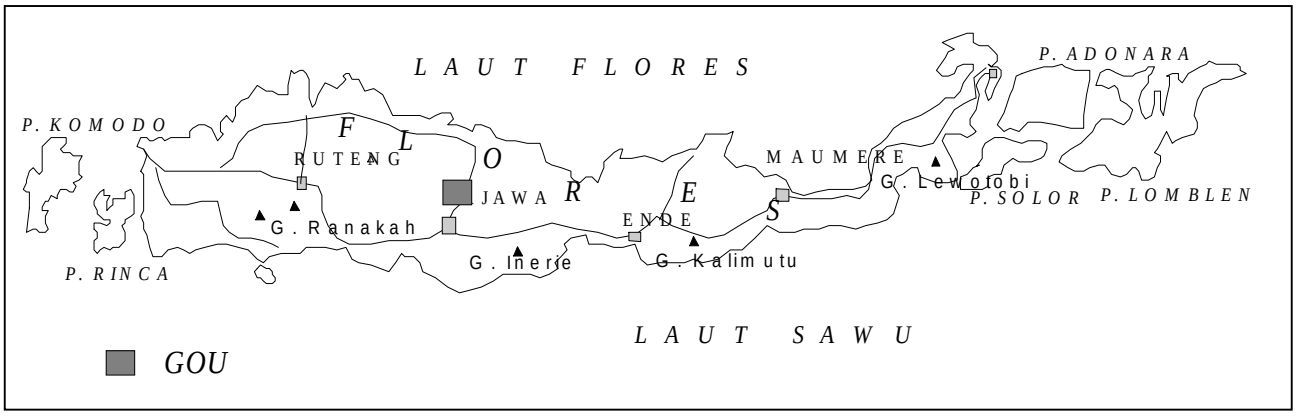

Figure-1
Location Map Of The Survey Area.

