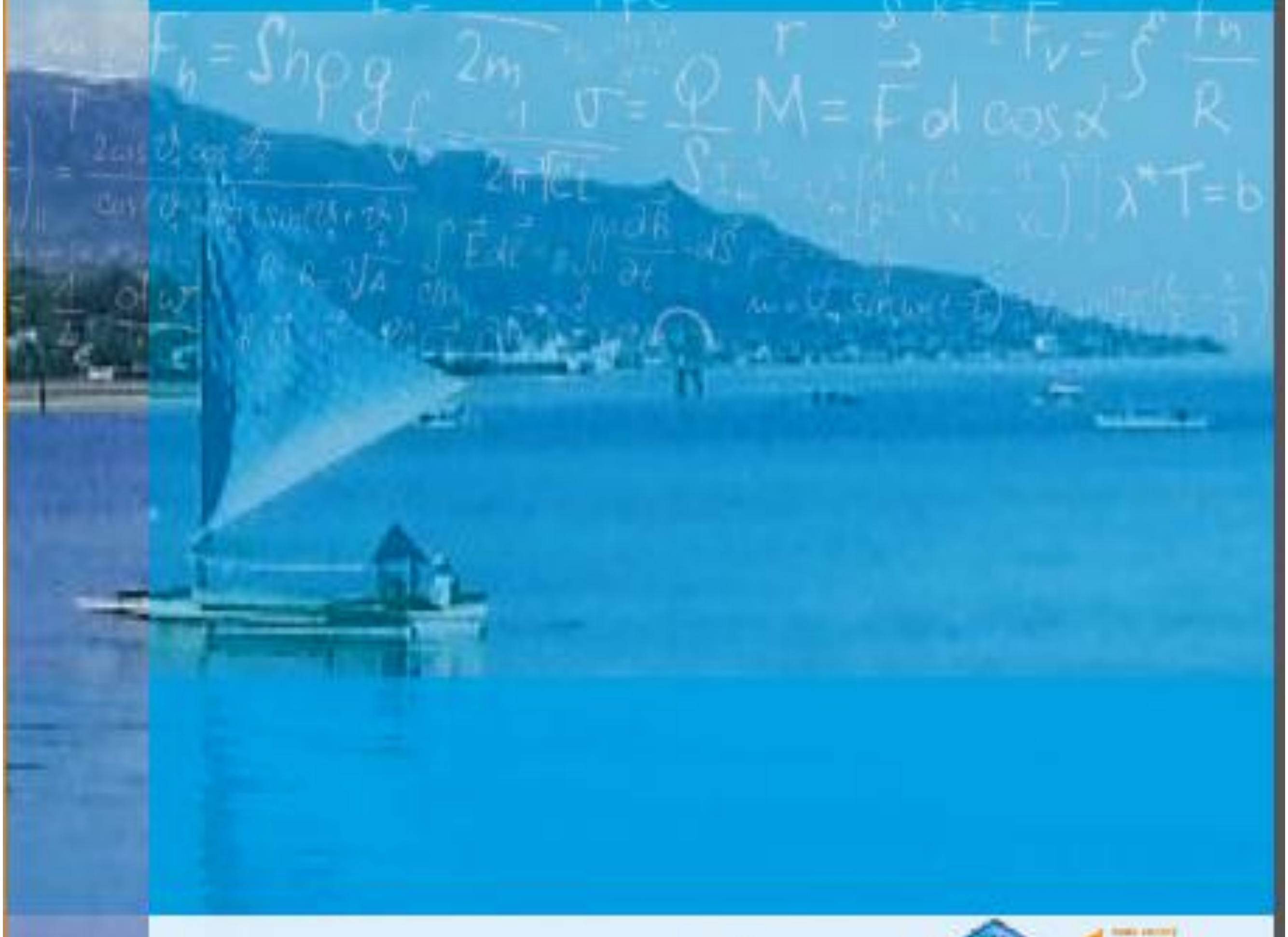
Basic Science
for Sustainable Marine Development

PROCEEDING
INTERNATIONAL SEMINAR 2015

Ambon, 3-4 June 2015



Organized by
Faculty of Mathematics and Natural Sciences
Pattimura University

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Welcoming Address by The Organizing Committee

The honorable, the rector of Pattimura University

The honorable, the vice rector of academic affair, Pattimura University

The honorable, the vice rector of administration and financial affair, Pattimura University

The honorable, the vice rector of planning, cooperation and information affair, Pattimura University

The honorable, all the deans in Pattimura University

The honorable, the key note speakers and other guests.

