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Bentonite Characteristic of Miocene Sedimentary Deposit in Bogor Basin, Its Application for Purifying Oil Waste

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Abstract— *Bentonite is a phyllosilicate layering mineral that have tremendous psyco-chemical properties making it versatile in industrial application. Bentonite in Indonesia found in widely geological environment, it can be obtained as weathering or devitrification product of volcanic glass, alteration of volcanic rocks, and deposited in many marine sedimentary rocks. Bogor Basin in the western part of Indonesian fulfilled with two Miocene sedimentary deposits containing clay shale that associated with bentonite. The clay shale in the Jatiluhur formation showed dark grey color calcareous clay with shally texture deposited as deep marine sedimentation, meanwhile clay shale of Cantayan Formation showed light grey color tuffaceous clay with massive texture, non-calcareous which related with volcaniclastic deposit. This research was conducted by geological mapping and laboratory analysis (petrography, X-Ray Diffraction, Scanning Electron Microphobe) to characterize shale clay from both Jatiluhur and Canyatan Formations, and also simply laboratory experiment in applying both shale clay as purify material to cooking oil waste. The purpose of the study was to determine the psychochemical of shale clay in Bogor Basin and seeing its potention as purify material of oil waste. The research showed that volcaniclastic clay shale of Cantayan Formation is more effective to purify the oil waste than the marine clay shale from the Jatiluhur Formation. The SEM and XRD analysis suggest the significant occurrence of montmorilonnite in volcaniclastic clayshale of Cantayan Formation that makes it more applicable to purify cooking oil waste*.

Keywords— *Bentonite; Cantayan Formation; Purify Oil Waste.*

I. INTRODUCTION

Bentonite $(Na,Ca)(Al,Mg)_6(Si_4O_{10})_3(OH)_6\text{-}nH_2O$ is a clay material that has a particular characteristic, it swells when exposed to water and has great cation exchange ability due to its layering crystal structure (Mukherjee, 2011). This characteristic makes bentonite applicable to various types of industries, especially those that require adsorbent media and catalysts in their production process (Abdou et al, 2013). Kusuma (2012) reveals that bentonite is very applicable in palm oil processing and pharmaceutical industries. Bentonite potency in Indonesia is large, according to the abundance of sedimentary clay deposits and volcaniclastics as the source of bentonite. But until now, only a few areas have been explored as bentonite mines, they are Pacitan in East Java and Tasikmalaya in West Java. The Miocene-aged clay shale unit exposed in the Sentul Regency, Bogor Area, along hills and river terraces, showed various colors ranging from dark to light grey, and these clays tend to swell when exposed to water. The clay shale is part of the sedimentary Jatiluhur Formation and volcaniclastic Cantayan Formation. The clay shale then associated with bentonite and how its psycho-chemical characterization affects their ability in purification uses, is examined in this research.

The research area took place in Babakan Madang, Sentul Regency. It is located in the Bogor basin, which is tectonically associated with Oligo-Miocene back-arc basin (Martodjojo, 2003). Bogor Zone showed high relief morphology with few structure anticline trend in the east-west axis. The main deposit of Bogor Anticlinorium consists of thick Miocene sedimentary rock that was uplifted and then eroded until it was exposed. Starting from the Plio-Pleistocene period, the Bogor basin was occupied by magmatic pathways until now (Soeria-Atmadja et al., 1998). The object of research is clay shale originating from the Middle Miocene Jatiluhur Formation and clay shale of the Cantayan Formation of the Late Miocene age. The Jatiluhur Formation is the oldest rock exposed in the Bogor Basin. This formation was overlain by limestones of the Klapanunggal Formation/ Parigi Formation in the northern part (Abdurrokhim, 2017; Martodjojo, 2003), while in the south area it is covered by volcaniclastic marine deposits of the Cantayan Formation (Abdurrokhim, 2017; Sudjatmiko, 1972). Both volcaniclastic Cantayan Formation and limestones of the Klapanunggal Formation are covered by the Subang Formation claystone. Pic. shows stratigraphy regional of the Bogor basin and distribution of sedimentary formation in the surface outcrop. There are two other names pinned to the formation Jatiluhur, namely: (1) Upper Cibulakan Formation or Cibulakan Formation (Martodjojo, 2003) and (2) Annulatus Sedimentary Complex (Van Bemmelen, 1949), which represents the oldest sedimentary rock exposed between the Bogor area. Formation Jatiluhur is often used as an analog for the reservoir potential of a deep marine turbiditic system for the exploration of oil and gas.

