IOSR Journal of Applied Geology and Geophysics (IOSR-JAGG)
e-ISSN: 2321–0990, p-ISSN: 2321–0982.Volume 4, Issue 6 Ver. I (Nov. - Dec. 2016), PP 67-71
www.iosrjournals.org

The heat conductionflow studyaround AUMgeothermal area of South Sumatera

F.Virgo[1, 2], Erni[2], W. Suryanto[3], Wahyudi[3]
[1](Postgraduate Student, Physics Department, GadjahMada University, Indonesia)
[2](Physics Department, Sriwijaya University, Indonesia)
[3](Physics Department, GadjahMada University, Indonesia)

Abstract: *The heat conduction study had been done around the Airklinsar-Ulu Musi (AUM) geothermal area, Empat Lawang Regency, South Sumatra. The study was carried out the measurements of surface temperature and temperature gradient. Surface temperature measurement data were used for the determination of the prospect area and thermal conductivity of rocks. Then, the temperature gradient measurement data were used to determine the value of geothermal temperature gradient. The parameters obtained, was used to calculate the value of the loss energy of heat conduction naturally. The study showed that the amount of heat energy by conduction was ± 5132.232 Watt.*

Keywords: *Conductivity, geothermal, temperature, gradient, thermal.*

I. Introduction

The Airklinsar village is located in Ulu Musi, Empat Lawang Regency,South Sumatra, Indonesia. The UTM Coordinates are X: 247256 and Y: 9577991. There are several geothermal manifestations, such as some hot springs, the warm ground and altered rocks. The manifestation area is about 4500 m^2, who's probably geothermal potential.

The geothermal potential is prospected to be developed into the power plants. It is shown by hot springs temperature ranging up to 65°C, type of fluid is cloride (pH=7), and reservoir temperature estimate higher than 320°C [1]. Accordingly the reservoir temperature is above of 225°C, which classified as high-temperature geothermal systems [2]. However, the estimated potential of geothermal reserves can be used as a power plant still unexposed. Information about the magnitude of the natural heat loss value either by conduction or convection is very important in the estimation of the potential of geothermal reserves.

For that reason, the study of the flow of heat conduction in this area has been conducted. The goal is to expose the value of the loss of heat energy that flows naturally to the surface in conduction. The benefits of the study can be combined with the value of the natural convection heat loss in the calculation of the total natural heat loss. Furthermore, the natural heat loss value of the total was used to estimate the potential reserves of geothermal energy.

II. Theory

2.1 Heat conduction

The heat can transfer with three ways: conduction, convection and radiation. Conduction of thermal conditions controls on the part of the solid earth, especially on the lithosphere. Convection dominates thermal conditions in the area are fluid, core and mantle. Heat transfer convection mass transfer followed by heat. In the Earth, radiation occurs only at the core part and the lower part of the coat. So the flow of geothermal heat in only related to heat transfer in conduction and convection.

Heat conduction can occur due to the transfer of kinetic energy of molecules or atoms in a hot object to a cooler object. Conduction can occur in medium solid and liquid, and is expressed by the following equation of Fourier; [3]

$$\vec{q} = -k\,\vec{\nabla}T \tag{1}$$

Where $\vec{q}$ is the heat flow per unit area per unit time (also known as heat flow), k is the thermal conductivity of the object (assumed isotropic) and $\vec{\nabla}T$ is a temperature gradient. The negative sign indicates heat flow toward the temperature decreases. In this case, the heat flow is considered toward the earth's surface, i.e. $k\,(\partial T/\partial z)$, wherein z in the vertical direction to the bottom. $(\partial T/\partial z)$ is called the geothermal gradient by unit $^{o}Ckm^{-1}$ or mKm^{-1}. The thermal conductivity depends on the natural conditions that fed heat (units in $Wm^{-1}K^{-1}$), and influenced by physical conditions such as temperature.

