THE CHARACTERISTIC OF RECENT SEDIMENT IN SEGARA ANAKAN LAGOON, CIAMIS REGENCY, WEST JAVA

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ABSTRACT

The high intensity of erosions at the rivers upstream which are rivermouthed into the Segara Anakan Lagoon, as sources of the materials which are causing the sedimentation on the lagoon systematically.

Based on smear slide analyses and major element contents, source of the sediment which is deposited in the lagoon floor, was predicted as the volcanic products. This condition is supported by the existence of non biogenic materials such as quartz, mica, ferro-oxides, manganese oxides and tuff in the lagoon. Beside that, the existence of major elements such as SiO_2 (36,6 – 51,4%) Al_2O_3 (13,38 – 24,70%), and Fe_2O_3 (8,69 – 30,6%), is particular element indicators of volcanic products.

The lithology in the survey area are volcanic products such as Jampang Formation and Panutuan Formation. Jampang Formation consist of volcano breccia, tuff intercalated with lava and sandstone, claystone, napal intercalated with conglomerate. Panutuan Formation consist of sandstone, napal and tuff, Formation Members of Tuff Napalan, Panutuan Formation, which are spread on the basinal area of Citanduy, Cibeureum, and Ciseel rivers which are rivermouthed into Segara Anakan Lagoon.

Key words : smear slide, major element, Segara Anakan.

SARI

Intensitas erosi yang tinggi di daerah hulu sungai-sungai yang bermuara di Segara Anakan sebagai sumber material yang mengakibatkan sedimetnasi laguna secara sistematis.

Sumber pasokan sedimen yang diendapkan di dasar laguna berdasarkan analisis sayatan oles, dan unsur utama mineral diperkirakan merupakan produk vulkanik yang bersifat basa. Hal ini didukung oleh terdapatnya mineral non biogenik seperti mineral kuarsa, mika, oksida besi, oksida mangan yang dijumpai tersebar secara merata, adalah produk vulkanik, berupa tuff. Disamping itu keterdapatan unsur utama mineral seperti SiO_2 dengan kisaran 36,6 – 51,4%, kemudian Al_2O_3

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dengan kisaran 13,38 – 24,70% sedangkan Fe_2O_3 dengan kisaran 8,69 – 30,6%, merupakan mineral khas hasil produk vulkanik yang bersifat basa.

Litologi daerah penelitian merupakan produk gunungapi, seperti Formasi Jampang yang tersusun oleh breksi gunungapi tuff dengan sisipan lava, berselingan dengan batupasir, batulempung napal dengan sisipan konglomerat. Formasi Panutuan yang tersusun batupasir, napal dan tuff, Anggota Tuff Napalan formasi Panutuan, dan berada di daerah rendahan sungai Citanduy, Cibeureum, Ciseel beserta anak anak sungainya yang bermuara di Segara Anakan.

Kata kunci : sayatan oles, unsur utama, Segara Anakan

INTRODUCTION

Controversy of Sagara Anakan lagoon shallowing and the exact method to overcome it reveals never ended. This is due to this bay is a unique geological phenomenon and has long history keeping a navigational channel between Ciamis Regency West Java Province and Cilacap City Central Java Province. Cilacap is a big harbour in the southern coast of Java Island.

Physiographically Segara Anakan is actually a lagoon which separates Nusakambangan Island in the south of Ciamis and Cilacap with Java Island with a unique ecosystem. It is protected from the Indian Ocean by Nusa Kambangan and has two openings to the ocean, one at the southwest corner of lagoon and the other via several easterly passages. The brackish lagoon, which is surrounded by an area of slough, tributaries, mangrove swamps and intertidal land converted to rice fields, its influenced by tidal effects from the Indian Ocean trough the western and eastern passages. The lagoon and its environs provide a unique and abundant aquatic ecosystem and a productive marine nursery (http://donko.civil.tohoku.ac.jp/estuary_Workshop_HP/2005indonesia/itinerary.pdf).

This lagoon is river mouths of Citanduy River Ciamis Regency West Java and Cibeureum River Central Java and many other rivers Cimuntur, Cijolang, Cikawung and Ciseel.

The most interesting thing of Sagara Anakan currently is shallowing problem resulted in narrowing of the lagoon and controversy relate to Citanduy artificial channel to overcome the problem in the lagoon.

The area of Segara Anakan is decreasing from year to year due to very active sedimentation of rivers mouthed in the lagoon (Sarmili et al, 2000).

This survey tries to discuss prediction of sediment supply sources which cause shallowing of Sagara Anakan lagoon based on smear slide analysis vertically from borehole core samples and sediment major elements, to give more clear picture of sediment sources.

Administratically the investigation area belongs to two regencies where the west included in Ciamis of West Java Province, while the west is the part of Cilacap Regency Central Java Province. Geographically the area is located at coordinates 108°40' – 108°52' East Longitudes and 7°38' – 7°44' South Latitudes (Figure 1).

