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### 9th International Conference on Physics and Its Applications (ICOPIA)

To cite this article: 2019 J. Phys.: Conf. Ser. 1153 011001

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# Proceeding

### 9<sup>th</sup> International Conference of Physics and Its Applications (ICOPIA) 14 August 2018, Surakarta, Indonesia

### Preface

International Conference of Physics and Its Applications (ICOPIA) is a biannual conference, started in 2001, for presenting and discussing current research in Physics and Its Applications. This year of 2018, this conference is the ninth one. Studies about material physics, optics, geophysics, instrumentation, magnetics and theoretical physics are presented orally. This conference is mainly supported by Department of Physics, Universitas Sebelas Maret, Indonesia.

The keynote presentations are provided to talk the current research in Physics. The keynote speaker Profesor Osamu Nakatsuka from Nagoya University presents the study of thin film growth and characterization of Group-IV alloy semiconductors for future nanoelectronic applications. The keynote from Universiti Kebangsaan Malaysia, Assoc. Prof. Dr. Mohd. Yusri Abd Rahman, presents about Dye-Sensitized Solar Cell Utilizing Titanium Dioxide-Strontium and Titanium Dioxide-Sulphur Composite Films Photoanode. The speech of analysis of groundwater level is also provided.

This proceeding contains the papers presented in ICOPIA 2018. The papers are divided into sections: Acoustic, Geophysics, Instrumentation Physics, Magnetism and Magnetic Material, Material Physics and Characterization, Optical, Theoretical and Computation Physics and Other Related to Physics magnetism and magnetic material, material physics and characterization, acoustics, theoretical physics, instrumentation physics, optics and geophysics. This structure is made so that readers are easier to find an article in this proceeding.

We would like to thank to all of the participants attending this conference and also to committee for their contribution to this high level conference and its overall success. We also would like to thank to the reviewers for their positive contribution to maintain the quality of the articles presented in this conference. We also appreciate the contribution of our sponsor supporting the conference.

IOP Conf. Series: Journal of Physics: Conf. Series 1153 (2019) 011001 doi:10.1088/1742-6596/1153/1/011001

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9th International Conference on Physics and Its Applications (ICOPIA)

IOP Conf. Series: Journal of Physics: Conf. Series 1153 (2019) 011001 doi

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doi:10.1088/1742-6596/1153/1/011001

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## Reconstruction of meratus by subduction modelling around Java, Borneo and Celebes Islands

To cite this article: Joko Soesilo et al 2019 J. Phys.: Conf. Ser. 1153 012015

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## Reconstruction of meratus by subduction modelling around Java, Borneo and Celebes Islands

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Abstract. Meratus mountain, located in Borneo Island is interpreted as sincerity of Subduction Zone in Java. It is predicted that there was a microcontinent in research area. This research aimed to predict the age and reconstruction the subduction zione around Meratus mountain by using earthquake data around Java, Borneo and Celebes islands. The data is relocated using Geiger method to get better description of Subduction Zone. Furthermore, the angle of subduction and velocity modelling is calculated to give more information to reconstruction the Meratus mountain hystory. From the subduction model, Meratus mountain is affected by subduction from Sumatera and Java, it is not affected by subduction from Celebes. From the subduction too, it is known that there are two subduction under Borneo, it is improve that there was microcontinent that shifted the early subdcution and borned the new one.

#### 1. Introduction

Indonesia is an archipelago country. It has many island that separated by the ocean. It is located between Australian and Eurasian continent plate and also between Pasific and Indian ocean plate. For the result, Indonesia has many volcanoes and prone of many disaster like earthquake, tsunami, etc. Beside the disaster, Indonesia has a large of minerals and energy. One of them is located in Borneo island. It is located in north of Java and between Sumatera and Celebes island.

Borneo is part of Sunda shelf, formed by igneous rocks, granitic. There are also alkali breakthrough, metamorphic and sediment. It's age is about Paleozoic to Quarter (Figure 1). The age can be devided into three periode, they are Paleozoic-Mesozoic, Mesozoic-Tertiary and Quarter.