We have to thank The Almighty God for the blessings that allow this International seminar can be held today. This is the first seminar about MIPA Science in which the Faculty of MIPA Pattimura University becomes the host. The seminar under the title Basic Science for Sustainable Marine Development will be carried out on 3 June 2015 at Rectorate Building, the second floor. There are 250 participants from lecturers, research institute, students, and also there are 34 papers will be presented.

This International seminar is supported by the amazing people who always give financial as well as moral supports. My special thanks refer to the rector of Pattimura University, Prof. Dr. Thomas Pentury, M.Si, and the Dean of MIPA Faculty, Prof. Dr. Pieter Kakissina, M. Si. I also would like to express my deepest gratitude to Dr. Kotaro Ichikawa, the director of CSEAS Kyoto University, Prof. Bohari M. Yamin, University of Kebangsaan Malaysia, Prof. Dr. Budi Nurani Ruchjana (Prisident of Indonesian Mathematical Society/Indo-MS), Dr. Ir. A. Syailatua, M.Sc (Director of LIPI Ambon), and Hendry Ishak Elim, PhD as the key note speakers. We expect that this international seminar can give valuable information and contribution especially in developing basic science for sustainable marine development in the future.

Last but not least, we realize that as human we have weaknesses in holding this seminar, but personally I believe that there are pearls behind this seminar. Thank you very much.

Chairman
Dr. Netty Siahaya, M.Si.

Opening Remarks
By Dean of Mathematic and Natural Science Faculty

I express my deepest gratitude to The Almighty God for every single blessing He provides us especially in the process of holding the seminar until publishing the proceeding of International Seminar in celebrating the 17th anniversary of MIPA Faculty, Pattimura University. The theme of the anniversary is under the title Basic Science for Sustainable Marine Development. The reason of choosing this theme is that Maluku is one of five areas in Techno Park Marine in Indonesia. Furthermore, it is expected that this development can be means where the process of innovation, it is the conversion of science and technology into economic value can be worthwhile for public welfare especially coastal communities.

Having the second big variety of biological resources in the world, Indonesia is rich of its marine flora and fauna. These potential resources can be treated as high value products that demand by international market. Basic science of MIPA plays important role in developing the management of sustainable marine biological resources.

The scientific articles in this proceeding are the results of research and they are analyzed scientifically. It is expected that this proceeding can be valuable information in terms of developing science and technology for public welfare, especially people in Maluku.

My special thanks refer to all researchers and reviewers for your brilliant ideas in completing and publishing this proceeding. I also would like to express my gratefulness to the dies committee-anniversary of MIPA Faculty for your creativity and hard working in finishing this proceeding, God Bless you all.

Dean of Mathematic and Natural Science Faculty

Prof. Dr. Pieter Kakisina, M.Si.

Contents

Thermal Analysis in Geothermal Prospect Suli-District Central Maluku

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ABSTRACT

Temperature measurements have been done in the prospect area of geothermal Suli, District Central Maluku, to determine the temperature distribution on subsurface. Temperature measurement in monitoring and mapping is done on an area of 400 m x 200 m with two different locations, Suli 1.1 and Suli 1.2.
Retrieval data of temperature measurement using a temperature sticks and electronic thermometer incorporating a thermistor as a sensor such as IC LM35. The working principle of this instrument is that the physical phenomena detected temperature sensor is converted into electrical signals in the potential difference, then converted in degrees Celsius.
The results of measurements of temperature monitoring at the Suli obtained average surface temperatures between 31.08°C – 31.13°C. Distribution of heat on subsurfaces is calculated by solving the heat conduction equation (Laplace) with a finite difference method that has been constructed (known as the Liebmann method). The modeling assumes that two-dimensional objects shaped the plate. The results of modeling heat source on subsurface with finite difference methods estimate the temperature reservoir in Suli is 300°C at a depth of 1100 m.

KEYWORDS: Geothermal, Monitoring, Mapping of surface temperature, Finite difference methods, Modelling of heat source

INTRODUCTION

Energy needs in human life at this time have increased to a primary requirement. Along with the increase in human population, energy requirements will also increase. Dependence of human life on fossil energy (oil, gas and coal) has shifted the priority of energy requirements commensurate with the need for food, clothing and shelter. Therefore, a wide range of efforts made to meet the energy needs. Given the human need for energy is increasing while the number of reserves on the wane, the current researchers continue to promote the search for new energy sources as an alternative to oil and gas, such as geothermal.

Indonesia is dominated by the energy sector such as oil, gas and coal. Petroleum holds 57% of the energy needs in Indonesia, gas 23%, coal 18%, while 2% is held by a carbon emission, free energy to lower air emissions (such as hydroelectric and geothermal). Data obtained from MEMR (the Ministry of Energy and Mineral Resources), indicates that the supply of geothermal energy in Indonesia amounted to 20,000 MW. Indonesia has 20 years developing the geothermal energy, but was only able to develop 787 MW, it means that only 4% of the total potential in Indonesia (Wulandari, 2004).

