Proceedings World Geothermal Congress 2010
Bali, Indonesia, 25-29 April 2010

Interpretation of DC Resistivity Data to Recognized Geothermal Prospect at Sampuraga, North Sumatera, Indonesia

Asep Sugianto and Bakrun

Geological Agency, Jl. Soekarno – Hatta No.444 Bandung, Indonesia

zhoegee@yahoo.com

Keywords: geothermal, resistivity, Sampuraga

ABSTRACT

Sampuraga is one of the geothermal areas in Sumatera. There are hot springs with temperature ranging from 97 to 100.8 ^{o}C, neutral pH and flow rate ranging from 2 to 4 liter/second. Resistivity survey was to know geothermal prospect in this area. This method was used to predict the depth and thickness of cap rock, and determine the location of top reservoir. The array measurement method was schlumberger configuration. The results indicated that low resistivity zone covered Sampuraga hot springs, with the area of 7 km^2. The depth of cap rock is about 200 – 500 m and its thickness is 500 – 700 m. The depth of top reservoir is about 650 – 800 m.

1. INTRODUCTION

Sumatera Island is one of the biggest islands in Indonesia which has great geothermal potential. The area of this island is 84 km^2, which has potential power of 13.419 MWe (Status 2008) which is mostly distributed along volcanic arcs. Sampuraga is under Mandailing Natal regency, and North Sumatera Province is one of these. The area is 13 km south-west from Panyabungan City (Figure 1).

Detailed survey in this area is needed to know geothermal prospecting. Resistivity is one of the most frequently used geophysical methods in geothermal survey. This method can give good results to show geothermal promising zone in the volcanic areas.

2. GEOLOGY AND SURFACE MANIFESTATIONS

Sampuraga area is located in Panyabungan depression zone ‘Panyabungan Graben’ which is part of Sumatera Fault. This area is not far from an active volcano ‘Mt. Sorik Marapi’ that is 15 km northwest to Sumatera volcanic arc ‘Mt. Bukit Barisan’. The area can be divided into Volcanic Tertiary Rocks and Quaternary Rocks according to geology. The composition of Volcanic Tertiary rocks is mainly andesitic, while Quaternary rocks are mainly consisted of Volcanic Quaternary rock, and the composition are dacitic and sedimentary rock. Structure of geology in this area is mainly SW-NE normal fault (Figure 2).

Thermal surface manifestation in this area is fumarola with a temperature of 97 ^{o}C and pH acid. Hot springs had temperatures ranging from 97 to 100.8 ^{o}C, pH neutral and flow rate ranging from 2 to 4 liter/second.

3. DC RESISTIVITY SURVEY IN SAMPURAGA

A resistivity survey was conducted in 2007 at Sampuraga area, North Sumatera, Indonesia using Schlumberger configuration. The measurement was divided into mapping (AB/2 = 250 m, AB/2 = 500 m, AB/2 = 800 m, and AB/2 = 1000 m) and sounding (AB/2 = 1600 – 2000 m). The total measurement included 46 mappings and 17 soundings along line surveys with direction NE-SW. (Figure 3)

4. DISTRIBUTION OF APPARENT RESISTIVITY

Contour maps of apparent resistivity are shown in Figures 4 – 7. Figure 4 shows the contour map of apparent resistivity with AB/2 = 250 m. In this map, a low resistivity anomaly concentrates around sampuraga hot spring and elongates to southeast (Sirambas Village). Figure 5 shows the contour map of apparent resistivity with AB/2 = 500 m. In this map, a low resistivity pattern is concentric around Sampuraga hot spring and wide to SW – SE.

A Contour map of resistivity with AB/2 = 800 m is shown in Figure 6. The contour of resistivity pattern is similar to that AB/2 = 500 m, except that the low resistivity anomaly now is longer extended to west of the AB/2 = 500 m. A low resistivity anomaly is disposed cover in southeast of Sampuraga hot spring.

The pattern of apparent resistivity with AB/2 = 1000 m is shown in Figure 7, which shows it is similar to that AB/2 = 800 m. In this map, a low resistivity anomaly is concentric around Sampuraga hot spring and wide to north and southwest, and then elongates to southeast survey area. Nevertheless, the width of low resistivity area with AB/2 = 1000 m is more extensive than the AB/2 = 800 m.

A low resistivity anomaly is generally concentric around Sampuraga hot spring. In addition, the wider the AB/2, the bigger the low resistivity zone (Figure 7).

