STUDY OF DELTA SEDIMENT DEPOSITS AT THE CITARUM RIVER MOUTH, BEKASI REGENCY, WEST JAVA

Firman Aldilah[1*], Pramudya Rinengga Datu Perdana[1]

[1] Geological Engineering, FTEP, Universitas Pertamina

***EMAIL**
firmanaldi@hotmail.com

KEYWORDS
Delta Sediment, Stratigraphic log, granulometry, Hydrometry, Foraminifera, Distribution Chart, Depositional Environment

ARTICLE HISTORY
Received: 15 August 2023
Accepted: 31 August 2024

HOW TO CITE
Aldilah, F. & Perdana, P. R. D. (2024). Study Of Delta Sediment Deposits at the Citarum River Mouth, Bekasi Regency, West Java. Subsurface, 02(02) 1-16.

ABSTRACT
Delta Muara Bendera is a meeting place between the Citarum river and the North coast of Northwest Java Basin which is known as one of the producers of hydrocarbons on the island of Java. The purpose of this study was to determine the relationship between environmental morphology, sediment characteristics, and microfauna characteristics found at the mouth of the Citarum River. The methods used during this study were field sampling, satellite imagery analysis, stratigraphic column analysis, granulometric analysis, hydrometric analysis, and foraminifera analysis. Based on satellite imagery analysis. It is divided into 3 morphological sections namely: Delta Plain, Delta Front, and Pro Delta. Stratigraphic column analysis on sample codes CDAF 1 to CDAF 5, the sediment characteristics are interbedded sediments from carbonic mud at the bottom to siliciclastic mud at the top. The carbonic mud in this sample is rich in organic material, there are also plant fragments such as roots, leaf bones, and twigs. The CDAF 6 to 10 have similarities with the previous samples but there are differences with high activity of bioturbation in sediment layer. CDAF 11 to 15 show a deltaic deposition pattern in the form of a fine and coarse pattern in sediments with a range of silt grains to medium sand. Sediment grain analysis in the sand fraction showed the presence of fine sand grains with moderate sorting, based on microscopic observations of sand grains having rounded roundness and low sphericity. Analysis of the mud fraction showed medium sand to medium silt, based on the overall sample the percentage of the fine sand fraction in the sample only had less than 60%. Benthic foraminifera found in research area has dominated by genus *Ammonia.*

INTRODUCTION

The Muara Bendera Delta in Bekasi (**Figure 1**) is the meeting point of the Citarum River with the Java Sea, located in the Northwest Java Basin which is known as a hydrocarbon producing region on the island of Java. This place also serves as a fishing boat route between the mainland and the sea. Erosion of various rock types produces sediment grains (Boggs, Sam, J. R., 2014). These sediments are then carried away by flowing water and deposited in a variety of environments from land to sea. The lithification process turns sediment into rock, which contributes to siltation (Boggs, Sam, J. R., 2014).

The activities of fishermen and local fishing ports have an effect on silting due to the disposal of the remains of the fish trade and waste. In the delta area, sediments containing inorganic and organic nutrients provide an ideal environment for living things (Saraswati, P. K., & Srinivasan, M., 2016; Sukandarrumidi., et al., 2020), including microorganisms. The research aims to understand the sedimentation characteristics of deltaic sediments, to study the biostratigraphy of the recent microfauna in the delta area and to create a depositional environmental scheme of the delta in the Muara Bendera area, West Java.

The specific location of the research area is in the Citarum River Delta Named Muara Bendera. Administratively, this area is included in the Muara Gembong District, Bekasi Regency, West Java Province. Geographically the coordinates of the study area are listed in Table 1.1 and are included in the Karawang Sheet. The study area is rectangular in shape with an area of ± 2.76 km2 Zone 48 S 9343723 mN, 719342 mE; 9343714 mN, 721615 mE; 9342500 mN, 721610 mE; 9342508 mN, 719338 mE.

Figure 1. Research location at Muara Bendera, Bekasi, West Java.

GEOLOGICAL SETTING

Based on the Geologic Map the West Java region follows Van Bemmelen's classification (1949) and is divided into four physiographical zones: the Jakarta Coastal Plains Zone, the Bogor Zone, the Bandung Zone, and the Southern Mountains of West Java.

The Jakarta Coastal Inland Zone stretches for about 40 km from Serang to Cirebon and consists of alluvial plains and folded Tertiary marine and lava deposits. The Bogor zone consists of hills and mountains with folded Neogene lithology to form an anticlinorium. The Bandung Zone is a depression zone between mountains with a width of 20-40 km from Sukabumi to Tasikmalaya. The Southern Mountains Zone is a mountain range with volcanic lithology and Tertiary sedimentary rocks, stretching from Ciletuh Bay to Nusakambangan, bounded by the Bandung Zone and the Indian Ocean.

Karawang Quadrangle Morphology according to Achdan and Sudana (1992) is divided into 3 units, which:

Steep Hills Unit located in the southeast, has a prominent hill with a height of 100-200m above sea level. Radial river flows, V valleys and steep cliffs. Contains limestone and sandstone.

Wavy Low Hills Unit, in the south, the hilltops are rounded and undulating, 20-100m asl. Dendritic stream, wide valley with several parallel streams. Contains sandstone, claystone, and conglomerate.

Lowland Unit, the widest in the middle to the coast, 0-25m asl, flat and swampy plains. The river flow is dendritic and meandering. Most of the alluvium is used as agricultural land and settlements which are frequently flooded.