Potential area of geothermal in Indonesia is Maluku. It is encouraging research in the areas of thermal methods, Suli-District Central Maluku. Geographically, the study area is located between the coordinates (3°36'12.07’’-3°36’21.34”) LS and (128°17'41.05"-182°17’56.19”) BT as in Figure 1.

Figure 1: Map geographic research (Atlas Maluku, 1998)

THEORY

Geological Research Area

In general, the geological characteristics of the Maluku islands is that the rock in the area is a sedimentary, metamorphic and igneous rocks are spread almost evenly in each island group. This is because the Maluku islands formed at 50-70 million years ago in the period Neogeon and Paleoceen. It is also because it is influenced by the location of the Maluku islands that lies between the Indo-Australian Plate, Pacific, Philippine Sea and the Banda Sea. sampling. Geological map of the study area image shown in Figure 2, with a scale of 1:50000.

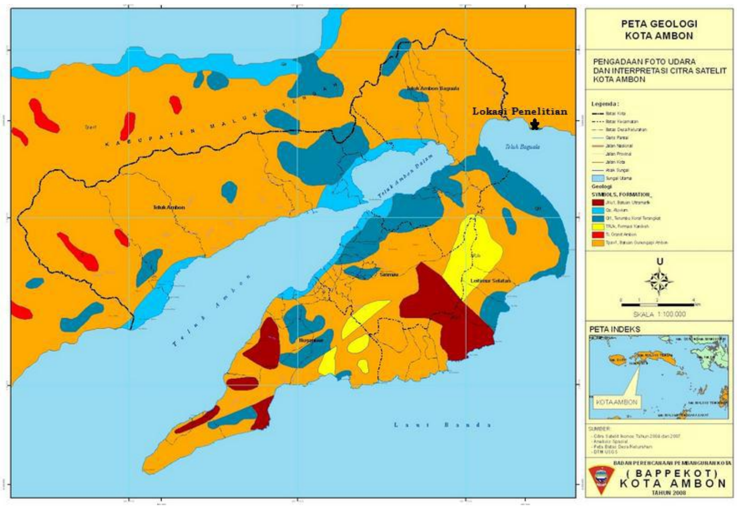

Figure 2: Geological maps of Ambon Island, (Bappekot Ambon, 2007)

Geomorphology conditions Ambon Island in particular the village of Suli, Central Maluku district is largely made up of the hills is an area that is very susceptible to the mass movement of debris, whether in the form of debris flow and landslides (debris flows, landslides and slope failures). Geological structure Ambon Island is mostly composed by sedimentary rocks and limestones old pre-tertiary and tertiary as well as a little sediment beaches in some areas.

Stratigraphy Research Areas unit hills stretching from the Northeast to the Southwestern occupy about 70% of the island of Ambon with a relatively steep slope. Except that, some fault lines (fault) that led Leihitu District. These fault lines included in the fault is not active. However, it could become active if there is movement of tectonic plates.

Basic Law of Heat Transfer by Conduction

The basic relationship for heat transfer by conduction method proposed by French scientists JBJ Fourier in 1882 (Lienhard et al., 2003). This relationship states that the rate of heat flow by conduction in a material way equal to the product of the amount of three ingredients namely thermal conductivity (*k*), cross-sectional area (*A*) and temperature gradient in the cross section or the rate of change of the temperature *T* of the distance in the direction of flow heat ($\partial T/\partial x$). The law of thermodynamics states that heat will flow automatically from point to point towards the high temperature low temperature, the heat conduction flow *qx* is positive if the temperature gradient is negative. Besides the increase in distance *x* toward a positive direction of heat flow (Figure 3).

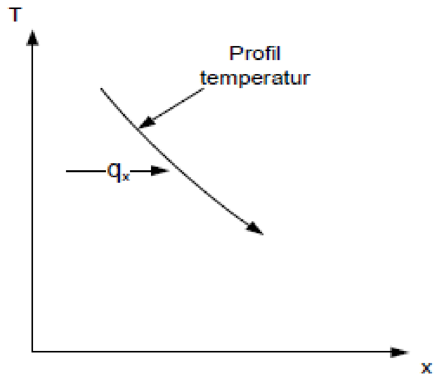

Figure 3: Direction of heat flow

To obtain the equation of heat flow rate plus the rate of heat flow entering the heat generation sources will result in the rate of heat flow out and the rate of change in energy (Wati, 2013). Here used the *z*-axis (depth states) are assumed to be positive

$$(q_x + q_z) + q(dx\, dz) = (q_{x+dx} + q_{z+dz}) + c\rho(dxdz)\frac{\partial T}{\partial \theta} \quad (1)$$

where,
q_x= heat flow in x-direction (W),
q_z = heat flow in z-direction (W),
c = specific heat ($W\frac{s}{kg}$, ℃),
ρ = density (kg/m),
T = temperature (℃),
θ = time (s).