Paleozoic-Mesozoic period take place in the middle of Borneo, specially around Schwaner High. It is a stable part of litosphere which has exposed by sedimentation process, orogenesis and old granitic breakthrough (Carbon-Mesozooic (Trias)). In north and south part of Schwaner High, there were thick flysh sediment rock, acid to medium volcanic, and melting rock in the age of Trias-Jura which has contact with granitic (breakthrough) in Lime period. As the result, the dominant rocks in the south is acid to medium volcanic (Matan Complex, Bammelen 1949 op cit [1]) that break by granitic and formed metamorphic. While in the north, there are andesit, dasit and pyroclastic in the age of Trias-Jura and also break by granitic. The existence of granitic is indicated as a part of subduction from the north.

Mesozoic-Tertiary periode was started by the breakthrough of igneous rock into granitic and dasit in last Lime- early Mesozoic in the north of Schwaner. In Serawak, Malaysia, there is Ophiolit Lupar way. It is melange zone, indicated that there is subduction process in the area that has direction to norht-west and come from South China sea beneath Borneo island (Katili 1973 & 1981; Hamilton, 1978; Hutchison 1973 & 1975 and Haile et al 1977 op cit [1]).

In Quarter Period, the sediment that has age in Plistosen to Resen was deposited in flood plains and river and for the last period, that continue from Holosen untill now, formed two transgression and

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doi:10.1088/1742-6596/1153/1/012015

regression cycle. It resulting beach and land. As we can see now, most of the river in Borneo cutting the lower part of Barito Basin that located in Borneo [1].



Figure 1. Geological Map of Borneo Island (Haile, 1968; Pupili, 1973 and Hamilton 1979 op cit [1]).

#### 2. Experimental Method

The geological condition of Borneo as metion before is related with Indonesia archipelago formed over the past 300 million years, especially in Borneo, it also related with Cretaceous active margin with Sumatera, Java and Celebes. Based on [2], there was Cretaceous margin that run the length of Sumatera into western Java and continued to northeast trhough sourthern Borneo and western of Celebes. It has high pressure-low temperature subduction that related to metamorphic rocks in Central Java, Meratus Mountains of southeastern Borneo and western Celebes (Figure 2).

Subduction zone is place that potentially occur earthquake and magmatism. So it can be well defined by seismicity. The depth of subduction zone in Indonesia can reach untill 600 km and by volcanoes (Figure 3 and Figure 4). Indonesia is passed by ring of fire with 95 active volcanoes that erupted since 1500. Two famous erupted evidence were Tambora and Krakatau in 1815 and 1883 [2].

Beside voelcano, Meratus Complex is one of subduction product. It located in Borneo with predominantly North-Northeast trending mountain belt with 65 km wide and 300 km in length. The elevation exceeds 1000 m, with the greatest topographic lies in central and northern parts. It includes metamorphosed arc and ophiolite rocs that interprated as result of oblique collision and accretion of East Java and West Celebes terrain to the Sundaland margin from mid-Cretaceous (e.g Sikumbang 1986; Hall, 2012 op cit [3]).

Based on Witts et al (2014), from the combination data of structural, sedimentological, provenance and satelite data of Montalat Formation, it show that uplift of the northern part of Meratus occur during the Early-Miocene. In contrast, in the upper part of Warukin Formation that also part of Meratus indicates that uplift further did not occur untill Late Miocene.

From the explanation above, we can see that subduction zone analysis can give information about the history of the area formed. In subduction, partial melting is taking place also. It contain of hot mantle material and resulting magmatism. Both of them has an important thing in the evolution processes of the earth. One way to analyse the subduction zone is by describing the seismic velocity structure from seismicity data. From seismic velocity, we can estimated physical properties of earth's interior because it related with seismic wave. There are two seismic wave often used, they are P and S wave. From P wave, we can interpret the existence of fluid, and from S wave we can get the information about the physical parameter [4].

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100'E P105'E 100'E 100'E 115'E 115'E 120'E 115'E 115'E

Figure 4. Volcanoes in Indonesia [2]

Subduction zone is one of earthquake source. It moves because of convection current in astenosphere following by plat movement, and the movement causing earthquake. Generally, there are three kinds of plate movement. They are divergent, convergent and transform (Figure 5).

Subdcution zones is product of convergent movement plate. It has some characterize, they are big magnitude and the depth source usually deep [5]. Earthquake resulting seismic wave. Seismic wave is all kinds of wave that spread both in the subsurface and in the surface. Generally, there are two kinds of seismic wave, P and S wave. They have their own characteristic. P wave's velocity usually bigger than S velocity, and it is the first wave recorded in seismometer. It can pass through the fluid so it can describe the fluid existence [6].

