DEVELOPMENT OF DEEPWATER FACIES AND PALEOGEOGRAPHY MODEL IN FORE ARC BASIN: AN EXAMPLE FROM THE HALANG FORMATION, BANYUMAS SUB BASIN, CENTRAL JAVA

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Mio-Pliocene Halang Formation is mostly distributed along Southern Serayu Mountains, Central Java. This formation is commonly deposited on deep marine environment and interpreted as a product of submarine fan deposits. This paper is concerned to interpret facies development and paleogeography model of Halang Formation during Middle Miocene in Cibangkong Area, Banyumas Sub Basin. This study is also passed several methods based on outcrop observations and laboratory analysis. The primer data such as measuring section, biostratigraphic and granulometry analysis, supported to build facies development. Integrated facies model, paleocurrent measurement, and secondary data (gravity, provenance, structure trend, and basement configuration) build a paleogeography model. In study area, Halang Formation is particularly characterized by interbeded carbonaceous sandstones facies and carbonaceous claystone facies which is capped by massive sandstone facies with erosional contact. The integrated analysis could lead interpretation in the study area that Halang Formation is a part of the fan lobes facies. Paleogeography model shows that sediment supply comes from Southwest to the Northeast. Karangbolong high is located in the West to Southwest, is thought to be the center erosion and supplies the Halang Formation. Discovery of volcanic and limestone fragment in one of sandstone layer in Halang Formation supported the paleogeography model. The presence of volcanic and carbonate material simultaneously indicates that there is a volcanic activity in proto-Kumbang as well as the possibility of carbonate that have grown in Karangbolong High in West to Southwest of the research areas.

Kata kunci : Halang Formation, Deepwater Facies, Paleogeography

I. INTRODUCTION

Mio-Pliocene Halang Formation is mostly distributed along Southern Serayu Mountains, Central Java. This formation is commonly deposited on deep marine environment and interpreted as a product of submarine fan deposits. This paper is specified discussing interpretation facies development and paleogeography model of Halang Formation during Middle Miocene in Cibangkong Area, Banyumas Sub Basin. Halang formation rocks were deposited in turbid current system that occurs in the deep sea. The generated sediment product is called turbidite deposit. Geometry problems in turbidite sedimentary rocks is very complex, and it’s existence depends on how, when, and the type of environment (Praptisih & Kamtono, 2011). Genetically turbidite deposit was strongly associated with the decline of sea level and abundance of sediments materials transported into basin. Geometric forms of turbidite deposition generally always resemble the “fan” which rich of sand "Sand-Rich Submarine Fan" (Mattern, 2004). The purpose of this research is to create a research study on the character of facies turbidite owned by a unit of sandstones of Halang Formation, characteristic of turbidite facies that grow in the research area, so can be identified the history of depositional environment and interpret the characters turbidite facies along with the environmental model deposition through profile analysis data of turbidite
II. GEOLOGICAL SETTING

Serayu Basin of South and North Serayu currently separated by Karangsambung basement high that extends with direction SSW-NNE on the island of Java. In this case, regionaly material sources of sediment or Provenance at Basin Serayu south is the Sub-basin Banyumas, derived from the uplifting of Geantiklin on the south side of the island of Java which composed of sedimentary material that is closely related to the volcano tertiary and carbonate rocks (Satyana, 2004). The research area is located in the Sub-basin Banyumas regionally located in a system of basin bounded by two right slip fault, namely Karangbolong Fault and Gabon Fault trending northwest - southeast, as well as normal fault trending northeast - southwest forming half graben in early Miocene. Graben developments caused by tectonic region in the Late Oligocene that begins with right slip fault heading to the horizontal with northwest – southeast trending (Muchsin et al., 2003) (Figure 1).