Regional Stratigraphy

The Jatiluhur Formation (Tmj) is the oldest unit in this area with Middle Miocene age, consisting of silt claystone interspersed with sandy limestone; The depositional environment is sublitoral – deep sea. This formation has the Pasirgomhong Member (Tmjp), which consists of silty sandstones and sandy clays, with a deep sublitoral depositional environment. The upper part of the Jatiluhur Formation has a finger relationship with the Parigi Formation (Tmp) which consists of clastic limestones and massive reef limestones of Middle Miocene (Tf) age, the depositional environment of which is sublitoral. In the eastern part of the Karawang Sheet, the Jatiluhur Formation is unconformably overlain by the Subang Formation (Tms) which is Late Miocene in age and consists of claystone, sandstone and limestone; The depositional environment is sublitoral to littoral. The Subang Formation has a Pacol Inclined Member (Tmst) which consists of sandstone interspersed with claystone; The depositional environment is littoral. The Subang Formation is unconformably overlain by the Early Pliocene Kaliwangu (Tpk) Formation consisting of sandstone, claystone and limestone; the depositional environment is littoral. The Kaliwangu Formation is conformably overlain by the Late Pliocene Cihowe Formation (Tpc), consisting of tuff and tuffaceous claystone. Rock units that are Tertiary are overlain unconformably by surface deposits whose ages range from the Pleistocene to the Holocene, and consist of several rock units, namely: the Conglomerate Sandstone and siltstone (Qoa) Unit and the Conglomerate and Tuffaceous Sandstone (Qav) Unit which are Pleistocene in age; Young River deposits (Qa), floodplain deposits (Qaf), coastal deposits (Qac) and coastal bund deposits (Qbr) are of Holocene age. Surface deposits generally consist of clay, silt, sand, gravel and cobbles. Conglomerate and Tuffaceous Sandstone (Qav) Units: Conglomerate, Tufan Sandstone, Tuff and Basalt

Tectonics and Regional Structure

Java Island is located in the southern part of the Sunda Shelf, part of the stable Eurasian plate, bordering the Indo-Australian Plate which is subducting under the Eurasian Plate. This subduction took place from the Late Cretaceous to the Cenozoic, triggered by collision between the Indian and Eurasian subcontinents about 55 million years ago (Hall, 2012), resulting in periodic compression tectonic regimes in Java. This tectonic impact is reflected in the Sheet Geological Map of Karawang (Achdan & Sudana, 1992), showing folds and faults. Folds generally appear in rocks from the Middle Miocene to Late Miocene Jatiluhur Formation, Parigi Formation, and Subang Formation. These folds form an anticline and syncline structure with a southeast-northwest axis. The slope angle of the bed is generally 30°, lower in the north. The Cihowe and Kaliwangu Formations, of Pliocene age, also show folding, although weaker. Faults in Sheet Karawang include up, down, and flat. The fault rises parallel to the fold axis, rising northward. The faults descend to the North-South, while the horizontal faults tend to be Northeast-Southwest, the up faults and the fold axis are oriented Northwest-Southeast.

METHODOLOGY

There are several stages carried out during the Research Project which consist of the preparation stage, the field activity stage, and the data processing stage.

This preparation stage consists of literature study, field survey, equipment preparation, and satellite imagery analysis. The literature study was carried out in the form of studying regional geological conditions where the research was conducted, as well as seeking guidelines for sampling procedures to be carried out in the field. Field surveys were conducted to study road access, field conditions, and boat rentals during the research. Furthermore, preparation of equipment is carried out to support the sampling process, as well as to support safety and security during activities in the field. Then, analysis of satellite imagery is carried out as a reference in determining the initial picture of the field as a whole and determining the observation station points.

Sediment sampling using a simple sediment hand core is carried out at each location point in accordance with the coordinate point planning. The length of the core of the sediment sample used is 40 cm from the surface. The number of sample points taken is 15 locations. Sampling locations were carried out along the coastline at a distance of 10m from the shoreline. The procedure for collecting sediment cores in the intertidal area is based on Sommerfield & Warwick (2013). In a sandy intertidal environment, the ideal sediment core diameter is 2 – 4cm, while for muddy estuarine conditions a diameter of 1cm is used. In muddy environments, where the fauna lives in layers above the surface of the sediment it is recommended to use a sediment core 6 – 8 cm long. In sand sediments, fauna species can live up to a depth of 50cm, thus requiring a sediment core with a length of about 20 – 30cm. The research environmental conditions which are included in the intertidal zone require the specifications of the tool with a tube length of 1m with a diameter of 8cm. The handle on the core sampler must be at least 2m long.

Data processing is a post-field stage consisting of laboratory works including stratigraphic log for sediment core, Then, microfauna sample preparation, microfauna genus and species determination, semi-quantitative data calculation and biostratigraphy analysis that has been obtained from residues from sediment sample preparations. Microfauna determination will be carried out qualitatively in determining the genus and species. Then a granulometric test was carried out quantitatively to determine the amount of grain size distribution contained in the sediment sample in order to study the processes that occur in the depositional environment.

In making observations on uncompacted sediment cores, there are several steps that need to be considered which are described as follows:

Determination of microfauna is determined by looking at some of the characteristics present in foraminifera and indicating a particular genus or species. After determining the genus or species of microfauna, a distribution chart is made based on the abundance and distribution of microfauna.

Granulometric analysis is a quantitative method for measuring the percentage of grain size variation in a clastic sediment and sedimentary rock using a statistical and mathematical approach. The grain size of a sediment can reflects the processes of weathering and erosion which will produce sediment grains of various sizes, as well as explaining the transport and deposition mechanisms of sediment carried by fluids.

According to Folk and Ward (1957), granulometric analysis has several statistical parameters that are used, namely grain size scale, mean, standard deviation, skewness, and kurtosis. The generally used grain size scale values come from the Udden–Wentworth scale.