The composition of bentonite will vary depending on the genesis and environment of formation. Yulianti, et al (2018) stated that there are three main processes for the formation of bentonite, such as devitrification of volcanic glass in volcanic deposits; alteration of minerals in hydrothermal alteration areas; and deposition of sediments rich in Ca-Na elements.

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Abdurrokhim (2013) stated that the clay rock units in the Jatiluhur Formation, Bogor Basin, are composed of smectite material that can swell when exposed to water, this rock unit is deposited through a process of marine sedimentation by turbidite mechanism.

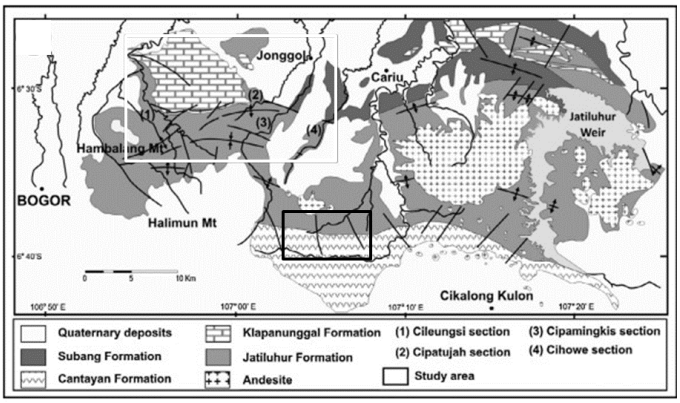

Fig. 1. stratigraphy regional of the Bogor Basin and distribution of sedimentary formation in the surface outcrop (Modified mainly after Sudjatmiko (1972))

The claystone units of the Cantayan Formation are much exposed in the southern part of the Bogor basin and were also deposited through the same process of marine sedimentation, but with an influx of volcanic material that distinguishes its physico-chemical characteristics from the Jatiluhur Formation. Begaya et al. (2006) stated that in the bentonite crystal structure, some of the silica ions in the tetrahedral group will be replaced with alumina ions, and some aluminum ions in the group octahedral ions will be replaced with Ca2+, Mg2+, Na+, K+ or H+ ions, depending on the type of charge the crystal. The Physical and chemical properties of bentonite found in both the Jatiluhur Formation and the Cantayan Formation will be different, depending on the impurities (impurities) that occur at diagenetic sedimentation and the environment in which they are formed. Although currently used bentonite mostly comes from Pacitan and Tasikmalaya,it is possible to develop potentiality in unexplored areas such as the research location, that can be used as an alternative uses in daily life.

II. Research Methods

The data in this research was obtained from outcrops of the Jatiluhur Formation and Cantayan Formation in Sentul Regency, Bogor Area. This study began with geological mapping and stratigraphic measurement from some areas in Babakan Makdang Regency. Representative clay shale from the upper part of the Jatiluhur Formation, and Cantayan Formation were examined for petrography analysis, X-Ray Diffraction (XRD) and also Scanning Electron Microphobe (SEM). The XRD and SEM were used to identify the smallest minerals, its distribution, and also examine the chemical composition of each clay shale from a different formation. Parallel with laboratory analysis, there were some laboratory experiments to test the application of bentonites as purification material for cooking oil waste. The physicochemical analysis combined with the experiment result would give the best description of bentonites in Bogor Basin and their application relating to daily activities.

III. Result & Discussion

Geological Mapping

The Bogor Basin area is formed from various geological and lithological formations, mostly young quarternary volcanic rocks and old quarternary volcanoes, and some tertiary sedimentary rocks, as well as limestone (Sudjatmiko,1972). During early-late Miocene, the Bogor Basin was a back-arc setting located on the southern margin of the Sundaland (Hall and Morley, 2004). The Bogor Basin was first initiated as a forearc basin during the Eocene through Oligocene (Hall, 1996; Soeria Atmadha et al., 1998; Martodjojo, 2003). The Jatiluhur formation represents the lower unit of the middle-earliest late Miocene that is exposed in a central area and extends in an east-west trend in Bogor Basin. It is conformably overlain by the Klapanunggal Formation in the west, and by Cantayan Formation in the south (Sudjatmiko, 1972). In the Buanajaya District, Bogor Residence, both Jatiluhur Formation and Cantayan Formation are exposed on the surface. Geological mapping was done, and it showed the occurrence and distribution of 4 unit of rock as follow: the calcareous sand unit; intercalation of clay shale with calcareous sandstone, sandstone with clay shale insertion; and andesitic volcanic rock. Figure 2 show geological-map that resulted from previously mapping activity.