If there is a heat source and the system is in steady state, then the equation would be:

$$\frac{\partial^2 T}{\partial x^2}+\frac{\partial^2 T}{\partial z^2}+\frac{q}{k}=0 \quad (2)$$

If the flow of body temperature in the steady state and without a heat source, it will be:

$$\frac{\partial^2 T}{\partial x^2}+\frac{\partial^2 T}{\partial z^2}=0 \quad (3)$$

A system is in a steady state rate of heat flow when a system does not change with time, ie the rate constant, the temperature at any point does not change (Kreith, 1985).

Numerical Methods

The method is a numerical solution technique is mathematically formulated in a way operation count/arithmetic and done repeatedly with computer assistance or manually (hand calculation). Basic use of numerical methods to solve partial differential equation is any partial derivative of a differential equation that is used is replaced by a finite difference approach. When the finite difference approach is applied throughout the dots variables contained in the concept model, then the solution of a series of simultaneous equations that are used directly or can be determined using the method of iteration (Setiawan, 2006).

Taylor series is the basis for solving problems in numerical methods, especially the completion of partial differential equations. If a function *T (x)* is known at the point xi and all the derivatives of *T* with respect to *x* is known at that point, then the Taylor series can be stated value of *T* at the point *xi +1* is located at a distance *Δx* from the point *xi* (Triatmojo, 2002). General form of the Taylor series are as follows:

$$T(x_{i+1})=T(x_i)+T'(x_i)\frac{\Delta x}{1!}+T^{"}(i)\frac{\Delta x^2}{2!}+\cdots+T^{(n)}(x_i)\frac{\Delta x^n}{n!}+R_n \quad (4)$$

where,

$T(x_i)$	: function at x_i,
$T(x_{i+1})$	: function at x_{i+1},
$T, T', T'', T''', \ldots, T^{(n)}$	: The first derivative, second, third, ..., n-th of function,
Δx	: distance between x_i and x_{i+1}
Rn	: truncation error
!	: factorial operator

If we let y = z (z is assumed to express the depth), then the first derivative of the variables x and z in a row can be written in differential form developed as follows:

$$\frac{\partial T}{\partial x}=\frac{T(x_{i+1},z_j)-T(x_i,z_j)}{\Delta x} \quad (5)$$

$$\frac{\partial T}{\partial z}=\frac{T(x_{i+1},z_j)-T(x_i,z_j)}{\Delta z} \quad (6)$$

Laplace equation with a heat source is,

$$\frac{T_{i+1,j}-2T_{i,j}+T_{i-1,j}}{\Delta x^2}+\frac{T_{i+1,j}-2T_{i,j}+T_{i-1,j}}{\Delta z^2}+\frac{q}{k}=0 \quad (7)$$

If $\Delta x = \Delta z$, equation 7becomes,

$$T_{i+1,j}+T_{i-1,j}+T_{i,j+1}+T_{i,j-1}-4T_{i,j}+\frac{q}{k}=0 \quad (8)$$

If $\Delta x \neq \Delta z$, equation 7becomes,

$$(T_{i+1,j})(\Delta z^2) + (T_{i-1,j})(\Delta z^2) + (T_{i,j+1})(\Delta x^2) + \left(T_{i,j-1}\right)(\Delta x^2) - T_{i,j}(2\Delta x^2 + 2\Delta z^2) + \frac{q(\Delta x^2)(\Delta z^2)}{k} = 0 \quad (9)$$

Liebmann equation is constructed of equation 9,

$$T_{i,j} = (T_{i+1,j})(\Delta z^2) + (T_{i-1,j})(\Delta z^2) + (T_{i,j+1})(\Delta x^2) + \left(T_{i,j-1}\right)(\Delta x^2) + \frac{q(\Delta x^2)(\Delta z^2)}{k} / \, (2\Delta x^2 + 2\Delta z^2) \quad (10)$$

Laplace equation without heat sources indicate that there is no heat source in the two-dimensional model of heat flow (q = 0). Therefore, the equation 8 becomes,

$$(T_{i+1,j})(\Delta z^2) + (T_{i-1,j})(\Delta z^2) + (T_{i,j+1})(\Delta x^2) + \left(T_{i,j-1}\right)(\Delta x^2) - T_{i,j}\,(2\Delta x^2 + 2\Delta z^2) = 0 \quad (11)$$

