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THE 9TH INDONESIA-MALAYSIA CONFERENCE

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BADAN GEOLOGI KEMENTRIAN ENERGI SUMBER DAYA MINERAL

DEPARTEMENT OF MINERAL RESOURCES THAILAND

Proceedings

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The 9Th Indonesia-Malaysia Conference

“Exotic Past for our Future”

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Proceedings

Regional Geoheritage Conference 2016

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2016

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Preface

Bismilahirrahmanirrahim, Assalamu'alaikum wa rahmatulahi wa barokatuh.

Dear distinguished participants and committee.

In this nice opportunity, I appreciate to all of you for your considerable effort that made the Regional Geoheritage Conference 2016 or the 9th Joint Conference Indonesia – Malaysia Geoheritage Conference happened.

I really thankful to your participations for joining and attending the Conference in Yogyakarta. Special Region of Yogyakarta is well known as education and cultural city. Yogyakarta also become a considerable touristic region especially in cultural heritage. Right now geoheritage in Yogyakarta become more attractive.

In this occasion, the conference is very simple. Conference will be held over two days. First day we will held conference and geotrack in the second day.

There is two main speakers for RGC 2016. The first speaker is Mr. Ibrahim Komoo as Vice President Global Geoparks Network (GGN) and Mr. Yunus Kusumahbrata as Expert Staf Ministry of Energy and Mineral Resources of Indonesia Republic. For the next season, we also have speakers from Thailand and two speakers from Gunungsewu UGG and Batur UGG Indonesia. Moreover, we have 30 outstanding papers that will be presented in this conference. The papers are consist in 12 oral papers and 23 posters presentation with the same value.

In geotrack we will discover several geoheritage sites in Gunungsewu UGG, such as Miocene pillow lava of Berbah; ancient volcanic product of Nglanggeran; exciting bioturbation within shallow marine Sambipitu Formation; and Karst Museum of Indonesia at Wonogiri.

I wish this conference will give us inspirations and enhance the cooperation in Southeast Asia countries, especially in the field of geoheritage. Happy sharing for the progress of our region.

Finally, I would like to express my gratitude to Geological Agency – Ministry of Mineral Resources, especially Center of Geological Survey performa a booth concerning the wonderful of geoheritage and geopark of Indonesia.

Wassalamu'alaikum wa rahmatulahi wa barokatuh.

Prof. Dr. Ir.Bambang Prastistho, M.Sc.
Chairman
Regional Geoheritage Conference 2016

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GEOHERITAGE OF BAU: AN IMPORTANT GEO-AREA IN THE PROPOSED SARAWAK DELTA GEOPARK

Dana Badang
Che Aziz Ali
Ibrahim Komoo
Mohd. Shafeea Leman

ABSTRACT

Bau geo-area is located at the southern end of the proposed Sarawak Delta Geopark. The geology of Bau geo-area is underlain by Bau Limestone, Pedawan Formation, igneous intrusion, Serian Volcanics, metamorphic rock and alluvium. Limestone is the dominant rock type and has contributed to the scientific interest when associated with the other geological elements such as dykes, sills and igneous batholiths. Located within the rich metalliferous belt of Borneo allows the Bau geo-area be known as the goldfield of Sarawak. Bau geo-area region is the only town that built by mining activities and among the few in Malaysia. The previous mining activities have moulded the modern development trends of Bau Town and accentuated the existing cultural heritage. Naturally, the Bau Limestone also bears significant geodiversities of high aesthetic and recreational values in the area. This paper discusses the importance of geoheritage in Bau geo-area from the scientific, aesthetics, culture and recreation heritage aspects.

STRIKE SLIP DEFORMATION OF THE POST CRETACEOUS PERIOD AT THE GENTING-KLANG QUARTZ RIDGE, SELANGOR, PENINSULAR MALAYSIA

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ABSTRACT

The residual of the natural rock erosion in the Gombak district of Selangor exhibit a ridge of quartz rock is incredible. In geology, preliminary studies indicate that the quartz dike has a close relationship with the local fracture pattern and major fault structure in the east-southeast trending which has been named as Kuala Lumpur fault by Stauffer (1968). The presence of so many small veins in quartz dikes, it shows that this quartz crystallize in the fracture system that has developed gradually in a relatively long period.This study used detailed research methodology with detailed data acquisition along the ridge, about 6 km. As expected found sufficient data for analysis Fault Zone, veins and faulted rock. In this detailed trajectory represented 18 blocks of detailed observations, detailed systematic observation focused on selected local area. Field observations show that not at all region have same quartz veins pattern in the ridge. In each block region observation, there are several combinations of quartz veins variation. Dispersion patterns of quartz vein in the ridge, always follow system of fractures and bounds on north and south side by ESE-WNW fracture system direction, and not found branches of veins. The 18 prominent strike modes of vein lineaments can be interpreted as being produced by two maximum horizontal stresses acting along 065^o and 090^o . It can be concluded that the E-W and 070^o-250^o compressions responsible for the Late Triassic orogeny, were still active during and after the emplacement of the granitoids. The 119 Ma Granites which are elongated parallel to the NW-SE regional structural trend, would best be regarded as post Jurassic Orogenic, and the 70 Ma Granites which trend NNW-SSE as post Cretaceous orogenic.

INTRODUCTION

The residual of the natural rock erosion in the Gombak district of Selangor show an incredible quartz vein. A completely different type of quartz vein is commonly found in west Peninsular Malaysia, usually on a very spectacular scale; these are the so called quartz reefs/ridge, which form prominent quartz ridges throughout the country, situated about 13 km northeast of Kuala Lumpur. In geology, preliminary studies indicate that the quartz ridge has a close relationship with the local fracture pattern and major fault structure in the northwest trend which has been named as Kuala Lumpur fault by Stauffer (1968). According to Stauffer (1968), young movements along the Kuala Lumpur fault zone seem to be indicated by a number of geological features. The main faults at the western end of this zone are shown in Figure 1.1.

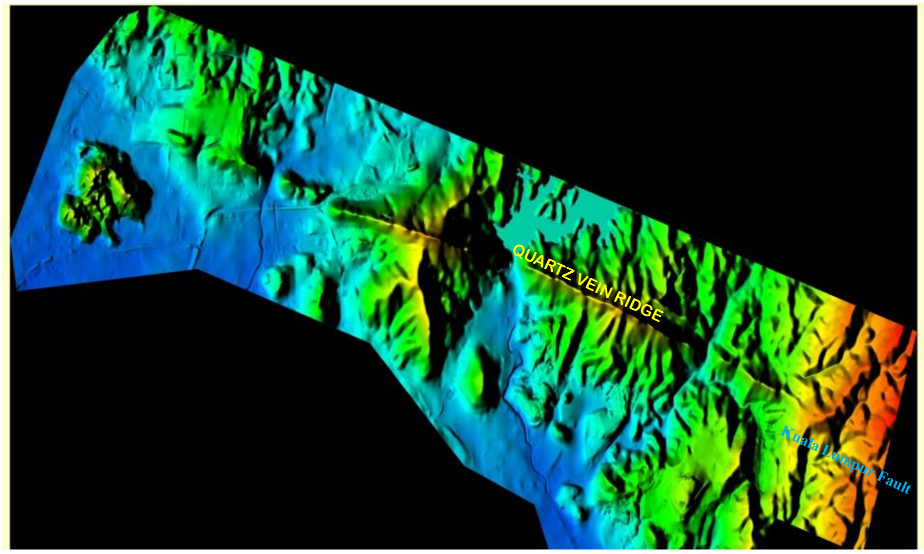

Figure 1.1 : DTM & DSM IFSAR Sattelite immagery showing the Quartz Vein Ridge has a relationship with the local pattern fracture and major fault structure in the northwest-trend which has been named as Kuala Lumpur Fault by Stauffer (1968)

Southeast and east-southeast striking faults are dominant and are frequently filled with vein quartz. The largest of these quartz dykes is the Klang Gates Ridge, which stands out from the adjacent land surface to a height of 350 m Kuala Lumpur Fault position as compared to several other fault systems in the vicinity of Kuala Lumpur and Peninsular Malaysia have been discussed by Shu (1969), while Gobbet & Tjia (1973) has correlate between Kuala Lumpur fault with Endau fault interpreted as faulting connection Kuala Lumpur fault. In 1997, for the first time Tjia used geographic names Permatang Kuarza Genting Klang (quartz ridge) characteristics to explain in his study of faulting connection Kuala Lumpur to Damansara area. Kuala Lumpur faulting cutting the granite body and all older rocks. The complex interlacing character of deformed and undeformed quartz vein with in the dyke, considered with remnants of partly to almost completely altered granite, reflects multiple intrusions. The presence of so many small veins in quartz dikes, it shows that this quartz crystallize in the fracture system that has developed gradually in a relatively long period

Based on the radiometric age by Bignell & Snelling (1970), Age of the Ulu Klang-Ampang Range Granite is 199 million years ago (Late Triassic age). Stauffer (1969) believed that the Kuala Lumpur Fault zone was active from Early Triassic to Miocene. Tjia (1977) assumed that fault movement ended only in Early Tertiary. Bignell and Snelling (1977) have attributed the lower K:Ar mineral ages of the granitoids, which range from 209 Ma to 32 Ma. Coarse muscovite gives a K:Ar age of 175 Ma (Jurassic) but second generation sericite yields a 91,5 Ma age (Middle Cretaceous) (Khoo, 1993). The Jurassic age must be interpreted as minimum, indicating that the dyke developed soon after the emplacement of the Upper Triassic granite. The Middle Cretaceous age suggest that the fault movement continued at least until Middle Cretaceous or it was reactivated during that time. (Mustaffa, 2009 vide Hutchison 2009)

METHODOLOGY

This study used detailed research methodology with detailed data acquisition along the ridge, about 6 km. As expected found sufficient data for analysis Fault Zone, veins and faulted rock. In this detailed trajectory represented 18 blocks of detailed observations. Detailed systematic observation focused on selected local area. The petrological study was carried out under microscope to unravel the more detailed information on the identity of rocks based on Mineralogical composition, texture, structure and petrogenesis. Orientational structural data were analysed by means of manual hemisphere stereographic projection plot, Dips software Version 3.7 and Paleostress Version 3:11. That is accomplished by a computer software.

Crosscutting Relationship

Quartz veins are usually the latest of all the intrusions in the granite, and they cut both aplite and pegmatite dykes. They are characteristically approximately parallel alignment, indicating injection along joint directions in the outer portions of batholith It was formed by the deposition of hydrothermal quartz along a near-vertical zone of weakness in the granite (Alexander and Procter 1955). Therefore, the focus of this study is to characterize the deformation style for each major fracture sets in the Genting-Klang Quartz Ridge, identify the cross-cutting relationships and attempt to reconstruct their structural evolution in view of that of the Kuala Lumpur Fault Zone.

EVIDENCE FOR QUARTZ RIDGE DEFORMATION

The quartz ridge on the Kuala Lumpur fault zone at the Genting-Kelang ridge area show evidence for four successive vein episodes: The first generations (D1) generally, conjugate quartz veins N265^{o}E – N275^{o}E and N225^{o}E – N230^{o}E (Figure 2.2), occurs most commonly in association with quartz vein N280^{o}E-N285^{o}E, those are major veins and have spaced 30 to 300 m apart.

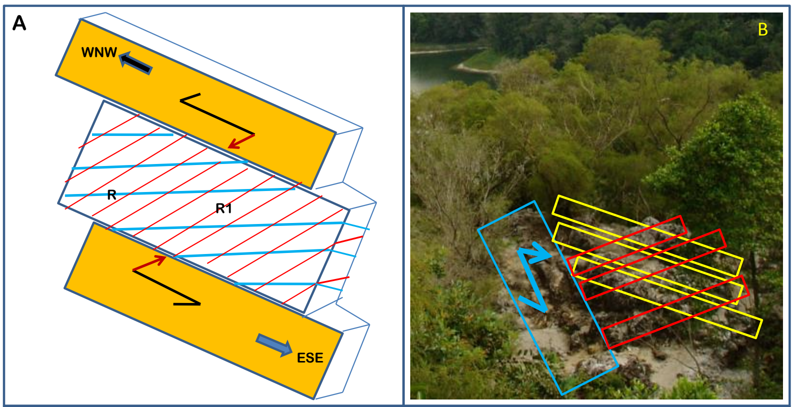

Figure 2.2 : (A) An idealised sketch to show the geometrical and genetical relationship between the large scale sinistral conjugate veins.
(B) The sinistral conjugate pattern outcrop can be observed on megascopic scales ranging from 33 m to more than 100 m, in Bukit Tabur Barat, near Kelang Dam (Block 3). Those trending are N265oE and N225oE, mostly associated with N285oE

The second generation (D2) minor to medium scale veins generally, incline to sub horizontal dipping quartz veins, with dip directions toward ENE, (Figure 2.3) most commonly in association with conjugate veins N070°E-N075°E and N240°E-N245°E,

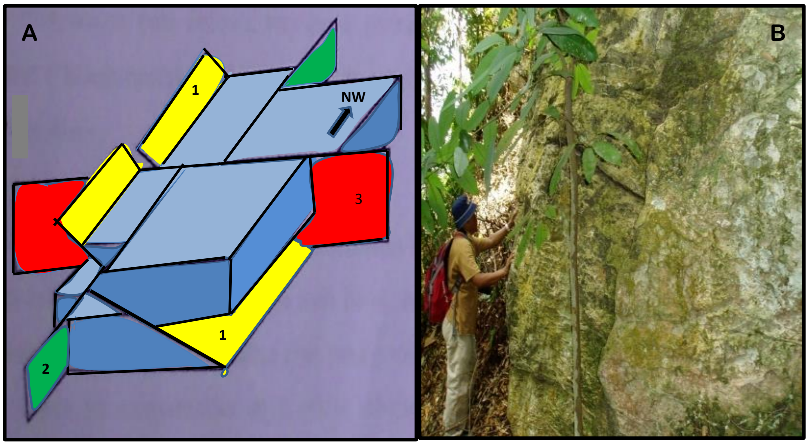

Figure 2.3 : (A) An idealised sketch to show the geometrical and genetical relationship between the shallow dipping veins and the dextral veins.
(B) The shallow dipping veins pattern outcrop can be observed on megascopic scales ranging from 1,20 m to 30 m in Gunung Tabur Barat, near Gombak (Block 10).

The third generation (D3) are minor to medium veins show spacings in the order of a few centimeters to about 300 cm, mostly conjugate quartz veins trend N250°E-N255°E and N215°E-N220°E (Figure 2.3) occur commonly in association with quartz vein N265°E-N270°E,

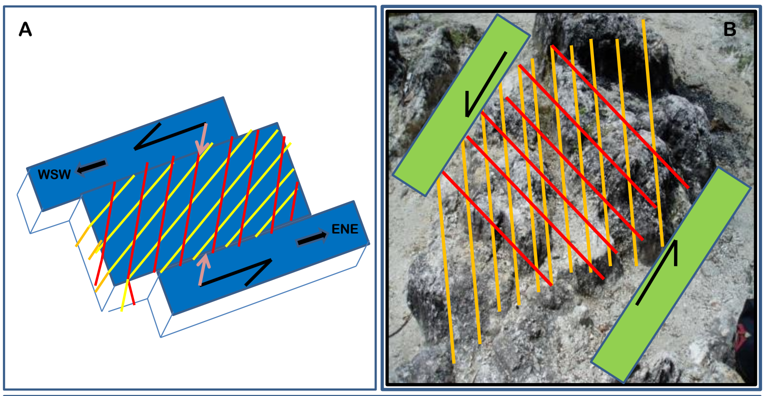

Figure 2.4 : (A) An idealised sketch to show the geometrical and genetical relationship between the medium scale sinistral conjugate veins.
(B) The sinistral conjugate veins pattern outcrop can be observed on megascopic scales ranging from 66 cm to more than 300 cm, in Bukit Tabur Barat, near Kelang Dam (Block 2. Those trending are N250oE and N215oe, most commonly association with N265oE

Finally, the fourth generation (D4) are minor veins show spacings in the order of a few centimeters to about 300 cm, mostly conjugate quartz vein trend N060°E-N065°E and N080°E-N085°E (Figure 2.3), occur commonly in association with quartz vein N045°E-N050°E.

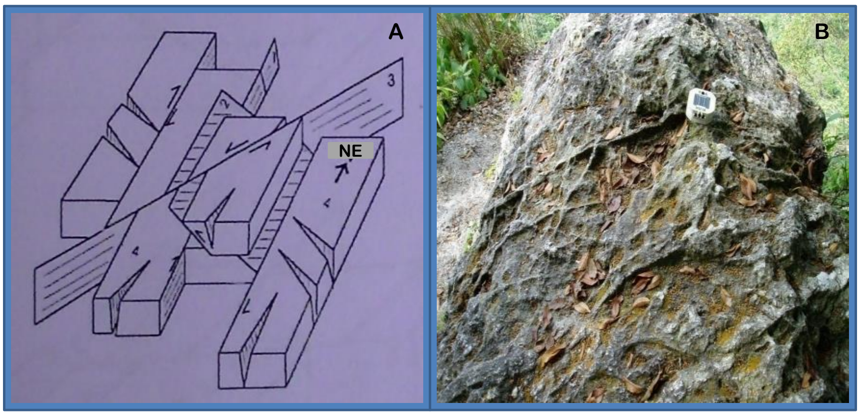

Figure 2.5 : (A) An idealised sketch to show the geometrical and genetical relationship between the conjugate dextral veins.
(B) The dextral conjugate veins pattern outcrop can be observed on megascopic scales ranging from 0,60 cm to 3 m in Gunung Tabur Timur , near Kelang Dam (Block 12). Those are trending N060oE and N085oE, mostly associated with N045oE

CHARACTERIZATION OF QUARTZ VEIN IN GENTING-KELANG RIDGE

The detailed structured of this ridge are character of deformed and undeformed quartz vein with in the ridge, considered with remnants of partly to almost completely altered granite, reflects multiple intrusions. In general major veins are spaced 30 to 300 cm apart, and minor veins show spacings in the order of a few centimeters to about 10 cm. At the whole Genting-Klang Ridge area, the major SE-NW veins (First Generation) were occured to be open fractures with very well comb structure.. In the eastern part of Bukit Tabur Barat area (Klang Gate – Top of Bukit Tabur Barat) or Block 1 to Block 7, enerally show minor to middle veins trends along N265^{o}E-N275^{o}E (Third Generation) whereas in the western part of Bukit Tabur Barat (Top of Bukit Tabur Barat-Gombak) area or Block 8 to Block 10 generally show minor to middle veins trends along N040^{o}E-N045^{o}E (Fourth Generation) and most commonly associated with thinning and thickening major quartz veins trends along N285^{o}E – N290^{o}E. In the western part of Bukit Tabur Timur (Klang Gate to Top of Bukit Tabur Timur) generally show minor quartz veins trends along N040^{o}E-N050^{o}E (Forth Generation) and most commonly associated with subhorizontal veins (Second Generation), whereas in the eastern part of Bukit Tabur Timur (Top of Bukit Tabur Timur to Kampung Tua) most commonly show intersection minor veins of the third generation and fourth generation.

The First Generation Of Quartz Veins (D1)

The first generation (D1) generally, major quartz vein and have thick variety from 15 to 30 cm, It is occurs most commonly in association with quartz gouge to mylonite cataclasite metamorphic, The D1 consists of three vein sets.

The first set of veins (N280^{o}E – N285^{o}E) is a directional veins aligned with the ridge and close or restrict the development of other vein sets, it is estimated that the first set is ***the Primary Shear (P)*** in simple shear system on a single fault. The second set of veins (N265^{o}E – N270^{o}E) makes a low angle with P shear and whole of ridge zone. It is estimate that the second set of veins is ***the Riedel's shear (R)*** or synthetic shear in simple shear system on a single fault. The third set of veins N225ºE – N230ºE that make a high angle to the whole zone, it is identified that the third set of veins is ***Riedel's$_o$ Shear (R$_o$)*** or as antithetic fractures in simple shear system on a single fault. Palaostress analysis showed that the first generation formed by sinistral strike slip fault WNW-ESE directional with the horizontal directional stresses ENE-WSW. (Figure 3.4).

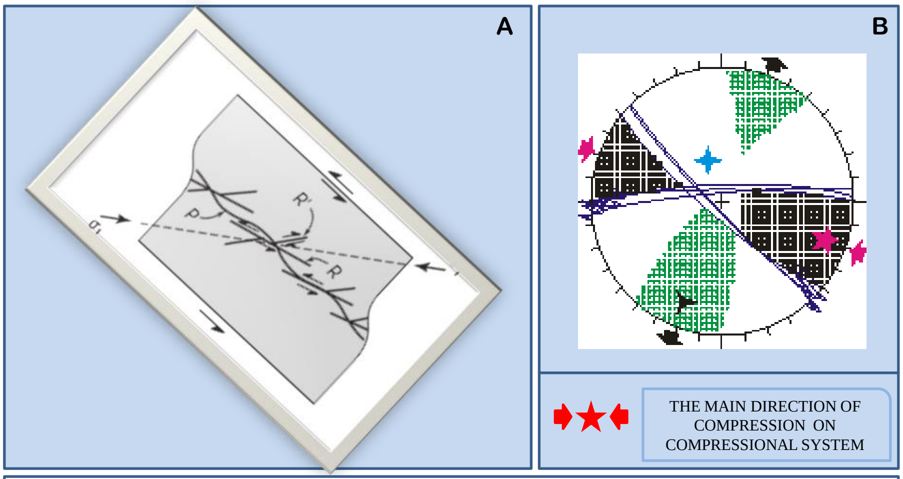

Figure 3.6 : (A) An idealised sketch to show the geometrical and genetical relationship between sinistral shear (R) and dexral shear (R1) in sinistral conjugate pattem of the Riedle's Law.
(B) Stereographic analysis of Paleostress to show E-W dextral and SE-NW Sinistral in the SSE-NNW sinistral conjugate pattern by compressional system with ESE- trending highest stress (The Main Direction)

The Second Generation Of Quartz Vein (D2)

The Second generation (D2) generally minor to medium scale veins, incline to sub horizontal dipping quartz veins, with dip directions toward ENE, (Plate 2.3). The second generation consists of two set of veins. The first set of veins are trending to N350ºE-N355ºE, generally incline to sub horizontal dip quartz veins, with dip directions toward ENE, perpendicular with horizontal stresses of D1, it is estimate that the first vein sets of the second generation is ***reverse shear fracture (RF)*** in simple shear system on a single fault with the horizontal directional stresses ENE-WSW. The second set of veins was conjugate N070ºE-N075ºE and N240oE-N245ºE, relatively parallel with resultante direction, it is estimate that the second vein sets is ***the tention fracture or T fracture (TF)*** in simple shear system on a single fault. The fracture formed in the competent beds are often highly dipping.

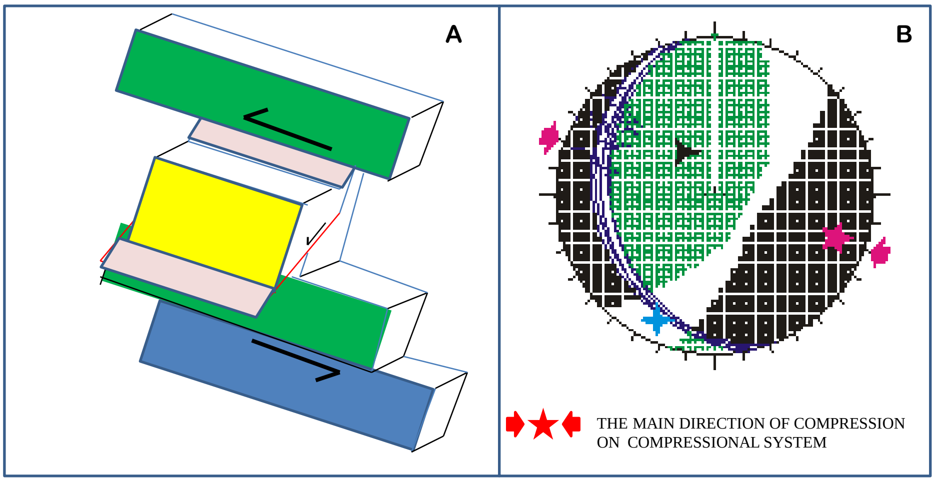

Figure 3.7 : (A) An idealised sketch to show the geometrical and genetical relationship the reverse shear fracture or reverse fault in ESE-WNW sinistral conjugate pattem of the Riedle's Law.
(B) An idealised Riedle's Law model to show the geometrical and genetical relationship between reverse shear fault (RF) and normal fault (TF) in dextral conjugate pattern

The Third Generation Of Quartz Veins (D3)

The thirdt generation generally, minor to medium quartz vein and have spaced 5 to 20 cm apart, and thick variety from 1 to 10 cm, It is occurs most commonly in association with quartz cataclasite brecciation to mylonite cataclasite metamorphic. The third generation consists of three sets of veins. The first set of veins N265ºE-N270ºE is a directional vein aligned with the block of local region and same with the second vein of the first generation. It is estimated that the first set of the third generation is the ***secondary Primary Shear (P^1 shear)*** in simple shear system on a single fault. The second set of the third generation veins N250ºE-N255ºE makes a low angle with P^1 shear and block of local region shear zones. It is estimate that the second set of veins is ***the secondary Riedel's shear (R^1)*** or as synthetic shear in simple shear system on a single fault. The third set of the third generation veins N215ºE-N220ºE that make a high angle to the block of local region shear zone, it is identified that the third set of veins is the ***secondary Riedel's$_o$ Shear (R_o^1)*** or as secondary antithetic shear in simle shear system on a single fault. Palaostress analysis showed that the second variation developed ***by sinistral strike slip or left lateral slip fault*** ENE-WSW directional, with horizontal stress direction of NE-SW.

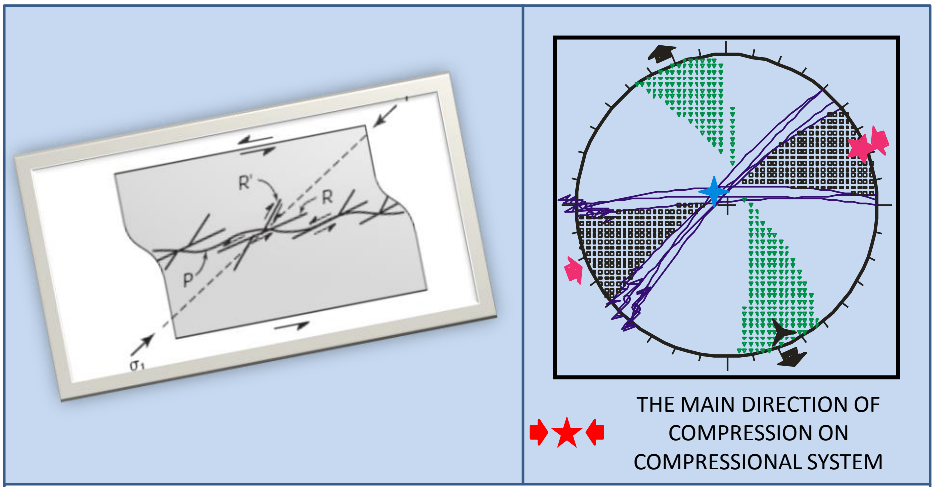

Figure 3.8 : (A) An idealised sketch to show the geometrical and genetical relationship between sinistral shear (R) and dexral shear (R1) in sinistral conjugate pattem of the Riedle's Law.
(B) Stereographic analysis of Paleostress to show E-W sinistral and NE-SW dextral in the ENE-WSW sinistral conjugate pattern by compressional system with ENE- trending highest stress (The Main Direction)

The Fourth Generation of Quartz Veins (D4)

The fourth generation generally minor to medium quartz veins, show spacings in the order of a few centimeters to about 10 cm, and thick from 3 to 5 cm. It is occurs most commonly in association with quartz cataclasite metamorphic, quartz cataclasite brecciation with xenoblast granite. The fourth generation consists of three sets of vein. The first set of veins N040ºE-N050ºE is a directional fracture aligned with the block of local region and same with the third set of veins of the first generation. It is estimated that the first set of the third generation is ***the secondary Primary Shear (*** P^1 ***shear)*** in simple shear system on a single fault. The second set of the fourth generation veins N060ºE-N065ºE makes a low angle with P^1 shear and block of local region shear zones. It is estimate that the second set of veins is ***the secondary Riedel's shear (*** R^1 ***)*** or synthetic shear in simple shear system on a single fault. The third set of the second generation veins N080ºE-N085ºE that make a high angle to the block of local region shear zone, it is identified that the third set of veins is ***the secondary Riedel's*** $_o$ ***Shear (*** R_o^1 ***)*** or as secondary antithetic shear. Palaostress analysis showed that the fourth generation developed by ***dextral strike slip or right lateral slip fault***, NE-SW directional, with horizontal stress direction of ENE-WSW.

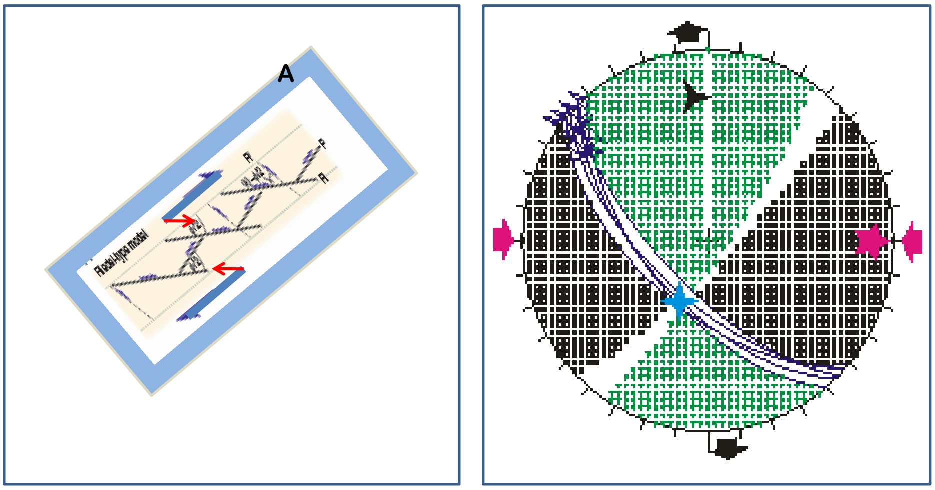

Figure 3.9 : (A) An idealised models to show the geometrical and genetical relationship between sinistral shear (R) and dexral shear (R1) in dextral conjugate pattem of the Riedle's Law.
(B) Stereographic analysis of Paleostress to show NE-SW dextral and SE-NW Sinistral in the NE-SW dextral conjugate pattern by compressional system with E-W trending highest stress (The Main Direction)

DISCUSSION

Block to block region analysis show that the first generation (D1) is oldest veins, They are vertical conjugate veins, characteristically approximately parallel toward ESE-WNW alignment or fault zone, indicating injection along joint directions in the ***a Single Sinistral Strike Slip Fault Zone*** with horizontal stress direction to ESE-WNW and we believed that is Kuala Lumpur Fault Zone. D2 stage, illustrated by reverse fault and sheared zone is also showing ESE-WNW compression and may be the continuation of the D1. This deformation is mostly expressed on top of the block, subsequently D1 vein sets. D2 stage also show conjugate tension fracture (T fracture), its suggest that the fault movement is not continued to the D3 deformation. The type of D1-D2 deformation is defferent with the collisional orogeny. According to Hutchison (2007) almost immediately after this collisional orogeny, pre-rift structures formed in many localities away from the collision zone, and major strike-slip faulting cut obliquely across the collision fold belt in a predominantly north-northwest- south-southeast direction and also possibly sub-parallel to the suture zone. Impressive post-collision S-type tin granites have been dated predominantly at 220-199 Ma (Bignell & Snelling,1970; Liew and Page, 1985; Kwan, 1989; Krahenbuhl, 1991 or Late Triassic age). The sinistral transpressive deformation of D1-D2 produced zones of high flattening strain and WNW-striking sinistral brittle shear zones. These WNW trending shear zones controlled the physiographic development of this area in such a way that the WNW-NW quartz ridge tends to be parallel to the shear zones. This trend can be traced right to the Kuala Lumpur-Endau Fault zone. The D1-D2 sinistral transpressive deformation could possible be a post Late Triassic age. However, from regional correlation, it can be speculated that the D1-D2 structures would have been resulted from strong sinistral transpressional deformation by the West Borneo Basement rifting from Indosinia.

D3 and D4 deformation, generally minor to medium fracture, both are conjugate of the secondary structures in simple shear system on a single fault, it was suggest that the fault movement continued or reactivated during that time. However, from regional correlation, it can be speculated that the D3-D4 structures would have been resulted from strong the collision a conjugated fault system by the collision of the Burma Arc to the East Asian Continent in Cretaceous time (Hutchison, 1988). The timing of D3 and D4 deformation based on magmatism and volcanism in the range 140-120 Ma magmatism and volcanism in the range 140-120 Ma. (Krahenbuhl, 1991; Khoo, 1993). The late-Cretaceous magmatism (90-80 Ma) of Peninsular Malaysia is contemporaneous with the major differential uplift phase infered from isotopic and petrographic evidences, as in the Main Range east of the Bukit Tinggi fault in the Kuala Lumpur area (Krahenbuhl, 1991).

MODEL AND CONCLUSION

Transpression Model Triassic to Jurassic prime time.
Kuala Lumpur-Endau Fault Zone indicates that the D1-D2 deformation was the result of an SE-NW sinistral transpressive resulting from oblique compressional stresses by the West Borneo Basement rifting from Indosinia.

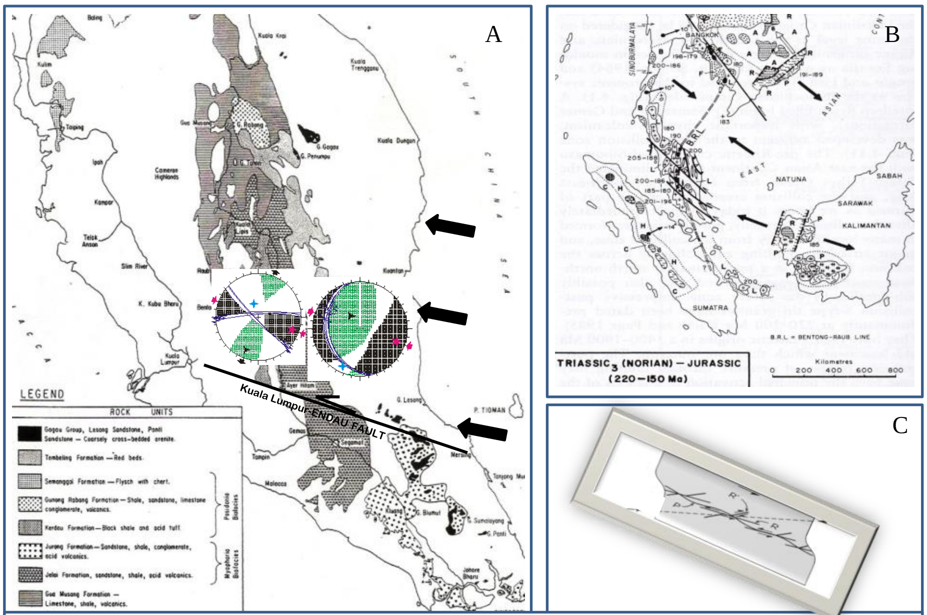

Figure 5.10 : (B) Tectono-stratigraphic map (Hutchison, 2007) showing the transpression structural units in their present geographical position. (A) Kuala Lumpur Fault would have been resulted from strong sinistral transpressional deformation for the time frame Triassic (Norian) to Jurassic (220-150 Ma). (C) The geometrical and genetical relationship P, R and R1 fracture in sinistral conjugate for Riedle's Law

Reactivated.Model Cretaceous prime time.
The conjugate NE-SW dextral faults and ENE-WSW sinistral faults have significant component of strike-parallel with R and R_1 fracture on sinistral fault zone pattern. It can be interpreted that the conjugate faults would have been reactivated from those fractures pattern.

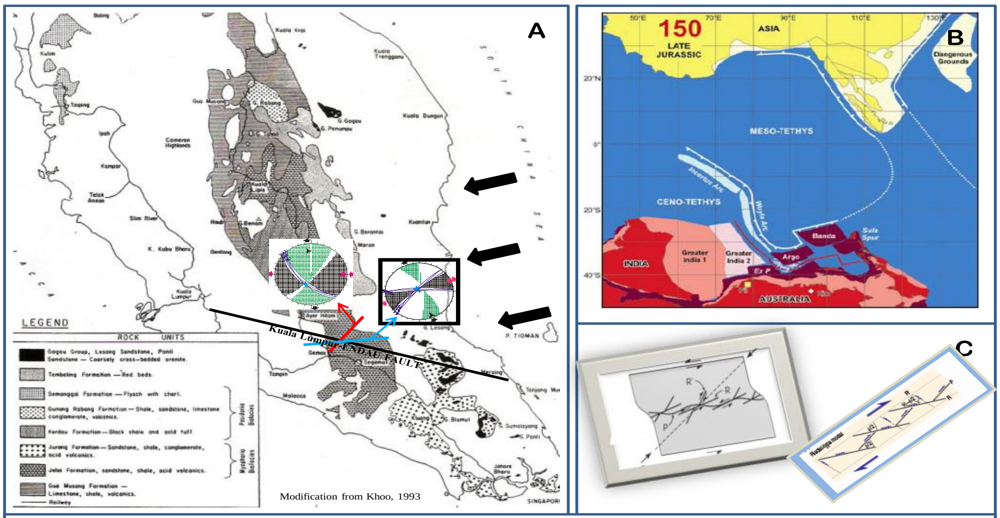

Figure 5.11 : (B) Tectonic Evolution map for the time frame Late Jurassic to Cretaceous (Robert Hall & D.J. Blundell, 1996) showing doubly subduction in SE Asia with ENE-WSW trending compressional subduction deformation. (B) Kuala Lumpur Fault would have been reactivated from WNW-trending to WSW and SW-trending. (C) The geometrical and genetical relationship between P, R and R1 fracture in transpressional deformation Riedle's Law.

CONCLUSION

Along the western foothills of the Main Range, the Lower Palaeozoic schist is intruded by a sub-vertical quartz dyke (Klang Gates Quartz Ridge) along the N300°E to N320°E - trending Kuala Lumpur Fault Zone. The strike slip structures indicated a different type with the Triassic-collisional orogeny, it can be interpreted that the structures would have been resulted from strong sinistral transpressional as soon as a after the emplacement of the Upper Triassic granites.

The Cretaceous age suggest that the fault movement continued at least until Middle Cretaceous or it was reactivated during that time with the ENE-WSW reorientation trending. Finally, the late-Cretaceous magmatism had been injected through a small and local area into Kuala Lumpur Fault Zone.

ACKNOWLEDGEMENTS

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MAGNIFICENCE GEOLOGICAL PHENOMENON ALONG SG. BATU PAHAT: INSPIRING THE JERAI GEOPARK INITIATIVE

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ABSTRACT

Geology of southern part of G. Jerai complex along the Sg Batu Pahat display a marvelous geological features. The origin of the G. Jerai deduced from the crustal thickening after the collision of Sibumasu with Indochina plate during Mid–Triassic, where the thick sequence of Cambrian clastic sedimentary rocks uplifted by granite intrusion. There are two distinctive lithologies present in G. Jerai, which are metasedimentary rock of Jerai Formation and granite. Sg. Batu Pahat is synonym to Candi Bukit Batu Pahat is the most well-known ancient Hindu temple found in Bujang Valley. These archaeological artifacts reveal that there was a Hindu-Buddhist polity here more than 2535 years old. Lithologically, it is mainly composed of fine-grained leucogranite which was cut by series of pegmatite dykes at different episodes. The magnetic differentiation process is the most prominent, where the highly evolved leucogranite intruded at an exceptional high level. It contains high felsic with two mica minerals. The spectacular pegmatite dykes intruded into granite striking to 030^o and 340^o with the thickness ranges from 0.8 to 4.5m. Extra-large muscovite flakes are the most magnificence mineral in pegmatite together with euhedral six-sided crystals of tourmaline. Garnet (grossularite) are also present as an accessory mineral. There are less fractures identified from the entire outcrop, which is generally massive and solid. However, one of the pegmatite dyke striking to 030^o has been sheared during plastic deformation, and shifted to the left or sinistral movement. Series of exfoliation fractures formed in granite due to unloading mechanism. This sub-horizontal fractures utilized by the ancient Hindu-Buddhist polity to chisel out rock slabs for Hindu temple construction in the vicinity of Bujang Valley. For geotourism element, there are a few activities for tourist. Along the river itself, tourists are able to traverse upstream for observing spectacular waterfalls and several sizes of potholes. The prismatic large crystal of tourmaline and extremely large flakes of muscovite are the main interest for mineral collector. Hence, the integrated activities should be emplaced and might attract more tourist to spend time there. The cultural and scientific values along Sg. Batu Pahat will definitely support the initiative to develop Jerai Inspiring Geopark in future endeavor.

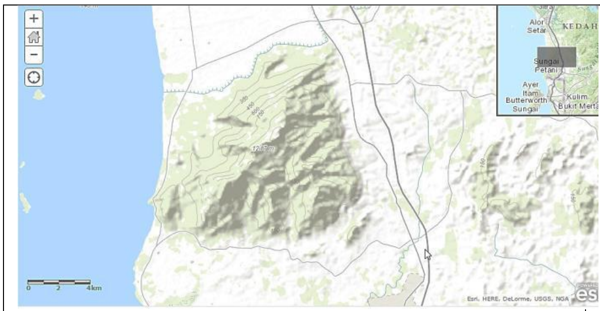

Fig 1: Location map of G. Jerai, Kedah, Malaysia.

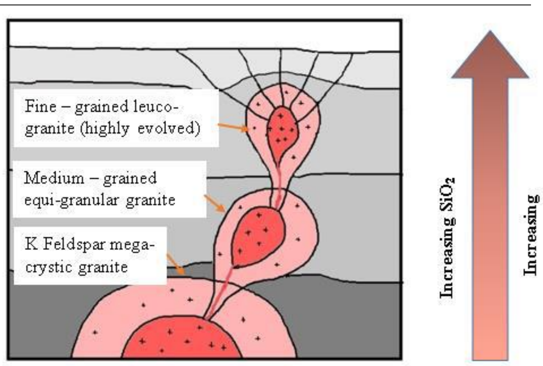

Fig 2: The Magmatic differentiation conceptual model

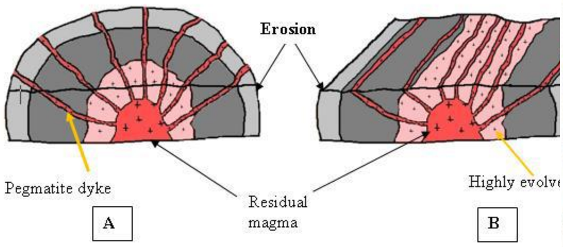

Fig 3: Pegmatite formation conceptual model. (A) Before erosion; (B) After erosion

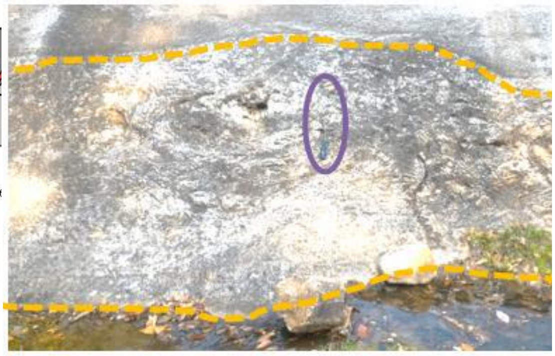

Fig 4: Pegmatite dyke with patches of tourmaline and muscovite.

PALEOCLIMATIC CHANGE ANALYSIS BASED ON STRATIGRAPHIC DATA, JAYAPURA AND ITS SURROUNDING AREA, JAYAPURA DISTRICT, PAPUA PROVINCE

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ABSTRACT
Paleoclimatic changes occuring in Papua are very important to be recognized, particularly in relation to the existence of permafrost snow covering The Jayawijaya Mountain. The study, which is focussed on Jayapura Formation, was carried out by applying a mapping method, detailed measuring sections, and petrography and micropaleontological analyses. Jayapura area has a variety and very complex rocks, one of them is a sedimentary rock having carbonate chemical composition, so called Jayapura Formation, which covers large enough of the studied area. A limestone sample of Jayapura Formation taken from the Base G area indicates the existence of a planktonic foraminifera fossils. By using these fossils content, the age of Pleistocene Epochs can be decided. The limestone of Jayapura Formation was deposited in bathyal to abysal zones, an open sea, where there was no more detrital (clastical) material from a continent, and showing that from the Late Miocene to Pleistocene the environment of studied area changed from lithoral to bathyal environments due to the sea level raising. Generally, this limestone uncoformably overlies the serpetinite lithodem of metamorphic unit which is part of the Cycloop Metamorphic Group. Taking a consideration of the right turning fossil, the climate during the formation of limestone can be interpreted as a warm and wet climate. Furthermore, a few fossils found in the middle part the limestone of Jayapura Formation shows a opposite turning. Therefore it is interpreted that during the Late Pliocene or Early Pleistocene Epochs the limestone was sedimented in the cold and dry climate. From the lithological development, the limestone generally consits of a calselutite intercalated by a marl in the middle part. In the Mawesday area, Sarmi District, that is the western part of the studied area, a paleoclimatic change during Plio-Pleistocene Epochs can be recognized. The appearance of nannoplankton, *Discoaster brouweri* characterzises the end of a cold climate. The Aurumi Formation containing claystone with coal intercalations demonstrates a dry cold climate. Further study concerning a paleoclimatic change, specially in Papua, it is very importance to be carried out, regarding Papua is one of two places along the equator where the snow still exist covering the mountaineous area. Hopefully, the paleoclimatic changes especially during Pleistocene Epoch, Quaternary Peiode, can be used to provocate or campaign in order to protect or preserve the existence of snow covering Jayawijaya Maountain, in Papua.

Key words : Paleoclimatic change, Plio-Pleistocene Epoch, Plankton Foraminifera Fossil.

QUANTITATIVE ASSESSMENT OF CAVE STABILITY ANALYSIS AT GUA DAMAI, BATU CAVES, SELANGOR

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ABSTRACT

The limestone hill of Batu Caves is now becoming a recreation park for slope climbing, base jumping and cave exploring. Assessment on cave stability is essential to ensure the public safety. This study aims to assess the cave stability for Gua Damai, Batu Caves, Selangor by using relationship of system Q classification system with cave width and ratio of cave roof thickness with cave width quantitatively. Stability of cave wall is identified too using slope mass rating (SMR). The lithology of the study area is limestone with low grade metamorphism and white in colour. Discontinuity survey on the slope under the cave shows that the rock mass is influenced by four main joint sets which are J1, J2, J3, J4 with the dip direction and angle of 110˚/73˚, 325˚/87˚, 243˚/39˚ and 054˚/30˚. According to kinematic analysis, the dip direction/dip angle of wedge failure is 051˚/59˚. Ratio of cave roof thickness and cave width shows that the cave is stable and the stability increasing from center to the wall. The relationship between Q system and the cave width shows that the cave at sections 4 and 8 are stable while the cave in sections 1, 2, 3, 5, 6 and 7 require support. Based on SMR, the cave walls stability for slope of c, d, and f are not stable while the slope walls of a, b, e and g are stable. Overall, the most stable parts of the cave are section 4 and section 8 followed by section 1 and section 5. Section 6 is moderate and sections 2, 3 and 7 have poor stability.

Key words**:** limestone, cave stability assessment, Gua Damai

INTRODUCTION

Geological hazards such as landslides, rockfalls, subsidence, sinkholes and the collapse of limestone bedrock are common engineering problem in tropical countries due to the quick process of dissolution. Hatzor *et al*. (2002) suggested that the failure of the cave was caused by the failure of the rock mass and the movement of block of cave walls and roof of cave. However, the hazards of limestone cave were difficult to estimate. Waltham (2002) and Waltham and Fookes (2003) assessed the stability of the limestone cave by using System Q and width of cave and also suggested that the cave is classified as stable when the thickness of the roof of the cave more than 70% of the width of the cave.