Extensive mangrove swamps threaded by channels and tidal creeks border the shallow estuarine embayment of Segara Anakan (Figure 1), which receives large quantities of silty sediment from the Citanduy River. At the eastern of lagoon, strong tidal currents maintain a navigable inlet for the port of Cilacap, which stands on the sandy barrier behind a shoaly bay. The meandering channell persists westwards, leading through the mangroves to Segara Anakan, which has a

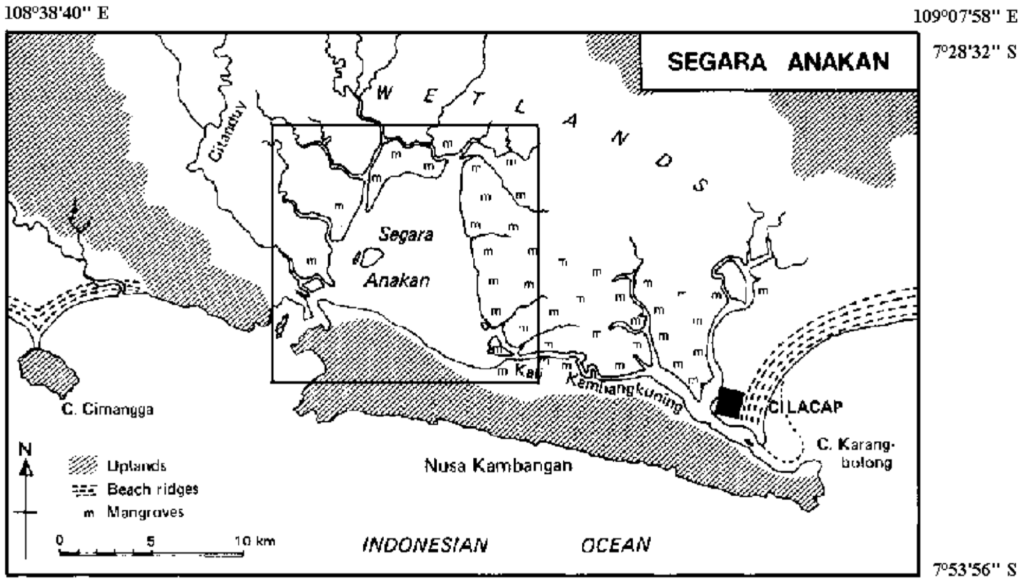


Figure 1. Segara Anakan located behind Nusa Kambangan island and rivermouths of many rivers (http://donko. civil. tohoku.ac.jp/ estuary_Workshop_HP/2005 indonesia/itinerary.pdf). Box is the Segara Anakan Lagoon.

larger outlet through a steep-sided strait to Penandjung Bay. Changes in the configuration of Segara Anakan between 1900 and 1964 were traced by Hadisumarno (1964 in http://donko.civil.tohoku.ac.jp/estuary_Workshop_HP/2005indonesia/itinerary.pdf), who found evidence for rapid advance of mangroves into the accreting intertidal zone. He reported surveys made in 1924, when the average depth (ignoring deeper tidal channels) was 0.5 to 0.6 metres, and 1961, when it had shallowed to 0.1 to 0.2 metres, the tidal channels having deepened. Mangrove advance is exceptionally rapid here, and much of the shallow lagoon is expected to disappear as mangroves encroach further in the next two decades.

Regional Stratigraphy of the investigation area

Based on geological mapsheet Pangandaran, Java by Simandjuntak and Surono (1992), the stratigraphy of the investigation area is consisted of five stratigraphic units arranged from young to old as follows :

- Alluvial deposit consisted of mud, sand and gravel which are covered almost 40% of the investigation area spread along coastal zone of Parigi Bay, Pangandaran Bay and river basins mouthed in Sagara Anakan.
- Coastal deposit occurred as iron sand found in southern coast of Nusa Kambangan island in Solok Cobodas area.
- Tapak Formation (Tpt) composed of sandstone intercalated with siltstone estimated deposited at Pliocene–Pleistocene age. This formation is outcropped sporadically in Citanduy and Ciseel basins at Sentul village elongated toward south until eastern of Nusa Wuluh, Karang Denang 1 and north of Mangupari village.

- Kalipucang Formation (Tmkl) consisted of reef limestone deposited at Middle Miocene. This formation is also spread sporadically north of Tanjung Sodong, elongated along the middle of Nusa Kambangan island continued to northwest until Kedung Halu village. It also outcropped at northwest of the investigation area at Cigayam and Karang Hantu villages.
- Nusa Kambangan Formation (Tmnt) composed of tuff, lapilli tuff, sand tuff and gravel with intercalation of sandstone at middle part, the intercalated sandstone increased toward upper part which interfingered with claystone and breccia. This formation is spread and covered up dominantly Nusa Kambangan island.

RESEARCH METHODS

Surficial lagoon sediment and subsurface sediment were obtained through lagoon floor sampling and drilling in three locations (BH-01, BH-02 and BH-03). All the sediment locations were navigated using GPS Map Garmin 210 (Global Positioning Sistem) and GPS Map Sounder Garmin 235. All the sediments either surficial or subsurface were prepared for smear slide and major element analyses.