Liebmann subsequent equations can be constructed from equation (11) becomes,

$$T_{i,j} = (T_{i+1,j})(\Delta z^2) + (T_{i-1,j})(\Delta z^2) + (T_{i,j+1})(\Delta x^2) + \left(T_{i,j-1}\right)(\Delta x^2) \; / \, (2\Delta x^2 + 2\Delta z^2) \quad (12)$$

To be able to solve equations (10) and (12), boundary conditions must be determined so that dapatdiperoleh unique solution. For simple cases, the temperature at the edges of the plate determined a fixed value (Figure 3). Such cases are referred to the Dirichlet boundary conditions (Setiawan, 2006). For this case the x-axis is used as a surface and a depth z.

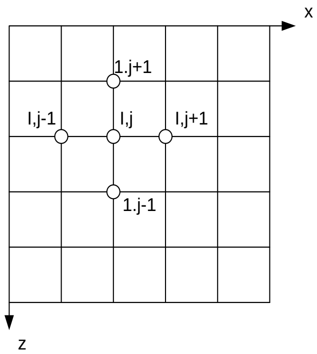

Figure 4: Grid for solutions of finite difference

Subsequently formed equation solved iteratively for i = 1 to n and j = 1 to m with over-relaxation equation.

$$T_{i,j}^{baru} = \lambda T_{i,j}^{baru} + (1-\lambda) T_{i,j}^{lama} \quad (13)$$

with $T_{i,j}^{new}$ and $T_{i,j}^{old}$ is present and previous iteration values, while λ is the relaxation coefficient magnitude can be taken between 1 and 2. λ can be found using the equation

$$\lambda = \frac{2}{1+\sqrt{1-\omega^2}} \quad (14)$$

with,
ω = the magnitude of the relaxation parameters

$$\omega = \frac{1}{1+\left(\frac{\Delta x}{\Delta y}\right)^2}\left[\cos\frac{\pi}{m} + \left(\frac{\Delta x}{\Delta y}\right)^2 \cos\frac{\pi}{n}\right] \quad (15)$$

Over-relaxation is used to speed of stability by using the formula in Eq. (13) is followed in each iteration (Chapra and Canale, 2002). As the initial value of the state at the point of the interior is taken equal to zero. Iteration can be terminated if the relative error has reached the limit. The magnitude of the relative error or an error value is defined as (Setiawan, 2006).

$$\left|(\varepsilon_a)_{i,j}\right| = \left|\frac{T_{i,j}^{baru} - T_{i,j}^{lama}}{T_{i,j}^{baru}}\right| x\ 100 \qquad (16)$$

For steady state with no heat source, can be applied to the Laplace equation assuming a constant value of thermal conductivity. The solution of these equations can be solved by analytic method. Form of the final solution can be written as follows (Holman, 1994):

RESULTS AND DISCUSSION

Based on the tools used, how the data retrieval and data processing thermal methods in PasemaAir Keruh, District Empat Lawang, which is in the Penantian, Air Keliansar and surrounding areas, this research can be divided into two parts, namely the temperature monitoring and mapping temperature thermal conductivity of rocks.

Temperature monitoring

Measurement of the temperature monitoring is done at two different locations namely on 15 September 2014 with a duration of monitoring for 12 hours in 1/2 hour intervals. Measurement stations on the local village of Suli were identified with a given name of Suli 1.1 and 1.2 Stations, respectively. The topographic map is depicted in Figure 5.

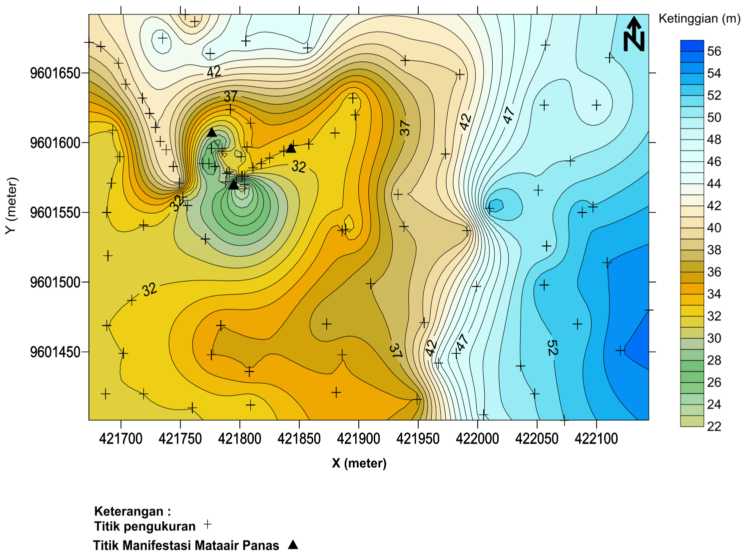

Figure 5: Topographic map Suli

Suli Station 1.1 located at position 3°36 '14.1 LS and 108° 17' 48.8" BT with a height of 33 m.dpl. On In this station, a mean value of the temperature at a depth of 1 m for at 31.08°C with the highest hoot contained at 32°C, while the lowest temperature was 29°C. The distribution of temperature Suli 1.1 can be seen in Figures 6.