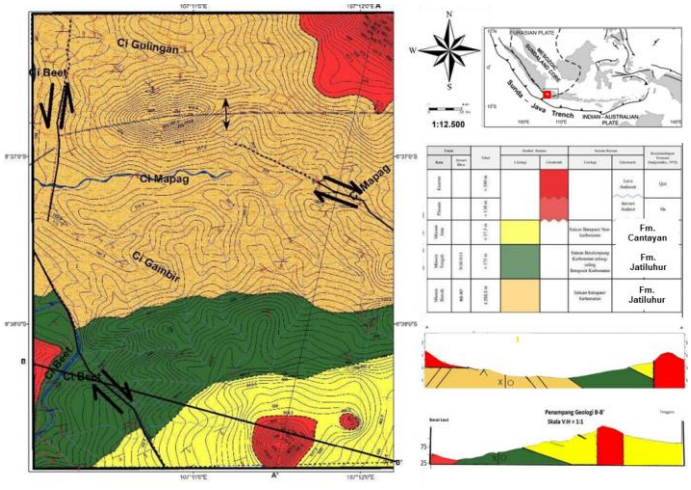

Fig. 2. Geological Map of Research Area

Referring to the geological mapping, clay shale as the object of the research was exposed both in Jatiluhur Formation and also Cantayan Formation. The occurrance of each clay in different formation that shown as follow.

1. Clay Shale of Jatiluhur Formation

Clay shale of the Jatiluhur Formation exists in the intercalation of clay shale with calcareous sandstone unit, which covered 17% of the research area. Based on cross-sectional reconstruction calculations, this rock unit has a thickness of ± 175 m. The clay shale occurs as dark grey or dark brown claystone, calcareous, and show shaly textured with conchoidal fractured in almost all of the outcrops. In

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some part, the clay shale shows sediment nodul and bioturbation. Figure 3 show the occurance of the clay shale in the field outcrop.

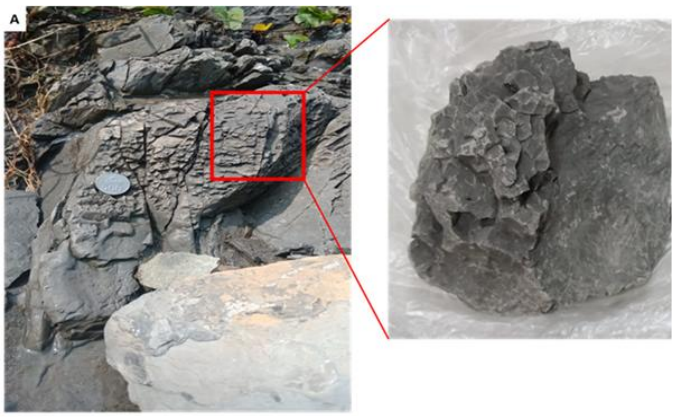

Fig. 3. The clay shale outcrop of Jatiluhur Formation

By microscopy, the clay shale classified as calcareous mudrock (Pettijohn, 1975), shows open fabric with less well-sorted grains consists K-feldspar, calcite, quartz, opaque mineral and benthonic. The matrix contains of abundant micrite, and both the calcite also clay minerals have cemented the rock in several parts. Based Scanning Electron Method (SEM) clay shale characterize by matrix that intensively recrystallized to siderite (Sid), Calcite (CA) and illite (I). Quartz (Qz) grain and microcrystalline pyrite disseminated in the rock. Porosity develops in the clayshale consist of microporosity (mP) that enhaced rosk's porosity. Figure 4 show the petrography and SEM analysis of shale clay from the Jatiluhur Formation.