Hydrometric analysis is the analysis of grain sizes smaller than sand (<2mm) using a hydrometer test kit. Hydrometric testing uses the principles of Stokes' law

Overall, the processed data will be used as a basis for developing a depositional environment model. The data used include the texture and structure of the sediment derived from the description of the sediment core and granulometric analysis, then supported by data distribution charts to help determine specific parts of the depositional environment model.

RESULT

Based on the satellite imagery analysis on the morphological field that can be observed heading southwest based on wind speed and direction data around the Jakarta Bay, it shows an East-West direction. Based on Walker and James (1992), the authors divide the morphology of the study area into 3 morphological divisions (**Figure 2**):

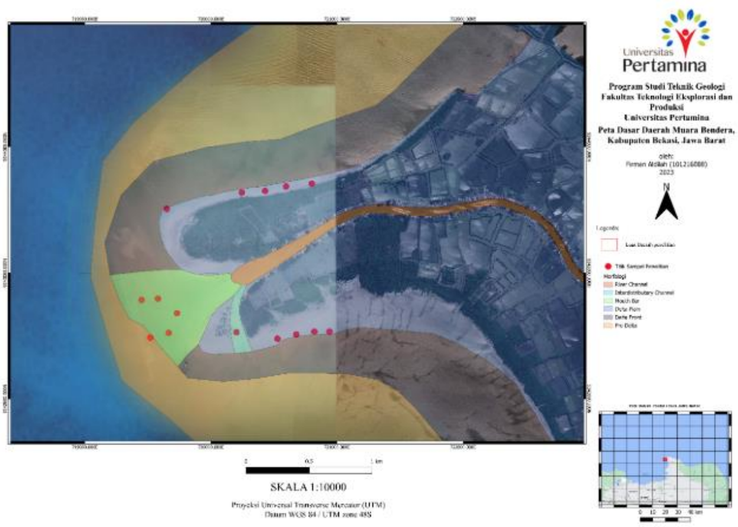


Figure 2. Morphological map of the research area.

1. Delta Plain
   The Delta Plain section is still found to be dominated by rivers in the process of transporting sediment to the river mouth. Based on the observation of satellite imagery and field activities, this area has flowing rivers, swamps, and surrounding mangrove forests.
2. Delta Front
   The Delta Front section is the place where the river meets the sea, in this section the main features commonly found in deltas are found, namely the mouth bar filled with sand and the interdistributary channel between the delta plain
3. ProDelta

This Pro Delta section is a morphological part that is in direct contact with the open ocean. This section contains a large number of mud grain sizes.

Based on data taken from the sediment core at several points on the Muara Bendera coast, macroscopically, there are similarities in the characteristics of sediment in the form of mud grains with organic plant material such as wood fibre etc. But on the mouth bar there is a layer of sand grains with a thickness of 5-10cm. the further away from the river mouth the organic material content in the mud decreases drastically to non-carbonaceous sediments

The sediment core of CDAF-1 has the size of a grain of mud with colors ranging from black, dark grey and grey. Based on observations, the black sediment contains 30% organic matter which contains fine roots and remaining leaves. Meanwhile, the dark grey sediment has organic material that can no longer be seen by the eye. The grey sediments are clastic sediments with clay minerals.

The CDAF-2 sediment core has the size of a mud grain with colors ranging from black, dark grey and grey. Based on observations, black sediment contains 20% organic matter which contains fine roots. The dark grey sediment has organic material that cannot be seen by the eye. The grey sediments are clastic sediments with clay minerals.

The sediment core of CDAF-3 has the size of a mud grain with a colour ranging from black, dark grey and grey. Based on observations, the black sediment contains 10% organic matter which contains fine roots. Meanwhile, the dark grey sediment has organic material that can no longer be seen by the eye. The grey sediments are clastic sediments with clay minerals. Although the upper part of the sediment is black, the organic material is highly decomposed and unrecognizable.

CDAF4 sediment cores have the size of mud grains with colors ranging from black, dark grey and grey. Based on observations, black sediments contain organic material that cannot be identified. Dark grey sediments have organic material that can no longer be identified. seen by the eye. Gray sediments are clastic sediments with clay minerals.

The sediment core of CDAF-5 has the size of a grain of mud with colors ranging from black, dark grey and grey. Based on observations, the black sediment contains 30% organic matter which contains fine roots and remaining leaves. Meanwhile, the dark grey sediment has organic material that can no longer be seen by the eye. The grey sediments are clastic sediments with clay minerals.

The sediment core of CDAF-6 has the size of a mud grain with colors ranging from black, dark grey and grey. Based on observations, the black sediment contains 30% organic matter which contains fine roots and remaining leaves. Meanwhile, the dark grey sediment has organic material that can no longer be seen by the eye. The grey sediments are clastic sediments with clay minerals.

The sediment core of CDAF-7 has the size of a grain of mud with colors ranging from black, dark grey and grey. Based on observations, the black sediment contains 20% organic matter which contains fine roots and remaining leaves. Meanwhile, the dark grey sediment has organic material that can no longer be seen by the eye. The grey sediments are clastic sediments with clay minerals.

The CDAF-8 sediment core has the size of a grain of mud with colors ranging from black, dark grey and grey. Based on observations, the black sediment contains 30% organic matter which contains fine roots and remaining leaves. Meanwhile, the dark grey sediment has organic material that can no longer be seen by the eye. The grey sediments are clastic sediments with clay minerals.

The sediment core of CDAF-9 has the size of a silt grain with colors ranging from black, dark grey and grey. Based on observations of black sediment containing 30% organic material containing leaf bones, the sediment is looser than the sediment. black containing fine roots. Meanwhile, the dark grey sediment has organic material that can no longer be seen by the eye. The grey sediment is a clastic sediment with clay minerals and there are traces of bioturbation.