The local researcher such as Goh *et al.* (2015a, 2015b, 2016a, 2016b), Norbert *et al.* (2015), Tan (2001) and Tan (2006) were more focused on limestone slope stability and rock material strengths. Less research and study had been reported in limestone cave stability in Malaysia. Therefore, this aims of this study was to assess the cave wall stability using slope mass rating (SMR) and cave stability by using rock mass classification of system Q, cave width and thickness of cave roof for Gua Damai, Batu Caves, Selangor quantitatively.

MATERIALS AND METHODOLOGY

Geological Setting

Batu Caves, Selangor is located at 13 km north of Kuala Lumpur (Figure 1). Gobbett & Hutchison (1973) reported that the limestone were crystalline, greyish to milky white, thick bedded, stripped marble, saccharoidal dolomite and pure calcatic limestone. Gua Damai is part of the Palaeozoic Formations of Selangor and Kuala Lumpur. The geology of the area consists of sedimentary rocks ranging in age from Middle-Upper Silurian to Mesozoic or Younger overlying the older Hawthornden Formation and the Kuala Lumpur Limestone Formation (Gobbett 1965).

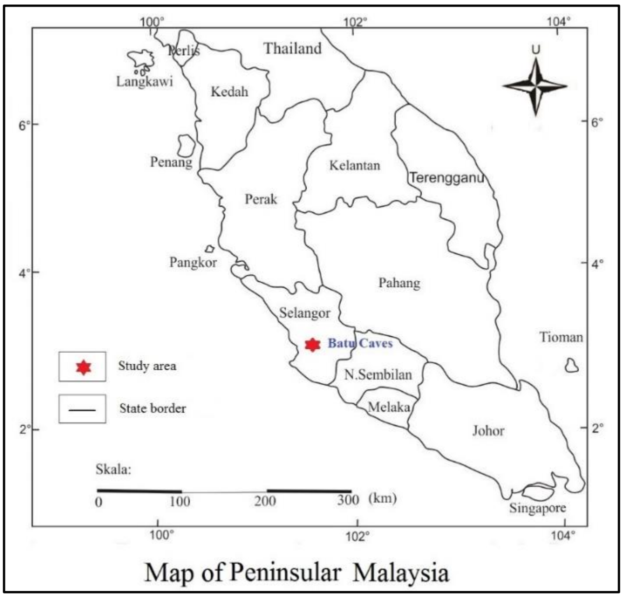

Figure 1: The location of study area in Peninsular Malaysia, Malaysia

Cave Wall Stability - Slope Mass Rating (SMR) Method

The slope mass rating method was proposed by Romana (1995) and used to assess the stability of rock slope. This method comprised of the following components:

(a) Uniaxial compressive strength (UCS)
(b) Rock quality designation (RQD)
(c) Discontinuities spacing
(d) Conditions of discontinuities
(e) Ground water condition
(f) Adjusting factors for joints (F1, F2, F3)
(g) Adjusting factor for excavation (F4)

The uniaxial compressive strength (UCS) of rock material was determined based on the recommendations of the International Society for Rock Mechanics (1981, 1985). The value of respective components of (b), (c), (d) and (d) were determined from scanline discontinuites survey, following suggestion of Ibrahim Komoo dan Ibrahim Abdullah (1983). F1 was the rating of in considering the difference of dip direction between joints and slope face. F2 was the rating of dip angle of the respective joint. F3 was the rating of considering the difference of dip angle between joints and slope face. The values of respective component of (a), (b), (c), (d) and (e) will be rated based on Romana (1995) suggestion. The total rating, RMR_b was (Bieniawski 1989) determined as:

$$RMR_b = \text{Rating (a)} + \text{Rating (b)} + \text{Rating (c)} + \text{Rating (d)} + \text{Rating (e)} \quad (1)$$

The rating for SMR was determined based on following equation suggested by Romana (1995) :

$$SMR = RMR_b + (F1 \times F2 \times F3) + F4 \quad (2)$$

Cave Stability Assessment

The value of system Q is calculated from Rock Mass Rating (RMR), suggested by Barton (1995) using the formula below:

$$RMR = 15 \log Q + 50 \quad (3)$$

The stability of limestone cave was classified based on recommendation of Waltham (2002) and Waltham and Fookes (2003). The value of system Q and width of limestone cave width was used to assess the stability (Figure 2). Waltham (2002) and Waltham and Fookes (2003) also suggested that the cave is stable when the thickness of the roof of the cave are more than 70% of the width of the cave.

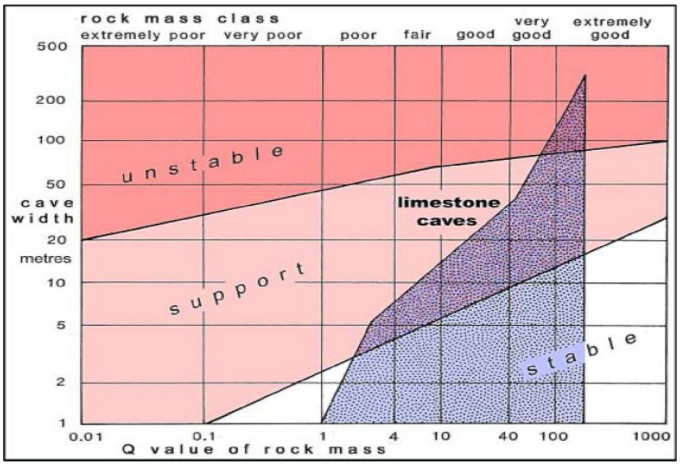

Figure 2: Cave stability assessment based on Q value and cave width.
Source : Waltham (2002) and Waltham and Fookes (2003)

RESULT AND DISCUSSION

A total of 200 of discontinuities survey was conducted on is the slopes beneath the cave (Figure 3). The cave was divided into 8 sections (1, 2, 3, 4, 5, 6, 7 and 8) (Figure 4). The cave wall was divided into seven portions which were (a), (b), (c), (d), (e), (f), and (g) according to the orientation of the wall (Figure 4).

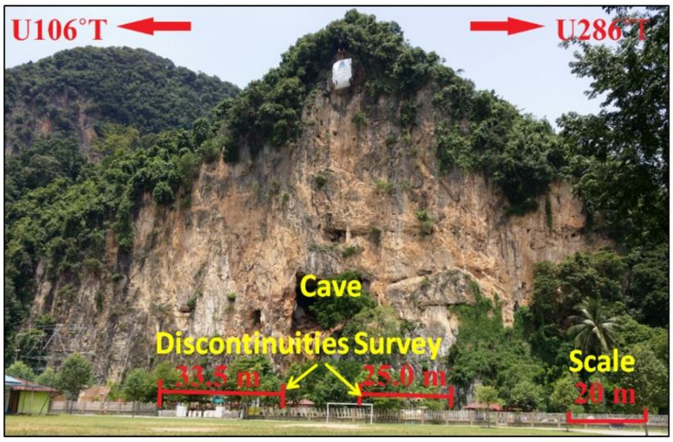

Figure 3: The location discontinuities survey and cave at Gua Damai, Batu Caves, Selangor.

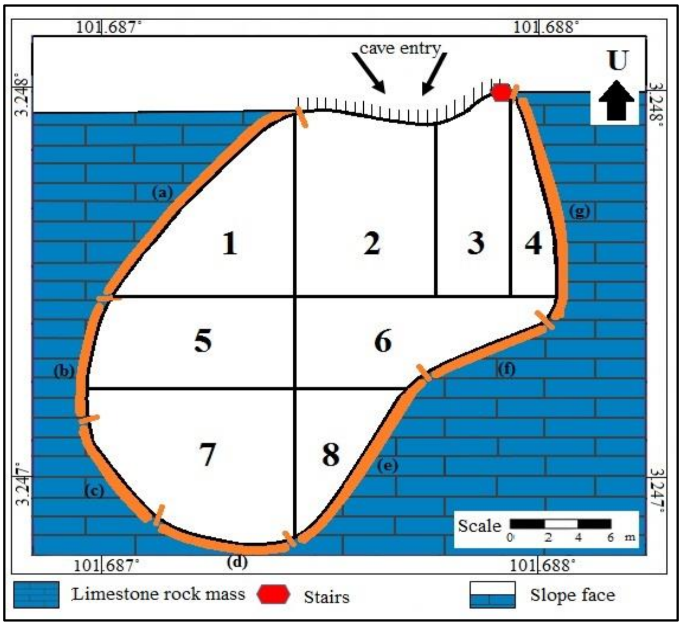

Figure 4: The cave walls and cave cavity were divided into 7 and 8 sections respectively according to the orientation on the cave walls.

Discontinuity survey show that the slope composed of four (4) major joint sets which are J1, J2, J3, J4 with the dip direction and angle of 110˚/73˚, 325˚/87˚, 243˚/39˚ and 054˚/30˚ (Figure 5). The orientations of major joint sets are exhibited in Table 1.

The average value of uniaxial compressive strength (UCS) of limestone rock was 30.5 MPa, classified as moderate strong based on classification of International Society for

Rock Mechanics (1981). The Rock Quality Designation (RQD) value for the limestone slope is 84.8%.

Table 1: Major Joint sets characteristic at Gua Damai, Batu Caves, Selangor, Malaysia

Joint sets	Orientation (°)	Spacing (m)	Average Persistence (m)	Aperture	Roughness	Water Condition
J1	110/73	0.98	1.79	very narrow	rough	dry
J2	325/87	1.14	1.60	very narrow	rough	dry
J3	243/39	0.45	1.03	tight	rough	dry
J4	054/30	0.36	2.12	extreme narrow	rough	dry

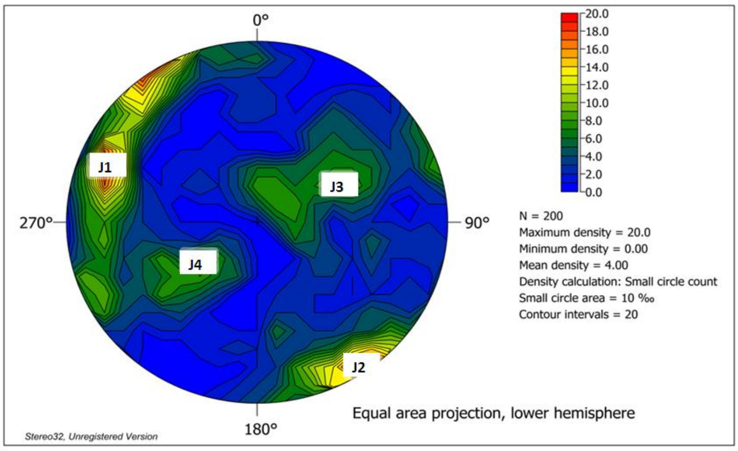

Figure 5: Four major joint sets are labeled J1, J2, J3, J4 with the dip direction and angle of 110˚/73˚, 325˚/87˚, 243˚/39˚ and 054˚/30˚.

Table 2 exhibits the summary rating for System Q for respective section 1, 2, 3, 4, 5, 6, 7 and 8 of Gua Damai, Batu Caves, Selangor, Malayasia. The rating for RMR_b was 66. The classification of Rock Mass Rating (RMR) suggested by Bieniawski (1989) for this limestone cave were from fair to good rock mass with the rating of 56 to 66.

The stability assessment based on relationship between Q system and the cave width according to Waltham (2002) and Waltham and Fookes (2003) shows that the cave at sections 4 and 8 are stable while the cave in sections 1, 2, 3, 5, 6 and 7 require support (Figure 6). However, the sections of cave that require support are still in a stable condition because of the formation of thick limestone pillars in the middle of the cave that support the cave roof (Figure 7).

Table 2: System Q value and classification system calculated from RMR value based on joint orientations. The rating for RMR_b was 66.

Section	Cave width (m)	Influence joint set	Direction of strike to cave axis	Orientation Effect	Rating	RMR	RMR classification Bieniawski (1989)	System Q	System Q classification (Barton 1974)
1	8.8	J1	parallel	very favourable	0	66	good	11.66	good
2	6	J3	perpendicular	unfavourable	-10	56	fair	2.51	poor
3	4.2	J3 J1	perpendicular parallel	unfavourable very favourable	-10 0	56	fair	2.51	poor
4	2.5	J2	parallel	very favourable	0	66	good	11.66	good
5	12.6	-	-	-	0	66	good	11.66	good
6	10.6	J2	parallel	very favourable	0	66	good	11.66	good
7	12.8	J4	perpendicular	unfavourable	-10	56	fair	2.51	poor
8	4	J2	parallel	very favourable	0	66	good	11.66	good

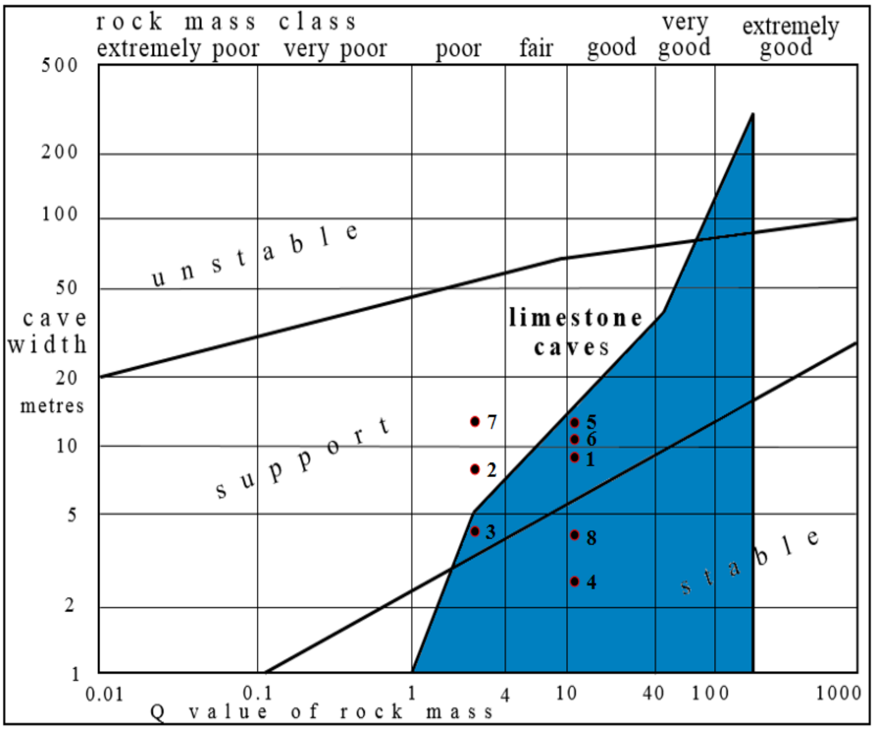

Figure 6: The stability assessment of cave based on Q system and cave width. The diagram shows that sections 4 and 8 are stable while sections 1, 2, 3, 5, 6, and 7 require support.

Source : Modified from Waltham (2002) and Waltham and Fookes (2003)

The Ratio of cave roof thickness with cave width was at the range of 2.5 – 4.0 (Figure 8). This indicated that the cave was stable where by the ratios were more than 0.7 and the stability increasing from center of the cave to the wall. This is because the cave was wider and higher in the middle of the cave and smaller near to the cave walls as shown in Figure 9. The higher the cave, the thinner the cave roof. This cause lower load and reduce material strength.

The results of assessment on the walls of cave based on Slope Mass Rating, SMR (Romana 1985) is exhibited in Table 3. The stability of cave walls for portion (c), (d), and (f) were not stable while the walls of (a), (b), (e) and (g) are stable. The portions of wall were not stable because the orientation of respective slope face of the cave wall was parallel to the wedge failure (051°/59°). Therefore, the walls rock in portion (c), (d), and (f) were potentially to have wedge failure with the probability of failure of 0.6.

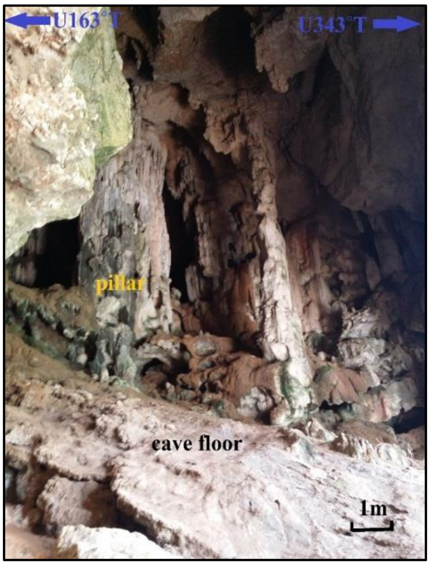

Figure 7: The presence of limestone pillars in the middle of cave act as support to prevent collapse of cave roof.

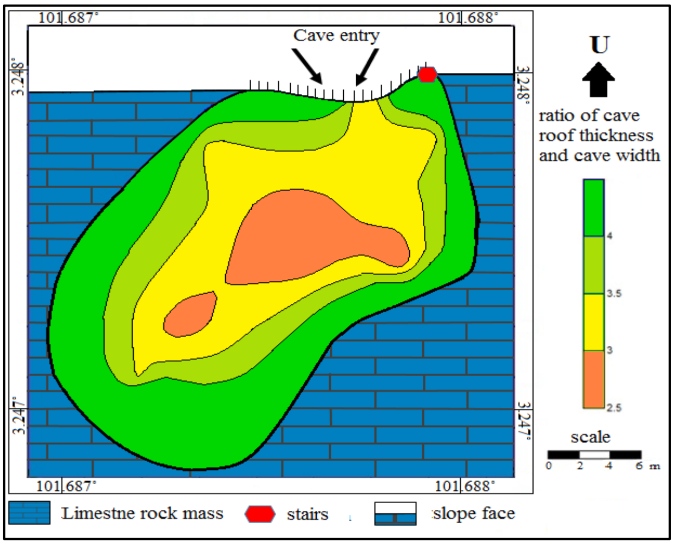

Figure 8: Contour map of the ratio of cave roof thickness with cave width. The higher the ratio shows more stable of the cave. This indicated that the cave was stable where by the ratios were more than 0.7.

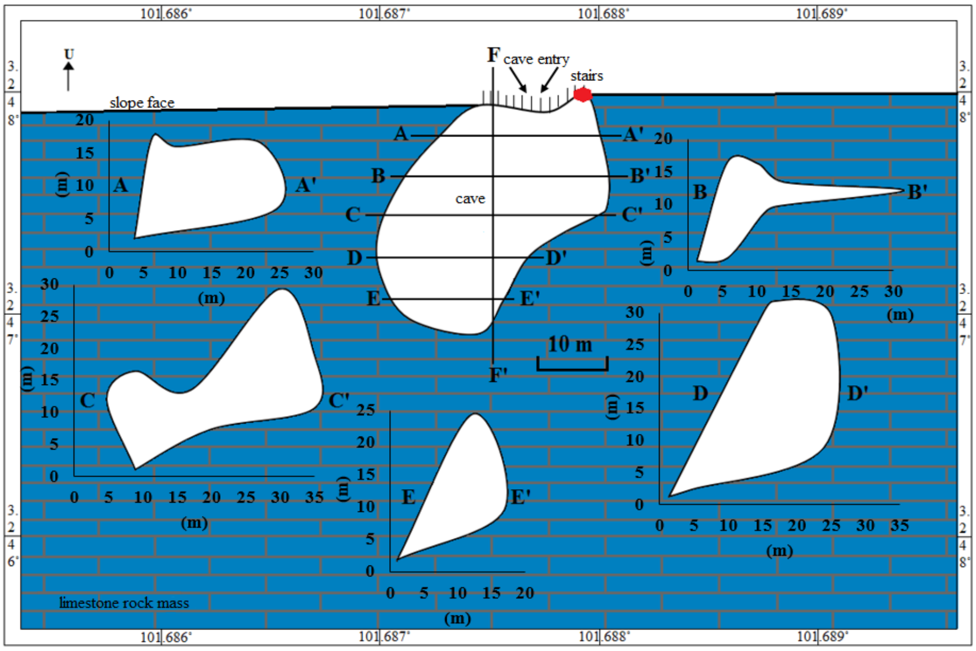

Figure 9: The plan view and cross section of the cave at A-A', B-B', C-C', D-D' and E-E' shows that the cave cavity is higher in the middle causing thinner cave roof and lower stability.

Table 3: Stability of cave walls based on SMR classification system, Romana (1985).

Portion of cave wall/ Orientation (°)	F_1	F_2	F_3	F_4	Failure mode	SMR	Stability	Probability of failure
a 138/81	-	-	-	-	none	66	stable	0.2
b 100/68	-	-	-	-	none	66	stable	0.2
c 55/71	1.00	1.00	-60	+15	wedge (51°/59°)	21	unstable	0.6
d 14/83	0.85	1.00	-60	+15	wedge (51°/59°)	30	unstable	0.6
e 300/77	-	-	-	-	none	66	stable	0.2
336/83	1.00	1.00	-60	+15	wedge (51°/59°)	21	unstable	0.6
256/64	-	-	-	-	none	66	stable	0.2

CONCLUSION

Figure 10 shows the final stability of cave for Gua Damai, Batu Caves, Selangor, Malaysia.
Based on the Q system and the cave width, the stabilities of sections 4 and section 8 of Cave Damai were stable while sections 1, 2, 3, 5, 6 and 7 require supports. Based on SMR, the cave walls stability at the portion of (c), (d) and (f) were not stable while portion (a), (b), (e) and (g) were stable. Overall, the most stable parts of the cave are section 4 and section 8 followed by section 1 and section 5. Section 6 is moderate and sections 2, 3 and 7 have poor stability.

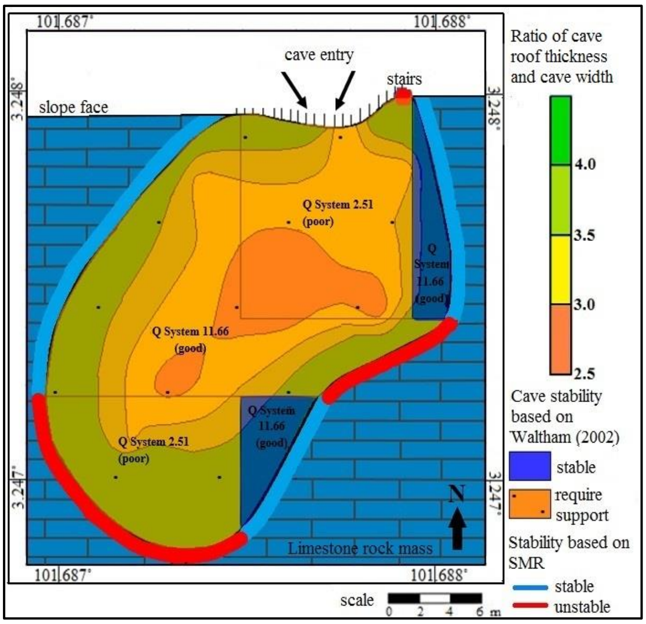

Figure 10: Cave stability map based on the ratio of cave roof thickness with cave width, Q system with cave width and stability of cave wall based on SMR assessment.

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KAJIAN POTENSI GEOPARK G. PENANGGUNGAN KABUPATEN MOJOKERTO DAN PASURUAN, PROVINSI JAWA TIMUR

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ABSTRACT

Penanggungan Volcano (7.615°N, 112.62°E), located at Mojokerto and Pasuruan districts, East Java Province. G. Penanggungan expressed as Penanggungan Volcanics and pyroclastics Unit Guarantee, in Upper Quaternary age. More detailed studies indicate that consists of diverse volcanic lithology, as lavas, pyroclastic flows and lahars, which confirmed his status as gunugapi Strato. In Penanggungan there are about 120 sites heritage of Mataram Kuno until the Majapahit (10 to 14 century). Until now this sites colected such as temples, baths / petirtaan, punden, cave hermitage, fences, and roads. These sites are scattered at the foot of the highest peaks. This paper argues about the geological conditions greatly affect the determination of the location of the site, the architecture and the material forming the temple. This peculiarity allows this area developed as a geopark.

Key words : Volcanostratigraphy, Geopark, G. Penanggungan

PENDAHULUAN

G. Penanggungan memiliki 6 kerucut parasiter yang tersebar di sekitarnya. G. Bekel di sebelah barat laut, G. Genting di sebelah utara, G. Kemuncup di sebelah timur, G. Bendo di sebelah selatan, G. Wangi di sebelah tenggara, dan G. Gajahmungkur di timur timur laut. Kehadiran beberapa pusat erupsi ini menunjukan adanya keanekaragaman litologi penyusun dari G. Penang-gungan. Dalam Peta Geologi lembar Malang (S. Santosa dan T. Suwarni, 2011) selama ini G. Penanggungan dinyatakan sebagai Satuan Piro-klastika Penanggungan berumur Kuarter Atas.

Lokasi ini diusilkan karena geopark bukan hanya tentang geologi, seperti dikemukaan pada pengertian geopark versi UNESCO sebagai berikut "A UNESCO Global Geopark must demonstrate geological heritage of international significance, the purpose of a UNESCO Global Geopark is to explore, develop and celebrate the links between that geological heritage and all other aspects of the area's natural, cultural and intangible heritages."

G. Penanggungan memiliki situs-situs peninggalan Mataram Kuno pada abad ke 10 hingga Majapahit pada abad ke 14. Situs-situs arkeologi ini tersebar di kaki hingga puncak G. Penanggungan dan berada juga pada kerucut parasite G. Penanggungan, situs ini berjumlah sekitar 120 situs. Situs-situs tersebut berupa candi, pemandian/petirtaan, punden berundak, goa pertapaan (ceruk), pagar, dan jalan. Dari sisi tempatan, 102 situs di G. Penanggungan di bagian tubuh, dan bagian bawah 18 situs.

METODE

Metode yang digunakan dalam penelitian penentuan stratigrafi G. Penanggungan dan hubunganya dengan keberadaan dan posisi situs-situs arkeologi ini adalah sebagai berikut :

1. Pengumpulan data sekunder, digunakan untuk mengetahui dan mempelajari hasil dari peneliti terdahulu yang bertujuan untuk mendapatkan gambaran hubungan dari litologi dan aktivitas vulkanisme di daerah penelitian terhadap posisi dan kondisi situs-situs.
2. Pengumpulan data lapangan, digunakan untuk data litologi, mata air, morfologi dan data profil stratigrafi, serta hubunganya dengan posisi dan kondisi situs-situs. Perlatan yang digunakan dalam metode penelitian lapangan ini antara lain Global Positioning System (GPS), kompas geologi, palu geologi, dan meteran.
3. Pekerjaan laboratorium dan analisis data, dilakukan hampir secara bersamaan yaitu mengenai analisa sayatan tipis petrografi.

GEOMORFOLOGI

Morfologi gunungapi merupakan bentukan morfologi permukaan bumi yang spesifik akibat dari hasil dari interaksi antara proses eksogen dan endogen. Morfologi gunungapi tidak hanya dipengaruhi oleh material-material hasil erupsi dan tipe erupsinya saja, tetapi juga dikontrol oleh tingkat erosi. Daerah Penelitian memiliki ketinggian 10 m dpl – 1605 m dpl. Berdasarkan aspek-aspek di atas maka morfologi G. Penanggungan dapat dibagi menjadi 5 satuan yaitu: Kerucut Vulkanik (V1), Lereng Vulkanik Atas (V2), Lereng Vulkanik Tengah (V3), Lereng Vulkanik Bawah (V4), dan Kerucut Parasiter (V5)

Satuan Kerucut Vulkanik disusun oleh lava dan breksi piroklastik. Menempati 10% dari daerah telitian, dengan ketinggian 1274 - 1605 m dpl. Satuan ini membentuk pola pengaliran radial, dengan lembah curam dan dalam bebentuk V. Bentuk lahan hanya ditumbuhi rumput-rumput liar.

Foto 1. Kenampakan kerucut vulkanik berlereng curam – sangat curam dari puncak G. Penang-gungan foto diambil dari desa Sukoreno, dengan arah kamera N 0300 E

Satuan Lereng Vulkanik Atas disusun oleh lava dan breksi piroklastik. Menempati 15% dari daerah telitian, dengan ketinggian 700 - 1000 m dpl. Satuan ini membentuk pola pengaliran radial dengan lembah curam dan dalam berbentuk V. Satuan ini ditumbuhi oleh rumput-rumput liar dan pohon besar.

Satuan Lereng Vulkanik Tengah disusun oleh lava, breksi piroklastik, dan breksi lahar. Menempati 40% dari daerah telitian, dengan ketinggian 200 - 700 m dpl. Satuan ini membentuk pola pengaliran radial dan subdendritik, dengan lembah curam dan dalam berbentuk V. Satuan ini digunakan sebagai lahan pertanian, perkebunan, dan peternakan, serta mulai ada permukiman.

Satuan Lereng Vulkanik Bawah disusun oleh lava, breksi piroklastik, dan breksi lahar. Menempati 30% dari daerah telitian, dengan ketinggian 40 - 200 m dpl. Satuan ini membentuk pola pengaliran radial dan subdendritik, dengan bentuk lembah curam - landai serta berbentuk V - U. Satuan ini digunakan sebagai lahan pertanian, perkebunan, peternakan, dan permukiman, serta daerah wisata.
Satuan Kerucut Parasiter disusun oleh lava, dan breksi piroklastik. Menempati 15% dari daerah telitian, dengan ketinggian 900 - 1400 m dpl. Satuan ini membentuk pola pengaliran radial, dengan lembah curam dan dalam berbentuk V. Satuan ini digunakan sebagai lahan pertanian, perkebunan, peternakan, dan sedikit permukiman.

VULKANOSTRATIGRAFI

G. Penanggungan memiliki 6 kerucut parasiter yang tersebar di sekitarnya. G. Bekel di sebelah barat laut, G. Genting di sebelah utara, G. Kemuncup di sebelah timur, G. Bendo di sebelah selatan, G. Wangi di sebelah tenggara, dan G. Gajahmungkur di timur timur laut. Kehadiran beberapa pusat erupsi ini menunjukan adanya keanekaragaman litologi penyusun G. Penanggungan, terdiri dari Satuan-satuan lava, aliran pirolastika, dan lahar.
Satuan-satuan lava dijumpai sebagai Satuan Lava Penanggungan 1 (PLv1) Watutalang, Satuan Lava Penanggungan 2 (Plv2) Watesnegoro, Satuan Lava Penanggungan 3 (Plv3) Kedungudi, Satuan Lava Penanggungan 4 (Plv4), Satuan Lava Penanggungan 5 (Plv5) Seloliman, Satuan Lava Penanggungan 6 (Plv6) Gajah-mungkur, Satuan Lava Penanggungan 7 (Plv7) Bekel, Satuan Lava Penanggungan 8 (Plv8) Genting, Satuan Lava Penanggungan 9 (Plv9) Kemucup, Satuan Lava Penanggungan 10 (Plv10) Bendo.
Satuan-satuan aliran piroklastika dijumpai sebagai Satuan Aliran Piroklastika 1 (Pap1) Wonosunyo, Satuan Aliran Piroklastika 2 (Pap2) Masedong, Satuan Aliran Piroklastika 3 (Pap3) Bekel, Satuan Aliran Piroklastika 4 (Pap4) Genting, Satuan Aliran Piroklastika 5 (Pap5), Kemucup, Satuan Aliran Piroklastika 6 (Pap6) Wangi.
Satuan-satuan lahar terdiri dari Satuan Lahar 1 (Plh1) Wonosunyo, Satuan Lahar 2 (Plh2) Masedong, Satuan Lahar 3 (Plh3) Bekel, Satuan Lahar 4 (Plh4) Kemucup, Satuan Lahar 5 (Plh5) Wangi

OBYEK GEOPARK

1. Petirtaan Jolotundo

Situs Petirtaan Jolotundo berada pada koordinat 0676021, 9158502. Situs ini secara administratif berada di Dukuh Balekambang, Desa Seloliman, Kecamatan Trawas, Kabupaten Mojo-kerto. Petirtaan ini berada di lereng G. Penang-gungan dengan ketinggian 525 m dpl. Petirtaan Jolotundo ini dibuat di lereng barat G. Penanggungan dan berdiri di atas litologi lava. Struktur bangunan yang mengikuti topografi lava yang ada di sekitarnya. Sumber air di Petirtaan Jolotundo berasal dari aquifer celah pada Satuan Lava Penanggungan 1 (PLv1) Watesnegoro. Kualitas sangat baik dan kuantitas air besar sehingga mampu mengairi air hampir di semua dusun yang ada di dekatnya.

Foto 2. Singkapan Lava Penanggungan 1 (PLv1) Watesnegoro pada petirtaan Jolotundo, foto diambil di petirtaan Jolotundo, dengan arah kamera N287^{0}E

4. Candi Kama II

Candi Kama II terletak di lereng barat G. Bekel pada koordinat 0677104, 9159053. Candi ini merupakan candi bercorak Hindu ini bertumpu pada endapan Lava Penanggungan 4 (PLv4) Bekel.

Foto 3. Candi Kama II bersndar piroklastik aliran, foto diambil di Candi Kama II, dengan arah kamera N 0630 E

5. Candi Kendalisodo

Candi Kendalisodo adalah candi tertinggi di G. Bekel, pada ketinggian 1200 m dpl. Candi ini terletak di lereng barat, 200 m dari puncak G. Bekel. Candi ini dipahat pada Lava Penanggungan 4 (PLv4) Bekel dan memanfaatkan resistensi batuan tersebut untuk menjaga keutuhannya.

Foto 8. Candi Kendalisodo yang dibuat langsung dengan menatahkan pada lava Bekel, pada sisi timur agak sedikit rusak karena piroklastik aliran, foto diambil di Candi Kendalisodo, G.Bekel, dengan arah kamera N 1520 E

2. Goa Buyung

Goa Buyung terletak di sisi lereng tenggara G. Bekel. Goa ini memanfaatkan Lava Penanggungan 4 (PLv4) Bekel untuk dijadikan ruangan (goa). Goa yang sering dipergunakan untuk pertapaan ini dipahat langsung di Lava Penanggungan 4 (PLv4) Bekel, yang memanfaatkan resistensi batuannya.

Foto 9. Goa Buyung dengan dinding lava pada bagian dalam,foto diambil di goa Buyung, G.Bekel, dengan arah kamera N 1150 E

3. Candi Wayang

Candi Wayang ini berada di lereng G. Penanggungan bagian timur laut tepatnya berada di G. Gajahmungkur.Candi wayang dipahat langsung di Lava Penanggungan 3 (Plv3) Gajahmungkur.

Foto 10. Candi Wayang yang langsung dipahat di lava genting, foto diambil di Candi Wayang, G.Gentingl, dengan arah kamera N 3700 E

6. Candi Kerajaan

Candi Kerajaan adalah candi di lereng G. Genting yang berdiri diatas Lava Penanggungan 5 (PLv5) Genting, dan memiliki adaptasi sebagai pencegah kerusakan berupa tatanan batu yang mengelilingi melindungi candi.

Foto 11 . Candi Kerajaan dengan dasar lava Genting, foto diambil di candi kerajaan, G. Genting, dengan arah kamera N 2950 E

7. Candi Carik

Candi Carik merupakan candi dilereng G. Penanggungan dengan jalur Kedungudi.Candi ini berdiri diatas Satuan Lava Penanggungan 1 (PLv1) Watesnegoro.

Foto 12. Candi Carik dengan dasar lava Penang-gungan, foto diambil di Candi Carik, G. Penanggungan, dengan arah kamera N 1110 E

9. Candi Lurah

Candi Lurah merupakan candi di atas Candi Guru yang juga terletak di lereng G. Penanggungan dan dapat dicapai melalui jalur pendakian dari Kedungudi atau Jolotundo. Candi ini juga berdiri diatas Satuan Lava Penanggungan 1 (PLv1) Watesnegoro.

Foto 13. candi Lurah dengan dasar lava penaggungan, foto diambil di candi Lurah, G. Penanggungan, dengan arah kamera N 1210 E

KESIMPULAN

1. G. Penanggungan terdiri dari 5 bentukan morfologi, yaitu Satuan Kerucut vulkanik (V1), Satuan Lereng vulkanik atas (V2), Satuan Lereng vulkanik tengah (V3), Satuan Lereng vulkanik bawah (V4), dan Satuan Kerucut Parasiter (V5).
2. Tubuh gunungapi terdiri dari 17 satuan litostratigrafi, terdiri dari 8 satuan-satuan lava, 5 satuan-satuan piroklastika dan 4 satuan-satuan lahar.
3. Situs arkeologi hadir di lingkungan mata air dan bertumpu atau langsung memanfaatkan lava lava.

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INVENTORI GEOTAPAK DIKEDAH UNTUK PERANCANGAN DAN PENGURUSAN

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ABSTRAK

Pemusnahan dan pengabaian geotapak sering berlaku disebabkan oleh projek pembangunan yang dijalankan. Ini adalah kerana pihak perancang tidak menyedari kewujudan dan kepentingan geotapak yang ada dalam kawasan mereka. Perkara ini menyebabkan banyak geotapak bernilai tinggi termusnah dan hilang buat selamanya. Menyedari masaalah ini satu program pengumpulan maklumat bagi tujuan inventori untuk digunakan oleh pihak perancang diperingkat negeri dan daerah dilakukan secara bersistematik. Hasil inventori ini dipersembahkan kepada pihak berkenaan dalam bentuk peta taburan lokaliti geotapak yang bersignifikan tinggi. Di samping itu usaha kesedaran dilakukan melalui penyediaan panel maklumat bagi menyedarkan sekurang-kurangnya masyarakat setempat tentang kewujudan geotapak bernilai tinggi di kawasan mereka. Usaha ini juga bertujuan melibatkan masyarakat setempat dalam menjaga dan mengurus sumber geologi di kawasan mereka sendiri. Kertas ini akan membincangkan proses pngumpulan maklumat, penghasilan peta lokali serta panel maklumat yang dihasilkan serta manfaat yang diperolehi.

OPTIMUM CARRYING CAPACITY ASSESSMENT USING REMOTE SENSING APPROACH IN CANDI IJO GEOHERITAGE OF YOGYAKARTA

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ABSTRACT
Candi Ijo is one of the temples that are included in Geoheritage of Yogyakarta, in accordance with the Decree of the Head of Geological Agency Number 1157K/40/BGL/2014. The purpose of this study was to calculate Optimum Carrying Capacity in Candi Ijo using remote sensing approach. Applied remote sensing application is doing with taking aerial photographs using a UAV. The aerial photos that taken using UAV have a resolution of 2.5 cm. Based on the analysis of aerial photographs, in-depth interviews and field surveys note that the value of Optimum Carrying Capacity in Candi Ijo Geoheritage is low, due to the limited land area. In terms of access, amenity and attractions aspects, Candi Ijo geoheritage area still needs to be improved further. The comfort level rating is also noteworthy given the enormous tourism potential of the Candi Ijo Geoheritage region.

Key words**:** Geoheritage, Candi Ijo, Carrying Capacity, UAV, Yogyakarta

GEOHERITAGE OF BUKIT PANAU, KELANTAN

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ABSTRACT

Bukit Panau, located about 8 km to the north of Tanah Merah town, in Kelantan state, is a solitaire hill of 234 m height and is surrounded by the vast alluvial plain. Bukit Panau is rich with aesthetic, scientific and recreational, as well as international level of cultural and historical values. Geologically, Bukit Panau is formed by the Boundary Range Granite which is overlain unconformably by the Cretaceous continental sedimentary rocks, which is suitable host for dinosaur fossil. Several interesting geological charecteristics at Bukit Panau are rock types diversity, plant fragment fossils, various geological structures, and iron mineralisation, as well as attractive landscape and morphology. Among significant structures found are noncomformity where the continental sedimentary rocks were deposited on, and overlying the older granite, palaeochannel and crossbedding. Scientific data obtained from Bukit Panau can be used to explain the geological history and palaeoenvironment of the area during the Permian until Recent. Besides geological diversity, Bukit Panau is also rich with biological diversity. Local residents surrounding Bukit Panau are still maintaining their cultural and traditions in their daily lifes. Historically, Bukit Panau is believed to be the place of hermitage for Sheikh Sayyid *Hussein Jamadil* Kubro, an ancestry of the Prophet Muhammad from Yaman, also ancestor of the Kelantan, Patani, Brunei, Mindanao, Demak, and Cirebon Sultanates, and a few other Sultanate in the Malay Archipelago. He was also the ancestor of *Wali Songo* (The Revered Nine Saints) who successfully spreading Islam in Java Island. Besides that, it had been told that Hang Tuah, the warrior of Melaka also did learning martial arts and mysticism from Sheikh Thanauddin, which is Sheikh Sayyid *Hussein Jamadil* Kubro's sibling, also known as Adi Putera at Bukit Panau. With the combination of geological diversity that is important in describing the history of the earth, flora and fauna diversities, as well as high values of cultural and history, Bukit Panau is very suitable to be developed as knowledge-based tourists attraction area.

Key words: Bukit Panau, Nonconformity, Geological Heritage, Cultural, Historical

KEMBANGSONGO FAULT ZONE: AN EXPOSED SEGMENT OF THE REGIONAL OPAK FAULT PROPOSED AS A NEW GEOSITE

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ABSTRACT

In the area of Kembangsongo, which is located approximately 10 km to the NE of Yogyakarta City, a good oucrop of a fault zone has been found exposed by a traditional mining activity. The fault exposure occurs in the rock unit of Oligo-Miocene Semilir Formation consisting mostly of interlayered tuff and pumice breccias associated with a big eruption event of ancient volcanoes part of the Oligo-Miocene Volcanic arc of Java. This newly found fault zone is then called as Kembangsongo Fault Zone. Based on field data collected in this area, it has been identified that the Kembangsongo Fault Zone is part or segment of the well-known regional Opak Fault. Results of field study indicate that the strike direction of the Kembangsongo Fault is about N 030^{o}E (NE-SW) with the fault plane is almost vertical. The slip sense of movement is sinistral or left-slip as shown by the slicken lines found on the fault plane. The regional Opak Fault has been well-known as the main fault associated with the occurrence of Jogja Earthquake in 2006. So far this fault has been poorly identified because of lacking its surface outcrops, besides most of its fault zone consist of very young fluvio-volcanic deposit derived from the Quartenary Merapi Volcano activity. Looking to the fact that it is very difficult to find a good outcrop of the Opak Fault then the finding of the exposure of the Kembangsongo fault zone is important in understanding better the characteristic of Opak Fault as the major fault in Jogjakarta region. Therefore the present study proposes the exposure of Kembangsongo Fault Zone as a geosite, adding and completing the Jogja Geoheritage with a new geosite featuring a geological structure outcrop.

GEOSITES IN GUA MUSANG AREA, KELANTAN: POTENTIAL FOR NATIONAL GEOPARKS

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Kota Bharu, Kelantan

ABSTRACT

Gua Musang area, which is situated in the southwestern part of the state of Kelantan, Malaysia is rich in natural resources, whether geological or biological resource. Even more special, Gua Musang is inhabited by several indigenous communities that are dependent on nature. In terms of geology, Gua Musang area is consist of Main Range Granite and Bentong-Raub suture Zone in the west, and the Central Belt of Peninsular Malaysia in the east. Geological features, origin and history of these two parts are very different. Some of the important geological sites have been identified in this area, which are show highly diversity of the landscape and morphology, rocks, minerals, fossils and tectonic structure. Scientific data obtained from geosites in Gua Musang explain that the Bentong-Raub Suture Zon is the remains of oceanic crust of the Paleozoic era, which is also indicated a location of collision between two ancient continents at the end of the Mesozoic era. While the eastern part consists of Gua Musang Formation which is generally formed in shallow seas during the Permo-Triassic period. This paper will discusses the geosites that attracts the public and tourists, such as landscape, morphology of limestone hills, caves, waterfalls and hot springs. Also, sites that have high scientific value such as a site of fossils, rocks, minerals and tectonic structure, which is a proof to the geological history of Peninsular Malaysia and Southeast Asia are also discussed. Apart from geological sites, Gua Musang is also rich in biodiversity and is inhabited by several tribes of indigenous people who still maintain the culture and customs in their daily activities. The combination of important geological diversity in explaining the history of the earth, the diversity of plants and animals, as well as the interaction and dependencies indigenous communities with nature, making the area of Gua Musang is very suitable to become a National Geopark. Geosites can be developed into a science-based tourist attraction areas. National Geopark Committee has listed Gua Musang as one of the potential areas to be turned into a national geopark. Hopefully, the idea Geopark Gua Musang will be able to strengthen the economy and culture of the people who live here.

PENGENALPASTIAN DAN PEMBANGUNAN GEOTAPAK DI DALAM CADANGAN JERAI GEOPARK

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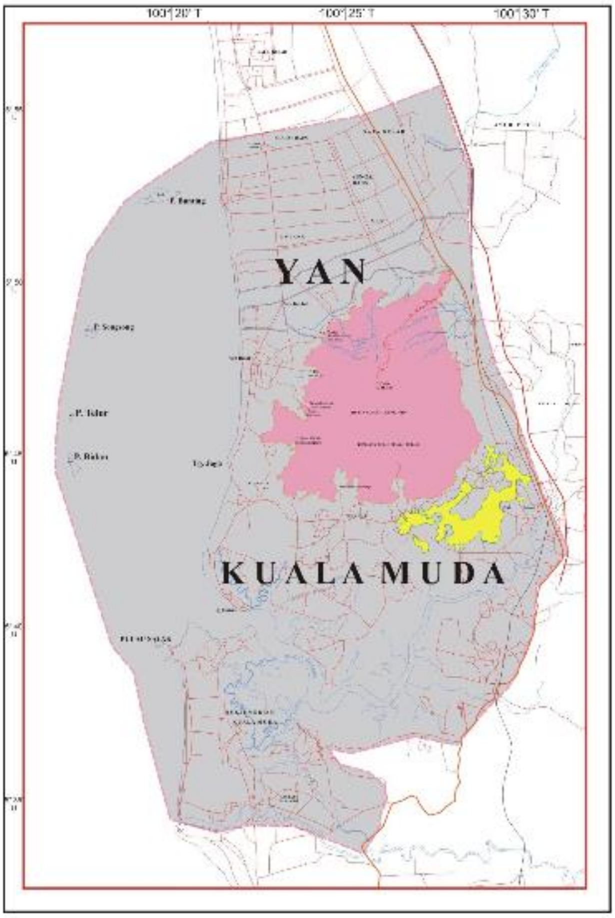
ABSTRAK

Pencalonan Geopark Jerai telah dicadangkan oleh Jawatan Kuasa Geopark Kebangsaan pada awal tahun 2016. Kawasan Jerai seluas 570km persegi telah dicadangkan sebagai geopark kerana memiliki pelbagai elemen dan kaya dengan geotapak yang boleh menjadi rujukan bertaraf kebangsaan serta boleh mencapai taraf dunia. Geopark merupakan konsep pembangunan sesuatu kawasan yang dikenalpasti mempunyai geotapak iaitu landskap geologi yang berupa struktur/mineral/monumen geologi yang penting untuk dijadikan rujukan peringkat kebangsaan (iaitu sebagai Geopark Kebangsaan) ataupun besar kemungkinan boleh menjadi calon Geopark Global. Sesebuah geopark mestilah diuruskan dengan konsep pemuliharaan, pendidikan, pembangunan secara lestari dan mampan serta berkait dengan budaya dan juga masyarakat. Kewujudan Geopark Jerai akan memberikan rasa bangga dan jati diri masyarakat setempat tentang rupa bentuk sekitaran sekeliling mereka yang unik dan menarik, nilai semulajadi struktur geologi yang patut dihargai, dipulihara setanding dengan nilai geowarisan yang tidak boleh diperbaharui untuk dikongsi bersama masyarakat dari luar Daerah Yan dan juga Kuala Muda. Konsep geopark membuka peluang ekonomi baharu dan jaringan perhubungan dalam bentuk geopelancongan berasaskan semulajadi yang dianugerahkan oleh tuhan untuk dikongsi dan dihayati bersama. Geopark Jerai akan memberikan manfaat untuk bukan sahaja lingkungan Geopark Jerai tetapi juga menyemarakkan industri pelancongan utara Semenanjung Malaysia. JMG dan UPEN Kedah telah mengambil langkah awal pada tahun 2015 untuk mengenalpasti geotapak dan memasang beberapa papan tanda untuk pemuliharaan di dalam kawasan cadangan Geopark Jerai iaitu di kaki Gunung Jerai, di Pusat Rekreasi Titi Hayun dan juga di Singkir Laut. Info panel yang mengandungi maklumat geologi ini dapat dikongsikan bersama untuk pengetahuan masyarakat secara umum dan memberikan kesedaran kepada masyarakat akan warisan milik bersama yang perlu diuruskan secara komited.