Smear slide analyses

Preparation of smear slide analyses was carried out in laboratory of Marine Geological Institute office Cirebon; while identification of biogenic, non-biogenic and autigenic material contents were examined in MGI office Bandung.

Major Element analyses

The purpose of major element analyses was to know detail major oxydes of marine sediment deposited in the investigation area which later be related to the source of sediment supply.

The method was also include analyses of correlation diagram between SiO_2 and other major elements. The purpose is to find out the geochemical characteristics of the source rocks of the sediments in the lagoon which mostly of volcanic products.

Bhatia (1983) Biavariate plot for Al_2O_3/SiO_2 versus (Fe_2O_3 + MgO) was also utilized to predict the type of volcanic rocks as the sources of sediments deposited in Segara Anakan. The authors try to use this method in order to identify what volcanic type exist in the hinterland as the source of sediment in the lagoon. This is based on the assumption that the chemical composition of the sediments deposited in Segara Anakan still keep or at least resemblance its original source rock composition.

RESULTS AND DISCUSSION

Smear slide analyses were carried out for the whole sediment samples from drilling cores BH-01, BH-02 and BH-03. These analyses meant to investigate in detail biogenic, non-biogenic and autigenic contents vertically in assist to find out the sources of sediment supply deposited in Segara Anakan. The analyses were also carried out for surficial lagoon sediment to look for laterally distribution of biogenic, non-biogenic and autigenic contents of the sediments. Figure 2 shows sample and borehole locations.

Results of smear slide analyses in borehole BH-01 (borehole depth up to 30 meter)

Lagoon bottom up to 30 meters below biogenic materials found were calcareous matters with very rare percentage less than 1%, silicate biogenics were not found. On the other hand, non-biogenic materials found generally quartz with percentages 50 up to 70%, heavy minerals 30 – 50%, iron and manganese oxydes occurred in boredepth 6-30 meters with percentages 1 – 5%; mica and