The area of geothermal indication is shown by distribution low apparent resistivity with AB/2 = 1000 m. Based on geological data, the rocks around hot spring area are volcanic rocks, so the low apparent resistivity in this area is predicted as rocks – geothermal fluids interactions. The width of low apparent resistivity zone is 7 km which is concentric around Sampuraga hot spring and elongates to north, southwest, and southeast.

5. RESISTIVITY MODELLING

The result of sounding measurement is shown in true resistivity cross section. This paper shows three sections which are line D, line E which is through hot spring areas, and combination section through every line. In general, Rock units can be divided into three resistivity groups, that is, low resistivity group, middle resistivity group and high resistivity group. The resistivity value of low resistivity group is less than 10 Ohm-m, middle resistivity value ranges from 10 to 40 Ohm-m, and high resistivity value is more than 40 Ohm-m.

A low resistivity layer is associated with saturated pyroclastic rocks which are predicted to be cap rock. The layers have thickness variously with ranging from 500 m to 700 m and depth ranging from 200 m to 500 m. The low resistivity layer which is over this layer is predicted as aquifer of groundwater.

High resistivity anomalies are below the low resistivity anomalies. It is associated with andecite porpiry lava which is predicted geothermal reservoir of Sampuraga area. Top of this layer is depth ranging from 650 m to 800 m.

Figures 8 and 9 show geological structure that controls the appearance of hot springs on the surface. These structures are predicted from geological data.

Resistivity model is resulted from 1-D modelling which is shown by Figure 11. This figure shows that the top of clay caps is below hot spring areas with shallow depth and thin layers. In this case, heat source is closer to surface than around area, so that this area is good to show geothermal indication which can be energy sources.

DISCUSSION

The use of resistivity method in this area is optimal. The results of resistivity survey in this area give relatively clear information about geothermal activities. The rocks with low apparent resistivity are predicted as clay cap of geothermal system in this area.

Reconstruction of resistivity model based on 1-D sounding modelling was made to describe geothermal systems in this area (Figure 12). Based on this reconstruction, geothermal reservoir is predicted below a cap rock which is relatively thin. Surveys with other methods like magnetotelluric or drilling are needed to support these results.

CONCLUSION

Geothermal indication in Sampuraga area is shown with appearance of hot springs and distribution of low apparent resistivity which is a boundary of these are decided with lateral distribution of apparent resistivity. This area is concentric around Sampuraga hot spring and elongates to north, southwest, and southeast. The width of this area which shows geothermal indication is about 7 km. The clay caps which are below hot spring areas with relatively low thickness show that heat source is near to surface.

ACKNOWLEDGEMENT

The authors would like to thank Dede Iim, Dudi Hermawan, Dedi Kusnadi, and Dahlan for discussions on geology and geochemistry of Sampuraga area.

REFERENCES

Akbar, N. 1972. Inventory and Early Survey of Geothermal Indication at West Sumatera, a part of Geothermal Energy Project. Official of Volcanology. Directorate of Geology. Bandung

Dobrin, M.B. 1981. Introduction to Geophysical Prospecting. McGraw Hill. New York.

Lawless, J. 1995. Guidebook: An Introduction to Geothermal System. Short Course. Unocal Ltd. Jakarta.

Pertamina, Geothermal Division. 1991. Integrated Survey of Geology, Geochemistry, and Geophysics at Sorik Marapi Area, North Sumatera, Indonesia.

Suhanto, E. et.al. 2007. Characteristic of Resistivity Structure at High Temperature Geothermal Area: Case Study Jaboi Geothermal Area – Weh Island. *Buletin Sumber Daya Geologi* 2 (1): 33 – 41.

Telford, W.M. et.al. 1982. Applied Geophysics. Cambridge University Press. Cambridge.

Tim Survei Terpadu. 2007. Report of Integrated Survey in Sampuraga Geothermal Area, Mandailing Natal Regency, North Sumatera Province. Center for Geological Resources. Departement of Energy and Mineral Resources Indonesia (Unpublished report).