The sediment core of CDAF-10 has the size of a silt grain with colors ranging from black, dark grey and grey. Based on observations the bottom black sediment contains 30% organic material containing leaf bones, the sediment is more loose than black sediment containing fine roots. Meanwhile, in the top black sediment the organic material is unrecognizable. The dark grey sediment has organic material that cannot be seen by the eye. The grey sediment is a clastic sediment with clay minerals and there are traces of bioturbation. CDAF-11 sediment cores range in size from silt to fine sand grains with colors ranging from black, dark grey, grey. And brownish grey. Based on observations of black sediment containing 30% organic material which contains leaf bones and pieces of leaves, the sediment is denser. Meanwhile, the dark grey sediment has organic material that can no longer be seen by the eye. The grey sediment is a clastic sediment with clay minerals and there are traces of bioturbation. While brownish grey sediments are unconsolidated sand, in sand sediments Bivalvia shells buried in the sand were found. The sediment pattern at the bottom shows a rough upward pattern, while at the top it shows a smooth upward pattern. This is probably due to a change in the delta mouth bar which has turned into a new channel

CDAF-12 sediment cores range in size from silt to fine sand grains with colors ranging from black, dark grey, grey. And brownish grey. Based on observations of black sediment containing 30% organic material which contains leaf bones and pieces of leaves, the sediment is denser. Meanwhile, the dark grey sediment has organic material that can no longer be seen by the eye. The grey sediment is a clastic sediment with clay minerals and there are traces of bioturbation. While brownish grey sediments are unconsolidated sand, in sand sediments Bivalvia shells buried in the sand were found. The sediment pattern at the bottom shows a rough upward pattern, while at the top it shows a smooth upward pattern. This is probably due to a change in the delta mouth bar which has turned into a new channel

The CDAF-13 sediment core has the size of a mud grain with colors ranging from black, dark grey and grey. Based on observations, black sediment contains 20% organic matter. Meanwhile, the dark grey sediment has organic material that can no longer be seen by the eye. The grey sediments are clastic sediments with clay minerals.

CDAF-14 sediment cores range in size from silt to fine sand grains with colors ranging from black, dark grey, grey. And brownish grey. Based on observations of black sediment containing invisible organic material, the sediment is denser. Meanwhile, the dark grey sediment has organic material that can no longer be seen by the eye. The grey sediment is a clastic sediment with clay minerals and there are traces of bioturbation. While brownish grey sediments are unconsolidated sand, in sand sediments

Bivalvia shells buried in the sand were found. The sediment pattern shows an upward trending pattern, this sand sediment is part of the sand bar at the mouth of the delta.

CDAF-15 sediment cores range in size from silt to fine sand grains with colors ranging from black, dark grey, grey. And brownish grey. Based on observations of black sediment containing invisible organic material, the sediment is denser. Meanwhile, the dark grey sediment has organic material that can no longer be seen by naked eye. The grey sediment is a clastic sediment with clay minerals and there are traces of bioturbation. While brownish grey sediments are unconsolidated sand, in sand sediments Bivalvia shells buried in the sand were found. The sediment pattern shows an upward trending pattern, this sand sediment is part of the sand bar at the mouth of the delta.

Granulometric analysis on sand samples showed the presence of fine sand grains with moderate sortation, based on microscopic observations on samples retained on sieve no.80, sand grains based on Power classification (1953) roundness sub-rounded to rounded and High Sphericity.

The sieve analysis that has been obtained is then made into a graph of the Percent Cumulative Weight to the inside diameter of the PHI **Figure 3**.

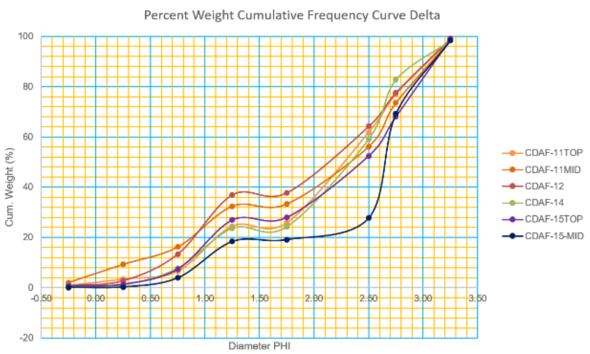


Figure 3. Cummulative distribution of sediment in Muara Bendera.

The curve that has been made into the graph is then calculated. The average value, standard deviation, slope size, and kurtosis are described in the following table (**Table 1**):

Table 1. Statistical properties of the samples.

Sample Code	Mean	Standard Deviation (Sortation)		Skewness		Kurtosis		Grain Size
	Value	Value	Classification	Value	Classification	Value	Classification	
CDAF-11 TOP	2.0592	0.8737	*Mod. Well Sorted*	-0.3069	*Coarse Skewed*	1.3022	*Mesokurtic*	Fine Sand
CDAF-11 MID	2.0067	1.0420	*Mod. Sorted*	-0.4592	*Str. Coarse Skewed*	0.7528	*V. Platykurtic*	Fine Sand
CDAF-12	2.1344	0.9355	*Mod. Well Sorted*	-0.2704	*Nr. Symmetrical*	0.6541	*V. Platykurtic*	Fine Sand
CDAF-14	2.1548	0.8228	*Mod. Well Sorted*	-0.4473	*Str. Coarse Skewed*	1.1508	*Mesokurtic*	Fine Sand
CDAF-15 TOP	2.2737	0.9016	*Mod. Well Sorted*	-0.4339	*Str. Coarse Skewed*	0.6234	*V. Platykurtic*	Fine Sand
CDAF-15 MID	2.2551	0.8190	*Mod. Well Sorted*	-0.5951	*Str. Coarse Skewed*	2.3633	*Leptokurtic*	Fine Sand

CDAF-11 which has two sand units namely CDAF-11 TOP and CDAF-11 MID as a whole has fine sand grain size. On the value of sortation (sortation) CDAF-11 TOP has a very good sortation and CDAF-11-MID has a good sortation. If seen based on the size of the slope of the CDAF-11 TOP tends towards coarse grain.