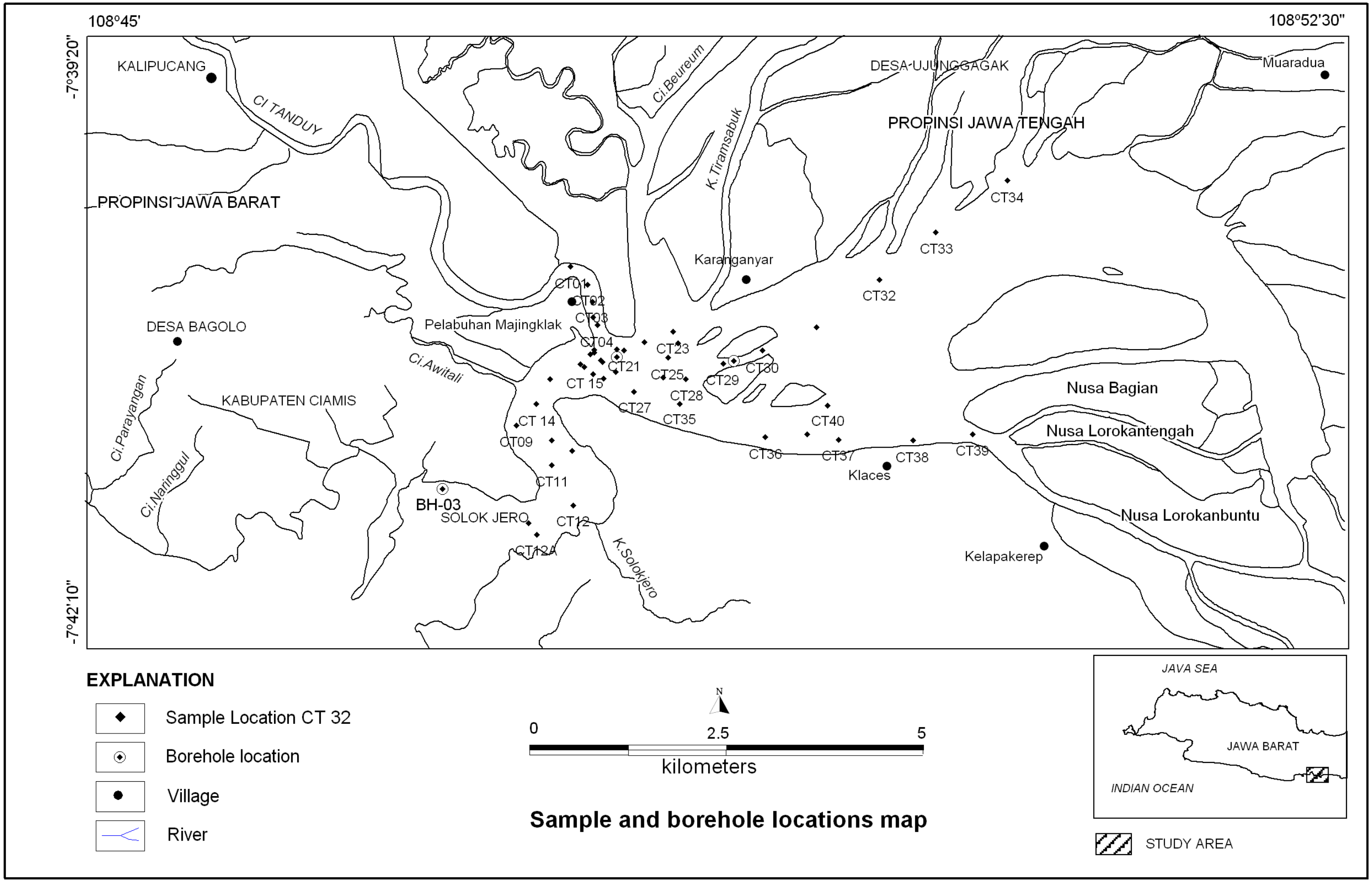


Figure 2. Sample and borehole locations map

clay minerals were found uniformly distributed from lagoon bottom up to boredepth 30 meters with percentages 1 – 5% and less than 1%. The autigenic materials discovered were dolomite at boredepth 4 – 6 meters with percentage less than 1%. Sediment types based on smear slide analyses of coredepths 1 – 4 meters were clay, silt, very fine up to fine sand, while at coredepths 4 -30 meters sediment types are clay, silt, very fine up to medium sand.

Results of smear slide analyses in borehole BH-02 (borehole depth up to 20 meter)

Almost the same as data in borehole BH-02 up to 20 meters boredepth biogenic materials found was calcareous occurred as fragments and micrites with percentages less than 1%, silicate biogenics were also not found. Non-biogenic materials found were quartz and heavy minerals of percentages 5 – 30% and iron oxyde and manganese were discovered of percentages around 30 % from lagoon bottom up to 20 meters coredepth. Mica and clay minerals were observed uniformly distributed started from lagoon bottom until the end of coredepth. The autogenic materials found were dolomite at coredepth 20 meters but with percentage less than 1%. Sediment types based on smear slide analyses from lagoon bottom up to 20 meter coredepths were clay, silt, and very fine to fine sand.

Results of smear slide analyses in borehole BH-03 (borehole depth up to 20 meter)

Lagoon bottom up to 20 meters below biogenic materials found were calcareous matters occurred as foraminifera, fragments and micrites with very rare percentage less than 1%, silicate biogenics were not found. Quartz and heavy minerals were found as non-biogenic materials of percentages 5 – 30% while iron oxyde and manganese were occurred of percentages around 30% from lagoon bottom up to 20 meters coredepth. From the lagoon battom until coredepth 20 meters, mica and clay minerals were observed uniformly distributed. The autogenic matters took place were dolomite with percentage less than 1%. Clay, silt, and very fine to fine sand were sediment types based on smear slide analyses from lagoon bottom up to 20 meter coredepths.

Complete results of smear slide analyses of BH-03, BH-01 and BH-02 can be seen in table 1a, 1b, 1c.

The smear slide results of surficial sediment of the lagoon

The results of the smear slide analyses for surficial sediment of Segara Anakan lagoon were chosen as closely representative as possible such as expressed in table 1a, 1b, 1c with detailed as follows :

The biogenic mineral type found uniformly were calcareous took place as fragments and micrites, while the siliceous materials were not found. The non-biogenic minerals distributed consistently were quartz, heavy minerals, iron oxyde and mangan, and clay. The autigenic minerals were not found from the whole surficial sediment smear slides of the lagoon bottom.

Results of major element analyses

Major element analyses were carried out for 10 selected samples of lagoon bottom surficial sediment assumed as representative for the whole investigation area which is shown in table 2. From the table, it is obvious that the most dominant element is SiO_2 with percentage ranges 36,6 – 51,4%, then Al_2O_3 with percentage ranges 13,36 – 51,4%; while Fe_2O_3 ranges between 8,69 – 30,6%. Other major elements found were Ti, Ca, Mg, K, Na with percentages between 1 -11%.

Bhatia (1983) Biavariate plot for Al_2O_3/ SiO_2 versus (Fe_2O_3 + MgO) of Segara Anakan