Rajah 1: Lokasi kawasan kajian di sekitar Negeri Kedah.



Rajah 2: Lokasi sempadan dan cadangan Jerai Geopark, Kedah, Malaysia

Rajah 3: Info panel yang telah dipasang pada tahun 2015.

Geotapak yang dibuat kajian;

SUNGAI BATU PAHAT, KUALA MUDA, KEDAH

Lokasi :	N 05° 44' 30.89"	N 635 272
	E 100° 25' 00.71"	E 270 119
Ketinggian:	119 m	
No. syit topo:	3367 Gurun	

Rajah 4 : Geotapak Aplo Pegmatit di Sungai Batu Pahat, Merbok, Kedah.

Rajah 5: Rancangan pembangunan geotapak Batu Kapal, Padang Tok Sheikh, Telaga Tok Sheikh dan Tangjung Jaga,

CONSERVING LOCAL MINING AS GEOHERITAGE IN THE REGION FOR GEOSCIENCES
(case study in local mining gold area in Paningkaban, Gumelar Subdistrict, Banyumas Regency, Central java)

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ABSTRACT

Local gold mining in the regions in Indonesia are usually considered as illegal gold mining by the government. However, if it is well-managed and is guided by the government, it will have added value. A large amount of profit will be received by central government and especially by the region, that are local revenue which make the economy around mining area is better, geological outcrop conservation which can be geotourism in the region and as geosciences education for the next generation. But the region of artisanal mining area has to be localized according to need and security of the region, if there is mining area that can be carried out by a bigger company, then the artisanal mining area must be placed in separated area.

The mining activities in this area is run by residents and is managed by cooperative. An observation shows that the agents of micro economy of artisanal mining are more likely to survive and not influenced by the lethargy of ore mineral exploration and exploitation both nationally and worldwide. In that case, local government must hurriedly make local regulation about artisanal mining which is referred to Law No.4 of 2009 and No.23 of 2014 about Implementation of Local Government which is autonomous, giving welfare to the people, and increase local revenue.

Key words : local mining, conservation, geotourism, geoheritage

INTRODUCTION

Local gold mining in the regions in Indonesia are usually considered as illegal gold mining by the government. However, if it is well-managed and is guided by the government, it will have added value. A large amount of profit will be received by central government and especially by the region, that are local revenue which make the economy around mining area is better, geological outcrop conservation which can be geotourism in the region and as geosciences education for the next generation. But the region of artisanal mining area has to be localized according to need and security of the region, if there is mining area that can be carried out by a bigger company, then the artisanal mining area must be placed in separated area.

Research about geology and its relation with mineralization and deposit of gold in Paningkaban area and its surrounding, Gumelar Subdistrict, Banyumas Regency, Central Java, show an indication that the gold mineralization in quartz veins are controlled by geological structure pattern. This is based on several researches and observations that AAS analysis result of quartz veins filling the tension and compression fractures shows relatively high (0.25 – 4.75 ppm) Au unsure (gold).

Gold mineral and its accompanying mineral are crystalized in quartz veins (late magmatic) in fractures channel, either in tension fractures, shear zone, or fault zones. The quartz veins follow fault and fracture structure pattern in study area, generally in northwest – southeast, northeast – southwest, north – south and west – east direction.

The mining activities in this area is run by residents and is managed by cooperative. An observation shows that the agents of micro economy of artisanal mining are more likely to survive and not influenced by the lethargy of ore mineral exploration and exploitation both nationally and worldwide. In that case, local government must hurriedly make local regulation about artisanal mining which is referred to Law No.4 of 2009 and No.23 of 2014 about Implementation of Local Government which is autonomous, giving welfare to the people, and increase local revenue.

GEOLOGY OF STUDY AREA

Geomorphology of study area is dominated by hills with steep slopes from relatively northeast – southwest and northwest – southeast direction, in erosion level of weak – strong. Generally, the landscape is controlled by lithology, geological structure and erosion process.

Based on data collection which covers preliminary interpretation, previous research data, field data and laboratory analysis, we can obtain stratigraphic sequence of study area according to the order of rock unit from old to young. From the result of data collection in the field and analysis conducted in laboratory, stratigraphy of study area is divided into 6 informal lithostratigraphy and 2 lithodem of igneous rock. Halang breccia – volcanic unit, Tapak breccia – volcanic unit, Tapak sandstone unit, Tapak limestone unit and Alluvial.

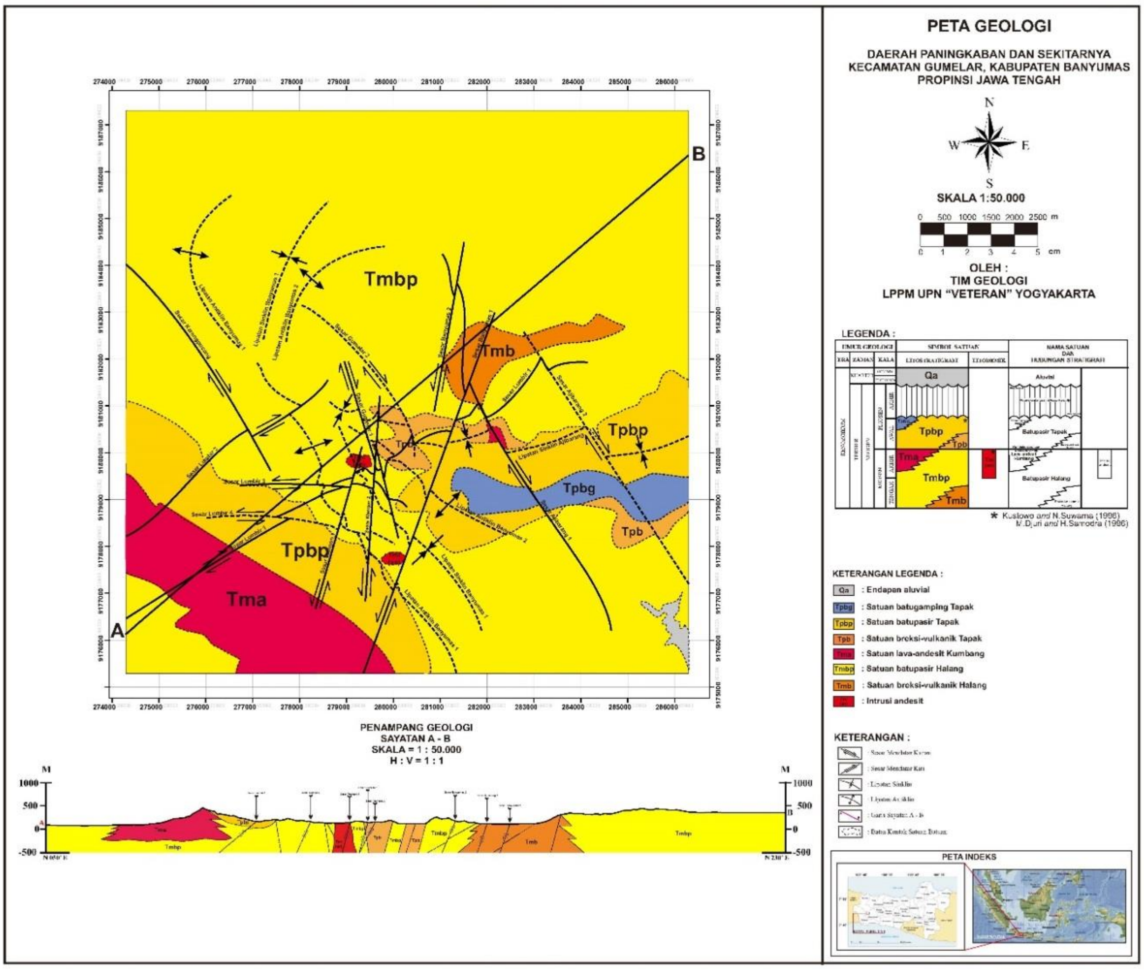

Figure 01. Geological map of Paningkaban area, Banyumas, Central Java

ALTERATION AND MINERALIZATION

Alteration and mineralization process is a process of rock changing in terms of chemical, physical, and others due to process impacted from hydrothermal hot solution medium. In this case, the rock subjected to impact or change is known as wall rock. Meanwhile the process occur in wall rock is known as wall rock alteration process, which is a chemical process that changes the original rock by the flowing hot fluid medium.

Based on all that information, the most important aspect in rock that make it able to be altered and mineralized is channel way which is the way out of hot fluid to the surface thus interact with wall rock. Usually, new minerals will be deposited, either secondary mineral or ore mineral (base metal) and the association of new mineral is usually reflected as an alteration type.

The mineralization in study area is relatively associated with quartz vein or veinlets, in Halang sandstone unit, and also in intrusion body found in the area. The ore mineralization in the study area is in form of sulfide mineral, such as; pyrite (FeS_2), chalcopyrite ($CuFeS_2$), few galena (PbS) and bornite (Cu_5FeS_4). The AAS analysis results show that Au (0,1 – 4,75 ppm), Cu (40 – 1250 ppm), Ag (4 – 19 ppm) and --- (60 – 8550 ppm).

Figure 02. One outcrop of rocks and minerals in the study area.

LOCAL MINING IN THE STUDY AREA

The study area with artisanal mining region is a part of Local Mining Area, based on the information from Agency of Energy and Mineral Resources of Central Java. A lot of sporadic holes had been dug by local residents. The search of location and direction of gold-contained quartz veins exploration are defined by reference from hole neighbor which has been successfully obtain that vein containing gold.

The digging of mining location that are not well structured with the bad condition of roof and wall of the hole or that are not safe for the miners will be threat for their safety anytime which can fall out and causing landslide, thus technical guidance from local government is needed.

Rock and quartz vein which are obtained or taken from inside the holes are then accommodated and put into iron drum and mercury is put into it, and then it is rolled either by water energy or diesel engine. The obtained gold will be sold to friends or shop that had pay all the needs for making holes, but only few given to the formed cooperatives

The money circulation from micro economy of artisanal mining sector in the regions is very useful and further study is needed, because their activities is not affected by the lethargy of either national or international mining activities.

Figure 03. Condition of hole in local mining area and the drum to accommodate the gold ore.

THE CONSERVATION OF LOCAL GOLD MINING LOCATION

The gold mining run by residents in anywhere in this world do not pay enough attention to the conservation of rock outcrops, the miners safety and environment's impairment. Whereas, the region or area of the gold mining is very rare, according to geology and not all area of alteration and mineralization have gold mineral, let alone the economic ones. In that case, the government needs to manage and give technical guidance needed by residents thus can raise the regional income and conserve the location of geological outcrops and mining area for geotourism of geosciences, at the same time.

The program will be really useful which can increase the local revenue and save geological outcrops and geological area that is very rare to be found so that the next generation will understand the geological history of certain area. It can be advantageous for geoscience and it is hopefully can be a reference for other regions.

Several things that is needed to be managed and conserved are:

1/ Managing local mining by making local regulation for taxation and circulation of gold metal obtained or the regional economic dynamics.

2/ Making road which is integrally connected between holes and mining activities

3/ Making books/brochure/text of brief geology of the mining area location.

4/ Making representative location site's building to explain about condition of the region and its geology to visitors.

5/ Building infrastructure related with geotourism and geoheritage of local mining area.

The lack of conception and government's standing to the society which related to the lack of central government's support in licensing and facilities in area in term of supporting the local mining activities had cause the lack of spirit of local government to seriously manage the artisanal mining in Indonesia.

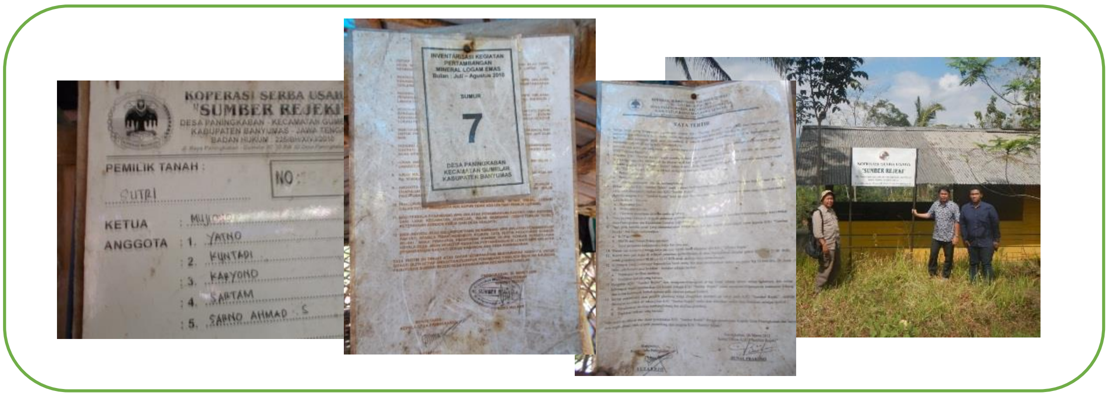

Figure 04. Activities in local mining area, which have had organization's activities that is well-structured and cooperatives that had been formed.


Figure 05. Resident's activities in the area of local mining and counseling from Institute of Research and Community Services (ICRS) of UPN Veteran Yogyakarta

PLANNING OF LOCAL REGULATION FOR GEOTOURISM AND GEOHERITAGE

Draft of local regulation for geotourism and geoheritage is very urgent, due to the lethargy of geotourism nowadays, especially for geoscience education geotourism which causing people to look for alternatives.

Interview and forum group discussion with local artisanal mining residents, has been executed. Study of Law No.4 of 2009 about mineral and coal and Law No.23 of 2014 about local government and several examples of local regulation about mining has been conducted. Based on Law No.4 of 2009 about law of mineral and coal, article of mineral mining in the regions has been regulated from how to do the mining up to processing before export. However, the artisanal mining area is not being cleared with the presence of unincorporated artisanal mining.

Based on that case and facts in the field, the arrangement and management ruled by local government is needed, especially in technical execution and processing and then the management of gold selling. Hereafter, local regulations are made for management of geotourism and geoheritage which can be acquired by coordination with education institution.

The explanation of several articles in Law No.4 of 2009 can be a reference to make autonomous local regulation. Those local regulations also can avoid conflict among residents.

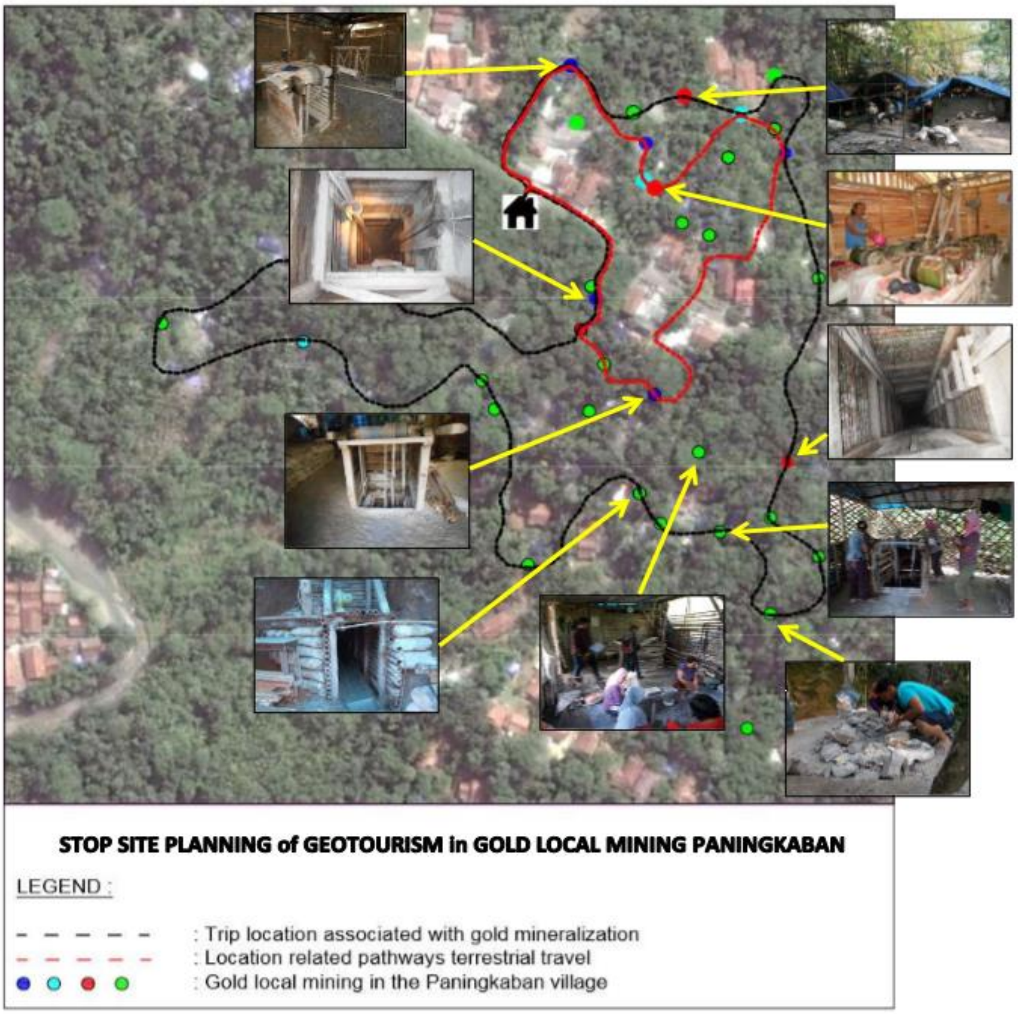

Figure 6. Stop site planning of geoheritage and geotourism area in Local mining, Paningkaban, Banyumas, Jawa Tengah, Indonesia

CONCLUSION

1. Local gold mining which is recently called as illegal mining, can be useful either to central or local government if it is well managed.
2. Geologically, the study area has a lot of gold and also a lot of local mining, which also can be found in every mining area in Indonesia, thus have to be regulated and managed well to be made as an area of geoheritage and geotourism
3. Activities in local mining area is very potential especially in micro economy, that is to keep the economic stability in the regions, thus can help local economy.
4. Local regulations must be made soon in order to conserve the artisanal mining area to be geotourism and geoheritage so it can save the geological outcrops for science and make that region become national or even world's heritage.

ACKNOWLEDGEMENTS

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KAJIAN POTENSI GEOPARK KAWASAN KARST BIDUK-BIDUK KABUPATEN BERAU, KALIMANTAN TIMUR

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ABSTRAK

Kawasan Karst Biduk-biduk merupakan sisi Timur Kawasan Karst Sangkulirang-Mangkalihat. Di tempat ini tinggal masyarakat Dayak Lebo, dan masyarakat Bugis. Masyarakat Dayak Lebo tinggal di pegunungan dan masyarakat Bugis tinggal di pantai. Nama Biduk-biduk berasal dari bahasa Bugis yang berarti tempat yang banyak disinggahi oleh kapal-kapal nelayan. Potensi wisata geologi yang terdapat di kawasan kars ini terdiri dari beranekaragam komponen ekosistem karst, berupa eksokarst, indokarst dan perikars. Indokars terbaik dalam bentuk sistem sungai bawah tanah dan keluar sebagai mata air di Labuhan Cermin dan Labuhan Kelambu. Eksokarst terdapat dalam bentuk morfologi kars. Perikars dalam bentuk pantai, pesisir, hutan mangrove. Dalam 6 bulan terakhir, wisatawan yang mengunjungi mencapai 26.000 orang. Jumlah ini berpotensi bertambah. Penguatan kapasitas warga dalam geowisata ini akan memastikan nilai wisata komunitas dapat melampaui nilai pemanfaatan karst untuk kegiatan ekstraktif.

Kata kunci: Geopark, Kars Biduk-biduk, Geowisata

PENDAHULUAN

Biduk biduk merupakan daerah Kecamatan di Kabupaten Berau, Provinsi Kalimantan Timur yang berada di Tanjung Sebelah Timur Pulau Kalimantan dengan luas wilayah mencapai 12.500 ha. Kecamatan Biduk Biduk secara administratif terbagi dalam 6 desa dengan jumlah penduduk mencapai sekitar 5000 jiwa. Mata pencaharian utama masyarakat adalah nelayan mencapai lebih dari 80%, selebihnya adalah berwirausaha dengan membuka rumah-rumah inap (*homestay*) berukuran kecil dan berdagang, berkebun serta pegawai pemerintahan. Mayoritas penduduk Biduk Biduk berasal dari Pulau Sulawesi yang telah hidup dan berada di Biduk Biduk semenjak zaman penjajahan Belanda yang hingga saat ini terus berkembang dan bertambah di sepanjang pesisir laut.
Kondisi topografi Biduk Biduk sangat bervariasi mulai dari perbukitan sampai dengan hamparan dataran rendah dan pesisir laut yang berhadapan langsung dengan Selat Makassar. Daerah Biduk Biduk merupakan hamparan kawasan karst mulai daratan hingga sampai ke laut yang masih ditutupi oleh hutan dataran rendah dan hutan mangrove yang masih baik. Pada beberapa daerah fenomena – fenomena bentangan kawasan karst masih bisa ditemukan dalam bentuk "*conical-conical*" dengan luas yang bervariasi, mataair-mataair yang bahkan ditemukan di bawah permukaan laut.

Dengan hamparan kawasan karst di Biduk Biduk mulai dari daratan hingga ke laut memberikan kekayaan alam yang sangat melimpah bagi Biduk Biduk, mulai dari memberikan sumber air tawar yang digunakan dan dikonsumsi masyarakat untuk memenuhi kebutuhan sehari-hari, kekayaan lautnya seperti potensi ikan, udang, cumi, terumbu karang serta beberapa jenis yang dilindungi seperti penyu, ikan lumba-lumba, ikan paus, ikan hiu semuanya sangat mudah dijumpai di Biduk Biduk pada waktu tertentu. Selain potensi lautnya, Biduk Biduk juga memiliki kekayaan dan keindahan panorama yang sangat menakjubkan dengan kebeningan air laut dengan dihiasi oleh hamparan terumbu karang yang berwarna – warni memberikan fenomena yang sangat menarik bagi masyarakat sekitar Biduk Biduk untuk berlibur di Biduk Biduk. Selain potensi laut Biduk Biduk juga menyimpan fenomena daratan yang tidak kalahnya seperti telaga-telaga karst saat ini yang sering dikunjungi adalah Labuan Cermin yang dijuluki sebagai telaga dua rasa, gua-gua karst, air terjun, mataair–mataair. Dengan kekayaan yang sangat melimpah di laut dan di daratan hal ini juga memberikan daya tarik tersendiri bagi beberapa jenis burung dan bahkan pada beberapa tempat ditemukan spesies burung migran dari daratan Cina pada musim-musim tertentu yang akan bermigrasi ke Selatan. Selain itu juga karakteristik kawasan karst sehingga banyak ditemukan spesies-spesies baru. Semua potensi-potensi tersebut di atas terancam rusak dan hancur dengan berkem-bangnya rencana kegiatan pembangunan yang bersifat ekstraktif seperti pertambangan batugamping, industri pabrik semen dan perkebunan sawit.

Maksud dari penulisan ini adalah untuk tetap menjaga dan mempertahankan kawasan karst Biduk Biduk daripada kehancuran serta menimbulkan bencana ekologi bagi masyarakat setempat serta spesies keanekaragaman hayati yang sangat tergantung pada kawasan karst Biduk Biduk dengan melibatkan semua pihak dan stake holder.

METODE PENELITIAN

Metode penelitian yang digunakan adalah melakukan observasi langsung di lapangan, wawancara dengan warga setempat dan melakukan studi analisa untuk mempelajari keterhubungan kawasan karst terhadap masyarakat dan sistem ekologi Biduk Biduk dalam upaya mitigasi bencana.

HASIL DAN PEMBAHASAN

Kondisi Geografi

Secara geografi daerah biduk biduk terletak di bagian Selatan dari Ibukota Kabupaten Berau Tanjung Redeb yang berbatasan : Sebelah Utara berbatasan dengan Kecamatan Batu Putih dan Laut Sulawesi. Sebelah Selatan berbatasan dengan Kabupaten Kutai Timur. Sebelah Barat berbatasan dengan Kabupaten Kutai Timur. Sebelah Timur berbatasan dengan Laut Sulawesi

Kecamatan Biduk Biduk termasuk sebagai wilayah pesisir pantai dengan curah hujan cenderung tinggi sepanjang tahun yang berkisar antara 99,5 – 576 mm3/bulan. Terletak pada garis koordinat 01° 00’ 13” LU – 01° 22’ 32” LU dan 118° 29’ 47” BT – 118° 59’ 05” BT dengan ketinggian berkisar dari 0 hingga 500 meter. Hampir sekitar 50% daerah berupa perbukitan dengan ketinggian mencapai 100-500 meter.

Kesampaian Daerah

Daerah Biduk Biduk secara umum dapat dicapai melalui dua jalur kedatangan yaitu melalui jalur udara dan jalur darat yang dimulai dari Kota Balikpapan, Provinsi Kalimantan Timur. Jalur udara dimulai dari penerbangan dari Kota Balikpapan menuju Kota Tanjung Redeb, Kabupaten Berau dengan waktu tempuh perjalanan udara sekitar 45 menit, kemudian dilanjutkan meng-gunakan transportasi darat kendaraan roda empat menuju Biduk Biduk dengan waktu tempuh mencapai 5 jam perjalanan. Penerbangan dari Kota Balikpapan menuju Kota Tanjung Redeb dilayani oleh beberapa maskapai dengan lebih dari 5 kali frekueusi penerbangan, sedangkan untuk transportasi darat tersedia transportasi umum yang berangkat secara reguler dari kota Tanjung Redeb setiap hari dengan frekuensi tergantung pada jumlah penumpang dengan harga yang relatif murah. Selain itu juga tersedia penyewaan-penyewaan kendaraan roda empat dari Kota Tanjung Redeb yang bisa berangkat sesuai dengan kebutuhan penumpang. Kondisi jalan baik dan telah beraspal.

Sedangkan melalui jalur darat dari Kota Balikpapan menuju Biduk Biduk dapat ditempuh dengan lama perjalanan mencapai 18-20 jam dengan menggunakan kendaraan roda empat dengan kondisi jalan 90% beraspal agak baik dan 10% masih berupa jalan tanah yang dikeraskan. Beberapa wilayah kabupaten dan kota yang akan dilewati selama dalam perjalanan adalah Kabupaten Kutai Kartanegara, Kota Samarinda, Kabupaten Kutai Timur (Kota Sangatta, Kec. Kaliorang, Kec. Kaubun), Kabupaten Berau (Kec. Batu Putih).

Objek-Objek Geowisata

Beberapa objek geowisata yang masih bisa ditempuh untuk dikunjungi adalah sebagai berikut :

a. Telaga dua rasa Labuan Cermin, di Desa Pantai Harapan

Secara geografis berada pada koordinat 1°15.640’ LU dan 118°41.334’ BT, dengan luas telaga mencapai 51 ha, morfologi perbu-kitan sampai dengan dataran rendah dan merupakan teluk pertemuan antara air laut dan air tawar. Ditemukan mata air yang berasal dari dalam telaga dengan keda-laman air mencapai 2 sampai 13 meter. Jenis batuan batugamping non klastik (bioherm), struktur masif dengan kekar-kekar. Dikarenakan Labuan cermin ini adalah telaga pertemuan air tawar dan air asin dengan jarak dari pantai mencapai 150 meter maka pada lokasi tertentu ditemukan daerah dengan 2 rasa yang berbeda yaitu air tawar dan air asin, karena itu dikenal sebagai telaga dua rasa.

b. Gua Kelelawar/Kalong, di Desa Teluk Sulaiman

Merupakan gua karst yang mulut masuknya terletak pada koordinat 01°255' LU dan 118°44.071' BT, dengan lebar mulut gua 12m dan panjang/kedalam gua 10-15m. Jenis batuan adalah batugamping non klastik (bioherm) dengan kekar-kekar. Gua ini memiliki banyak percabangan dan diperkirakan terbentuk dengan sistem pengontrol utama *waterlevel* dan kekar. Hal ini dikuatkan dengan lorong goa yang memiliki tiga level, pada lorong level paling bawah terdapat aliran air. Karena terletak di tepi laut, Gua Kelelawar dipengaruhi oleh pasang surut air laut. Sesuai dengan namanya, Gua Kelelawar maka sangat banyak dijumpai kelelawar dan kotorannya (guano) di dasar gua.

c. Mata air Bawah Laut (kolam ikan) di Desa Teluk Sulaiman

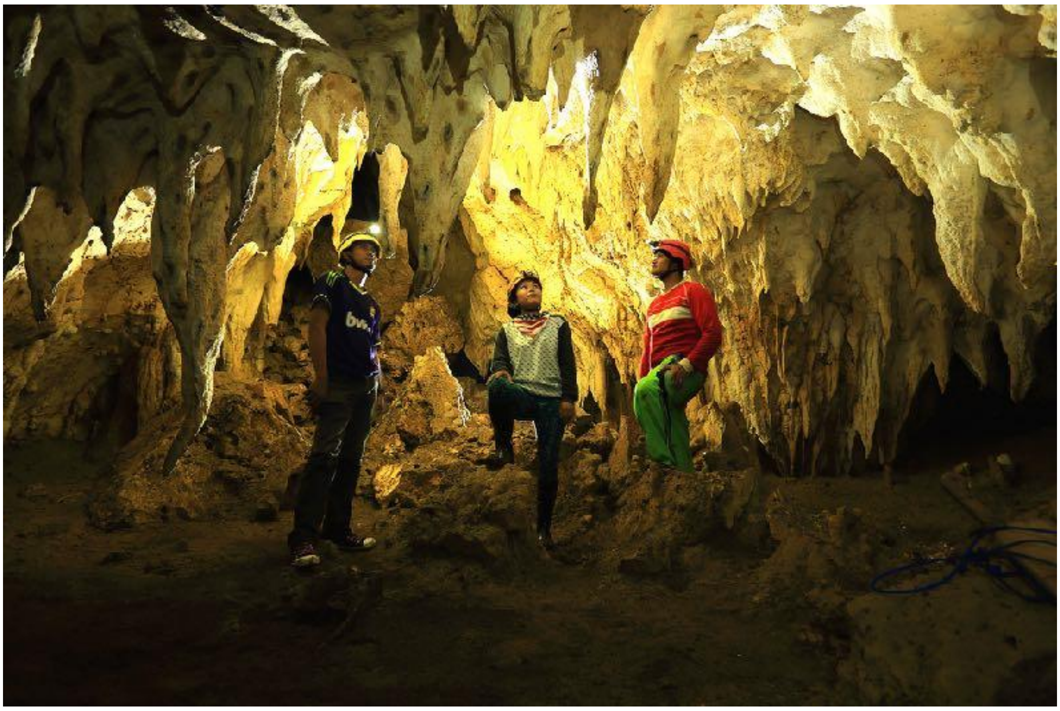
Merupakan kolam mata air tawar dari kawasan karst di hulunya yang keluar di bawah permukaan laut, yang terletak pada koordinat 01°09.626' LU dan 118°45.605' BT. Mata air ini sangat mudah ditemui pada saat air laut surut dengan luas areal mencapai 50 m^2 dengan kedalaman mencapai sekitar 7-10 meter. Jenis batuan adalah batugamping non klastik (bioherm), struktur masif. Pada daerah kolam mata air ini masih bisa ditemukan ikan-ikan laut berukuran kecil-sedang yang bergerak lalu lalang dan bersembunyi pada lorong-lorong batuan.

d. ***Kolam Mata Air Belanda di Desa Teluk Sulaiman***

Merupakan mata air peninggalan zaman Belanda yang digunakan oleh masyarakat sebagai sumber air minum. Lokasi mata air ini terletak pada koordinat 01°09.068' LU dan 118°44.057' BT. Luas kolam mata air ini mencapai 100 m^2 dengan kedalaman mencapai 5-8 meter. Dari informasi masyarakat bahwa mata air ini tidak pernah kering walaupun musim kemarau panjang.

e. ***Gua Sigending di Desa Teluk Sulaiman***

Merupakan gua karst yang terletak pada koordinat 01°09.002' LU dan 118°44.078' BT, dengan lebar mulut gua 4m dan panjang/kedalam gua 20-25 M. Jenis batuan adalah batugamping non klastik (bioherm), struktur masif dengan kekar-kekar. Meskipun tidak memiliki mata air, proses pelarutan masih terus berlangsung dengan masih dapat diamatinya tetesan-tetesan air pada ornamen stalaktit yang aktif. Gua Sigending memiliki bentukan ornamen yang sangat menarik. Beberapa jenis spesies biota gua bisa ditemui di sini seperti jangkerik dan laba-laba gua.



f. Danau Sigending, di Desa Teluk Sumbang

Merupakan telaga dengan luas lebih kurang 2.500 m^2 dan terletak pada koordinat 01°08.012' LU dan 118°45.916' BT dengan jenis batuan batugamping non klastik (bioherm). Telaga ini berada pada lembah di natara bukit batugamping, pada dasar telaga ditemukan adanya beberapa mata air tawar.

g. Resurgen Sigending, di Desa Teluk Sumbang

Merupakan titik keluarnya sungai bawah tanah dari mulut gua. Berada di wilayah hutan yang dikelola oleh PT. Daisy Timber pada koordinat 01°08.598' LU dan 118°44.436' BT. Debit air pada saat pengamatan lebih kurang 250 liter/detik dengan pH air 8 atau cenderung basa.

h. Pulau Kaniungan Besar, Desa Teluk Sumbang

Merupakan Pulau karang, dengan luasan mencapai 55,4 ha yang terletak pada koordinat 01°06.932' LU dan 118°50.253' BT yang dihuni sekitar 50 Kepala Keluarga dalam 1 RT. Sumber mata air tawar masyarakat berasal dari sumur-sumur tanah dengan kedalaman sekitar 3m. Pulau kaniungan besar ini dikelilingi oleh hamparan terumbu karang yang masih sangat baik, menjadi lokasi pendaratan dan bertelurnya penyu di sekitar Biduk Biduk. Selain itu juga sangat mudah dijumpai gerombolan ikan lumba-lumba pada waktu-waktu tertentu di sekitar perairan laut Pulau Kaniungan Besar. Pada sekitar bulan mei dan juni setiap tahunnya bisa ditemukan gerombolan ikan Paus hitam dan paus orka yang melintasi selat antara Pulau Kaniungan dan Daratan Biduk Biduk untuk memasuki masa kawin.

i. Air terjun Bidadari, di Desa Teluk Sumbang,

Ketinggian air terjun mencapai lebih kurang 30 meter. Lokasi air terjun ini terletak pada koordinat 01°01.845’ LU dan 118°49.881’ BT. Jenis batuan dasar pembentuk air terjun adalah batugamping non klastik, struktur masif. Air terjun ini adalah merupakan sumber air tawar bagi masyarakat di Desa Teluk Sumbang.

Tips Perjalanan

Beberapa tips perjalanan saat akan berkunjung ke Biduk Biduk :

a. Dikarenakan jarak tempuh perja-lanan yang sangat lama sangat disarankan jika melalui jalur udara berangkat mnggunakan pesawat yang pagi agar keberangkatan kendaraan roda empat dari Tanjung Redeb ke Biduk Biduk bisa dilakukan dibawah jam 14:00 WITA agar anda bisa menikmati pemandangan hutan Kalimantan dan bentangan karst dari kejauhan selama perjalanan.
b. Untuk keberangkatan melalui transportasi darat dari Balikpapan sangat disarankan untuk beristirahat dan menginap di Kecamatan Kaubun sebelum melanjutkan perjalanan pada pagi hari keesokan harinya, dan sikecamatan tersebut telah tersedia penginapan kecil yang dikelola oleh masyarakat.
c. Dikarenakan terbatasnya fasilitas penginapan yang umumnya dikelola oleh masyarakat, maka sangat disarankan untuk membawa perlengkapan alat mandi sendiri.
d. Di masing – masing penginapan telah disediakan brosur ataupun informasi wisata beserta sarana transportasi dan harganya secara terbuka sehingga dengan mudah dan jelas bagi kita untuk menen-tukan lokasi yang ingin kita datangi serta perkiraan biaya agar sesuai dengan uang kita.
e. Sangat disarankan melakukan kunjungan secara rombongan maksimal 10 orang, karena setiap sarana menuju daerah wisata umumnya dibatasi pada jumlah penumpang 10 orang dengan harga yang sama.

KESIMPULAN DAN SARAN

Dengan mempertimbangkan keterhubungan masyarakat dan ecology Biduk Biduk terhadap kawasan karst di sekitarnya maka sangat diperlukan etikad yang baik dari pemerintah dan para pihak untuk memper-tahankan kondisi Karst Biduk Biduk agar tetap terjaga dengan aktifitas serta pembangunan yang lebih mengutamakan konservasi daripada ekstarksi sehingga bencana yang akan dialami oleh masyarakat dan ekologi Biduk Biduk tidak sampai terjadi.

Beberapa saran dan tindak lanjut yang perlu dilakukan oleh semua pihak diantaranya :

1. Melakukan pendampingan kepada masyarakat tentang keterhubungan wilayah Biduk Biduk dengan kawasan karstnya.
2. Meningkatkan pemahaman masyarakat tentang praktek – praktek pengelolaan kawasan karst yang baik dan sesuai dengan karakteristiknya.
3. Menolak semua aktifitas dan pembangunan yang bersifst ektraktif dalam pemanfaatan kawasan karst secara masif dan industrial.
4. Mengenalkan dan mempersiapkan masyarakat tentang adaptasi dan mitigasi bencana ekologi karst.
5. Melakukan kajian dan penelitian lebih lengkap dan detail tentang kawasan karst Biduk Biduk dan keterhubungannya terhadap potensi yang terbentuk saat ini.

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GEOTAPAK DI GUA MUSANG, KELANTAN: POTENSI UNTUK GEOPARK KEBANGSAAN

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ABSTRAK

Gua Musang terletak di bahagian baratdaya negeri Kelantan, Malaysia dan kaya dengan sumber bumi (geologi dan biologi) serta mempunyai beberapa komuniti orang asal yang saling bergantung kepada alam semula jadi. Dari segi geologi, kawasan baratdaya negeri Kelantan ini terdiri daripada Granit Banjaran Besar serta Zon Sutur Raub-Bentong di bahagian barat, dan Jalur Tengah Semenanjung Malaysia di bahagian timurnya. Kedua-dua bahagian ini mempunyai ciri-ciri, sejarah dan asalan geologi yang sangat berbeza. Beberapa tapak geologi penting telah dikenal pasti di kawasan ini, antaranya yang dapat menunjukkan kepelbagaian jenis langskap dan morfologi, batuan, fosil serta struktur tektonik. Data-data saintifik yang diperolehi daripada tapak-tapak geologi di kawasan Gua Musang ini dapat menjelaskan bahawa bahagian barat, iaitu Zon Sutur Raub-Bentong adalah tinggalan kerak lautan dalam zaman Paleozoik dan juga merupakan tempat perlanggaran di antara dua benua kuno pada masa akhir Mesozoik, manakala bahagian timur pula terdiri daripada Formasi Gua Musang yang umumnya terbentuk di lautan cetek pada zaman Permo-Trias. Kertaskerja ini akan membincangkan geotapak yang menjadi tarikan pelancong dan orang awam seperti landskap kars, morfologi batu kapur, gua, air terjun serta tapak mata air panas. Selain itu tapak-tapak yang mempunyai nilai saintifik yang tinggi juga akan dijelaskan, antaranya tapak fosil, batuan serta struktur tektonik yang menjadi pembuktian kepada sejarah geologi Semenanjung Malaysia serta Asia Tenggara. Selain daripada tapak-tapak geologi, kawasan ini juga kaya dengan kepelbagaian biologi serta dihuni oleh beberapa suku masyarakat orang asal yang masih mempertahankan budaya dan adat resam dalam aktiviti harian mereka. Gabungan kepelbagaian geologi yang penting dalam menjelaskan sejarah bumi, kepelbagaian tumbuhan dan haiwan yang ada serta interaksi dan kebergantungan komuniti orang asal dengan alam semula jadi menjadikan kawasan Gua Musang ini sangat sesuai dijadikan Geopark Kebangsaan. Geotapak yang ada boleh dimajukan untuk menjadi kawasan tarikan pelancongan berasaskan ilmu. Jawatankuasa Geopark Kebangsaan telah menyenaraikan Gua Musang sebagai salah satu kawasan yang berpotensi untuk dijadikan geopark peringkat kebangsaan. Diharapkan gagasan Geopark Gua Musang ini akan dapat memperkasakan ekonomi dan budaya masyarakat yang ada di sini.

THE TRADITIONAL PETROLEUM WELL IN WONOCOLO AREA AS A BEAUTIFUL EDUCATION TOURISM OBJECT

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ABSTRACT

Wonocolo is located in Bojonegoro District who one of geosite of 20 geosite point to support The Petroleum Geoheritage Bojonegoro. Wonocolo is area's of Asset-4 Pertamina Cepu. Wonocolo area is a good interesting to develope as Geological Tourism object of old well, because in this area to exploitation of hidrocarbon with tradisional system use car's mechine and with rig of Jati Threes. The deep of reservoir Wonocolo only about 200-400m from survace. The many rig to explorer hidrocarbon tradisionally, so like in the Texas. So this study to make the Geological Tourism Object of Wonocolo Old Well with economy improvement of Wonocolo Community, Bojonegoro, East Java. Things that can be developed there among other: 1. Tracking get the jeep, tracking trail and tracking a bicycle, 2. Wells pilot; 3. Places beautiful to photograph a selfi, 4. The existence of transit equipped with photographs wonocolo from year to year of fossils, and Wonocolo's maket, 5. The development of its tourism education in all quarters. This intended to give addition to entrepreneurs mining with the tourism and finally as an alternative income if later oil in wonocolo up.

Key words : Anticline, Wonocolo, Petroleum, Bojonegoro

INTRODUCTION

Wonocolo is located in Bojonegoro District, East Java Provice. The western boundaries is Bengawan Solo River, Ngawi District and Blora District; the Northern bounderies is Tuban District; the Eastern Boundaries is Lamongan District; the Southern Boundaries is Madiun District, Jombang District and Nganjut District (**Figure 1**).

We to fit into bojonegoro of four directions; among others of direction Blora-Bojonegoro (from the west); Tuban-Bojonegoro (from the north); Lamongan-Bojonegoro (from the east) and Nganjuk-Bojonegoro (from the south).

Wonocolo is area's of Asset-4 Pertamina Cepu. Wonocolo area is a good interesting to develope as Geological Tourism object of old well, because in this area to exploitation of hidrocarbon with tradisional system use car's mechine and with rig of Jati Threes. The deep of reservoir Wonocolo only about 200-400m from survace. This study to make the Geological Tourism Object of Wonocolo Old Well with economy improvement of Wonocolo Community, Bojonegoro, East Java. This intended to give addition to entrepreneurs mining with the tourism and finally as an alternative income if later oil in wonocolo up.

METHODS

The Methode used in this research was detail mapping in the field such a delineation; photography, the take or rock's sample and making profils and the determination of example oil rig traditional representing.

DATA AND ANALYSIS

Data the measurement of directly in the field found the wonocolo anticline that can be used to trap of petroleum, and the examples of outcrop representing : souce rocks; reservoir rocks, and cup rocks that is the petroleum system who could be found directly in the field and that this is rare found in the place of another (**Figure 2, 3** and **4**).

The height of the top Wonocolo Antiklin more or less 450m, while the dept of traditionally drilling oil at the top of antiklin most shallow between 200-400m (**Figure 5**).