CDAF-12 as a whole has the size of a fine grain of sand. On the value of sortation (sortation) CDAF-12 has a very good, disaggregated sortation. If you look at the slope gradient of the CDAF-11-TOP, the grain distribution is almost symmetrical.

CDAF-14 as a whole has the size of a fine grain of sand. On the value of sortation (sortation) CDAF-12 has a very good, disaggregated sortation. If seen based on the size of the slope of the CDAF-11-TOP grain distribution tends to be coarse

CDAF-15 which has two sand units namely CDAF-15 TOP and CDAF-15 MID as a whole has fine sand grain size. The value of sortation (sortation) CDAF-15 TOP and CDAF-15 MID have very good sortation. If you look at the size of the slope of the CDAF-15-TOP, the distribution tends towards coarse grain.

Hydrometric analysis refers to the principle of sediment velocity in water in all silt sediment samples showing moderate sand to medium silt, based on the overall sample the percentage of fine fraction in the sample only reaches less than 60%, this possibility occurs because there are organic fragments in the sample that do not decompose.

Then the value of the calculation of fine percent and sediment grain size is depicted on the graph of the cumulative grain weight percent of the hydrometer test carried out by sampling. The results of the calculation of the hydrometer analysis graph are explained as follows (**Figure 4** and **Figure 5**).

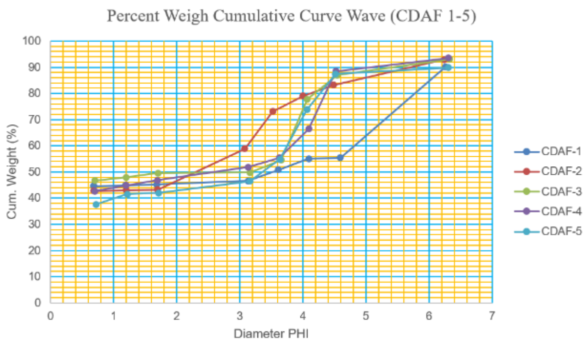


Figure 4. Cumulative distribution of CDAF 1-5.

The CDAF-1 sample has a moderate sand content of 40% and gradually becomes finer, at the 90th percentage of grain size the remaining is fine silt. based on Wentworth's scale (1922) in (Boggs, 2006). The grain size changes towards the silt fraction starting from the 58th percentage.

The CDAF-2 sample has a medium sand content of 44% and gradually becomes finer, at the 92nd percentage of grain size remaining is fine silt. based on Wentworth's scale (1922) in (Boggs, 2006). The grain size changes towards the silt fraction starting from the 79th percentage.

The CDAF-3 sample has a medium sand content of 46% and gradually becomes finer, at the 93rd percentage of grain size remaining is fine silt. based on Wentworth's scale (1922) in (Boggs, 2006). The grain size changes towards the silt fraction starting from the 77th percentage.

The CDAF-4 sample has a medium sand content of 42% and gradually becomes finer, at the 93rd percentage of grain size remaining is fine silt. based on Wentworth's scale (1922) in (Boggs, 2006). The grain size changes towards the silt fraction starting from the 66th percentage.

The CDAF-5 sample has a moderate sand content of 37% and gradually becomes finer, at the 90th percentage of grain size remaining is fine silt. based on Wentworth's scale (1922) in (Boggs, 2006). The grain size changes towards the silt fraction starting from the 73rd percentage.

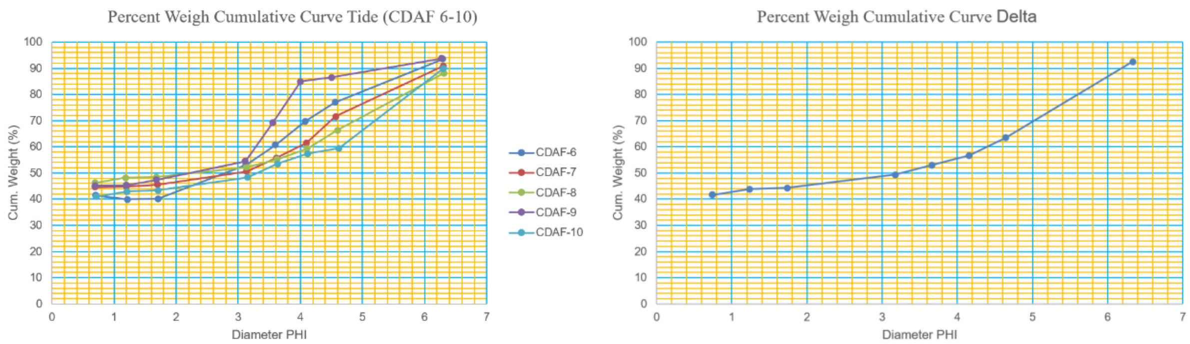


Figure 5. Cumulative distribution of CDAF 6-10 and CDAF13.

The CDAF-6 sample has a moderate sand content of 41% and gradually becomes finer, at the 93rd percentage of grain size remaining is fine silt. based on Wentworth's scale (1922) in (Boggs, 2006). The grain size changes towards the mud fraction starting from the 70th percentage.