One example of subduction and seismic velocity description can be seen in Figure 6. It is a P wave Tomography beneath Tonga arc and Lau bac arc region. The P wave anomaly is describing by the colour. The blue one show high velocity anomaly while the red is low velocity anomaly. The anomaly is declared by percentage (%). It has a meaning as standard deviation of the real P wave velocity.

From Figure 6, the blue one, the high velocity interpreted as a medium that has a high density. As we know that high density does not absorbing the velocity too much. It give the description about oceanic plate that lies beneath the continental. Otherwise, the red one is a low density, that we can interpreted as fluid also. While the black dots is a seismicity data around the area. Again, it give us information that subduction description gives many information about earth physical parameters.



**Figure 5.** (a) Convection current in astenosphere; (b) Three kinds of plate movement (divergent (A), convergent (B) and transform (C) ([5])



Figure 6. P wave Tomography beneath Tonga arc and Lau back arc region (Zhao et al, 1976 op cit [4])

Besides velocity, attenuation and anisotrophy can be calculated and modelled by tomography technique. However it needs a good model parameterization, forward modelling and ray tracing, earthquake relocation and inversion methode [7]. Romanowics in 1994 [8] also studied about anelastic tompgraphy. It can describe thermal strucutre in the subsurface that associated with hospot. Other example of tomographic inversion is to describe magma chamber under the volcano by Paulatto et al in 2012 [9]. As mention before that P wave can describe fluid, Paulatto et al in 2012 use this characterize to predict magma chamber and thermal modelling at Monstreat. Magma chamber descripted from low velocity of P wave.

Seismic Tomography is one way to get description of subduction zone. To do it, seismicity data, velocity model and travel time is needed. In this research, ISC data during the period 1930 to 2018 for seismicity and AK 135 velocity table is used. Before get in to tompgraphy process, relocating of seismicity

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(hipocenter) data is important to get a better description of subduction zone. Generally, determination of hypocenter location is used homogeneous velocity model. In real condition, the subsurface is heterogeneous. Relocating has aimed to look for new better location of hypocenter by using heterogeneous velocity value with AK 135 table as refference. This research is focused on relocating process while the tomopgrahy process will be done in the next research.

One simple method of relocation is Geiger method. Calculation of hypocenter location is a non linier inversion problem. Geiger method make it simple by differentiating the forward modelling equation into the parameter model (hypocenter location).

$$t_p = t_0 + \frac{\sqrt{(x_i - x_0)^2 + (y_i - y_0)^2 + (z_i - z_0)^2}}{v_p}$$
(1)

Equation (1) is a forward modelling formulation to calculate the arrival time of P wave in each station. In this research, the model parameter is  $x_0$ ,  $y_0$  and  $z_0$ . While  $x_i$ ,  $y_i$  and  $z_i$  is station location,  $v_p$  is P wave velocity and  $t_0$  is origin time of earthquake. To get the parameter model, the first step is differentiate the equation (1) into the parameter model (equation (2.1) untill (2.3)).

$$\frac{\partial t_p}{\partial x_0} = \frac{(x_i - x_0)}{v_p \sqrt{(x_i - x_0)^2 + (y_i - y_0)^2 + (z_i - z_0)^2}}$$
(2.1)

$$\frac{\partial t_p}{\partial y_0} = \frac{(y_i - y_0)}{\nu_n \sqrt{(x_i - x_0)^2 + (y_i - y_0)^2 + (z_i - z_0)^2}}$$
(2.2)

$$\frac{\partial t_p}{\partial z_0} = \frac{(z_i - z_0)}{v_p \sqrt{(x_i - x_0)^2 + (y_i - y_0)^2 + (z_i - z_0)^2}}$$
(2.3)

Then, equation (2.1) untill (2.3) is arranged to a Jacobian Matrix:

$$J = \begin{bmatrix} \frac{\partial t_{p1}}{\partial x_0} & \frac{\partial t_{p1}}{\partial y_0} & \frac{\partial t_{p1}}{\partial z_0} \\ \frac{\partial t_{p2}}{\partial x_0} & \frac{\partial t_{p2}}{\partial y_0} & \frac{\partial t_{p2}}{\partial z_0} \\ \vdots & \vdots & \vdots \\ \frac{\partial t_{pN}}{\partial x_0} & \frac{\partial t_{pN}}{\partial y_0} & \frac{\partial t_{pN}}{\partial z_0} \end{bmatrix}$$
(3)

The final step is calculate new hypocenter location by inversion process of equation (3) with give the initial guess of new hypocenter location (a priori information).