The magnitude of the rate of heat flow conduction to the surface can be calculated using the following equation: [4]

$$Q = A\,k\,dT/dz \qquad (2)$$

Where Q is the conductive heat flow (Watt), A is the surface manifestation (m^2), k is the thermal conductivity (W/m°C), and T is the temperature (°C).

2.2 The conductivity of rocks

The determination of the value of the thermal conductivity of rocks from the results of the measurements obtained from the following relations: [5]

$$T = Q\,(4\pi k)^{-1}\ln(t/t_0) \qquad (3)$$

$Q/4\pi k$ is the gradient of temperature change (m), so it can be written:

$$k = Q/4\pi m \qquad (4)$$

Where T is the temperature measured (°C), Q is the heat flow generated by the gauge (Watt), k is the thermal conductivity of rocks (W/m°C), t_0 is the initial time measurement (seconds), t is the time of the end measurement (seconds), and m is a temperature gradient (°C/m).

The knowledge of thermal conductivity of materials is one of the main input parameters in geothermal modelling since it directly controls the steady state temperature field. An evaluation of this thermal property is required in several fields, such as designing ground source heat pump plant, modelling the deep geothermal reservoir structure, assessing the geothermal potential of subsoil [6].

III. Method

The equipment used in this study as follows; 1.5 m stick electronic thermometer is used to measure surface temperature. Stick electronic thermometer of temperature gradient of 2.5 m is used to measuring the vertical temperature gradient. Shallow drilling tools are used for shallow drilling. The stopwatch is used as a timer measurement. GPS is used to determine the position of the measurement. Digital thermometer is used to measure air temperature and manifestations.

The procedures for temperature monitoring using an electronic thermometer with five sensors planted as deep as 2 m, monitoring done during 48 hours in one-hour intervals. The measurement is performed at each of three different positions of manifestation. The goal is to find out the depth of temperature measurement is no longer influenced by the secular variation.

The measurement of the surface temperature procedure is as follows; stick of the electronic thermometer inserted into the ground as deep as 1 meter. Measurements made at any point during the 15 minutes, within area 800 x 800 m^2. The number of measurement points is 84 points. Temperature changes on record in the minutes to 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 200, 300, 400, 500, 600, 700, 800, 900. After that, the value of the measured temperatures is plotted into a graph as a function of time. From the graph can be defined gradient dT/dt. The value of this gradient is used in the equation (4), to determine the value of the thermal conductivity of rocks.

The temperature gradient measurement procedure is as follows; the measurement is carried out on the three different positions around the manifestation. Measurement using an electronic temperature gradient stick that was planted at a depth of 2 m. The stick is equipped with temperature sensors for each interval of the depth of 0.5 m to get good results, this embedded thermometer left in advance in 1 day 1 night, so going to the environment temperature equilibrium. After that, the temperature changes recorded each of the intervals of 0.5 m. Furthermore, the value changes of temperature as a depth function or the vertical temperature gradient will be obtained.

IV. Results And Discussion

Measurement results of temperature monitoring at three different positions can be seen (Fig. 4.1, Fig. 4.2, and Fig. 4.3). According to the third of the picture, at a depth of 0 m can be seen that the influence of the secular variation very dominant, especially from the sun. The influence can still be seen up to a depth of 0.5 m, although much smaller than the depth 0 m. Instead of each sensor in a depth of 1 m, 1.5 m and 2 m, seen that the temperature measurement is relatively constant with respect to time. Based on the above, the measurement of the surface temperature should be done at a depth of 1 m, because the secular variation does not affect the measurement.