The CDAF-7 sample has a medium sand content of 45% and gradually becomes finer, at the 91st percentage of grain size remaining is fine silt. based on Wentworth's scale (1922) in (Boggs, 2006). The grain size changes towards the mud fraction starting from the 61st percentage.

The CDAF-8 sample has a moderate sand content of 46% and gradually becomes finer, at the 88th percentage of grain size remaining is fine silt. based on Wentworth's scale (1922) in (Boggs, 2006). The grain size changes towards the silt fraction starting from the 59th percentage.

The CDAF-9 sample has a moderate sand content of 45% and gradually becomes finer, at the 94th percentage of grain size remaining is fine silt. based on Wentworth's scale (1922) in (Boggs, 2006). The grain size changes towards the silt fraction starting from the 84th percentage.

The CDAF-10 sample has a moderate sand content of 41% and gradually becomes finer, at the 90th percentage of grain size remaining is fine silt. based on Wentworth's scale (1922) in (Boggs, 2006). The grain size changes towards the silt fraction starting from the 57th percentage.

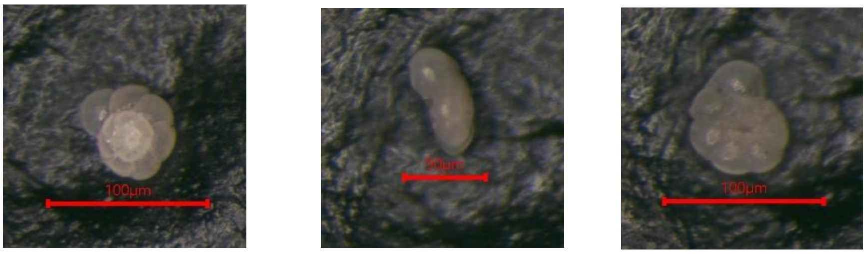
The CDAF-13 sample has a moderate sand content of 41% and gradually becomes finer, at the 90th percentage of grain size remaining is fine silt. based on Wentworth's scale (1922) in (Boggs, 2006). The grain size changes towards the silt fraction starting from the 57th percentage.

Based on observations made in the laboratory, overall, the foraminifera found in the study area consisted of 10 genera with 14 species of foraminifera. Benthic foraminifera have 7 genera, and the rest are planktonic foraminifera. Based on the whole benthic foraminifera genera, 3 genera were found with hyaline limestone shells, 2 genera with porcelain limestone shells, and 2 genera with sandy shells. benthic foraminifera dominate the northern delta plain region, the dominating genus in the samples in this study area is Ammonia.

Based on observations made in the laboratory, overall, the foraminifera found in the study area consisted of 10 genera with 14 species of foraminifera. Benthic foraminifera have 7 genera, and the rest are planktonic foraminifera (**Table 2** and **Figure 6**). Based on the whole benthic foraminifera genera, 3 genera were found with hyaline limestone shells, 2 genera with porcelain limestone shells, and 2 genera with sandy shells. benthic foraminifera dominate the northern delta plain region, the dominating genus in the samples in this study area is Ammonia.

Table 2. Distribution of foraminifera in the sediment..

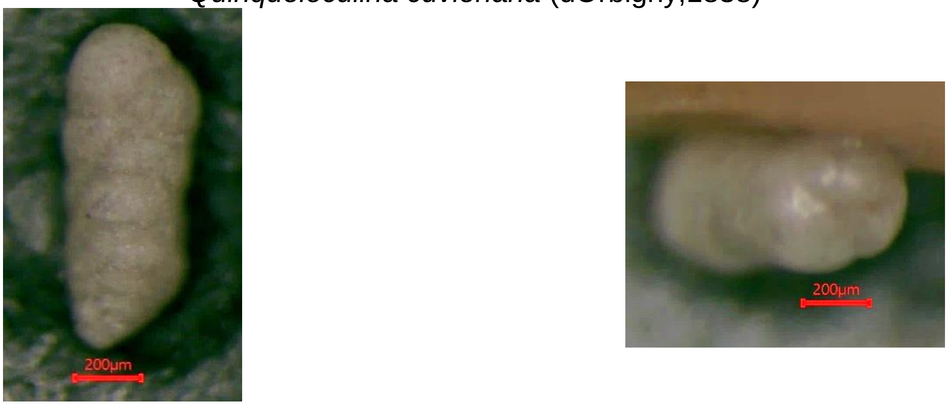
							Distribution Chart												
				Calcareous Foraminifera								Non-Ca		Planktonic					
Code	Depth (cm)	Lithology/ Sediment	Sample	*Ammonia beccari*	*Ammonia parkinsoniana*	*Ammonia*	*Elphidium advenum*	*Elphidium crispum*	*Gyroidina sp.*	*Nonion commune*	*Quinqueloculina cuvieriana*	*Ammodiscus sp.*	*Bigenerina sp.*	*Globigerionides conglobatus*	*Globigerinoides ruber*	*Globigerina sp.bulloides*	*Globigerina immaturus*	*Globigerina triloba*	*Turborotalia*
CDAF-1	50	Silty Mud	Core	68			14		1	8	12			3				1	
CDAF-2	80	Silty Mud	Core	8	2														1
CDAF-3	70	Silty Mud	Core	2												1			
CDAF-4	80	Silty Mud	Core												2		1		
CDAF-5	100	Silty Mud	Core																
CDAF-6	50	Silty Mud	Core	3	10								1						
CDAF-7	60	Silty Mud	Core																
CDAF-8	50	Silty Mud	Core				2												
CDAF-9	80	Silty Mud	Core																
CDAF-10	90	Silty Mud	Core																
CDAF-11	120	Sand Bar	Core	3															
CDAF-12	140	Channel	Core																
CDAF-13	170	Mud	Core									1							
CDAF-14	150	Sand Bar	Core																
CDAF-15	140	Sand Bar	Core					1							1				



Ammonia beccari (Linnaeus, 1758)

Elphidium advenum (Cushman,1922)

Quinqueloculina cuvieriana (dOrbigny,1838)



Bigenerina sp. (d'Orbigny, 1826)

Figure 6. Foraminifera shells observed in the samples.