ATTACHMENT FILES OF FIGURES

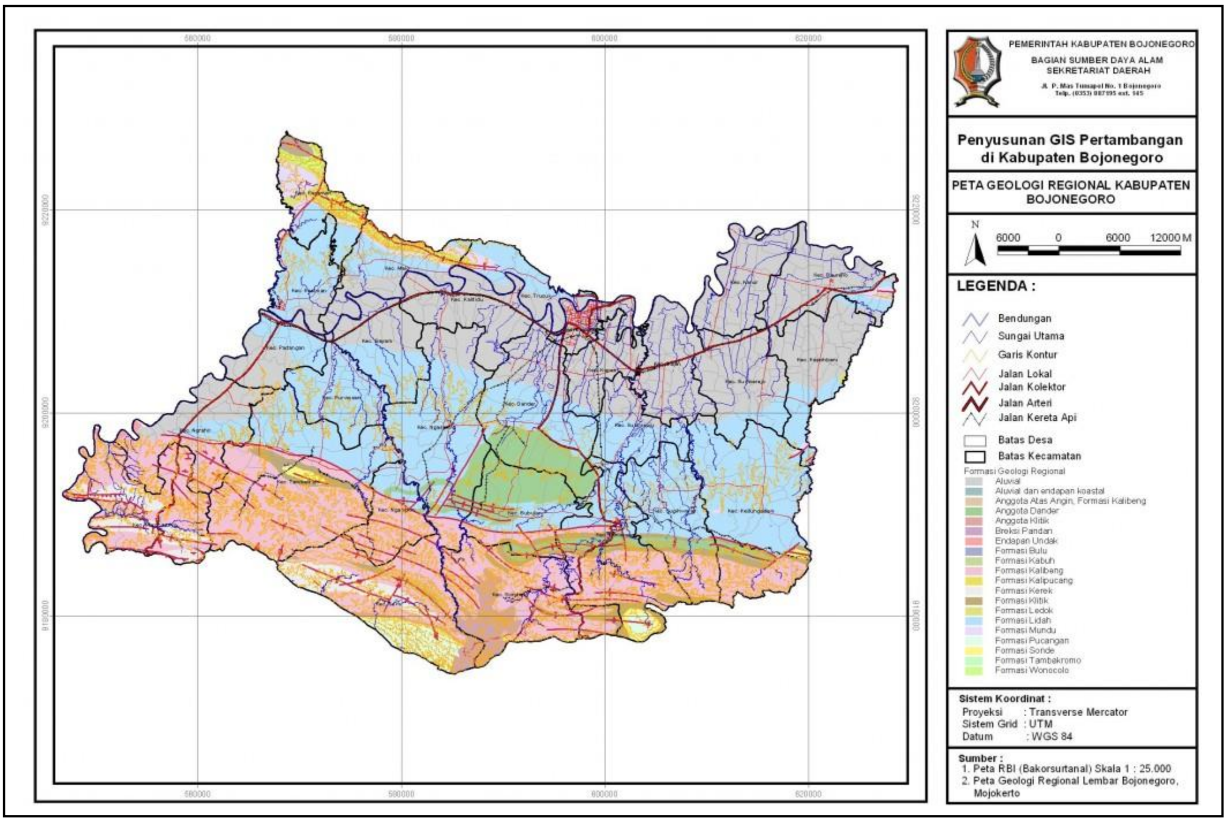

Figure 1. The area of Bojonegoro District

Figure 2. Wonocolo Formatoin as a reservoir in the Wonocolo Petroleum System

Figure 3. Ledok Formation as a cuprock in the Wonocolo Petroleum System

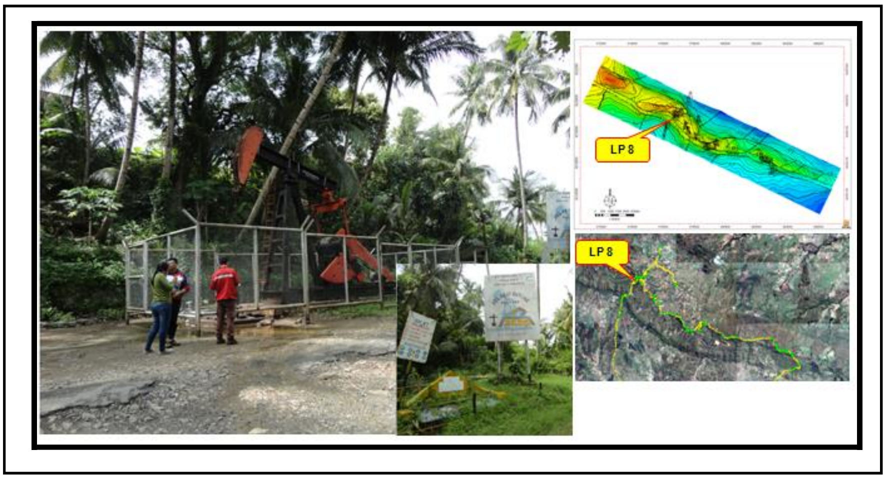

Figure 4. The top of Wonocolo Anticline have
A active drilling

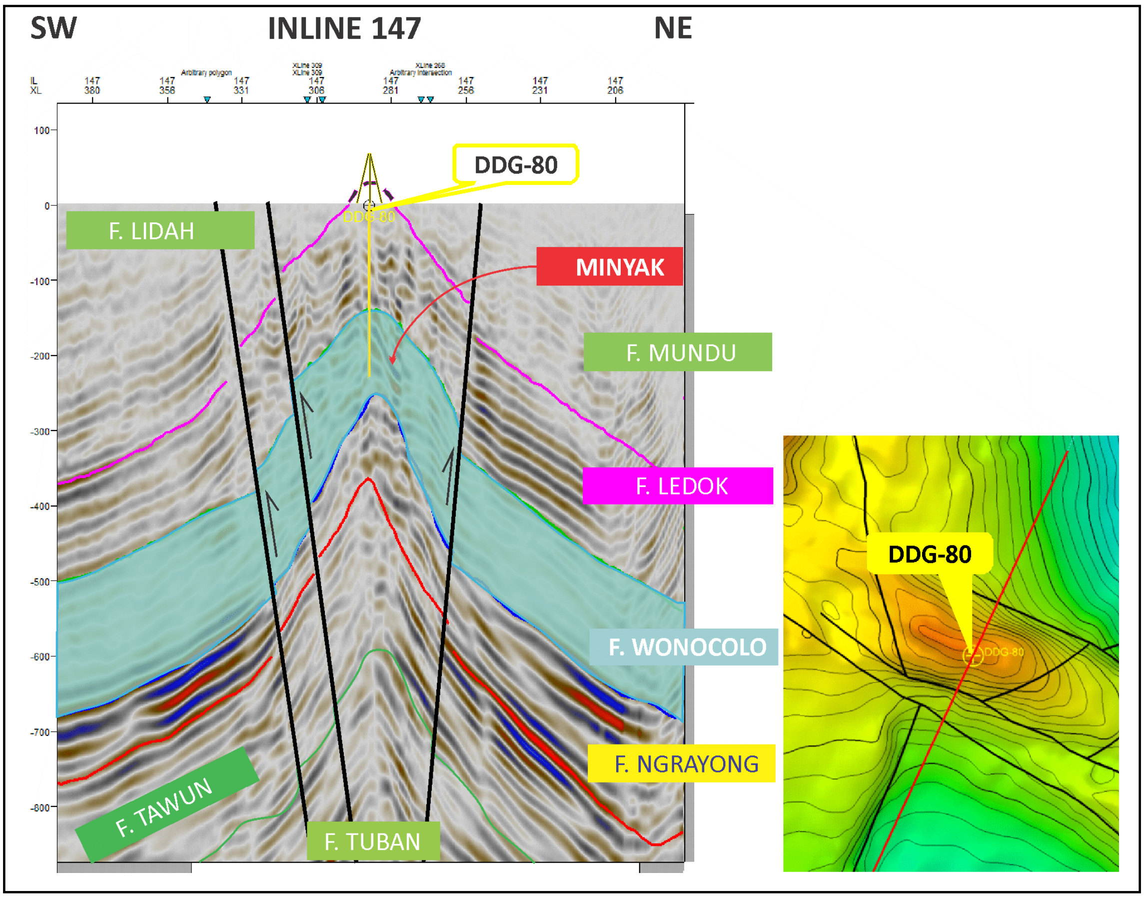

Figure 5. Geological Section of Wonocolo Anticline

DISCUSSION

The top Wonocolo Anticline who have height of about 450m, while petroleum drilling at the top of Wonocolo Anticline in a depth of about 200 to 400 m. Then the oil in Wonocolo still above of the sea water level. So that it can be said that the existence of petroleum most shallow in indonesia, even throughout the world is in the Wonocolo, Bojonegoro District, East Java. In the area of wonocolo and surrounding areas we can also see outcrop directly of source rocks, reservoir rocks, and cup rocks in the petroleum system.

CONCLUSION

From the result of discussion so can be concluded among other:

1. In the Wonocolo area the existence of oil still above sea level, by depth of petroleum drilling most shallow across indonesia even all over the world just range 200m.

2. Found the outcrops who representing of petroleum system in the Wonocolo area.

3. In the Wonocolo Area can be develop as Geological Tourism Object of Old Drilling..

4. If tourism developing it can be an alternative additional income for the people of Wonocolo area besides taking oil traditionally.

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THE STRUCTURE OF KAWENGAN ANTICLINE AS A LOWEST PETROLEUM SYSTEM IN INDONESIA

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ABSTRACT

Kawengan is one area in Bojonegoro, East Java , which is the area between Pertamina EP Joint Operation Asset - 4 with GCI (Geology Cepu Indonesia). This area is one point Geosite of 20 points geosite of Petroleum Geoheritage Bojonegoro. This area was selected to become an applied research UPN "Veteran " Yogyakarta, cause in the region exposed rock layers that are petroleum system in Kawengan. As well as still found anticline are exposed at the surface and at its peak there were wells modern means of extracting the oil. So it can be used as educational areas for geoscience students mainly Petroleum Geology and Geophysics department.

Key words **:** geosite, geoheritage, petroleum, anticline

INTRODUCTION

Struktur antiklin kawengan ditemukan oleh Belanda pada tahun 1894 dan mulai dikembangkan pada tahun 1926 oleh BPM. Struktur antiklin Kawengan merupakan salah satu struktur penghasil minyak dan gas bumi di Cekungan Jawa Timur bagian Utara. Struktur tersebut masuk didalam kelompok lapangan tua yang masih terus berproduksi sampai sekarang, hal tersebut dibuktikan dengan terdapatnya sumur-sumur yang masih aktif berproduksi sampai sekarang baik yang dioperasikan oleh perusahaan maupun dikelola oleh masyarakat.

THE AIMS OF STUDY

Tujuan penelitian untuk mengetahui proses perkembangan sistem petroleum yang terjadi pada struktur antiklin kawengan, dengan melakukan kajian tentang geofisika, geologi dan reservoir secara terpadu. Dimana hasil dari penelitian tersubut dapat menjadi bahan ajar didalam mempelajari proses perkembangan sistem petroleum khususnya di struktur antiklin kawengan.

THE PROBLEMS IDENTIFICATION

Rumusan masalah yang dikemukakan pada penelitian ini adalah melakukan kajian tentang proses perkembangan sistem petroleum di struktur antiklin kawengan.

THE LOCATION OF STUDY

Secara geografis Struktur Antiklin Kawengan terletak sekitar 20 km sebelah Timurlaut dari Kota Cepu, termasuk didaerah Bojonegoro Jawa Timur (**Gambar 1.**)

METHODOLOGY

Penelitian dilakukan dengan menggunakan analisa dari data lapangan (data primer) dan data skunder. Dimana nantinya akan dilakukan analisa yang terpadu antara evaluasi gologi, geofisika, dan reservoir, sehingga akan menghasilkan pola/konsep suatu perkembangan sistem petroleum di Struktur Antiklin Kawengan.

GEOLOGY AND REGIONAL STRATIGRAPHY

Struktur Antiklin Kawengan terletak di Cekungan Jawa Timur Utara yang memanjang berarah Barat – Timur dari Zona Rembang (*Suyanto dan Yanto, 1977*). Cekungan ini terbentuk sejak Awal Tersier berkaitan dengan penunjaman Lempeng Indo-Australia dibawah Lempeng Eurasia. Sejak itu pula terbentuk sebagai *foreland basin* atau *back-arc basin* (*Hamilton, 1979*) hingga kini. Secara fisiografi Cekungan Rembang berupa antiklinorium yang dihasilkan dari inversi dan reaktivasi sesar-sesar lama. Hal ini menyebabkan terbentuknya perlipatan dan pensesaran, yang ditunjukan **Gambar 2**.

Regional of Structural Geology

Struktur aktif sejak Miosen Awal hingga kini yakni zona sesar *sinistral strike slip* RMKS (Rembang-Madura-Kangean-Sakala) membatasi Zona Kendeng dan Zona Randublatung (*Bransden and Matthews, 1992*) (**Gambar 3**). Cekungan ini telah terjadi 2 (dua) rezim tektonik pada *back-arc basin*. Rezim regangan atau tension terjadi pada Paleosen sampai Miosen Tengah dan rezim kompresi terjadi pada Miosen Tengah sampai Kuarter. Pada rezim regangan terjadi *subsidence* dan sedimentasi, sedangkan rezim kompresi terjadi pengangkatan, perlipatan, dan pensesaran. Pola struktur Jawa berarah Barat Timur searah dengan memanjangnya Pulau Jawa.

Bukti rezim kompresi adalah dari penampang seismik terlihat bahwa *basement* yang mengalami sesar normal pada Zaman Paleogen aktif kembali dan menerus ke sedimen yang lebih muda mengalami sesar naik atau *thrusting*, sedangkan *basement* mengalami inversi *transtentional basin system* (*Bransden dan Matthew, 1992*). Distribusi sedimen dan pola struktur di Jawa Timur dikontrol oleh arsitektur *basement.*

Menurut Bransden dan Matthew (1992), Cekungan Jawa Timur Utara secara struktur terjadi 2 (dua) periode besar dari reaktivasi sesar yang menghasilkan struktur-struktur baru, mengikuti akresi Lempeng Indo-Australia pada Kapur Akhir. Fase pertama, dari reaktifasi melibatkan fase regangan Paleogen di atas sesar anjakan Pra-Tersier yang menghasilkan geometri regangan listrik secara lokal bersudut rendah. Fase kedua, reaktifasi selama inversi Neogen ketika sesar-sesar utama Palaeogen bergerak kembali menghasilkan pengangkatan maksimum dari deposenter Paleogen. *Rifting* Paleogen di Jawa Timur dievaluasi secara regional sebagai bagian dari *back-arc extensional system* yang dipengaruhi oleh Lempeng Eurasia Tenggara. Pengangkatan pada Neogen sebagai hasil kompresi orthogonal dari subduksi Lempeng Indo-Australia di bawah Lempeng Eurasia.

Regional Stratigraphy

Samuel dan Genevraye (1972) dan Pringgoprawiro (1983) membagi stratigrafi Cekungan Jawa Timur Utara atas dua Mandala, yaitu Mandala Kendeng dan Mandala Rembang. Mandala Rembang mencakup daerah dalam zona Tektono-fisiografi Randublatung, sedang Mandala Kendeng meliputi zona Tektono-fisiografi Kendeng. Stratigrafi Mandala Rembang disebut Stratigrafi Rembang. Secara umum sedimentasi Mandala Rembang merupakan endapan paparan, kaya endapan karbonat (batulempung, napal, batugamping) dan hampir tidak dijumpai endapan piroklastik, endapannya melandai ke arah selatan, tebal mencapai 1500 m. Pringgoprawiro (1983) telah membagi Mandala Rembang menjadi empat belas satuan batuan. Stratigrafi regional Zona Rembang (Pringgoprawiro, 1983) dan perubahan muka laut dari (Exxon, 1996) menunjukkan gambaran pengaruh tektonik dan perubahan muka laut yang menjadikan Zona Rembang memiliki kompleksitas struktur dan sedimentasi (**Gambar 4**). Penjelasan stratigrafi Mandala Rembang dari tua ke muda secara singkat adalah sebagai berikut :

Batuan dasar Pra-Tersier, Formasi Ngimbang, Formasi Kujung, Formasi Prupuh, Formasi Tuban, Formasi Tawun, Formasi Ngrayong, Formasi Bulu, Formasi Wonocolo, Formasi Ledok, Formasi Mundu, Formasi Paciran, Formasi Lidah and Undak Solo.

Petroleum System of North Easts Java Basin

Bransden & Matthews (1992) dan Phillipi *et al*. (1991) menyatakan bahwa batuan induk potensial dalam Cekungan Jawa Timur Utara yang kaya bahan organik adalah Formasi Ngimbang berumur Eosen yang dijumpai pada sumur-sumur pemboran merupakan sedimen asal laut dangkal, transisi, delta dan danau, dengan TOC sekitar 1,1%, pada kedalaman sekitar 2500 meter untuk menghasilkan hidrokarbon. Jenis kerogen merupakan algal sapropel danau bercampur dengan materi tanaman dataran tinggi sebagai penghasil potensial minyak dan gas.

Specific gravity hidrokarbon di Cekungan Jawa Timur Utara berkisar 10^o – 60^o API, namun yang produksi terbesar sekitar 30^o – 40^o API. Formasi Kujung di atasnya adalah batuan induk potensial juga. Litologi berupa batulempung *Orbitoid Kalk* kaya organik berumur Miosen Akhir khususnya sebagai batuan induk di *onshore* cekungan ini.

Adapun migrasi/sejarah pematangannya berlangsung pada Miosen Tengah sampai Akhir saat inversi tektonik pensesaran inversi pada sedimen Paleogen dan Neogen dari batuan induk ke reservoir. Ini disebabkan oleh faktor-faktor *heat flow*, inversi cepat pada zona RMK (Rembang-Madura-Kangean) dan reaktiviasi dan subsidens pada cekungan-cekungan di utara zona RMK setelah terjadi *burial*.

Manur and Barraclough (1994), menyimpulkan jenis cebakan pada umumnya cebakan struktur yakni dibatasi oleh blok sesar *tilting*, komplek terumbu Oligosen sampai Pliosen dan struktur kompresi/inversi Miosen Akhir. Jenis cebakan yang dibatasi oleh blok sesar berkaitan dengan pembentukan *rifting* dan *graben* pada cekungan-cekungan yang terbentuk oleh antiklin dalam Antiklinorium Rembang.

Umumnya pembentukan hidrokarbon dimulai pada awal pensesaran Eosen Tengah – Oligosen yang berasosiasi dengan *heat flow* selama masa inversi. Reaktivasi selama deformasi Miosen Tengah membentuk struktur *flower* dan lipatan hingga deformasi Awal Plistosen (Suparyono and Lennox, 1989).

Batuan reservoir pada mandala ini: Batugamping klastik Formasi Ngimbang, Batugamping Terumbu Formasi Prupuh atau Satuan Kujung, Batupasir kuarsa Formasi Ngrayong, Batugamping Orbitoid sisipan dalam Formasi Ngrayong, dan Batupasir foraminifera Formasi Selorejo. Cebakan berupa jenis struktural (antiklin dan sesar) dan stratigrafi (batugamping terumbu). Batuan penutup, secara regional yakni Formasi Wonocolo dan Formasi Mundu, sedangkan secara intraformasional yakni batulempung dan serpih dari Formasi Ngrayong.

Batuan Reservoir

Di Cekungan Jawa Timur akumulasi utama minyak dan gas ditemukan pada reservoir:

(1) Batupasir Eosen pada Ngimbang Bawah

(2) Batugamping Eosen pada Ngimbang Atas
(3) Batugamping Miosen pada Anggota Prupuh (Kujung Unit I)
Target Reservoir sekunder adalah:
(1). Batupasir Miosen pada Formasi Ngrayong
(2). Batupasir Formasi Wonocolo dan,
(3). Batupasir Formasi Ledok.

RESULT AND DISCUSSION

Survey of Kawengan Field

Survey kondisi lapangan perlu dilakukan untuk menambah hasil analisa, dimana survey dilakukan di Lapangan Kawengan. Lokasi pengamtan (LP) yang diamati berjumlah 22 (duapuluh dua) Lokasi Pengamatan (LP) yang dapat dilihat pada **Gambar 6**.
Survey lokasi dimulai dari sebelah Selatan sayap antiklin Kawengan sampai kearah Tenggara struktur antiklin kawengan. Pengamtan yang dilakukan meliputi kondisi singkapan batuan serta indikasi terdapatnya sesar, yang ditunjukan pada **Gambar 7**. sampai dengan **Gambar 10**. dan sumur minyak yang aktif diproduksikan oleh PT GCI atau dikelola oleh warga yang ditunjukan pada **Gambar 11**. dan **Gambar 12.**

Reconstruction of Kawengan Anticline

Pembentukan struktur antiklin kawengan secara regional di interpretasikan dipengaruhi oleh sesar besar yang membentuk Jawa Timur yaitu sesar RMKS (Rembang-Madura-Kangean-Sakala), serta tinggian yang berada disisi sebelah Timur dan Barat pada Cepu, dapat dilihat pada **Gambar 13.** dan perkembangan struktur antiklin kawengan ditunjukan pada **Gambar 14.** Serta kondisi struktur antiklin kawengan sekarang ditunjukan pada **Gambar 15.**

The Period of Oligocene - Miocene

Sejarah Geologi adalah perpaduan antara cekungan paengendapan yang dikontrol struktur dan dipakai untuk pengendapan lapisan-lapisan batuan atau formasi. Di Lapangan Kawengan pengendapan lapisan paling tua dimulai dari Oligesen Awal. Oligosen Awal (Periode *syn-rift*), terjadinya sesar turun berarah hampir Baratlaut-Tenggara yang membentuk cekungan di Kawengan, bersamaan dengan terjadinya sesar turun tersebut terjadi pengendapan Formasi Ngimbang berupa *brownshale* kemudian ditutupi secara selaras oleh Formasi Kujung pada lingkungan laut dangkal. Formasi Ngimbang berupa *brown shale* yang bisa menjadi batuan induk paling dalam di Cekungan Kawengan, sedangkan Formasi Kujung yang berupa batugamping berlapis bisa menjadi reservoir yang paling dalam di Cekungan Kawengan.

Late Oligocene (*syn-rift* Period)

Masih didalam periode *syn-rift* selaras di atas Formasi Kujung diendapkan Formasi Prupuh pada lingkungan laut dangkal. Formasi Prupuh yang berupa napal sisipan batugampig tipis-tipis ini bisa menjadi batuan induk di Cekungan Kawengan.

Early Miocene (*syn-rift* Period)

Pada periode *syn-rift* yang masih menerus ini, secara selaras di atas Formasi Prupuh diendapkan Formasi Tuban pada lingkungan menengah. Formasi Tuban ini terdiri dari batulempung abu-abu kehitaman yang berpotensi sebagai batuan induk di Cekungan Kawengan.

Middle Miocene (*syn-rift* Period)

Pada Miosen Tengah ini proses *syn-rift* masih terus berlangsung dan secara searas di atas Formasi Tuban diendapkan Formasi Tawun. Formasi ini diendapkan di lingkungan laut dangkal hingga menengah. Formasi ini terdiri dari batulempung berwarna kelabu bersisipan batugamping dan batupasir tipis-tipis. Formasi ini berfungsi sebagai batuan induk di Cekungan Kawengan.

Late Miocene (Late Period of *syn-rift*)

Pada akhir periode *syn-rift* ini diendapkan Formasi Ngrayong selaras diatas Formasi Tawun di lingkungan laut dangkal. Formasi ini disusun oleh batupasir kuarsa sehingga baik sebagai reservoir pada Cekungan Kawengan.

The Period of Late Miocene - Pliocene

Pada periode Miosen Tengah bagian Akhir hingga Miosen akhir (Periode kompresi), pada periode ini Tektonik mulai aktif yaitu tumbukan antara Indoaustralia dengan mikrosunda (Jawa). Pada periode ini minyak mulai matang pada batuan induk Formasi Ngimbang, Formasi Kujung, Formasi Prupuh, Formasi Tuban dan Formasi Tawun. Lipatan yang berarah hampir Baratlaut-Tenggara mulai terbentuk dan mulai terjadi inversi melalui sesar-sesar turun utama yang berarat hampir Baratlaut-Tenggara. Sehingga mulai terjadi migrasi hidrokarbon dari batuan induk melalui antar perlapisn dan sesar menuju ke reservoir Formasi Ngimbang bagian atas, Formasi Kujung bagian atas, Formasi Prupuh, Formasi Formasi Ngrayong, Formasi Bulu dan Formasi Wonocolo.

Periode Miosen Akhir-Pliosen (Periode Kompresi)

Pada periode ini mulai terjadi pengaktifan kembali sesar-sesar turun berubah menjadi sesar-sesar naik (Inversi), terbentuk lipatan-lipatan yang berarah hampir Baratlaut-Tenggara. Serta pada periode ini sudah terbentuk *trapping* hidrokarbon di dalam *trap-trap* yang terbentuk

Pliocene - Pleistocene

Pada periode ini tumbukan antara Indo-Australia dengan Jawa (mikro Sunda) sudah terjadi sangat kuat, sehingga terjadi inversi (Sesar naik periode 1) selanjutnya terjadi sesar naik (periode 2). Kompresi terus berlangsung sehingga terbentuk sesar-sesar *backthrust* (sesar-sesar periode 3) dapat dilihat pada Gambar 10., selanjutnya terjadi akumulasi hidrokarbon pada bagian puncak-puncak antiklin Kawengan.

The Petroleum System of Kawengan Field

Sistem Petroleum yang berkembang di Lapangan Kawengan terdiri dari batuan induk, batuan reservoir, perangkap, batuan penutup dan migrasi minyakbumi. Hal tersebut dapat diuraikan sebagai beikut

Source Rocks

Batuan yang dapat menjadi batuan induk di Lapangan Kawangan antara lain Formasi Ngimbang, Formasi Kujung, Formasi Prupuh, Formasi Tuban dan Formasi Tawun. Formasi-formasi tersebut berupa *shale* dan batulempung yang tebal yang mengandung fosil plankton.

Reservoir Rocks

Batuan reservoir yang dijumpai di Lapangan Kawengan sebenarnya terdiri dari Formasi Ngimbang bagian atas, Formasi Kujung Bagian atas, Formasi Prupuh, Formasi Ngrayong, Formasi Wonocolo dan Formasi Mundu. Tetapi kontrak untuk Geo-Cepu Indonesia hanya pada reservoir Formasi Ngrayong yang terdiri dari batupasir kuarsa yang berbutir halus hingga sedang dengan sedikit campuran lempung dan gampingan. Hal tersebut akan mengurangi fungsi besar porositas batupasir kuarza sebagai reservoir di Lapangan Kawengan.

Traps

Perangkap yang dijimpai di Lapangan Kawengan terdiri dari perangkap struktur berupa antiklin (antiklinorium) berarah umum Baratlaut-Tenggara dan perangkap stratigrafi yang *berupa onlapping* serta *cross bedding.*

Pematangan Minyakbumi dan Migrasi

Di Lapangan Kawengan khususnya minyak bumi sudan matang mulai Miosen Awal hingga Miosen Tengah dan mulai bermigrasi pada Miosen Akhir melalui antar perlapisan dan sesar-sesar naik menuju ke perangkap struktur dan stratigrafi.

Cup Rocks

Batuan penutup di Lapangan Kawengan terdiri dari batulempung *interlayer* pada setiap Formasi. Tetapi penutup utama untuk reservoir Formasi ngrayong adalah napal Formasi Wonocolo, Napal Formasi Ledok dan batulempung Formasi Lidah.

CONCLUSSION

1. Pembentukan struktur antiklin kawengan secara regional di interpretasikan dipengaruhi oleh sesar besar yang membentuk Jawa Timur yaitu sesar RMKS (Rembang-Madura-Kangean-Sakala), serta tinggian yang berada disisi sebelah Timur dan Barat pada Cepu
2. Pembentukan struktur antiklin kawengan dimulai pada beberapa periode yaitu periode Oligosen – Miosen dimana pengendapan dikontor oleh struktur dan pengendapan lapisan paling tua dimulai dari Oligosen Awal (Periode *syn-rift*) pengendapan Formasi Ngimbang berupa *brownshale* kemudian ditutupi secara selaras oleh Formasi Kujung pada lingkungan laut dangkal, Oligosen Akhir (Periode *syn-rift*), Miosen Awal (Periode *syn-rift*), Miosen Tengah (Periode *syn-rift*), Miosen Akhir (Akhir Periode *syn-rift*), Periode Miosen Akhir-Pliosen (Periode Kompresi) dan Pliosen – Pleistosen.
3. Petroleum sistem Lapangan Kawengan, yaitu batuan induk Formasi Ngimbang, Formasi Kujung, Formasi Prupuh, Formasi Tuban dan Formasi Tawun; batuan Reservoir Formasi Ngrayong dan Formasi Wonocolo; perangkap berupa perangkap struktur berupa antiklin (antiklinorium) berarah umum Baratlaut-Tenggara dan perangkap stratigrafi yang *berupa onlapping* serta *cross bedding*; pematangan minyakbumi mulai Miosen Awal hingga Miosen Tengah dan mulai bermigrasi pada Miosen Akhir; batuan penutup di Lapangan Kawengan terdiri dari batulempung *interlayer* pada setiap Formasi, tetapi penutup utama untuk reservoir Formasi ngrayong adalah napal Formasi Wonocolo, Napal Formasi Ledok dan batulempung Formasi Lidah.

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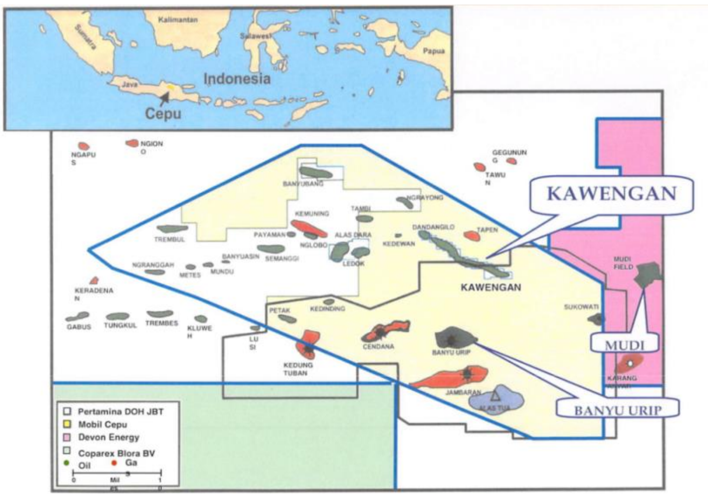


Figure 1.
Locality of Study
(*PT Pertamina EP*)

Figure 2.
Fisiography of North East Java
(*Van Bemmelen, 1949*)

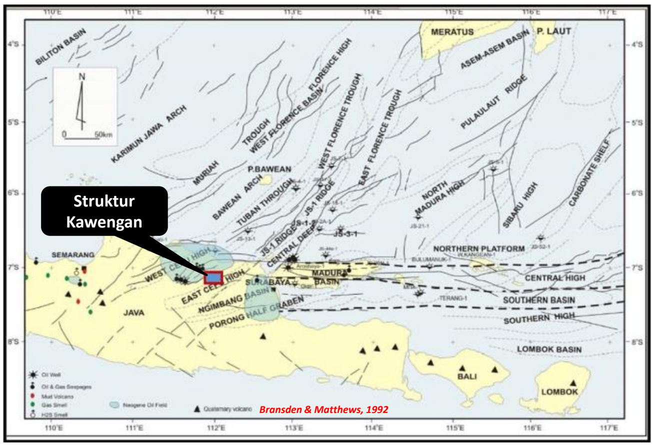


Figure 3.
Regional Structural Geology of East Java
(*Bransden and Matthews, 1992*)

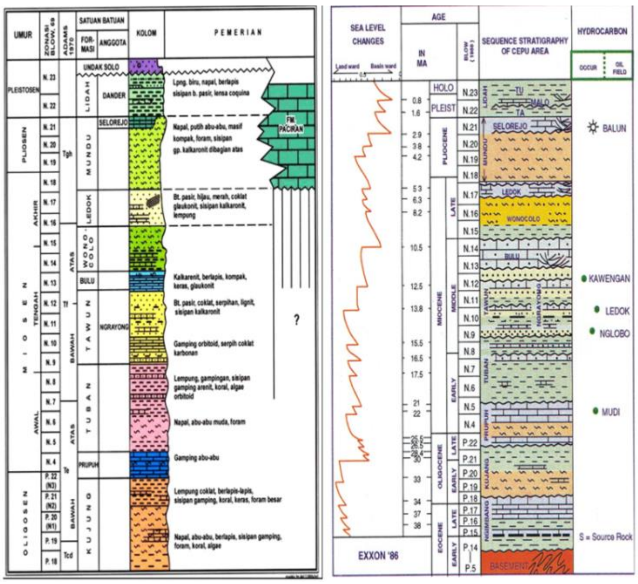


Figure 4.
Regional Stratigraphy of Rembang Zone

(*Pringgoprawiro, 1983, kiri dan Exxon, 1996 Kanan*)

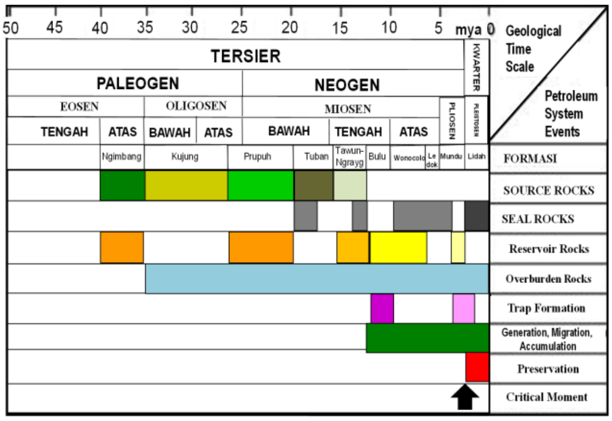


Figure 5.
Petroleum System of South East Java Basin

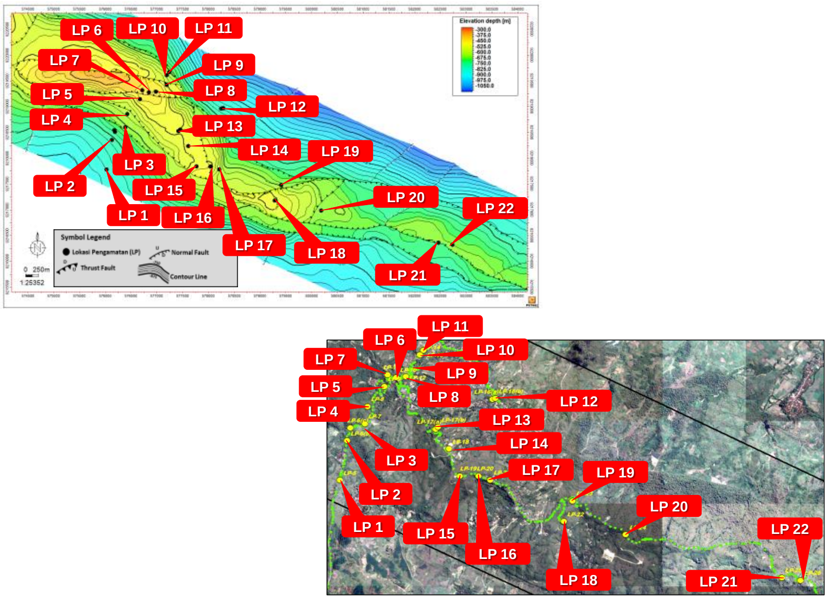


Figure 6.
Locality of survey (LP) in Kawengan Field

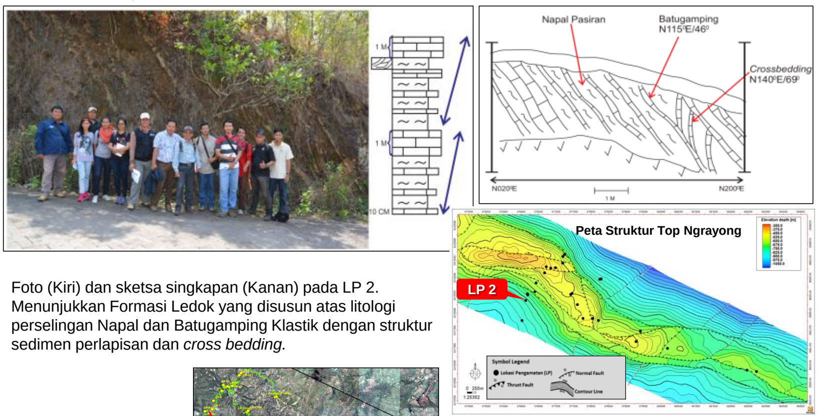


Foto (Kiri) dan sketsa singkapan (Kanan) pada LP 2. Menunjukkan Formasi Ledok yang disusun atas litologi perselingan Napal dan Batugamping Klastik dengan struktur sedimen perlapisan dan *cross bedding.*

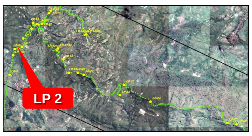


Figure 7.

Photo outcrop in LP 2

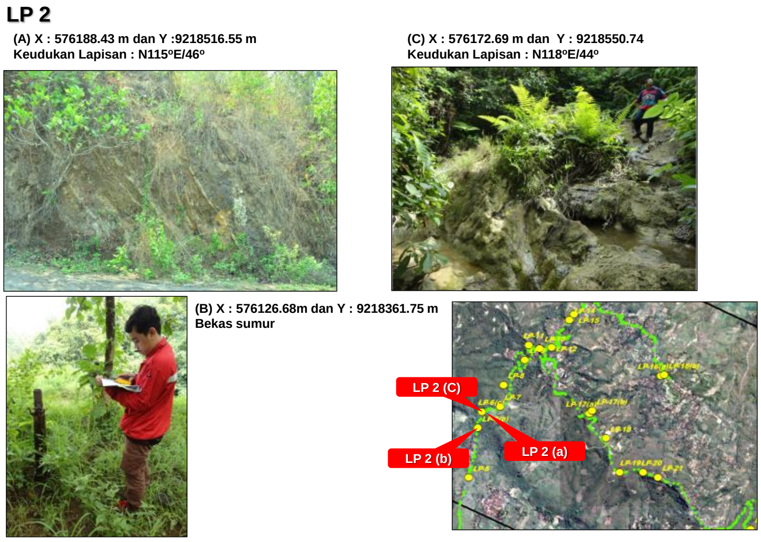


Figure 8.
Outcrop of Ledok Formation (LP 2)

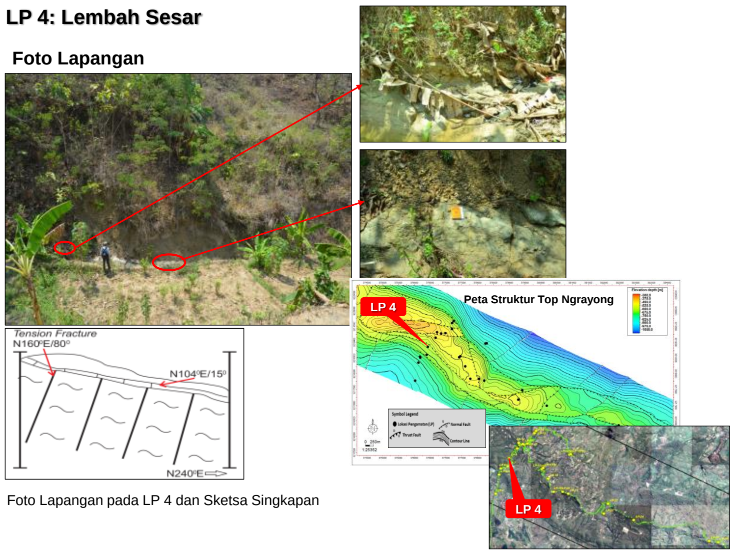


Figure 9.
The data of fault (LP4)

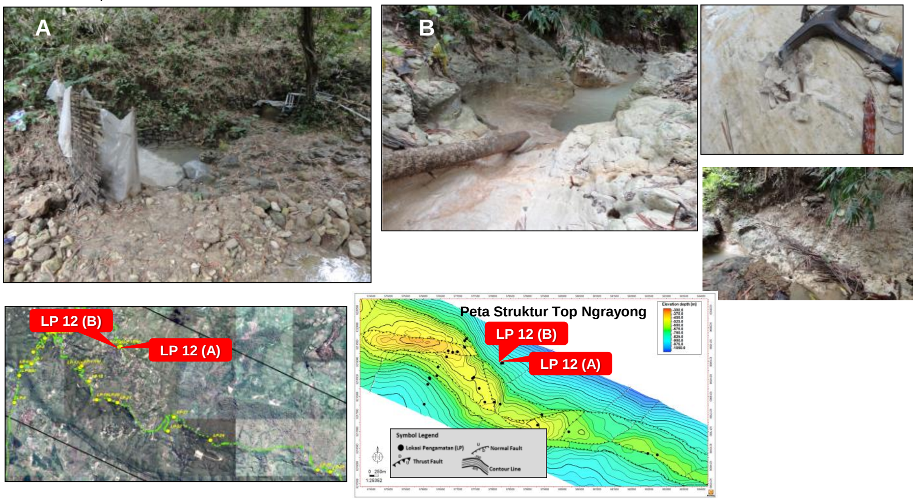


Figure 10. Mata Air and Wonocolo Formation in Banyuurip Village (LP 12)

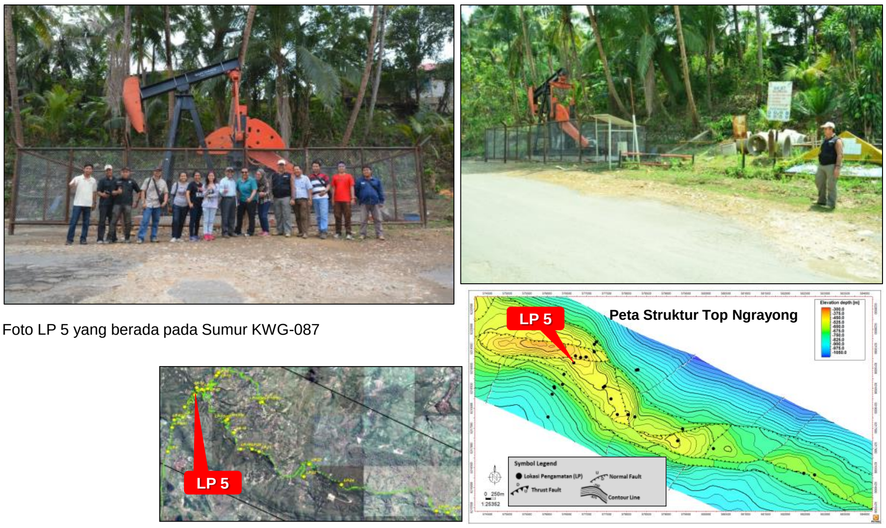


Figure 11
Well of KWG-087 (LP 5)

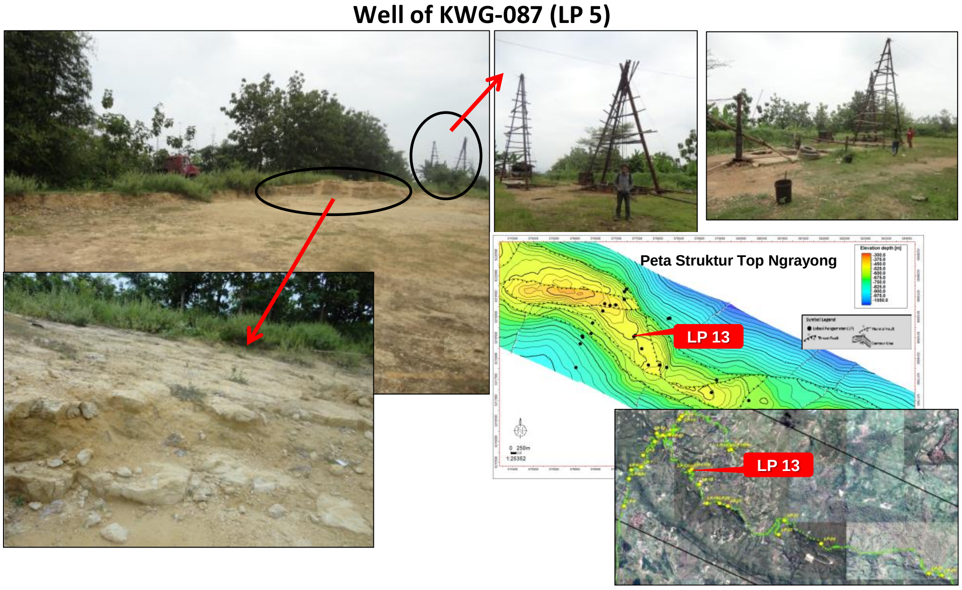
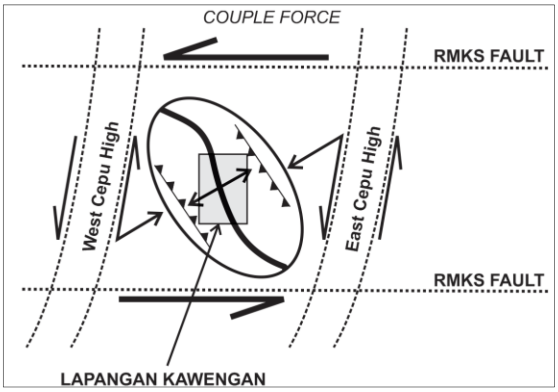
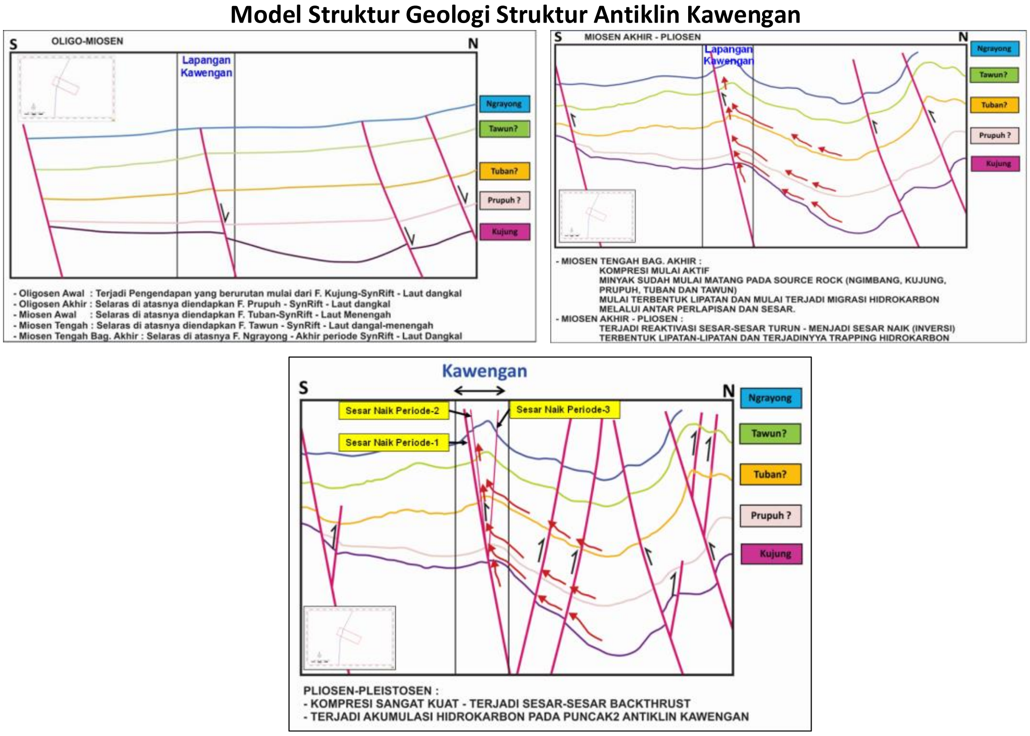


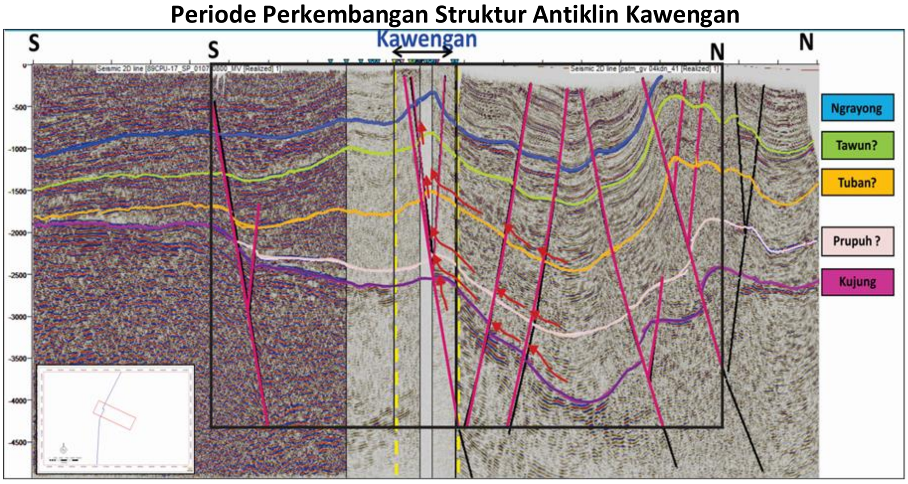
Figure 12.
The outcrops and tradisional Rig in LP13



Gambar 13.
Model Struktur Geologi Struktur Antiklin Kawengan



Gambar 14.
Periode Perkembangan Struktur Antiklin Kawengan



Gambar 15.
Kondisi Sekarang Struktur Antiklin Kawengan

DEVELOPMENT OF PUNDONG AREA AS GEOHERITAGE AND EDUCATION TOURISM PUNDONG PARANGTRITIS YOGYAKARTA

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ABSTRACT

Pundong region is part of an ancient volcano fossil area that grows in the southern part of the city of Yogyakarta. This ancient volcano located at the westernmost tip of volcanoes series that lined east-west. Range of this volcano is covered by limestone sediment that showing the distribution of marine fossils. The fossils can be seen on the rock.

On the lines from Kretek to the top of Pundong hill can be seen educational sites from volcano product, traces the history of the Dutch colonial era to the Japan era, and story of local legend. Education sites are lava basalt with structural sheeting joint and autobreccia, springs, pools that have occurred since the Dutch era, Sunan Mas cave, Sunan Mas mosque, unconformity boundary between andesite lava and Wonosari limestone, Japanese cave and distribution of mollusc fossil and coral as constituent of limestone.

This study uses a methodology to conduct cross-sectional profile of rock, outcrop observations and preparation of the information. This study aims to provide insight education Geotourism and education about the history of the Indonesian nation. Understanding the occurrences surrounding nature and understanding the history of the nation, it is expected to grow motivation patriotism and defend the state for the Indonesian nation. By better understanding the geography and culture of the Pundong people, the hope of the future obtained a much better idea for enhancing Pundong tours and welfare of local communities.

Key words: ancient volcano, historical sites, culture, tourism

INTRODUCTION

Pundong tourist area is part of the tourist area of Bantul, which still need to be developed and published. This area is fully loaded with the geological history of the past, the history of the struggle of the Indonesian people to the cultural history of the local community Pundong. With the planning of the south-south lane road that will pass through the region of Bantul, With the planning of the south-south lane road that will pass through the region of Bantul, so Bantul tour should be more developed, because it will get more tourists both local and foreign to prefer Bantul than other areas. In addition to the economy and welfare of Bantul people will be increased.