Halang formation is generally composed of calcareous sandstones, pebbly sandstones, tuffaceous sandstone, marl, tuff marl, claystone, claystone marl, breccia marl and inserts kalkarenit. Lithostratigraphi units of this formation had rock stratotype in the Geger Halang area, Kuningan, West Java. This formation deposited above Lawak formation, followed by Tapak formation. Tapak formation shows unconformity relationship with the underlain formation. The thickness of this formation range from 400 meters to 700 meters or more. Halang Formation aged Middle Miocene to Early Pliocene (N15 - N18). Based on the findings of benthic foraminifera such as, Lepidocyclina (Tryblolepidina) ruteni, Lepidocyclina borneensis, Lepidocyclina douviilet, Cycloclypeus indopacificus, C. Postindopacificus. Depositional environment of Halang formation is on upper bathial based on the finding of Gyroidina sp. and Eponides sp., with a depth of between 200 to 500 meters (Safarudin, 1982).

III. METHODS & DATA

Methodology in research divide into three stage, i.e.: Observation stage; field work such as observation, measuring section, description, and collecting sample. Laboratory analysis stage; Petrography analysis, and Paleontology analysis. Interpretation stage; Sedimentological analysis, structural geology analysis, and establishing paleogeographical model (Figure 2).

Primary data acquired from observation including rock description along with rock sampling, detailed profile, measuring section. Continue with various analysis, including biostratigraphic and granulometry analysis, measuring section analysis, petrography analysis and structure analysis based on acquired data on field. The result used to conduct facies development analysis resulting integrated facies model. Integrated facies modelling were build based on three observation site data, BMS-54, BMS-64, and BMS-80.

Integrated facies model, paleocurrent measurement, and secondary data (gravity provenance, structure trend, and basement configuration) then combined to build paleogeography models.

IV. DEPOSITIONAL FACIES ANALYSIS

Based on appearance in field, the low part consists of interbedded calcareous sandstone - calcareous claystone sufficiently tight called “Flysch Deposited”. Whilst on the upper part present massive sandstone with erosional contact, with grain sized coarsed to medium sand, recurring into floysch deposition again (Figure 3). According to Walker’s, 1978 facies model turbidite deposit, these outcrop belongs to “Smooth portion of suprafan lobes” facies. Overall dimension of the outcrop is ± 5.2 to 8 meters, with height ± 2.3 to 3 meters. Measurement strike and dips have been done at all three observation sites with result at BMS-54 is N 255° E/45°, BMS-64 N 250° E/15° and BMS-80 N 257° E/42°. The following is detailed description of lithology consisting the outcrop.
Calcareous sandstone with thickness ± 40 cm to 1.27 meters, colored grey to dark grey, grain size medium sand to coarse (1/4mm-1mm), sub angular to sub rounded, medium sorting, open fabric consisting quartz pyroxene, feldspar, claystone lithic, tuff with clay matrix. At the body of massive sandstone frequently encountered sediment structure “dish structure”, characterized with the presence shape of concave upwards, formed as the result of fluids squeezed out either vertical or lateral through rock pores during sedimentation burial. The sandstone has erosional contact with flysch deposits under it.

Calcareous claystone with thickness 5 cm to 25 cm, colored dark grey, grain size clay (>1/125mm), sediment structure parallel lamination, mixture of carbonate with silica cement.

Based on Kuenen (1950) concept, Turbidite facies on the three observation sites characterized on lower sequence by the presence of interbedded calcareous sandstone - calcareous claystone sufficiently tight (Flysch). Whilst on the upper present massive sandstone with erosional contact, with grain sized coarsed to medium sand (1mm-1/4mm), featuring appearance of dish structure. Based on Kuenen, 1950 concept, interpretation of turbidite facies of three observation sites is “Proximal to Distal Turbidite”.

Based on Bouma (1962) concept, Bouma facies on the three observation sites only Td-Te interval, that is parallel lamination and pelagic clay.

Addressing the appearance Td-Te interval, on the three observation sites based on Walker, 1978 viewpoint, belongs to Classical Turbidite (CT) facies, while sandstone with thickness more than 1 meter constitute as Massive sandstone (MS). Those presented facies depositioned on middle fan-lower fan (Walker, 1976).