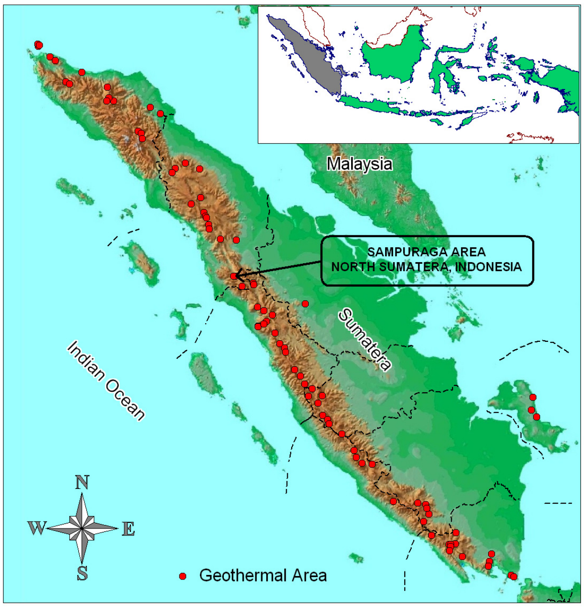

Figure 1: Distribution of geothermal area in Sumatera, Indonesia

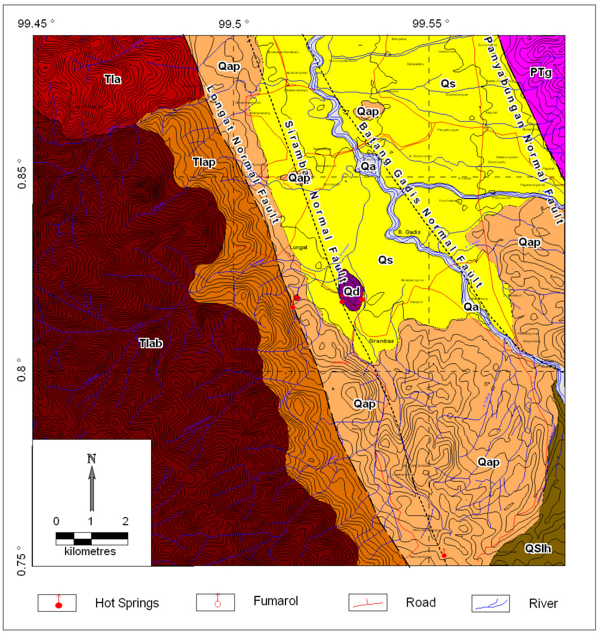

Figure 2: Geological Map of Sampuraga Area, North Sumatera, Indonesia (Modified from Iim D., etc, 2007)