DISCUSSION

Based on the data that had been analyse, the authors divided the 3 parts of the depositional environment in the study area as follows:

Samples CDAF 1 - CDAF 5 have sedimentary characteristics in the form of repeating sediments from carbonic mud at the bottom to siliciclastic mud at the top (**Figure 7**). The carbonic mud portion of this sample is very rich in organic matter apart from the colour of the sediment, which is deep black, plant fragments in the form of fine roots are also found., leaf bones, and twigs. No sand grain sizes were found in this area due to its position that leads directly to the open sea so that there are longshore currents that carry sand grain sizes to the west away from the edge of the beach. This area has minimal visible organism activity due to direct exposure to ocean waves and currents, but microscopically the samples in this area had the highest foraminifera abundance compared to the other samples. The dominant foraminifera found in this region have a hyaline calcareous shell composition with the genera *Ammonia*, *Elphidium*, *Quinqueloculine* and *Nonion*.

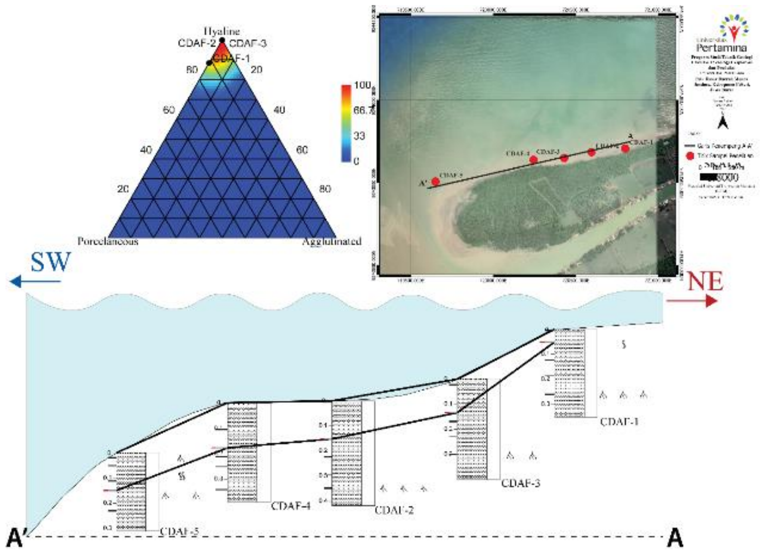


Figure 7. Characteristics of sediment from CDAF 1-5.

CDAF samples 6 to 10 have similarities with the previous samples but there are differences in the form of higher bioturbation activity in the sediment layer (**Figure 8**), this is probably caused by the depositional environment that is in the spit of the delta so that it has calmer currents and makes it easier for organisms to move. but the high organic matter makes foraminifera unable to live in this environment. Foraminifera found in this region. microscopically the samples in this area have relatively few Foraminifera with hyaline flaky shell composition with the genera Ammonia, Elphidium, and Nonion. No foraminifera with sandy shells were found in this area, due to the dominating grain size in this sample, namely silt grains.

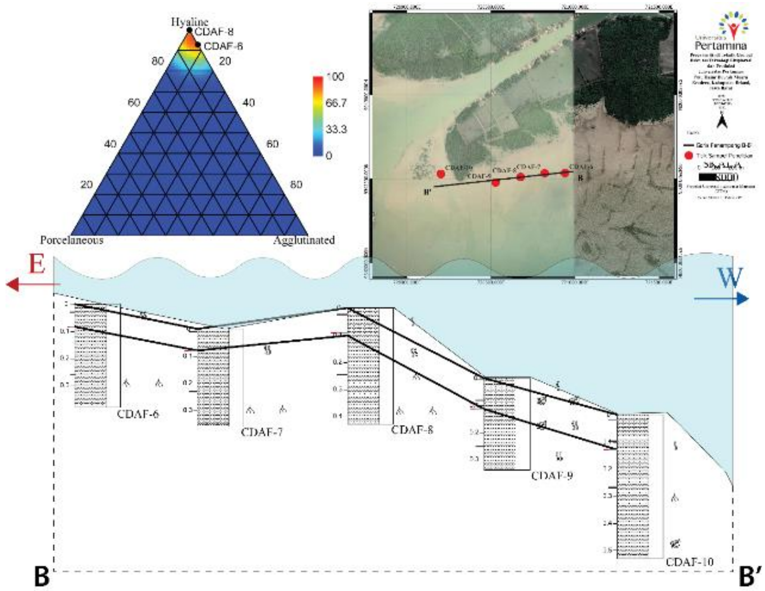


Figure 8. Characteristics of sediment from CDAF 1-5.

CDAF 11 to 15 shows a deltaic depositional pattern in the form of a fine and coarse pattern in sediments ranging from silt to medium sand grains (**Figure 9**). This group belongs to the mouth of the delta. Organisms found in this area consisted of macrofauna in the form of shellfish that died in situ in the sand layer, while microorganisms in the form of foraminifera were found in this area at least compared to other areas.