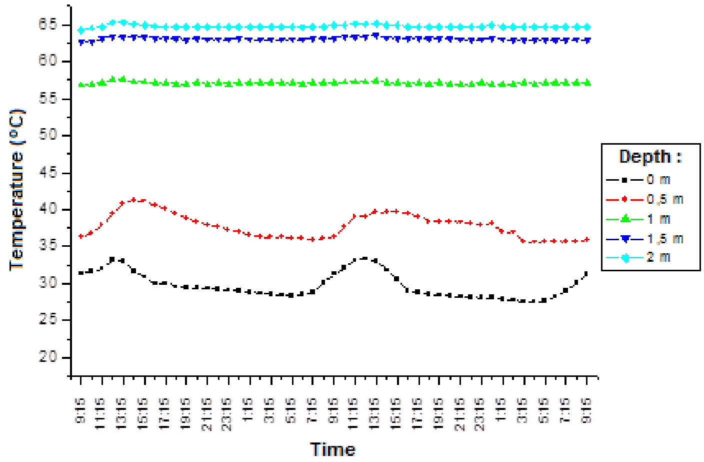

Fig. 4.1: Graph of temperature changes, at the point of monitoring-1.

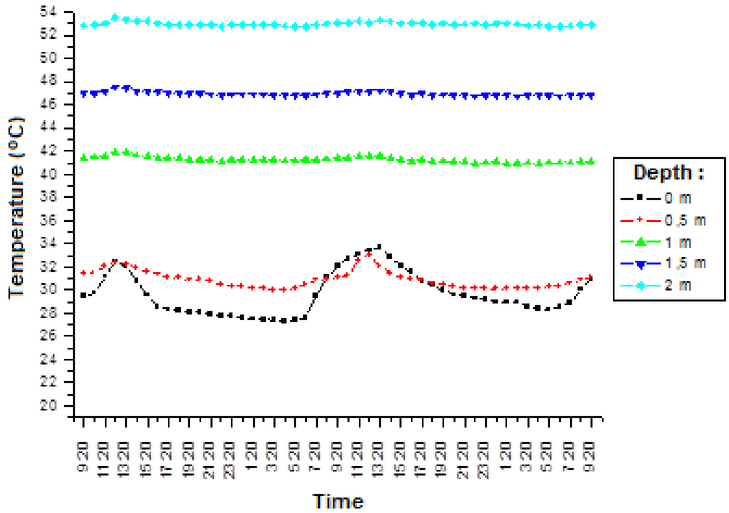

Fig. 4.2: Graph of temperature changes at the point of monitoring-2.

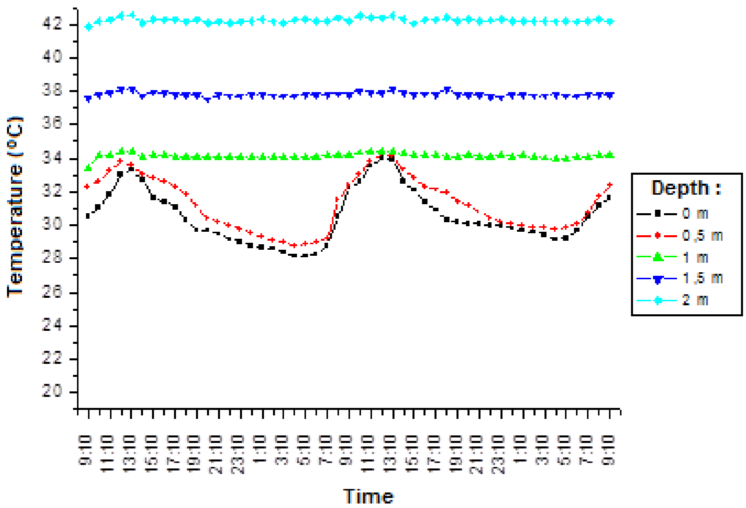

Fig. 4.3: Graph of temperature changes at the point of monitoring-3.