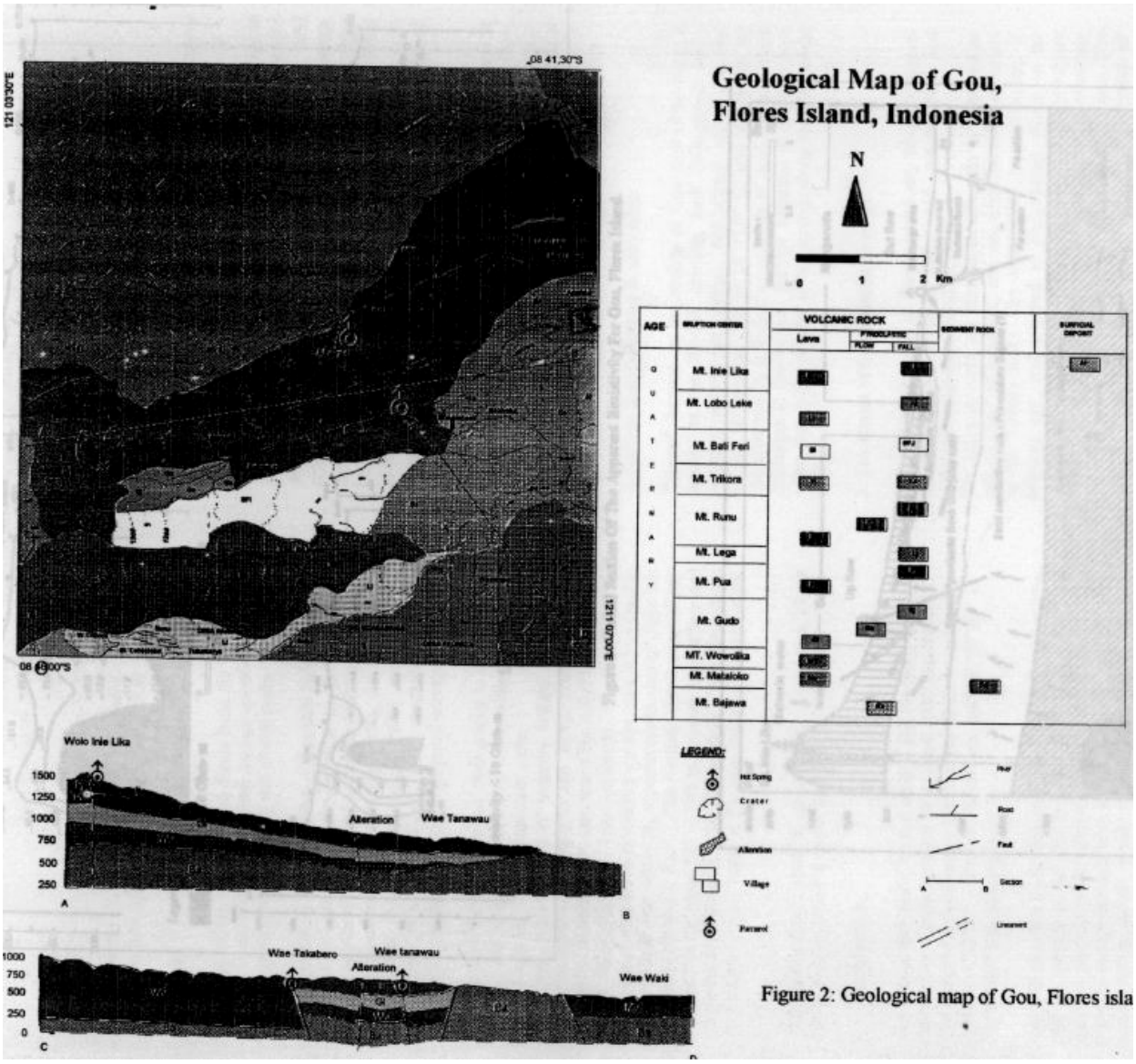

Figure 2: Geological map of Gou, Flores isla

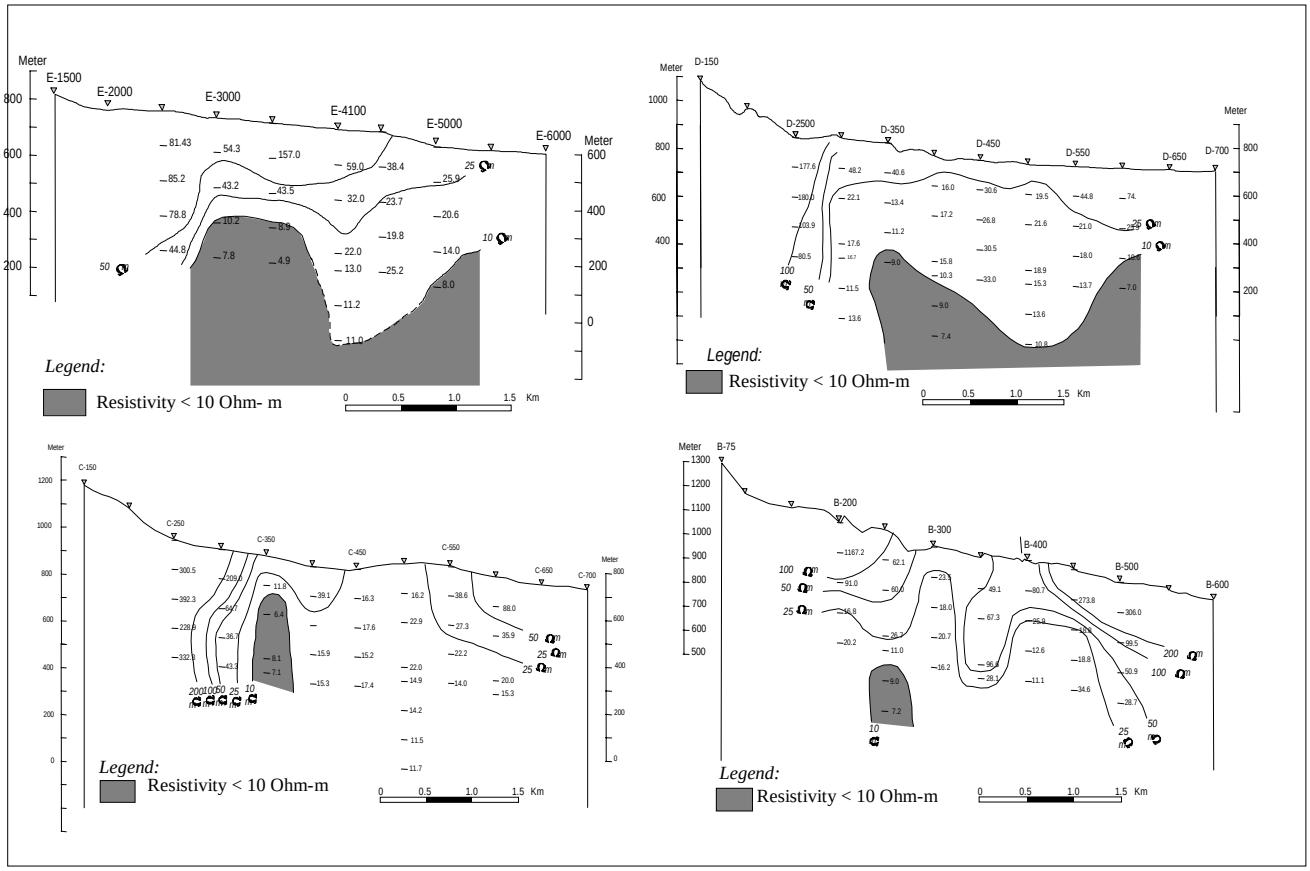

Figure-3