Pundong hills limited by the wide expanse of the Indian Ocean in the south and the Opak river in the north. The western part is the area of sand dunes, as well as in the eastern part is a series of volcano fossils lined from west to east. This area is located in the Kretek district, Bantul, Yogyakarta, which is about 20 km to the south of the Yogyakarta city.

GEOLOGICAL PARANGTRITIS

The research area is part of the western Indonesian region affected by tectonic activity which is the collision between the Eurasian continental plate and the Indo-Australian Plate Ocean that has lasted since the Late Cretaceous and still continues today. In Java, the collision between the plates is directed perpendicular subduction which produces magmatic arc lines east-west trending.

Morphologically Pundong area is Tertiary volcanic morphology that is covered by limestones and surrounded by beaches and river sediment. Morphology this volcano does not show the form of a cone, as has been eroded. Morphology is organized by litostratigrafi unit of the Southern Mountain. Some researchers in explaining litostratigrafi Southern Mountain to one another there is a difference. This difference is primarily litostratigrafi unit of western parts (Parangtritis-Wonosari) and the eastern region (Wonosari-Pacitan). Proposed sequence stratigraphy of west part of South Mountain expressed by Bothe (1929) and Surono (1989). In the eastern part submitted by Sartono (1964), Nahrowi (1979) and Pringgoprawiro (1985), while Samodra et al. (1992) proposed stratigraphy in the transition area between the western and eastern parts. The geological map prepared by Raharjo, et al. (1977).

Parangtritis is the western part of Southern Mountain with the oldest stratigraphic sequence is a Pre-Tertiary metamorphic rock and are exposed at Jiwo Mountain, Bayat. Then precipitated unconformity by Tertiary rocks consisting of Kebo-Butak, Semilir, Nglanggran, Sambipitu, Oyo, Wonosari and Kepek Formation. Lithologies of formation contain volcanic activity results include: Kebo-Butak, Semilir, Nglanggran, Sambipitu and Oyo Formation.

Rocks in the study area consisted of Nglanggran Formation, Wonosari Formation and beach sediment. Nglanggran Formation is the volcanic eruption products that are part of a series of Tertiary volcanic complex. Age of lines of this volcanoes according Soeria-Atmadja *et al*. (1990, 1991) from Paleocene (58.58 ± 3.24 Ma) to Oligo-Miocene (33.15 ± 1.00 Ma - 24.25 ± 0.15 Ma). Volcanoes affinity including toleitic-calc alkaline series rocks constituent of basalt, basaltic andesites, andesite and dacite (Soeria-Atmadja *et al*., 1990, 1991 and Hartono, 2000). Wonosari Formation consists of limestones Middle-Late Miocene, while the Quaternary sediment includes alluvial of Opak river and sand beaches sediments.

RESEARCH METHODOLOGY

In conducting this research, problem solving is done by using a methodology that includes: profile cross-section of rocks, outcrop observations and preparation of the information. Because this study aims to provide insight education Geotourism and education about the history of the Indonesian nation.

RESULTS AND DISCUSSION

Basalt lava

Basalt lava exposed western slopes of the Pundong hill, currently planned as a four-wheeler parking. Lava shows the structure of sheeting joint and autobreccia. Description of basalt lava is gray, massive, hipocrystaline, afanitic- moderate faneric, inequigranular, suhedral-anhedral crystal form. Mineralogical composition consisting of pyroxene, plagioclase embedded in volcanic glass groundmass.

Figure 1. Basalt lava showing sheeting joint and autobreccia structures.

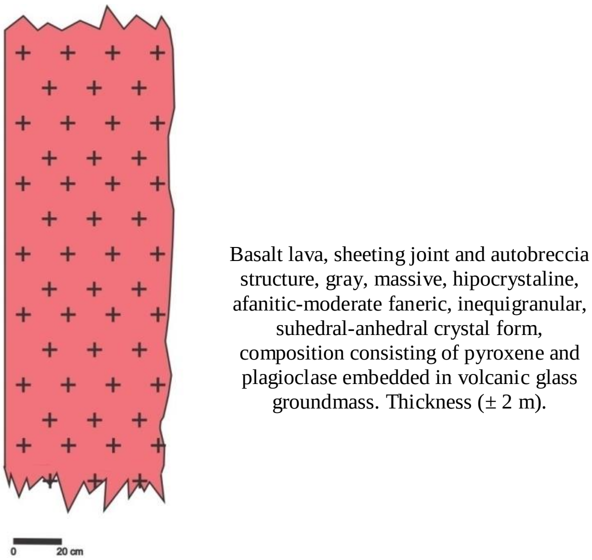

Figure 2. Cross-section profile of basalt lava.

Water spring

Spring and pool of water has been around since the Dutch era about 350 years. These springs are not exhausted during the drought. These springs are used by inhabitants as a source of daily necessities. It is said that in the era of Sultan Hamengkubowono VII, the spring water is used to irrigate sugar cane plantations. At that time Yogyakarta already using the technology of making sugar cane. Then in the era of Japan, this spring is used to support military activities in the area.

Total spring there are about 7 locations and the rise of the water is in the form of the temple. The water is then collected into large tubs and used inhabitants to meet their daily needs and the rest is collected into the pond to keep the fish. Flow of water is constant, then the future development of this spring can be developed as a ponds Pundong, thus increasing tourist destinations. Some of the facilities that had been awakened are toilets and some information about the history of the springs. The geology of this spring is generated by differences in rock types. Andesite lava serves as an impermeable layer is covered by a layer of limestone Wonosari as a water reservoir. As a result of the topography and fault structure, the water can appear in the zone. The boundary of rocks is unconformity between basalt lava of Nglanggran Formation with Wonosari limestones Formation.

Figure 3. Tub of water, ponds and springs are constructed as a temple.

Surocolo cave

Surocolo cave or Sunan Mas cave is a historical relic of a story Sunan Mas or Sunan Amangkurat Amangkurat III. This cave is the hiding place of the sunan during confrontation with the Netherlands. In the vicinity of the cave was built Sunan Mas mosque and the mosque was used for religious by local residents. Planning ahead, the mosque was developed to increase the value of history in the form of spiritual tourism.

Figure 4. Sunan Mas or Sunan Amangkurat III cave.

Unconformity Boundary

The next geological phenomenon found in this area is the relationship between andesite lava and Wonosari limestone. On the track of Surocolo spring to Japanese cave there are outcrops of andesite lava with Wonosari limestone. Andesite is covered by limestones, the boundary between these two rocks are shown in dark brown discoloration (andesite) and tawny (limestone). Stratigraphic relationship of rocks between the two rocks is unconformity. Based on petrographic analysis of limestone (wackestone) is yellowish brown, massive, grain size <0,062 mm, moderate rounded-angular, unsorted and open fabric. Fragments are allochem, interclast and carbonate lime as cement. While andesite shows gray, hipocrystaline, moderate faneric-afanitic, inequigranular and suhedral-anhedral form crystal. Mineralogical composition composed of plagioclase and hornblende in volcanic glass groundmass.

Figure 5. Shows the boundary between two lithologies. The brown color is andesite and brownish yellow color is limestone.

Figure 6. Cross-section profile andesite and limestone (wackestone).

Japanese cave

At this location there are several Japanese caves that has built road, so that the relationship between a Japanese caves to the location can be easy. The caves are a manifestation of the concept of Japan's defense when fighting with the Dutch in defending colonialism in Indonesia. This caves as a defense when there are attacks from the south and the air.

Japanese caves are built on limestone sediment that shows the distribution of molusca fossils as a constituent of limestone and coral reefs. These fossils should be protected, because it can provide educational experiences regarding basic knowledge of biology or biostratigraphy. These organisms can be explained that these limestone forming in the sea. Petrographic of limestone is showing brownish yellow color, composed of fragments of corals and molluscs are cemented by calcite. Fragments measuring 2-4 cm with moderate rounded-angular grain shape.

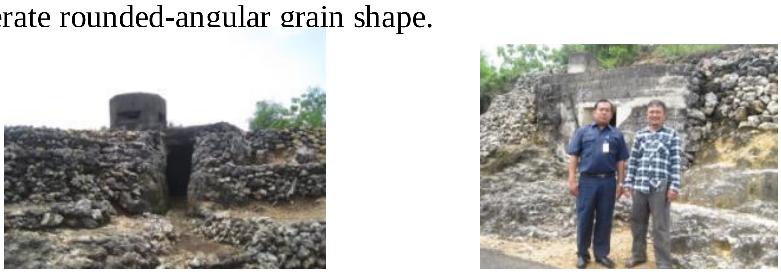

Figure 7. Japanese caves, which serves as a bastion Japanese in the Pundong hill.

Figure 8. Fossil as a constituent of Wonosari limestone.

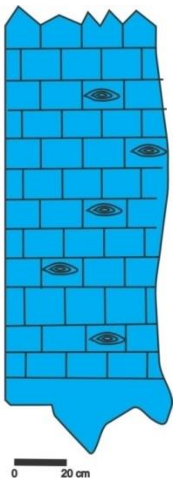

Figure 9. Cross-section profile of reef limestones.

CONCLUSION

Pundong region has the potential Geotourism educational tours and educational history of the Indonesian nation. This tourist area is part of the tourist area of Bantul, which still need to be developed and published. The educational potential can be found on the path of Kretek to the top of the Pundong hill.

Line of educational tours are basalt lava with sheeting joint and autobreccia structure, springs, pools that have occurred since the Dutch era, Sunan Mas cave, Sunan Mas mosque, unconformity boundary between andesite lava and Wonosari limestone, Japanese cave and mollusc and coral fossils distribution as constituent of limestone. By developing tourist areas in Bantul, it will improve the economy and welfare of the Bantul people.

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CHARACTERISTICS OF KARST AND ITS ENVIRONMENT IN WAIGEO ISLAND RAJA AMPAT ARCHIPELAGO

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Abstract

Karst has strategic value as one of the economically valuable minerals. The main content of chemical elements in the karst is Calcium Carbonate (CaCO3). Tectonic role is pivotal in the appointment process (upduction) of shallow marine sedimentto the surface, called limestone and in forming a landscape typical of the so-called karst landforms. Climate or rainfall area determining factor in the process of forming the landscape as well as typical forms of dissolution of the results contained in the karst region. Karst has a geological diversity into geological heritage that must be protected as a conservation area. Geopark is a means of development in which the conservation of protected areas can be strengthened and at the same time provides an opportunity for economic and social development of local communities simultaneously. Geopark area authorities are responsible for ensuring that the protection of geological heritage is implemented in accordance with the values of local tradition and required regulatories. This study aims to propose geological approach of the diversity of geology, geological heritage, and world heritage. The assessment resulting from 6 (six) samples chemically limestone rock samples showed that all elements contain a very high CaO ranging from 53.45% - 55.67%.The highcontentswere found in the sample of SG2, SG4 and SG5 which are kalkarenit limestone and limestone formations resultedfrom the dissolution process in the form of stalactites and stalagmites. The high carbon content in the karst would react with oxygen and isreleased to the atmosphere as carbon compounds. Geological diversity as geological heritage, world heritage is the basis for setting the karst region as a conservation area. Waigeo Island is one area possesing karst areas in Raja Ampat with the characteristics of high geological diversity.Based on the results of the assessment weighting assigned classification karst areas in the ESDM No17 Year 2012,eksokarst and endokarst criteria were found virtually in the inner bayarea as an area of karst landscape. Based on the scoring of parameters assessed and observed in the inner bay area of Waigeo karst landscape utilization is only allowed to a protected area prescribed by the regulations, namely a). Protected forest area, b). Conservation forests to national parks, nature reserves, cultural heritage and knowledge. As such, this region can be implemented various strategies for regional development in a sustainable approach of the diversity and geological heritage sector that should be supported by regencial and federal government programs.

PENGELOLAAN SUMBER DAYA GEOLOGI SECARA KERKELANJUTAN DI PULAU LOMBOK NTB

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ABSTRAK

Sumber daya geologi tidak hanya bisa dimanfaatkan secara ekstraktif untuk meningkatkan pertumbuhan ekonomi. Pemanfaatan sumber daya geologi juga bisa dilakukan secara berkelanjutan dengan menerapkan konsep Geopark. Dalam konsep ini pengelolaan sumberdaya geologi dilakukan secara komprehensif dengan memperhatikan konservasi terhadap keragaman geologi, biologi dan budaya. Geowisata merupakan basis pengembangan geopark untuk menciptakan nilai ekonomi dan pengembangan ekonomi masyarakat lokal. Kegiatan geowisata akan membuka peluang pasar bagi produk kerajinan tradisional dan makanan khas. Keduanya merupakan bagian dari budaya yang tercipta sebagai hasil dari sebuah kearifan lokal. Geopark Rinjani-Lombok adalah anggota jaringan Geopark Nasional Indonesia yang ada di Provinsi NTB. Luas kawasannya mencapai 3.065 km^2 dengan 50 situs geologi, 7 kawasan konservasi biologi dan 18 situs budaya. Tujuan pembentukan geopark ini adalah untuk meningkatkan pertumbuhan ekonomi masyarakat dalam kawasan dengan memanfaatkan sumber daya geologi secara berkelanjutan

Kata Kunci : Sumber daya geologi, Geowisata, Geopark Rinjani-Lombok

PENDAHULUAN

Eksploitasi sumber daya geologi masih menjadi primadona dalam mendorong pertumbuhan ekonomi di Indonesia. Hal ini tidak dapat diingkari bahwa kontribusi terbesar pendapatan negara selain pajak sekarang ini masih bersumber dari sektor energi dan sumberdaya mineral (ESDM), yakni migas, mineral dan batubara. Namun ada sisi lain dari sumber daya geologi yang dapat dimanfaatkan untuk meningkatkan pertumbuhan ekonomi karena sumber daya geologi dapat berwujud fenomena geologi yang indah, unik dan langka. Fenomena ini antara lain berupa bentang alam yang indah seperti gunung, lembah, sungai, danau. Dalam skala yang lebih kecil berbentuk singkapan berbagai jenis batuan dan fosil langka serta gua-gua kars dengan stalaktit dan stalagmit. Keragaman geologi tersebut dapat dimanfaatkan sebagai modal pembangunan berkelanjutan.

Sehubungan dengan pembangunan berkelanjutan, banyak wilayah di dunia menawarkan potensi sumberdaya yang dimiliknya secara langsung untuk pembangunan ekonomi karena adanya beragam fenomena geologi seperti struktur, mineral dan fosil. Situs warisan geologi yang dikelola dengan baik, dapat menciptakan lapangan kerja dan kegiatan ekonomi baru, Mengingat Deklarasi Milenium PBB, khususnya pernyataan dari nilai fundamental "Respect for Nature" dalam pengelolaan dari semua spesies mahluk hidup dan sumber daya alam. Di seluruh dunia, telah tumbuh kesadaran masyarakat terhadap kebutuhan untuk konservasi alam dan semakin banyak orang menyadari bahwa fitur geologi memainkan bagian penting dalam mengelola lingkungan dengan cara yang bijaksana (Eder & Patzak, 2004)

Keragaman hayati (biodiversity) digunakan untuk menggambarkan berbagai sifat biotik demikian juga halnya dengan keragaman geologi (geodiversity) dapat disetarakan untuk menjelaskan berbagai sifat abiotik. Jika keragaman hayati telah dimanfaatkan sebagai obyek tujuan dari kegiatan ekowisata maka keragaman geologi juga dapat digunakan sebagai daya tarik wisata melalui kegiatan geowisata (Gray, 2008).

Geopark merupakan konsep pengembangan kawasan yang dapat disinergikan dengan prinsip-prinsip konservasi, edukasi, penumbuhan ekonomi lokal melalui geowisata (Kusumabhrata & Suwardi, 2012). Menyatukan konservasi dengan pariwisata tidak hanya menyebabkan perlindungan terhadap situs warisan geologi yang unik, tetapi juga akan membangkitkan penelitian ilmiah, pendidikan lingkungan dan peningkatan pembangunan ekonomi berbasis pariwisata lokal (Azman, Halim, Liu, Saidin, & Komoo, 2010).

Geopark memiliki jaringan global yang bernaung dibawah UNESCO, untuk mencapai tujuannya, ada 5 (lima) kriteria yang harus di penuhi (GGN-UNESCO, 2010), yaitu :

1. Ukuran dan kondisi

Batas kawasan geopark harus jelas dan meliputi wilayah yang cukup luas untuk pengembangan budaya dan ekonomi lokal. Selain itu situs-situs warisan geologi dalam wilayah geografis harus menjadi bagian konsep holistik dalam perlindungan, pendidikan dan pengembangan berkelanjutan.

2. Manajemen dan Keterlibatan Masyarakat Lokal

Syarat pengusulan Geopark adalah telah adanya rencana dan badan pengelola yang terbentuk melalui proses bottom-up. Pengelolaan yang terorganisir dengan melibatkan publik, komunitas lokal, kepentingan swasta dan badan-badan penelitian/pendidikan. Pariwisata berkelanjutan dan kegiatan ekonomi lainnya dalam Geopark hanya dapat berhasil jika dilakukan bersama dengan masyarakat setempat. Ciri Geopark harus terlihat jelas bagi pengunjung melalui branding atau labelling yang khas, publikasi dan aktivitas.

3. Pengembangan ekonomi

Salah satu tujuan Geopark adalah merangsang kegiatan ekonomi dalam kerangka pembangunan berkelanjutan. Geopark harus menjadi penghubung antara aspek warisan budaya dan warisan geologis, menghormati lingkungan dan menstimulasi pembentukan usaha-usaha lokal yang inovatif.

4. Pendidikan

Geopark harus mengkomunikasikan pengetahuan geosains/geologi dan konsep-konsep lingkungan kepada masyarakat. Hal ini akan dipengaruhi oleh program wisata, staf yang kompeten dan dukungan logistik bagi pengunjung, kontak personal dengan penduduk setempat, wakil media dan para pengambil keputusan. Beberapa cara untuk menyampaikan informasi di antaranya dengan ekskursi anak-anak sekolah dan guru, seminar dan kuliah-kuliah saintifik.

5. *Perlindungan dan Konservasi*

Tanggung jawab geopark adalah melindungi warisan geologi terutama yang berhubungan dengan kepentingan / hajat hidup masyarakat setempat. Geopark harus patuh pada hukum lokal dan nasional yang berkaitan dengan perlindungan warisan geologi.

Konsep Geopark terbukti telah mampu meningkatkan pertumbuhan ekonomi dan menyediakan lapangan kerja. Sebagai contoh adalah Geopark Yuntai di Henan, Cina. Geopark ini, disetujui pada tahun 2001, meliputi area seluas 190 km persegi. Pada tahun 2001, jumlah pengunjung mencapai 600.000 orang dengan pendapatan sebesar 14 juta yuan. Pada tahun 2002, jumlah pengunjung meningkat mejadi 940.000 orang dan pendapatan menjadi 27,2 juta yuan. Selain itu pariwisata juga memacu industri penunjang dan peningkatan lapangan kerja lokal. Pada tahun 2002, pendapatan dari industri penunjang meningkat menjadi 620 juta yuan atau naik 15% dibandingkan tahun sebelumnya. Lebih dari 60 hotel baru telah dibangun di daerah tersebut dan menyediakan lapangan pekerjaan bagi sekitar 4.000 orang (Xun & Ting, 2003).

Tulisan ini akan menjabarkan dua hal, pertama, kondisi keragaman geologi yang ada di Pulau Lombok sebagai obyek geowisata dan kedua, hubungan unsur geologi, biologi dan budaya dalam pengembangan ekonomi masyarakat lokal.

Geopark Rinjani-Lombok

Gunung Rinjani sebagai bagian dari kawasan Taman Nasional Gunung Rinjani (TNGR) telah beberapa kali meraih penghargaan internasional, salah satuanya adalah '*World Legacy Award"* (2004). *World Legacy Award* merupakan suatu penghargaan dalam pengelolaan pariwisata yang bertanggung jawab sosial, budaya dan lingkungan dengan tujuan untuk melindungi kekayaan keanekaragaman budaya dan sumberdaya alam. Hal ini kemudian menjadi latar belakang dari para pemerhati geowisata Indonesia untuk mengusulkan Gunung Rinjani sebagai anggota GGN-UNESCO pada pertemuan tahun 2007 di Badan Geologi Bandung.

Pada tahun 2008, Ikatan Ahli Geologi Indonesia (IAGI) Pengurus Daerah Nusa Tenggara menyelenggarakan seminar Geopark Nasional pertama di Indonesia, bertempat di Mataram Lombok, dengan tujuan merekomendasikan langkah untuk menwujudkan Kawasan Gunung Rinjani sebagai Kawasan Geopark. Dalam seminar Geo SEA (Geo South East Asia) XI- CCOP di Kuala Lumpur Malaysia yang diselanggarakan pada tanggal 8-10 Juni 2009, diusulkan 3 kawasan sebagai geopark pertama di Indonesia, yaitu Taman Nasional Gunung Rinjani di Pulau Lombok, Gunung Batur di Bali, dan Gunung Sewu di Pacitan, Jawa Timur.

Pada FGD tanggal 5 Desember 2011 di Jakarta yang dihadiri unsur dinas/badan terkait Provinsi NTB, Pakar Geopark/Komite Nasional Geopark Indonesia, Pimpinan dan staf Direktorat Produk Wisata Kemenparekraf, dan Konsultan Masterplan Geopark Rinjani, diputuskan : *Geopark Rinjani* menjadi *Geopark Pulau Lombok*. Pada tanggal 17-19 Nopember 2012 dilakukan kegiatan aspiring Geopark Pulau Lombok dengan mendatangkan tiga orang asesor UNESCO yang dipimpin oleh Guy Martini, merekomendasikan luas Kawasan Geopark Pulau Lombok agar dipersempit, meliputi kawasan bagian Utara dengan pusat kawasan Gunung Rinjani dan untuk nama diusulkan menjadi "*Geopark Rinjani-Lombok*". Sejak tanggal 7 Oktober 2013, Geopark Rinjani-Lombok resmi menjadi anggota jaringan Geopark Nasional Indonesia dan saat ini sedang dipersiapkan menjadi anggota jaringan Geopark Global

Ukuran dan Kondisi Kawasan Geopark Rinjani-Lombok

Pulau Lombok merupakan salah satu dari dua pulau utama yang ada di Provinsi Nusa Tenggara Barat. Luas pulau ini 4,738.70 kilometer persegi dengan panjang pulau dari barat ke timur sejauh 80 Km. Di sebelah barat berbatasan dengan Pulau Bali dan dipisahkan oleh Selat Lombok. Sedangkan di sebelah timur terdapat Selat Alas yang menjadi pemisah antara Pulau Lombok dan Pulau Sumbawa. Adapun luas kawasan Geopark Rinjani-Lombok 3.065 km^2 termasuk pulau-pulau kecil seperti Gili Trawangan, Meno dan Air (Gambar 1)

Secara administrasi, Pulau Lombok dibagi menjadi 4 kabupaten dan 1 kota, yaitu Kota Mataram, Kabupaten Lombok Barat, Kabupaten Lombok Tengah, Kabupaten Lombok Timur dan Kabupaten Lombok Utara. Pulau Lombok dihuni oleh 3,2 juta jiwa atau sekitar

70,38 persen dari jumlah penduduk di Nusa Tenggara Barat. Kota Mataram merupakan kota terpadat di NTB yakni dengan kepadatan sebesar 6.740 orang per km^2, disusul Kabupaten Lombok Tengah dengan Kepadatan 724 orang per km2 berikutnya Kabupaten Lombok Timur dengan kepadatan sebesar 699 orang per km^2 (BPS Provinsi NTB, 2013)
Bentang alam pulau Lombok dicirikan oleh morfologi gunungapi Kuarter-Resen yang menempati bagian utara pulau ini, morfologi dataran terdapat di bagian tengah, memanjang dengan arah barat-timur dan merupakan cekungan sedimentasi. Sedangkan morfologi perbukitan bergelombang yang terbentuk oleh Formasi batuan Tersier berada di bagian Selatan (Rachmat, 2013).

Pulau Lombok terletak pada zona transisi garis imajiner yang membagi peta keanekaragaman hayati dunia, yakni Garis Wallacea. Hal ini membuat Pulau Lombok menjadi pusat persinggungan antara flora fauna tropis Asia dengan flora fauna Australia. Persinggungan dua hal selalu menciptakan sesuatu yang unik dan berbeda, begitu pula dengan Pulau Lombok, sebagai zona transisi, kawasan ini memiliki flora fauna yang sangat beragam dan beberapa diantaranya merupakan flora fauna endemik.

Tumbuhan endemik Nusa Tenggara yang kemungkinan masih terdapat di kawasan Taman Nasional Gunung Rinjani adalah jenis anggrek, antara lain : *Peristylus rintjaniensis* dan *Peristylus lombokensis*. Sedangkan jenis mammalia endemik, salah satunya adalah musang rinjani dengan nama latin *Paradoxurus hermaprhroditus rindjanicus* (Gambar 2) (WWF Indonesia, 2004).

Penduduk asli Pulau Lombok adalah suku Sasak. Kebudayaan masyarakat Sasak merupakan sebuah kebudayaan yang multietnis dan multikulturalisme, dan merupakan gambaran wajah kebudayaan yang alkulturatif. Proses akulturasi ini bisa diamati dari beberapa peninggalan cagar budaya di Lombok seperti pura maupun masjid tua tradisional (Gambar 3). Akulturasi budaya juga terjadi dalam bentuk kesenian di lombok yang sangat beragam. Kesenian asli dan pendatang saling melengkapi sehingga tercipta bentuk-bentuk kesenian yang khas. Kesenian Hindu Bali dan kebudayaan Islam memberi pengaruh cukup besar terhadap perkembangan kesenian-kesenian yang ada di Lombok hingga saat ini.

Keragaman Geologi Pulau Lombok Sebagai Obyek Geowisata

Wilayah NTB merupakan tempat pertemuan 2 lempeng aktif dunia yaitu : Lempeng Indo-Australia di bagian selatan dan Lempeng Eurasia di bagian utara. Interaksi antar lempeng-lempeng tersebut menempatkan NTB sebagai wilayah yang memiliki fenomena sumber daya geologi yang beragam, sebagai akibat berlangsungnya proses geologi yang dinamis dan kompleks dalam kurun waktu jutaan tahun.

Proses dinamika lempeng yang cukup intensif menjadikan wilayah NTB sebagai daerah yang mempunyai aktifitas kegunungapian. Ada 3 buah gunungapi aktif di wilayah NTB, yaitu Gunung Tambora (+2851 m dpl) di Pulau Sumbawa, Gunung Sangeang Api (+1849 m dpl) di Pulau Sangeang dan Gunung Rinjani (+3726) di Pulau Lombok. Gunung Rinjani tercatat sebagai gunungapi aktif tertinggi kedua di Indonesia setelah Gunung Kerinci (+3800 m dpl) di Pulau Sumatera.

Gunung Rinjani telah beberapa kali mengalami letusan besar. Sebaran material letusannya dapat dijumpai hingga ke daerah pantai. Rangkaian letusan tersebut telah membentuk bentang alam yang indah dengan variasi batuan yang unik. Keindahan bentang alam berupa kaldera, aliran lava, gua vulkanik, air terjun, pantai vulkanik dan danau (Gambar 4). Keunikan batuan seperti batuan beku dengan struktur skoria dan struktur aliran, lava bantal, kekar berlembar (sheeting joint), singkapan batuan terobosan (dike), mata air panas dan dingin, mata air bawah laut dan singkapan batuan yang mengandung charcoal (Gambar 5). Keindahan bentang alam dan keunikan batuan tersebut merupakan fitur yang menarik sebagai obyek geowisata.

Dalam kawasan Geopark Rinjani Lombok terdapat 50 situs geologi yang tersebar baik di dalam maupun di luar kawasan konservasi geologi. Sebanyak 29 situs geologi berada dalam kawasan konservasi biologi seperti taman nasional, hutan lindung, taman wisata alam, tahura nuraksa dan kawasan konservasi perairan. Sedangkan 21 situs geologi terletak diluar kawasan konservasi biologi (Pemerintah Provinsi NTB, 2013). Daftar lokasi situs geologi dapat di lihat pada tabel 1 dan sebarannya ditunjukkan pada gambar 6.

Pengembangan Ekonomi Masyarakat lokal

Pengembangan ekonomi masyarakat lokal dapat dilakukan dengan memanfaatkan potensi sumber daya suatu daerah yang bersifat khas atau bahan bakunya tersedia cukup banyak di daerah tersebut. Bentuknya dapat berupa makanan maupun kerajinan tradisional, keduanya merupakan bagian dari budaya yang berkembang pada suatu kelompok masyarakat.

Makanan Khas Pulau Lombok

Produk kuliner yang khas menjadi salah satu daya tarik dalam aktivitas geowisata. Selain obyek wisata, untuk memberikan pengalaman unik bagi pengunjung dapat dilakukan dengan menyajikan makanan khas yang tidak dapat dijumpai di daerah lain. Pengalaman unik ini akan menjadi bahan cerita yang akan ditularkan dari satu orang ke orang lain sehingga akan menimbulkan rasa penasaran untuk mencobanya. Semakin banyak pengunjung yang datang tentu akan berdampak pada meningkatnya pertumbuhan ekonomi masyarakat lokal.

Masyarakat Lombok mempunyai beragam makanan khas, diantaranya Ares, olah-olah, bulayak, Plecing Kangkung dan lain-lain (Gambar 7). Ares merupakan jenis makanan yang terbuat dari batang pohon pisang, dimasak dengan santan dan umumnya disajikan sebagai sayur dalam acara-acara pesta seperti perkawinan. Olah-olah merupakan jenis sayur yang bahan dasarnya berasal dari tumbuhan paku-pakuan. Bulayak adalah makanan sejenis lontong, tetapi pembungkusnya tidak terbuat dari daun pisang namun dari daun pohon enau yang masih muda.

Dari semua makanan yang ditelah disebutkan di atas, *plecing kangkung* adalah makanan khas yang paling populer dan mudah di temukan di Pulau Lombok. Makanan ini merupakan jenis masakan dari sayur kangkung rebus yang dirobek memanjang dan dicampur dengan sambal yang bahannya terdiri dari terasi, tomat dan cabe. Sebagai pelengkap biasanya ditambahkan parutan kelapa dan perasan jeruk limau, serta ada juga yang menambahkan gorengan kacang tanah.

Dalam pergaulan masyarakat Pulau Lombok dikenal istilah "*Begibung*" yang artinya makan bersama. Salah satu menu yang disajikan dalam acara tersebut biasanya adalah *plecing kangkung*. Kegiatan makan bersama ini menjadi sarana untuk menjalin hubungan silaturahmi. Menu *plecing kangkung* tidak hanya populer di kalangan masyarakat Lombok tetapi telah dikenal oleh wisatawan yang berkunjung ke pulau ini karena hampir setiap rumah makan besar di Lombok menyediakan menu *pelecing kangkung*.

Kangkung Lombok telah terdaftar sebagai produk Indikasi Geografi di Direktorat Jendral Hak Kekayaan Intelektual, Kementerian Hukum dan Hak Azasi Manusia RI dengan nomor agenda IG.24.2011.000002. Permohonan ini dilakukan oleh Asosiasi Komoditas Kangkung Lombok (AKKL) yang terbentuk pada tanggal 19 Agustus 2011.

Kangkung Lombok mempunyai sifat yang khas dan menjadi salah satu sumber *plasma nutfah* spesifik yang tidak dimiliki daerah lain. Secara fisik Kangkung yang tumbuh di Pulau Lombok memiliki bentuk dan ukuran batang yang gemuk berwarna hijau segar, tidak elastis, renyah dan cepat patah. Keistimewaan lainya adalah panjang pucuk yang di panen melebihi rata-rata kangkung pada umumnya, yaitu mencapai 40–50 cm dan Kangkung Lombok yang sudah dimasak bertekstur lembut, gurih, dan renyah serta tidak berubah warna setelah dimasak (AKKL, 2011).

Ketersedian air sepanjang tahun dan tanah vulkanik yang subur menjadi faktor penting dari keberadaan tanaman kangkung air (*Ipomoea aquatica* Forsk) di Pulau Lombok. Kangkung Lombok menunjukkan keunggulannya apabila air genangannya berasal dari sungai-sungai yang mengalir dan bersumber dari mata air di hulu sungai, seperti Sungai Babakan, Sungai Jangkok, Sungai Dodokan, dan Sungai Meninting. Jenis tanah yang sesuai untuk tanaman Kangkung Lombok adalah jenis tanah yang memiliki kandungan pasir dan debu tinggi (jenis tanah Regosol) (AKKL, 2011).

Kawasan Gunung Rinjani merupakan salah satu warisan geologi gunungapi yang ada di Indonesia. kawasan pegunungan ini berfungsi sebagai daerah resapan air (recharge area) bagi seluruh wilayah kabupaten dan kotamadya yang ada di Pulau Lombok. Secara ekologis komposisi vegetasi pada komplek hutan Gunung Rinjani dan hutan disekitarnya mempunyai arti yang sangat penting dalam menjaga keseimbangan tata air di Pulau Lombok (WWF Indonesia, 2004).

Suplai air tanah Pulau Lombok erat kaitannya dengan struktur geologi dan bahan vulkanis yang dominan. Pulau Lombok memiliki potensi air tanah yang baik, karena adanya proses pengisian melalui banyak patahan dan retakan. Pulau Lombok didominasi oleh gunung berapi dan hampir seluruh mata air muncul dari endapan abu vulkanis di dasar Gunung Rinjani yang dapat menyerap air dan bertemu dengan tanah lempung yang tidak mudah ditembus air (Monk, K.A. 1997 dalam WWF Indonesia, 2004).

Kerajinan Tradisional Masyarakat Pulau Lombok

Produksi kerajinan tradisional sangat tergantung pada ketersediaan sumber daya alam disekitarnya. Sumber daya alam yang melimpah akan dimanfaatkan oleh tangan-tangan trampil para perajin untuk menghasilkan produk-produk kerajinan tradisional dengan ciri khas yang unik. Keunikan tersebut tercipta karena proses produksinya dilakukan secara tradisional dengan berbasis kearifan lokal. Kearifan lokal (*local wisdom*) merupakan tindakan yang dilakukan oleh masyarakat lokal untuk mengatasi berbagai masalah dalam pemenuhan kebutuhan mereka (Samodro, 2012).

Industri kerajinan dapat berkembang dengan baik bila proses produksinya memiliki akses pasar yang baik. Pariwisata merupakan salah satu kegiatan yang dapat mendukung berkembangnya pasar kerajinan, seperti di Bali. Berbagai kerajinan tradisional masyarakat Bali dijual sebagai cindramata.

Dalam konsep Geopark, pengembangan ekonomi masyarakat dilakukan melalui kegiatan geowisata. Hal ini akan membuka peluang pasar bagi produk-produk kerajinan tradisional masyarakat Lombok. Salah satu produk kerajinan tradisional yang khas di Pulau Lombok adalah kerajinan "*ketak"* (Gambar 8).

Pulau lombok memiliki keragaman hayati yang melimpah, salah satunya adalah jenis tumbuhan paku-pakuan. Jenis tumbuhan ini dimanfaatkan oleh sebagian penduduk Pulau Lombok sebagai bahan baku dalam kerajinan "*Ketak*". Pada awalnya ketak dibuat untuk

keperluan sehari-sehari. Seiring dengan berkembangannya keterampilan masyarakat, tercipta berbagai bentuk kerajinan tangan seperti, kotak tempat menyimpan perhiasan, keranjang, nampan, tempat tissue, tempat buah, tas dan lain-lain.
Ketak adalah jenis tumbuhan paku dengan nama latin *Lygodium circinnatum Sw.* Jenis paku yang merambat ini umumnya tumbuh pada ketinggian hingga 1000 m dpl. Ketak dengan panjang batang lebih dari 3 meter dapat dijumpai di kawasan hutan Pusuk pada ketinggian 500 – 1000 m dpl. Ketak juga dapat ditemukan di ladang dan kebun penduduk di daerah pedesaan (Arinasa, Sudiarsa, & Santa, 2005).
Proses pembuatan sebuah "*ketak*", dimulai dari proses penjemuran, pengasapan selama 3 hari untuk mendapatkan warna yang sesuai, kemudian dilanjutkan dengan proses pengeringan yang berlangsung selama 1 hari 1 malam, sehingga menghasilkan produk kerajinan yang aman dari jamur, rayap, bebas bahan kimia, dan semakin lama kerajinan ketak itu disimpan, warnanya akan semakin timbul dan eksotis. Ditambah dengan sentuhan bahan pewarna yang umumnya mirip dengan warna alami dari komponen bahan bakunya akan semakin menambah keindahan "*ketak"* (Setiawan, Tanudjaja, & Banindro, 2014).

Diskusi

Terdapat 21 situs geologi dalam kawasan Geopark Rinjani Lombok yang berada di luar kawasan konservasi biologi dan umumnya merupakan situs geologi yang kurang spektakuler. Hal ini menjadi tantangan bagi pengelola Geopark Rinjani Lombok untuk meningkatkan daya tarik situs geologi tersebut agar sesuai dengan kriteria dan tujuan dari Geopark.

Kesimpulan

Pulau Lombok mempuyai warisan geologi gunung api yang dapat dimanfaatkan secara berkelanjutan melalui kegiatan geowisata. Pengelolaan sumberdaya geologi tersebut dilakukan secara komprehensif dengan konsep Geopark. Sejak tanggal 7 Oktober 2013, Geopark Rinjani-Lombok resmi menjadi anggota jaringan Geopark Nasional Indonesia.
Unsur geologi, biologi dan budaya mempunyai hubungan yang saling berkaitan dalam menciptakan nilai ekonomi dan pengembangan ekonomi masyarakat lokal di Pulau Lombok. Unsur geologi tidak hanya berperan sebagai daya tarik wisata tetapi juga mempunyai pengaruh terhadap keragaman dan keberadaan unsur biologi yang khas. Ketersediaan unsur biologi yang khas dan melimpah merupakan sumber bahan baku untuk menghasilkan produk budaya yang berbeda dengan daerah lain.

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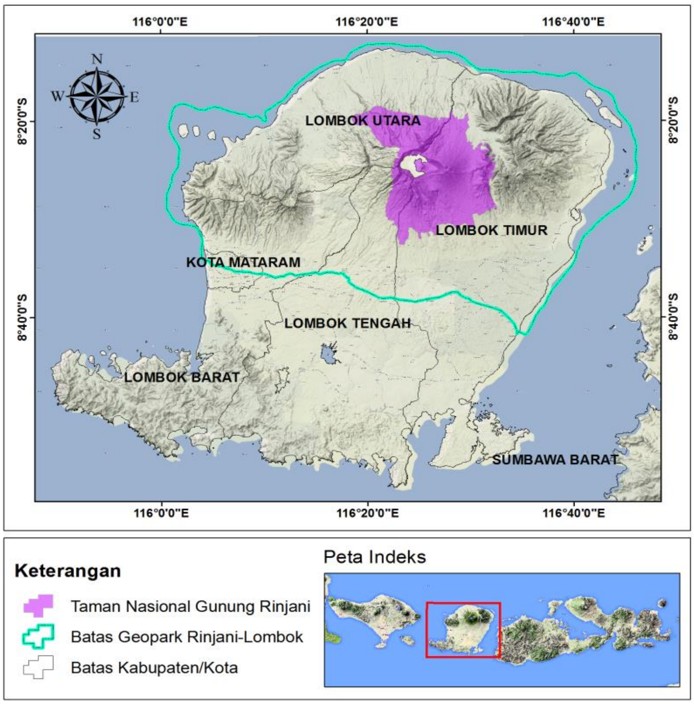


Gambar 1. Peta Deliniasi Geopark Rinjani Lombok

Sumber Foto : TNGR
Gambar 2. Musang Rinjani

Masjid Beleq Bayan

Masjid Lokaq Sesait

Pura Suranadi

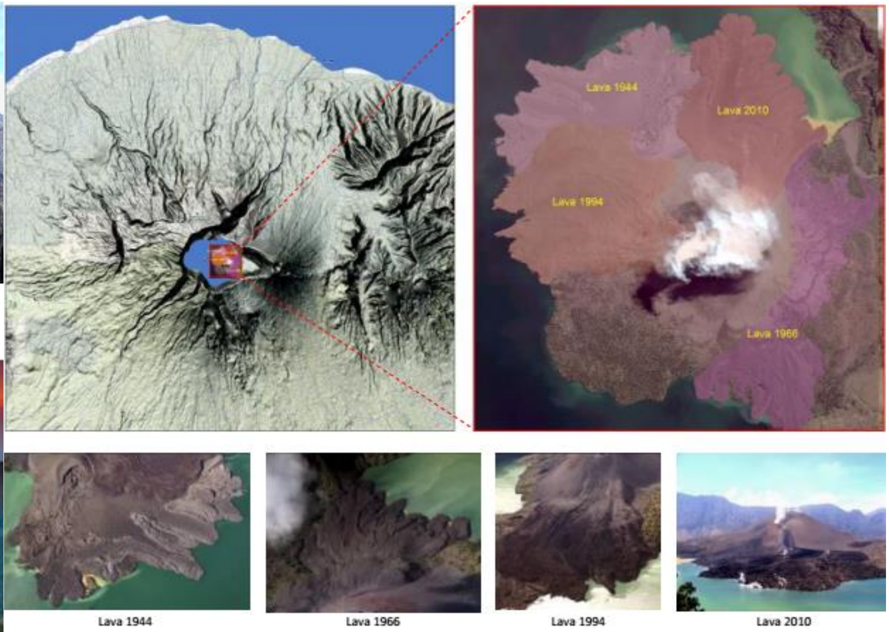
Pura Meru

Pura Lingsar

Pura Batu Bolong

Gambar 3. Masjid Kuno dan Pura dalam Kawasan Geopark Rinjani Lombok
(*Sumber Foto: Dokumen Usulan Geopark Rinjani-Lombok)*

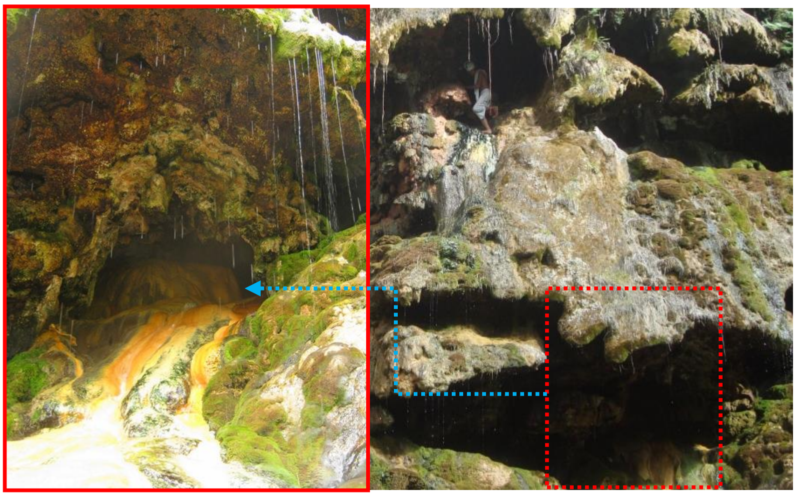
Dinding Kaldera G. Rinjani



Aliran Lava Kompleks Gunungapi Rinjani

Kaldera Danau Segara Anak

Air Terjun Senanggile



Gua Susu

Air Terjung Kertagangga

Danau Gili Meno

Air Terjun Benang Kelambu

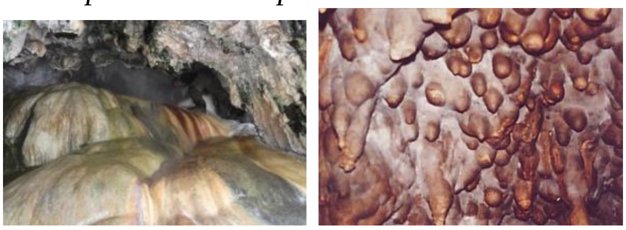
Batu Candi dan Batu Bolong Pantai Nipah

Gambar 4. Obyek Geowisata Bentang Alam Kawasan Geopark Rinjani
(*Sumber Foto: Dokumen Usulan Geopark Rinjani-Lombok)*

Mata air panas Aik kalak

Kompleks mata air panas disekitar Gua Susu

Ornamen batuan Gua Payung



Ornamen batuan Gua Susu

Lava dengan struktur aliran

Lava dengan struktur vesikuler

Pantai Korleko dan Sisa batang kayu yang terarangkan

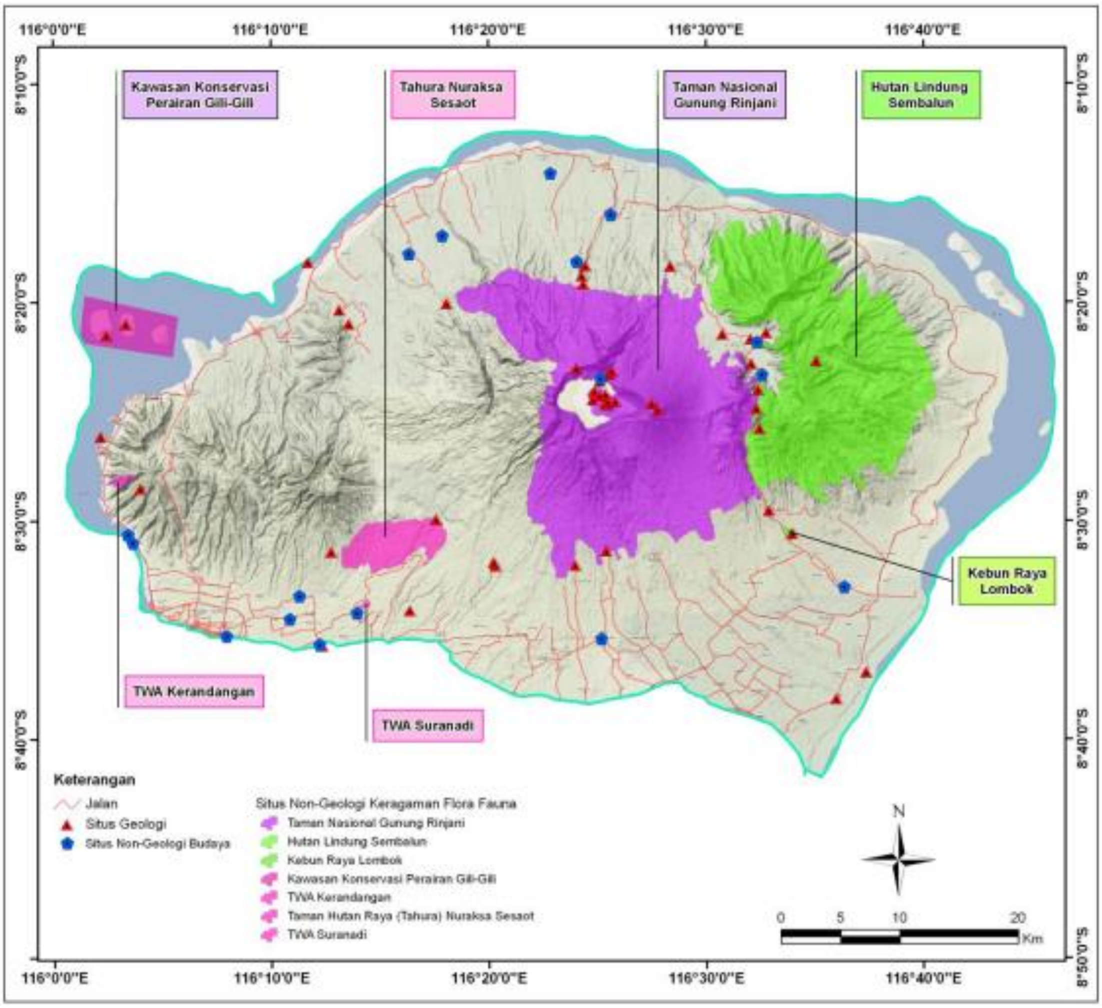
Lava bantal dan dike Pantai Nipah

Rekahan berlembar Pantai Batu Layar

Lava bantal Gili Trawangan

Mata air bawah laut Pantai Krakas

Gambar 5. Obyek Geowisata Keunikan Batuan Kawasan Geopark Rinjani
(Sumber Foto: Dokumen Usulan Geopark Rinjani-Lombok)