Table 1a. Result of smear slide analyses of borehole BH-03

NO. BOREHOLE	BIOGENIC										NON BIOGENIC								AUTIGENIC					EXPLANATION
DEPTH	Calcareous					Siliceous					Sand and Silt													
	Foraminifera	Nanno	Fragment	Micrite		Radiolariant	Diatomae	Sponge Speculae		Carbonate	Q	F	M	HM	Total Dendritus	Fe/Mn Oxyde	Volcanic Shard	Clay	Zeolite	Dolomite	Gypsum	Glouconite		
BH-03																								
1 - 7m	R	-	TR	c		-	-	-		-	C	TR	TR	C	A	TR	-	C	-	TR	-	-		clay, silt, very fine sand, med. sand
8 m	c	-	a	R		-	-	-		-	c	-	TR	C	a	-	-	c	-	R	-	-		clay, silt, very fine sand, fine sand
9 m	c	-	C	C		-	-	-		-	C	TR	TR	c	a	TR	-	c	-	R	-	-		clay, silt, very fine sand, fine sand
10 m	c	-	A	a		-	-	-		-	c	-	TR	c	C	TR	-	c	-	R	-	-		clay, silt, very fine sand, fine sand
11 m	C	-	a	c		-	-	-		-	c	-	TR	c	C	TR	-	c	-	c	-	-		clay, silt, very fine sand, fine sand
11,5 m	C	-	A	c		-	-	-		-	c	-	-	R	c	TR	-	R	-	C	-	-		clay, silt, very fine sand, fine sand
12 m	c	-	C	A		-	-	-		-	R	-	-	TR	R	R	-	C	-	TR	-	-		clay, silt, very fine sand, fine sand
15,5 m	R	-	R	A		-	-	-		-	TR	-	-	TR	TR	R	-	a	-	-	-	-		clay, silt, very fine sand
19 m	TR	-	-	TR		-	-	-		-	a	TR	R	a	D	R	-	R	-	-	-	-		clay, silt, very fine sand
20 m	TR	-	R	c		-	-	-		-	TR	-	-	R	R	R	-	A	-	TR	-	-		clay, silt, very fine sand

D = abundant (75 %)
A = most general (75-50%)
C = rather general (30-15%)
R = rare (5 - 1%)
a = general (50-30%)
c = common (15-5%)
TR = very rare (less than 1%)

Table 1b. Result of smear slide analyses of borehole BH-01

NO. BOREHOLE	BIOGENIC										NON BIOGENIC								AUTIGENIC					EXPLANATION
DEPTH	Calcareous					Siliceous					Sand and Silt													
	Foraminifera	Nanno	Fragment	Micrite		Radiolariant	Diatomae	Sponge Speculae		Carbonate	Q	F	M	HM	Total Dendritus	Fe/Mn Oxyde	Volcanic Shard	Clay	Zeolite	Dolomite	Gypsum	Glouconite		
BH-01																								
0 - 1 m	TR	-	R	TR		-	-	-		-	A	TR	TR	C	D	-	-	R	-	-	-	-		clay, silt, very fine sand, fine sand
4 m	TR	-	c	R		-	-	-		-	C	TR	R	A	D	-	-	R	-	TR	-	-		clay, silt, very fine sand, med. sand
6 m	TR	-	TR	R		-	-	-		-	C	-	R	a	A	R	-	c	-	TR	-	-		clay, silt, very fine sand, med. sand
8 m	TR	-	R	R		-	-	-		-	C	-	R	a	A	c	-	c	-	-	-	-		clay, silt, very fine sand, med. sand
10 m	-	-	R	R		-	-	-		-	C	-	R	a	A	c	-	R	-	-	-	-		clay, silt, very fine sand, med. sand
30 m	-	-	TR	TR		-	-	-		-	a		R	a	D	TR	-	TR	-	-	-	-		clay, silt, very fine sand, med. sand

D = abundant (75 %) **A = most general (75-50%)** **a = general (50-30%)**
C = rather general (30-15%) **c = common (15-5%)**
R = rare (5 - 1%) **TR = very rare (less than 1%)**

Table 1c. Result of smear slide analyses of borehole BH-02

NO. BOREHOLE	BIOGENIC										NON BIOGENIC								AUTIGENIC					EXPLANATION
DEPTH	Calcareous					Siliceous					Sand and Silt													
	Foraminifera	Nanno	Fragment	Micrite		Radiolariant	Diatomae	Sponge Speculae		Carbonate	Q	F	M	HM	Total Dendritus	Fe/Mn Oxyde	Volcanic Shard	Clay	Zeolite	Dolomite	Gypsum	Glouconite		
BH-02																								
0 - 0,8 m	-	-	TR	R		-	-	-		-	C	TR	TR	C	a	R	-	c	-	-	-	-		clay, silt, very fine sand, fine sand
0,9 m	-	-	TR	R		-	-	-		-	C	TR	TR	C	a	R	-	c	-	-	-	-		clay, silt, very fine sand, fine sand
3 m	TR	-	TR	TR		-	-	-		-	c	-	TR	a	c	c	-	c	-	-	-	-		clay, silt, very fine sand, med. sand
3,6 m	-	-	-	TR		-	-	-		-	c	-	TR	A	D	c	-	c	-	-	-	-		clay, silt, very fine sand, med. sand
5 m	-	-	-	R		-	-	-		-	c	-	TR	C	a	c	-	C	-	-	-	-		clay, silt, very fine sand, fine sand
11 m	TR	-	TR	c		-	-	-		-	C	TR	TR	c	a	R	-	c	-	-	-	-		clay, silt, very fine sand, fine sand
16 m	-	-	TR	R		-	-	-		-	c	-	-	c	c	C	-	a	-	-	-	-		clay, silt, very fine sand, fine sand
18,5 m	-	-	R	c		-	-	-		-	c	-	TR	R	c	C	-	A	-	-	-	-		clay, silt, very fine sand, fine sand
20 m	TR	-	C	C		-	-	-		-	c	-	TR	R	c	TR	-	a	-	TR	-	-		clay, silt, very fine sand, fine sand