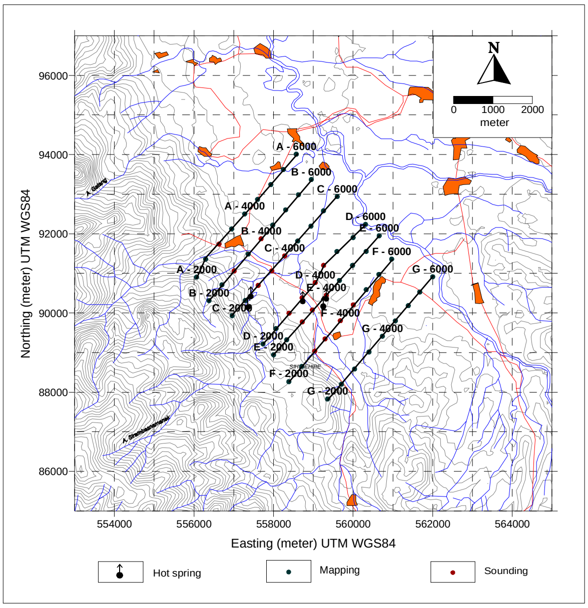

Figure 3: Resistivity survey points in Sampuraga area

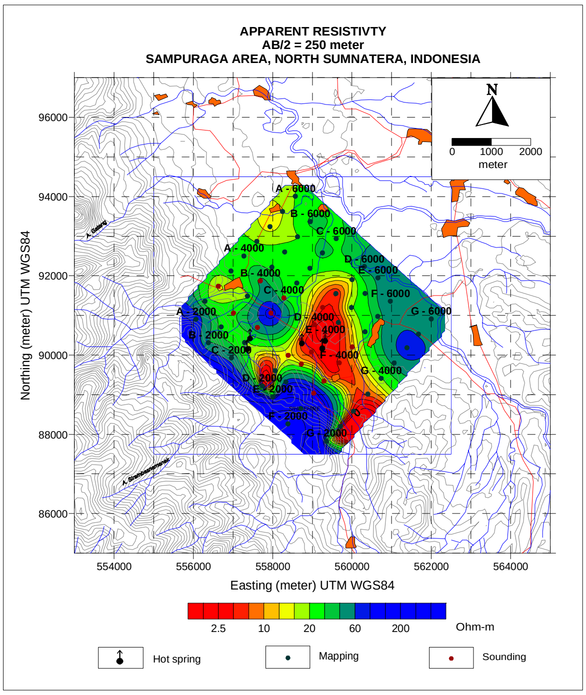

Figure 4: Apparent resistivity map with AB/2 = 250 m

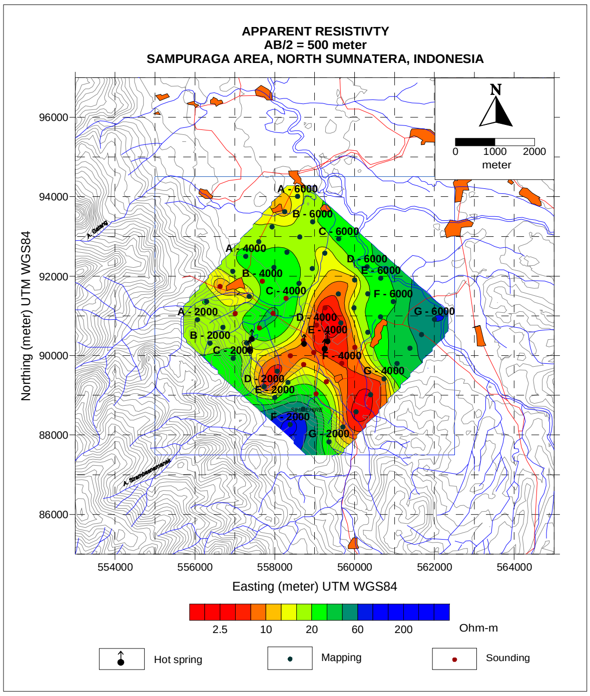

Figure 5: Apparent resistivity map with AB/2 = 500 m

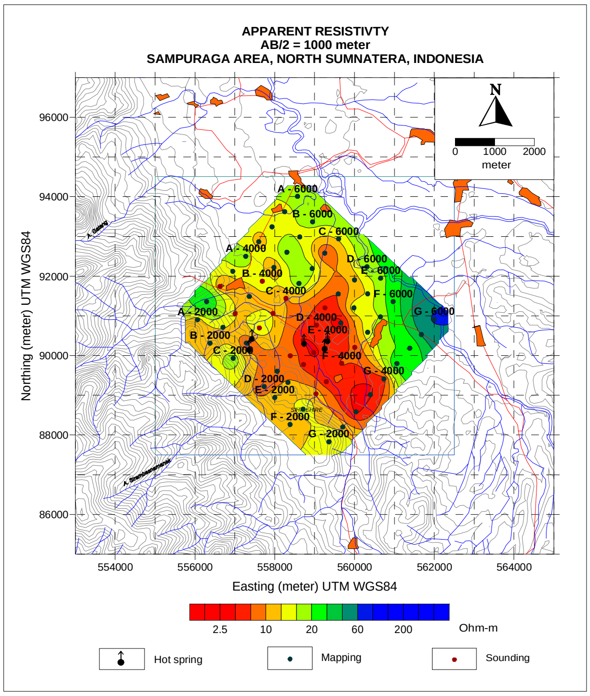

Figure 7: Apparent resistivity map with AB/2 = 1000 m

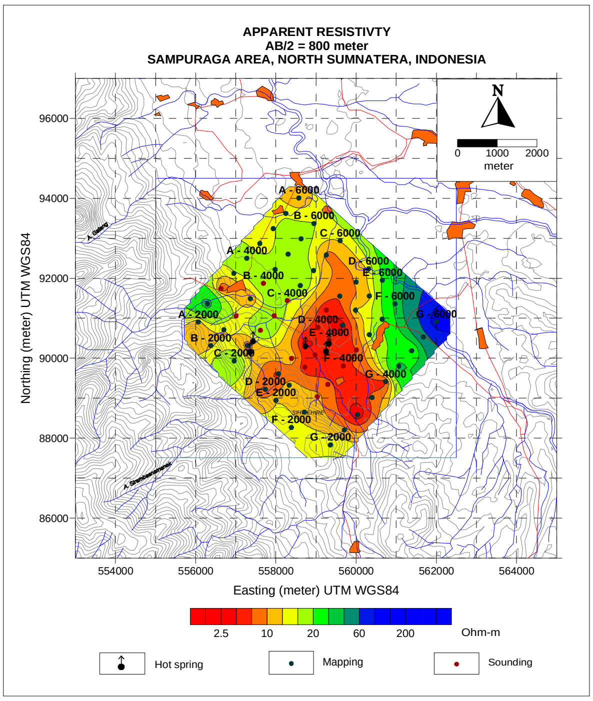

Figure 6: Apparent resistivity map with AB/2 = 800 m