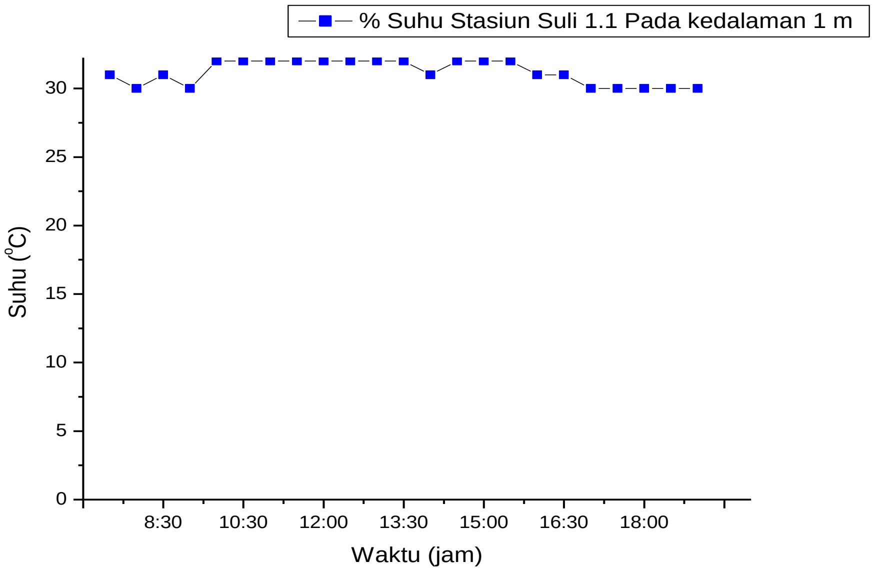

Figure 6: Distribution of Temperature Suli 1.1 in depth of 1 m

Suli Station 1.1 located at position 3°43 '28.1 LS and 108° 21' 43.2" BT with a height of 32 m.dpl. On this station, a mean value of the temperature at a depth of 1 m at 31.13°C with the highest temperature is at 32°C, while the lowest temperature was 30°C. The Distribution of Temperature Suli 1.1 can be seen in Figure 7.

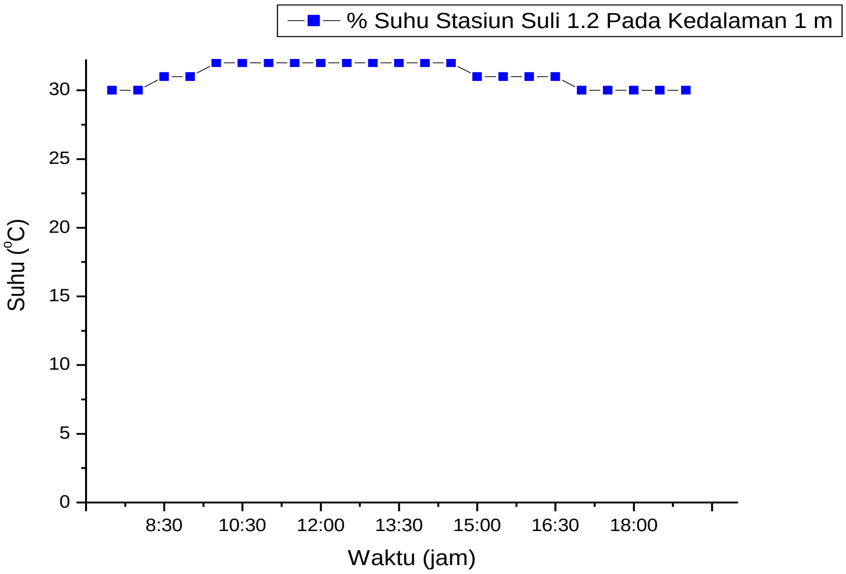

Figure 7: Distribution of Temperature Suli 1.2 in depth of 1 m

Temperature Mapping

Temperature mapping results showed the presence of several concentrations of heat that leads to the north. Some heat concentration showed a pattern of heat flow controlled by the presence of the fault with a northwest-southeast direction. Temperature measurements were carried out in the area research, shows temperature information spread evenly. The closure temperatures were in some places it has not shown the limits of the horizontal flow pattern. This pattern is most likely still in the area above the weak zone fault plane so that the spread of the temperature evenly. In order to determine the concentration and distribution of temperature measurement points in the study area can be seen in Figure 8.