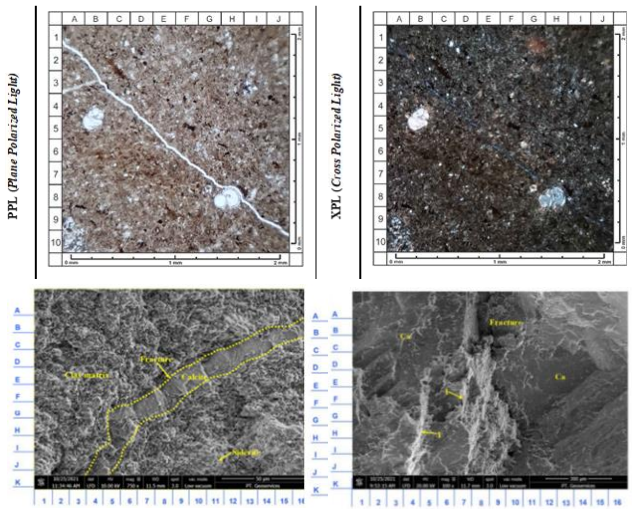

Fig. 4. The Petrography and SEM analysis of clay shale from Jatiluhur Formation

2. Clay Shale of Cantayan Formation

Clay shale of Cantayan Formation exist in intercalation of tuffaceous clay shale with non-calcareous sandstone unit, which covered 13% of the research area. Based on cross-sectional reconstruction calculations, this rock unit has a thickness of ± 36.5 m. The clay shale occurs as light grey claystone, tuffaceous, non-calcareous, partly show conchoidal weathering, and contain quartz fragmen. Figure 5 show the occurance of the clay shale in the field outcrop.

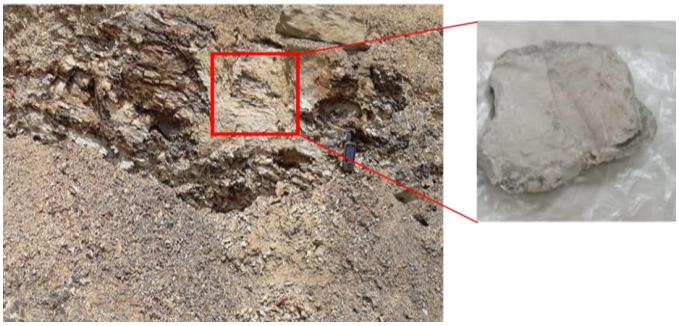

Fig. 5. The clay shale outcrop of Jatiluhur Formation

By microscopy, the clay shale classified as tuffaceous mudrock (Pettijohn, 1975), shows open fabric with less well-sorted grains consists K-feldspar, quartz, muscovite, and opaque mineral, with 0,1-0,25 mm measured in size. The matrix contains of abundant clay matrix, partly laminar clay that has been rechrystallized into medium birefringence illite. Based Scanning Electron Method (SEM) clay shale characterize by numerous quartz (qz) floating on matrix, partly of the matrix began to recrystallize to calcite (Ca) and Smectite. Microcrystalline pyrite (Py) is disseminated on the matrix. Figure 6 show the petrography and SEM analysis of shale clay from the Cantayan Formation.

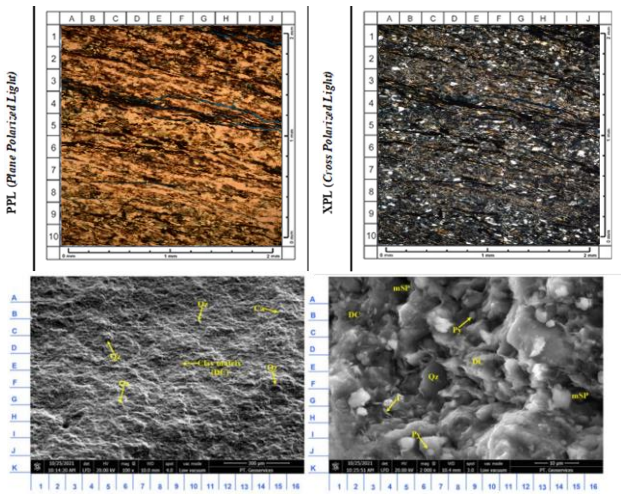

Fig. 5. The Petrography and SEM analysis of clay shale from Cantayan Formation

Bentonite Application

Clay shale from calcareous Jatiluhur Formation and tuffaceous Cantayan Formation have been examined and tested experimentally in a laboratory as purifying material for cooking oil waste. Clay shale from hand speciments is then powdered into very fine size material. The clay powder was afterward mixed with cooking oil waste at 50^0 C, and stirred constantly in several time durations. Time duration consists of 15', 30', and 60'. Mixing was carried out by rate material at 1:10, 1 gram of bentonite was used to purify 10 mL of oil