D = abundant (75 %)
A = most general (75-50%)
C = rather general (30-15%)
R = rare (5 - 1%)
a = general (50-30%)
c = common (15-5%)
TR = very rare (less than 1%)

Samples reveals the provenance of lagoon sediments belong to Oceanic Arc adjacent to Volcanic Arc (Figure 3). This confirms with regional geological condition where Segara Anakan Lagoon is located at the south of Sunda – Banda Volcanic Arc. The lagoon acts as basin for sediments deposited by rivers that drained hinterland abundances in volcanic deposits.

The correlation diagrams of SiO_2 to other major elements show positive correlation between SiO_2 and Al_2O_3 and K_2O. It means that the increase of SiO_2 contents are followed by increase the percentages of Al_2O_3 and K_2O. On the other hand, SiO_2 demonstrates negative correlations with Fe_2O_3, TiO_2, CaO, MgO and Na_2O; the increased of SiO_2 is followed by decreasing of the mentioned oxydes. This situation can be used to predict the composition of the volcanic source rock that possibly more basic than acid as revealed by domination of these mafic oxydes.

Table 2. Results of major element analyses of surficial sediment of Segara Anakan Waters

NO.	SAMPLE NO.	Si O_2 %	Al_2O_3 %	Fe_2O_3 %	TiO_2 %	CaO %	MgO %	K_2O %	Na_2O %	LOI %
1.	CT-01	51,5	18,89	9,33	1,97	1,68	1,71	0,55	0,77	13,43
2.	CT-04	46,4	24,70	10,33	1,28	2,52	2,58	0,82	1,72	9,45
3.	CT-09	36,6	13,38	30,60	4,56	2,60	7,75	0,45	1,70	2,09
4.	CT-12A	44,9	18,89	15,92	1,54	5,73	4,54	0,82	2,04	5,45
5.	CT-17	44,2	20,50	15,20	1,70	4,57	3,81	0,77	1,65	7,39
6.	CT-21	43,0	18,11	16,50	1,70	7,30	5,52	0,66	1,89	5,10
7.	CT-31	51,3	21,30	8,69	1,15	2,60	2,58	1,15	1,28	9,78
8.	CT-34	51,0	21,30	8,46	1,20	1,53	2,60	1,31	1,18	11,31
9.	CT-38	46,8	24,70	9,16	0,85	0,83	2,06	1,11	1,79	12,46
10.	CT-39	46,6	18,89	13,00	1,84	1,51	1,99	1,18	1,87	12,93

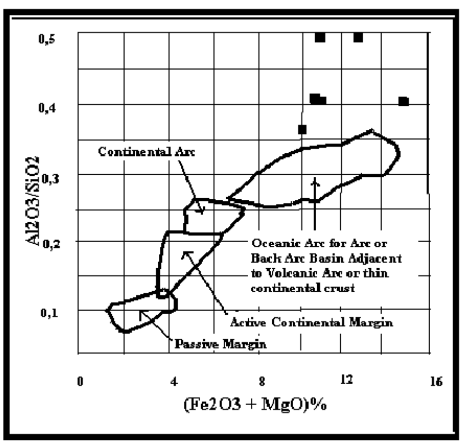


Figure 3. "Bivariate Plot" (Bhatia, 1983) diagram with plottings of Segara Anakan samples fall closed to Oceanic Arc Adjacent to Volcanic Arc. Only 6 samples can be plotted in the diagram, the other 4 values are outside.

Smear slide analyses results for BH-01, BH-02 and BH-03 show almost the same percentages of biogenic and non-biogenic materials.

The occurrences of calcareous biogenic as fragments and micrites at all boreholes is interpreted resulted from limestone weathering of Kalipucang Formation distributed vastly in the investigation area. On the other hand, quartz, mica and heavy minerals, iron oxyde and mangan minerals were estimated derived from weathered volcanic rocks and transported through fluvial systems of West Java and Central Java to coastal area.

Twenty smear slide analyses for lagoon surficial sediments (for lateral distribution purpose) show the same tendency as vertical borehole data. The biogenic contents of calcareous fragments and micrites as well as non-biogenic materials such as quartz, heavy minerals, mica, iron oxyde and mangan also demonstrate the same tendency as the verticals.

This condition is interpreted that sediment supply in times are originated from the same rock types either from the east or from the west of the investigation area.