 $m = (J^T J)^{-1} J^T d$ 

(4)

Equation (4) is inversion formula to calculate new hypocenter location, where m is model parameter, J is Jacobian matrix, and d is the difference between travel time data observation and calcualtion [10].

#### 3. Result and Discussion

Location and description about subduction zone around Meratus after relocation by using Geiger method and AK 135 velocity Table for initial model can be seen in Figure 7 and Figure 8

In Figure 6.a, we can see the boundary of subduction zone of Sumatera, Java and Phillipine. The red one is subduction model, reach the depth about 250 km, the yellow one is Sumatera and Java island, and the green circle is seismicity from Phillipine. Beside that, there are ellips one, it is the early subduction that formed and shifted by microcontinent. The subduction zone has angle about  $28.37^{\circ}$  and  $30.93^{\circ}$  under the red subduction. The subduction angle of the green ellips are about  $41,67^{\circ}$  and  $36.5^{\circ}$ . From the depth and AK 135 velocity Table, times of this subduction zone is about 93 million years, younger than Meratus for the magmatism that has the age hypothesis about 190 million years. But the age in this research is not final yet, tomographic inversion is needed to re calculate about the age.

In Figure 8.b, beneath Borneo, it can be seen that the subduction zone of Celebes is not reach under the Borneo (Kalimantan), so we can prove that subduction of Sumatera and Java only that give the influenced of Borneo.



Figure 7. Location of Subduction modelling





Figure 8. (a) Subduction zone in area 1 and 2 (yellow squre in Figure 6) and (b) Subduction zone in area 3 (red square in Figure 6).

#### 4. Conclusion

Subduction zone between three island, that is Sumatera, Java and Celebes was descripted to know the influence in Meratus mountain in Borneo. Geiger method was used to described it. This method is

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simple and easy to applied. Based on the result, it can be known that the subduction of Sumatera and Java that have an influence to Borneo and Meratus and improve that there was a microcontinent in research area. The angle of the Sumatera's subduction zone is sloping and has the time of magmatism younger than in Meratus predicted but it should re calculate by tomographic inversion for the next research.

#### 5. Reference

- [1] Herman, Danny Zulkifli. 2007. Kemungkinan Sebaran Zirkon pada Endapan Placer di Pulau Kalimantan. Jurnal Geologi Indonesia Vol. 2 No. 2, Juni
- [2] Hall, Robert. 2009. Indonesia, Geology. Royal Holloway University of London
- [3] Witts, Duncan., Lorin Davies., Robert Morley. 2014. Uplift of The Meratus Complex: Sedimentology, Biostratigraphy, Provenance and Structure. Proceedings, IPA
- [4] Zhao, Depeng. 2001. Seismological Structure of Subduction Zones and Its Implications for arc Magmatism and Dynamics. Physics of The Earth and Planetary Interiors.
- [5] Sunarjo., M. Taufik Gunawan dan Sugeng Pribadi. 2012. Gempa Bumi Edisi Populer. BMKG
- [6] Afnimar. 2009. Seismologi. Bandung : Institut Teknologi Bandung
- [7] Zhao, Depeng. 2015. Multiscale Seismic Tomography. Japan : Springer Geophysics
- [8] Romanowics, Barbara. 1994. Anelastic Tomography : A new Perpsective on Upper Mantle Thermal Structure. Earth and Planetary Science Letters 128 (1994) 113-121
- [9] Paulatto, M., C. Annen., T.J. Henstock., E. Kiddle., T.A. Minshull., R.S.J. Sparks., B. Voight. 2012. Magma Chamber Properties From Integrated Seismic Tomography and Thermal Modelling at Mostreat. Geochemistry Geophysics Geosystem Journal Volume 13, Number 1
- [10] Grandis, Hendra. 2009. Pengantar Pemodelan Inversi Geofisika. HAGI