Gambar 6. Peta Sebaran Situs Geologi dalam Kawasan Geopark Rinjani Lombok
(Sumber Foto: Dokumen Usulan Geopark Rinjani-Lombok)

Gambar 7. Makanan Khas Masyarakat Pulau Lombok

Gambar 8. Kerajinan Ketak

Sumber foto : Yuniari Setiawan, 2014

Tabel 1. Daftar situs geologi dalam kawasan Geopark Rinjani-Lombok

No	Nama Situs Geologi	BT	LS	Makna Situs/Keterangan
1	Pantai Vulkanik Batulayar	116.0567	-8.5102	Geomorfologi Pantai Vulkanik, bermakna estetika, budaya dan pendukung pariwisata
2	Pantai Vulkanik Nipah	116.0357	-8.4358	Geomorfologi Pantai Vulkanik, bermakna estetika dan pendukung pariwisata
3	Danau Gili Meno	116.0531	-8.3479	Geomorfologi dan struktur bermakna ilmu pengetahuan, estetika dan pendukung pariwisata
4	Lava Bantal Gili Trawangan	116.032	-8.3593	Batuan, bermakna ilmu pengetahuan, estetika, sejarah dan pendukung pariwisata
5	Pantai Vulkanik Papak/krakas	116.1947	-8.3031	Geomorfologi dan struktur geologi bermakna ilmu pengetahuan
6	Air Terjun Semporonan (Sengigi)	116.0662	-8.4753	Struktur geologi bermakna estetika dan pendukung pariwisata
7	Charcoal Punikan	116.2067	-8.5576	Fosil Kayu bermakna Ilmu Pengetahuan
8	Air terjun Tiu Pupus	116.2186	-8.3395	Struktur Geologi bermakna estetika dan pendukung pariwisata.
9	Air terjun Kerta Gangga	116.2258	-8.3503	Struktur Geologi bermakna estetika dan pendukung pariwisata.
10	Air Terjun Tiu Teja	116.3008	-8.3344	Struktur Geologi bermakna estetika dan pendukung pariwisata.
11	Air terjun Sindanggile	116.4071	-8.3058	Struktur Geologi bermakna estetika dan pendukung pariwisata.
12	Air terjun Tiu Kelep	116.4046	-8.3135	Struktur Geologi bermakna estetika dan pendukung pariwisata.
13	Air Terjun Batara Lenjang	116.4057	-8.3199	Struktur Geologi bermakna estetika dan pendukung pariwisata.
14	Air Terjun Mayung Putih	116.4724	-8.3062	Struktur Geologi bermakna estetika dan pendukung pariwisata.
15	Dinding Kaldera Gunungapi Rinjani	116.4002	-8.3841	Geomorfologi bermakna Ilmu pengetahuan, Estetika, dan pendukung pariwisata
16	Danau Segara Anak	116.4183	-8.3938	Geomorfologi bermakna Ilmu pengetahuan, Estetika, budaya dan pendukung pariwisata
17	Kerucut G. Rombongan	116.4179	-8.4052	Geomorfologi bermakna Ilmu pengetahuan, Estetika, dan pendukung pariwisata

18	Kerucut G. Barujari	116.4239	-8.4118	Geomorfologi bermakna Ilmu pengetahuan, Estetika, dan pendukung pariwisata
19	Kawah 1 G. Barujari	116.4223	-8.4114	Geomorfologi bermakna Ilmu pengetahuan, Estetika, dan pendukung pariwisata
20	Kawah Samping G. Barujari (kawah 2004)	116.4239	-8.4098	Geomorfologi bermakna Ilmu pengetahuan, Estetika, dan pendukung pariwisata
21	Lava 1944	116.4142	-8.4014	Geomorfologi bermakna Ilmu pengetahuan, Estetika, dan pendukung pariwisata
22	Lava 1966	116.4298	-8.4095	Geomorfologi bermakna Ilmu pengetahuan, Estetika, dan pendukung pariwisata
23	Lava 1994	116.4129	-8.4081	Geomorfologi bermakna Ilmu pengetahuan, Estetika, dan pendukung pariwisata
24	Lava 2009	116.4225	-8.4039	Geomorfologi bermakna Ilmu pengetahuan, Estetika, dan pendukung pariwisata
25	Kerucut Gunungapi Rinjani	116.4579	-8.4112	Geomorfologi bermakna Ilmu pengetahuan, Estetika, budaya dan pendukung pariwisata
26	Kawah Rinjani (Segara Muncar)	116.4624	-8.4159	Geomorfologi bermakna Ilmu pengetahuan, Estetika, dan pendukung pariwisata
27	Aik Kalaq	116.4198	-8.3906	Struktur geologi bermakna Ilmu pengetahuan, Estetika, dan pendukung pariwisata
28	Gua Susu	116.425	-8.3886	Geomorfologi bermakna Ilmu pengetahuan, Estetika, budaya dan pendukung pariwisata
29	Gua Payung	116.4276	-8.3862	Geomorfologi bermakna Ilmu pengetahuan, Estetika, budaya dan pendukung pariwisata
30	Breksiasi S. Grengengan (Geoevidence)	116.5478	-8.4927	Struktur Geologi bermakna ilmu pengetahuan dan estetika
31	Mata air panas Sebau (Geoevidence)	116.5409	-8.4301	Struktur Geologi bermakna ilmu pengetahuan dan pendukung pariwisata
32	Kaldera Gunungapi Purba Sembalun (View Point Pusuk)	116.5382	-8.4149	Geomorfologi bermakna ilmu pengetahuan, estetika dan pendukung pariwisata

33	Dinding Kaldera Sembalun (Gawir Sesar View Point Jalan menuju Pusuk)	116.5396	-8.4005	Struktur Geologi bermakna ilmu pengetahuan dan estetika
34	Dinding Kaldera Sembalun	116.5345	-8.3807	Geomorfologi bermakna ilmu pengetahuan, estetika dan pendukung pariwisata
35	Lava dengan Struktur Aliran	116.5339	-8.3618	Batuan bermakna ilmu pengetahuan dan estetika
36	Lava Lentih	116.5123	-8.3583	Batuan bermakna ilmu pengetahuan
37	Alterasi (ubahan Andesit) (Geoevidence)	116.5457	-8.3569	Batuan bermakna ilmu pengetahuan
38	Mata air panas/Aik Kalak Sembalun (Geoevidence)	116.5841	-8.3785	Struktur Geologi bermakna ilmu pengetahuan
39	Mata Air Narmada	116.2053	-8.5955	Struktur Geologi bermakna budaya, sejarah dan pendukung pariwisata
40	Air Terjun Prabe	116.2123	-8.5239	Struktur Geologi bermakna estetika dan pendukung pariwisata
41	Air Terjun Segenter	116.2926	-8.4993	Struktur Geologi bermakna estetika dan pendukung pariwisata
42	Lembah Cerorong	116.2723	-8.5688	Geomorfologi dan struktur geologi bermakna ilmu pengetahuan
43	Charcoal Batu Kliang	116.3001	-8.5894	Fosil Kayu bermakna Ilmu Pengetahuan
44	Air Terjun Benang Stokel	116.3381	-8.5344	Struktur Geologi bermakna estetika dan pendukung pariwisata
45	Air Terjun Benang Kelambu	116.3367	-8.5322	Struktur Geologi bermakna estetika dan pendukung pariwisata
46	Air terjun Otak Kokok Gading	116.3993	-8.5344	Struktur Geologi bermakna estetika, budaya dan pendukung pariwisata
47	Air terjun Jerukmanis	116.4229	-8.5235	Struktur Geologi bermakna estetika dan pendukung pariwisata
48	Mata Air Lemor	116.5658	-8.5102	Struktur Geologi bermakna budaya dan pendukung pariwisata
49	Bekas Tambang Lembah Hijau	116.5994	-8.6363	Geomorfologi bermakna sejarah dan pendukung pariwisata
50	Ignimbrit Korleko	116.6223	-8.6159	Struktur Geologi bermakna ilmu pengetahuan dan estetika

THE NEW ENERGY AND RENEWEBLE ENERGY IN NGENTAK-KUWARU, SRANDAKAN REGENCY OF BANTUL AS INTERESTING PLACE OF TOURISM

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ABSTRACT

This research are located at Ngentak, Kuwaru, Srandakan, Regency of Bantul. They have two kind of energy resources which is new energy like a wind energy and renewable energy like waste of cows. The new renewable energy in this area had transferred like as Liquid Natural Gas (LPG). Besides, this biogas is used at most of restaurant at Pantai Baru Kuwaru, Bantul. This purpose are to make Ngentak, Kuwaru as destination for energy tourism as geosite to support geology tourism at province D.I. Yogyakarta.

Key words : Ngentak-kuwaru, wind energy, Geosite, geology tourism,

THE PROPOSED KUDAT-BENGKOKA PENINSULA GEOPARK: A POTENTIAL GEOPARK AT NORTHERN SABAH, MALAYSIA

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ABSTRACT
Study carried out at mainland Northern Sabah, Malaysia has identified geoheritage resources such as geological structures, ancient oceanic crust, oil seepages, former mines, extensive shore platforms and several other spectacular geomorphological features. These geoheritage resources are significant as they contribute to the better scientific understanding of the geomorphological, geological and tectonic history of the area and the region in general. Besides, several of them have high aesthetic, recreational and cultural values. Several of the geoheritage resources have high geotourism potential and are proposed for geotourism development. These resources are under threats of destruction due to the absence of legal protection and lack of awareness of their geoheritage values. A holistic conservation approach which integrates the living and non-living things through the establishment of a geopark at Northern Sabah, named as the Kudat-Bengkoka Peninsula Geopark is therefore highly proposed. The creation of a geopark at Northern Sabah will not only provide economic benefit to the local community but will also ensure protection and sustainable development of the natural and cultural resources that are found in the area. This paper highlights the geoheritage resources input essential for the creation of a geopark at Northern Sabah. The other inputs such as the biodiversity, socio-economic, cultural and historical aspects, and legislation and management plan need to be pursued further.

Key words: Geopark, geoheritage, geoconservation, geotourism, Kudat-Bengkoka Peninsula

KAJIAN POTENSI GEOWISATA G. LEMONGAN, KABUPATEN LUMAJANG, JAWA TIMUR

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ABSTRACT
G. Lemongan (8.00^{o}S, 113.34^{o}E) was active in 1799-1899, situated in the district of Lumajang and Probolinggo a strato volcanoes. This volcano has a prehistoric eruption center and the center of a new eruption. Prehistoric eruption centers namely G. Tarub (1,651 m) and G. Tjupu. G. Lemongan as new central eruption is located 650 meters to the southwest of the highest peak, G.Tarub. G. Lemongan region has a natural attractions, education and conservation. In addition to the peaks, it has 29 maar volcanoes and cinder cones 61 exciting to be developed as a tourist attraction. Maar has a center line between the 150 and 700 meters. Some have a maar lake, among Ranu Pakis, Ranu Ranu Klakah and Bedali. Object identification, management and effective supervision needs to be done to develop this area. This paper will inform the general character of the tourism potential and the general direction of the management and supervision. Community-based geotourism management is an good choice.

Key words: G. Lemongan, Geotourism, Geopark.

KAJIAN GEOLOGI AIR TERJUN CURUG CILONTAR SEBAGAI OBJEK WISATA GEOLOGI DI DESA KRACAK, LEUWILIANG, BOGOR, JAWA BARAT

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Abstrak

Saat ini pembangunan suatu wilayah semakin berkembang pesat.Tidak hanya dalam segi peningkatan kawasan pemukiman dan fasilitas penduduk, pembangunan juga semakin meningkat dalam sektor pariwisata. Perkembangan sektor pariwisata dapat memberikan dampak positif dalam meningkatkan perekonomian suatu wilayah. Air Terjun Curug Cilontar mempunyai potensi yang dapat dikembangkan menjadi objek wisata alternatif yang berlokasi di Desa Kracak, Leuwiliang, Bogor, Jawa Barat. Curug Cilontar merupakan bagian dari tubuh sungai Cianten yang berhulu di Gunung Halimun Salak.Air terjun ini memiliki ketinggian sekitar 35 meter dengan keindahan berupa kolam yang luas dengan air berwarna hijau. Air terjun yang tergolong masih tersembunyi ini berada di dekat pekarangan rumah warga. Akses menuju lokasi air terjun berupa jalan setapak yang belum mendukung dengan fasilitas umum yang masih minim. Dari sisi geologi, Curug Cilontar merupakan air terjun yang unik. Batuan yang dijumpai di sekitar lokasi Curug Cilontar berupa perlapisan batupasir dengan fragmen bongkahan batuan beku, batulempung, dan batuan beku basalt dengan fragmen obsidian berwarna hitam. Pada air terjun ini terdapat struktur berupa *Columnar Joint* yang menambah keindahan Curug Cilontar. Di bagian atas struktur tersebut berkembang struktur *Sheeting Joint* yang berasal dari aliran lava.Gambaran kondisi geologi yang dijumpai di Curug Cilontar dapat menjadi bukti serta ciri dari aktivitas vulkanik Gunung Halimun Salak pada kala Holosen. Keunikan geologi Curug Cilontar ini diharapkan dapat dikembangkan sebagai salah satu situs geologi (*Geosite*) di Kabupaten Bogor yang harus dilestarikan.Selain dapat meningkatkan perekonomian dari sektor pariwisata Kabupaten Bogor, keunikan yang terdapat di Curug Cilontar diharapkan dapat menjadi sarana wisata edukasi alam, khususnya di bidang geologi.

Kata Kunci: Curug Cilontar, Wisata, Edukasi, Geologi, *Columnar Joint*, *Sheeting Joint*

GEODIVERSITY OF LANDSCAPE PAPUMA BEACH, JEMBER, EAST JAVA

Sugeng

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ABSTRACT

Geodiversity forms the landscape in the region Papuma Beach (Jember) has a diverse landscape forms. The landscape of unique Papuma Beach area designed to set as geoheritage region. Determination of which will be accompanied by the sale is expected to be improve the quality of the community's economy around Papuma Beach. Aim this study is the inventory geotapak-geotapak (geosites) which potentially and useful in the field of science and tourism which will then be projected to be geopark. The method used in achieving this goal is to do geological mapping and morphological landscape Papuma beach neighborhood, conduct geological analysis related to the genesis of a unique landscape. Papuma beach region consists of two lithologies that Sukamade and Puger Formations. Forms of poles that are found in coastal areas this part of Sukamade Formation consisting calcareous sandstones , breccias, and limestones tuffaceous, form a perforated texture on a calcareous sandstones as a result of the dissolution process . Shape unique landscape on the Papuma beach include landscapes shaped like a pole and frog annimals.

INTRODUCTION

Beach Papuma located south of the city of Jember, East Java, distance from the town of Jember 45 km can be reached by vehicle for 1 hour, administratively beach Papuma located in the village Lojejer, Wuluhan Districs, Jember, the position coordinates of 8^0 25 '48 "and 113^0 33 '13 ". (Figure 1.)

Indonesia is known as a country with beautiful landscapes. But this time Natural Resource quality declines as utilization is not well structured.

Therefore, there should be a structured preservation and the need for a breakthrough to develop the Natural Resources.

Geopark is a nationally protected area, has several sites geoheritage important, rare, and have aesthetic value (Leman et al, 2006). Papuma beach is one of the beaches located in Jember, East Java Province potential as geoheritage region, even potentially to be projected as a geopark.

Visually, the landscape morphology Papuma Coast region is one of the best in the island of Java . The process of formation (geological) need to be studied as an important information for travel enthusiasts.

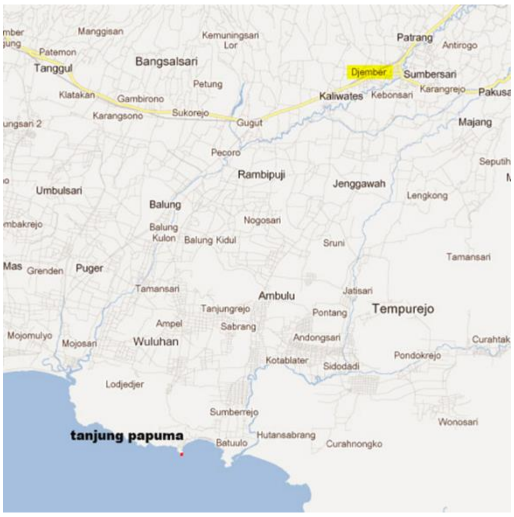

Figure 1. Position Papuma coast of the town of Jember

1. Geology

Regional tectonic framework carefully situations and Java in general is very closely related to the period of the end (Post-) volcanic Oligocene-Miocene,it known as OAF (Old Andesite Formation) by experts of geoscience. It is characterized by carbonate rocks srdimentary in the marine environment, it is found in many places on the island of Java, one of them around the area of the research sites.Stratigraphy in the study area include (Figure 2).

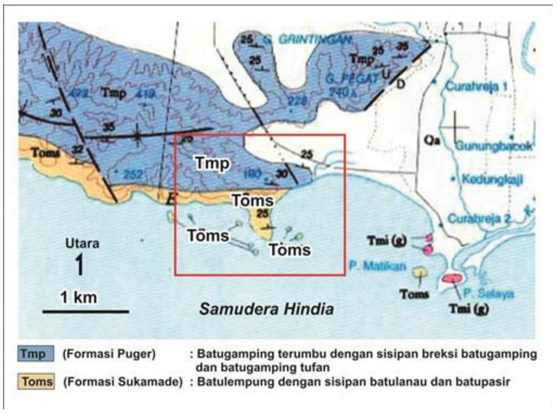

Figure 2. Geological map of Papuma beach

2.1. Sukamade Formation

Sukamade Formation have composed sandstones an insert of siltstone and mudstone. These rock units are generally greenish gray, very hard and quilted bedding well. Thickness average of 30 cm. sedimentary structures that are found are aligned laminate, cross bedding laminate , konvolut laminate , greded bedding and some fine massif. Clastic rocks contain many fossils, including Globorotalia periperhoda, Globorotalia mayeri, Globorotalia peripheroacuta which shows age the bottom middle Miocene (N10-N12) .Formasi is deposited on the marine environment of the slope to the seabed and interfingering with volcanic rocks Merubetiri formations . The basic of interfingering the age of Sukamade Formation allegedly late Oligocene - early middle Miocene. It is spreading around the mountain Jagatamu and Alit in the southeast corner of the map sheet, the thickness of approximately 400 m, the best outcrops are along the Sukamade river.

2.2. Igneous rocks

Igneous rocks contained in Jember and surrounding areas in the form of granodiorite, diorite and dacite the Middle Miocene age.

2.3. Puger Formation

Puger formation consists of a reef limestones insert breccia limestones and tuffaceuos limestones. Reef Limestones color white and pink, composed of limestone, gravel calcareous and coral. Breccia limestones and tuffaceous limestones calor gray, solid, well-bedded with an average l thickness layer of 40 cm. Distribution located at the southern coast of the part southwestern on the map sheet Jember and continuous Lumajang , some places contain manganese are deposited on the limestone unit, location Type at Puger districts. This formation is thought to Miocene middle to late Miocene (Van Bemmelen, 1949) thickness more than 400 meters , relationship Sukamade Formations with Puger Formations unconformity.

2.4 Structural geology

Geological structures developed in beaches Papuma are folds and faults, folds syncline axis is located Puger Formation in the direction of East – West. Longitudional faults generally have a direction Northwest - Southeast, normal faults have towards the Northeast - Southwest .

3. Beach Papuma

3.1. Morphology Beach Papuma

This beach is located area of forestry is a beautiful beach in the form cape (Figure 3). the access road to the beach is very good, very beautiful scenery left - right of way either morphology composed by alluvial plains and very steep cliffs composed by breccias and limestones. Beach Papuma can be classified based on its constituent materials, namely: the rock beach (rocky shore) ie beaches composed by host rock hard of calcareous sandstones and beaches composed by loose material in the white sand.

Figure 3. The access road to Papuma beach.

Based on the morphology Papuma beach it can be divided into: beach cliffs (cliffed coast), That the beach has a vertical cliff. This suggests that the existence of a cliff in a coastal erosional conditions, cliffs that form may be climbing on the bed rock breccias

3.2. Geology of Papuma Beach

Distribution of rock contained Papuma beach consists of turns calcareous sandstones with silt, sandstone, breccia, and coastal sediment. Stratigraphy can be seen clearly on the steep coast from the bottom to the top is turns calcareous sandstone with silt, sandstone and breccia. Position bedding in general N 350^0 E / 10^0.

Calcareous sandstones color whitish gray , the size of grains of medium - coarse sand, sedimentary structures parallel bedding, the mineral composition of the material

consists of rocks and carbonate minerals, the thickness of these rocks are exposed on the coastal line of 1.5 m.
Gray sandstone, grain size medium - coarse, mineral composition composed of rocky material, sedimentary structures graded bedding and parallel bedding , the sandston thickness is 1.6 meters.
Breccia is color gray , grain size gravel, andesite fragments, matrix of sand, silica cement, the thickness of 2m.
The rocks above anyone encountered alteration propilit with many found veins of quartz an average thickness of 1 cm , the general direction of vein N 110^0 E / 30^0.
The structure that develops on the beach Papuma generally direction plane fault longitudional N 330^0 E / 60^0 and N 20^0 E / 70^0, this fault are each intersection which causes the formation of the landscape that exists today.(Figure 4).

Figure 4. Direction of fault plane N330^0/60^0

3.3. Geoheritage Landscape
Based on the preparation of technical specifications geopark (May Wu, 2013), Papuma beach area is divided into three main categories, 5 (five) category 5, 5 (five) subkatagori (Table 1).

Landscape shaped Column
The landscape is composed by lithology consists of a thick calcareous sandstones with a 2.5 meter (Figure 5), above pebbly sandstones with thickness of 4.5 meters, the top composed by breccias with a thickness of 3.5 meters, at the bottom of the east side has suffered abrasion and dissolution.
This isolated landscapes due to faults trending N 200 E, lithology consists of calcareous sandstones which further due to abrasion by the sea water is formed landscape pole.

Figure 5. Landscape shape column.

Landscape like frog animals

The landscape resembles a frog animal composed lithology sandstones with a thickness of 25 cm - 1.2 m (Figure 6) the structure of sedimentary graded bedding, parallel bedding, and convolute lamination notch bedding N 340^0 E / 20^0, the landscape was formed due to a fault with directions N 330^0 E, where the breccia above the sandstones have experienced landslides due to abrasion by the activity of sea water.

Figure 6. Landscape like frog animals

The landscape of stone with a hole

The landscape has a rock formation perforated and rock fractures, lithology making up the landscape calcareous sandstones alternating with silt, thick calcareous sandstones 20 cm - 50 c, silt 10 cm, the position of the layer N 350^0E / 10^0 (Figure 7), the age of rocks based on foram plangton N 10 - N12 (lower Miocene), the landscape as a result of the dissolution process to form a hollow stone, stone broken due to abrasion of sea water due process of sandstone with hole. The boundary between the rocky coast with sandy beaches such as fault longitudional directions N 3300E (Figure 8).

Figure 7. The landscape of stone with hole

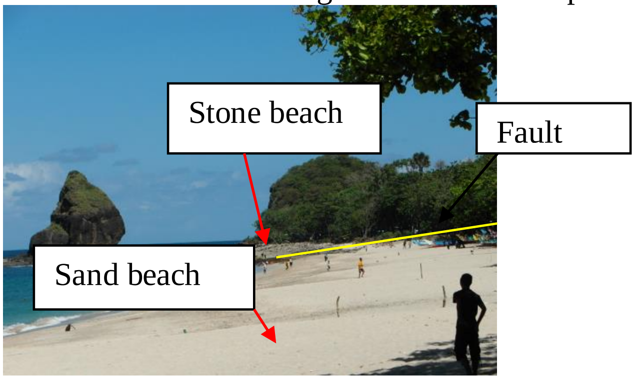

Figure 8. boundary beaches stone with sand

Ecology at the Papuma beach

The existence of some animals accustomed to human activity adds to the atmosphere of the Papuma beach very charming and beautiful, because visitor Papuma beach can see and close the animals that have been benign among other lizards and monkeys (Figure 9).

Figure 9 . Lizard animals on Papuma beach

Tabel 1. classification type geoheritage Papuma region

CONCLUSION

Papuma beach with various forms of geoheritage landscapes as great for tourism, research, and education. Besides the beach is famous the beauty for the beach and the mountains, and excellent ecological conditions that contribute to the high aesthetic taste and behavior of the existing fauna. Therefore it can be built into a science park integrating functions such as scientific research, roads, recreation ecology, and cultural arts activities that entertain by see direct forms of landscape diversity.

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Maincatego	**Category**	**Subcatagory**	**Remarks**
Geologic	Stratigraphic	Stratigraphic	Sukamade Formation , Puger
	Sedimentary	Fasies	Sediment beach
Geologic	Structural	Little structural	Fault longitudional of
Landscape	Landscape	Landscape	Cliff
	structural		
	Landscape	Landscape	Rock and sand beach
	beach	And dissolution	

FOSSIL HERITAGE OF THE SINGA FORMATION, LANGKAWI GEOPARK, MALAYSIA

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ABSTRACT

Fossil can be describe as the remains of prehistoric organisms that are preserved in sedimentary rock layers. Fossil can be classified into two types, namely body fossils and trace fossils. Body fossils are the remains of the actual organism that include moulds and casts, whereas trace fossils include any impression or other preserved sign of organism activity. Singa Formation consists of a sequence of clastic rocks of Carboniferous-Permian age, which exposed in central to southwestern part of Langkawi Archipelago. This formation is unique and important to the geological history of Malaysia with the presence of pebbly mudstone, which was considered as marine glacial diamictite or dropstone (Stauffer and Mantajit, 1981; Stauffer and Lee, 1986). Body fossils in Singa Formation only exposed in upper part of the formation (Selang Member) and can be divide into two brachiopod assemblage zones, namely *Arctitreta-Bandoproductus* assemblage (Asselian – Early Sakmarian) and *Spinomartinia prolifica* assemblage (Late Sakmarian) (Mohd Shafeea Leman 2003). The existence of body fossils in Singa Formations have been recorded in 9 localities around Langkawi Archipelago, which is in Pulau Singa Besar, Pulau Lalang, Bukit Tekoh, Kelibang, Batu Asah, Taman Helang Perdana, Kampung Kisap, Kilim and Sungai Itau. The existence of trace fossils including bioturbation structure can be found in nearly all parts of Singa Formation sequence, but the best localities to see it were in Pulau Intan Kecil, Tanjung Mali and Tanjung Mat Sah. Fossils in Singa Formation have high heritage value in terms of scientific and aecstatic values. These fossil localities are an important geological heritage sites for scientific research and education, and can also be used as a site for tourism. Some of these important geoheritage sites must be preserved and conserved as a national heritage, and must be sustainably developed for geotourism.

GEOLOGY AND GEOHERITAGE OF MUARA WAHAU COAL FIELD, EAST KALIMANTAN, INDONESIA "CONCERN OF: GEOLOGY, MICROSCOPY, ORGANIC GEOCHEMISTRY AND COALBED METHANE POTENTIAL

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ABSTRACT

Indonesia coal have the coal-forming material (plants) as well as the parameters that are relatively the same deposition conditions (tropical) although it is located in the sprawling region Indonesia with diverse geological conditions, hence Indonesia is one of the significant coal producer in the world. Research site located in Muara Wahau, East Kalimantan, including the Upper Kutai Basin. Coal bearing formation in the area of Muara Wahau is Wahau Formation Late Oligocene - Early Miocene age. Laboratory analyses was conducted using method coal microscopy observations to determine vitrinite reflectance random (Rr) and maceral composition as well as method of Gas Chromatography-Mass Spectrometry (GC-MS) to determine facies, organic compound (biomarker), maturity and precursor of plant MuaraWahau coal. Maceral composition of the Muara Wahau coal is dominated by vitrinite maceral group, ranging from 76% to 82.4.0%. Liptinite maceral group accounts 0.4% – 1.8 %. The composition of inertinite maceral group ranges from 8% to 18.8%. Huminite reflectance of coal samples from Muara Wahau range from 0.44 to 0.45 Rr (%), according to huminite reflectance, all studied samples are low rank sub-bituminous coals. Maceral composition to detect coalbed methane potential. The presence of 2-series long chain *n*-alkane indicates the changes of peat forming facies condition from oxic condition (increasing odd carbon proportion) and anoxic condition (increasing even carbon proportion) Geological Outcrop along the Telen River and Wahau River, is the type locality of Wahau Formations, should become a geology conservation area in Muara Wahau as Geoheritage and it is very interesting to study geology.

Key words: geology, coal; tropical; facies; high plants; long chains; oxic; anoxic; methane

INTRODUCTION

Muara Wahau is an area of Muara Wahau, East Kutai Regency, East Kalimantan province, including in the Upper Kutai Basin. Coal bearing formation in Muara Wahau is Wahau Formation, the age Late Oligocene - Early Miocene.

Regional geology of Muara Wahau is part of the Kutai Basin which economically is one of the sedimentary basins in Indonesia, most importantly, in addition to rich in oil and gas, the area is also rich in coal deposits.

Indonesia is one of the countries producing big enough coal in the world, some of the factors that affect it are the geological environment and climate.

Indonesia as a tropical country with two seasons (wet and dry), greatly contributed to the accumulation of peat formation, especially fluctuations in water level changes in the peat bog, as the primary control in the accumulation of peat (Dehmer et al., 1993). This causes the Indonesian coal generally has the characteristics of microscopic, organic geochemistry, and almost the same quality.

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This study will discuss Geology of Muara Wahau particularly Wahau Formations where the type locality is on the Telen River and the Wahau River, and both rivers are expected to conservation area as Geoheritage of Muara Wahau.

GEOLOGICAL SETTING

Administratively location area of research is in the area of Muara Wahau East Kutai Regency, East Kalimantan Province (Figure 1).

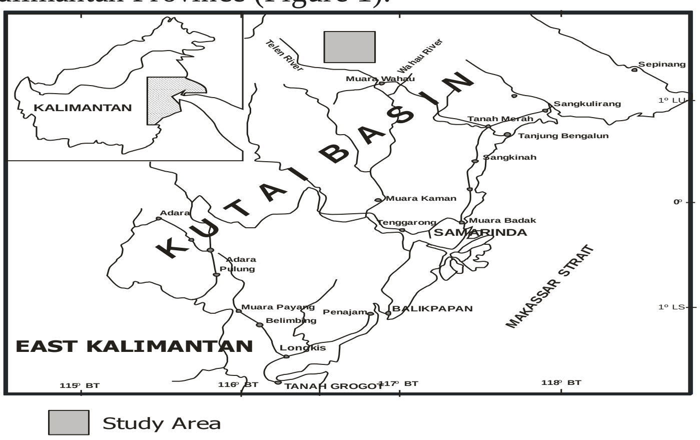

Figure 1. Location map of Muara Wahau coal field in Kutei Basin, East Kalimantan

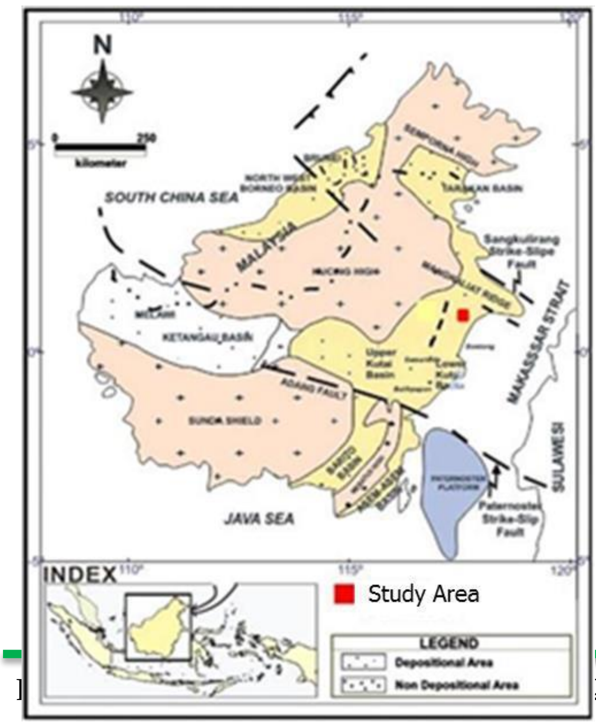

Figure 2. Kutai Basin of the elements of Regional Tectonics (Ott, 1987)

Regionally Muara Wahau is part of the Kutai Basin which economically is one of the sedimentary basins in Indonesia, most importantly, in addition to rich in oil and gas, the area is also rich in coal deposits. According to Ott (1987), the Kutai Basin is restricted by Tinggian Kuching in the west, the north ridge Mangkalihat, Adang Fault to the south and the Makassar Strait to the east (Figure 2). This basin is the largest and deepest of the Tertiary basins in Indonesia with more than 14 km thick fluvial sediments which are accumulated until batial (Allen and Chambers, 1998).

The age of Marah Formation is Late Eocene lithology composed by marl, mudstone, conglomerate and limestone. The age of Marah Formation Late Eocene sequence is an interbedded marl, mudstone, conglomerate and limestone exposed in Muarawahau Sheets and Muara Ancalong, East Kalimantan. The location is the type of formation Angry Angry River at Muara Wahau Sheet (Supriatna and Abidin, 1995). The thickness of this formation is approximately ranging between 400 to 800 meters. Marah Formation cropping in the Marah River is a series of sub-littoral sediment deposited on the foreland basin (Supriatna and Abidin, 1995). The content of the fossil of a layer of marl constituent Marah Formations show Late Eocene age.

Conformly on the top of Marah Formation was deposited Wahau Formation the age is Oligocene - Early Miocene, lithology consists of interbedded claystone, quartz sandstones, silty sandstones and sandy mudstone. Wahau Formation is divided into 2 (two), lower Wahau Formation consists of limestones rich in fossilized algae and corals, while the upper Wahau Formation containing inserts of tuff and lignite.

Unconformly on the top of Wahau Formation deposited Metulang volcanic rocks, the lithology consists of andesite, basalt, lava, lava breccia, tuff, agglomerate and lava breccia. Intrusion Sintang cross cut the Wahau Formation consists of andesite and diorite. Radiometric dating is based on K - Ar, Sintang Intrusion age is 16-21 million years old, Early Miocene (Soeria Atmadja et al., 1999).

Based on the stratigraphic framework and tectonics, the development of the basin coal in the Kutai Basin during the Tertiary related to continental margin, where the basin coal is found in parts of the continental crust that is on the edge of the continent (continental margin) and is passsive margin associated with the system rifting. The age of coal of Wahau Formation is Early Miocene deposition during the regression phase in conjunction with orogenesa process known as Syn-orogenic Regressive Phase Deposition. Deposition coal associated with deltaic floodplain environment of prograding delta during the Miocene. Coal layer tends to be thick, lateral distribution is relatively constant (Koesoemadinata, 2002). Muara Wahau regional stratigraphy based on the correlation of rock units Geological Map Sheet Muara Wahau (Supriatna and Abidin, 1995), ranging from old to young Tertiary shown in Figure 3.

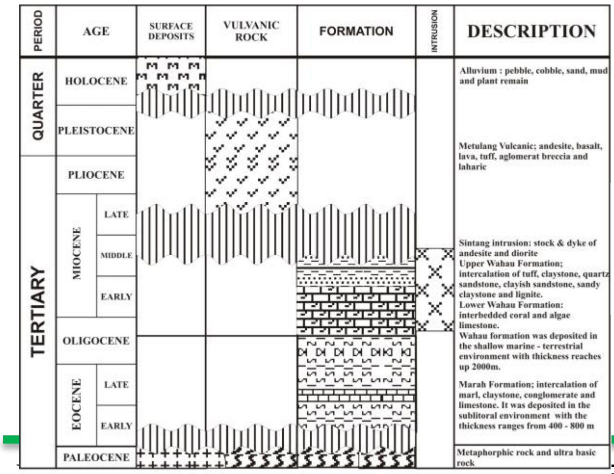

Figure 3. Regional Stratigrapic of Muara Wahau area (Supriatna and Abidin, 1995).

METHOD OF RESEARCH

Stages of the research started from the preparatory phase which includes planning work and literature study, research and collection of field data through geological survey and sample the rocks and the coal is taken directly core drilling, followed by laboratory analysis consists of the preparation and analysis of samples of coal which includes petrographic analysis of rocks and coal, organic geochemistry in the form of Gas Chromatography - Mass Spectrometry (GC - MS) and proximate analysis of coal.

RESULT AND DISCUSSION

GEOLOGY OF MUARA WAHAU

Generally, the condition of morphological research areas undulating low (5 ° - 10 °) almost all areas of research covered in oil palm plantations (Figure 4) so most of the outcrop and coal are already covered by the waste ground at the beginning of the opening of oil palm plantations formerly primary forest.

Figure 4. The Landscape of study area in Muara Wahau

Local Stratigraphy Wahau Formation in the study area consisted of interbedded black carbonaceous claystone, tuffaceous mudstone, fine sandstone, medium sandstone inserts of thick coal and andesite igneous intrusions (Figure 5).

Coal deposition associated with floodplain deltaic environment of the delta during the Miocene progradation. Inclined thick coal layers, spread laterally relative basis (Koesoemadinata, 2002). Wahau Formation lithology in the study area consists of black claystone containing carbonaceous, claystone tufaceous, fine sandstones, sandstones and interbedded thick coal.

The geological map of MuaraWahau area consist of one unit lithology is claystone unit (Figure 6). The pattern of distribution of the geological structure of coal (coal cropline) in the study area is trending north-west of syncline-southeast. Commonly position of the main seam of coal seam and the seam-1-2 is a northwest-southeast with a slope of the coal seam ranges from 8^{o} to 12^{o}. In general, the Muara Wahau coal thickness is in the range 8 to 66 meter (Figure 6).

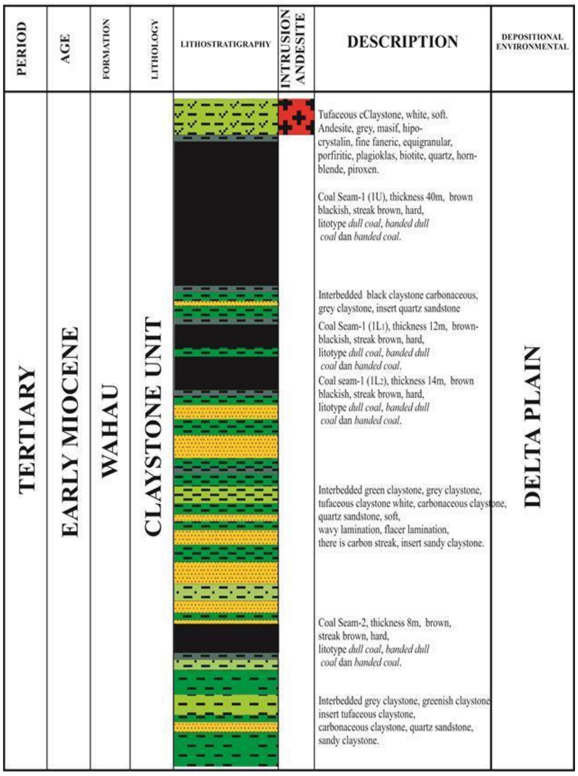

Figure 5. Stratigraphy of Wahau Formation in MuaraWahau area (source: PMB01-08 drill)

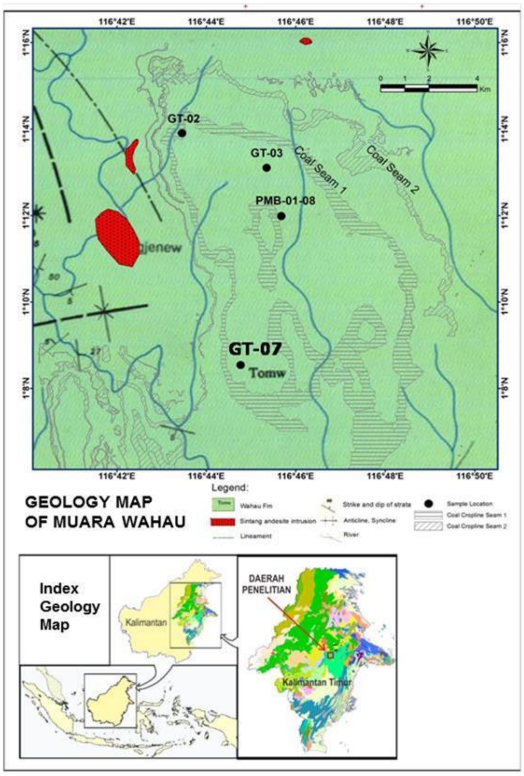

Figure 6. Geological Map of Muara Wahau area

The top of the coal seam seam-1 revealed distributed in Telen River. In general, the physical properties of coal Muara Wahau are: dark brown, hard, dull coal, banded coal and coal banded dull, dull gloss, streak brown color, containing resin. Igneous intrusions as part of the intrusion of andesite Sintang (Supriatna and Abidin, 1995) one of them exposed in Ben Hes residence is the northern part of the study area (Figure 7).

Figure 7. Geological Outcrop type locality Wahau Formation on Wahau River.

a. Coal Seam-1 outcrop
b. Claystone unit
c. Andesite Sintang Intrussion
d. Interbedded Sandstone and claystone

COAL MICROSCOPY (MACERAL) OF MUARA WAHAU

Maceral composition of the Muara Wahau coal is dominated by vitrinite maceral group, ranging from 76% to 82.4.0%. Liptinite maceral group accounts 0.4% - 1.8%. The composition of inertinite maceral group ranges from 8% to 18.8% (Table 1). Huminite reflectance f coal samples from Muara Wahau range from 0.44 to 0.45 Rr (%), According to huminite reflectance, all samples studied are low-rank sub-bituminous coals.

Microscopic analysis shows that the Muara Wahau coals are predominantly consist of vitrinite macerals (Figure 8), with minor liptinite and inertinite. Vitrinite maceral of the coals composed of telocollinite, desmocollinite, densinite, and corpocollinite. Liptinite maceral consist of cutinite, resinite, suberinite, and sporinite. Inertinite maceral is dominated by fusinite, semifusinite, and sclerotinite. Cutinite mainly presents as thin continuous bands in association with vitrinite maceral (Figure 9)

Sclerotinite shows rounded to oval forms and has high reflectance. This maceral is present in all coal samples (Figure 8)

Table 1. Result of Microscopy Analysis (Maceral) coal of Wahau Formation in Muara Wahau area

No. Sampel	Total Vitrinite (% vol)	Total Liptinite (% vol)	Total Inertinite (% vol)	Total Mineral Matter (% vol)	Reflektan Vitrinite (Rv) %
1	79.8	-	18.8	1.4	0.44
2	76.2	1.4	17	5.4	0.44
3	79.4	0.4	17.8	2.4	0.44
4	79.4	1	15.4	4.2	0.45
5	78.8	1.8	17.6	2	0.45
6	82.4	1	8	8.6	0.44
7	79.4	0.4	17.8	2.4	0.45
8	79	1	16.2	3.8	0.45
9	82.4	1	10.8	5.8	0.44
10	79.4	1	15	4.6	0.44
11	80	2	17	1	0.44
12	76	1.2	17.2	5.6	0.45

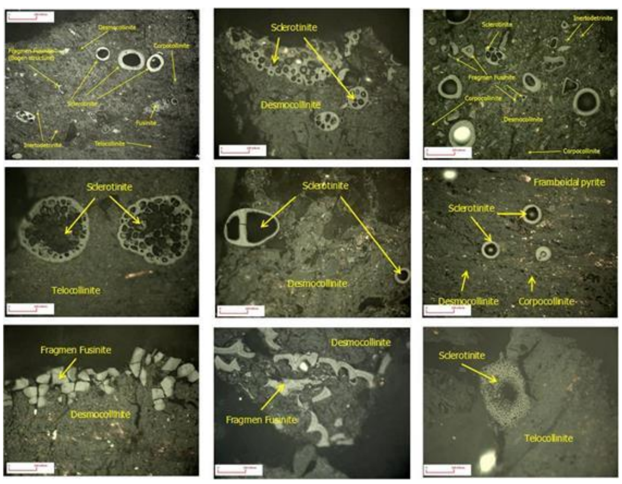

Figure 8. The appearance of microscopic maceral vitrinite and inertinite Muara Wahau coal using white light, a magnification of 200 times

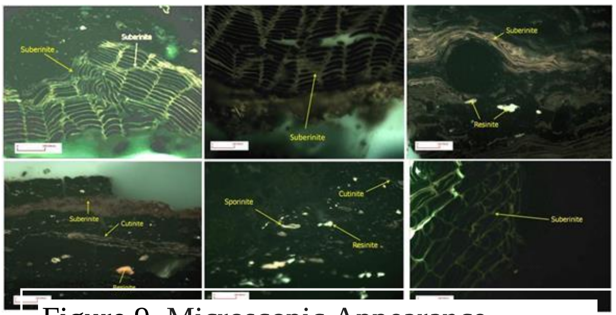

Figure 9. Microscopic Appearance maceral liptinite Wahau Muara coal, using blue light, magnification 200 times

ORGANIC GEOCHEMISTRY OF MUARA WAHAU COAL

Saturated fraction from Muara Wahau coal samples was detected forming long chain series *n*-alkane, the ranging of first series from *n*-C_{21} to *n*-C_{35}, with a high odd over even predominance peaking at *n*-C_{31}, this condition is very specific for higher plant. Additionally, second series long chain n-alkane ranging from *n*-C_{36} to *n*-C_{40} with even over odd predominance peaking at *n*-C_{38}.

High concentration of saturated non-hopanoid triterpenoid dominated saturated hydrocarbon Muara Wahau Coal such as: Olean-13(18)-ene; Olean-18-ene and Urs-12-ene, indicated much input from higher plant (*angiosperm*) which long chain *n*-alkane characteristics.

The presence of long chain *n*-alkane at Muara Wahau Coal are very exclusive especially carbon number *n*-C_{36} to *n*-C_{40}. The long chain in Indonesia was found only in the Kalimantan Coal, beside in Muara Wahau, it was also found in Palangkaraya peat, Central Kalimantan and in Embalut, East Kalimantan (Lower Kutai Basin) at coal of Balikpapan Formation.