Based on Mutti (1992) concept, seeing the grain size of sediments material in every layer, facies of these outcrop belongs to lithofacies F8 and F9. F9 facies characterized by layers consist of upper Bouma sequence (Td-Te). Whilst F8 facies characterized by relatively coarse sandstone sediments.

Based on Shannugam (2005) referral concept, transportation process of sediments material on profile section of CT facies is Newtonian Turbidity current/bottom current, while on MS facies is Sandy Debris Flow.

From analysis result above, the three observation sites namely BMS-54, BMS-64, and BMS-80 interpreted formed at middle fan – lower fan floor with facies type smooth portion of suprafan lobes – lower fan (Walker, 1978).

Based on foraminifera plankton content at BMS-54 consisting Globigerinoides trilobus, Globorotalia plesiostumida, Globigerina decoraperata, Globigerinoides ruber, Orbulina universa, Globorotalia crassaformis, Globorotalia menardii and Globorotalia pseudopima. From paleontology analysis, concluded that turbidite facies “smooth portion of suprafan lobe” at observation site BMS-54 have relative age at N.17-N.18 (Late Miocene-Early Pliocene).

At observation site BMS-64 consisting of foraminifera plankton as Globorotalia cultrata, Globigerina decoraperata, Globorotalia plesiostumida, Sphaerodinellopsis subdehiscens, Orbulina universa, Globigerinoides sacculifer, and Globigerinoides trilobus. Observing the component and the result of paleontology analysis, turbidite facies of “smooth portion of suprafan lobe” at observation site BMS-64 have relative age at N.17-N.18 (Late Miocene-Early Pliocene).

Last observation site BMS-80 consisting of foraminifers plankton such as Globigerinoides fistulosus, Globigerina sacanus, Orbulina universa, Globigerinoides altiaperturus, Globoquadrina dehiscens, Globorotalia merotumida and Globigerinoides ruber. Based on this paleontology analysis, author conclude that turbidite facies “smooth portion of suprafan lobe” at observation site BMS-80 have relative age at N.16-N.18 (Late Miocene-Early Pliocene). This outcrop relatively older than BMS-54 and BMS-64.

By the result of paleontology analysis that have been performed, turbidite facies of
BMS-54 and BMS-64 still have same age range. This reflect both of facies founded at two observation site still linked as one type of deposits environment and the same age as sedimentation occur. On the other side at observation site BMS-80 have older relative age. Meaning that turbidite facies “Smooth portion of suprafan lobe” at BMS-80 didn’t have linkages both at the age or when sedimentation occur. This might be affected by existence of Depok reverse fault act as boundary between the three facies that has been correlated in three dimensional using diagram fence (Figure 4.a). The reverse fault allegedly rises a stratigraphic unit at Halang calcareous sandstone unit, where rock layers which relatively older exposed on the surface (Figure 4.b).

From the result of petrography analysis of both lithology, sandstone at BMS-64 has a name “Chiefly Vulcanic Wacke”, Gilbert 1954, while claystone at BMS-54 based on petrographic analysis named “Claystone”, Gilbert 1954.

Based on the result of measurement cross-lamination structure at observation area related to interpretation direction of paleo current near observation site BMS-99, BMS-113, and BMS-106. After conducting stereographic analysis, continued by plotted to roset diagram, obtaining information at observation area have trend of general direction value N 085° E (East) and N 232° E (Northeast) (Figure 5).

Primary data result of measurement sediment structure related to determine the pattern of paleo current direction combine with gravity data of Java Island in attempt to interpret paleogeography deposits model of Halang formation, evolved structure pattern, basic basin configuration, provenance source, and tectonic order that happened in observation area. By using relief-shaded Bouguer’s anomaly pattern, it’s possible to interpret structure pattern, basin geometric, and the highs at Banyumas sub-basin (Figure 6).