Verical Section Of The Apparent Resistivity For Gou, Flores Island.

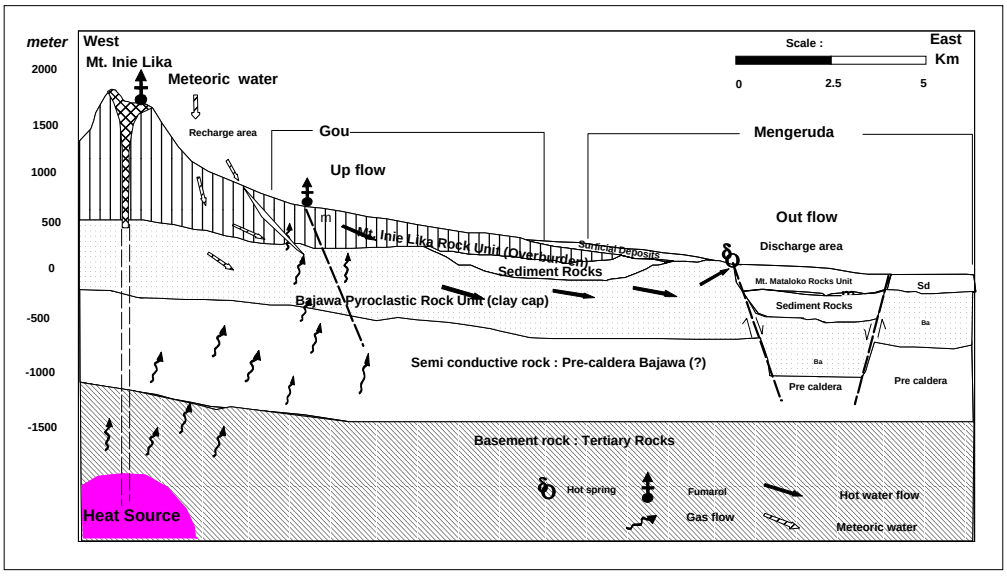

Figure-4
Tentative Model of Gou Area, Flores Island, Indonesia