The presence of 2-series long chain *n*-alkane indicates the changes of peat forming facies condition from oxic condition (increasing odd carbon proportion) and anoxic condition (increasing even carbon proportion) (Figure 10; Table 2)

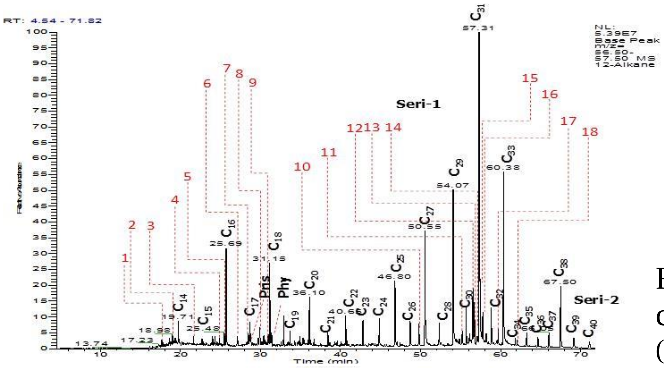

Figure 10. Distribution of long chain *n*- Alkane Muara Wahau coal (Basuki RAHMAD, et al., 2012)

Table 2. Result of identification substance number 1 s/d 18 *n*-alkane fraction Muara Wahau coal sample G2S1C12 (Basuki RAHMAD, et al., 2012)

PEAKS	RET.TIME	COMPOUND (G2S1C12-ALKANE-M/Z 57)	BASE PEAK	M.W.	CONCENT. µg/g TOC
1	17.63	DODECANE (Wiley)	57	170	2.71
2	18.98	TETRADECANE,2,6,10-TRIMETHYL (Wiley)	57	240	3.78
3	21.63	DOTRIACONTANE (Wiley)	57	450	3.42
4	25.38	8-ISOPROPYL-2,5-DIMETHYL-1,2,3,4-TETRAHYDRONAPHTHALENE (Wiley)	187	202	1.18
5	25.48	2-ICOSANETHIOL (Wiley)	57	314	3.42
6	27.08	TETRADECANE,2,610-TRIMETHYTL (Wiley)	57	240	4.89
7	28.48	N-TRICOSANE (Wiley)	57	282	9.64
8	29.87	DOCOSANE (Wiley)	57	310	10.08
9	30.39	TRICOSANE (Wiley)	57	324	3.8
10	49.78	23-NORLUPANE (Haven et al.,1989)	177	398	9.94
11	55.2	ERGOST-22-EN-3-OL, (3β,5α,22E,24R)-(Wiley)	55	400	5.47
12	56.55	OLEAN-13(18)-ENE (Philp, 1985; Dehmer, 1993; Anggayana, 1996; Amijaya, 2006; Widodo, 2008)	218	410	31.37
13	56.66	OLEAN-12-ENE (Philp, 1985; Dehmer, 1993; Anggayana, 1996; Amijaya, 2006; Widodo, 2008)	218	410	13.68
14	56.77	OLEAN-18-ENE (Philp, 1985;Dehmer, 1993; Anggayana, 1996; Amijaya, 2006; Widodo, 2008)	218	410	10.32
15	57.31	URS-12-ENE (Philp, 1985; Anggayana, 1996; Amijaya, 2006; Widodo, 2008)	218	410	32.1
16	57.42	NEOHOP-13(18)-ENE (Wiley)	191	410	4.16
17	58.21	22R-17α(H), 21β(H)-HOMOHOPANE (Philp, 1985; Dehmer, 1993; Anggayana, 1996; Amijaya, 2006; Widodo, 2008)	191	426	5.44
18	59.71	(22R)-17β(H)-HOMOHOPANE (Philp, 1985; Dehmer, 1993; Anggayana, 1996; Amijaya, 2006; Widodo, 2008)	205	426	2.26

COALBED METHANE POTENTIAL

Vitrinite content is relatively high in Muara Wahau coal included in kerogen type III as an identifier of humic organic matter derived from the woody tissue of higher plants (Angiosperm). Vitrinite maceral which is a cellulose-rich network on herbaceous plants forming methane (gas prone) high. The physical properties maceral groups, such as vitrinite has a specific gravity of 1.3 - 1.8 with a high oxygen content and volatile matter content of about 35.75%, it can produce methane (CH_4) or as gas prone.

In essence, the network of cellulose plants more easily hydrolyzed, such as disaccharides, starch, cellulose, hemicellulose, pentosanes, pectins and proteins are decomposed without any difficulty by bacteria and fungi, some produce methane (CH_4) and the solution (carbon dioxide, ammonia, methane/CH_4 and water), which will come out and left to produce a solid material (mainly humic substances), which participated in the formation of coal.

The average quality of coal Muara Wahau Formation: Calorivic Value 4087 kcal/kg (adb), sulfur 0:11% (adb); ash 3.41% (adb); inherent moisture 33.25% (adb); volatile matter 34.48% (adb); fixed carbon 28.86% (adb), Total Moisture 43.51% (Ar); 1:34 relative density. Random vitrinite reflectance from 0.44 to 0.45. Classification rank of coal: sub-bituminuous.

CONCLUSION

- Geological Outcrop along the Telen River and Wahau River, is the type locality of Wahau Formations, should be become a geology conservation area in Muara Wahau as Geoheritage and it is very interesting to study geology.
- Characteristics of Coal Wahau Formation very unique and interesting aspects of microscopic, organic geochemistry and potential for development coalbed methane.

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GEOHERITAGE GUNUNGAPI PURBA BATUR, YOGYAKARTA" : SEBUAH KAJIAN TERINTEGRASI UNTUK KONSERVASI WARISAN GEOLOGI DAN PENGEMBANGAN WISATA EDUKASI KEBUMIAN

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ABSTRAK

Indonesia merupakan negara kepulauan yang memiliki sumber daya alam yang sangat melimpah termasuk kekayaan keragaman geologi *(geodiversity)*. Keragaman geologi ini merupakan warisan geologi *(geoheritage)* yang tidak ternilai harganya mulai dari keragaman batuan, mineral, fosil, struktur dan termasuk bentang alam yang memiliki potensi wisata menjanjikan sehingga di beberapa wilayah layak untuk dikembangkan menjadi wisata edukasi kebumian maupun taman geologi *(geopark)*. Objek wisata Gunung Batur pada kawasan Geopark Gunungsewu merupakan salah satu objek wisata yang memiliki potensi untuk untuk dijadikan wisata edukasi kebumian, namun hingga saat ini masih kurangnya perhatian pemerintah untuk memaksimalkan aspek keilmuan warisan geologi tersebut. Kawasan Geoheritage Gunung Batur merupakan warisan geologi yang berupa sisa tubuh gunungapi purba yang aktif pada Kala Oligo-Miosen yang terhampar luas di sepanjang Teluk Wediombo hingga Teluk Siung. Lokasi objek wisata ini yang menghadap langsung kepada Samudra Hindia menjadi daya tarik tersendiri di samping keunikan geologi objek tersebut. Keberadaan Gunugapi Purba Batur ini dapat diidentifikasi dari berbagai parameter pendukung seperti kondisi geomorfologi gunungapi, stratigrafi serta struktur geologi yang berkembang pada daerah ini. Penelitian mengenai geologi Gunung Batur ini disintesis dengan melakukan analisis terintegrasi berdasarkan kajian data geologi permukaan dan survei magnetik untuk mengetahui fakta unik mengenai aspek kegunungapian serta sejarah pembentukannya yang akan di sajikan dalam konsep wisata edukasi kebumian. Kajian kelayakan unsur wisata dan keamanan merupakan prioritas dalam penelitian ini sehingga dapat di lokalisasi geosite yang menarik dari kajian kepariwisataan dan keilmuannya. Berdasarkan kajian komprehensif di lapangan, Kawasan Geoheritage Gunung Batur dapat dibagi menjadi beberapa geosite yang dinilai memiliki daya tarik wisata kebumian yaitu kekar tiang Wediombo, pantai lava Wediombo, *dyke* Wediombo, *sea stack* Watubolong, kubah lava Gunung Batur, bukit breksi Watulumbung, dan kubah gunungapi Siung. Geosite tersebut akan disajikan dalam sebuah konsep wisata edukasi kebuamian yang komunikatif, representatif dan menarik untuk dikembangkan pada objek wisata Gunung Batur. Beberapa rekomendasi program dengan mengusung tema laboratorium alam Gunungapi Purba Batur dengan memadukan aspek keindahan alam dan ilmu kebumian disajikan dalam bentuk papan informasi, buku panduan wisata serta video promosi objek wisata. Pengembangan wisata edukasi kebumian Gunung Batur ini secara implisit merupakan upaya melestarikan warisan geologi dan sekaligus memperoleh manfaat yang berkelanjutan bagi masyarakat setempat sebagai kontribusi keberadaan warisan geologi tersebut.

KONSERVASI GEOHERITAGE DI JAWA TIMUR DAN ANALISA AREA KERENTANAN TANAH BERDASARKAN PENGUKURAN MIKROTREMOR: KOMPLEKS KALDERA TENGGER

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ABSTRACT

Indonesia merupakan negara kepulauan dengan latar tektonik pertemuan antar lempeng yang sangat kompleks. Latar tektonik ini menyebabkan kepulauan Indonesia memiliki banyak gunung berapi yang sampai sekarang masih aktif. Salah satu contoh gunung berapi yang masih aktif dan dijadikan kawasan wisata adalah Gunung Bromo. Kawasan ini mencakup tiga kabupaten, Kabupaten Malang, Pasuruan, dan Probolinggo. Pegunungan Tengger memiliki morfologi kaldera lautan pasir yang sangat luas dan merupakan tempat berkumpulnya material pelapukan vulkanik. Di sana terdapat suku Tengger yang masih memegang teguh kepercayaan, dengan melakukan upacara kasada di setiap tahunnya yang menjadi daya tarik bagi wisatawan lokal ataupun mancanegara. Dari segi geomorfologi kawasan Bromo-Tengger Semeru memiliki bermacam-macam satuan geomorfologi, seperti satuan geomorfologi lereng gunung api terdendusi dan satuan geomorfologi sisa kerucut gunung api. Dalam satuan geomorfologi lereng gunung api terdendusi ada beberapa bukit yang termasuk didalamnya misal bukit-bukit Argawulan, Ider-ider, Pandak Lembu, Jantur, Gentong, dan Penanjakan. Ini yang menjadi menarik bahwa pegunungan tengger merupakan kompleks gunung api dengan morfologi yang bervariasi. Dari dasar kaldera terdapat tujuh pusat erupsi, dengan kelurusan menyilang barat-timur dan timur laut – barat daya, masing –masing erupsi adalah: Widodaren, Watanggan, Kursi, Segarwedi Lor dan Kidul, Batok, dan Bromo. Secara umum kompleks Bromo – Tengger morfologinya berada pada ketinggian 750 – 2581m dpl. Kemudian di sekitar komplek Bromo-Tengger terdapat lautan pasir yang memiliki luasan berkisar 5,250 ha dan dikelilingi oleh dinding kaldera yang sangat terjal dan kemiringan lereng 60º-80º dan tingginya 120-130 m dari dasar kaldera tengger. Diantara luasnya lautan pasir ada satu titik yang dinamai dengan pasir berbisik merupakan lokasi yang banyak dikenal oleh wisatawan karena pasir tersebut ketika terkena hembusan angin dapat mengeluarkan bunyi yang unik. Kemudian untuk mengidentifikasi kerentanan tanah akibat gempabumi telah dilakukan pengukuran mikrotremor di area kaldera pasir Bromo-Tengger, didapatkan nilai frekuensi dominan sebesar 2,9Hz dan ketebalan sedimen di kaldera pasir sebesar 480 meter. Dimana lokasi yang memiliki ketebalan paling tebal pada kerucut Gunung Muda yag terbentuk palling awa yaitu Gunung Widodaren. Dengan mengetahui nilai ketebalan sedimentasi disekitar kaldera pasir dapat memberikan informasi mengenai kerentanan tanah terhadap gempabumi.

Kata kunci: Geomorfologi, kaldera pasir, frekuensi, ketebalan sedimen, mikrotremor

PENDAHULUAN

Indonesia merupakan negara kepulauan dengan latar tektonik pertemuan antar lempeng yang sangat kompleks. Latar tektonik ini menyebabkan kepulauan Indonesia memiliki banyak gunung berapi yang sampai sekarang masih aktif. Salah satu contoh gunung berapi yang masih aktif dan dijadikan kawasan wisata adalah Gunung Bromo yang terletak di

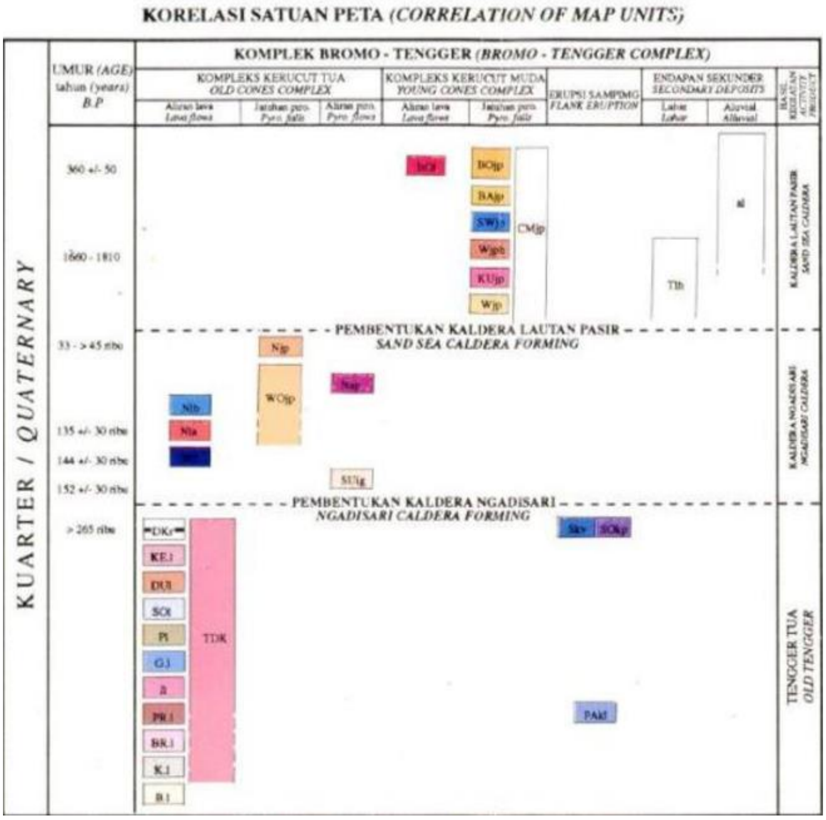
Pegunungan Tengger kawasan Taman Nasional Bromo Tengger Semeru. Selain keindahannya alamnya, terdapat pula eksotisme budaya yang di miliki oleh suku Tengger. Seperti perayaan Kasada yang tiap tahunnya dirayakan untuk mensyukuri nikmat yang telah diberikan oleh Sang Maha Pencipta. Dibalik itu kehidupan suku tengger dan para wisatawan memiliki resiko akan bencana alam yang sewaktu-waktu
mengancam, seperti letusan gunung berapi dan amblesan tanah ketika terkena guncangan gempa vulkanik gunung Bromo. Maka dari itu penelitian ini digunakan untuk menganalisa kerentanan tanah berdasarkan data mikrotremor di Kaldera Tengger.

Geologi Regional

Kawasan Taman Nasional Bromo Tengger, terdiri atas kaldera lautan pasir yang luasnya 180 km2, Gunung Kursi, Gunung Watangan, Gunung Widodaren, Gunung Bathok, dan Gunung Bromo. Kawasan ini memiliki formasi geologi yang terdiri dari hasil gunung api Kuarter Muda dan Kuarter Tua.

Gambar 1. Hasil Citra Satelit (google Earth) Kawasan Gunung Bromo tahun 2015

Kawasan pegunungan ini memilki satuan geomorfologi, yaitu geomorfologi lereng gunung api terendusi dan geomorfologi sisa kerucut gunung api. Disekitaran kaldera ditemukan beberapa batuan hasil erupsi, di bagian timur laut batuan basalt vesikuler yang berupa bombom vulkanik. Sementara di dinding luar dari kerucut gunung Bromo dan gunung Bathok dijumpai batuan piroklastik dan endapan abu gunung api. Pada dinding kaldera, jalur Cemoro Lawang maupun jalur penanjakan di dominasi oleh endapan freatomagmatik, fragmen lava andesit basaltik, selang-seling piroklastik jatuhan,
dan piroklastik aliran. Hal ini menunjukan endapan piroklastik yang terbentuk tersusun oleh klastika bom vulkanik, lapili dengan matriks yang sangat pekat dari pasir-pasir vulkanik yang relatif kasar, adn bentuk runcing-agak runcing. Susunan endapan vulkanik Bromo hasil letusan Gunung Tengger Tua adalah salah satu fenomena kegunungapian yang menarik, eksotik, spesifik pada suatu tipe gunung api yang membentuk kerucut silinder dalam kaldera, dan hasil berbagai endapan Gunung Tengger Tua ini tersaji disepanjang jalur wisata yang berkembang sekarang. Dari hasil pengendapan materialnya diketahui bahwa letusan Bromo terjadi berkali-kali . dibuktikan dengan sortasi pasir yang tidak merata.



Gambar 2. Umur satuan geologi G.Bromo (Sumber: www.vsi.esdm.go.id)

Analisa HVSR

Metode HVSR diperkenalkan pertama kali oleh Nakamura (1989), digunakan untuk mengestimasi frekuensi natural dan amplifikasi geologi setempat dari data mikrotremor dan metode ini berkembang dapat mengestimasi nilai kerentanan daerah pengukuran. Metode HVSR didasari oleh terperangkapnya gelombang geser pada medium sedimen diatas bedrock.

$$f = \frac{Vs}{4h} \qquad (1)$$

Dengan Vs adalah kecepatan gelombang geser dan 4h mewakili kedalaman bedrock.

Amplifikasi

Amplifikasi merupakan pembesaran/ kenaikan gelombang seismik yang diakibatkan oleh penjalaran gelombang yang melewati medium lebih lunak dari medium sebelumnya. Pada suatu jenis batuan akan memiliki nilai amplifikasi yang berbeda bergantung pada deformasi yang terjadi pada batuan tersebut

$$A^0 = \frac{\rho_b v_b}{\rho_s v_s} \qquad (2)$$

Keterangan A0 = amplifikasi
ρb = densitas basement
ρs = densitas lapisan lunak
vs = kecepatan rambat gelombang lapisan lunak
vb = kecepatan basement
Perhitungan ketebalan sedimen

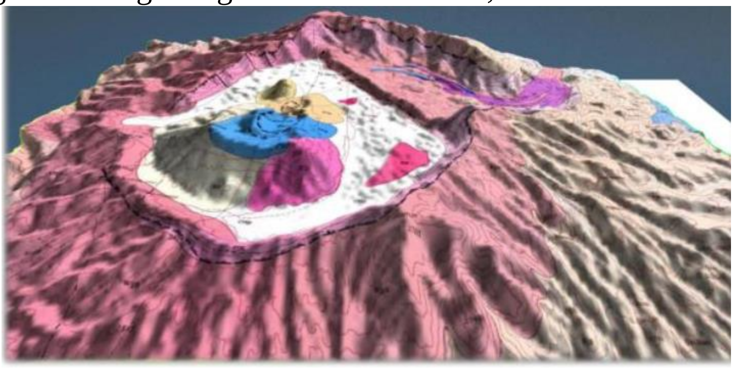
Dalam penelitian ini juga akan dihitung ketebalan sedimen dengan mencari nilai Vs30 yang dapat dicari melalui web USGS, sesuai lokasi peneitian, untuk perhitungan secara matematisnya seperti berikut,

$$h = \frac{Vs30}{4f_0} \qquad (3)$$

Dengan nilai h merupakan kedalaman sedimen, Vs30 kecepatan geser pada kedalaman 30 meter, dan f0 merupakan frekuensi natural pada lokasi penelitian.

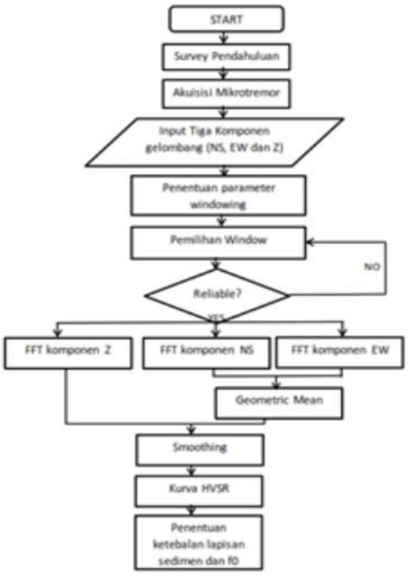
METODOLOGI PENELITIAN

Pada penelitian ini digunakan metode mikrotremor tipe MAE, pengukuran didasari oleh peta geologi regional dari gunung Bromo dibawah ini,



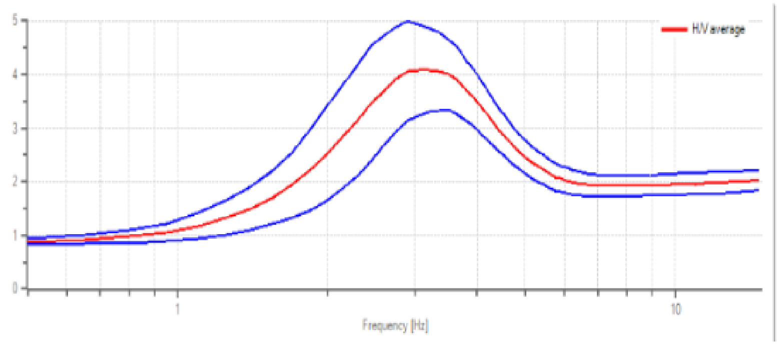
Gambar 3. Model geologi permukaan gunung Bromo hasil pengolahan menggunakan geomodeller

Penggunaan metode ini ada beberapa hal yang harus diperhatikan seperti kondisi tanah saat pegukuran (keras atau lunak), kondisi vegetasi dan permukaan daerah penelitian. Serta perlu adanya catatan indikasi penyebab noise dalam hal ini, adanya aktivitas yang dilakukan manusia, sehingga memudahkan dalam proses pengolahan data. Adapun diagram alir penelitian mikrotremor.



Gambar 4. Diagram alir penelitian

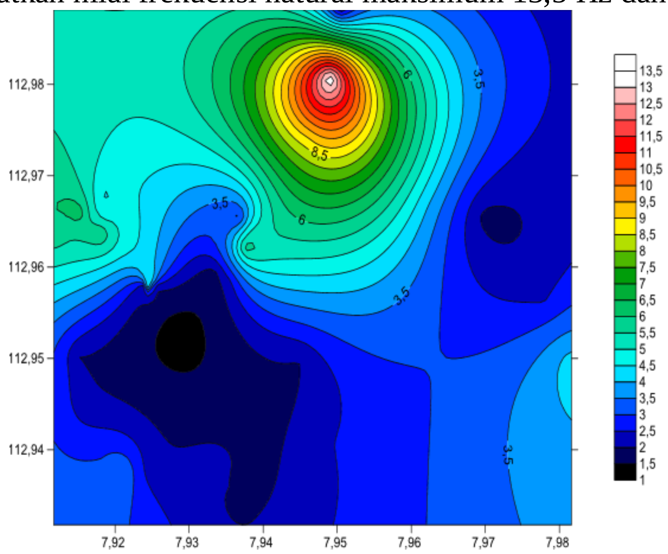
Hasil pengolahan yang didapatkan berupa grafik Horizontal to Vertikal (H/V), merupakan hasil Fast Fourier Trnasform (FFT) dari data yang didapatkan dan didalam grafik tersebut memuat informasi frekuensi dominan dan amplifikasi.



Gambar 5. Kurva H/V, dengan sumbu Y merupakan nilai H/V (Amplifikasi), sumbu X merupakan nilai freskuensi, dan garis berwarna merah merepresentasikan H/V rata-rata.

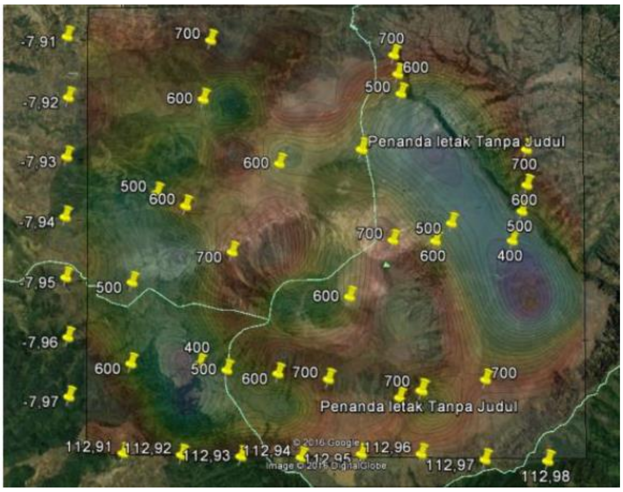
PEMBAHASAN

Hasil dari pengolahan data mikrotremor adalah nilai dari frekuensi dominan pada area penelitian, sehingga didapatkan nilai frekuensi dominan dari beberapa titik, dan diplotkan dalam sebuah peta kontur frekuensi dominan dan ketebalan sedimen. Pada dasarnya nilai frekuensi natural dapat merepresentasikan nilai dari ketebalan sedimen di kaldera Tengger. Dengan nilai frekuensi natural 0,5-5 Hz maka ketebalan sedimen pada area tersebut semakin tebal dan akan menipis pada frekuensi 5,5-13,5 Hz. Hasil dari pengolahan didapatkan nilai frekuensi natural maksimum 13,5 Hz dan minimum 1,5 Hz.



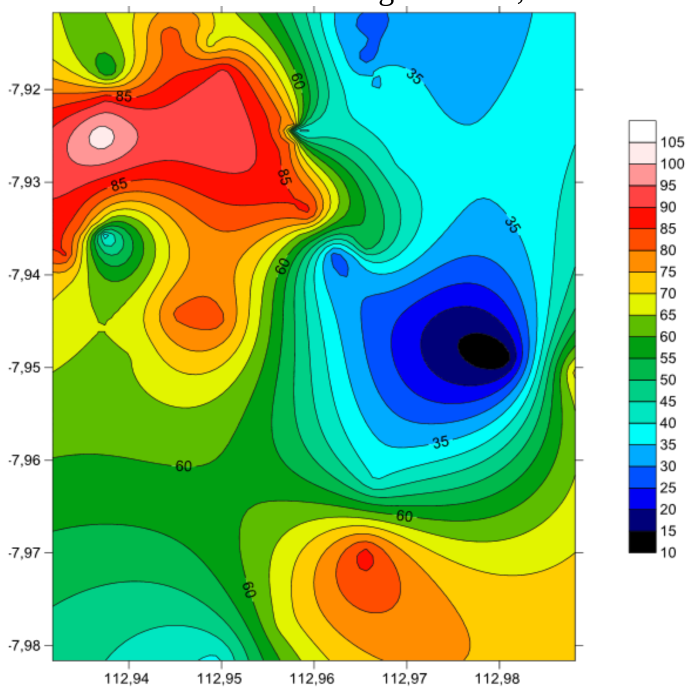
Gambar 6. Kontur frekuensi natural. Nilai X dan Y merupakan koordinat titik pengukuran dan skala warna merepresentasikan frekuensi natural.

Untuk melakukan analisis lebih lanjut mengenai nilai ketebalan sedimen yang ada di kaldera Tengger, akan dilakukan pengambilan nilai Vs30 dari data USGS, sehingga didapatkan kontur Vs30.



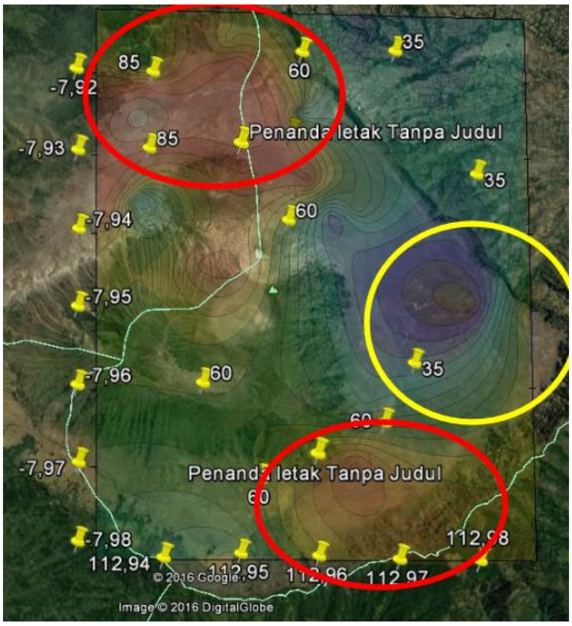
Gambar 7. Kontur Vs30 diambil dari http://earthquake.usgs.gov/hazards/apps/vs30/

Kemudian dilakukan perhitungan untuk tebal sedimen dengan menggunakan persamaan (1), didapatkan kontur ketebalan sedimen sebagai berikut,



Gambar 8. Kontur kedalaman sedimentasi nilai x,y merupakan koordinat dan skala warna persebaran kedalaman sedimentasi

Dari hasil kontur tersebut didapatkan kedalaman sedimen kaldera lautan pasir berkisar 5-105 meter. Ketika medium sedimen dilewatkan gelombang nilai amplifikasi akan menjadi besar, dengan karakter batuan sedimen yang lunak akan lebih destruktif dibandingkan batuan yang lebih kompak



Gambar 9. Peta overlay data ketebalan sedimen dengan peta bromo, lingkaran merah merepresentasikan wilayah rentan dan lingkaran kuning merepresentasikan assembly point.

Sehingga dari hasil penelitian dapat ditentukan rekomendasi titik assembly point dan jalur evakuasi saat terjadi gempa disisi timur kaldera pasir Bromo-Tengger.

KESIMPULAN

Dari hasil penelitian yang dilakukan, diperoleh nilai frekuensi dominan 1,5-13,5 Hz. Kemudian dalam menentukan ketebalan sedimen dilakukan pendekatan seismik refraksi dan VES untuk menentukan nilai Vs30, sehingga didapatkan nilai ketebalan sedimen 5-85 meter. Ketika medium sedimen dilewatkan gelombang nilai amplifikasi akan menjadi besar, dengan karakter batuan sedimen yang lunak akan lebih destruktif dibandingkan batuan yang lebih kompak. dari hasil penelitian dapat ditentukan rekomendasi titik assembly point dan jalur evakuasi saat terjadi gempa disisi timur kaldera pasir Bromo-Tengger.

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THE EXTREME KARST CLASS OF ASPIRING GEOPARK OF KINTA VALLEY, PERAK, WEST MALAYSIA

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ABSTRACT

Kinta Valley in Perak, Peninsular Malaysia is important historically as the richest tin mine in the world was located here. The tin-rich placer has been deposited across the wide valley, sourced from two granitic highlands. It is believed that the unique subsurface karst feature of planation with jagged surface formed by limestone pinnacles have trapped the sediments from being washed. Most of the tin have been mined from the placer deposits. Many caves are situated at ground level and many of them have been developed into temple caves by Buddha and Hindu worshippers. Due to the historical and heritage values, Kinta Valley has been proposed to be developed as a Geopark. The maturity of the karst has been measured by the calculation of the surface to subsurface karst ratio. The surface karst which consists residual of hills with cockpit features and isolated towers, protruding from the vast valley plain only makes up about only 7% of the area underlain by the limestone. The ratio of surface and subsurface karst can be used as an indication of intensity of the dissolution that occurs in the karst terrain. The surface dissolution rate of the limestone in the study area obtained using the micro-erosion meter is found to be from 224 mm / ka and 369 mm / ka for calm, pond water and running water environment respectively. These dissolution rates are rather high when compared to the rates of dissolution in other karst areas in other parts of the world including in other tropical areas. The dissolution rate coupled with topographic setting of Kinta Valley has provided a suitable environment for high rate of karstification. The advanced stage of karstification in Kinta Valley could possibly show the end product of the first cycle of karstification process on the surface and begins to show the possible rejuvenation of karst by further karstification of the subsurface limestone, most probably without a period of fossilisation throughout Middle Tertiary till present. This unique karst topography, together with numerous other values makes it worthy of a Geopark status.

FRACTURES CONTROL OF GROUNDWATER AQUIFER CONFIGURATION AT BATURAGUNG VOLCANIC RANGE, A POTENTIAL NEW GEOSITE OF GUNUNG SEWU GEOPARK

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ABSTRACT

The residual of the natural rock erosion in the Baturagung range area of Gunung Kidul exhibit a cuesta of volcanic sedimentary rock is incredible. In preliminary studies indicate that the remains cuesta has a close relationship with the local faults pattern and major fault structure in the ENE-WSW trending which has been named as Dukuh and Mertelu faults by Lestanto Budiman (1990), and Sudarno (1997). The presence of so many major, meso and minor faults in the cuesta , it shows that this minor and meso faults in the major fault system that has developed imbricated graben and horst in a relatively long period. This study used detailed research methodology with detailed data acquisition along the cuesta. As expected found sufficient data for analysis fault zone and faulted rock. In this detailed trajectory represented 3 blocks of detailed observations. Field observations, resistivity geo-electrical, and Pole-dipole geo-electric method show that not at all region have same faults pattern in the cuesta. In each block region observation, they usually have several combinations of minor, meso and major faults variation. The first block, varies from minor, meso, major and nothing fractures with fault plane generally steeply dipping to the SSE. Their fault plane ranging from steeply to very steeply dipping and commonly associated with E-W half graben faults. The second block varies from meso, minor and nothing fractures with fault plane generally steeply dipping to the north or south. They are commonly called synthetic-antitethic normal fault, and parallel with major fault. Transposition of layering during deformation is not uncommon and the occurences of high-strain zone of horst fault suggest that the deformation were derived from intense NNW-SSE tention. The third block, always follow system of NNW-SSE tention fault and commonly associated with steeply dipping ENE-WSW half graben. The varies structures in the all blocks is produced by ***footwall collapse on half grabens system***. Baturagung groundwater basin are compiled by some rock formations and also fractures which is as a controller of recharge and discharge areas. There are three rock formations that have properties permeability rock with unfavorable ie Kebobutak Formation, Semilir Formation and Nglanggran Formation. Fracture patterns that develops relatively leads North-South and East-West, which is where the pattern of North-South is controllers of a recharge area while the fracture pattern with alignment relative direction West-East is a fracture pattern which controls a discharge area.

The physical dimension of the mountain range, the geological history of the structures and the aesthetic beauty of panoramic landscape it produced make the Baturagung miosen volcanic range a unique cuesta geoheritage resources not only to Indonesia but also in the world especially for tropical countries where intense weathering will rapidly transform rocks into thick soil in very short time.

INTRODUCTION

Baturagung range is a top cuesta mountain of Miosen volcanic residual erosion at Gunungkidul, with the Main Range which is well endowed with lush green tropical rainforest and green valley. Silhoueted by these forests, on the north-northwestern border of the city protruded an amazing great cuesta of Gunungkidul. The Baturagung

Range, named by Bemmelen (1949) after the Geology of Indonesia published in which this range belonged to. (Figure 1). Often mistaken with synclinal structure for its cuesta-like morphological features, this 24 km long (up to 9 km wide and 750 m tall) cuesta is almost entirely made of Miosen volcanic clastic, hence a giant volcanic cuesta. The physical dimension of the cuesta, the geological history of the cuesta and the aesthetic beauty of panoramic landscape it produced make the Baturagung groundwater basin a unique geosite resources not only to Gunung Sewu Geopark, Indonesia but also in the world especially for tropical countries where intense weathering will rapidly transform rocks into thick soil in very short time.

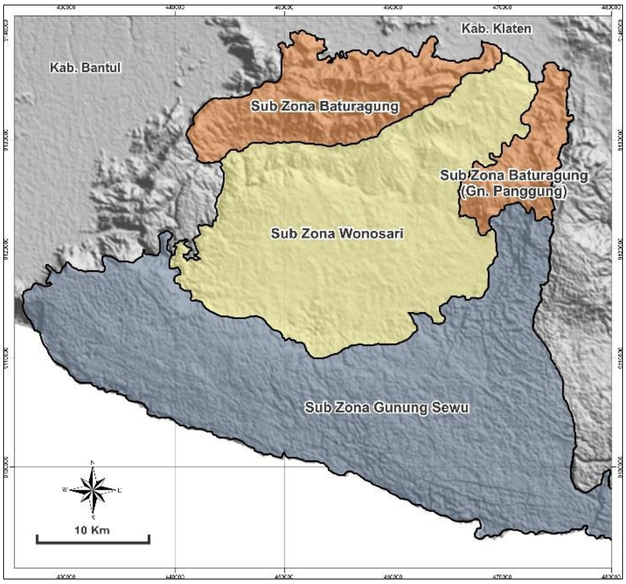

Figure 1: Physiographic region of Gunungkidul area, show the physical and dimension of the Baturagung cuesta Range.
(Modivication from Bemmelen, 1949)

THE GEOLOGY OF GUNUNGKIDUL

The geology of Gunungkidul and its surrounding area is mainly made up of Lower Miosen Kebobutak-Semilir volcanic sandstone and Nglanggran volcanic breccia and the Late Lower Miosen Sambipitu volcanic calcareous sandstone Formation which all were intruded by the Late Miosen Tegalrejo Basaltis (Mahfi, 2003). Structurally, Gunungkidul area was affected by a series of major post-volcanic cuesta implacement's half graben faulting (Figure 2) known as Baturagung Fault Zone (Bemmelen, 1949; Lestanto Budiman, 1990; and Sudarno 1997). The low lying areas was covered by thick Quarternary alluvial deposits at northern part and thick Late Miosen Oyo tuffaceous limestone Formation.

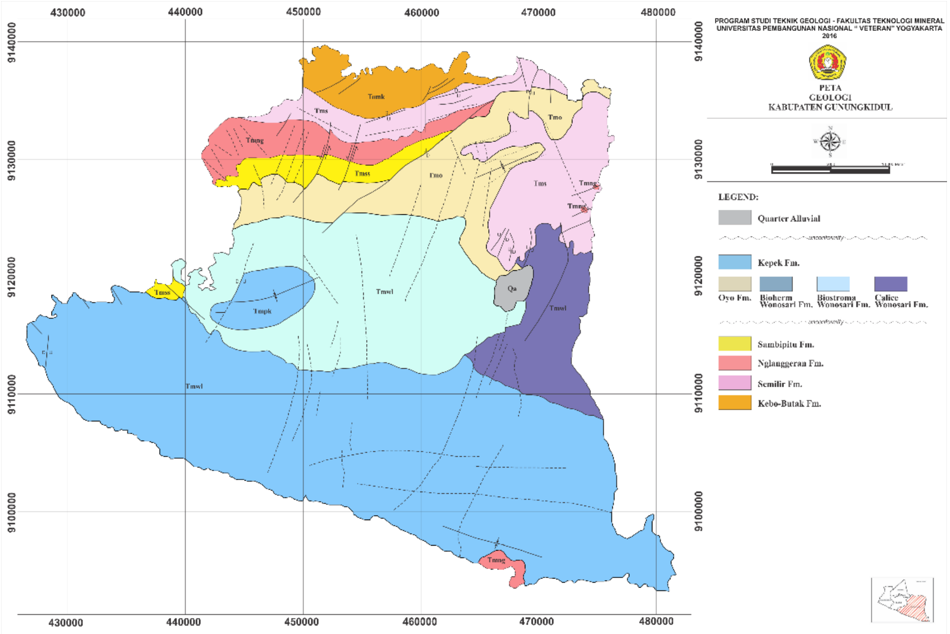

Figure 2: Geogical Map of Gunungkidul area (Modivication from Rodhi, et al, 2016)

THE BATURAGUNG CUESTA RANGE

Baturagung volcanic cuesta range is an elongated body extended to about 14 km in E – W direction exposing more than 9 km of volcanic of different lithological characteristics. It is mainly located in gunung Semilir-Baturagung, Kecamatan Gedangsari, extended a little into gunung Nglanggran, Kecamatan Patuk, Gunungkidul. The cuesta is undulated forming several hills with Bukit Baturagung (827m) as it highest peak rising up to 500m above the Wonosari plain. The width of the cuesta is ranges from 1km-3km. The cuesta geomorphology is unique with its nearly valley (to surrounding hills in places) ghostly green sea with giant ship resembling volcanic foot hill geomorphology (Sudarno, 1997). Tog the south-southwest lies the bustling Wonosari City with Gunung Sewu Geopark and to the north-northeast is the serene artificial lake of Rawa Jombor, Bayat where a narrow gap in which Dengkeng River flows through along northern of Tegalrejo escarpment.

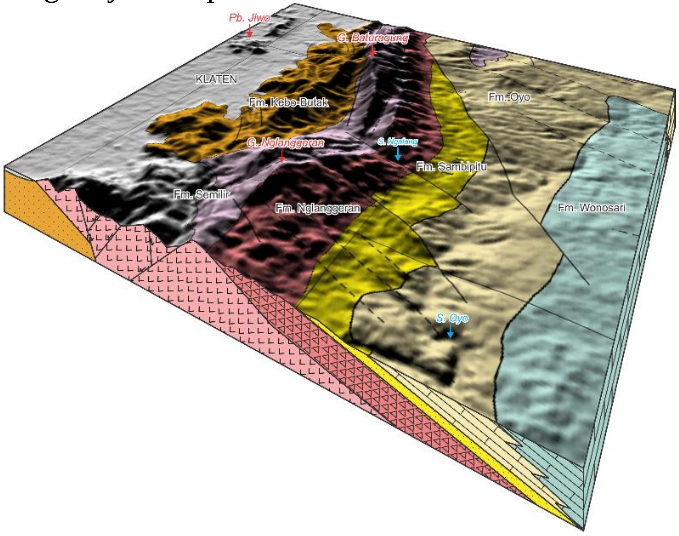

Figure 3: Diagram Block of Baturagung area, show geomorphology the cuesta control by lithology and fractures (Source : Rodhi et al. 2016)

Petrology

Baturagung cuesta is not a simple single giant-sized cuesta as it was often misunderstood. Instead it is a combination of several types and generations of volcanic layers with different lithology, texture and fractures associations. In general it is intercalation volcanic sandstone and tuff with volcanic breccia and calcareous volcanicsandstone. There are three variations of volcanic unit lithology. The first variation varies sandstone in thick from 5cm to 20cm thick, generally show distal turbidite structure with parallel lamination structures, sometimes brecciated and associated with quartz-zeolite tuff. The second variation is mostly major volcanic sandstone with proximal turbidite structure showing thickening up-ward sometimes breccia and associated with lapilli tuff and vitric tuff, while the third variation is generally volcanic breccia major to moderate thick layers with debrise to grain flow structure showing thinning up-ward , and most commonly associated with andesite and basalt fragmens. All lithology variations show matrik supported with porosity range 1%-2%. (Figure 4).

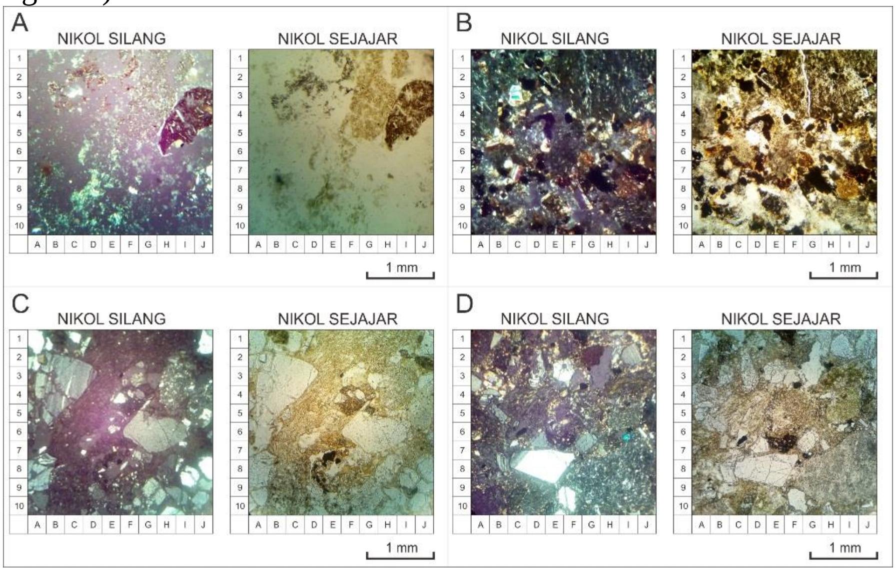

Figure 4: Petrographic analysis thin section with blueday liquid porosity analysis. (A) Left-upper show vitric tuff, with porosity 2%. (B) Right-upper show matrix supported of breccia withporosity 1%. (C) Left-lower show matrix supported of volcanic wacke with porosity 1%. And (D) Right-lower show matrix supported of volcanic wacke with porosity 1%.

Structure and tectonic

Baturagung Cuesta is part of the Baturagung graben fault system that cut all volcanic rocks in Gunungkidul area, hence interpreted to have been formed after the final emplacement of the Miosen volcanic. Based on the radiometric age by Mahfi et all (2003) and Suryaatmadja, et al (1993) age of the Bayat-Gunungkidul volcanic is 26 - 33 million years ago (Late Oligocene-Early Miocene age). Rodhi et al. (2016) believed that the Baturagung cuesta fault zone was active from Early Miocene to Middle Miocene, while Sudarno (1997) assumed that fault movement ended in Early Miocene. This is evidence from the presence of various types of deformation to the earlier volcanic foothill environment and half graben cuesta. At least three different generations of half graben were identified forming at different dip directions, angles and attitudes. The first generation is develop Kebo-Butak domino system, second develop Semilir horst complex, and the last Semilir half graben. (Figure 5).

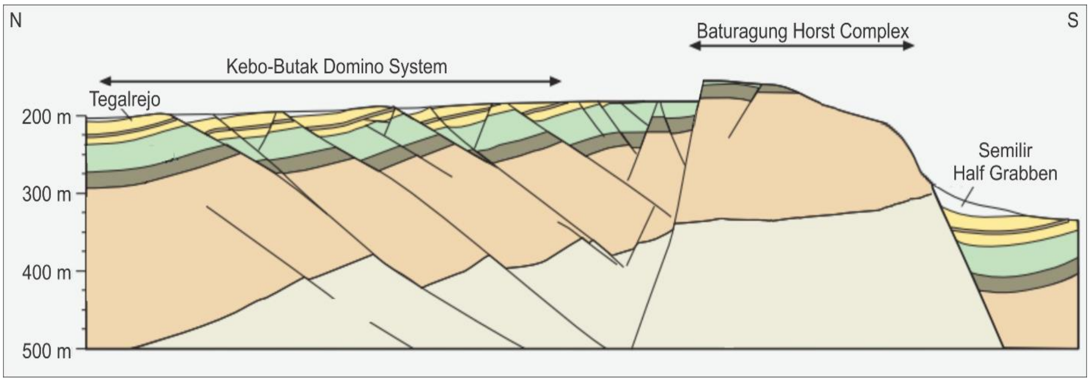

Figure 5: Ideal section Baturagung cuesta show half graben system which Kebo-Butak Domino System in northern part, Baturagung Horst in central part and Semilir half graben in southern part. (modivication from Fossen, 2010)

From prominent strike modes of fracture lineaments it can be interpreted that Baturagung half graben cuesta has been produced .by horizontal tentional acting along 172º - 352º that were responsible for the Middle Miocene orogeny, and were still active for quite sometimes after the emplacement of the volcanic cuesta (Figure 6).

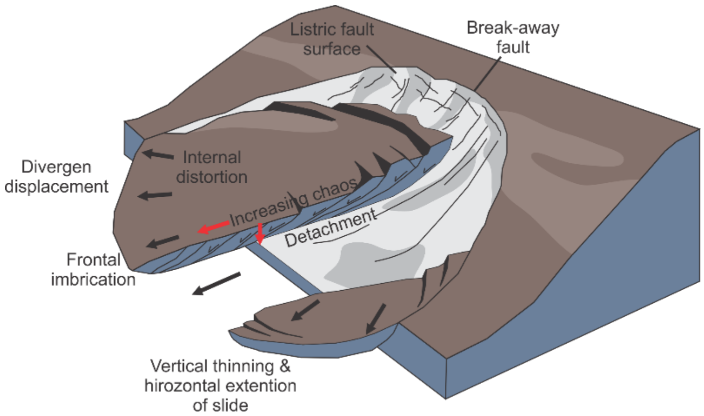

Figure 6: Ideal Model half graben show Footwall collapse controlled by the presence of weak layer from Wungkal Formation. (Rodhi et al, 2016, modivication from Fossen, 2010)

Hydrogeology

Field observations, resistivity geo-electrical, and Pole-dipole geo-electric method show that not at all region have same faults pattern in the cuesta. In each block region observation, they usually have several combinations of minor, meso and major faults variation. (Figure 7). The first block, varies from minor, meso, major and nothing fractures with fault plane generally steeply dipping to the SSE. Their fault plane ranging from steeply to very steeply dipping and commonly associated with E-W half graben faults. The second block varies from meso, minor and nothing fractures with fault plane generally steeply dipping to the north or south. They are commonly called synthetic-antitethic normal fault, and parallel with major fault. Transposition of layering during deformation is not uncommon and the occurences of high-strain zone of horst fault suggest that the deformation were derived from intense NNW-SSE tention. The third block, always follow system of NNW-SSE tention fault and commonly associated with steeply dipping ENE-WSW half graben.