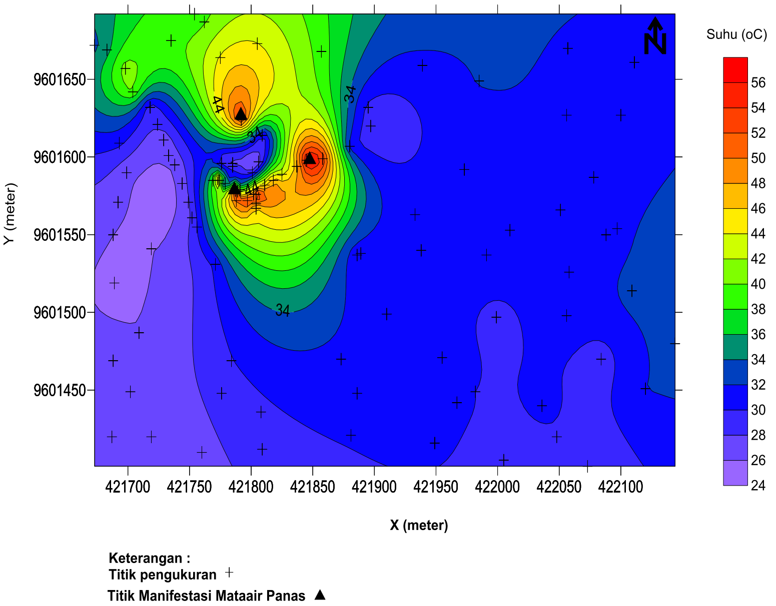

Figure 8: Concentration temperature in Suli in depth of 1 m

Quantitative Interpretation

Of algebraic equations at each grid coupled with other supporting information (temperature, conductivity and temperature gradient), it can be presumed depth of the source and reservoir temperature below the earth's surface. Discrete models are constructed with Liebmann method further solved using a Matlab 2012b. The results are displayed in the GUI (Kelibulin, dkk., 2014) as follows:

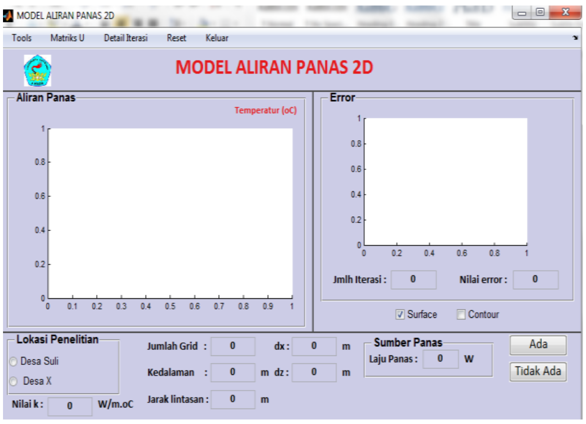

Figure 9: Display program of model heat flow 2D

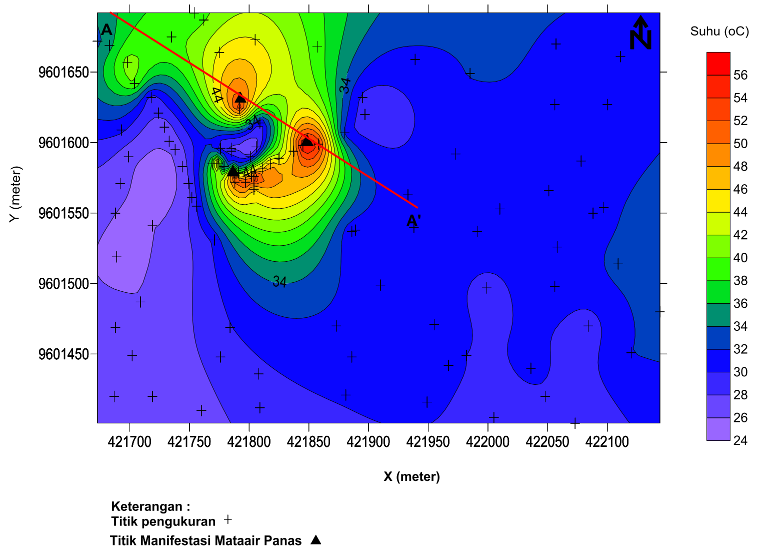

Figure 10. Selection of temperature data incision at Suli (A-A')

Temperature contour measurement data in Figure 10. chosen the most symmetrical incisions and then matched with the modeling of heat distribution. In the measurement data matching and data model will be seen patterns or trends of each test value. Basis for making an incision was cut geothermal manifestations are located along the fault.