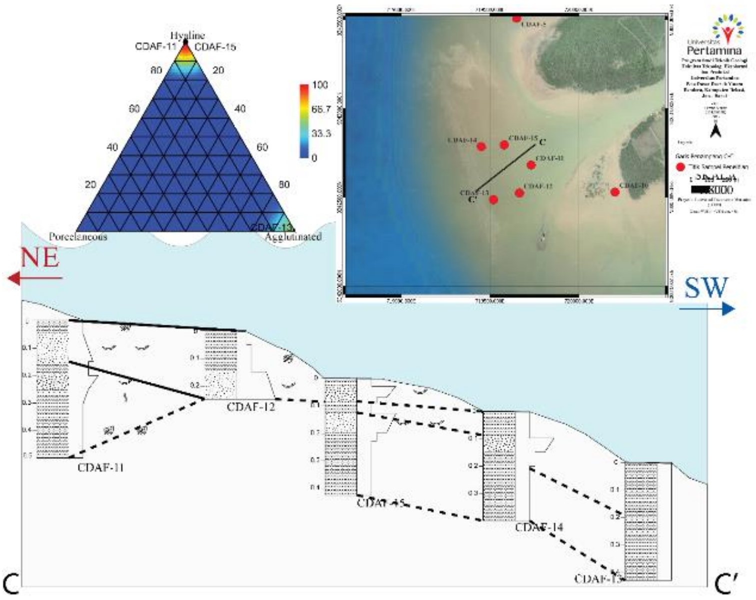


Figure 9. Characteristics of sediment from CDAF 11-15.

CONCLUSION

Based on the data from results and discussion that has been analyzed, the following conclusions can be drawn

Satellite Imagery analysis from the field. There are 3 morphological distinctions such as Delta Plain, Delta Front, and Pro Delta.

The sample codes CDAF 1 to CDAF 5 have sedimentary characteristics in the form of repeating sediments from carbonic mud at the bottom to siliciclastic mud at the top. The carbonaceous mud portion of this sample is very rich in organic material apart from the deep black sediment color. There are also plant fragments in the form of fine roots, leaf bones, and twigs. The CDAF Samples 6 to 10 have similarities with the previous samples but there are differences in the form of higher bioturbation activity in the sediment layer, this is probably caused by the depositional environment found in the spit of the delta so that it has a higher current. calmer and allows organisms to move more easily compared to CDAF1 to 5 which are affected by ocean waves and currents. CDAF 11 to 15 show a deltaic depositional pattern in the form of a fine and coarse pattern in sediments with a range of silt grains – to medium sand

Sediment grain analysis in the sand fraction showed the presence of fine sand grains with moderate sortation, based on microscopic observations of sand grains having degrees of rounded roundness and elongated sphericality.

Hydrometric analysis of all silt sediment samples showed moderate sand to medium silt, based on the entire sample the percentage of fine fraction in the sample only reached less than 60%, this possibility occurred because there were organic fragments in the sample that were in the sample.

Based on observations made in the laboratory, benthic foraminifera are easier to find in the study area, the genus that is abundant in this research area is Ammonia

In conducting this research, the writer found several shortcomings during the research. Suggestions for further research can be even better. It is necessary to measure the speed of the water flow using a current meter (a device for measuring current or water discharge), observing the tides in the estuary area. Measuring wind speed and direction in the area around the mouth of the delta using an anemometer. Measuring salinity and pH in the estuary delta area to determine environmental conditions. Increase the 200-mesh size in the sieve analysis to obtain a wider range of grain sizes. Dissolving the sediment in the dispersion solution in order to obtain optimal measurement readings in hydrometric analysis.

REFERENCES

Achdan, A., Sudana, D. (1992). Peta Geologi Lembar Karwang, Jawa. Skala 1:100.000. Bandung: Pusat Penelitian dan Pengembangaan Geologi.

Armandita, C., Mukti, M. M., & Satyana, A. H. (2009). Intra-arc trans-tension duplex of Majalengka to Banyumas area: Prolific petroleum seeps and opportunities in west-Central Java border. *Proc. Indon Petrol. Assoc., 33rd Ann. Conv.* doi:10.29118/ipa.2066.09.g.173

Boggs, S. (2014). Marginal Marine Environments. In *Principles of Sedimentology and stratigraphy* (p. 282). Harlow: Pearson Education.

Folk, R. L., & Ward, W. C. (1957). Brazos River Bar [Texas]; a study in the significance of grain size parameters. *Journal of Sedimentary Research, 27*(1), 3-26. doi:10.1306/74d70646-2b21-11d7-8648000102c1865d

Hall, R. (2012). Late Jurassic-Cenozoic reconstructions of the Indonesian region and the Indian Ocean. Tectonophysics, *570–571*, 1–41. https://doi.org/10.1016/j.tecto.2012.04.021

Nichols, G. (2009). Deltas. In *Sedimentology and Stratigraphy* (pp. 179-181). Oxford, United Kingdom: Wiley-Blackwell.

Saraswati, P. K., & Srinivasan, M. (2016). Calcareous-Walled Microfossils. In *Micropaleontology principles and applications* (pp. 81-94). Cham, Switzerland: Springer International Publishing.

Sukandarrumidi., Heriyadi, NWAAT., & Wiloso, D. A. (2020). *Mikropaleontologi Foraminifera: Konsep Dasar dan Aplikasinya*. D.I. Yogyakarta, Indonesia: Gadjah Mada University Press.

Somerfield, P. J., & Warwick, R. M. (2013). Meiofauna techniques. *Methods for the Study of Marine Benthos*, 253–284. https://doi.org/10.1002/9781118542392.ch6

van Bemmelen, R. W. (1949). The Geology of Indonesia Vol-IA General Geology of Indonesia and Adjacent Archipelagoes. The Hague: Martinus Nijhoff.

Walker, R. G., & James, N. P. (1992). *Facies model: Response to sea level change*. Geological Association of Canada.