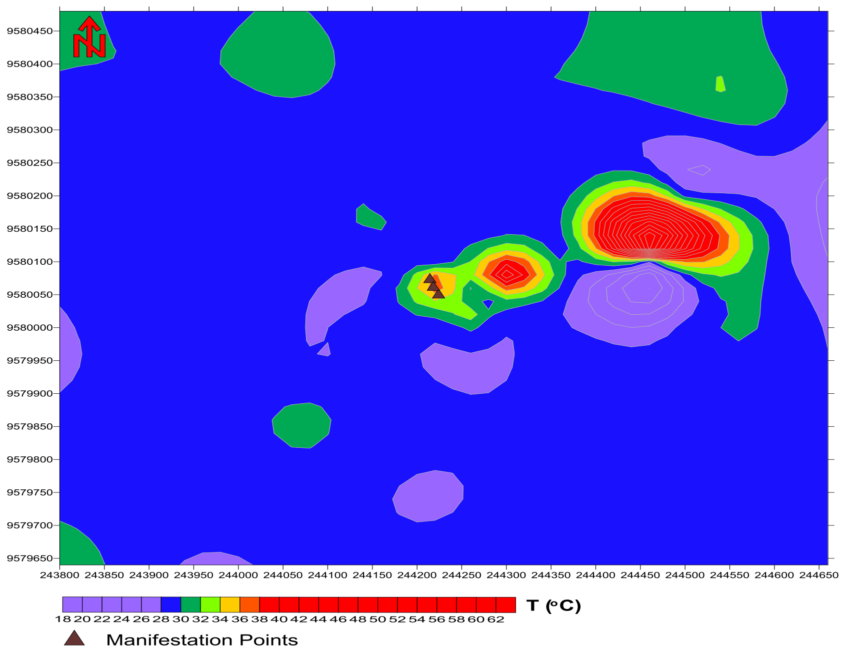

Fig. 4.4. Surface temperature distribution map in the study area.

Distribution of closer contour patterns of surface temperature (see Fig. 4), can be considered as a hot prospect area extension. Later, the area is calculated using software Rockwork. The results of the calculation of the total area of the region the prospects obtained is ± 8400 m^2. This area was later used in the calculation of the magnitude of the loss in natural heat conduction.

Measurement of the surface temperature at a depth of 1 m temperature gradient values obtained at each measurement point. Using Equation (4), the value of thermal conductivity measurement at each point can be determined (Qtools = 10.99 Watts). Fig. 5 shows that the distribution of the value of k varies between 0.065 up to 0.17 W/m°C. The relatively high value of k is concentrated around the manifestation. This is in accordance with the distribution of heat on the surface temperature distribution map.

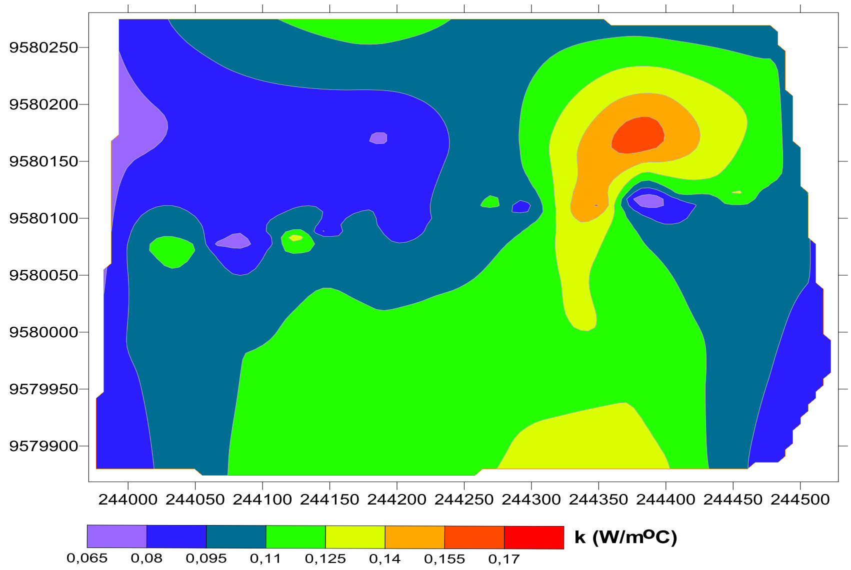

Fig. 4.5: Map of the distribution of the thermal conductivity of rocks in the study area.

The results of measurements of the vertical temperature gradient can be seen in Table 4.1. The gradient value is retrieved (using Equation 2) is used together with the value of the thermal conductivity of rocks and the prospect area extents to determine the magnitude of the value of natural heat loss by conduction. From Table 4.2 it can be seen that the value of natural heat loss is equal to 5132.232 Watt.