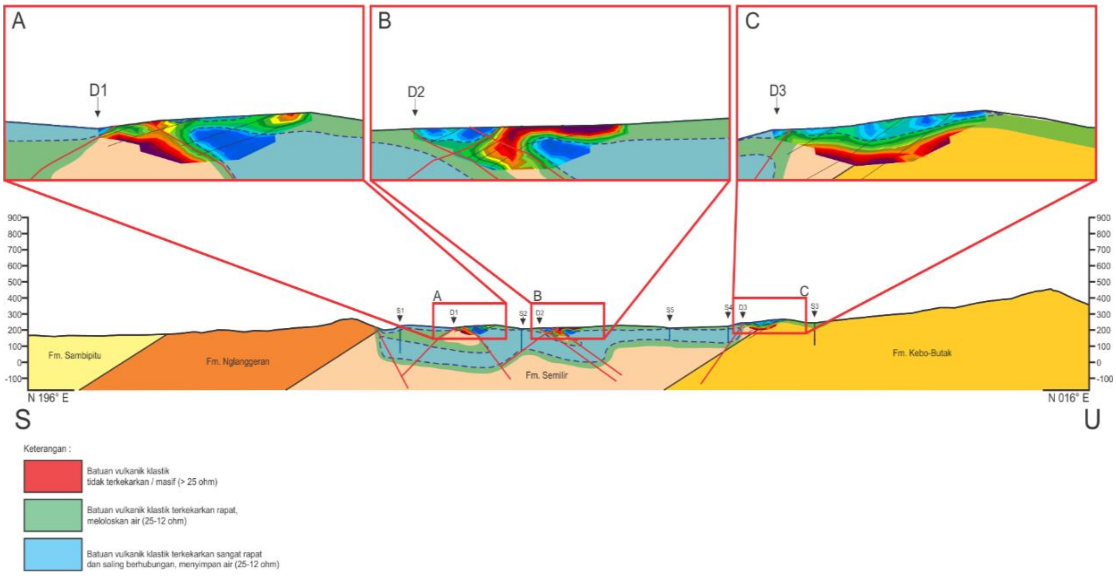

Figure 8 : Field and geo-electrical method analysis shows relationship the structural patterns and three block of the cuesta range. (Source : Rodhi et al. 2016).

The pattern of east-west trending is a pattern structure in one direction with a stance rock and forming normal fault. The pattern of these structures shows that the groundwater many trapped and stored in the valleys between the hills of homoklin-cuesta discharge, many found the springs in the valleys of the structure, acting as a path (channel) groundwater flow from the hills as recharge (Figure 8).

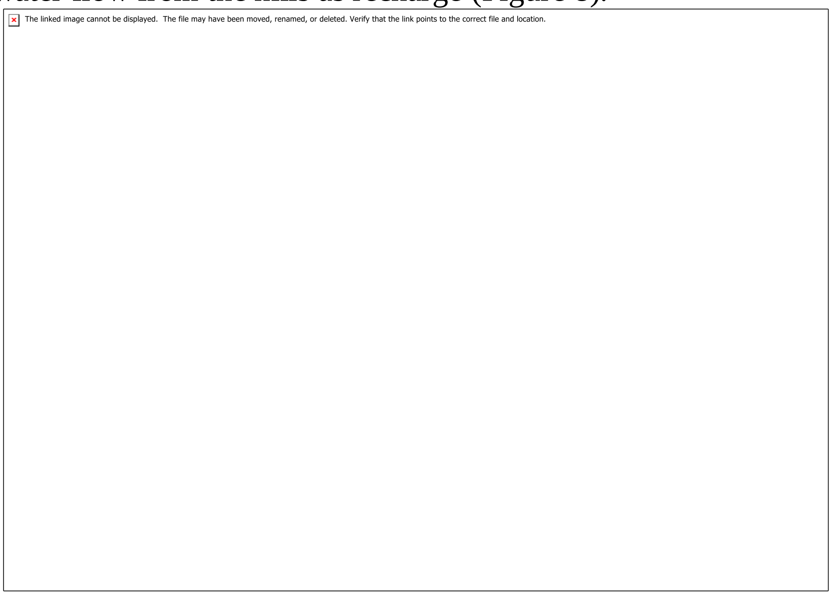

Figure 8 : Hydrogeology and sub-surface groundwater flows countur map show the structural patterns, lithology and topographic combination are forming groundwater aquifer trap

Landform and landscape

Differential weathering has been responsible in producing an undulating vertical cuesta stood proudly above the background made of insitu volcanic sandstone soil with both slopes are formed by collovium where volcanic sandstone soils and fractured are mixed porosity together (Rodhi et al.,2016). That is a good secondary porosity and it was a good aquifer, too. (Figure 8)

Figure 9: Sriten pond at southern slope of the top Baturagung cuesta an a good porosity sample. Tog the south-southwest lies the bustling Wonosari City with Gunung Sewu Geopark

The undulating nature of the cuesta is due to the formation of weak zone by later faults that form several gaps including those cut by two main valley that are surrounding Bukit Semilir, Bukit Baturagung and Bukit Nglanggran. At larger scale, the various peaks of these landforms formed different morphological features such as dome, cuesta, half-conical and hogback, (Figure 10)

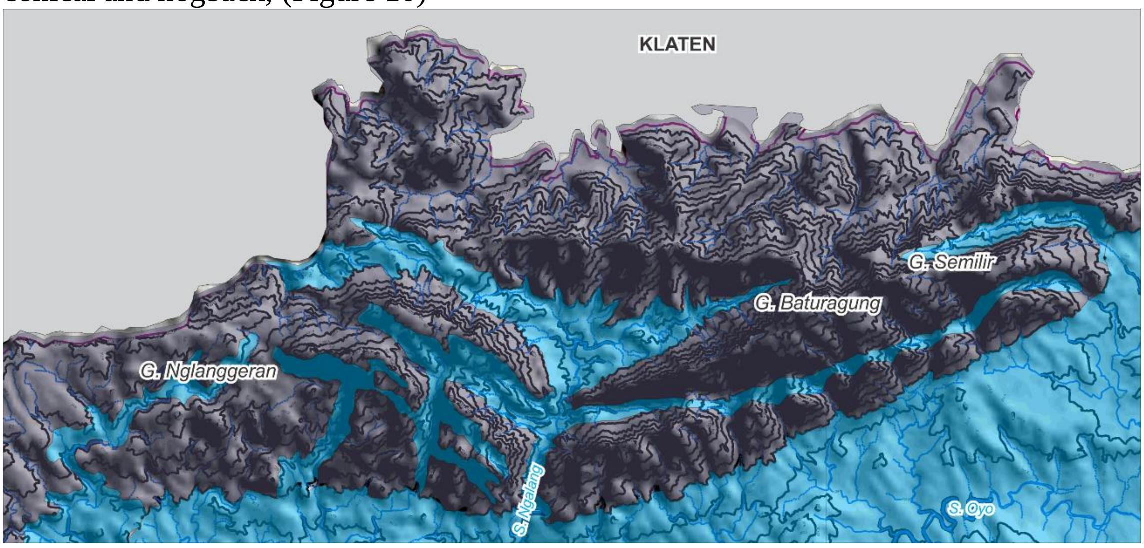

Figure 10: The various peaks of these landforms formed different morphological features such as dome, cuesta, half-conical and hogback

Heritage value and conservation

Rodhi et al., (2016) have pointed out several scientific, aesthetic and recreational values for this cuesta and have propose it to be established as a geological monument, reservoir and recreational reserves. At this moment part of this cuesta is located under the Forestry Department Act as a State Park for conservation of rare wildlife and flora associated with the volcanic cuesta. At present, the Gunungkidul State Government with supports from various federal government agencies and academia have put their conserted efforts in nominating this unique geoheritage site to the new geosite List..

SUMMARY

The Baturagung cuesta range is the longest visible volcanic cuesta in Indonesia and one of the longest in the world. It is part of the half graben Baturagung Fault zone, made up of a single cuesta with multiple fractures at volcanic lithology representing various stage of the fault development. The formation of the entire cuesta represents a special event in geological history where tectonic forces continue to take place long after the suturing of two major plates. Deep tropical weathering exposed the cuesta to create a majestic landscape and groundwater basin at the background of Wonosari city, Gunungkidul. Its unique geomorphological features resembles cuesta landscape is a special feature of tropical weathering. This volcanic cuesta should be preserved for its scientific (geological) and aesthetic values as well as for its ecological values.

ACKNOWLEDGEMENT

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Kementrian Energi Dan Sumber Daya Mineral Badan Geologi Pusat Sumber Daya Airtanah Dan Geologi Lingkungan, 2015, *Eksplorasi Dan Pelayanan Air Bersih Melalui Pemboran Airtanah Dalam Paket SB – 6 Dusun Kampung Lor, Desa Kampung, Kecamatan Ngawen, Kabupaten Gunungkidul*

Kementrian Energi Dan Sumber Daya Mineral Badan Geologi Pusat Sumber Daya Airtanah Dan Geologi Lingkungan, 2015, *Eksplorasi Dan Pelayanan Air Bersih Melalui Pemboran Airtanah Dalam Paket SB – 6 Dusun Mertelu Kulon, Desa Mertelu, Kecamatan Gedangsari, Kabupaten Gunungkidul*

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Melalui Pemboran Airtanah Dalam Paket SB – 16 Dusun Pulutan, Desa Pulutan, Kecamatan Wonosari, Kabupaten Gunungkidul, DIY

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Pemerintah Provinsi Daerah Istimewah Yogyakarta Dinas Pertambangan, 1996-1997, *Pekerjaan Penyusunan Rencana Zona Tata Guna Air Bawah Tanah Di Kecamatan Gedangsari, Karangmojo, Ngawen, Nglipar, Patuk, Ponjong dan Semin Kabupaten Gunungkidul Bagian Utara, DIY*

Pemerintah Provinsi Daerah Istimewah Yogyakarta Dinas Pertambangan, 1998-1999, *Pekerjaan Penyusunan Rencana Zona Tata Guna Air Bawah Tanah Di*

Kecamatan Rongkop, Semanu Dan Tepus, Kabupaten Gunungkidul Bagian Utara, DIY

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PEOPLE PERCEPTION ON BERBAH PILLOW LAVA GEOHERITAGE

(Study in the community at the Pillow Lava area in Yogyakarta, Indonesia)

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ABSTRACT

This study aims to know the perception of community surrounding Pillow Lava which is the earliest former of volcano's in Java island and lately develops become strato volcano with explosive eruption along mountainous Southern Java Island. The Pillow Lava is definitely one of the most rare and its the unique one in the world.Unfortunately, the people whose lives surrounding Pillow Lava does not care of their environment including the existence of the potency ol Pillow Lava as the exotic geological heritage tourism. This study founds that the local people surrounding Pillow Lava's area does not have knowledge about what the value they have in their area. According to those, the transfer of knowledge from the experts are really needed for the community in that area of study. As the community realize of what advantage they have and they can do empowering the resources, it will ends up to the increasing of the community welfare. This research conducted as library research and observation on the community in the Pillow Lava's area about the potency of Pillow Lava as geoheritage tourism. The analysis technic using Qualitative approach. The result of this study can lead the next researcher and the decision maker in order to develop the Pillow Lava as the geoheritage for tourism and in the same time to maintain the environment.

Key words: Perception, Pillow Lava, Transfer of knowledge, Geoheritage

PROPOSED REPACKING – BOYOLALI GEOHERITAGE

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ABSTRACT

Geological phenomena complete for learning for future generation (new geologist) in nature is very hard to find. Moreover, Indonesia is a tropical country with very high rainfall resulting in erosion and weathering are very intensive. In the area of District Repaking, Wonosegoro, Boyolali Central Java, Indonesia with coordinates (07012'34'SL, 110037'55'EL), (07012'34''SL, 110040'43"EL), (07016'22"SL, 110037'55"EL), (07016'22"SL, 110040'43"EL), Geological phenomena have a very full interesting and still relatively intact and very good for learning for prospective geologist (new geologist). Phenomena in the form of sediment srtructure, whereas flute casts, humocky, sand dike, slump bedding, mega slump, lamination, bedding, convolute, cross bedding, graded bedding, flysch, mega block, burrow, Load cast. Geological structure, such as Left Reverse Slip Fault, Reverse Slip Fault, Reverse Left Slip Fault, Left slip Fault, Fold. Geological manifestations, can be found Oil seepage (2 points), carbon gas (8 points), Waterfalls (9 locations) with aheight between 3m – 18.5 m, and Cave. In addition to the above phenomenon, the existence of the source rock or origin of oil and gas seepage is still widely discussed and debated by many experts, as yet unresolved. Aside from being a laboratory of geology, this area is proposed as well as regional geology-based Tourism.

Background

Importance as a natural laboratory for the urgent needs of geologists, as well as geological sights is based is in need

Geological phenomena in nature that complete and ideal for learning for future generations (new geologist) has been very hard to find, especially Indonesian is a tropical country with a very high rainfall resulting in erosion and weathering is very intense.

Purpose and Objectives

The purpose of this study is to provide information about the phenomenon - the geological phenomenon that is ideal for learning the Wonosegoro district, Boyolali regency and Kedungjati district, Grobogan regency, Central Java Province, Indonesia, was destination of this study for potential addition to learning geologist (New Geologist) can also be used as a tourist attraction based on geology.

Regional locations and accomplished

Location of administrative, the study sites included in the Wonosegoro district, Boyolali regency and Kedungjati district, Grobogan regency, Central Java Province. ± 40 Km^2 area, with coordinates 07° 12' 34" - 07° 16' 22" SL and 110° 37' 55" - 110° 40' 43" EL.

Location of Yogyakarta can be reached by following the route from Yogyakarta to Boyolali taken using a landline to a distance of ± 80 km, taken for ± 2 hours, and from the city to the location in the District Boyolali - Wonosegoro a distance of ± 24 km, taken for ± 1 hour

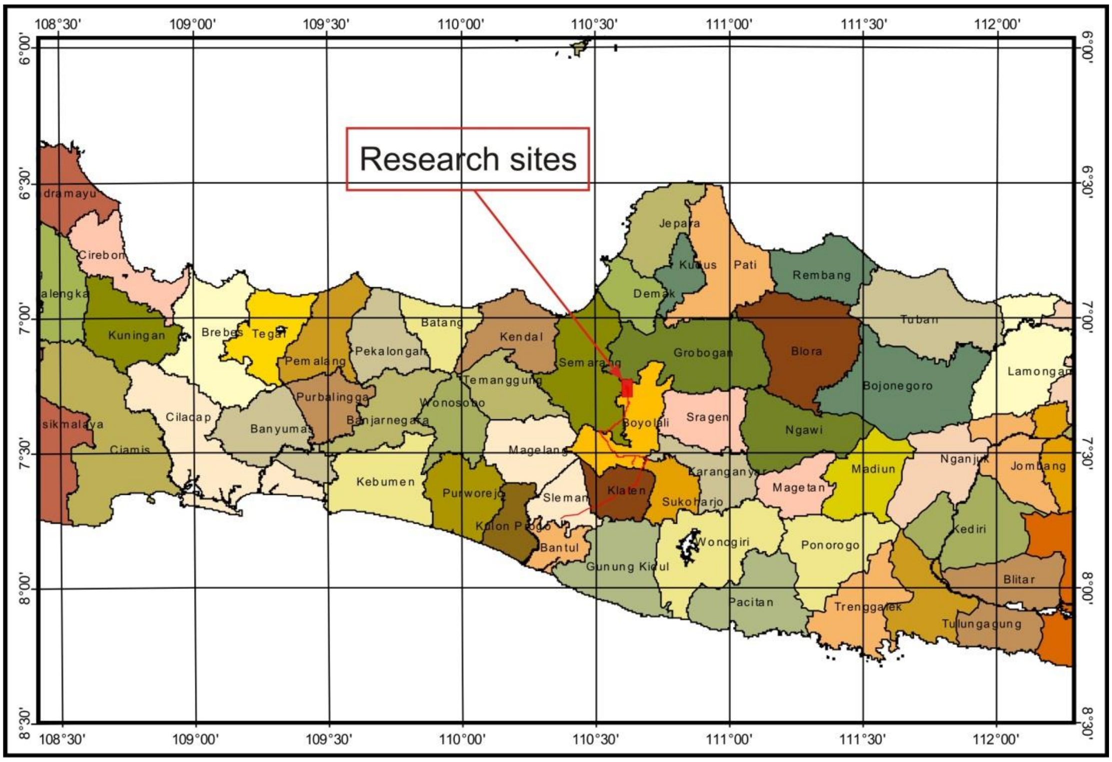


Figure 1. Regional Location Map and Accomplished

Tectonic

The first deformation occurs in Kendeng zone at the end of the Pliocene (Plio - Plistosen), the deformation zone is a manifestation of tectonic plates converge on the concept of compression forces caused by the relative trending north - south with a ductile type of formation is the final phase of brittle deformation turns into a shifting block - basic block Kendeng basin zone. The greater the intensity of the compression force to the western part of Zone Kendeng which caused a lot of folds and faults found up where a lot of reverse fault zone is also the contact between formations or formation members.
Deformation Plio - Plistosen can be divided into three phases, namely the first phase resulting in the formation of folding Geantiklin Kendeng with the general direction west - east and lead in the Eastern Kendeng, the second phase of faulting which can be divided into two, namely faulting due folding and faulting has changed due to deformation of brittle ductile deformation because the rocks have been beyond the depth of plastic. Both of these faults is generally a reverse fault and some have a recumben fault section.
The third phase of a shift in the basic blocks Kendeng basin zone which resulted in a fault - fault trending shear relatively north – south.
The second deformation occurred during the last quarter of a slow and resulted in the formation of structure in the Sangiran dome. This deformation has continued until today with the relatively small intensity with evidence of the formation of the youngest sediments in Kendeng zone the deposition steps.
general, the structure - a structure that is in Kendeng zone form:

A. Fold

That there are fold in the folds Kendeng mostly there are even some asymmetry in the form of overturned folds. the folds in this area there that has a pattern enechelon fold and there is a folds menunjam. In general trending folds in the Kendeng area west - east.

B. Reverse fault

Reverse fault is common in folds that are often found in Kendeng zone, and usually the contact between formations or formation members.

C. Slip Fault

Fault shear zone Kendeng usually air on the northeast-southwest and southeast-northwest.

D. The dome structure

The dome structure that is in Kendeng zone usually found in the Sangiran area lithologies Quaternary age. The evidence shows that the dome structure in this area generated by the second deformation, namely in Plistosen epoch.

Stratigraphy

Most of the sediments are exposed in Kendeng zone in Neogen or Quaternary age. Sediments is often different facies from west to east and from south to north. Stratigraphic Kendeng zones began when sediments were deposited in depressions Kendeng erosional products derived from a series of sedimentation that occurred in Northeast Java Basin to the south.
Kendeng stratigraphic zones can be divided into 3 (three) big primary Sequence, that is;

1. Eocene - Early Oligocene Sequence;
2. Late Oligocene Miocene Sequence;
3. Plio - Plistosen Sequence.

Sequence Eocene - Early Oligocene associated with the initial expansion of the East Java Basin. Late Oligocene section - the underlying Miocene Sequence distinguished by a regional unconformity. Sikuen Plio - Plistosen is not aligned on Sequence Late Oligocene - Miocene.

De Genevraye and Luki Samuel in his GEOLOGY OF THE KENDENG ZONE (CENTRAL & EAST JAVA)**,** 1972 Kendeng share more detailed stratigraphic zones into three parts, namely Kendeng West, Central and Eastern. Refers to this area of research is on the western Kendeng Zone (Figure 2) with the stratigraphic formations from oldest to youngest are:

1. Pelang Formation

This formation began settling in the strip Kendeng Zone. The characteristics of lithology consists of looping between the marl and marl lempungan with insert bioklastik limestone lenses. Stratigraphic relationship with the older rock units can not be known, because it has not been revealed. Based on the content of planktonic foraminifera are abundant in the marl rock bottom of this formation indicates Zone N4 (Blow, 1969) or Early Miocene age.

By looking at the ratio of planktonic foraminifera fossils bentonik content is relatively high (80%), this is interpreted in sedimentation of Pelang formation on the open ocean environment, away from the beach, that is the bathyal zone to a depth of about 1000 to 2000 meters.

2. Kerek Formation

Pelang Formation was deposited over the kerek Formation is aligned. Lithological characteristics, the the bottom of the loop consists of marl clay, marl and clay with calcareous tufa sandstone and tuff sandstones. The middle section between the rocks compiled by intercalation clay with pyroclastic deposits. The top of this formation occupied by clastic limestones that can reach thicknesses of up to 150 meters

In this formation lies stratigraphically below are not aligned Kalibeng Formation which is characterized by the presence of base conglomerates, known as the interval "a" of the sediment sequence of turbidit kerek formation.

This formation is well developed in the mountains of western and central Kendeng, began Purwodadi to Pandan Mount, even to the east is still exposed (to the north Kertosono), then under the plains of the Brantas River. Thickness of this formation + 1000 meters,

Based on planktonic foraminifera, the age of this formation ranges from N 13 - N 16 according to the zoning Blow (1969) or Middle Miocene - Upper Miocene.

With the srukture discovery parallel lamination, konvolut lamination, current strukture interval is interpreted as c, d and e of the sediment sequence of Bouma turbidit are found in almost all layers of this formation, it is clear that the environment of deposition which is a Kerek Formation sediments deposited distal turbidit the a slope basin in upper bathyal environments, with depths between 200-500 meters. From west to east and from south to north, found a change in facies in this formation. Volcanic materials found in this formation is generally coarser grained and more often found in the west, on the contrary to be relatively more smooth and less in the east of Mandala Kendeng. In general, the deposition of pyroclastic material deposited along the Mandala Kendeng, decreases from south to north. Kerek Formation to the north allegedly changed facies into Wonocolo Formation exposed at Mandala Rembang.

3. Kalibeng Formation

Lithology of the Kalibeng formation consists globigerina marl deposits from the massive, greenish and are clay marl, blue or bluish green contain many planktonic foraminifera. Based on stratigraphic relationships, the location of the type of fault with the formation and kerek formation contact, and deposited aligned under a Sonde Formations. Have a broad spread along the Kendeng Mountains starting from Gundih the west until Mojokerto in the east. The thickness of this formation, ranging from 500-700 meters. Age of this formation is Late Miocene to Lower Pliocene, or Zone N 17 - N 19 of the classification of Blow (1969). The characteristics of this formation is the abundance of planktonic foraminifera content of 70% - 80%.
Which characterizes the deposition environment and in that is open sea in bathyal zone to a depth of between 200-500 meters. Kalibeng Formation is divided into three formations member who has a different relationship with the Kalibeng formation own facies are:

a) Member **Banyak of** Kalibeng Formation

This member intercalation consists of tuffs sandstone, breccias and volcanic-rich marl tufaan globigerina, which contain material that is andesite. The thickness of this member is not uniform, ranging from a thickness of 1600 meters - 100 meters. By the age of this member is Late Miocene. Looking at the structure of sedimentary bedding compound intercalation, parallel to bedding, parallel lamination turbidit indicating a precipitate, which was deposited in the marine environment.
Banyak members of the lower part of the Kalibeng Formation the stratigraphic relationships aligned with the older formations, that is kerek formation. whereas the formation Kalibeng own, many members have a different relationship togue facies.

b) Damar Members of Kalibeng Formation

Damar is composed of members of the lithology of conglomerates, pebbles sandstone, calcareous sandstones with mudstone inserts. Where generally the composition of the lithology is andesite. Based on the content of fossils found in these Member of is relative age of the conclusions obtained Moisten end-Pliocene (N17-N20) with the environment of deposition in the form sublitoral (Purnamaningsih, 1982).Another name of this unit is used by Damar Formation Van Bemmelen, 1941 located in Damar river type, Waleri south, east of Central Java. Damar members have different relationships with the Formation intrfingering facies own Kalibeng

c) Kapung Members of Kalibeng Formation

Kapung members are part of the formation lithology Kalibeng who have a solid limestone on the bottom. on the top of the Members Kapung intercalation prepared by the lithology of sandylimestone, bioclastic limestone, coral limestone and marl. Analysis of the data contained in the fossil content of kapung members get it at the age of this unit is the Late Miocene-Early Pliocene (N17-N20) with the deposition of shallow marine environment with activities that coral growth is influenced by volcanic activity. Kapung Formation name used by Van Bemmelen (1941, 1949) located at on Mount Kapung 4 km west of the Kali Tuntang. This member has a relationship with the Kalibeng formation lenses facies.

4. Notopuro formation

In type Notopuro Formation consists of tuff rock sandstones alternating with tuffs, volcanic breccias and conglomerates. This formation is located above the Kabuh Formation was deposited aligned. This formation is widespread in the Kendeng mountains, the south wing from Salatiga in the west to the east Mojokerto. Its thickness varies, at the Kali Rejuno can reach over 240 meters. In general, a lahar deposits that occur on land. This formation was deposited at the age of late Plistosen.

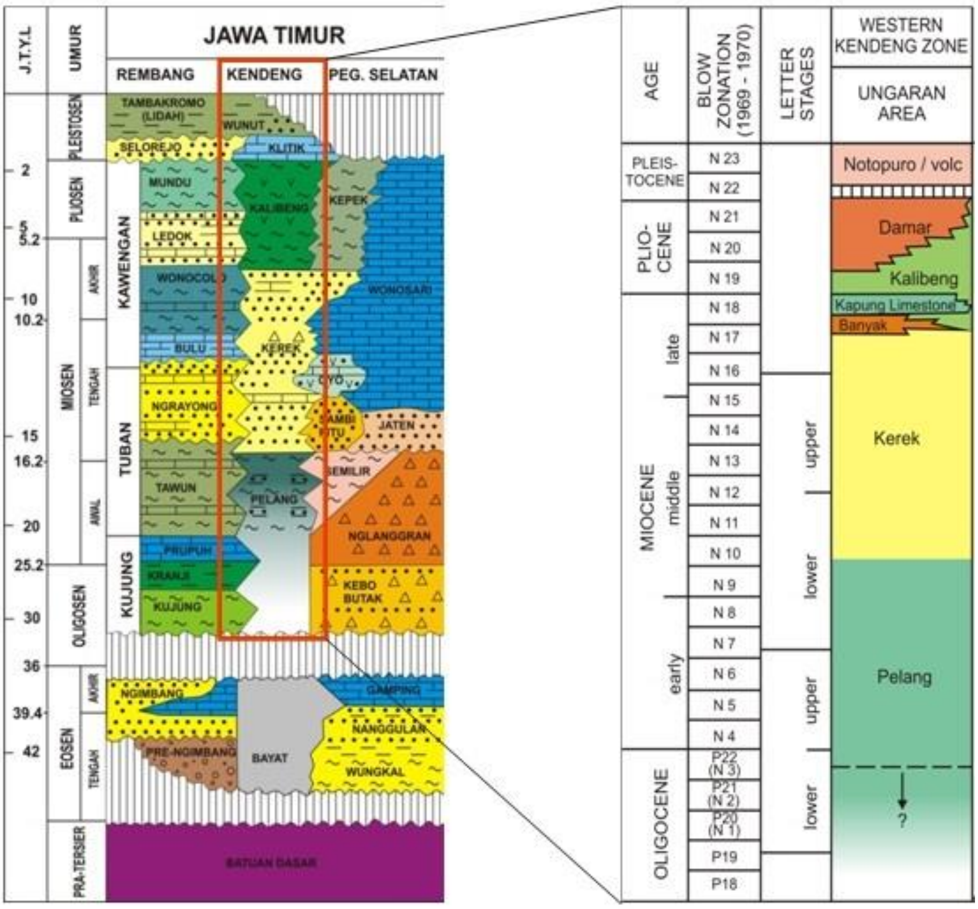


Figure 2. Summary of regional stratigraphy of eastern Java by H. Pringgoprawiro, 1983 (left), the stratigraphic column of the western zone Kendeng by Luki Samuel De Genevraye and 1972 (right), a simple stratigraphy of the Cenozoic Zone Kendeng Smyth et al, 2005

The potential of Local Geology

a) Stratigrafi

1) Kerek Formation

Characteristic lithology of this unit of sandstone and mudstone intercalation tightly enough (Flysch), intercalation mudstone, sandstone and calcareous sandstone found in several places tuffan, this unit is dominated by mudstone with a ratio of 3:1. sedimentary structures in the form Humocky, graded bedding, slump, mega slump, ripple mark, parallel lamination, flute cast, clay pellet, convolute lamination, sand dike, wavy lamination, cross lamination, mudstone is gray to greenish, massive, konkoidal, contain carbonate cement, thick 15-70 cm, calcareous sandstone, brown, fine to medium-sized, fine to medium distinct, rounded, is calcareous, composed of calcite, quartz, and tuff, thick, 5-25 cm. In the southern part of the research areas of high volcanic kerek formation elements in the zone above bathymetri bathial center - with flute cast sedimentary structure with the current direction of an ancient relative of the south to north.

While on the northern part of the research areas of volcanic elements decreases and is dominated by shallow marine elements in terms of sedimentary structures characterized by the presence of micro Humocky and abundant fossils. Flute cast on the northern part of the study area trending north-south, as opposed to the flute casts found in the southern area of research.

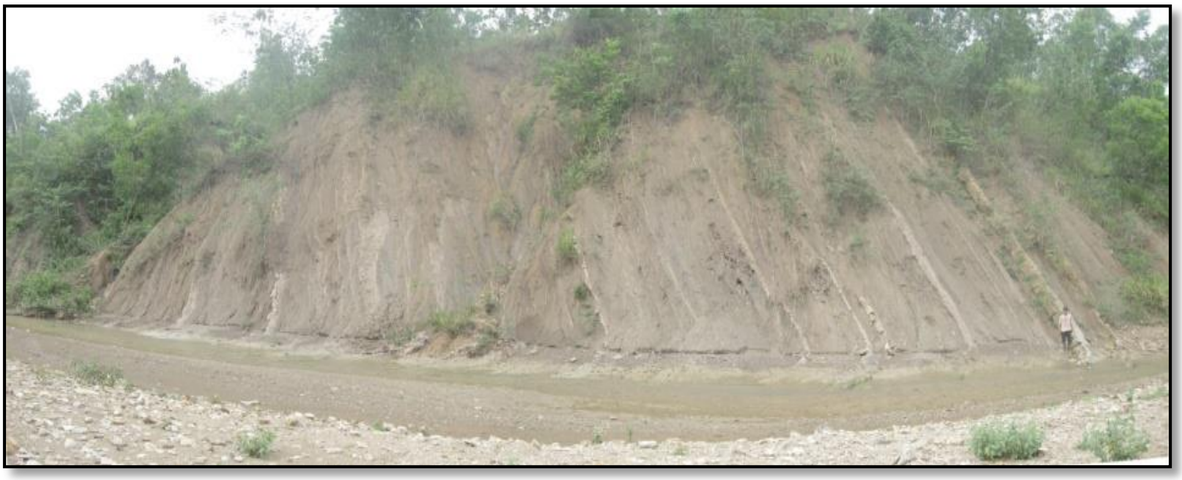


Figure 3. intercalation between sandstone calcareous mudstone which is dominated by mudstone, kerek Formation, on the Village Bengle, District Wonosegoro, Boyolali Regency - Central Java.

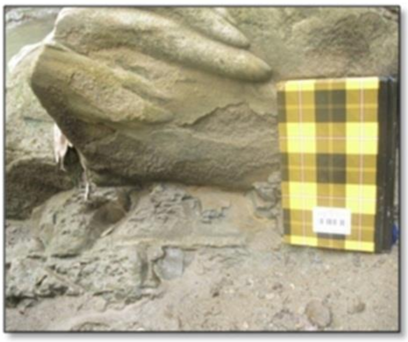
Figure 4. intercalation calcareous sandstones with mudstone between (Flysch) and graded bedding (Ta), parallel to bedding (Tb), convolute lamination, slump bedding (Tc), Parallel lamination (Td), Mega Slump is an indication of sediment turbidit.

Figure 5. The appearance of Sediment Structure in kerek Formation Sand Dike Padasmalang in the Village, District Wonosegoro, Boyolali Regency - Central Java.

fluet cast has an ancient current direction to NE-SW
, Kerek formation, the camera to the Southeast

fluet cast has an ancient current direction to N-S
, Kerek formation, the camera to the West

fluet cast has an ancient current direction to S-W
, Kerek formation, the camera to the Southeast



fluet cast has an ancient current direction to S-W
, Kerek formation, the camera to the Southeast

Figure 7. Flute cast and direction of deposition of ancient currents

1) Members of the Formation Kalibeng

Lithology units making up this form of alternation between Tufan sandstone, calcareous sandstone, calcareous sandstone and pebble sandstone. Generally well layered, sedimentary structures are frequently encountered form of bedding, parallel lamination, graded bedding, mega block, sometimes found sphaerodal wheatering, with the dominance of sandstones tuffan.

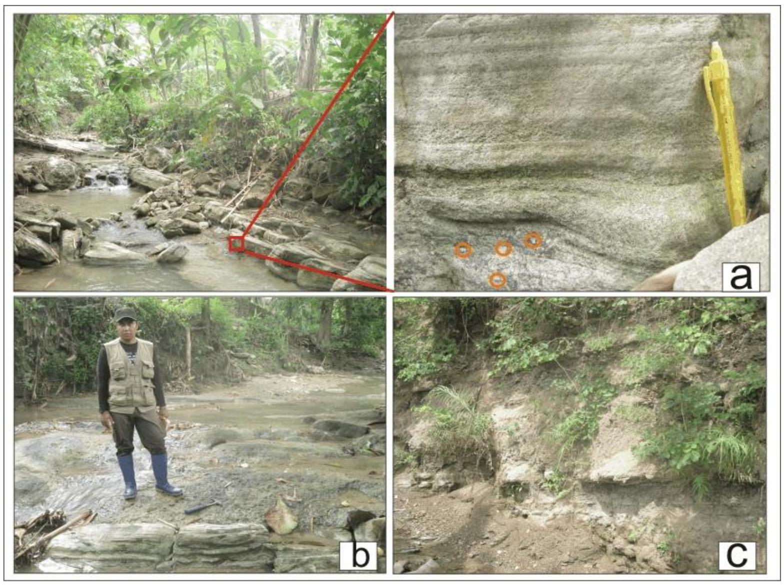


Figure 8. Tuffan sandstones with graded bedding and parallel structure of the laminate (A), calcareous sandstone and pabbles sandstone (B), calcareous siltstone (C).

Figure 9. Mega bloks Structure Banyak Member of the Kalibeng Formation In Grogol village, Grobogan Regency - Central Java.

a) Geology Structure

1. Jatilawang Fault

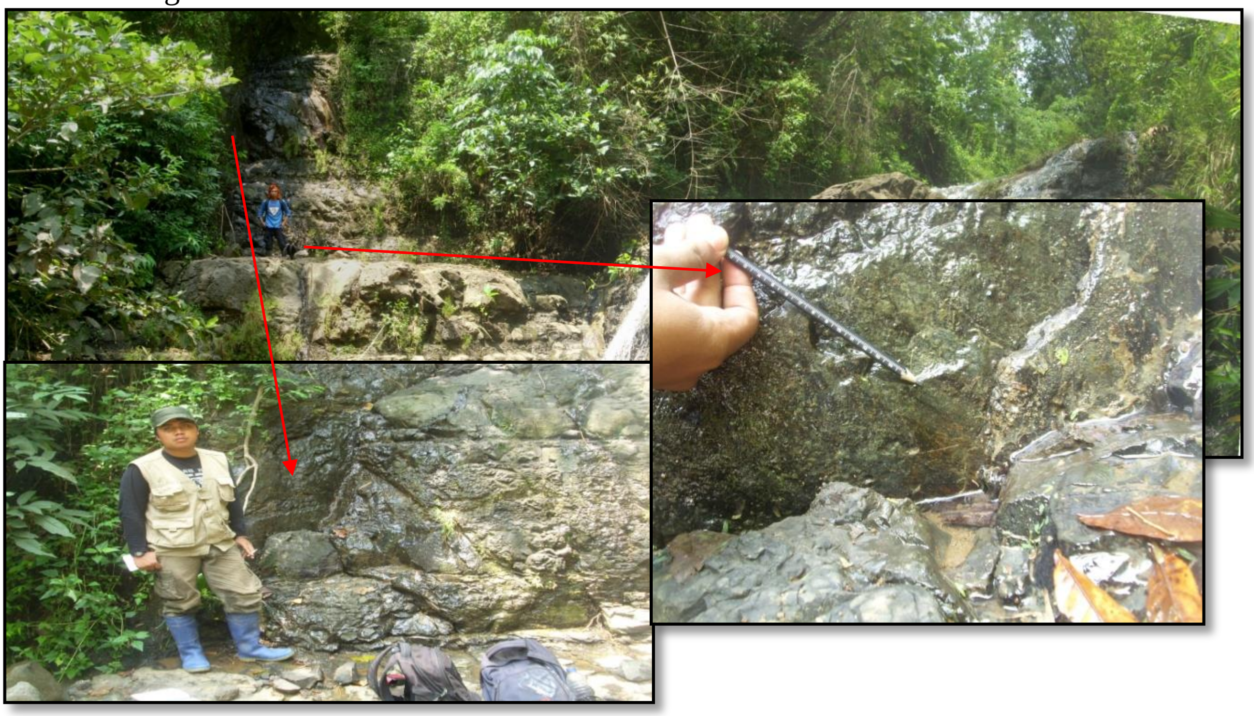


Figure 10. The appearances Jatilawang fault (Left Reverse Slip Fault (Rickard (1972)) in Banyak members of the Kalibeng formation, Jatilawang Village, District Wonosegoro, Boyolali Regency - Central Java

2. Garangan Fault

Figure 11. The appearance of vertical layers and fault zone in Garangan fault (Reverse Slip Fault (Rickard (1972)).

3. Panimbo Fault

Figure 12. The appearance of Panimbo faults (Reverse Left Slip Fault (Rickard (1972)) in Kerek Formation in the Panimbo Village, Wonosegoro District, Boyolali Regency - Central Java

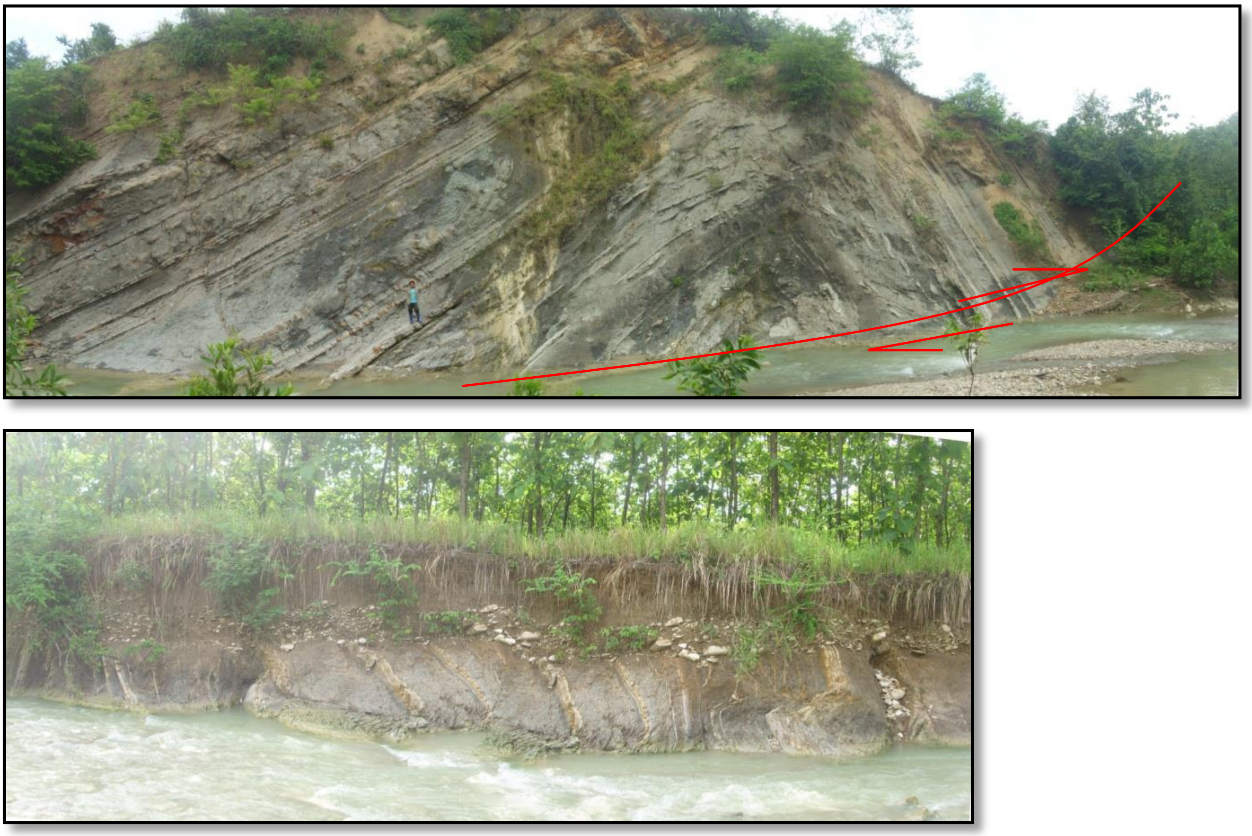


Figure 13. The appearance Wuluhan Fault (*Thrust left Slip Fault* (Rickard, 1972)) in Kerek Formation in the Wuluhan Village, Wonosegoro District, Boyolali - Central Java

Figure 14. The appearance Ngetuk Fault (*Right Reverse Slip Fault* (Rickard, 1972)) in kerek Formation in the Ngetuk village, Wonosegoro District, Boyolali Regency - Central Java

4. Wuluhan Fold

Figure 15. The appearance of the fold axis (C), wing folds (A, B) from Gandu Fold *Upright (Gentle Plunging Fold* (Fluety, 1964)) Kerek Formation in the Gandu Village, Wonosegoro District, Boyolali Regency - Central Java

c. Oil and Gas Seepage

At the location there are two seepage of oil and gas seepage 8 location.

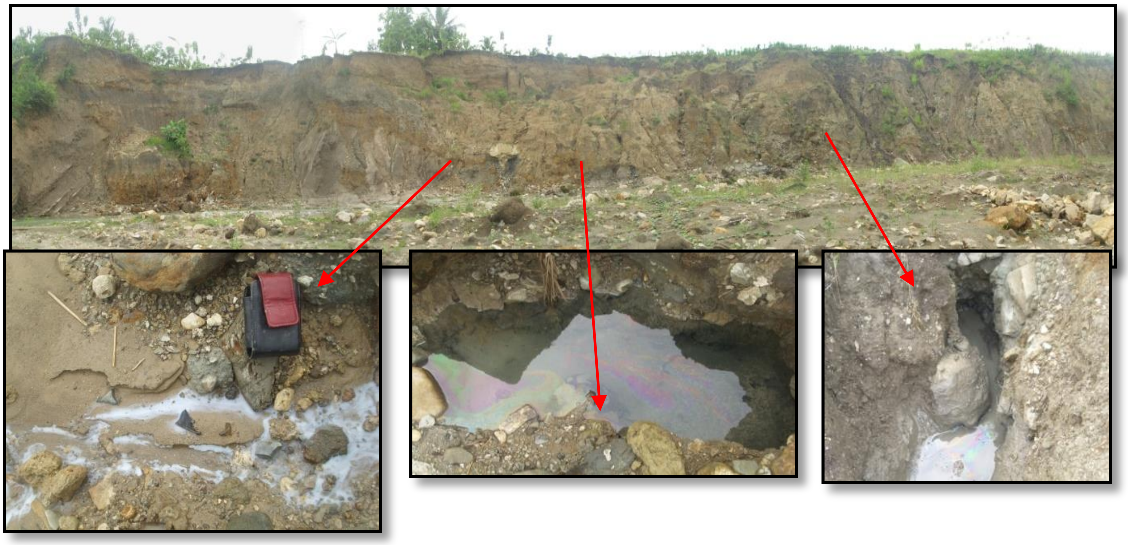


Figure 16. Oil seepage in kerek Formation, the Repaking Village, Wonosegoro District, Boyolali Regency - Central Java.

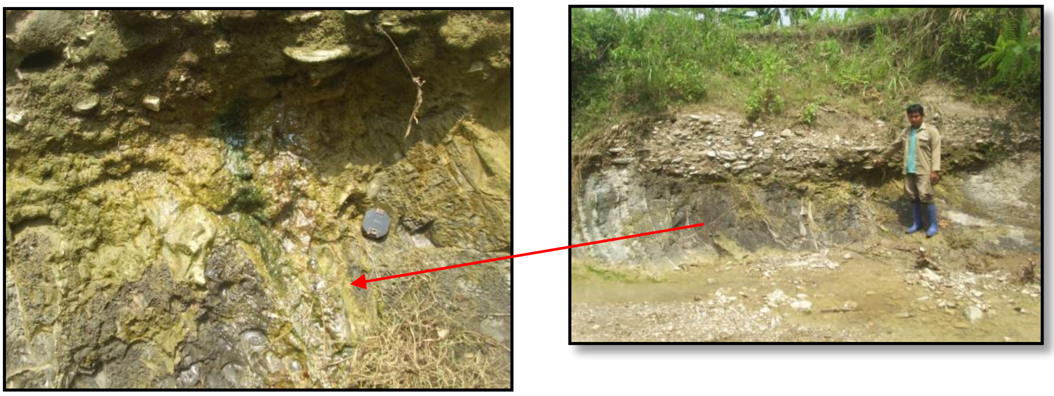


Figure 17. Oil seepage in kerek Formation, Panimbo village, Wonosegoro District, Boyolali Regency - Central Java

Figure 18. Gas is mixed with water seepage in kerek Formation, Bendungan Village, Wonosegoro District, Boyolali Regency - Central Java

Figure 19. Gas is mixed with water seepage in kerek Formation, Muning Village, Wonosegoro District, Boyolali Regency - Central Java

Figure 20. Gas is mixed with water seepage in kerek Formation, Padasmalang Village, Wonosegoro District, Boyolali Regency - Central Java.

Positive Geological Potential

1.Tourism

Figure 21. Waterfall with a height of ± 18.5 meters which is the contact boundary Kerek formation and Banyak members of the Kalibeng formation, Gunungsari village, Wonosegoro District, Boyolali Regency - Central Java

Figure 22. Waterfall with a height of ± 95 meters in first and ± 12 meters on the second waterfall located at Banyak Members of the Kalibeng Formation, Tegalsari Village, Wonosegoro District, Boyolali Regency - Central Java

Figure 23. Ngrincing Cave with ± 6 meters in height Kapung Member Kalibeng Formation in the village of Gunungsari, Wonosegoro District, Boyolali Regency - Central Java

CONCLUTION

At the Wonosegoro subdistrict, Boyolali district and Kedungjati subdistrict, Grobogan district-Central Java, Indonesia. has the potential geological interest if the review of aspects of lithology, geological structure and the geological-based tourism, among others:

1. Aspect turbidit sediment lithology found shallow and deep.
2. Aspect of sedimentary structures found ***Humocky, graded bedding, slump, mega slump, ripple mark, parallel lamination, flute cast, clay pellet, convolute lamination, sand dike, wavy lamination, cross lamination, bedding, mega block, sphaerodal wheatering.***
3. Aspects of the geological structure of faults, folds and fracture presence in the area of research is still clear and very nice.
4. Aspect of current measurements found Flute Cast ancient ideal that is still an indication of ancient currents in the study area there are two opposing currents in which the ancient southern study area trending from south to north, while in the northern part of the study area has a direction from north to south.
5. There are aspects of the geological manifestations of the oil and gas seepage.
6. Aspects of tourism found many waterfalls and caves.
7. The area we are proposing as a natural laboratory and attractions