Pink-red colour (>95mGal) reflecting bed rocks and consolidated igneous rock such as Gabon High, Karangbolong High, and southern mountain lane stretch out south side of Java island. The lowest value of Bouguer’s anomaly (<0mGal), dark blue to light blue colored usually reflecting groups of sediments at sub basin with significant thickness. Orange-yellow color represents high value of Bouguer’s anomaly (>60mGal), usually forming ridge and consolidated hills which interpreted as lineament or fault and the possibility residual from volcanic body.

The lineament connected with Karangbolong fault with northwest-southeast direction, form of right strike-slip fault (Muchsin, et al., 2002). Geophysics data showing the Karangbolong fault constantly towards offshore as deep fault (Bolliger and de Ruiter, 1975) same as Gabon dextral strike-slip fault collateral with Karangbolong fault (Bolliger and de Ruiter, 1975, Muchsin, et al., 2002).

Aside from above matter, author try to interpret the existence of paleohigh located on west-southwest observation area is Karangbolong High. Karangbolong high as source of sediment supplier which this area act as the center of erosion. Furthermore, the discovery of limestone fragment ingained at the body of massive Halang calcareous sandstone layers (Figure 7). The discovery located near observation site BMS-99. Related to geological phenomenon which has been encountered, and supported by the presence volcanic and carbonate materials simultaneously indicated the existence of proto-Kumbang volcanic body as well as the possibility carbonate growth and development at Karangbolong high located west-southwest of observation area. Limestone assumed equivalent as Kumbang limestone.

V. PALEOGEOGRAPHY MODEL

By seeing the direction of sediment transport that develop from West to East and southwest towards Northeast, it can give the idea about the sediment supply. The supply is derived from the ancient high located in the West-
Southwestern area of research. According to previous researchers (Martodjojo, 1984; Martodjojo, 1994; Clements and Hall, 2007), the source of the Halang formation comes from the south. In a previous study of Turbidit Facies, the source of the Halang Formation turbidite deposits in the southern part of Central Java area, mainly around ciliacap towards banyumas comes from the south – southwest (Praptisih and Kamtono, 2011).

In addition to the primary data in the form of the results of sedimentary structure measurements associated with the ancient flow direction pattern determination, the author also combines with gravity data, structural pattern, basin configuration, provenance, and tectonic that occurred in the area of research to interpret the paleogeographic model of the Halang formation. By utilizing the pattern of Bouguer anomalies, it can interpret the bedrock structural patterns, forms of basins, and altitude specifications on Sub-Basin Banyumas. The pink – red color (> 95 mGal) reflect on the bedrock and consolidated volcanic rocks such as Gabon High, Karangbolong High, and the South mountains stretching along the southern side of Java. The rock has relatively high-very high anomalies. While the very low value of Bouguer anomaly (< 0mGal) indicated with dark blue to light blue color reflects the rocks that have low anomaly. Generally, it is a sedimentary rock that deposited on the sub basin. It can be seen on the Bogor basin, and North Serayu Basin. While on some locations, the value of the Bouguer anomaly is moderate (40 – 60 mGal) reflected by the green color. These colors can be seen on some of the sub-basins in Central Java including Banyumas Sub-basin. Bouguer anomalies in Tegal district forming the Ridge, which is a disturbed zone are referred to Tegal diapirs (Suyanto and Sumantri and also, 1977). This diapirs acts as the boundary between the western part and eastern part of North serayu Basin. The Orange – yellow color represents the high value of the Bouguer anomaly (> 60mGal), generally form a ridge or isolated hills which are interpreted as liniation or faulting and possible residual volcanic body. Early results showed unequivocally structure interpretation with west - east liniation in Banten towards Majalengka is likely the trace of the southern boundary from Bogor Basin (see Martodjojo, 2003) or traces of thrust faulting. The liniation is connected with the Karangbolong fault with Northwest-Southeast direction, in the form of right slip fault system (Muchsin, et al., 2002). Geophysical data suggest that the Karangbolong fault continuously towards offshore as faults in (Bolliger and de Ruiter, 1975), as well as the right slip fault of Gabon who aligned with the Karangbolong fault (Bolliger and de Ruiter, 1975, Muchsin, et al, 2002). Pamanukan-Cilacap liniation zone (Satyana, 2005, 2007; Armandita et al., 2009) is interpreted as right slip fault most likely joined the Karangbolong fault. The estimated Gabon dextral fault and Pamanukan – Karangbolong which evolved into a duplex fault system or pull-apart structure. Thinning of the crust, the formation of basins or sub basins, or volcano activity is controlled by a system of structural geology that occur in the area of Majalengka – Banyumas. Regardless of the explanations, the authors try to interpret that the existence of the ancient high in the West-Southwestern area of research is the specifications of Karangbolong High. A Karangbolong stable altitude act as a sediment source supplier which at this altitude is also acting as a focus for erosion. In addition, a limestone fragment found embedded in a layer of Halang calcareous-sandstone with massive structure. The location of this discovery is around BMS – 99. Related about geological phenomenon that found in the field, the figure of carbonate and volcanic materials found simultaneously, this indicates the presence of a volcanic body of proto-Kumbang along with the possibility of carbonate ever growing on Karangbolong high in the Southwest area of research. This limestone is assumed to be equivalent to the Kumbang limestone.