Analysis Models

According to the value of the temperature gradient measurement data and local lithological information materials in a dry location solid ground, pyroclastic rocks are heated continuously. Based on the measurement data pengeplotan (incision) with the data model gives results almost identical shape patterns. Subsurface temperature pene area; itian with numerical method begins at a temperature of 300°C. Test the depth of the information obtained from previous investigations in the area around the location of the research with other methods.

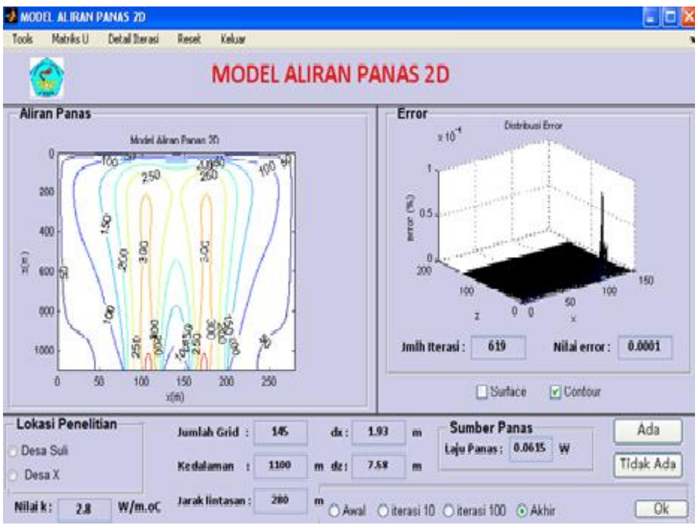

Figure 11. Graph of heat flow (surface) at Suli with an error value of 0.01%, heat flow 0.0615 W at a depth of 1100 m (with a heat source)

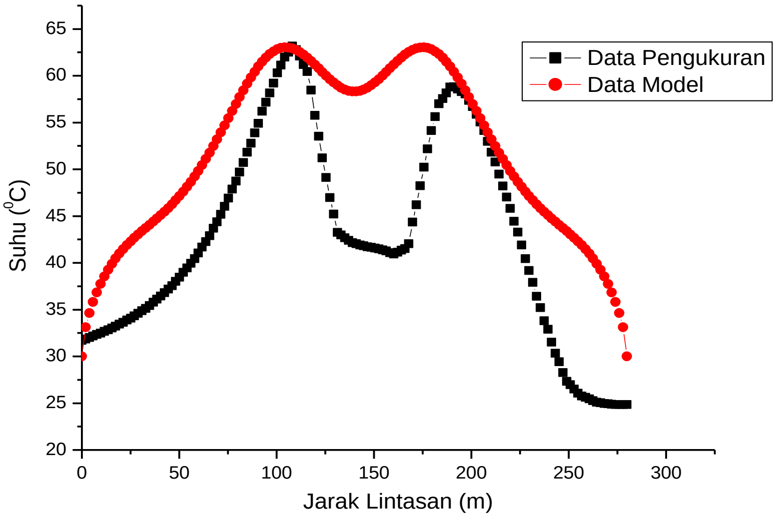

Figure 12. The results of the measurement data matching and data model depth of 1100 m (with a heat source)

Heat flow graph above explains that by inserting the values of parameters such as image visualization produced Figures 11 and 12. To obtain equilibrium with 0.01% error value at each point Ti, j, carried 654 times for iteration and 619 times without a source with the source. At the temperature of the flow picture looks for red areas are areas that have a high temperature is the temperature above 300°C, for the orange area is an area with a temperature between 300°C to 250°C, for the yellow area is an area with a temperature between 250°C to 200°C. For the green area is an area with a temperature between 200°C to 150°C, for the aqua-colored areas are regions with a temperature between 150°C to 100°C, for the blue area is an area with a temperature between 100°C to 80°C, for the area the light blue area temperature is between 80°C to 50°C, for the dark blue area is an area with a temperature below 50°C, which means that the lower the temperature on the color image is getting older (dark blue). Results matching measurement data and model data at a depth of 1,100 meters at Penantian can be seen in Figures 12.

CONCLUSIONS

Based on a map of the spread of surface temperature, concentration and temperature in Suli have two different temperatures closure. The temperature closure spread evenly but has not shown the limits of heat flow pattern horizontally. This means that temperature closures is still above the weak zone fault plane.

The results of modeling the heat source below the surface with a 2D finite difference method can estimate the order of the source reservoir temperature of 300ºC Waiting locations at a depth of 1100 m.

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