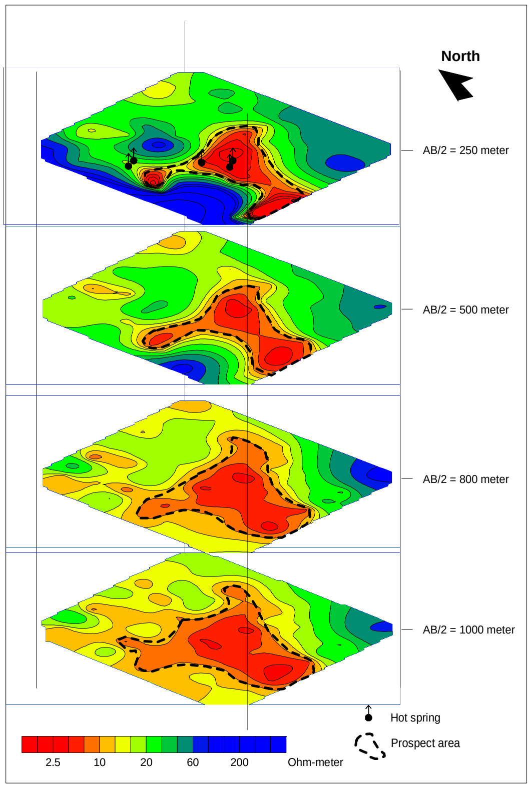

Figure 8: Combination of apparent resistivity

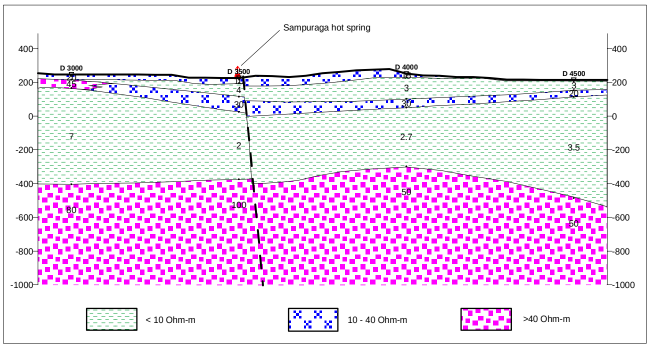

Figure 9: Resistivity cross section of Line D

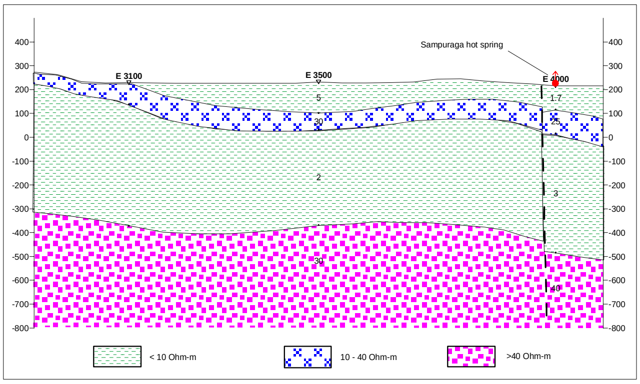

Figure 10: Resistivity cross section of Line E

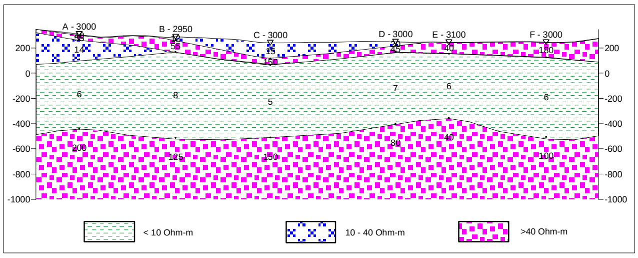

Figure 11: Resistivity cross section which through every line

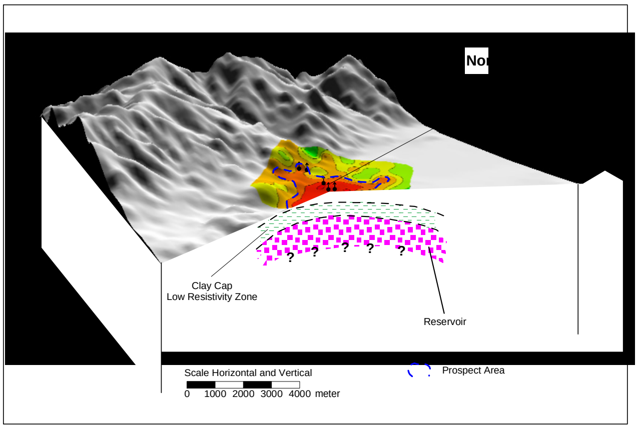

Figure 12: Tentative model of resistivity based on 1-D modelling sounding data