Heavy mineral analyses were conducted to 20 samples of grain size greater than 3 phi. The results demonstrate that the investigation area is still dominated by magnetite minerals ranges between 1,2 – 16,7% from total 12 mineral types identified. Other heavy minerals significantly identified are augite, hornblende, olivine biotite, limonite, rutile, quartz and hypersthene.

The existences of some determinant minerals from smear slide, heavy mineral and major element analyses indicate that the source of especially heavy minerals deposited in Segara Anakan lagoon possibly derived from volcanic rocks of basic composition as revealed in Figure 2. This condition is in accordance with regional geology of the investigation area which mostly consisted of volcanic products, such as Jampang Formation composed by volcanic breccia, tuff with lava intercalations, sandstone intercalations, claystone, marl with conglomerate intercalations; Panutuan Formation consisted of sandstone, marl and tuff, and Marly Tuff Member of Panutuan Formation. Almost all the geological formations occur at catchment area of Citanduy river with its distributaries.

Analitically as discussion mentioned, sediment supplies deposited in Segara Anakan lagoon are mostly derived from catchment of Citanduy River in the hinterland.

Conclusions

Consistent distribution of biogenic and non-biogenic materials in the investigation area either laterally or vertically indicate that the source of sediment supply in times derived from the same source.

The biogenic contents of calcareous and micrite in lagoon sediments evenly distributed vertically and horizontally are estimated as the result of weathering of limestone of Kalipucang Formation widely spread in the investigation area.

Non-biogenic products such as quartz, mica, iron oxyde, and manganese oxyde evenly distributed are products of volcanic rocks such as tuff.

Biavariate plot for Al_2O_3/SiO_2 versus (Fe_2O_3 + MgO) of Segara Anakan Samples reveals the provenance of lagoon sediments belong to Oceanic Arc adjacent to Volcanic Arc.

The occurrences of major elements SiO_2 with ranges 36,6 – 51,4%, Al_2O_3 13,38 – 24,70% and Fe_2O_3 8,69 – 30,6% are characteristic of volcanic products of basic composition. This view is also supported by negative correlations between SiO_2 and mafic oxydes Fe_2O_3, TiO_2, CaO and MgO which are all indicative for basic composition source rocks.