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waste. After completing the process, the solution then cooled at room temperature for 24 hours. In the end, there would the dark grey-colored bentonite settled at the bottom of the solution meanwhile the oil became clean and separated in the upper part of the solution. The experiment showed that tuffaceous clay shale that contains illite and montmorillonite matter is more effective to purify the oil waste compared to calcareous clay shale that is dominated by illite and also kaolinite. The figure 6 shows the purification process using claystone from the two formations, and the figure 7 is the experiment result.

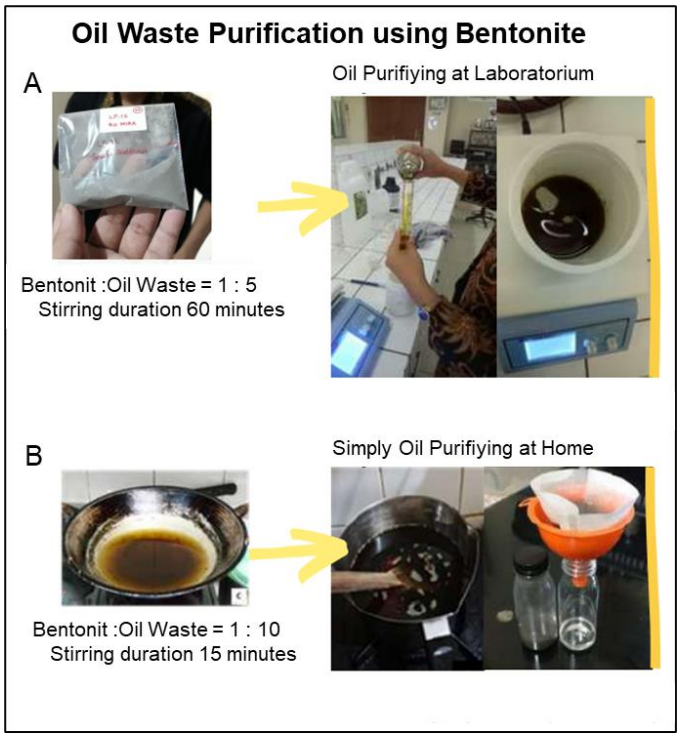

Fig. 6. The purification process using bentonite from Jatiluhur and Cantayan Formation

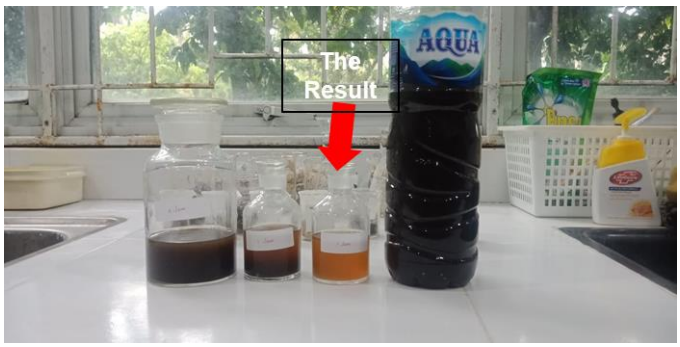

Fig. 7. The result of oil waste purification using bentonite from Cantayan Formation

IV. Conclusion

- Clay shale of Miocene sedimentary deposit in Bogor Basin characterize as follow: clay from Jatiluhur Formation contains numerous calcareous materials such as calcite-siderite and its matrix began recrystallize to illite and kaolinite. While clay from Cantayan Formation contain more detritus material (quartz, albite), tuffaceous, and its matrix contain abundant smectite and minor illite.
- Clay from Cantayan Formation more effective to purify oil waste due to smectite composition
- The purification of oil waste more effective by stirred it with Cantayan's bentonite for 15 minutes in temperature at 50^0C, if it is stirred for different durations, the oil products is less purify.

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