Table 4.1. The vertical temperature gradient measurement data.

Measurement Points	Position (m)			Temp. (°C) of sensor position (m)					Grad. (°C) of each sensor				Gradient	Av. Grad.
	X	Y	Elev.	0	0.5	1	1.5	2	0.5	1	1.5	2	(°C/m)	(°C/m)
Manifestation-1	253373	9570214	341	29.74	37.79	57.11	63.11	64.79	8.05	19.32	6.00	1.68	6.488	3.594
Manifestation-2	253359	9570213	349	29.66	30.88	41.26	46.98	52.97	1.22	10.39	5.71	6.00	1.933	
Manifestation-3	253362	9570222	346	30.51	31.25	34.13	37.83	42.23	0.74	2.87	3.70	4.40	2.360	

Table 4.2. Calculation of heat loss occurs naturally in conduction.

Measurement Points	Temperature Gradient (°C/m)	Thermal Conductivity (W/m°C)	Prospect Area (m^2)	Q (Watt)
Manifestation-1	3.594	0.17	8400	5132.232
Manifestation-2				
Manifestation-3				

The study shows that the value of heat loss by conduction is relatively small. This was caused by a number of manifestations encountered a bit, and extent of the heat prospect area obtained from the data processing is also relatively small. However, these results can be used together with the results obtained from the convection heat flow analysis, to determine the total of potential loss of heat to the actual surface.

If combined with the results of geochemical research that has been done [1] which states that the geothermal potential in this area is the prospect to be developed into a power plant. Thus, it can be interpreted that the small amount of fluid flow of heat reaching the surface can not be linked directly to the amount of the potential for geothermal energy is produced. In contrast, little or the least amount of fluid flow of heat rising the surface can be interpreted that the potential heat energy stored below the surface likely still relatively large.

V. Conclusion

The value of loss energy by conduction which flows to the surface around the AUM geothermal area was 5132.232 Watt.

Acknowledgements

On this occasion, I convey many thanks to the Director General of RISTEKDIKTI of the Ministry of Technolgy Research and Higher Education, through the Fundamental Research Funding fiscal year 2016. So the study could be completed.

References

[1]. Virgo F., Karyanto, Ady M., Agus S., Wahyudi, Suharno, and Wiwit S., Water Geochemical Analysis Within Airklinsar Geothermal Area in Pasema Air Keruh, Empat Lawang District, South Sumatra. *Proceeding, 1st Earth Science International Seminar-ISBN 978-602-19765-1-7,* UPN Yogyakarta, Indonesia, 2012.

[2]. Anonymous, Angka Parameter Dalam Estimasi Potensi Energi Panas Bumi. *SNI 13-6482-2000, ICS 07.060, BSN,* Jakarta, 2000. Retrieved from ITB website: *http://geothermal.itb.ac.id/sites/default/files/public/Angka_parameter_energi_geothermal.pdf.*

[3]. Gupta H., andRoy S., *Geothermal Energy; An Alternative Resource for the 21st Century*. (Amsterdam, The Nerherlands: Elsevier B V, 2007)

[4]. Mwawasi H. M., Geothermal mapping using shallow hole temperature measurement: A case study of Korosi, Chepchuk and Paka, *Proceeding, Kenya Geothermal Conference, Kenyatta International Conference Centre,* Nairobi, Kenya, 2011.

[5]. Hidayat A.H., Sismanto, and Suparwoto, Pengukuran Suhu dan Konduktivitas Panas di Daerah Sumber Mata Air Panas Krakal, Alian, Kebumen, Jateng. *Proceeding, PITXXVI HAGI,* Jakarta, Indonesia, 2001.

[6]. Sipioa E.D., Chiesa S., Destro E., Galgaro A., Giaretta A., Gola G., and Manzella A., Rock Thermal Conductivity as Key Parameter for Geothermal Numerical Models, *Energy Procedia, 40,* 2013, 87 – 94.