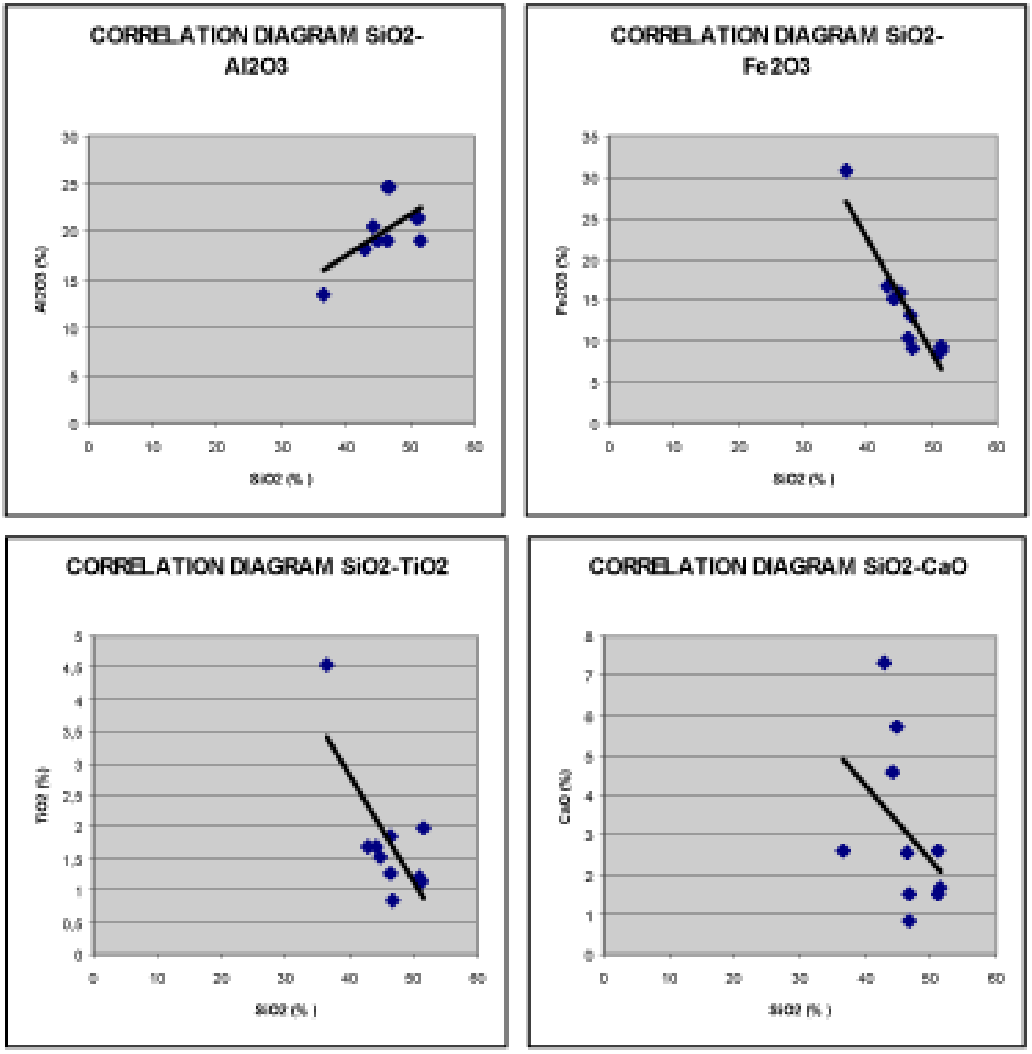
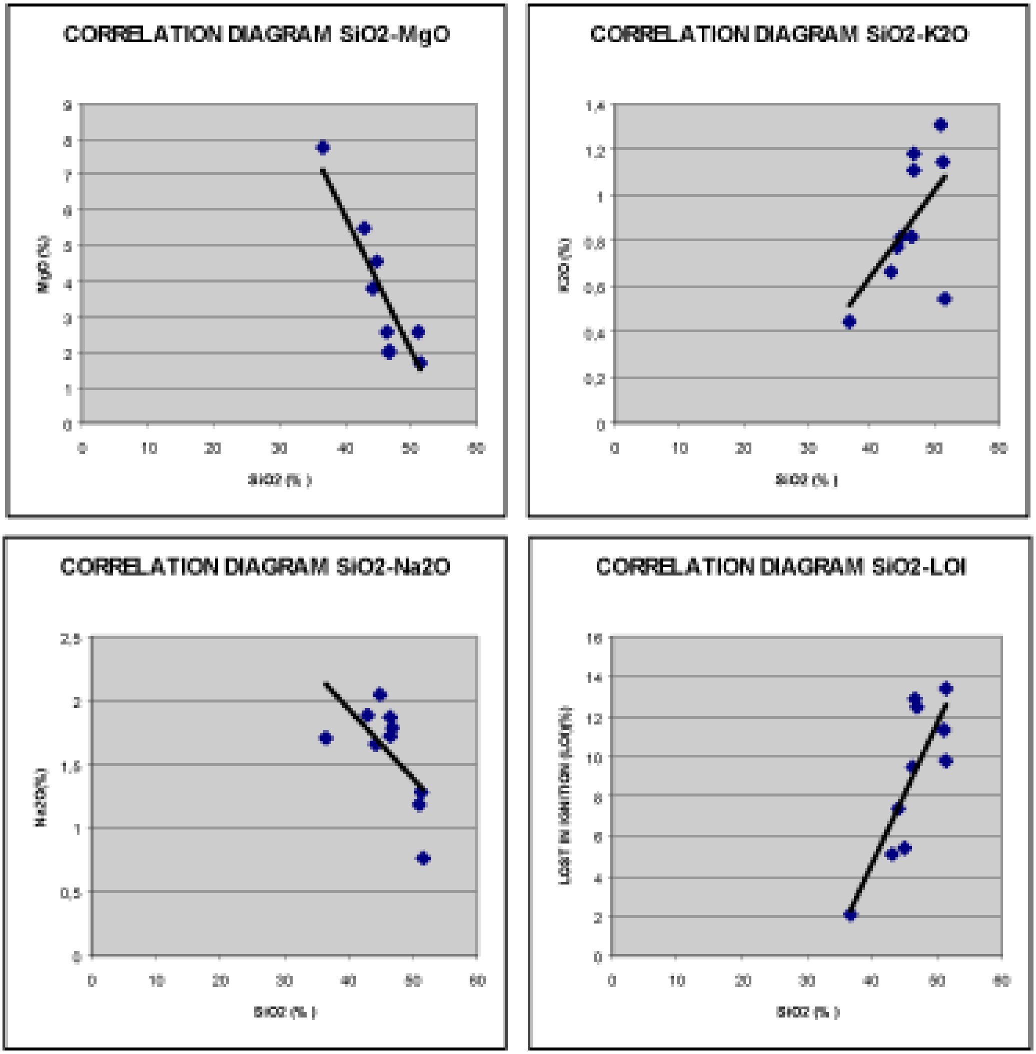


Figure 4. Correlation diagrams SiO2 to Al2O3, Fe2O3, TiO2, CaO, MgO, K2O, Na2O and LOI (Kurnio et al, 2005)
Note: LOI is abbreviation of "Lost In Ignition" for elements lost during heating of sediment samples in the laboratory at temperatur about 110°C.

Figure 4. *(Continued)*



Regional geology condition of the investigation area support the conclusion cited, because almost all geological formations are volcanic products, such as Jampang Formation consisted of volcanic breccia, tuff with lava intercalations, sandstone intercalations, marly claystone with conglomerate intercalations, Panutuan Formation consisted of sandstone, marl and tuff, and Marly Tuff Member of Panutuan Formation. Almost all the geologicall formations occur at catchment area of Citanduy, Cibeureum and Ciseel rivers with its distributaries.

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