VI. CONCLUSION

- Based on the observations about the texture and sedimentary structures, the deposition occurs in the units of Halang Calcareous-Sandstones are influenced by the presence of a turbidity currents that deposited on the submarine fan
progradation systems. The turbidite facies dominated by CT (Classical turbidite) & MS (Massive sandstone) that are deposited in the environment of the Middle fan and Lower fan.

- Correlation can be interpreted that the submarine fan lobe of Halang calcareous-sandstone has convex-shaped geometry towards southeast-east. The existence of the Depok thrust fault contribute significant deformation over older lithology at BMS - 80 lifted at the surface.

- Based on the paleocurrent measurements in the area of research, the sediments source material derived from the West-Northwest. It illustrates that the presence of an ancient high (Paleohigh) located in west-southwest of the area of research. Author assumed the paleohigh is Karangbolong high. Then based on the volcanic elements and carbonate material simultaneously indicating the presence of a volcanic body (Proto-Kumbang) as well as the possibility of carbonate at Karangbolong high in the west - southwest area of research. The limestone assumed to be equivalent with the Kumbang limestone.

VII. ACKNOWLEDGEMENT

We would like to thank all SEMNAS UGM committee for publishing this paper, and also all of the GPRG member, and Dr. Ir. H. Suyoto, M.Sc. and Ir. H. Kuwat Santoso, M.T.

REFERENCES


**FIGURES**

![Map of Central Java Basin](image)

**Figure 1.** Structure and the basic configuration of the southern part of Central Java Basin the Miocene (Muchsin, 2003), the research area is located in Banyumas-Tract Low.

![Methodology Flowchart](image)

**Figure 2.** Flow chart of methodology
Figure 3. Appearance of few outcrop of Halang calcareous sandstone unit which has been correlated as “Smooth portion of suprafan lobe” turbidite facies, Walker 1978.

Figure 4. a.) Two-dimension diagram fence correlating “Smooth portion of suprafan lobe” facies. The presence of the effect from the Depok reverse fault is visible as the fault contribute of the exposed older layer at observation site BMS-80. b.) Three-dimension diagram fence correlating “Smooth portion of suprafan lobe” facies at observation site BMS-54, BMS-64, and BMS-80.
**Figure 5.** Plotting result at roset diagram of paleo current data cross lamination structured found at observation area.

**Figure 6.** Model approach regarding paleogeography history interpretation of Halang formation sedimentation. Where west part of observation area occurs *stable high* which interpret as Karangbolong high.
Figure 7. Measuring section at Kali Sawangan